Planar Edgeless Detectors for the TOTEM Experiment

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On the behalf of the

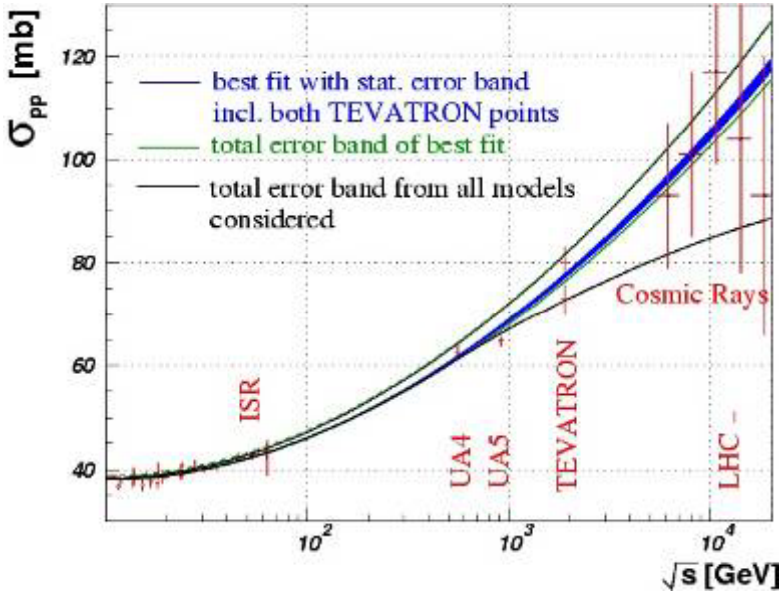
TOTEM Collaboration

http://totem.web.cern.ch/Totem

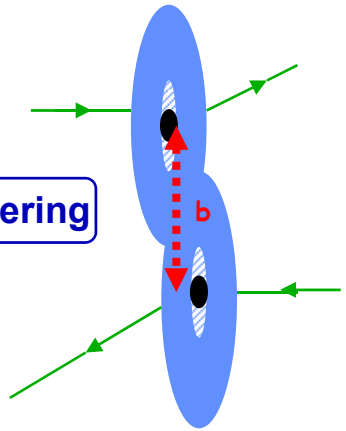
8th International Conference on Position Sensitive Detectors

