GlueX Example Analysis:
$\gamma p \rightarrow \omega p$ (Run 3185)

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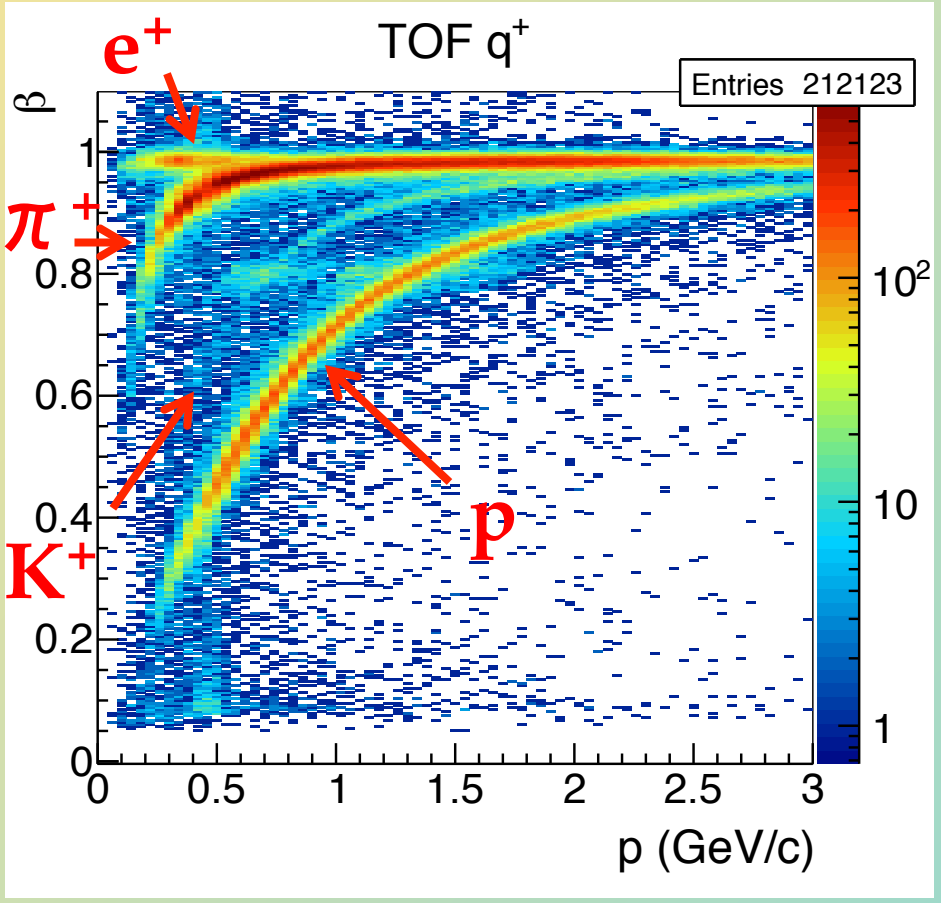
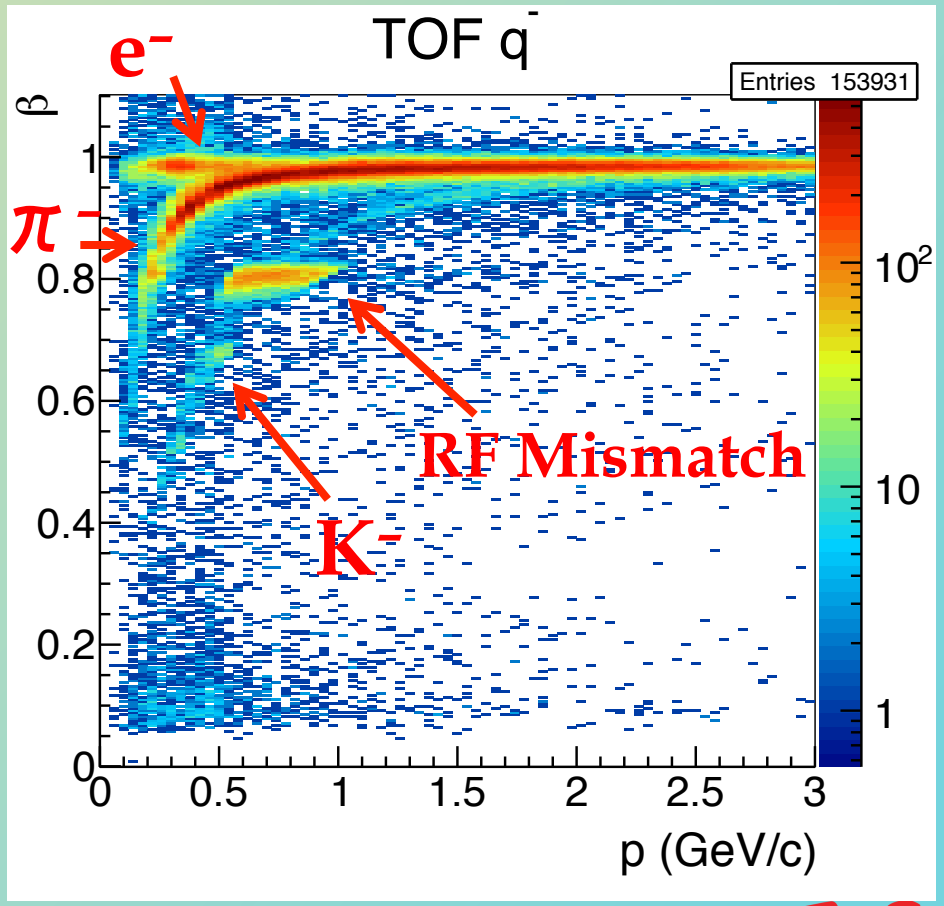
*Changes since 2013 Analysis Workshop highlighted in **BLUE**

Aside: Particle ID (All data)

* Can identify π/K/p with TOF
  * "Good" tracks, hypothesis w/ best tracking FOM, ≥ 2 tracks chose RF
  * **monitoring_hists**, monitoring webpage: RECO: "TOF1"





~No RF mismatch with "Combo" DEventRFBunch

Generate Plugin

- Create your plugin by running the perl script:
  - https://halldsvn.jlab.org/repos/trunk/scripts/analysis/MakeReactionPlugin.pl
  - Run with no arguments for instructions
  - Already has lots of example code, just uncomment & tweak
- Code/plots I'm covering today from the **p3pi_hists** plugin:
  - https://halldsvn.jlab.org/repos/trunk/sim-recon/src/programs/Analysis/plugins/p3pi_hists/
  - Specifically, the "p3pi_preco_any" & "p3pi_pmiss_any" **DReaction**'s

$\gamma p \rightarrow \omega p$: Create Steps

* In DReaction_factory init() method:
  * $\gamma p \rightarrow \omega p$, $\omega \rightarrow \pi^+ \pi^- \pi^0$, $\pi^0 \rightarrow \gamma \gamma$

```
// g, p -> omega, p
locReactionStep = new DReactionStep();
locReactionStep->Set_InitialParticleID(Gamma);
locReactionStep->Set_TargetParticleID(Proton);
locReactionStep->Add_FinalParticleID(omega);
locReactionStep->Add_FinalParticleID(Proton);
locReaction->Add_ReactionStep(locReactionStep);

// omega -> pi+, pi-, pi0
locReactionStep = new DReactionStep();
locReactionStep->Set_InitialParticleID(omega);
locReactionStep->Add_FinalParticleID(PiPlus);
locReactionStep->Add_FinalParticleID(PiMinus);
locReactionStep->Add_FinalParticleID(Pi0);
locReaction->Add_ReactionStep(locReactionStep);

// pi0 -> g, g
locReactionStep = new DReactionStep();
locReactionStep->Set_InitialParticleID(Pi0);
locReactionStep->Add_FinalParticleID(Gamma);
locReactionStep->Add_FinalParticleID(Gamma);
locReaction->Add_ReactionStep(locReactionStep);
```

