CLAS12 PID

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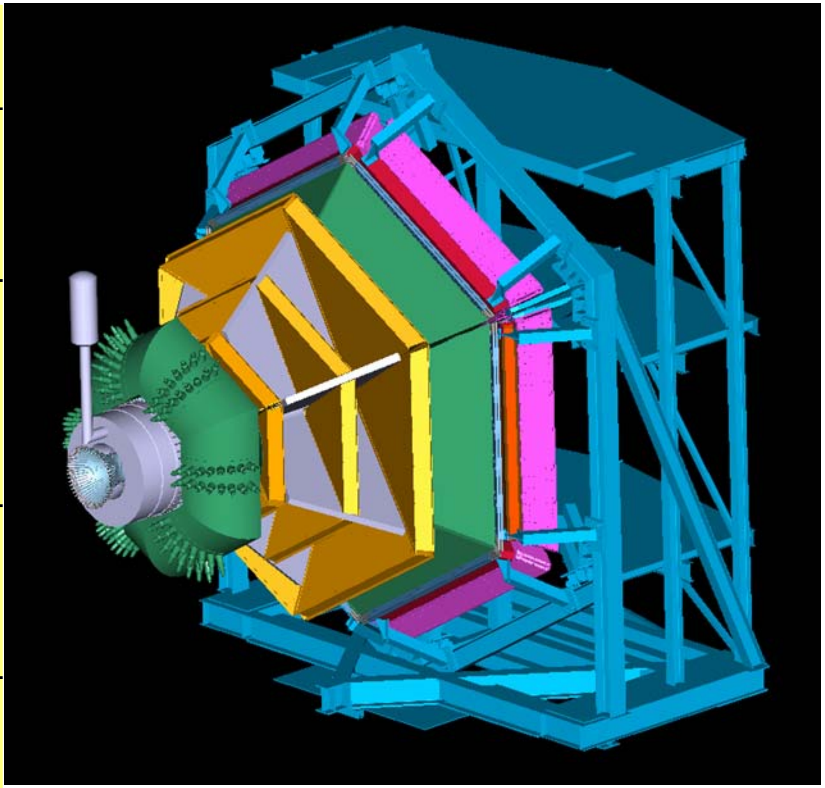
CLAS12 RICh, Jefferson Lab, January 28-29 2008

- CLAS12 and PID detectors
- Charge hadron identification in forward region
- Neutral particle detection and identification
- e/π separation
- Charge hadron identification in the central detector

CLAS12

	Forward detector	Central detector
Angle range		
tracks	**$5^0 - 40^0$**	**$42^0 - 135^0$**
photons	**$3^0 - 40^0$**	**NA**
Resolution		
dp/p	**0.005-0.01**	**$dp_T/p_T = 0.02$**
$\delta\theta$ (mr)	**< 1**	**< 8**
$\delta\phi$ (mr)	**< 3**	**< 2**
Photons	**E>0.2 GeV**	
dE/E	**$0.1/ E^{1/2}$**	**NA**
$\delta\theta$ (mr)	**4 (@ E=1GeV)**	**NA**
Neutrons		
efficiency	**0.1 to 0.75**	**0.05**



