

Coherent pion analysis with garsoft: status report

October 22, 2019

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DUNE ND Workshop @ DESY

Towards a CDR

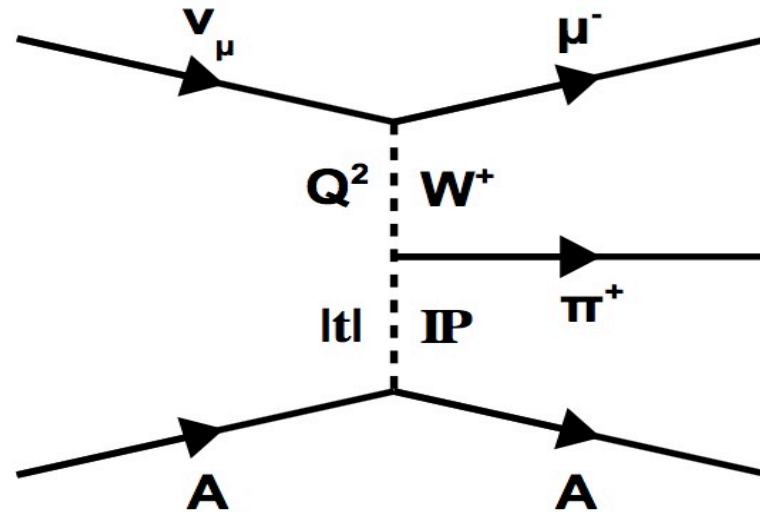
- Doing a complete analysis done with a full reconstruction & simulation will be a good contribution to the CDR
- Provides a perspective on what upgrades and bug fixes are need for GArSoft, and with what priorities
- It will also be our first worked example of background suppression from interactions in the ECAL and overlay activity
- Use of CC coherent π^+ production to constrain the flux has been discussed. (Actually, it might be more interesting in 3DST because ^{12}C is isoscalar; so $\sigma(\nu) = \sigma(\bar{\nu})$ for $\theta_\mu \cong 0$)

Towards a CDR

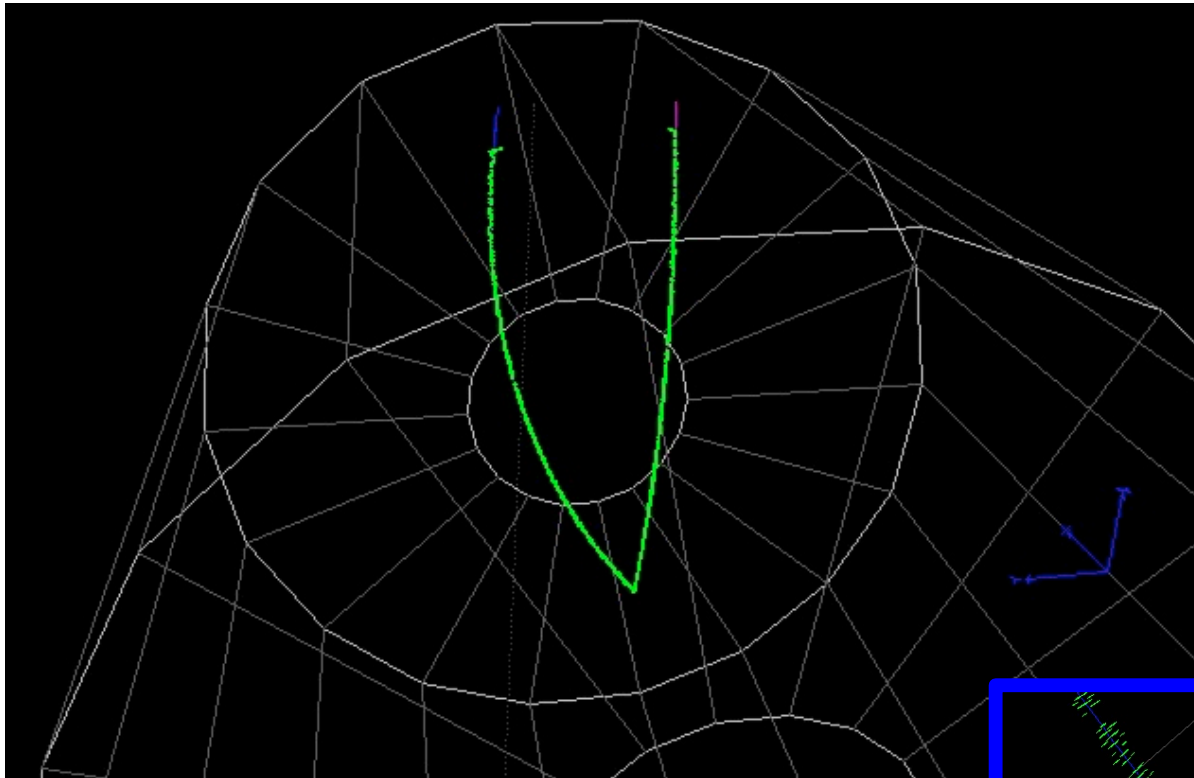
- “Data” is a set of $\sim 22 \times 10^6$ GENIE 2.12.10
- Corresponds to about 11 shifts of data at 1.2 MW and 100% uptime
- Nov 2017 optimized flux, 4 flavors of ν , FHC
- “Strawman_9” ECAL geometry (80 layers of 2mm Cu, 5mm polystyrene)
- Major missing components at this time:
 - Overlay from other activity in the 10 μ sec spill
 - Reliable quantities to use for track & vertex quality cuts
 - Tagging of proton stub- /non- tracks near the vertex
 - Matching of MCTrue particles to detector activity is rudimentary
 - So is the dE/dx calculation
 - Modeling of TPC pad/electronics response, wire gain, noise, non-uniform B field not in the simulation...

