The ATLAS Electromagetic Calorimeter

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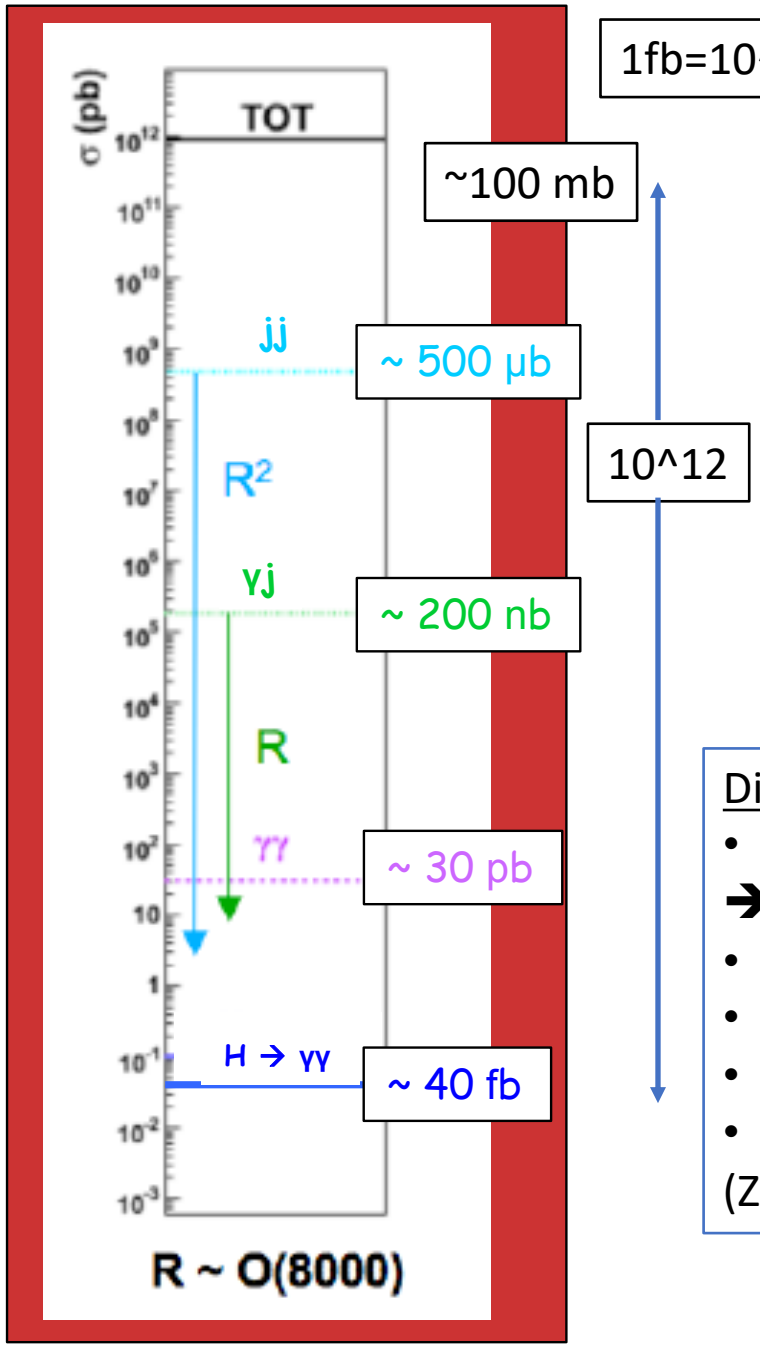
Experiment at LHC

1fb=10^-39cm^2



8 TeV

LHC Design parameters:

E=14 TeV ∫Ldt (1 year)= 100 fb^-1= 10^41 cm^-2

Running time/1 year=10^7 sec ➔L_inst=10^34 cm^-2s^-1

σ_inel~100 mb=10^-25cm^2➔10^9 int/s

Collisions each 25 ns➔ ~25 collisions/bc

➔pile-up noise

➔radiation damage /detector

➔radiation damage/electronics

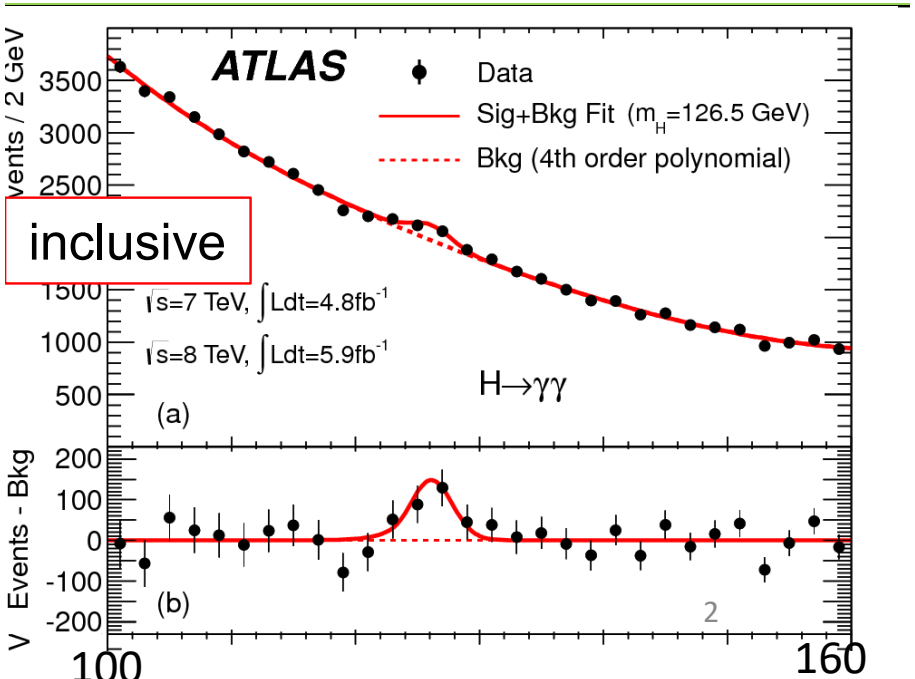
Discovery paper:

- At 8 TeV ,M=125 GeV Sigma (H)~ 20pb

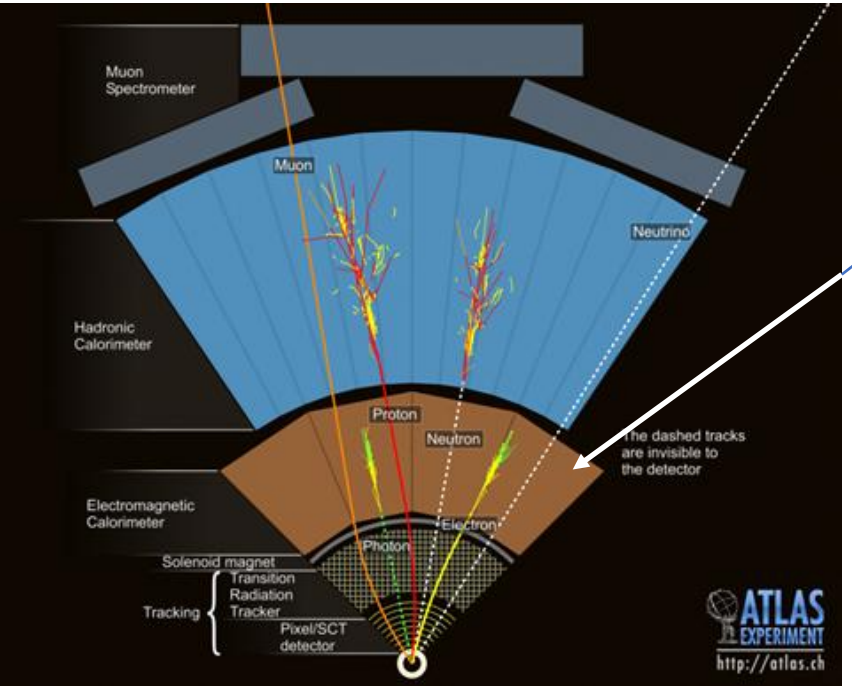
➔ 40 fb for the yy decay mode.

- acceptance of ~25% ➔~10 fb
- 5 fb^-1 at 7 TeV
- 23 fb^-1 at 8 TeV
- ~250 signal evts in peak

(ZZ->4 leptons and WW->ll also used)



M_$\gamma\gamma$=sqrt(2 E1E2*(1-cos (θ_12)))



Electromagnetic calorimeter for LHC

Main task: measure electrons an d photons

Choice of Basic Technique for LHC

- Gas based calorimeters (Aleph) ruled out/ rad resistance, non-linearity,…
- Plastic scintillators (CDF, Spacal) ruled out/ granularity, rad resistance, precision
- Inorganic scintillators (BGO, PbWO4): development needed (CMS)
- Noble liquids

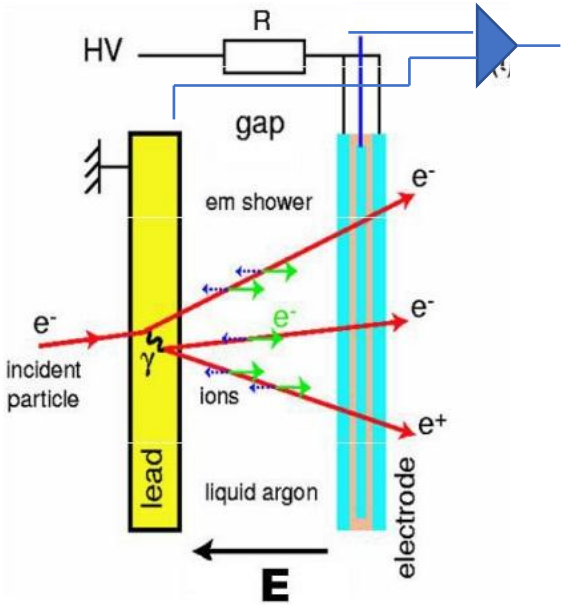
  -homogeneous: LXe too expensive; LKr too bulky

  -sampling: Pb-LAr or Pb-LKr : development needed

  speed of response and granularity➔**geometry** (« accordion »)

  and **electronics** (current instead of charge)