Geared towards deeply exclusive and inclusive electroproduction reactions

Detectors used for PID

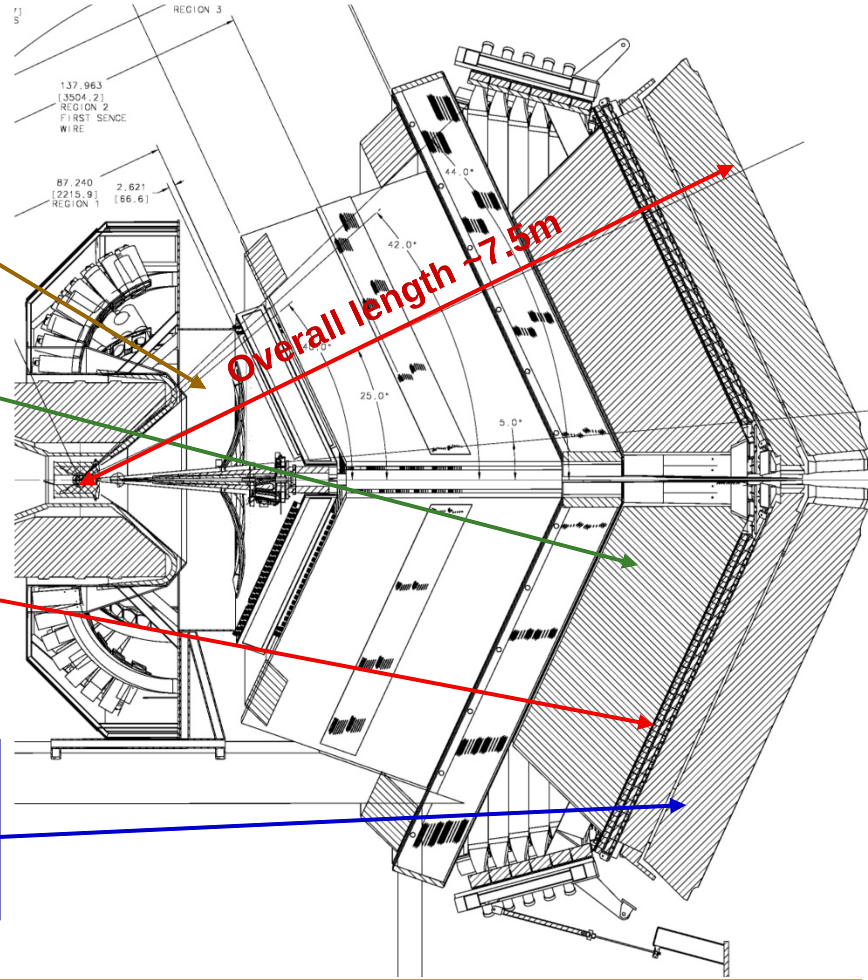
CLAS12, Sector mid-plane

High Threshold Cherenkov Counter (HTCC) for e/π separation, $P_{th}^{\pi} > 4.7\ GeV/c$

Low Threshold Cherenkov Counter (LTCC) for (p,K)/π separation, $P_{th}^{\pi} > 2.7\ GeV/c$

Scintillator counters (TOF) @ ~650cm from the target, 2 planes with time resolutions of 80ps and 150ps, for charged hadron ID

Electromagnetic calorimeters (PCAL&EC), 54 layers of lead and scintillators, for e/π separation and (γ,n) detection

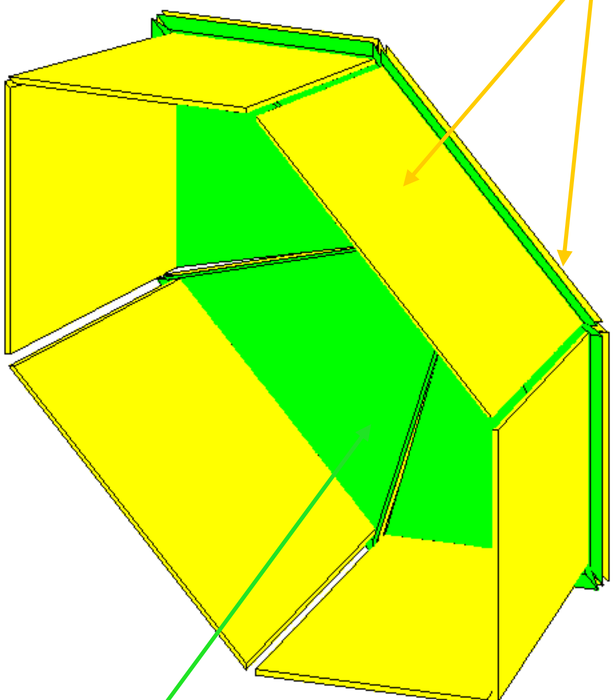


Cherenkov counters

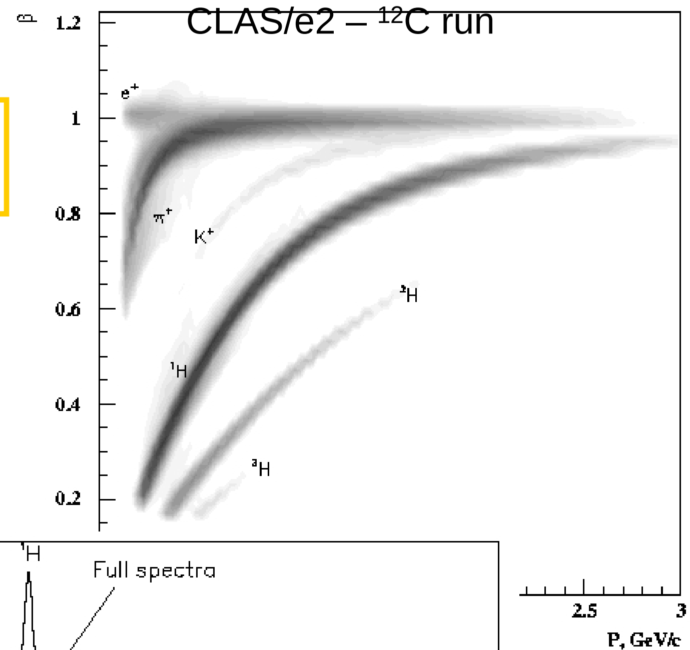
HTCC (new detector):		
Working gas	CO_2 @ 1 atm	e/π separation at P < 4.9 GeV/c
Angular coverage	8^o to 35^o	Will be used in the trigger
Mirror type	Ellipsoidal	
e-threshold	15 MeV	
π-threshold	4.9 GeV	
LTCC (existing detector, will be modified)		
Working gas	C4F10 (or C4F8O)	Aids e/π separation at P < 2.6 GeV/c
Angular coverage	8^o to 35^o	π/K and π/p separation P > 2.6 GeV/c
Mirror type	Ellipsoidal/hyperbolical	
e-threshold	10 MeV	
π-threshold	2.6 GeV	
K-threshold	9.3 GeV	

