NuFact conference
WG7: Inclusion, Diversity, Equity, Education and Outreach (IDEEO)
2022-08-05

3D visualization of astronomy data using virtual reality

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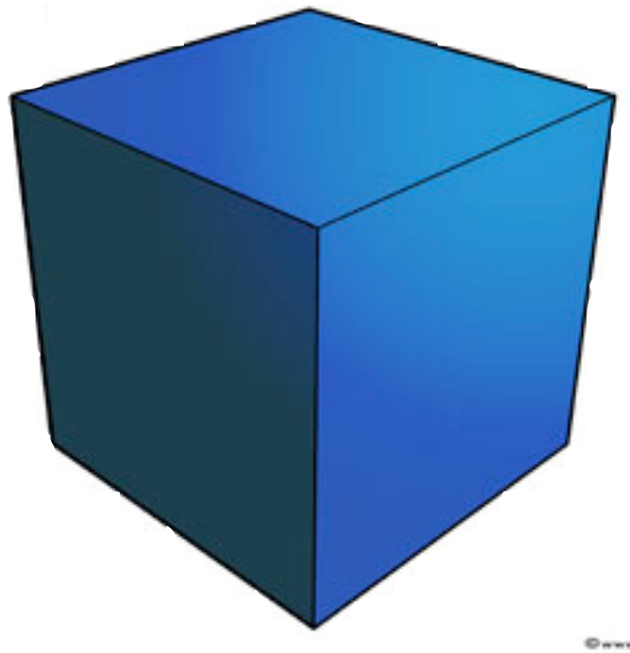
(currently visiting the University of Manitoba)
+ Jayanne English, Don Warren

What do we mean by 3D visualization?

The world as represented in the visual arts tradition



The world as we actually perceive it

2D → **flat 3D** → **stereo 3D** → **immersive 3D**

2D	flat 3D	stereo 3D	immersive 3D
slices/ projections	perspective and shading	stereoscopy (fixed viewpoint)	stereoscopy + motion parallax (can explore the scene)

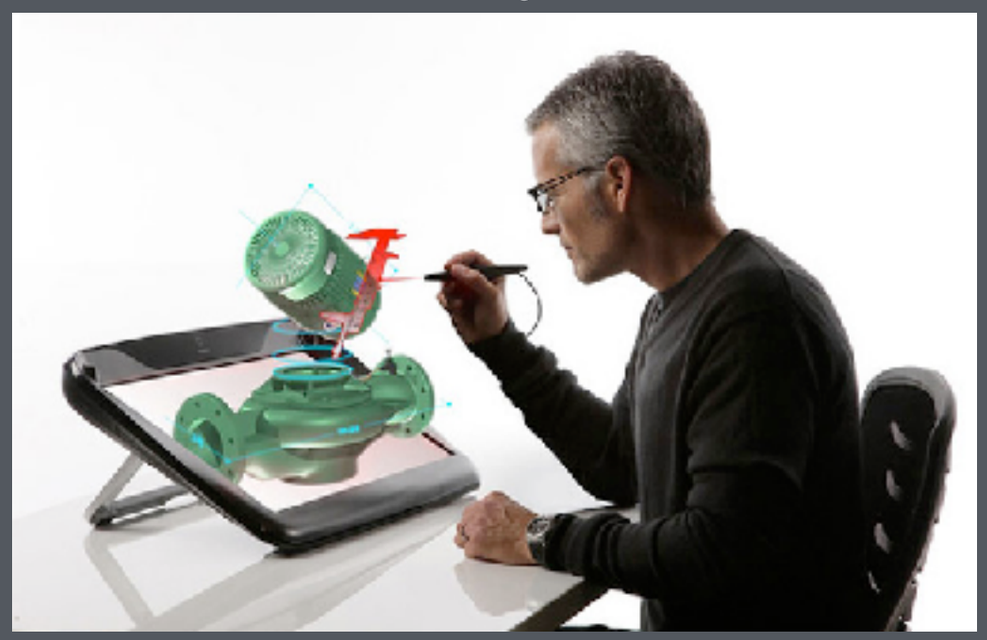
on any personal computer

on advanced displays: dual projectors, tracking cameras

3D displays for Virtual Reality (mid 2010s)

fish tanks

a CAVE by Visbox



the zSpace tabletop

headsets

the “Rift” by Oculus (Facebook)

the “Vive” by HTC / Valve

The landscape for VR headsets (early 2020s)

internal tracking (“inside out”)

external tracking

PC-tethered

all are 6 d.o.f.

