T2K upgrade news

Davide Sgalaberna, CERN
EP-NU group meeting
15th February 2018

Positive feedback from SPSC referees
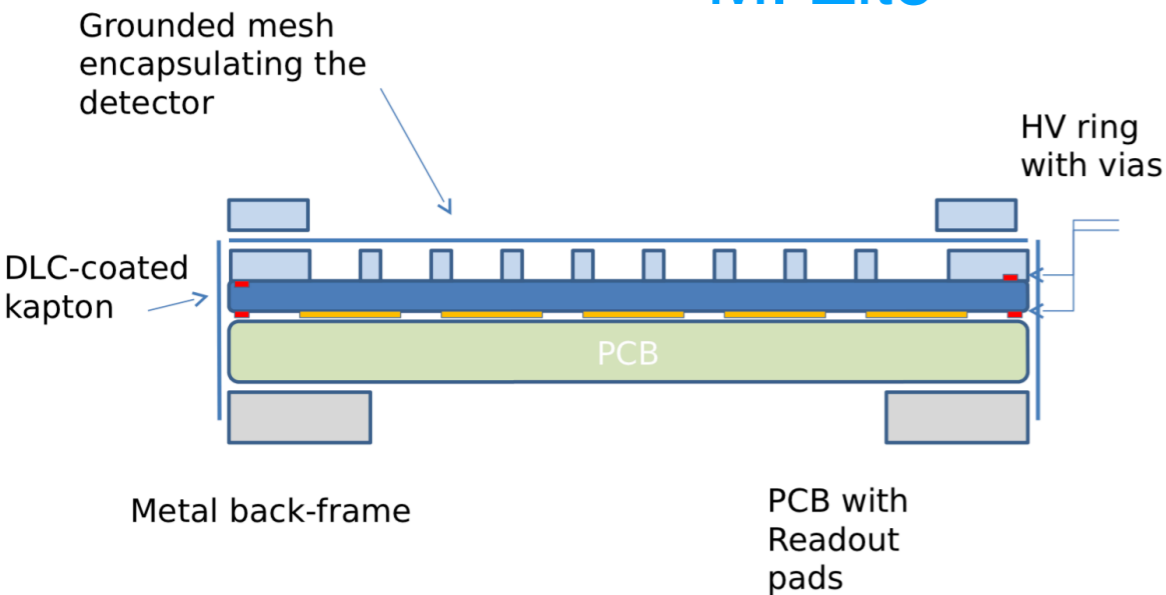# A. Bueno, F. Terranova (26/01/2018)

Dear Marco, Alain,

- the SPSC reviewed your proposal for an upgrade of the T2K ND280 detector during its closed session last Wednesday.

- <u>Physics wise we found your proposal sound, clearly written and with well defined goals. We consider your plans for 2018 realistic and feasible. For those reasons we supported your request of allocating two periods of test beam (of two weeks each) in the T9 line.</u> Please note that in the schedule presented by Henric Wilkens, the first two weeks span the last week of June and the first of July. The second period runs at the end of August.

- <u>The Committee finds that your proposal fits well in the spirit of the Neutrino Platform call that will be closed in October 2018.</u> However, concerning the requests you made on a substantial CERN contribution, we urge you to start conversations with the CERN management to define the level of involvement of CERN in the T2K near detector. Such decision falls outside the scope of the SPSC.

- Best regards,

Francesco, Antonio.

3

Atmospheric TPCs

M. Zito

Grounded mesh encapsulating the detector

HV ring with vias

DLC-coated kapton

PCB

Metal back-frame

PCB with Readout pads

Fabrication scheme

• The composite structure will be constructed by layering over a mandrel, followed by curing in an autoclave

• This approach allow for constructing whole parts or sub-modules.

ILC

T2K

INFN-Padova
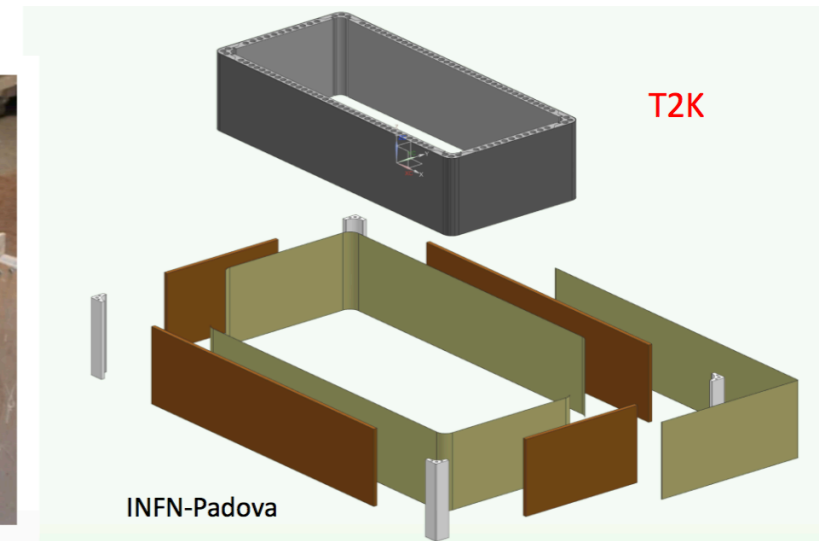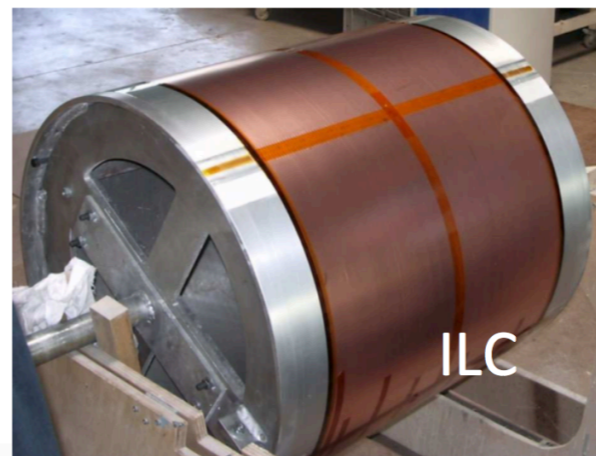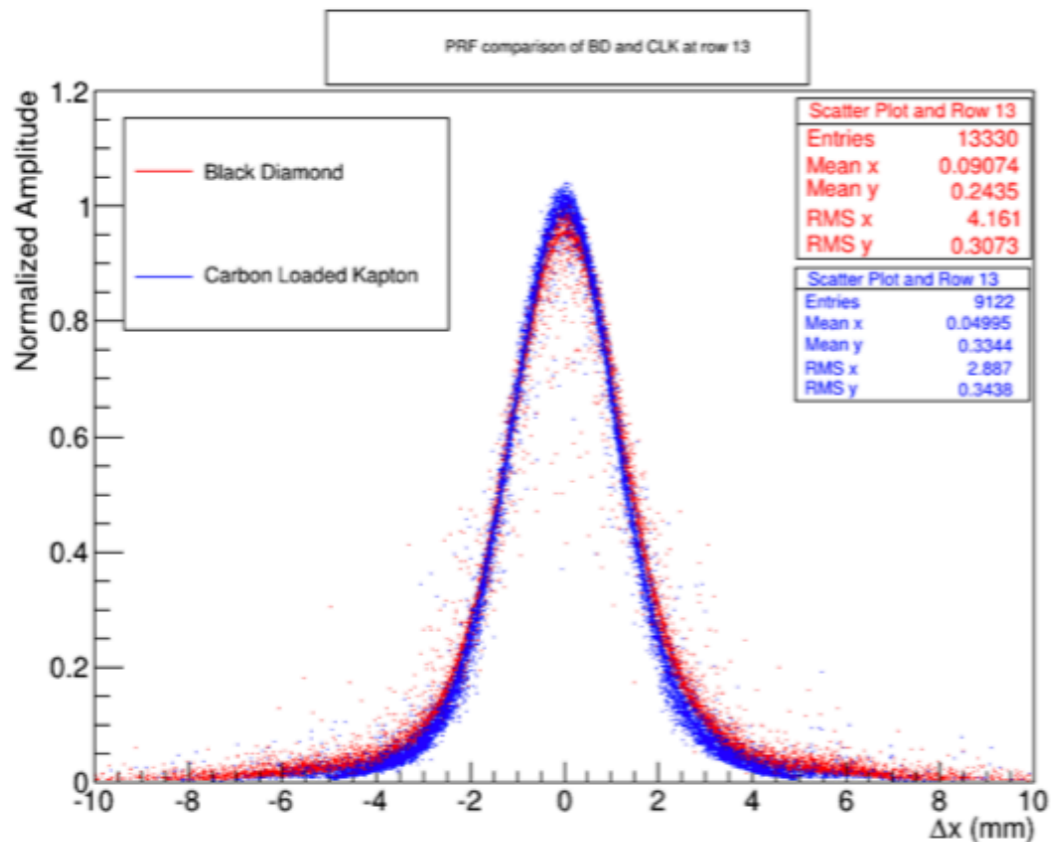
Aim to <2.5% radiation length field cage

