Minutes of the General Purpose Electgromagnetic Calorimeter Workshop
Oct. 31, 2008
Jefferson Lab

In attendance:
Liping Gan, B. Zihlaneus, A. Puckett, Vina Punabi, Dan Dale, Alexander Camsonne, Ron Pedroni, Charles Perdrisat, Rory Miskimen, Eugen Chudakov, Mahbub Khandaker, Mikhail Kumautsev, L. Pentchev, Erik Johnson, Drew Von Maluski, Mark Ito, Ashot Gasparian

Ed Brash. ***Presented Gep-IV in Hall C.***
Q2 up to 13 GeV^2. Target: 30 cm LH2. Using SHMS with 3.5 msr, which is probably good to 5 msr. Electron angle of 30 degrees. Radiation hardness is important. Calorimeter is used to tag the electron. Angular resolution is important: need angular resolution of around 0.5 mr. Need 1 m x 1m calorimeter , 4.5 m target distance, with 30 cm target length.
Requirements:
Delta x = 97 cm, Delta y =65 cm.
Electron energy 3-4 GeV, Angle 30 deg, 1m x 1m @ 4.5 m, angular resolution around 0.5 mr.
A LOI went into the last PAC, using BigCAL; a proposal will go into the next PAC.
Min size 1 x 1 m2
Energy res. < lead glass
Position < 2 cm
Timing 100 ns
Moliere rad. 2 cm important

L. Pentchev. ***Presented GEp(5) in Hall A.***
Gep/Gmp in Hall A with 12 GeV. Use EM calorimeter for electron detector. Need 1m x 2 m detector 3.5 m from the target to match solid angle coverage. Position res. σ 7 mm, Energy res. 5% for 2.5 GeV electrons.
Requirements:
Need 1m x 2 m @ 3.5 m from target,
7 mm res @ 3.5 m from target
Timing 100 ns
Need 5% energy res @ 2.5 GeV (this is the minimum electron energy). (8%/sqrt(E))
Rad hardness 55 J/cm2 deposited energy (need to convert to radiation units, 100 Krad?)
Moliere radius ?
Shashlyk preferred type of cal.
Need modularity

L. Gan. ***Presented rare eta decays in Hall D.***
Focus on eta -> pi0 γ γ and eta -> pi0 pi0
Branching ratio 4.4 x 10^{-4} for the pi0 γ γ

SM pred. for pi0 pi0, BR = 10^{-17}. There are few flavor conserving CP violating experiments. The present experimental limit is around 10^{-4}.
At JLab tag the eta to reduce non-reson. backgrounds. Higher energy can reduce pi0 pi0 pi0 background. In Hall D tag eta by measuring recoil p with GlueX; showed missing mass resolution. Minimum separation beween 2 showers must be better than 4 cm. To reach acceptance of 30% need 118 x 118 cm. The 10 cm x 10 cm central hole is OK.
Requirements:
High granuality is crucial,
Minimum size 1.2 m x 1.2 m, 10 cm x 10 cm central hole is OK,
Radiation damage is not crucial,
First test pi0 $\gamma\gamma$, then pi0 pi0
Energy resolution is important
Moliere rad is crucial,
Elke comment: many detectors in front of FCAL, chambers, … Do they need to be removed? Need full montecarlo.

Ashot Gasparian. ***Real photon eta Primakoff experiment***
Primakoff (Cornell) is inconsistent with collider experiments. Analysis will see if experiment can be done with FCAL, and then removing FCAL and using HYCAL. 1.2 m x 1.2 m is a good size for eta experiment. Factor of 3 angular res. improvement from FCAL to FCAL + 75 x 75 blocksPbWO. Factor of 3 energy res. improvement from FCAL to FCAL + 75 x 75 blocks PbWO.
Requirements:
1.2 m x 1.2 m (size of existing frame)
Resolutions: Energy 2.5% @ 1 GeV, position 2.8 mm @ 1 GeV
Fast time response, 100 ns light collection time
Small Moliere radius is essential, 2 cm is OK
Modular structure is needed,
Elke comment: crystals are approximately 2 times better than leadglass

