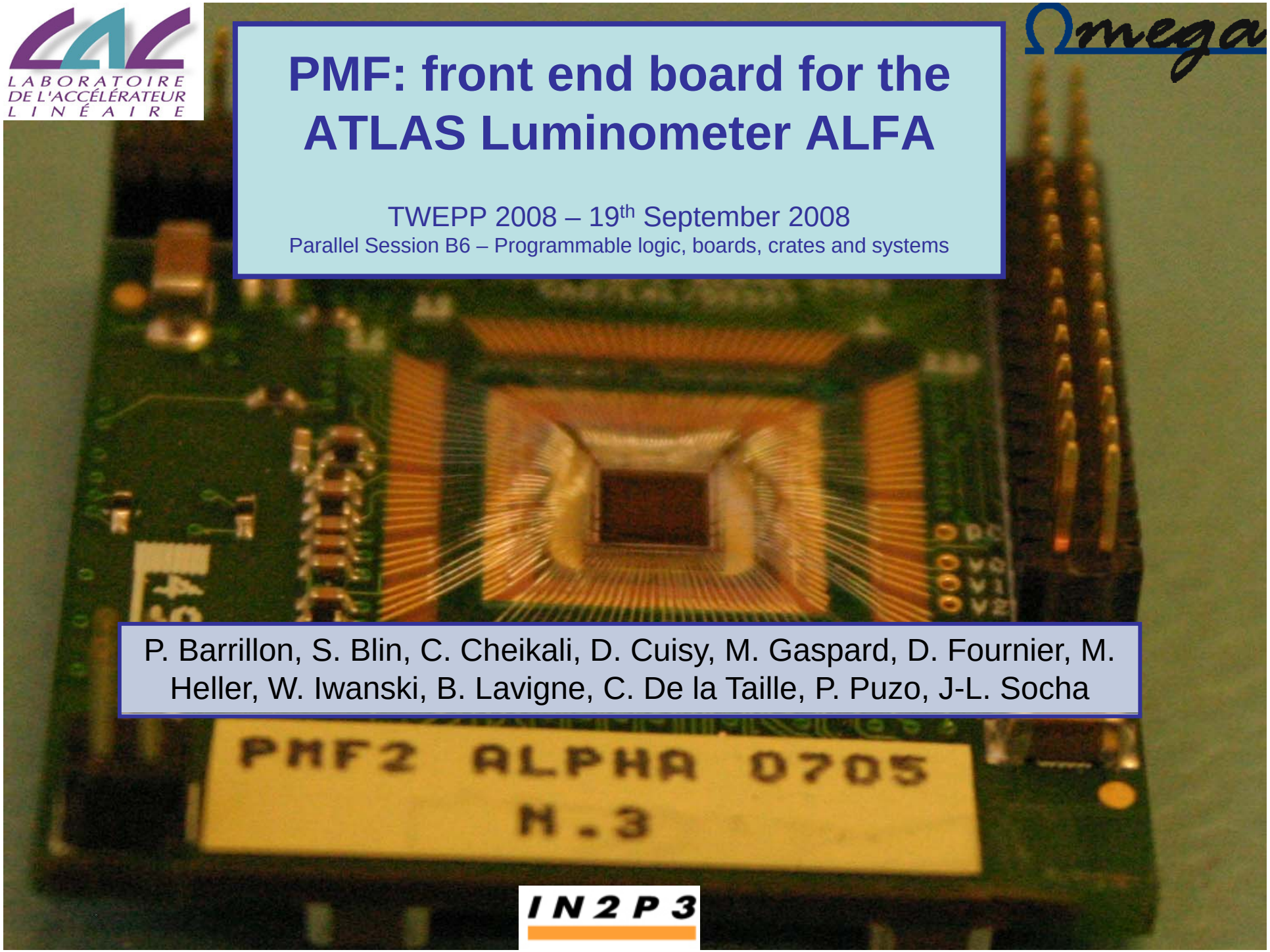


PMF: front end board for the ATLAS Luminometer ALFA

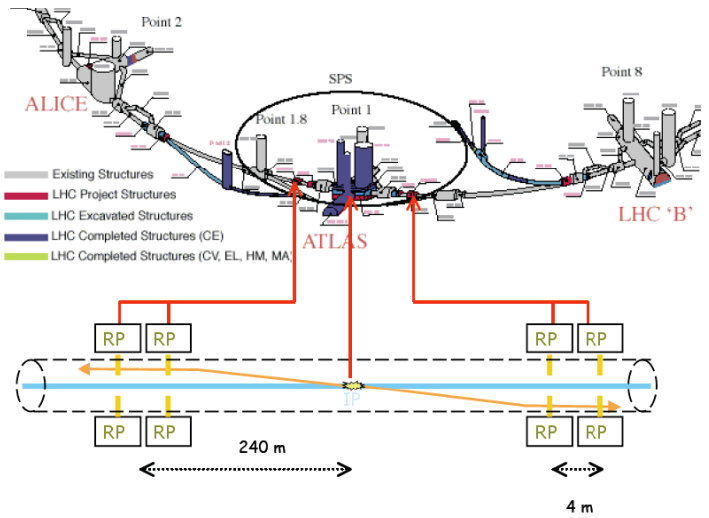
TWEPP 2008 – 19th September 2008

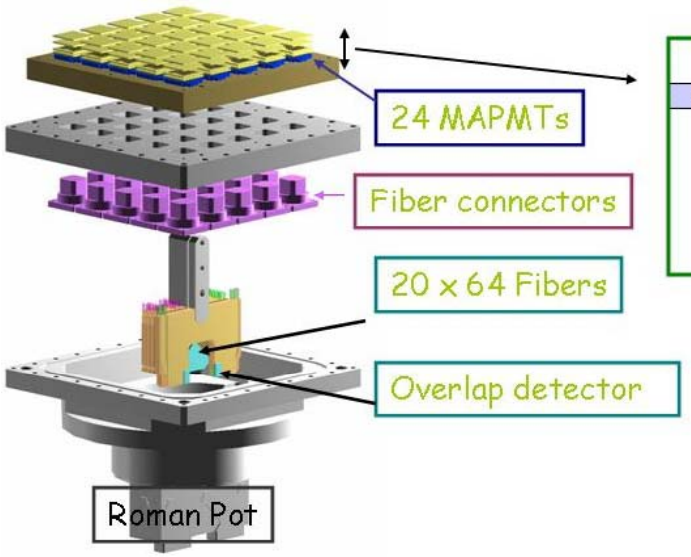
Parallel Session B6 – Programmable logic, boards, crates and systems

