

HPTPC for DUNE and Synergies with T2K/HK

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Science & Technology Facilities Council
Rutherford Appleton Laboratory

Countries & Institutions

- ◉ UK: Liverpool, RAL, RHUL, Imperial, Oxford, Warwick, Lancaster, QMUL
- ◉ Spain: IFAE, IFIC
- ◉ France: Saclay
- ◉ Switzerland: Geneva
- ◉ Poland: Wrocław, NCBJ
- ◉ Germany: Aachen

Ongoing Efforts

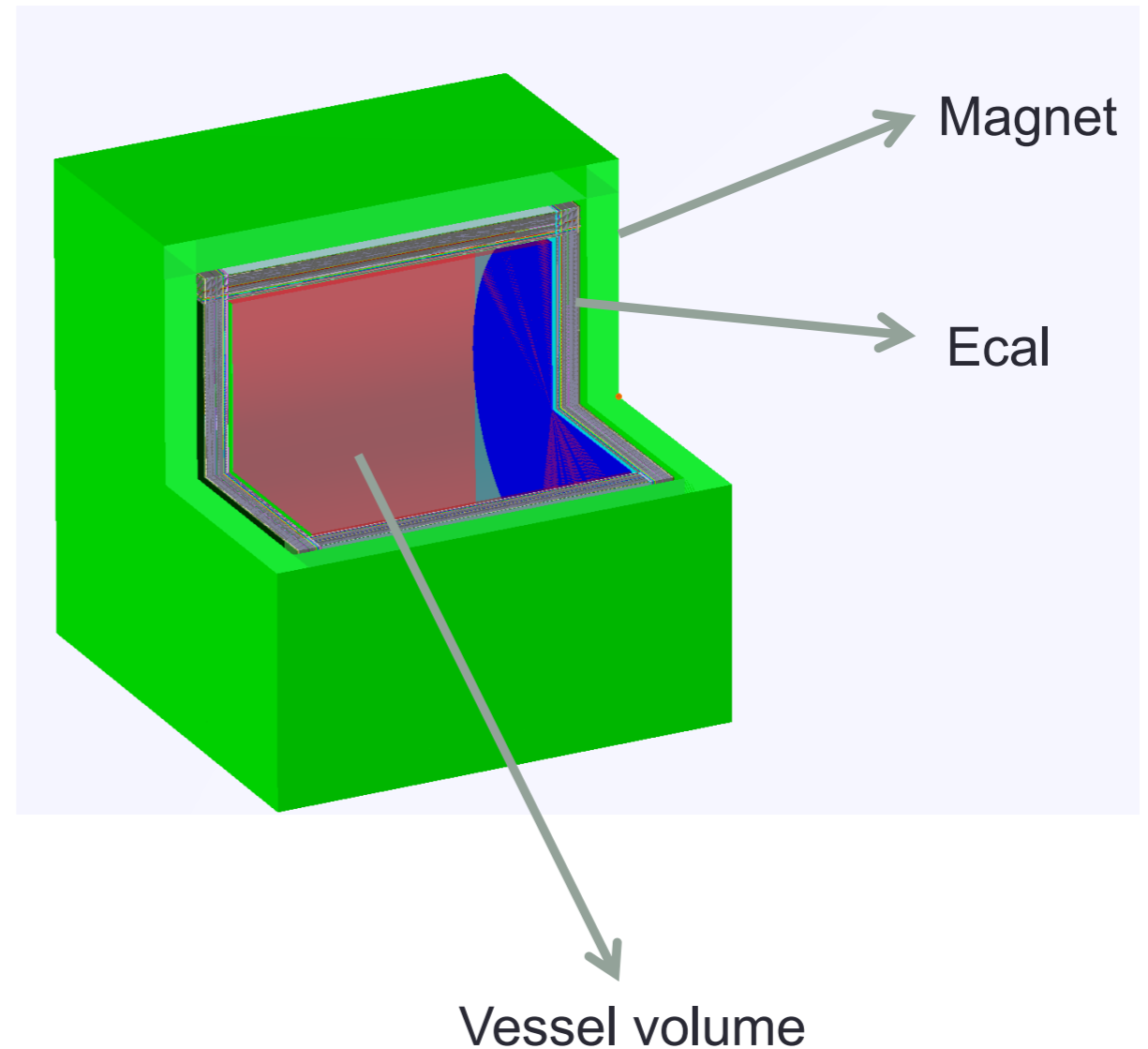
- DUNE ND HPTPC
- UK Prototype
- T2K Analyses
- T2K ND280 Upgrades

DUNE ND TPC

- “Nominal” design
 - 10 bar cylinder; 5 m diameter, 5 m length
 - Surrounding ECal
- Implemented in a Geant4 simulation
- Truth-based reconstruction

