# Introduction to DUNE

## (overview of DUNE and the collaboration organization)

**André Rubbia (ETH Zürich)**

European DUNE Meeting
CERN Thursday/Friday April 6-7th, 2016

v3

# An Experimental Program in Neutrinos, Nucleon Decay and Astroparticle Physics Enabled by the Fermilab Long-Baseline Neutrino Facility

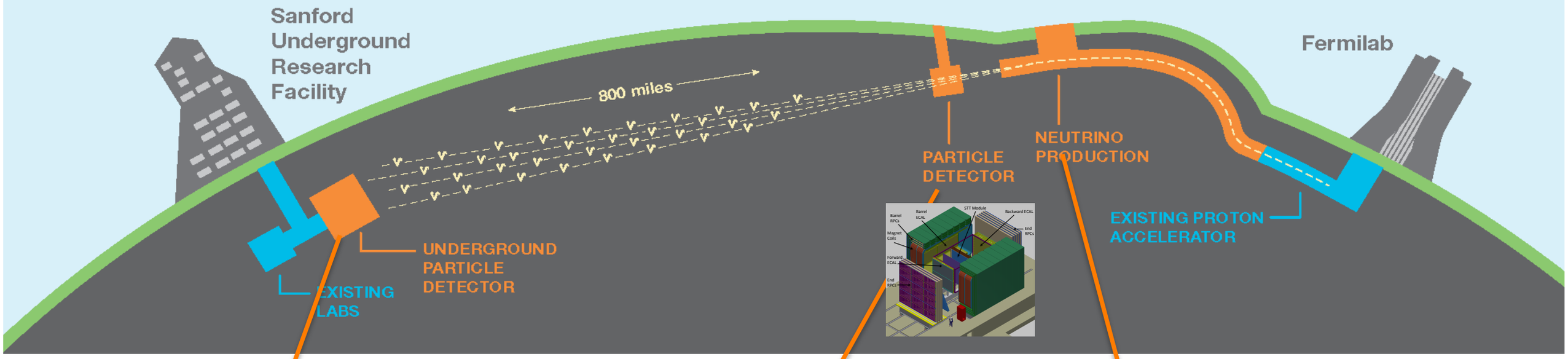
DEEP UNDERGROUND NEUTRINO EXPERIMENT

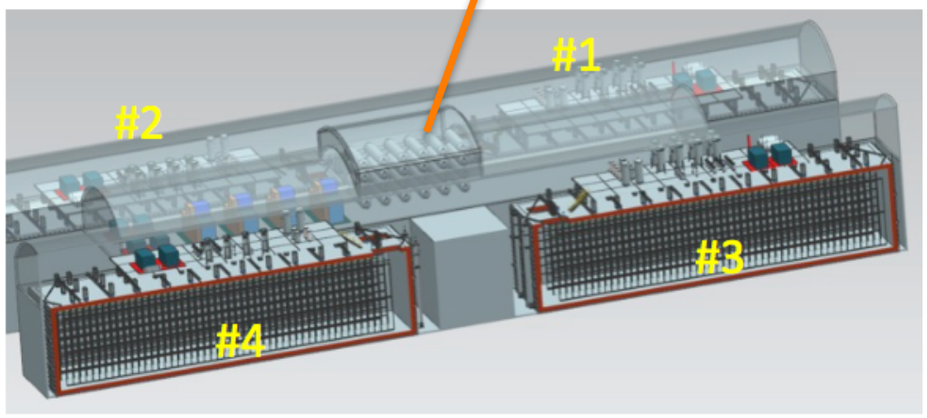
- The **DUNE international Collaboration** has been formed **merging strengths and expertise from all previous efforts** (LBNE, LBNO, others) to carry out a next-generation long-baseline neutrino experiment hosted at Fermilab.
- The Collaboration has adopted and integrated several design options.

| | LBNE (FNAL) | LBNO (CERN) | LBNF/DUNE |
|---|---|---|---|
| **Baseline** | 1300 km | 2300 km | **1300 km** |
| **Protons power** | 1.2 MW | 0.75 & 2 MW | **1.2 MW then upgrade to 2.4 MW** |
| **Beam focusing** | NUMI-style | CP-optimised | **NUMI-style or CP-optimised** |
| **Far detector** | 10+30 kton | 20+50 kton | **4x10 kton** |
| **Far detector technologies** | single phase LAr TPC | dual phase LAr TPC | **single and/or dual phase LAr TPC** |
| **Near detector design** | Magnetised fine grained tracker (FGT) | HP GAr TPC | **Magnetised FGT and/or LAr TPC and/or HP GAr TPC** |

# DUNE Experimental Strategy

***"Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE) Conceptual Design Report Volume 2: The Physics Program for DUNE at LBNF" (arXiv:1512.06148)***




high precision
near detector complex

Wide band, high purity $\nu_\mu$ beam with peak flux
at 2.5 GeV operating at ~1.2 MW and upgradeable

- four identical cryostats deep underground
- staged approach to four independent 10 kt LAr detector modules
- Single-phase and double-phase readout under consideration

***"Conceptual Design Report Volume 4: The DUNE Detectors at LBNF" (arXiv:1601.02984)***

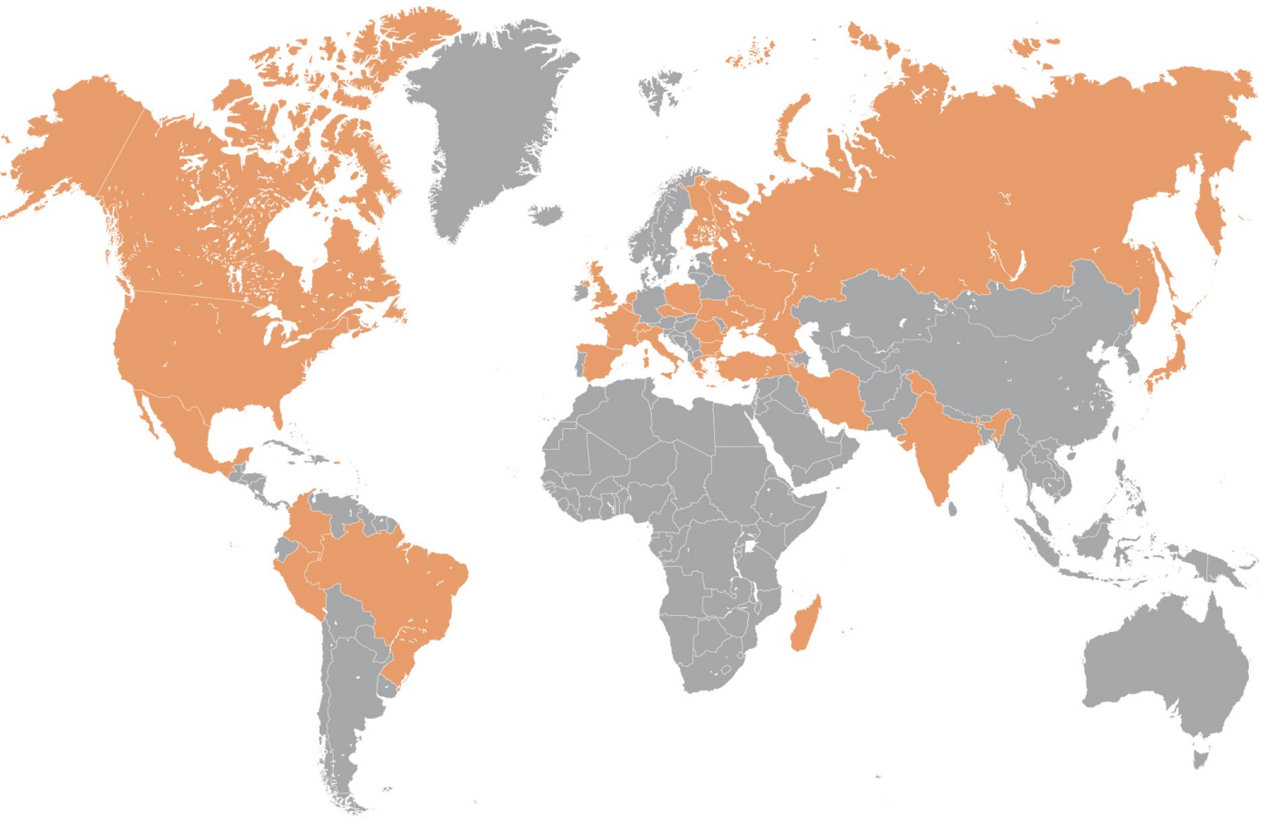
# DUNE: An International Collaboration

**A rapidly evolving international scientific collaboration built around the organisation model successfully implemented at the LHC**

