

Energy Measurement of clinical proton beams with a telescope of Ultra-Fast Silicon Detector

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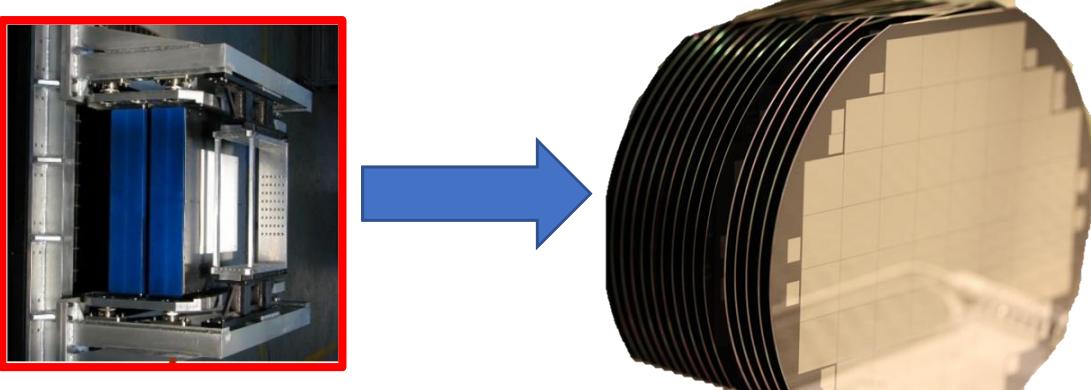
² now at FBK, Fondazione Bruno Kessler, Trento, Italy.



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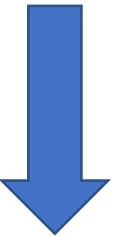


Motivation



Two devices are begin developed based on Ultra Fast Silicon Detector:

1. to **directly count** individual protons.
2. to **measure the beam energy** with Time-of-Flight techniques, using a telescope of two UFSD sensors
error < 1 mm range in water

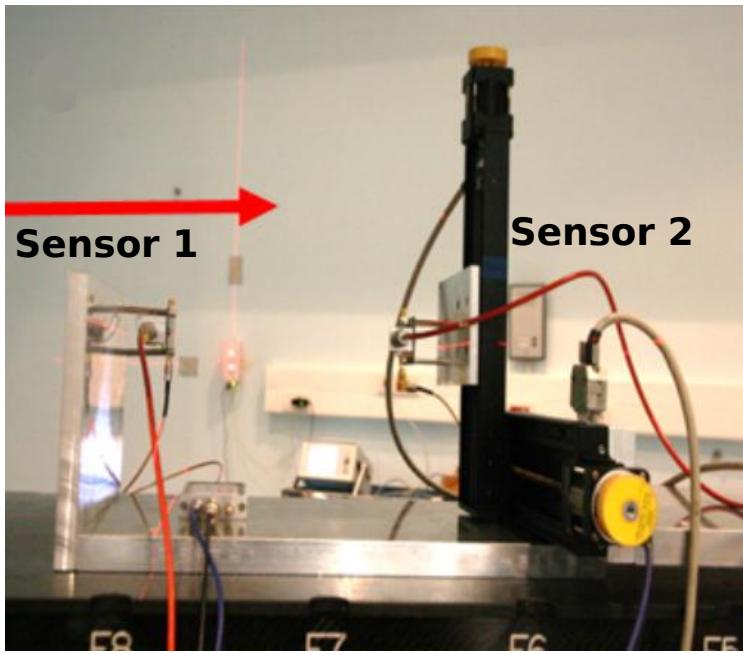
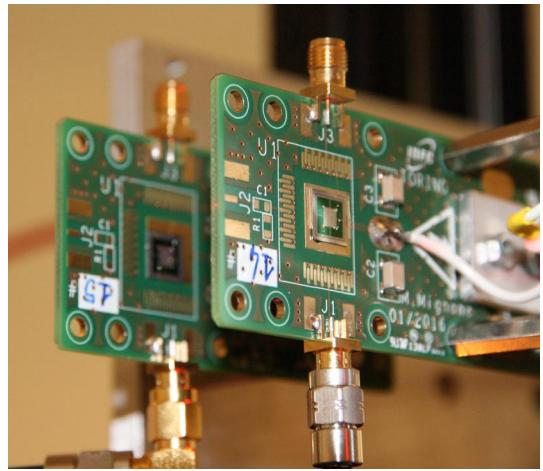
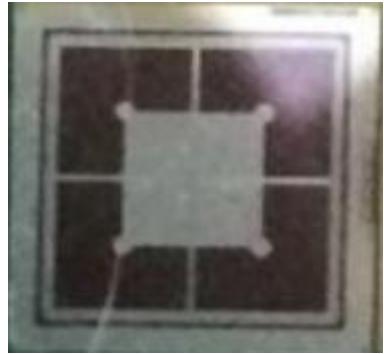


