Hall D Status

E. Chudakov

\(^1\text{Hall D Group Leader}\)

UGBOD meeting, Jan 2015
Overview

Physics with high intensity linearly polarized photon beams
- Experiment *GlueX*: search for exotic hybrid mesons
- Primakoff reactions:
  - Radiative widths of pseudoscalars ($\eta$)
  - Pion polarizability
- Rare decays of $\eta$ (conditionally approved)
- Other topics are under discussions

Running schedule (tentative for FY16-...)
- 2014 Oct-Dec: commissioning with 10 GeV beam (reduced setup)
- 2015 Apr-May: engineering run at 10 GeV (full setup)
- 2015 Oct-Dec: - (accelerator development) 12 GeV
- 2016 Spring: Physics commissioning 12 GeV
- 2016 Fall: GlueX production
Hall D Complex

Civil
Photo July 2011
Ready Dec 2011

Beam/detector
Ready 99.9% by Oct 2014
First beam Oct-Dec 2014
The Hall D/GlueX collaboration and responsibilities

Active responsibilities for Oct-Dec 2014 are marked green

- Jefferson Lab (CDC, FDC, BCAL, beamline, software)
- Carnegie Mellon (CDC, software)
- Indiana University (FCAL, software)
- University of Regina (BCAL)
- Florida State (TOF)
- University of Connecticut (Tagger TAGM, diamonds, MC)
- Catholic University (Tagger TAGH)
- Florida International (Start-Counter)
- Glasgow (polarized beam)
- University of NC, A&T (PS)
- University of NC, Wilmington (PS)
- University Santa Maria (Chile) (controls)
- University of Arizona (beamline)
- MIT (Cherenkov, Level-3, software)
- University of Massachusetts (targets, electronics)
- University of Athens (B/FCAL monitoring)
- Yerevan (controls)
- MEPhI Moscow (FDC, BCAL, PS, software)
- ITEP Moscow (calorimetry)
- Northwestern Univ. (calibration)

20 institutions, 110 people
12 GeV $e^-$ beam 0.05 – 2.2 $\mu$A
20 $\mu$m diamond: coherent <25 $\mu$rad
Collimation $r$ <1.8 mm at $\sim$ 80 m
Coherent peak 8.4 – 9.0 GeV $P \sim 40\%$
2.2 $\mu$A $\Rightarrow$ 100 MHz $\gamma$
Energy/polarization measured:
- Tagger spectrometer $\sigma E/E \sim 0.1\%$
- Pair spectrometer: spectrum $\Rightarrow \sigma P/P \sim 5\%$
Hall D/GlueX Spectrometer and DAQ

**GLUEX**

Resolutions

- \( h^{\pm} : \sigma p/p \sim 1 - 3\% \)
- \( \gamma : \sigma E/E \sim 6\%/\sqrt{E} \oplus 2\% \)

Acceptance \( 1^\circ < \theta < 120^\circ \)

**Detectors**

- CDC, FDC
- BCAL, FCAL
- TOF, ST

**Plans to add**

- 2017 L3
- 2018 Cherenkov

**Photoproduction** \( \gamma p \) 15 kHz for a 100 MHz beam

Beam 10 MHz/GeV: inclusive trigger 20 kHz \( \Rightarrow \) DAQ \( \Rightarrow \) tape

Beam 100 MHz/GeV: inclusive trigger 200 kHz \( \Rightarrow \) DAQ \( \Rightarrow \) L3 farm \( \Rightarrow \) tape
Commissioning Run: Equipment and Program

Tagger Hall
- Tagger magnet
- Radiators: Diamond & amorphous
- Tagger counters

Collimator Cave
- Active collimator
- Profiler
- Holes: 3.4mm, 5.0mm

Pair Spectrometer - Hall D
- Detectors: all the major detectors have been installed and are being tested.
- To be done: Pair spectrometer hodoscope (by June), start counter (FIU) to be delivered in August.

Hall D
- CDC In the bore
- TOF
- BCAL
- FDC
- FCAL

Commissioning Oct-Dec 2014
- Amorphous radiators only
- Solid target (1cm thick plastic), not LH2
- Solenoid current 1200A (1300A nominal)
- Beam tuning through the collimator
- Verification of the beam alignment in Hall D
- Detector checkout
- Data taking with various triggers

E. Chudakov
UGBOD meeting, Jan 2015
Hall D Status
Beam Tune

**Beam Parameters**
- Beam current 50-200 nA
- Radiator (Al) $0.2-3 \times 10^{-4}$ RL
- Beam energy 10.08 GeV

- Measure the photon spot on the collimator (profiler, act. collimator)
- Steer the electron beam: center the spot on the hole (beam counter, PS)

Results
- Radiation levels - as expected (no issue)
- Beam tune through collimator: good enough - will be improved by fast feedback from active collimator
- Photon beam was found to be well aligned on the target and photon dump
Detector Commissioning

Commissioning Program
Starting with the initial calibration/alignment of the detectors, several tasks were done in parallel.

