



Production and test of the LHCf microstrip silicon system

Florence, June 28th 2007 - **RD07**

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Outline

- **Introduction**
 - About the LHCf experiment (method and location)
- **The LHCf apparatus**
 - Some details about the detectors
 - **The μ -strip silicon system: production and test**
- **Beam test**
 - CERN, Sept. 2006 (few preliminary results)
- **Summary and schedule**
 - Toward the 2008 LHC operation

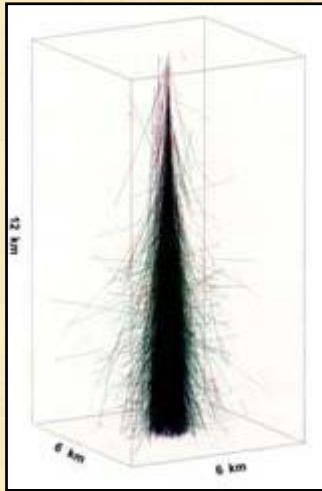
1) Introduction: the LHCf experiment

a) Method

b) Location

c) Detector

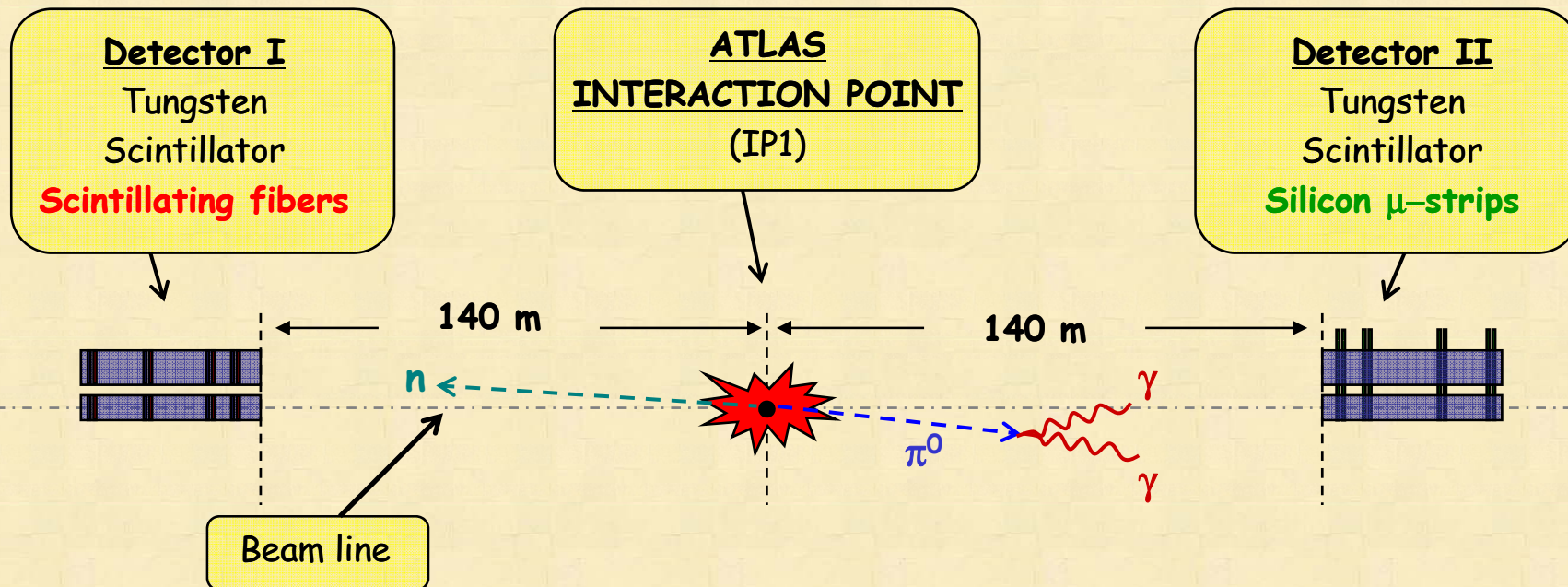
The direct measurement of the π production cross section as function of p_T is essential to correctly estimate the energy of the primary cosmic rays (LHC: 10^{17} eV)



Simulation of an atmospheric shower initiated by a 10^{19} eV proton.



LHCf experimental method is based on 2 independent detectors installed on both sides of IP1

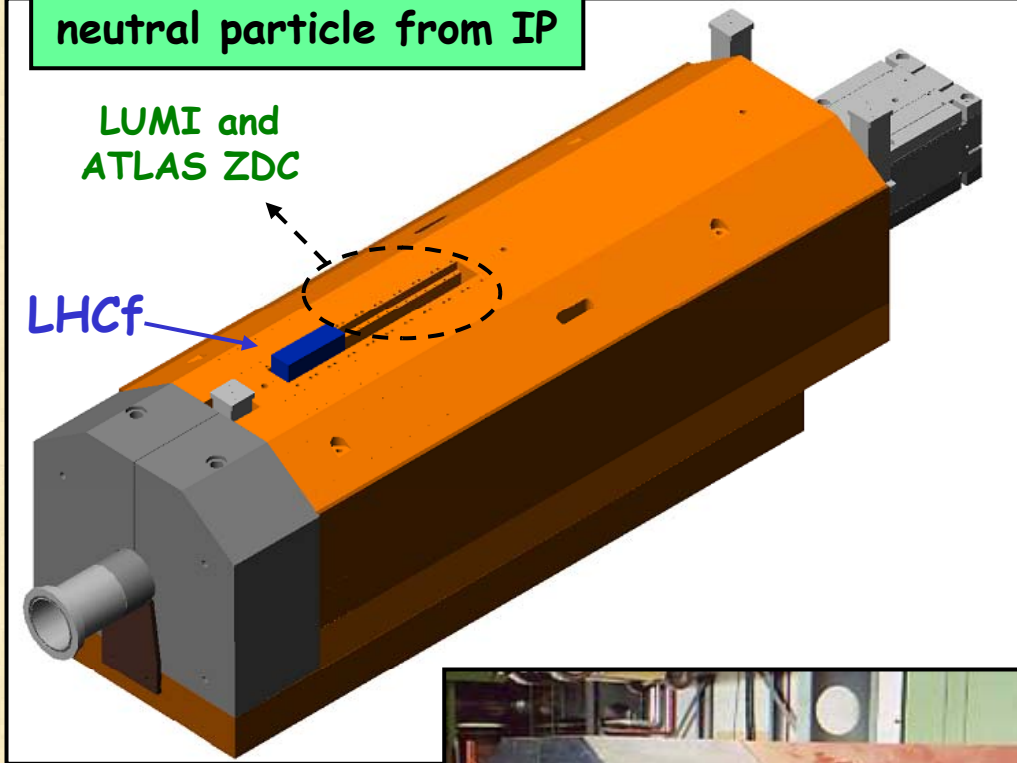


Location of detectors: TAN absorbers at $\pm 40\text{m}$ from IP

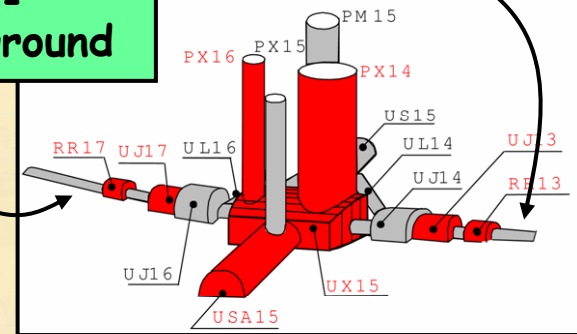
TAN: absorber for neutral particle from IP

LUMI and ATLAS ZDC

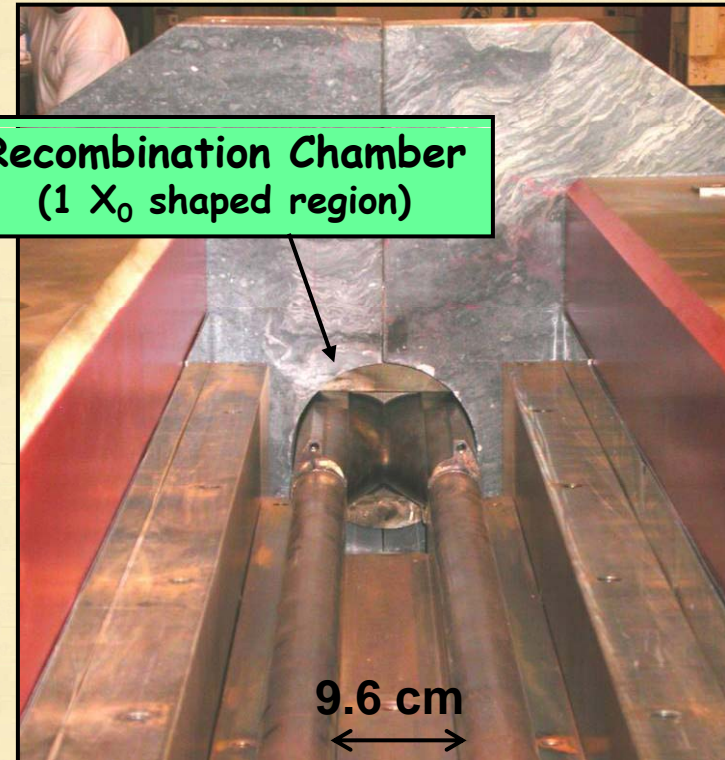
LHCf



IP1 underground

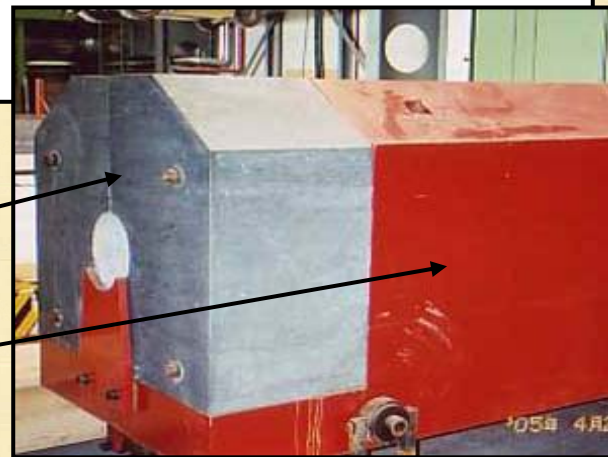


Recombination Chamber (1 X_0 shaped region)



Front: marble

Body: iron



Detector #1

2 independent calorimeter "towers" 24 cm long vertically stacked (5 mm gap)

Lower tower: 2 cm x 2 cm area

Upper tower: 4 cm x 4 cm area

Each calorimeter tower allows reconstructing **energy** (scintillator) and **impact point** (SciFi) of incoming γ or n

4 pairs of SciFi layers for tracking purpose (6, 10, 30, 42 X_0)

