ATLAS Muon Testbeam 2004

Rachel-Maria Avramidou
University of Michigan

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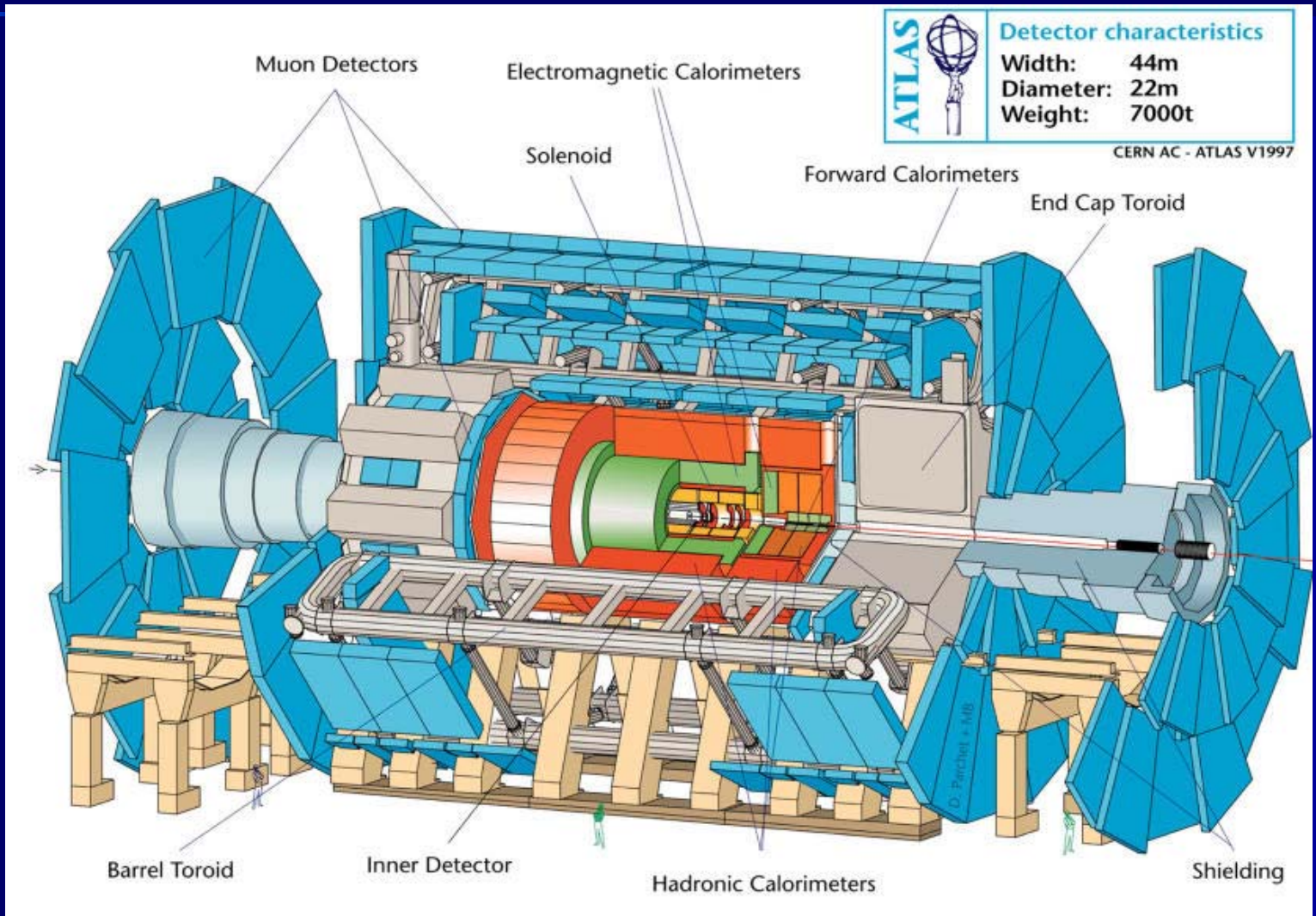
Outline

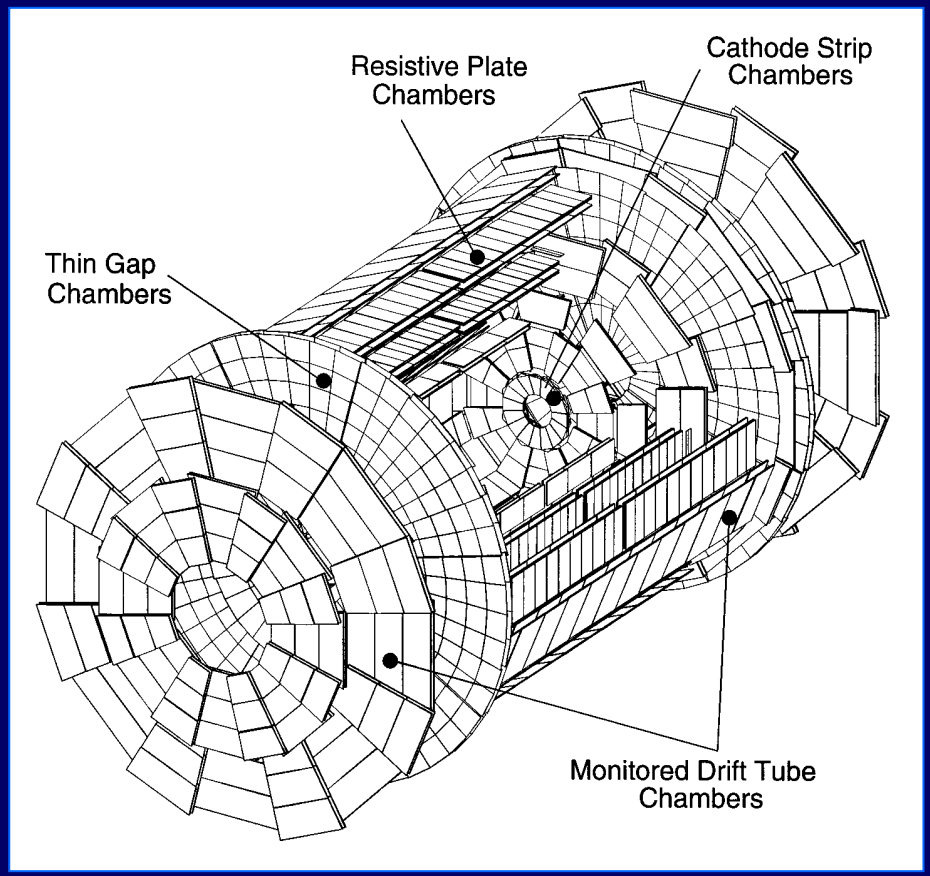
- ATLAS Detector
- Muon Spectrometer
- Muon testbeam 2004
  - Setup
  - Test beam objectives
  - Data Sets
  - Analysis methods
  - Results
- Combined testbeam 2004
- Conclusions

