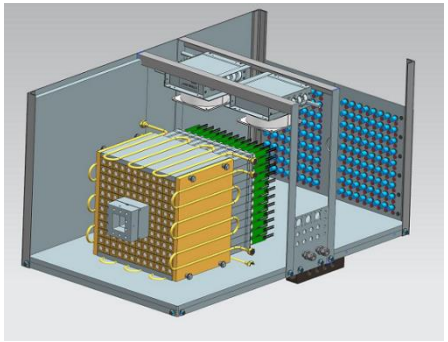
Jefferson Lab



PrimEx Overview and Preparation for 2021

A. Somov

on behalf of the PrimEx group

GlueX collaboration meeting, October 22, 2020

Overview

- PrimEx Phase I run in Spring 2019
- Status of calibration
- Status of data analyses
- Preparation for run in 2021

PrimEx Phase I (Spring 2019)

Approved by PAC

LH_2 target	40 days
LHe_4	30 days
Empty target	6 days
Setup, Calibration	3 days
Total	**79 days**

Time	Beam energy	Calendar Days	PAC days
02/21 – 03/05 03/08 – 04/15	11.61 GeV 11.17 GeV	15 38	8 16
Total		**53**	**24**

Phase I

Efficiency 0.45

Collected data sample

	He empty	He target		Be target	Be empty
Total (M)	3288	40970		2789	643

Have to take data for 6 PAC days on He target

(no FOM corrections applied due to smaller beam ebergy)

PrimEx Phase II (Summer 2021)

Time	Beam energy	Calendar Days
06/21/2021 - 08/14/2020	10.1 GeV	54

- Significantly smaller beam energy

  - about 4 times smaller photon flux in the energy range between 9.5 GeV + (for the same rate of accidentals in the tagger)
  - larger contribution from coherent nuclear background at small energies

- Some overhead needed to calibrate CCAL, FCAL, and TAC run
  - expect to replace about 300 bases, calibration run may be required

- Have to run on Be target for target density calibration

- Expect to finish taking data on 4He target

Status of Calibration

A lot of help received from the collaboration (thanks to Sean, Zisis, and many others).
PrimEx group members have to be deeply involved in many calibration activities:

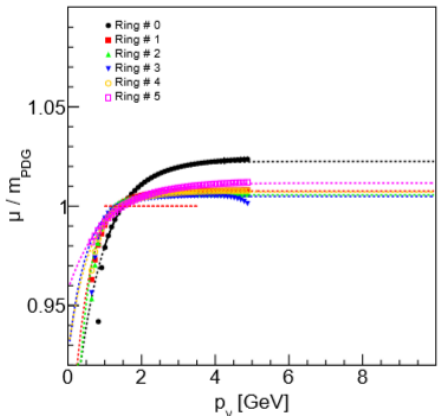
CCAL calibration	Drew	(done)
FCAL time calibration	Drew	(done)
FCAL energy calibration	Igal	(final steps)
FCAL mask of dead / suspicious channels	Chandra	(in process)
FCAL / CCAL alignment	Drew	(in process)
TAGH / TAGM / PS energy calibration	Sasha	(done)
PS timing	Sasha	(done)
TAGM timing	Sasha	(in process)

FCAL Energy Calibration

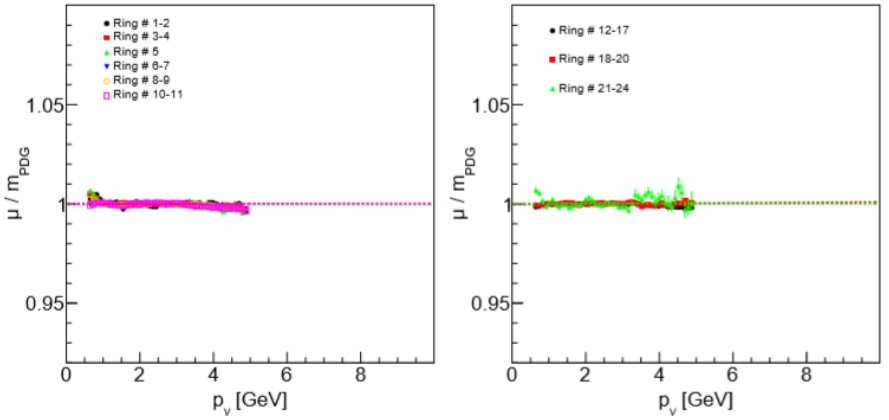
Igal

- Apply energy-dependent corrections in different FCAL rings
  - select symmetric photon pairs: $0.7 < p_\gamma^1 / p_\gamma^2 < 1.3$

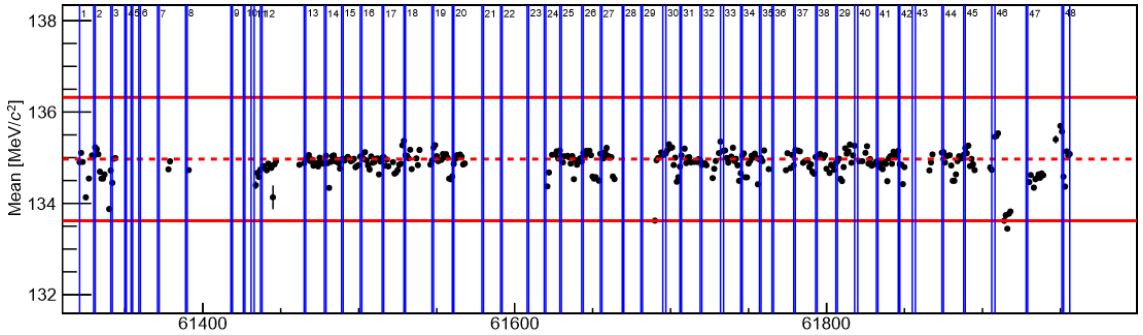
before corrections



after corrections



- Energy calibration for 48 run periods. **Stability of the π^0 mass better than 1 %**



