Neutrinos @ CERN:

The CERN Neutrino Platform
The EP Neutrino Group
The TH Neutrino Group

Tokai, 9th October 2017

Albert De Roeck, CERN

2013 European Strategy

Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector. *CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.*

2014: CERN announced that it will freeze all types of neutrino beam at CERN in favor of world wide activities (Japan/US)

→ CERN NEUTRINO PLATFORM

CERN's role

CERN support for accelerator-based neutrino experiments, both short and long baseline

- ✓ As a support structure for all these activities, where CERN expertise can be a VALUE
- ✓ As the support Laboratory for all European Groups interested in a collaborative effort
- ✓ As a unique R&D and test facility of detectors and components (hardware and software)
- ✓ As a research group active at these facilities and later on physics experiments

We react on demands from the community : MOU frame

- 6 Projects presented to the SPSC and approved:

✓*NP01: WA104, ICARUS as far detector for the US SBN*
✓*NP02: protoDUNE WA105, demonstrator + engineering prototype for a double ph. TPC*
✓*NP03: PLAFOND, an generic R&D framework*
✓*NP04: ProtoDUNE, engineering prototype for a single phase TPC*
✓*NP05: Baby Mind, a muon spectrometer for the WAGASCI experiment at T2K*
✓*Argon Cube : a modular TPC R&D*

- A few Projects in the pipeline : *T2K near detector, DUNE near detector, HPgas TPC, ENUBET, ….*

- COOPERATION PROTOCOL with the US Neutrino Program *(Neutrino Protocol signed in 2015, Addendum 1 just signed)*

NP05: Baby MIND

A muon spectrometer for the WAGASCI experiment at T2K

- A 75-tonne neutrino detector with a new magnetization scheme
- A prototype for a Magnetised Iron Neutrino Detector (MIND)
- Baby-Mind will be transported at the end of July to Japan

Baby MIND moved to East Hall

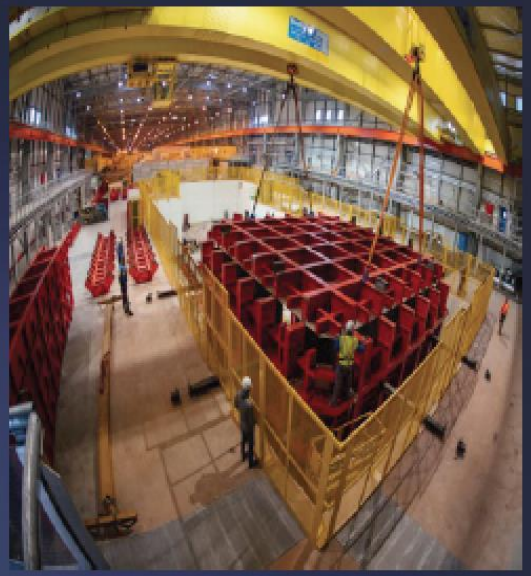
by Stefania Pandolfi

On 14 June, the Baby MIND neutrino detector was moved, module by module, from Building 180 to Building 157 (East Hall). The succession of coil windings and (red) iron plates is clearly visible. (Image: Etam Noah/University of Geneva)

