

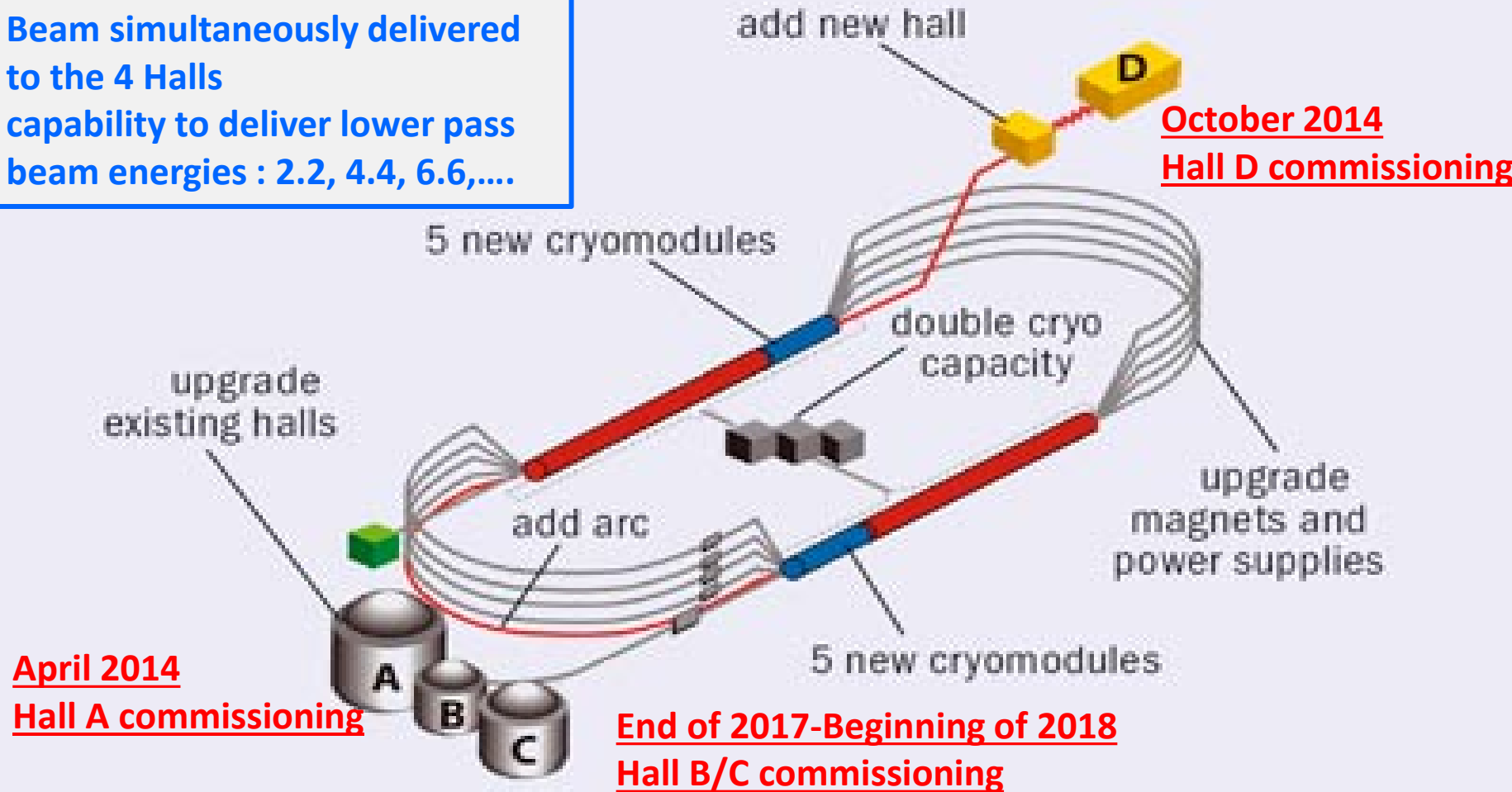
Recent results from JLab12

Marco Mirazita

INFN Laboratori Nazionali di Frascati

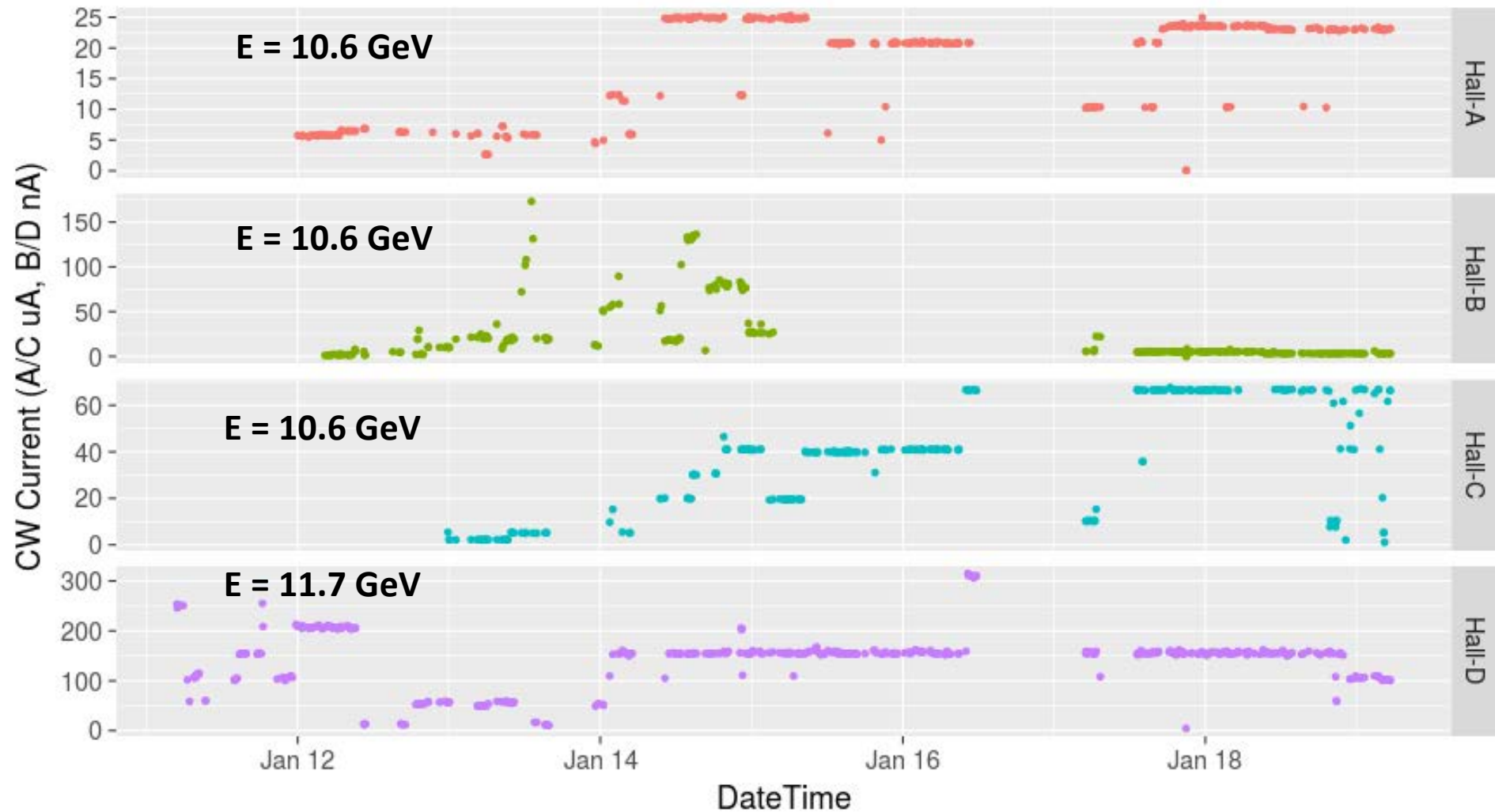
CEBAF: from 6 to 12 GeV

- CEBAF Upgrade
 - $E_{\text{max}} = 12 \text{ GeV}$
 - $I_{\text{max}} = 90 \mu\text{A}$
 - $\text{Polmax} = 85\%$
- Beam simultaneously delivered to the 4 Halls
- capability to deliver lower pass beam energies : 2.2, 4.4, 6.6,....



Four Hall operation started in January 2018

Four Halls operation



TMD studies at JLab12

Hall B-CLAS12

➤ Run Group A

- polarized electrons on an unpolarized H target
- 25% of assigned run time completed
- data taking will continue in 2019

➤ Run Group B

- polarized electrons on an unpolarized D target
- will start in 2019

Hall C

➤ Experiment E12-09-017

- polarized electrons on unpolarized H, D, Al targets
- more than 60% of data taken so far

CLAS12 in Hall B

Forward Detector (FD)

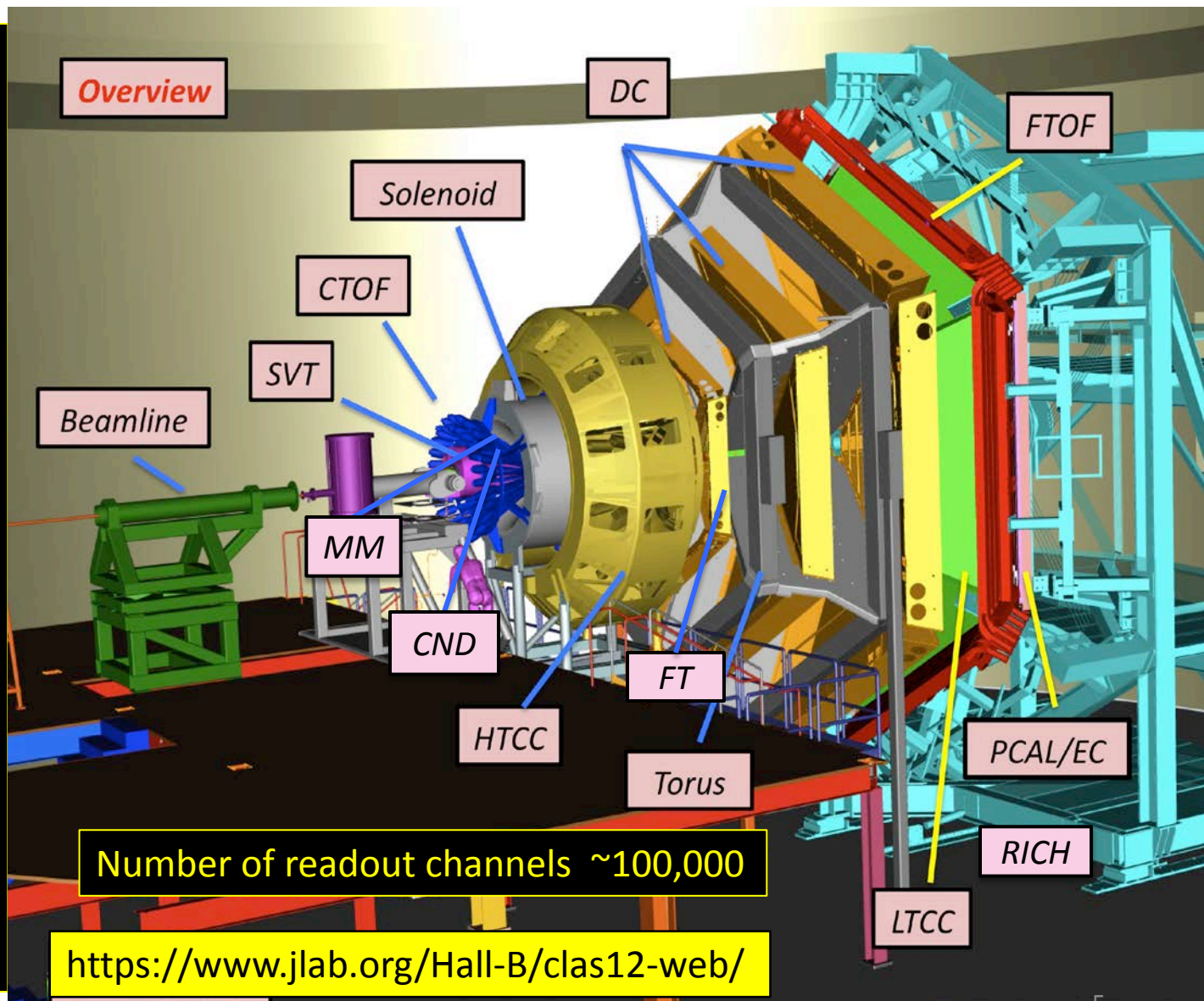
- TORUS magnet
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter
- Forward Tagger
- RICH detector

Central Detector (CD)

- Solenoid magnet
- Silicon Vertex Tracker
- Central Time-of-Flight
- Central Neutron Detector
- MicroMegas

Beamline

- Photon Tagger Dump
- Shielding
- Targets
- Moller Polarimeter
- Faraday Cup



Data collected and status

Run Group A

Total assigned days: 189

Spring 2018: 22 d

Fall 2018: 29 d

Total: 51/189=26%

Data analysis milestones

1) September 2018

- 10% of the Spring data cooked
- First physics results presented at DNP

2) October-December 2018

- Major revision of the reconstruction software

3) Beginning of 2019

- cooking of the Spring data (10% of the approved run time)

Proposal	Physics
E12-06-108	Hard exclusive electro-production of π^0 , η
E12-06-108A	Exclusive $N^* \rightarrow KY$ Studies with CLAS12
E12-06-108B	Transition Form Factor of the η' Meson with CLAS12
E12-06-112	Proton's quark dynamics in SIDIS pion production
E12-06-112A	SIDIS Λ production in target fragmentation region
E12-06-112B	Collinear nucleon structure at twist-3
E12-06-119(a)	Deeply Virtual Compton Scattering
E12-09-003	Excitation of nucleon resonances at high Q^2
E12-11-005	Hadron spectroscopy with forward tagger
E12-11-005A	Photoproduction of the very strangest baryon
E12-12-001	Timelike Compton Scatt. & J/ψ production in e^+e^-
E12-12-001A	J/ψ Photoproduction & study of LHCb pentaquarks
E12-12-007	Exclusive ϕ meson electroproduction with CLAS12