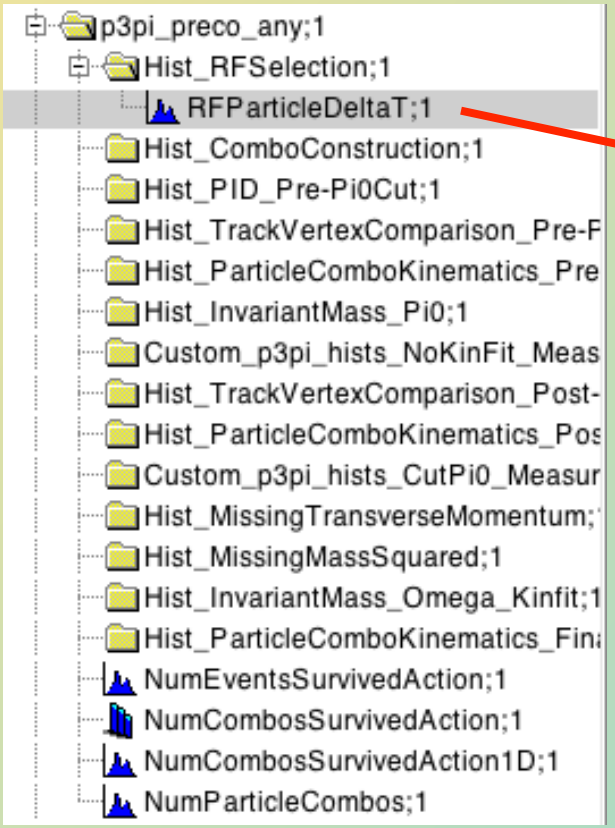
NEW: Pre-Combo Cuts

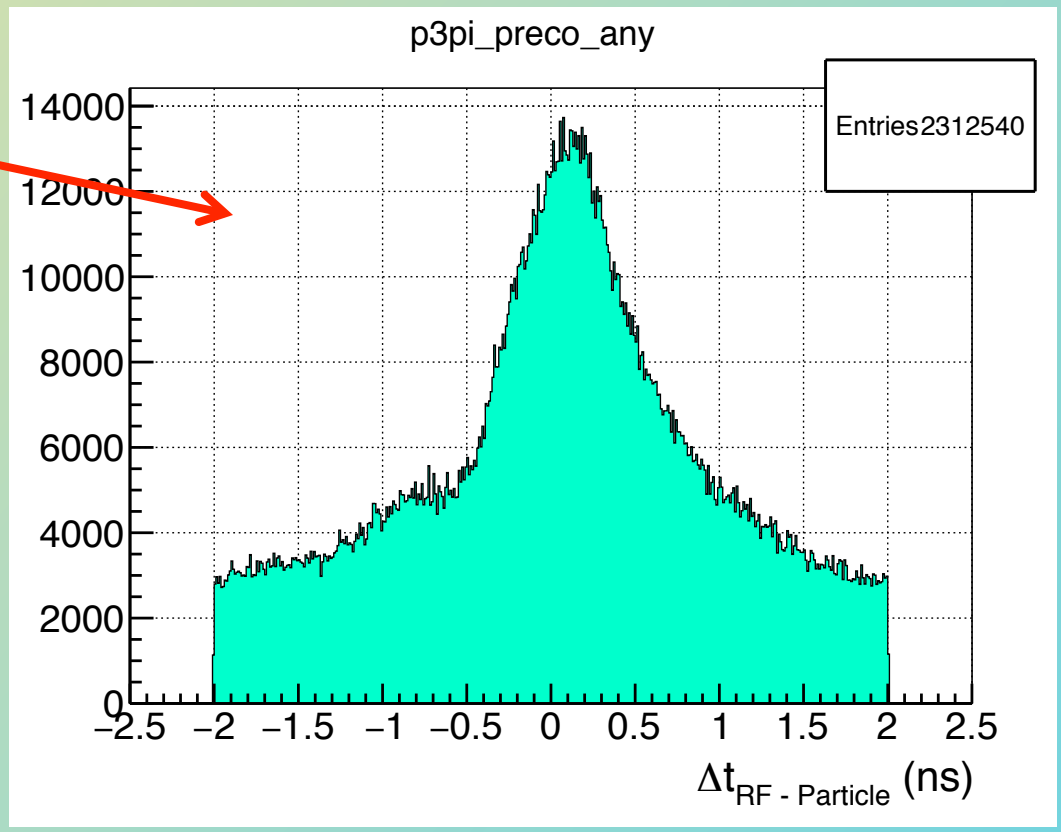
* Place no-doubt, super-loose cuts prior to combo creation
  * Saves time, memory
  * Super-loose: Save side-band regions for study/context later
* Invariant mass cuts (π^0, ω): Special **DReaction** call (soonest)
  * **DReaction**::Set_InvariantMassCut()
* Other (e.g. missing mass) cuts: Add any action via:
  * **DReaction**::Add_ComboPreSelectionAction()

```
// Loose Pi0 Cut, Applied during Blueprint Construction
locReaction->Set_InvariantMassCut(Pi0, 0.0, 0.3);

// Loose omega Cut, Applied during Blueprint Construction
locReaction->Set_InvariantMassCut(omega, 0.5, 1.1);

// Loose missing mass squared cut
   //Applied just after creating the combination (before saving it)
DCutAction_MissingMassSquared* locCutAction = NULL;
locCutAction = new DCutAction_MissingMassSquared(locReaction, false, -0.06, 0.06);
locReaction->Add_ComboPreSelectionAction(locCutAction);
```

NEW: "Combo" DEventRFBunch

* **DEventRFBunch** is (auto)-selected separately for each combo
  * Voted on by all particles in combo (except massive neutrals)
  * Uses TOF/BCAL/FCAL times (PID is forced since combo-specific)

