Application of virtual reality in visualisations of Pb-Pb Collisions

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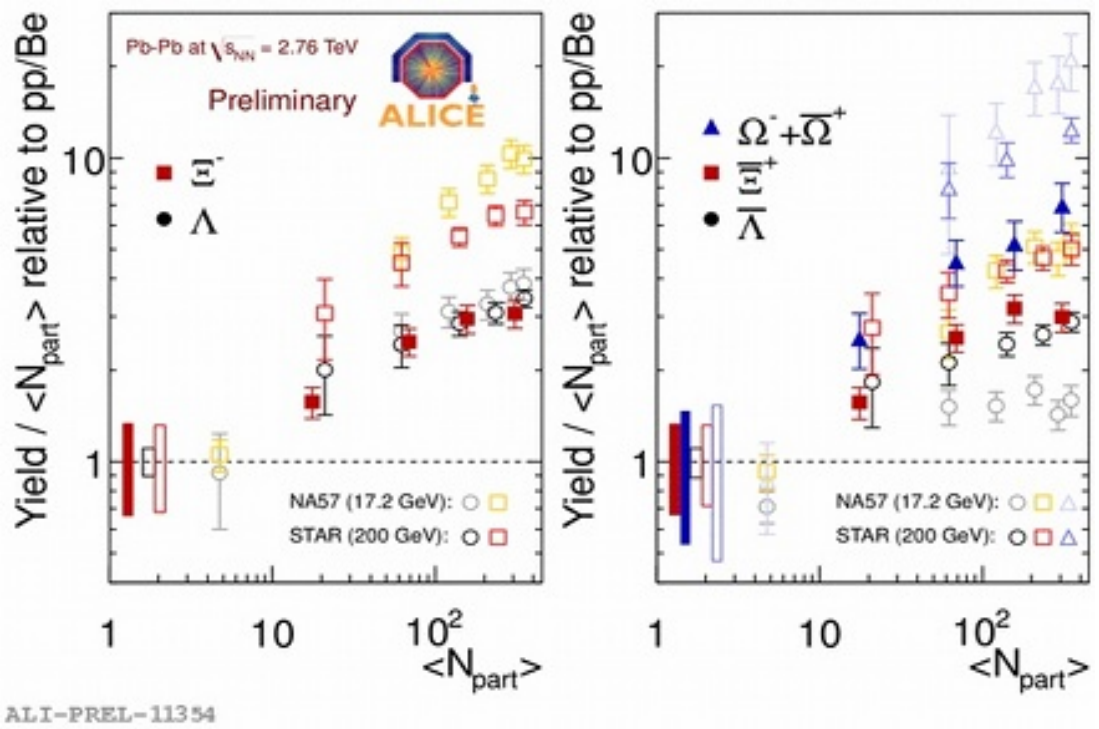
Problem

- Visualisation is important
- ... to see is to understand (for scientists)
- ... to see is to understand (for not scientists)
- ... to see is to understand (for decision makers)
- Current implementation is astonishing
- ... but is tight coupled with millions lines of code of code
- ... uses depreciated version of OpenGL
- ... ... which was wise decision when it was written
- ... ... but now even cheep processors are equipped with graphics

