Introduction and meeting aims

Imperial College London

K. Long, 17 April 2012

Contents:

- θ_{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
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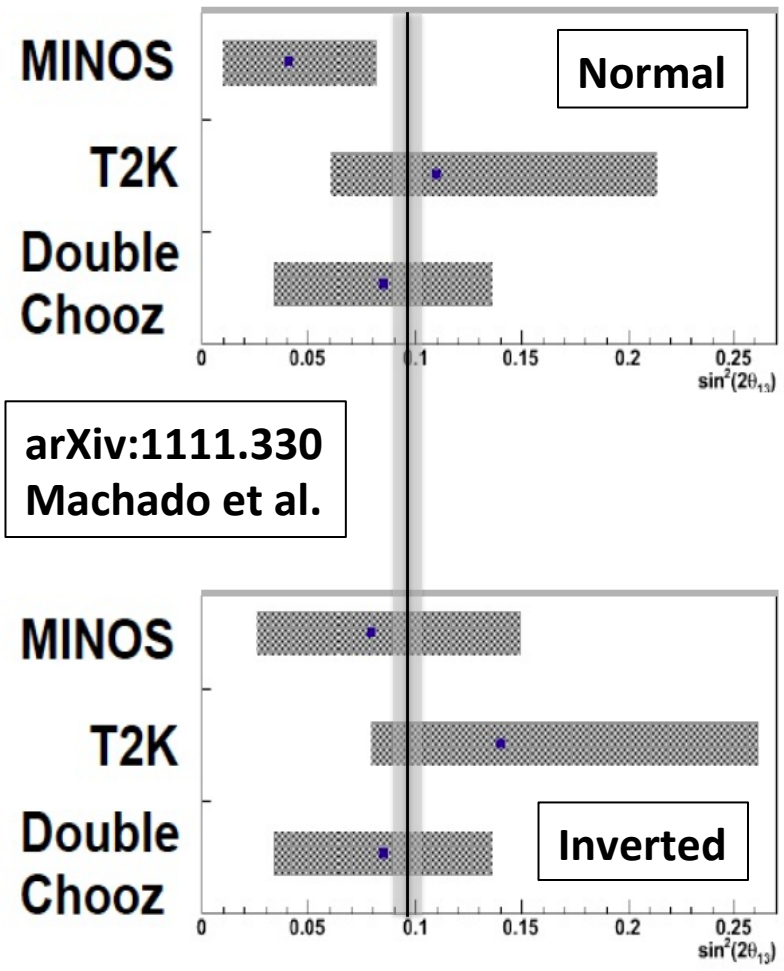
- Next meetings

