Cosmic-ray tracker improvements & augmented reality event-display for GIF++

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WP 15.5.4

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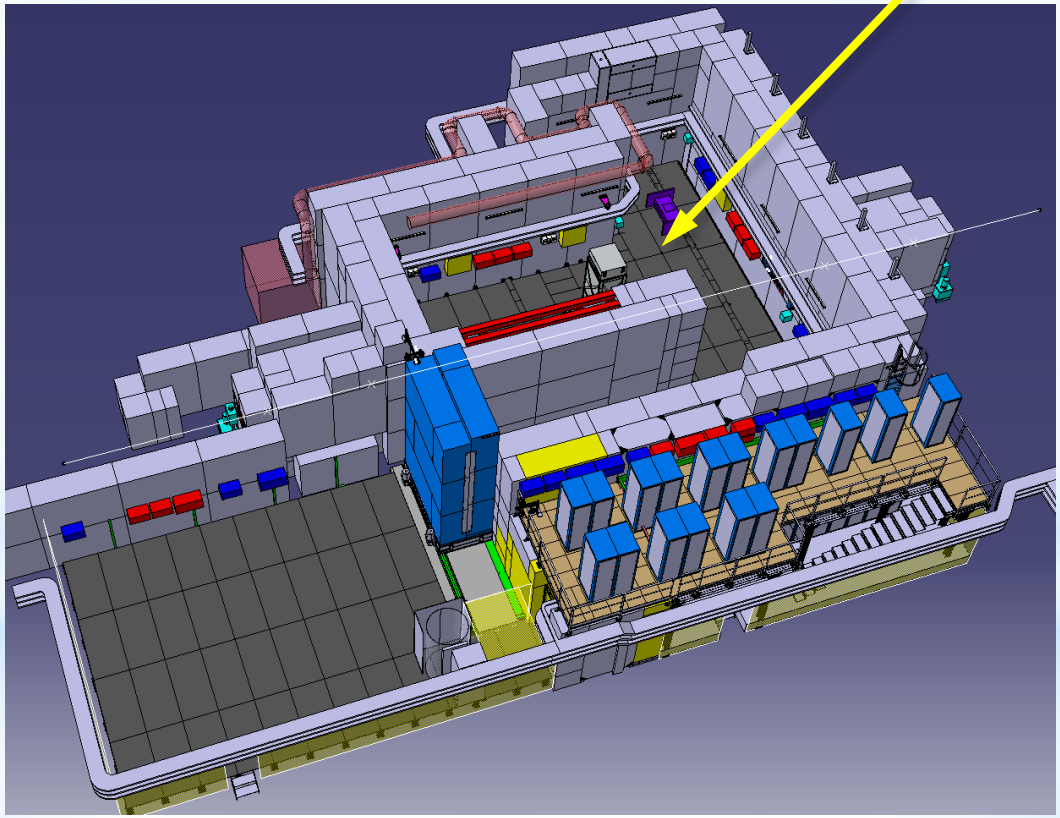
Improvement of the GIF++ cosmic-ray tracker

