First CLAS12 results in SIDIS measurements

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for the CLAS Collaboration

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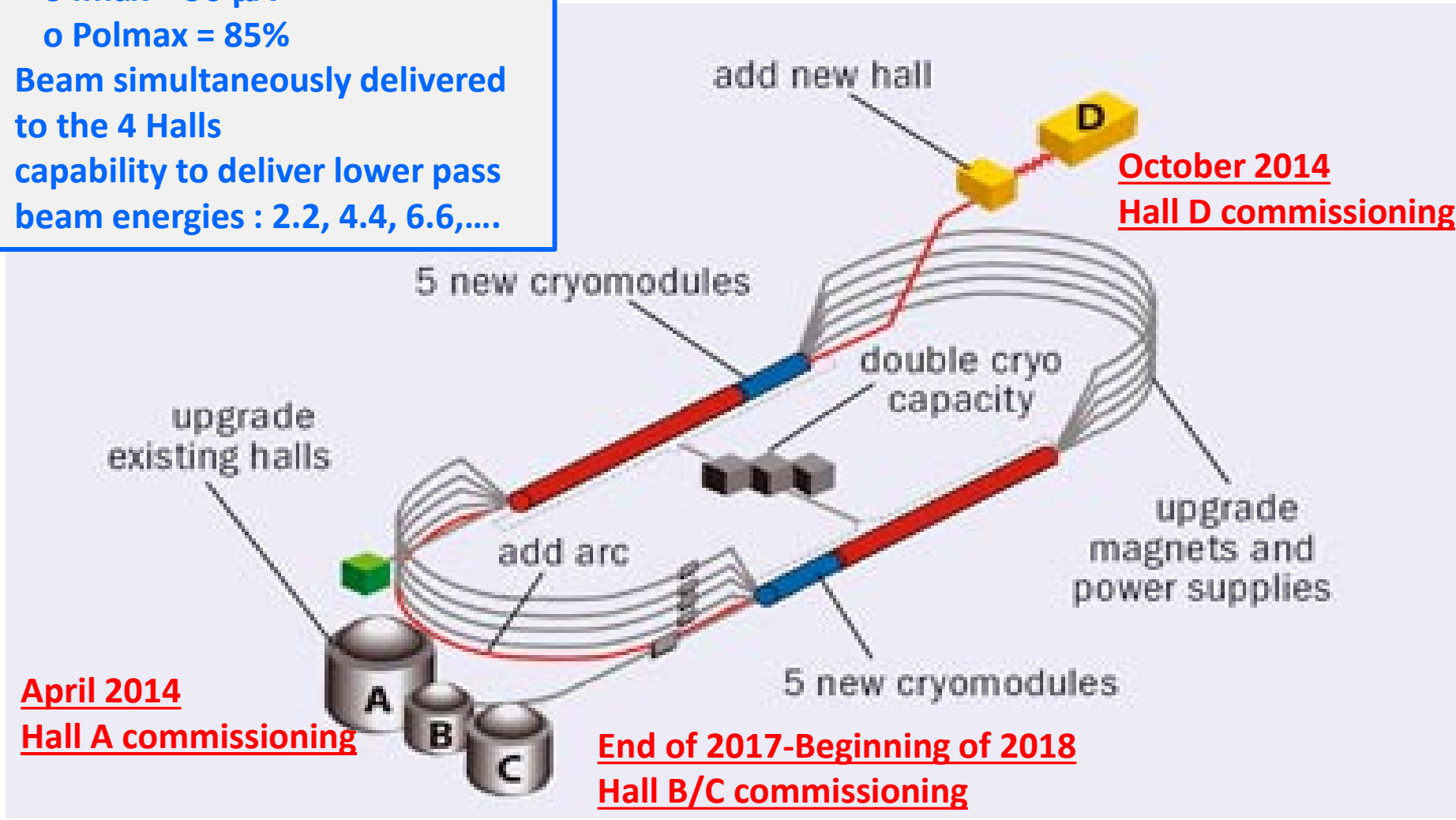
Jefferson Lab

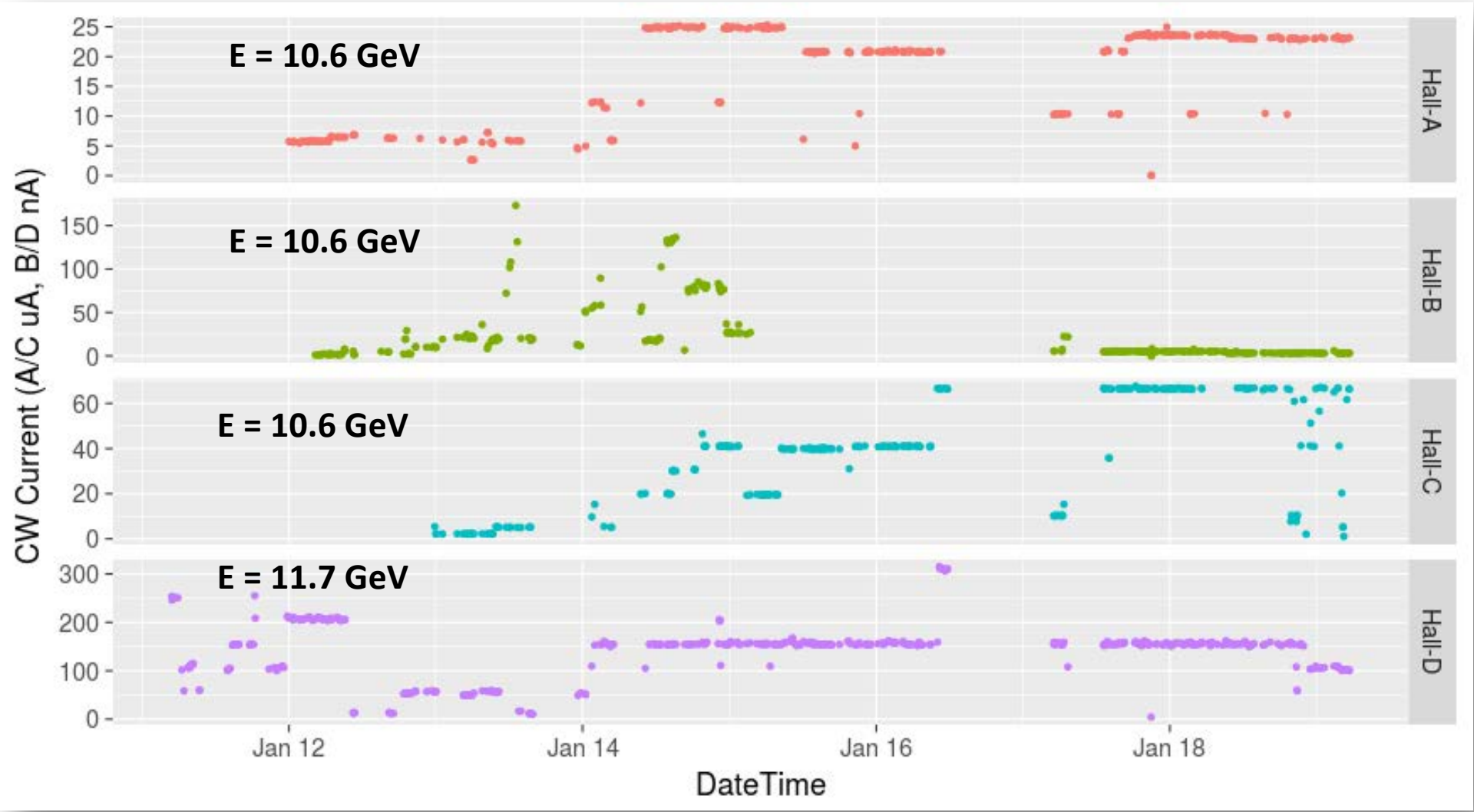
CEBAF: from 6 to 12 GeV

- CEBAF Upgrade
  - o Emax = 12 GeV
  - o Imax = 90 µA
  - o 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