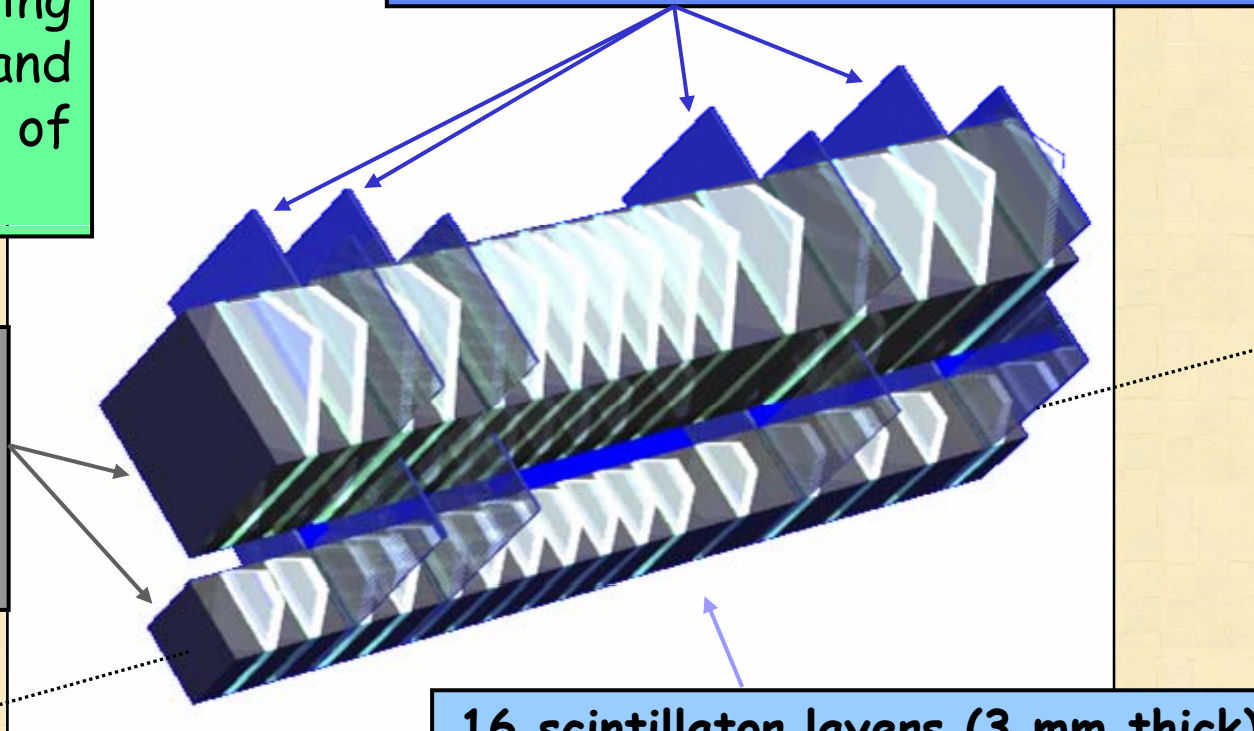
22 absorber layers
(Tungsten, 7mm thick)

Total: 44 X_0 ($1.6 \lambda_I$)
(W: $X_0 = 3.5\text{mm}$, $R_M = 9\text{mm}$)

Beam line

16 scintillator layers (3 mm thick)

Trigger and energy profile measurements

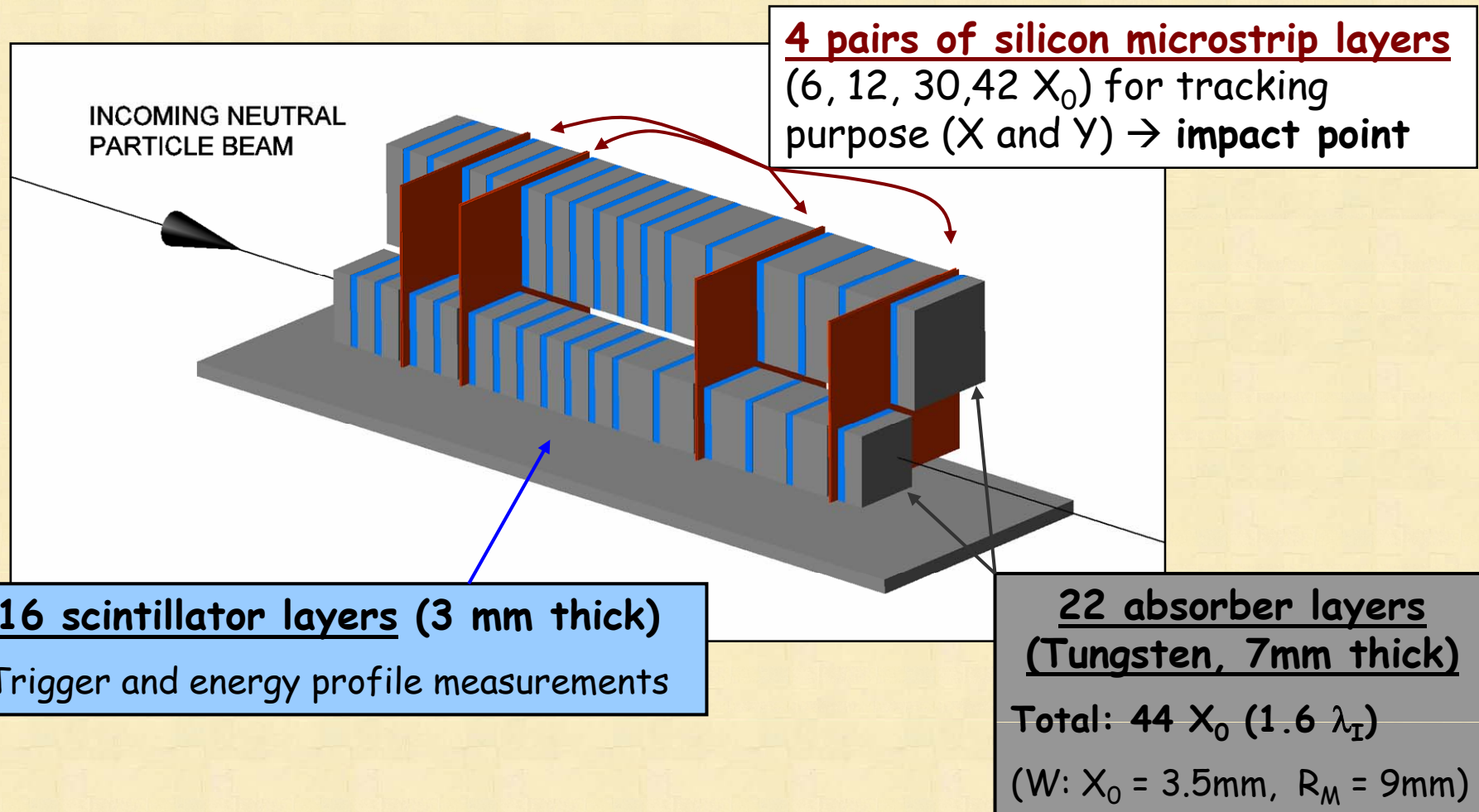


Detector #2

2 independent calorimeter towers 24 cm long stacked on their edges and offset from one another

Lower: 2.5 cm x 2.5 cm area

Upper: 3.2 cm x 3.2 cm area

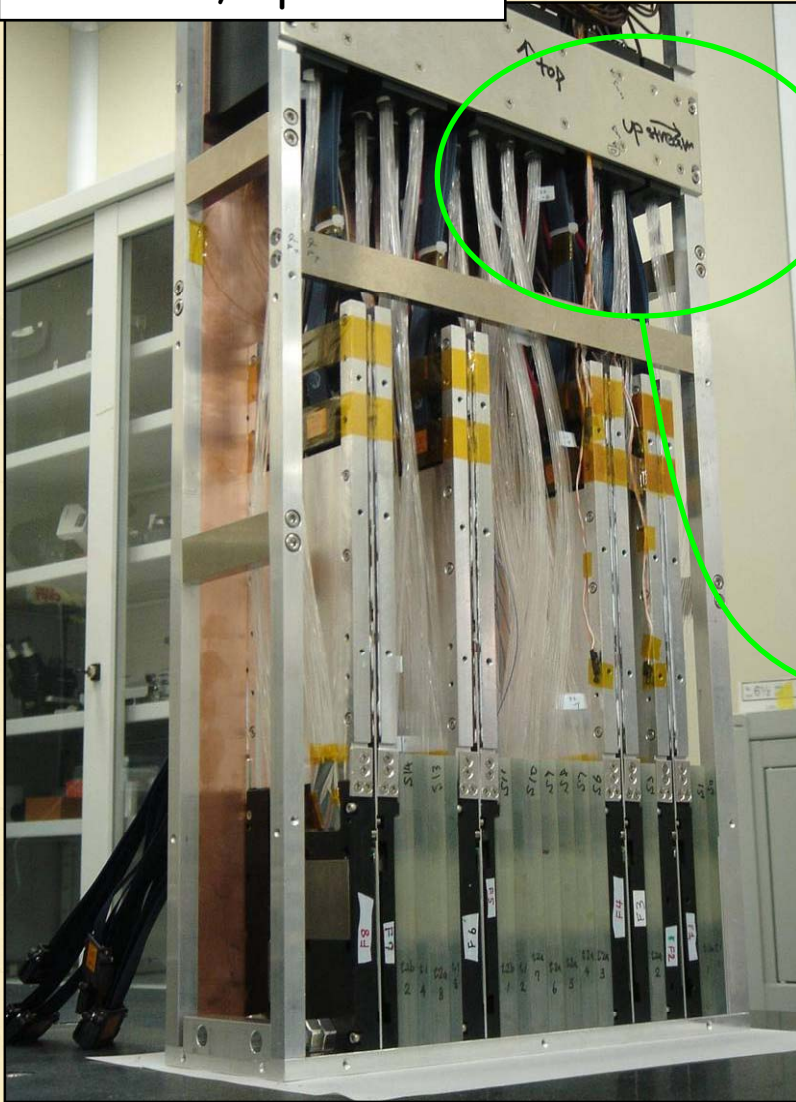


2) The LHCf detector

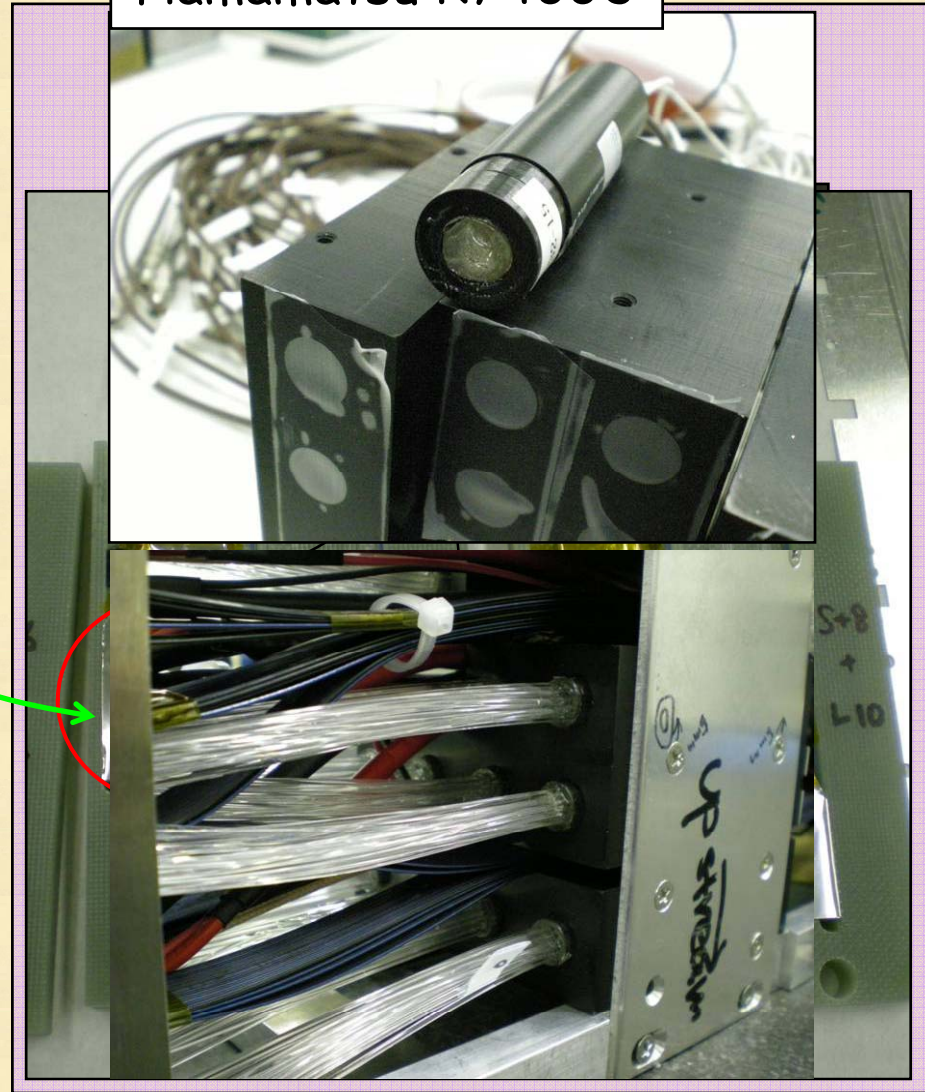
- a) Some details about detector #2
- b) Production of silicon modules
- c) Test of front-end chip

