Analysis of electrical measurements on ATLAS Electromagnetic End-Cap calorimeter

Student session

August 2004

Anne-Fleur Barfuss

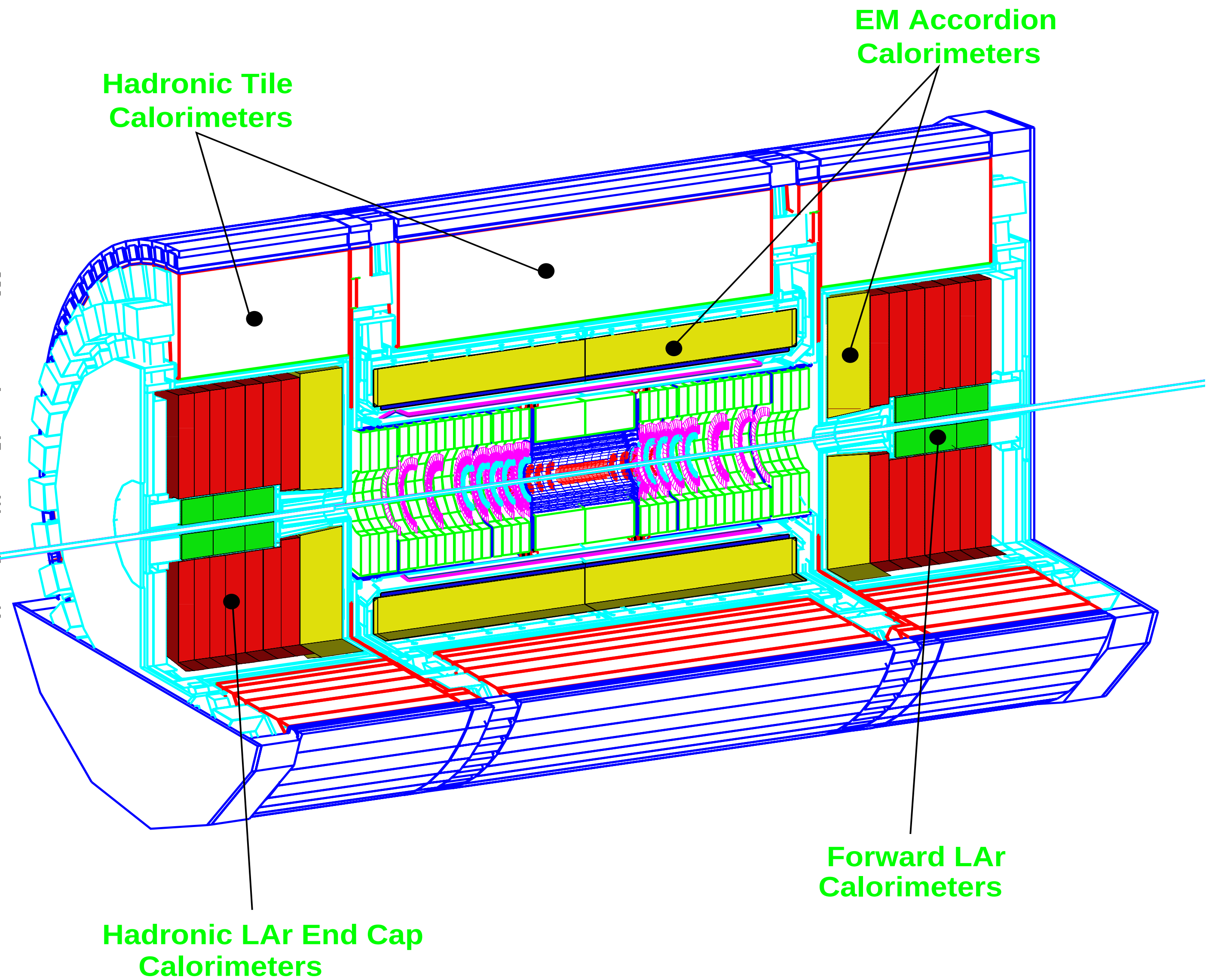
Outline

1. Introduction : ATLAS, the e.m. calorimeter
2. Electrical tests
3. Capacitance measurements
4. Resonance frequency measurements
5. Conclusions

ATLAS Calorimetry (Geant)

