ATLAS-GTU TAI Agreement –

Status and Upcoming Plans

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ATLAS-GTU TAI Agreement

Application’s Development Status

Done
1. Tracer-VR: Virtual Reality Application for visualisation of the ATLAS detector at Point-1

Done
2. Tracer-ART: Augmented Reality application for learning the ATLAS detector hardware

Done
3. Tracer-ARB: Augmented Reality extension of the printing materials

Work
4. Tracer-ARD: Augmented Reality application for navigation inside the detector

Work
5. Tracer-ARL: Augmented Reality Landscape

All applications will work in Browsers!

Application’s Development Timetable

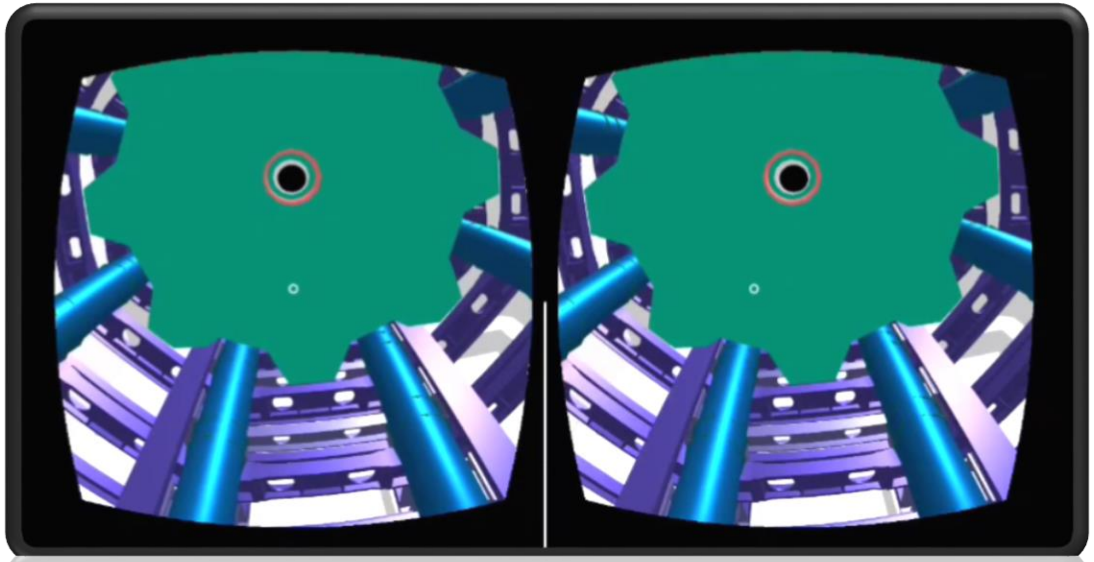
WP02	Tracer/VR	Geometry descriptions of Point-1 infrastructure and services	Q4 2022
		Full functionality application	Q4 2023
	Tracer/ART	R&D work	Q4 2022
		Prototype with basic functionality	Q4 2023
		Extended functionality	Q4 2024
	ARB	Five 3D Scenes per year	Q4 2026
	Tracer/ARL	R&D work	Q4 2025
		Full functionality application	Q4 2026
	Tracer/ARD	Identification and development of contents of the virtual rooms	Q4 2024
		Development of 3D geometries of the virtual rooms	Q4 2025
		Development of the AR navigation functions in the virtual rooms	Q4 2026

I. Tracer-VR

Tracer-VR Interface

- Application Repository

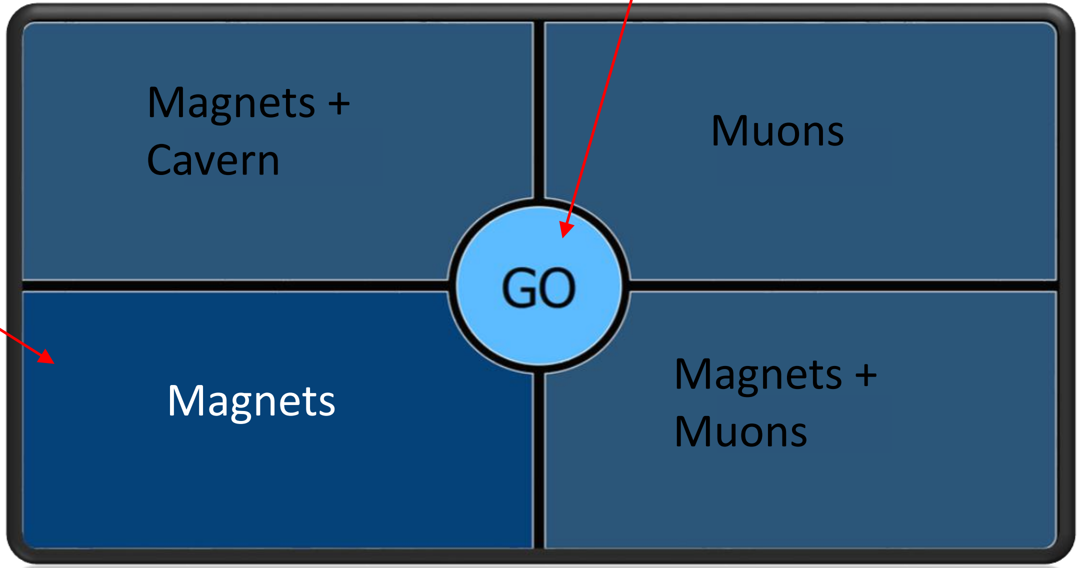
https://gitlab.cern.ch/tracer/tracer-vr.git



1

Choose Scene

2 Click for Start



3 Use Cardboard

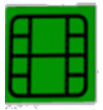
*Better to use Google Chrome

Tracer-VR

The Control Menu permits changing the drone's flight modes:

Circular flying – drone moving around on the fixed radius

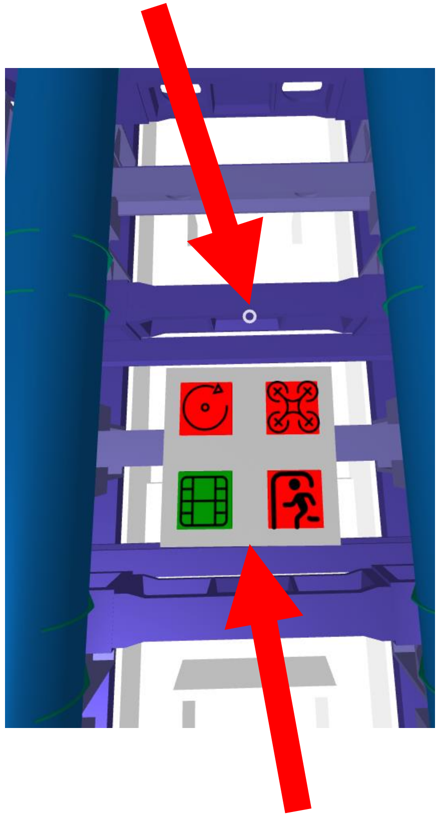
Free flight - drone moving in the direction of the Ray Caster marker. Markers position controlled by head movement



Beam Pipe flying - drone moving alongside the beam pipe forward and back

Exit

Ray Caster Marker

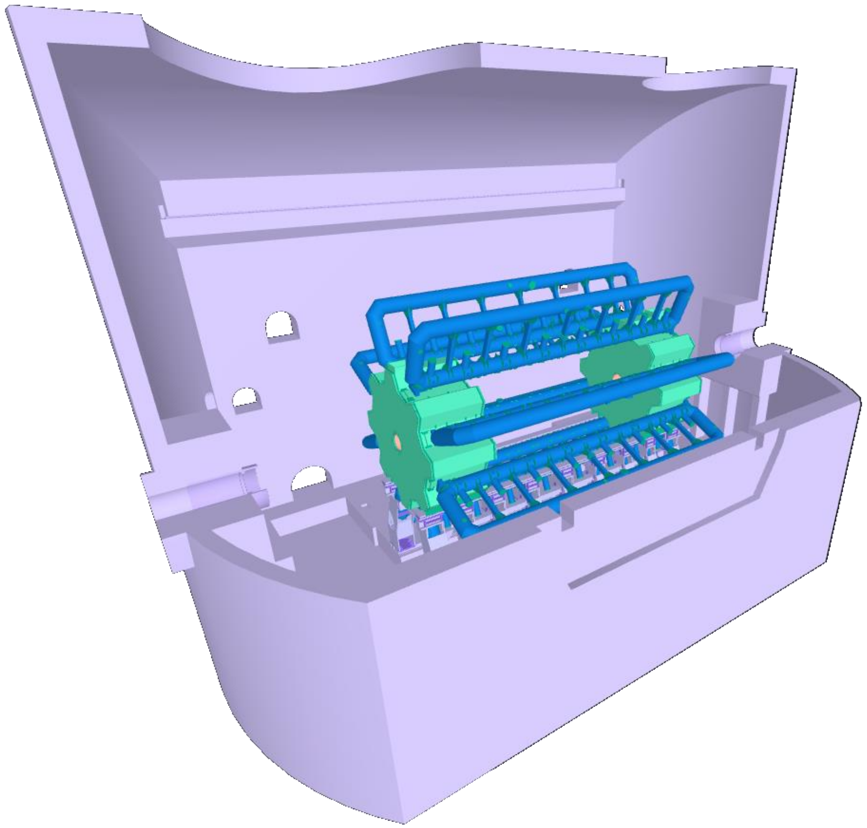


Control Menu

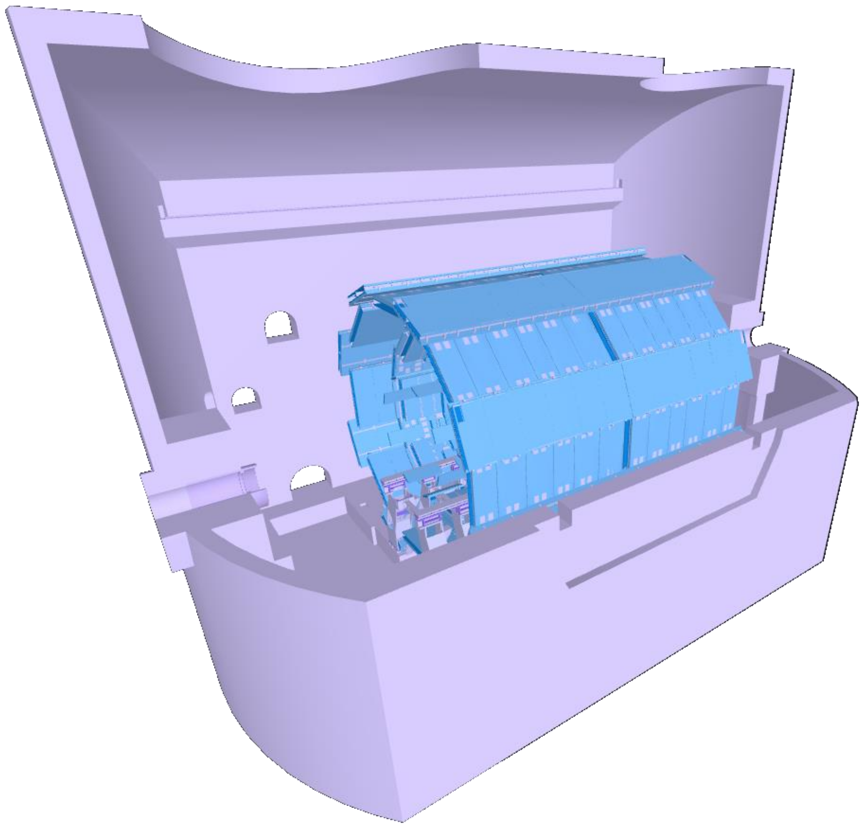
Tracer-VR Scenes

There are *four* VR scenes:

Scene #01: Magnets in Cavern

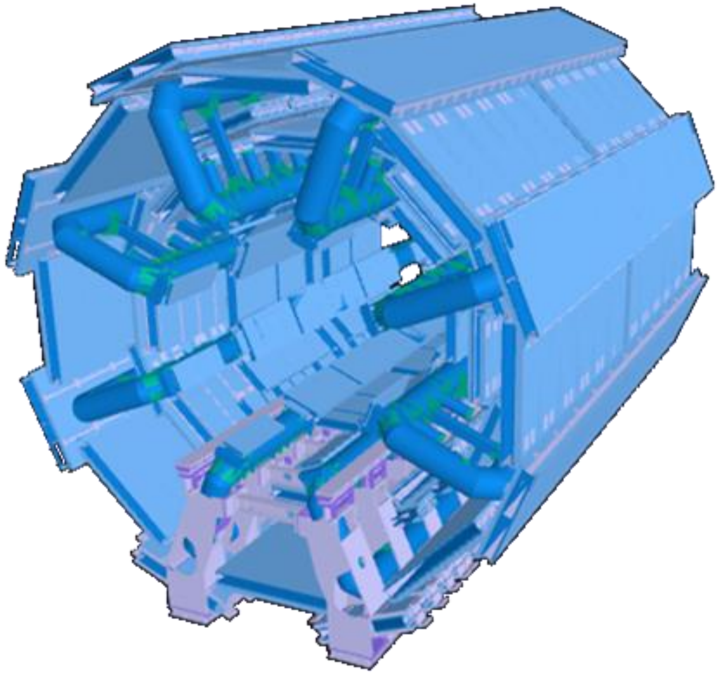


Scene #02: Muon Spectrometer

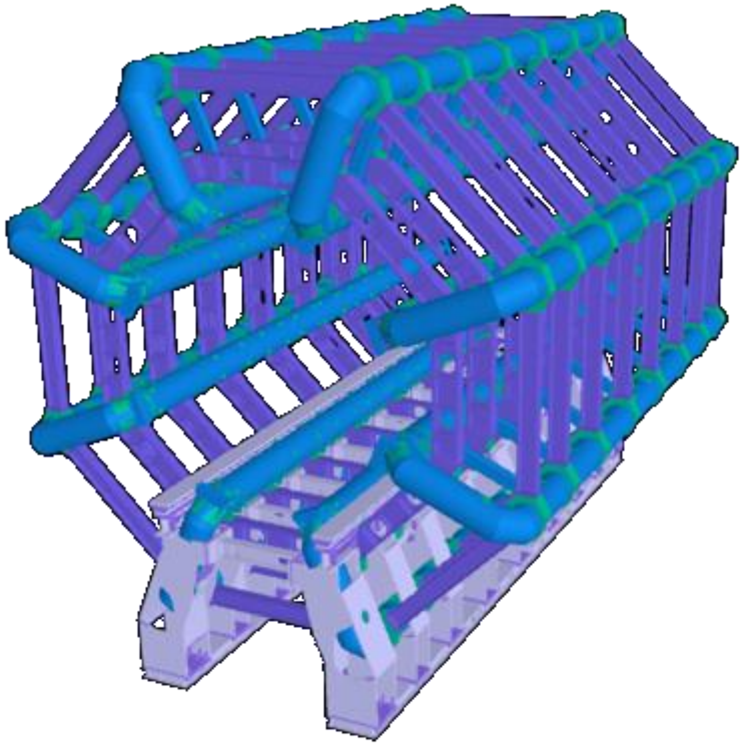


Tracer-VR Scenes

Scene #03: Muon Spectrometer with Magnets



Scene #04: Magnet System



II. Tracer-ART

Tracer-ART

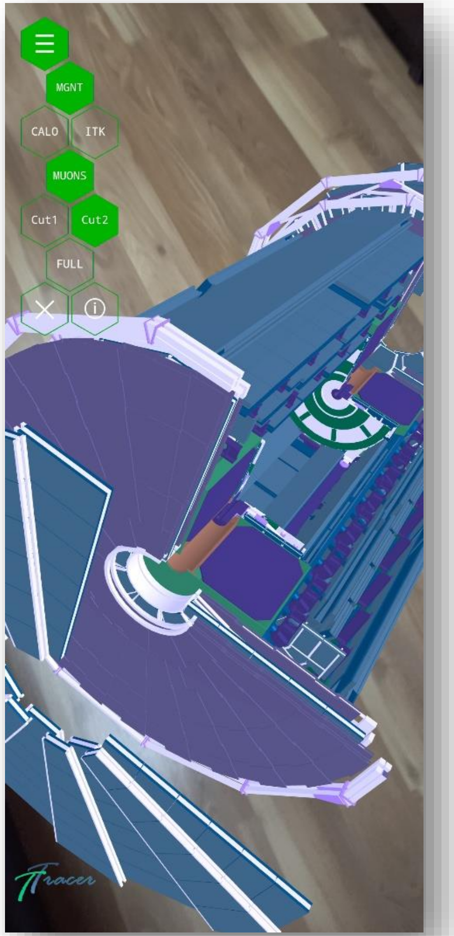
- Tracer-ART – Augmented Reality Table for visualisation of the ATLAS detector components in the way most comfortable for users
- The application is running in the browser and compatible with a majority of the software and hardware platforms
- Tracer-ART makes it possible to "put" the ATLAS detector on any flat surface and navigate through
- Various geometry cuts permit the best visualisation of the internal content of components and learn the topology of the detector
- 3D geometries use a moderate load on the GPU and ensure good quality of the 3D scenes on the average power phones