Some details for detector #2

Florence, April 2007



Hamamatsu R7400U

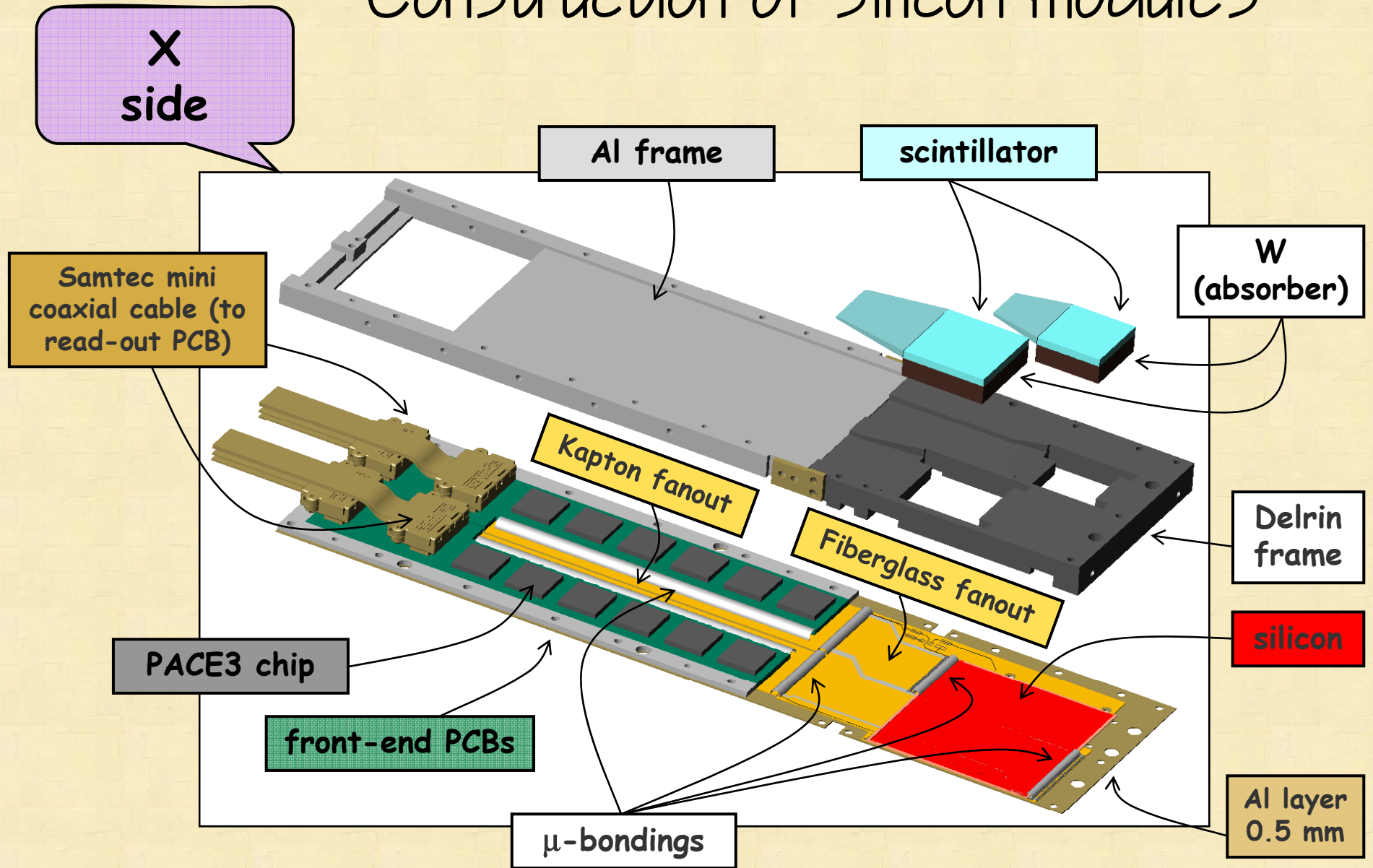


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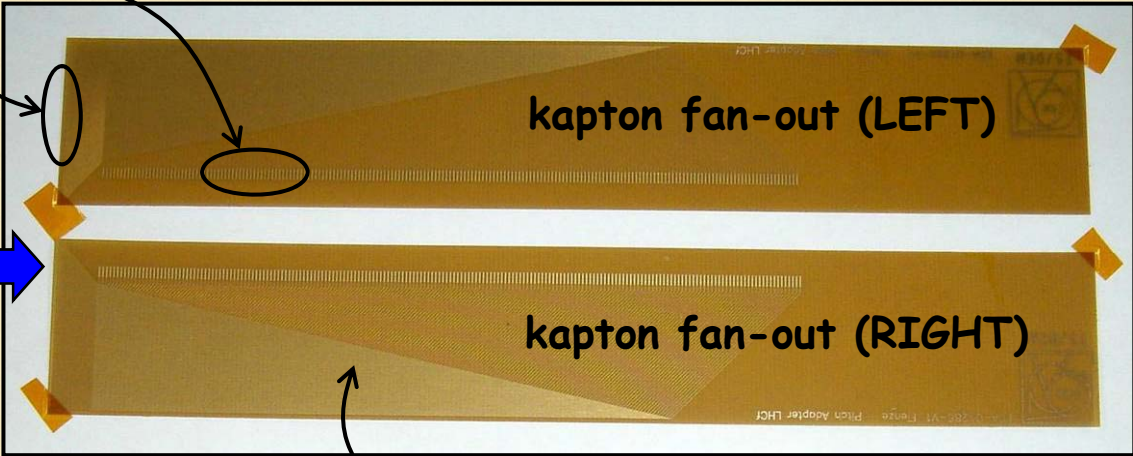
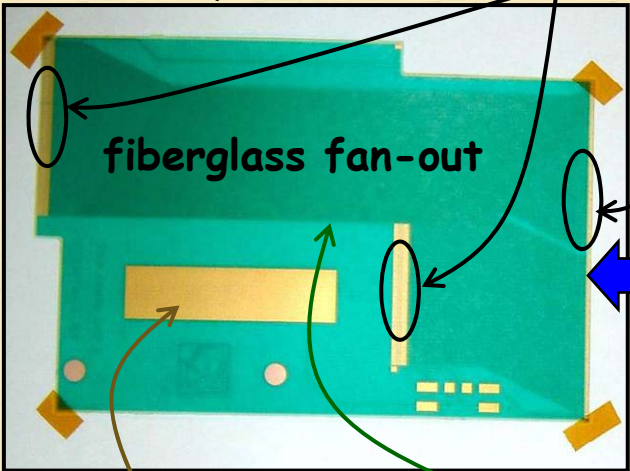
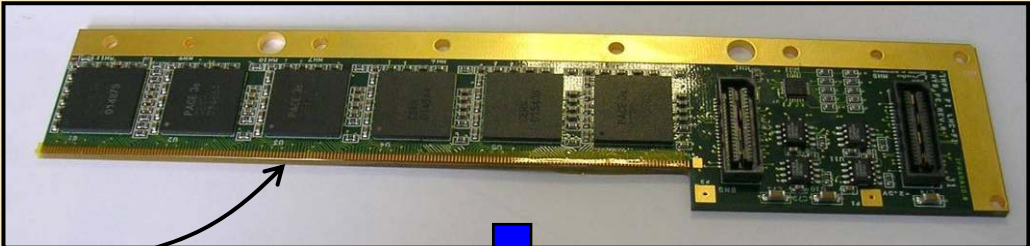
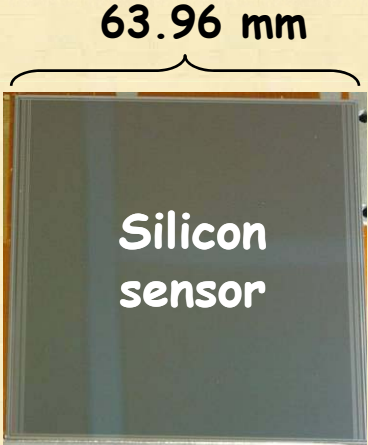
LHCf microstrip silicon system

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Construction of silicon modules



Assembling silicon module, X-side



bonding pads

bias pad (conductive Ag-gluе between pad and sensor backplane)

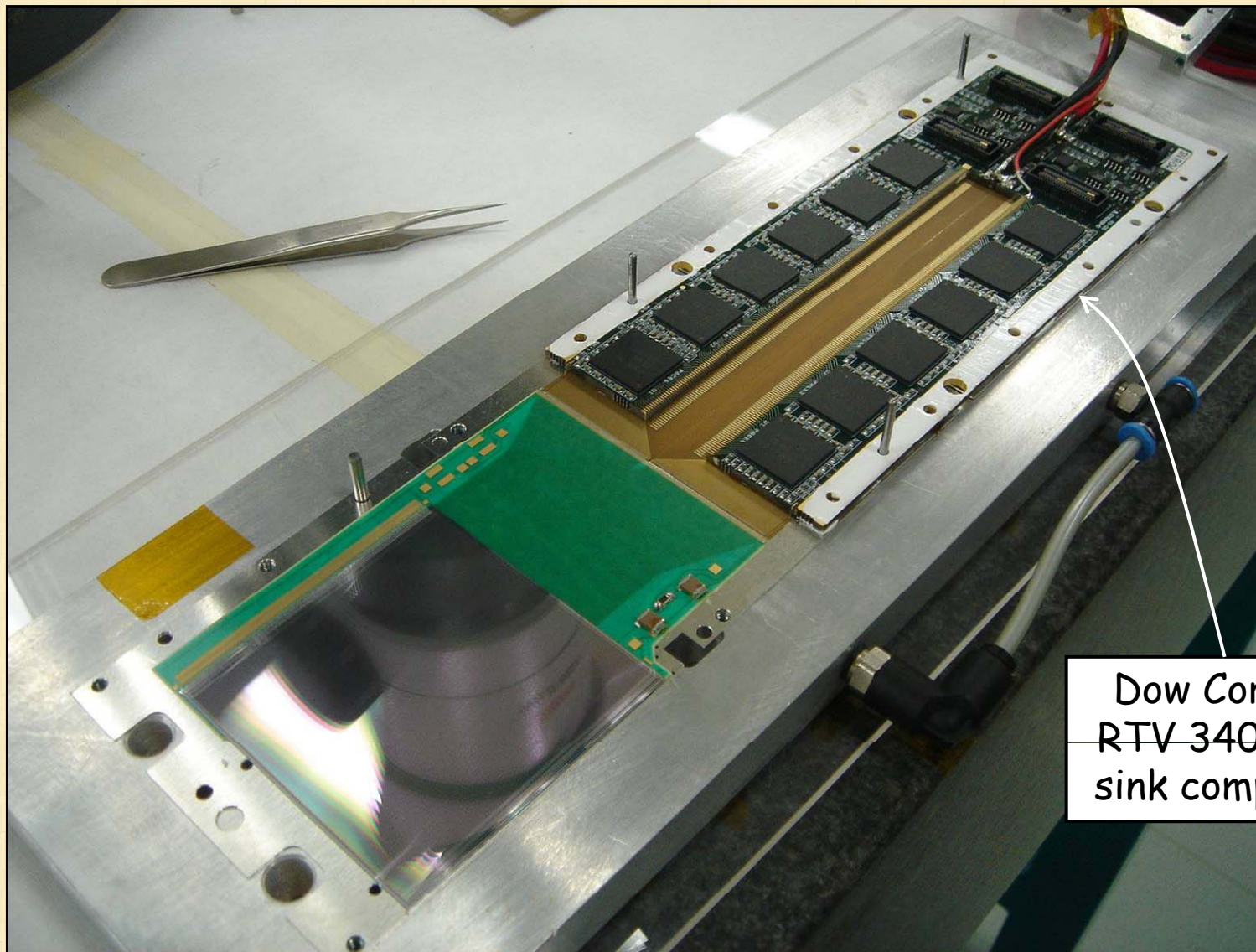
thin uniform epoxy glue layer Araldite 2020

Electrical insulation (50μm kapton tape) plus thin uniform epoxy glue layer (Araldite 2020)

