Goals:

- Identify important systematics
- Determine what we know about them (from control samples, external data, cosmics, etc)
- Propagate that knowledge to pion analyses
    - Choice of parametrization
    - Choice of propagation tool (new MC? fcl/weighing parameters? etc)
- Discuss limitations

Discuss workplans for the "big ones". What do we need to know to start identifying issues? Or propagate what we do know? What technical limitations or issues have shown up?

In addition, trying to put together a short summary document of allllll the systematics in the detector for folks to review. Please contact Kendall if you want to help (or comment when it's done). (chance to check we are all on the same page with approaches)

X Lifetime + diffusion: (Richie) -> dQ/dx uncertainty

- ** add slides from previous presentations, ICHEP **
- Renamed. There is a flattening in the calibration which corrects this
- Approach from uB, nice job Ajib! And Reddy
- dQ/dx nominally varies. Measure coefficients with cathode crossing cosmic rays + cut on angle.
    - Limitation: angular effects? RD: for uB MCC8 (previous data push, 2018) to evaluate it is to force the dQ/dx into 4 different angle bins-- 0-negative 4 degrees is beam angle. Evaluate dQ/dx there. Maya W. (uB calib team), and formed a systematic on it. => Richie wants to look at that.
    - CM: Differences between MCC8 or 9? RD: Same method, it's but people in sterile neutrino mode, not published.
- => Suggestion: data/MC disagreements (shape issues?) and statistical uncertainties on this set up. (because don't implement drift electron lifetime)
    - RD: issue is for beam samples, would need to do it day by day because purity monitors fluctuating. Can't apply purity monitors-- 2nd element is dependant on the purity. (reached 20 ms). MM: If the purity is changing, then it tracks? How is this reliable? RD: It's run by run, with that many cosmics. MM: So, could split it within a run, and for different track angles, and see if different dQ/dx post calibration. RD: Sure-- but I want to first look at beam angle specifically. And we can then look at secondary particles later.
        - => Data driven tests of whether this is complete
    - CM: If we have fluctuations, can we remove runs? How would that affect us?
        - RD: Took modified box model-- took highs and lows. Fluctuations, from Nitish + Jiangmin. Across two days-- on a run by run basis shielded, but still need to consider it when look at run periods.
    - => Suggestion: get rid of 5387, go to 5842 high purity and more pion triggers
        - Also 5817 (combined → 45k pions)

        - Pick runs where as little calibration to do with that-- lowest systematic as possible.
        - Once we can settle on a run, then look at correction factors for that.
    - => Production question:
        - We changed our dQ/dx correction, now, with a purity monitor as a first step… where we did yz/etc. We applied it, then do all the steps outs. Want to clarify this.
    - MM: Limitation: purity level varies through the detector-- constrained and measured with Ar39 z direction. RD: It's hard to see with the cosmics-- if find the dQ/dx with x?
    - => Add to limitations
- KM: What MC variations do we want to consider?
- RD: Did fluctuation the purity monitor-- input 30ms. What if 25ms? Closure test-- to change purity monitor! If you want adjusted lifetime samples… let him know. It's just applying an exponential. If we want to do it through the chain, through detsim samples
    - => Need to walk through this part. Ritchie + Kendall
- JB: Recirculation in system, has some accident in the run. Not purity. Beam runs have this issue. Nov 1st - 11th. If we look into the run record, most of 3 GeV and 6 GeV run fail in these periods. Not realistic to choose high purity runs for that energies. Good runs are 1 GeV. KM: This analysis is just for starting with
- JB: Purity monitor database-- shown in workshop (postdoc of tingjun?) in P3, all use this lifetime runs. And then possible to put the realistic purity in the simulation
    - => Clarify what is intended for that.
- JB: Low purity measurement, and Richie studied with CRT data-- systematic appeared smaller. So, it may be possible to use CRT data to combine at some point and reduce the systematic.
    - We would still need to propagate that final uncertainty from the dQ/dx calibration

General:

Discuss again when we have the systematic uncertainties. +1/-1 sigma, propagated to the analysis chain; This doesn't account for correlations-- if we can find another way to handle it

KM: Agreed. This is why we want to outline what exists, and also look for where weighting is possible

Method for Changing in Simulation:

Changing input drift electron lifetime:

-governed by protoDUNE_refactored_detsim_stage1.fcl

Found at line 67

// Electron lifetime [ms]

lifetime: 35.0

Changing the purity monitor correction factor (this is done before the correction and will create issues since the XYZ calibration that simulation automatically uses assumes that the purity monitor perfectly matches input)

-governed by protoDUNE_refacotored_reco_stage1.fcl and

protoDUNE_refacotred_reco_stage2.fcl

Change this line (it could be in different places)

services.DetectorPropertiesService.Electronlifetime: 35000

Action Items for Richie: Look and understand how the same correction method systematic was applied in MicroBooNE. Be wary of theta_XZ bins as the beam pipe encompasses a narrow angle.

E field: SCE:

=> Kendall get slides, ICHEP talk

MM: Large effect, creates spatial distortions, and energy, also affects recombination. (track angle and location, and dE/dx. As long as feed sim the right map)

=> Limitation: How well we know detector geometry (thermal contraction)

=> LImitation: Fluid flow

Map can be used to do spatial and the electric field map.

MM: Expected to be small (<10%?)

=> Map assumes linearly changing density

Expect updated map in the next few months.

Suggestion:

1. Map-map comparisons:
    a. Use anode-anode tracks, similar to ICARUS before, probe spatial distortion in x direction. Can compare it in limited region of coverage, see how it agrees with whole volume methods.
2. (Control sample?) Using the boundaries of the CPAs in the cathode show, for track endpoints. Clear gauges of how the calibration is doing. For near the cathode, can test agreement.
3. Then, produce new MC with the map variation. Make the CV the average of the two-- and +/- 1 sigma of it.

Work ongoing of the TPC face measurements.

KM: Shall we discuss how to expose the E field more readily? ANd outline where this shows up in the analysis?
MM: In recombination module, queries local E field when it does it. Fcl file to point to a new TH3 Calib file, to DUNEpar data product. In legacy LArG4, in the readout-- query the spatial distortion maps. For dE/dx, in the calibration step, both E field and spatial maps are queried there.
Each time you have a variation-- within a file, upload to DUNE par data. Point to a different file
JB: For the bottom right plot-- is it sim and then show effect-- charge accumulation, higher dQ/dx at the beginning of the shower? MM: dE/dx increases, because squeezed.

TJ: Interpolation vs. extrapolation. Cathode isn't quite the same in data and MC. How extrapolate that to the bulk. Discrepancy may diminish further away-- but actually get more and more uncertain where don't have the measurement? MM: In Ajib's-- permeates in x, can use the two together. One helps with y vs. z, and since correlated via magnitude of the space charge density. Use dx vs. x to extrapolate in x as well. TJ: The Ajib method has data in bulk, and this is
Take Ajib as central value. MM: Calibrates in bulk as well. It's a subset of this method. Nominal calibration as well, delta y, z, and x. His is Delta x strictly. Hence why we are focusing on crossing talk method. Good for short term.
We don't have a direct bulk measurement yet. Can be used-- can't take strictly in x, and translate it without something.

RD: When you say x? Mean E field in x? MM: Both spatial distortion, and. RD: But only E field is in x, but Ajib also measures x,y,z?
AP: In my method, use anode cathode crossing tracks. But then, coverage is only in central part of the detector. MM: Is that with crossing tracks? AP: Yes-- this correction factors, to determine drift velocity. AP: for the final result, need the drift velocity distortion maps.
MM: Still extrapolate it out.

KM: What's a next step you'd like to see?
MM: I'd start propagating it all the way through. Doesn't have to be realistic-- though we could produce one. Imagine that SCE varies by 10, 20%, then get a few alternative maps. What do you do with it? And then how it gets through.

> => Francesca to start looking at SCE on and off.
> MM: Analysers
>
> => Kendall send an email to Mike with some ideas

MM: Have been holding bi-weekly at ProtoDUNE-- can invite to that? Paused for Snowmass and teaching. All things SCE!

=> Next time

Alignment: (Kendall + Izzy, Miranda, Stefania)

AOB (If time)

Geant4RW systematics:

1. Overall cross sections

Impact of secondary particle production: Delta rays.

2. Solution? Lower threshold very low.

Recombination

E field: Spatial Displacement map

Negligible?

- Wire response
- Electronics response

…