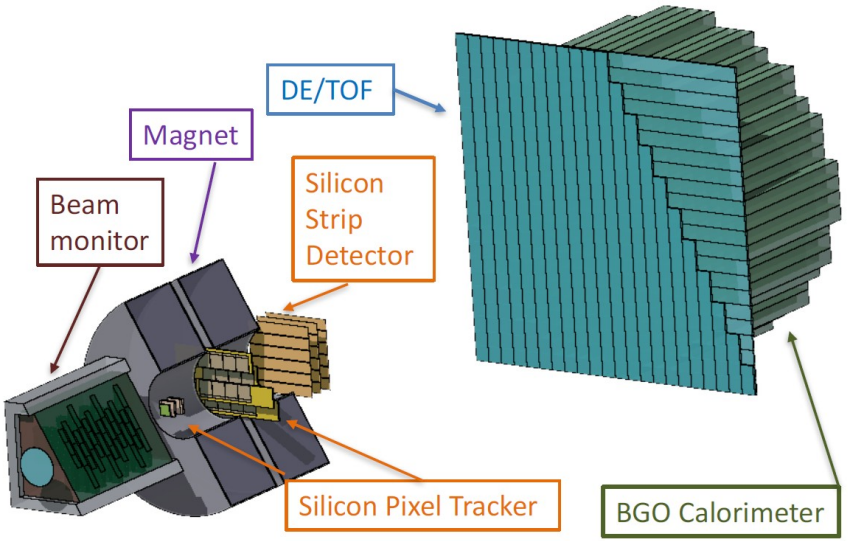
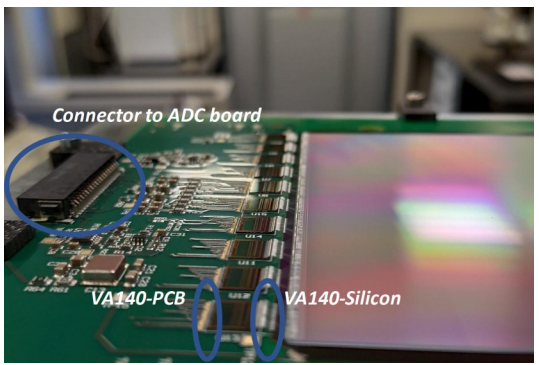
Characterization of FOOT silicon microstrip detectors with protons.

L. Servoli on behalf of Perugia MSD group

FOOT experiment

An experiment to measure differential nuclear fragmentation cross-sections for Particle Therapy & Radioprotection in Space.