First CLAS12 results

Presented at the DNP Conference in Hawaii October 23-27, 2018

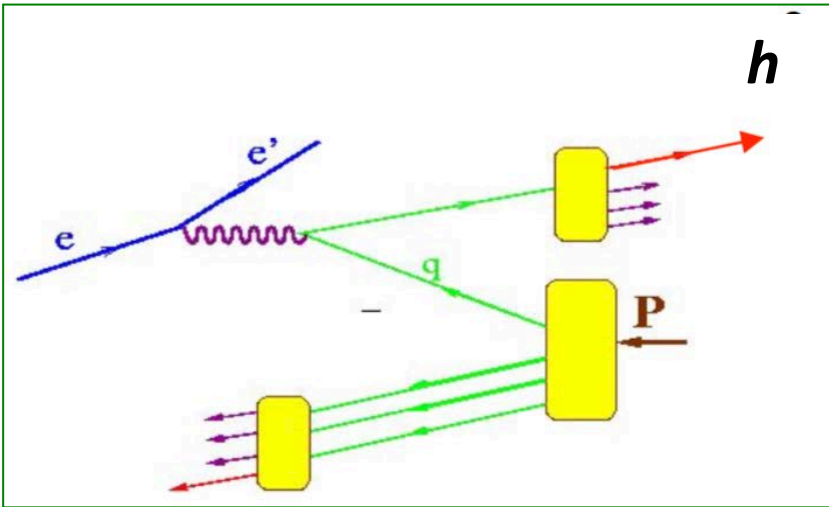
- J/psi at threshold
- Pentaquark search
- Nucleon resonances
- DVCS
- pi0 multiplicity
- pi+ Beam Spin Asymmetry
- dihadron Beam Spin Asymmetry
- Exclusive phi
- Time-like Compton Scattering

G. Angelini (GWU)

S. Diehl (UConn&Giessen)

A. Vossen (Duke)

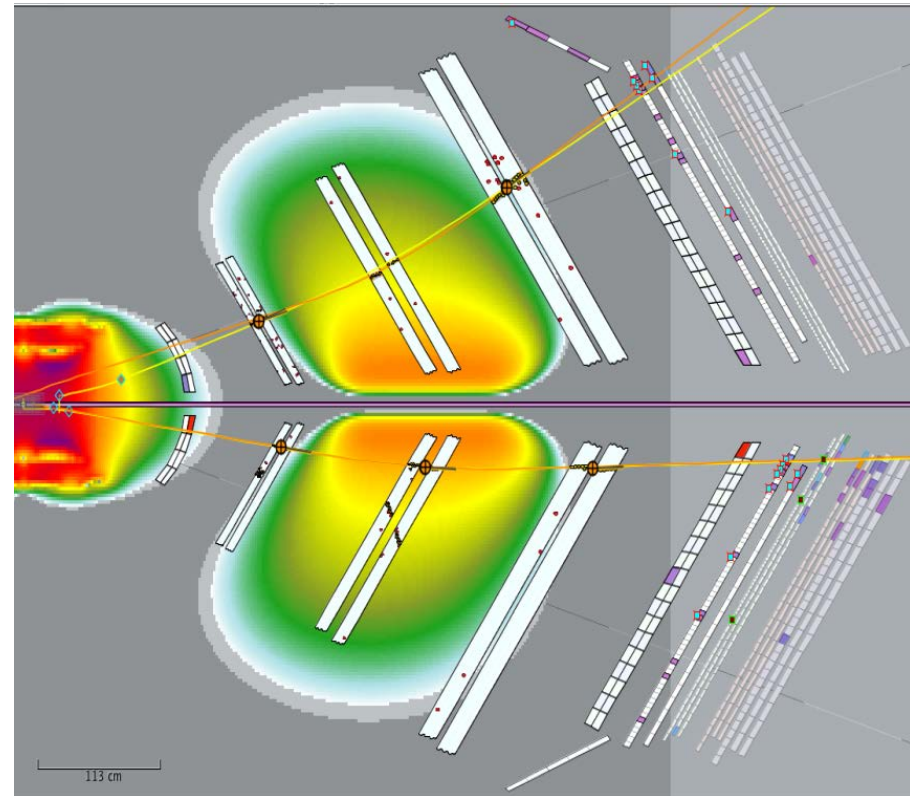
SIDIS in CLAS12



$$e p \rightarrow e' h X$$

$$h = \pi^+, \pi^-, \pi^0, \dots$$

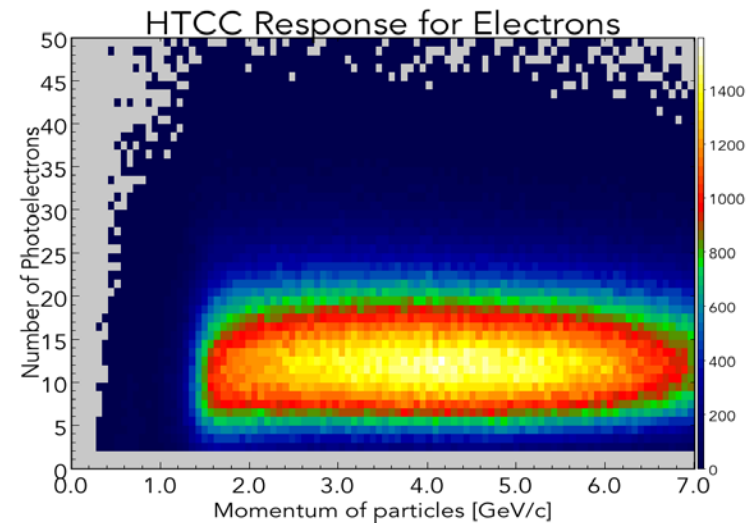
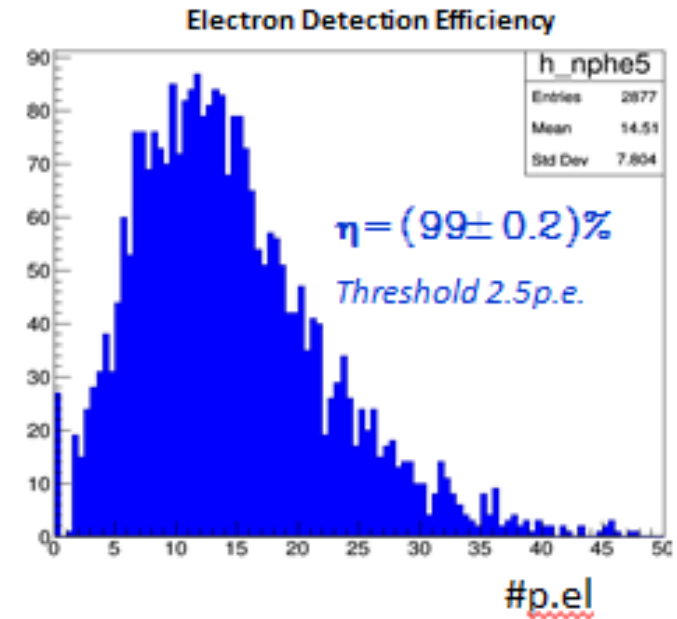
- Charged tracks measured in the drift chambers
- Electron PID: Cherenkov counters and forward calorimeters
- Charged hadrons ID: Forward Time-Of-Flight, RICH
- Neutral hadrons: Forward calorimeters



Electron ID: Threshold Cherenkov

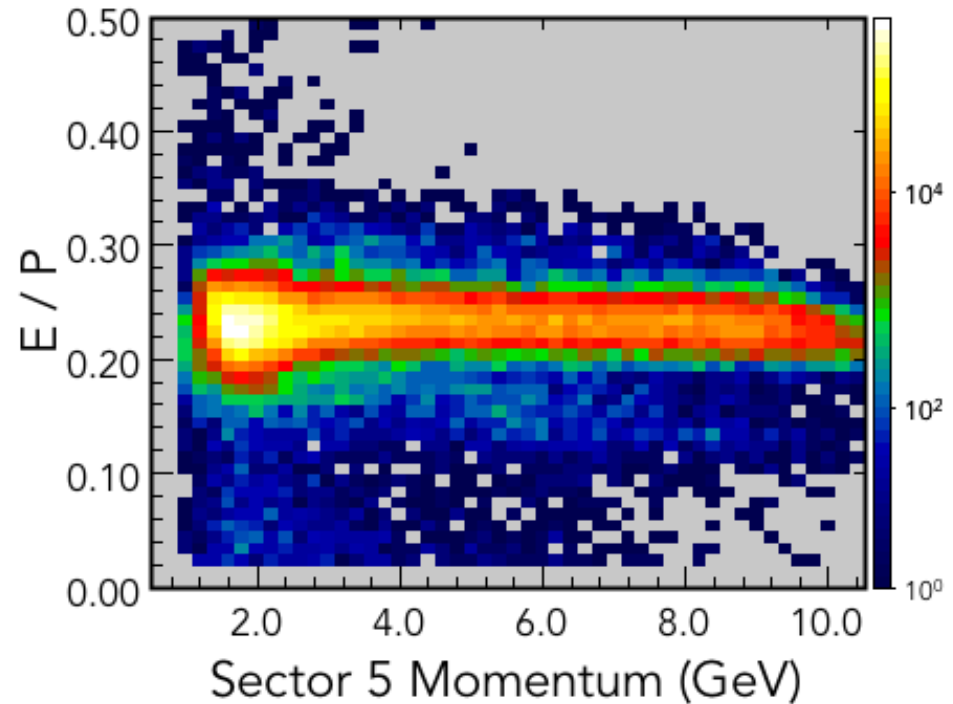
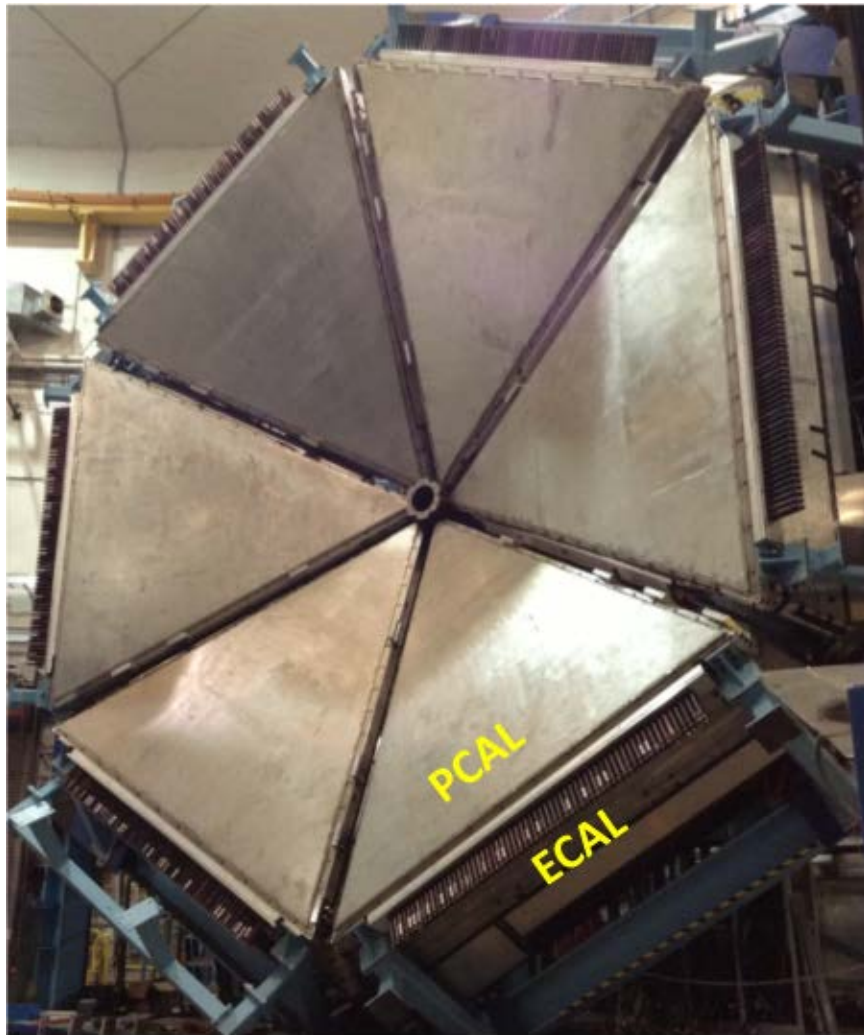
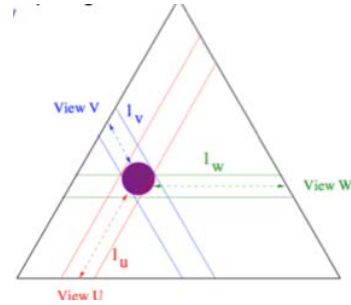
High Threshold Cherenkov Counter

- 360° coverage in azimuth
- Radiator Gas: CO₂
- Threshold for pions: 5 GeV/c



Electron ID: Calorimeter

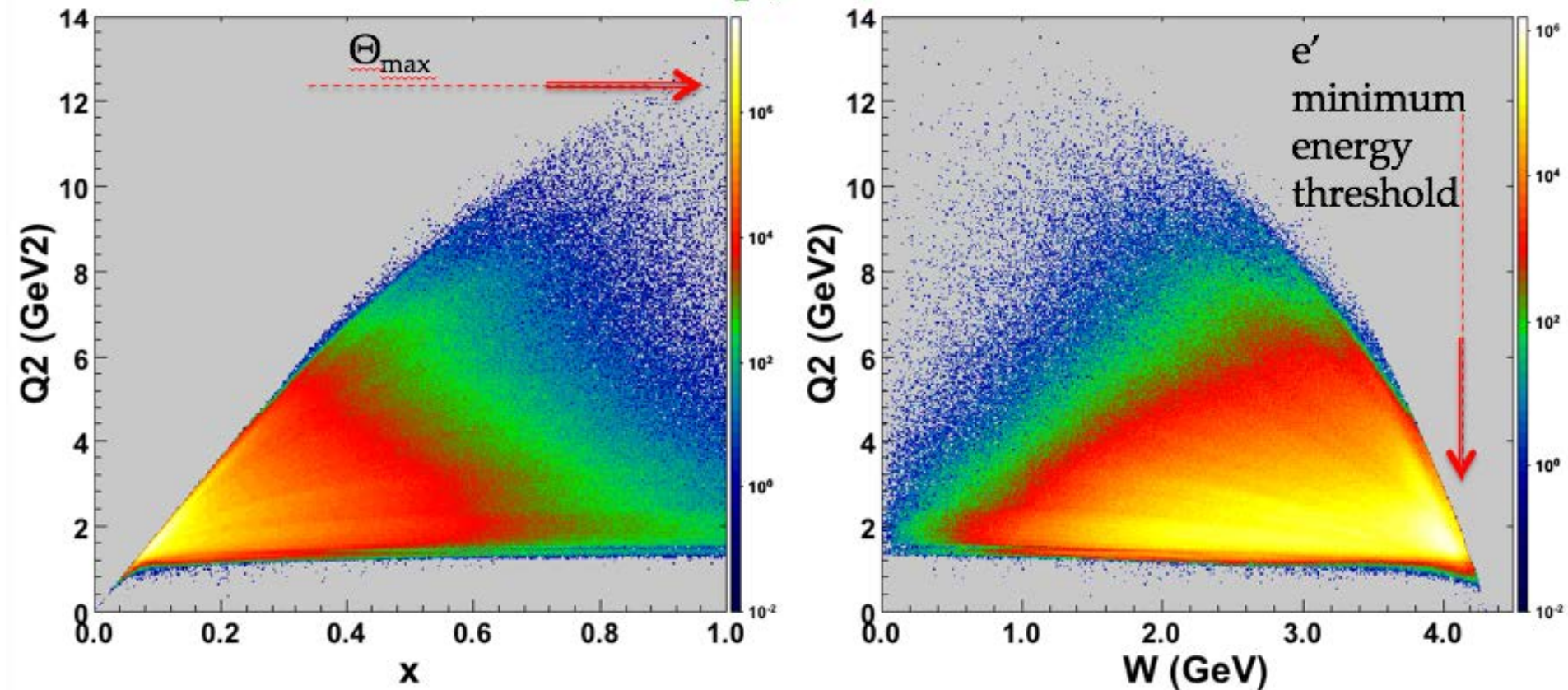
- Sandwich of scintillator bars and lead
- Each layer with 3 u,v,w bars rotated by 60 deg
- Three readout views of 5/5/8 layers