- Final calibration steps, new constants in the CCDB

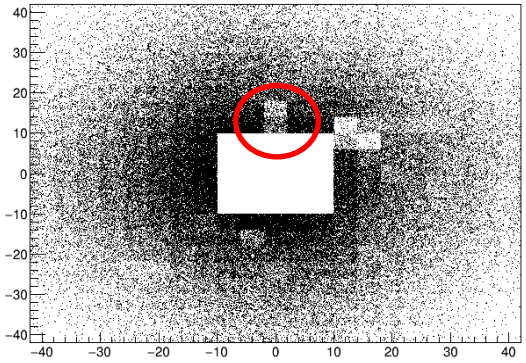
FCAL Performance and Masks of Suspicious Channels

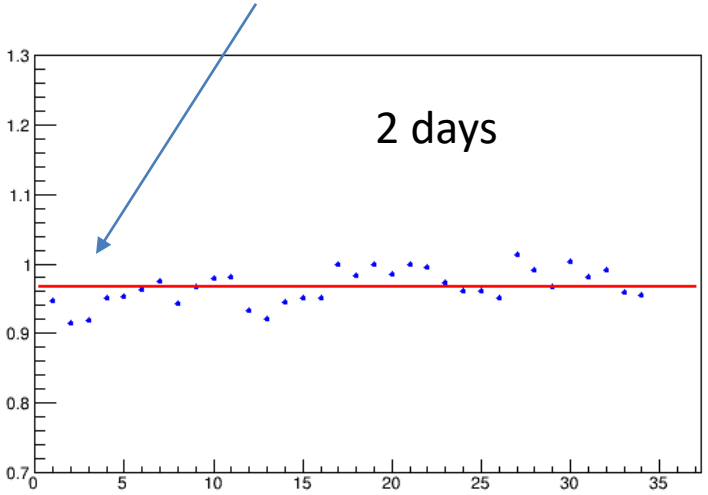
Relatively unstable behavior of the FCAL

- dead PMT bases during run
  (several bases were replace every week)

- missing communication to the base
  (channels dead for some time)

FCAL XY of clusters





- Flux normalized yield of
- two-cluster events

Masks of Suspicious Channels

Chandra

FCAL data quality: suspicious and dead channels

- Determine mask of suspicious and dead channels for every run.

- occupancies from LED and data

- FCAL masks implemented for PrimEx GlueX-doc-4610 (A. Somov)

- Masks have to be determined for about 50% of PrimEx data

Production on He target RUN Period 1

Run	Events (M)	FCAL bad ch	FCAL inner
61495	179	7(7)	1
61496	159	3(3)	1
61497	146	4(5)	1
61498	176	6(7)	2 (-5,8; -6,-4)
61499	160	5(6)	2
61500	173	6(5)	2
61501	175	5(1)	2
61502	173	6(1)	2
61503	82	5(3)	1 (-6,-4)
61504	92	4(4)	1 (-6,-4)
61505	72	4(3)	1
61506	143	4(5)	1
61507	34	5(1)	2(-6,-4; -5,8)
61508	133	4(6)	
61509	175	5(5)	1(-5,8)
61510	174	5(3)	1
61511	176	4(4)	1 (-5,8)

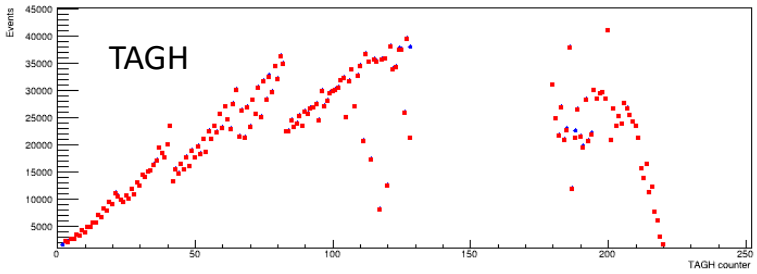
https://halldweb.jlab.org/primexd/data_quality_2019/quality_check_2019.pdf

Work in progress

Luminosity Determination for PrimEx

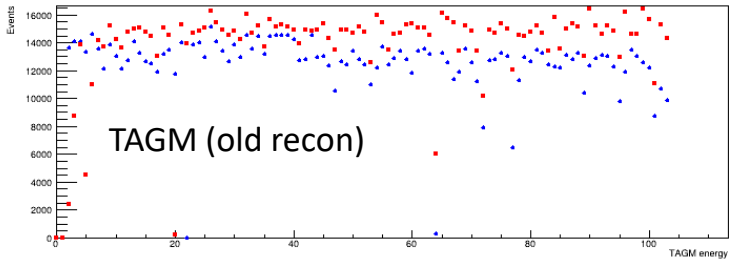
- Energy calibration of the PS, TAGH / TAGM
- Implement correct beam energy in the reconstruction and MC simulation
- Initial lumi numbers for PrimEx runs are in the CCDB since last year
- Not smooth energy dependence of the Compton cross section in the TAGM region
  - require TDC hit in the TAGM reconstruction (adopted by GlueX)
- Reprocess photon flux:
  - PS timing calibration has been screwed in April 2020 - recalibrated (lumi dropped compared with numbers from previous year)
  - work on understanding the TAGM reconstruction. Re-calibrating TAGM time-walk corrections