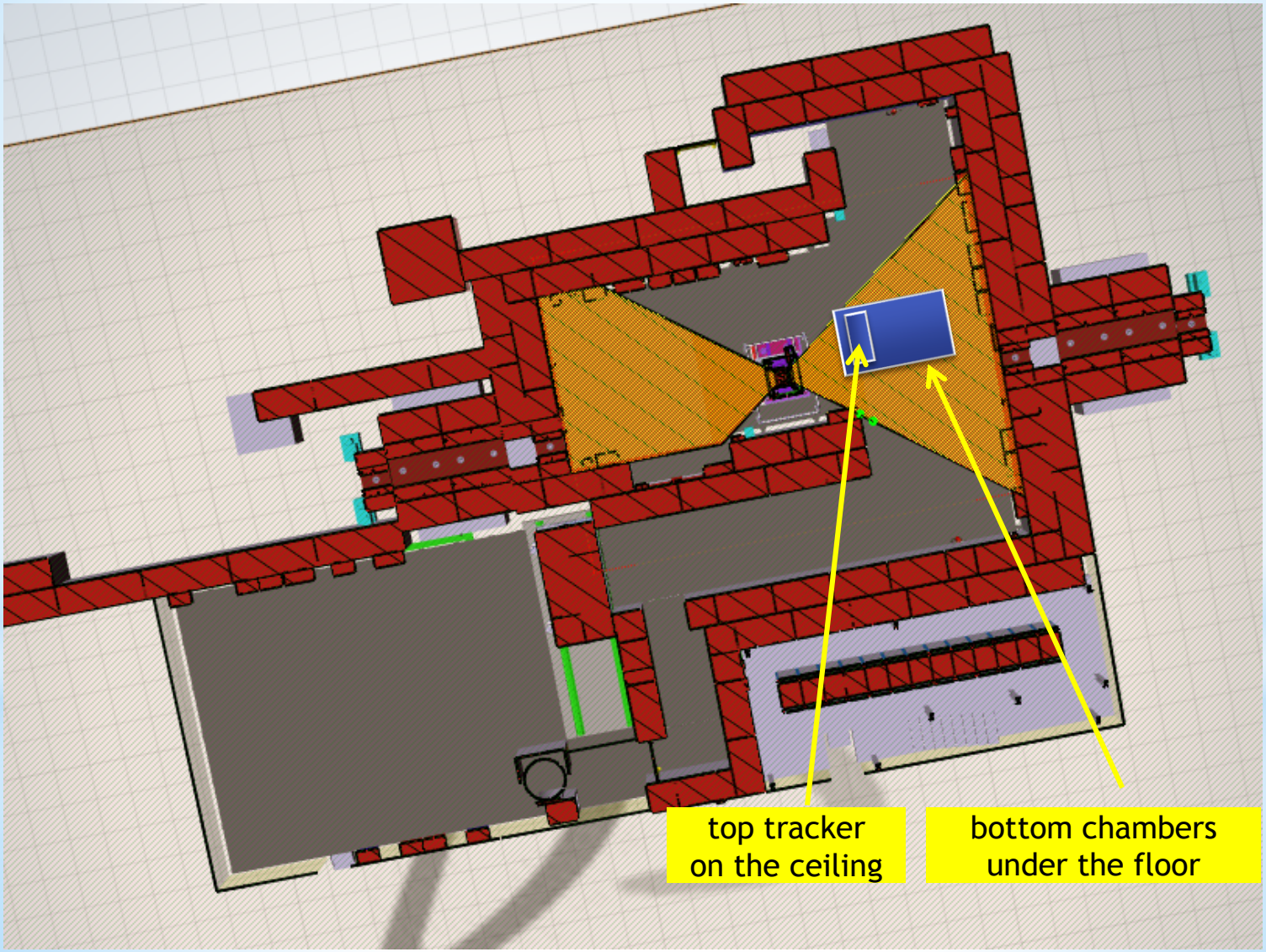
Current cosmic-ray tracker setup at the GIF++ is covering just one side of the bunker (wrt the irradiation source)
Useful when the muon beam is not available (expected ~6-8 weeks/year as main users, plus similar time as parasitic users)



GIF++ bunker surface is ~2x the old-GIF, but it is already very crowded!

Current cosmic tracker setup

Based on **Resistive Plate Chamber** technology



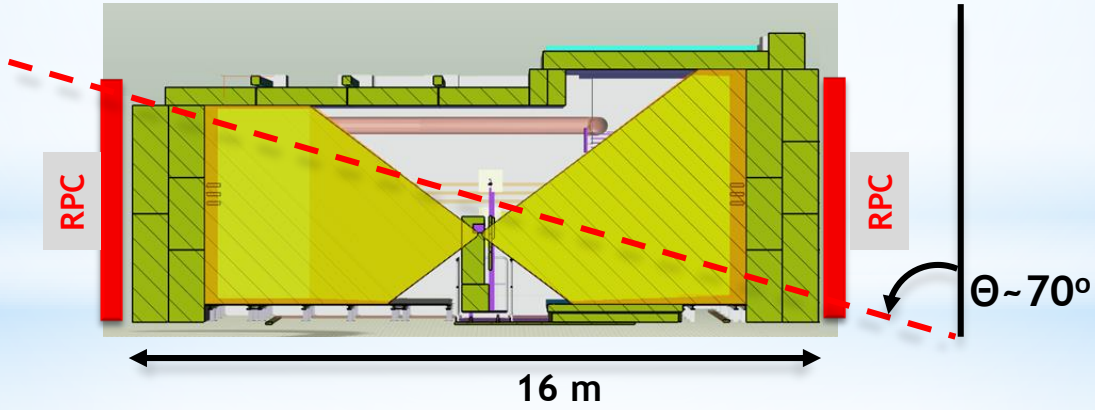
Motivations of the project

Improvement of the cosmic muon selection

- Instrument a larger area of the facility
- Select higher momentum muons

Possibility to **trigger on the beam-halo**, if position of new chambers chosen appropriately

