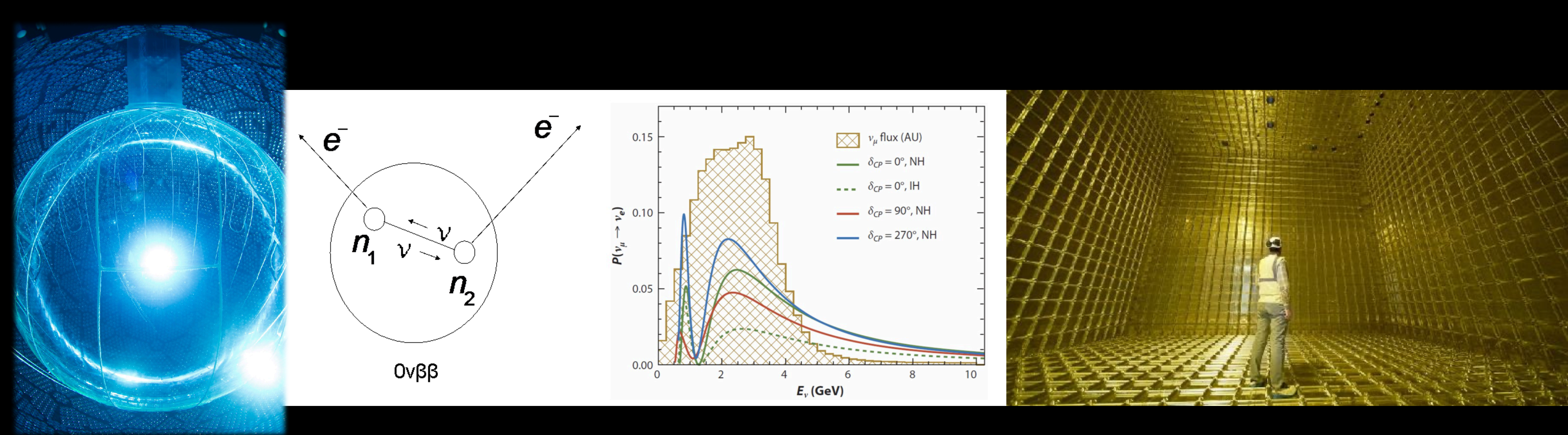




NEUTRINO PHYSICS

JOSÉ MANEIRA
FOR THE LIP
NEUTRINO PHYSICS GROUP

LIP ADVISORY COMMITTEE MEETING
LIP LISBOA, APRIL 23, 2025

LIP NEUTRINO PHYSICS GROUP

Senior Researchers



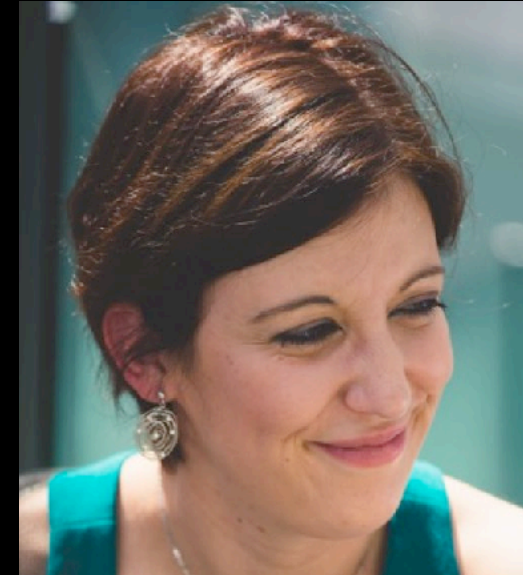
Sofia
Andringa



Fernando
Barão



Nuno
Barros



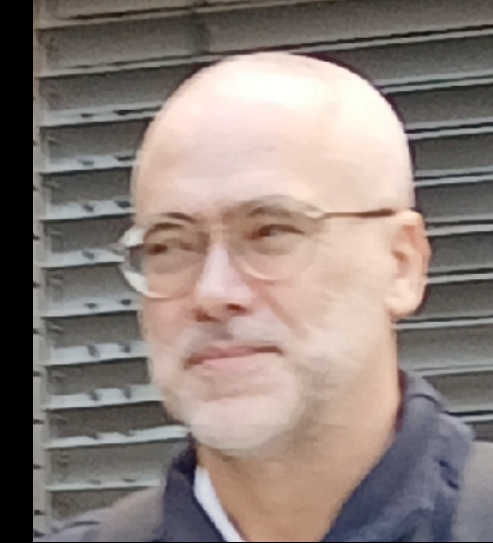
Valentina
Lozza



Amélia
Maio



José
Maneira



Francisco
Neves

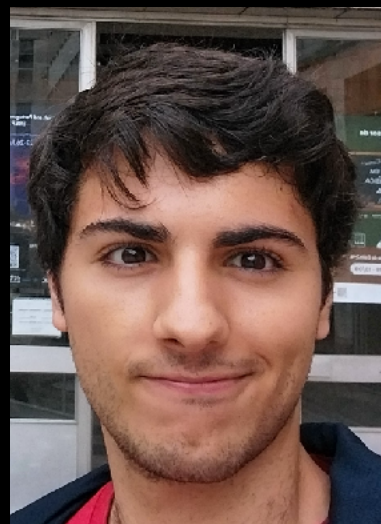


Vladimir
Solovov



Cristóvão
Vilela

Students



Manuel
Abreu



Tomás
Baltazar



Wallison
Campanelli



Joan
Kladnik



Beymar
Quenallata



Joana
Vences

GROUP OVERVIEW

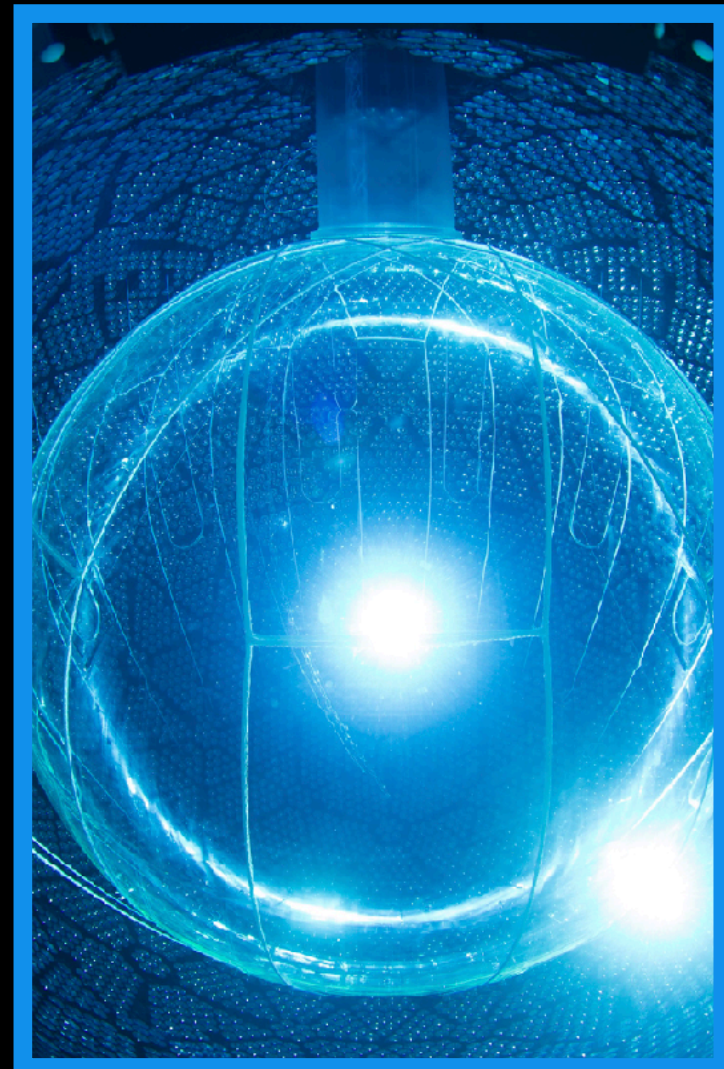
- Group structure
 - We are present in the Lisbon and Coimbra nodes, and participate in SNO+ and DUNE
 - Group PI: JM
- Funding:
 - Current, ending 2025:
 - PTDC for SNO+
 - CERN fund for DUNE
 - Applied to PTDC2023 for SNO+
- Students
 - Steady increase
 - Two ongoing PhD grants, just applied for two more
- Coordination responsibilities SNO+
 - VL: Analysis Coordinator, Backgrounds group, co-PI of PTDC project
 - NB: PI of PTDC project
 - SA: Antineutrino Physics group
 - JM: Double-beta decay group, Source Review Committee, Executive Committee
- Coordination responsibilities DUNE
 - JM: Calibration and Cryogenic Instrumentation consortium, Executive Board
 - NB: DAQ and Computing liaison of CALCI consortium, PI of FCERN project
 - FB: Bismuth sources group

HIGHLIGHTS

- SNO+ highlights 2024
 - Results and papers
 - New results in solar and reactor neutrinos, in water and scintillator phases
 - Second best Δm_{21}^2 measurement!
- DUNE highlights
 - Installation, operation of laser calibration system at ProtoDUNE-HD, CERN
 - First results!
 - Installation of laser system at PD-VD
- Conferences, etc (both)
 - Plenary talk + 2 posters at Neutrino 2024
 - +4 talks at Moriond, ICHEP, NNN24
 - +set of 5 lectures at SNOLAB

SNO+ TIMELINE AND PLANS

2017 2018 2019 2020 2021 2022 2023 2024 2025



Water phase

best invisible nucleon
decay limits; first
reactor $\bar{\nu}$ in pure water

Partial fill phase

solar ν directionality
reactor $\bar{\nu}$ in LS



Scintillator phase

reactor $\bar{\nu}$: 2nd world
measurement of Δm_{12}^2 ;
first solar CC on ^{13}C
low energy ^8B solar ν

SNO+ ANALYSIS COORDINATORS

WATER: NUNO BARROS

PARTIAL FILL, OVERALL (>2021): VALENTINA LOZZA



2026

2027

2028

2029

2030

2031

2032

Fill 0.5% Te

0.5% data

Fill 1.5% Te

1.5% data

Tellurium-loaded phases:

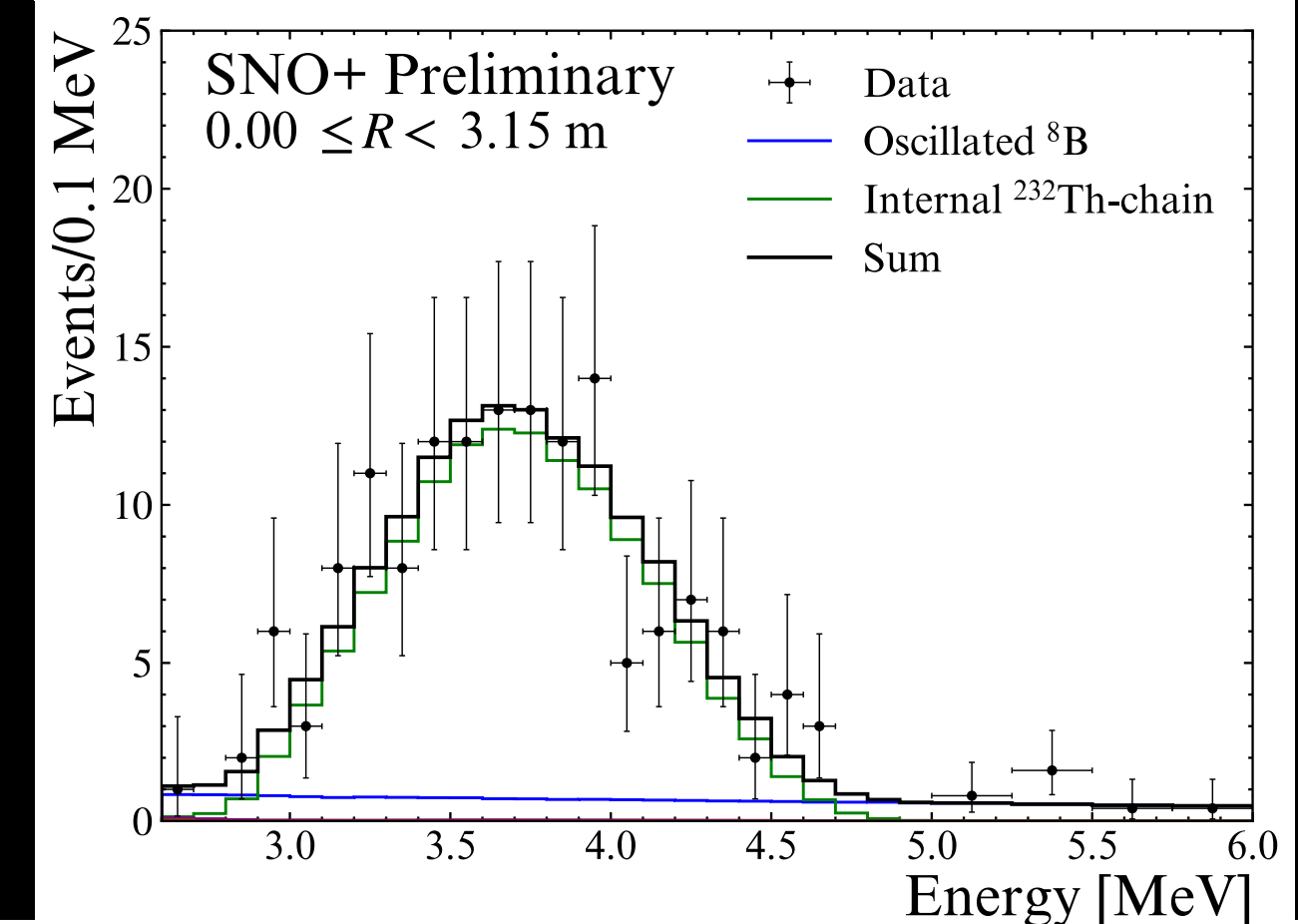
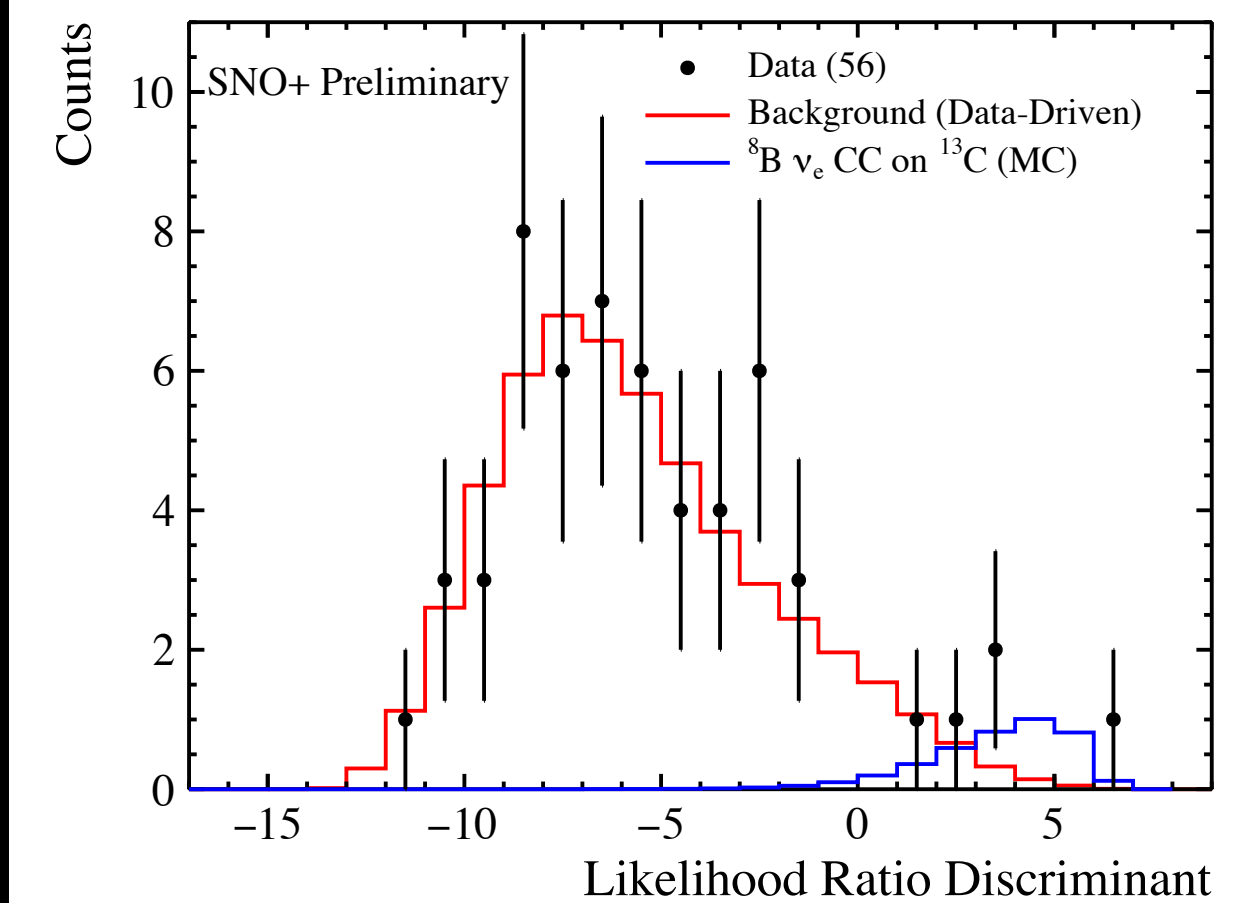
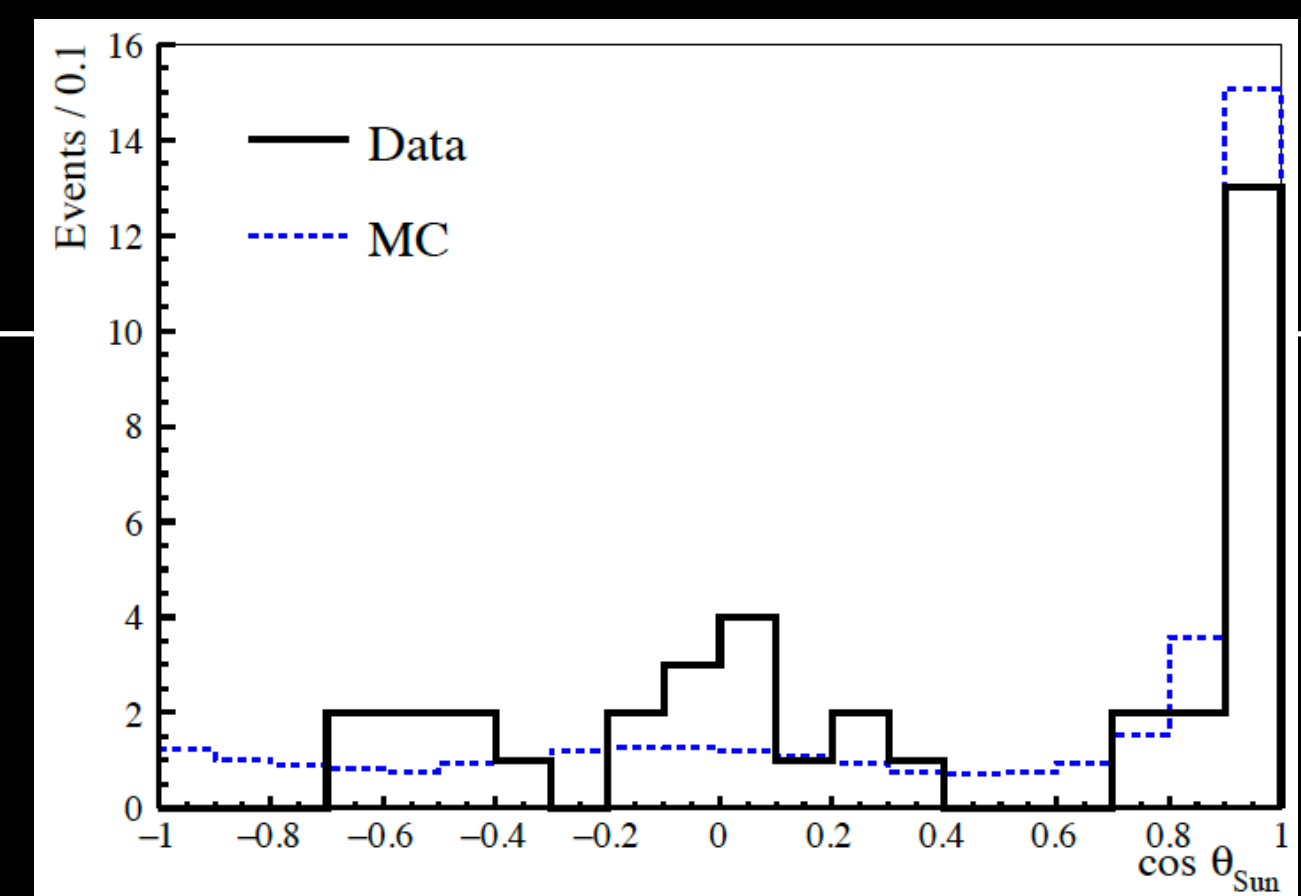
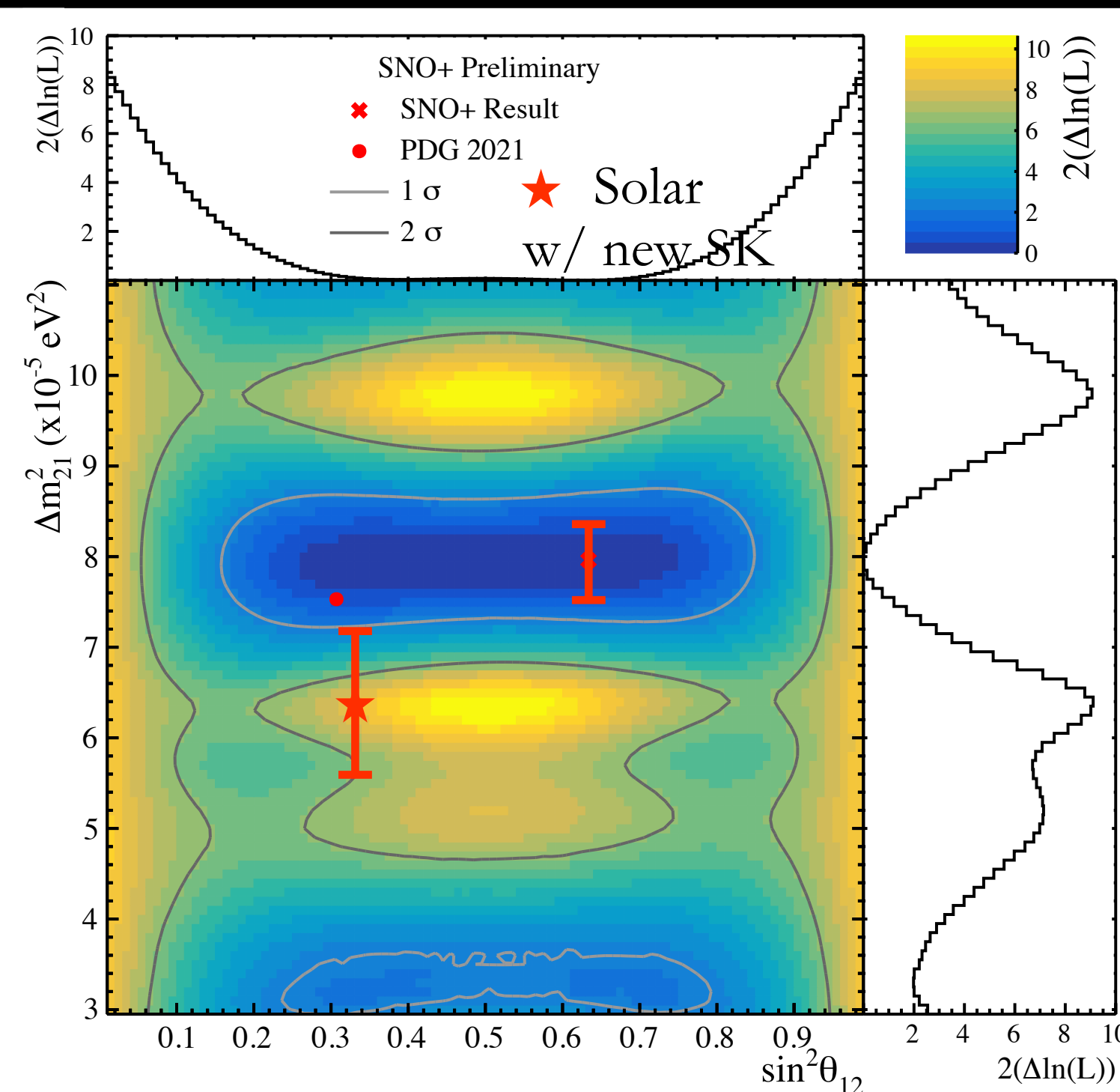
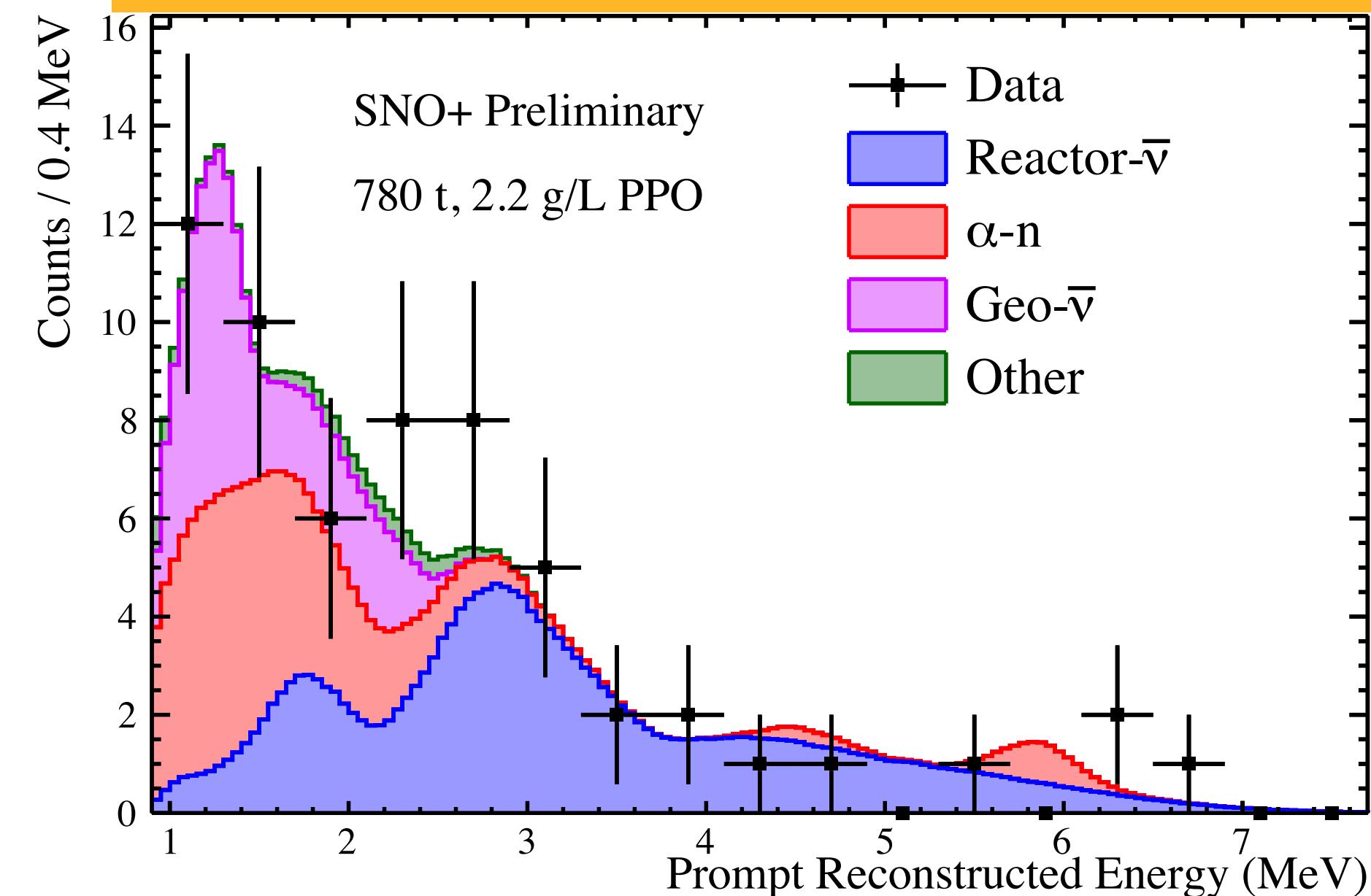
0.5%: best sensitivity to ^{130}Te $0\nu\beta\beta$ (2×10^{26} yr in 3 yrs)