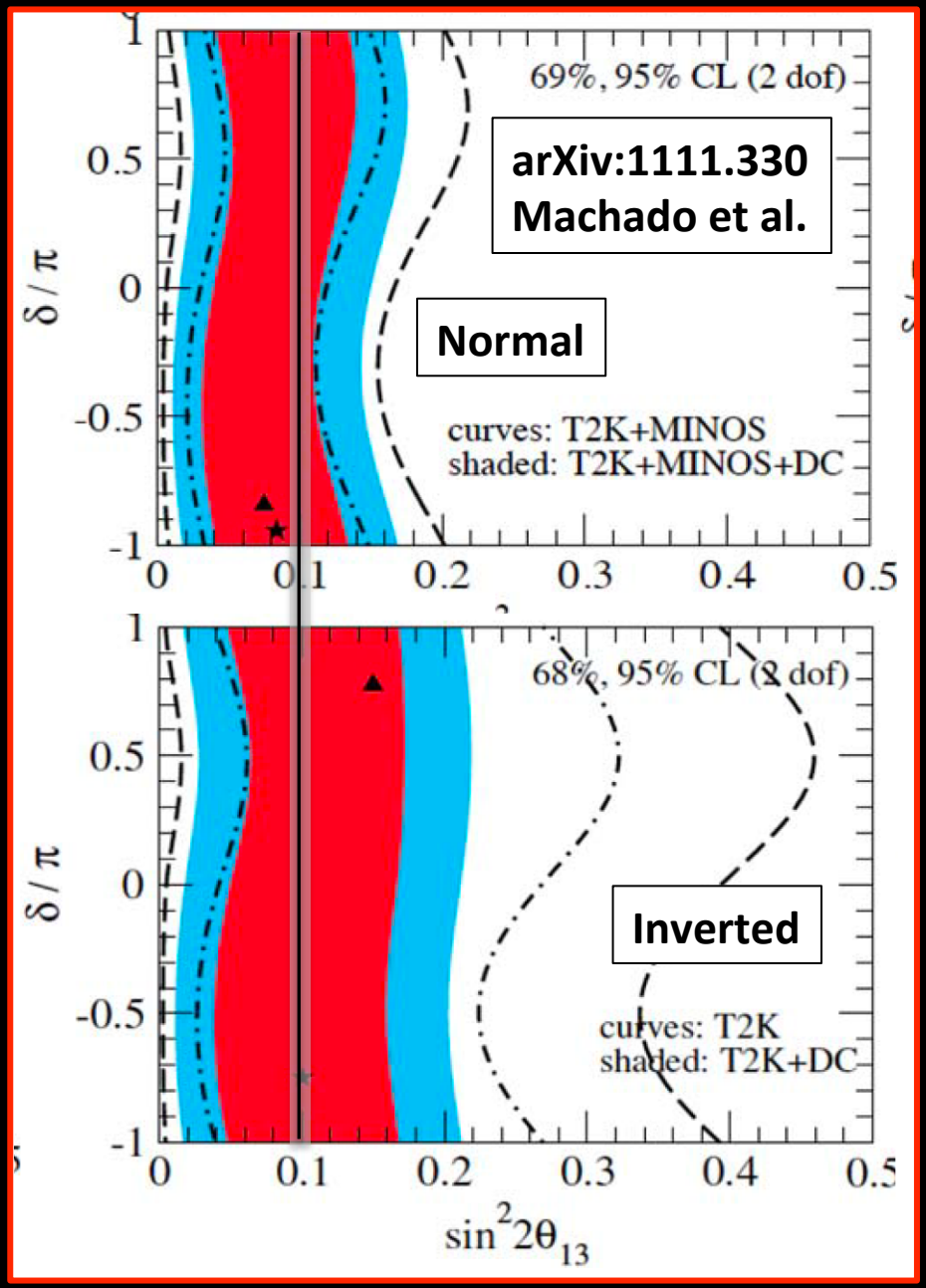
Introduction and aims:

θ_{13} and the IDS-NF baseline

Recent results:

	$\sin^2\theta_{13}$		
	Value	Statistical	Systematic
D-Chooz	0.086	0.041	0.030
Daya Bay	0.092	0.016	0.005
RENO	0.103	0.013	0.011
Mean	***0.097***	***0.012***	



