The T2K Near Detector Upgrade

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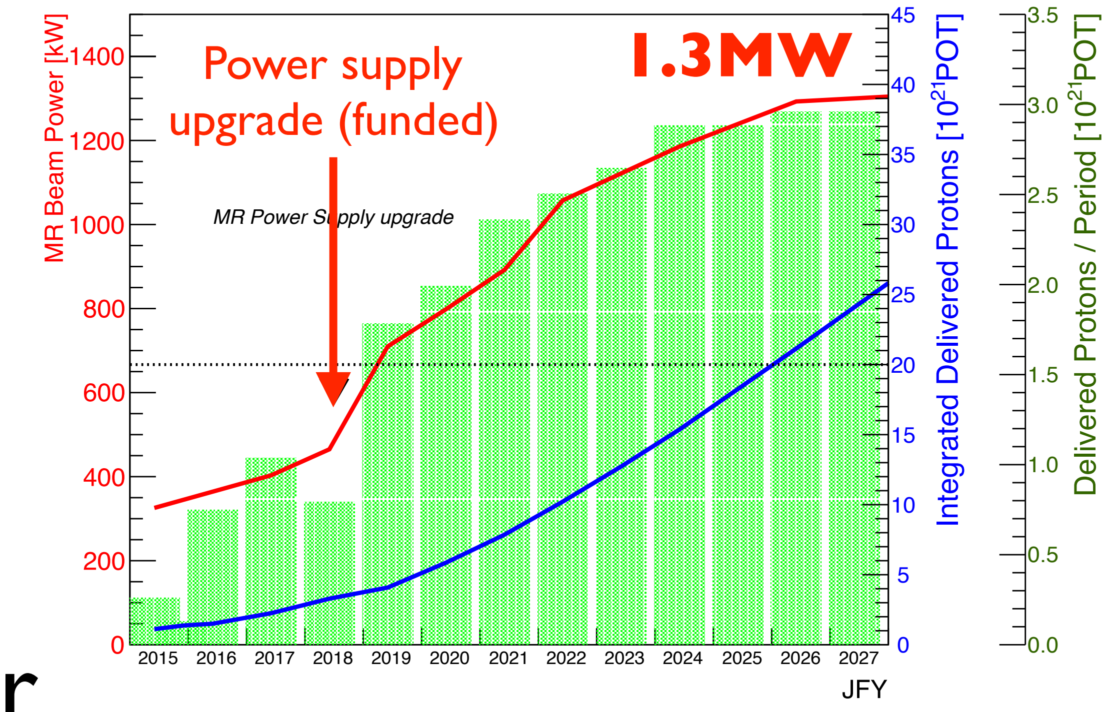
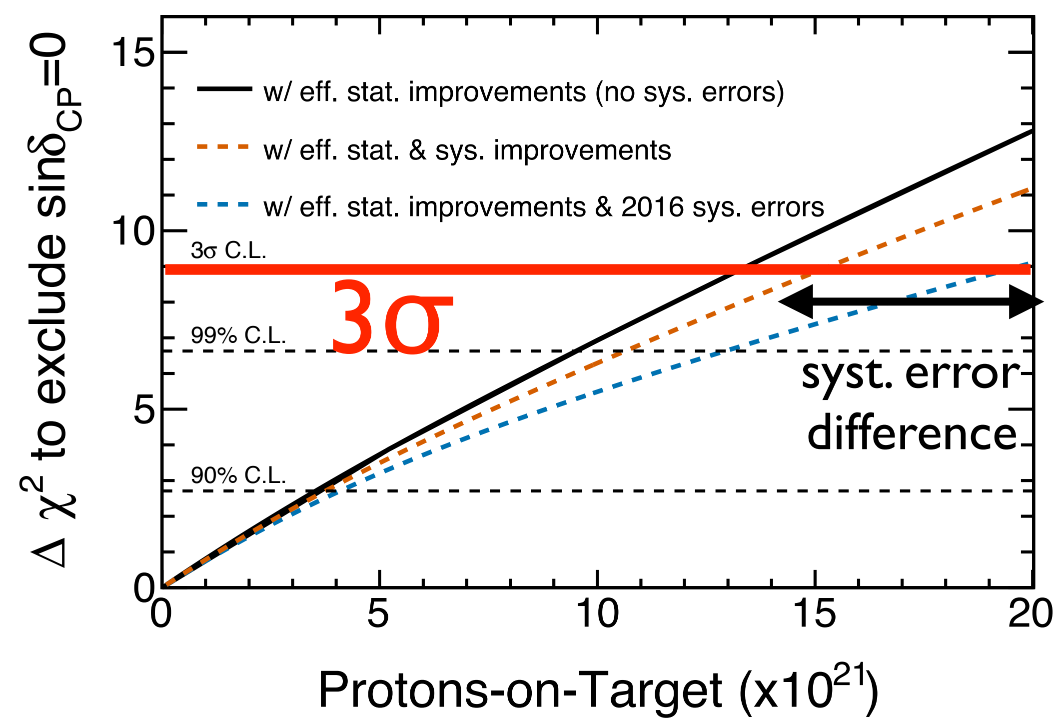
Workshop on Neutrino Near Detectors based on gas TPCs
Nov. 8-9 2016, CERN

T2K Phase II (T2K-II) and ND upgrade

- T2K-II extension proposal (arXiv:1609.04111): got stage-1 at PAC
  - Aim for 3σ CPV sensitivity by 2026 by accumulating 2×10^{22}POT with upgraded J-PARC (1.3MW)
  - Goal of systematics: 4% in total for number of ν_e (~400evts expected) → ND measurement is a key!
- Upgrade of Near Detector (ND280) is under discussion inside T2K
  - Target of installation date: ~2020
- New collaborators are WELCOME!