- Trigger tests and tune: FCAL, BCAL, FCAL+BCAL, TOF, ST, PS
- Adjustments: timing, HV, thresholds
- Checkout of the detectors
- FDC alignment (running with no magnetic field)
- Data taking with various triggers

Results
- All the detectors and the subsystems are functional
- Detectors’ performance - as expected. For quantitative results more work on calibration and alignment is needed
- $\sim 650$ M events taken
- DAQ gradual improvements (many issues found and fixed), but still short of the 20 kHz goal (some firmware issues with the FADC-125 MHz)
- 12GeV Key Performance Parameters achieved: approved by DOE
Event Display

- 2 positive tracks
- 1 negative track
- Hits in FDC, CDC, BCAL, FCAL, TOF
Vertex Reconstruction

![Vertex y vs x](image)

Vertex position in z from multiple tracks, r<1 cm

<table>
<thead>
<tr>
<th>slice_px_of_vertex_rz</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Entries</td>
<td>23909</td>
</tr>
<tr>
<td>Mean</td>
<td>77.39</td>
</tr>
<tr>
<td>$\chi^2 / ndf$</td>
<td>7.147 / 5</td>
</tr>
<tr>
<td>Constant</td>
<td>1806 ± 24.3</td>
</tr>
<tr>
<td>Mean</td>
<td>64.28 ± 0.02</td>
</tr>
<tr>
<td>Sigma</td>
<td>1.441 ± 0.028</td>
</tr>
</tbody>
</table>

Target (1cm plastic) location
Matching Tagger Signals

Nominal SC-TAGM Energy vs Δt

Entries: 5,097,939
Mean x: -69.51
Mean y: 7.261
RMS x: 100.1
RMS y: 0.2579

Nominal SC-TAGH Energy vs Δt

Entries: 1.456149e+07
Mean x: -55.63
Mean y: 6.524
RMS x: 98.9
RMS y: 2.431

Time offset between SC and TAGM/H

TAGM: corrected time nicely centered at Δt = 0
TAGH: some "curvature" with energy (i.e., counter ID) but still centered at Δt = 0

Try to adjust for counter ID dependent offset (i.e., slope in Nominal plots)

• Require tracks have matched hit in SC
• Use pathlength to determine time of SC hit propagated to the target
• Calculate "Nominal" Δt (SC-TAGM/H) at target, and correct to center at 0

Only consider higher energy TAGH hits
Charged Particle PID

Positive FCAL track: E/p vs θ

Entries: 682,260
Mean x: 4.83
Mean y: 1.105
RMS x: 2.825
RMS y: 0.8114

Positive FCAL track: E/p vs Track_E2PvsTheta_Pos_FCAL

Entries: 417,844
Mean x: 0.7074
Mean y: 0.8042
RMS x: 0.4023
RMS y: 0.4592

FDC Positive: dE/dx vs p

Entries: 758,074
Mean x: 1.205
Mean y: 7.926
RMS x: 0.4226
RMS y: 1.849

Positive SC to TOF: β vs p

Entries: 59,083
Mean x: 2.29
Mean y: 0.9284
RMS x: 0.9103
RMS y: 0.1018

- Remove electrons with E/p cut in the FCAL
- Remove protons with dE/dx in CDC and FDC and β from SC-TOF coincidence
- All other tracks are π± candidates

TOF not used because timing not synced for some runs of FCAL-BCAL trigger
Reconstruction

- About 90% of data taken before 12/11/14 (3 nights of running and mix between FCAL and BCAL triggers)
- Both gammas in the BCAL
- Both gamma shower energies > 1 GeV
- $Z$-position of vertex between 62 cm and 68 cm
- Time difference between showers less than 5 ns.

- About 90% of data taken before 12/11/14 (BCAL and FCAL data combined)
- One gamma in FCAL and one gamma in BCAL
- FCAL and BCAL shower energies > 1.5 GeV
- $Z$-position of vertex between 62 cm and 68 cm

- $\pi^0$ sample will be used for individual channel calibration

- FCAL: initial calibration is off by a factor of 2
- BCAL: initial calibration is off by 15%
Event Reconstruction

- $\pi^+\pi^-$ combinations
- Using the tagger energy the missing mass is reconstructed
- For the nucleon recoil there is a strong $\rho$ signal
Outlook

Ongoing Data Analysis

- Calibration
  - Timing: existing data are sufficient
  - Calorimeters: significant improvement expected, but more data are needed to reach the specs
- Alignment: FDC - ongoing, CDC - needs more data

Preparations for the next run

- Full configuration:
  - Liquid Hydrogen target
  - Diamond radiator - commissioning
  - Solenoid: 1300A
- Fixing DAQ issues

It was a good start. Credit to GlueX collaboration and JLab staff!
Thanks to the postdocs and students for doing prompt analysis!