1.5%: best sensitivity, any isotope (6×10^{26} yr in 5 yrs)

SCINT. PHASE PHYSICS

- Antineutrinos from reactors and Earth
- SNO+ Δm_{21}^2 data consistent with KamLAND, tension with solar
- Solar neutrinos
- Directionality in low-PPO phase, hints of (first) observation of ν_e CC interaction with ^{13}C , good prospects for ^8B meas. @ 2.5 MeV

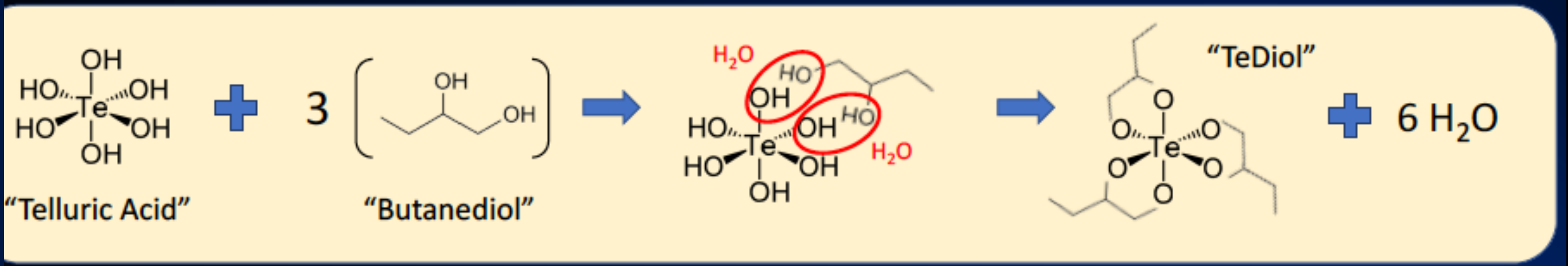
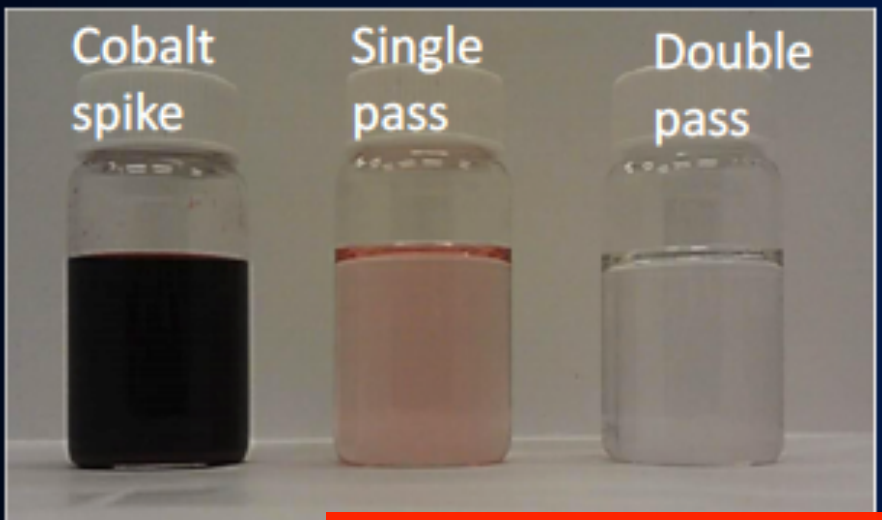
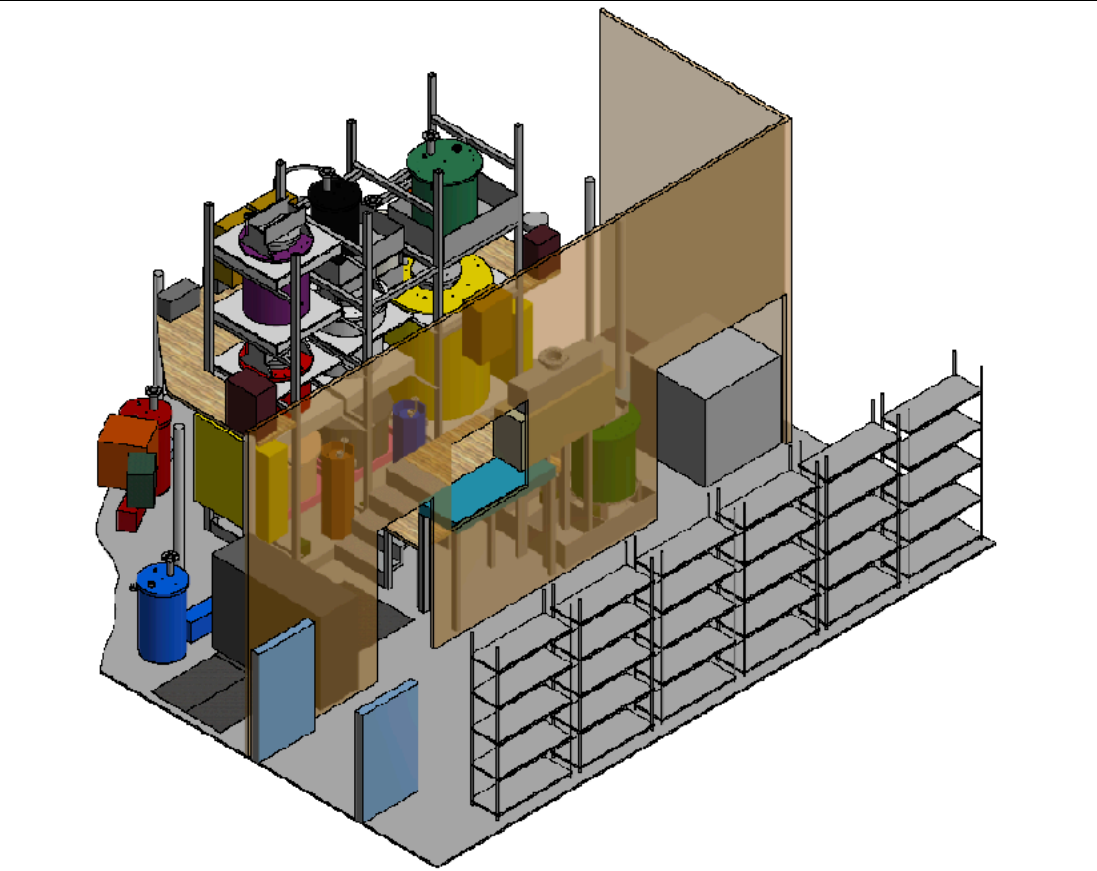
ANTINEUTRINO PHYSICS GROUP
LEADER: SOFIA ANDRINGA