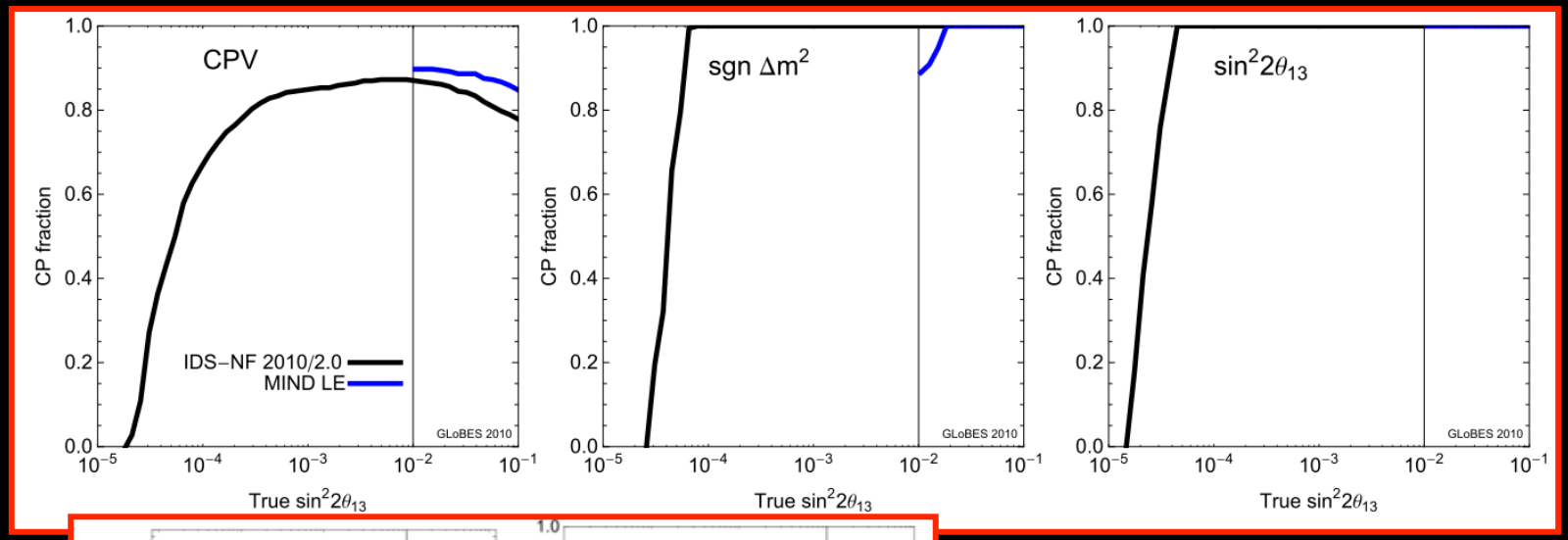


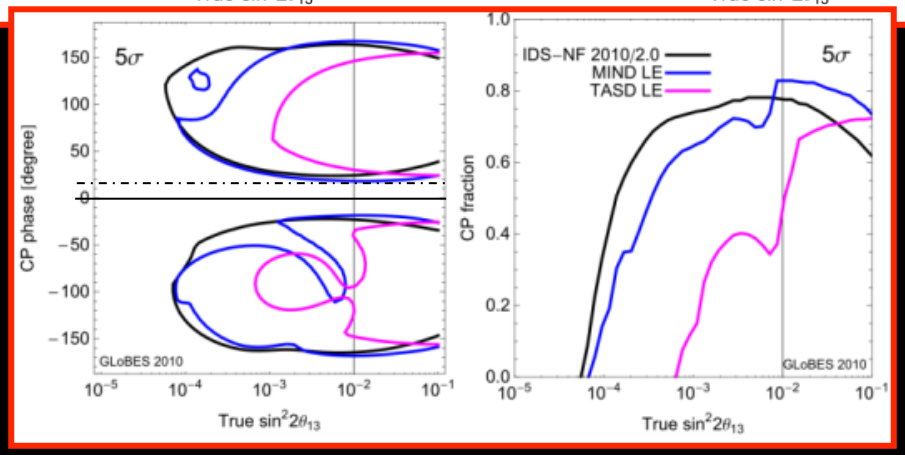
A game-changer!

- Rapid development:
  - 2011:
    - Indications for $\sin^2 2\theta_{13} \sim 0.1$ from LBL experiments T2K and MINOS
    - Indications also from D-Chooz
  - 2012:
    - Measurements of $\sin^2 2\theta_{13}$ from Daya Bay and RENO
- Consequences for IDS-NF:
  - Next session, but:
    - Motivates "more than ever" that best possible programme to search for CP-invariance violation is a must;
    - Emphasizes need to get a strong grip on systematic errors to allow precision measurements;
    - De-emphasizes need for "magic baseline":
      - θ_{13} can be measured very well by reactor and LBL experiments;
      - Mass hierarchy likely to be measured before Neutrino Factory begins to take data

