



DUNE

Deep Underground Neutrino Experiment

Part I

Mark Thomson
University of Cambridge



3-for-the-price-of-1



★ **LBNF**

- Covered in Jim Strait's presentation

★ **DUNE: part I**

- Mark Thomson

★ **DUNE: part II**

- André Rubbia



Pre-History



Pre-History of DUNE



- ★ During past few years a strong community has developed targeting CPV in the neutrino sector, utilizing **large LAr-TPC detectors**
 - US-led: **LBNE** collaboration
 - European-led: **LBNO** collaboration
- ★ **European Strategy Update (May 2013)**
 - CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. **Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.**
- ★ **P5 Report (June 2014)**
 - (To paraphrase): calls for the reformulation of LBNE as a truly international endeavor: “**LBNF**”



History of DUNE



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- ★ **August 2014: Fermilab director creates LBNF iEB**
 - Interim International Executive Board
 - Key stakeholders from LBNE, LBNO, others + FAs
- ★ **September 2014: Face-to-face iEB meeting**
 - Defines broad scope of LBNF + experiment “ELBNF”
- ★ **November 2014: Sergio Bertolucci - interim IB chair**
 - Overseeing the formation of the new collaboration
- ★ **January 2015: LBNF Lol released**
 - Signatories define basis of new collaboration
- ★ **January 2015: First “ELBNF” proto-collaboration meeting**
- ★ **March 2015: “ELBNF” Spokespersons elected**
- ★ **March 2015: A name: “ELBNF” → DUNE**
- ★ **April 16th-18th: First DUNE Collaboration meeting**
 - Over 200 collaborators attended in person



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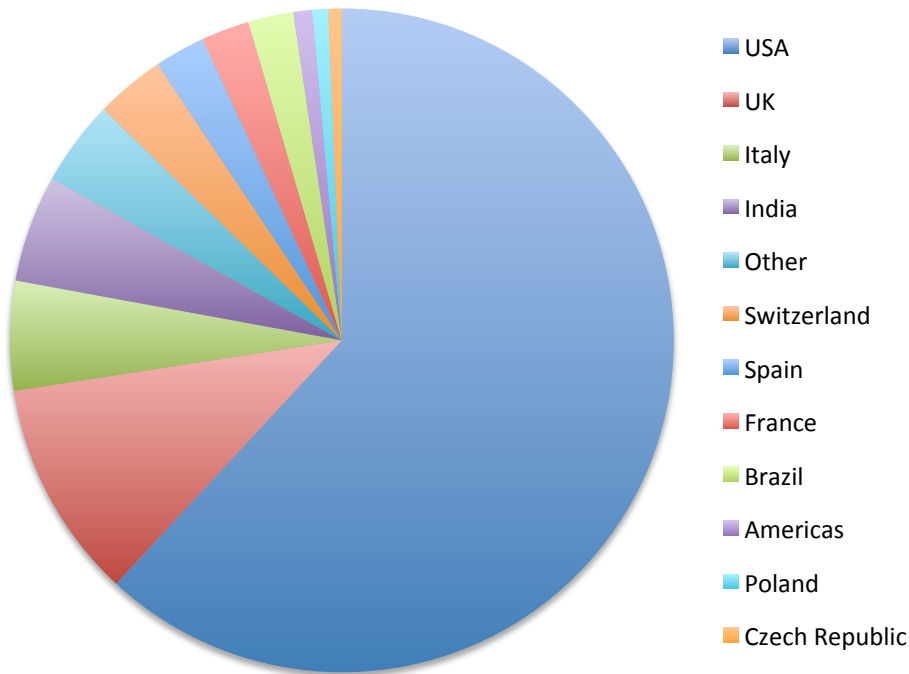
A huge amount of progress since the last APPEC



