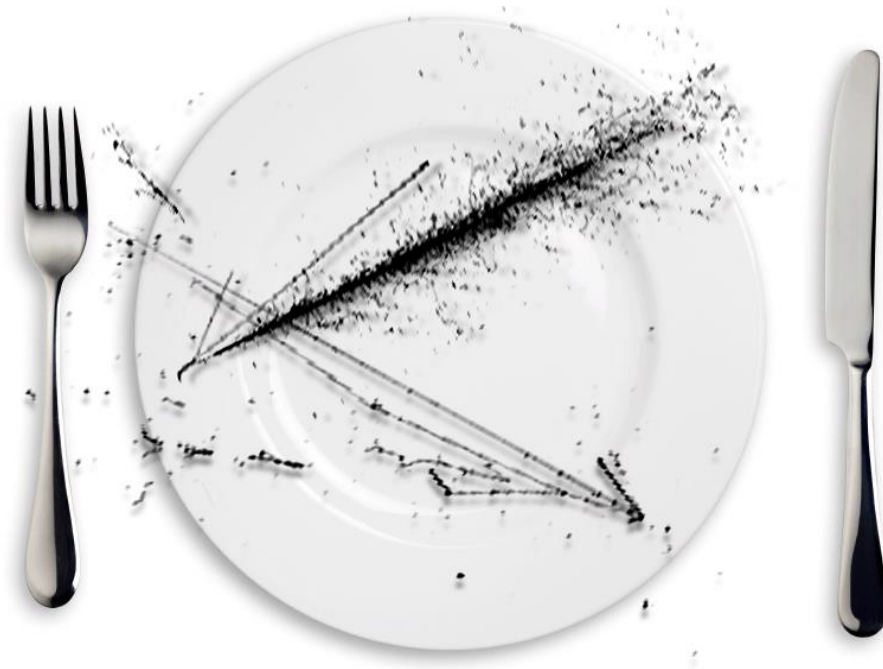


Simulation/Data – Reconstruction – Analysis for ProtoDUNE's, DUNE TDR, both with one shot in the optimal scenario



Simulation/Data – Reconstruction – Analysis

- Address missing reconstruction features in LArSoft for DP, to enable **coherent analysis of SP and DP ProtoDUNE's data**.
 - Address most critical reconstruction features required for DUNE physics, on the time scale of **TDR preparation**.
- some technical issues, and some reconstruction/analysis problems are ProtoDUNE's specific
- but, whenever possible, do the work with the far detector physics in mind **ProtoDUNE gives the real data**, even if some ADC, SCE, CRM may change
- reuse the work between SP and DP
- crosscheck results and follow progress of each other