Clinical requirement

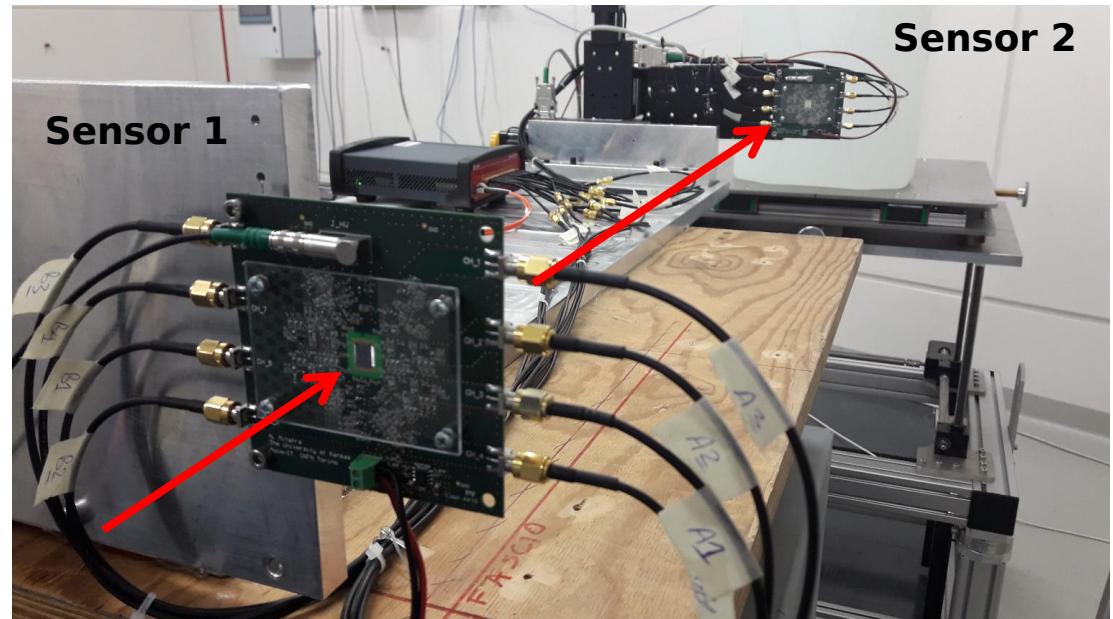
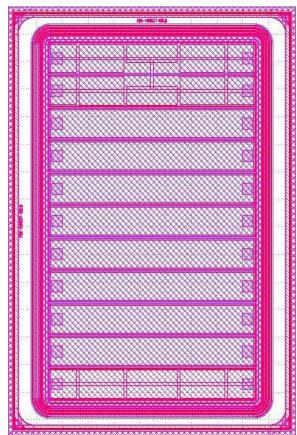
1 mm

98 % for fluxes up to $10^8 \text{ p/s} \cdot \text{cm}^2$

Experimental Setup used at CNAO



Hamamatsu 4 pad (3x3)
mm², 80 µm active
thickness



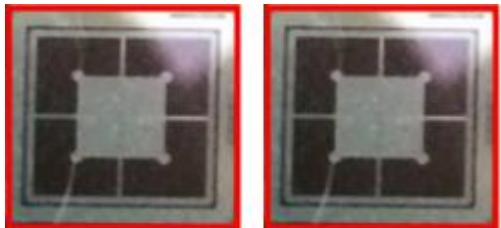
11 strips of 2.2 mm²,
pitch 600 µm, 50 µm
active thickness

Experimental Setup used at CNAO (cont.)

Beam test at
CNAO (A)

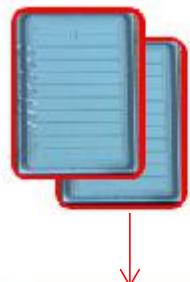
Beam test at
CNAO (B)

2 signals configuration



Two (CIVIDEC
broadband
40 dB amplifiers)

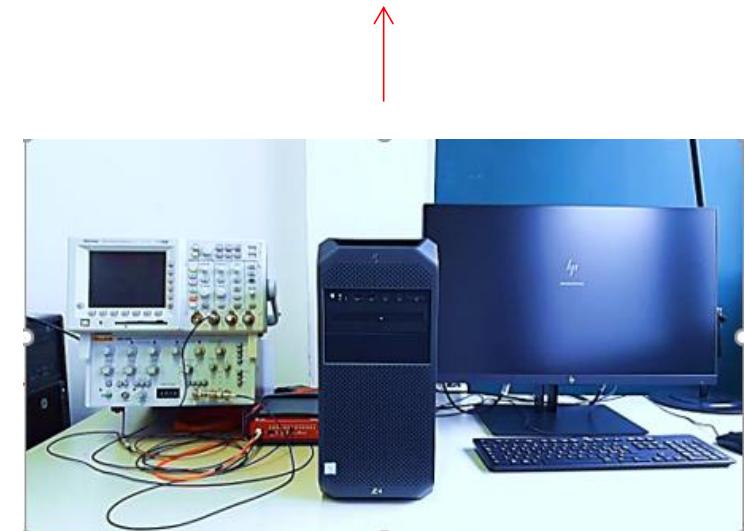
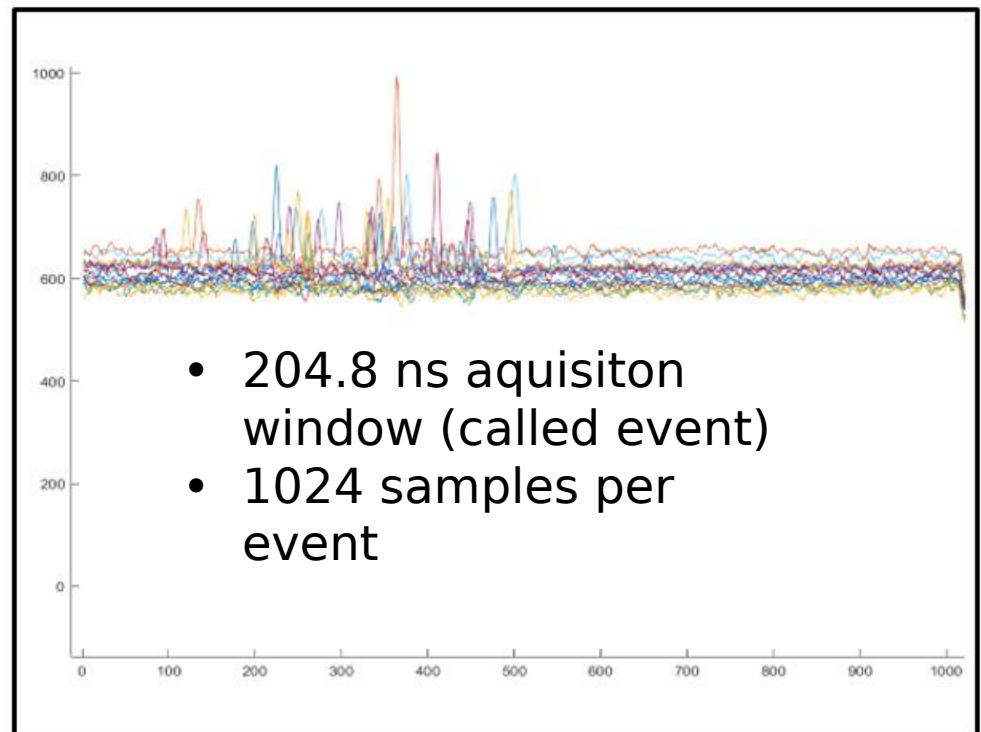
16 signals configuration