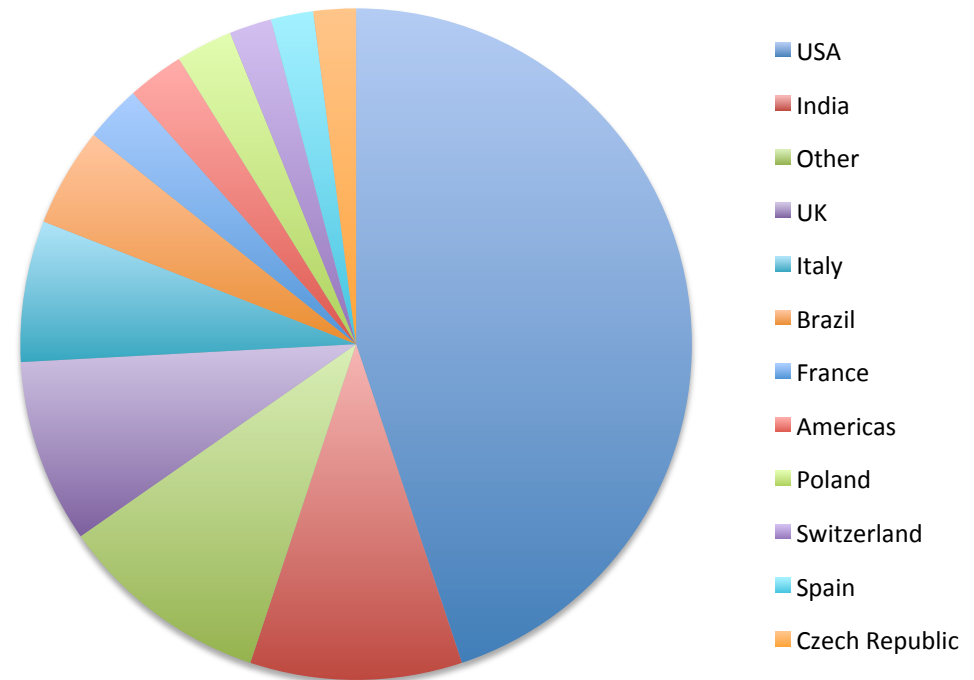
The DUNE Collaboration



★ **As of today:**
769 Collaborators



147 Institutes



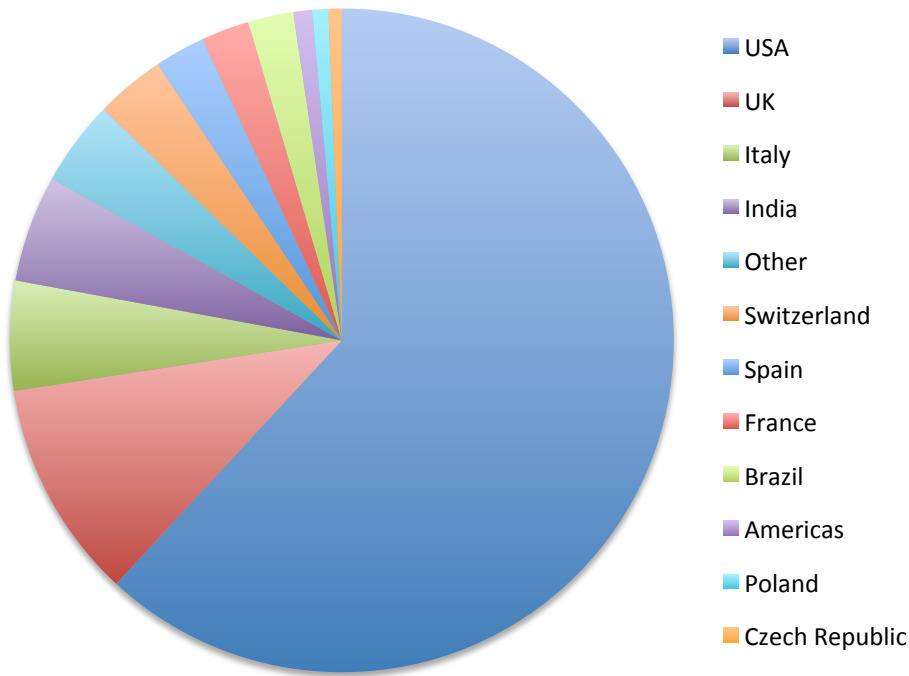
★ **Already a large collaboration**



The DUNE Collaboration



★ **As of today:**
769 Collaborators



25 Nations

Armenia, Belgium, Brazil, Bulgaria, Canada, Colombia, Czech Republic, France, Germany, India, Iran, Italy, Japan, Madagascar, Mexico, Netherlands, Peru, Poland, Romania, Russia, Spain, Switzerland, Turkey, UK, USA

★ **Already a large international collaboration**
- bringing together **LBNE, LBNO & others**



DUNE Scientific Priorities



DUNE Science



★ DUNE Collaboration is quite youthful - only “two days old”