LHC + ATLAS

- ✓ Search the boson to under the origin of mas
- ✓ Test new the (supersymmetry,
- ✓ Study top physic
- ✓ …

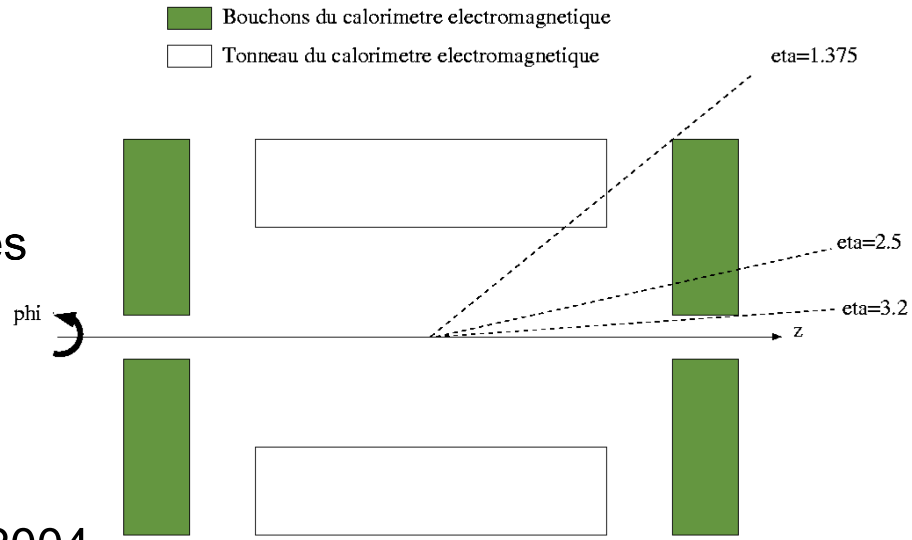


A lot of *e* and γ over a wide energy range (2 GeV – 3 TeV) in the detector :

- ☞ ATLAS will have to be very sensitive to events as $H\rightarrow\gamma\gamma$ et $H\rightarrow 4e$
- ☞ It needs a very accurate calorimetry to identify these particles

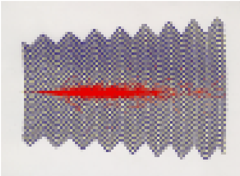
1. The electromagnetic end-cap calorimeter (EMEC)

- Features :
  - ✓ 25 T/wheel
  - ✓ 4 m diameter
  - ✓ 1 wheel = 8 wedge-shaped modules
  - ✓ 1.375 < η < 3.2 i.e. 5°<θ<28°

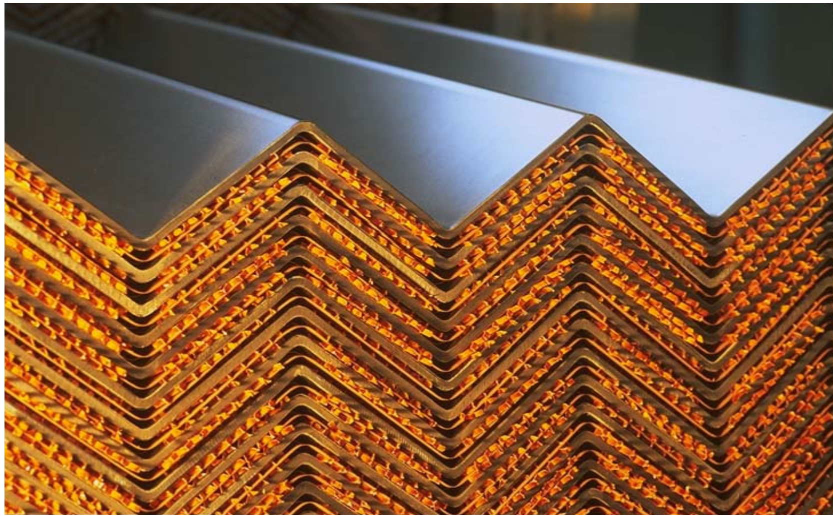


- Schedule :
  - Modules stacking : 02/2001 → 03/2004
  - Completion of ECC wheel : 09/2003
  - Completion of ECA wheel : 07/2004

- Stacking sites : CPPM (Marseille, France) & UAM (Madrid, Spain)



