THE INTERNATIONAL DESIGN STUDY FOR THE NEUTRINO FACTORY

Accelerator systems for the International Design Study of the Neutrino Factory

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Abstract

The Neutrino Factory produces high-energy neutrino beams with a well-defined flavour content and energy spectrum from the decay of intense, high-energy, stored muon beams. The muon storage rings include long straight sections that are directed toward neutrino detectors that are sited several thousand kilometers away. This poster defines the muon-beam requirements and describes the accelerator facility that is required to deliver them. We give a baseline specification for the accelerator facility and describe the accelerator subsystems of which it is comprised. We will briefly present some of the accelerator-physics challenges such a facility presents and alternative designs for some of the subsystems.

IDS-NF Accelerator Baseline

The Neutrino Factory [1, 2] based on the muon storage ring will be a precision tool to study neutrino oscillations. It may also serve as the front-end of the Muon Collider.

The baseline IDS-NF accelerator facility consists of:

- High power proton driver.
- Pion production target and capture system.
- Muon buncher and phase rotator.
- Muon cooler.
- Linear muon accelerator up to 0.9 GeV.
- Two Recirculating LInear Accelerators (RLAs) to boost muons to 12.6 GeV.
- Non-Scaling Fixed Field Alternating Gradient (NS-FFAG) ring for the final acceleration up to 25 GeV.
- Two decay rings for the short and long baseline neutrino oscillation experiments.

Repetition rate	50 Hz
Proton power on target	4 MW
Proton energy on target	5-10 GeV
Number of proton bunches in the macropulse	3
Sequencial delay between proton bunches	80 us
Proton bunch length on target	~2 ns rms
Muon capture momentum	~232 MeV/c
Muon accelerator normalized acceptance	3 cm rad
Final energy in the decay ring	25 GeV

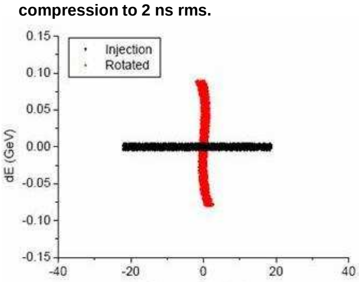
Table of the selected IDS-NF baseline parameters.

Proton Driver

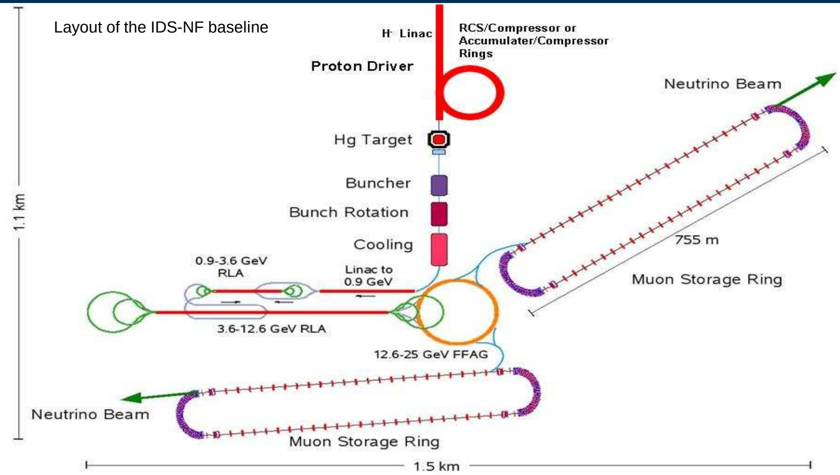
Current options for the NF proton driver:

- Linac based (SPL) proton driver at CERN – the most advanced.
- Synchrotron(s)/FFAG based proton driver (green field solution) – under study at RAL.
- Project X based solution at Fermilab.
- Solution based on synergy between neutron spallation source (MW ISIS upgrade) and NF.
- Other solutions (multiple FFAGs, NS-FFAGs, etc.) – in the state of ideas.