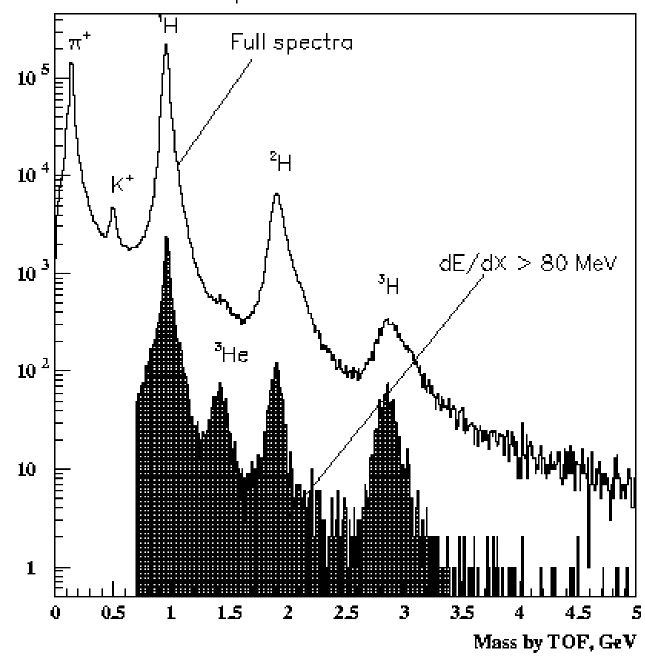
Forward TOF

Existing TOF counters, time resolution σ_t=150ps-180ps



New TOF plane, will have better time resolution (σ_t=80ps) and will be located farther from the target

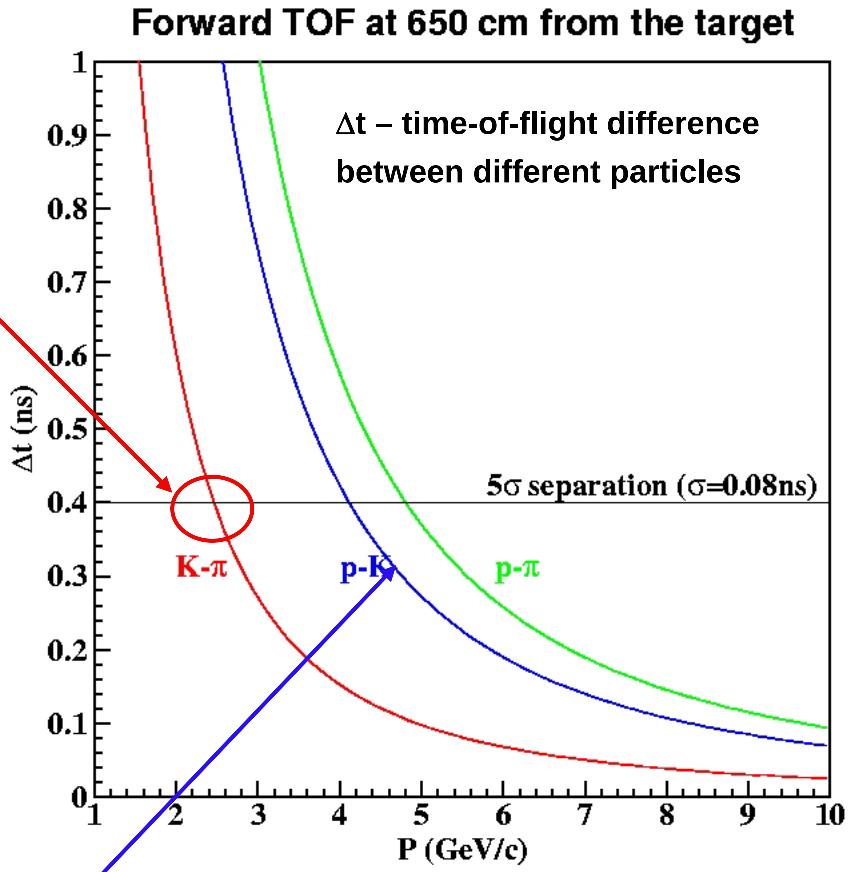




Charged hadron ID: forward detector

Pion detection threshold in LTCC (P=2.7 GeV/c)

CLAS12 fTOF with 80ps – 100ps time resolution, together with LTCC, is well suited for π/K and π/p separation in the kinematical range accessible with 11 GeV beams



What about p-K separation above ~5 GeV/c!

Technically, there is a gap in that region of CLAS12 PID, BUT ...

