Imperial College London

K. Long, 16 April 2012

# Introduction and meeting aims:

# Contents:

- $\theta_{13}$ and the IDS-NF baseline
- Opportunities and increments
- How we left it at IDS-NF #7 and goals for #8
- Costing exercise and RDR timeline
- ICFA, taking an interest …
- Next meetings

Introduction and aims:

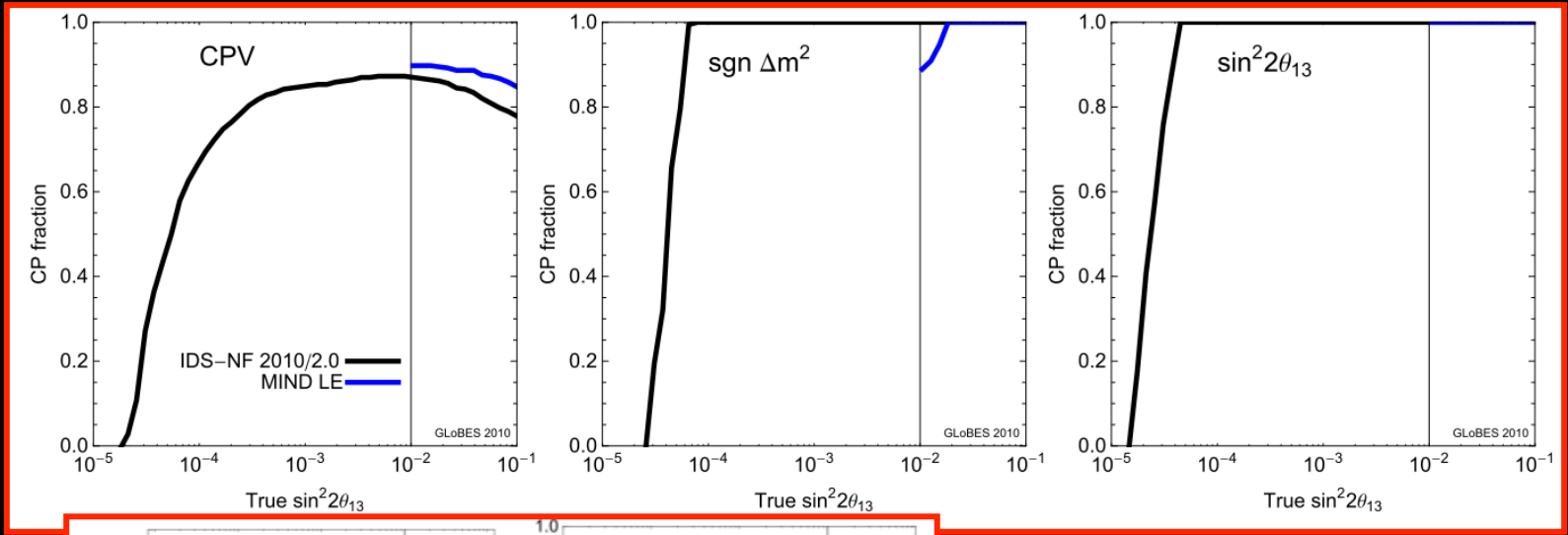
# $\theta_{13}$ and the IDS-NF baseline

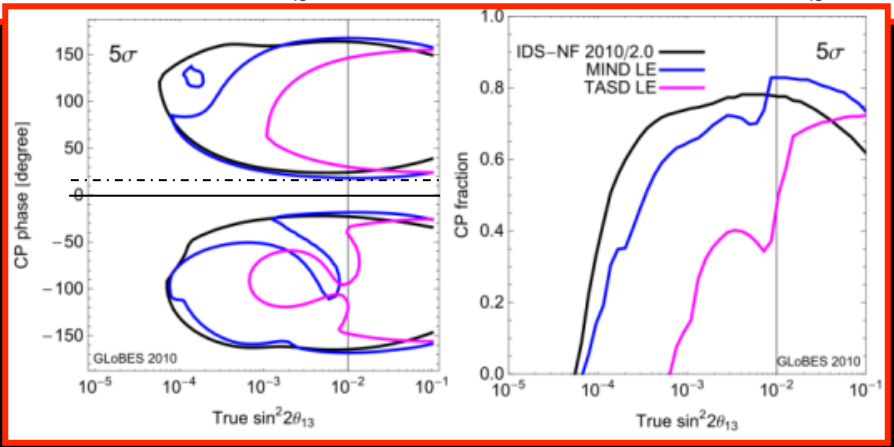
# Recent results:

- Proper slide to be written, argument:
  - 2011:
    - Indications for $\sin^2 2\theta_{13} \sim 0.1$ from LBL experiments T2K and MINOS
    - Indications also from D-Chooz
  - 2012:
    - Measurements ov $\sin^2 2\theta_{13}$ from Daya Bay and RENO
- Combination not yet done by "the professionals", but my school-boy version indicates:
  - Calculation not yet done!

# Neutrino Factory performance:

- IDR presented two options:
  - Baseline optimised for discovery reach at 3σ
    - Discovery reach extends down to $\sin^2 2\theta_{13} \sim 5 \times 10^{-5}$
  - Alternative: example of optimisation for $\theta_{13} > 0.01$:
    - 10 GeV muon energy serving a single 100 kTon MIND at a baseline of 2000 km

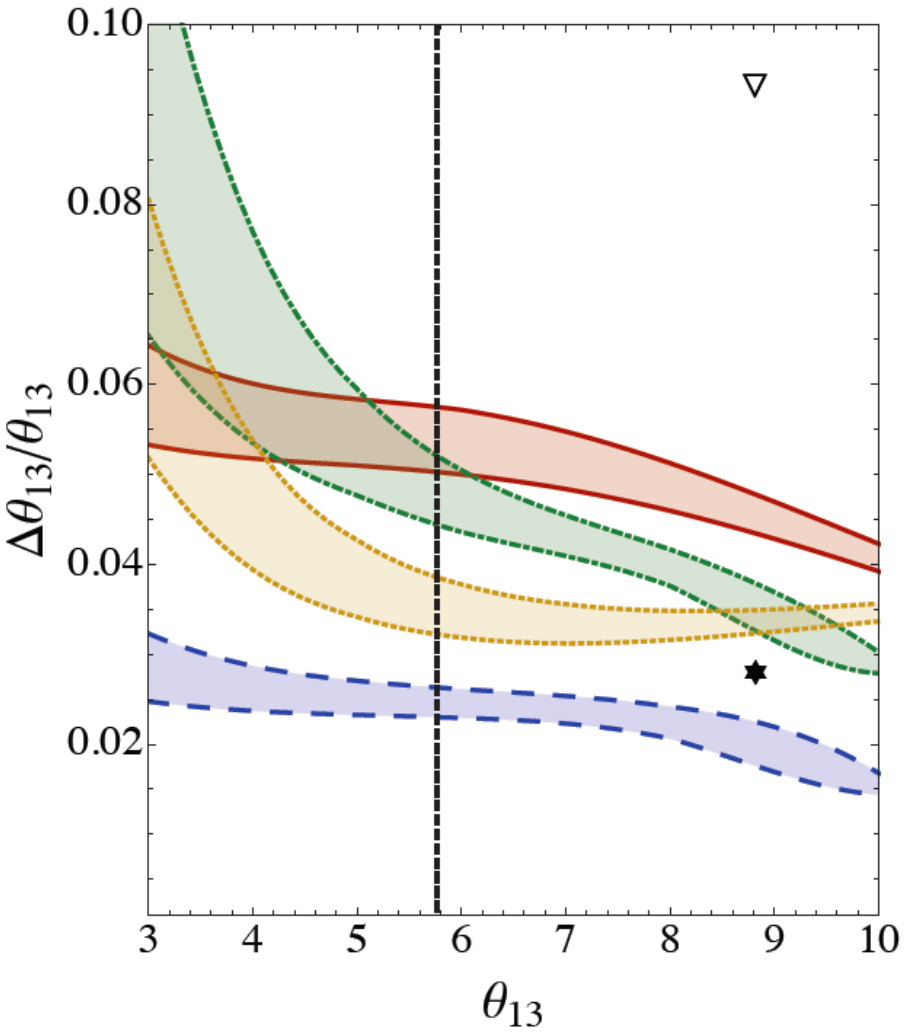


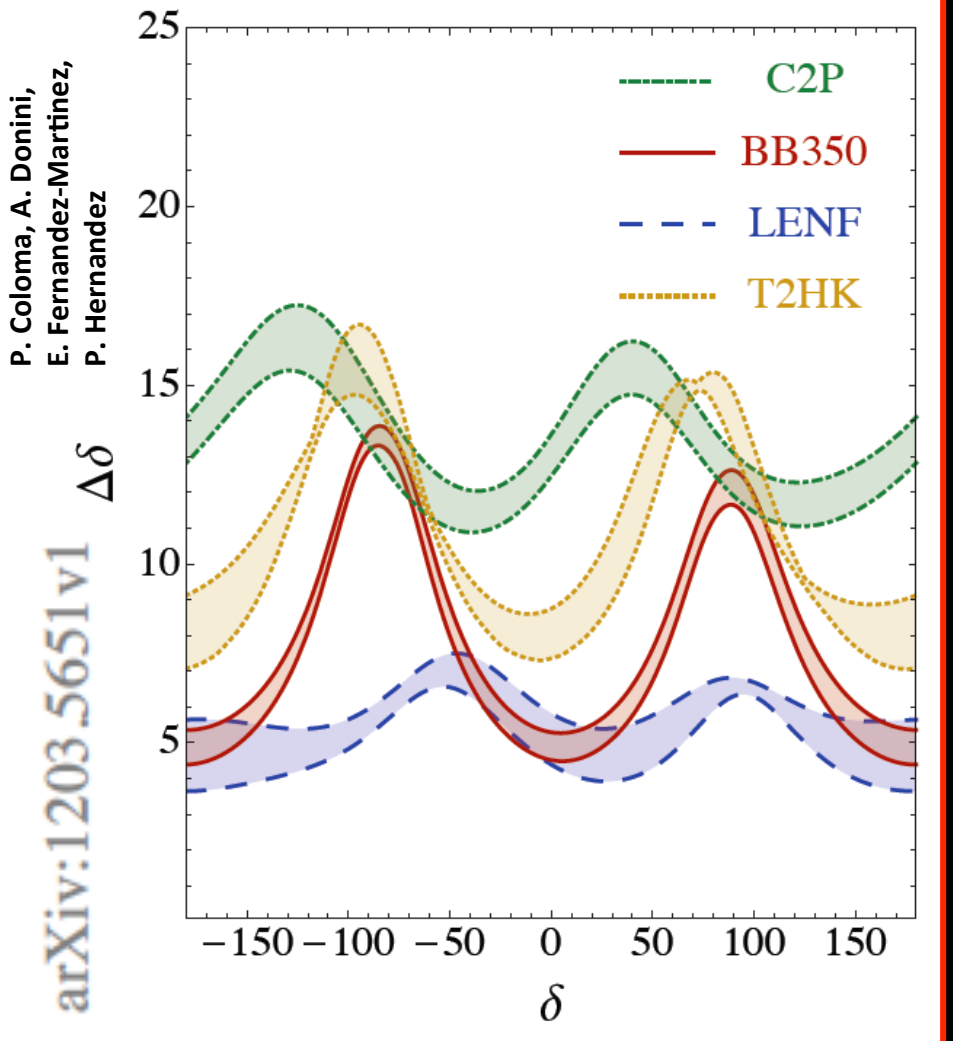




**Precision:**

- 18° at 5σ
- i.e. ~3°—4° at 1σ

# Comparison with alternatives:




- **Neutrino Factory offers best precision:**
  - **Issue now is control of systematic effects**