Silicon sensors details

- HAMAMATSU single side sensors developed for the barrel of the **ATLAS SCT**
- **Size: (63.56 x 63.96) mm² x 285μm**
- **Implantation pitch: 80μm**
- **768 strips + strip 0 and strip 769 as field shaping strips**
- About 75V full depletion voltage

Y-side silicon layer with front-end



Dow Corning
RTV 340 heat
sink compound

Silicon modules final production (4 X and 4 Y)



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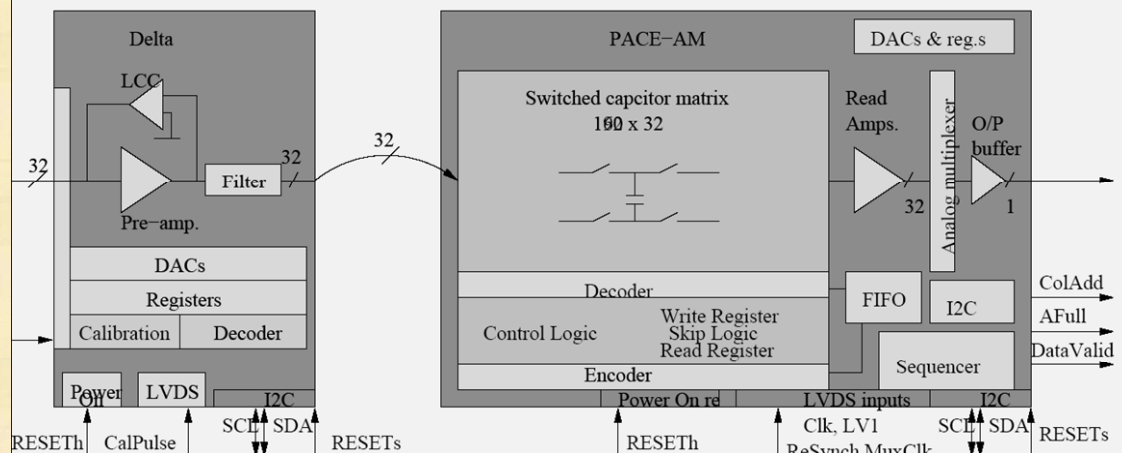
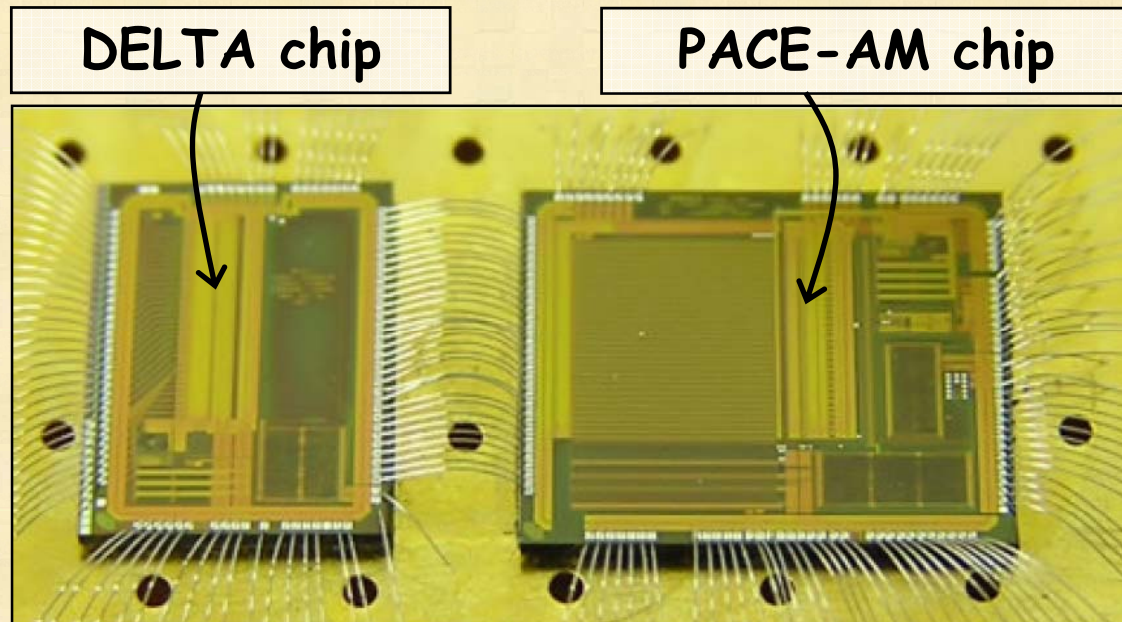
PACE3 front-end chip

Developed for the CMS ECAL silicon preshower

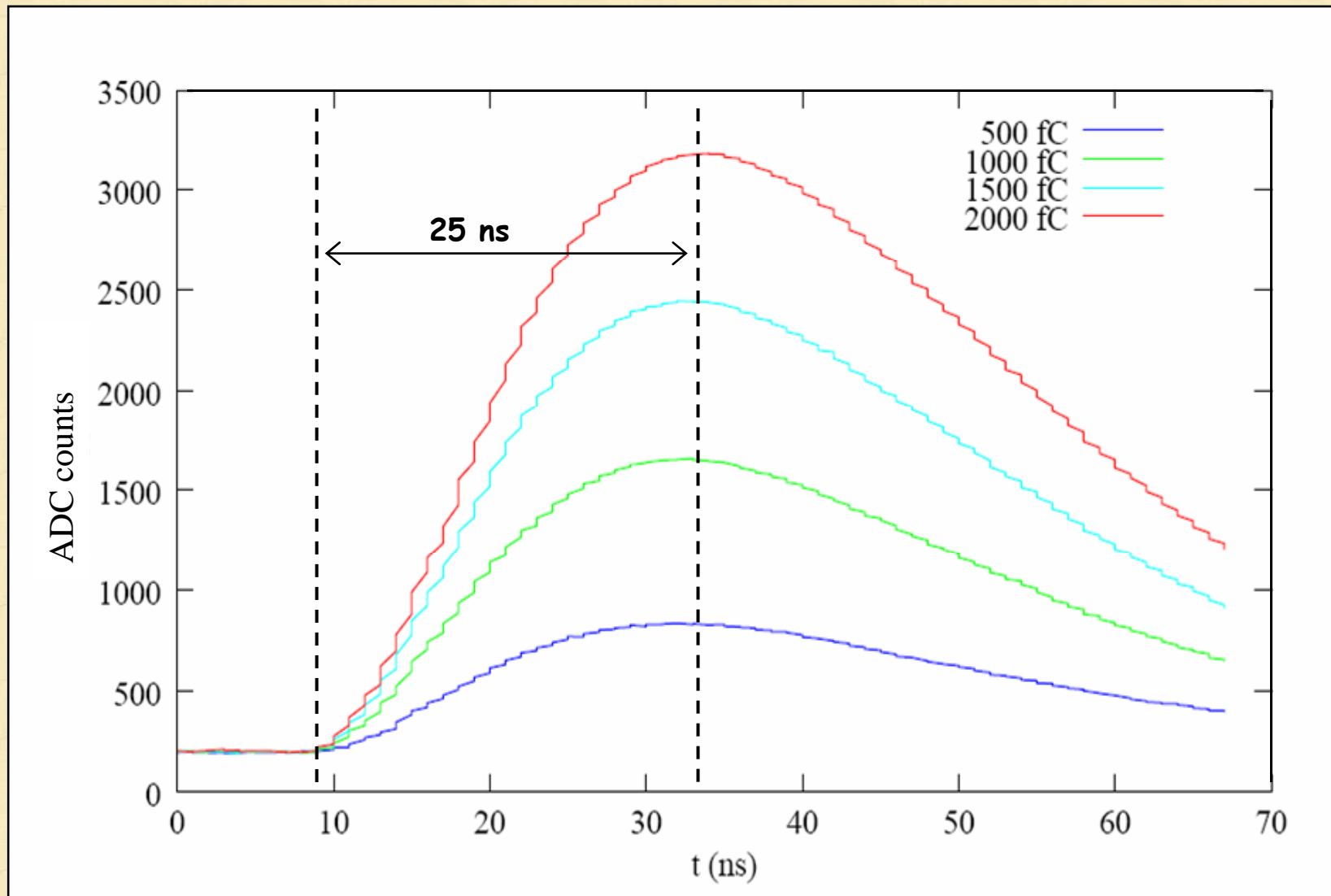
- 32 analog-in channels
- high dynamic range
- 25 ns peaking time
- CMOS sub-micron
- 600 mW consumption

DELTA chip: preamp. stage, shaping, and internal calib. sys

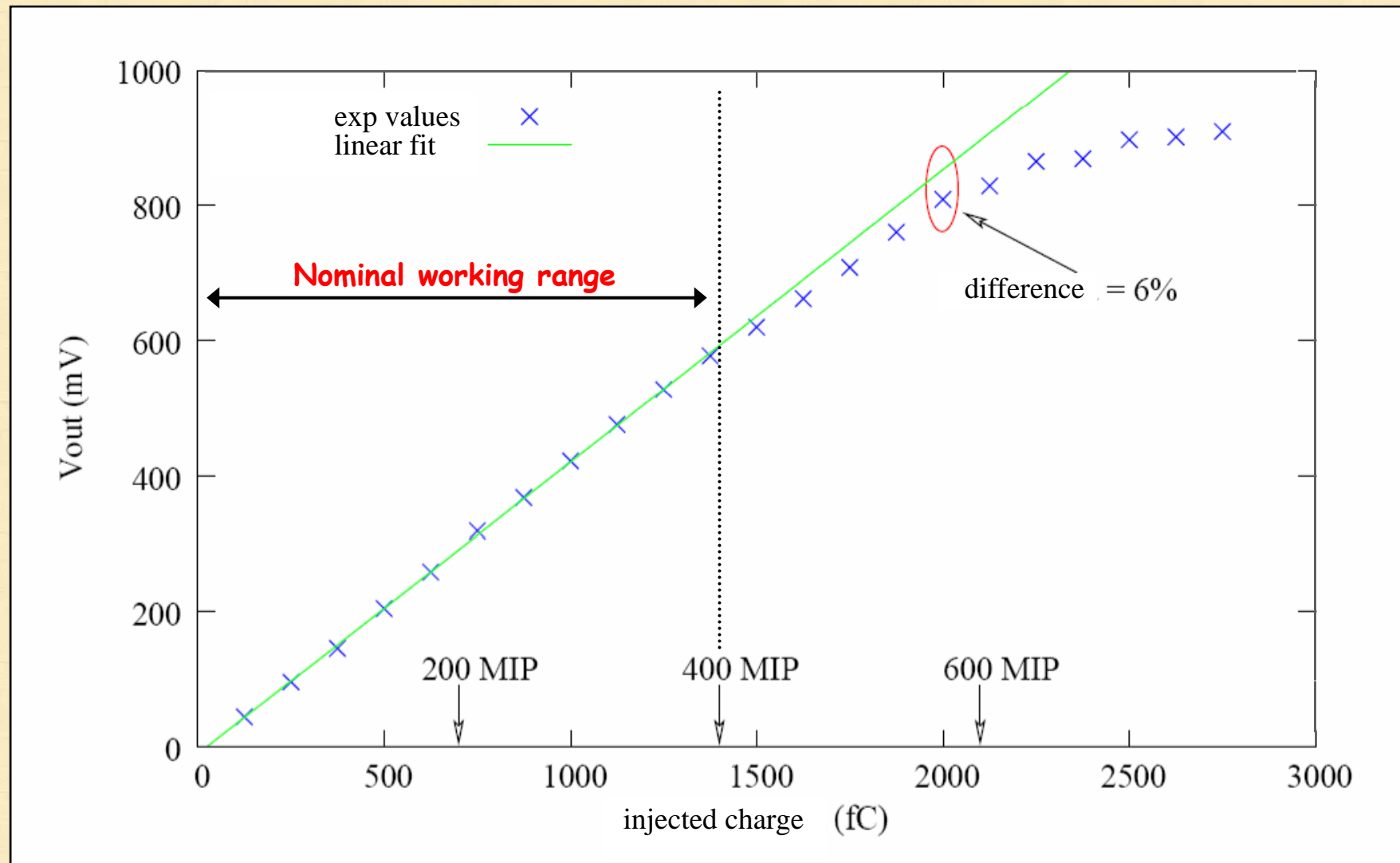
PACE-AM chip: analog pipeline (matrix 192x32 capacitors), control logic and output lines



