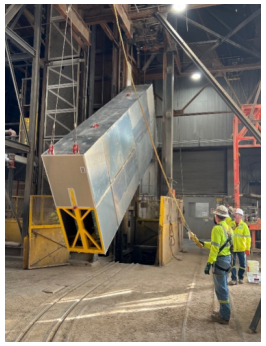
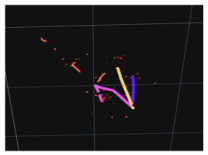
LBNC Report : Fermilab Physics Advisory Committee

Summary from the LBNC Meeting March 24-25, 2023





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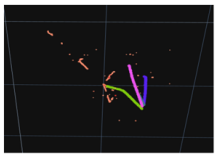

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Niki Saoulidou, for the LBNC

June 5th , 2023

Fermilab CERN Sanford Underground Research Facility U.S. DEPARTMENT OF ENERGY Office of Science

Outline

- LBNC Charge and Membership
- LBNC mode of operation and actions
- DUNE Goals
- DUNE and LBNF/DUNE-US News
- DUNE Status and Progress from last LBNC (March 2023)
  - LBNC Executive Summary

LBNC Charge

- **The LBNC is charged by the Fermilab Director to provide external scientific peer review and to monitor the technical progress of the International DUNE collaboration, and those aspects of the facility construction that have direct impact on the DUNE experiment, by**:
  - **Evaluating** the **scope** of the **DUNE experiment** relating to **scientific objectives** and the **technical capabilities** including scientific computing to meet them. In particular, evaluating and providing assessments regarding the final technical configuration of the Near Detector, including its phased implementation and upgrade options.
  - **Evaluating** the **technical development** and **overall progress** of the entire **international DUNE endeavor** towards the technical design provided in the **approved Technical Design Reports**. Specifically, reviewing the execution and management of the construction plan, including scope, schedule, interfaces with LBNF, and key technical risks and effectiveness of plans to mitigate these risks.
  - **Providing review** and **recommendations** on **interface** and **performance issues** with **LBNF,** which could **impact DUNE**. The LBNC scope **does not include** review of **LBNF** or PIP-II beyond these relevant interfaces impacting DUNE, as these projects are reviewed through the U.S. project management process.

LBNC Charge cont'd

- **Assessing** the **validity** and **appropriateness** of the **proposed technical design** and **construction readiness** of the DUNE experiment, through review of the **remaining Technical Design Reports (TDRs).**

- **Coordinating with** and **receiving input from** the **Neutrino Scope Group (NSG)** to be aware of the **overall funding constraints.**

- **Evaluating scope** or other changes to DUNE (e.g. descoping decisions) and proposed solutions by the DUNE collaboration management, within the input and **budget constraints determined** by the **NSG,** and providing **recommendations** from **scientific** and **technical perspectives**, in order to reach an overall **optimal solution**. These recommendations **shall be presented** to the **RRB** for **discussion** and **approval** by the **funding agencies.**

- **Evaluating** possible **upgrades** to DUNE, their scientific motivation and merit and technical feasibility.

- In executing the above, **LBNC recognizes** and **acknowledges DOE's special role** with respect to DUNE, compared with the rest of the funding agencies, as **the sole funding agency** of **Fermilab**, the DUNE **host laboratory**. At the same time, **recognizing** and **acknowledging** the **essential contributions** from all **international partners** and keeping them **engaged** in all **major discussions** and **decisions made.**

Membership

- Chair, Niki Saoulidou (Univ. of Athens)
- Martin Aleksa (CERN)
- Austin Ball (CERN/UKRI)
- Daniela Bortoletto (Oxford)
- Simone Campana (CERN)
- Mark Champion (ORNL)
- Marco Delmastro, Annecy, IN2P3
- Francesco Forti (INFN Pisa)
- Andre de Gouvea, Northwestern
- Alexander Gottberg(U.Victoria/TRIUMF)
- Eric Kajfasz (CPPM)
- Joachim Kopp (CERN)
- Adam Para (FNAL)
- John Parsons (Columbia)
- Marco Rescigno (Roma)
- Paolo Rumerio (Alabama)
- Vadim Rusu (FNAL)
- Brigitte Vachon (McGill University)
- Rainer Wallny (ETH/Cornell)
- Darien Wood (Northeastern U.)
- Joseph Zennamo (FNAL, Sci Sec)

