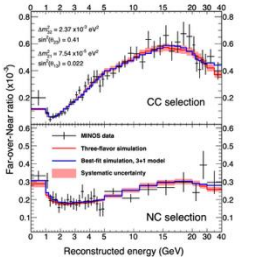
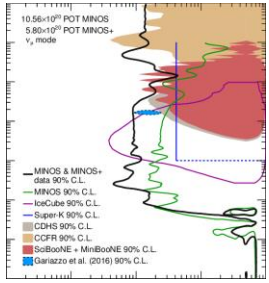
DUNE Efforts at IIT Kanpur

Navaneeth Poonthottathil,
IIT Kanpur
DUNE-India meeting, TIFR
06th June 2025

IIT Kanpur Neutrino Research Group & SSCD Lab

Navaneeth Poonthottathil,
Ph.D. – MINOS Experiment
(Sterile neutrino Search)
Graduate Students:
Mudit Kumar
Anuj Gupta
Postdoctoral Researcher:
Sarath Nelleri *(2023–2025)*





Solid State Circuit Design Lab

Faculty

The following faculty members work full-time on integrated circuit design.

Chithra

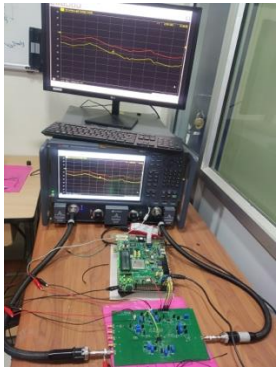
Imon Mondal

R.S. Ashwin Kumar

Solid-State Circuit Design Lab SSCD at IIT Kanpur

Procure VMM3a Chips and Test Boards:

- Obtain existing VMM3a test board or its design files for fabrication (chip from Vitaliy)
- Plan to print test board at IIT Kanpur's facilities in future (facility will be functional by end of this year – NMTronics)

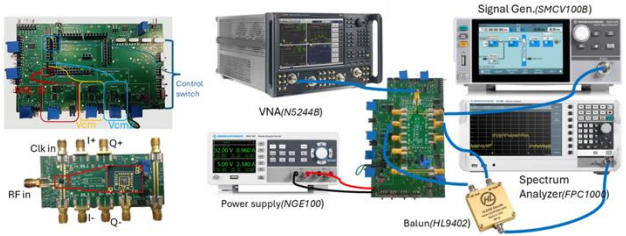


•Initial Testing Phase:

- Set up test environment using VMM3a chips and test board.
- Evaluate performance under STT conditions: Timing resolution (target: time resolution few ns , and ≤200 μm spatial resolution) and charge measurement accuracy.

•ADC Design Improvement:

- Address VMM3a's ADC limitations (e.g., time resolution).
- Develop hybrid readout using VMM3a's direct analog output with an external ADC:



Supernova Detection and Pointing

- DUNE, mostly sensitive to electron neutrinos, accounting for > 90% of detected events can provide an early update.

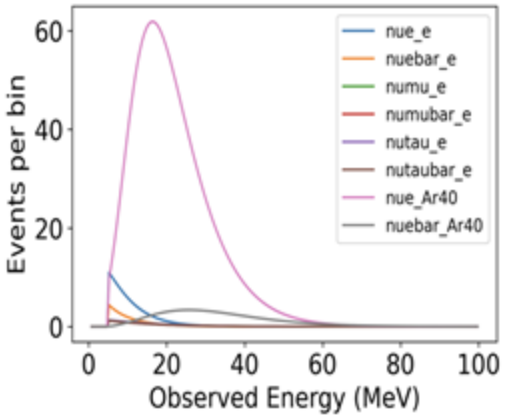
- Neutrino Interaction Modes:

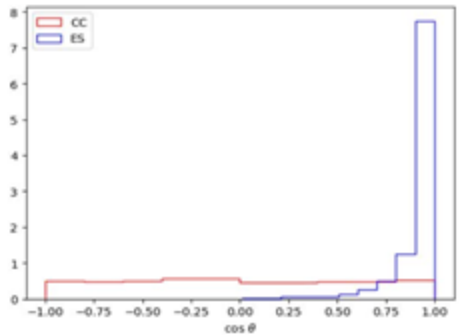
$$\nu_e + Ar^{40} \rightarrow e^- + {}^{40}K^* \Longrightarrow \text{CC}$$

$$\nu_e + e^- \rightarrow \nu_e + e^- \Longrightarrow \text{ES}$$

In CC interactions, the electron's direction correlates weakly with the neutrino direction due to competing nuclear transitions (Fermi and Gamow-Teller).

ES events carry directional information





ProtoDUNE - VD commissioning Efforts

- The major difference between Top and Bottom CRPs is the sampling frequency.
- Top CRPs will take data at a sampling rate of 2MHz = 500 ns
- Bottom CRPs will take data at a sampling rate of 1.953125 MHz , 1 tick = 512 ns (need resampling)

Cross Sections of Hadrons on Argon

- Thin slice method for cross section measurement.
- Example: 1 GeV charged pion inclusive cross section on Argon.

ProtoDUNE measures cross sections of test beam particles on argon nucleus and improve our understanding on FSIs.

Conclusion - IIT Kanpur – DUNE Contributions

Group Involvement

Neutrino Research Group and Solid-State Circuit Design Lab (SSCD) at IIT Kanpur will focus on future ADC ASIC design for STT

- Testing VMM3a chip for STT: targeting good spatial and time resolution
- In-house fabrication of test boards (by end of this year) and design inbuilt ADC

Physics Analysis

Enabling supernova detection and pointing via CC and ES interactions.

- Machine learning Techniques for identifying CC and ES
- Correlating the nuclear transition Fermi and GT with CC interaction
- Increase statistics for pointing studies

ProtoDUNE –VD Physics

Contribute to FD2-VD commissioning and expand ProtoDUNE-VD efforts.

- Integrate resampling for unified waveform processing form top and bottom electronics
- Measurements of hadron–argon cross-section measurements in VD to improve FSI modeling.

Thank you!