



VIRUP : Real-Time Rendering of Astrophysical Data

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BACKGROUND

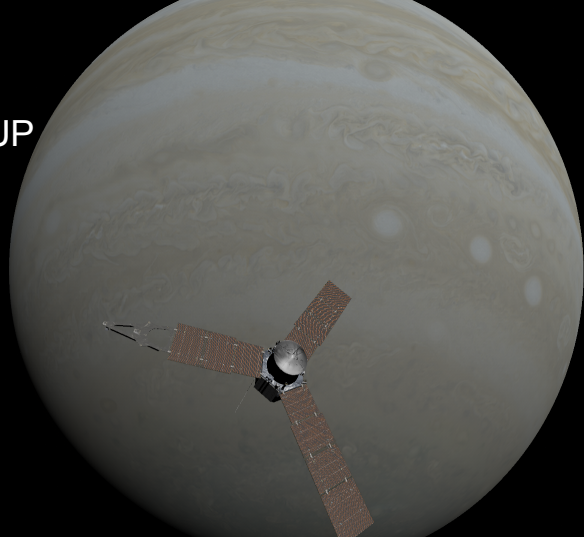
- Will to enhance outreach material at the Geneva Observatory
- 3D movie made by Yves Revaz using Celestia
- New outreach project started in 2018
- Consumer Virtual Reality headsets were just out at the time
- VIRUP : the Virtual Reality Universe Project

GOALS

- Originally :
 - Make a VR real-time rendering application
 - Aggregate data from multiple large datasets
 - Help develop an intuition for the sense of scale in the Universe
- Added over the years :
 - Multimodality
 - Pre-rendered movies
 - More complex types of data (volumetric, dynamic, planetary science, etc...)