About coherent π^\pm production

- **Typical selection criteria:**
 - Veto detector activity near vertex other than μ and π
 - $|t| = (q - p_\pi)^2$ must $\lesssim 0.1 \text{ GeV}^2$
 - PID for proton veto
- **Detector backgrounds:**
 - Vertices from ECAL activity
 - $\gamma \rightarrow e^+ e^-$
- **Physics backgrounds:**
 - Single π^+ (possibly through a resonance)
 - CCQE producing $\mu^- p$;

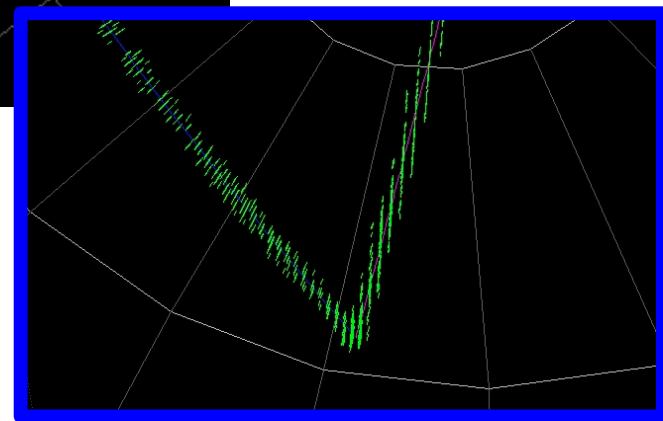


Signal Event in HPgTPC



*Require a 2
track opposite
charge vertex*

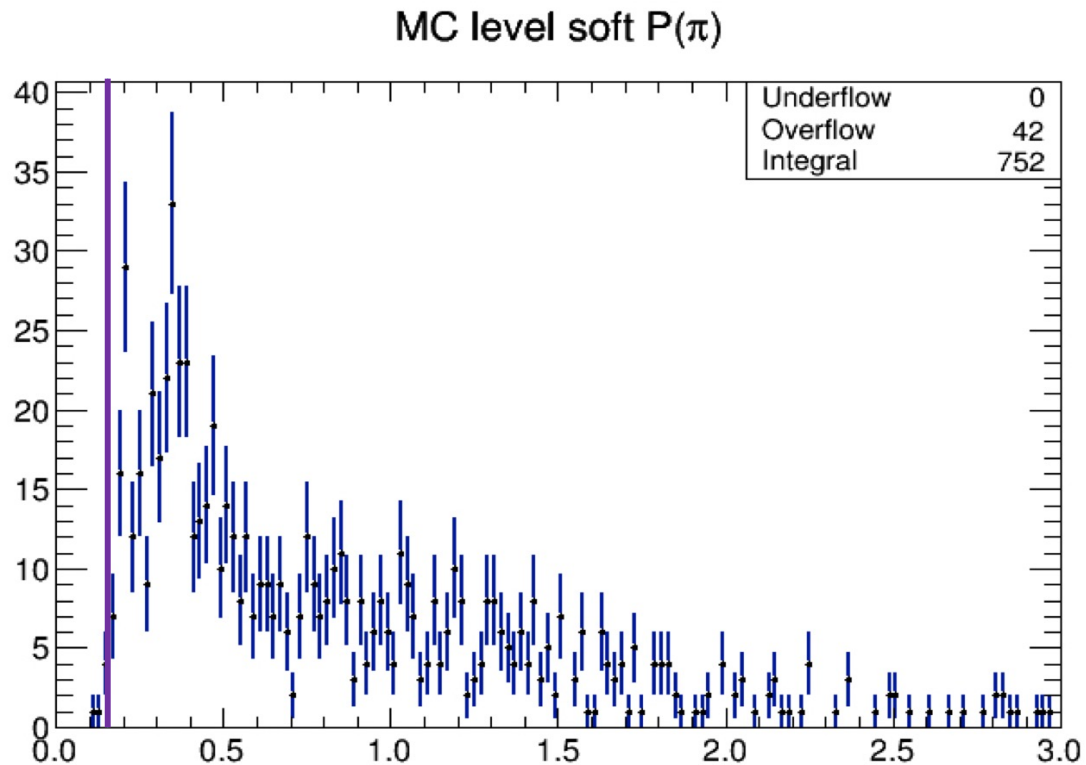
*Effectively, a
vertex activity
cut*



$$\gamma \rightarrow e^+ e^-$$

- Normally, suppress with $m(ee) < 15$ MeV or some such
- That folds in the reconstruction efficiency of narrow V's
(It isn't that great yet)
- However signal does not have low $P(\text{tracks})$
- Remove tracks & vertices with tracks with $P \leq 150$ MeV

- Could go back and investigate $m(ee) < 15$ MeV cut later.

