Calibration, Alignment, and PID for KLF

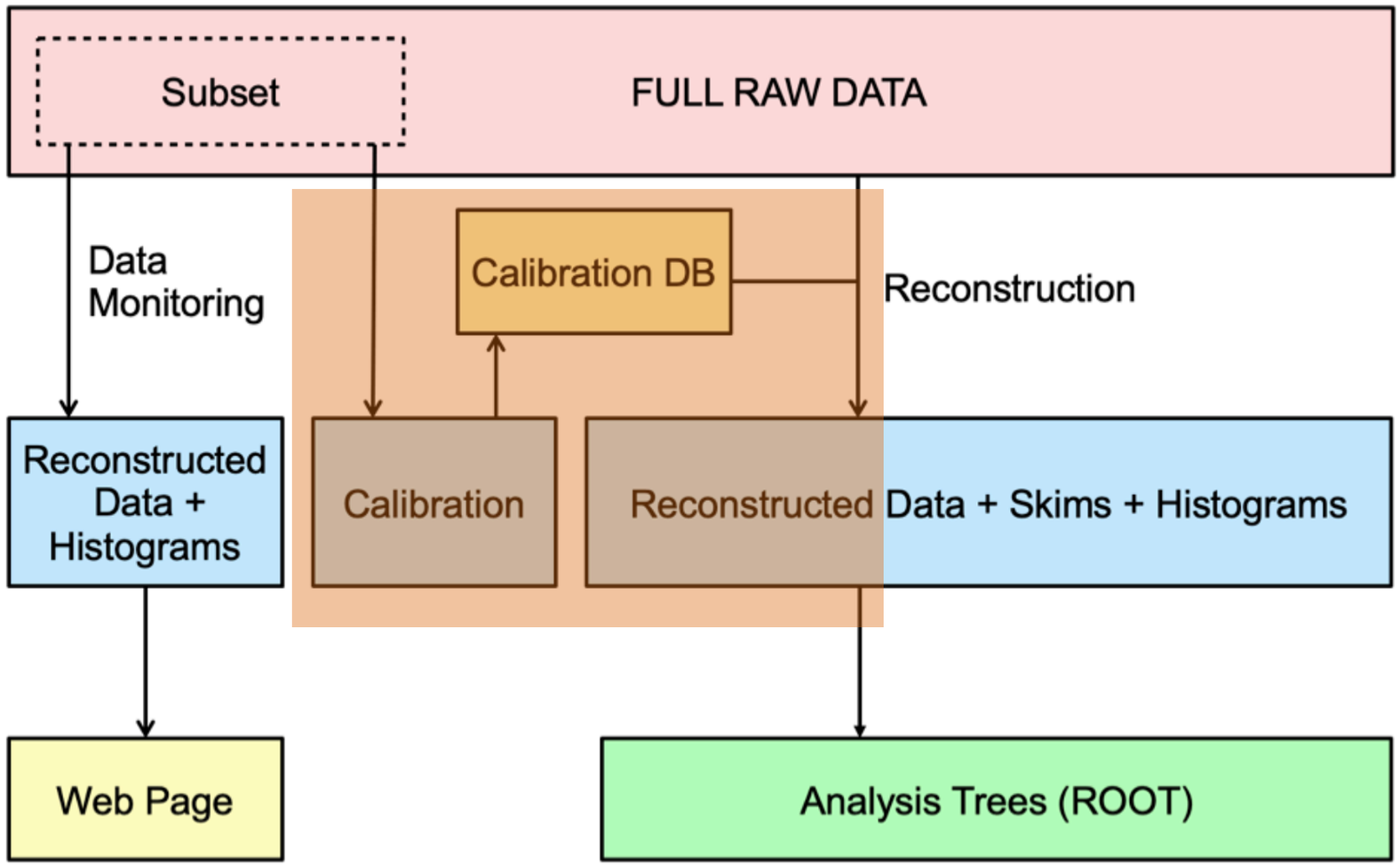
Sean Dobbs
Florida State U.

KLF IERR
Aug. 29, 2024

KLF Software Overview

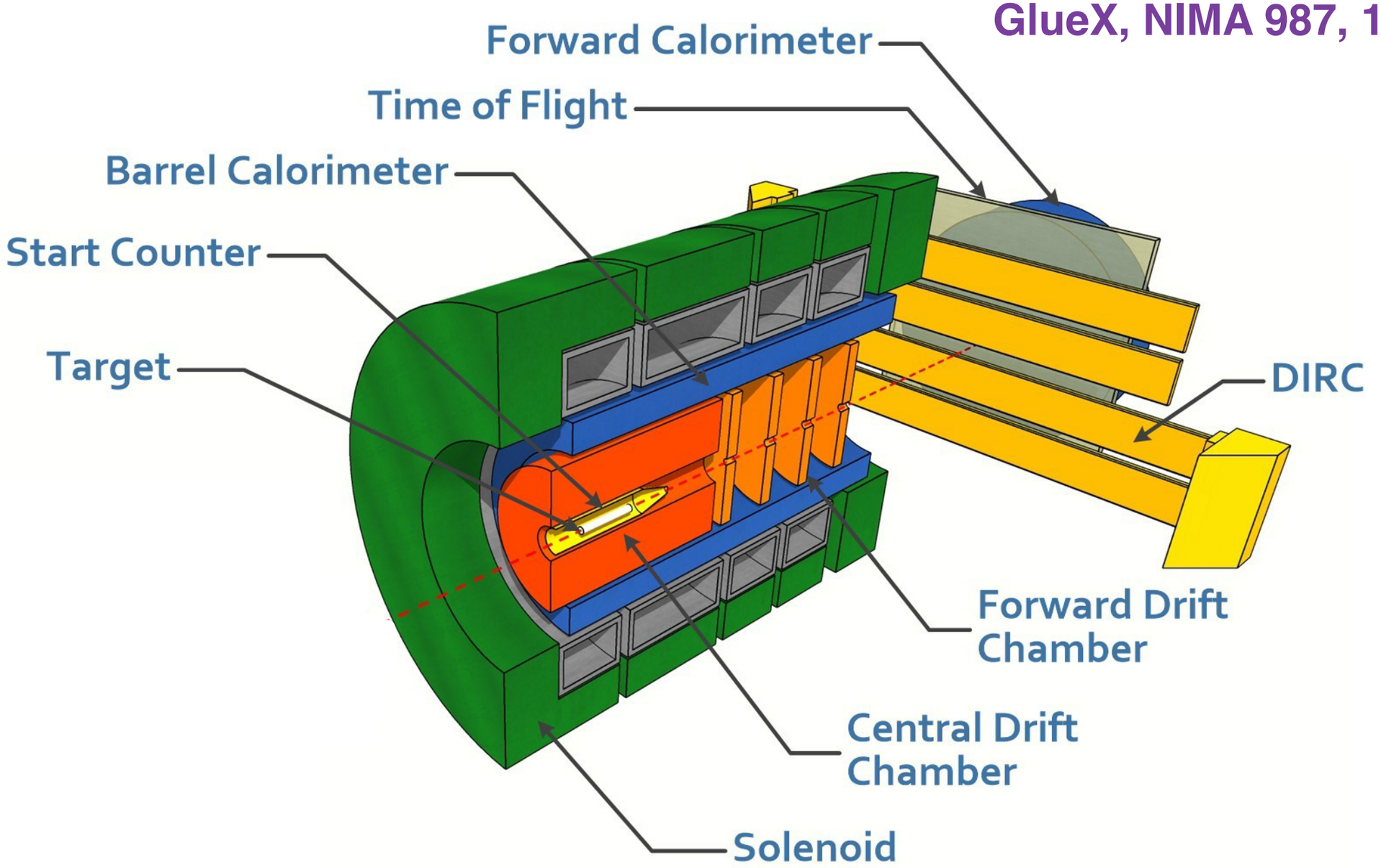
- KLF Software stack based on existing GlueX stack
- Detector generally stable and calibrations procedures well established
- Existing procedures have been adapted for KLF running

