THE INTERNATIONAL DESIGN STUDY FOR THE NEUTRINO FACTORY

The International Design Study for the Neutrino Factory

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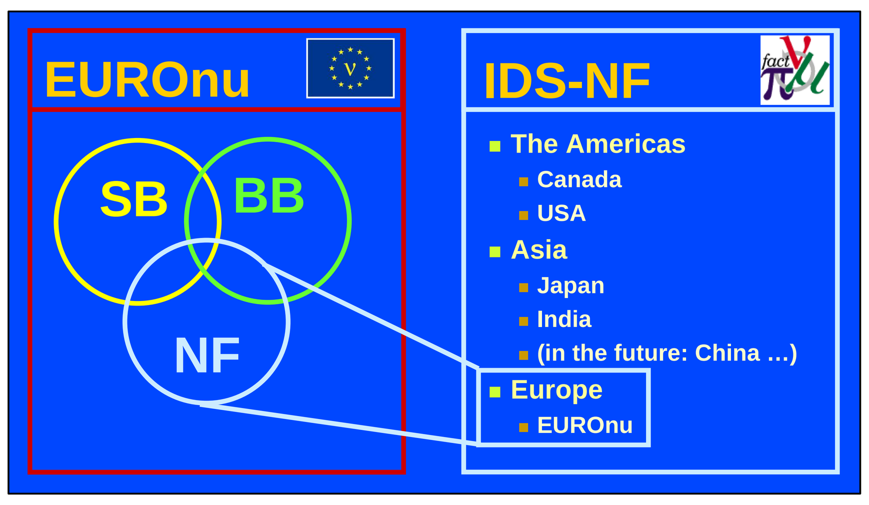
Scope and organization of the study

The International Design Study for the Neutrino Factory

- 52 institutes from the Americas, Asia, and Europe (as part of EUROnu)
- 126 physicists and engineers
- Launched in 2007 as successor of the International Scoping Study of a future Neutrino Factory and superbeam facility (ISS)
- https://www.ids-nf.org/wiki/FrontPage