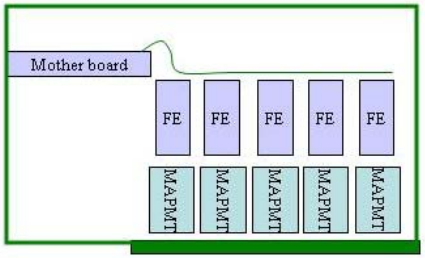
P. Barrillon, S. Blin, C. Cheikali, D. Cuisy, M. Gaspard, D. Fournier, M. Heller, W. Iwanski, B. Lavigne, C. De la Taille, P. Puzo, J-L. Socha

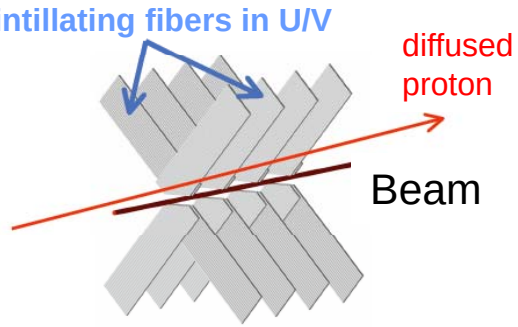
ATLAS Luminometer

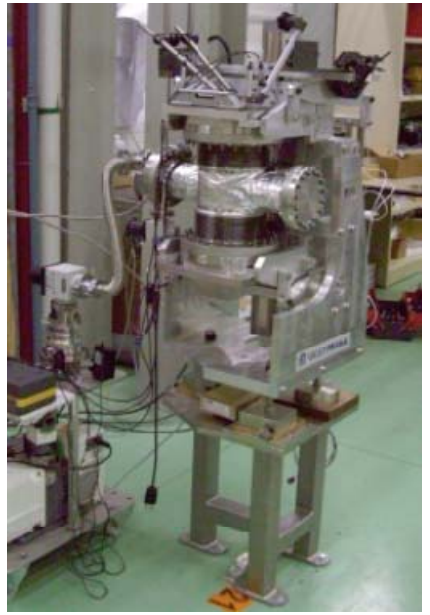
- Goal: measure the absolute luminosity of ATLAS detector at the LHC looking at elastically diffused protons
- ALFA (Absolute Luminosity For ATLAS) detector is made of 8 Roman Pots located at 240 m from the ATLAS interaction point.
- Each RP is made of 20 layers (10 in U and 10 in V) of 64 scintillating fibers connected to a MAPMT.
- The front end electronic is located in a matrix directly in the shadow of the PMs.





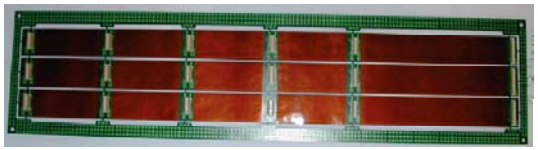






Front end electronic

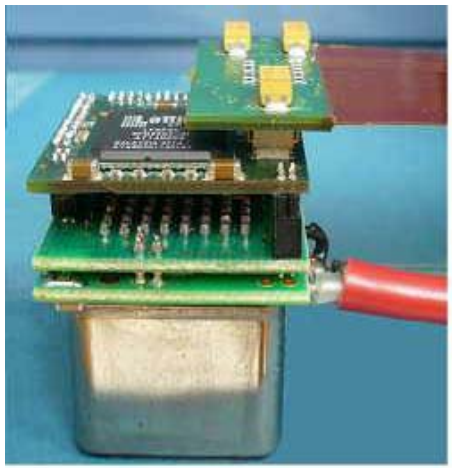
The front end electronic is made of a matrix of 5x5 PMFs connected by lines of 5 to the mother board (or a test board) thanks to a kapton cable.