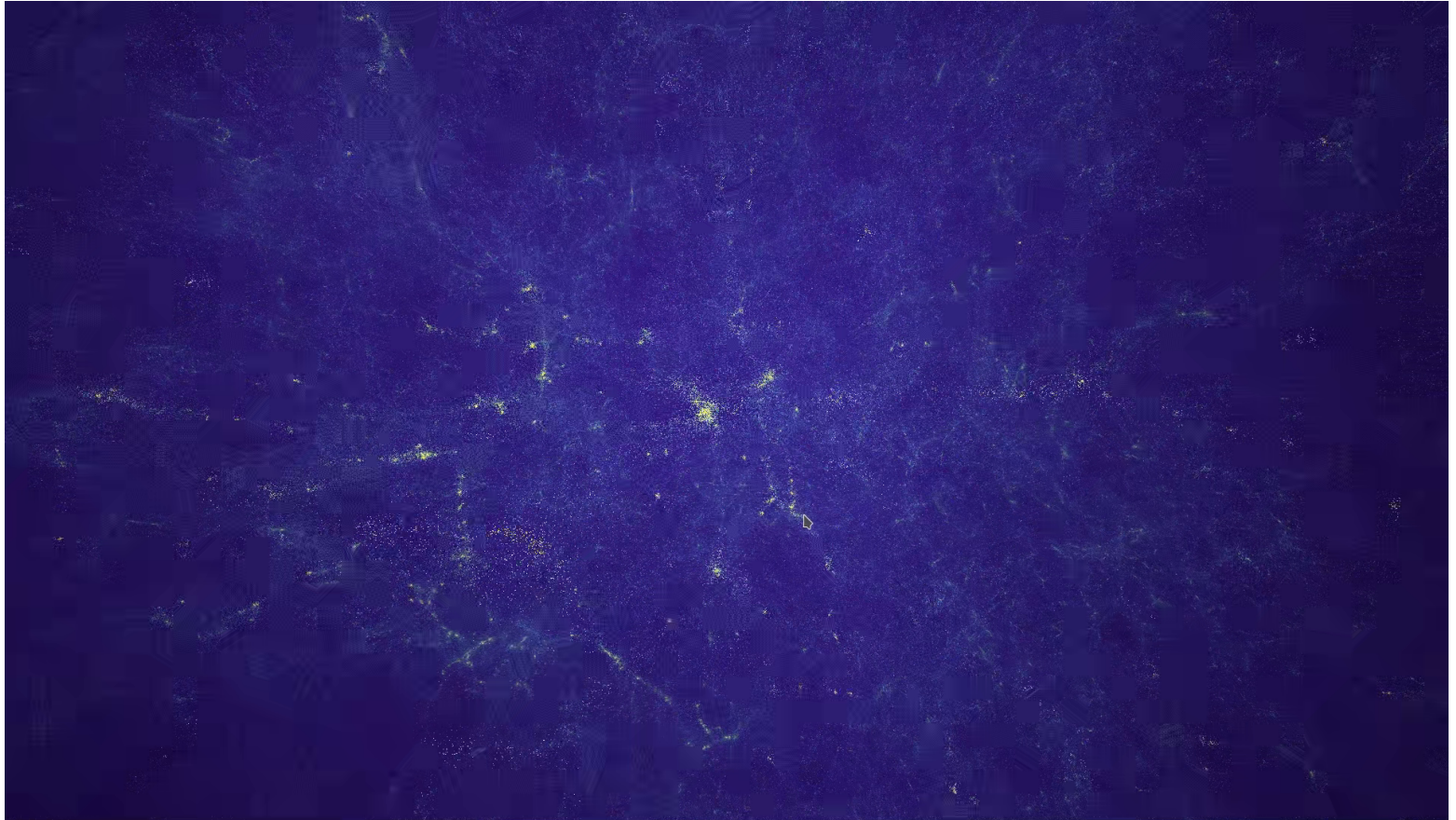
EPFL

VIRUP

