DUNE

Alessandra Tonazzo (on behalf of the DUNE Collaboration)
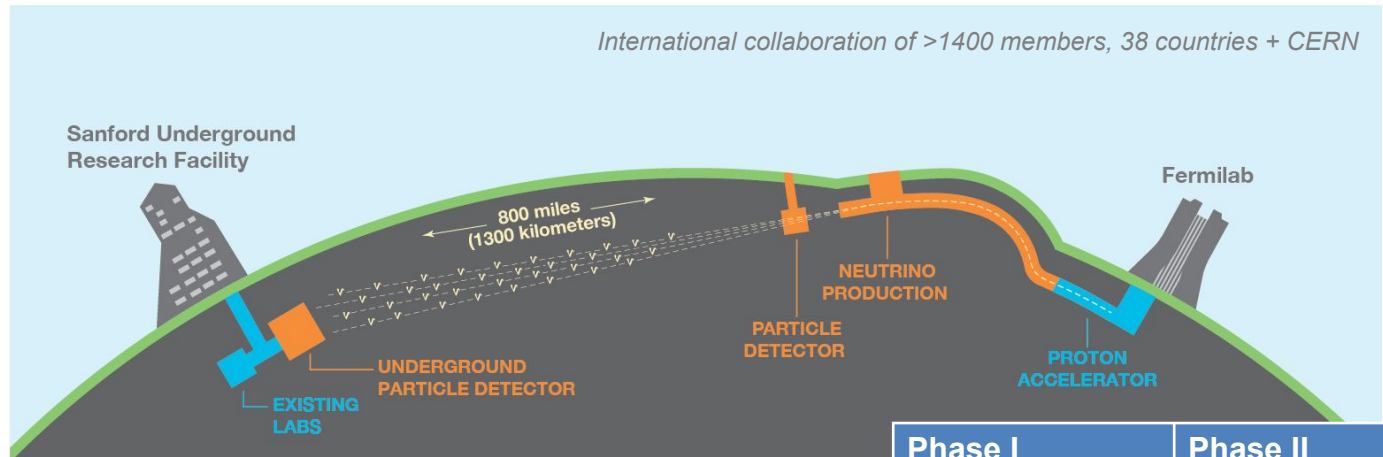IRN Neutrino – Discussion on ESPPU
Paris, 09/10/2024

DUNE

International collaboration of >1400 members, 38 countries + CERN

DUNE TDR
JINST 15 (2020) 08,
*T08008, T08009, T08010,*
arXiv:2002.03005,
2312.03130

- The most powerful **beam** in the world (>2 MW)
  - wide band: precise measurement of oscillations
  - 1300 km baseline: unambiguous determination of Mass Ordering
- **Far Detector** @SURF (>40 kton)
  - LArTPCs: precise reconstruction of ν interactions
  - underground: astrophysics measurements
- **Near Detector** system @FNAL
  - unprecedented control of systematics
  - rich physics programme (ν cross-sections, BSM..)

| Phase I	Phase II
Beamline upgradable to 1.2 MW [2031]	Beam >2 MW
FD Modules 1 and 2 [2029]	+ FD Modules 3 and 4
ND-LAr+TMS (PRISM), SAND [2031]	ND-LAr(PRISM) SAND + ND-GAr

LBL neutrino oscillations

ν_e appearance spectrum at the FD

- enhancement/reduction of ν_e/anti-ν_e depending on δ_{CP} value

- much larger enhancement of ν_e (reduction of anti-ν_e) for NO wrt IO

- different effects on spectral shape from MO, δ_{CP} , θ_{23} → solve degeneracies
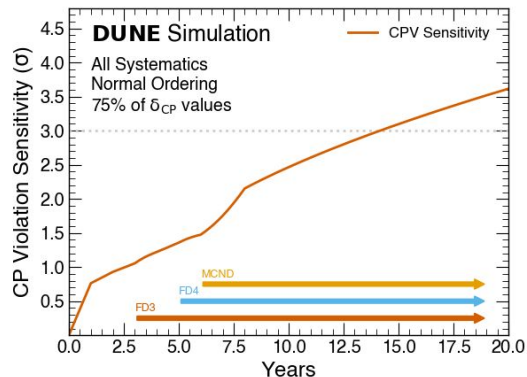