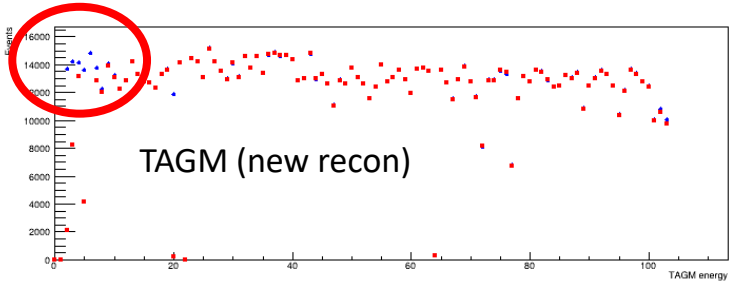
Tagged Flux for TAGH / TAGM



PS tagged flux extracted using two methods:

- Read points: Beam photon
- Blue points: FADC time (require ADC and TDC hits)





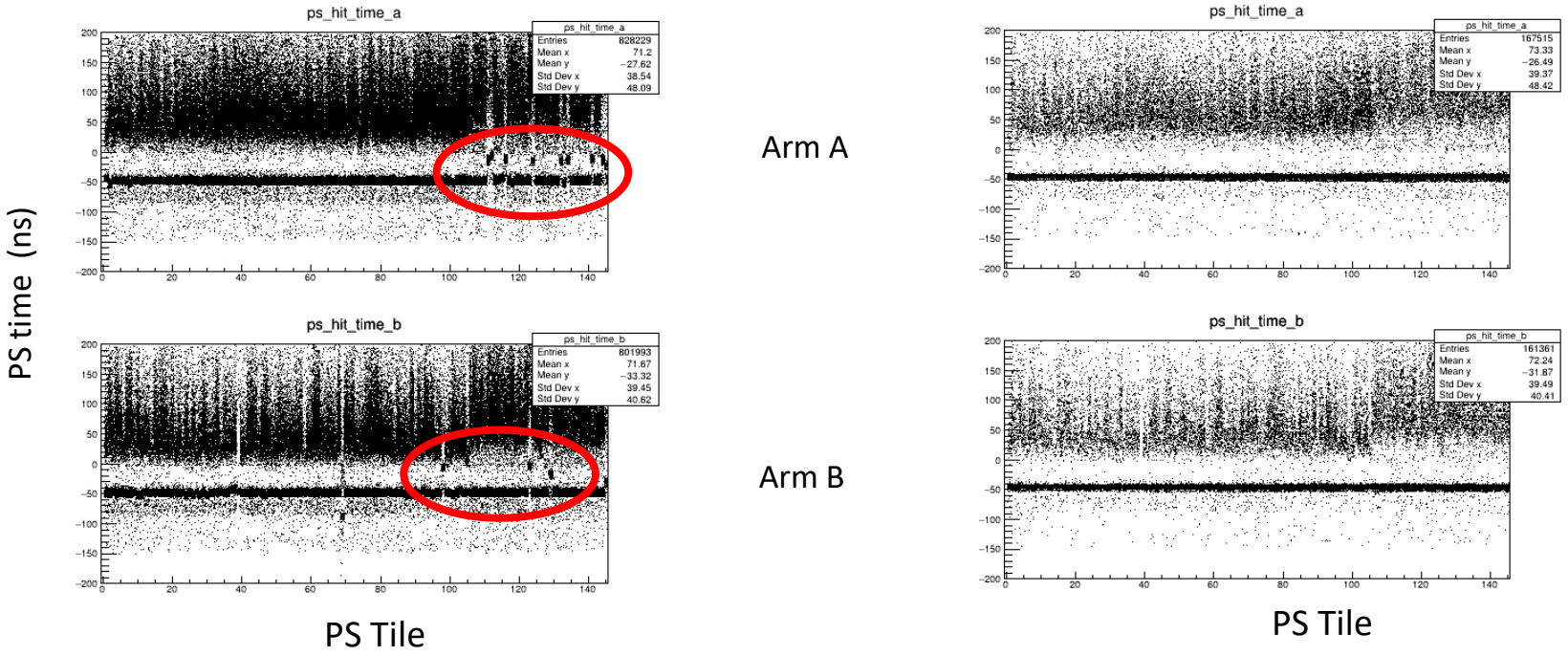
New reconstruction of the TAGM: (1) Require both ADC and TDC hits, remove amplitude thresholds

PS Timing Calibration

Run 61914 (He)

Before Calibration (Calibration updated in May)

After Calibration (New)



- Some PS hIts in Arm A and Arm B are out of time – missing PS coincidence
- Recalibrate PS time for all PrimEx runs (new constants in CCDB)
- Still some minor issues with TAGH/TAGM timing for some runs

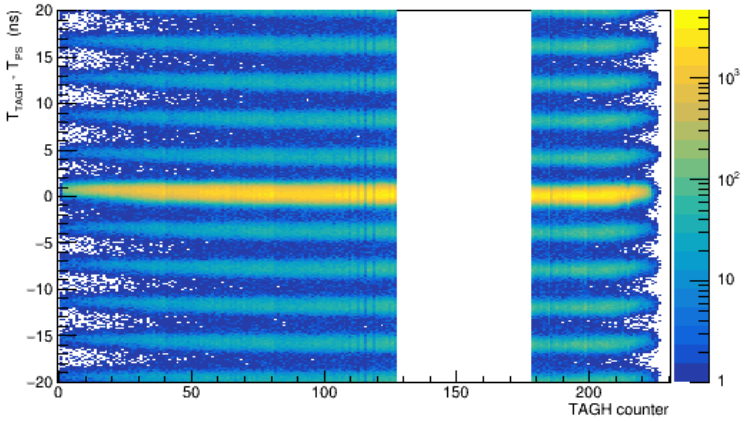
- https://halldweb.jlab.org/primexd/data_quality_2019/quality_check_2019.pdf

