Accelerator systems for the International Design Study of the Neutrino Factory

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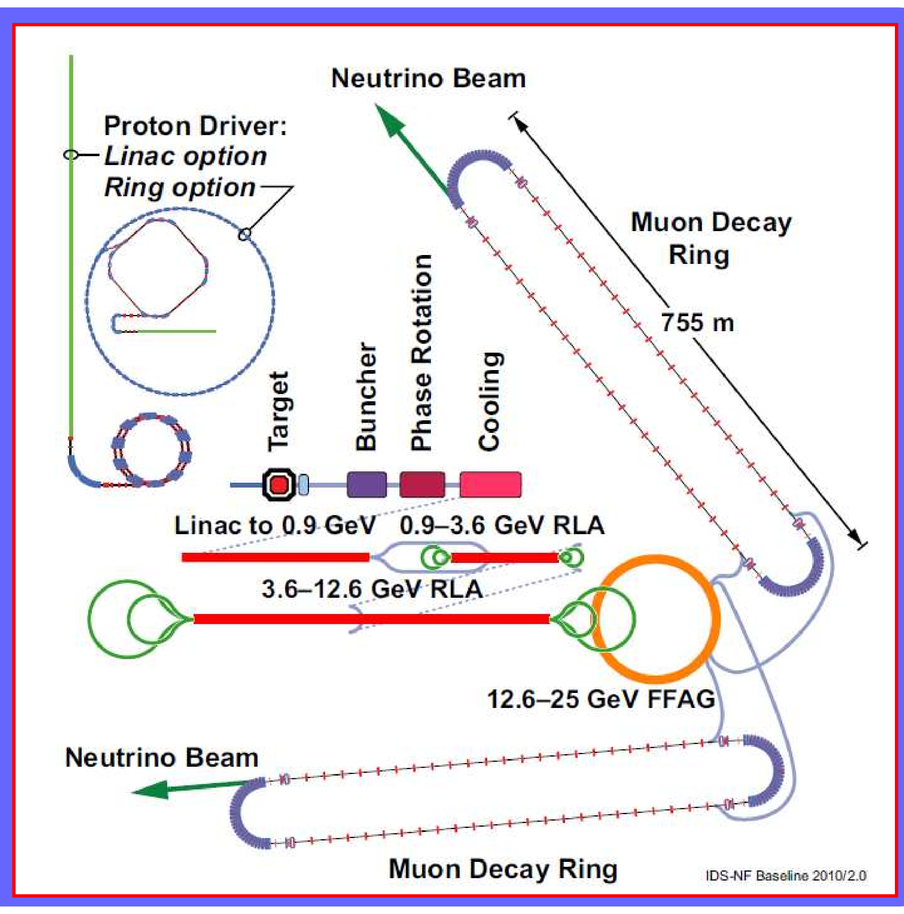
THE INTERNATIONAL DESIGN STUDY FOR THE NEUTRINO FACTORY

University of Glasgow

Neutrino Factory:

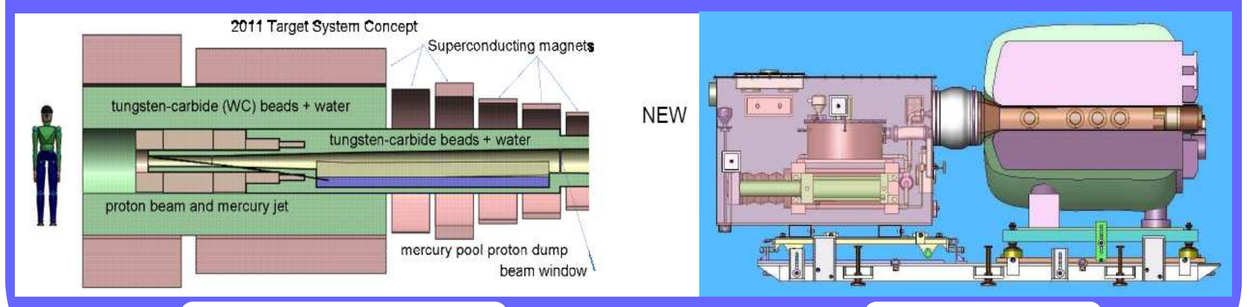
- Physics goals:
  - Measurement of neutrino mixing parameters
  - Precise measurement of θ_{13}
  - Determination of mass hierarchy: sign Δm_{31}^2
  - Discovery of CP violation and measurement δ_{CP}
- Neutrino Factory offers best sensitivity for all of the above amongst all future facilities
- International Design Study for a Neutrino Factory is an international collaboration formed to define:
  - Physics performance of the Neutrino Factory
  - Specification of accelerator, diagnostic and detectors
  - Schedule and cost of all the systems.