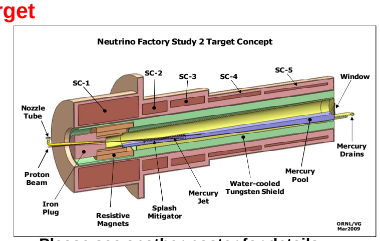
The main challenge is the final bunch length compression to 2 ns rms.



Final bunch compression in the CERN scheme.



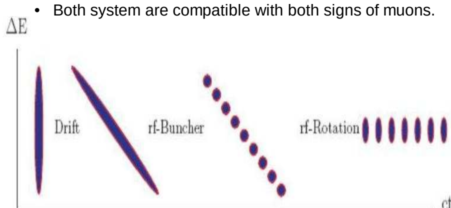
Target



Please see another poster for details.

Bunching and phase rotation

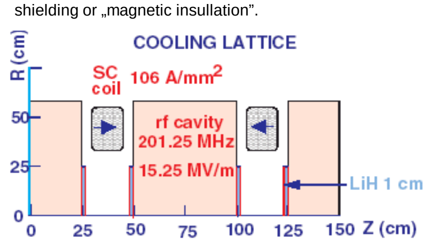
- The bunching system is transforming a single muon bunch into the set of microbunches compatible with 200 MHz RF system
- The phase rotation is reducing the momentum energy spread
- Both system are compatible with both signs of muons.



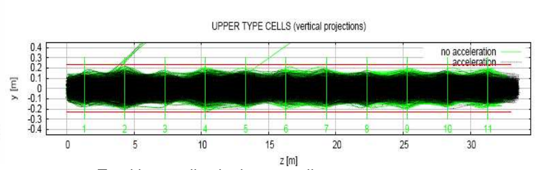
Longitudinal evolution of muon beam in the buncher and rotator.

Muon Cooling

- The high performance cooling lattice has been developed.
- The principles of the ionization cooling will be challenged by the MICE experiment.
- **The main problem is the high voltage RF break down in the magnetic field.**
- The possible cures include gas filled systems, magnetic shielding or „magnetic insullation".



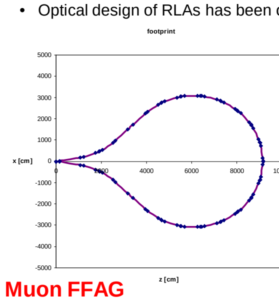
Linac and RLAs



Tracking studies in the muon linac.

Linac and RLAs (cont.)

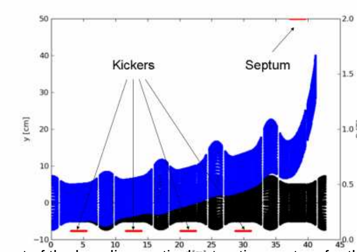
- **E**M modeling and beam dynamics simulations are being extensively studied in the muon linac.
- Optical design of RLAs has been optimised.



Layout of the droplet arc.

Muon FFAG

- Beam dynamics was crosschecked with independent codes.
- Lattices are being further optimised.
- Injection/extraction geometries were proposed.
- Preliminary desisgn of kickers were studied.
- Low energy scaling FFAG option are being considered.
- **Main challange is the design of the superconducting extraction septum.**



Layout of the baseline vertical extraction system for the muon FFAG based on triplet cells

Decay Ring

- Large acceptance was crosschecked with independent codes.
- Energy monitoring via muon depolarisation was proposed.

Conclusions and Future Plans

- **T**he design work is progressing very well within the IDS-NF!
- The priniple properties of the baseline subsystems like acceptances, transmissions etc. have been confirmed.
- The main challenges have been identified and are being intensively studied.
- The performance of the accelerator chain will be addressed in the end-to-end simulations and the cost will be estimated.
- The Interim Design Report will be published at the end of 2010 and the Reference Design Report will be produced by 2012/13.

References

[1] http://www.ids-nf.org/
[2] J. Scott Berg et al., RAL-TR-2007-23.