ATLAS Detector



Muon Spectrometer – Muon Drift Chambers

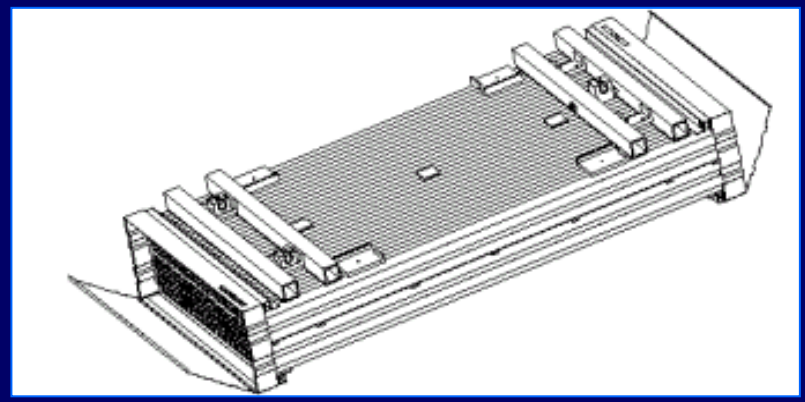
Muon Spectrometer



Stand-alone Muon Spectrometer

$H \longrightarrow \mu^+\mu^-\mu^+\mu^-$

Muon Drift Chamber

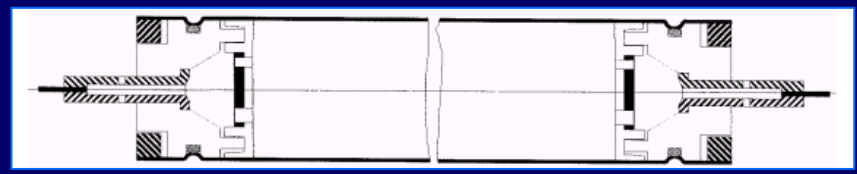


2 multilayers in a distance 7 mm

8 layers

30 drift tubes per layer of length 1.7 m

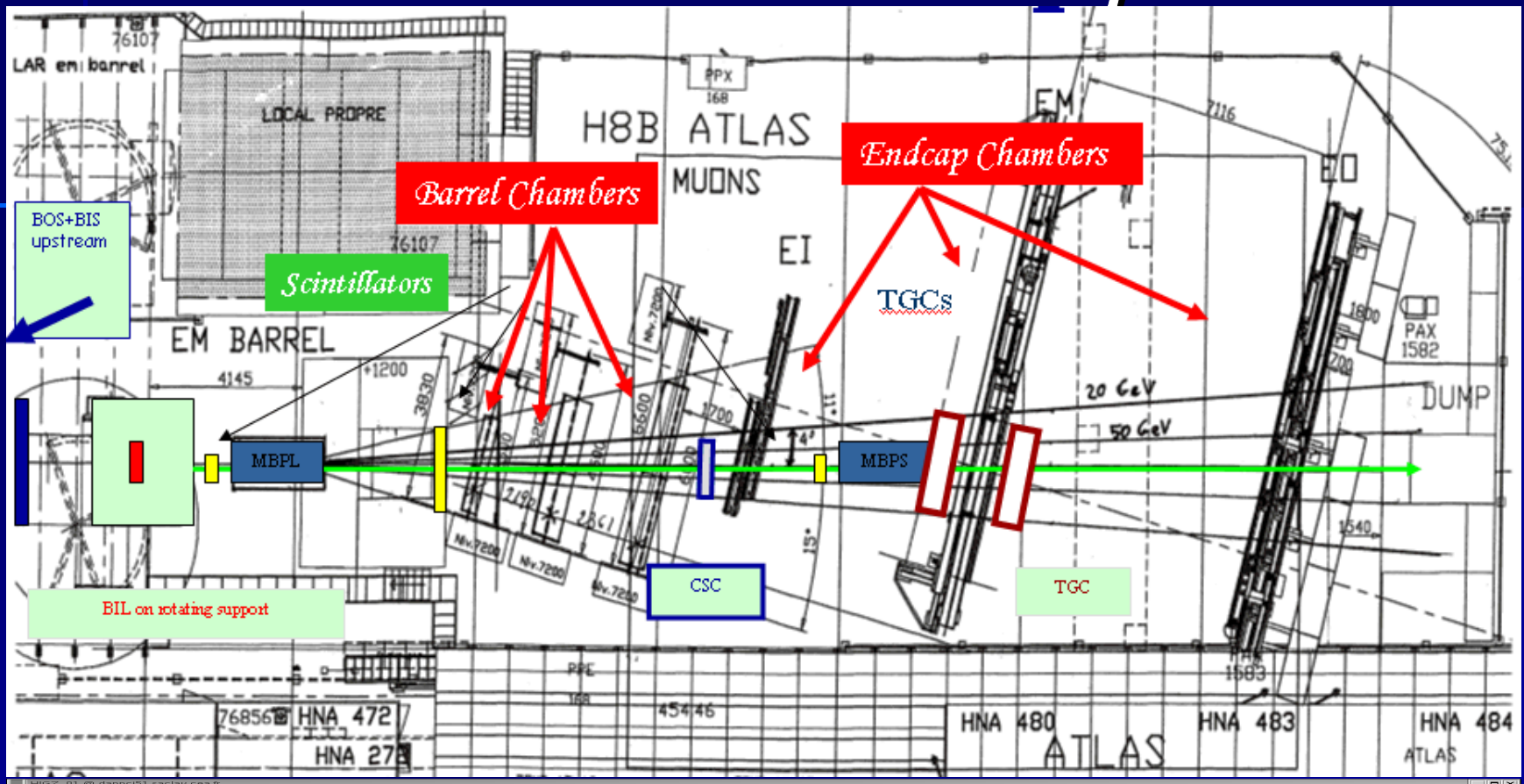
Muon Drift Tube

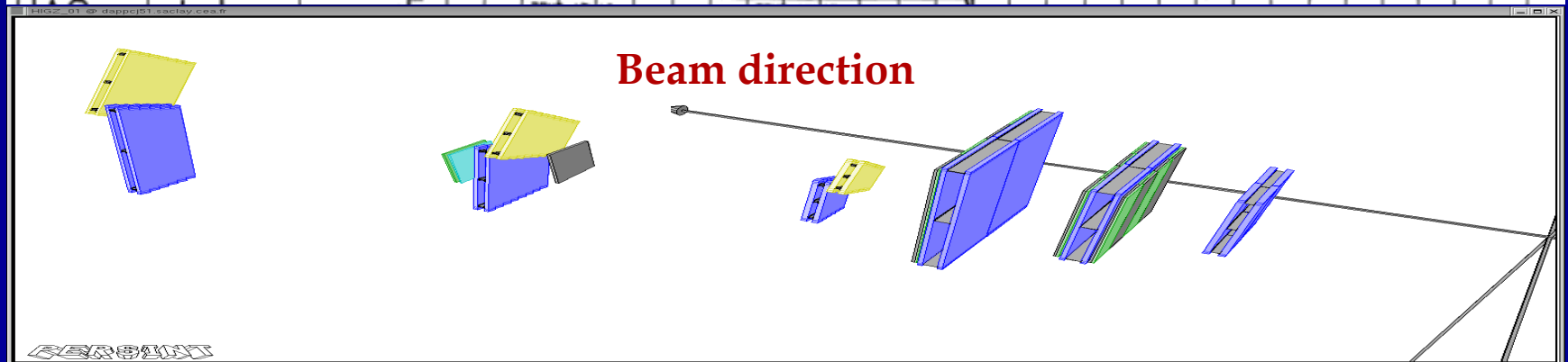


Aluminium tube of diameter 30 mm

Anode wire W-Re of diameter 50 μm

Muon H8 Setup





H8 Muon Testbeam 2004

The 2003 muon setup included

6+3 barrel MDTs fully equipped with alignment system and elx

4 RPC BML (low-Pt) stations and 2 RPC BOL (high-Pt) stations equipped with elx

6 EC MDTs fully equipped with alignment system and elx

1 TGC triplet and 2 TGC doublets equipped with trigger elx