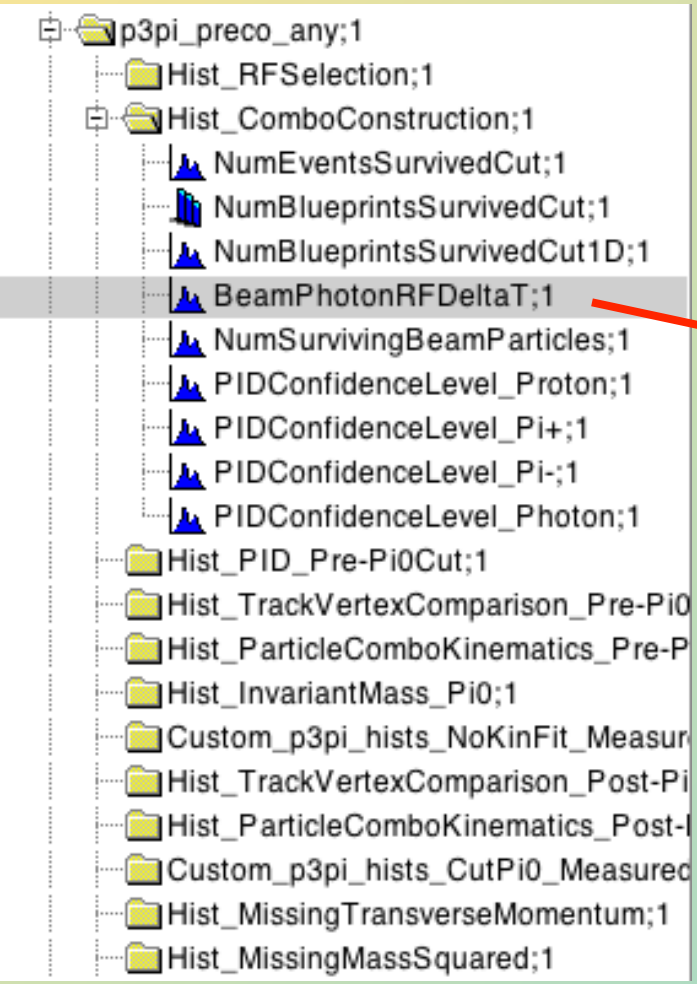


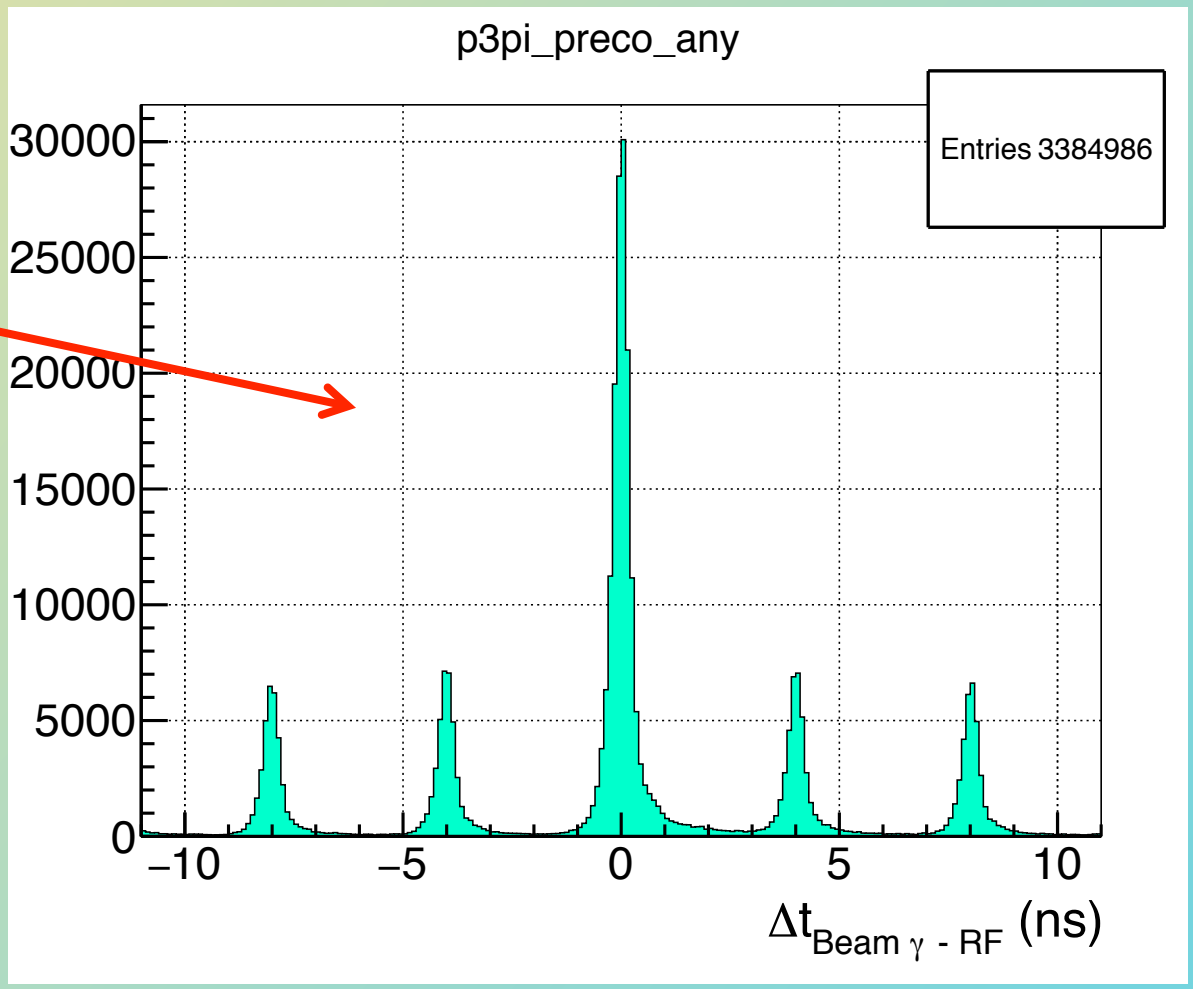


Histogram is automatically in ROOT file

NEW: Select Beam Photons

* Histogrammed automatically, cut via **DReaction**



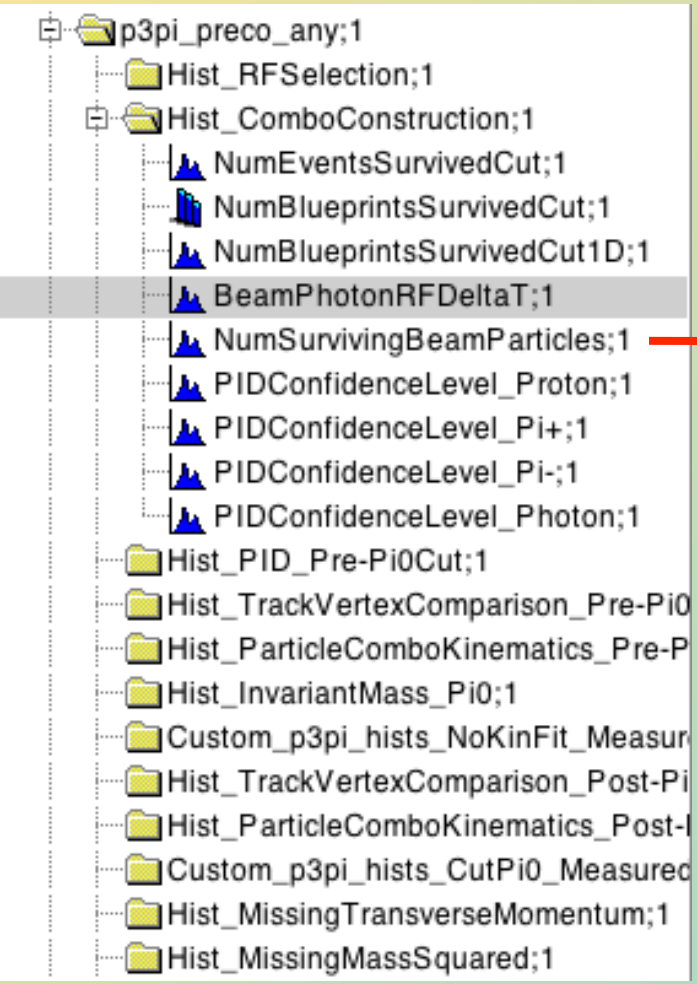


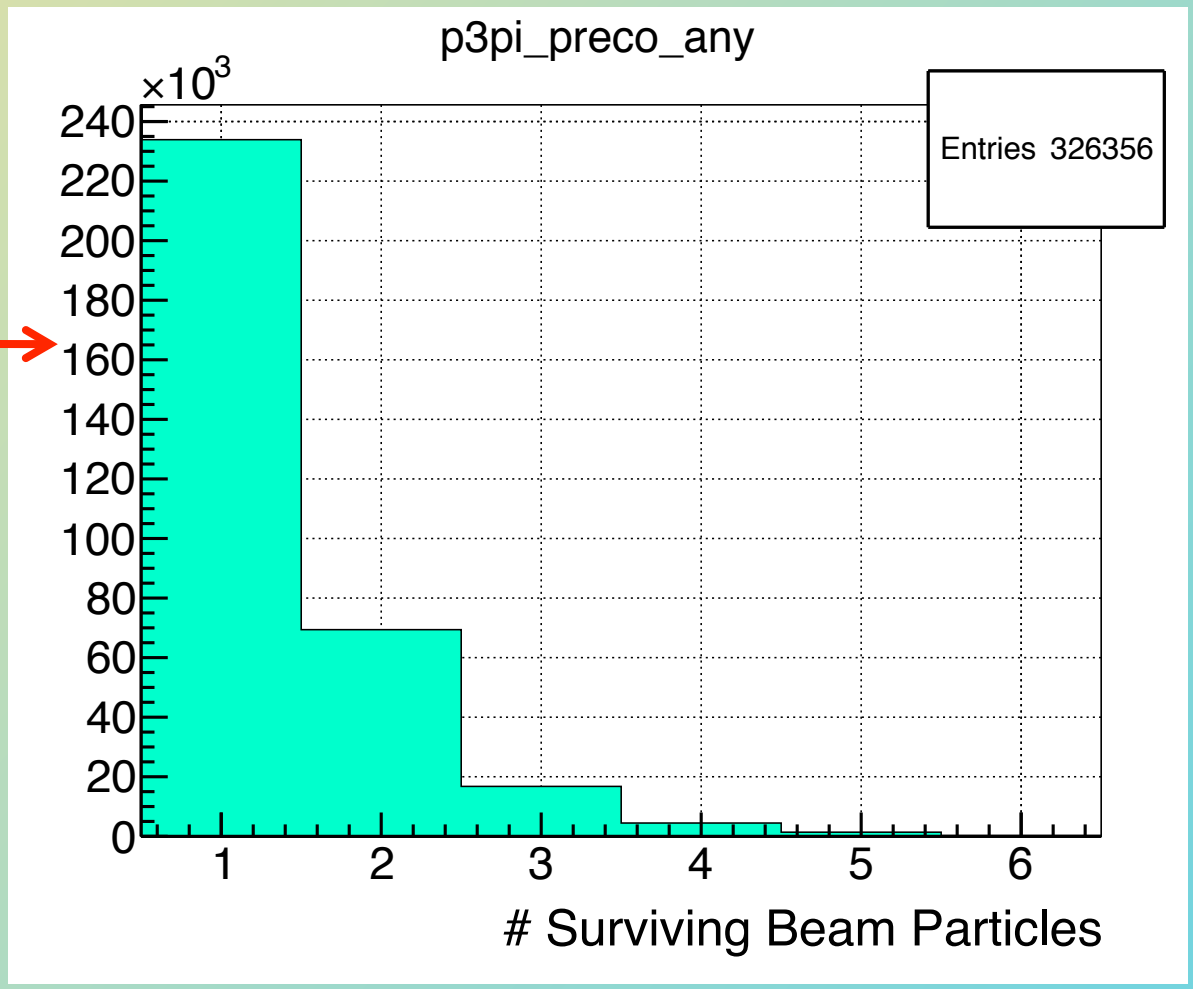
CUT:

```
//beam bunches are every 4.008 ns
locReaction->Set_MaxPhotonRFDeltaT(0.5*4.008);
```

