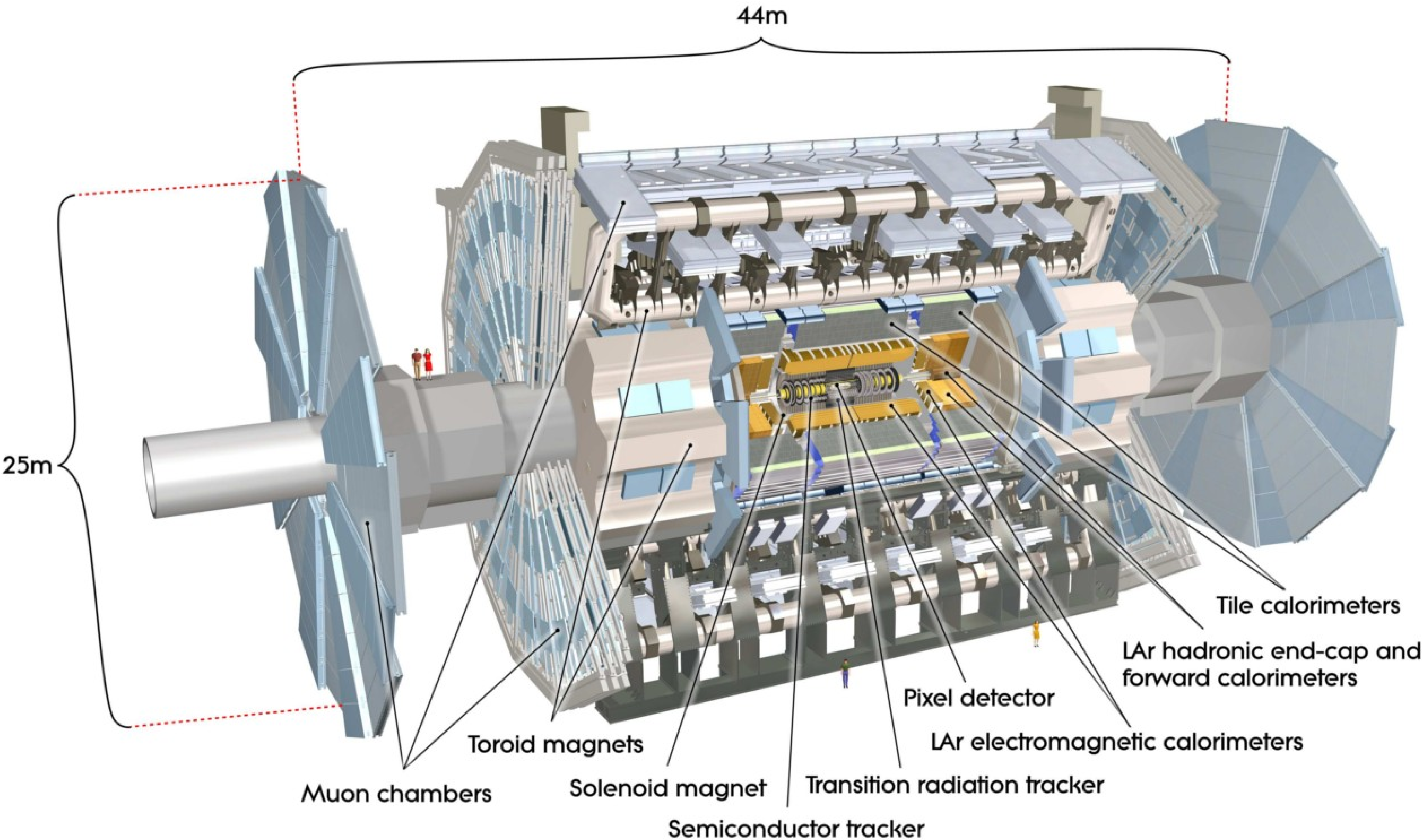
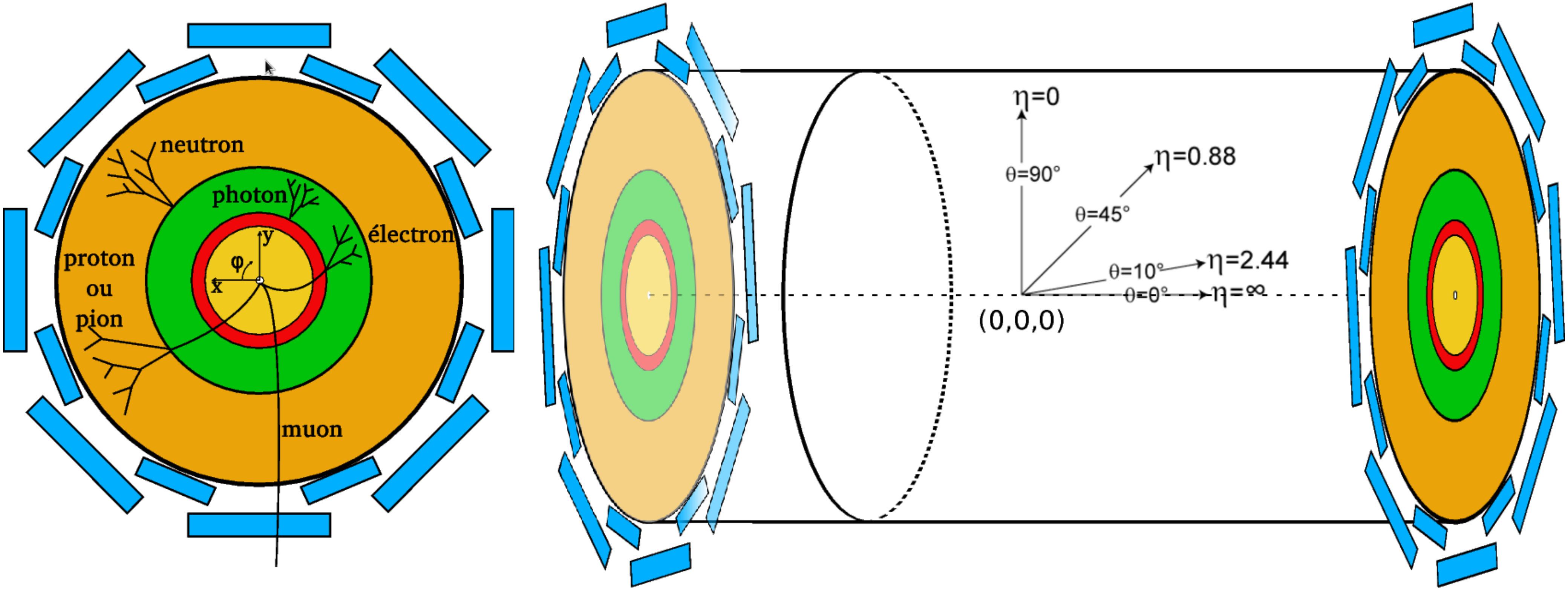
Première physique auprès du détecteur Atlas préparation à la recherche du boson de Higgs

Jérôme ODIER

The ATLAS detector



The ATLAS detector

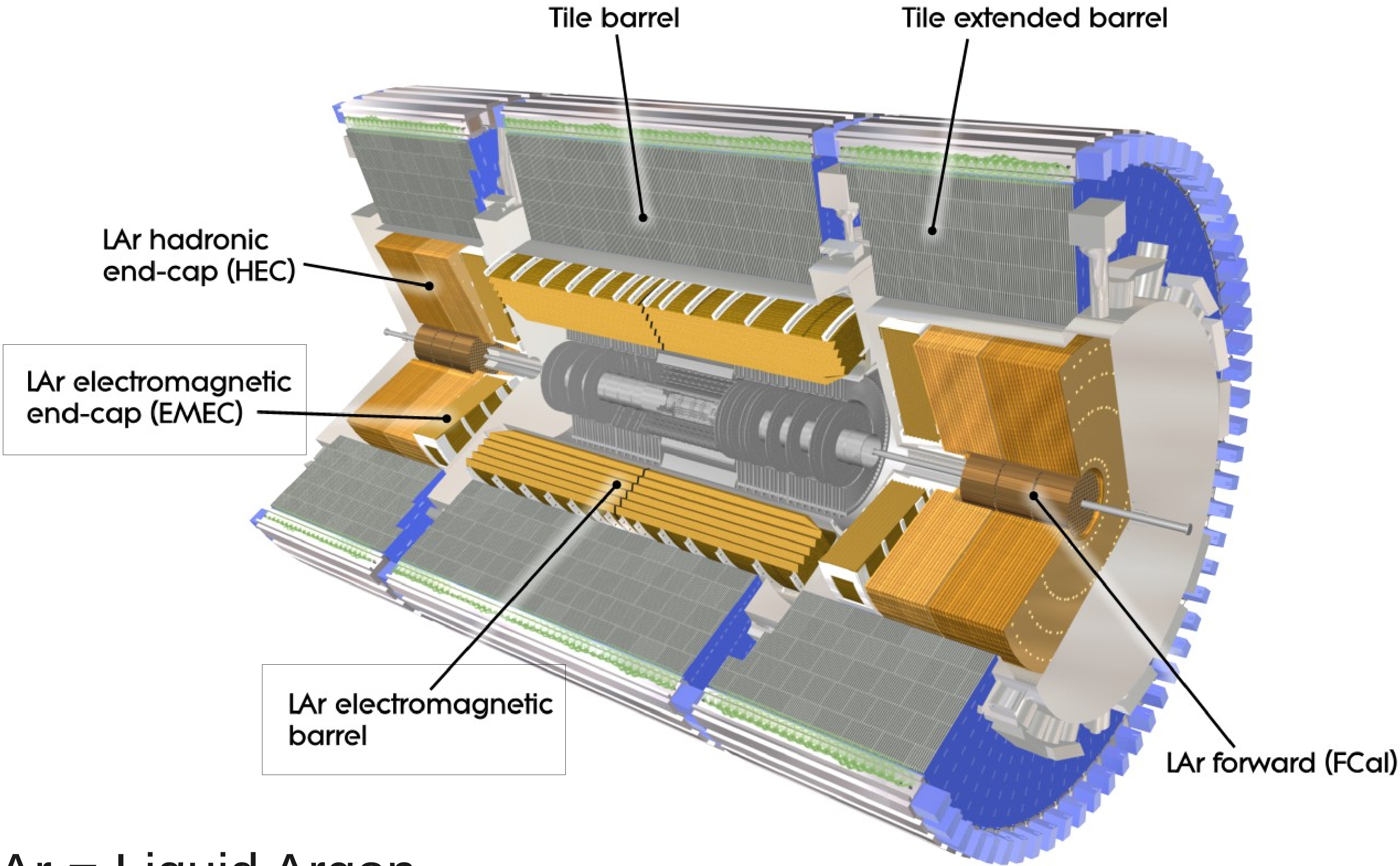


Coordinate system: $\left(\eta = -\ln \tan\frac{\theta}{2}, \phi, z\right)$ $\qquad dR = \sqrt{d\eta^2 + d\phi^2}$