2 beam magnets used to steer the beam

Scintillator triggers (10×10 cm^2 , 60×100 cm^2)

Data analysis

Studies of long term stability of MDT performance and readout (r(t) relations, noise, inefficiencies, single tube resolution, sagitta resolution, comparison with G4)

Alignment tests: studied with large displacements and induced deformations

RPC and TGC: detector and trigger performance

Software

Athena framework (reconstruction with Moore and Muonboy, Ntuples for the analysis)

Calib (Rome), Mutrak (Michigan), Munich code for calibration

2004 Testbeam was successful
Aims achieved and many analyses have been done

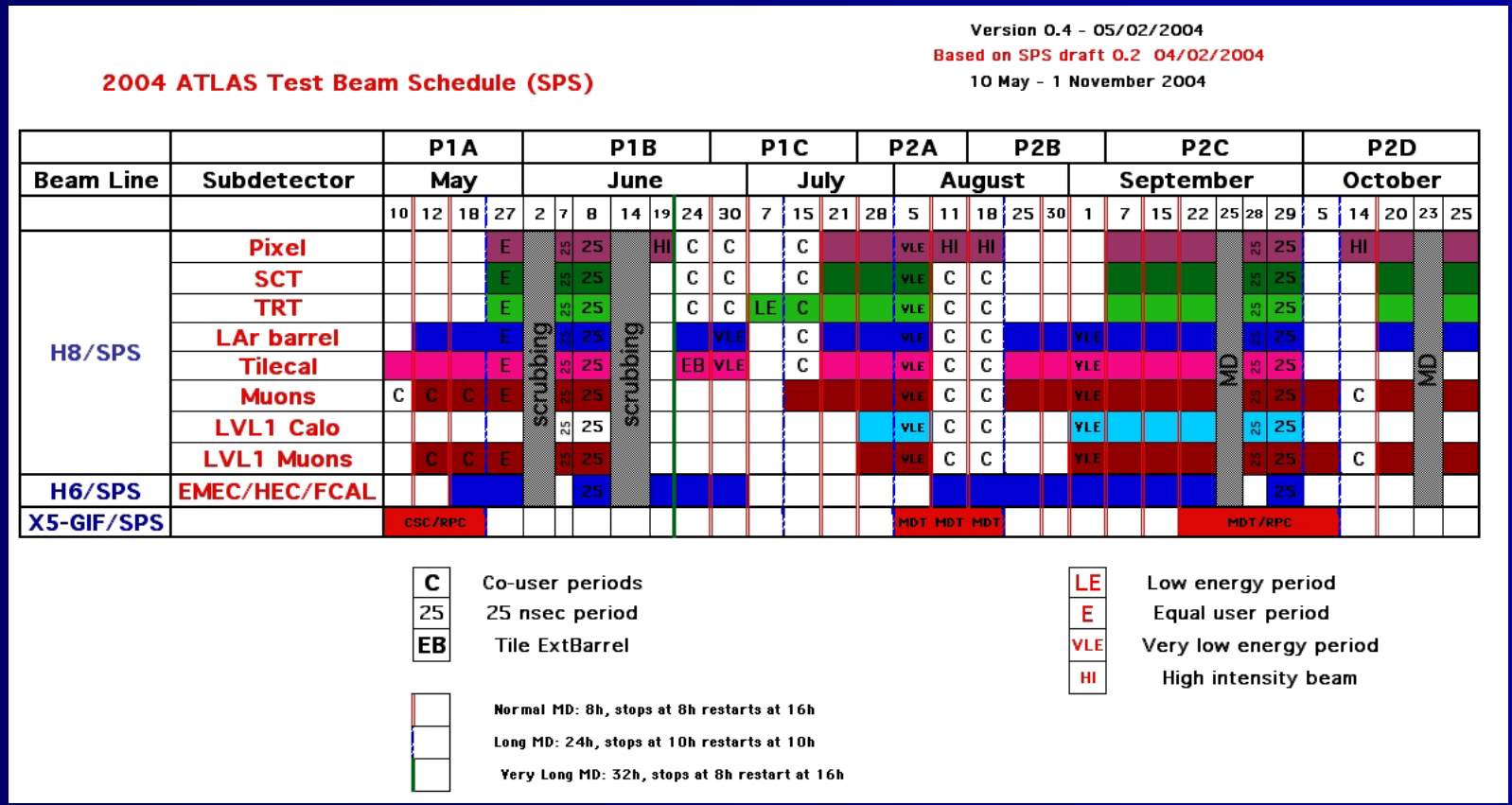
Electronics Studies

*A survey of data for *ALL* H8 chambers has been done*

Endcap chambers 1920 channels (0 problematic channels)
Barrel chambers 2016 channels (7 problematic channels-0.3%)