Kinematic coverage

Inclusive electrons
In-bending torus fields

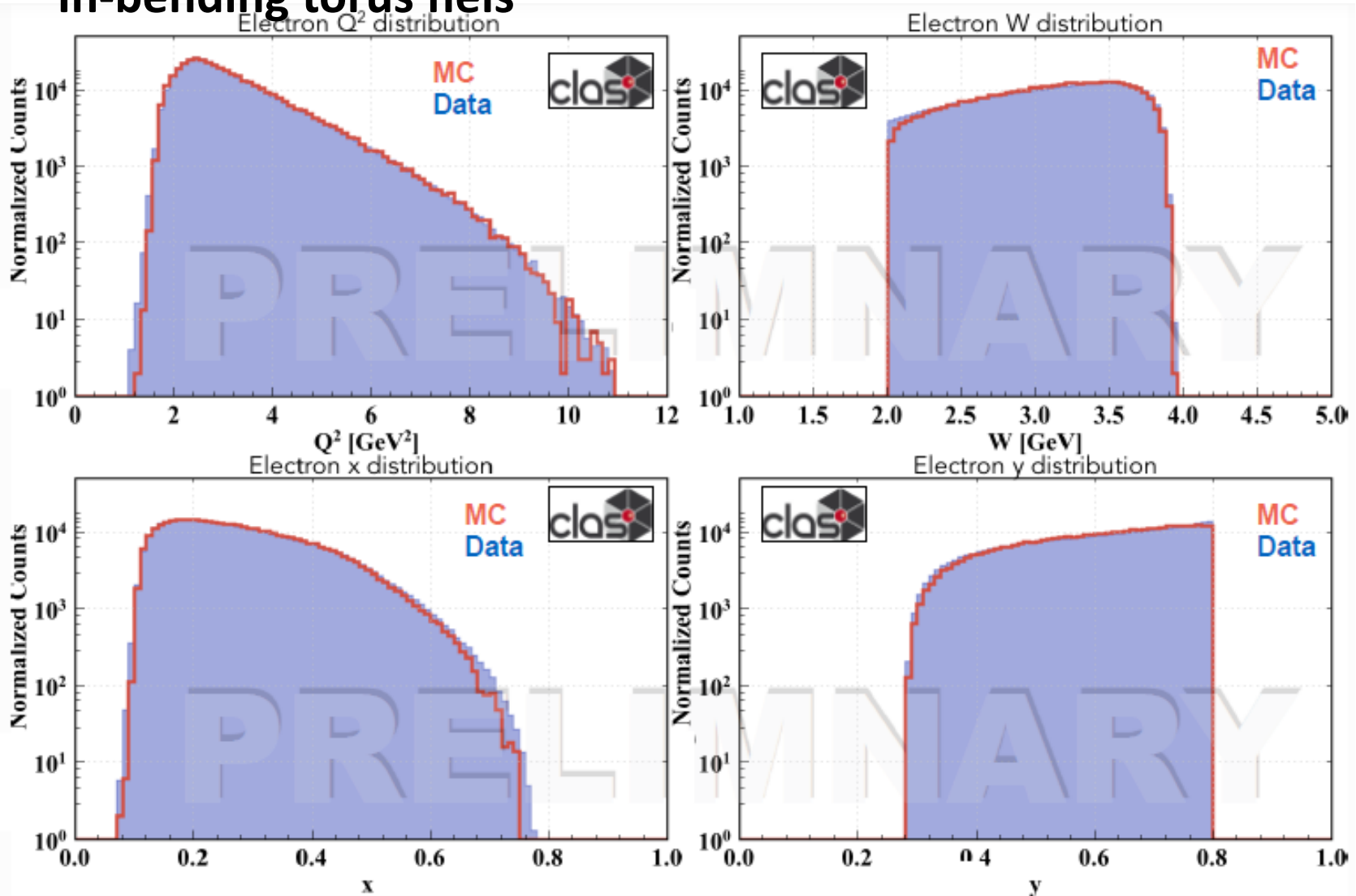
$p(e,e')X$



Data-MC comparison

Inclusive electrons

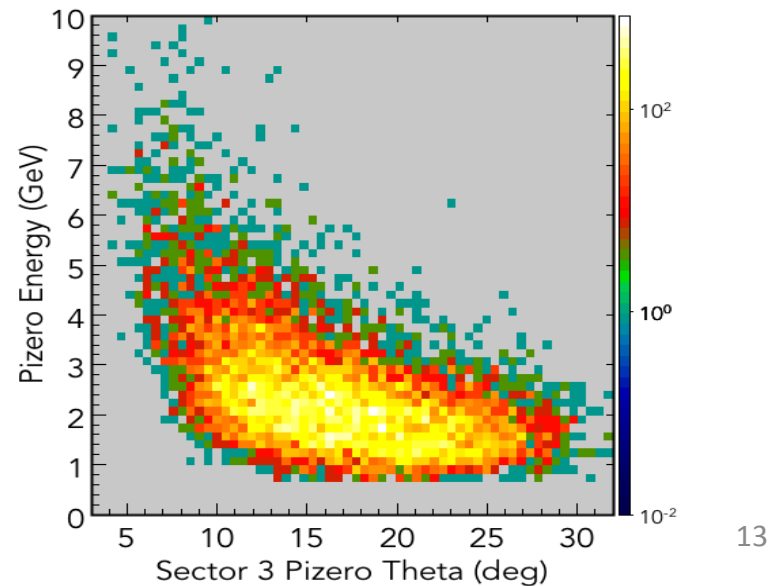
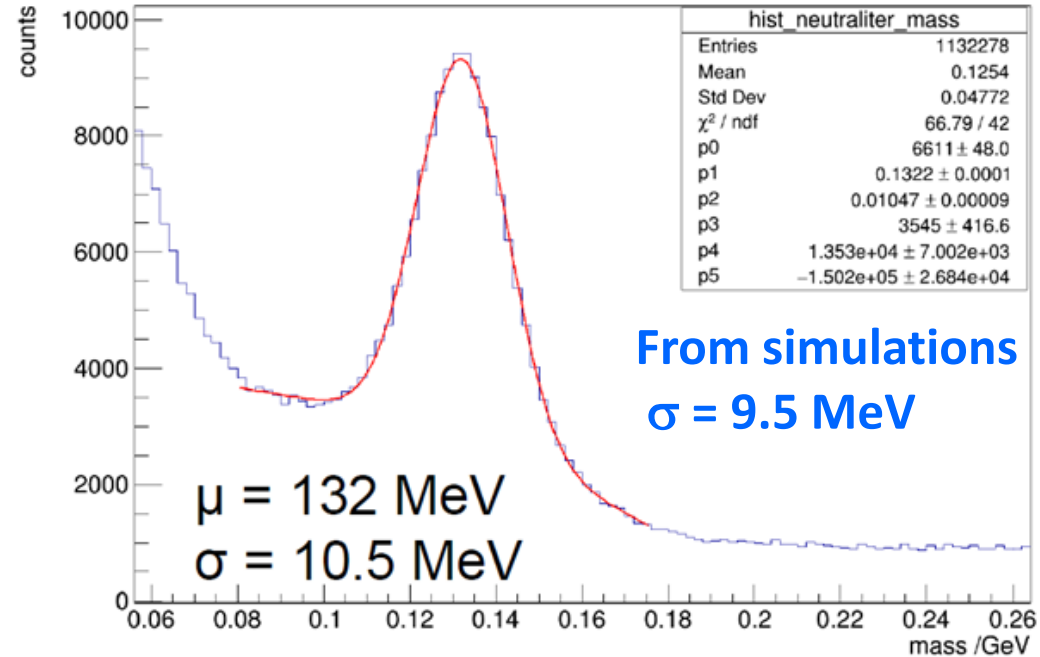
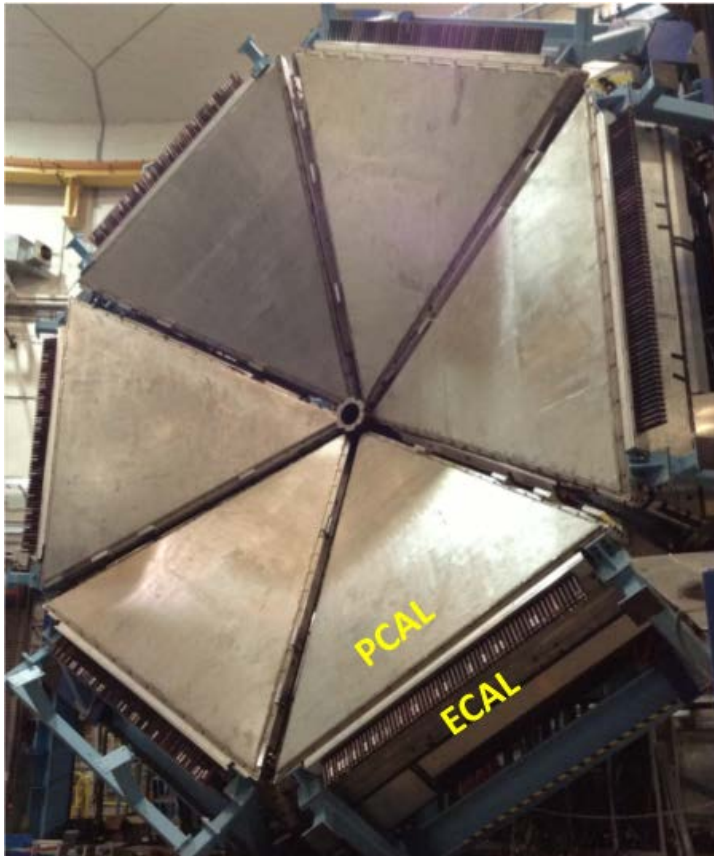
In-bending torus fiels



Neutral hadron ID

$$\pi^0 \rightarrow 2\gamma$$

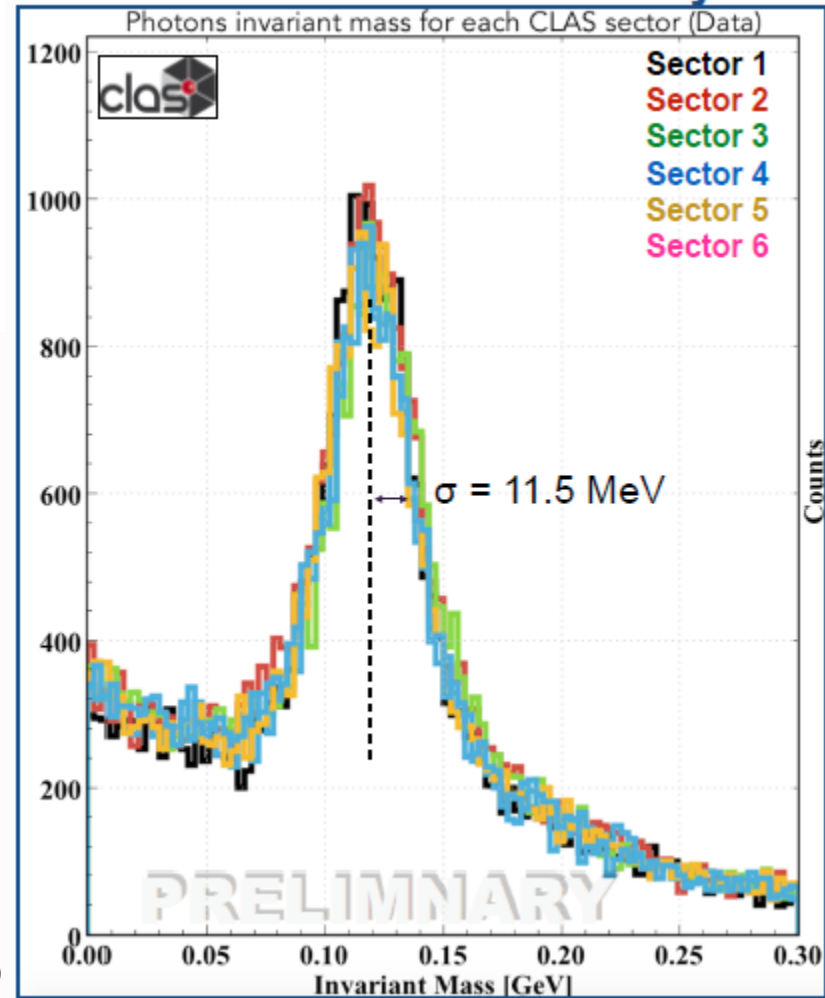
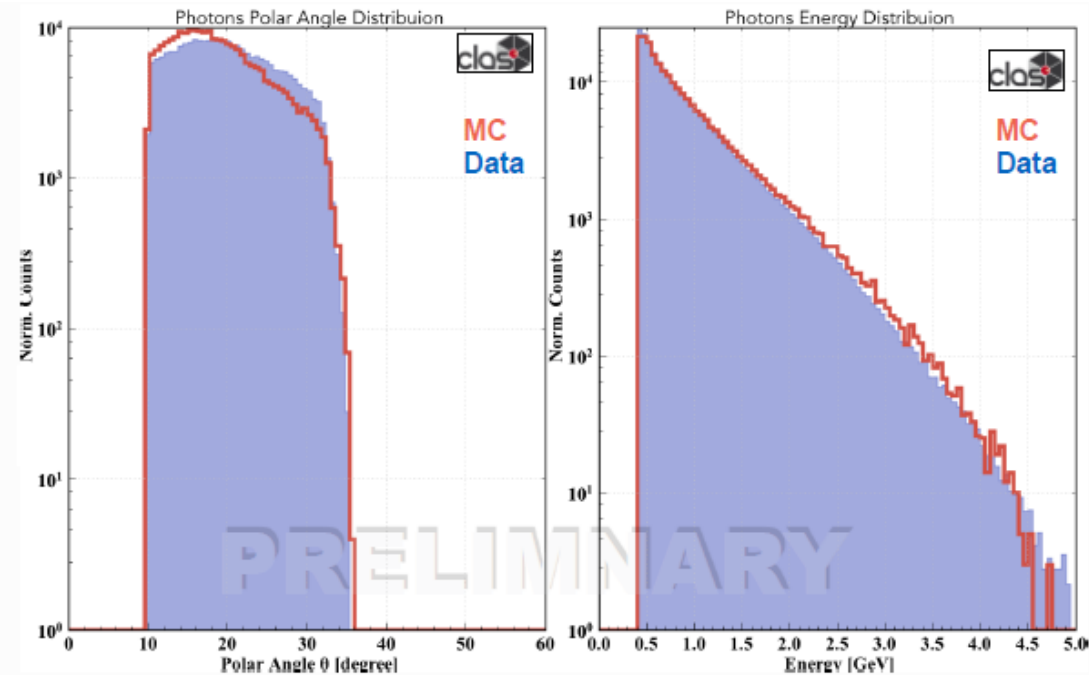
- two photons detected in the forward calorimeters
- $E_\gamma > 400$ MeV