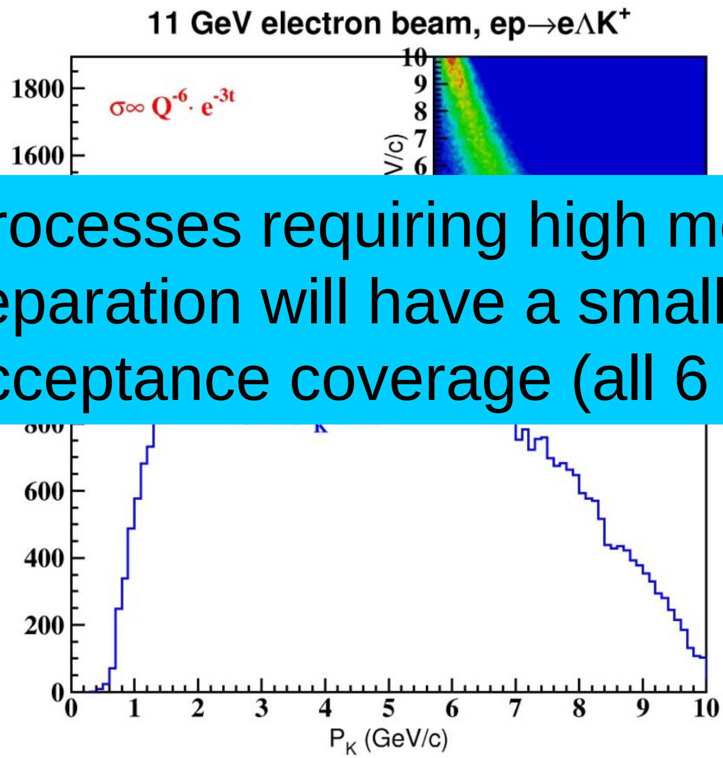
(K$^+$,p) kinematics at 11 GeV

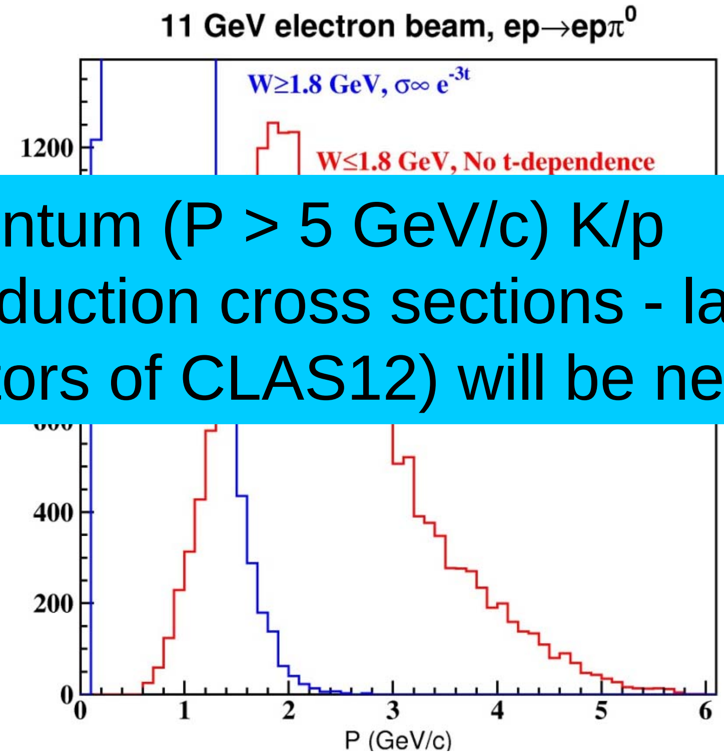
High energy kaons will be produced at small momentum transfer (*t*) in the processes such as e.g. KY or KKN

In high energy diffractive processes production of energetic recoil nucleon is highly suppressed

