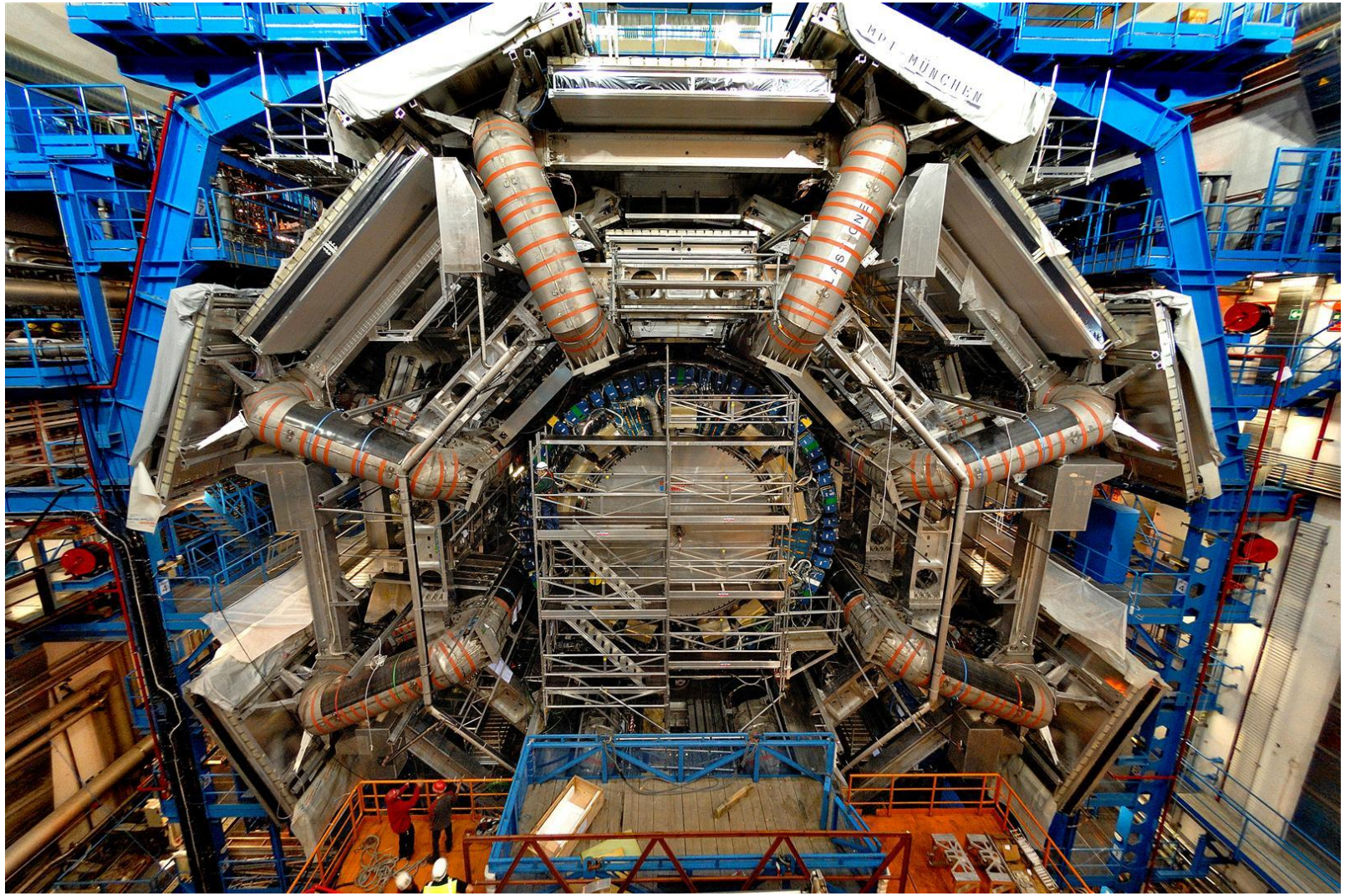
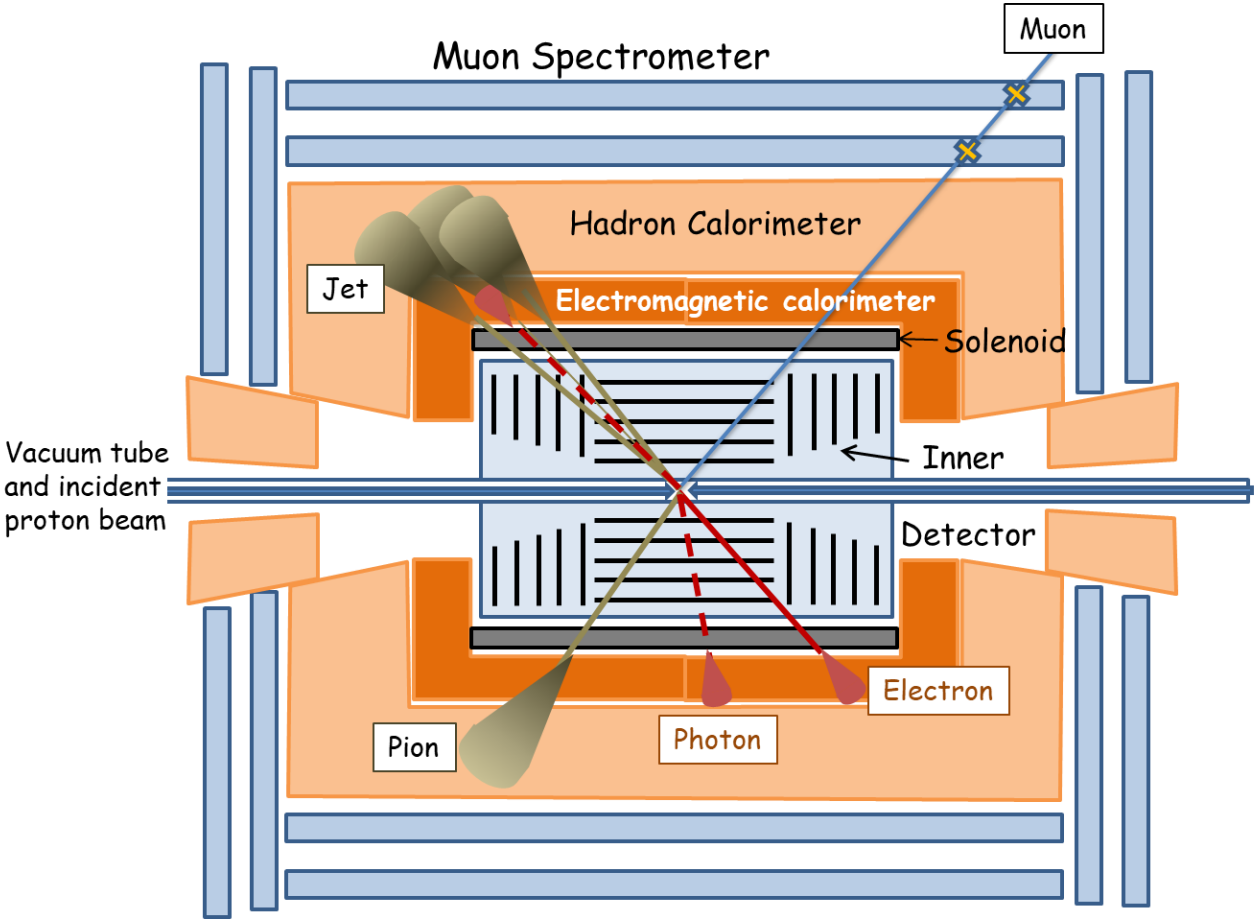
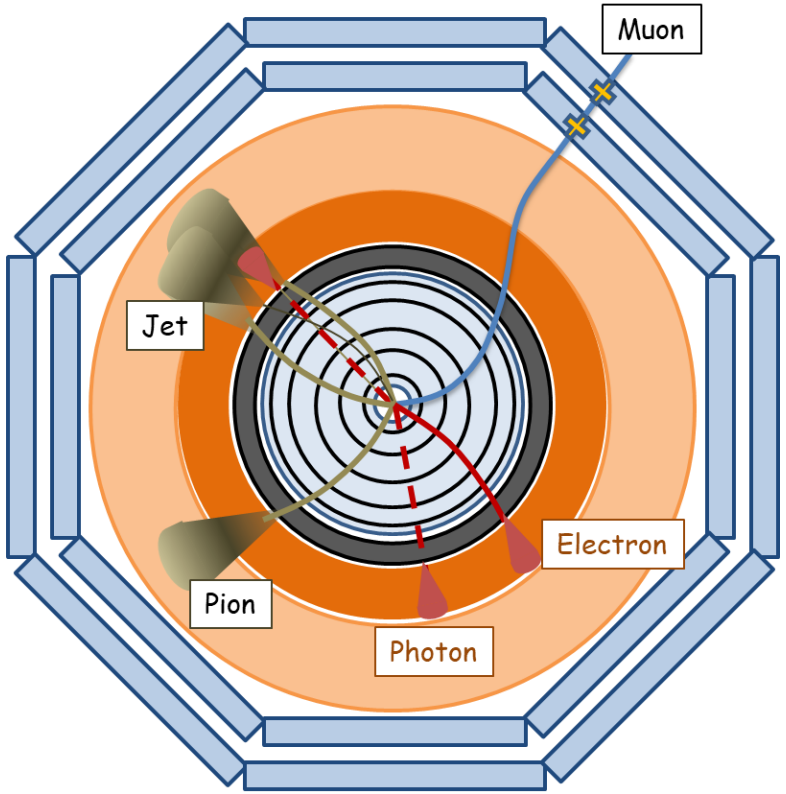
The muon spectrometer of the ATLAS detector