99.8 % of channels functioned as expected

Testbeam 2004 program



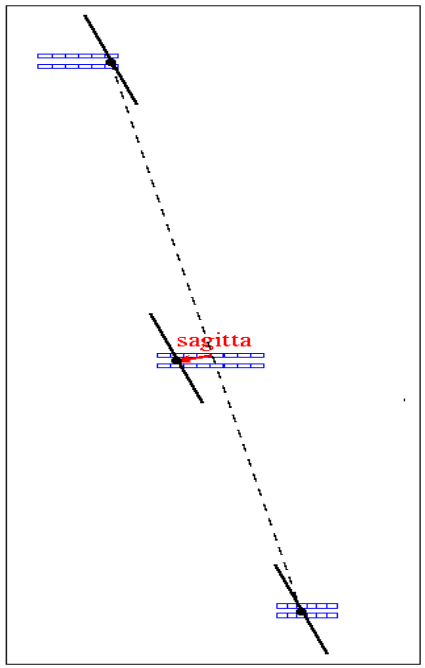
Measurement program for 2004 test

Quite ambitious program for the muon spectrometer system

- General stability and uniformity test
- Study of sagitta resolution
- Alignment studies with calibrated systems
- Beam muons momentum measurement
- Test of CSC chambers performance
- Test of RPC and TGC performance (new electronics)

Sagitta Studies

Motivation: **Determination of the sagitta width as a function of beam energy (100-250 GeV) for the muon chambers and comparison with the results coming from G4 simulation.**



Sagitta definition

Distance of closest approach of EML impact parameter to the line connecting EIL-EOL superpoints.

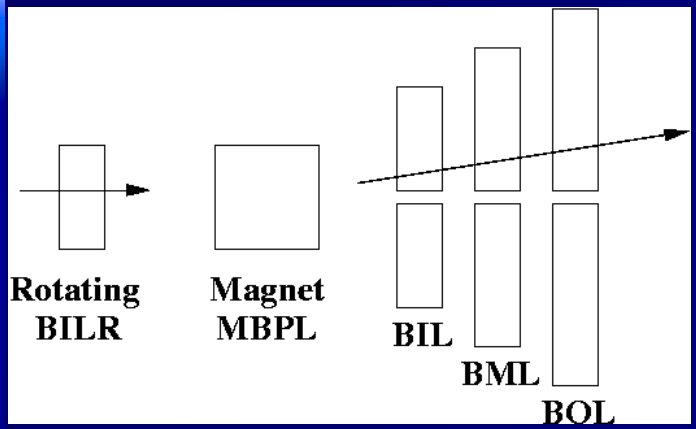
Sagitta

- ✓ **Sagitta reconstruction based on EIL/BIL, EML/BML, EOL/BOL segments**
- ✓ **Second coordinate information taken from BOL/BML-RPC**

Athena framework - Moore

- ✓ **Release 10.0.0**
- ✓ **Calibration files from CALIB package**

Sagitta Studies



Procedure

- A run with Rotating BILR moving

For the r-t relation measurement

- A run with Rotating BILR fixed and magnet current OFF (0 A)

For the measurement of the misalignment between BILR and Barrel/Endcap chambers

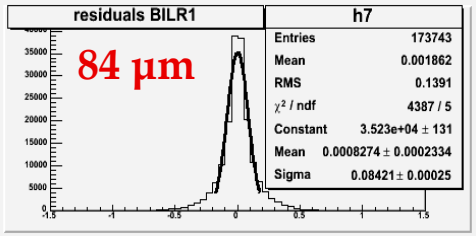
- A run with Rotating BILR fixed and magnet current ON (600 A)

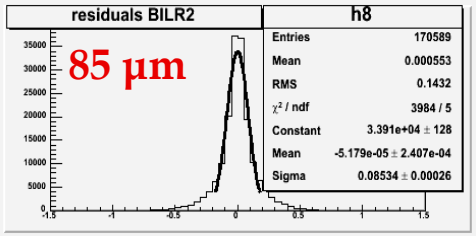
For the measurement of the beam momentum and the Barrel/Endcap chambers sagitta

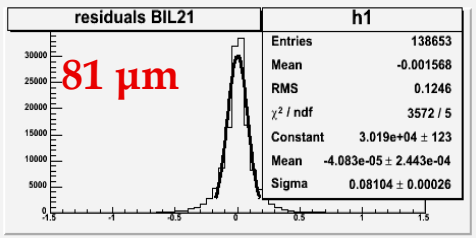
Nominal momentum	Run files	Threshold	Trigger
250 GeV	600724-600725	40 mV	10×10
220 GeV	600847-600850	40 mV	10×10
180 GeV	600964-600966	40 mV	10×10
150 GeV	601089-601095	40 mV	10×10
100 GeV	601131-601135	40 mV	10×10

