Photon testbeam

Data/G4 comparison

1. Motivation
2. Testbeam setup & simulation
3. Analysis & results
4. Conclusion

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Motivation

Photon identification is crucial for physics analysis in **ATLAS**

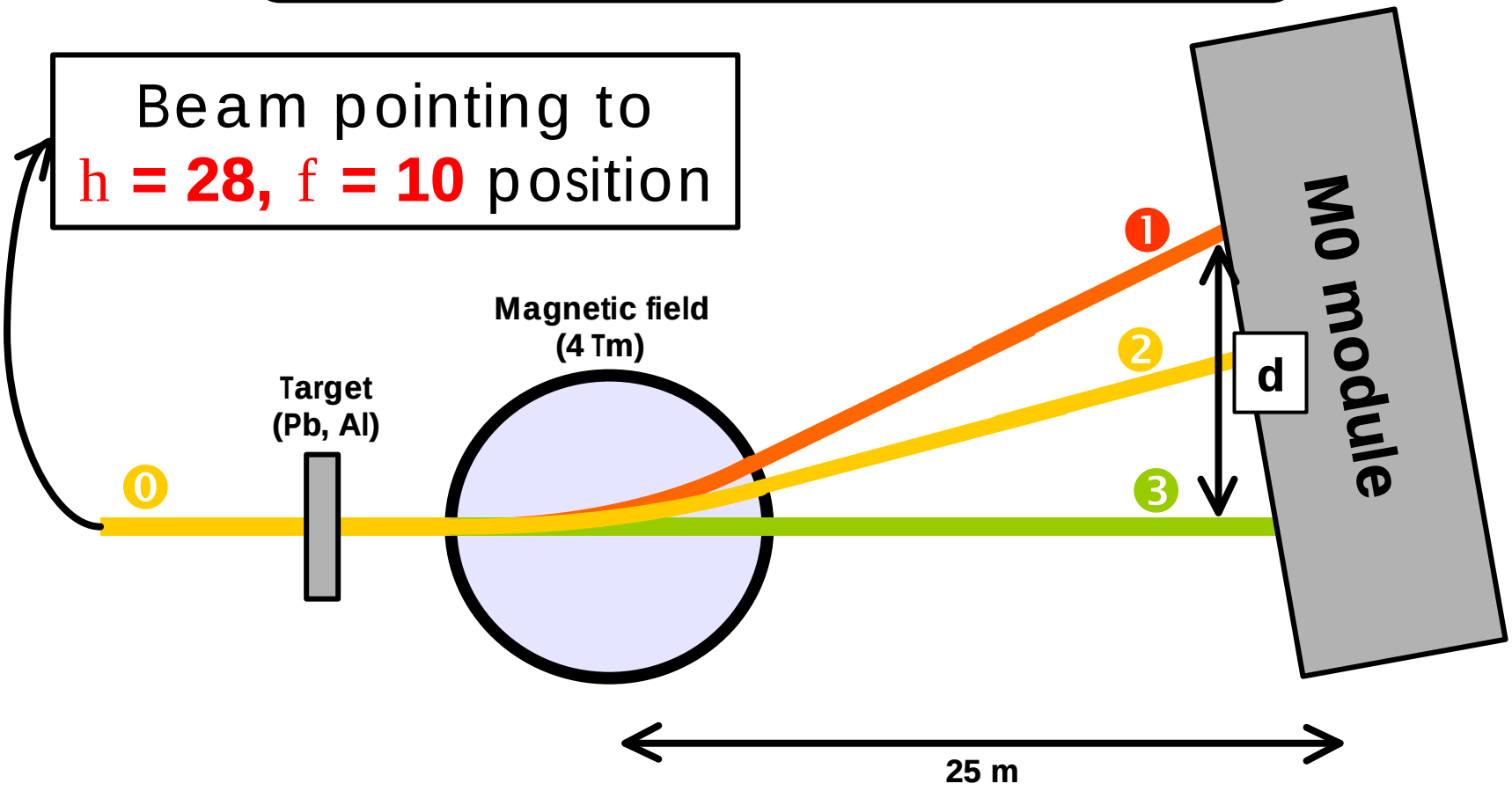
Numerous complex effects are involved (**cross-talk**, **electronic noise**,...)

Is **G4** able to reproduce correctly photon in the Ecal?

Compare data (taken on Ecal barrel in **August 2000**) to a G4 simulation taking into account those effects

The Photon TestBeam experimental setup
1. Technical description

Beam pointing to
h = 28, f = 10 position

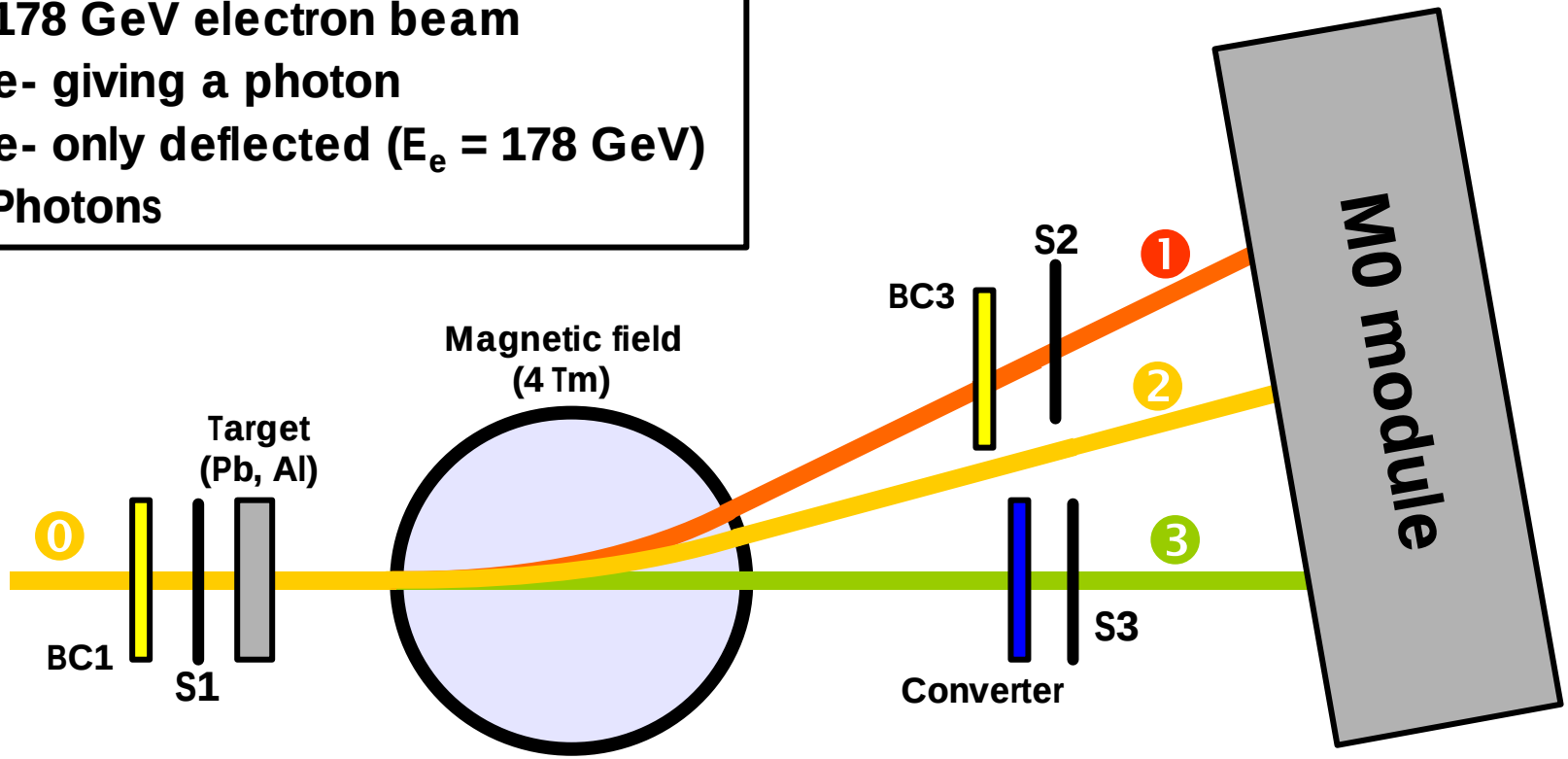


- 0 178 GeV electron beam
- 1 e- giving a photon
- 2 e- only deflected (E_e = 178 GeV)
- 3 Photons