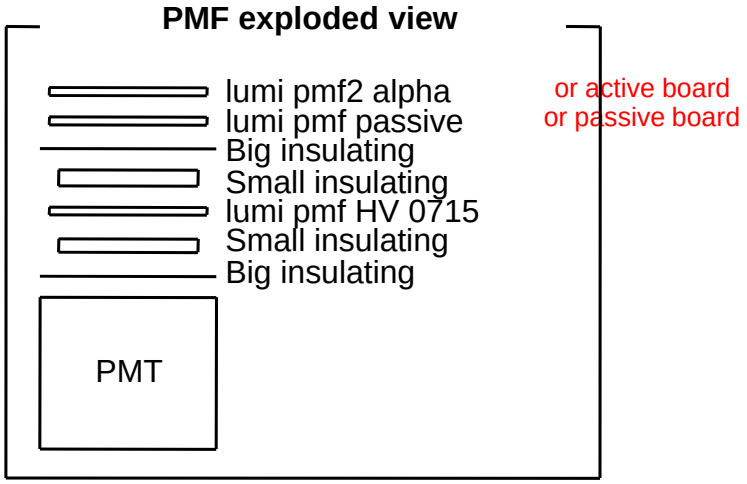


Test board

PMF = PhotoMultiplier Front-end

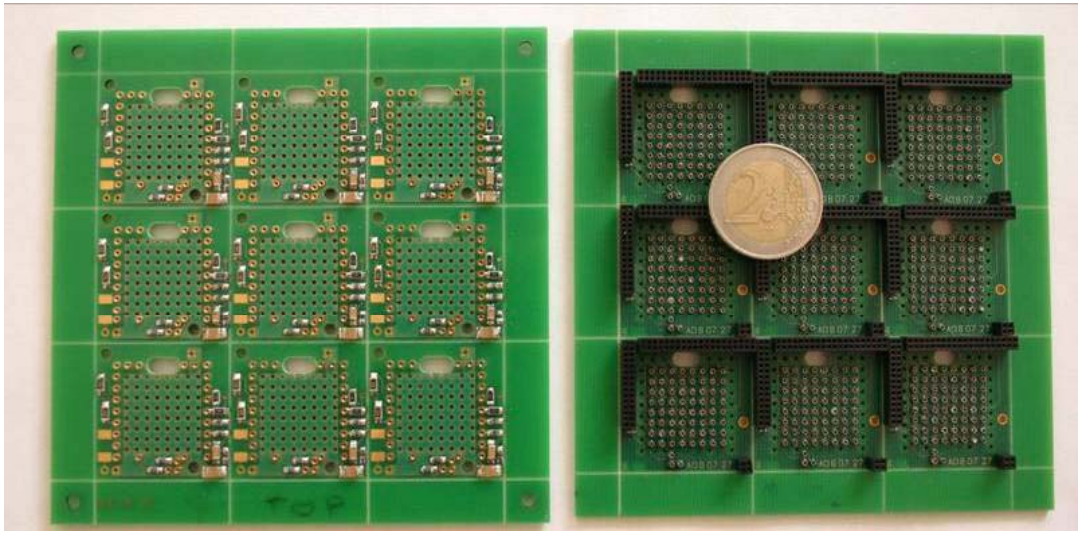
PMF



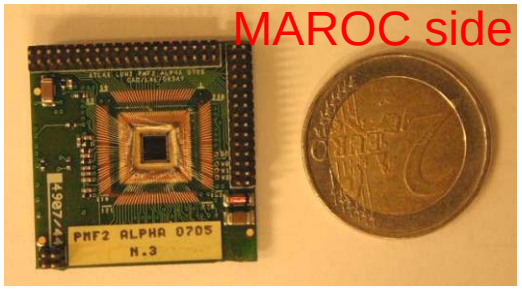


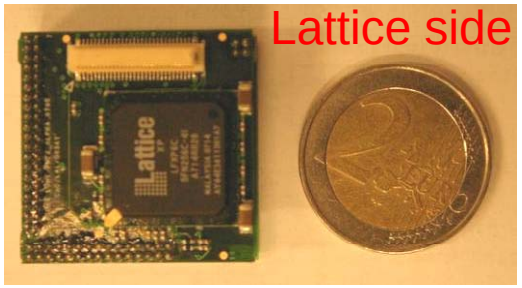
PMF structure

- The PCB part of the PMF is made of 3 boards (3 × 3 cm^2) :
  - ✓ HV board: allows bringing high voltage tot the MAPMT (64ch)
  - ✓ Passive board: roots signals to connectors on the edges of the board
  - ✓ Active board: readout and treatment of the PM output signals successively by the MAROC ASIC on one side and a Lattice FPGA on the other side.
- A 60 points connector allows connection of the PMF with the mother board or the test board thanks to a kapton cable.
- The 3 PCBs, the cable and the test board were developed at LAL, the mother board in Lund and the Lattice firmware at CERN.



