The Neutrino Factory, Muon Production and Acceleration

Stephen Brooks / stephen.brooks@stfc.ac.uk
RAL-DL joint accelerator workshop, RAL, January 2009

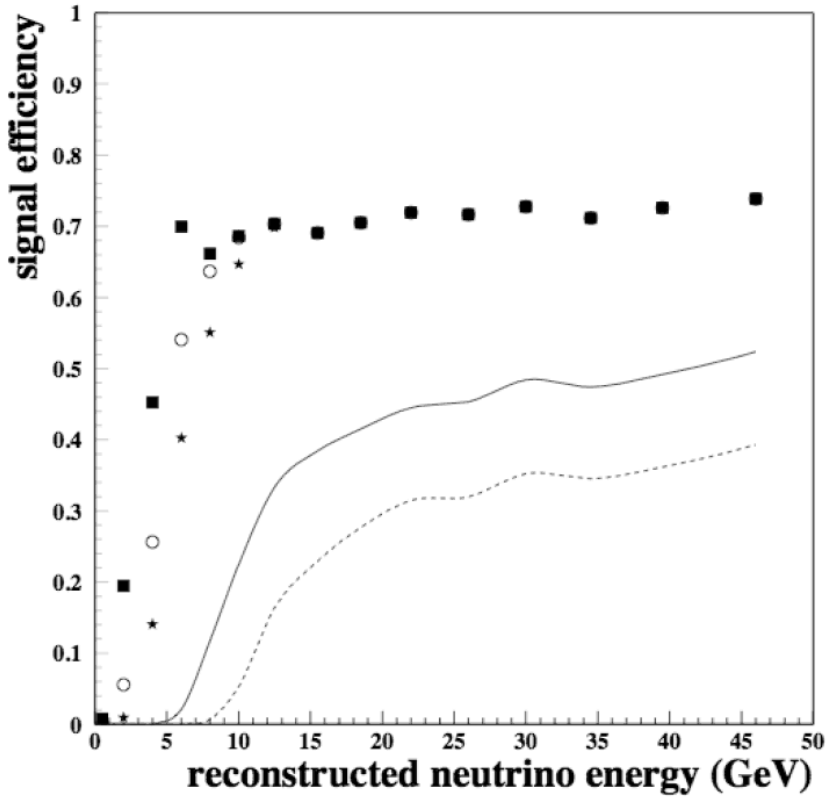
What is the Neutrino Factory?

- Produces a focussed beam of neutrinos from *boosted* muon decays
  - Energy in the region of 10s of GeV
- Baseline uses 25GeV muon parents
- Muons are made from pion decays
  - Must be accelerated fast from 100s of MeV
- Pions come from hadronic fragmentation of target nuclei bombarded by multi-GeV, multi-MW protons

Why 10s of GeV Neutrinos?

- Puts the oscillation wavelength of neutrinos on the same scale as the Earth
  - Upper limit (barring space travel)
- Also we have some trouble detecting slower neutrinos
  - Lower limit
- Boost collimation vs. oscillation distance cancel, but detector cross-sections increase with energy

