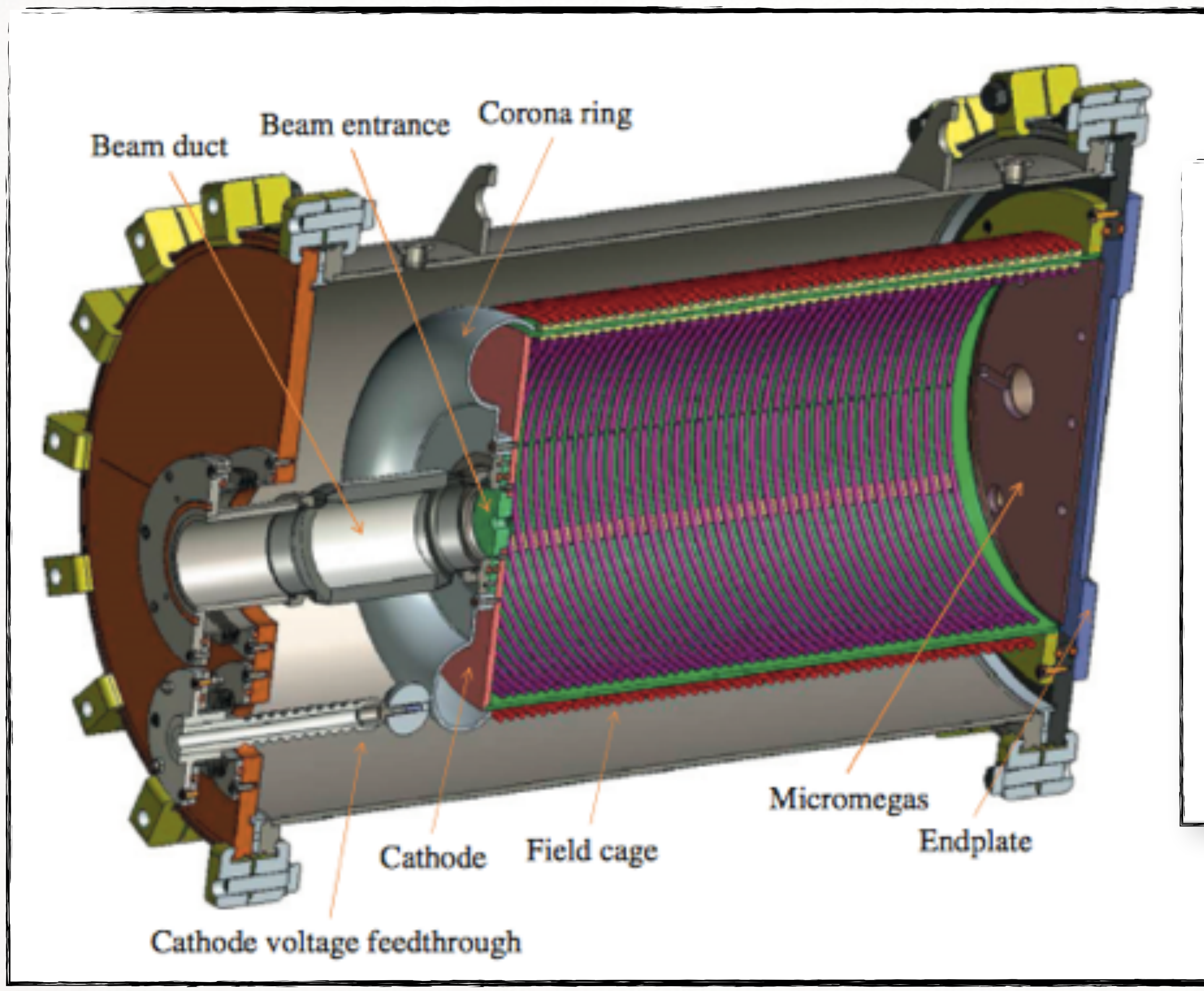
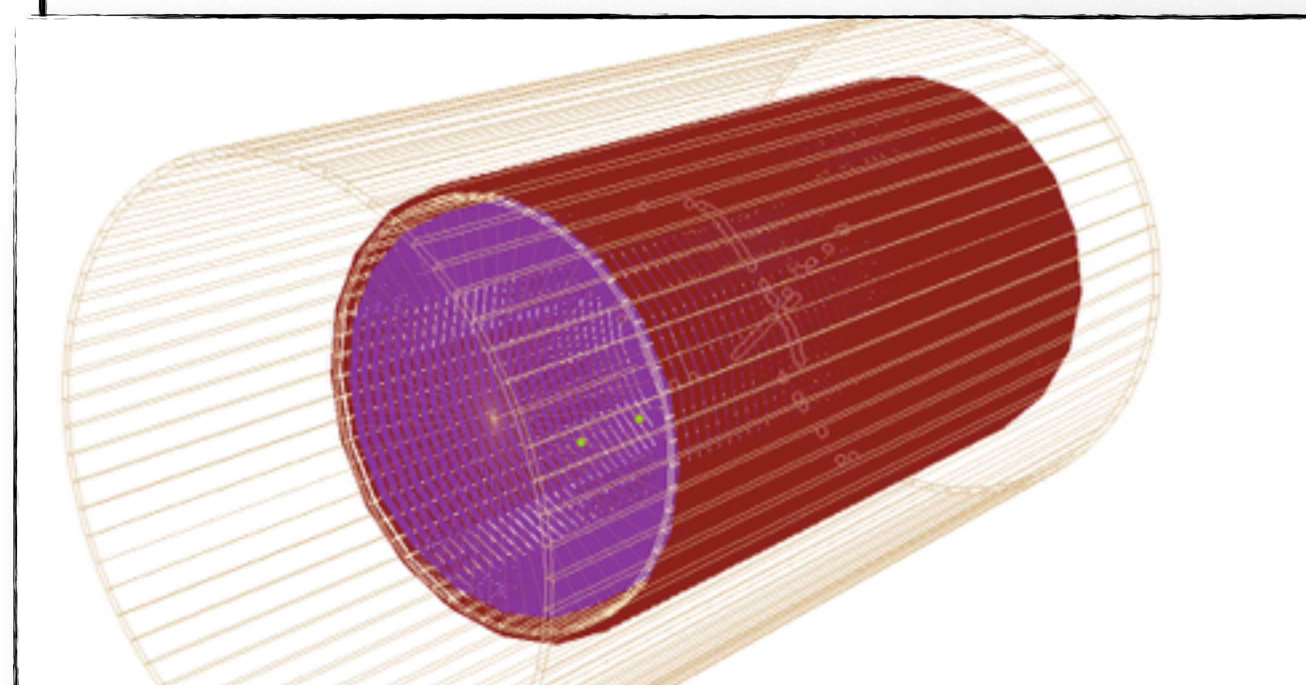
ATTPCROOT Analysis Framework

Y. Ayyad, G. Jhang and Jung Woo Lee





Project started on February 2015

Fairsoft and FAIRROOT

Fairsoft packages:

- ROOT, Geant3, Geant4, VMC (Monte Carlo), VGM (Geometry)...
- gsl, gtest, Pythia6, Pythia8, Pluto, XRootD, CLHEP, boost...
- Millipede, ZeroMQ
- Many other libraries...

FAIRROOT (http://fairroot.gsi.de):

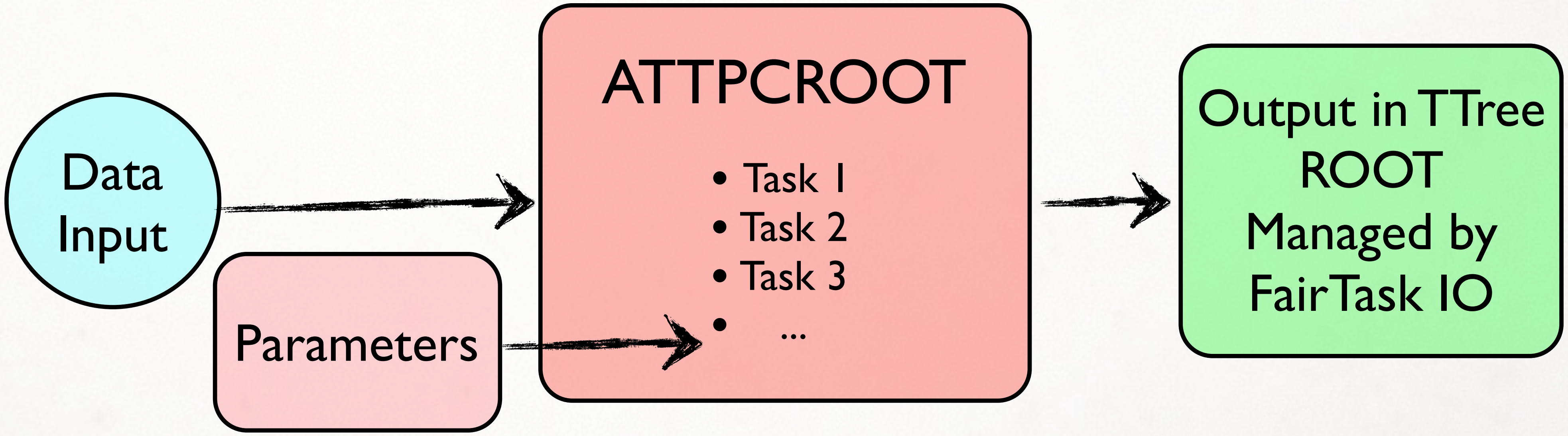
- Fully ROOT-Based framework. Base C++ classes for detector construction, simulation and data analysis.

