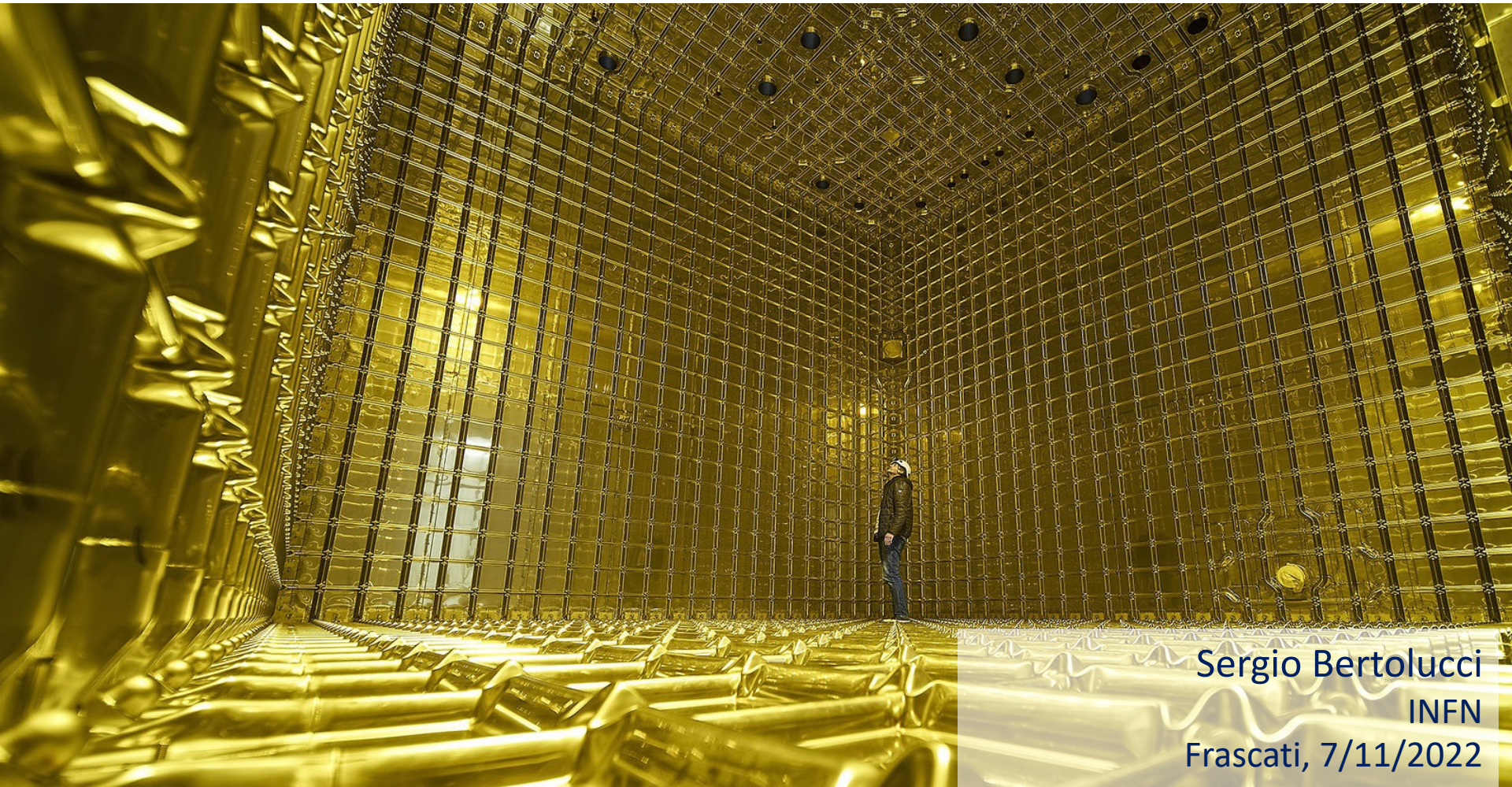


DUNE Status and Outlook



Sergio Bertolucci
INFN
Frascati, 7/11/2022

What has happened since our last general meeting

- DOE contribution to LBNF/DUNE divided in 5 subprojects
 - Far site excavation
 - Buildings and Site Infrastructures at SURF
 - Far Detector
 - Near Site Conventional Facilities and Beamline
 - Near Detector
- Laborious definition of the total DOE project cost and of the associated spending profile
- **Turning point at the beginning of 2022:**
 - A new and accelerated spending profile from DOE
 - A CD-1 Reaffirmation Review (CD-1RR) in July 2022

CD-1RR (July 2022)

- Propose of review:

- Reaffirm alternative selected (1.2MW upgradeable neutrino beamline; contributions to capable near detector; contributions to 20kt fiducial underground argon TPCs at first oscillation maximum; facilities to support expansion/upgrades)
- Re-establish project point estimate and cost range
- Implement subproject execution strategy

- Review was built on:

- The new “CD-1RR Funding Profile”
- February DOE HEP guidance to cap project’s contribution to Near Detector at \$200M (which must include expenditures to date)

- Hybrid review, but most reviewers were on-site:

- Very strong support from LBNF/DUNE partners, with senior representatives of CERN, INFN, IN2P3, and STFC participating in person and expressing strong commitment

- Outcome

- All eight subcommittees recommended proceeding to CD-1RR milestone

CD-2 Summary


- **Baselined** the first subproject – Excavation at Far Site. Official approval received on 19 August.
- **Baselining** the second subproject – Building & Site Infrastructure at Far Site – right now.
 - DOE completed Independent Cost Estimate – closely aligned with our estimates
 - DOE CD-2/3 IPR is set for 15 – 17 November; ESAAB anticipated first quarter CY2023.
- **Planning for baselining** for the third and fourth subprojects (FDC and NSCFB) in 2023
 - CD-3a reviews scheduled in November and December, respectively, to be able to make long lead procurements