$$d = \left(\frac{3060}{E_e}\right) \text{ cm}$$

The Photon TestBeam experimental setup
2. Triggering & event filtering

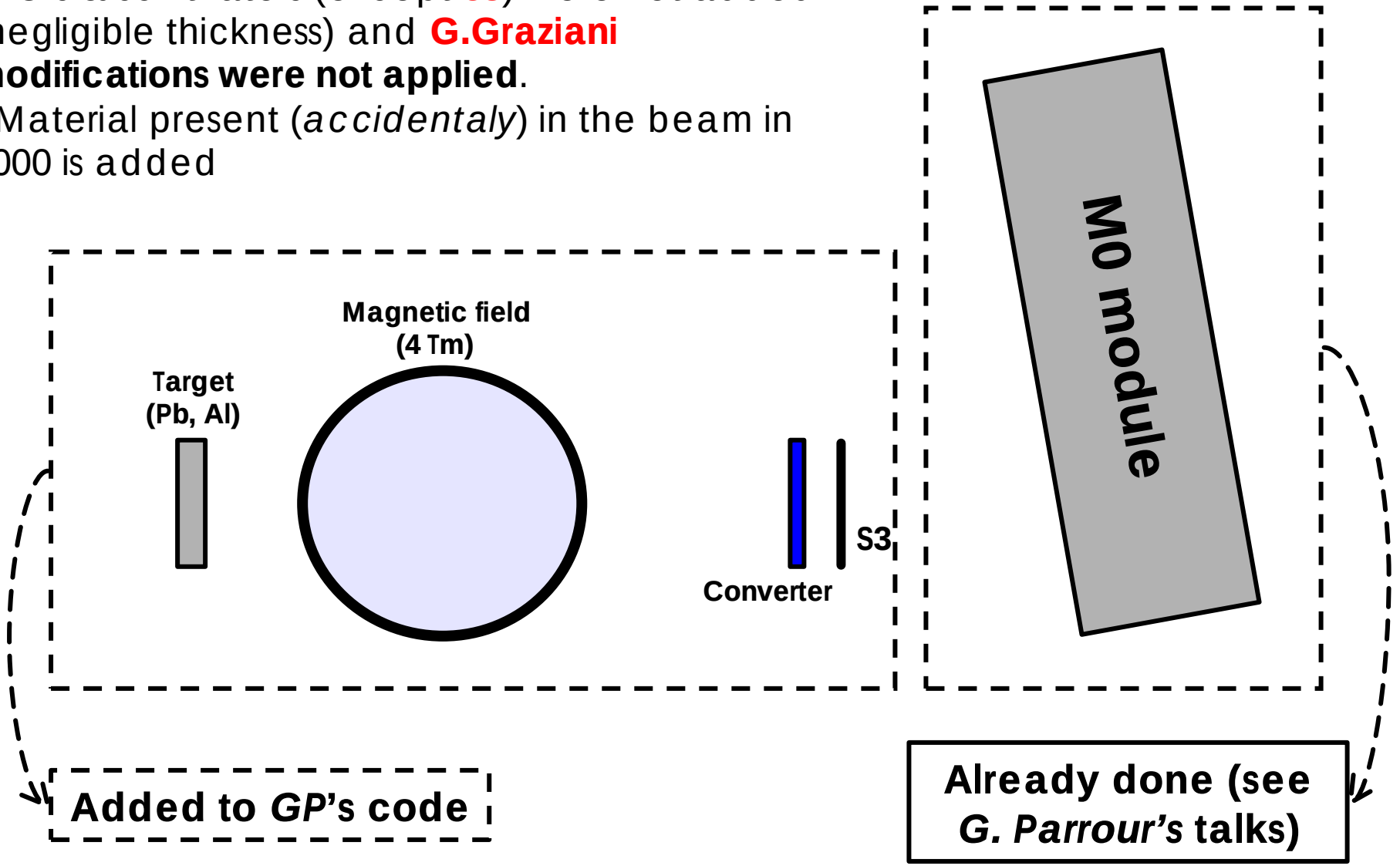
- ⓪ 178 GeV electron beam
- ❶ e- giving a photon
- ❷ e- only deflected (E_e = 178 GeV)
- ❸ Photons



- **Trigger Û S1 Ù S2**
- **Multiphoton rejection Û Converter + S3**
- **Beam profile Û BC's**

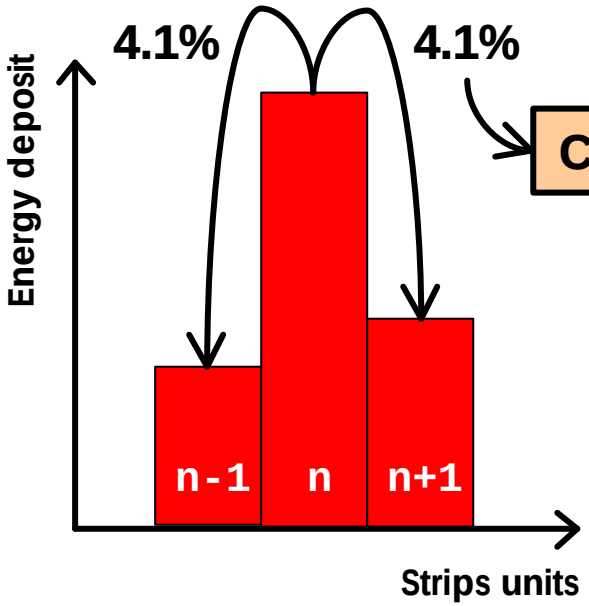
The Photon TestBeam experimental setup
3. G4 Modelisation

- Simulation developped with G4 **release 4.4.1**
- BC's & scintillators (except **S3**) were not added (negligible thickness) and **G.Graziani modifications were not applied**.
- Material present (*accidentaly*) in the beam in 2000 is added

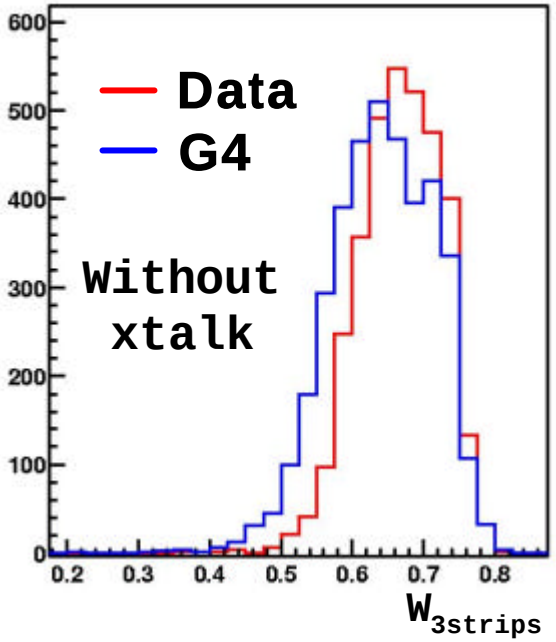


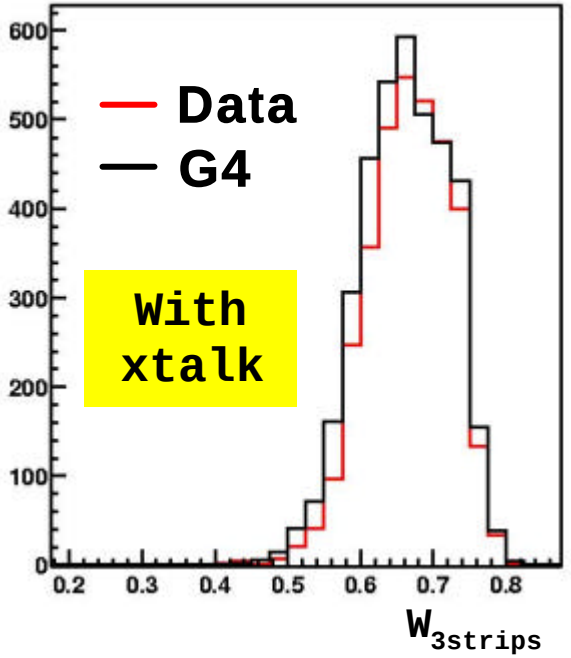
Calibration
1. Crosstalk

Significant effect on **precise** parameters (Width on 3 strips,...)



CERN-EP-2002-087

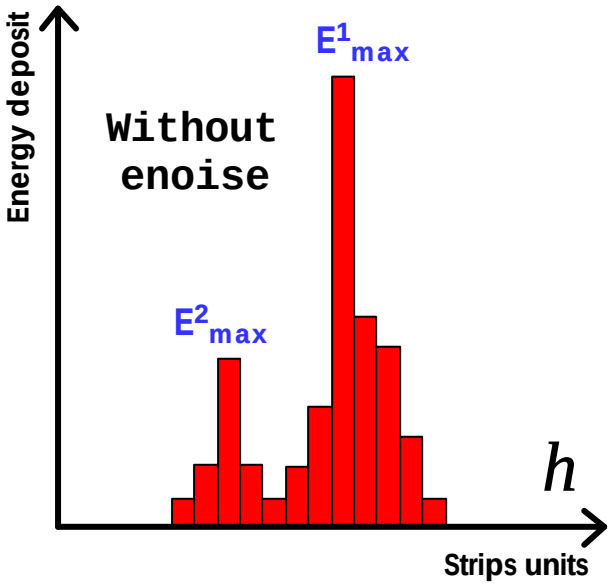


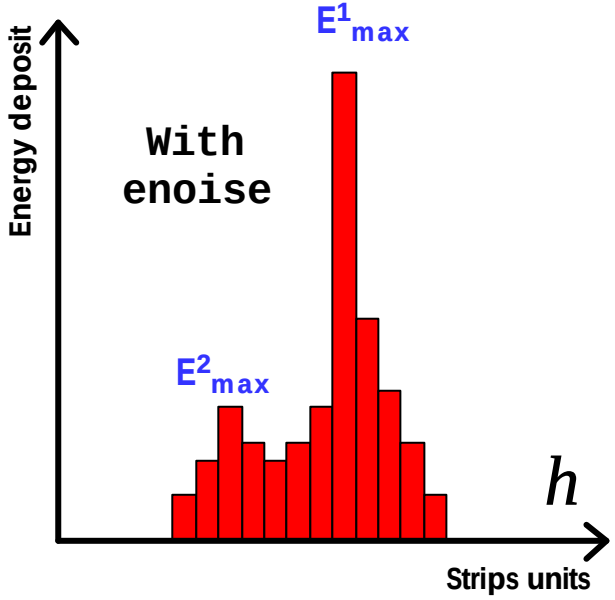


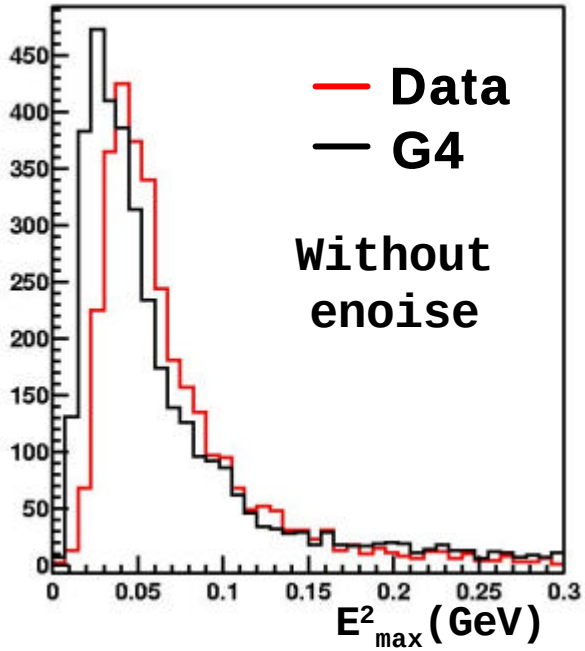
Only x-talk from **closest neighbours** in the **strips** is added