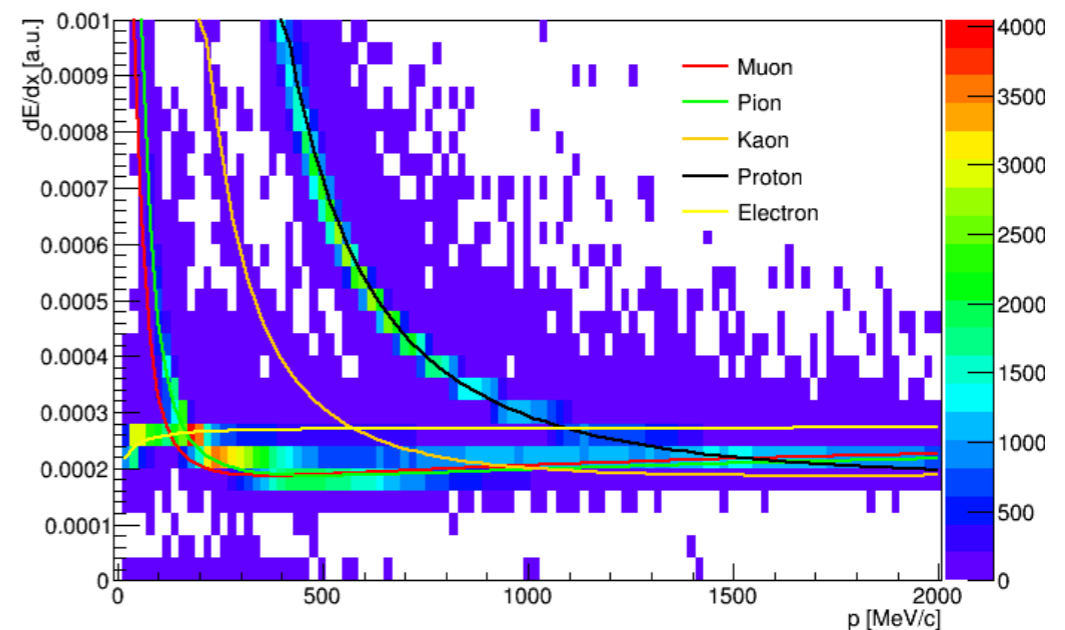
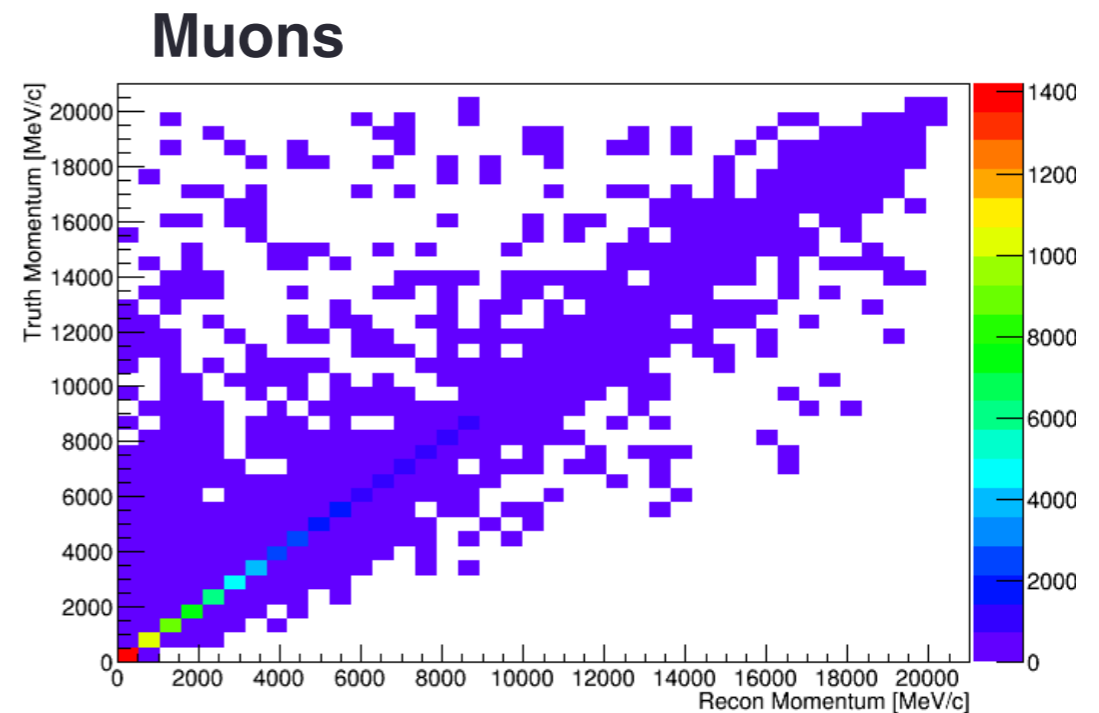
Reference Design

- Cylindrical vessel
 - 5m length and 5m diameter
 - T2K gas mixture: 95% Ar + 3% CF₄ + 2% iC₄H₁₀
 - 10 bar
 - 0.0135 g/cm³
 - ~ 1.3 tons
- Surrounded by plastic-lead Ecal
 - 35 layers, 1 cm thick plastic, 0.1 cm thick lead
- Magnetized – 0.4T; 50 cm iron



Current 'Reconstruction'

- Base a lot of reconstruction effects on T2K measurements
 - dE/dx
 - p_μ resolution
 - Efficiency
 - etc...
- Base ECal reconstruction on T2K ECal



Ongoing work

- ◉ Check the TPC pulls for PID
 - ◉ Not centralized at zero
 - ◉ Truncate dE/dx
- ◉ Efficiency loss from events without T0
 - ◉ Determine fiducial volume
 - ◉ Signal efficiency and background contaminations from Ecal and magnet
- ◉ Interactions of neutral particles inside the gas volume
 - ◉ Gamma conversions
 - ◉ Neutron interactions etc.
- ◉ Effect of the vessel

How does this connect to DUNE?

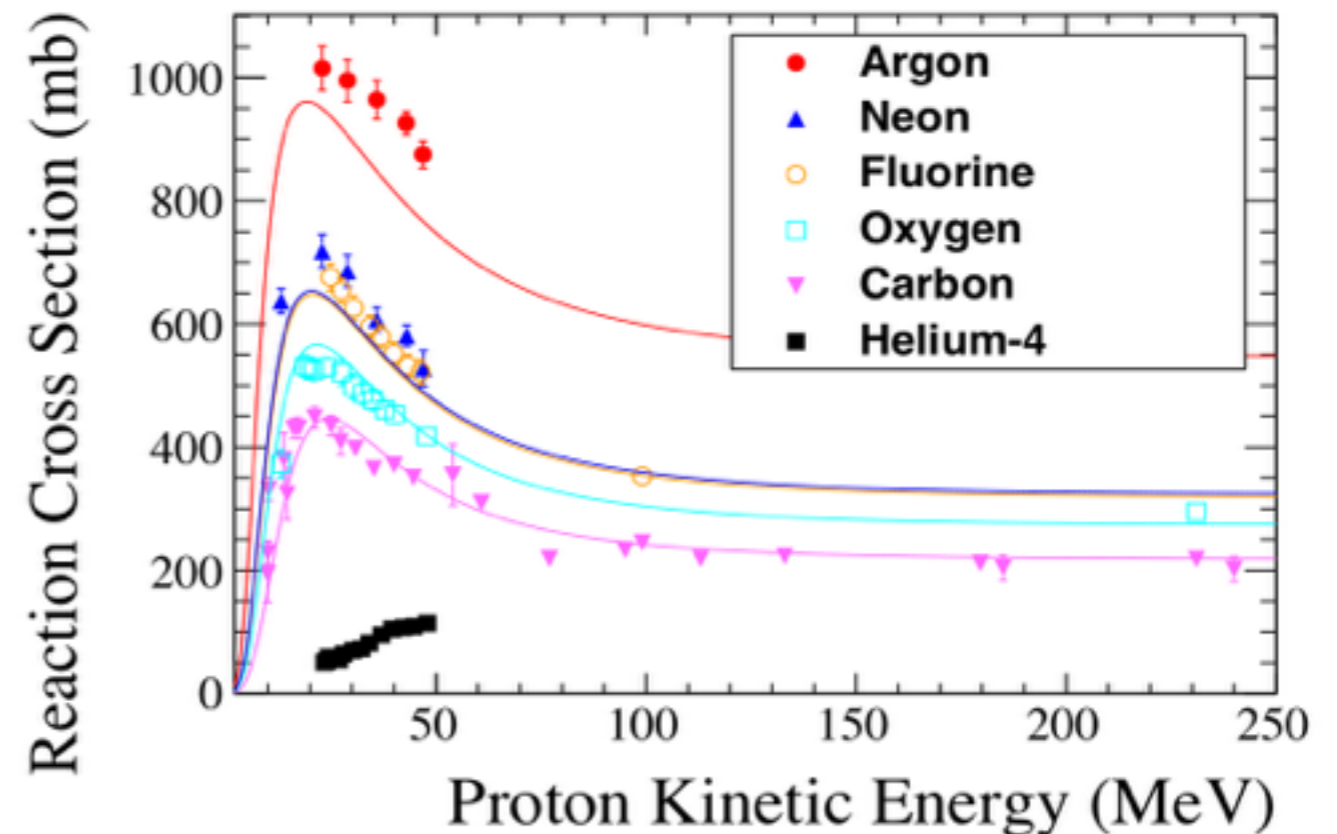
- This is part of the ND Task Force
- Produce simulated data and put it into the same fitting framework to determine systematics
- Within about a year, there will be a report about building a ND (or suite of detectors)