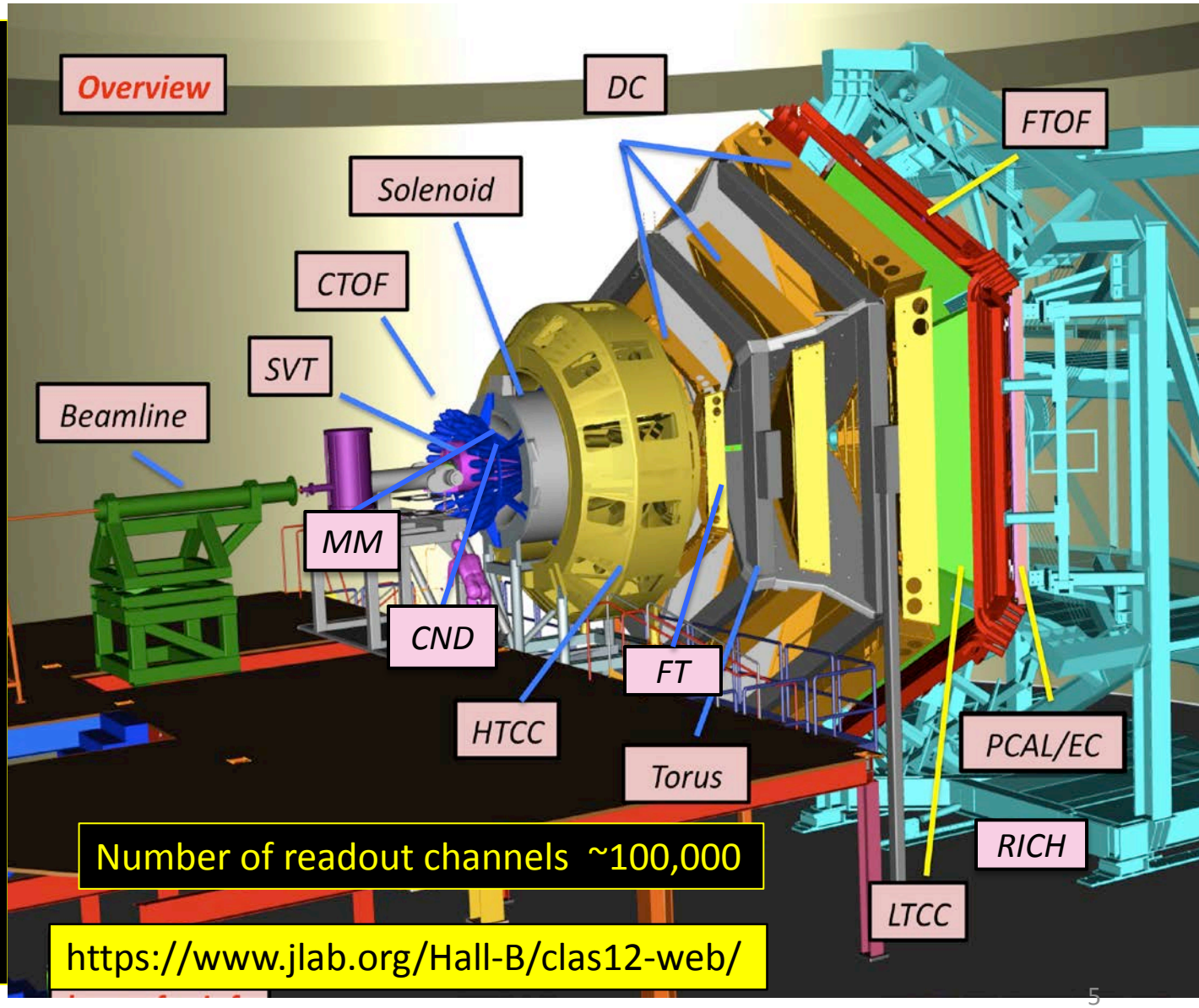


CLAS12 in Hall B

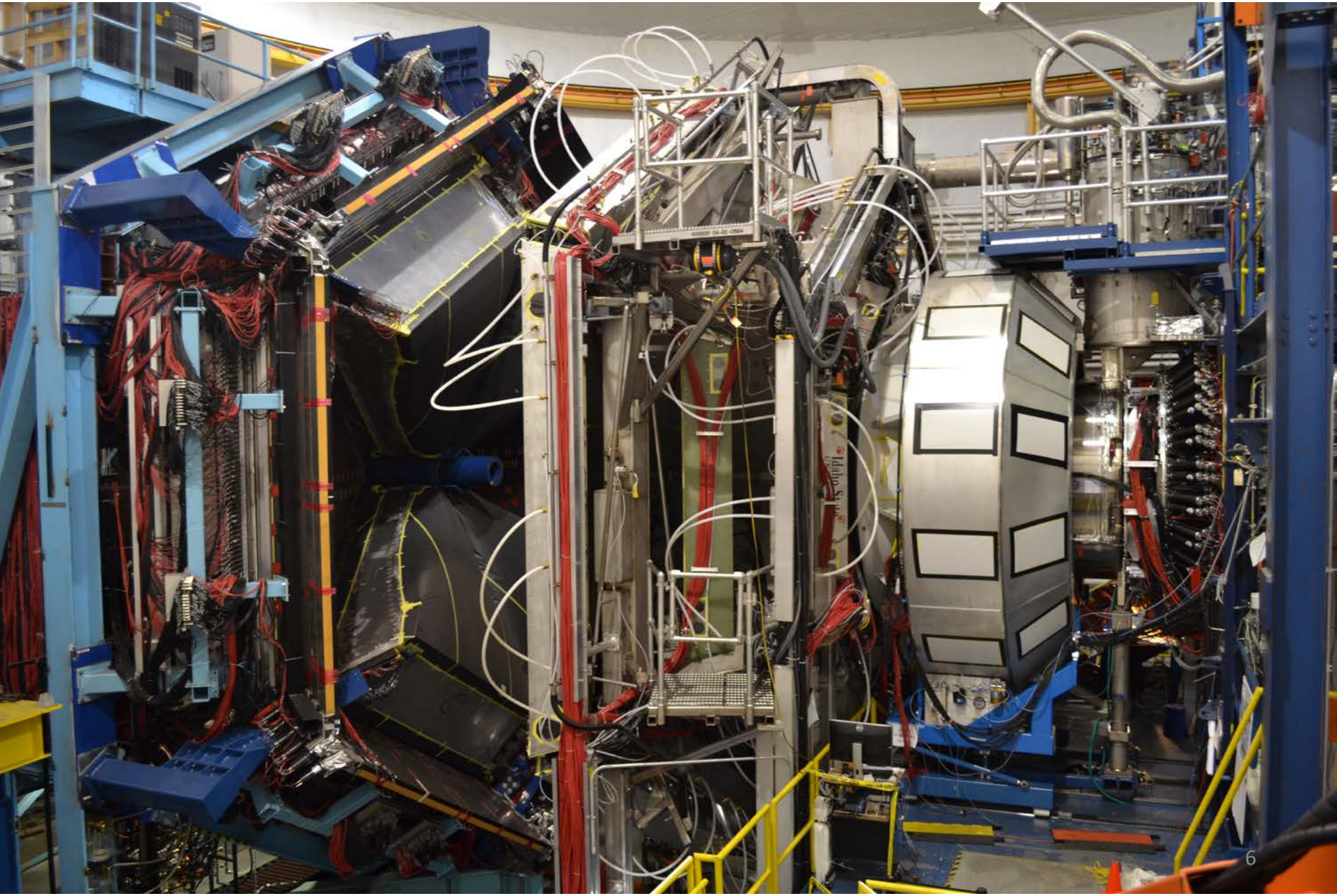
Forward Detector (FD)
- TORUS magnet
- HT Cherenkov Counter
- Drift chamber system
- LT Cherenkov Counter
- Forward ToF System
- Pre-shower calorimeter
- E.M. calorimeter
- Forward Tagger
- RICH detector

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

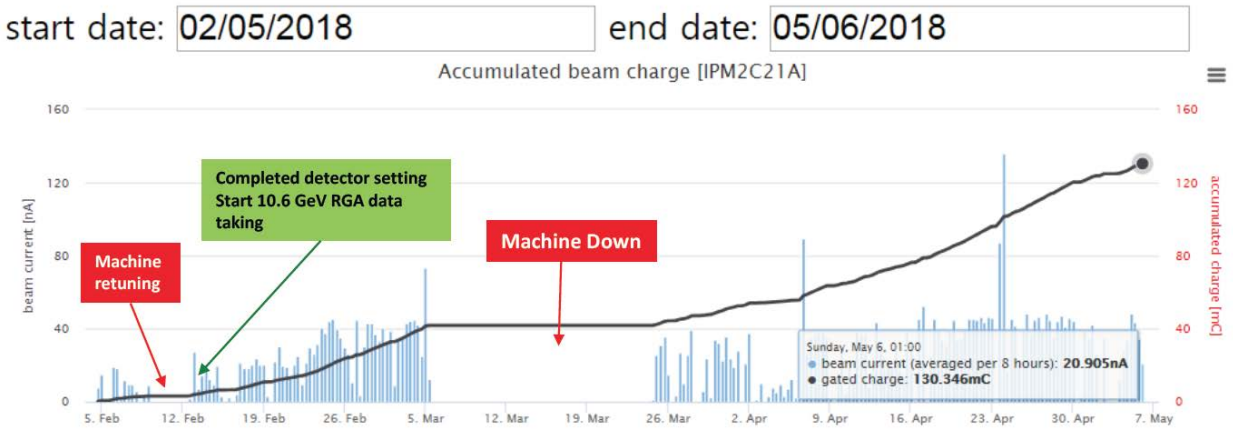


CLAS12: Installation complete



First 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 / May 2018: Run Group A**
  - **Liquid hydrogen target**
  - **10.6 GeV electron beam energy, polarization >80%**
  - **two torus configurations: 75% inbending, 25% outbending**