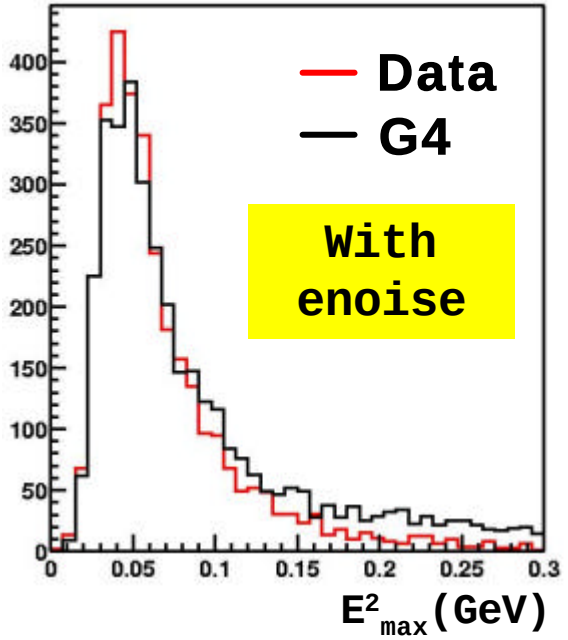
Calibration
2. e-noise

Significant effect on γ/π^0 **rejection** parameters (Energy of 2nd maximum,...)









e-noise **softens** the difference between E^2_{max} the **valley**, particularly at **low energy**

Analysis
1.Cuts applied

Þ **Photon candidate if :**

5 GeV < E_{ph} < **55 GeV** — *Too much background under 5 GeV*

0.93 E_{calo} < $E_{ph} + E_{el}$ < **0.96E_{calo}** — ~~*Multiphoton*~~

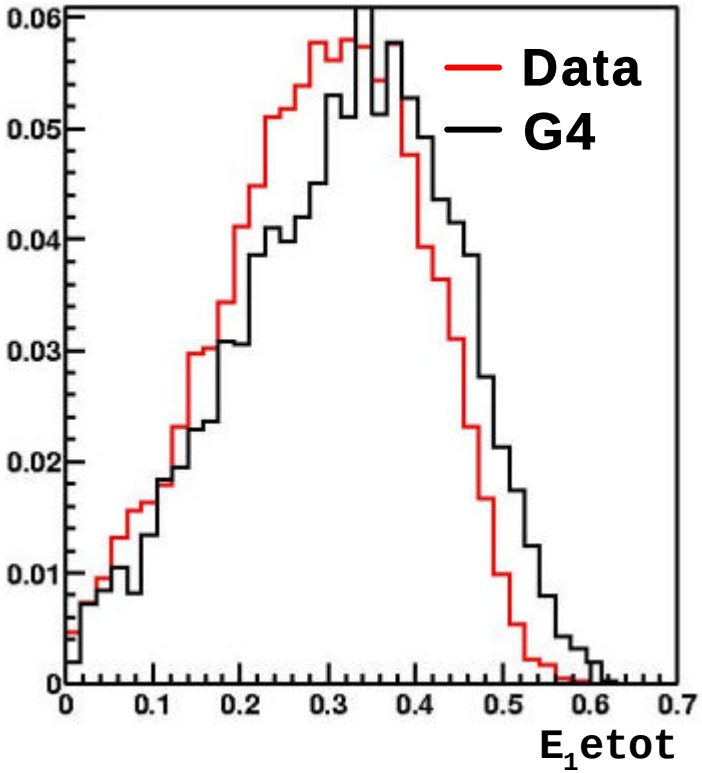
226. < η_{strips}(Photon) < **230.** — *Electron position dispersion*

S3 signal Û **pedestal** — ~~*Multiphoton*~~

Results
1. Energy in the strips & leakage proportion

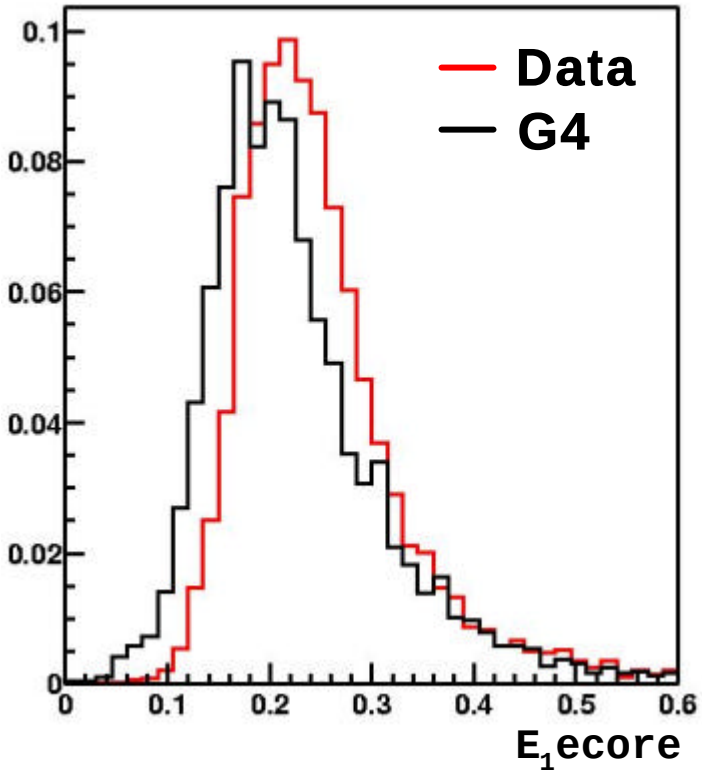
Fraction of energy in the strips

$$E_1etot = \frac{E_{photon}(strips)}{E_{photon}}$$



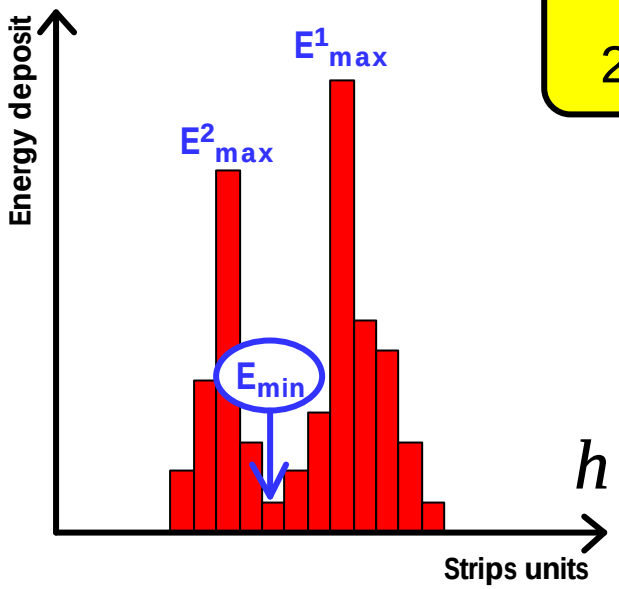
Leakage fraction in the strips

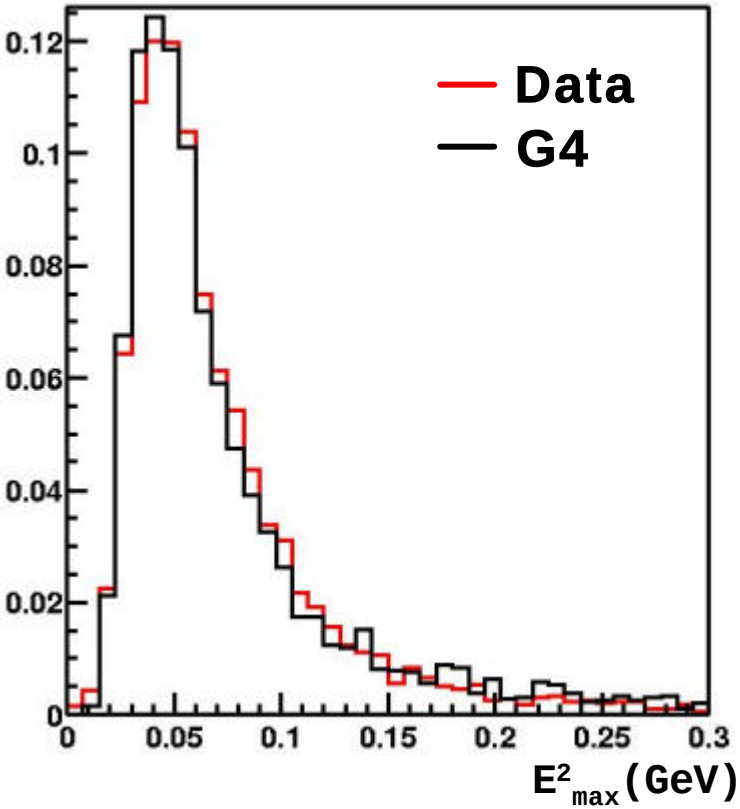
$$E_1ecore = \frac{E_{photon}(7strips) - E_{photon}(3strips)}{E_{photon}(3strips)}$$

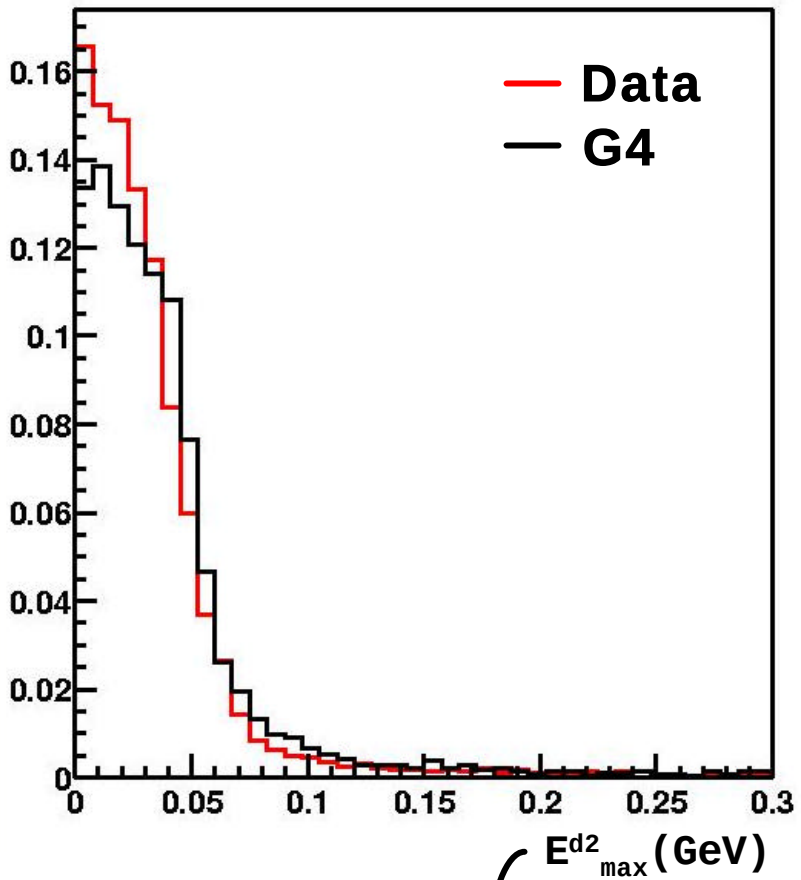


➡ Problem with **upstream material modelisation** and **calibration with xtalk** in the strips (see **G. Graziani 's** 01/10/03 talk)