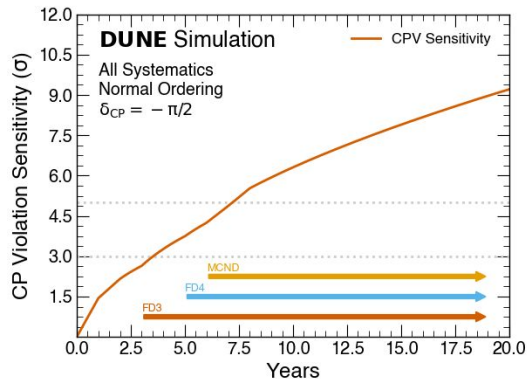*DUNE TDR, Physics: arXiv:2002.03005*
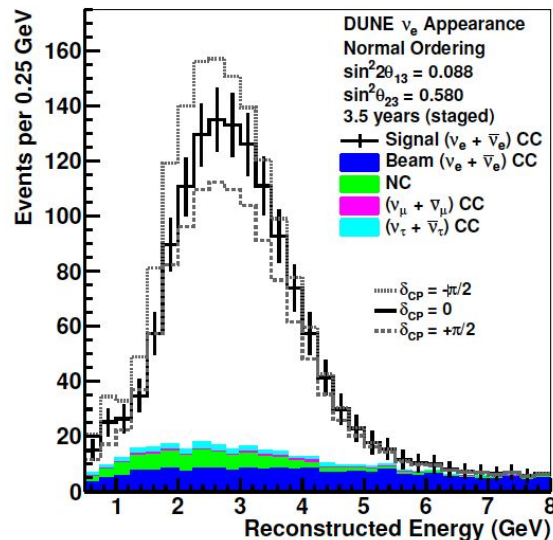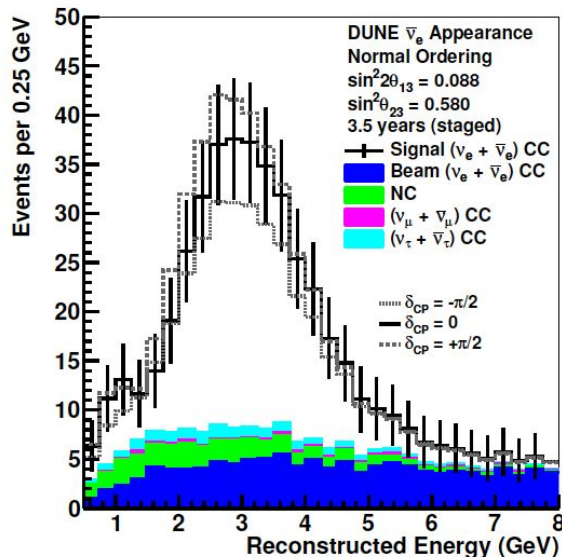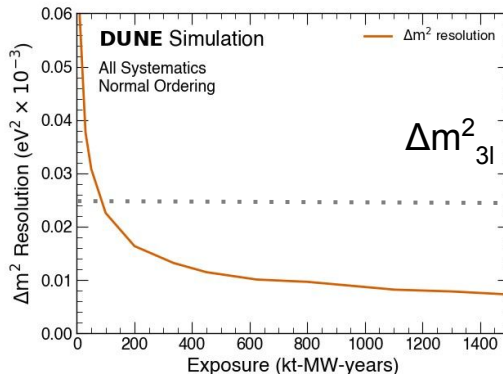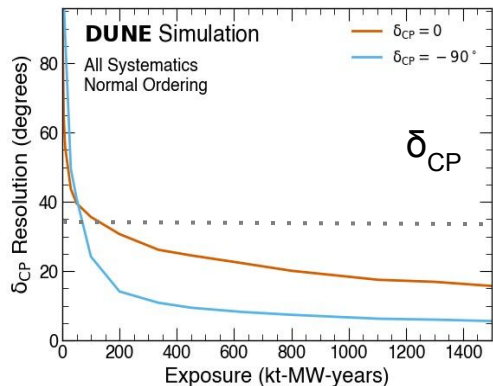