Sub-committees formed **focusing** on the **review** of the **different thematics :** *Far detector Vertical Drift, Far Detector Horizontal Drift, Near Detector Complex, Beam, Computing, Simulation and Reconstruction, Physics Reach*

Recent LBNC Meeting and Report

- The **full Meeting Report** from the recent, March 2023, LBNC Meeting is **complete.**
- The **executive summary** that follows is taken from the Closeout presentation given at the end of that meeting.
- **Information related** to the **LBNC activities** can be found at:

  https://lbnc.fnal.gov/

- **Next LBNC meeting September 6th**

An LBNC Meeting

- LBNC Chair, CRO, DUNE Spokespersons Discussion/Charge ~ 3-4 weeks prior to meeting
- Review of TDRs (i.e. Vertical Drift TDR & Horizontal Drift TDR) and provide feedback
- Hold special reviews (i.e. ND review) requested by the Fermilab Directorate
- **Day 1**
  - Executive Session
  - **Plenary Presentations:** Status of LBNF, DUNE, Far Detectors Near Detector, Computing, Reconstruction-simulation and updated of oscillation analyses
  - Executive Session
- **Day 2**
  - Executive Session
  - **Breakouts (2 hrs)**
    - ✓ Beamline Status and Progress
    - ✓ Vertical Drift Progress
    - ✓ Horizontal Drift Progress
    - ✓ Computing Progress
    - ✓ Near Detector Progress
  - **Meeting LBNC and Spokespersons only (no management)**
  - Executive Session
- **Day 3**
  - **Executive Session/Report Preparation/Discussion**
  - Dry Run of Closeout with Director
  - **Closeout with LBNF/DUNE, Management, DOE**

LBNC, RRB and NSG

- **LBNC Charge:**

  - ***Coordinating with*** *and* ***receiving input from*** *the* ***Neutrino Scope Group (NSG)*** *to be aware of the* ***overall funding constraints.***
  - ***Evaluating scope*** *or other changes to DUNE (e.g. descoping decisions) and proposed solutions by the DUNE collaboration management, within the input and* ***budget constraints determined*** *by the* ***NSG,*** *and providing* ***recommendations*** *from* ***scientific*** *and* ***technical perspectives****, in order to reach an overall* ***optimal solution****. These recommendations* ***shall be presented*** *to the* ***RRB*** *for* ***discussion*** *and* ***approval*** *by the* ***funding agencies.***