~2 cm thick wall

SuperFGD

Yokoyama-san's slides

Timeline

- Need to establish responsibilities for both beam test and real construction
- Including "new" institutes :CERN, Kyoto, US group, ..
  - Possibly engineers from KEK? (electronics, mechanics)
    → need to specify what we request
- Coordination between work in Japan and Europe (&US)
  → regular meeting

Tentative table: to be discussed and refined

Scintillator	INR, …
WLS fibers	Tokyo, Yokohama, …
MPPC	Tokyo, KEK, …
Optical connection	…
Mechanical structure and assembly	CERN, KEK, Geneva, …
Electronics	Geneva, Japan, CERN??, …

- Test beam at CERN in the end of June
  - Earlier than original assumption
  - Optimization of resource necessary
    → more discussion later

- Design definition by summer towards TDR (we need "optimization" based on available resources)
  - Granularity
  - Readout dimensions
  - Assembly procedure
  - Electronics

- Japanese budget need to be spent from the next JFY
  - Can start procurement of MPPC, WLS fibers,.. once the number of channels is known

- Broad interest from other Japanese institutes, US and ESS-nu project

SuperFGD R&D

- Results from October 2017 test beams at CERN with 5x5x5 cm^3 prototype

Summary

Preliminary results with the digitizer:

- Average L.Y. $\approx$ **41.0 p.e.** per a fiber
- Average L.Y. $\approx$ **79.8 p.e.** per two fibers (a cube)
- Average $\sigma_t \approx$ **0.92 ns** per a fiber
- Average $\sigma_t \approx$ **0.68 ns** per two fibers (a cube)
- Average $\sigma_t \approx$ **0.53 ns** per two cubes (four fibers)
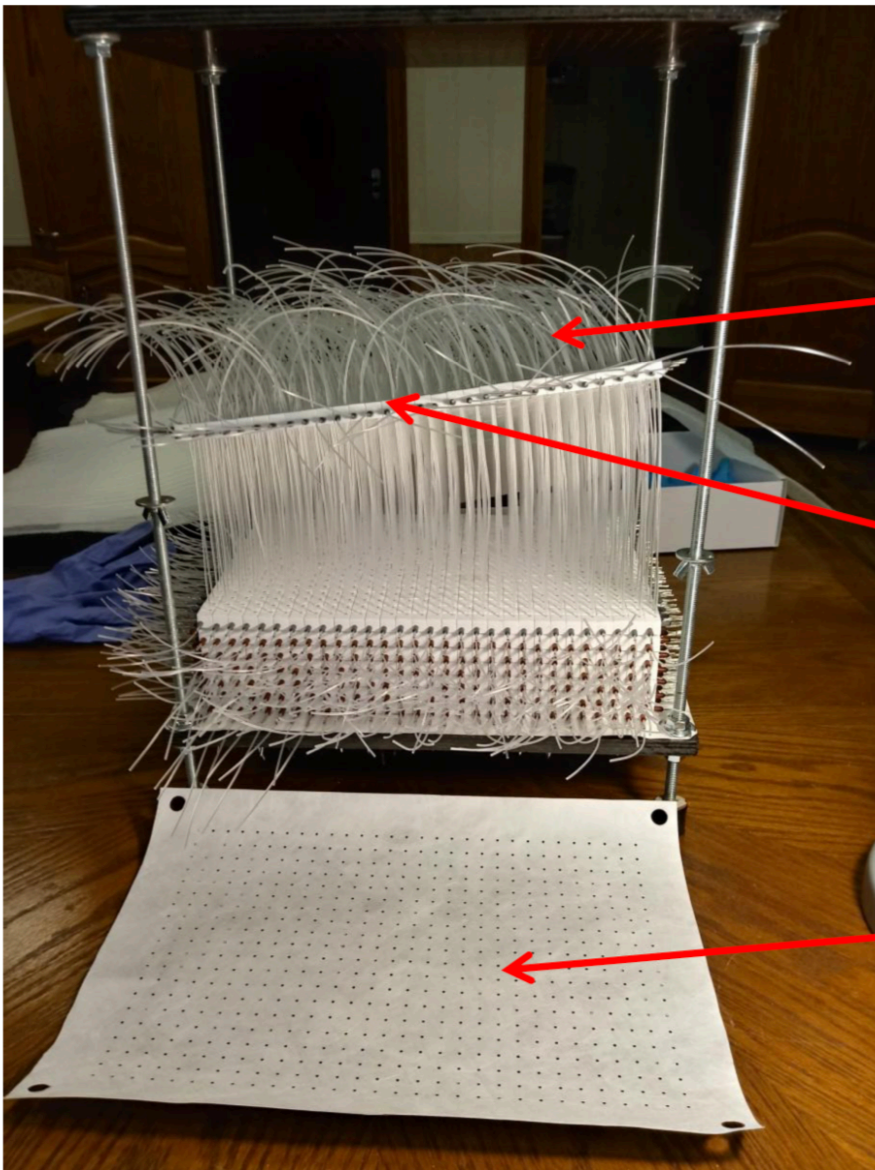- Average crosstalk per cube side: Crosstalk $\approx$ **3.7 %**