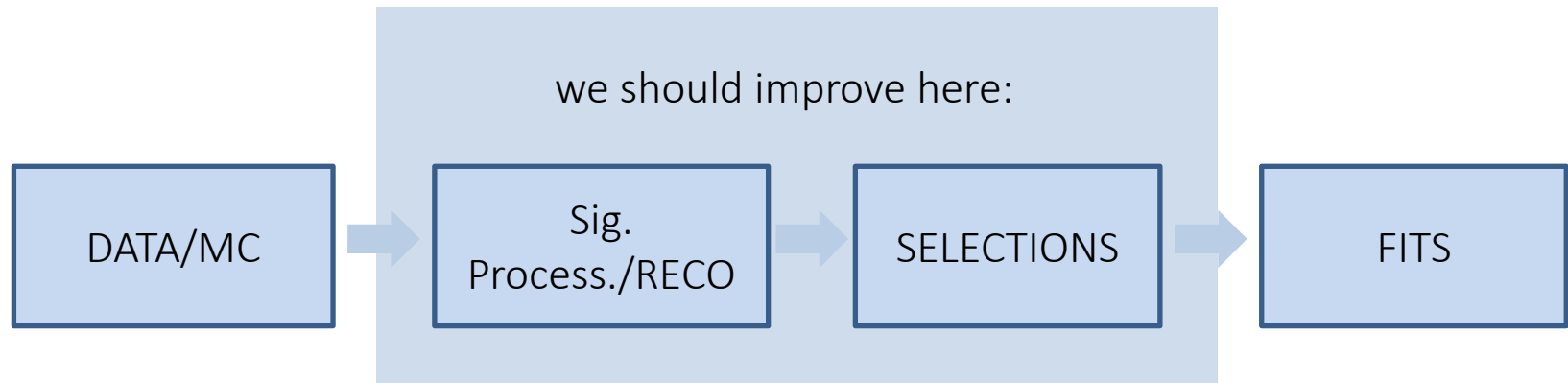
Some examples

- Interface module for the ProtoDUNE beam simulation only needs changed configuration to work for the DP beam.
- The whole work on EM separation and π^0 detection is progressing in parallel in SP and DP.
- No-deconvolution DP hits mix the ideas from old SP code with generic machinery for MVA results saving.

The aim is to develop this collaboration and cover all issues:

- [tasks in google doc](#) (we'll edit now)

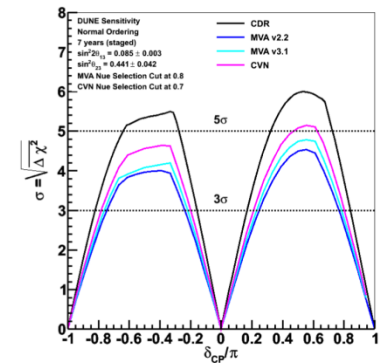
Far Detector (TDR) point of view



- Tracks
- Showers
- Vertices
- Full event (particle hierarchy)
- Energy

- Currently BDT
- Most discriminative features (region of the primary vertex) – still quite missed
- Not using information from particle hierarchy

Currently:



Coordinate with the full Collaboration: LBL, SNB groups, DP teams, ...

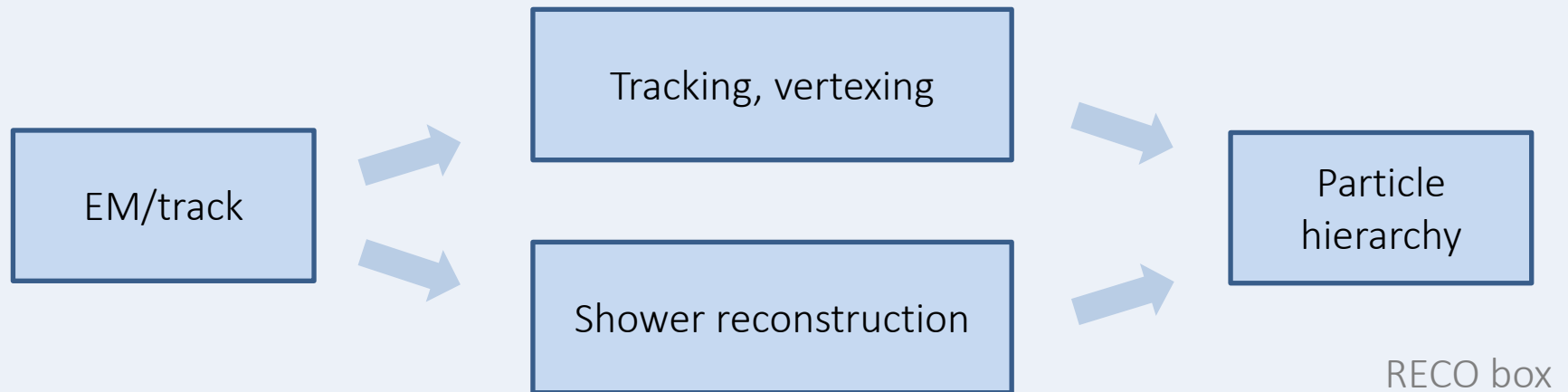
→ many parts do exist and are progressing well

