Test Beam Results of Proton Irradiated Czochralski Silicon Strip Detector

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Outline

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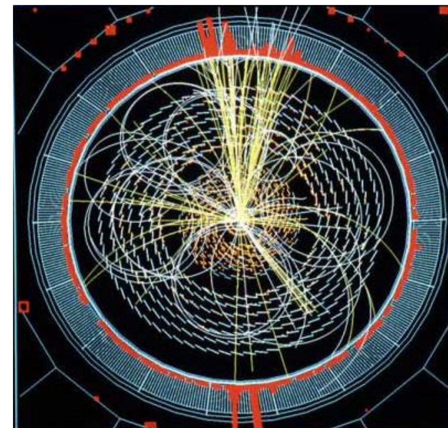
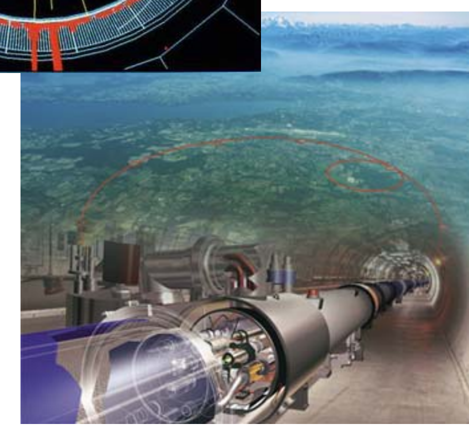
- Conclusions

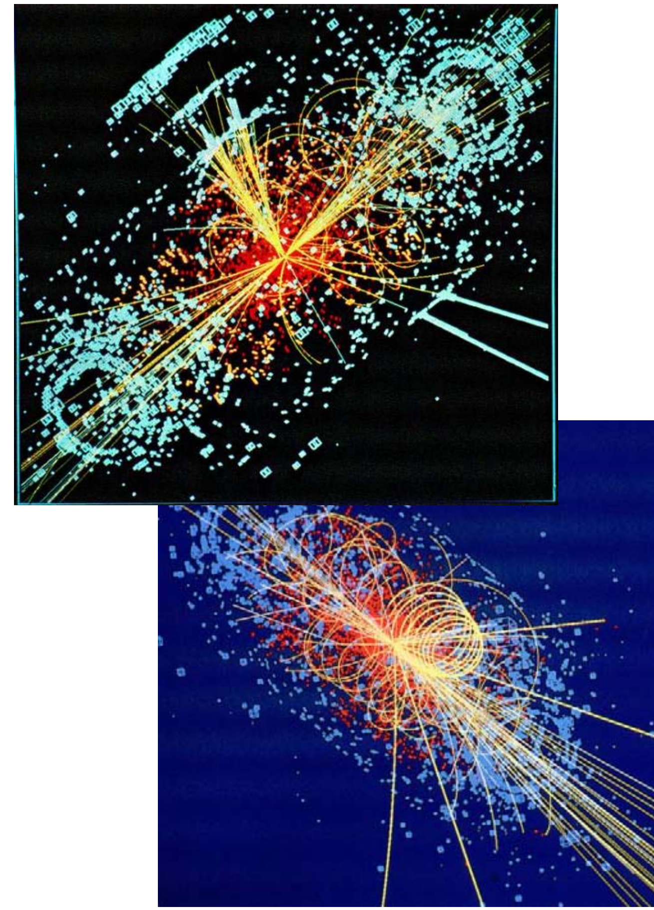




Motivation and background

In the summer 2003 we tried to test an irradiated ($1.6*10^{14}$ 1-MeV neutron equivalent fluence) large-area (32.4 cm^2) Czochralski silicon strip detector in a beam, but did not succeed, because there were problems with the beam telescope DAQ.

This year we wanted to find an explanation to the problems seen the year before and in addition to see if the irradiated Czochralski detector still can detect particles after 1 year annealing at room temperature.



