Towards a Detector Simulation

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The physics

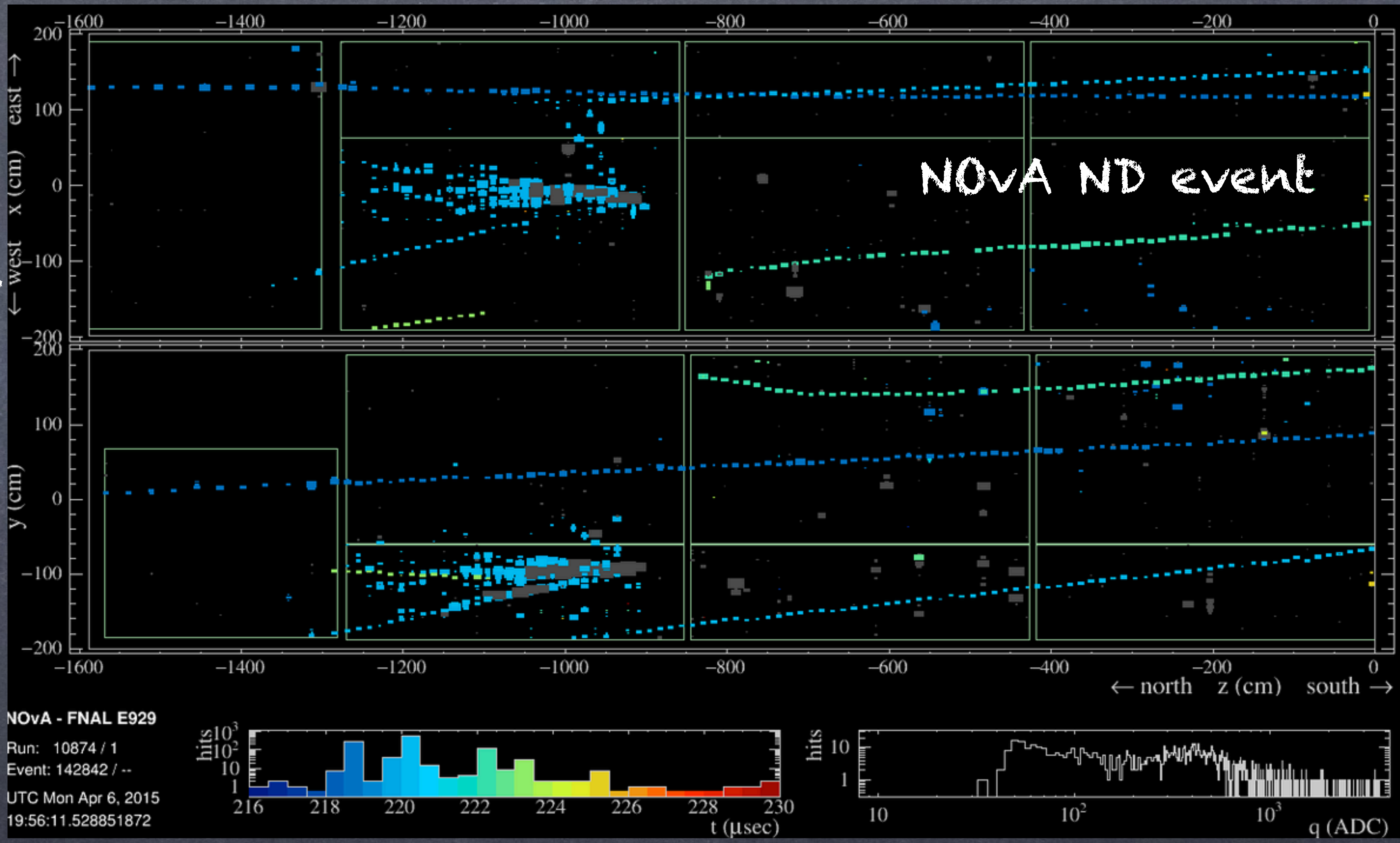
- Sterile neutrino oscillations?
- Cross-sections?
- BSM physics?
- Possible FD further away for 3-flavour oscillations? Oscillation peak at 0.6GeV for ~300km, ~1.5GeV for ~700-800km
- We need to create accurate predictions for all those scenarios/ideas to see how well we can do

What is the goal?

- We would like to find out:
  - Our event rate in our detector
  - What size detector we need
  - How much it will cost
  - What is the granularity we need to do the physics we want

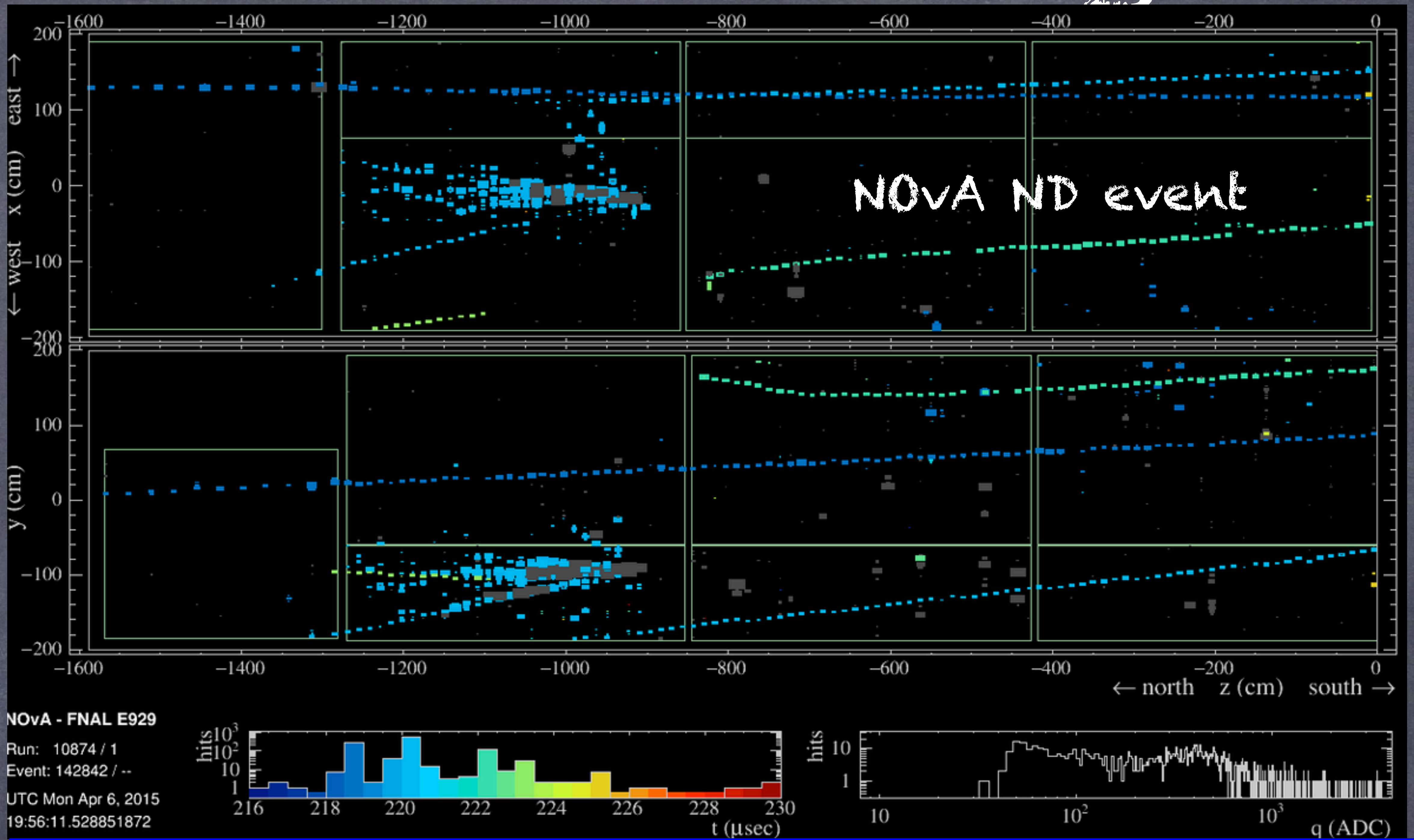
What do we have to go on?