Neutral pion ID

$$\pi^0 \rightarrow 2\gamma$$

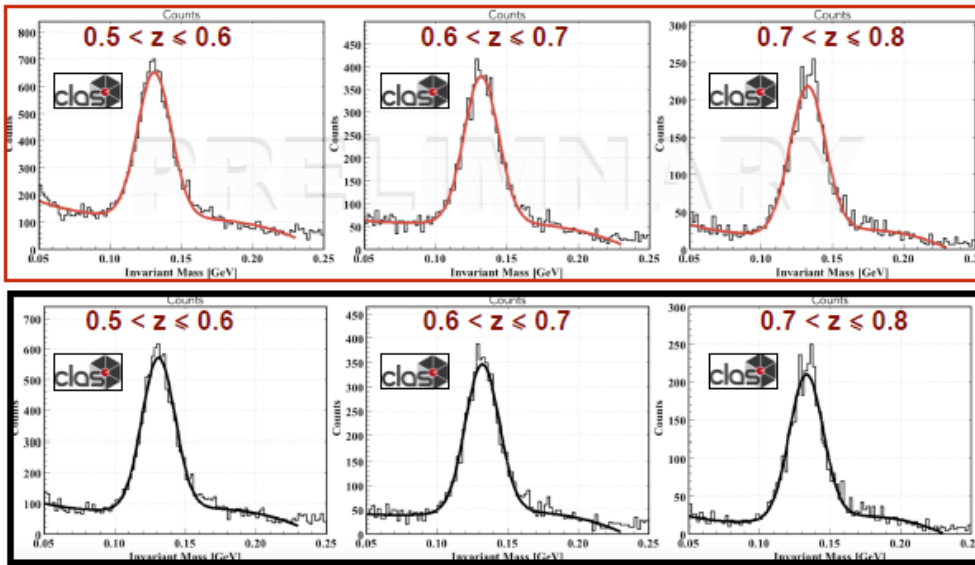
- two photons detected in the forward calorimeters
- $E_\gamma > 400$ MeV
- $\theta(\gamma e') > 2$ deg



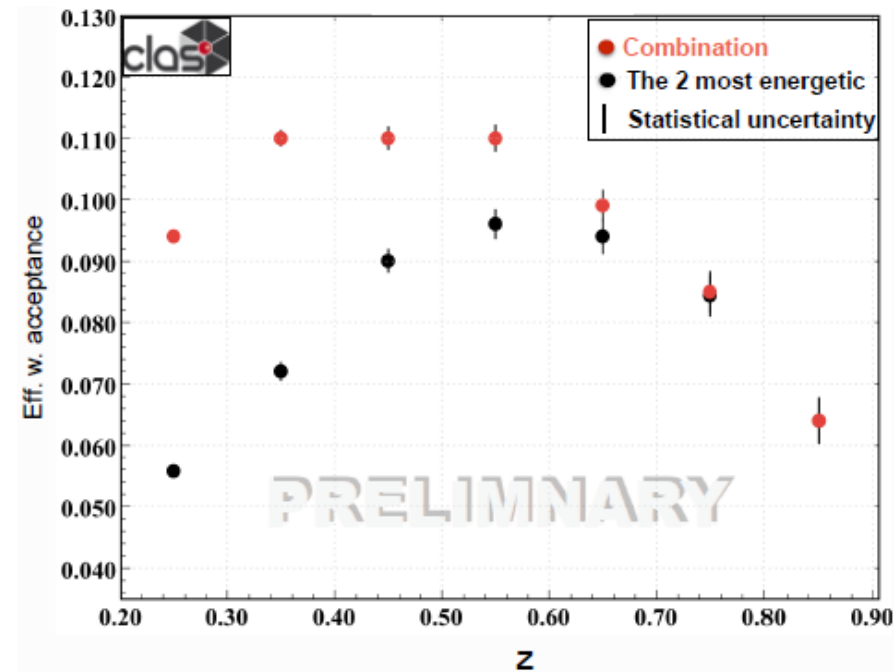
Neutral pion reconstruction

Neutral pion detection efficiency computed with two methods

- 1) Combination of all the photon in the event
- 2) Two most energetic photons

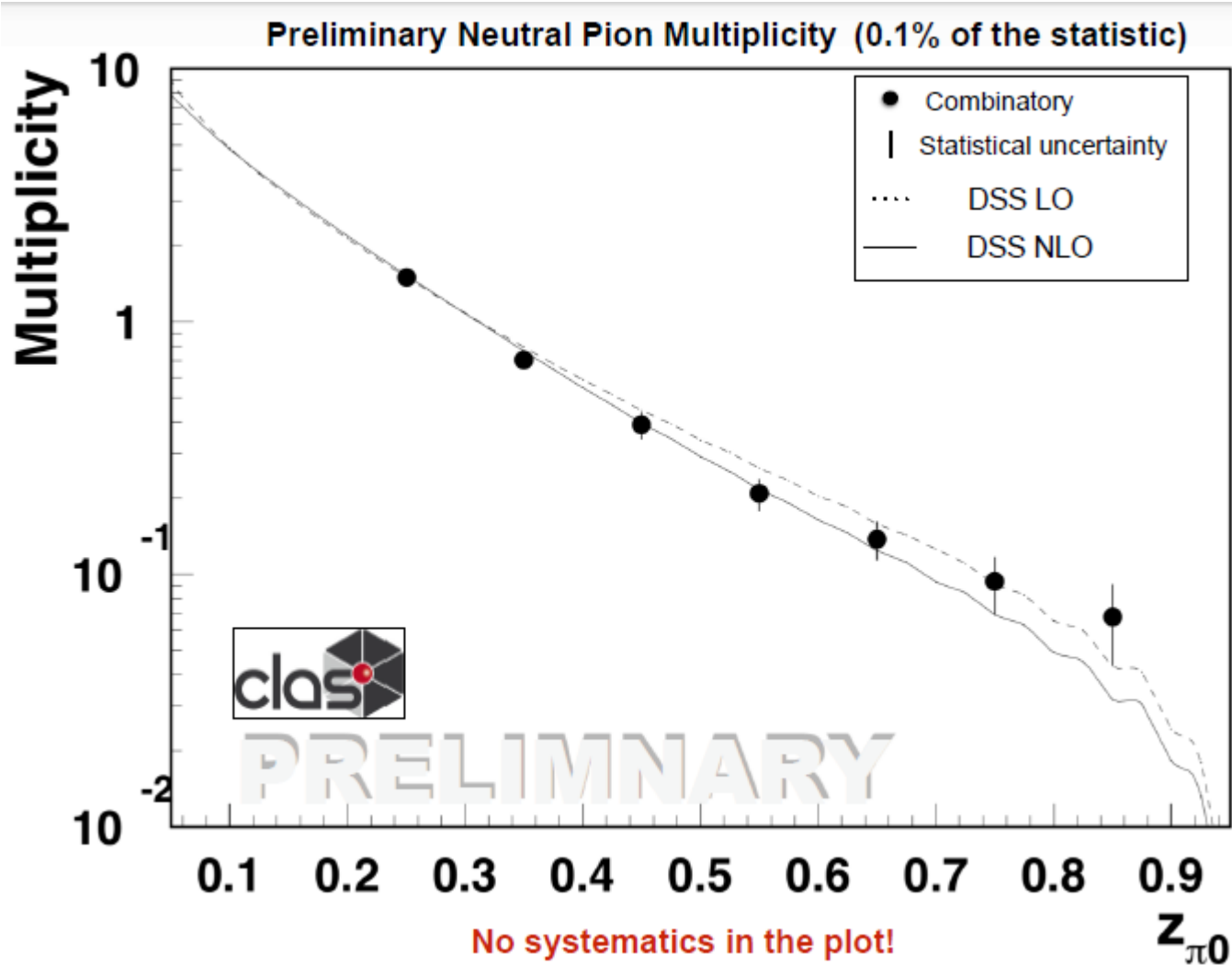


Detection Efficiency from MC simulation



- No difference in the π^0 resolution
- Almost the same S/B ratio
- Same efficiency as z increases

Multiplicity results



$Q^2 > 1 \text{ GeV}^2$
 $W > 2 \text{ GeV}$
 $y < 0.80$

- 1 day of data taking
- no difference with the two most energetic photons

Single pion BSA

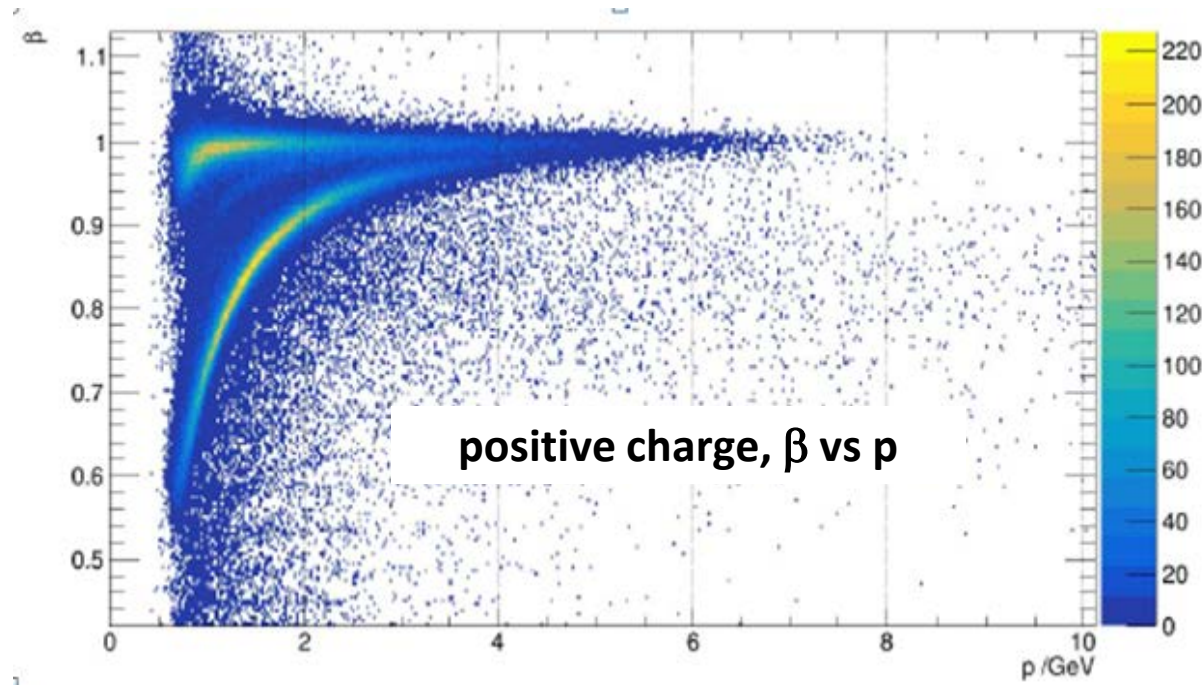
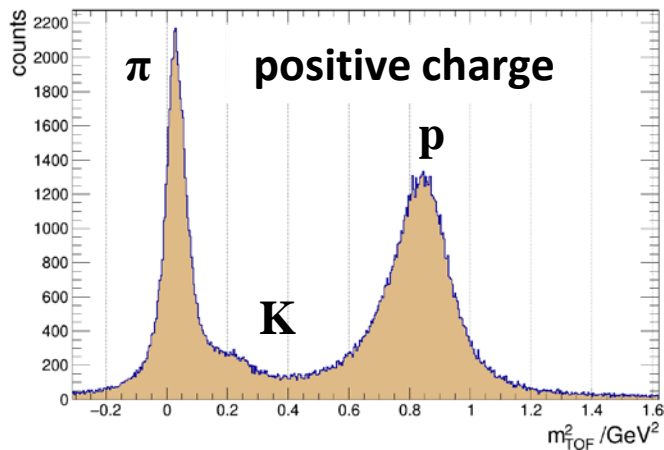
$$e p \rightarrow e' \pi X$$