Data analysis with multichannel electronics is in progress.
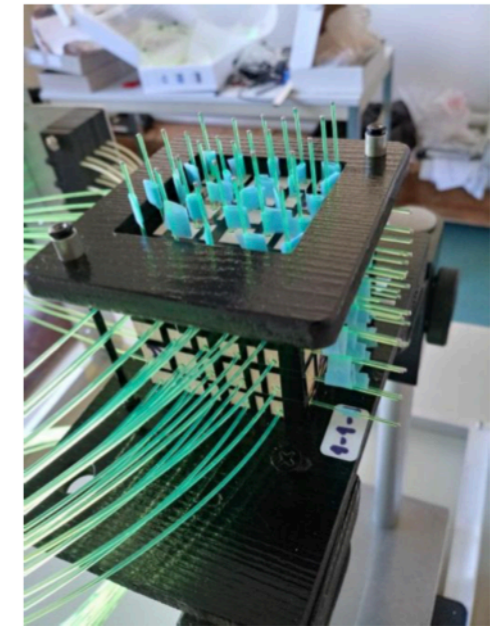
Y. Kudenko

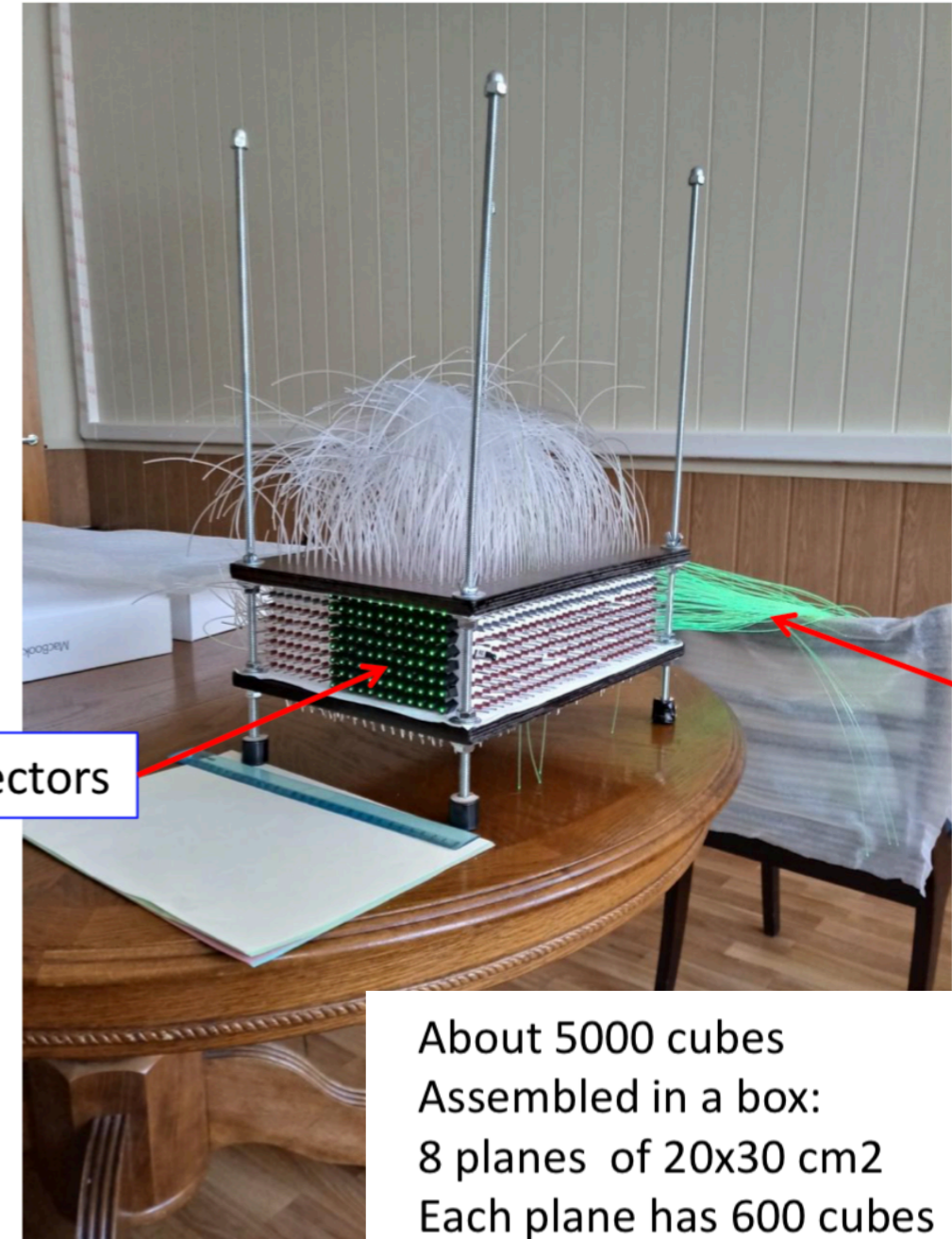- Results very promising (as expected) for light yield and intrinsic time resolution

SuperFGD

Kudenko

Fishing lines

Plane of 600 cubes

Reflector:
Tyvek sheet
~100 mkm

connectors

About 5000 cubes
Assembled in a box:
8 planes of 20x30 cm2
Each plane has 600 cubes