Results
2. γ/π^0 rejection parameters





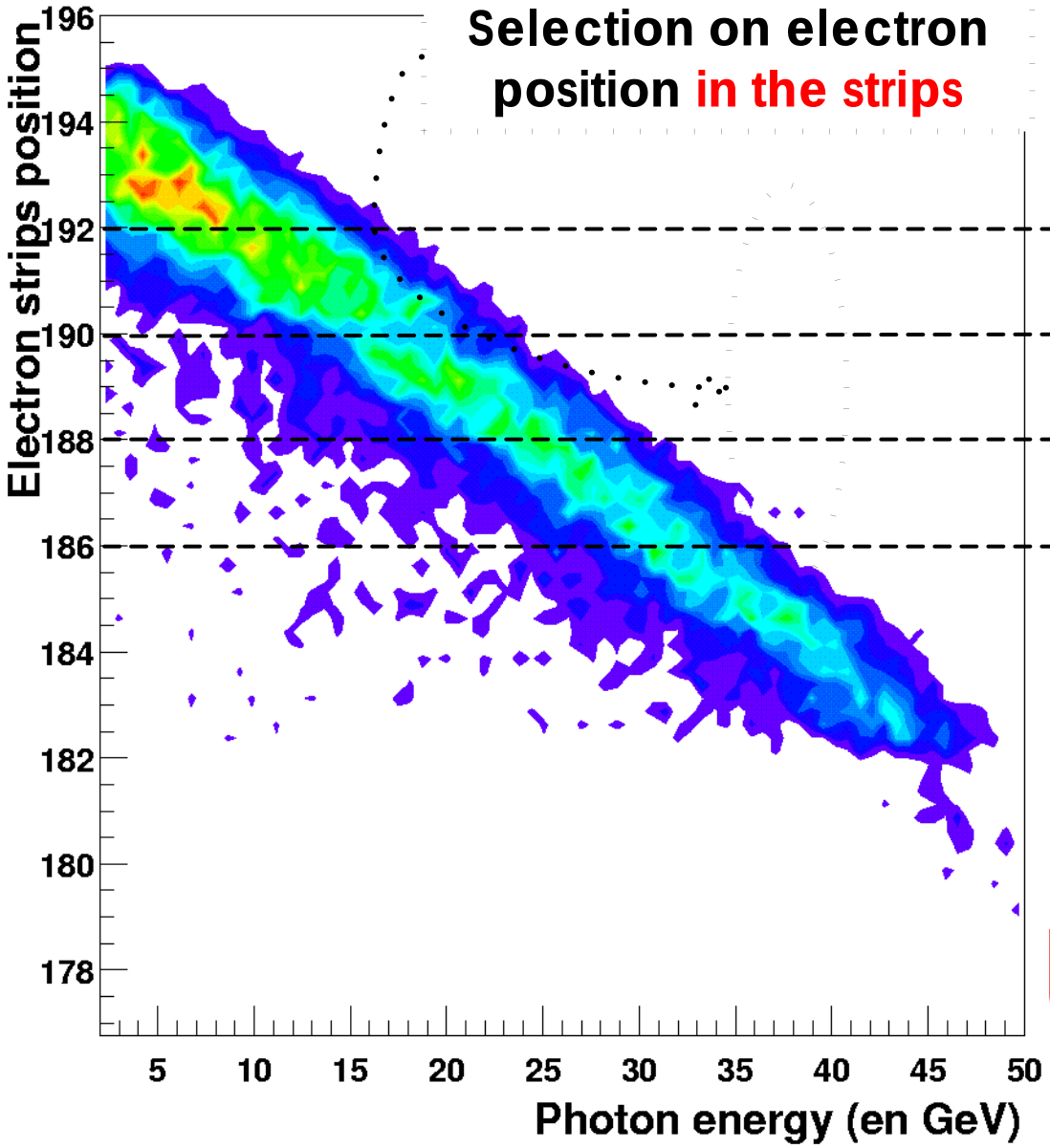


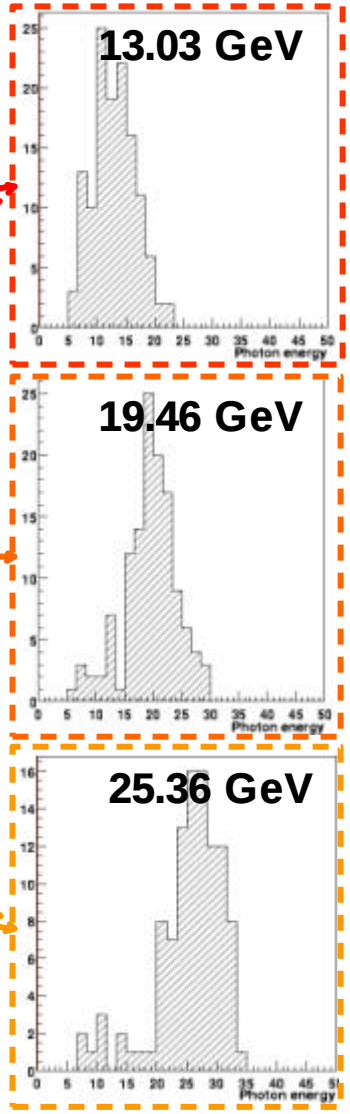
$E^{d2}_{max} = E^2_{max} - E_{min}$

→ **Good agreement G4/Data**

Analysis

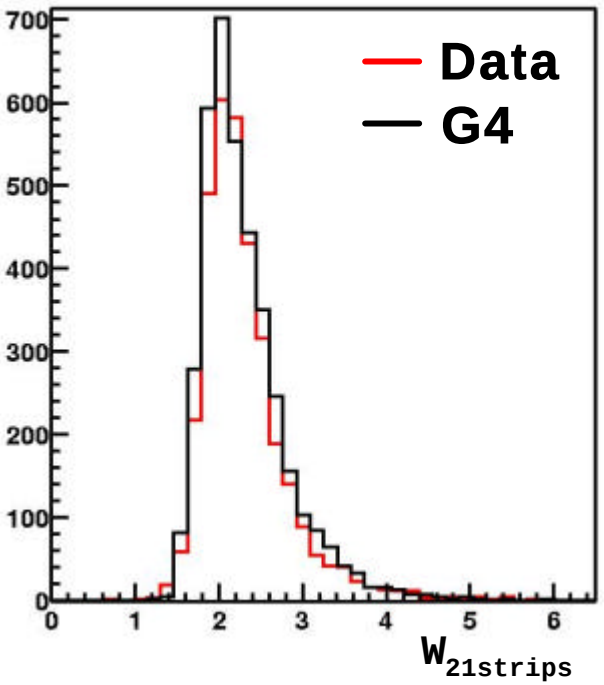
2. Using correlation between electron deviation & photon energy