Total luminosity collected corresponding to about 22 days (15% of the assigned time)

Run Group A Experiments

Comprises 13 different experiments

- TMDs
- GPDs
- Fracture functions
- Form Factors
- hard exclusive meson production
- baryon and meson spectroscopy
- nucleon resonances
- strange baryons
- J/psi
- exotics

Proposal	Physics
E12-06-108	Hard exclusive electro-production of π^0, η
E12-06-108A	Exclusive N*->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 productiuon in target fragmentation region
E12-06-112B	Colinear 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

Different experiments have different patterns in CLAS12

- **Trigger decision is based on PMT detectors and tracks in drift chambers and configured for 3 groups of experiments: "electrons", "MesonEx", "muons"**

Data aquisition

- **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%**

“Electron” trigger: 5 kHz (40 %)

“Muon” trigger: 2.7 kHz (20 %)

“MesonX” trigger 4.5 kHz (40 %)

CLAS12 Trigger Bits

Menu

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

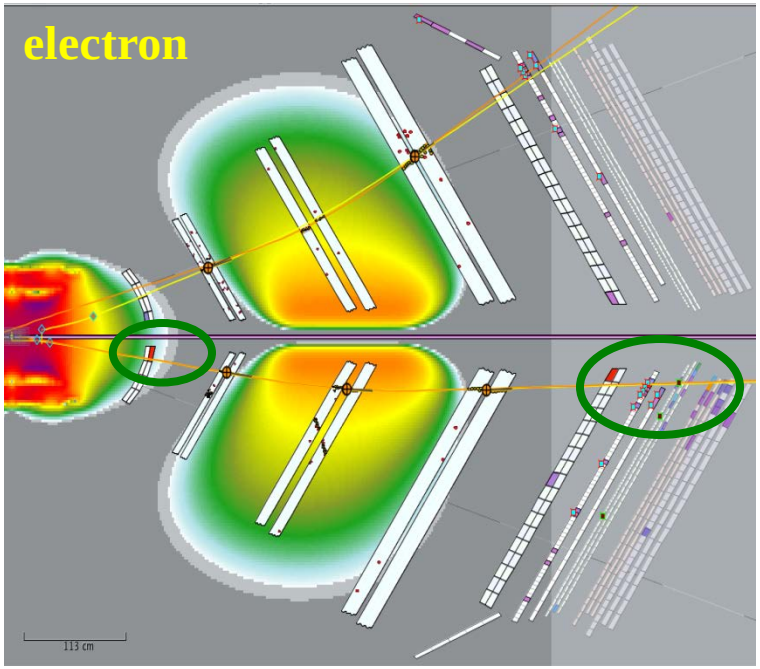
Livetime: 91.3 %

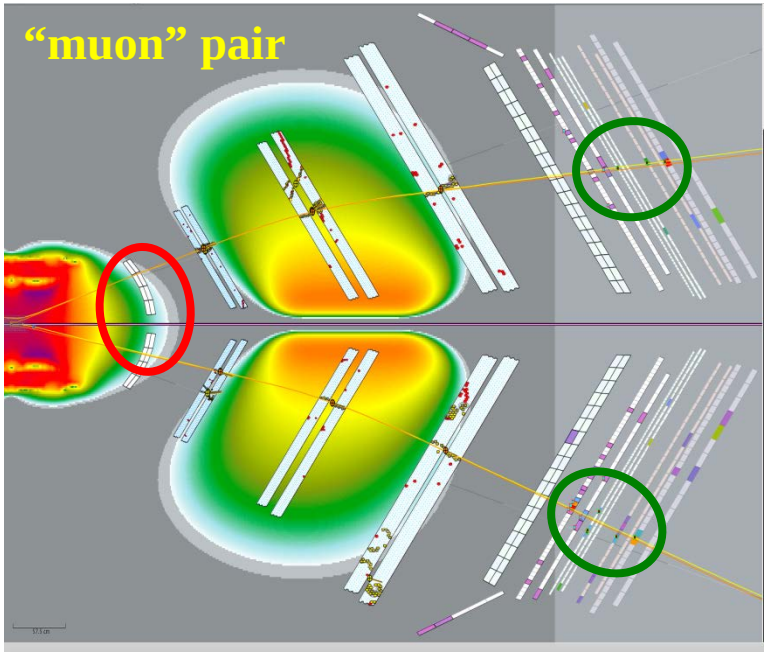
Heartbeat:

Totals (Hz): 2401371 13373

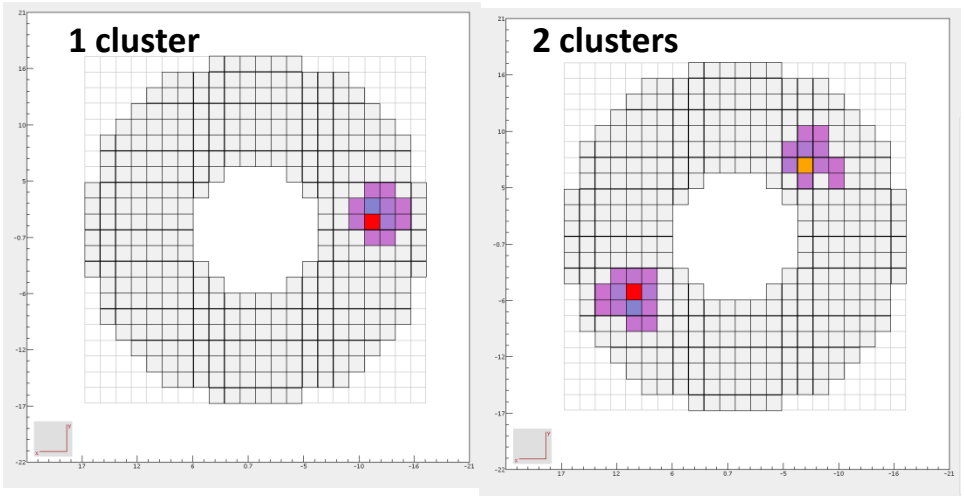
Bit	Description	Raw (Hz)	Prescaled (Hz)	Fraction (%)	Prescale	In Totals
0	Electron - OR of 1-6	5183	5183	38.8	0	
1	Sector 1	733	733		0	
2	Sector 2	754	754		0	
3	Sector 3	902	902		0	
4	Sector 4	1081	1081		0	
5	Sector 5	956	956		0	
6	Sector 6	791	791		0	
7	ElectronOR noDC >300MeV	7509	442	3.3	5	
8	PCALxECAL >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	

