ENUBET

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on behalf of ENUBET collaboration

Enabling high precision flux measurements in conventional neutrino beams

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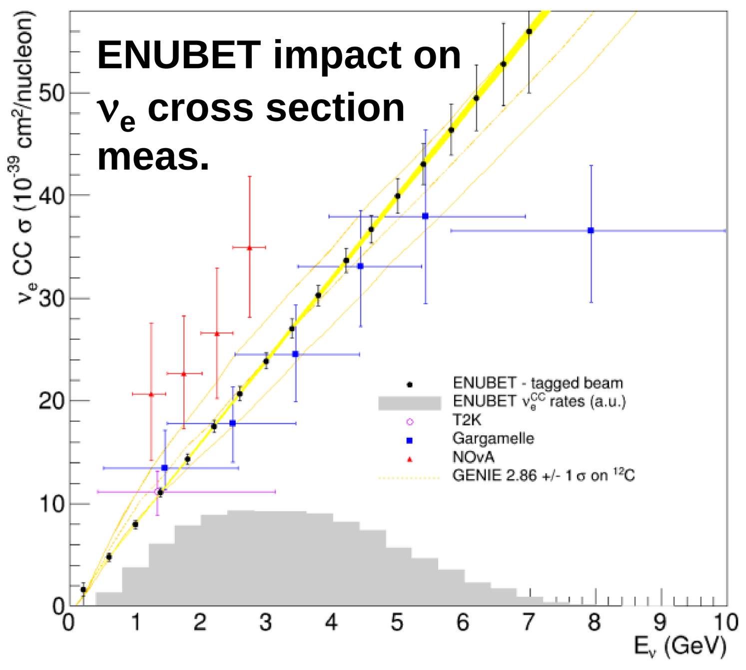
ENUBET (Enhanced NeUtrino BEams from kaon Tagging)

A novel ν_e **source** based on tagging of e^+ from $K^+ \to e^+ \pi^0 \nu_e$ decays in an instrumented decay tunnel

The goal of the project is to demonstrate the **feasibility of real time monitoring of the positrons produced at large angles in the decay tunnel of conventional neutrino beams** to reduce in the systematics on the neutrino flux to a O(1%)

- A new generation of neutrino cross section experiments with unprecedented control on the flux
- The first step toward a time-tagged ν-beam, where the ν at the detector is time correlated with the lepton in the tunnel
- Highly beneficial for the **leptonic CP violation** international program at long baselines ($\nu_\mu \to \nu_e$)



ENUBET conceptual design

A traditional beam

- Passive decay region
- ν_e flux relies on ab-initio simulations of the full chain
- large uncertainties from hadroproduction, K/π ratio, PoT

