

on behalf of the ENUBET Collaboration: F. Acerbi, G. Ballerini, M. Bonesini, C. Brizzolari, G. Brunetti, M. Calviani, S. Carturan, M.G. Catanese, S. Cecchini, F. Cindolo, G. Collazuol, E. Conti, F. Dal Corso, G. De Rosa, C. Delogu, A. Falcone, B. Goddard, A. Gola, R.A. Intonti, C. Jollet, V. Kain, B. Klicek, Y. Kudenko, M. Laveder, A. Longhin, P.F. Loverre, L. Ludovici, L. Magaletti, G. Mandrioli, A. Margotti, V. Mascagna, N. Mauri, A. Meregaglia, M. Mezzetto, M. Nessi, A. Paoloni, M. Pari, E. Parozzi, L. Pasqualini, G. Paternoster, L. Patrizii, C. Piemonte, M. Pozzato, F. Pupilli, M. Prest, E. Radicioni, C. Riccio, A.C. Ruggeri, G. Sirri, M. Soldani, M. Stipcevic, M. Tenti, F. Terranova, E. Vallazza, F. Velotti, M. Vesco, L. Votano

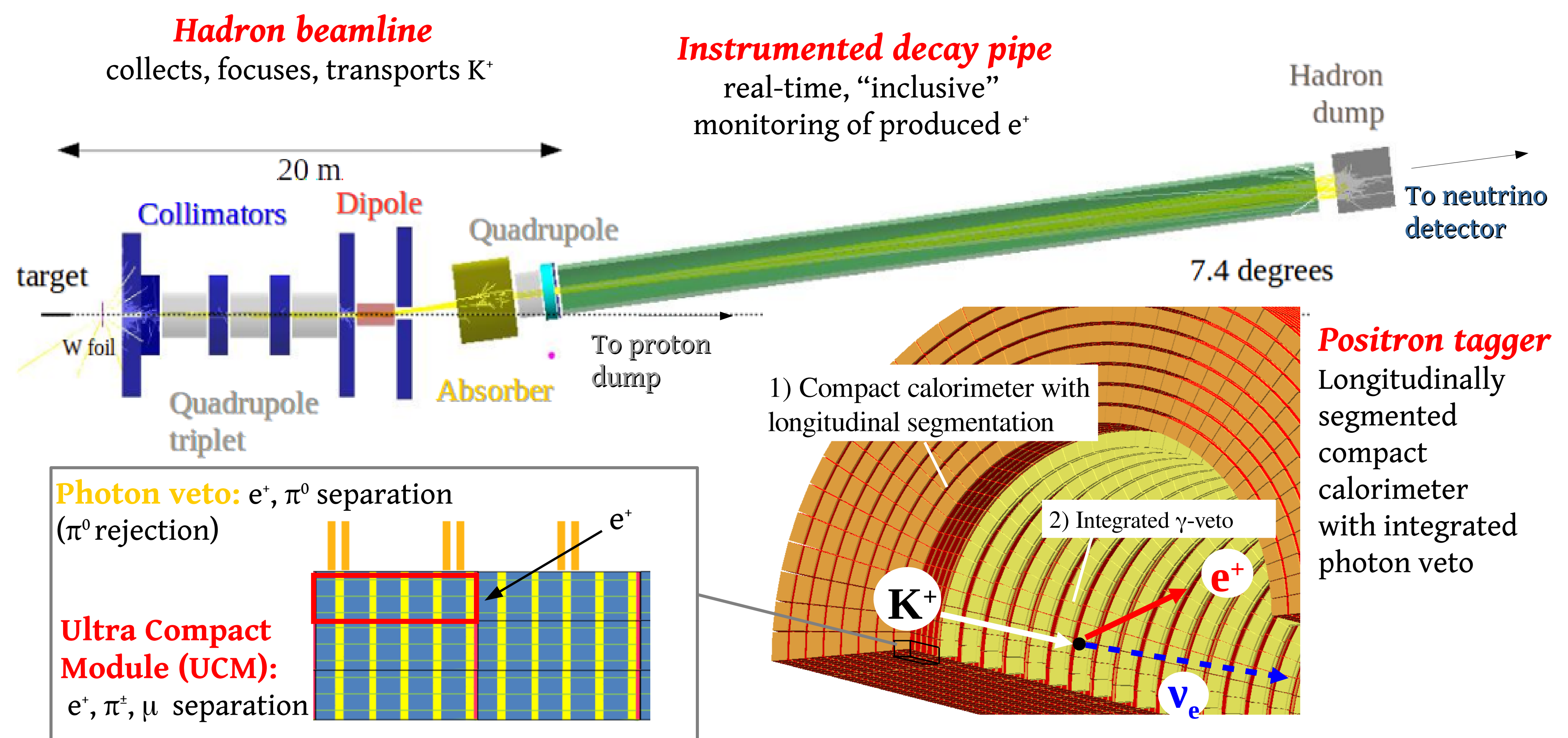
ENUBET (Enhanced NeUtrino BEams from kaon Tagging)

- New-concept ν_e source based on tagging of large angle e^+ from $K^+ \rightarrow e^+ \pi^0 \nu_e$ decays in an instrumented decay tunnel (98% ν_e from K^+ decays)

- Reduction of the systematic uncertainties on the knowledge of the initial neutrino flux to $O(1\%)$ level

Physics programme

- Unprecedented high precision measurement of ν_e and $\bar{\nu}_e$ cross sections
- Highly beneficial for tackling the main open neutrino-related issues: mass hierarchy, θ_{23} octant, leptonic CP violation
- First step towards a **time tagged neutrino beam**: direct ν production/detection correlation



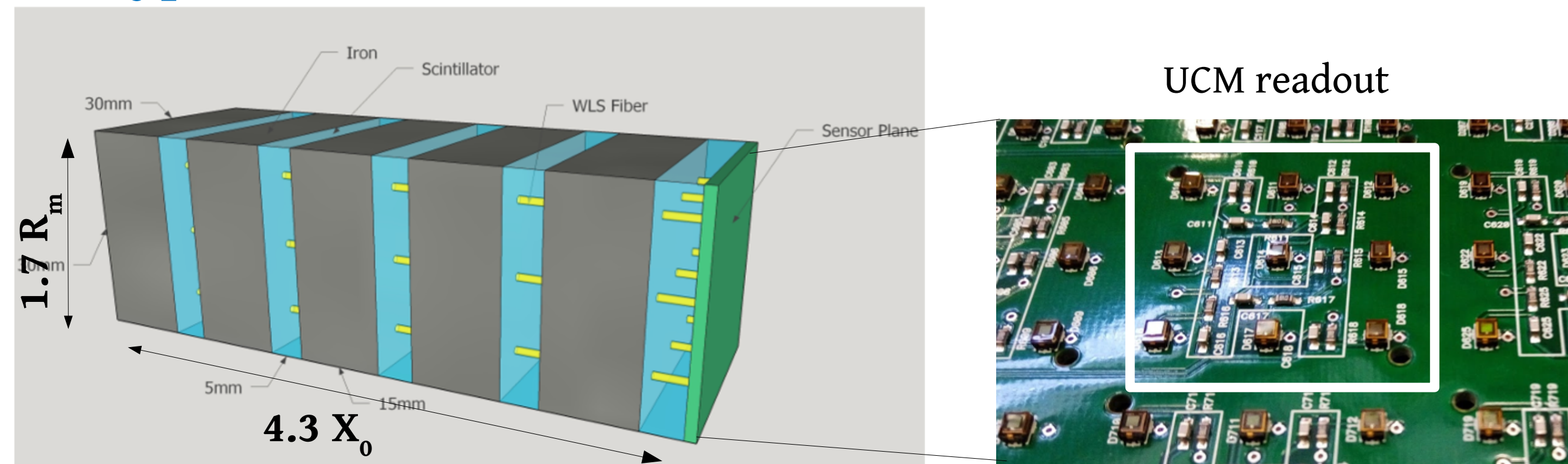
Ultra-Compact Calorimeter prototypes

Shashlik with integrated readout

Basic shashlik calorimeter: Scintillator / absorber sampling calorimeter, read out by Wavelength Shifter (WLS) optical fibers, routed to PMT

Ultra-Compact shashlik prototype: basic iron/scintillator shashlik where each WLS fiber is read out by one single SiPM. Electronic r/o in the bulk of detector: **compact structure**

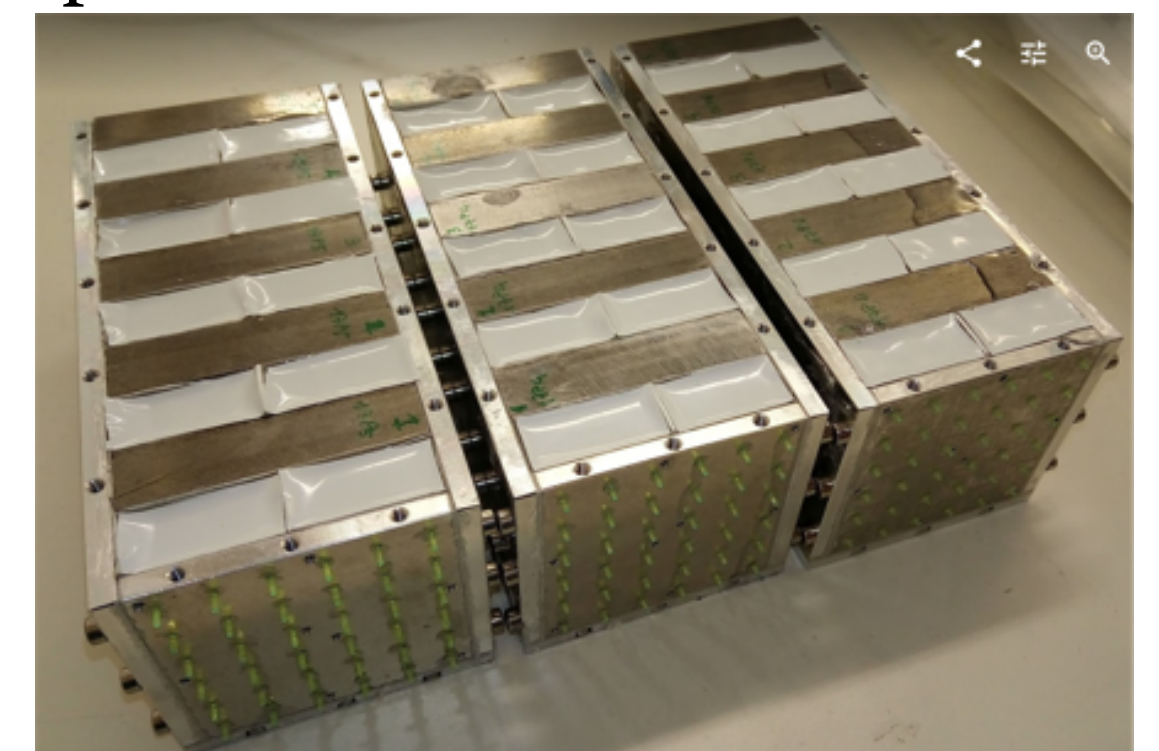
Prototype tested @ CERN (PS-T9) → G. Ballerini et al. JINST 13 (2018) P01028



Polysiloxane shashlik calorimeters

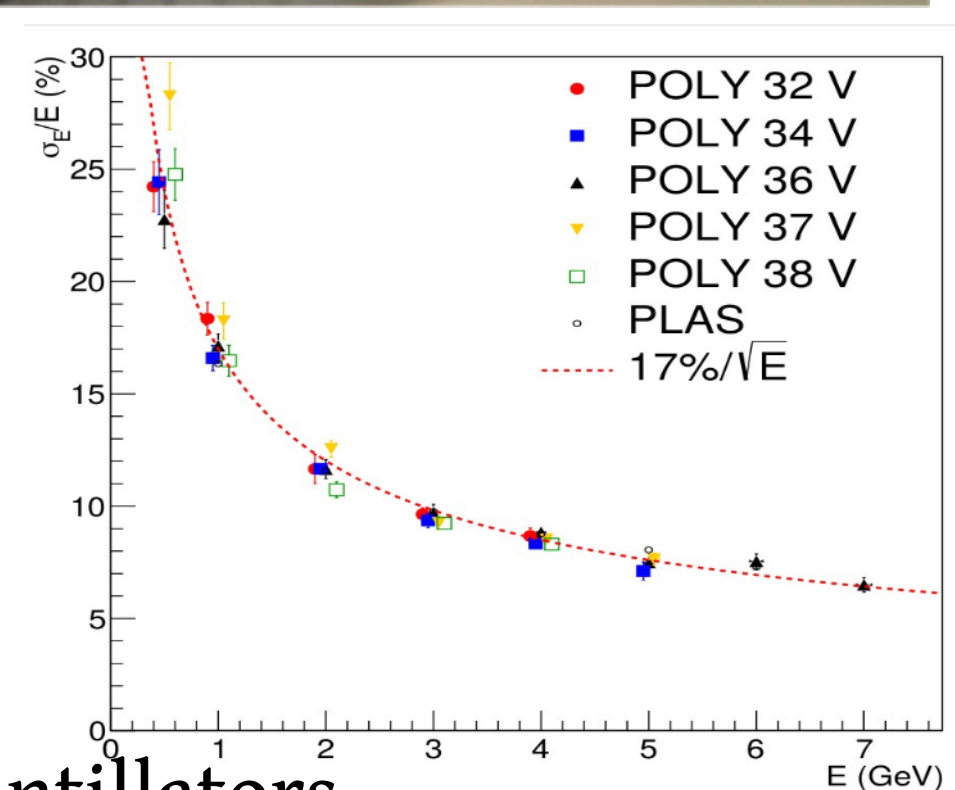
First use in HEP. Elastomeric material with interesting properties

- **Superior radiation hardness** (transparent after 10 kGy dose exposure)
- **Easier fabrication** process: initial liquid form poured at 60° . No drilling of the scintillator.
- **Good optical contact with fibers**



Prototype tested @ CERN (PS-T9)

- 12 UCMs: 3 (beam direction) x 2 x 2
- Active layer 3 times thicker: 15 mm compensate 30% lower light yield w.r.t. EJ200
- **Energy resolution:** 17% / $\sqrt{E(\text{GeV})}$ comparable with plastic scintillator based prototype
- **Good linearity:** < 3% in the 1-5 GeV
- **Fiber-scintillator coupling** after pouring is comparable to that obtained from injection molding of conventional scintillators

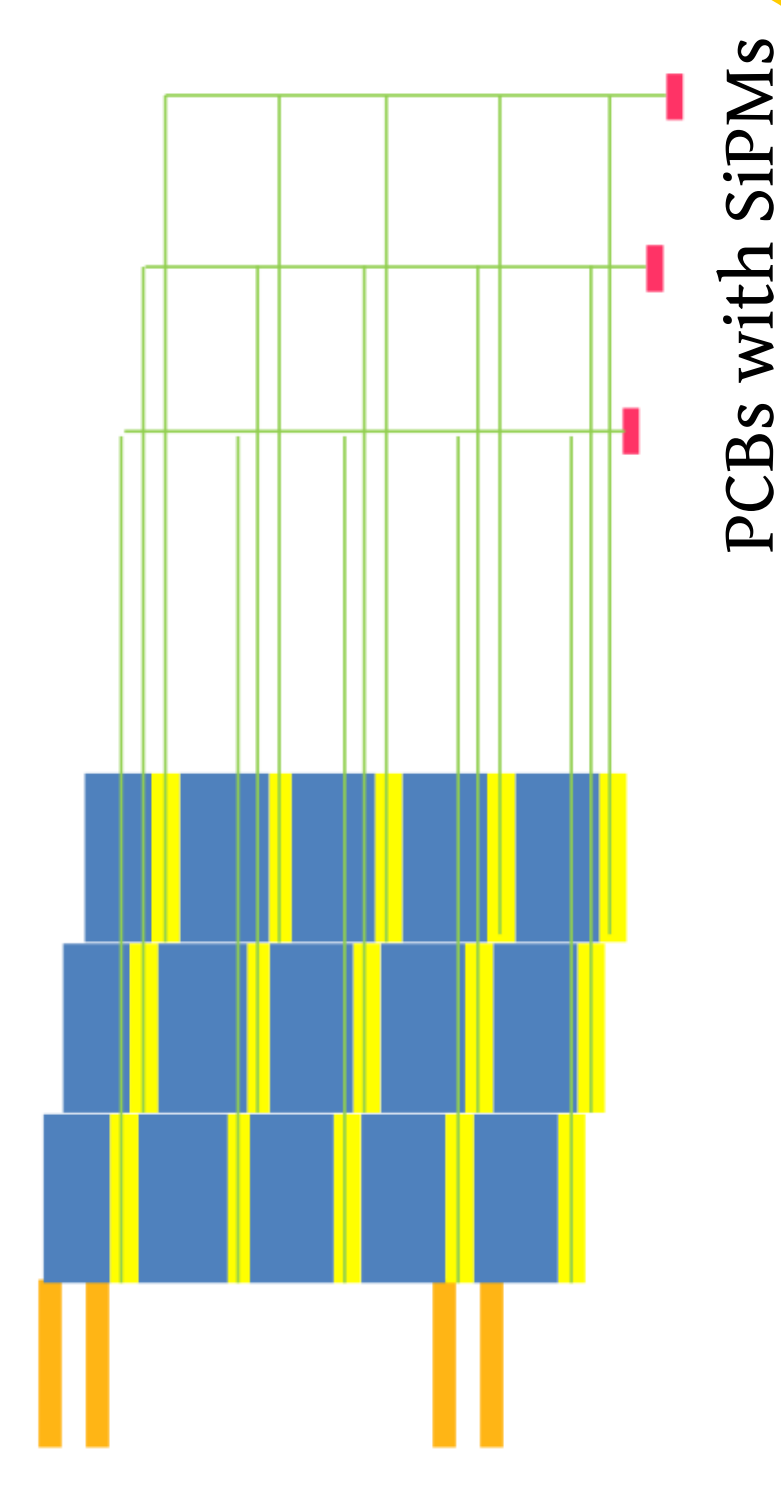
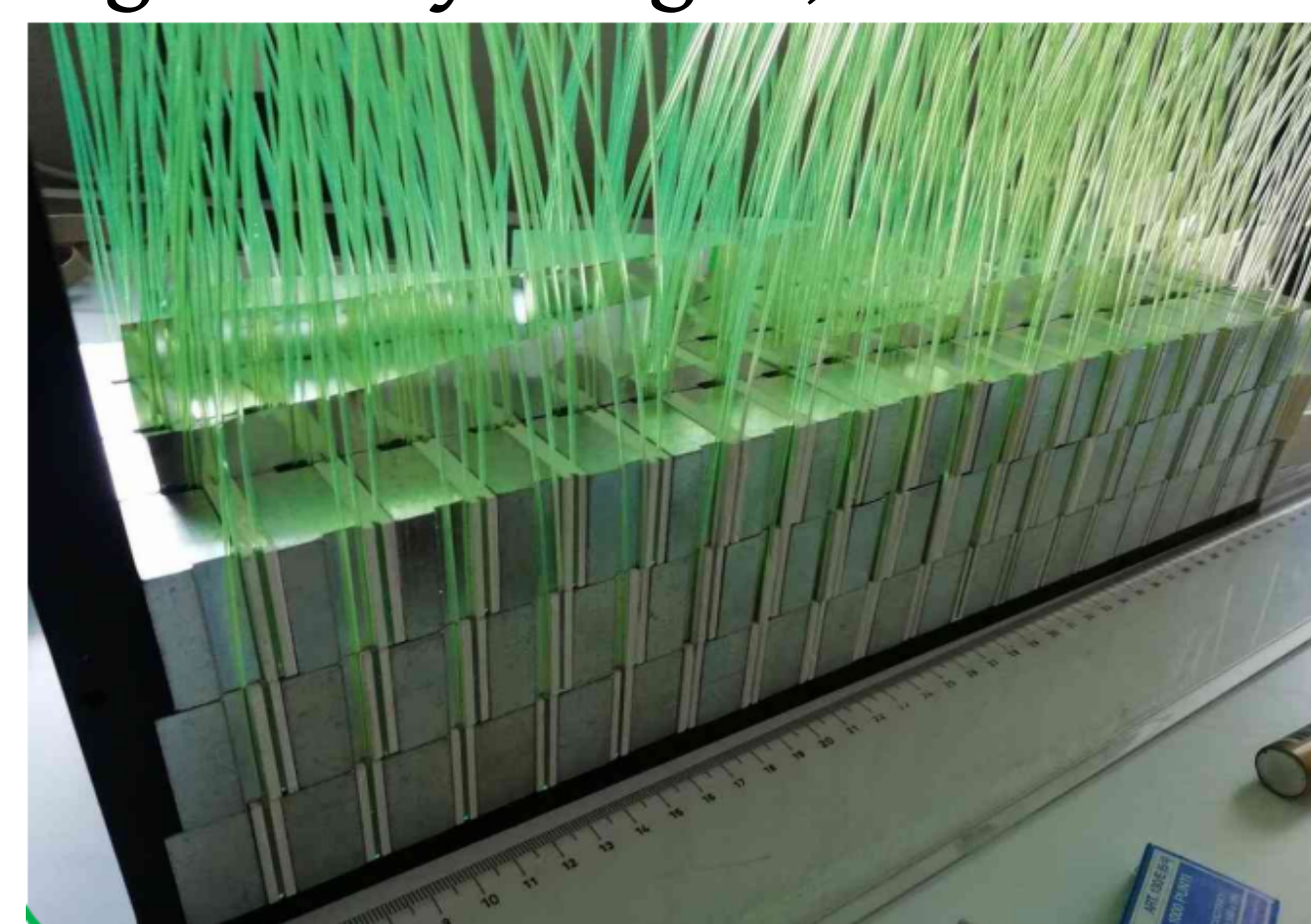


Lateral scintillation light readout

Light collected from scintillator sides and bundled to a single SiPM reading 10 fibers (5 scintillators)

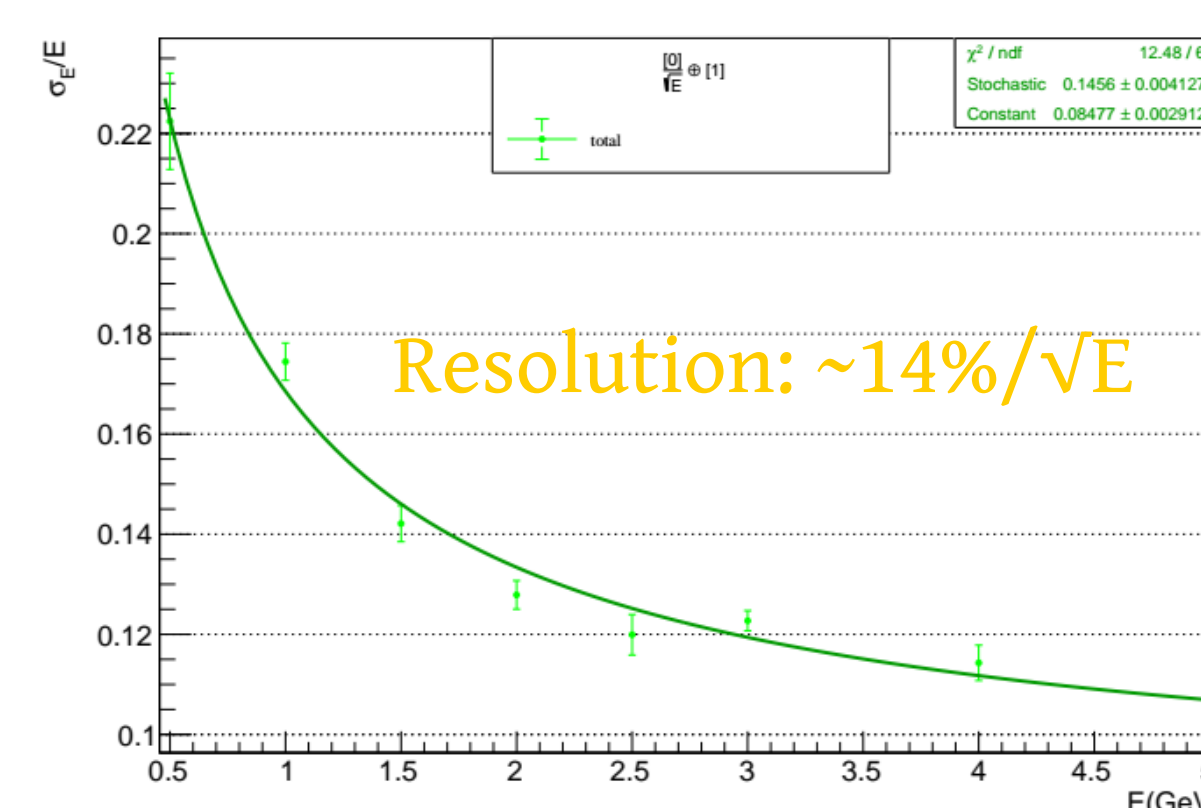
SiPM are not immersed anymore in the hadronic shower thus less compact but ..

- Much **reduced neutron damage** (larger safety margins)
- **Better accessibility**
- **Safer WLS-SiPM coupling**



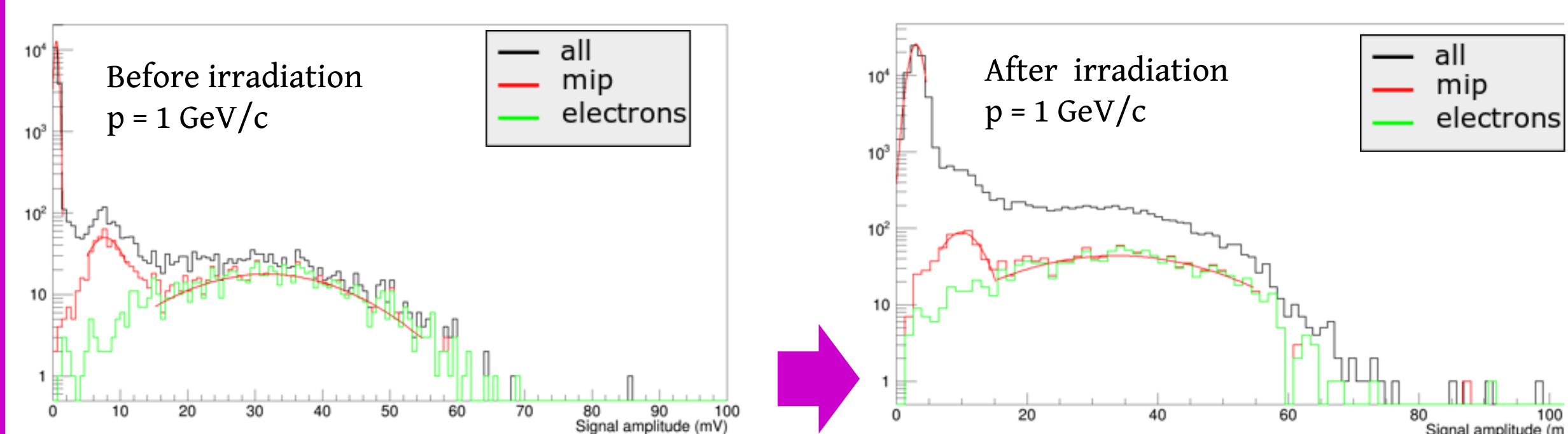
Tagger prototype tested @ CERN (PS-T9)

- 84 UCM :
 - ✓ EJ204 plastic scintillator
 - ✓ Y11 & BCF92 WLS fibers
 - ✓ FBK 4x4 mm² SiPMs
- Measures repeated with different tilt angle (from 0 to 200 mrad)
- Uniformity, optical coupling to photo-sensors, e/π separation → **In progress**
- Comparison with Geant4 simulation of the detector → **In progress**



Test of SiPM radiation-hardness

- Van de Graaf CN accelerator at Laboratori Nazionali di Legnaro $p(5 \text{ MeV}) + {}^9\text{Be} \rightarrow n + X$ (p currents < $1 \mu\text{A}$, $n \sim 1-3 \text{ MeV}$)
- **Test beam @CERN (PS-T9)**
- **Loss of single p.e sensitivity** after $3 \cdot 10^9 \text{ n/cm}^2$
- **Constant mip peak/e peak**



Irradiation: $10^{11} \text{ 1 MeV-eq n/cm}^2$

F. Acerbi et al. JINST 14 (2019) P02029

More information: enubet.pd.infn.it

- Eur. Phys. J. C (2015) 75:155, **A novel technique for the measurement of the electron neutrino cross section.** A.Longhin, L. Ludovici, F. Terranova
- CERN-SPSC-2018-034 ; SPSC-I-248, **The ENUBET project.** ENUBET Collaboration
- IEEE Trans. Nucl. Sci. 64 (2017) 1056, **Shashlik Calorimeters With Embedded SiPMs for Longitudinal Segmentation.** A. Berra et al.