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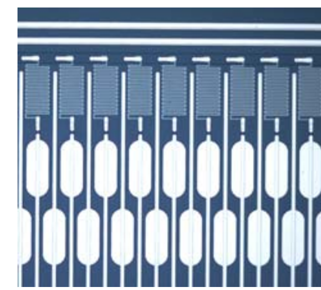
Device processing



The tested device was processed at the Helsinki University of Technology Microelectronics Center with a simple process containing:

- four lithography steps, two thermal oxidations, two ion implantations and three sputter depositions.

The size of the AC-coupled detector was 32.4 cm^2.
The width of the 1024 p^+-strips was 10 μm, length 6.154 cm and pitch 50 μm.

The detector silicon substrate was grown with Magnetic Czochralski method

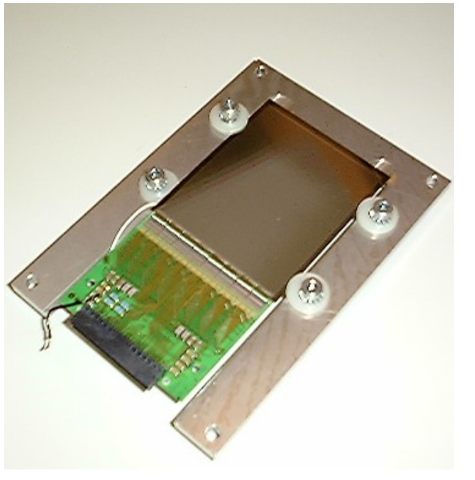
- nominal resistivity 900 Ωcm,
- thickness 380 μm,
- orientation <100>,
- oxygen concentration <10 ppma

After processing, the detector was measured to deplete at 420V and its leakage current to be 2.3 μA.

The detector was irradiated at the Jyväskylä University Accelerator Laboratory with 10 MeV protons to a $1.6*10^{14}$ 1-MeV neutron equivalent dose.

After the irradiation the depletion voltage (225V) and the leakage current (261μA) was measured in -10°C.

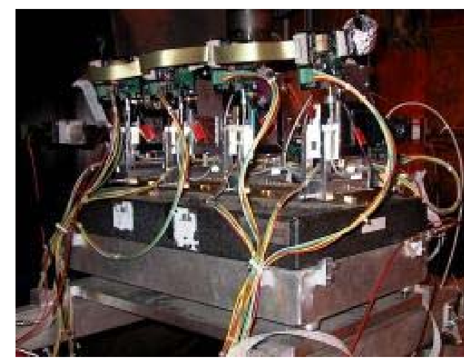
For the beam test, the detector was attached to a hybrid that contained 8 VA1 chips.



