Studies of radiation hardness of Silicon Carbide detectors at n_TOF

S. AMADUCCI

Finanziato dall'Unione europea NextGenerationEU

Ministero dell'Università e della Ricerca

Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

CONTEXT

SiC detectors are an alternative for Silicon detectors for harsh environments that require higher durability and resistance to the damage of charge particles, gamma and neutrons.

While irradiation with ions have been already performed in the last years, studies involving neutrons (especially high energy) are lacking.

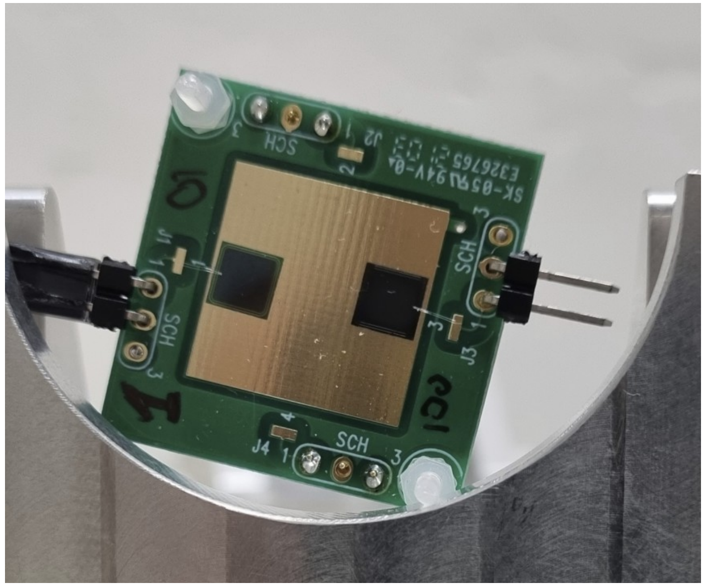
Physical property	4H-SiC	Si	Diamond
Energy gap (eV)	**3.26**	1.12	5.45
Displacement energy (eV)	**30-40**	13-15	40-45

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

THE DETECTORS

Two SiC mounted on the same board were provided by LNS, both 5x5 mm^2 but different thickness (10 and 100 um).

New generation SiC with low depletion voltage (about 350V, instead of 800V).

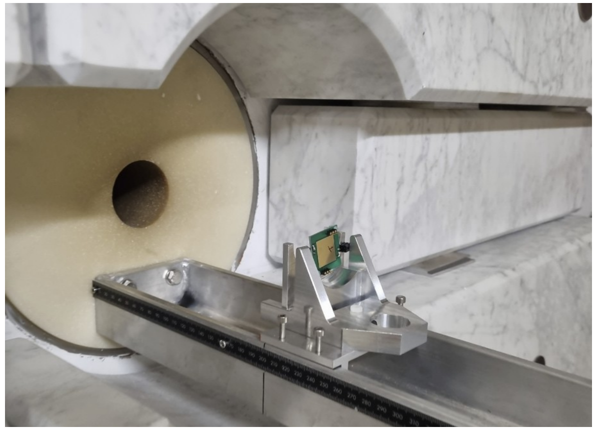


Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

IRRADIATION

Three irradiation were performed from July to October:

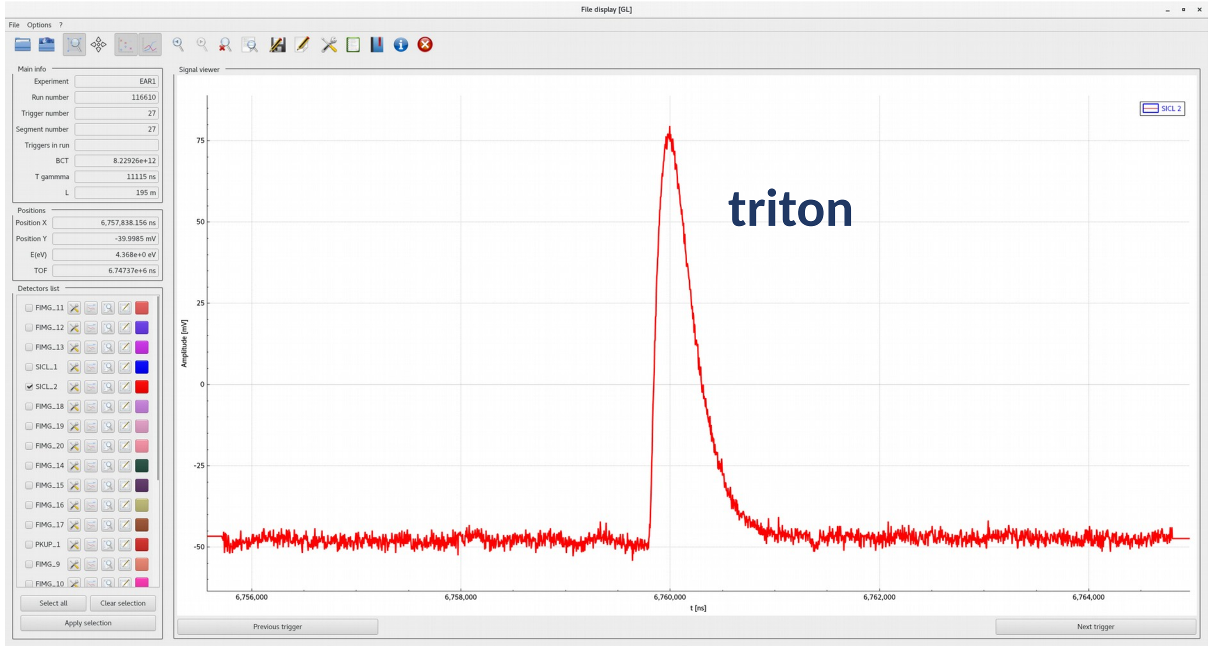
- 1 week in-beam in EAR1 with ^{6}LiF sample in air – active (high energy neutrons and low flux and to determine response to gflash)
- 1 week in-beam in NEAR – passive (high fluence)
- 4 weeks in-beam in EAR2 with ^{6}LiF sample in vacuum – active (response to thermal neutrons and g-flash)



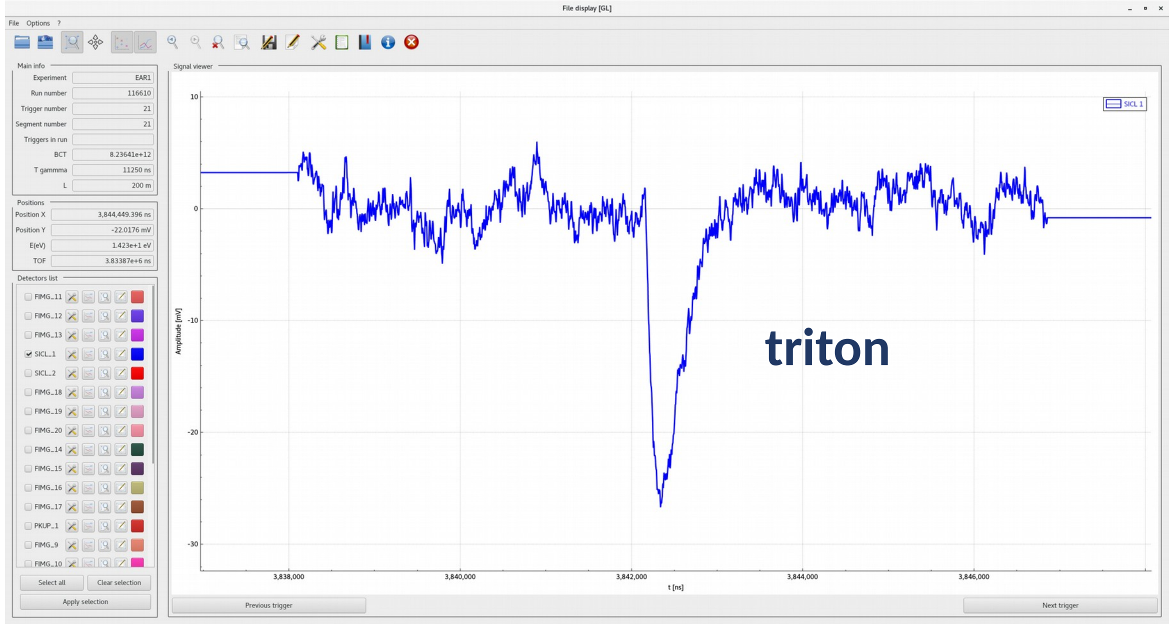
Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

HIGHLIGHTS - EAR1

Data acquired with TFA, good signal/noise for the 100um, worst for 10um (expected – higher capacitance).