Example Detector Sensitivity

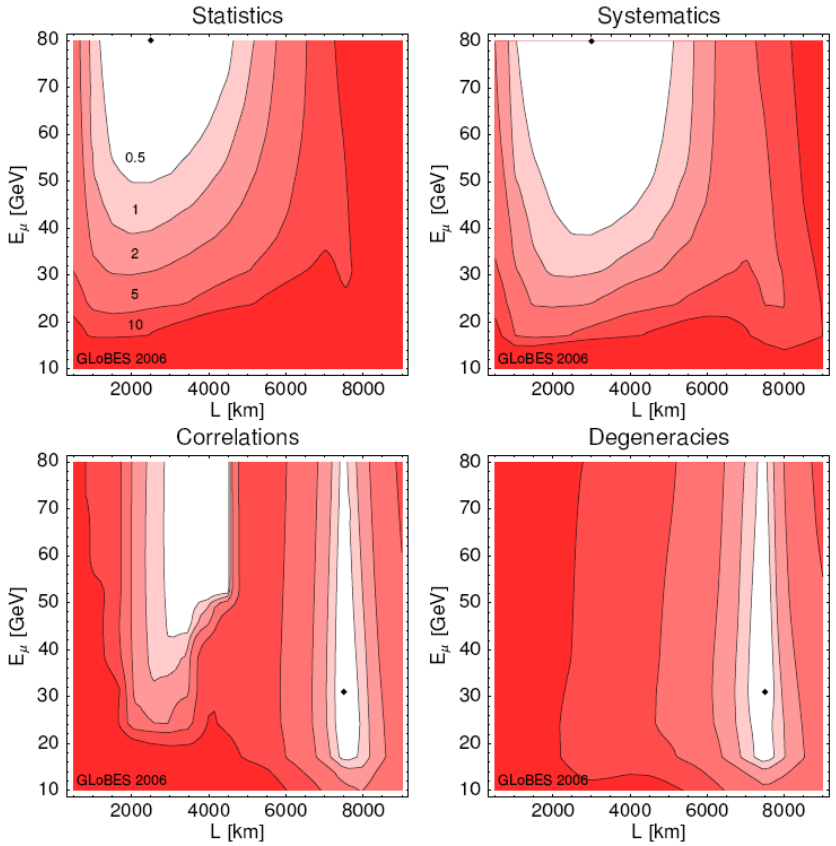


From current baseline document

ids-nf.org

Figure 3: Muon identification efficiency for MIND. The points indicate the efficiency assuming a minimum muon-track-length cut of 75 cm (solid squares), 150 cm (open circles), and 200 cm (stars). The cut used in the baseline analysis (table 3) is 150 cm.