Opportunities

- **Basically anything for the software!**
- **Outer detector integration**
- **Reconstruction**
- **Readout simulation**
- **Interfacing with neutrino cross section models**

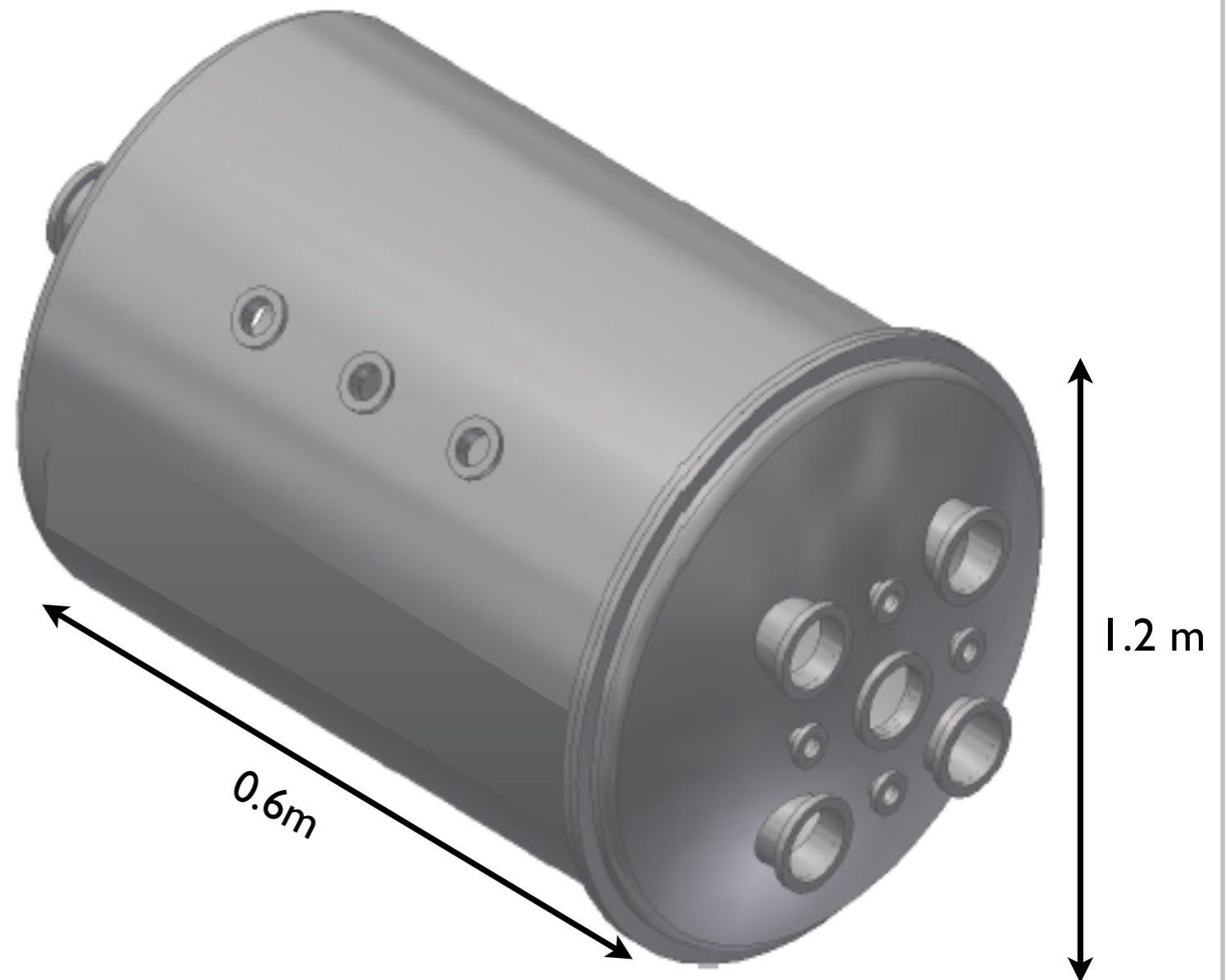
UK Prototype

- Imperial, RHUL, Warwick, and Lancaster were awarded a grant from the Projects Research and Development Scheme in the UK
 - Physics goal: build something to put in a proton/pion test beam at CERN to measure ρ/π
 - Physics goal: do the ν generator and simulation development to evaluate impact on future experiments
 - Detector design: $(0.5 \text{ m})^3$ to $(1 \text{ m})^3$ TPC with optical and charge readout



