Inner Calorimeter in CLAS/DVCS experiment

- Motivation
- E1-DVCS run Configuration
- Inner Calorimeter Performance
- Summary

Exclusive Reactions Workshop R. Niyazov (JLAB)
e1-dvcs run Physics Goals

- DVCS Beam Spin Asymmetry: $ep\gamma$
- DVCS cross sections
- Exclusive $\pi^0$ and $\eta$ Beam Spin Asymmetry
- Exclusive $\pi^0$ and $\eta$ cross sections
- $e\gamma\pi^+ (\rho^+)X, e\gamma\pi^0 (\rho^0)p, e\pi^0\pi^0p$
- Exclusive pion pair production
- Semi-inclusive $\pi^0$ production

Need high precision calorimeter to detect photons at small angles
Dedicated DVCS Experiment With CLAS

GOALS
- Detection of 3 particles in the final state (full exclusivity)
- Measurements of BSA in the wide range of kinematics
- Increase kinematical coverage of the photon detection (4-15°)
- Increase luminosities (2 × 10^{34} \text{ cm}^{-2}\text{ s}^{-1})

New CLAS Configuration
- New Calorimeter built by Collaborators: Jefferson Lab, ITEP (Moscow, Russia), IPN (Orsay, France), DAPNIA/SPhN (Saclay, France), Jefferson Lab
CLAS and
✓ Super-conducting solenoid magnet to shield detectors from Møller background (field=4.5 T)
✓ 2.5 cm Hydrogen target (upstream of CLAS Center -66 cm)

Inner Calorimeter (IC)
✓ 424 PbWO₄ crystals, 16 cm long, 1.3x1.3 cm²
✓ High resolution calorimeter to detect photons at small angles (4-15°)
✓ Light read-out via APDs (avalanche photo-diodes)
✓ Low-noise fast preamplifiers
✓ Temperature stabilization for high precision energy measurements ( < 0.1°)
✓ Laser Monitoring System
CLAS + Solenoid + IC

- Higher luminosity
- Larger acceptance for $\gamma$

Inner Calorimeter

Superconducting solenoid magnet
The Superconductive Solenoid

Simulation of the magnetic shielding

With the magnetic field

Møller electron energy - 1-10 MeV
The e1-dvcs Run Summary

- DVCS run; 67 days (March 17-May 27, 2005)
- $E_0=5.8$ GeV; Luminosity=$1.7 \times 10^{34}$ cm$^{-2}$s$^{-1}$
- Average Beam Polarization = 80%
- Average Beam Current 25 nA
- Number of production triggers = $7.5 \times 10^9$
- 7 Tb of production data (440 runs)
- FC charge=58.9 mC
Inner Calorimeter

IC assembly/Front View

PbWO₄ Crystal

16
13.33
160
Inner Calorimeter

IC assembly/Back View
IC insertion in CLAS
Temperature Stability

Temperature fluctuations $\sim 0.02^\circ$ in 12 days
π₀ Reconstruction and Calibration

π₀ Calibration is based on 2 photon reconstruction and correction of channel Gains by fitted $M_{\gamma\gamma}$ value

$$M_{\gamma\gamma} = \sqrt{2E_{\gamma_1}E_{\gamma_2}(1 - \cos \theta_{\gamma\gamma})}$$

Two cluster single data event from π₀

$\pi^0(\eta) \rightarrow \gamma\gamma$

Size of the box is weighted by hit energy
Gains by fitting $M_{\gamma\gamma}$

One of the gain correction iterations
IC Calibration Results

6 special $\pi^0$ calibration runs (no CLAS involved)

$\sigma_{M\pi^0} \sim 7.2$ MeV

Comparable with $\sigma_{E/E} \sim 4\%$ at $E_\gamma = 1$ GeV
IC Energy and Position Resolution

$\Delta E/E = 4\%$ at $1\,\text{GeV}$

Noise & stochastic terms are consistent with expected values based on 7 MeV preamplifier noise and 2 phe/MeV photostatistics
IC Resolution Timing

- T₀ time corrections
- Vertex time corrections
- Time walk corrections

Very few accidentals with good electron trigger

Beam packet structure

Time spectra for several deposited energy bins

Higher the energy - better resolution and lower background
Laser Monitoring System

Linearity checks and gain monitoring during the run
IC Monitoring

Monitor channel occupancy, ADC, TDC, cluster reconstruction
IC Monitoring

IC Scalers
Radiation Doses in IC

Doses derived from pedestal runs with beam ON
Agrees with Møller electron simulation
The light output of the crystals depend on dose rate and accumulated dose.

Relative gains from LMS
For the whole run period
No damage from radiation found

Doses after 30 days (rad)
π₀ and η Reconstruction in IC

Invariant Mass of two photons

(e,e'p) + 2\γ in IC

MC

8 MeV sigma

12 MeV sigma
CLAS+IC Measurements

\[(e,e'\pi^0)\text{ Missing Mass}\]

\[\theta_{\pi^0x} < 0.7^\circ\]

2\(\sigma\) cut on \(M_{\gamma\gamma}\)

Match Data and Simulation proton peak

select \(e\pi^0p\)

Clean Proton peak
IC Performance was very good during the run
First functional PbWO$_4$ calorimeter with APD readout
Resolution is better than anticipated

DVCS, $\pi^0$ and $\eta$ BSA results were already reported
Cross-sections are still in progress

Will be used in the second part of the e1-dvcs run + several
new experiments were already approved

ER-07-009 Meson Spectroscopy in the Coherent Production on 4He with CLAS
ER-05-113 Semi-Inclusive Pion Production with Longitudinally Polarized Target at 6 GeV
ER-05-114 DVCS at 6 GeV with Polarized Target and Polarized Beam using the CLAS

Calorimeter may be used in conjunction with polarized target
CLAS+IC Measurements

Cut on direction of the measured photon to select $ep\gamma$

Consistent peak position and width

2$\gamma$ in IC

Cut on $M_{\gamma\gamma}$ in IC is applied

1$\gamma$ in IC

$\theta_{\gamma X} < 1^\circ$
Cut on direction of the measured $\pi^0$ to select $ep\pi^0$
✓ Magnetic shielding of the Møller electrons

Superconductor solenoidal magnet:

✓ Cu+Nb/Ti composite at 4.3 K
✓ Original cryogenic system
✓ Additional coil to compensate fringe field

Average field at the target location - 4.5 T at 534 A