Charged pions: DC + TOF

Neutral pions: Calorimeters

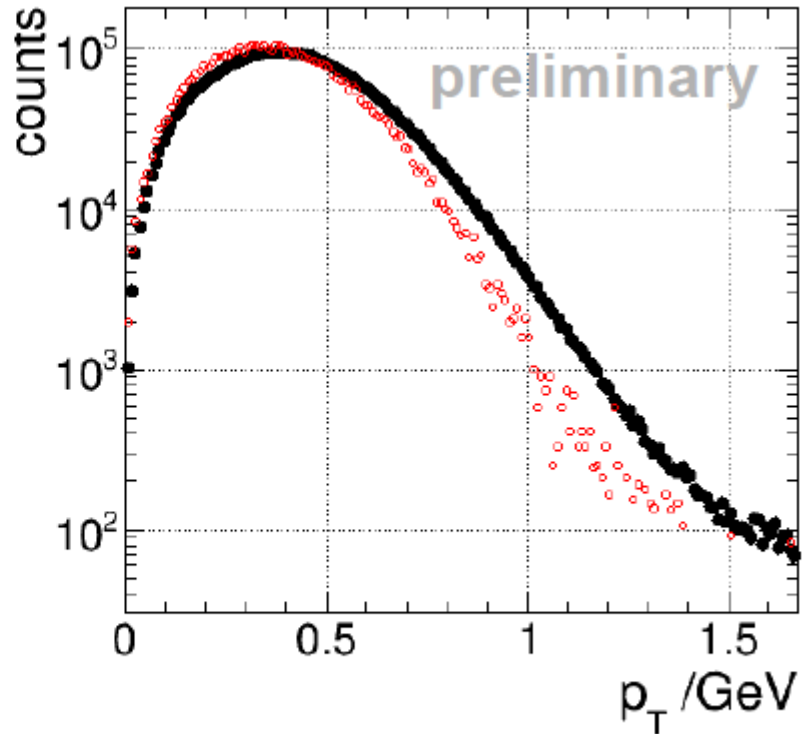
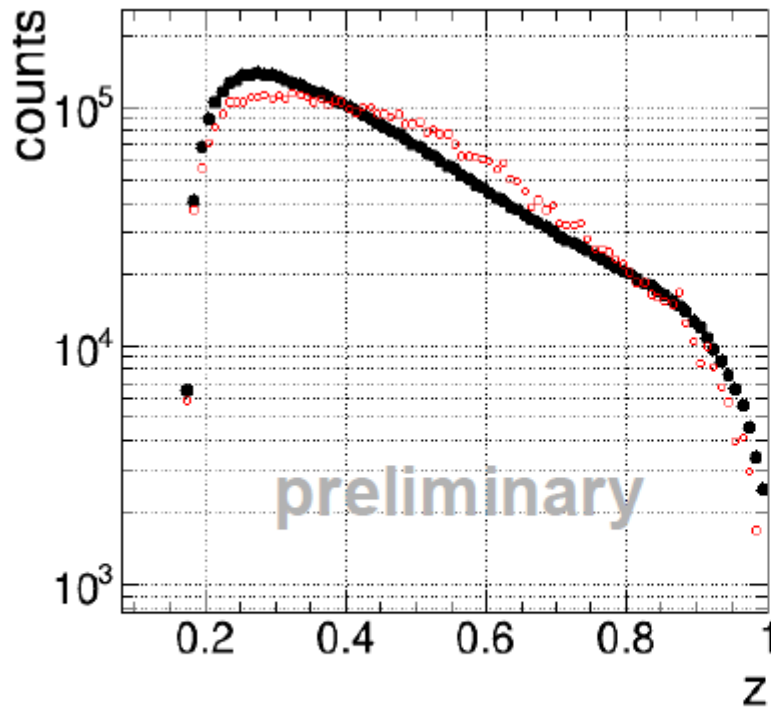
Forward time-of-flight

- scintillator bars in 3 panels
- time resolution 100-300 ps



Charged pion reconstruction

Plots for positive pions



● Experimental ● GEANT based Monte Carlo

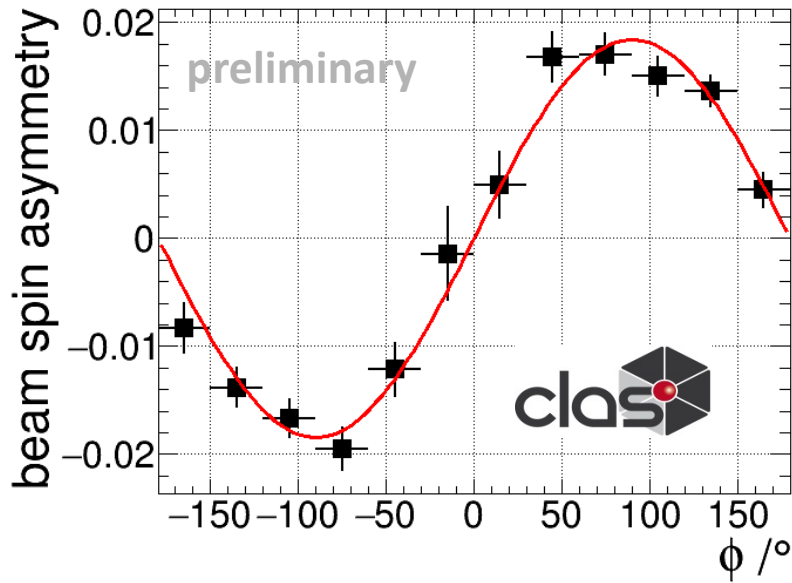
Integrated BSA

$$BSA_i = \frac{1}{P_e} \cdot \frac{N_i^+ - N_i^-}{N_i^+ + N_i^-}$$

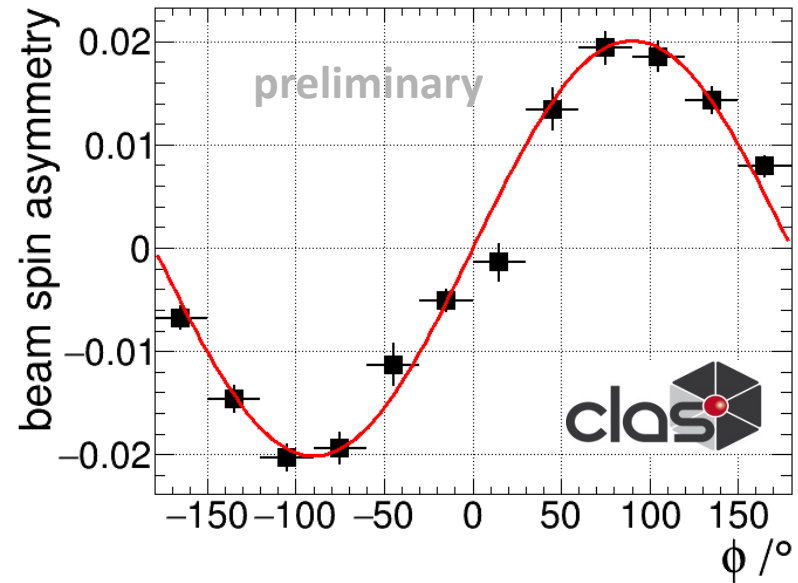
$P_e = 85\%$: average e^- beam polarisation

$A_{LU}^{\sin \varphi} \sin \varphi$

π^+

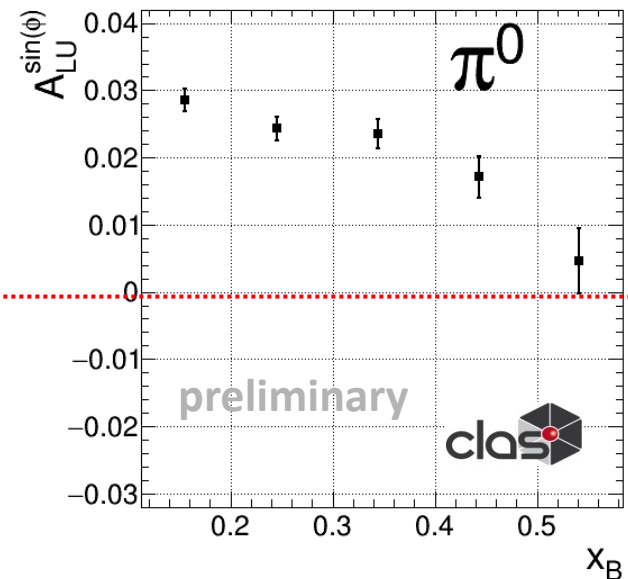
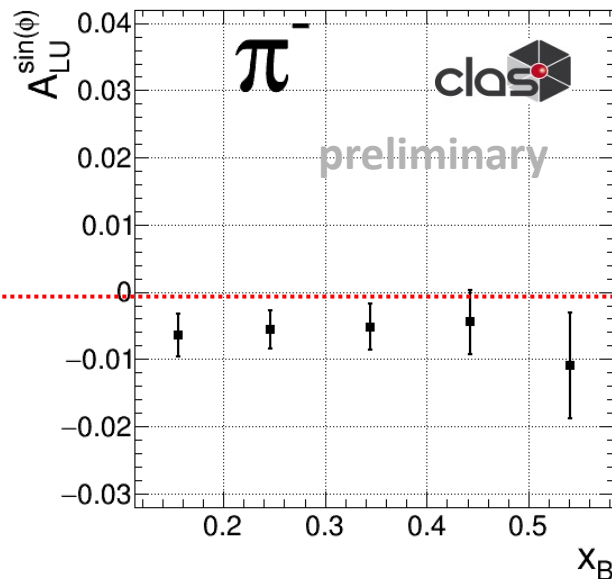
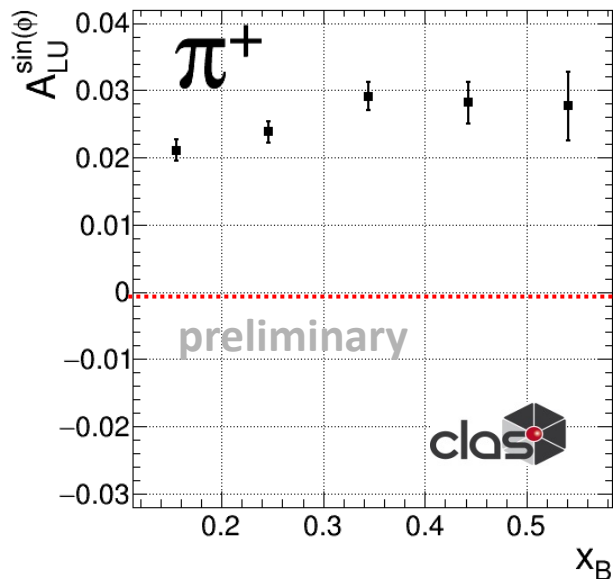
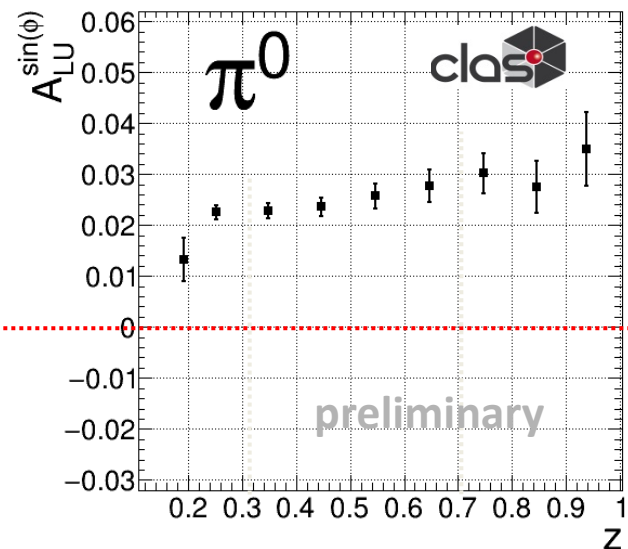
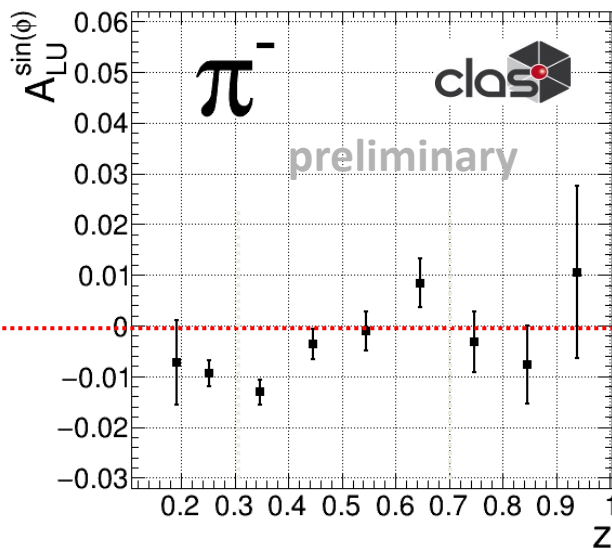
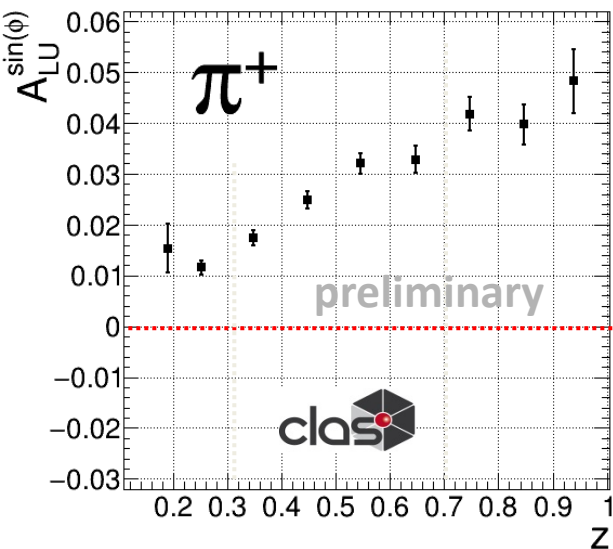