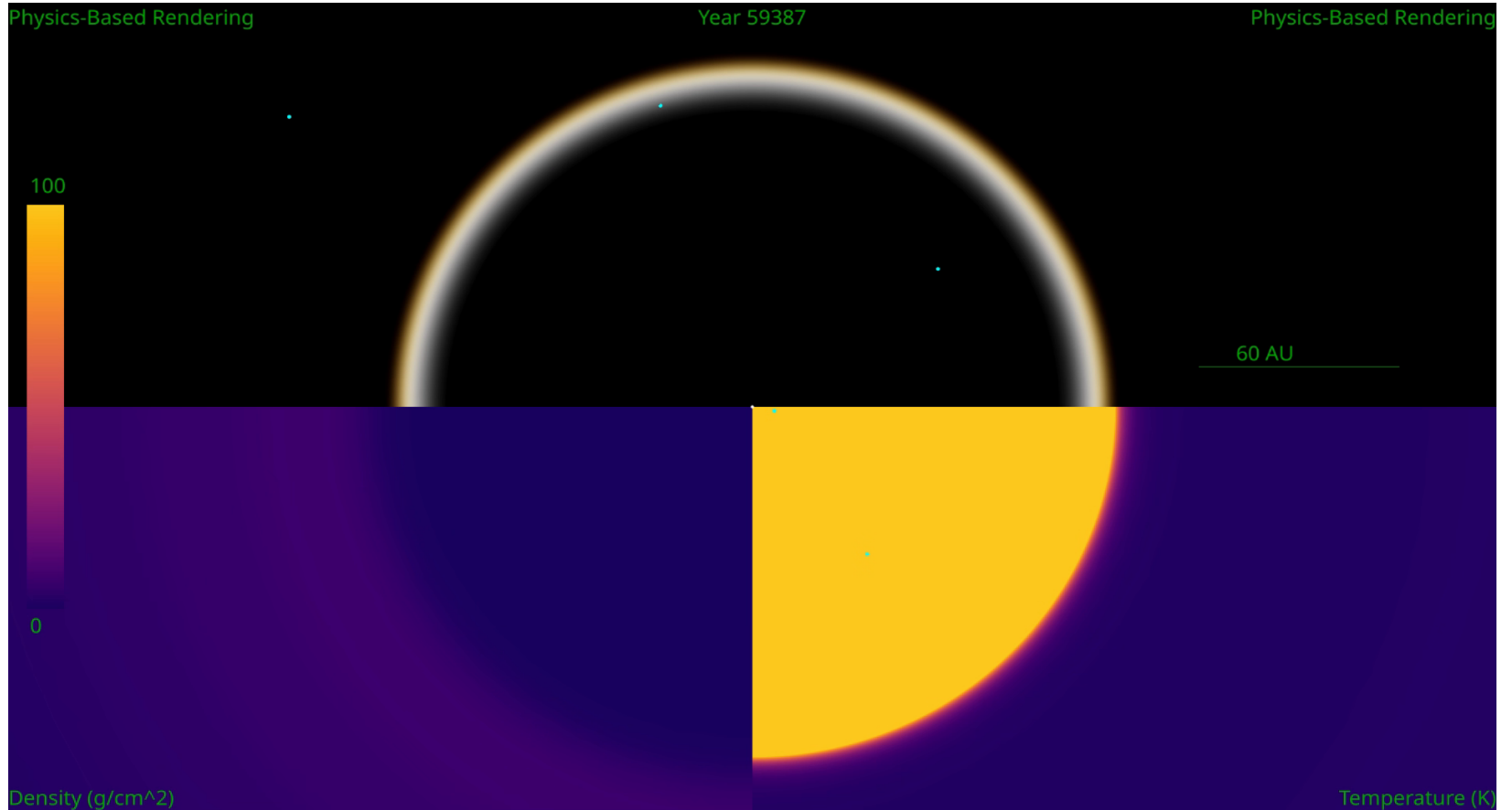


LIVE DEMO TIME!