Example Physics Sensitivity

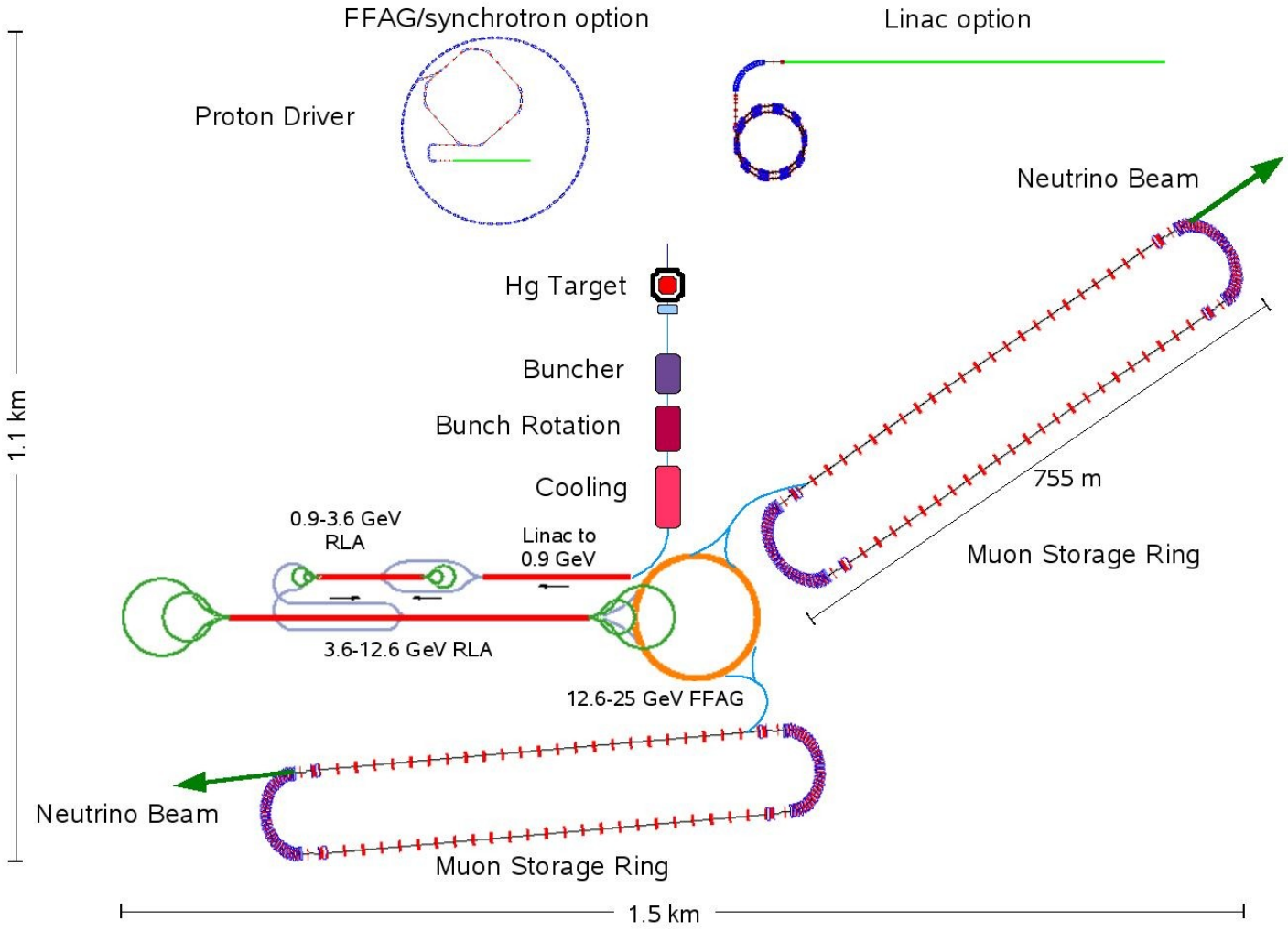


From International Scoping Study (ISS) physics report

RAL technical reports 2007

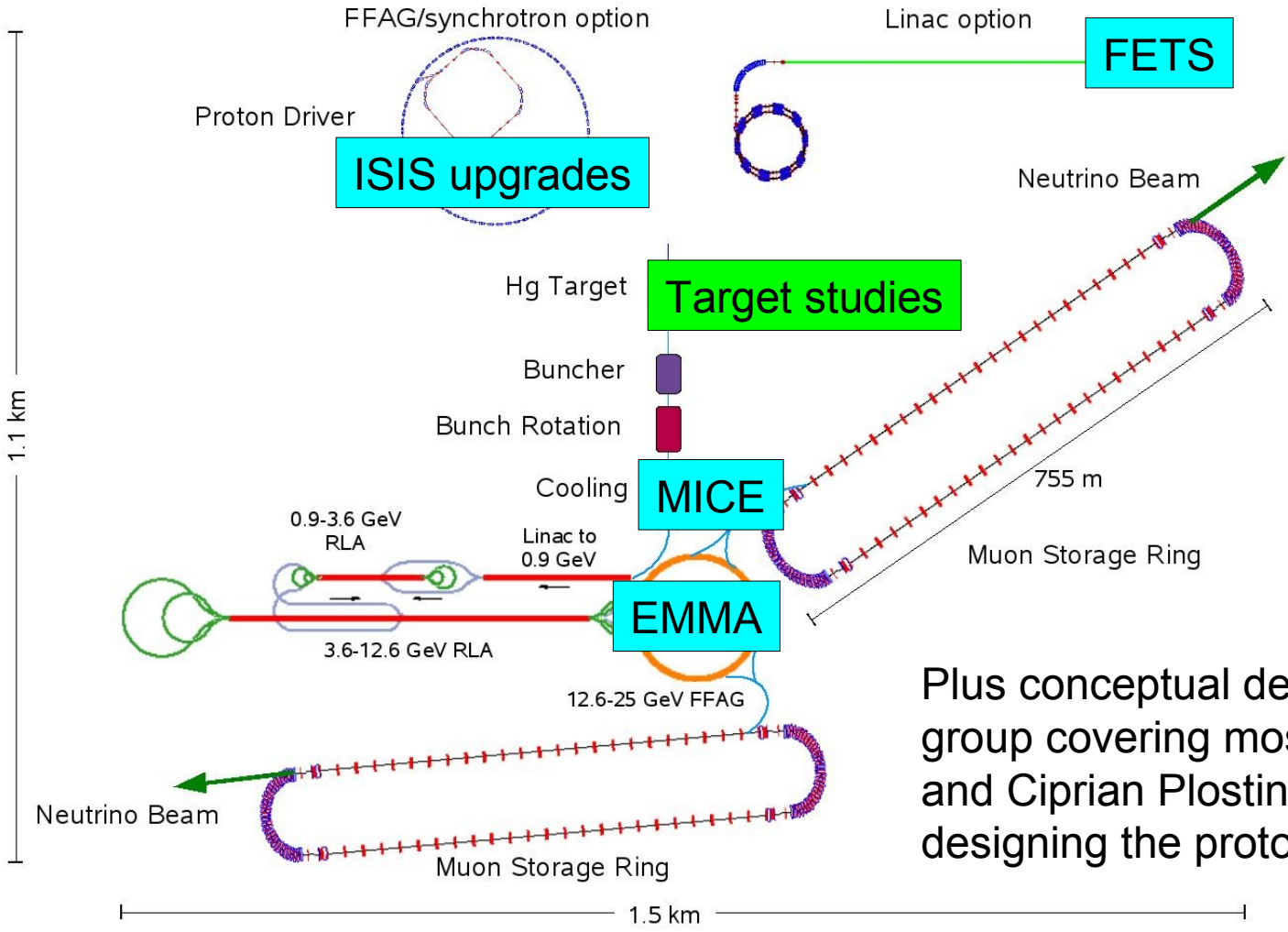
Figure 84: Sensitivity to $\sin^2 2\theta_{13}$ (5σ) relative to the optimum (white) within each plot. The different panels correspond to successively taking into account statistics, systematics, correlations, and degeneracies. The different contours represent the region within a factor of 0.5, 1, 2, 5, and 10 above the maximal sensitivity in each plot. The maximal sensitivities are $\sin^2 2\theta_{13} < 1.4 \cdot 10^{-5}$ (statistics), $2.8 \cdot 10^{-5}$ (systematics), $2.4 \cdot 10^{-4}$ (correlations), and $5.0 \cdot 10^{-4}$ (degeneracies), obtained at the energies and baselines marked by the diamonds.

Current “IDS” Baseline v1.0



Stephen Brooks / stephen.brooks@stfc.ac.uk
RAL-DL joint accelerator workshop, RAL, January 2009

R&D Projects in the NF Context



Plus conceptual design group covering most areas and Ciprian Plostinar designing the proton linac

Stephen Brooks / stephen.brooks@stfc.ac.uk
RAL-DL joint accelerator workshop, RAL, January 2009