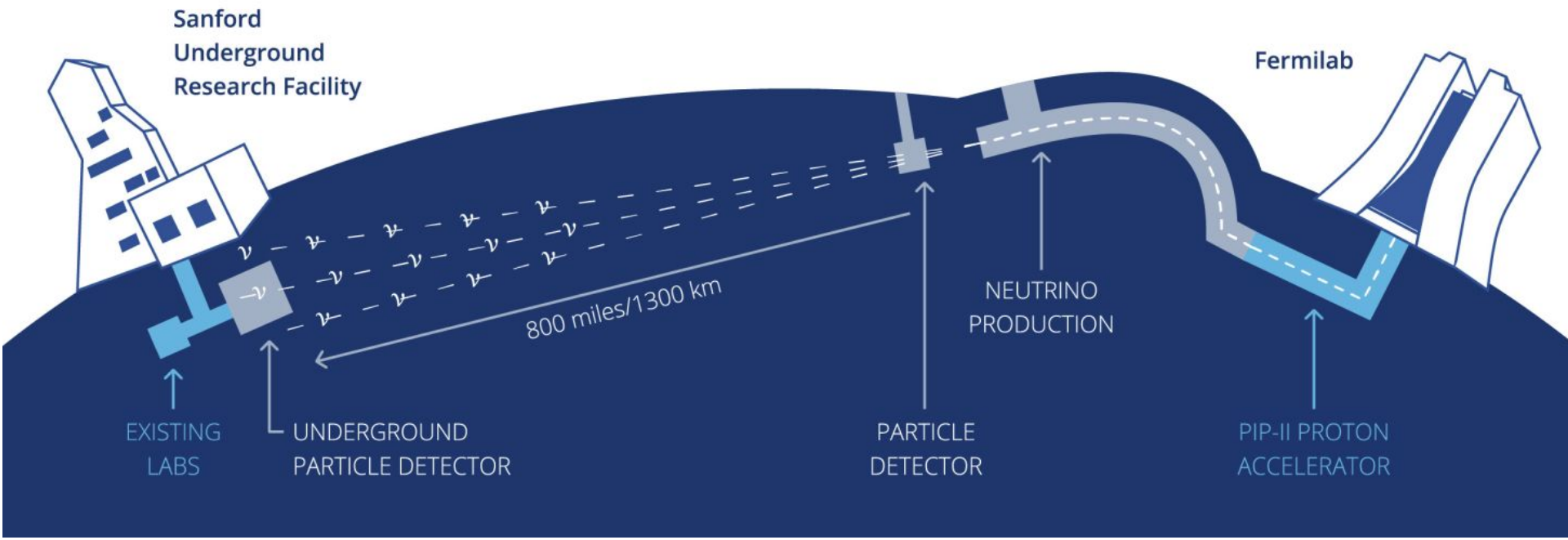
- **LBNC presented a summary in the :**

  - **March 30th DUNE Resources Review Board (RRB) Meeting**
  - **May 18th Neutrino Scope Group (NSG) Meeting**

DUNE: “Best in Class” neutrino experiment, driven by LBNF and PIP-II

From Lia Merminga, RRB, March 30th 2023

Delivering on LBNF/DUNE is Fermilab’s highest priority



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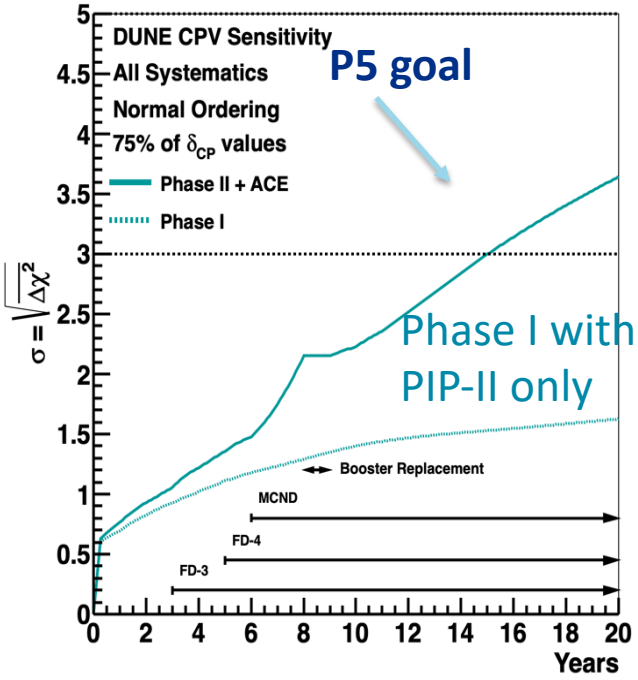
DUNE Phase I and Phase II : Snowmass