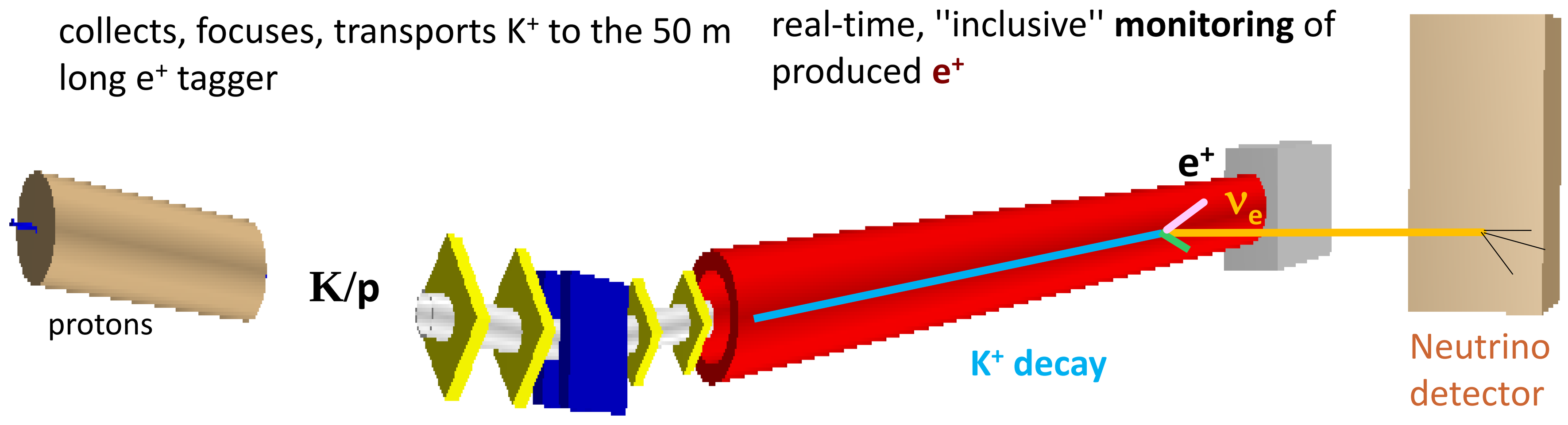
The tagged beam

- Fully instrumented decay region
- $K^+ \to e^+ \pi^0 \nu_e$ → large angle e^+
- **ν_e flux prediction = e^+ counting**

O(1%) systematic error achievable

Hadron beam-line
collects, focuses, transports K^+ to the 50 m long e^+ tagger

e^+ tagger
real-time, "inclusive" **monitoring** of produced **e^+**

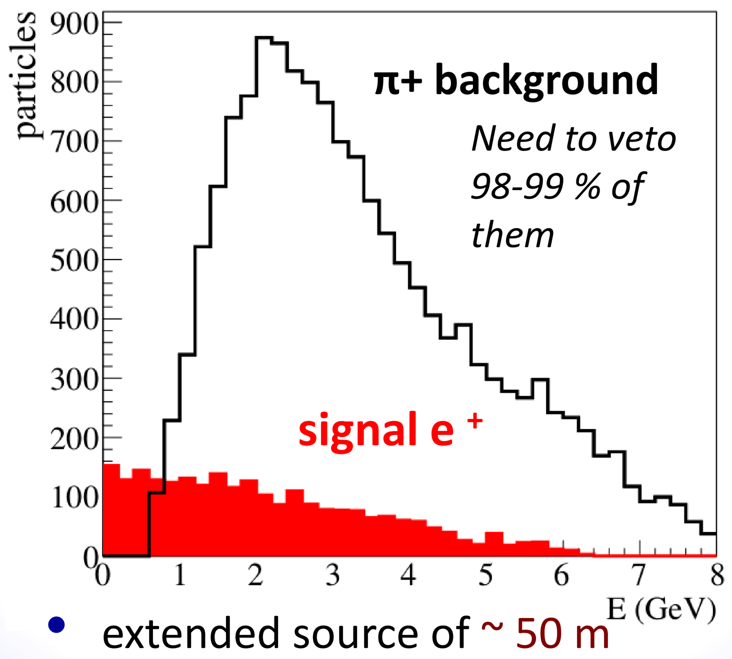


The positron tagger

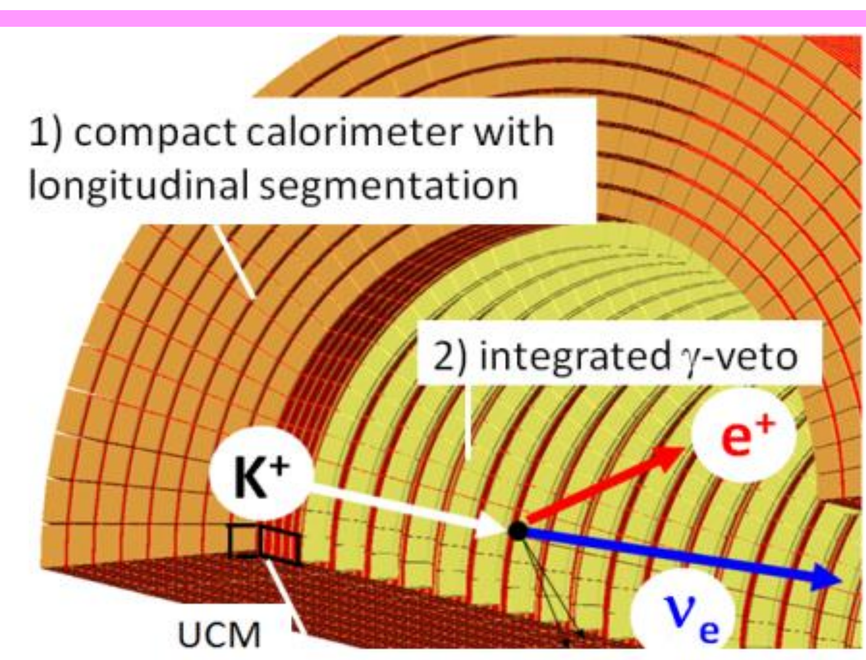
Challenges:

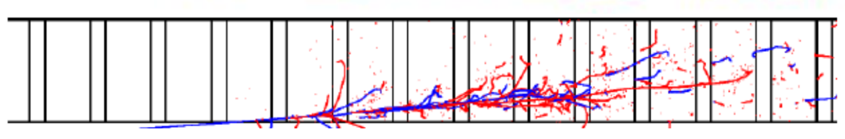
The decay tunnel is a harsh environment:

- particle rates > 200 kHz/cm²
- backgrounds: pions from K^+ decays



- extended source of ~ 50 m
- spread in the initial direction





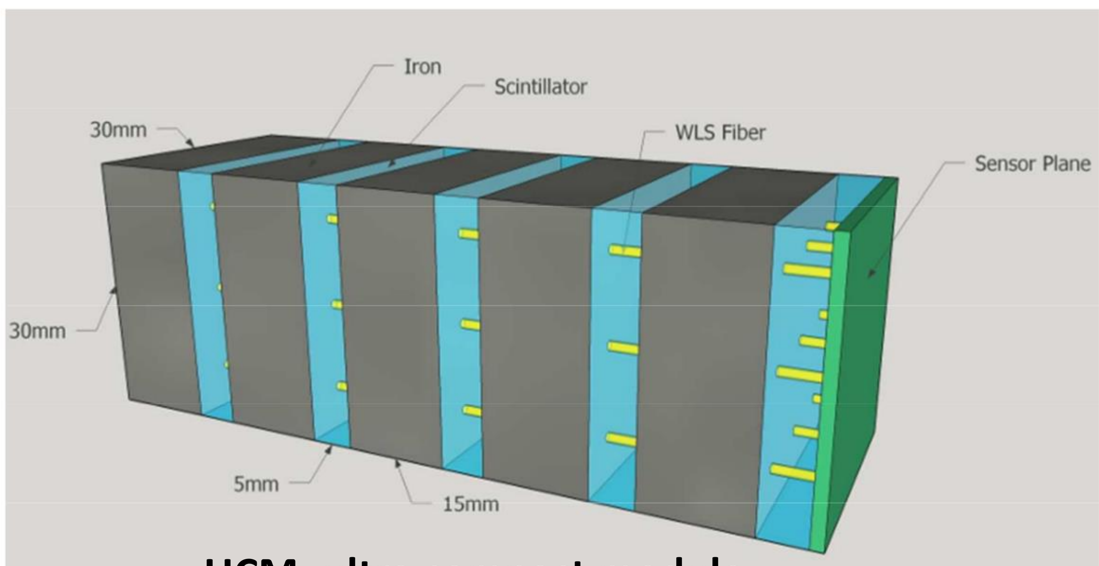
Adopted solutions

Conventional beam-pipe replaced by active instrumentation:

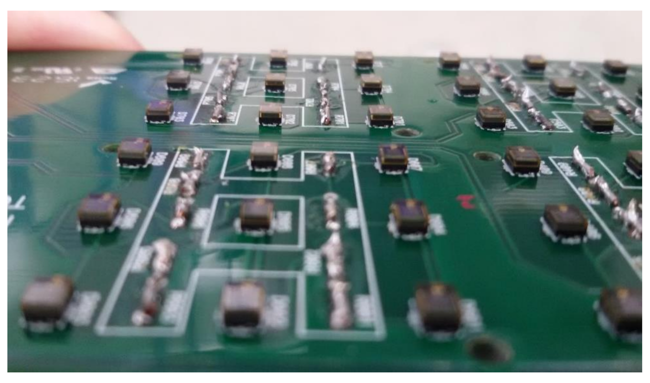
- longitudinal sampling
- good uniformity
- radiation hardness
- cost effectivness

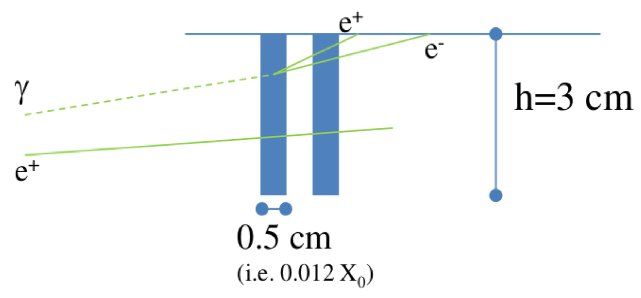
1) Shashlik calorimeter: π^+ rejection

- UCM (4 X_0 thick) read-out by **SiPMs directly coupled to WLS fibers**
- longitudinal sampling without dead zones
- cheap, fast (<10 ns recovery time), rad. hard