→ need to add work to the weak/missing points

Reconstruction box

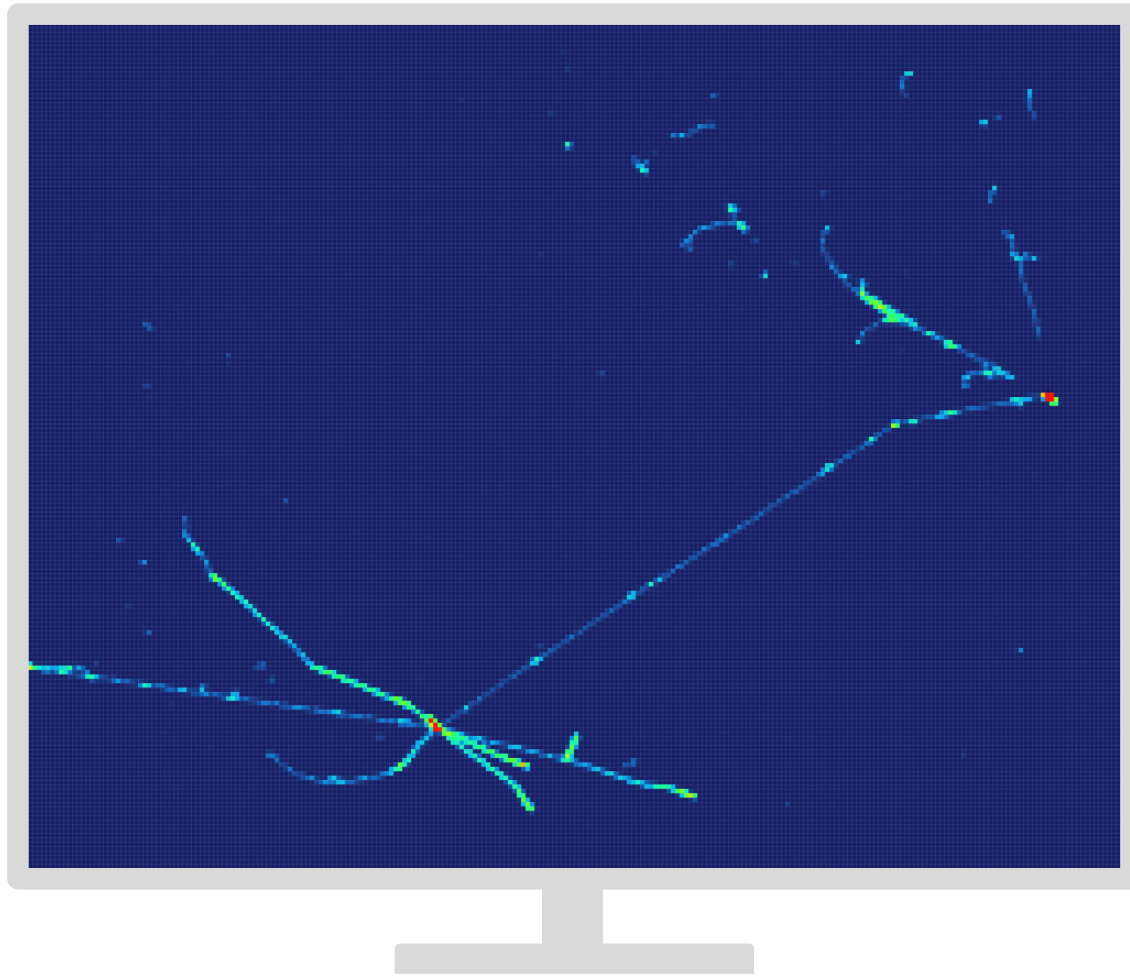
(details in [Alex's slides on CM](#), he has light included, I don't have it here)

Main focus should be on the reconstruction of the features important to the neutrino flavor selection & energy:



NB: first reco stage: ADC \rightarrow signal processing \rightarrow deconvolution + ROI
- well settled in SP, but still deploying in DP LArSoft

Event for today and tomorrow



ProtoDUNE DP work: need to come first...