The above requirements can be fulfilled by installing large area RPCs on the vertical walls of the facility



Furthermore, using large angle cosmic muons, no need to change orientation of the detectors under test wrt the setup for beam muons

Spectrum of cosmic muons at sea level

from PDG

C. Patrignani et al. (Particle Data Group), Chinese Physics C, 40, 100001 (2016)
The Review of Particle Physics, chapter 29.3, page 8
http://www-pdg.lbl.gov/2016/reviews/rpp2016-rev-cosmic-rays.pdf

θ = 0°

θ = 75°

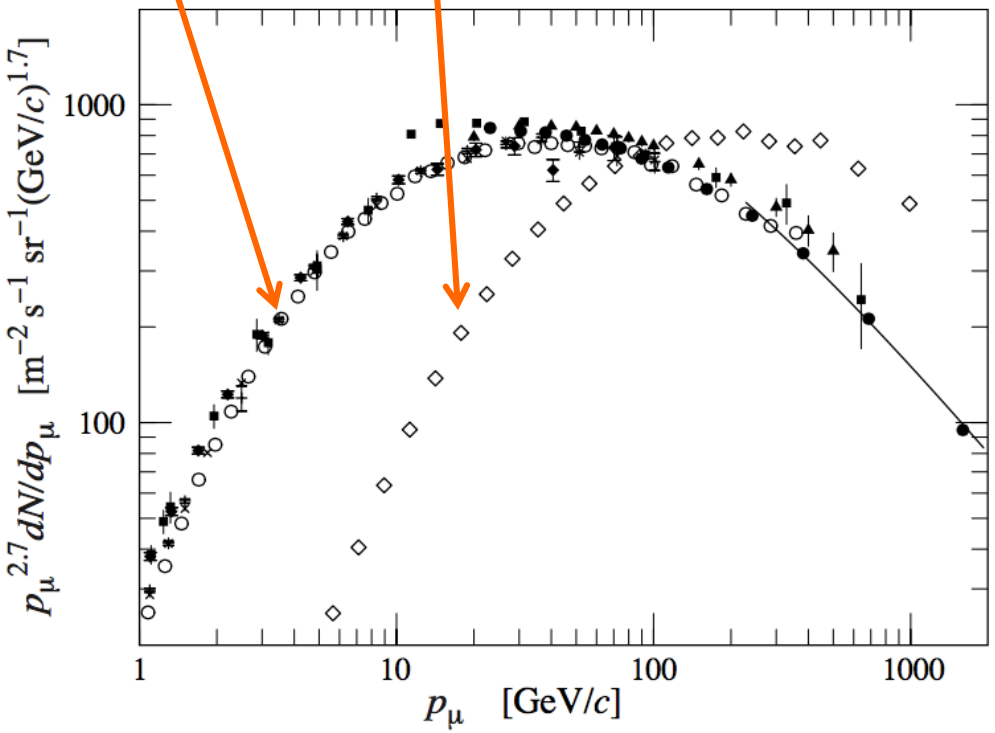


Figure 26.4: Spectrum of muons at $\theta = 0°$ (♦ [41], ■ [46], ▼ [47], ▲ [48], ×, + [43], ○ [44], and • [45] and $\theta = 75°$ ◇ [49]) . The line plots the result from Eq. (26.4) for vertical showers.

Harder spectrum at larger incidence angles

Project description

Build RPC chambers to be placed on the vertical walls of the bunker (see pictures in next slide) with a total surface of ~12 m^2

Chamber stratigraphy:

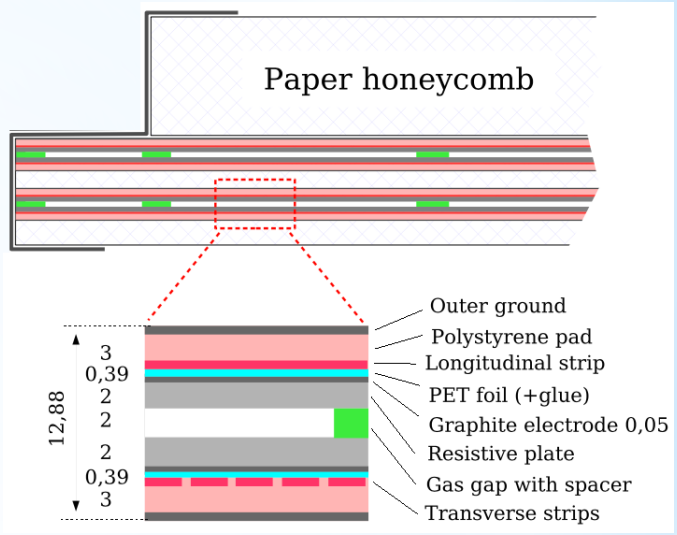
- 2 independent detector layers
- 4 readout panels