- **First formal collaboration meeting April 16th - 18th 2015**
- **Conceptual Design Report (4 volumes) June 2015**
- **Passed DOE CD-1 Review July 2015**
- **Second collaboration meeting September 2nd - 5th 2015**
- **DOE CD-3a Review December 2015**
- **Third collaboration meeting UTA, Texas January 12th - 15th 2016**
  - Over 150 people attending in person
- **Fourth collaboration meeting SDSMT, South Dakota May 2016**
- **Collaboration meetings at FNAL (Sep 16) & CERN (Jan 2017)**


*Photo taken during 2nd Collaboration meeting*

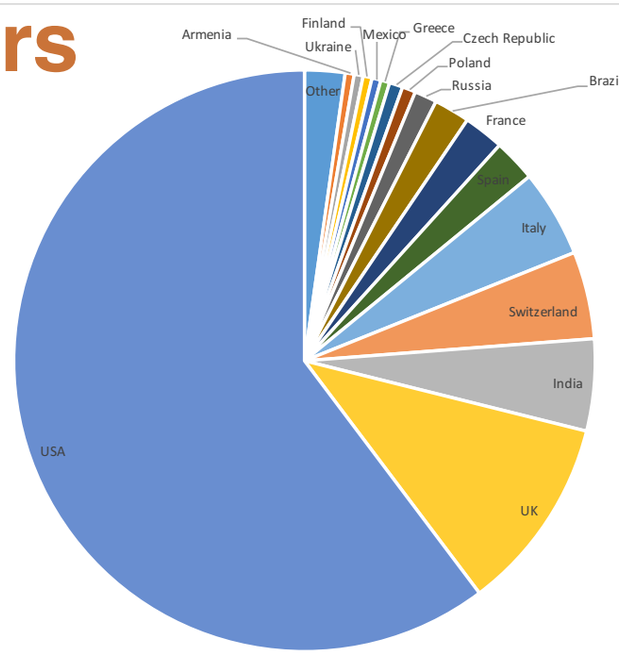
# The DUNE Collaboration



## Keeps growing:

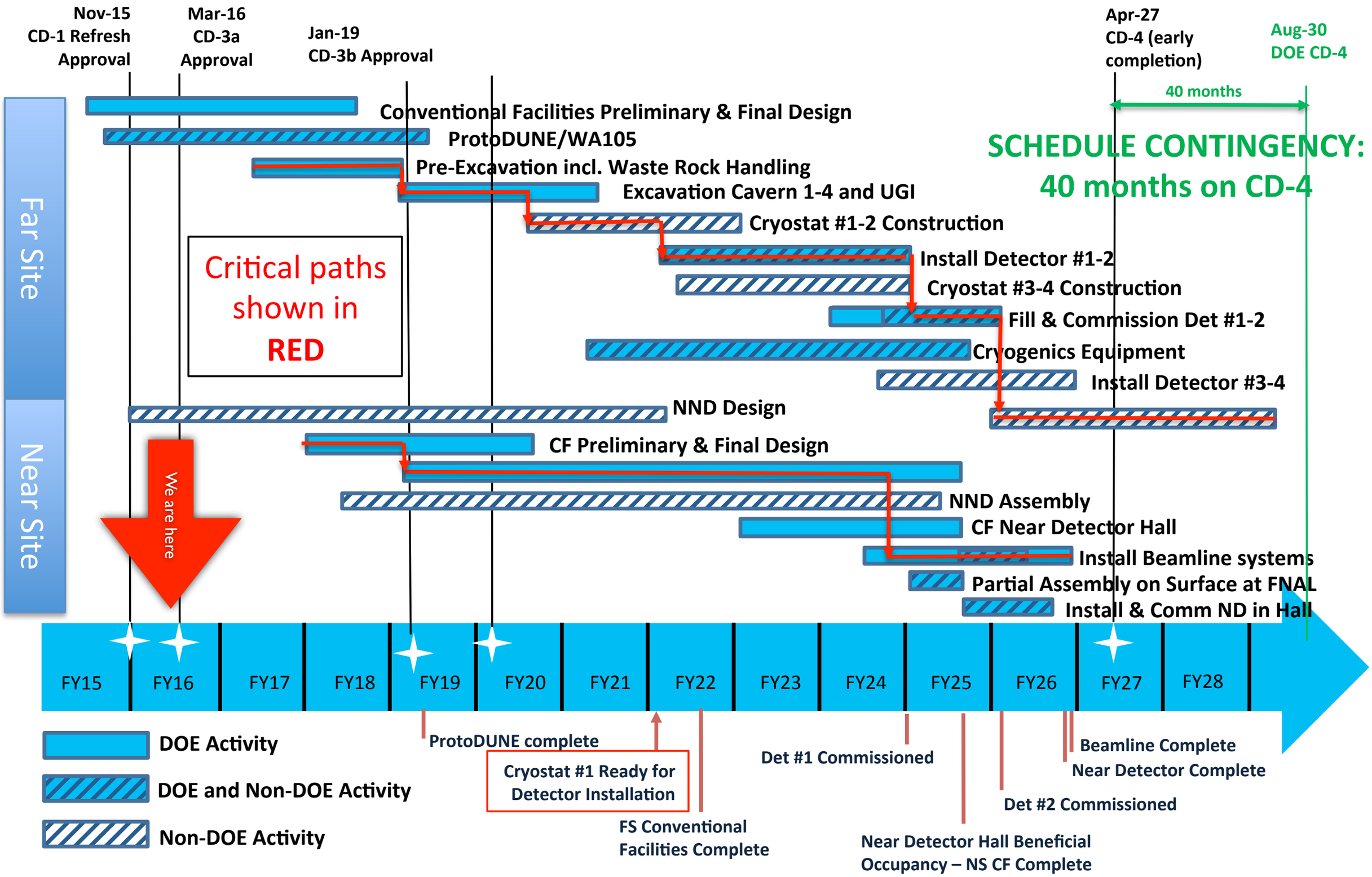
**805 Collaborators**
**27 Nations**
**146 institutions**