(and you will find synergy with DUNE FD needs)

1. Signal processing: simulation and reconstruction

- diffusion in gas phase, any other DP-specific effects: e.g. gain variation, dependence on the position or inclination in 2D projection, cross-induction between planes?
- noise parameterization (filtering),
- double-slope in sim/reco,
- other signal properties

2. ProtoDUNE beam particles simulation in TPC, via interface:

- use existing interface modules, adopt DP rotation, beam position,
- beam window geometry
- beam particle reconstruction: matching with beam instrumentation data

ProtoDUNE DP work: need to come first...

(and you will find synergy with DUNE FD needs)

3. Cosmic muon simulation

- cryostat material in the geometry
- adjust readout window, prepare library if needed

4. Space charge effect simulation / measurement in LArSoft:

- verify if LArSoft's infrastructure is sufficient
- estimation method: the same as in SP (crossing muons)?

5. Finalize algorithms for the geometry rotated to the vertical drift

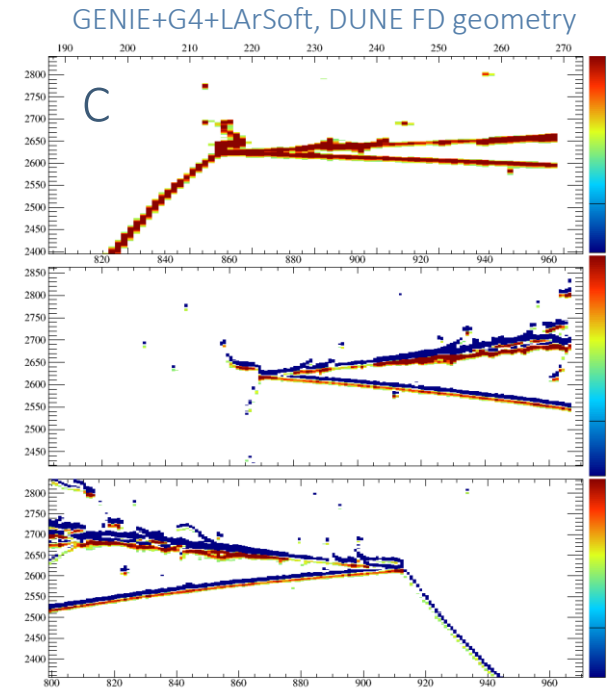
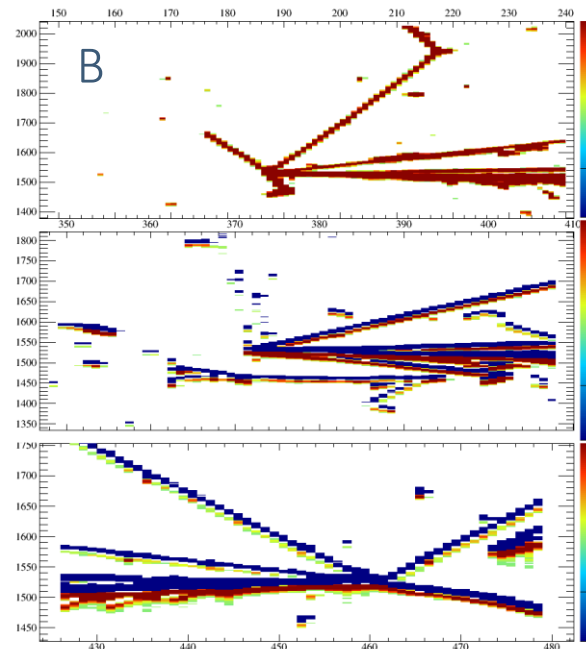
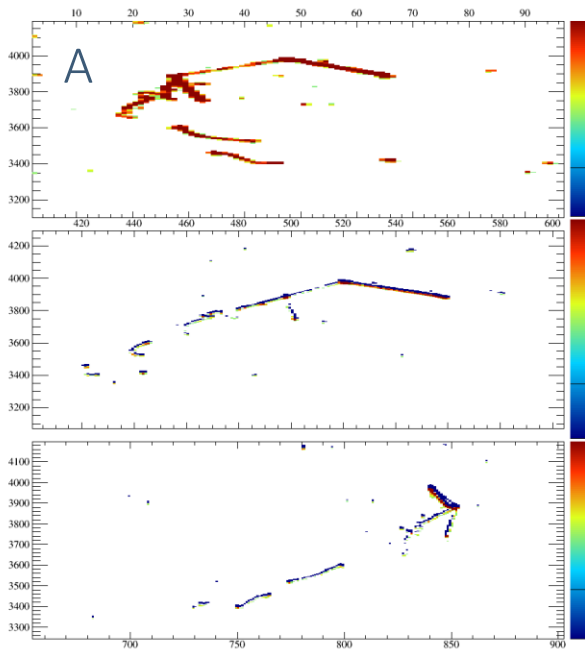
Calibration: a whole team in SP, not covered now for DP-LArSoft (from ADC to 3D-based calorimetry).