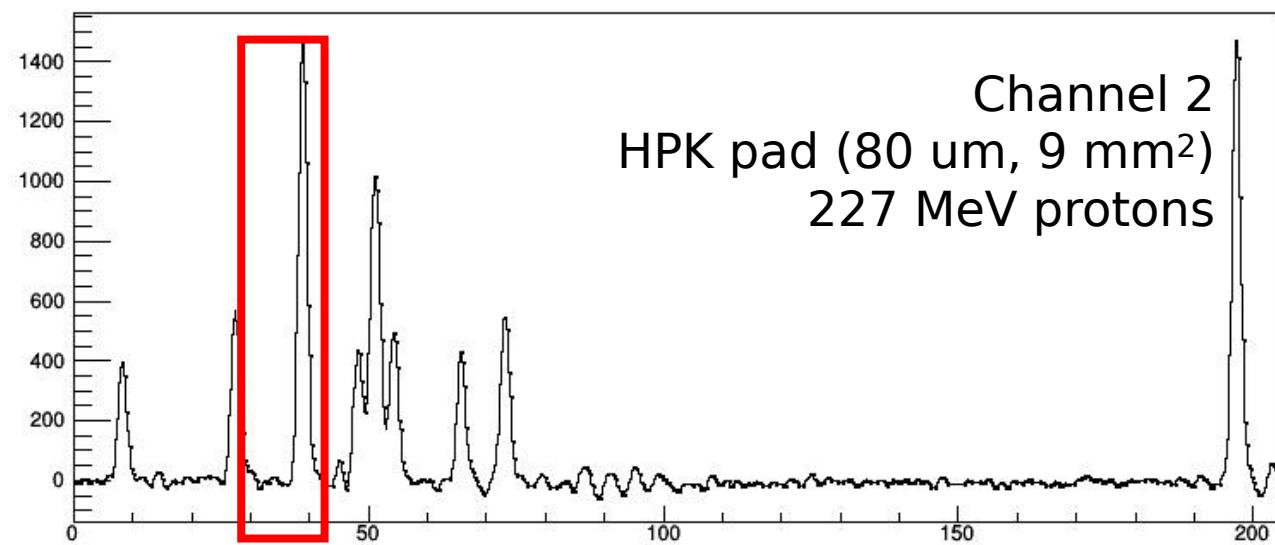
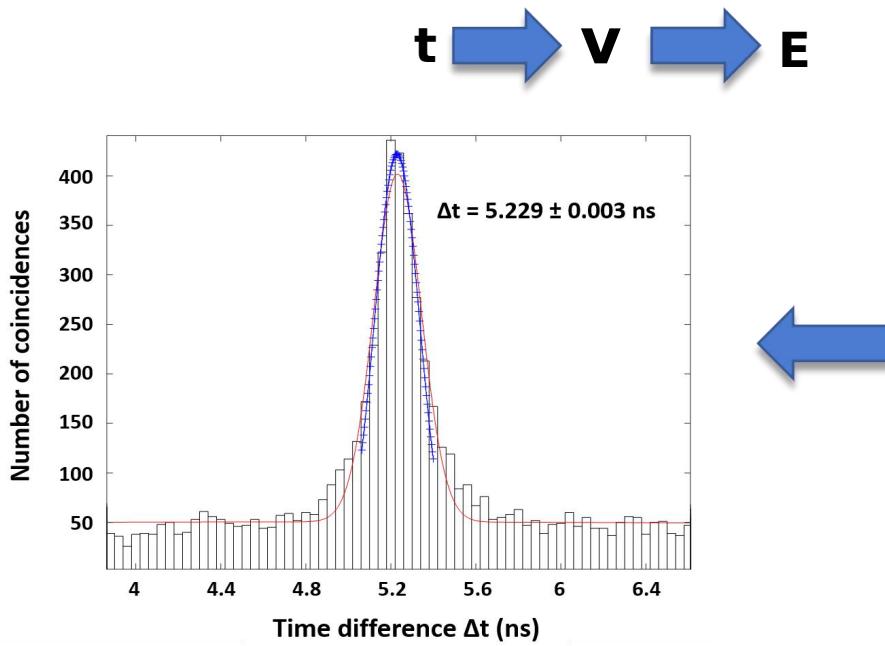
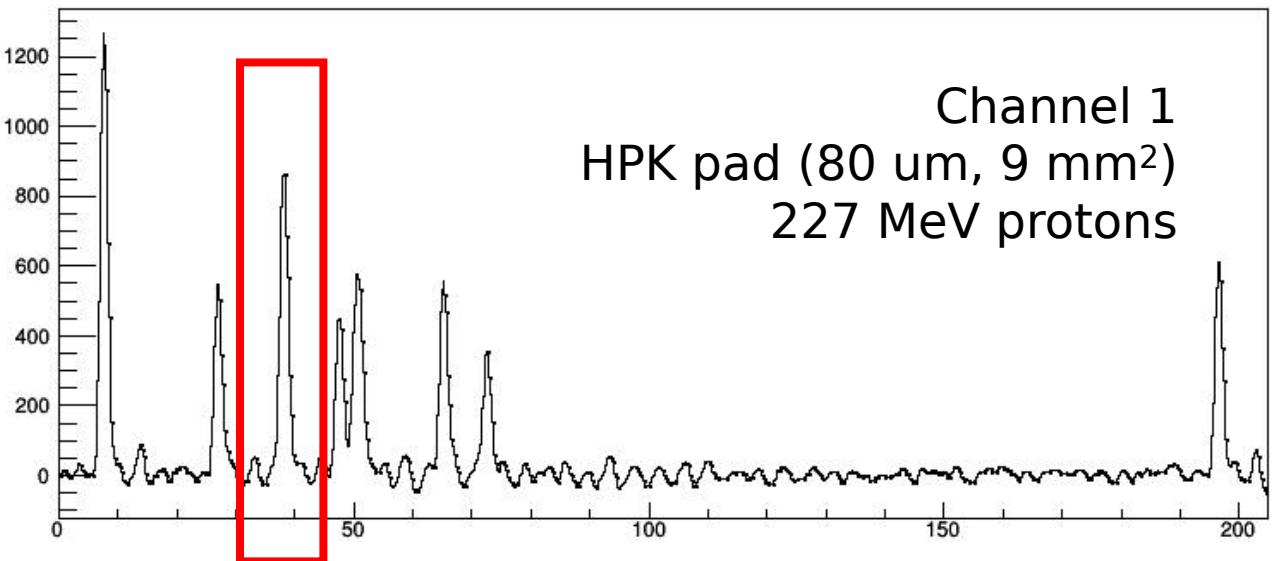
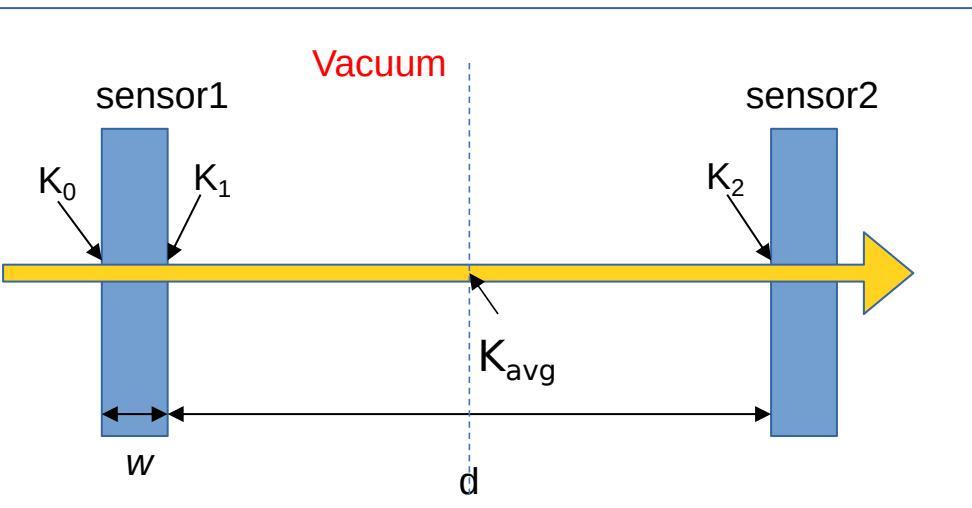
Two (8 channels
Minafra Board)