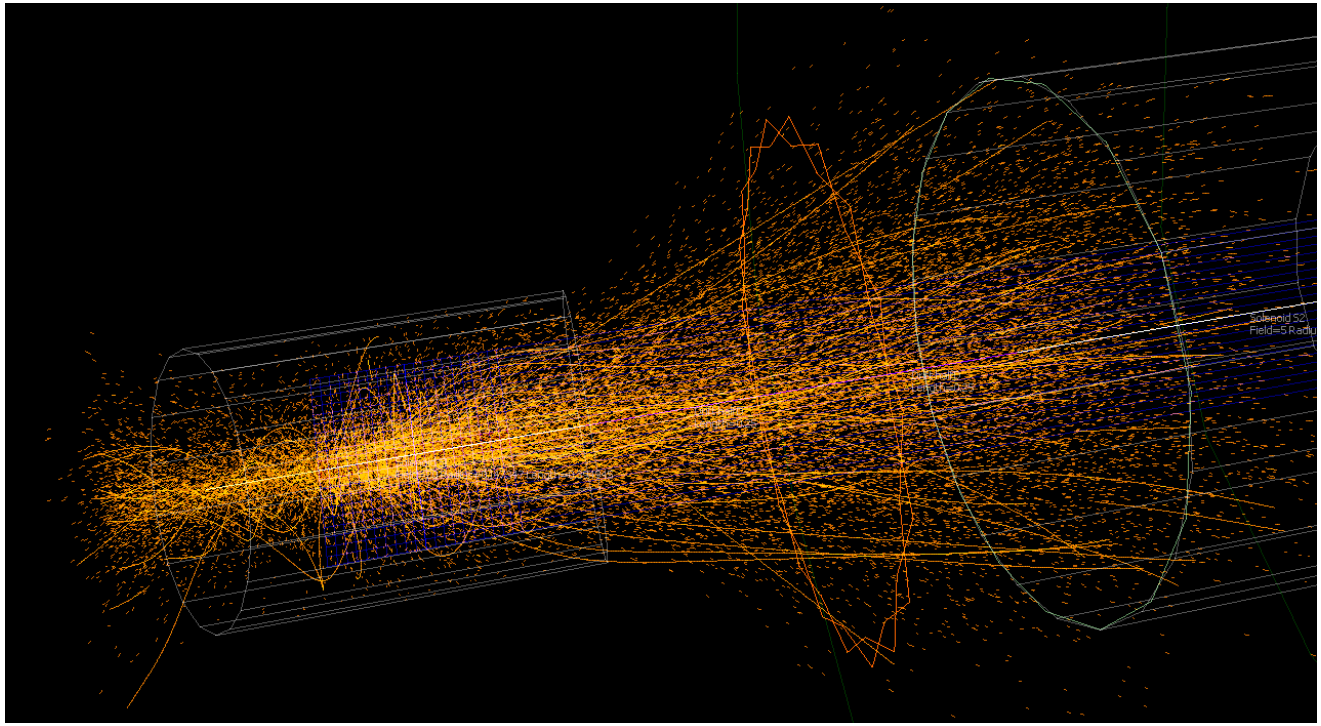
Target Studies at RAL

- Pulsed current wire test (video 1)
- Simulations
  - Pion production
  - Target (and wire) thermal shock
  - Mercury jet engineering issues (video 2)
  - Target station magnet forces
- Tungsten powder jet flow loop (video 3)
- Collaboration with MERIT