where η is the **pseudo-rapidity** and φ the **azimuthal angle**

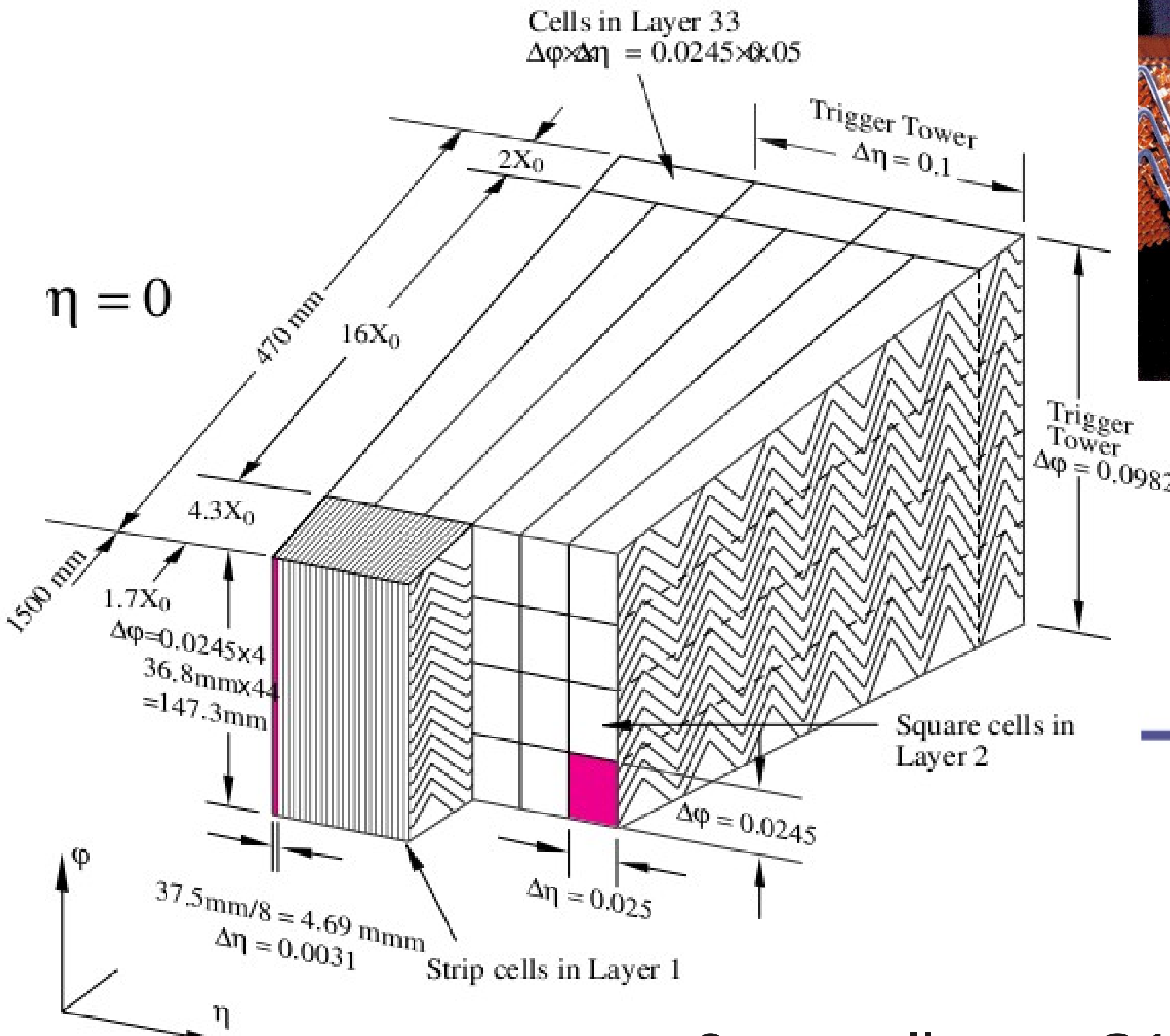
The LAr electromagnetic calorimeter

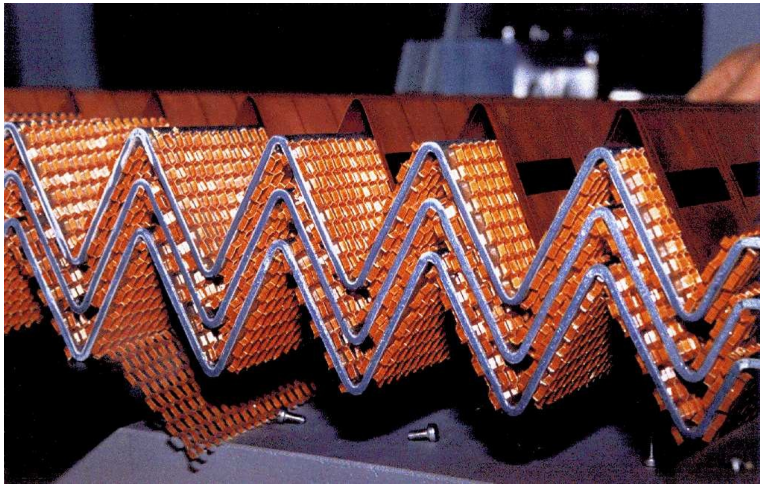
The calorimetric system

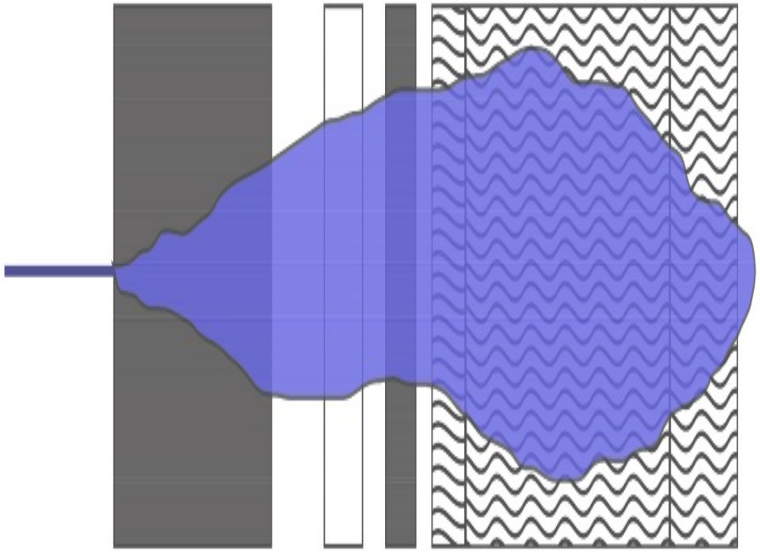


LAr = Liquid Argon

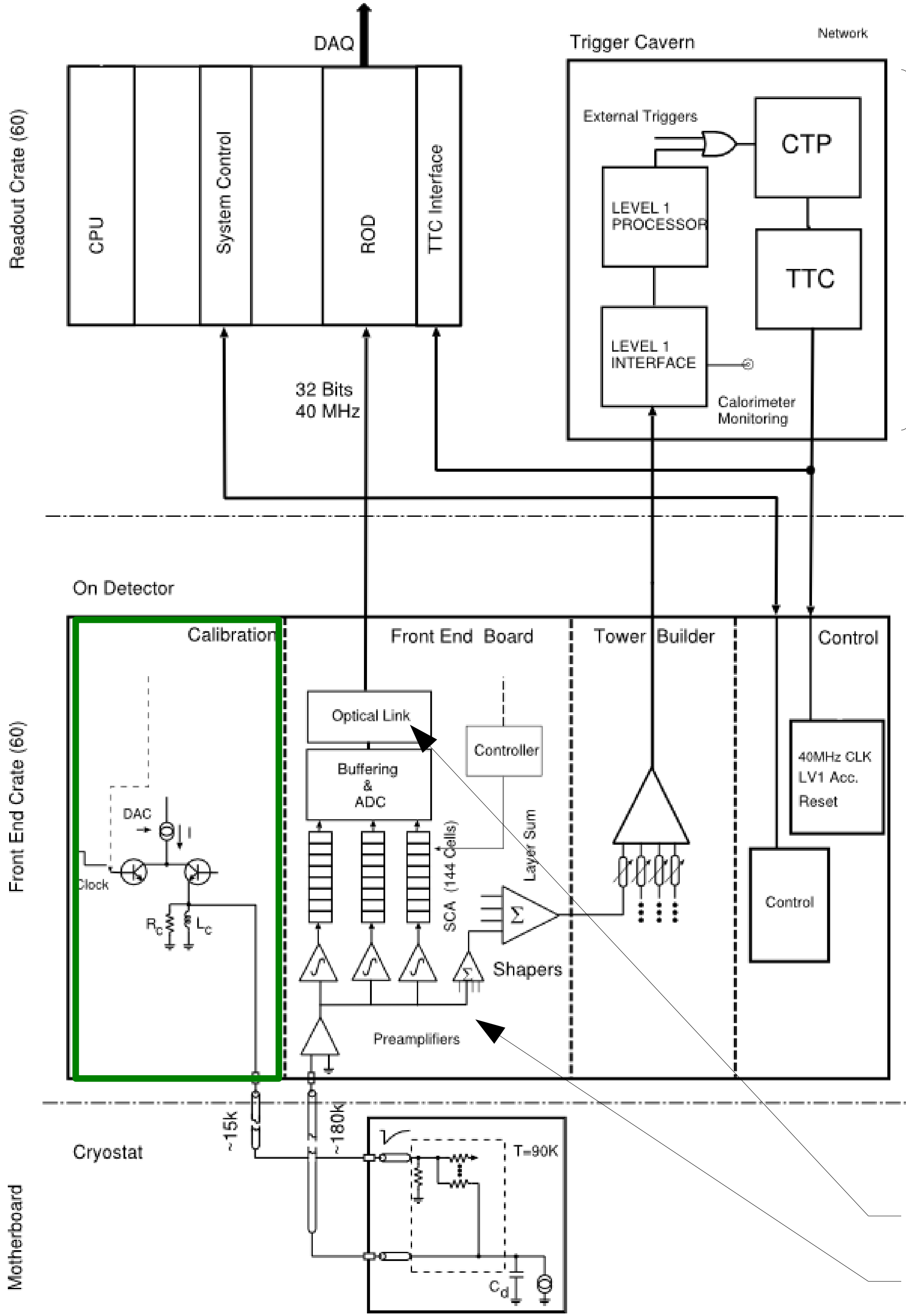
LAr electromagnetic





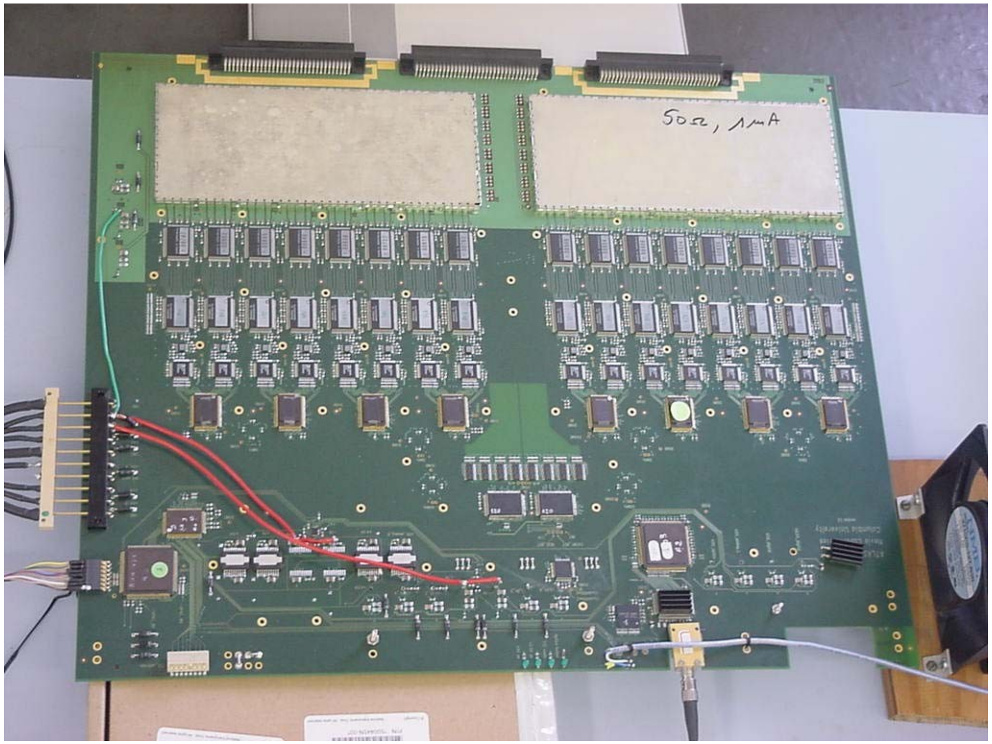


3 samplings : S1 (= strips), S2 and S3



L1CaloEM

Front End Board (FEB)



OTX (optical link)

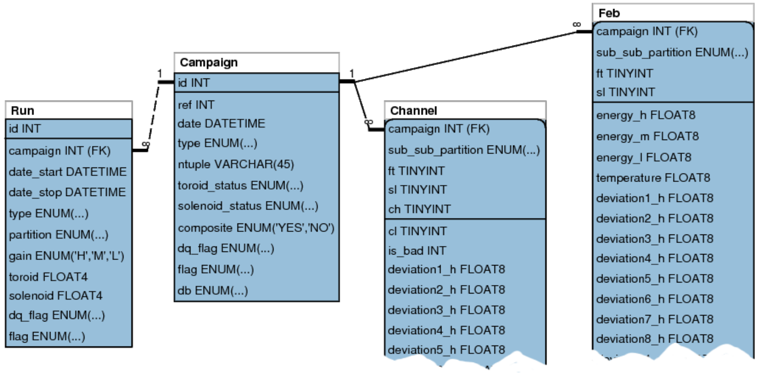
3 gains: low, medium, high to avoid saturations

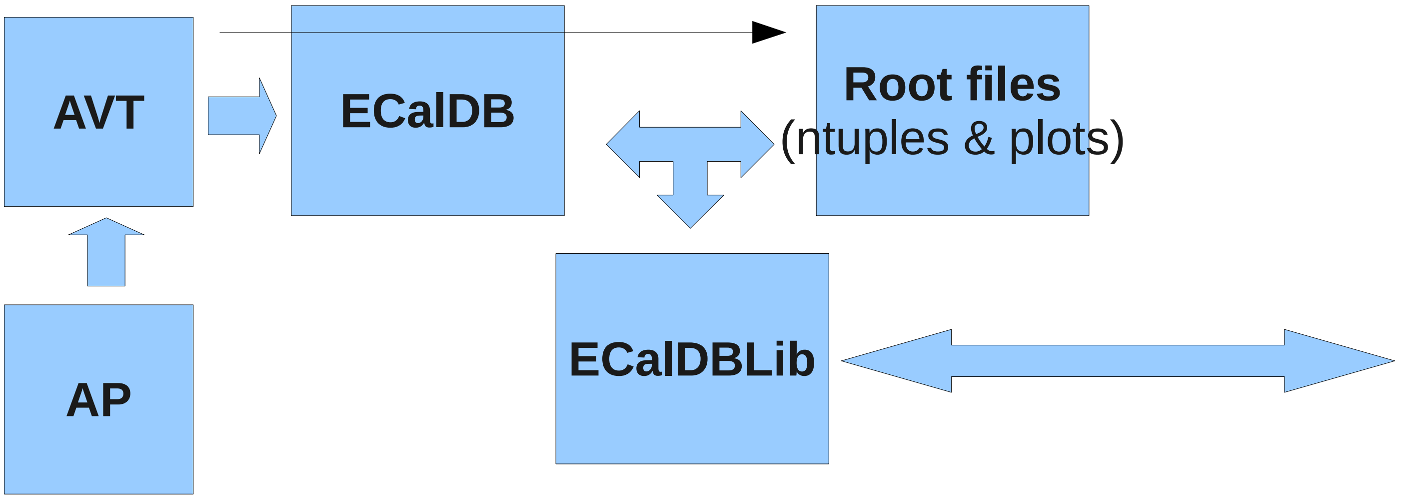
Electronic calibration procedure and the Automatic Validation Tool

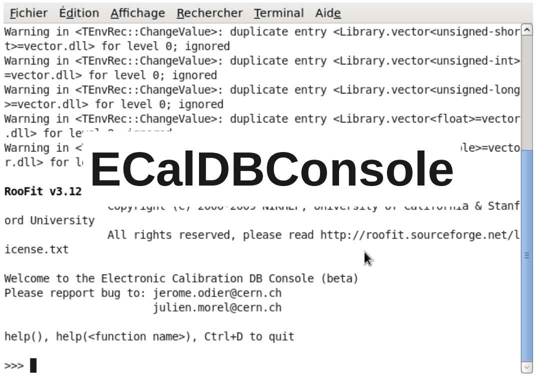
- **Several times a week, calibration runs are taken**.
- The validation consist in **choosing a reference run** and **check the stability for each cell** (pedestal, delay, ramp and autocorrelation).
- The stability depend on: the solenoidal and the toroidal magnetic field, the temperature, etc...
- It is done using the **Automatic Validation Tool** (AVT).
- **Update the calibration database if needed**.