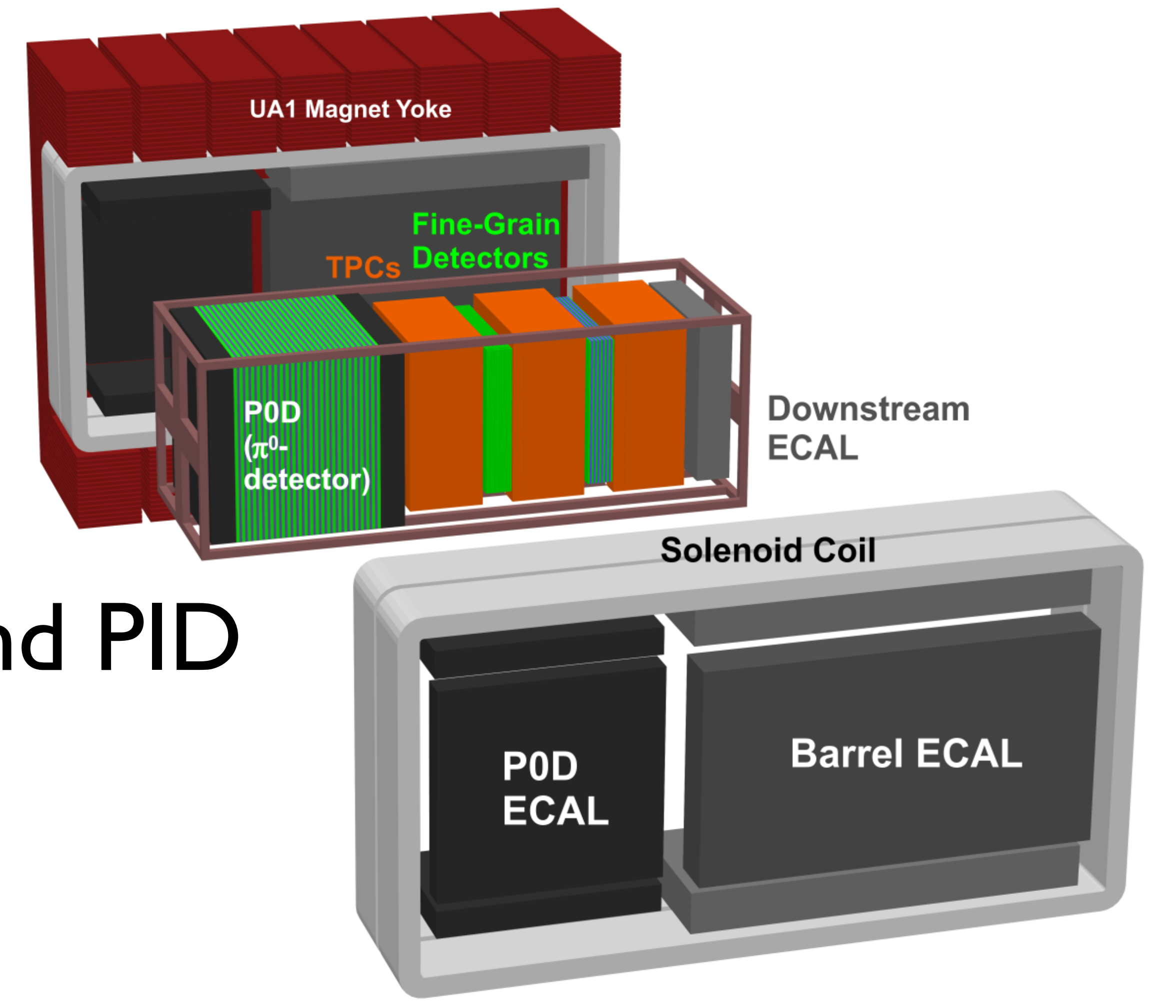




T2K ND upgrade task force

- Formed in fall 2015 with a charge:
  - To deliver CDR-like document describing the preferred configuration for an ND280 upgrade in Fall 2016
  - Based on a quantitative evaluation of the performance
  - Assuming installation around 2020, within the ND280 pit, reusing the magnet facility
- Report being finalized, yet work for further optimization/technical design continues

(current) ND280

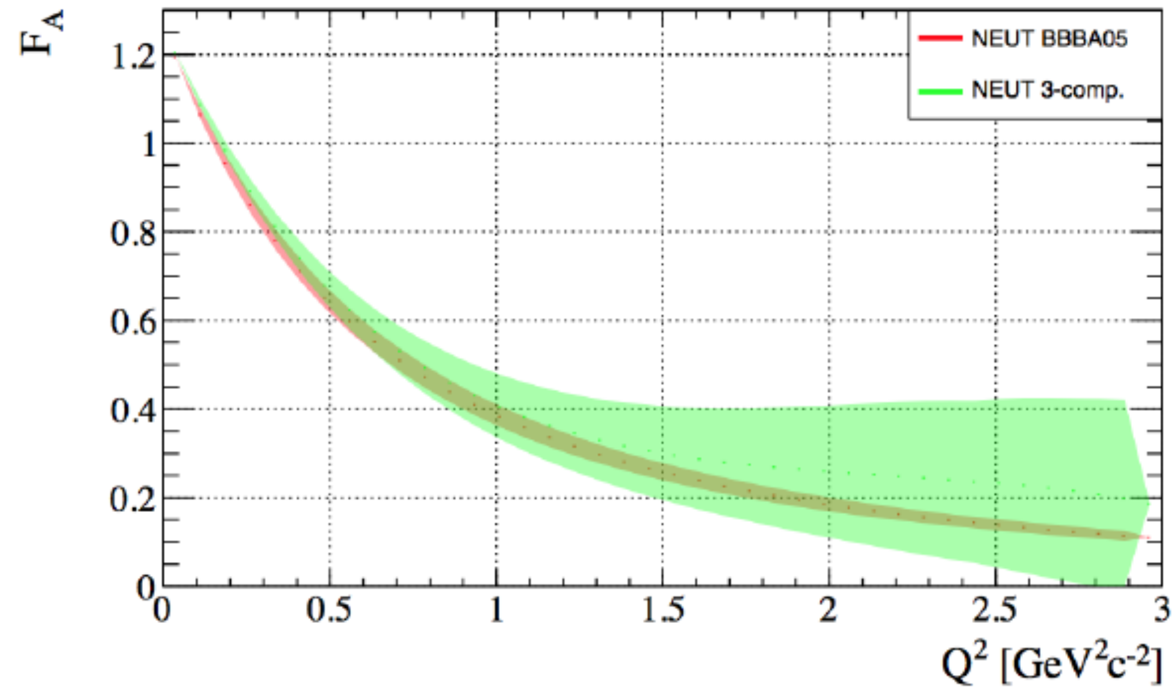


- Excellent performance as designed
  - FGD with carbon and oxygen targets
  - TPC with charge, momentum, and PID
  - Calorimeter coverage
  - Inside UA1 magnet (B=0.2T)
- Weak for high angle and backward tracks
  - When designed, emphasis was on background and forward-going tracks
  - With the large value of θ_{13}, precise understanding of signal becomes more important