Stephen Brooks / stephen.brooks@stfc.ac.uk

Muon Acceleration

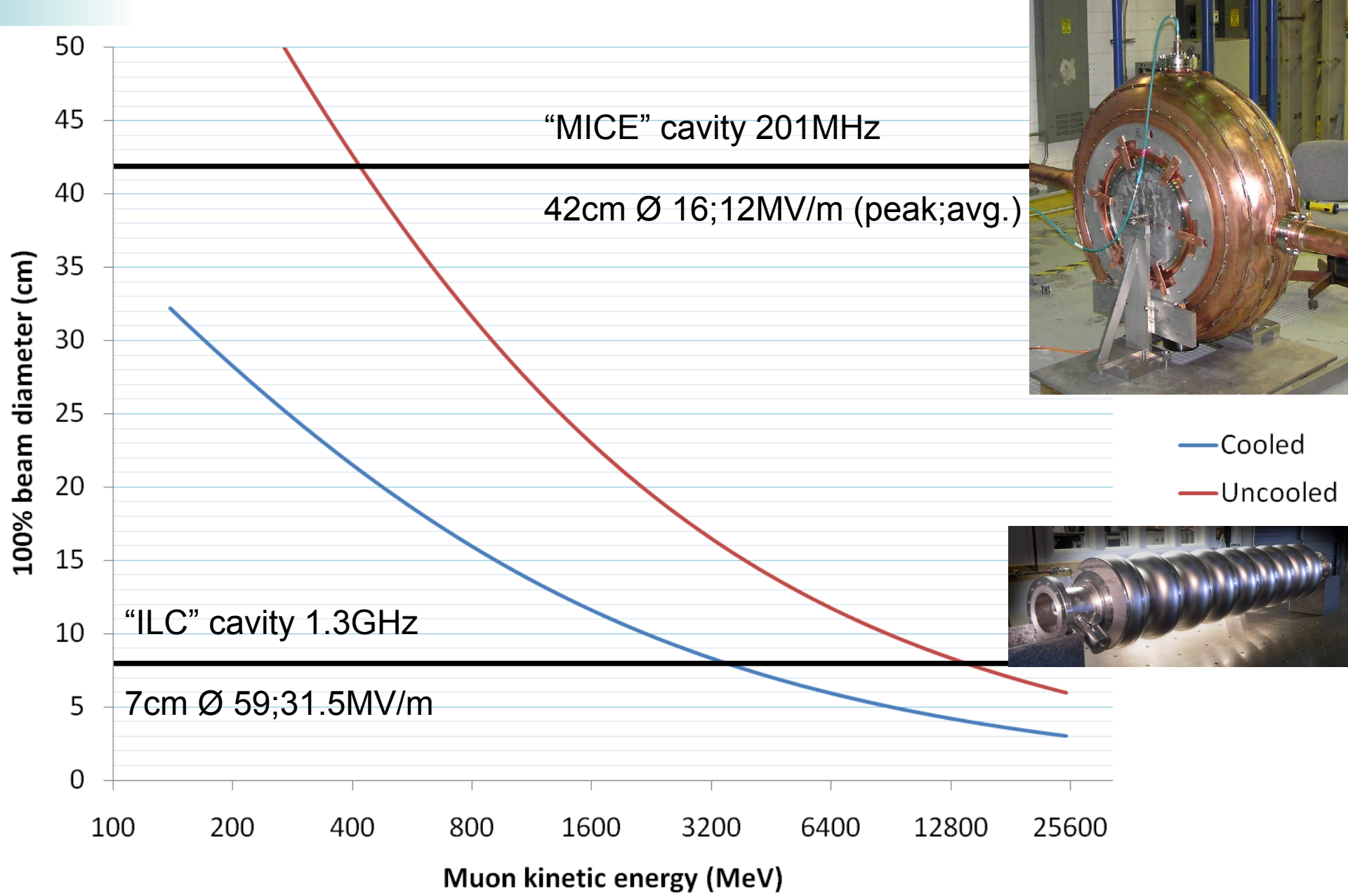
- Problem with secondary beams is that they are not well collimated (large emittance)



