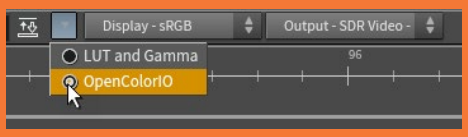
HOUDINI FOUNDATIONS

DESTRUCTION FX

One of the things that makes visual effects fun is that you get to blow things up without causing any real damage. In this lesson, you will light a fuse using particle sparks then explode a cartoon bomb using rigid body dynamics for the shell of the bomb and Pyro FX for the fire and smoke. This lesson will teach you how to set up dynamic simulations using a variety of shelf tools and network nodes.

To give you a complete understanding of the shot being developed, you will build all the elements from scratch, then simulate the effects. This will help you understand how the simulation nodes work within the wider context of a Houdini scene. In the end, you will render out the shot using the Karma renderer.

ACES | OPENCOLORIO SETUP



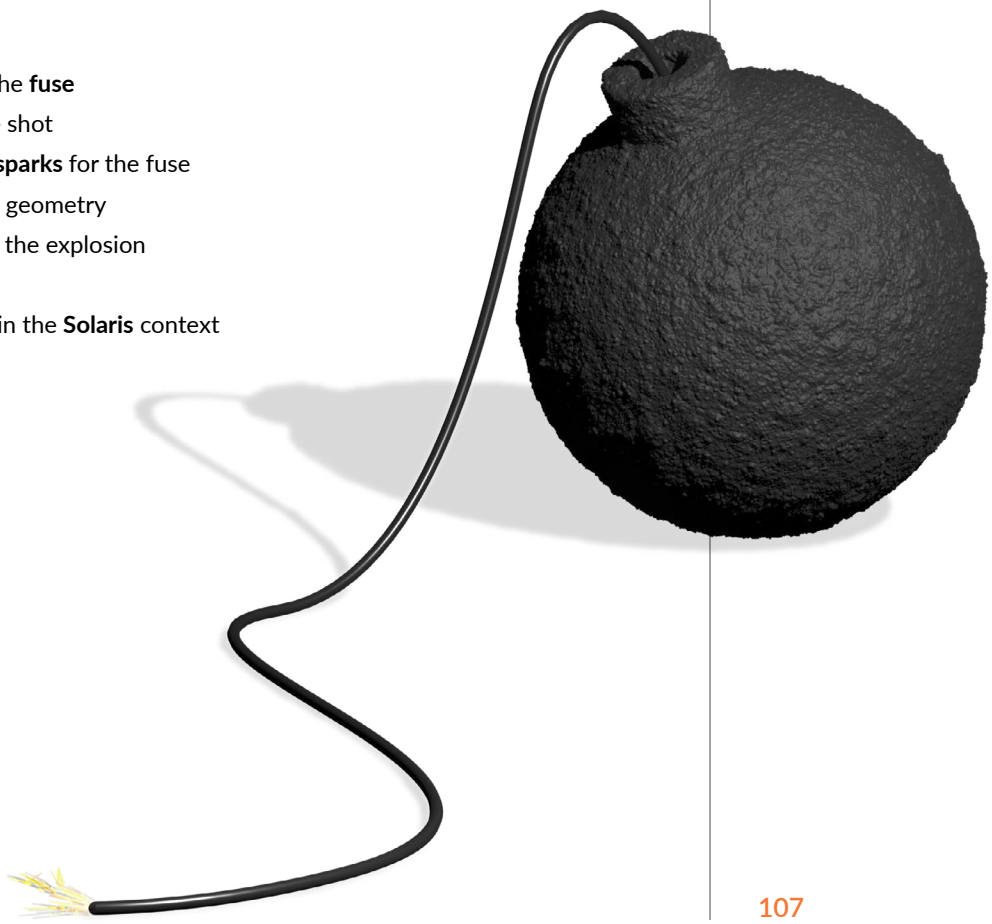
For more accurate color display when working with Pyro FX, you should use the **Academy Color Encoding System (ACES)**. To use it, bring up the **Correction Toolbar** from the **viewport (persp)** menu in the scene view. From the arrow button on the right, choose **OpenColorIO**. This will give you a Display of **sRGB** and an output of **SDR Video - ACES 1.0**. This setting only works for your current session and will need to be turned back on each time you open Houdini.

LESSON GOAL

Model then blow up a bomb using particle sparks, rigid body dynamics and Pyro FX.

WHAT YOU WILL LEARN

- How to model the **bomb** and animate the **fuse**
- How to **animate a camera** to set up the shot
- How to set up a **particle soot trail** and **sparks** for the fuse
- How to **shatter** then explode the bomb geometry
- How to set up a **Pyro FX** simulation for the explosion
- How to set up **materials** and **textures**
- How to **render** the effects with **Karma** in the **Solaris** context



LESSON COMPATIBILITY

Written for the features in Houdini 19.5+

The steps in this lesson can be completed using the following Houdini Products:

Houdini Core	✘
Houdini FX	✔
Houdini Indie	✔
Houdini Apprentice	✔
Houdini Education	✔

Document Version 1.0 | July 2022
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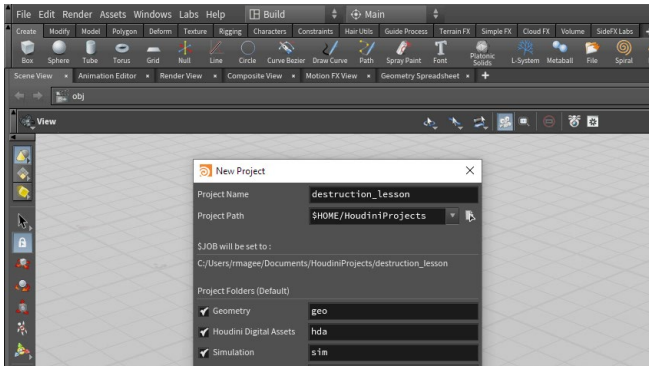
PART ONE

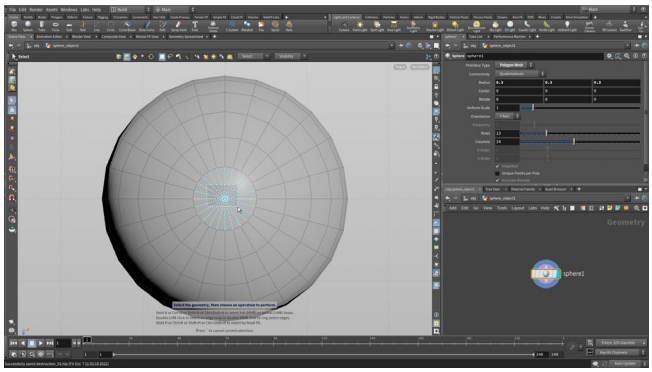
Model the Bomb

To create the bomb geometry, start with a primitive sphere and modify it to define the opening at the top. This will involve a few poly extrudes and bevels to define the geometry you will need for the final shape. Later in the lesson, you will fracture the bomb.



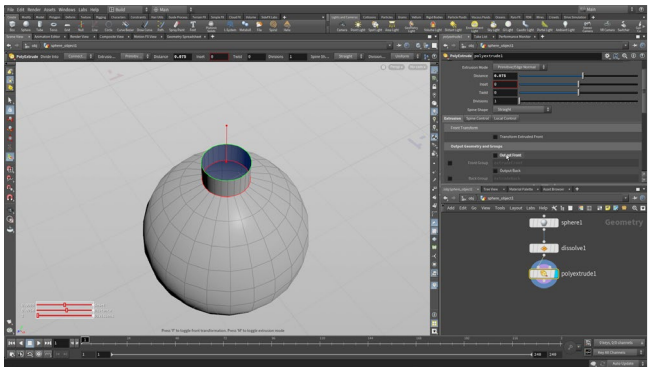
01 Select **File > New Project.** Change the **Project Name** to *destruction_lesson* and press **Accept**. This creates a project directory with sub directories for all the files associated with this shot.

Select **File > Save As...** You should be looking into the new *destruction_lesson* directory. Set the file name to *destruction_01.hip* and click **Accept** to save.



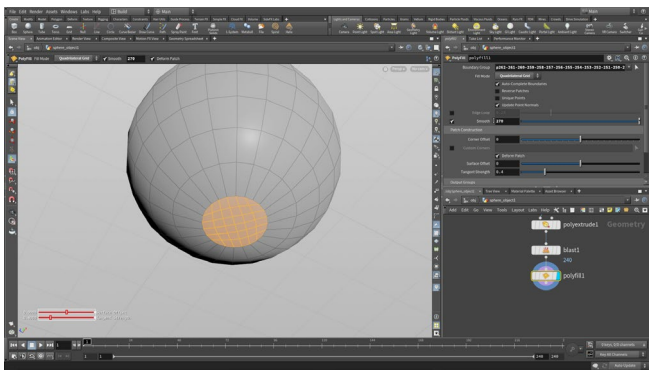
02 In the viewport, **press c** to bring up a radial menu. From this menu, choose **Create > Geometry > Sphere**. In the viewport, press **Enter** to place it at the origin. In the Operation Control bar at the top, set **Radius** to **0.3, 0.3, 0.3**.

Press s to get the select tool then **3** to invoke edge selection. Press **Spacebar 2** to go to a Top view. Box select the edges at the top and bottom of the circle and press **delete**. This dissolves the edges and leaves two circular polygons in their place Press **Spacebar 1** to go back to a perspective view.



03 **Press s** to get the select tool then **4** to switch to primitive (face) selection. Select the circular polygon at the top of the sphere.

Press c to bring up the radial menu and select **Model > Polygons > Polyextrude.** Move the handle up by a **Distance** of about **0.075.** Set **Output Front** to **Off.**



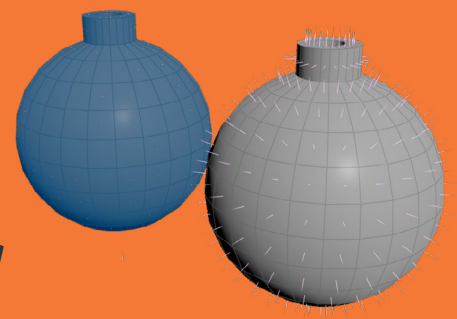
04 **Select the** circular polygon at the bottom of the sphere and **press Delete.** This will add a **blast** node to the network. **Press s** to go to the **Select** tool and **3** to change to edge selection. **Double click** on the edge of the hole you just created to select all the edges.

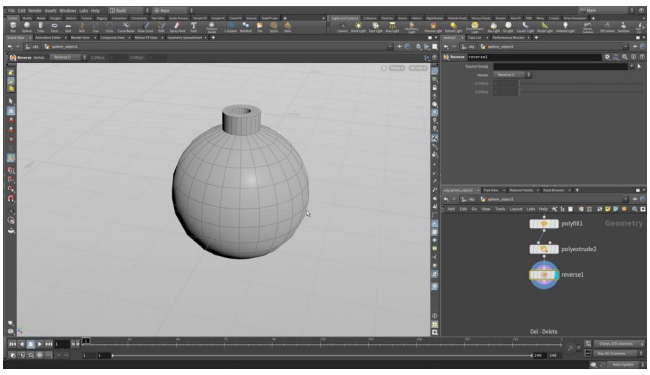
Press **tab > Polyfill**. In the Parameter pane, set **Fill Mode** to **Quadrilateral Grid** and **Smooth** to **270**. This creates a cleaner topology for the bottom of the sphere that doesn't go to a single point.

SURFACE NORMALS

Every primitive has a normal direction where one side is the inside and one is the outside. When you polyextrude the bomb geometry it will be inside out at first. This is indicated with the blue color on the faces. You can then use a Reverse node to redirect the normals.

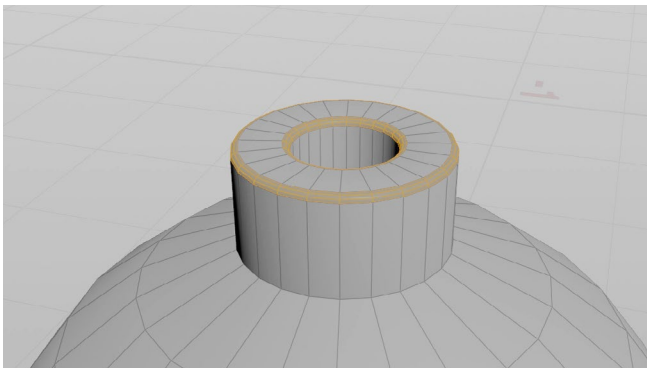
You can see the normals on the surface using the **Display Primitive Normals** button found in the **Display Options** bar on the right side of the **Scene view** pane.





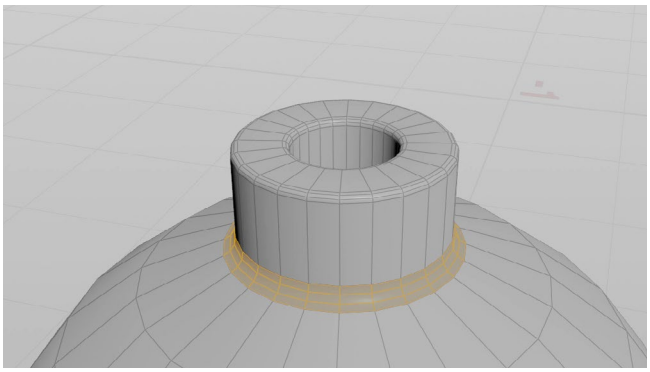
05 **Press n** to select all Faces and again get the **Polyextrude** tool. Extrude to a **Distance** value of around **-0.04.** In the Parameter pane in the **Extrusion** tab, turn on **Output Back**.

Press n to select all Faces and again press **tab** and start typing **Reverse**. This node reverses all the polygon normals. Now they are pointing in the right direction.



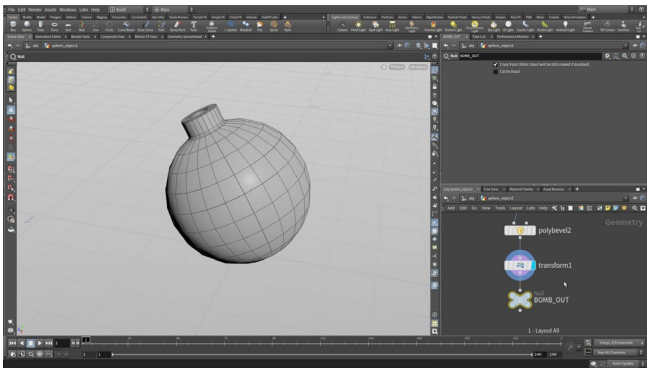
06 **Press s** to go to the **Select** tool and **3** to change to edge selection. **Double click** on the edge at the top of the bomb and then press **Shift** and **double click** to select the inner circle at the top.

Press c to use the radial menu to go to **Model > Polygons > Polybevel**. Set **Distance** to **0.005**. Set the **Shape** to **Round** and **Divisions** to **3**.



07 **Press s** to go to the **Select** tool. **Double click** on the edge where the circular part of the bomb meets the extruded section at the top.

Press q to repeat the last tool which was **Polybevel** and set **Distance** to **0.01**, Shape to **Round** and **Divisions** to 3.



08 In the Network view, press **tab > Transform** and add it to the end of the network. Set **Translate Y** to **0.3** and **Rotate X** to around **27** degrees.

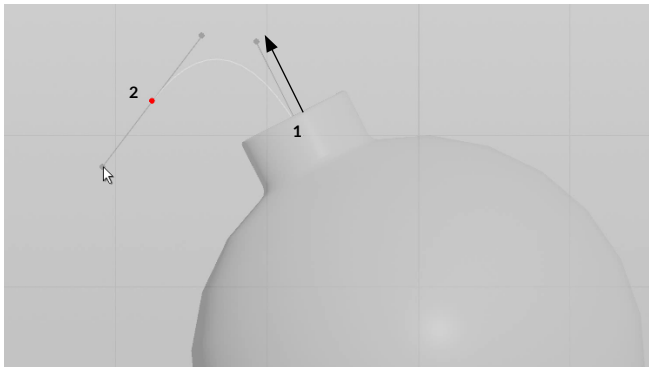
Add a **Null node**. Wire the end of the *polybevel* to the *null* then set the **display flag** on the *null* node to display it. **Double click** on its name and change it to *BOMB_OUT*.

Go to the **Object** level and rename the object to *bomb_geo* since it holds the bomb's geometry.

