

The TOTEM Detector at LHC



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on the behalf of the
TOTEM Collaboration

TOTEM Collaboration: Bari, Budapest, Case Western Reserve, CERN, Genova, Helsinki, Penn State, Pisa/Siena, Prague, Tallin (~ 80 physicists)

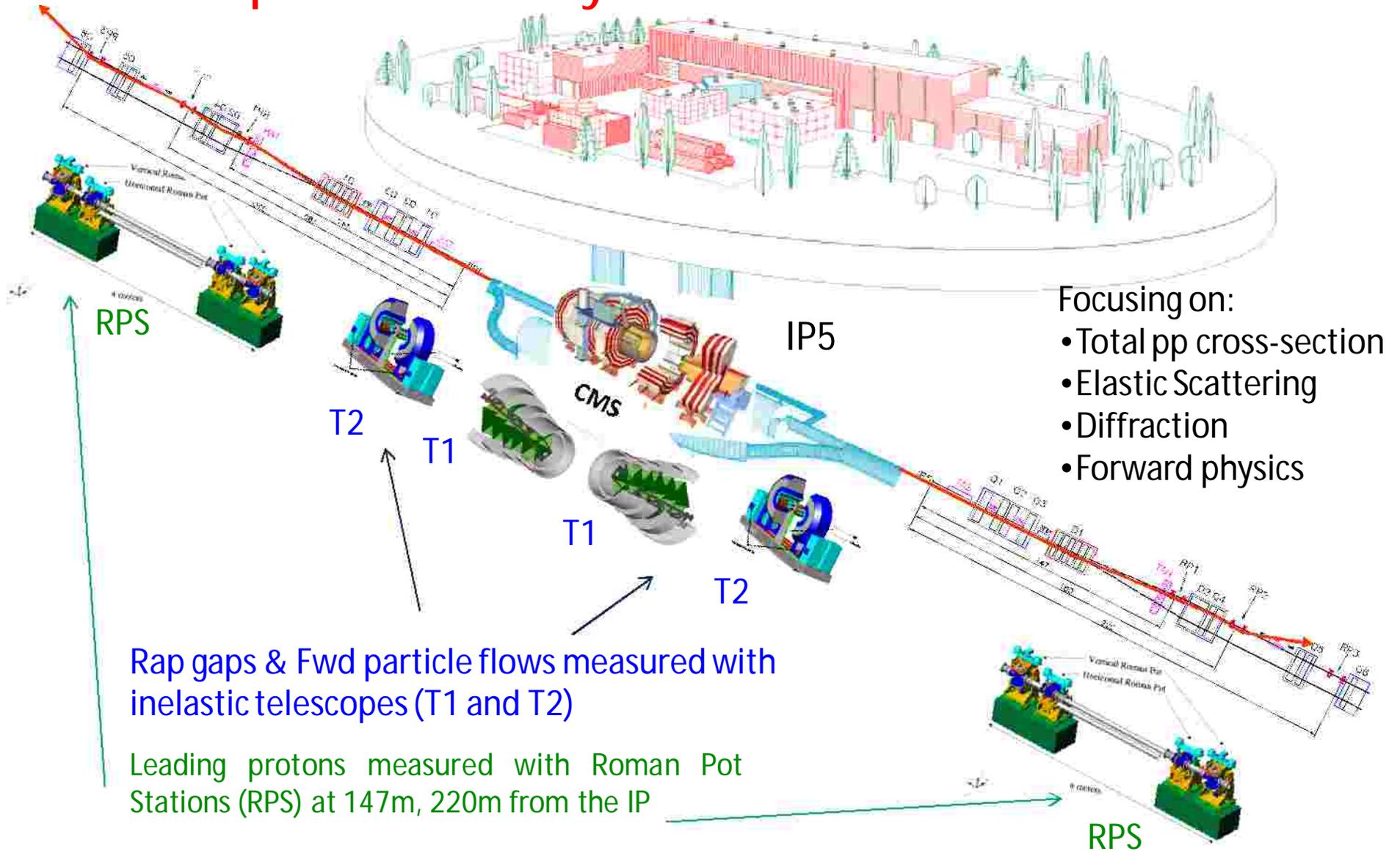
Frontier Detectors for Frontier Physics

11th Pisa meeting on advanced detectors

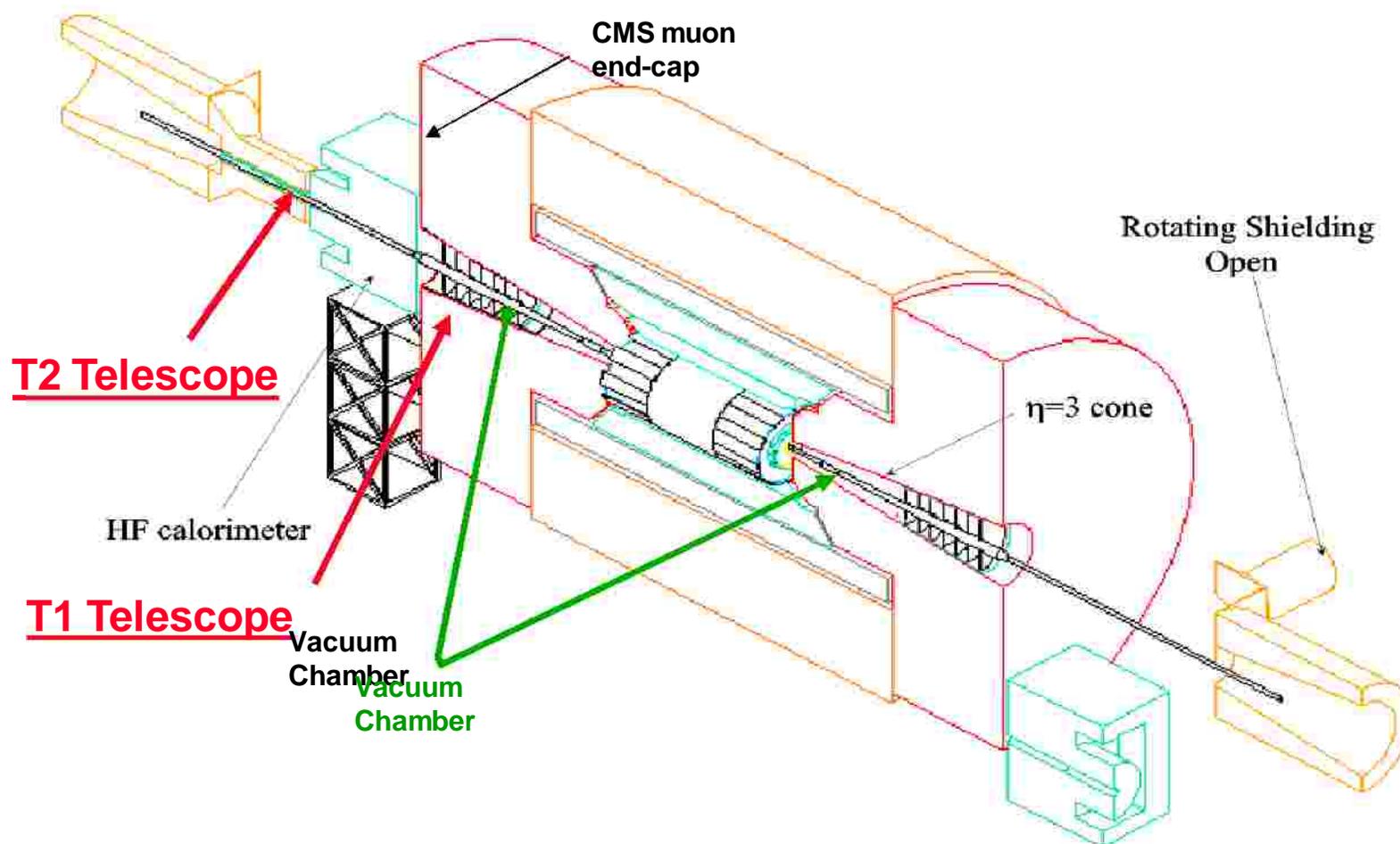
La Biodola • Isola d'Elba • Italy

May 24-30, 2009

Experimental layout of the TOTEM Detector

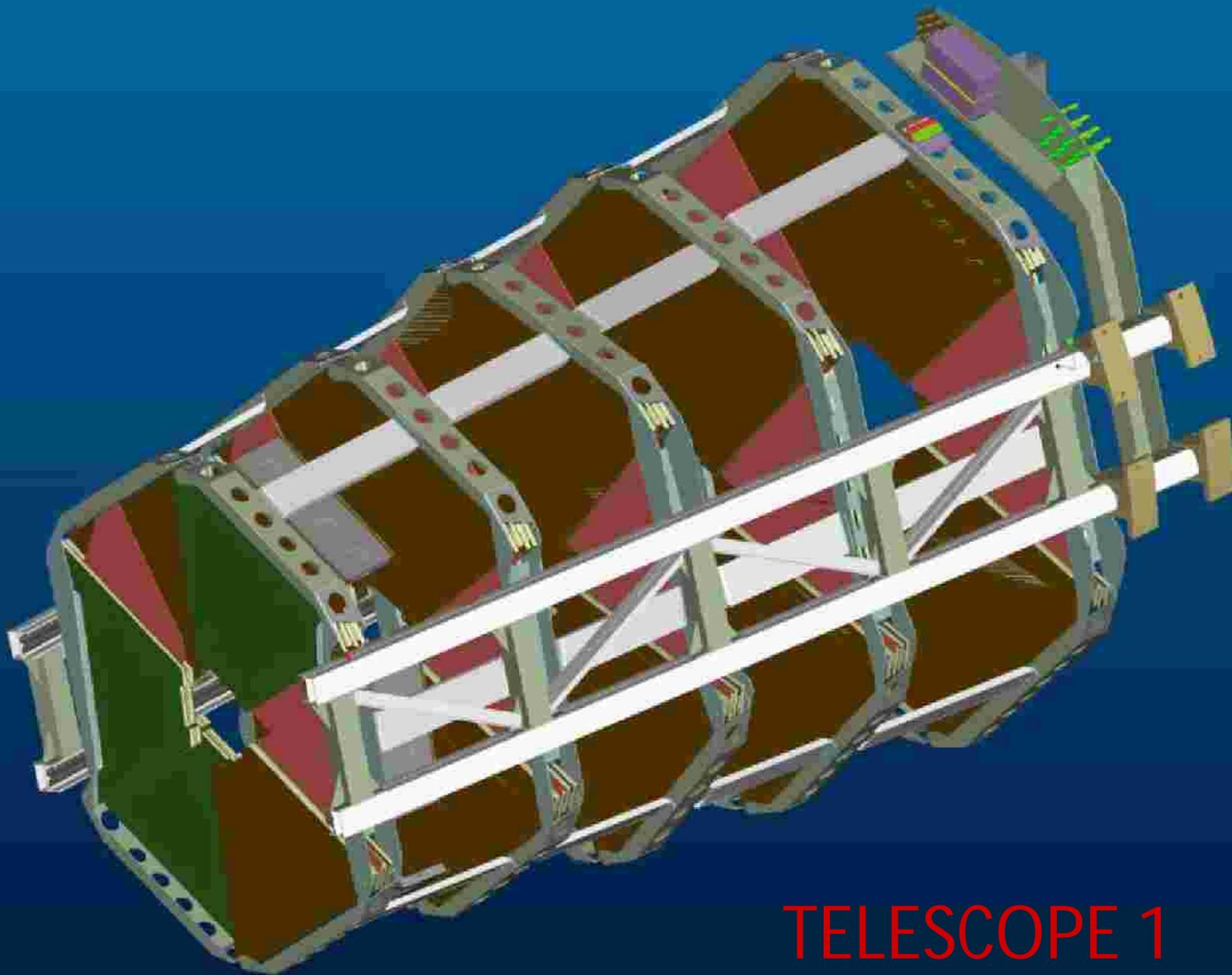


The inelastic forward charged particle detectors



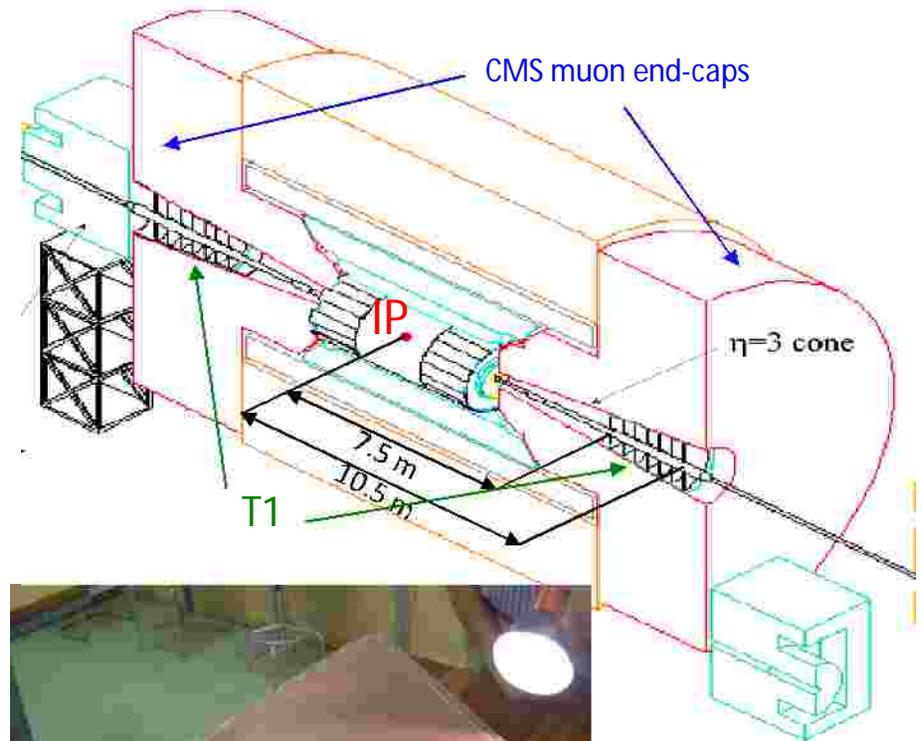
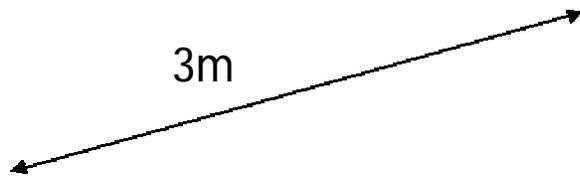
Measurement of the inelastic rates identifying beam-beam events with detectors capable to trigger and reconstruct the interaction vertex

- Cathode Strip chambers (CSC) for T1
- Gas Electron Multiplier chambers (GEM) for T2

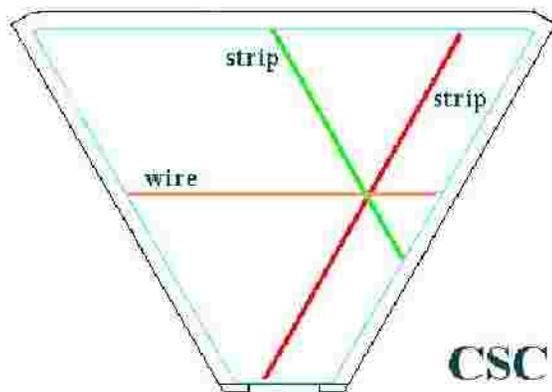