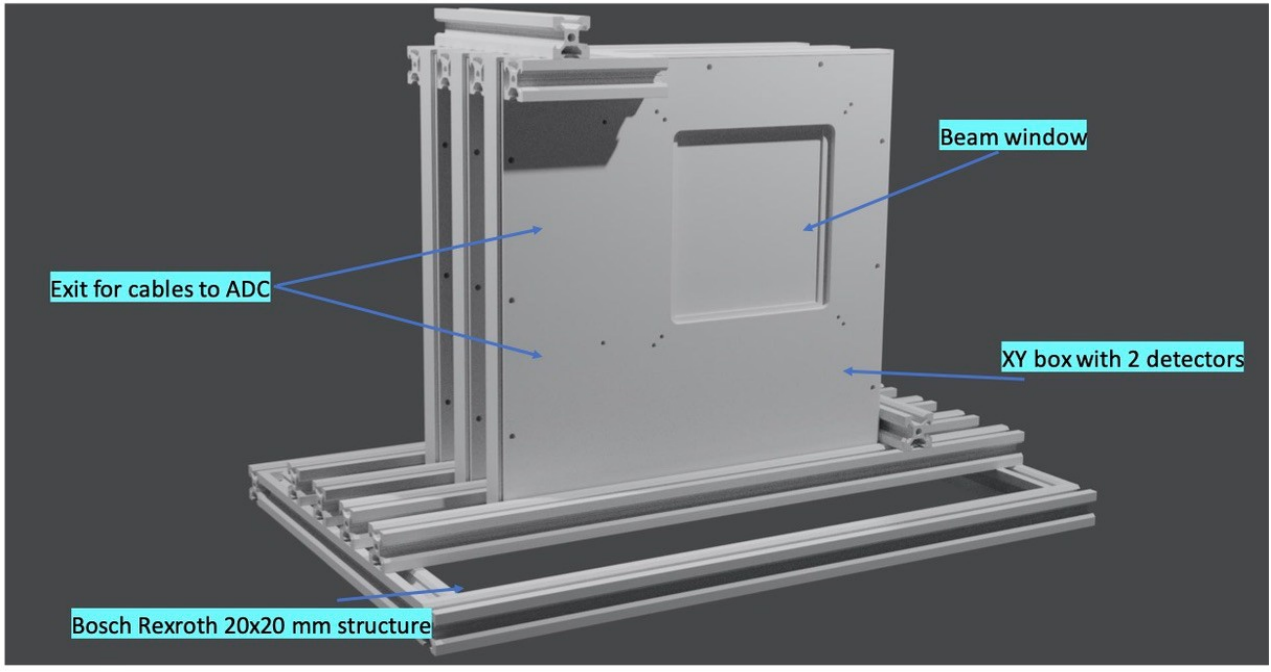




***MSD** is the Silicon Strip Detector after the magnets, for measuring the charged fragment positions (momentum) and their dE/dx.*

MSD detector

1) three layers of single side silicon microstrip detectors, each one composed of 2 sensors for the x-y position measurement.



2) 150 μm sensor thickness, 150 μm strip pitch.

3) readout by 64-channels IDE1140 chip.

Test at Trento proton beam line

Why we have used the Trento proton beam line?

→ Protons of right energy for clinical use (228 MeV) and almost MIP.

→ Possibility of protons with smaller energy to allow higher dE/dx (down to 50 MeV with degrader)

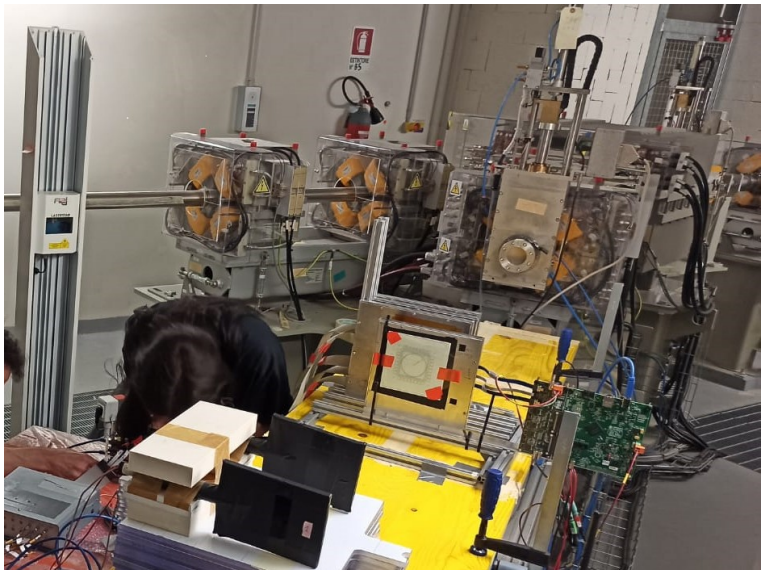
→ Possibility to leave the setup without removal for the entire test period.

