SBND
Liverpool contributions
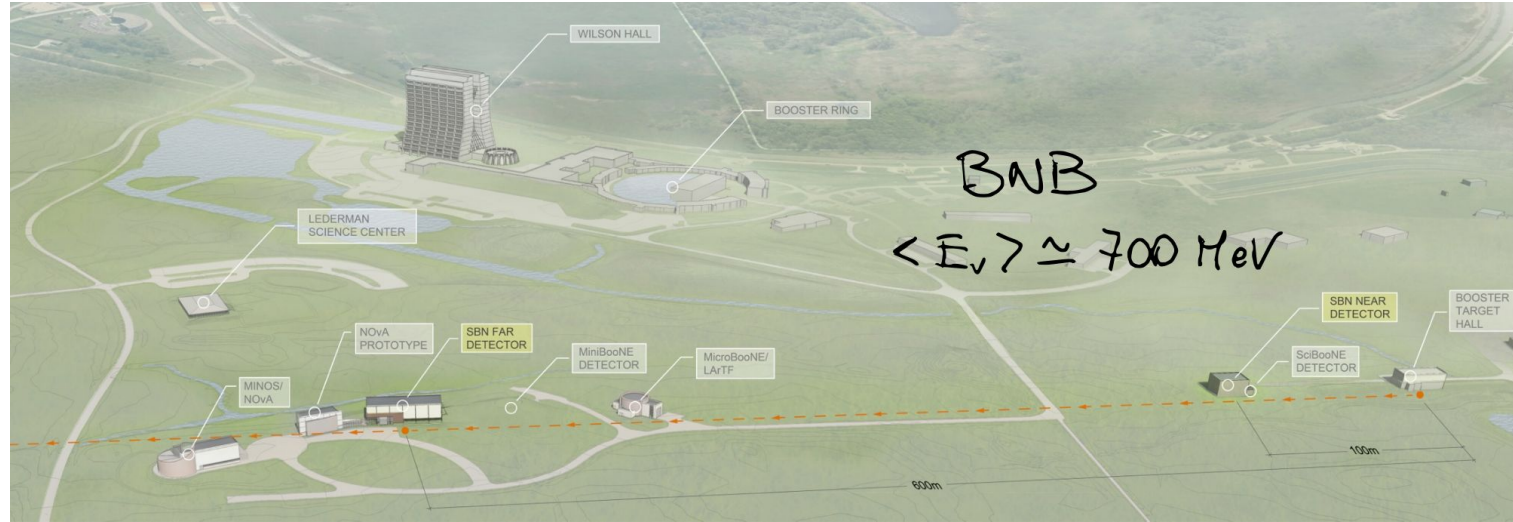
Marco Roda

HEP annual meeting - part 2
29 April 2021

Liverpool SBND group: Costas Andreopoulos (IB), Jaggar Henzerling, Rhiannon Jones, Kostas Mavrokoridis, Neil McCauley, Dave Payne, Adam Roberts, Marco Roda, Peter Sutcliffe, Julia Tena-Vidal, Christos Touramanis
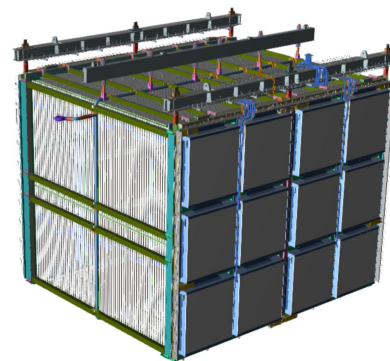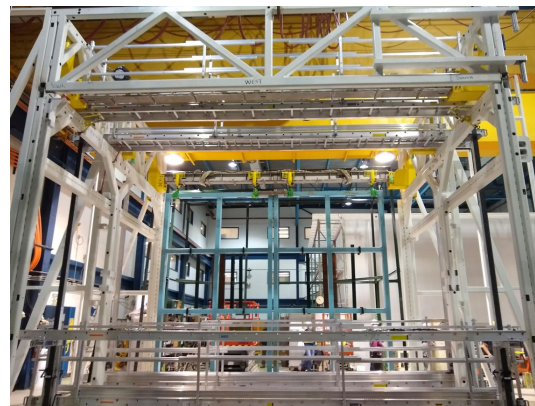
SBND as a near detector for the SBN program