TAGM Time Calibration

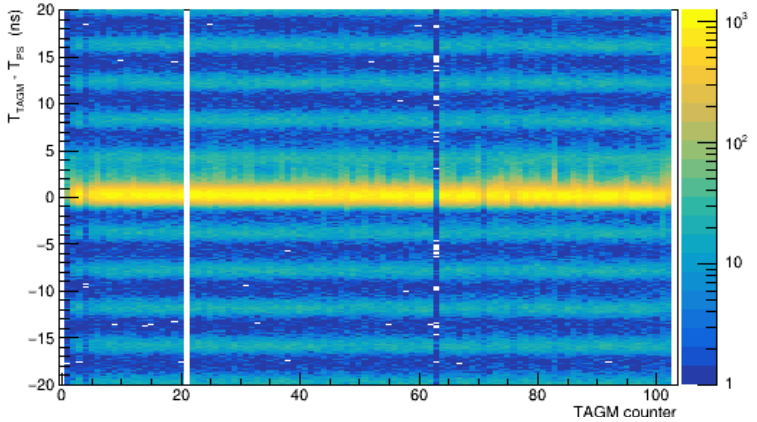
Run 61321 (Be)

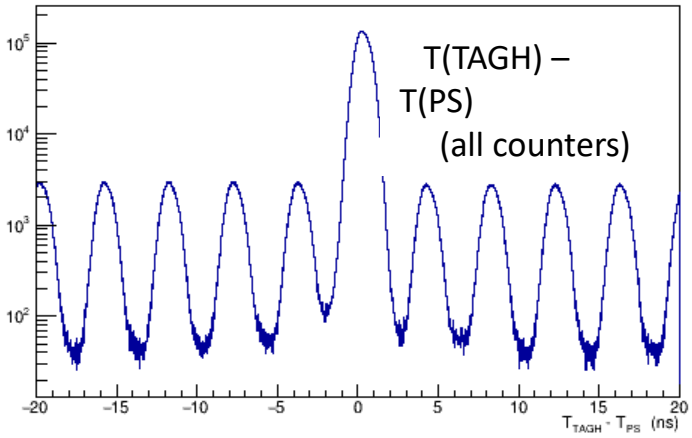
Sasha, October 9, 2020

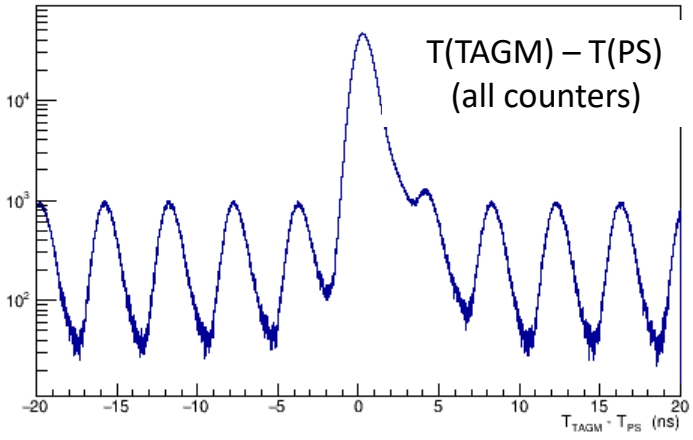
T(TAGH) – T(PS)



T(TAGM) – T(PS)