HV board Passive board

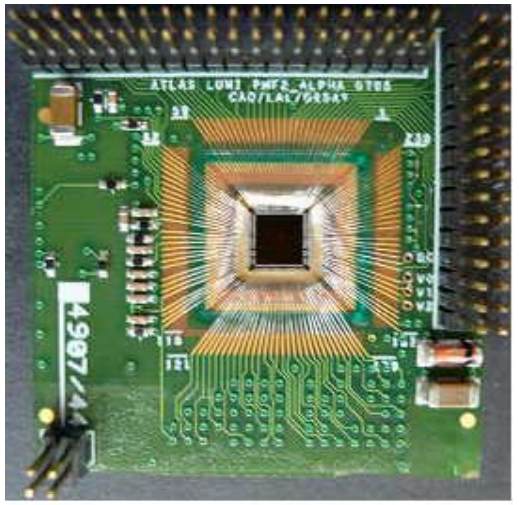


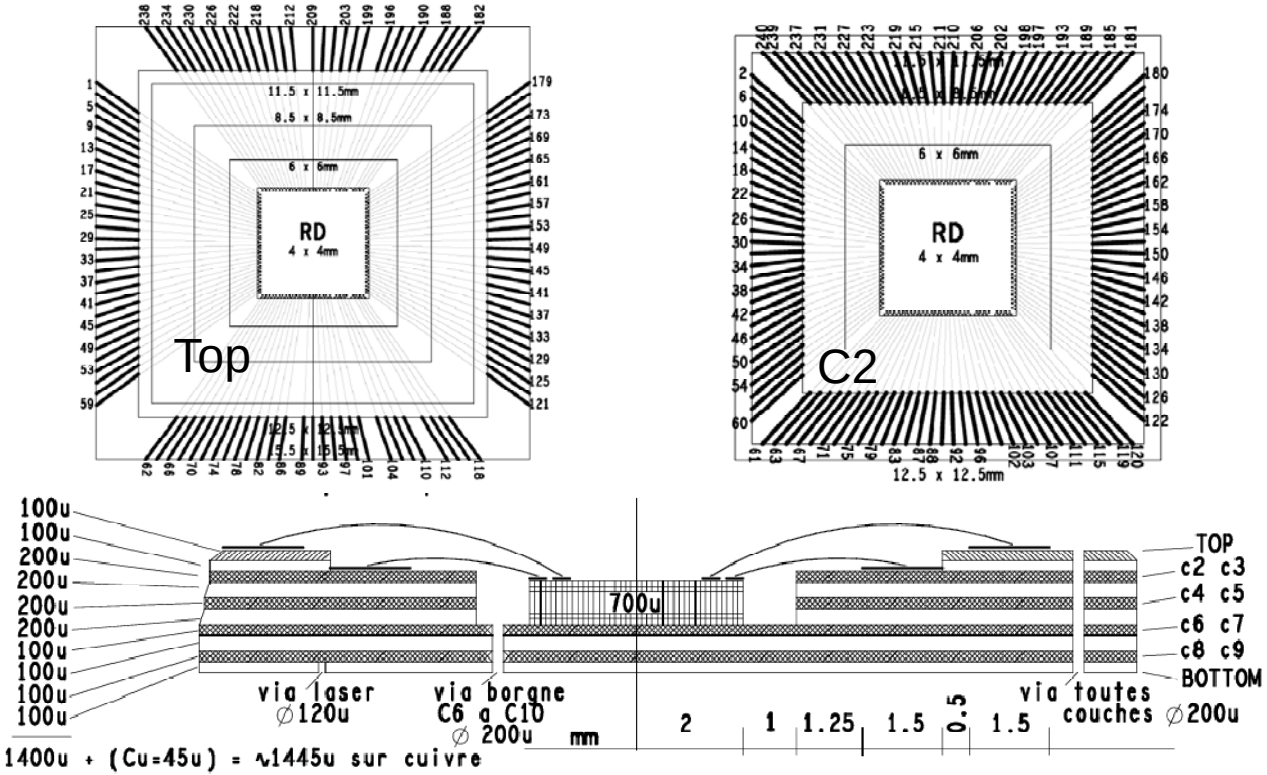


Active board

The active board

- Challenging part of the project !
- Design of a 10 layers printed circuit board with MAROC chip bounded (at CERN) directly on the PCB on one side and a FPGA/BGA on the other side.
- Different types of crossing vias
- Limited space available for the other components (connectors, capacitors, resistors) and the test points.



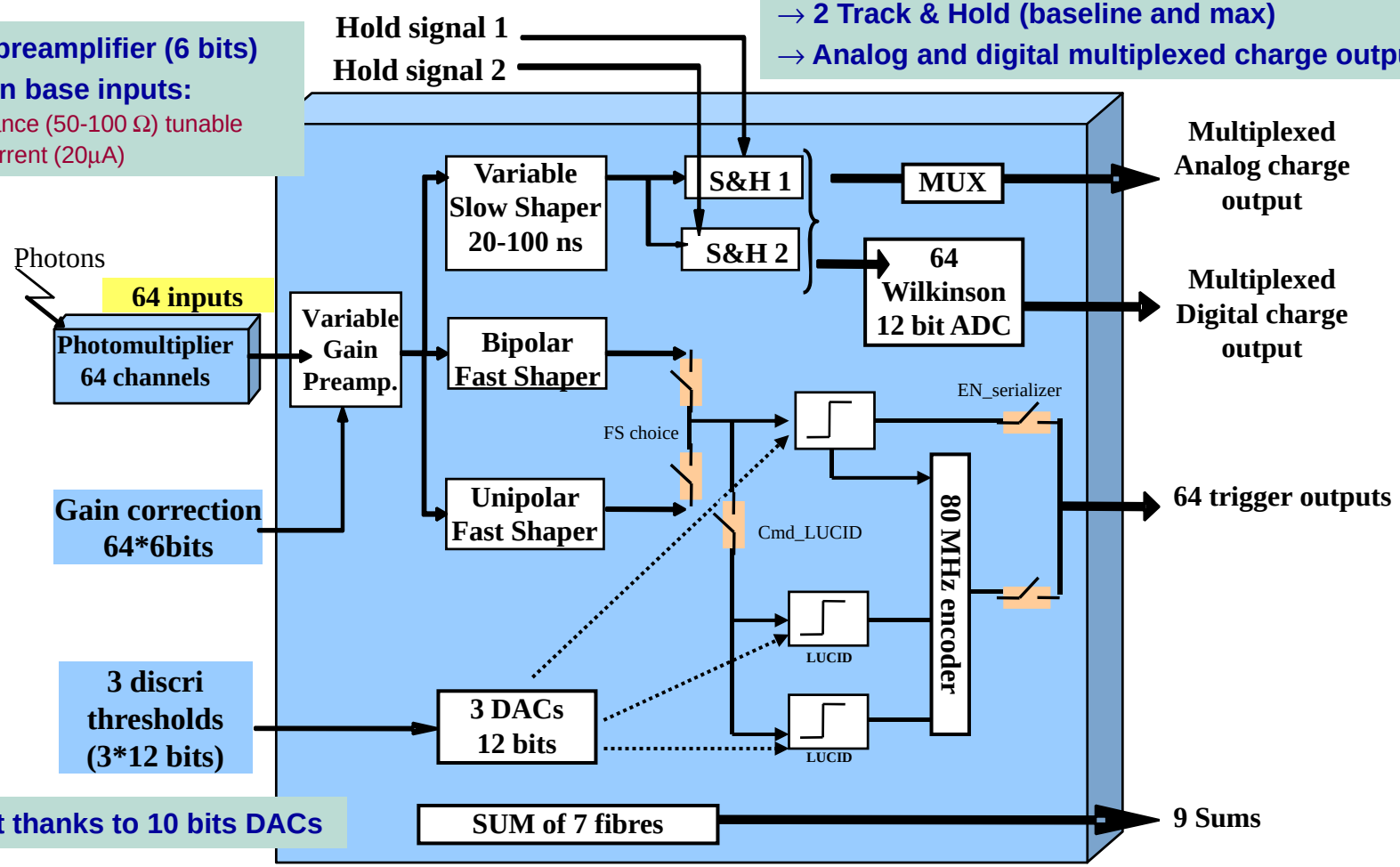


MAROC description

- MAROC (Multi Anode ReadOut Chip) is a 64 ch ASIC which has a variable gain preamplifier and produces 64 trigger outputs and a multiplexed charge measurement.