So there is good moment for thinking about alternate solutions

We could visualise

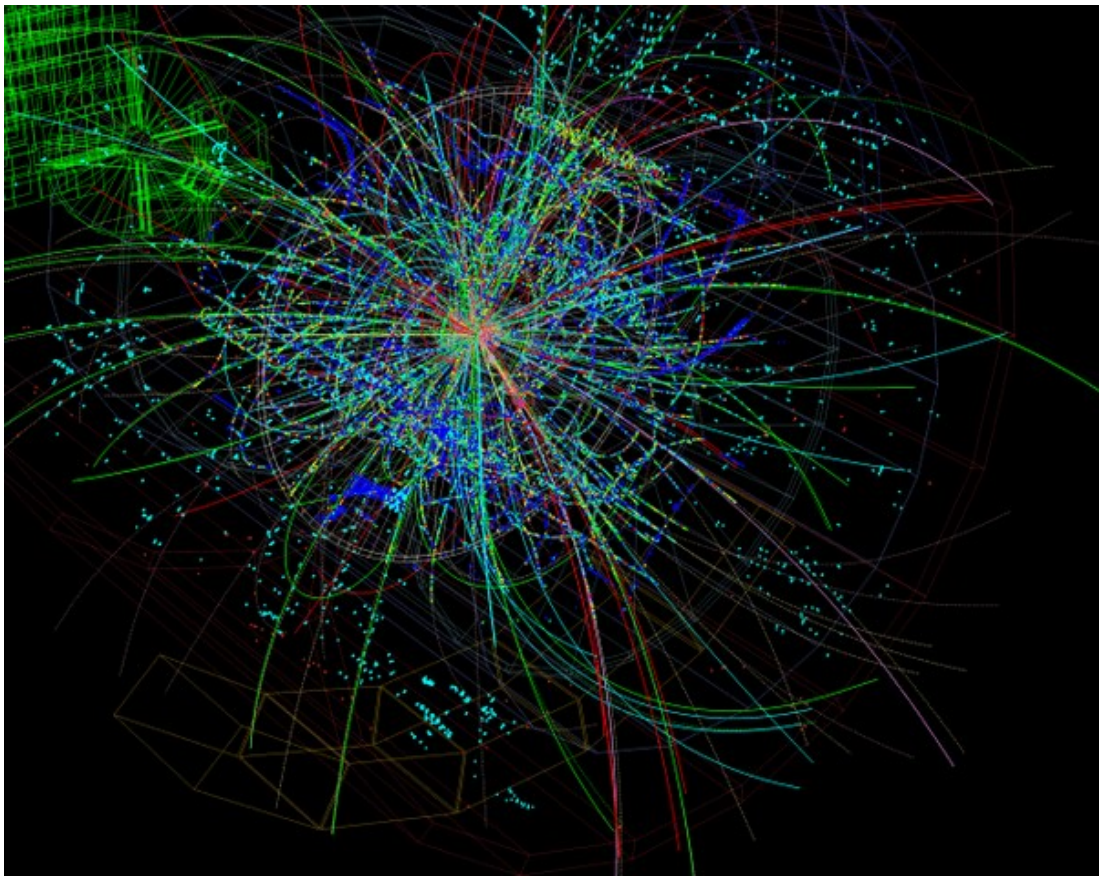
- Data ...
- Could be 2D plot ...
- Could be 3D plot ...
- Lots of physical parameters ...



good for scientists, bad for scientist's budgeting ...

We could visualise

- Physical phenomena ...
- Lots of physical parameters, not only traces of particle ...



that could sell the idea to decision makers too ...

What is Virtual Reality

- Good Virtual reality consist of:

immersion - surrounding the user with the virtual context

presence - result of good immersion - user react in the same way as if it a real world

- In scientific visualisation only point 1 is crucial

Possible solutions

monitor based - cheapest, employs glasses and typically special monitors, limited fulfillment

headset based - costly headsets, each user independent, problems with longer work

room based - extremely costly, occupying a lot of space

So maybe we could improve cheapest solution

- main problem - user expect that displayed scene stay fixed when user move his head
- no presence - but we are not fighting with collider tracks, it is no game
- because we senses real environment (monitor, computer room) there no headache
- 3D scene visits us, not we visit 3D scene

Oculus Rift and similiar solutions

Problems with hardware like Oculus Rift

- non zero latency after movement
- headache after half an hour of usage - not only delay, but lack of other senses (like sense of balance)
- cost
- cables

Monitor based solutions

For scientific visualisation monitor based solution is a reasonable compromise

- we need special monitor capable displaying in 3D
- it means that monitor:
  - **3D decode** - understand how to decode displayed image into two (`None`, `Side-by-Side`, `Top-Bottom`)
  - **3D display** - Colour, Polarize or Time Share
  - **3D glasses** - uses special glasses to provide that images to left/right observer eye (`None`, `Passive Polarized`, `Active`)

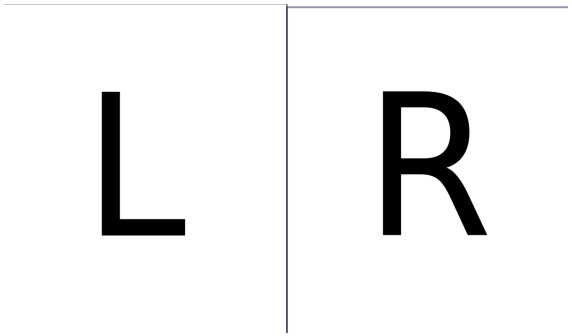
- Side-by-Side
- Top-Bottom
- Anaglyph

In principle, displaying is simple

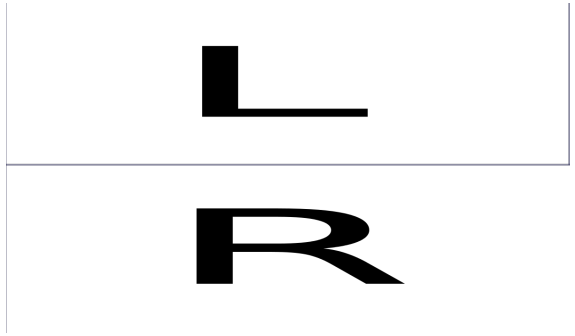
We need:

- properly prepared source ...
- which monitor understand how to display so ...
- having compatible glasses (headset) user got different image provided for each eye

properly prepared source ...

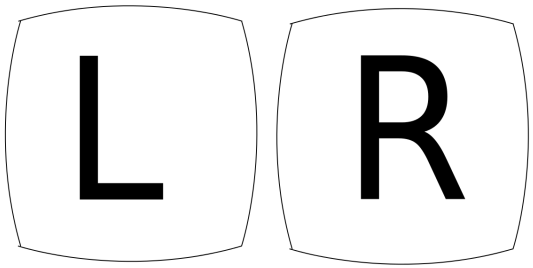


Side-by-Side



Top-Bottom

Anaglyph

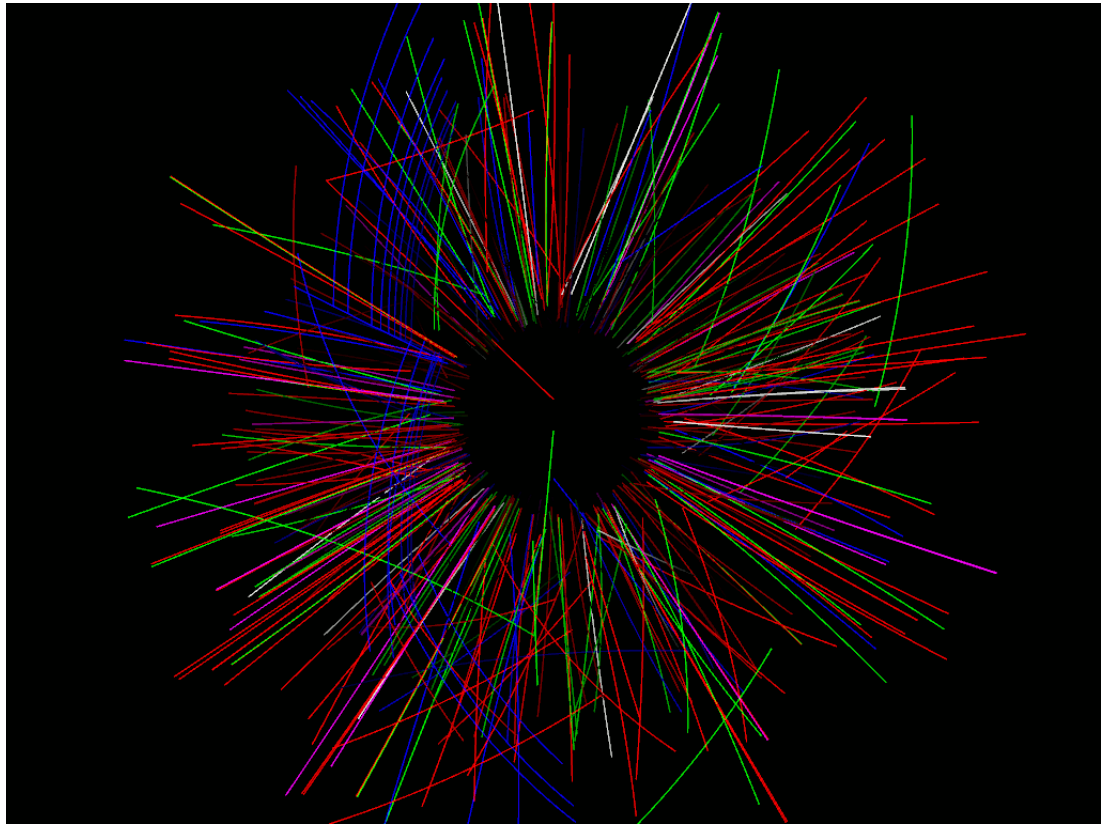


Oculus

In any case viewing program should prepare image properly to the display type

How to display Particle Traces

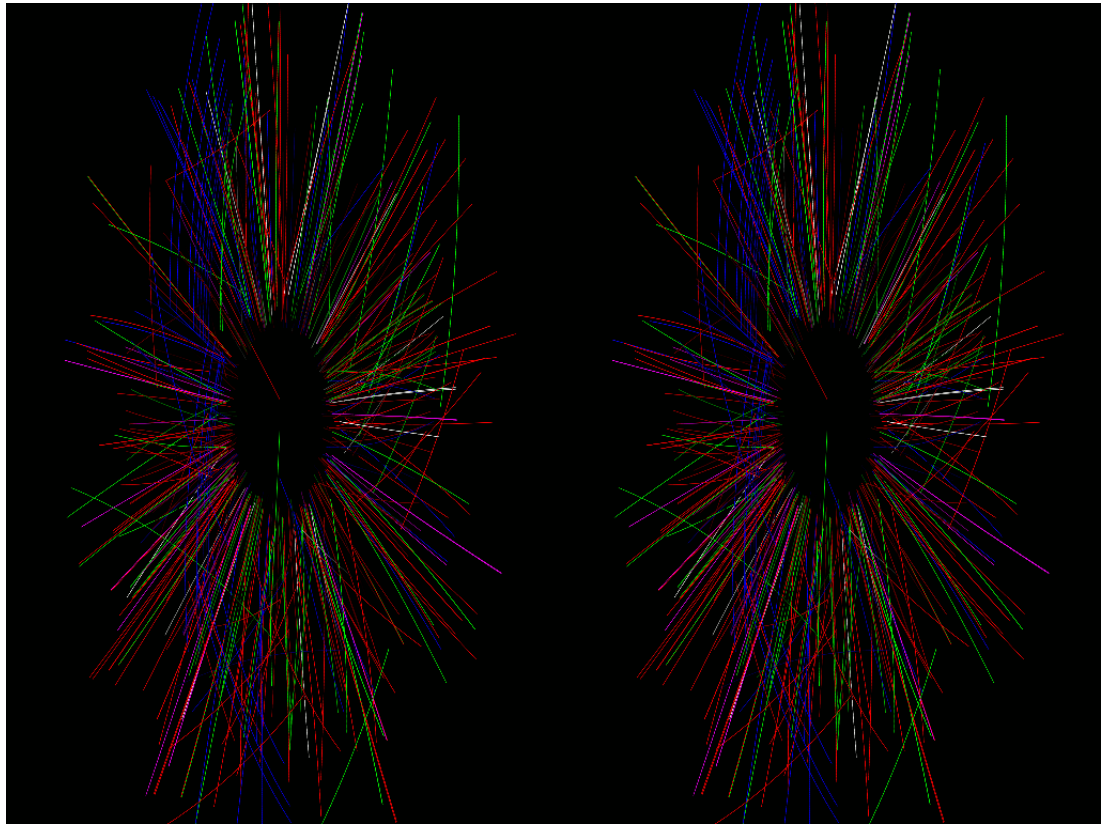
- **Mono**
- Stereo Side-by-Side
- Stereo Top-Bottom
- Stereo Anaglyph
- Oculus