TELESCOPE 1

T1 with Cathode Strip Chambers (CSC)



$$3.1 < |\eta| < 4.7$$



- 5 planes with measurement of 3 coordinates per plane
- 3 deg rotation and overlap between adjacent planes
- Primary vertex reconstruction allows background rejection
- Trigger with anode wires

Production of CSCs



Production at Gatchina (PNPI):
70 CSCs

Test and assembly done
at Genoa and CERN

Acceptance tests:

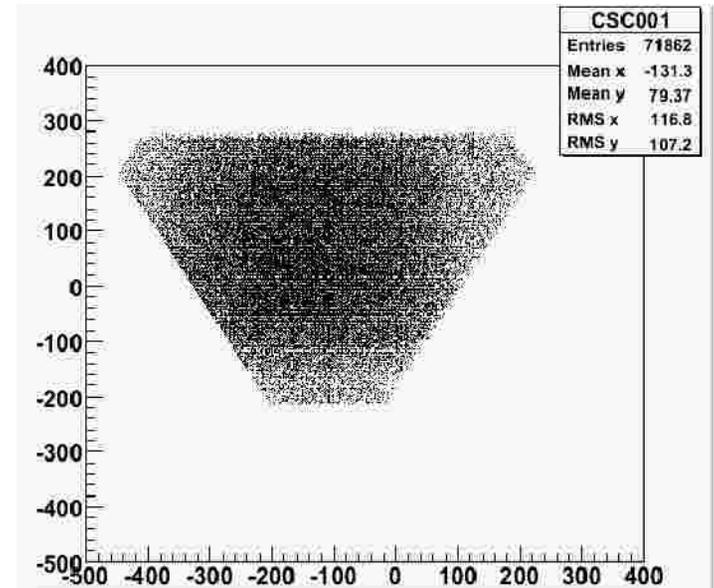
HV, gas tightness and gas
gain uniformity

Ageing studies at the GIF: 12-month test with ~ 0.07 C/cm accumulated charge on wires corresponding to ~ 5 years at $L=10^{30}\text{cm}^{-2}\text{s}^{-1}$

CSC test stand for commissioning with Cosmic Rays in Genoa

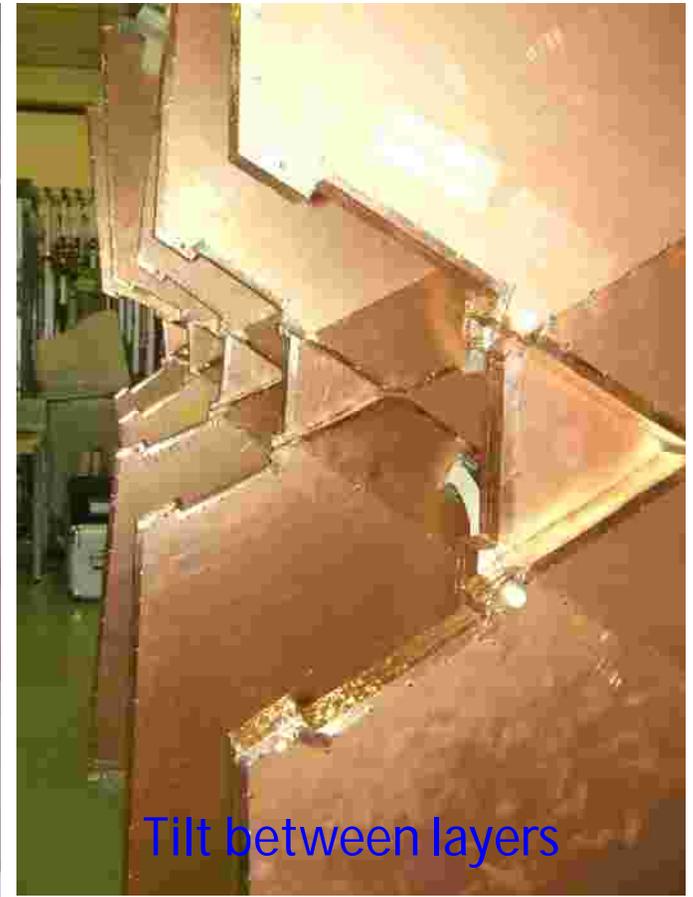


CSCs tested with complete readout chain



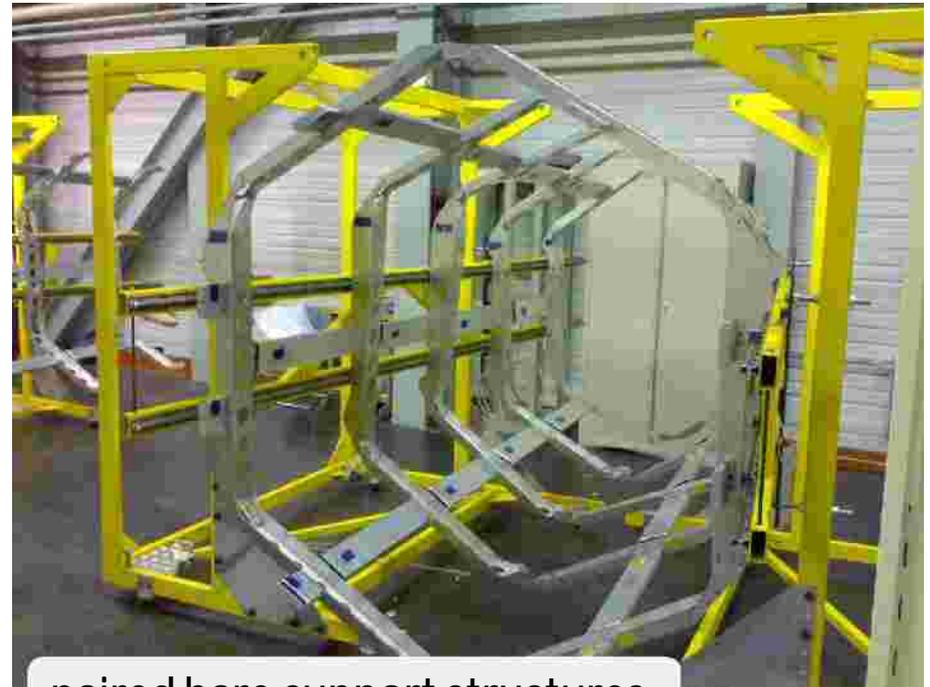
cosmic rays data for testing the complete reconstruction chain written and integrated in the TOTEM off-line framework, based on CMSSW

