Software for KLF

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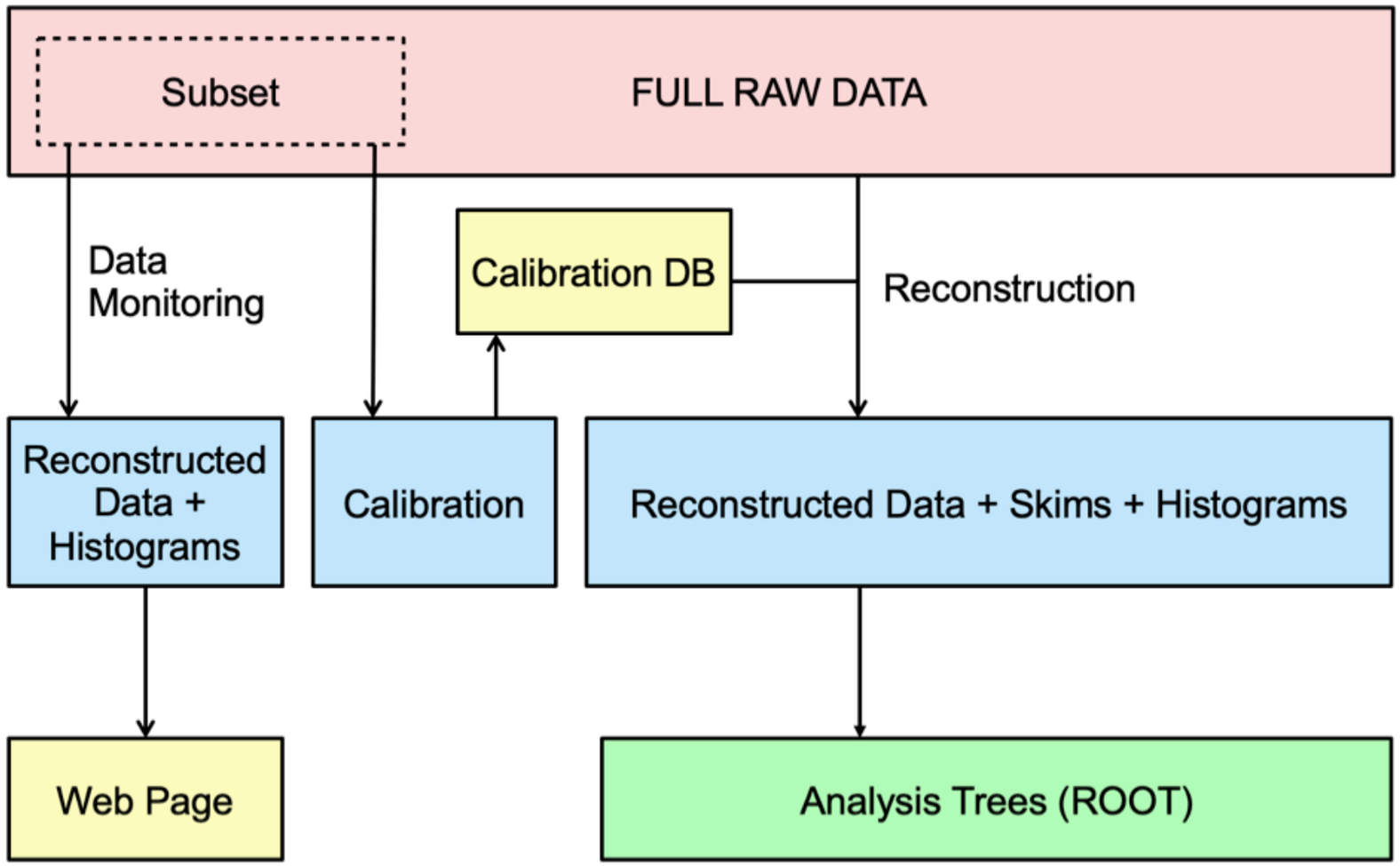
KLF IERR
Aug. 29, 2024

KLF Software Overview

- KLF Software stack based on existing GlueX stack
- Highly parallelized processing
- Centralized production
- Standardized analysis ROOT trees
- Will focus on KLF specific developments

GlueX data flow



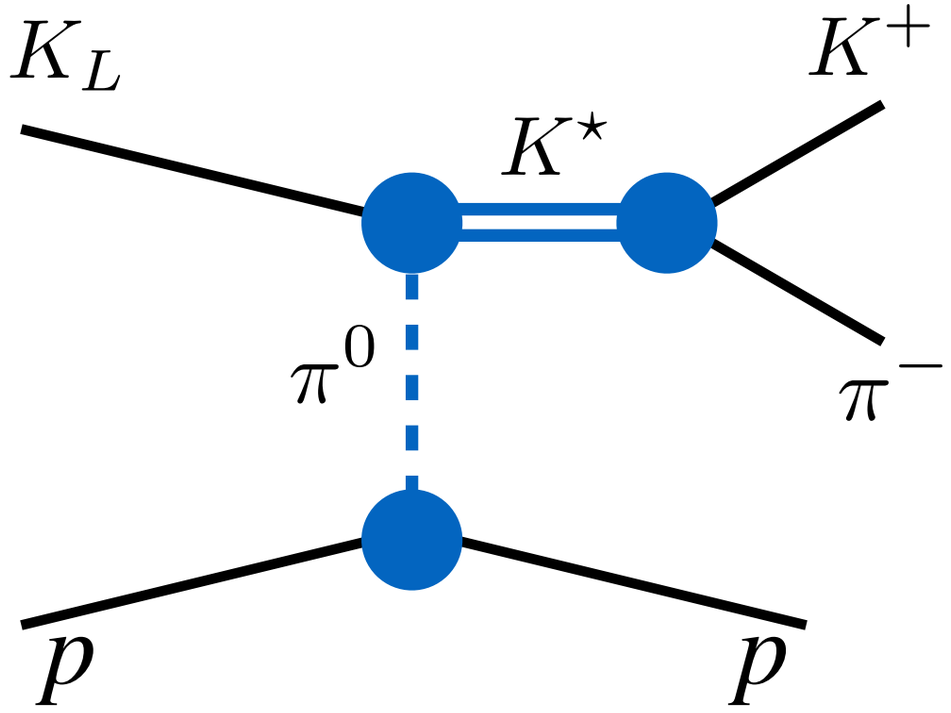
Event Generators — KLGenerator

- Generates menu of K_L and n induced processes, primarily for hyperon spectroscopy analyses
- Assumes uniform population of events in KPT and cryotarget, derives K_L propagation time
- Assumes phase space population of final state particles
  - Focus on s-channel reactions
  - Efficiency determinations
  - Cross-feed backgrounds between channels

