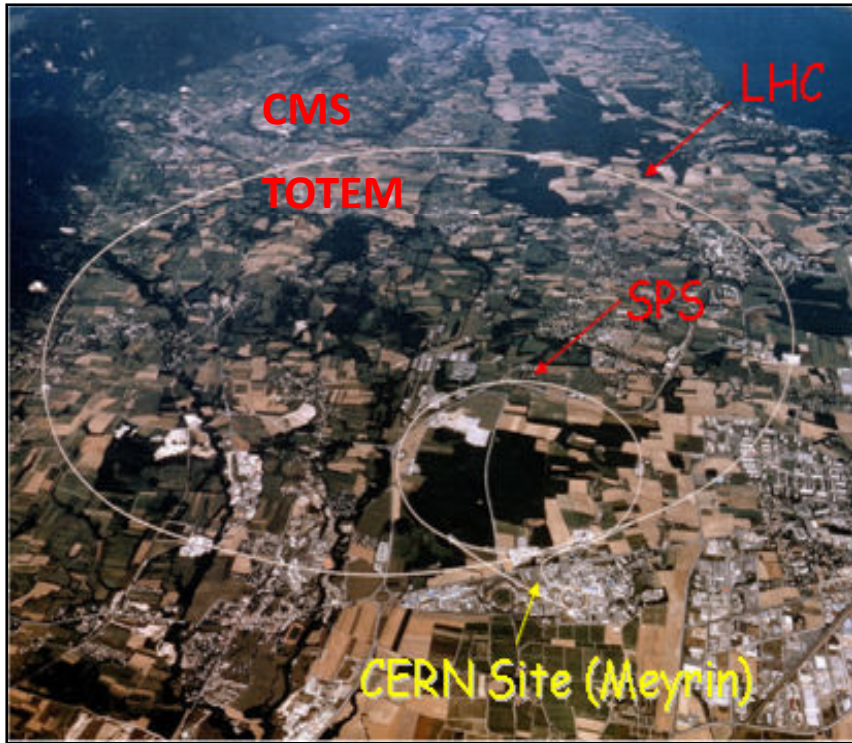


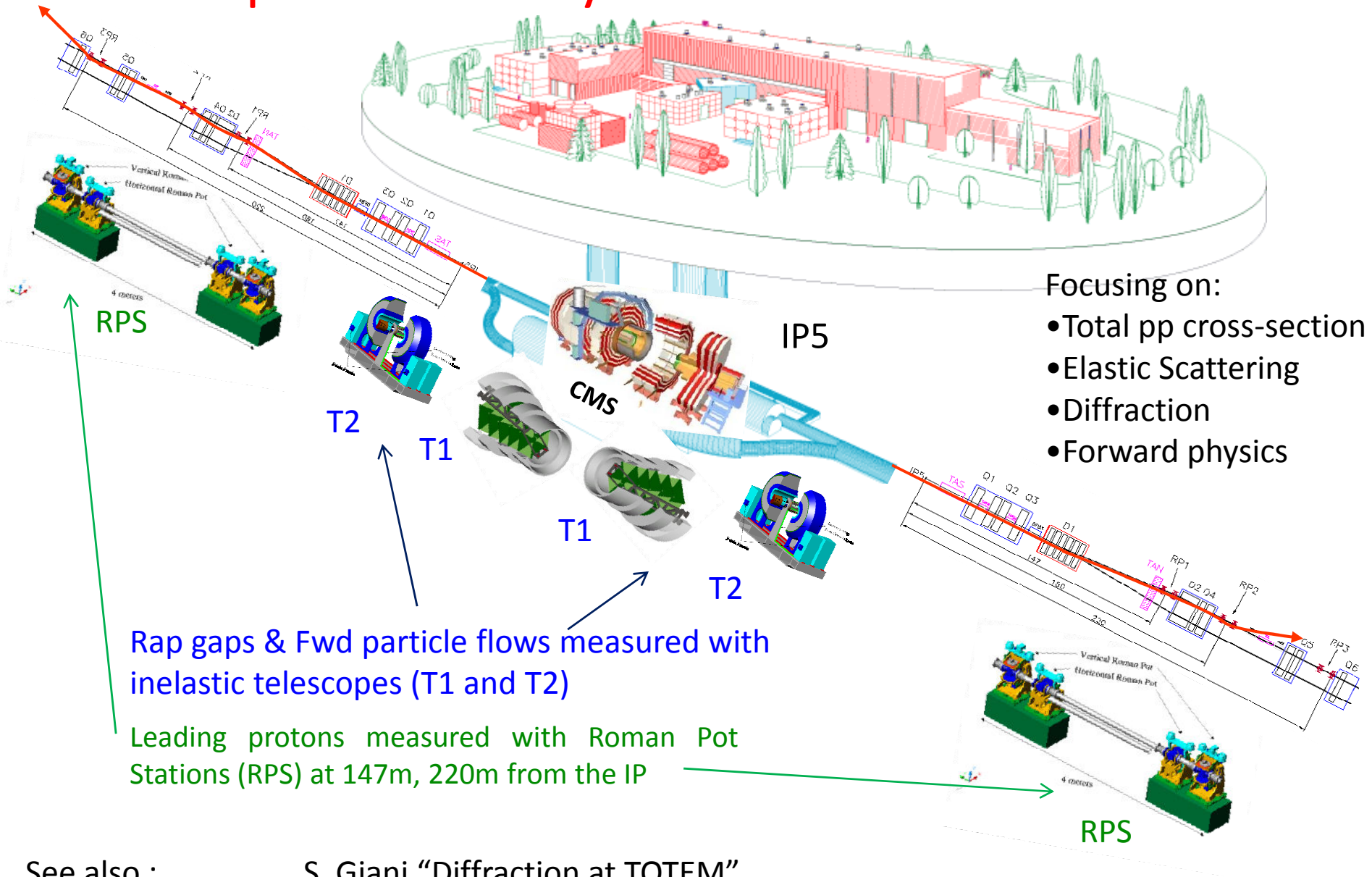
# The TOTEM Detector at LHC



Gennaro Ruggiero/CERN-PH  
on behalf of the  
TOTEM Collaboration

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

# Experimental layout of the TOTEM Detector

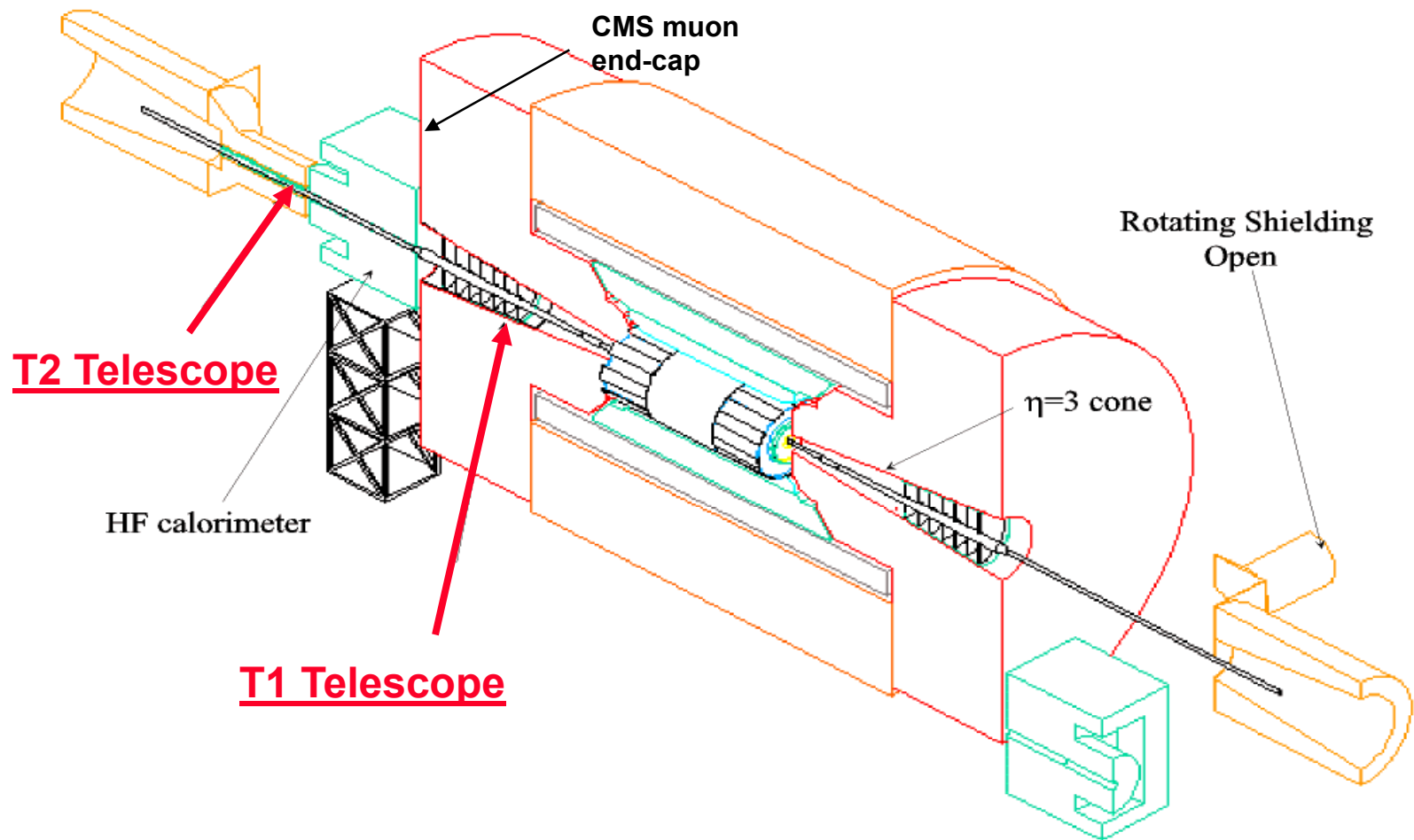


See also :

S. Giani "Diffraction at TOTEM"

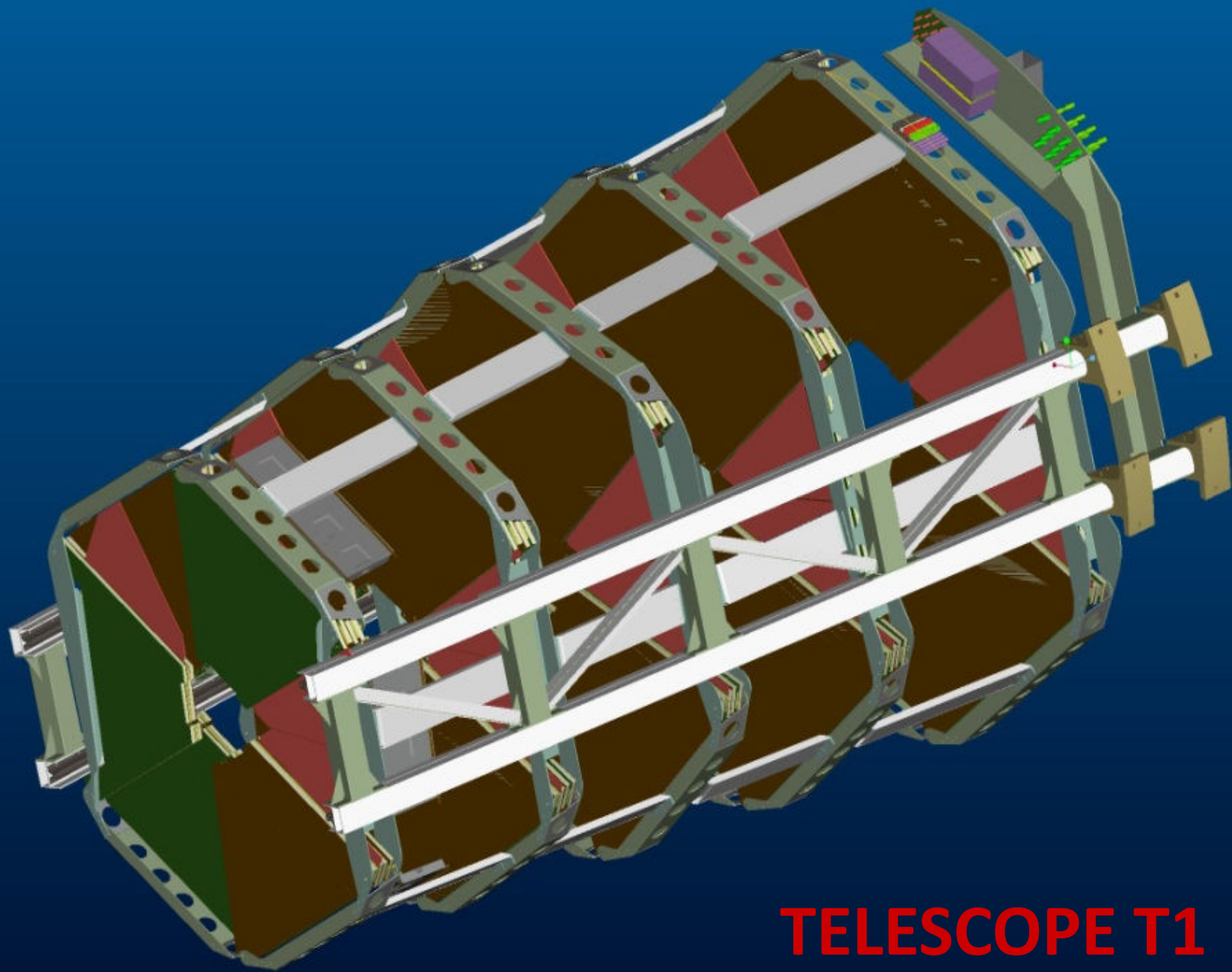
J. Kaspar "TOTEM Experiment: Elastic and Total Cross Sections"