GlueX data flow



KLF Calibrations

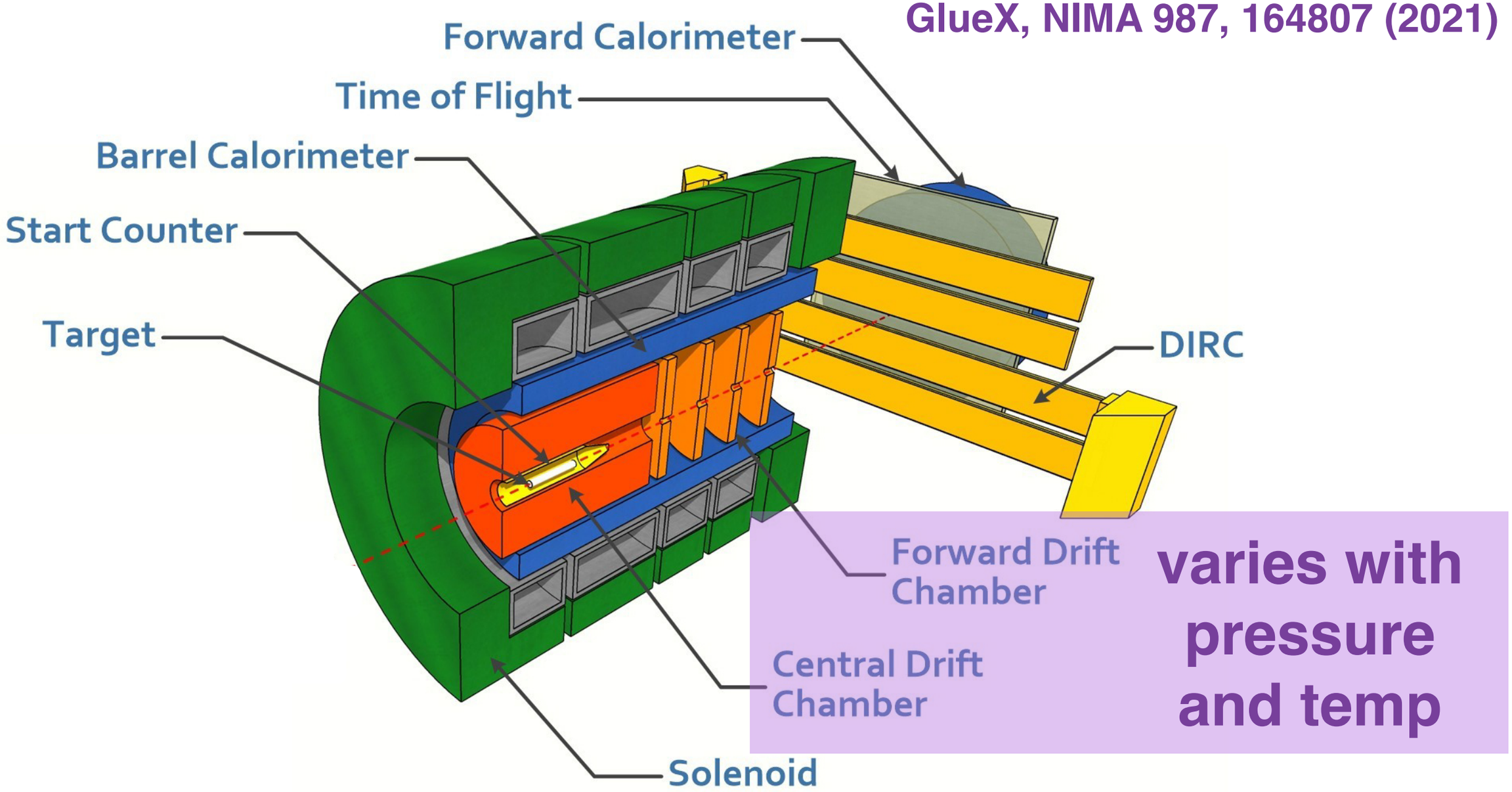
GlueX, NIMA 987, 164807 (2021)



- Subdetector calibrations require individual charged tracks or $\pi^0 \to \gamma\gamma$ decays, not exclusive reactions. Generally stable.

KLF Calibrations

GlueX, NIMA 987, 164807 (2021)

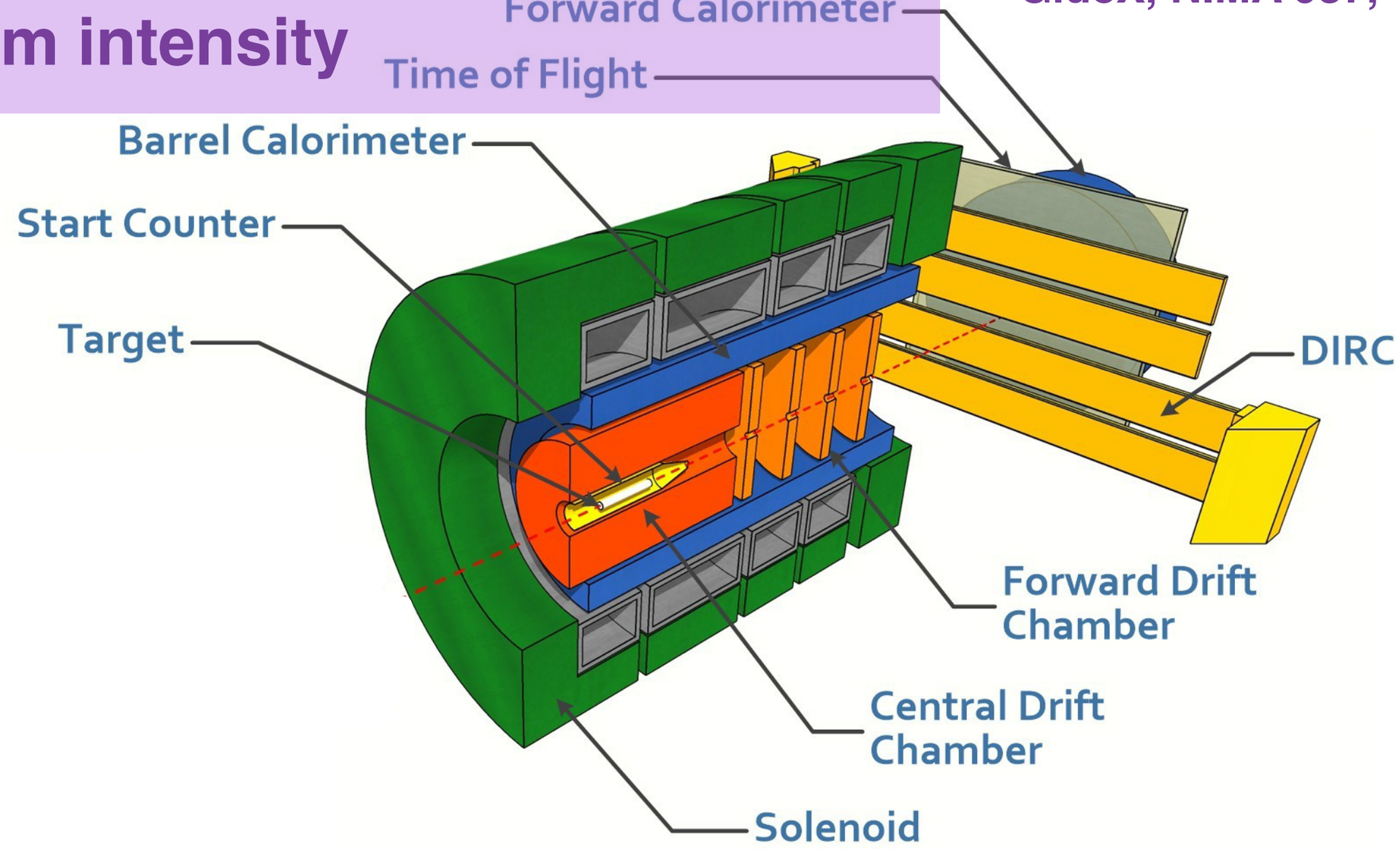


- Drift chamber calibrations vary with atmospheric conditions
- CDC drives 2 hour run time, partially corrected by RoboCDC

KLF Calibrations

beam intensity

GlueX, NIMA 987, 164807 (2021)