TOTEM, a different LHC Experiment

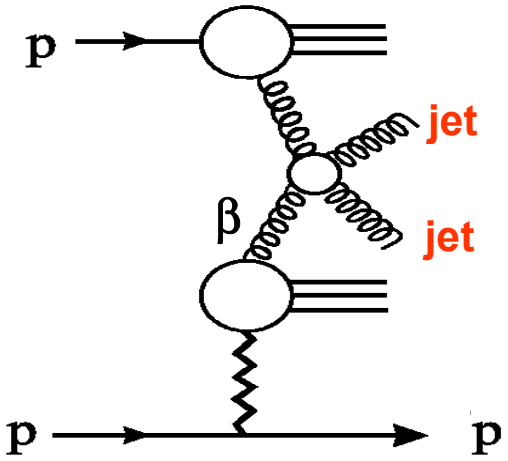
Total cross-section



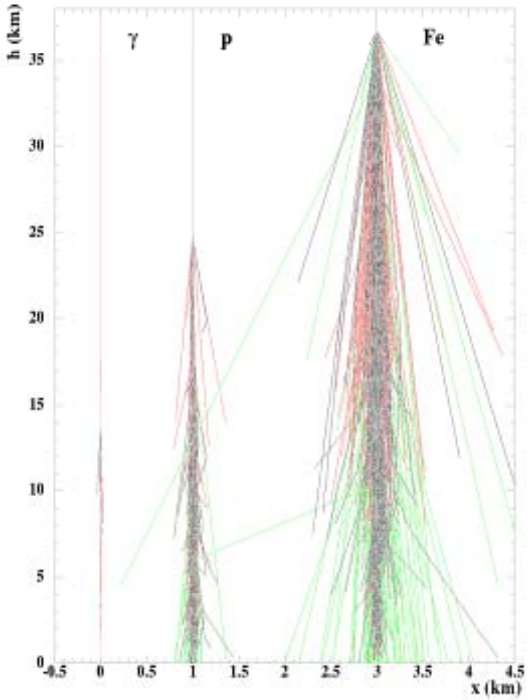
Elastic Scattering

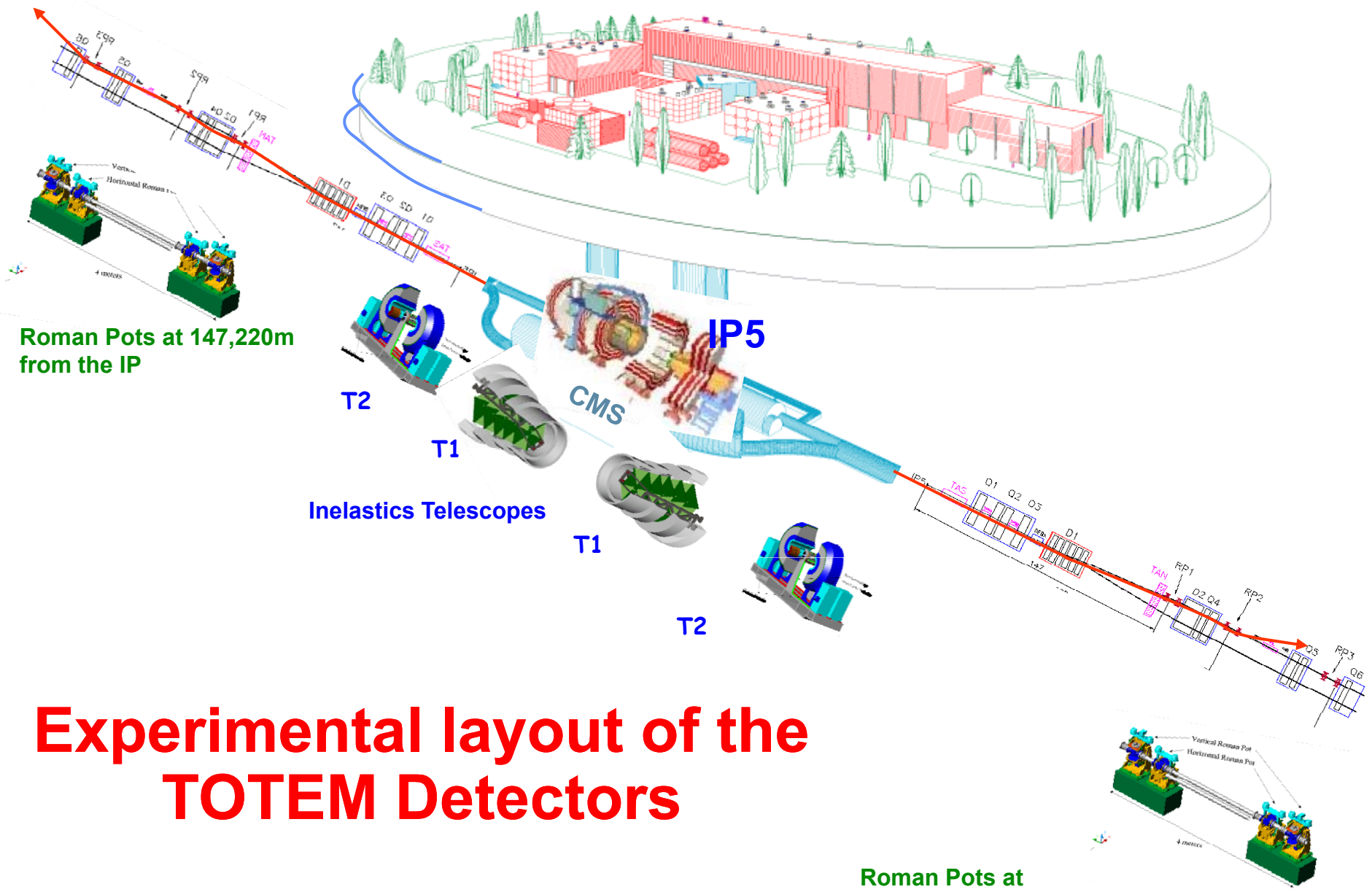


Diffraction: soft and hard



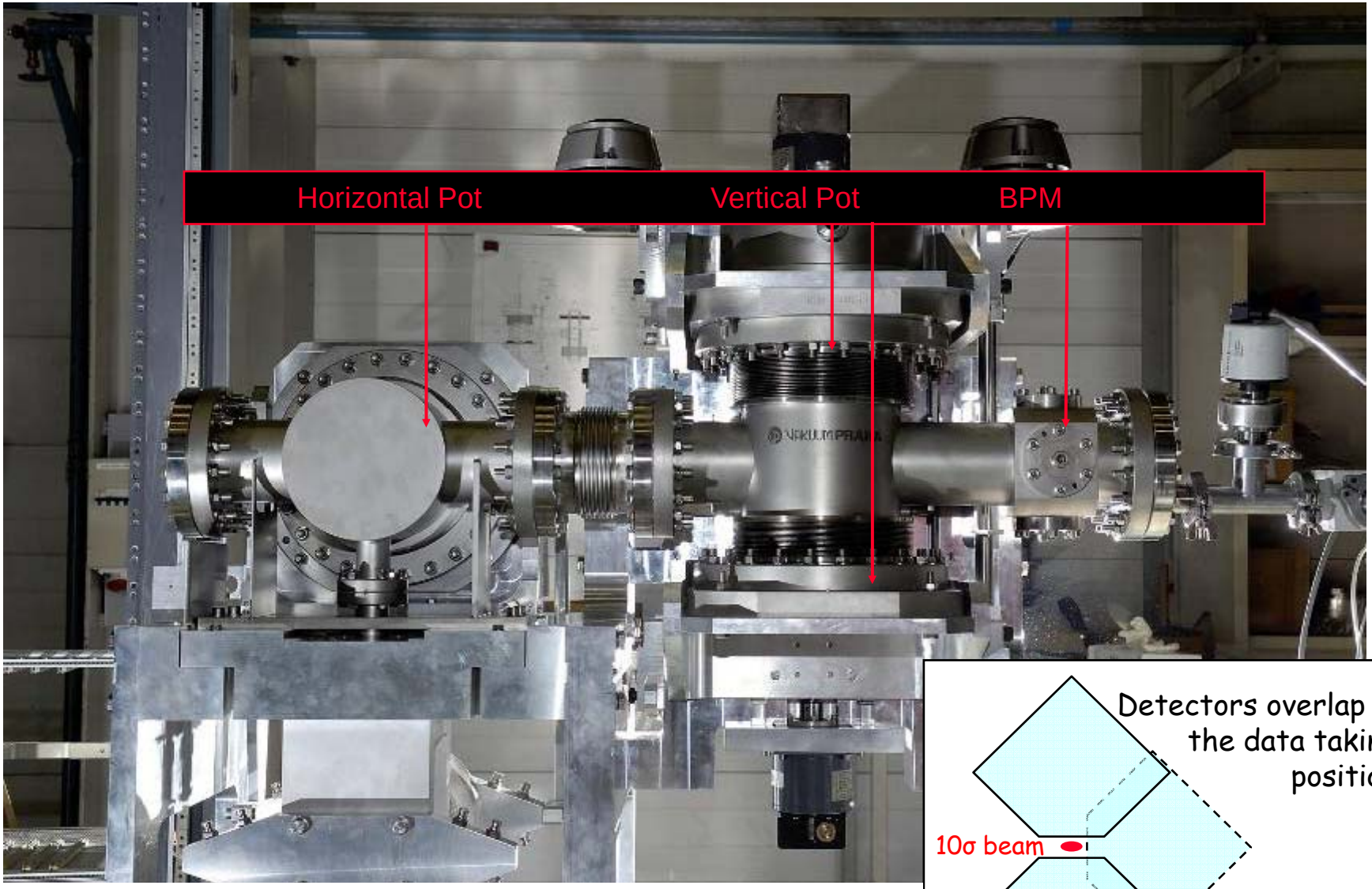
Forward physics





Experimental layout of the TOTEM Detectors

Roman Pot Unit



Special beam insertion allowing to approach the detector very close to the beam. Compensation system allows the movement from garage position (detectors away from the beam) to data taking position (detectors close to the beam) Roman Pot Motion Control integrated with collimator control system Each RP Unit equipped with one BPM

Condition imposed on the Roman Pots

- Maximise acceptance at low |t|:

edgeless Si-detectors

minimised space between detector edge and window

minimised window thickness

- Resolution in t, ϕ; precision of elastic extrapolation to t = 0

Spatial detector resolution

- Background suppression:

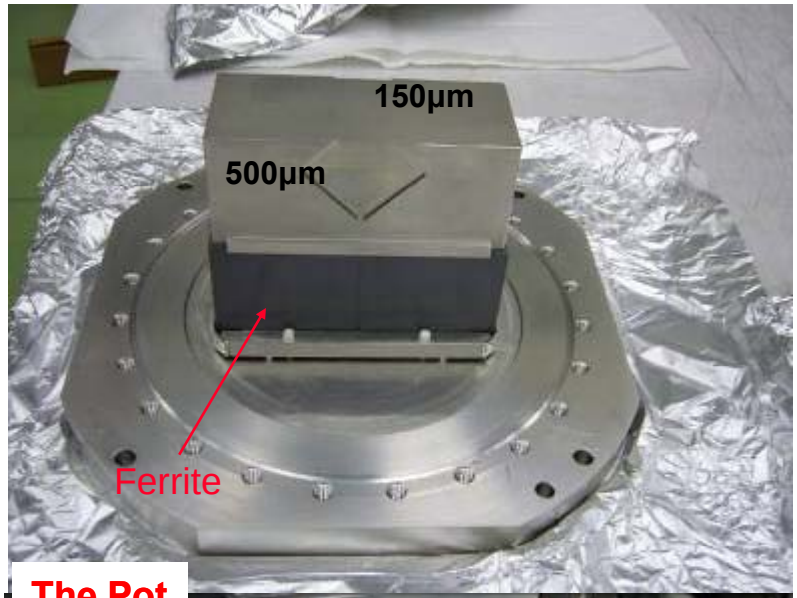
trigger segmentation

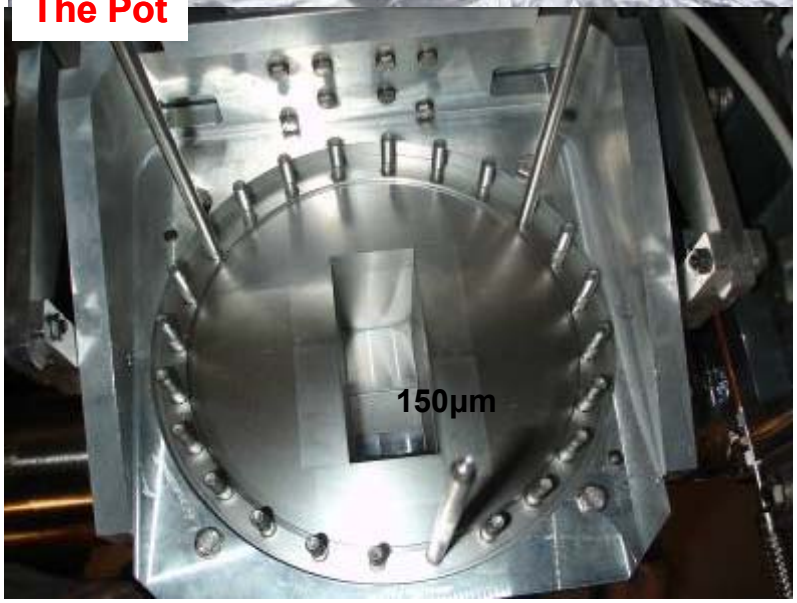
number of planes

- Redundancy

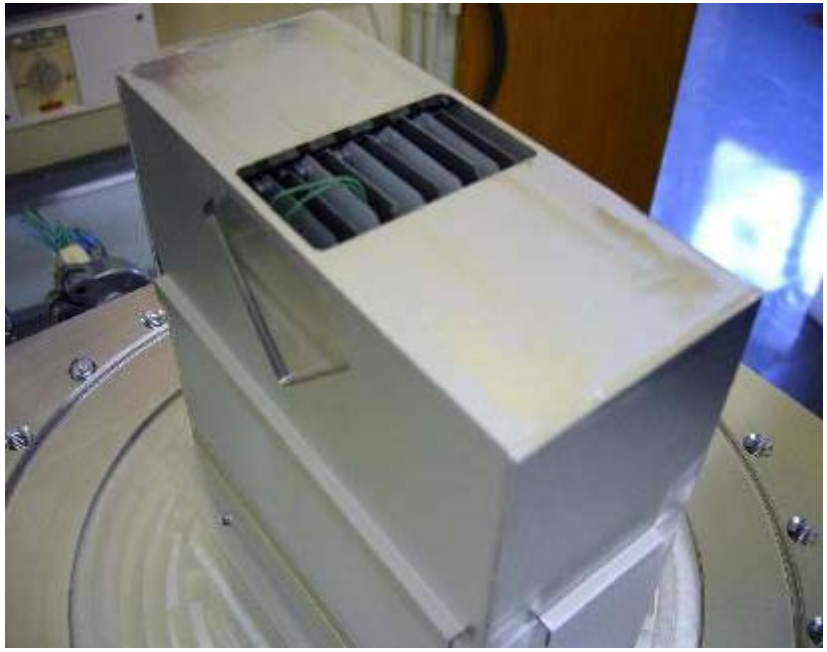
enough planes

The Pot



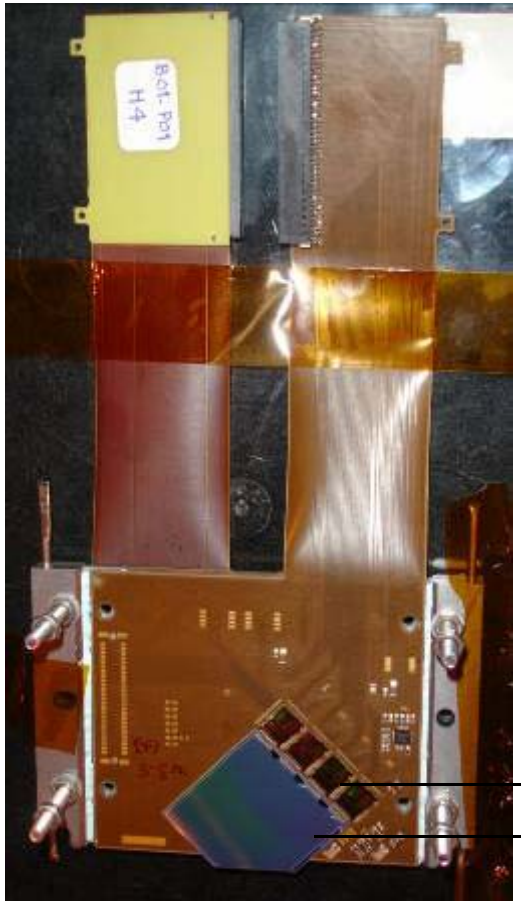


The Pot



The Pot has been object of a specific development. Is a stainless steel box. It's thin window 150 µm thick with planarity of 20 µm is brazed on the bottom of the pot. It and separates the secondary vacuum of the detectors from the vacuum of the machine. When the RP is in the Data taking position will approach the 10σ of the beam . Ferrite plates mounted on the pot to reduce RF Interference

The detector package

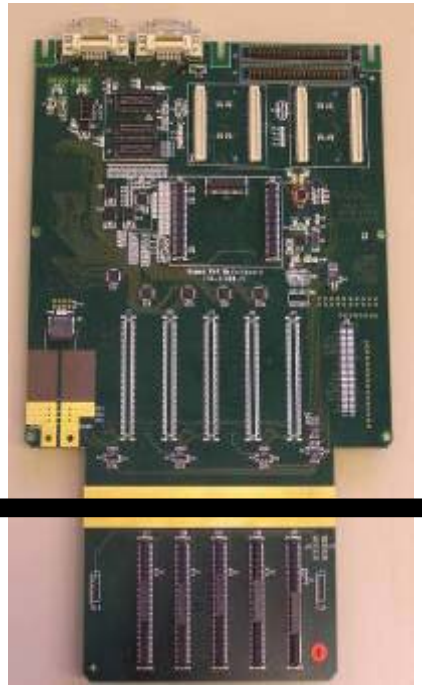


VFAT chis

Si microstrip detector

the “Champignon”

Roman Pot Motherboard connecting the detector packages in the vacuum to the outside world