HTC Vive Cosmos 2019 $400+

HTC Vive Pro 2018 $1000+

Valve Index 2019 $1000

Windows Mixed Reality Headsets by Acer, ASUS, Dell, HP, Lenovo, Samsung 2017+

Pimax 4K / 5K / 8K 2016+

“all in one”:
embedded computing power and tracking

varying d.o.f.

Meta Quest 2 2020 $400+

HTC Vive Focus 3 2021 $1500

“mobile VR”
with a smartphone

most are 3 d.o.f.

Google Cardboard 2014 $10

and many more

Testing the HTC Vive for astronomy data

with radio observations of a galaxy

Jayanne English
Physics and Astronomy
radio astronomer

Pourang Irani
Computer Science
Human-Computer Interaction Lab

University of Manitoba (Winnipeg, Canada) 2016/08

Unity as a development platform

PROS

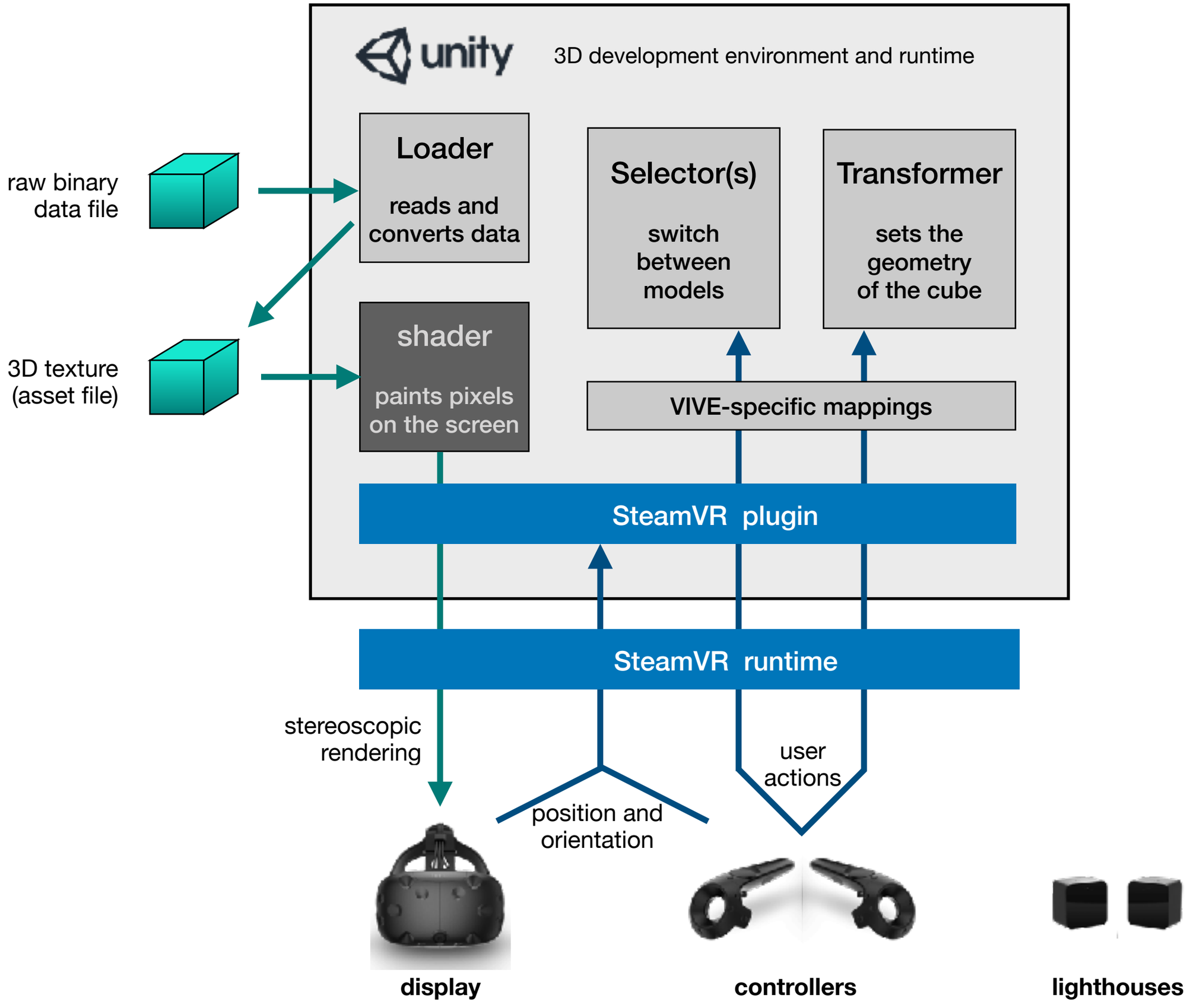
• widely used in the (growing) gaming industry:
millions of users, continuous development
(a momentum that scientists simply cannot get)
• has already been used for “serious” applications,
e.g. medical and architectural, also natural sciences
• already used by the HCI lab for their research