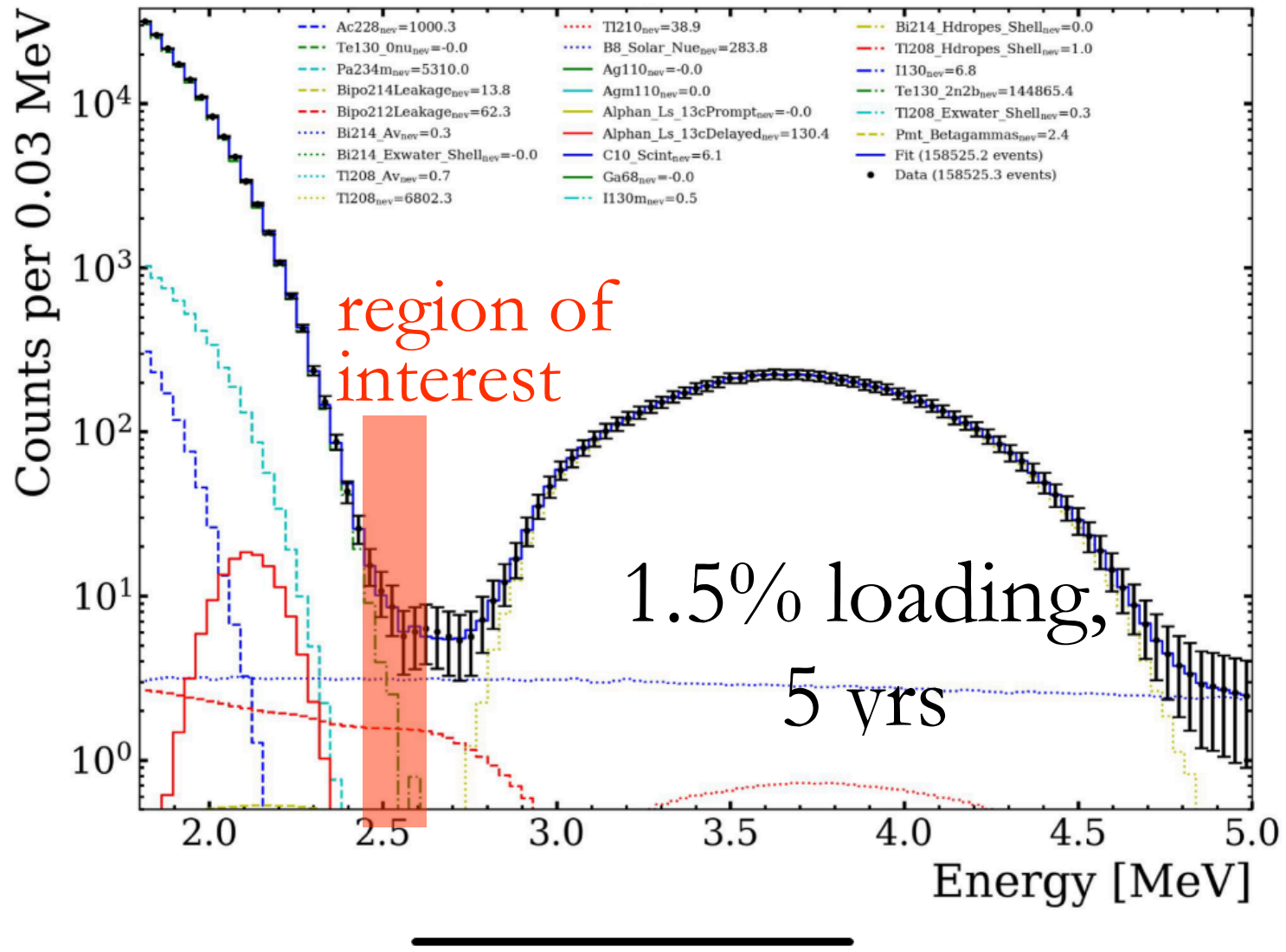
SNO+ WITH TELLURIUM

DOUBLE BETA DECAY
GROUP LEADER: JM

LIQUID SCINTILLATOR LOADING TECHNIQUE:
HIGH ISOTOPE MASS, LOW BACKGROUNDS

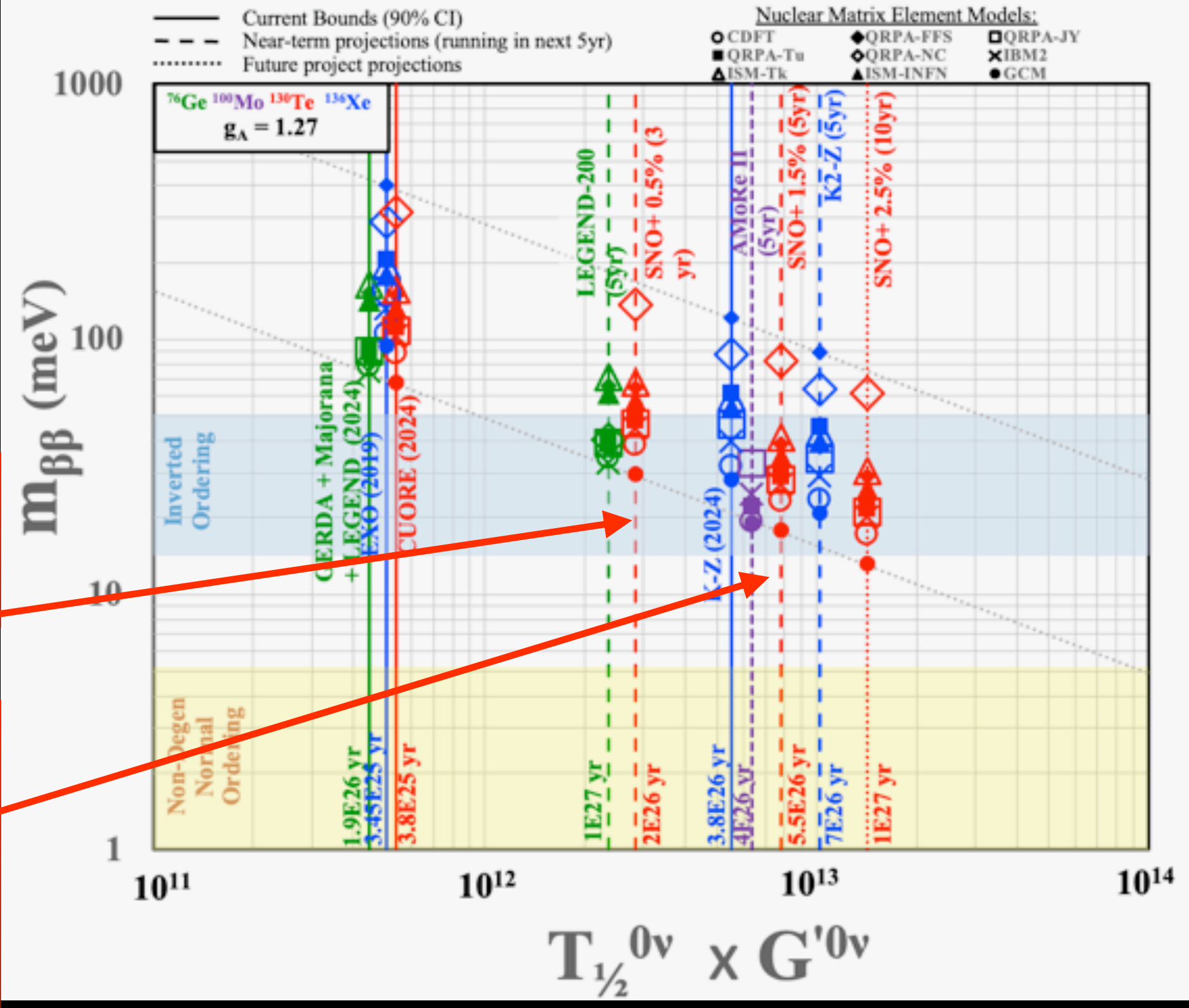


SNO+ DEVELOPED
TECHNIQUES FOR
TELLURIUM PURIFICATION
AND LOADING



0.5% LOADING: BEST ¹³⁰Te
SENSITIVITY

1.5% LOADING: WINDOW OF
OPPORTUNITY FOR BEST
SENSITIVITY, ANY ISOTOPE
(BEFORE "TON-SCALE")