Claude Guyot (CEA-IRFU)

What is a muon spectrometer?





Expected functionalities:

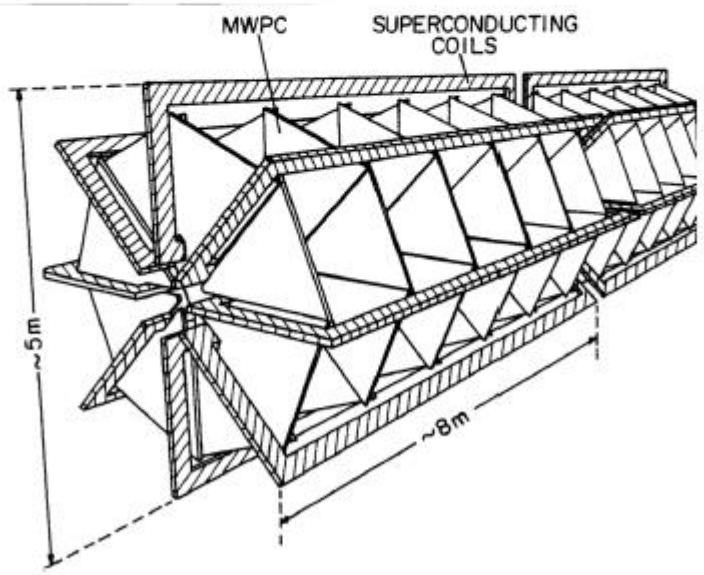
- Muon identification
- Triggering
- Momentum measurement (in addition to the ID measurement)

A bit of history

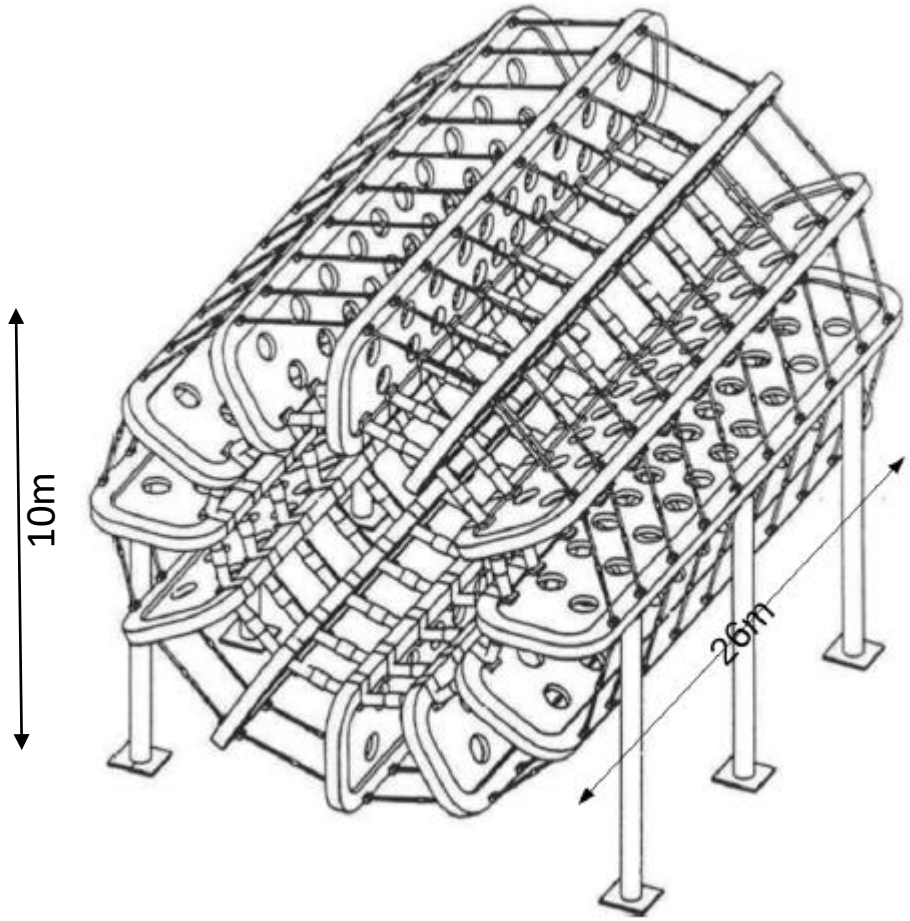
March 14, 1989

A new fixed-target experiment for precise tests of QCD

C.Guyot[1], A.Milsztajn[1], A.Ouraou[1], A.Staude[2], K.M.Teichert[2], and M.Virchaux[1]



Proposal for a fixed target muon scattering experiment based on an air core superconducting toroid magnet

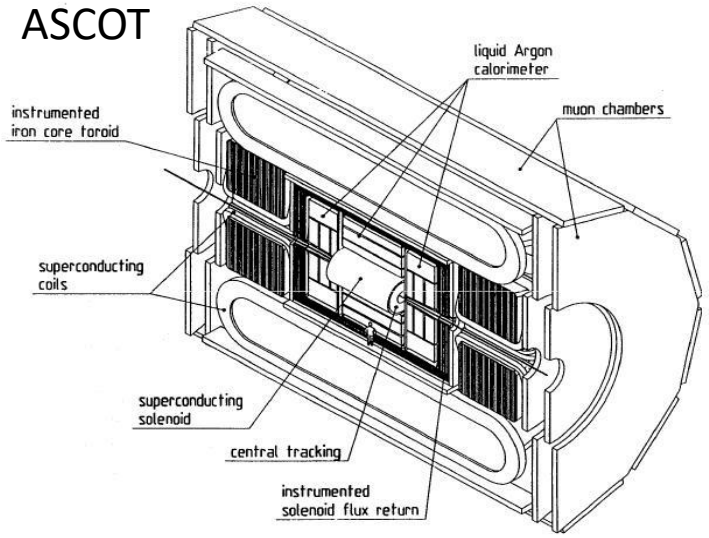


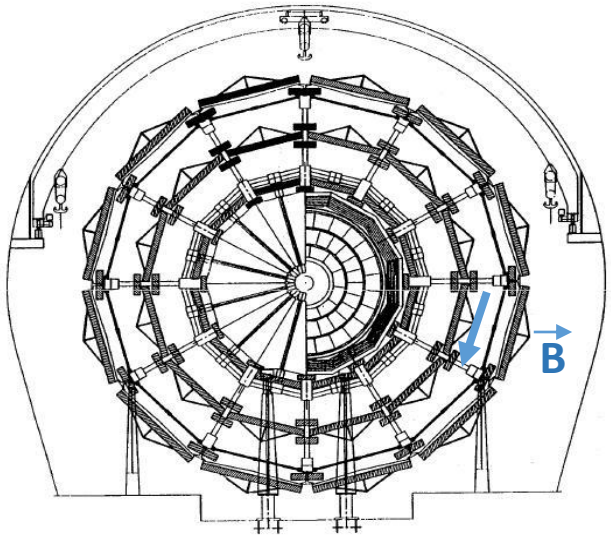
Magnet for the muon spectrometer of a LHC collider experiment