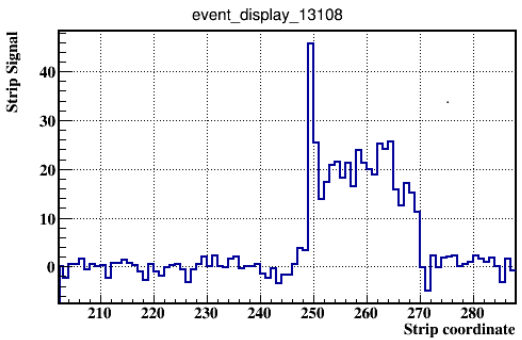
Several tests: 2019, 2021, 2023.

MSD: typical setup for tests

Typical standard configuration:

- *Beam window*
- *devices under test*
- *scintillators for trigger*

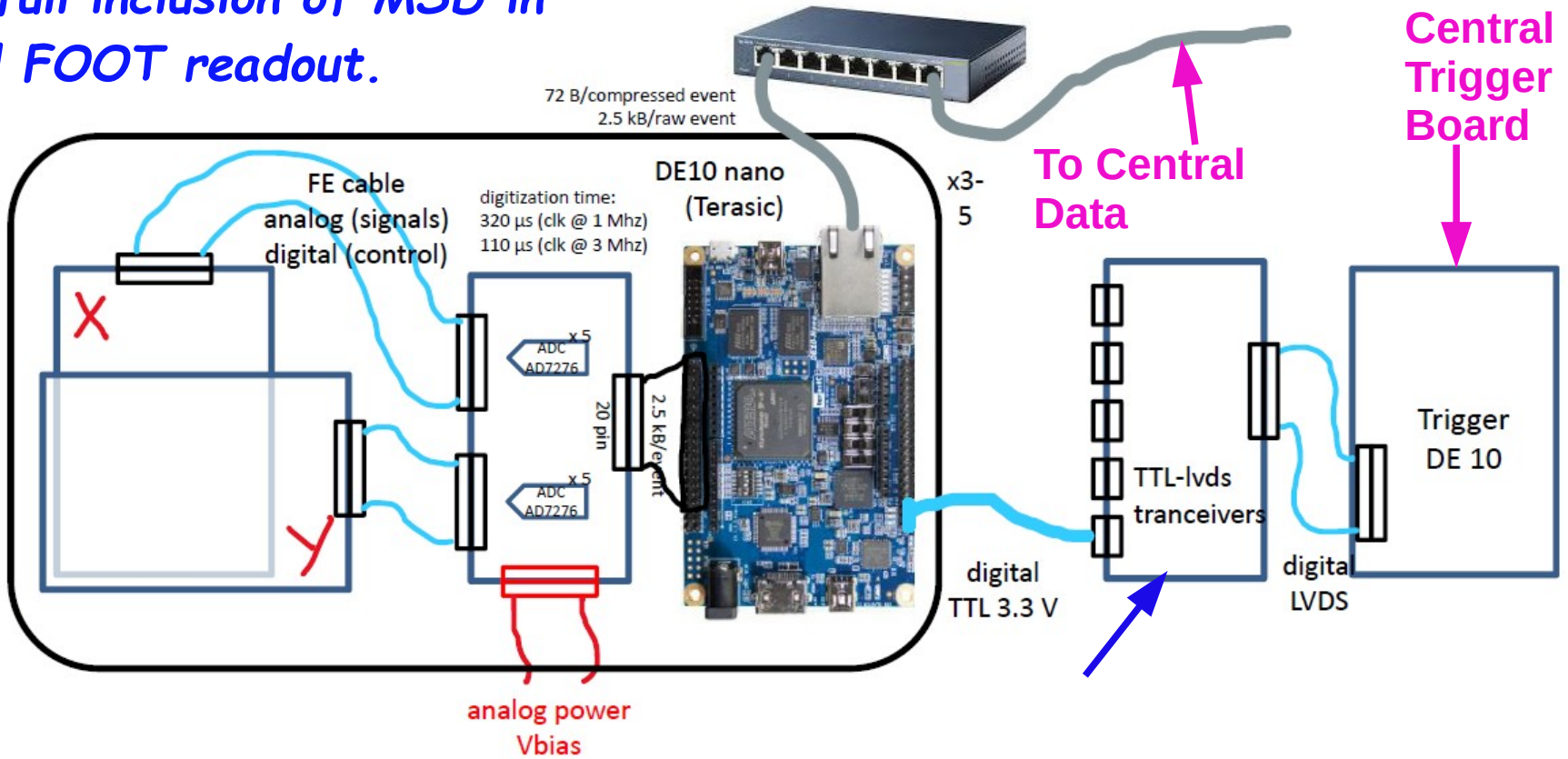