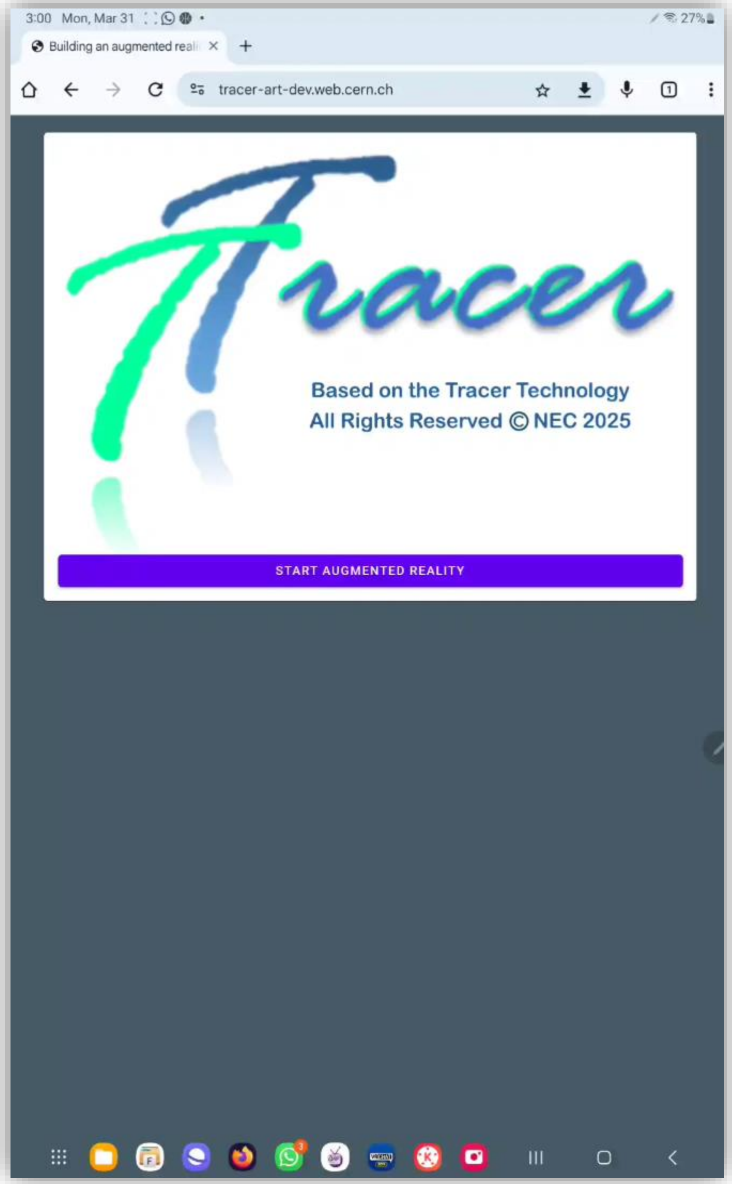
Tracer-ART Interface

- Application Repository

https://gitlab.cern.ch/tracer/tracer-art.git

Application Menu

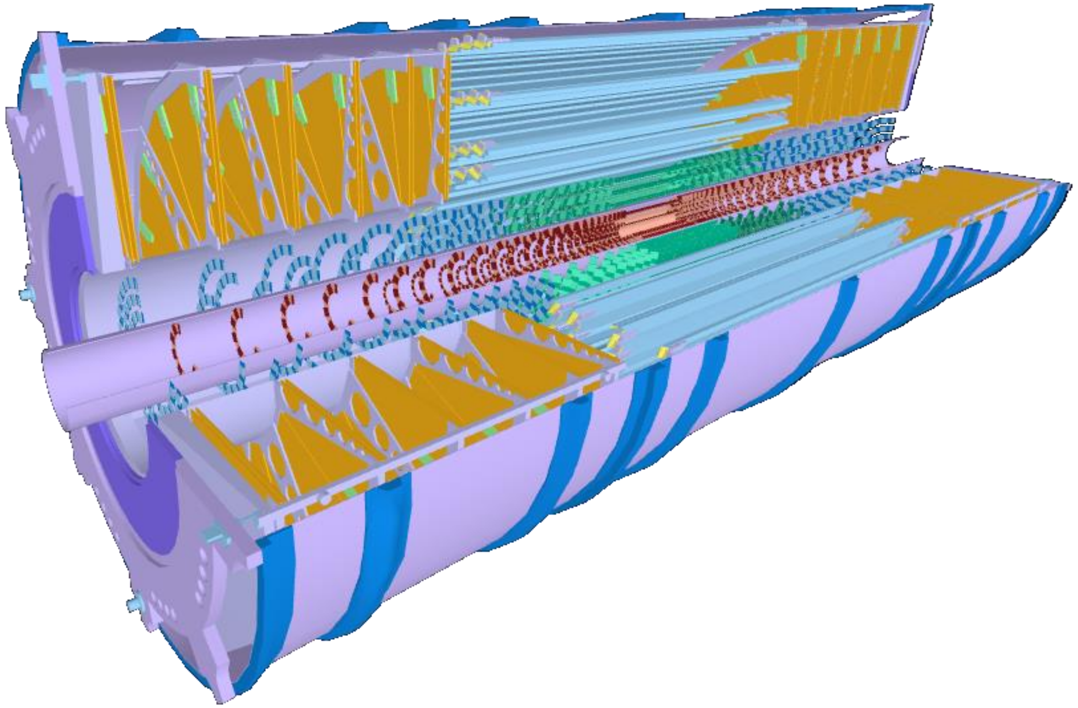




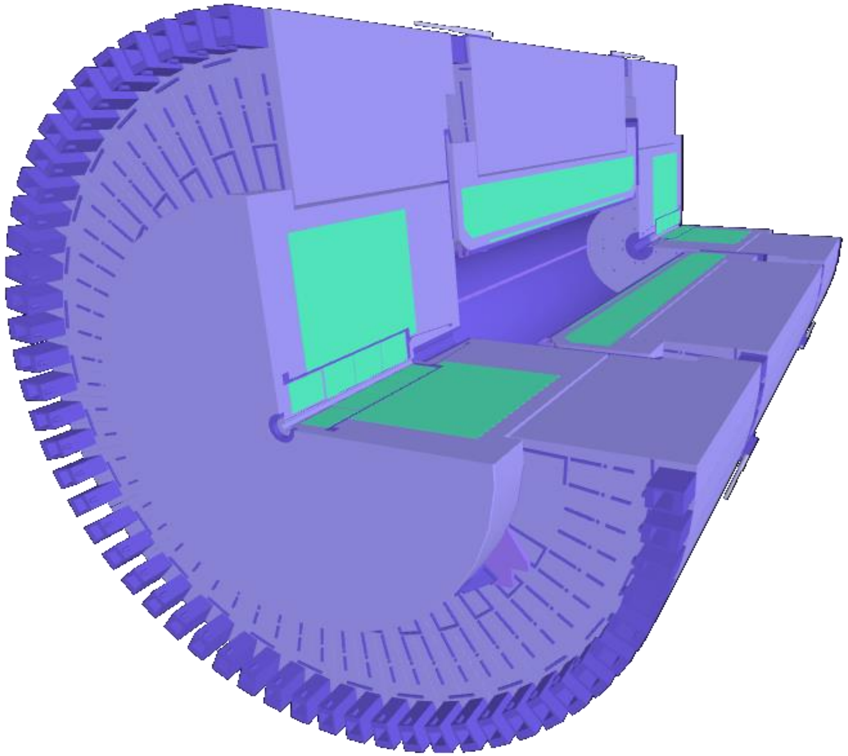
*Better to use Google Chrome

There are *four* components of the ATLAS Detector:

<u>#01</u>: ITK Detector

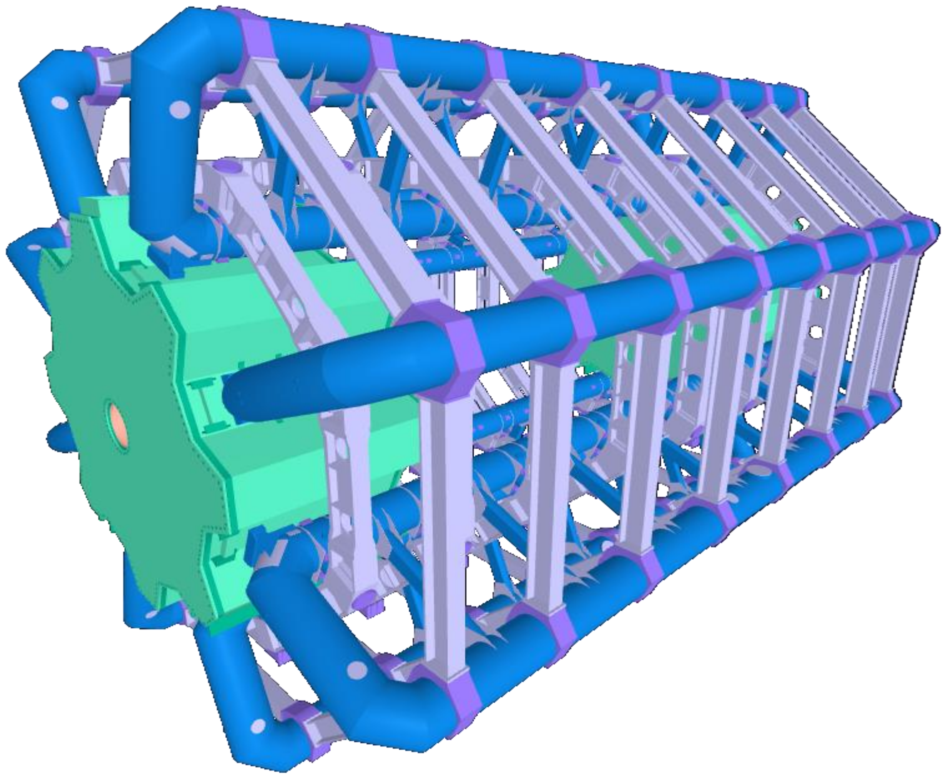


<u>#02</u>: Calorimeters

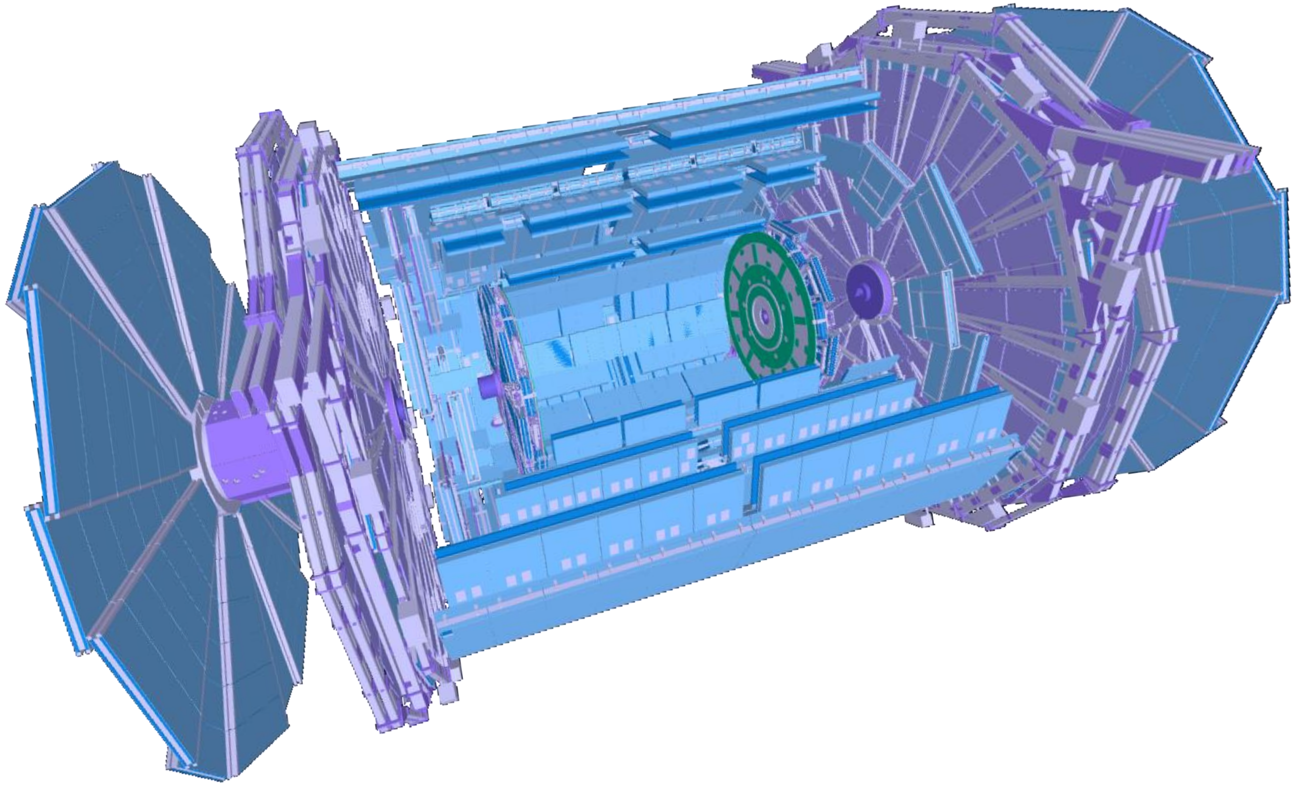


Tracer-ART

#03: Magnet System



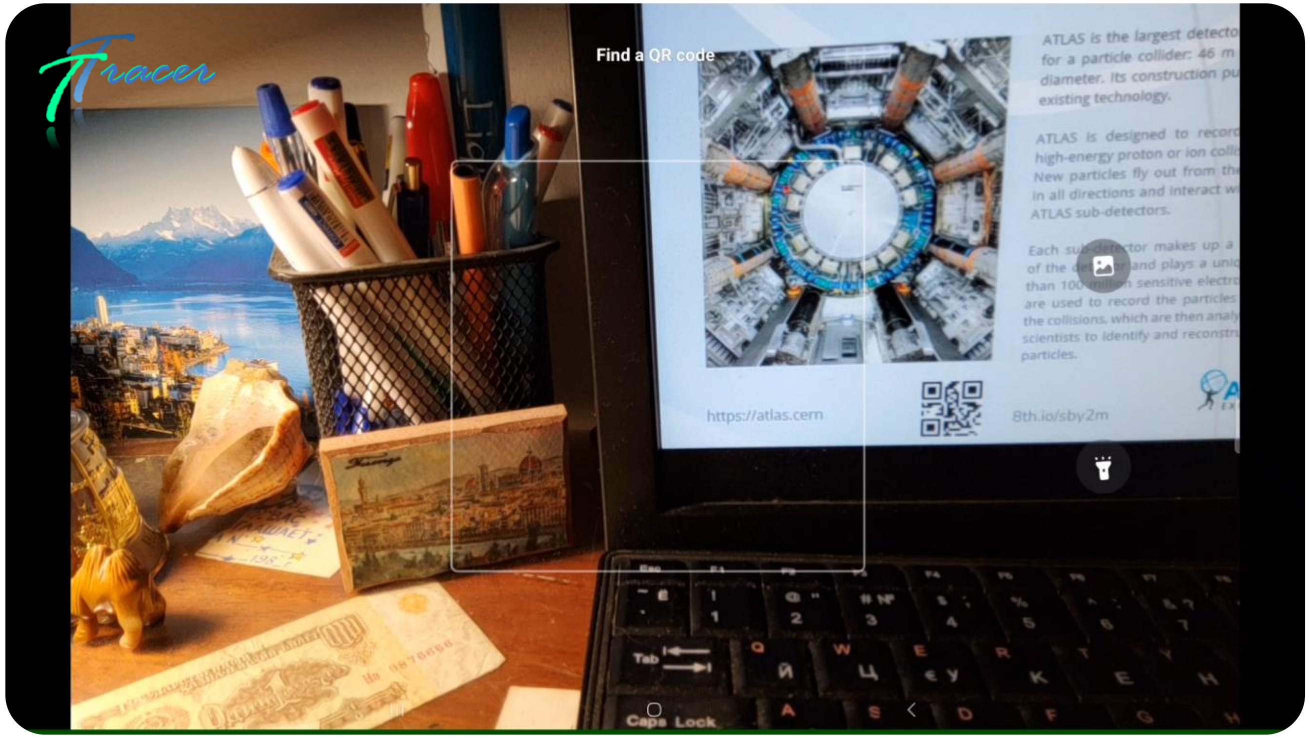
#04: Muon Spectrometer



III. Tracer-ARB

Tracer-ARB

- Tracer ARB is the **A**ugmented **R**eality **B**ook application for the ATLAS paper sheets
- The application runs in the browser without any installations
- Compatible with the majority of browsers. However, Google Chrome is recommended
- The application brings 3D scenes on top of the paper images



Tracer-ARB / Project #01: Magnet System

MAGNET SYSTEM

ATLAS uses two different types of superconducting magnet systems – solenoidal and toroidal. When cooled to about 4.5 K (–268°C), these are able to provide strong magnetic fields that bend the trajectories of charged particles. This allows physicists to measure their momentum and charge.

CENTRAL SOLENOID MAGNET

The ATLAS solenoid surrounds the inner detector at the core of the experiment. This powerful magnet is 5.6 m long, 2.56 m in diameter and weighs over 5 tonnes. **It provides a 2 Tesla magnetic field in just 4.5 cm thickness.** This is achieved by embedding over 9 km of niobium-titanium superconductor wires into strengthened, pure aluminum strips, thus minimising possible interactions between the magnet and the particles being studied.

TOROID MAGNET

The ATLAS toroids use a series of eight coils to provide a magnetic field of up to 3.5 Tesla, used to measure the momentum of muons. There are **three toroid magnets** in ATLAS: two at the ends of the experiment, and one massive toroid surrounding the centre of the experiment.

At 25.3 m in length, the central toroid is the **largest toroidal magnet ever constructed** and is an iconic element of ATLAS. It uses over 56 km of superconducting wire and weighs about 830 tonnes. The end-cap toroids extend the magnetic field to particles leaving the detector close to the beam pipe. Each end-cap is 10.7 m in diameter and weighs 240 tonnes.

