L. Pasqualini (University and INFN of Bologna)
on behalf of the ENUBET Collaboration

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NP06 Experiment at CERN Neutrino Platform

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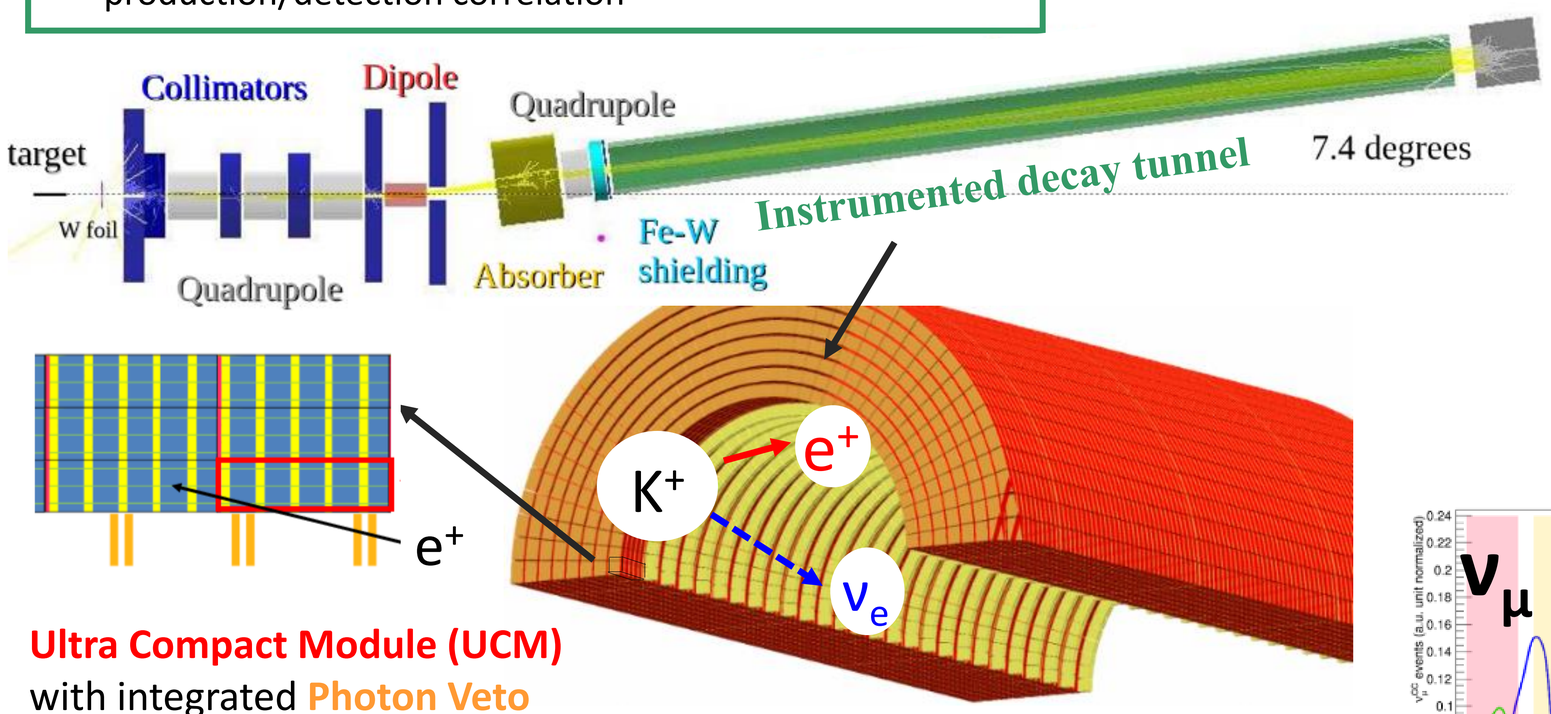
ENUBET: decay tunnel instrumentation for neutrino beams

Physics programme

- Improve by one order of magnitude the ν_e and ν_μ cross sections
- Highly beneficial to future long baseline $\nu_\mu \rightarrow \nu_e$ programs
- First step towards a time tagged neutrino beam: direct ν production/detection correlation

Enhanced NeUtrino BEams from kaon Tagging

- New concept to measure the **neutrino flux** by monitoring positron from $K^+ \rightarrow \nu_e\, e^+\, \pi^0$ decays on an event by event basis
- **Calorimeter system** to instrument the decay tunnel of a narrow band neutrino beam



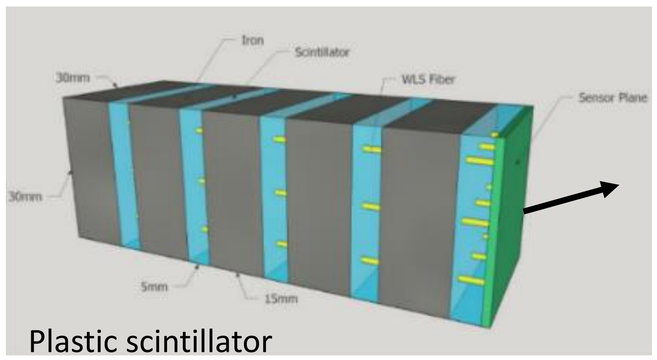
Ultra Compact Module (UCM)
with integrated **Photon Veto**