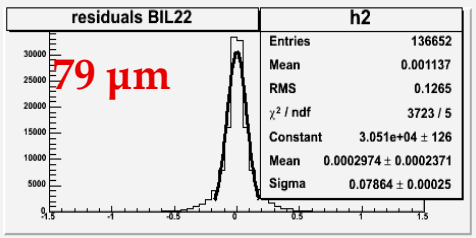
Sagitta Studies

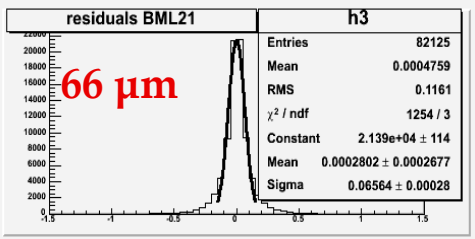
RUN 600964

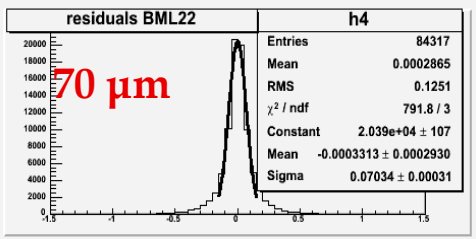


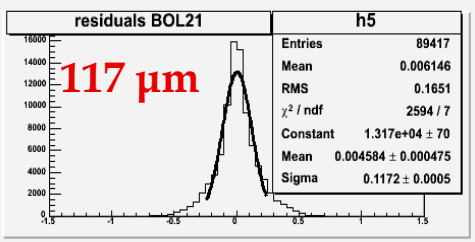


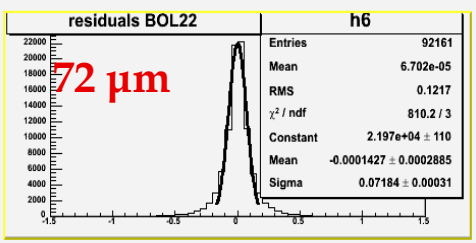


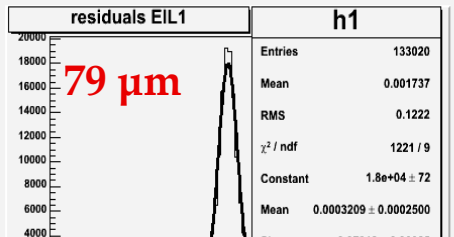


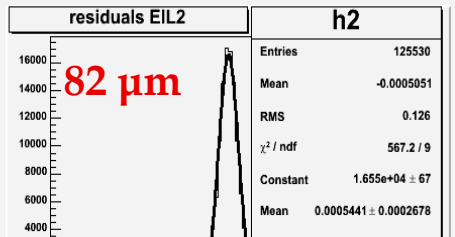


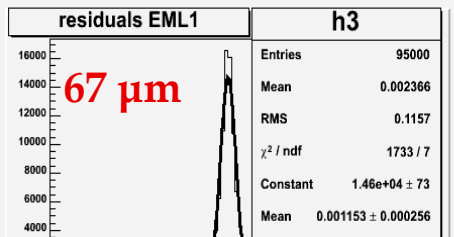


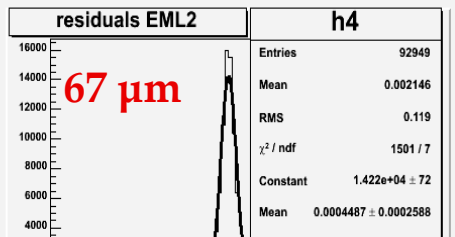


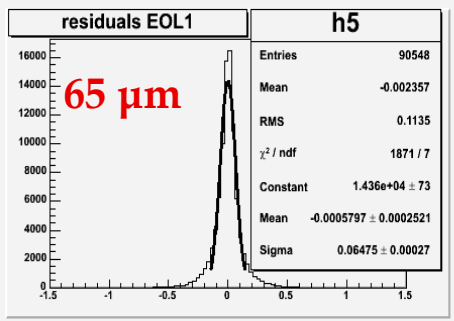