100um

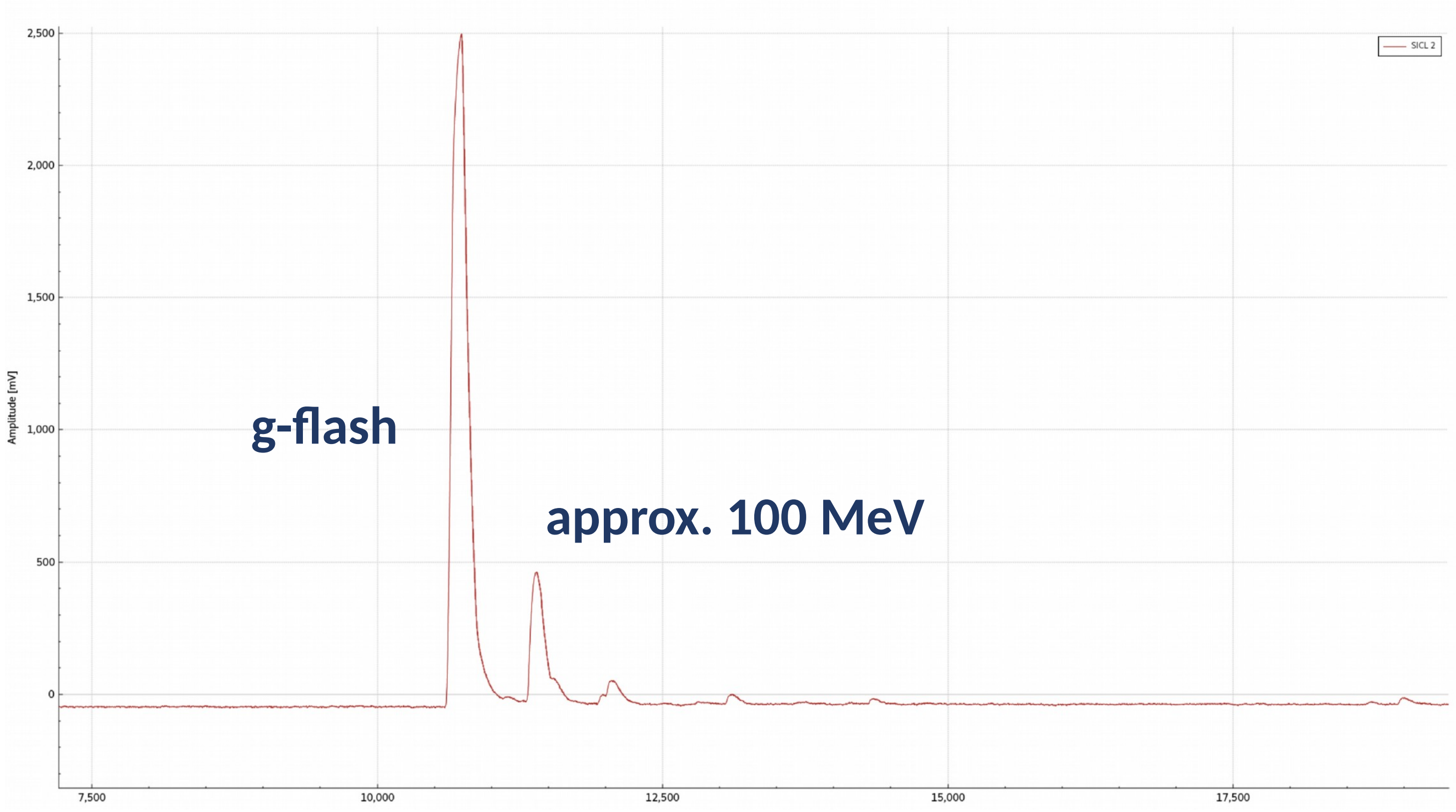


10um

Finanziato dall'Unione europea
NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

HIGHLIGHTS - EAR1

With proper parameters for Shaping a tof of few hundreds of ns can be reached (neutron energy of about 100 MeV).