- Short baseline - 600 m - SBND is at 110 m from the target
- 3 LAr TPC experiments: SBND, MicrobooNE and Icarus
- Main goal: Search for sterile neutrino via oscillations
    - neutrino data in the TPC expected in late 2022

Status - assembling a detector during pandemic

- Lots of different area relatively in parallel
  - Cryostat
    - External layers completed
    - work on surrounding infrastructures
  - Cryogenics
    - This is its year
  - TPC Assembly
    - So far tests - Rhiannon Jones
    - assembly begins this year
    - Cathode plane - Kostas Mavrorkoridis, David Payne, Peter Sutcliffe
  - DAQ
    - Crates completed
      - It does not mean job done
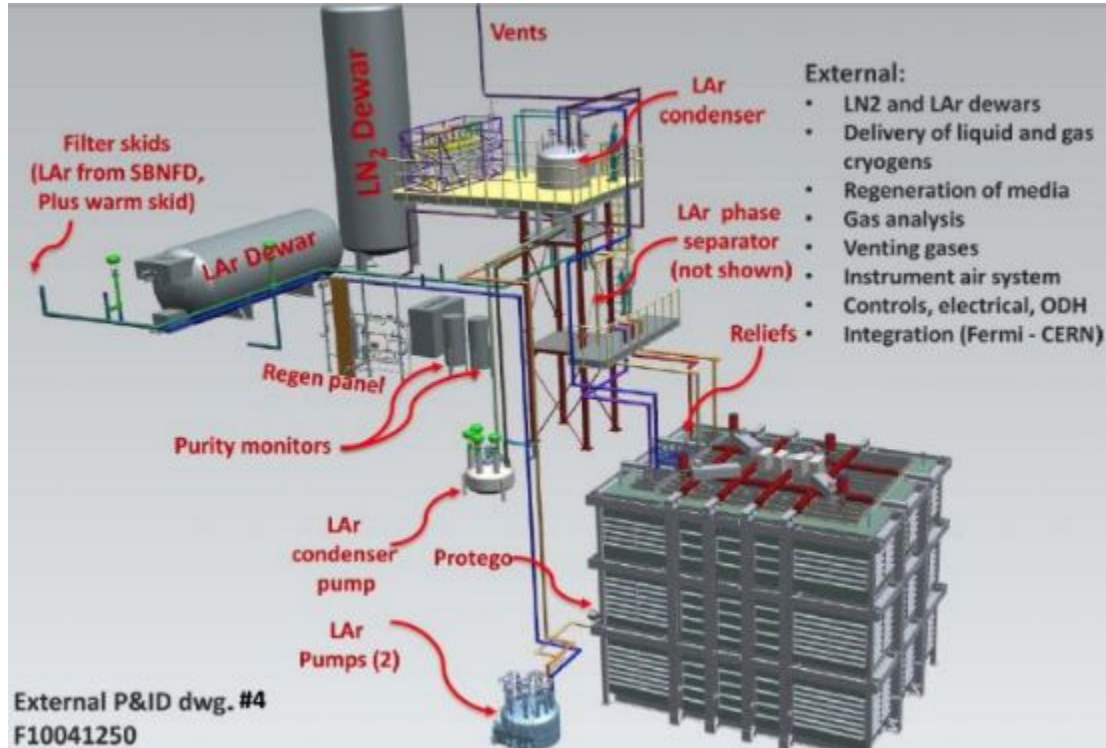   - Already taking CRT data

Status - Before pandemic

Completed cryostat

DAQ racks in the background

Status - a few pictures

Filter skids
(LAr from SBNFD,
Plus warm skid)