PACE3 analog output for different input charge



Study of PACE3 output linearity



3) Beam test (sept. 2006)

A few VERY preliminary results

Beam test at CERN-SPS (Sept. 2006)

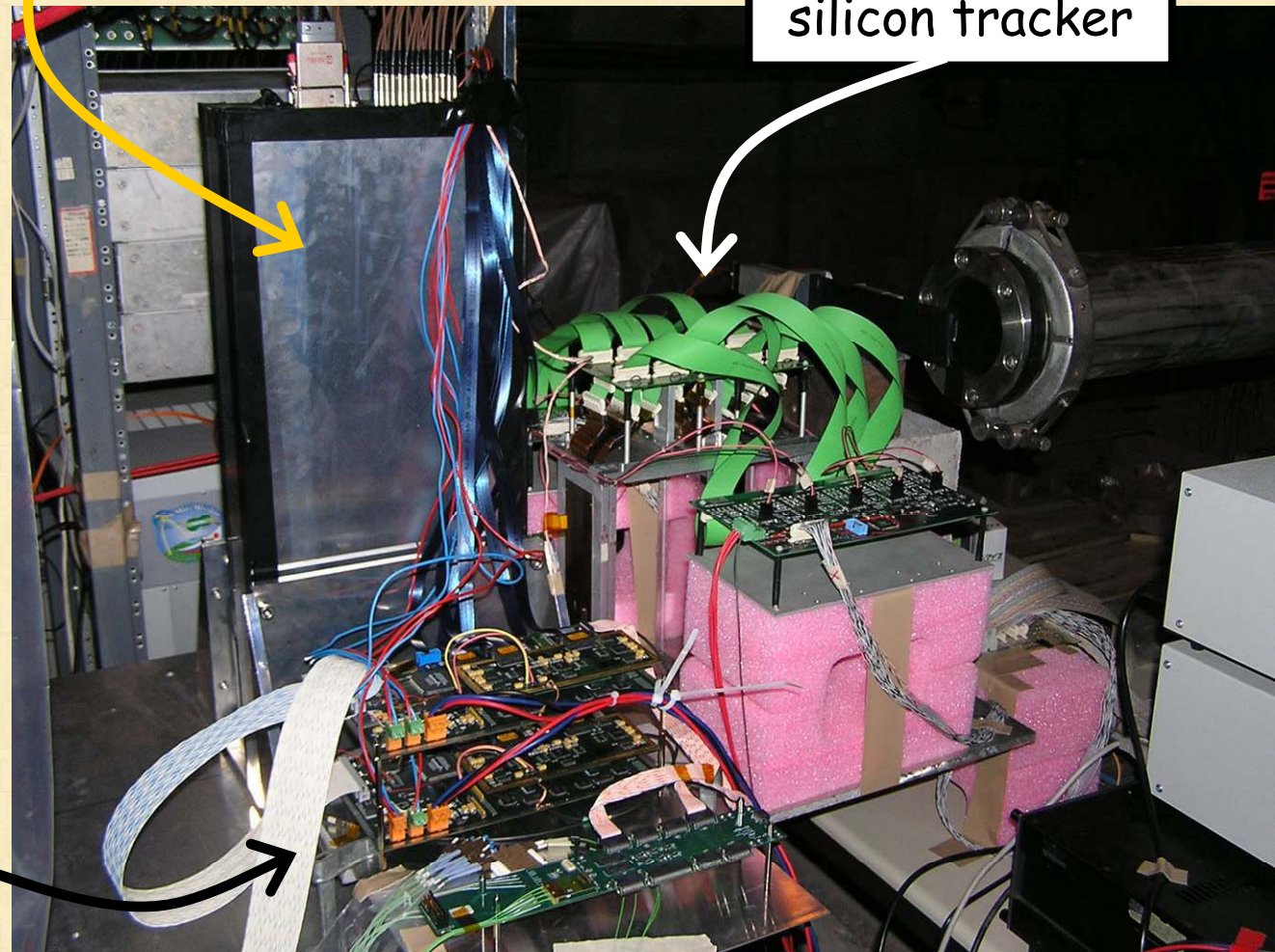
LHCf detector #2

Additional silicon tracker

e, p, μ beams

energies between
100 and 350 GeV

LHCf silicon
system read-out
PCBs



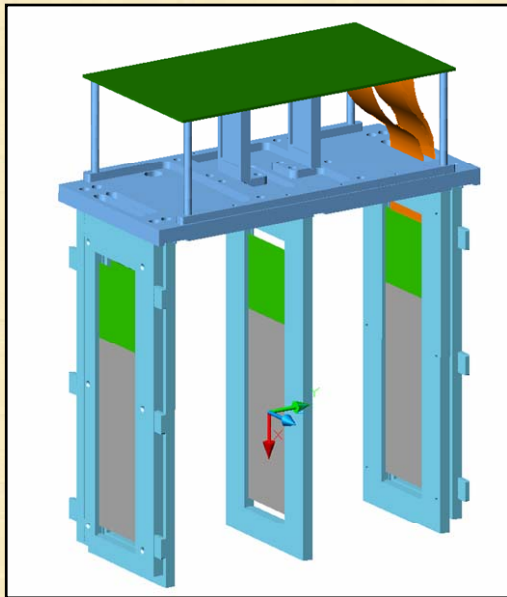
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LHCf microstrip silicon system

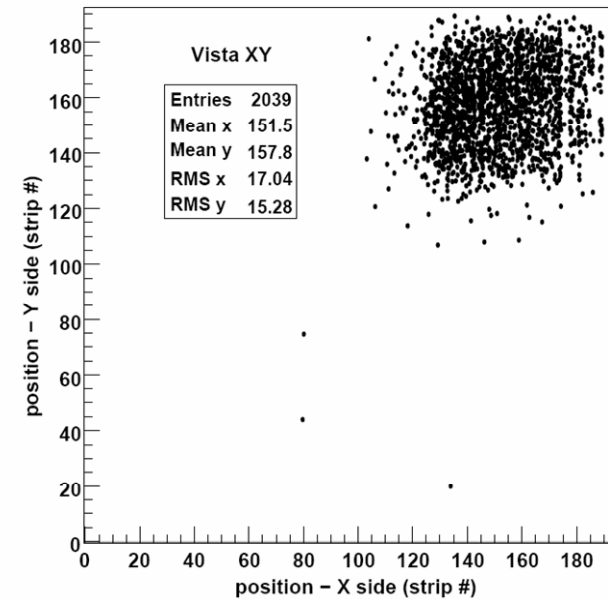
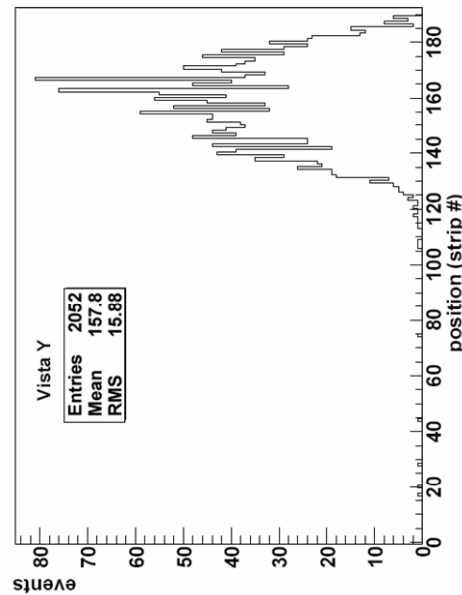
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Beam profile

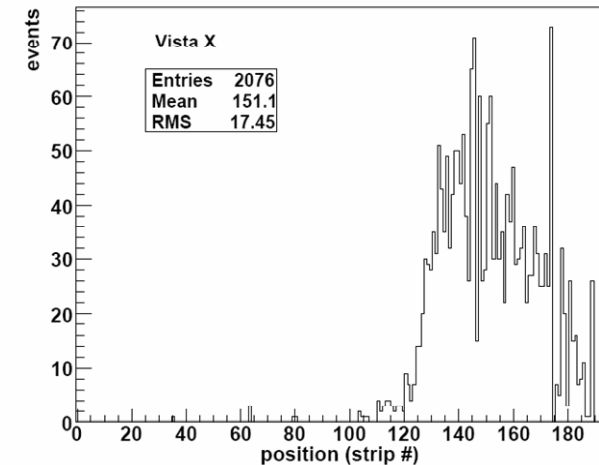
Beam profile is measured by means of an **additional silicon tracking system** made of 5 double-sided layers with intrinsic resolutions about $3 \mu\text{m}$ and $11 \mu\text{m}$ along X and Y direction