# The inelastic forward charged particle detectors



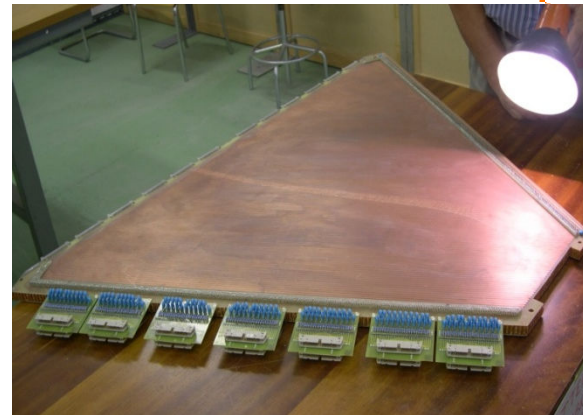
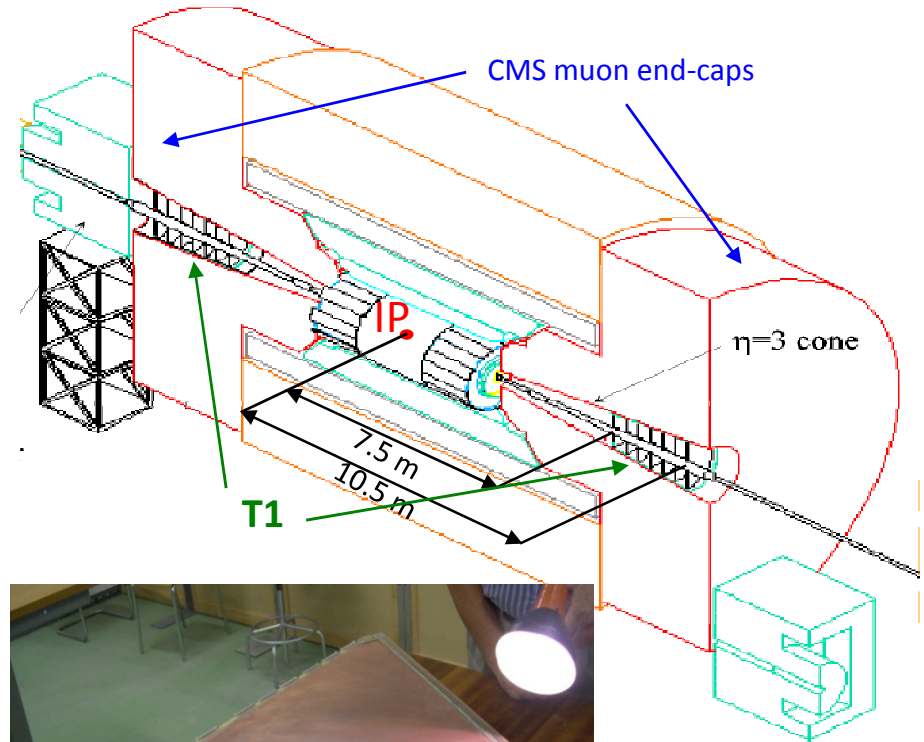
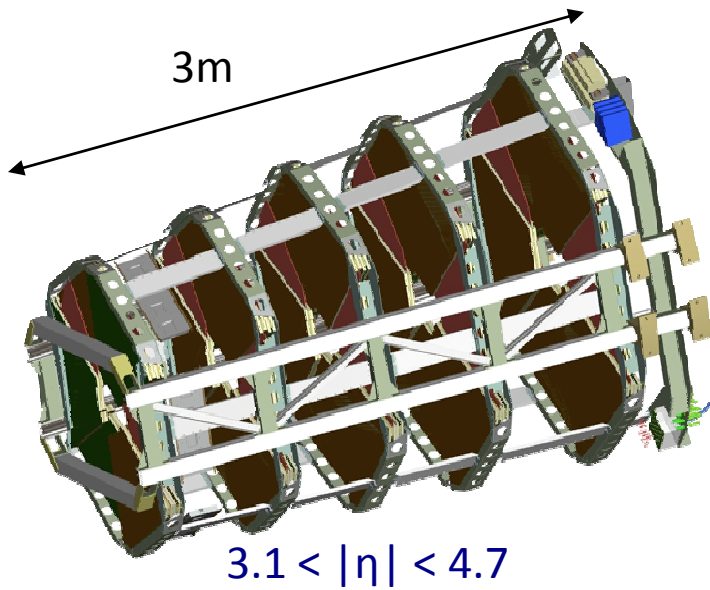
Measurement of the inelastic rates identifying beam-beam events with detectors capable to trigger and reconstruct the interaction vertex

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

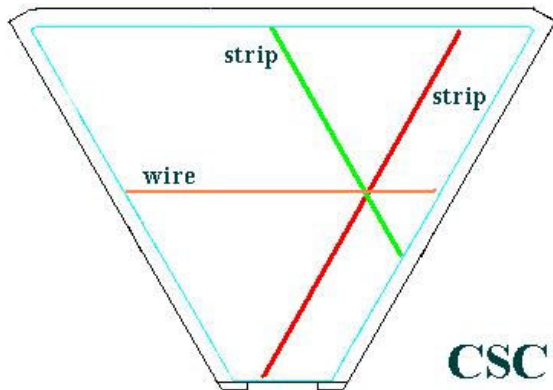


**TELESCOPE T1**

# T1 with Cathode Strip Chambers (CSC)



- 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**

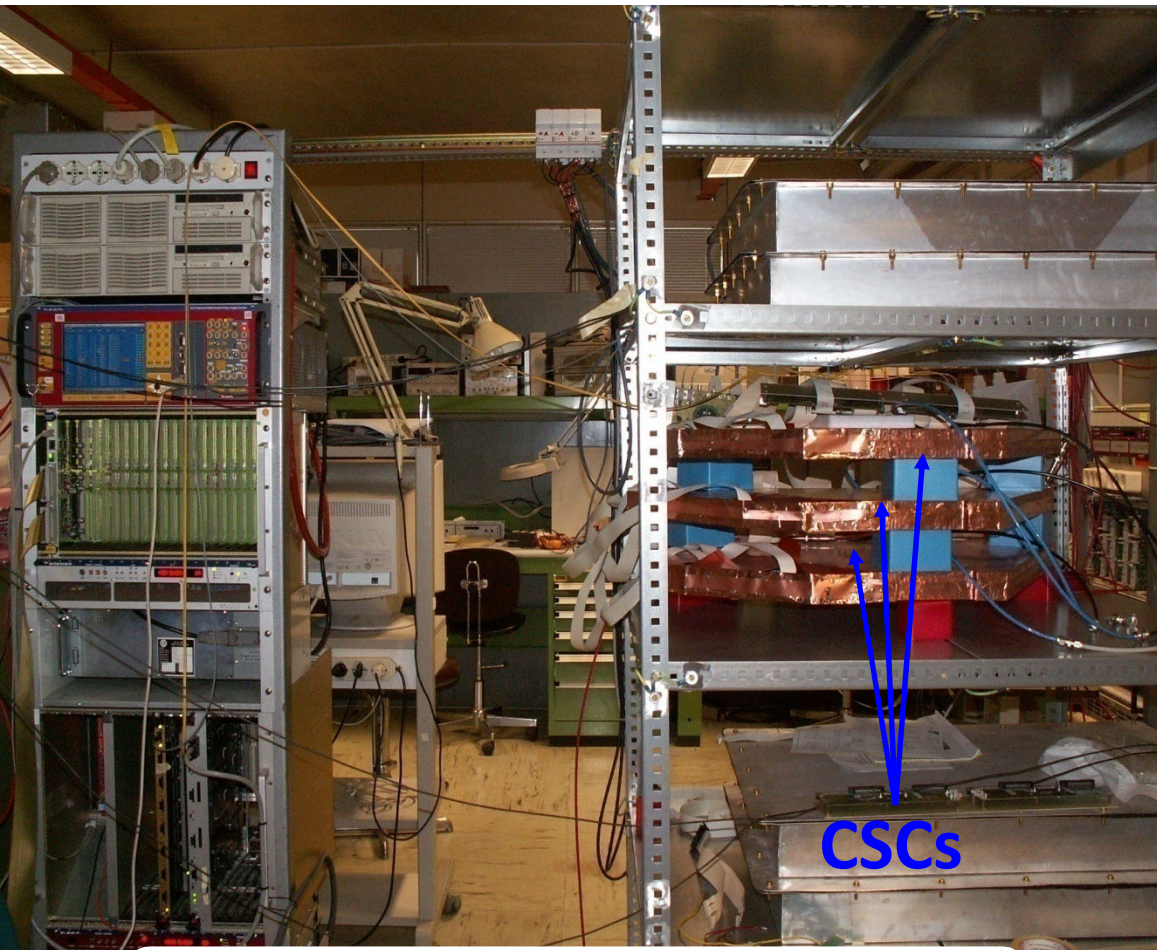
**Test and assembly done  
at Genoa and CERN**

**Acceptance tests:**

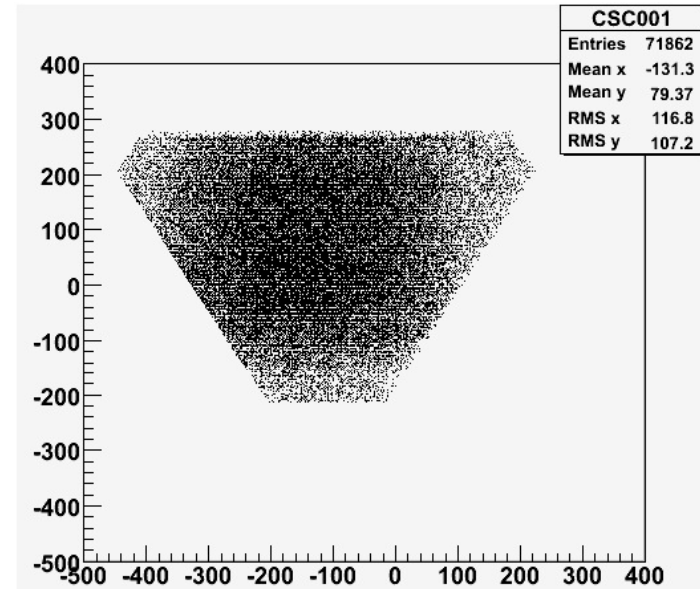
**HV, gas tightness and gas  
gain uniformity**