ASCOT and EAGLE proto-detectors

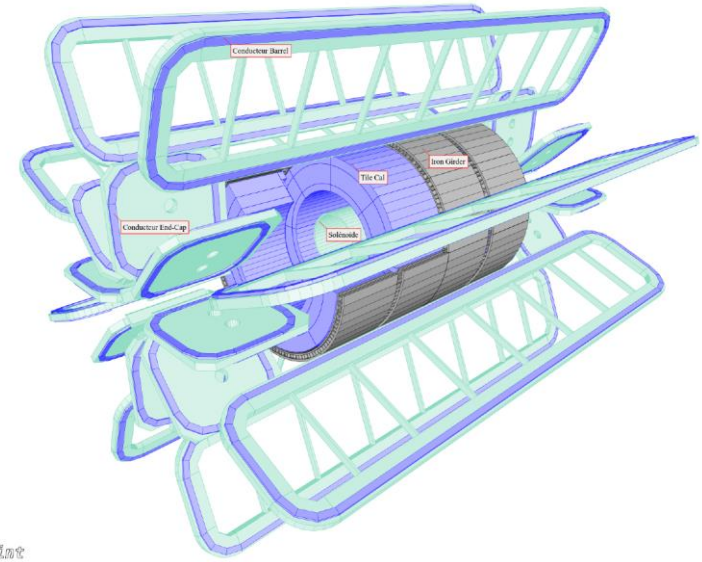
Evian-les-Bains workshop
March 1992

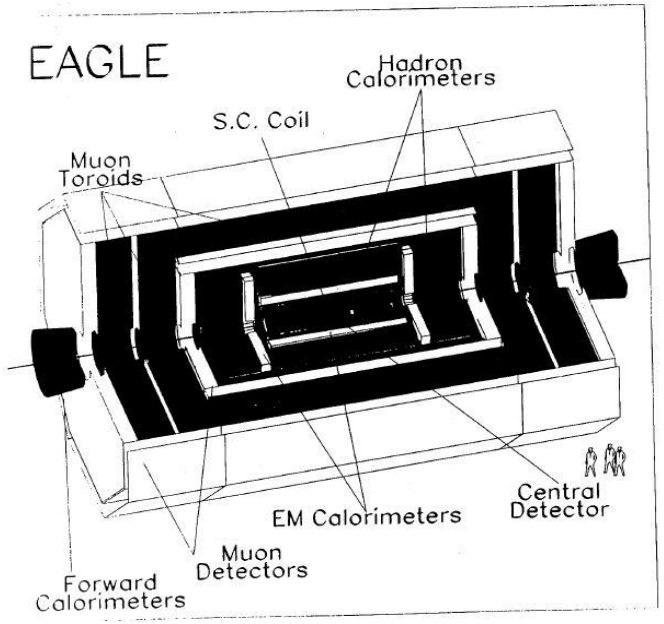
ASCOT

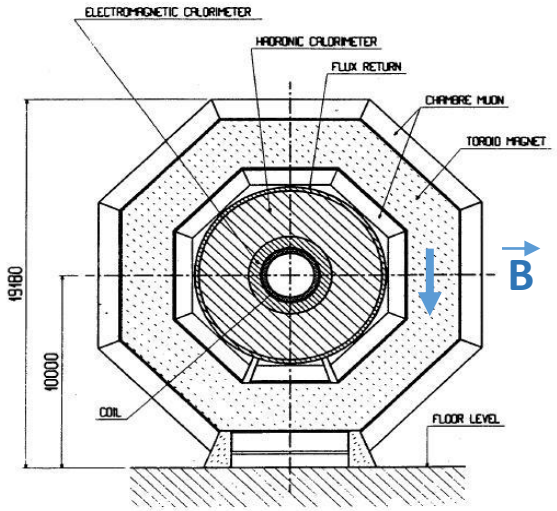




12 coils -> 8 coils





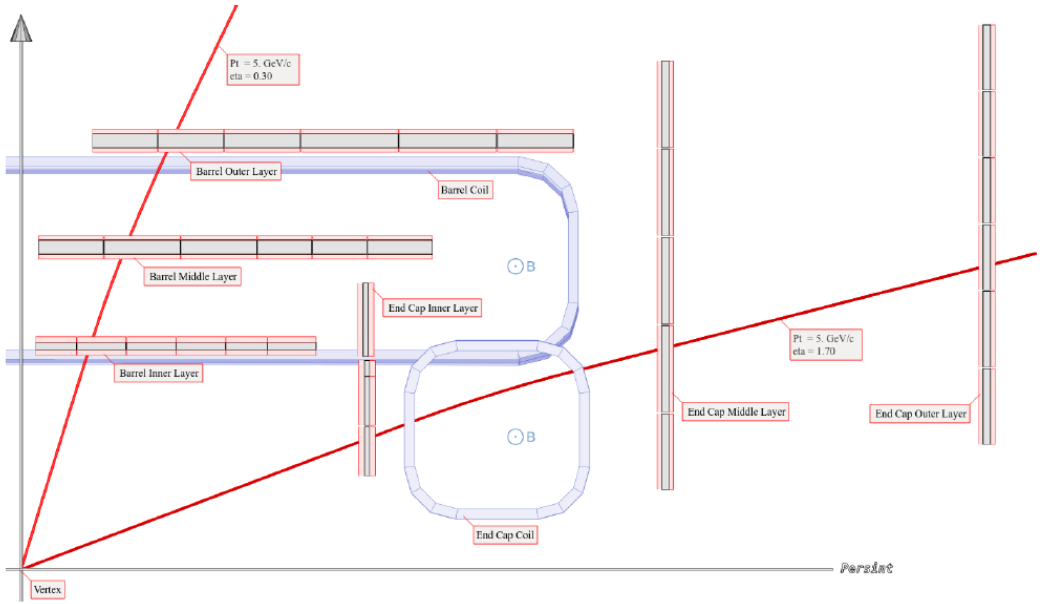


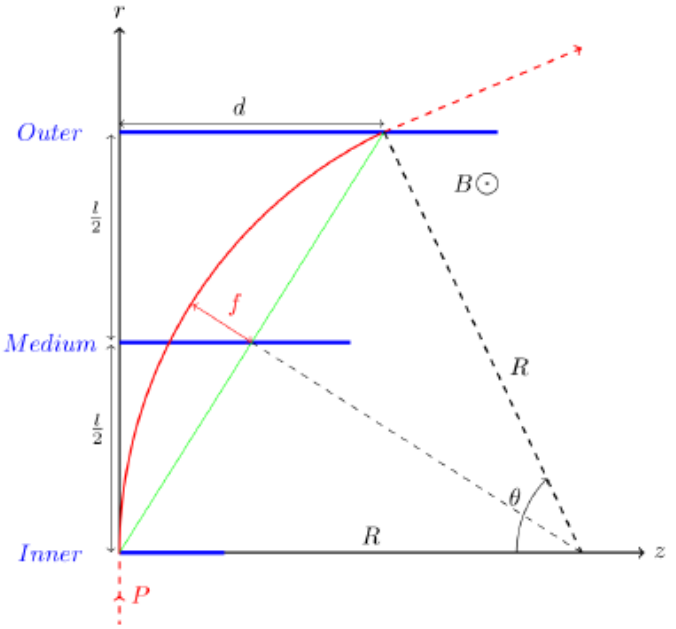
Motivations for an air core toroid based muon spectrometer

- **Toroid**: full coverage up to small polar angles in the forward region (large pseudo-rapidity up to $|\eta|$~2.7).