NEW: #-Beam Photons

* Histogrammed automatically, **ONLY CUT IF NECESSARY**



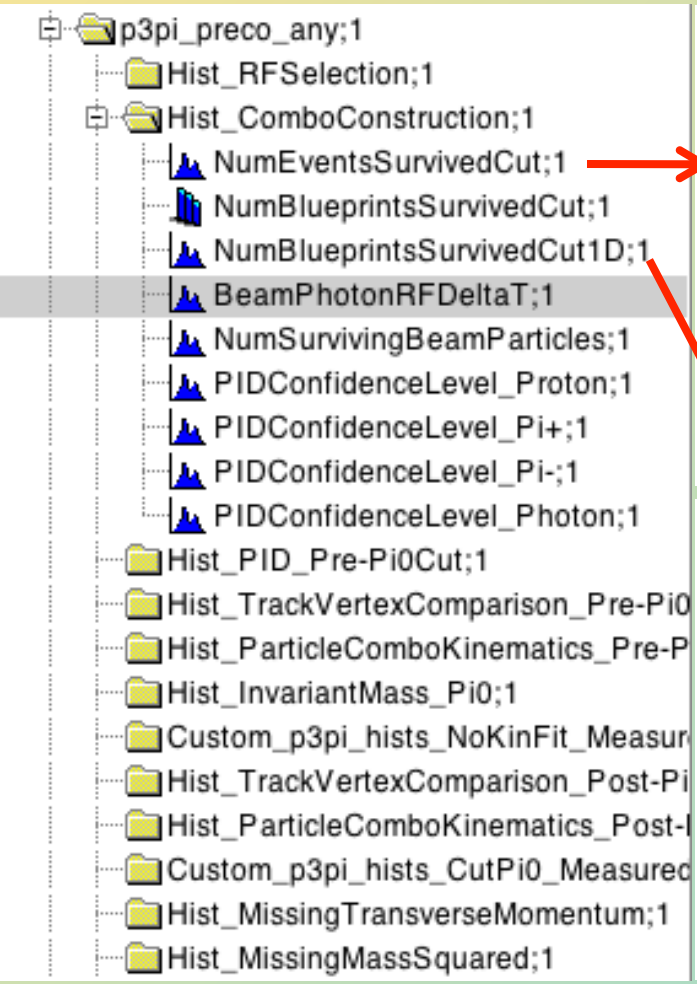


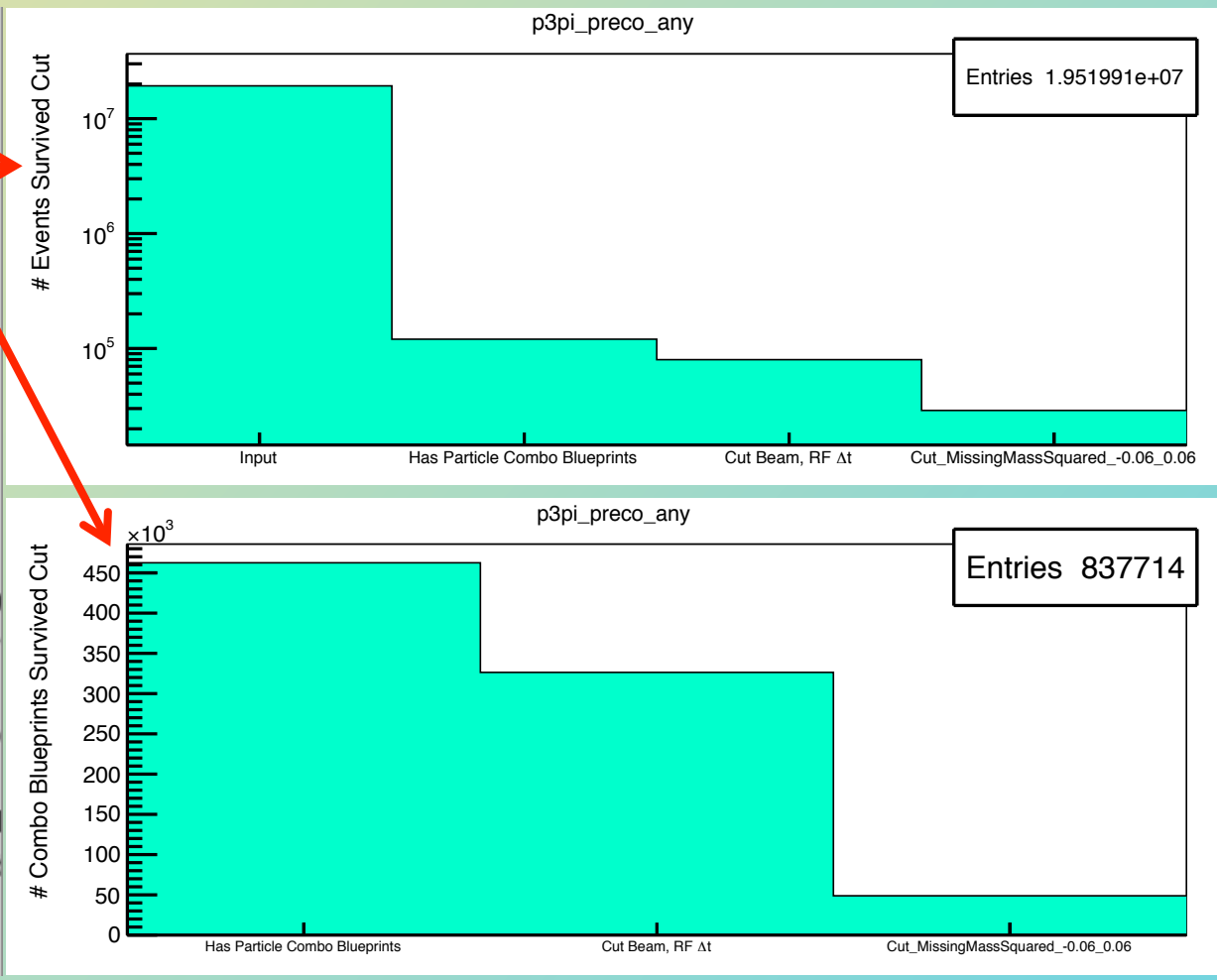
Cut (is post RF-Δt):

```
//USE WITH CAUTION: throws away ~25% signal
locReaction->Set_MaxNumBeamPhotonsInBunch(1);
```

NEW: Pre-Combo Cut Status

* **DParticleComboBlueprint**: Has final-particles (no beam yet)

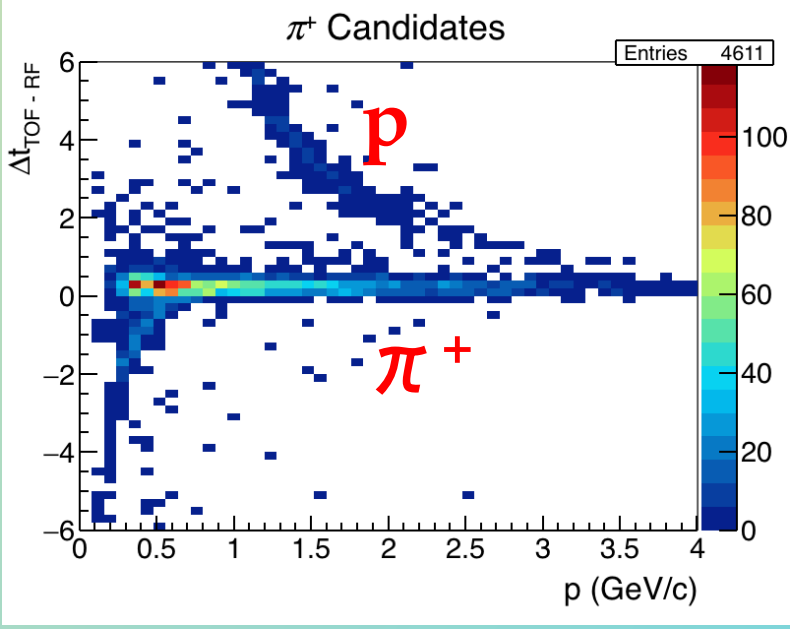




Histograms are automatically in ROOT file

Particle ID

* p/K/π at small-θ : TOF Δt
  * **NEW:** DCutAction_PIDDeltaT
* p/π^+ at large-θ : CDC dE/dx
  * **NEW:** DCutAction_ProtonPiPlusdEdx
* e/π at small-θ : FCAL E/p
  * $e^{\pm}$ background negligible here
* No γ PID: Timing not calibrated yet