π^0



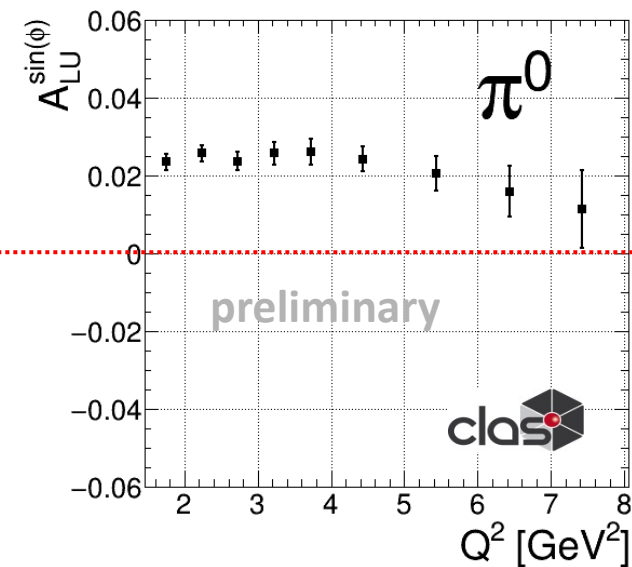
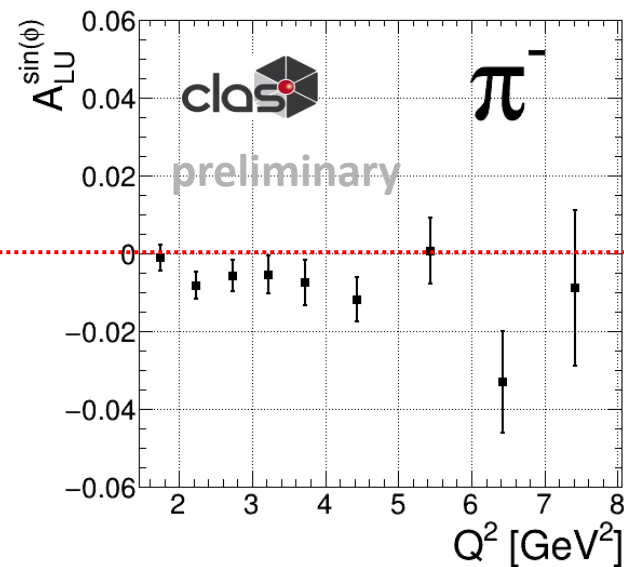
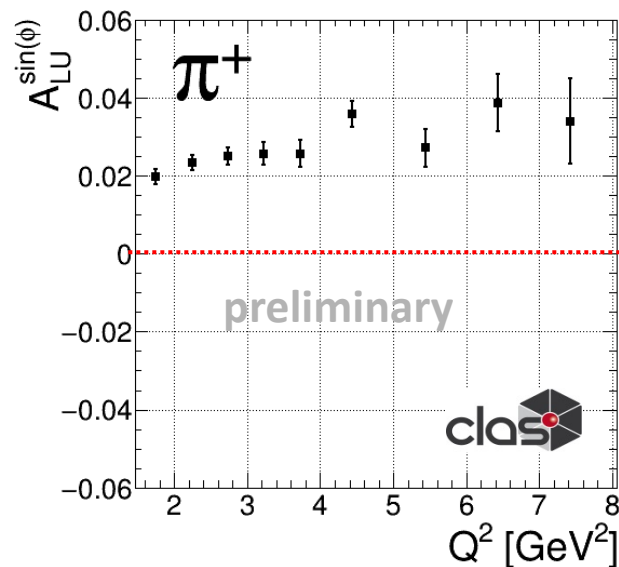
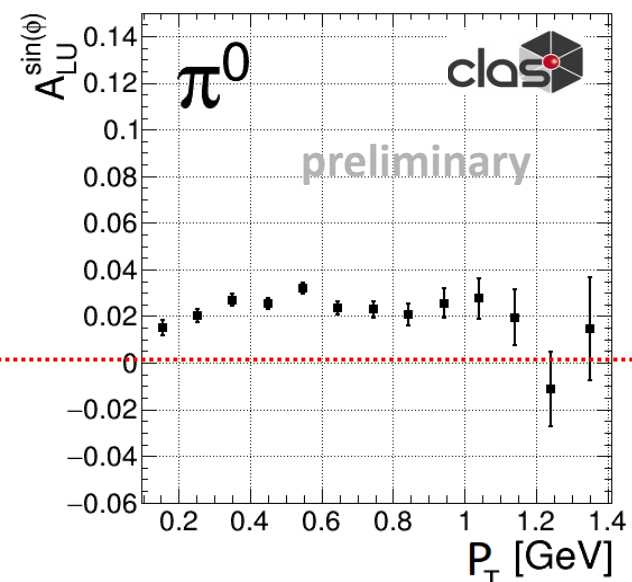
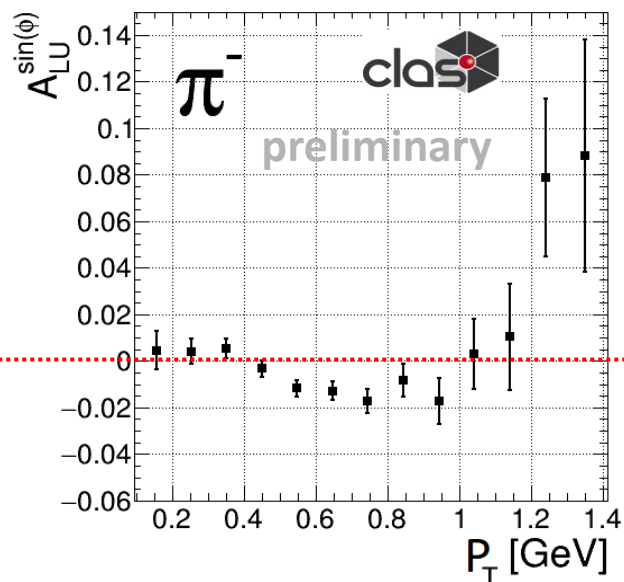
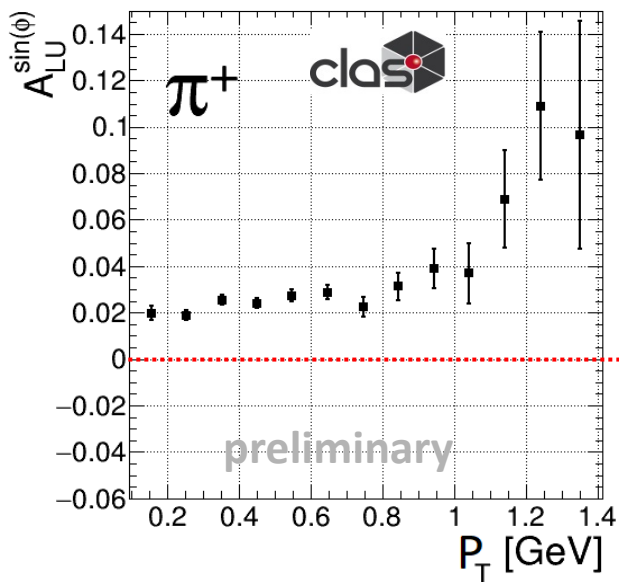
➤ About 3% of the approved run time

BSA vs z and x_B



➤ About 3% of the approved run time

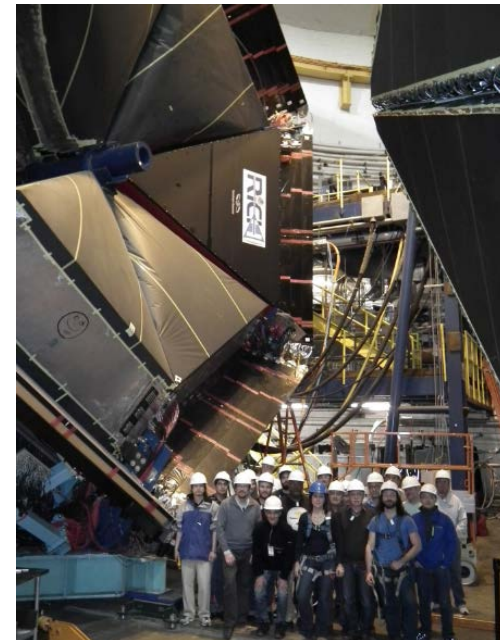
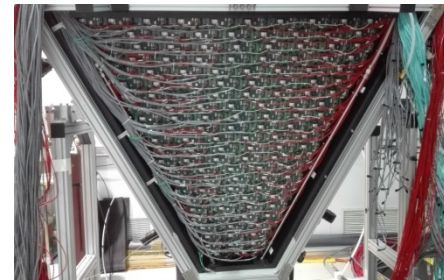
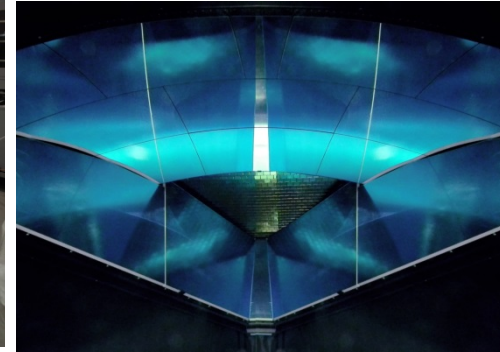
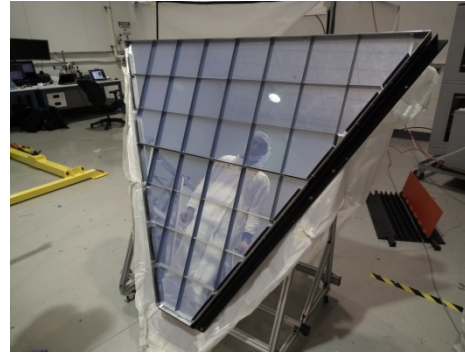
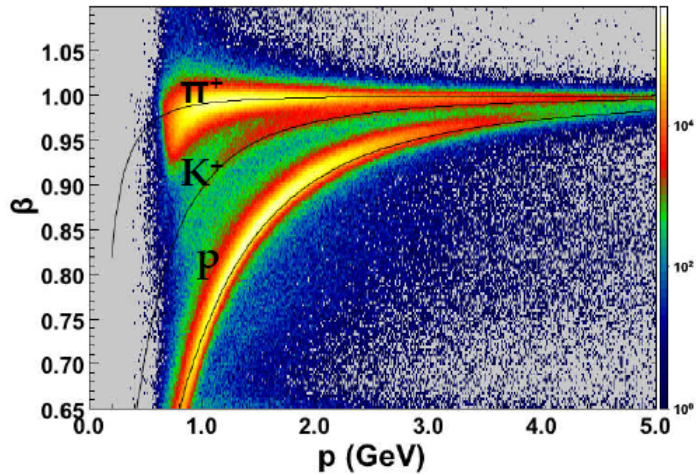
BSA vs p_T and Q^2



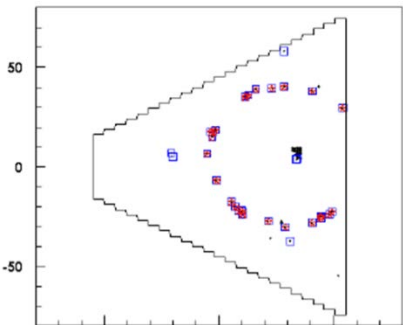
➤ About 3% of the approved run time

Kaon ID: RICH

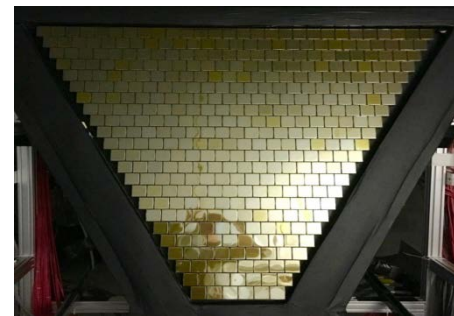
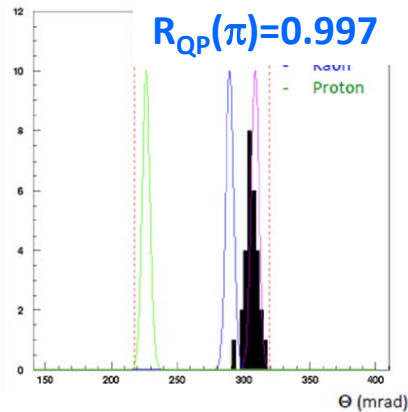
- Kaon ID in the momentum range 3-8 GeV is performed with the RICH
- First RICH module installed in January 2018



$P=4.3 \text{ GeV}/c$

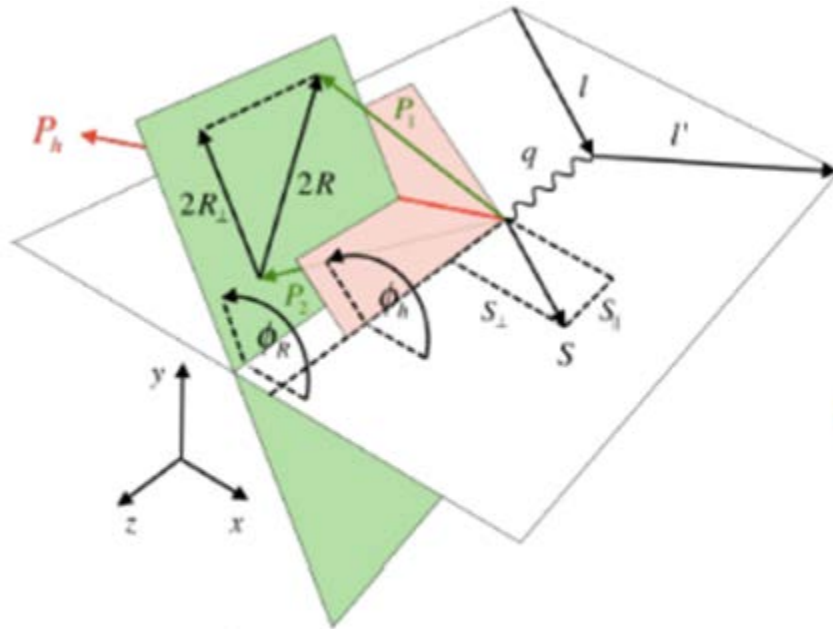


$R_{QP}(\pi) = 0.997$



Two pion production

Beam Spin Asymmetry in $e p \rightarrow e' \pi^+ \pi^- X$



$$\vec{P}_h = \vec{P}_{\pi^+} + \vec{P}_{\pi^-}, \quad \vec{R} = \vec{P}_{\pi^+} - \vec{P}_{\pi^-}$$

Particle selection

- $Q^2 > 1.0 \text{ GeV}^2$
- $W > 2.0 \text{ GeV}/c^2$
- $z_i > 0.1$
- $z < 0.95$
- $M_{\text{miss}} > 2.05 \text{ GeV}/c^2$
- $x_F > 0$
- $y < 0.8$
- $p_{\pi i} > 1 \text{ GeV}/c$