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

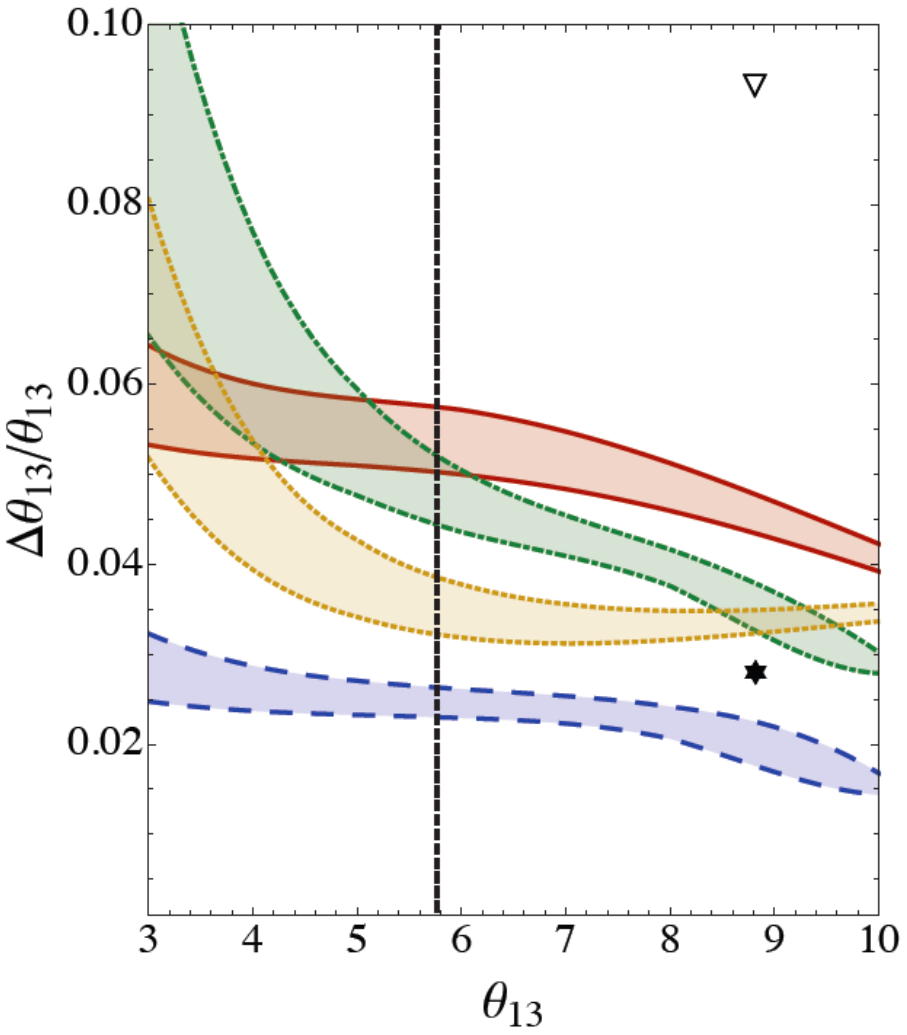


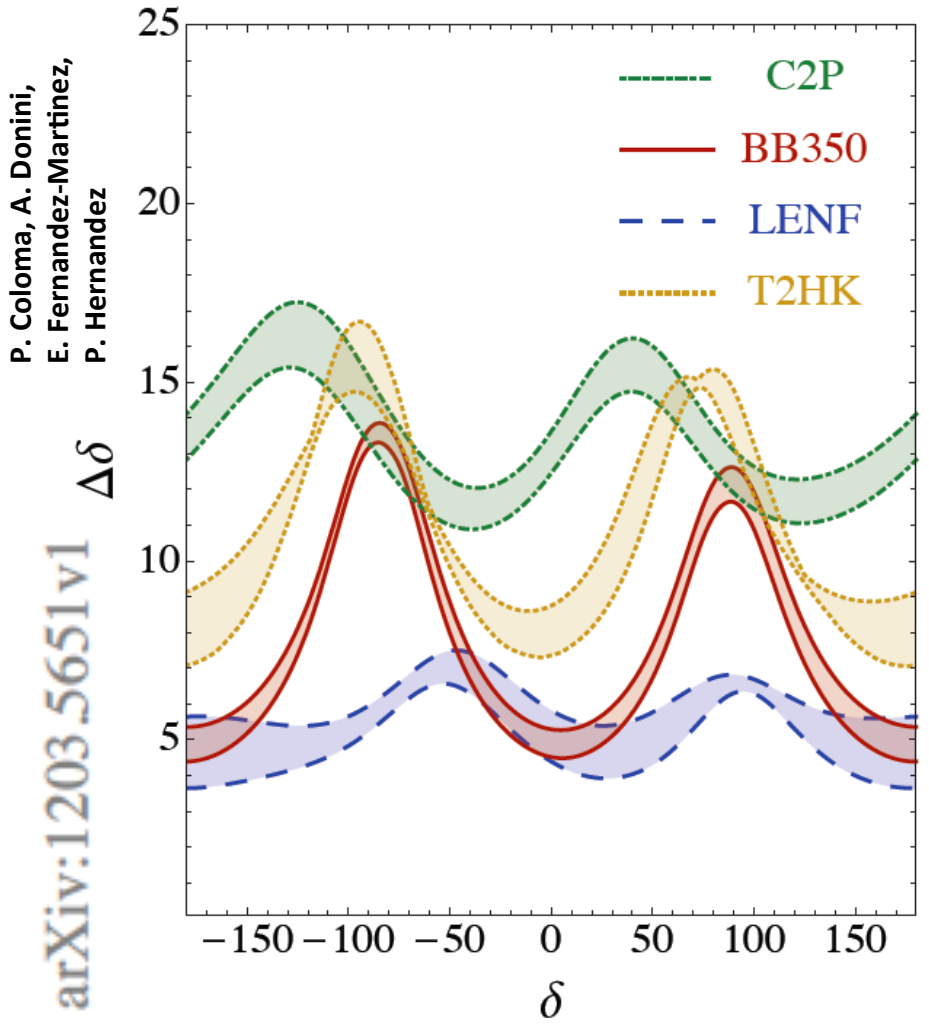


Precision:

- 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:

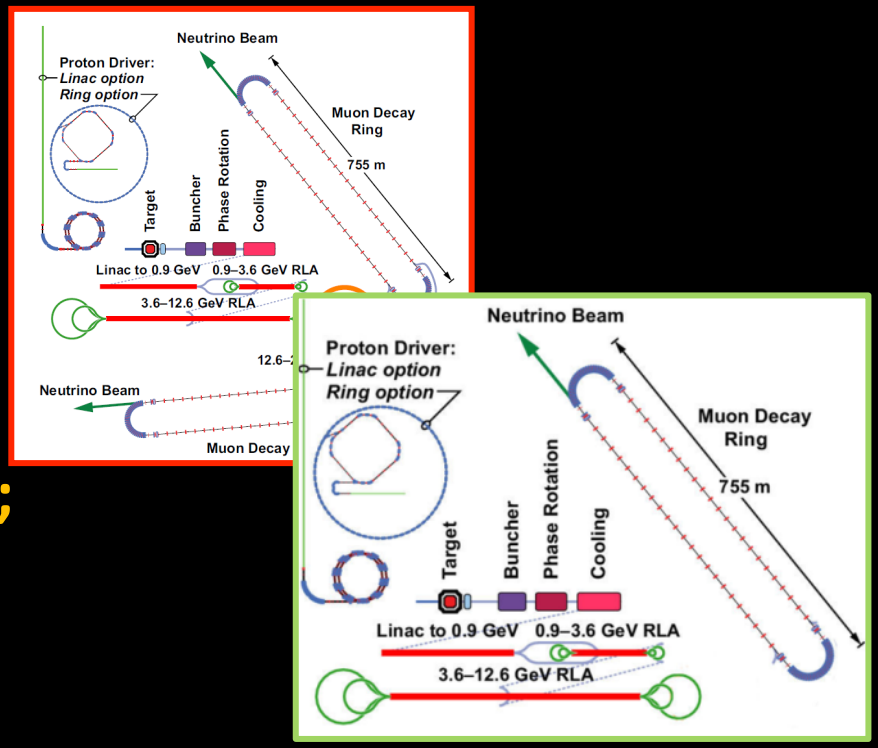
- Coloma et al comment:
  - "We should stress … that the performance of the facilities … depends significantly on the assumed systematic errors."
- Consequences for IDS-NF:
  - Baseline:
    - Alternative, 10 GeV/2000 km, favoured
  - Increased emphasis on ensuring control of systematics:
    - Storage-ring 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

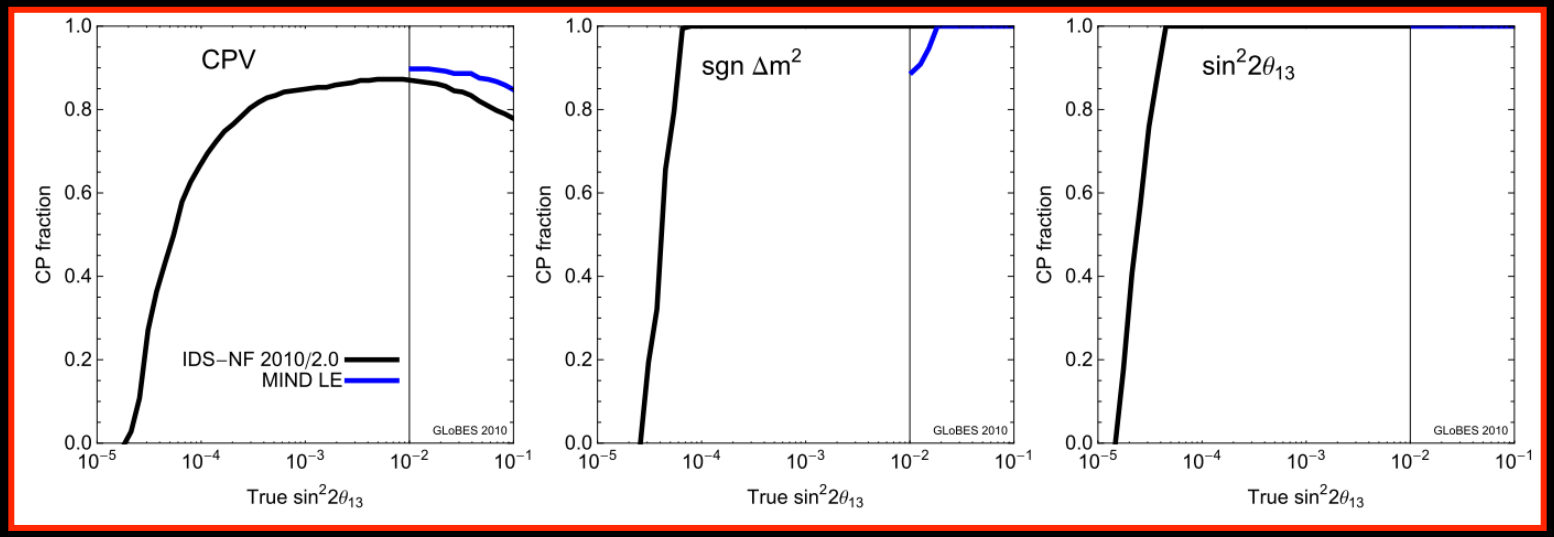
Introduction and aims:

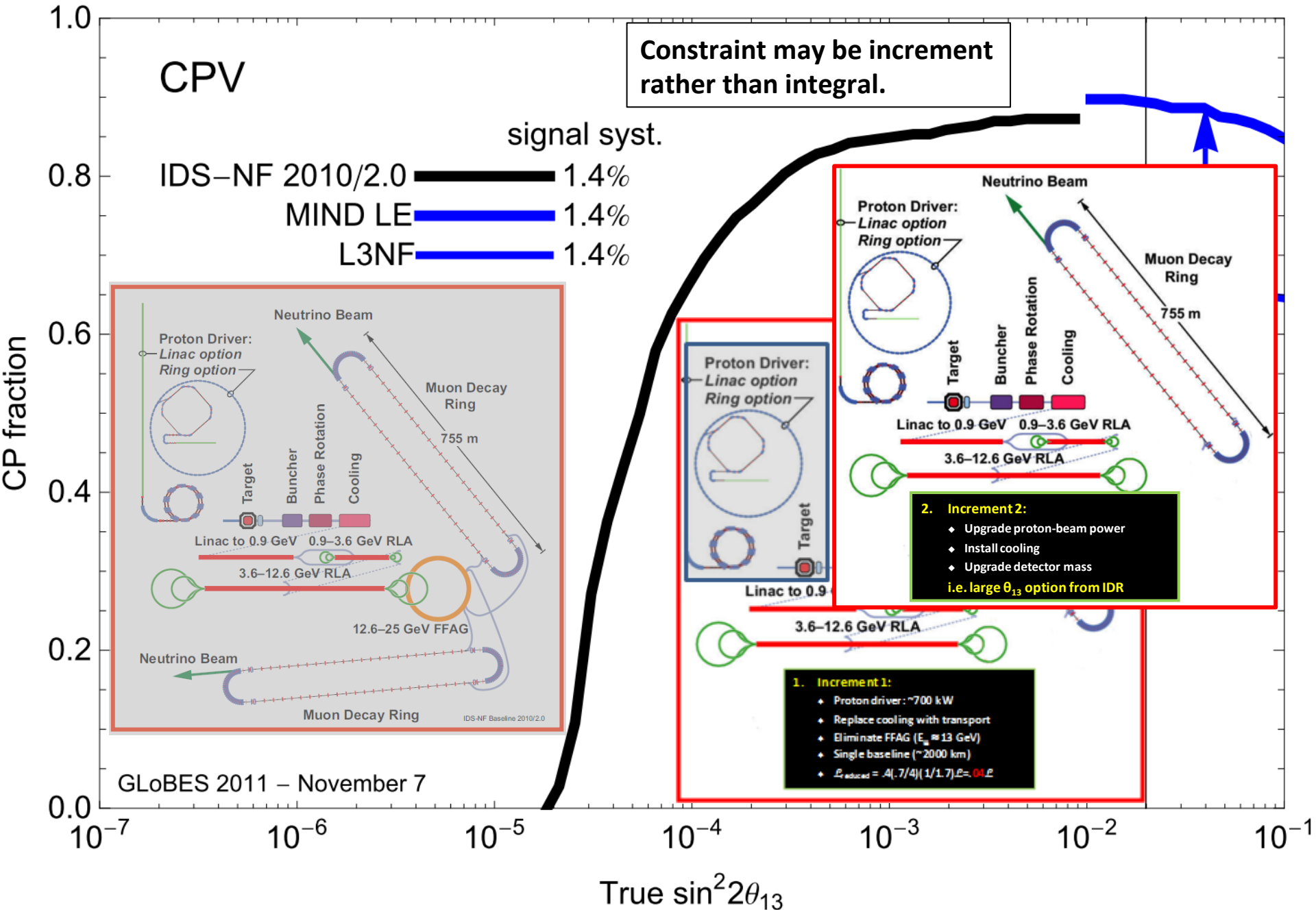
Opportunities and increments

The IDS-NF Interim Design Report:

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



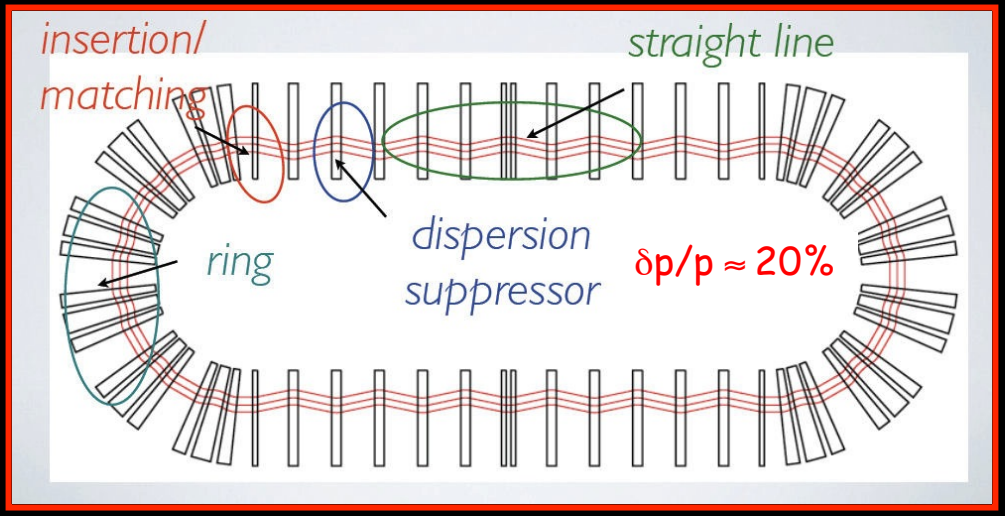


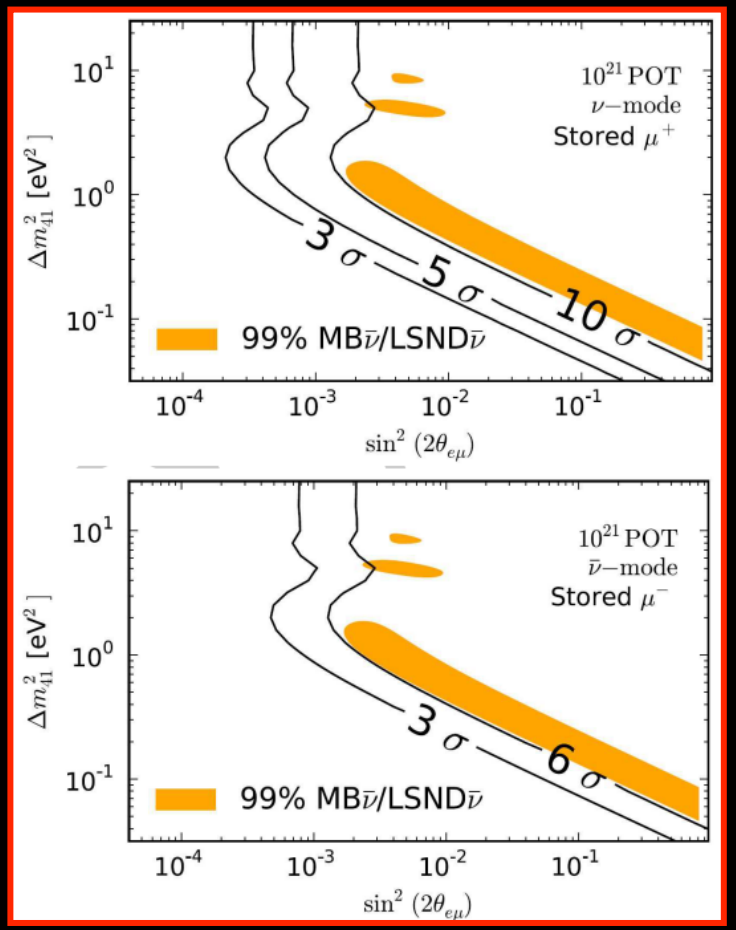

CPV
signal syst.
IDS–NF 2010/2.0 1.4%
MIND LE 1.4%
L3NF 1.4%
Constraint may be increment rather than integral.
CP fraction
True $\sin^2 2\theta_{13}$
1.0
0.8
0.6
0.4
0.2
0.0
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
Neutrino Beam
Proton Driver:
Linac option
Ring option
Muon Decay Ring
755 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 θ_{13} option from IDR
1. Increment 1:
Proton driver: ~700 kW
Replace cooling with transport
Eliminate FFAG ($E_\mu \approx 13$ GeV)
Single baseline (~2000 km)
$\mathcal{L}_{reduced} = .4(.7/4)(1/1.7)\mathcal{L} \approx .04\mathcal{L}$
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 θ_{13} is "large"**
    - **Precise determination of oscillation parameters increasingly important**
  - **Reduction in systematic uncertainties must match reduction in statistical uncertainties:**
    - **Require detailed understanding of:**
      - **ν_e and ν_μ 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 Δm^2 sterile neutrino search**
  - **Possible at CERN or FNAL**





Opportunities and increments:

- ~~If indication of~~ large θ_{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} (5×10^{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: 5×10^{19}; 1×10^{20}; 5×10^{20}; 1×10^{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"