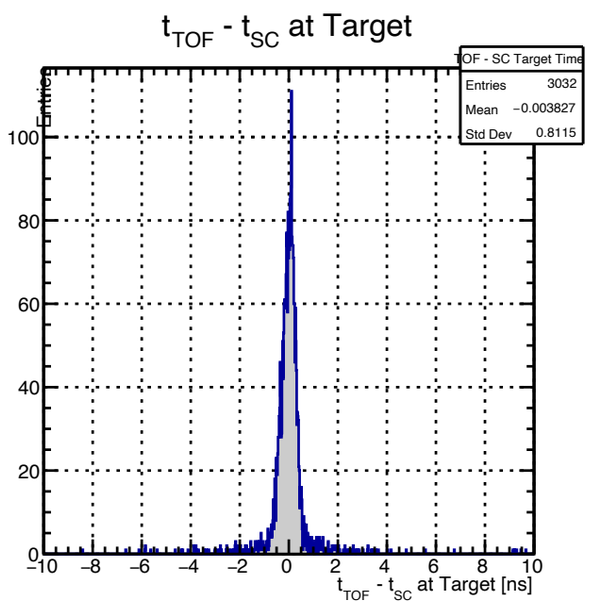
- Subdetector elements close to the beam line can have some dependence on beam intensity

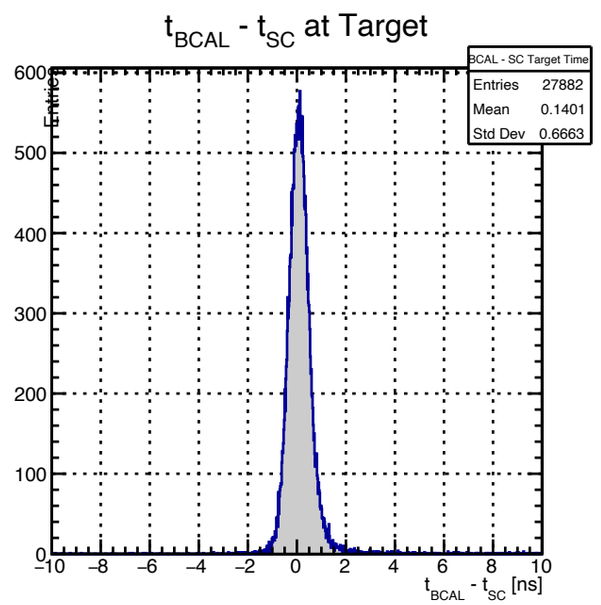
KLF Calibrations — Overview

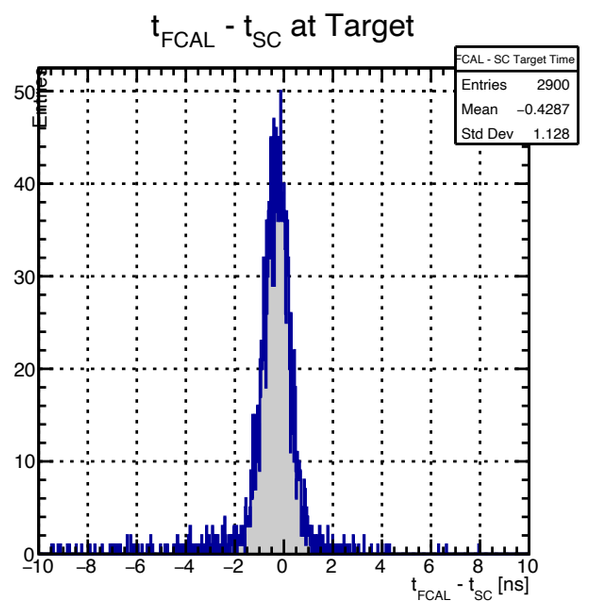
Detector	Procedure	Est. data required	Frequency
BCAL	per-channel timing	50M events	once
	attenuation length	1B events	once
	z-position	1B events	once
	gains	70M π^0's	monthly
	energy non-linearity	70M π^0's	monthly
CDC	per-channel gain	100M events	once
	overall gain, dE/dx	1M events	per-run
	time-to-distance	1M events	per-run
FCAL	per-channel timing	5M events	per-run
	gains	60M π^0's	weekly-monthly
	energy non-linearity	60M π^0's	weekly-monthly
FDC	per-channel timing	1M events	per-run
DIRC	timing	1M events	per-run
SC	timewalks	10M events	once
	propagation time	100M events	once
TOF	per-channel timing / timewalks	50M events	per-run/several runs
	gains / propagation speed	–	avg. over run
Overall	timing alignment	1M events	per-run

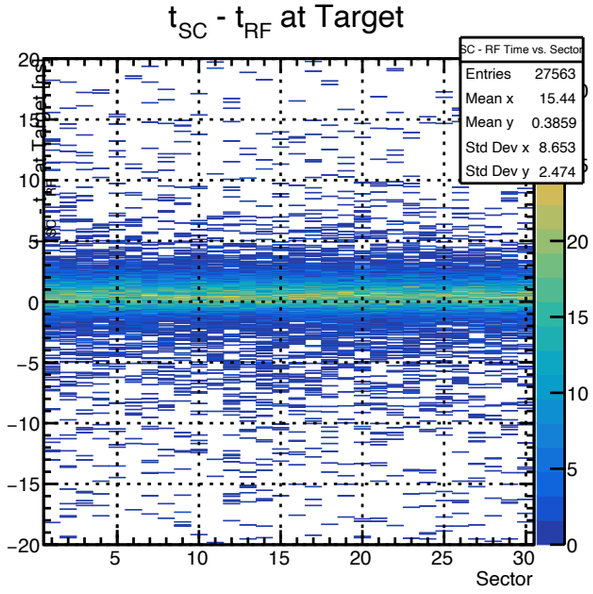
- Order of magnitude estimate for data required
- Expected KLF rates sufficient for calibrations