LN₂ Dewar

LAr Dewar

Vents

LAr condenser

Regen panel

Purity monitors

LAr condenser pump

Protego

LAr Pumps (2)

Reliefs

LAr phase separator (not shown)

External:
- LN2 and LAr dewars
- Delivery of liquid and gas cryogens
- Regeneration of media
- Gas analysis
- Venting gases
- Instrument air system
- Controls, electrical, ODH
- Integration (Fermi - CERN)

External P&ID dwg. #4
F10041250

@ CERN, ready to be shipped

5

Physics package

- 1 eV sterile neutrino search
  - Long lasting puzzle that needs a solution before DUNE searches for Lepton CP violation

- Neutrino Cross section measurements on Argon
  - Unmatched mix of statistics and resolution
  - Data will become a legacy for the whole community

- Beyond standard model physics
  - Many explanations for MiniBooNE electromagnetic excess
    - Fermilab theory group very active and engaging with SBN people

- Detector physics performance useful in preparation for DUNE

Analysis structure and Liverpool's roles
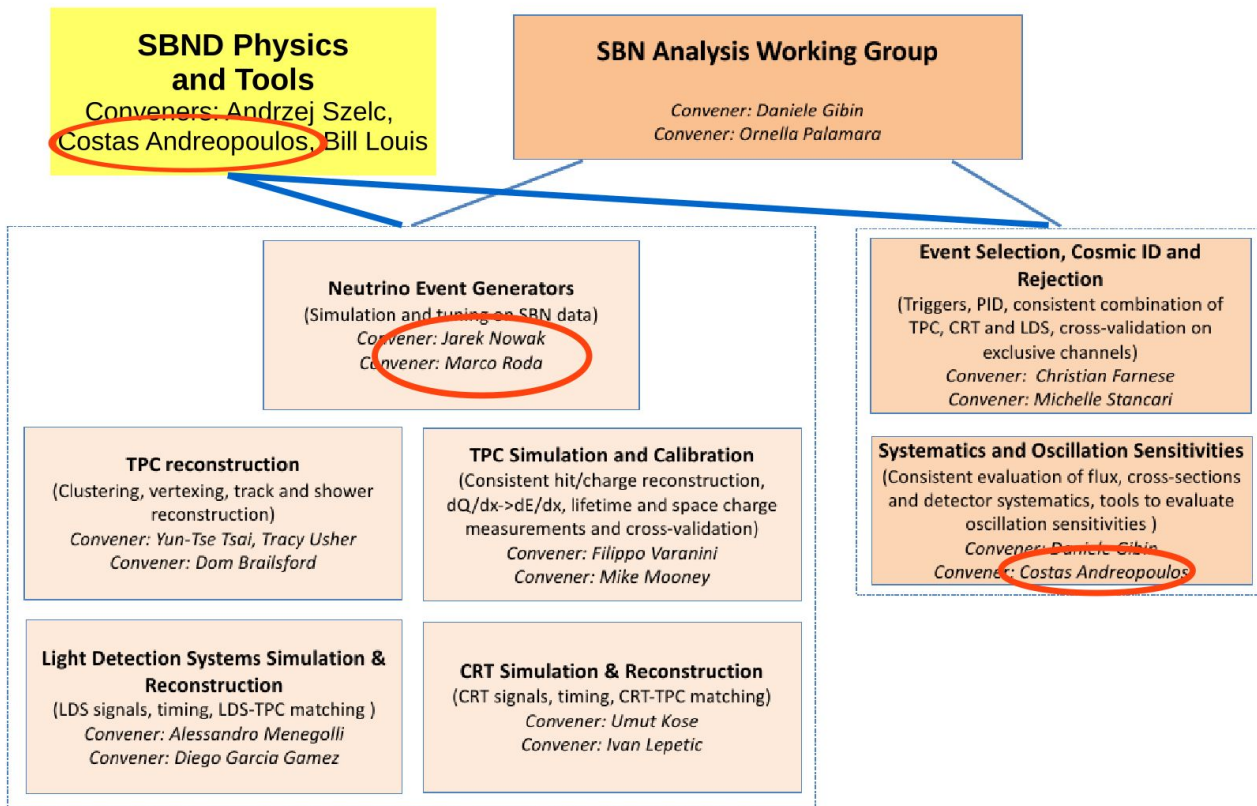
- Structure of the analysis organisation
  - Organised at the SBN program level
  - Structure re-adopted internally in SBND