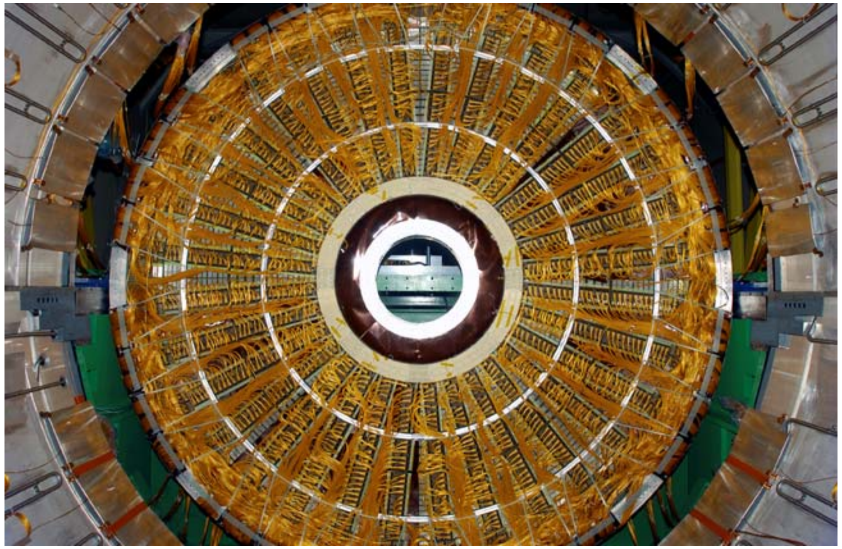
1. The EMEC



SB

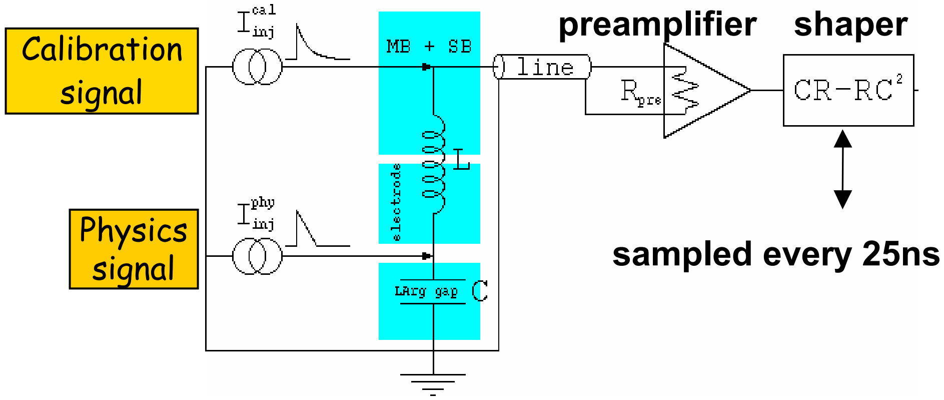
One gap (0.7 to 3 mm) = sandwich of accordion lead plates (absorbers) + spacers + copper electrodes segmented in η and depth (detection).

Each wheel is inserted in a cryostat filled with liquid argon (active media).



2. Electrical tests

- **Motivations**
  - Check modules integrity before and during integration (HV holding, signal continuity, gap thickness,…)
  - Precise measurements of cell characteristics to improve detector performance and answer the ATLAS requirements



Cells capacitance related to gap thickness ($C=\varepsilon S/\boldsymbol{gap}$)