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Organization

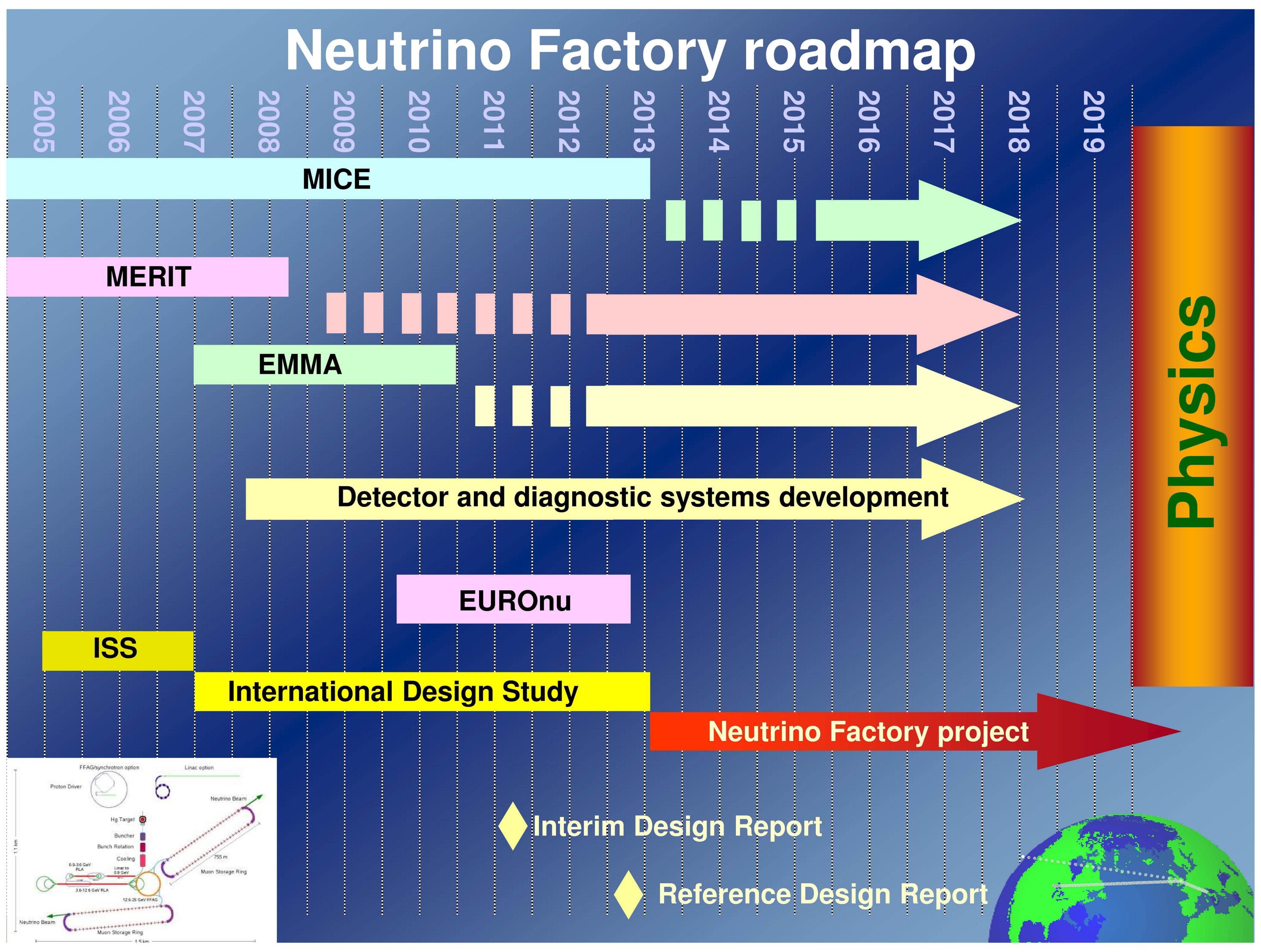
Steering group

Three working groups

Physics and performance evaluation | Accelerator | Detector

Goals:

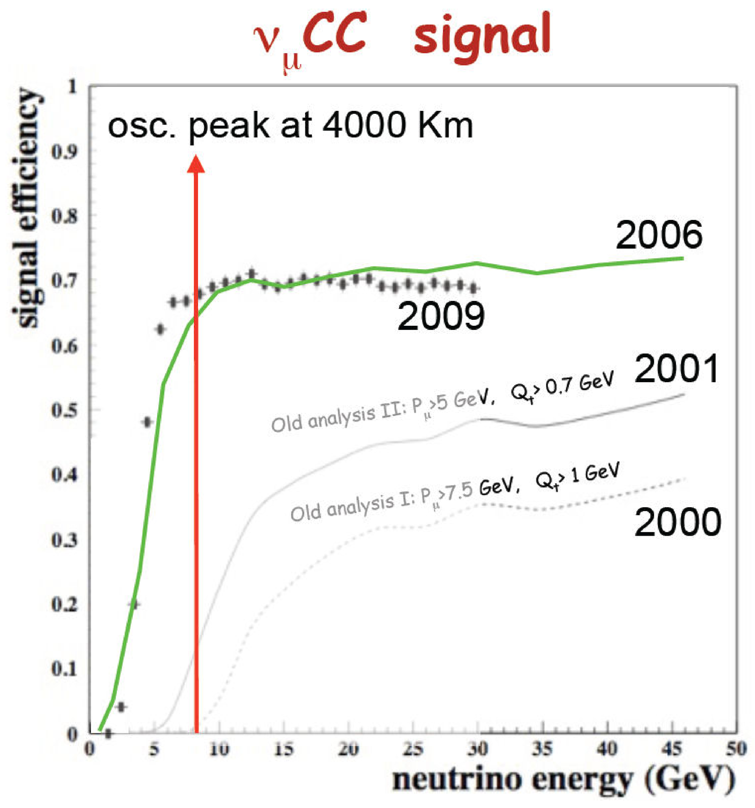
- Reference Design Report (2012/13): in time for decisions based on reactor/superbeam results, component and systems R&D programmes and design studies
- Interim Design Report (2010/11): A step on the way to the RDR. Defines the baseline accelerator facility and neutrino detectors to be taken forward to the RDR