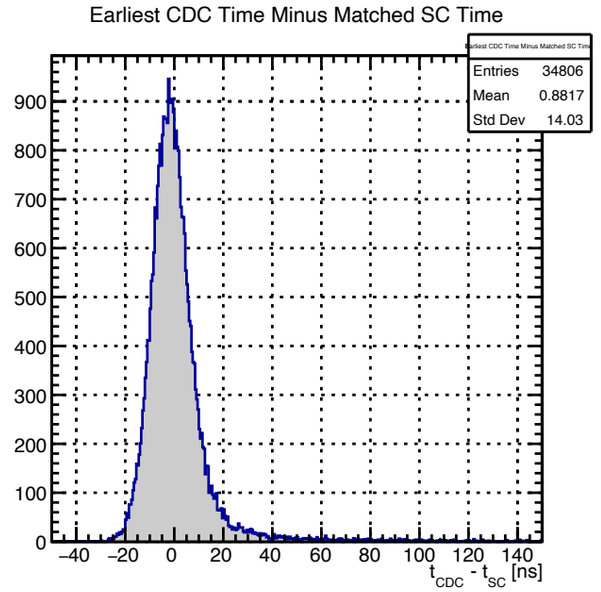
KLF Calibrations — Timing Alignment

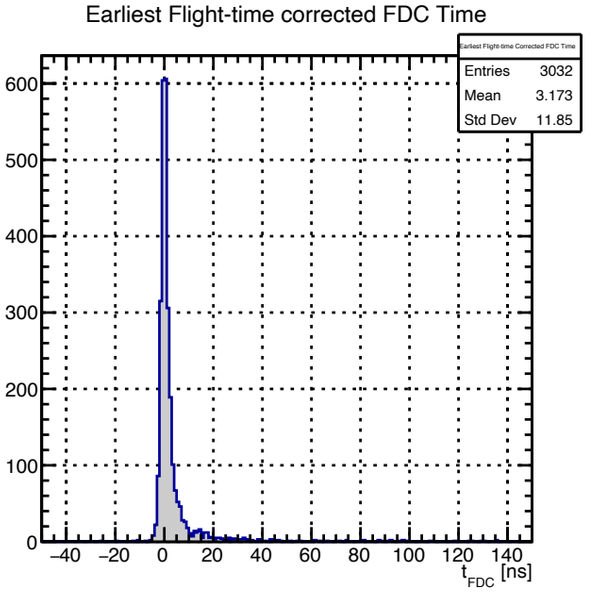










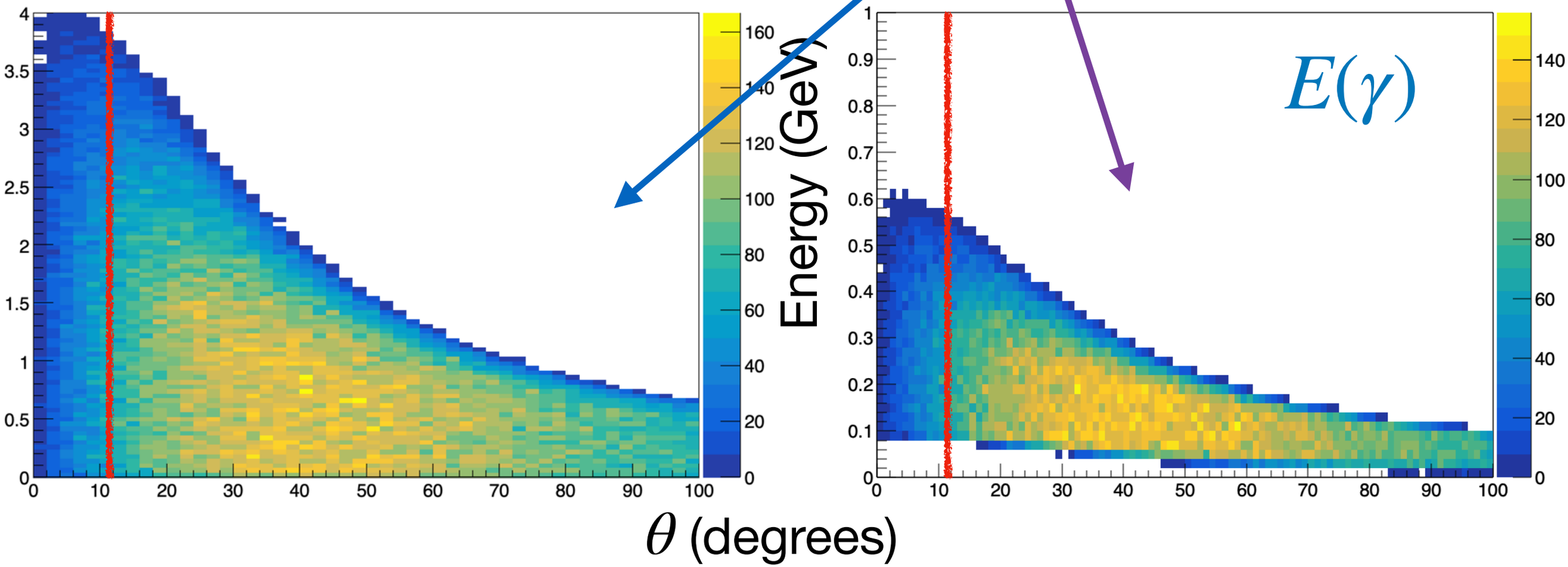


- Timing alignment between detectors with respect to ST works well for KL beam
- Example for $K_L p \rightarrow K_S p$ events

KLF Calibrations — Hyperon Photon Kinematics

$$K_L p \rightarrow \pi^0 \Sigma^+ \rightarrow \pi^0(\pi^0 p)$$

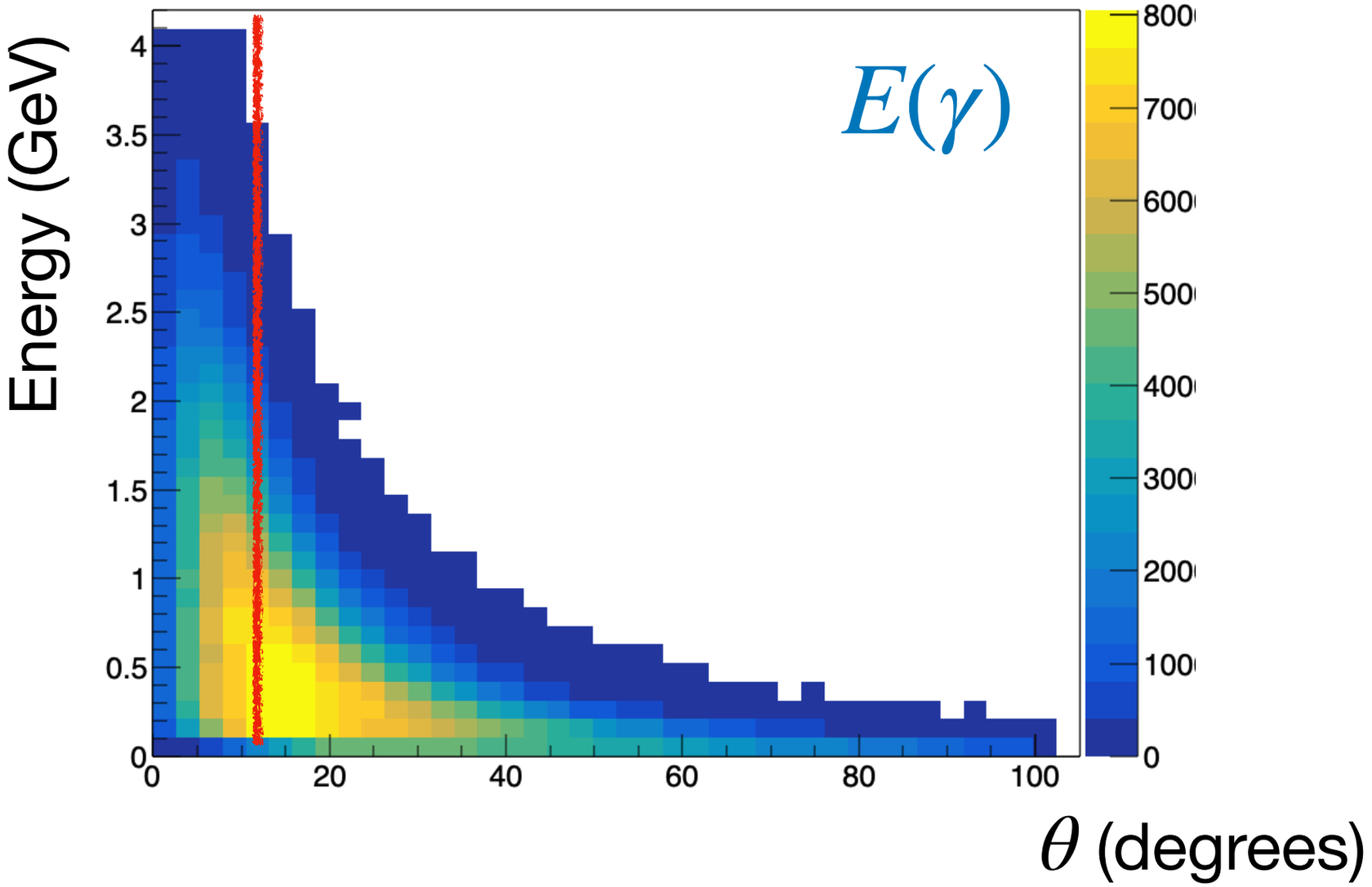
$\sqrt{s} < 3$ GeV



- Photons from hyperon decays cover large kinematic range, mostly in central detector