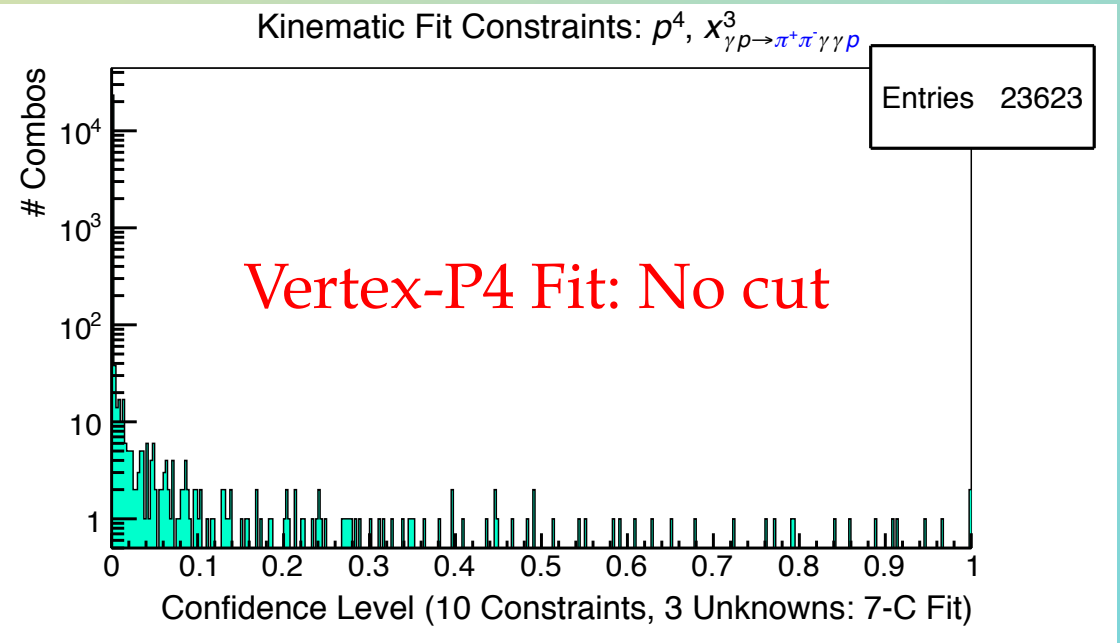


Plot with **DHistogramAction_PID**

```
// Hist PID
locReaction->Add_AnalysisAction(new DHistogramAction_PID(locReaction));

// Cut Delta-t //false: measured data //Unknown: All PIDs
locReaction->Add_AnalysisAction(new DCutAction_PIDDeltaT(locReaction, false, 1.0, Unknown, SYS_TOF));

// Cut dE/dx //select p/pi+ above/below 2.2, //true/false: cut all/no proton candidates above p = 1 GeV/c
locReaction->Add_AnalysisAction(new DCutAction_ProtonPiPlusdEdx(locReaction, 2.2, false));
```

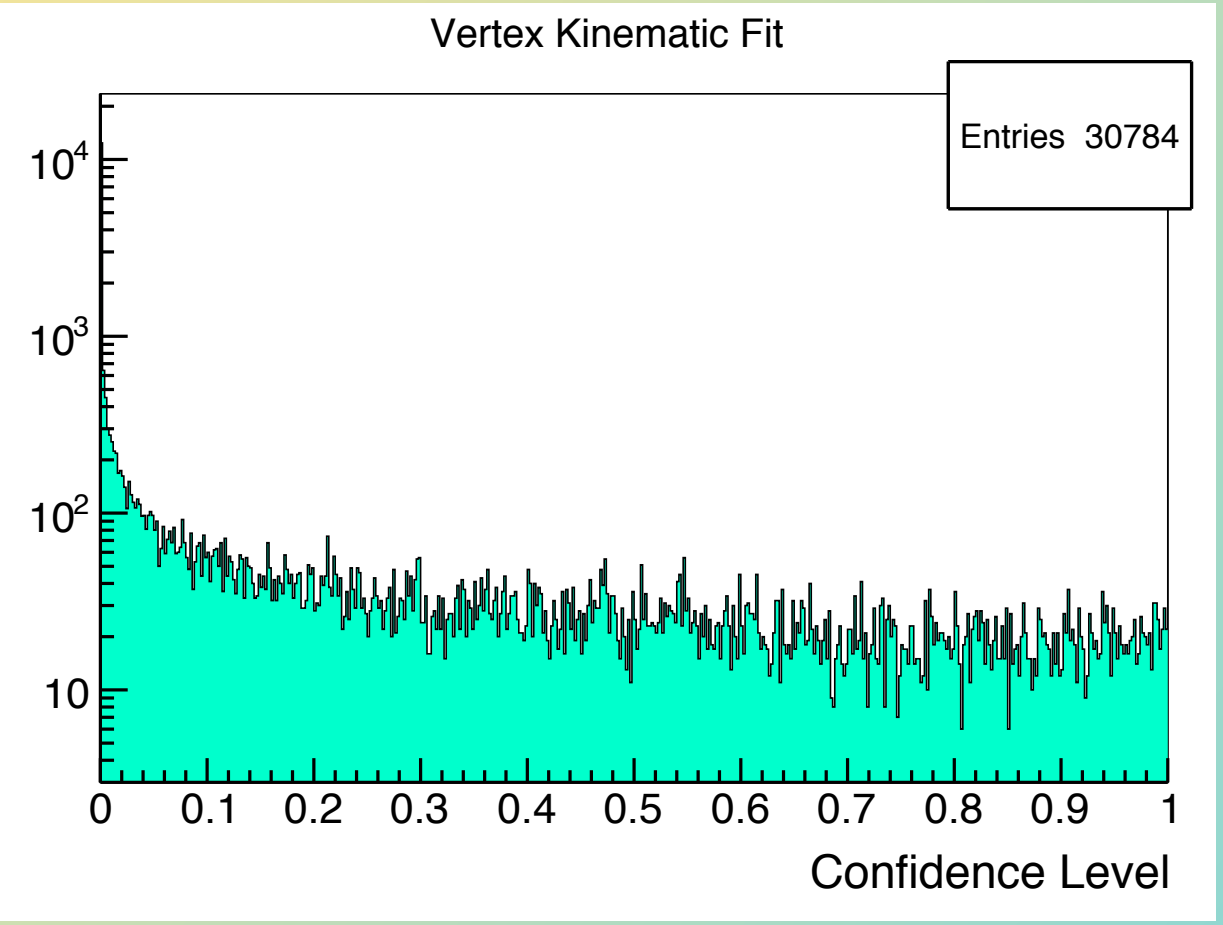
Kinematic Fitting

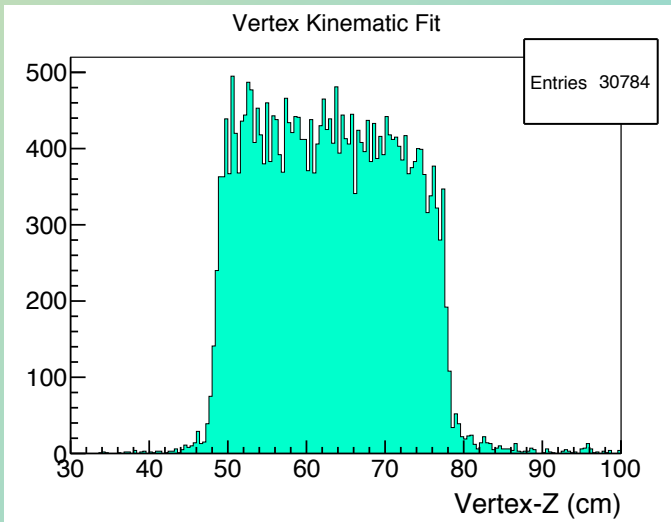
* Be careful when kinematic fitting: Not everything ready yet
* Tracking covariance matrix not perfect, but usable
  * Vertex-fitting appears to be OK
* Appears to be a bug when applying mass constraints
  * Disable mass constraints via DReactionStep (see other talk)
* This analysis: Very low confidence level: Neutral σ's too small?