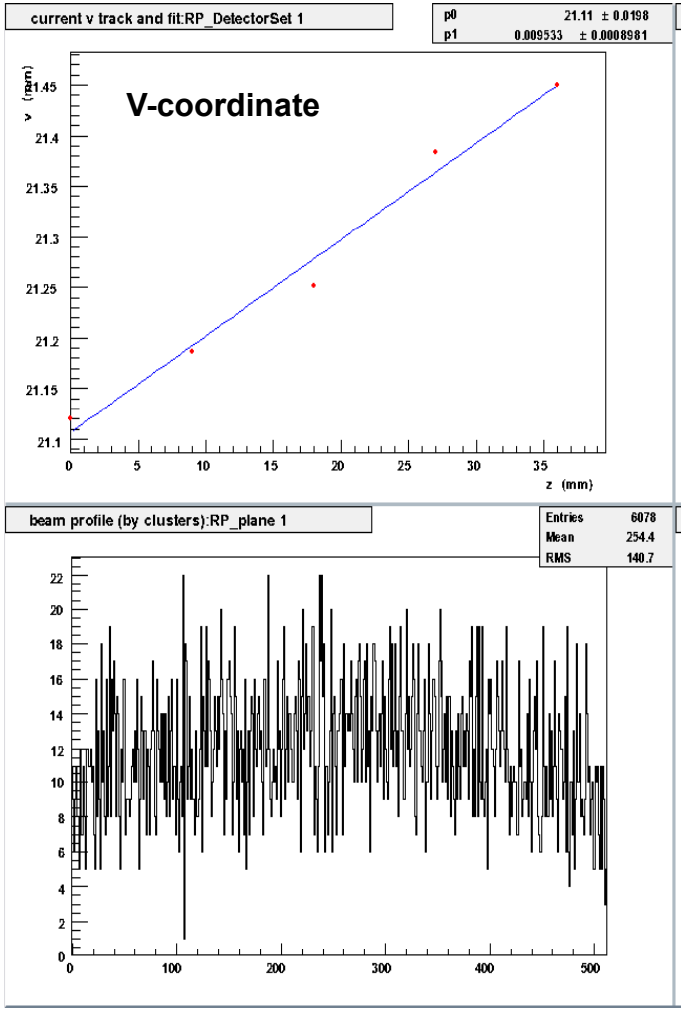
Vacuum flange

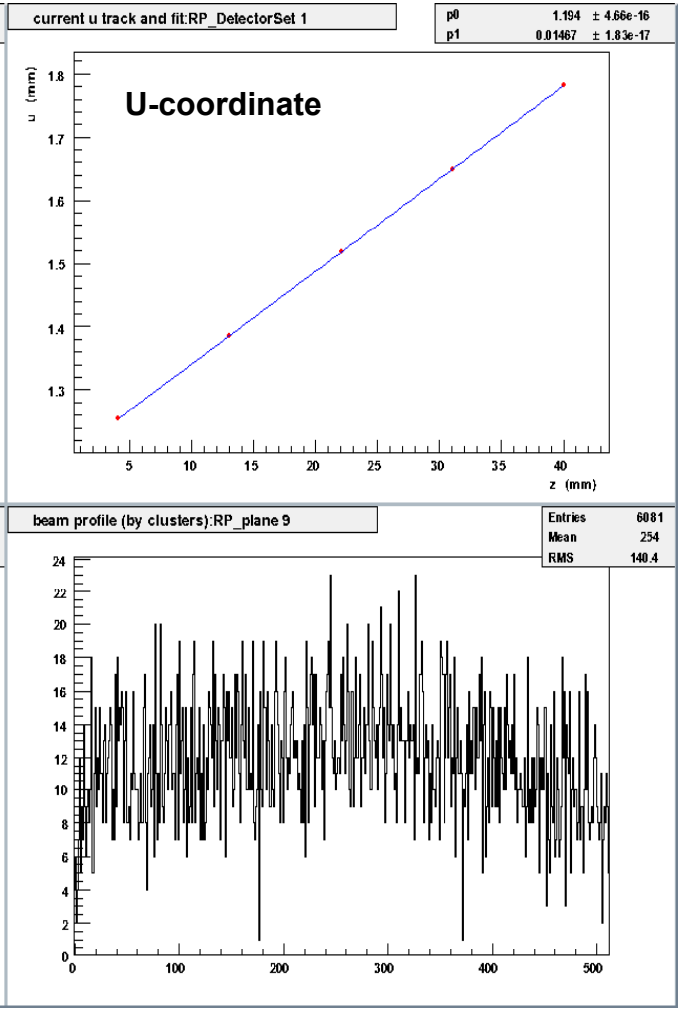
Feed-through

Connectors to detector hybrids

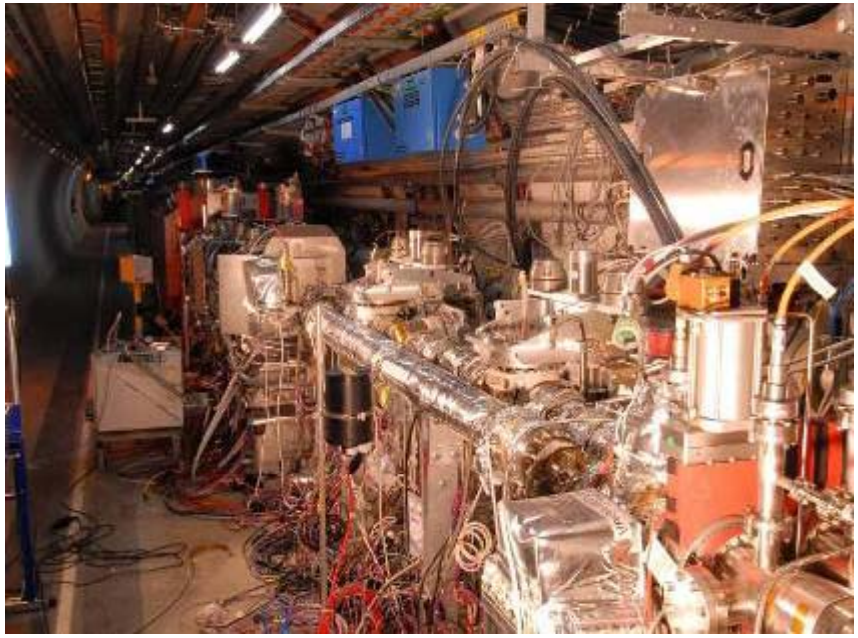
In each pot 5 u and 5 v oriented planes are inserted in form of a detector package. The plane-hybrid is made of kapton laminating a support plate of CE07 (70% Si and 30% Al alloy) which matches the thermal expansion of the silicon detector. The flexible pigtail guarantees a mechanical decoupling of the detector package from the “champignon” to align on the pot inner surface.

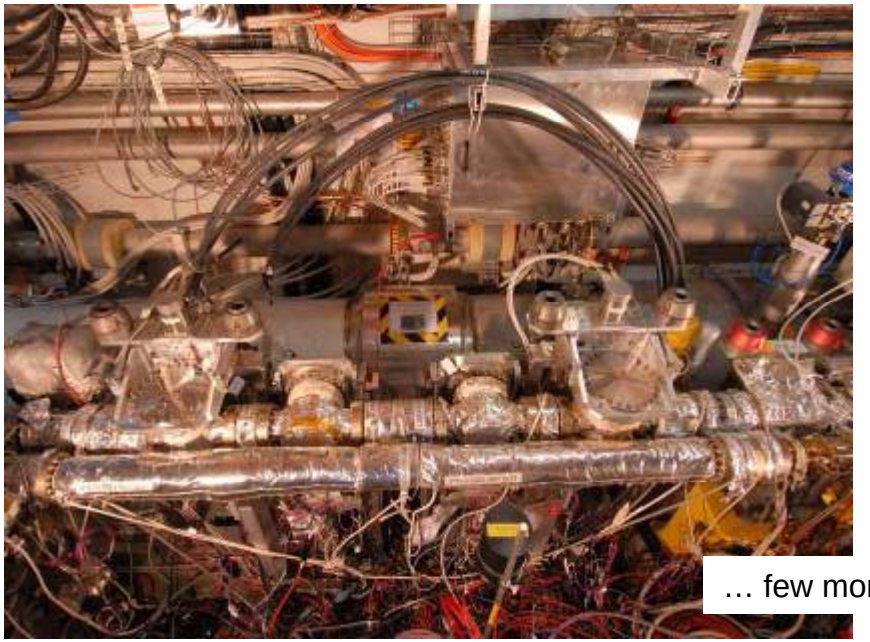
Commissioning of the pots in H8 with muons





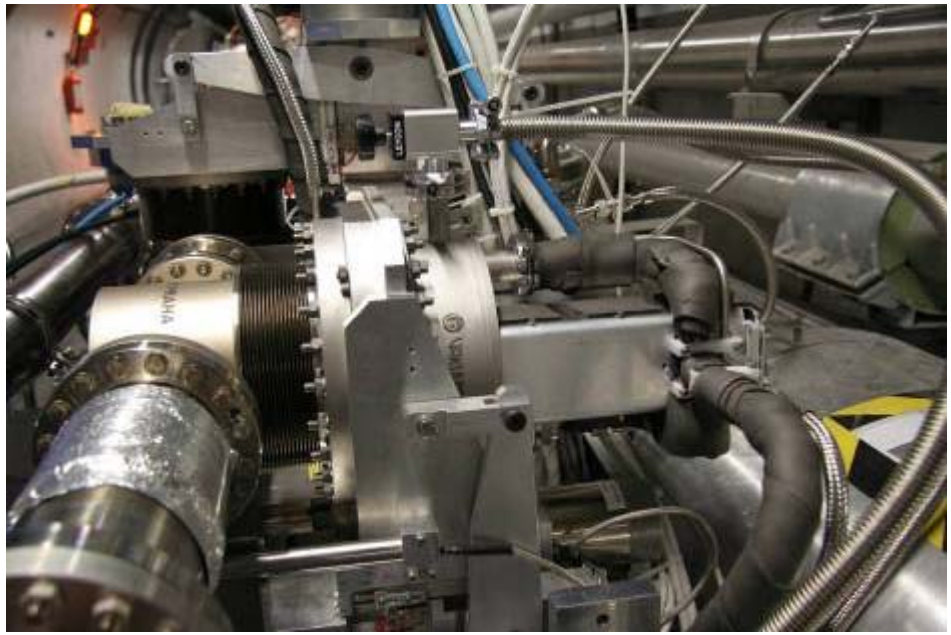
All 8 Roman Pots Units Installed in the LHC