My job

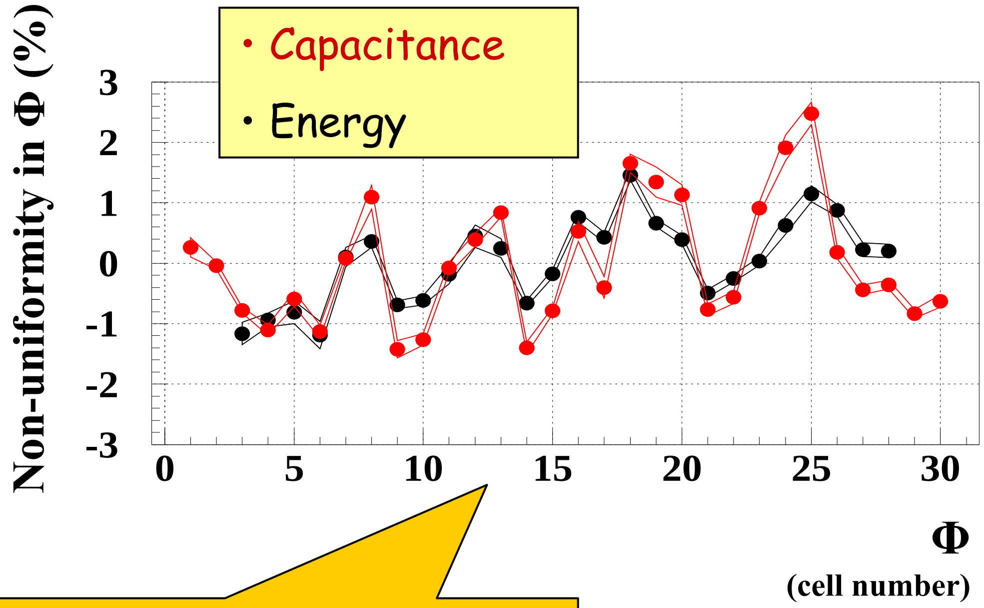
- Capacitance measurements to correct energy response
- Extract $\omega_0=1/\sqrt{LC}$ for signal reconstruction

3. Capacitance measurements

- **Motivations**

Cell capacitance **correlated with energy in Φ** (see TB results & non-uniformity E%C plot)

  - Correction to improve global uniformity (non-uniformity < 0.7 %)
  - Tiny effects which require precise measurements