$$-t = 2m_p T_p$$

at $P_p = 4.5 GeV/c,\ -t \approx 8(GeV/c)^2$

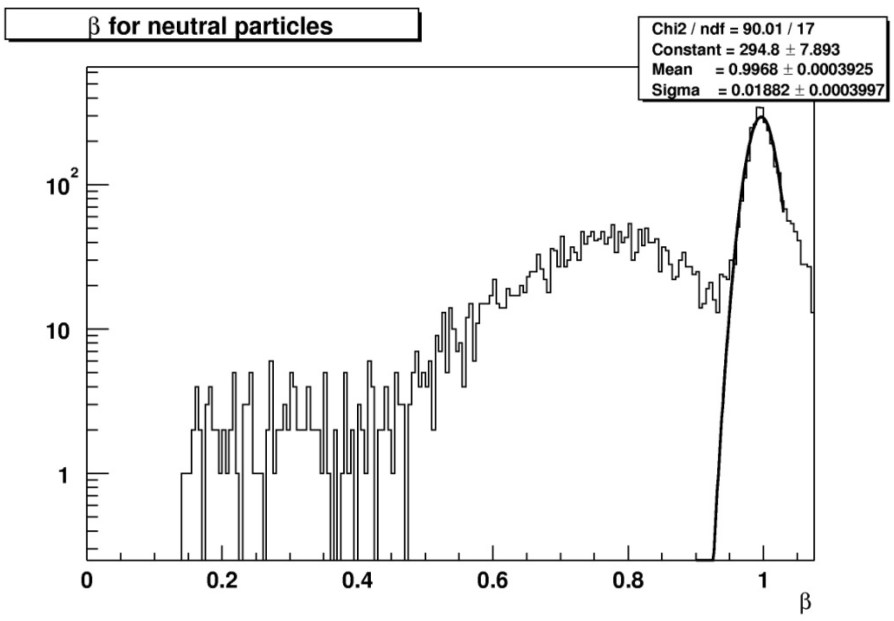




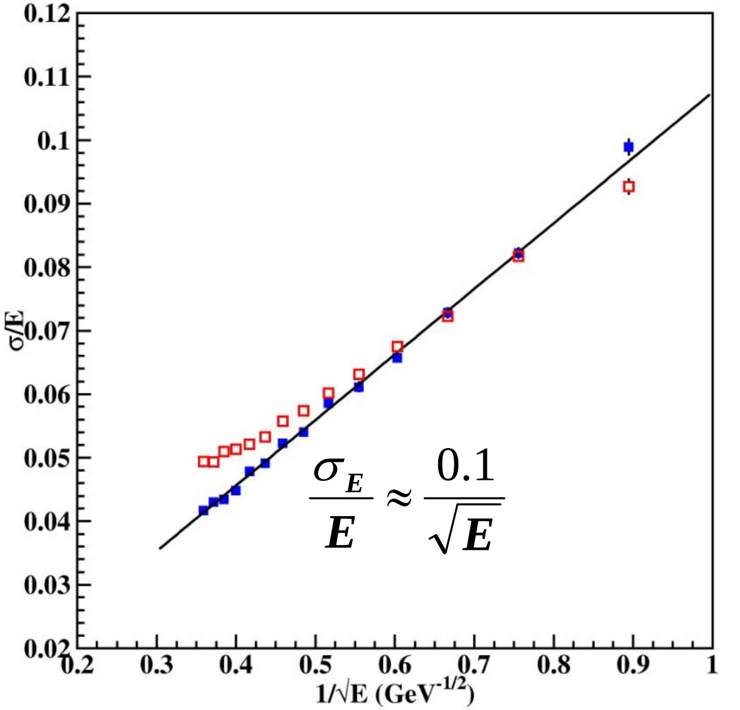
Processes requiring high momentum (P > 5 GeV/c) K/p separation will have a small production cross sections - large acceptance coverage (all 6 sectors of CLAS12) will be needed

Neutron, γ, and π^0 detection

For neutron identification and momentum measurements, time-of-flight from the target to EC planes will be used. At time resolution ~0.3ns – 0.4 ns neutrons with P<3 GeV/c can be identified



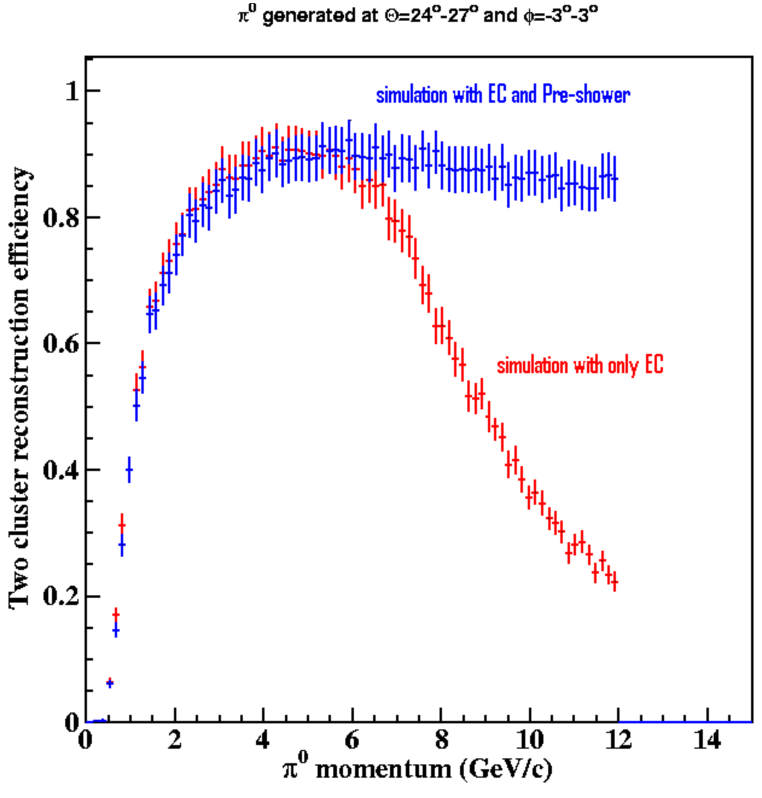
Added pre-shower calorimeter (PCAL with 15 lead-scintillator layers) will allow to retain good energy resolution for up to 11 GeV/c



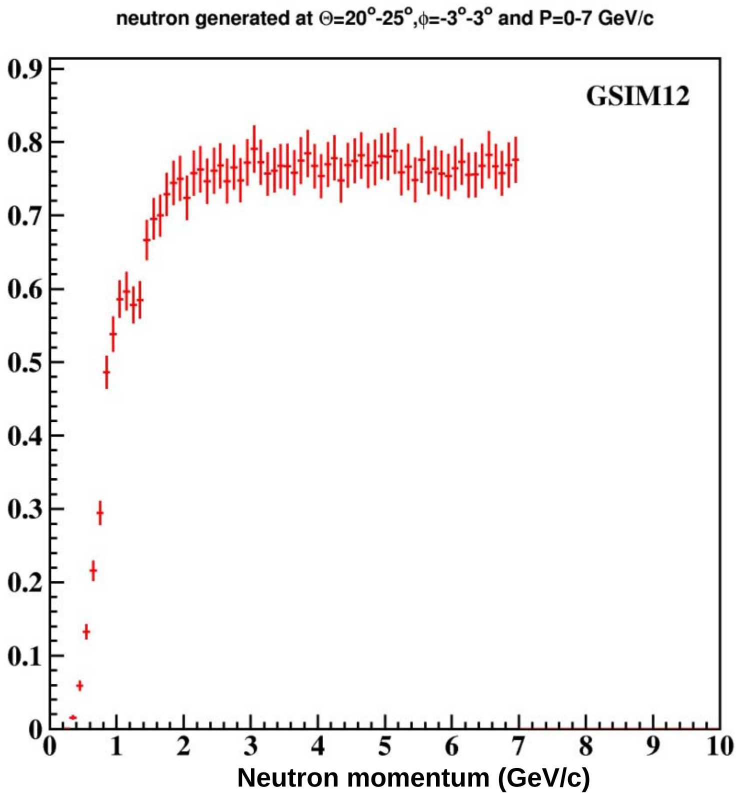
$$\frac{\sigma_E}{E} \approx \frac{0.1}{\sqrt{E}}$$