CD-2 Summary

Subproject	CD	Q3 2022	Q4 2022	Q1 2023	Q2 2023	Q3 2023	Q4 2023	Q1 2024	//	Q3 2024	//	Q2 2025	//	Q4 2025
FSCF-EXC	CD-2/3	ESAAB 9 Aug												
FSCF-BSI	CD-2/3		IPR 15-17 Nov	ESAAB										
FDC	CD-3a		IPR 8 Nov	ESAAB										
	CD-2/3				IPR		ESAAB (6 mon after IPR)							
NSCFB ²	CD-3a		IPR 6 Dec	ESAAB										
	CD-2/3					IPR		ESAAB						
ND	CD-2							IPR ³		ESAAB				
	CD-3										IPR		ESAAB	

Notes

- Quarters shown are calendar year; **bolded** dates are set
- FSCF-EXC is baselined
- FSCF-BSI: baseline review schedule is set.
- ¹FDC: working to finalize timing for CD-2/3 IPR; expect May 2023 timeframe
- ²NSCFB: tailoring plan not updated in P6 yet
- ³ND: plan is under development

 DOE critical milestone review (CD-2, CD-3, or CD-3a)

 DOE critical decision (ESAAB)

Impressive Progress of the Excavation at SURF

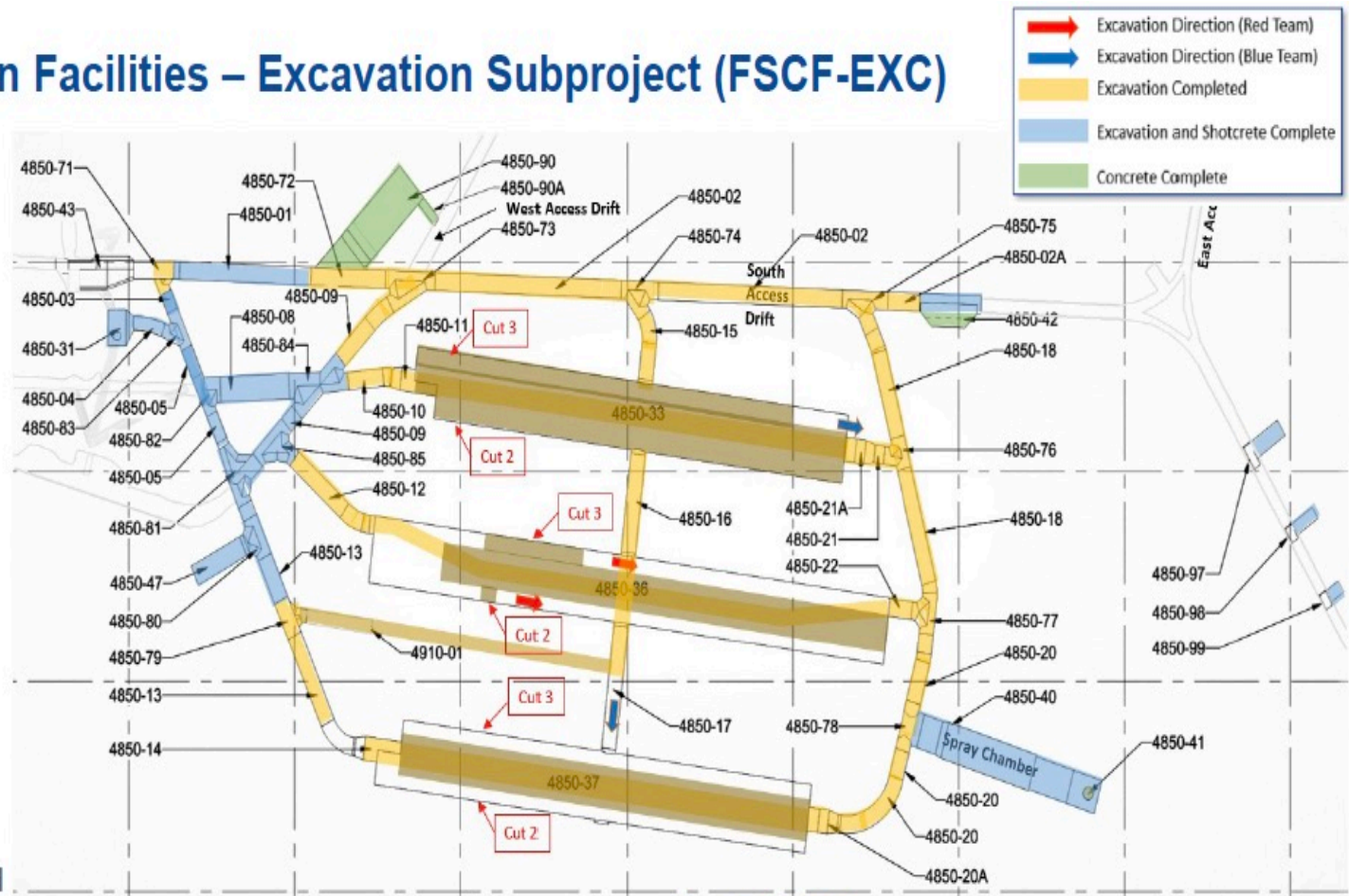


Far Site Convention Facilities – Excavation Subproject (FSCF-EXC)

- Excavation at 41.2% complete; overall sub-project > 67% complete

- All drill and blast excavation outside the main caverns completed except Ross Brow

- All three caverns progressing concurrently
- Concrete placement started with maintenance shop