Greece and
Finland
recently joined

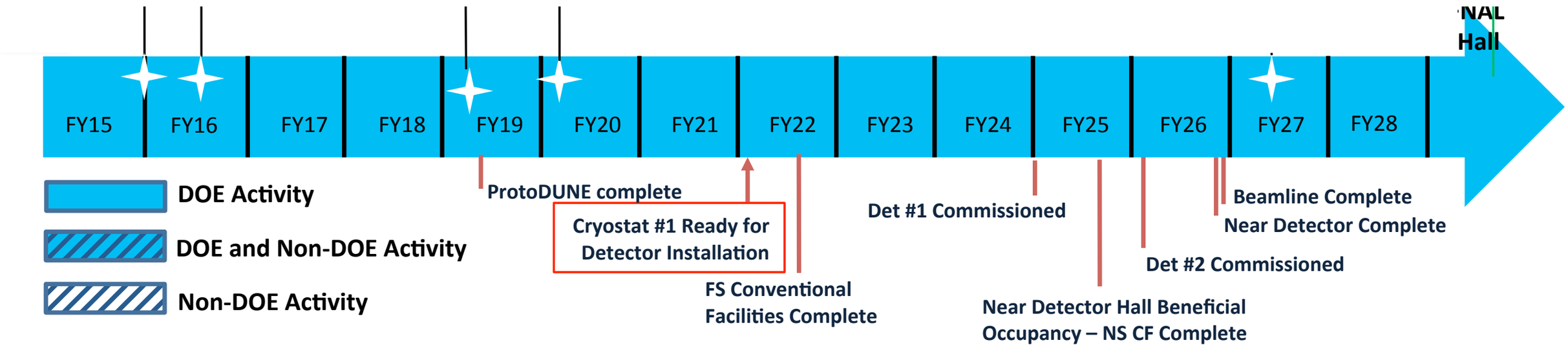



**Armenia** Yerevan Inst. for Theoretical Physics and Modeling
**Belgium** Univ. de Liege
**Brazil** Univ. Federal do ABC; Univ. Federal de Alfenas em Poços de Caldas; Univ. de Campinas; Univ. Estadual de Feira de Santana; Univ. Federal de Goias; Observatorio Nacional
**Bulgaria** Univ. of Sofia
**Canada** York University
**Colombia** Univ. del Atlantico
**Czech Republic** Charles University, Prague; Czech Technical University, Prague; Institute of Physics ASCR, Prague
**France** Lab. d'Annecy-le-Vieux de Phys. des Particules; Inst. de Physique Nucleaire de Lyon; APC-Paris; CEA/Sacla
**Finland** Jyväskylä
**Greece** Athens
**India** Aligarh Muslim University; Banaras Hindu University; Bhabha Atomic Research Center; Univ. of Delhi; Indian Inst. of Technology, Guwahati; Harish-Chandra Research Institute; Indian Inst. of Technology, Hyderabad; Univ. of Hyderabad; Univ. of Jammu; Jawaharlal Nehru University; Koneru Lakshmaiah; Univ. of Lucknow; Panjab University; Punjab Agri. University; Variable Energy Cyclotron Centre
**Iran** Inst. for Research in Fundamental Sciences
**Italy** Lab. Nazionali del Gran Sasso, Assergi; Univ. di Catania; Gran Sasso Science Institute; Univ. di Milano; INFN Sezione di Milano Bicocca; INFN Sezione di Napoli; Univ. of Padova; Univ. of Pavia, INFN Sezione di Pavia; CNI Pisa; Univ. di Pisa
**Japan** KEK; Kavli IPMU, Univ. of Tokyo
**Madagascar** Univ. of Antananarivo
**Mexico** Univ. de Colima; CINVESTAV
**Netherlands** NIKHEF
**Peru** PUCP
**Poland** Inst. of Nuclear Physics, Krakow; National Centre for Nuclear Research, Warsaw; Univ. of Warsaw; Wroclaw University
**Romania** Horia Hulubei National Institute
**Russia** Inst. for Nuclear Research, Moscow
**Spain** Inst. de Fisica d'Altas Energias, Barcelona; CIEMAT; Inst. de Fisica Corpuscular, Madrid
**Switzerland** Univ. of Bern; CERN; ETH Zurich
**Turkey** TUBITAK Space Technologies Research Institute
**Ukraine** Kyiv National University
**United Kingdom** Univ. of Cambridge; Univ. of Durham; Univ. of Huddersfield; Imperial College of Science, Tech. & Medicine; Lancaster University; Univ. of Liverpool; University College London; Univ. of Manchester; Univ. of Oxford; STFC Rutherford Appleton Laboratory; Univ. of Sheffield; Univ. of Sussex; Univ. of Warwick
**USA** Univ. of Alabama; Argonne National Lab; Boston University; Brookhaven National Lab; Univ. of California, Berkeley; Univ. of California, Davis; Univ. of California, Irvine; Univ. of California, Los Angeles; California Inst. of Technology; Univ. of Chicago; Univ. of Cincinnati; Univ. of Colorado; Colorado State University; Columbia University; Cornell University; Dakota State University; Drexel University; Duke University; Fermi National Accelerator Lab; Univ. of Hawaii; Univ. of Houston; Idaho State University; Illinois Institute of Technology; Indiana University; Iowa State University; Kansas State University; Lawrence Berkeley National Lab; Los Alamos National Lab; Louisiana State University; Univ. of Maryland; Massachusetts Institute of Technology; Michigan State University; Univ. of Minnesota; Univ. of Minnesota (Duluth); Univ. of New Mexico; Northwestern University; Univ. of Notre Dame; Ohio State University; Oregon State University; Pacific Northwest National Lab; Univ. of Pennsylvania; Pennsylvania State University; Univ. of Pittsburgh; Princeton University; Univ. of Puerto Rico; Univ. of Rochester; SLAC National Accelerator Lab; Univ. of South Carolina; Univ. of South Dakota; South Dakota School of Mines and Technology; South Dakota Science And Technology Authority; South Dakota State University; Southern Methodist University; Stanford University; Stony Brook University; Syracuse University; Univ. of Tennessee; Univ. of Texas at Arlington; Univ. of Texas at Austin; Tufts University; Virginia Tech; Wichita State University; College of William and Mary; Univ. of Wisconsin; Yale University

# DUNE/LBNF schedule overview



# DUNE/LBNF milestones




- Nov-15: CD-1R approval ✔
- Dec-15: CD-3a Review ✔
- May-16?: CD-3a Approval – triggers far site construction
- FY16-FY19: ProtoDUNE SP & DP prototyping @ CERN
- FY20: CD-2
- FY22: Start FD installation
- FY26: 20 kton (=10+10) FD commissioning
- FY26(27?): Beamline + ND commissioning + Completion FD

DUNE CDR

Conceptual Design Report, Volumes 1-4

DUNE TDRs

Technical Design Report, Volumes …

- DUNE FD SP
- DUNE FD DP ?
- DUNE ND

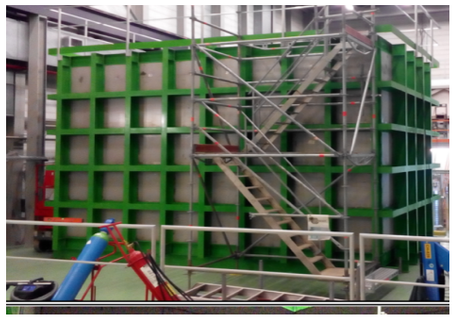
(*) preparation of TDRs and ProtoDUNE prototyping occur in parallel

# Far Detector Prototyping Program

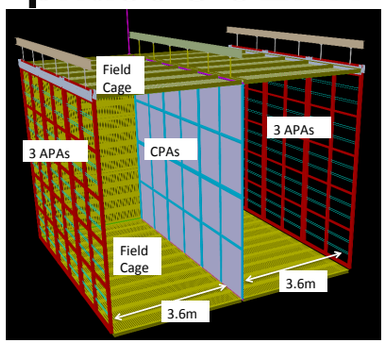
- Basic technologies demonstrated by ICARUS, ArgoNEUT/LArIAT, MicroBooNE, WA105 but **DUNE scale is very different** (each module is 40x ICARUS) and different in many details → **need strong prototyping**
- DUNE has well-developed plans for a series of detector prototypes that will provide input to the process leading to the final design(s) for the DUNE far detector modules.
- **ProtoDUNE single- and dual-phase 300 tons prototypes to operate in 2018.**