Neutron, γ, and π^0 detection in PCAL+EC

Two cluster reconstruction from high energy $\pi^0 \rightarrow \gamma\gamma$ decays

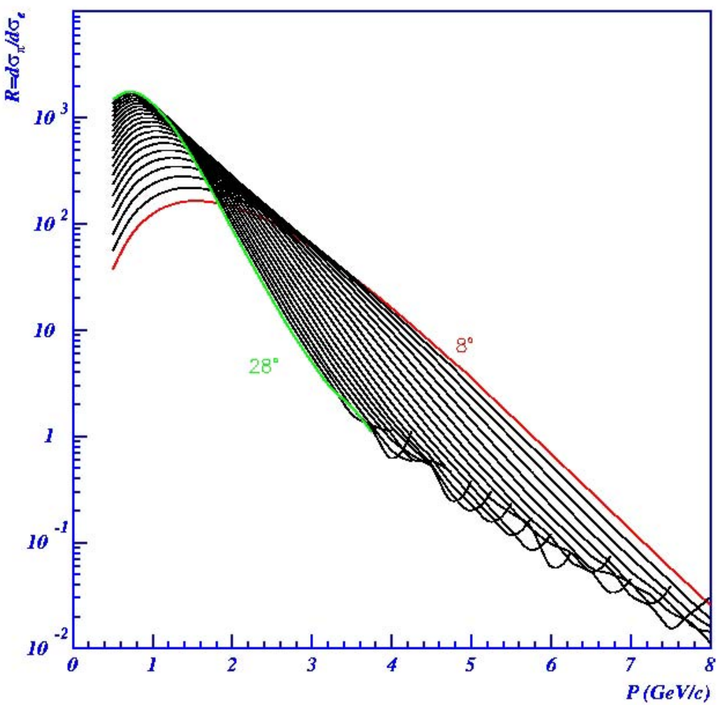


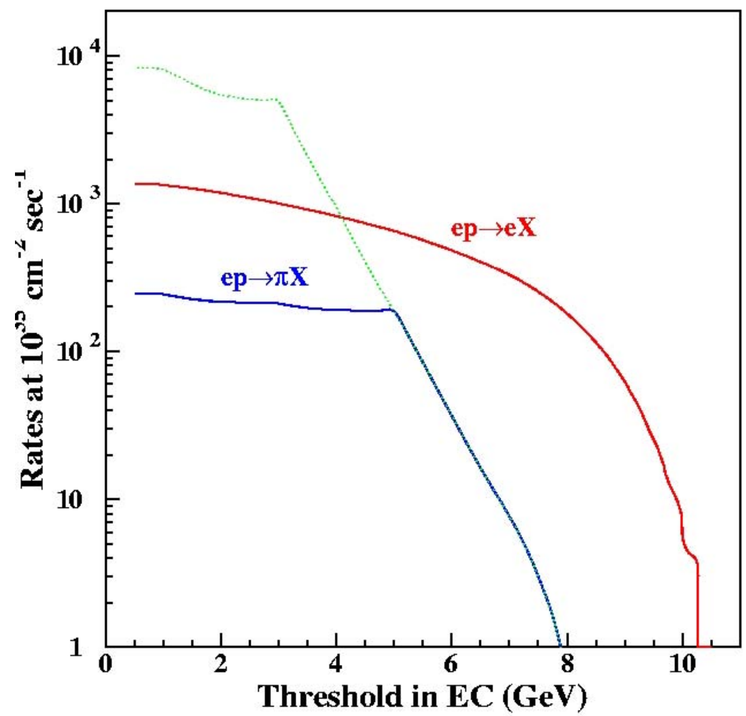
Neutron detection efficiency



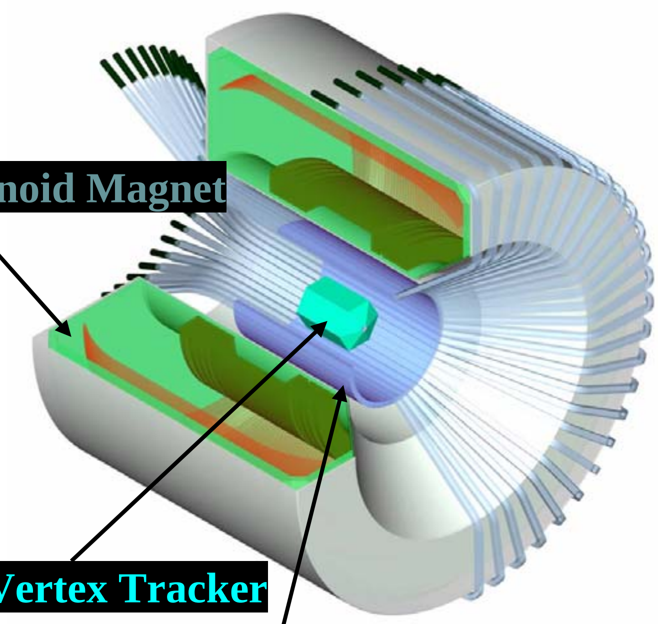
e/π separation

- LTCCxHTCCxEC for P < 2.7 GeV/c (will be used in the trigger)
- HTCCxEC for P < 4.9 GeV/c
- EC for P > 4.9 GeV/c (will require π/e rejection better than 1%)