Proton Driver and Target

- Proton driver requirements:
  - Regional decision: eg. green field FFAG, Project X or SPL
- Target baseline:
  - Liquid Hg in 20 T solenoid
  - Demonstration: MERIT at CERN

Parameter	Value
Kinetic energy	5–15 GeV
Average beam power	4 MW (3.125×10^{15} protons/s)
Repetition rate	50 Hz
Bunches per train	3
Total time for bunches	240 μs
Bunch length (rms)	1–3 ns
Beam radius	1.2 mm (rms)
Rms geometric emittance	< 5 μm
β^* at target	≥ 30 cm

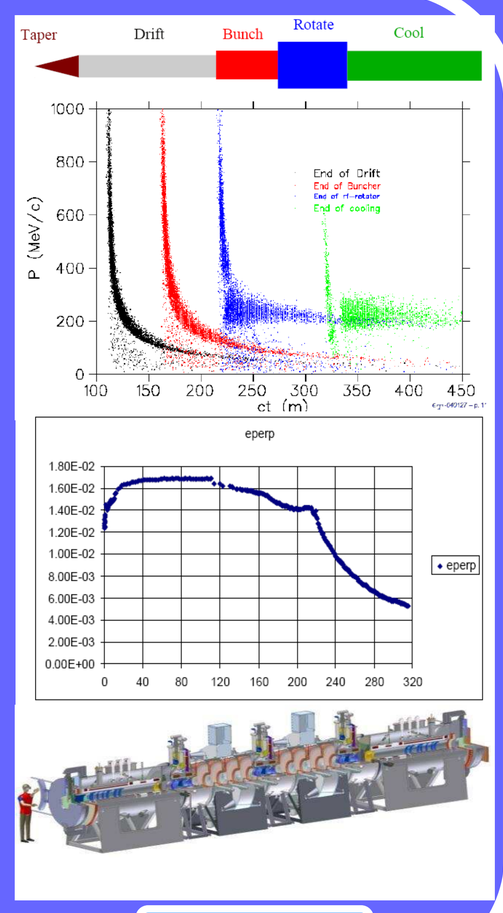


Neutrino Factory Target

MERIT

Muon Front End

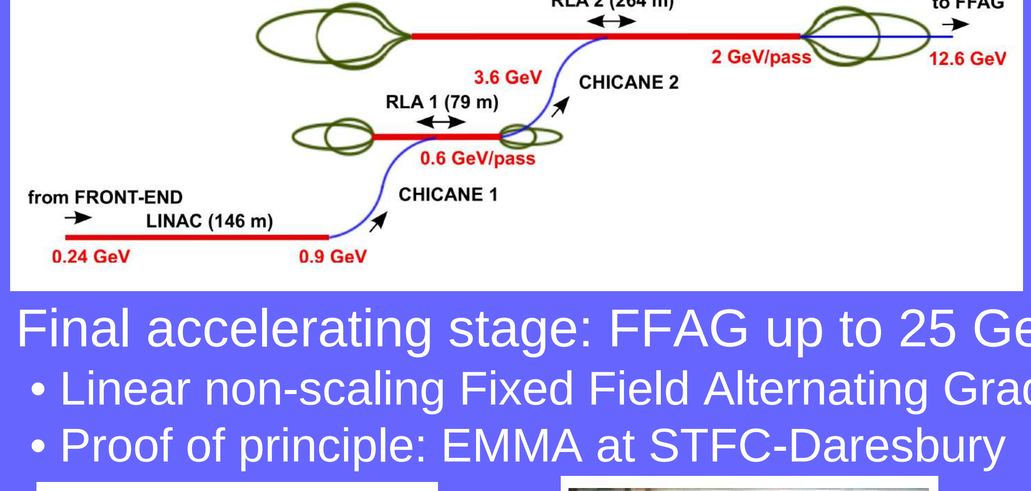
- Target transition:
  - Adiabatic B-field taper from Hg target to longitudinal drift
- Drift region:
  - Drift in ~1.5 T, ~100 m solenoid
- Muon buncher:
  - Adiabatic RF voltage
- Phase rotation:
  - Phase rotation using variable frequencies: small energy spread
  - High energy front: accelerating field
  - Low energy tail: decelerating field
- Muon cooling:
  - Reduction transverse emittance
  - Demonstration: MICE at STFC-RAL