Optical link
(80 MB/s)



Energy measurement

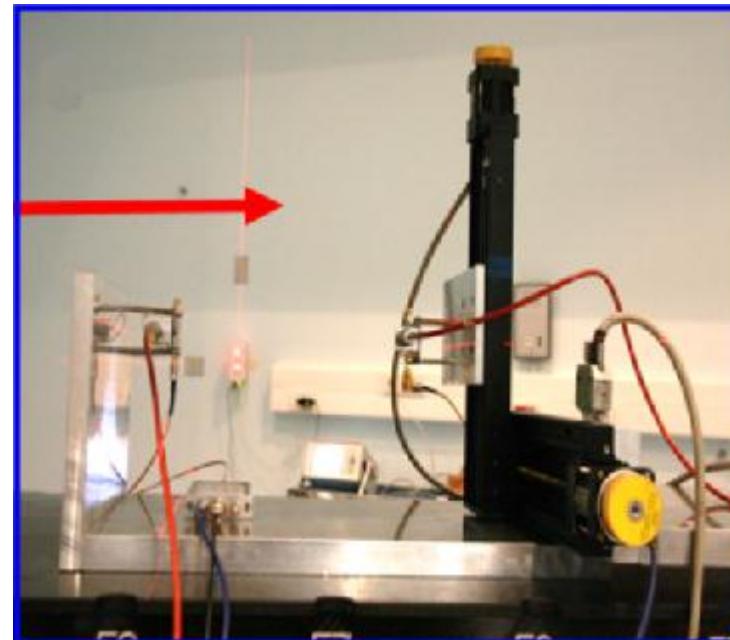


time [ns]