EPFL REAL-TIME GRADIENT MANIPULATION



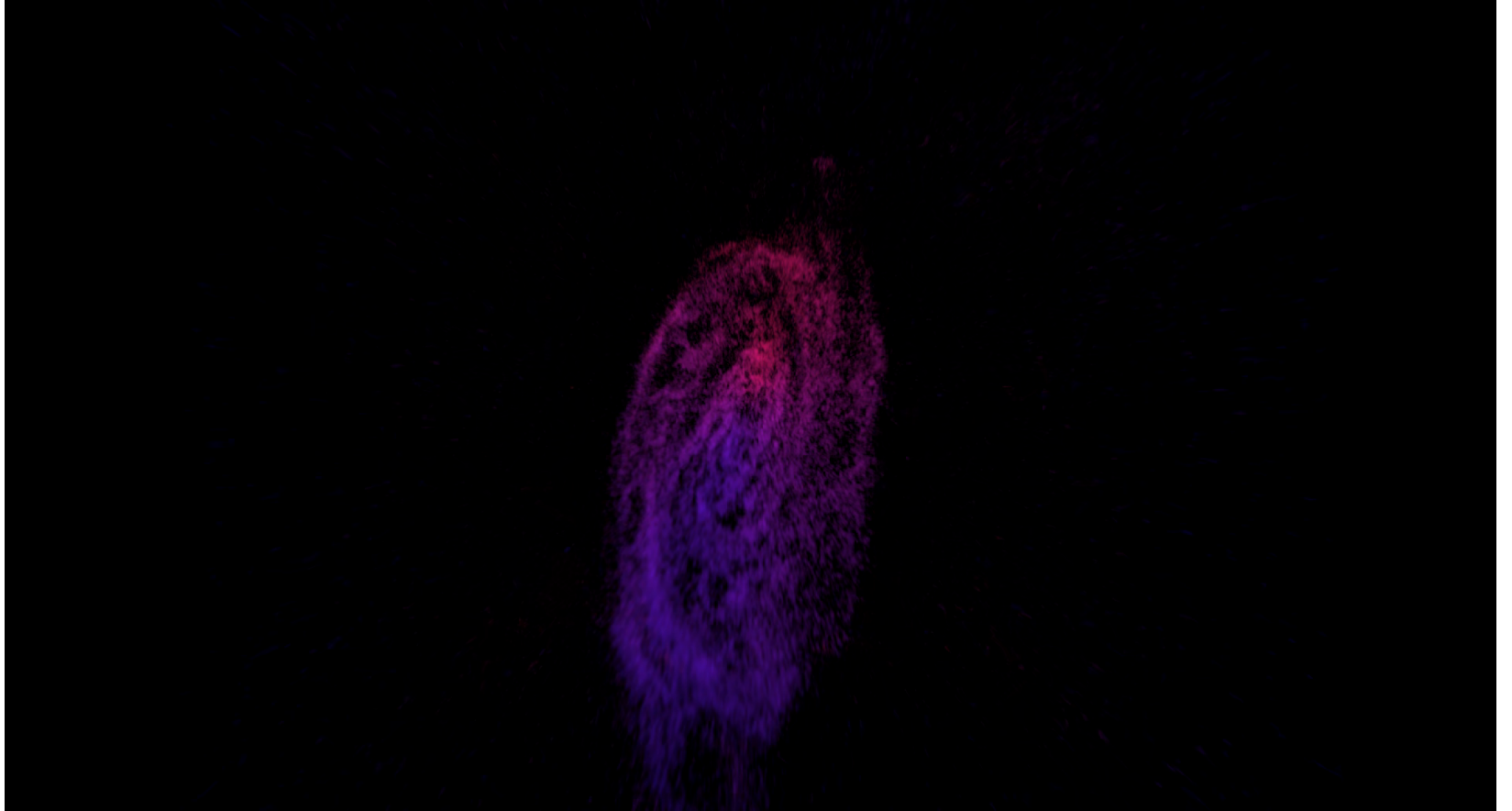
EPFL PROTOPLANETARY DISCS



PROTOPLANETARY DISCS : 3D



EPFL VOLUMETRIC VISUALIZATION



```
17:01:29 Florian@laptop-dev:~$ otreegen generate -h
Usage:
  otreegen generate [-h|--help]
  otreegen generate [INPUT-OPTIONS] <INPUT> --output [OUTPUT-OPTIONS] <OCTREE-FILE-OUT>
  otreegen generate [INPUT-OPTIONS] <INPUT> --output [OUTPUT-OPTIONS] <OCTREE-FILE-OUT>
  Takes some input data and generates an octree written in OCTREE-FILE-OUT.

INPUT OPTIONS:
  --sample-rate=<RATE> : resamples the input to only take RATE fraction particles (ex: --sample-rate=0.5 halves the input data).

INPUT:
  Either of:
  --input-random <PARTICLES-NUMBER> [ADDITIONAL-DIMENSIONS] : specifies random data as particles, generates PARTICLES-NUMBER particles. Additional random dimensions can be specified
as ADDITIONAL-DIMENSIONS :
  --add-radius
  --add-lum
  --add-rgb-lum
  --add-density
  --add-temperature
  --input-octree <OCTREE-FILES> : specifies octree file(s) as input (globbing works). If several files are specified, they must share the same flags (check flags using otreegen info
).
  --input-hdf5 <HDF5-FILES> --coord-path=<COORD-DATASET-PATH> [ADDITIONAL-DATASET-PATHS] : specifies hdf5 file(s) as input (globbing works). If several files are specified, they must