ATTPCROOT:

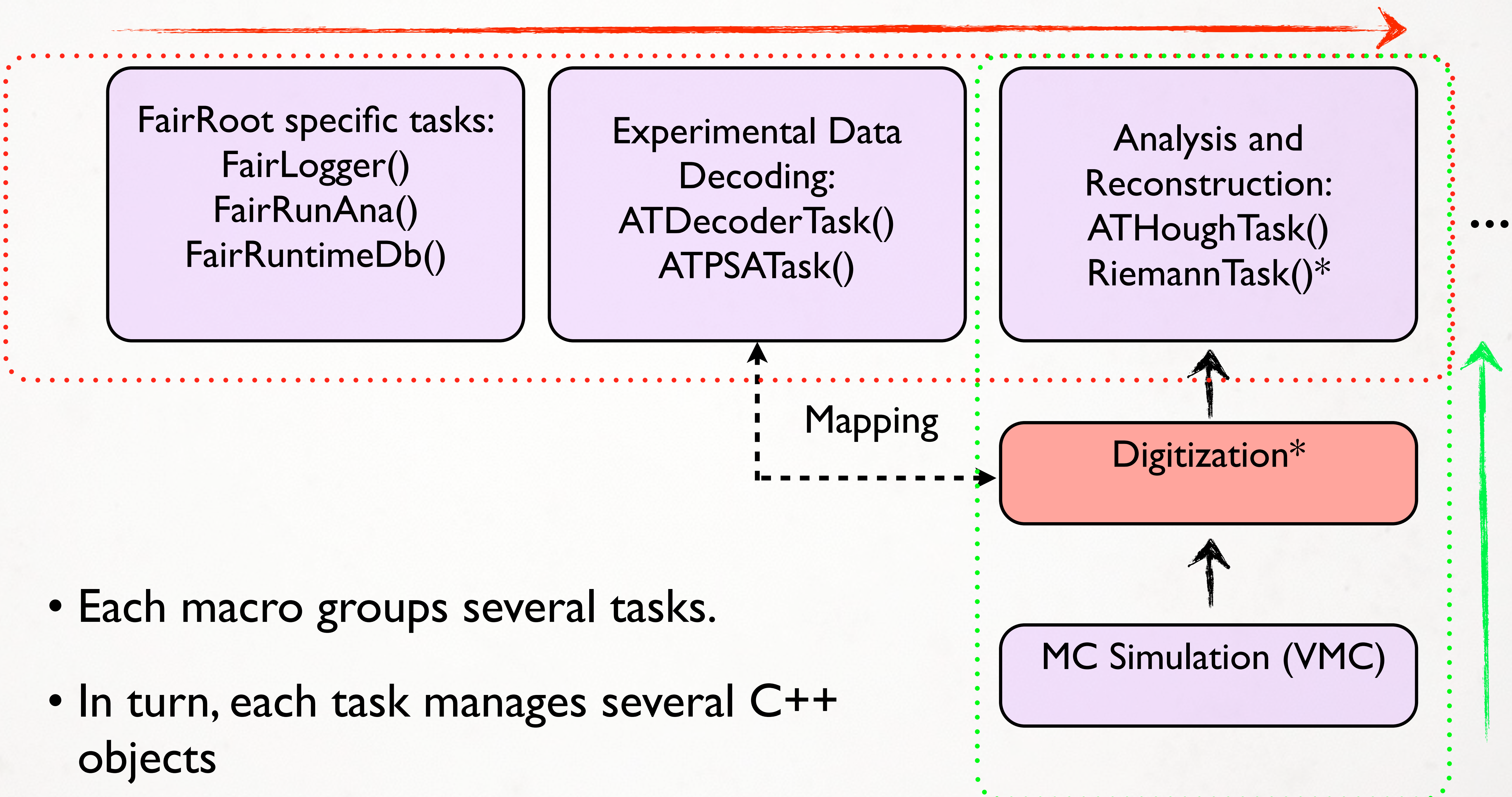
- Framework to analyze data and simulate data from AT-TPC ("big" chamber and prototype).
- SπRITROOT and PANDAROOT "little" brother.
- Tested on Fedora 21, Scientific Linux 6 and OSX Yosemite

Concepts and basics

- FAIRROOT provides generic mechanisms to deal with the physics and transport of the particles.
- Geometry of detector and reactions defined by end user. ATTPCROOT prepared for two different geometries and several cases of interest.
- Analysis/Simulation runs with simple ROOT macros divided in tasks (FairTask class).
- Different ways to input data: GET electronics raw data, ASCII, ROOT, TClonesArray (ROOT Object Container), TTree...



Flow Diagram of ATTPCROOT tasks and libraries

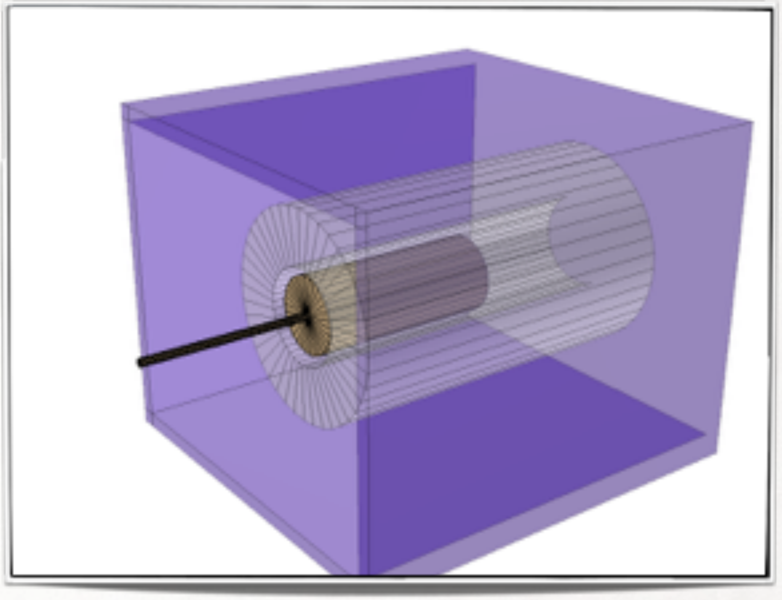


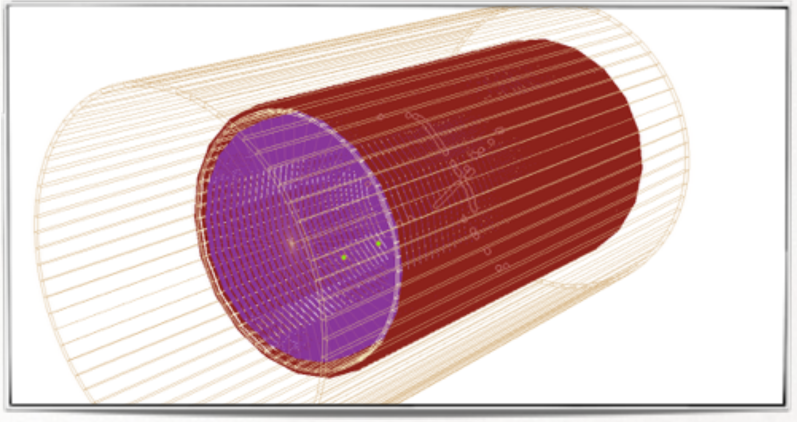
- Each macro groups several tasks.
- In turn, each task manages several C++ objects

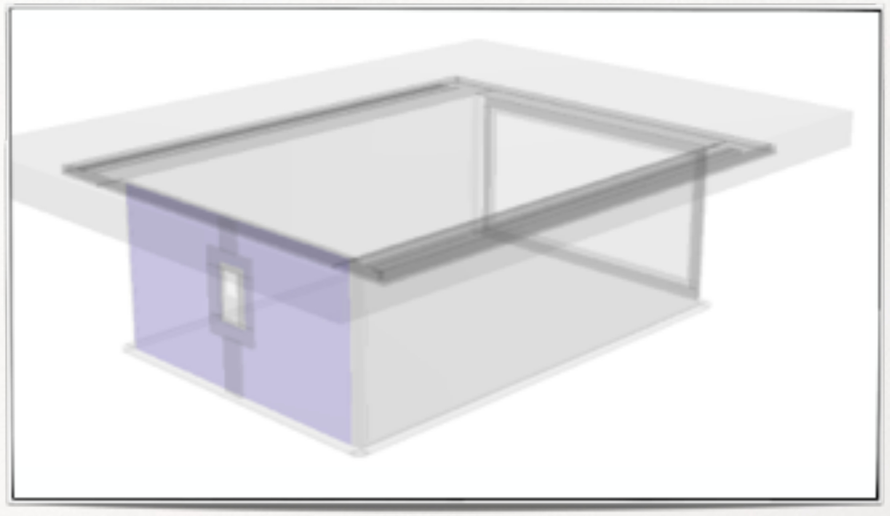
*Only implemented in SPiRITROOT

ATTPCROOT detector geometry

- The geometry of each detector is created and managed by the TGeo Class in ROOT.
- Each geometry is saved in a ROOT file used for visualization and simulation (https://root.cern.ch/root/html/TGeoManager.html).
- Each geometry includes active elements, namely the gas volume and passive elements.
- A map of the pad plane is associated to each one of the different geometries