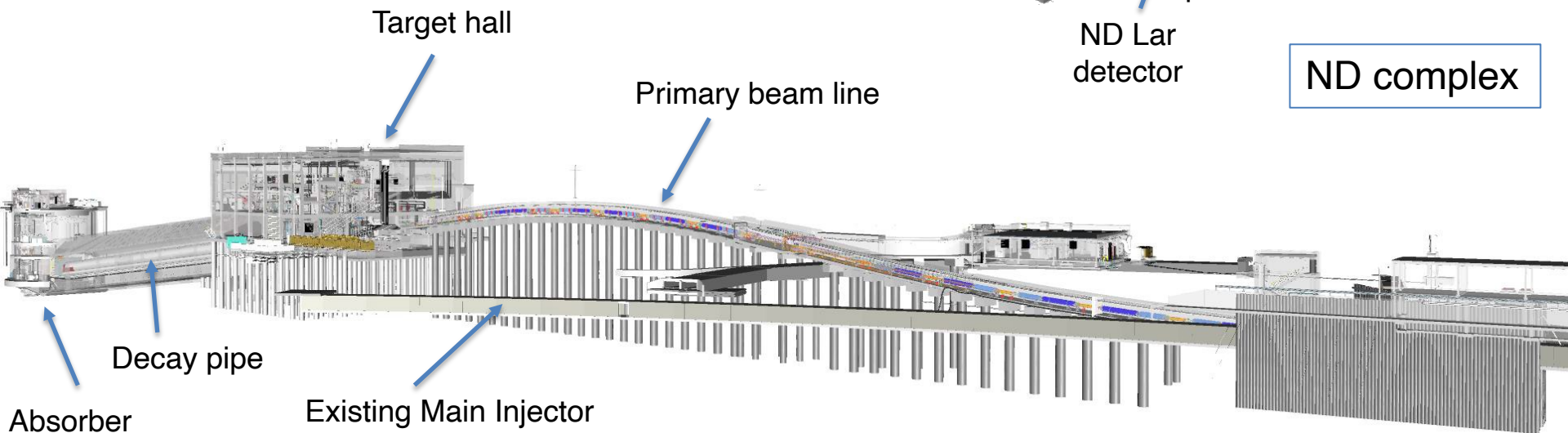
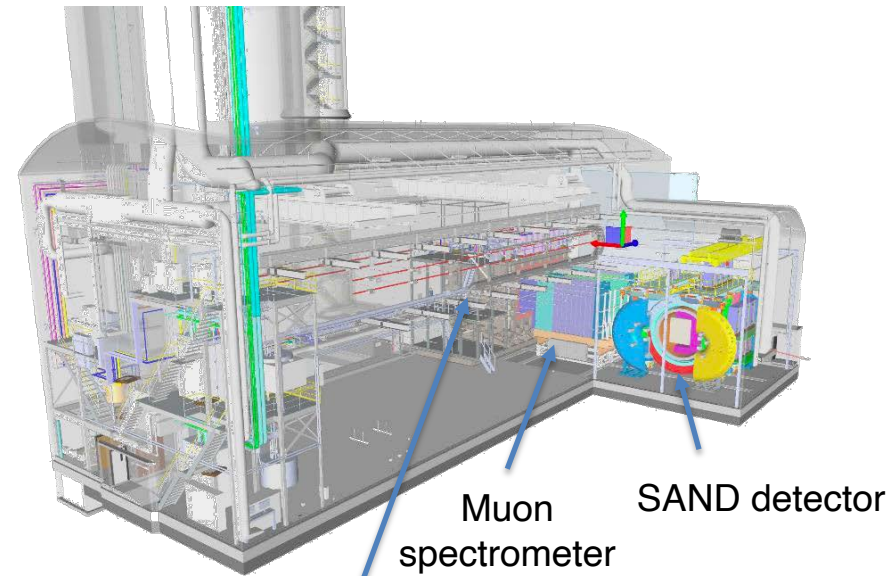
As of 3 Oct 2022

- The Raise Bore was completed (reamed and shotcreted) on 28 March 2022
- The Excavation Subcontractor has maintained 0.0 TRC for almost 700 days through August

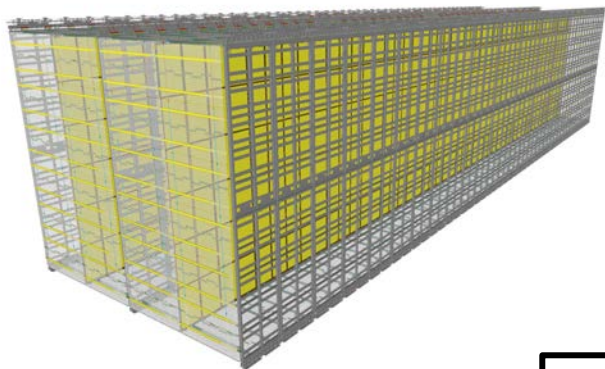
Near Site Conventional Facilities

Status:

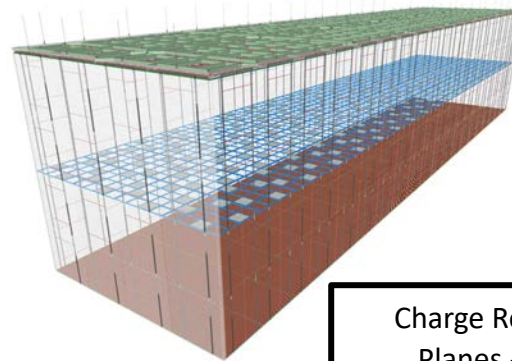
- 100% final *design* completed on 28 Sep 2021 for the Beamline Complex and Near Detector Complex
- NSCF will start construction upon funding availability (*possibly better sooner than later*)