share the same dataset path structure. COORD-DATASET-PATH is the 3D dataset path of particles coordinates. Additional variables dataset path can be specified as ADDITIONAL-DATASET-PATHS :
  --radius-path=<RADIUS-DATASET-PATH> : 1D dataset
  --lum-path=<LUM-DATASET-PATH> : total luminosity (1D dataset)
  --rgb-lum-path=<RGB-LUM-PATH> : luminosity per band (3D dataset)
  --density-path=<DENSITY-DATASET-PATH> : 1D dataset
  --temperature-path=<TEMPERATURE-DATASET-PATH> : 1D dataset

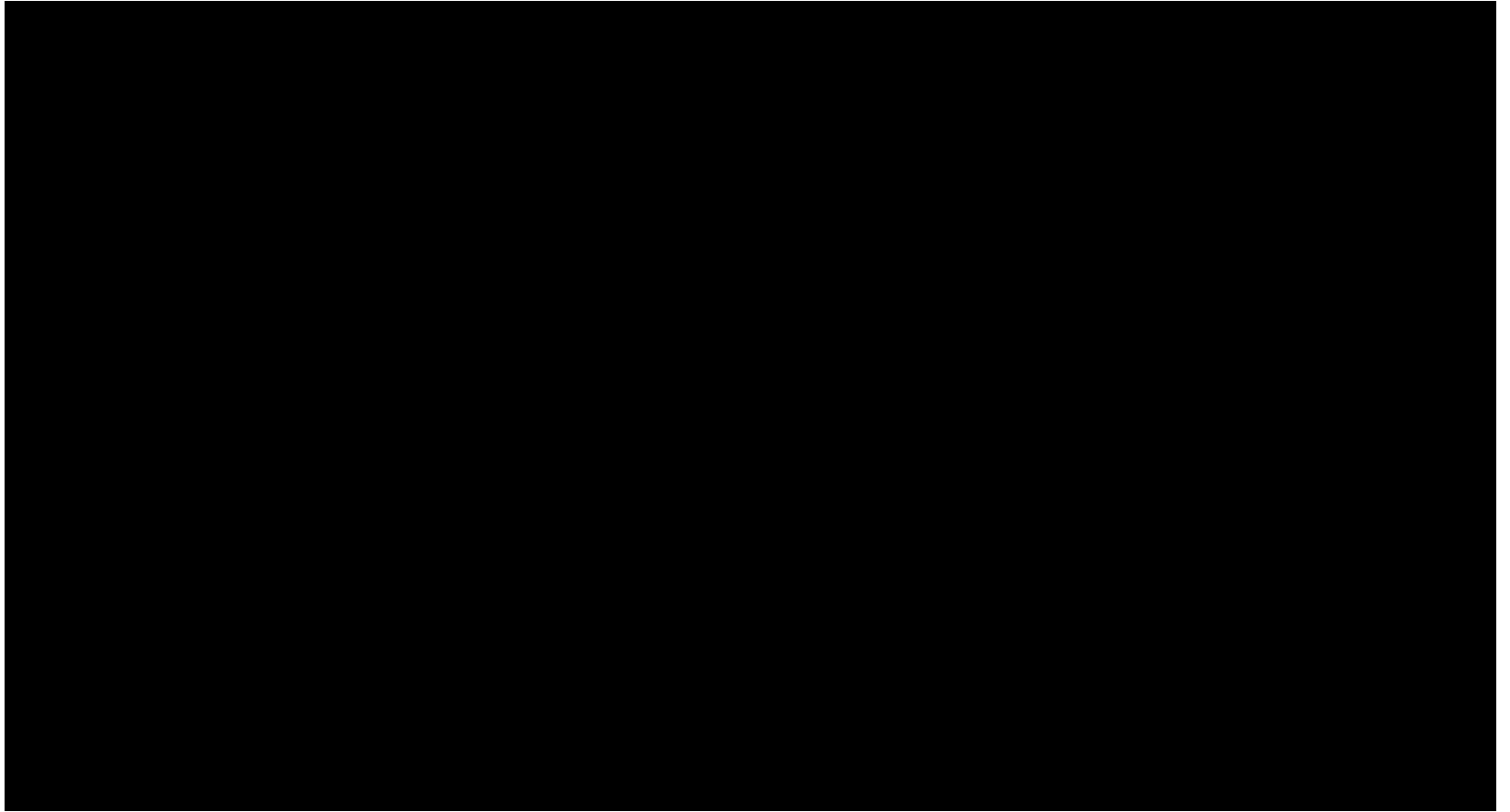
OUTPUT-OPTIONS
  --disable-node-normalization : disables particles having coordinates in [0;1] relative to their node, which is on by default
  --use-zstd-compression : uses zstd to compress each node's data. Will result in smaller files but can make data loading longer. You should benchmark to see if it's worth it (but zs
td is supposed to be fast).
  --max-particles-per-node=<MAX_PART_PER_NODE> : defines a particle number above which a node is split in 8 sub-nodes (and below which it becomes a leaf). MAX_PART_PER_NODE is 16000
by default.

Examples:
  To read gaz data coordinates and luminosity within snapshot.*.hdf5 files (will be expanded as "snapshot.0.hdf5 snapshot.1.hdf5" for example) in group /PartType0 and write the corresponding
octree in the gaz.octree file :