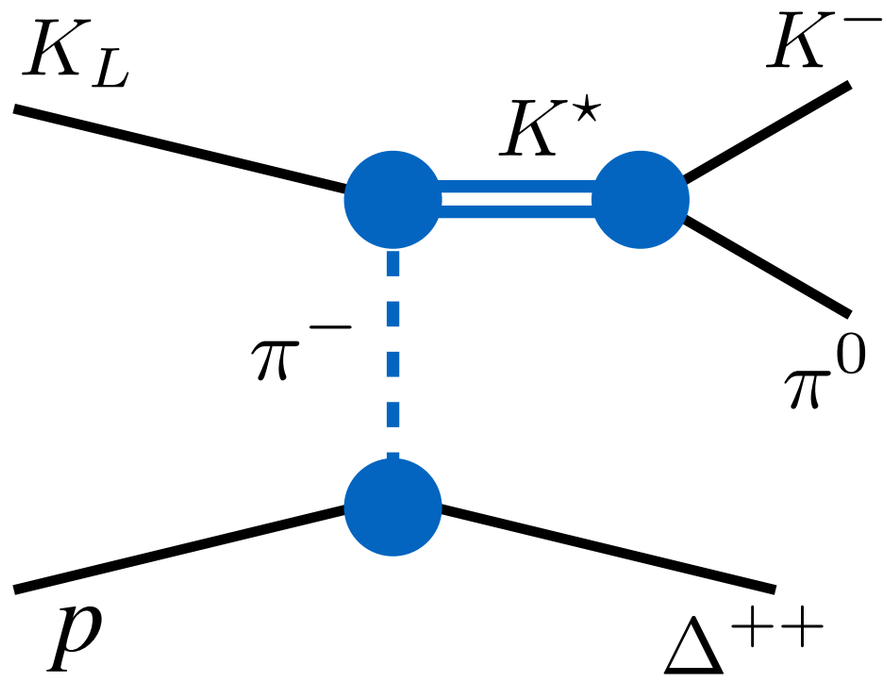
```
 <reaction code>
kl1       Klong p --> K+ n
kl2       Klong p --> Ks p
kl3       Klong p --> K+ Xi
kl4       Klong p --> pi+ Lambda
kl5       Klong p --> pi0 Sigma+
kl6       Klong p --> pi+ Sigma
kln1      Klong n --> K- p
kln2      Klong n --> Ks n
kln3      Klong n --> K+ Xi-
kln4      Klong n --> pi0 Lambda
kln5      Klong n --> pi0 Sigma
kln6      Klong n --> pi- Sigma+
kln7      Klong n --> pi+ Sigma-
kln8      Klong n --> Ks Xi
g1        g p --> K+ Lambda
g2        g p --> K+ Sigma
g3        g p --> Ks Sigma+
n1        n p --> K+ Lambda n
n2        n p --> K+ Sigma n
n3        n p --> Ks Sigma+ n
n4        n p --> Ks Lambda p
n5        n p --> Ks Sigma p
n6        n p --> n n pi+
```

Event Generators — KPiGenerator

- Generates $K\pi$ events using model including S-, P- and D- waves
  - $K_L p \to K^+ \pi^- p$:
    Dass and Froggatt, NPB 151, 10 (1969)
  - $K_L p \to K^{*-} \Delta++$:
    Pelaez and Rodas, PRD 93, 076025 (2016)

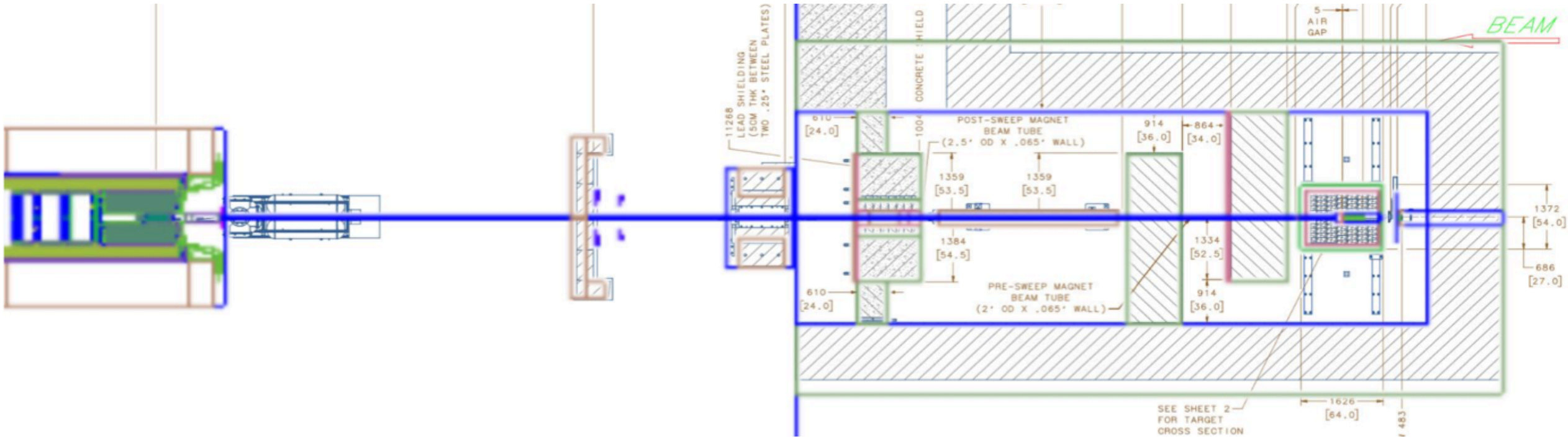


- Different $K\pi$ final states recoiling against p, n, Δ^{++}

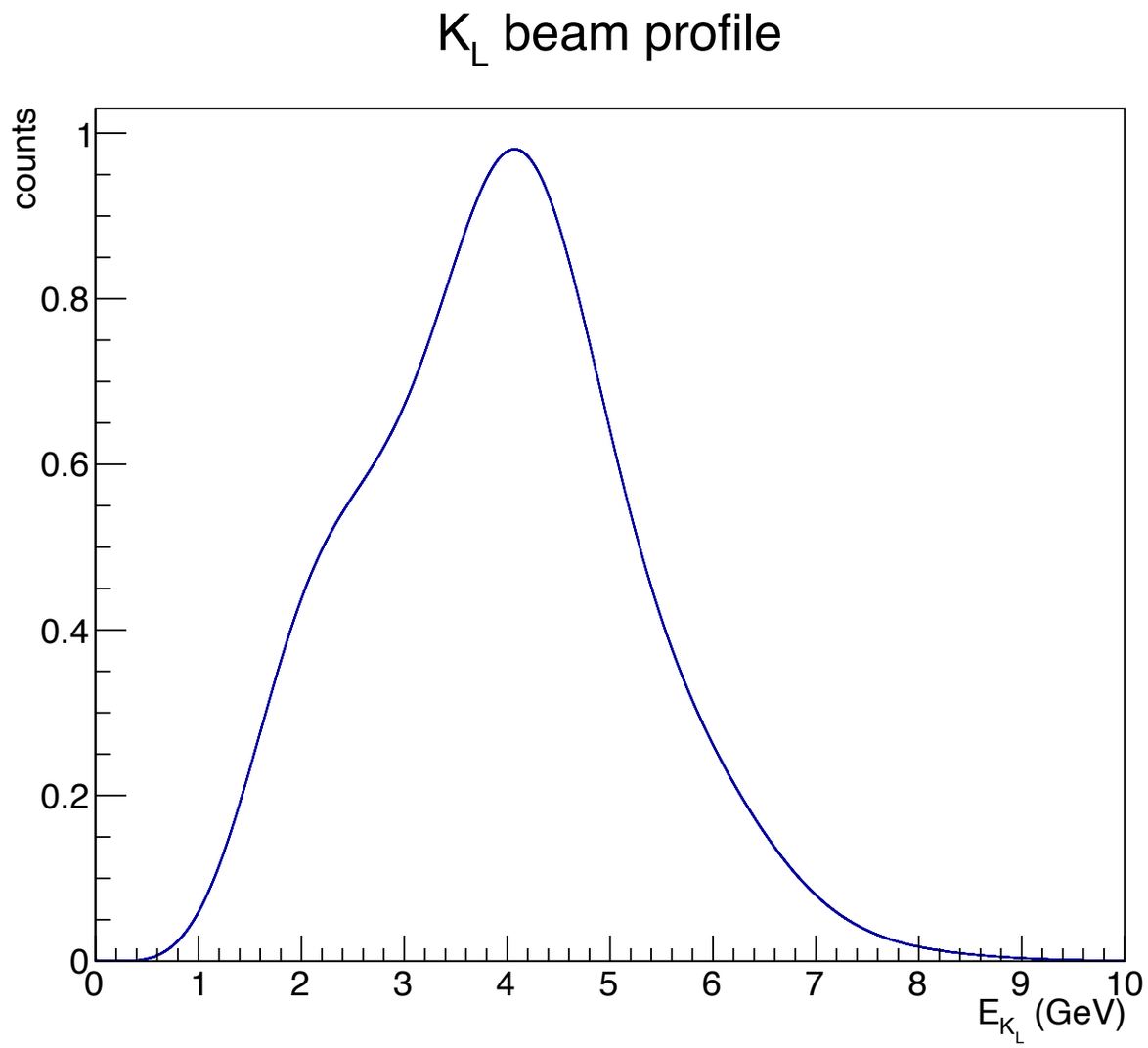


Event Generators — HDGeant4

- Recent progress in implementing KLF beamline in standard Hall D GEANT4 simulations (see talk of R. Jones)
- Simulates beam properties and effect of beam backgrounds on final state reconstructing
- Generating large sample of beam background interactions to “mix-in” with simulated events