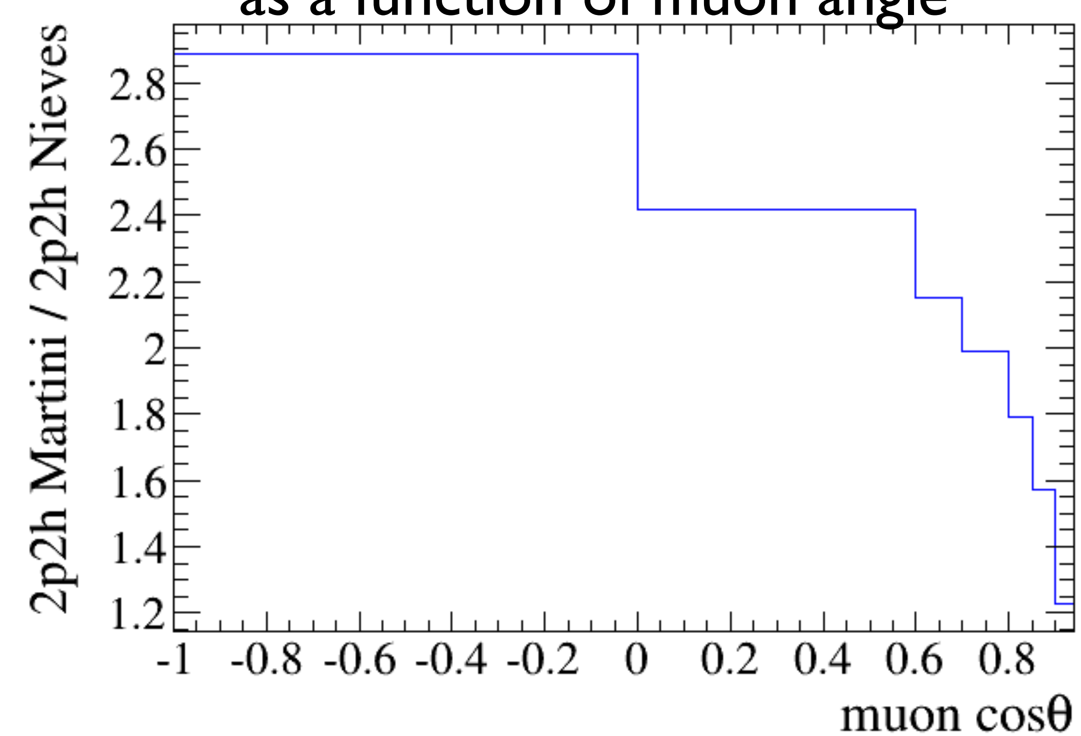
Constraining/choosing cross section models

- Various nuclear effects make the understanding of cross sections complicated
- Enlarging the phase space is a promising way to differentiate various effects and constrain/choose cross section models

Axial nucleon form factor with uncertainties extracted from a fit to bubble chamber data



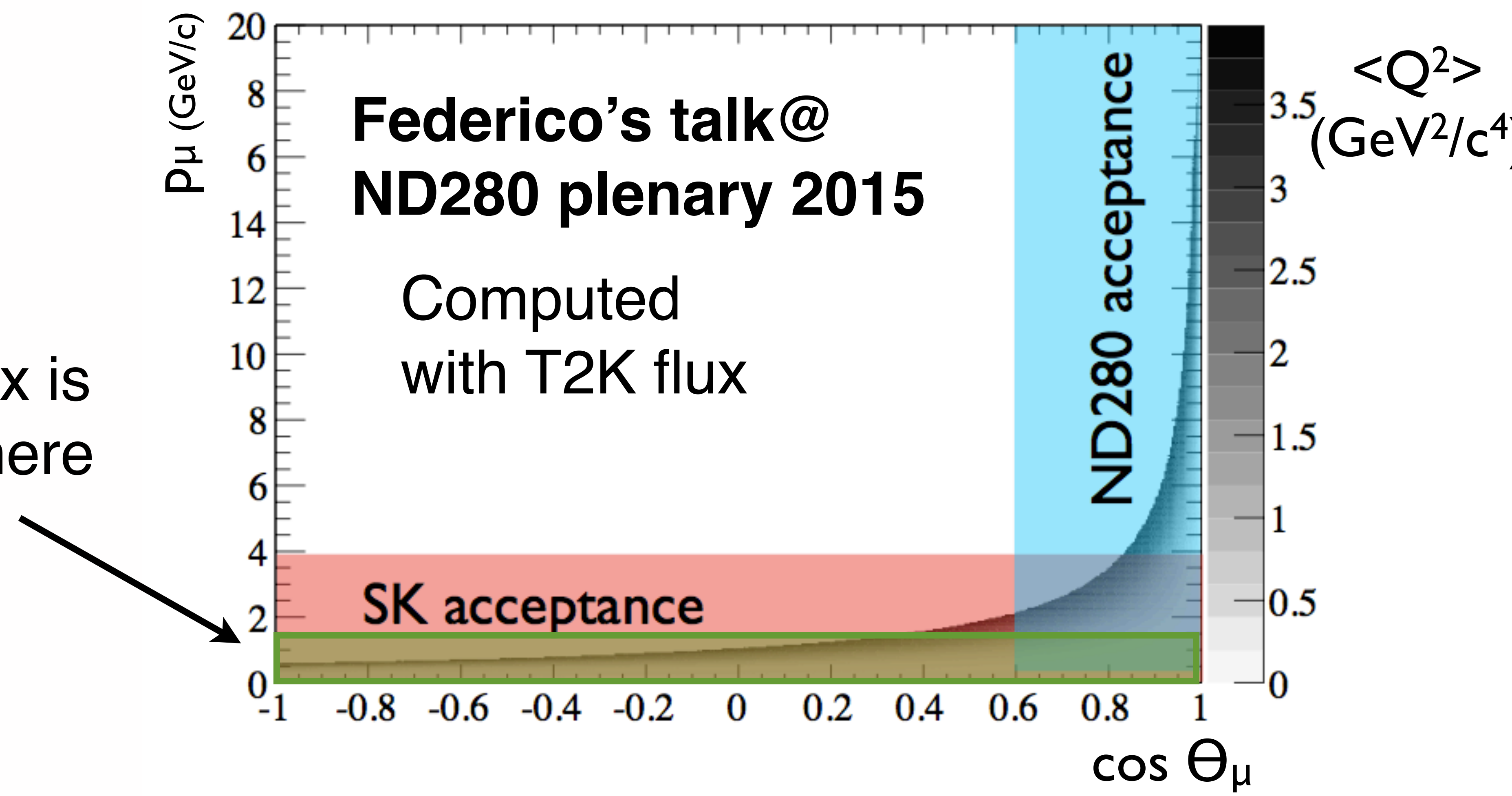
Ratio of 2p2h cross sections by Martini/Nieves as a function of muon angle