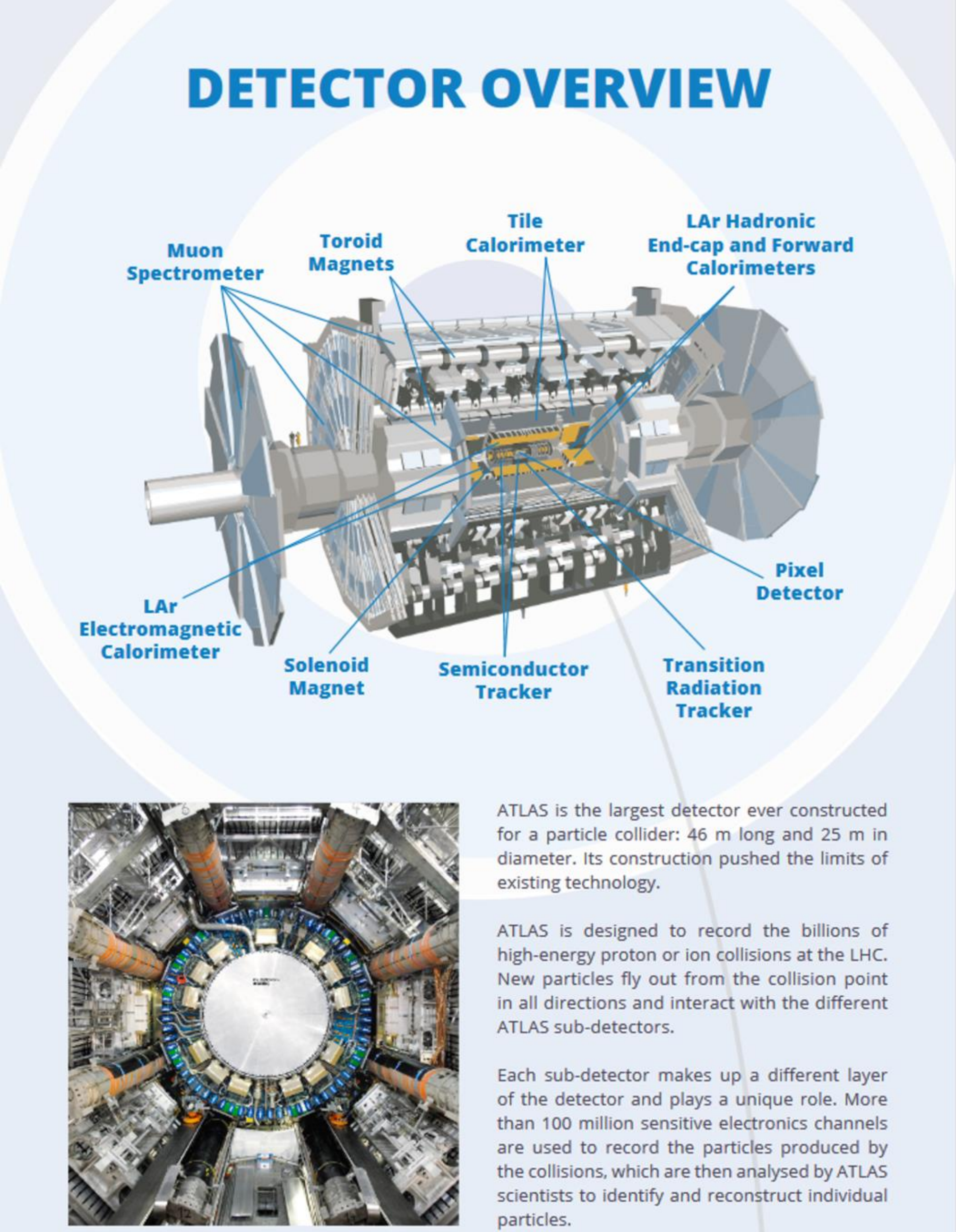
<u>Steps to be done:</u>

1. Scan QR code and open the link
2. Launch
3. Allow camera activation
4. Watch pictures on the sheet and enjoy

- Project is Open source under the Apache licence and available on CERN Gitlab

Tracer

Tracer-ARB / Project #02: Detector Overview



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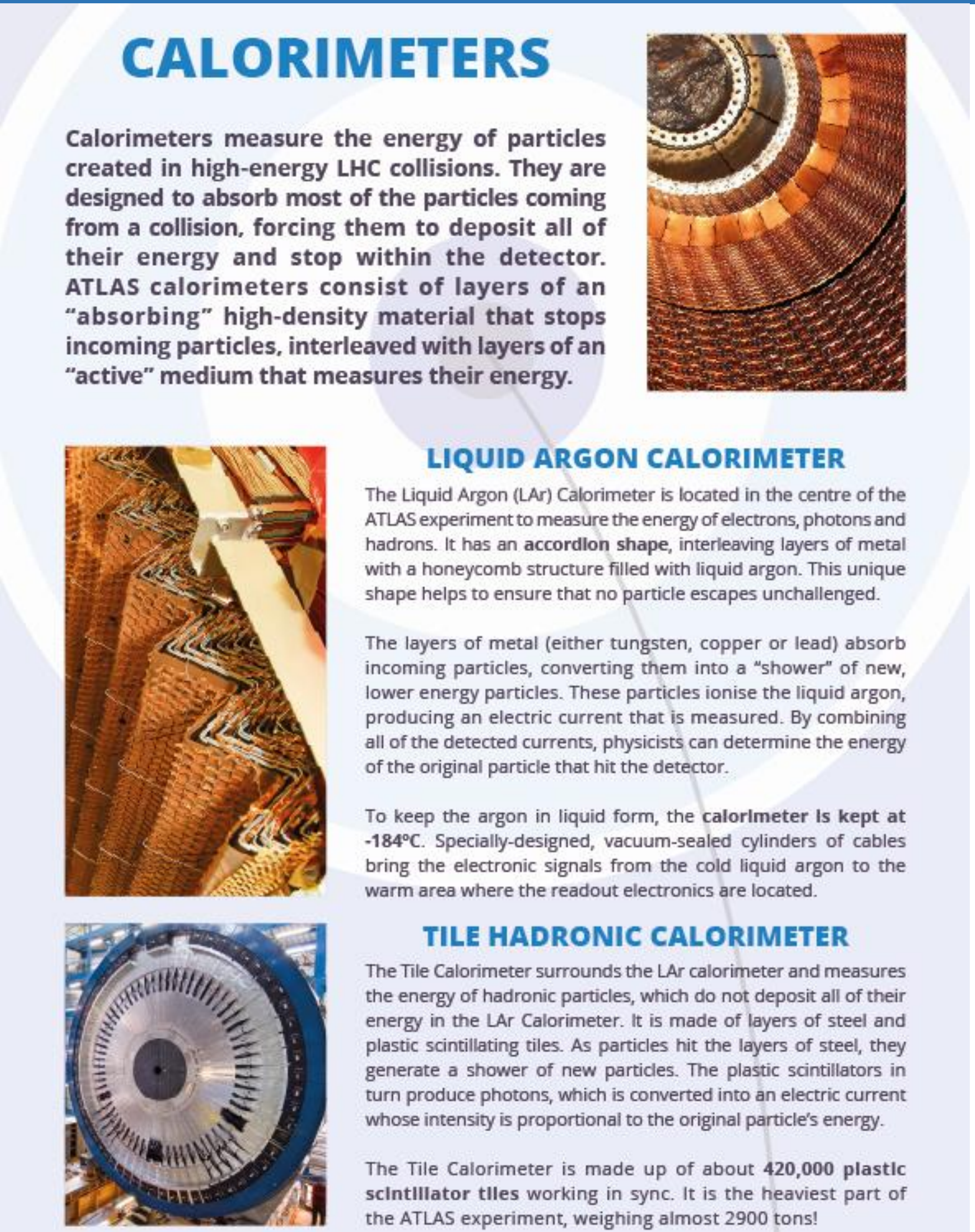
Tracer-ARB / Project #03: Calorimeters



CALORIMETERS

Calorimeters measure the energy of particles created in high-energy LHC collisions. They are designed to absorb most of the particles coming from a collision, forcing them to deposit all of their energy and stop within the detector. ATLAS calorimeters consist of layers of an "absorbing" high-density material that stops incoming particles, interleaved with layers of an "active" medium that measures their energy.