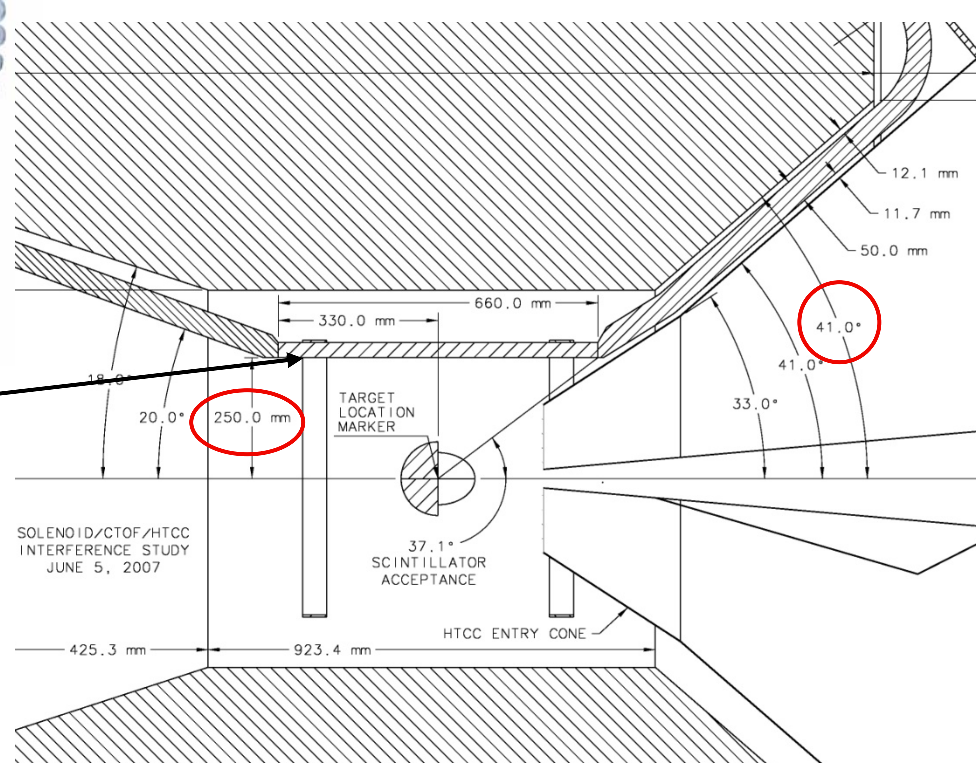




Central detector



Will be used in multi-particle, semi-exclusive final states, PID is important for pion-kaon separation