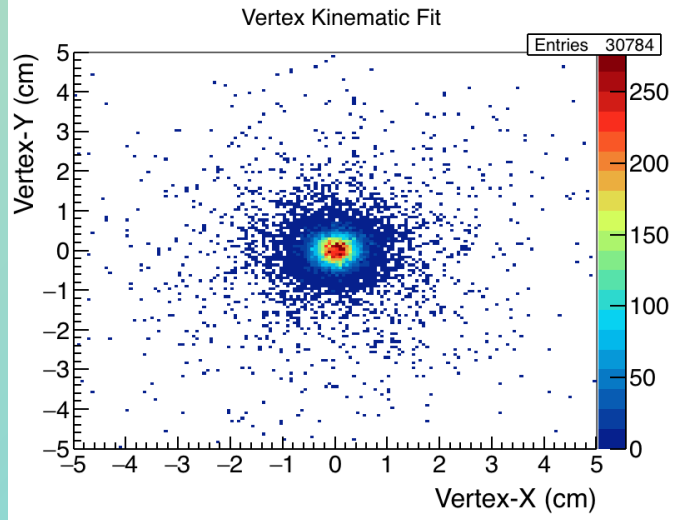


Vertex-Only Kinematic Fit

* **NEW: DCutAction_OneVertexKinFit** (Fits & cuts)
  * Cut CL at 5.73303×10^{-7} ($\sim \pm 5\,\sigma$)

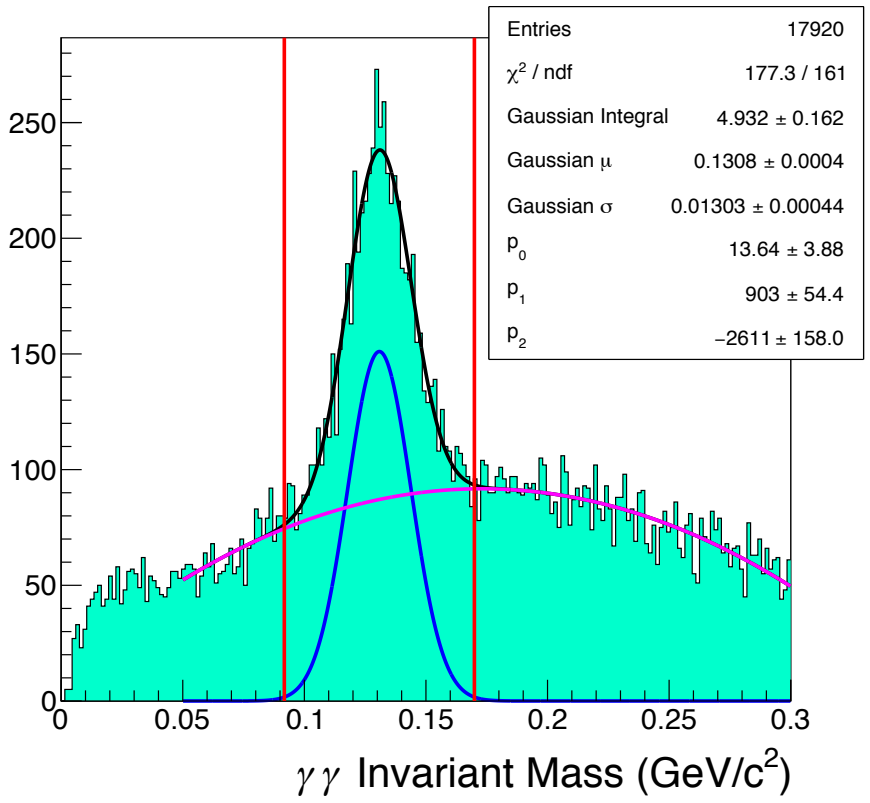






π^0 Histogram, Cut

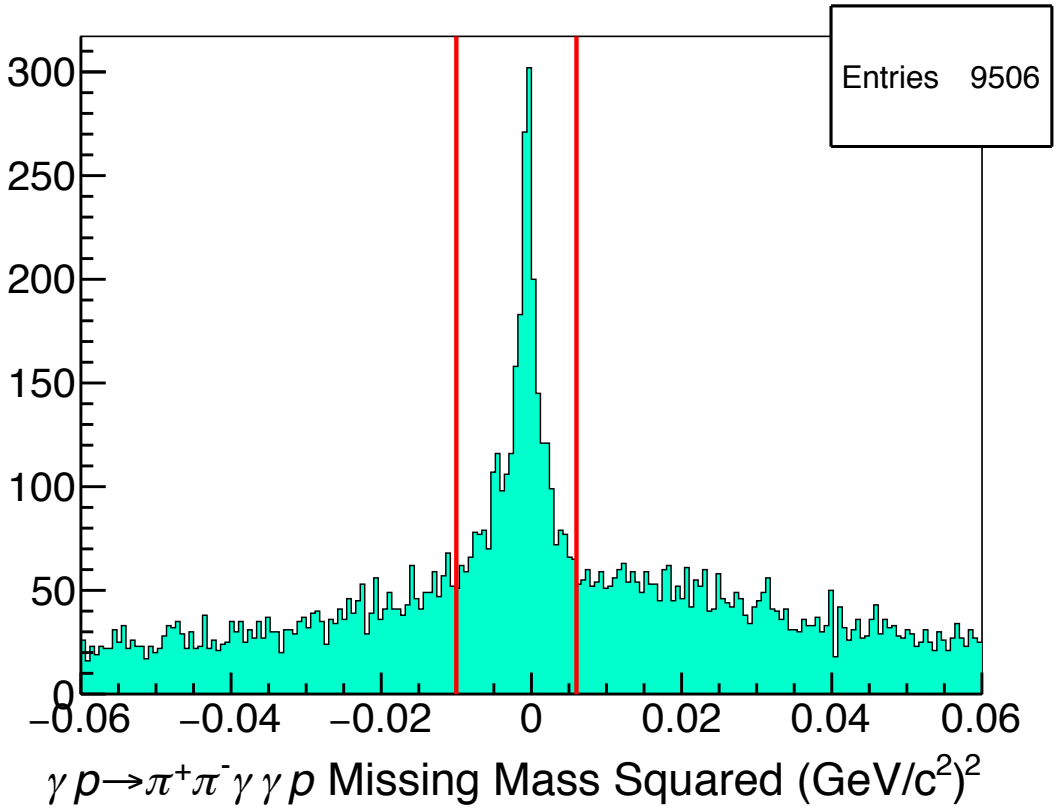
* Rough fit: Gaussian + quadratic, cut at ±3 σ
* Signal: Better is double-Gaussian
  * Signal has non-Gaussian effects
* Background tricky: BCAL+FCAL
  * MC lineshape probably best (?)
* Can reduce background:
  * γ PID cut when ready
  * Require γ far from tracks
    * **DDetectorMatches**
    * Be careful: Will lose signal




```
// Pi0
locReaction->Add_AnalysisAction(new DHistogramAction_InvariantMass(locReaction, Pi0, false, 600, 0.0, 0.3, "Pi0"));
locReaction->Add_AnalysisAction(new DCutAction_InvariantMass(locReaction, Pi0, false, 0.0947349, 0.166653));
```

Missing Mass Squared

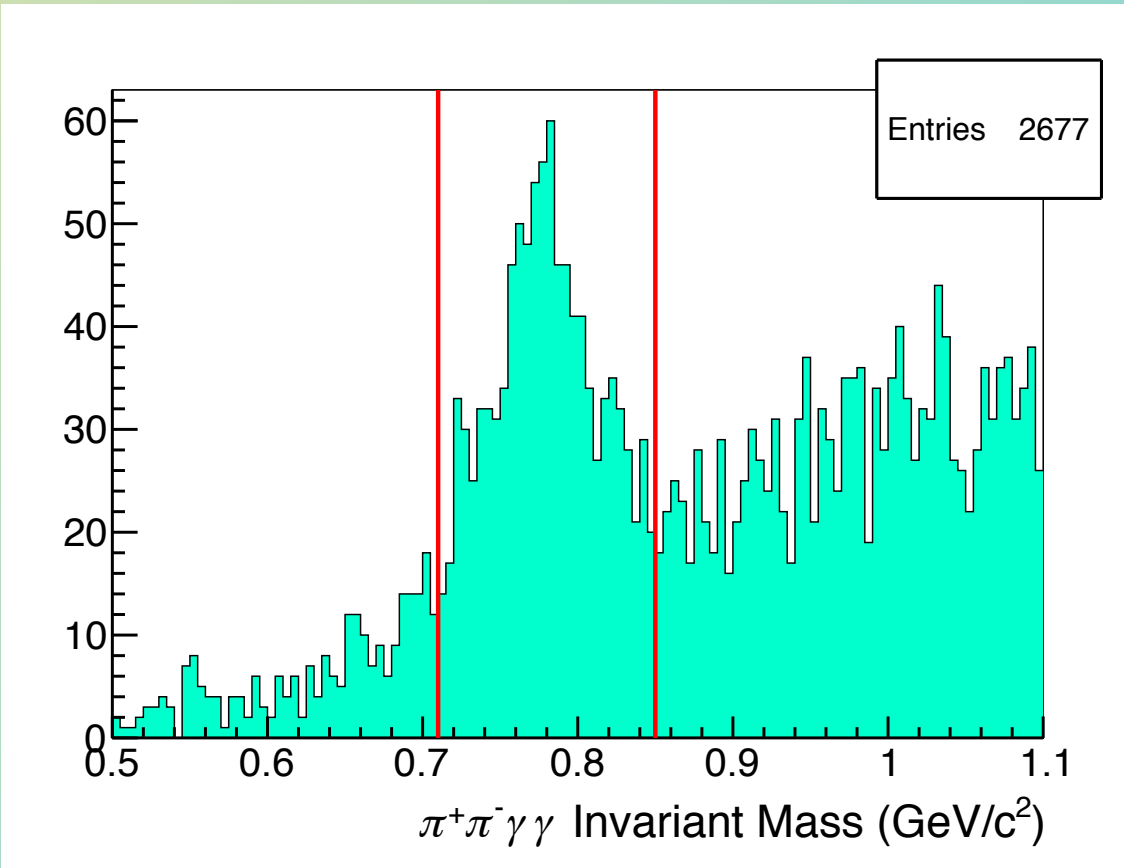
- Even if pure signal, distribution is asymmetric (kinematics)
  - Not easy to fit
- Data survey: Eyeball cut
  - -0.01 to 0.006 $(GeV/c^2)^2$
  - Maybe best to fit to MC?
- Could have also cut on:
  - Missing transverse p
    - Library has actions
  - ω/p Co-planarity (angle)
    - No built-in actions yet




```
// Missing Mass Squared (Hist and Cut)
locReaction->Add_AnalysisAction(new DHistogramAction_MissingMassSquared(locReaction, false, 600, -0.06, 0.06));
locReaction->Add_AnalysisAction(new DCutAction_MissingMassSquared(locReaction, false, -0.01, 0.006));
```