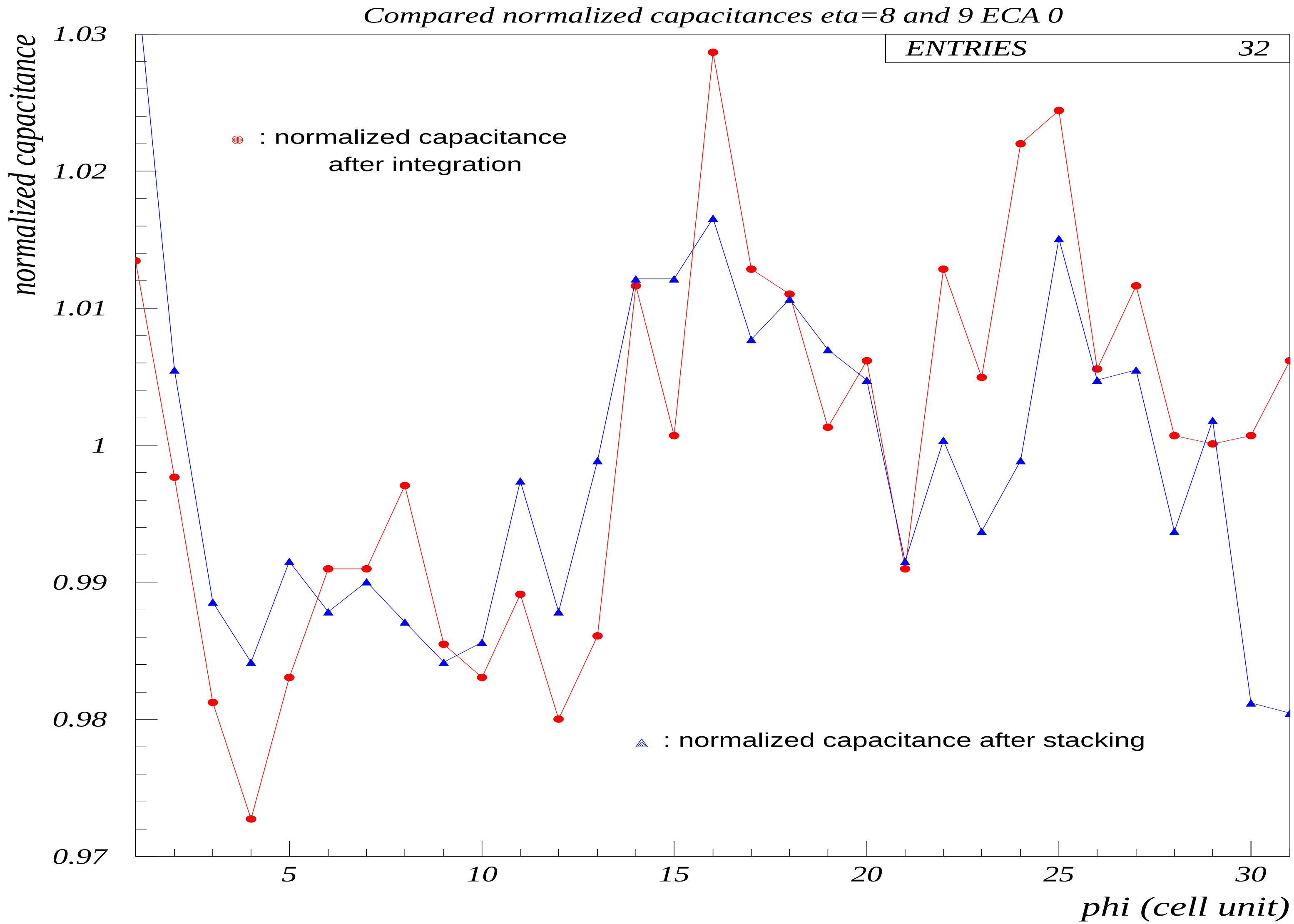


Results for one module
Analysis of the other modules to be done

- **Data**

Capacitance measured on the detector at 1 MHz (stacking frame & wheel) ⇒ 400< C <1200 pF

3.



Good correlation between capacitance on stacking frame and in the wheel…

4. Resonance frequency measurements

- Motivation

  Extract the resonance frequency ω_0 for each cell to perform signal reconstruction

- Data

  Frequency scan (100kH – 100 MHz) on the wheel → cables !

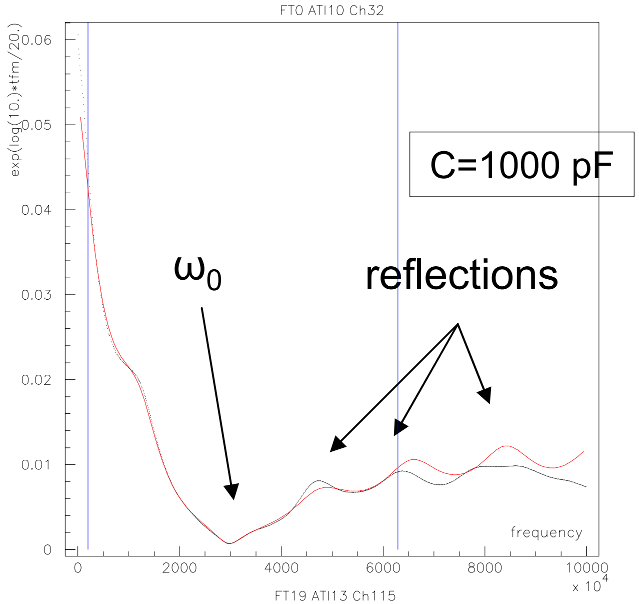
- Analysis

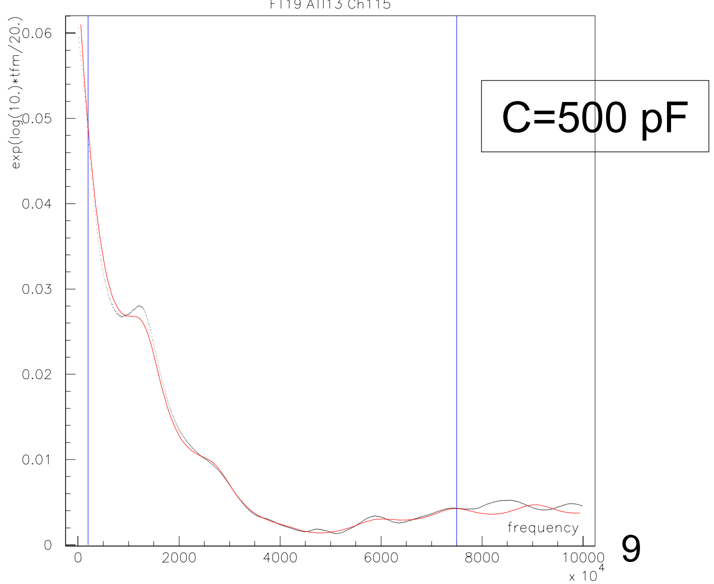
  3 methods, choose the most precise :

  – Minimum of the transfer function

  – Polynomial fit (2-order, 3-order ?)