Chamber dimensions (active area):

- 3.4 x 0.9 m^2

Spatial resolution:

- ~1 cm



New chambers will be integrated into the already existing infrastructure of the cosmic tracker:

- gas system
- power supplies
- DCS
- DAQ

Chamber status

Mechanics of new chambers is available

Need to produce the active elements of the detectors:

- gas volumes being ordered
- readout panels available (front end-electronics to be tested)

Test stand for chambers is being prepared at Cern-BB5 area

Views of GIF++ end-walls

Upstream view

Downstream view

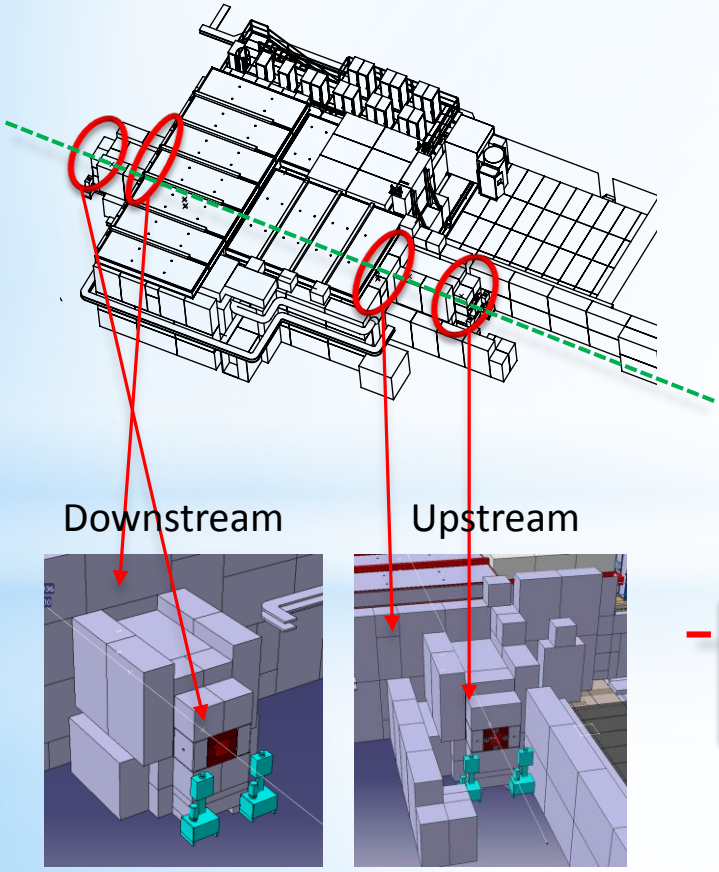
Chamber positioning

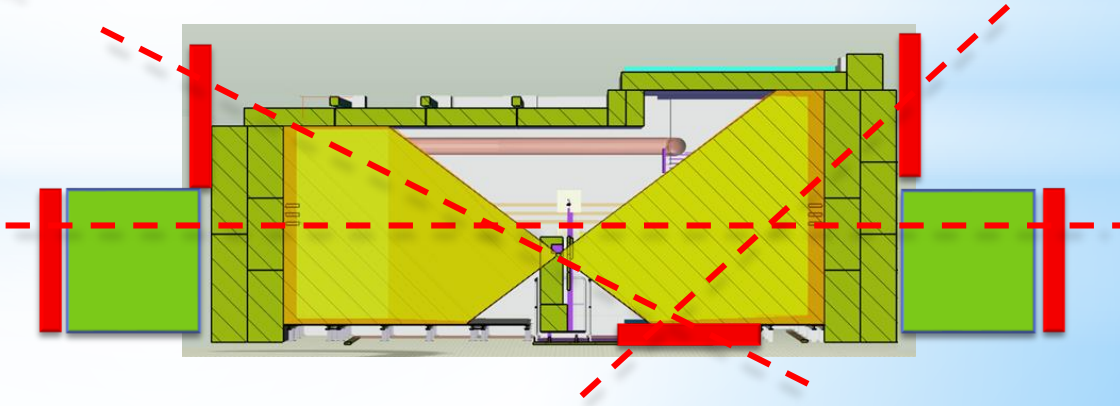
Positioning of chambers has to fit the geometrical constraints