→ Slow shaper
→ 2 Track & Hold (baseline and max)
→ Analog and digital multiplexed charge output

→ Variable gain preamplifier (6 bits)
→ Super common base inputs:
- ✓ Low impedance (50-100 Ω) tunable
- ✓ Low bias current (20µA)

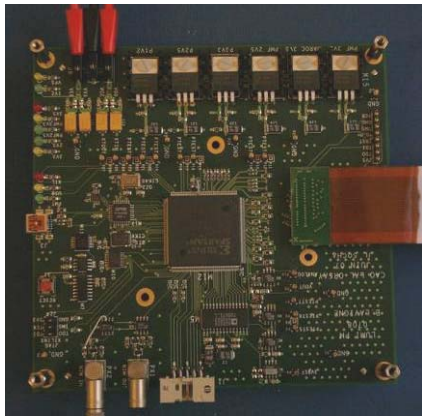


→ Thresholds set thanks to 10 bits DACs

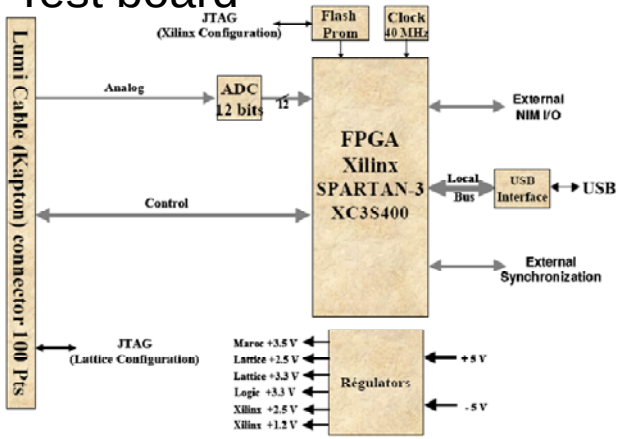
Laboratory tests of the first prototypes

- The tests were carried out at LAL in collaboration with CERN
- At first: development of both test board (Xilinx) and PMF (Lattice) FPGA firmwares as well as the test software.
- Then: tests of the different PMF features (hits and charge measurements) with prototype couples passive/active boards