DUNE sensitivity
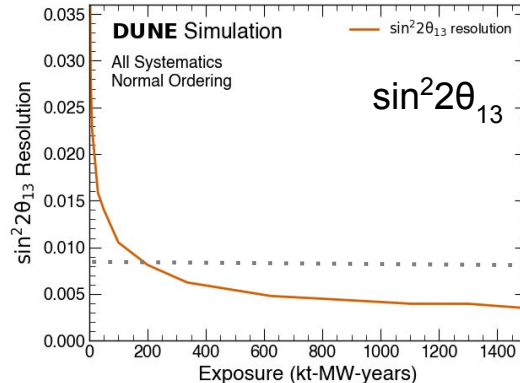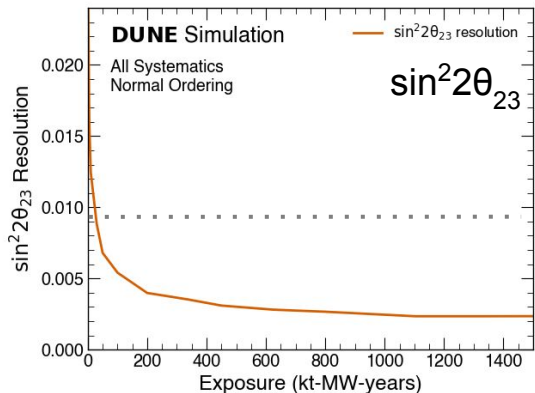
Neutrino Mass Ordering
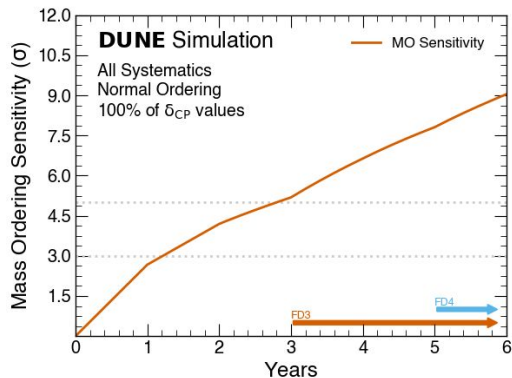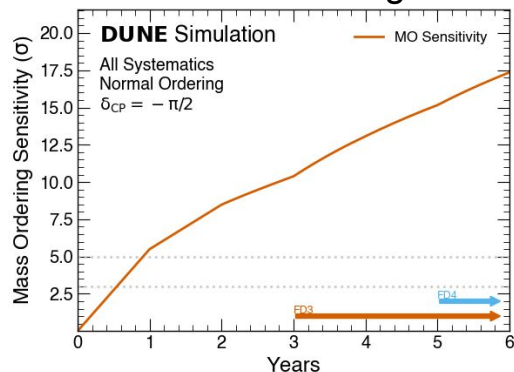
CP Violation