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200 GeV
electron



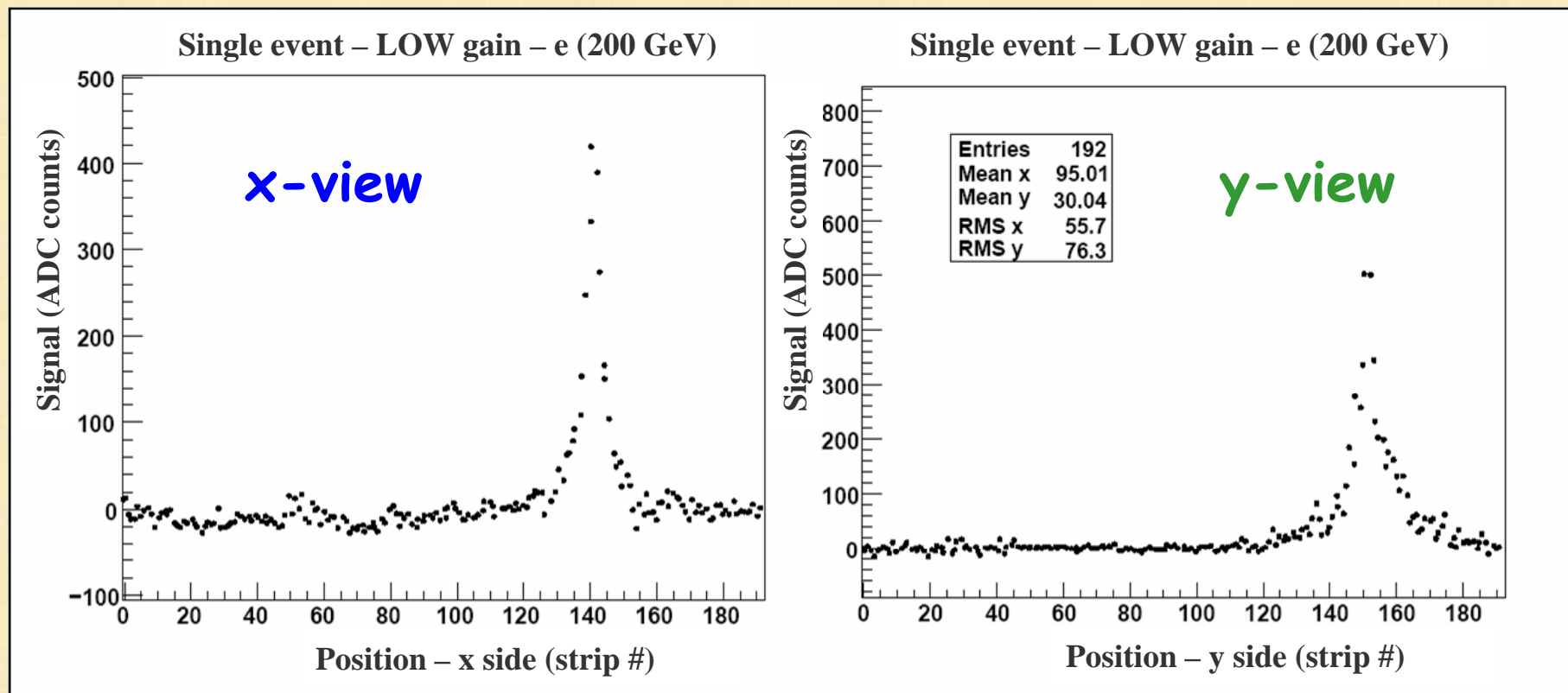
LHCf microstrip silicon system

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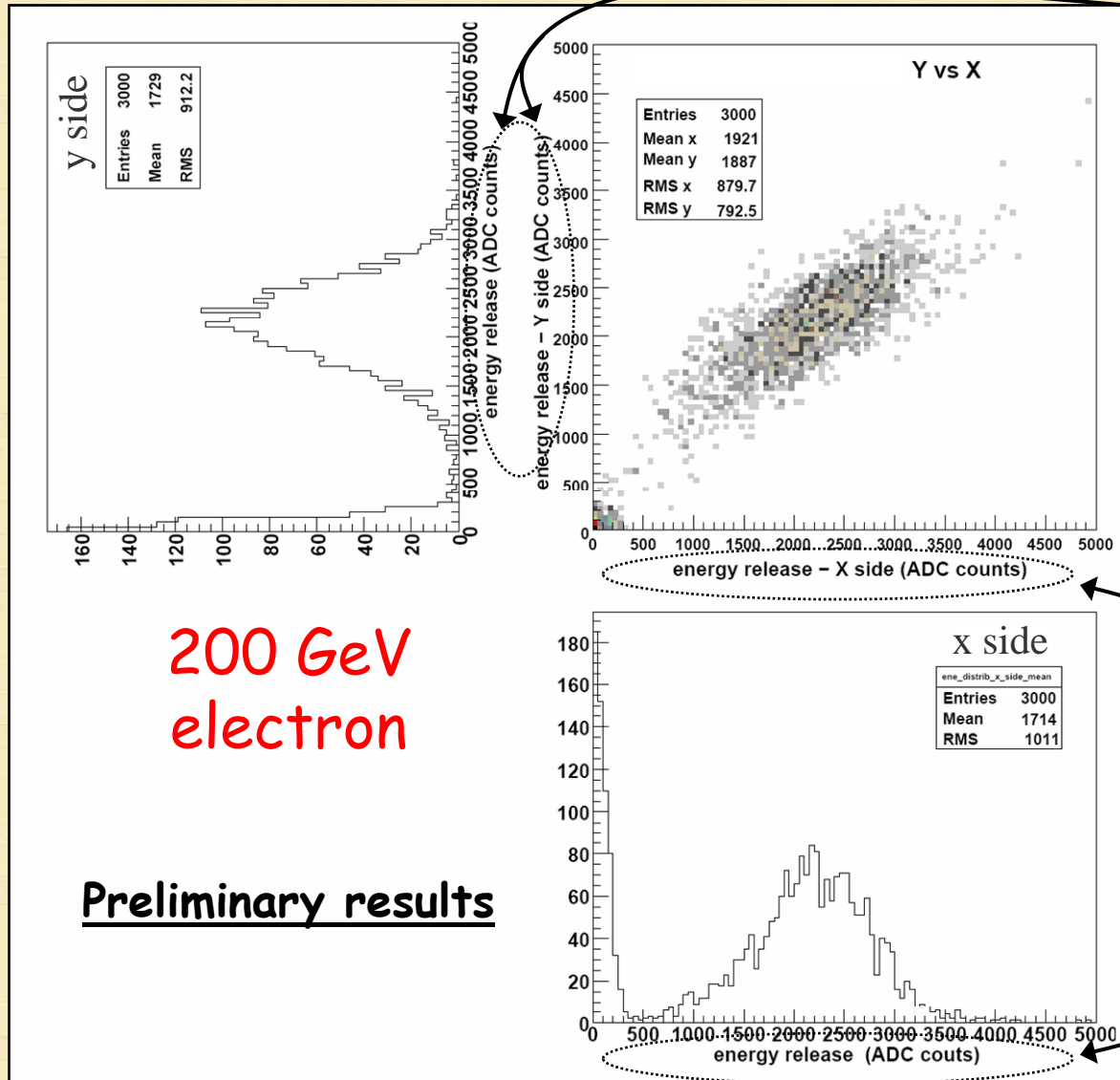
Shower transverse profiles for a single electron event

200 GeV electron

Preliminary results



Charge distribution and correlation



Energy release - y side (ADC counts)

Energy release - x side (ADC counts)

200 GeV electron

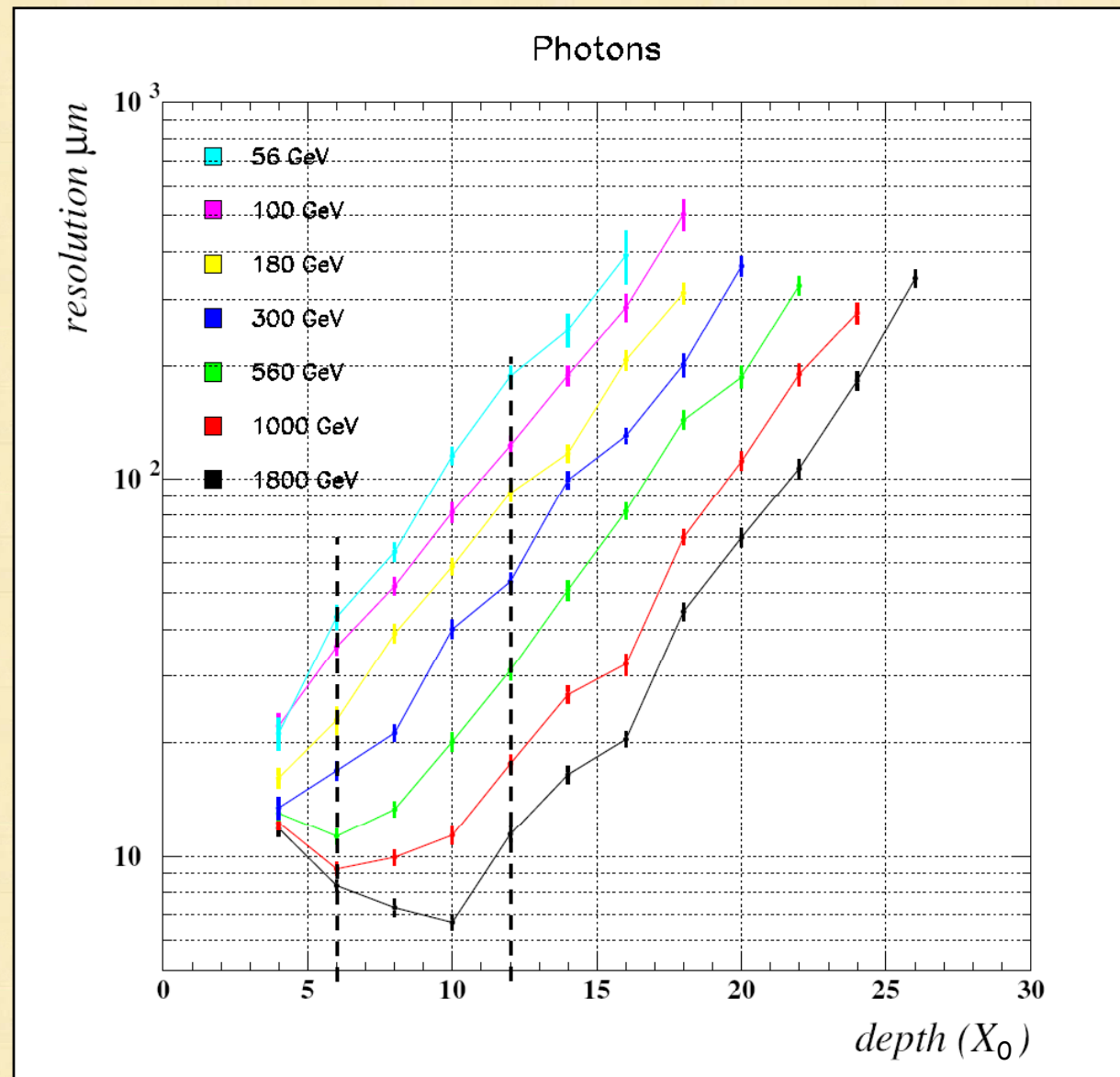
Preliminary results

Expected spatial resolution for shower center

Simulation with the **FLUKA** software of silicon layers installed at different depth inside the LHCf towers.

Shower transversal shape is approximated using a generalized **Lorentz function**:

$$L = \frac{p_1}{\left[p_2 + (x - p_3)^2 \right]^{p_4}}$$



A few conclusions and schedule

① LHCf apparatus

- Both LHCf detectors have been completed
- Read-out electronics is under development for detector #2 silicon system

② Installation

- Successful pre-installation done in 2007 for both detectors
- New pre-installation and test foreseen in autumn for detector #2 to test some modifications with respect to first pre-installation
- **Final installation between end 2007 and first months of 2008**

③ Beam test at CERN SPS (August 24th - September 11th)

④ Running

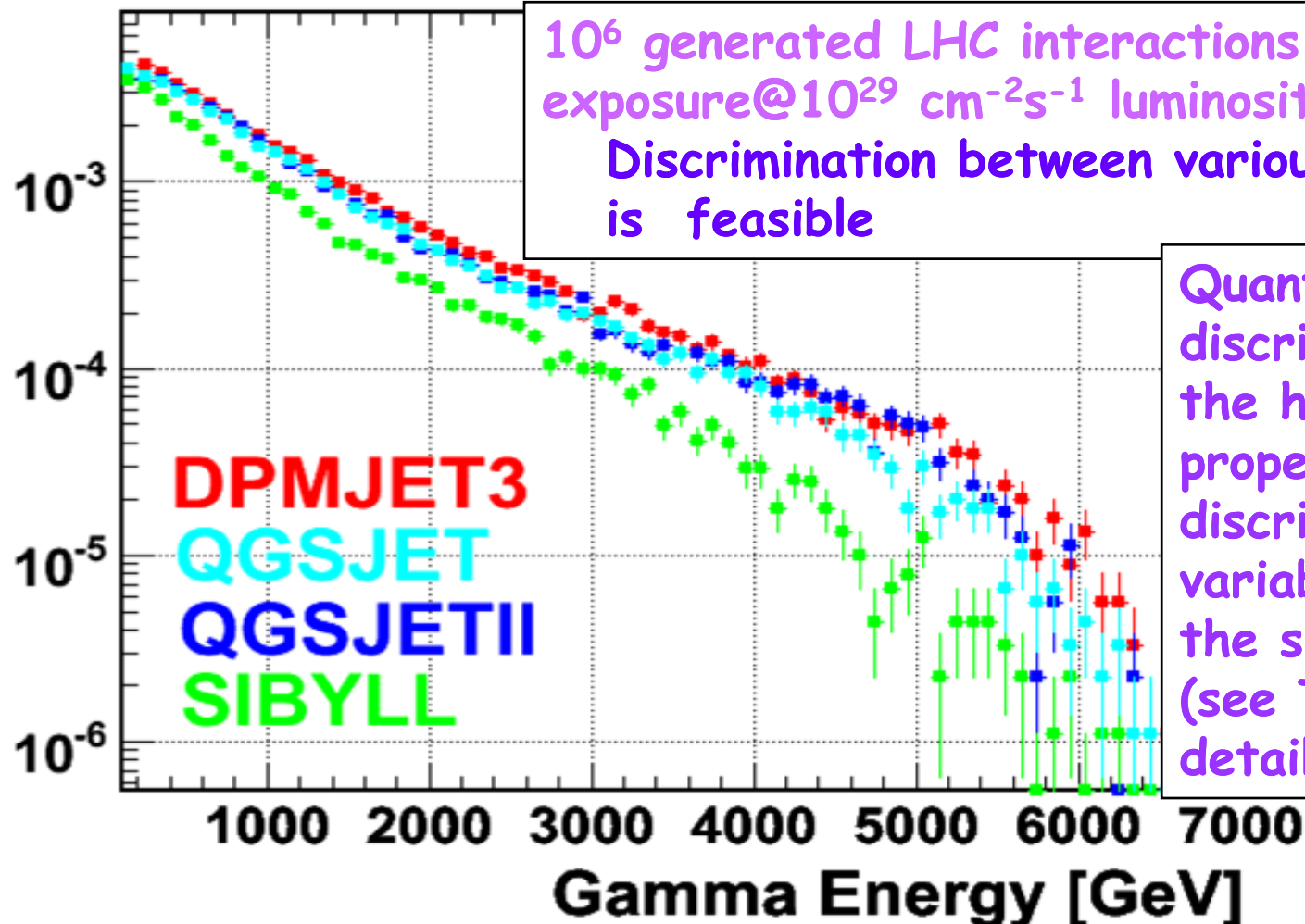
- Data taking foreseen at the beginning of LHC running at low luminosity (less than $10^{31}\text{cm}^{-2}\text{s}^{-1}$), in 2008