- **3D decode** : `None`
- **3D display** : `None`
- **3D glasses** : `None`

How to display Particle Traces

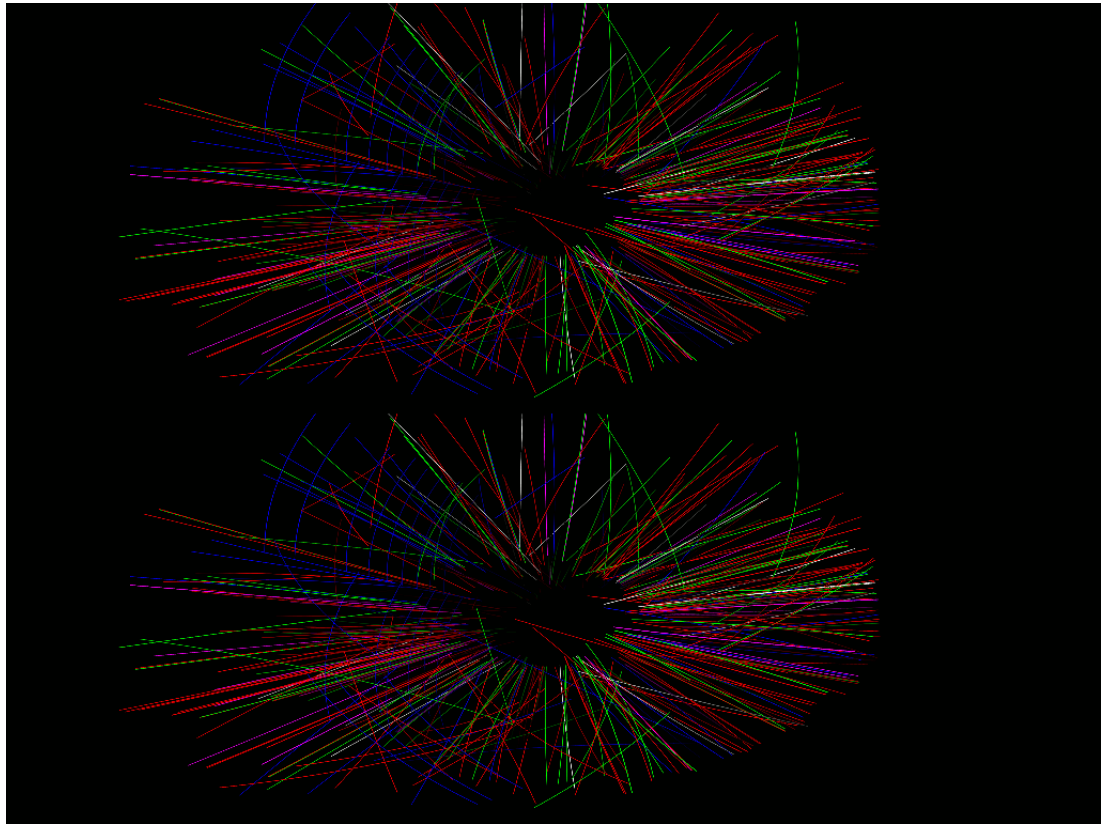
- Mono
- **Stereo Side-by-Side**
- Stereo Top-Bottom
- Stereo Anaglyph
- Oculus



- **3D decode** : `Side-by-Side`,
- **3D display** : `Passive Polarized`, `Active`,
- **3D glasses** : `Passive Polarized`, `Active`,

How to display Particle Traces

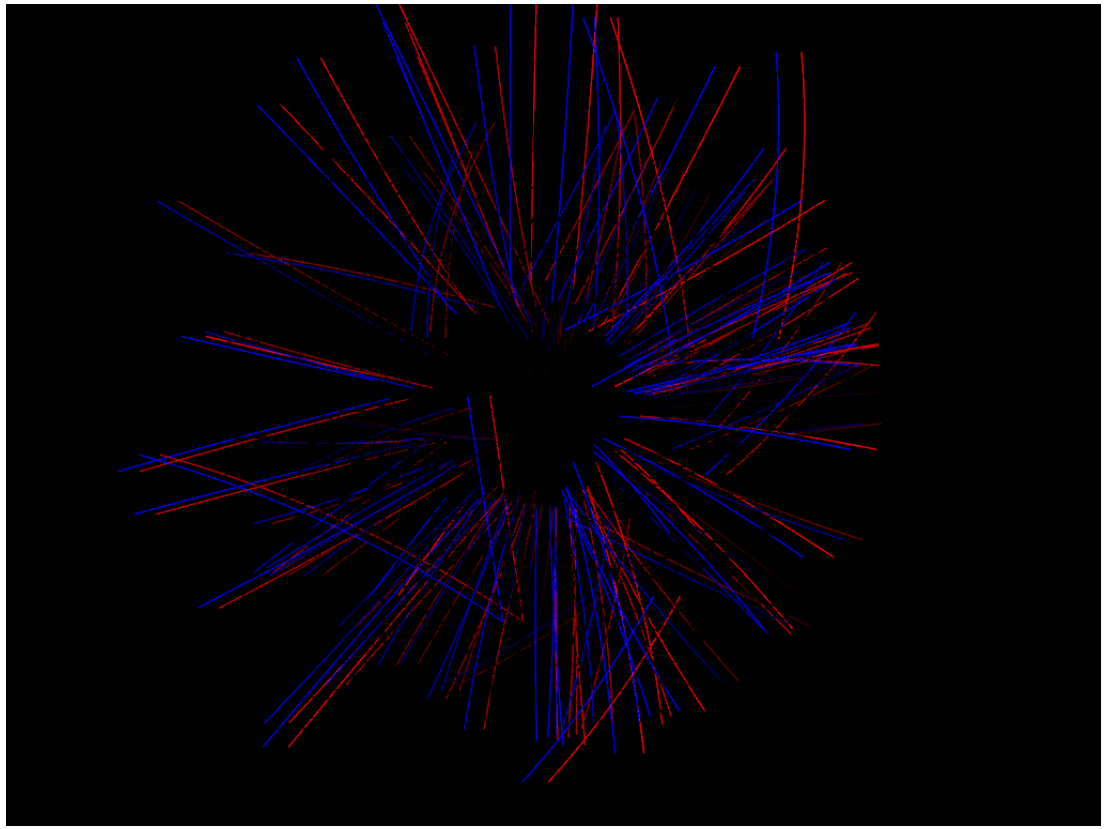
- Mono
- Stereo Side-by-Side
- **Stereo Top-Bottom**
- Stereo Anaglyph
- Oculus