- **Air core magnet**: Stand alone capabilities with precision measurements comparable to that of the ID for low and medium energy muons (a few %)→ Possible backup in case of problems with track reconstruction in the ID (large occupancy, Si radiation hardness still a concern at the beginning of the 90's)

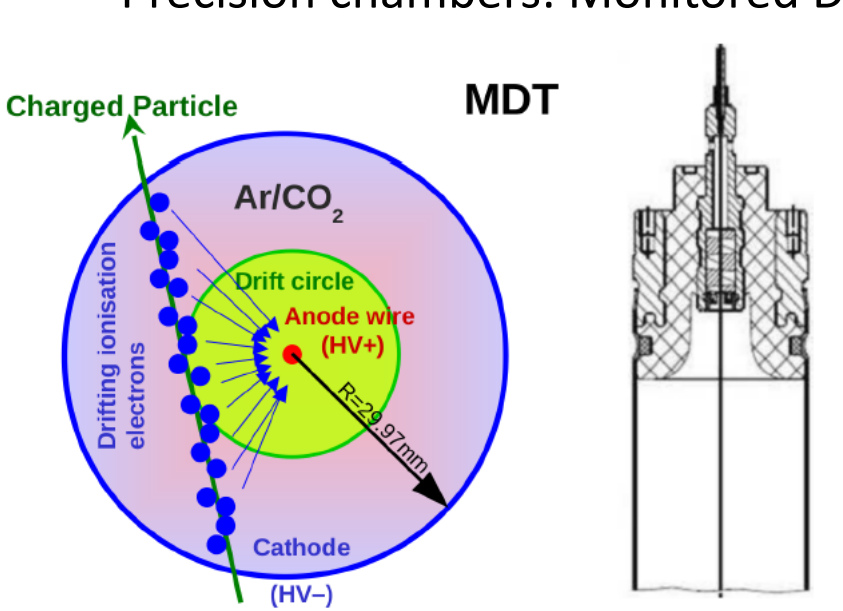
- Keep a good enough measurement precision at large momentum (>~500 GeV where the ID measurement degrades) for very high energy exploration.
  - Requirement: $\delta p_T/p_T$ ~ 10% for p_T = 1 TeV over the full pseudo-rapidity range $|\eta|$<2.7.
  - Translates into a 50 μm precision of the sagitta measurement with wire chambers (f~500 μm for p_T=1TeV)

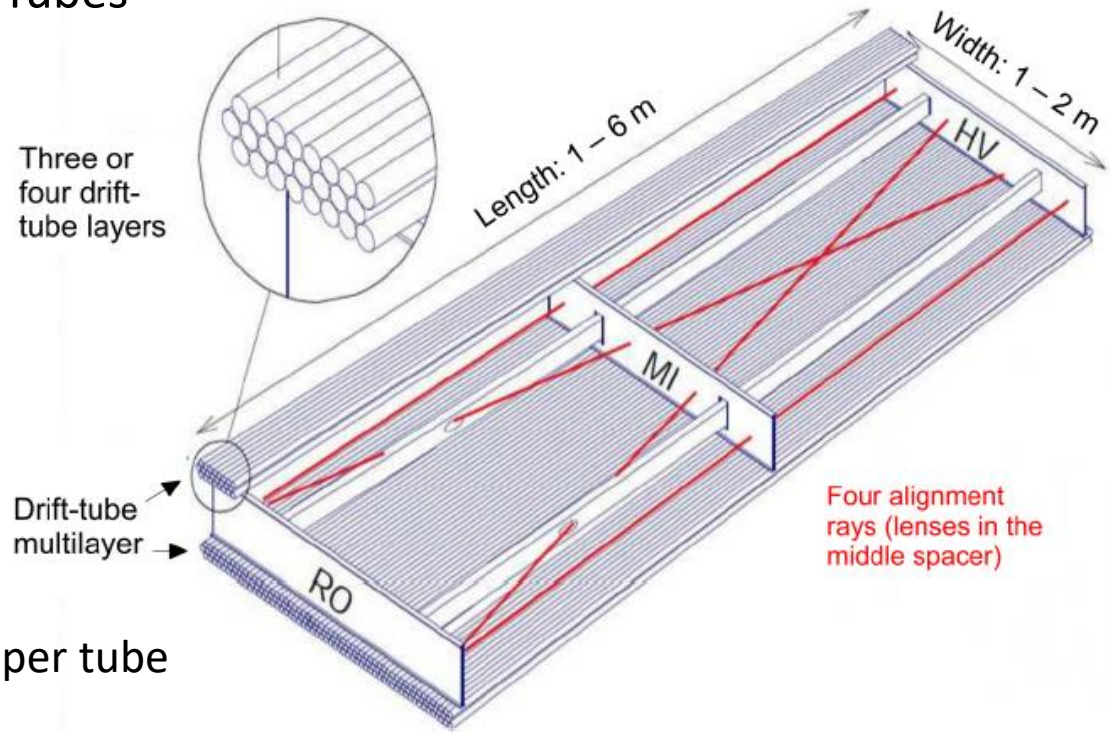


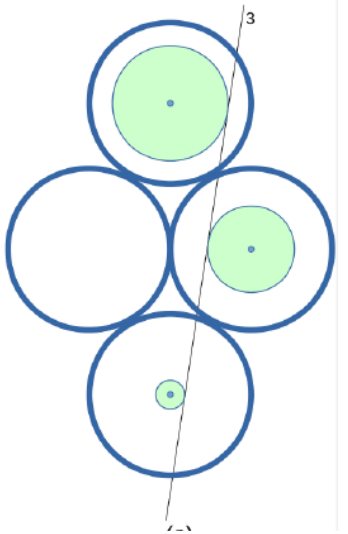


Chambers for the ATLAS muon spectrometer

- Precision chambers: Monitored Drift Tubes





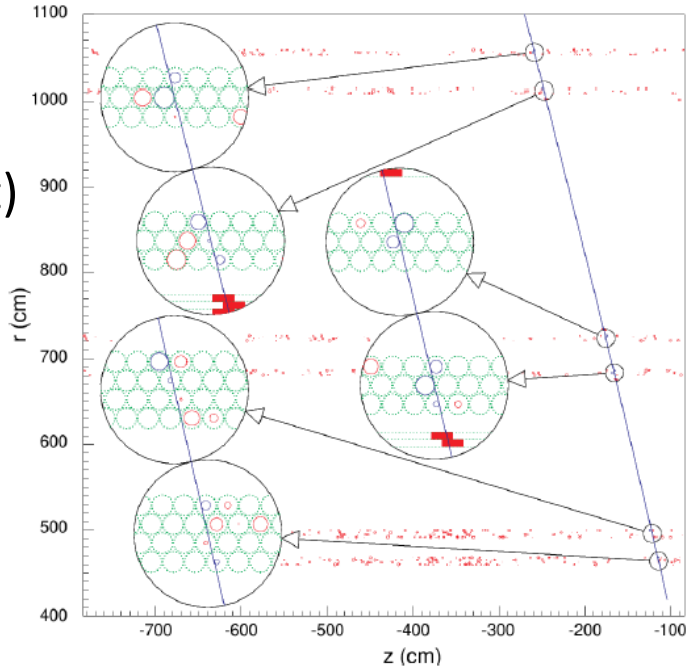


Average precision ~ 100 μm per tube

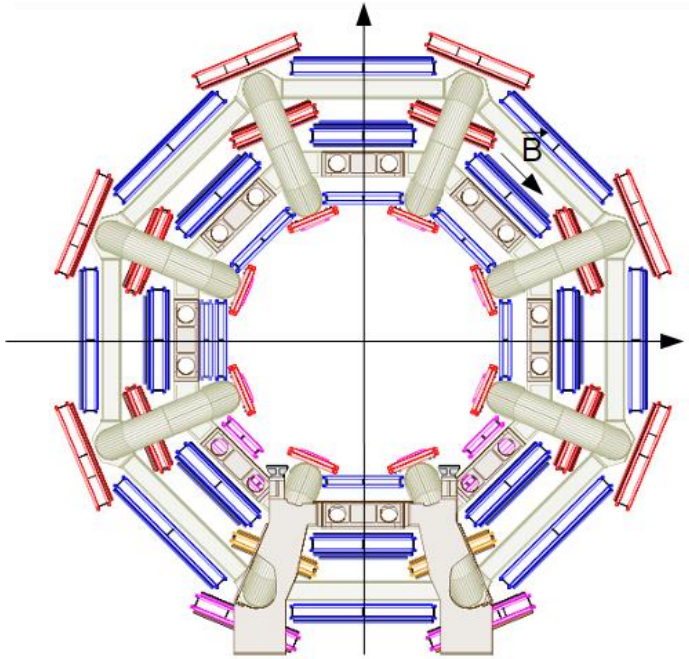
- Fast trigger chambers (also used for second coordinate measurement along the tube direction)
  - Resistive Plate Chambers (RPC) in the barrel
  - Thin Gap Chambers (TGC in the end caps)