Once we inclined the sensors to study the passage of protons through several strips to measure dE/dx distribution.

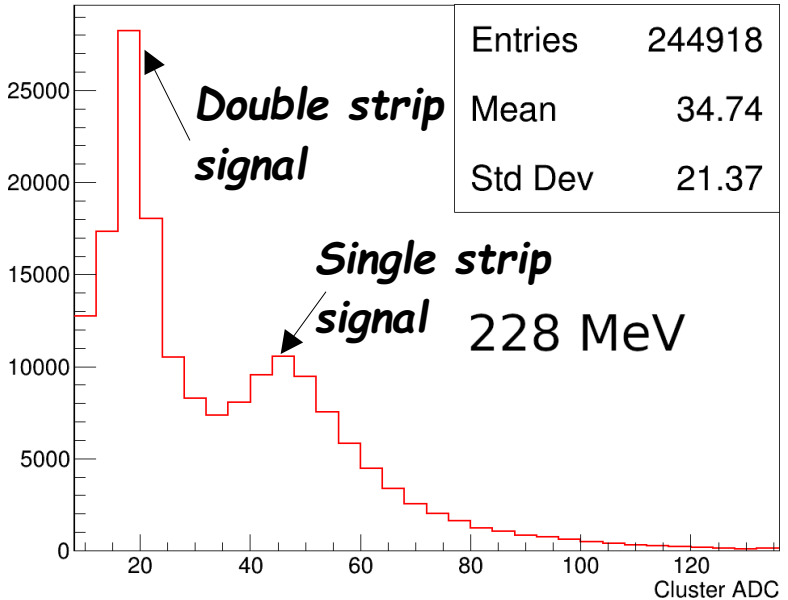
MSD: results from Trento beam tests

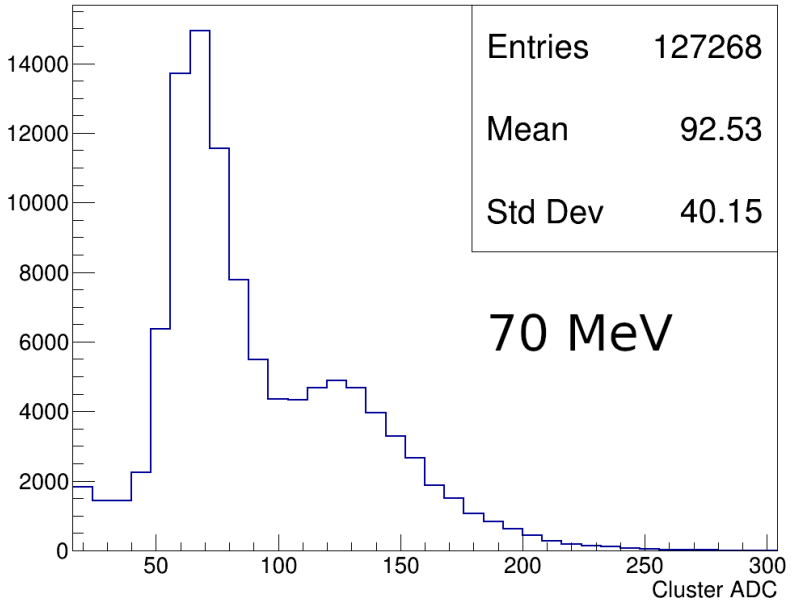
→ *Succesfull inclusion of MSD in general FOOT readout.*