**35T @ FNAL**

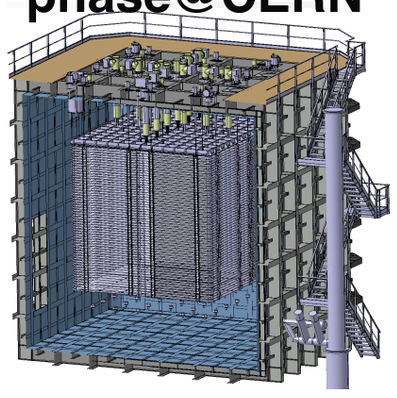
**WA105 3x1x1@CERN**



**protoDUNE single phase@CERN**




**protoDUNE dual phase@CERN**



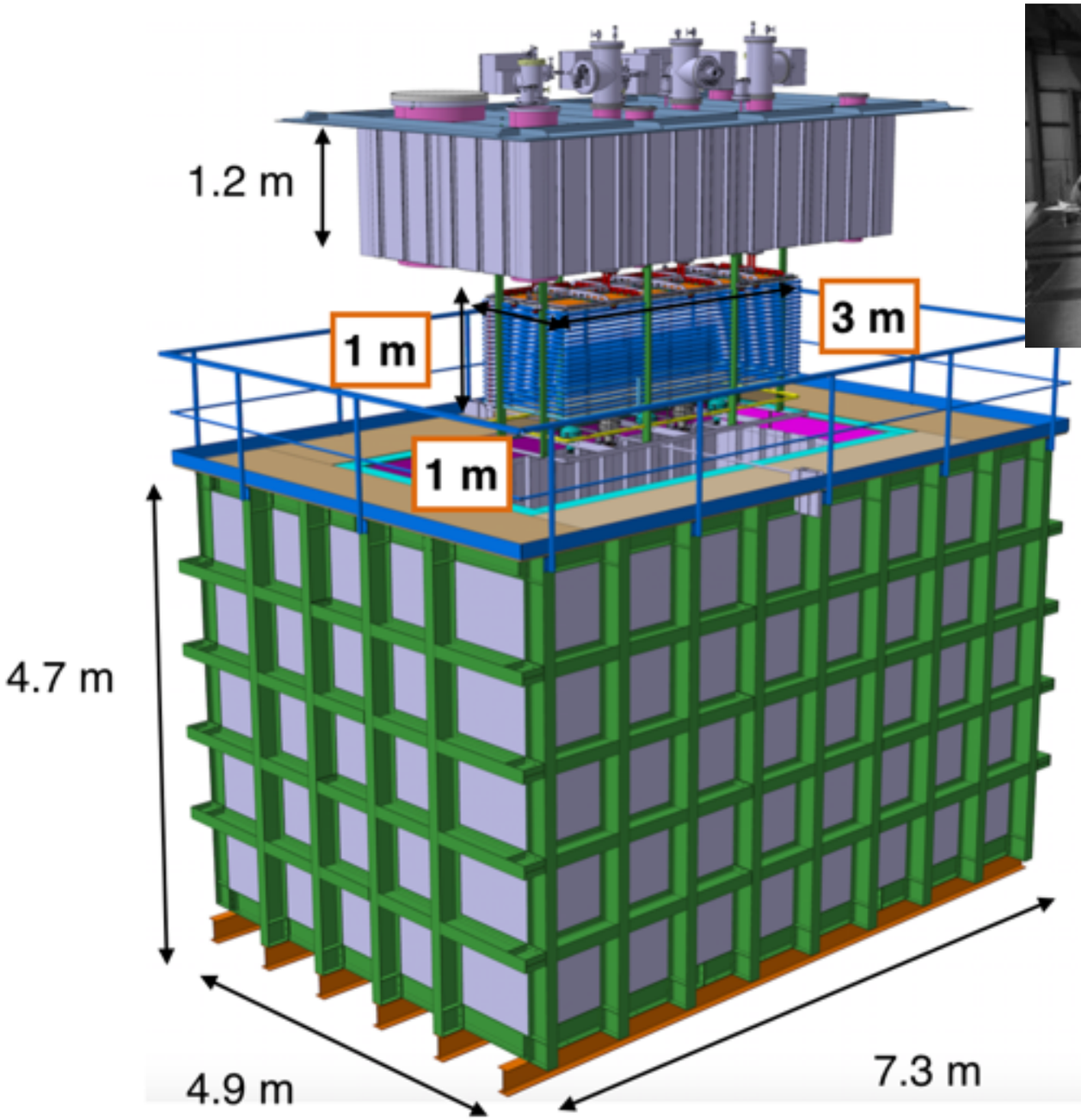
- *Mitigation of risks associated with current detector designs*
- *Establishment of construction facilities required for full-scale production of detector components*
- *Early detection of potential issues with construction methods and detector performance*
- *Provide required calibration of detector response to particle interactions in charged particle test beams*

# Currently @ CERN

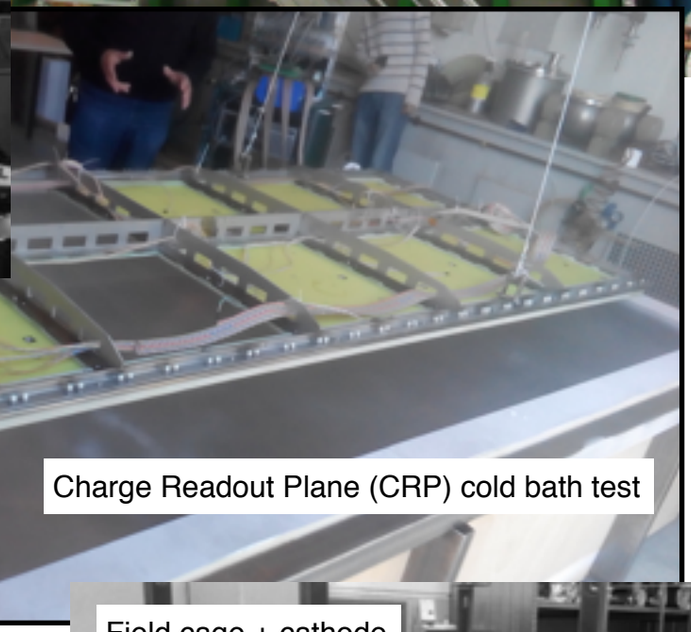
**10-ton scale Dual Phase LAr TPC**

(3x1x1 $m^3$ active 24 ton LAr total)

**Detector integration in progress**
**Cryogenic Operation: September 2016**









chimneys

light readout

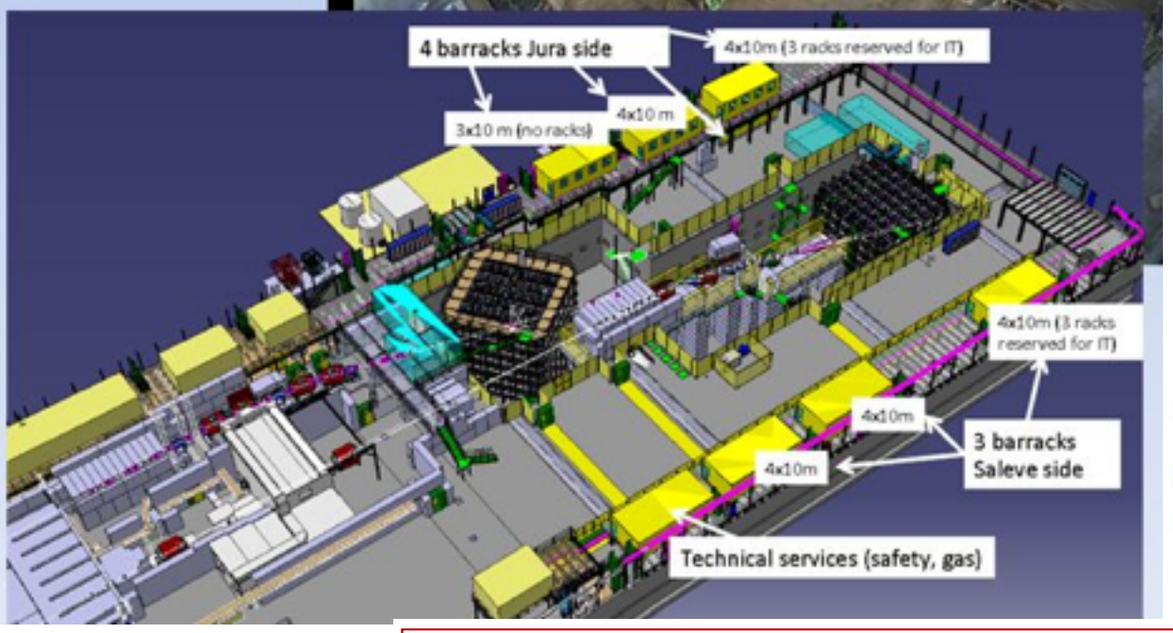
# CERN EHN1 test beam extension

EHN1:

**WA105**
6x6x6 will be here


**NP04**

**Ready for Data taking in spring 2018**



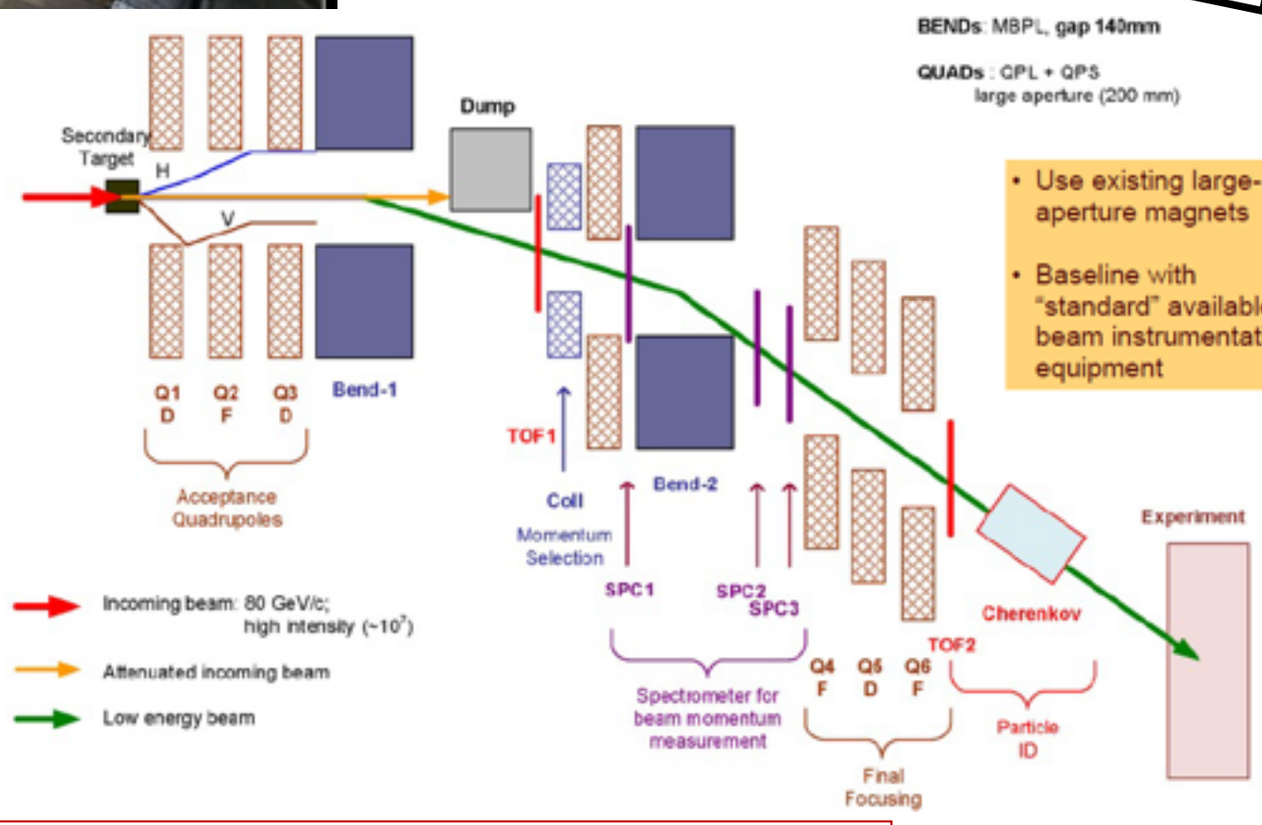




TABLE XIX: *Requirements for particles and their momenta. The particle rate here is the rate within a spill, regardless of the spill length, slow extraction is assumed.*

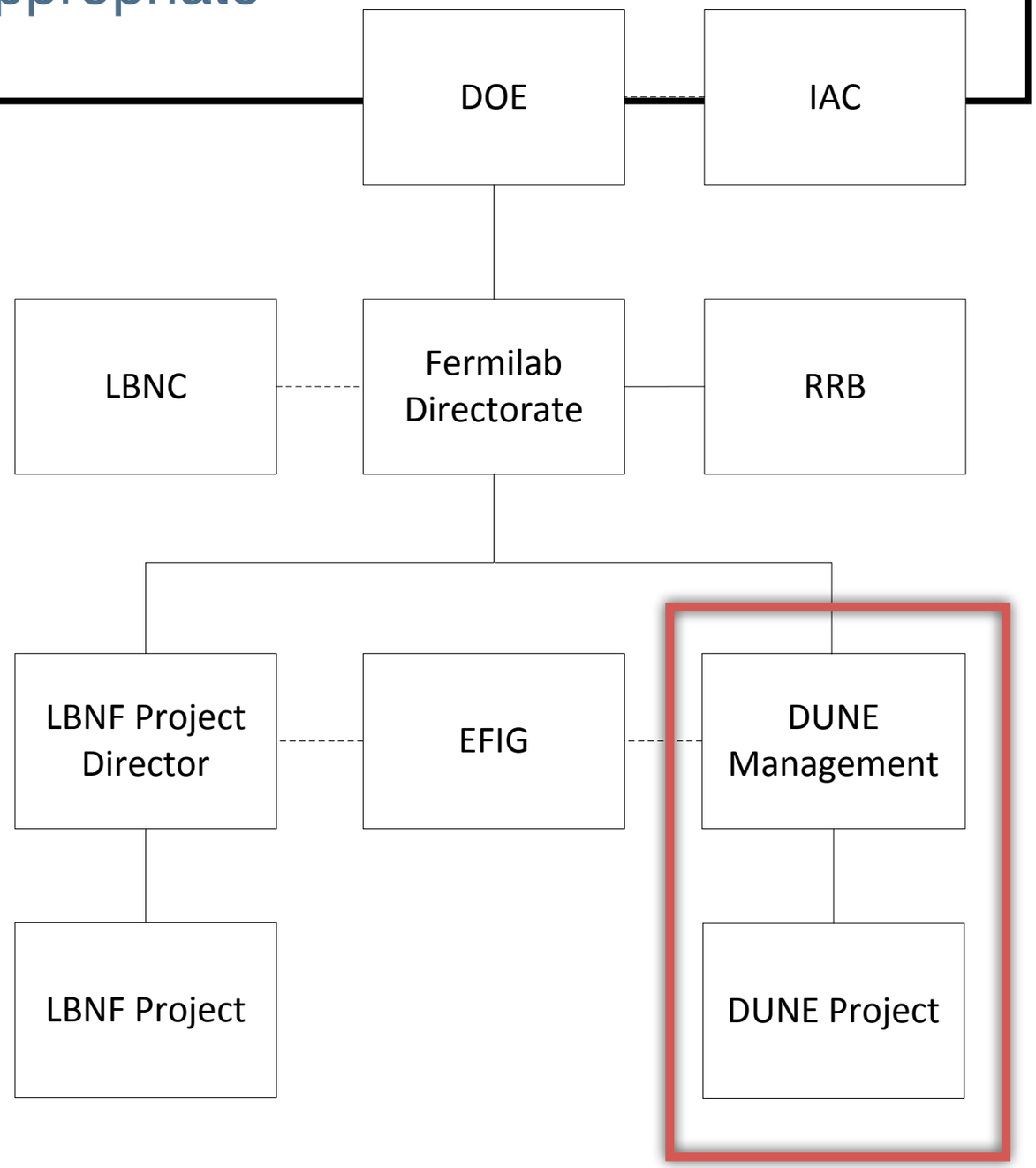
| Type | Momentum [GeV/c] | Rate [kHz] | Total | Time est. [hrs] |
|---|---|---|---|---|
| Muon tracks | | | | |
| $\mu^{+/-}$ | 0.8, 1.0, 1.5, 2.0, 5.0, 10.0, 20.0 | 0.1 | $5 \times 10^6 \times 14$ | 200 |
| Shower reconstruction | | | | |
| $\pi^{+/-}$ | 0.5, 0.7, 1.0, 2.0, 5.0, 10.0, 20.0 | 0.1 | $5 \times 10^6 \times 14$ | 200 |
| $e$ | 0.5, 0.7, 1.0, 2.0, 5.0, 10., 20.0 | 0.1 | $5 \times 10^6 \times 7$ | 100 |

# LBNF/DUNE top-level governance structure

**Separation of responsibilities for "Facilities" and "Detectors"**

- **LBNF** : A DOE/Fermilab project with contributions from international partners
- **DUNE** : An international project, with appropriate oversight by stakeholders

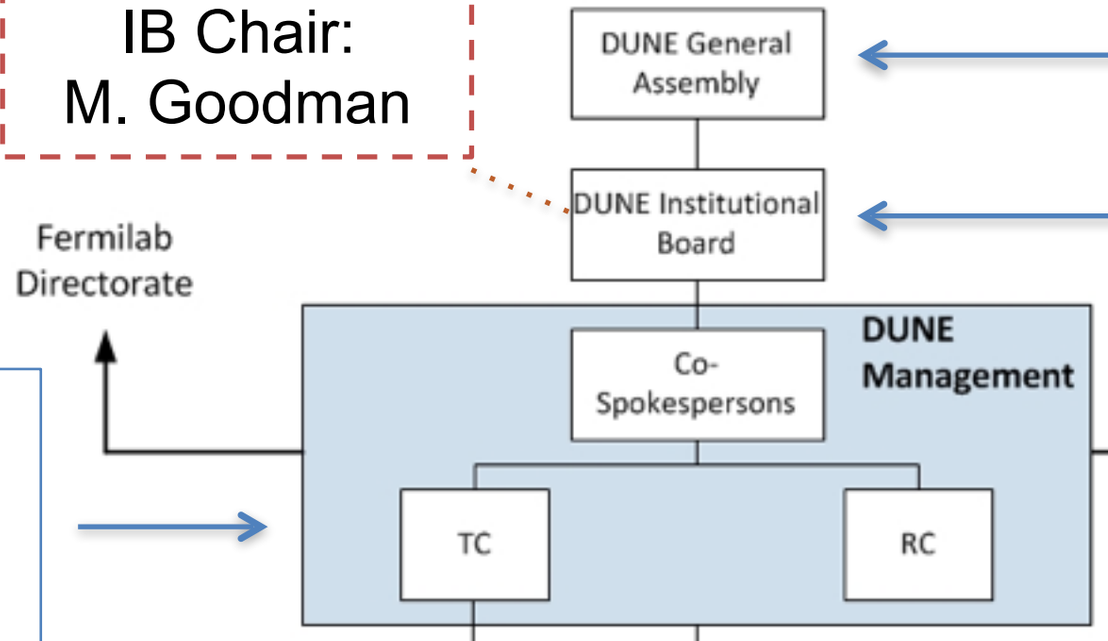
- INC: International Neutrino Council
- RRB: Resources Review Boards
- LBNC: Long-Baseline Neutrino Review Committee
- EFIG: Experiment-Facility Interface Group
- Fermilab Directorate: The Fermilab Director and the two Deputy Directors
- LBNF Project Director/Project
- DUNE Management/Project
- All councils, boards, and committees are in place and fully functioning