LIQUID ARGON CALORIMETER

The Liquid Argon (LAr) Calorimeter is located in the centre of the ATLAS experiment to measure the energy of electrons, photons and hadrons. It has an **accordion shape**, interleaving layers of metal with a honeycomb structure filled with liquid argon. This unique shape helps to ensure that no particle escapes unchallenged.

The layers of metal (either tungsten, copper or lead) absorb incoming particles, converting them into a "shower" of new, lower energy particles. These particles ionise the liquid argon, producing an electric current that is measured. By combining all of the detected currents, physicists can determine the energy of the original particle that hit the detector.

To keep the argon in liquid form, the **calorimeter is kept at -184°C**. Specially-designed, vacuum-sealed cylinders of cables bring the electronic signals from the cold liquid argon to the warm area where the readout electronics are located.

TILE HADRONIC CALORIMETER

The Tile Calorimeter surrounds the LAr calorimeter and measures the energy of hadronic particles, which do not deposit all of their energy in the LAr Calorimeter. It is made of layers of steel and plastic scintillating tiles. As particles hit the layers of steel, they generate a shower of new particles. The plastic scintillators in turn produce photons, which is converted into an electric current whose intensity is proportional to the original particle's energy.

The Tile Calorimeter is made up of about **420,000 plastic scintillator tiles** working in sync. It is the heaviest part of the ATLAS experiment, weighing almost 2900 tons!

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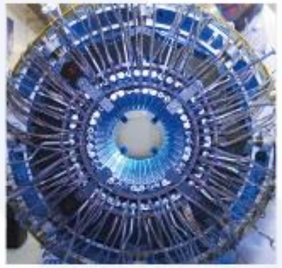
Tracer-ARB / Project #04: Inner Detector

THE INNER DETECTOR

The Inner Detector is the innermost part of ATLAS to see the decay products of the collisions, so it is very compact and highly sensitive. It consists of three different systems, measuring the direction, momentum and charge of electrically-charged particles produced in collisions.



PIXEL DETECTOR

Located just 3.3 cm from the LHC beam line, the Pixel Detector is the **first point of detection** in the ATLAS experiment. It is made up of **four layers of silicon pixels, with each pixel smaller than a grain of sand**. As charged particles burst out from the collision point, they leave behind small energy deposits in the Pixel Detector. These signals are measured with a precision of almost 10 μm to determine the origin and momentum of the particle. The Pixel Detector is incredibly compact, with over **92 million pixels and almost 2000 detector elements.**

SEMICONDUCTOR TRACKER

The SCT sorrounds the Pixel Detector and is used to detect and reconstruct the tracks of charged particles produced during collisions. It consists of over 4,000 modules of **6 million "micro-strips" of silicon sensors.** Its layout is optimised such that each particle crosses at least four layers of silicon. This allows scientists to **measure particle tracks with a precision of up to 25 μm** - that's less than half the width of a human hair!

TRANSITION RADIATION TRACKER

The third and final layer of the Inner Detector is the TRT. Unlike its neighbouring sub-detectors, the TRT is made up of **300,000 thin-walled drift tubes** (or "straws"). Each straw is just 4 mm in diameter, with a 30 μm gold-plated tungsten wire in its centre. The straws are filled with a gas mixture. As charged particles cross through the straws, they ionise the gas to create a detectable electric signal. This is used to reconstruct their tracks and, owing to the so-called transition radiation, **provides information on the particle type** that flew through the detector, i.e. if it is an electron or pion.

<u>Steps to be done:</u>

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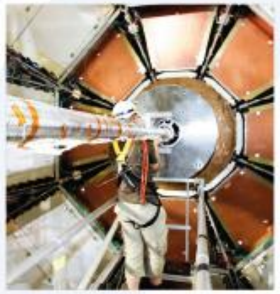
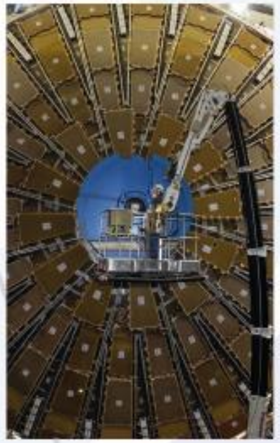
Tracer-ARB / Project #05: Muon Spectrometer



MUON SPECTROMETER

The outer layer of the ATLAS experiment is made of muon detectors. They identify and measure the momenta of muons – particles similar to electrons but 200 times heavier, which allows them to cross the thick calorimeter layers.

PRECISION DETECTORS



The precision detectors of the Muon Spectrometer are able to determine the position of a muon, to an **accuracy of less than a 10th of a millimeter!**

Monitored Drift Tube (MDTs) detectors are composed of 3 cm wide aluminum tubes filled with a gas mixture. Muons pass through the tubes, knocking electrons out of the gas. These then drift to a wire at the tube's centre to induce a signal. Over **380,000 aluminum tubes** are stacked up in several layers in order to precisely trace the trajectory of each muon.

Cathode Strip Chambers (CSCs) complement this task at the ends of the ATLAS experiment. CSCs are composed of copper strips crossed by arrays of wires in a gas mixture. Muons travelling through the gas are detected by both electron-collecting wires and ion-collecting strips.

FAST-RESPONSE DETECTORS

ATLAS uses fast-response detectors to quickly select collision events that are potentially interesting for physics analysis. They **make this decision within 2.5 μs** (400,000th of a second).

The Resistive Plate Chambers (RPCs) surround the central region of the ATLAS experiment. They consist of pairs of parallel plastic plates at an electric potential difference, separated by a gas volume. Thin Gap Chambers (TGCs) are found at the ends of the ATLAS experiment and consist of parallel 30 μm wires in a gas mixture. Both chambers detect muons when they ionise the gas mixture and generate a signal.

The combined data from fast-response detectors gives a coarse measurement of a muon's momentum, allowing ATLAS to choose whether to keep or discard a collision event.

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2. Launch
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IV. Future Steps

Future Steps

1. We have finished development of three applications: VR, ART, and ARB
2. We are currently working on **ARD** (**A**ugmented **R**eality **D**oor), an application that enables navigation within the ATLAS detector through virtual portals.
3. ARD is at the R&D stage
4. In 2026, we are planning to move on to the development of the **ARL** – **A**ugmented **R**eality **L**andscape, an application to visualise the ATLAS detector on a landscape at full scale

Thanks!