UCM: ultra compact module

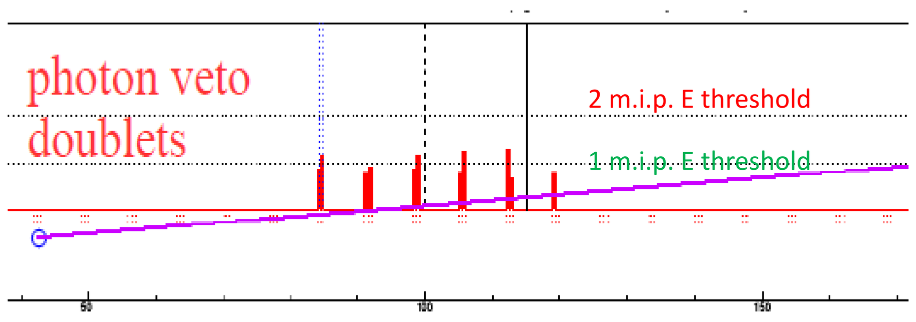




2) Integrated γ- veto: π^0 rejection

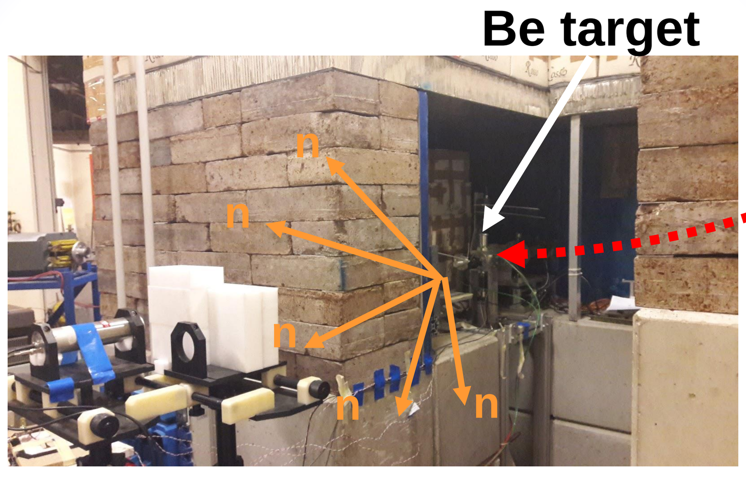
rings of 3x3 cm² pads of plastic scintillator

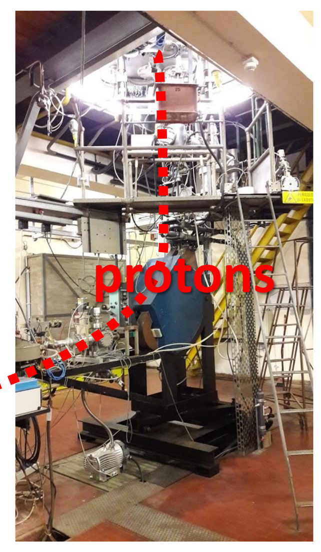
1 mip/2mip separation: successfully tested at CERN in October 2017