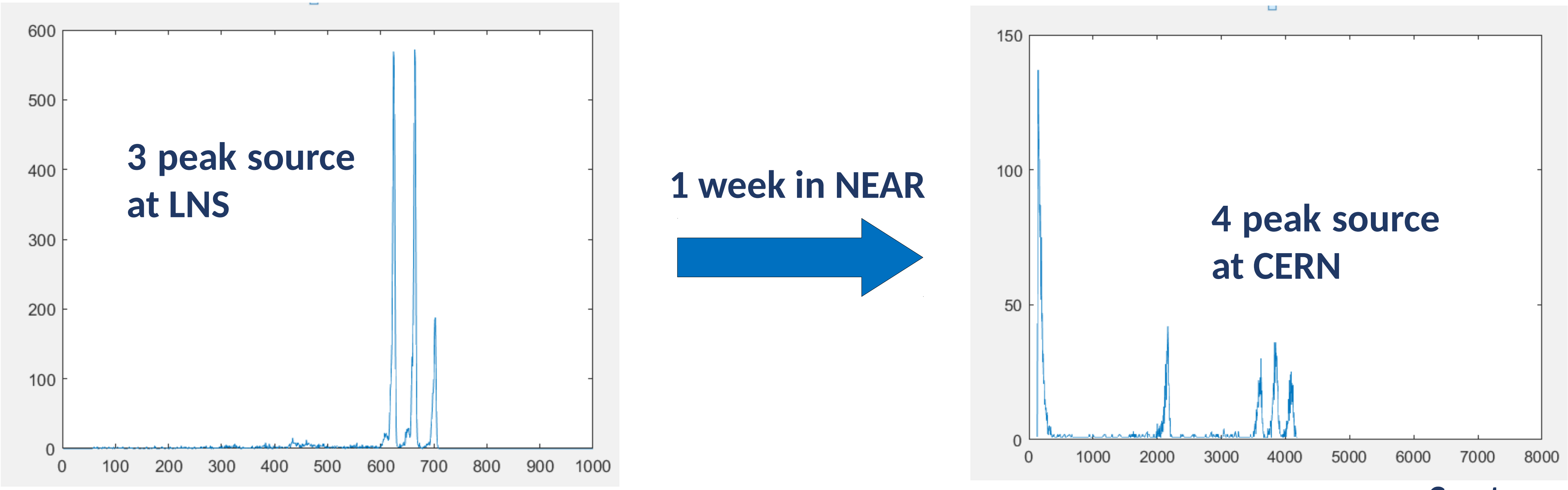


100um

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

HIGHLIGHTS - NEAR

Degradation for the 100um after one week in NEAR is visible, resolution for the ^{241}Am peak drops from 0.8% to 2.4% even if it can be partially compensated by increasing the Vbias.