- Liverpool has two convenerships
  - Systematic and oscillation
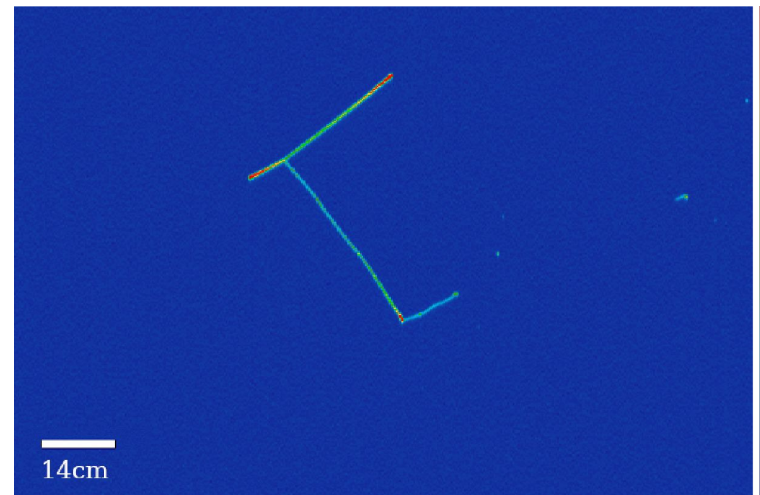 - Generators

Oscillation analysis

- A number of different analyses
  - muon disappearance (Rhiannon Jones)
  - electron appearance (Thomas Ham)
  - Inclusive samples so far versions

- Systematic studies have a specific place
  - On top of sensitivity analyses
  - Mock data studies (Rhiannon Jones)
    - To check the model dependencies
  - Model extensions and tuning (Julia Tena-Vidal)
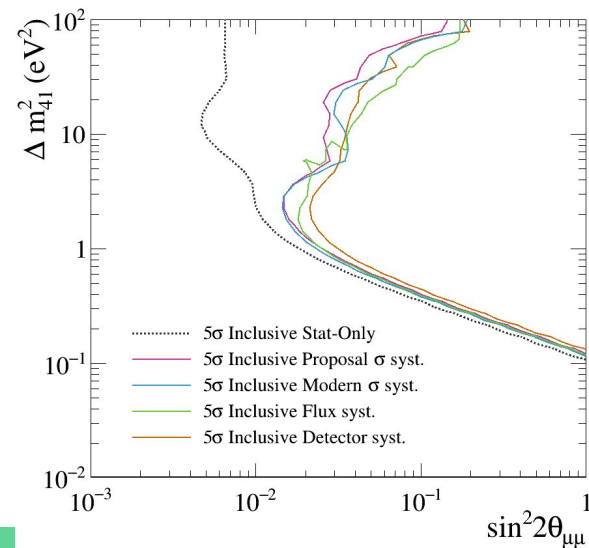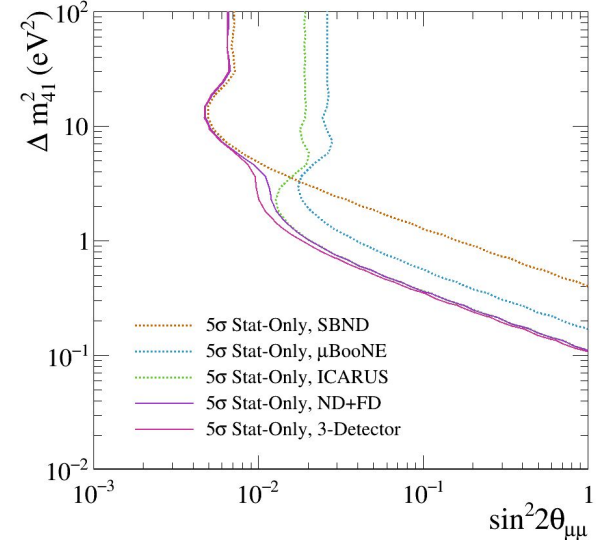
Event Reconstruction in Liquid Argon