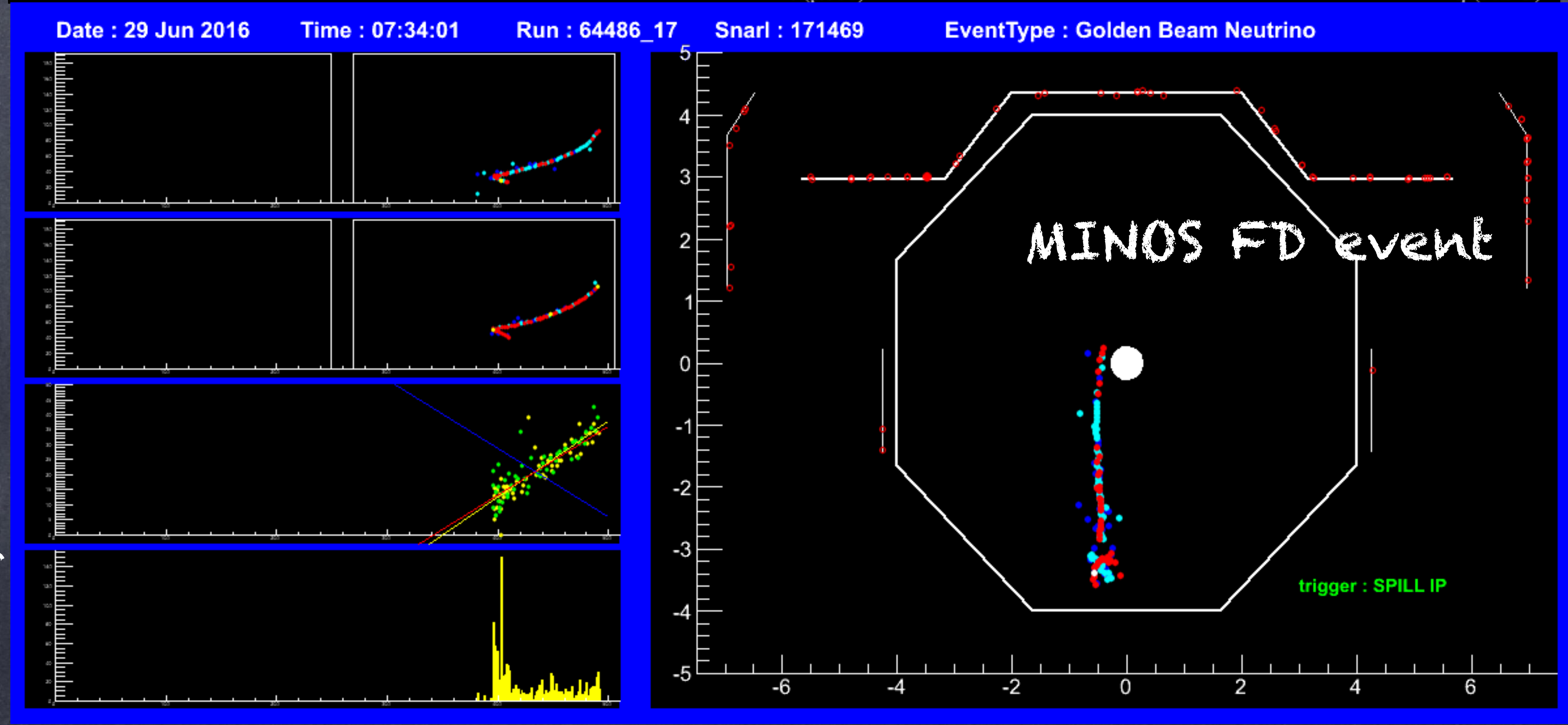
- Obvious, but needs saying: this is meant to be a neutrino detector, not a collider experiment
- Events can happen anywhere in the detector, they rarely happen in the middle
- There is no advantage really in having higher granularity in one area of the detector, ideally we want to be the same everywhere
- As simple a detector as possible is easiest to understand and model, and also scale up if need be at as small a cost as possible



Typical neutrino detectors are big

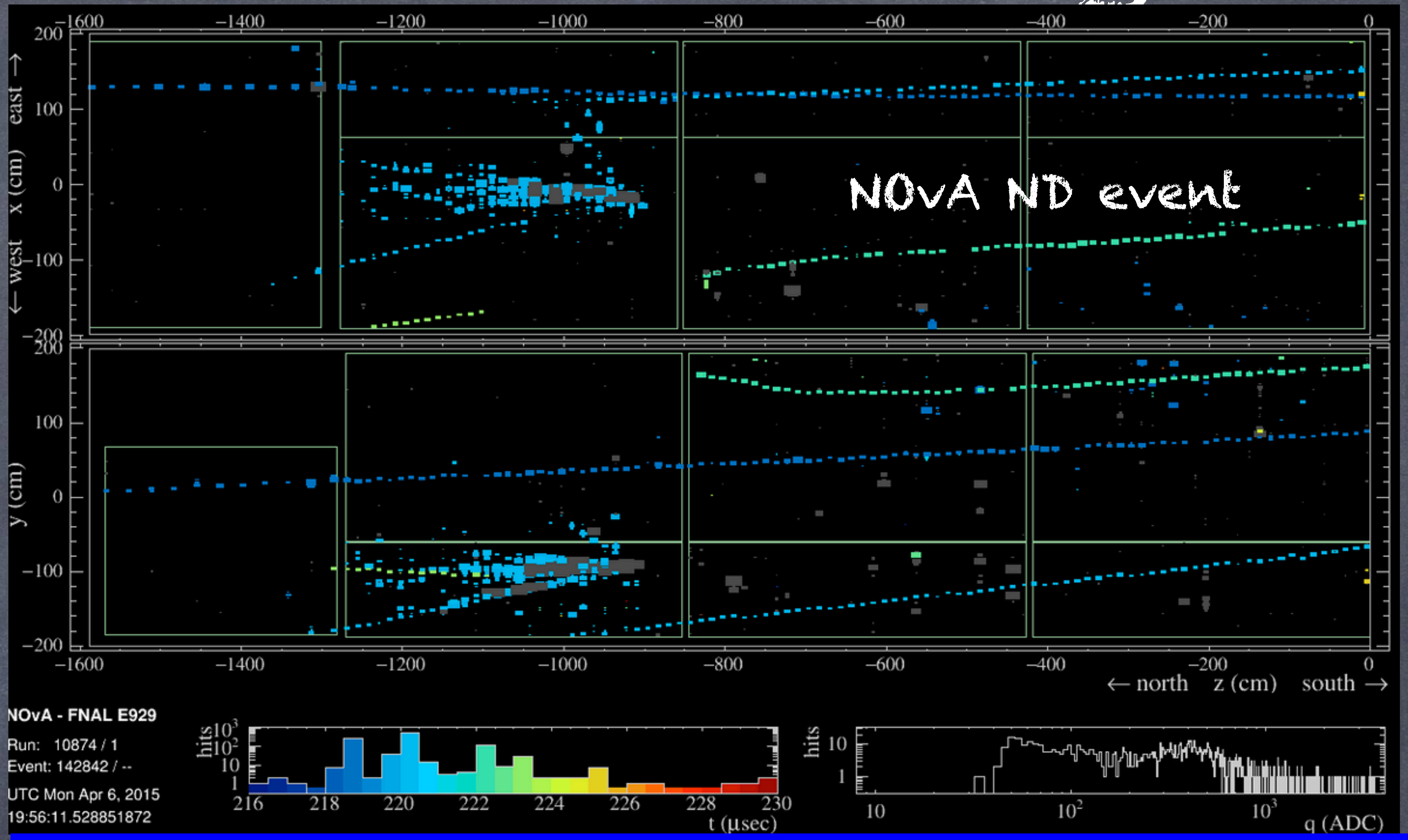
- Typical FD are tens of m long and many metres tall and wide to contain the neutrino events
- Full containment is usually necessary to determine the energy of a neutrino event
- Neutrino events can be many m long
- Can make a magnetised detector to see the charge of a track/particle
- e.g. MINOS detectors, which were iron scintillator plane calorimeters