Electronic calibration procedure

- AP (Automatic Processing) : reconstruction of calibration runs
- AVT (Automatic Validation Tool) : stability of cells (pedestals, etc...)
- ECalDB : database
- EcalDBConsole : console







ECalWebDisplay

Fichier Édition Affichage Historique Marque-pages Outils Aide

cern.ch https://lar-elec-automatic-validation.web.cern.ch/lar-elec-automatic-validation/cgi-b Aucun Google

ECalWebDisplay

Campaigns information

	Id	Date	Type	Partition	Toroid	Solenoid	DQ Flags	Flags
Reference campaign	id=44	Fri, 01 Apr 2011 11:05	WEEKLY	EM EMBPS HECFCAL	OFF	OFF	UNDEFINED	YELLOW
Compared campaign	id=48	Thu, 07 Apr 2011 15:22	DAILY	EM	OFF	OFF	UNDEFINED	GREEN

Validation plots

[AUTOCORR] [PEDESTAL] [NOISE] [RAMP]

Deviating channels

Table summarizing the deviations (normalized to threshold)

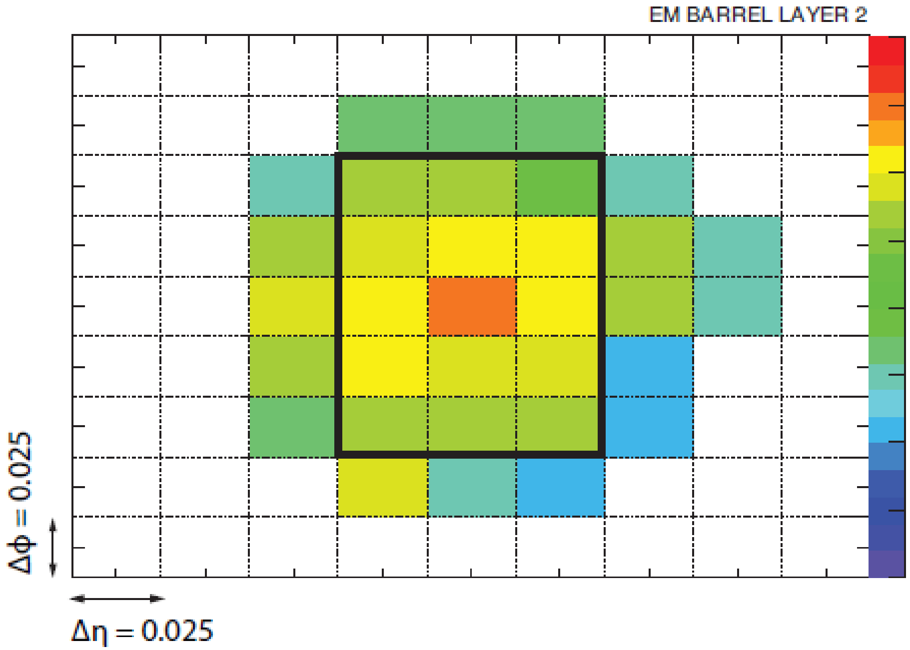
Side	FT	Slot	Channel	CL	BadCh	AutoCorr	Ped	Noise	Ramps	Ch history
EMBA	1	5	16	48	3=deadReadout/deadCalib	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	1	5	17	49	3=deadReadout/deadCalib	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	1	5	18	50	3=deadReadout/deadCalib	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	1	5	19	51	3=deadReadout/deadCalib	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	6	10	54	118	4=deadPhys	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	7	6	83	67	0=None	1.185 _ _	_ _ _	_ _ _	_ _ _	History
EMBA	8	8	111	99	4=deadPhys	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	8	8	115	99	4=deadPhys	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	9	3	0	16	0=None	_ _ _	_ _ _	_ _ _	_ 1.839 32.287	History
EMBA	9	3	64	16	0=None	_ _ _	_ _ _	_ _ _	_ 1.878 32.931	History
EMBA	9	4	1	33	4=deadPhys	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	9	8	74	98	4=deadPhys	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	14	9	64	12	4=deadPhys	_ _ _	_ _ _	_ _ _	_ _ _	History
EMBA	19	8	4	96	0=None	-1.225 -1.890 -2.989	_ _ _	1.629 5.788 11.211	_ 1.014 1.507	History
EMBA	19	8	5	97	0=None	-1.477 -1.209 -2.785	_ -1.097 _	4.580 21.664 14.394	_ 1.251 1.476	History

Terminé Proxy: Aucun

Low energy
$\sqrt{s}$=7TeV data (2010)

Low energy (E~500MeV)

- I worked on low energy **photon** reconstruction.

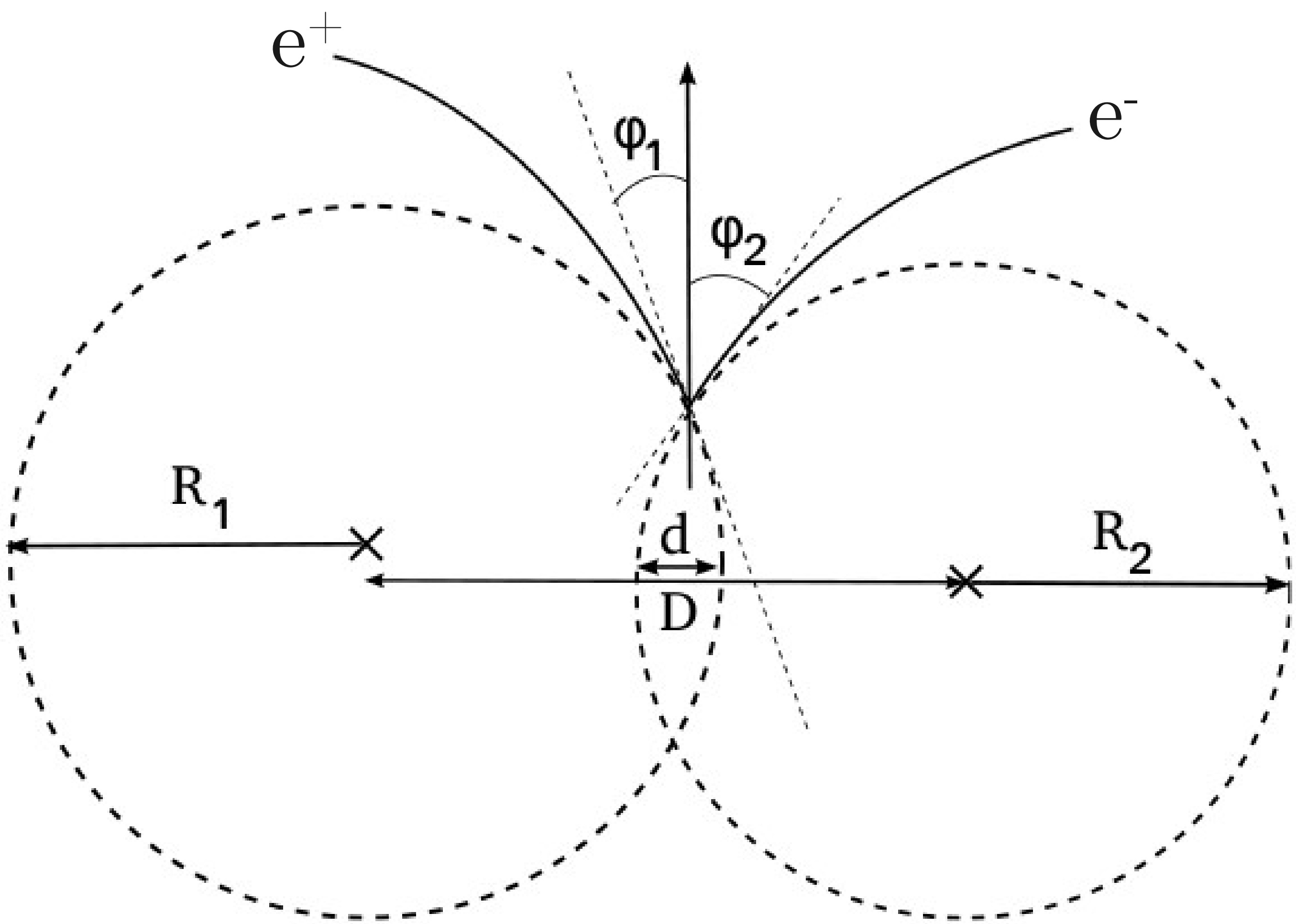


➔Cell cluster reconstruction (seed = topological cluster => fixed size cluster 3x3).
➔Cell cluster energy calibration (longitudinal weight method).
➔Inner detector track-cluster association.

- Photon ~ cluster with no associated track.

Low energy (E~500MeV)

- I worked on low energy **photon conversion** reconstruction $\gamma \rightarrow e^{+} e^{-}$.



Low energy (E~500MeV)

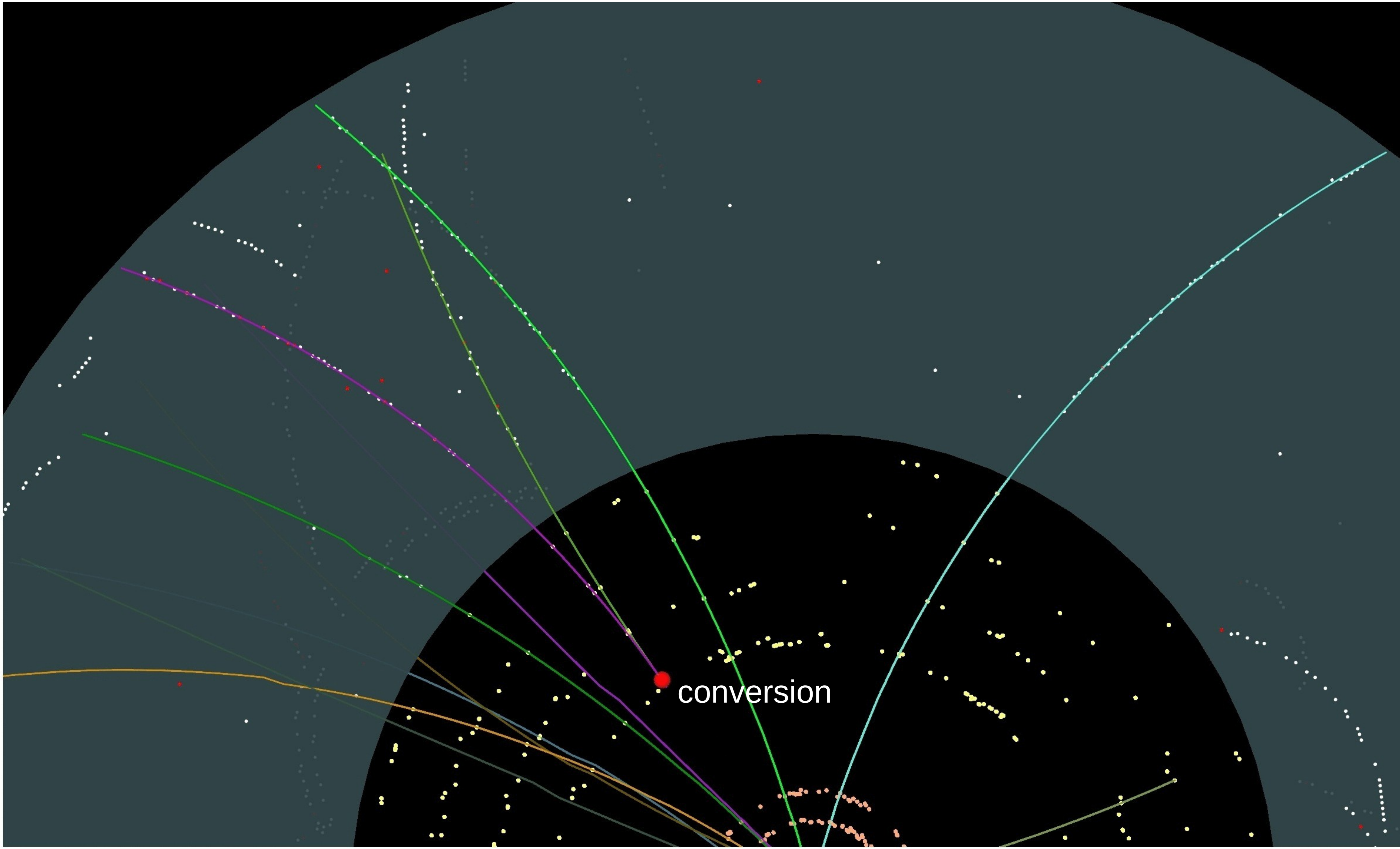
➔ I worked on low energy **photon conversion** reconstruction.

(1) We select single tracks (inner detector).

(2) Conversion candidates are then created by **pairing oppositely charged tracks**.

(3) Photons are **massless** therefore the emerging tracks have to be parallel at the vertex (small opening angle, D-R1-R2→0).