- Scientific priorities defined in the preceding “ELBNF” LoI
- Currently being fleshed out for DUNE

★ Three main pillars

1) LBL Neutrino Physics

- CPV in the leptonic sector
- Mass Hierarchy
- Precision oscillation physics (θ_{23} octant, ...)
- Testing 3-flavour paradigm

2) Nucleon Decay

- Targetting SUSY-favoured modes, e.g. $p \rightarrow K^+ \nu$

3) Astro-particle Physics

- Core collapse super-nova, sensitivity to ν_e

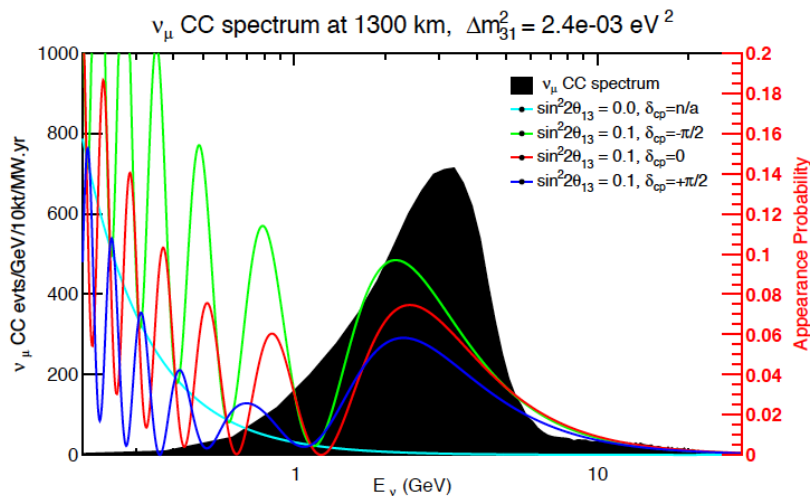
+ Precision neutrino physics in the near neutrino detector



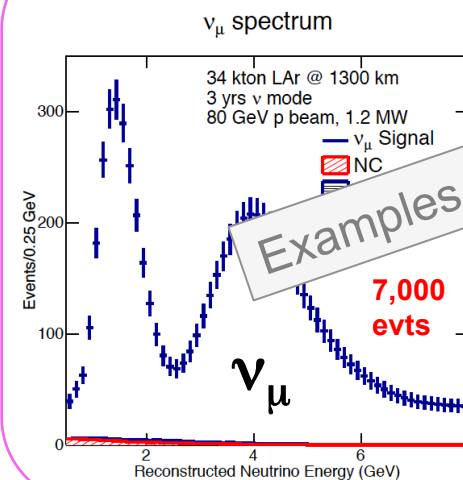
LBL Scientific Strategy



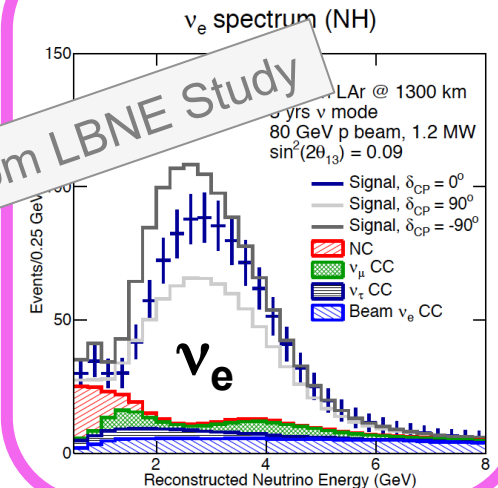
- ★ Measure oscillated spectra at 1300 km in a wide-band beam
- ★ Determine **MH** and θ_{23} octant, **probe CPV** and search for ν non-standard-interactions (NSIs) in a single experiment
 - Long baseline:
 - Matter effects are large ($\sim 40\%$)
 - MH and CPV effects are separable: removes ambiguities
 - Wide-band ν_μ beam:
 - Measure ν_e and ν_μ spectra over wide range of energies