# Sensitivity and precision:

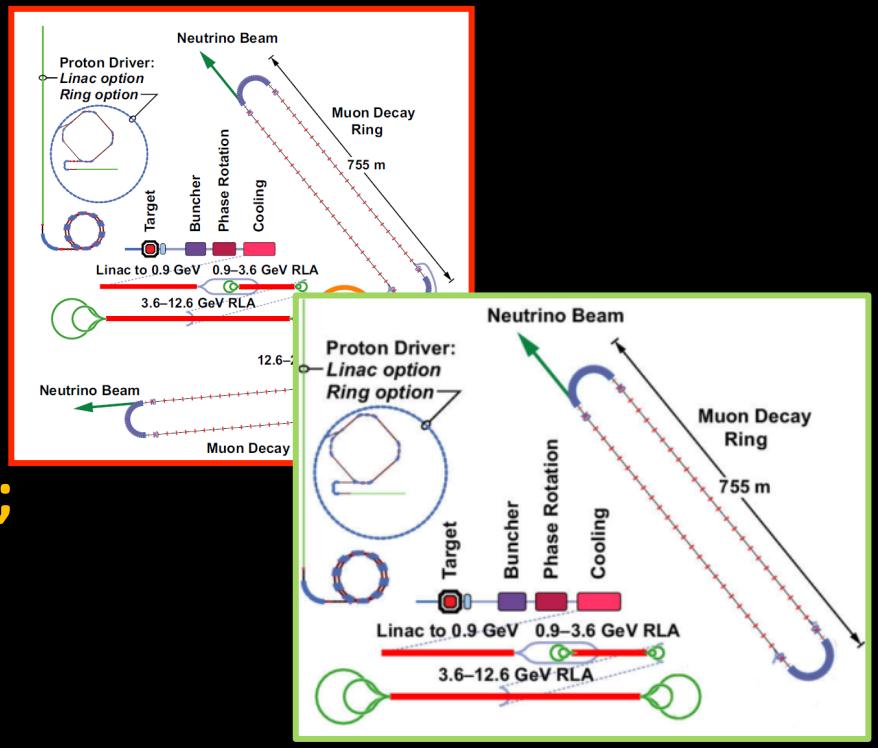
- Coloma et al comment:
  - "We should stress … that the performance of the facilities … depends significantly on the assumed systematic errors."
- Consequences for IDS-NF:
  - Baseline:
    - Alternative, 10 GeV/2000 km, favoured
  - Increased emphasis on ensuring control of systematics:
    - Storage-ring instrumentation
    - Near detector
    - Far detector
  - Clear and well motivated documentation of level of systematic errors that can be tolerated
  - Measurement and prototyping programme that is required to deliver systematics
    - Might include:
      - Facilities such as VLENF
      - Detailed detector development and test programme

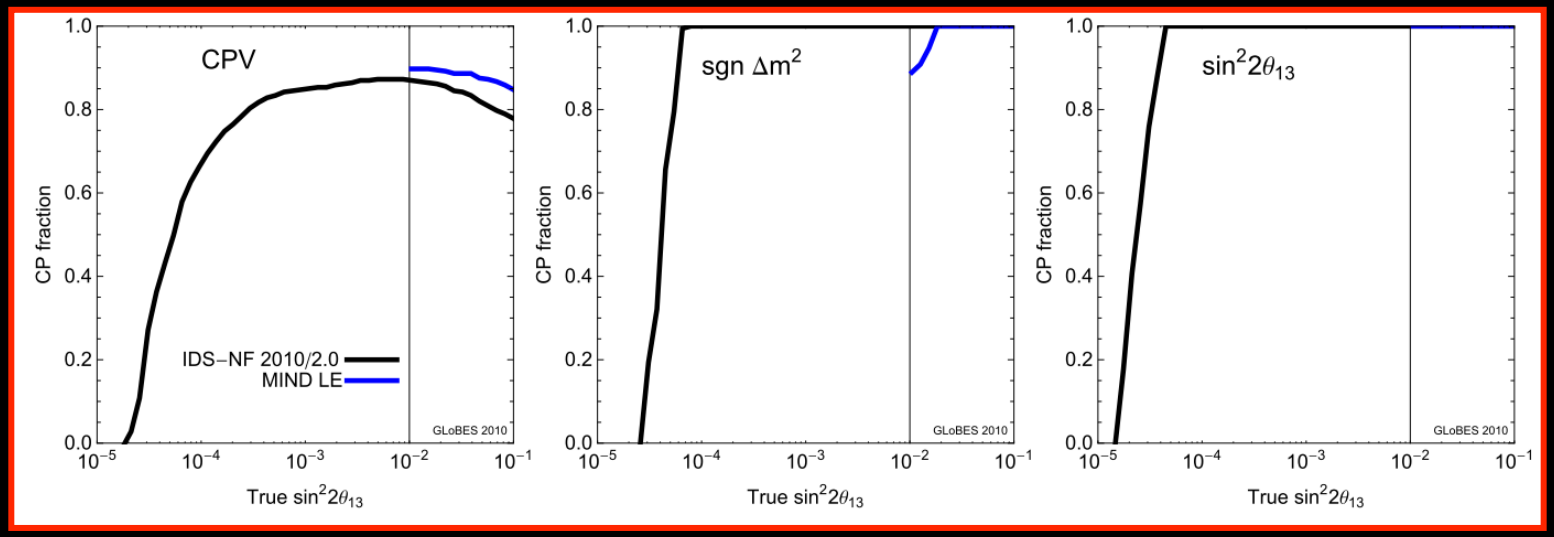
Introduction and aims:

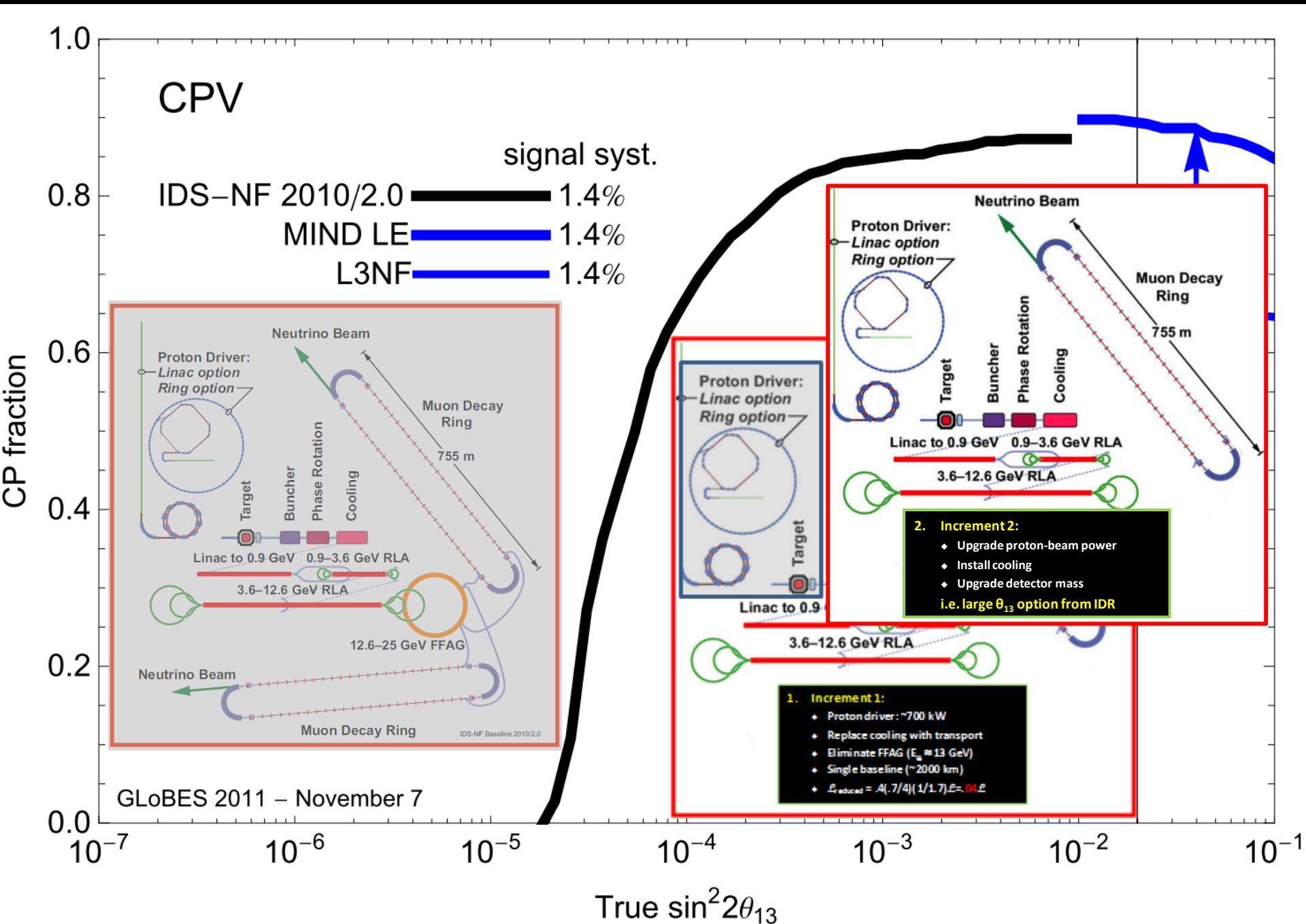
# Opportunities and increments

# The IDS-NF Interim Design Report:

- The IDS-NF IDR documents:
  - Baseline: $E_\mu$ = 25 GeV; 2 baselines; $10^{21}$ μ/yr
    - Best discovery reach
    - Best precision
    - Best sensitivity to NSI
  - "Large $\theta_{13}$ option": $E_\mu$ = 10 GeV; 1 baselines; $10^{21}$ μ/yr
    - Best "CP coverage"
    - Best precision