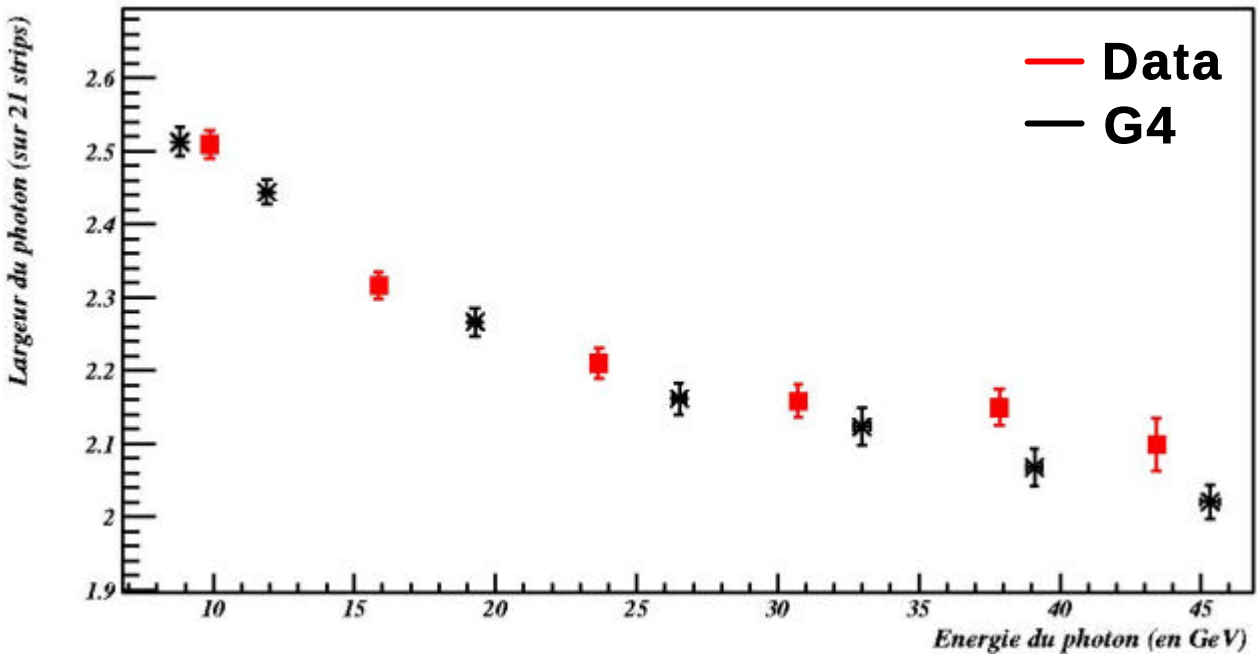




Compare photon widths at different $\langle E_{ph} \rangle$

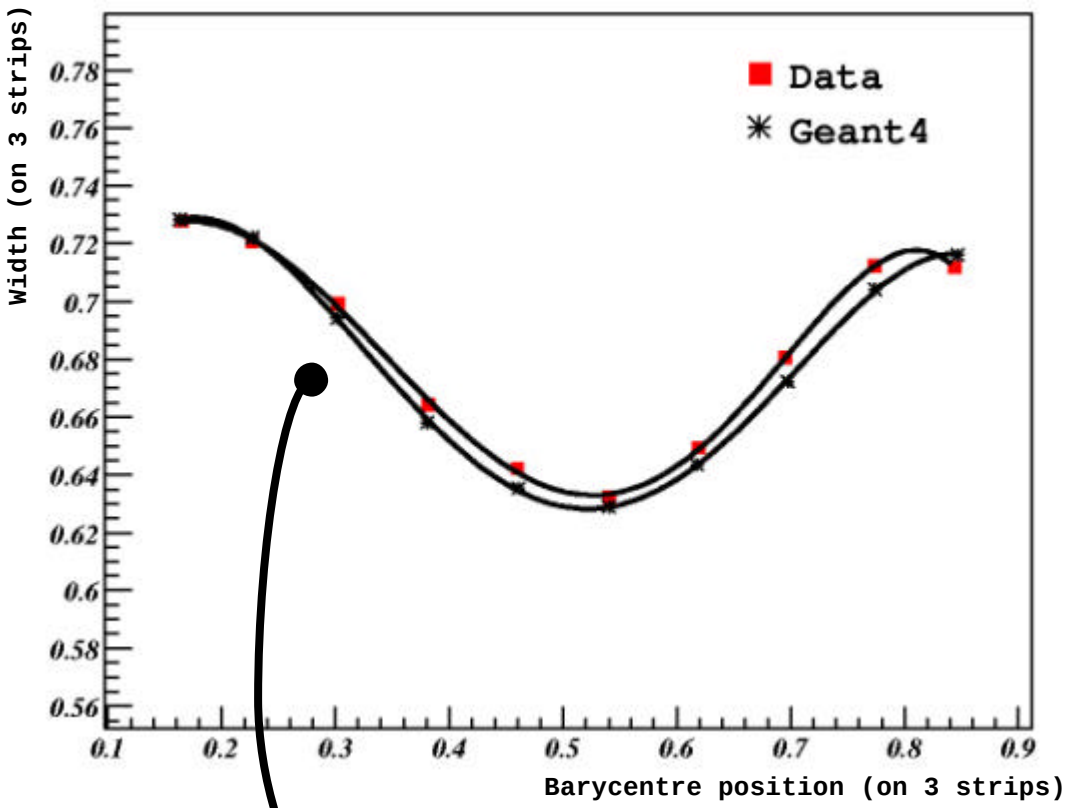
Results
3. Width on 21 strips



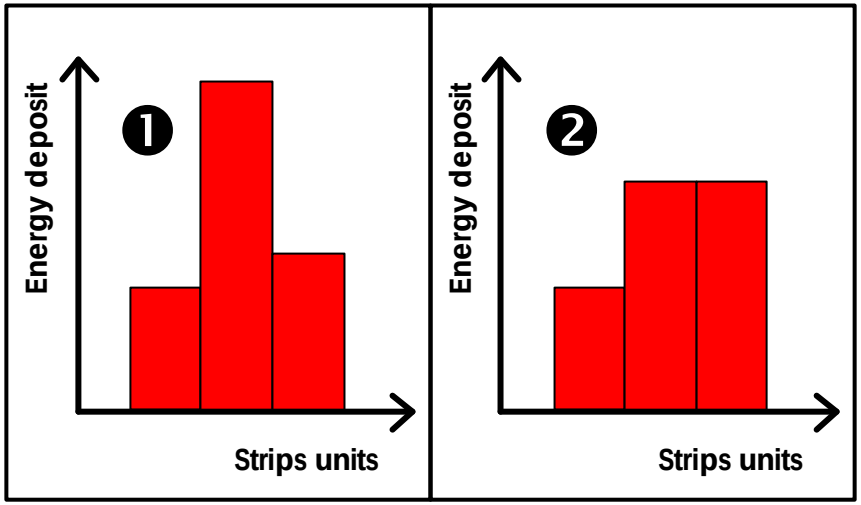


- **Good agreement (**the **width reduction with energy** is correctly reproduced with **G4)**
- **xtalk effect small**
- **enoise effect significant at low energy**

Results
4. Width on 3 strips (1/2)



Strip granularity effect

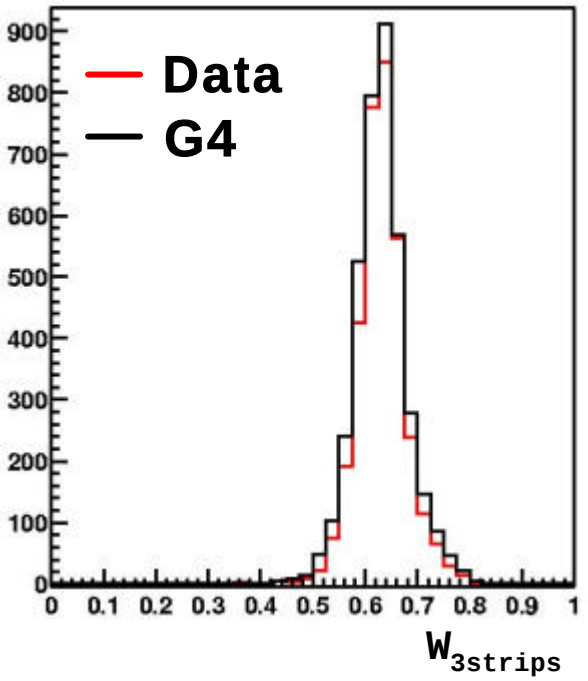


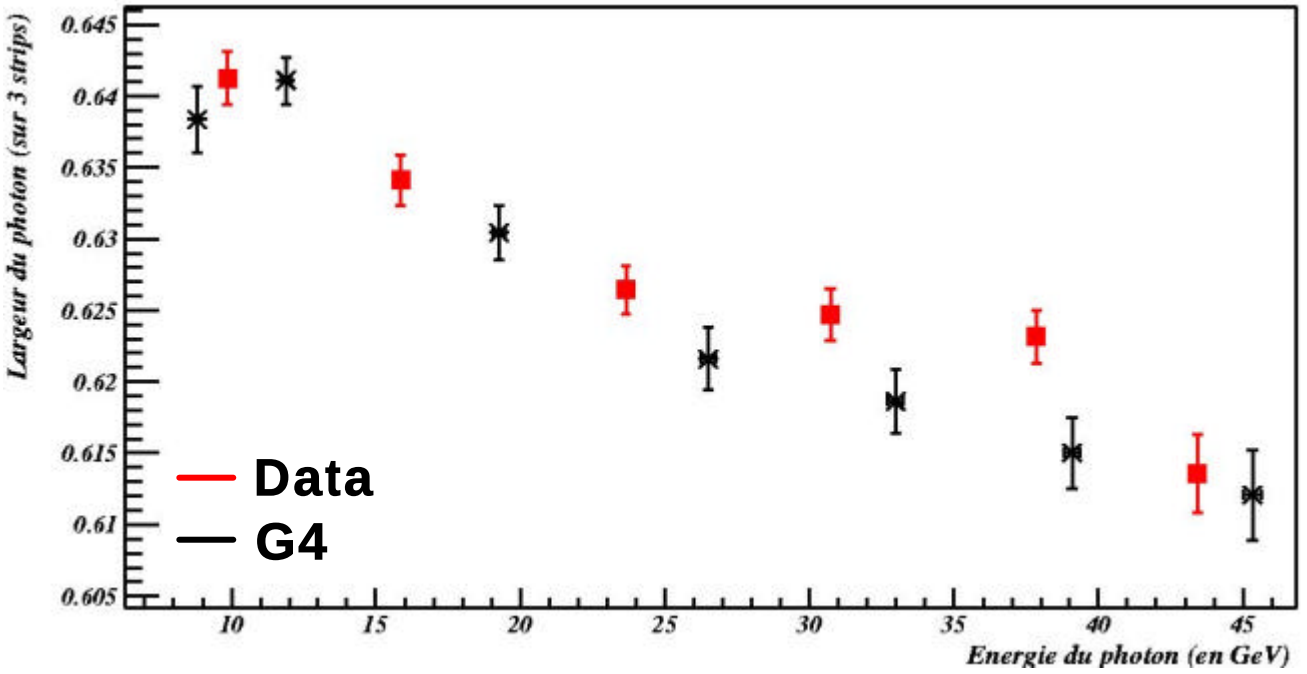
$E^{❶}_{strips} = E^{❷}_{strips}$
but
$W^{❶}_{3} < W^{❷}_{3}$

Geometrical effect well reproduced by G4 simulation **including xtalk**

Results
5. Width on 3 strips (2/2)

® **After correction of granularity effect (**polynomial fit**)**





- **Good agreement**
- **xtalk effect significant (see slide 9)**
- **enoise effect small**

Conclusions

- A comparison G4/Data of **photon shape parameters** in the ATLAS Ecal was performed.
- **Crosstalk** & **e-noise** were included
- The **real experimental setup** (with mag. field, converter, and target) was simulated (in order to compare width evolution with photon energy).