Experiment Stage	Physics Milestone	Exposure (kt-MW-years)	Years (Staged)
Phase I	5σ MO ($\delta_{CP} = -\pi/2$)	16	1-2
	5σ MO (100% of δ_{CP} values)	66	3-5
	3σ CPV ($\delta_{CP} = -\pi/2$)	100	4-6
Phase II	5σ CPV ($\delta_{CP} = -\pi/2$)	334	7-8
	δ_{CP} resolution of 10 degrees ($\delta_{CP} = 0$)	400	8-9
	5σ CPV (50% of δ_{CP} values)	646	11
	3σ CPV (75% of δ_{CP} values)	936	14
	$\sin^2 2\theta_{13}$ resolution of 0.004	1079	16

TABLE II. Exposure, in kt-MW-years, and time, in calendar years, required to reach selected physics milestones. The time in years assumes that Phase I is complete at Year 0 and that the Phase II staging scenario described in the text is realized. The range of time in years covers the effect of the beam ramp, with the lower bound corresponding to full 1.2 MW proton beam power at Year 0 and the higher bound corresponding to a scenario where the full power is achieved after 4 years. When no range is provided, the difference between these scenarios is less than one year. Time in years is rounded to the nearest whole year.



arXiv:2203.06100v1 [hep-ex] 11 Mar 2022

Parameter	Phase I	Phase II	Impact
FD mass	20 kt fiducial	40 kt fiducial	FD statistics
Beam power	up to 1.2 MW	2.4 MW	FD statistics
ND config	ND-LAr,TMS, SAND	ND-LAr, ND-GAr, SAND	Syst. constraints

TABLE I. A description of the two-phased approach to DUNE. ND-LAr, including the PRISM movement capability, and SAND are present in both phases of the ND.

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LBNF/DUNE-US: Status and recent achievements

From Lia Merminga, RRB, March 30th 2023

- **Far site excavation ~60% complete** proceeding **on time** and **on budget**
- DOE approved the **CD-1R "Reaffirmation" milestone**, reaffirming **strong commitment** to the **project**
- **DOE approved the CD-2/3** milestone for the buildings and site infrastructure (BSI) subproject in SD
- **Detector installation begins 2024**; **fabrication** by **CERN and partners is underway**
- **Science starts in 2028, "beam on date" in early 2031**
- **First draft of DUNE Host Lab Plan completed**, final in June
- **Next major milestone: FDC CD-2/3 approval**




DUNE News and Updates :

From Mary Bishai & Sergio Bertolucci , RRB, March 30th 2023

- **M. Bishai,** Brookhaven National Lab started as **new co-Spokesper**son on Jan 16th, 2023
- DUNE **phase transition toward construction** in **full swing**, **spurred** by the **impressive progress** in the **LBNF Far Site work.**
- A very **lively workshop** held on 2-4 Nov. 2022 in Valencia **on Far Detector 3 and 4.**
- **FD2-VD** and **FD1-HD TDR drafts completed** and sent to the LBNC, igniting an extremely fruitful flow of feedbacks.
- **Activities** at the **Neutrino Platform progressing steadily**, **delays** in the **LAr procurement** might **defer beam test to 2024.**
- **Steady progress** on the activities of the **ND compl**ex.
- **DUNE collaboration Meeting** at **CERN** 23-27 Jan 2023, with **record attendance**.

DUNE News and Updates cont'd :

From Mary Bishai & Sergio Bertolucci , RRB, March 30th 2023

- Studied the **impact** of the **recent developments** of the **Accelerator Complex Evolution.**
- Discussed the draft of the **Community Agreement** with the EB, the IB and the Collaboration, with the goal to **approve** it by next **IB meeting**.
- **Data Challenge 4 executed** continuing the **structural work** on DUNE **computing framework.**
- Progressing in the **update** of our **global simulation/analysis framework**
- **MoU annexes** for **FD1** and **FD2** sent to the **RRB Funding Agencies**.
- Draft proposal to establish a **common fund** for **Construction and Integration**(C&I) submitted to the **Funding Agencies**.
- Established a **working grou**p to organize the **US DUNE operations funds** needs and management, in **collaboration** with the **FNAL operations organization.**
- Presented our **plans for Phase 2 at the P5 Town Hall Meeting**