Event based triggers

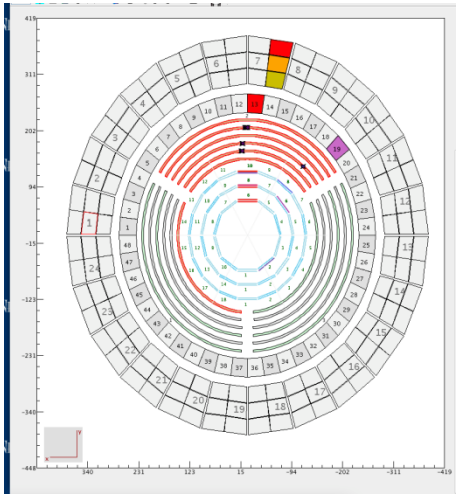




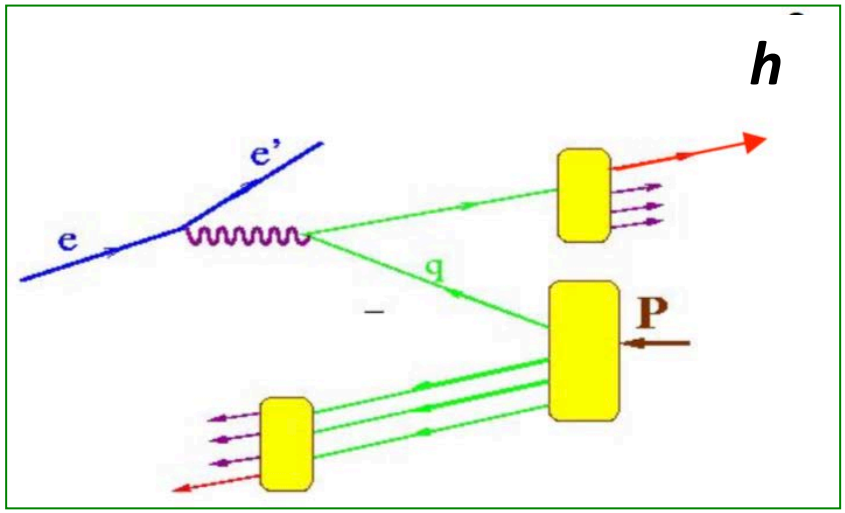
FT-CAL Trigger



CD - CTOF



SIDIS in CLAS12



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

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

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

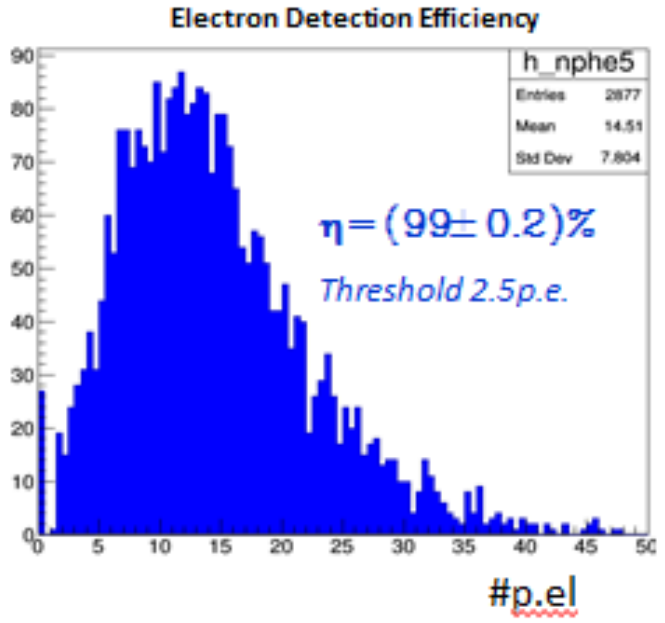
Next plots from data with inbending torus field

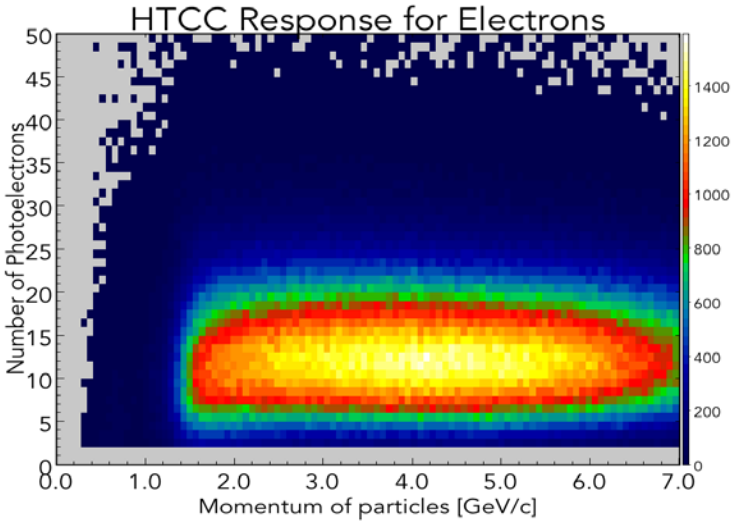
- positive charge bent to higher polar angle (far from the beam line)
- negative charge bent to lower theta (toward the beam line)
- data from 1 day of run

Electron ID: Threshold Cherenkov

High Threshold Cherenkov Counter

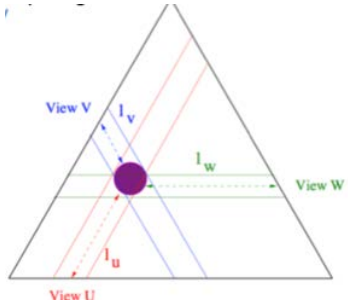
- **360^o coverage in azimuth**
- **Radiator Gas: CO_2**
- **Threshold for pions: 5 GeV/c**