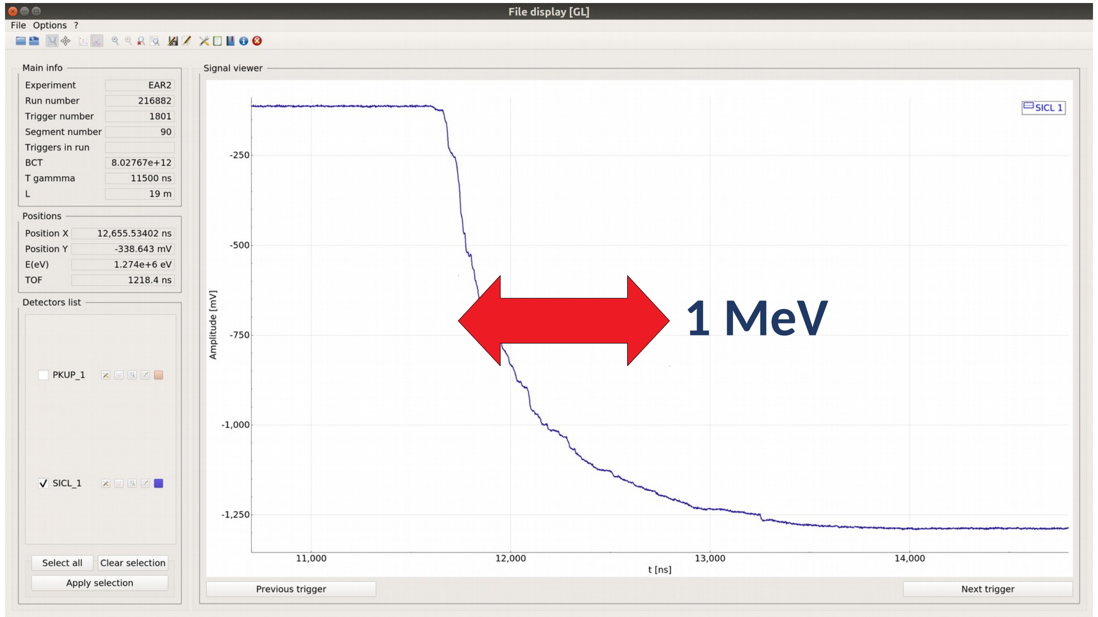
Courtesy of C. Altana

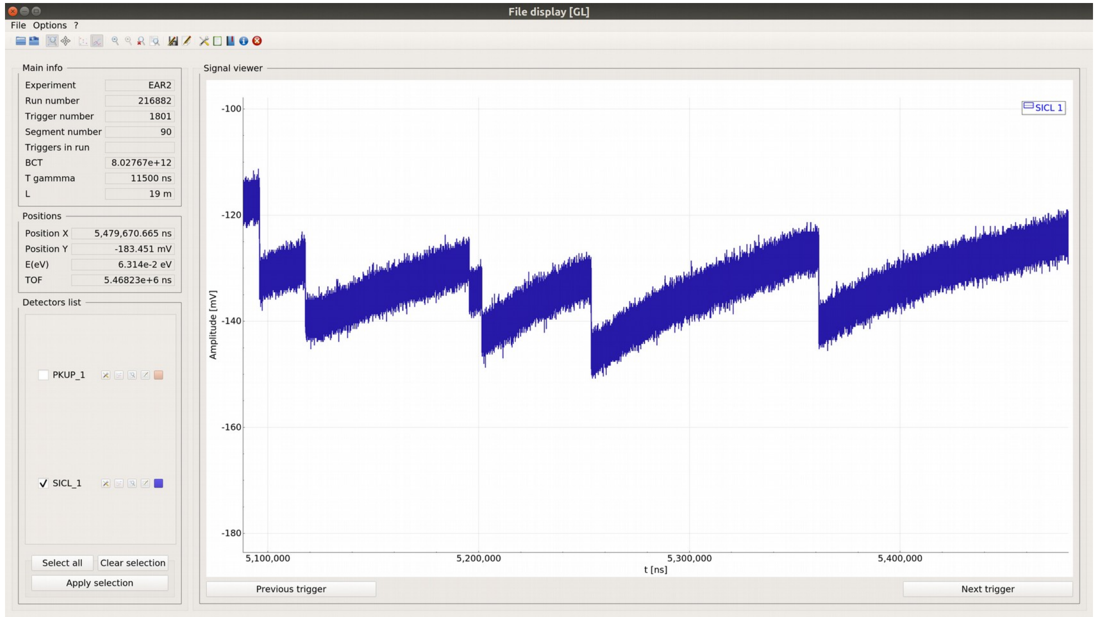
Finanziato dall'Unione europea
NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

HIGHLIGHTS - EAR2

SPOKE 5

A bit tricky to judge the g-flash, we are ok after about 1 us (about 1 MeV), before we are affected by the material in front (thick window and support), we are perfectly ok at lower energies (of course).