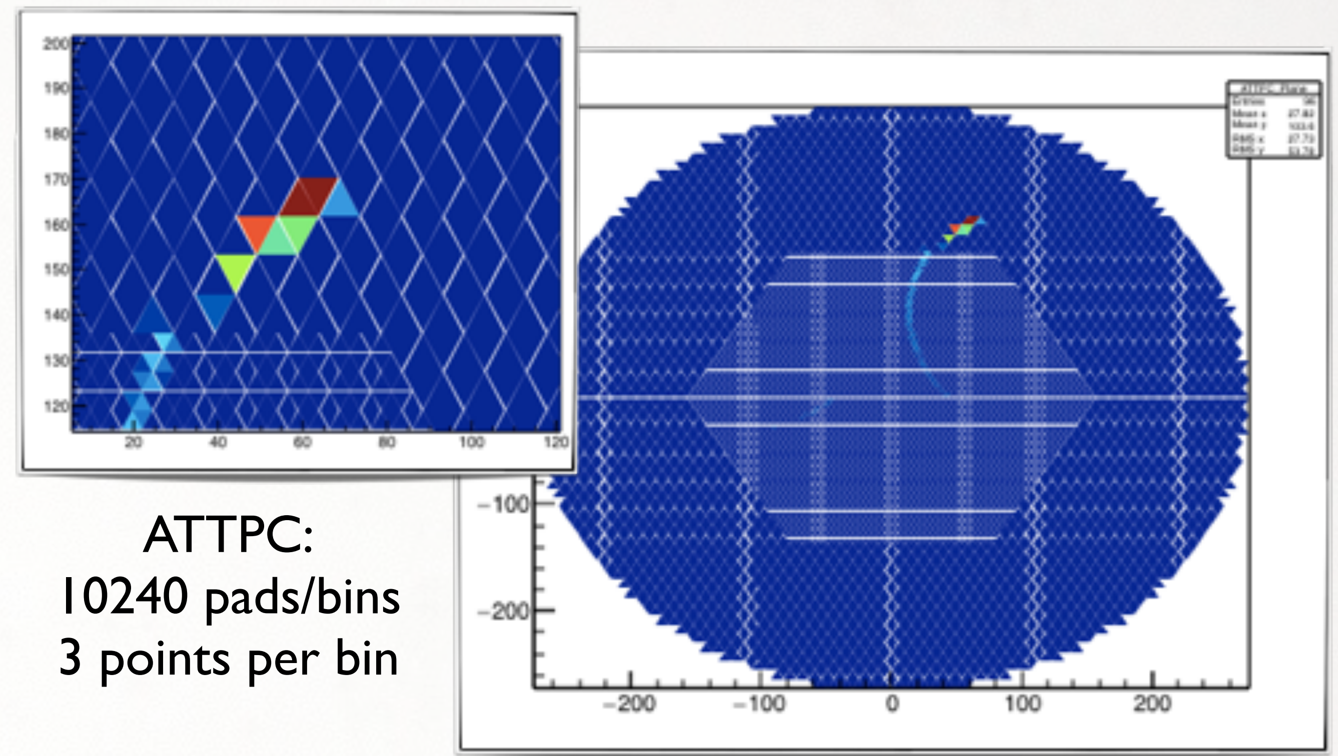




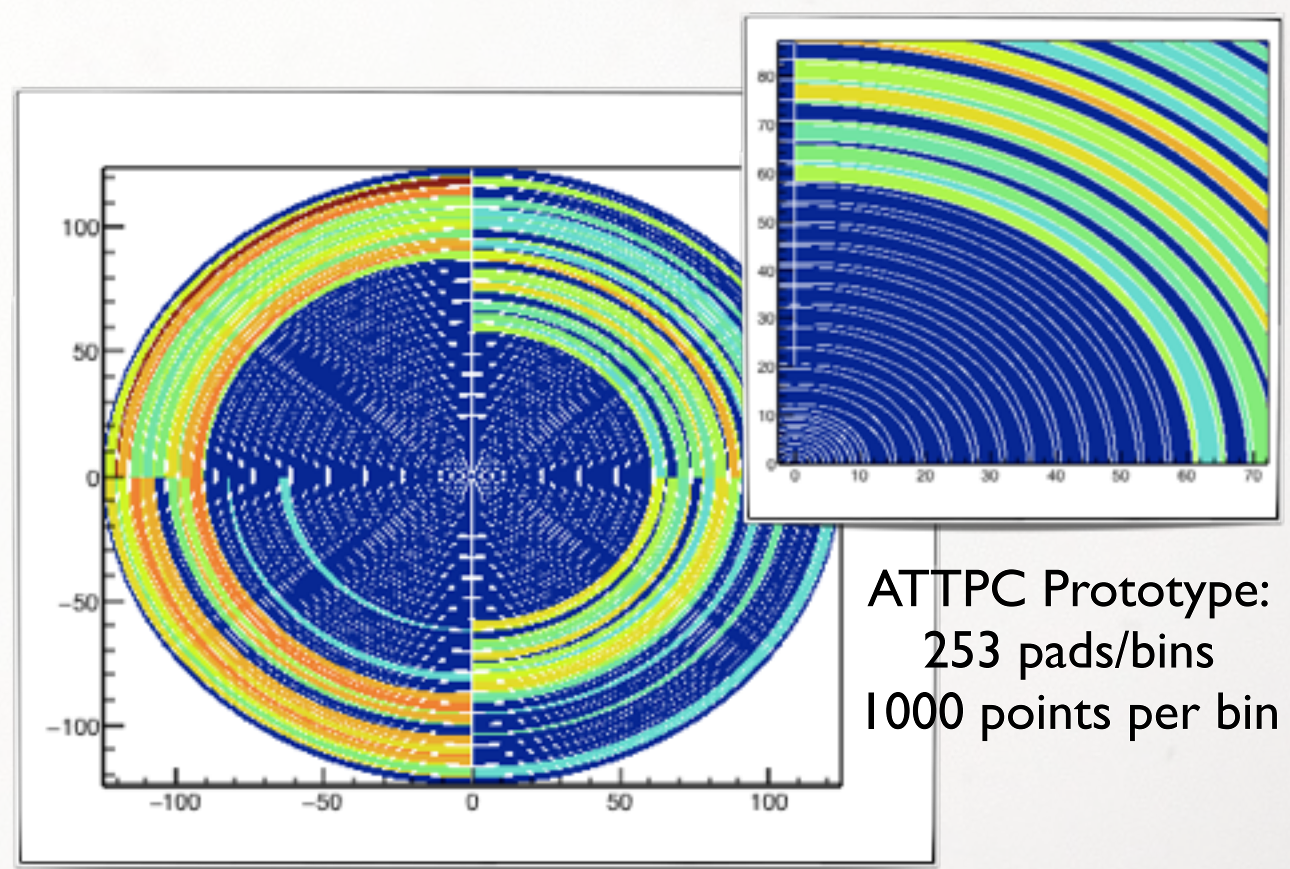


ATMap: ATTPCROOT Pad Plane Mapping

- Each micromegas pad plane is decomposed in single pad units.
- Each pad unit is a physical bin unit of a TH2Poly ROOT histogram (https://root.cern.ch/root/html/TH2Poly.html).
- The geometry account for the dead areas between pads.
- A csv file (excel) contains the whole mapping. The map is encoded-decoded with XML.
- Maps are stored in a std::map and in a ROOT histogram.
- A user can modify the map without re-compiling the program