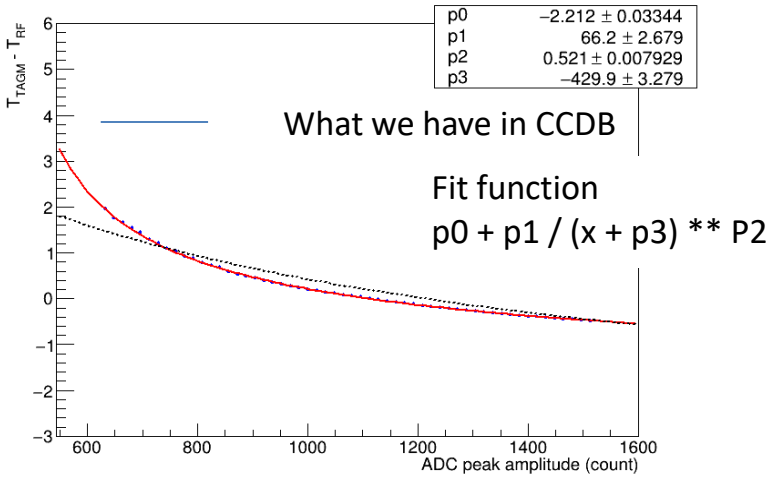




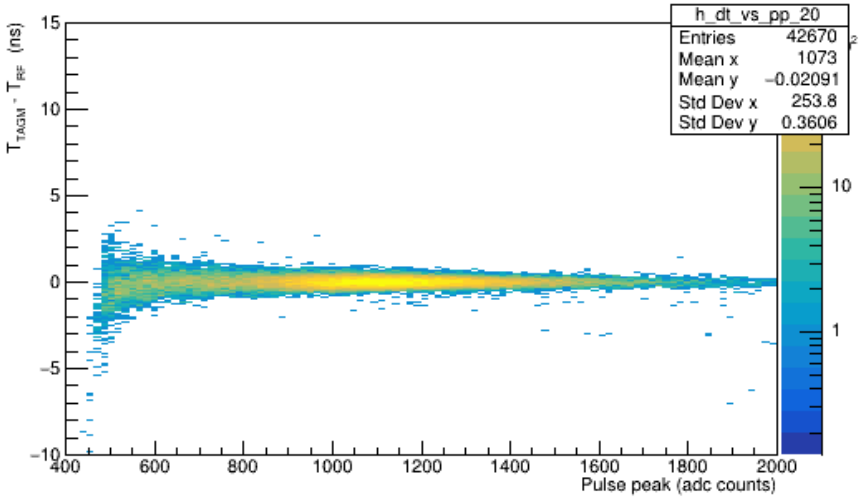


TAGM Time Walk Calibration

TAGM Counter 20



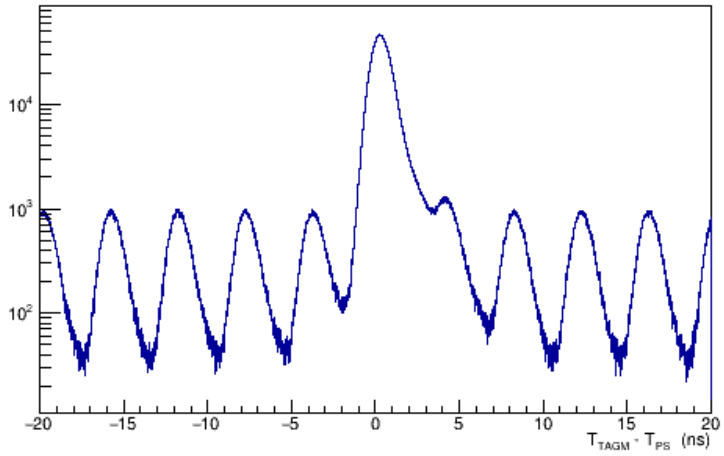
After Calibration



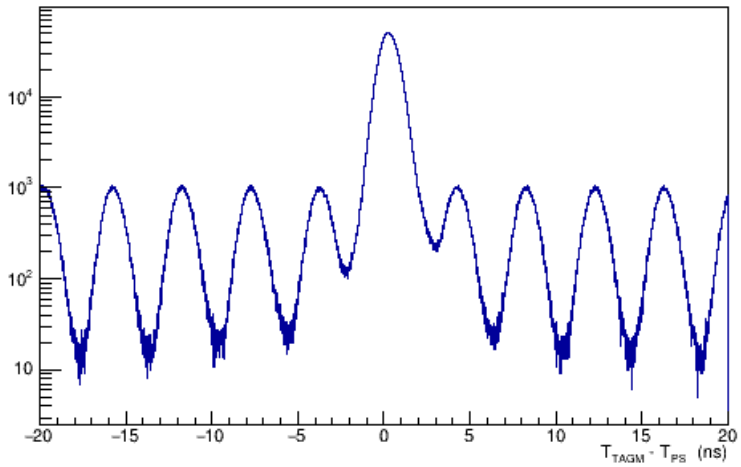
Run 61321

TAGM Time Walk Calibration Results

Before Calibration



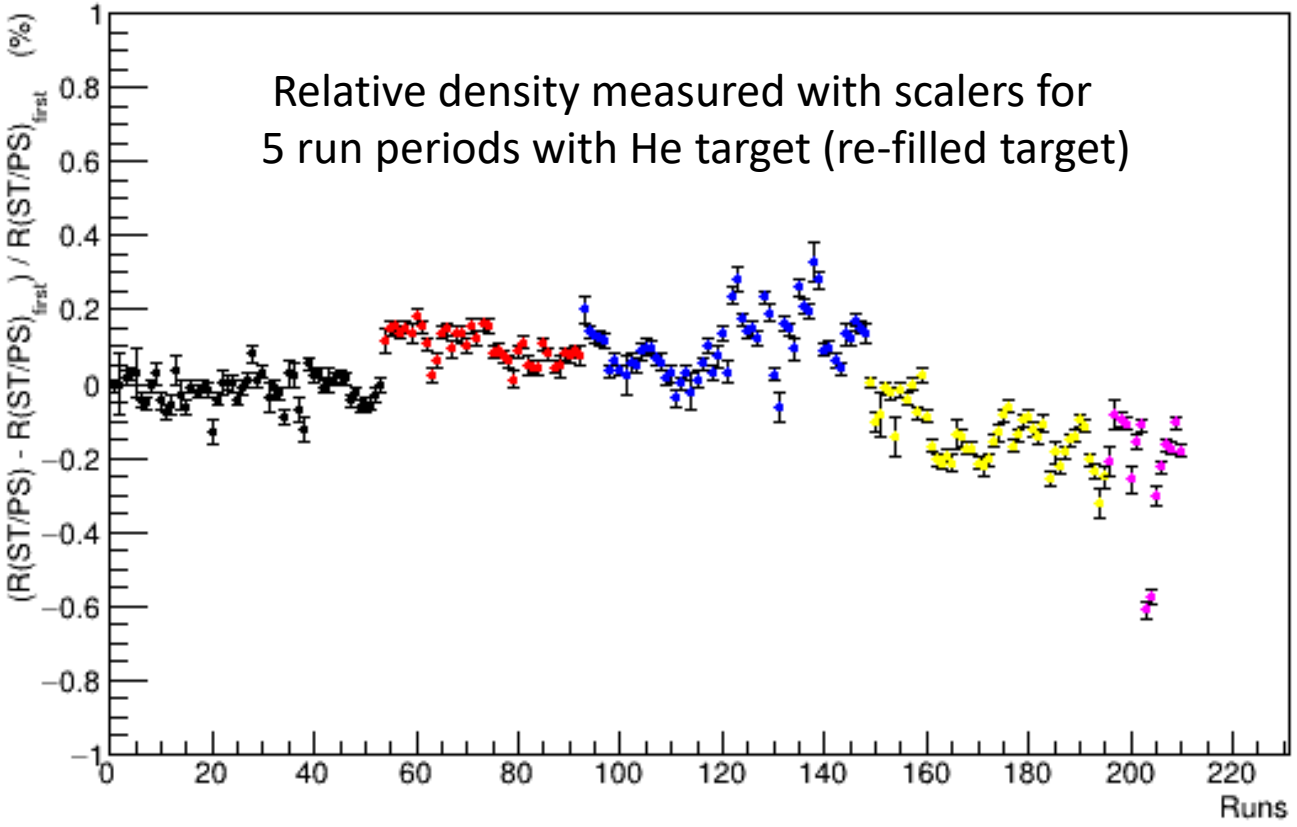
After Calibration



Monitoring ^{4}He Target Density

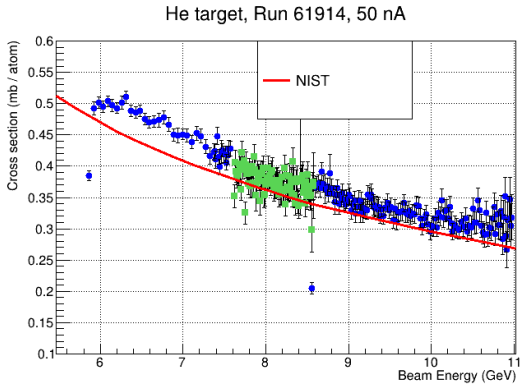
- Use PS and ST fadc scalers to monitor target density
  PS rate – flux, ST rate – proportional to target density