- **Mass Ordering (MO) > 5σ**
  - in 1 year in "best case" scenario ($\delta_{CP}=-\pi/2$,NO)
  - in 3 years in "worst case" scenario ($\delta_{CP}=\pi/2$,NO)

- **CP Violation**
  - > 3σ sensitivity in 3.5 years ($\delta_{CP}=-\pi/2$,NO)
  - over 75% of δ_{CP} values at > 3σ in the long term

DUNE TDR, Physics: arXiv:2002.03005

DUNE precision measurements

Precision measurement
of many oscillation
parameters
in a single experiment

...... NuFit 5.3
(2024) NO

sensitivity to new
physics from
comparison to
reactors

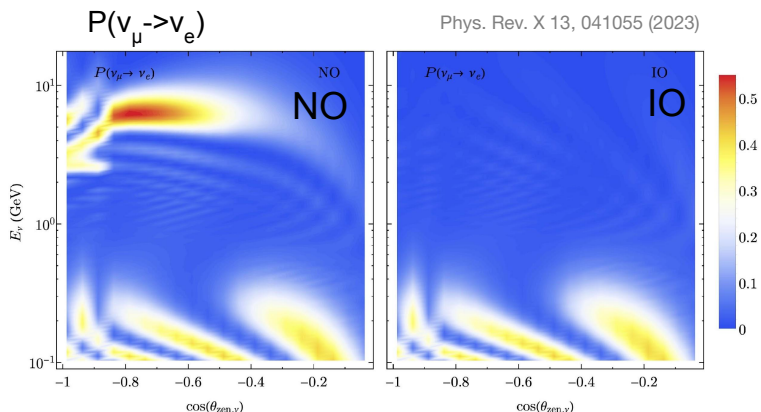*DUNE TDR, Physics:*
arXiv:2002.03005

Not just LBL

- **Atmospheric neutrinos**
  - data before the beam

  Talk by Camille Sironneau

P(ν_μ->ν_e) Phys. Rev. X 13, 041055 (2023)

  - independent measurement of MO and θ_{23}
  - sensitivity to CPV at E<GeV
  - searches for new physics

- **Astrophysics**
  - unique sensitivity via two channels
    - CC: ν_e + Ar $\rightarrow$ e- + ^{40}K*
    - ES: ν_x +e- $\rightarrow$ ν_x +e-

  - **SuperNovae** core collapse
    - burst's flavor and spectral content as a function of time
    - measurement of neutronisation burst, sensitive to MO
   - pointing from ES

  Talk by Dario Pullia

  - **Solar Neutrinos**
    - >10 MeV: excellent sensitivity to ^{8}B, discovery potential for **hep**
    - improvement of day-night asymmetry

+ broad BSM physics programme with ND and FD

Far Detectors

18 m

19 m

66 m

- **Horizontal Drift technology** *JINST 15 T08010 (2020)*
  - wire readout planes, 4 drift regions (3.6m)

- **Vertical Drift technology** *arXiv:2312.03130 (2023)*
  - PCB readout planes, 2 drift regions (6.25m)