PART TWO

Model the Fuse

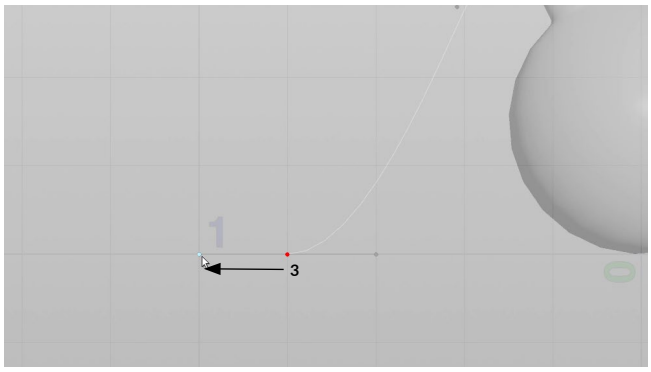
To create the Fuse, start with a Bezier curve that emerges from the top of the bomb. You can then snake the curve on the ground to create a longer fuse. Reverse the curve direction to get ready for animating the fuse then add a Polywire node to give the fuse thickness.



01

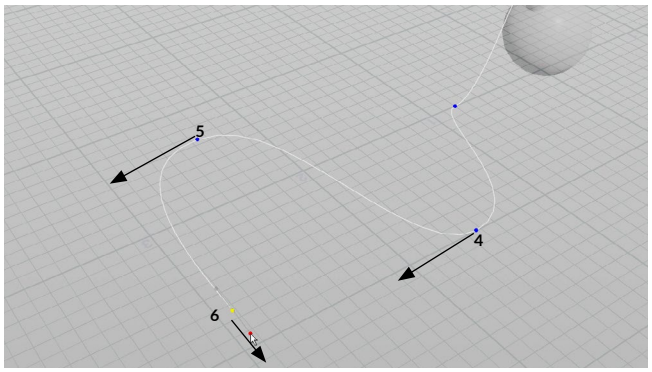
Press **spacebar-b** to see the bomb from all angles. Move over the **Right** view and press **spacebar-b** to expand it.

Press c to bring up the radial menu and choose **Create > Geometry > Curve**. **Click drag** up to create the first point and tangent handle for the curve. Next add a point and **drag down** to quickly draw the curve pointing down.



02

Press x and choose **Grid** to turn on grid snapping. Click and drag on the ground to create a third point with its tangent handle aligned along the ground.



03

Press **spacebar-b** to go back to 4 views then mouse over the *perspective* view and press **spacebar-b** again expand the view.

Turn off **Grid Snapping** then turn on the **Construction Plane** using the second button at the top of the **Display Options** bar. This will make sure that any edits you make stay on the ground.

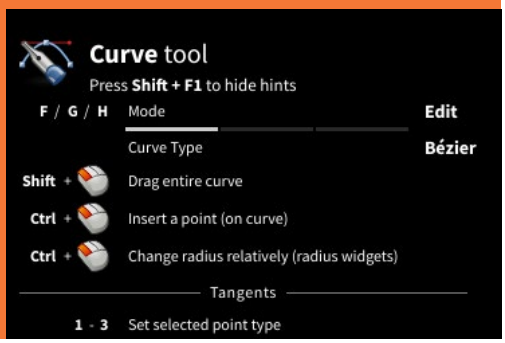
Draw three new points with their tangents dragged out to define the curve's shape.

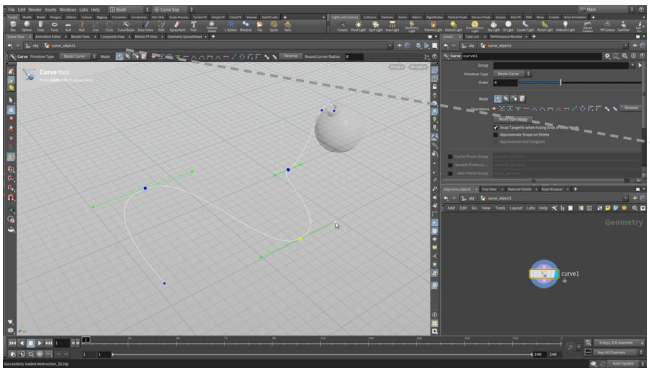
MMB-click to complete the curve.

TOOL HINTS

The curve tool comes with tool hints that display in the Scene view as you work. These provide different shortkey options for this tool and help you get familiar with how it works.

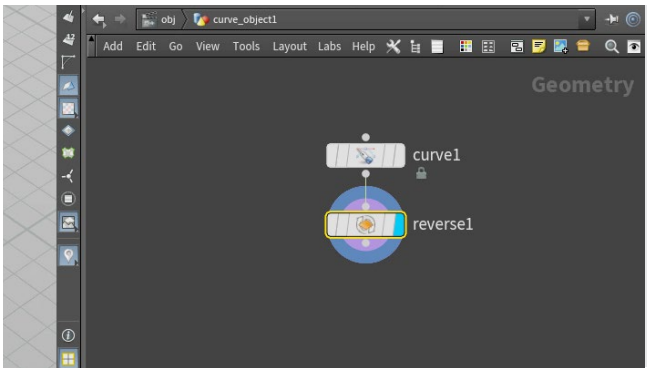
You can collapse it using **Shift + F1** and only the tool name will display. There are a growing number of tools that use tool hints and you will see more of them in future versions of Houdini.



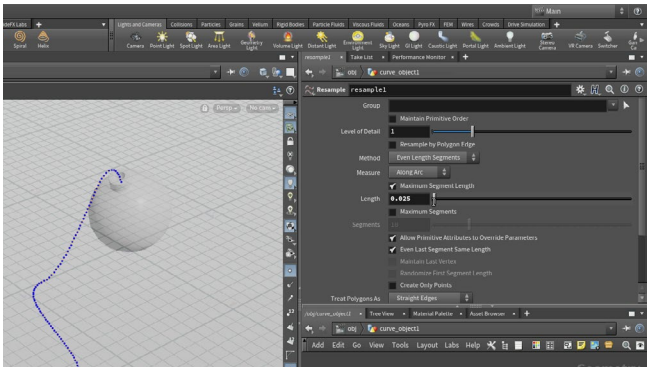


04 In the **Operation Control** bar, change the curve **Mode** to **Select/Edit**. Now you can click on the edit points on the curve and make changes to refine the shape of the curve.

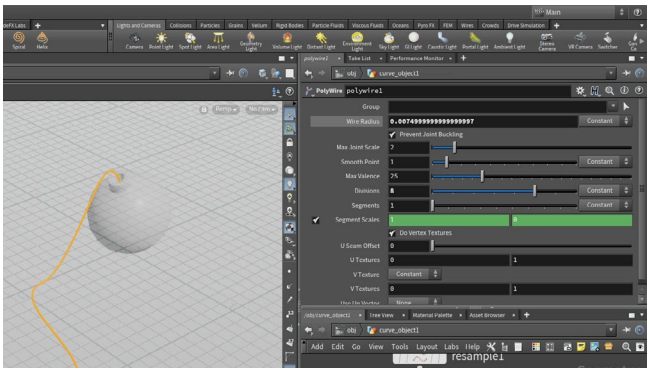
Select and edit the points on the ground to get the desired look for the curve. Tumble around to make sure that your curve stays above the ground plane.



05 In the Scene View, press **tab > Reverse**. **Press n** to select the whole curve and press **Enter**. Since the curve was drawn from the bomb out, it will not animate in the direction you need. This will put the start of the curve where the fuse begins.



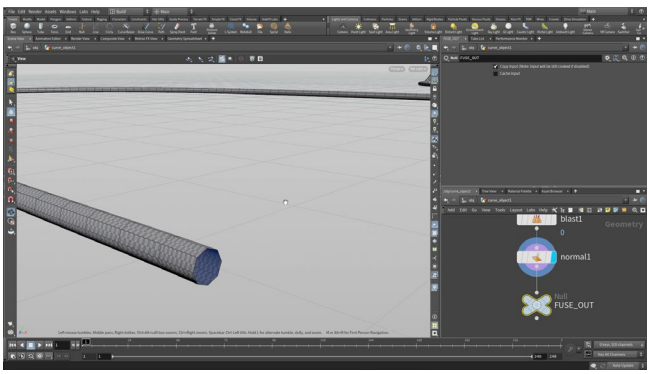
06 Turn on the **Display Points** option in the **Display Options** bar. Add a **Resample** node. On the *resample* node, set the **Maximum Segment Length** to **0.025** to add more detail. The *resample* node evens out the points.



07 Add a **Polywire** node to add thickness to the wire. Set the **Wire Radius** to **0.0075** and the **Divisions** to **8**.

Between the *reverse* and *polywire* nodes, add a **Transform** node. Go to the polywire node and **RMB-click** on the **Wire Radius** parameter and choose **Copy Parameter**. Now go back to the *transform* node and **RMB-click** on **Translate Y** and choose **Paste Relative References.**

This will lift the whole fuse up so that it is not halfway under the ground grid.



08 Add a **Blast** node Set **Group** to **0**. This deletes the end of the fuse geometry. Next add a **Normal** node to the end of the chain.

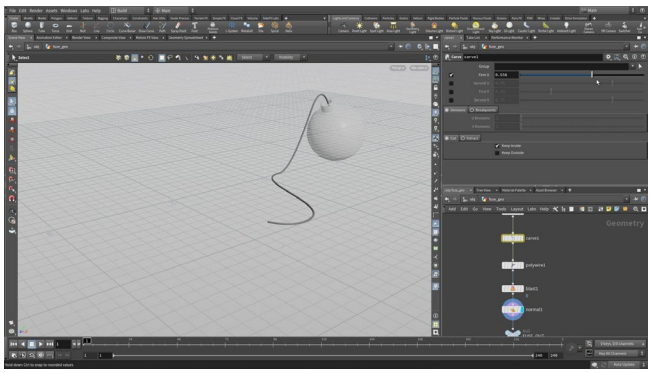
After the *normal* node, add a **Null** node and name it *FUSE_OUT*. This gives you a node representing the whole fuse geometry.

Go back up to the object level and rename this object to *fuse_geo*.

PART THREE

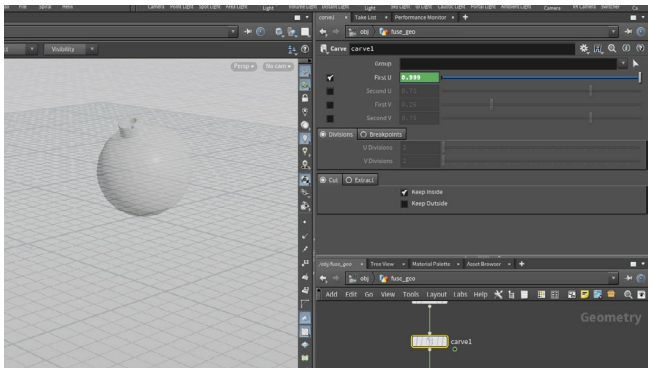
Animate the Fuse

Animate the fuse using a Carve node that lets you control the length of the curve over time. Add a round cap to the fuse that will be used to emit soot and sparks. You need to set up tangents on the curve to ensure that the cap follows along properly. Next add some NULL objects to make it easier to export the cap for use in emitting particles.



01 Dive back into the *fuse_geo* object. Between the *transform* node and the *Polywire* node add a **Carve** node. Drag on the **First U** slide to see how this affects the curve.

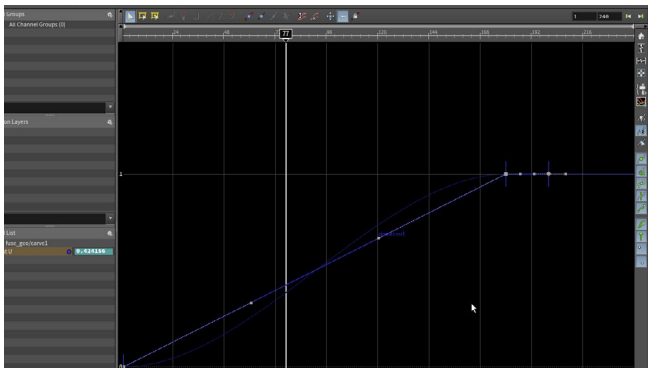
Set **First U** to **0**. **Alt click** on **First U** to set a keyframe at **frame 1**. The parameter box will change color to indicate that it has been keyframed and that there is a key at the current frame.



02 Go to **frame 180**. Set **First U** to **0.999**. This will set a keyframe. You can see that the fuse will. Go to **frame 200**. Set **First U** to **1.0**. This will set another keyframe.

In the bottom left of the Playbar, toggle **realtime playbark** on so that it doesn't play back too fast and press **Play**.

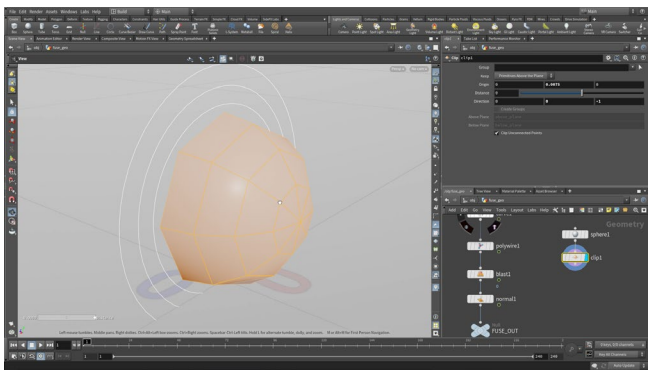
The fuse now animates into the bomb geometry where you will set up the explosion.



03 Click on the **Animation Editor** Pane tab. Select the animation curve and click on the **Straight** button at the top of the panel. This will straighten the curve and the fuse will animate evenly from start to finish instead of speeding up then slowing down at the end.

Go back to the Scene View pane tab and **playback** the animation to see how this change affects the motion.

Save your work.



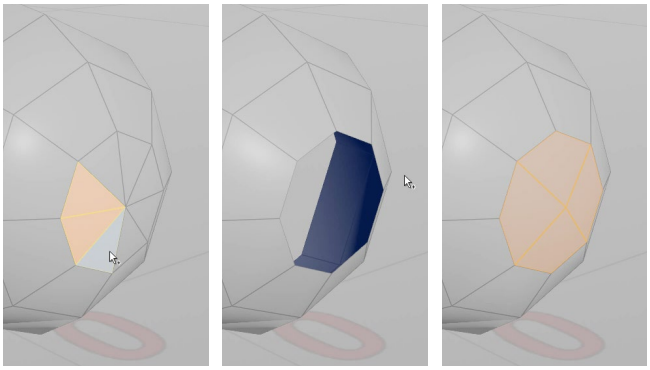
04 In the Network View, add a **Sphere** node and set its **Display Flag**. Set the following:

- **Radius** to **1, 1, 1**
- **Center Y** to **0.0075**
- **Uniform Scale** to **0.0075**

Press **Spacebar-F** to focus on it.

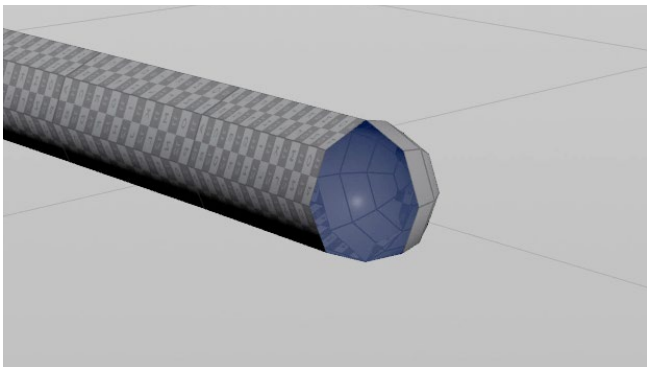
- **Orientation to Z Axis**
- **Rows** to **9** and **Columns** to **8**

In the Scene view, **press n** to select all then **tab>Clip** node and set its **Direction** to **0, 0, -1**.



05 Tumble around and **press s** to get the select tool and **4** to get **face/primitive** selection. Select one of the triangles at the tip of the sphere then **press and hold** the **a key** and then **middle click** two triangles over to select all the triangular faces. Press the **Delete** key to remove them. This adds a *blast* node to the network.

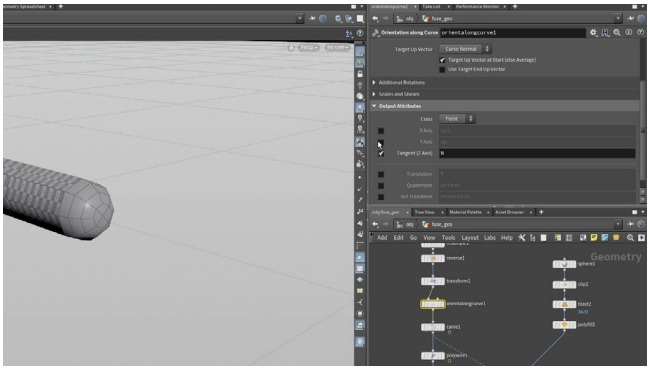
Press 3 to go bring up edge selection then double click on the edge of the area you just blasted. Press **tab > polyfill** which places the node after the *blast*. Set **Fill mode** to **Quadrilateral Grid** then turn on its **Display flag**. Set **Smooth** to **100** and **Tangent Strength** to **0**. This will create quad topology at the tip of the sphere.