  otreegen generate --input-hdf5 snapshot.*.hdf5 --coord-path=/PartType0/Coordinates --lum-path=/PartType0/Luminosities --output gaz.octree
  which is equivalent to :
  otreegen generate --input-hdf5 snapshot.0.hdf5 snapshot.1.hdf5 --coord-path=/PartType0/Coordinates --lum-path=/PartType0/Luminosities --output gaz.octree

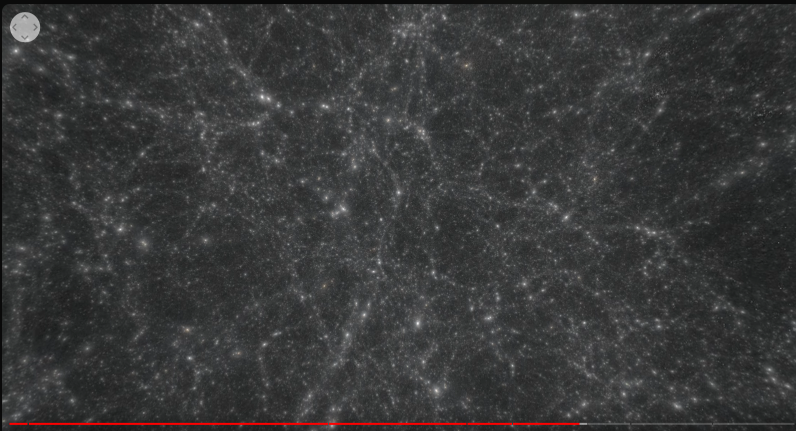
  To generate 1 million uniformly random particles and
  write the corresponding octree in the random.octree file :
  otreegen generate --input-random 1000000 --output random.octree

17:01:30 Florian@laptop-dev:~$ otreegen info random.octree
Loading octree structure...
Reading octree file version 3.0
[#####] 100%
random.octree :
Bounding box :
  x:[4.34928e-07,1]
  y:[2.70549e-07,1]
  z:[6.58026e-06,1]
Flags : NORMALIZED_NODES, VERSIONED
Vertex dimension : 3
Number of vertices : 1000000
Data sample :
  0.894992, 0.138621, 0.309267,
  0.463549, 0.0700861, 0.545226,
  0.267795, 0.36733, 0.342377,
  0.677194, 0.651039, 0.208577,
  0.213569, 0.512209, 0.355291,
  0.796275, 0.140999, 0.570835,
  0.998989, 0.422978, 0.611693,
  0.00248531, 0.715184, 0.621436,
  0.428628, 0.68865, 0.140866,
  0.812600, 0.415691, 0.699552,
  0.854902, 0.83853, 0.222231,
  0.237682, 0.969347, 0.324068,
  0.750148, 0.488218, 0.84669,
  0.962697, 0.877287, 0.469386,
  0.546316, 0.179036, 0.939171,
  0.466134, 0.586839, 0.0672952,
```