LBNC Executive Summary (1/4)

- LBNC **congratulates LBNF/DUNE** on the **CD1RR approval** which is a **major accomplishment.**

- LBNC continues to be **very impressed** with the **progress made** by LBNF/DUNE on **all five sub-projects**, both in the Far and the Near Site. LBNC is **concerned** with the **restricted availability** of the **Yates shaf**t and the **impact** and **associated risk** this might have during the **project construction phase.**

- LBNC **congratulates DUNE** on progress made on several fronts: **for completing the FD2-VD TDR** and addressing the first set of comments from the committee, the **advancement of ProtoDUNEs**, the **progress** on the **ND sub-detector systems**, and the **global simulation**, **reconstruction** and **analysis efforts**.

- LBNC **commends DUNE** for **submitting** the **MOU Annexes** for **FD1 and FD2,** and for **initiating** the **formation** of a "**common fund" mechanism** for **Commissioning** and **Integration,** and later for **Experimental Operations.**

LBNC Executive Summary (2/4)

- LBNC **welcomes** the **formation** of a **dedicated group** that will look into the **strategy** for achieving the **Phase II physics goals** with the **appropriate FD3, FD4**, and **Near Detector Complex**. The committee would welcome advances of this plan and a refined strategy on how decisions on FD and ND detector technologies will be made. Related to this, LBNC notes that the **success of Phase I** should remain **DUNE's highest priority**, along with **securing all** resources needed for this **effort.**

- LBNC **commends DUNE** on **progress** made on **ProtoDUNE-HD-Module 0.** LBNC **strongly suggests** that **DUNE continues** to **study** and try to **better understand** the **APA broken wire issues,** with a plan to **develop a viable mitigation strategy,** that would be **sustainable** in the **longer term**. LBNC **is concerned** about the **APA production issues** and urges DUNE to continue to **develop short** and **long term mitigation plans, evaluate** their **performance** and **associated risks,** and **assess possible impacts** on the overall **project schedule** and **cost.** The LBNC fully supports the request for the new resources that will be needed to implement these plans.

LBNC Executive Summary (3/4)

- The committee **congratulates DUNE** for continuing to make **impressive progress** on **FD-VD prototyping,** on **advancing** the **FD-VD design,** and **improving project planning.** The committee notes that given th**e positive developments** on **LAr supply issues in Europe** DUNE should develop a **timely plan** for the **order of filling of ProtoDUNE-VD and ProtoDUNE-HD.**

- The committee **commends DUNE** for having **completed the computing CDR**, for having **designs** for **most computing components** and **working implementations** for **many**, and for having **successfully completed data challenges for ProtoDUNE-II**. Given that **FD** and **ND offline software** will **need major infrastructure** work to operate at **scale**, LBNC **suggests** that DUNE starts to **identify** and **put in place** the **needed resources.**

LBNC Executive Summary (4/4)

- LBNC **commends DUNE** for making **substantial** and **continuing progress** on **reconstruction** and **analysis** on several fronts: **oscillation, low energy physics** and **BSM searches**. LBNC notes that **DUNE should continue** to **prioritize** the **full oscillation analysis** that **includes ND on axis** and **off axis measurements,** and make sure the **appropriate resources** are **identified** and **put in place** for this. LBNC **urges DUNE** to **update** and **communicate** the **experiment's capabilities** on contributing to **proton decay searches.**

- **LBNC reiterates the request that LBNF/DUNE conducts a systematic exploration of the availability for all upcoming purchases well in advance of procurement to identify supply chain issues.**