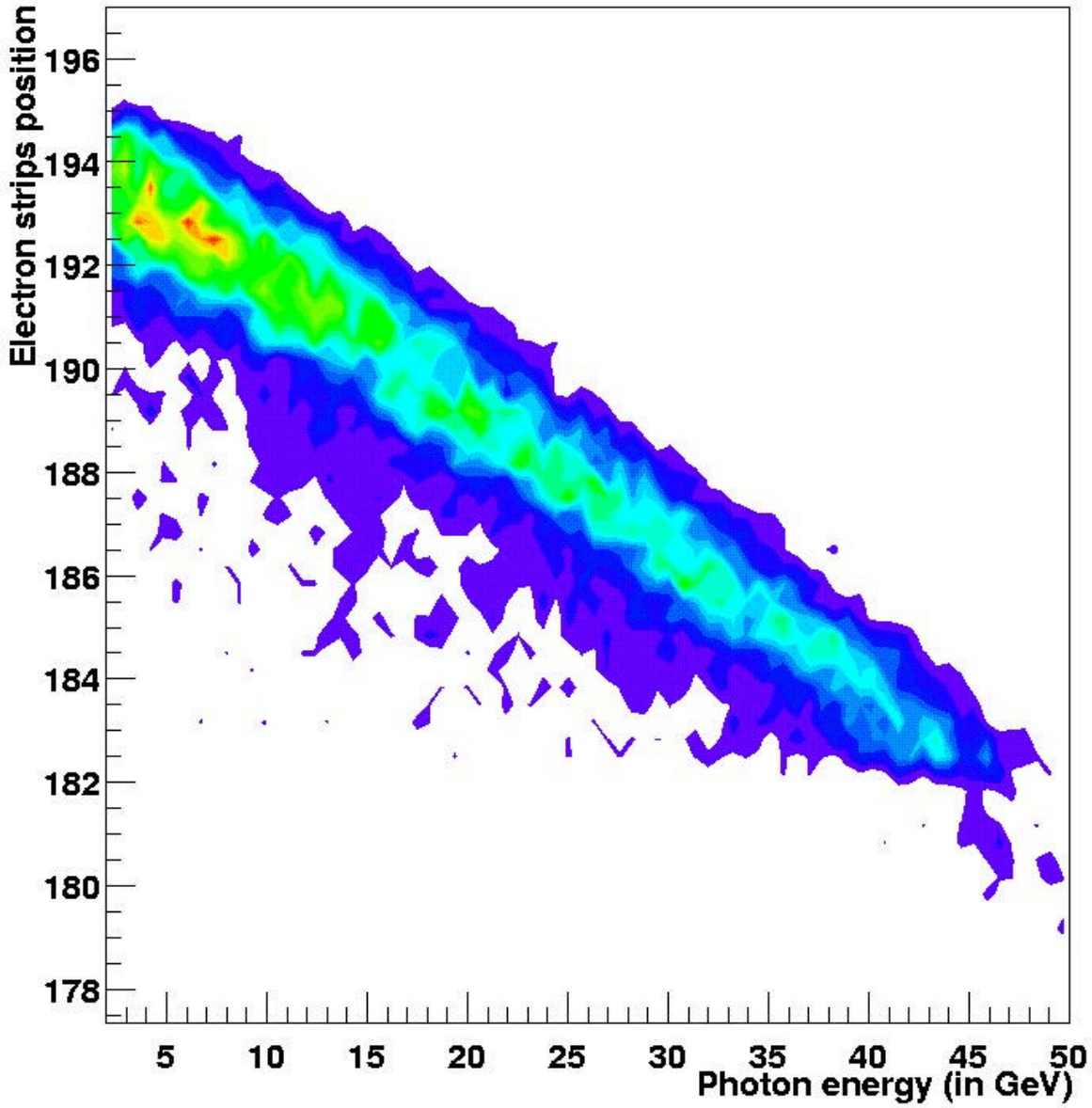
Energy independent measurements were **compatible** with G3 and data (except $\mathbf{E_1^{ecore}}$ and $\mathbf{E_1^{etot}}$).

Energy dependent measurements (*not done with G3*) were **in good agreement** with data. The width reduction is well reproduced by Geant4

- **The description of photon shower by G4 is equivalent to G3's.**
- But some points **still need to be understood** (Is G. Graziani's electron's description valid for photons ?,...).

Backup slides

The correlation between electron position and Photon energy

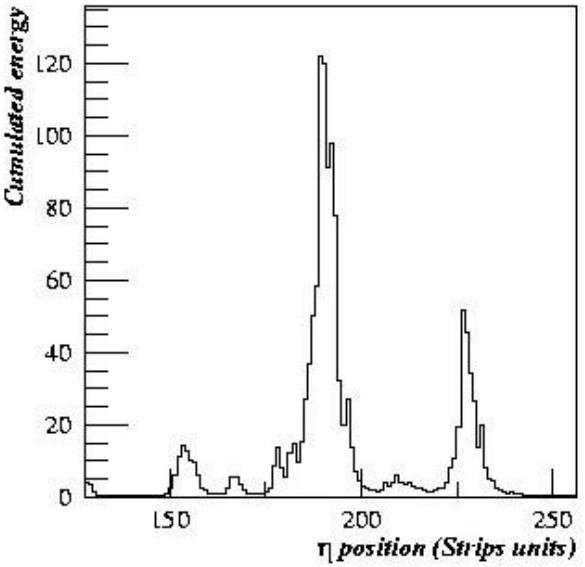


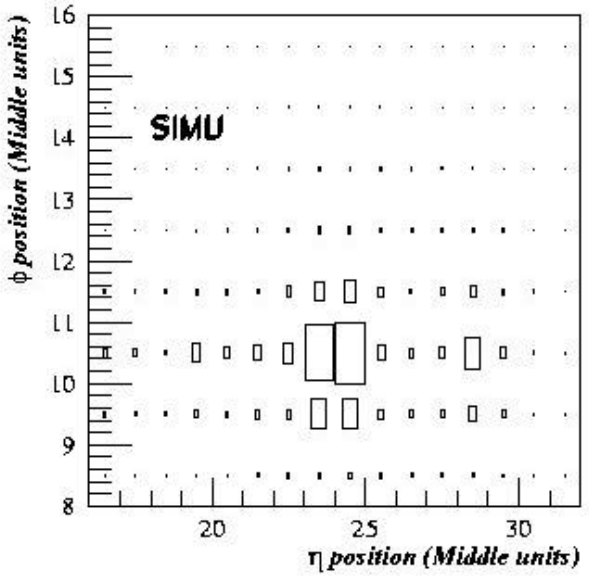
$E_{ph} + E_e = 178$ GeV

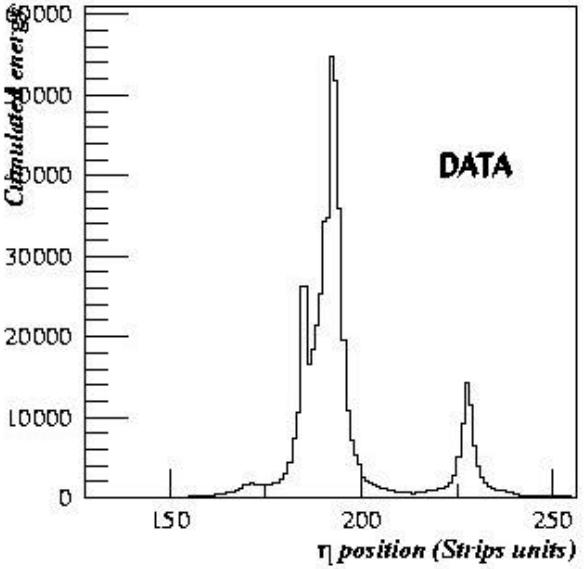
$$d = \left(\frac{3060}{178 - E_{ph}} \right) \text{cm}$$

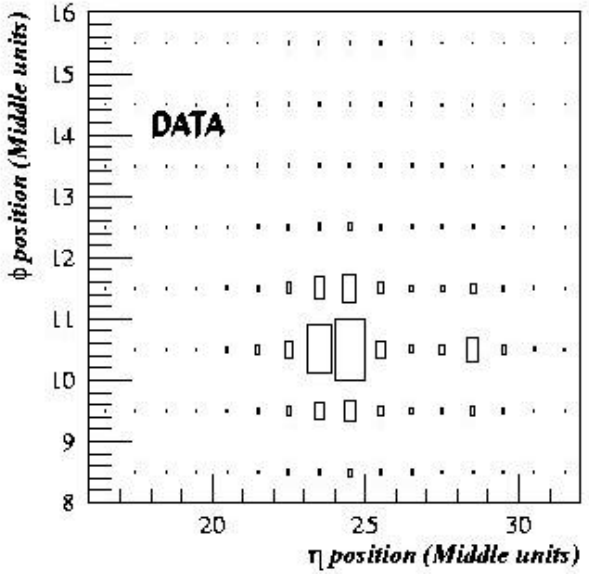
Applying cuts on d, we could study photons at different energies

Geometry & magnetic field verification









f & h position in agreement with data

Geometry & **Magnetic field** are OK

Next step: **Physics calibration**

Energy calibration
1. The method

Data output (energy) ← $E_{tot} = \alpha(\beta I_{ps} + I_{barrel})$ → **Simu output (current)**