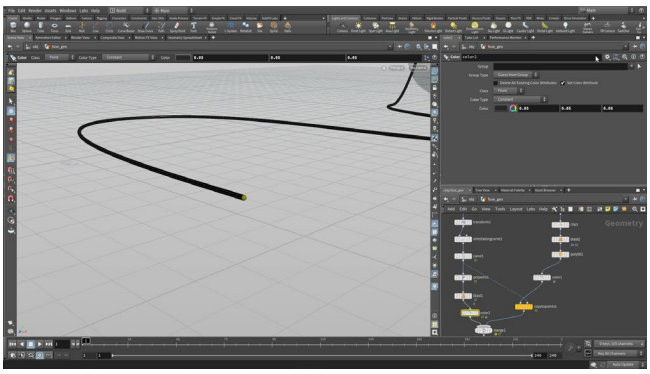
06 Add a **Copy to Points** node into the network. Feed the *polyfill* node from the sphere into the first input and the *carve* node into the second input. Set **Target Points** to **0**.

Add a Merge node. Feed the *blast* node and the *copytopoints* node into it then wire it into the *normal* node.

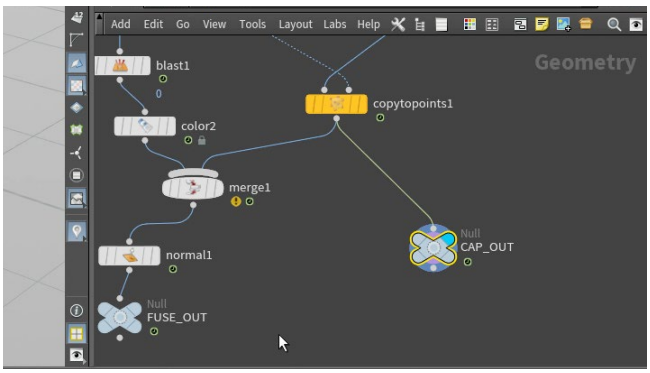
The cap it positioned properly at the end of the curve but it isn't oriented correctly. You need to add normals to the curve to allow for proper alignment.



07 Add a **Orientation Along Curve** node between the *reverse* and the *carve* nodes. Under **Output Attributes** turn off the **Y Axis** option. Leave **Tangent (Z axis)** set to N. This adds normals to the curve that will align the end cap as it moves along the fuse.



08 Add a **Color** node after the *polyfill* node and set the Color to **yellow**. Add another **Color** node after the fuse's *blast* node and set its **Color** to **Dark Gray**. These colors will be helpful for visualizing the fuse as you work and can also be used to affect the materials being assigned later.



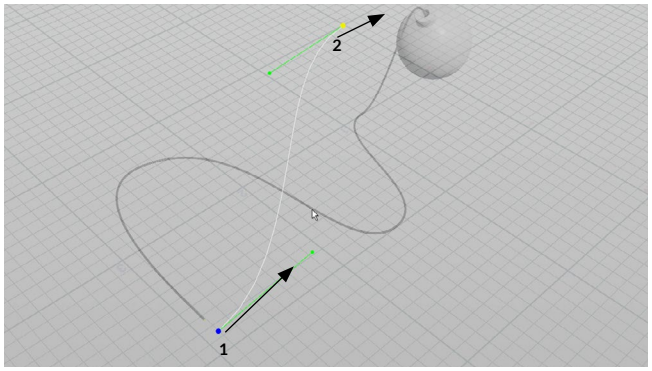
09 Branch off a **Null** node after the *copytopoints* node and place it to the side. Name the *null* node *CAP_OUT*. You will use this later to extract the cap into another network that you will reference to emit particles. Set its **Display Flag** to see only the half sphere. You can scrub the **Playbar** to see it move with the carve.

When you are finished, set the **Display Flag** back to the FUSE_OUT null.

PART FOUR

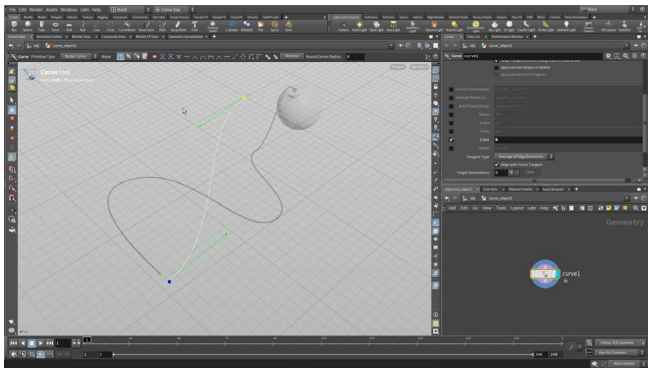
Create an Animated Camera

As you develop this shot further, it would be helpful to have a camera set up to frame the final shot. This camera rig will be built by constraining a null object to a curve then using an aim constraint to point the camera to the null object. This will give you a camera that follows the end of the fuse to make it easier to evaluate the particles as they are being emitted.

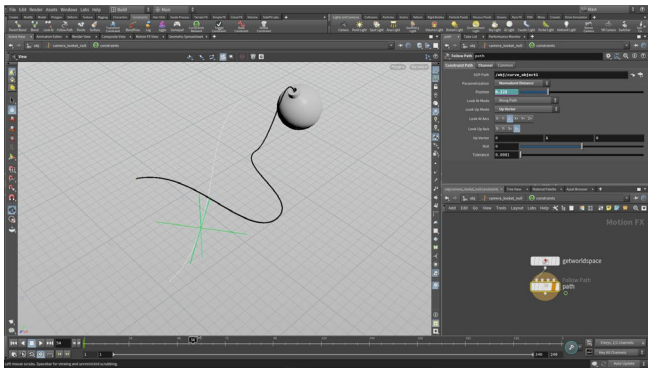


01 Dolly out to see the whole scene from above. Make sure the **construction plane** is **on**. **Press c** to bring up the radial menu and choose **Create > Geometry > Curve**. **Click-drag** a point near the start of the fuse and drag forward to extend the tangent.

Next, **click-drag** a second point behind the bomb and drag to pull out the tangent to create an s shaped curve. **MMB-click** to finish and use **Select/Edit** mode if you want to tweak the shape.

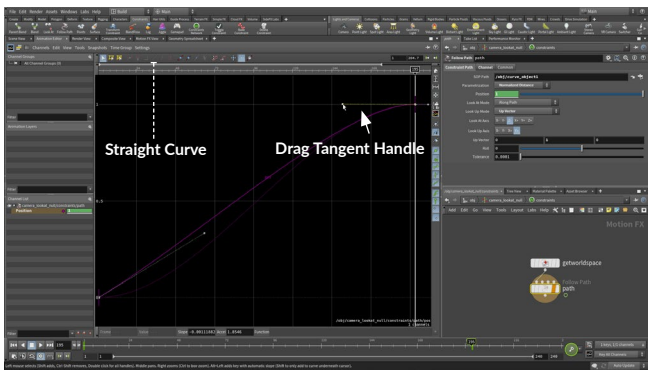


02 On the Curve node, turn on the Z Axis option and set it to N. This will create normals that will assist with animation along the curve.



03 Add a **Null** object at the origin. Rename this node *camera_lookat_null*. From the **Constraints** shelf, click on the **Follow Path** tool. This accepts the null as the starting object. Select the *curve* as the path object then press **Enter**. Press **Enter** twice more since you don't need a **look-at** object or a **look-up** object.

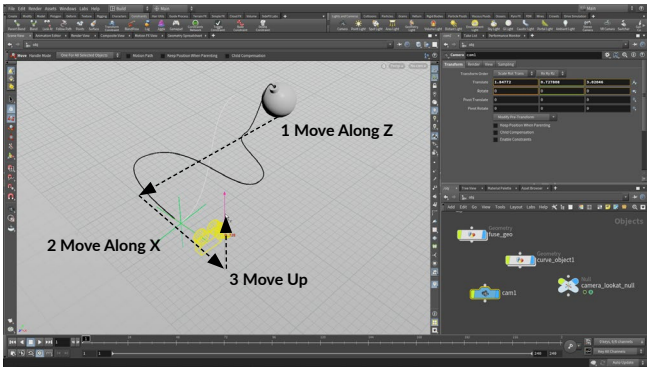
Now if you scrub in the timeline, you can see that the null object is moving along the Path from the first frame to the end frame at an even pace.



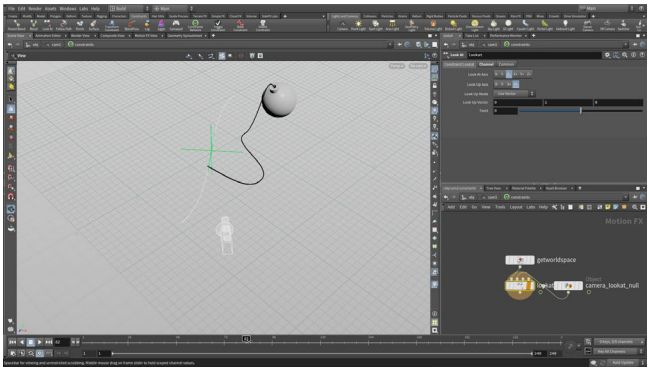
04 A constraint network was added to the null object and a path node is created. Go to **frame 1**. With the Path node selected, RMB click on the **Position** parameter and choose **Delete Channels** to remove the expression that is animating the null along the path. Set **Position** to **0**. **Alt click** on **Position** to set a keyframe.

Go to frame 195 and set **Position** to **1**. **Alt-click** on **Position** to set a second keyframe.

Click on the **Animation Editor** tab and **press h** to see the whole curve. Select it and press the **Straight** button to make it linear. Grab the tangent on the second point and adjust to smooth out the end.

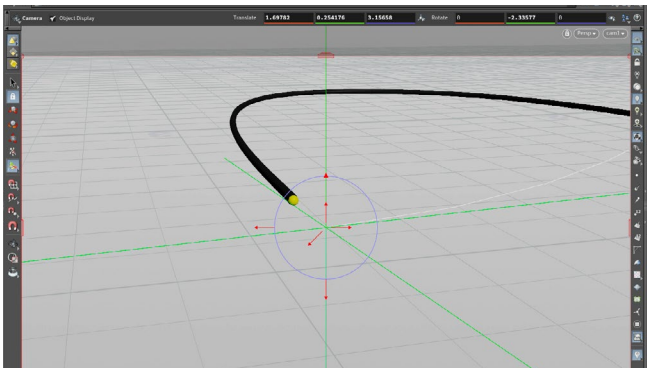


05 In the Network view, press **tab > Camera** and press **Enter** then click to place it at the origin. Now use the **Move** tool to move it in front of the fuse and a bit to the right. Next move it up along the Y axis to raise it from the ground by about **0.75** units.



06 From the **Constraint** shelf, click on the **Look At** tool. This will use the selected Camera as the look at object. Select the *null* object as the **look at** object and press **Enter**. Press **Enter** again to not assign anything as the **look up** object.

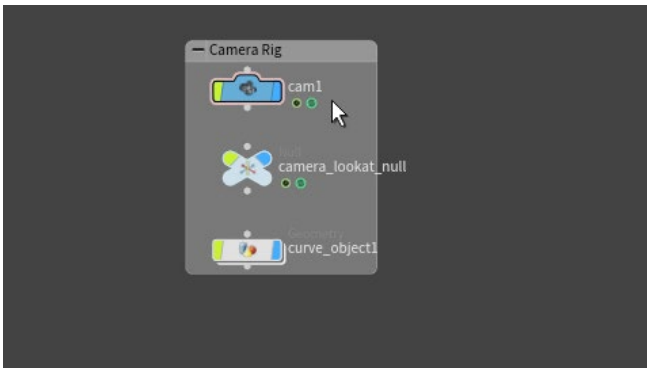
Now the camera is looking at the Null object. From the Camera menu, select *cam1* to look through this camera.



07 Go to **Frame 1**. Select the *camera* and make sure the **Handle** tool is active. This brings up a camera handle which you can use to reposition the camera to have a better view of the fuse's starting point.

Go to **Frame 195**. Use the same handles to reposition the camera to make sure the bomb in nicely positioned in the frame.

You may need to scrub back and forth to tweak the camera to work properly throughout the sequence. Make sure you can see the fuse throughout the whole sequence.



08 Go to the object level and select the *curve*, *camera_lookat_null* object and *cam1* node and align them then put them into a network box. Double click on the box's title bar and name the box *Camera Rig*. **Turn off** the display of all the parts so that you don't see them in the scene view as you work. You can collapse this box if you want or keep it open if you want to work with it further.

Save your scene.

CONSTRAINTS

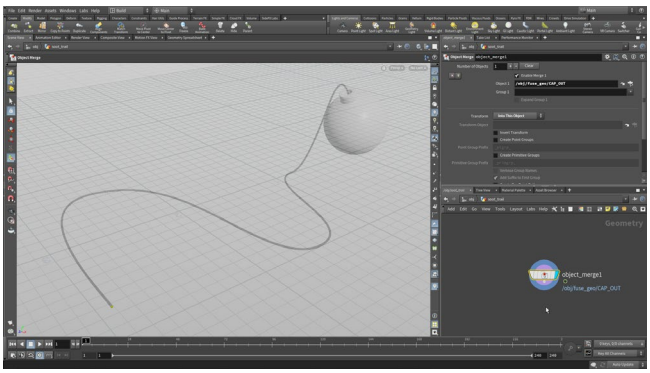
To get the null object to follow the path and then to get the camera to look at the path, you used animation constraints found on the **Constraints** shelf. The are accomplished using a special node type called **Channel Operators** or **CHOPS**. You can find these nodes inside the null and camera nodes. You can use these to control how the constraints work.

Another way to work with CHOP nodes is to use the **Motion FX** menu that you find when you **RMB-click** on any parameter.

PART FIVE

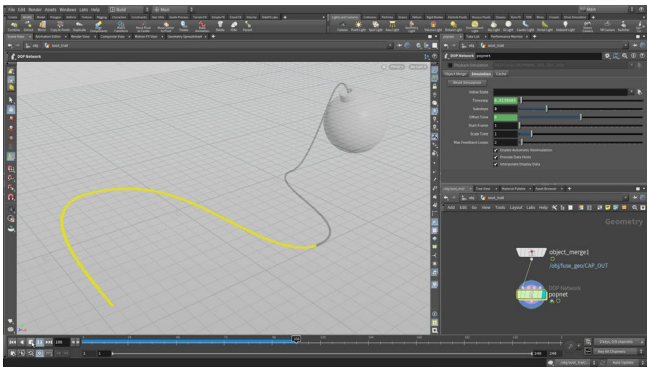
Create a Soot Trail

To create a soot trail, use the end cap to emit a trail of particles. Learn how to emit these points properly and how to add forces such as gravity to control the motion of the particles. Learn how to set up collisions where the particles either stick to the ground or slide off the bomb surface.



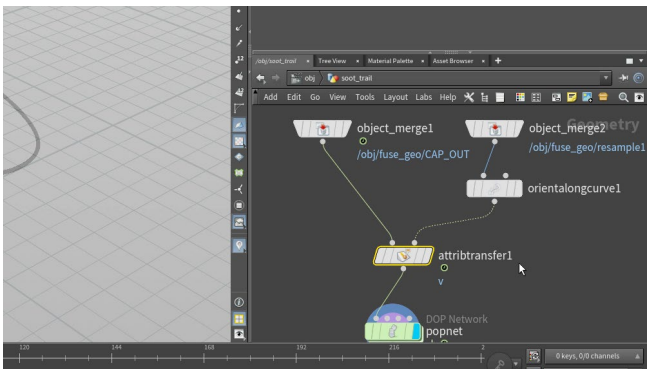
01 Dive back into the *fuse_geo* object node. With the display flag on *CAP_OUT*, go to the **Modify** shelf and use the **Extract** tool. **Press n** to select all the faces then press **Enter** to create a new object with the Cap being imported using an *Object Merge* node. Go up to the object level and name this object *soot_trail*.

Go back to the *fuse_geo* object and set the display flag to FUSE_OUT. Now you will see the combined fuse geometry when you render and the new object will be used to generate particles.



02 Dive into the *soot_trail* node and add a POP network node to the end of the chain. Dive in and on the *Source First Input* node, set **Const Birth Rate** to **1000**. Press **Play**. You can see particles being emitted but they aren't doing anything.

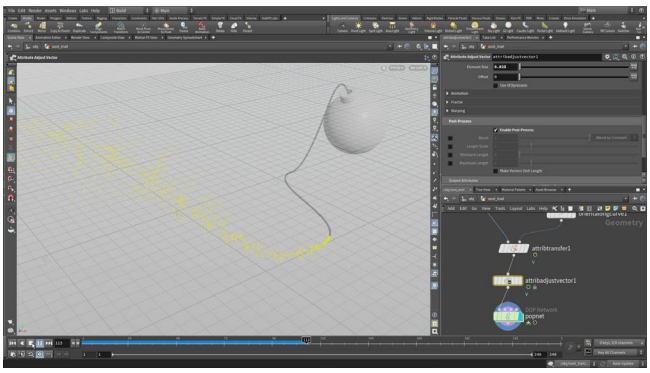
Go back up one level and on the **Simulation** tab, set **Substeps** to **3**. Press **Play**. You can see particles being emitted more evenly.



