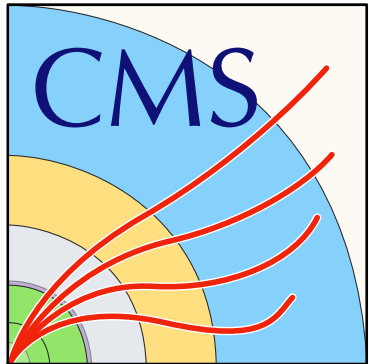




CMS VR, CED VR

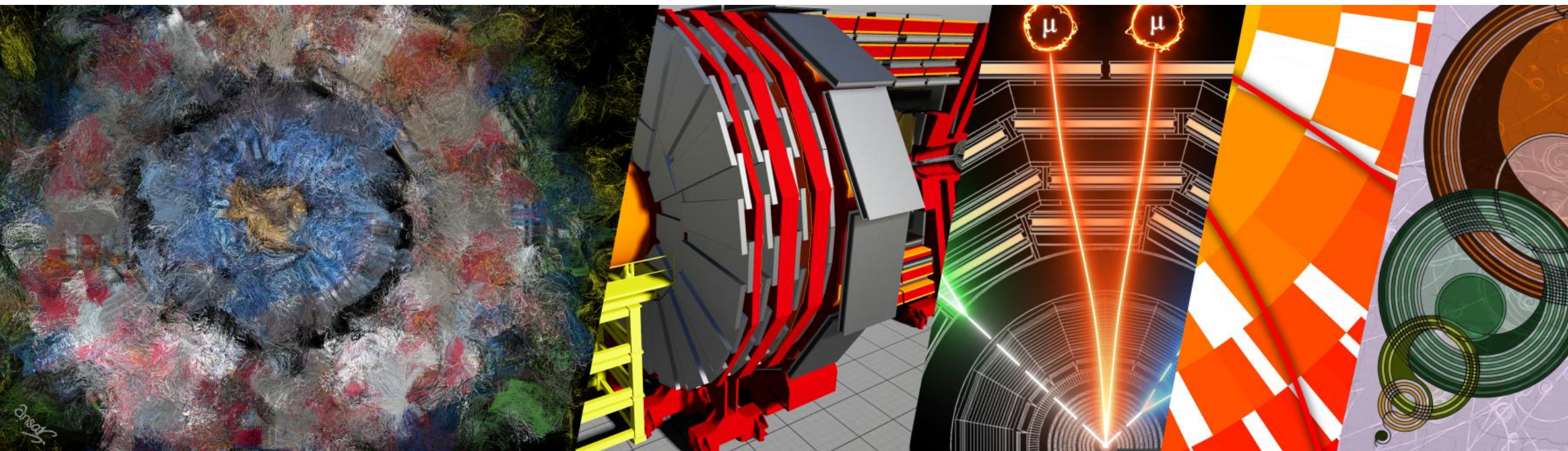
EXPLORING THE CMS DETECTOR AND ITS LHC DATA



Supported by US Dept. of
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UCLA VR for science workshop | 25 October 2026

Ansar Iqbal

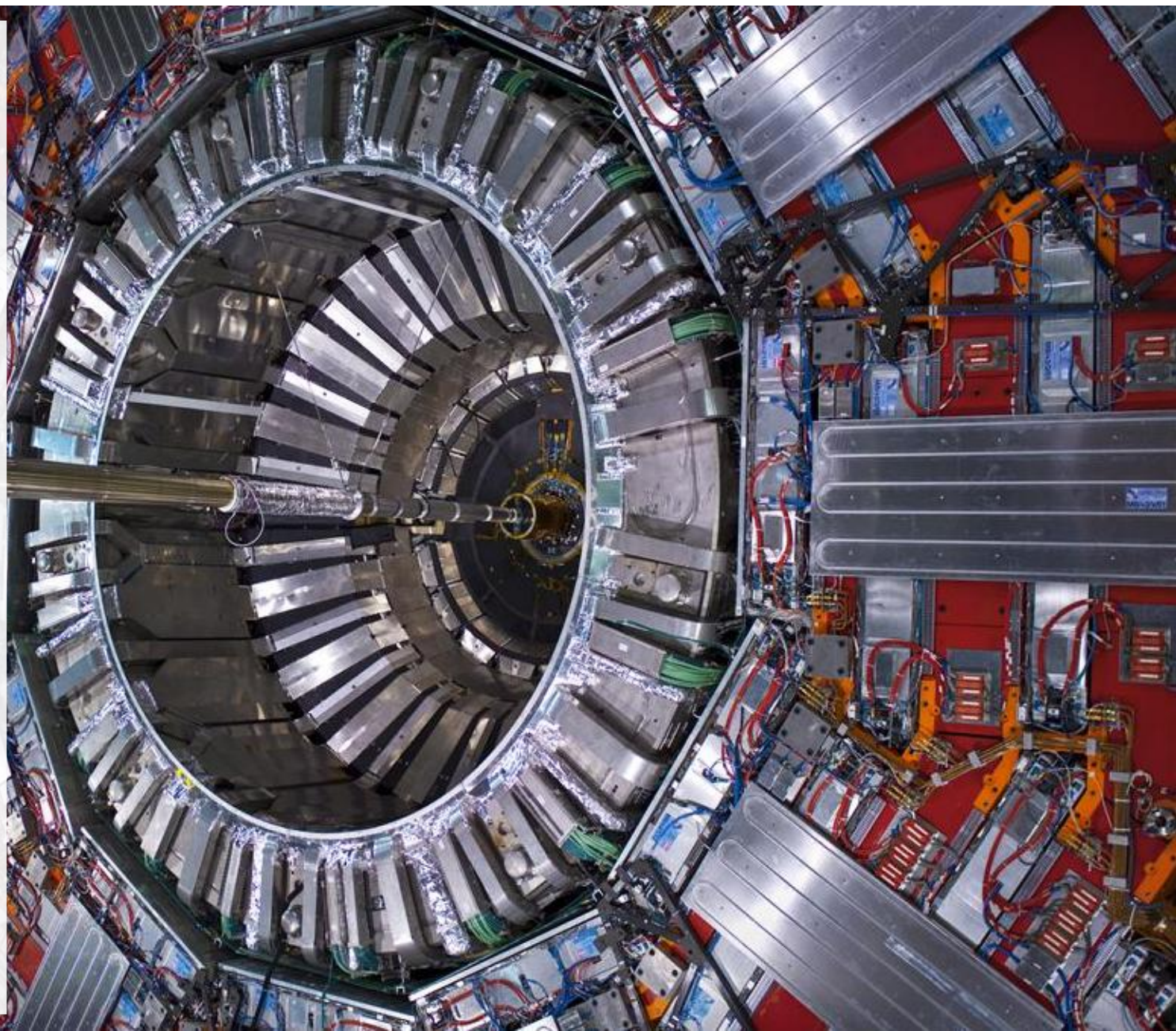


Why virtual reality?

THE CMS DETECTOR

sits 100 metres underground, at the foothills of the Jura mountains on the Swiss–French border.

When the LHC is colliding protons, and CMS is recording data, **it's not possible to visit the detector** – *one can still go underground to explore the "services" housed in an auxiliary cavern!*



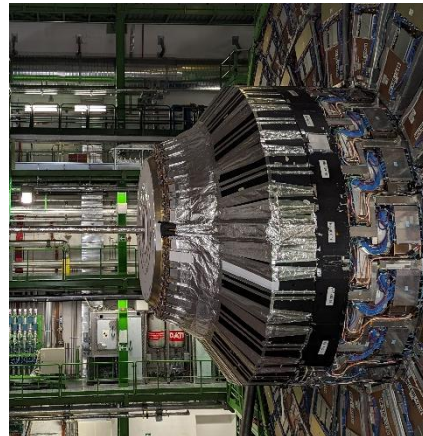
CMS VR – the concept

Go around the limitations by utilising the **transformative technology of virtual reality (VR)**.