Signal results from the drift of ionisation electrons



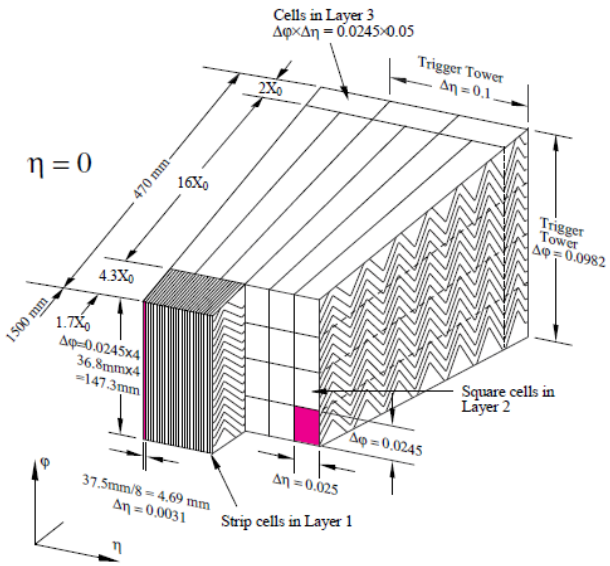
Active Liquid argon gap

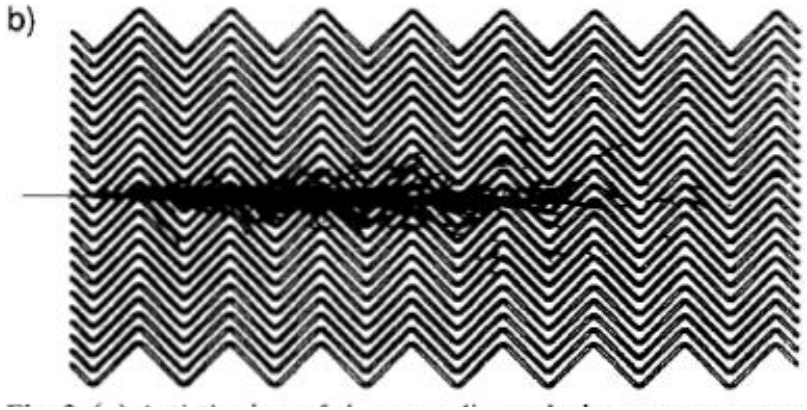
Trigger Capability Essential

Collision rate=40 MHz➔DAQ rate <100 kHz

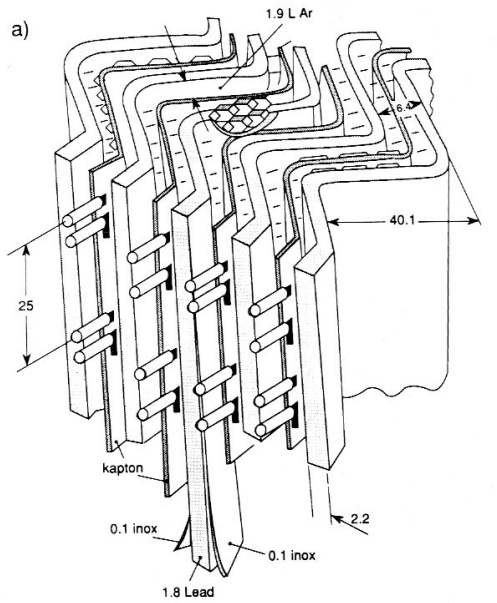
- Rather easy for pointing geometry « automatic » with accordion geometry

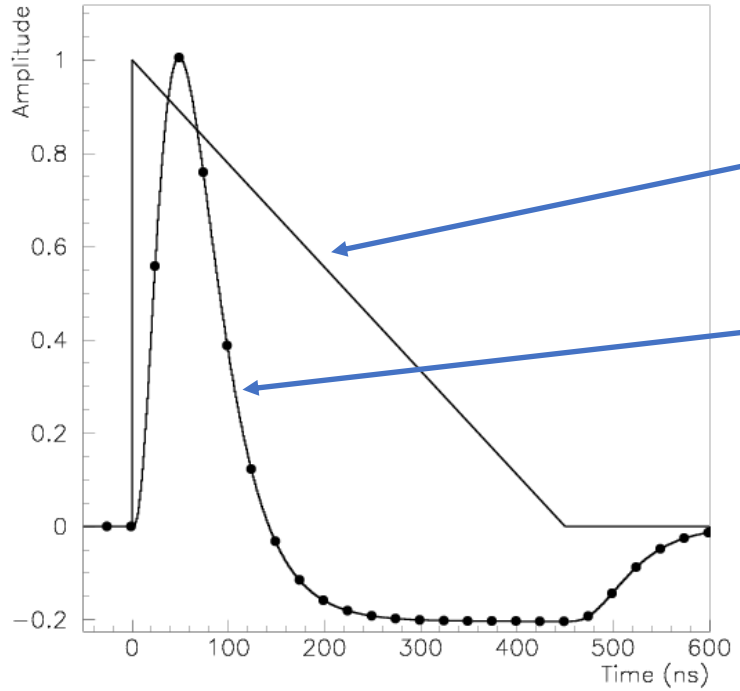
Accordion geometry





Argon liquide
-insensitive to radiations
-« easy » to calibrate (no internal gain)
-resolution <~ 10%/sqrt(E)
ie ~1% at 100 GeV possible
« accordion » geometry allows
- pointing structure in « towers »
- fast signals (current derivative)
-segmentation in depth(➔photon pointing➔ relevant for $\gamma\gamma$ inv. mass)