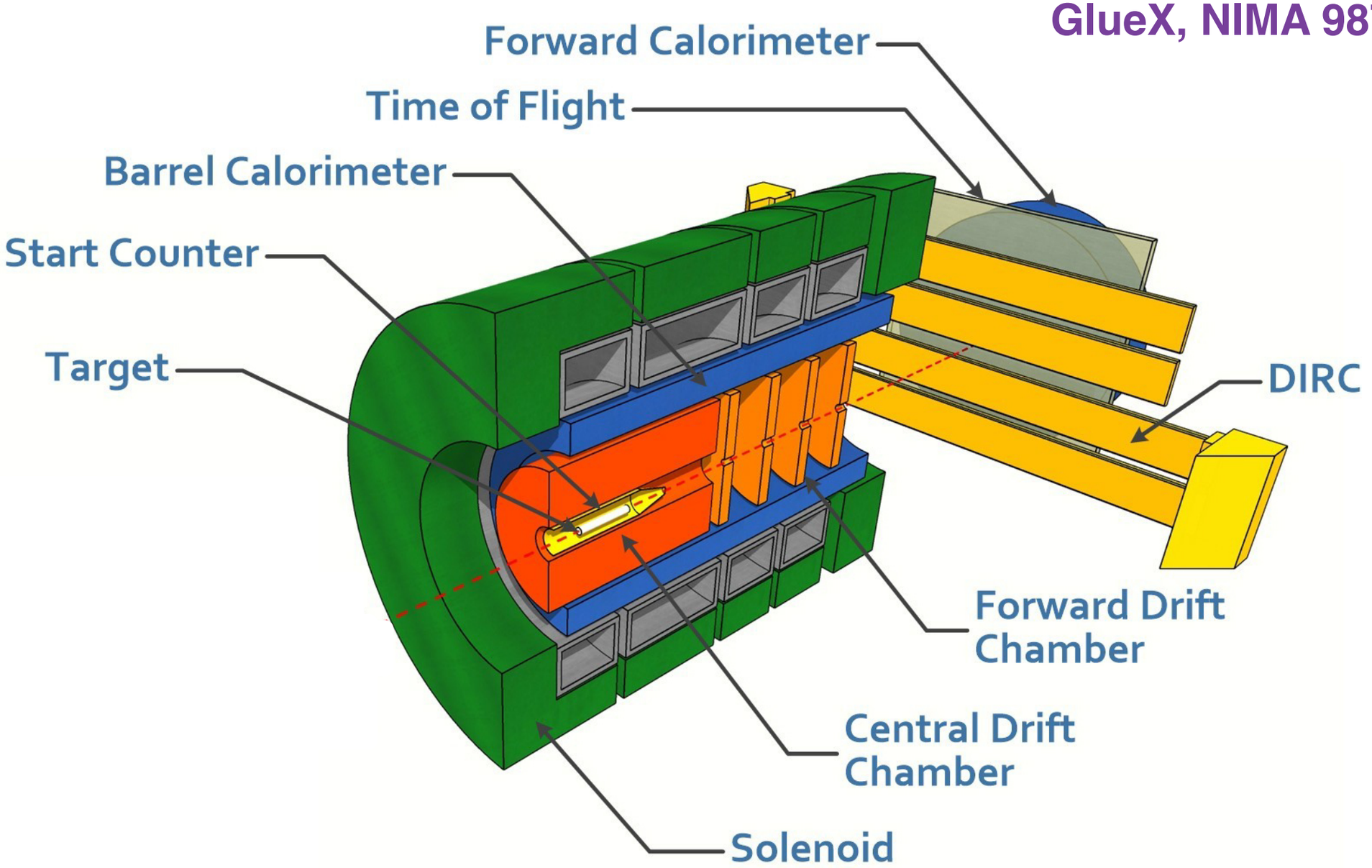
Event Generators — K_L beam properties



- FLUKA simulations provide energy spectrum of the beam at the cryotarget, beam particles are distributed evenly across the face of the target

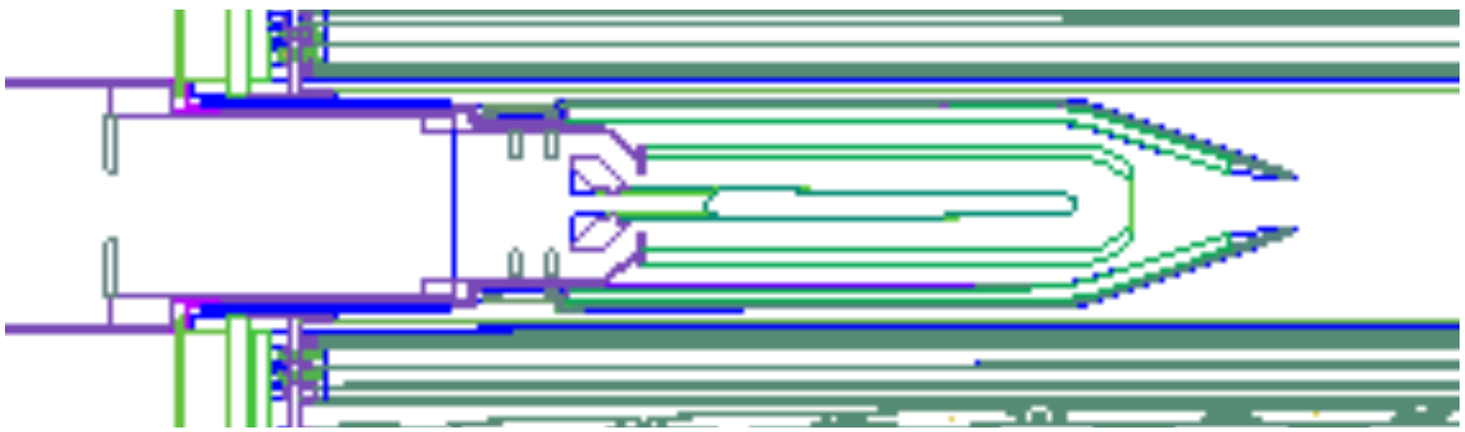
GlueX Spectrometer

GlueX, NIMA 987, 164807 (2021)



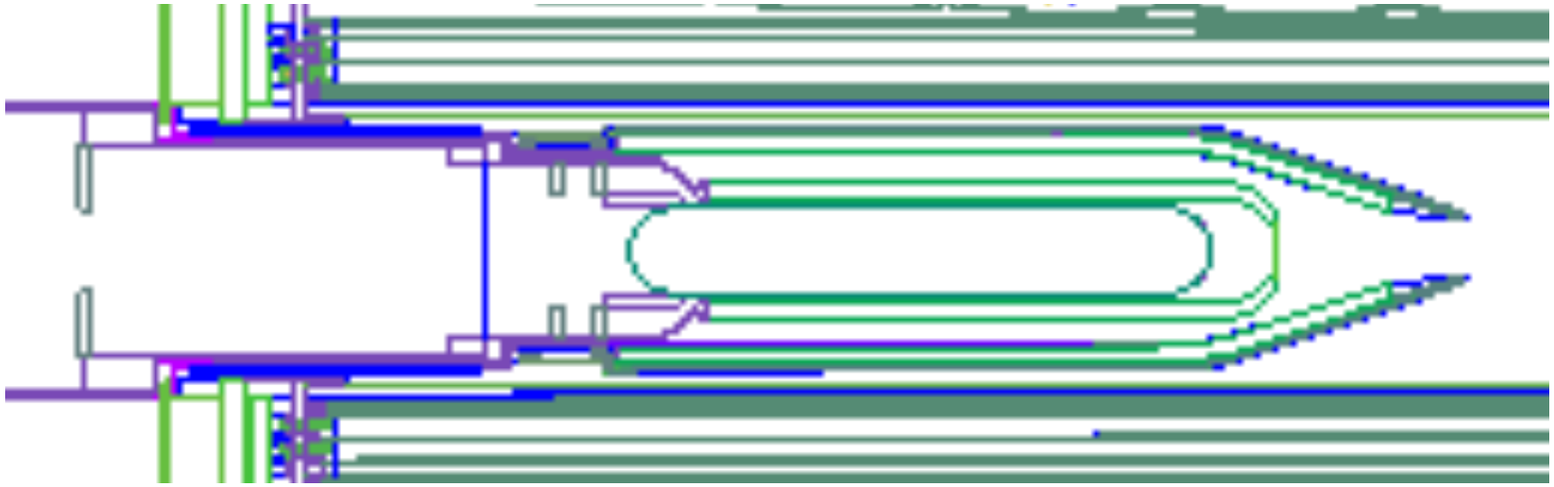
- Only modification of standard GlueX-II spectrometer configuration is a larger target cell