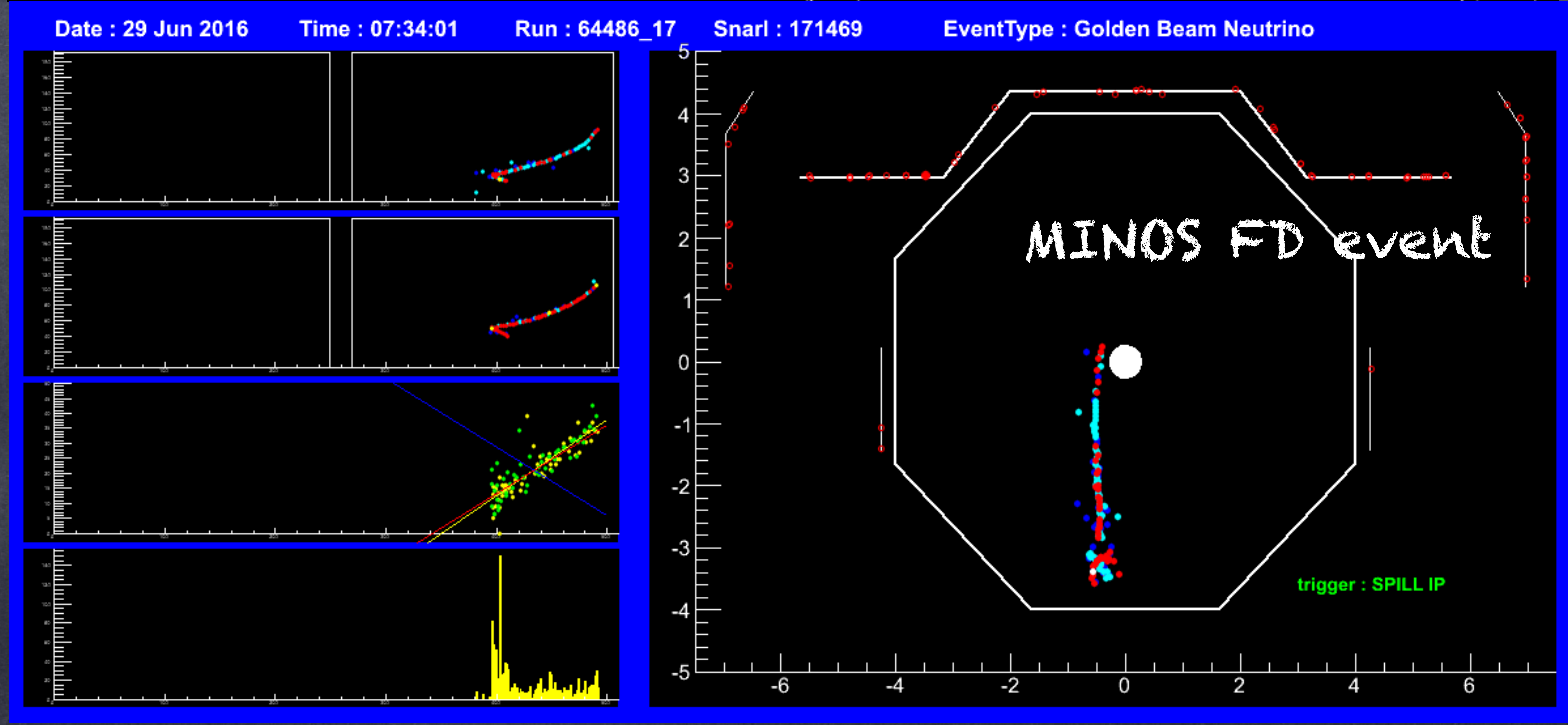




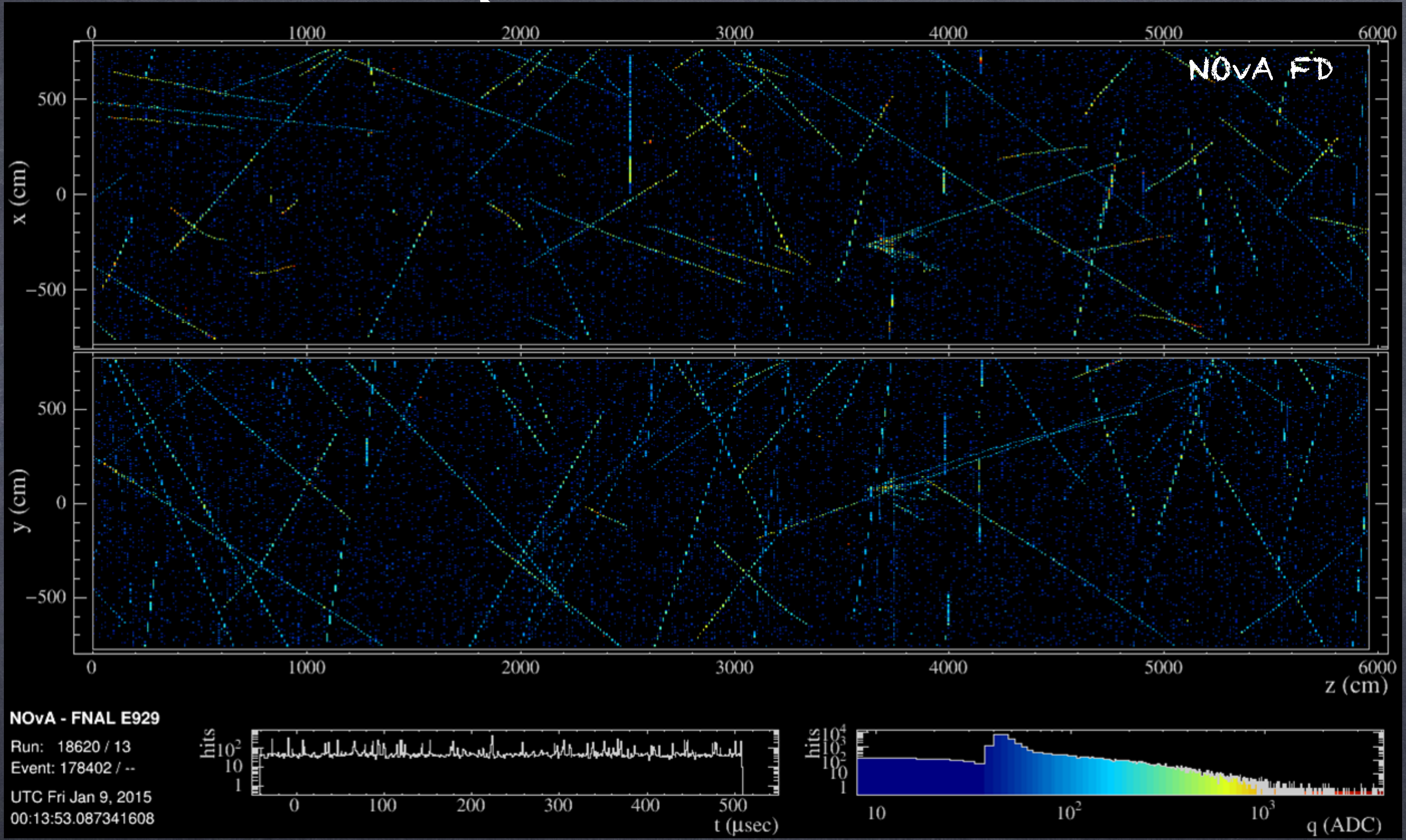
Typical neutrino detectors are big

- Ideally we want a magnetised detector a la MINOS - allows track charge separation - needed for precision measurements
- But the iron in MINOS was very thick (2.54cm), it stopped accurate electron neutrino identification