• high-level programming
• cross-platform (all OS, desktop/web/mobile)
• support for all the advanced displays

CONS

• not tailored for our needs, performance?
• pretty confidential in our community

VR with the Unity engine and a VIVE headset



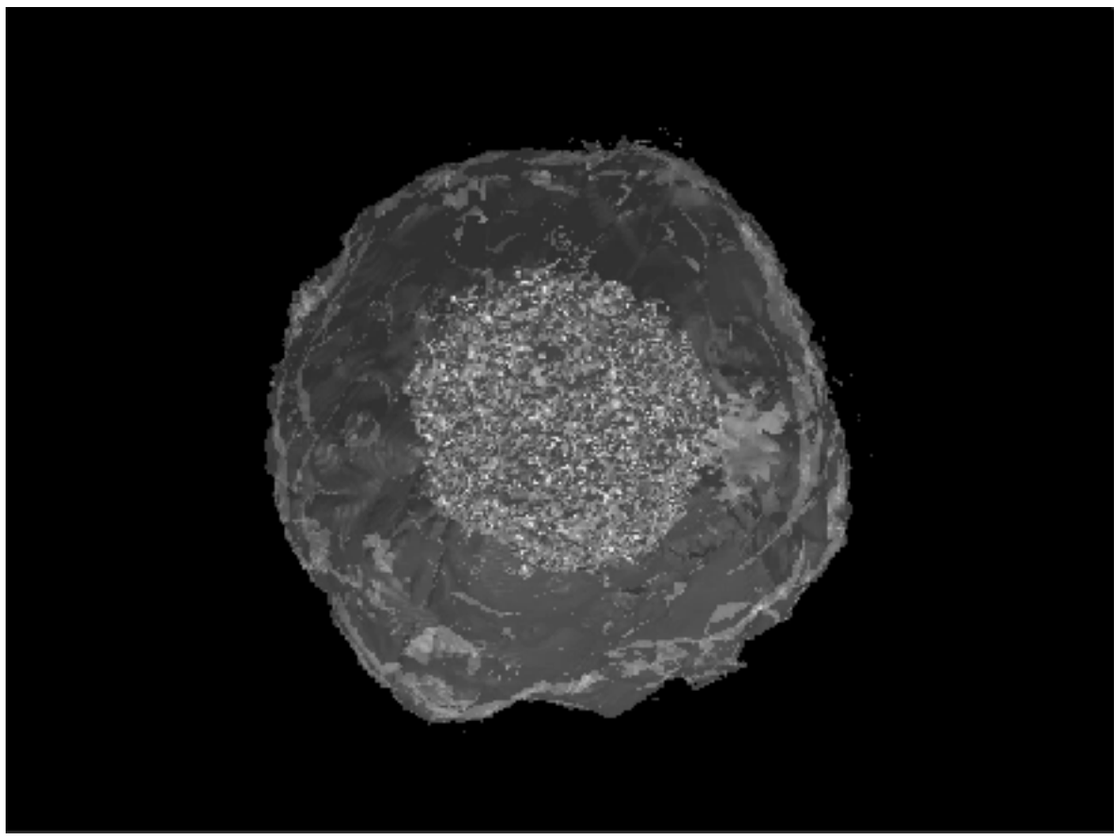
Scientific visualization of 3D data cubes

How to proceed in 3D?