  – Theoretical fit (7 parameters) ⇒ plot

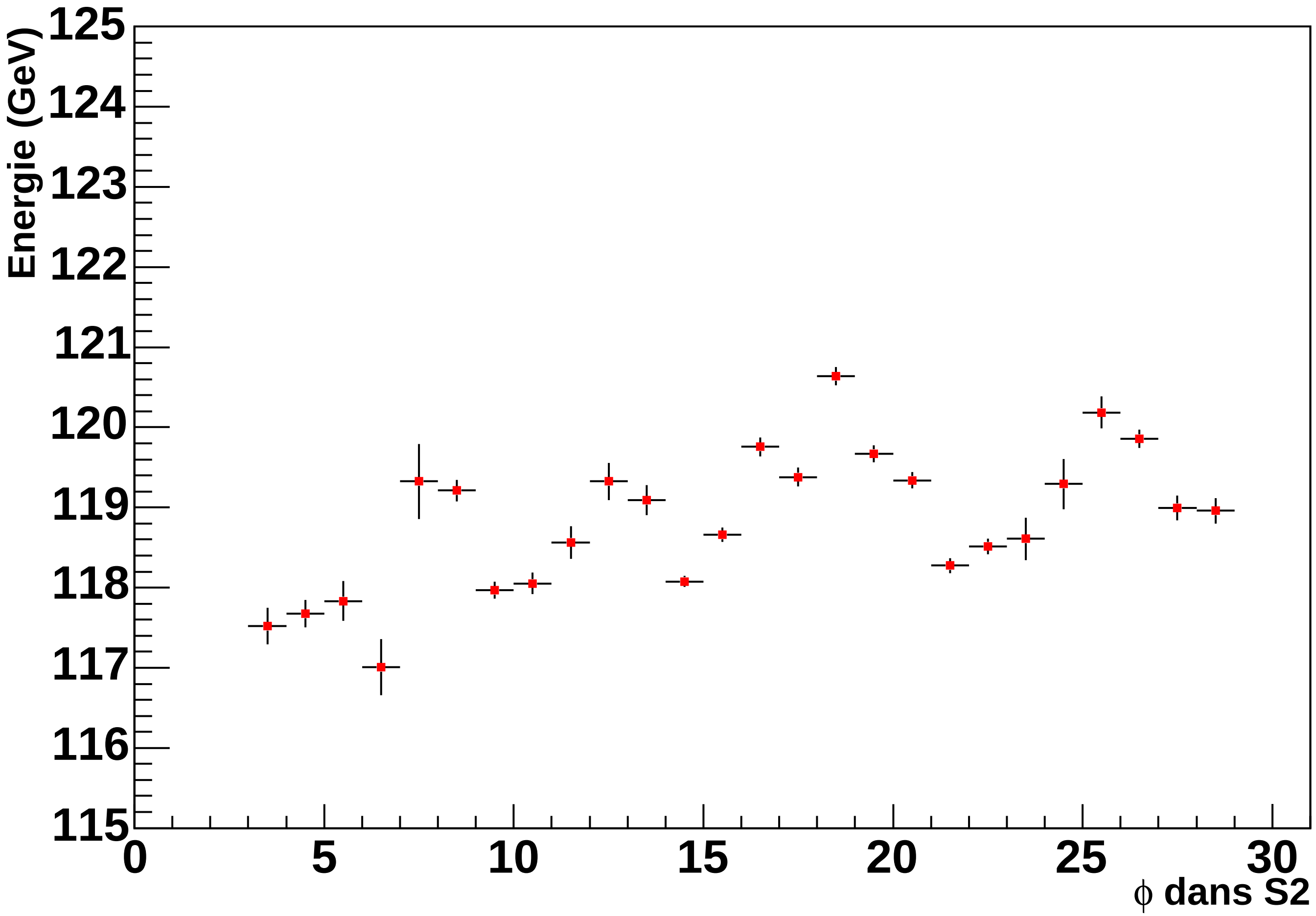


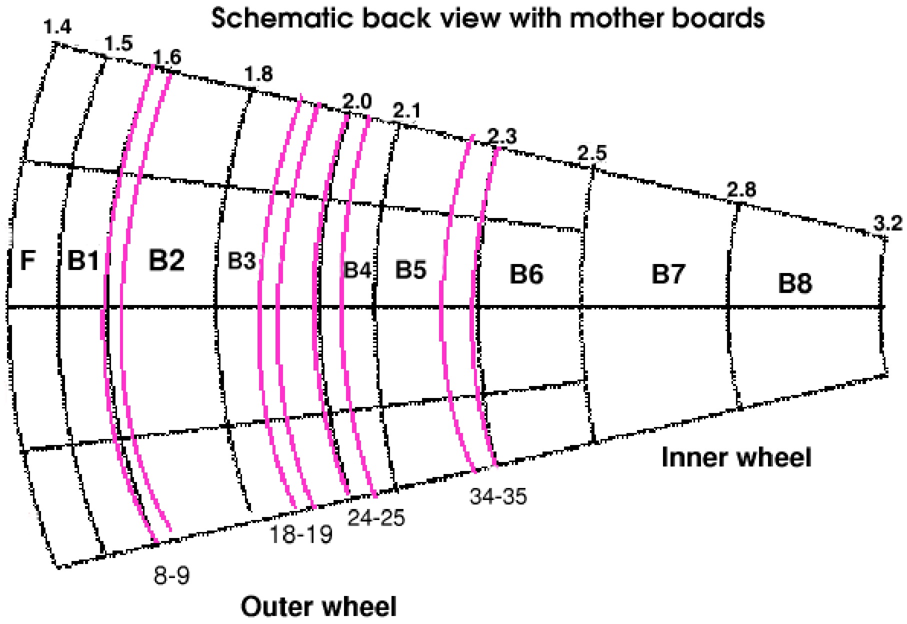


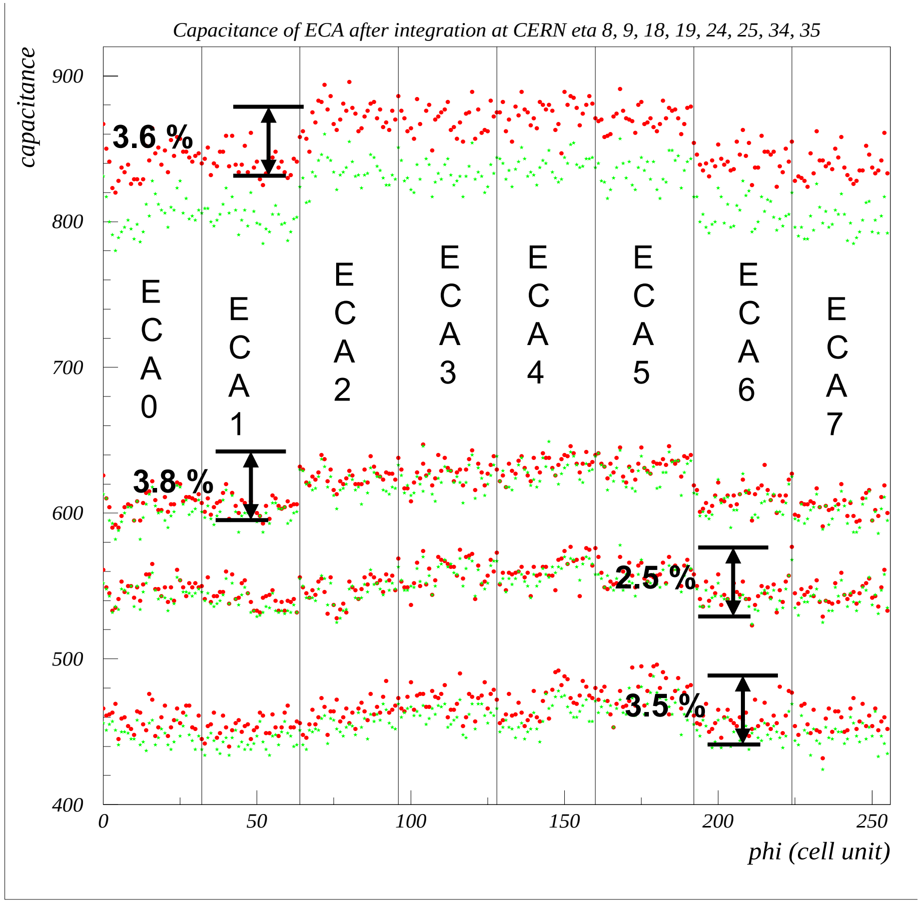
Conclusions

- Analysis of precise electrical measurements on the EMEC required for ATLAS are going on
- Capacitance measurements :
  - Correlation Energy – Capacitance in Φ
  - Correlation $C_{stacking}$-C_{wheel} proven
- Extraction of ω_0 for signal reconstruction