Far Detector Partners




High Voltage
FD1, FD2




Charge Readout
Planes - FD2




Anode Plane
Assemblies - FD1



TPC
Electronics
FD1, FD2-B




Electronics
FD2-T



CALCI
FD1, FD2



Photon Detection
FD1, FD2

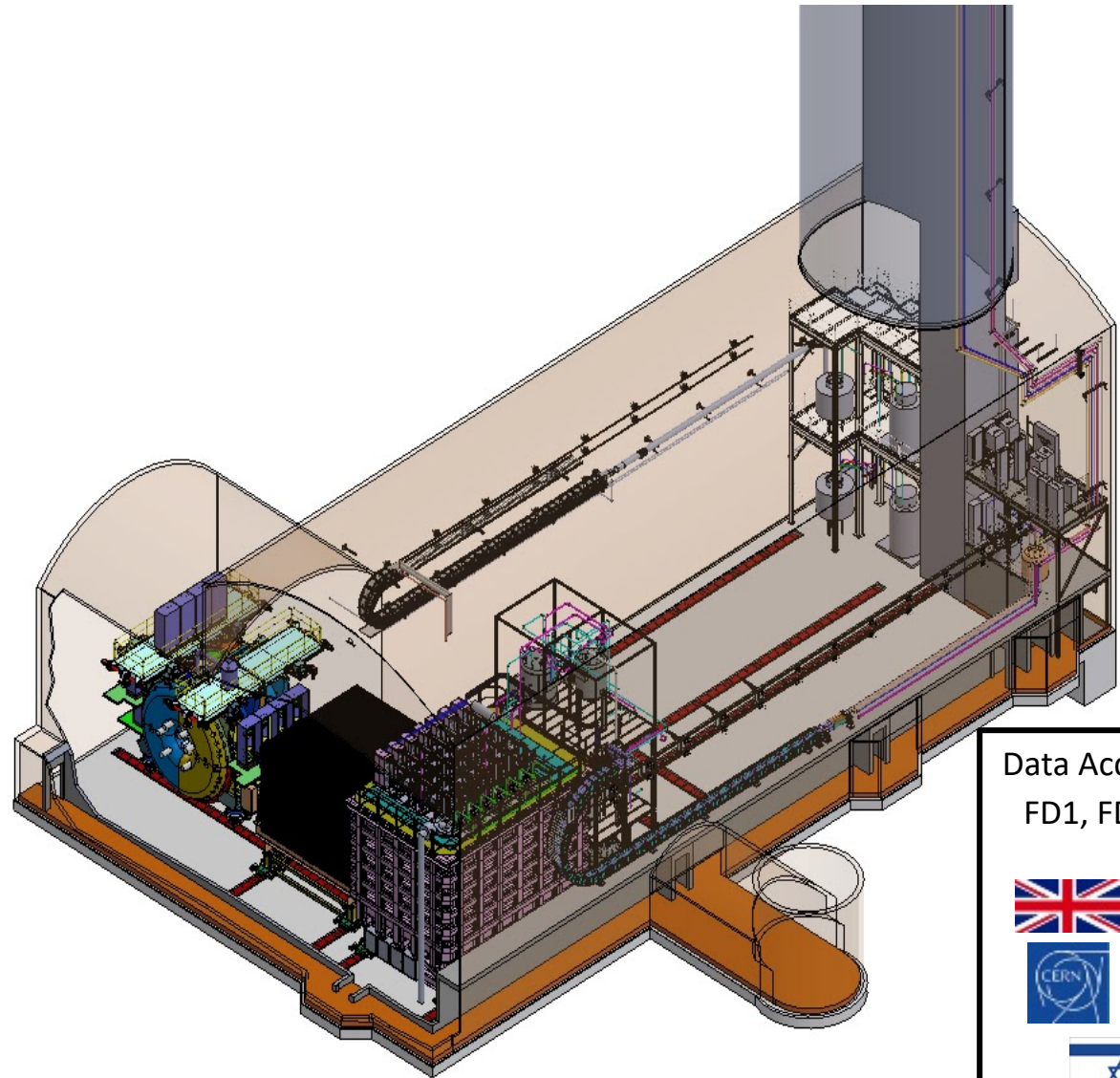


Data Acquisition
FD1, FD2, ND



All scope defined in Consortia Annexes to Multi-institutional MOU

Near Detector Partners

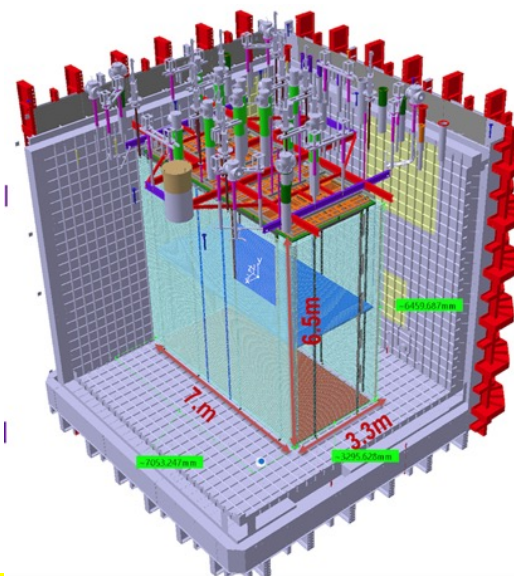
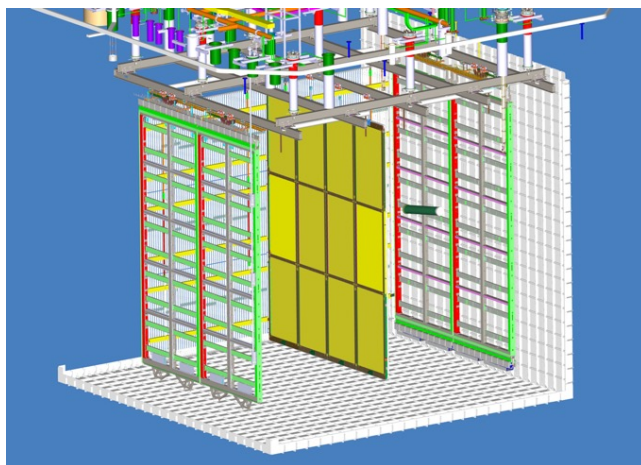
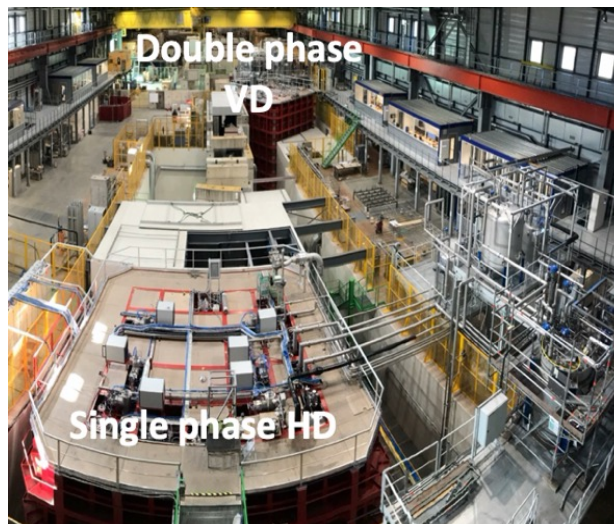