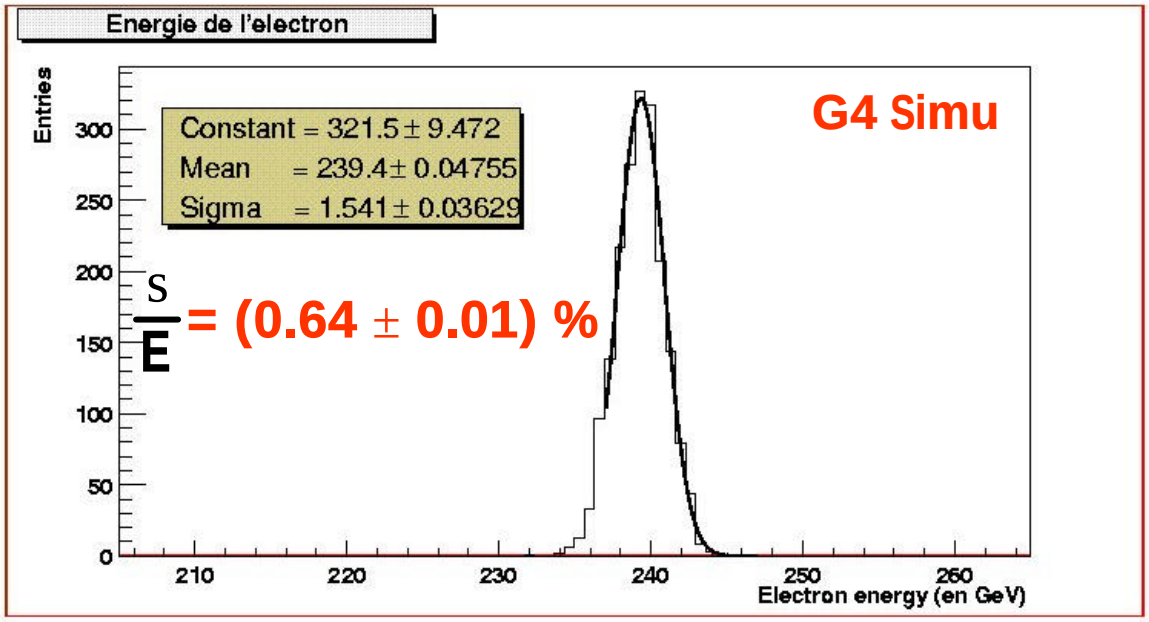
Energy calibration Û Find α & β

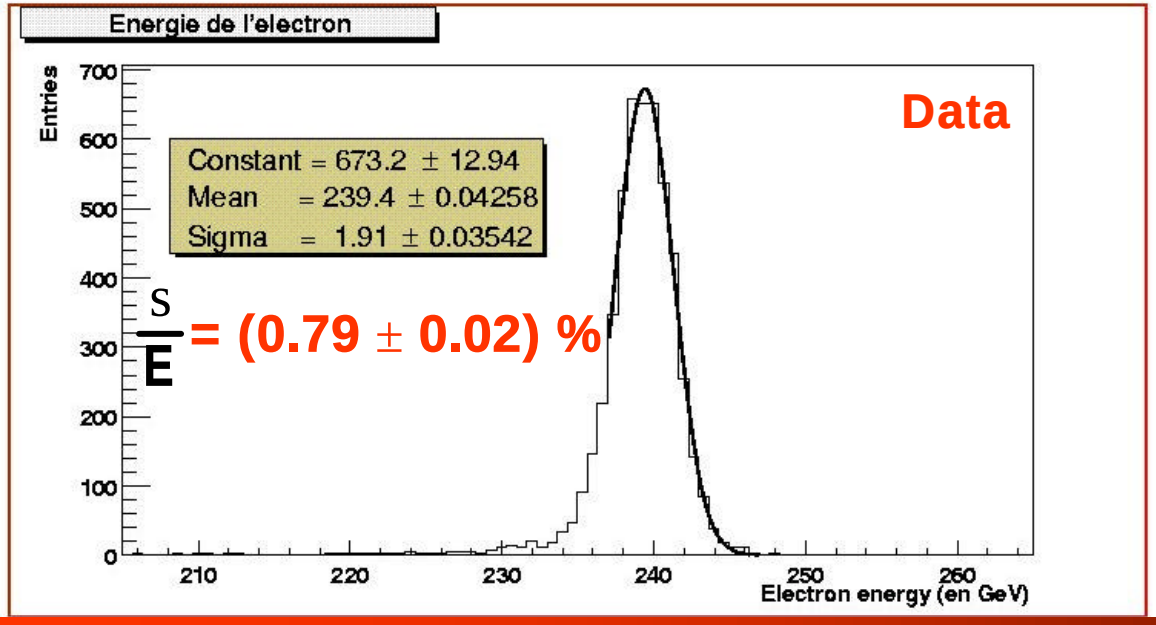
Þ Basic method (only one cell (28,10)):

❶ Correct ϕ & η modulation → ❷ Determine $\langle E_{ps}\rangle_{data}$, $\langle I_{ps}\rangle_{simu}$, $\langle E_{tot}\rangle_{data}$, and $\langle I_{barrel}\rangle_{simu}$

❸ $$ab = \frac{\langle E_{ps}\rangle_{data}}{\langle I_{ps}\rangle_{simu}}$$ → ❹ $$a = \frac{\langle E_{tot}\rangle_{data} - \alpha\beta\langle I_{ps}\rangle_{simu}}{\langle I_{barrel}\rangle_{simu}}$$

Energy calibration
2. The problem





245 GeV electrons were simulated with the same program

↓

MC resolution was **better** than expected

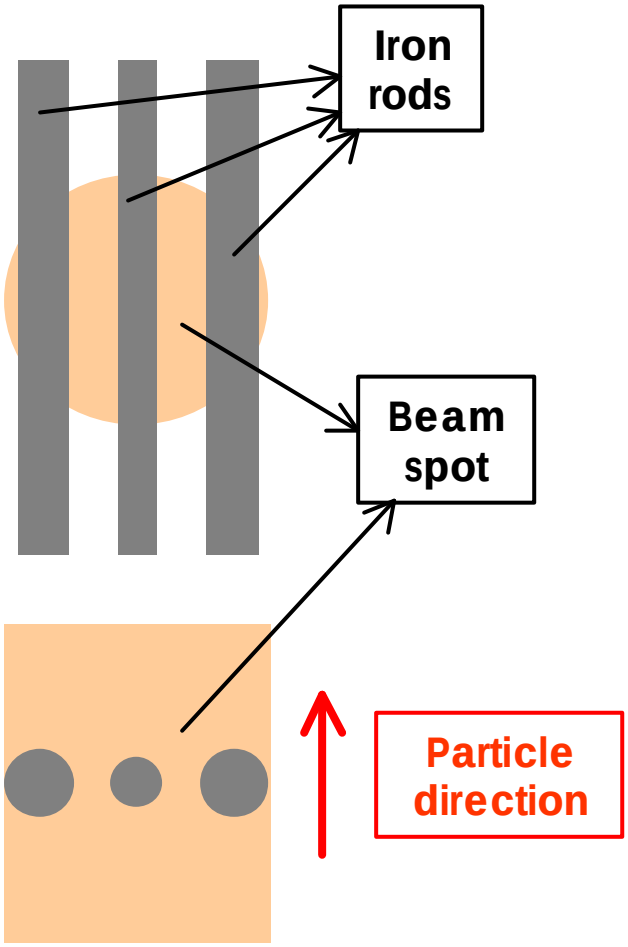
↓

Something was missing in the simulation

↓

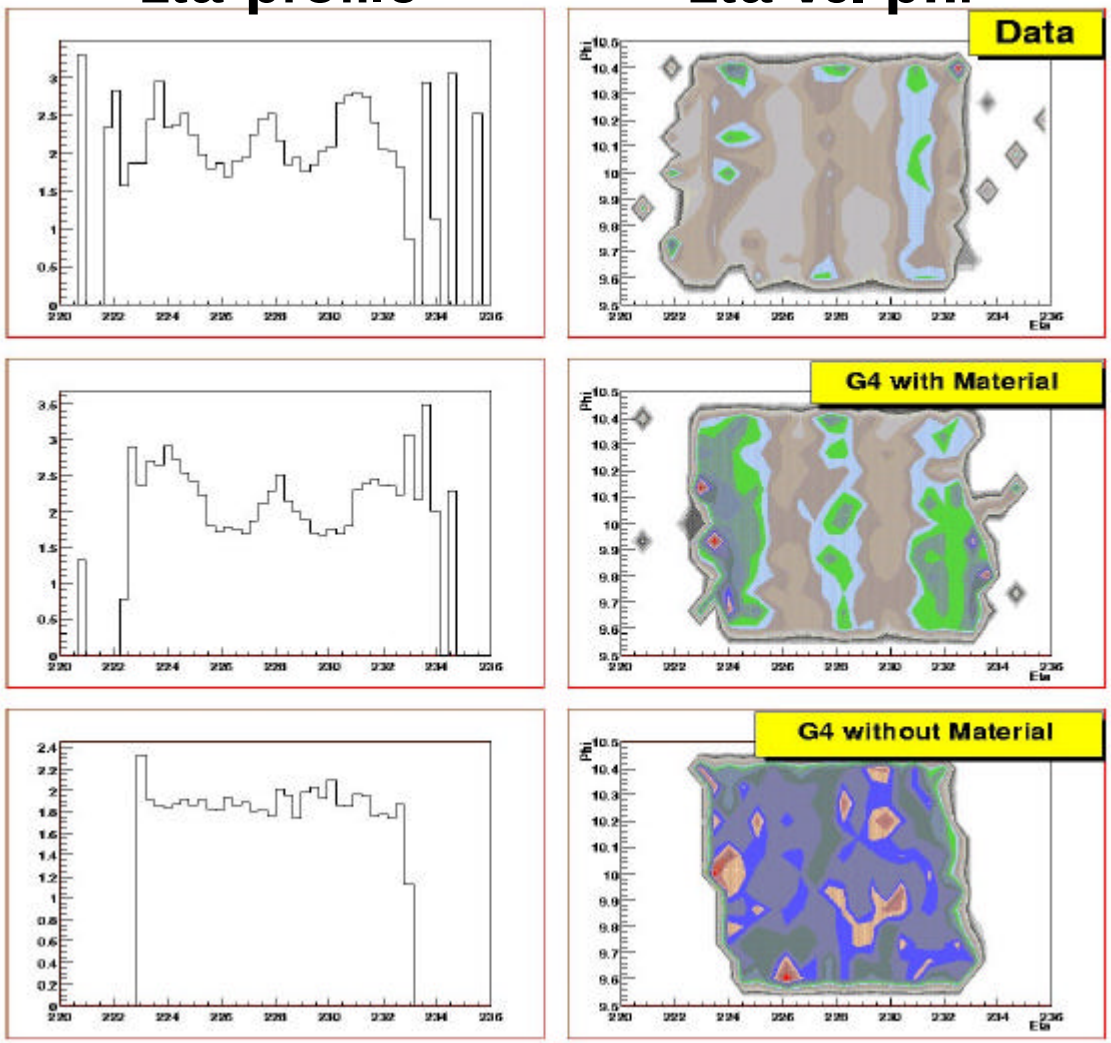
Material found in the beam in 2001 could be an answer to this problem