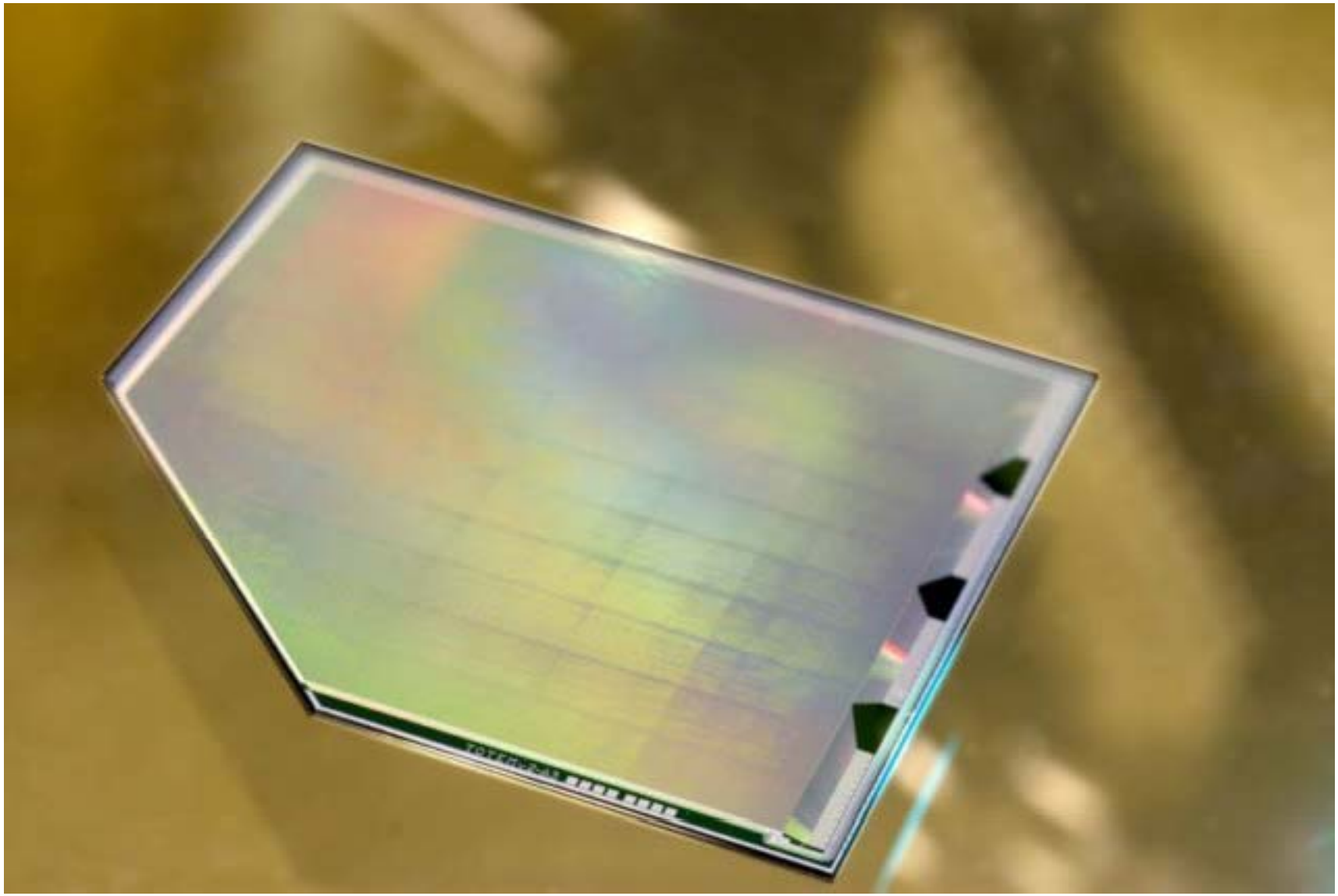
… few months ago

First 2 Roman Pots Detector Packages



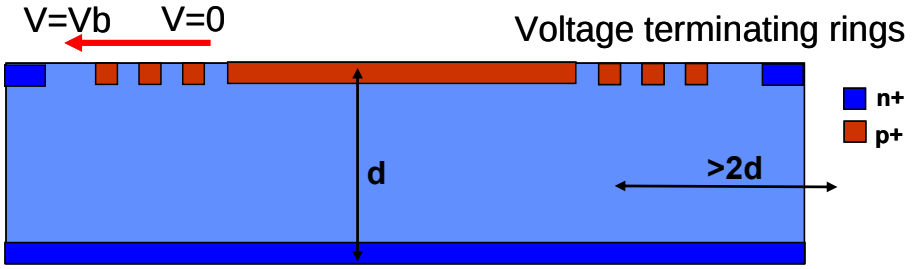
… few weeks ago

The sensor: Edgeless Detector



Edgeless? How does it work…

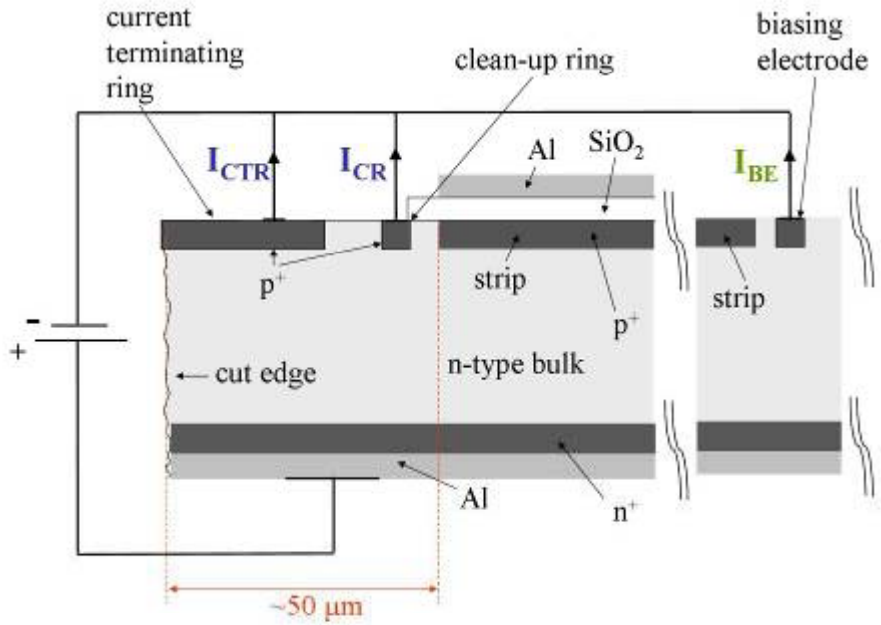
Standard Planar Silicon detectors have an edge.



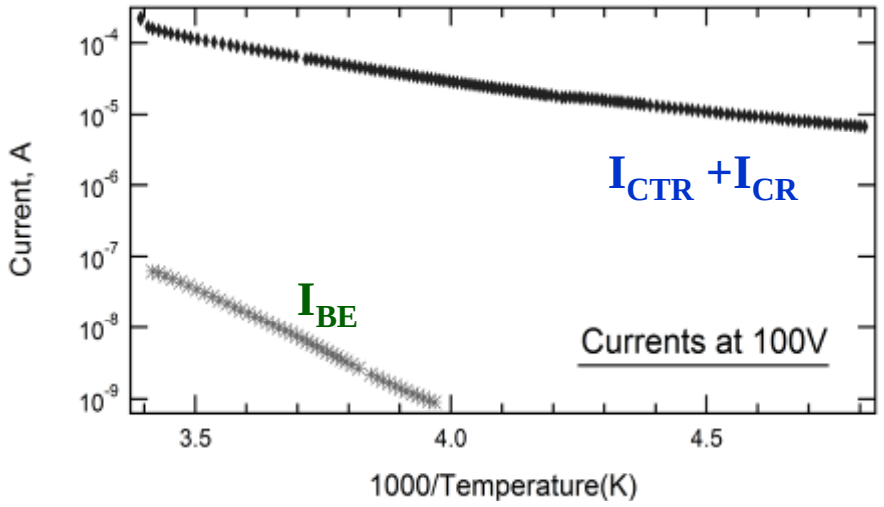
- **Protective structure at the edges**
- **Enhancement of the performance at higher bias**
- **Reduction of surface effects**