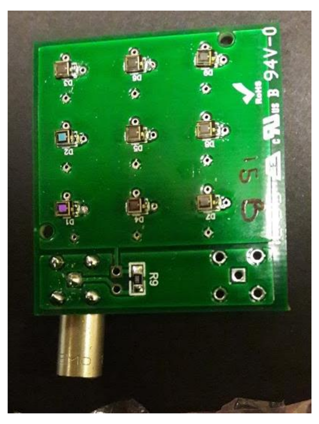


Tests of SiPM radiation-hardness

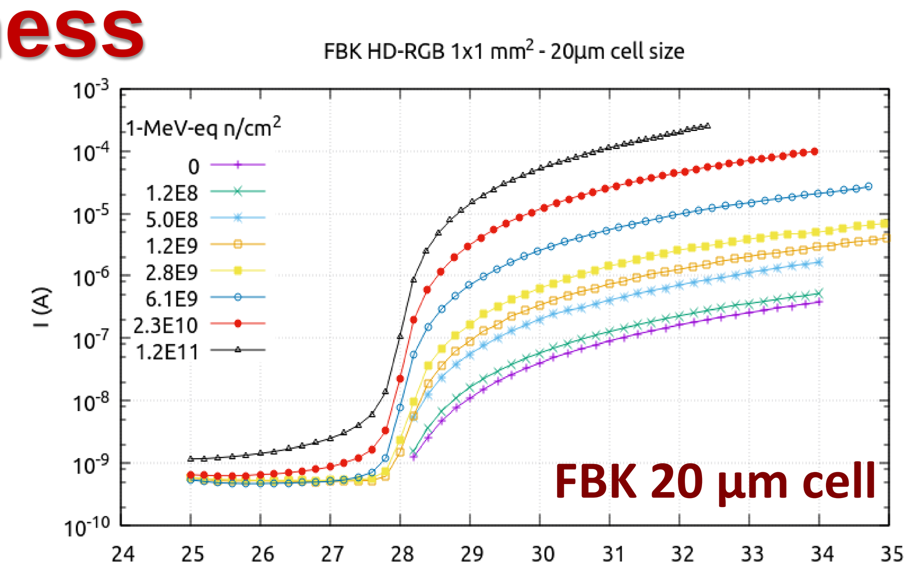
Van de Graaff CN accelerator @ INFN LNL

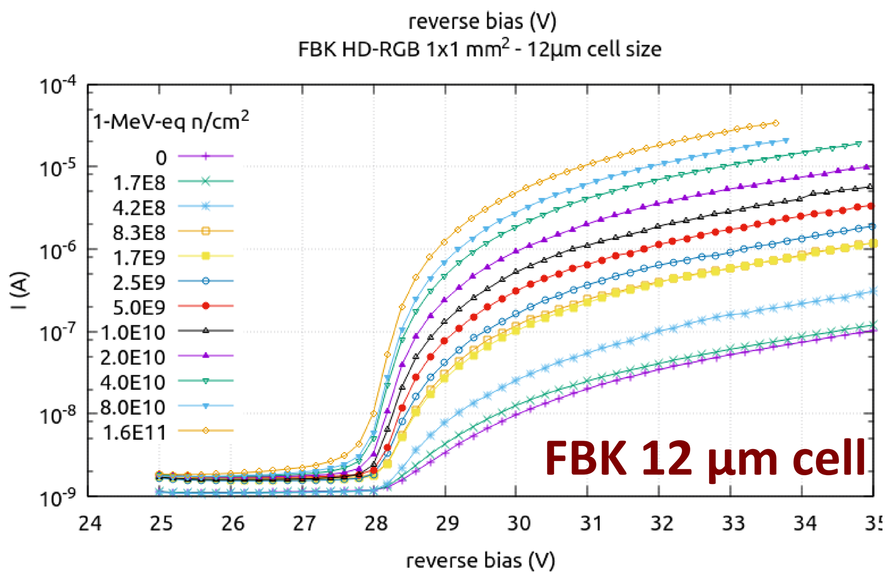






- p (5MeV)+ ^{9}Be→ n + X
- p currents < 1μA
- n spectrum 1-3 MeV up to 10^{12} n/cm² 1MeV equiv. [Doses in ENUBET: < 2×10^{11} n/cm²]