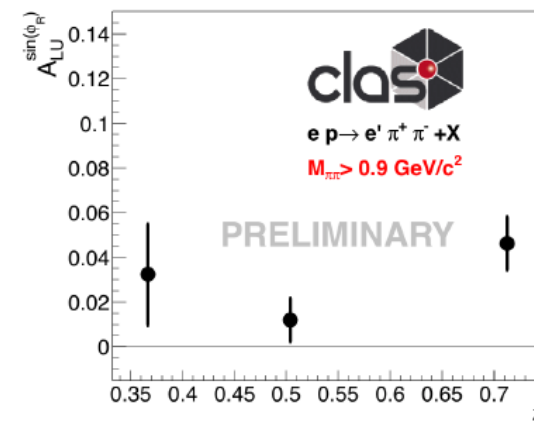
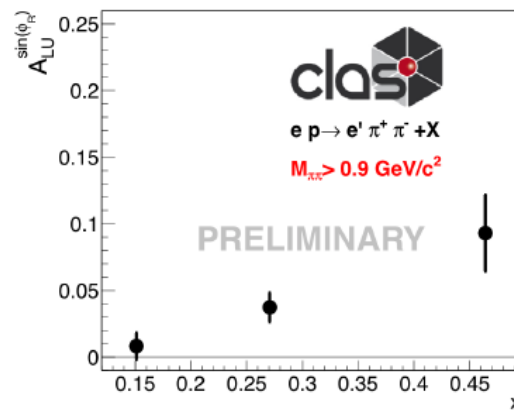
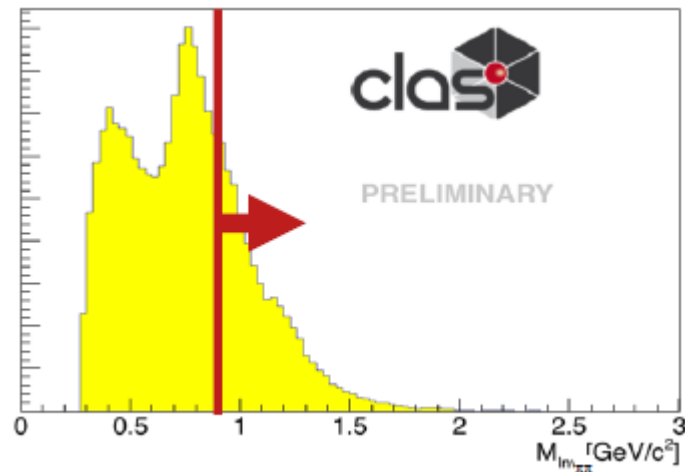
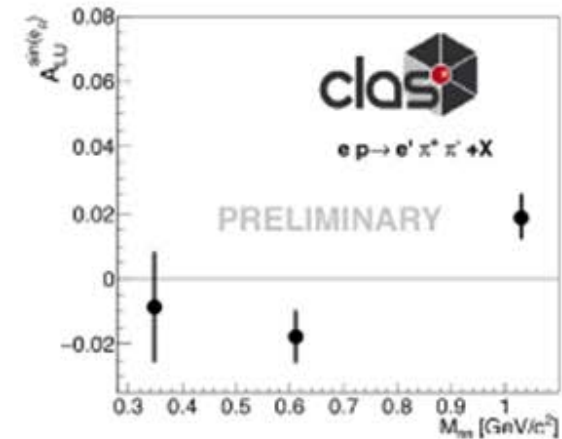
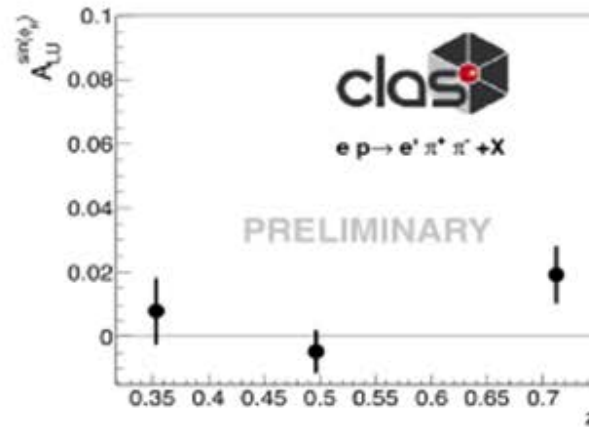
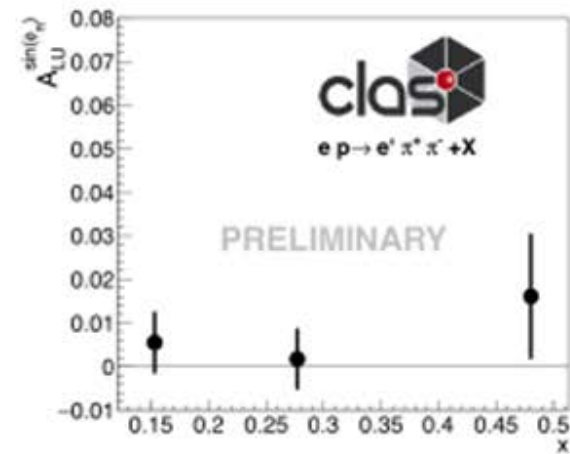
- **Raw asymmetry:**

$$A_{\text{raw}}^{LU}(\phi_R, \phi_h) = \frac{N^+ - rN^-}{N^+ + rN^-}(\phi_R, \phi_h)$$

- **2D fit:** $A_{LU}^{\sin(\phi_R)} \sin(\phi_R) + A_{LU}^{\sin(\phi_h - \phi_R)} \sin(\phi_h - \phi_R)$

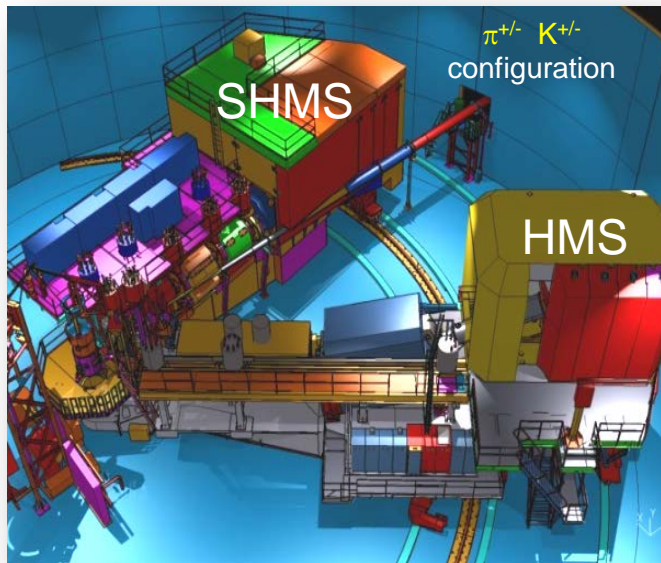
- **Correct with kinematic factors and beam polarization**

Two pion BSA



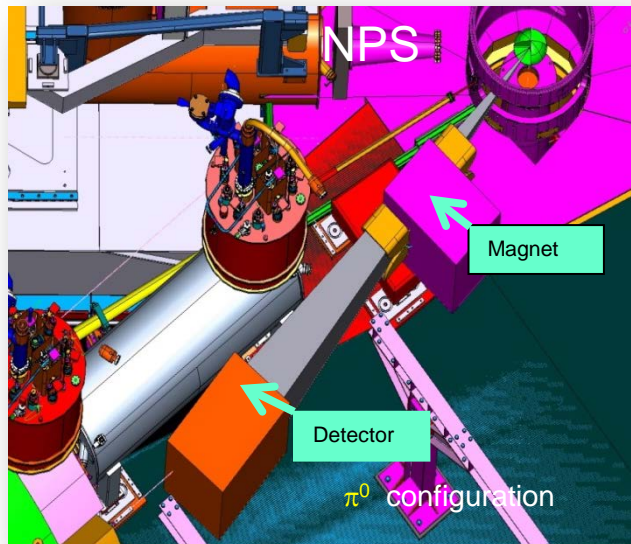
➤ About 3% of the approved run time

SIDIS measurements in Hall C



SHMS+HMS

Precise measurements of absolute cross-sections ($\sim 1\%$) and p_T dependence $\pi^{+/-}$ and $K^{+/-}$ on p & d



NPS

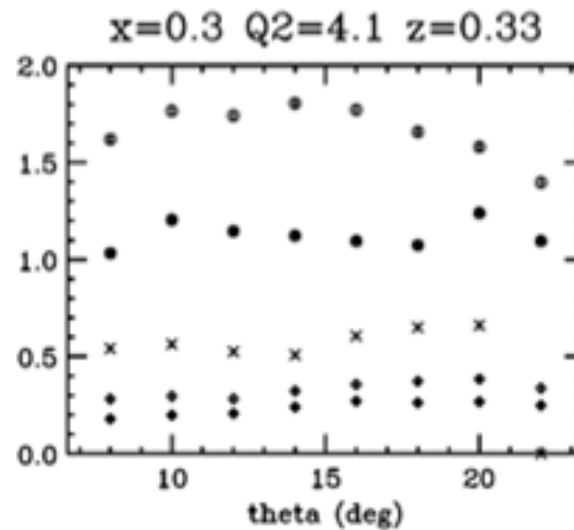
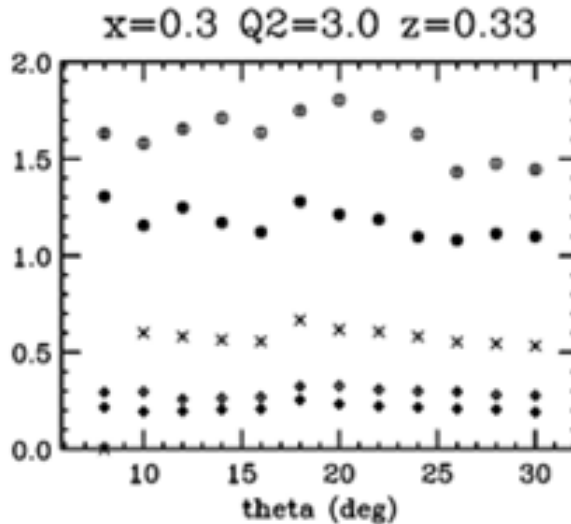
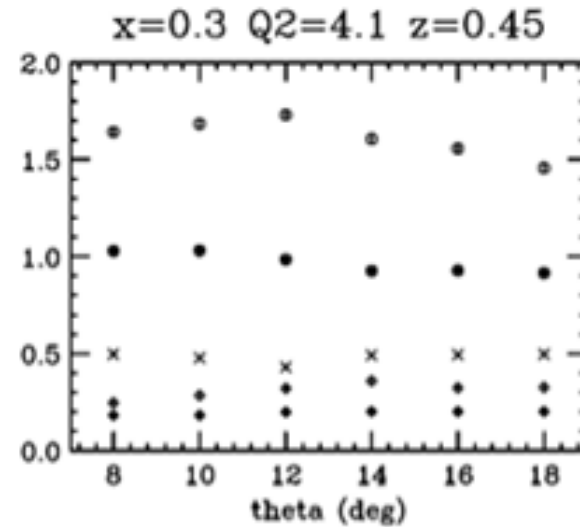
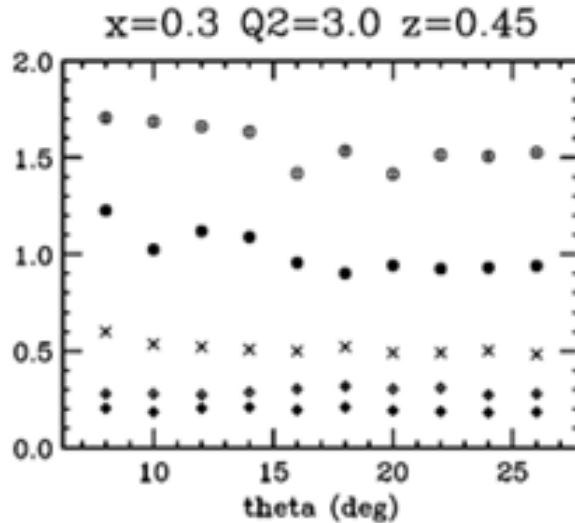
Extend measurements to π^0
Construction is starting, data taking foreseen by 2021