Opportunities and increments:

- The RDR:
  - Must:
    - Document what we believe should be built;
    - Present our best estimate of cost
    - Include our best assessment of technical issues and timescales;
- Opportunities:
  - I believe there is a need to discuss, and perhaps evaluate, incremental approaches both:
    - Staged:
      - Where an upgrade path exists to the baseline facility presented in the RDR; and
    - Incremental:
      - Where the investment required to deliver a certain outcome is justified by the likely scientific outcome
  - How much effort is invested, how much is presented in the RDR and the manner in which it is presented are all issues to be discussed, but:
    - We must remain focused
      - Without being too inflexible

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

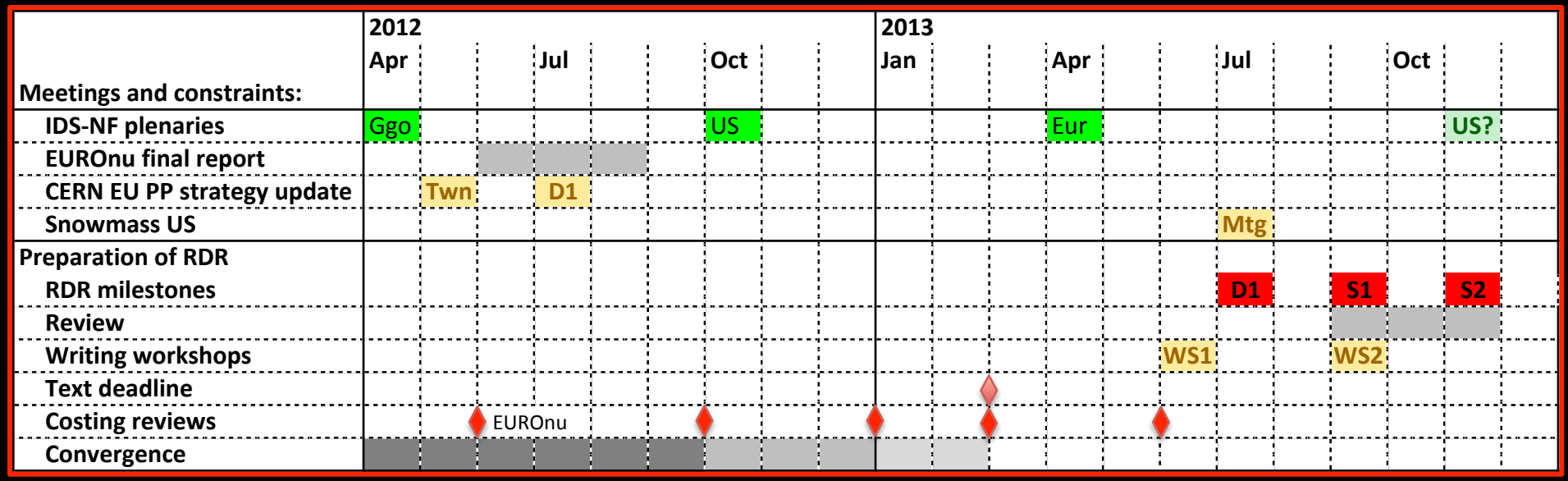
IDS-NF#7	Goal for IDS-NF#8
• Evaluate options for staged approach to accelerator facility	• Seek to agree elements of incremental approach – Includes "1-increment" approach
• RDR and costing: – Specification required at least by Oct12 – First iteration of costing of whole facility at IDS-NF#8, second iteration at IDS-NF#9	• RDR and costing: – Identify items where specification is not complete and define timeline for closing specification – 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: – My view is "yes": • Needs to be short; – 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?