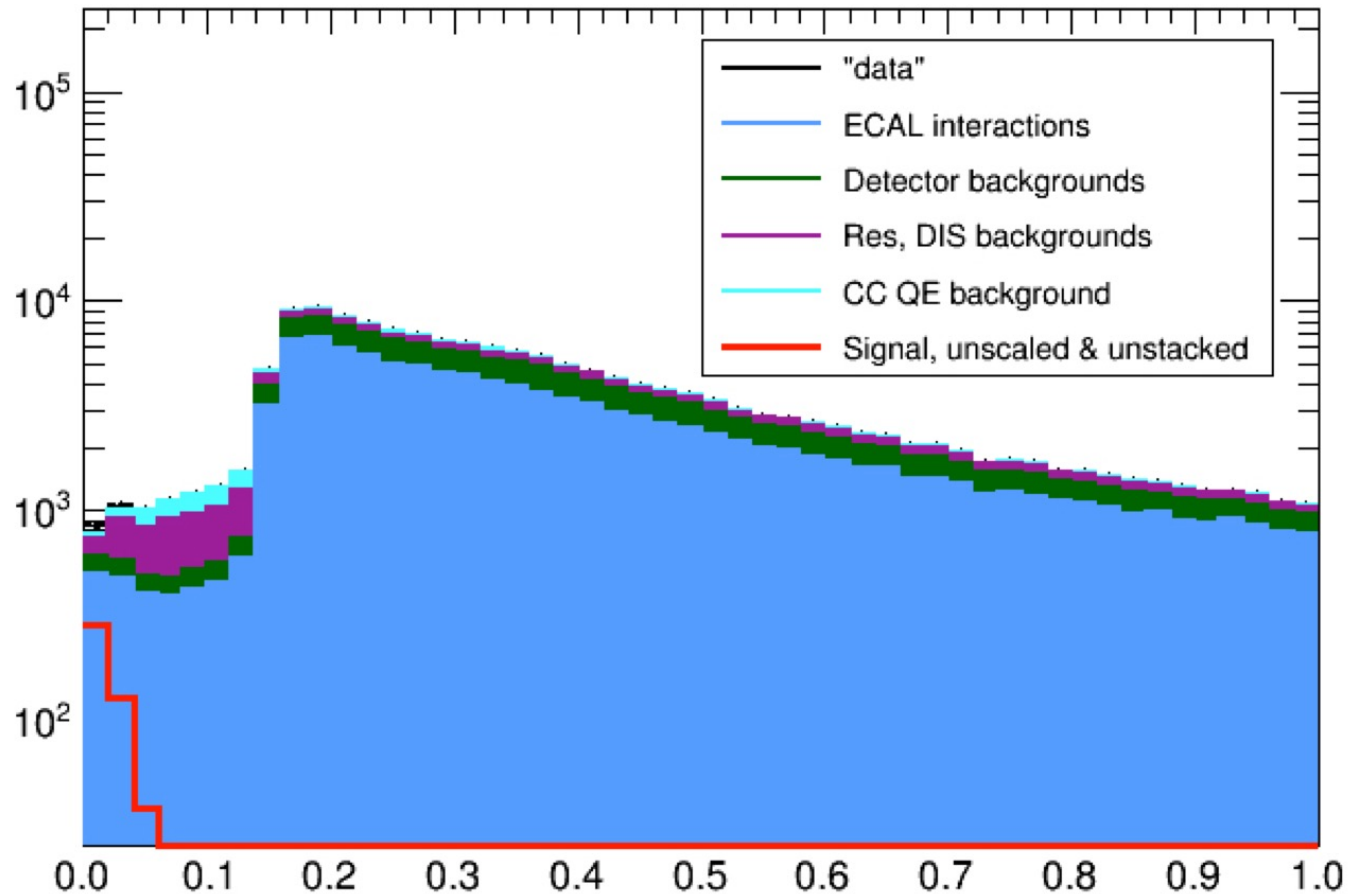


Background definitions

- **ECAL:** The primary vertex is in the ECAL, but the reconstructed vertex is in the fiducial.
- **detBkg:** The PV is not inside the ECAL, and the reconstructed vertex is in the fiducial. The reconstructed fiducial is more than 15 cm from the MC true vertex.
- **phyBkg:** The vertex is in the fiducial and matches the MC true vertex. The GENIE interaction type corresponds to a resonant or DIS process.
- **isCCQE:** The vertex is in the fiducial and matches the MC true vertex. The GENIE interaction type corresponds to a CCQE process.