(4) The **selected track pairs are fitted to a common vertex** with the constraint that they be **parallel at the vertex**. The quality of the fit is evaluate with the χ^2.


conversion

1^{st} application : neutral pions

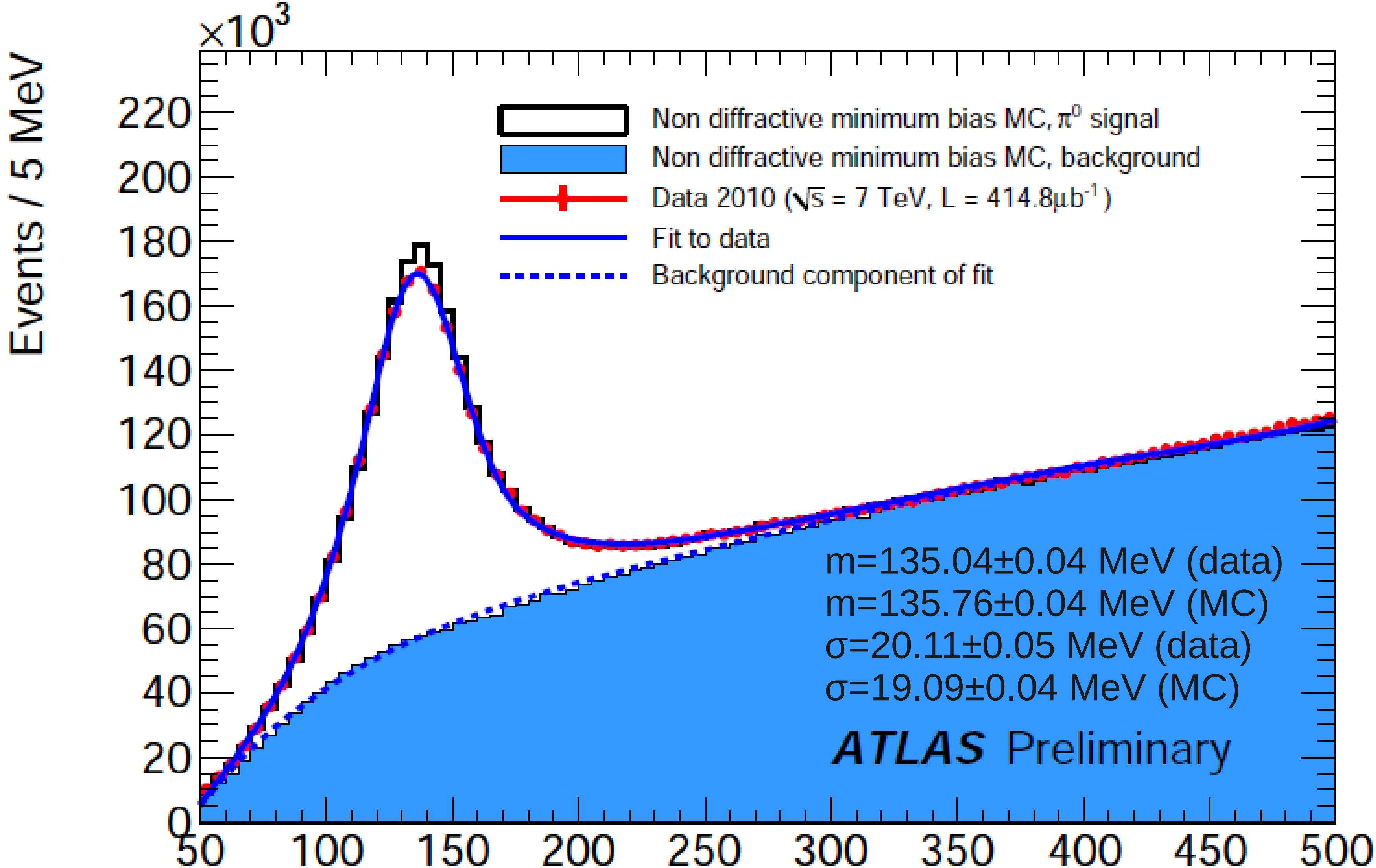
- The π° meson has a small mass of 134.9 MeV/c² and a short mean lifetime of 8.4e-17 second (decay at interaction point).

- Its most common decay mode:

  - Three situations have been studied:
    - no photon conversion: $\pi^0 \rightarrow \gamma\,\gamma$
    - one photon conversion: $\pi^0 \rightarrow \gamma\,\gamma\,(\rightarrow e^+ e^-)$
    - two photon conversions: $\pi^0 \rightarrow \gamma\,(\rightarrow e^+ e^-)\,\gamma\,(\rightarrow e^+ e^-)$

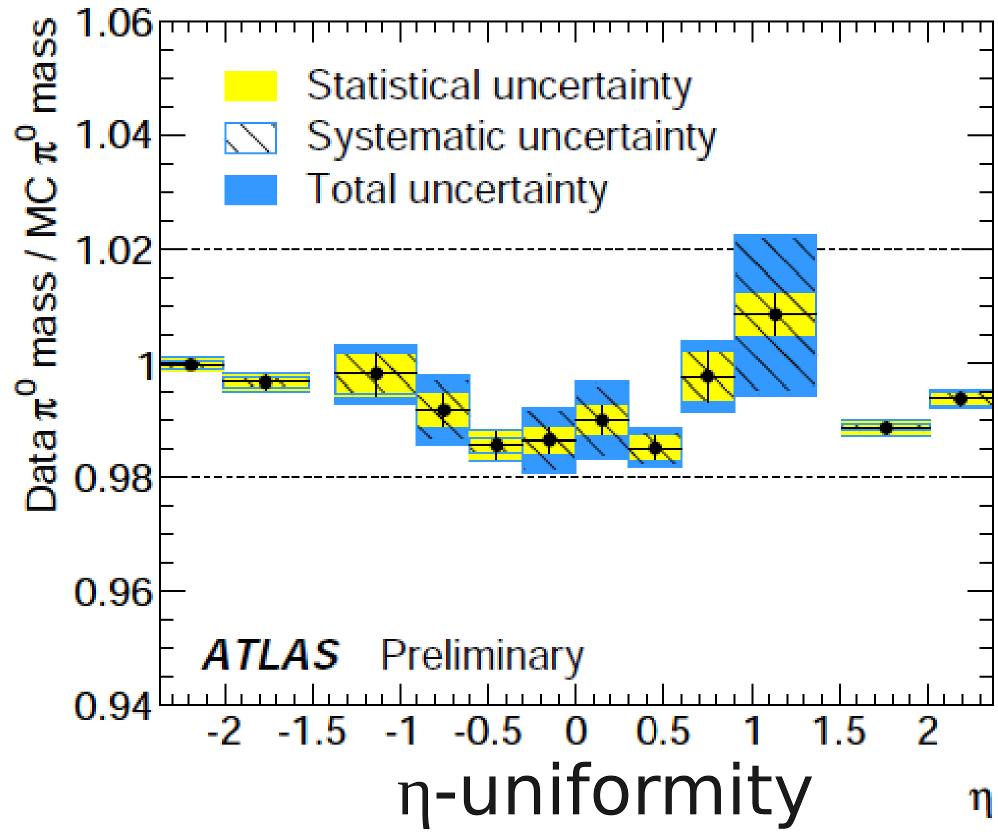
neutral pions $\sqrt{s}$=7TeV

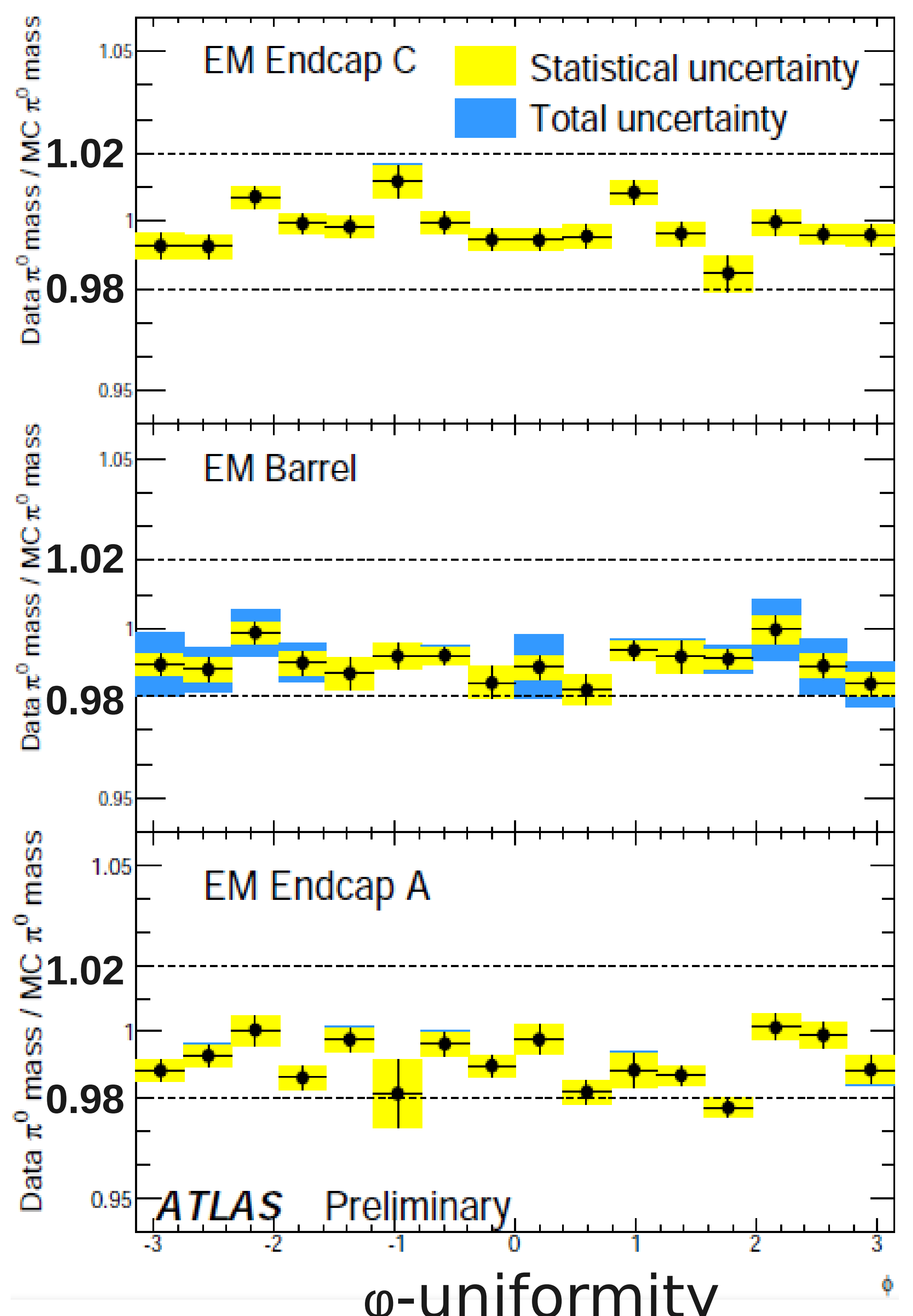
$$\pi^0 \rightarrow \gamma\gamma$$



Good agreement for both mass and width.

Fit = Gaussian + crystal ball + 4th order Chebyshev polynomial.



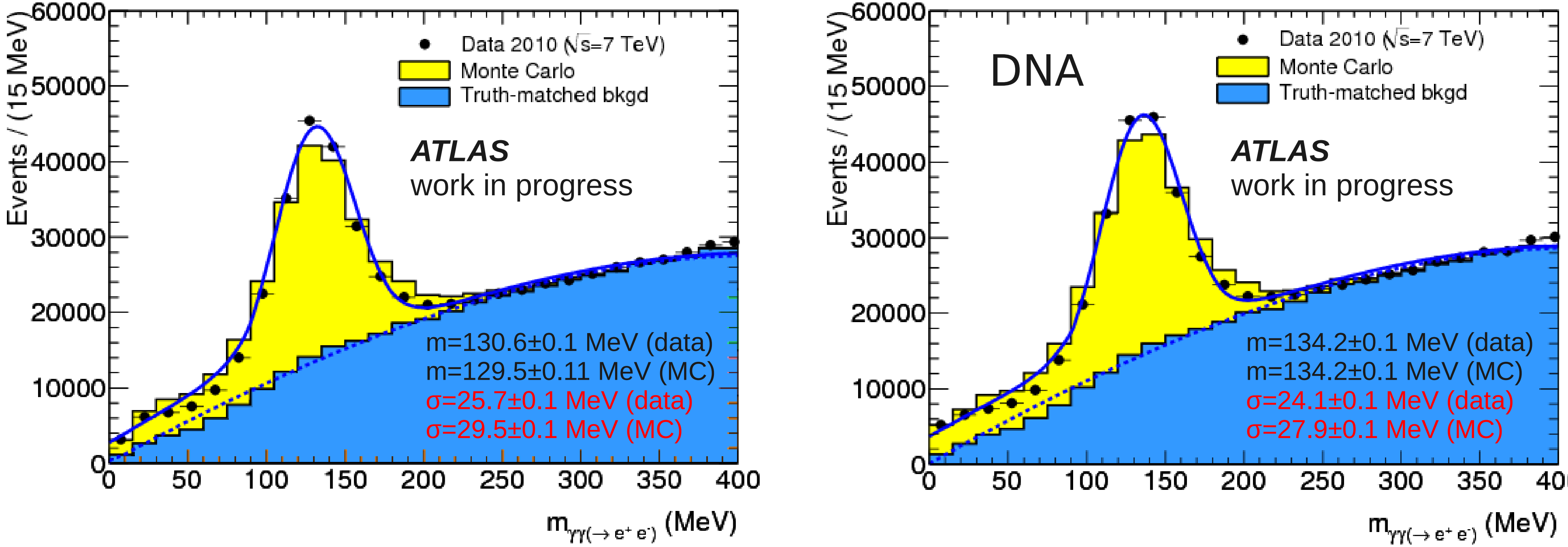


- The η-uniformity better than:
  - 2% in the barrel,
  - 1% in the end-cap.
- The φ-uniformity better than:
  - 2% in the barrel,
  - 2% in the end-cap,
  - the RMS is always better than 7%.

Results compatible with the expected ones at startup.

neutral pions $\sqrt{s}$=7TeV

$$\pi^0 \to \gamma\gamma(\to e^+ e^-)$$



- The DNA (Dynamic Noise Adjustment) track fitter have been used to apply Bremsstrahlung corrections.
  - The mass is closer to the PDG one and the resolution is improved.
- The simulation is larger than the data.

neutral pions : conclusion

- Both mass and width are in agreement with the PDG values (better than 1%).
- The (η,φ)-uniformity is better than 2% for both barrel and end-cap.