**Ageing studies at the GIF: 12-month test with  $\sim 0.07$  C/cm accumulated charge on  
wires corresponding to  $\sim 5$  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

# ¼ T1 Telescope complete with CSC chambers



15 CSCs mounted 3 by 3

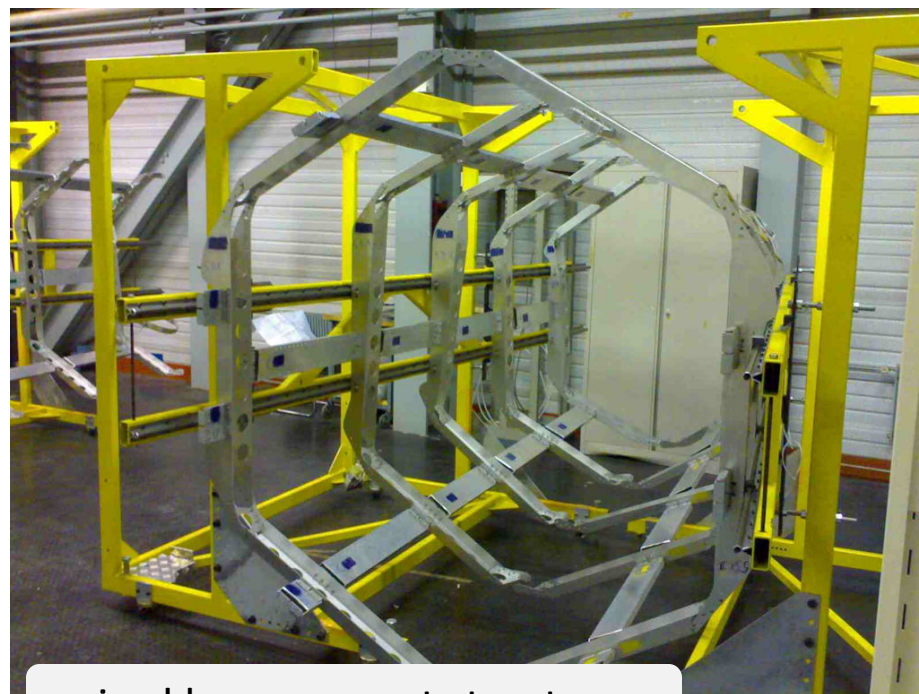
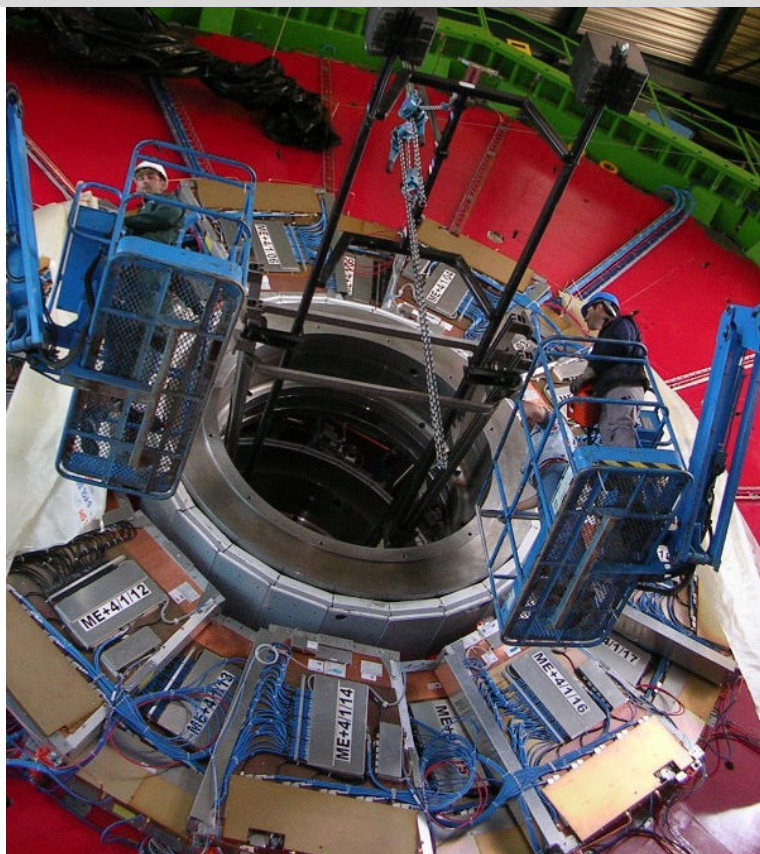


Tilt between layers

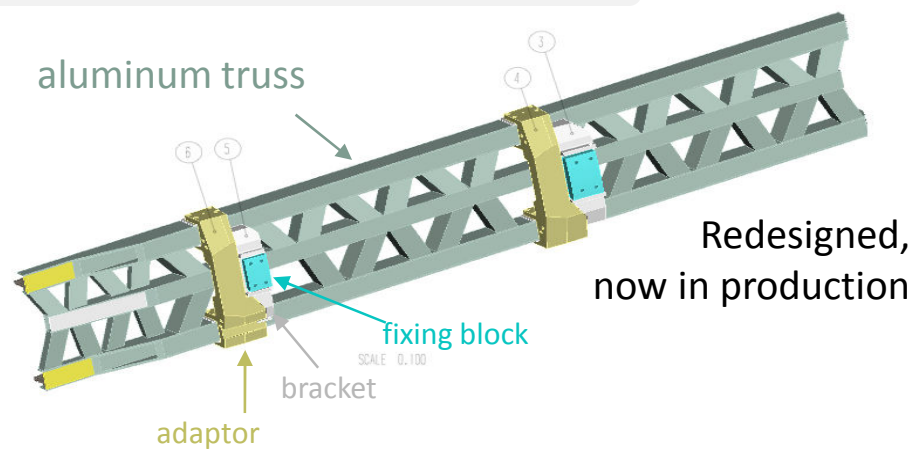


# Installation of T1 in CMS

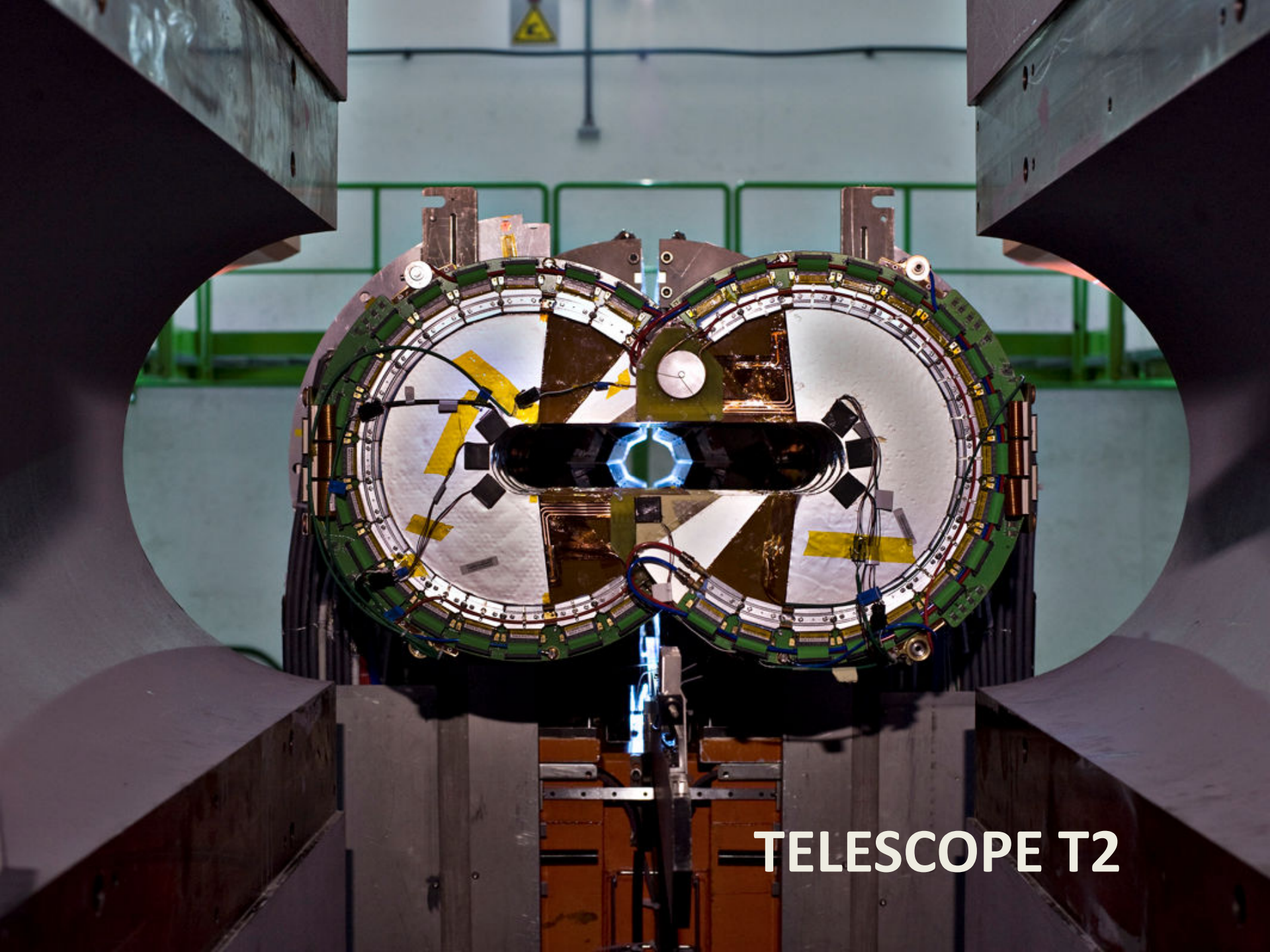
Two trusses with rails will be fixed to the internal walls of CMS return yoke



paired bare support structures



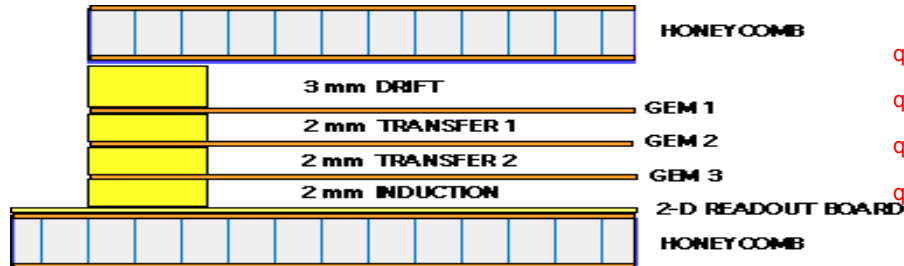
INSTALLATION OF T1 FORESEEN FOR SEPTEMBER, AFTER THE CMS CRAFT



**TELESCOPE T2**

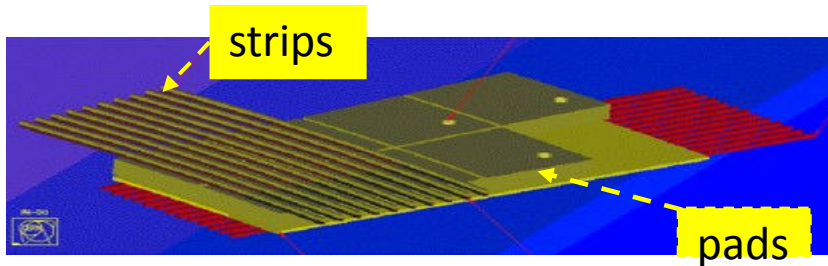
# T2 with Gas Electron Multiplier (GEM)

F. Sauli, L. Ropelewski (1997)



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

charge amplification struct. and charge collection / readout struct. geometrically decoupled.