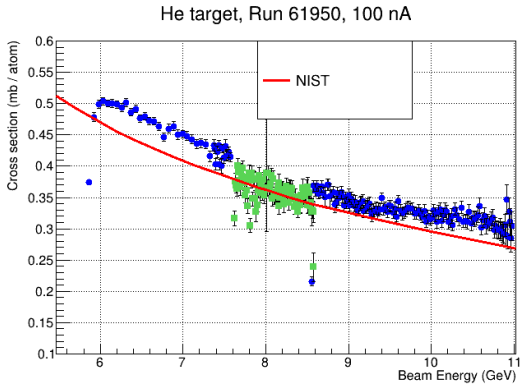
  - sensitivity verified with MC simulation, run in parallel with taking data

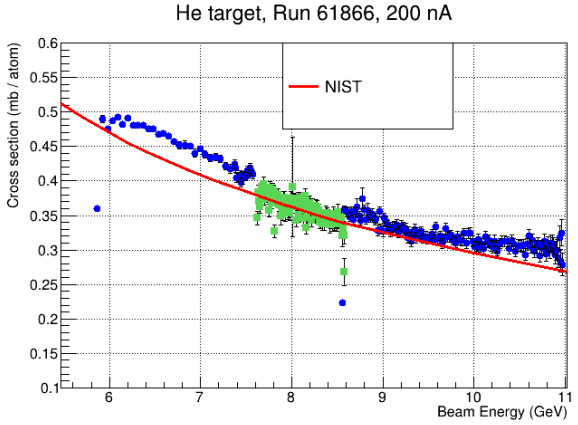


- Density stability better than 1 % (have to use Compton to verify)

Compton Cross Section (He Runs)







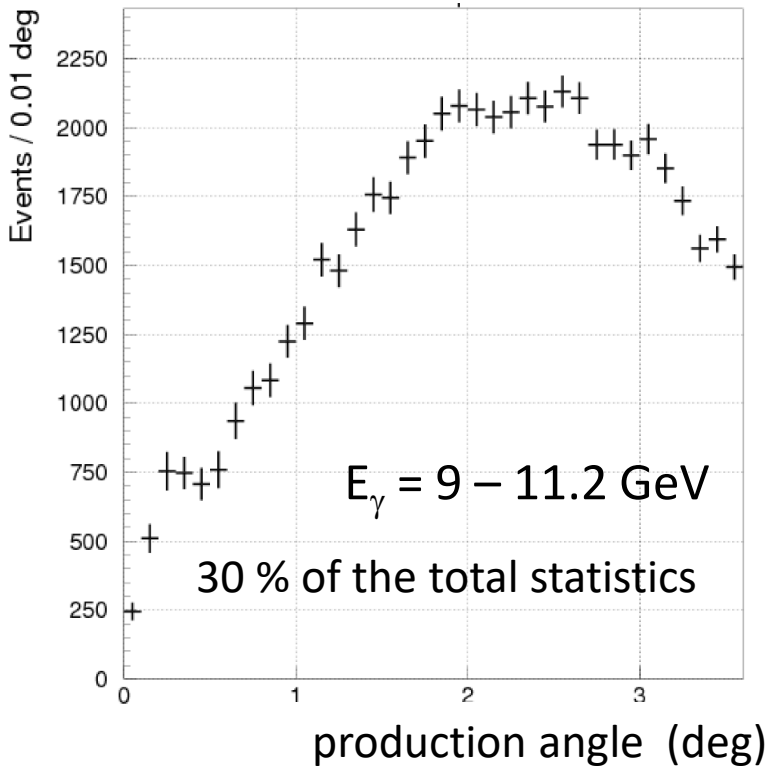
Low intensity

Runs from different target fills

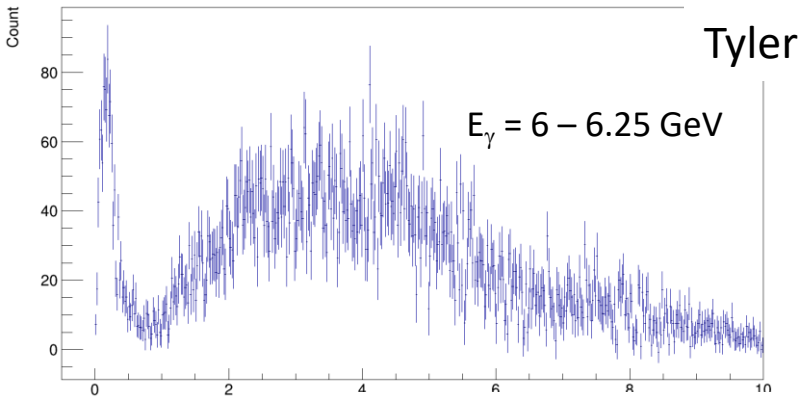
- Some small discrepancies in cross section shapes
- Lumi for TAGM has not yet been updated
  - Checking TAGM reconstruction