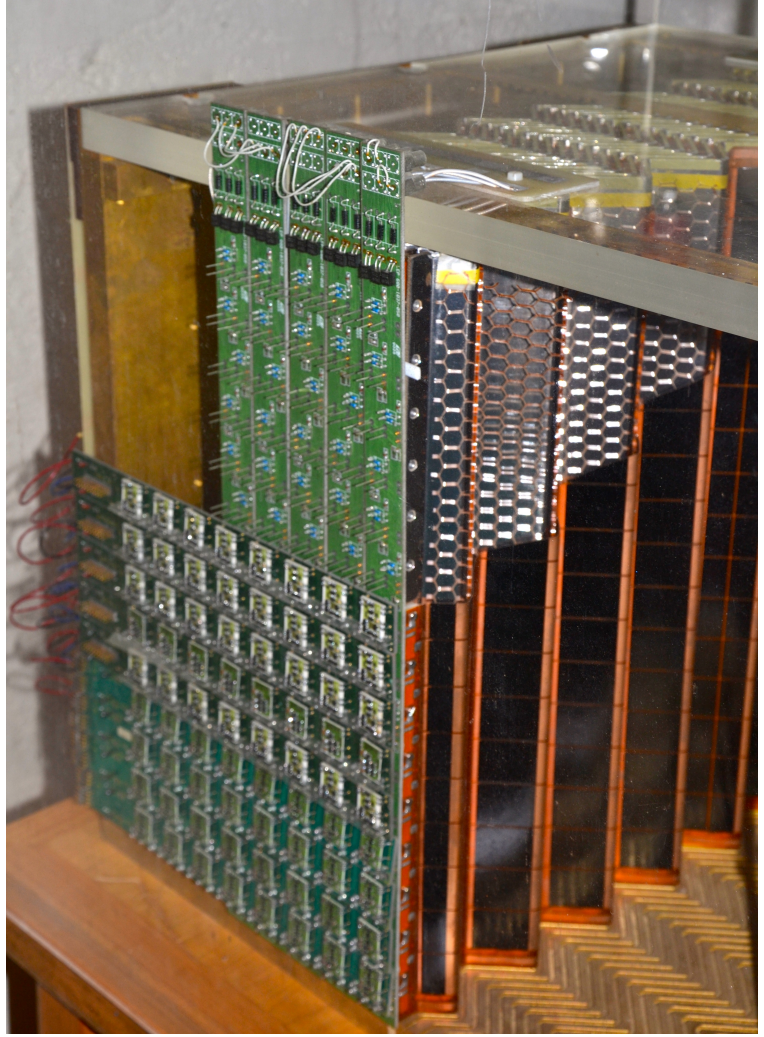


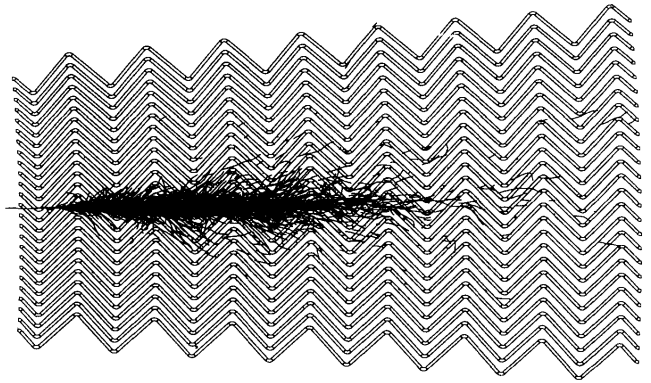


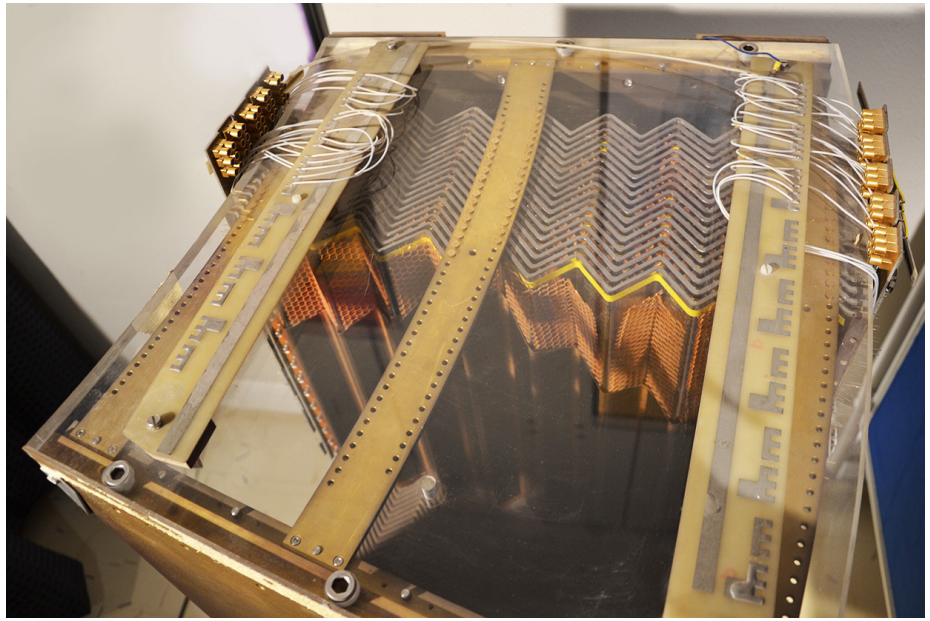
Current from electron drift

after electronic shaping

Early prototypes





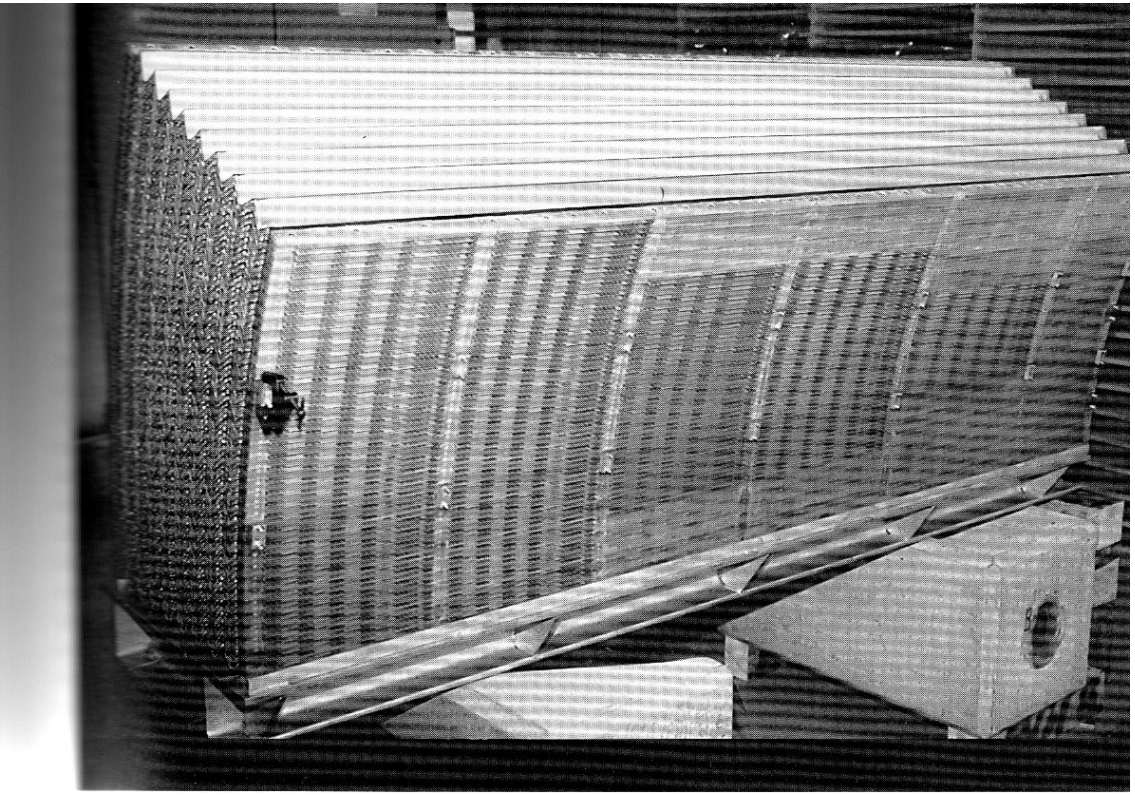


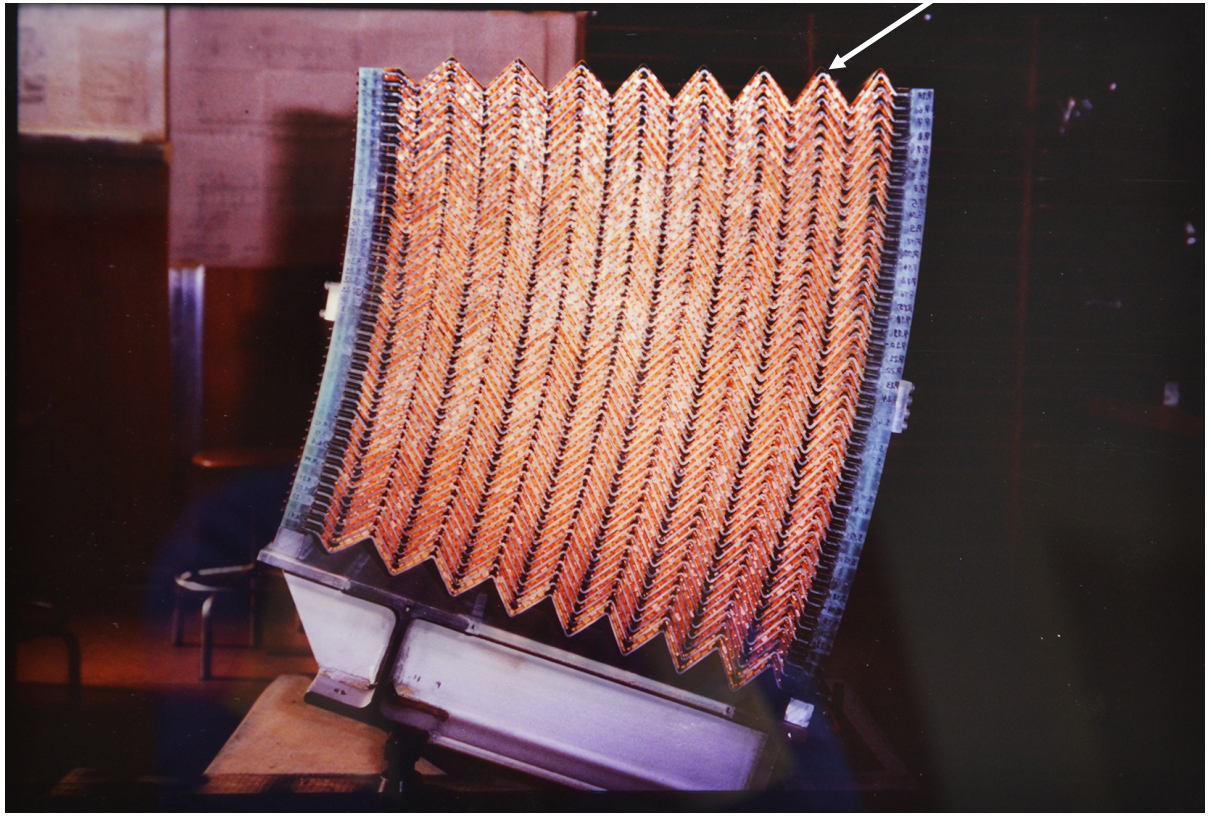
Very first (XY)prototype (1990-mostly built/CERN)
-absorber
-honeycomb
-electrode
-cold electronics (BNL, Milano)
-Warm electronics « 0T » /Orsay later on

First cylindrical prototype
(1991-mostly built/Orsay)

Proto 1992 : final ideas in place « Atlas like »

Variable folding angle
→gaps constant in depth





Approved by the Collaboration ➔Final design and modules construction (0,series) could start(~1996)

A few years necessary to

- adapt the calorimeter design to fit in the ATLAS experiment
- place contracts with outside firms.