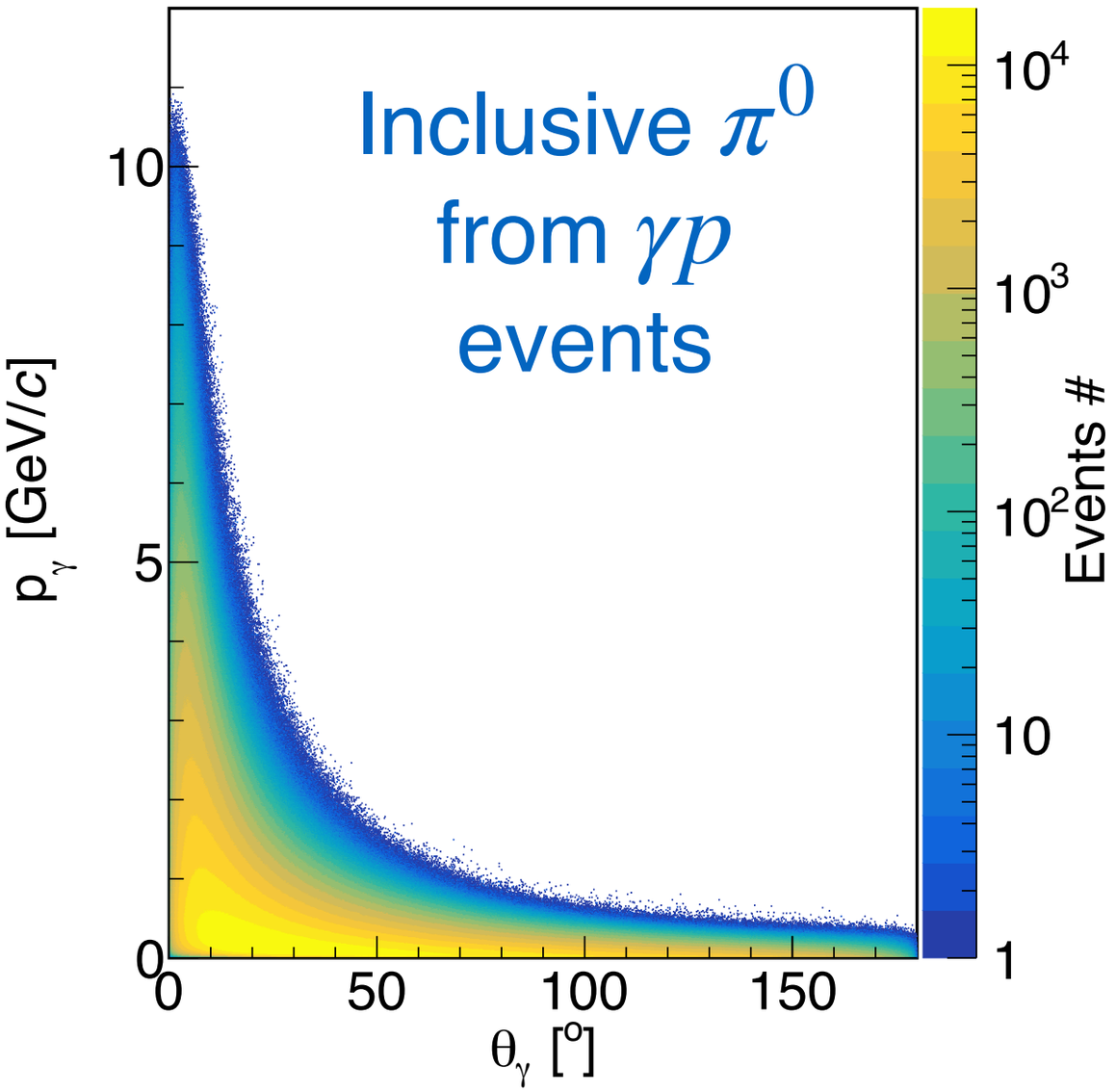
KLF Calibrations — $K\pi^0$ Photon Kinematics

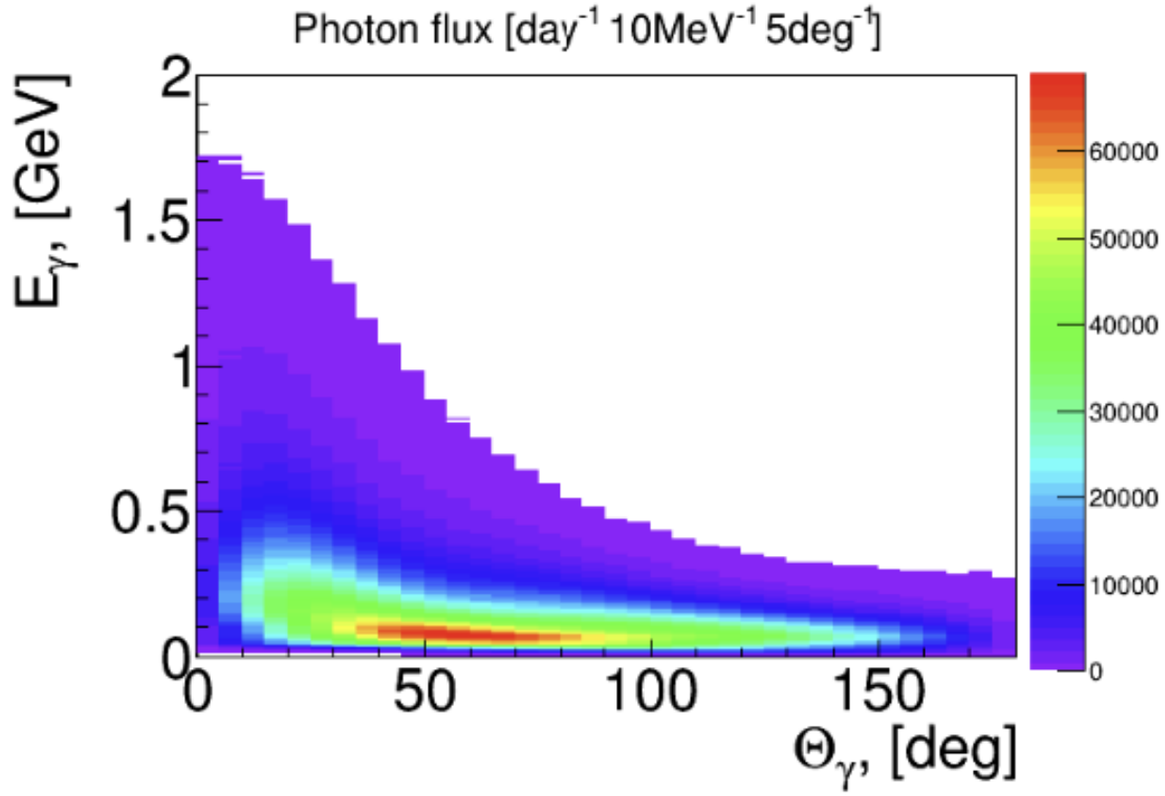
$$K_L p \rightarrow K^{*0}(892)p \rightarrow (K_L \pi^0)p$$



- Photons from $K\pi^0$ events go more forward

KLF Calibrations — π^0 Calibration Kinematics





$np \to np\pi^0$

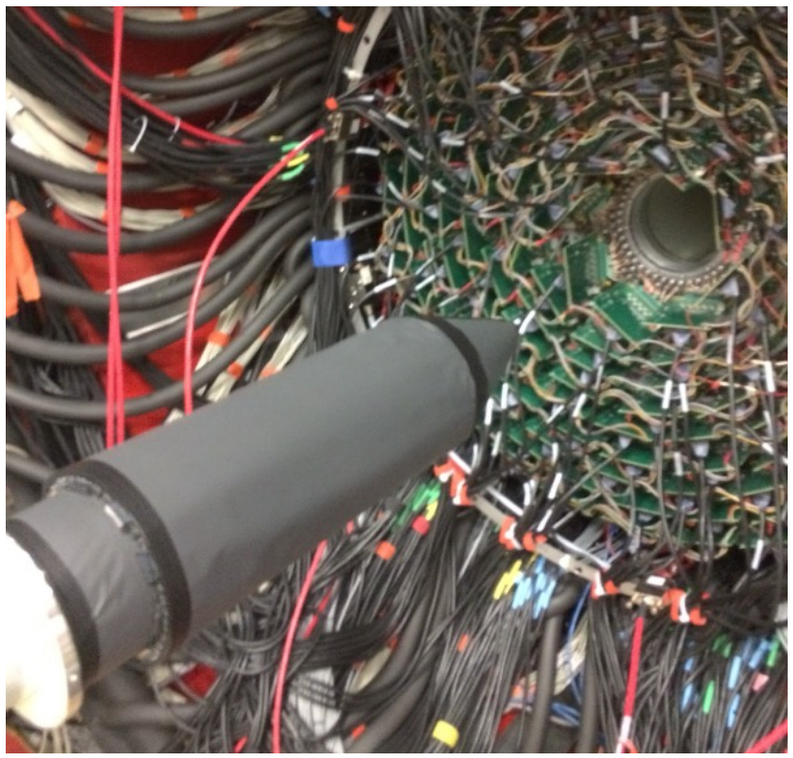
- Photons from π^0 produced in γp events cover full angular range, full energy range for nonlinearity corrections
- Photons from neutron-induced reactions excellent for gain stabilization