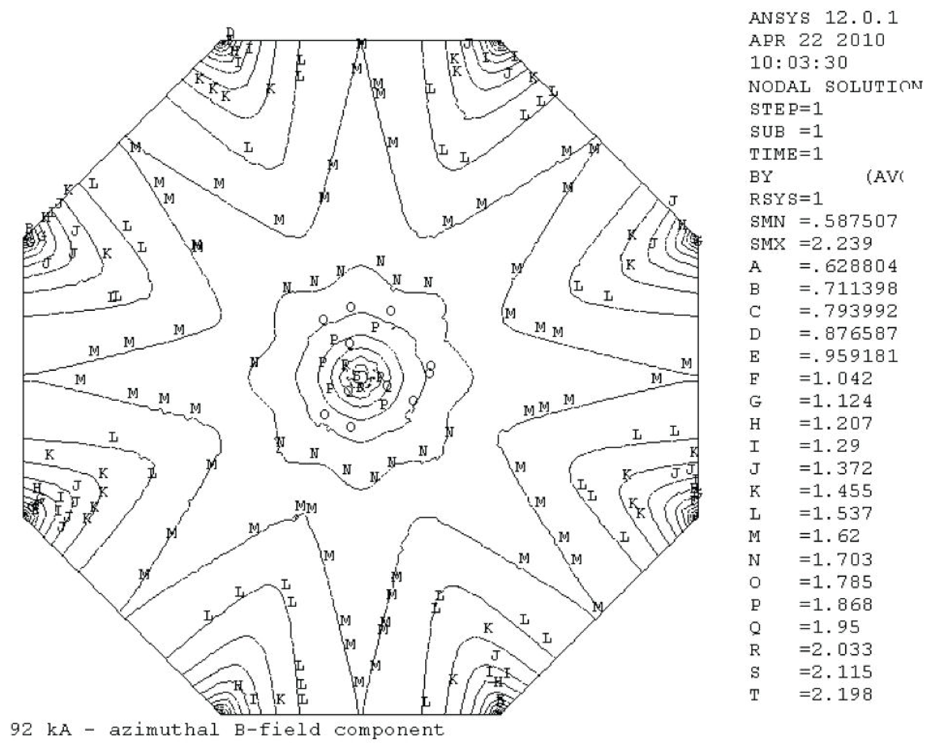
Detector development

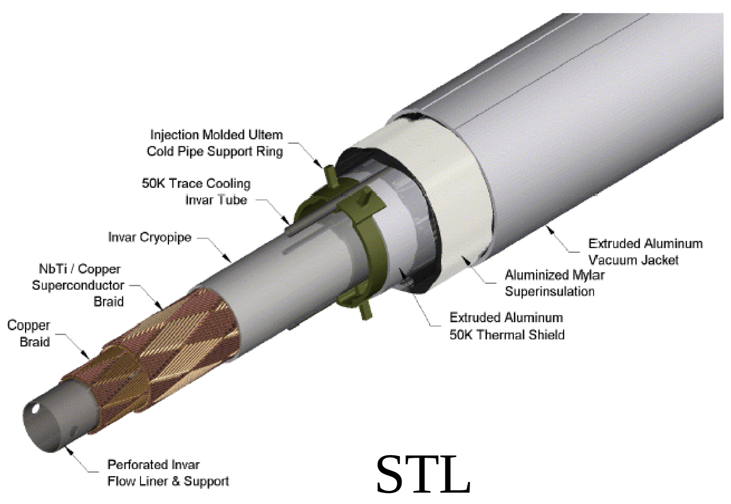
100 kT Magnetized Iron Neutrino Detector (MIND)