03 **Alt-drag** on the *object_merge* node to make a second copy. Set **Object 1** to the *fuse_geo>resample* node. You are going to use this curve to transfer velocity onto the cap.

Now add a **Orient Along Curve** node and under **Output Attributes** turn on **Tangent (Z Axis)** and set it to **v**.

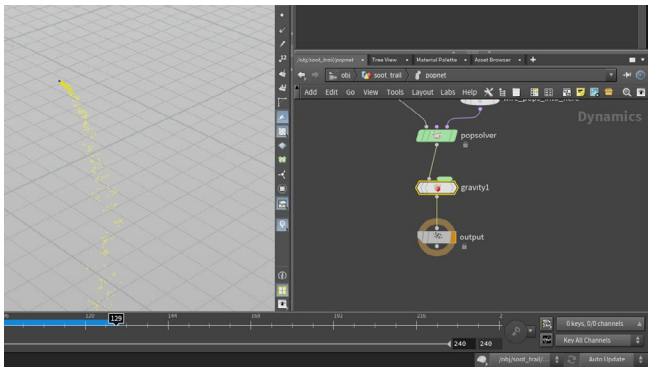
Add an **Attribute Transfer** node between the original *object_merge* and the *popnet* node. Turn off the **Primitives** checkbox and set **Points** to **v**.



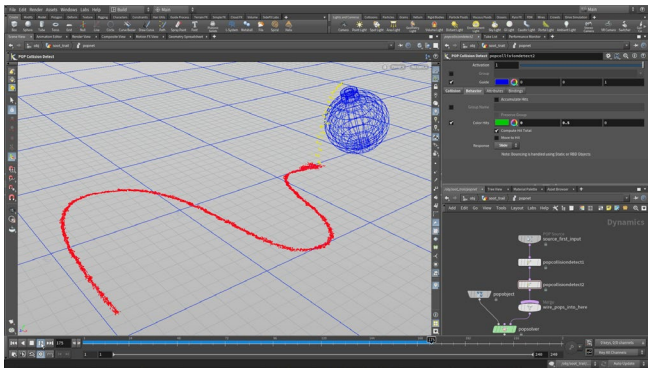
04 Place an **Attribute Adjust Vector** node in between the *attributetransfer* and the *popnet*. Under Adjustment value set the following:

- **Adjustment for** to **Direction Only**
- **Adjust with** to **Noise**
- **Range Values** to **Zero Centered**
- **Amplitude** to **0.5**

Under **Noise Pattern** set **Element Size** to **0.025** and under **Post Process**, turn on **Enable Post-Process**. Press **Play** to test.



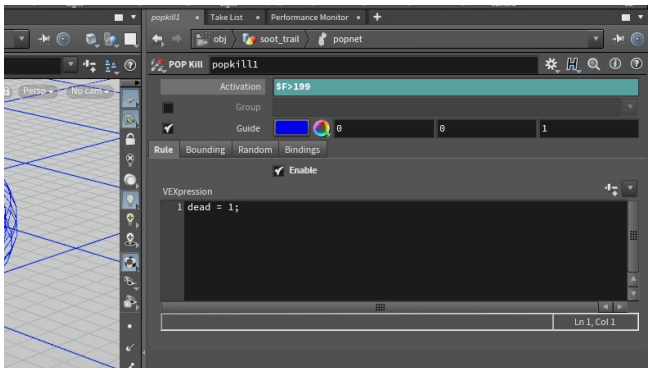
05 Dive back into the *popnet* and add a **Gravity Force** node under the *popsolver*. Now if you **play** the simulation the particles fall below the ground.



06 Go back up to the Object level and create a **grid**. Set **size** to **30, 30** and **Rows and Columns** to **31, 31.**

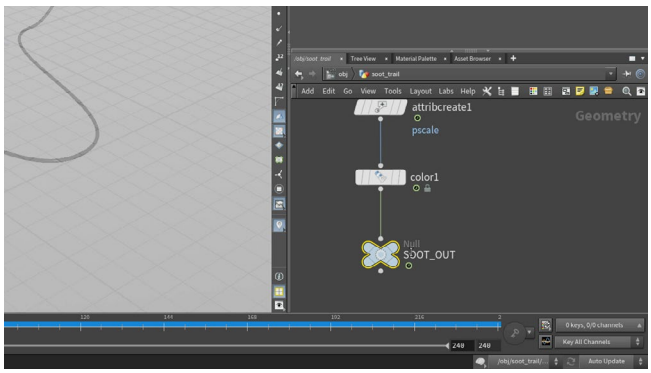
Rename this to *ground*. Go back into the *popnet* and add a **Pop Collision Detect** node after the *source_first_input* node. Set the **SOP** Path to the `obj/ground/grid1`. On the **Behavior** tab, set **Response** to **Stick**. Keep **Color Hits** set to **Red**.

Add another **Pop Collision Detect** node. Set the SOP to the *bomb_geo* geometry object. Set **Response** to **Slide**. Change **Color Hits** to **Green**. Press **Play**.



07 Right now the particles will be emitted throughout the whole sequence. You need them to stop them just as the bomb explodes. Add a **POP Kill** node after the *wire_pops_into_here* merge node. Go to frame 1. Set **Activation** to **$F>199**. This will kill the particles at frame 200.

Now under the Rule tab, turn on Enable. Press **Play** to test.



08 Jump back up to the geometry context and wire the *popnet* into an **attribute create** node. Set **Name** to **pscale** and **Value** to **0.001**.

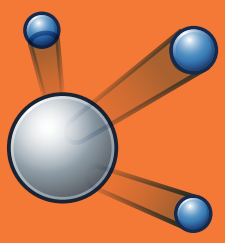
Add a **Color SOP** and set the **Color** to **dark grey**.

Add a **null** to the end of the chain and name it *SOOT_OUT*.

PARTICLE FX

The soot trail is created using particle dynamics. Particles are points that you can affect using forces such as wind or gravity. Starting with the end of the fuse, you give birth to points that are then simulated using a number of different techniques.

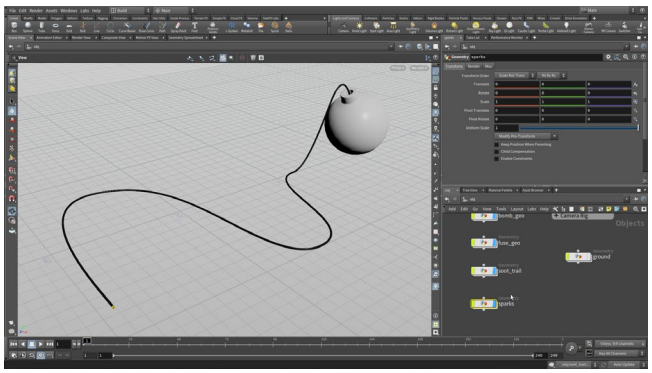
Particles are simulated using the Dynamics or DOPS section of Houdini then brought back into SOPS where you can work with them as geometry. In the next section, you will use particles to create sparks at the end of the fuse.



PART SIX

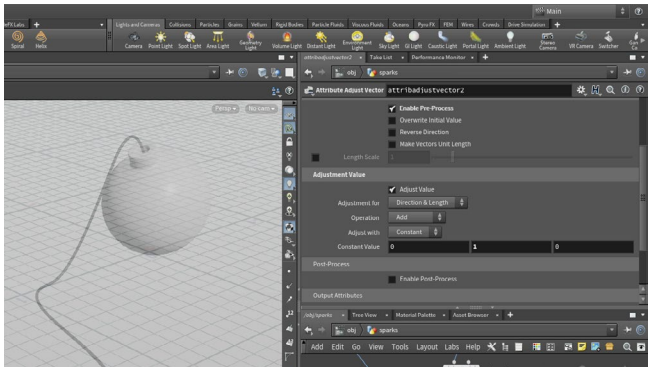
Create Particle Sparks

To create sparks, start by copying the soot particle object and make changes to the new object to generate sparks. These particles will have shorter lifespan and will be more active. The Spark Trail node will give you the look you need to add sparks to the shot. You can adjust parameters on this node to get the look you need.



01 Go to **frame 1** then navigate to the **Object** level. Hide the **Ground** object. **Alt-drag** on the *soot_trail* object to make a copy. Name the copy *sparks*.

This new object already has a popnet and can be modified to generate the spark particle simulation. In Houdini, it is often a good idea to re-use a network you already have as opposed to building everything from scratch.

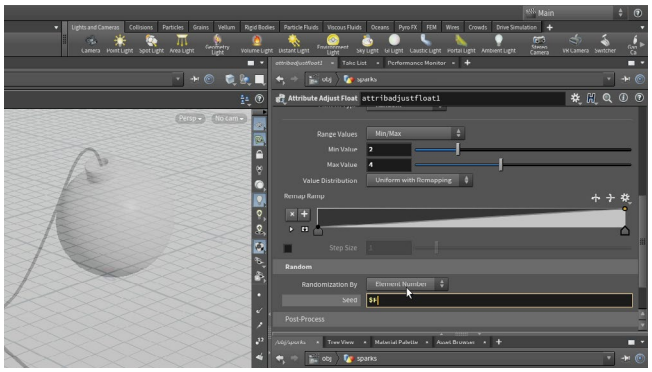


02 Dive into the *sparks* object. You will make a few changes to get the network set up to create sparks.

Delete the *atttributecreate* and *color* nodes. These are not needed for this particle network. Rename the null node to *SPARKS_OUT*.

On the *attributeadjustvector* node change **Amplitude** to **1.75.**

Add a new **Attribute Adjust Vector** node above this one. Turn on **Enable Pre-Process** and set **Constant Value** to **0, 1, 0**. Now the particles will rise up before dropping down. Press **Play**.



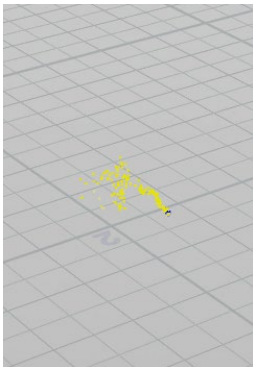
03 Got Frame 1. Add an **Attribute Adjust Float** node just before the *popnet* node. Set the following:

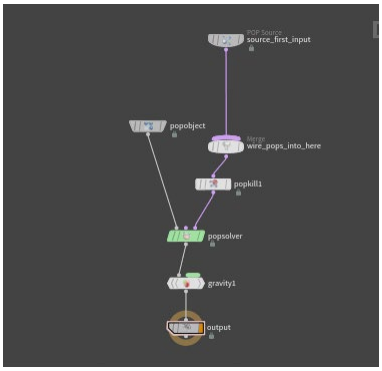
- **Attribute Name** to **life**
- **Unit Settings** to **Duration**
- **Pattern Type** to **Random.**
- **Min Value** to **2** and **Max Value** to **4**
- Under **Random**, set **Seed** to **$F**

SPARKS | PARTICLE TRAIL

The **Particle Trail SOP** takes an animated particle system and generates motion trails from its particles. These trails can be used for various effects such as sparks, fireworks, and rain.

This node also allows you to control the look of the trails. This enables you to fine-tune their look in the SOP context, without the need to render the points with large amount of motion blur.

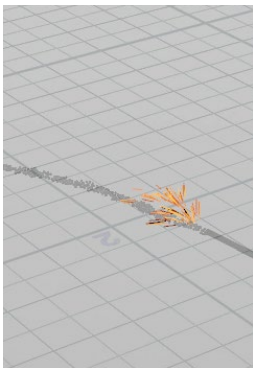


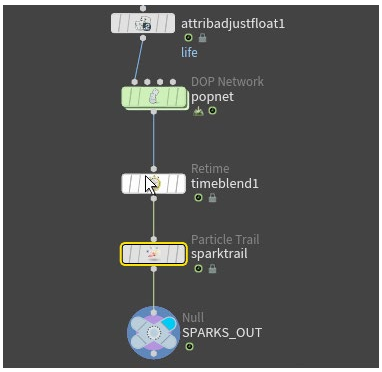


04

Dive into the *popnet* and **delete** the two *collisiondetect* nodes. You will not need to worry about collisions at this point. You will add other nodes back later when needed.

Press **Play** to see the particles being emitted.



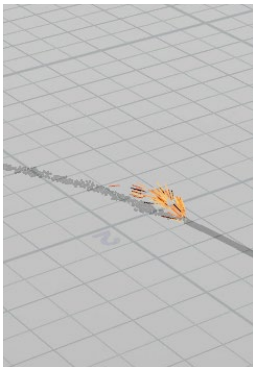


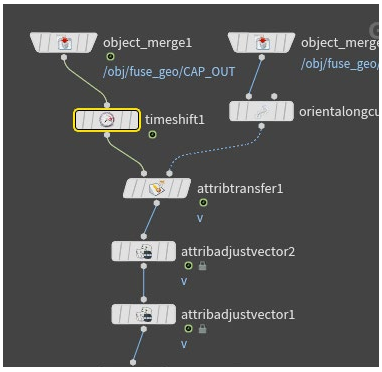
05

Go back up to the Geometry level. Go to frame 1.

In the Network view, press **tab > Spark Trail.** After a short delay, this will put down two nodes - a *timeblend* and a *sparktrail* node. Wire the *popnet* into the *timeblend* node and the *sparktrail* into the *SPARKS_OUT* null.

Press **Play**. You will see sparks but they will be lagging behind by the end of the fuse.

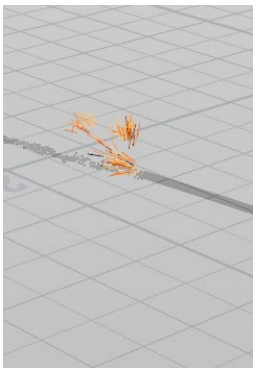


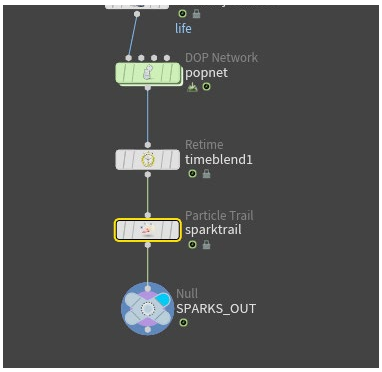


06

Add a Time Shift node after the *object_merge* which brings in the cap and the *attributetransfer* node. Click on the **Frame** parameter name to see the expression being used. Change it to `$FF + 1`

This will move the cap forward a frame but at the same time align the sparks with the end of the fuse. Press **Play** to test.



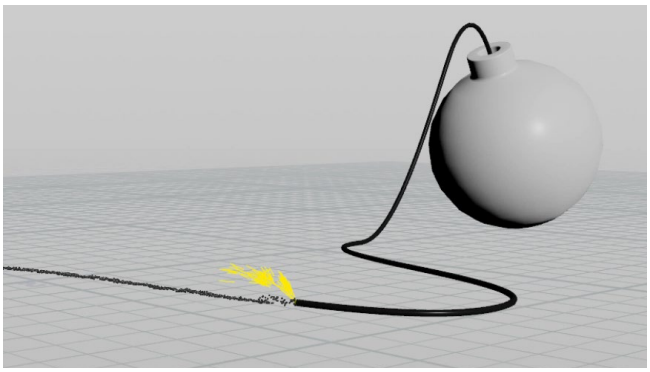


07

Go to frame 1. Select the *sparktrail* node. Click on the **Split** tab and turn **on** the **Enable Split** checkbox. Set **Percent to Split** to **40**.

Under **Shape**, set **Splits per Point** to **4**.

Press **Play** to test.



08

Go to frame 1. Jump up to the Object level.

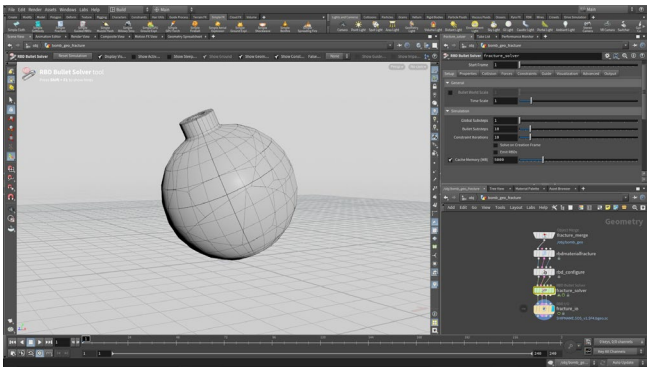
Set the camera to *cam1* and press the **Flipbook** button on the bottom of the toolbar. Click **Start** on the window that pops up. This will create an animated sequence of the scene view that you can use to evaluate the motion of your particles.