- Iron is also useful for slowing down muons to contain muon tracks - track energy from dE/dx and range is often better than from curvature



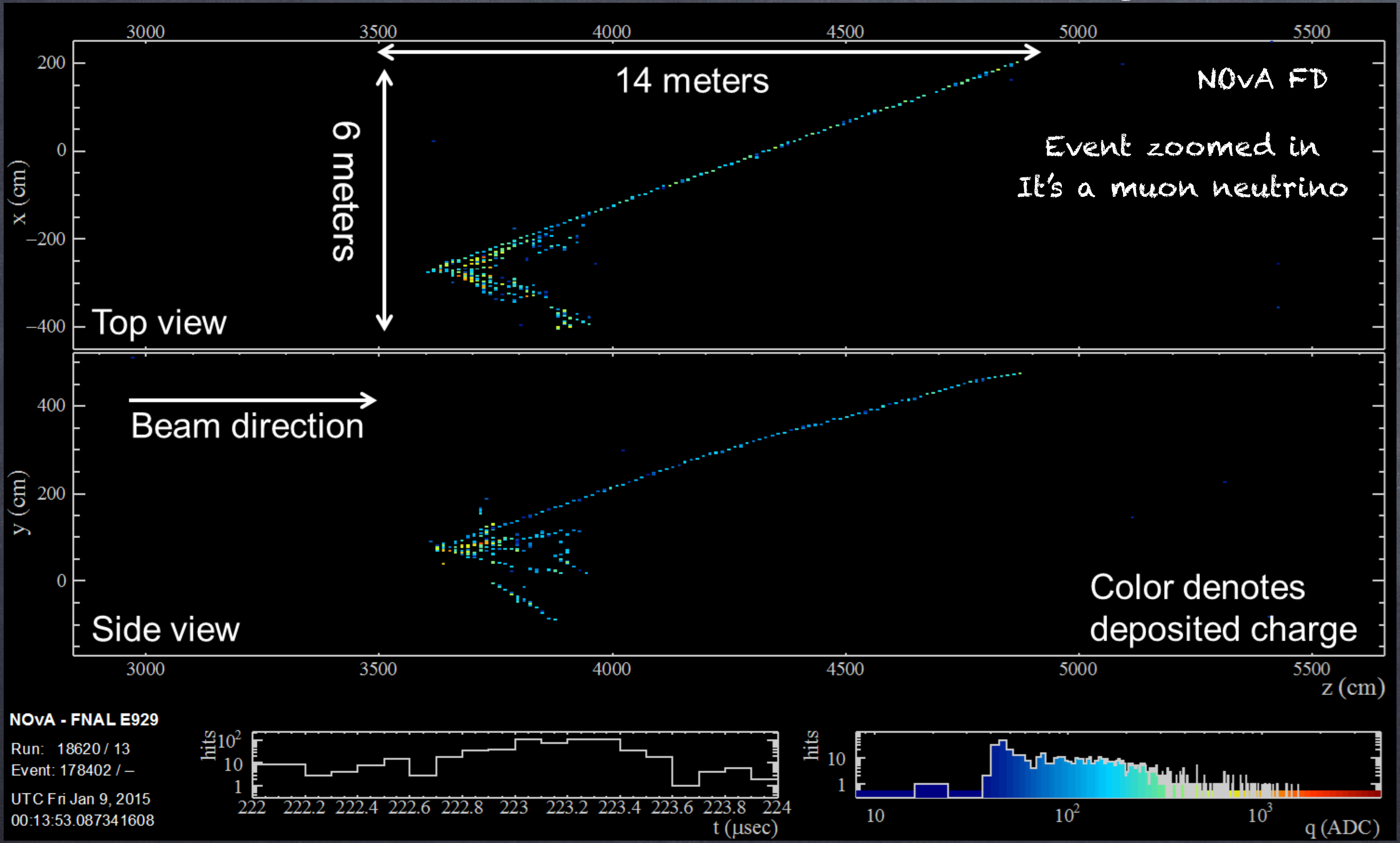


Additional problem - cosmics



- We will very likely need a veto shield so as to reduce cosmic muon background as unlikely to be able to cut on beam spill timing as effectively as other neutrino experiments