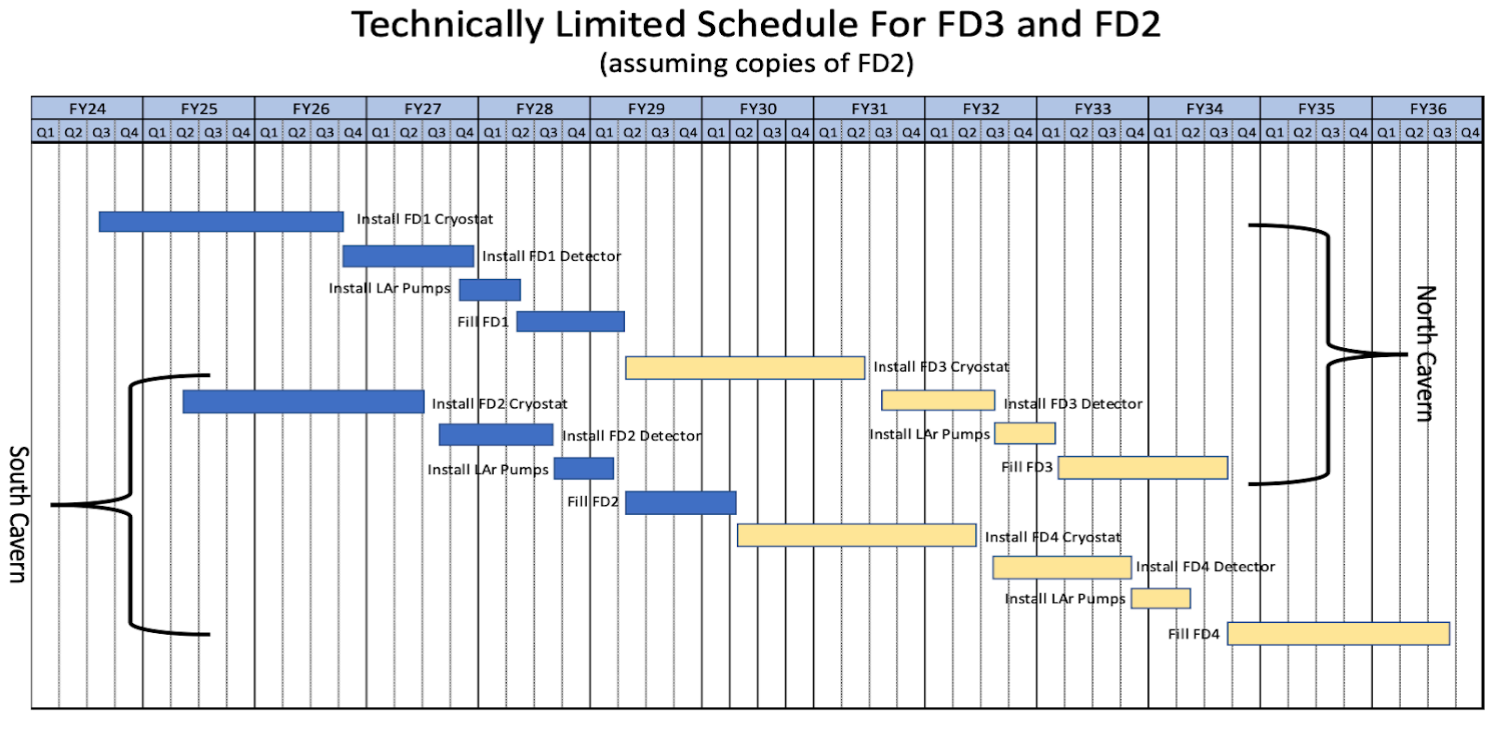
BACKUP

NSG Charge

- The NSG is a review and advisory committee charged by and reporting to the Fermilab Director as well as to the Resources Review Board (RRB). Along with the Long Baseline Neutrino Committee (LBNC) and RRB, the NSG is part of the Deep Underground Neutrino Experiment (DUNE) oversight governance.
- The overall purpose of the NSG is to review the scope completeness, the availability and sufficiency of resources to complete the scope on schedule, and identify any non-technical risks associated with the DUNE program. The primary responsibilities of the NSG include:
- Evaluating the completeness of the DUNE scope necessary to deliver the detectors, the complete mapping onto the DUNE partners, and verifying there are no scope gaps.
- Assessing the credibility of the schedule for DUNE, major milestones, and coordination with the LBNF/DUNE-US project schedule.
- Assessing the appropriateness of the estimate of available resources, including staffing resources and M&S funding for the DUNE experiment, including computing.
- Reviewing non-technical risks for DUNE, such as supply-chain issues, including proposed levels of cost realism and schedule contingency to address identified strategies for mitigation of those risks.
- Monitoring DUNE progress against the scope and schedule associated with the Technical Design Reports.
- Coordinating and receiving input from the LBNC on the overall scientific and technical status of DUNE program.