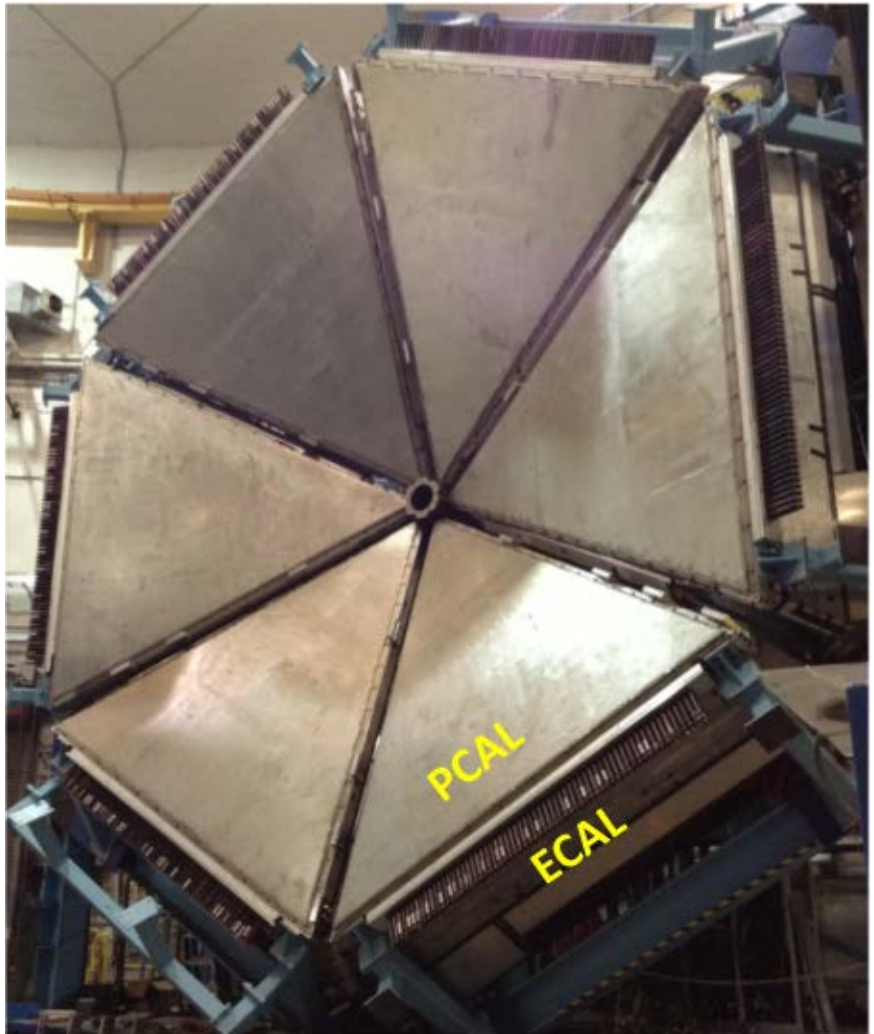


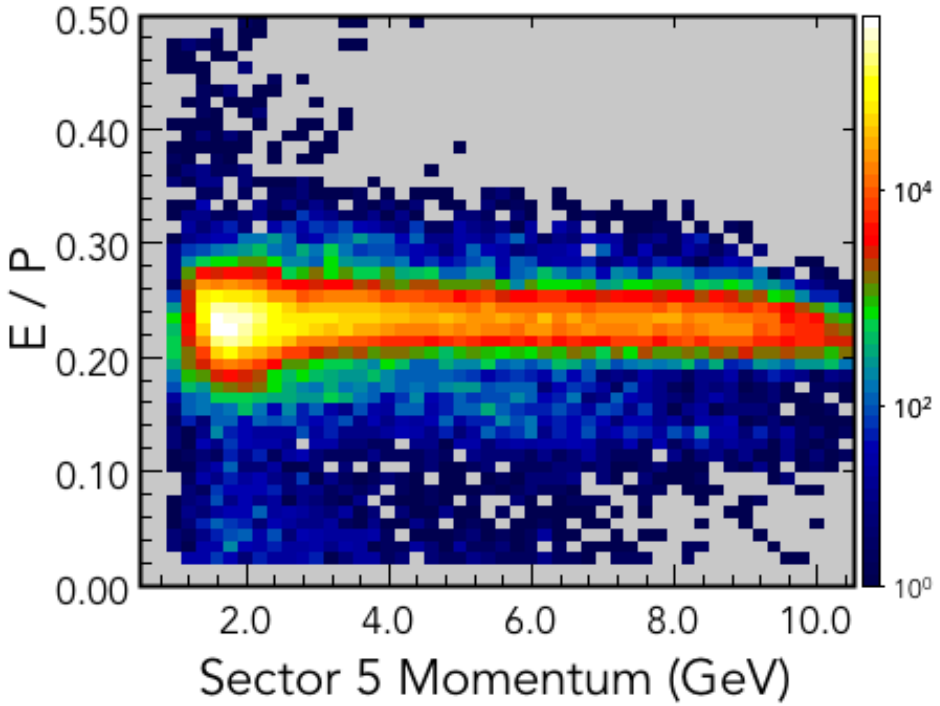


Electron ID: Calorimeter

- 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



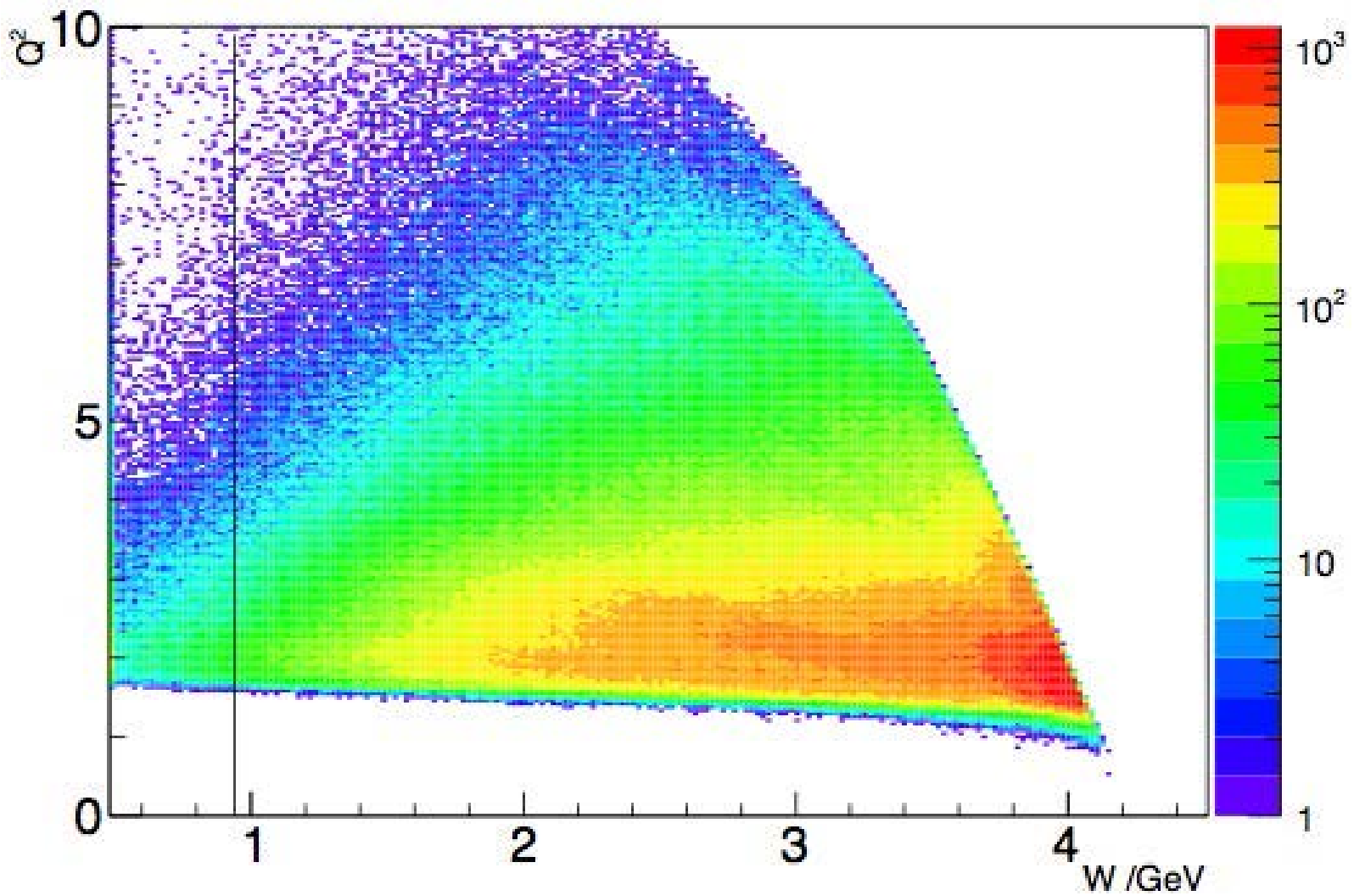




Kinematic coverage

Inclusive electrons

$Q^2 > 1$ GeV^2 **W > 2 GeV**

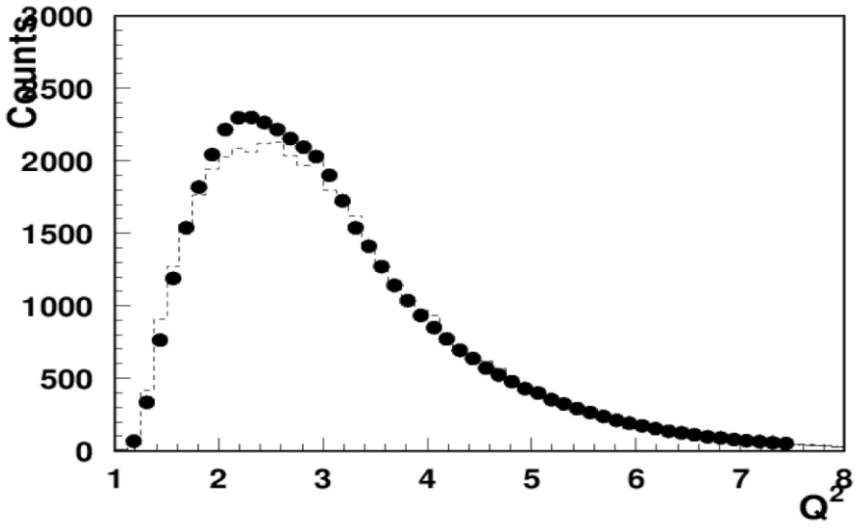


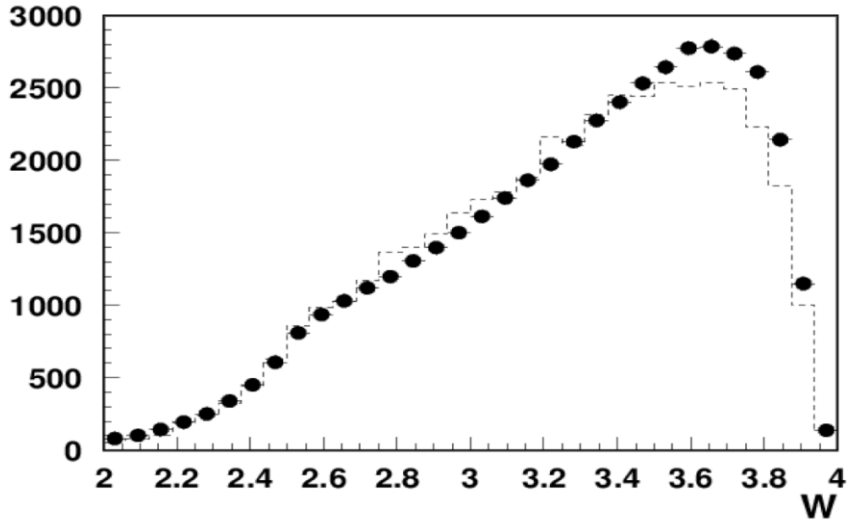
Data-MC comparison