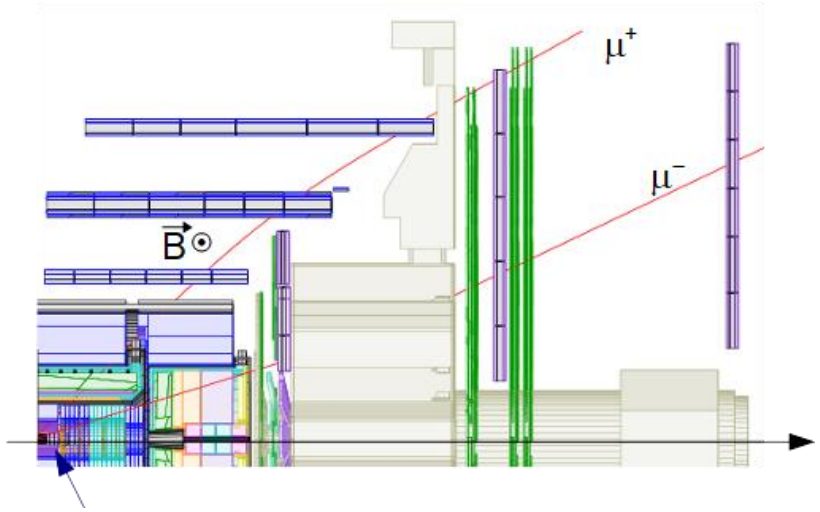
Contributions of the DAPNIA/IRFU group (1)

- Track reconstruction (pattern recognition and momentum measurement)
  - Muonboy program used until 2012



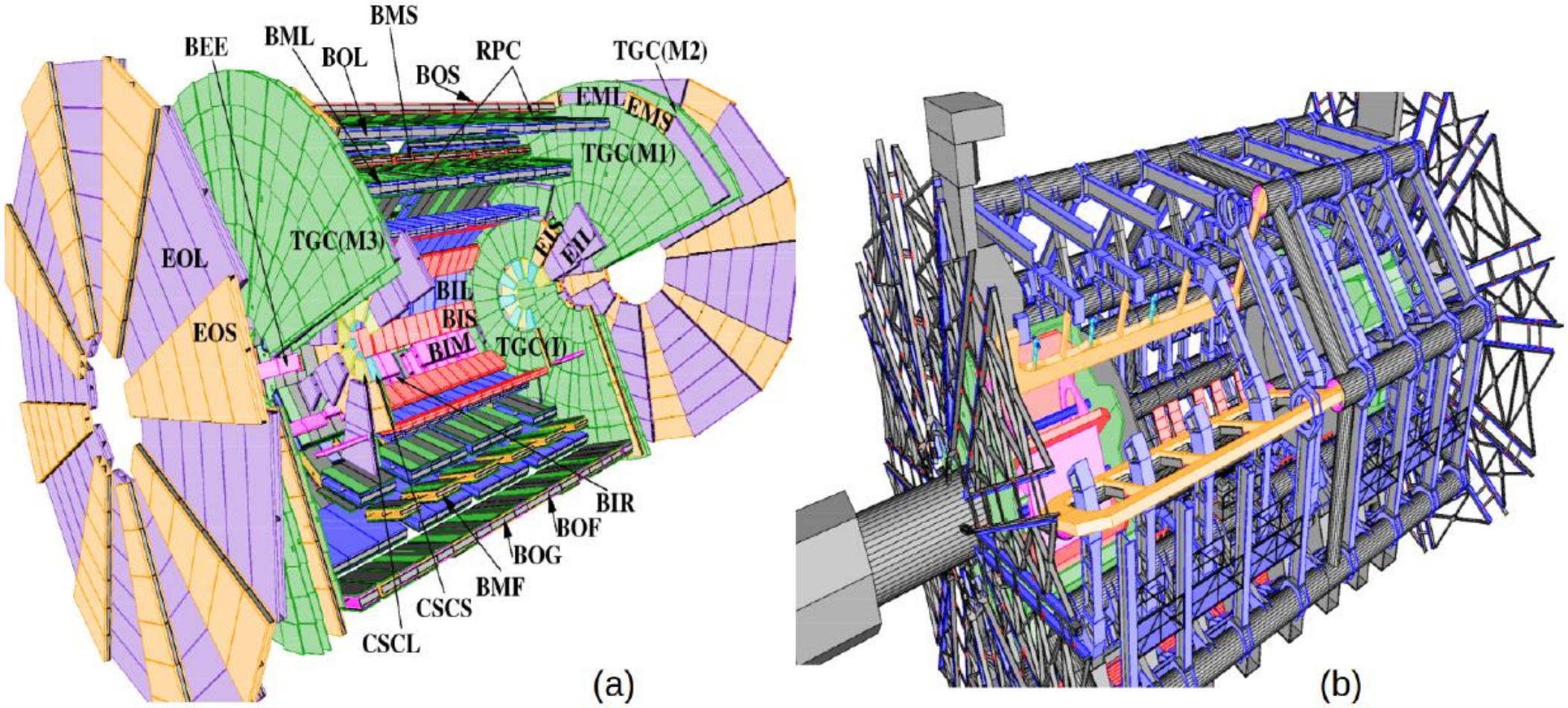
- Optimisation of the chambers layout





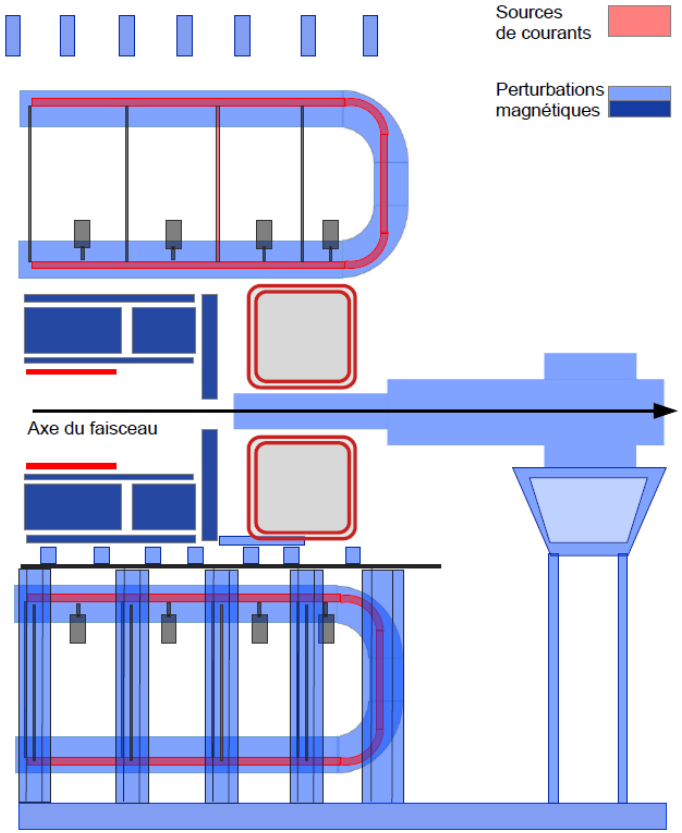
- Full muon spectrometer description (active chambers and structural supports)
  - → ATLAS data base
- Event display program (Persint)

