MPD software (etc) update

- Last time / since then
- Parameterized model
- Stand alone full simulation results

ND SW Integration meeting
30 Aug 2019
Leo Bellantoni for MPD group

Last time

MPD: Reconstruction: GArSoft

Implemented

- Event Generation
- Detector Geometry
- Particle Interactions & Energy Deposits
- Drift and Diffusion
- Digitization
- Hit finding and clustering
- Pattern recognition
- Track fitting
- ECAL Digitization
- ECAL Reconstruction
- Ionization-Based Particle ID
  - Initial version exists – needs work

To do (to some degree optimization)

- TPC Field Response and Electronics Response
- Optimize pattern recognition in difficult cases
- Optimize track fit
- Very short tracks in crowded environments will require innovative algorithms
  - Deep learning methods being studied now
- Vertexing
  - Preliminary vertex-finding algorithm written and tested
- ECAL
  - Cluster-Track matching
  - Full energy reconstruction (only visible energy for now)
  - …..

Slide from Alan Bross

🟦 **Fermilab**

8   July 24, 2019   T. Junk | DUNE/GArSoft

GArSoft is an end-to-end simulation: GENIE, GEANT, Reco, analysis tree.

From Tom's talk in ND Integration Workshop 24 July   *Indico link*

Since then

Update of MPD Geometry.
Update of the file on dunendggd

- Going towards a common ND geometry
- On the request of Perri Zilberman
  - Cleanup of the MPD files in dunendggd
  - Provided files for generating the geometry
    - MPD alone
    - MPD + ArgonCube
- Not final geometry but integrates
  - GArgon (1t FM)
  - Pressure Vessel (Al, 0.5 X_0)
  - ECAL (Barrel and Endcap) -> reduced to 60 layers to fit within the magnet (~250t mass)
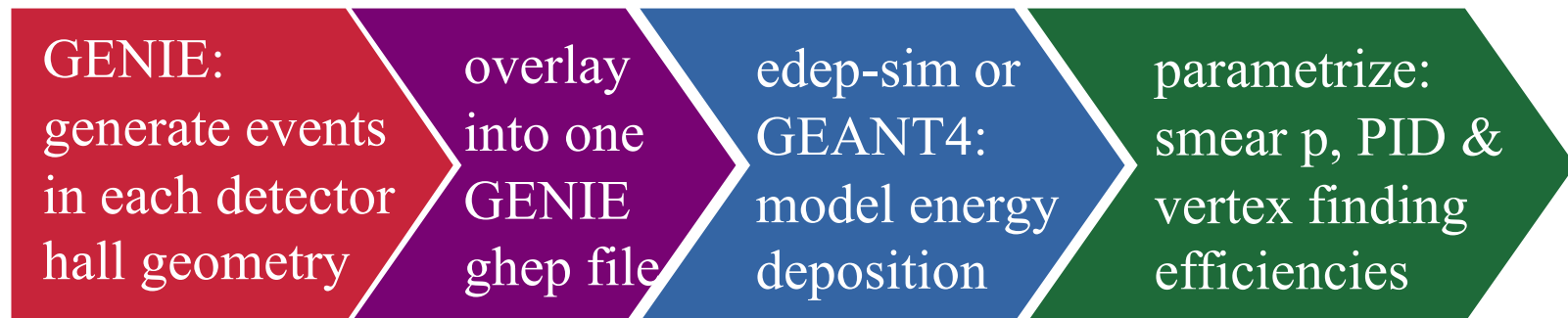 - Magnet (100t mass)
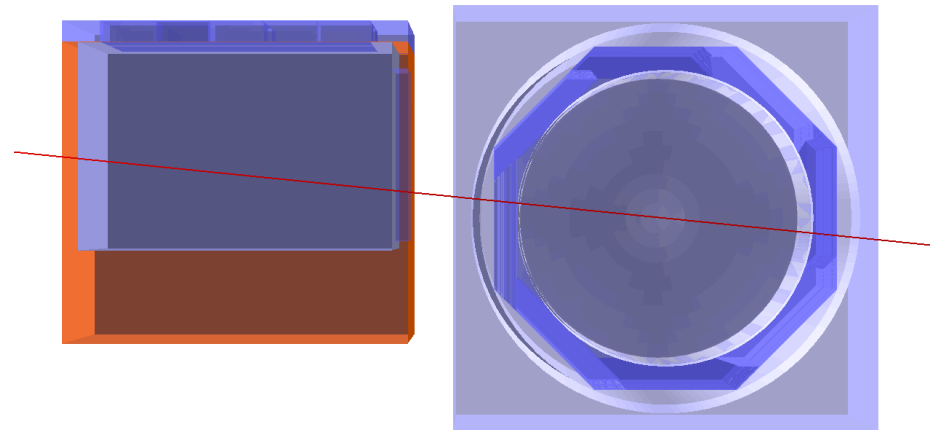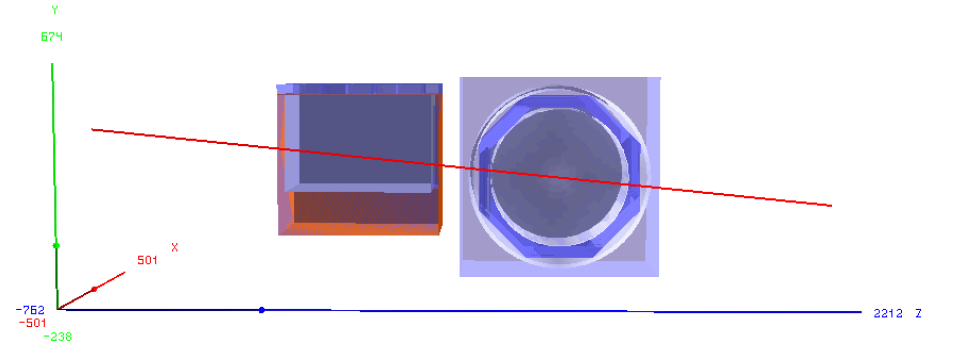
Eldwan Brianne / DESY