- **Wide dead volume at the edge (>2d)**

But if…



Surface Current Suppression

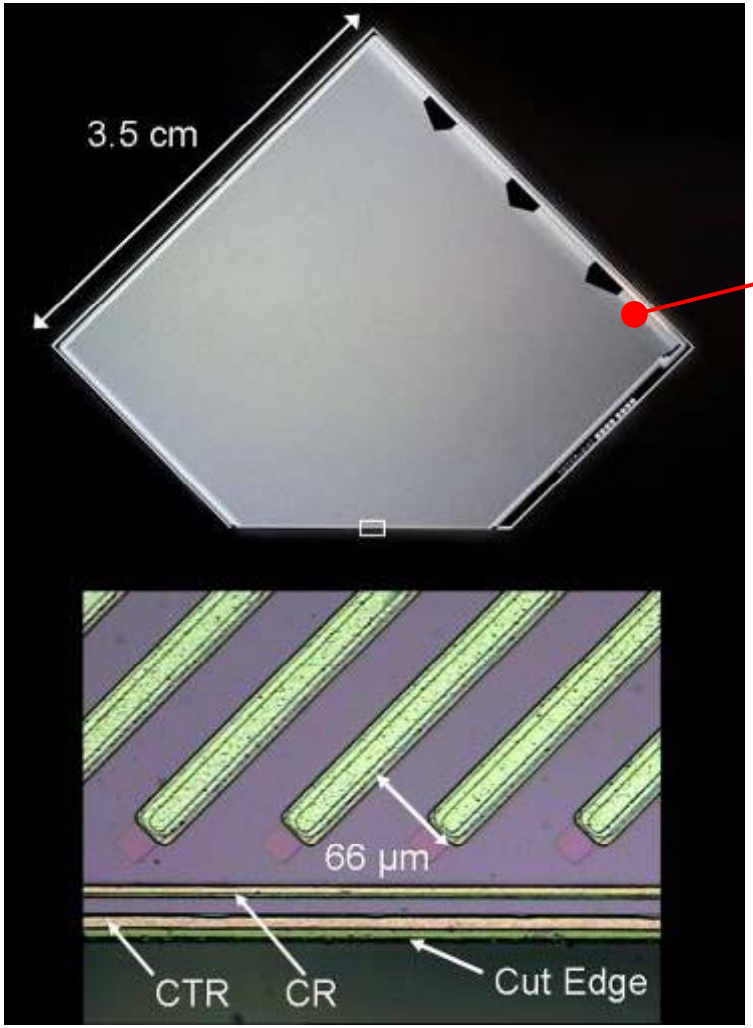


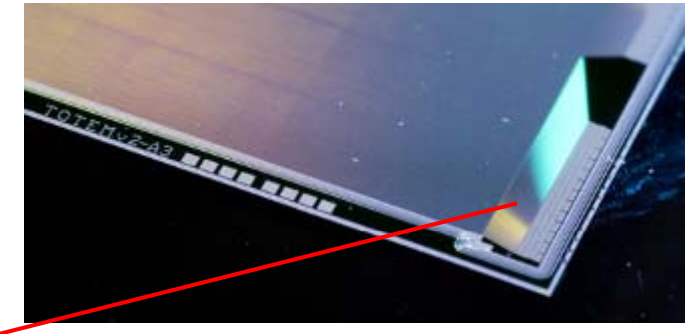
EDGELESS DETECTORS with Current Terminating Structure

Developed by: CERN/PH-TOT, Ioffe PTI- St. Petersburg, RIMST- Zelenograd

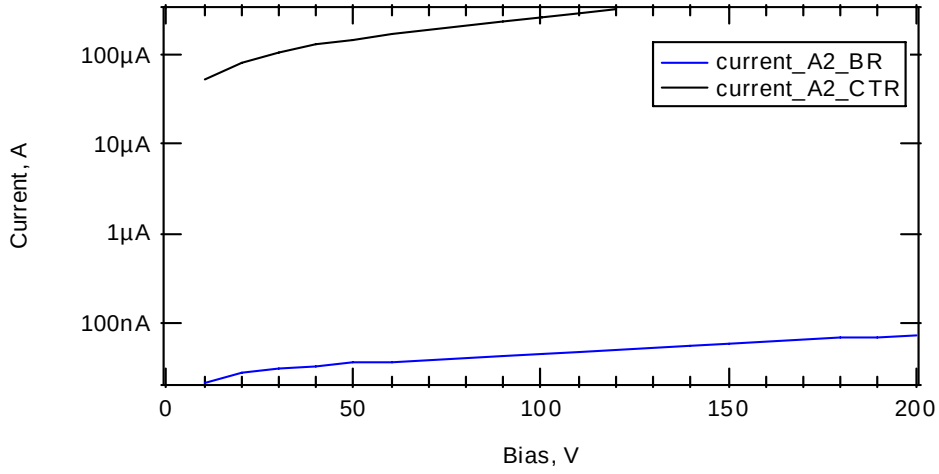
Roman Pot Si Edgeless detector

- Very High Resistivity Si n-type <111>, 300um thick, Vdep=20V
- Standard planar technology fabrication / dicing with diamond saw
- Single sided detector, 512 microstrips (pitch 66um)
- strips at 45° from the sensitive edge
- AC coupled (punch-through)





Pitch adapter on detector
(VFAT / APV25 compatible)

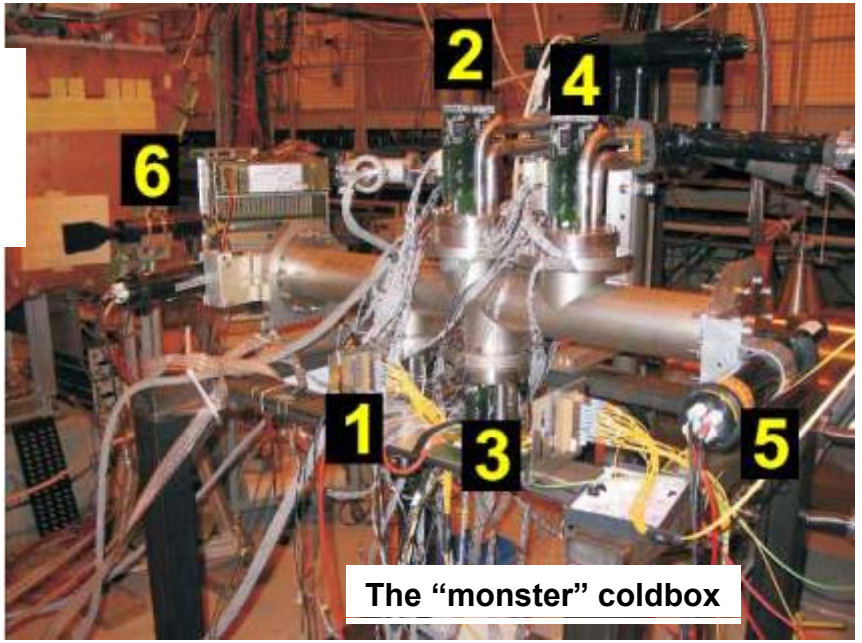


Measurement of leakage (bulk) current
70 nA at 200 V

performance at the edge

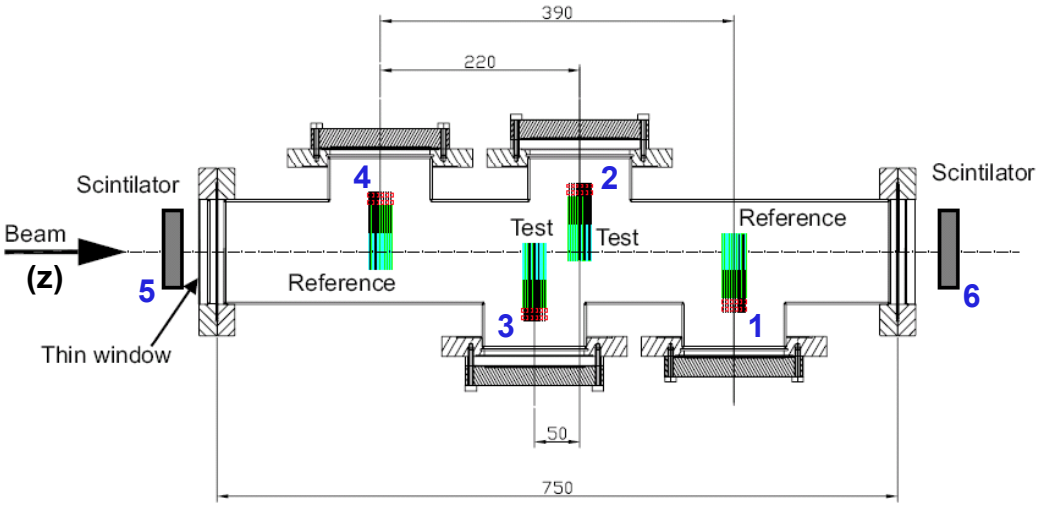
- Testbeam with muons (cern, X5)
- 4 prototypes of RP Detectors Packages with APV 25 chip
- Packages (mis)aligned along the beam axis
- The whole hosted in a coldbox for a (T_{sensor}= -10°C)

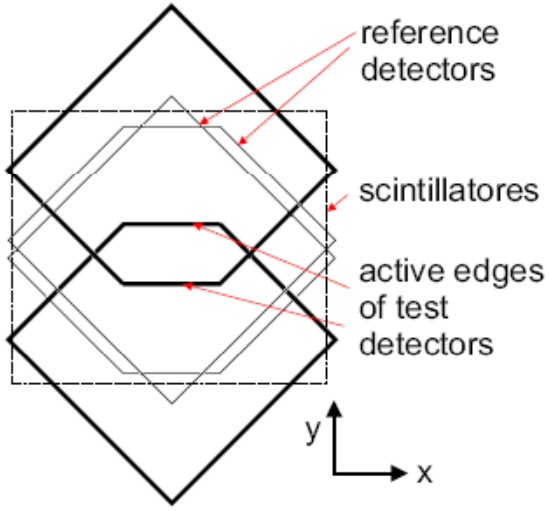
Detector Package (6 tracking and 2 trigger planes)