- presence of beam dumps on both sides

Triggering on beam-halo needs chambers on both sides

Coincidence with floor chambers possible





Project deadlines

Milestone:

Design of chambers

18 months

Deliverable:

Cosmic tracker installed and commissioned

44 months

Timeline

2018 First Half

- Chamber assembly
- Chamber test

2018 Second Half

Chamber installation and integration into the existing system

Augmented reality cosmic-rays event display

AR event display framework

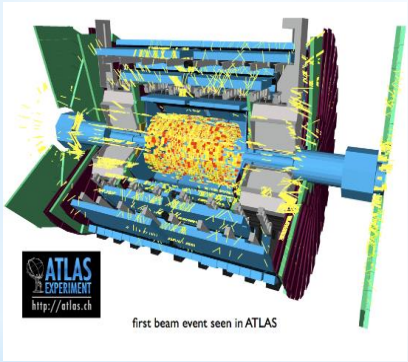
- Combine particle physics detector, real-time data acquisition and Augmented Reality
- Produce a direct experience of cosmic rays for an operator inside the GIF++ bunker
- GIF++ hardware infrastructure provides most of the needed support
- GIF++ becoming pilot project for a new generation of tools for commissioning and maintenance of complex experimental apparatus (reduce time of interventions, enhance operator safety, …). Interfacing the system with DCS to show power status of boards or any detector element in the operator view
- Using a good timing detector (RPCs) will allow to view / stop / re-play / view in slow-motion a cosmic shower event and see its impact on a test detector