- Create a **virtual 3D environment** of the underground spaces leading to the detector cavern, integrate **3D models of the detector**, and **deploy on VR headsets**.
- **An immersive and interactive framework for a wide range of on-site and “remote” audiences.**



The detector is behind this thick concrete wall.



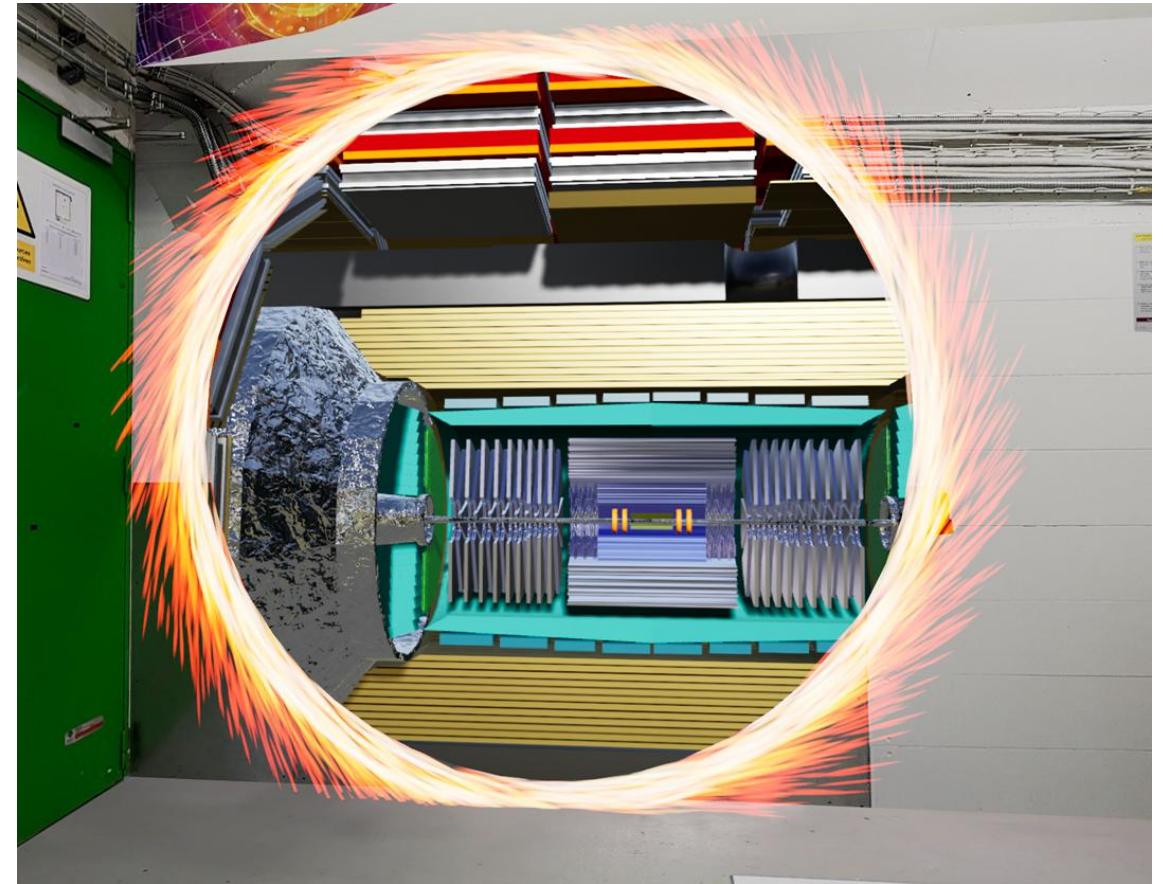
CMS VR – visualisation



- The virtual visitor starts in the hallway just before the **entrance to the detector cavern.**
- Can use hand controllers and virtual interfaces to **interact with the environment.**



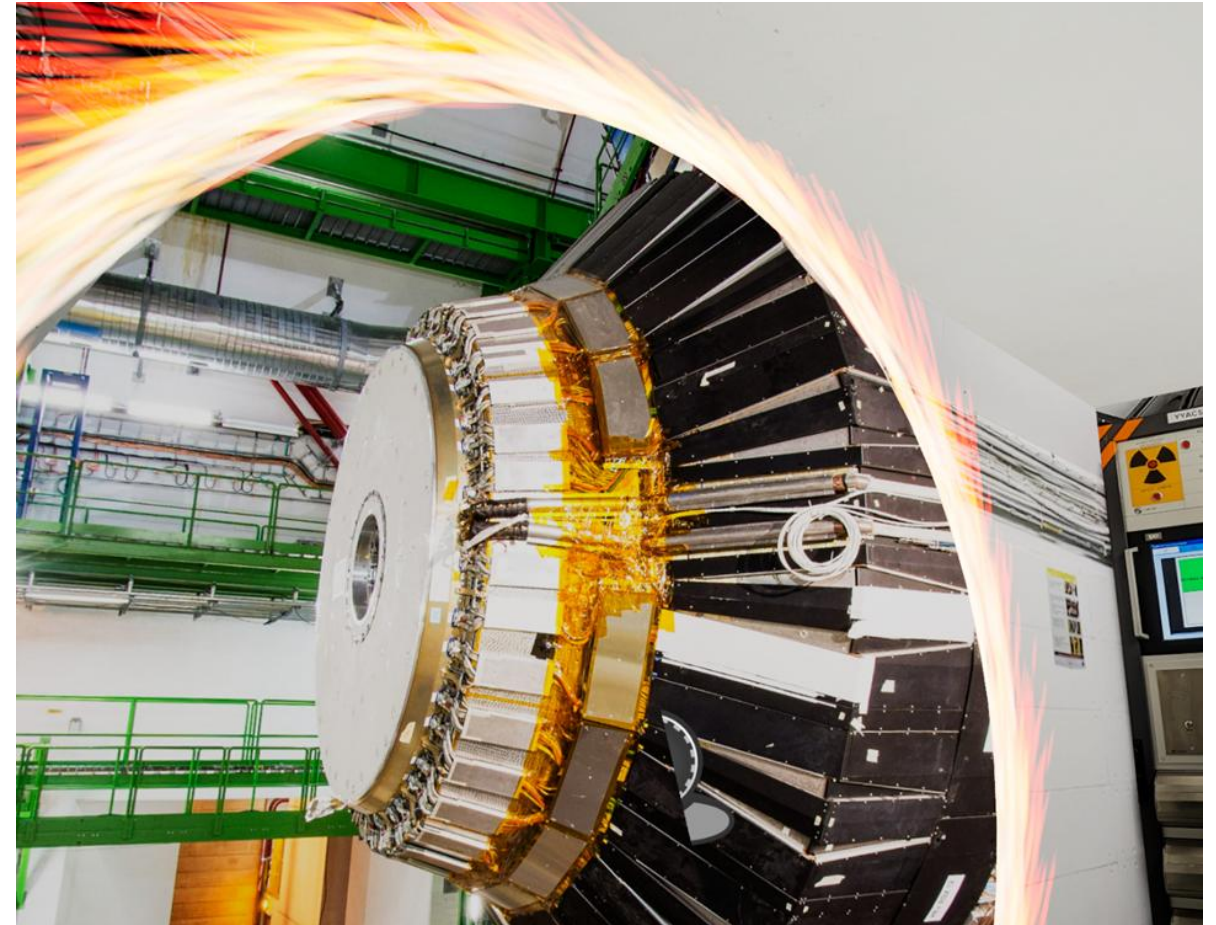
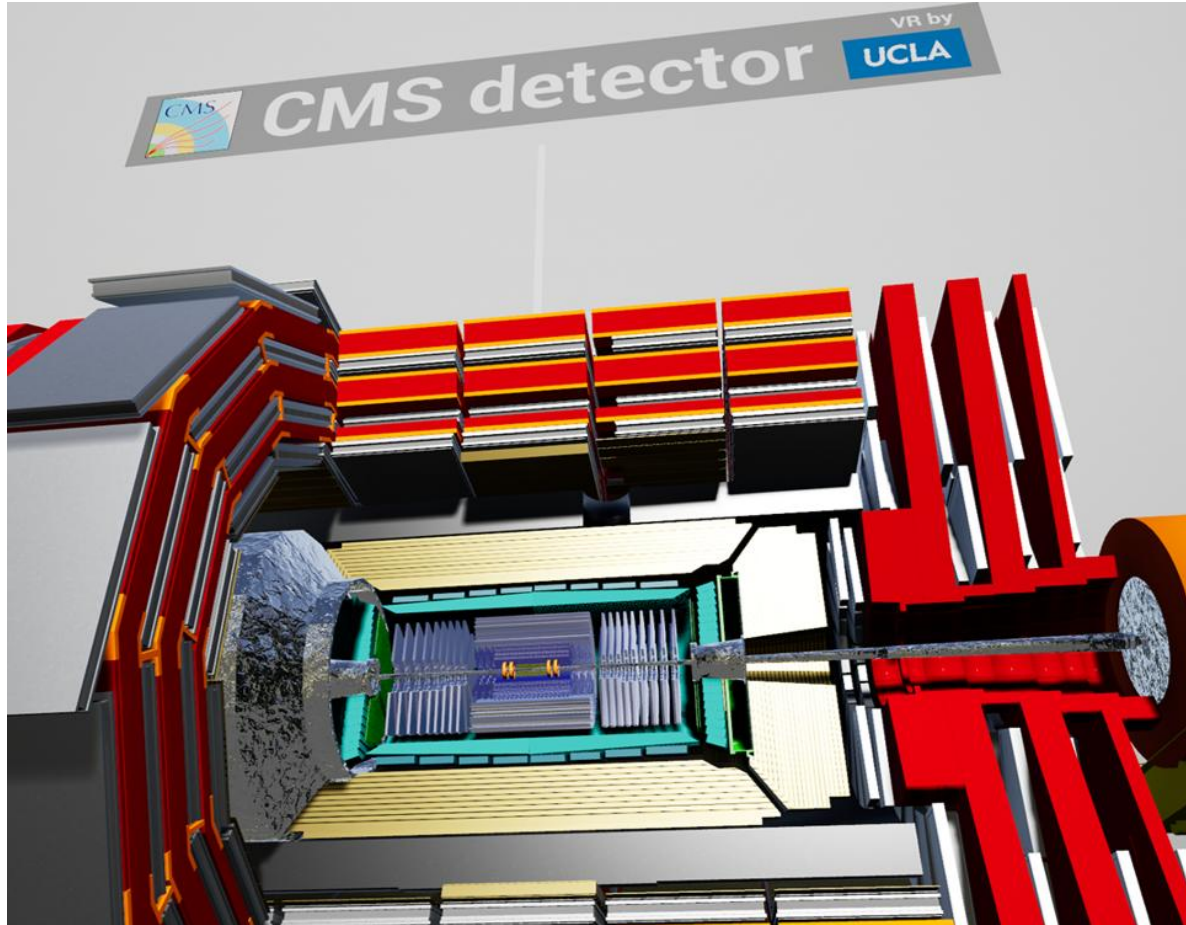
- The interface in the starting hallway can be used to open a ***“portal”*** to the detector.