KLF cryotarget geometry in GEANT4



GlueX cryotarget
$r = 1.5$ cm
$z = 30$ cm

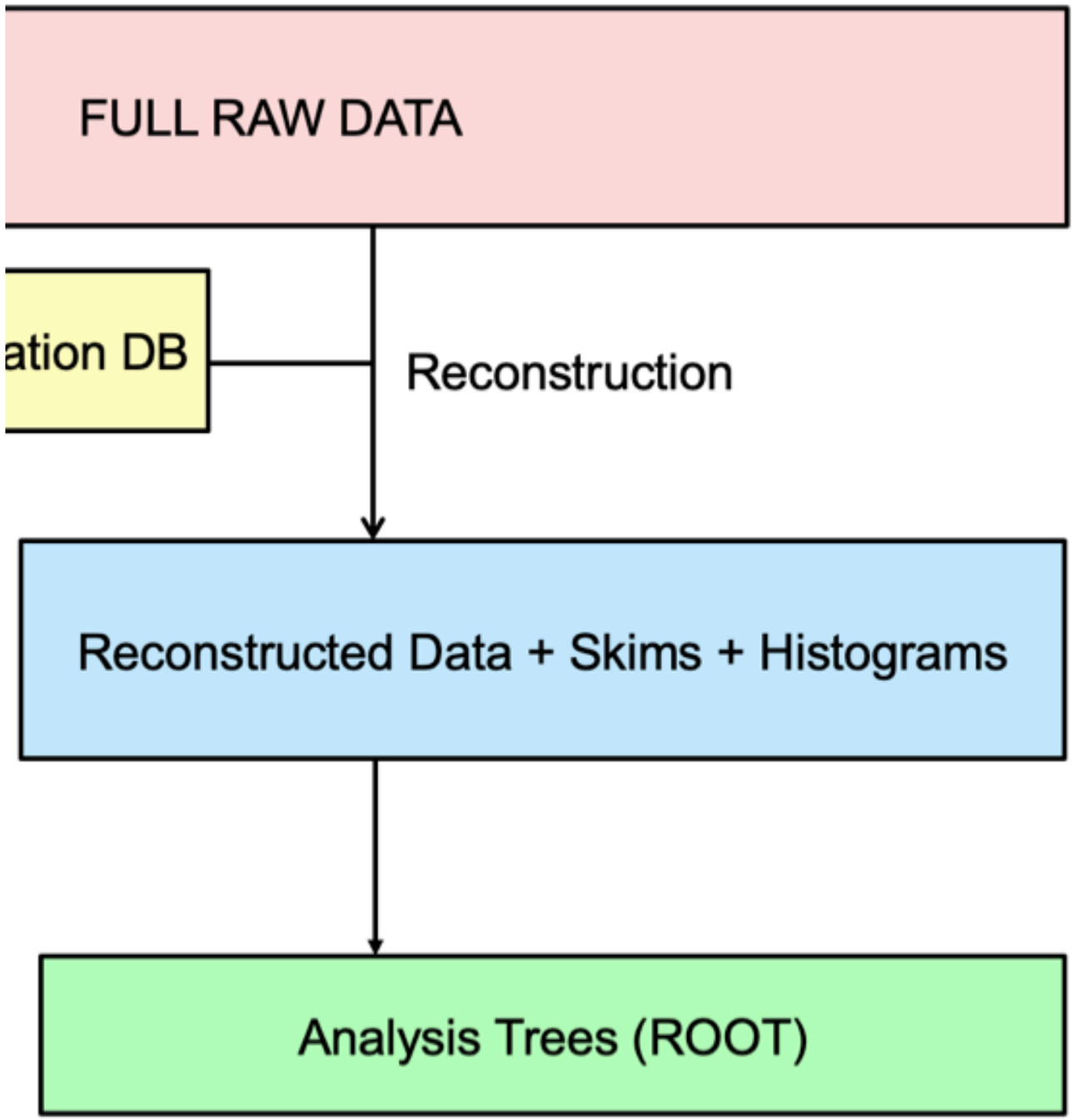
KLF cryotarget
$r = 3$ cm
$z = 40$ cm



- Nominal KLF target geometry implemented in GEANT4

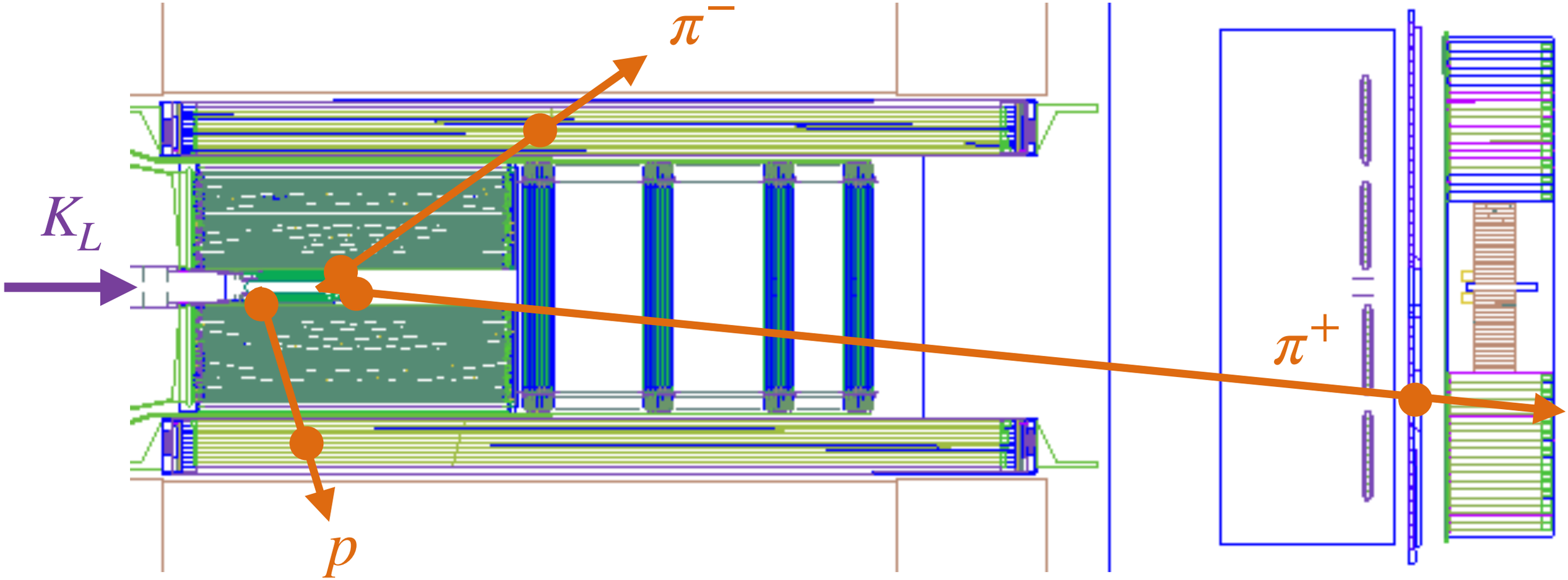
KLF Reconstruction and Analysis

- Standard tracking and shower reconstruction algorithms are used
- Analysis library applies loose PID selections and kinematic fit to selected reactions
  - Position and timing of primary vertex determines K_L momentum
  - Resolution is reaction-dependent
  - Best performance for exclusive reactions with kinematic fit