After the $P_{\text{trk}} > 150\text{MeV}$ cut

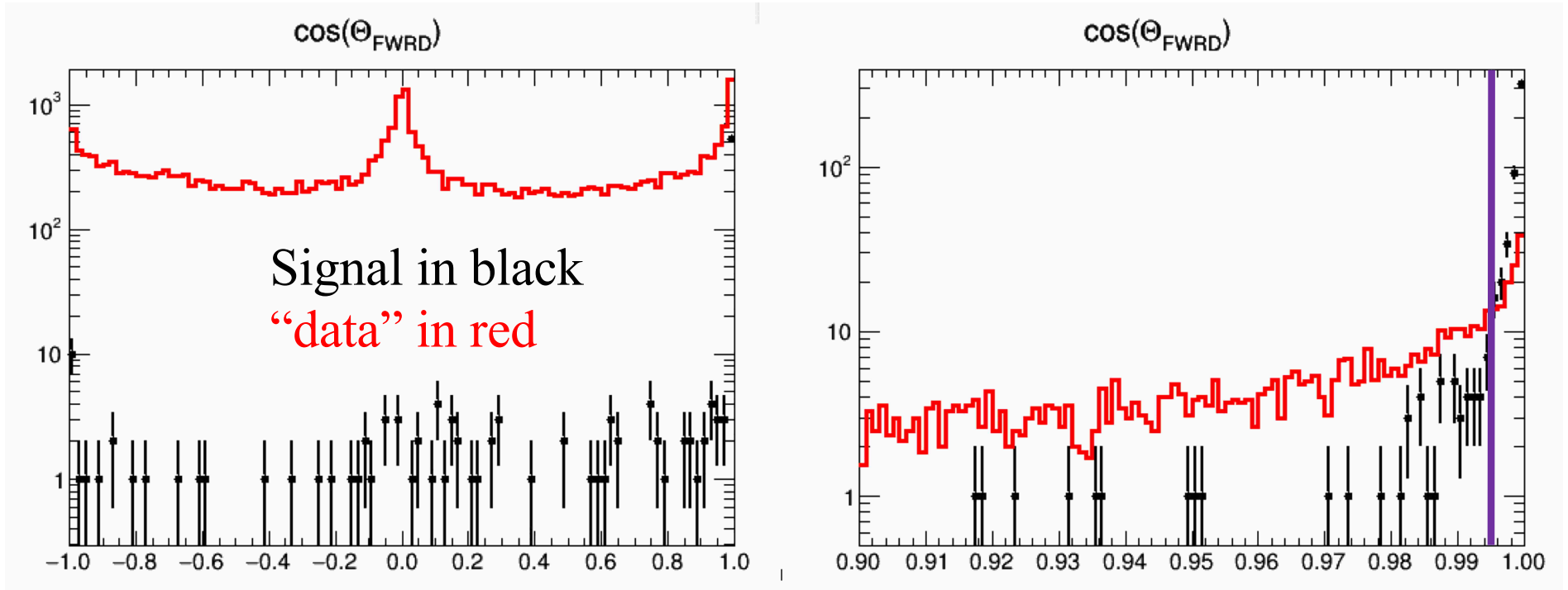
|t| "data": after P_{trk} cut



Forward angle cut

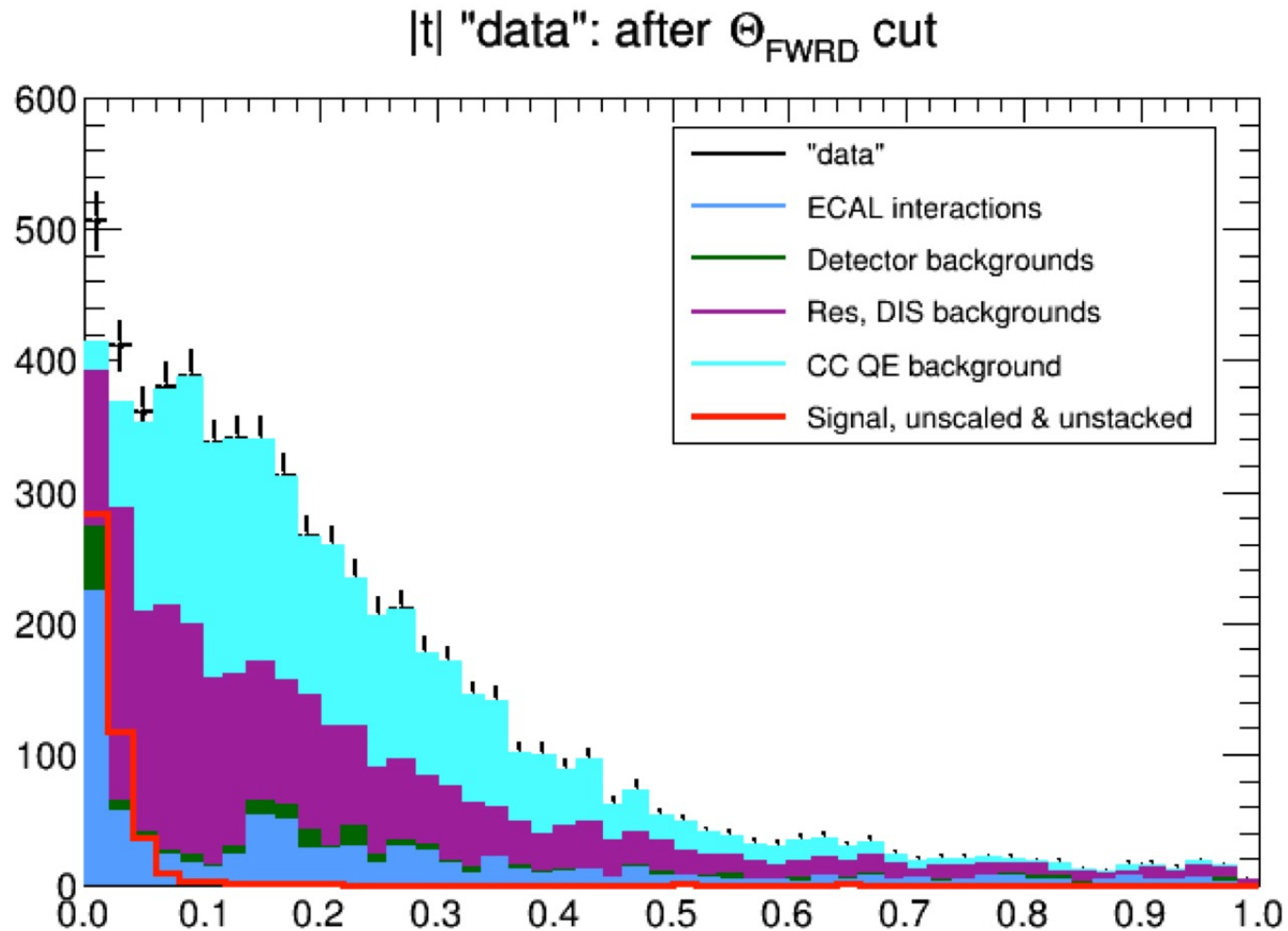
- The large mass of ECAL gives a high rate of charged particles entering the gas which interact to create kinks or δ rays
- At this stage in (a) cuts in the sample and (b) the level of reconstruction code development, many of these reconstruct as 2 track neutral vertices
- $\sum \vec{P}_{track}$ for this background points in any direction
- But because we have a fully reconstructed mode, $\sum \vec{P}_{track}$ for the signal points in the direction of the neutrino beam