Requirements/goals of ND upgrade

- Improvement of angular acceptance

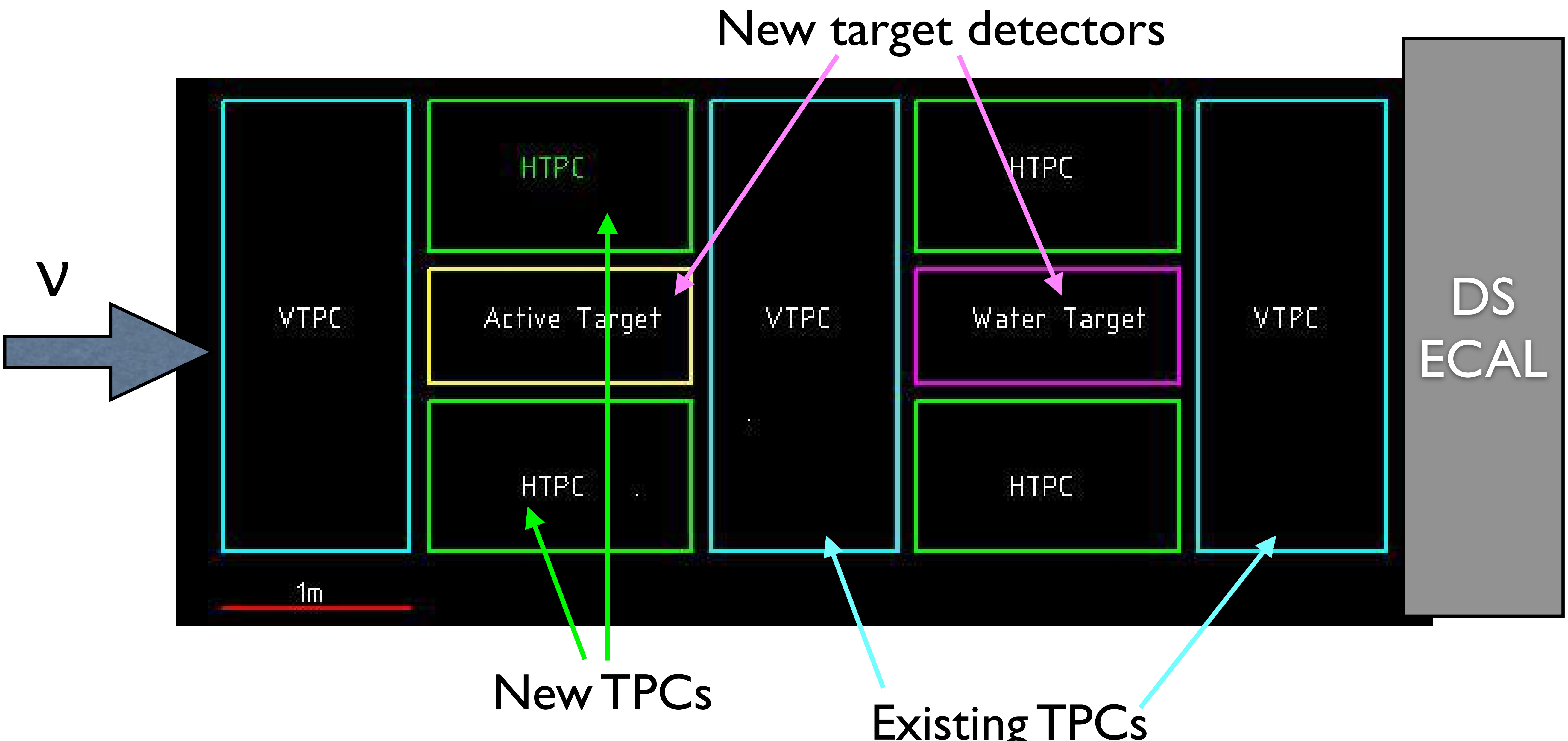
The neutrino flux is approximately here



- Contains water target
- Low momentum threshold for pions & protons
- ν_e measurement capability (fiducial mass, BG rejection, PID)
- Track direction with timing measurements

The “reference design”

Inside calorimeter and magnet (seen from side)