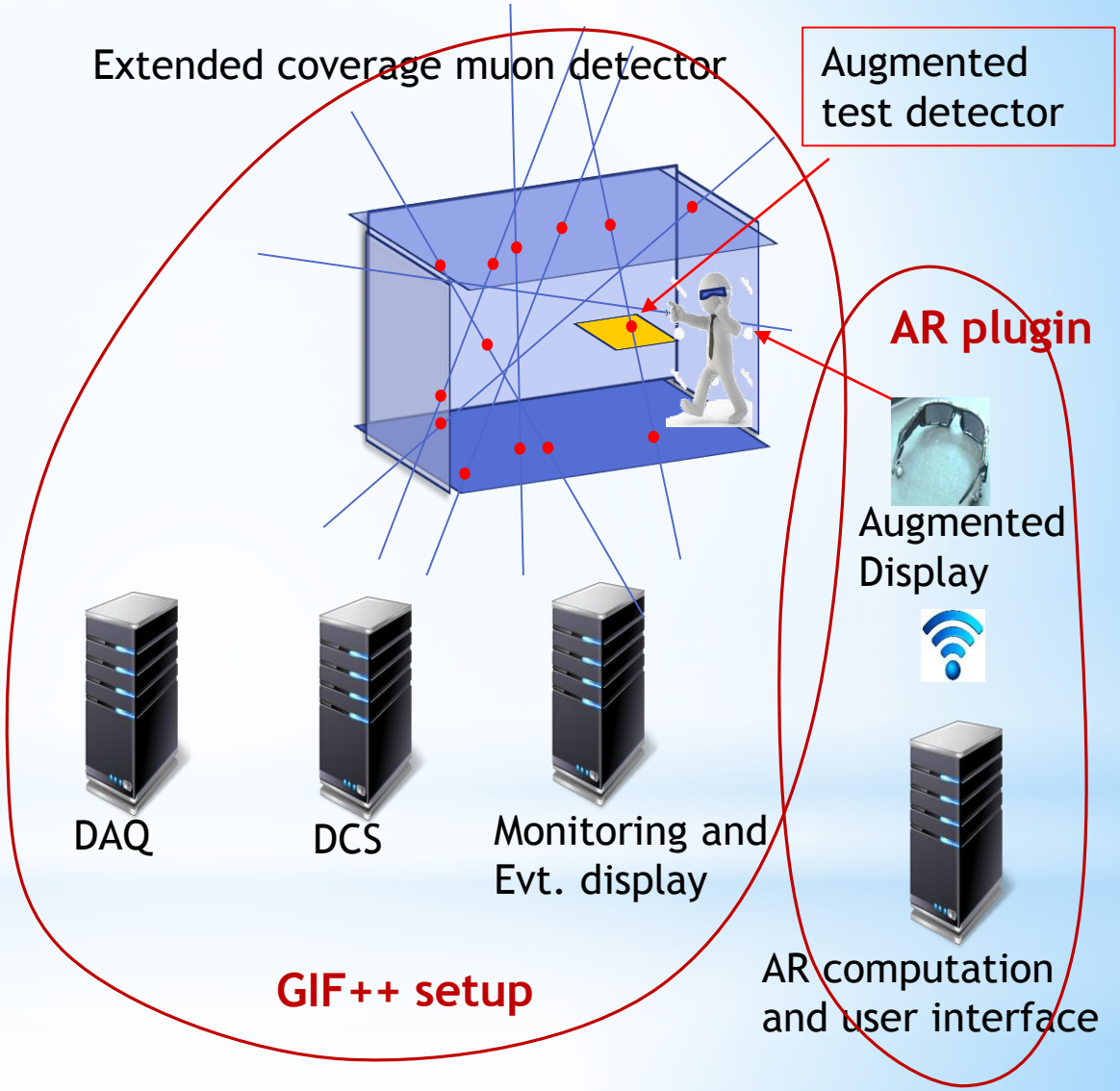
Applications

- industrial control, production and safety
- cosmic-rays visualization for education and outreach (Universities, exhibitions, museum, etc.)
- visualization of any source of invisible field of radiation by replacing the type of sensors, e.g. Radio Frequency, Infrared, UV…

Relation between GIF++ and AR event display (1)

* Most of the HW is already enclosed in the GIF++, especially if the CR detector coverage will be extended and we will add the 3D event display features to the online monitoring system





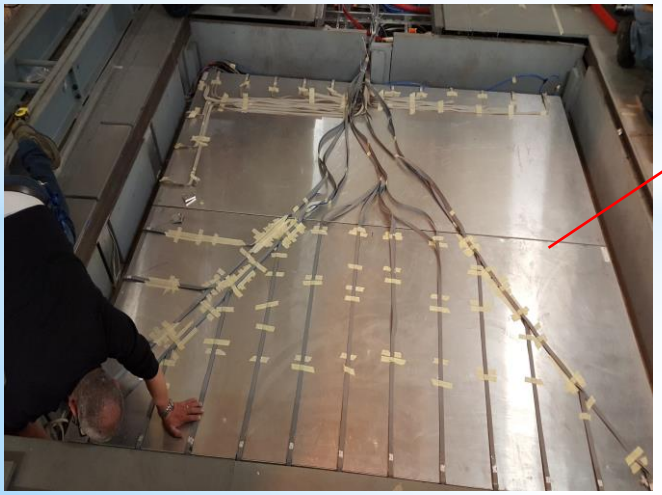
* Needed:
- development of software for AR and user interface
- AR display hardware