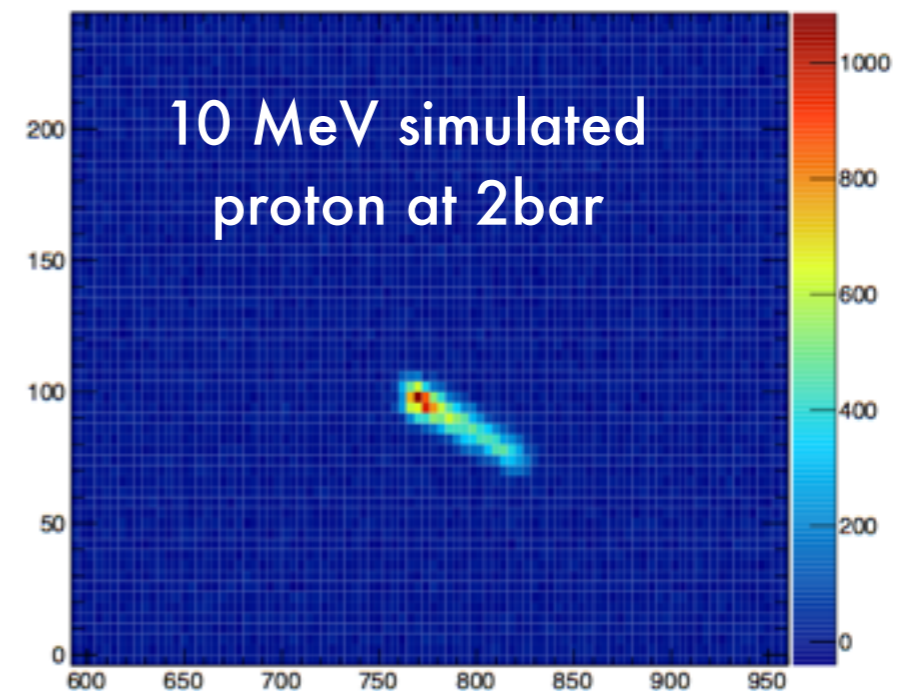
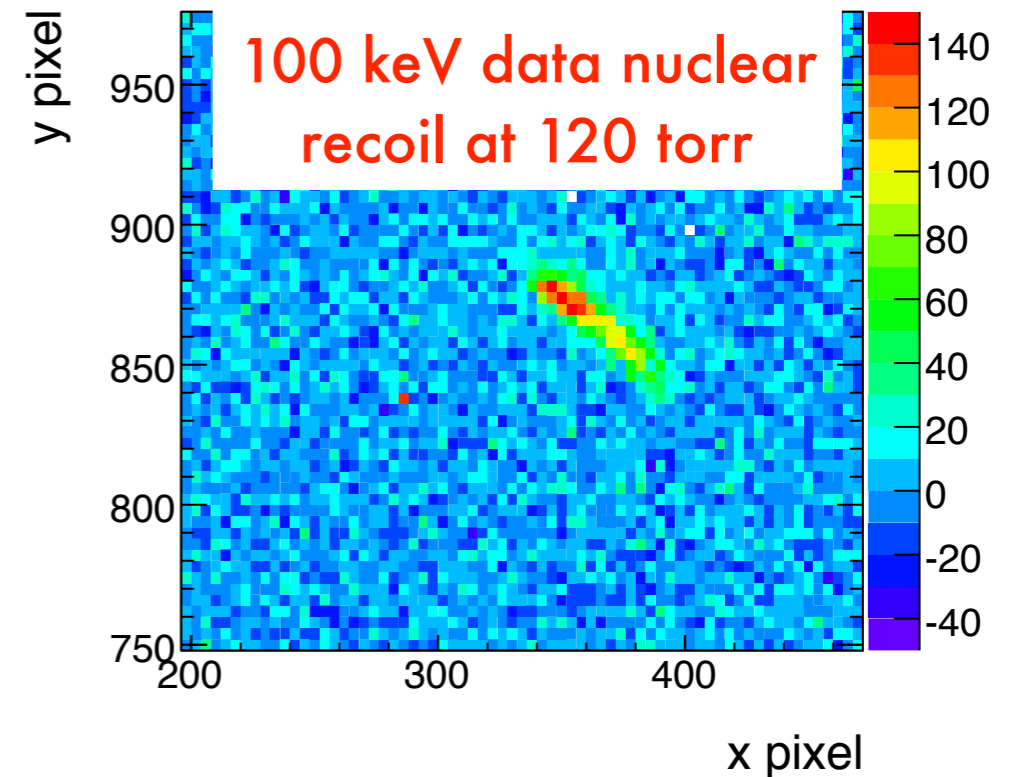
UK Prototype

- 5 bar
- 0.5 m drift, 1 m² readout plane
- Primarily looking at Argon (easy and cheap) with plans to look at CF₄, Ne, He...



Optical Readout

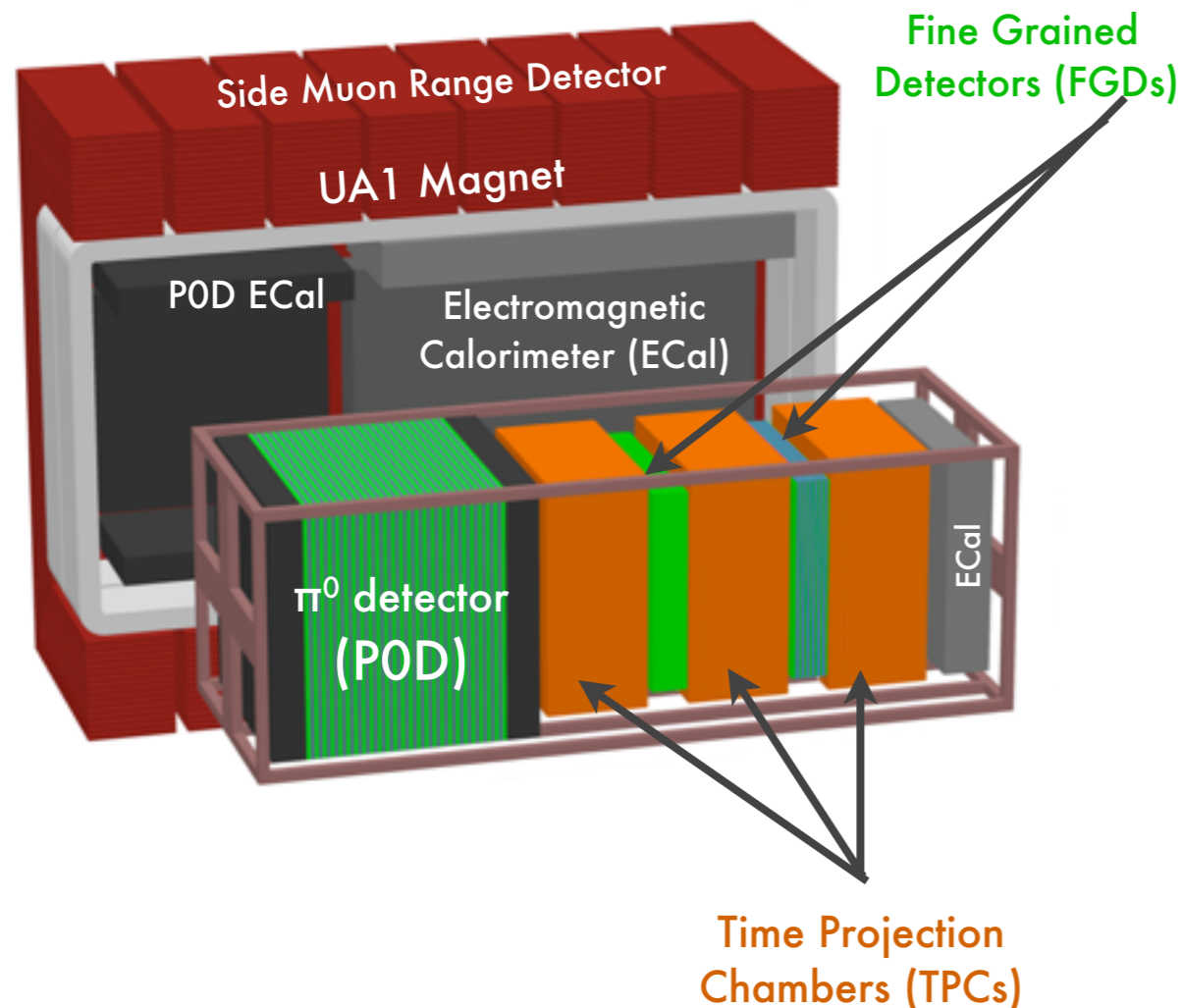
- Big problem is how to instrument a large gas volume
- RHUL runs the DMTPC project, which uses CCD cameras to read out a gas TPC for dark matter
- Pressures & energies scale correctly so that HPTPC can build on this work—if we can make it fast enough