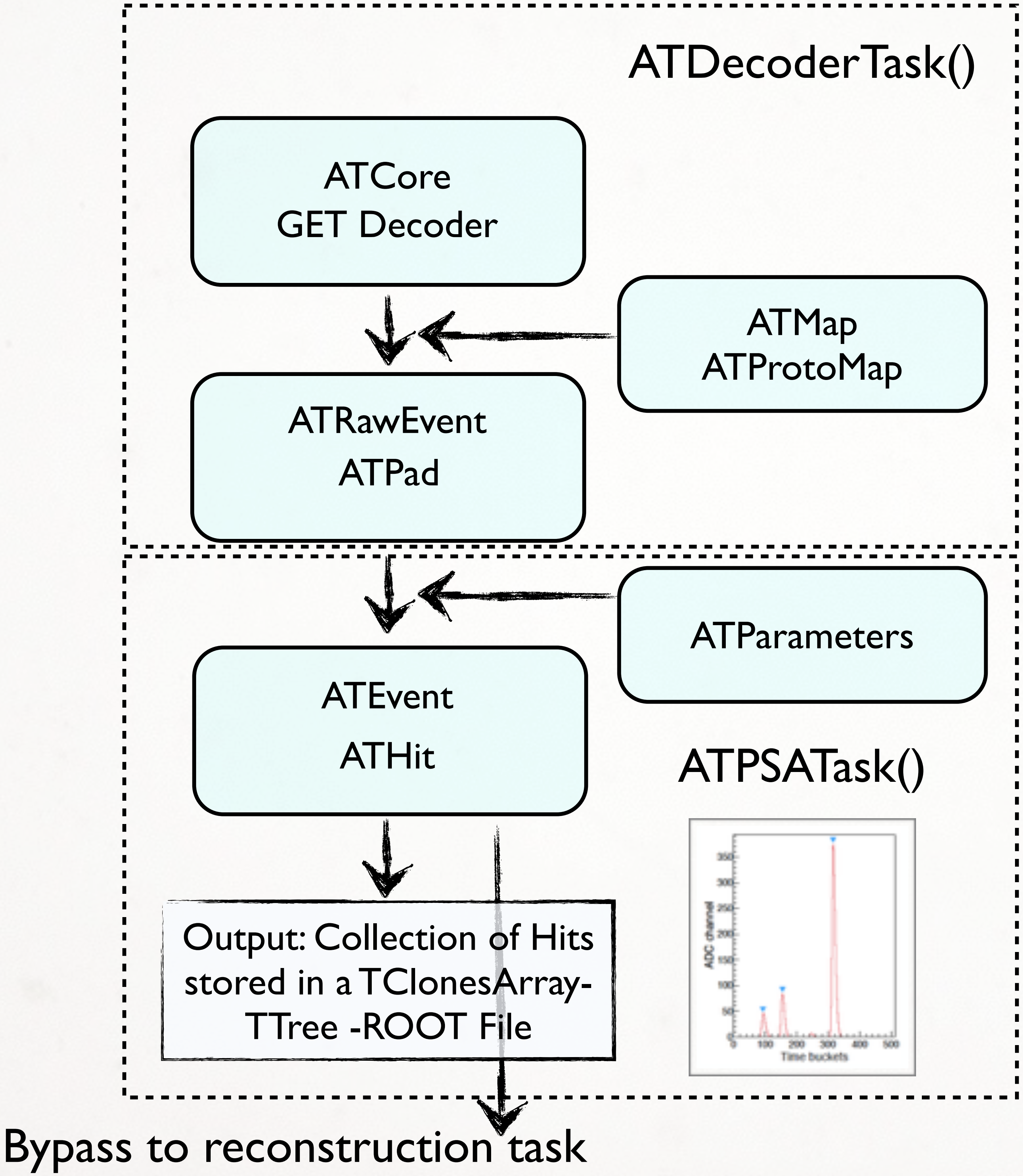


ATTPC:
10240 pads/bins
3 points per bin



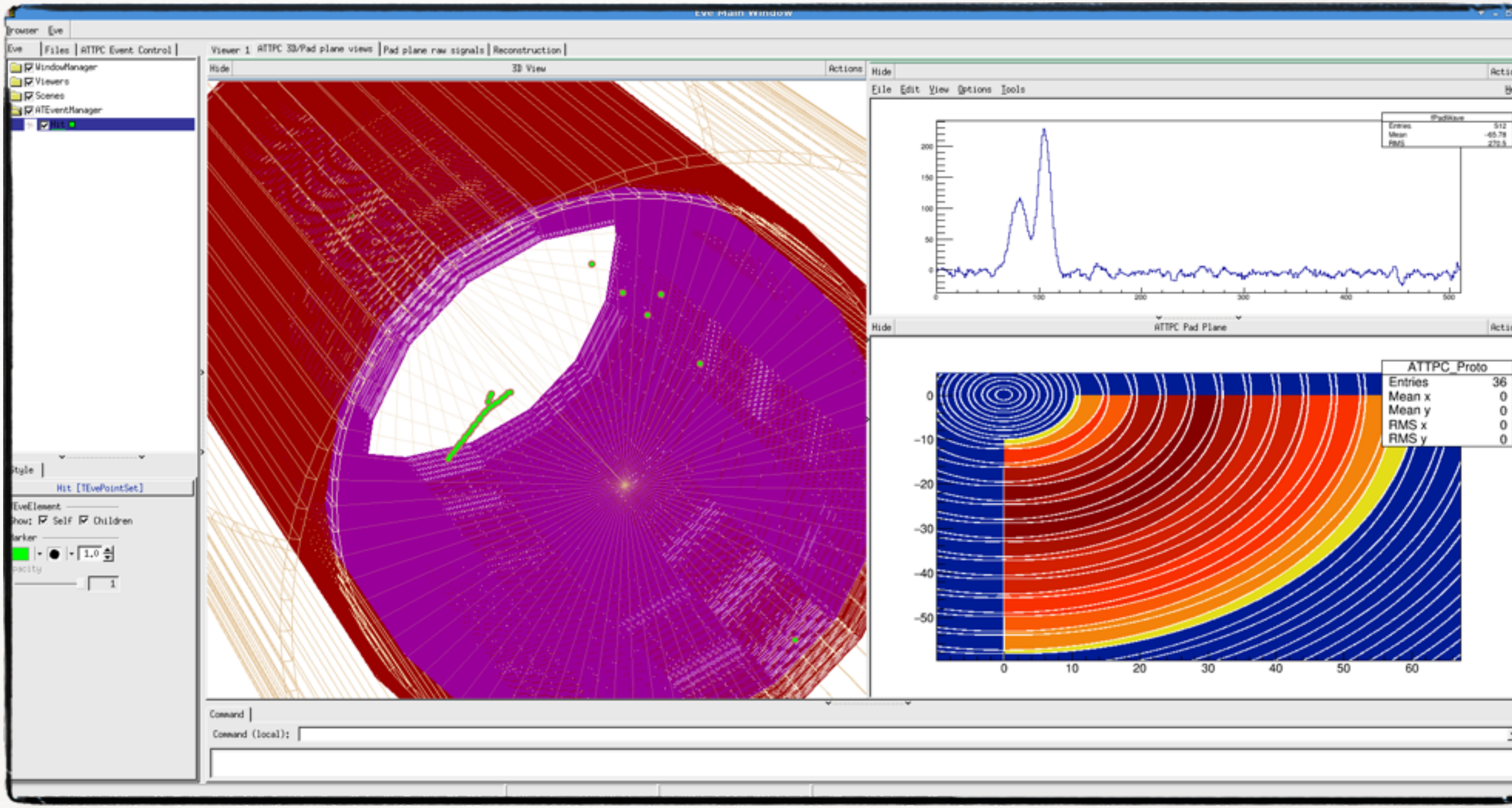
ATTPC Prototype:
253 pads/bins
1000 points per bin

Experimental Data Task 1: Decoding



- A modified version of GETDecoder (G. Jhang) is used to unpack the data (https://github.com/ATTPC/GETDecoder.git).
- Cobo, Aget, Asad and Channel stored in a std::vector stored in turn in a std::map where the Key is the Pad Number.
- A Raw Event contains the information of every pad after pedestal subtraction (Base Line and FPN).
- The Pulse Shape Analysis tasks processes each pulse to determine the number of Hits per pad depending on a threshold defined by the user.
- TSpectrum class (https://root.cern.ch/root/htmldoc/TSpectrum.html) gives the number of peaks.
- Three methods: Center of gravity, leading edge and constant fraction (in development).
- A Hit contains the position in the space and the physical pad coordinates.
- In the case of the ATTPC, Garfield is used to correct the Lorentz Angle due the detector tilting.

An example…

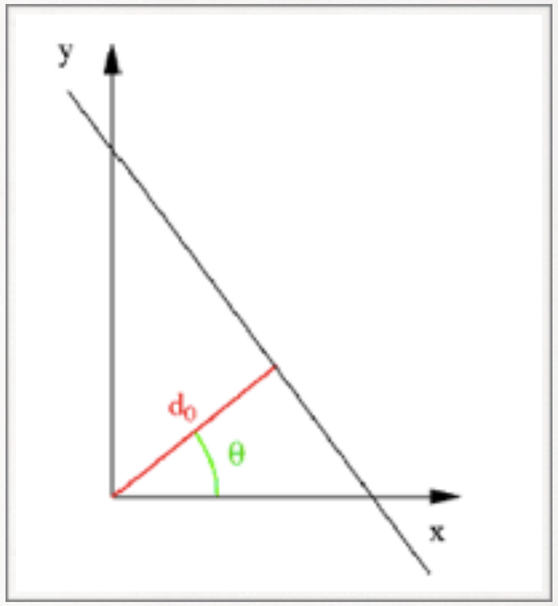


Browser Eve
Eve
Files
ATTPC Event Control
WindowManager
Viewers
Scenes
ATEventManager
Viewer 1
ATTPC 3D/Pad plane views
Pad plane raw signals
Reconstruction
Hide
3D View
Actions
File Edit View Options Tools
ATTPC Pad Plane
ATTPC_Proto
Entries 36
Mean x 0
Mean y 0
RMS x 0
RMS y 0
Style
Hit [TEvePointSet]
Self
Children
Command
Command (local):

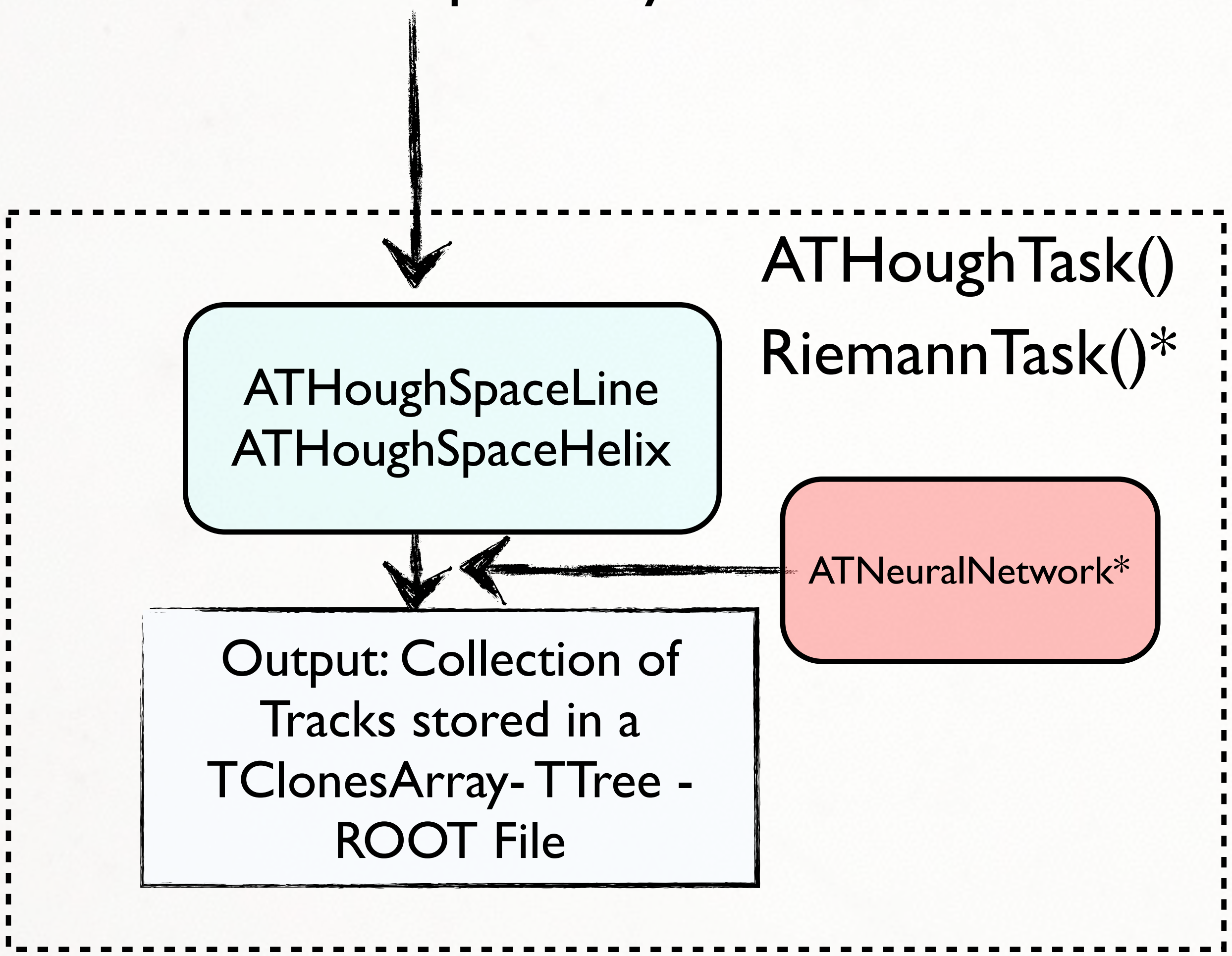
Experimental Data Task II: Reconstruction