- **3D decode** : `Top-Bottom`,
- **3D display** : `Passive Polarized`, `Active`,
- **3D glasses** : `Passive Polarized`, `Active`,

How to display Particle Traces

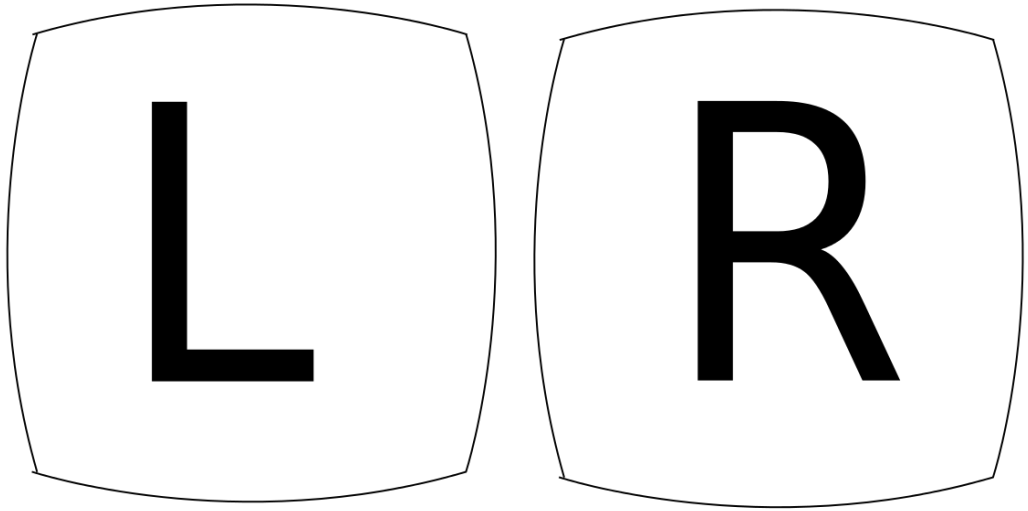
- Mono
- Stereo Side-by-Side
- Stereo Top-Bottom
- **Stereo Anaglyph**
- Oculus



- **3D decode** : `None` (Anaglyph color code provided by the viewer)
- **3D display** : `None`
- **3D display** : `anaglyph`

How to display Particle Traces

- Mono
- Stereo Side-by-Side
- Stereo Top-Bottom
- Stereo Anaglyph
- **Oculus**
  - **3D decode** : `Oculus`,
  - **3D display** : `Oculus`,
  - **3D glasses** : `Oculus`,

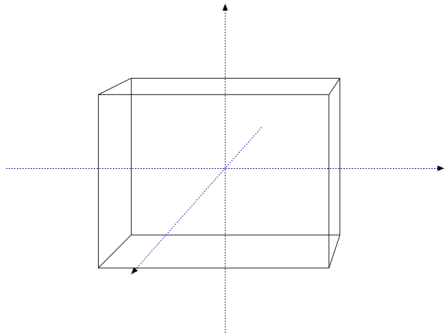


Improving monitor-based 3D

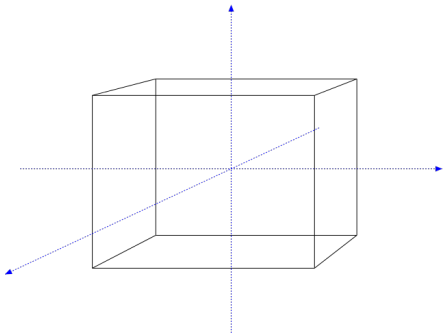
main problem - user expect that displayed scene stay fixed when user move his head