What we will be looking at



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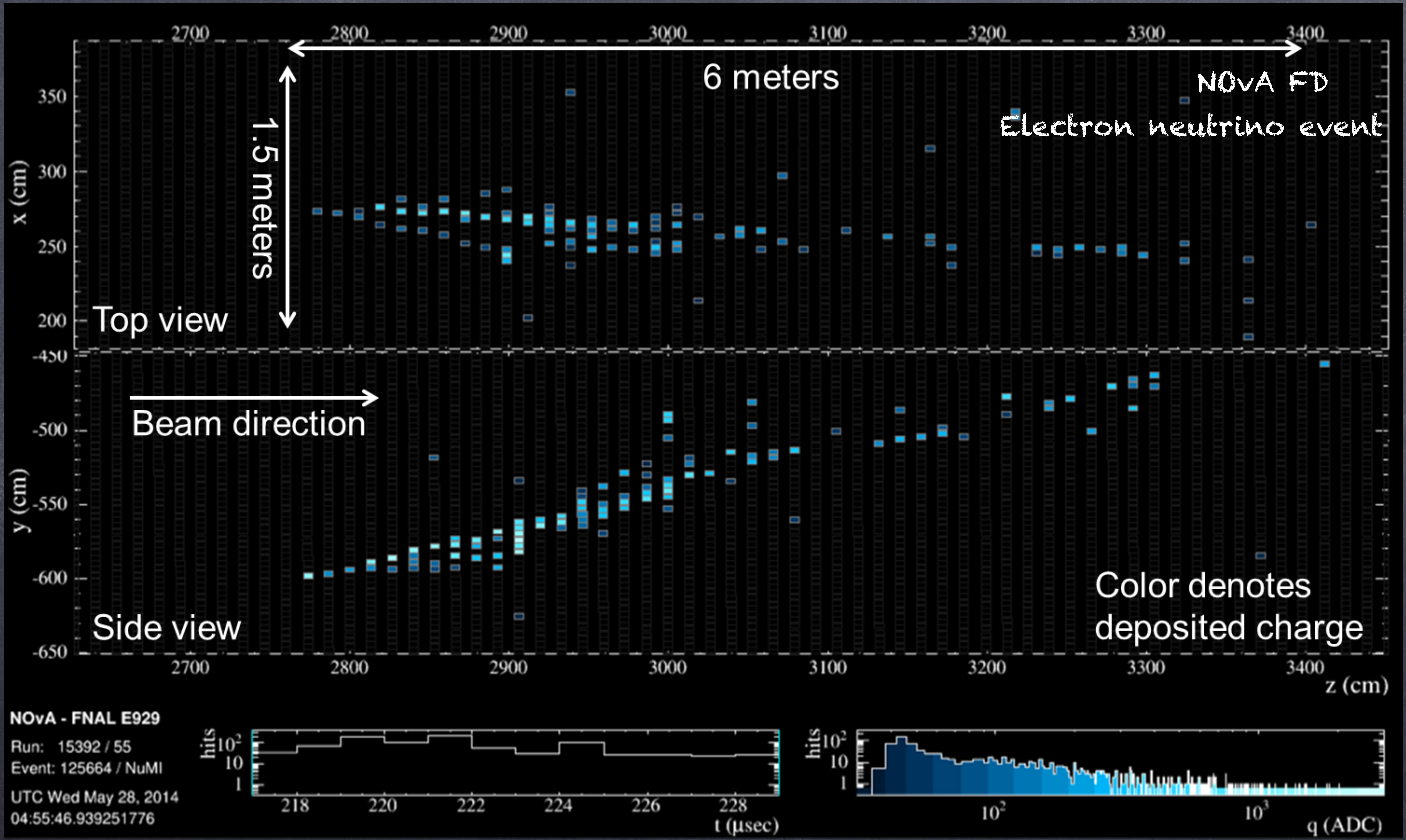
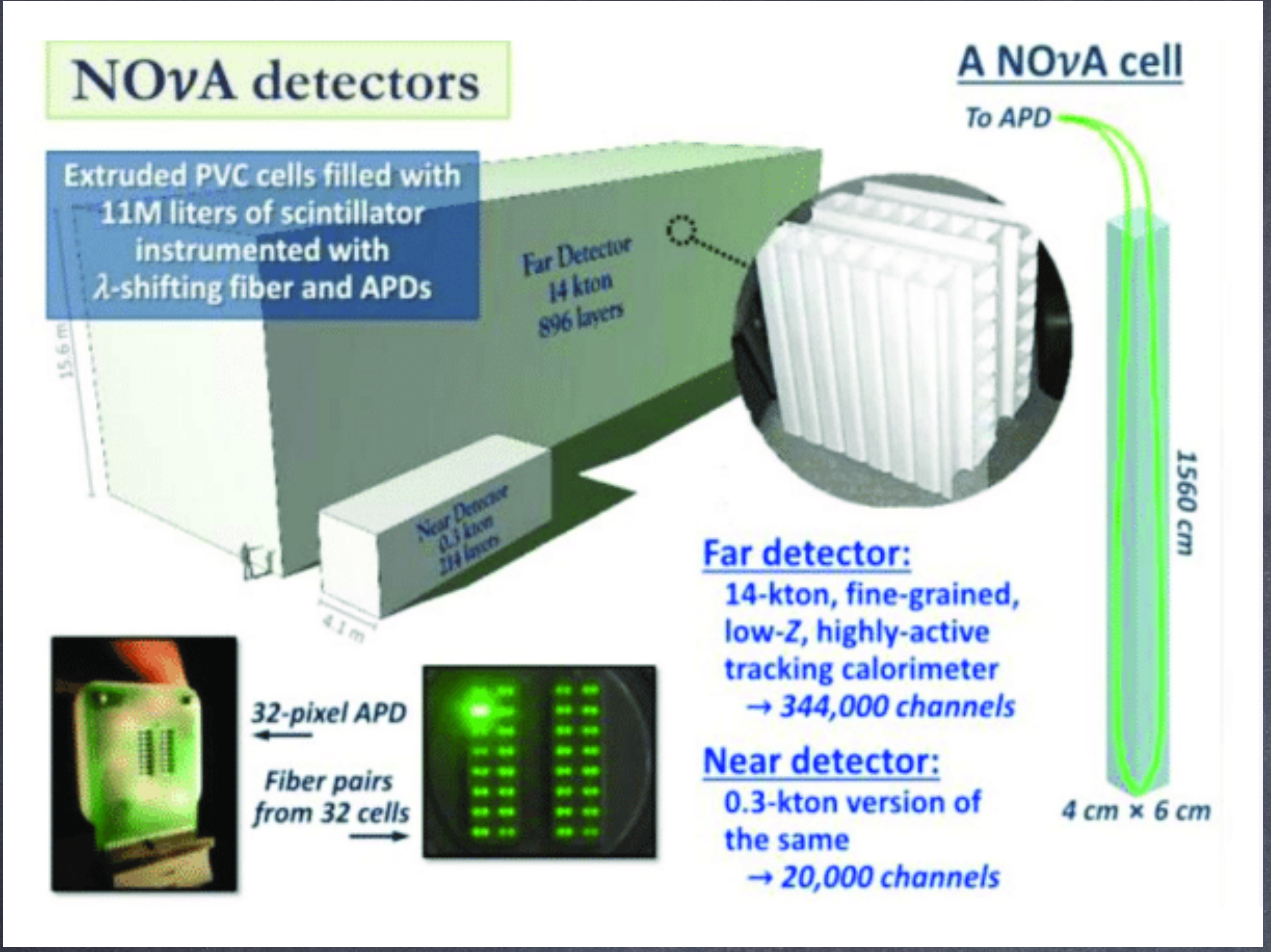


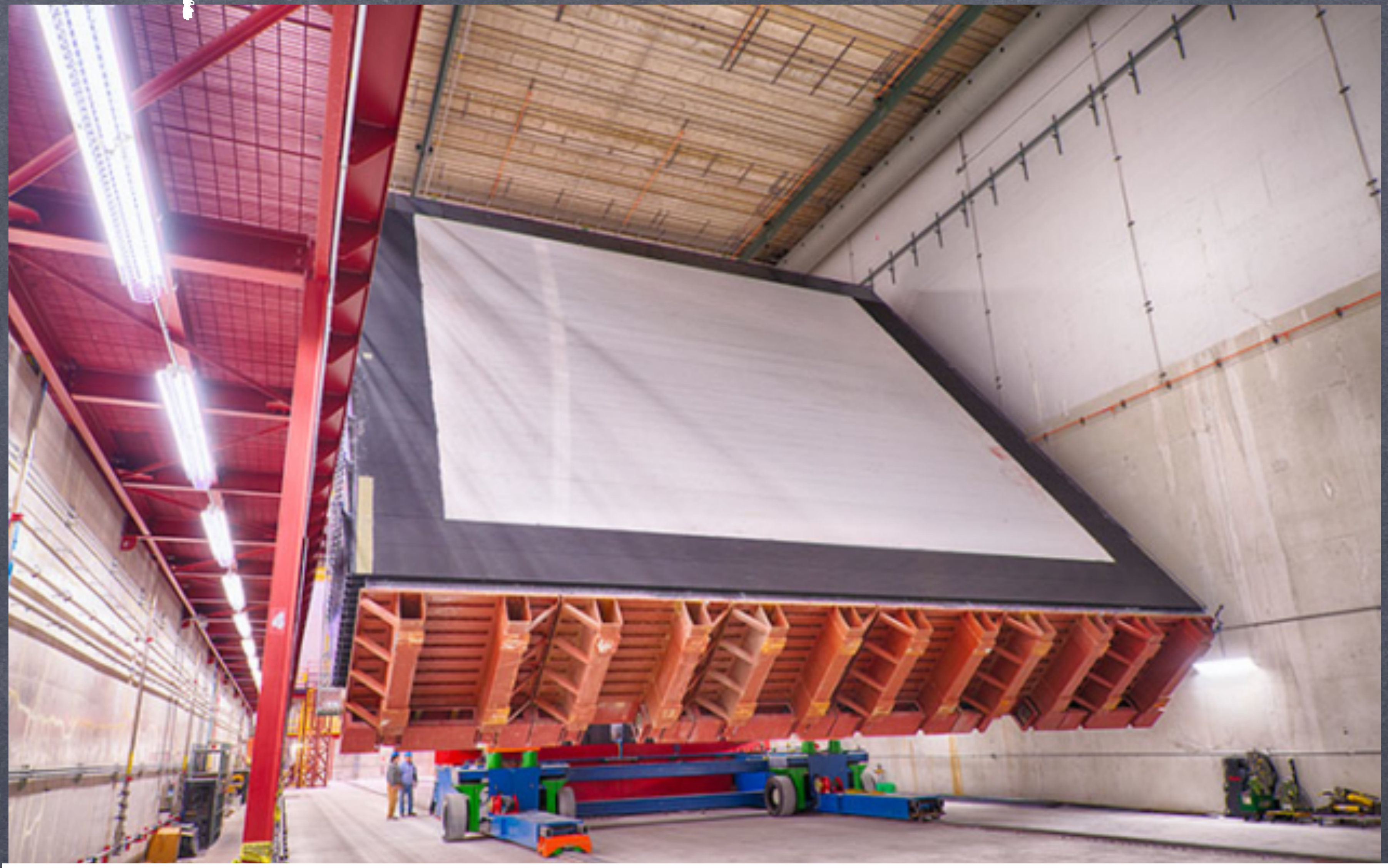
Can we design a magnetised detector that can accurately determine electron neutrinos, while being cheap to build?