2^{nd} application : material mapping

- Converted photons can be used to study the ID geometry in R, η and φ and to provide radiation length estimates :

$$\gamma \rightarrow e^{+} e^{-}$$

- **Basic method: the quantity of conversions depends on the material density.**

$$\frac{X}{X_0} = -\frac{9}{7}\ln(1 - F_{\mathrm{conv}})$$

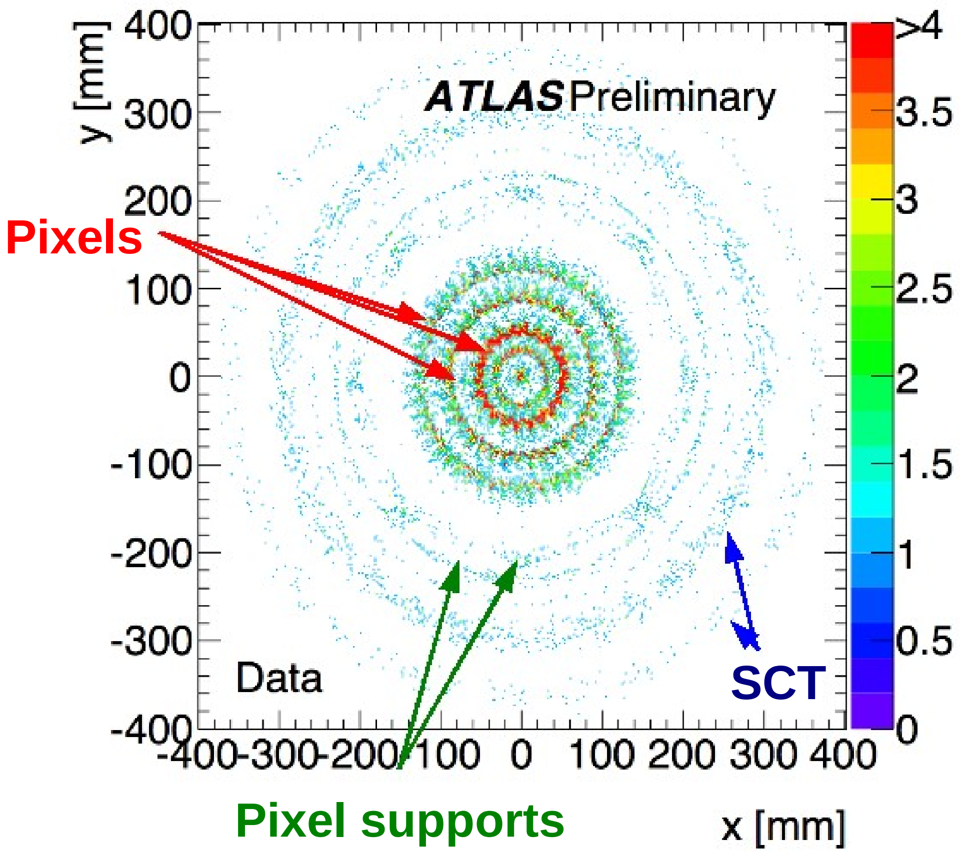
$$F_{\mathrm{conv}} = \frac{N_{\mathrm{reco}}}{N_{\mathrm{tot}}} \frac{F_{\mathrm{comb}} F_{\mathrm{mis}}}{\epsilon} \frac{1}{\exp(-7/9 M_{\mathrm{up}})}$$

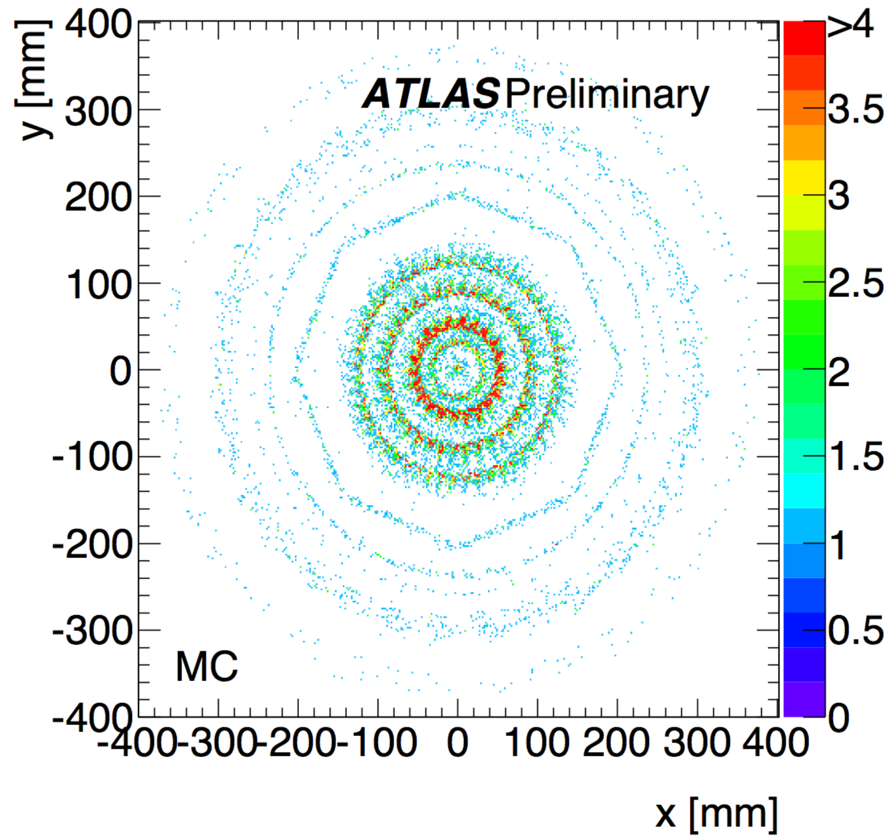
- **Goal estimation ~1%.**

Period A, B, C

GEOMETRY GEO-10-00-00

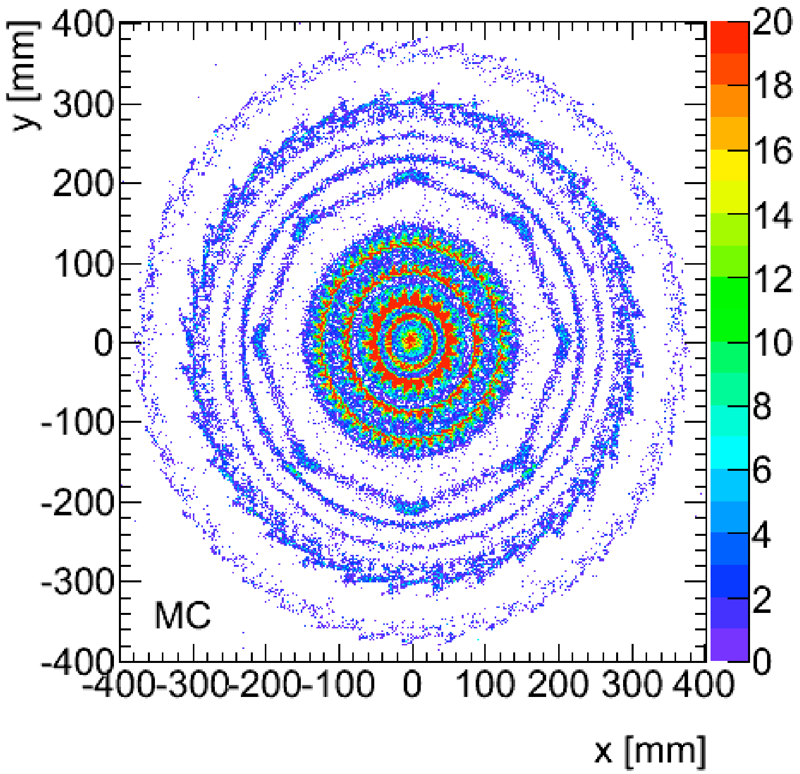
- For now focus on conversions fully contained in tracker barrel, $|\eta|<0.6255$
- Important differences for the pixel supports !

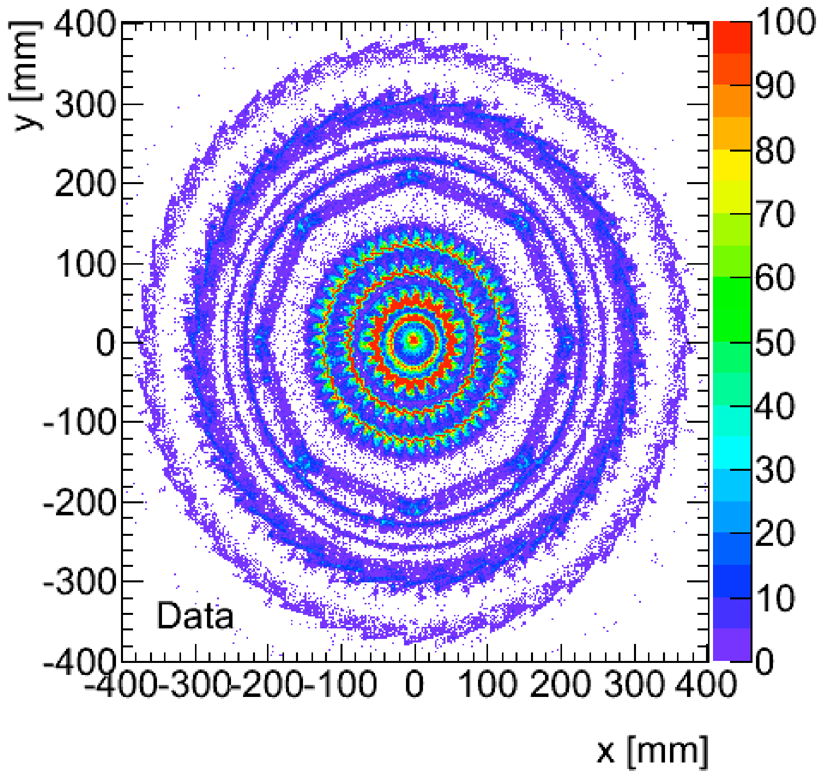


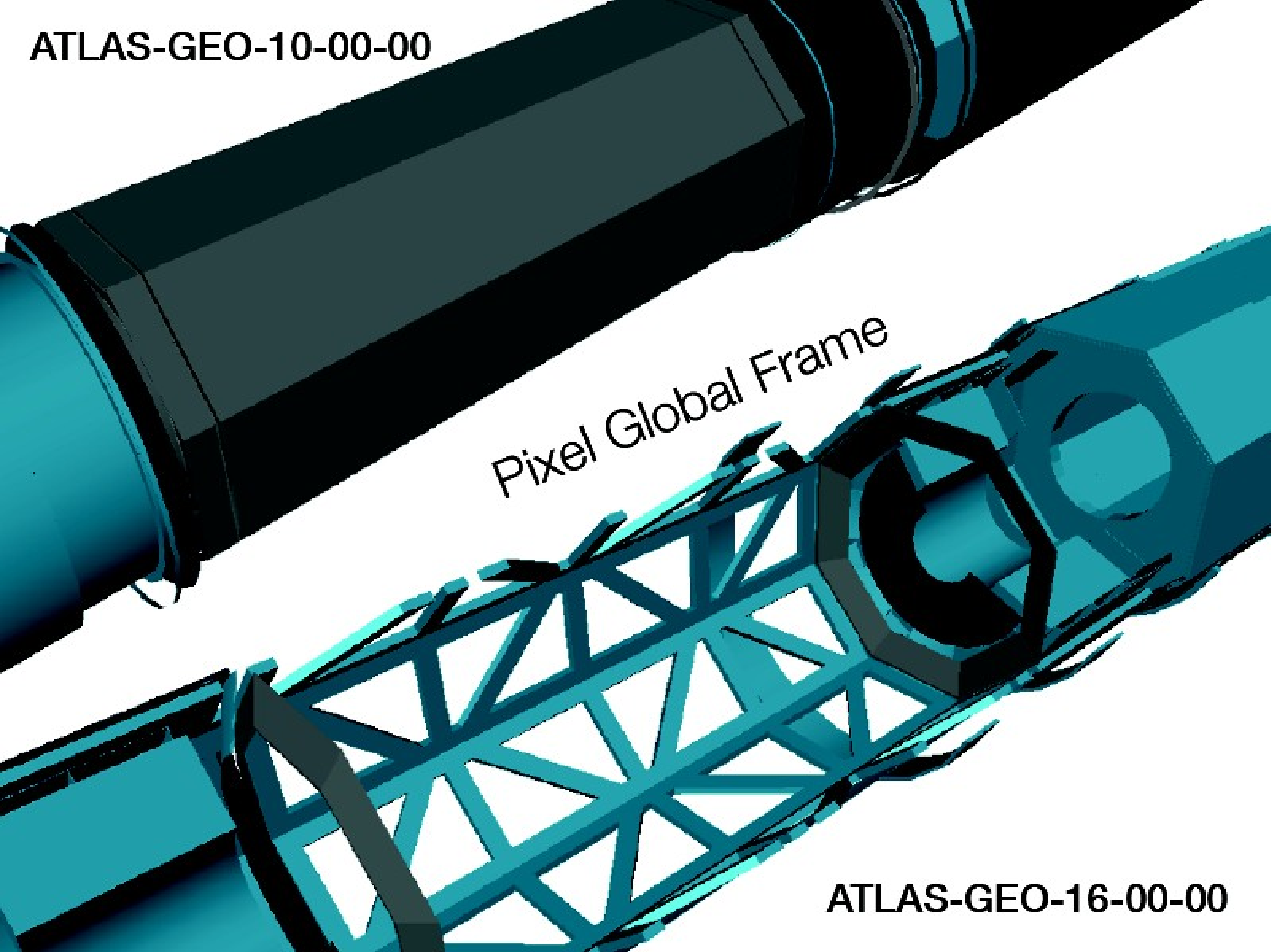


GEOMETRY GEO-16-00-00

- For now focus on conversions fully contained in tracker barrel, $|\eta|<1$
- Better agreement !