Disappearance



Appearance



Examples from LBNE Study



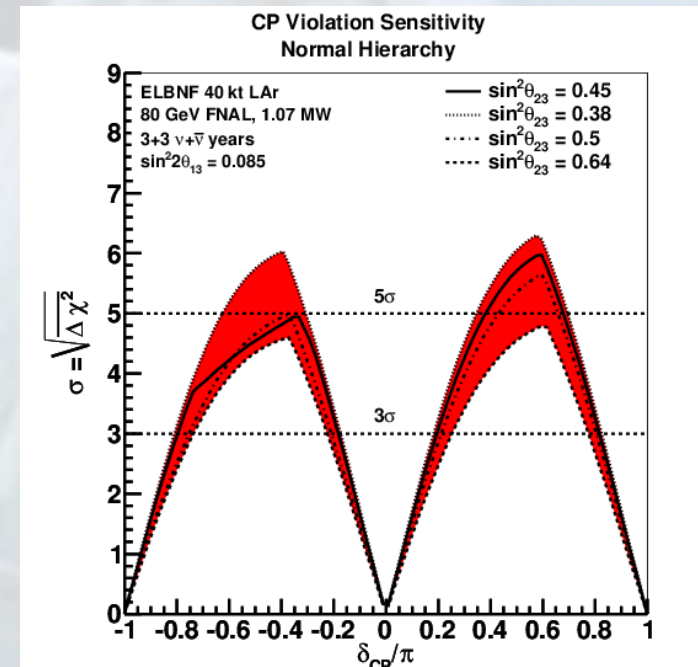
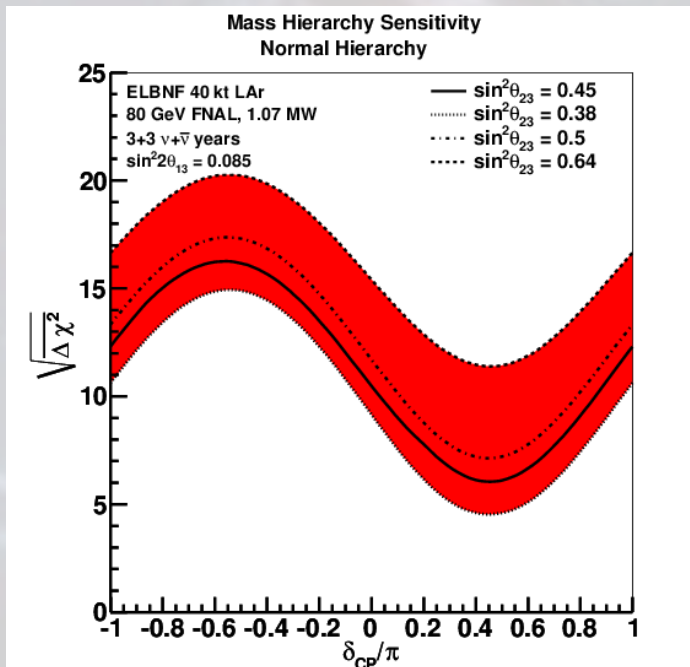
e.g. CPV & MH



★ Ultimate sensitivity depends:

- Beam power – need ν s
- Detector mass – detect the ν s
- Experiment/Facility design – optimize for CPV
- Beam efficiency

★ Sensitivities (as presented in “ELBNF” LoI)