Other Notes and Timescale

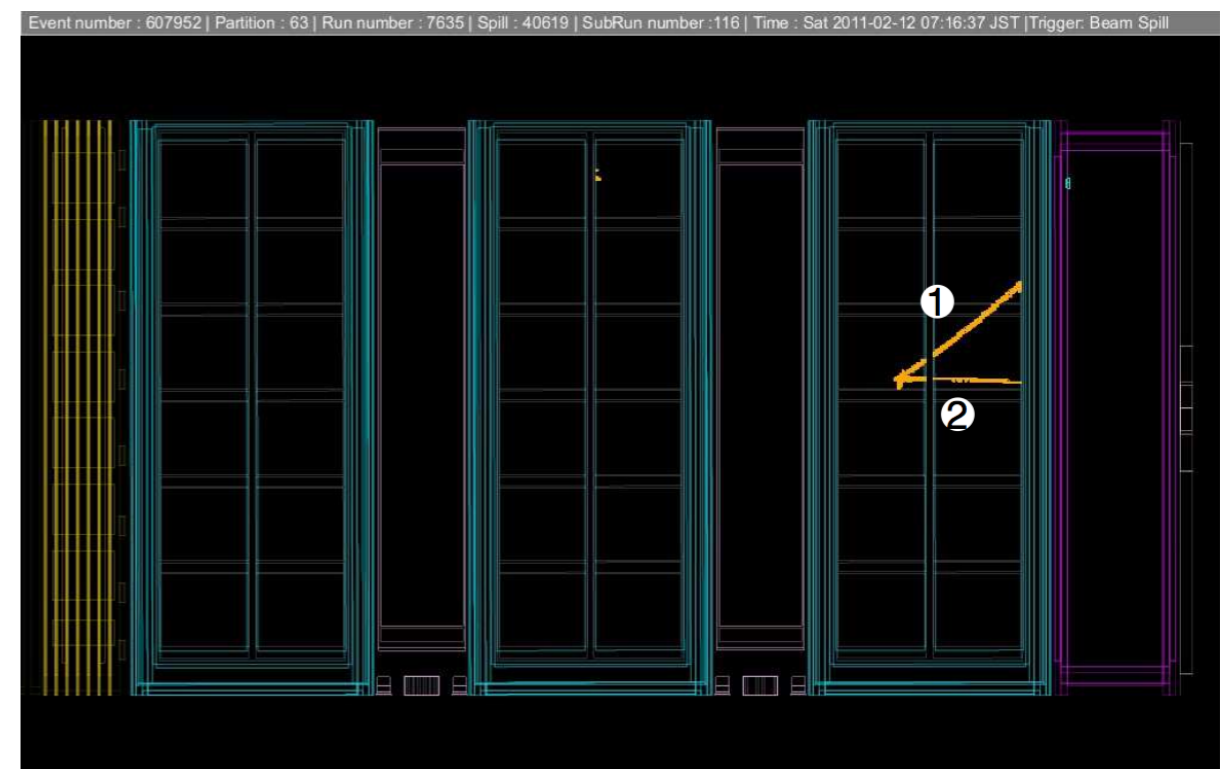
- Investigating using *Micromegas* for readout plane
- Construction will begin this summer on the detector
- Data taking in late 2017

Ongoing T2K Analyses



Occasionally events
seen on the event
display

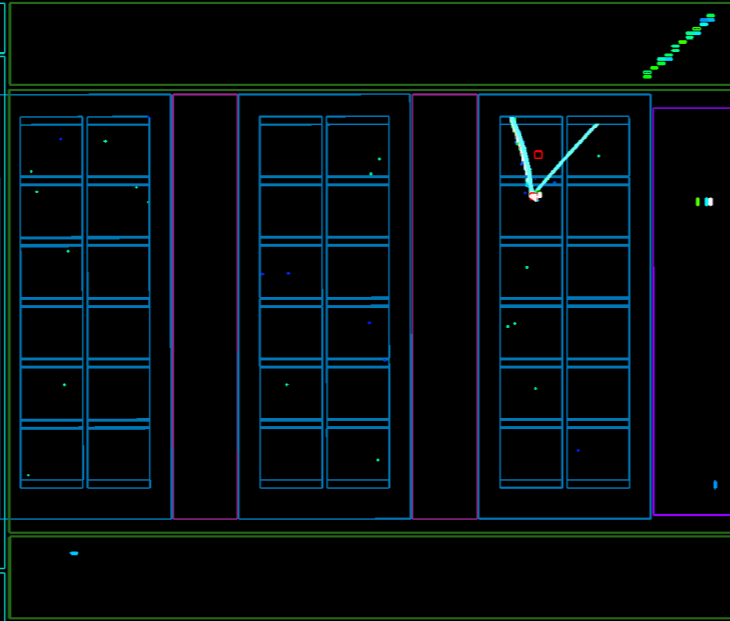
ND280 has three TPCs,
surrounded by solid detectors;
TPCs are ~ 1 atm, 95% Ar and
5% quenching gases



Data!