CMS VR – visualisation

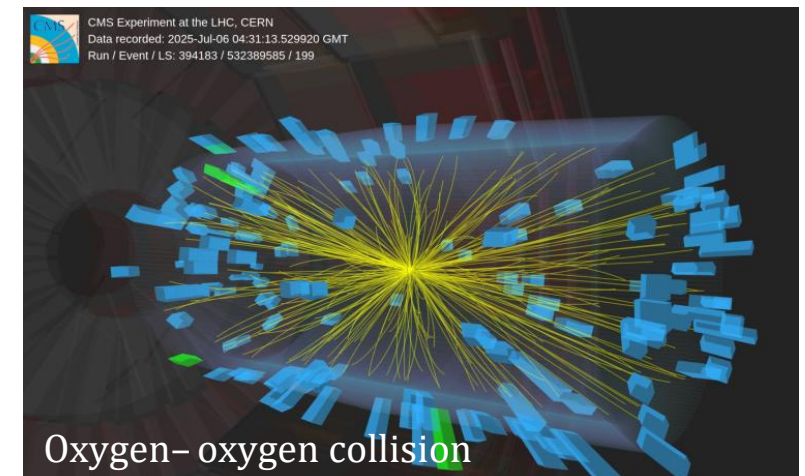
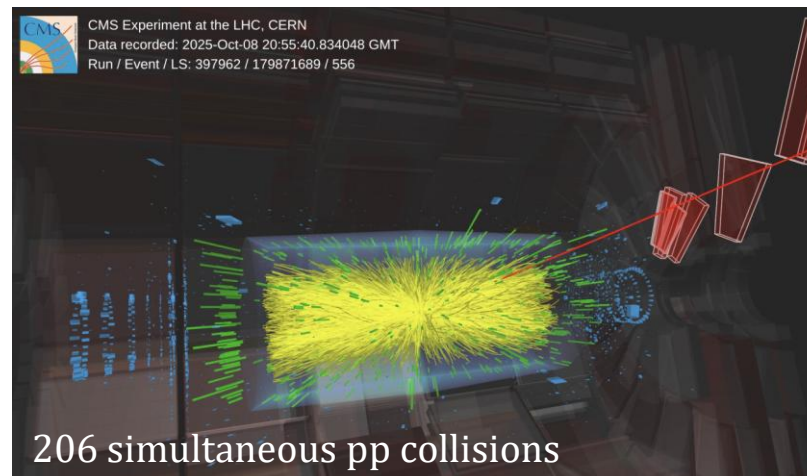
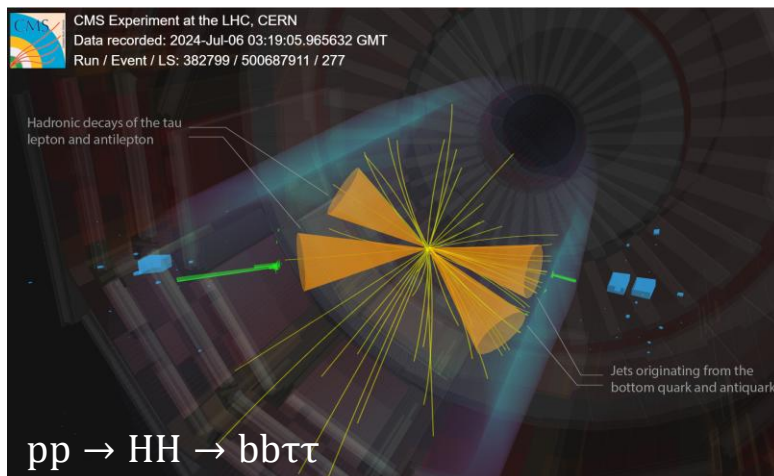
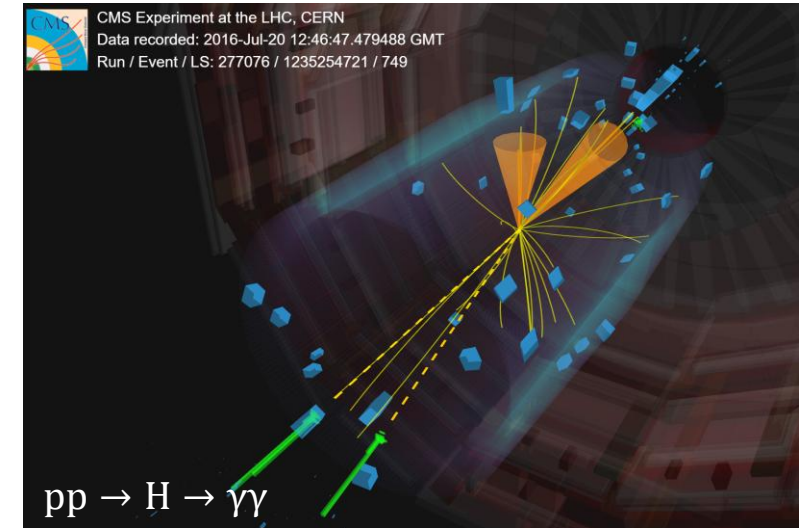
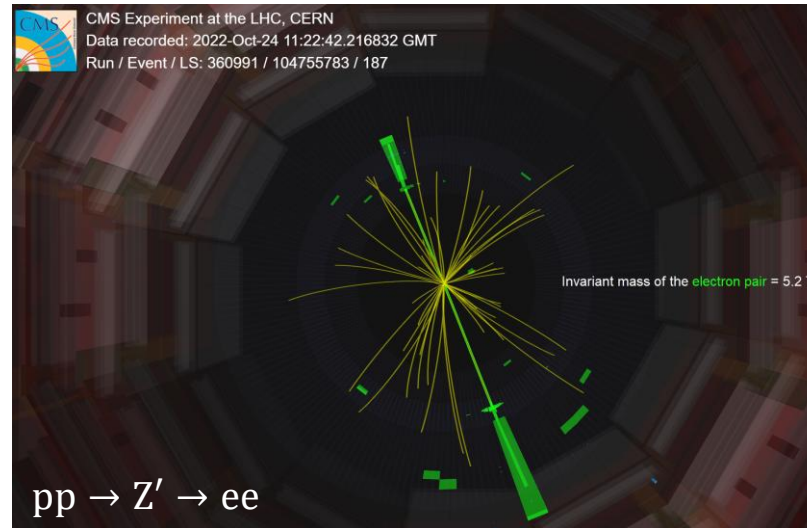
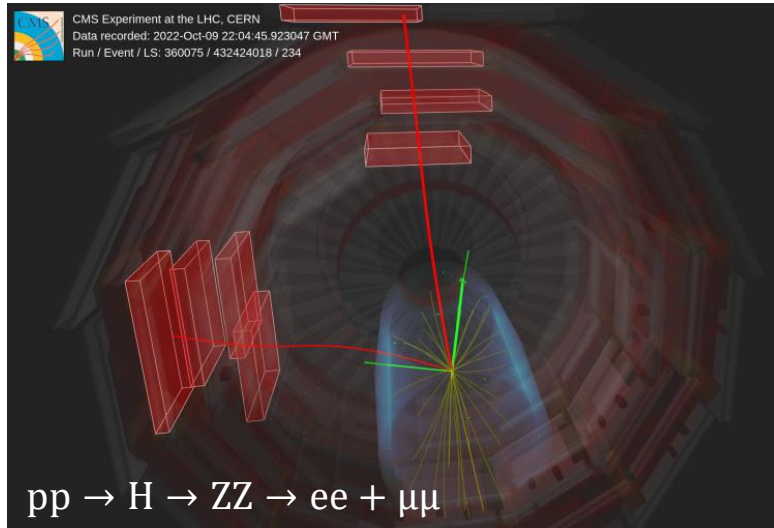


