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ENUBET: a monitored neutrino beam for the precision era of neutrino physics

Evgenii Lutsenko (on behalf of the ENUBET Collaboration)
Università degli Studi dell'Insubria & INFN - Sezione di Milano Bicocca

ENUBET (Enhanced NeUtrino BEams from kaon Tagging)

Checkout more: https://enubet.pd.infn.it/

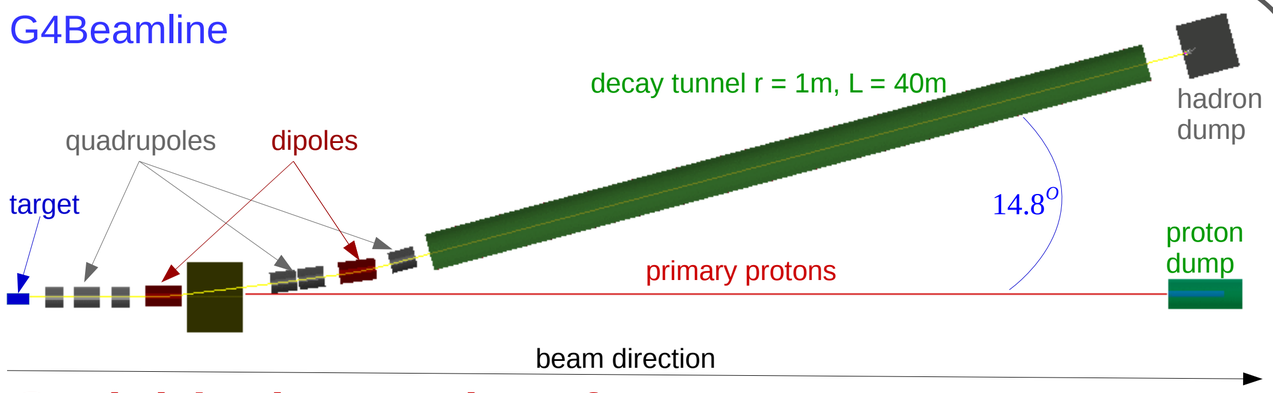
- New-concept source based on tagging of large angle positrons from K_{e3} decays in an instrumented decay tunnel.
- Reduction of the systematic uncertainties on the knowledge of the initial neutrino flux to O(1%) level.

Physics implications

- Unprecedented high precision measurement of cross sections (short baseline neutrino experiments).
- Highly beneficial for tackling the main open neutrino-related problems: mass hierarchy, octant, leptonic CP violation.
- First step towards a time tagged neutrino beam: direct production/detection correlation.

The experiment full simulation

G4Beamline

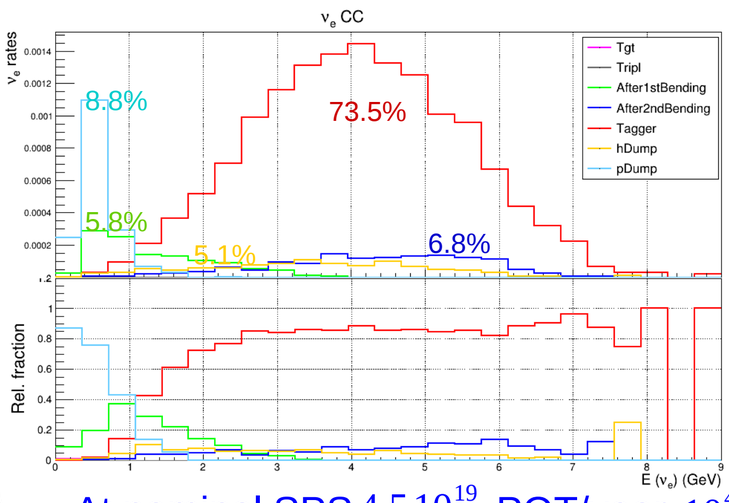


Static(slow) extraction of protons:

- Strong reduction of the rate in the instrumented decay tunnel.
- No need for fast-cycling horn.

Primary protons moment	$\pi^+[10^{-3}/POT^*]$ $[8.5\pm5\%]GeV/c$	$K^+[10^{-3}/POT]$ $[8.5\pm5\%]GeV/c$
$400\,GeV/c$	4.2	0.4

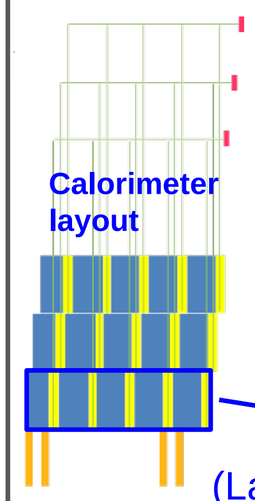
*POT = protons-on-target

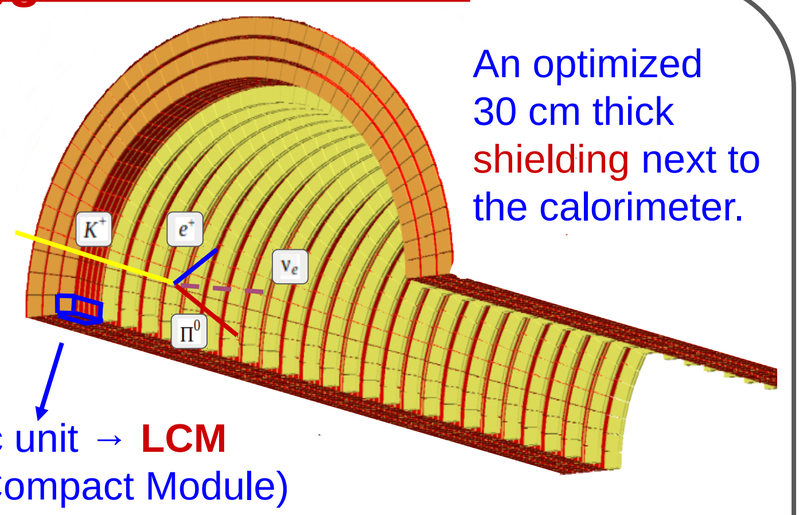


- 73.5% of the total ν_e flux generated inside the tunnel → more than 80% above 1 GeV.
- Below 1 GeV main component is produced in the proton-dump region.
- 12% given by the straight section in front of the tagger.

At nominal SPS $4.5\,10^{19}$ POT/year $10^4\,\nu_e^{CC}$ @500tons LAr neutrino detector located 50m from the tunnel in ~2 years.

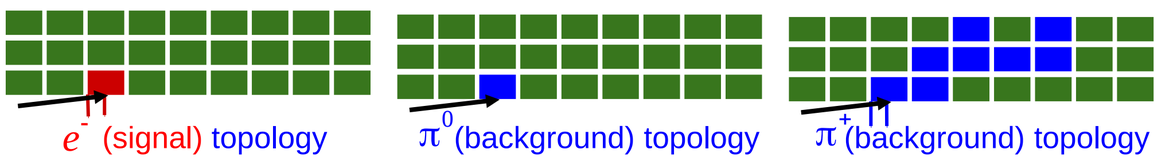
Tagger & Calorimeter





An optimized 30 cm thick shielding next to the calorimeter.

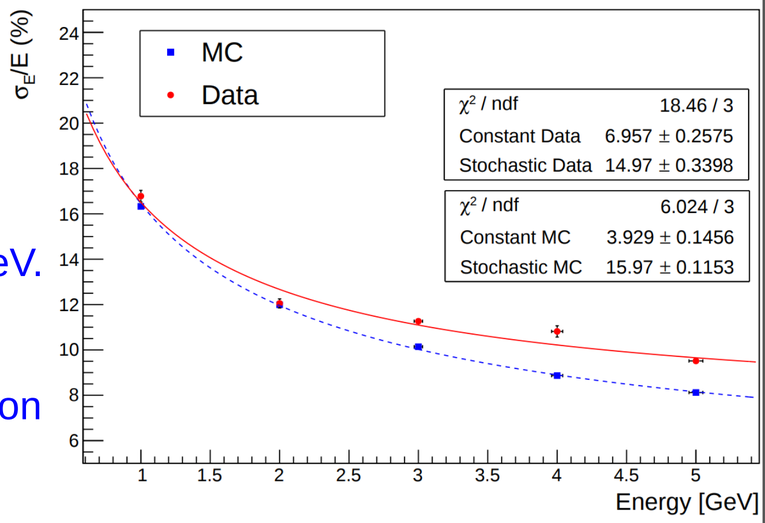
Basic unit → **LCM** (Lateral Compact Module)



The test beam results

Sampling calorimeter: sandwich of plastic scintillators and iron absorbers.

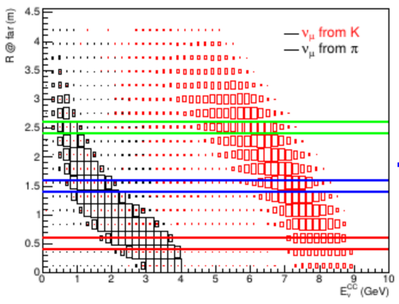
- 17% en res. at 1 GeV.
- Impact point of the particle affects contribution to saturation at higher energy.



- Mean Energy deposited by π^- in each plane of the calorimeter from data evaluated and compared to simulation.
- discrepancy below 10% and comparable to uncertainty due to low-energy hadronic shower simulation.

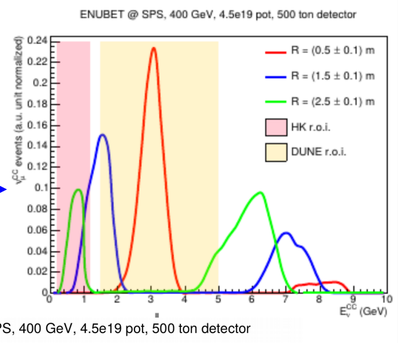
Narrow-band Off-axis Technique

Narrow momentum width of the beam (O(5-10%)) and finite transverse dimension of the neutrino detector show a strong correlation between E_ν in the detector and the radial distance (R) of the interaction vertex from the beam axis.

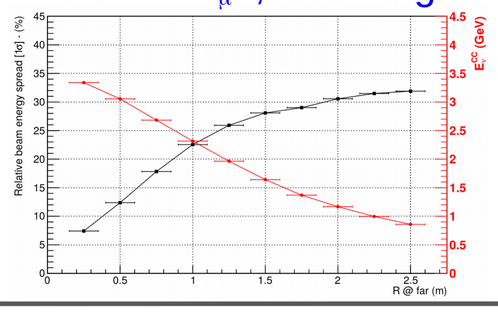


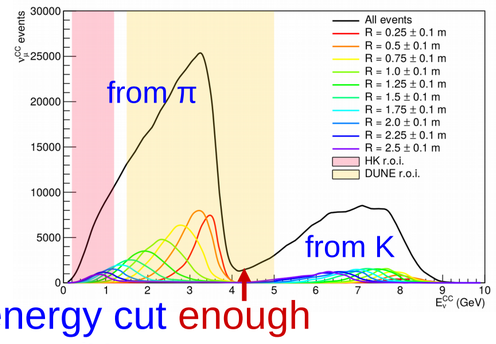
By selecting interactions in radial windows of ±10 cm

we collect respective samples of ν_μ^{CC} events.



- Interaction rates from convolution of flux and CC x-sec, full detector response not yet included.
- Total $10^4\,\nu_\mu^{CC}$, assuming $4.5\,10^{19}$ POT.



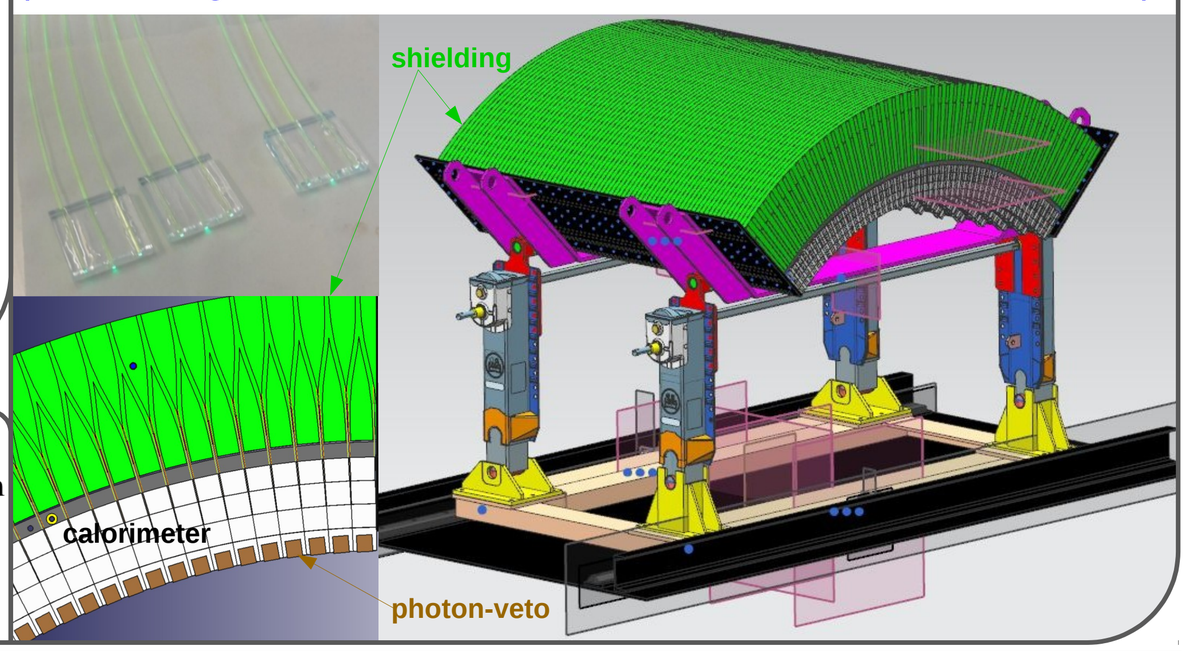


- Loose energy cut enough to separate π/K component.
- Width of pion peak at different R → estimator of the precision on E_ν.

The Demonstrator

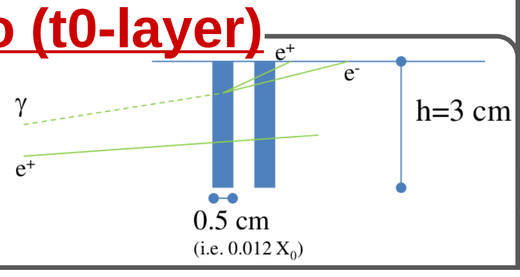
ENUBET is building a detector prototype to demonstrate performance, scalability and cost-effectiveness.

- New light readout scheme: from lateral to frontal light collection.
- The shielding is in borated polyethylene and it will acts as a protection for SiPMs against neutron irradiation.
- To be tested at CERN in 2022 (1.65m long, covers 90° in azimuth, the 45° will be instrumented).



Integrated Photon-veto (t0-layer)

- $3x3\,cm^2$ plastic scintillator pads.
- e^+/π^0 separation.
- Positrons of K decays in ENUBET cross 5 tiles on average.



ENUBET is a ERC Consolidator Grant. Jun 2016 - May 2022. Since April 2019, it's also a CERN Neutrino Platform experiment: NP06/ENUBET.

Invisibles 2021 on-line Workshop 31 May - 4 June 2021