- Demonstrated it's feasible to assemble big modules
  - It took ~2 days at first trial —> could be better in future
  - No problems during assembly —> should be easy with 60x60x60 cm^3
- Improvements are expected: tolerance (goal is 20 mum as current FGD), thinner reflector
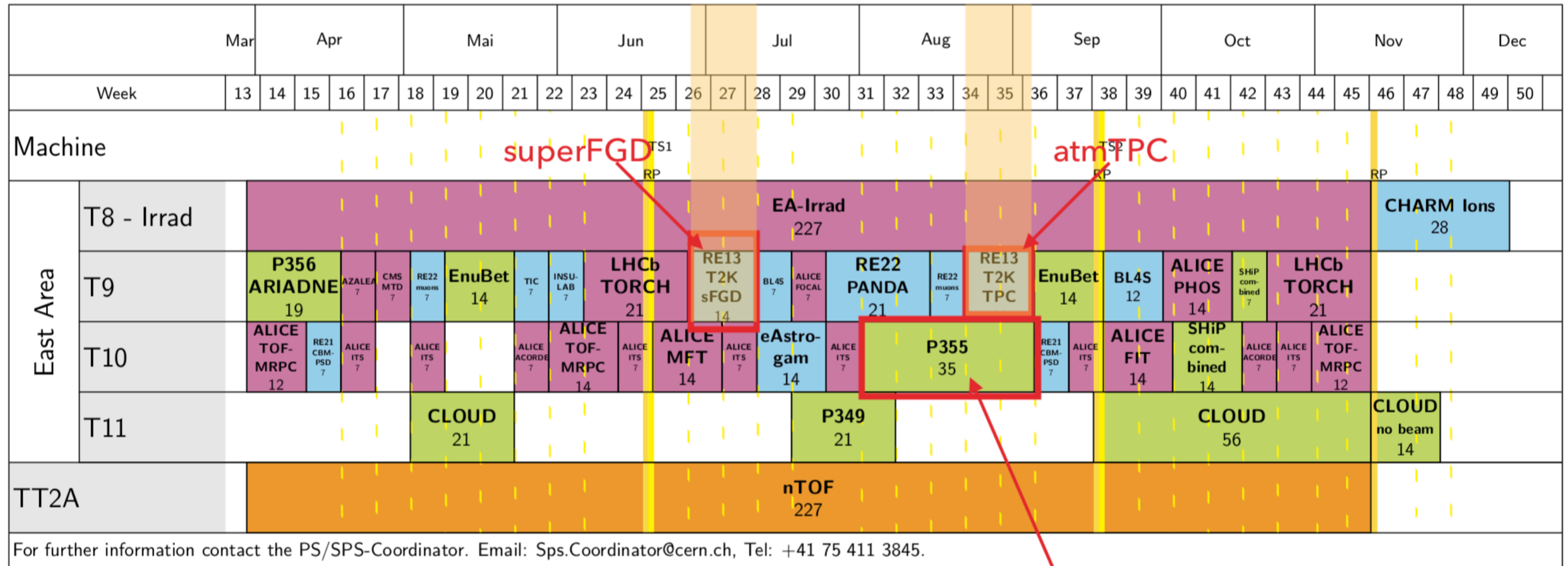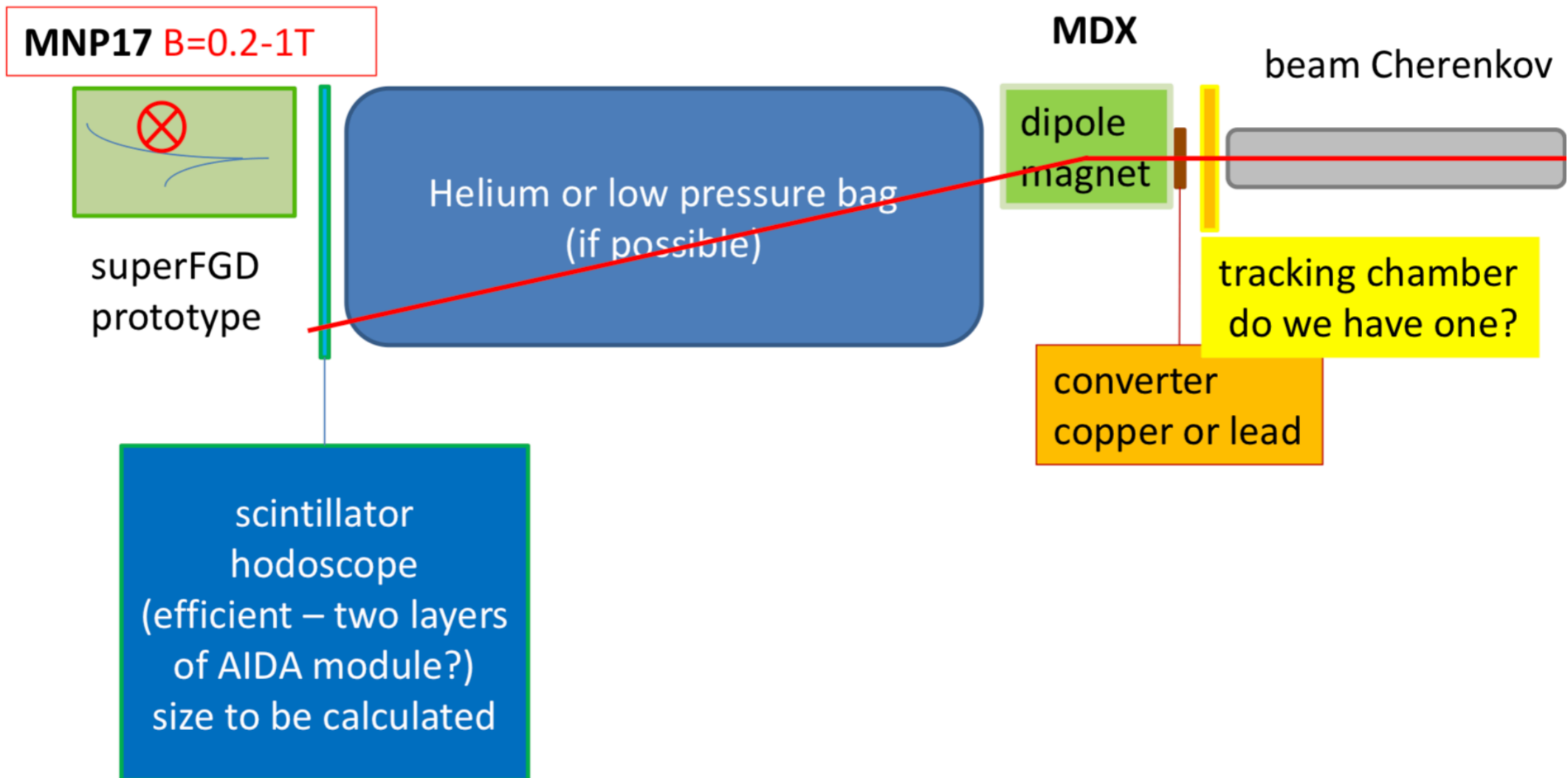
TEST BEAM AT CERN

Stefania

PS user schedule for 2018

- ▸ sFGD : 25 June - 11 July

- ▸ TPC : 22 August - 5 September

- ▸ HPTPC : 2 August - 5 September

- ▸ Aim for a detector of 10x20x50 cm^3 ~O(10k cubes / 1700 channels) to do some physics measurements

- ▸ Allocated time slot very early. Really challenging to have such "big" ready, for June. Electronics will not be ready yet

Test beams

superFGD prototype:
50x20x10 cm³

MNP17 B=0.2-1T

superFGD prototype

Helium or low pressure bag (if possible)

MDX

dipole magnet

beam Cherenkov

tracking chamber do we have one?

converter copper or lead

scintillator hodoscope (efficient – two layers of AIDA module?) size to be calculated

- Possibilities to do very important measurements and test the capability of SuperFGD with already 10k cubes and 1800 readout channels

- Gamma identification, tracking, etc…
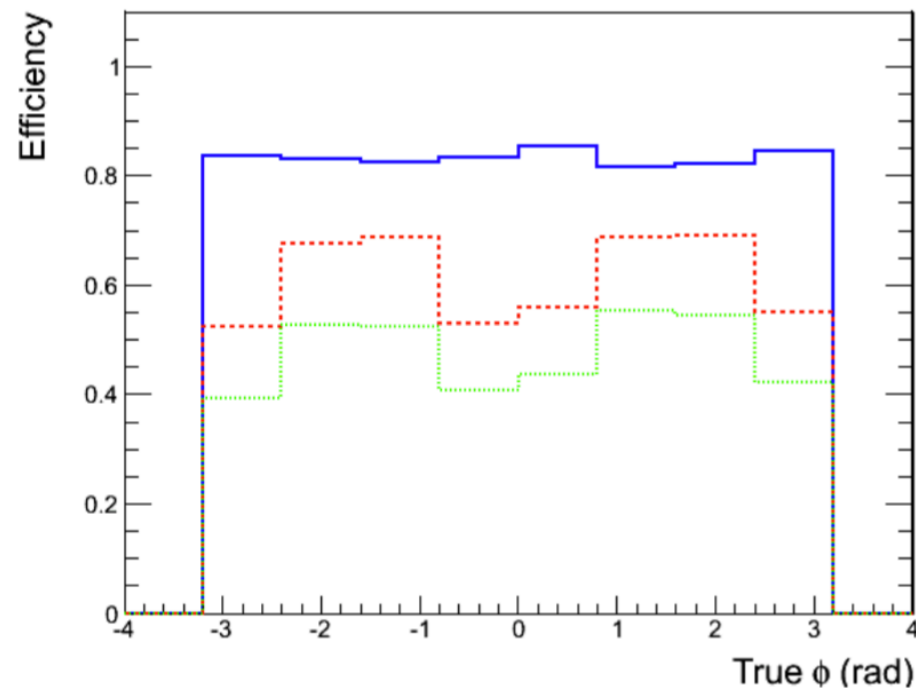
- Discussions for the veto in the TPC test beam

