H2020, M. Sklodowska-Curie
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Neutrino Physics:

Data Analysis

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University and INFN Padova (Italy)

INTENSE General Meeting November 6th – 7th 2019

Status of activities – 1

- The present activities are concentrated on the study of simulated events to prepare common analysis tools to be exploited with real events collected in the BNB and NuMI neutrino beams of the Fermilab Laboratory.

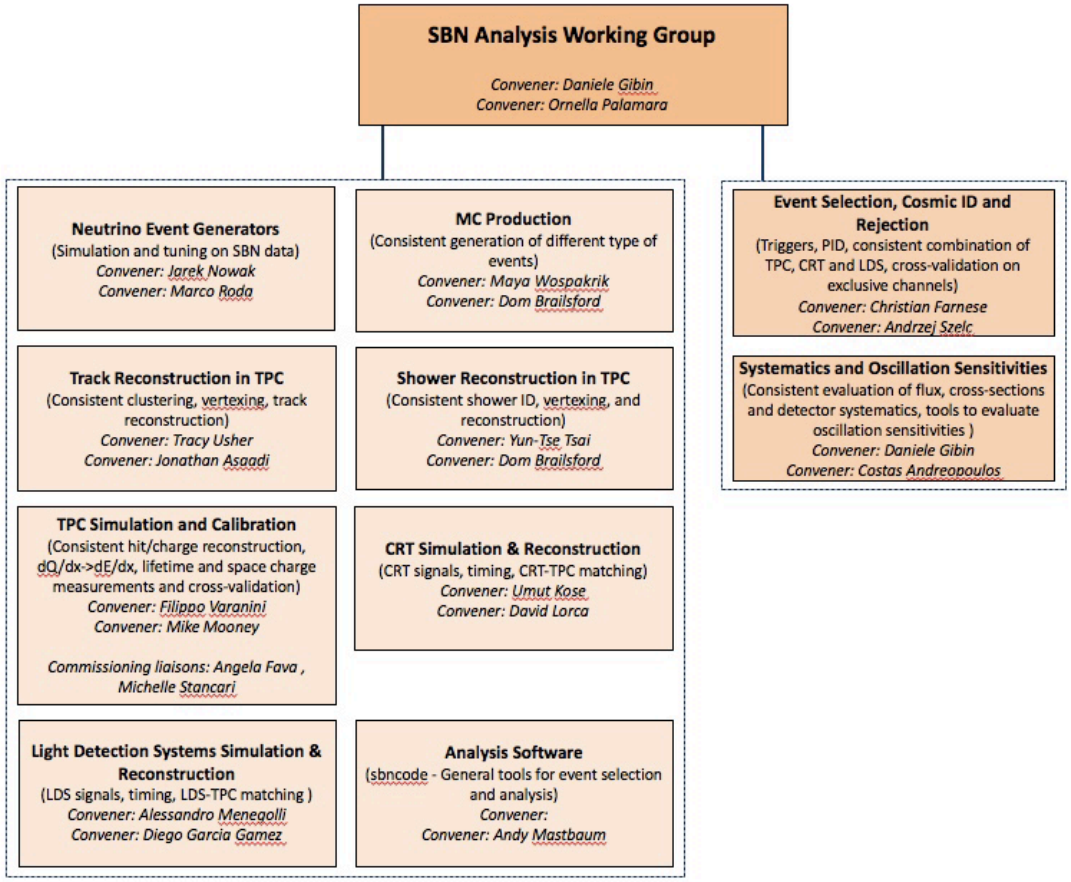
- In particular the focus is at the moment on the oscillation analysis of the detectors of the SBN program exploiting the BNB

- To reach a consistent treatment of the different detectors the LarSoft framework has been adopted as the common software framework for the SBN detectors.

- Developments proceed in close contact between the collaborators of the different experiments, with periodic meetings of an SBN analysisto monitor the progress and to promote scientific and technical discussions between the different participants.