# The DUNE Management : Overview

Top-level management structure defined in Collab. Governance document – approved by DUNE institute board in April 2015

IB Chair:
M. Goodman




All collaboration members discussion forum

Representatives from each institute: defines collab. rules

**DUNE management:**
Co-spokespersons
Technical Coord.
Resource Coord.

EFIG: formal interface between DUNE & LBNF

Executive Committee: Decision making

DUNE project management

Technical & Resource Management

# The Collaboration Resource Board

- Chaired by the **DUNE Resource Coordinator (RC)**
- Deals with all matters related to collaboration resources (financial, personnel, etc.) such as contributions to project common funds and division of project responsibilities among the collaborating institutions.
- **Meetings held in 11/2015, 02/2016 - next on April 13th 2016.**
- **Presently focusing on updating DUNE Matrix and preparing a DUNE Human Resource Survey at the institutional level.**
- [Next RRB meeting tentatively scheduled for May 2016.]

| Country/FA | CRB Member |
|---|---|
| Armenia | N/A |
| Belgium | Diego Aristizabal |
| Brazil-FAPESP | Ernesto Kemp |
| Brazil-MCTI/RENAFAE | Ricardo Avelino Gomes |
| Bulgaria | N/A |
| Canada | Scott Menary |
| CERN | Marzio Nessi |
| Colombia | Mario Andres Acero Ortega |
| Czech Republic | Filip Jediny |
| France-CEA | Marco Zito |
| France-IN2P3 | Dario Autiero |
| Germany | N/A |
| India | empty |
| Iran | N/A |
| Italy | Sergio Bertolucci (TBC) |

| Country/FA | CRB Member |
|---|---|
| Japan | Takuya Hasegawa |
| Madagascar | Laza Rakotondravohitra |
| Mexico | Alfredo Aranda |
| Netherlands | Patrick Decowski |
| Peru | Alberto Gago Medina |
| Poland | Robert Sulej |
| Romania | Bogdan Mitrica |
| Russia | N/A |
| Spain | Ines Gil Botella |
| Switzerland | Antonio Ereditato |
| Turkey | Fatih Bay |
| UK | Alfons Weber |
| Ukraine | Vladimir Aushev |
| USA-NSF | Edward Blucher |
| USA-DOE-U | Marvin Marshak |
| USA-DOE-NL | Bonnie Fleming |

**Majority of CRB members now in place**

*[Greece, Finland very recently joined and still need to be included]*

} 3 US CRB members

# The DUNE Management : Details

IB Chair:
M. Goodman

DUNE General Assembly

DUNE Institutional Board

Fermilab Directorate

Co-spokespersons:
A. Rubbia
M. Thomson

**DUNE Management**

Co-Spokespersons

TC

RC

EFIG

EFIG: formal interface between DUNE & LBNF

Technical coordinator:
E. James

Resource coordinator:
CK Jung

Executive Committee (Co-Spokesperson)

Executive Committee: Decision making

**EC Minutes available here**

International project manager:
S. Kettell

Project Office (PM)

Technical Board (TC)

Collaboration Resource Board (RC)

Far Detector (Coordinator & Manager)

Near Detector (Coordinator & Manager)

ProtoDUNE Single-Phase (Coordinator & Manager)

ProtoDUNE Dual-Phase (Coordinator & Manager)

Computing & Software (Coordinator)

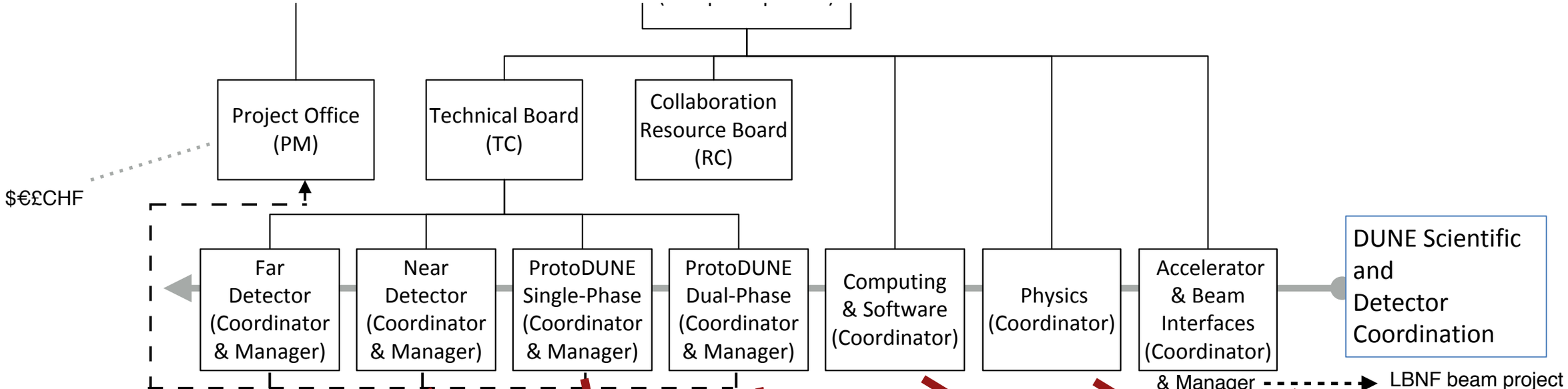
Physics (Coordinator)

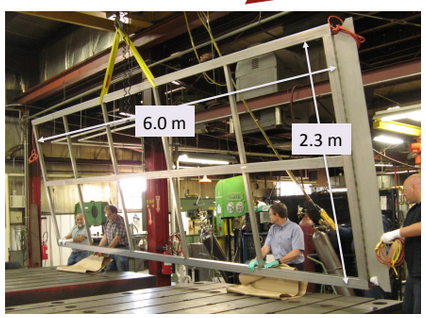
Accelerator & Beam Interfaces (Coordinator) & Manager

DUNE Scientific and Detector Coordination

LBNF beam project

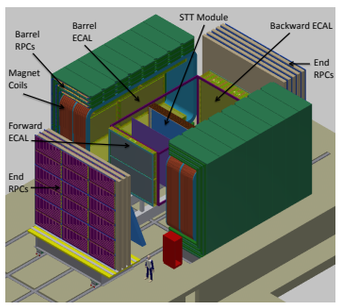
# The DUNE organisations : overview



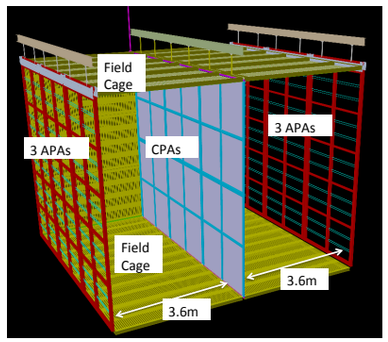

FD SP/DP

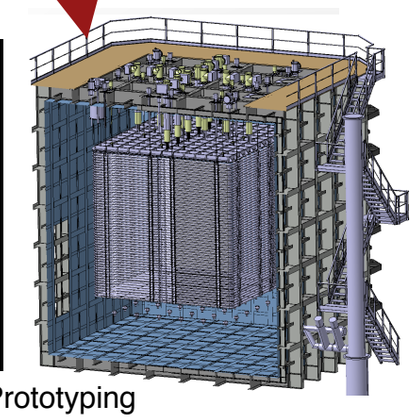
Research
Design
Engineering
Procurement




+LAr+HPTPC options

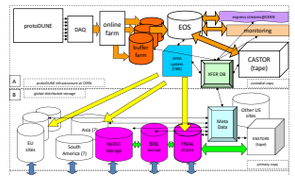
Research
Design
Engineering
Procurement



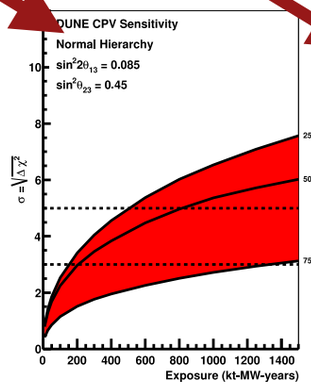
Large scale Prototyping

Integration
Commissioning
Operation
Interface to CERN infrastructure
Online Computing