- A high-fidelity 3D model of the detector for one to **get close**, and study the different constituent **sub-components**.
- Possible to switch between **3D-rendered** and **photographic panoramic views** of the detector, showcasing the **complexity and detail** of the detector in real life.



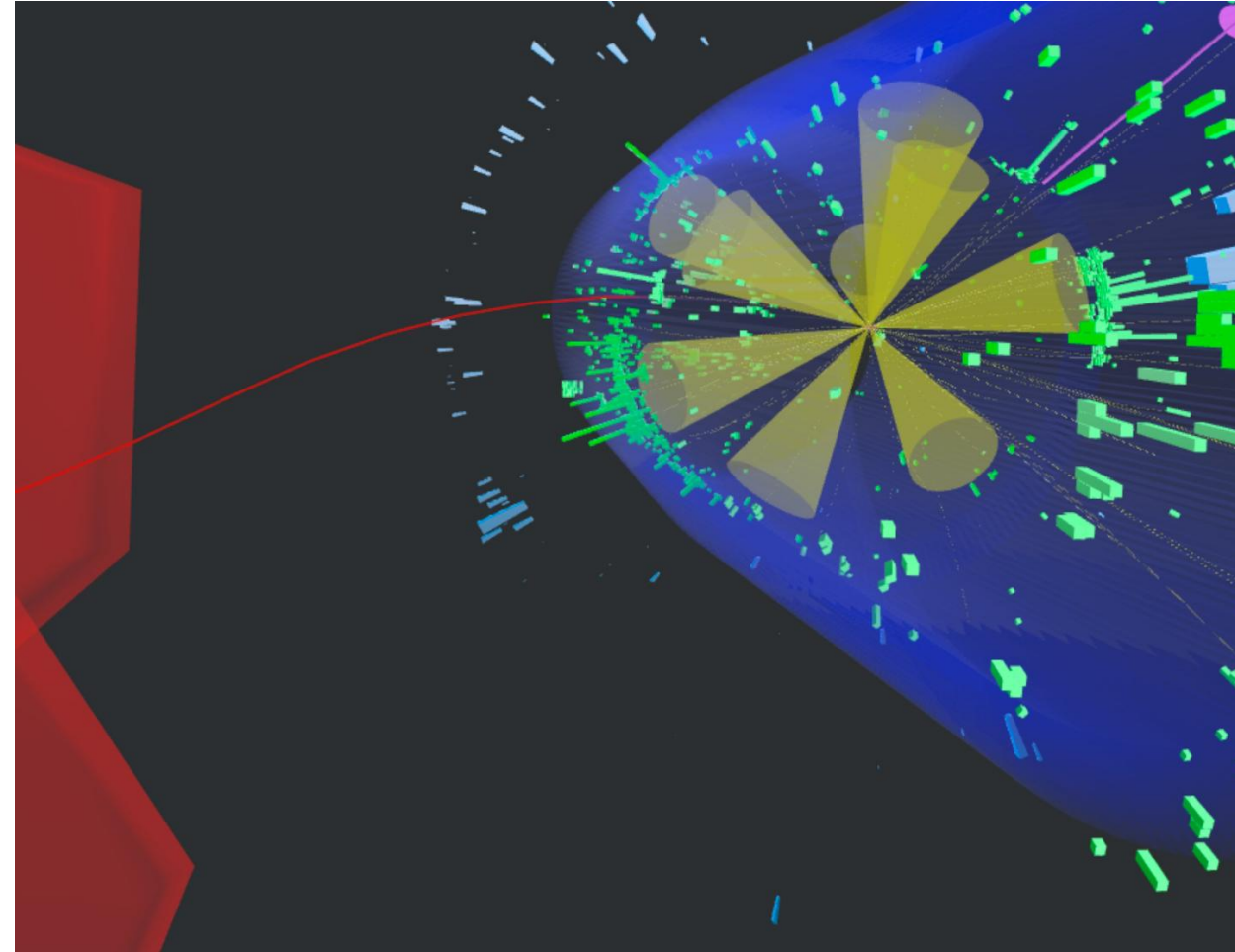
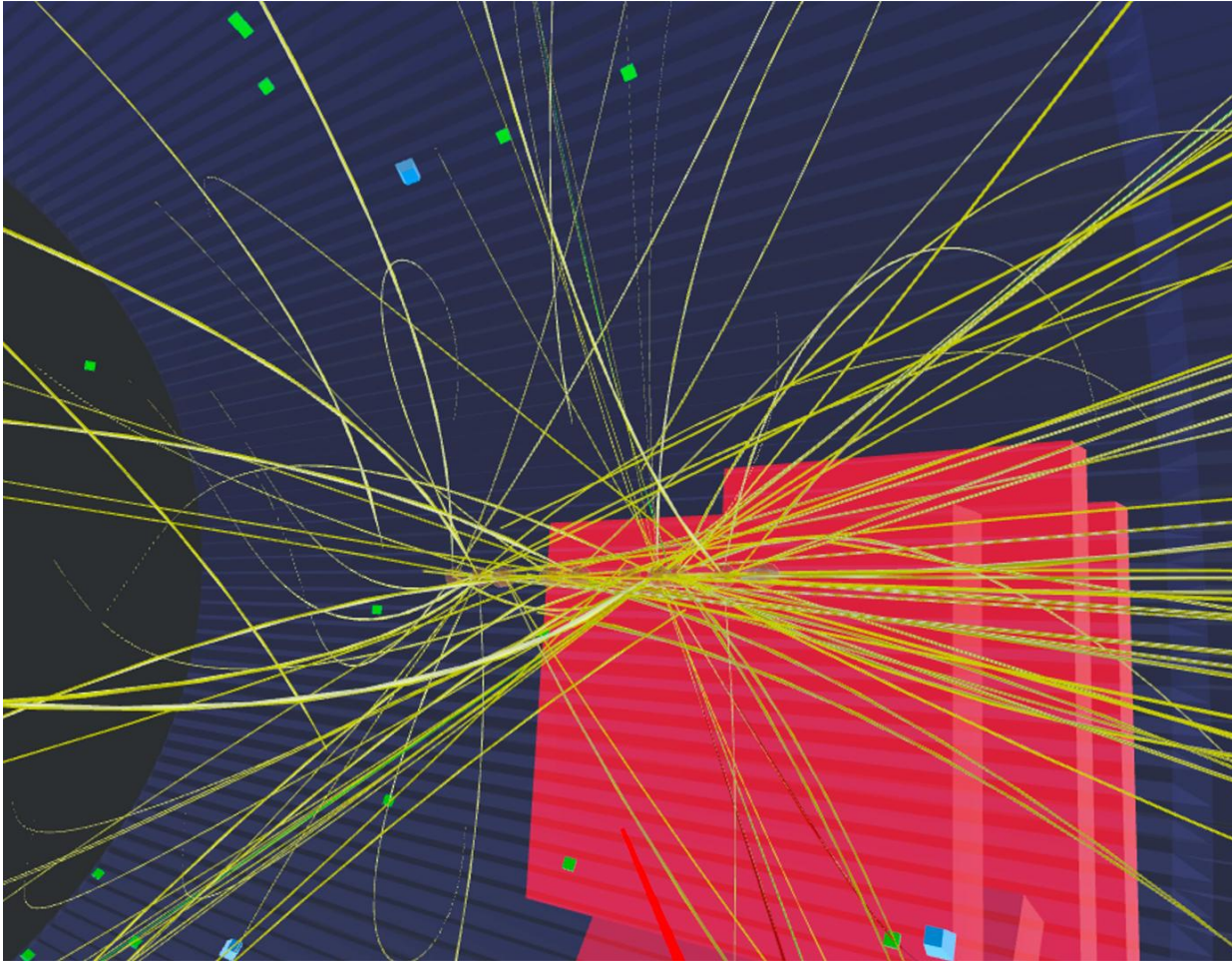
CMS event display (CED) VR – the concept