DUNE TIMELINE AND PLANS



ProtoDUNE@CERN

installation

operation of PD Horizontal Drift

this year: PD Vertical Drift

Far Detector Construction
& Installation@SURF

start with FDVD, then HD

build laser calibration HW @ LIP

install at SURF in 2028/29

Physics

2029: live for

atmospheric, supernova

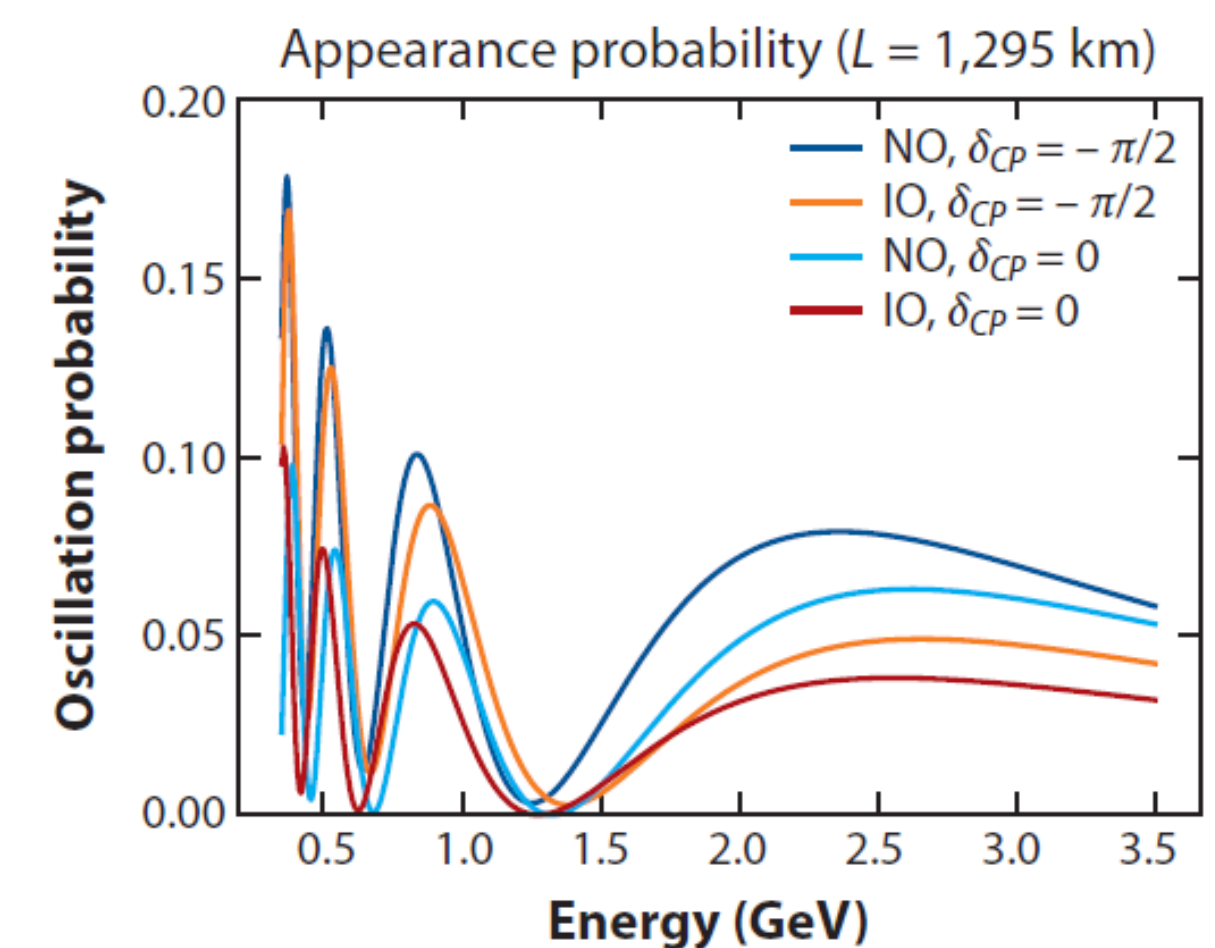
and solar neutrinos

2031: beam starts!

LASER TENTS

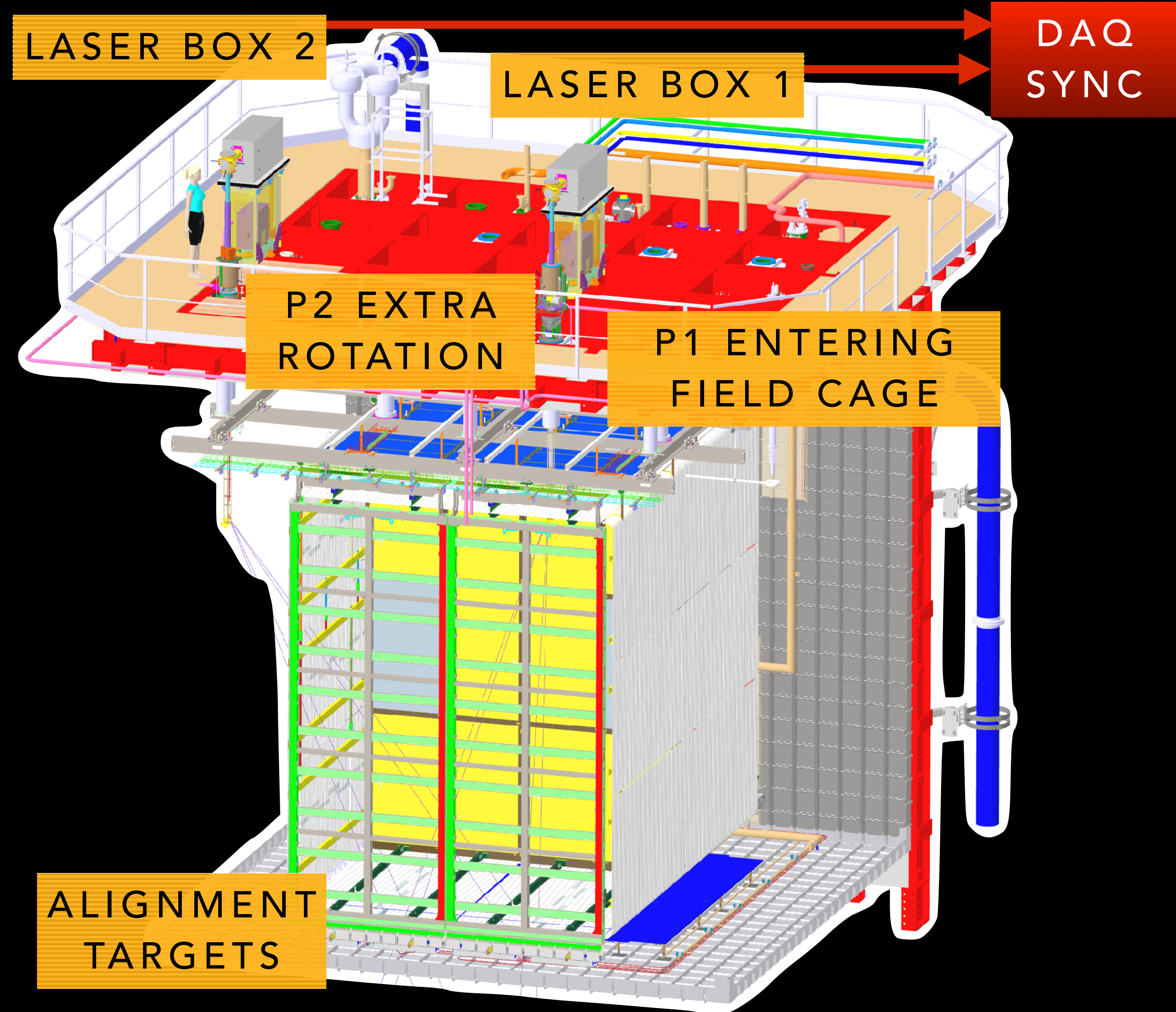
PDVD

PDHD



LASER CALIBRATION FOR PROTODUNE

- Several improvements for DUNE
 - Periscopes entering field cage (P1)
 - External periscopes with extra movement (P2)
 - Alignment targets: PIN diodes, mirrors
 - Integration with DAQ
- Goals
 - Map space-charge distortions
 - Measure detector misalignments
 - Characterize charge collection in APAs
 - Characterize electron lifetime