Inclusive electrons

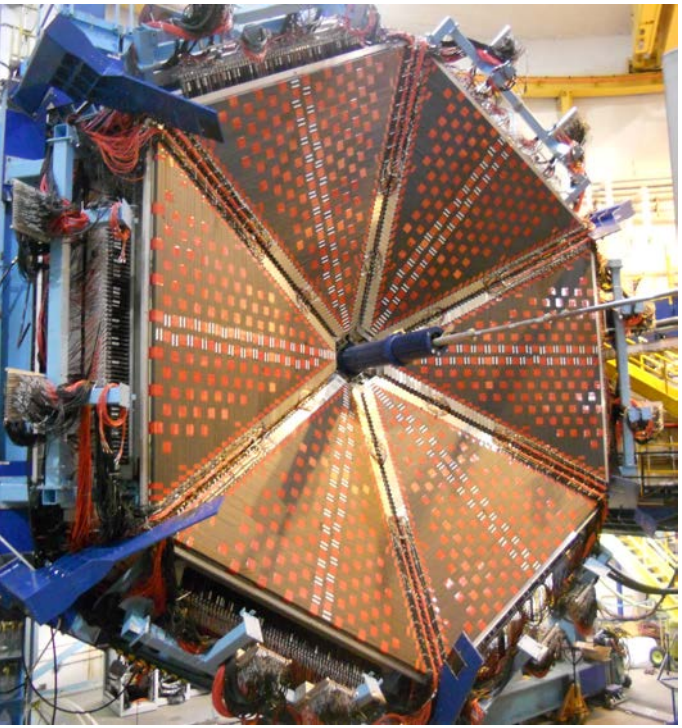
$Q^2 > 1$ GeV^2 **W > 2 GeV**

Points: Exp data
Lines: MC data



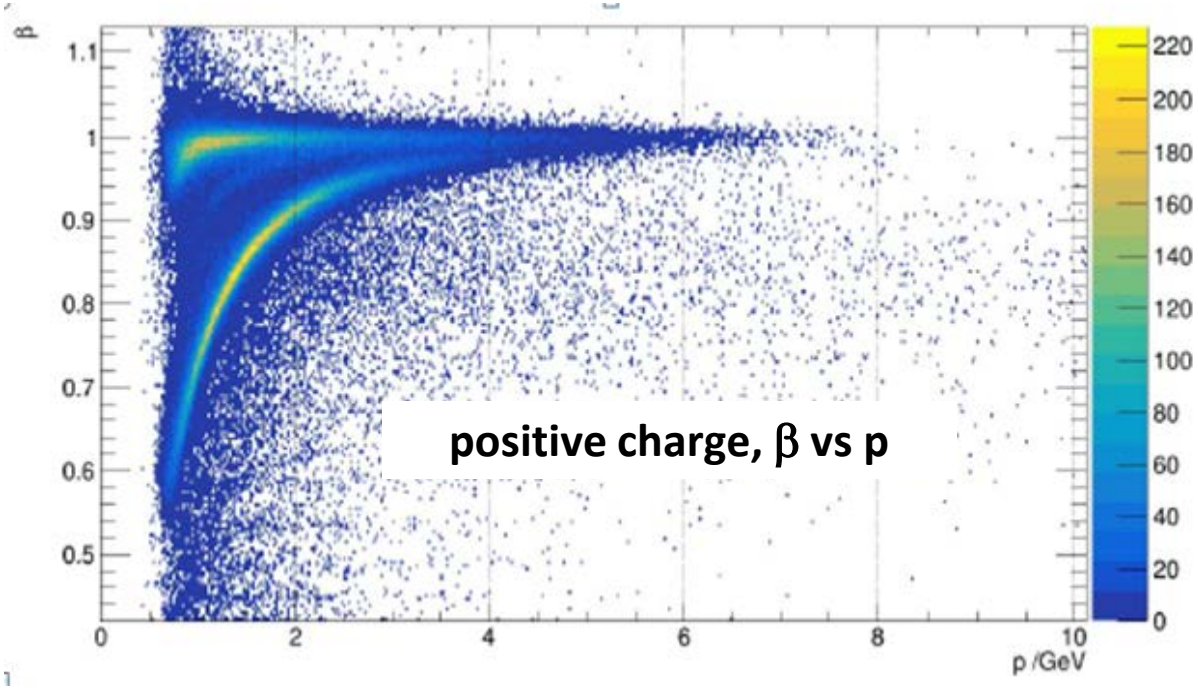


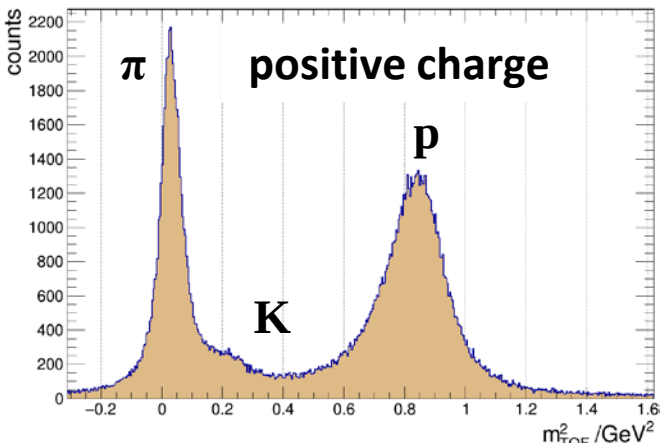
Charged hadron ID: FTOF



Forward time-of-flight

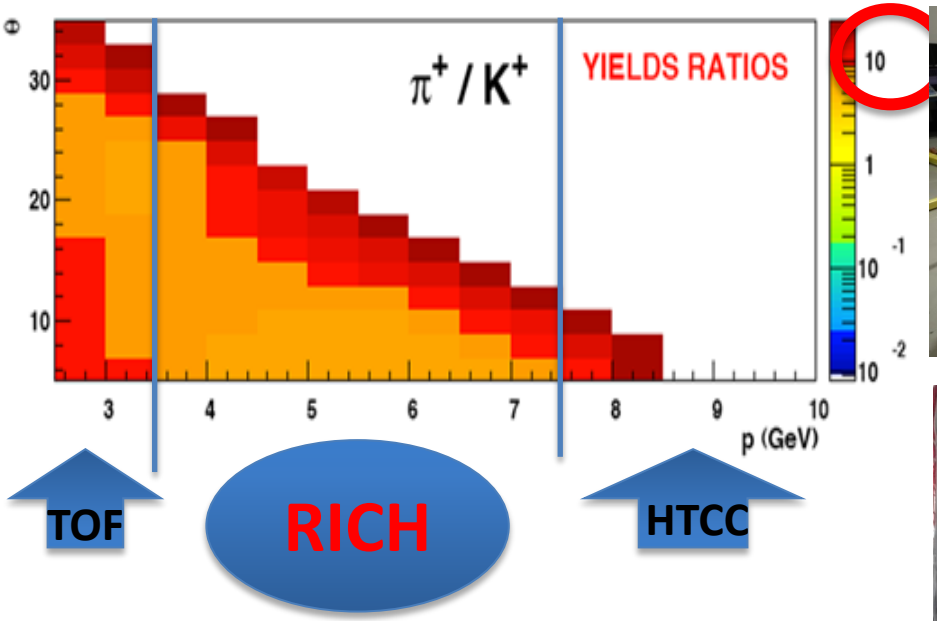
- **scintillator bars in 3 panels**
- **time resolution 100-300 ps**