- For each event the Linear Hough Space is calculated for every hit in two different projection planes Hit(x,y,z):

$$f(x) = \tan(\phi_0) \cdot x + \frac{d_0}{\cos(\phi_0)}.$$



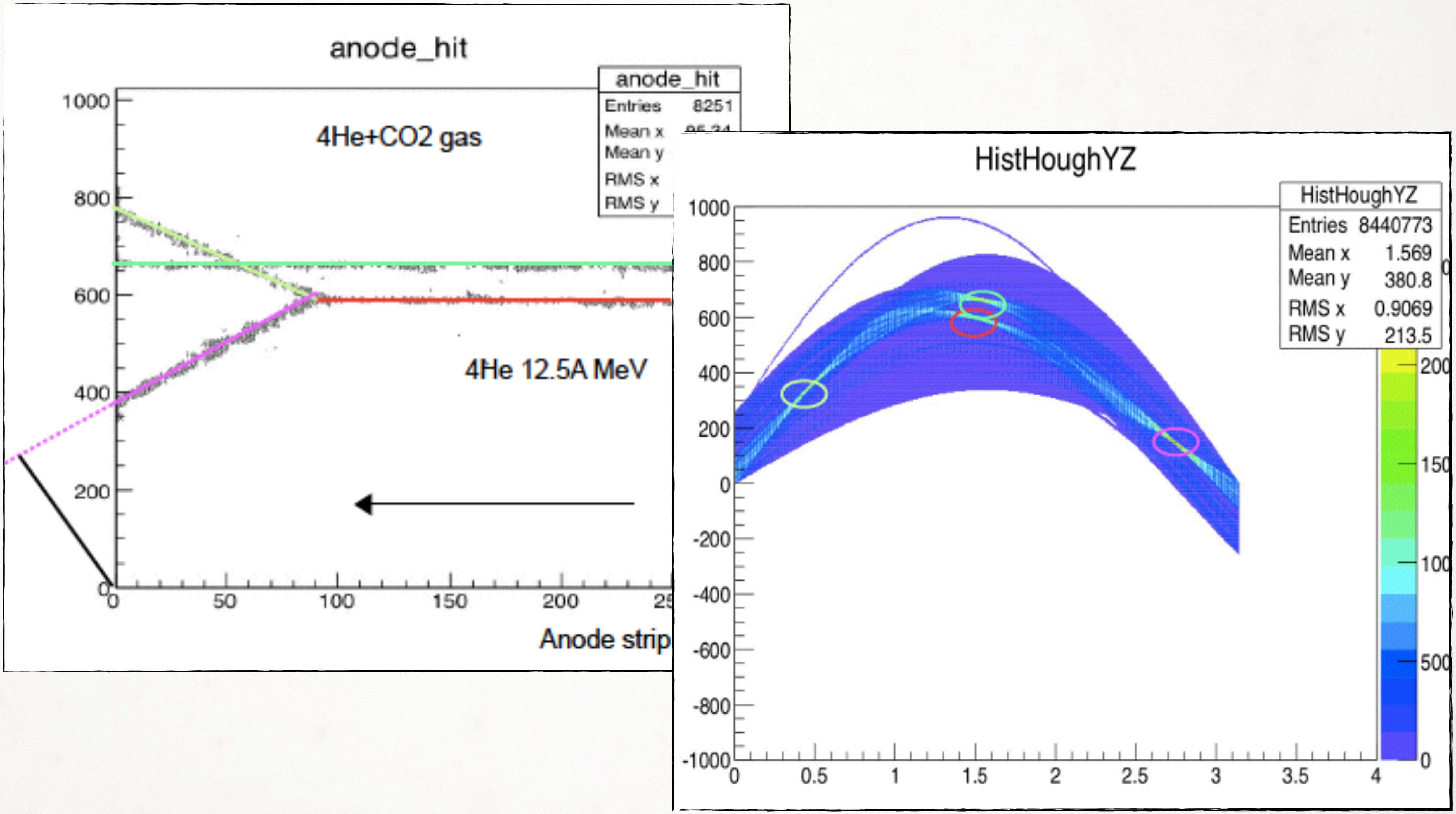
From Pulse Shape Analysis task



- For each event the Linear Hough Space is calculated for every hit in two different projection planes Hit(x,y,z).
- Points in the same straight line are in the same Hough Space point.
- Pattern recognition: maximums in the Hough Space are lines in the coordinate space. Line parameters are easily extracted

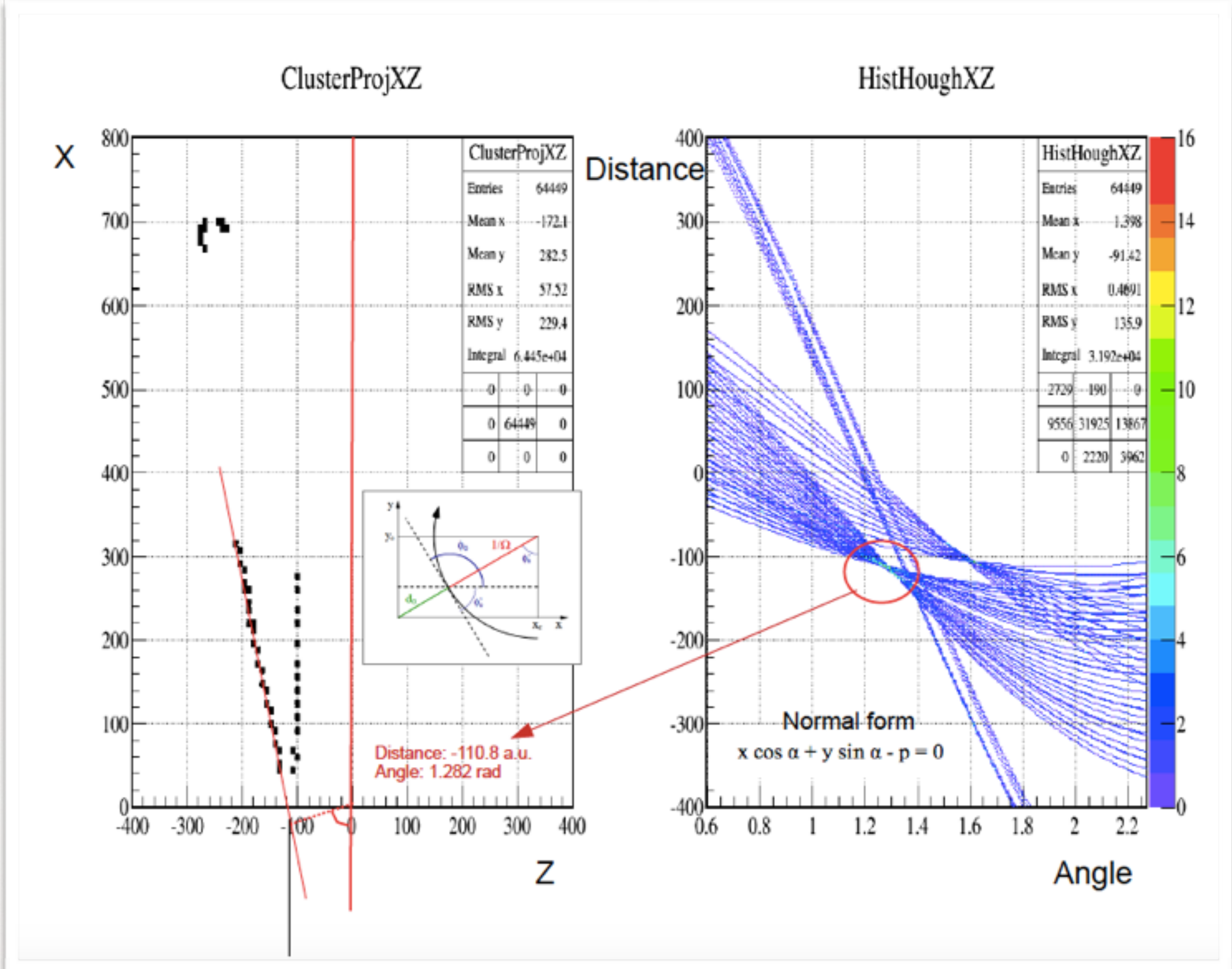
Experimental Data Task II: Some examples I

MAIKo Active Target (RCNP, Osaka)