Forward angle cut

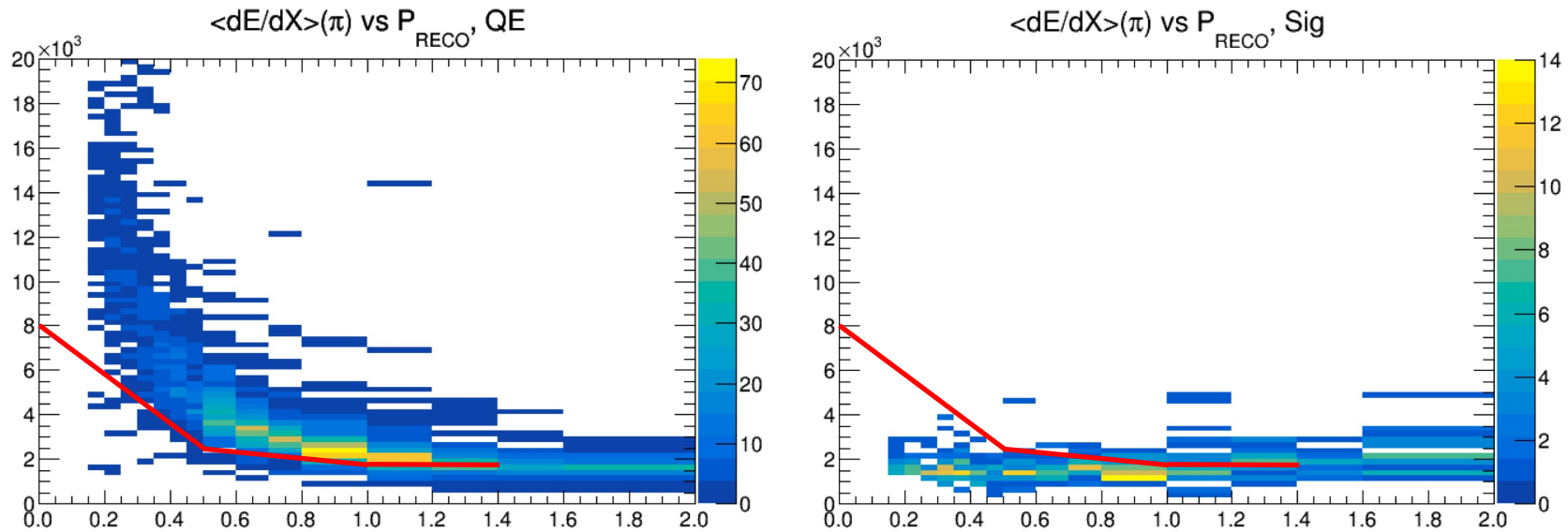


- Require angle between $\sum \vec{P}_{track}$ & $\hat{d}_{BEAMLINe} > \text{acos}(0.995)$
- Will need to think of a different cut for other signals

After the Forward angle cut



dE/dx to kill CC QE-like



100% truncated mean from default GENIE

70% truncated mean gave bizarre plots because of tracking issues

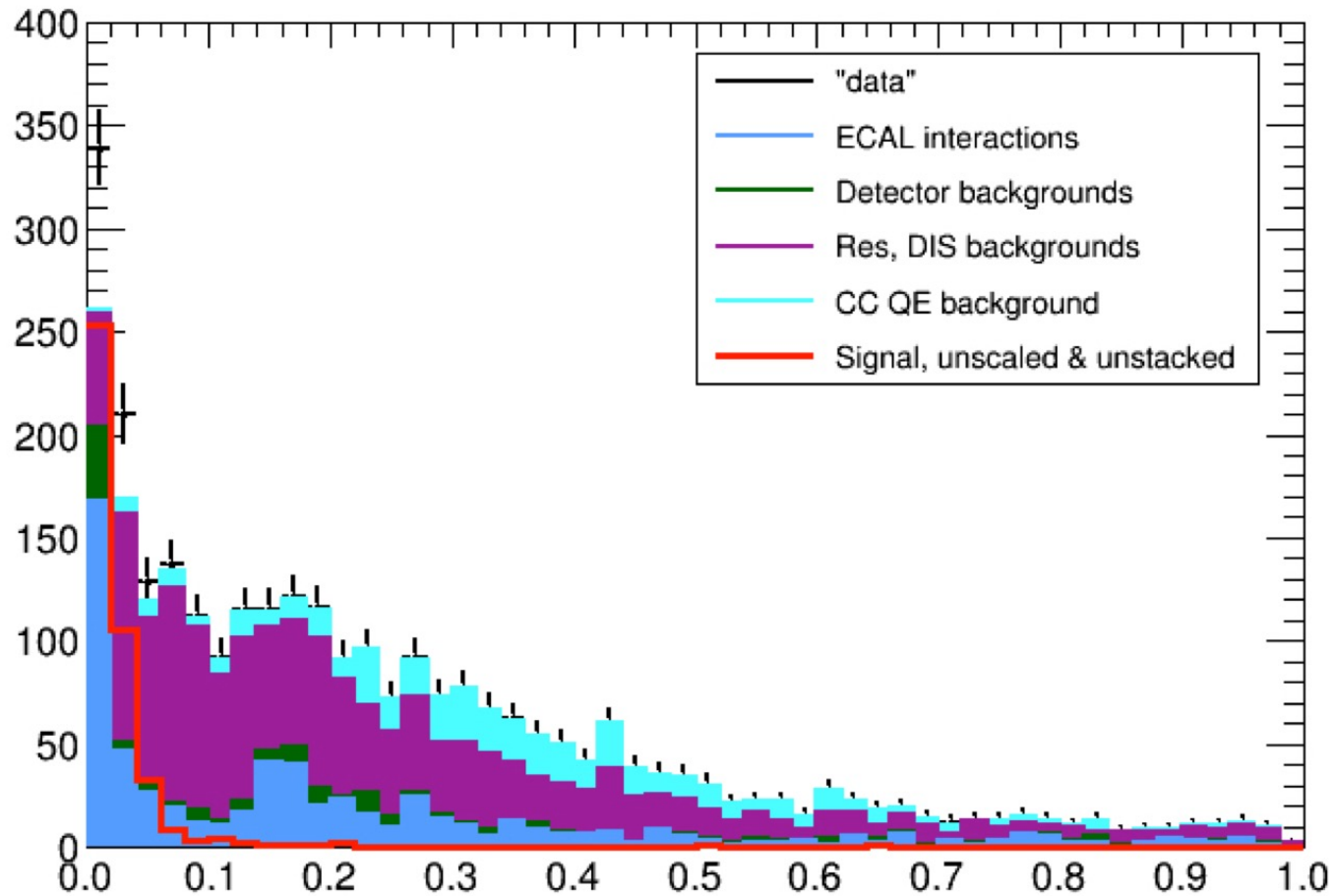
Haven't had a chance to investigate further

Tracking is improved since then

(later) put sector boundary corrections in

After the dE/dx cut

|t| "data": after dE/dx cut



Next steps / Conclusion

- On $\sim 3 \frac{1}{2}$ days of data, have $135 \pm 18_{\text{STAT}}$ of CC coherent π^+ visible in $|t|$ plot
- Need to address the overlay background next
- $40\times$ overlays makes the computing $40\times$ more interesting 🤔
- More garsoft upgrades coming
- Should try a harder channel too!