Status of activities – 2

- SBN analysis group: the technical forum to promote and coordinate common activities



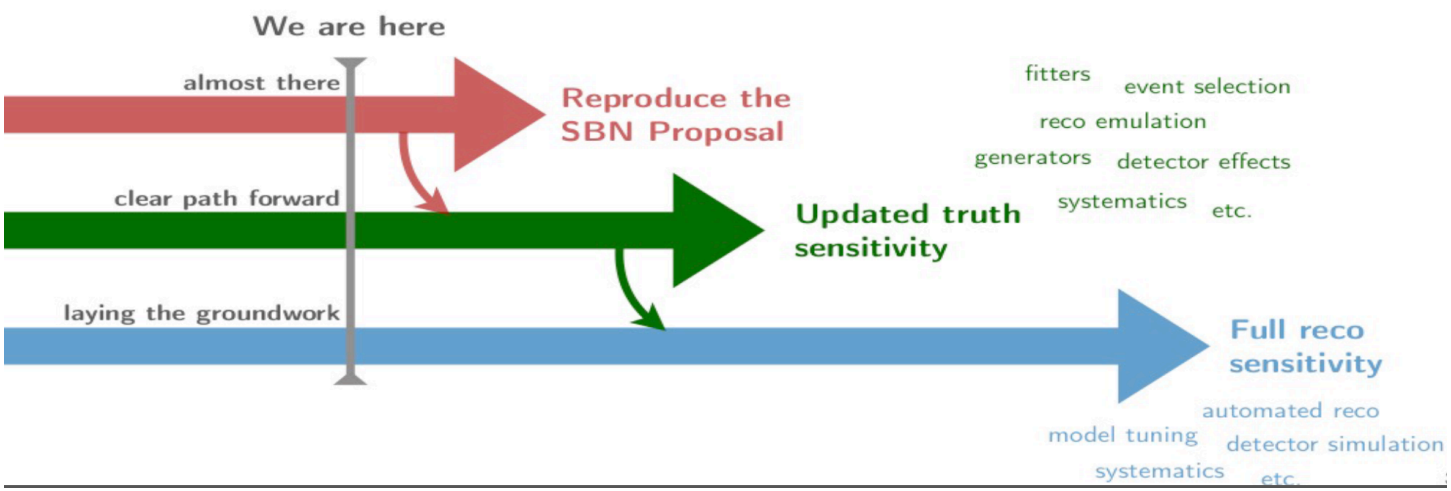
- Biweekly meetings
- 2 1-week workshops during 2019 to foster collaboration and preparation of common analysis tool (important contributions from INTENSE participants)

SBN Analysis Workshop in Oxford: March 30 April 3 - Goals

- More than 30 participants from Europe and USA with significant participation of INTENSE researchers