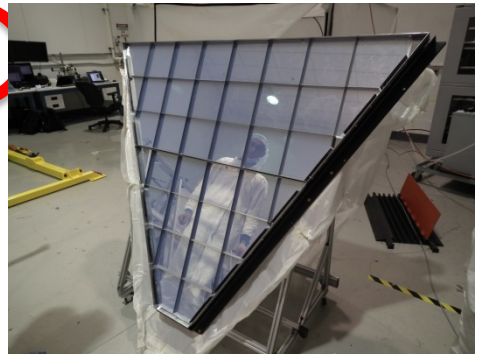


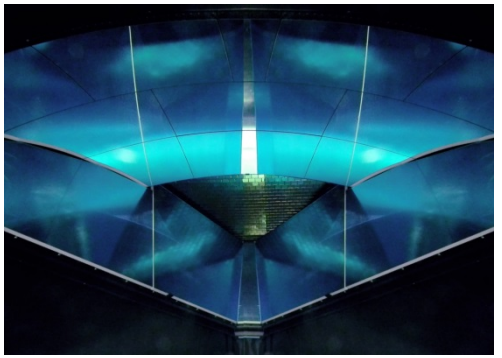


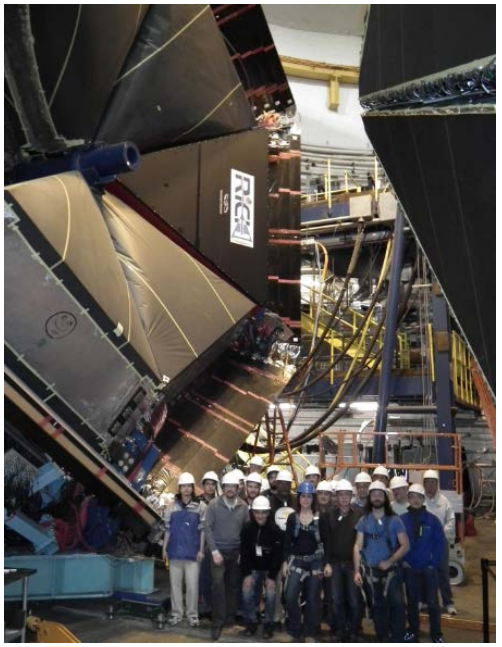
Kaon detection

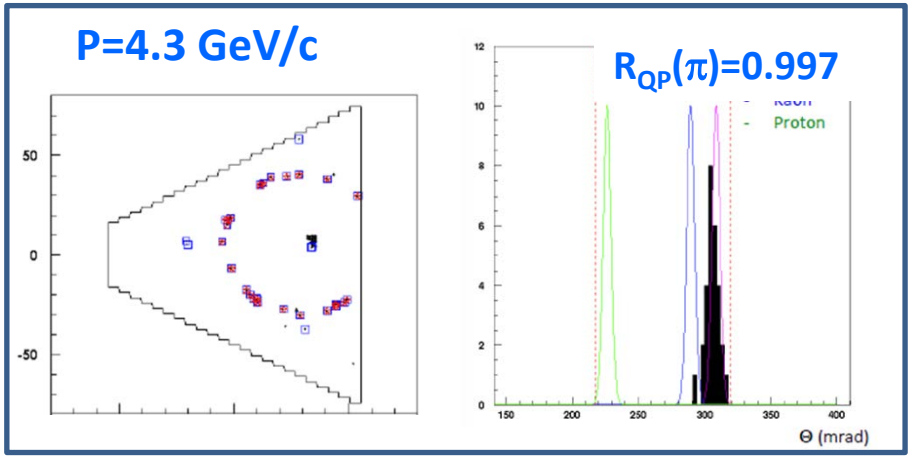
- Kaon ID in the momentum range 3-8 GeV is performed with the RICH
- First RICH module installed in January 2018