$\frac{1}{4}$ T1 Telescope complete with CSC chambers

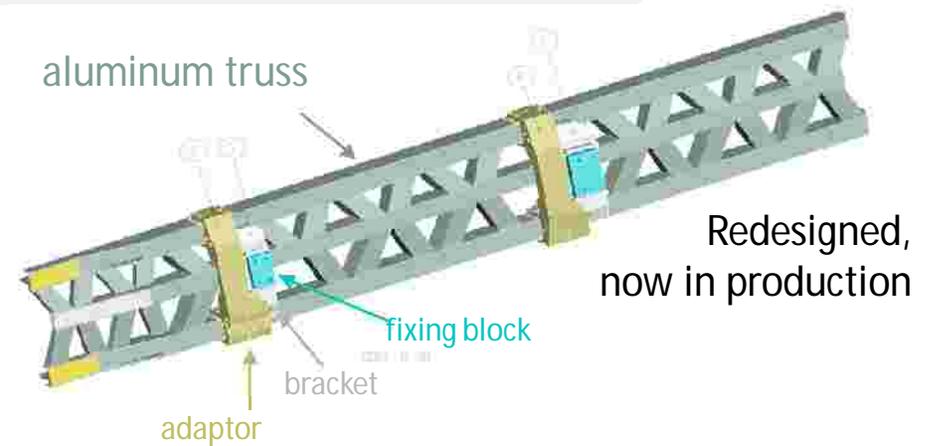


Installation of T1 in CMS

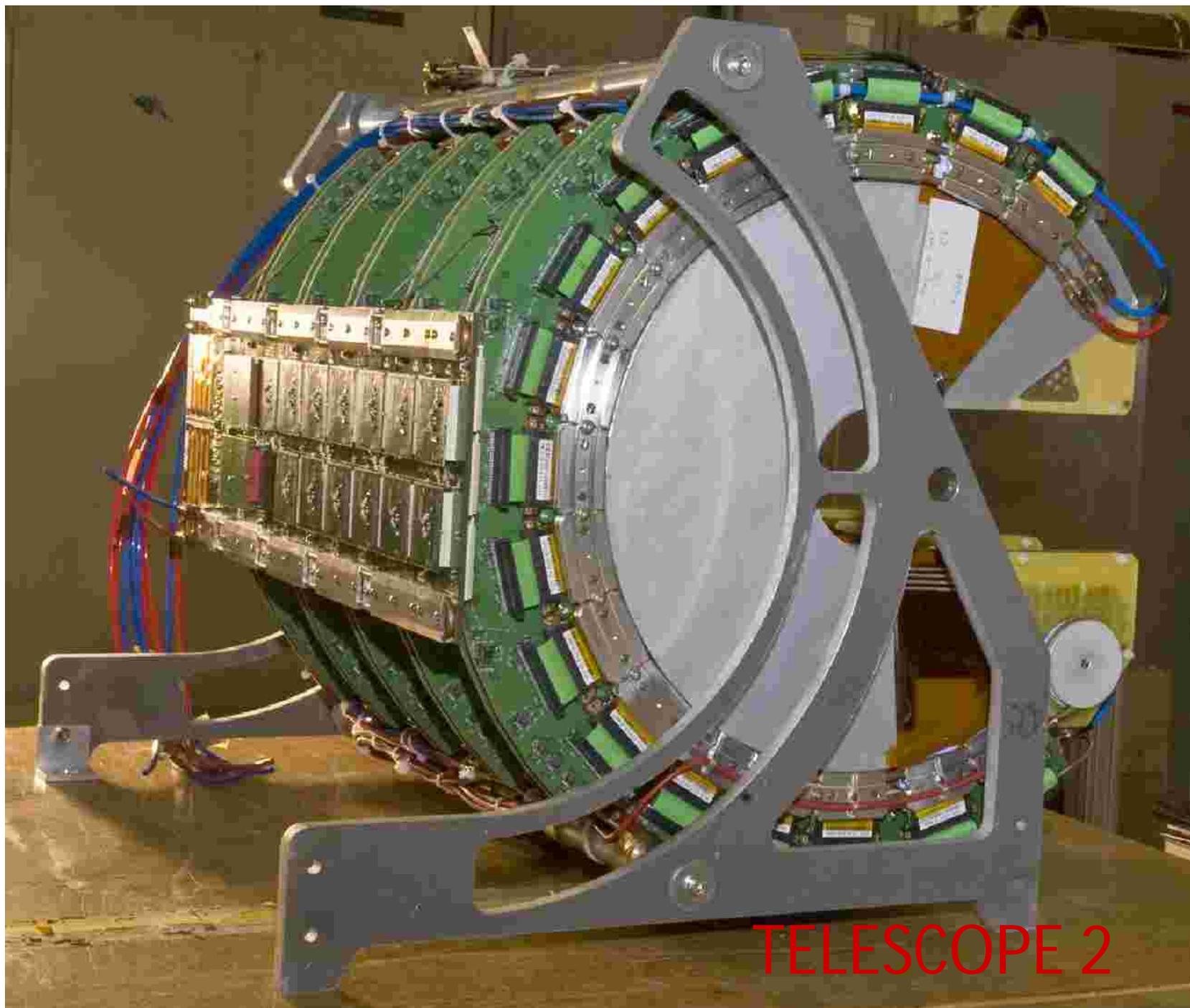
Two trusses with rails will be fixed to the internal walls of CMS return yoke



paired bare support structures



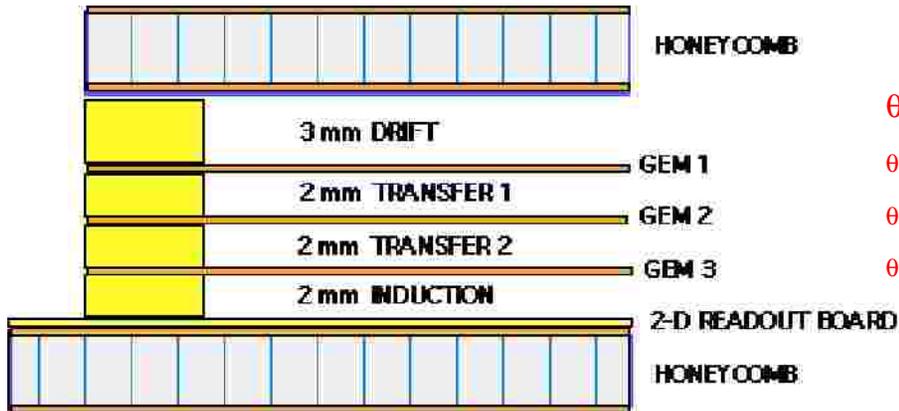
INSTALLATION OF T1 FORESEEN FOR SEPTEMBER, AFTER THE CMS CRAFT



TELESCOPE 2

T2 with Gas Electron Multiplier (GEM)

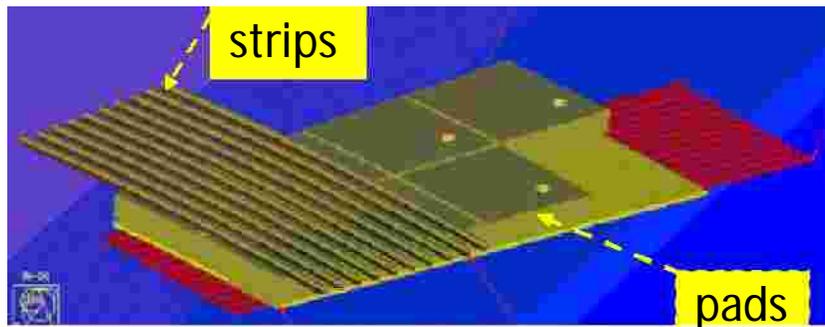
F. Sauli, L. Ropelewski (1997)



- ⊖ Ar/CO₂ 70/30 gas mixture
- ⊖ Operating gas gain $M = 8000$
- ⊖ Digital readout (VFAT)
- ⊖ Triple GEM technology adequate for T2 up to $L=10^{33} \text{ cm}^{-2}\text{s}^{-1}$



Production at Helsinki



Pads: 65(f) x 24(?) = 1560 pads
~2x2 mm² - ~7x7 mm²

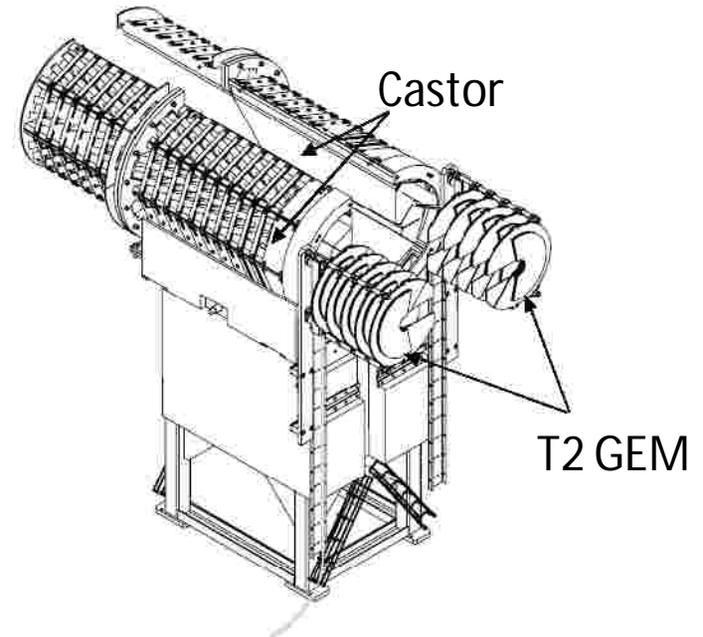
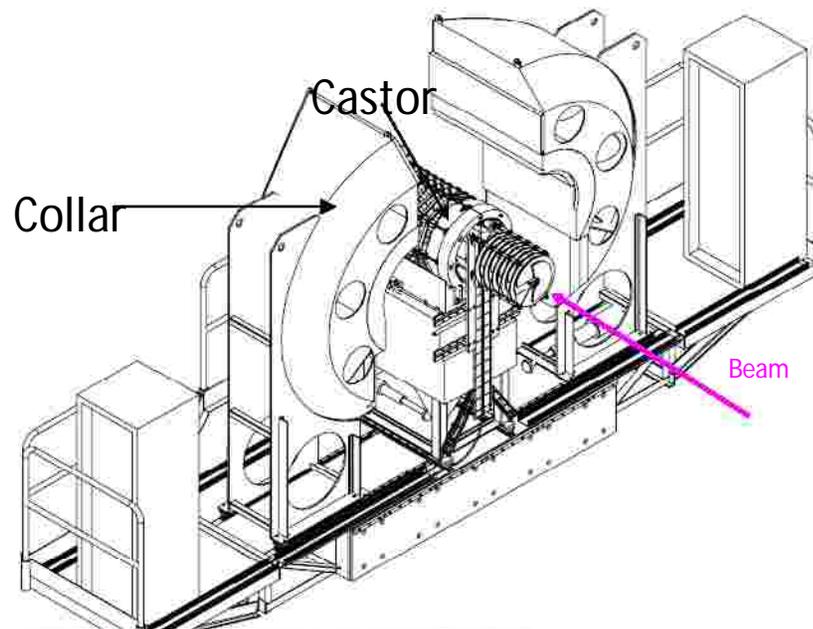
Strips: 256x2 (width 80? m, pitch 400? m)

Acceptance tests: Leakage current, optical scanning,

Final assembly at CERN

es (foils); gas sealing, humidity...