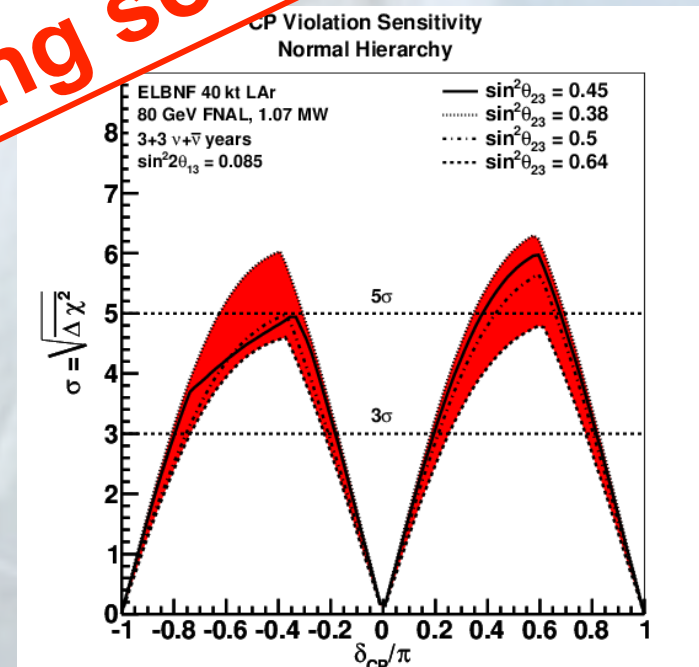
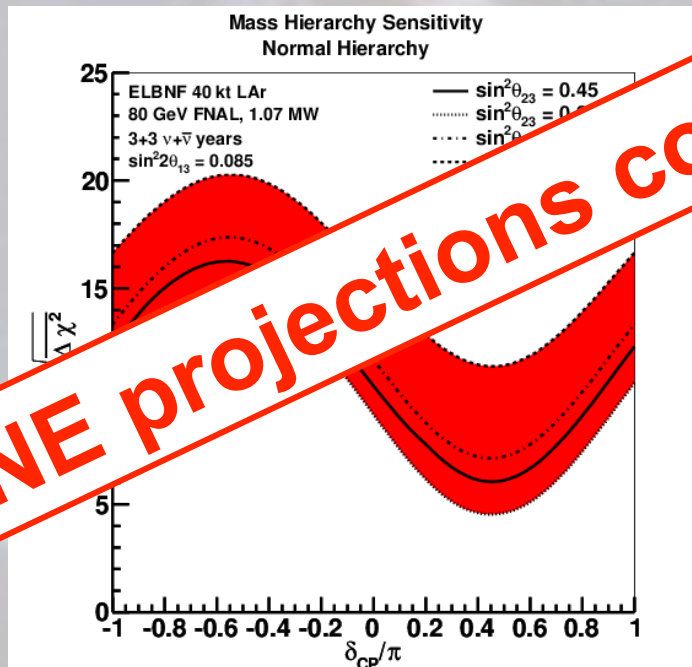
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★ Sensitivities (as presented in “ELBNF 40 kt LAr”)



DUNE projections coming soon: CDR (July)





DUNE and LBNF



★ Division of the Facility and Experiment along lines of LHC model

- e.g. The LHC and the ATLAS/CMS* experiments
 ➡ LBNF and the DUNE experiment

★ LBNF (Long-baseline Neutrino Facility)

- **1.2 MW** wide-band ν beam, upgradable to **2.4 MW**
- Conventional facilities at Fermilab and SURF
- Cryostats and cryogenic systems at SURF

★ DUNE (Deep Underground Neutrino Experiment)

- **40 kt LAr-TPC** Far Detector (1300 km baseline)
- Near Detector systems
- Science collaboration

* + LHCb, ALICE



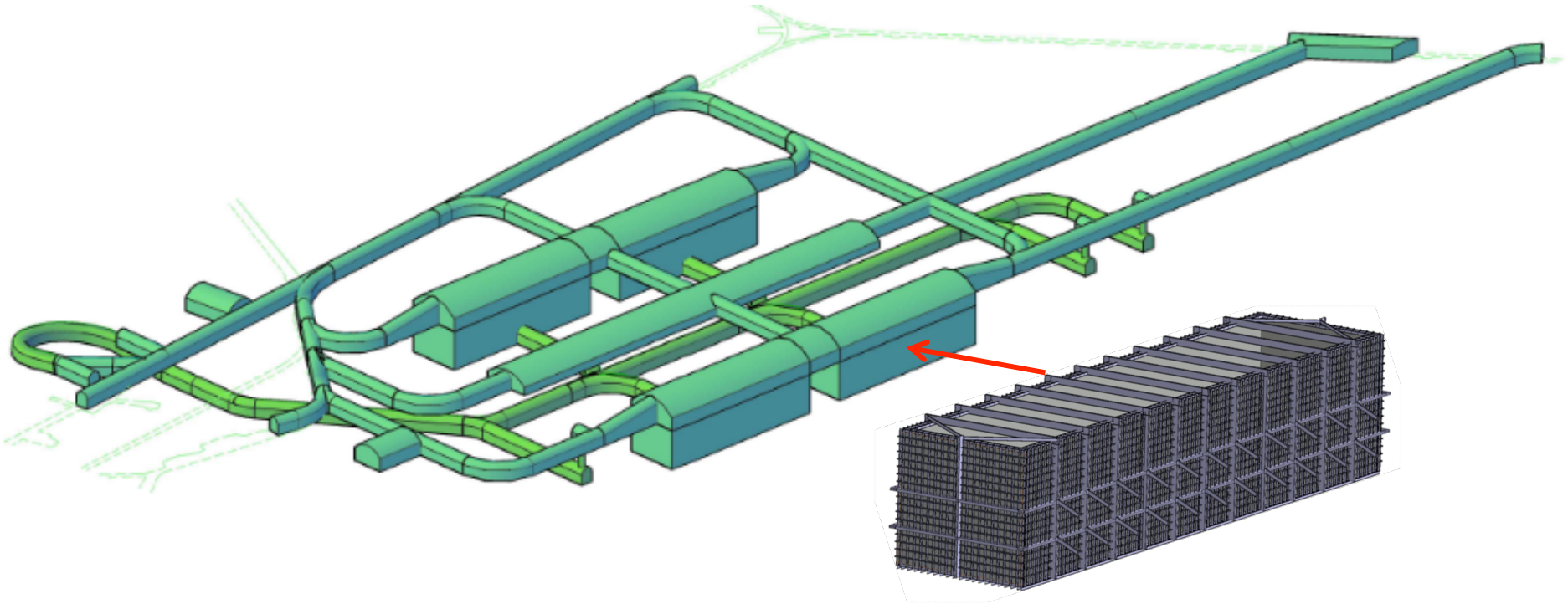
DUNE Scope (in CDR)