- In CMS, we rely regularly on **displays** of proton–proton and heavy-nuclei **collision events**.
- Use a framework called [iSpy](#) that can construct **displays** for **two-dimensional screens** – *examples below*.



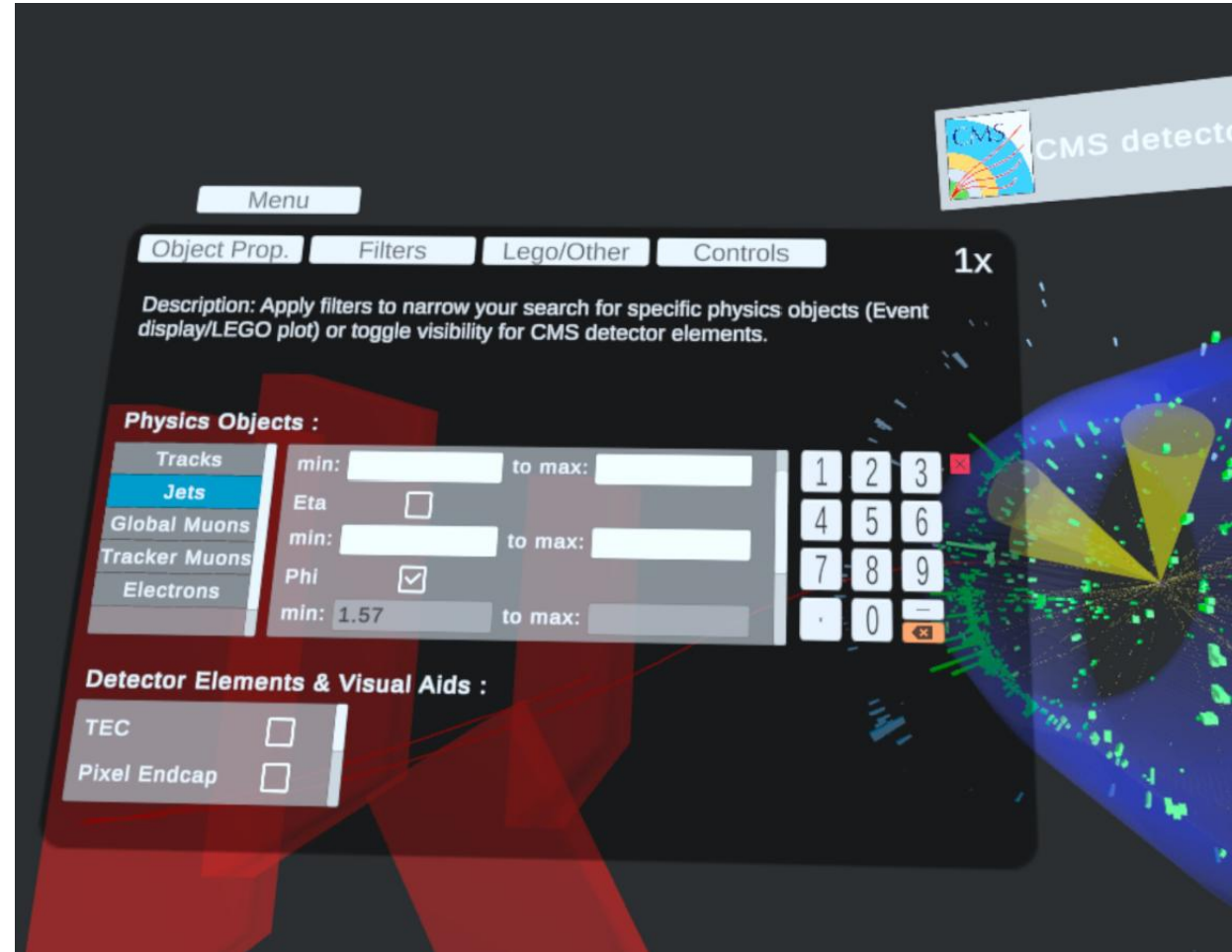
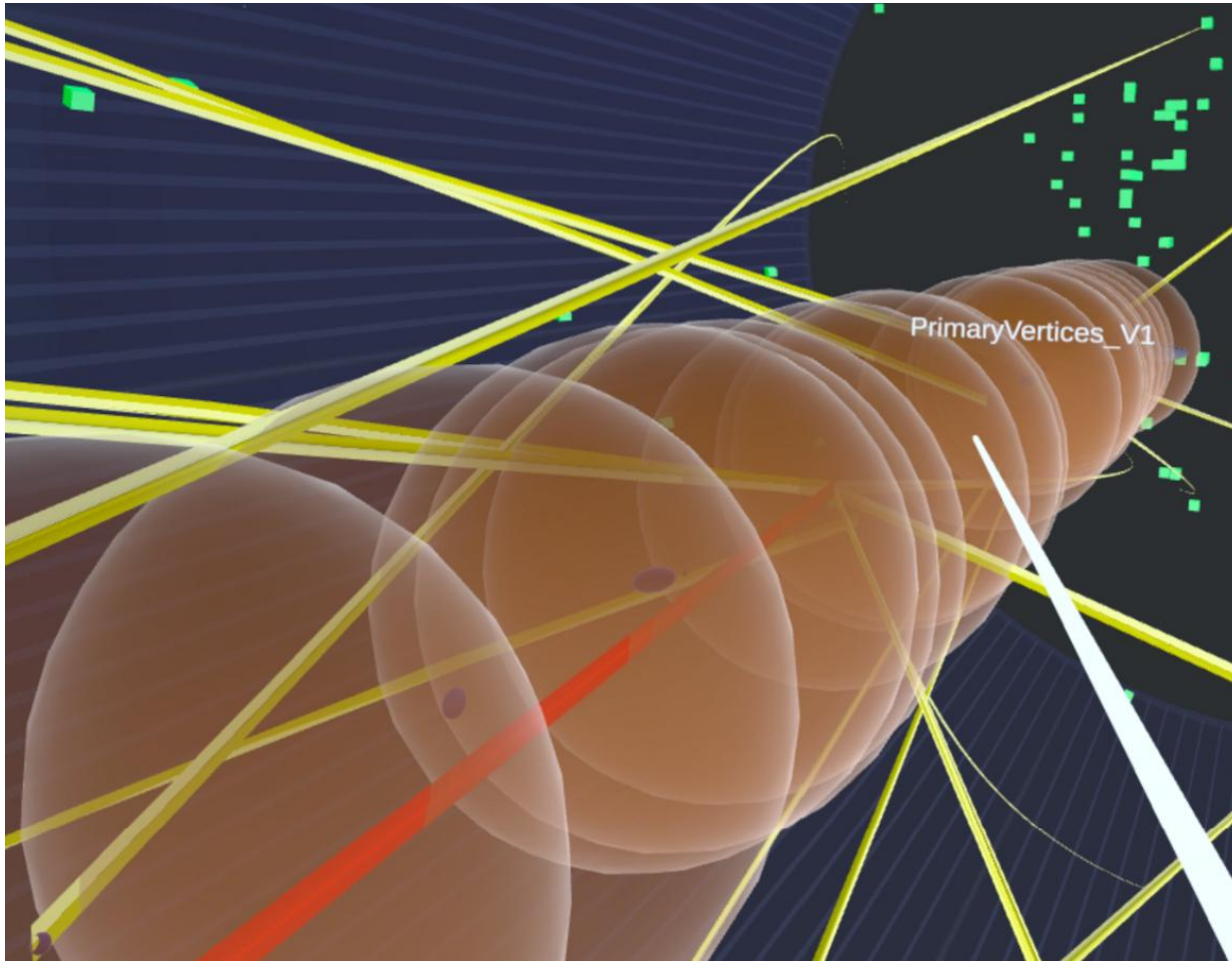
CED VR – visualisation