TOTEM T2 integration with CMS



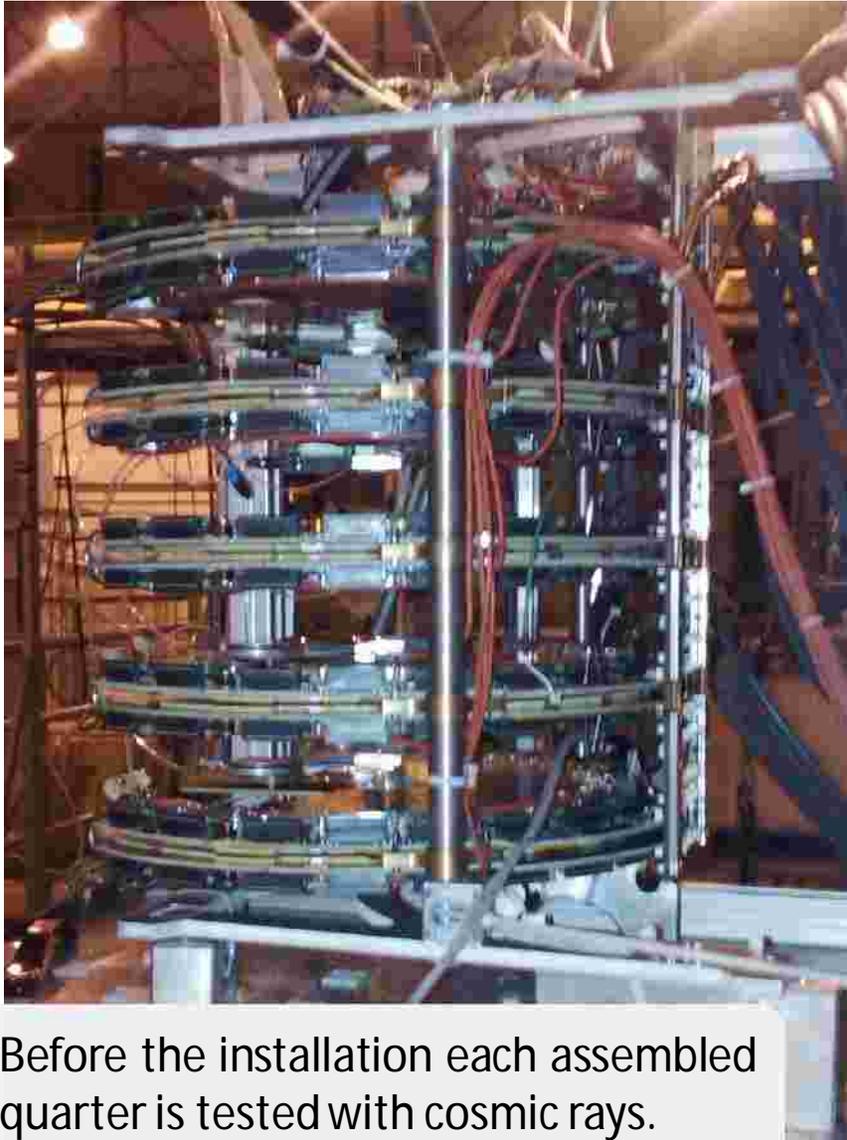
Insertion design together with CMS



10 triple-GEM planes on each side of the IP to cope with high particle fluxes.

$$5.3 < |\eta| < 6.6$$

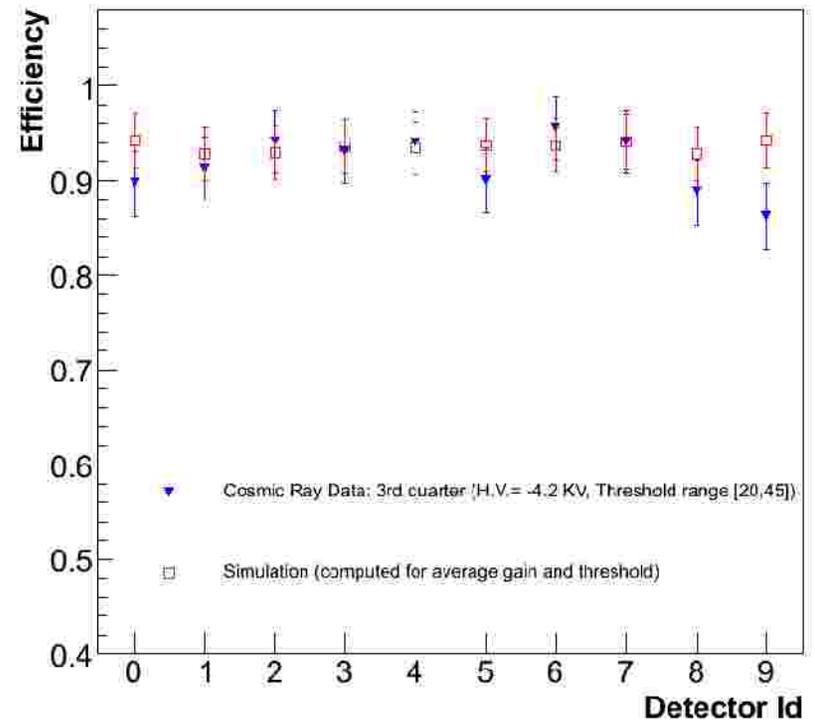
Commissioning with cosmic rays



Before the installation each assembled quarter is tested with cosmic rays.

In these tests we used the readout chain, the HV and the LV supplies foreseen for the final system in IP5.