Make sure the **Realtime toggle** is on and playback the flipbook to see how the shot is progressing.

PART SEVEN

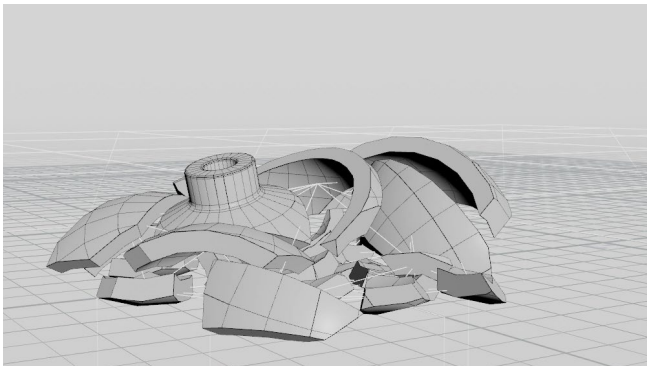
Blow up the Bomb

For the bomb geometry, a rigid body dynamics simulation will be needed. Start by fracturing the geometry then adding attributes that will create an explosion. You can then control the speed of the moving parts to art direct the look. Once the simulation is ready, you will cache out the geometry to work more efficiently as you move on to the PyroFX stage.



01 Hide the *fuse_geo*, *soot_trail*, and *sparks* objects. Press **Spacebar-G** to focus on the bomb geometry. Go to **Frame 1** in the Playbar. Press **Spacebar G** to focus on the bomb.

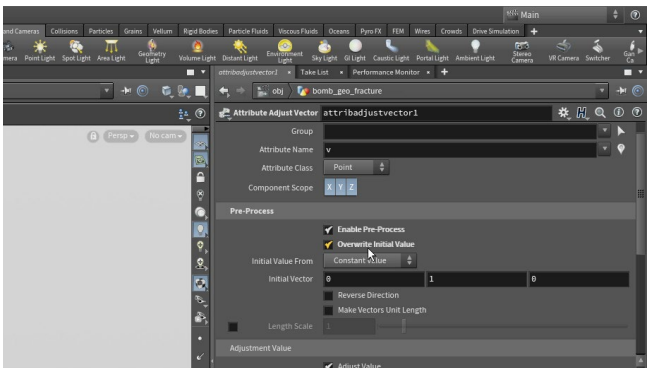
Select the *bomb_geo* object and from the **Simple FX** shelf, select **Simple Fracture**. When asked to *Select Collision Object* just press **Enter** with nothing selected. It will then take a short time to set up this network. This object merges out the bomb geometry and sets up nodes for fracturing and simulating.



02 On the *fracture_solver* node, set **Start Frame** to **200**. Now set the start frame in the **Playbar** to **200**. Click the **First Frame** button to go to frame 200. You will only need to simulate the explosion from frame 200 to 240.

On the *fracture_solver* node go to the **Collision** tab in the **Ground Collision** section, set **Ground Type** to **Ground Plane**. Click on the **Advanced** tab then in the **Constraints** >**Glue** section, remove the word *Glue* from the **Data Name** field.

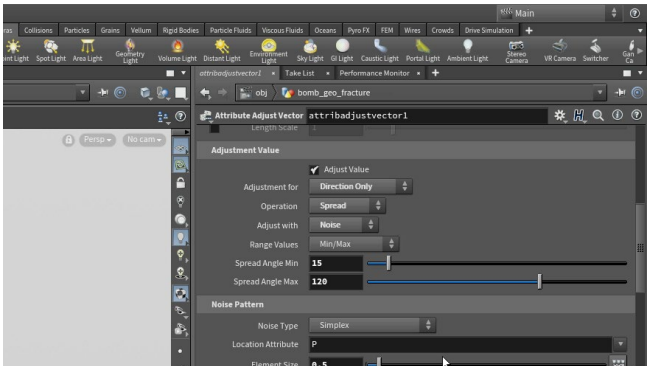
Press **Play** to watch the bomb fall apart. Now you want to add a starting velocity to explode the parts.



03 Go to **Frame 200**. **Add an Attribute Adjust Vector node and place it to the right of the other nodes. Wire the third output of the *rbd_configure* node into the *attributeadjustvector* node then wire the *attributeadjustvector* node into the third input of the *fracture_solver* node.**

Set the following on this node:

- **Turn on Enable Pre-Process**
- **Turn on Overwrite Initial Value**
- **Initial Vector to 0, 1, 0**

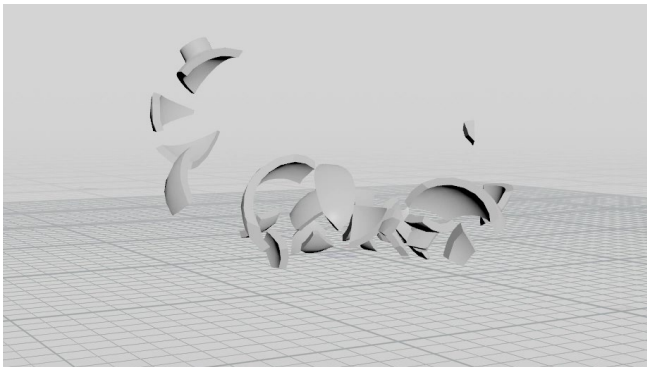


04 Under **Adjustment Value**, set the following:

- **Adjustment for** to **Direction Only**
- **Operation** to **Spread**
- **Adjust with** to **Noise**
- **Spread Angle Min** to **15**
- **Spread Angle Max** to **120**

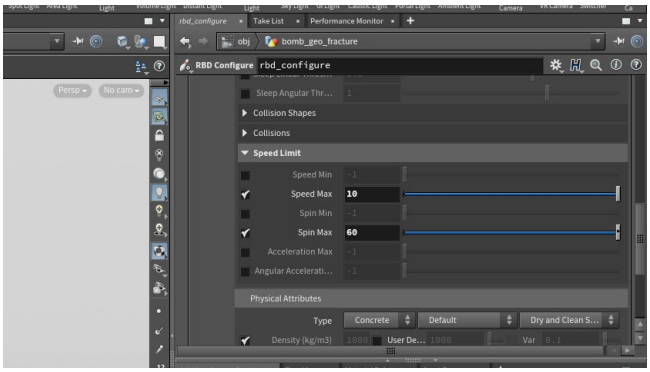
Under **Noise Pattern** set **Element Size** to **0.5**.

Under **Post-Process** turn on **Post Process** then turn on **Length Scale** and set it to **20**.



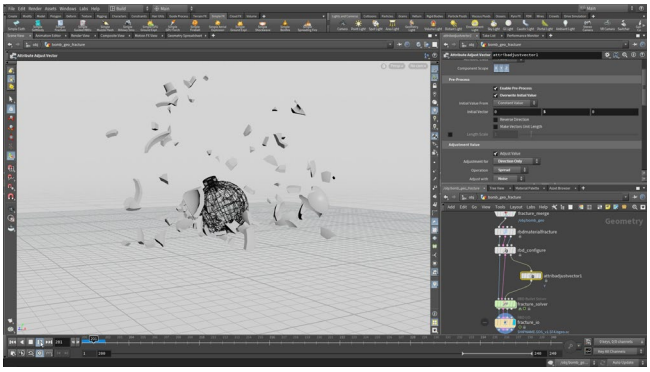
05 Press **Play**. Now you have the bomb exploding. Setting velocity attributes on the geometry feeds into the simulation which uses the initial velocity of the pieces to propel them forward.

The manipulation of attributes plays a bit role in many visual effects setups in Houdini.



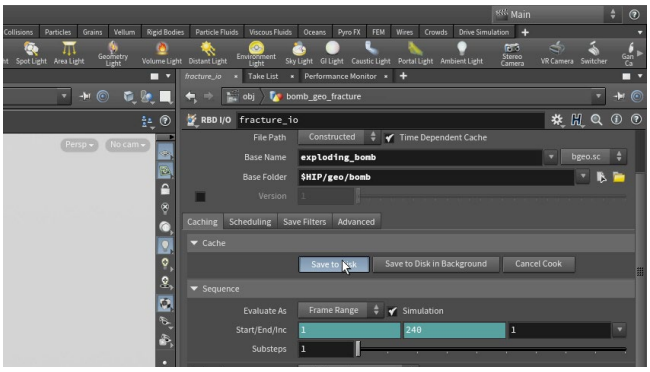
06 Select the *rbdconfigure* node. Open up the **Speed Limit** section and turn on the **Speed Max** and **Spin Max** parameters. Set **Speed Max** to **2** and **Spin Max** to **30**. Press **Play**. The simulation slows down a lot from its original speeds.

Now set **Speed Max** to **10** and **Spin Max** to **60**. Press **Play**.

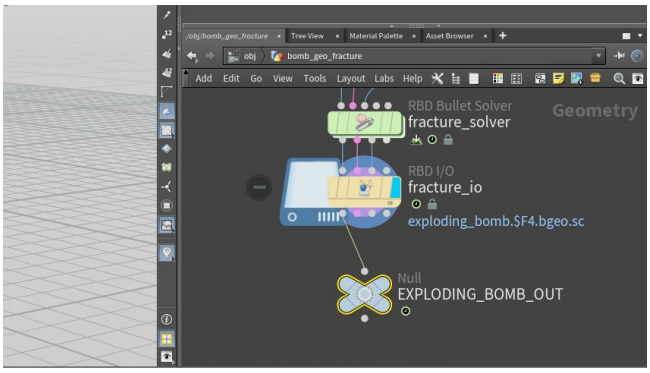


07 Select the *rbdmaterialfracture* node and under **Cell Points** set **Scatter Points** to 25. Press **Play**. Now you have a lot more pieces.

Go back to the *attributeadjustvector* node and set **Length Scale** to **50** and **Initial Vector** to **0, 5, 0**. Press **Play**.



08 Go to **frame 200**. On the *fracture_io* node, set **Base Name** to *exploding_bomb* and **Base Folder** to *$HIP/geo/bomb*. Click **Save to Disk** which will then turn on **Load From Disk**. Press **Play** to preview the cached geometry.

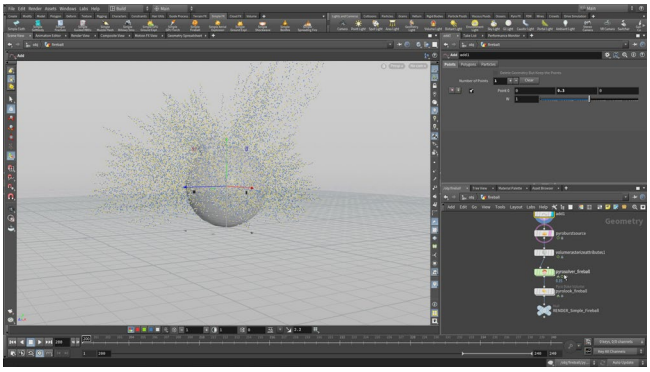


09 Add a **Null** node and wire the first output of the *fracture_io* node into it. **Rename** this node *EXPLODING_BOMB_OUT*.

PART EIGHT

Create the PyroFX Explosion

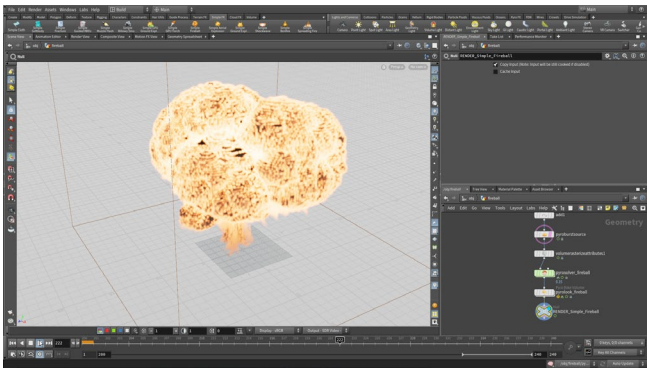
As the bomb explodes there needs to be an accompanying fireball. You will start with a Simple Fireball that works on the GPU then make changes to create a look that works for the shot. You can also incorporate the parts of the exploding bomb to push and influence the PyroFX volume in interesting ways.



01 Go to the **Object** level. From the **Simple FX** shelf, click on **Simple Fireball**. In the Scene view, press **Enter** to place it at the origin. This creates several nodes inside a *fireball* object.

Set the **Display Flag** on the *pyroburstsource* node and on the **Burst Animation** tab, set **Start Frame** to **200**. Go to **frame 200**. This node represents the initial blast of the explosion.

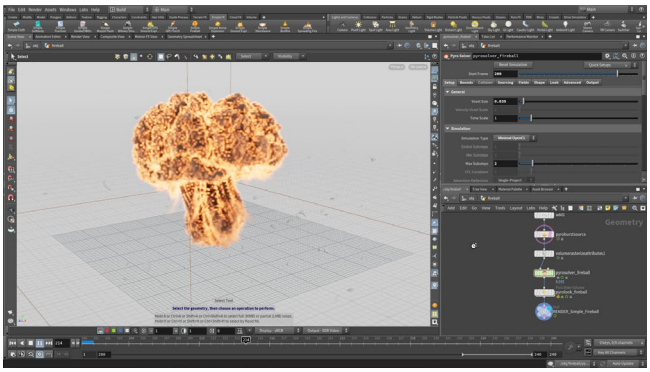
From the **Quick Setup** menu, choose **Single Input Point**. This adds a single point. Use the transform handle to raise it up to around 0.3 which is the middle of the bomb geometry.



02 On the *pyrosolver_fireball* node, change **Start Frame** to **200**. Set **Simulation Type** to **Minimal OpenCL** to simulate using your GPU.

Under the **Sourcing** tab, open the **Limit Source Range** option and set the **Frame Range** to **200, 240**. Turn off **Cycle Length.**

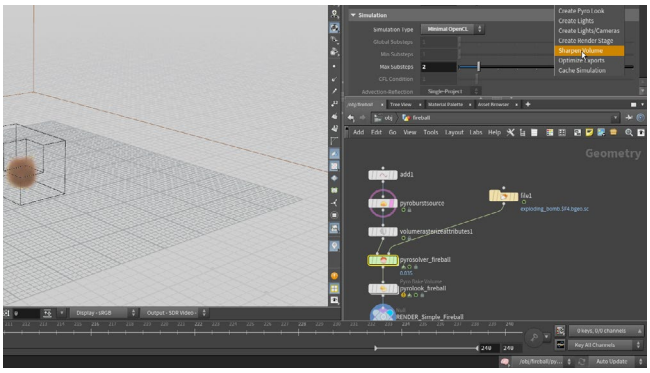
Set the **Display Flag** on the *RENDER_Simple_Fireball* null node. Zoom out to see more of the scene then press **Play** to test the simulation. The Fireball is very big. Zoom out to see the whole explosion.



03 Go to **frame 200**. On the *pyroburstsource* node go to the **Burst Shape** tab and set **Initial Size** to **0.35** and **Spread Angle** to **180**.

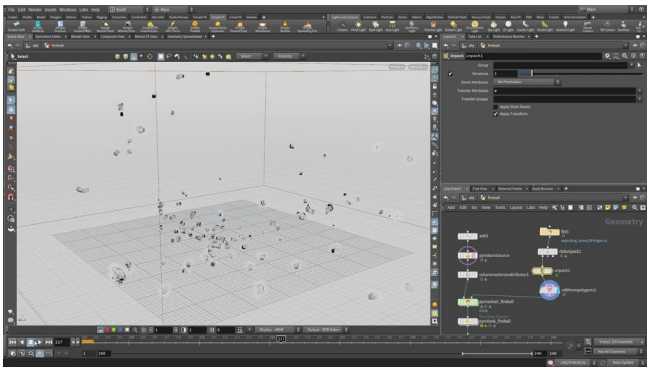
Now go to the *fireball* Pyro Solver node and click on the **Bound** tab and set **Size** to **15, 12, 12** and **Center** to **0, 4, 0**. This will make a smaller box which will fit better on the GPU. On the **Setup** tab, set the **Voxel Size** to **0.035** - this will add more detail to this smaller simulation.

Press **Play** to test the simulation. Now the explosion fits better in this scene.



04 The next step is to integrate the Pyro FX with the exploding bomb. Add a **File** node and load the *$HIP/geo/bomb/exploding_bomb.$F.bgeo.sc* geometry sequence from disk. Wire this node into the second input of the *fireball* Pyro Solver node.

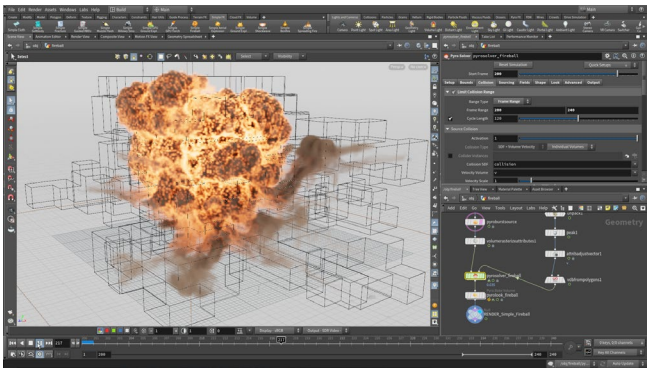
Press **Play** to test the simulation. The collision geometry isn't having an effect because it hasn't been prepared properly.