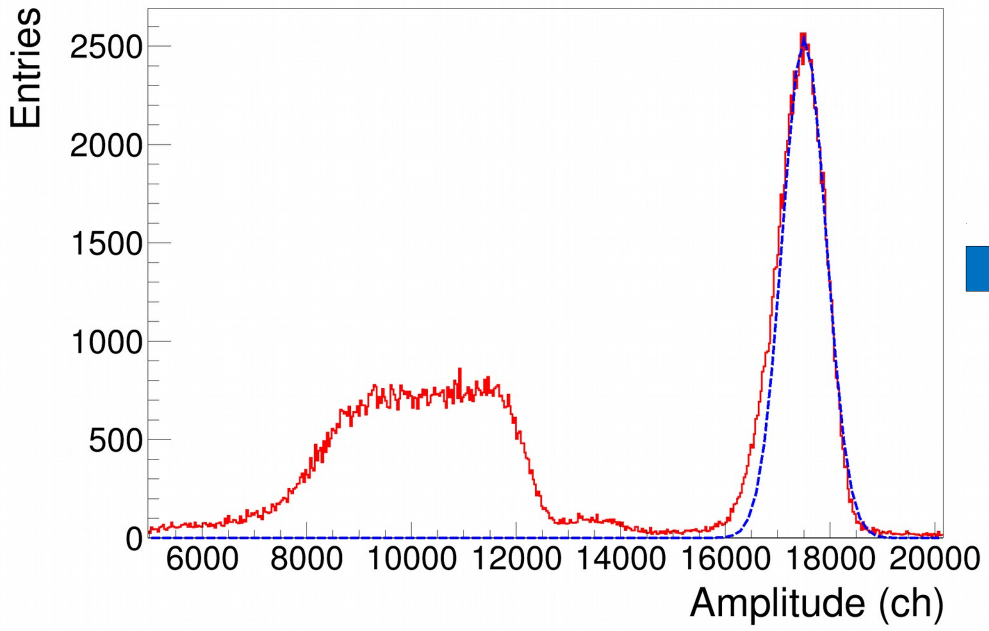


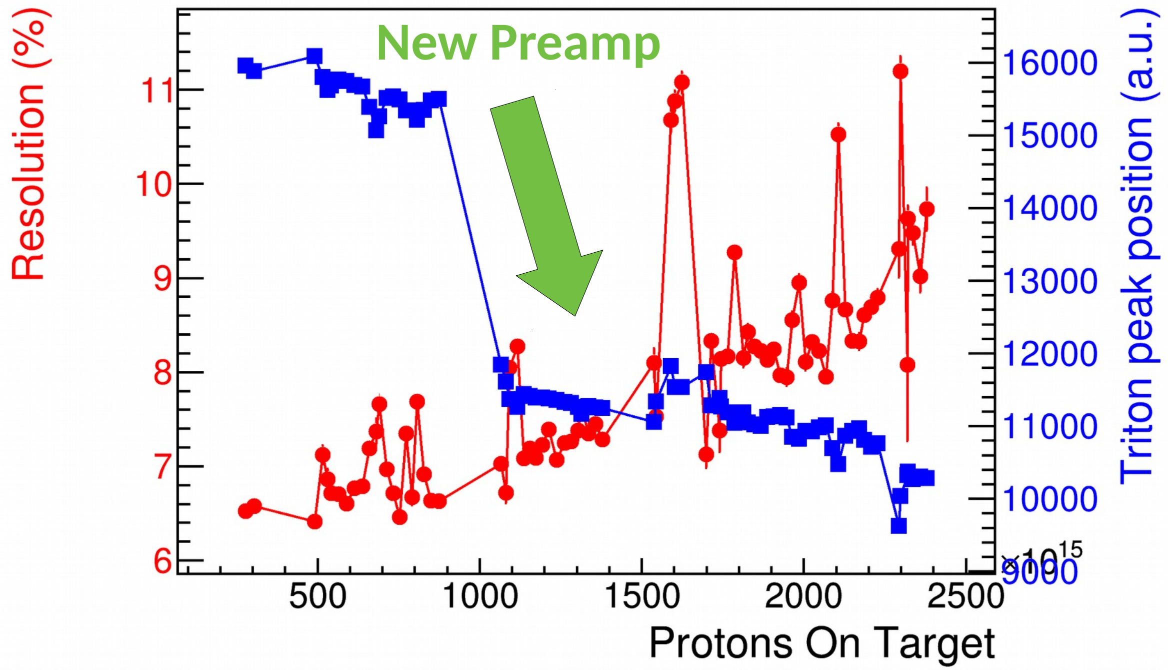
S. AMADUCCI

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

HIGHLIGHTS - EAR2

Stability of the detector in EAR2 was monitored considering mean and resolution of the triton peak.