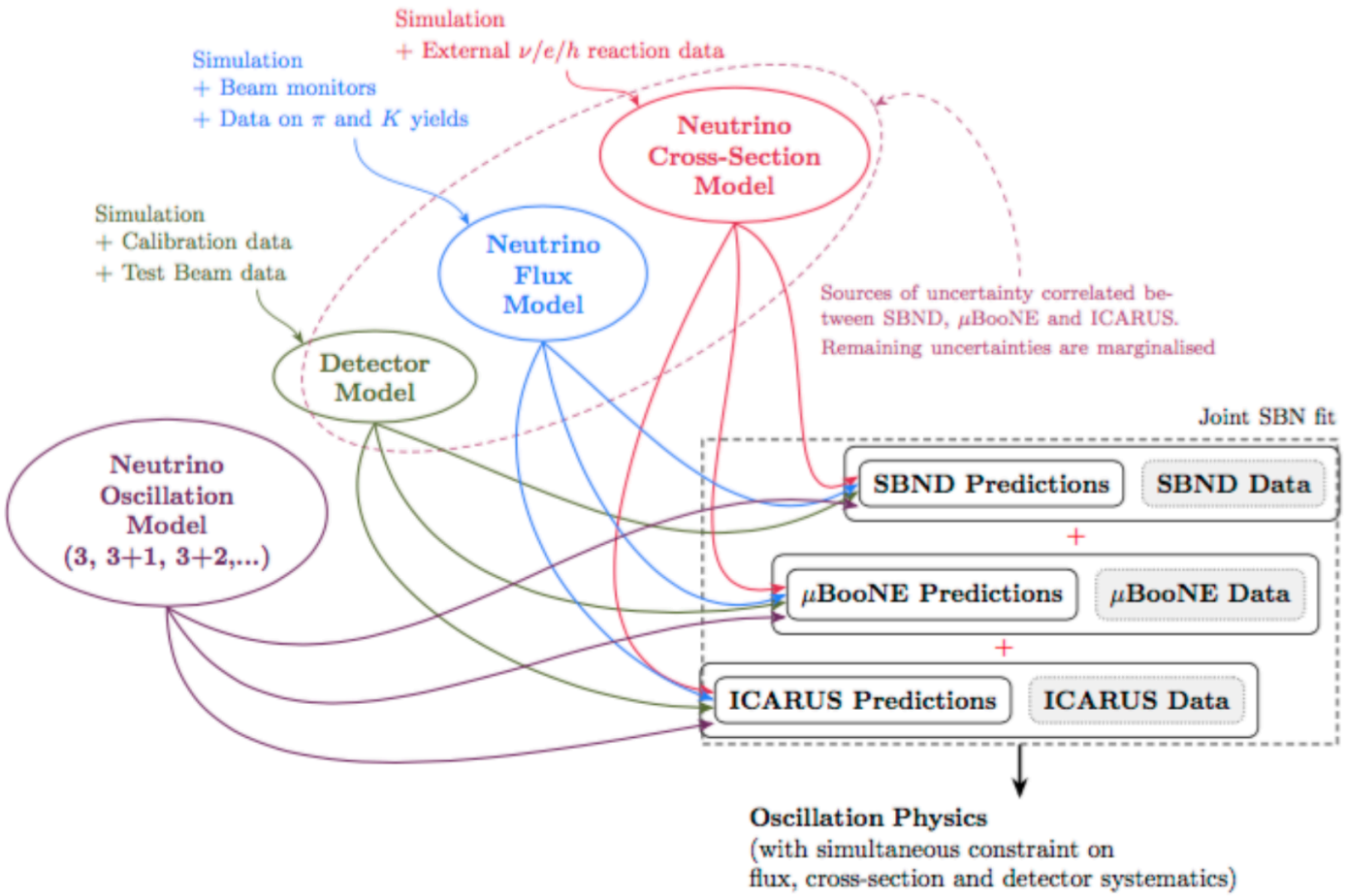
High level goals

- Updating the SBN proposal sensitivity, using full multi-detector MC simulations and automated event reconstruction tools
- By the end of the workshop, we'd like to have in place:
  - an end-to-end oscillation fit (preferably multiple fitters) using as input the SBNCode-based truth-level event selections
  - realistic efficiencies/resolutions based on demonstrated reconstruction performance
  - MC-driven estimates of detector uncertainties



SBN Analysis Workshop in Oxford: March 30 April 3 – achievements 1

- Definition of a scheme of common oscillation analysis and comparison between the different detectors
- Three independent fitters developed to improve robustness and validate results