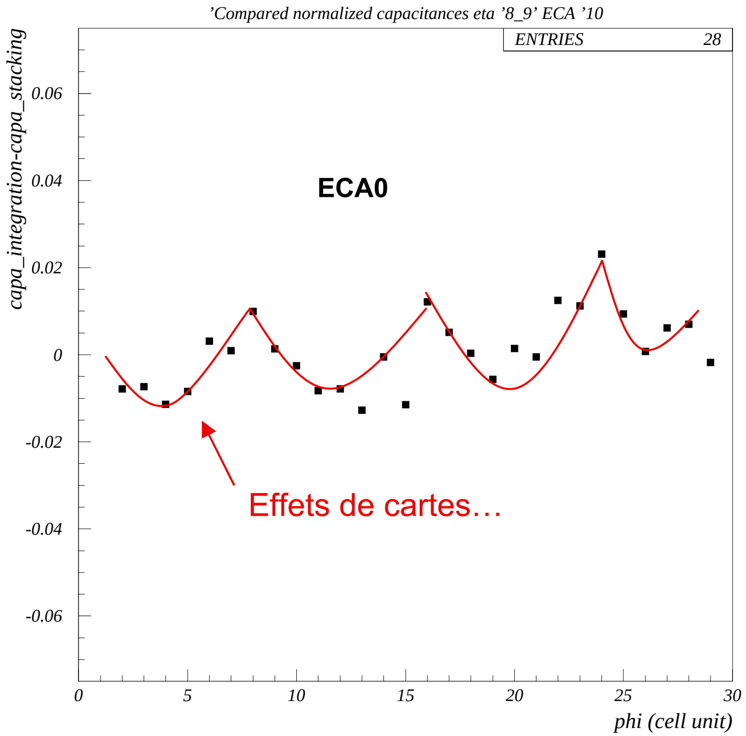
1. Exemple de résultats de test sous faisceau




Schematic back view with mother boards
1.4
1.5
1.6
1.8
2.0
2.1
2.3
2.5
2.8
3.2
F
B1
B2
B3
B4
B5
B6
B7
B8
Inner wheel
8-9
18-19
24-25
34-35
Outer wheel


Capacitance of ECA after integration at CERN eta 8, 9, 18, 19, 24, 25, 34, 35
capacitance
900
800
700
600
500
400
3.6 %
3.8 %
2.5 %
3.5 %
ECA 0
ECA 1
ECA 2
ECA 3
ECA 4
ECA 5
ECA 6
ECA 7
0
50
100
150
200
250
phi (cell unit)

2. Comparaison avec les données après assemblage (suite)



		8-9	18-19	24-25	34-35
ECA 0	σ capa moyenne intégration (%)	1.4	1.4	1.3	1.5
	σ capa moyenne stacking* (%)	**0.99**	**1.1**	1.4	2.0
	σ int/ σ stack -1 (%)	**0.85**	1.4	1.4	1.7
ECA 4	σ c. m. int.	0.99	1.1	1.3	2.2
	σ c. m. stack.	**0.77**	1.2	1.3	2.4
	σ int/ σ stack -1	0.78	1.5	1.9	3.2
ECA 5	σ int	0.98	1.1	1.1	2.0
	σ st	**0.83**	1.3	1.4	1.9
	σ int/ σ st -1	**0.78**	1.1	1.2	1.2
ECA 6	σ int	1.1	1.2	1.2	1.4
	σ st	**0.80**	**0.91**	1.1	1.5
	σ int/ σ st -1	**0.81**	1.1	1.2	1.3
ECA 7	σ int	1.1	1.3	1.2	1.8
	σ st	**0.75**	1.2	1.5	2.4
	σ int/ σ st -1	0.83	1.2	1.4	2.2

*stacking : empilement

Cellules pour lesquelles le σ_{stack} est inférieur au σ_{int}

Cellules pour lesquelles le ratio $\sigma_{int}/\sigma_{stack}$ -1 est inférieur aux 2 σ individuels

✋ **! La physique voit « réellement » les modules intégrés…**