Stephen Brooks / stephen.brooks@stfc.ac.uk

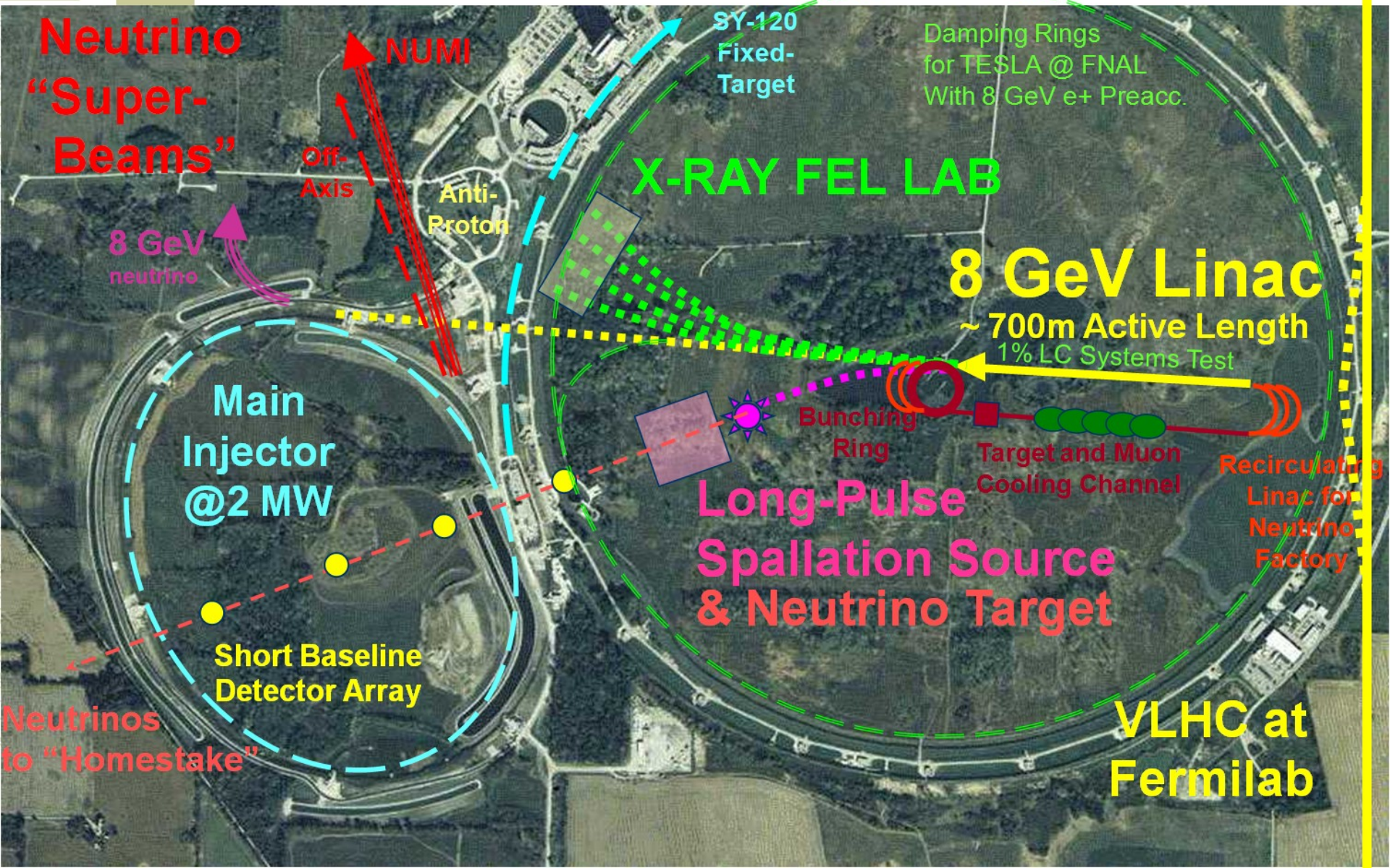
Muon Acceleration

- Problem with secondary beams is that they are not well collimated (large emittance)
  - Large RF aperture
- Muons also decay in 2.2 + 20.8(E/GeV) μs
  - 0.66 + 6.23(E/GeV) km/*c*
  - Need high gradient, can't rephase
- Fortunately we are slowing down time *and* compressing space as E increases!



Stephen Brooks / stephen.brooks@stfc.ac.uk

Project X at Fermilab



Conclusion

- Neutrino factory is a very ambitious project
- Fortunately ASTeC and STFC is funding work on almost every area of it
- It might not be built in the UK
  - But there are several interesting opportunities for collaborations
    - Must not forget CERN and the US
- Talking of CERN, the LHC will decide what really gets built around 2011-12!