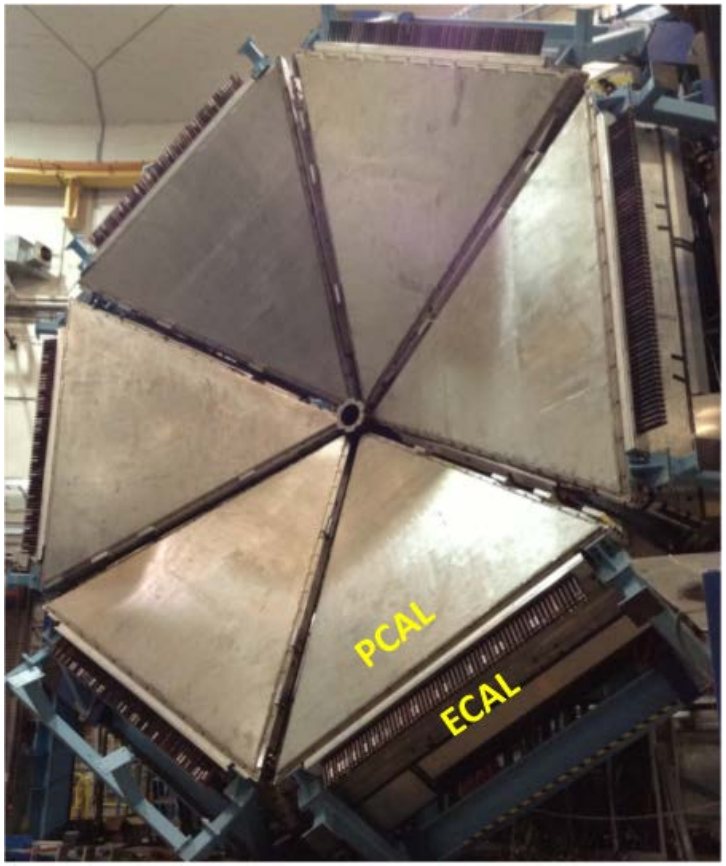


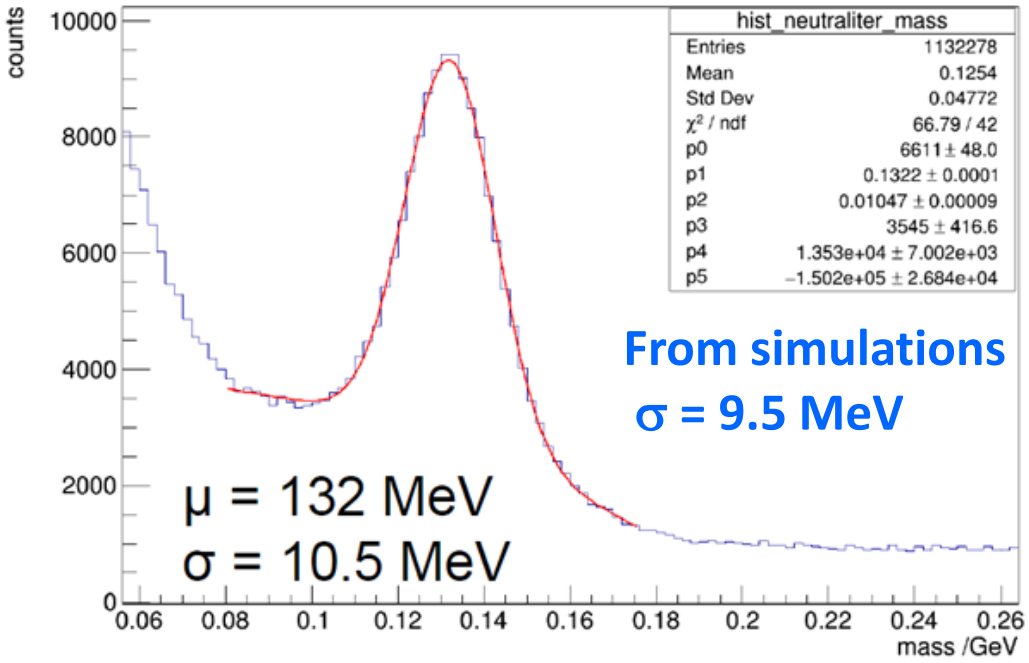


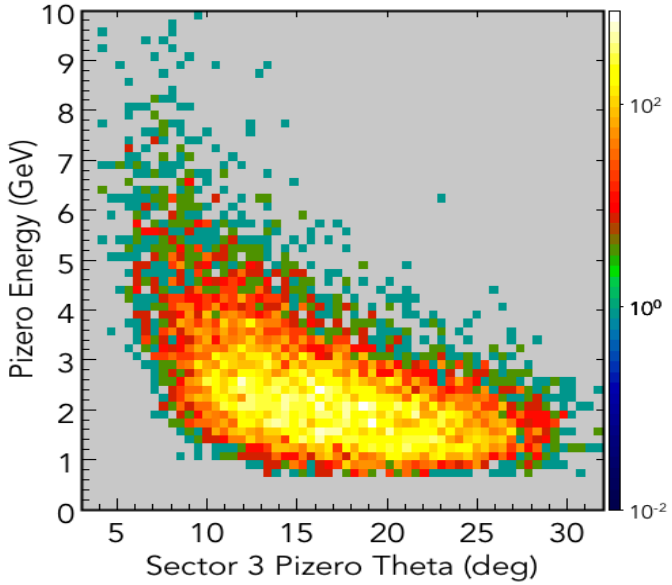
Neutral hadron ID

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

- two photons detected in the forward calorimeters
- E_γ > 400 MeV



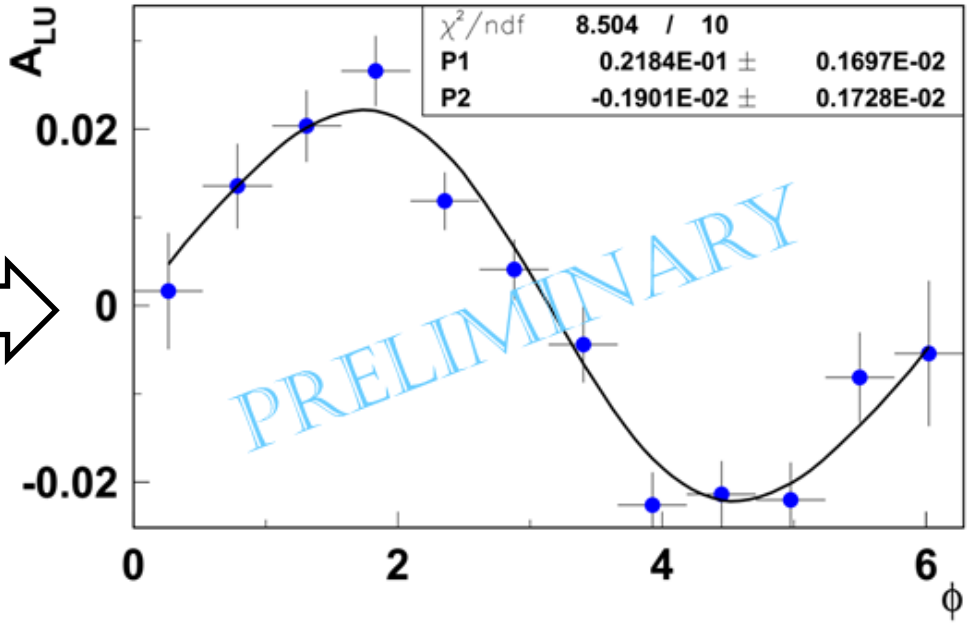


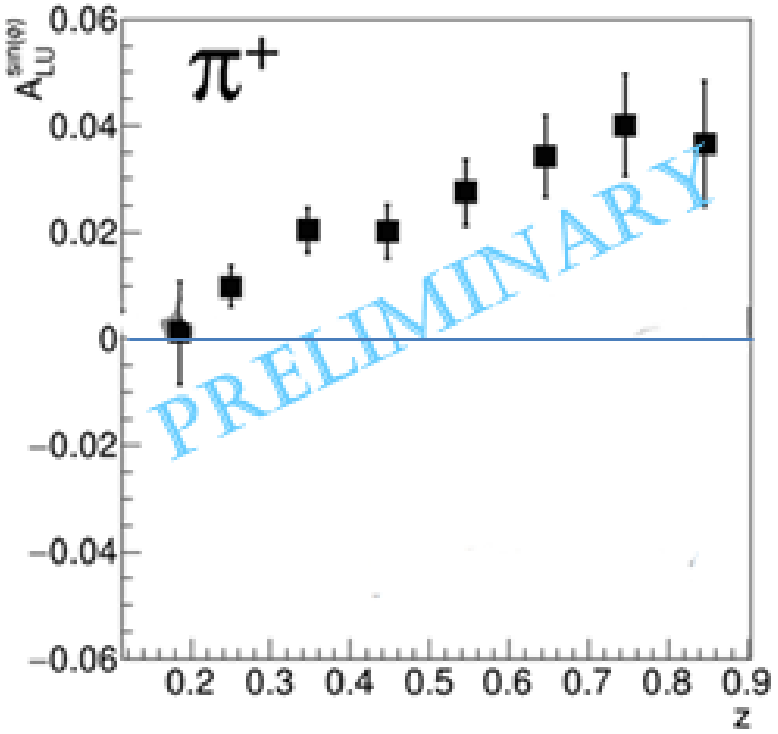


Pi+ Beam Spin Asymmetry

One day of data taking
Q^2>1 GeV^2 W>2 GeV

Fully integrated kinematics





z-dependence
- **positive asymmetry**
- **rising with z**

Conclusions and outlook

1) **CLAS12 First experiment had a very successful run during the spring operation.**
   - **Detectors performed generally well**
   - **Detector performances are confirming the expectations, but calibration is still in progress**

2) **Data analysis is progressing, the first preliminary physics results at the APS/DNP meeting in October**

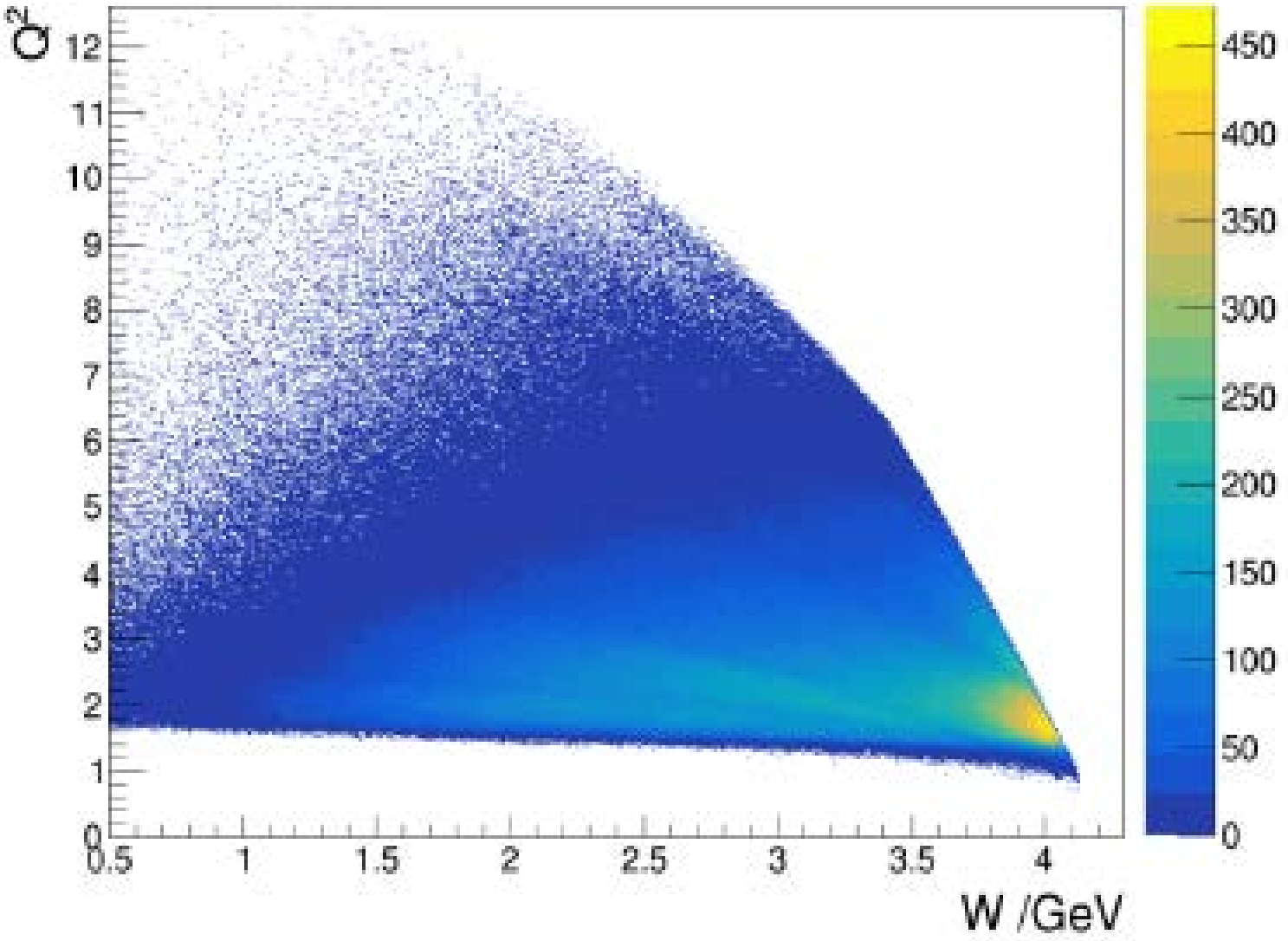
3) **Fall run is in preparation and will restart in these days, it will continue up to spring 2019**
   - **Run Group A: continue data taking**
   - **Run Group K: lower beam energy for baryon spectroscopy**
   - **Run Group B: liquid deuterium target**

backup

Kinematic coverage

SIDIS cuts

Q2 > 1 GeV2 W > 2 GeV



Kinematic coverage

SIDIS cuts

Q2 > 1 GeV2 W > 2 GeV

Outbending torus field