Detector Intrinsic Efficiency



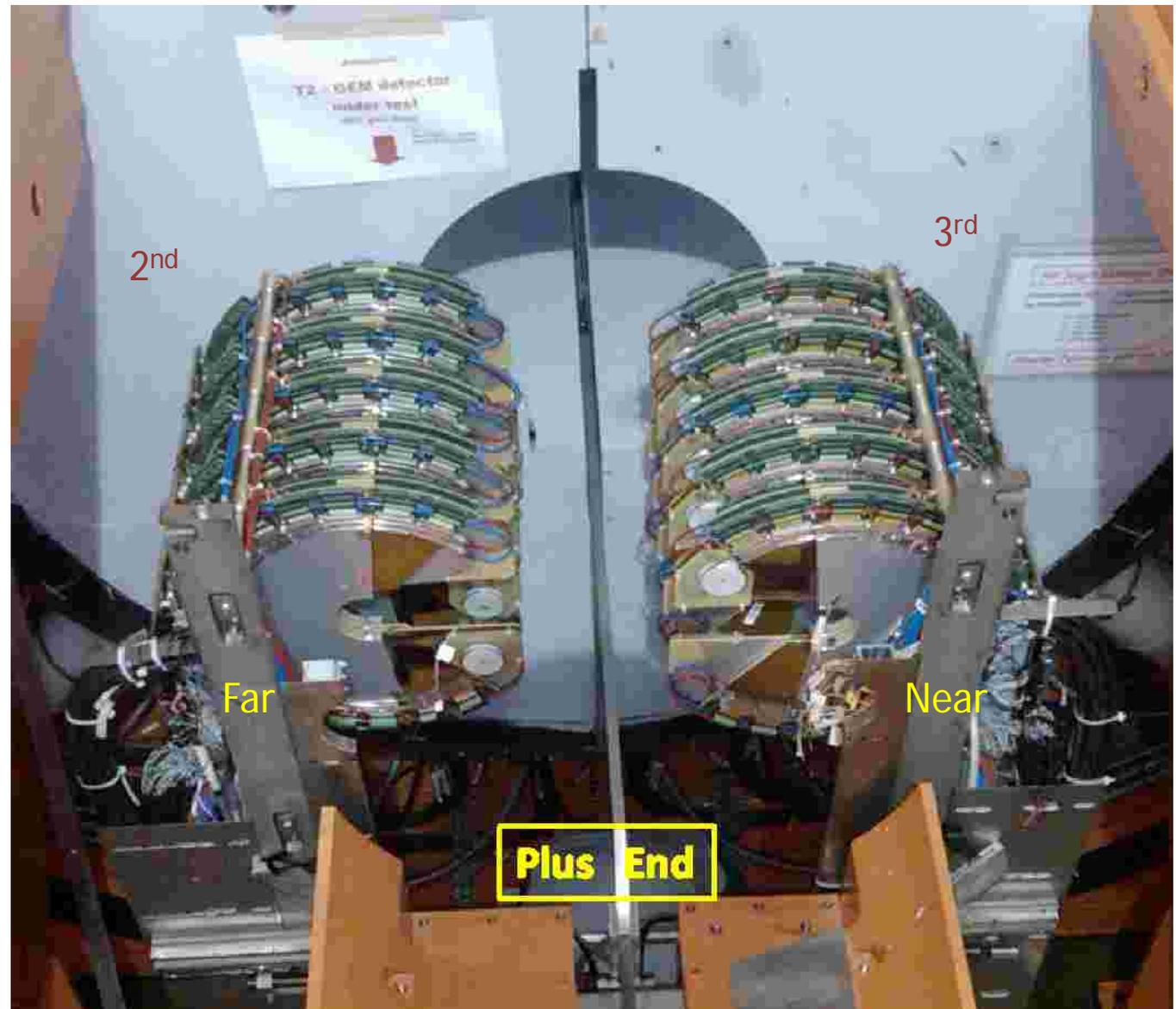
Installation of T2 in CMS

1st quarter ◊
Installed in the
minus far side

2nd quarter ◊
Installed in the
plus far side

3rd quarter ◊
Installed in the
plus near side

4th quarter ◊
Will be installed in
the next days

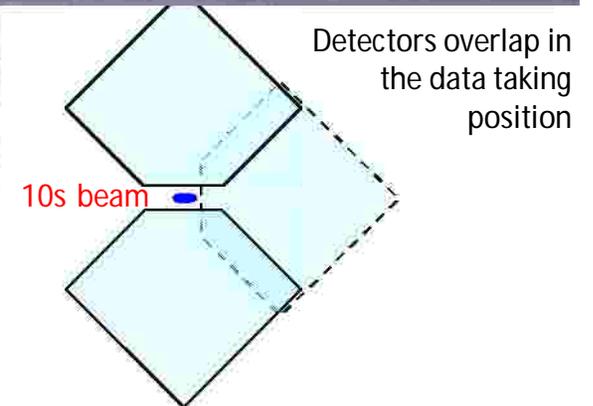


The Roman Pots with Silicon Detectors

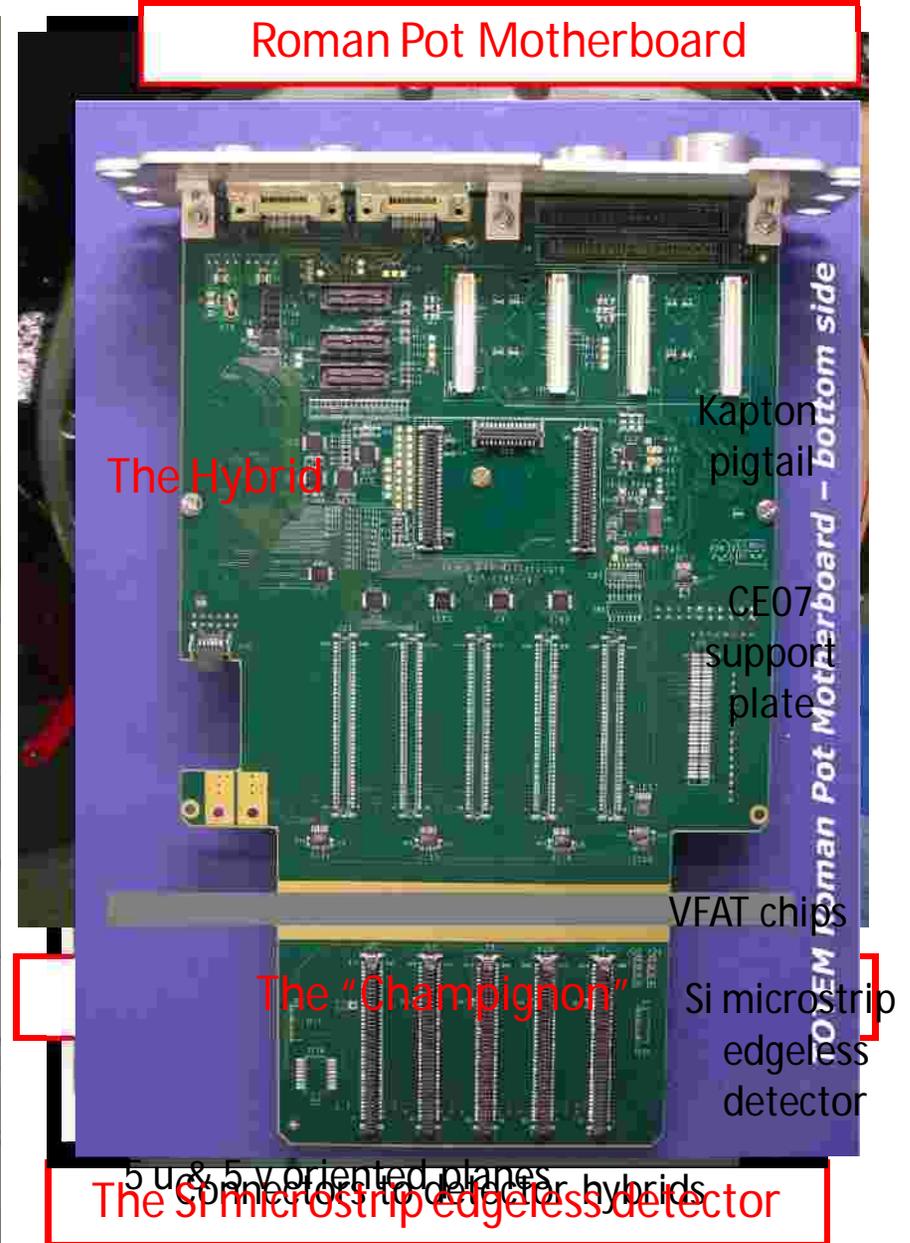
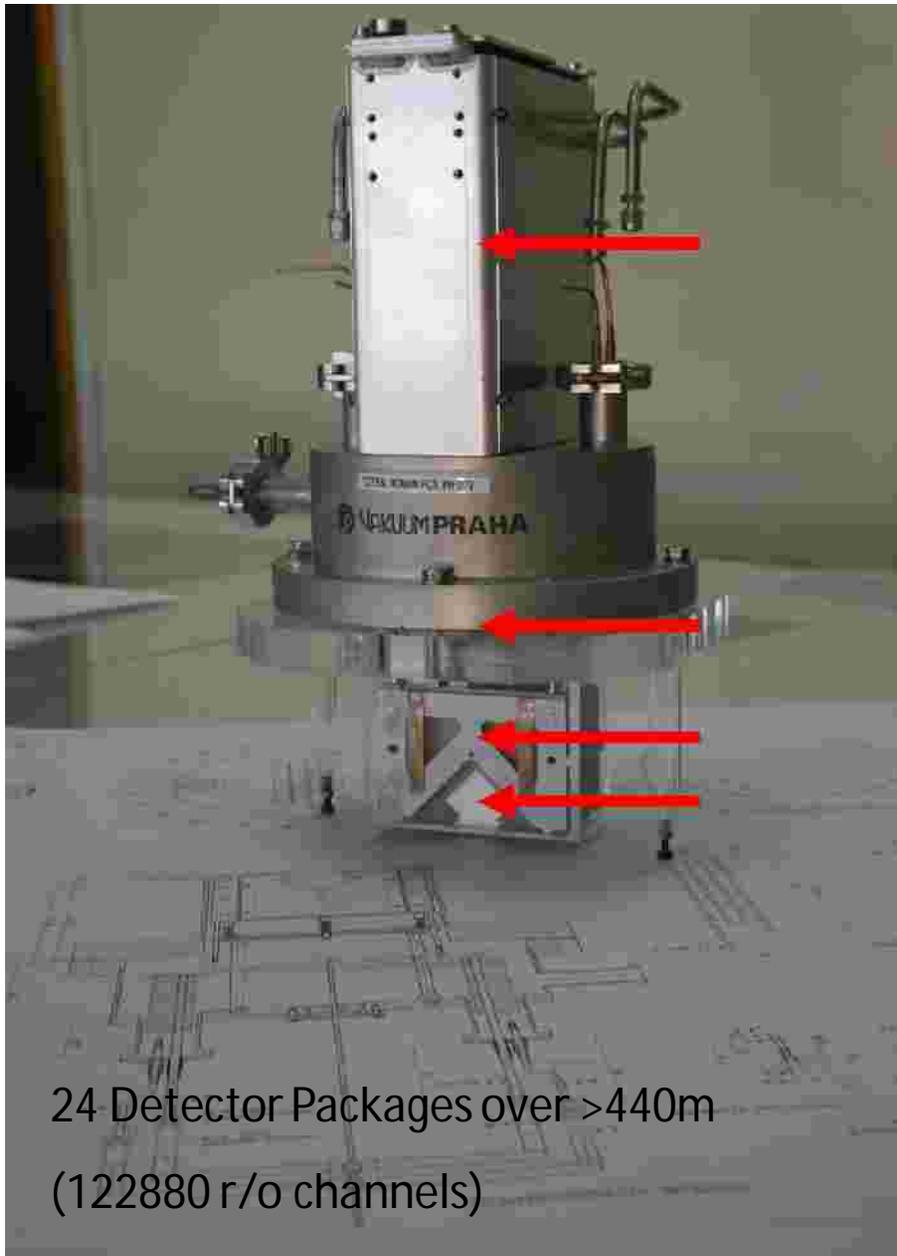


Maximize acceptance at low $|t|$:

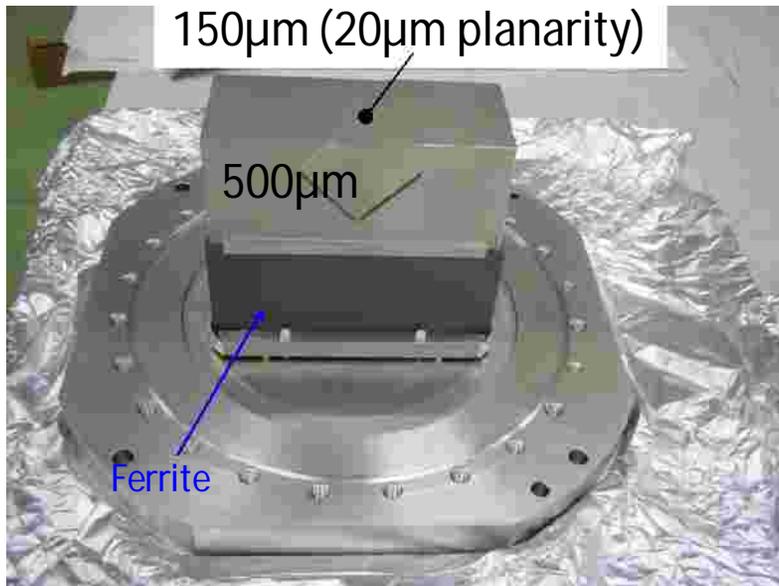
- edgeless Si-detectors
- minimized space between detector edge and window
- minimized window thickness



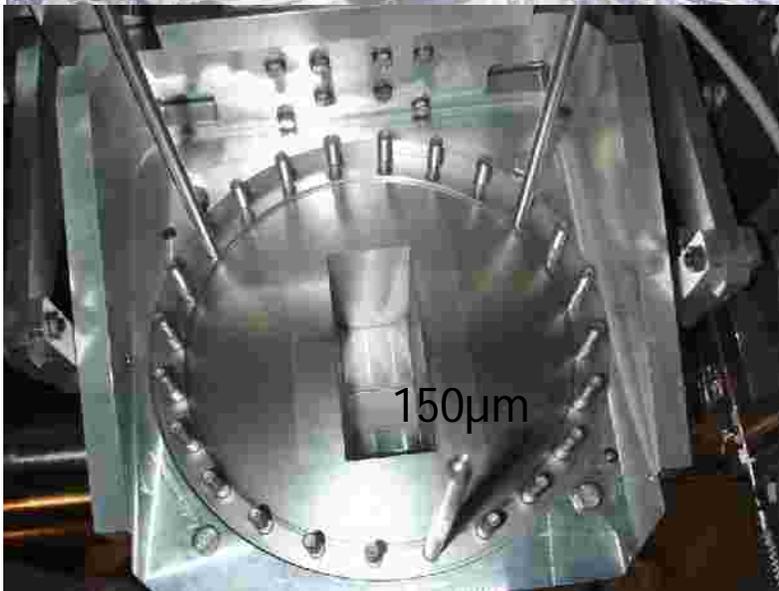
The Detector Package (DP)