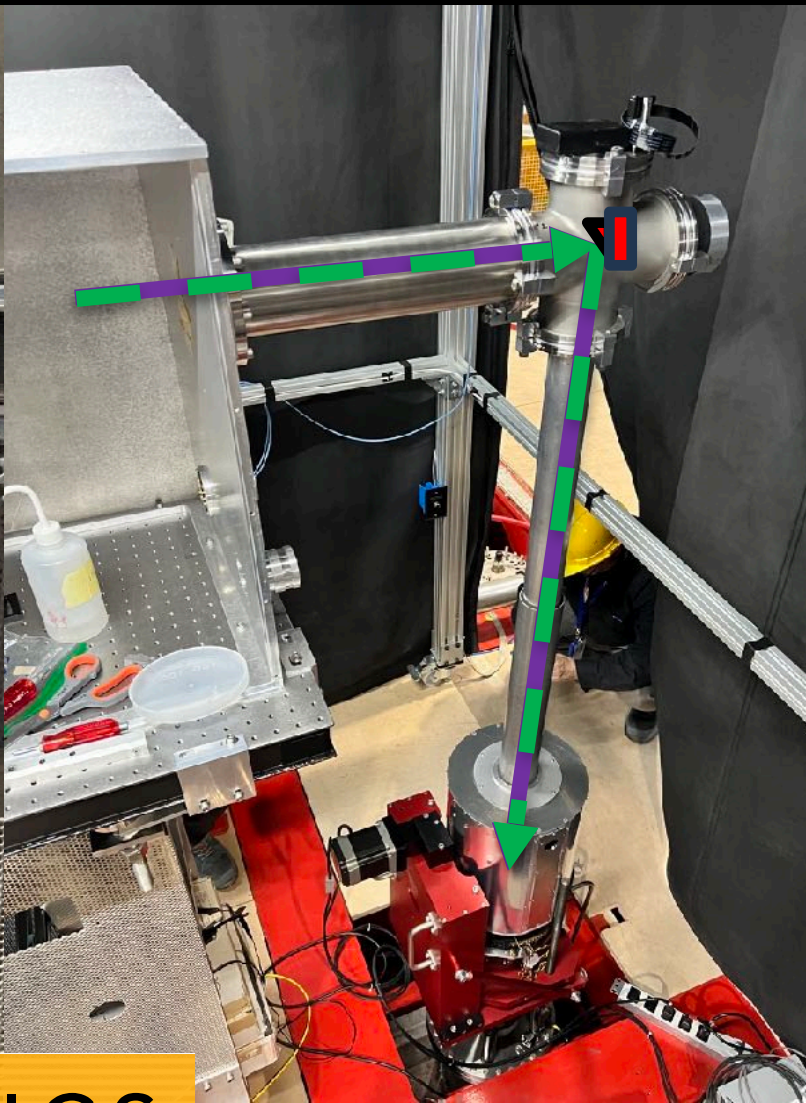
SYSTEM COMPONENTS, PD-HD

Laser box + Electronics

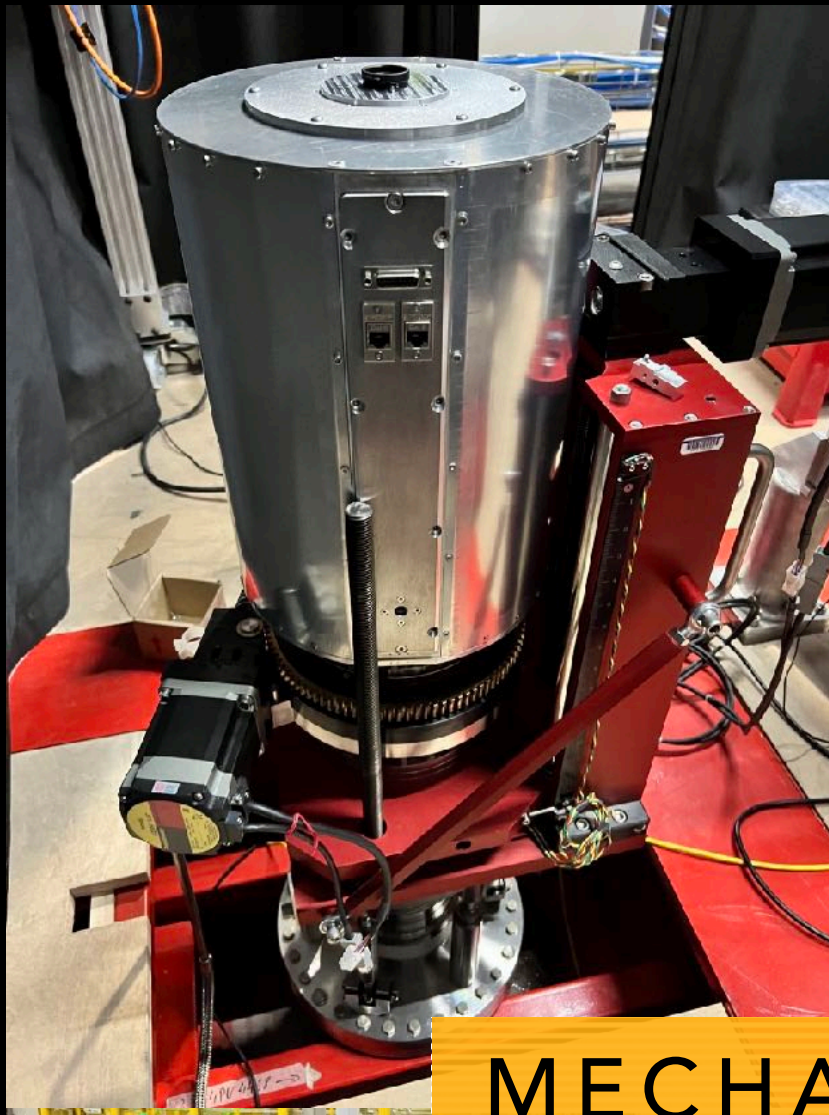


DAQ INTERFACE ELECTRONICS
BY NUNO BARROS

Connections



Cryostat feedthrough

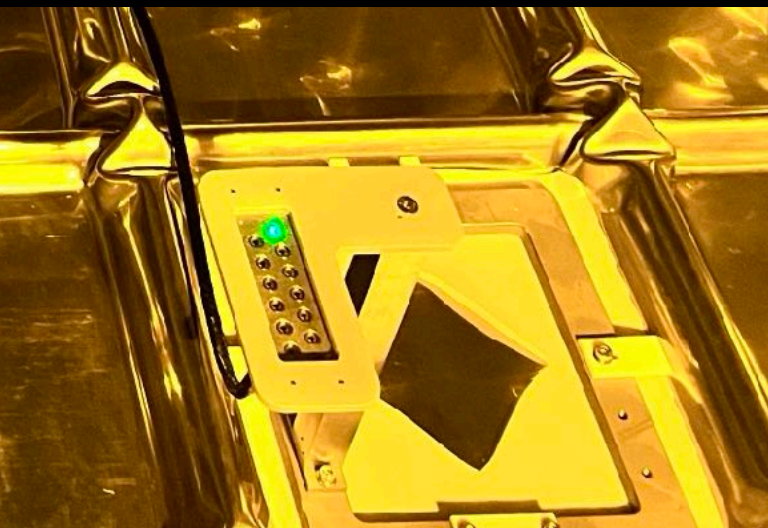


Periscope

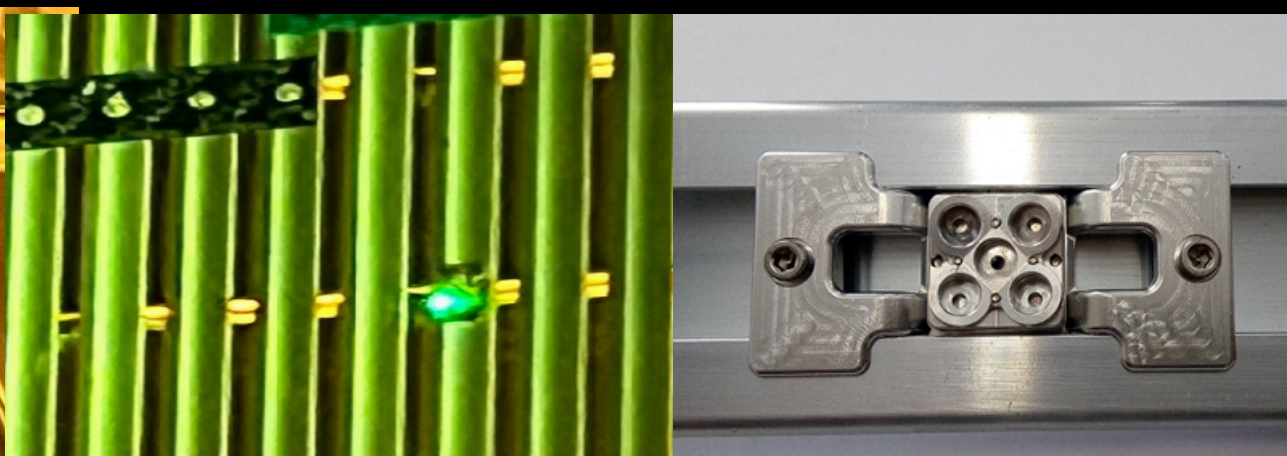


MECHANICAL DESIGN:
RUI ALVES, JM

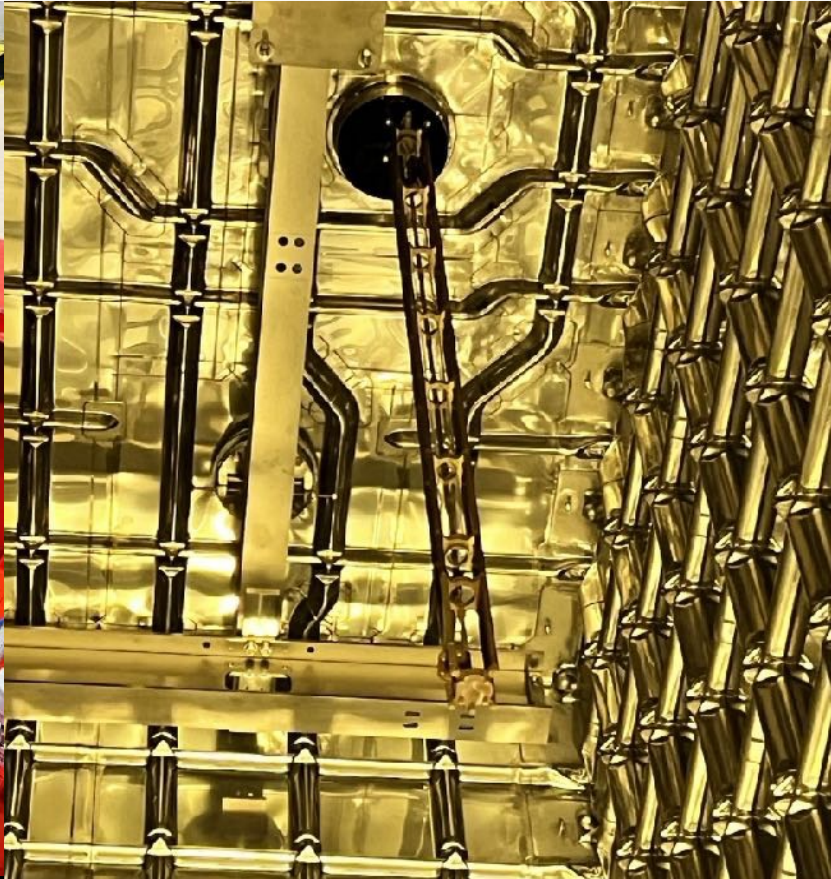
Targets: PIN diodes



Mirror pads



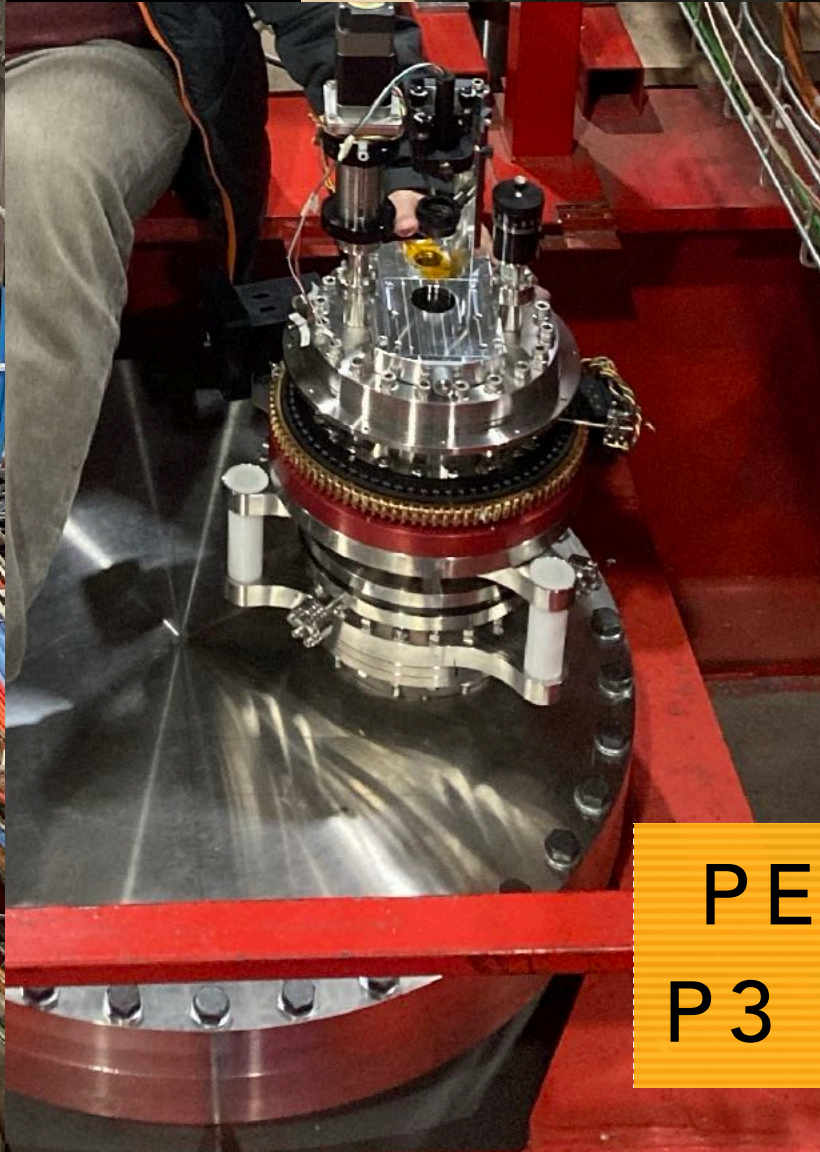
FRANCISCO NEVES, JM