top and endwall
field cage

bottom field cage

SURF caverns completed
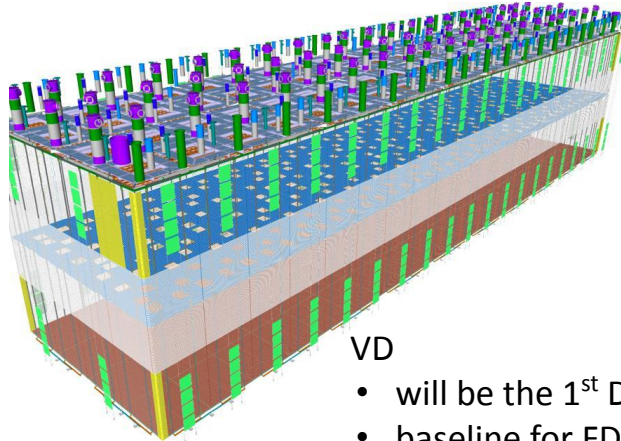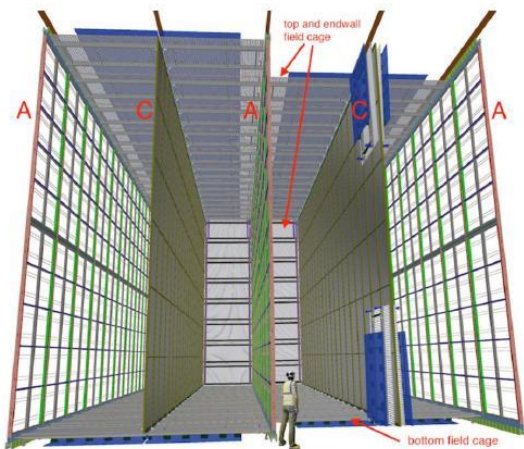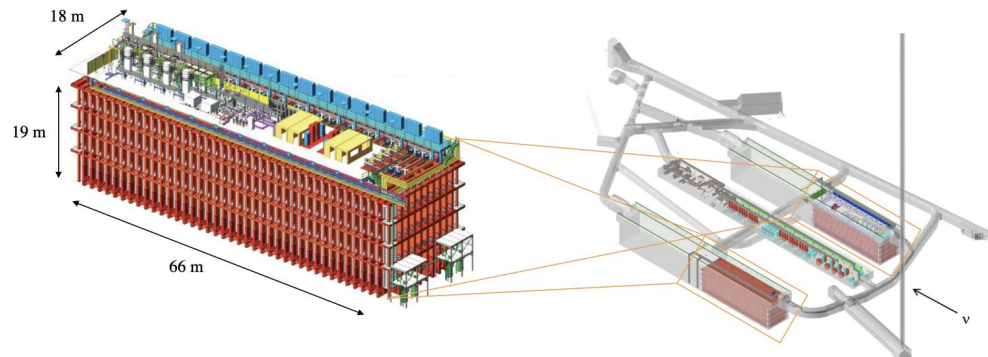
VD
- will be the 1st DUNE module → **IN CONSTRUCTION!**
- baseline for FD3, with enhanced light collection (APEX)
- option for FD4 ("Module of Opportunities")
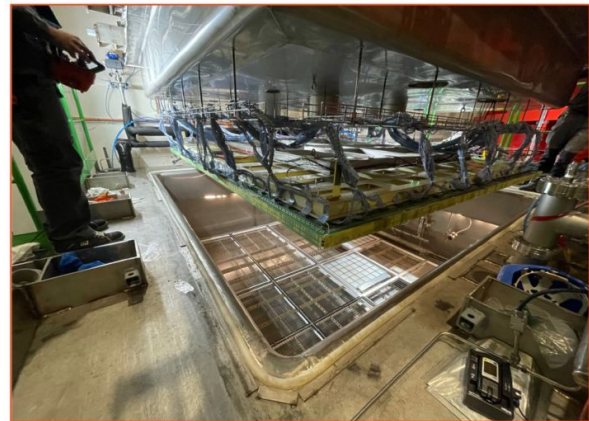
Prototyping at CERN

ProtoDUNE (~700 tons LAr)
Cosmics, Beam p,π,K,e

- Demonstration of LArTPC
- Analyses published and ongoing (performance, cross-sections)
- Xe doping
  - of interest also for DM and non-LBL

Talk by Richie Diurba

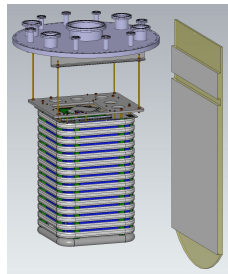- Final technical solutions for FD-HD
- Module0 for FD-VD

- **ColdBox** tests
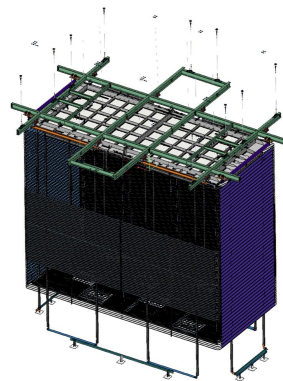 - VD readout electronics
  - PDS develop-ment and validation