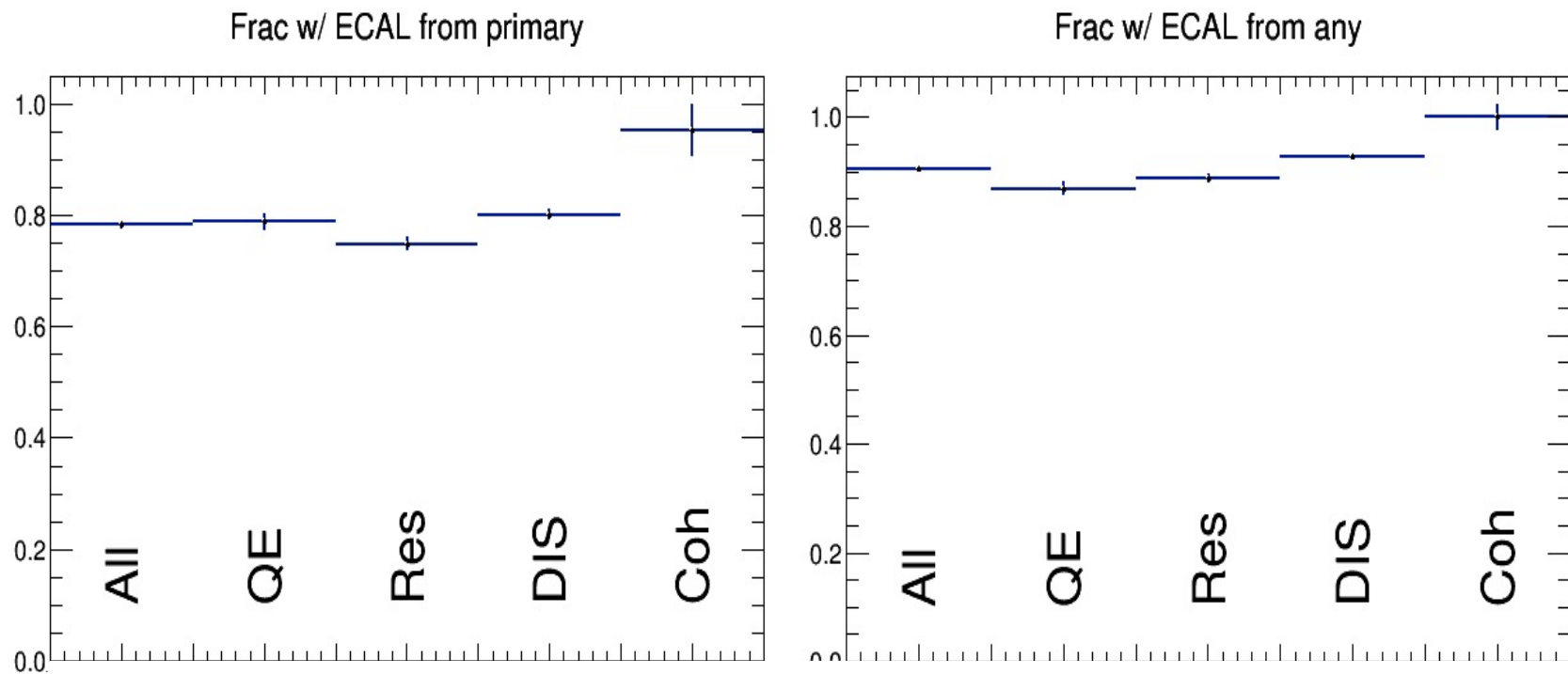
Extra slides

- **Level 1**
 - **Level 2**
 - **Level 3**

Looking in ECAL

Extrapolated tracks into the ECAL for 2 reasons

- 1) Fraction of events can we get timing info from ECAL

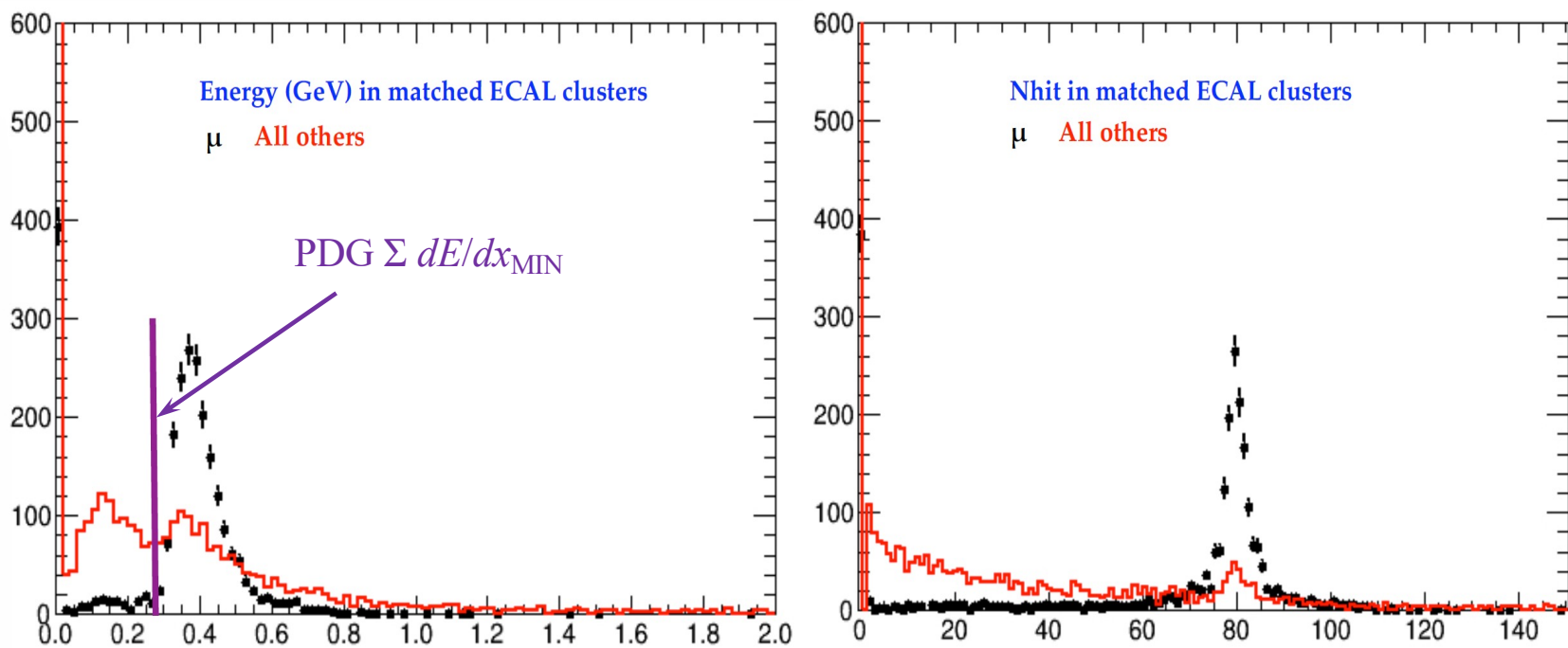


(before $P > 150$ MeV cut
& extrapolation optimization)