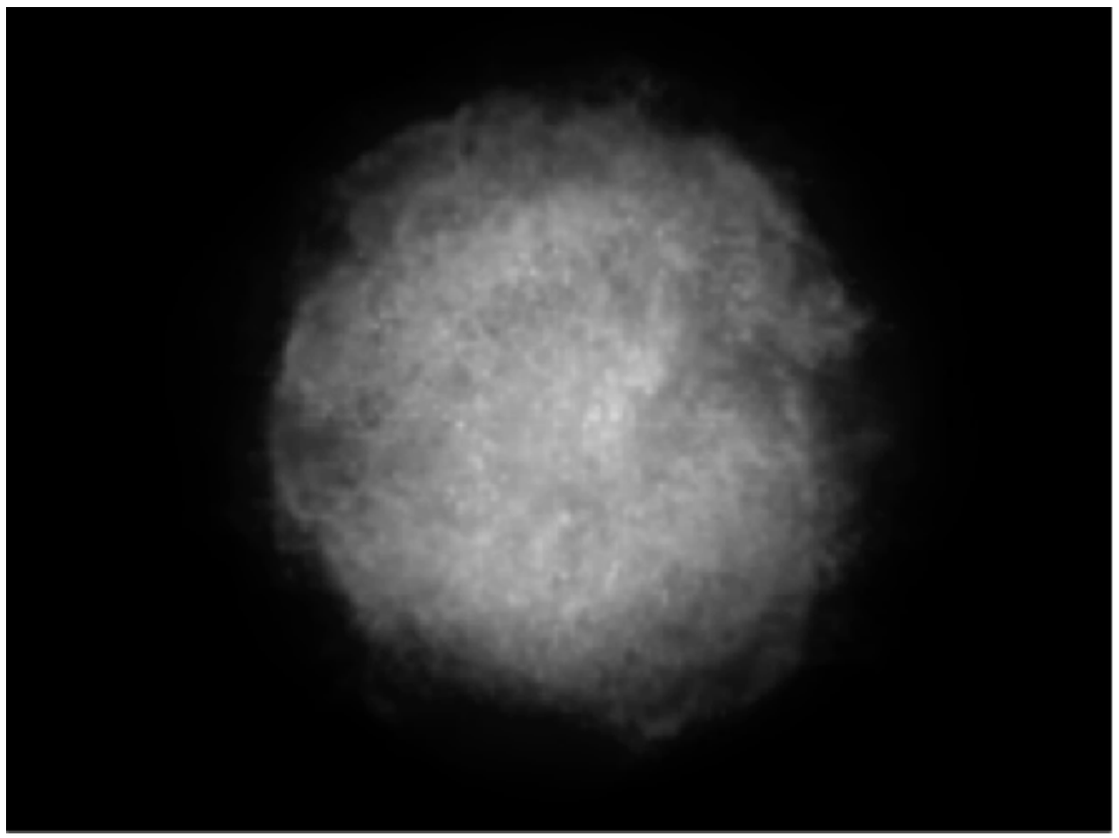
(Here assuming scalar data – more techniques for vector/tensor fields)

extract a shape, e.g. by iso-contouring, as a “mesh”, and render it using standard computer graphics techniques (needs external lighting)

assign a colour and opacity to each grid cell (voxel), cast “rays” inside the cube and integrate along the line of sight (data is shining on its own)