Beam tests at CNAO (Pavia-Italia)

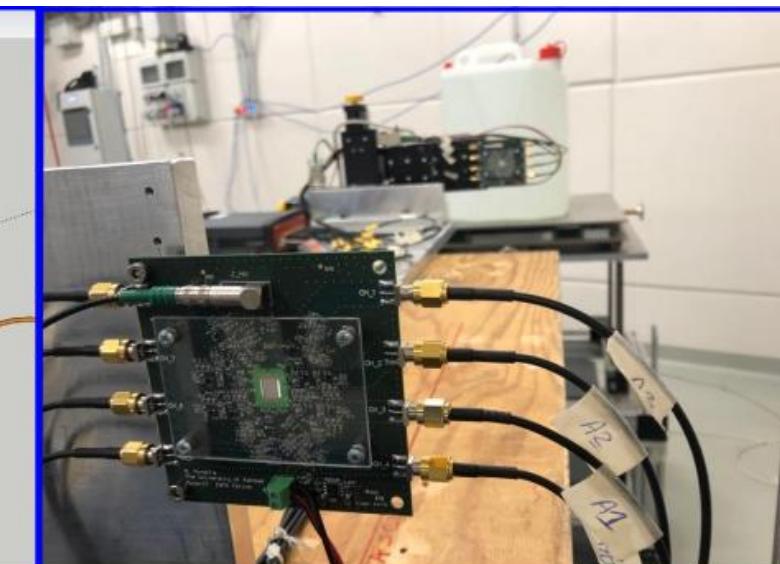
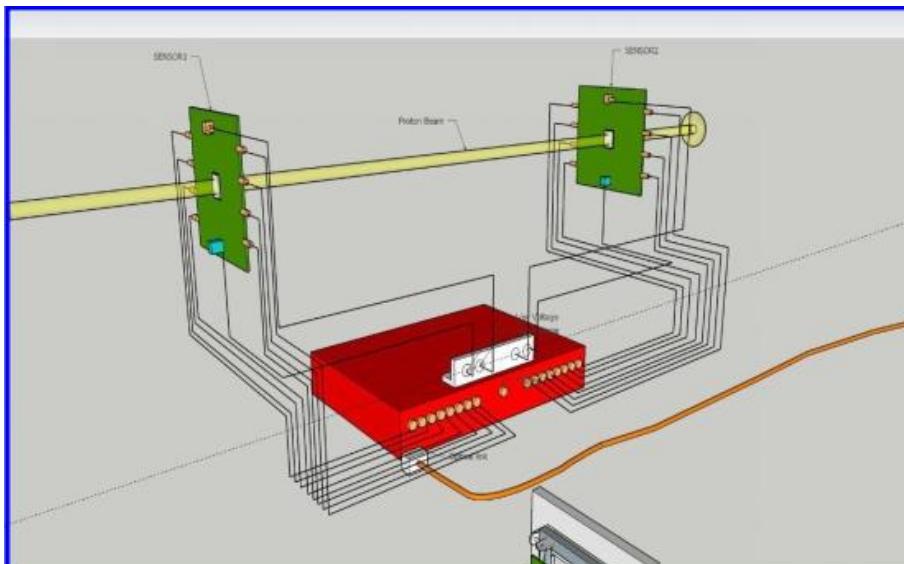
- 4 distances= 7, 27, 67, 97 cm
 - 5 energies= 58 - 227 MeV

Beam test at CNAO (A)