Constraints on Near Detector

- The DUNE-US Project has been charged with a “Build to cost” mandate; this applies to all sub-projects
- The DUNE-US Near Detector has been given two more specific constraints :
 - Total Cost of DOE contribution : not to exceed \$200M (including \$26M spent to date)
 - At least 50% of the remaining \$174M must be put in a category called “Objective Scope”
 - \leq 50% of the \$174M will be assigned to “Threshold Scope” which will be the minimum scope that the project will be REQUIRED to deliver
- DOE has indicated that the Threshold scope must provide the capability of doing science
 - “doing science” means collecting data from Day 1 of neutrino beam that can be used to produce oscillation results
- The collaboration standpoint is that to produce a publishable oscillation result requires a Near Detector which is functionally the same as the Far Detector -> a liquid argon time projection chamber
- We want to emphasize that we have significant Partner contributions to the Near Detector coming from Bern for ND-LAr and INFN for SAND; we need to leverage these contributions with a sensible approach to utilizing the DOE funding.

ProtoDUNE

2017-2020



2022 - 2024 Full scale production quality modules

FD1 – Anode Plane Assemblies

- Optimization of the production plan...
- After consultations inside the APA consortium, and between the UK and US projects we have proposed an optimized production plan for 150 + 2 APAs for FD1; 4 are already at CERN
- This plan still needs official approval by Change Control Boards on both UK and US projects
 - In the new plan, the UK would construct 134 APAs at Daresbury
 - A 5th winder will be added to the existing 4
 - The US will construct 14 APAs at Chicago, with the possibility to assemble more if necessary
 - The UK supplies frames, geometry boards, grounding mesh panels and combs
 - The US (PSL) will manufacture 160 sets of CR boards, G-bias boards, CE adapter boards, cable harnesses, SHV boards and procure the required capacitors
 - The UK will procure all (76) shipping frames
 - 10% of the APAs will be cold tested at CERN
 - All APAs will be inspected and stored at Fermilab, and then shipped to SURF for installation

Production Schedule

	2022	2023	2024	2025	2026
Daresbury	4	25	30	35	40
Chicago		2	4	4	4

- Last APAs ship from Daresbury in January 2027
- The Chicago schedule is conservative; could make several more APAs from UK sourced parts if schedule requires that

Daresbury factory: 4 operating winders, 5th in preparation.



Perforat



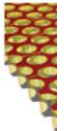
mes (outside field cage)

3x3 m2 PCB Anode

2 x 6.5-m vertical drift

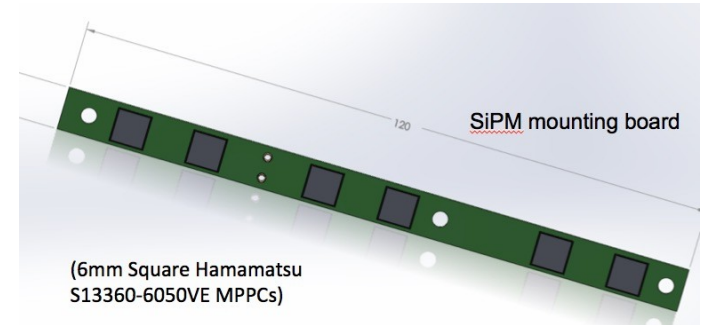
Chicago factory

Perfo



FD1 Photon System SiPMs

- September 2021 : down select to 50% Hamamatsu (S16517) and 50% FBK (NUV-HD-CRYO-TT)
- March 2022 : production and testing for PD-HD-II complete; failure rate in QC testing $<1\%$ in 4000 SiPMs
- Tenders for the mass production (300,000) prepared by Spain and INFN
 - Delivery of 1000 boards per month starting end of October 2022
 - Delivery of 2000 boards per month starting in August 2023
 - Completion : June 2025



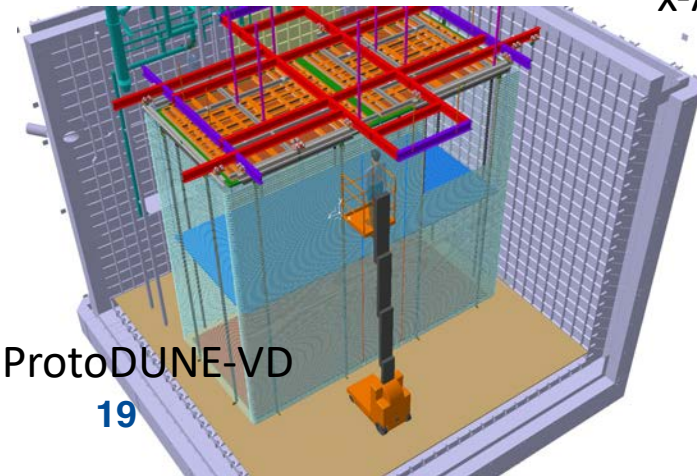
FD2-VD technical progress

- R&D and prototyping progress
 - HV stability and 6m drift in NP02 completed
 - Coldbox CRP1, CRP1b, CRP2(TDE) complete
 - CRP3 soon, CRP4-5 later this year
 - PDS dedicated coldbox runs, including GaAs PoF
 - CRP5a assembled at Yale, in transit to BNL for CE/test
 - ProtoDUNE-VD installation plan being developed