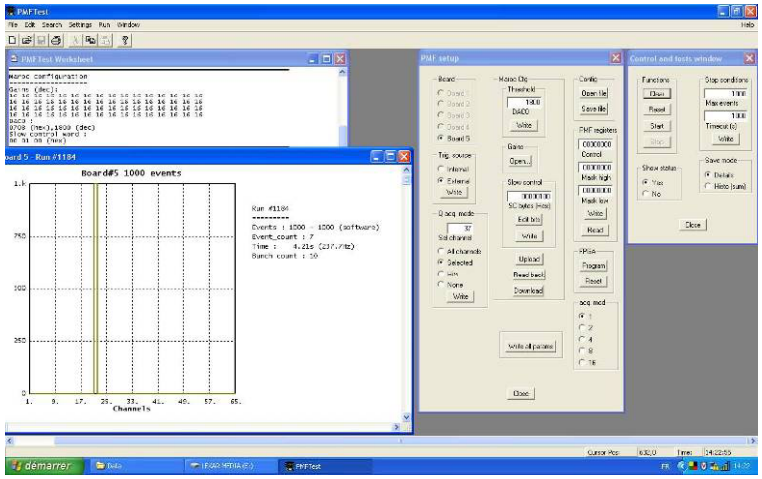
USB

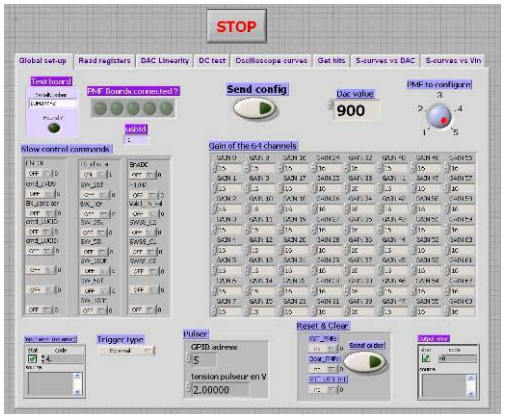


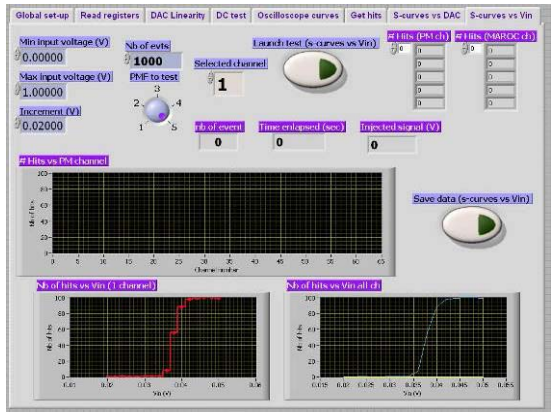
Test board

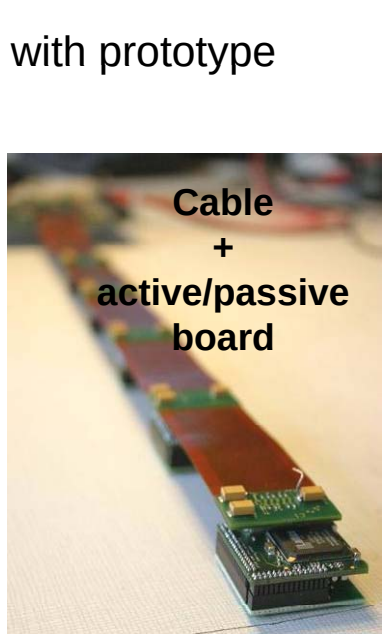


Test software





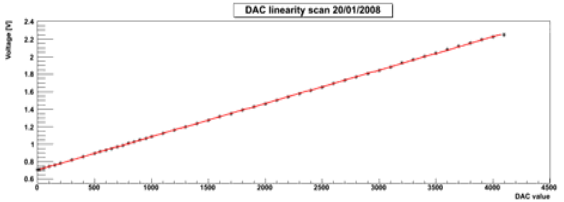


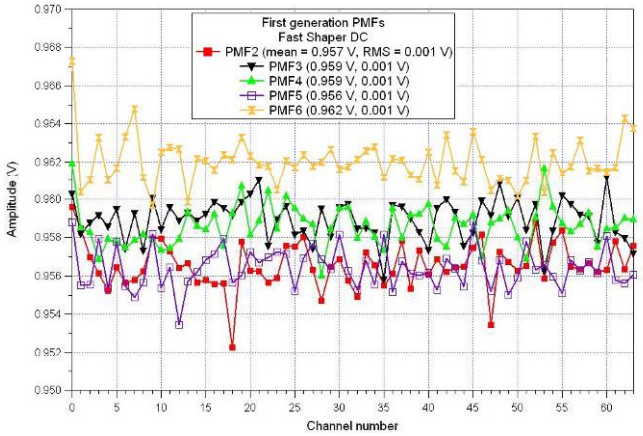


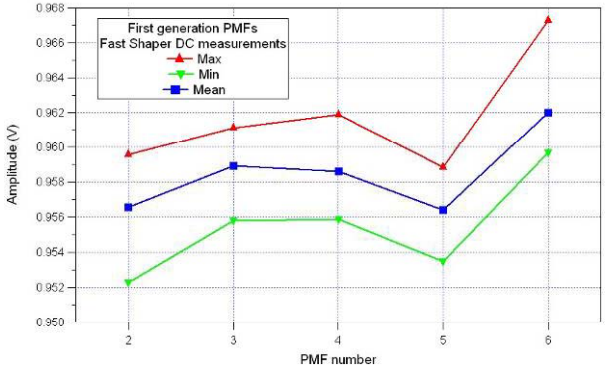
Results (prototype tests)

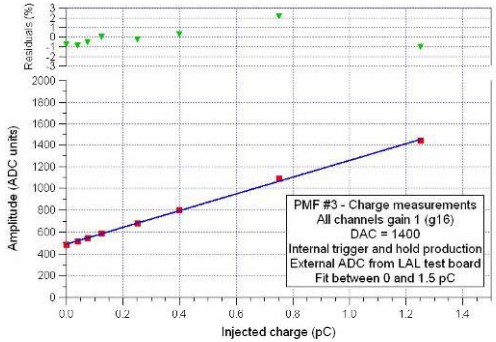
Tests of 5 PMFs :

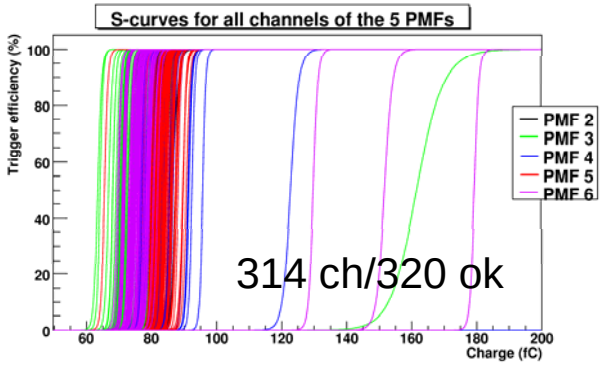
- DAC linearity as satisfactory as for MAROC2 (< ± 1 %)
- Homogeneous fast shaper pedestals (dispersion = 1 ‰)
- Nice homogeneity of the s-curves
- Cross talk at same level as MAROC2 (2-3 %)
- Charge measurement: good linearity