05 Go to frame **200**. Select the *fireball* node. From the **Quick Settings** menu in the top right, choose **Setup SDF Collision**. This adds a *vdbfrompolygons* node. This node gets it's **Voxel Size** from the Pyro Solver node.

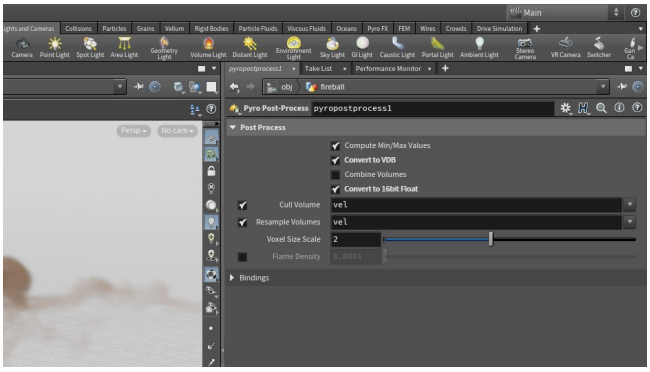
Add an **RBD Unpack** node between the *file* and *vdbfrompolygons* nodes.

Add an **Unpack** node between the *rbdunpack* and *vdbfrompolygons* nodes. On the *unpack* node, set **Transfer Velocity** to **v**. Set the **Display Flag** on *vdbfrompolygons* then press **Play** to see the collision geometry.



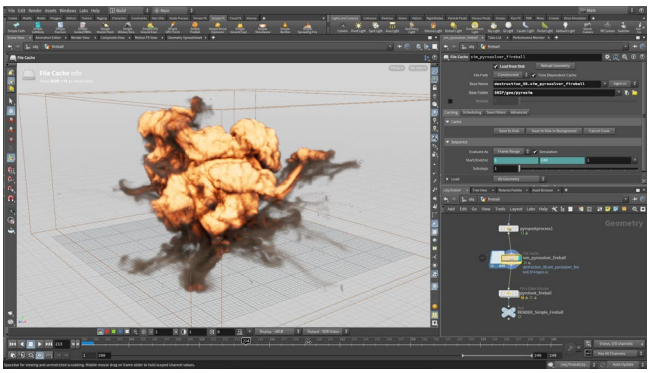
06 Between *unpack* and *vdbfrompolygons*, add a **Peak** node to make pieces bigger. Set **Distance** to **0.1**. Between the *peak* node and the *vdbfrompolygons* node, add a **Attribute Adjust Vector** node. Turn off **Adjust Value** and turn on **Enable Post Process** then turn on **Length Scale** and set it to **2**.

Set the **Display flag** back to the *fireball* node. From the **Collision** tab, open the **Limit Collision Range** section and set **Range Type** to **Frame Range** and **Frame Range** to **200, 240.** Turn off **Cycle Length.** Press **Play** to test the simulation. The exploding bomb is now colliding with and influencing the Pyro FX simulation.



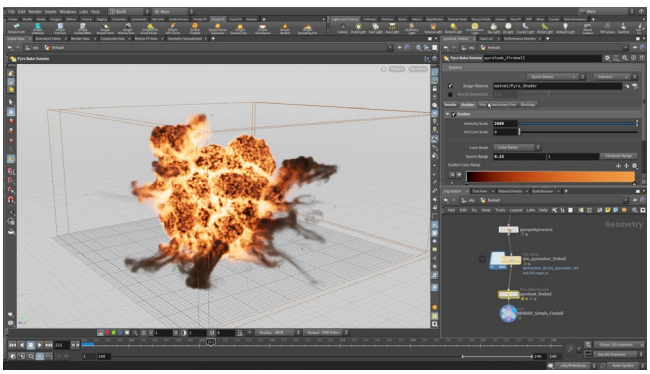
07 Between the *fireball* Pyro Solver node and the *pyrolook* node, insert a **Pyro Post Process** node. Turn on the **Convert to VDB** and the **Convert to 16bit Float** checkboxes. Next turn on the **Cull Volume** and **Resample Volumes** options and leave them both set to *vel*.

This node will make your volume more efficient and save you disk space when you cache your volume.



08 On the *fireball* Pyro Solver node click on **Quick Setups** and choose **Cache Simulation**. Move the node to the side then wire the *pyropostprocess* node into the sim_fireball cache node then wire the cache node into the *pyrolook* node. Set Base Folder to *$HIP/geo/pyrosim/* then click **Save to Disk**.

Now with the **Load from Disk** option set to on, you can scrub in the Playbar to see the PyroFX explosion.



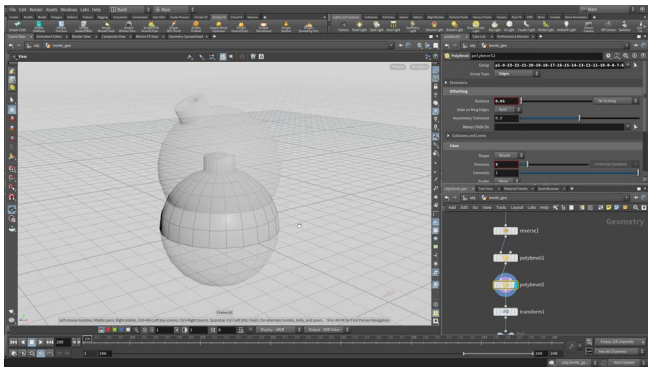
09 Set the Display Flag on the *pyrolook* node. This is the **Pyro Bake Volume** node that can be used to visualize the simulation in the Scene View. It is designed to provide a similar interface to the Pyro Shader you will use later when rendering.

Under the **Smoke** tab, darken the **Smoke Color** then under the **Scatter** tab set **Intensity Scale** to **2500**. Make other adjustments to get a look that you like for your simulation.

PART NINE

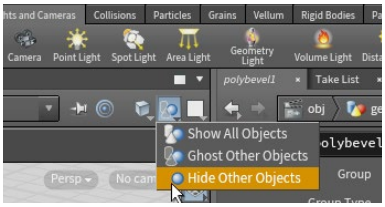
Export the Geometry to USD

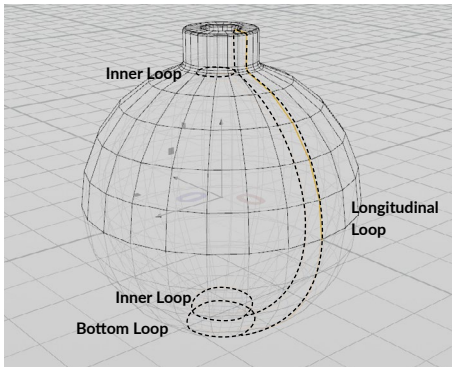
To set up the shot for rendering, you need to export the geometry to USD files that can be referenced into the Solaris context. While you could import the geometry directly, having it cached out as USD will allow you to lock down your sequences then focus on lighting and rendering in Solaris. For some of these objects, you will add UVs before exporting to prep for texturing.

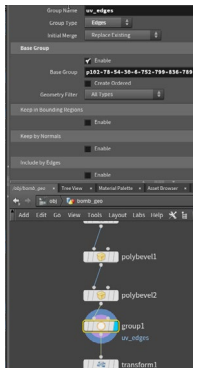


01 Go to the Object level and hide the *fireball* object. Double click on the *bomb_geo* and set the **Display Flag** on the second *polybevel* node. This shows you the bomb geometry before it was rotated into place.

Set the **Display** to **Hide Other Objects** to stay focused on the contents of this network.



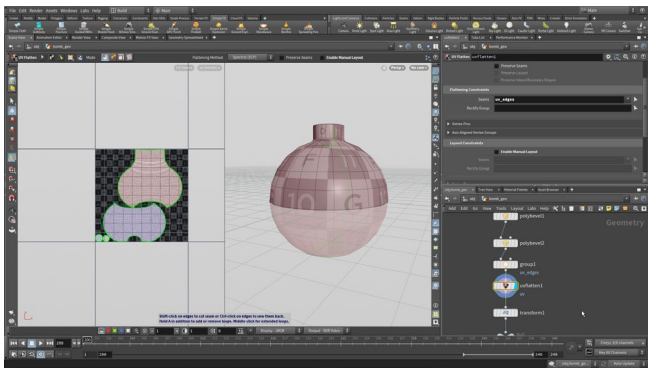




02 Go to the **Select** tool then **press 3** to select **Edges**. **Press w** to go into wireframe mode and then press **Shift** and **double click** to select part of the loop at the bottom. Press **Shift** and **double click** to select all four parts. Repeat for the inner loop.

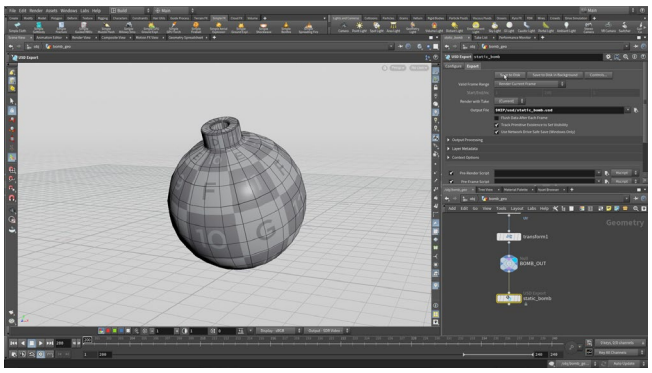
Now go to the loop on the top of the inner sphere and press **Shift** and **double click** to select. Now pick the latitudinal line that aligns with the X axis and press **Shift** and **double click** to select.

In the Scene View, press **tab > Group**. Change the **Group Name** to *uv_edges*.



03 In the Scene View press **tab > UV Flatten** which adds a *uvflatten* node after the *group* node. Set **Seams** to *uv_edges* and under **Layout Constraints**, turn off **Enable Manual Layout**. This provides a good looking UV layout that will be perfect for texturing the bomb.

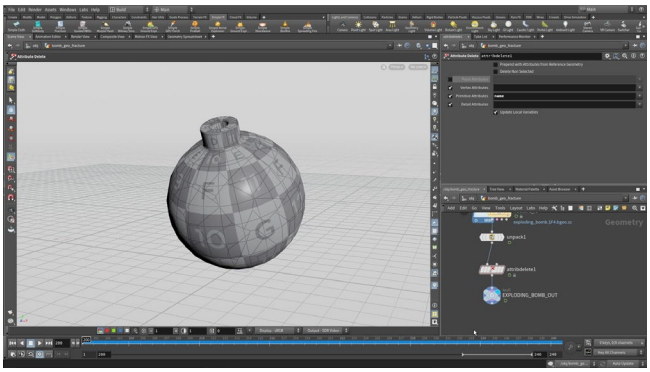
Set the **Display Flag** on the *BOMB_OUT* null node.



04 Add a **USD Export** node to the end of the chain. **Rename** it *static_bomb*. Set the following

- **Valid Frame Range** to **Render Current Frame**
- **Output File** to *$HIP/usd/static_bomb.usd*

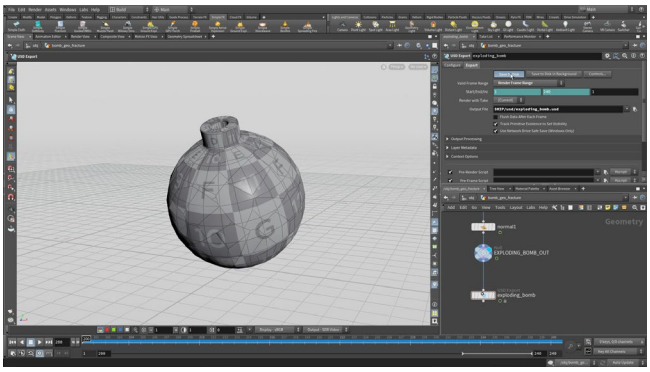
Press **Save to Disk**.



05 Go back to the Object level then double-click on the *bomb_geo_fracture* network. Select the *fracture_io* node and press **Save to Disk** to cache out the geometry with the new UVs. You won't see them yet because the geometry is packed.

After the *fracture_io* node and before the *EXPLODING_BOMB_OUT* node, add an **Unpack** node then an **Attribute Delete** node. On the *attributedelete* node, enter *name* next to **Primitive Attributes**. Turn off the **Point Attributes** section.

This ensures that the sequence comes into Solaris as a single mesh. The name attribute would break the sequence into individual parts.

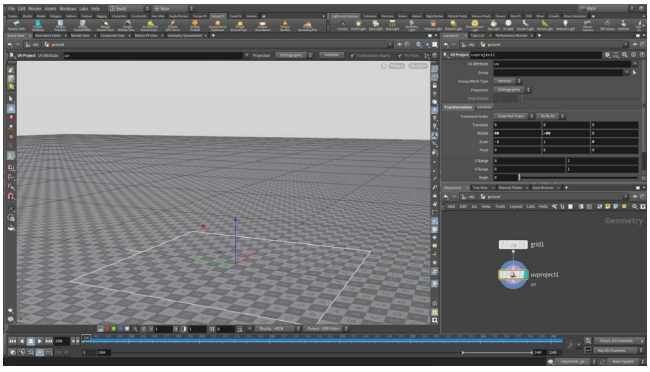


06 After the *attributedelete* node, add a **Normal** node. This will help the bomb geometry display properly in Solaris.

Add a **USD Export** node to the end of the chain. **Rename** it *exploding_bomb*. Set the following

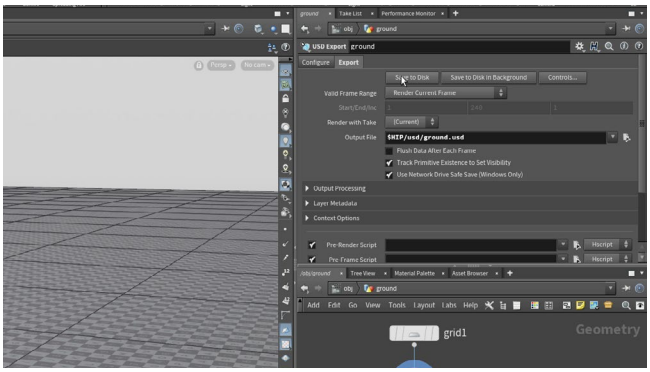
- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/exploding_bomb.usd*

Press **Save to Disk.**



07 Go back to the Object level then **double-click** on the *ground* network. After the *grid* node, add a **UV Project** node and set its **Display Flag**. Go to the **Initialize** tab and press the **Initialize** button. On the **Transformation** tab, change **Scale X** to **-1**, **Scale Y** to **1** and **Rotate Y** to **-90**.

This will allow the texture to repeat on the ground surface rather than create one large texture,



08 Add a **USD Export** node to the end of the chain. **Rename** it *ground*. Set the following

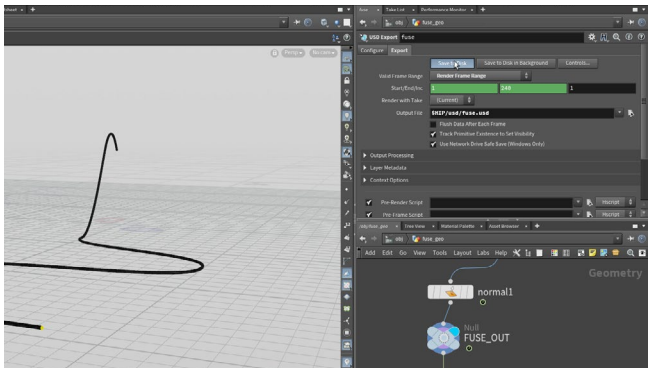
- Leave **Valid Frame Range** set to **Render Current Frame**
- **Output File** to *$HIP/usd/ground.usd*

Hit **Save to Disk.**

USD and SOLARIS

To support the look development stage of this project, layout, lookdev and lighting workflows are set up in the **Solaris** context. This is represented by **LOP networks**. The **USD** caches you are creating here will go into the Solaris context.

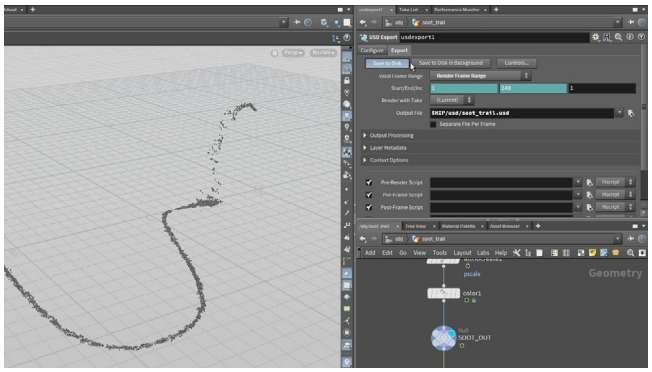
You will reference the USD caches into the LOP network using this scene file but in a larger pipeline another option would be to start a new scene file and import the USD files in a fresh scene. This would let you focus on lighting and rendering your shot but would make it harder to go back and tweak the geometry and simulations.