Far Detector Scope



- ★ **LBNF will provide “homes” for the DUNE FD modules**
 - Four caverns + four cryostats for four 10 kt FD LAr-TPCs



- ★ **Modular design provides flexibility w.r.t. FD design and funding**

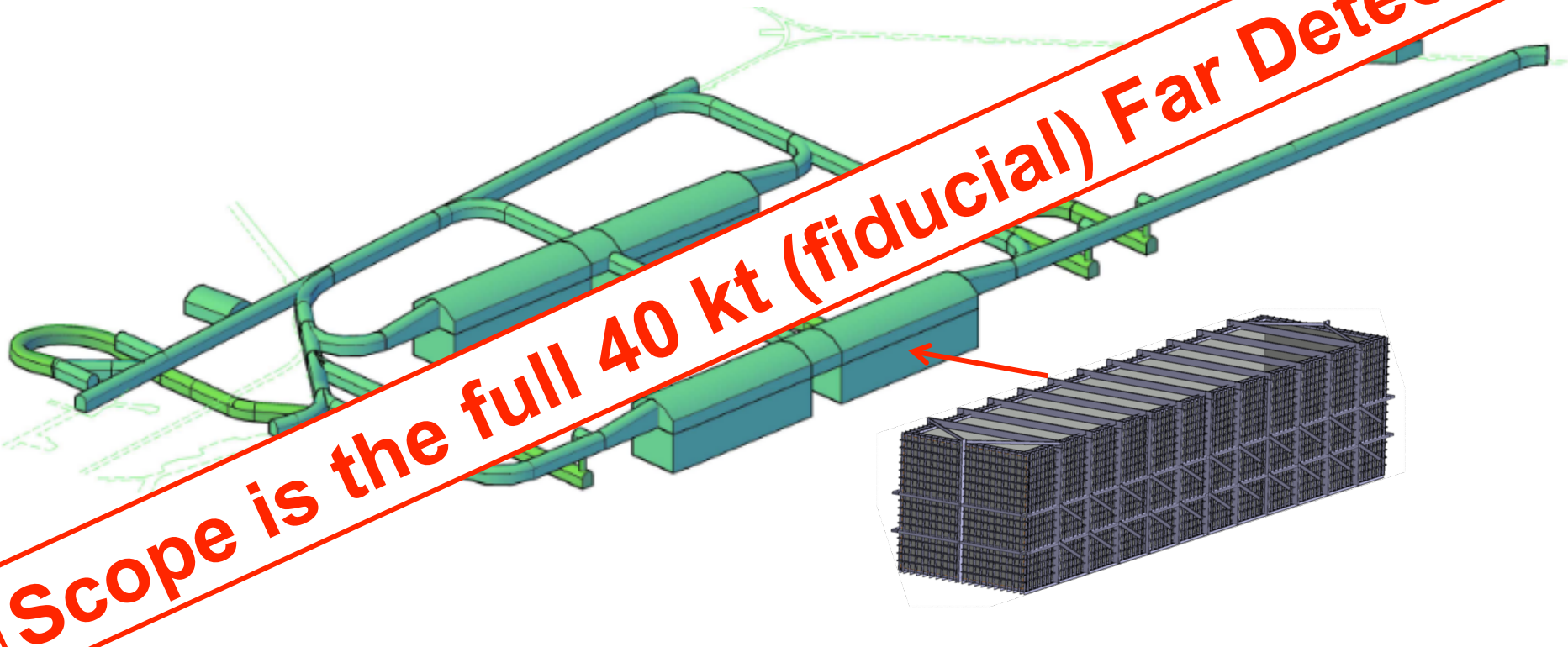


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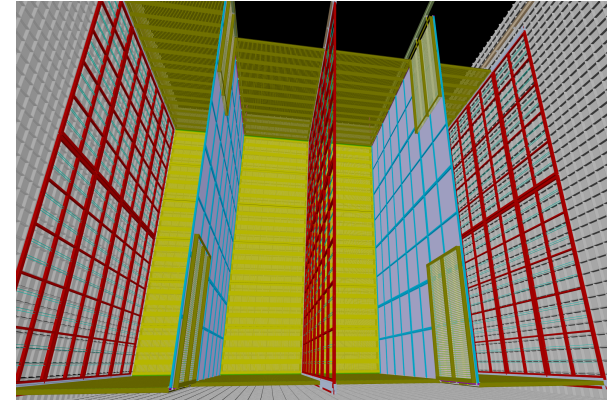
★ **Modular design provides flexibility w.r.t. FD design and funding**



Far Detector Scope



★ **Total 40 kt (fiducial) LAr-TPC**; four separate 10 kt fiducial mass (~ 17.5 kt liquid mass) modules, housed in four nominally identical steel-frame membrane $\sim 13 \times 10^3 \text{ m}^3$ cryostats.



★ **“Reference design” (for cost)** is the LBNE APA/CPA concept. The design may **evolve** from this, either **improved single-phase** or **dual-phase** based on prototyping efforts at CERN and from SBN experience.

★ **Prototypes** at the CERN Neutrino Platform are an essential part of the DUNE engineering prototyping

+ Benefit from Developments at the Fermilab SBN program

[Details in Andre's talk]