Backup slides

LHCf performances: Monte Carlo γ -ray energy spectrum
(5% energy resolution is taken into account)

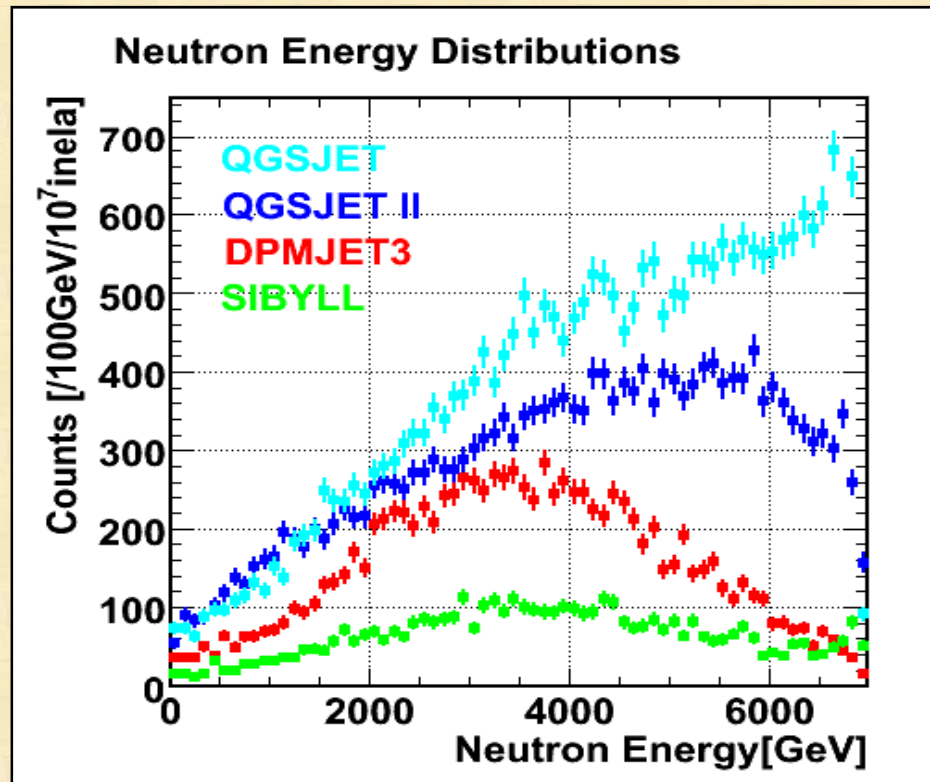
Gamma Energy Spectrum of 20mm square at Beam Center

particles/bin

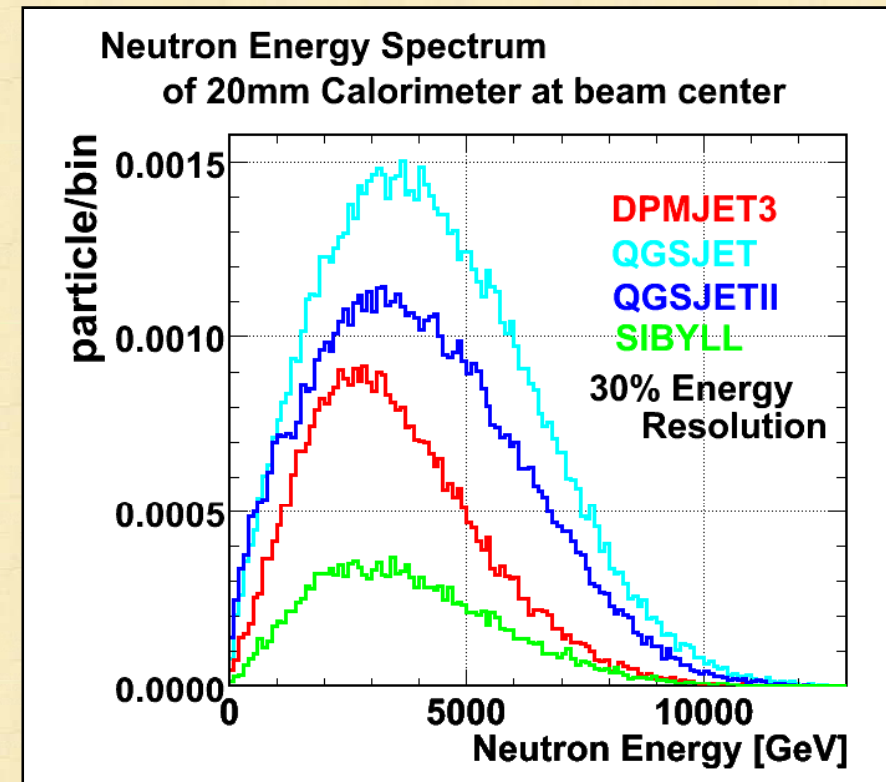


LHCf performances: model dependence of neutron energy distribution

Original n energy



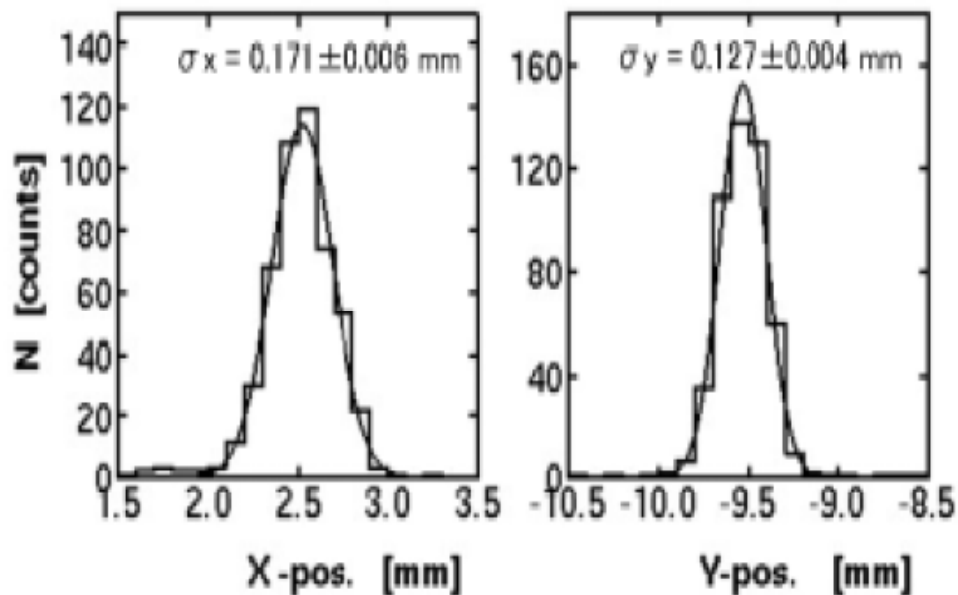
30% energy resolution



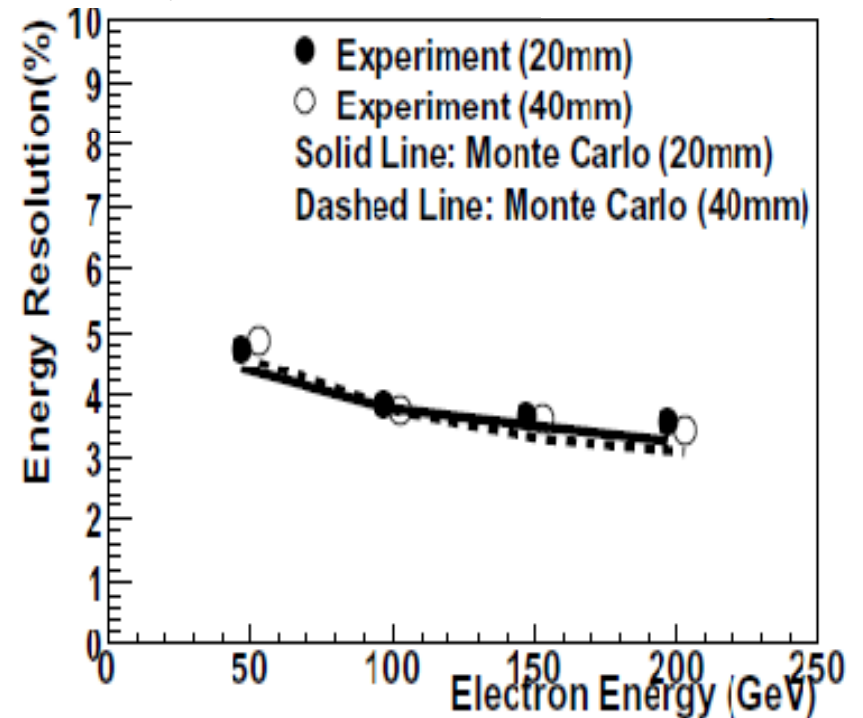
Performances of the LHCf Detector

*Measured at the SPS
Beam Test in 2004*

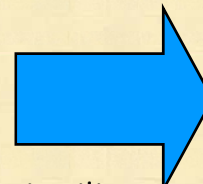
SciFi Position Resolution



Energy Resolution



LHCf can measure (and provide to LHC) the center of neutral flux from the collisions

