Status of the NP06/ENUBET neutrino beam

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NP06/ENUBET OVERVIEW

NP06: CERN Neutrino Platform experiment number 6
ENUBET: Enhanced NeUtrino BEams from Kaon Tagging

GOAL: developing a new narrow-band neutrino beam in which the flux and flavor composition are known at 1% level, and the energy with 0(10%) precision.

MOTIVATION: supported by the European Strategy for Particle Physics Deliberation document (page 5): “To extract the most physics out of DUNE and Hyper-Kamiokande, a complementary programme of experimentation to determine neutrino cross-sections and fluxes is required. [...]. The possible implementation and impact of a facility to measure neutrino cross-sections at the percent level should continue to be studied.”

THE DECAY TUNNEL

NP06/ENUBET will be the first “monitored neutrino beam”:

- $\nu_e$ flux monitored by tagging positrons in the instrumented decay channel.
- $\nu_e$ flux monitored by tagging muons in the instrumented decay channel and range-meter in the hadron dump.

$K^0$ decay mode: Branching ratio (%)

<table>
<thead>
<tr>
<th>Decay Mode</th>
<th>Branching Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+$</td>
<td>66.0</td>
</tr>
<tr>
<td>$\pi^0$</td>
<td>25.7</td>
</tr>
<tr>
<td>$\pi^-$</td>
<td>7.3</td>
</tr>
<tr>
<td>$\mu^+$</td>
<td>1.2</td>
</tr>
<tr>
<td>$\mu^-$</td>
<td>0.1</td>
</tr>
<tr>
<td>$\nu_e$</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Constrast from MC simulation PDF (e.g. $P_{\nu e}$) and store it as a histogram

EXAMPLE: consider as observable the position $Z$ along the calorimeter of the muons from $K$-decays.

$D$-FLUX SYSTEMATICS

Lepton monitoring data coming from the calorimeter and range-meter can constrain the hadro-production and beamline parameters, implying a reduction of the systematic uncertainty on the neutrino flux.

REFERENCEs

* The ERC ENUBET Project site: https://enubet.pad.infn.it/
* Fabio Iacob, CERN-SPSC-2021-013, SPSC-IR-290, Geneva, 2021
* Fabio Iacob et al., The ENUBET positron tagger prototype: construction and testbeam performance, JINST 15 P08010, 2020
* Fabio Iacob et al., The ENUBET positron tagger prototype: construction and testbeam performance, JINST 15 P08010, 2020
* Fabio Iacob et al., CERN-SPSC-2021-013, SPSC-IR-290, Geneva, 2021
* Fabio Iacob et al., CERN-SPSC-2021-013, SPSC-IR-290, Geneva, 2021

THE PROTON TARGET

The design of the cylindrical target has been studied to optimize the challenging trade-off between flux and systematic uncertainties. The final output of the optimization is: $\nu_e$ re-interactions in the target.

Studied to optimize the challenging trade-off between flux and systematic uncertainties:
- The hadro-production parameters are constrained to the values maximizing the likelihood
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THE MESON TRANSFER LINE

Assuming a realistic operation at CERN-SPS corresponding to $4.5 \times 10^{10}$ POT/year, the newly simulated transfer line TL6 would ensure, in a far detector displaced 50 m downstream, the occurrence of $10^6$ $\nu_e$CC interactions in about 2 years.

Simplified hadro-production toy model shows systematic uncertainty reduction from initial 13% down to 1.8%. Complete study of systematics budget ongoing.