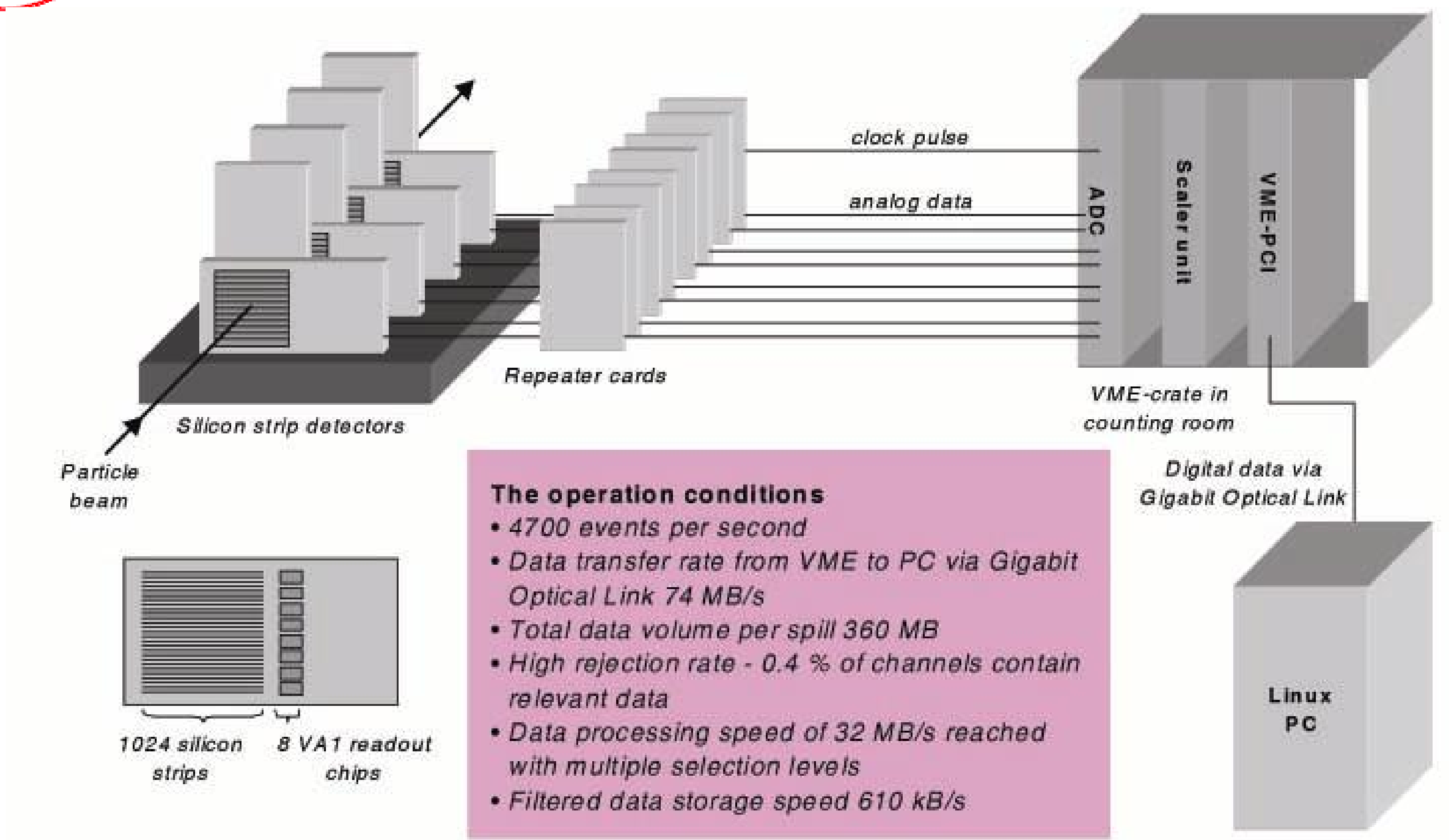
Silicon Beam Telescope

The Silicon Beam Telescope measured the tracks of incoming particles and it provided the reference tracks for the detector characterization.

The telescope consisted of pairs of horizontal and vertical position sensitive silicon detectors attached to read-out electronics and a data acquisition system that was realized with Linux based C++-code using object oriented techniques.



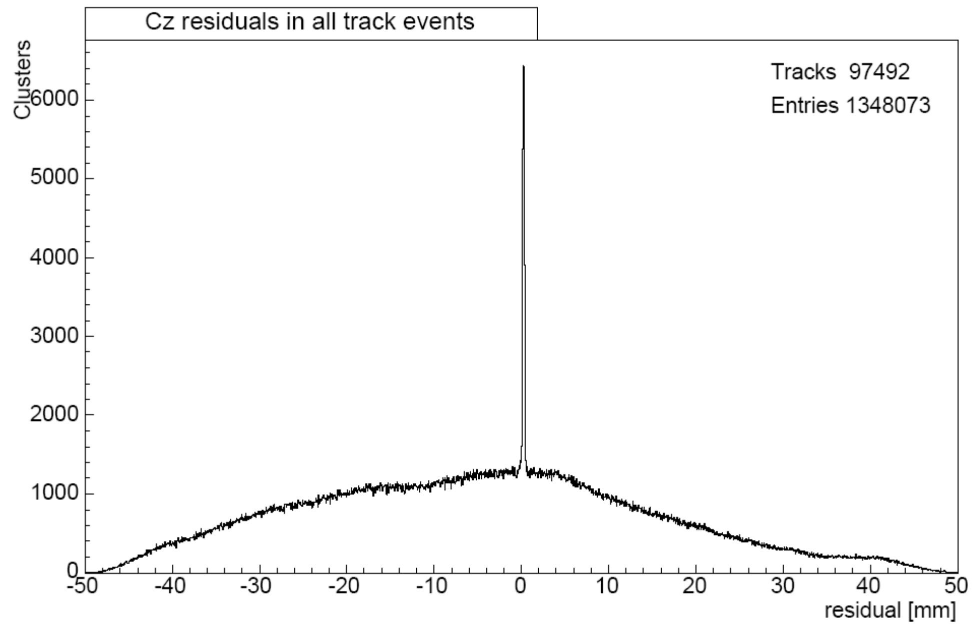
The offline analysis of the collected data was performed with a dedicated object-oriented software package.