- If we could precisely track observer head position we could adjust displayed content to his movements
- Such tracking is build in other hardware solutions, so adding it we could reduce the gap between achieved results

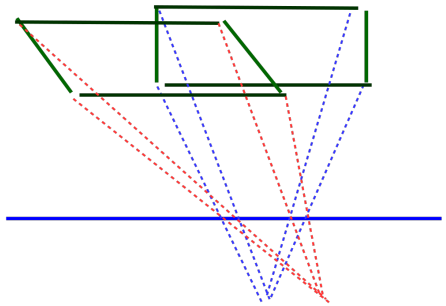
Move of the observer from left to right



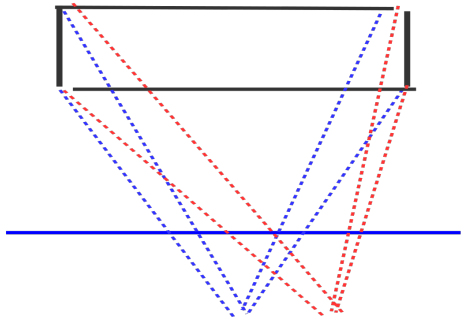
Scene viewed from central position



Scene viewed from right position



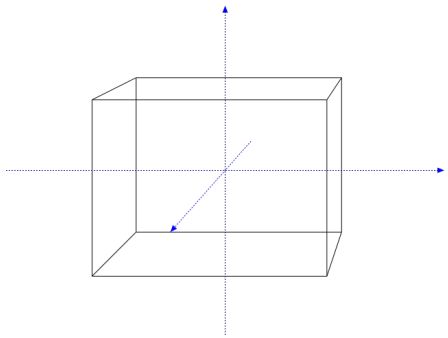
Right position - no change



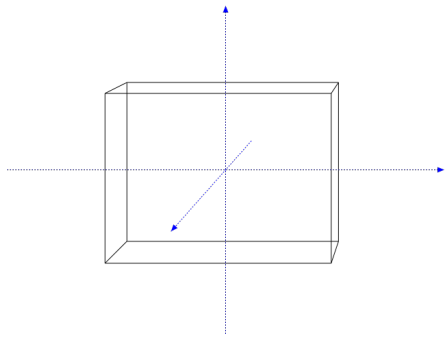
Right position - with change

displayed object bends following observer movement
to achieve scene freezing in the space, we should trace observer position

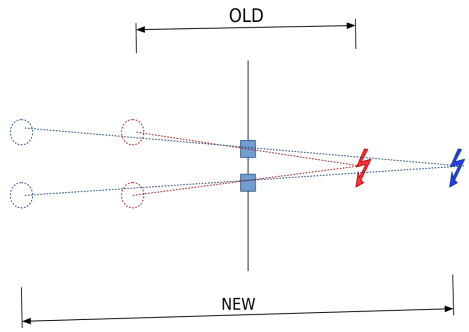
Change observer distance from the screen