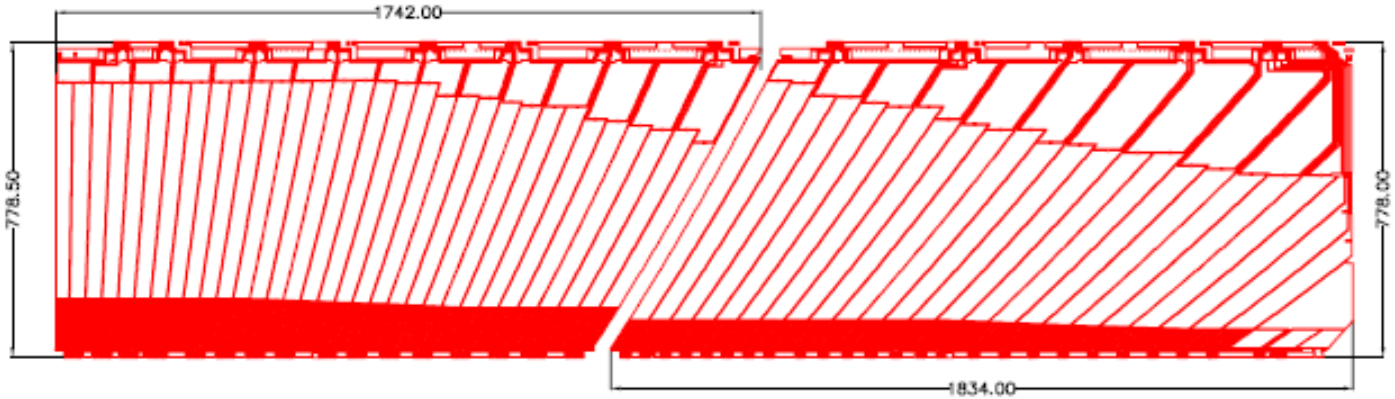
Absorber fabrication

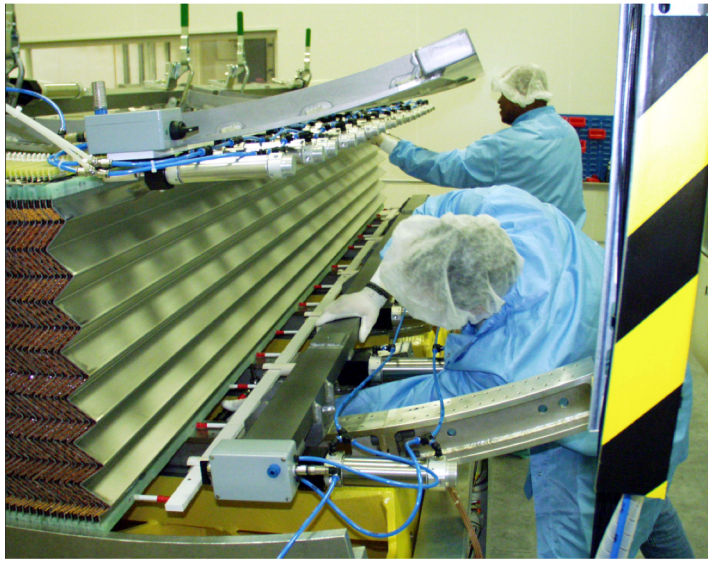
2048 pieces
(SSteel/prepreg/Lead/prepreg/SSteel)
produced in « Hall Lagarrigue »