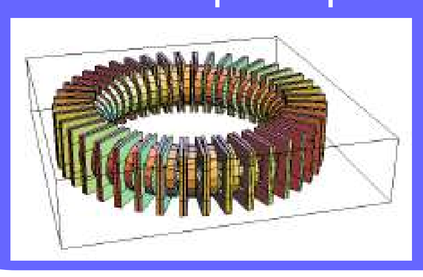
MICE

Muon Acceleration

- Accelerator baseline:
  - One linac + 2 cascaded RLA (recirculating linear accelerators): 0.9 GeV, 3.6 GeV, 12.6 GeV

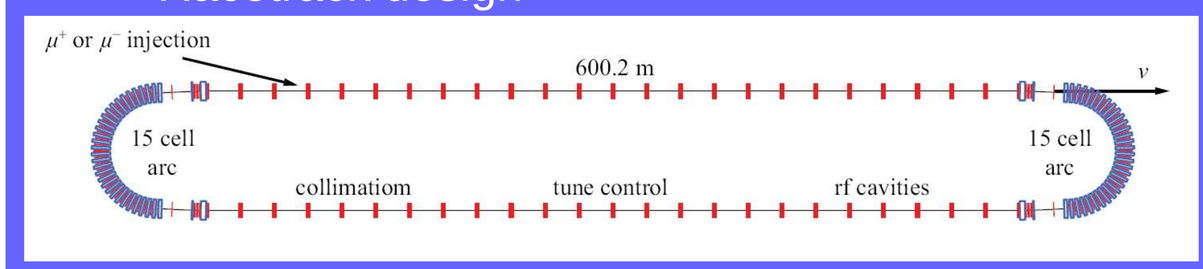


- Final accelerating stage: FFAG up to 25 GeV
  - Linear non-scaling Fixed Field Alternating Gradient
  - Proof of principle: EMMA at STFC-Daresbury



Muon Decay Ring

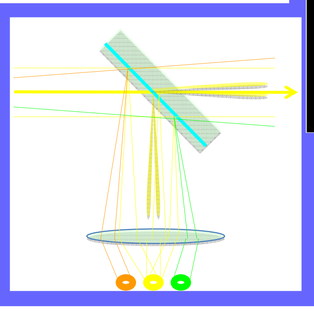
- Decay ring baseline:
  - Racetrack design

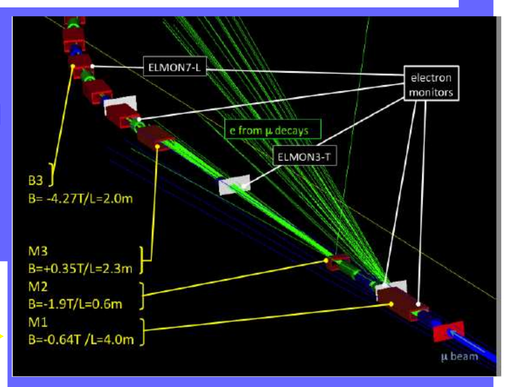


- Muon energy:
  - Fit electron spin polarisation

$$\mathcal{E}(t) = \mathcal{E}_0 e^{-\alpha t}\left[1 + \frac{\beta}{7} e^{-\frac{1}{2}(\omega \frac{\Delta E}{E} t)^2} \cdot \mathcal{P} cos(\phi + \omega t)\right]$$

- Divergence:
  - ~ 0.1/γ
  - OTR: Optical Transition Radiation





Status:

- Main concepts for accelerator systems have been defined
- Main areas of work are at interfaces between components