- We developed a framework to **visualise the collision events in VR** – *physicists can get “inside” the event.*
- Enables physicists to gain a new perspective, which is **impossible to get from two-dimensional visualisations.**



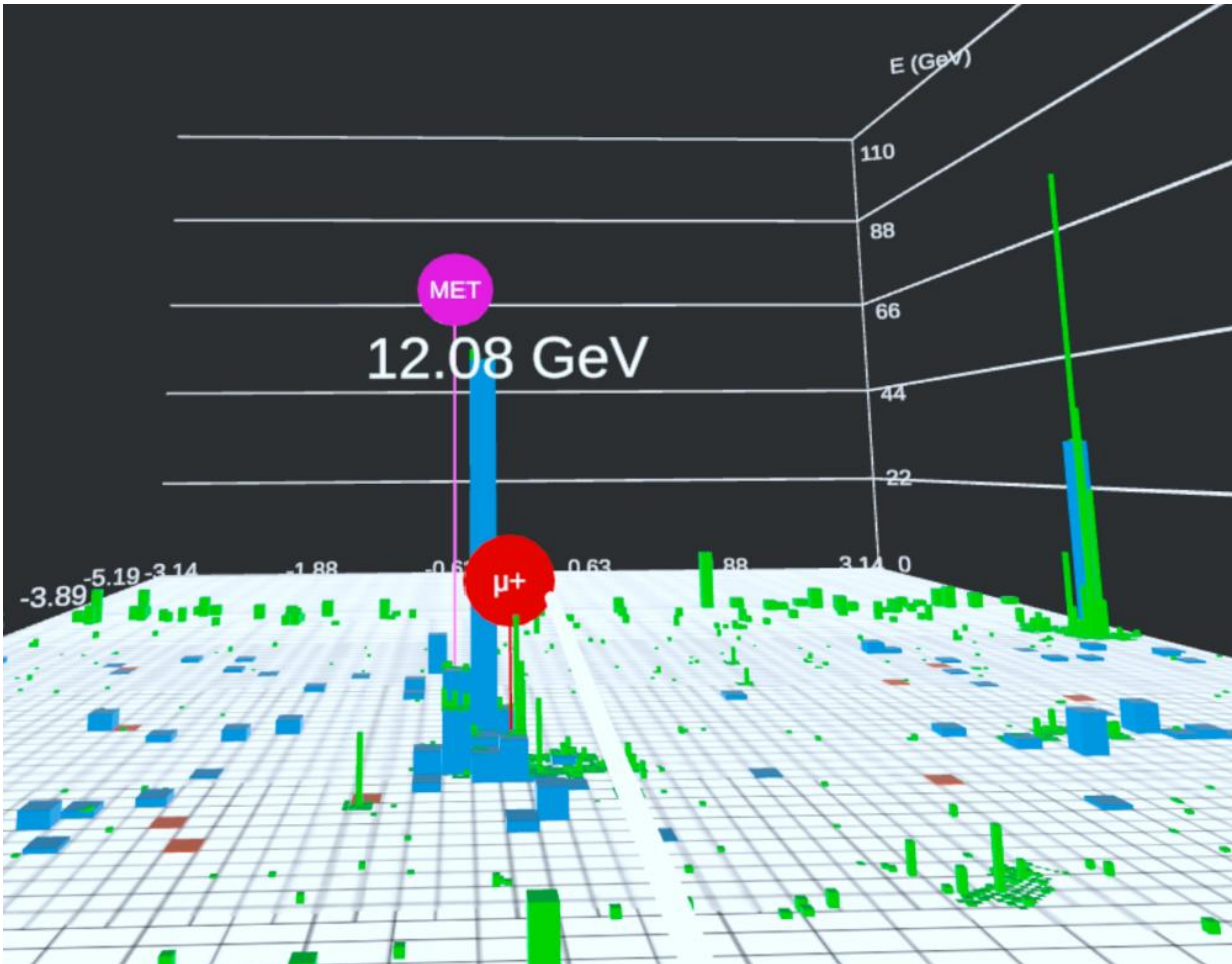
CED VR – features

- Several features to aid analysts identify “**physics objects**” in the reconstructed collision event and **understand its topology**.
- Possible to study **object properties**, apply “**selection requirements**”, and perform **basic analysis**.