UCM

R&D studies to develop and test interspersed Fe/scintillators calorimeters coupled to WaveLength Shifter (WLS) fibers readout by Silicon PhotoMultipliers (SiPM): aim at separate $e^+/\pi^\pm/\mu$

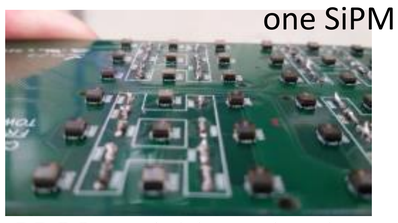
Different prototypes

- **longitudinally segmented shashlik calorimeter**



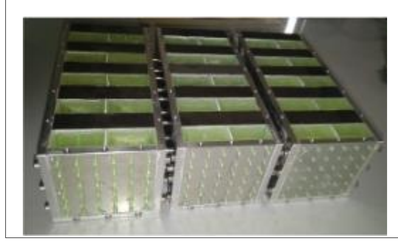
Plastic scintillator

Each fiber readout by one SiPM



PROS: scalable technology
CONS: SiPM exposed to high neutron flux (10^{11} 1 MeV-eq n/cm^2)

- **polysiloxane shashlik calorimeter**



- easier fabrication process: initial liquid form poured at 60 °C, no drilling of the scintillator
- increased radiation hardness of scintillator: transparent after 10 kGy dose exposure
- optimal optical contact with fibers

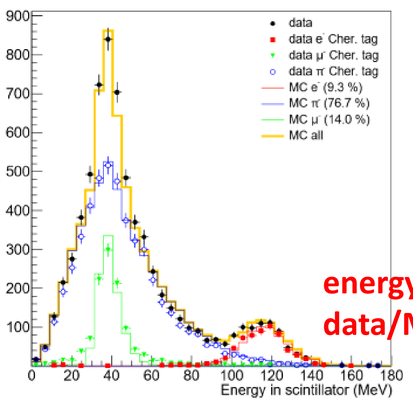
- **lateral readout calorimeter**

fibers bundled and coupled to SiPM 40 cm from the bulk calorimeter

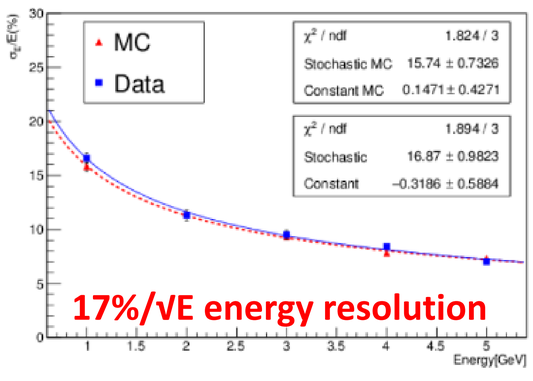
SiPM less exposed to radiation and better SiPM-WLS coupling

results of test beam @ CERN-PS:

UCM shashlik calorimeter
- EJ200 plastic scintillator
- Y11 & BCF92 WLS fibers
- FBK 20 μm SiPMs



energy distribution data/MC agreement



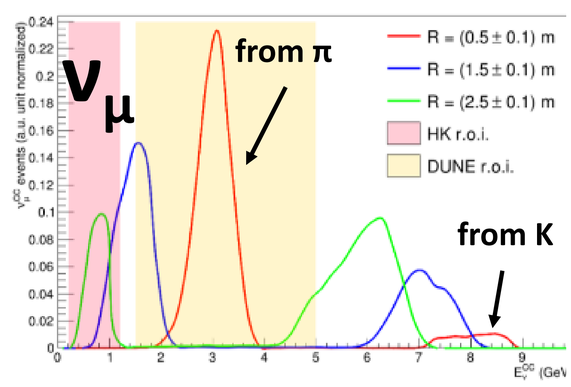
17%/√E energy resolution

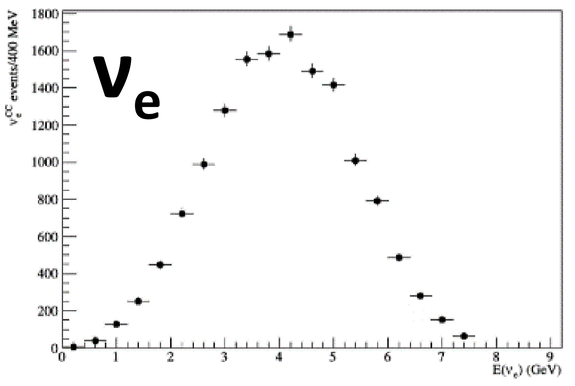
Good e/π separation based on longitudinal segmentation (mis-id. < 3%)
Similar results from other prototypes