Looking in ECAL

Extrapolated tracks into the ECAL for 2 reasons

2) To what level can we tag μ by looking for MIP in ECAL

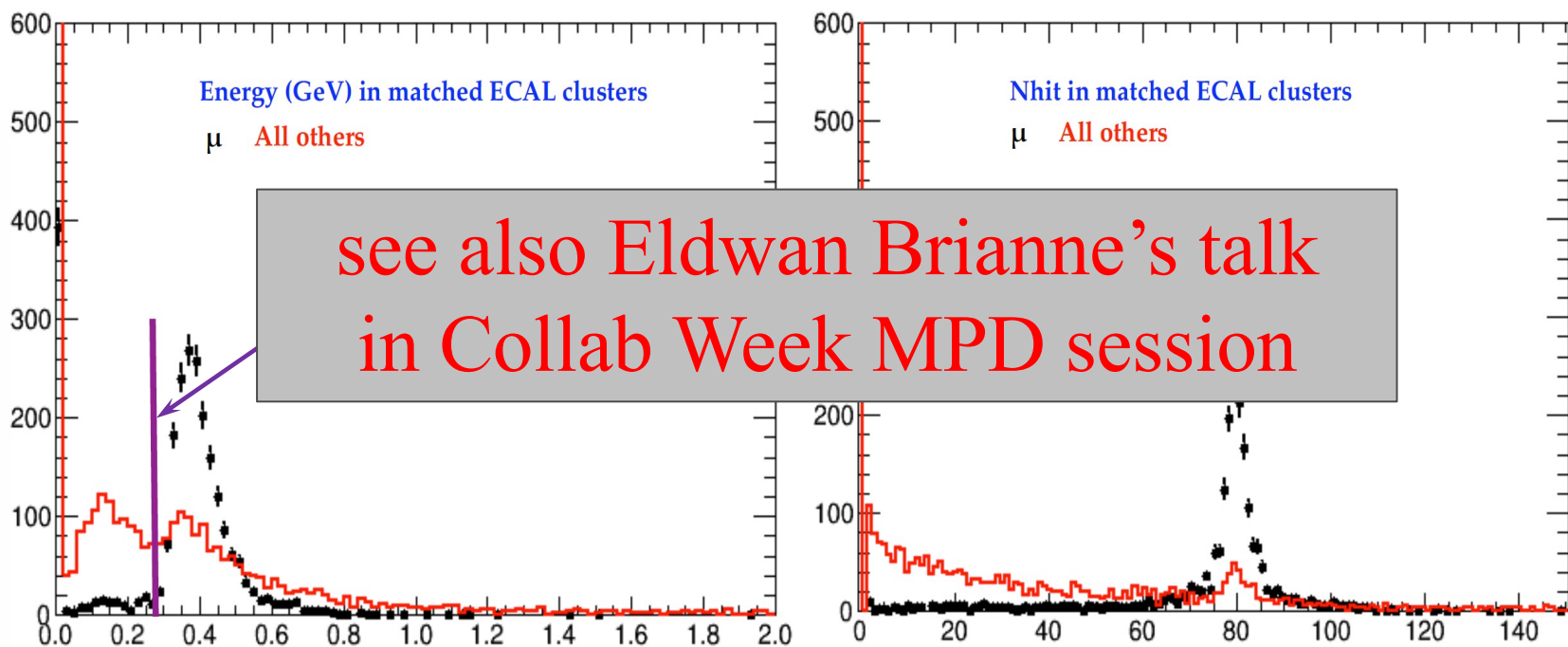


(before $P > 150$ MeV cut
& extrapolation optimization)

Looking in ECAL

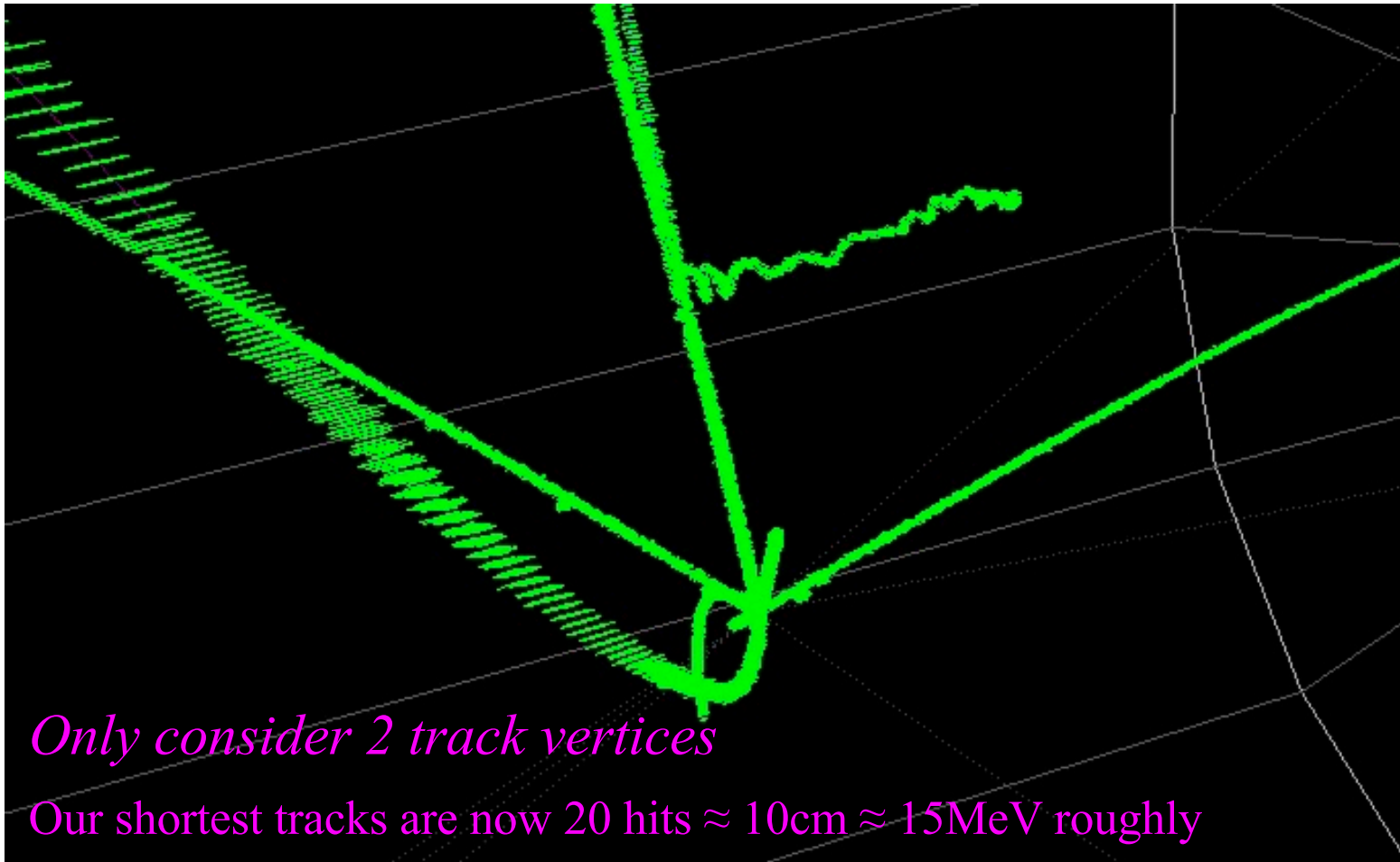
Extrapolated tracks into the ECAL for 2 reasons