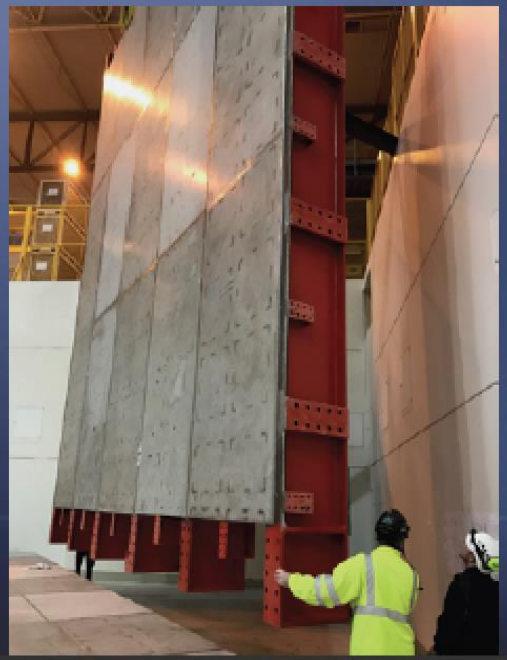
ProtoDUNE Area

Next step : ~800 ton LAr prototypes

2016-2017 : ProtoDUNEs ~800 ton LAr cryostats



NP04: single phase



NP02: double phase

ProtoDUNE

protoDUNE strategy

- ✓ Modular structure that will be repeated many times inside DUNE
- ✓ ProtoDUNE prototypes as DUNE module 0, as basis for the final detector construction and assembly
- ✓ Full engineering done as a basis for the final production (PRRs), both for detectors and cryostat/cryogenics

- ✓ Check detector response with cosmics (DCS, DAQ, Computing, Reconstruction, …)
- ✓ Calibrate with charged beam the response to leptons and hadrons

Very ambitious program :

- detectors cooled by April 2018
- in beam in 2018 before LS2 shutdown

CERN EP-NU Group

EP-NU: about 30 people.
- Many of these full time on detector challenges
- About 10 for physics, analysis or detector optimization studies

Neutrino Group in EP

Established October 1 2016

Neutrino Group EP-NU (https://ep-dep.web.cern.ch/organisation/nu)

Interim Group Leader: **MK** **Manfred Krammer**
Deputy Group Leader: **Albert De Roeck**

1/10/2016: GL ->ADR

Excerpt form the Mandate (full mandate in backup slides):

- Act as focal point for the activities of the accelerator-based experimental neutrino community in Europe, in close connection with the activity in the TH Department.
- Coordinate contributions from EP-NU and other EP groups, such as the support groups (DT, ESE, SFT), to the Neutrino Platform projects.
- Coordinate, together with the Project Leader of the Neutrino Platform, CERN's participation in those experiments that CERN joins as a collaborating institute (currently ICARUS and DUNE).

EP–NU group & the neutrino experiments
Presently: DUNE (FNAL) & ProtoDUNE (CERN)
FNAL short baseline (ICARUS)
Under study: T2K upgrade

New: EP- Neutrino Group @ CERN

- No Neutrino Experimental Physics (EP) group at CERN since 2001!
- In view of the effort in the established neutrino forum a new group was created in fall 2016
- EP group focus at present
  - Experimental neutrino physics -> take part in experiments. So far DUNE and SBL at FNAL. T2K/T2HK on the radar.
  - Focal point for activities for the neutrino community in Europe
  - Collaborate with the neutrino platform on ProtoDUNE (data analysis, computing, simulations, reconstruction, beamline optimization, physics analysis…)
  - Collaborate with the platform on detectors R&D, test beams
  - Liaise with CERN-TH neutrino group on the physics program
  - Organize workshops for the Neutrino community
  - Recently: Special focus on near detector challenges

Projects: Overview

- DUNE: Activities at several levels
  - ProtoDUNE: Simulation and reconstruction, cross section measurements, beam line, …
  - Physics TDR of DUNE: Physics TDR by 2019
  - DUNE Near Detector: Studies to evaluate/optimize options. Connection with hardware projects
- FNAL short Baseline: ICARUS Data analysis in 2018
- Next: T2K upgrade?
  - Useful for involvement of CERN staff in a running neutrino experiment

T2K Upgrade

CERN on the LOI for the TPCs (January 2017)

- Waiting for ok from SPSC to negociate participation to the project. Hardware related contributions by CERN have been compiled in discussions with Marzio Nessi. Next discuss the R&D contributions that can be included in neutrino platform assignment.
- **Requests to CERN** were listed in an addendum to the EOI-015.
- Participation in WPs: WP3/WP5/WP8 &WP10/11…

CERN in FGD/cubes detector (?)

- To be defined.