iso-surfaces



volume rendering

Using VR to communicate our work

to our colleagues

ABBL international workshop "Theories of Astrophysical Big Bangs" 2017-11-06–10

Using VR to communicate our work

to non-scientists: RIKEN Open Day 2018-04-21

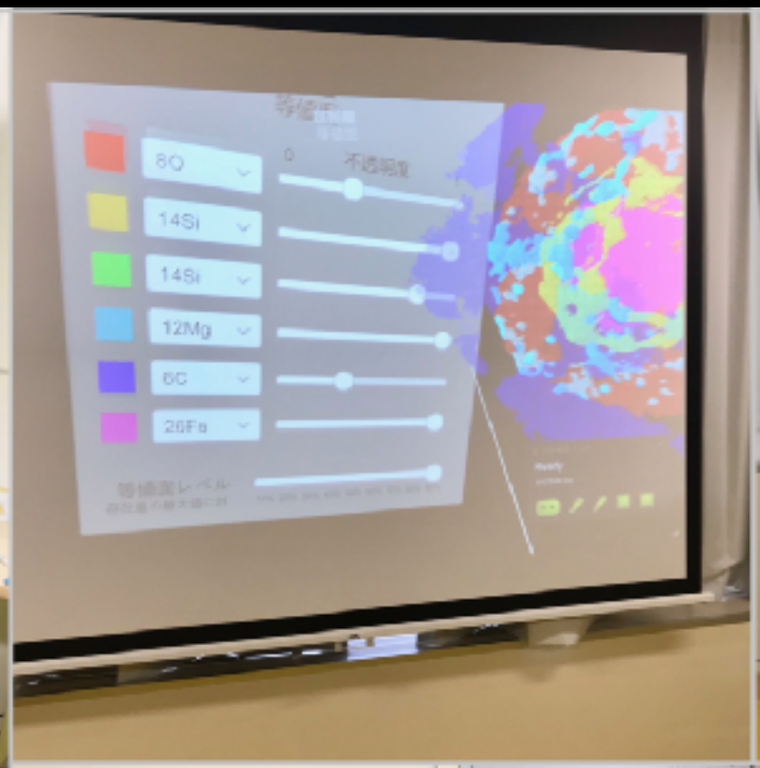
A great tool for public engagement