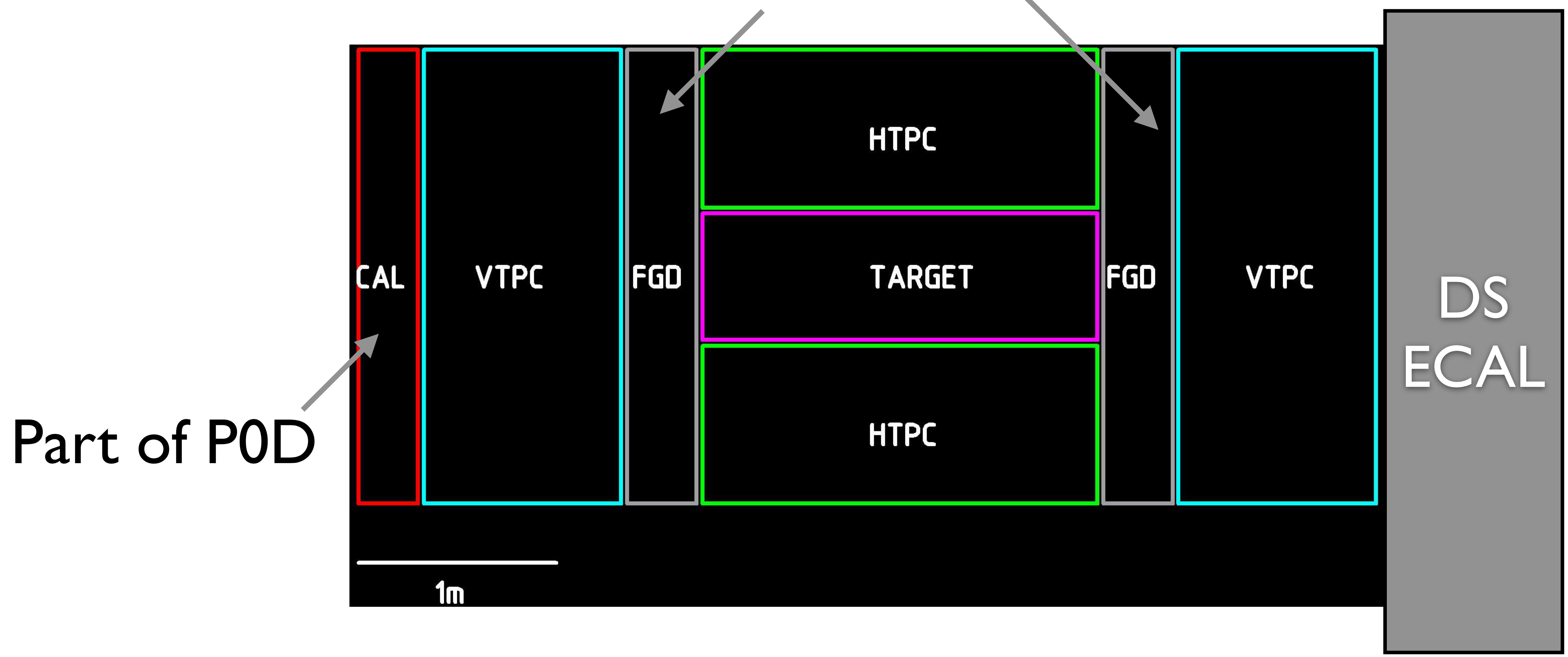
+scintillator planes around TPCs for timing

Reconfiguration + new detectors to cover full cosθ

Following talks assume this configuration

Alternative design

Keep also existing two FGDs(Fine Grained Detectors)



Target divided to water and scintillator parts (to be studied)

Retain forward acceptance and target mass

Recently proposed and to be studied

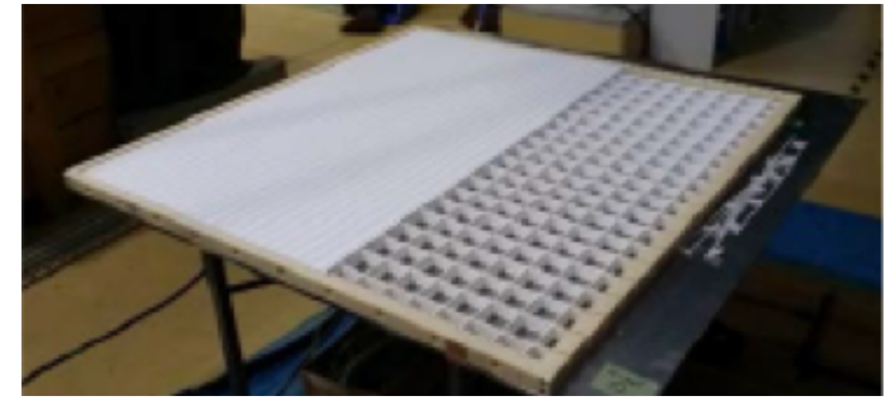
Target detectors

- Requirements:
  - Sufficient target mass with proper target material
  - Large angular acceptance for charged leptons
  - Capability to reconstruct and identify short tracks of low energy hadrons
- Can be realized with a combination of multiple detectors (like FGD1+FGD2)