Metrology space not visible

- lead before stacking (LPNHE)
- Finished absorbers

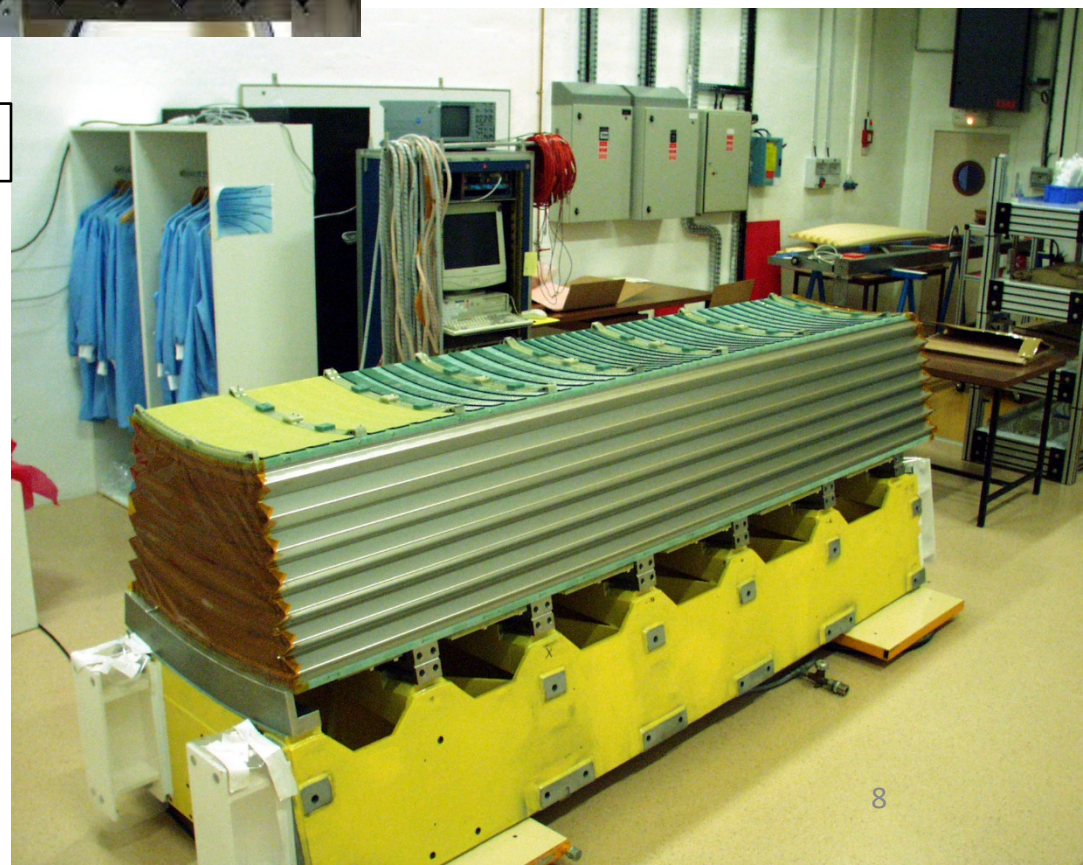
Module Construction





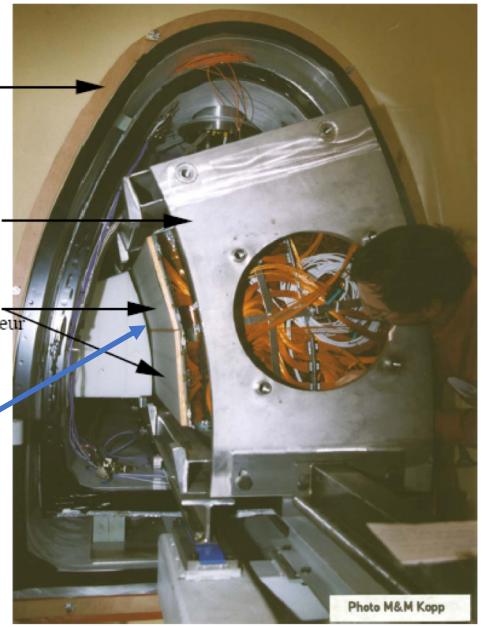
Two flexible electrodes/ 1 absorber (Industry+CERN,LPNHE,LAPP,Milano)

Module (2x16) stacking



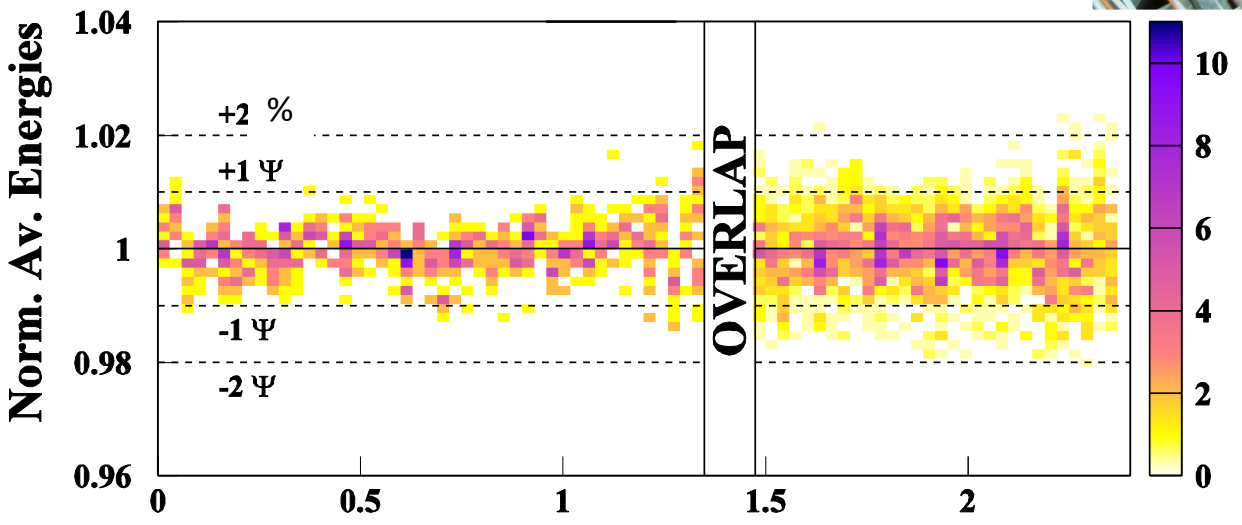
Honeycomb:
-space industry
-shaping and HV-tests at Saclay

Test-beam campaigns



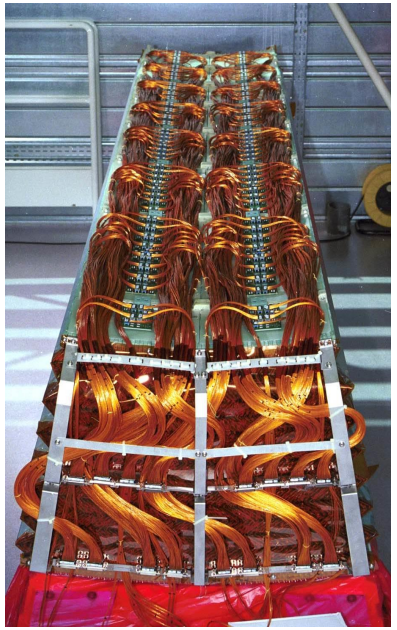
presampler

Barrel test stand (1998-2002)



Overall uniformity (series modules) : 0.6%

In situ, from LHC data: constant term associated to non-uniformities: between 0.6 % and 1.4 %
➔OK for di-photon mass resolution.