Simulation studies

- Muons stopping in SuperFGD (200-500 MeV/c)
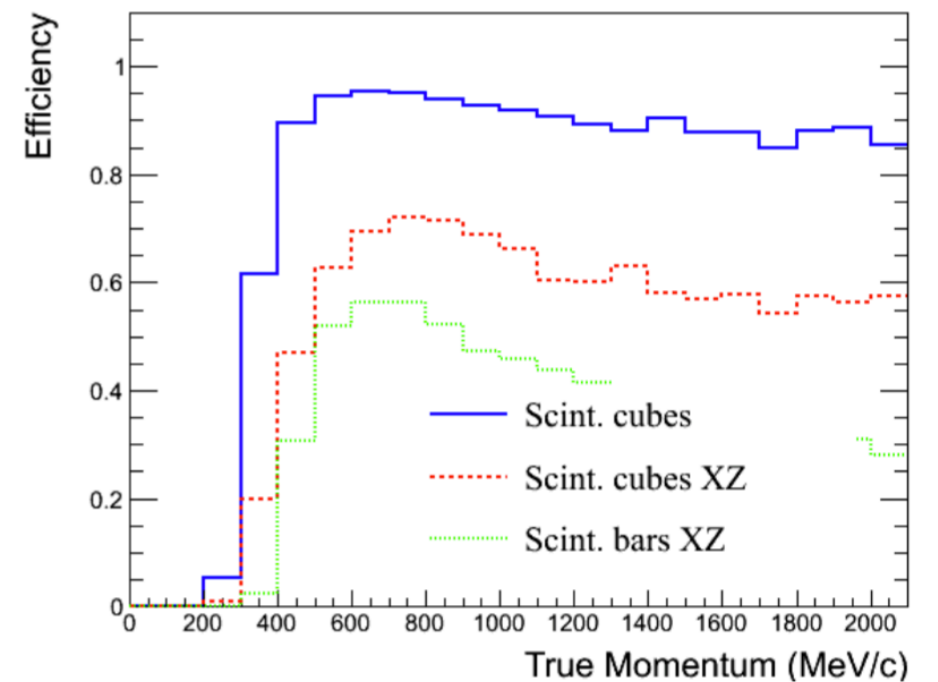
- Expect ~3% momentum resolution at any angle
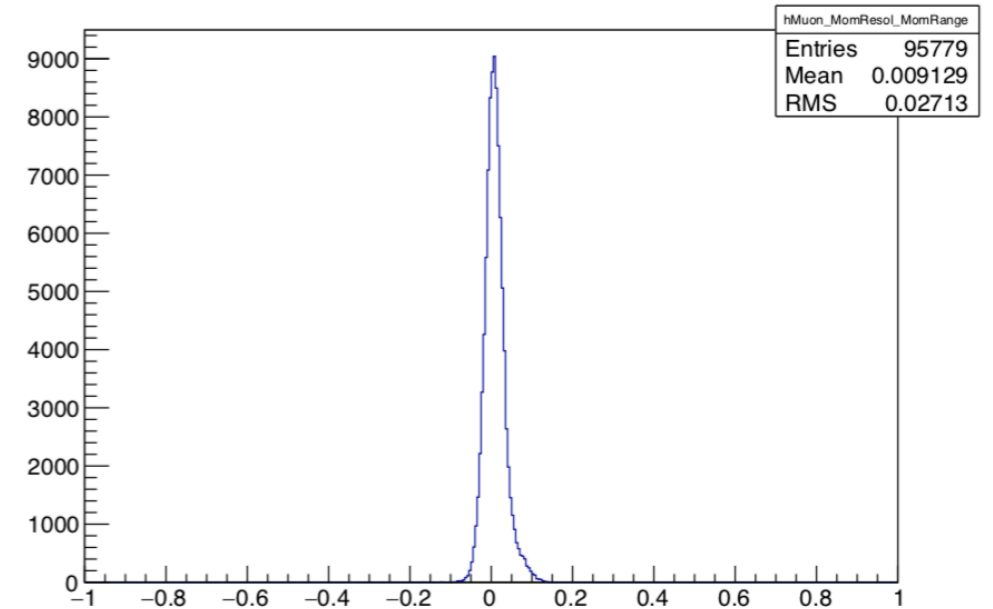
- 4pi acceptance and better proton momentum threshold with 3-views readout
- Time to lower the work on the simulation to focus on R&D and organize test beams
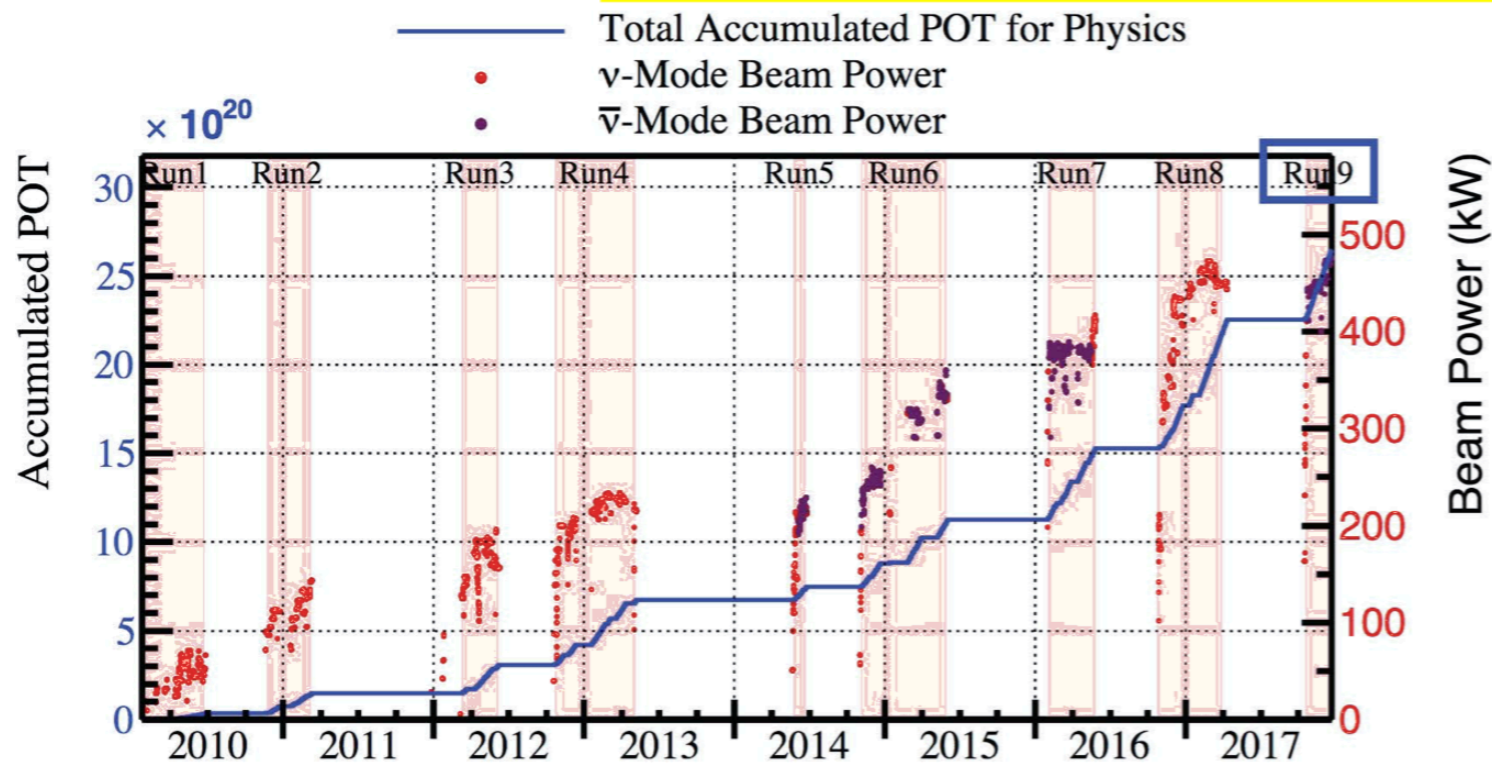
CERN & ND280 upgrade