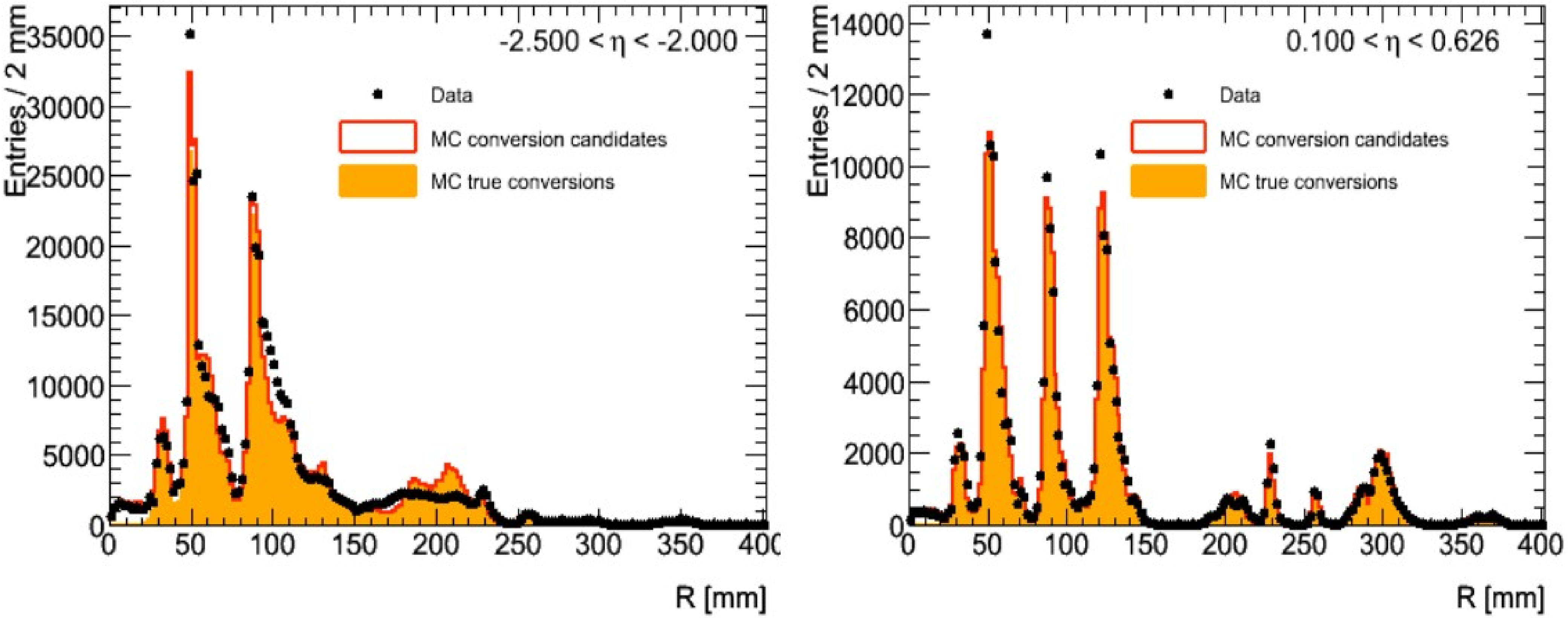






ATLAS-GEO-10-00-00
Pixel Global Frame
ATLAS-GEO-16-00-00

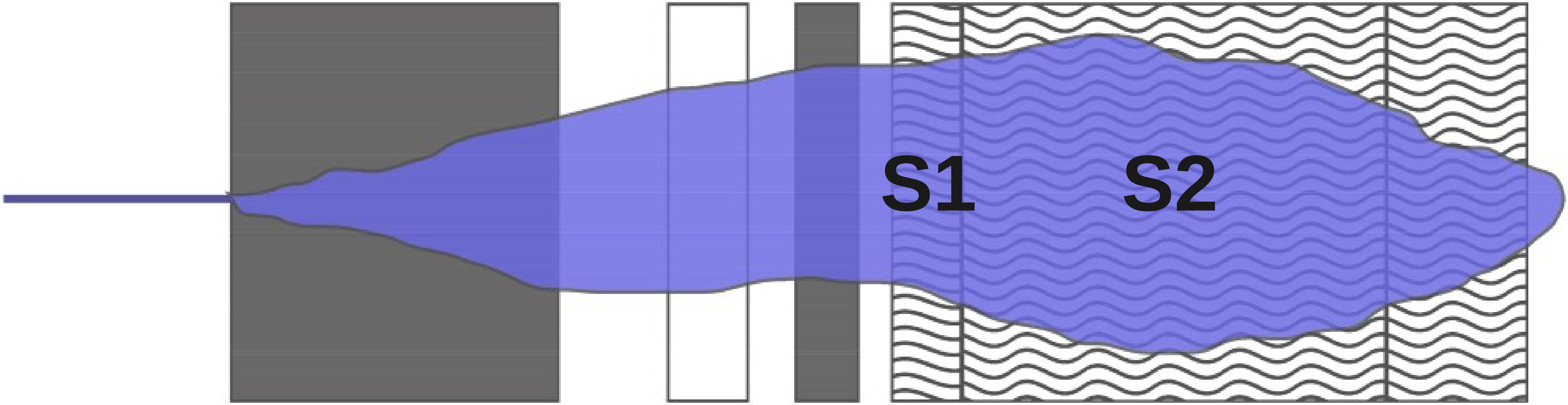
GEOMETRY GEO-16-00-00



Layer	Purity	Efficiency	Material (Data/MC)
BP	0.994	0.100	1.00 ± 0.15
BL	0.995	0.114	1.04 ± 0.12
P1	0.996	0.085	0.93 ± 0.11
P2	0.997	0.113	0.94 ± 0.11
PST*	1.000	0.093	0.97 ± 0.13
SCT1	1.000	0.043	0.92 ± 0.13

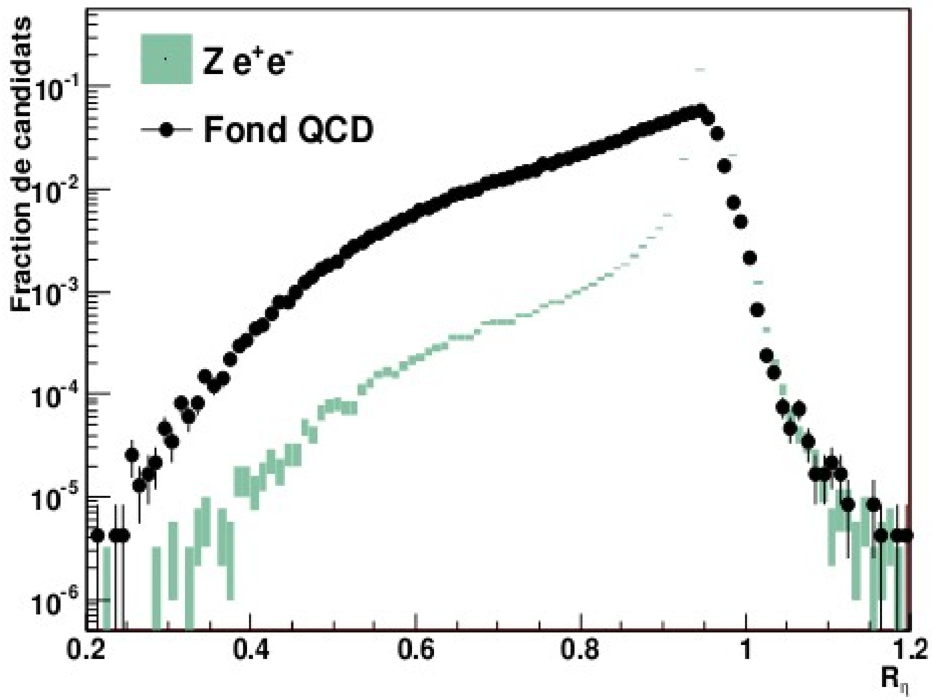
Validation of shower shap variables with cosmic muons (2009)

Shower shape variables



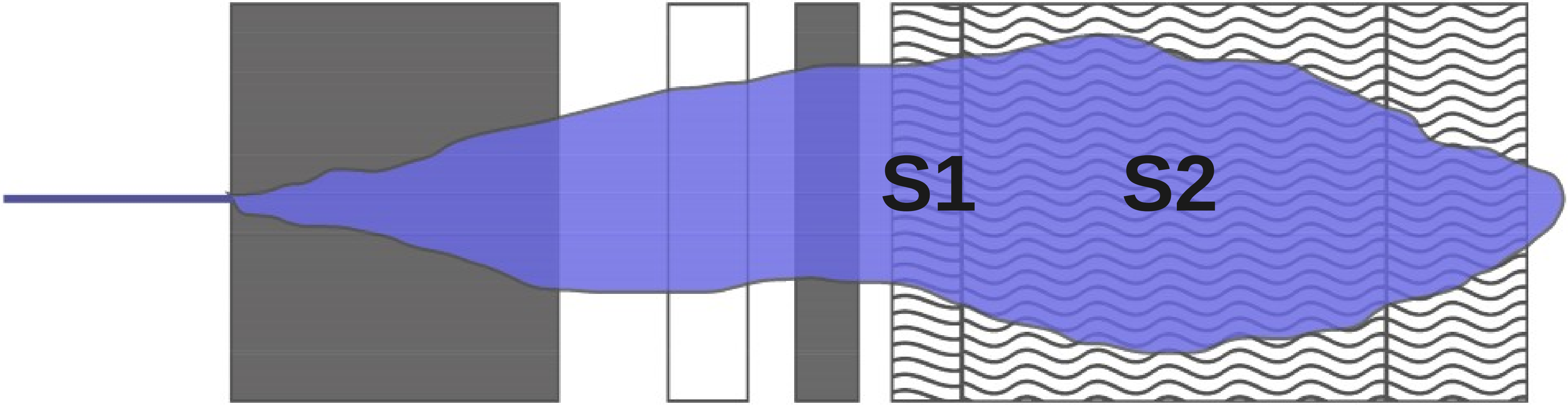
- Electron and photon identification done from shower shape variables.
- For S2 (for instance) :
  - Reta : ratio of the energy in a 3x7 cluster and the energy in a 7x7 => eta extension
  - Rphi : ratio of the energy in a 3x3 cluster and the energy in a 3x7 => phi extension

Shower shape variables



- For S2 (for instance) :
  - Reta : ratio of the energy in a 3x7 cluster and the energy in a 7x7 => eta extension
  - Rphi : ratio of the energy in a 3x3 cluster and the energy in a 3x7 => phi extension

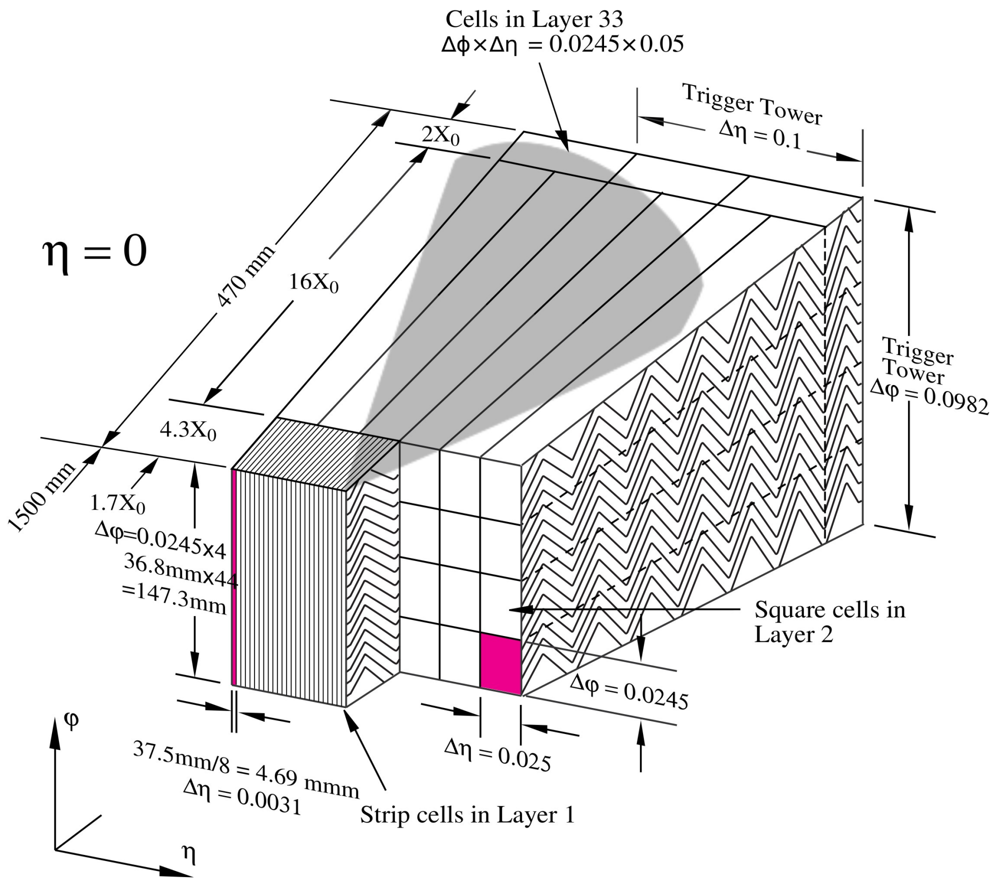
Shower shape variables

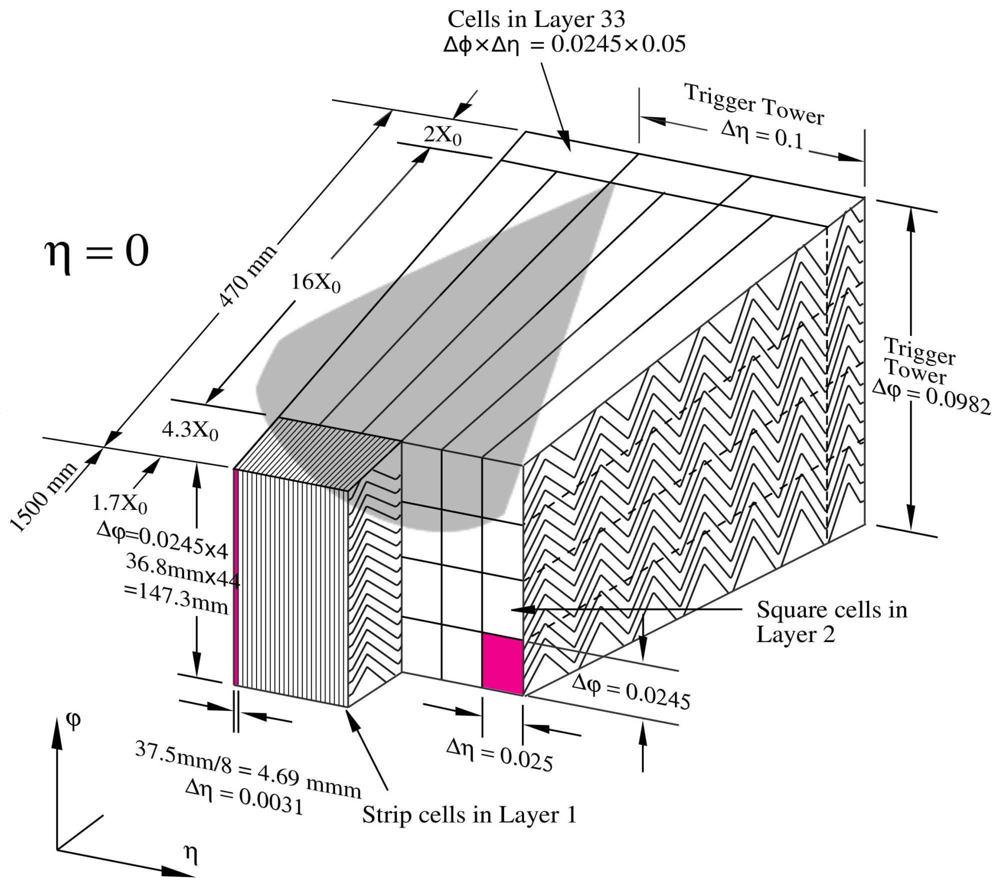


- Electron and photon identification done from shower shape variables.
- For S1 (for instance) :
    - Fside : energy outside a core of 3 strips