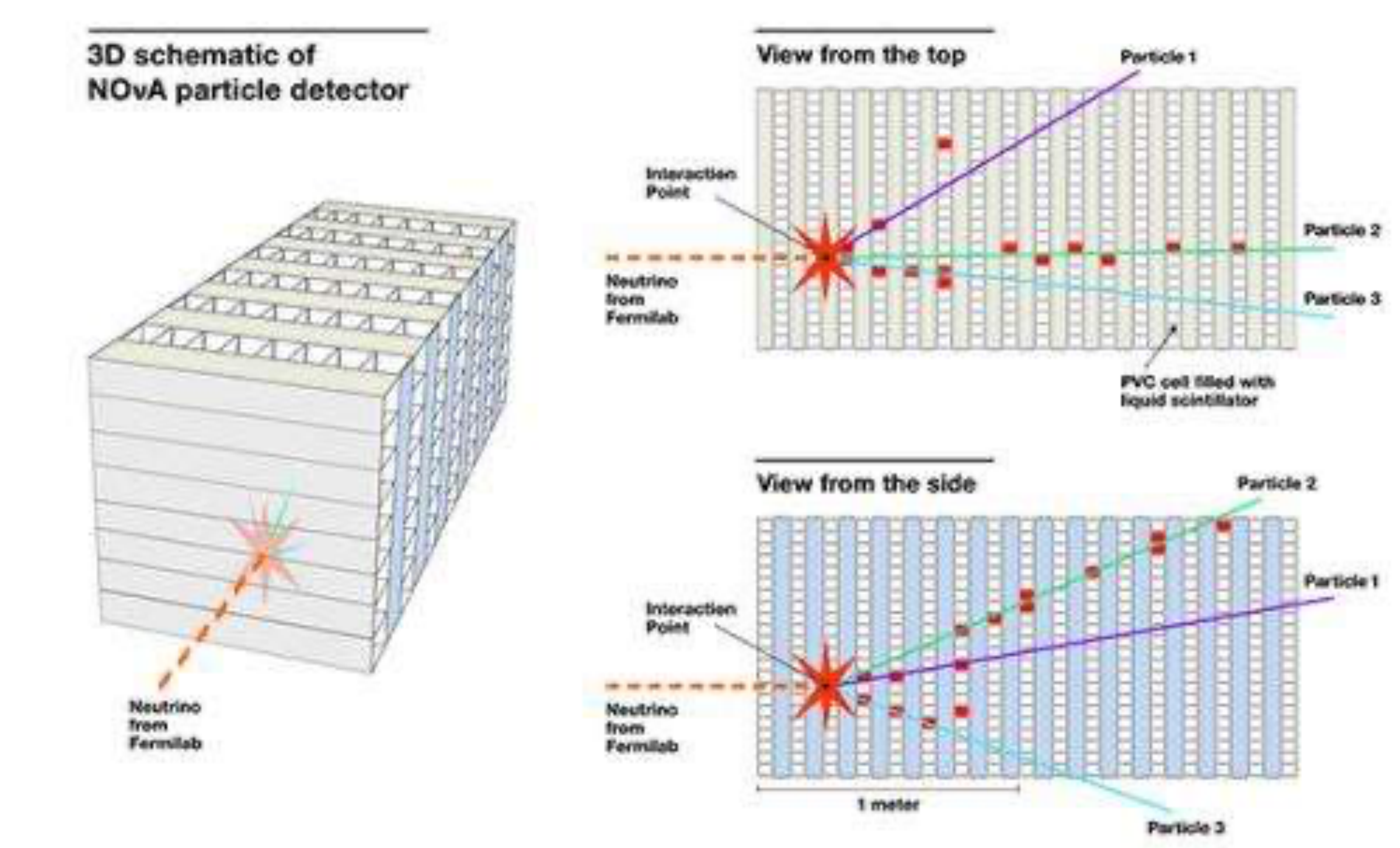
- Currently inspired by two ideas:
  - NOvA detector construction
  - MINERvA detector design
- Both evolved and perform much better in electron neutrino identification and event detail than MINOS did
- Can we combine all three designs into the next step?