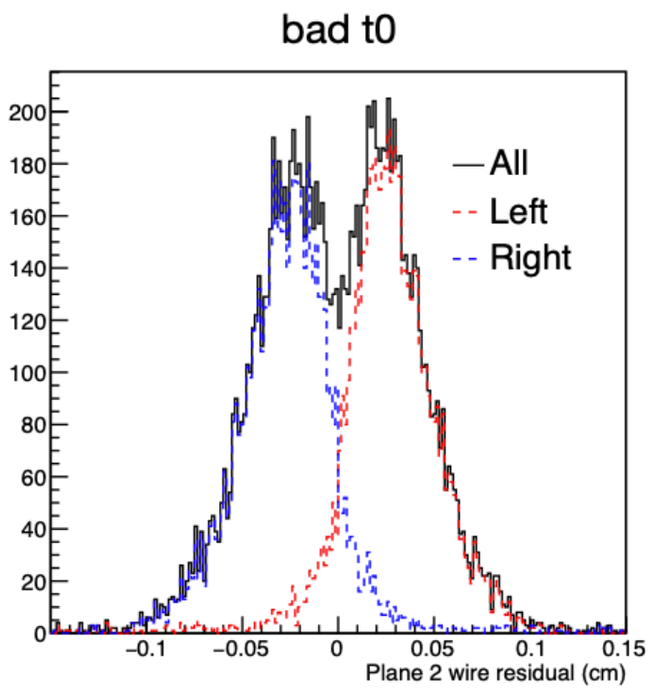
KLF Calibrations — Plan

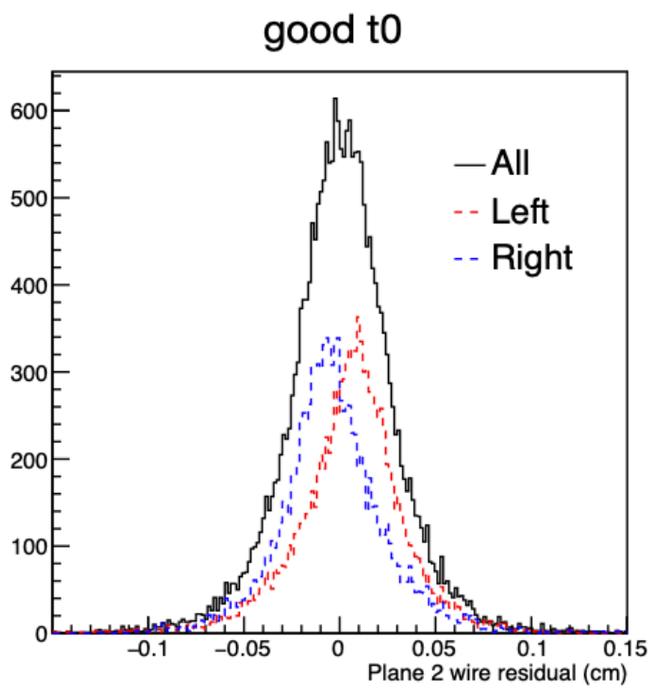
- Current calibration plan
  - Collect data during experiment commissioning using “low” intensity photon beam on cryotarget
  - Calibration of time-of-flight measurements from KPT
  - Perform all standard spectrometer calibrations, particularly calorimeter calibrations
  - Expected to require 3-4 days of beam time, depending on available beam intensity
- Use K_L beam events to monitor and refine calibrations

Detector Alignment for KLF

- Subdetector positions are stable over the years and regularly updated based on survey measurements
  - Example: Start Counter
- Detailed alignment of tracking elements performed using samples of data with solenoid on and off, using Millepede-based procedure
- Little to no run dependence observed so far, except for t_0