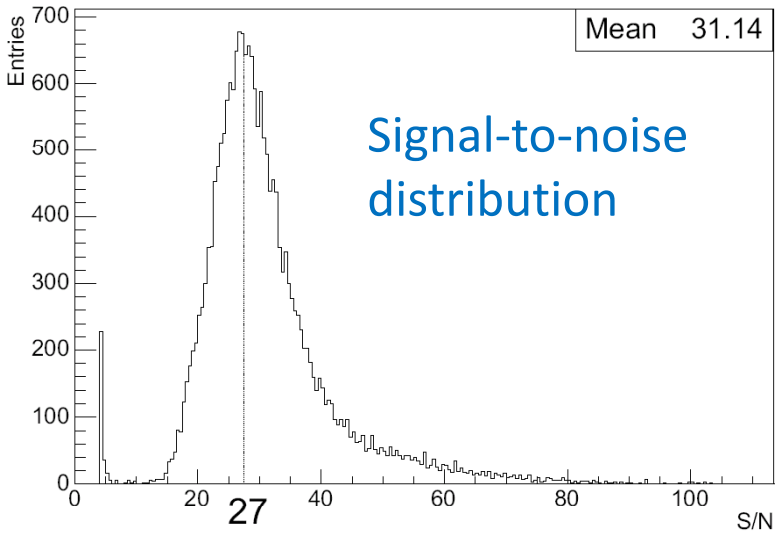
The “monster” coldbox

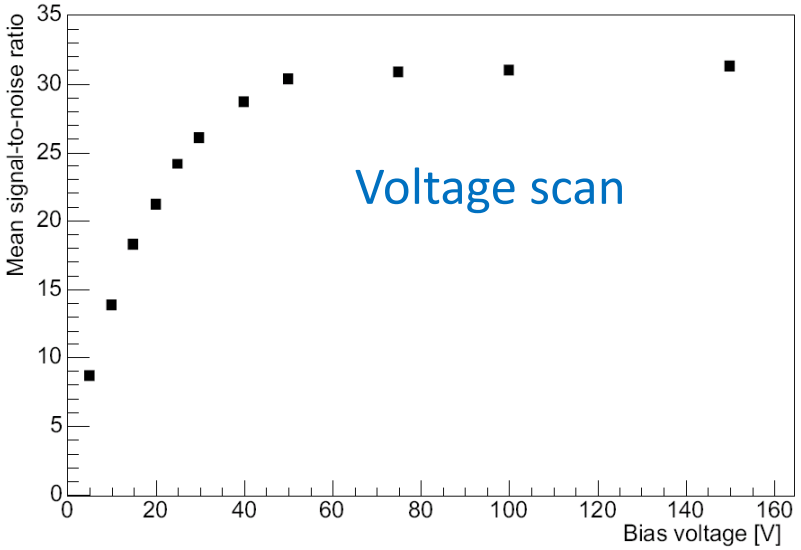
Orientation and overlapping of the 4 detector packages optimized two study the edges on the two internal packages