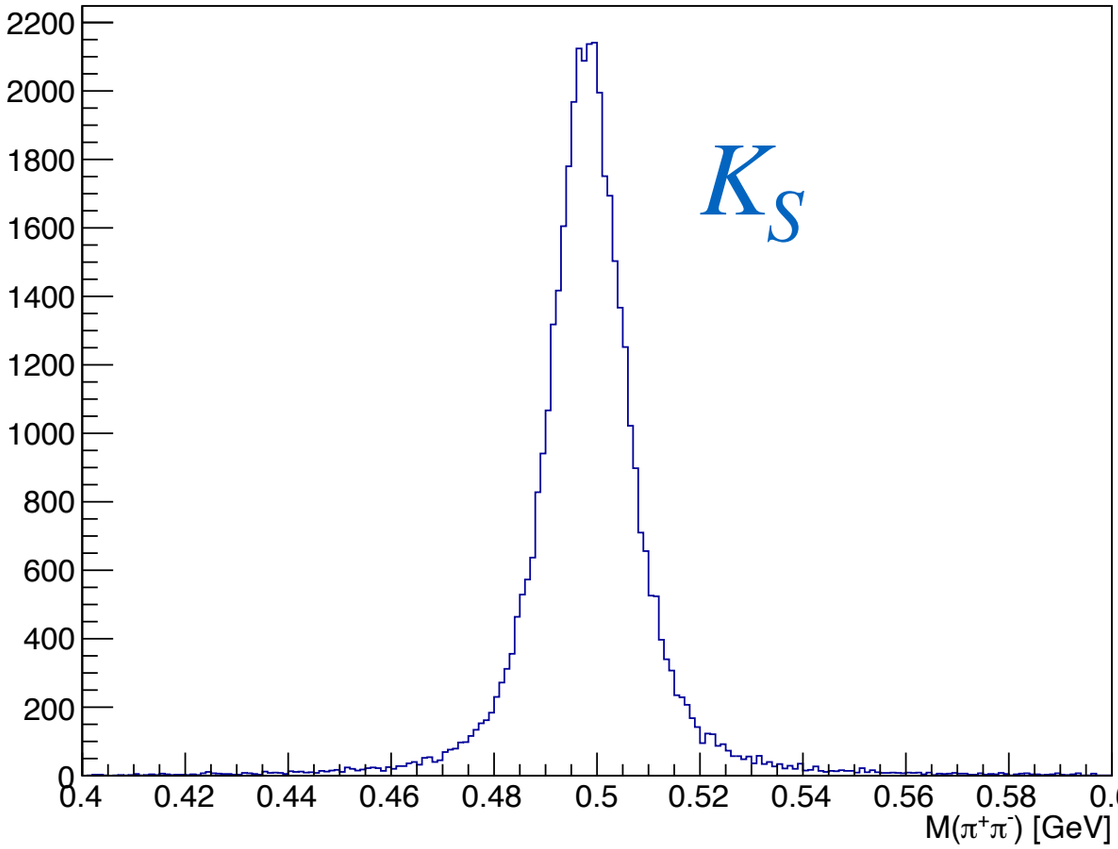
K_L Beam Reconstruction

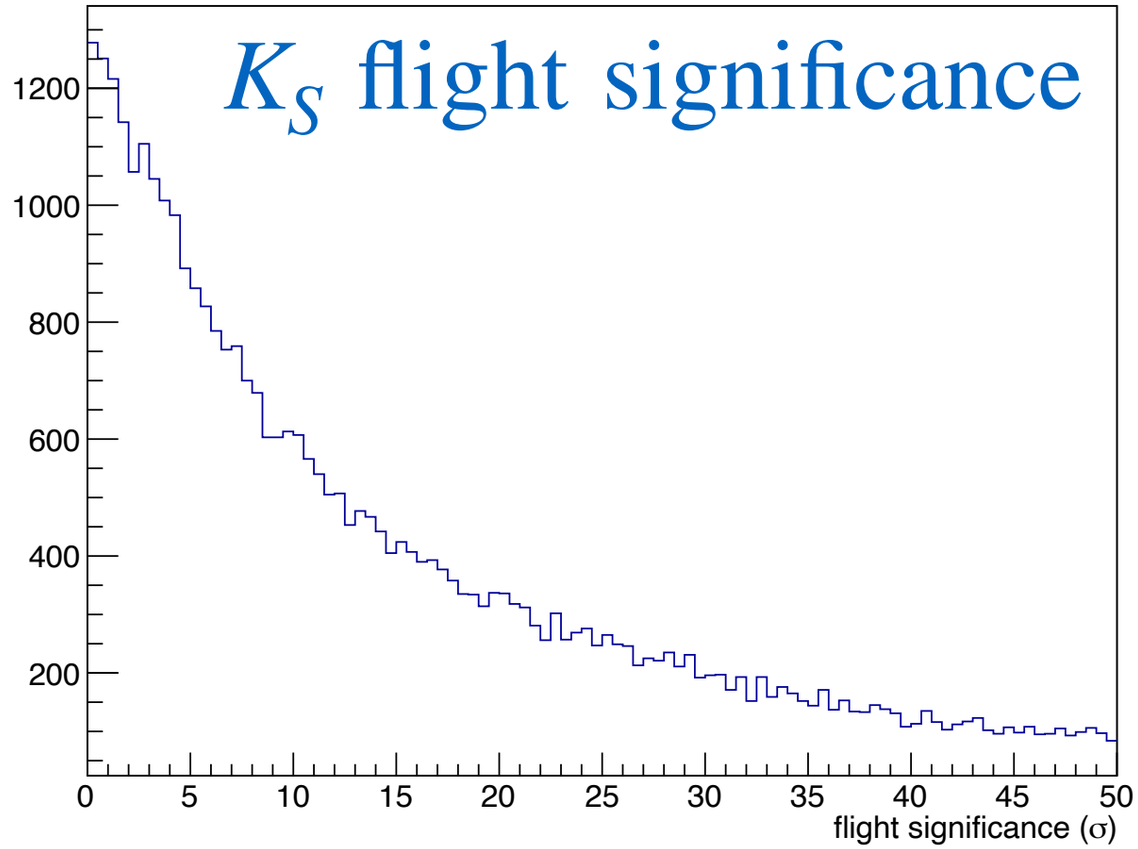
σ(BCAL) ≈ 150 ps σ(TOF) ≈ 105 ps σ(ST) = 230 ps



- K_L momentum determined from time-of-flight measurement from KPT to primary vertex
- Primary vertex resolution depends on final state kinematics