The Pot



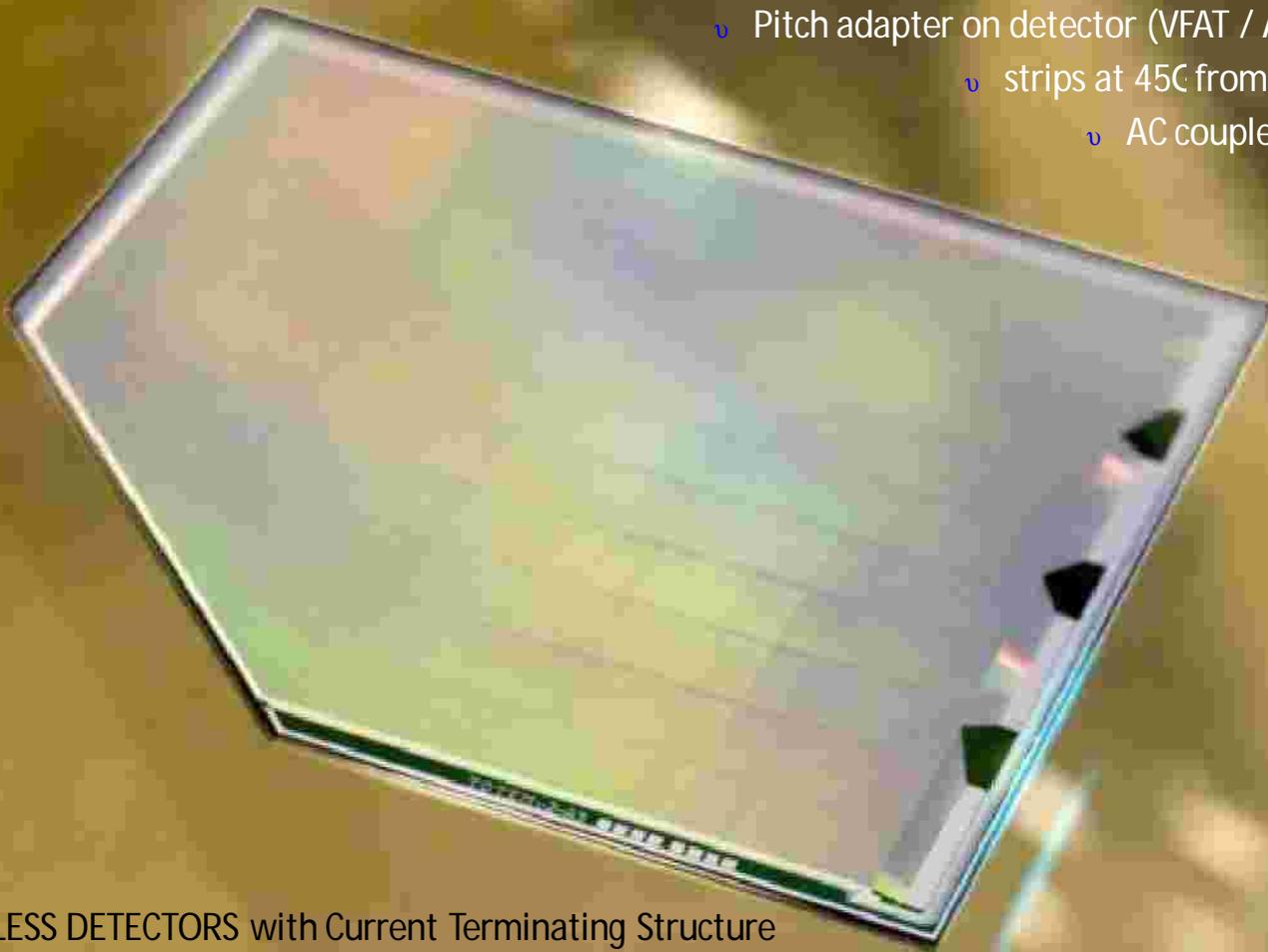
Separates the high vacuum of the machine from the detector's vacuums.



When the RP is in the Data taking position will approach the 10s of the beam .

The Edgeless Silicon Detector (I)

- Very High Resistivity Si n-type <111>, 300um thick, $V_{dep}=20V$
- Standard planar technology fabrication / dicing with diamond saw
 - Single sided detector, 512 microstrips (pitch 66um)
 - Pitch adapter on detector (VFAT / APV25 compatible)
 - strips at 45C from the sensitive edge
 - AC coupled (punch-through)

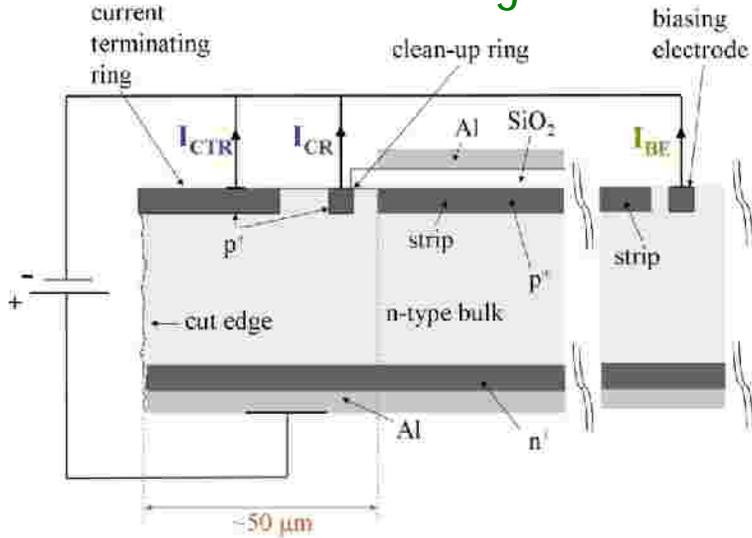


EDGELESS DETECTORS with Current Terminating Structure

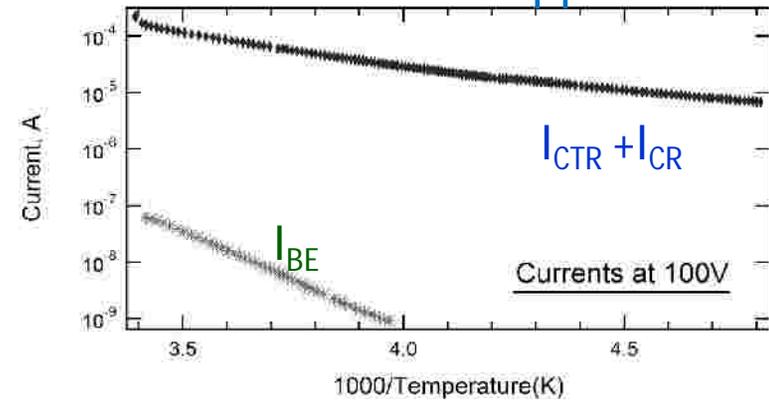
G. Ruggiero, V. Eremin et al. ([CERN/PH-TOT](#), [Ioffe PTI- St. Petersburg](#), [RIMST- Zelenograd](#))

The Edgeless Silicon Detector (II)

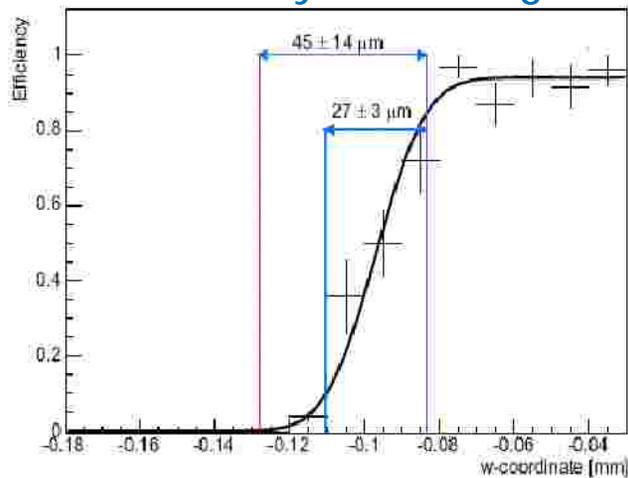
Current Terminating Structure



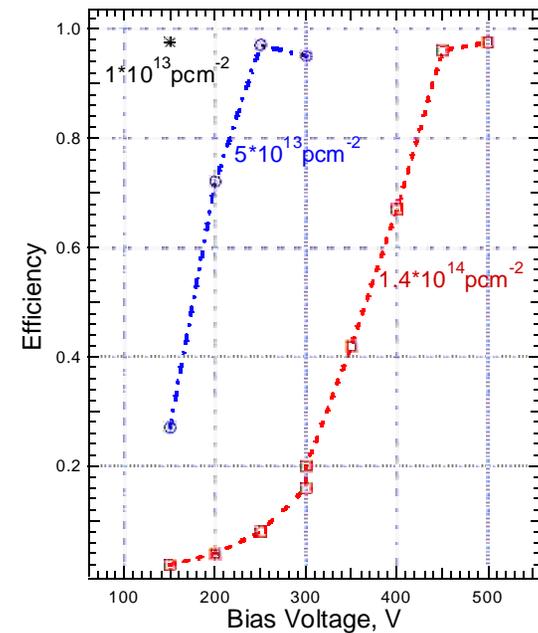
Surface Current Suppression



Efficiency at the edge



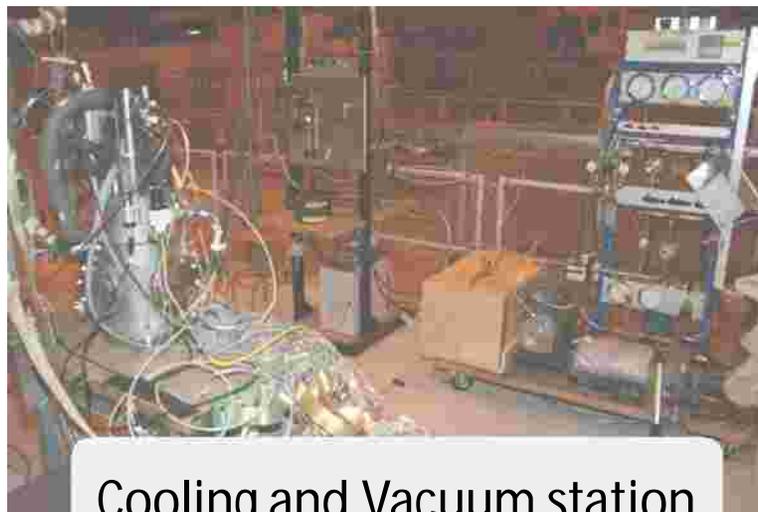
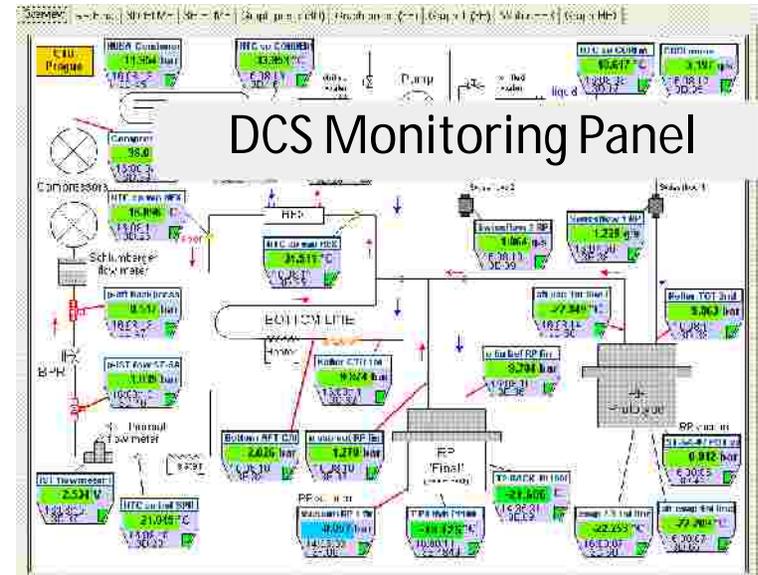
Radiation Hardness