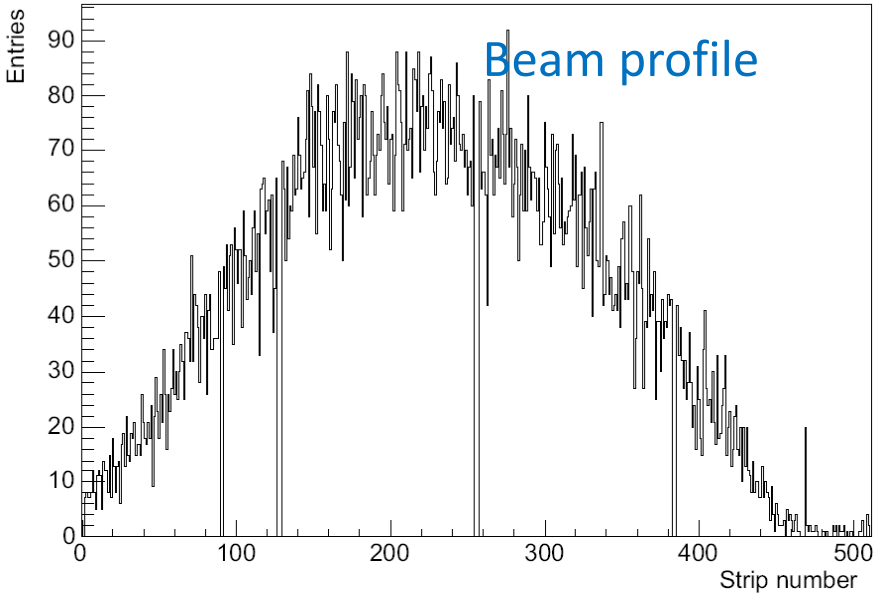




Signal in Edgeless detectors, 100 V

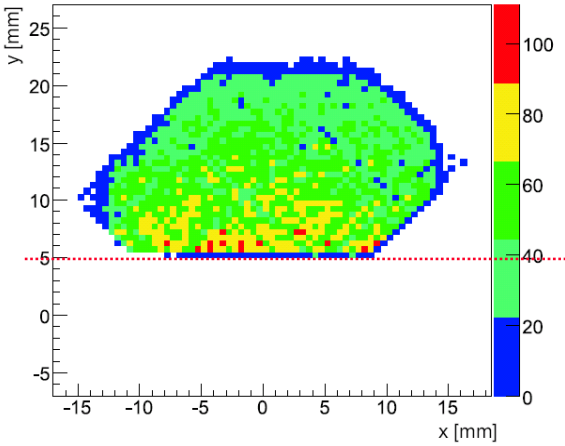






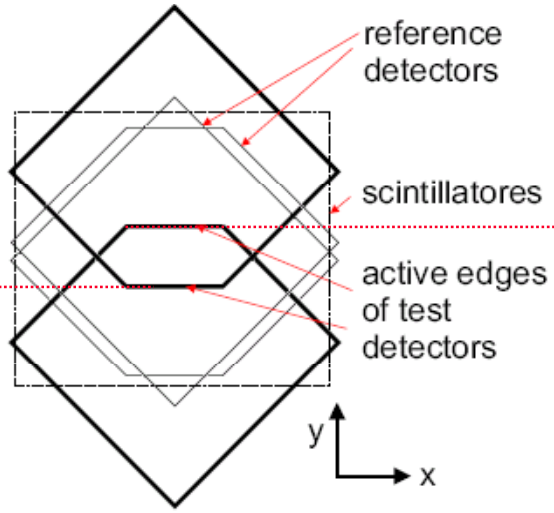
Efficiency and resolution

Top test detector

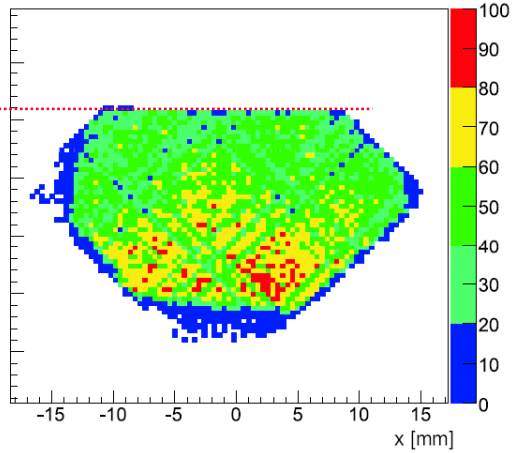


*bins are 0.5 x 0.5 mm^2

Accepted tracks in the test detectors

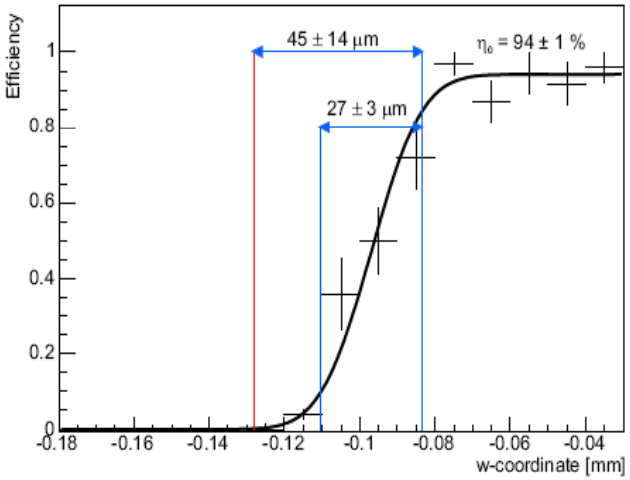


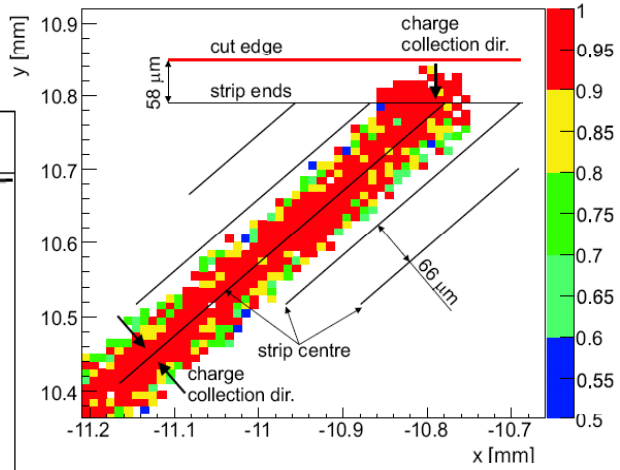
Bottom test detector



Strip charge sharing map

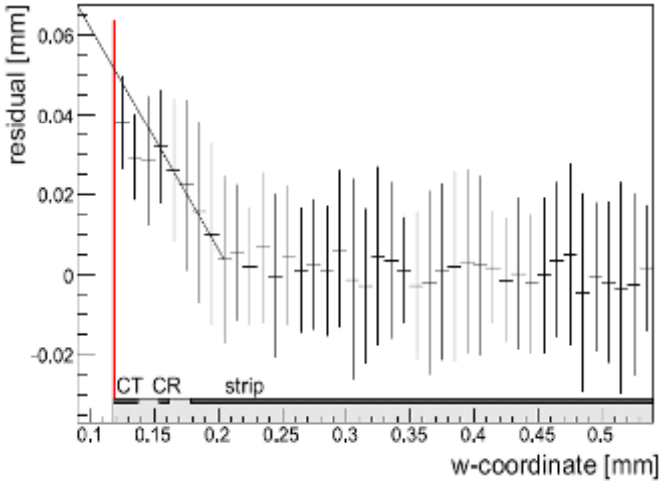
Efficiency at the edge





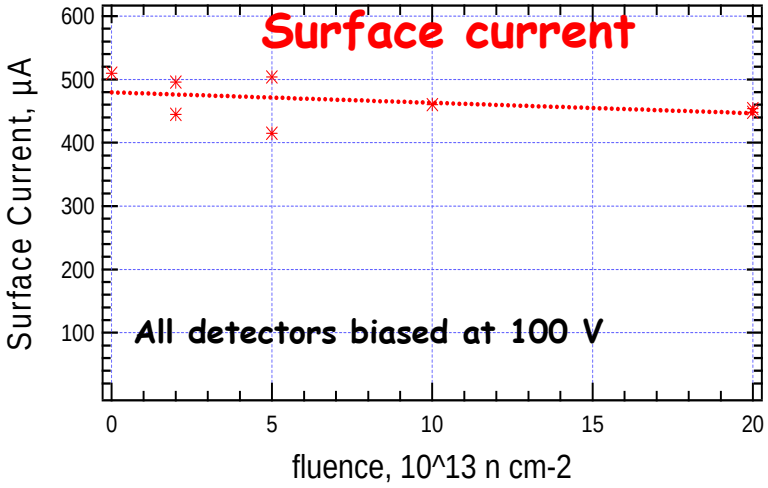
$$\varrho = Q_{\mathrm{Mainstrip}}/Q_{\mathrm{Cluster}}$$

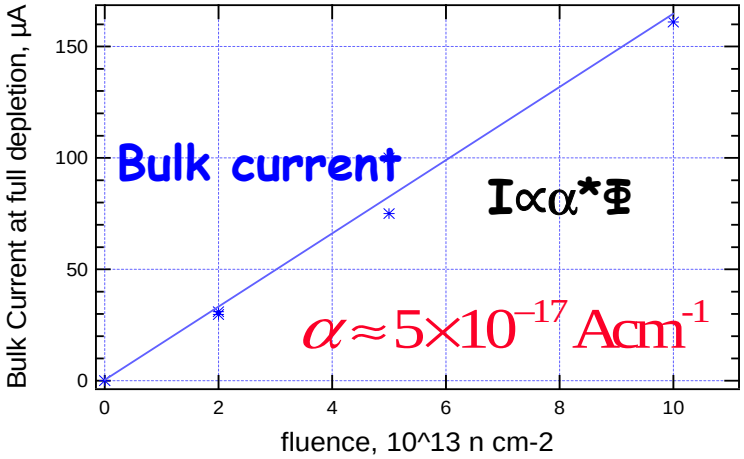
Residual profile



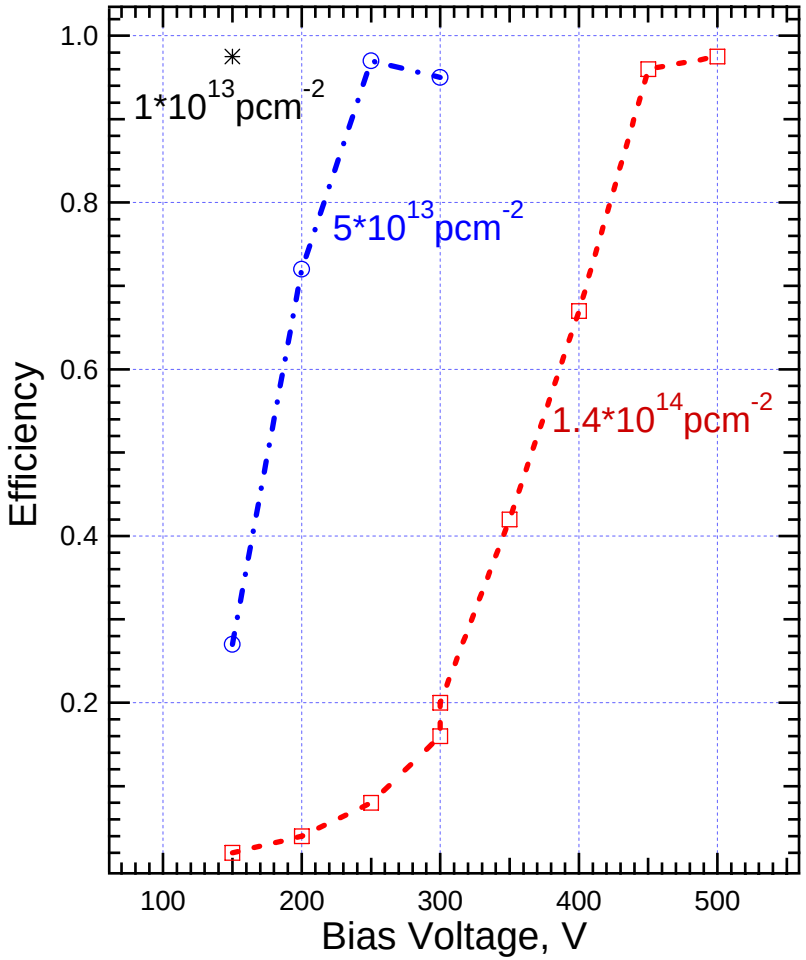
Radiation hardness?

Test samples 1cm² / 1MeV neutrons





Real devices/ 24 GeV protons



Data from a recent test beam (muons, H8) comparing hits with a non irradiated detector superposed on the beam axis

At the tested fluences these edgeless detectors seem to behave as standard p^+-n strip detectors

Radiation harder?

Further studies on radiation hardness are ongoing.

Lately a Consortium under INTAS umbrella (groups from Barcelona CNM, University of Bologna, CERN, Lappeenranta TU, Ioffe St. Petersburg, RIMST Zelenograd) has joined together to mainly address radiation issues for Planar Edgeless Detectors with CTS (TOSTER Project).

- **Study of electric field at the edge with differt experimental tests**
- **Test of different cut techniques**
- **Simulations of the detector behaviour starting from the data acquired**
- **Extrapolation at high dose**
- **Design optimization**

(Part of the story can be read at the poster by E. Verbitaskaya)

Fabrication of Edgeless detectors with Czochralski material, with an adapted CTS design

We will see…


TOTEM