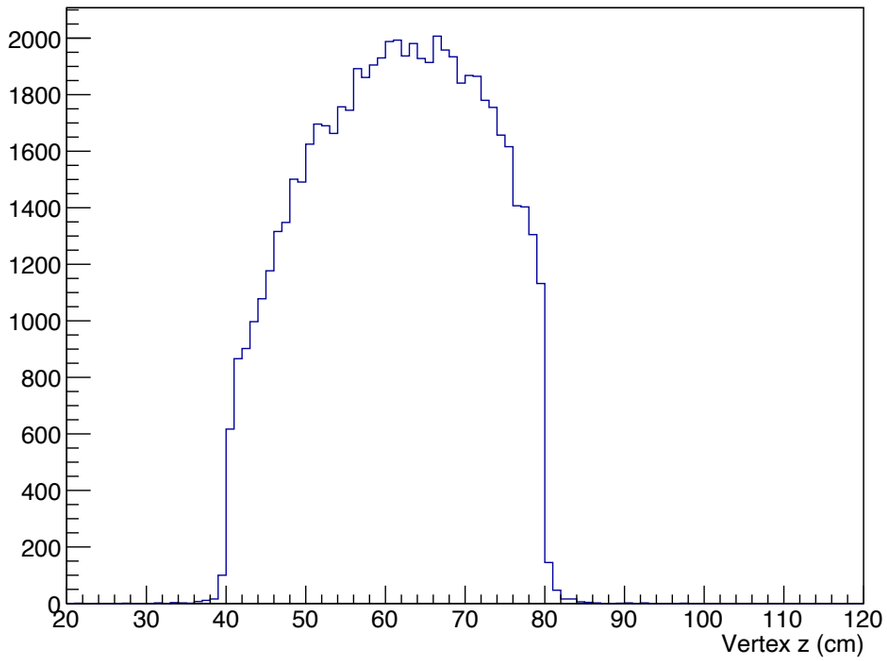
Example: $K_L p \to K_S p$

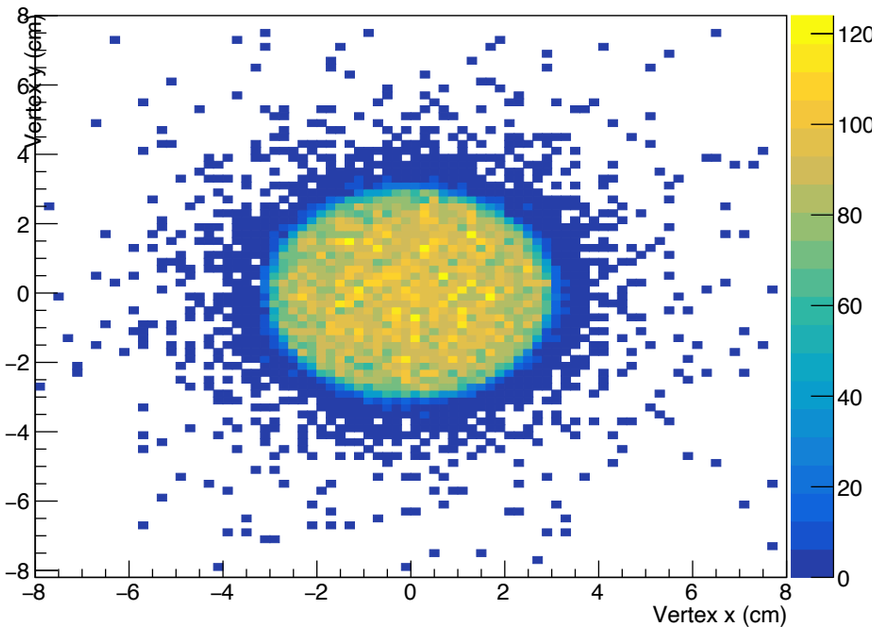


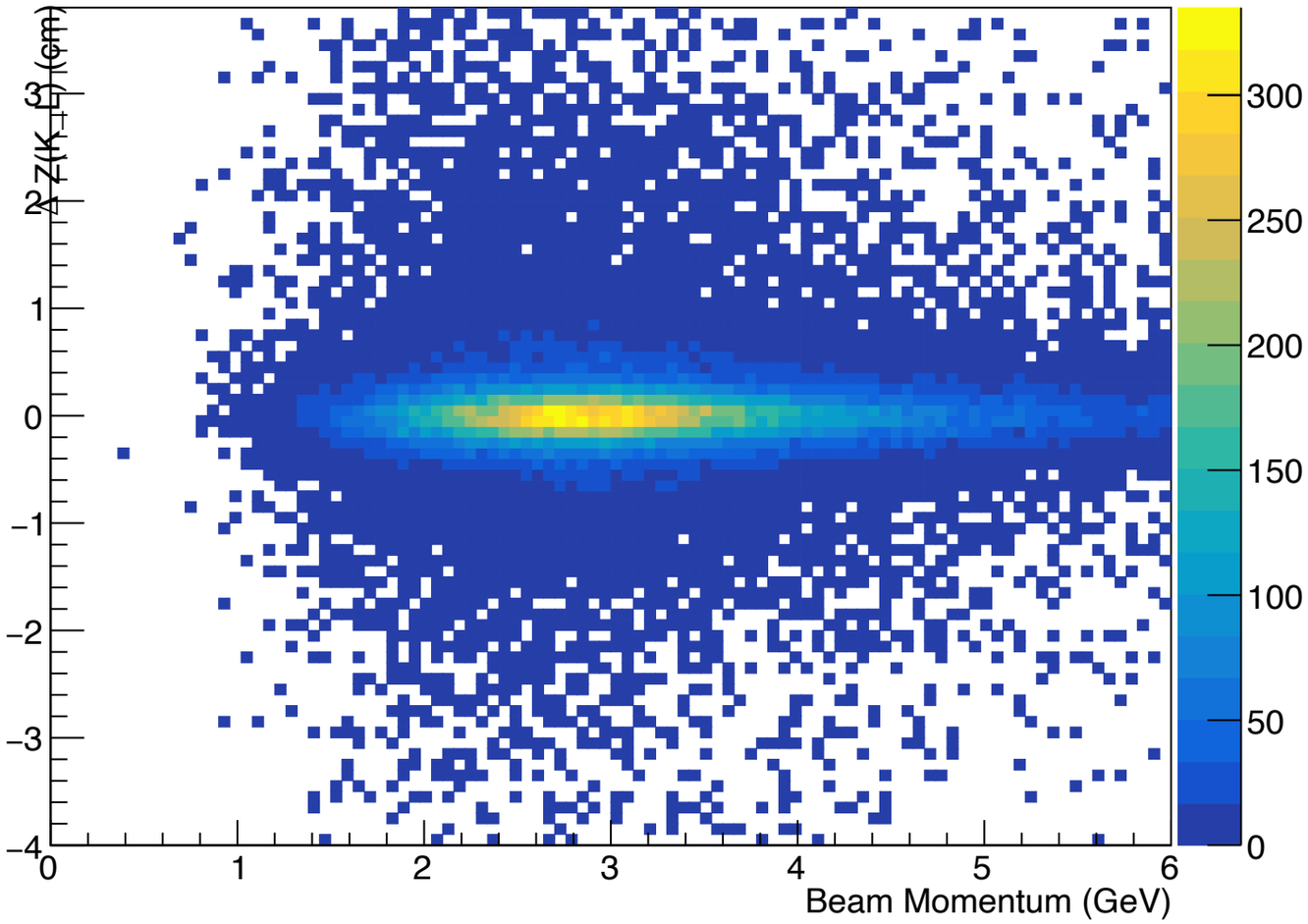


- Generated $K_L p \to K_S p$, $K_S \to \pi^+\pi^-$ events with nominal K_L momentum distribution and phase space decay
- Reconstructed with standard analysis tools, vertex-only kinematic fit
- $K_S \to \pi^+\pi^-$ decay cleanly reconstructed