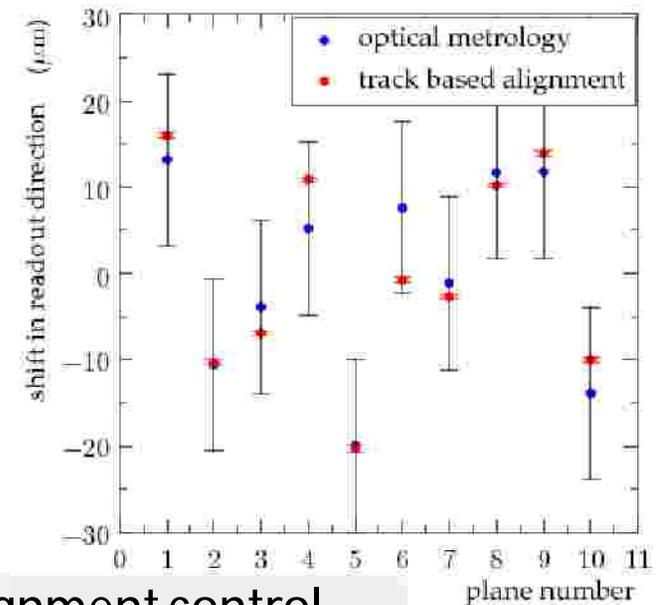
Commissioning of the DPs with beams in H8



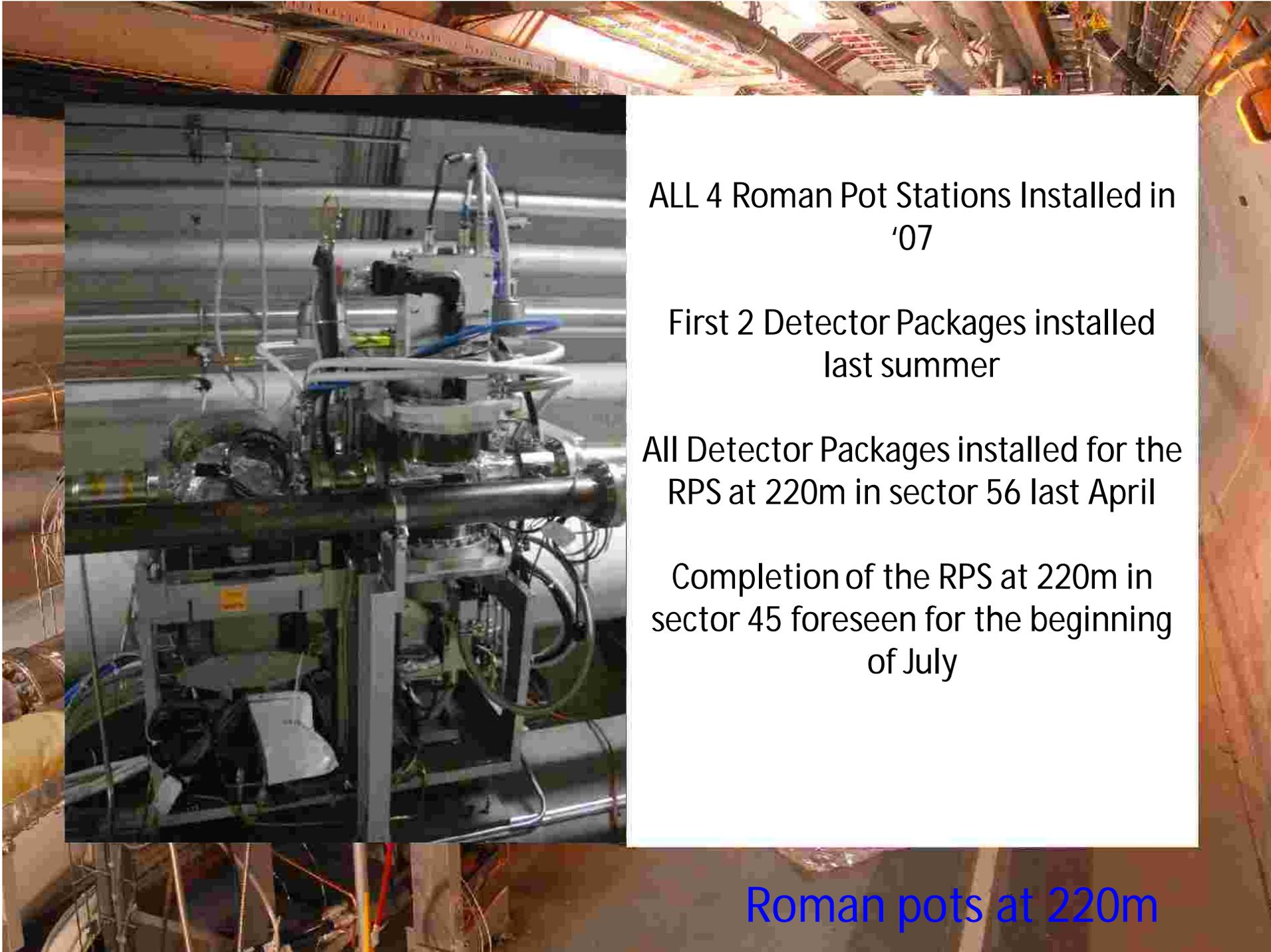
Commissioning setup in H8



Cooling and Vacuum station



Alignment control



ALL 4 Roman Pot Stations Installed in
'07

First 2 Detector Packages installed
last summer

All Detector Packages installed for the
RPS at 220m in sector 56 last April

Completion of the RPS at 220m in
sector 45 foreseen for the beginning
of July

Roman pots at 220m

System Tests in the Tunnels

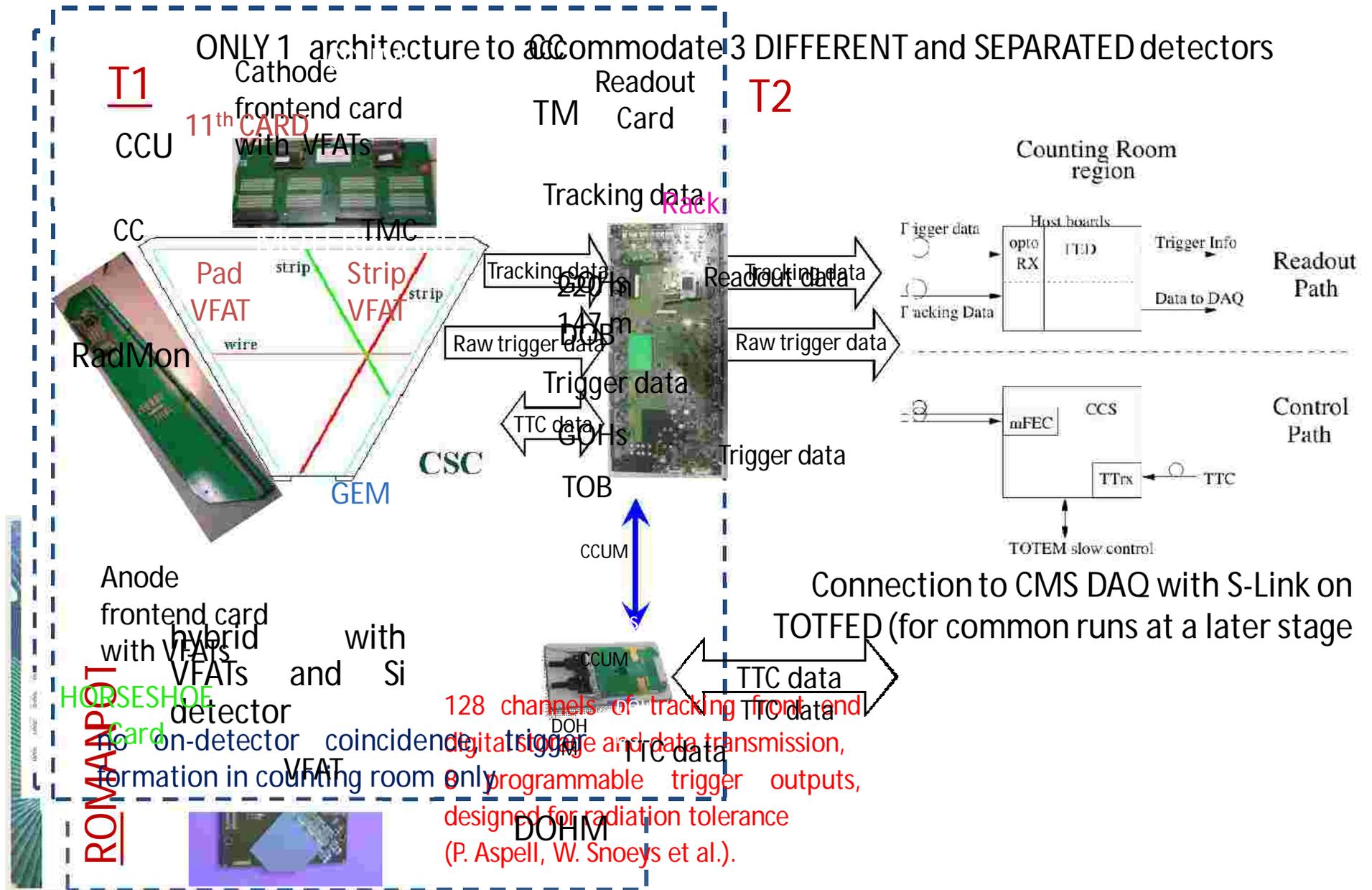
Staging strategy for 2008: 2 Detector Packages on both sides of IP5



Mini-DCS and DAQ serving the first two pots

- Cooling commissioning
- Control and r/o tests
- Radmon and all environmental sensors monitored from September to November 2008

The TOTEM Readout Electronics



SUMMARY

(TOTEM coarse History)