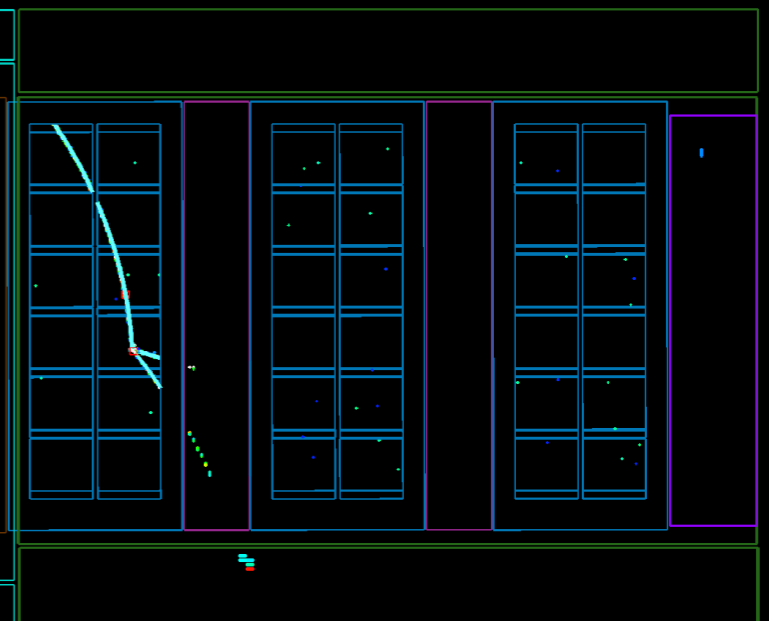
Run number : 9178 | SubRun number :34 | Event number : 382174 | Spill : 62680 | Time : Sat 2012-12-01 08:05:23 JST | Partition : 63 |Trigger: Beam Spill

YZ View



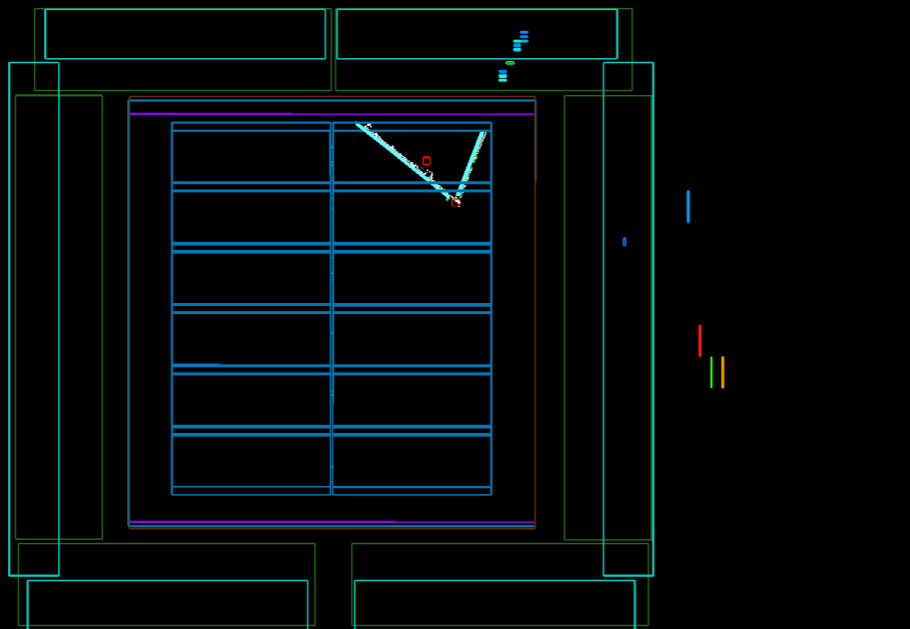
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YZ View



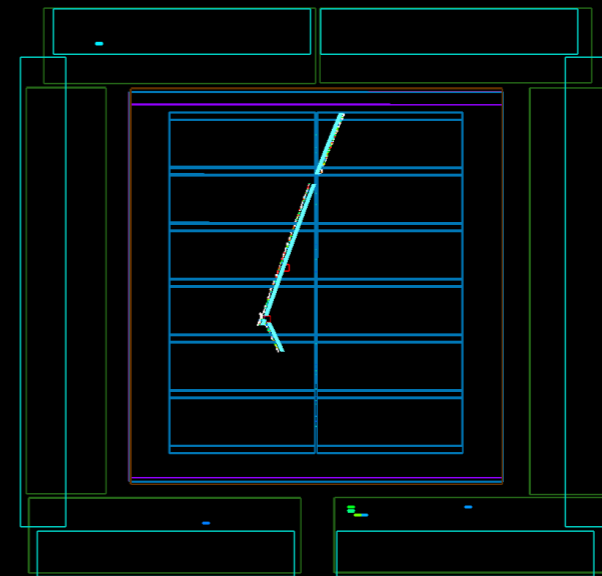
Run number : 9178 | SubRun number :34 | Event number : 382174 | Spill : 62680 | Time : Sat 2012-12-01 08:05:23 JST | Partition : 63 |Trigger: Beam Spill

XY View



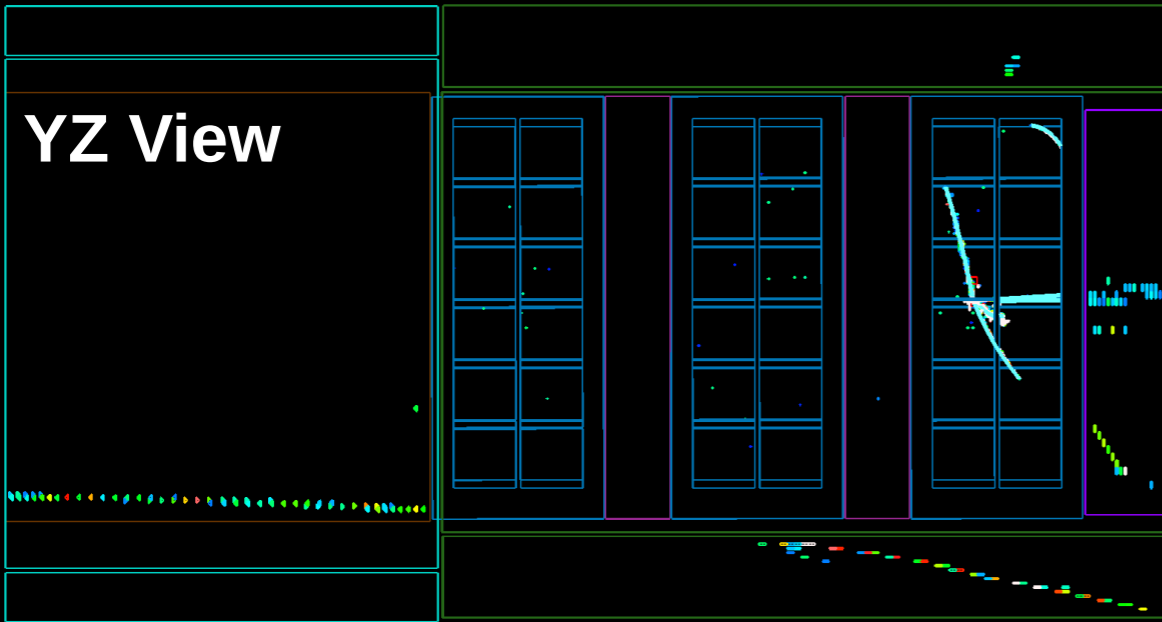
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XY View