x-ARAPUCA 2 x-ARAPUCA 3



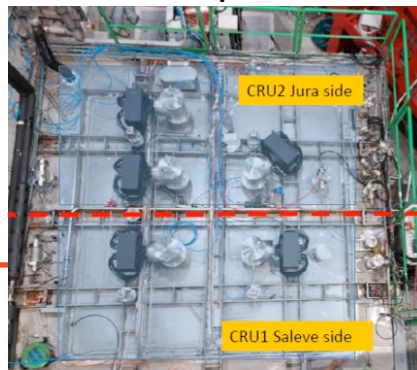
x-ARAPUCA 1



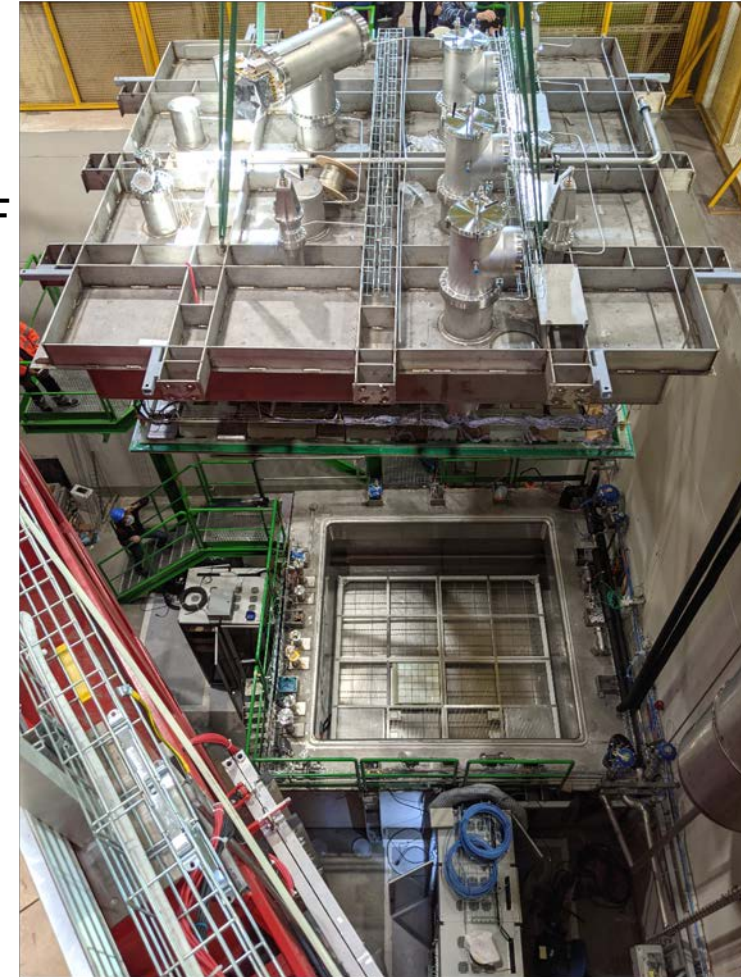
ProtoDUNE-VD

19

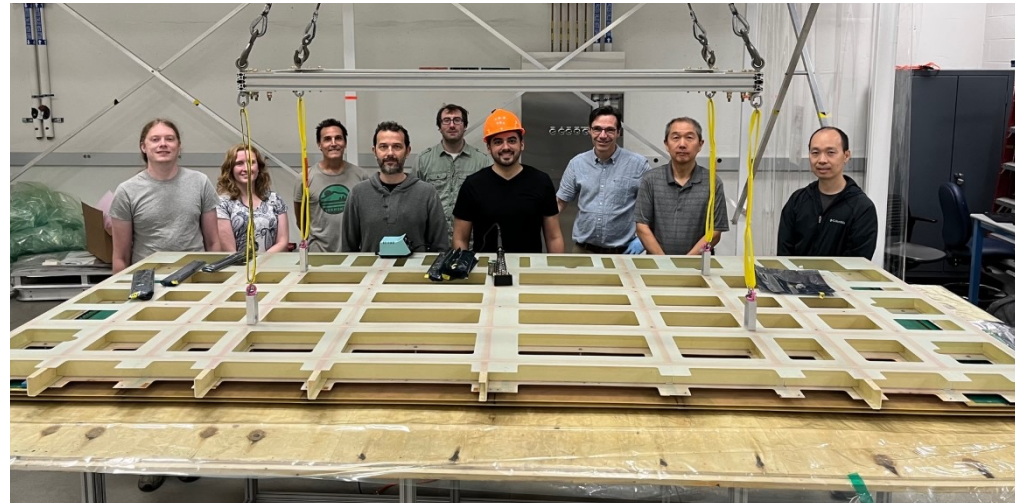
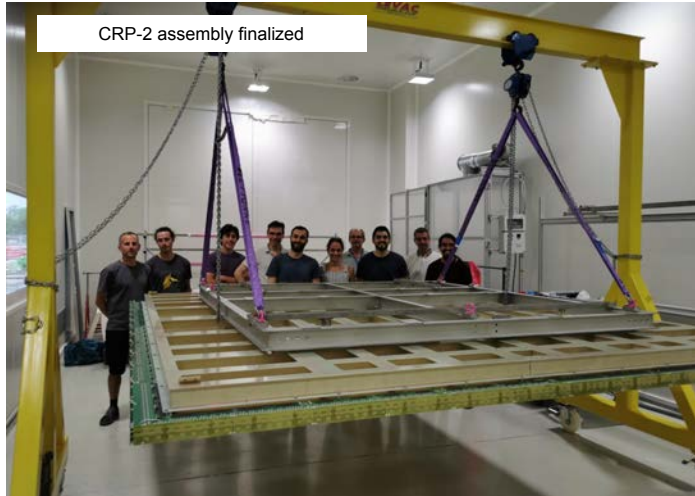
CRP2 – top, coldbox