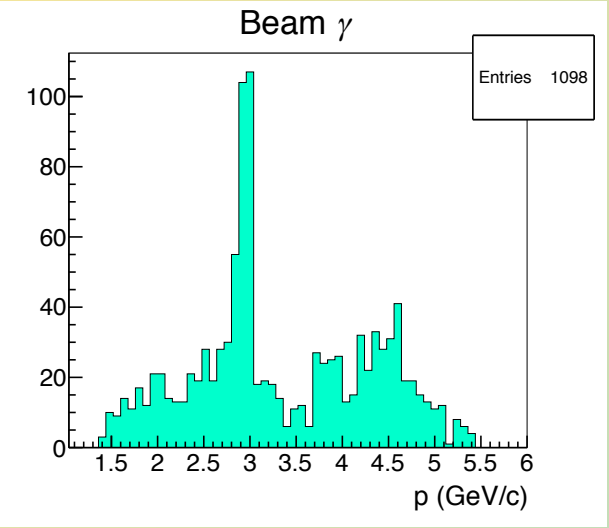
ω Histogram, Cut

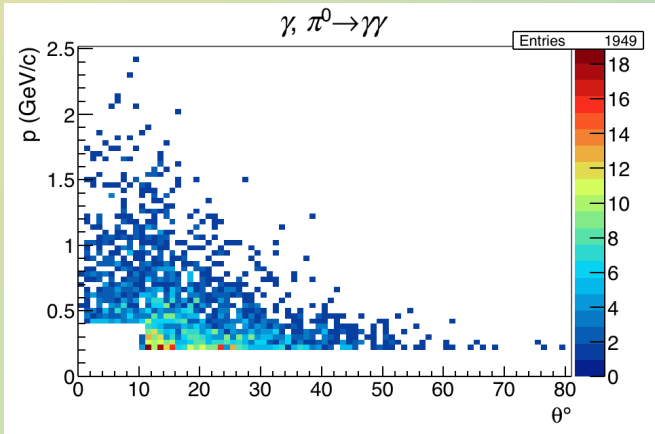
* ω has width of 8.49 MeV/c^2
  * Probably should fit to Voigtian
    * Convolution of Gaussian (detector smearing) & Breit-Wigner
* Instead: Eyeball cut
  * 0.71 to 0.85 GeV/c^2