Since then

- **`GNumiFlux.xml`**
  - **Part of GENIE and it specifies a rectangle where the ν tracing starts**
  - **Separate entry for each experiment, but the DUNE/LBNE entries were old and wrong; added a new entry to simulate MPD and put it into `GArSoft`**
  - **Will need further updates for integrated ND**

- **Code cleanup:**
  - **With Paul Russo, now have a thread-safe C++11 based generator of ID numbers for objects**
  - **Added ID numbers to Track, Vertex, CaloCluster, TPCCluster & TPC hits classes, along with robust == and != operators**
  - **`<vertex> == <track>` won't compile**
  - **May be of broader use?**
  - **Made the analysis tree code a lot simpler**

- **Various other tracking, event display fixes**

Parameterized Model

Motivation

- Why a parametrized simulation:
  - ★ CDR timeline is aggressive – a dedicated simulation effort based on parametrization of common assumptions can help
- End goal: create a module that can read both edep-sim and GEANT4 ntuples containing the truth-level information
- Module for reading edep-sim already in place and working (was used for TDR). Whether edep-sim or GEANT4, the roadmap is the same:

GENIE: generate events in each detector hall geometry → **overlay into one GENIE ghep file** → **edep-sim or GEANT4:** model energy deposition → **parametrize:** smear p, PID & vertex finding efficiencies

- New module for reading GEANT4 MC Particle tree recently created ◀ by Tanaz & Eldwan Brianne

See talk of Tanaz Mohayai 20 Aug: _Indico link_

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Parameterized Model

- ## At this time:

    - There is a reasonable threshold parameterization in place

    - There is a reasonable track momentum parameterization in place using Gluckstern

    - The PID efficiency from dE/dx & ECAL combined still needs a parameterization to be put into place