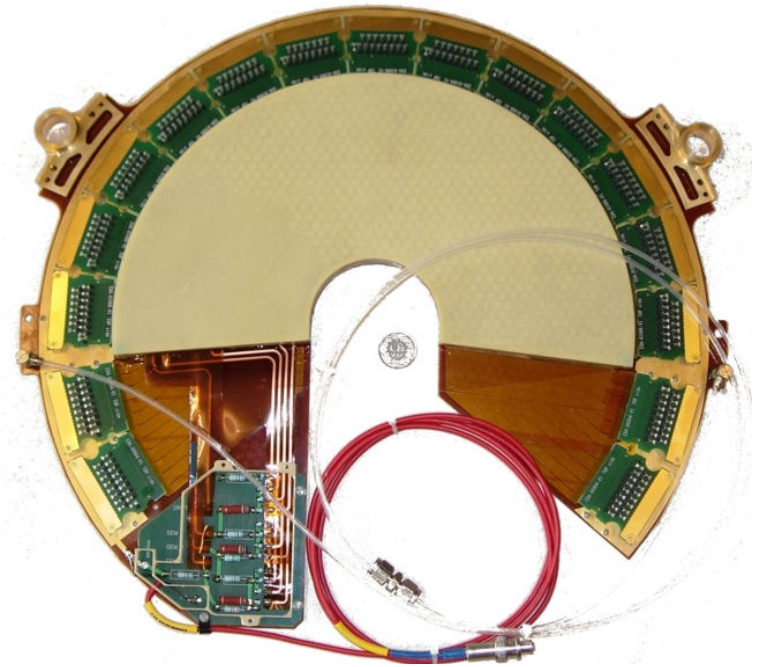


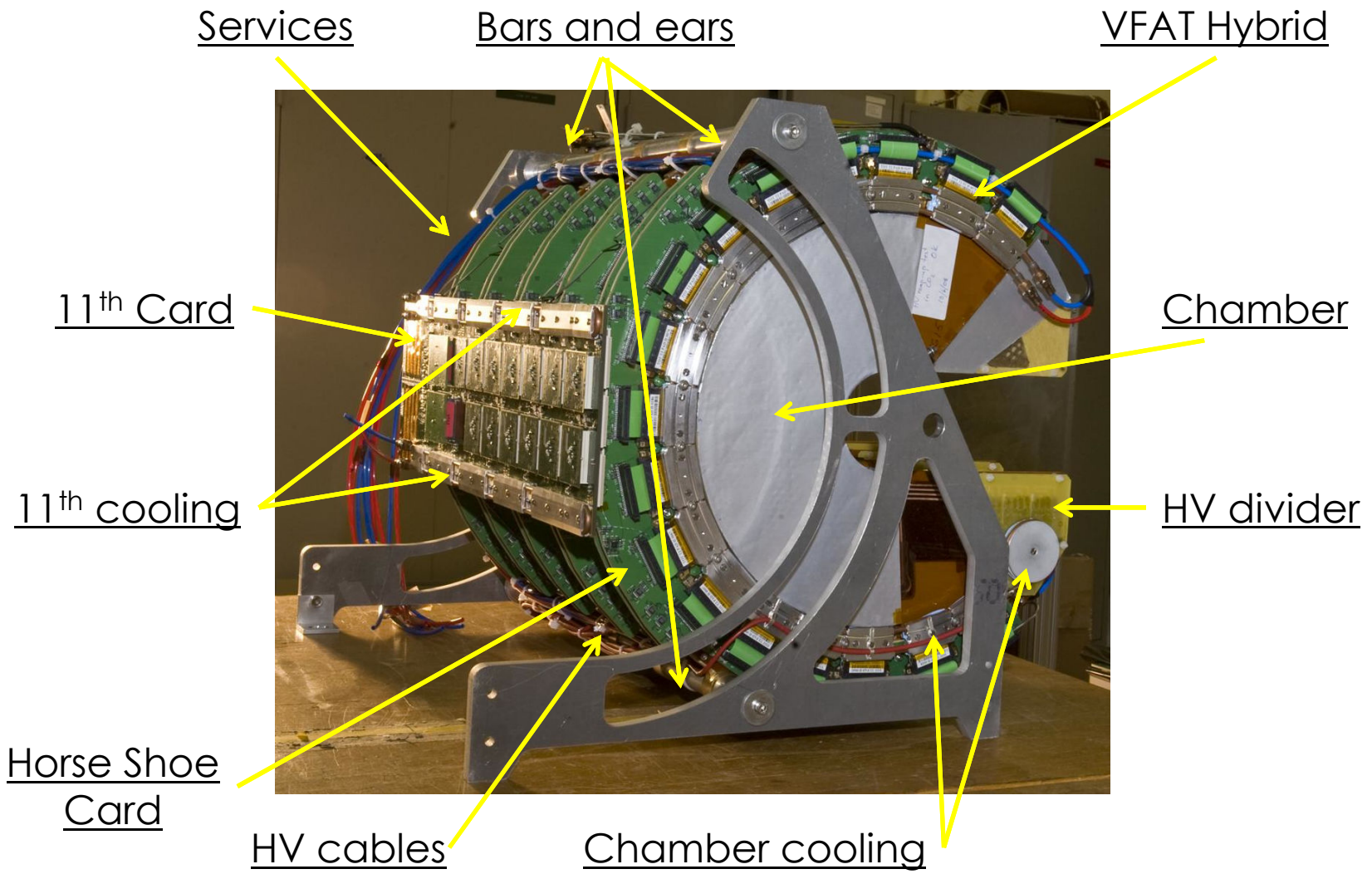
**Pads:**  $65(\phi) \times 24(\eta) = 1560$  pads  
 $\sim 2 \times 2 \text{ mm}^2 - \sim 7 \times 7 \text{ mm}^2$

**Strips:**  $256 \times 2$  (width  $80 \mu\text{m}$ , pitch  $400 \mu\text{m}$ )

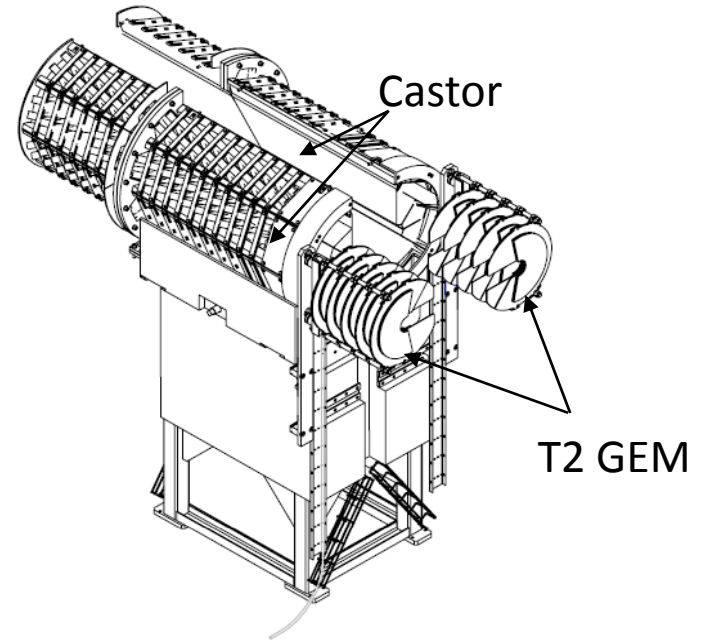
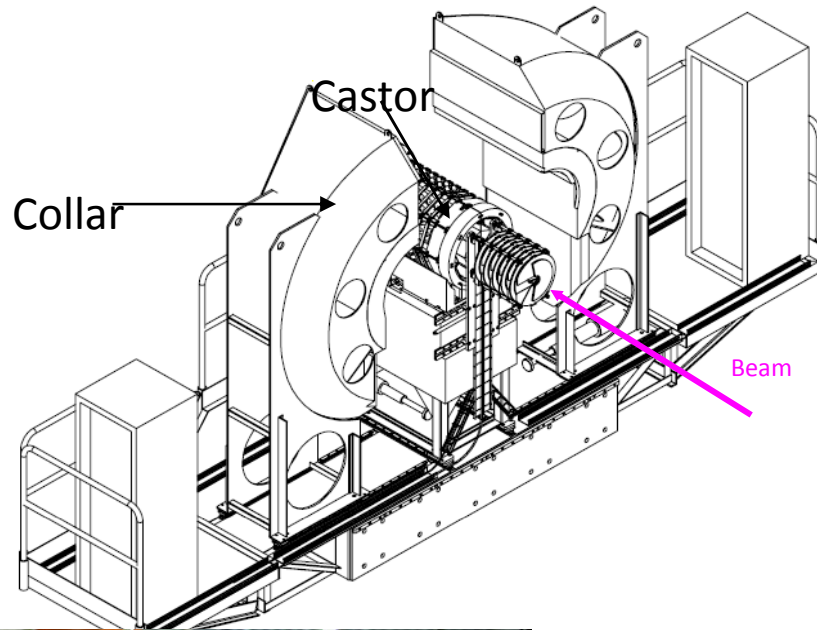
Acceptance tests: Leakage current, optical scanning, hole sizes (foils); gas sealing, humidity...