- Follows the example of MINOS
- 15m X 15m cross-section
- Recent Studies have shown much improved E_ν threshold turn-on
- R&D on magnetization needed
- Large excitation current for large plates
- R&D on Magnet and photodetectors for the scintillator readout still needed
- SiPM candidate photodetector



Field Map





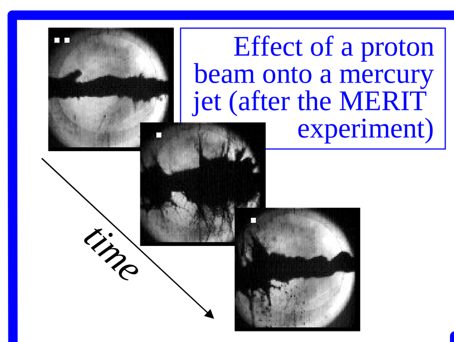
100kA Test Loop

Superconducting Transmission Line

- Developed for VLHC
- Single turn-100kA sufficient to meet field requirements
- Smaller hole (less dead region)
- No heating

The test apparatus used at MW-9 for developing the transmission line.

Accelerator development



Effect of a proton beam onto a mercury jet (after the MERIT experiment)

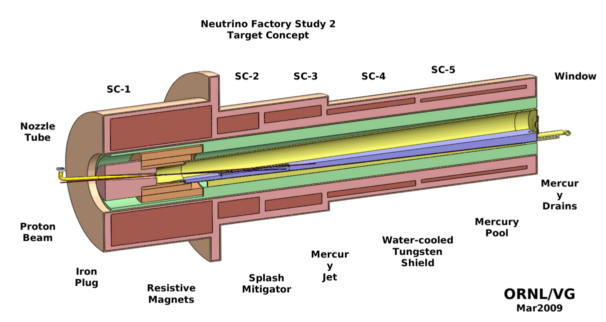
time

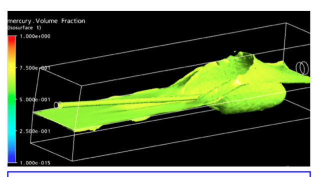
(1) Proton Driver Options:
a) Rapid Cycling Synchrotron or NS-FFAG (ISIS-upgrade)
b) Superconducting Proton Linac (CERN-SPL / Fermilab-ProjectX)

OPTION (a)
- 800MeV (LINAC) / 0.8 → 3.2 GeV (RCS1) / 3.2→6.4 (10.3) GeV (RCS2)
- 4MW / 50 Hz rep. rate
- 2ns bunches / 3 proton bunches per pulse