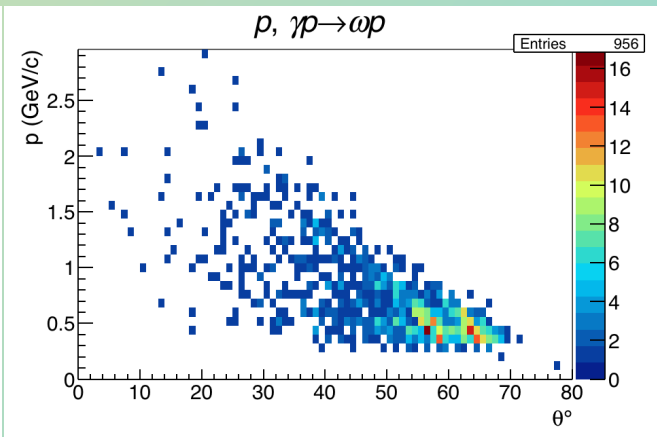


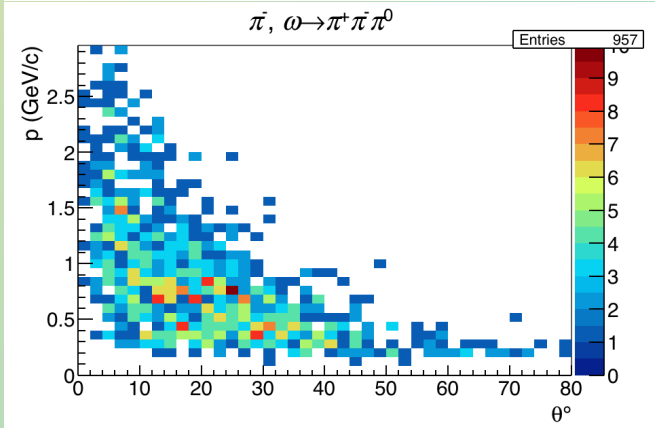
Kinematics

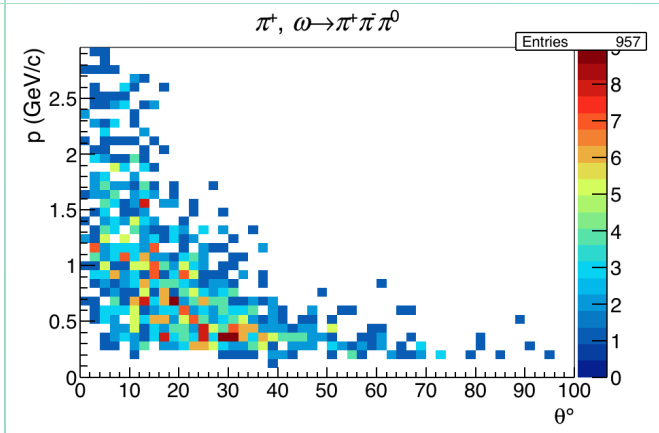
* Beam-E, p-vs-θ







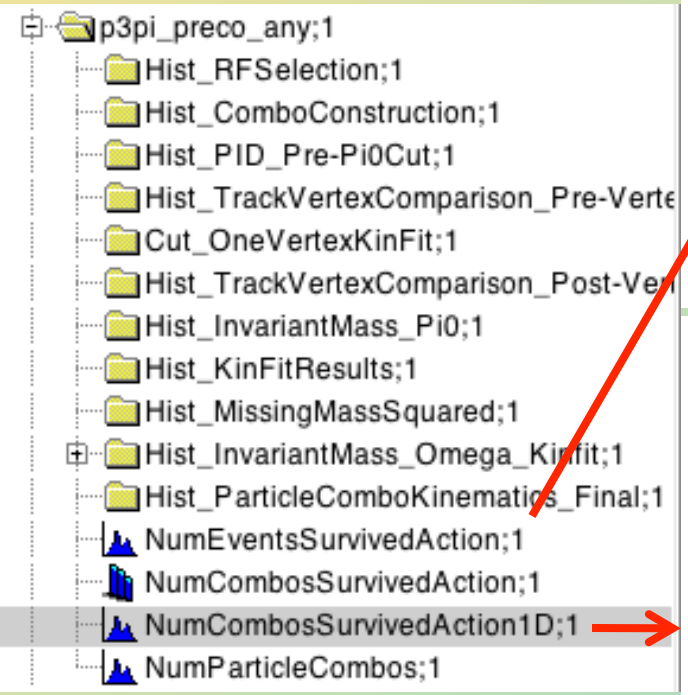


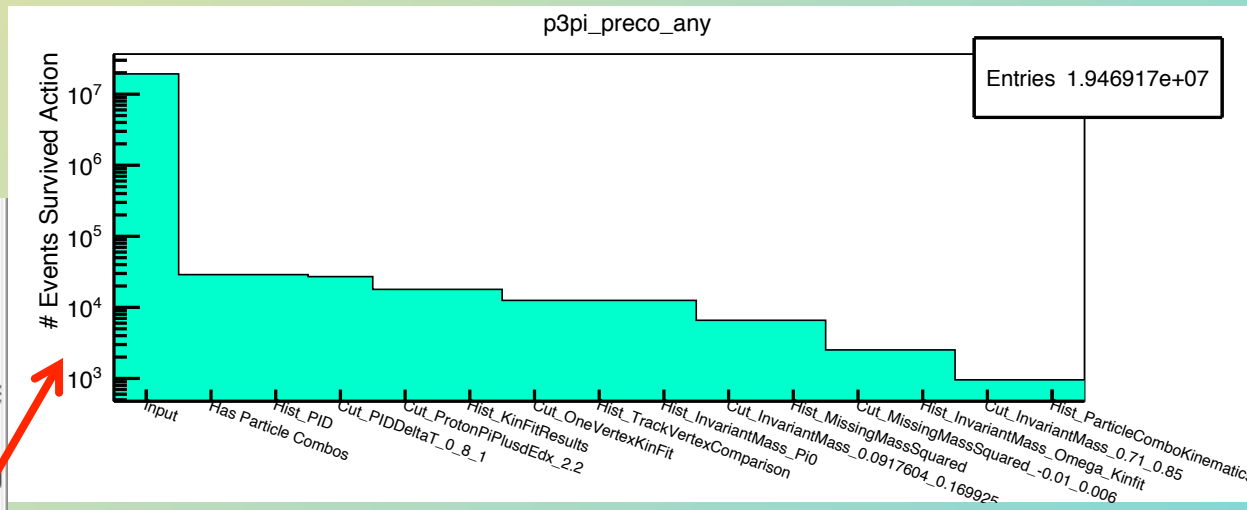


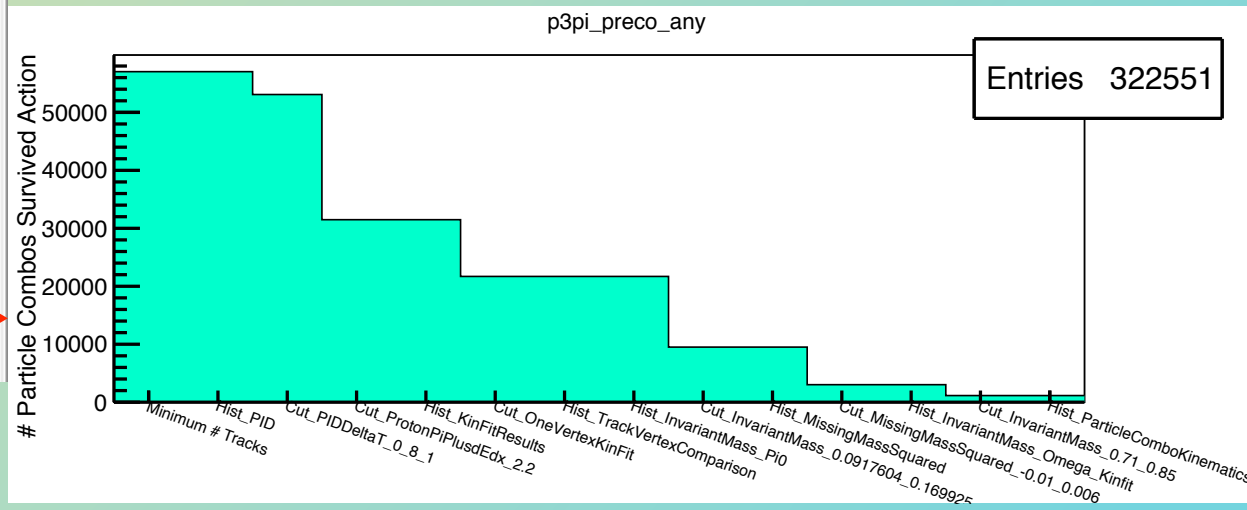

```
// Kinematics of final selection
   //false: fill histograms with measured particle data
locReaction->Add_AnalysisAction(new DHistogramAction_ParticleComboKinematics(locReaction, false));
```

When Were the Events Cut?

* Use this to help double-check that things make sense



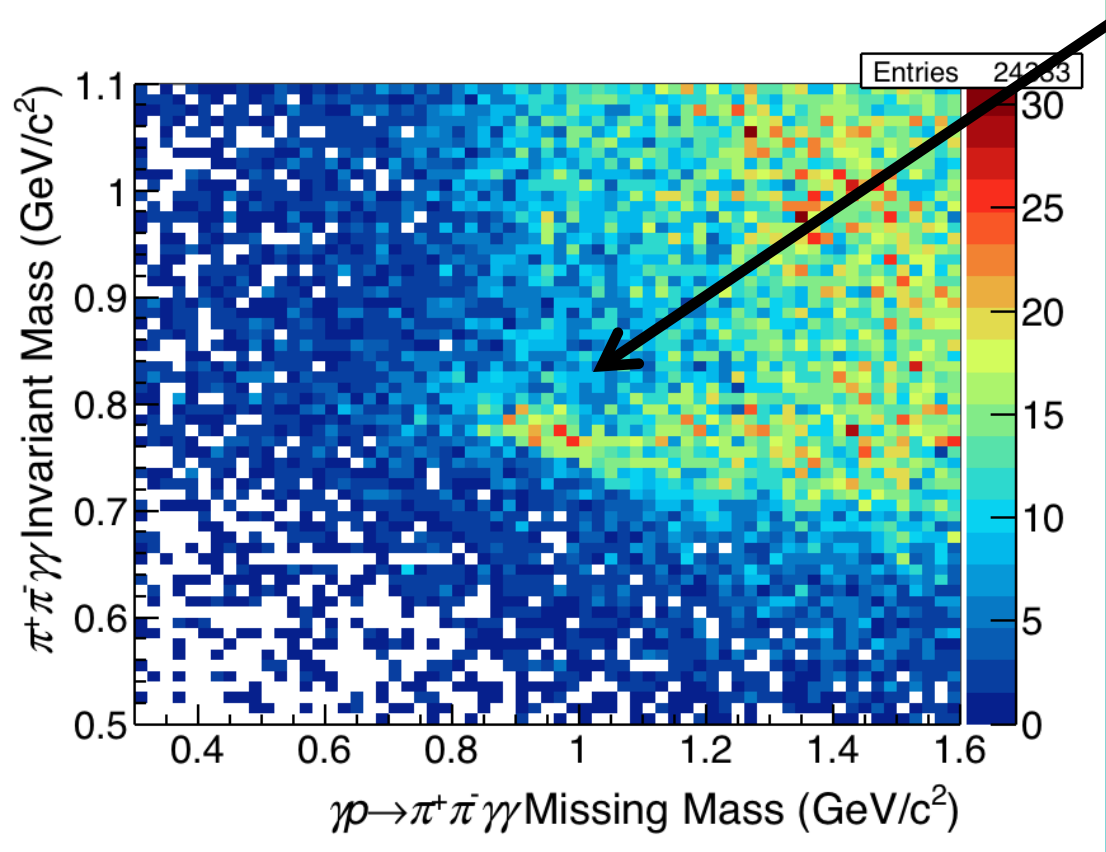




Histograms are automatically in ROOT file

Missing Proton

- Same cuts for: PID, vertex, π^0
- Can't see ω or missing proton peaks in 1D, but can in 2D
  - Can see missing proton clearly in other channels though



Technicalities: Bad Cuts (Rant)

* Don't cut on timing from BCAL/FCAL:
  * Not-yet calibrated
* Don't cut on PID FOM:
  * Uncertainties are way off, let alone actual timing, dE/dx
* Don't cut on β, $\Delta\beta$:
  * Changes along path due to energy losses
  * Cut on Δt instead: **DKinematicData**::time() has E-loss incorporated
* Don't cut on individual-track vertex-z:
  * Very-low-θ tracks have low-vertex-z resolution
  * Common-vertex-z cuts are OK (**DParticleComboStep**::Get_Position())
* **DO NOT** try to select the "most-probable" combo:
  * Multiple combo/event background is **REAL**
  * **ANY** cut will bias distributions: **NO** handle on remaining background
  * If you must, can cut **ALL** events with > 1 combo (Other things likely better)

Summary

* Lots of physics to start looking for
  * Simulation data ready soon too
* Software & calibrations are work-in-progress, but usable
* If you have any questions, feel free to ask