Courtesy to L.A. Wendland

Results

- Resolution 42 μm
- Efficiency 29%
- Ratio of S and N clusters near track 5.8
- S/N 3.0
- Correlation of noise for adjacent strips 20.4%
- Correlation of noise for next-to-adjacent strips 18.2%



Residuals of CZ.

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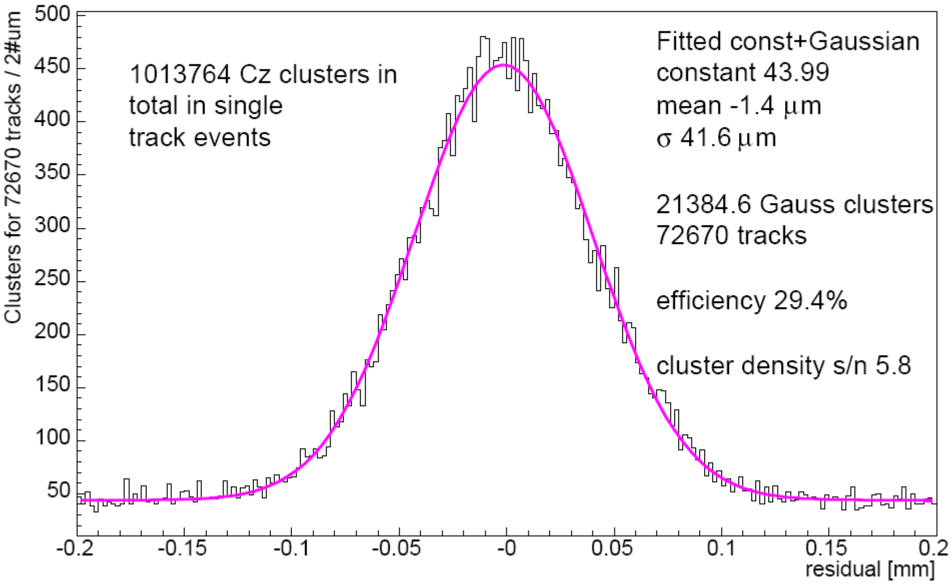
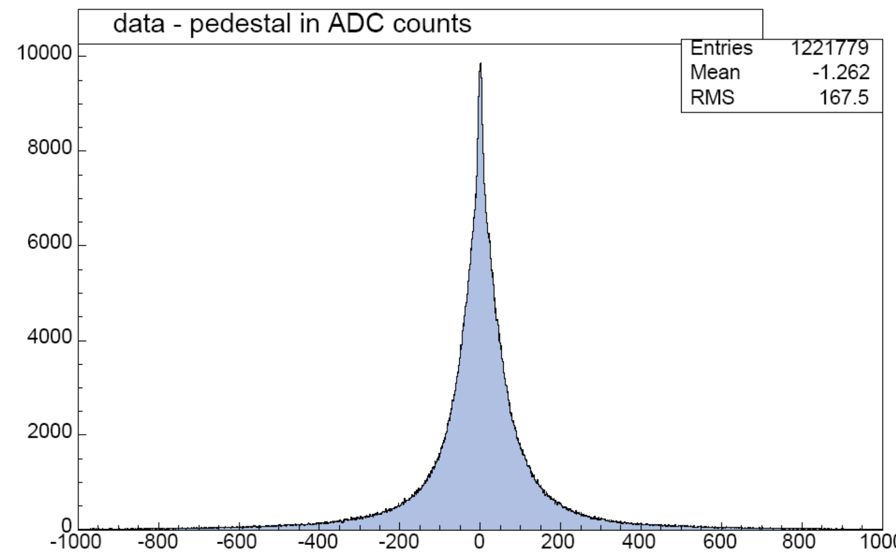
Results



Residuals and efficiency of the CZ



Raw data values recorded outside a Spill. Why doesn't this follow the normal distribution?