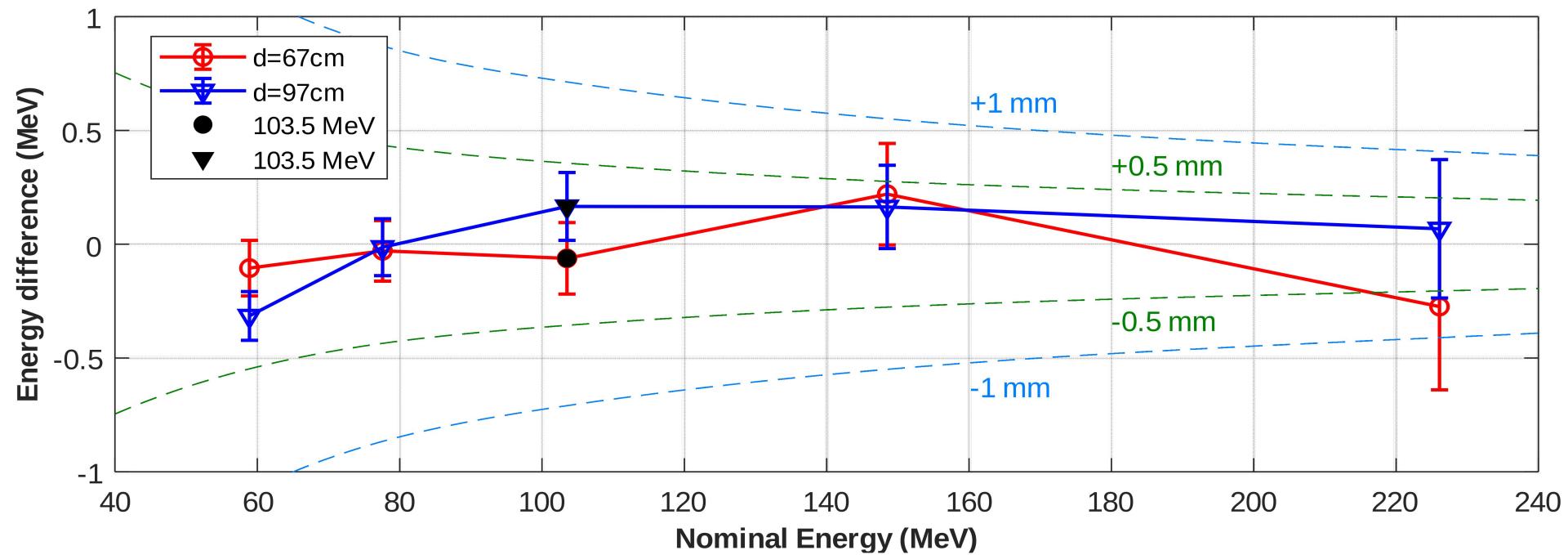
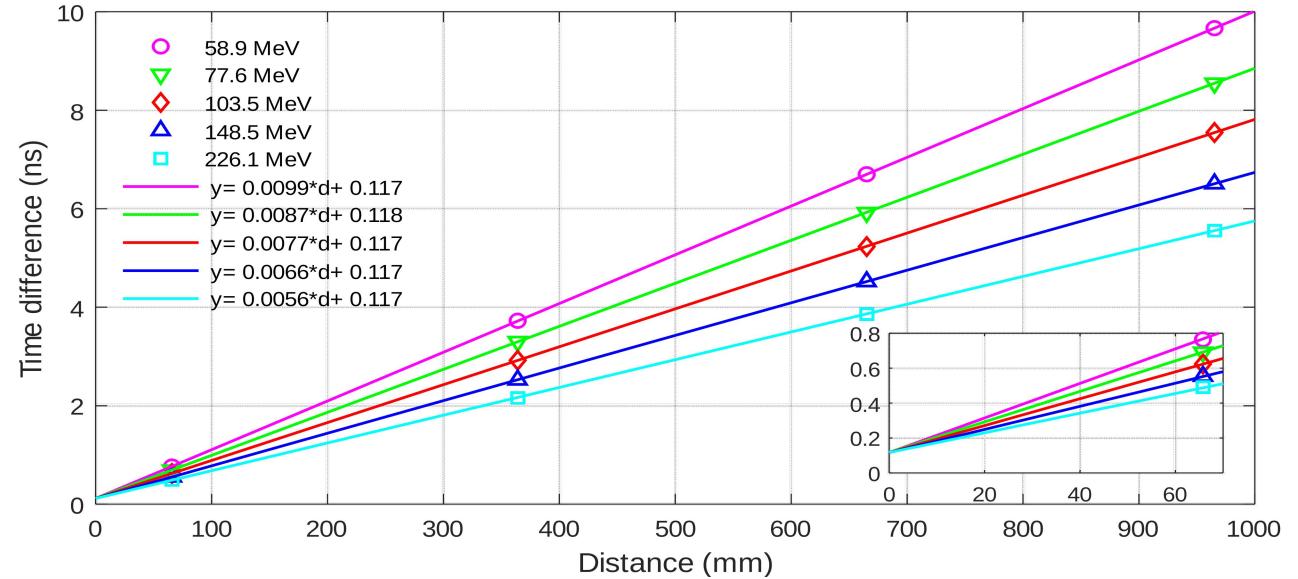
- 2 distances = 46 and 106 cm
 - 8 energies (106 cm) = 60-227 MeV
 - 3 energies (46 cm) = 60-227 MeV

Beam test at CNAO (B)

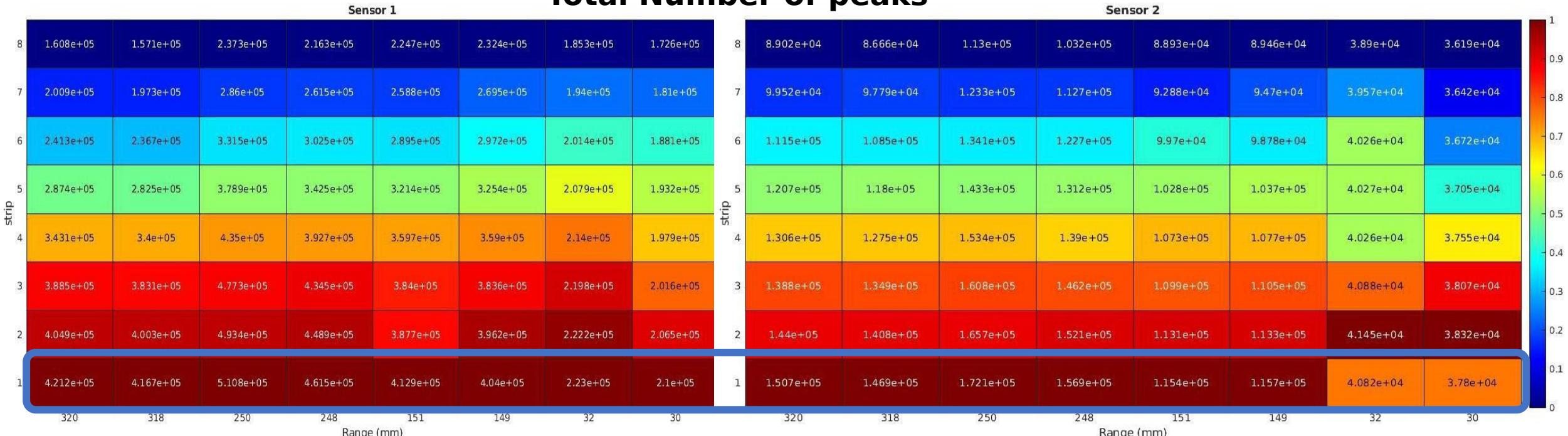


Beam test at
CNAO (A)