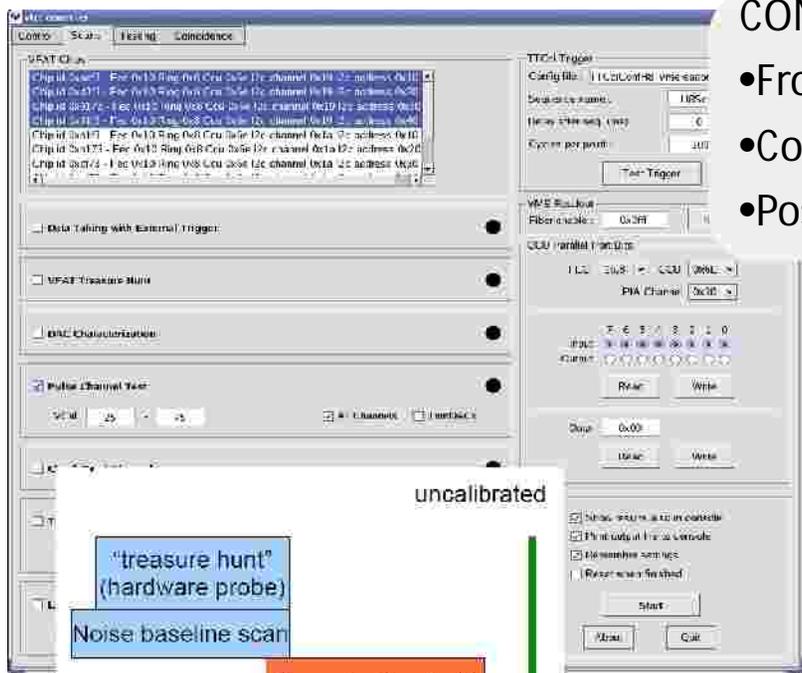
2009: Complete the
On/Near Detectors Cards
Prototyping to installations to be ready for
production of the restart of LHC :
sensors T2 now...
Proof of Concept for
the 3 Sensor RPs at 220m in early July
T1 in September



Technical Design
VFAT (design to
Report production) installations (RP and T2)
2007>2008

2005>2007
.... 2004

Commissioning of the 3 TOTEM Detectors

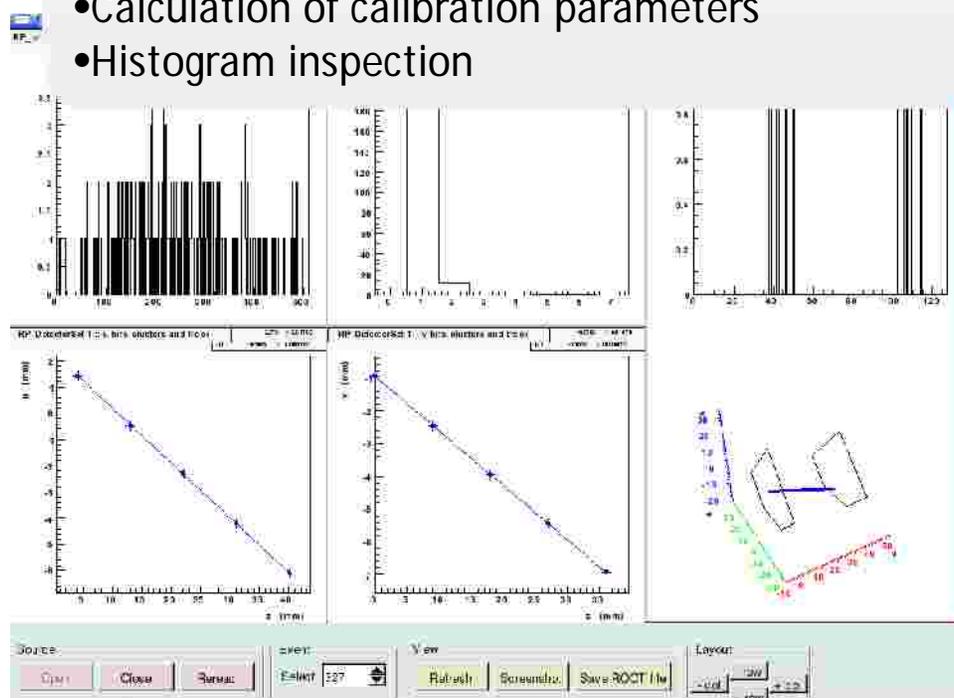


CONTROL PANEL (configuration and readout)

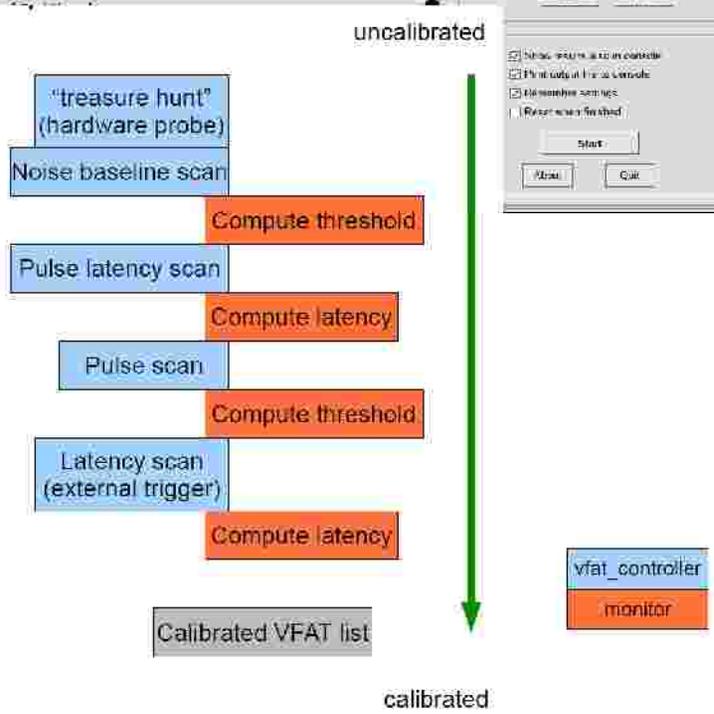
- Front-end probe and mapping
- Configure and run the system for detector calibration
- Possibility of running with external trigger

DATA QUALITY MONITORING

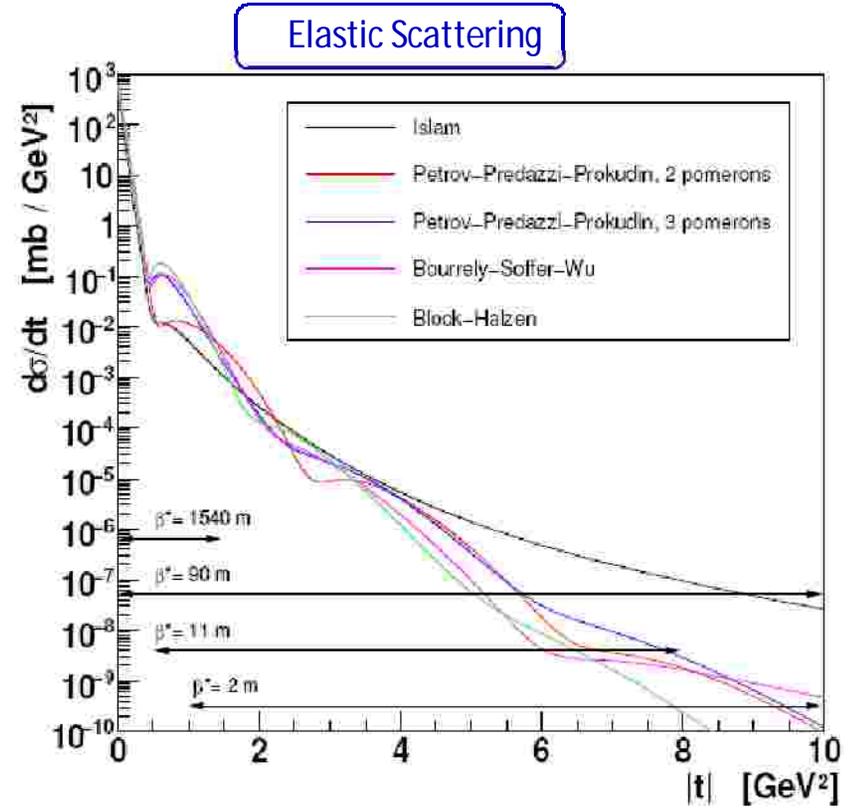
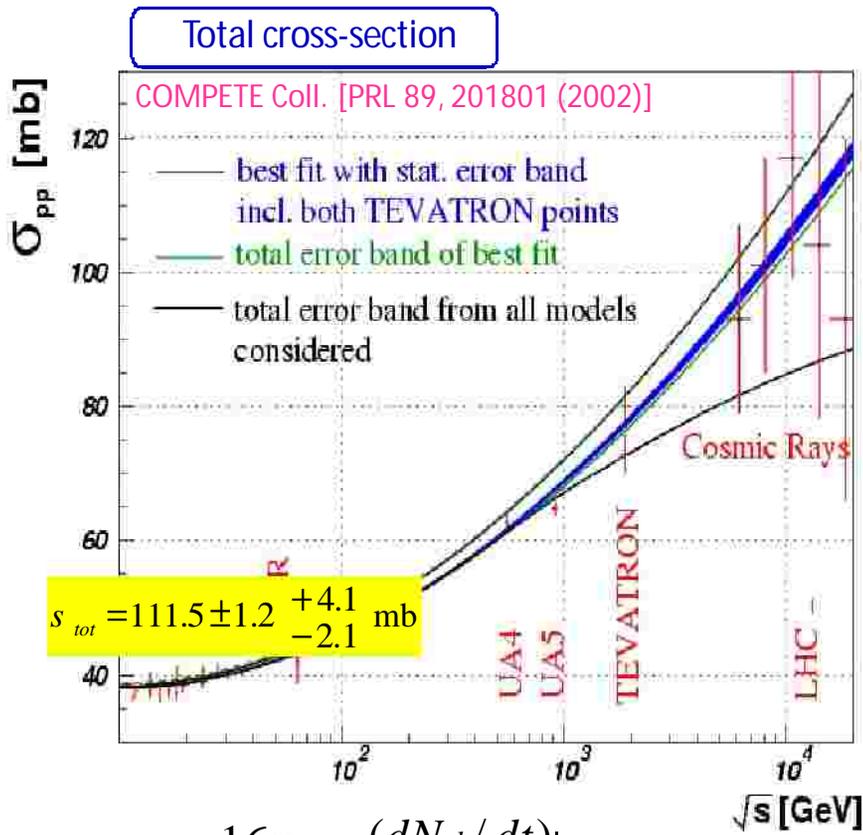
- Data consistency check
- Calculation of calibration parameters
- Histogram inspection



Monitor snapshot- Cosmic run in H8



TOTEM will focus on:



$$s_T = \frac{16p}{1+r^2} \times \frac{(dN_{el}/dt)|_{t=0}}{N_{el} + N_{inel}}$$

Accuracy 1% with $\beta^* = 1540 \text{ m}$ final
 5% with $\beta^* = 90 \text{ m}$ early

But also Diffraction, soft and hard, forward physics...

Common physics program with CMS at a later stage