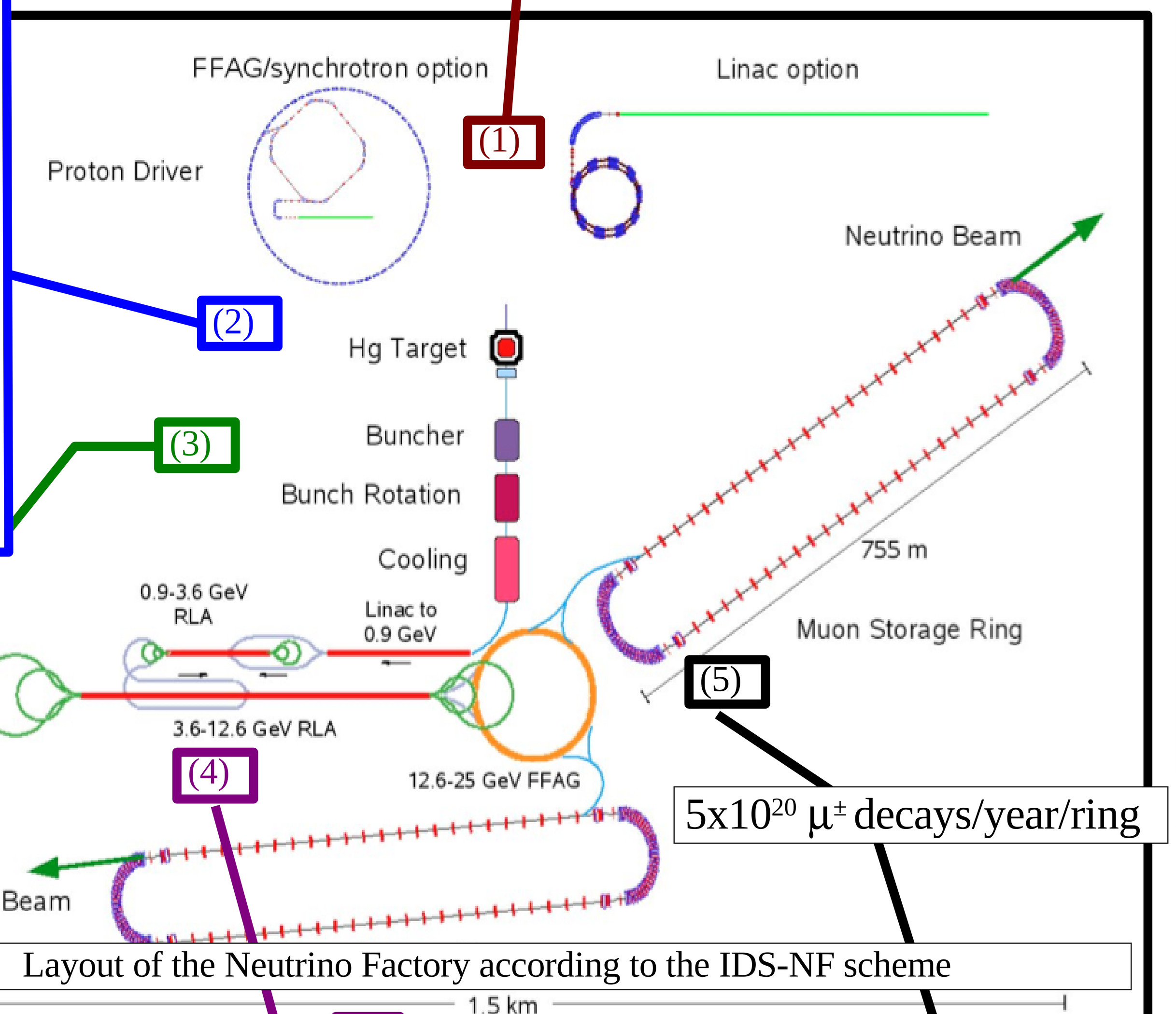
p

(2) Target: p→π
- baseline: mercury jet [∅=1cm, v=20 m/s, B=20T (solenoidal field)]
- alternative: solid target / fluidized powder





Agitation of mercury pool surface due to a 20 m/s impinging jet

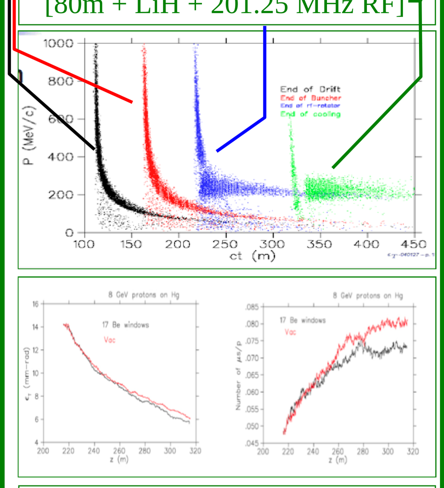


5x10[20] $\mu^\pm$ decays/year/ring

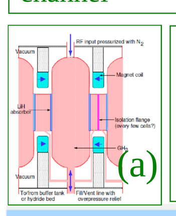
Layout of the Neutrino Factory according to the IDS-NF scheme

(3) Front End: π→μ
- drift [100 m]
- buncher [50 m]
- Φ-rotation [50m]
- cooling [80m + LiH + 201.25 MHz RF]