• Announced by Marco Zito at the beginning of the workshop

• T2K people were extremely happy to welcome us in the project

• We are in "sim&opt", "mechanics and integration", "test beam" and "SuperFGD" working groups

• Some ideas about how we could play a very important role to trigger some discussions

• SuperFGD:

    - development of electronics is fundamental: compact (within 5cm thickness) and high rate (aim is <1ns time resolution in 1cube / 1fiber)

    - mechanics (already on board): design of the CF box (simulations, stress tests, compatibility with chosen MPPCs) and integration

• Atmospheric TPCs:

    - Gas system —> fundamental

    - MicroMegas

T2K beam schedule and power supply

Data taking status in Run 9 [15]

Nakaya-san's slide at J-PARC PAC in January

Legend:
— Total Accumulated POT for Physics
• ν-Mode Beam Power
• ν̄-Mode Beam Power

- Total POT in Run1-9 : 2.65×10^{21} POT (17% increase from Run8)
  - ν-mode POT : 1.51×10^{21} POT (57.1%) ⇔ 1.49×10^{21} POT (Run1-8)
  - Anti-ν-mode POT : 1.13×10^{21} POT (42.9%) ⇔ 0.76×10^{21} POT (Run1-8)
  - Note: Beam window successfully replaced in 2017 summer

2018 J-PARC Acc. Op. Plan (draft)

Based on 2/1 J-PARC Machine time meeting

Schedule of MR op. until Jun. and MLF op. until mid-Nov. are almost fixed.

NU beam operation:
3/9 evening ~ 5/31 9:00
(Total: net 70.5 days)
→ ~5.1×10^{20} POT
assuming 470kW 85% eff.

MR Op. after summer is totally unclear.

- Discussions on the upgrade of the main ring power supply for T2K-II

T2K beam schedule and power supply

• Preliminary results on the impact of the NA61/SHINE long target data on the T2K flux prediction

Flux with Incorporated NA61 2009 Replica-Target Data: SK FHC
Hadronic Interaction Model Parts of Flux Uncertainties
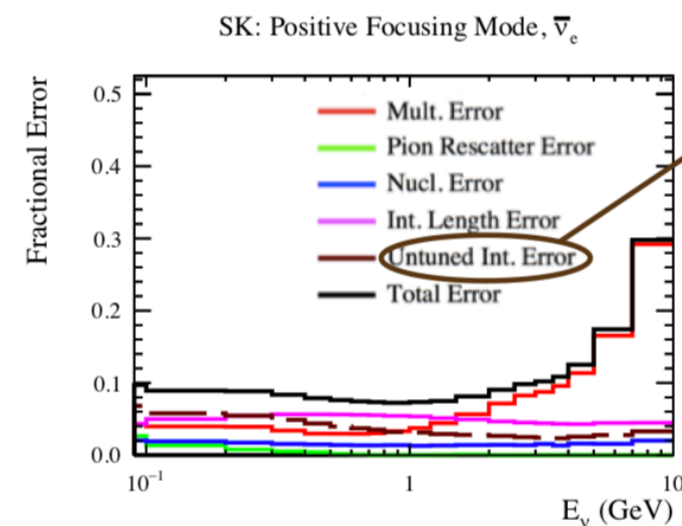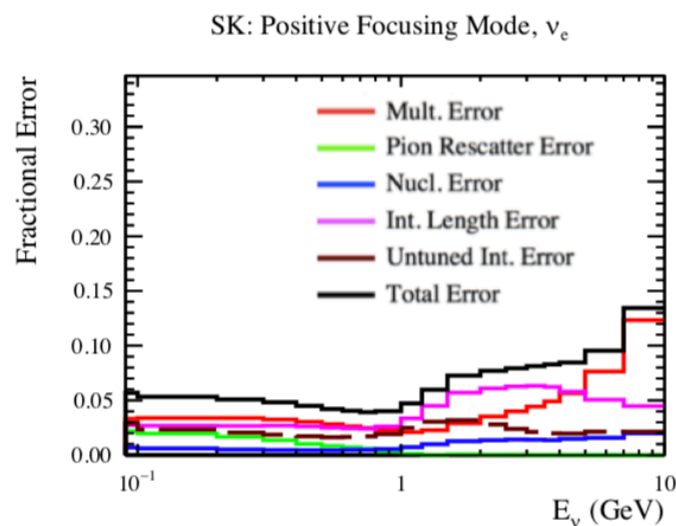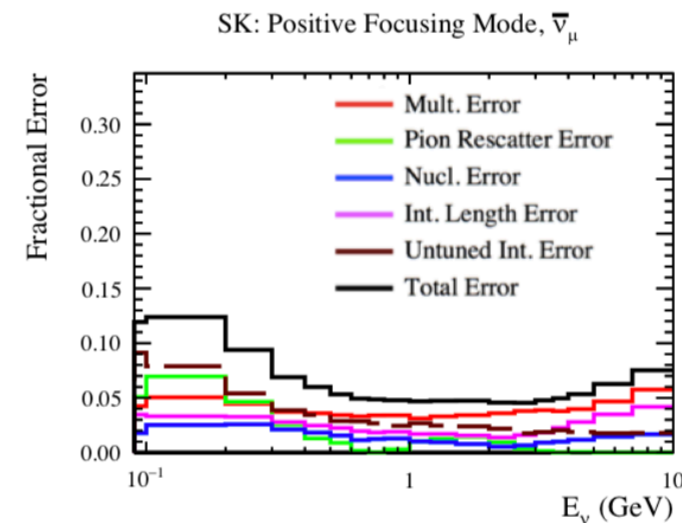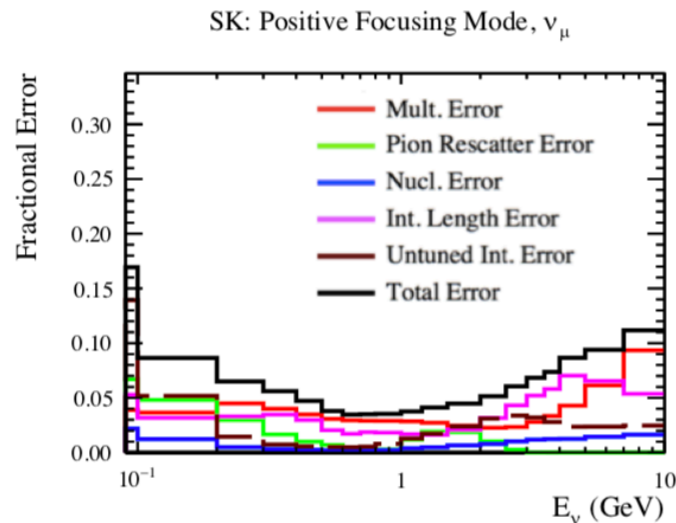
Using same error format as in TN217 + Untuned Interactions