MSD: results from Trento beam tests

→ *Determination of proton signal on sensors at different beam energies*

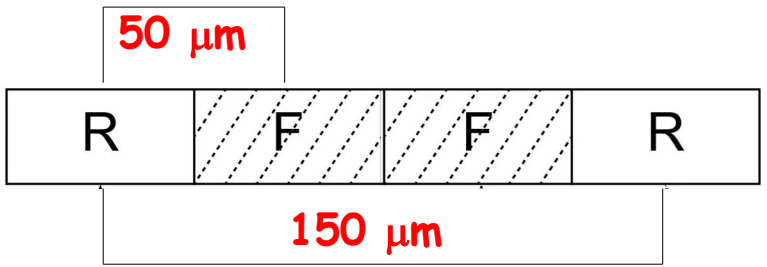


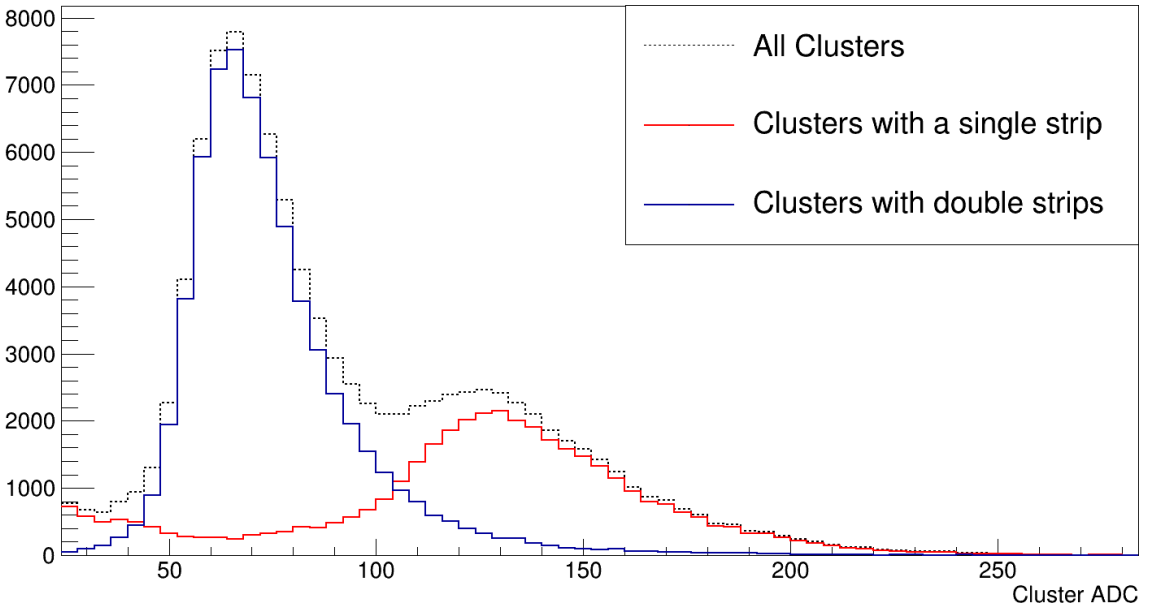


Two peaks response is due to the floating strips configuration chosen:
1 over 3 strip readout. → different CCE according to position

MSD: results from Trento beam tests

→ *Two strip clusters collect less signal due to the different capacitive coupling*