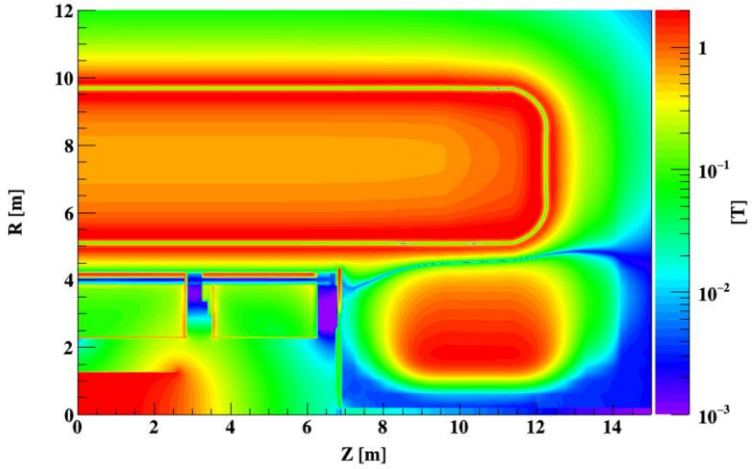
Detector description

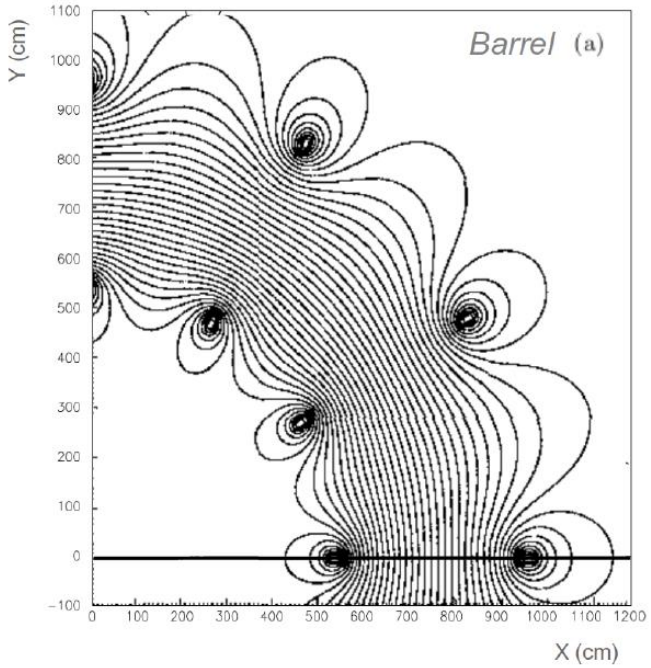


Contributions of the DAPNIA/IRFU group (2)

- Mapping of the inhomogeneous magnetic field
  - Account for the presence of ferromagnetic material