Final assembly at CERN





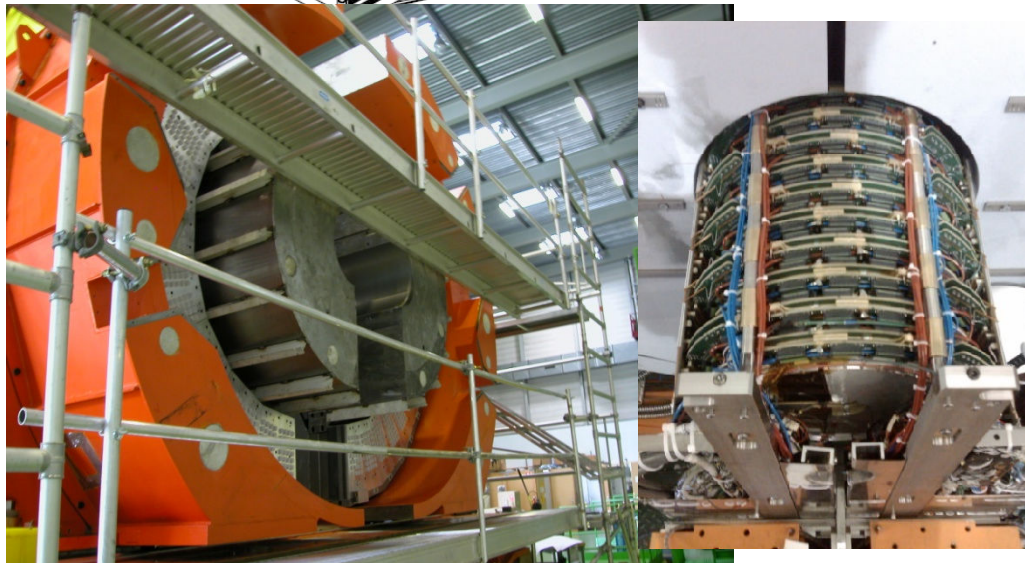
# TOTEM T2 integration with CMS



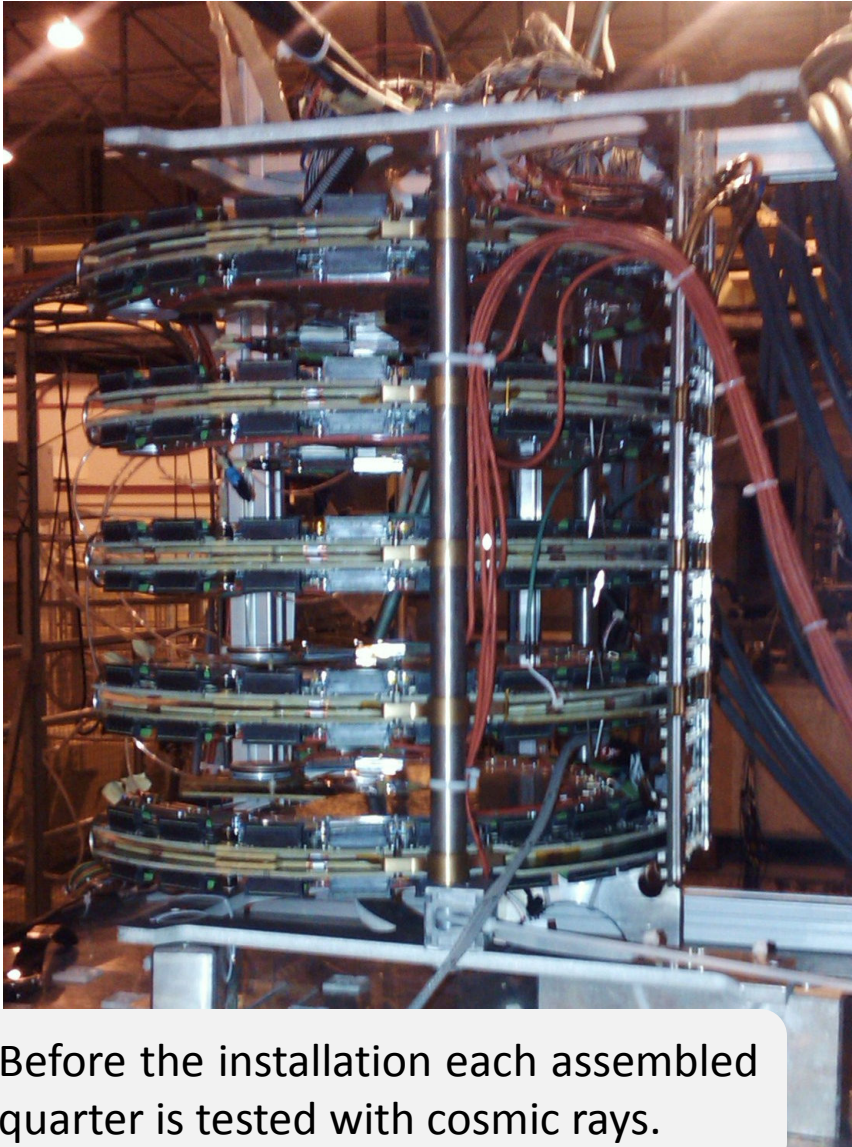
**Insertion design together with CMS**

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

$5.3 < |\eta| < 6.6$



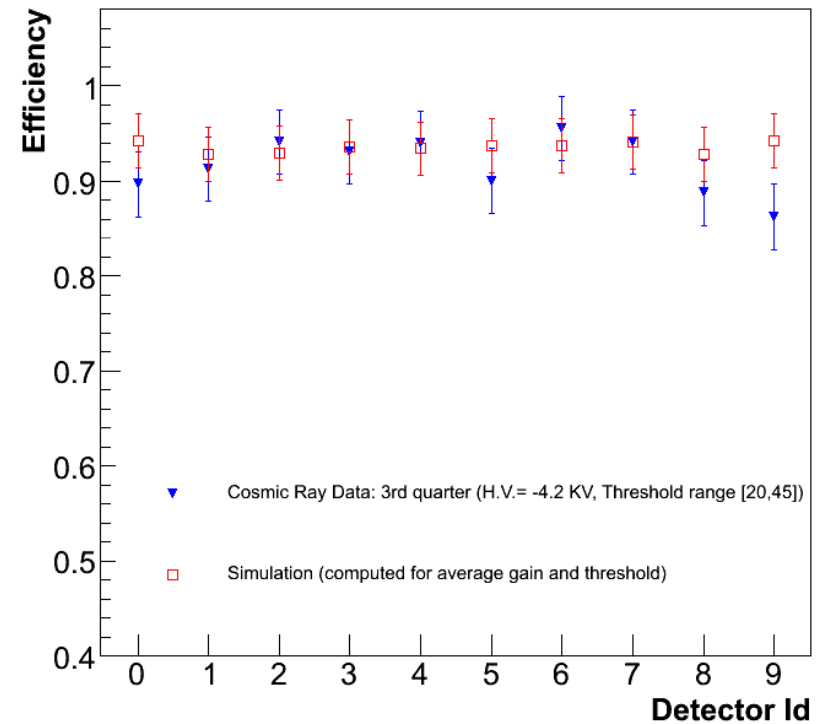
# Commissioning with cosmic rays



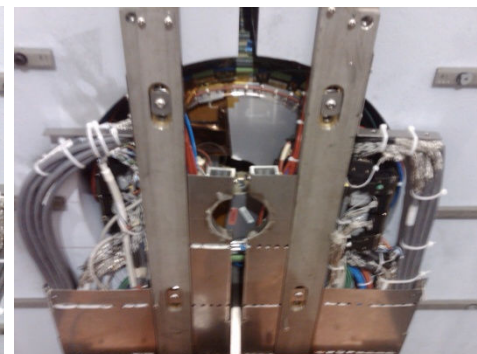
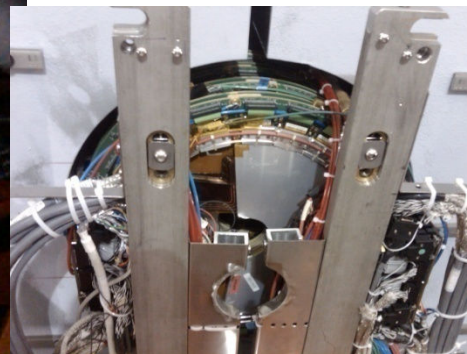
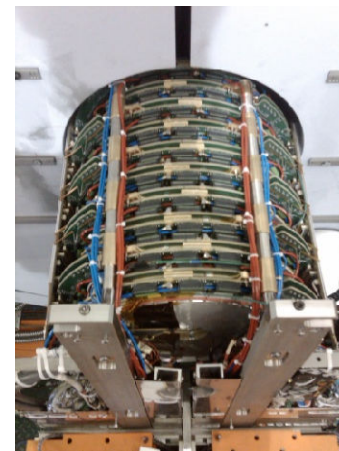
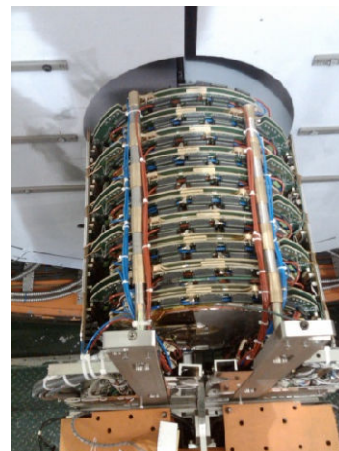
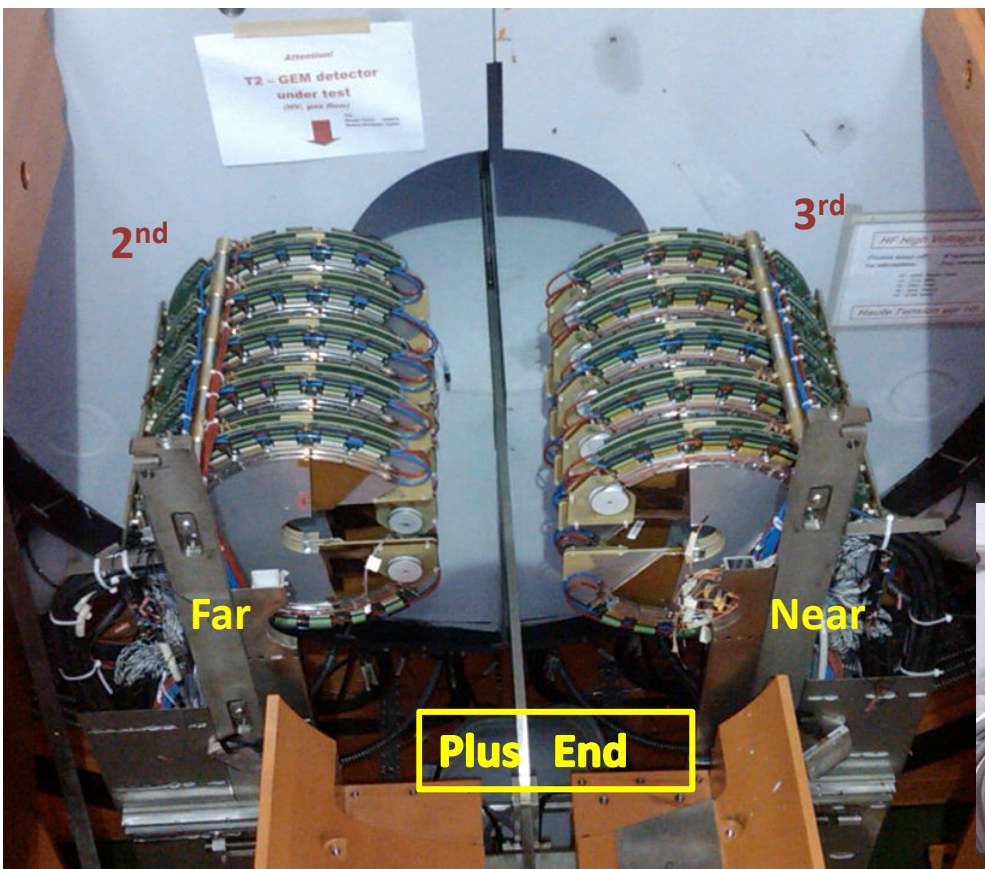
Before the installation each assembled quarter is tested with cosmic rays.

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



T2 is installed inside CMS on both ends  
Will perform the CRAFT (cosmic ray magnetic field) test during this summer  
Is ready to take data for the fall 2009 at the start of the LHC