Energy calibration
3. Adding the material



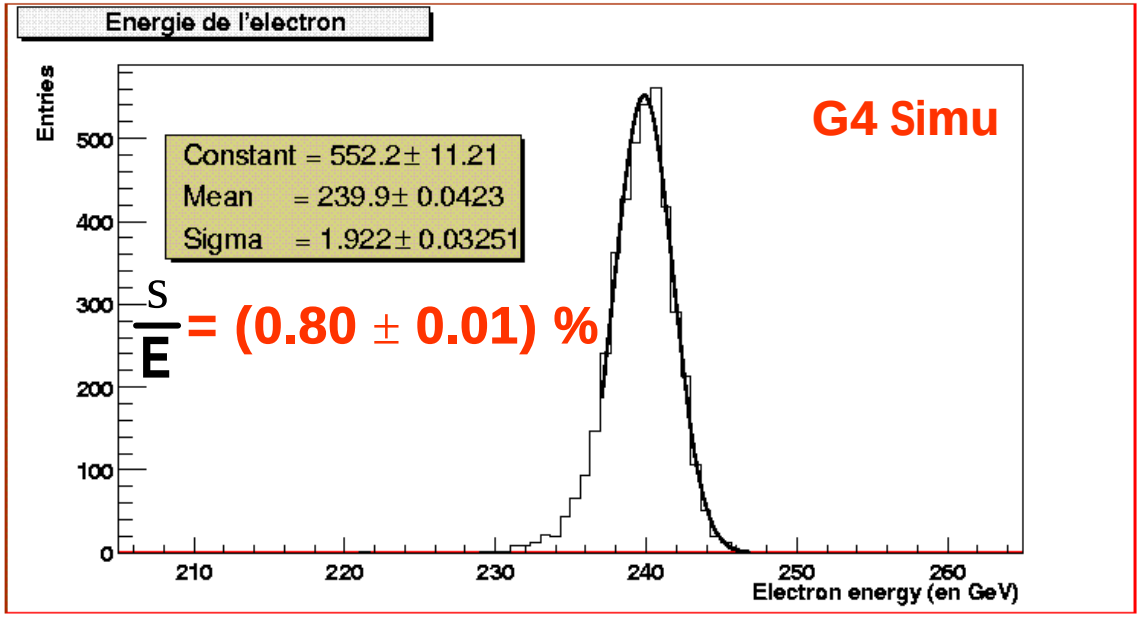
Material found in the beam in 2001

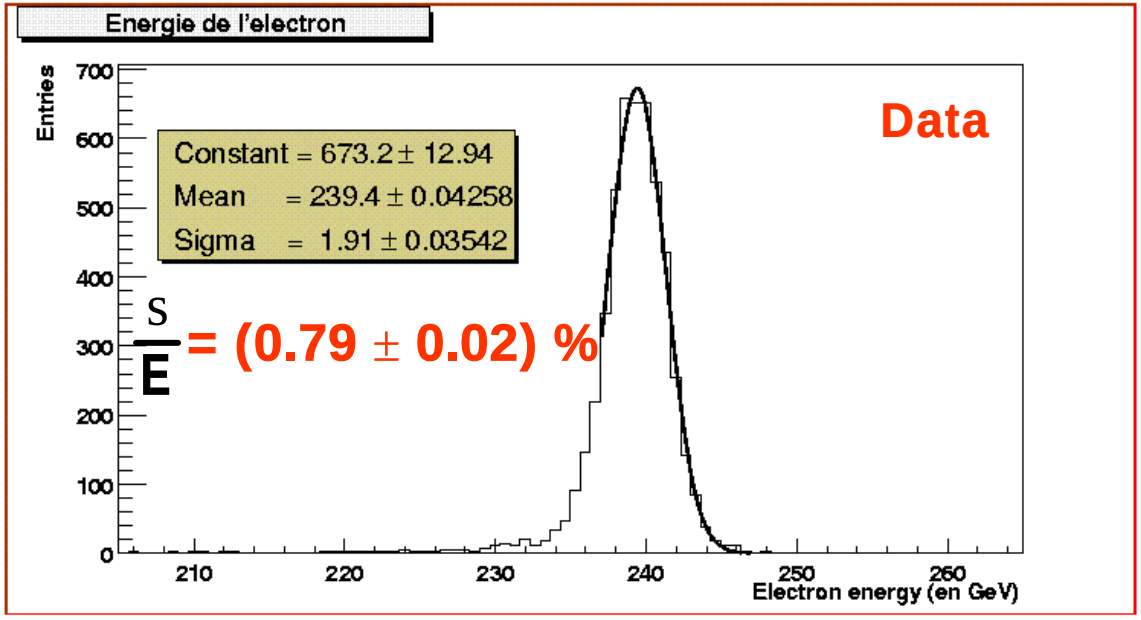
Eta profile | **Eta vs. phi**



Energy deposit in PS: material seems to be well reproduced

Energy calibration
4. It looks better...





$\alpha = 2.614$

$\beta = 5.787$

MC & Data resolution in agreement

↓

Energy calibration OK (for (28,10) cell)

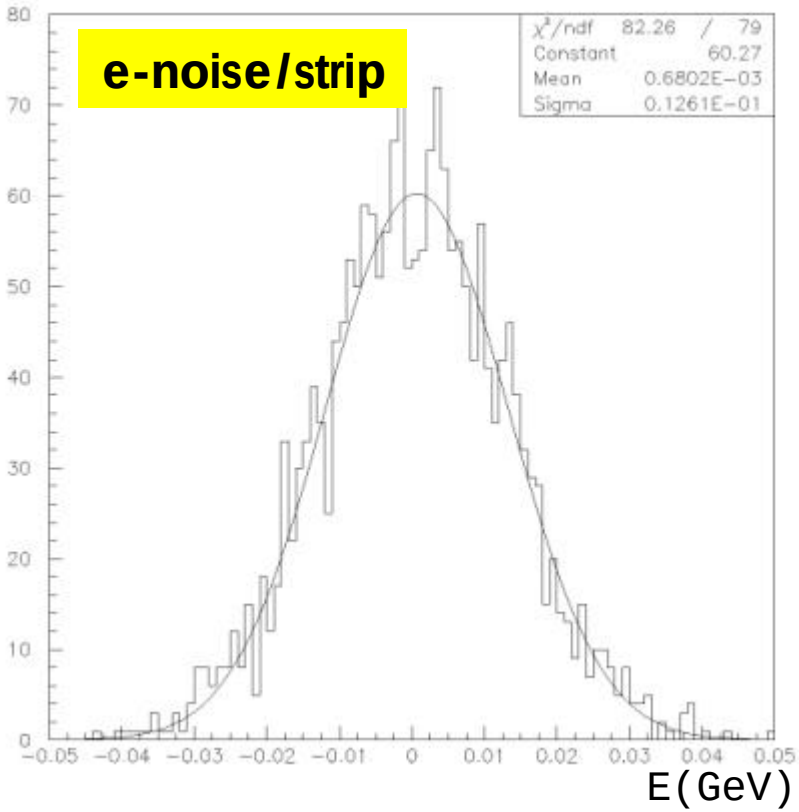
↓

Next step: photons

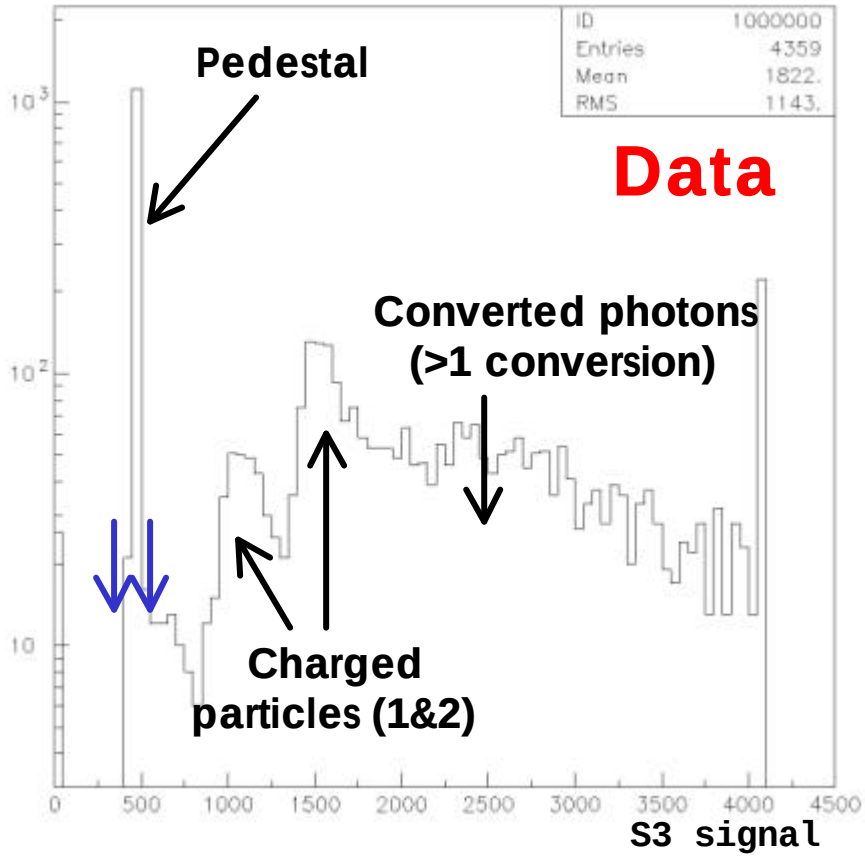
e-noise determination

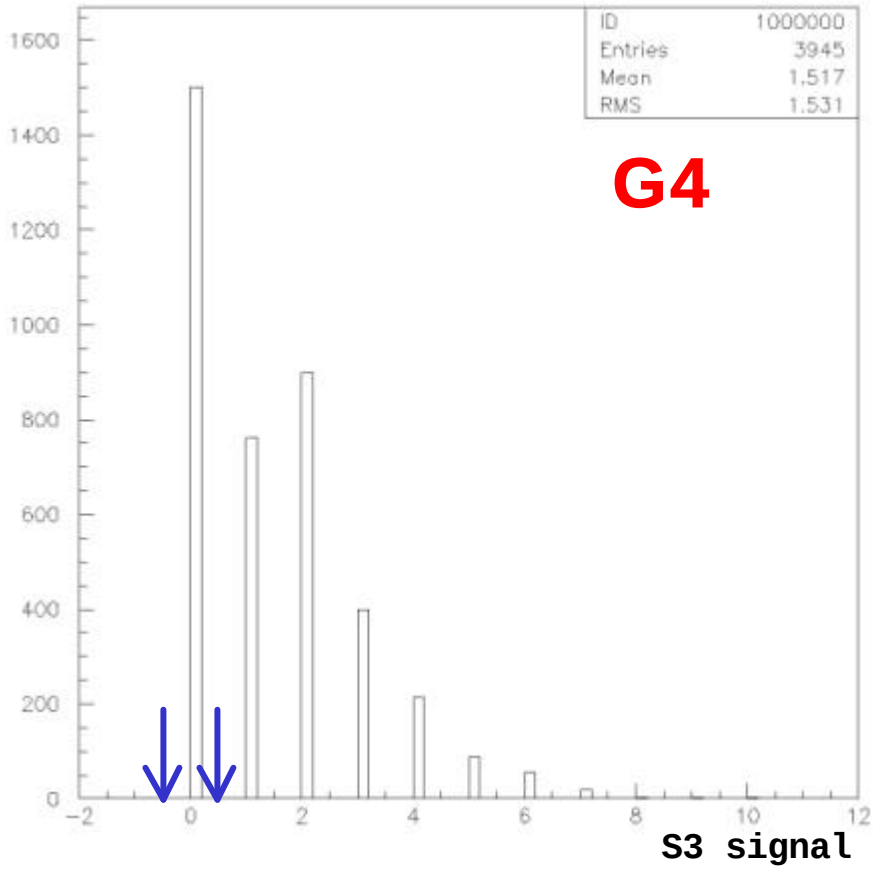
e-noise could be deduced using **random** events (no signal)

Fitted with a gaussian centered on **0** and with **s = 13MeV**
(*compatible with TDR value*)



S3 cut





↓ ® cut values

Peak heights are not similar because data's values are smeared