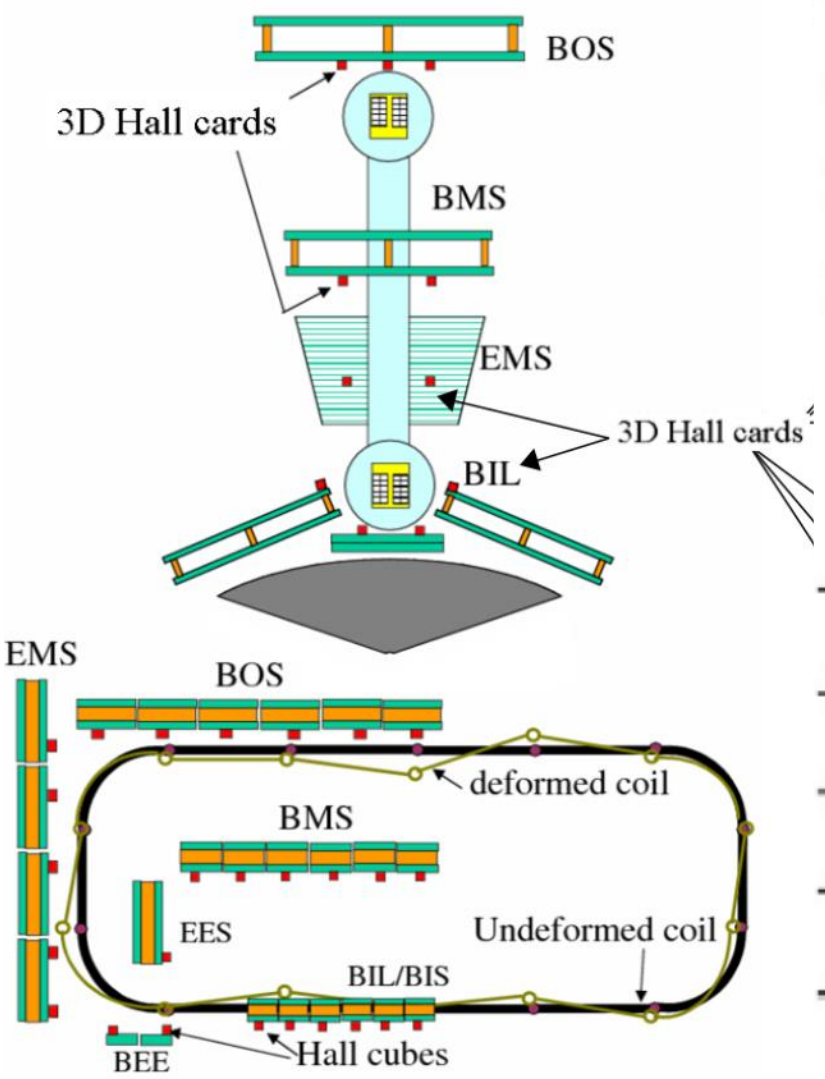


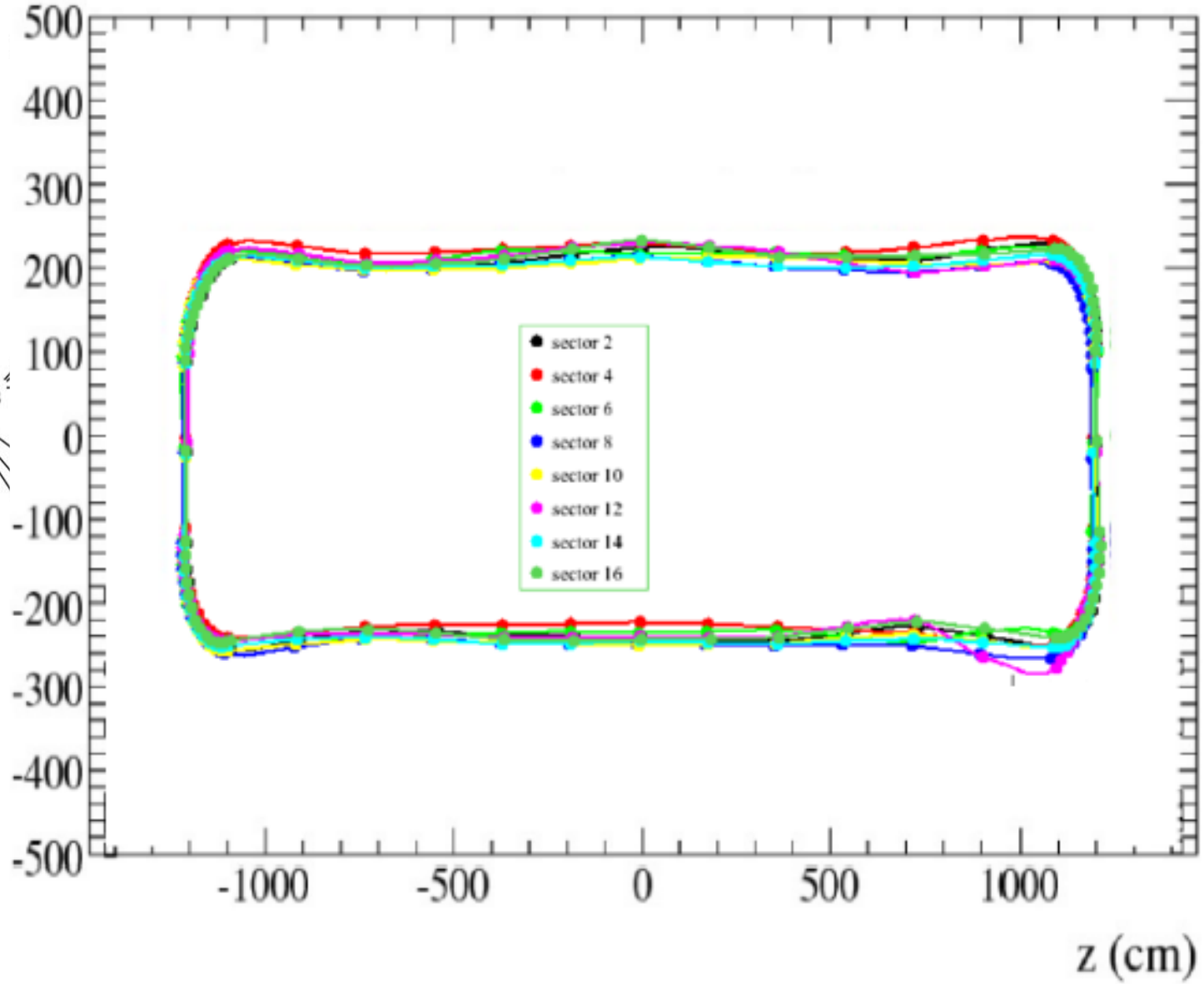




- Reconstruction of the exact toroid coil shape (at the mm level) using 3D Hall probes (DIS/DEDIP)

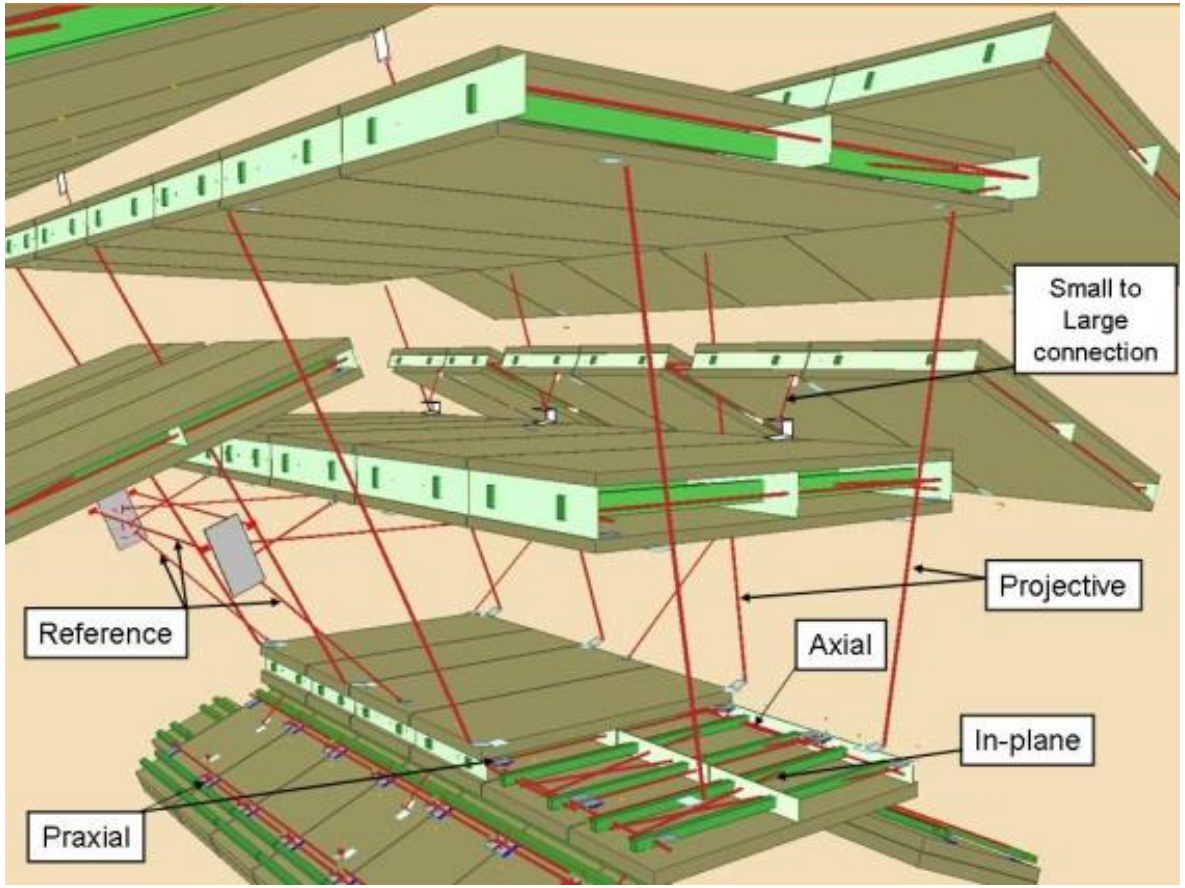
Toroid shape reconstruction using Hall probes (~1700)



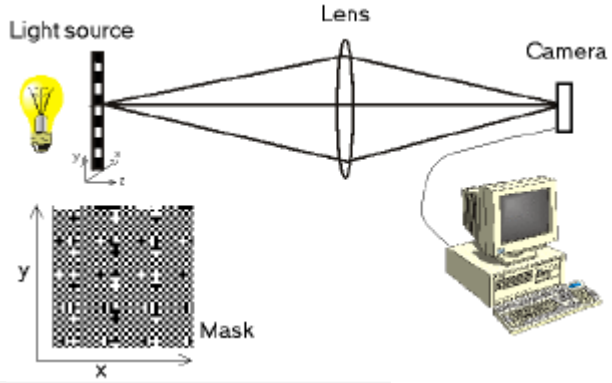


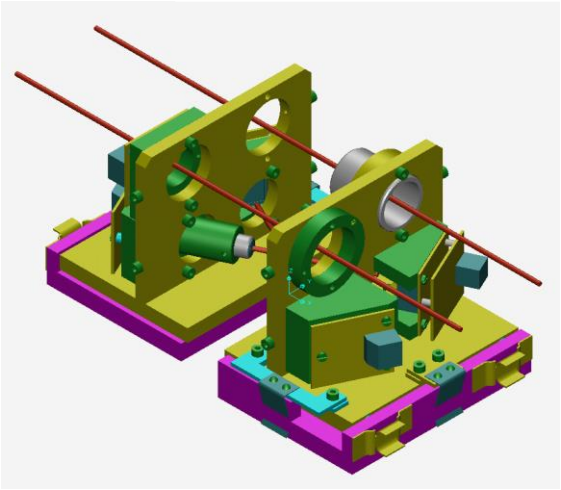
Contributions of the DAPNIA/IRFU group (3)

- Design, construction, installation and exploitation of the alignment system of the barrel part of the spectrometer (DIS-DEDIP)