ν-mode

New contribution to flux uncertainty has been added

• Total flux error is ~5% in the region of interest for oscillation measurements

NA61/SHINE prospect beyond 2020

NA61 upgrade

- NA61/SHINE is proposing program extension after CERN LS2 (2021-2024)
  - Discussed intensively at the "NA61 beyond 2020" workshop
- Several upgrades are under discussion, especially important ones are:
  - Silicon pixel detector as a vertexing detector right downstream of the target
  - Construction of new tertiary beam-line (< 10 GeV/c beam)

  —> Close work with SPS experts is necessary

Possibilities for future neutrino projects

- Increased statistics to get better kaon rates
  - Important to improve ν_e ($\overline{\nu}_e$) vs ν_μ ($\overline{\nu}_\mu$) cross section
- Measurements using very low momentum beams (< 10 GeV/c)
  - Study of the untuned phase-space (e.g. pions interact out of target)
  - Measurements required for atmospheric neutrino flux prediction (for SK, Hyper-K)
- Measurements with different nuclear targets
  - new target material (Super-Sialon?), support materials (Al, Fe, water, Ti…)
  - new thick target (T2K-II/HyperK, if prototype or replica are ready)

Oscillation Analysis

- Observed non negligible bias in some of the fake data studies
- Added one extra systematic parameter for the Eb fake dataset, smearing in Δm^2_{32} for the other ones
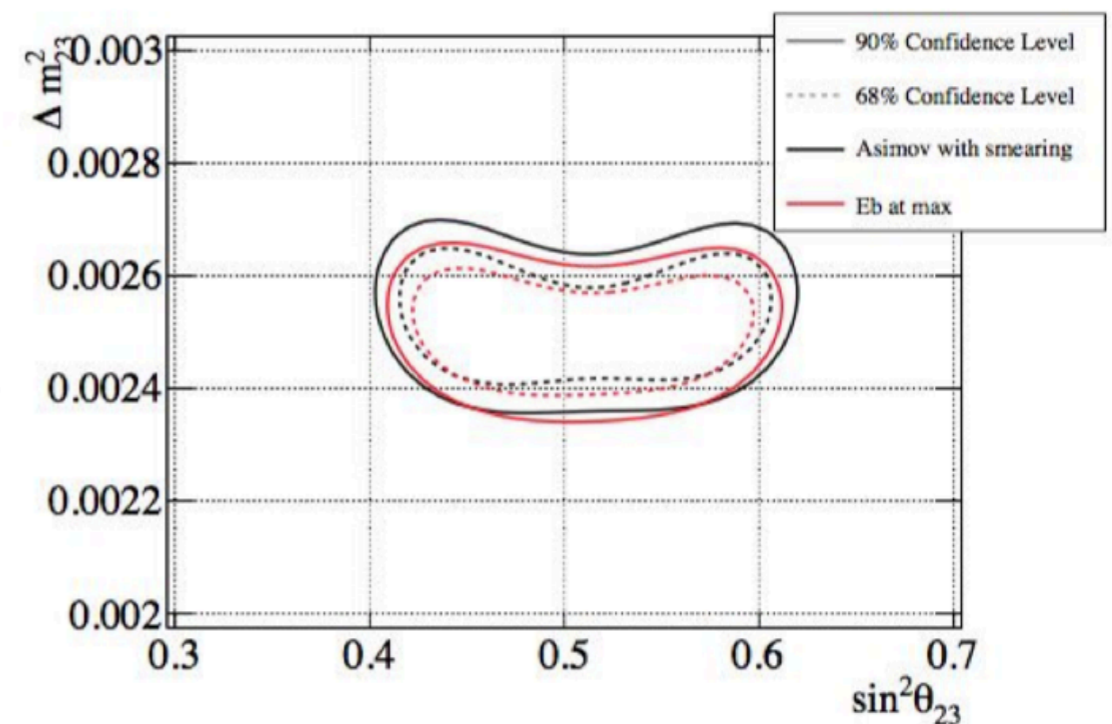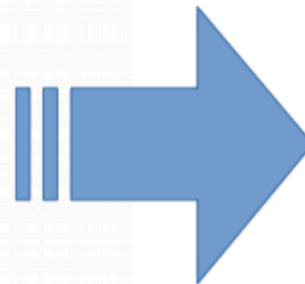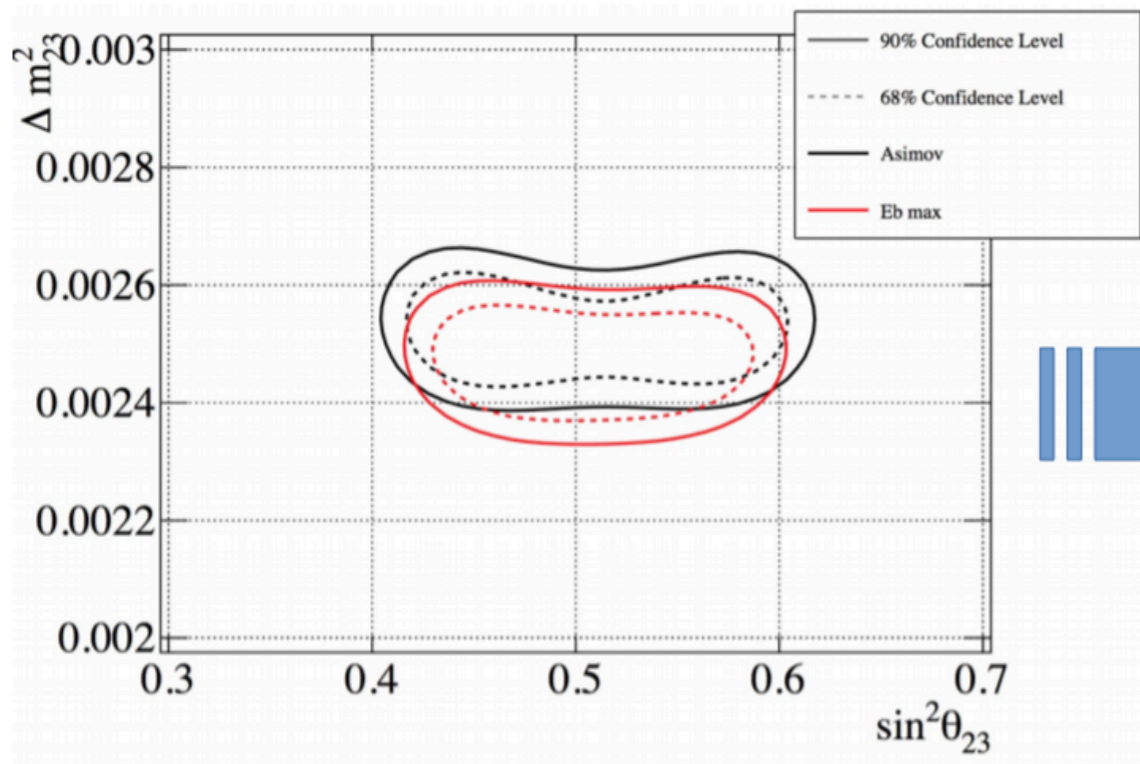
- Ready for publication with 2017 data after Feldman-Cousins is run