T2K FGD

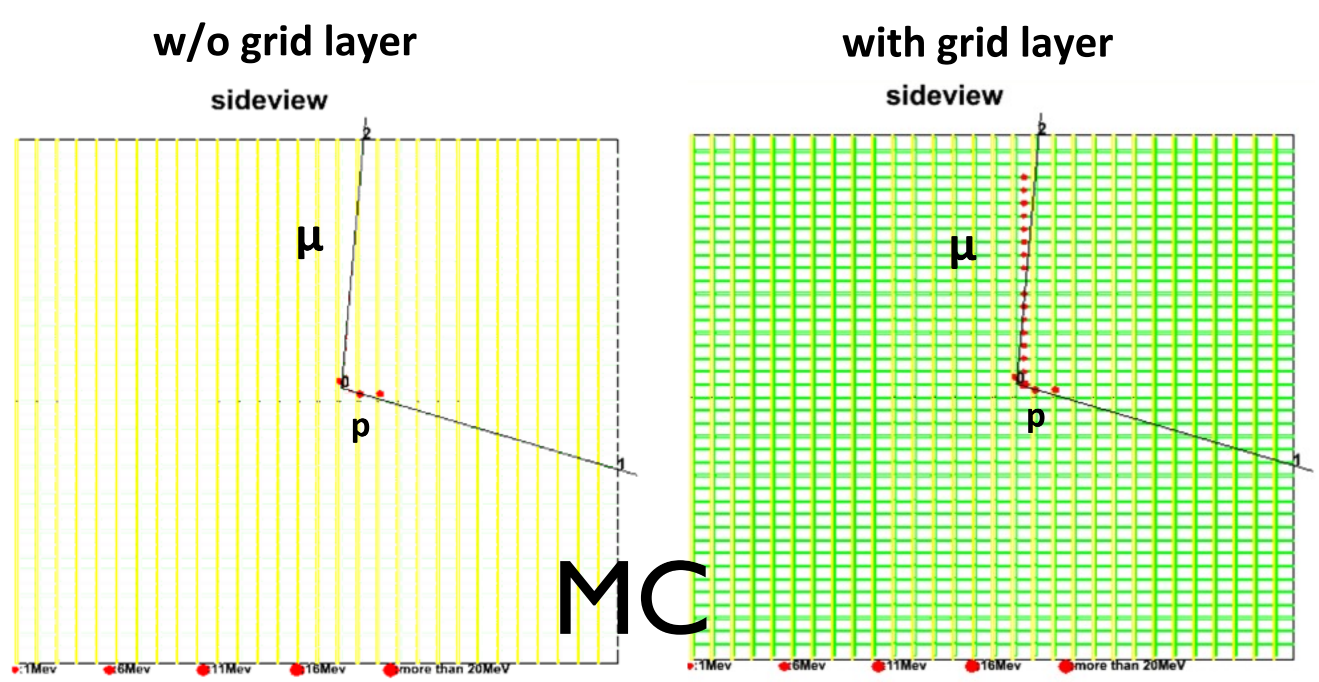
See Benjamin's talk

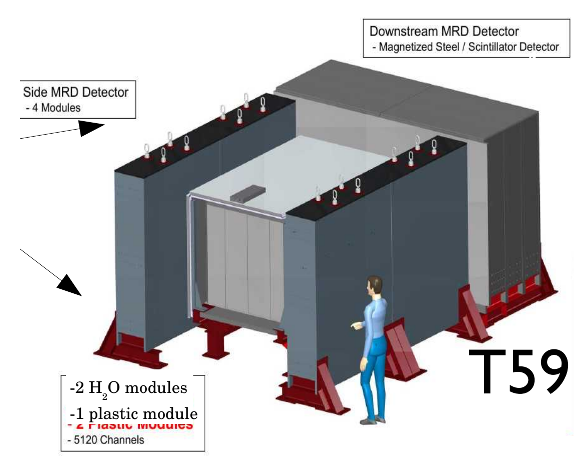
“WAGASCI” structure



- 3D grid structure with ~3mm-thick plastic scintillators
  - Using improved MPPCs
- Reference option for the target detectors
  - 4π acceptance with water target
  - H_2O:CH=7:3 for $(2.5cm)^3$ cell
- Test detectors to provide real measurements
  - INGRID water module (installed 2016)
  - T59/WAGASCI (from next year)

INGRID water module with WAGASCI structure installed in summer 2016



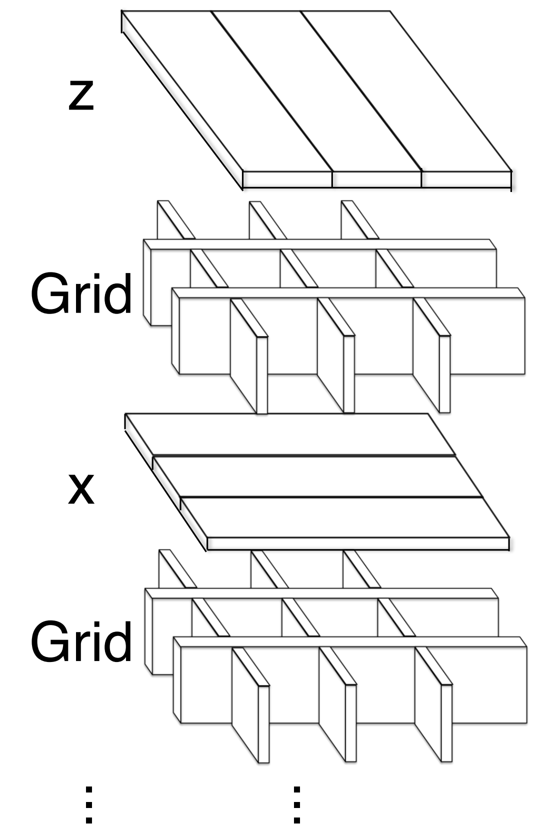


T59 detector

See Benjamin’s talk

Target considerations

- How to minimize dead material between target and TPC
  - Needs to hold O(ton) mass, water tight
  - Service (fiber readout, electronics, water tubes,) on side
- Options of fully scintillator detector
  - "empty WAGASCI" option
  - FGD-type detector with finer segmentation
  - Non-water contribution subtraction to be considered
- Possibility of ν_e background suppression