Call by SPSC for proposals for the neutrino platform expected this October

CERN EP-NU group

Important consequences

- People can apply for Fellowships, LD-Staff, scientific associateship, technical doctoral and project associate positions for neutrino experimental physics.
- Take advantage of that!!! (it is of course a competion…)

Activities

- Summer 2017: Initiated a forum for Near Detector study discussions, especially targeting European groups. For details see

  https://twiki.cern.ch/twiki/bin/view/CENF/NearDetector
- 6/7 November 2017 : DUNE near detector meeting @CERN, to allow strong direct European Participation in the ongoing ND developments.
- 29/1/2018-1/2/2018: DUNE General collaboration meeting @ CERN
- Several T2K upgrade working meetings @ CERN
- Several Neutrino related study groups/meetings suggested to be held at CERN (Nustorm, NuFact, NuSTEC, meetings on models….)

Near Detector Forum

A collaborative effort toward the design of a Near Detector for the new generation of accelerator long-baseline neutrino oscillation experiments

WG1

Measurement of neutrino flux

Mailing list: CENF-ND-Wg1

The working group will focus on the neutrino flux measurements. Measurements both in-situ and/or with the help of complementary experiments will be considered. Physic studies will be performed to assess advantages and limitations of each approach and define which detector characteristics would be the most suitable to perform the measurement. The WG1 is expected to work in close contact with the WG4 in order to estimate the reduction of the systematic

WG2

Cross sections, theory and generators

Mailing list: CENF-ND-Wg2

This working group will focus on the capability of theoretical models and Monte Carlo generators to describe neutrino interactions. Starting from a thorough comparison of existing models with experimental data, the group will foster and participate in the improvement of event generators.

more infos...

WG3

Cross sections, experimental

Mailing list: CENF-ND-Wg3

This working group will focus on the detector effects and designs that are necessary to identify specific neutrino interactions and to measure their cross sections and thus constrain theoretical uncertainties. It will provide input to and work in collaboration with WG4

more infos...

WG4

Sensitivity studies

Mailing list: CENF-ND-Wg4

This working group will focus on evaluating the impact of experimental and theoretical uncertainties on the experiment sensitivity. It will work in close collaboration with WG2 and WG3 and as part of the DUNE and HyperKamiokande experiments and also learn from already existing methodologies and experiments like MINOS, T2K, NOvA.

more infos

WG5

Requirements for detectors and R&D

Mailing list: CENF-ND-Wg5

This working group will identify and support the R&D necessary to implement possible ND concepts.

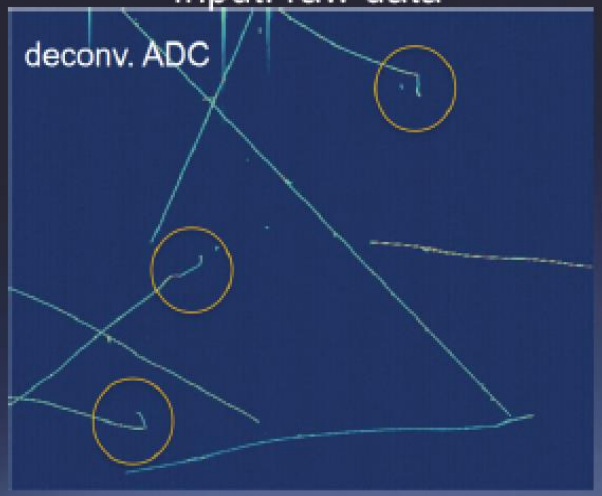
more infos ...

Organizers

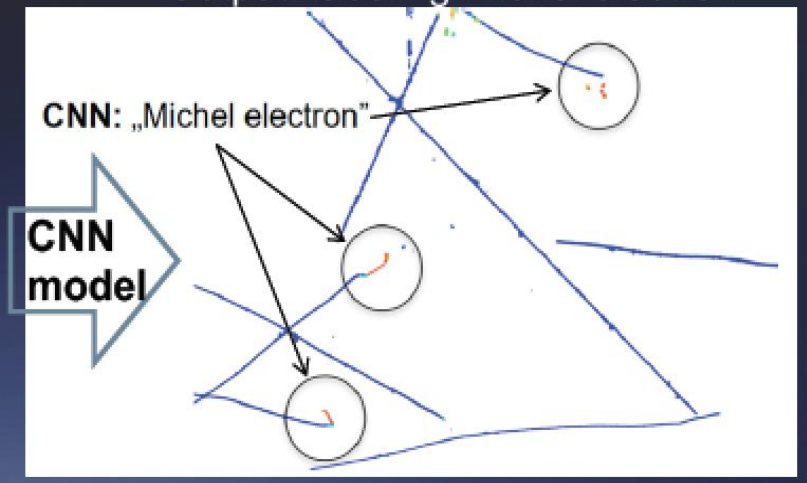
- Paola Sala
- Stefania Bordoni
- Alfons Weber
- Marco Zito