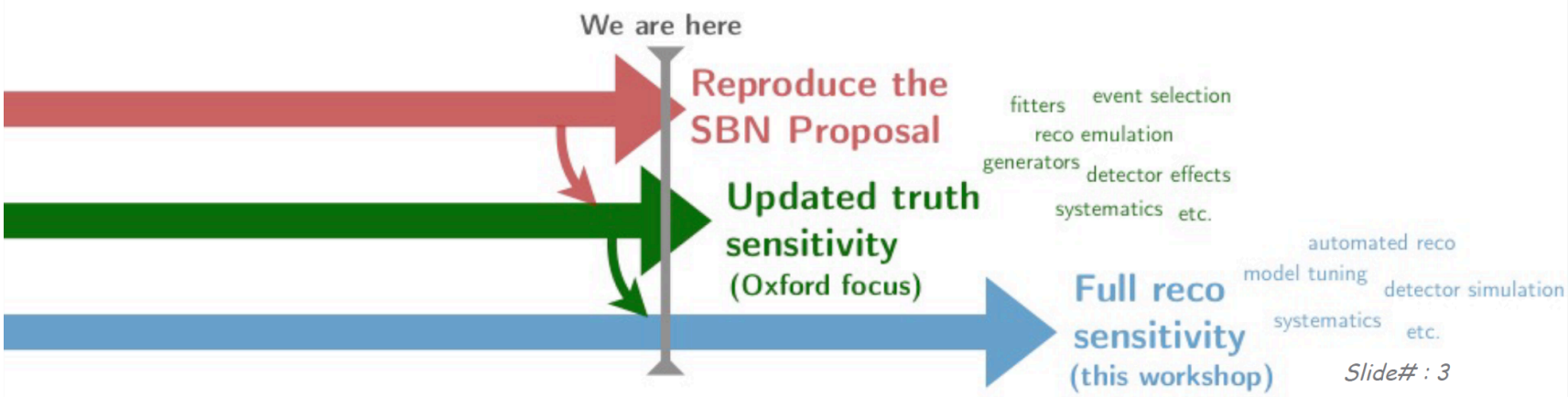
SBN Analysis Workshop in Oxford: March 30 April 3 – achievements 2

- Strategies for detector effect studies and development of sw tools
- Discussion of many ideas for CRT/TPC/PMT matching, and its use for cosmic removal/calibration/commissioning
- First application to the near detector of Pandora based tools:
  - For the identification and measurement of showers in the TPC
  - For identification and rejection of cosmic rays with the TPC and the CRT
- First application of Machine Learning tools to the 3D reconstruction of cosmic rays.
- Training of new people

SBN Analysis Workshop @Fermilab: September 26-30 - 1

- ~40 participants with important presence and contributions of INTENSE researchers

  - Transition from truth variables to as much as possible reconstructed quantities for the event selection and measurement
  - Verifying the sensitivity reach at the present stage of our code
  - Start discussing for the introduction of detector related systematics and for a cross calibration within the different detectors
    - Define a list of the dominant systematics
    - Energy resolution for different particles, post calibration
    - Efficiency (correlations) for different event topologies
    - Status/differences in optical systems/simulation/reco



SBN Analysis Workshop @Fermilab: September 26-30 – 2

- Generation of consistent samples of different types of simulated events, including single particles, neutrino interactions and cosmic rays, with coherent assumptions for the near and the far detector
- Reconstruction of simulated PMT signals in combination with TPC: first implementation of ligtht and charge matching
- study of light yield for the far detector for different sorts of interactions
- Porting of Pandora reconstruction from the near to the far detector with assessment of neutrino vertex reconstruction
- Analysis of the auto-veto probability for the CRT in ICARUS detector and work towards its integration in the SBND detector
- First example of an event display including the CRT detector
- Addressing some possible source of systematical differences between the event selection and reconstruction in the near and the far detector
  - Front end electronic noise and event reconstruction
  - Initial study of Michel electrons to be exploited as "standard candles" for detector calibration and systematic assessment
  - Simulation and correction for the space charge effects on the event reconstructiom

Collaboration on Machine Learning approach to analysis

- In parallel a collaboration started with SLAC experts on alternative approaches to neutrino identification and cosmic ray removal based on Machine Learning and machine vision techniques
- Workshop in Padova from July 1st to July 5th to introduce the ML techniques, with hands on examples, held by SLAC experts, with the participation of ~10 people (6 INTENSE researchers)
  - First tutoring of INTENSE researched and
  - Launching collaboration on optical simulation/ reconstruction