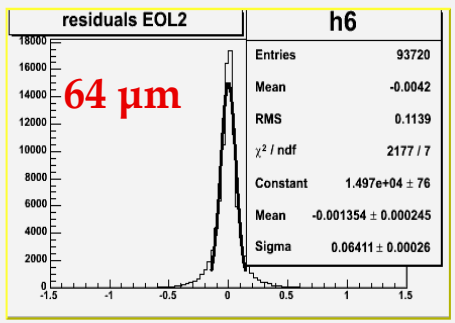






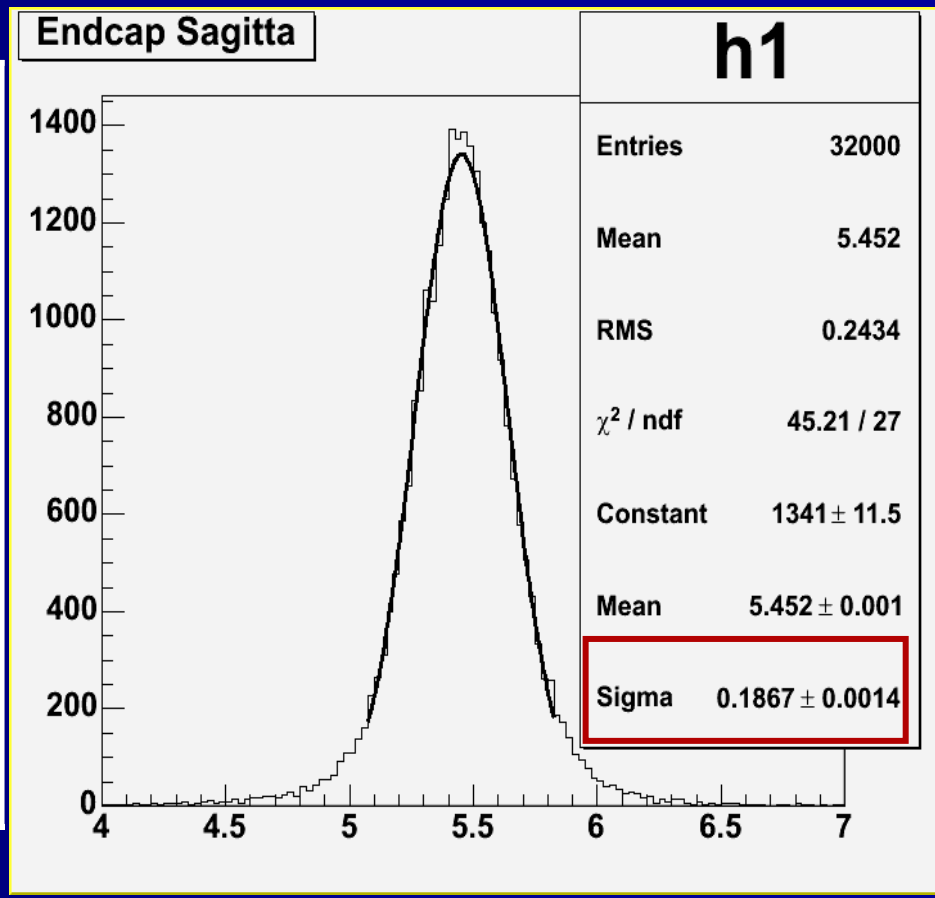






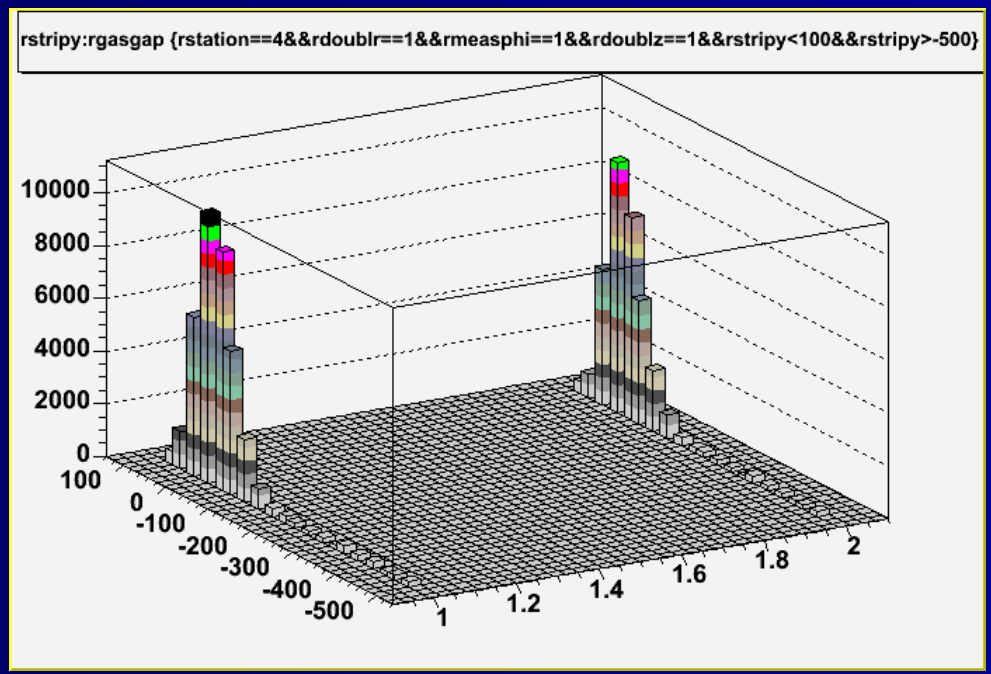
Sagitta Studies – No RPC Cuts

Beam Energy (GeV)	Sagitta Width (μm)
250	187 ± 1
220	193 ± 1
180	223 ± 2
150	256 ± 3
100	350 ± 4



Sagitta Studies

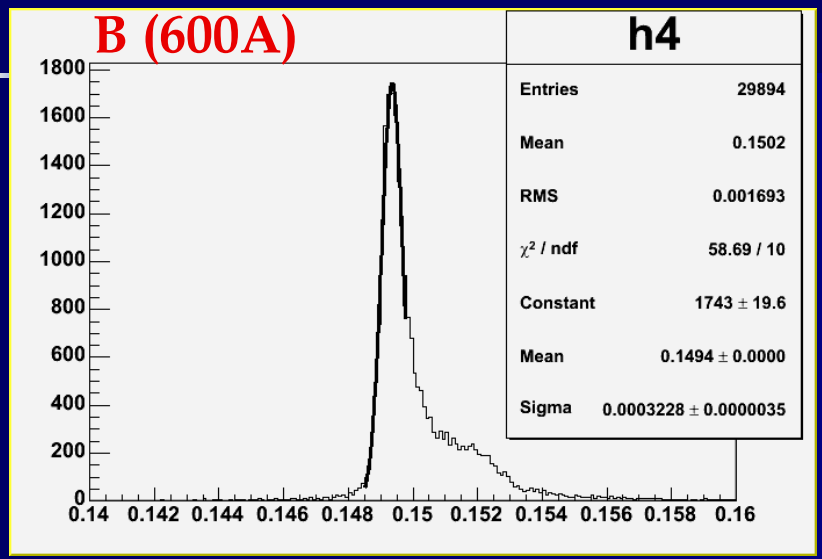
BOL RPC

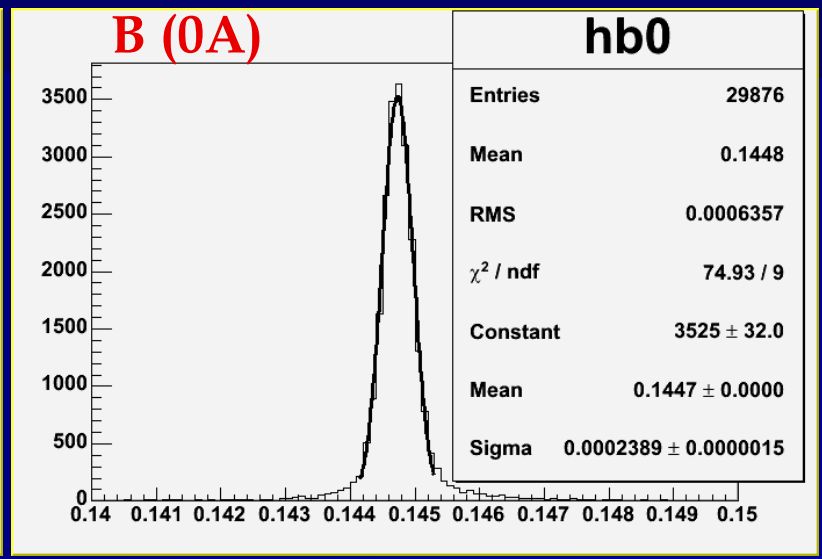


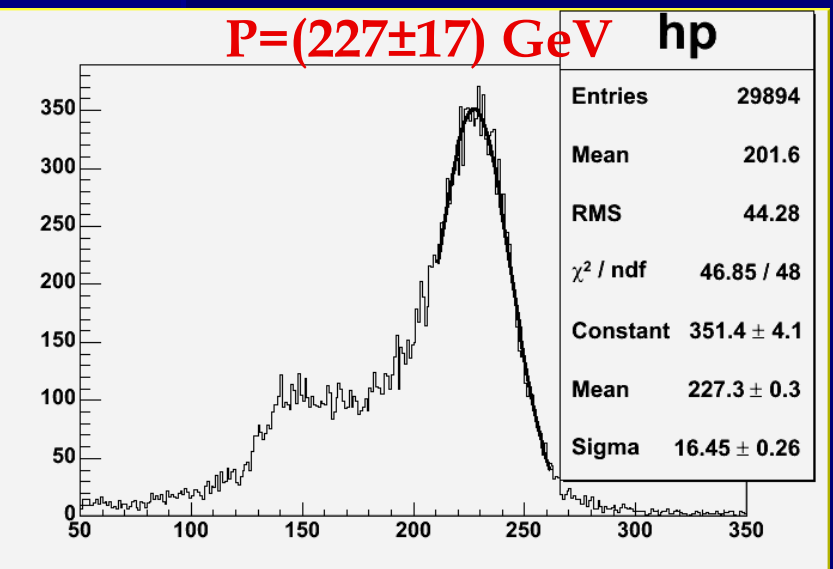
Selection of the four most illuminated strips