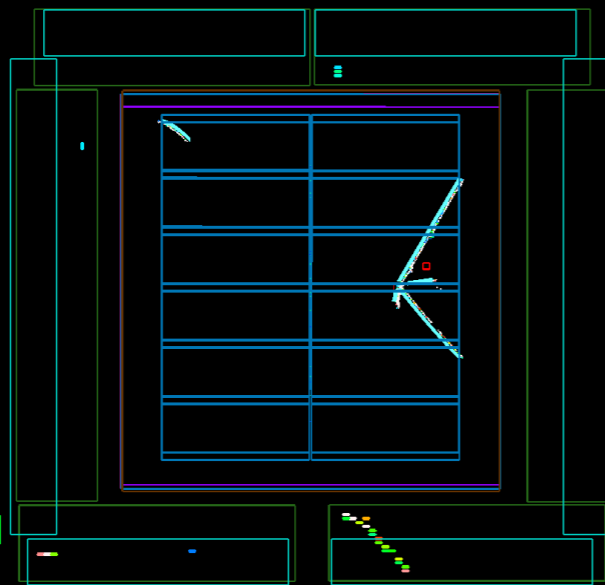
Data!

Run number : 8570 | SubRun number :84 | Event number : 950998 | Spill : 55799 | Time : Tue 2012-04-17 20:10:35 JST | Partition : 63 |Trigger: Beam Spill

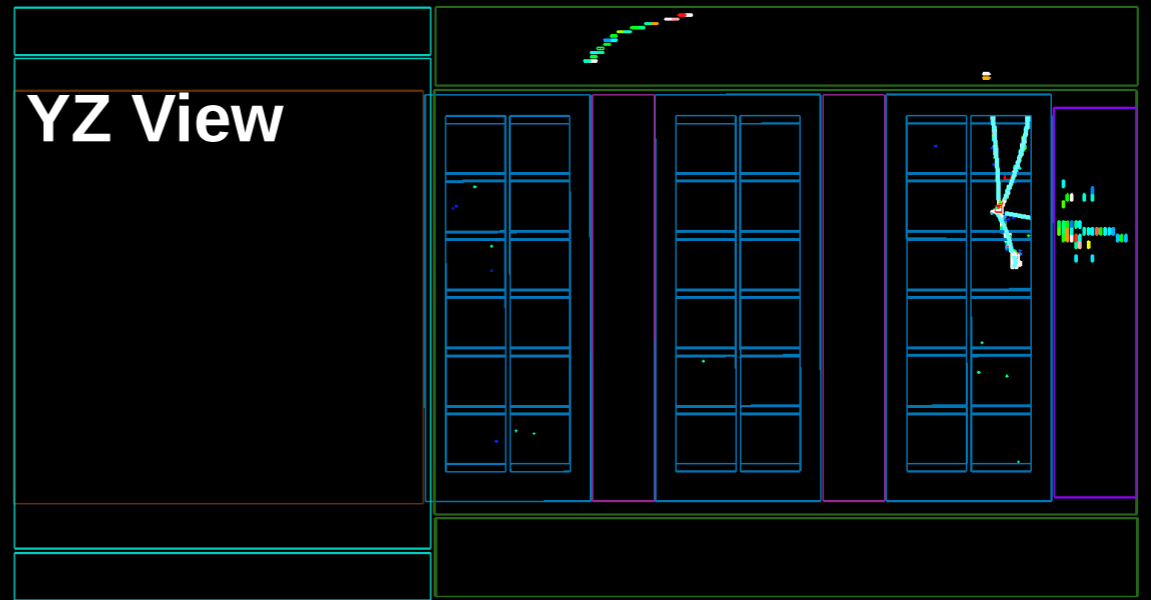


Run number : 8570 | SubRun number :84 | Event number : 950998 | Spill : 55799 | Time : Tue 2012-04-17 20:10:35 JST | Partition : 63 |Trigger: Beam Spill

XY View

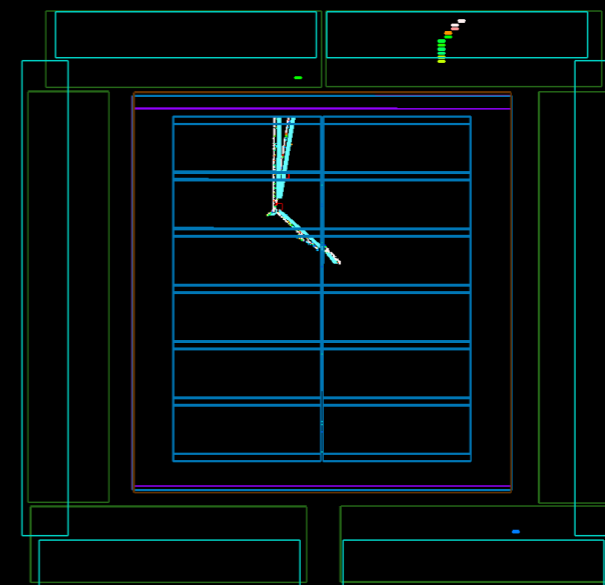


Run number : 8571 | SubRun number :32 | Event number : 369902 | Spill : 22588 | Time : Wed 2012-04-18 23:09:32 JST | Partition : 63 |Trigger: Beam Spill