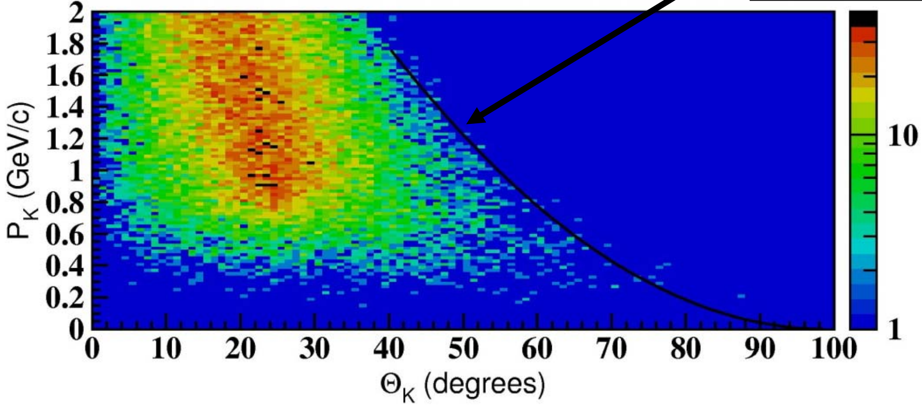


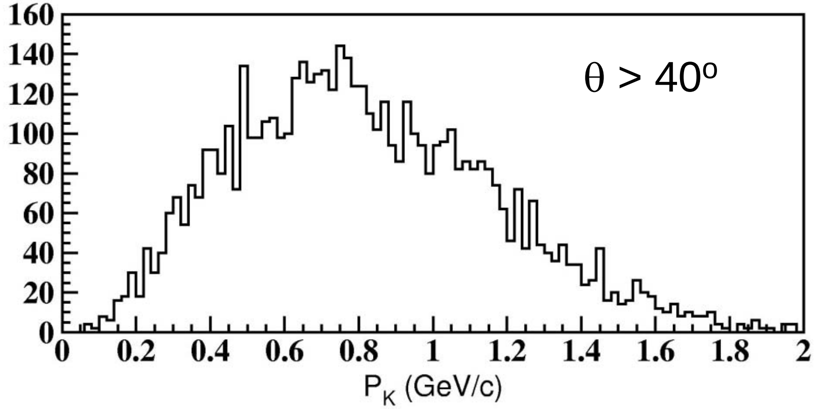
Charged hadron ID: central detector

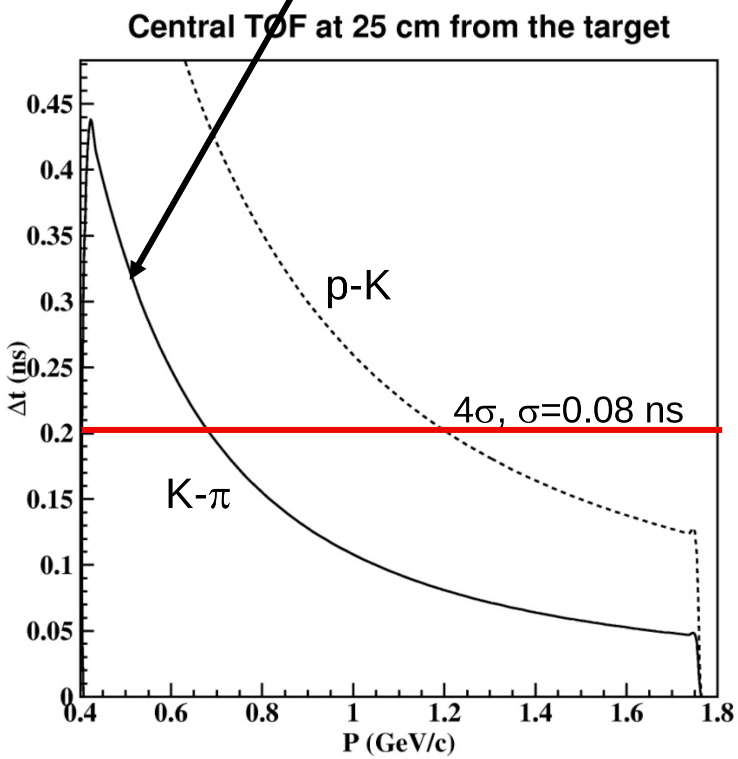
$ep \to pK^+K^-$, $\sigma \sim e^{-3t}$

$$P_{max} = P(\vartheta)$$

$$t = \frac{L(\theta)}{\beta(P_{max})}$$







p/K separation at P > 1.2 GeV/c is not a problem, in most cases recoil nucleon will be detected.

π/K at P > 0.7 GeV/c is an issue, background to KK final states comes from ππ production

Summary of CLAS12 PID

- Charged hadrons:
  - fTOF (L>650 cm, σ_t < 100 ps) and LTCC (P_π>2.7 GeV/c) cover the full range of kinematics for π/K and π/p separation
  - fTOF will provide 3σ - 4σ K^+/p separation for P<5 GeV/c, above 5 GeV/c - proton yield is expected to be insignificant
  - cTOF (L=25 cm – 40 cm, σ_t = 50 ps), good for π/K separation for P < 0.7 GeV/c
- Neutrons and photons will be detected and identified in PCAL-EC
  - neutron detection efficiency 0.1 to 0.75, ID range P < 3 GeV/c
  - photons will be detected with good energy resolution for up to 11 GeV
- Excellent π/e separation for P<4.9 GeV/c, for P > 4.9 GeV/c - ~1%

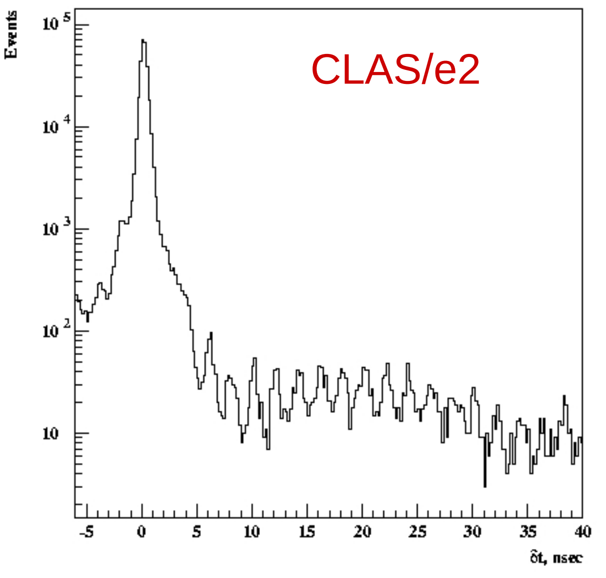
Well designed system

RICH for CLAS12

- For the forward detector, if covers the full acceptance region (all 6 sectors)
  - can improve overall PID quality
  - will provide K^+/p separation for P>5 GeV/c for specific, low cross section processes
  - will help to suppress accidentals

Two proton events from CLAS/e2 carbon run. Protons identified using energy loss in TOF counters.

δt – time between the electron and proton in the event



- For the central detector, in the region of 40º to 60º, areogel radiator RICH can work for π/K ID for P > 0.7 GeV/c