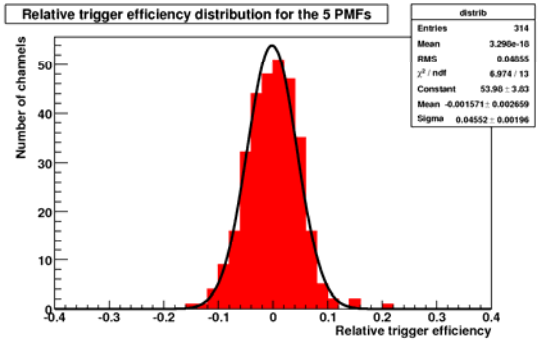


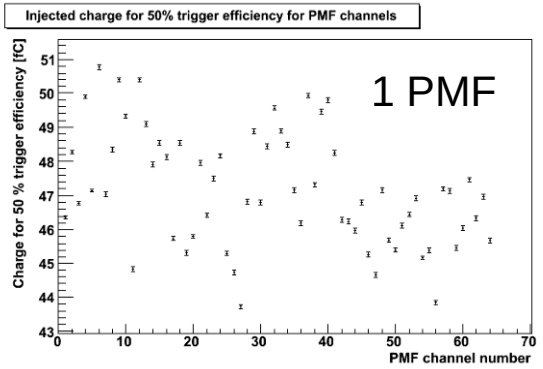






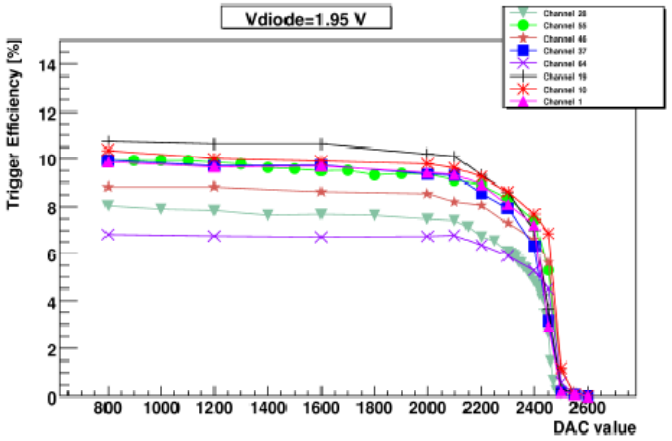


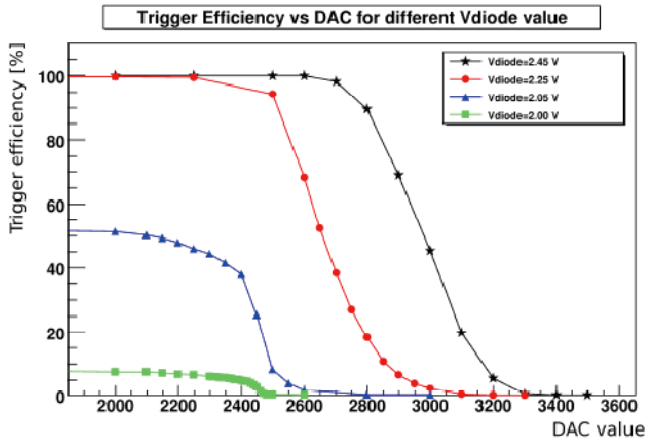


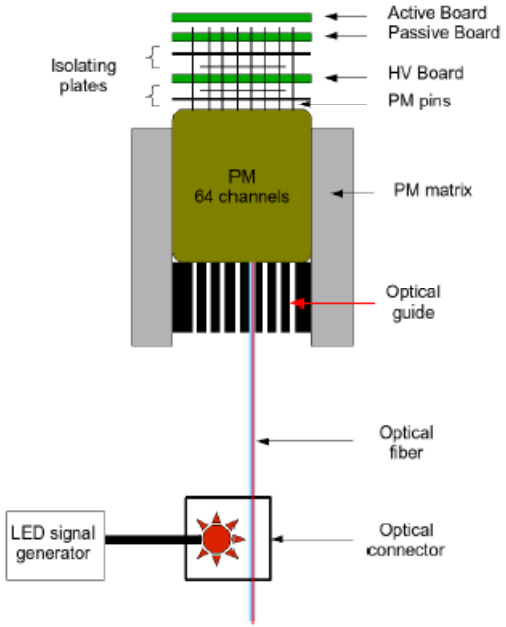


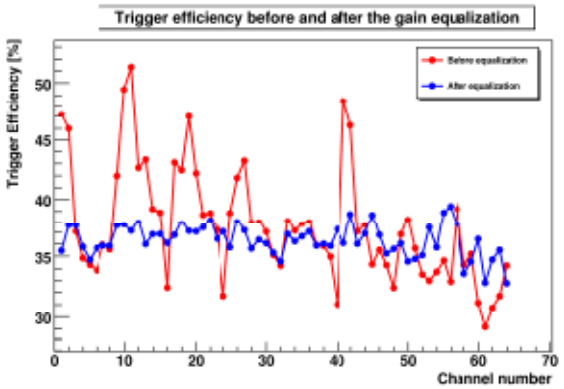
Tests with full PMF + LED

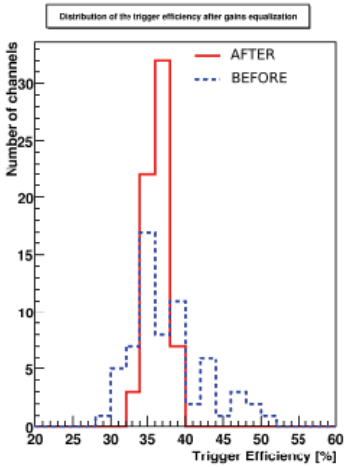
- Tests carried out at CERN with a full PMF (PMT + 3 PCBs) and a LED lighting up a single channel or all of them.
- The whole system works correctly and as expected.
- Gain correction is efficient.









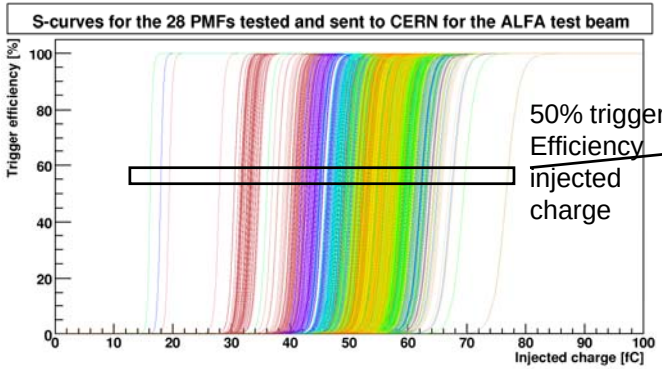


<u>Before gain correction</u>:
Mean = 37.5 %
RMS = 4.9
Dispersion = 13.3 %

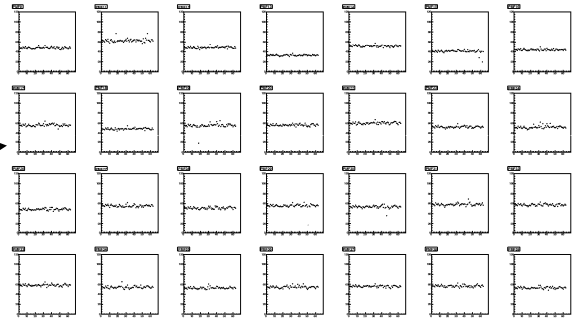
<u>Before gain correction</u>:
Mean = 35.8 %
RMS = 1.3
Dispersion = 3.8 %

Test beam preparation

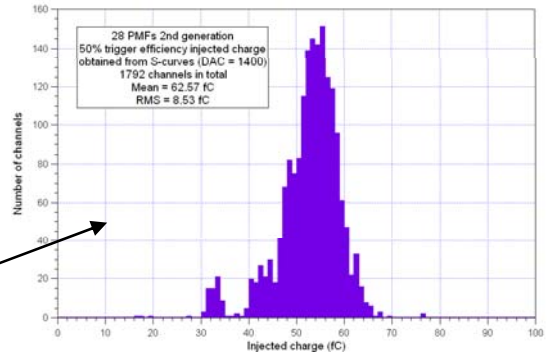
- 28 (23 needed) pre-series active, passive and HV boards were produced to equip a full roman pot together with the mother board
- All active boards were tested (coupled with a passive board) at LAL before shipping to CERN and found ok for installation.