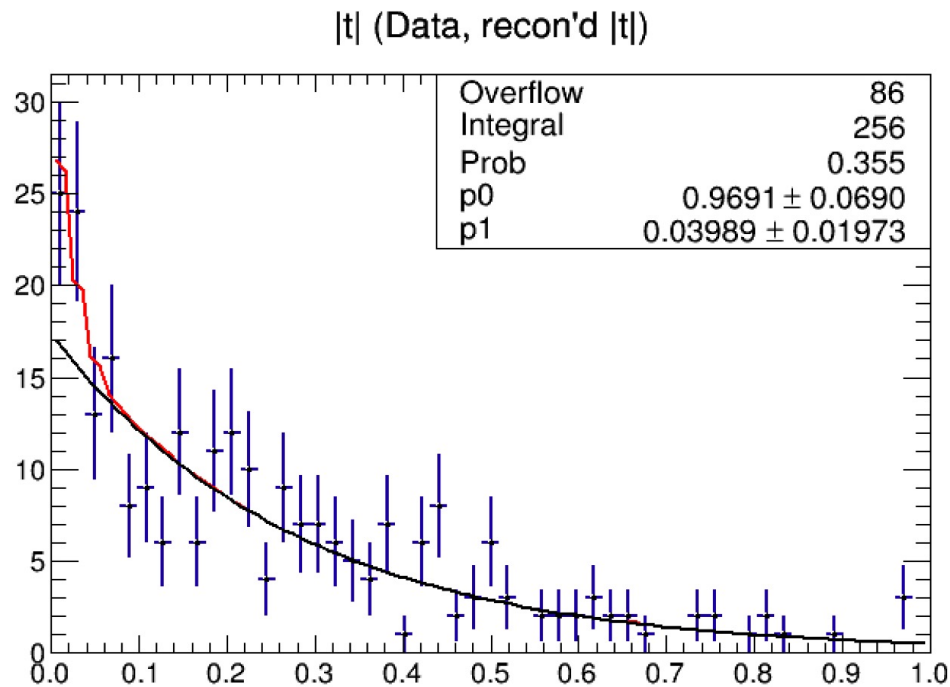   - Then integrate into a unified ND simulation package
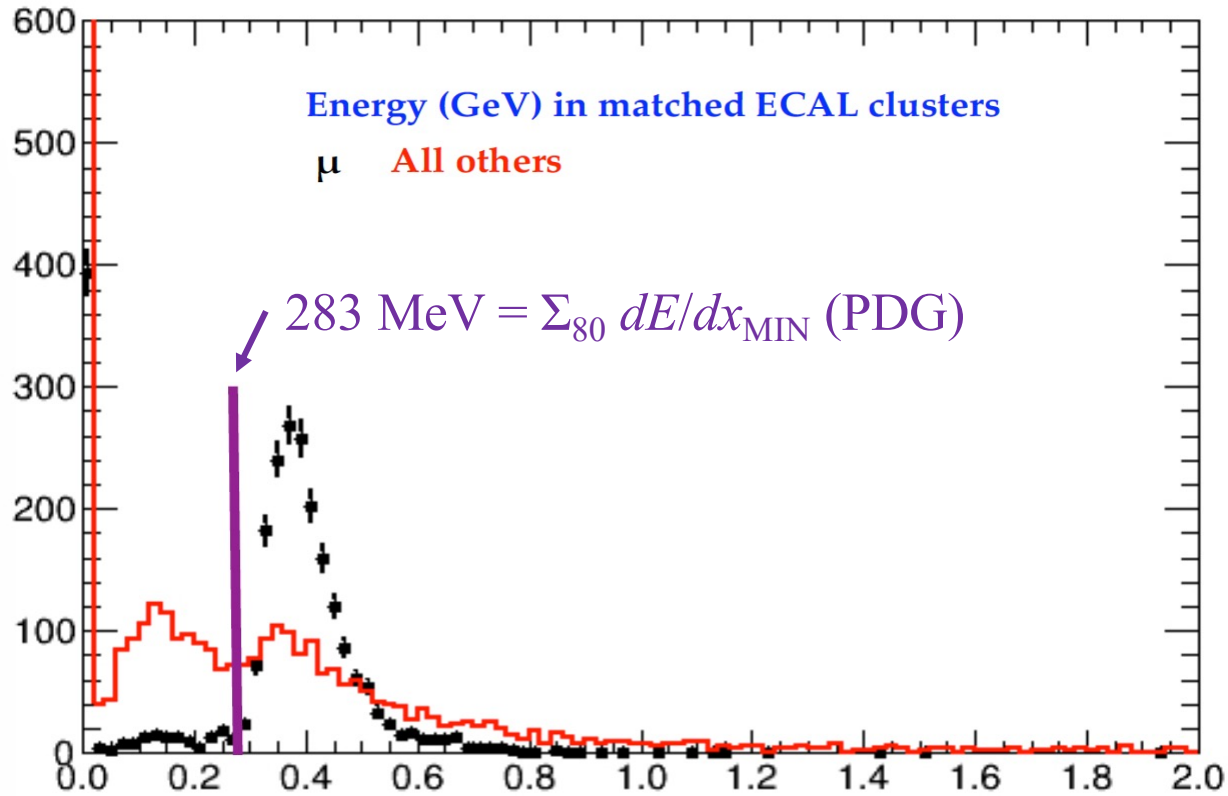
Indico. link warning: do not believe TPC/ECAL matching fractions in that talk