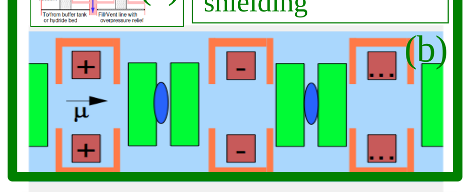
MICE@RAL



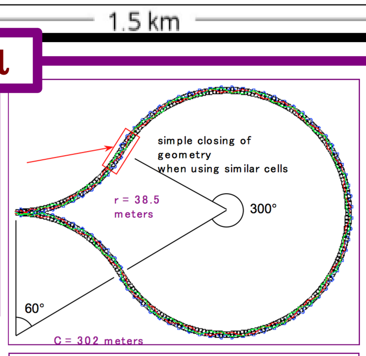
Emittance reduction and Transmission in the cooling channel



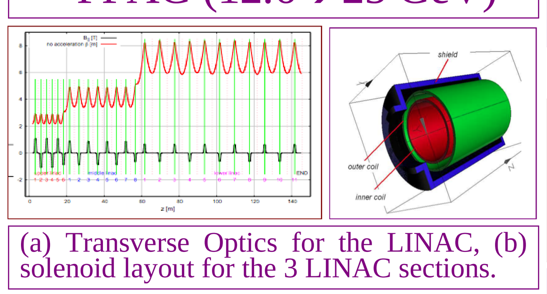
Mitigation of RF degradation in axial magnetic field: (a) High Pressure RF and (b) B field shielding



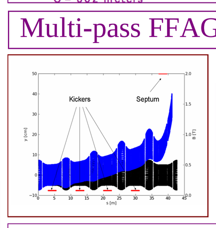
(4) Acceleration: μ
- LINAC (0.2→0.9 GeV)
- RLA1 (0.9→3.6 GeV)
- RLA2 (3.6→12.6 GeV)
- FFAG (12.6→25 GeV)



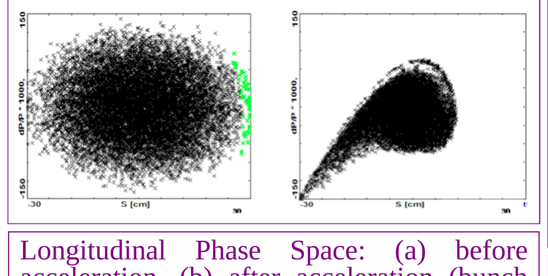
Multi-pass FFAG RLA arcs



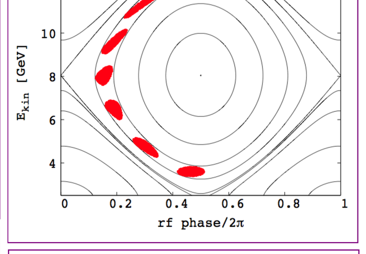
(a) Transverse Optics for the LINAC, (b) solenoid layout for the 3 LINAC sections.



FFAG Extraction Scheme

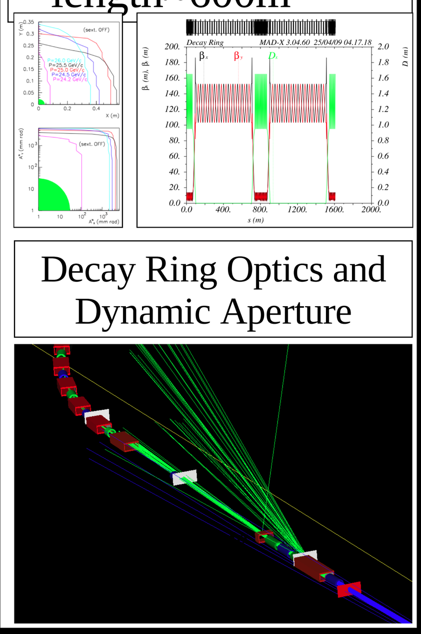


Longitudinal Phase Space: (a) before acceleration, (b) after acceleration (bunch compression) through the LINAC