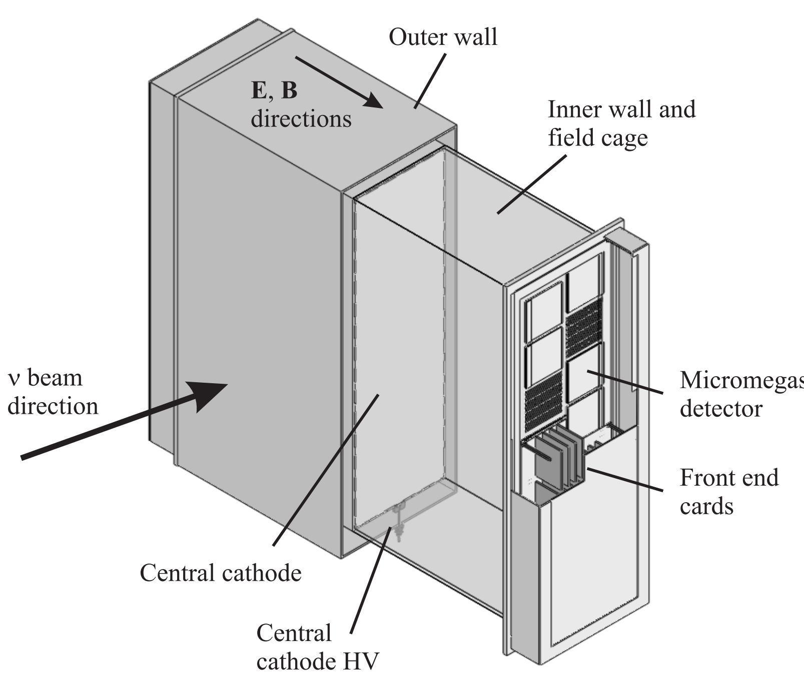


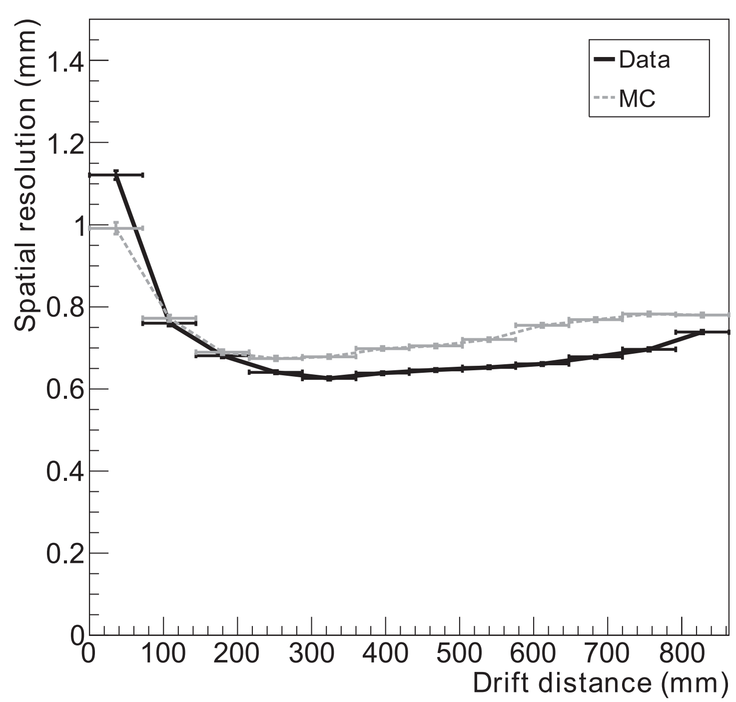
Many areas open to new groups also for target detectors!

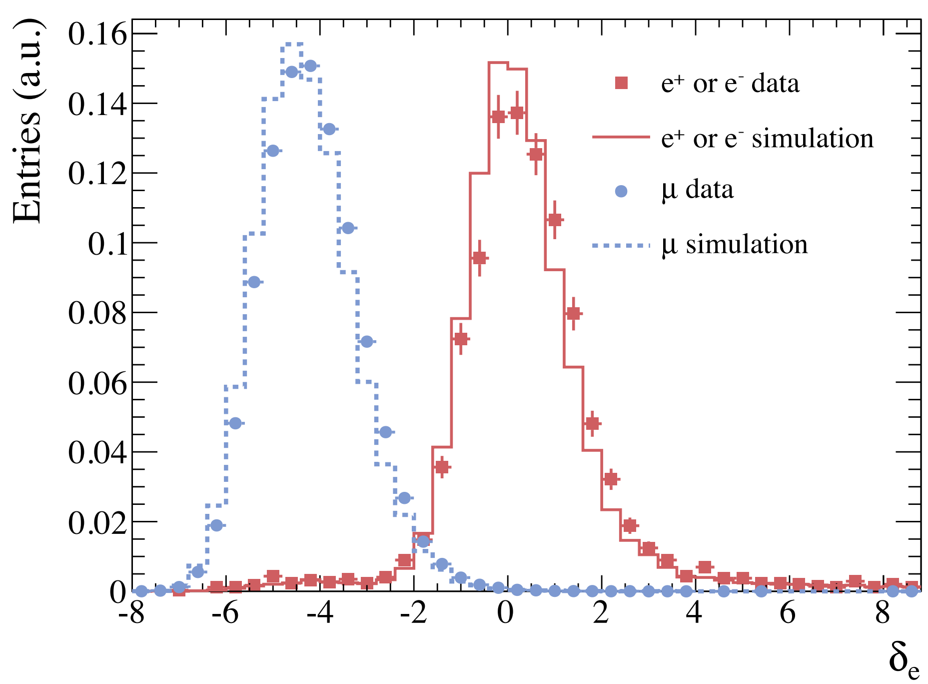
(for TPC see later talks)

New TPCs

- Basic requirements quite similar to the current TPCs
  - Momentum resolution <10% (space resolution <0.8mm)
  - dE/dx resolution 8% for MIP
- Plan to incorporate some improvements
  - Thin field cage
  - New technology (resistive anode MM, readout, ..)