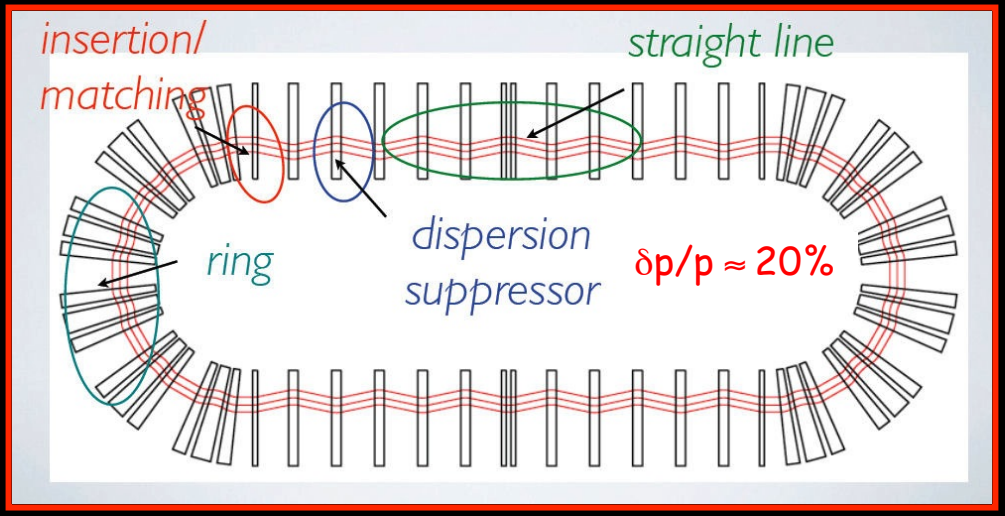



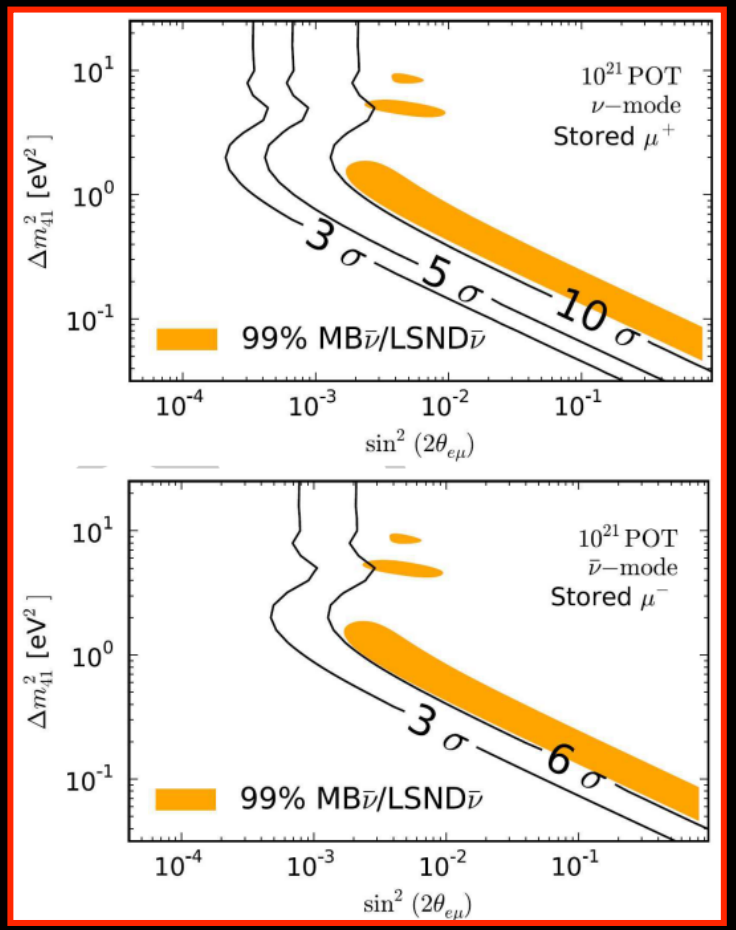

CPV
signal syst.
IDS–NF 2010/2.0 1.4%
MIND LE 1.4%
L3NF 1.4%
CP fraction
True sin²2θ13
1.0
0.8
0.6
0.4
0.2
0.0
10⁻⁷
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
10⁻²
10⁻¹
Neutrino Beam
Proton Driver:
Linac option
Ring option
Muon Decay Ring
755 m
Target
Buncher
Phase Rotation
Cooling
Linac to 0.9 GeV
0.9–3.6 GeV RLA
3.6–12.6 GeV RLA
12.6–25 GeV FFAG
Neutrino Beam
Muon Decay Ring
IDS-NF Baseline 2010/2.0
2. Increment 2:
Upgrade proton-beam power
Install cooling
Upgrade detector mass
i.e. large θ13 option from IDR
1. Increment 1:
Proton driver: ~700 kW
Replace cooling with transport
Eliminate FFAG (E ≈13 GeV)
Single baseline (~2000 km)
GLoBES 2011 – November 7

Bross, Geer, Mori, Tunnel, Winter, …

# ν-physics: [*with a stored muon beam*]

- **Next generation of oscillation experiments *must* be "high precision":**
  - **For example:**
    - **CP invariance violation hard to observe if $\theta_{13}$ is "large"**
    - **Precise determination of oscillation parameters increasingly important**
  - **Reduction in systematic uncertainties must match reduction in statistical uncertainties:**
    - **Require detailed understanding of:**
      - **$\nu_e$ and $\nu_\mu$ cross sections;**
      - **Hadro-production in neutrino interactions**
- **Unique opportunity:**