Alternative to RLA2: Scaling FFAG

(5) 2 Decay Rings: μ→ν
- E_μ=25 GeV
- L=1608 m
- decay length≈600m



Decay Ring Optics and Dynamic Aperture

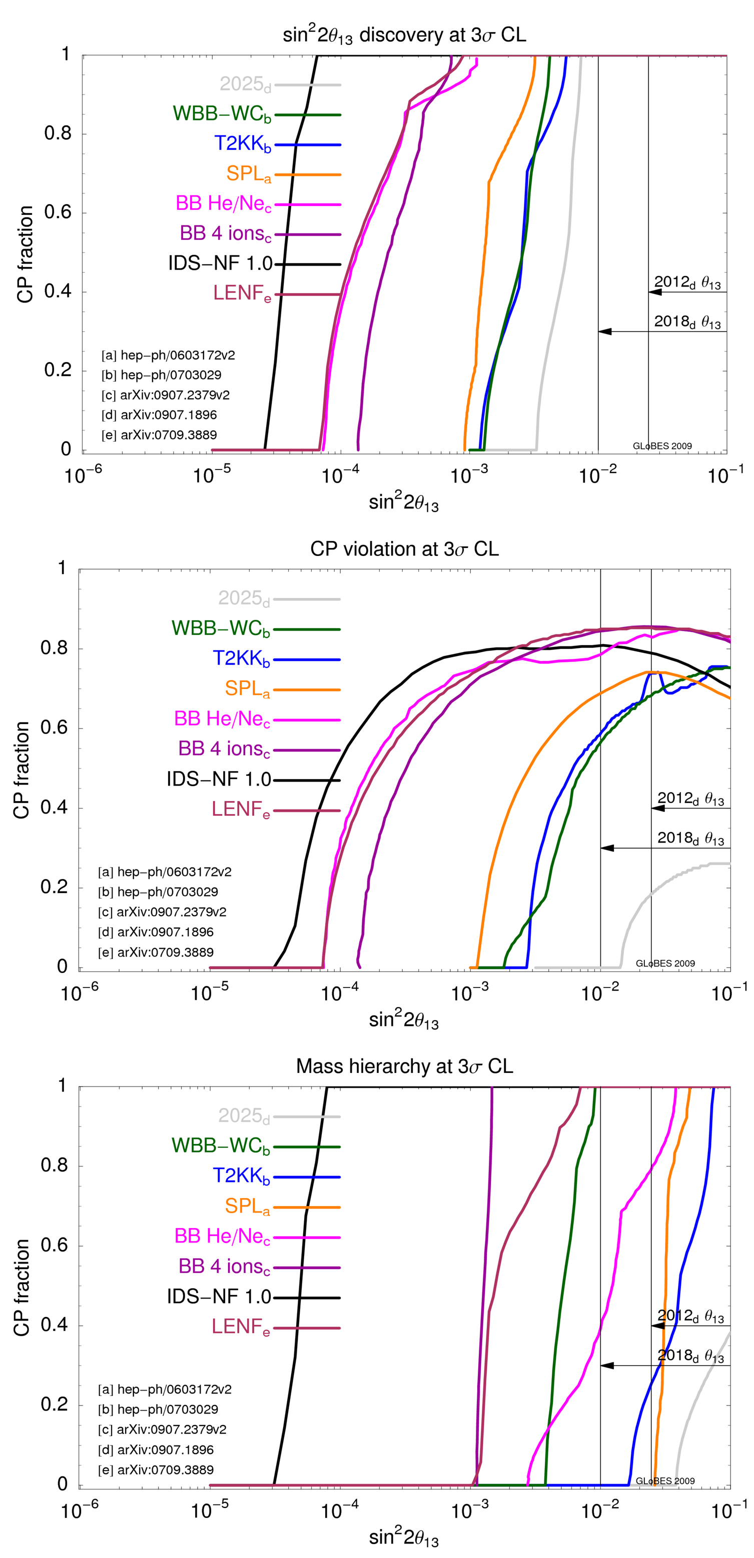
Physics and performance evaluation

Sensitivity studies
- θ_{13}
- Mass hierarchy
- CP violation
- Non-standard physics
- ...

