Header informations:
VR for domes
by Lionel Ruiz
Planetarium of Marseille (France)
lionel.ruiz@live.fr

Abstract:
The world of Virtual Reality contents is expanding and those files can be played into our digital theaters through some adaptations. What are the formats available, are these formats providing enough quality for us, which are those related to astronomy, which are really free for use, and how to adapt the files to the dome to fully appreciate the contents.

Narrative text:
In our eternal quest to provide new contents for our domes or to find the proper illustration for the topics we want to use for our audiences,
we are stuck sometimes with the lack of data that takes benefits to be used in the dome. Getting a rectangular video would fit but isn't immersive enough if not integrated. Nowadays, a lot of contents are available in VR format, a format covering more surface than what the dome can offer.

This point will raise a problem for some contents. First we will need to choose the part of the image that we want to show and in some cases, it can make people dizzy because some contents will impose to look downwards while in a planetarium, you are limited to a half sphere which is always upwards. For instance, imagine looking at ants from above, in a dome you'll get the feeling that the scene is upside down.
With VR we are no longer limited to the up direction, so we can deal more easily with everything in appropriate orientation. A dome by its conception is more predestined to display clouds, stars, something that flies or some fish from the bottom of the ocean. It is difficult to speak about something else without the orientation being an issue if the dome is not strongly tilted.

We can separate VR files into categories. We won't talk about 3D stereoscopic VR files, those files can be cropped to fit our needs if the resolution is not an issue (because for many reasons, the resolution is divided by a factor of 2 in most of the cases).

Equirectangular format (or spherical)
An historical format that is used by all of the 3D renderer softwares to put a texture into a sphere.
Advantages: Easy to use, no discontinuity, accepted by mostly all of the planetarium softwares
Drawbacks: non uniform resolution - too much resolution wasted for the polar zones and too low resolution for the equatorial zone

Cubefaces format
New formats emerged to overcome these shortcomings, using the principle of the six faces of a cube. Six contiguous square images reproduce the visual information in all directions while maintaining a homogeneous resolution without concentration artifacts. The arrangement of these cubes being arbitrary, placing them in a cross like unfolded cubes wasted pixels in the image. The mapping in 2 rows of 3 columns is more relevant and is used in particular by YouTube, with addition of non linear mapping to uniformize the pixels use.
Advantages: more homogeneous resolution
Drawbacks: Impose to do a cubemapping for projection

This link provides informations about mapping precisely your cube for better stitching equi-angular cubemaps.
https://blog.google/products/google-ar-vr/bringing-pixels-front-and-center-vr-video/?

fbclid=IwAR01xMk2UiJADwudyl7Y46iKZmZzE-DEajJWJnrd24FBlXolyUPJEzq6g4s

Lots of VR content are playing with the user to find where to watch. This allows a dynamic and a feeling of orientation which is much better than with a projection where changing the direction from the point of view of the sky could be penalizing in the recognition of the sky outside. Conversely, most of the so-called "oriented" planetarium shows do not even require turning your head, all the action taking place only around a limited direction, thus not maximizing the use of the projection space.

Some VR contents are now available in a so-called 8K quality, but most of them are in 4K. Be careful, when we talk about 4K, it is actually an image (often equirectangular) of 3840x1920 pixels. 3840 pixels to cover from 0 to 360 degrees in azimuth and 1920 pixels to cover from +90 to -90 degrees from top to bottom. This gives a fisheye resolution comparable to only 1.2K horizontally, 1.9K vertically, which can be detrimental in rooms with a resolution greater than 2K. However, the more we go towards the zenith, the more the resolution increases with 2.4K at 45 degrees of height parallel to the horizon.
In the case of an image in cube faces, the resolution observed is often 3840x2160, or "squares" of 1280x1080 leading to a fisheye of 1566 pixels in diameter but almost homogeneous. Not appealing for 2K projection systems and up but far enough for single fisheye systems of up to 1600p and spherical mirror projection systems.