FD 3 and 4 Timeline

From Mary Bishai & Sergio Bertolucci , RRB, March 30th 2023



Earliest installation start in 2029 with FD3 completed in Q4,2034 and FD4 in Q4,2036

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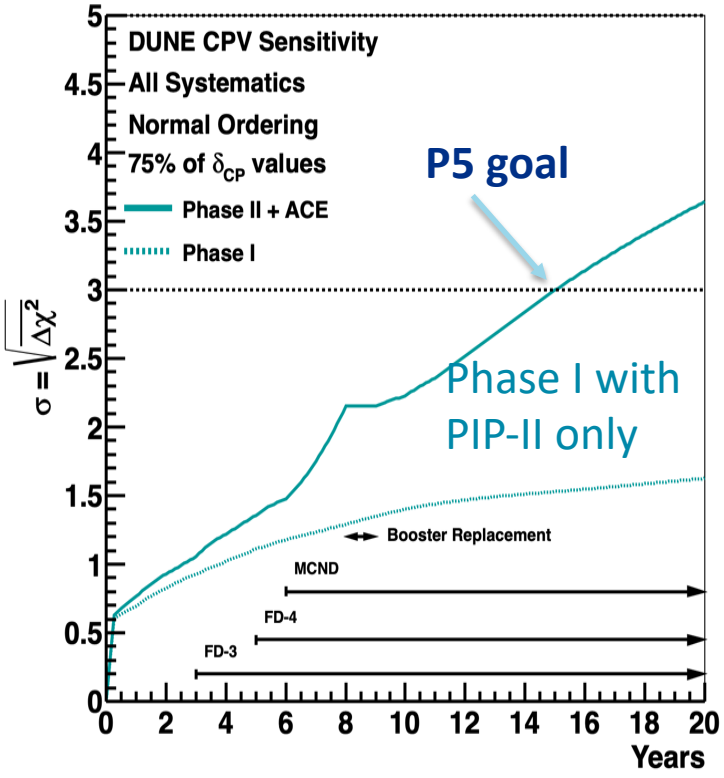
DUNE Message to P5

From Mary Bishai & Sergio Bertolucci , RRB, March 30th 2023

- **DUNE Phase II (beam+detectors) will be essential to complete the DUNE program as outlined by the 2014 P5: reach 3σ sensitivity for 75% of δ_{cp}**
- The DUNE Phase II Far Detector baseline design is based on two vertical-drift LArTPC modules which meets all the requirements needed to reach the full DUNE physics goals.The technically driven schedule for Phase II would have FD4 completed by end of 2036
- Several LArTPC R&D lines have been identified that will enhance the physics performance of the DUNE FDs. Non LArTPC options for FD4 such as WbLS detectors could be considered if they meet the performance requirements of DUNE.
- *DUNE Phase II R&D is already engaging potential partners from the existing effort and attracting new communities.*
- *The enhanced physics potential of DUNE enabled by Phase II far detectors ranges from physics at 10 GeV ($\nu\tau$ appearance) to physics at ~ few MeV (solar ν) and below (DM?)*
- *Reaffirming the US commitment to full DUNE scope would ensure continued support of the international community and the realization a transformational scientific program*



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