Study/optimization of physics reach:
- High-energy NF (optimal for small θ_{13})
- Low-energy NF (optimal for large θ_{13})
- With/without ν_τ detector
- Different detector masses/baselines
- Impact of near detectors/systematics
- Staging scenarios

Simulation tools
- Mostly using GLoBES
- Standardized
- Reproducible
- Documented

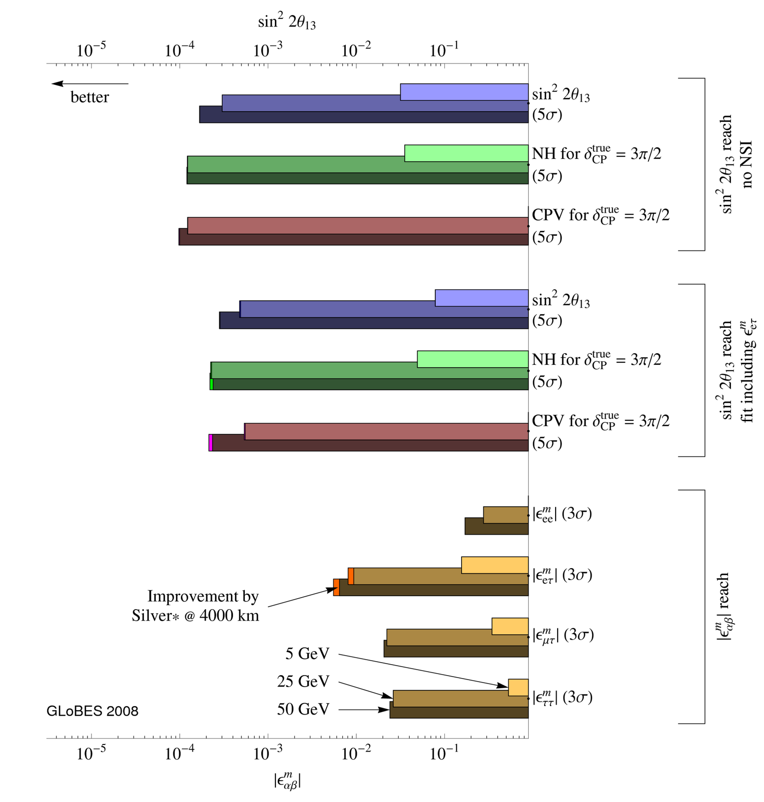
Results for Standard Oscillations



Plots taken from arXiv:1005.3146

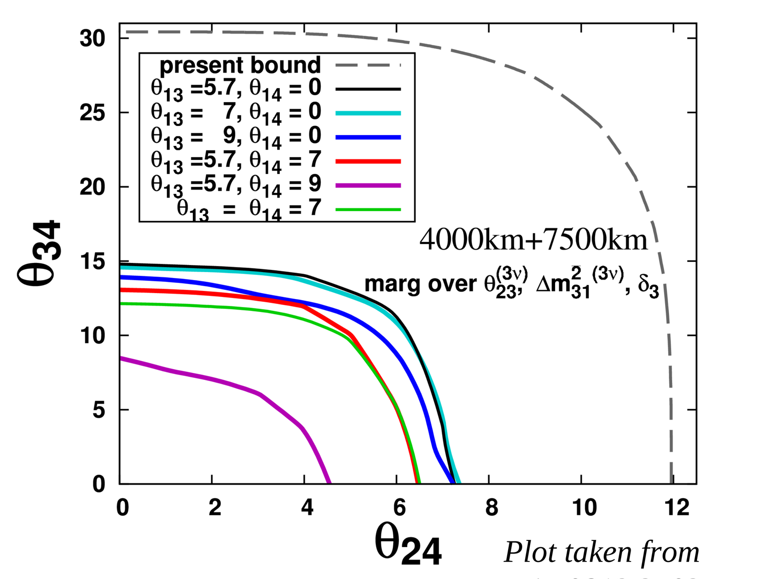
Results for Non-Standard Oscillations

Disc. reach for non-standard matter effects



Plot taken from arXiv:0804.2261

Sensitivity to sterile neutrinos



Plot taken from arXiv:0812.3703