- Now first look at 2018 data

- Development of new samples to increase the statistics —> NuMu CC1pi+

- Work ongoing toward a T2K+SK joint fit

Next appointments

- We will start next week with the by-weekly meetings

  - SuperFGD meeting on next Tuesday

  - general ND280 upgrade meeting on next Wednesday

  - Restart with simulation & optimization meetings in two weeks

- ND280 upgrade mechanics workshop at CERN on 2nd of March

- ND280 upgrade general meeting on 16-17th of April

- Next T2K collaboration meeting on 7-12 of May

BACKUP

Simulation studies

➤ Fitted BeRPA nominal data set (Asimov) with Current :
  ➡ BeRPA fixed at nominal χ^2 = 1e-12
  ➡ BeRPA fixed at +1σ χ^2 = 38.3305

➤ Fitted BeRPA nominal data set (Asimov) with Upgrade :
  ➡ BeRPA fixed at nominal χ^2 = 0.809756
  ➡ BeRPA fixed at +1σ χ^2 = 79.9355

➤ Fitted BeRPA +1 fake data set with Current :
  ➡ BeRPA fixed at nominal χ^2 = 39.4193
  ➡ BeRPA fixed at +1σ χ^2 = 1e-12

➤ Fitted BeRPA +1 fake data set with Upgrade :
  ➡ BeRPA fixed at nominal χ^2 = 85.7191
  ➡ BeRPA fixed at +1σ χ^2 = 1.22432

Can build a PDF for nominal and 1σ for both current and upgrade with $\Delta\chi^2$ as mean and $2\sqrt{\Delta\chi^2}$ as standard deviation.
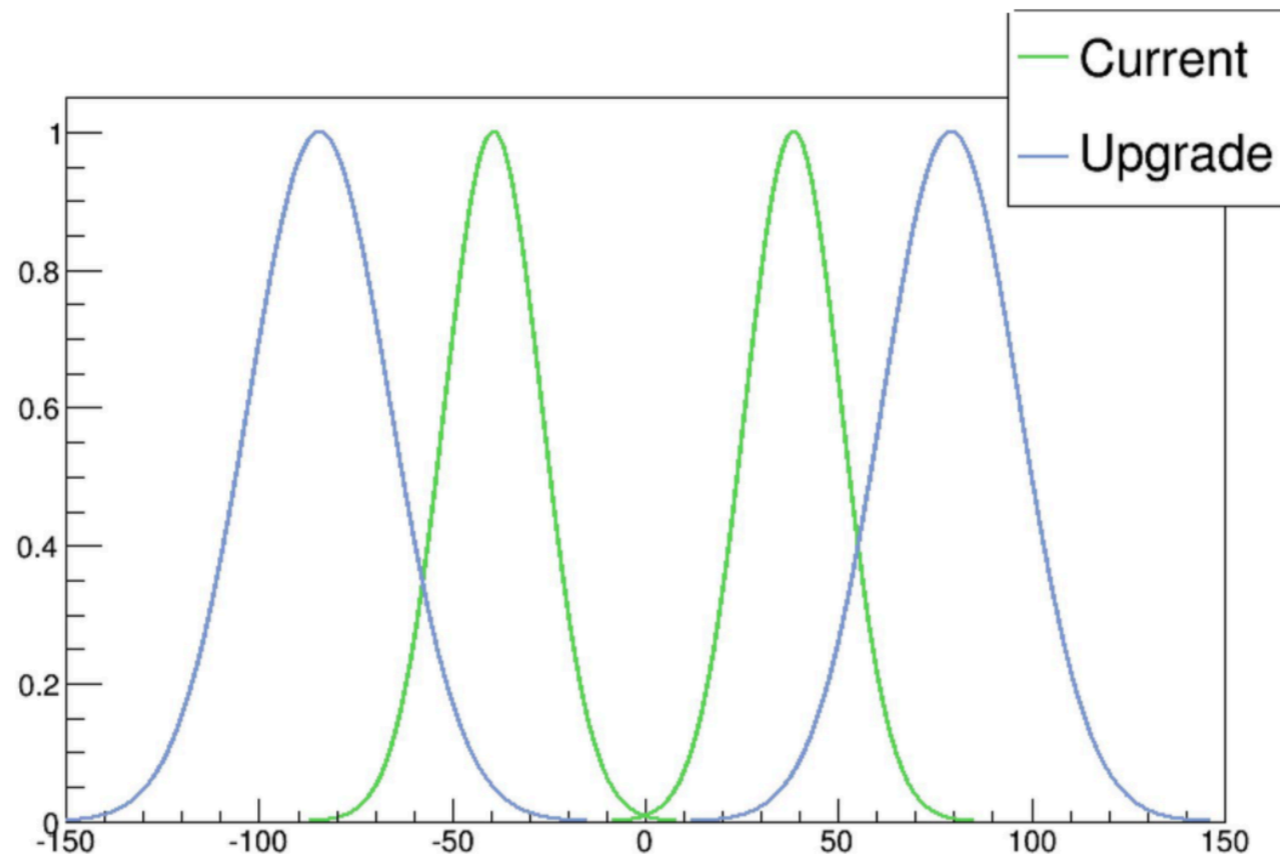
• Simplified approach to study the sensitivity to discriminate between 2 models (non-nested hp, like MH). Work still ongoing to validate the fit framework

Super-K analysis

- Toward a T2K+SK joint fit

  - Bayesian analysis
  - Software:
    - SK atmospheric MC specifically generated to match the software of T2K MC 14c
      - NEUT 5.3.2 and fQv4r0
    - T2KReWeight has been checked on SK atmospheric MC
    - MaCh3 framework (Markov Chain Monte Carlo)
  - Systematic uncertainties
    - T2K 2017 summer analysis cross-section modeling
      - Official SK analysis uses different cross-section systematic errors
    - Honda *et. al.* atmospheric neutrino flux model
    - $L \rightarrow \alpha L + \beta$ detector systematic uncertainties parameterization