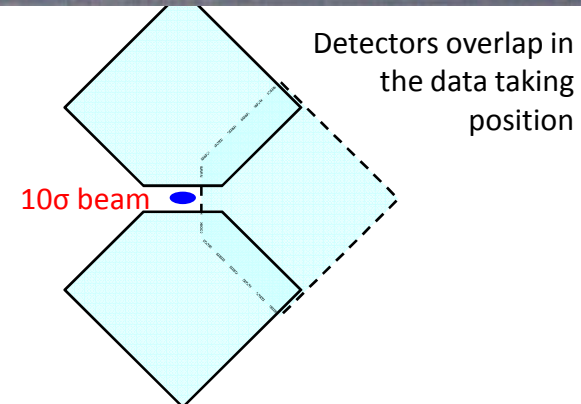
# The Roman Pots with Silicon Detectors



Roman Pot Detector Packages

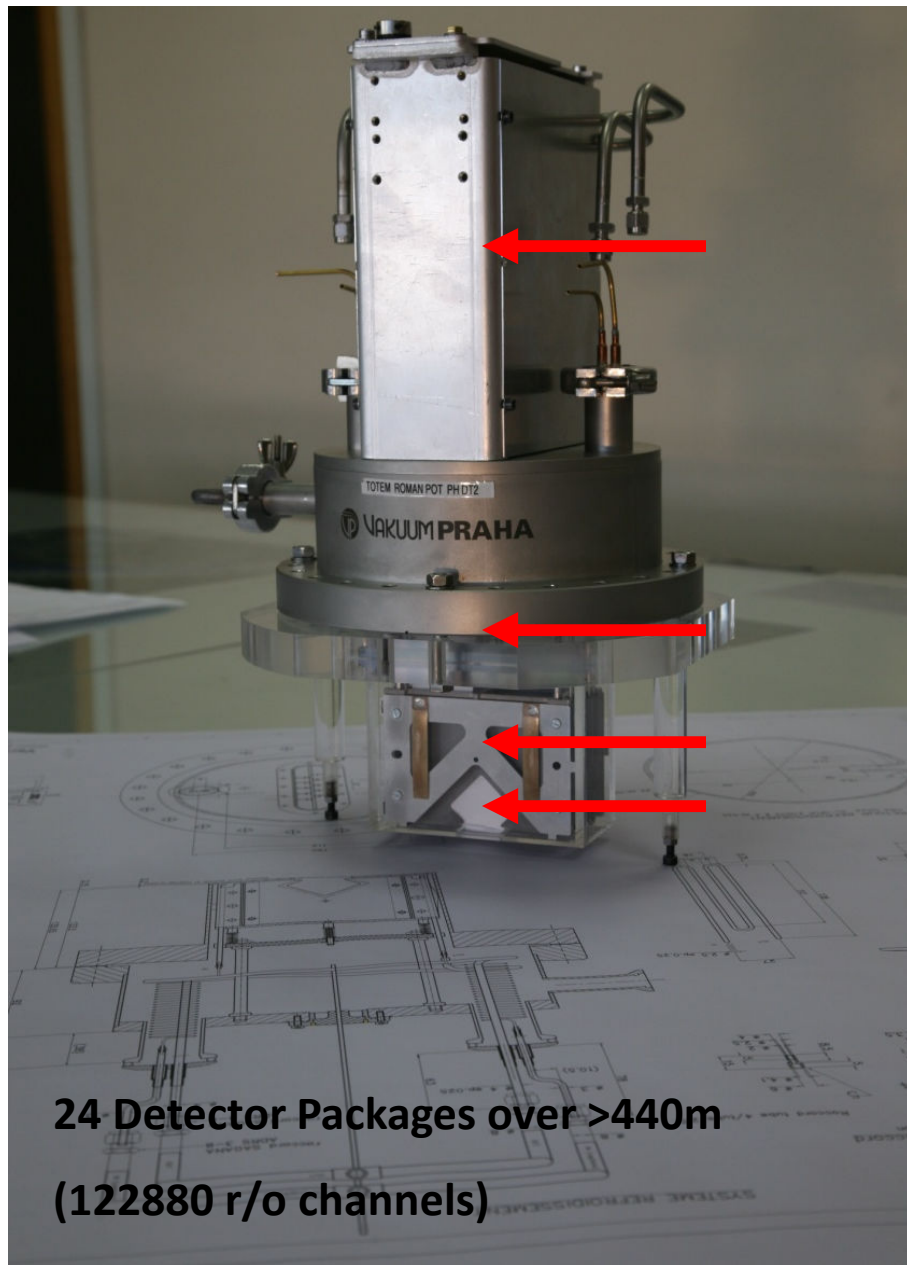
Maximize acceptance at low  $|t|$ :

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

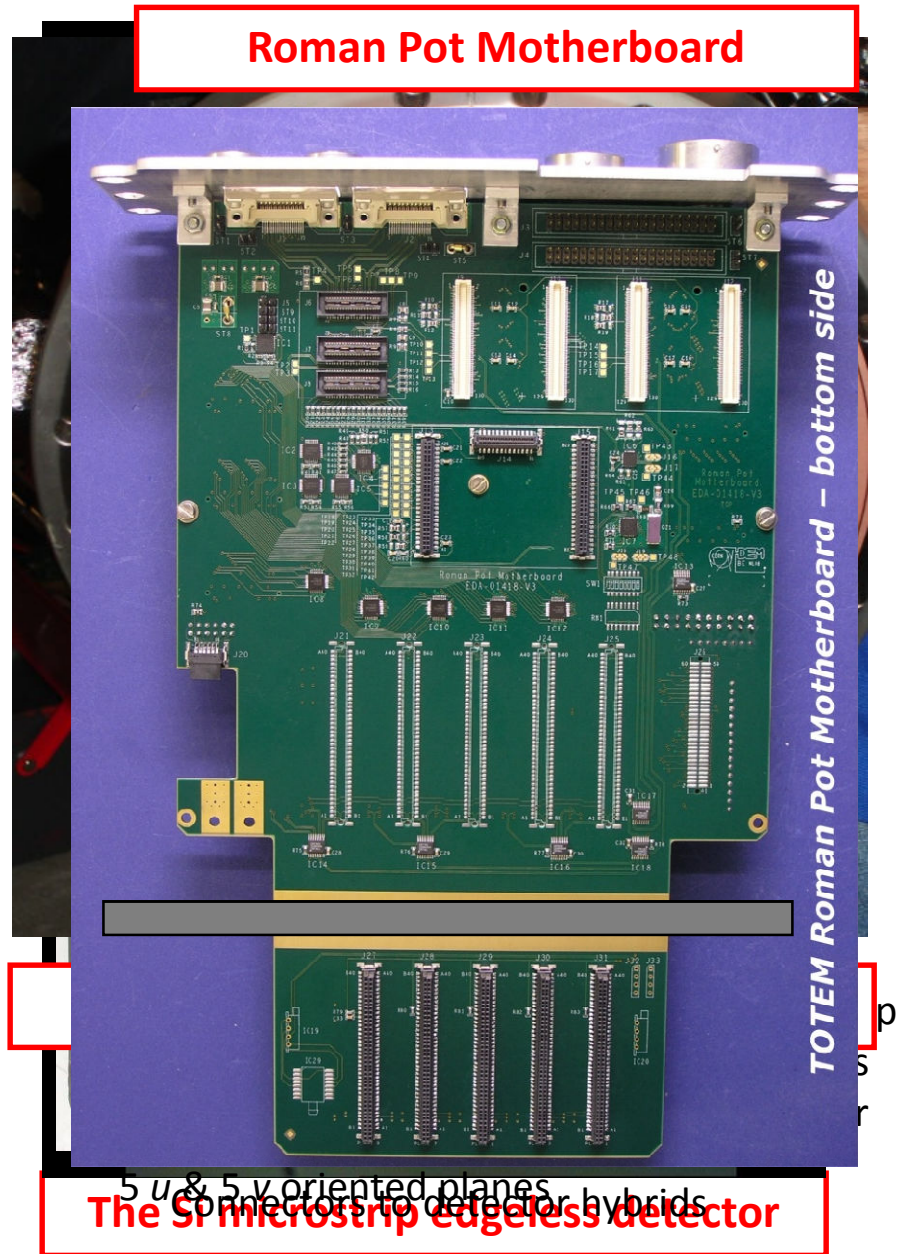




# The Detector Package (DP)



24 Detector Packages over >440m  
(122880 r/o channels)

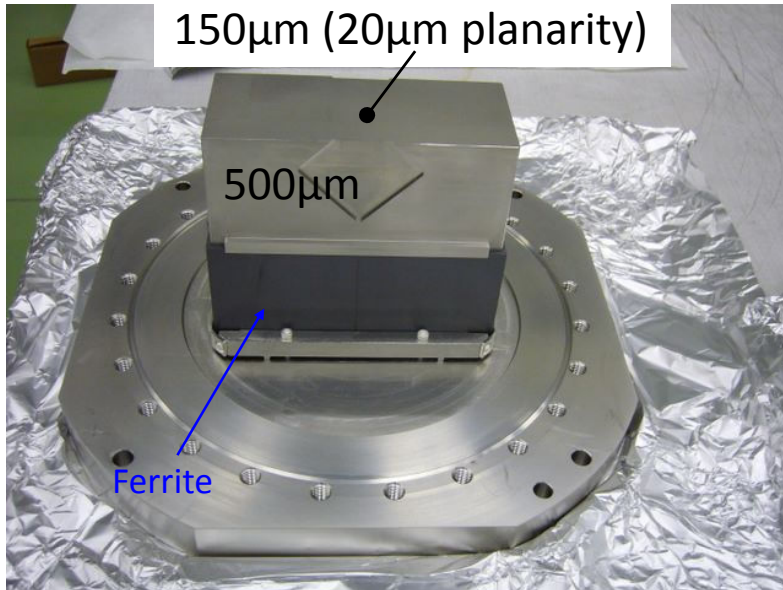


Roman Pot Motherboard

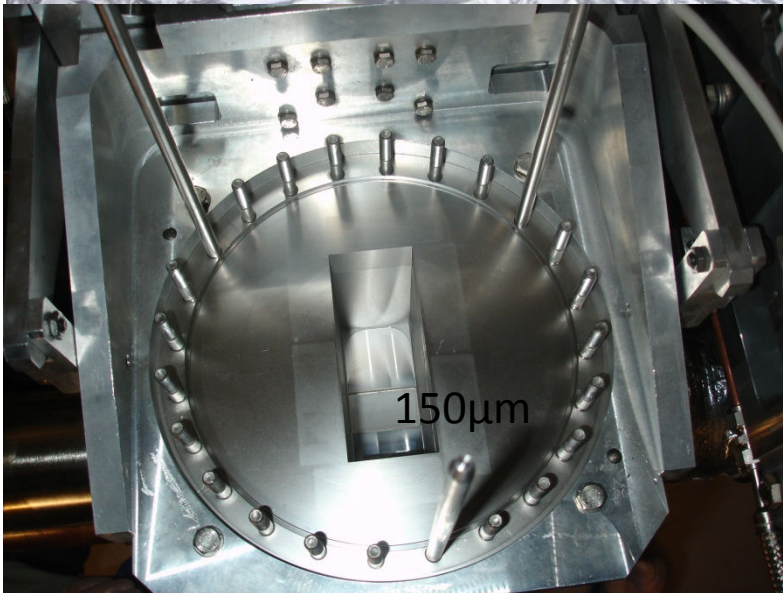
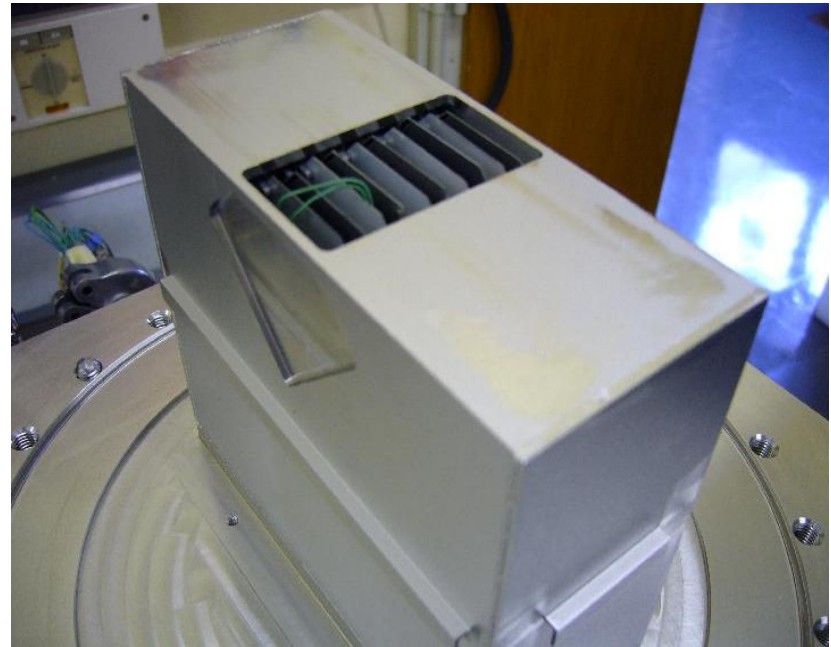
TOTEM Roman Pot Motherboard - bottom side