09 Go back to the Object level then **double-click** on the *fuse* network. Add a **USD Export** node to the end of the chain. **Rename** it *fuse*. Set the following

- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/fuse.usd*

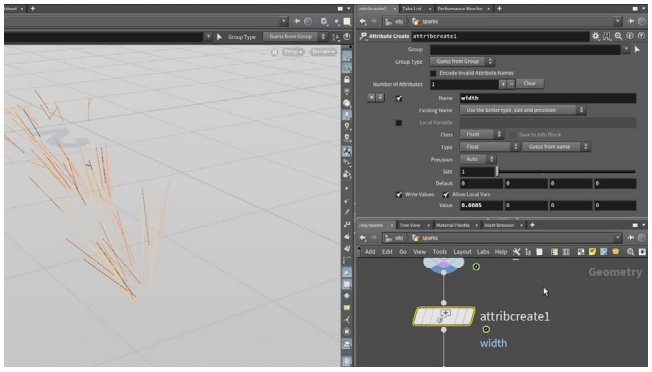
Hit **Save to Disk.**



10 Go back to the Object level then **double-click** on the *soot* network. Add a **USD Export** node to the end of the chain. **Rename** it *soot_trail*. Set the following

- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/soot_trail.usd*

Hit **Save to Disk.**



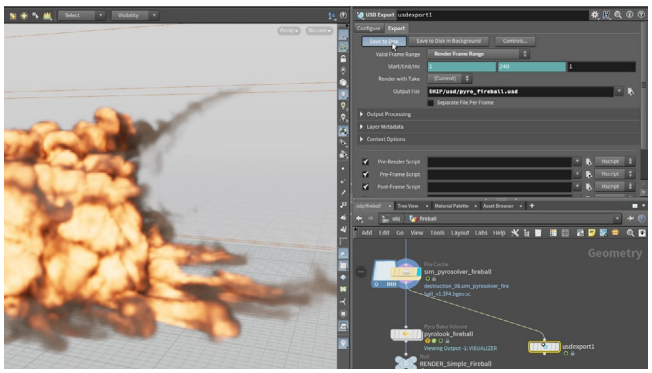
11 Go back to the Object level then **double-click** on the *sparks* network.

Add an **Attribute Create** node to the end of the chain. Set the **Name** to *width* and the **Value** to **0.0005**. This will determine the look of the sparks when they are rendered.

Add a **USD Export** node to the end of the chain. **Rename** it *sparks*. Set the following

- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/sparks.usd*

Hit **Save to Disk.**



12 Go back to the Object level then **double-click** on the *fireball* network. From the *sim_fireball* node, branch off a **USD Export** node. Be sure to bypass the *pyrolook* node. **Rename** it *pyro_fireball*. Set the following

- **Valid Frame Range** to **Render Frame Range**
- **Output File** to *$HIP/usd/pyro_fireball.usd*

Hit **Save to Disk.**

Scene Import

Another way to get your geometry and simulations into Solaris is using the **Scene Import LOP**. This creates a direct connection between the geometry and objects you are working with and the LOP network. This approach would require cache LOPs to support motion blur which is an extra step not needed if you are referencing in USD files.

This tool is going to be used to bring the animated camera from the object level into the Solaris context.

PART TEN

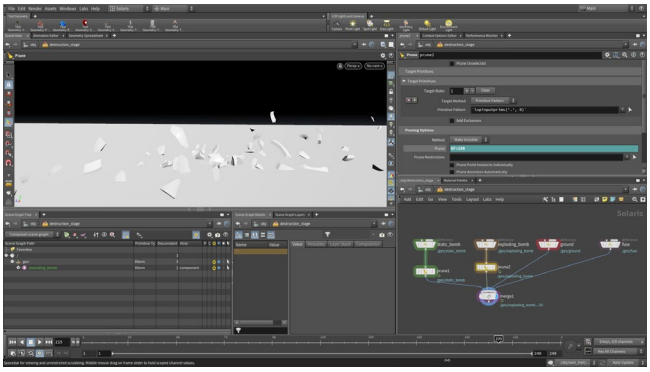
Set up the Shot in Solaris

Learn how to reference all of the USD files into Solaris then import the camera from the object level. Apply materials to all the elements and start rendering with Karma to evaluate the results. Learn how to add a key light and prepare render settings to explore the final look of the shot.

01 Go back to the Object level. Press **tab > LOP Network** to create a subnetwork to use to set up your shot. Name it *destruction_stage*. **Double click** on the node to dive into it.

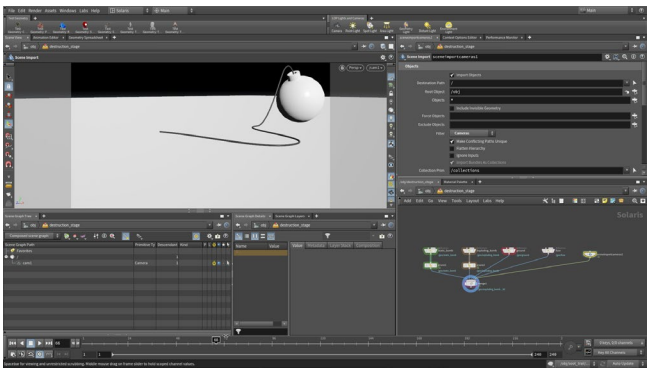
Change the desktop to **Solaris**. Make sure you see *obj > destruction_stage* in the Scene view's path bar. **Press D** over the scene view and go to the **Background** tab and set **Color Scheme** to **Dark**.

In the Network View press **tab > Reference** then click to add a *reference* node. Next to **Reference Pattern**, click on the **File Chooser** and find the *static_bomb.usd* file. **Rename** the node to *static_bomb*. Set the **Primitive Path** to */geo/$OS*.



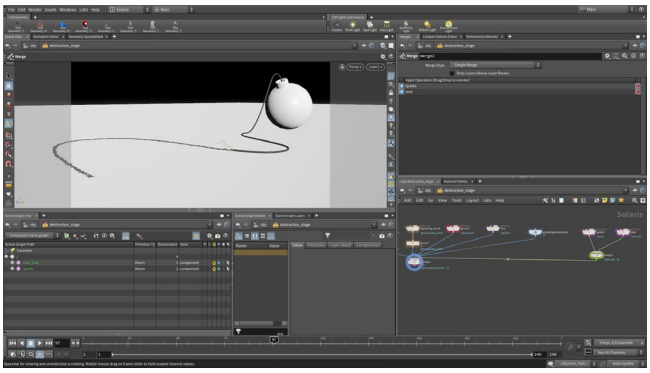
02 **Alt-drag** on this node to make three copies. Name them *exploding_bomb*, *ground* and *fuse* then point the **File Chooser** parameter to these USD files.

Feed these into a **Merge** node and set its **Display Flag**. After the *static_bomb* node, add a **Prune LOP**. Set the **Prune** parameter to *$F >200*. After the *expoding_bomb* node, add another **Prune LOP**. Set the **Prune** parameter to *$F <199*. Now when you scrub in the Playbar, the bomb will switch between the static and exploding bomb at frame 200.



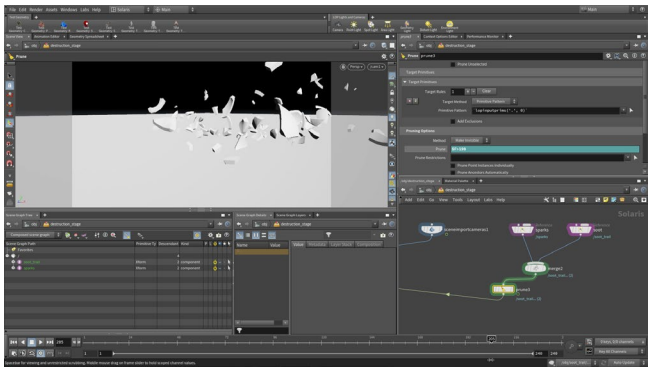
03 Press **tab > Scene Import (Cameras)**. Place down this node and wire it into the *merge* node. Set the **Destination Path** to */cam/*. This adds any camera found at the object level into the Solaris context.

Go to the **camera** menu choose *cam1* to look through this animated camera. Make sure you have the merge node selected. Scrub in the Playbar to see the fuse and the exploding bomb animate and then explode through the lens of the camera you set up at the object level. If you were to make changes to that camera it would be reflected here in Solaris.

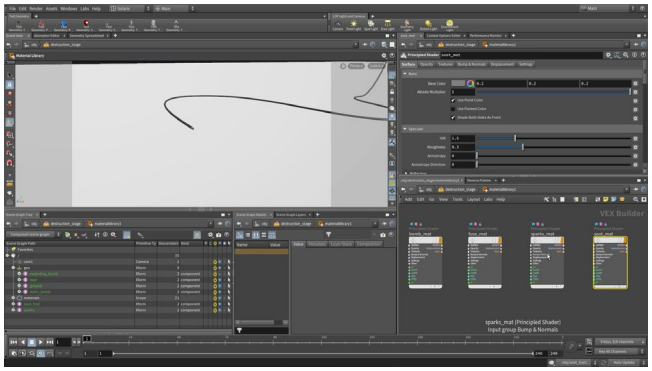


04 In the Network View press **tab > Reference** then click to add a *reference* node. Next to **Reference Pattern**, click on the **File Chooser** and find the *sparks.usd* file. **Rename** the node to *sparks*. Set the **Primitive Path** to */fx/$OS*.

Alt -drag on this node to make a copy. Name it **soot** then point the **File Chooser** and find the *soot_trail.usd* file. Add a **Merge** node to bring these files together then feed them into the main **Merge** node and set it's **Display Flag**. If you scrub in time, you will see the sparks and the soot persist after they were killed. The USD file holds onto the particles right until frame 240.

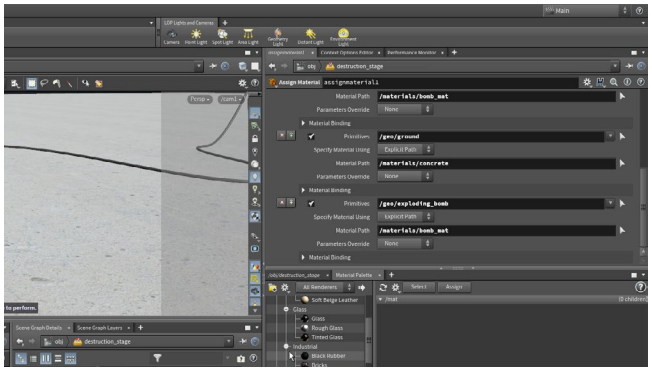


05 After the effects *merge* node, add a **Prune LOP**. Set its **Display Flag**. Set the **Prune** parameter to **$F >199**. Now the soot and sparks disappear at this point.



06 Add a **Material Library** node after the *merge* node. Go to the **Material Palette** and drag a **Principled Shader** and a **Concrete Shader** into */stage/materiallibrary*.

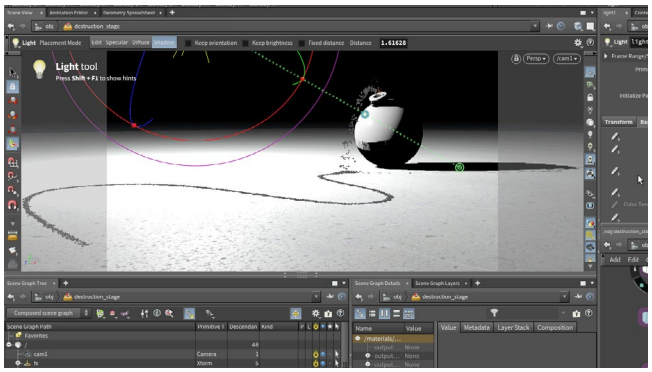
Go to the Network view and rename the principled shader to *bomb_mat*. **Alt drag** to make three copies of the principled shader and call them *fuse_mat*, *sparks_mat* and *soot_mat*.



07 Go back up one level and add an **Assign Material** node to the end of the chain. From the Scene Graph, drag *static_bomb* and *exploding_bomb* to the **Primitives** field.

Now click on the arrow next to **Material Path** and select the *bomb_mat*. Press the **plus sign** to add more sections and repeat these steps to assign materials to the *fuse*, *sparks* and *soot*.

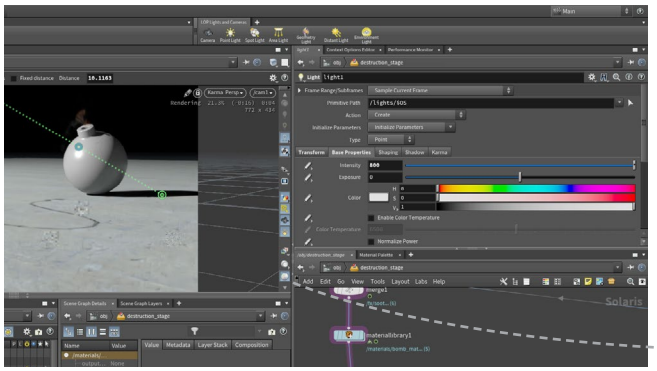
Assign the *concrete* Material to the *ground*.



08 Go to around frame 180. Click on the **Light** tool in the **LOP Lights and Cameras** shelf. This adds a light to your shot and has you looking through it.

Go to the **Base Properties** tab and set **Intensity** to **50**.

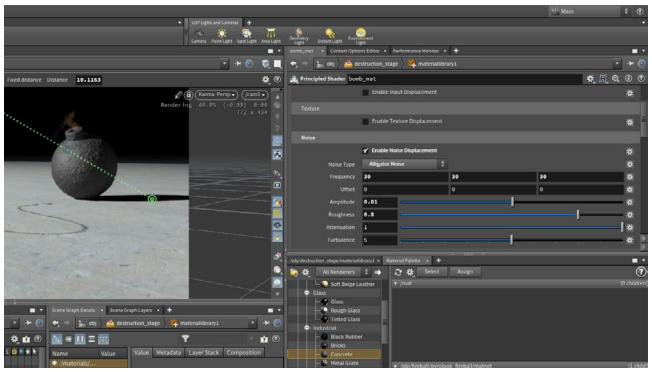
In the Scene View, click on the **Shadow** button and **click** on the surface of the bomb then **Shift click** behind it to create a shadow.



09 In the Scene view, select **Karma** from the **Persp** menu. Turn off the **Reference Plane**.

Go back into the **Material Palette** and select the *concrete* shader. In the **Texture** section, set **Effect Scale** to **0.01**.

Turn on the **Denoiser** in the side bar. This will use your graphics card (nVidia cards only) to more quickly resolve the noise in your rendering.



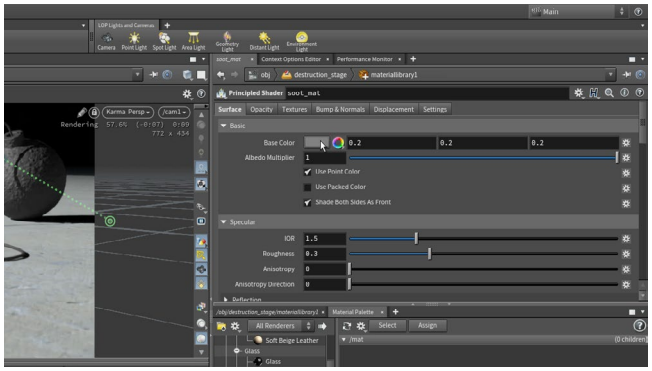
10

Select the *bomb_mat* shader. Under **Surface**, set the following:

- **Base Color** to **Black [0, 0, 0]**
- **Roughness** to **0.7**

Under **Displacement**, turn on **Enable Noise Displacement** and set the following:

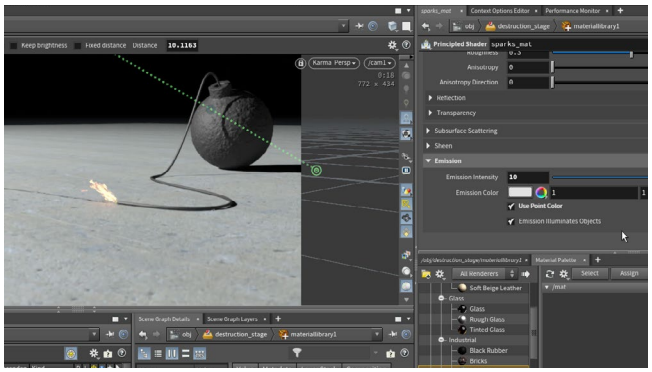
- **Noise Type** to **Alligator Noise**
- **Frequency** to **30, 30, 30**
- **Amplitude** to **0.01**
- **Roughness** to **0.8**



11

For the *fuse_mat* and *soot_mat* shaders, set the **Base Color** to a **Dark Grey**.

