High precision neutrino flux measurements with ENUBET

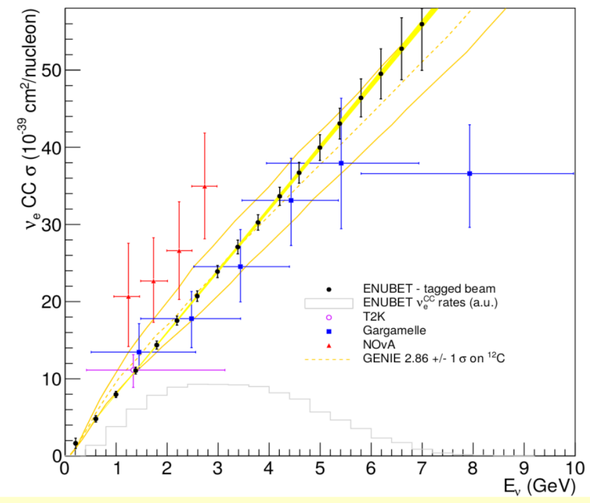
M. Pozzato (INFN-Bologna) on behalf of ENUBET collaboration - P2.040

ENUBET (Enhanced NeUtrino BEams from kaon Tagging)

A new-concept ν_e source based on tagging of e^+ from $K^+ \rightarrow e^+\pi^0\nu_e$ decays

The goal of the project is to demonstrate the **feasibility of real time monitoring of the positrons produced at high angle in the decay tunnel of conventional neutrino beam** to obtain a x 10 reduction in the systematics on the neutrino flux → Highly beneficial for the **leptonic CP violation** international program at long baselines ($\nu_\mu \rightarrow \nu_e$).ENUBET is a **ERC Consolidator Grant-2015** project (n° 681647, P.I. A. Longhin) with a **2 MEUR** funding **started on 1/6/2016 w. a 5 years duration**.

O(10^4) ν_e^{CC} in a few years of run at existing proton drivers with a 500 t scale detector [1]



A traditional beam

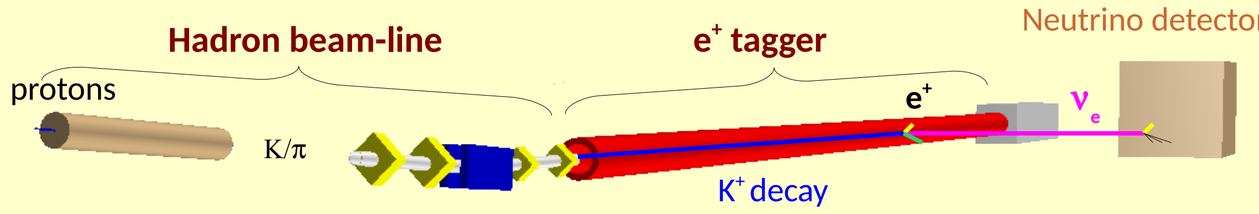
- **Passive** decay region
- ν_e flux relies on **ab-initio simulations** of the full chain
- **large uncertainties** from model dependency

The tagged beam

- **Fully instrumented** decay region

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

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



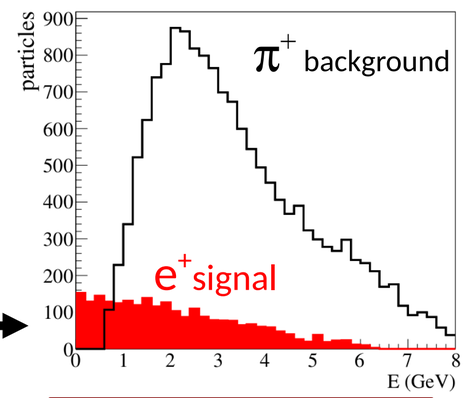
- **Hadron beam-line:** collects, focuses, transports K^+ to the e^+ tagger
- **e^+ tagger:** real-time, "inclusive" **monitoring** of produced **e^+**

The positron tagger

The decay tunnel: a **harsh environment**

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

Need to veto 98-99 % of them



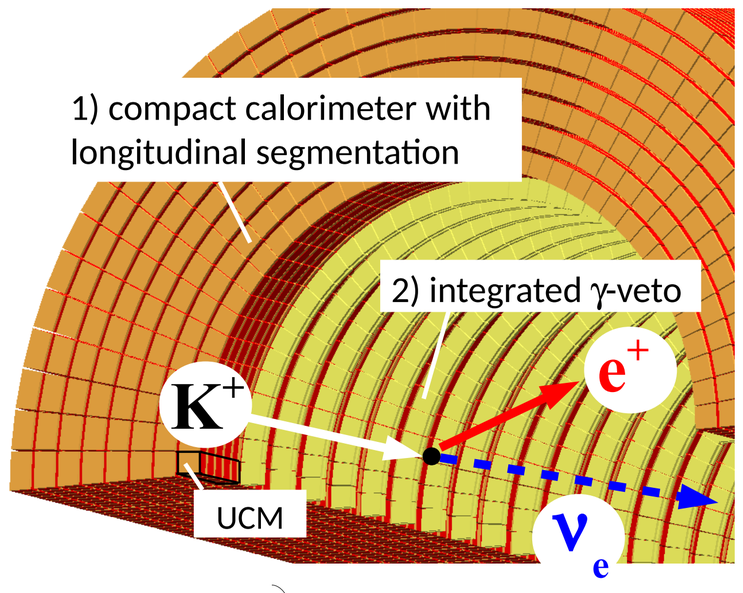
- **extended source of ~ 50 m**
- grazing incidence
- significant spread in the initial direction

→ an unprecedented challenge

Conventional beam-pipe replaced by **active instrumentation** →

Key point:
- longitudinal sampling
- perfect homogeneity

→ integrated light-readout

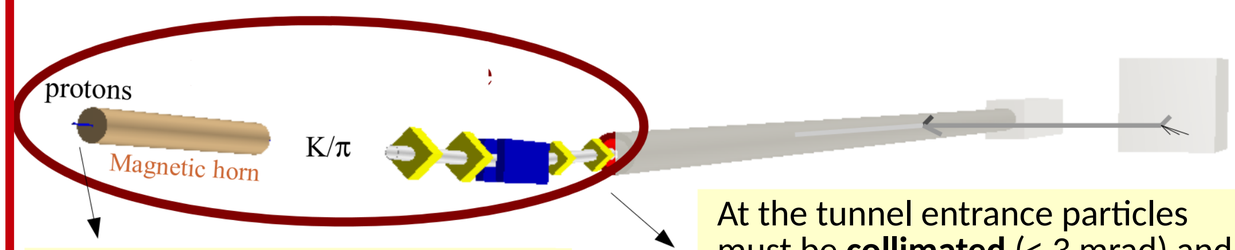


1) Calorimeter ("shashlik") → $\pi^\pm$ rejection
- Ultra-Compact Module (UCM)

2) Integrated γ -veto → π^0 rejection
- plastic scintillators or
- large-area fast avalanche photodiodes

A rich program of detector **R&D activities** of general interest for **particle physics**

The hadron beamline



The proton extraction must be efficient and **"slow"** (saturation)

At the tunnel entrance particles must be **collimated** (< 3 mrad) and **energy selected** (20% spread)

Scenarios	Focusing system	Proton extraction from accelerator
A	**pulsed device** (magnetic horn) →	**Unconventional:** many (10^8), short (2 ms) pulses with few protons (< 3 x 10^{11})
B	**static devices** (DC magnets) →	**O(1s) long slow extractions**

Scenario B is the way to **a "time-tagged" ν beam**
proton "time-dilution" → t-coincidences between e^+ and ν_e

Bruno Pontecorvo

ENUBET final results:

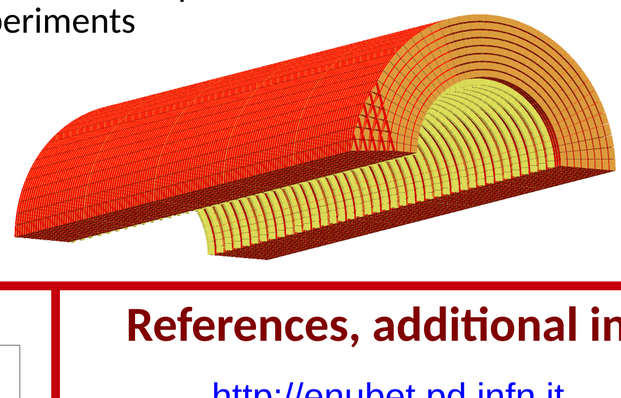
- **1) e^+ tagger** validated with **particle beams data**
- 2) a detailed design for the **hadron beam-line**

The complete picture to move to a full scale experiment

By-products and cross-fertilization:

- **calorimetry** → new low-cost, ultra-compact detectors
- **accelerator physics solutions** → novel proton extraction schemes for fixed-target and beam-dump experiments

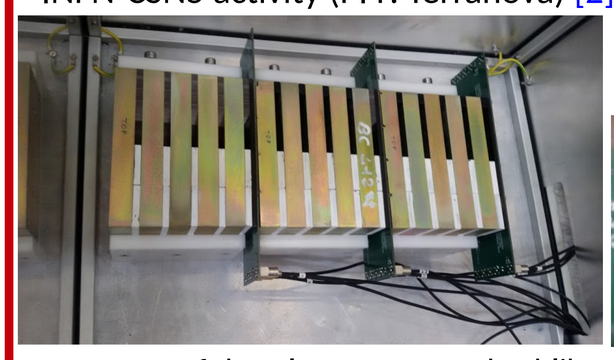
Prototype dimensions:
3 m × π
60 cm outer radius



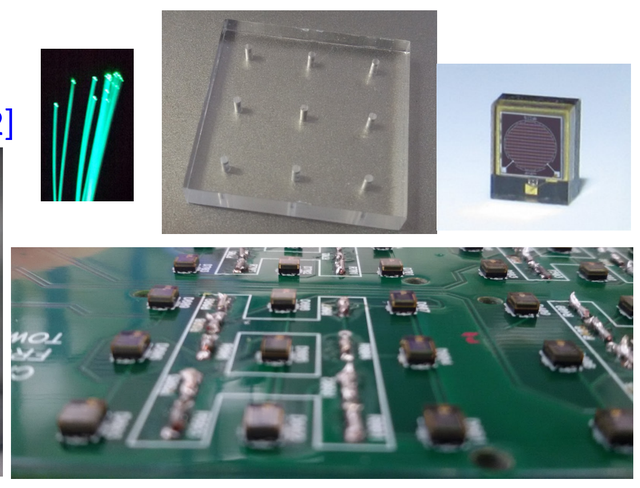
Tagger detector R&D:

SCENTT **Shashlik Calorimeters for Electron Neutrino Tagging and Tracing**

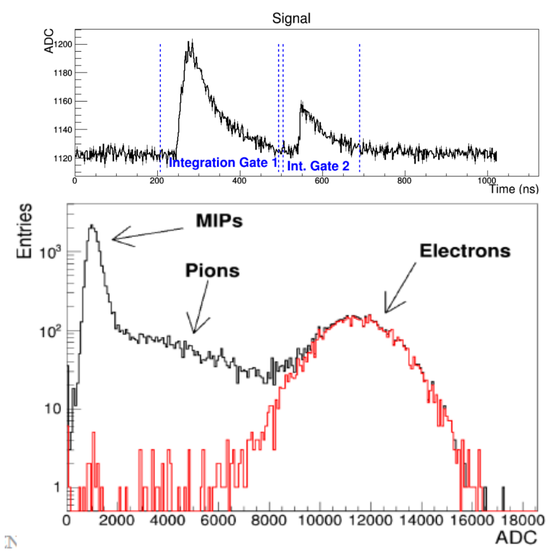
INFN-CSN5 activity (PI F. Terranova) [2]



Prototype of the Ultra-Compact shashlik calorimeter. CERN East Area, T9 beamline (29/06/2016)



SiPM array coupled directly to WLS fibers



Timing and PID studies

References, additional info

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[1], L. Ludovici[2], F. Terranova[3,a]

[2] N.I.M. **A**, 2016.05.123 arXiv:1605:09630

A compact light readout system for longitudinally segmented shashlik calorimeters

A. Berra[a,b,*], C. Brizzolari[a,b], S. Cecchini[c], F. Cindolo[c], C. Jollet[d], A. Longhin[e], L. Ludovici[f], G. Mandrioli[c], N. Mauri[c], A. Meregaglia[d], A. Paoloni[e], L. Pasqualini[c,g], L. Patrizii[c], M. Pozzato[c], F. Pupilli[e], M. Prest[a,b], G. Sirri[c], F. Terranova[b,h], E. Vallazza[i], L. Votano[e]