ENUBET

Enabling high precision flux measurements in conventional neutrino beams

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on behalf of the ENUBET collaboration

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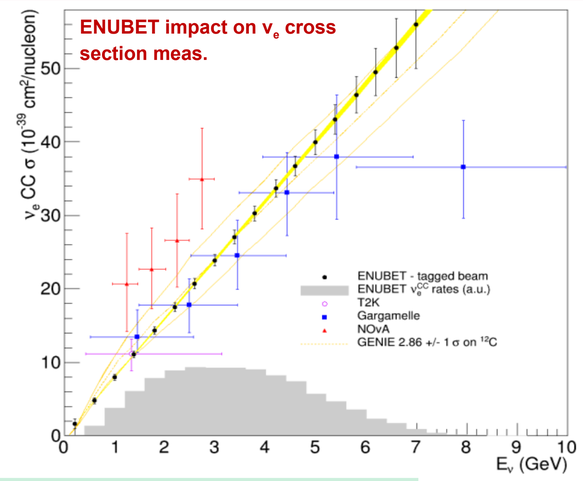
ENUBET (Enhanced NeUtrino BEams from kaon Tagging)

- A new source based on **tagging of large angle e^+ from $K^+ \rightarrow e^+ \pi^0 \nu_e$ decays** in an instrumented decay tunnel
- Reduce systematic uncertainties in the knowledge of the neutrino flux to a **O(1%) level** [1]
- **ERC** funded **project** (n. 681647, P.I. A. Longhin), **Expression of Interest** to **CERN-SPSC** [2]

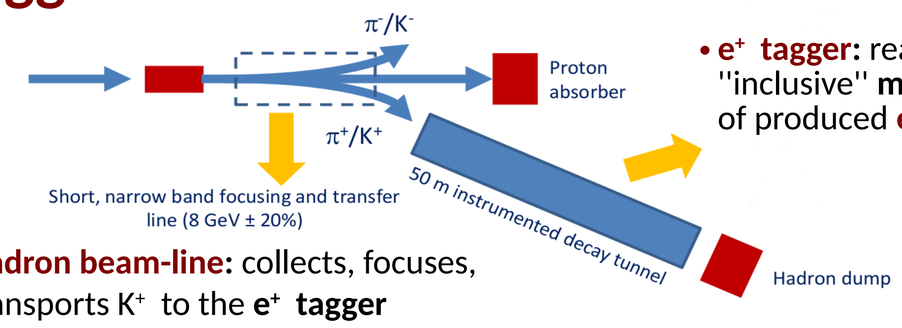
Physics case and applications

- A new generation of **neutrino cross section** experiments with unprecedented control on the flux
- The first step toward a **time-tagged v-beam**, where the v at the detector is correlated with the lepton in the tunnel
- A phase-II **sterile neutrino search**, especially in case of a positive signal from the FermiLab SBL program



Deliverables: **1)** design of the hadron beamline **2)** construction of a demonstrator of the instrumented tunnel (~ 3m)

Tagged neutrino beam



- **e^+ tagger:** real-time, "inclusive" **monitoring** of produced **e^+**
- **Hadron beam-line:** collects, focuses, transports K^+ to the **e^+ tagger**

A traditional beam

- **Passive** decay region
- ν_e flux relies on **ab-initio simulations** of the full chain
- **large uncertainties** from hadro-production, k/π ratio, PoT

↔

The tagged beam

- **Fully instrumented** decay region

$K^+ \rightarrow e^+ \nu_e \pi^0 \rightarrow$ large angle e^+

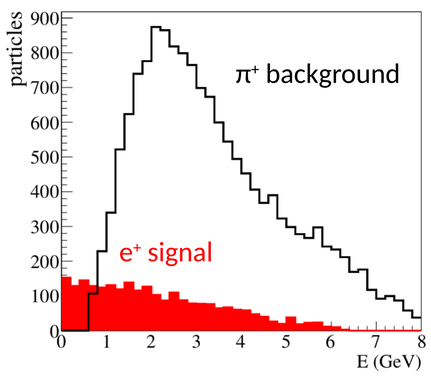
- **ν_e flux prediction = e^+ counting**

O(1%) systematic error achievable

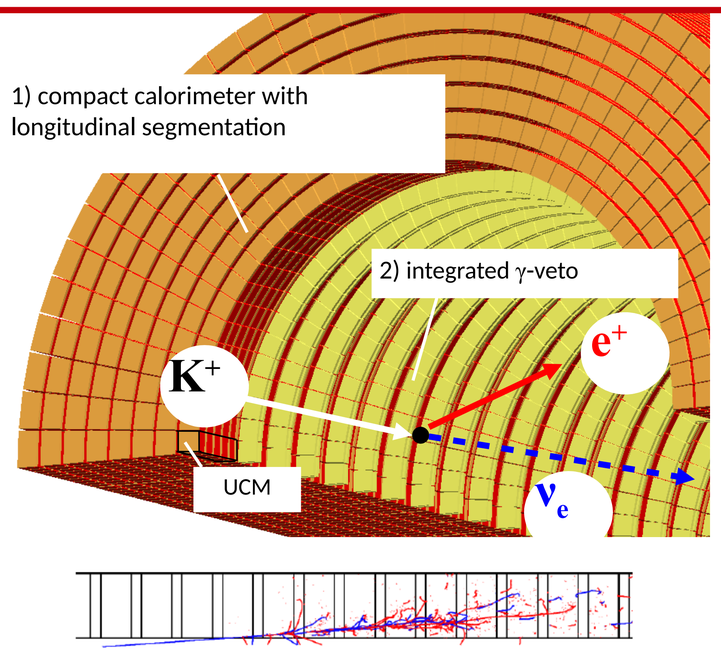
The positron tagger

a **harsh environment:**

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



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

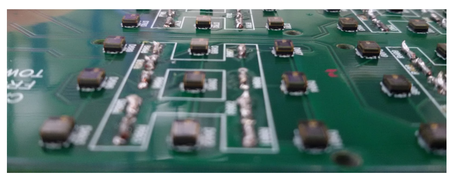


Requirements:

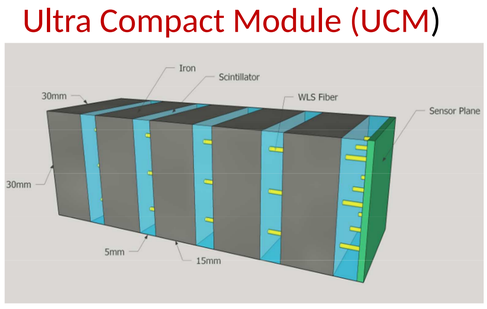
- Homogeneous longitudinal sampling
- radiation hardness
- cost effectiveness

1) Calorimeter ("shashlik") → $\pi^\pm$ rejection

- UCM (4 X_0 thick) read-out by **SiPMs directly coupled to WLS**

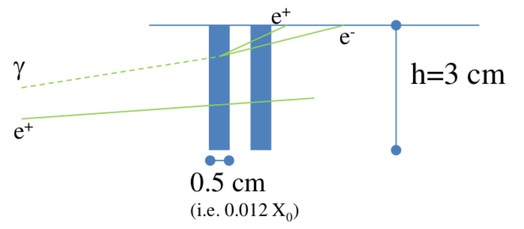


Ultra Compact Module (UCM)



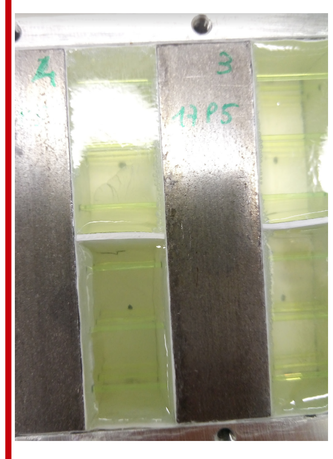
2) Integrated γ –veto → π^0 rejection

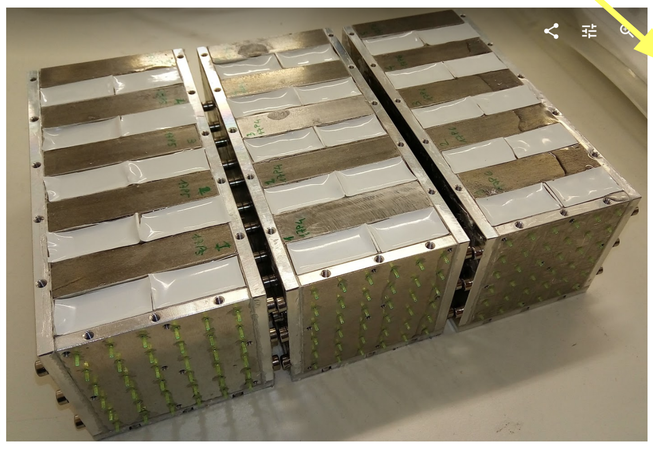
- rings of 3x3 cm² **pads of plastic scintillator** doublets
- 1 m.i.p./2 m.i.p. separation
- alternative solutions allowing superior timing under study (large area fast APD, LAPPD with Cherenkov radiator)

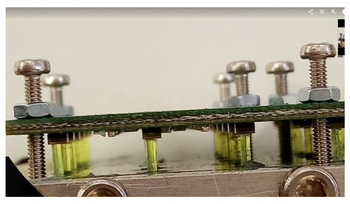


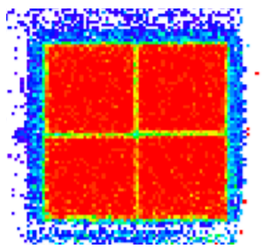
Polysiloxane shashlik calorimeters

- no plastic drilling/molding
- higher rad. Hardness
- optimal optical contact
- Three 4.3 X_0 prototypes successfully tested at the CERN-PS (Oct. 2017)







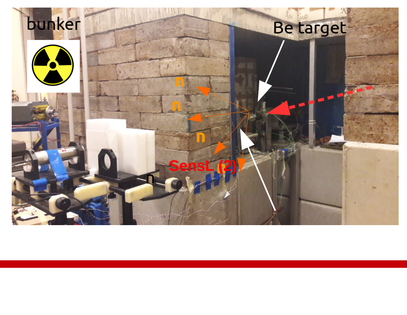


Tests of SiPM radiation-hardness

Van de Graaff CN accelerator
@ INFN **L**aboratori **N**azionali di **L**egnaro

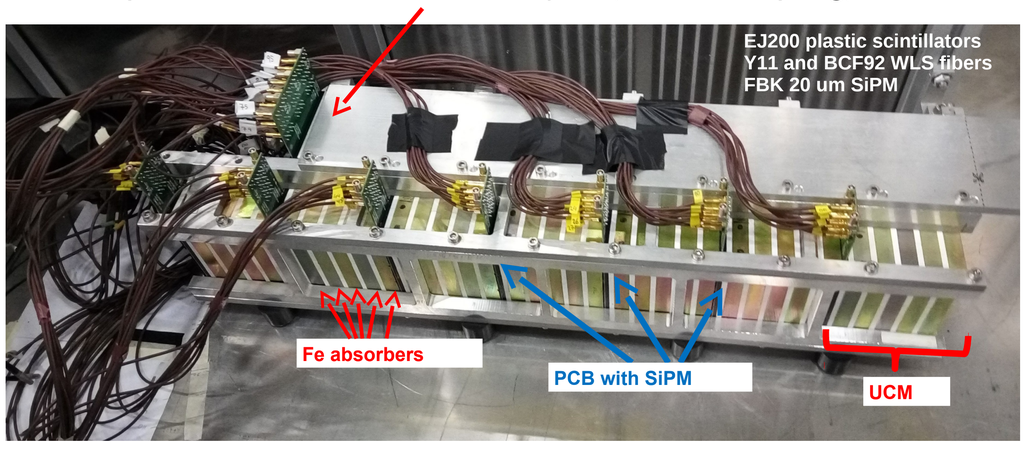
p (5MeV)+^{9}Be → n + X
p currents ~< 1uA
n spectrum ~1-3 MeV

Up to $10^{11\text{-}12}$ n-1MeV-eq/cm²
06/17: irradiation at LNL
08-10/17: tests at CERN



Tagger prototype tests at CERN

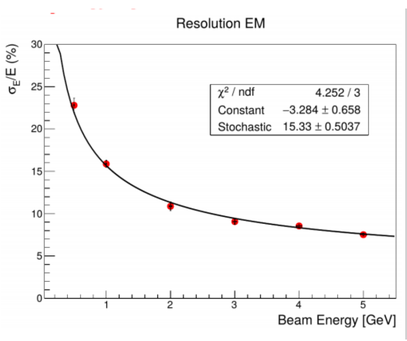
Full SuperModule with "hadronic" layers (coarse sampling)



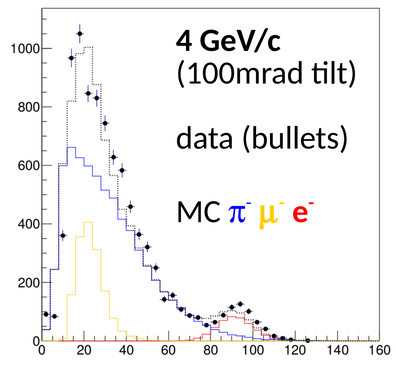
SuperModule tested at CERN-PS East Area, T9 beamline – 01/11/2016

Energy resolution for electrons

In agreement with MC simulation



Electron/pion separation



References

http://enubet.pd.infn.it

[1] 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

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

[3] N.I.M. **A**, 2016.05.123 arXiv:1605:09630
A compact light readout system for longitudinally segmented shashlik calorimeters

[4] IEEE Trans.Nucl.Sci. 64 (2017) no.4, 1056-1061
Shashlik Calorimeters with embedded SiPM for Longitudinal Segmentation, ENUBET Collaboration.

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