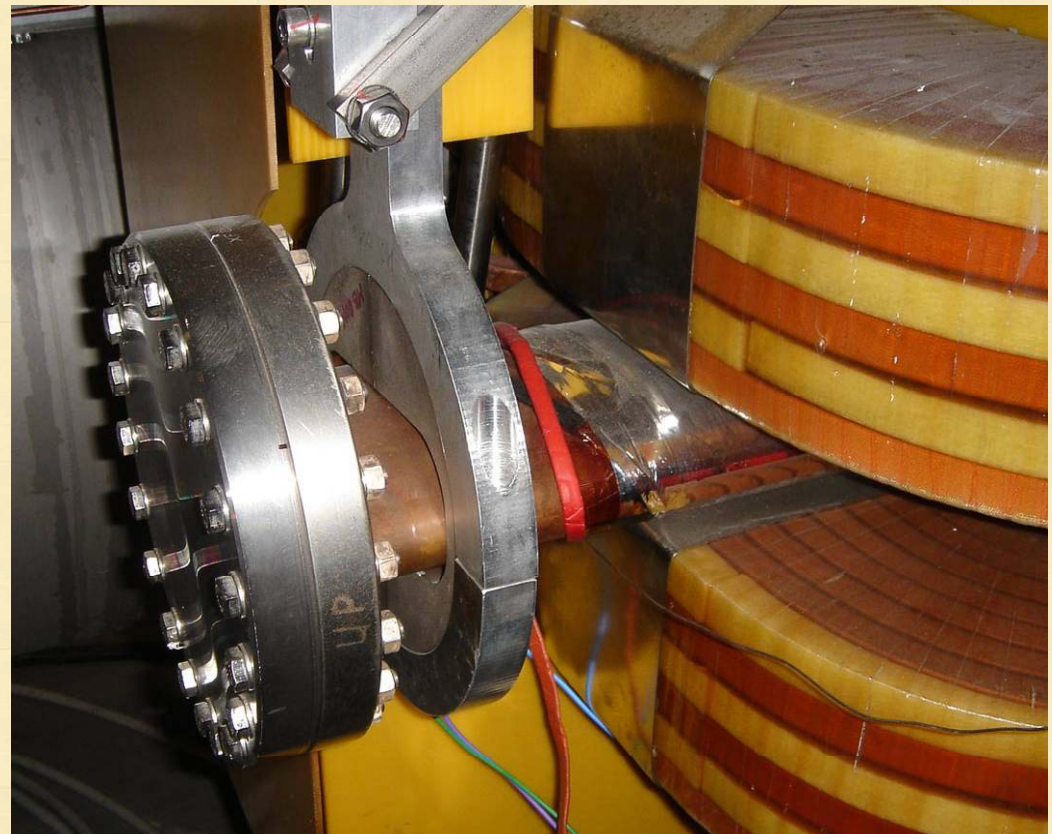


If the center of the neutral flux hits LHCf
→ << 1 mm resolution

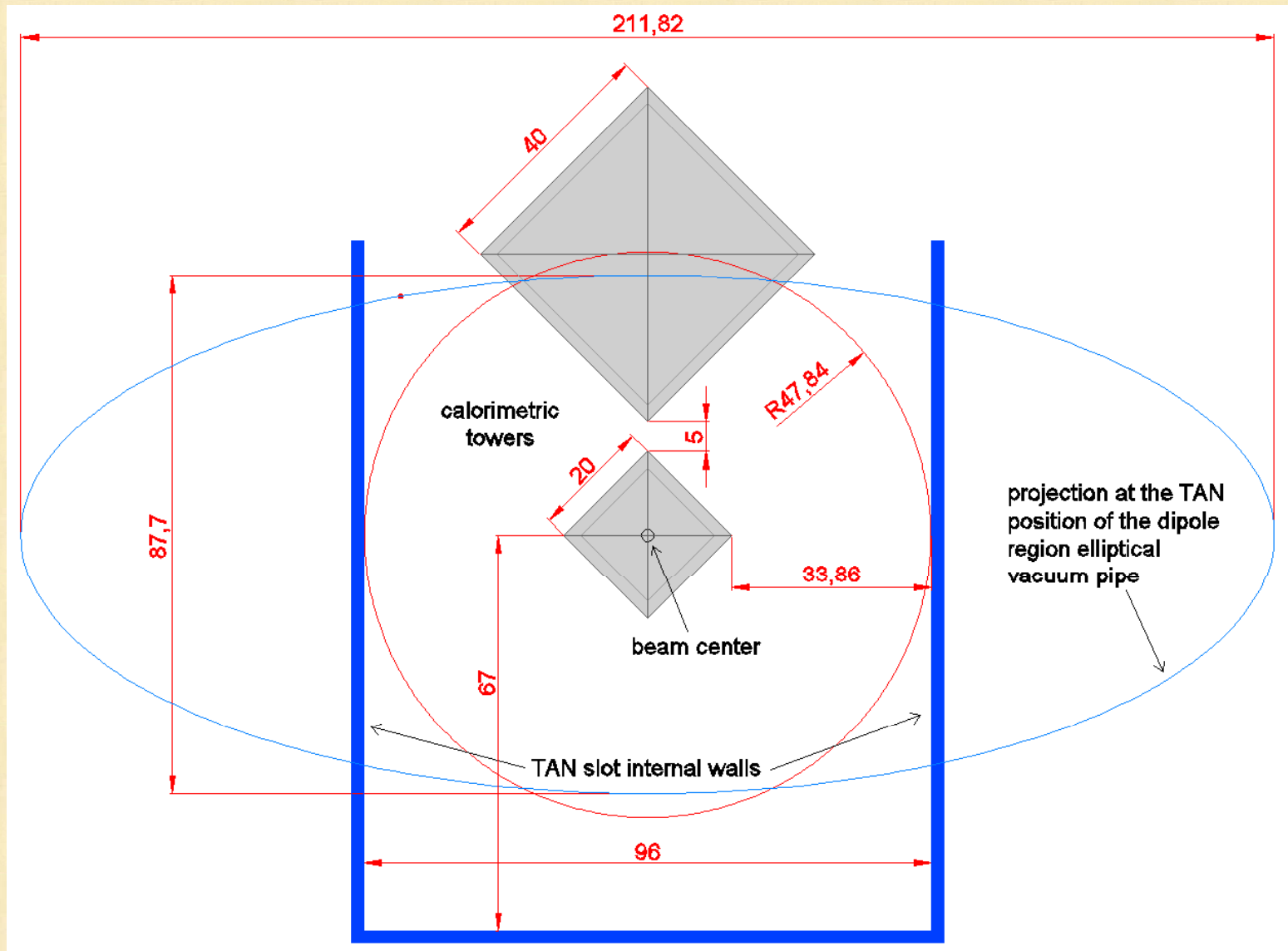
Geometrical limits for LHCf measurements

- I. Free space between the two beam pipes in the recombination chamber is 96 mm wide
- II. Critical part of beam pipe is in D1 magnet region, where it is of elliptical shape

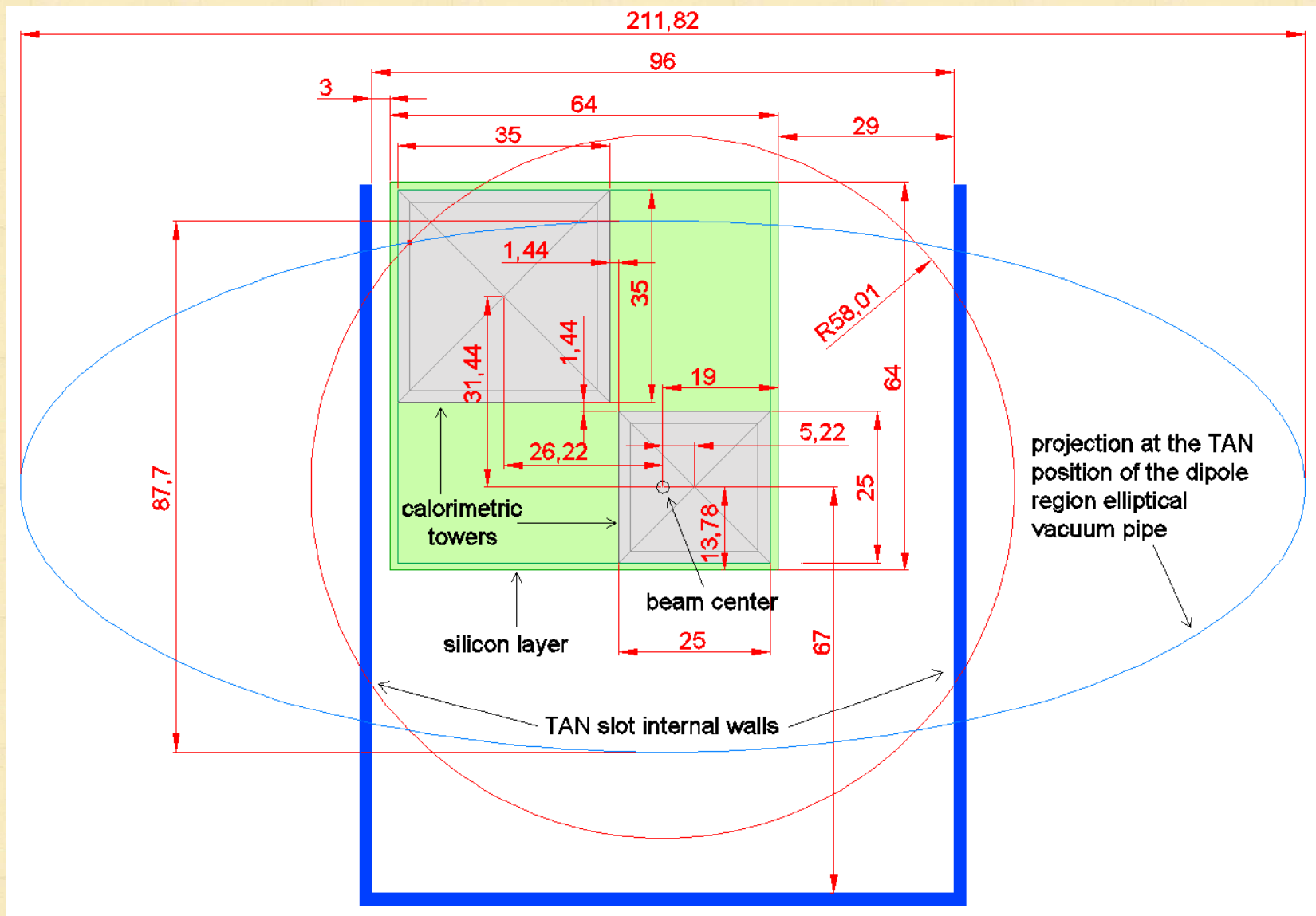
Combination of these two limits for detector #1 and #2 is sketched in the two following slides, superimposed to the detector geometry



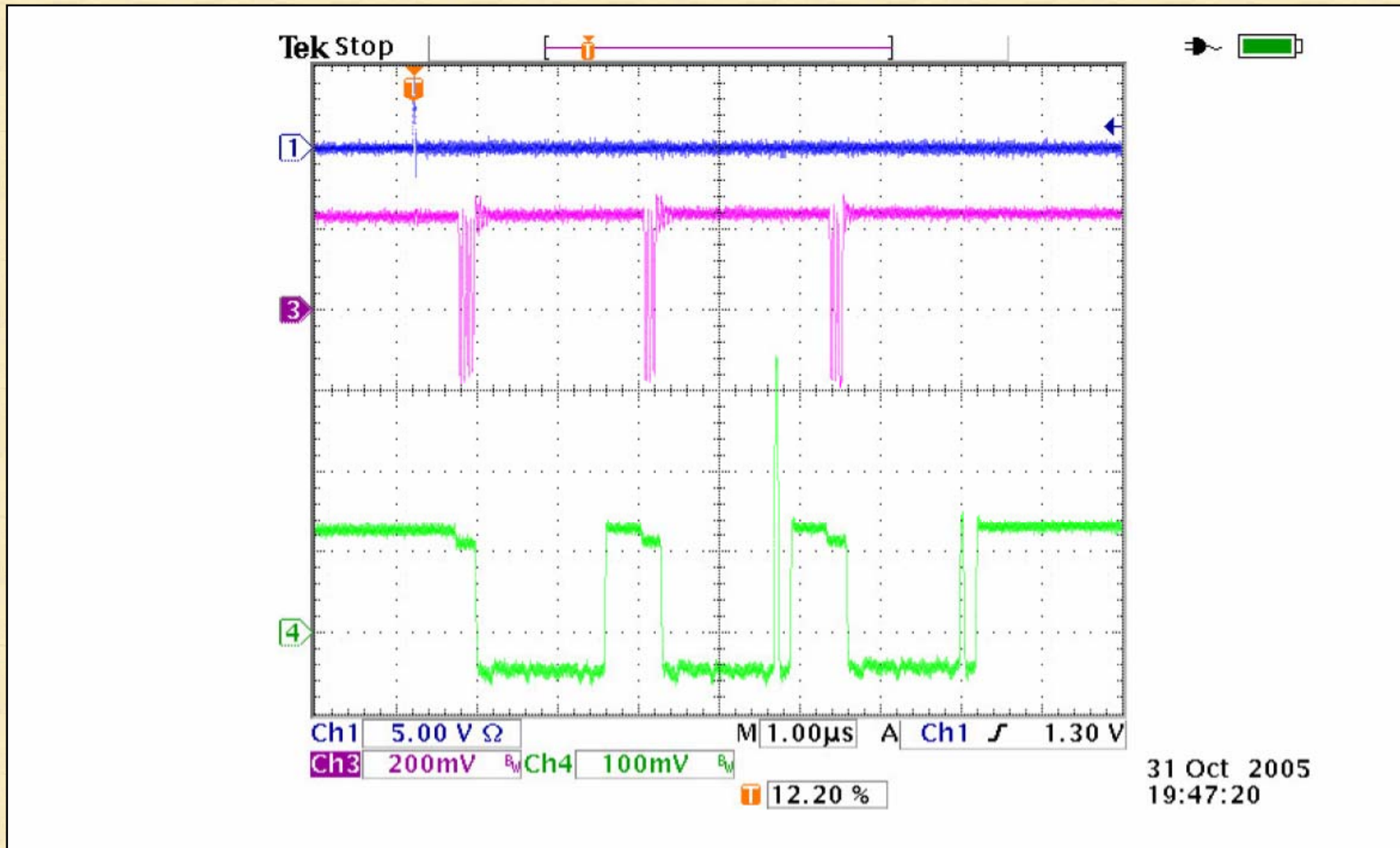
Transverse position of detector #1 in TAN slot



Transverse position of detector #2 in TAN slot



Calibration of PACE3 channels



Readout and control scheme for Arm2 Silicon