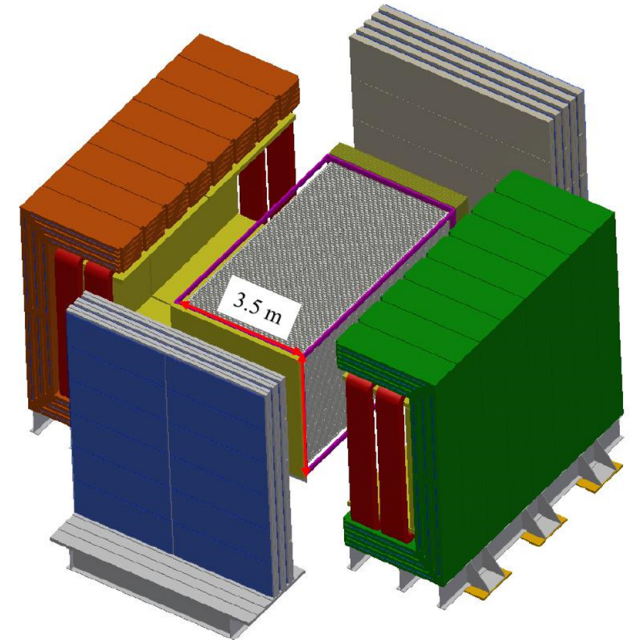


DUNE Near Detector



★ The CDR *reference design* is the NOMAD-inspired “fine-grained tracker” (FGT) concept (developed by US - India)

- Low-mass straw-tube tracker with pressurized gaseous Ar + calorimeters + ...
- Magnetic field



★ Beyond the CDR, study to validate/optimize design and to assess possible way of augmenting the FGT: **based on ability to constrain FD systematics**

[Issues covered in Elizabeth's talk]



The DUNE CDR and Beyond



Towards Construction



★ **DUNE-LBNF design builds on strength**

- i.e. the in-depth work from LBNE, LBNO and others
- Design at or beyond “conceptual design level”
- Realistic resource-loaded schedule being assembled
- DOE CD-1-Refresh in July 2015
 - “CDR level” review – defining cost range

★ **Things are progressing very rapidly**

- DOE CD-2a/CD-3a for **Far Site CF** in Nov 2015
 - Would allow early start to far site excavation
 - **A major milestone**

★ **Aiming (realistically) for**

- Far site excavation starting ~2018
- Far detector installation starting **2021/2022**



over to André...