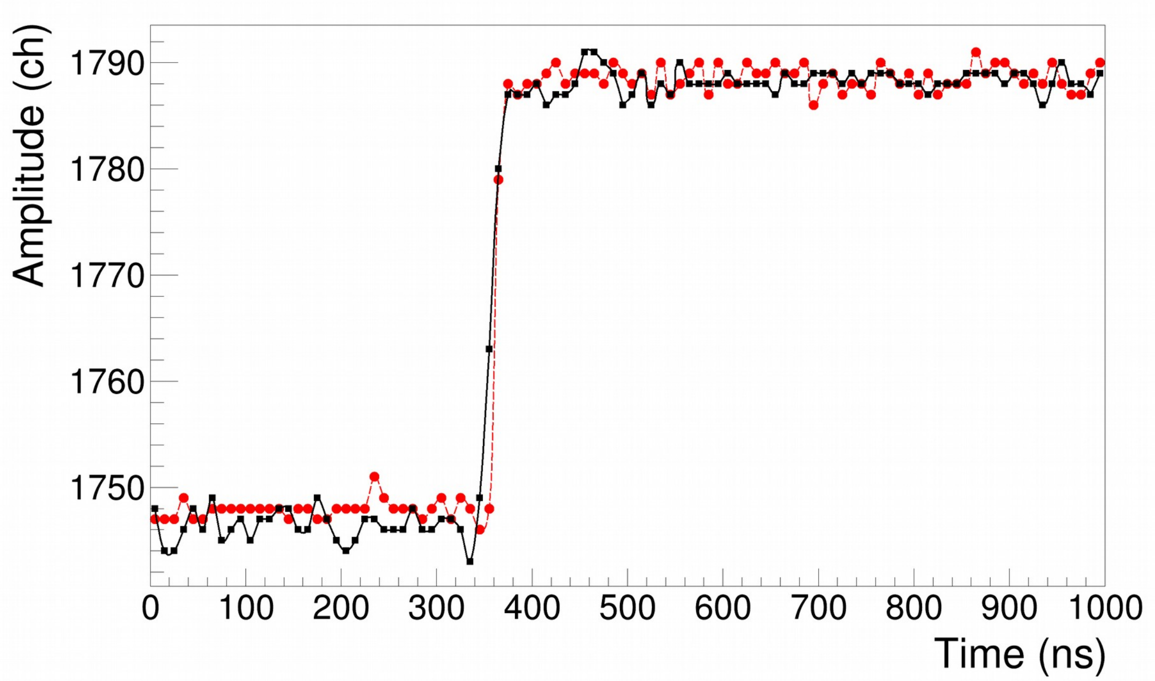
Detector survived 1 month of EAR2, with slightly worsening of the resolution (not fully depleted).

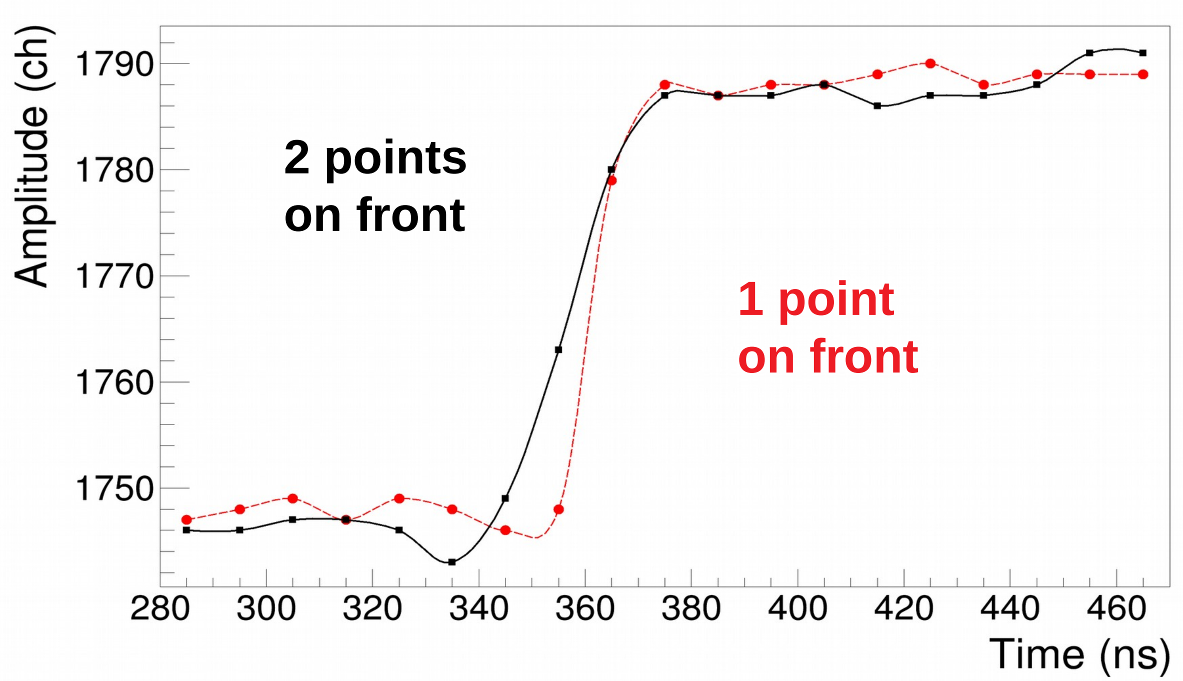
Finanziato dall'Unione europea
NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani
PIANO NAZIONALE DI RIPRESA E RESILIENZA