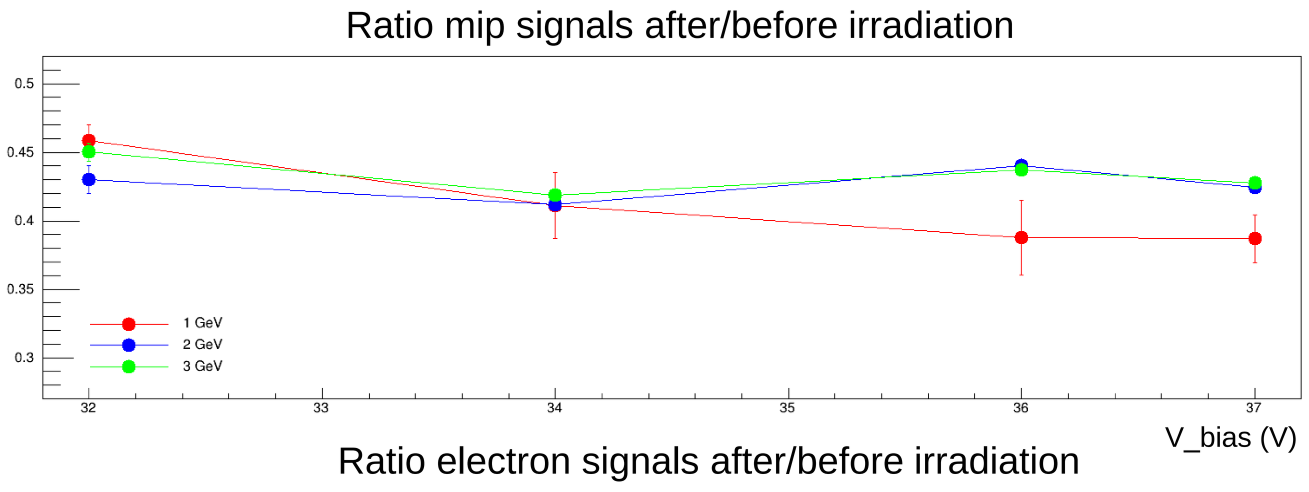




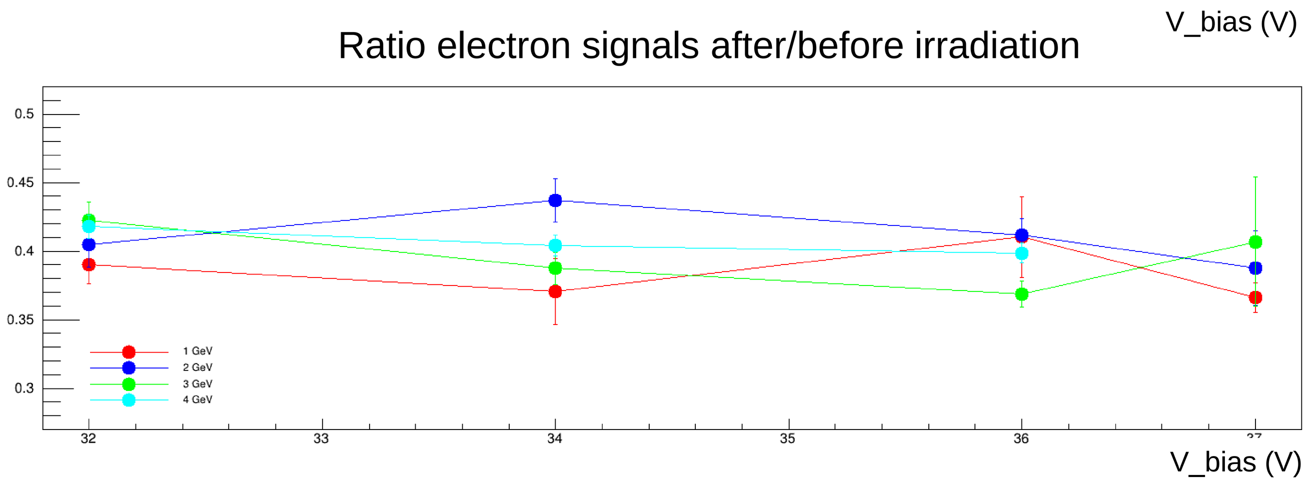
Oct 2017: Tests at CERN

Prototype:
UCM (1.5 cm scint, 1.5 cm Fe x 5) with UNIPLAST injection molded tiles and Kuraray Y11 fibers

Ratio mip signals after/before irradiation

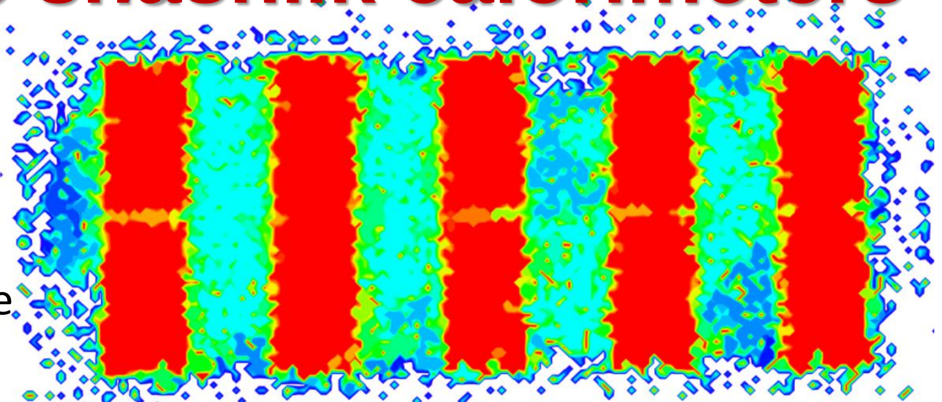


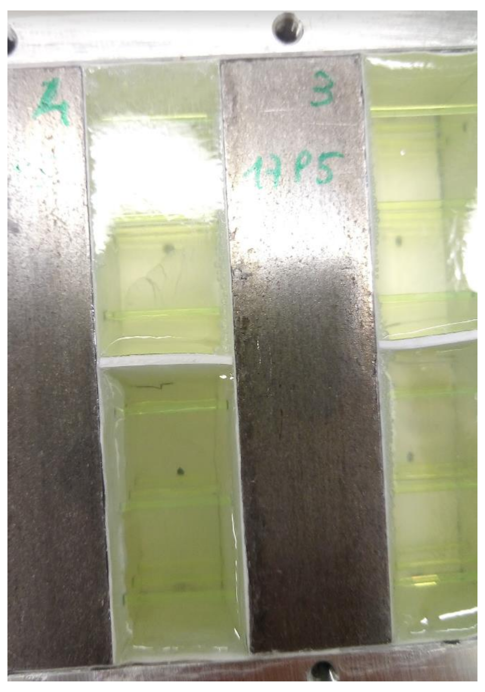
Ratio electron signals after/before irradiation

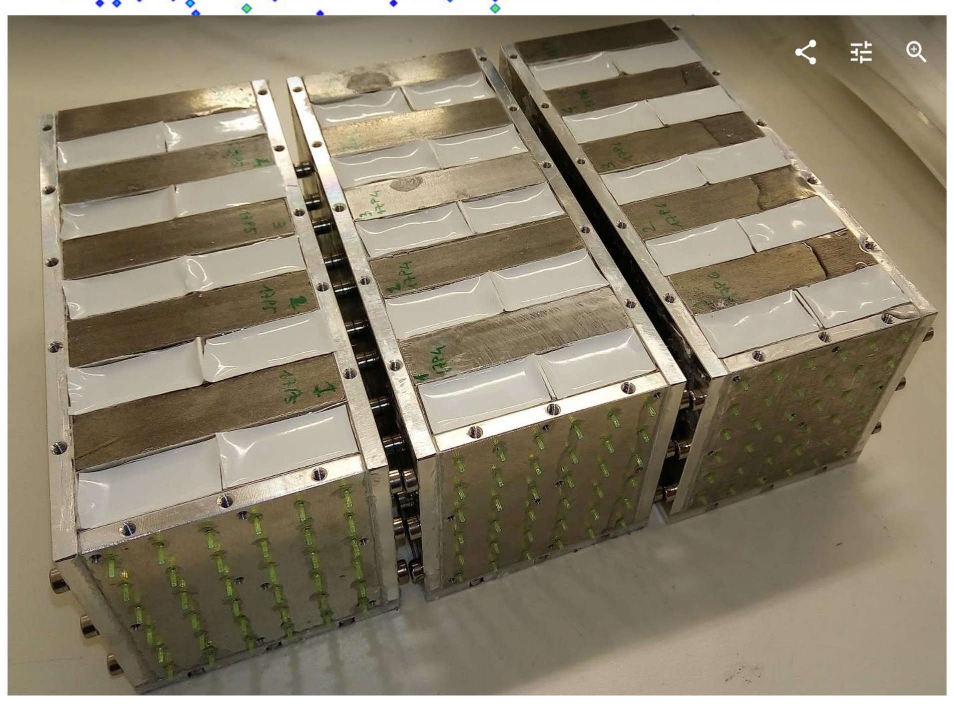


Polysiloxane shashlik calorimeters

- no drilling of the scintill.
- higher rad. hardness
- optimal optical contact
- Three 4.3 X_0 prototypes successfully tested at the CERN-PS (Oct. 2017)







References

[1] **"A novel technique for the measurement of the electron neutrino cross section"** A. Longhin, L. Ludovici, F. Terranova Eur. Phys. J. C (2015) 75:155

[2] **"Enabling precise measurements of flux in accelerator neutrino beams: the ENUBET project"** The ENUBET collaboration CERN-SPSC-2016-036; SPSC-EOI-014

[3] **"Shashlik Calorimeters With Embedded SiPMs for Longitudinal Segmentation"** A. Berra et al., IEEE Trans. Nucl. Sci. 64 (2017) 1056

http://enubet.pd.infn.it