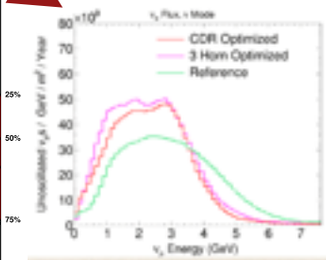


Computing

Offline computing
simulation SW
reconstruction SW
Computing model




Physics




Beam optimisation
Beam instrumentation
Beam systematics

# DUNE Coordination Team

**Since September 2015 all coordinators are in place**

**Role: responsible for coordination of DUNE working groups**

| Far Detector WG | Near Detector WG | CERN prototyping WG (till December 2015*) | Accelerator & Beam interface WG | Computing&Software WG | Physics WG |
|---|---|---|---|---|---|

COORDINATORS






| T. Bolton | S. Mishra | T. Kutter (interim until 12/15) | A. Marchionni Dep: Mary Bishai | T. Junk Dep: A. Farbin | J. Urheim Dep: R. Patterson |
|---|---|---|---|---|---|

- **In December 2015 following approval of the single phase protoDUNE by CERN, the DUNE prototyping working group managed interim has been expanded (see later).**

# ProtoDUNEs management

The **DUNE prototypes form an integral part of the DUNE collaboration** and consequently their Management is embedded in the DUNE Management and organization, with a local coordination for each of the single & dual phase prototype. Although separate CERN projects, they are managed within a tightly coordinated structure of DUNE under the Technical Board.

F.Cavanna/ FNAL

C.Touramanis /Liverpool

T.Kutter/ LSU

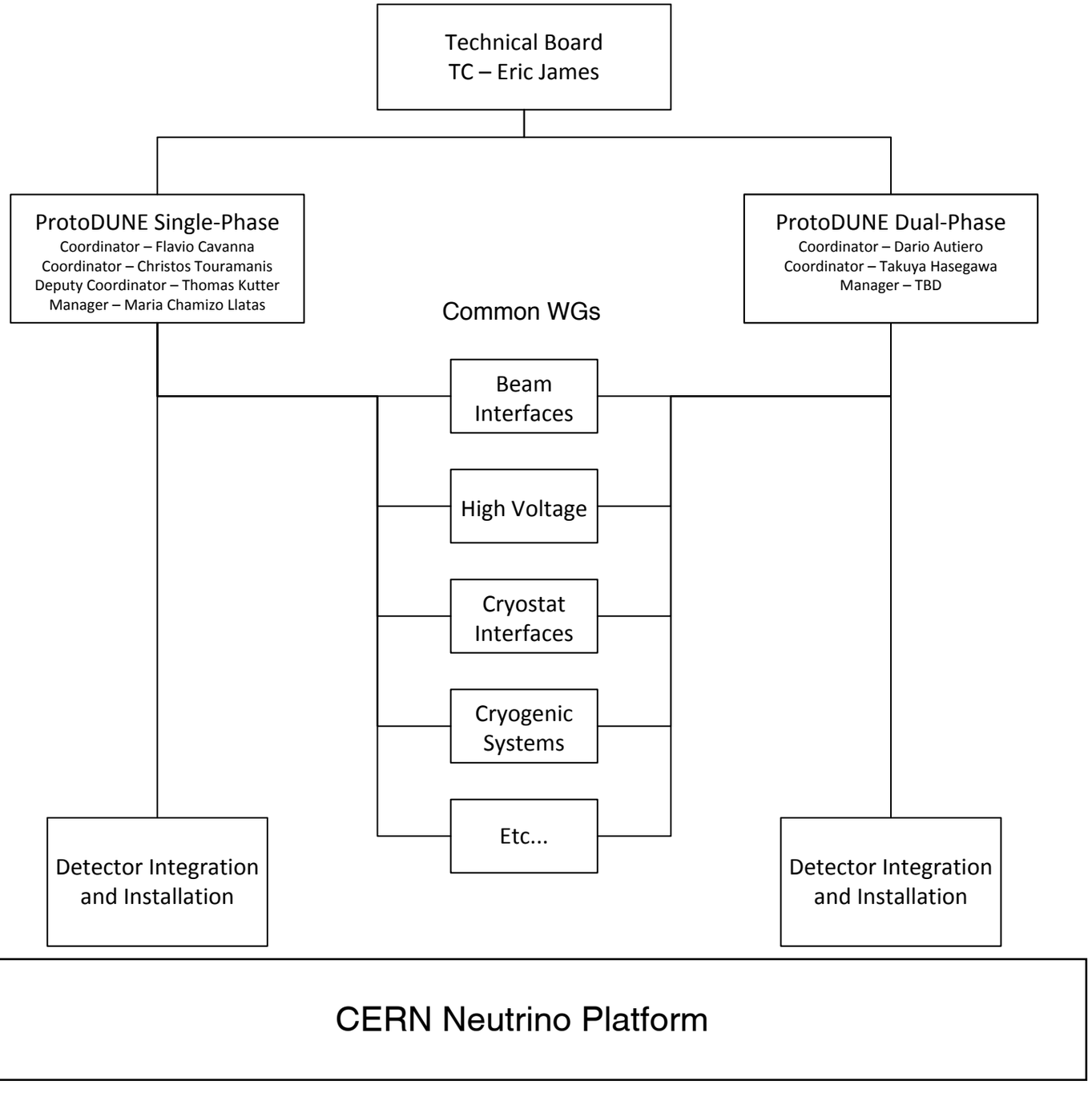
M.Chamizo/ Stony Brook (from 1.1.16)