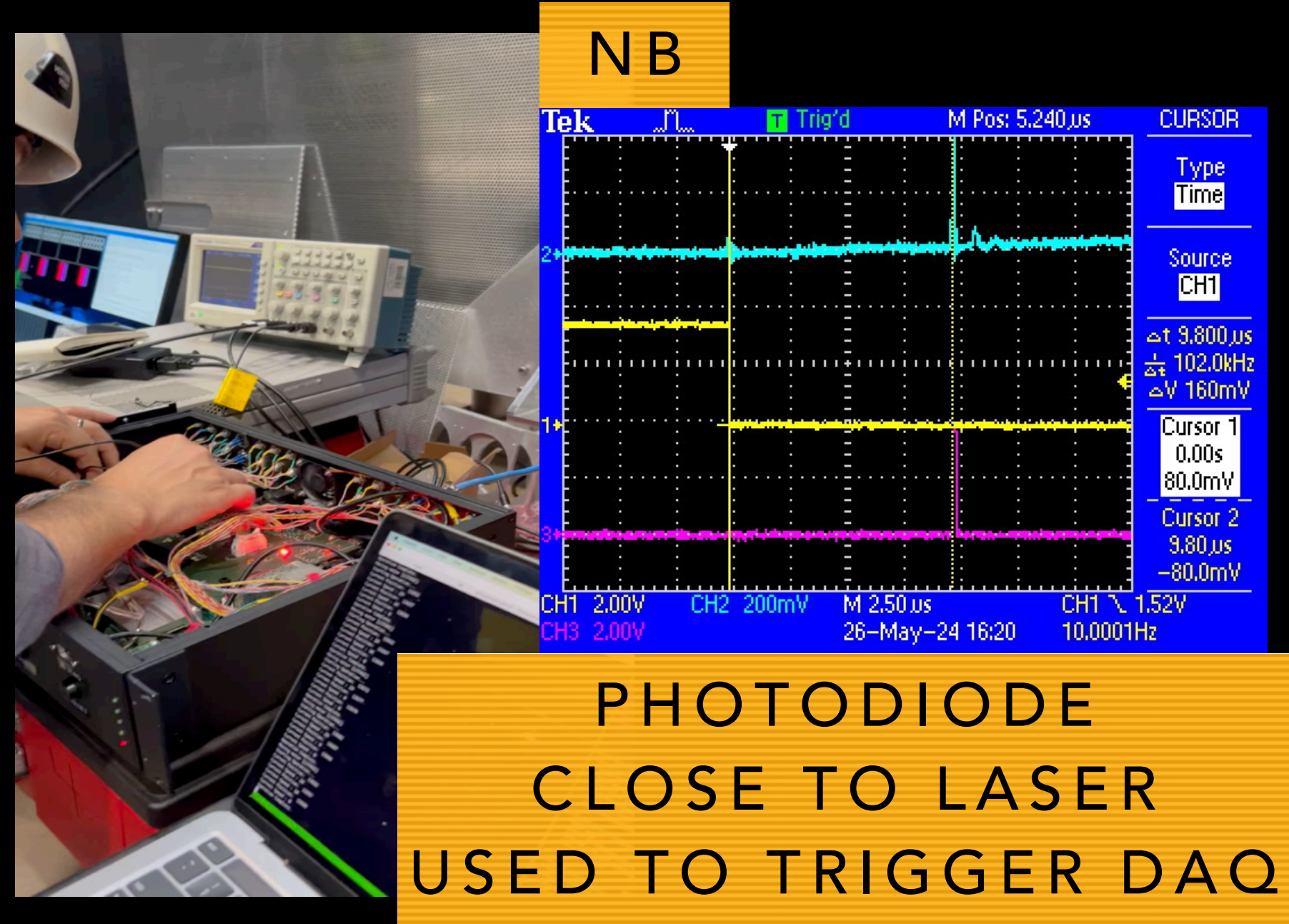
P1 enters top of field cage P2 Outside field cage

ASSEMBLY, INSTALLATION

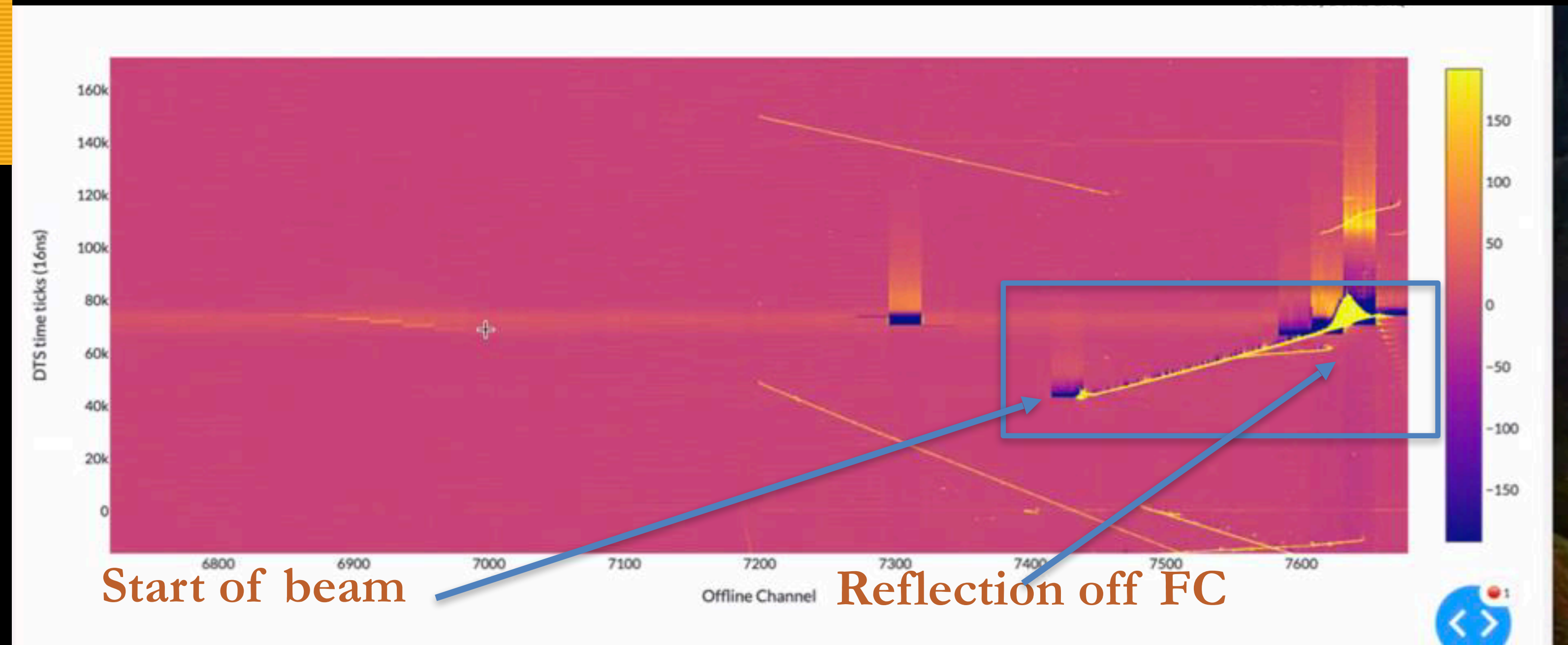
by LIP and Los Alamos team



COMMISSIONING/FIRST DATA



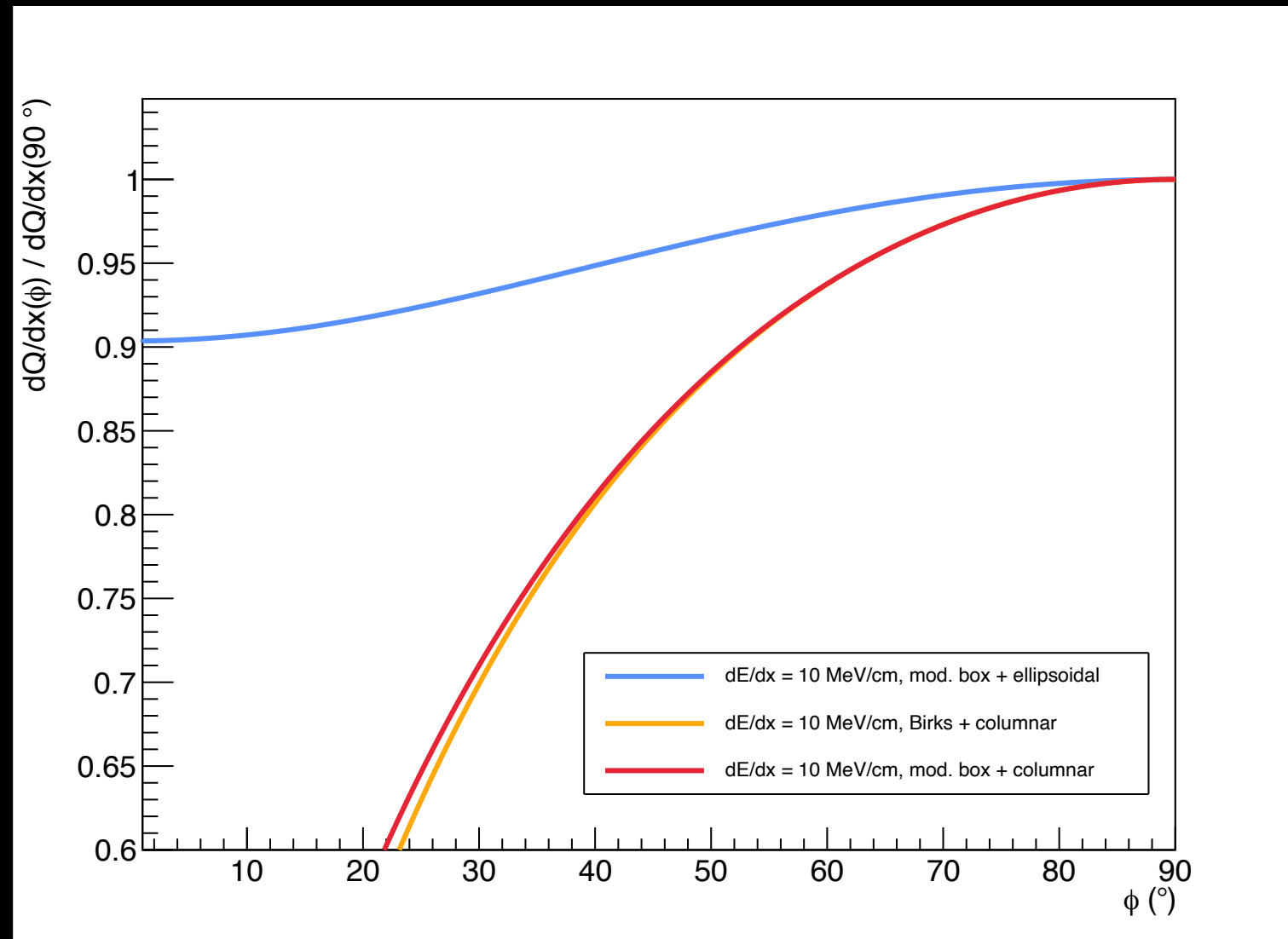
- First laser tracks in the ProtoDUNE: June 1
- Integration and commissioning was large job by several people from LIP and LANL
- First tracks with laser-triggered DAQ in September
- GUI integration October - November