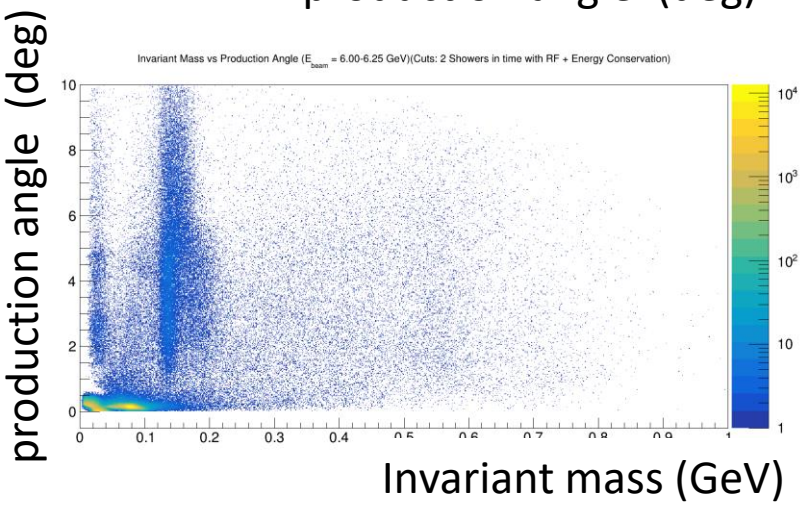
Analyses of PrimEx Data

$\eta \rightarrow \gamma\gamma$ Angular Distribution



$\pi^0 \rightarrow \gamma\gamma$ Angular Distribution





Several ongoing analyses:

Andrew (Compton, see next talk), Tyler (π^0 Primakoff)

Preparation for 2021 Run

Aligning FCAL in the Hall Tim

Moving FCAL platform by about 5 mm in X-direction to make sure
that the beam goes through the middle of the FCAL hole (3x3 modules).

Maintenance of FCAL PMT bases Mark, Chris, Nick, Fernando

Change dead bases and bases which draw excessive current (> 13 mA)

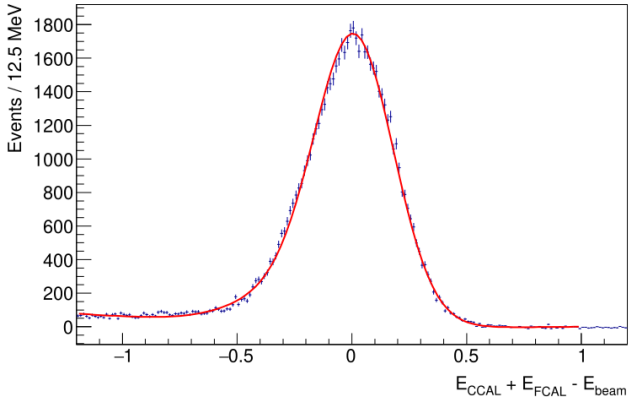
- There are about 200 high-current bases.
- 80 bases removed from FCAL (cleaning, change resistors on the base)

Improve firmware for handling communication to the base Ben, Mark

- Several bases can lose communication per day.
- The HV drops to zero. Power cycling is needed to recover

CCAL Improvements

- Relatively stable performance during 2019 run
- Provide clean reconstruction of Compton events



Two projects we are currently working on

I) Replace PMT active bases (improve linearity)

- reduce gain on the active base from 24 to 3
  (original divider taken from NPS)

- active base design has been slightly modified by V. Popov. Tested during Summer run

- perform a few more checks in the lab. Finalize resistor values (coordinate with Fernando)

- new active base layout prepared by Chris S.

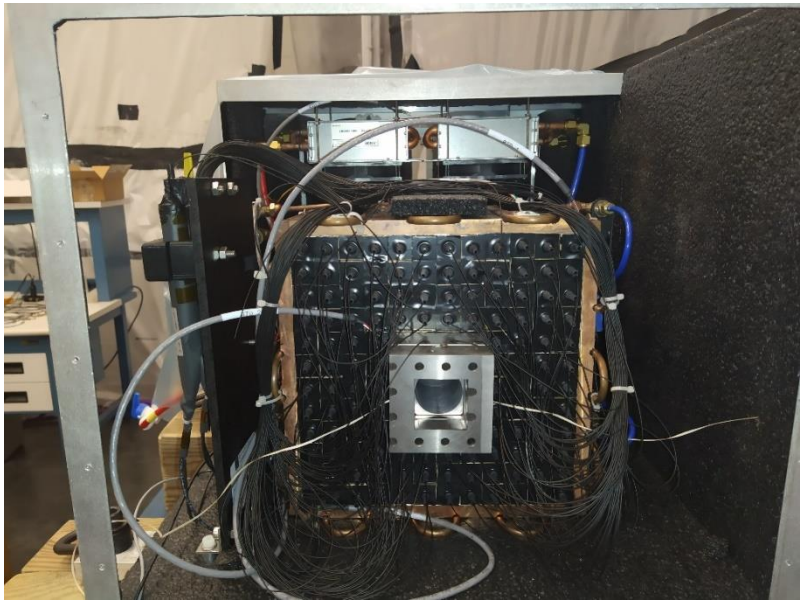
- order new bases for CCAL (November)

CCAL Improvements

II) Increase light pulse in the LMS monitoring system

- typical signal pulses – a few hundred ADC counts
- new light sources, replace optical fibers

- CCAL has been recently moved to TEDF



Summary & Discussion

- Some progress has been done with the calibration of the PrimEx data and understanding data quality. We are currently trying to finalize calibration. We'll need more help from collaboration to calibrate data after the new run.