2) To what level can we tag μ by looking for MIP in ECAL



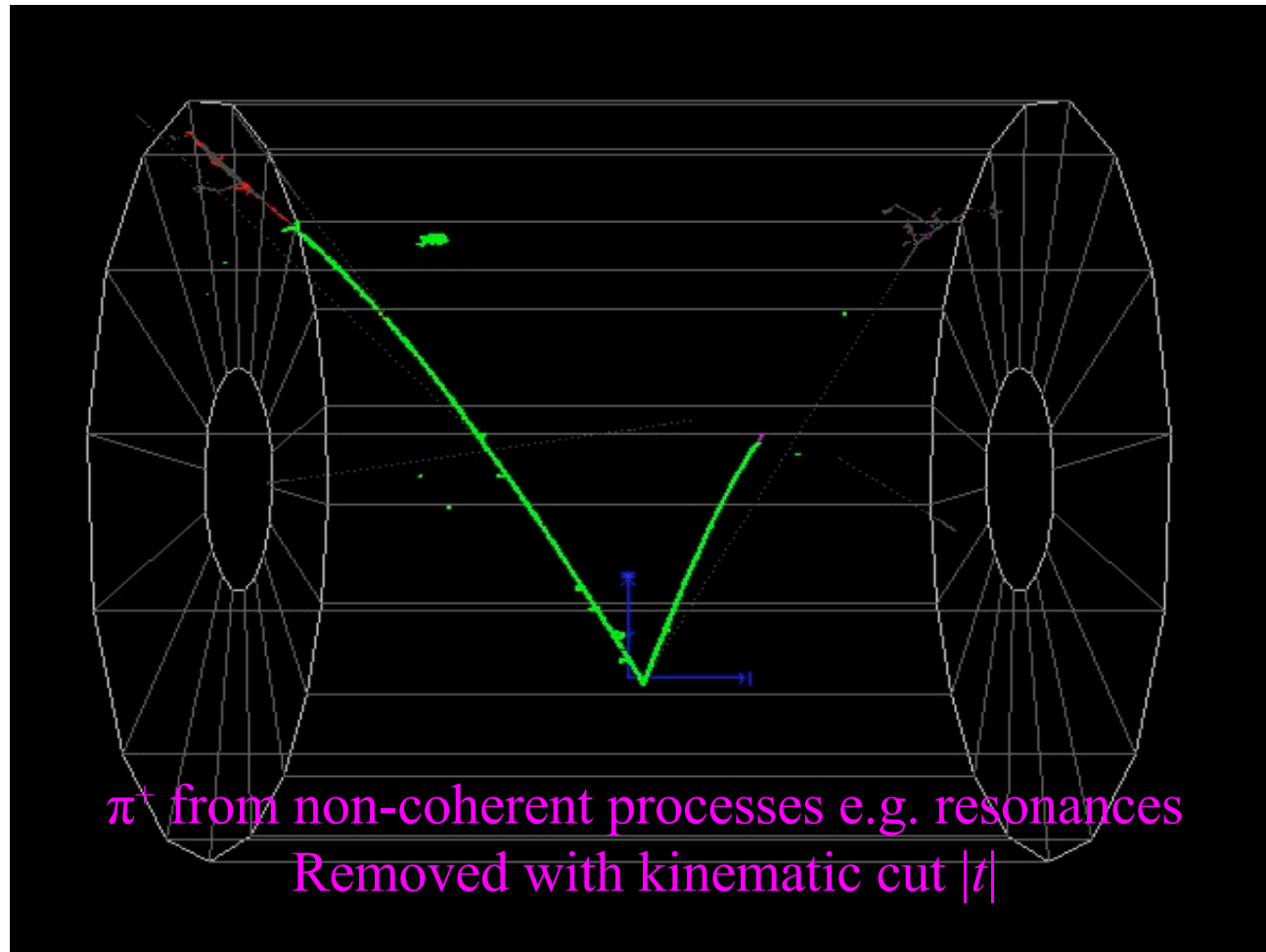
(before $P > 150$ MeV cut
& extrapolation optimization)

A background event with vertex activity



Other activity or noise that does not belong on a track neither modeled nor tagged yet; expect to be able to see $\sim 5\text{MeV}$ excesses

A background event with a π^+



A background event with a p