- Event reconstruction is one of the technical challenges of LAr TPC technology
  - It has to be automatic
  - deal with a lot of information

- Liverpool group is involved in these activities
  - Rhiannon Jones
    - Implemented the first selection tool available for the Collaboration
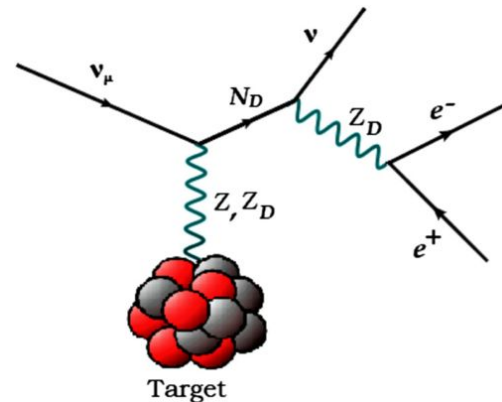 - Jaggar Henzerling
    - selection tools based on Machine learning

14cm

Example of 2p2h event
- 2 protons (back to back)
- 1 muon ➜ electron

BSM physics

- Models are required to be added to generators (M. Roda)
  - In order to make sensitivity analyses for BSM physics

- So far focus on the Dark neutrino sector
  - Heavy neutral lepton O(100 MeV)
  - coupling with a light neutral boson O(10 Mev) - also coupling with EM charge
  - Neutrino interactions producing electron-pairs from the decay of the dark neutrino
  - Dominant scattering type is coherent interaction

$$\nu_\alpha = \sum_{i=1}^{3} U_{\alpha i}\nu_i + U_{\alpha 4}N_{\mathcal{D}}, \quad \alpha = e, \mu, \tau, \mathcal{D}$$

$$\mathcal{L}_{\mathcal{D}} \supset \frac{m_{Z_{\mathcal{D}}}^2}{2} Z_{\mathcal{D}\mu}Z_{\mathcal{D}}^\mu + g_{\mathcal{D}}Z_{\mathcal{D}}^\mu \bar{\nu}_{\mathcal{D}}\gamma_\mu \nu_{\mathcal{D}} + e\epsilon Z_{\mathcal{D}}^\mu J_\mu^{\mathrm{em}}$$
$$+ \frac{g}{c_W}\epsilon' Z_{\mathcal{D}}^\mu J_\mu^Z,$$

Proposed Plans

- Commissioning
  - With the start of operations Payne will move full time to FNAL
    - As run coordinator

- Analysis
  - Costas will continue coordinate the overall SBN oscillation analysis effort
  - Marco will keep acting as Physics Generators WG convener
  - Main goals
    - joint analyses of different SBN exclusive channels
    - Extend the neutrino-argon interactions cross section measurements
    - support the development of appropriate theoretical model uncertainties

Conclusions

- You have seen a quick overview of the SBND experiment
  - Status
  - Liverpool contributions

- Delayed due to pandemic
  - work is proceeding
  - We published the first 2 SBND Collaboration articles in 2020
    - https://iopscience.iop.org/article/10.1088/1748-0221/15/06/P06033

- Clearly this is not the end of the story
  - Experience gained here will be fundamental for DUNE
    - Same technology, similar implementation
  - Liverpool very much involved as well
    - But that's a story for another talk

Backup

The SBND Collaboration

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