Example: $K_L p \to K_S p$ — Primary Vertex



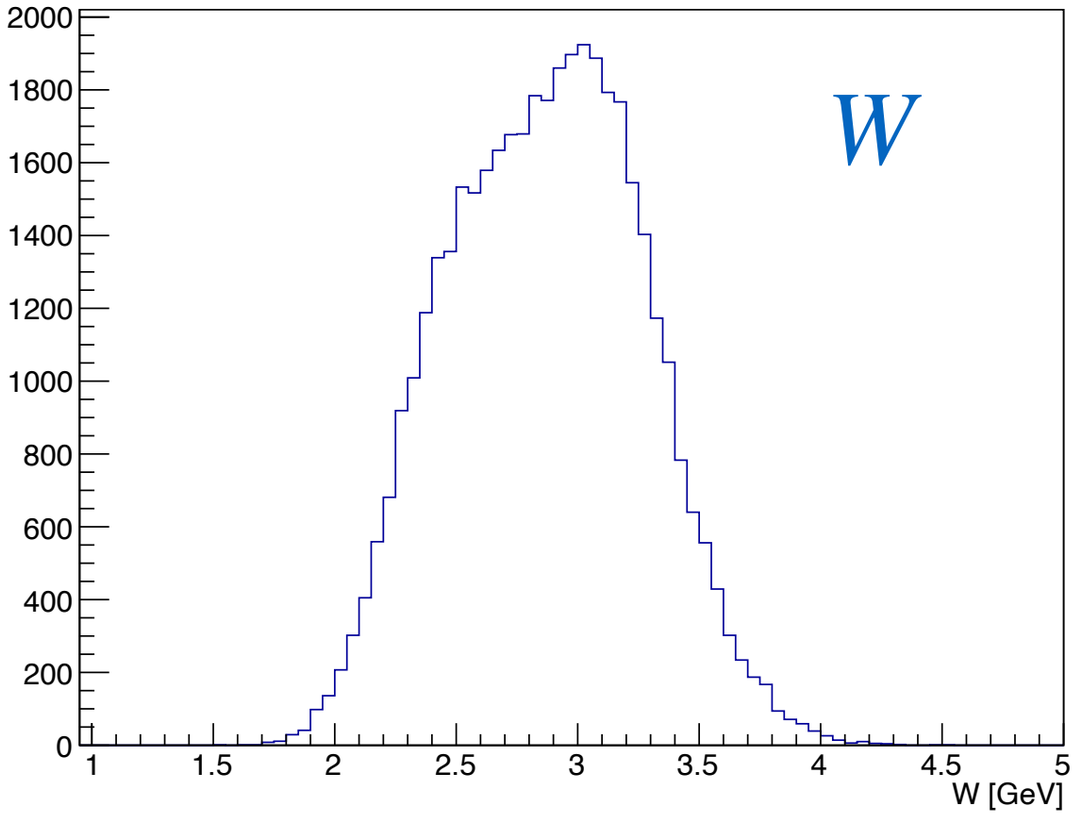


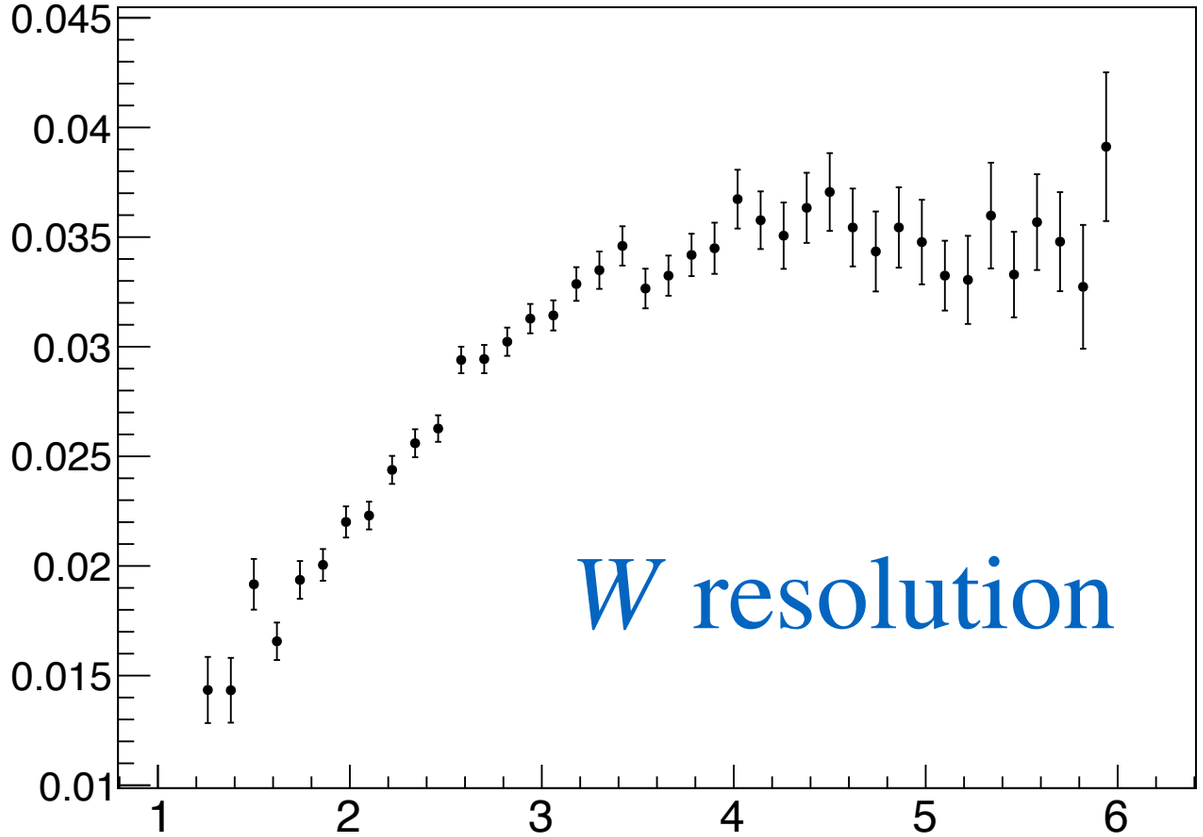


$\sigma(z) \approx 0.17$ cm

- Primary vertex reconstructed inside cryotarget

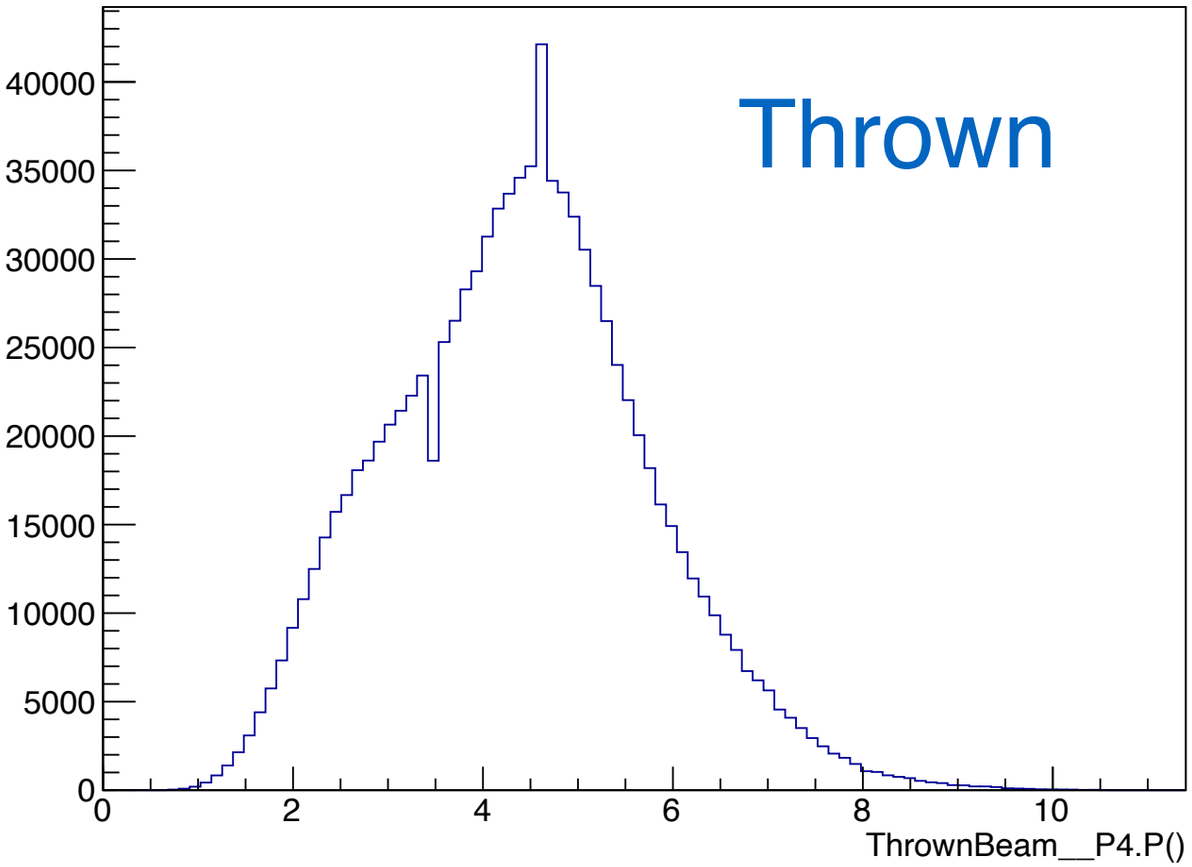
Example: $K_L p \to K_S p$ — Mass Resolution