Ferrand & Warren 2018 CAPjournal

A great tool for public engagement

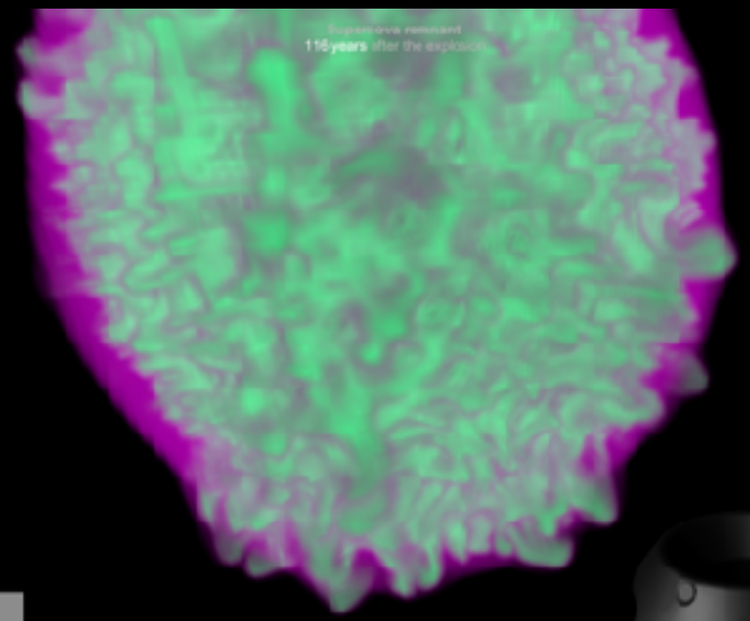
RIKEN Open Day 2018-04-21

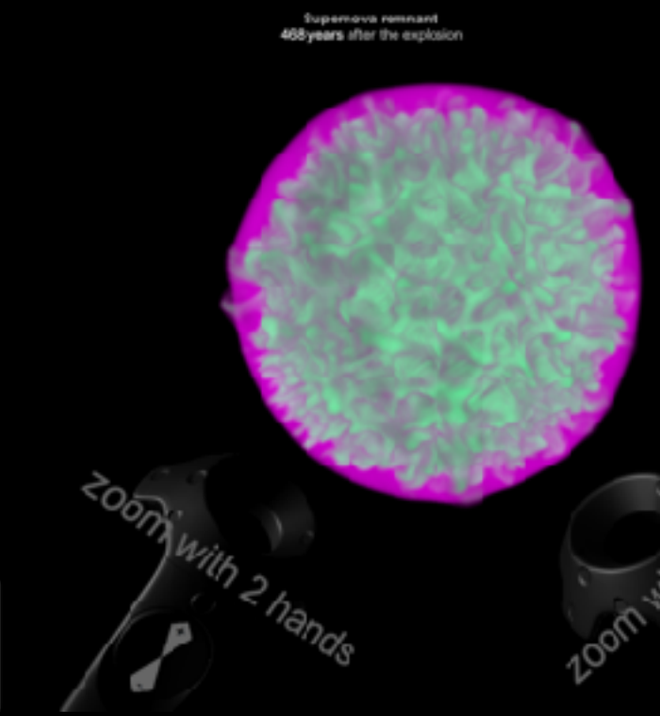
A great tool for public engagement

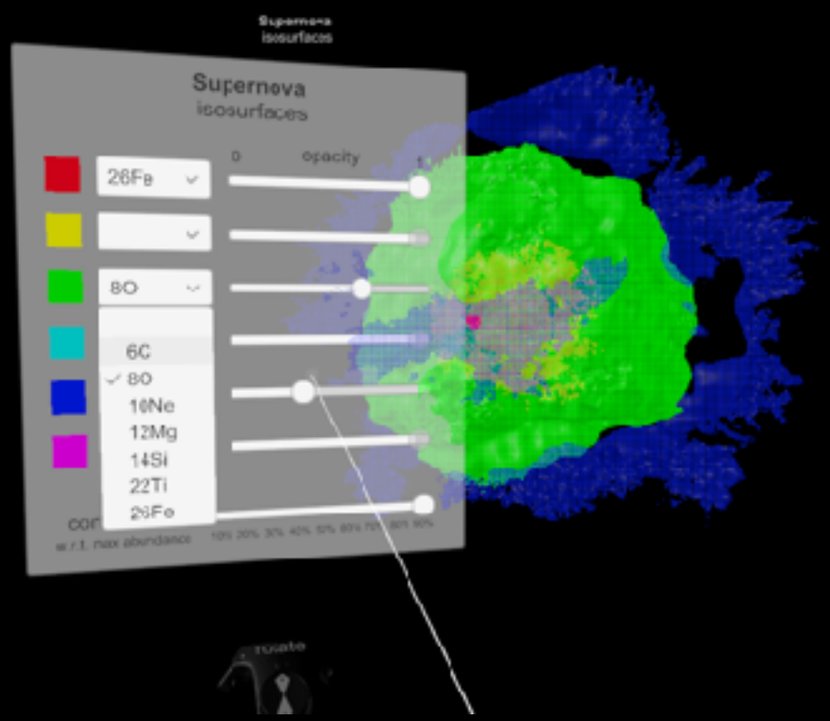


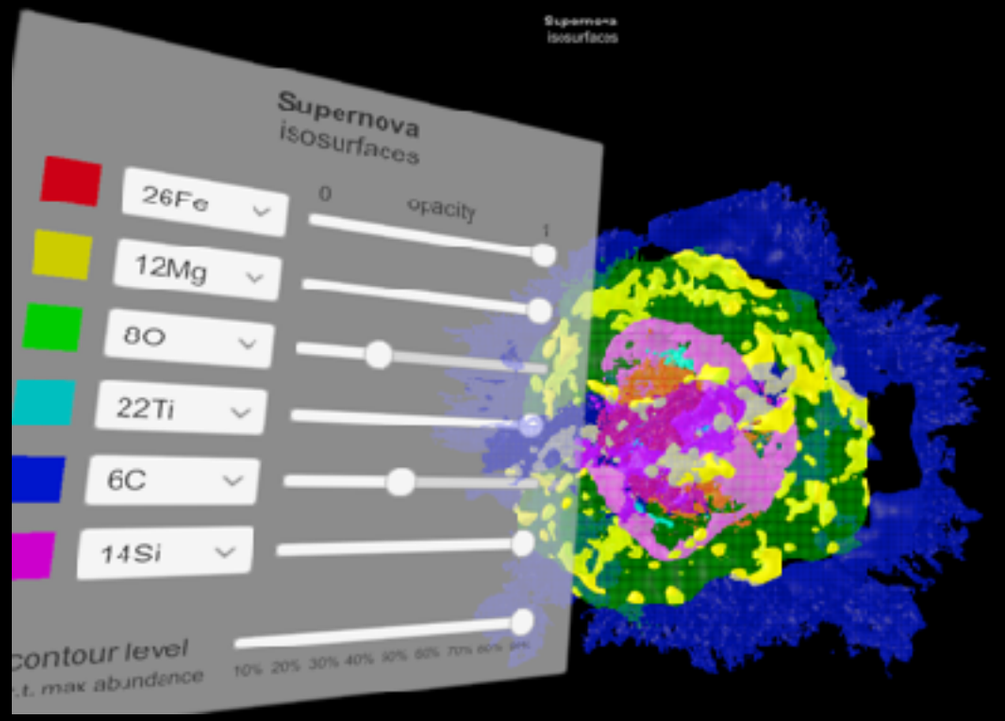
RIKEN Open Day 2019-04-20

The SN2SNR VR experience