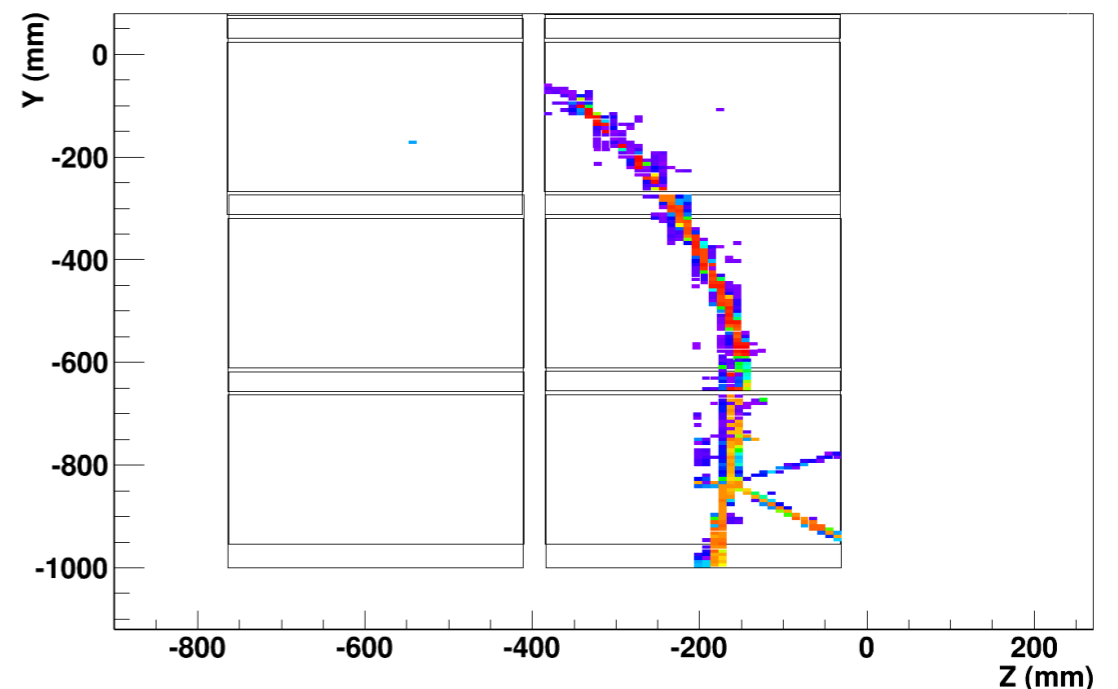
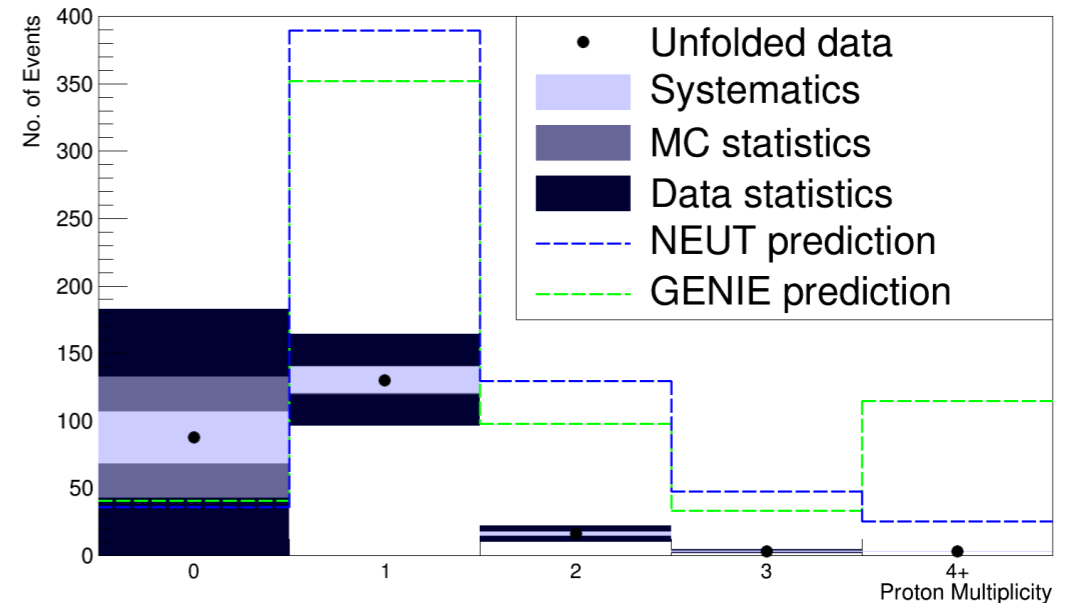
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XY View

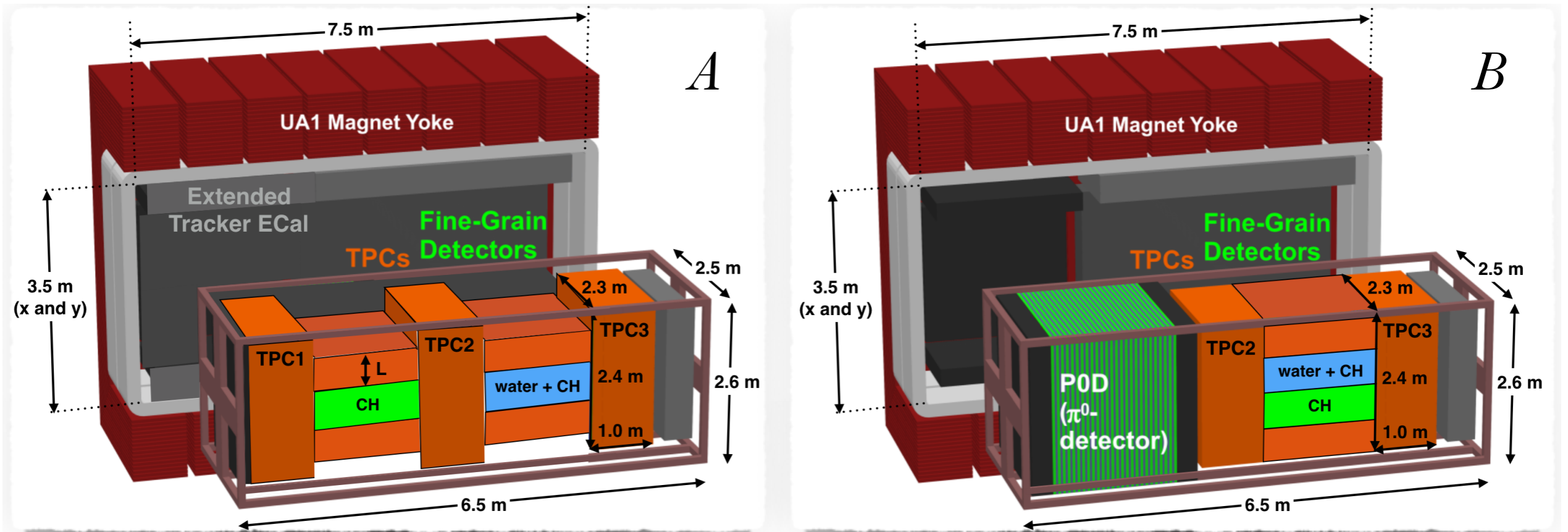


Challenges

- Saw many fewer events than expected!
- Problem has been traced readout saturation
- Second generation analysis is underway, taking into account this effect
- Reconstruction is being separated out from T2K software to be applied to other detectors



T2K/HK ND280 Upgrades



Mark Rayner, Yordan Karadzhov, and Alain Blondel, U de Genève

- Program of work to evaluate ND280 upgrades
- Two scenarios being studied; in either of these, some TPCs may be HPTPCs
- Longer term upgrade plans may involve HPTPC, depending on WC near detector

Points of Mutual Aid

- **Software!**
 - **One GEANT4 package (for non-T2K work)**
 - **Reconstruction package shared between all groups**
 - **Lots of reusable slow control and DAQ work**
- **Current prototype is fairly agnostic to efforts and will produce useful data for existing & future experiments**

Challenges for Collaboration

- Human effort—most people are working on this in their spare time between other projects
- Different goals for some groups—DUNE/HK/
Cross section
 - Different gases
 - Different detectors have different optimization