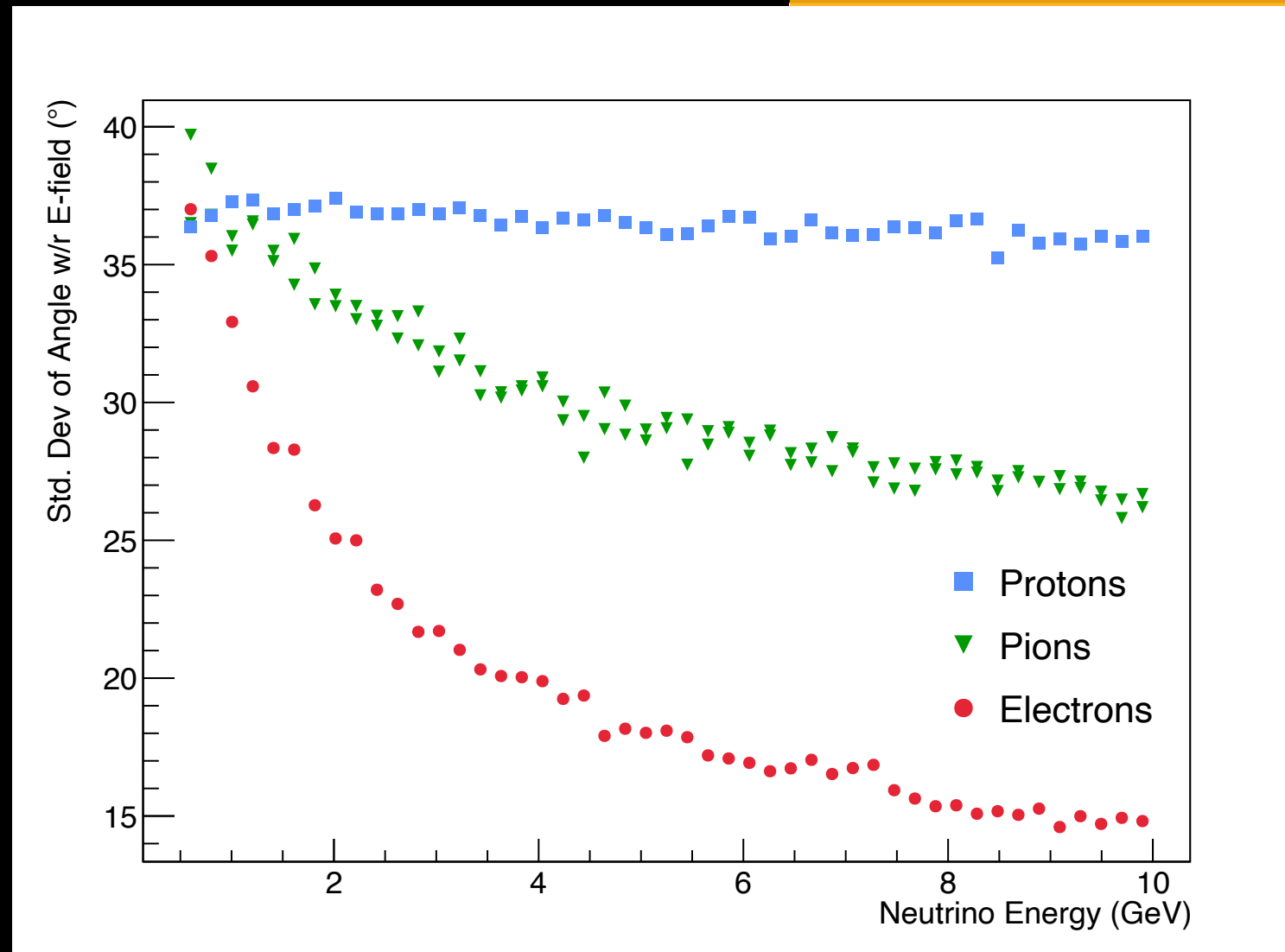
PHYSICS STUDIES

- Impact of angular-dependent recombination on energy reconstruction

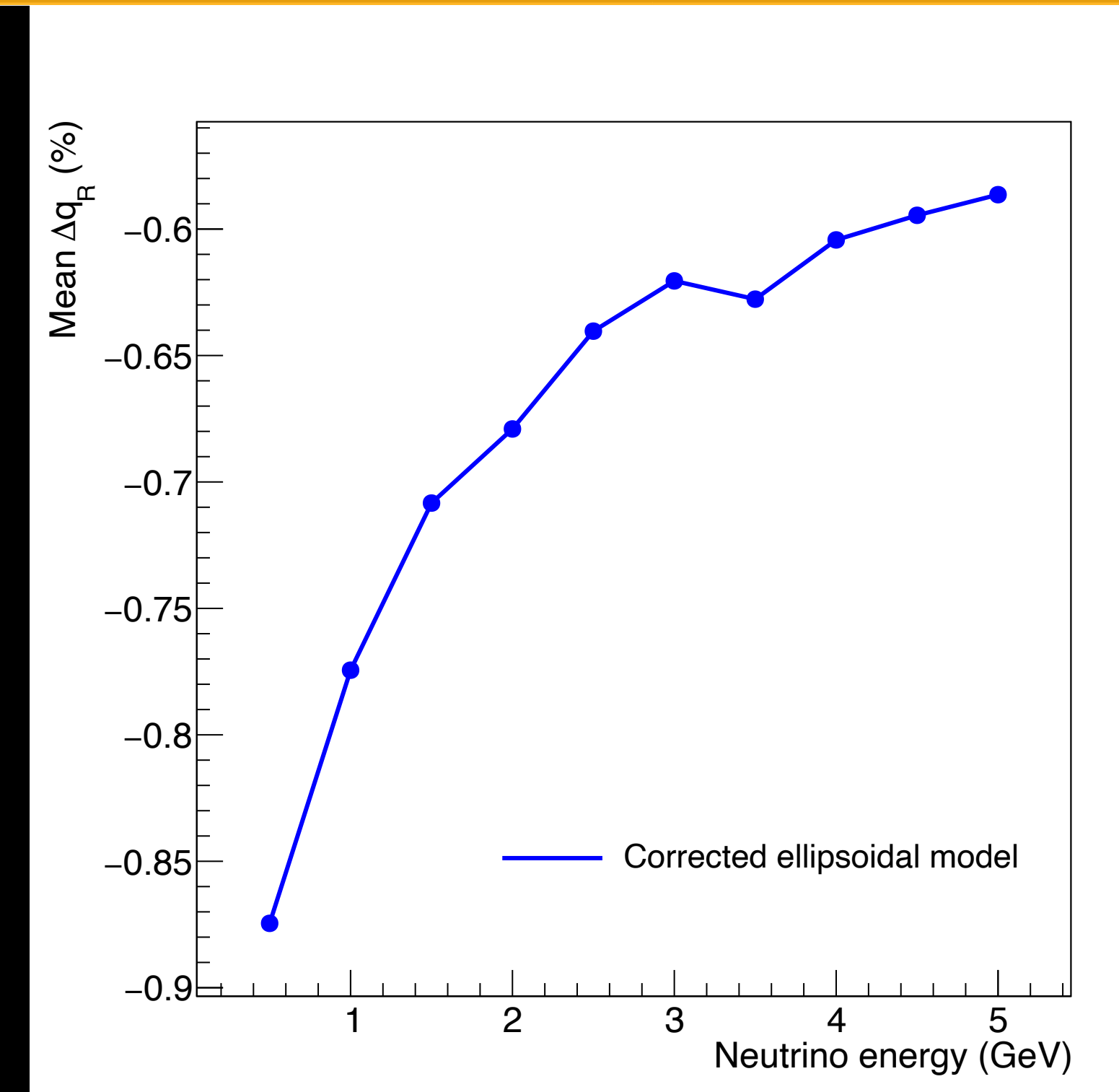
JOANA VENCES, CRISTÓVÃO VILELA, JM



Electron-ion recombination depends on angle w/ electric field latest ICARUS results show small but non negligible effect



Electron kinematics electron from low energy neutrino interaction have wider angular distributions



Energy bias

If effect not corrected, bias between -0.6% and -0.9%

NEXT STEPS

- SNO+
 - Full analysis of antineutrino data, before JUNO...
 - Careful analysis of scint. data before loading Tellurium
 - Contribute to DBD and solar data analysis
- DUNE
 - Operation of ProtoDUNE Vertical Drift calibration system
 - Laser data analysis
 - Bi source data analysis
 - Construction of far detector VD laser system
 - Ramping up of physics analysis: FD systematics
 - Increase collaboration with Campinas (Brazil)

SWOT

- STRENGTHS

- Experienced group with very complementary skills
- Many responsibilities within the two collaborations

- WEAKNESSES

- 0 postdocs
- 2 PhD students, still needs to increase

- OPPORTUNITIES

- Both SNO+ and DUNE have data to analyse, good for students
- After intense year for ProtoDUNE laser system, road ahead is clearer

- THREATS

- Uncertainty in national funding
 - >1 yr delay in PTDC result, FCERN not annouced yet
 - End of dedicated PhD calls
- Instability in international science funding, esp. USA