BIG data … DAQ, event reconstruction

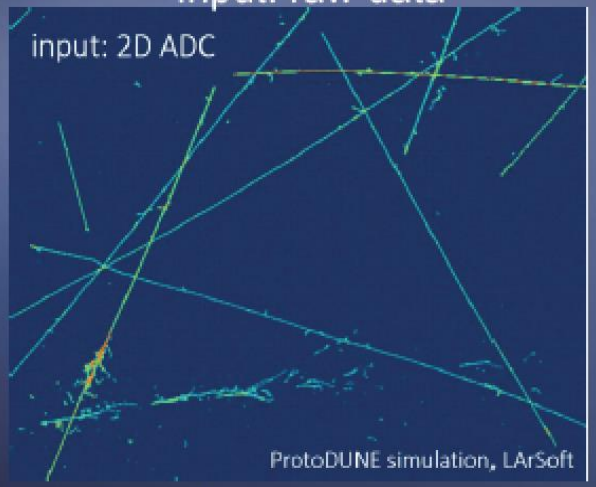
Input: raw data



Output: labeling Michel electron



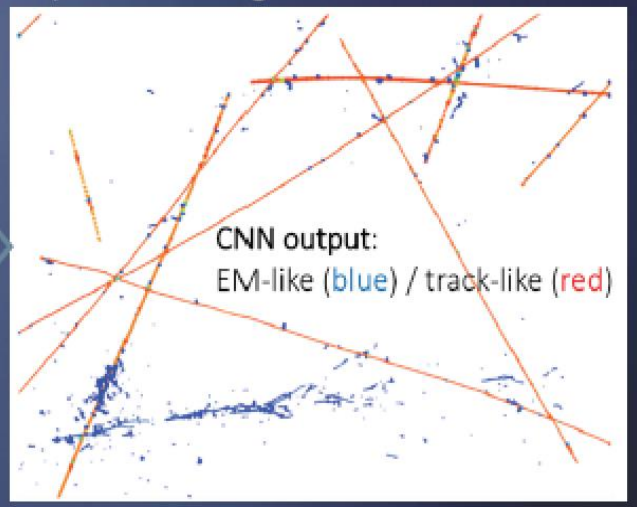
Input: raw data



Drift time

Channel number

Output: labeling EM-like / track-like



MACHINE LEARNING TECHNIQUES

✓ **First steps in automatic event reconstruction and pattern recognition**

Analysis of the ProtoDUNE data

- Beams of e, mu, and hadrons (pions, proton, kaons)
- Beam energies from 0.5 to 7 GeV
- Inclusive and exclusive pion-Argon cross sections
- …proton-Argon cross sections
- …electron-Argon cross sections

Momentum Bins (GeV/c)	# of Spills per Bin	# e^+ per Bin	Beam Time per Bin (days)
0.5, 06, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7	5000	300K	1.4

Possible run scenario

P (GeV/c)	# of Spills	# of e^+	# of K^+	# of μ^+	# of p	# of π^+	Total # of Events	Beam Time (days)
1	70K	84K	≈ 0	70K	689K	625K	1.5M	19.4 days
2	16K	19K	9K	36K	336K	572K	1.0M	4.4 days
3	13K	16K	26K	17K	181K	540K	780K	3.6 days
4	11K	13K	19K	16K	107K	510K	660K	3.1 days
5	11K	13K	29K	13K	96K	510K	660K	3.1 days
6	11K	13K	36K	12K	94K	510K	660K	3.1 days
7	11K	13K	42K	8K	87K	510K	660K	3.1 days
Total	143K	171K	161K	172K	1.6M	3.8M	5.9M	39.7 days