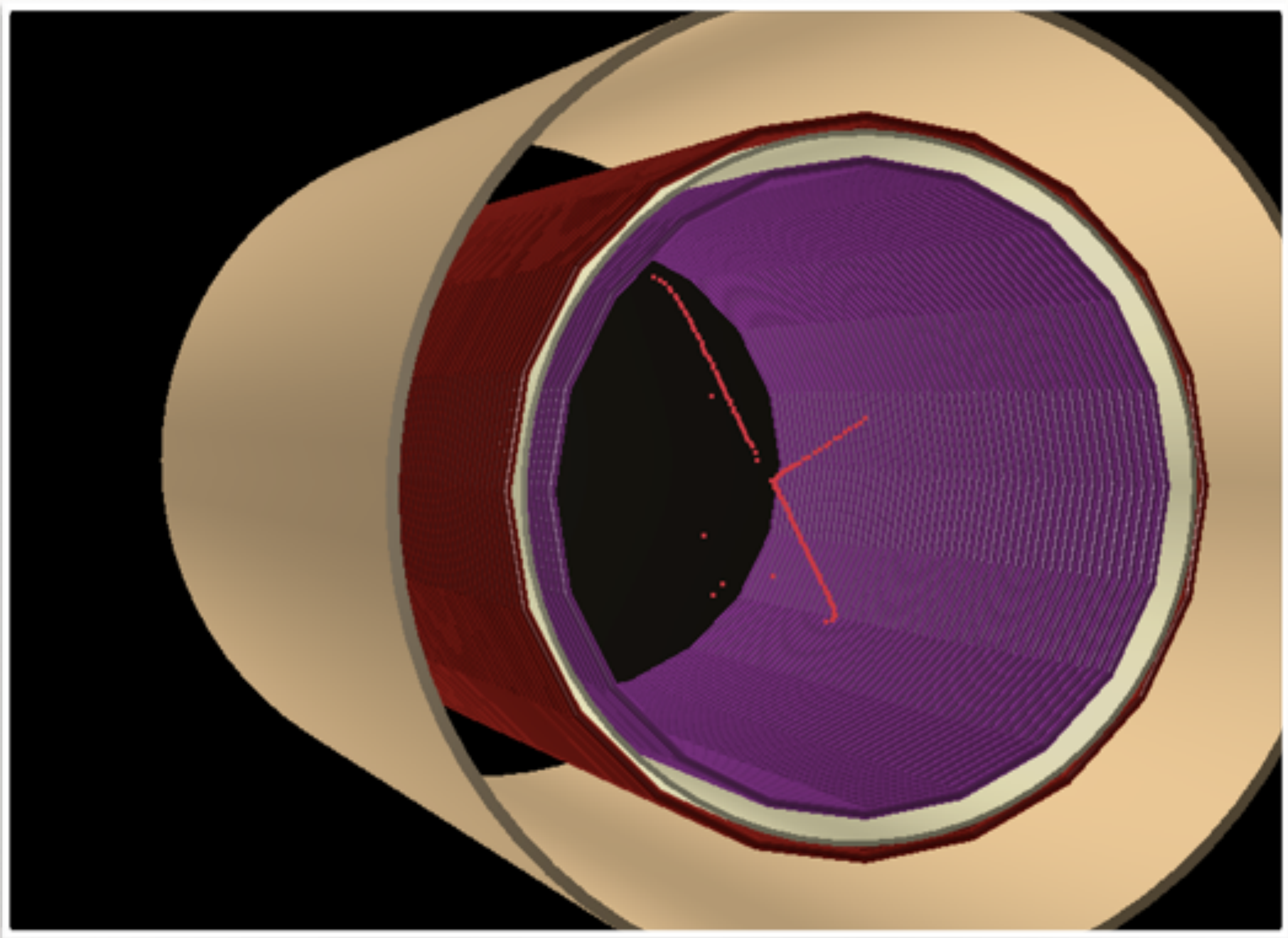
Experimental Data Task II: Some examples II

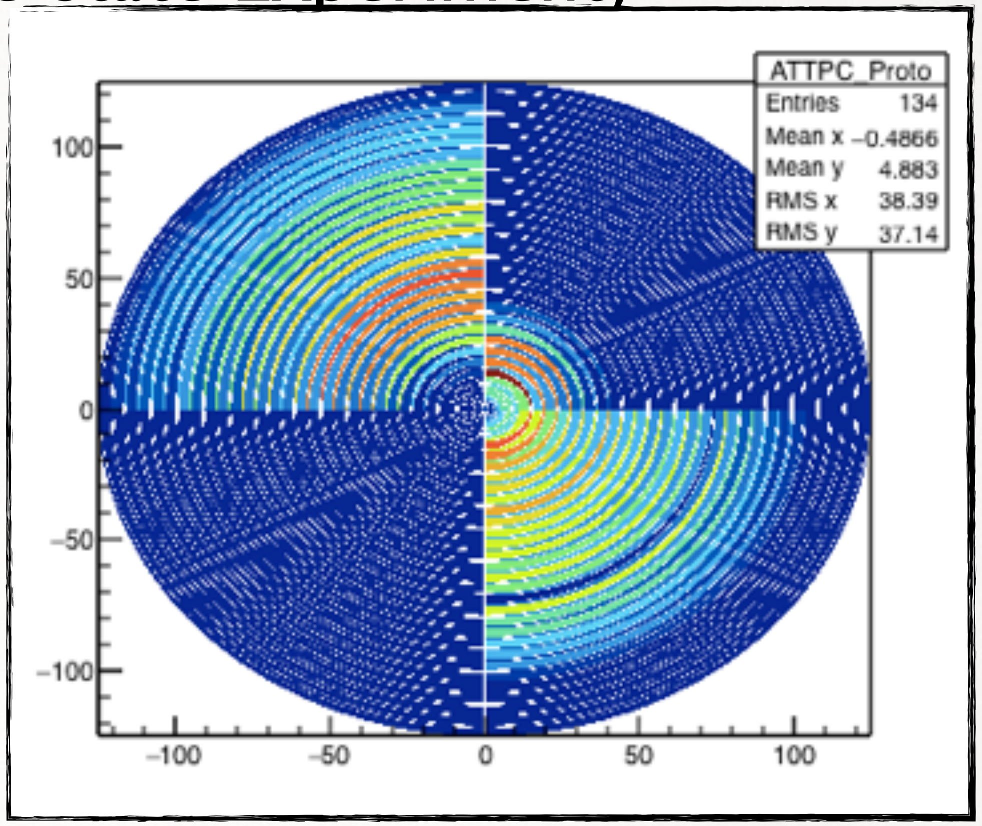
SPiRIT TPC (Beta Source)

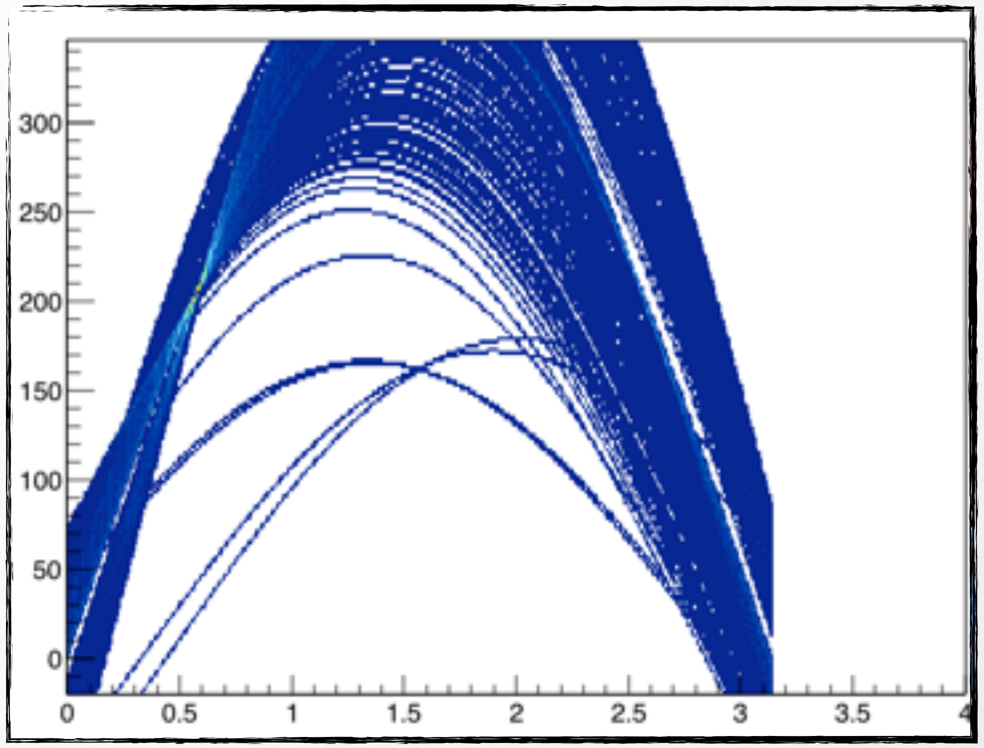


Experimental Data Task II: Some examples III

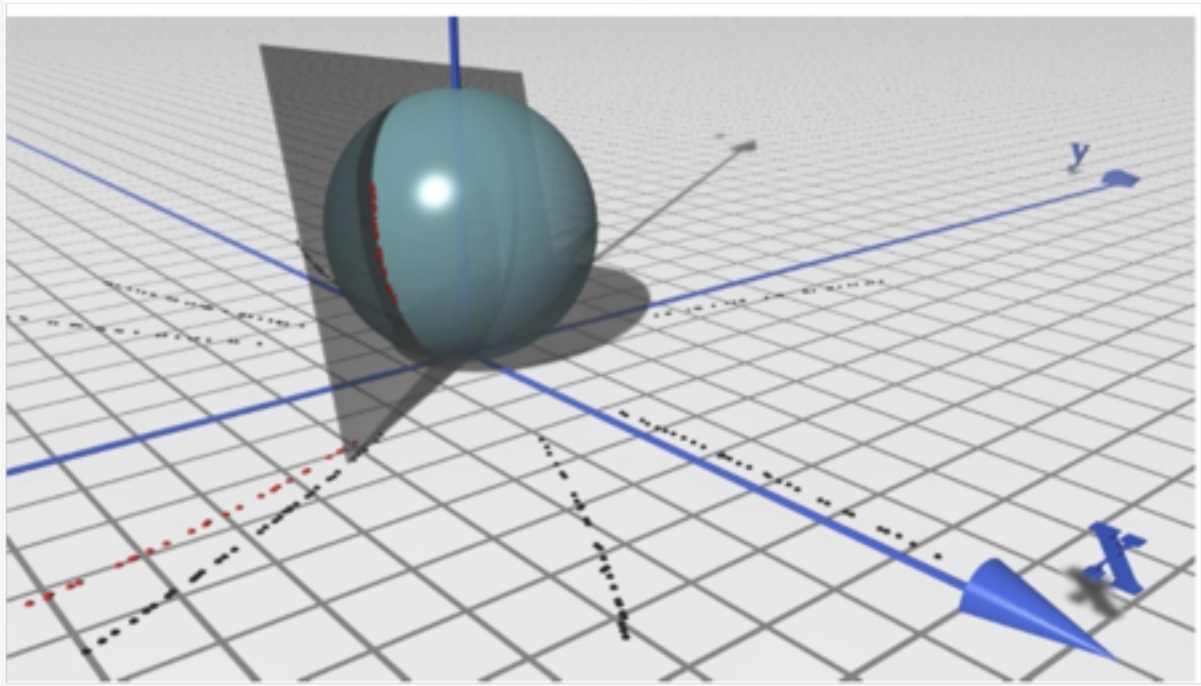
ATTPC Prototype (Data from Hoyle State Experiment)