- APEX prototyping for FD3 PDS

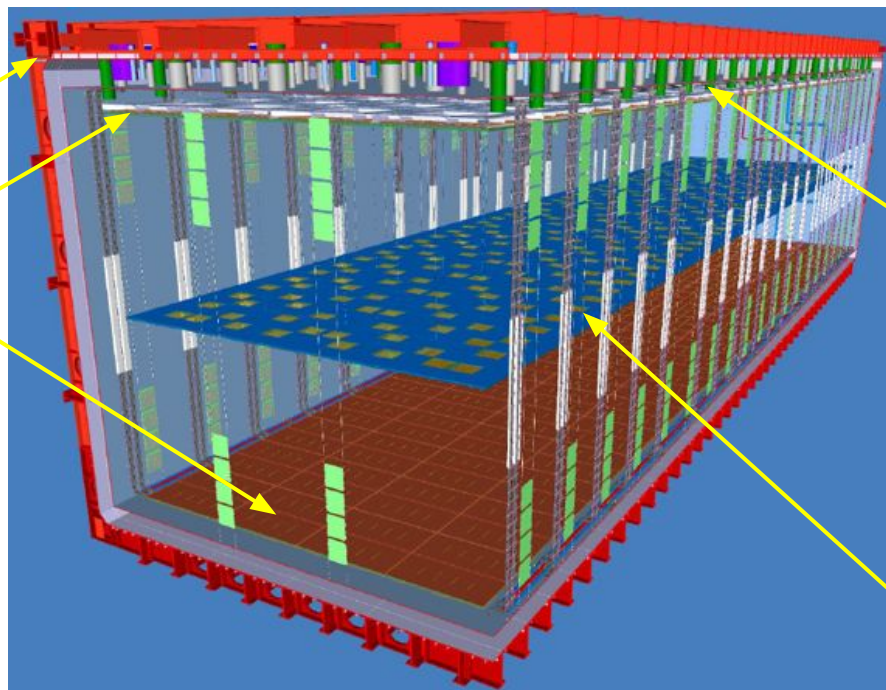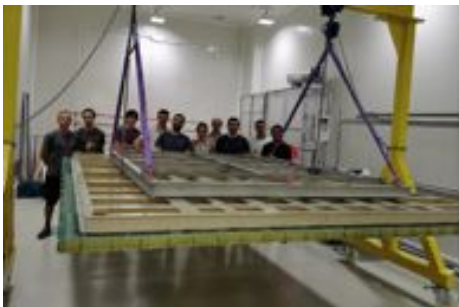ProtoDUNE-HD   ProtoDUNE-VD

ton-scale 2024-25

kton-scale 2025-27

France – VD detector contributions

6 CNRS labs + IRFU
~80 people

Signal feedthrough
chimneys

CRP structures

Assembly of top CRPs

+ contribution to PIP-II

Top drift charge
readout electronics

Electronics for photon
detection system
(Signal-over-fiber
transmission and reception)
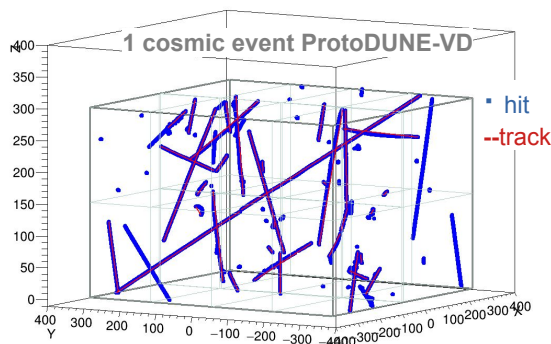
Funding from IN2P3/CNRS via IR*

France – Analysis contributions

6 CNRS labs + IRFU
~80 people

- Detector response (Simulation and ProtoDUNE + ColdBox data analysis)
  - CRP performance / transparency
  - field response
  - calorimetry (dE/dx)

1 cosmic event ProtoDUNE-VD

· hit
--track

  - convenership of ProtoDUNE-DRA [**L. Zambelli**]

- Statistical oscillation fit frameworks

- Neutrino interaction reconstruction
  - energy (tracks and showers), direction, vertex, charge tagging

- Atmospheric neutrinos
  - full analysis chain
  - coordination of AMA WG [**P. Granger**]

- Low-Energy studies
  - radiologicals
  - light simulation
  - use of PDS for physics (SN vertex)

Key points for discussion

DUNE will provide unprecedented results on neutrino oscillation parameters and has unique potential for many other physics topics (MeV neutrinos, BSM searches…)

DUNE is highly complementary to other experiments

An active prototype activity is ongoing, in particular at CERN (ProtoDUNEs, ColdBox, APEX…)

France provides key contributions to FD-VD, PIP-II and many analysis topics