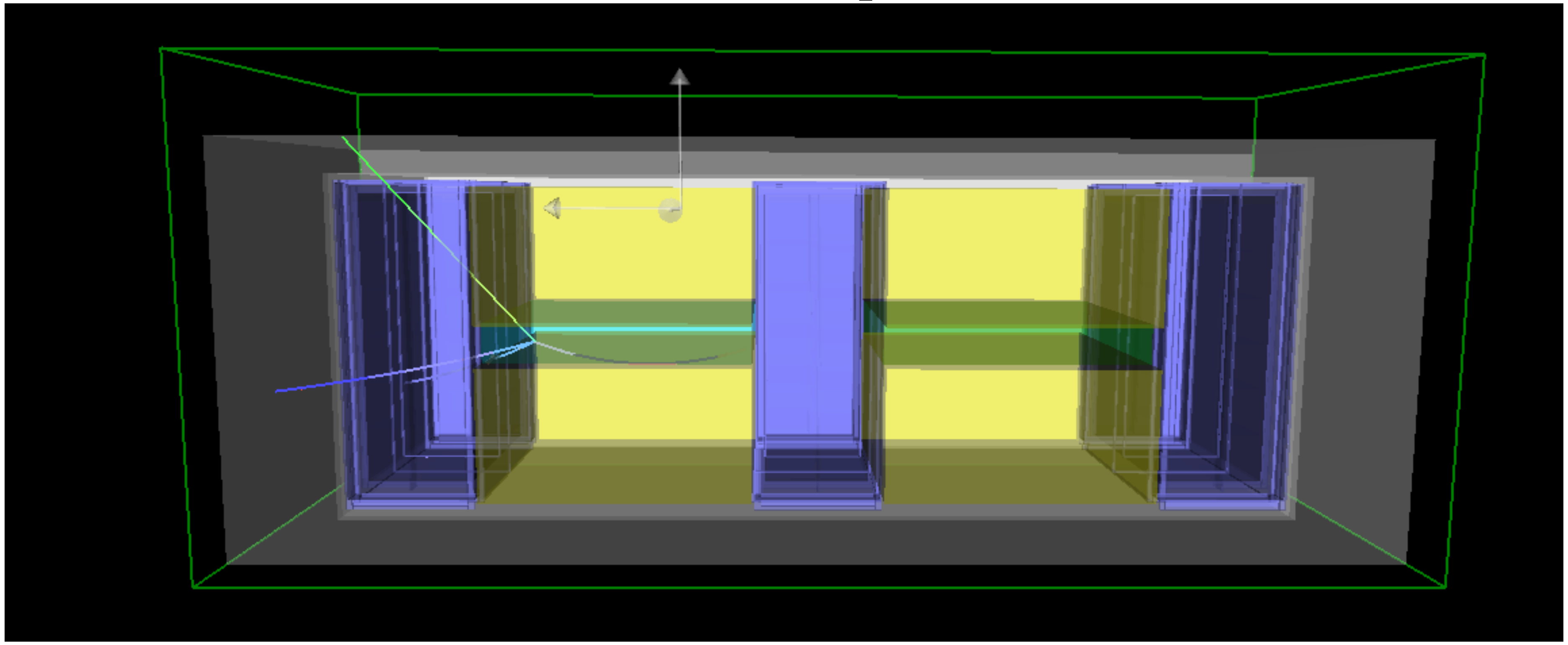






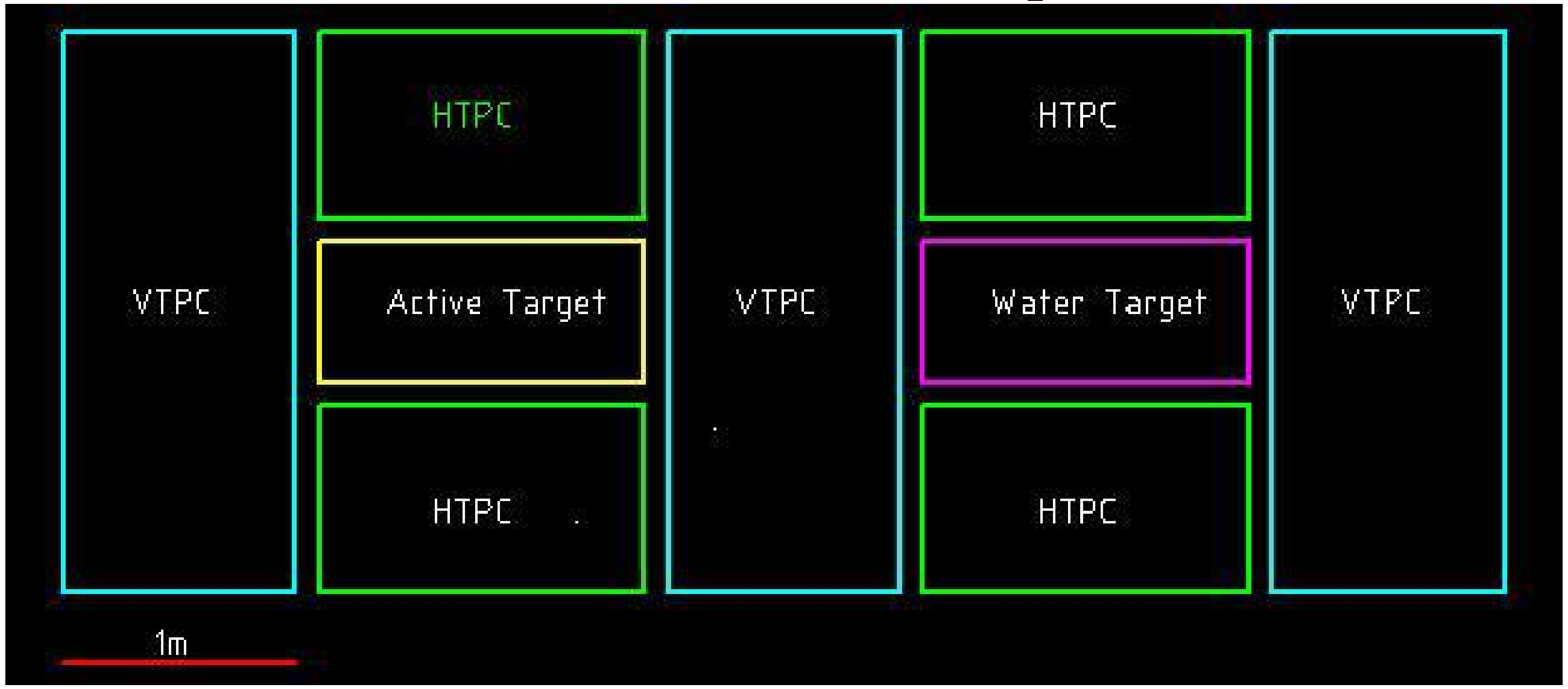
Marco's talk and next session

Assessment of performance



- Efficiency studied using GEANT4-based simulation, currently with two directions
  - Optimization of target (WAGASCI) [Benjamin's talk]
  - Performance of upgraded detector, target+TPC [Davide's talk]
- To be merged into a unified simulation, soon
- Assessment of the impact to physics sensitivity with ND-fit tools also foreseen in very near future

Beyond first conceptual design



- Time to consider more details of the new detectors (need to make simple line drawing into real design!)
  - Recent technological advances for TPC
  - Separating νe from γ conversions in target
  - Define and design needs for the T0 determination
  - Mechanical design and integration (existing basket)
  - etc., etc., …

Future steps

- Foreseen timeline:
  - 2016: finalize first conceptual design report
  - 2017: detailed design of the detectors/setting up the project and the funding, proposal to SPSC
  - 2018-2019: construction of new detectors, possible beam test
  - 2020: shipment, installation, and commissioning
- Schedule is very tight, need to accelerate the project

New groups are very welcome to the project.

Let's have fruitful discussions!