VR players for the dome
-The simulators of the big manufacturers like Sky Explorer from RSA Cosmos, Digistar from Evans & Sutherland, Digital Sky, Uniview and probably others manage the projection of a video texture on a sphere to project any VR content.
-DigitalisMediaBrowser manages the playback of equirectangular videos for their systems equipped with the Universal Console by managing the direction of aim with the Xbox controller.
-FishTank from ePlanetarium manages the distortion of equirectangular videos for spherical mirror based systems.
-ShiraPlayer allows playing equirectangular videos as animated panoramas.
-SpaceCrafter in its version integrating the Pro plugin of Immersive Adventure manages the equirectangular videos but also the videos in faces of cube and also allows to choose the orientation and the compression of the field of vision interactively with the Joypad.

What astronomical contents for your planetarium ?

NASA provides a large number of royalty-free VR videos such as, for example:
The training of astronauts in the swimming pool.
The Juno mission.
Curiosity rover mission.
The recovery of cosmonauts from a Soyuz.
Spitzer final voyage.
Exoplanet excursions available in 8K
https://informal.jpl.nasa.gov/museum/360-video

4000 exoplanets from System Sounds
https://www.youtube.com/watch?v=aiFD_LBx2nM

Seeking Pluto from The New York Times.
https://www.youtube.com/watch?v=jIxQXGTl_mo&t

One strange Rock from National Geographic about the ISS.

https://www.youtube.com/watch?v=dwHBpykTloY

Journey to the Orion Nebula from Hubble Science Institute.
https://hubblesite.org/contents/media/videos/1013-Video.html?keyword=360

Stonehenge from English Heritage.
https://www.youtube.com/watch?v=_RyqU1r1Fmk

Northern Lights in Alaska from William Briscoe.
https://www.youtube.com/channel/UCXA0I4DDGFn_0EJBmIQ_Qkw

What happened in the Tunguska from Science Channel.
https://www.youtube.com/watch?v=JKm3uzL_A4c

360 degrees view of the galactic center from Chandra team.
https://www.youtube.com/watch?v=wBxW2_B9_Is

Syene's well from Lionel Ruiz. Don't forget to look down to see the Sun's reflection!
https://www.youtube.com/watch?v=gi0jGcAgC80

Mission ISS from Magnopus, the presentation of an interactive free game for Oculus Rift.
https://www.youtube.com/watch?v=adAavaYqcAM

Sounds of the solar system in 360 from Guru da Ciencia.
https://www.youtube.com/watch?v=LVI55mSmXo4

And many others. Be careful though to ask for authorization of use from their authors for what you will do with it because except for NASA where it is clearly announced on their site, it is not the same for private productions even if they are offered to Internet users free of charge.

Some examples of non astronomical contents available through Youtube.

Om nom stories - Unexpected guest.
https://www.youtube.com/watch?v=0XlPxhd7Ljo

Invasion from Baobab.
https://www.youtube.com/watch?v=SZ0fKW5PttM

Crow the Legend from Baobab. A stunning story about the birth of seasons with the magical voice from John Legend.
https://www.youtube.com/watch?v=DR1gT36OtJQ&t=44s

Lightning, a VR story
https://www.youtube.com/watch?v=4fK4UlhKoT8

Falling clouds from mechanism digital.
https://www.youtube.com/watch?v=u5zP38NrTbk&t

What happens inside your body from bright side.
https://www.youtube.com/watch?v=kw9EJbezlK4&t

Nuclear explosion from teatime research.

https://www.youtube.com/watch?v=ShZGwgFmzoI

Human digestive system from education in 360.
https://www.youtube.com/watch?v=r8-6Z1Efgzg

Swimming with giants from American Museum of Natural History.
https://www.youtube.com/watch?v=wOsq7fQ9Z3A

And why not to convert it into domemasters or videos with the proper orientations fixed ?
This can be a good turnaround, especially if you need to change the point of view at some critical moments. The use of BLENDER software or other 3D renderers like Cinema4D can be useful to place the camera where you want.
To get compression, put the camera below the sphere center.
To get a tilted view, rotate the sphere around the Y axis to elevate the horizon at the desired height.
Rotate the sphere around the Z axis to get the proper orientation for the smooth spot.
Record the keys to move the camera at your will and render the result to obtain the fisheye video needed.

Virtual reality will not throw the planetarium into oblivion if we take care to use our planetariums in the way that best suits them: joint experiences with a live presenter who can adapt his presentation to the needs of his audience. Using virtual reality is a boon for planetariums because we can take advantage of the emergence of this technology to transcend these contents through immersive sequences for the delight of our audiences.