Based on ~5000 RASNIK systems

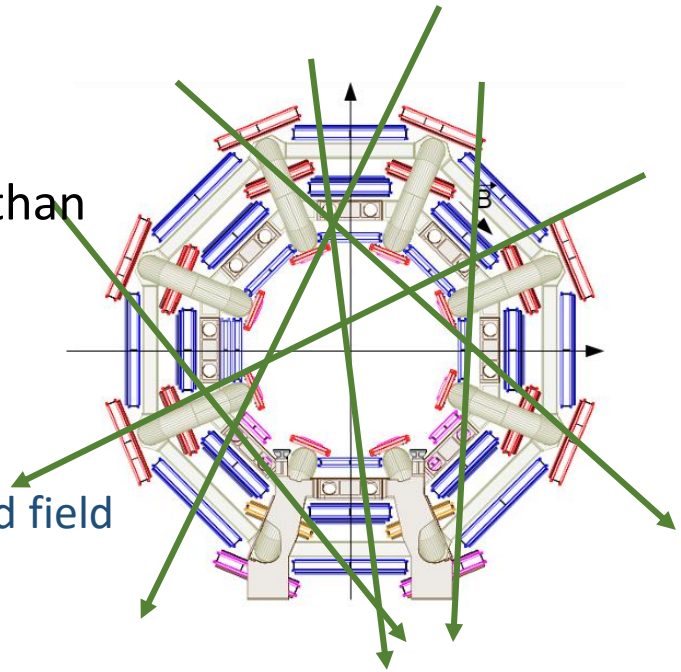




Example of a Praxial optical detector for the measurement of adjacent chambers positions

Alignment of the ATLAS muon spectrometer

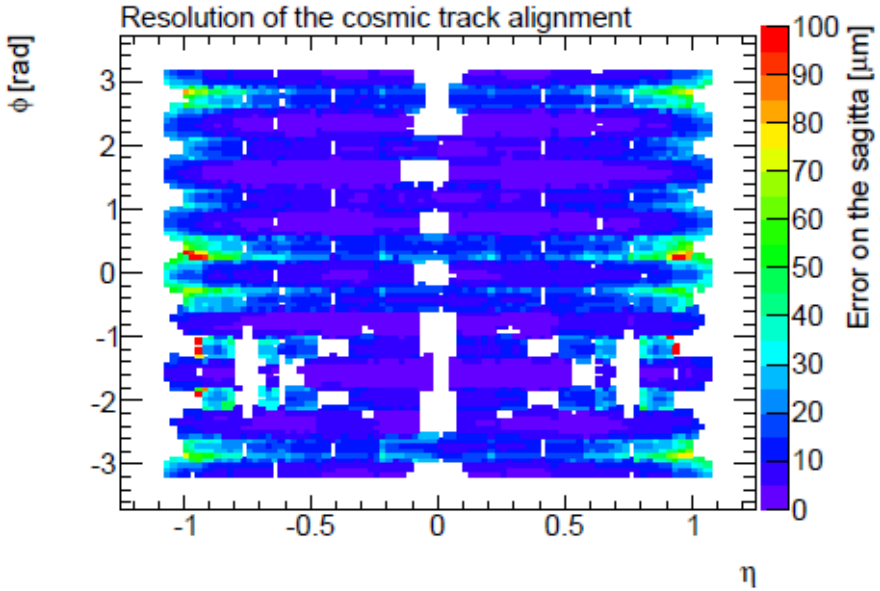
Several data sets used to achievement the final alignment at a precision better than 50 μm on the measured sagitta.



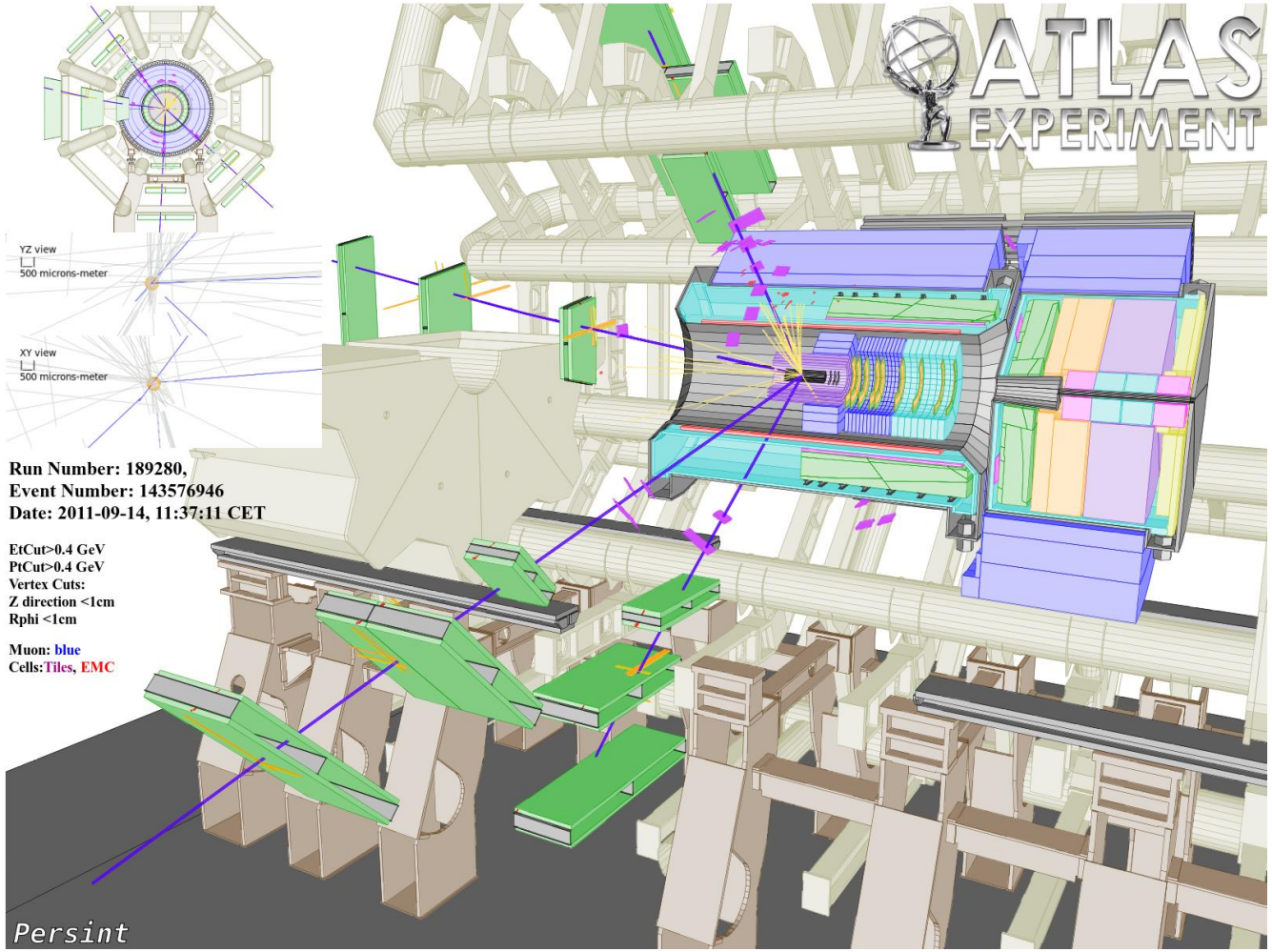
- Calibrated optical detectors
  - Provide absolute chamber positions with a precision of ~100-200 μm
  - Used to follow chamber displacements with time and between field off (B=0) and field on runs with a precision of better than 10 μm

- Cosmic tracks (B=0) used for the 3D reconstruction of all (~200) barrel chambers
  - Global fit using tracks (~50M) and optics (~5000 RASNIKs)

- Collision tracks (field off and field on) used to:
  - align barrel w.r.t. EC,
  - muon spectrometer w.r.t. ID,
  - align chambers not connected with the optical system
  - check the cosmic+optical sensors combination



H→ZZ(*)→4 muons


ATLAS
EXPERIMENT
YZ view
500 microns-meter
XY view
500 microns-meter
Run Number: 189280,
Event Number: 143576946
Date: 2011-09-14, 11:37:11 CET
EtCut>0.4 GeV
PtCut>0.4 GeV
Vertex Cuts:
Z direction <1cm
Rphi <1cm
Muon: blue
Cells:Tiles, EMC
Persint

Many thanks to my colleagues, physicists, engineers and technicians, who contributed to the design, construction and successful exploitation of the ATLAS muon spectrometer.

With a special thought to those whose left us prematurely:
Marc Virchaux, Florian Bauer, Ahmimed Ouraou

For a detailed description of the ATLAS muon spectrometer:
HDR de Laurent Chevalier

Extra slide

Momentum precision measurement using the muon spectrometer only