CNAO



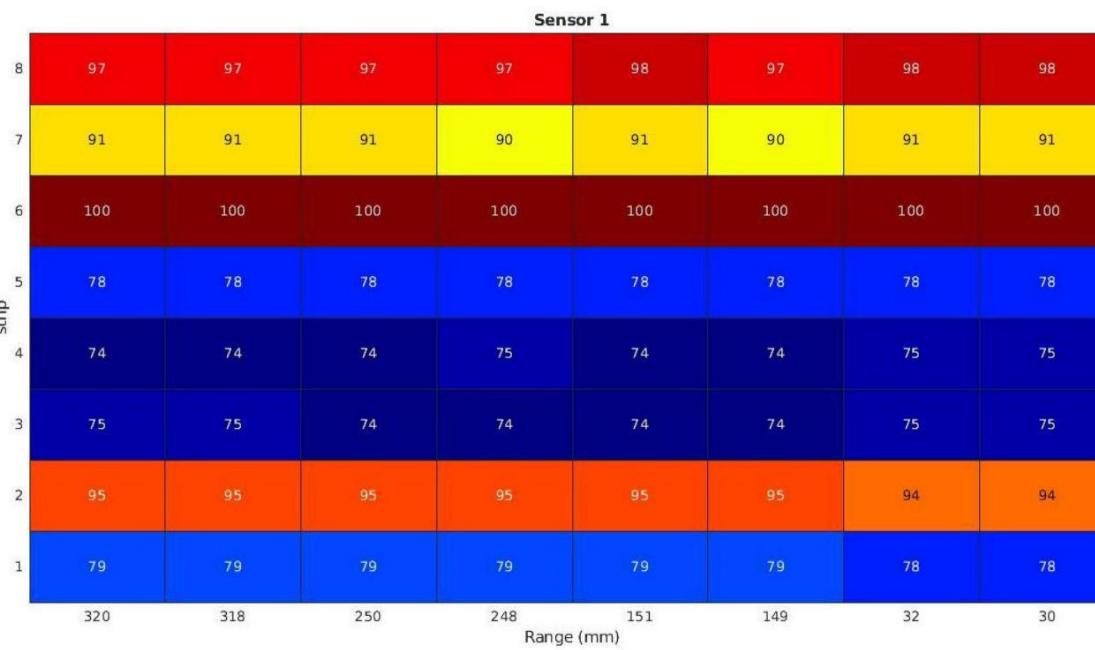
Total Number of peaks



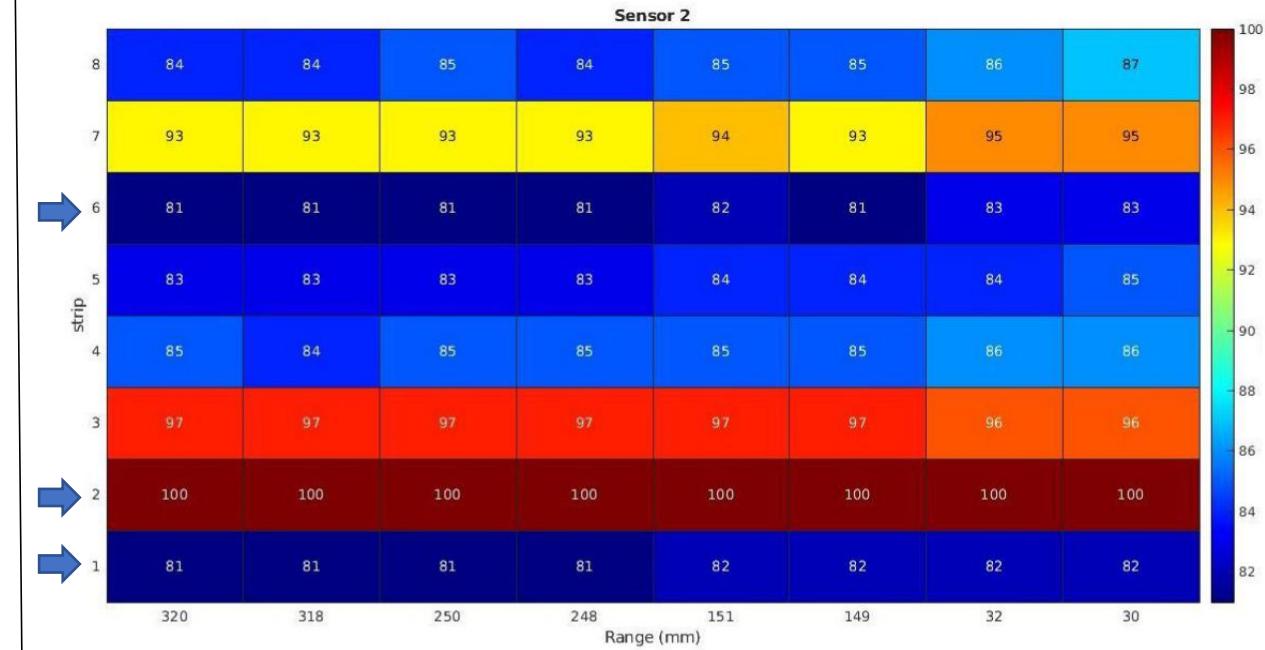
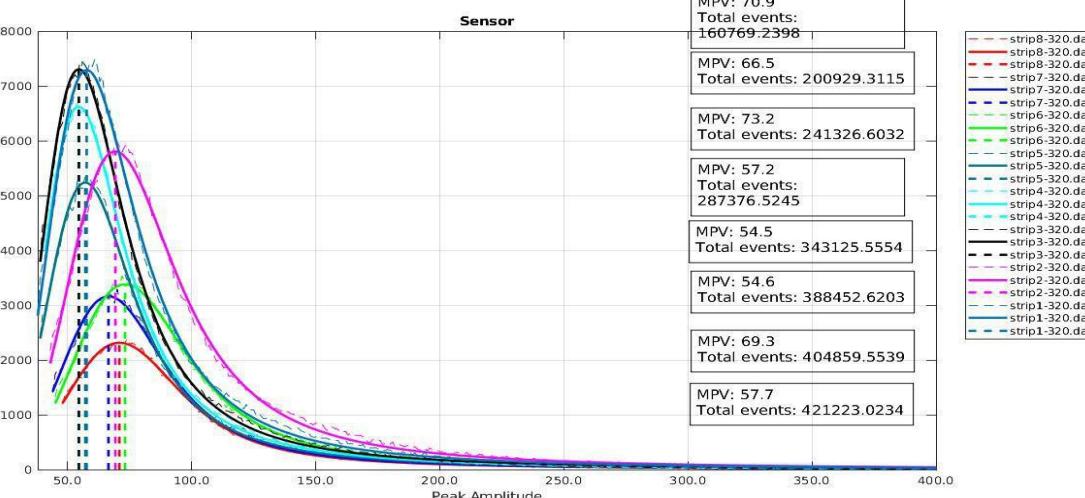
Beam test at
CNAO (B)