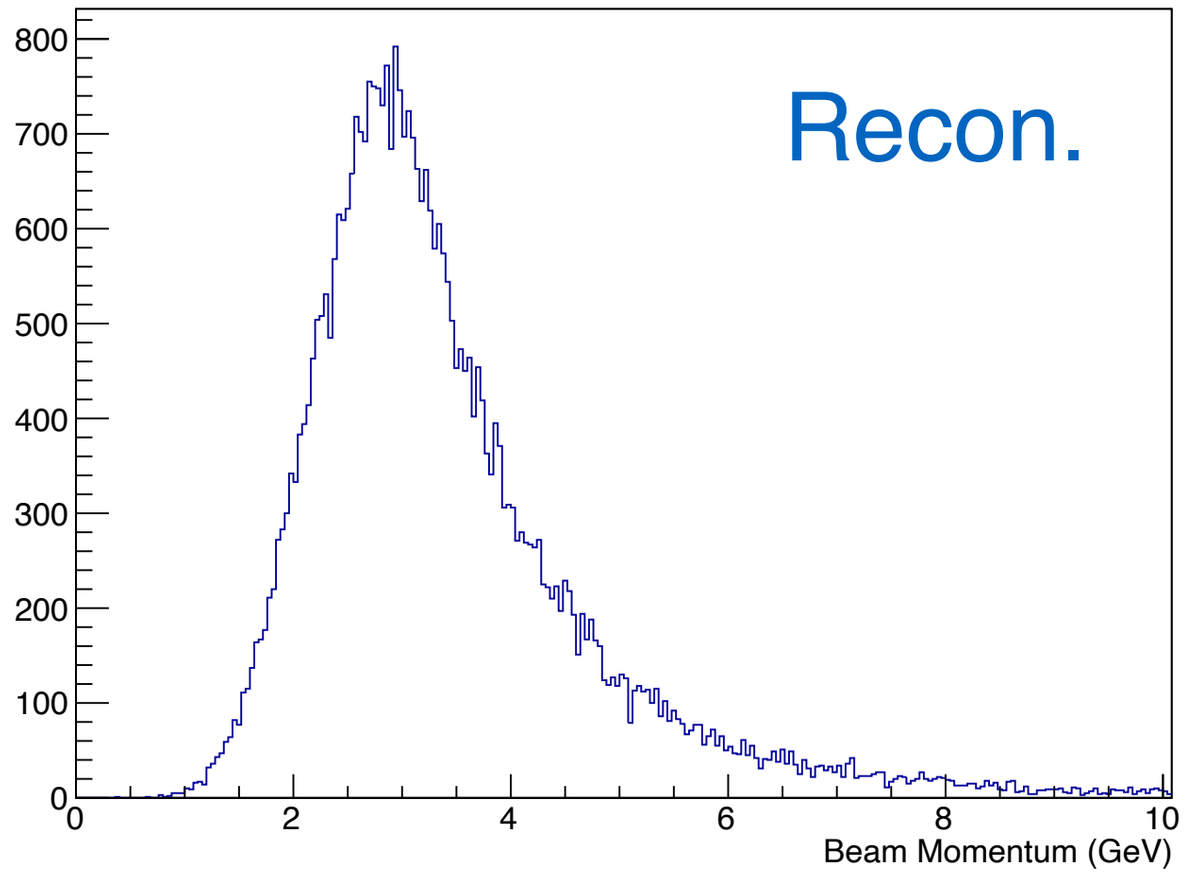




- Mass resolution of reconstructed final states is < 35 MeV

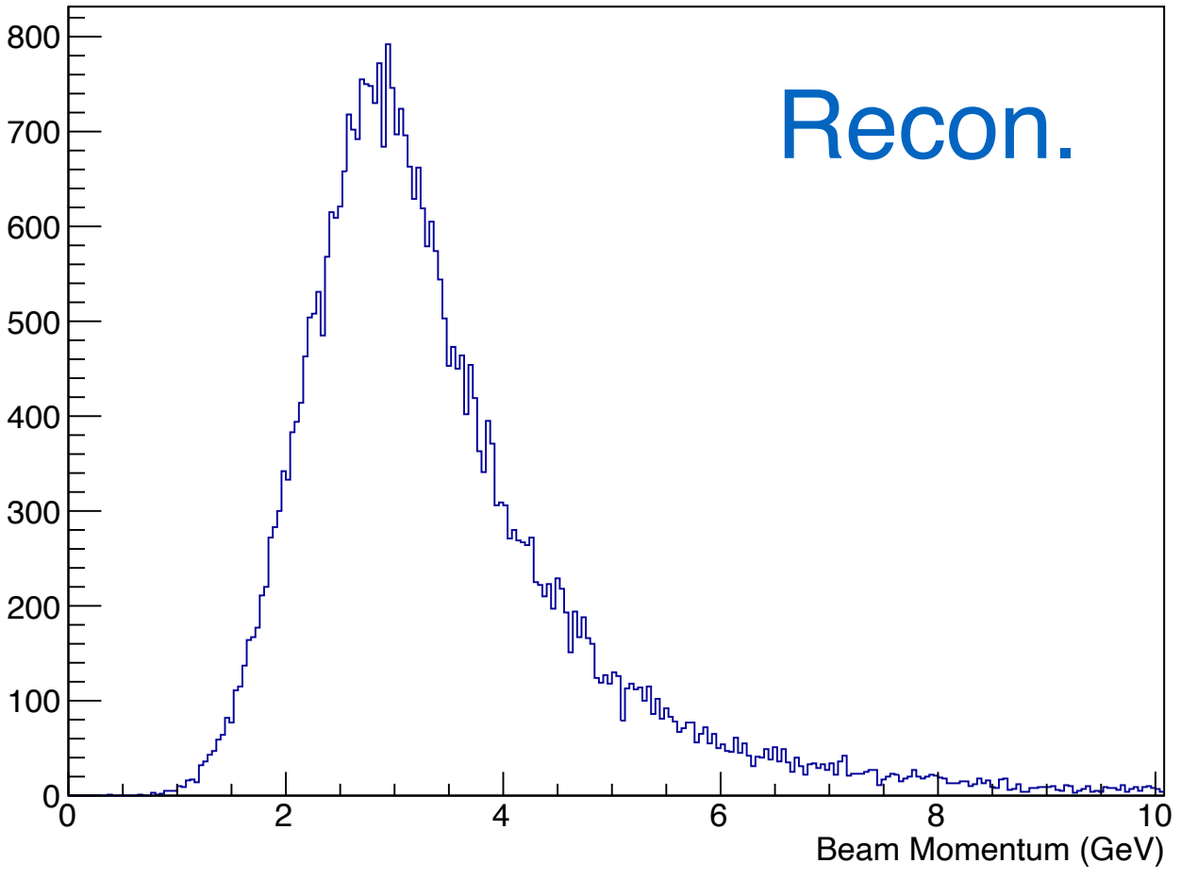
Example: $K_L p \to K_S p - K_L$ reconstruction





- K_L reconstructed over a wide range of momenta

Example: $K_L p \to K_S p - K_L$ reconstruction



- K_L reconstructed over a wide range of momenta

Summary

- KLF software based on well-tested GlueX software stack
- Nominal KLF geometry implemented in GEANT4
- Several event generators in use
  - KLGenerator — 2-body, s-channel reactions
  - KPiGenerator — $K\pi$ scattering
  - Beam backgrounds in GEANT4
- Standard reconstruction and analysis codes have been modified to produce ROOT trees for analysis of K_L-induced reactions
  - K_L beam reconstruction depends on final state reconstruction
  - particle well reconstructed
  - Additional examples in upcoming analysis talks

Backup slide

- text