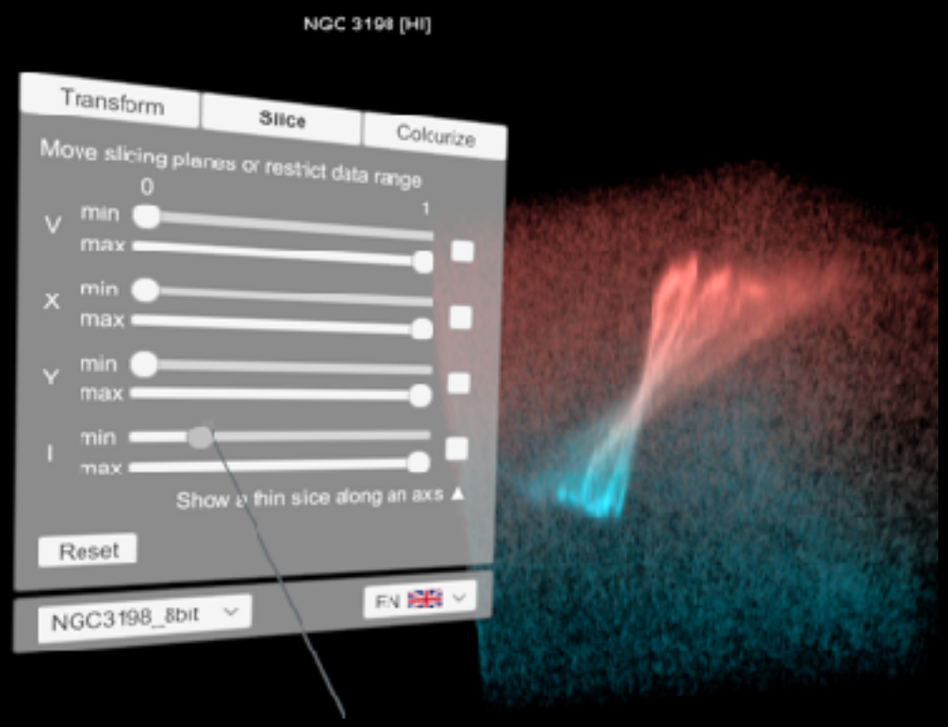


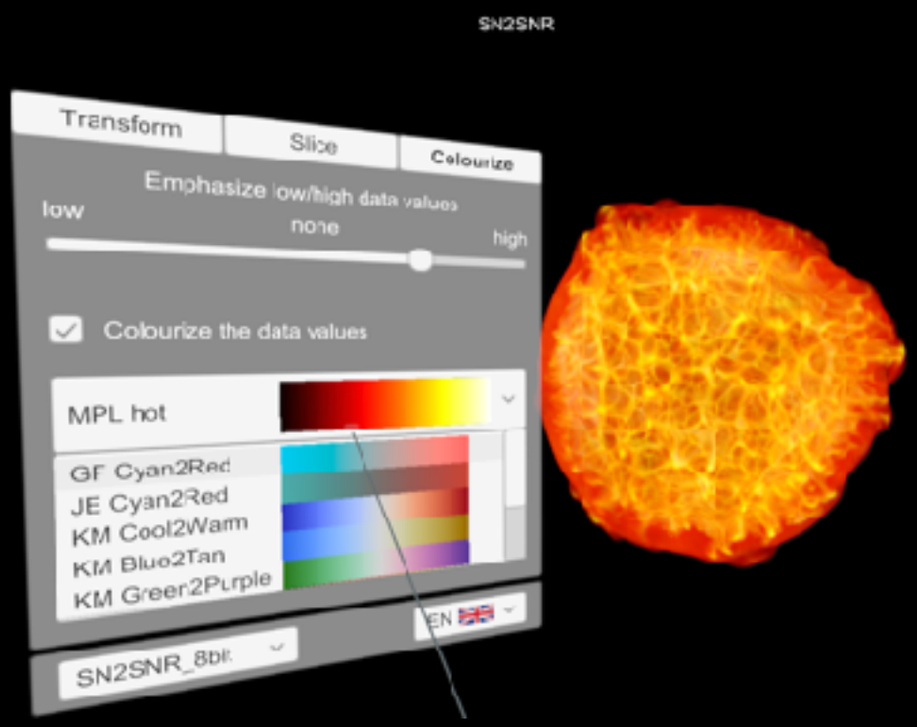


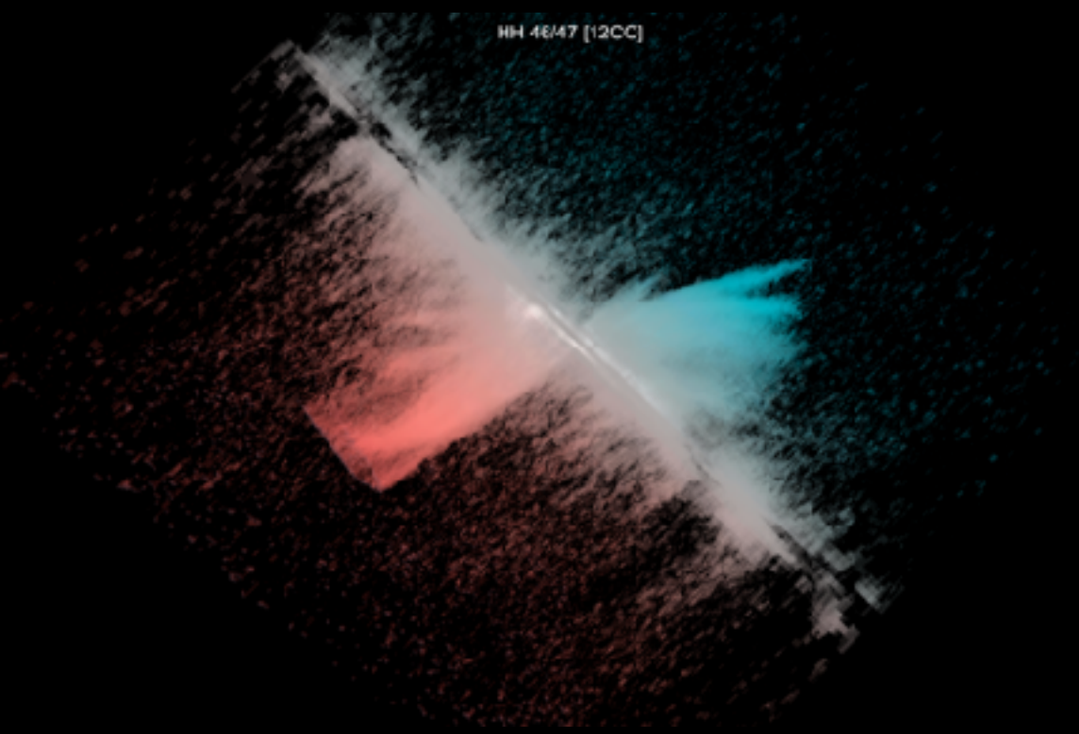


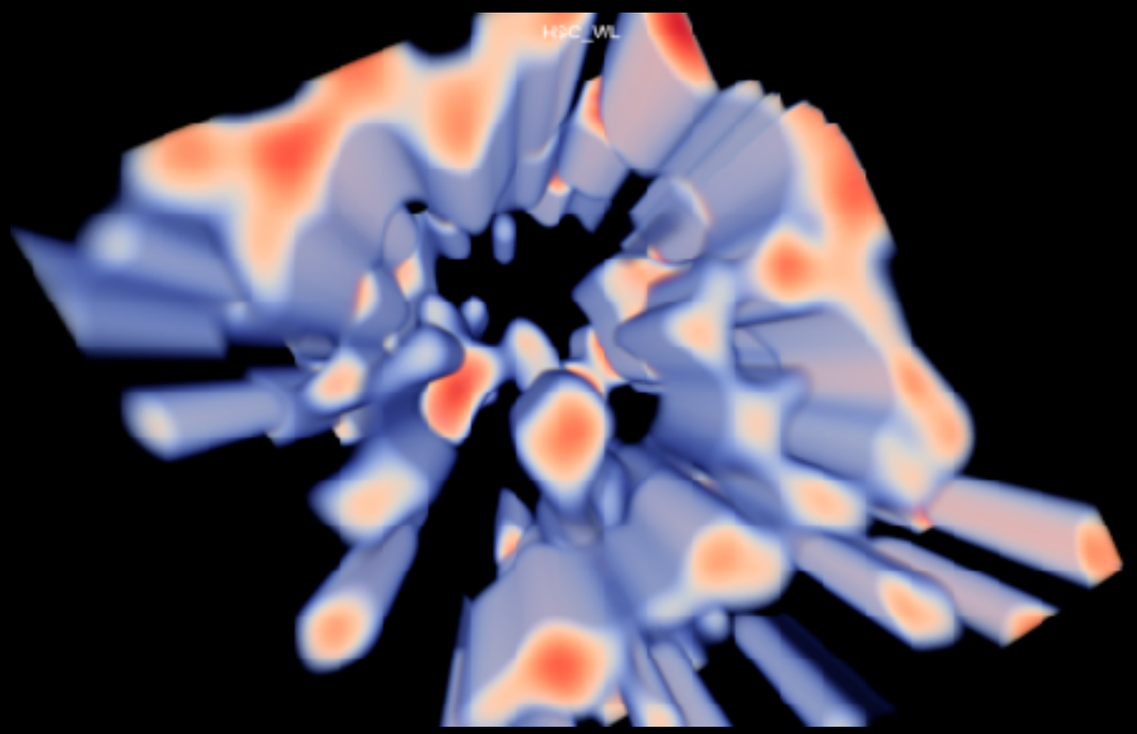


The Cube2 VR experience









Conclusion

Our brains work in 3D, and we do have 3D displays

- How can we use the technology to better understand our data (from observations or simulations) and accelerate our research?

- We can certainly use it for public outreach, to engage the public more actively!

http://ithems-members.riken.jp/warren/vrav
https://chandra.harvard.edu/vr/vr.html
https://fpavogt.github.io/E0102-VR/

We welcome new collaborators, including non-academic partners