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Results

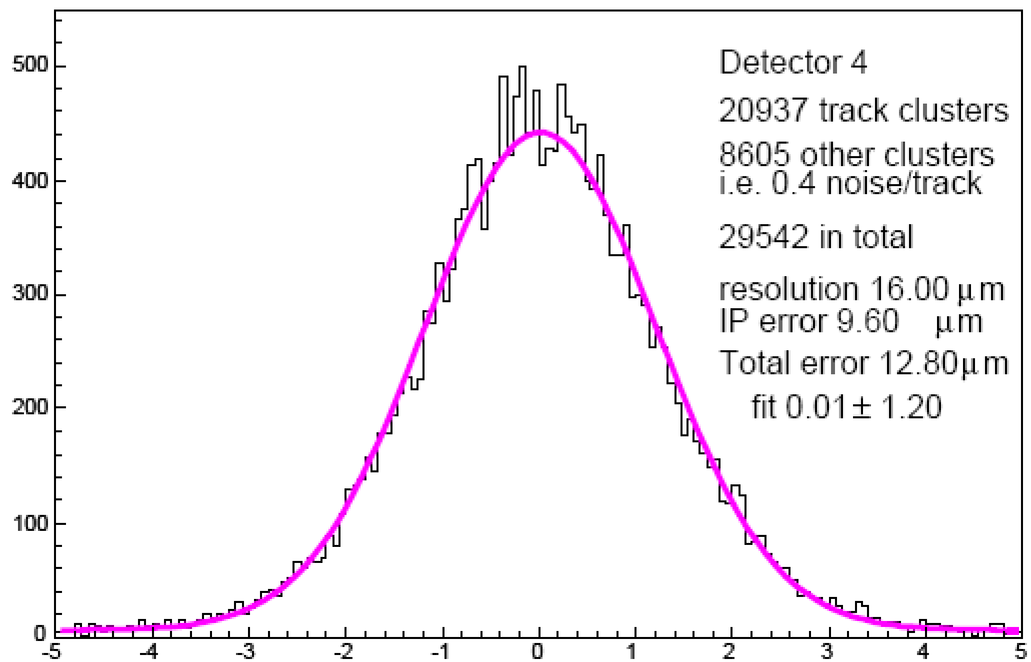
Signal-to-noise ratio was defined by calculating the signal value for each cluster related to a track (residing within ±2σ of CZ resolution from the interpolated impact point of the track) by summing over the signal values of the strips ($S=S_1+S_2+..+S_n$).

When there is no correlation between strips, the average strip-wise noise is:

$$\overline{\sigma} = \sqrt{\frac{1}{n}\left(\sum_i \sigma_i^2\right)}$$

The S/N value is then obtained by dividing the average signal by the obtained average noise. If no correlation is taken into account the value is 2.84. However there is a correlation between strips, so when this is taken into account a value of 2.99 is obtained.

Results



Residual pull of the resolution analysis

As a reference, a non-irradiated detector made of FZ with the same design than the *CZ*, had a resolution of 16 *µm*.

So why is the resolution of the irradiated *CZ* detector as large as 42 *µm*?

Conclusions

We tested an irradiated large-area silicon strip detector processed on Magnetic Czochralski silicon wafer using Helsinki Silicon Beam Telescope at CERN H2 area.

We verified that even after $1.6*10^{14}$ 1 MeV neutron equivalent irradiation fluence and annealing 1 year at room temperature the detector detected particles.

Its S/N ratio was 3, its resolution 42 μm and efficiency ~29%.