5 u & 5 v oriented planes  
The Si microstrip edgeless hybrids

# The Pot



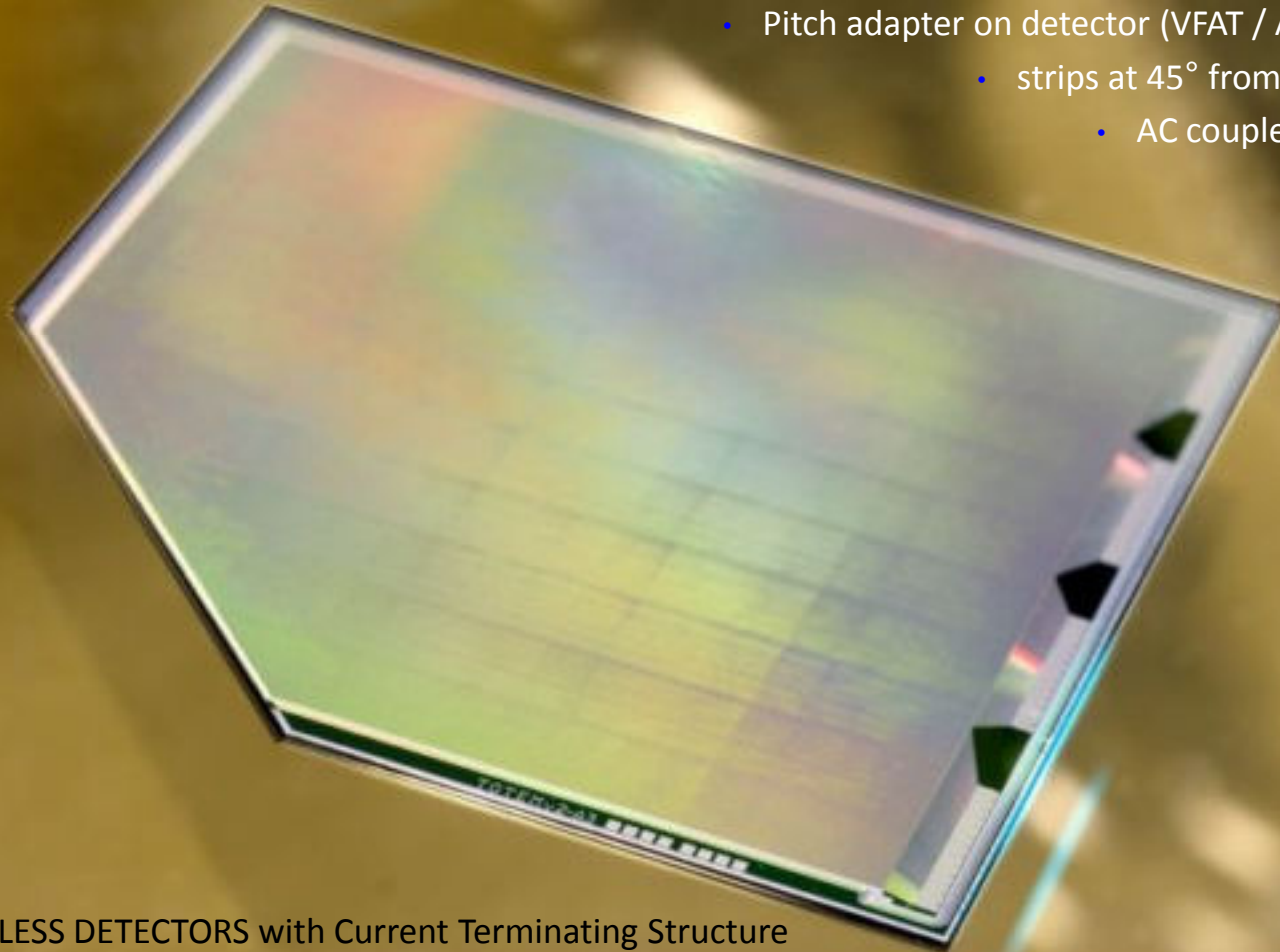
Separates the high vacuum of the machine from the detector's vacuums.



When the RP is in the Data taking position will approach the 10 $\sigma$  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 45° from the sensitive edge
    - AC coupled (punch-through)

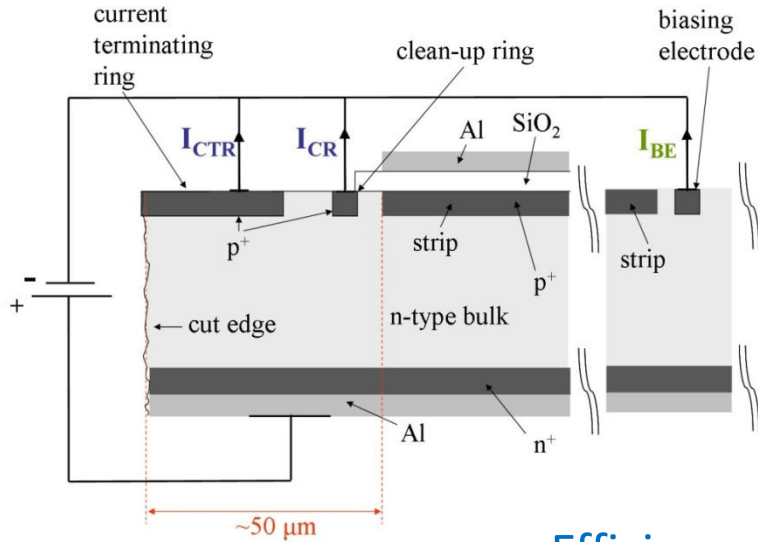


EDGELESS DETECTORS with Current Terminating Structure

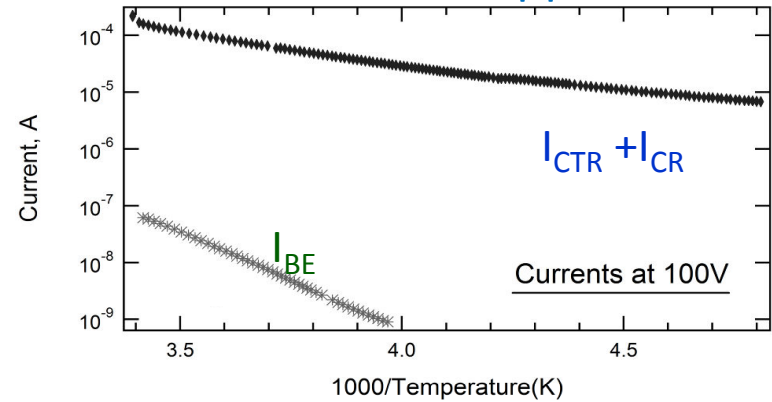
# The Edgeless Silicon Detector (II)

In general Si sensors have an insensitive edge of >1mm...

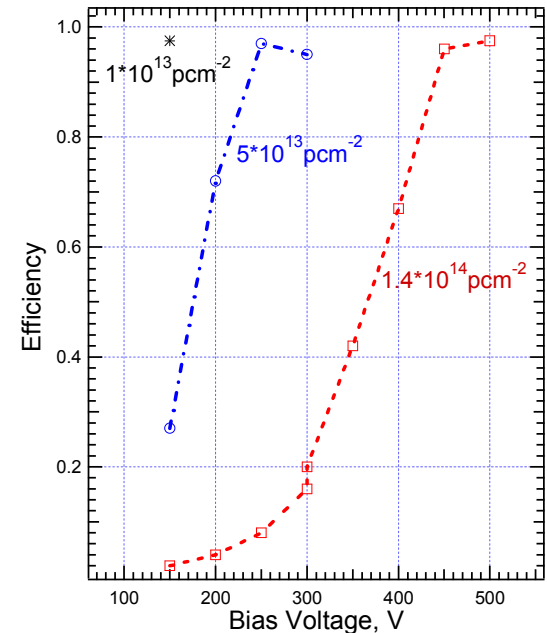
## Current Terminating Structure



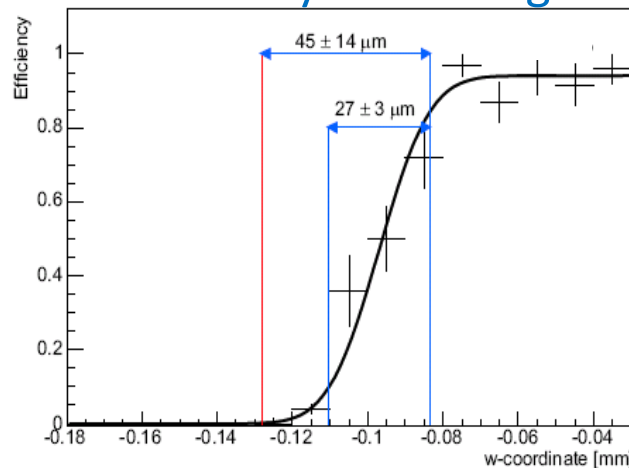
## Surface Current Suppression



## Radiation Hardness



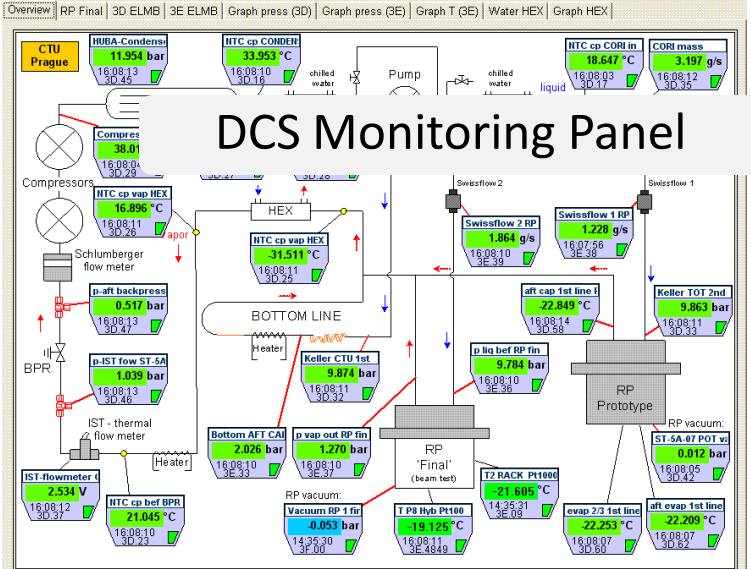
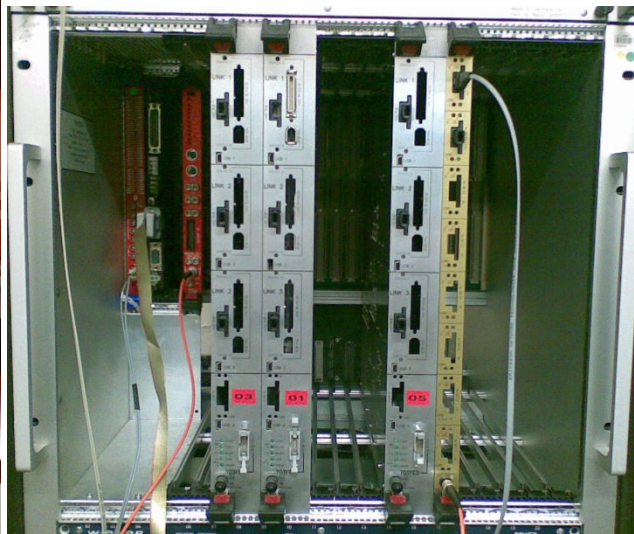
## Efficiency at the edge



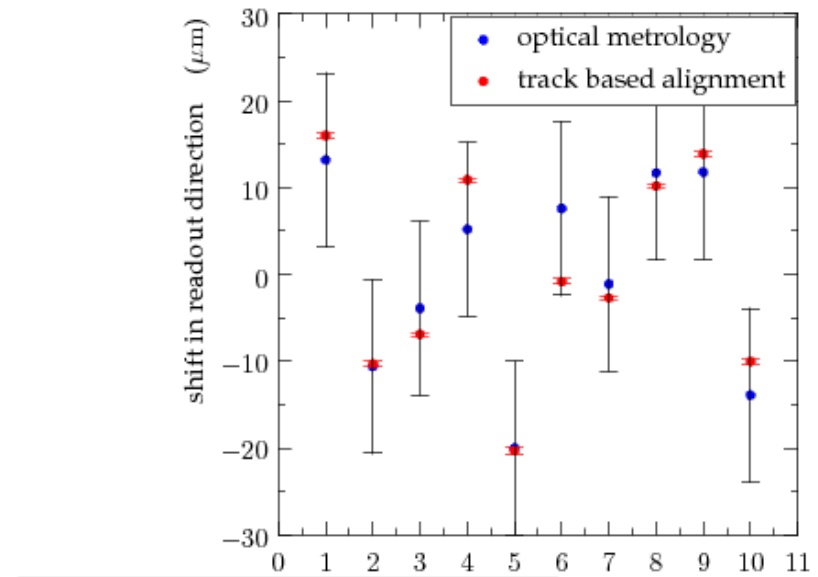
# Commissioning of the DPs with beams in H8