Sagitta Studies – P Cuts

RUN 600724







$$P(GeV) = \frac{0.3BL(Tm)}{\Delta\vartheta(B,600A) - \Delta\vartheta(0,600A)}$$

$$\Delta\vartheta(B,600A) = \vartheta^{(B,600A)}_{BarrelSegment} - \vartheta^{(B,600A)}_{BILRSegment}$$

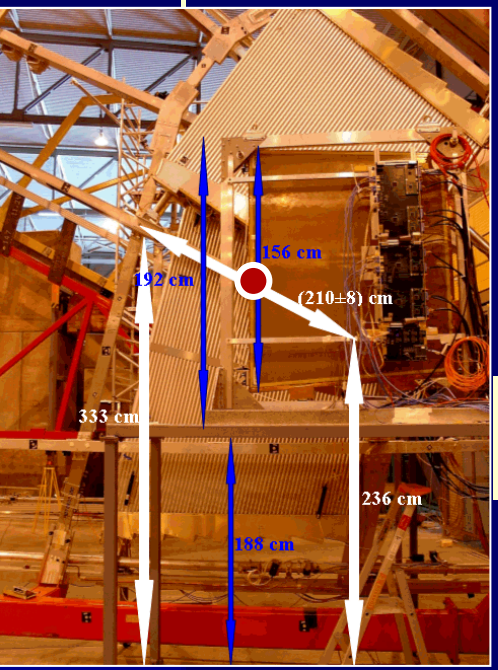
$$\Delta\vartheta(B,0A) = \vartheta^{(B,0A)}_{BarrelSegment} - \vartheta^{(B,0A)}_{BILRSegment}$$

Sagitta Studies – P & RPC Cuts

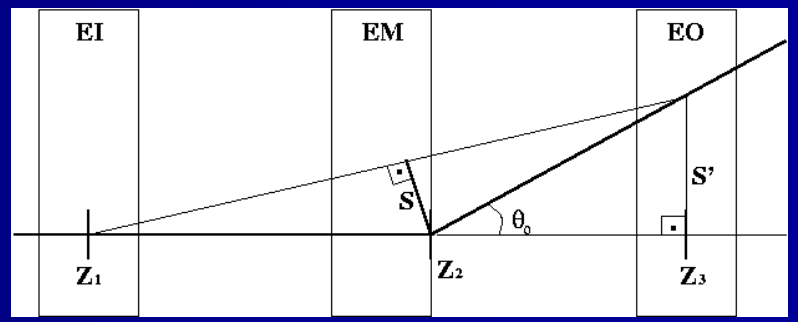
Momentum (P-σ<P<P+σ) + RPC cuts

Beam Momentum (GeV)	*Measured Momentum (GeV)*	*Barrel Sagitta Width (μm)*	*Endcap Sagitta Width (μm)*
250	227 ± 17	65 ± 3	164 ± 8
220	204 ± 12	66 ± 1	175 ± 8
180	165 ± 7	70 ± 1	209 ± 14
150	137 ± 6	83 ± 1	242 ± 17
100	89 ± 5	102 ± 3	330 ± 16

Sagitta Studies – Endcap chambers Multiple Scattering contribution



Multiple scattering contribution to sagitta resolution



$$\sigma(S_{m.s.}) = \frac{(Z_2 - Z_1)(Z_3 - Z_2)}{(Z_3 - Z_1)} tan\theta_0$$

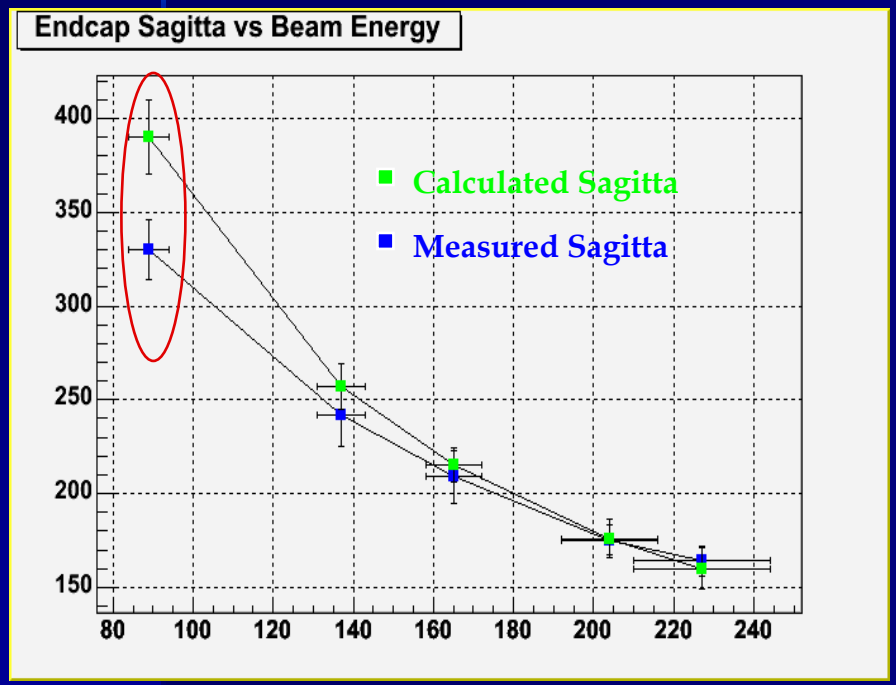
where

$$\theta_0 = \frac{13.6\,MeV}{p}\sqrt{x/X_0}\left[1 + 0.0038\,ln(x/X_0)\right]$$

Total Sagitta $\sigma(S) = \sqrt{\sigma(S^2_{i.r.}) + \sigma(S^2_{m.s.})}$

Beam Momentum (GeV)	Sagitta (μm)	Sagitta (μm) (+Intrinsic Resolution=50 μm)
250	152 ± 11	160 ± 11
220	169 ± 10	176 ± 10
180	209 ± 9	215 ± 9
150	253 ± 12	257 ± 12
120	320 ± 12	324 ± 12
100	387 ± 20	390 ± 20