  - **Definitive sterile-neutrino search**
  - **Neutrino physics with a stored muon beam:**
    - **Pion capture in, or direct transport to, 3 GeV muon ring**
    - **Near detector (20 m) for cross section measurement**
    - **1 km detector for large $\Delta m^2$ sterile neutrino search**
  - **Possible at CERN or FNAL**



# Opportunities and increments:

- ~~If indication of~~ large $\theta_{13}$ is confirmed, competition ~~will be~~ to:
  - Search for CP violation
  - Determine mass hierarchy
  - Search for non-standard effects

Slide from IDS-NF#7

- Neutrino Factory is competitive with $10^{20}$ ($5\times10^{19}$) muon decays per year
- Is there a benefit from presenting a staged approach?
  - Must present full facility (i.e. $10^{21}$ muon decays per year), but
  - If steps can be justified on physics grounds and have substantial cost advantages then an incremental development may be appropriate
- So, need to evaluate options:
  - Accelerator:
    - Consider strategies to deliver: $5\times10^{19}$; $1\times10^{20}$; $5\times10^{20}$; $1\times10^{21}$
  - Detector:
    - Evaluate feasibility of surface detector:
      - Scalability of detector
      - "Free" choice of baseline
  - PPEG:
    - Review/evaluate physics case for each of the above options
    - Review systematics analysis from above

Likely need a "position paper"

Introduction and aims:

# How we left it at IDS-NF#7

# How we left it at IDS-NF#7 and goals for IDS-NF#8

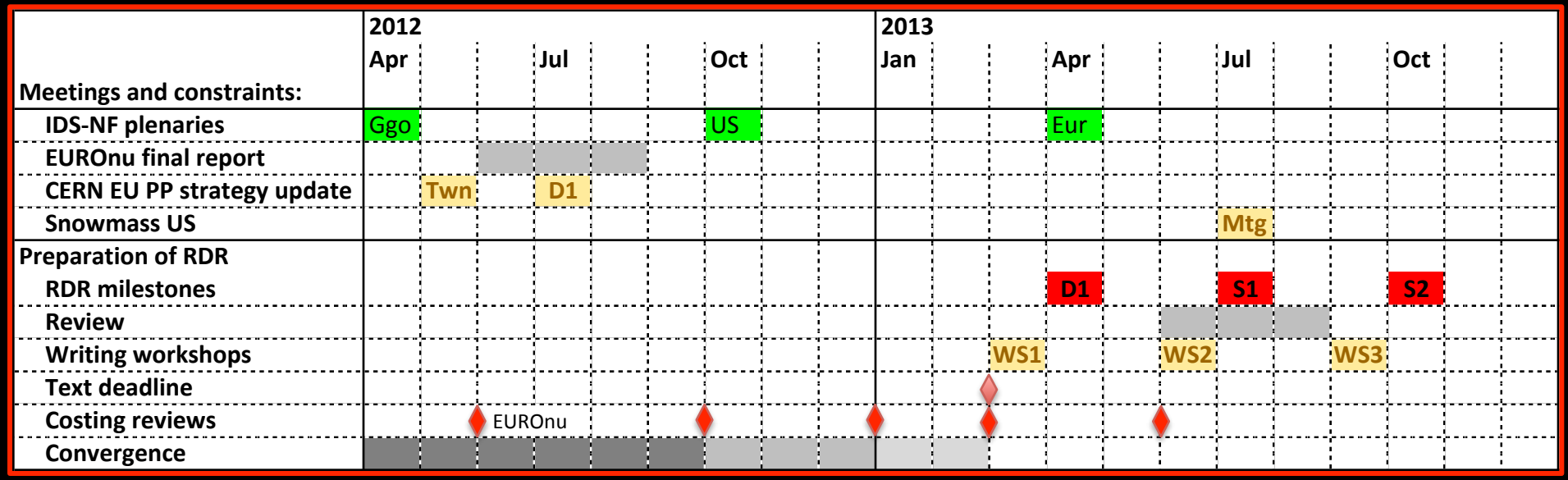
| IDS-NF#7 | Goal for IDS-NF#8 |
| --- | --- |
| • Evaluate options for staged approach to accelerator facility | • Agree on the elements of staged approach to accelerator facility |
| • RDR and costing:<br>– Specification required at least by Oct12<br>– First iteration of costing of whole facility at IDS-NF#8, second iteration at IDS-NF#9 | • RDR and costing:<br>– Identify items where specification is not complete and define timeline for closing specification<br>– First iteration of costing will be reviewed in "extended SG" on Friday afternoon |
| • Decide at IDS-NF#8 whether we need "position paper" | • Position paper:<br>– My view is "yes":<br>• Needs to be short;<br>– Produce template by Friday |
| • Timeline for RDR required | • RDR timeline follows |

Introduction and aims:

# Costing exercise and RDR timeline

# Costing exercise and RDR timeline:

- For discussion:
  - Finalize on Friday 20Apr12



Introduction and aims:

# ICFA taking an interest

# ICFA taking an interest:

- ICFA asked for a report on the IDS-NF at its meeting in Oxford on 02Feb12:
  - Slides presented:
- The question of the possible role of ICFA in the "incubation" of the neutrino oscillation programme was raised;
  - P. Oddone's suggestion that the Neutrino Conference in Kyoto in June 2012 might form part of the community consultation process was discussed;
  - No conclusion was reached, it was agreed to return to the issue at the next ICFA meeting;
- What is the IDS-NF view:
  - Discussion over the course of the meeting;
    - Will try and summarize opinions at the end of the meeting

Introduction and aims:

# Next meetings:

# Next meetings:

- IDS-NF plenaries:
  - #9:
    - October 2012; US
      - Volunteers?
  - #10:
    - April 2013; Europe
      - Volunteers?