$$F_{side} = E_{\pm 3} - E_{\pm 1} / E_{\pm 1}$$

Shower shape variables

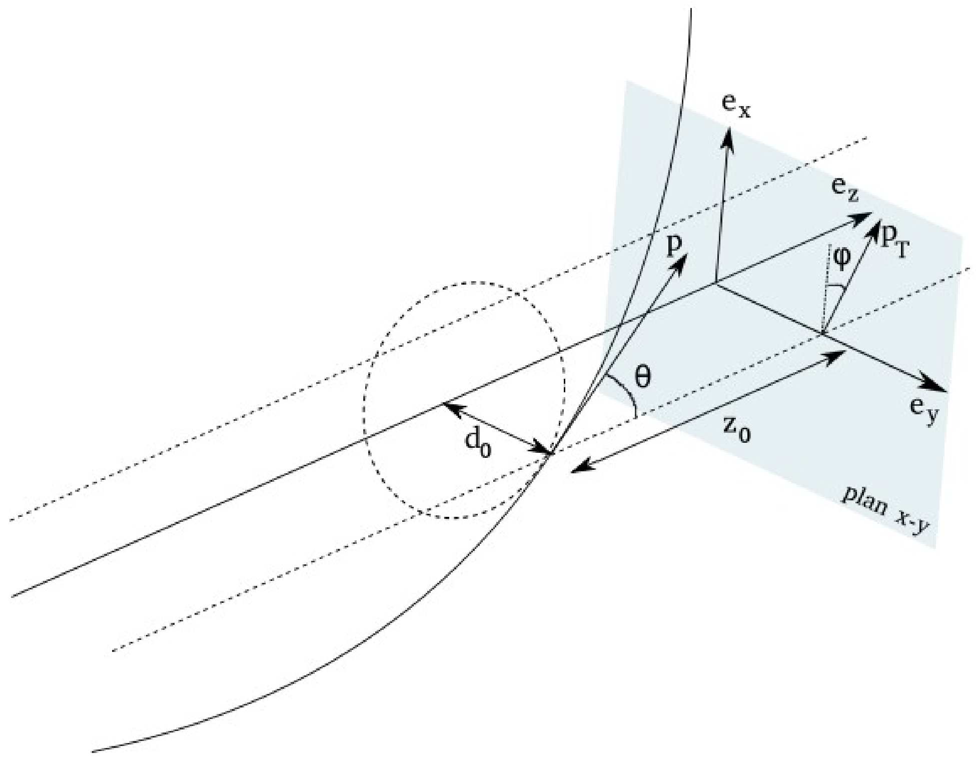




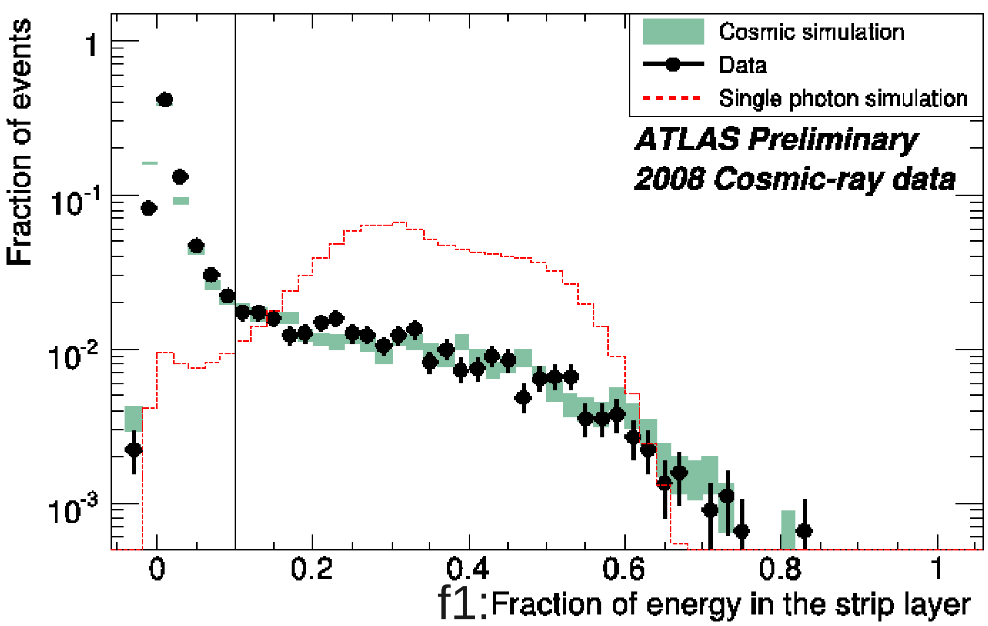
=> Important effect on Fside.

Cosmic muons
2008 (before pp collision)

- **Method**: select « collision like » cosmic muons: projective muons: small z0 and small impact parameter d0 (relatively to (0,0,0)).

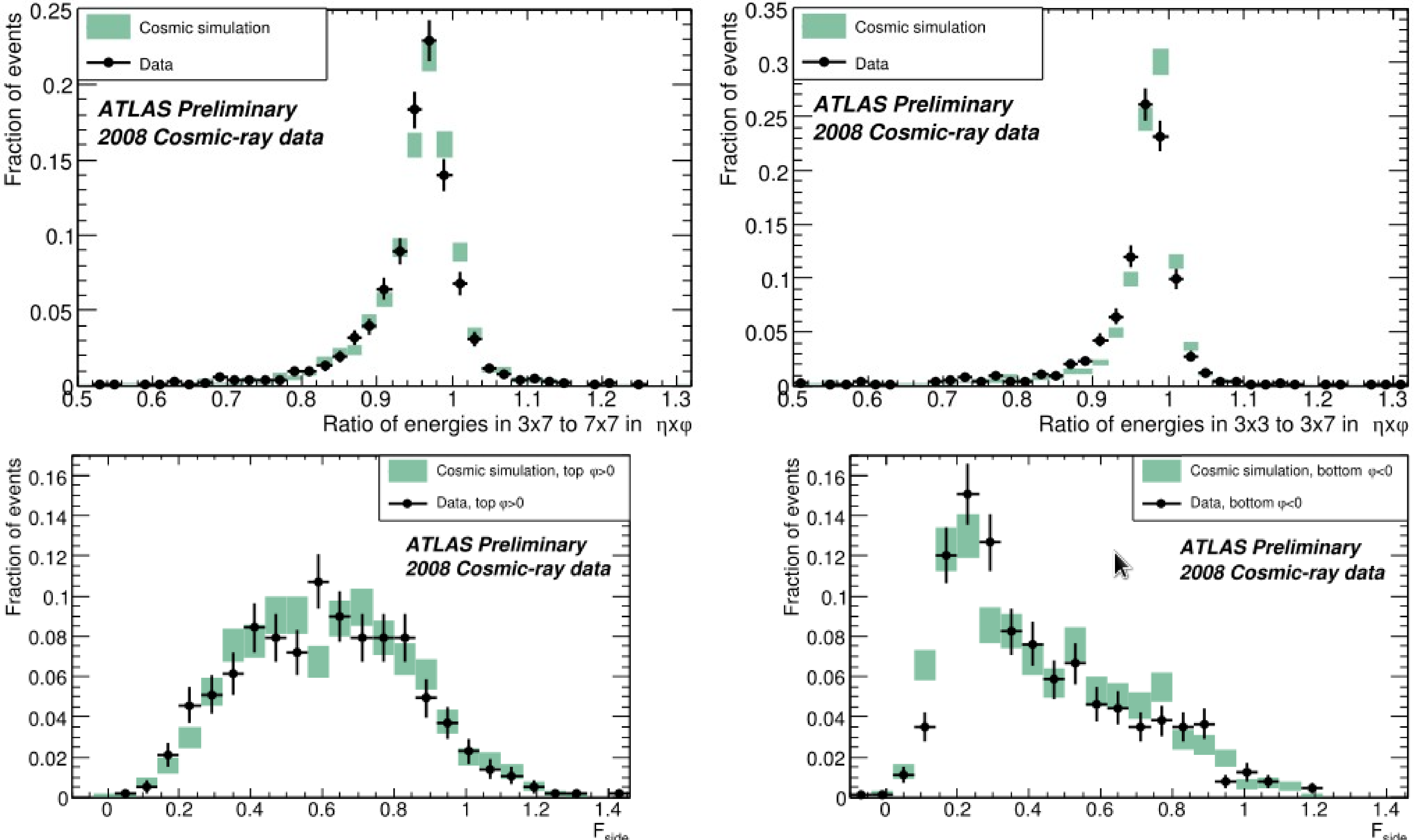


d0<220mm
f1<20%



→Full selection not describe here.

Cosmic muons

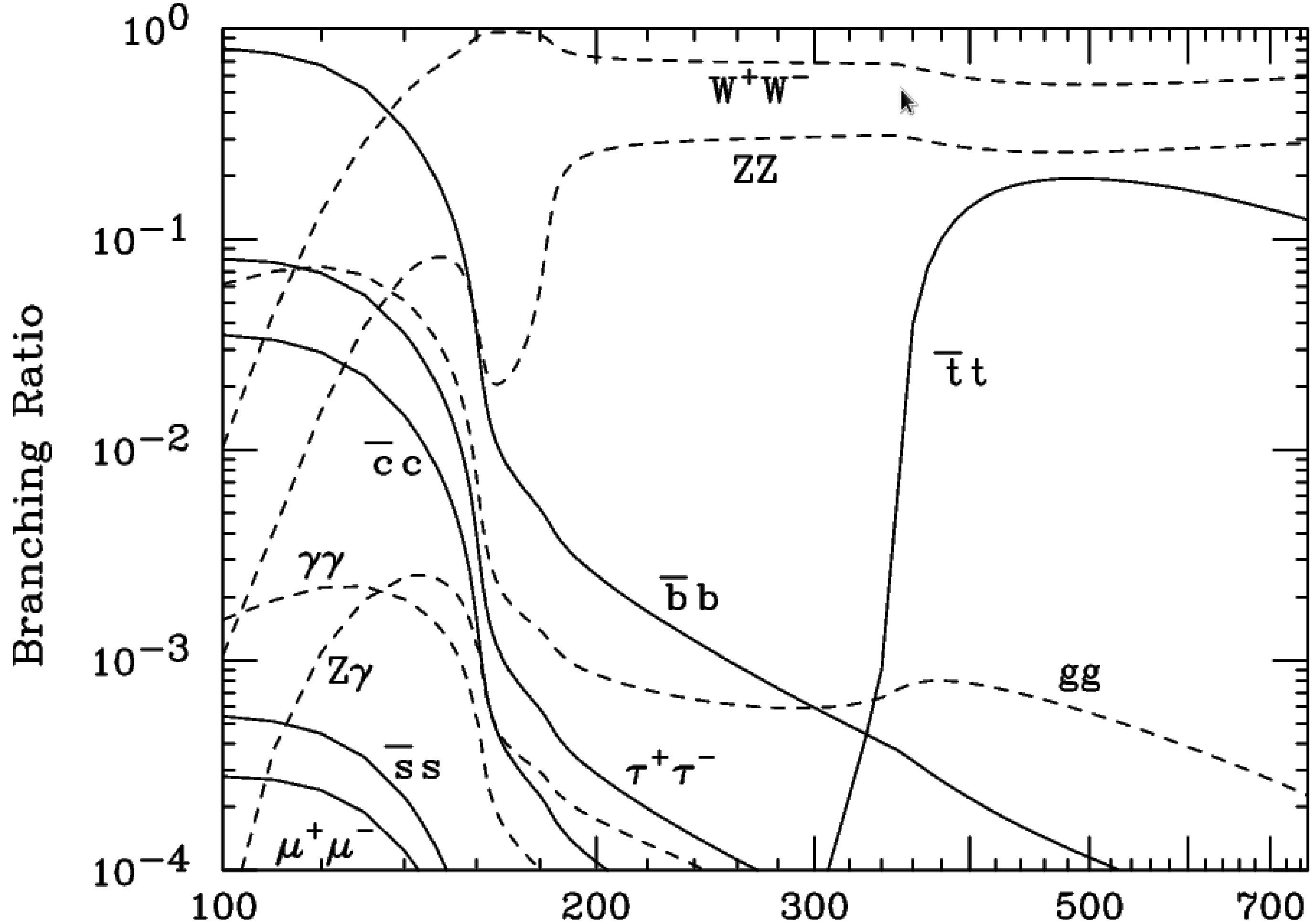


Good agreement data/MC.

Higgs search preparation
H->ZZ->4l (l=e,μ)
√s=7TeV data (2011)

H->ZZ->4l

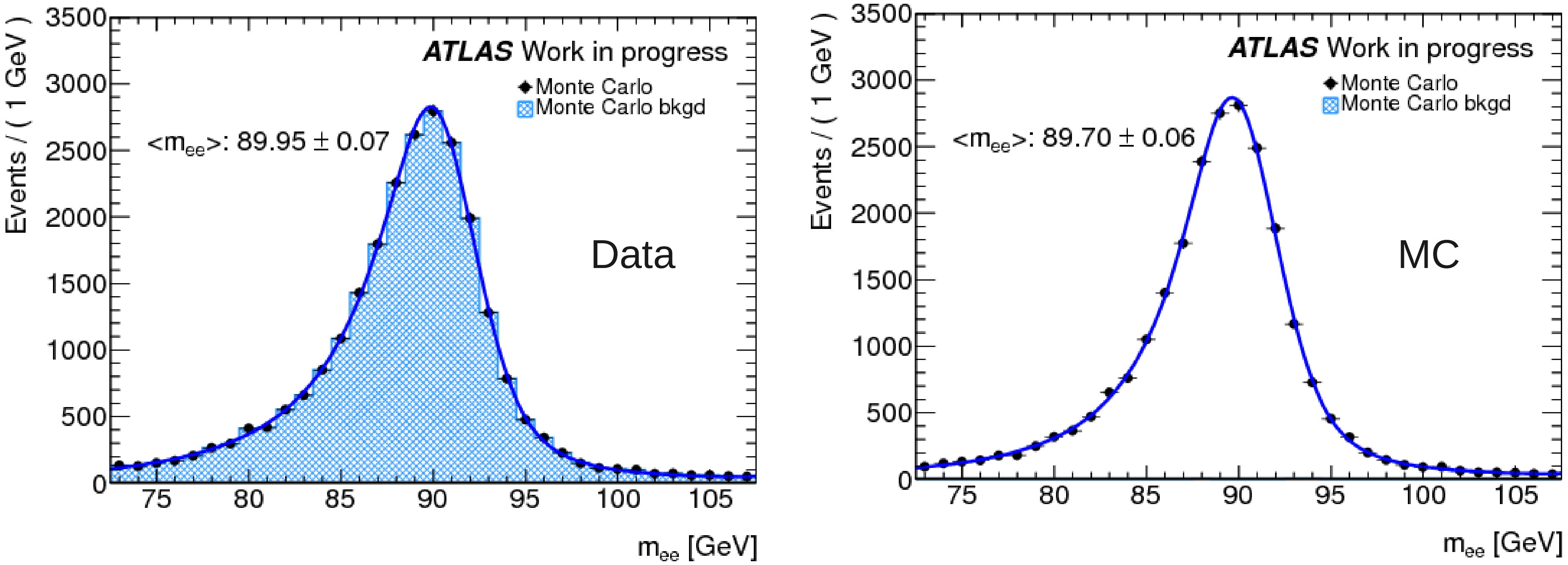
H->4l (H->eeee, H->μμμμ, H->eeμμ) is the golden channel for ATLAS.