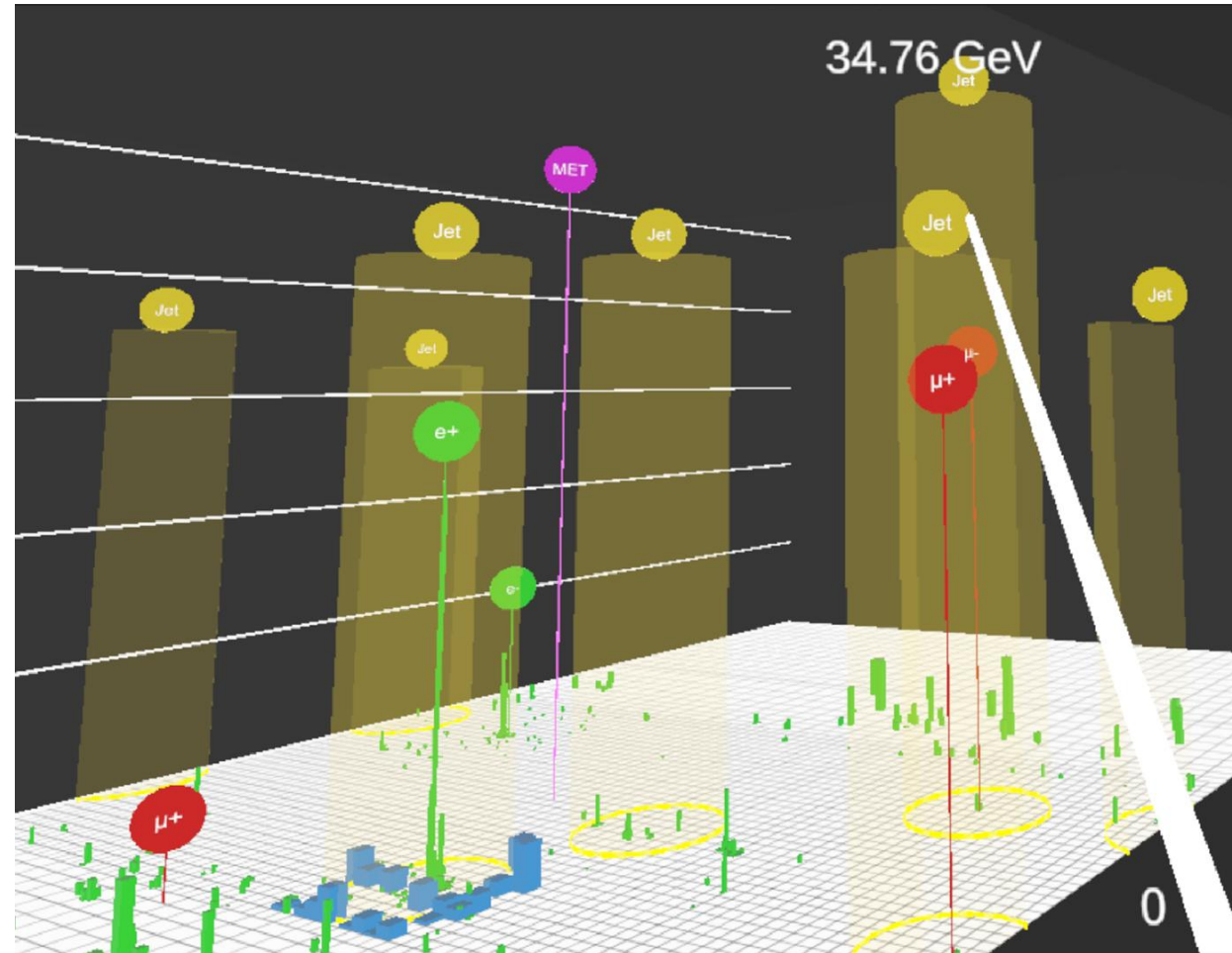


CED VR – features

- A “lego”-plot feature to flatten out the cylindrical coordinates and visualise the energies of objects in this space.
- Helpful to **overlay energies** deposited in the *calorimeter* detectors with those of reconstructed physics objects.



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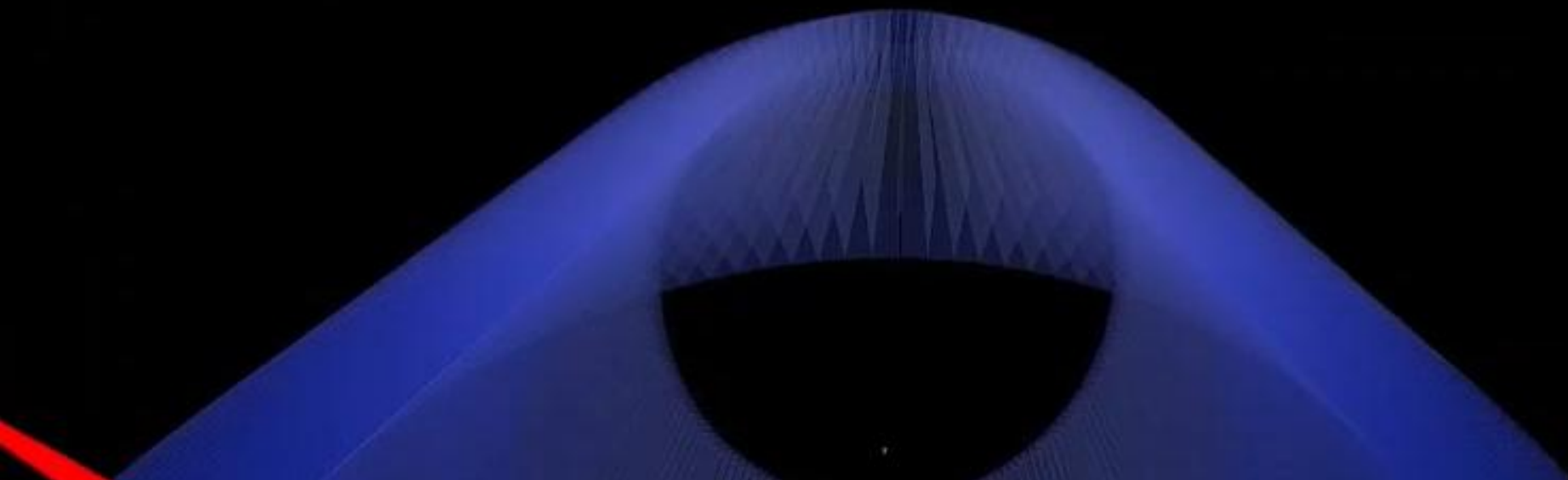
Ansar Iqbal