NOvA detector

https://physicsworld.com/a/fermilabs-nova-neutrino-experiment-kicks-off/



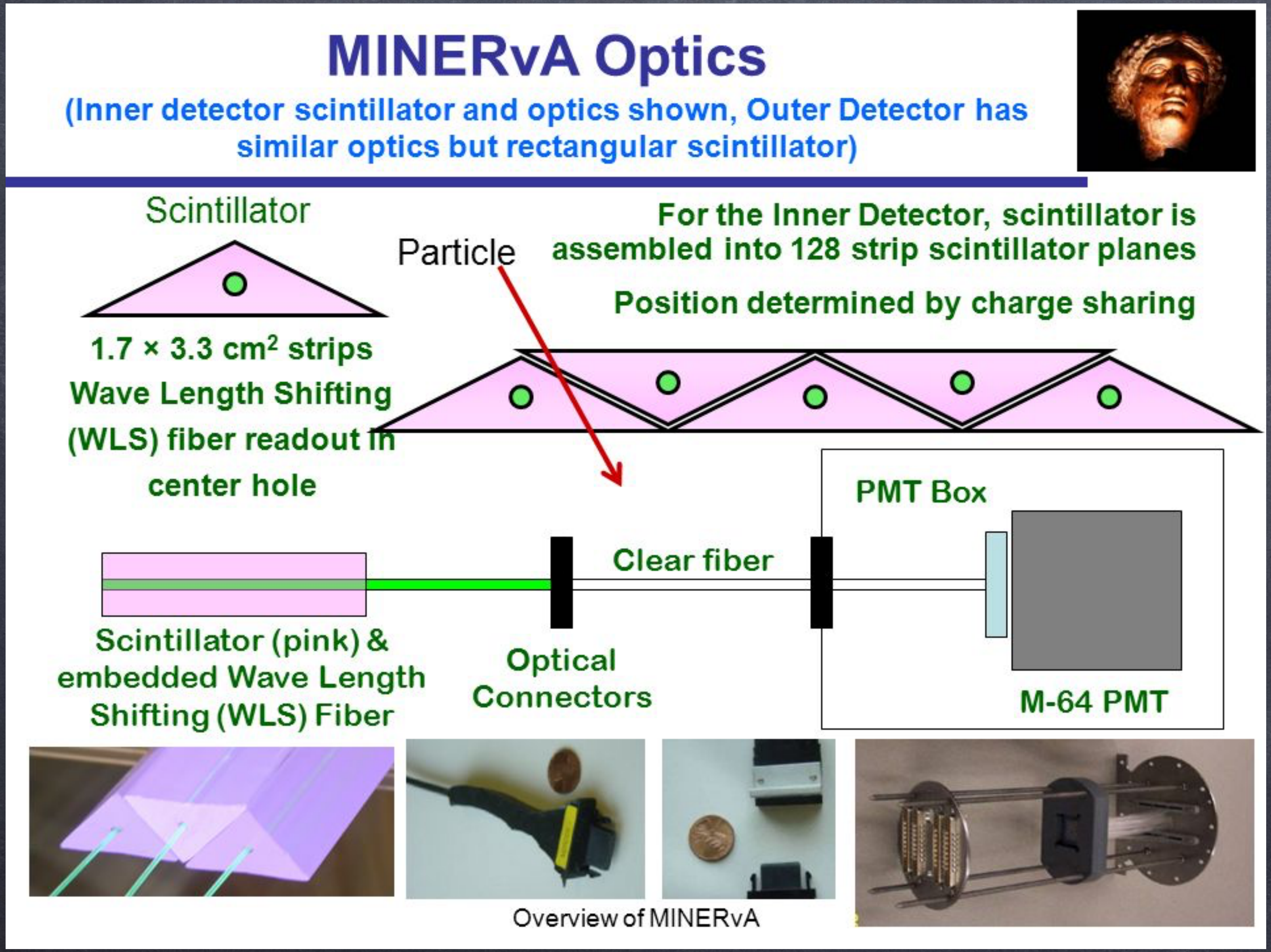


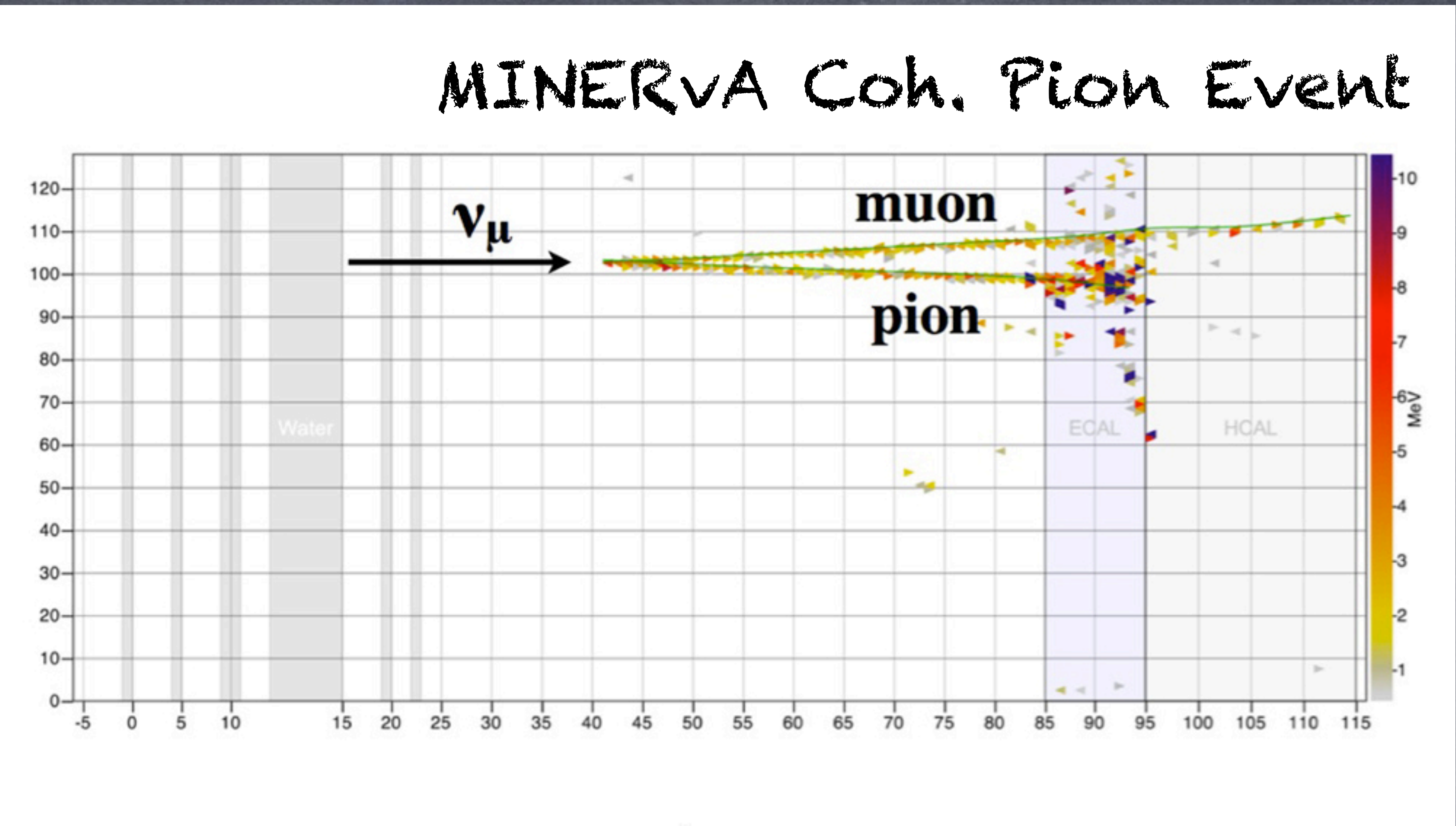


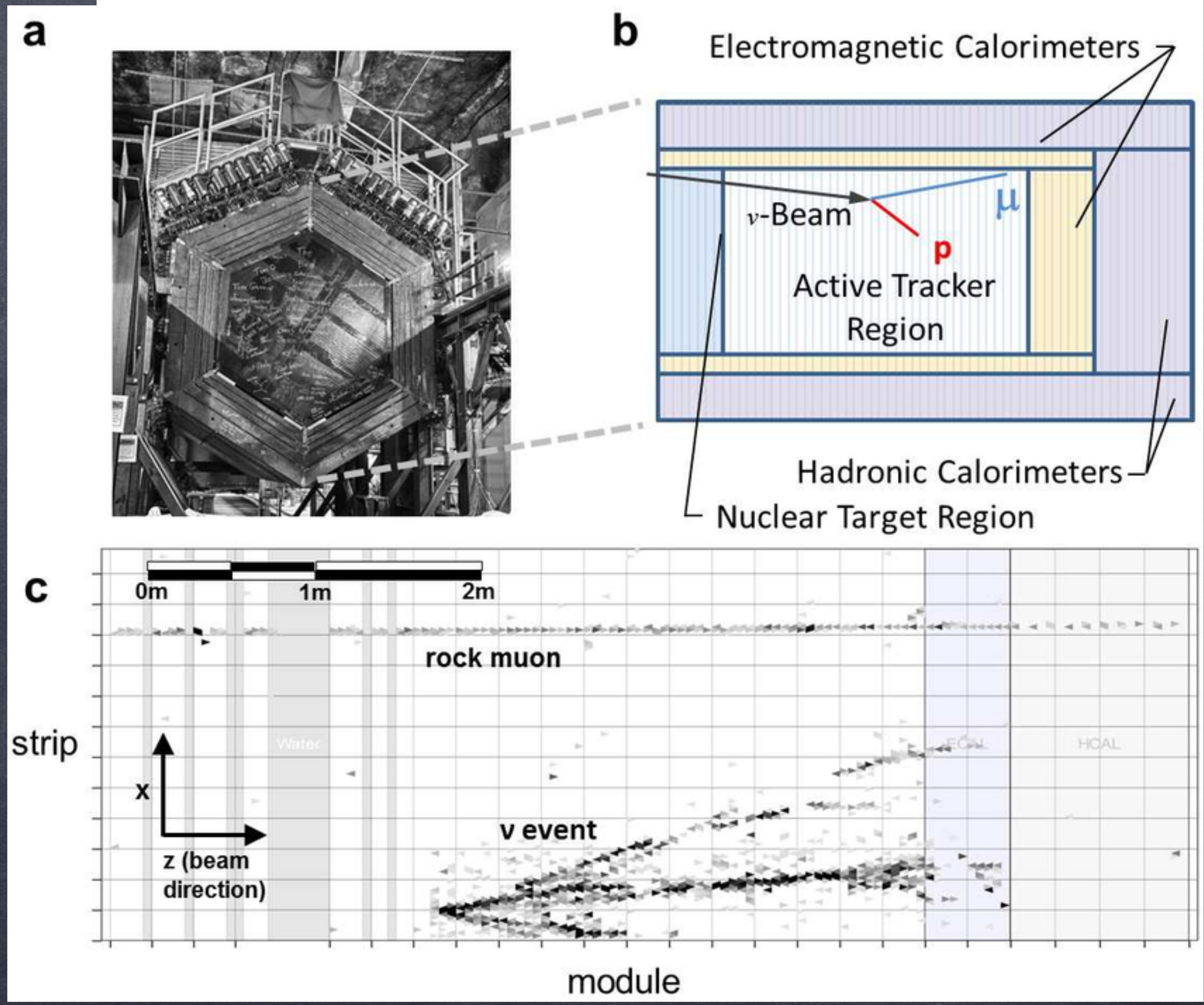
- NOvA is made of plastic blocks filled with liquid scintillator
- Clever idea, for stability, the blocks were assembled/glued together horizontally and then lifted into position by a special tilting crane
- Read out by APDs

MINERvA detector

- MINERvA used a very clever trick to get excellent reconstruction
- Use triangular cross-section scintillator strip planes for better precision





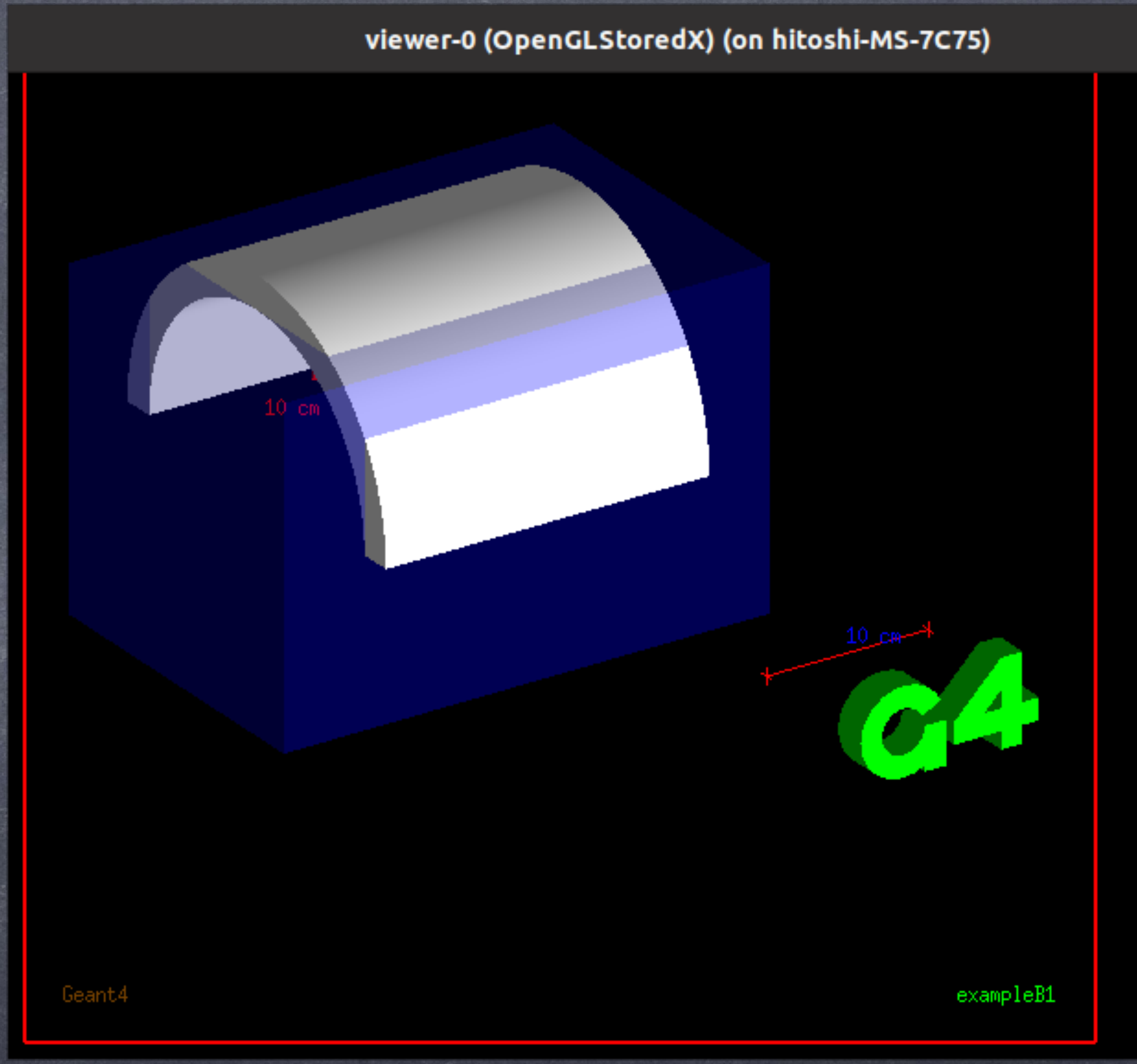


How we can use this

- Scintillator strips/bars are cheap, can be metres long, and a well understood technology in neutrino physics
- Idea is to combine all three detector types
- Iron planes for magnetic field like MINOS, but thinner so as to reduce the impact on electron neutrino identification
- Glue with scintillator into modules a la NOvA for stability
- Use triangular cross-section for scintillator if possible for higher precision

Current Plan

- Have started working with Peter Hobson from QM who brings detector technology expertise - we have started discussing different options and ideas
- Hitoshi Baba is a CERN summer student who will hopefully be able to simulate a simple prototype detector in Geant4 to give us a better idea whether we are on the right track
- He has started his simulations work already and is currently getting to grips with Geant4 and simulating with it
- Hopefully Hitoshi will be able to have an easily modifiable initial detector simulation by the end of his studentship, which is the first week of August



Longer term plan

- Once we have a prototype detector, we need to use a neutrino event generator to evaluate the detector's performance
- Ideally want to fold in the neutrino flux to have the whole chain:
    - Neutrino flux -> neutrino event generator -> detector MC
- Once we have the whole chain we should be able to start running realistic studies of the physics we will be able to do with nustorm