Many corner cases (here ν_e)

→ makes the difference when looking for $\sim 95\%$ purity / $\sim 90\%$ efficiency selection

→ ...and per cent level systematics

- low energy electron (A)
- electron + π^0 induced cascades (B)
- electron overlapped with other tracks (B)
- 2 electrons (C)
- ...and other configurations



Far Detector (TDR) point of view

(starting from the **SELECTIONS**, useless in ProtoDUNE)

Remember to focus on missing parts:

- there is already MVA-based selection machinery for SP
 - there is CNN-based „all in one” selection, also now made for SP
6. Selections based on MVA on flat feature vector (standard, but try not only BDT):
- **TASK: prepare it for DP, likely with modified reco features, since DP is not running exactly the same reconstruction chain**
 - required new features, related to the vertex and electron candidate: next slides
 - no harm in trying SP/DP comparison
7. Selections exploiting full particle hierarchy (hidden weapon):
- not attempted, likely should try on SP first
 - will need vertex features (as in point 1.) anyway

SELECTIONS performance is strongly bound to the input from the RECONSTRUCTION

Far Detector (TDR) point of view

(**RECONSTRUCTION**: all can be tested and useful in ProtoDUNE)

Ordering attempt: from the most needed

8. EM/track separation:

- **Basic start to complete event reconstruction**
- it was hard for a long time, now CNN work advanced, other approaches are also growing (e.g. TrajCluster)
- now tuning for neutrinos
- models need to be applied to data: **TASKS:**
 - **realistic signal and noise simulations, based on real data when available,**
 - **adjust and validate EM/track ID**

9. Electron/Photon separation \Leftrightarrow ν_e selection:

- given the selected vertex candidate, and also electron candidate (seem to be possible to solve separately: see point 3., next slide)
- **TASK: vertex features detection: electron candidate signal displacement from vertex (gap) and 1m.i.p. dE/dx**

Far Detector (TDR) point of view

(**RECONSTRUCTION**: all can be tested and useful in ProtoDUNE)

10. **TASK: vertex identification**

- nucleon decay (Kaon and muon decays, atmospheric ν interaction),
- primary vertex selection in LBL ν events,
 - to me both seem solvable with one approach,
- can be validated on ProtoDUNE: muon decays, various interactions identification

11. Michel electrons:

- calibration in ProtoDUNE's, **TASK: detect Michel electron / muon decay, reconstruct electron energy**
- SNB in FD, **TASK: how much it is similar to Michel electron energy reco?**

Light sim/reco issues: I leave the discussion to Alberto and Christoph

Thanks

(...for listening to the incomplete list)

[tasks in google doc](#) (we'll edit now)