Experimental Data Task II: Riemann Reconstruction

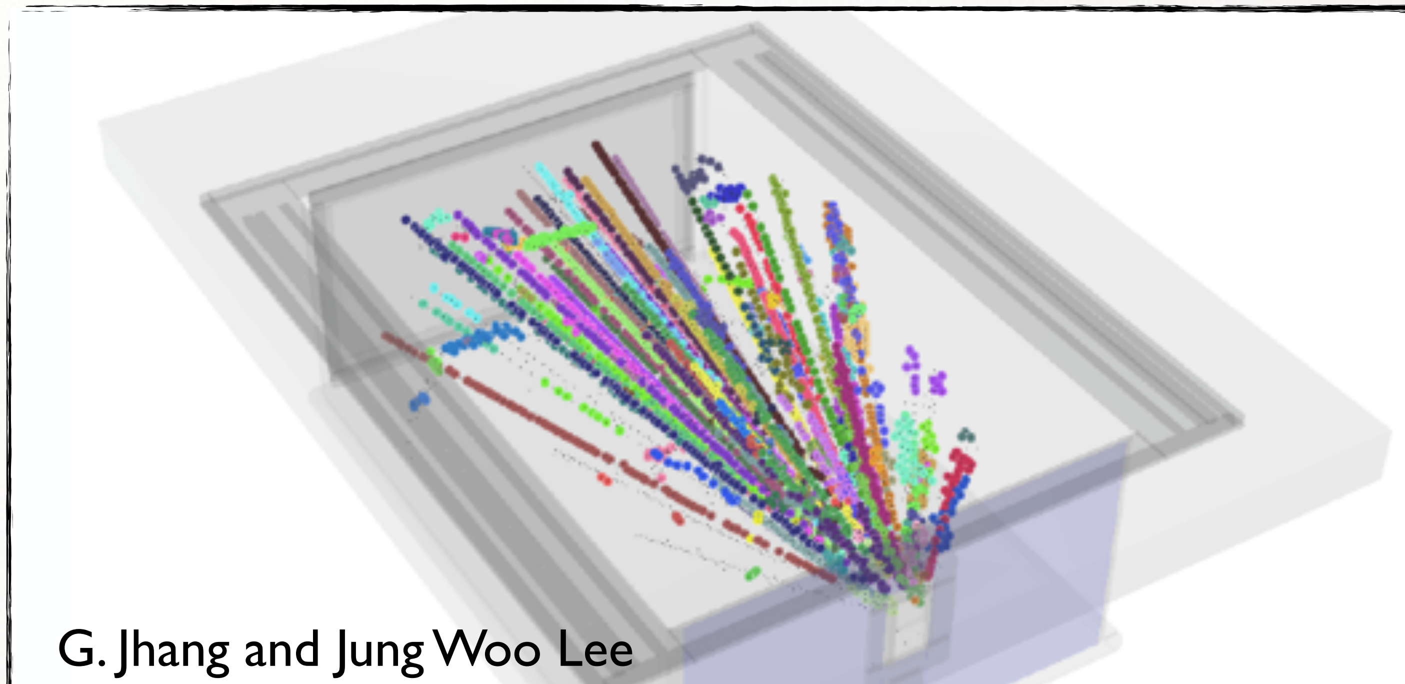


- Riemann transformation: Project points into a Riemann Sphere:

$$x_s = R \cdot \cos\phi \,/\, (1 + R^2),$$
$$y_s = R \cdot \sin\phi \,/\, (1 + R^2),$$
$$z_s = R^2 \,/\, (1 + R^2).$$

- Circles and lines map to a circles/planes in the sphere. The planes gives the parameters of the trajectory