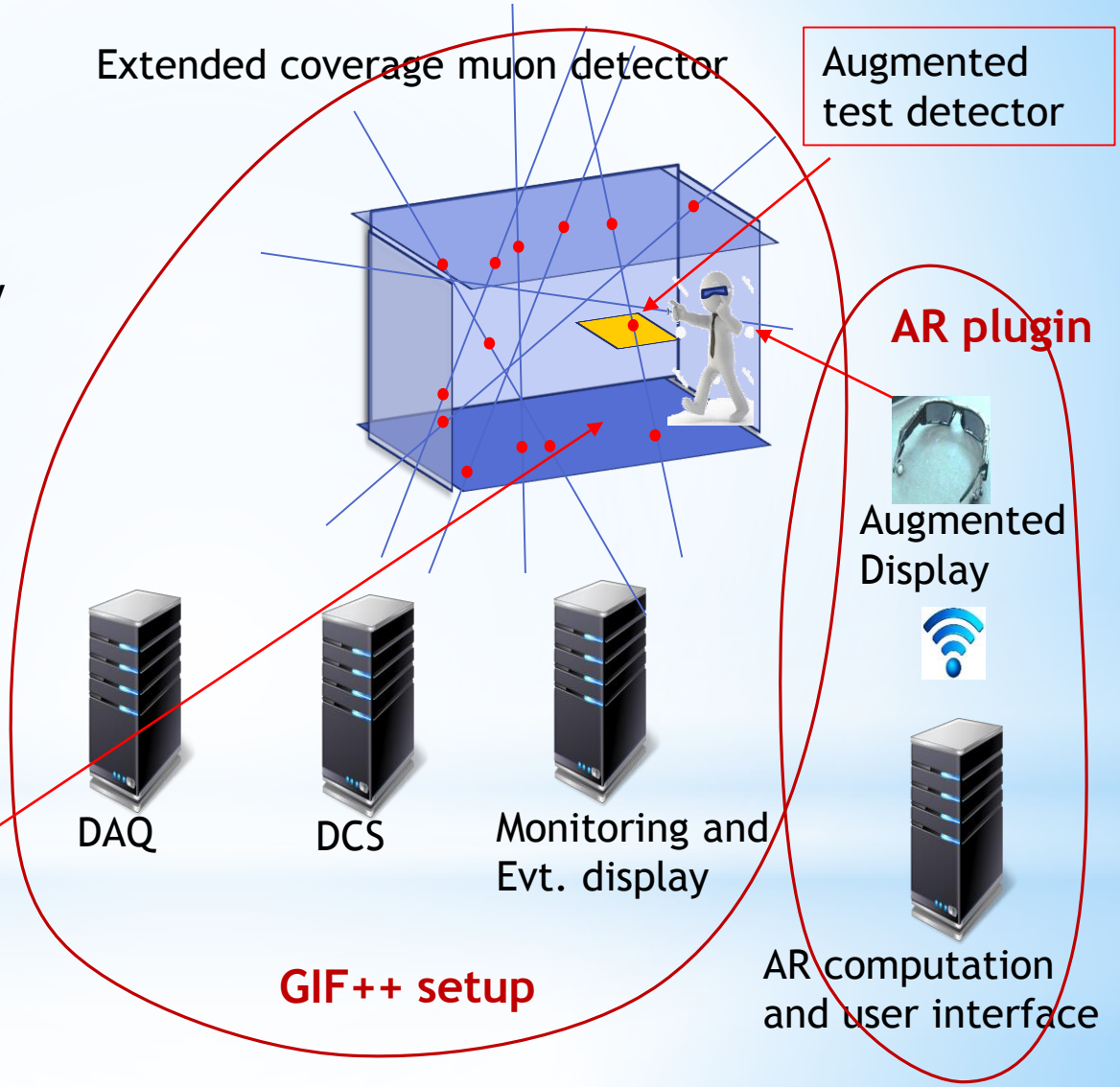
Relation between GIF++ and AR event display (2)