Octreegen tool for easy data importing from HDF5



ARCHAEOLOGY OF LIGHT



Archaeology of Light - VR180

VR180

LASTRO_EPFL

1.6K

137K Views · 2 years ago
 "Archaeology of Light - An Immersive Journey Through Space and Time" is one possible Journey through the most detailed 3D model of the universe.
 Watch in 4K: [Archaeology of Light - An Immersive J...more](#)

32 Comments

@AilorNothing27 5 months ago
 Just watched this through VR. Whoever's idea it was to make this video and put it out there for free, for all to see, is an absolute legend. I would have payed good money for that experience.

@ossacpro 2 years ago
 Everyone needs to see this they need to see how little we are and how much it matters that we all collaborate on something to be at least one shine in the universe.

@SjaakSchuttels 2 years ago
 I saw this video today in VR. I think it was the most impressive movie I have seen in a long time. It was truly breathtaking. I have been watching many videos about the universe. Your video in VR gave me the feeling I was actually there. Im 64 now and all my life I wanted to experience something like that. I placed a link in all the VR groups I'm connected to in the hope that many more will watch it.

@harpoonsteman1559 2 years ago
 A numinous experience.

Without a doubt the best VR video I've come across.

@THORMYNI 2 years ago (edited)
 I've watched this already numerous times

THE DEEPEST WE HAVE EVER SEEN INTO THE SUN | SDO 4K
 Altium
 7M views · 9 months ago

What would we see at the speed of light?
 ScienceClic English
 5.6M views · 1 year ago

If the universe is only 14 billion years old, how can it be 92...
 Fermat
 6.6M views · 5 years ago

THE SIGHTS OF SPACE: A Voyage to Spectacular Alien...
 melodysheep
 5.4M views · 1 year ago

The Babylonian Map of the World with Irving Finkel |...
 The British Museum
 1.4M views · 1 month ago

Deep Field: The Improbable Magnitude of our Universe
 Eric Whitacre
 5.7M views · 5 years ago

How does Starlink Satellite Internet Work?
 Branch Education
 6.6M views · 2 years ago

THE CURIOUS LIFE OF A MARS ROVER | Nat Geo Live
 National Geographic
 14M views · 9 years ago

How Big Is the Universe?
 Science Time
 5.3M views · 6 months ago

TIMELAPSE OF THE FUTURE: A Journey to the End of Time (4K)
 melodysheep
 102M views · 5 years ago

EINSTEIN'S QUANTUM RIDDLE | Full Documentary | NOVA | PBS
 NOVA PBS Official
 3.1M views · 1 year ago

LIFE BEYOND II: The Museum of Alien Life (4K)
 melodysheep
 19M views · 3 years ago

Something Strange Happens When You Follow Einstein's...
 Veritasium
 13M views · 4 months ago

Archéologie de la Lumière - VF - Un voyage immersif à travers...
 LASTRO_EPFL
 2.7K views · 1 year ago

The Story of Shor's Algorithm, Straight From the Source | Pet...
 Qiskit
 531K views · 3 years ago

Journey to the Center of the Milky Way Galaxy Like Never...
 V101 SPACE
 1.4M views · 2 years ago

Hacking Reality (Official Film)

Cosmos Archaeology

Explorations
in Time
and Space

16.9.²⁰²²

-5.2.²⁰²³



FUTURE

- Currently writing an SNSF Agora proposal with Tanya Petersen and Yves Revaz
 - Focus on putting VIRUP in the hands of as many people as possible
 - Use social media and public events more
 - Distribute data in a more accessible way to propose more datasets
 - Allow scientists to publish their data themselves or use the tool for their own outreach communication
 - Experiment with generative AI and voice recognition for automatic guidance through the data
 - Support even more hardware
 - Dynamic cosmological simulations



**Thank
you !**

go.epfl.ch/VIRUP

Florian CABOT

09.01.2024