Sagitta Studies - Endcap Chambers



G4 Simulation → 120 μm for energy 227 GeV

Aluminum I-beam not simulated → 88 μm

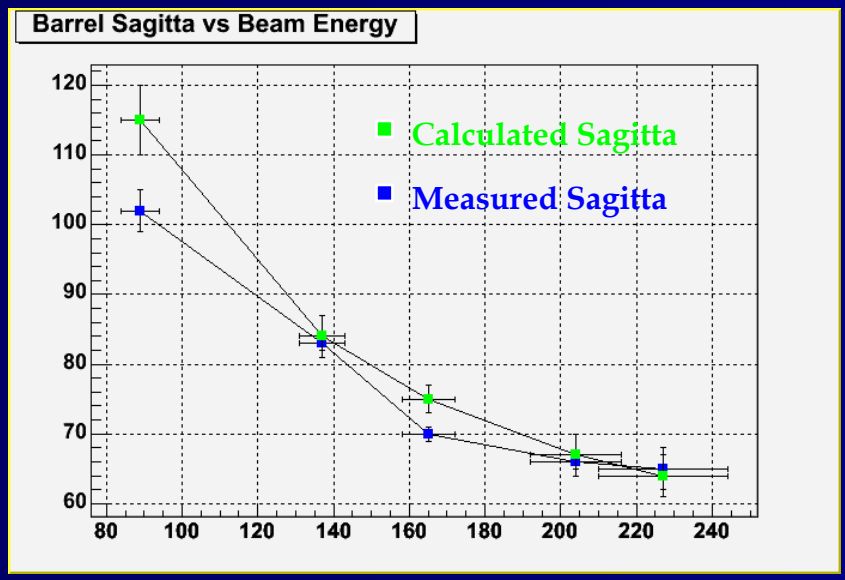
(149±11) μm

Intrinsic Resolution=50 μm

(157±11) μm

Simulation for endcap sagitta all the other energies will be done in the close future

Sagitta Studies – Barrel Chambers



Beam Momentum (GeV)	Sagitta (μm)	Sagitta (μm) (+Intrinsic Resolution=50 μm)
250	40 ± 3	64 ± 3
220	45 ± 3	67 ± 3
180	55 ± 2	74 ± 2
150	67 ± 3	84 ± 3
100	103 ± 6	115 ± 6

Combined Testbeam 2004

A small scale experiment based on ATLAS subdetectors

Integration of detectors

Integration of the electronics, synchronization

Integration of detectors with DAQ and Trigger

- System test, chamber performance
- Synchronization, timing
- Integration of hardware/software
- Implement full trigger chain
- Use the trigger chain to trigger

} Trigger

Use of new reconstruction tools

Request for physics studies for the understanding the detector and tuning of MC

Real stand-alone runs

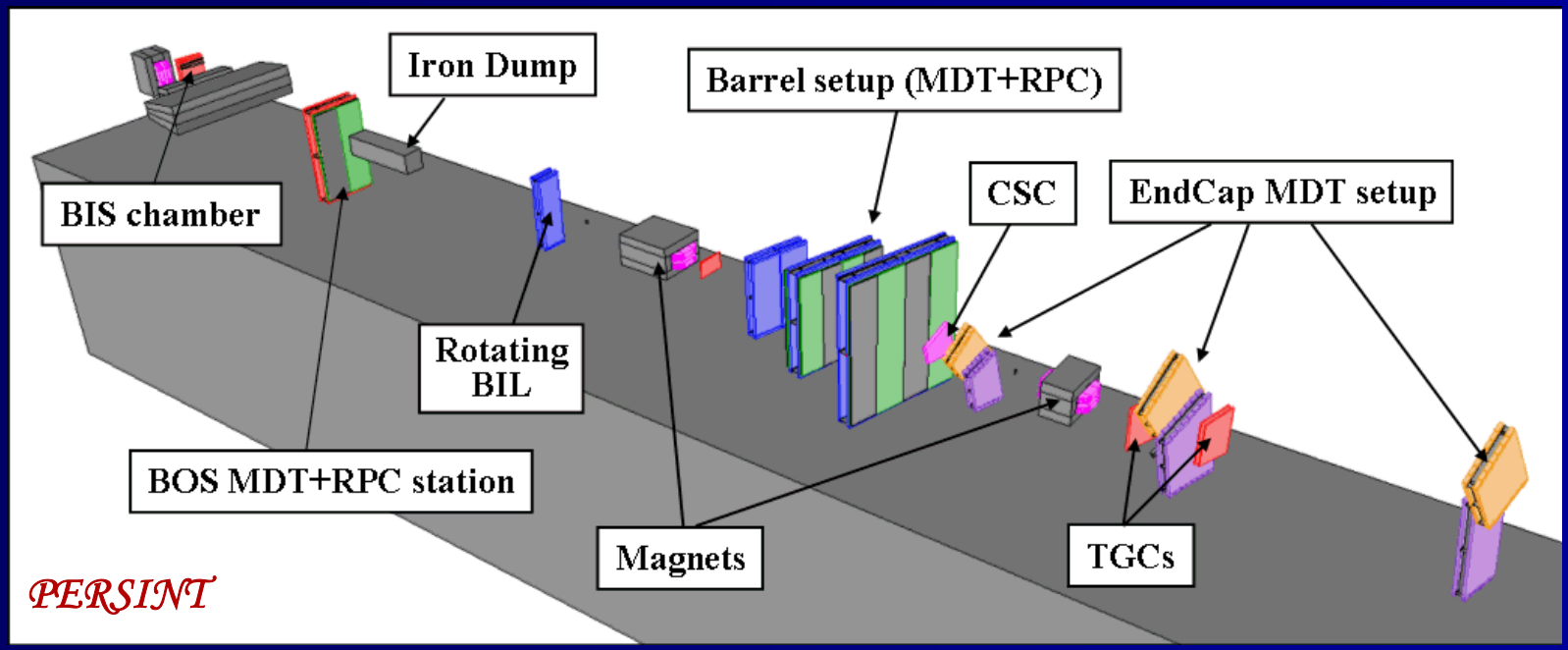
Combined calorimetry measurements

ID-Muons tracking

Particle ID studies

Combined Testbeam 2004

H8-2004 Combined Testbeam
Muon system : 15 MDTs, 7 RPCs, 3 TGCs, 1 CSC
Calorimeters (LAr, Tile), Inner Detector, 3 magnets



Combined reconstruction with inner detector
Muons out of the Tile Calorimeter
Integration of DAQ and Trigger a la ATLAS

Conclusions

Muon 2004 test beam was a success in terms

- **Electronics commissioning**
- **Alignment system performance**
- **MDT performance**
- **TGC/RPC response**
- **Experience, detector understanding, solved problems and data analysis**

Testbeam provides the chance to perform installation, commissioning, integration and operation exercise in a realistic environment

Full muon system tested and integrated

All aspects from services (grounding, cabling,..) to high level software (track reconstruction, monitoring, condition database,..) are covered

Combined 2004 test beam was as much as possible an *ATLAS-like* detector concerning *hardware* and *software*