Cold Box

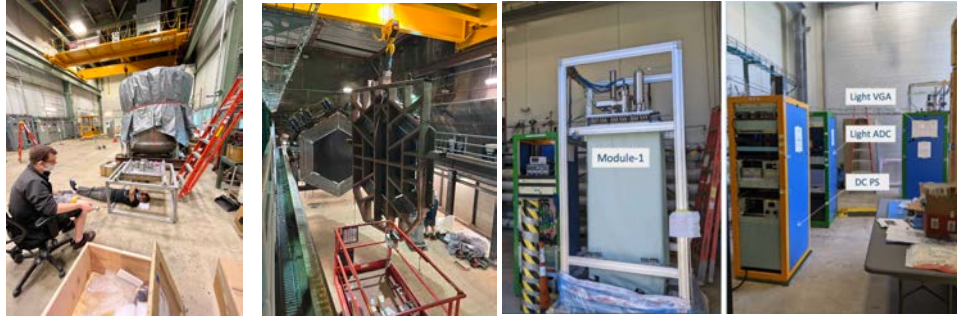


FD2 – Charge Readout Planes



CRP5a – bottom at Yale

Technical Progress on Near Detector



Progress on ArgonCube 2x2: critical test of multi-module operation in NuMI beam at FNAL

- Two modules test at Bern and delivered to LArTF@FNAL
 - Testing, assembly, modifications, op. reviews underway
 - Elec./HV/Power/DAQ Racks assembled
- MINERvA plane installation underway in NuMI Near Hall
- Delivery of critical cryo components in coming months
- 3rd module to be assembled, operated at Bern in coming months
- New analysis organization coming together

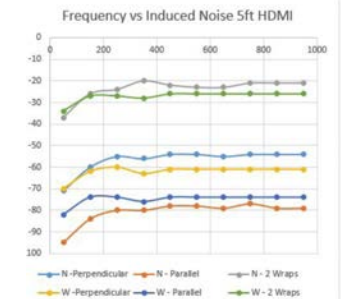
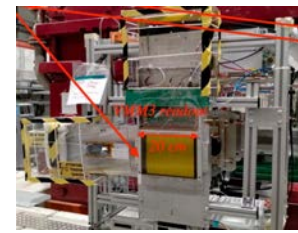
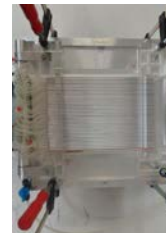
SAND

• STT:

- Mockup tests (JINR), test beam (CERN)
- Gas leak measurements (JINR)

• GRAIN

- Planning for large-scale prototype

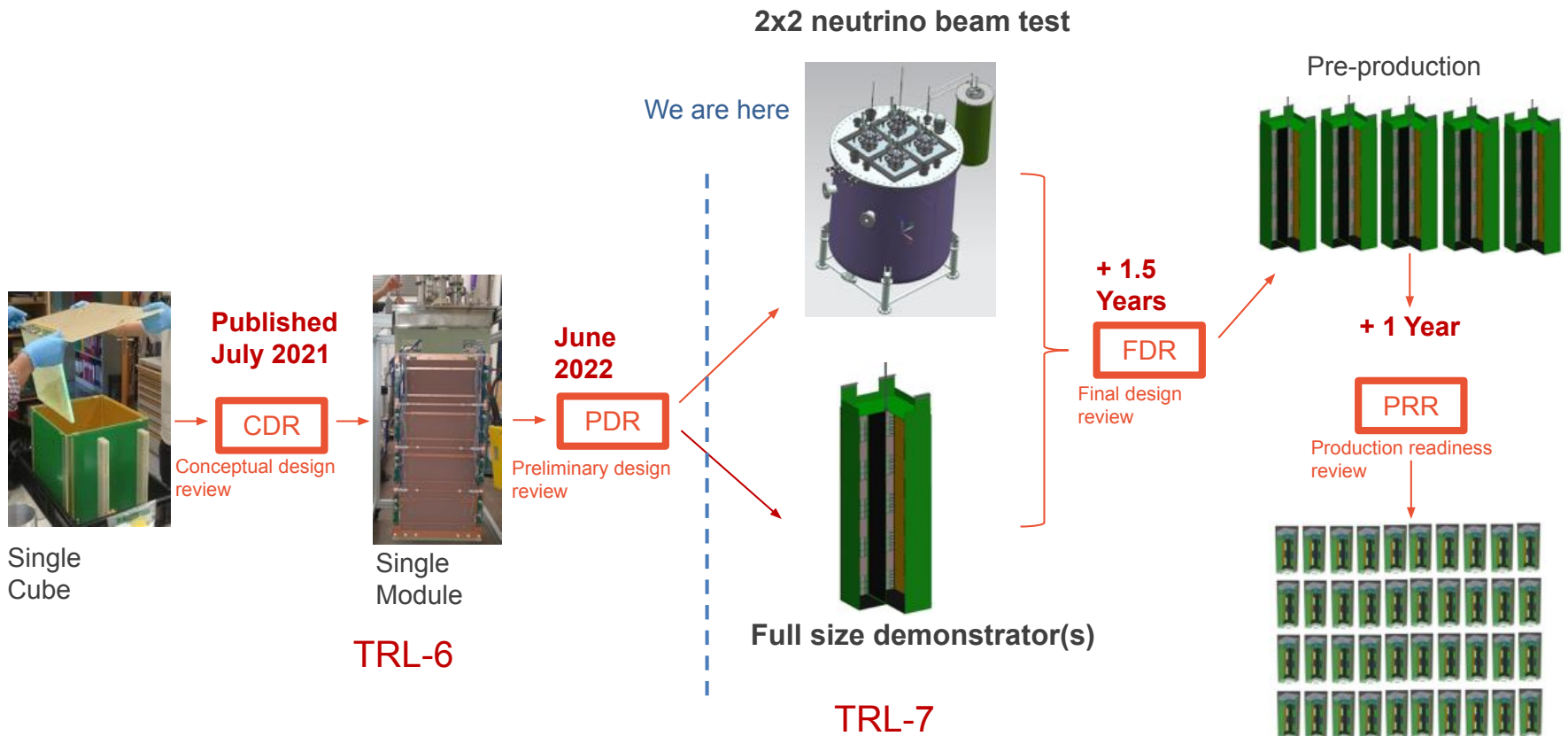


TMS

- Coil-induced noise on SiPM signal test at Wichita
- Discussion on scintillator production at FNAL
- Potential steel sources from OPERA, MINOS ND
 - “Shorter” design