CED VR – animation

Menu

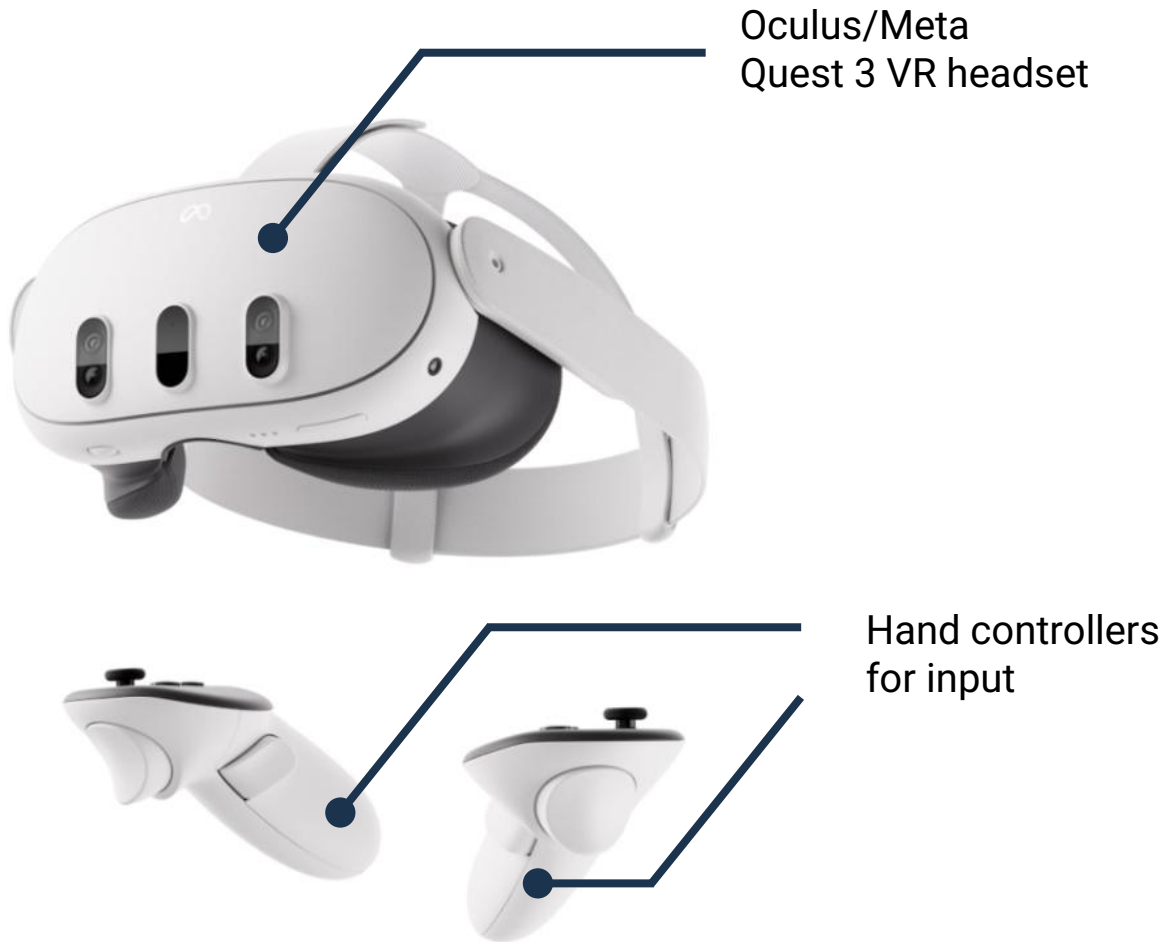


CMS detector VR by
UCLA



Technical implementation

Hardware



Software

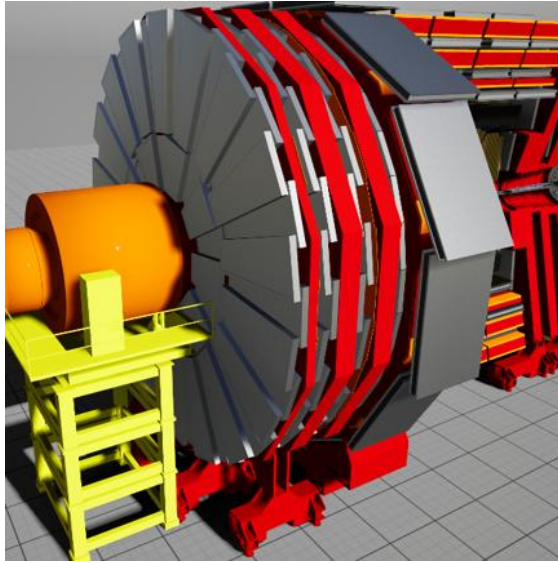
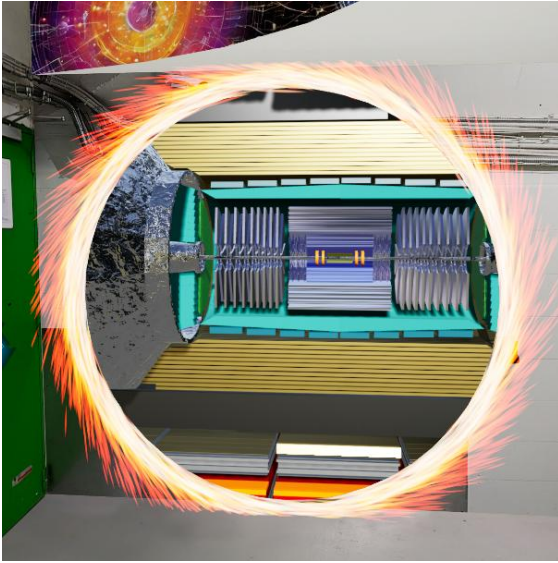
CMS VR

- **Central dev. framework:** [Unreal Engine 5](#)
- **Detector 3D model:** Blender, textures in Photoshop
- **Environment:** photogrammetry, Gaia, portal effects with Niagara particle system + After Effects
- **Artworks:** Done mostly in Photoshop, with some Maths vis. scripted in p5.js at the back end
- **Code:** Unreal blueprints, C#

CED VR

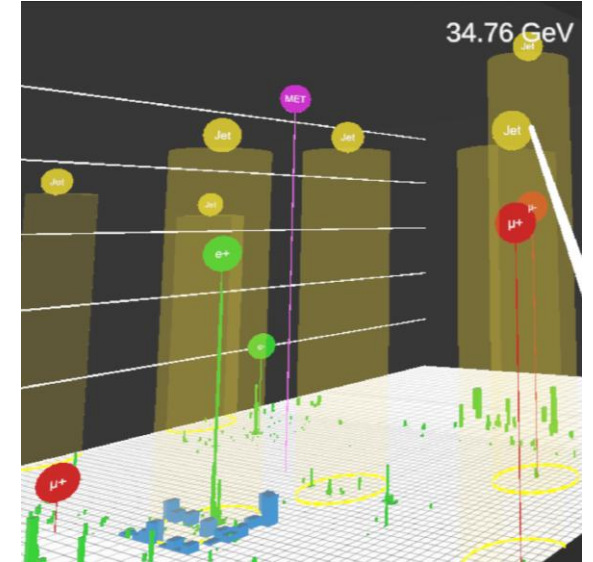
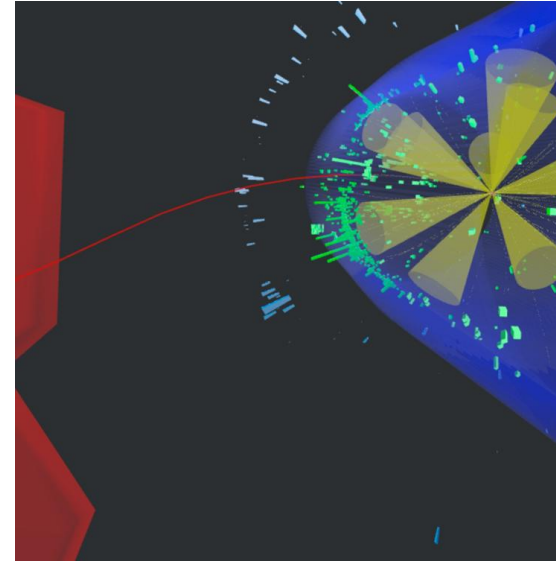
- **Central dev. framework:** [Unity](#)
- **Physics objects input:** iSpy CMS framework
- **Physics objects 3D models:** Blender
- **Code:** C#

Summary



CMS VR

- Visualise the CMS detector using **virtual reality**.
- **High-fidelity** CMS model.
- Engaging and **realistic visuals**, coupled with interactive elements.



CED VR

- Visualise collision events in **virtual reality**.
- Enables a **new perspective** for physicists.
- **Several features**, including visibility tools, selection requirements, and lego-plots.