On the *fuse_mat* shader turn off **Use Point Color** to allow the Base Color to control the look.

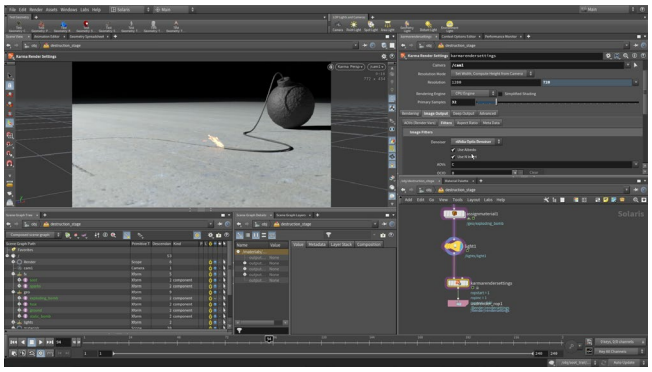


12

Select the *sparks_mat* shader and under **Emission** set the following:

- **Emission Color** to **1, 1, 1 [white]**
- **Emission Intensity** to **10**
- Turn on **Use Point Color**

This will make the sparks shine brighter and even create a bit of illumination on the ground surface.



13

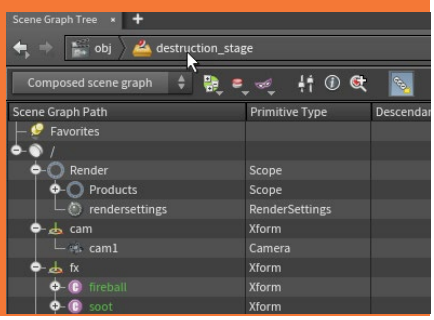
Go back to the Stage level. In the **Network View**, press **tab > Karma** to add a **Karma Render Settings** and **USD Render ROP** node. Wire them into the end of the chain. Select the *karmarendersettings* node and set **Primary Samples** to **32**. On the **Image Output > Filters** tab set **Denoiser** to **nvidia Optix Denoiser** to turn the denoiser back on.

On the **Advanced** tab, go to the **Sampling** section and set **Convergence Mode** to **Path Traced**.

RENDER SETTINGS

The **Karma Render Settings** node adds render settings that become part of the **Scene Graph** and will be used to render to the viewport and to disk.

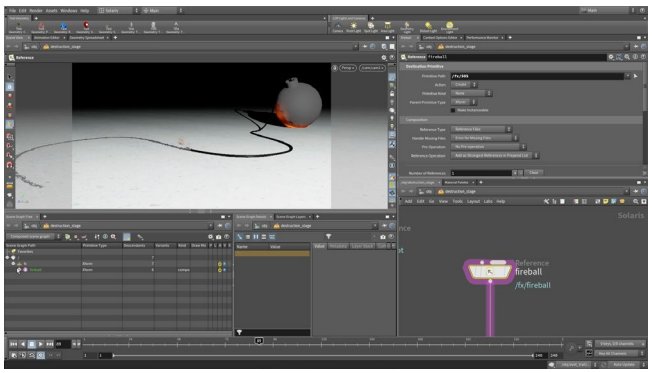
Before you added these settings the viewport settings were being used when you rendered in the viewport. If you have Karma rendering set up in the Scene view then **Press D** to see these settings. If you have render settings in your Scene Graph then they will override the viewport settings.



PART ELEVEN

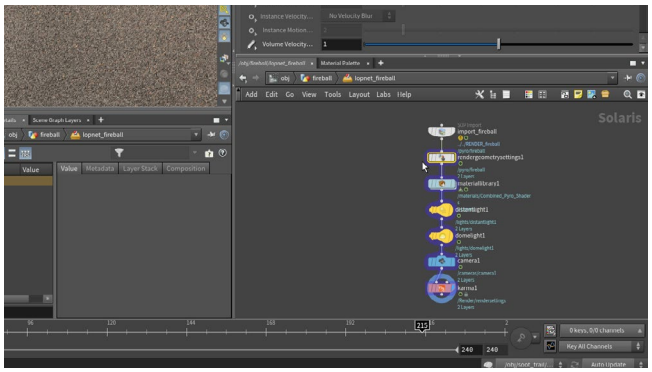
Render the PyroFX

To complete the shot, add the fireball USD file then assign the proper material. Next, you will set up another camera to create a wide angle shot of the explosion and then render out the two sequences to achieve the final sequence. You can then preview the results using the Mplay image viewer.



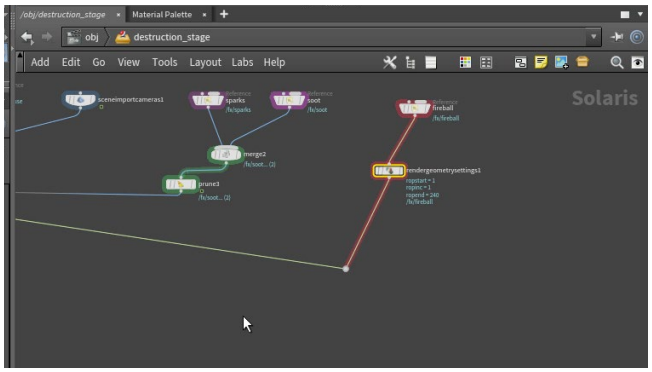
01 Set the Persp view menu back to **Houdini GL**. In the Network View press **tab > Reference** then click to add a *reference* node. Next to **Reference File**, click on the **File Chooser** and find the *pyrofx_fireball.usd* file. **Rename** the node to *fireball*. Set the **Primitive Path** to */fx/$OS*.

Feed this node into the original *merge* node. **Alt click** on the connecting wire to add a dot and move the dot to the lower right. With the **Display Flag** on the *Karma* node, scrub to around **frame 204** to see the explosion.



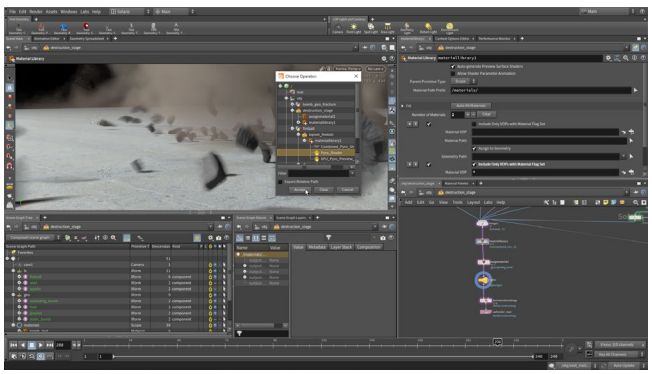
02 Navigate back to the Object level then into the *fireball* object. Select the *pyrosolver_fireball* node. From the **Quick Setups** menu, select **Create Render Stage**. This adds *lopnet_fireball* into this network. You can dive into it to see the suggested setup. You could use this to render the fireball on its own but you need it as part of our existing LOP network.

Select the *rendergeometrysettings* node and press **Cmd-C** to copy it.



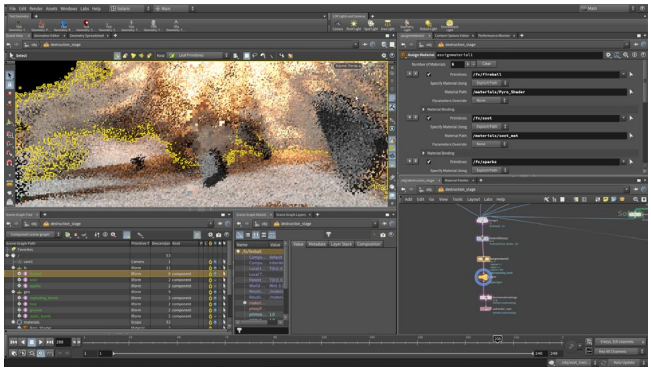
03 Navigate back to the *destruction_stage* LOP network and press **Cmd-V** to paste it into the network. Wire it just under the *fireball* reference node.

This node does two things. First it sets up velocity motion blur on the fireball then it uses the volume to help light the shot.



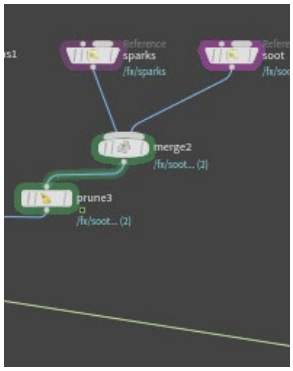
04 Select the *materiallibrary* node and click the plus sign next to **Number of Materials**. Click on the Operator chooser button next to **Material VOP** on the new listing and navigate into the *fireball* object then into the *lopnet_fireball* then into the *matnet* to select the **Pyro_Shader**. Click **Accept**.

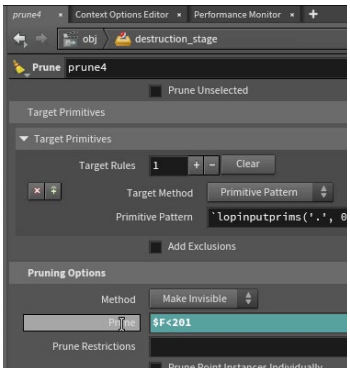
Even though this material is in a different LOP network, it can be referenced from its location to this *materiallibrary* node.



05 On the *assignmaterial* node, add another material listing and from the Scene Graph drag */fx/fireball* to the **Primitives** section then click on the **Material Path** arrow and choose **Pyro_Shader.**

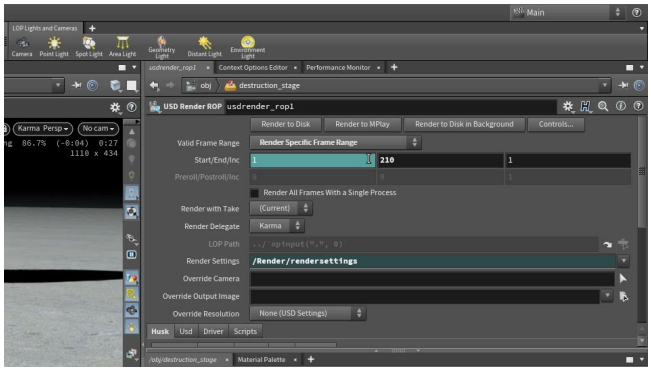
Set the Persp view menu back to **Karma**.





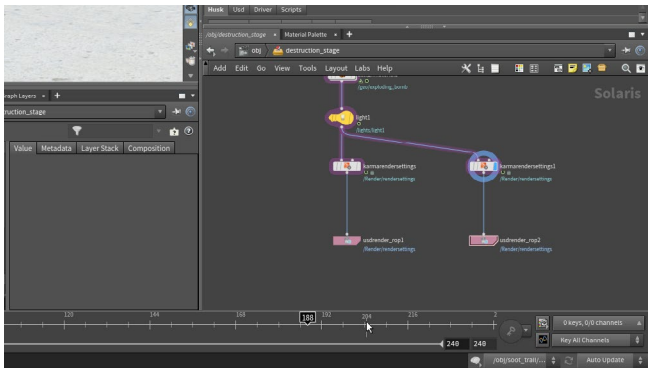
06 Add **Prune** node to the network and wire it just under the *rendergeometrysettings* node. Under Pruning Options, set **Prune** to **$F<201**.

The fireball at frame 200 was poking through the bomb geometry and this will delay the explosion for one extra frame.

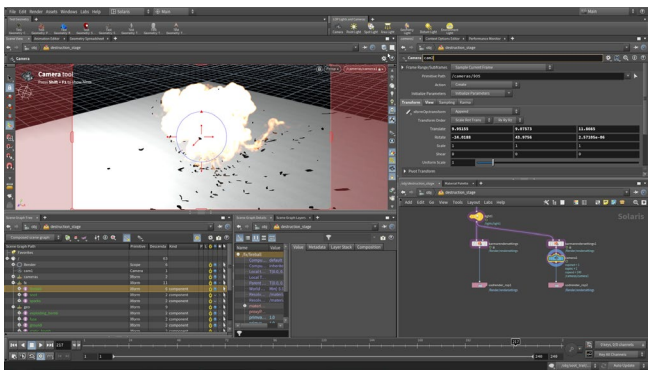


07 On the Karma node, set **Valid Frame Range** to **Render Frame Range**. **RMB-click** on the **End** value which shows **240** and select **Delete Channels**. Change the **End** value to **210**.

You will use the animated camera for the first 210 frames then cut to a different camera for the last 30.

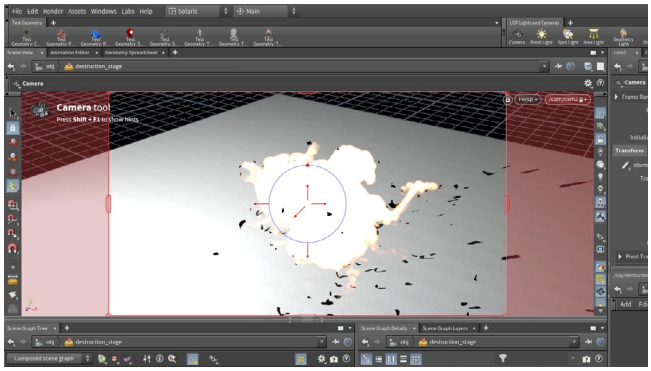


08 Set the Persp view menu back to **Houdini GL**. In the Network view, **Alt-drag** on the *karmarendersettings and usdrender_rop* nodes to the right. Set its **Display Flag**.

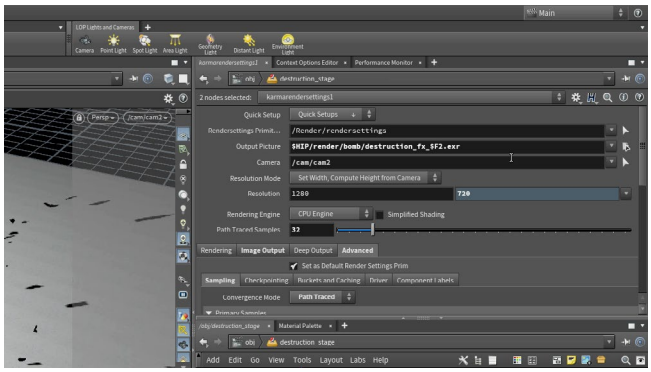


09 **Tumble** in the Scene view to get a new camera angle that is looking down on the explosion from above. Press the **Ctrl** key and click on the **Camera** tool in the **LOP Lights and Cameras** shelf.

Set its **Primitive Path** to */cam/$OS* and its **name** to *cam2*.



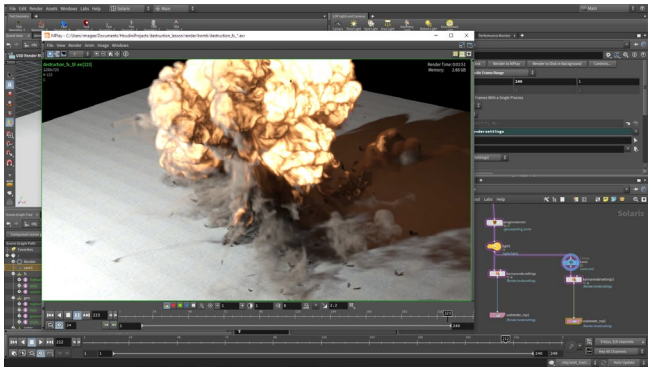
10 **Lock the Camera to View** and tweak the viewpoint to get the shot you are looking for. Check it at various points between frame 210 and 240. Turn the **Lock the Camera to View** option off when you are ready.



11 Move the *cam2* node up above the *karmarendersettings2* node. On the *usdrender_rop2* node, change the **Start** and **End** to **211** and **240** then change the camera to point to */cameras/cam2*.

Select the first *karmarendersettings* node and make sure that its camera is set to */cam/cam1*. Otherwise the node will not render since the default *camera1* isn't in our scene.

Select both *usdrender_rop* nodes, and change the Output picture to: *$HIP/render/bomb/destruction_fx_$F2.exr*



12 Select the *usdrender_rop1* node. Click on the **Render to Disk** button. Repeat for usdrender_rop2.

Go to the **Render** menu and select **MPlay > Load Desk Files**. Go to the *render/bomb* directory and select the image sequence then click **Load**. This will play the images as a single animation.

CONCLUSION

You have now built a destruction shot using particles, rigid body dynamics and Pyro FX. You built the complete project from scratch and have experienced many of the tools and techniques that Houdini artists use on a daily basis.

You have also had a chance to bring your work into Solaris where you used USD to set up the scene graph for rendering to Karma.

Now you can take these skills and begin exploring your own Destruction FX shots.