CNAO

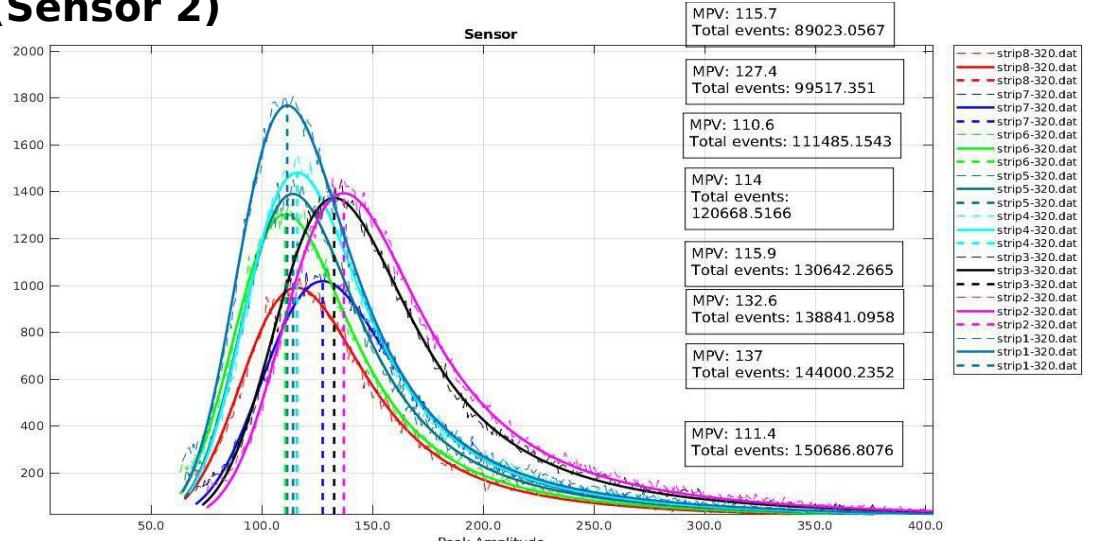
Most Probable Value analysis (Percentage)



Range 320 mm/226.91 MeV
(Sensor 1)



Range 320 mm/226.91 MeV
(Sensor 2)



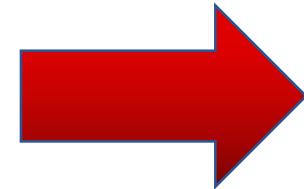
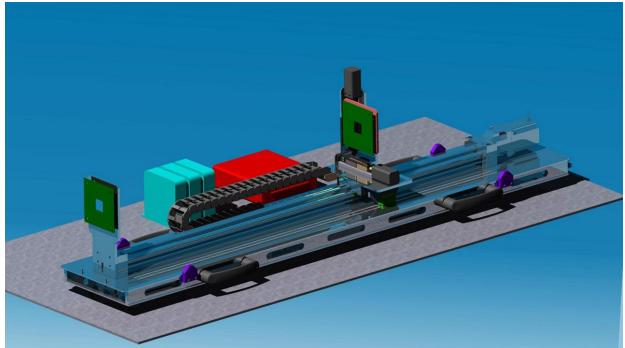
106° CONGRESSO NAZIONALE



Conclusion

- Few hundreds of keV deviations from nominal energies were achieved for all beam energies at 67 and 97 cm distances between the sensors, corresponding to < 1 mm range.
- The Minafra board was successfully tested in 16 signal configuration showing reliable results.

Ongoing work



FINAL TEST