Coherent $\pi^\pm$ in SA full simulation

- **Having a complete full-sim analysis of ≥1 mode will be a significant addition to the CDR**

- **Coherent π^+ is a simple channel that *could* constrain flux (theoretical input in the form of PCAC)**

- **Is also a study in background suppression**
  - **ECAL interactions (no in-spill overlays yet): Require angle between beam direction and $(P_\mu + P_\pi) < \mathrm{acos}(0.995)$**
  - **Signal has ≈no $P < 150\mathrm{MeV}$ tracks. We have lots in "data"; probably converted pairs – cut on P for now**
  - **After dE/dx, there is irreducible π background; Ar is a largish nucleus and there's a lot of DIS, FIS from resonances etc.**

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Coherent $\pi^{\pm}$ in full simulation

- **Use $\cong$ 8 hours of Default GENIE as "data"**
- **Coherent π appear at kinematic variable $-t \cong 0$**
- **Is that a peak there? Whaddaya think?**

|t| (Data, recon'd |t|)

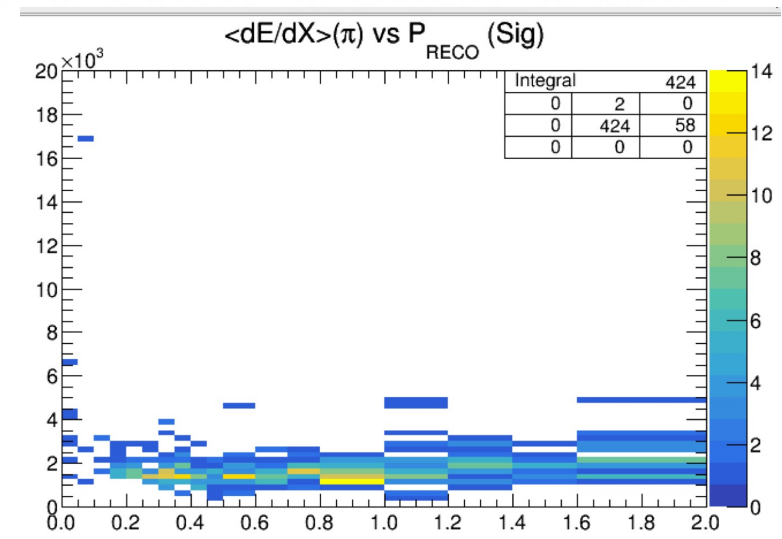| Overflow | 86 |
Integral	256
Prob	0.355
p0	0.9691 ± 0.0690
p1	0.03989 ± 0.01973