Flux monitoring and expected event rates:

ν_μ from K or π well separated in E_ν
→ radius of interaction strongly correlated with E_ν
$\nu_{e/\mu}$ from K: constrained by the tagger (K_{e3}, $K_{\mu 2}$)
ν_μ from π: μ monitoring after hadron dump

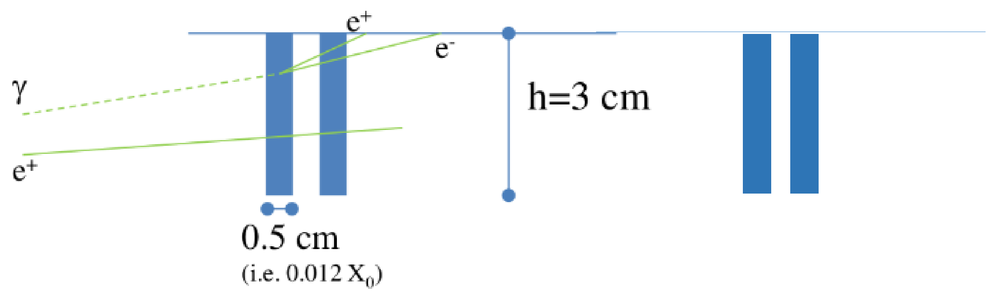
ENUBET @ SPS, 400 GeV, 500 ton detector





Photon Veto

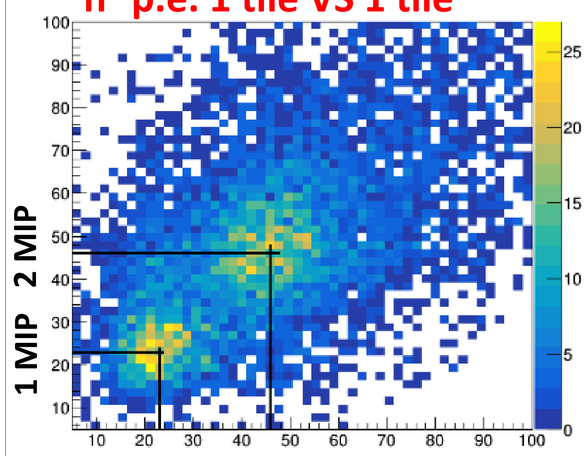
- Below the UCM 3x3 cm^2 plastic scintillator doublets with WLS fibers readout by SiPM
- Tag positron from K^+ decays and rejects e^+e^- pairs produced in γ conversion from π^0



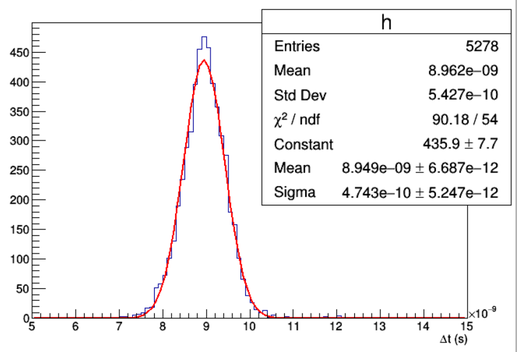
results of test beam @ CERN-PS:

Photon Veto characterization

n° p.e. 1 tile VS 1 tile

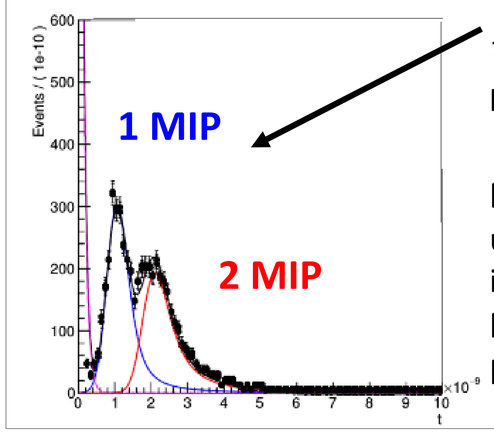


Timing resolution of **400 ps**



- Single MIP response: **24 photo-electrons**
- Light collection efficiency **> 95%**

1 m.i.p/2 m.i.p. separation studies



Tuning of a composite model using test beam data (CERN-PS) of **1 single tile**

MC simulations → pdf sum of **2 or 3 tiles**

Results:
using a cut on the sum of **3 tiles** signal integrals that maximize the significance
Purity > 80 % for N_s/N_b = 1 ‰
Purity > 90 % for N_s/N_b = 1 %

REFERENCES

[1] http://enubet.pd.infn.it
[2] 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
[3] IEEE Trans. Nucl. Sci. 64 (2017) 1056, **Shashlik Calorimeters With Embedded SiPMs for Longitudinal Segmentation**, A. Berra et al.
[4] JINST 13 (2018) P01028, **Testbeam performance of a shashlik calorimeter with fine-grained longitudinal segmentation**, G. Ballerini et al.