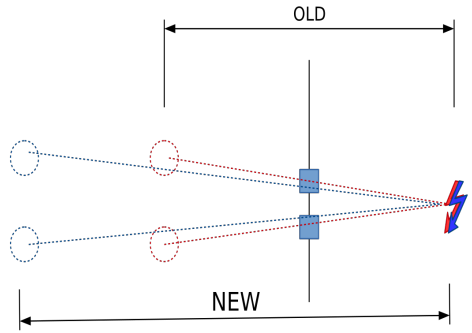
3D depth incorrectly grows



Scene viewed from right position



Right position - no change



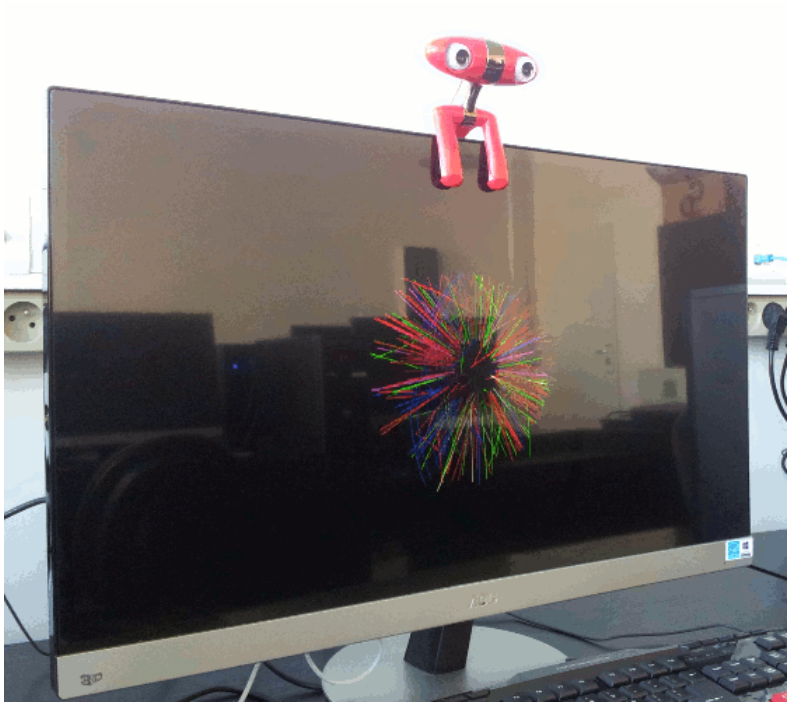
Right position - with change

displayed object extends following observer movement

to achieve scene freezing in the space, we should trace observer position

Compute vertical location of the observer

- We could use stereo camera to precisely locate the observer
- The problem is to precisely calibrate camera according the monitor



Compute vertical location of the observer

- Only one observer, we require glasses
- Tracing is simplified using marker on the glasses
- Other (not implemented) option was SIFT/SURF

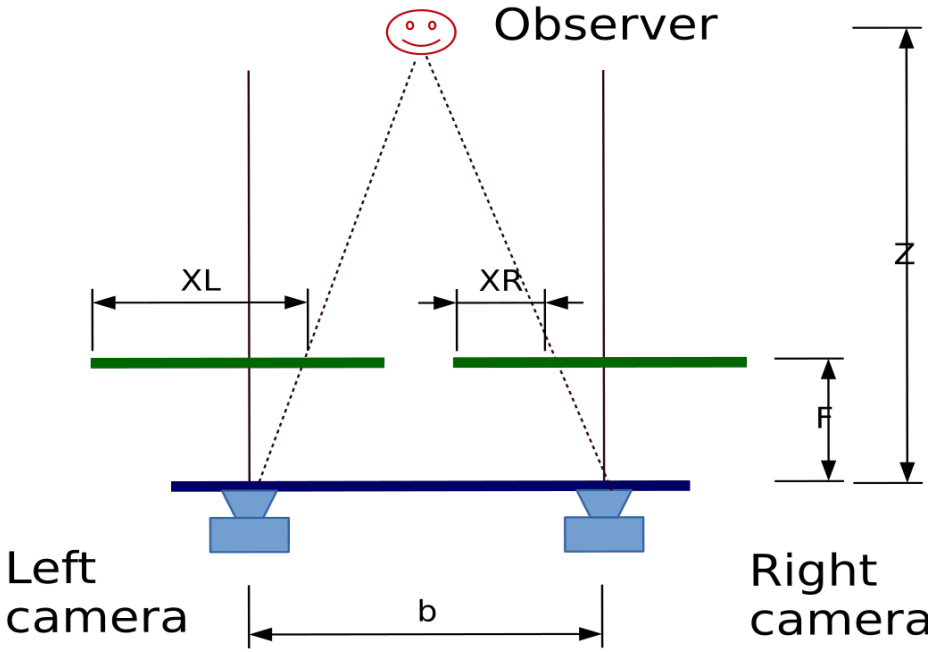
Obtaining distance from disparity

b -base

f -focal length

$$\frac{b}{z} = \frac{b + x_l - x_r}{z - f} \quad (1)$$

$$z = \frac{bf}{x_r - x_l} \quad (2)$$



- locate glass marker on images from both cameras
- compute xr and xl from images
- compute z

Results:

- What we are trying to achieve is the stability of the freeze stereoscopic View
- Measure of it difficult (user judgement?)
- It is much more stable, but still there are noticeable changes
- It is no problem in static scenes, but in interaction it must be solid
- Monitor resolution become noticeable in passive modes
- Single user only

Conclusions:

- It is possible to reduce 3D artefacts
- Could be done cheep, but require precise calibration
- Could be useful in PR activities (MasterClasses?)
- Good starting point for new visualisations in ALICE