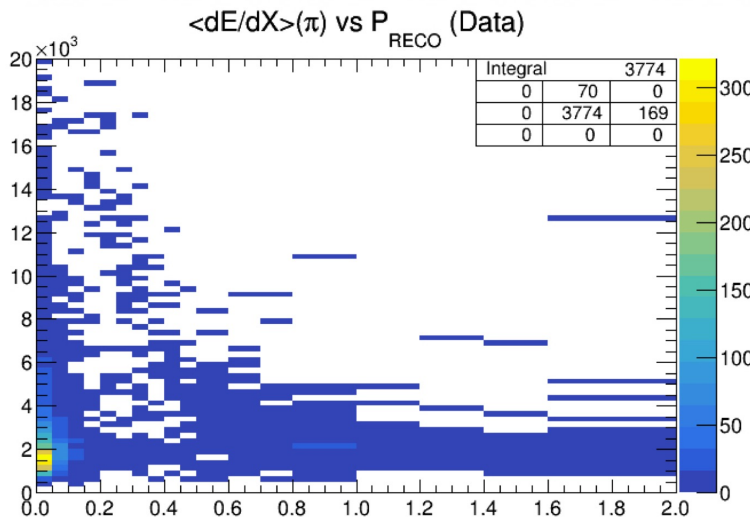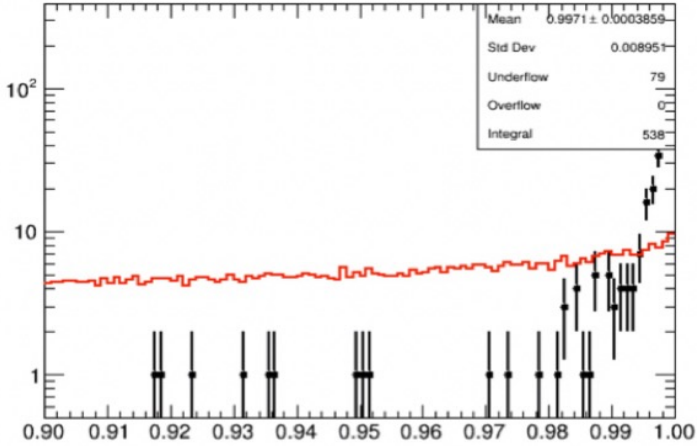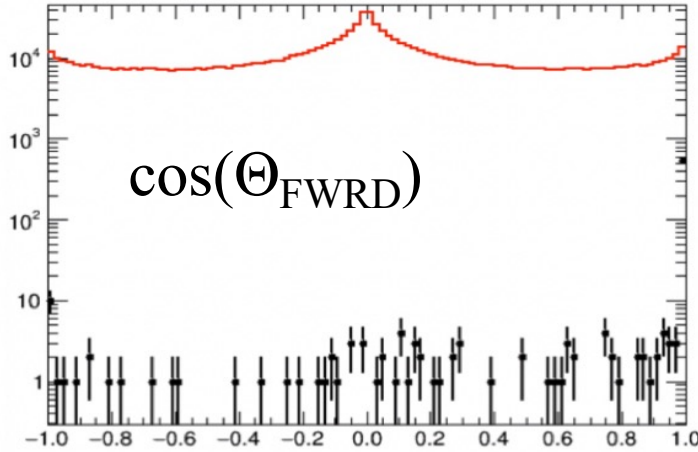**I think it need more stats**

Fit says (16.0 ±7.8) events, vs 13.8 expected So it's not wrong.

Final note

We've lost the efforts of Thomas Campbell (Boulder) - to industry. He was working on very short tracks with machine learning

2nd year Boulder grad student Timur Beremkulov has started to work with GArSoft

$\cos(\Theta_{\text{FWRD}})$

In A Single Slide

- ## Level 1
  - ### Level 2
    - #### Level 3