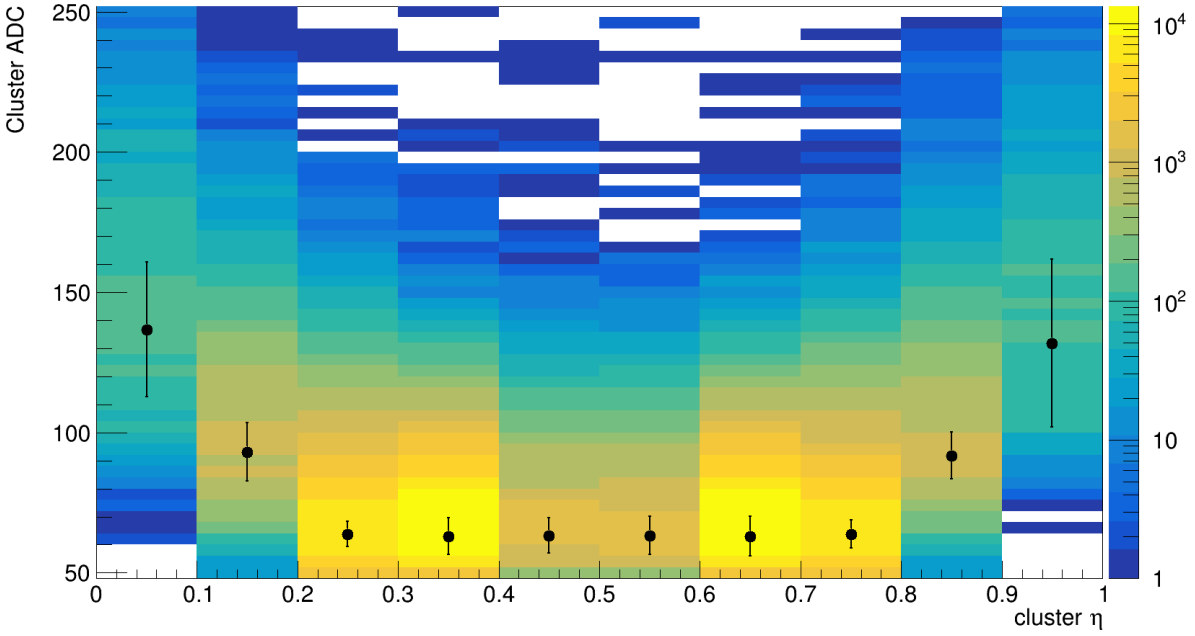




MSD: results from Trento beam tests

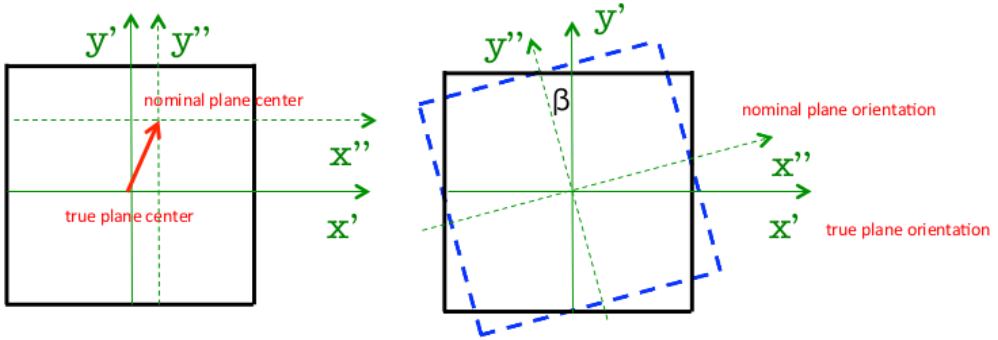
→ *dE/dx distribution as a function of proton position among two readout strips for 70 MeV protons.*

[η-function correction]