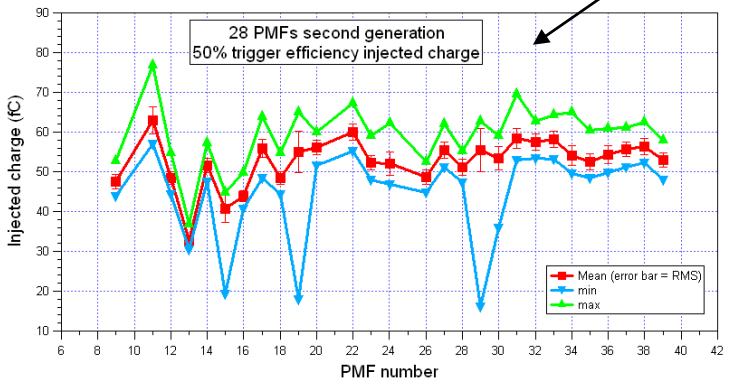


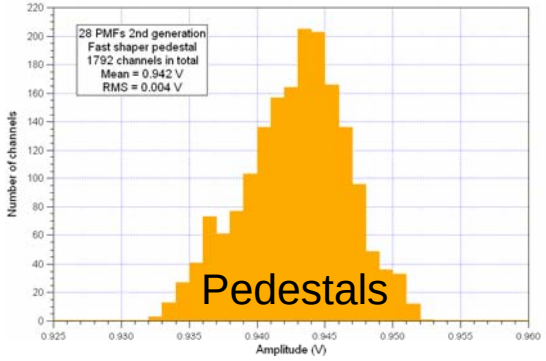
50% trigger Efficiency injected charge



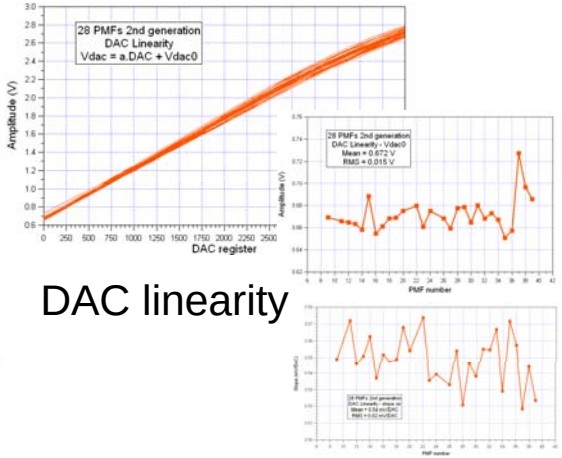
28 boards







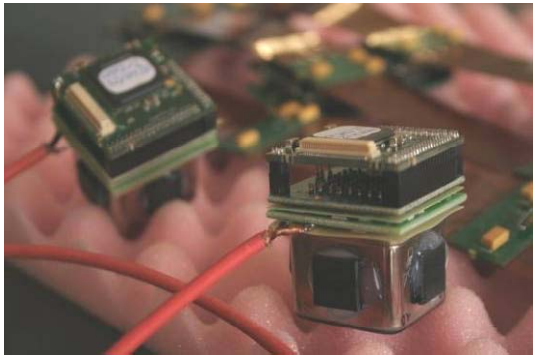
Pedestals

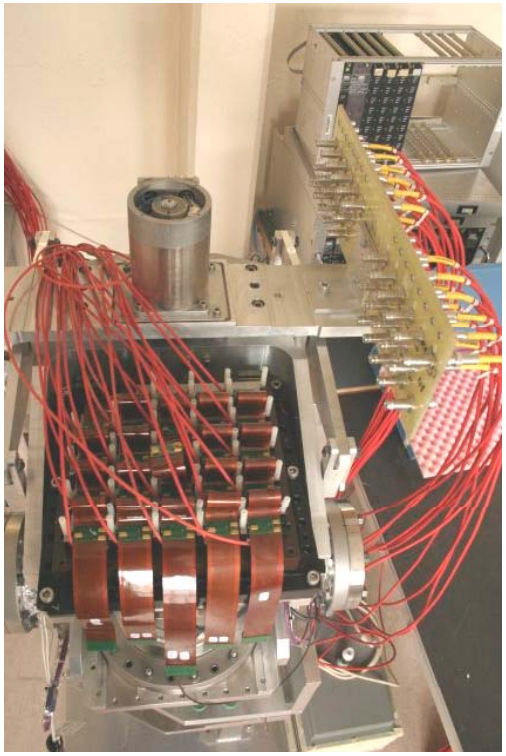


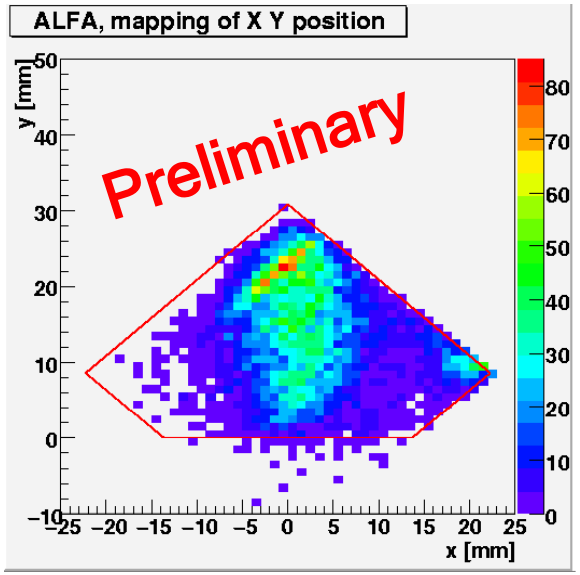
DAC linearity

August 2008 beam tests

- Carried out at CERN.
- Matrix of 23 PMFs readout by the last version of the mother board or 2 test boards (by group of 2×5 = 10 PMFs)
- Offline analysis ongoing. Online one showed nice reconstruction of the beam position
- All PMFs worked nicely as well as the kapton cables







Conclusions

- PMFs showed excellent performances with and without PMT
- The group kapton cable + 5 PMFs works well
- A nice homogeneity was observed between all PMFs tested
- Just a few (7) channels cold or hot among 1792 tested
- Protection of the ASIC with so-called jaja seems suitable
- For the first a full matrix of 23 PMFs was tested with beam

- Future:
  - Production of the 184 PMFs needed for the 8 final roman pots
  - Series test of the active boards produced