O(1) fb^{-1} expected to discover the Higgs...

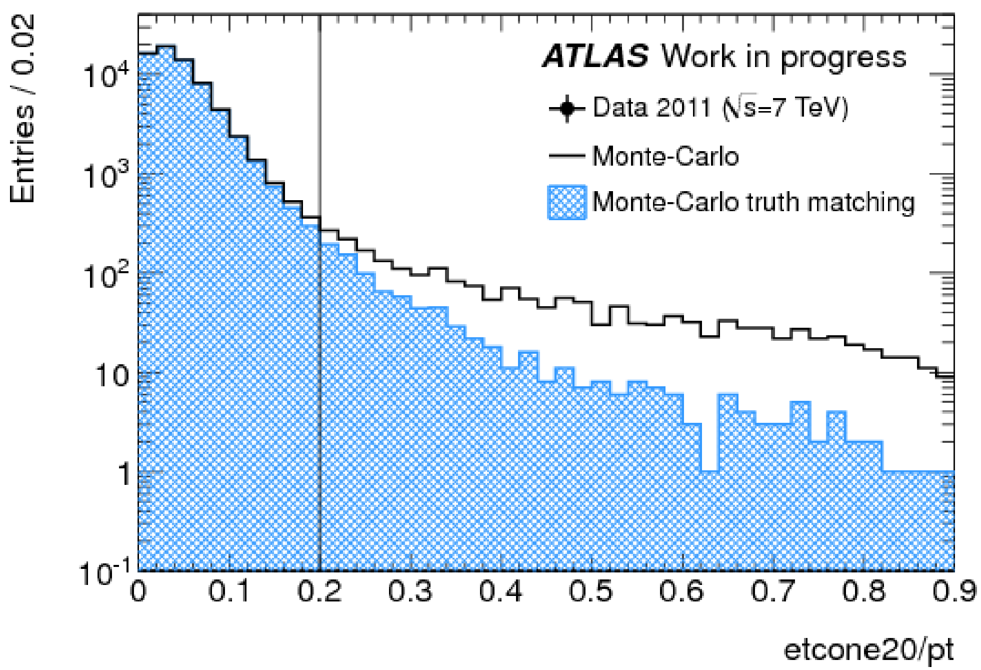
Higgs - Electron study $\sqrt{s}=7TeV$

- I am working on the reconstruction of Z bosons supposed from Higgs boson in the channel $Z \rightarrow e^+e^-$.

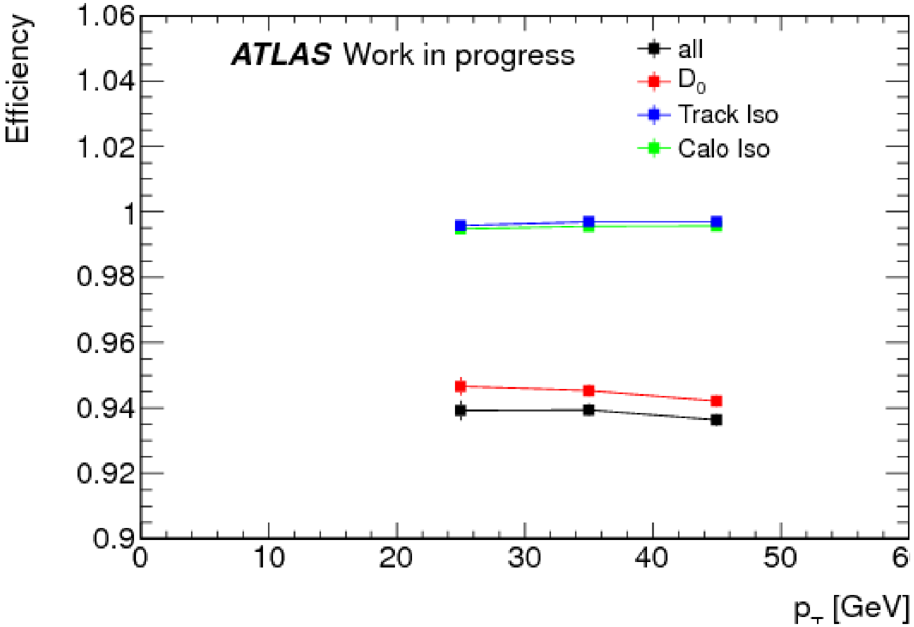


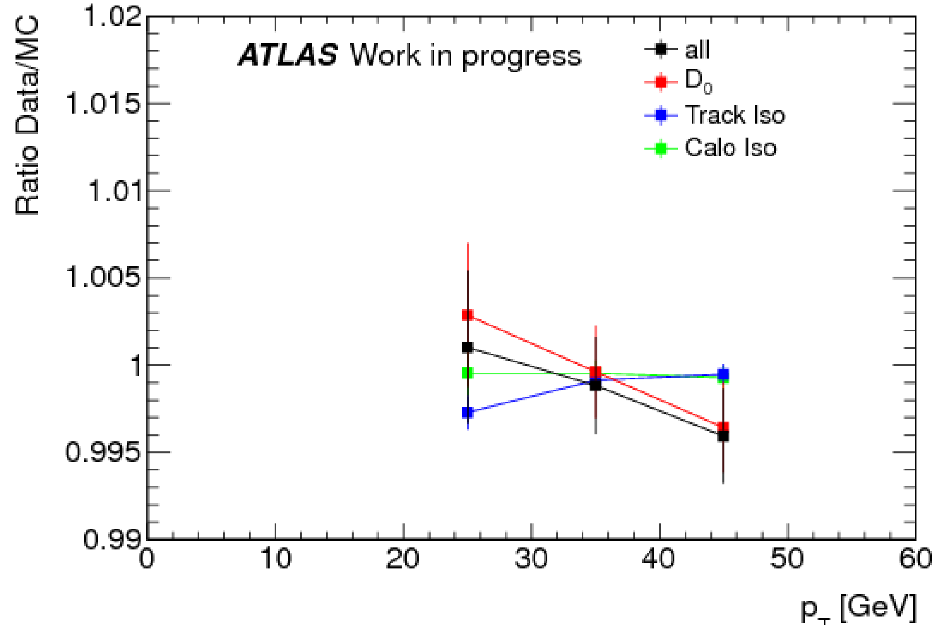
Higgs - Electron study

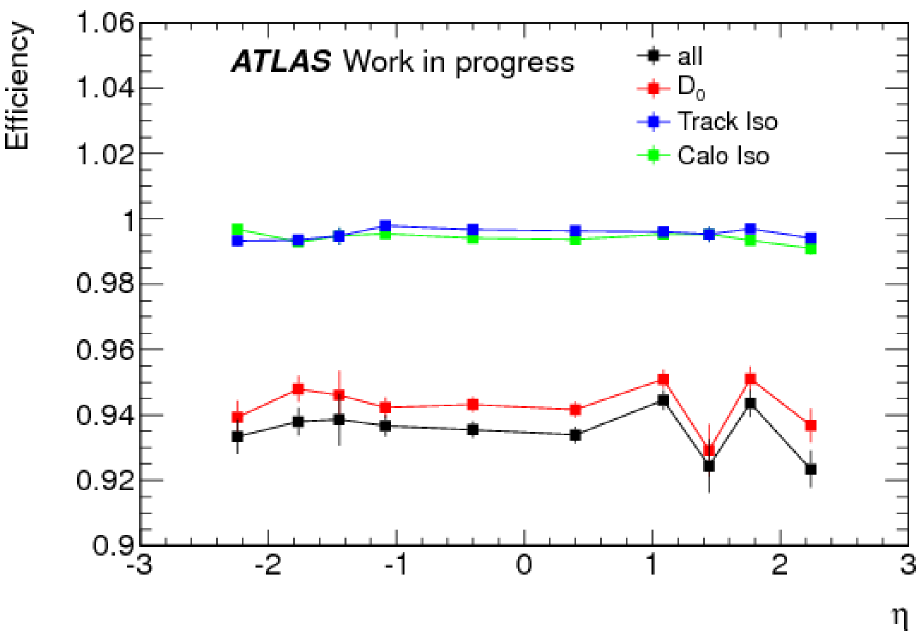
- We keep only isolated electrons from Z (to reject jets for example).
- I am working on the electron selection.
  - $\sum Etcone^{20°}/pt<0.3$ (calorimetric isolation)
  - $\sum ptcone^{20°}/pt<0.2$ (tracking isolation)
  - ...

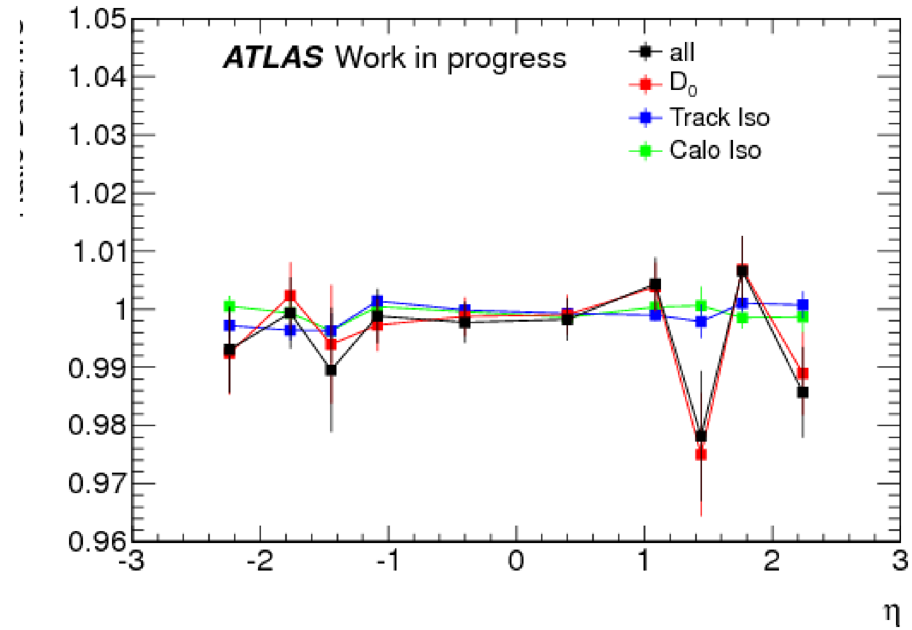


Isolation efficiency









Full Higgs reconstruction process

- Finally, I am working on the full higgs reconstruction process.

Physics Object Selection	
Muons	
μ-ID	TightMuons (MCP group recommendation). Please include both **Muid** and **Staco**
Cosmic Cut	$\lvert d_0 \rvert < 1\ mm$ (where d_0 is relative to the primary vertex)
Kinematics	$p_T > 7\ GeV$, $\lvert\eta\rvert < 2.5$
Electrons	
Algorithm	Author = 1 or 3
e-ID	Medium
Kinematics	$E_T > 15\ GeV$ (EM cluster energy/track direction), $\lvert\eta_{Cluster}\rvert < 2.47$ (including the crack region)
ObjectQuality	Not Available yet
Overlap Removal	
e-μ	Electrons sharing the same ID-track with a muon candidate are removed. Recommended: el_track[d0, z0, phi, qoverp] and mu_muid/staco_id_[d0, z0, phi, qoverp].
llll selection	
Quadruplet Selection (DILS)	Two same flavour (SF) and opposite sign (OS) lepton pairs. Within a quadruplet, the SFOS pairing that give the mass closest to the Z-boson is considered the primary di-lepton, and the other the secondary di-lepton
Kinematics	Quadruplet should contain at least two high E_T leptons, with $E_T > 20\ GeV$.
	Following comment in CDS we should consider matching at least one of the leptons in the quadruplet to the trigger object
Primary Di-Lepton Mass	$\lvert m_Z - m_{l_1 l_2} \rvert < 15$ GeV
Secondary Di-Lepton Mass	Please refer to the table
ΔR of leptons in the quadruplet	$Min[\Delta R(l_i, l_j)] > 0.10$

Full Higgs reconstruction process

Track Isolation	All leptons of the quadruplet should have relative track isolation [cone $\Delta R<0.30$] less than 20%. Contribution of overlapping leptons from the quadruplet is removed for $\Delta R<0.30$
Calo Isolation	All leptons of the quadruplet should have relative calo isolation [cone $\Delta R<0.20$] less than 30%. The contribution of overlapping leptons is removed for $\Delta R<0.18$ [see section 5.2.1 of the note]
Impact Parameter Significance	$\|d_0\|/\sigma(d_0)$ applied to the two lowest p_T leptons for $m_{4l} < 190$ GeV. For electrons <6, for muons <3.5. Recommended variables : el_trackd0pvunbiased & el_tracksigd0pvunbiased and mu_*_trackd0pvunbiased & mu_*_tracksigd0pvunbiased
Mass Window	For the final quadruplet mass calculation a Z mass constraint is applied

Currently : six H->eeμμ candidates !

TODO: Study the background: electrons from b quarks.