Preliminary results

Quasi on-line results: Normalized counts ratio to π^+ on H

π^+ from LD2
 π^+ from AI

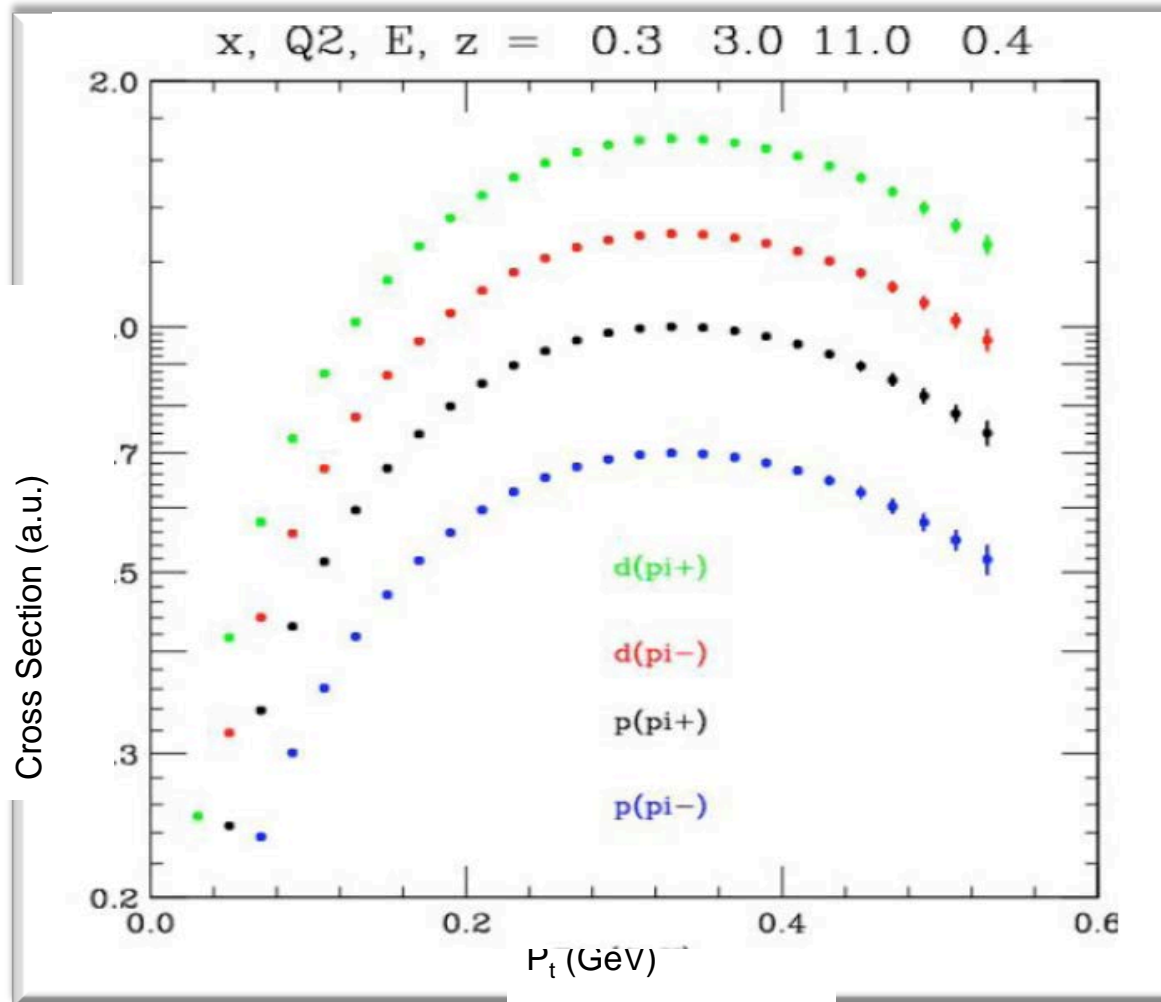
π^- from LH2
 π^- from LD2
 π^- from AI



Preliminary results

Cross section vs pT

- charged pions on proton and deuteron



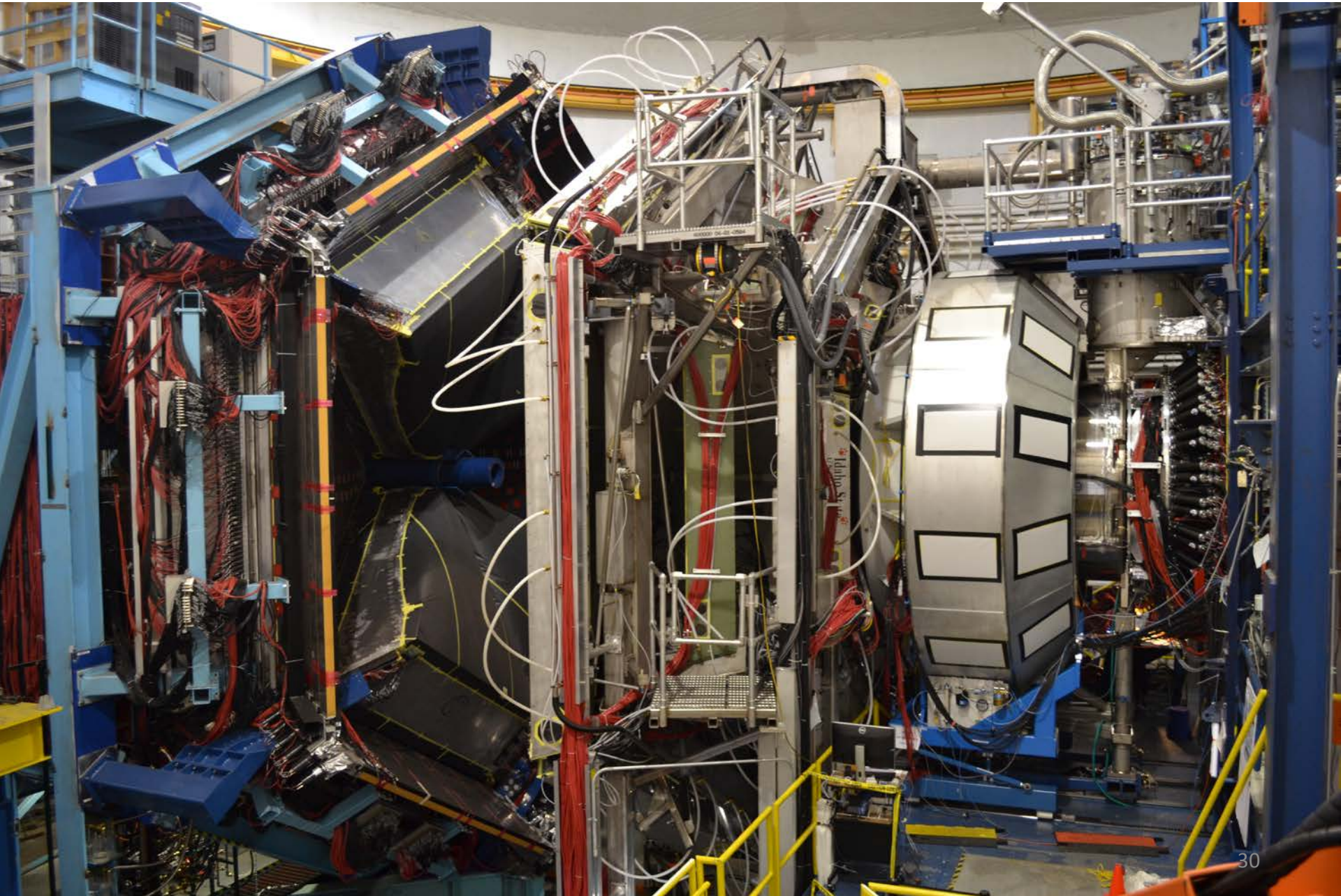
➤ 60 % of assigned run time

Summary and outlook

- 1) JLab is fully operational in the 4 Hall mode since January 2018
- 2) Detectors performed well, confirming the expectations, but calibration is still ongoing
- 3) First results from a (small) fraction of the run time has been released
- 4) Plans for 2019
 - CLAS12: continue Run Group A, first part of Run Group B (unpolarized liquid deuterium target)
 - Hall C: complete the unpolarized cross section measurements, beginning of σ_L/σ_T data taking

backup

CLAS12: Installation complete



CLAS12 data taking

- Major CLAS12 Installation completed in November 2017
- Dec. 2017 / Jan. 2018: Engineering Run
 - Commissioning of the beam line and of the detectors
 - Optimization of the running conditions
 - First look at the detector performance
- Feb. 2018: Beginning of physics operation with polarized electrons (>80%) on an unpolarized H target
 - Run Group A
 - 10.6 GeV: TMDs, DVCS, target fragmentation, J/psi, exclusive phi, etc.
 - Run Group K
 - 6.6 and 8.8 GeV: hybrid baryons, Nucleon resonances, DVCS
- Plan for 2019
 - Continue with Run Group A
 - Beginning of Run Group B: polarized electrons (>80%) on an unpolarized D target

Data acquisition

- Original DAQ requirements: 10kHz event rate, 100MB/sec data rate, LT= 0.9
- Production rates at 50nA beam, FT=ON: 12kHz event rate, 550MB/sec data rate, LT=0.94%

CLAS12 VTP Trigger

03/01/2018 13:24:26

Beam Current: 53.4 nA

Electron Alarms: 1-6: NO_ALARM 1-6 Tolerance: 0.60

Lifetime: 91.3 %

Heartbeat: ●

Totals (Hz): 2401371 13373

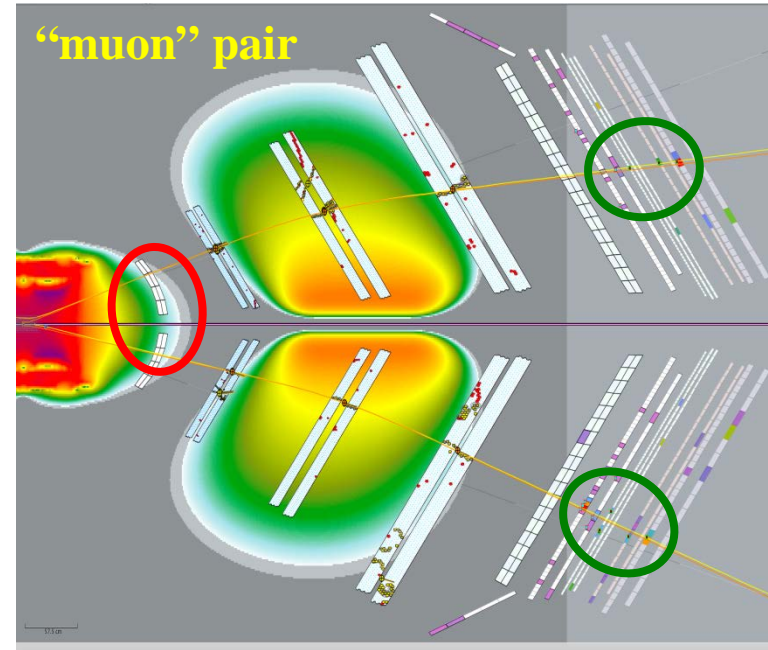
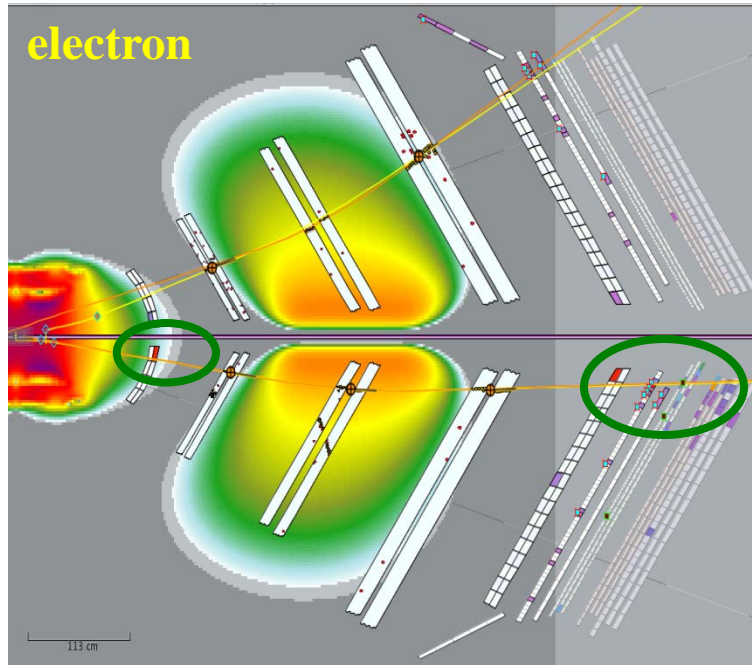
Bit	Description	Raw (Hz)	Prescaled (Hz)	Fraction (%)	Prescale	In Totals
0	Electron - OR of 1-6	5183	5183	38.8	0	■
1	Sector 1	733	733		0	■
2	Sector 2	754	754		0	■
3	Sector 3	902	902		0	■
4	Sector 4	1081	1081		0	■
5	Sector 5	956	956		0	■
6	Sector 6	791	791		0	■
7	ElectronOR noDC >300MeV	7509	442	3.3	5	■
8	PCALxECAL > 10MeV	321348	157	1.2	12	■
19	FTOFxPCALxECAL 1-4	904	904	6.8	0	■
20	FTOFxPCALxECAL 2-5	917	917	6.9	0	■
21	FTOFxPCALxECAL 3-6	966	966	7.2	0	■
24	FTxHDxFTOFxPCALxCTOF	9342	550	4.1	5	■
25	FTxHDx(FTOFxPCAL)^2	3989	3989	29.8	0	■
26	FTxHD > 100MeV	338971	165	1.2	12	■
27	FT > 100MeV	1713031	105	0.8	15	■
31	Pulser	100	100	0.7	0	■

“Electron” trigger:
5 kHz (40 %)

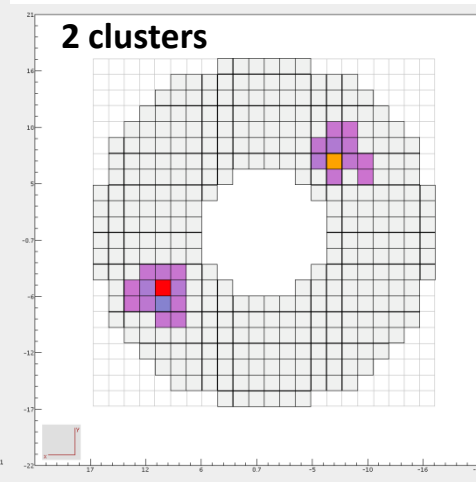
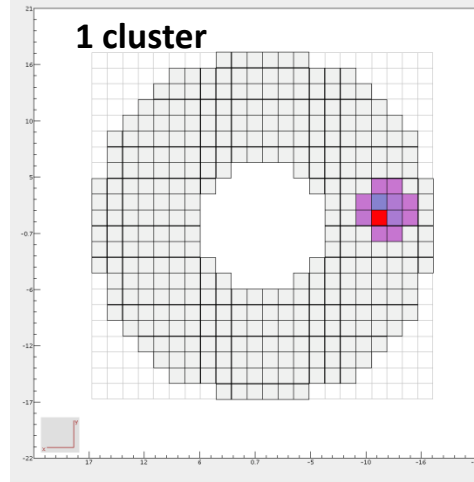
“Muon” trigger:
2.7 kHz (20 %)

“MesonX” trigger
4.5 kHz (40 %)

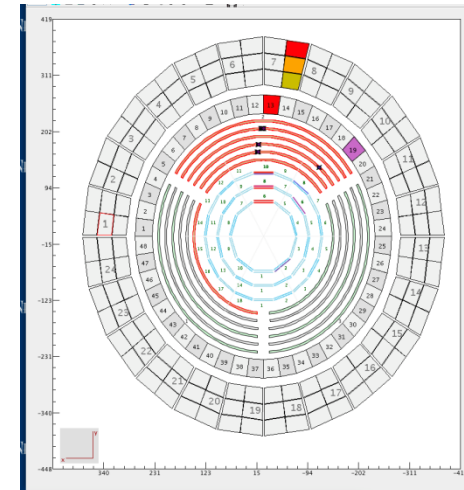
Event based triggers



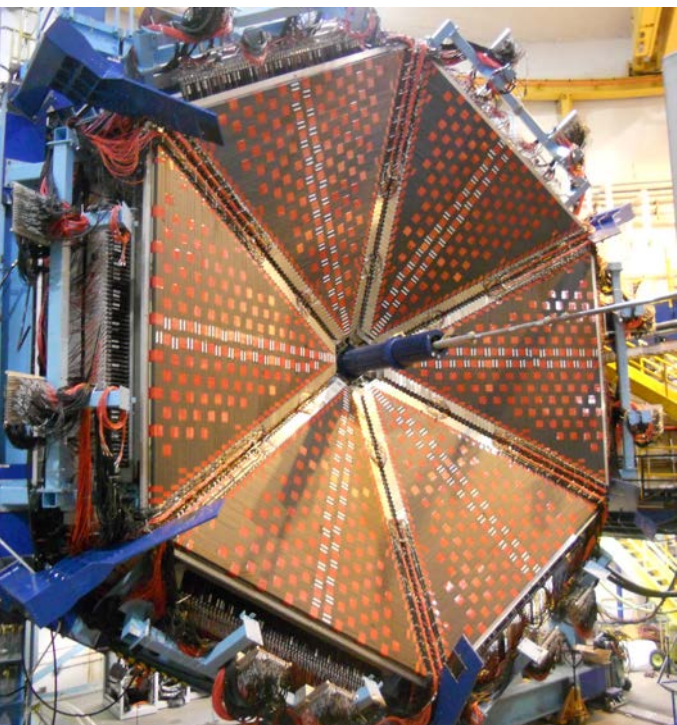
FT-CAL
Trigger



CD -
CTOF



Charged hadron ID: FTOF



Forward time-of-flight

- scintillator bars in 3 panels
- time resolution 100-300 ps