MSD: results from Trento beam tests

→ *Spatial Resolution* *[no η-function correction]*

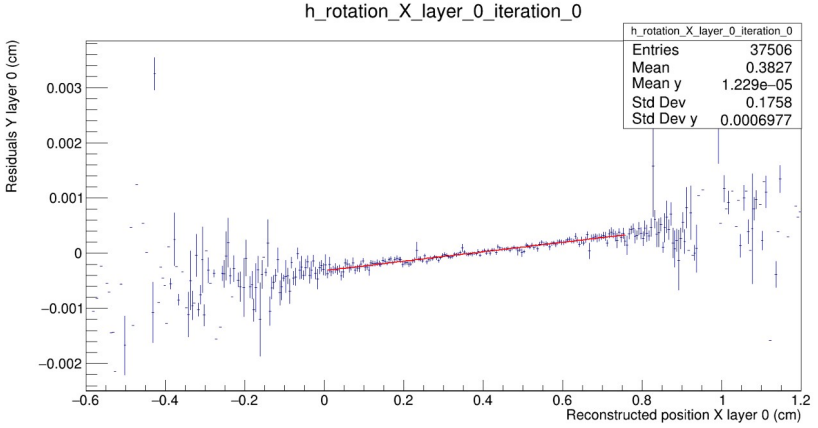


$x'' = x' - dx$
$y'' = y' - dy$

$x'' = \cos(\beta)\, x' - \sin(\beta)\, y'$
$y'' = \sin(\beta)\, x' + \cos(\beta)\, y'$

→ *determination of offsets and rotation around beam axis*

No esternal telescope



→ *Several iteration after each correction (order of 200) to reach stability in results*

MSD: results from Trento beam tests

→ ***Spatial Resolution*** *[no η-function correction]*

MSD Plane	Resolution (μm)	Offset (μm)
1X	12.82	50.47
2X	12.75	100.9
3X	12.82	504.7
1Y	12.20	135.9
2Y	12.10	271.8
3Y	12.20	135.9

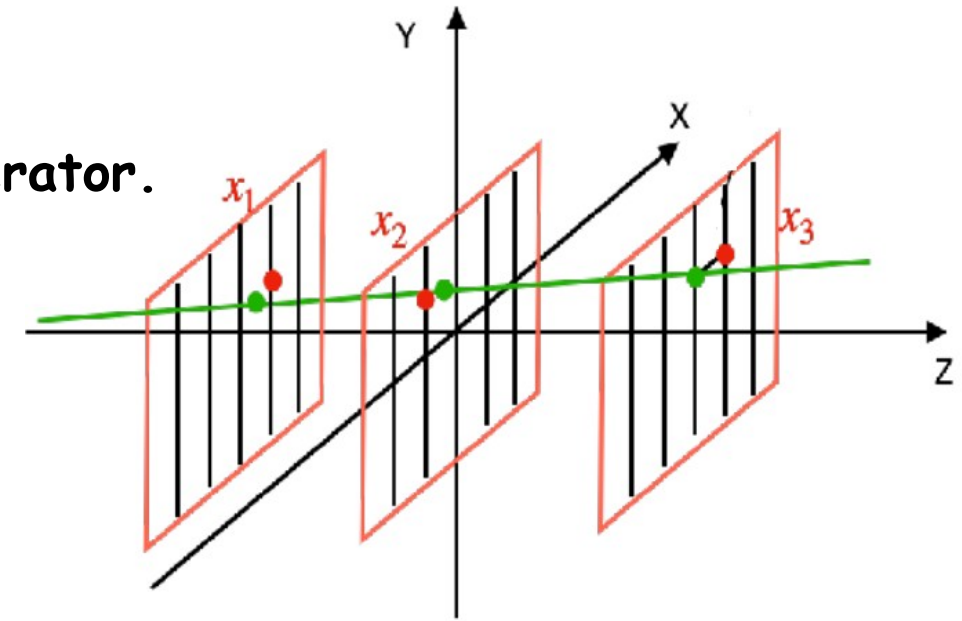
Single strip cluster resolution

$$\sigma_{1S} = 47.8\mu m \sim \frac{150\mu m}{\sqrt{12}} = 43\mu m$$

Multistrip cluster resolution

MSD: proton detection efficiency

→ single sensor proton detection efficiency:
In progress.
Data from 2021 MSD dedicated
data taking at Trento proton accelerator.



Thanks!!