M.Nessi/ CERN

D.Autiero/ IPNL

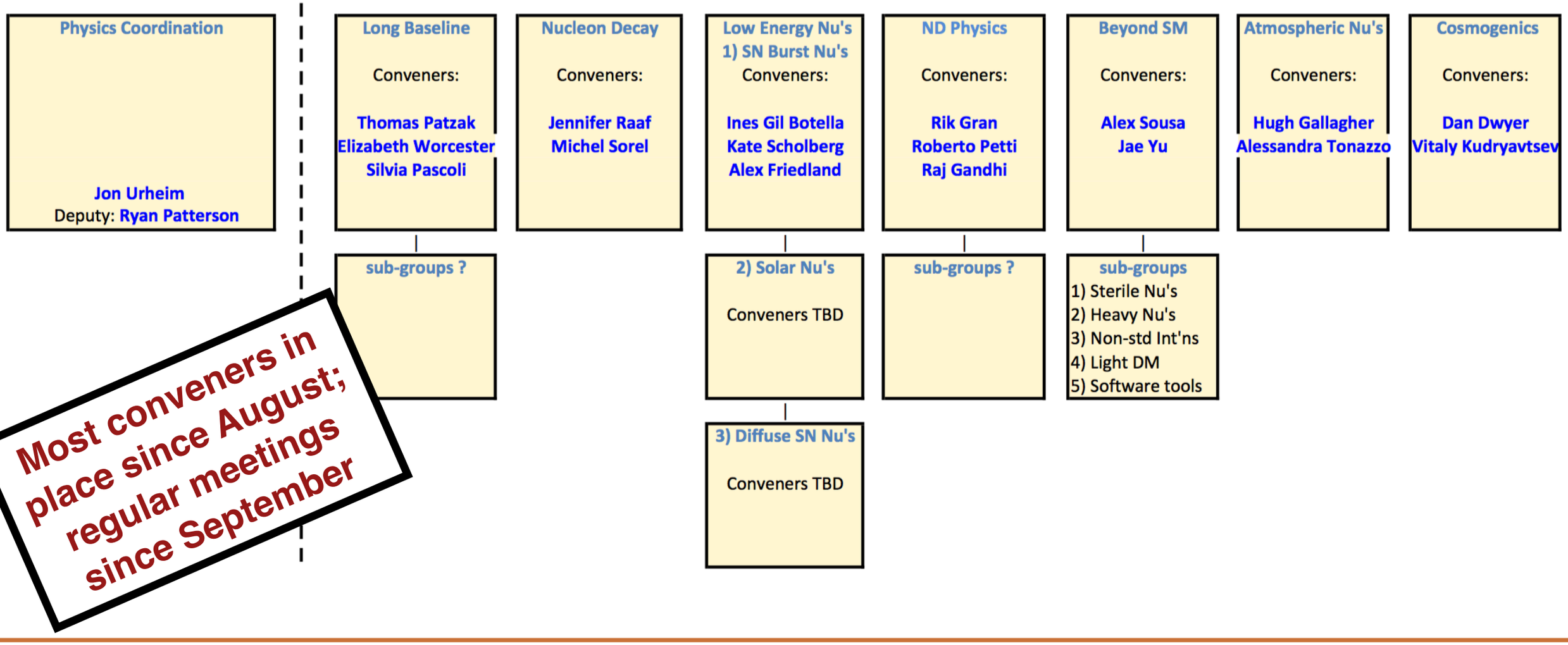
T.Hasegawa/ KEK

tbd



# DUNE Physics WG organisation

- **Seven sub-WGs focused on primary but also secondary physics program**
  - LBL, NDK, SNB/lowE, ND physics, BSM, ATM, Cosmogenics
- Also engage **the theory/phenomenology community** (conveners, dedicated workshops, …)
  - e.g. 11/2015 Supernova Neutrino workshop at SLAC
  - planning an atmospheric neutrino workshop



# DUNE Task Forces

- **In addition to WGs, we have set up three "Task Forces" to address strategically important issues:**
  - Task force leadership reports the DUNE executive committee
  - Focus on collaboration goals/open questions for CD-2
  - Activities cross boundaries of various working groups
    - For example physics, reconstruction software and far detector WGs
  - **Limited duration: deliver report in 18 months → ≈Summer 2017**

| TF 1: Near Detector Optimiz. | TF 2: Far Detector Optimiz. | TF 3: Beam Optimiz. |
|---|---|---|
| **Steve Brice** | **Lisa Whitehead** | **Alfons Weber** |
| Deputy: **Dan Cherdak** | Deputy: **Andy Blake** | Deputy: **Laura Fields** |
| Deputy: **Kendall Mahn** | Deputy: **Slavic Galymov** | |

**Very critical efforts**

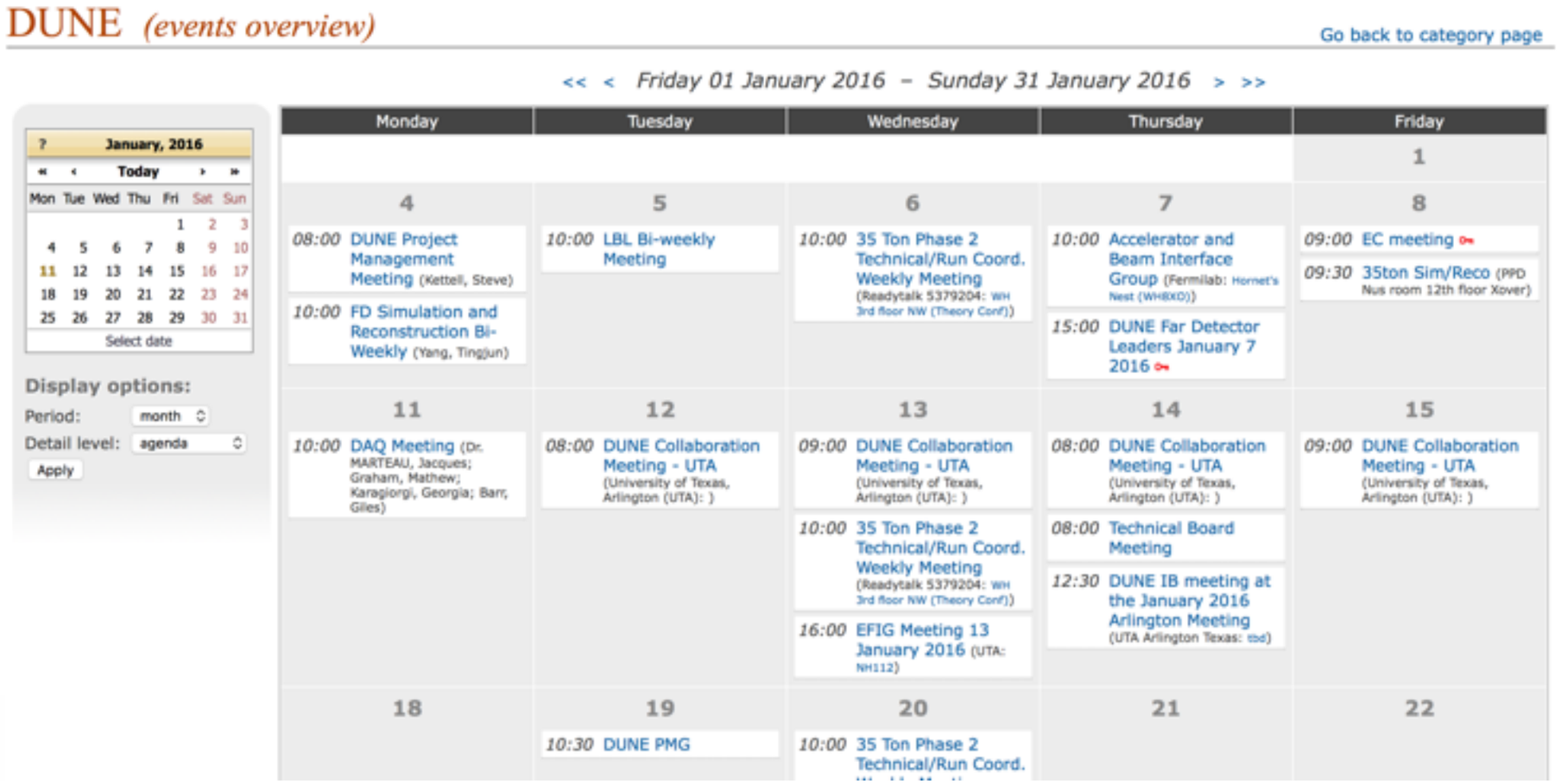
- ★ End-to-end simulation of Near Detector design and analysis
- ★ Evaluate impact on far detector systematics
- ★ Evaluate benefits of alternative designs

- ★ End-to-end simulation and full reconstruction of far detector
- ★ Validation (optimization) of design parameters (e.g. wire spacing)
- ★ Update physics sensitivities with full simulation for CD-2

- ★ Further develop physics-driven optimization of the beam line
- ★ Identify options for improvements and present a first-order cost-benefit analysis

# DUNE regular meetings

- **Weekly, Bi-weekly and or Monthly high-level meetings fully in place and working well, alternating between “detector weeks” & “physics weeks”**
- Effort to select time-slots that are practical for members located in different timezones around the world. Predefined favoured fixed slots (e.g. 10am-12pm CT) leaving time outside them.
- Fully integrated “indico” system with automatic calendar generation, easily accessible from the “DUNE @ Work” web page (DUNE @ work link)



# Summary

- DUNE/LBNF is moving quickly based on years of previous work at LBNE, LBNO, SURF and elsewhere to address the challenges of the next generation long-baseline experiments. The DUNE CDR (Vols 1-4) has been submitted and approved by DOE (CD1-R).
- DUNE has rapidly emerged as a highly motivated, experienced and well-organised large international Collaboration, eager to start physics within an incremental staging of FD mass and capable ND coupled to a powerful neutrino beam.
- We are thrilled by the prospects of getting DOE CD-3a approval in 2016 - this will trigger start of excavation at SURF.
- The DUNE Working Groups and Task Forces organisations are making significant and steady progress. Manpower is being identified and is getting engaged. This working structure enables new group to join in and to effectively contribute to DUNE.

# Summary (II):

- The CERN Neutrino Platform offers a unique infrastructure for construction and test of large-scale LAr prototypes of the DUNE FDs. We want to take full profit of the large CERN investment. We have established clear FD prototyping efforts based on SP&DP technologies and new groups are welcome and needed to contribute.
- A strategy towards CD-2 is being discussed within the Collaboration that defines milestones and the path to develop the consortia that will produce the TDRs by 2019.
- A Collaboration Resource Board is in place with national contacts and is ready to help bottom-up discussions with funding agencies.

**The Collaboration is functioning effectively well at all levels ! Several opportunities for new groups to join and contribute visibly from day 1.**

# Thank you for your attention

# Backup