Based on the CR tracker enclosed in the GIF++

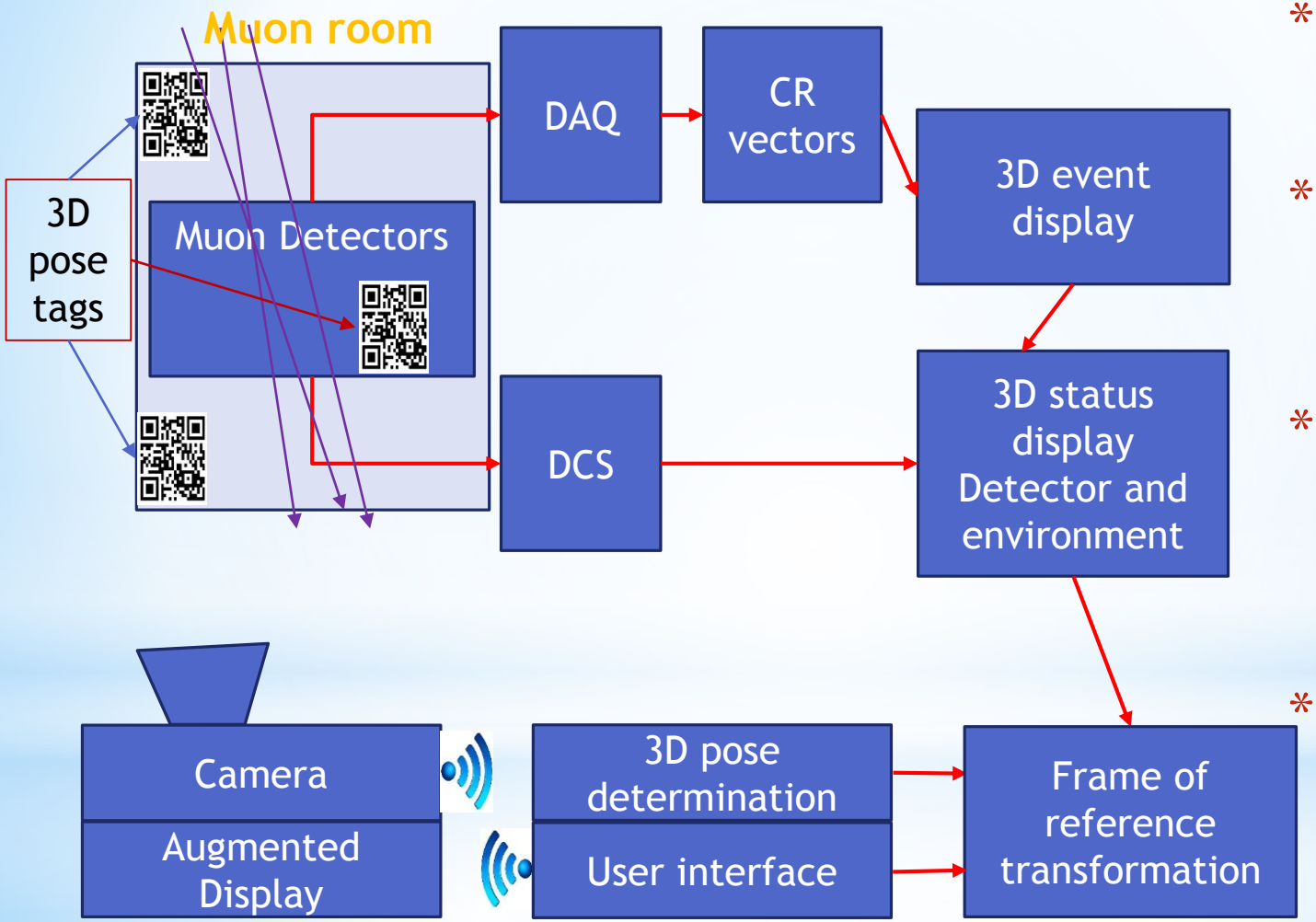
CR detector coverage will be extended and 3D event display features will be added to the online monitoring system

GIF++ floor detector X-Y doublet





Functional description of the AR display in the GIF++



* Muon detectors data to construct the event display
* Camera reconstruct its pose through local tags
* The event display is transformed in the reference frame of the operator
* 3D event is sent to the augmented display through the user interface

Status of augmented reality event-display

Next milestone MS86 due in M36:

Test of the different software modules as event display, camera position tracking and user interface

Present status of the infrastructure software:

GIF++ Cosmic rays tracker DAQ and event reconstruction

* Software in development as a C program on a Linux machine, reading VME timing pattern readout modules
* Event reconstruction is a module of the DAQ generating the track vectors. The simulated tracks generator is ready
* Tracks are available on an UDP port

GIF++ DCS

* Software developed as a WinCC software on a Windows machine, connected to a CAEN mainframe and receiving gas system data form the gas DCS.
* DCS module publishing DCS data for the ARtDeCo (Augmented Reality to DCS) module is in development. It will associate virtual instruments tags and monitoring data

Augmented Reality Software development platform defined: App running on Android

Software platform → test ongoing

OPEN CV

- general purpose image processing library G-Streamer
- Video data management engine ARToolKit (2D only capturing)
- Free AR SDK for Android

Next steps for MS86

- Install in GIF++ markers on free surfaces
- Define local coordinate system
- Project dummy animations from the simulator data

Involved institutes/people

Beneficiary is **INFN**

Bologna:
INFN: G.L.Alberghi, D.Boscherini, C.Gessi, P.Giacomelli, A.Polini, M.Romano

Roma "Tor Vergata":
INFN: R.Cardarelli, B.Liberti, E.Pastori
UNIVERSITY: G.Aielli, A.Caltabiano, P.Camarri, A.DiCiaccio, L.DiStante, L.Massa, R.Santonico

Summary

- GIF++ is a unique place for detector R&D for HL-LHC:
  many users will benefit of improvements to its infrastructure
- The upgrade of the cosmic tracker will extend the current setup coverage
  Possibly, it will allow to trigger also on muon beam halo
- The mechanics of the large area RPC chambers is available
  The active detector elements are being ordered
- The demonstrator for an augmented reality display will greatly benefit of the facility infrastructure
- While waiting for the DAQ system to be available,
  starting soon with software development for user position reconstruction