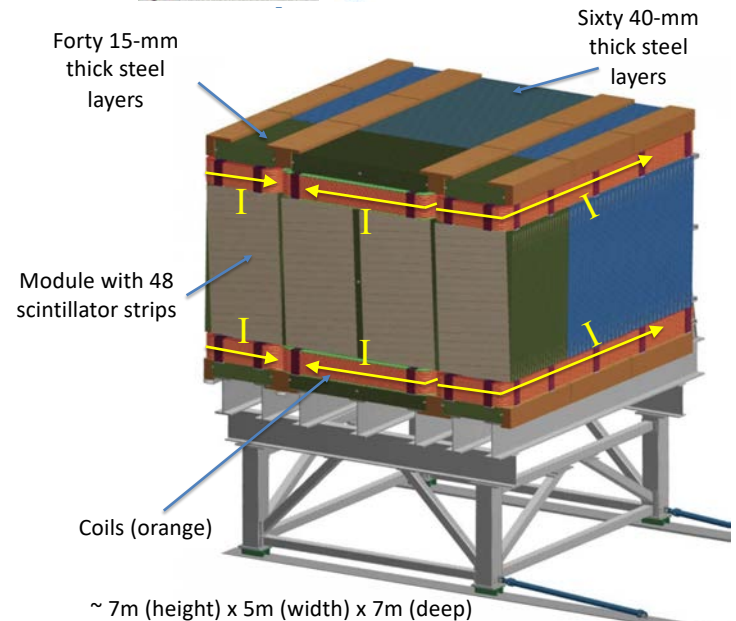
ND LAr status

Technology development from the PDR toward the Final Design Review

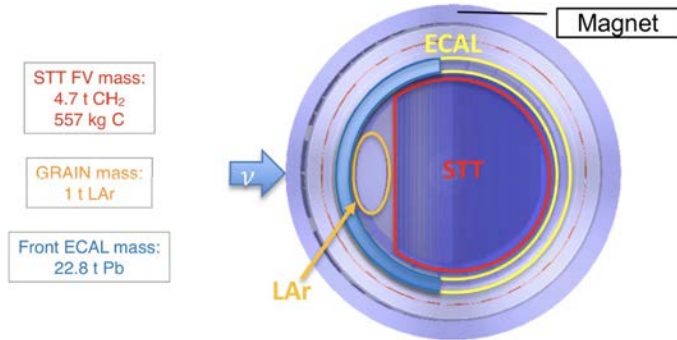


The Muon Spectrometer (TMS)

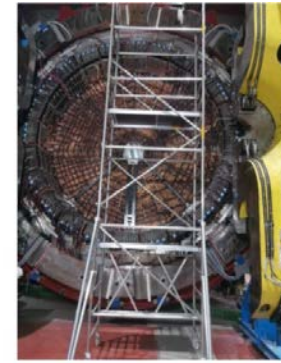
- Consortium Status : report from Consortium leaders Hugh Gallagher and Tom LeCompte
 - A very strong mix of groups with a variety of expertise on similar experiments (MINOS, Minerva, T2K) or analogous subsystems in DUNE or SBND
 - A balanced mix of senior and junior collaborators
 - A highly capable group of simulation, reconstruction and analysis experts
- Roles and Responsibilities
 - Scintillator + WLS fiber : Minnesota, ANL, Rochester, W&M, FNAL, Tufts (MINOS, Minerva experience)
 - Steel and Coils : W&M, SLAC
 - SiPM photodetectors, electronics, DAQ : VT, Mainz Cambridge, Houston
 - Software, simulation and Reconstruction : KSH, Rochester, Mississippi, Wichita State, U. Atlantico
- Several ideas under consideration to optimize design



SAND Milestones



SAND, a multipurpose detector with an high-performant ECAL, light-targeted tracker, LAr target, all of them in a magnetic field



Cleanup and removal of non re-usable instrumentation

- Design review of Yoke + Magnet + ECAL and related installation procedures : **April 2023**
- Preliminary design review of STT : **November 2023**
 - Prototyping **through 2024**
- Preliminary design review of GRAIN : **April 2024**

Long-baseline oscillation analysis: major update in early 2024

- Goal: Complete respin of oscillation sensitivities, including full ND simulation & algorithmic reconstruction, with multiple samples including ND-LAr+TMS and SAND
- Successful workshop at CERN August 15-19: progress toward updated cross section uncertainty model, ND sample integration, new fitting techniques
- Much work remains: systematics, systematics, systematics

Second Workshop at LNF in Spring 2023

	Stage 1 Geo + GENIE	Stage 2 GEANT	Stage 3 Detector Response	Stage 4 Detector Reco	Stage 5 Analysis files
ND-LAr	done	done	full	ML-Reco	CAFs
ND-LAr + TMS	done	done	partial	ML-Reco + Hough/A*	CAFs
TMS Only	done	done	cheated	Hough/A*	CAFs
ND-GAr	done	done	full	GArSoft	CAFs + GArAna
SAND (ECAL, STT, GRAIN)	done	done	full	Fast and full mixed	CAFs

Thank You