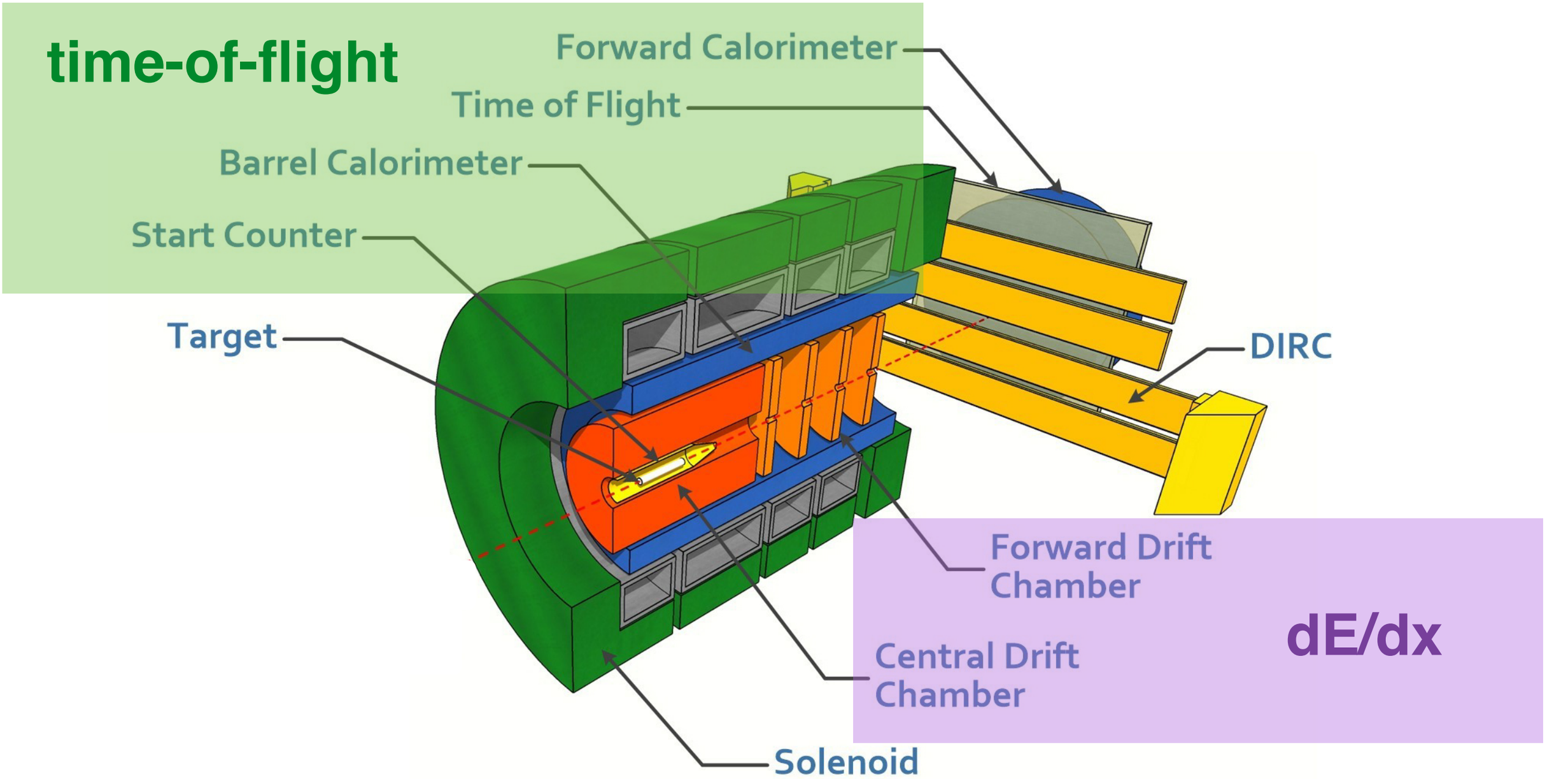






KLF Particle Identification

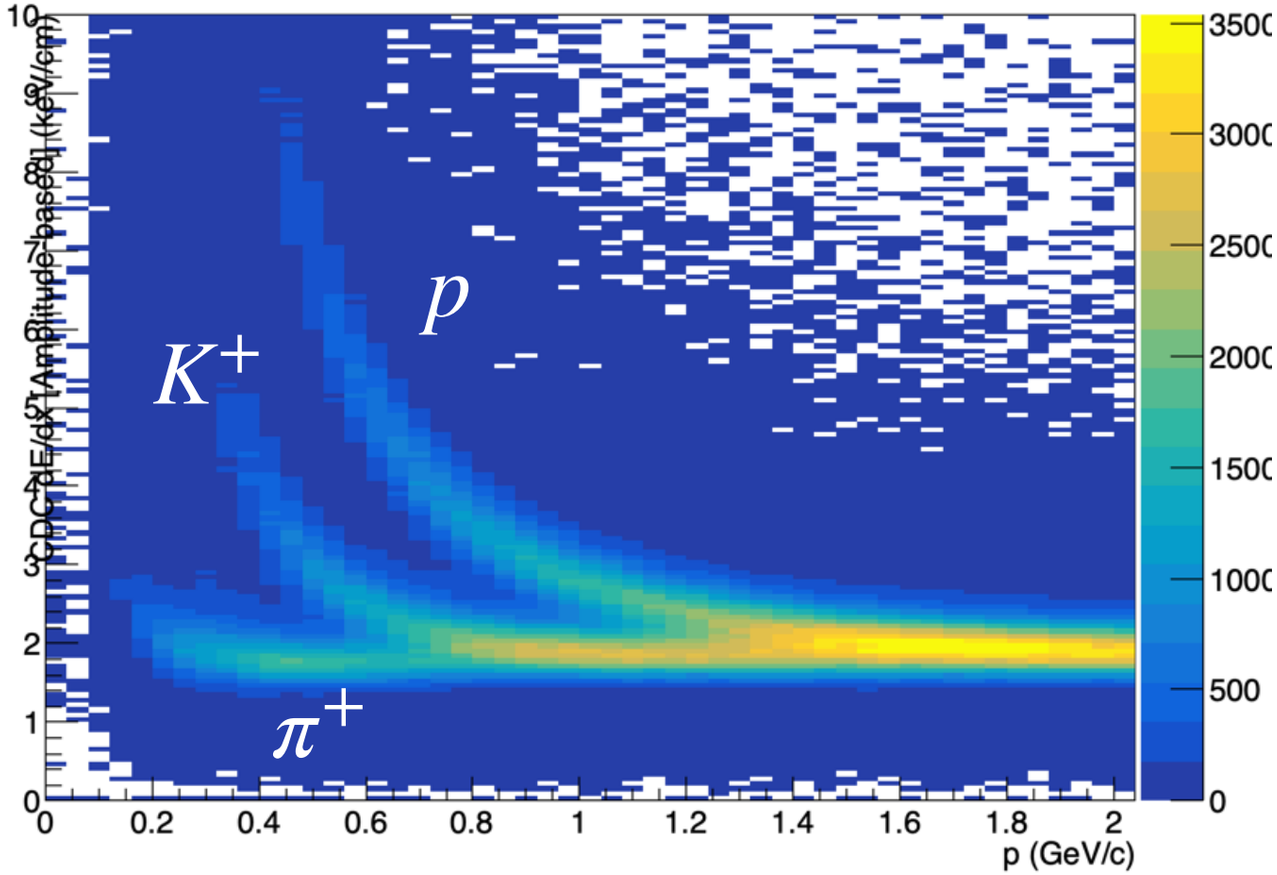
GlueX, NIMA 987, 164807 (2021)



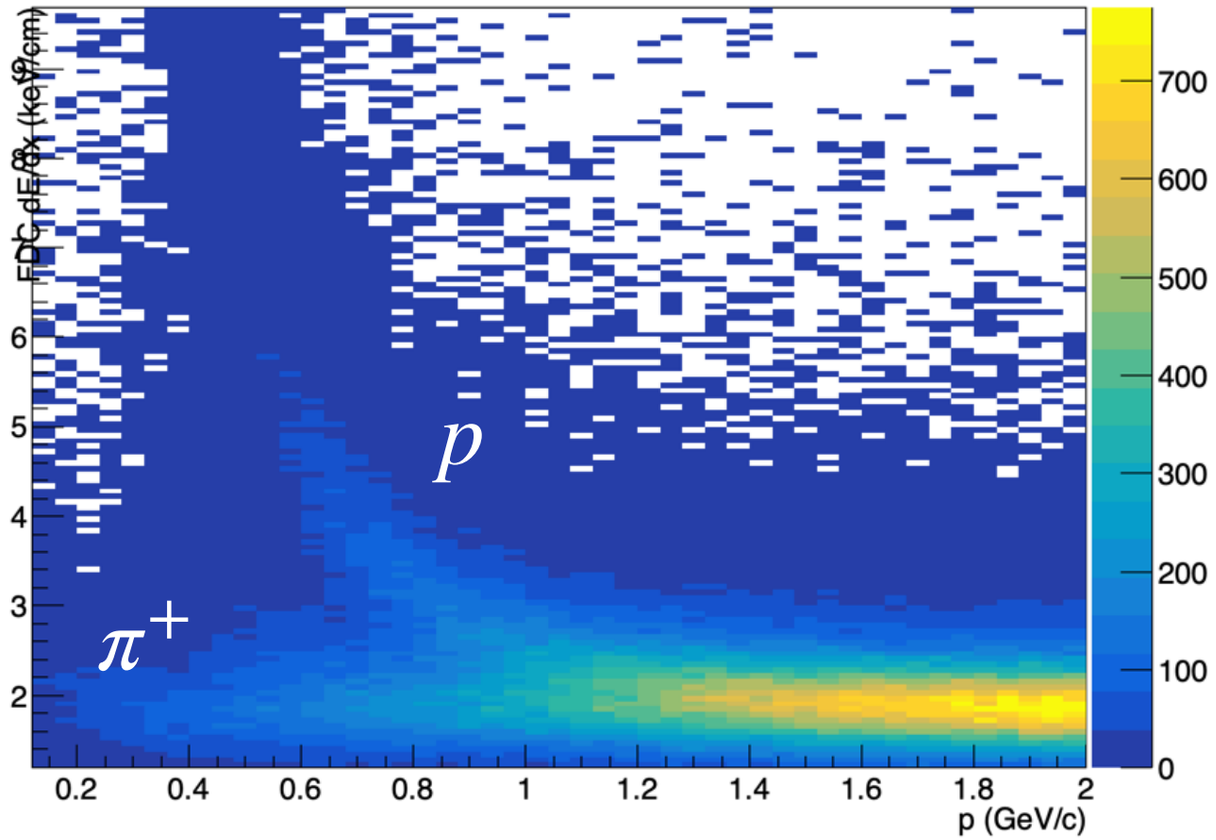
- Also identification of decays like $K_S \to \pi^+\pi^-$ and $\Lambda \to p\pi^-$