PULSE SHAPE - ILL

SPOKE 5

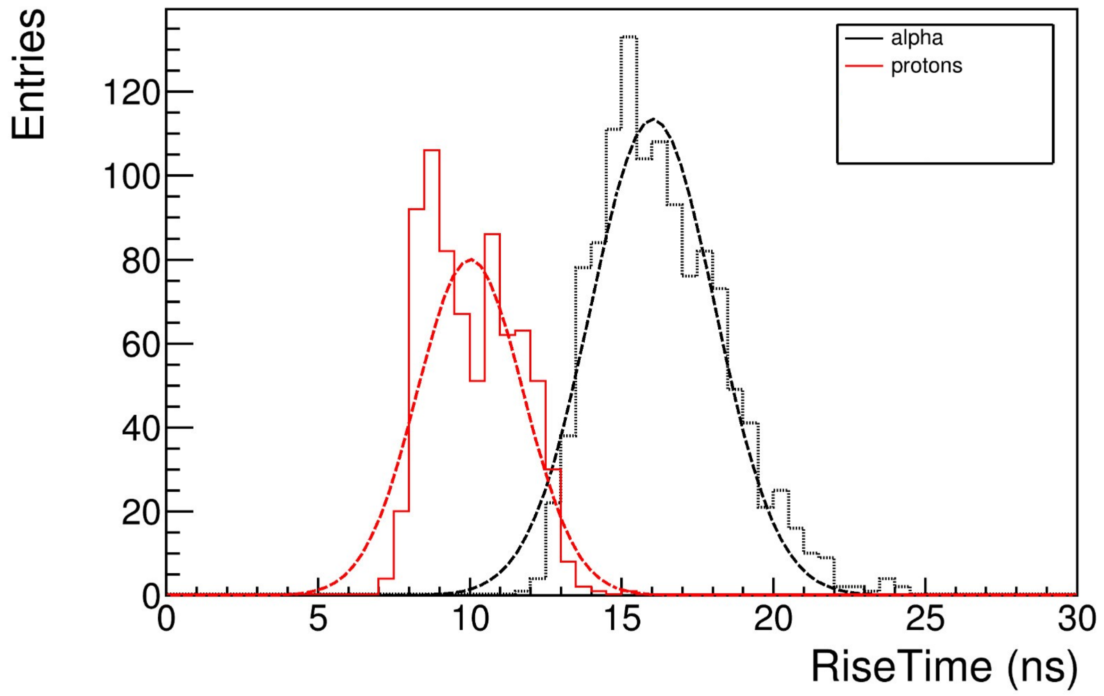
Experimental campaign at ILL to evaluate pulse shape feasibility for light particles, we collected waveforms (Alpha and Proton at 2.7 MeV below) at 100 MHz rate (totally not enough).





PULSE SHAPE - ILL

Data collected at ILL with light particles suggest that pulse shape can be applied for SiC to discriminate alpha from proton&tritons (even with only one single parameter).



FOM alpha/tritons at 2.7 MeV is around 0.7 (considered a good separation)

Same pulse shape routine of the Annular (G.Vecchio et al.)

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA

FUTURE DEVELOPMENTS

When a more detailed analysis will be done new activities will be evaluated as:

- active NEAR irradiation (diamond like)
- studies of pulse shape discrimination
- longer parasitic run in EAR2 with a new detector (we used one that was already in NEAR, with degraded resolution) with background estimation to further investigate their use for physics.

→ LOI in 2024

Finanziato dall'Unione europea NextGenerationEU
Ministero dell'Università e della Ricerca
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA