1 β-beam from CERN to Frejus ($\gamma = 100$)

- Used ions: ^{18}Ne, ^{6}He
- Neutrino spectra calculated according to [1]
- ν_μ **appearance:**

Item	Evaluation	LENA	Remarks
Signal	MC simulation, [2]	Generated events: 3901 (CC) μ^- tagged: 3448 (88%)	Full oscillation (ν_μ sample)
Background $\pi^\pm$	MC simulation, [2]	Generated events: 4800 (CC)/ 300 (NC) $\mu^\pm$ tagged: 3800 (79%) /223 (74%)	No oscillation (ν_e generated $\pi^\pm$ only)

- $\bar{\nu}_\mu$ **appearance:**

Item	Evaluation	LENA	Remarks
Signal	MC simulation, [2]	Generated events: 1457 (CC) μ^- tagged: 1312 (90%)	Full oscillation (ν_μ sample)
Background $\pi^\pm$	MC simulation, [2]	Generated events: 2000 (CC)/ 1600 (NC) $\mu^\pm$ tagged: 118 (6%) / 673 (42%)	No oscillation (ν_e generated $\pi^\pm$ only)

- **Energy resolution:**
  Full migration matrices from MC simulations for both signal channels as well as for the respective $\pi^\pm$ background channels (combined NC + CC) [2]

Channel	Item	Used events
$\nu_e \to \nu_\mu$	Signal	3448
$\nu_e \to \nu_\mu$	Background	4023
$\bar{\nu}_e \to \bar{\nu}_\mu$	Signal	1312
$\bar{\nu}_e \to \bar{\nu}_\mu$	Background	755

- **Physics potential:**
  Discovery reach of $\sin^2(2\theta_{13}) = 0.05$ mean [2]. Currently no algorithm to veto $\pi^\pm$ is available. It was found that such an algorithm would greatly improve the discovery potential.

Note: All neutrino interactions were simulated in the center of LENA.

2 Superbeam from CERN to Pyhäsalmi

- **Energy resolution :**

Approach	Evaluation	LENA	Remarks
Simple photon counting (calorimetric approach)	MC simulation Generated events: 2000 (ν_μ-CC) 1000 (ν_e-CC)	$\lesssim 10\%$	Flat spectrum $[0.1, 5]$ GeV, no track reconstruction used
Full event reconstruction	Scinderella MC Code, [3] Generated events: $\lesssim 100$ (all types)	$\lesssim 3\%$	For full potential FADC readout required

- **Particle identification:**

Item	Evaluation	LENA	Remarks
e $\leftrightarrow \mu$	Scinderella MC Code, [3] Generated events: $\lesssim 100$ (all types)	No misidentification observed	For full potential FADC readout required
$\pi^0 \leftrightarrow e^\pm$	MC Simulation, MVA [4] Generated events: 213 676 e^- and 210 000 π^0, flat spectrum, $E_{tot} \in [135\,\text{MeV}, 1\,\text{GeV}]$, no neutrino vertex	30% background at 94.1% efficiency 10% background at 65.3% efficiency 1% background at 14.2% efficiency	Constant event position and direction

- **NC-suppression for ν_e-appearance**

Event type	Fraction of NC-events	LENA	Remarks
At least one π^+	44%	Discrimination by tagging of decay muon, efficiency 86% [2]	Efficiency determined at sub GeV energies, π^- captured at ^{12}C
At least one π^0 but no π^+	32%	MVA[4] 10% contamination	Discrimination should be better for events with multiple π^0
At least one $e^{\pm}$, γ, $K^{0,\pm}$ or heavier, neither π^0 nor π^+	1.7%	No discrimination available	To be studied
"pure" π^-	7%	Kinematic of pion corresponds to $\mu^{\pm}$, pulse shape discrimination should be applicable.	For pure e-μ discrimination via pulse shape, see [2]
Events with only $p^{\pm}$ or $\overset{(-)}{n}$	15%	Quenched to lower energies different pulse shape	

Dependant on how good the discrimination for the last two event categories will be, the NC-background contamination will be between 11.4% and 33.4%.
Notes:

  - This has been compiled looking only at the interactions generated with the GENIE neutrino event generator [5]. No full detector simulation has been performed.
  - The neutrino flux spectrum used for GENIE was taken from [6].
  - Simulated interactions: 50 000 for each (anti-)neutrino type.
  - To derive this result, the assumption that the different cuts are independent of each other was made. This assumption is conservative as it implies that e.g. a π^+-event which passes the first cut, automatically passes all further cuts.
  - These cuts would reduce the efficiency to the ν_e-CC signal to about 27.7%, assuming that the cuts on the last two items in the tables have 100% signal efficiency.

References

[1] S. K. Agarwalla, A. Raychaudhuri and A. Samanta, Physics Letters , 33 (2005), [hep-ph/0505015].

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[3] J. Peltoniemi, ArXiv e-prints (2009), [0909.4974].

[4] S. Lorenz, Discrimination of Neutral Current Background in a Future Long-Baseline Experiment with LENA, Diploma Thesis, 2012.

[5] C. Andreopoulos *et al.*, Nucl. Instrum. Meth. **A614**, 87 (2010), [0905.2517].

[6] A. Longhin, PoS **325** (2010), `http://irfu.cea.fr/en/Phocea/Pisp/index.php?id=72`.