- Some data analyses are ongoing: Compton (see Drew's talk), reconstruction of Primakoff η and π^0 (Tyler)

- Preparation steps for the new run in Summer 2021

  Improve FCAL performance
  - align FCAL
  - replace bad bases and bases, which draw an excessive current (more than 200 bases)
  - improve communication firmware with the base

  Improve CCAL performance
  - replace active bases
  - optimize the LMS system in order to increase signal amplitudes

Backup Slides

PrimEx Phase I: Run Conditions

- Beam energies: 11.6 GeV and 11.2 GeV
- Radiator: 10^{-4} R.L. Aluminum
- Beam current: 200 nA for production runs

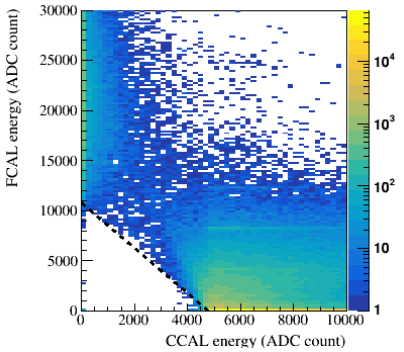
  50 nA and 100 nA for calibration runs with the CDC/FDC

  < 2 nA TAC run, CCAL calibration
- PS converter: 750 μm

PrimEx Phase I: Run Conditions

- Main production triggers

Bit 1: CCAL & FCAL $E_{CCAL} + E_{FCAL} > 3$ GeV
Bit 2: FCAL
Bit 4: PS
Bit 10: CCAL



TS Front Panel: CCAL LED, CCAL ALPHA, FCAL & BCAL LED, Random

- Calibration

CCAL: CCAL calibration, snake scan
PS & CCAL, PS & TAC PS calibration

- Efficiency Studies

TAGH & ST

Typical trigger rates for PrimEx production:

Total: 23 kHz
CCAL & FCAL: 17.7 kHz (FCAL only 1.2 kHz)
PS: 5.5 kHz

Active Base Tests and Optimization: Timeline

Use Hall C PWO crystals and electronics for CCAL

Test of the 3x3 PWO prototype installed behind the Pair Spectrometer, *GlueX-doc-3590, May 2018*

- first indication of potential problems: too large amplifier gain (x25), energy resolution worse than expected
- light yield is large, an amplifier is not needed, PrimEx rate (anode current) was not measured, some amplification may be needed. Discussions how to proceed (PrimEx group, Fernando, V. Popov, Hall C guys) – test performance with beam

CCAL fabricated in September 2018. Beam tests in December 2018

- some non-linearities observed during calibration run (snake scan). Linearity improves when increasing HV

PrimEx production, February 2019 (switch FADCs to 2 V range, increase HV)

- linearity tests, modified versions of divider (gains x3, x6, and x1), *GlueX-doc-3998*
- install bases with bypassed amplifiers (3x3 array), measure energy resolution - agrees with the HyCal resolution. Later confirmed with the PS prototype

After PrimEx run

- modifications of the active base by V.Popov (increase divider current, change resistors in amplifier)
- more tests in the lab to check performance *GlueX-doc-4076 (GlueX-doc-3272)*

Active Base Tests and Optimization: Timeline

Bench Tests after PrimEx run

- high rate performance: no degradation of the base with bypassed amplifier up to the anode current of 40 – 50 μA (1 V pulse amplitude)

GlueX high-intensity run in 2020

- Measure divider anode current (compare GlueX and PrimEx run conditions), *GlueX-doc-4361*
- 24 modified dividers (gains x3 and x6) were installed on inner rings of the CCAL. Used CCAL in GlueX runs (data analysis is in process)

- *Amplifier (seems to be) is not needed for PrimEX run conditions*
- *Small gain (x3) is recommended if we use CCAL in GlueX production runs*

Run Plan for PrimEx Phase II

- Tentative calibration plan, has to be coordinated

Condition	Scheduled Work	Total Time	Beam & Radiator (X_0)
Pre-experiment		7 shifts	
	CCAL calibration (ramp magnet down)	4 shifts	< 2 nA, $2 \cdot 10^{-5}$
	Install Be target: Disassemble beam pipe. Retract target. Remove Start Counter (ST). Remove vacuum snout. Remove GlueX cell. Mount Be target (survey). Attach vacuum snout. Attach ST. Target in place. Assemble beam pipe. Pump vacuum.*	3 shifts	

Detector checkout		3 shifts	10 – 300 nA, 10^{-4}
	Establish photon beam, FCAL mask/gain checks, trigger and DAQ test, lumi scans, check scalers		
Production on Be		1 day	200 nA, 10^{-4}
Target change	**Remove target cell**	2 shifts	no beam
Empty target run no target cell		0.5 days	200 nA, 10^{-4}
Target change	**Install He cell**	3 shifts	no beam
Empty target run		0.5 days	200 nA, 10^{-4}

Total 3.2 PAC days