KLF Particle Identification — DC dE/dx

CDC dE/dx



FDC dE/dx

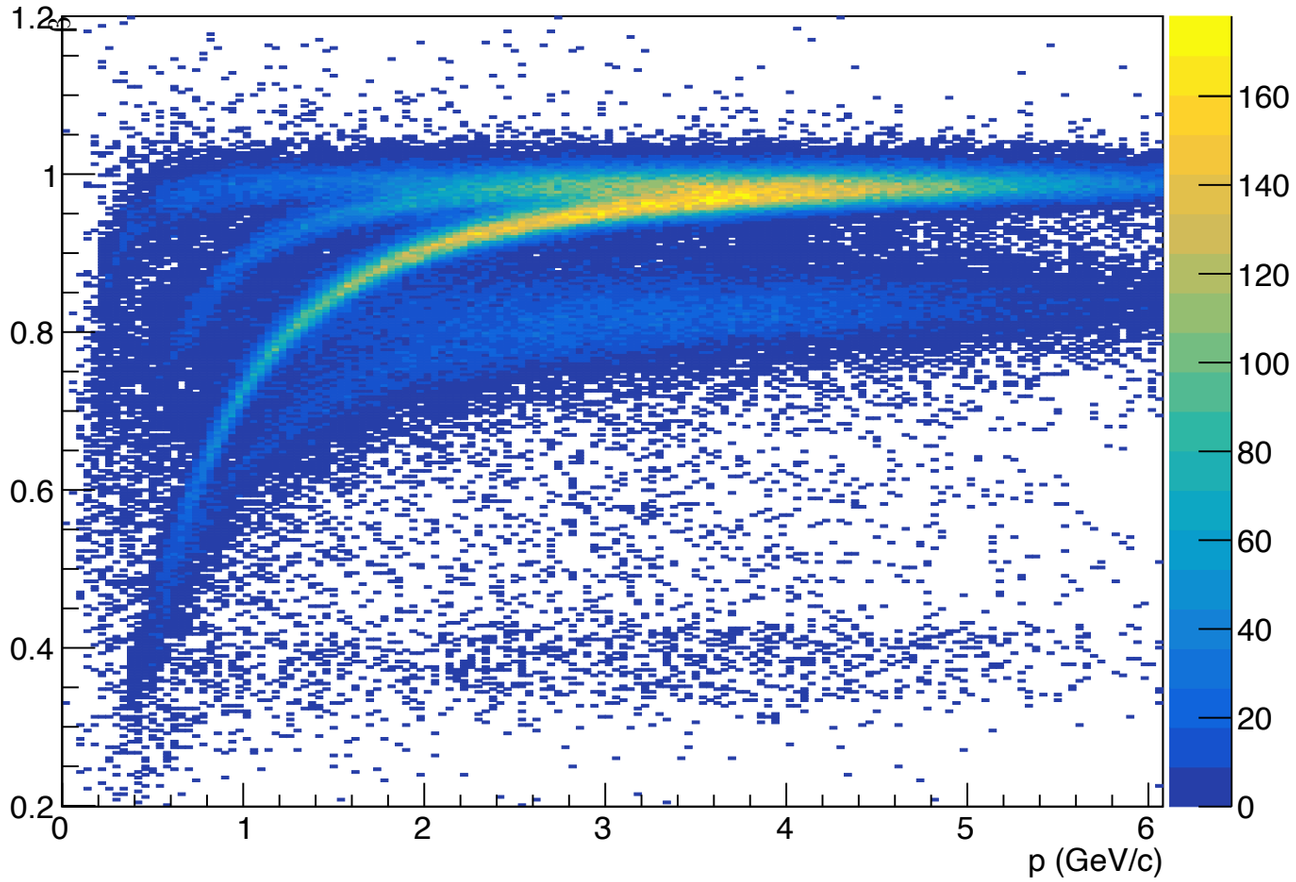


- CDC provides π/K separation up to ≈ 0.6 GeV and p/π separation up to ≈ 1.1 GeV
- FDC has less distinguishing power

KLF Particle Identification — Time of Flight

BCAL β

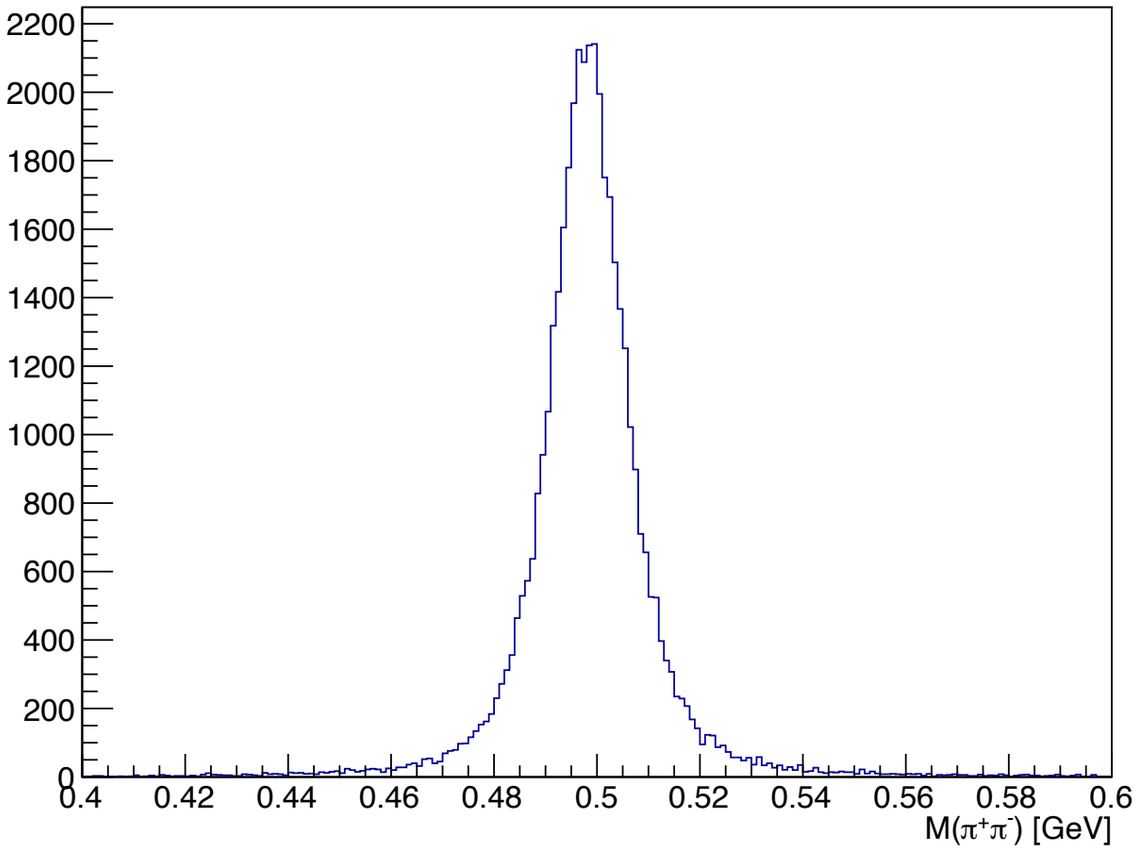
TOF β



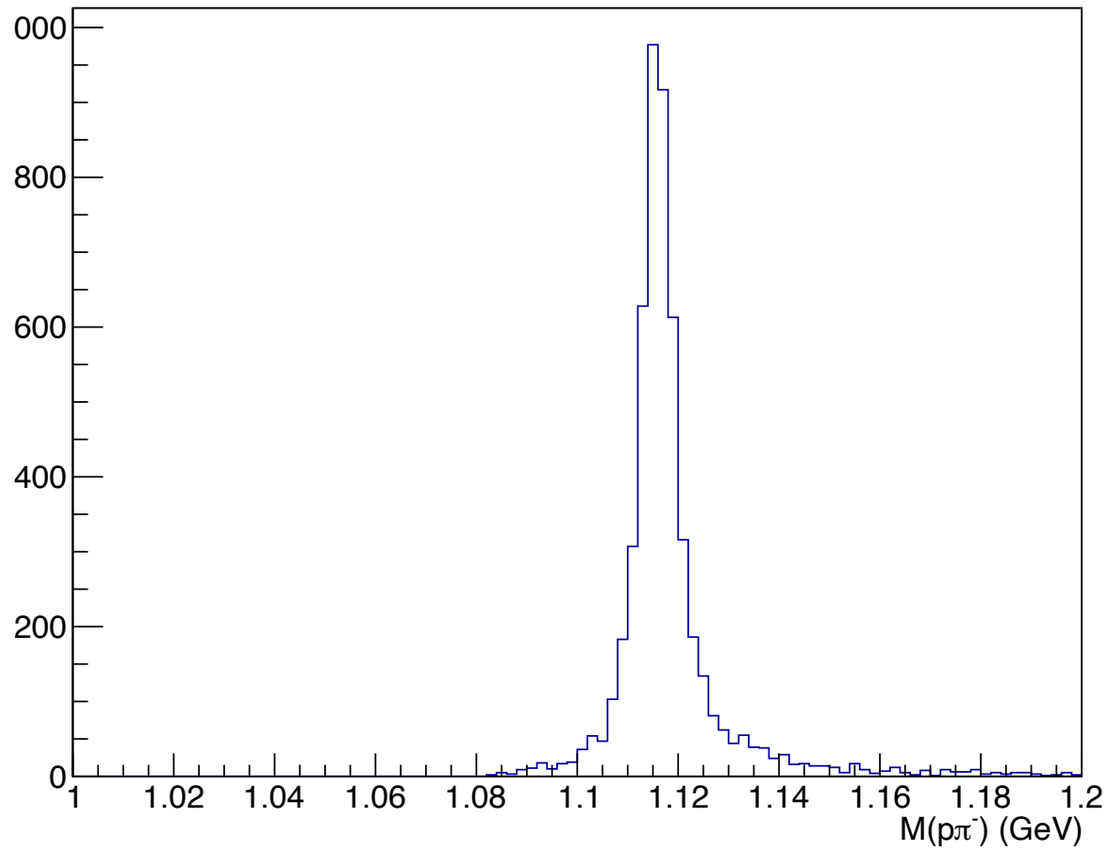
- TOF provides π/K separation up to ≈ 1.5 GeV and p/π separation up to ≈ 2.5 GeV

KLF Particle Identification — Strange Particle Decays

$K_S \to \pi^+\pi^-$



$\Lambda \to p\pi^-$



- Also identification of decays like $K_S \to \pi^+\pi^-$ and $\Lambda \to p\pi^-$

Summary

- KLF software based on well-tested GlueX software stack
- Calibration plans follow known GlueX procedures
  - Considering collecting data with photon beam during experiment commissioning
  - Existing procedures work well with K_L beam data
- Detector alignment procedures well developed and stable
- Particle ID based on dE/dx and TOF
  - DIRC will provide additional discrimination for forward particles
  - Reconstruction of intermediate resonances additional tool for many channels