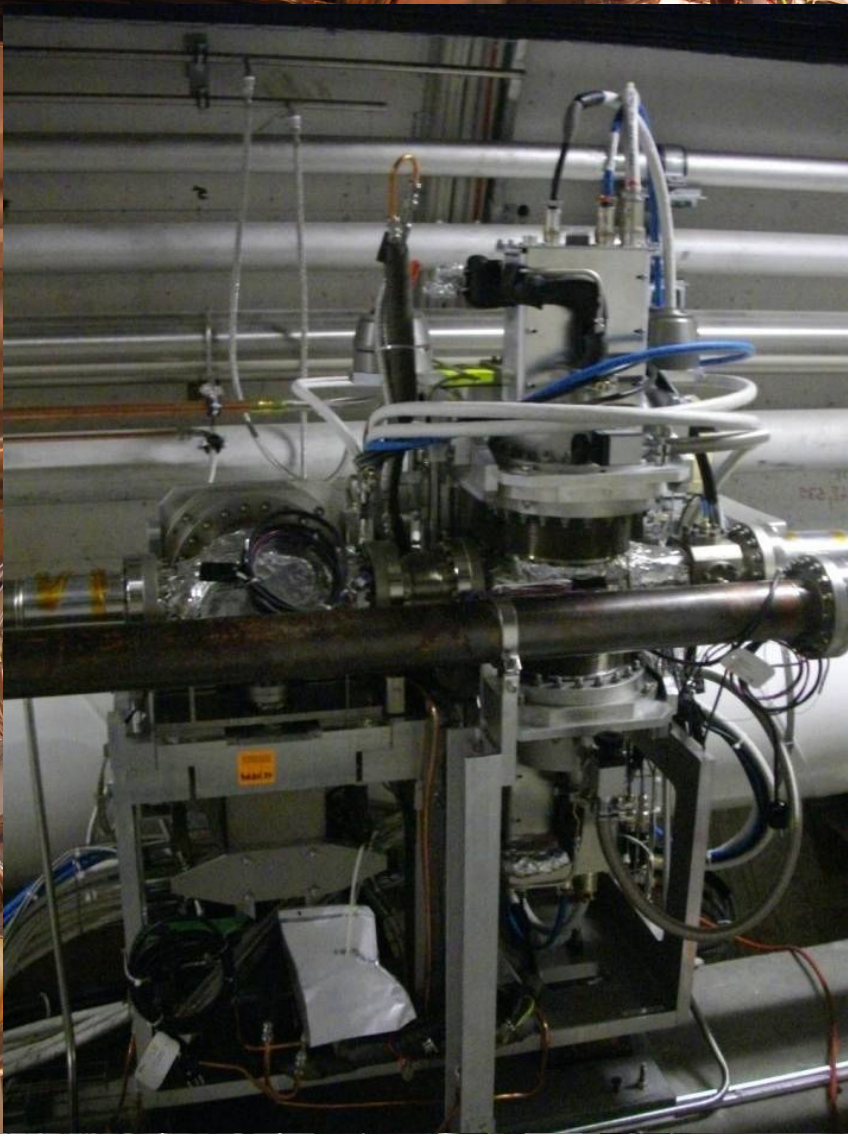
Commissioning setup in H8



Cooling and Vacuum station



Alignment control



ALL 4 Roman Pot Stations Installed in '07

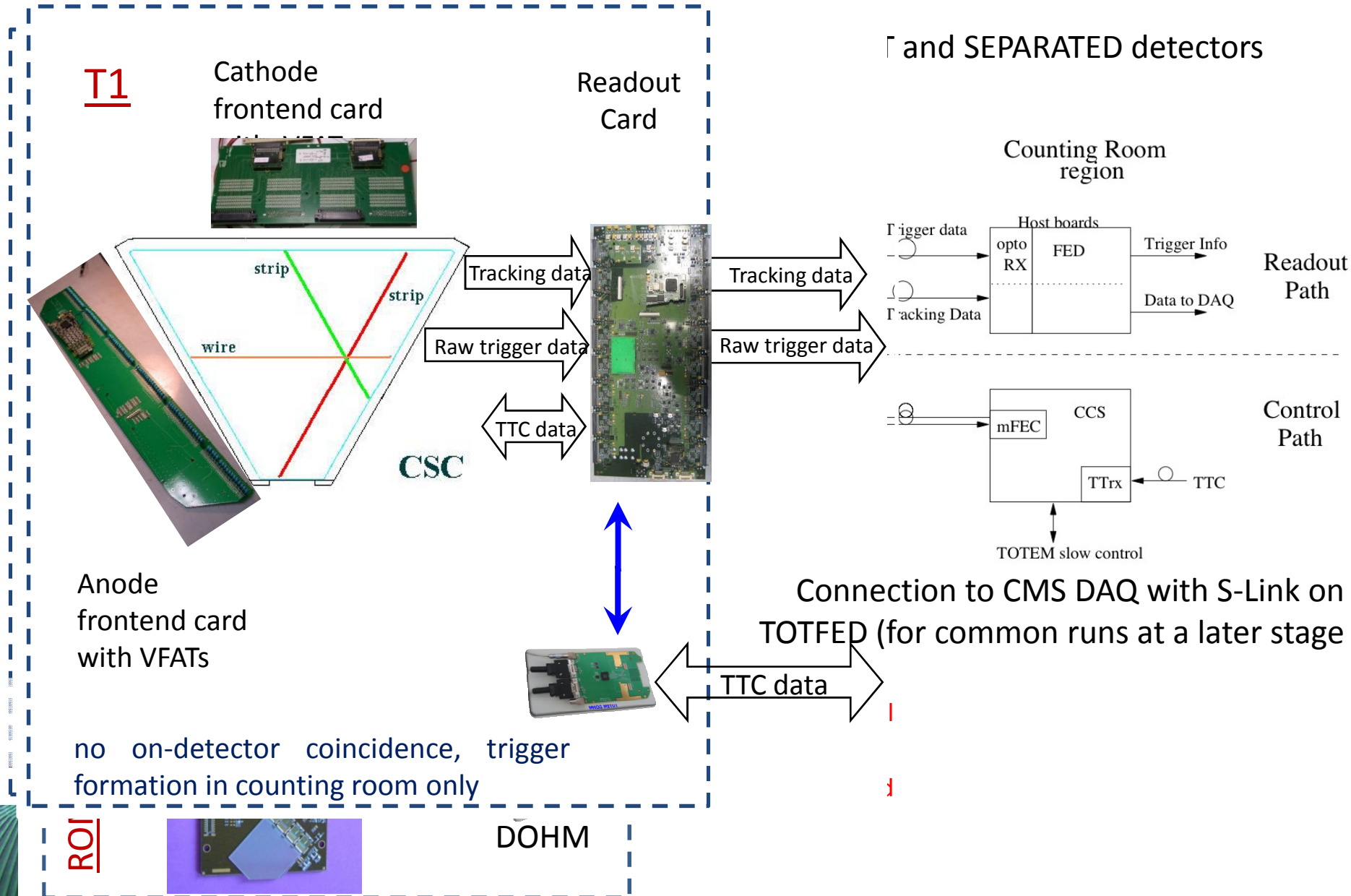
First 2 Detector Packages installed last summer

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

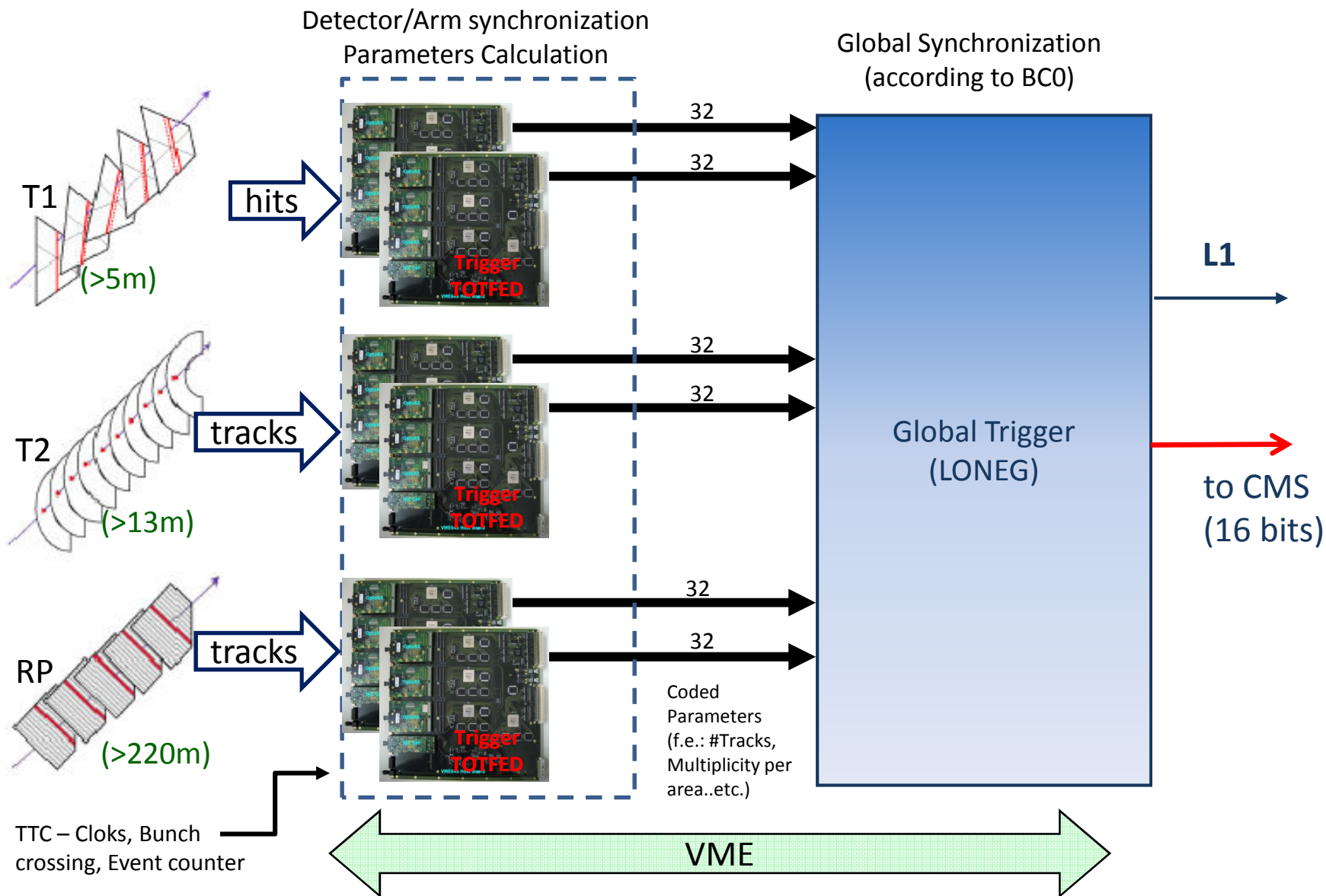
Completion of the RPS at 220m in sector 45 foreseen in July

Roman pots at 220m

# The TOTEM Readout Electronics



# The TOTEM trigger strategy





# SUMMARY

(TOTEM *coarse* History)

Proto  
produ



C

2009: Complete the  
installations to be ready for  
the restart of LHC :  
T2 completed  
RPs at 220m in July  
T1 in September

First ins



2007>2008

2005>2007

.... 2004