SPiRIT TPC Simulated Events



G. Jhang and Jung Woo Lee

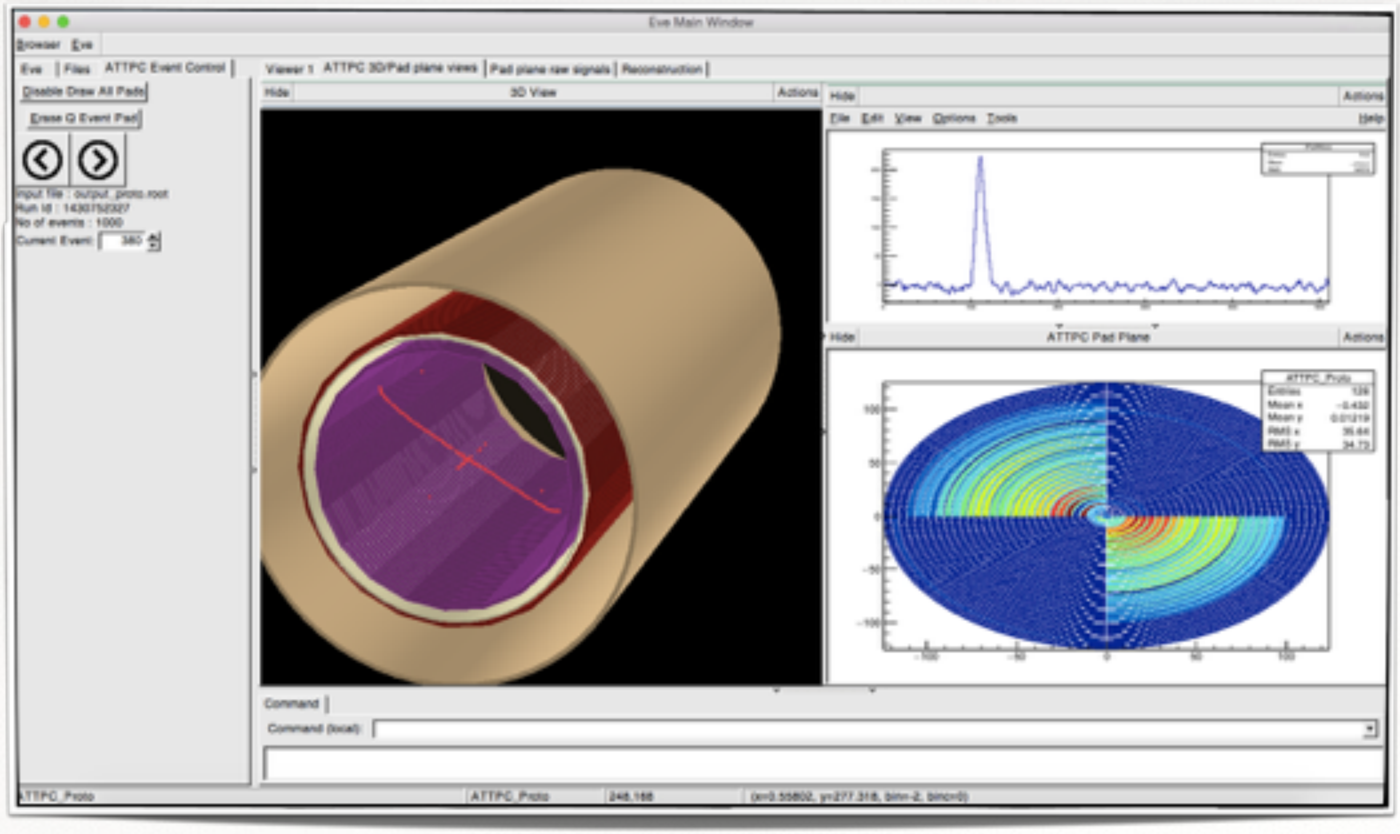
Simulation Task 1: Virtual Monte Carlo

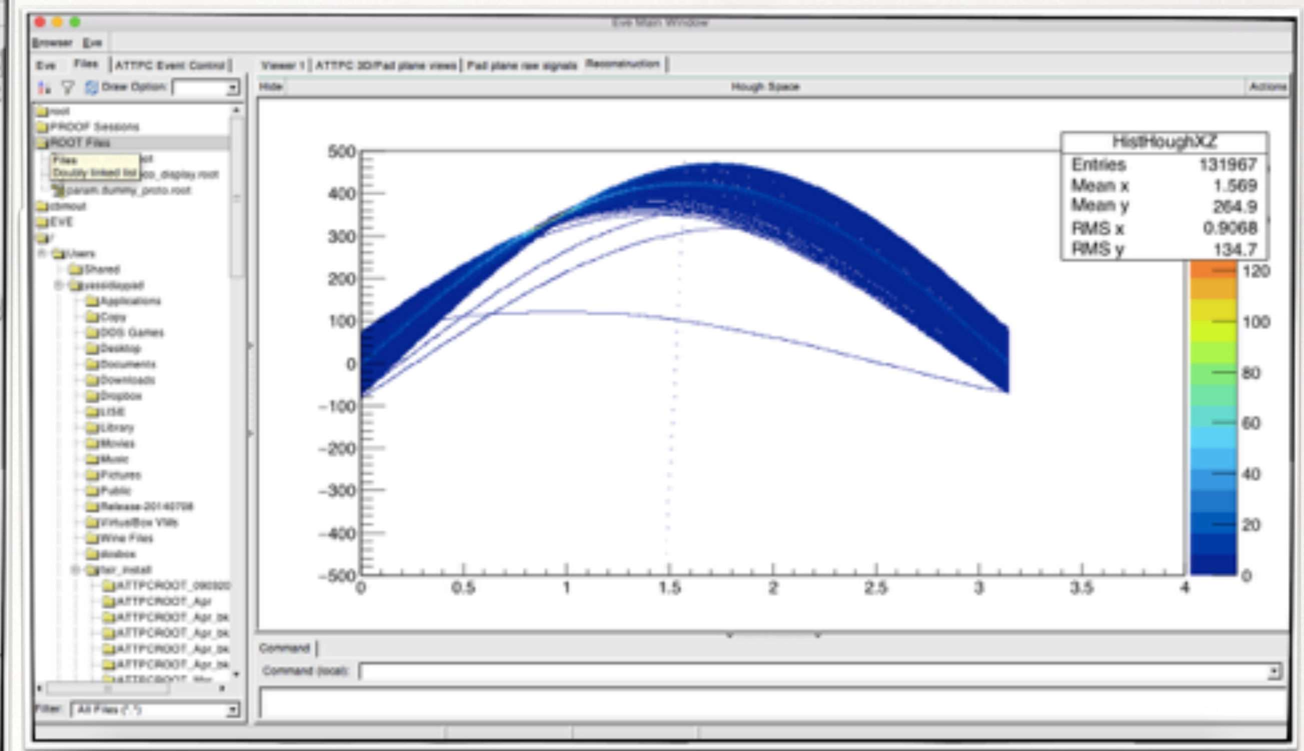
- The VMC offers an interface between ROOT and Geant4/3 engines.
- Parameters are tuned via the simulation macro.
- The energy loss is computed with Geant4/3 libraries.
- A task can be created for the digitization of the signal and the response of the pads (Under developent).

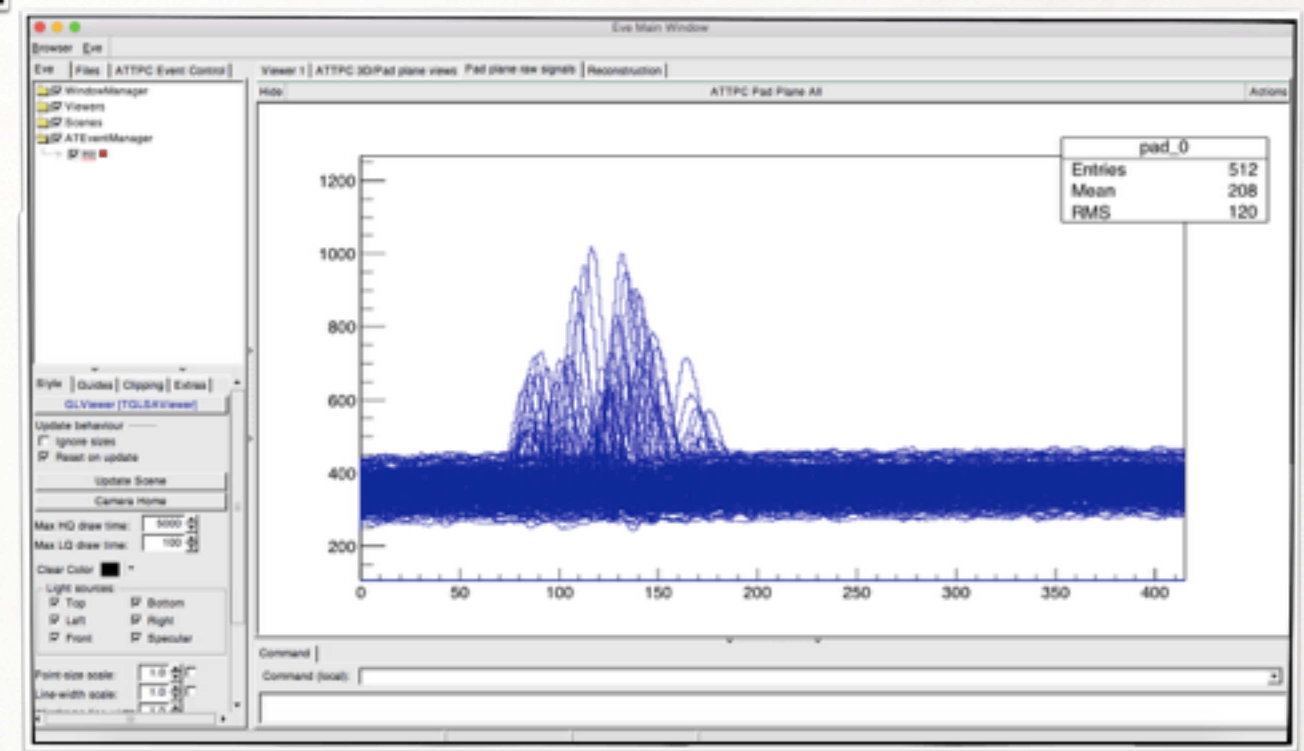
ATTPCROOT event generators:

- N-body kinematics with N-body decay
- Fission fragment emission (Wilkins model). Distribution generated with ABLA, GEMINI++...
- PYTHIA6 and PYTHIA8: High energy

ATTPCROOT as Data Visualizer





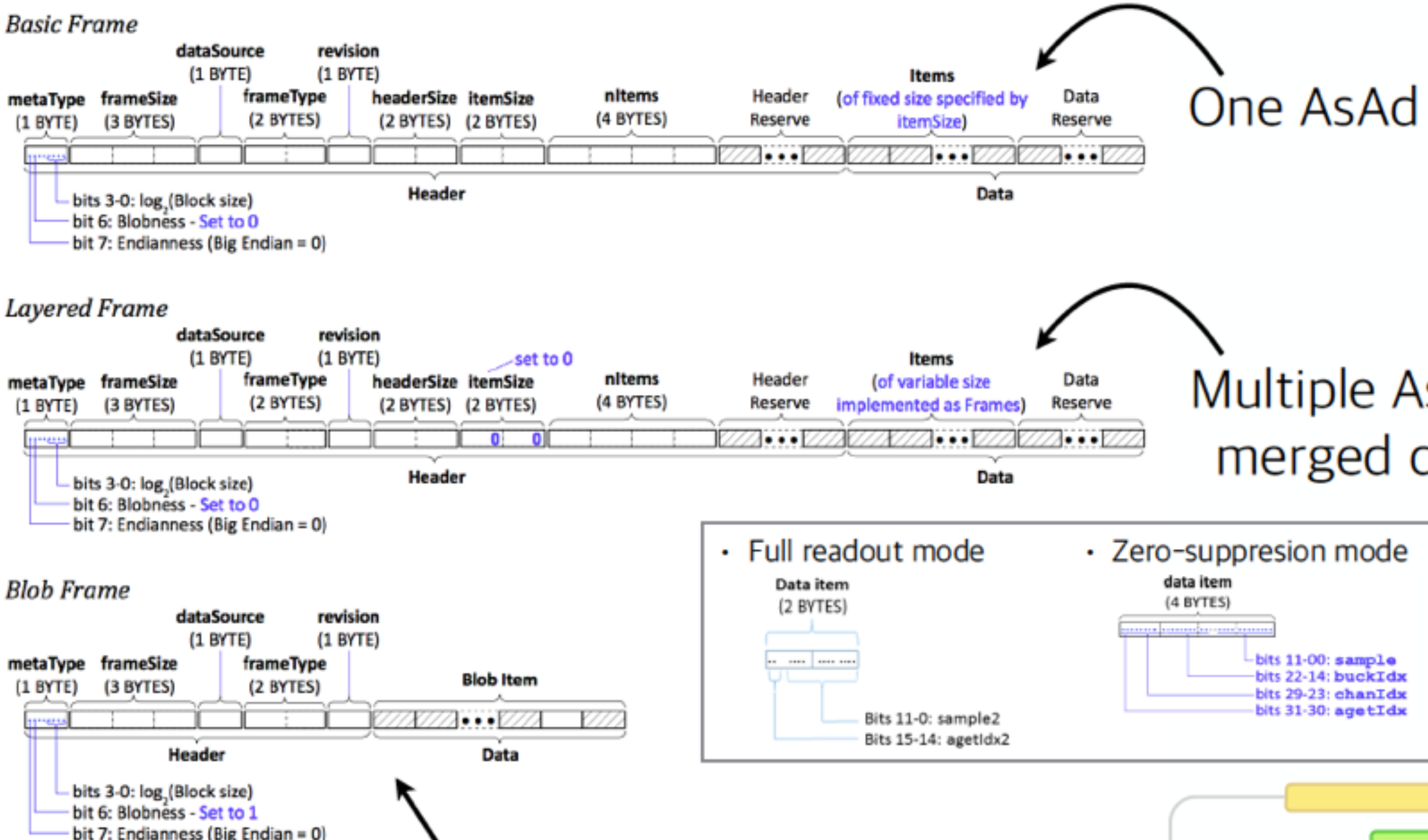


- TEveManager (https://root.cern.ch/root/htmldoc/TEveManager.html)
- Compact visualization with embedded canvas.
- Fast navigation through events.
- Interactive and dynamic histograms.

Outlook

- Simulation with digitization: Avalanche with calibrated pad response.
- Riemann tracking coupled to Kalman filter.
- Neural networks for specific cases

Experimental Data (GRAW file, binary)



One AsAd data

Multiple AsAds merged data

Only for additional information

Courtesy of G. Jhang