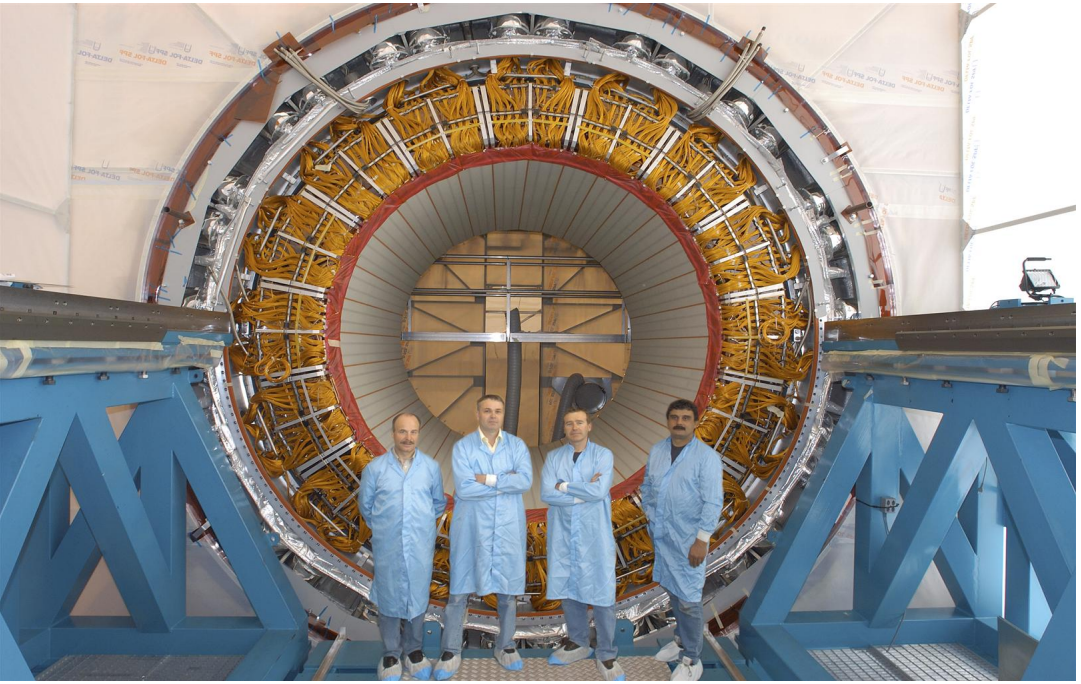
A barrel module fully cabled-up

A barrel module fully cabled-up (Annecy, CERN-Orsay, Saclay)

Cold test in Saclay stand

Half-wheel ← assembly and rotation at CERN ↓

Barrel Assembly and Integration at CERN

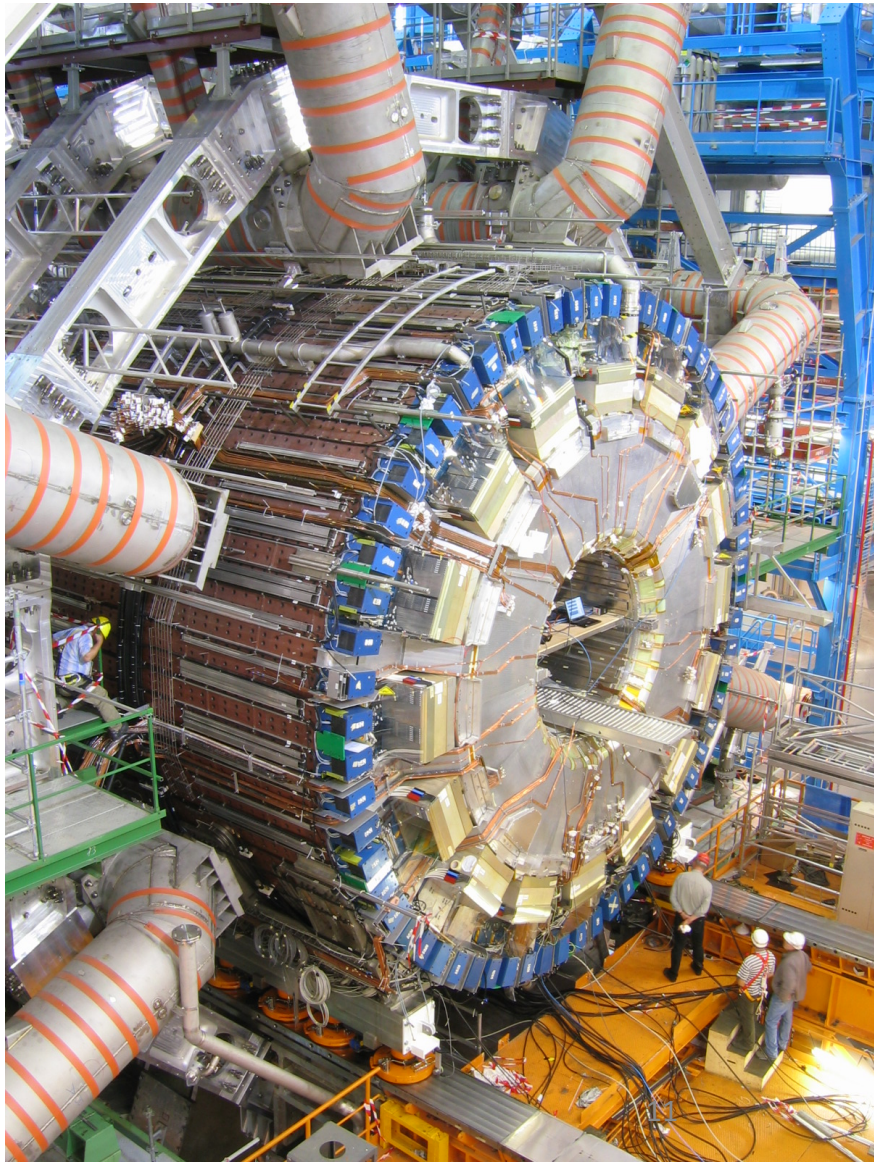


←Firtst half-wheel inserted

← Solenoid insertion

Calorimeter in place→

Filled with L Ar in 2007;
In principle will remain
« cold and full »
until ~2040



IJCLab contribution to EndCaps:
cryostat design, electrode testing, integration

Summary

- 22 years between the first prototype and the Higgs boson discovery
- Targeted performances met, thanks to rigorous design and highly qualified staff.
- Large teams involved (~ 50 persons at Orsay at the peak level)
  tightly coordinated (~25 groups in total for the calorimeter)
  (Collaboration tools like CAO, EDMS,..very important)
- Wide range of competences involved: mechanics, cryogenics, electronics,..beyond HEP
- sizeable cost (Calorimeter ~ 25 % of ATLAS ie ~130 MEuros)
- Operation planned, with electronics upgrades, until ~2040 (HL-LHC),…further discoveries?