Dan Dale. ***Virtual Primakoff reaction.***
Measuring transition FF at low Q2 for pi0, extrapolate to photon point to get slope. Same for the eta. Measure scattered electron and pi0 with calorimeter. Q2 resolution is approx. +/- .02 GeV2.
Elke comment: why not do this using CLAS12?
Requirements:
1.2 m x 1.2m OK
Resolution 3%/sqrt(E)
Position res is very important
Moderate radiation hardness
Moliere rad. is crucial,

Prefer crystal
Modularity needed

Bogdan Wojtsekhowski. ***Wide angle Compton scattering , and pi0 photoproduction @ 12 GeV.***
Discussed GPDs and FFs for WACS. Mixed e/gamma beam, magnet sweeps away electrons and calorimeter detects gammas. Experimental program: proton WACS, neutron WACS, pi0 from proton, pi0 from neutron, strange FF at large Q2
Requirements:
20 cm long target
Calorimeter resolution <10%, 2 cluster resolution <10 mrad, radiation hardness 1 krad
moliere radius about 4 cm,
1.2 m x 2 m, 6% resolution, 1 cm coordinate resolution
Same requirements as Gep(5) requirements
Moliere radius and radiation hardness drives detector preference,
Angular resolution of 1-2 mrad

Alexandre Camsonne. ***Calorimeter for DVCS in Hall A***
Luminosity up to 10^37. Using PbF2 for gamma detection. Measuring helicity dependent cross sections with PbF2 (Cherenkov material). PbF2 was at 1.1 m from target, compact calorimeter. Also looking at pi0 electroproduction. New experiment: going from 132 to 208 blocks, gives larger acceptance in t, covers HRS acceptance better. Radiation hardness: 750 kR for previous experiment, this proposal will need 2000 kRad, 8400 kRad at 12 Gev. Lead fluoride is sufficient 2.4% @ 4.2 GeV, 2% +3.2%sqrt(E). Position resol. 3 mm. Radiation hardness to preserve resolution, around 20% change for 750kRad. Can expect 4.9kRad/h @ 12 GeV. Need curing of blocks every 2 weeks. 200 modules is sufficient for 12 GeV, are building this calorimeter. 11 x 12 blocks to 13 x 16 blocks covers full acceptance of HRS @ 110 cm.
Requirements:
Min size .4 m x .5 m,
Energy resolution is important
Moderate position resolution
Fast 20 ns timing
Radiation hardness is very important
Small Moliere radius
Prefer PbF2
Comment: is scintillation of PbF2 important?

L. Gan. ***Discussion of minimum configurations of the calorimeter***
Gep(5) has a conflict in size (1 m x 2 m) with other experiments. The size is critical, running times are on the order of a month per data point.

PbGlass seems to be ruled out. On the table: crystal versus Shashlyk.
For 1 m x 2 m, price for crystal around $4M.
Shashlyk module 10cm x 10 cm unit, $1500/unit , $0.5M total without electronics.
0.5cm x 5 $700 with APD readout for PANDA.
PbWO crystal $250 per 2 cm x 2cm, PMT $230/each , other $100 , total $600 per unit
Shashlyk @ BNL 5 x 5 cm2, $340,000 /sq meter, σ_x = 1.5 cm
Panda: 5 x .5 cm^2 $850 / module
1 m x 2 m crystal around $2.3M
1 m x 2 m Shashlyk around $700k

L. Gan, *PbWO crystals*
4 ns (95%), 15 (5%), 100 (<1 %) light collection time
Peak wavelength 440 nm
Temp. dependence 2%/deg C
Review of PbWO characteristics,
Average saturated light loss of 8% after 1-2 krad , 85% of damage recovered in 2 months,
Radiation damage changes transparency, can be observed in light calibration, through color centers.
Beam tests @ JLab: For 6 x 6 crystals 1.3% @ 4 GeV.
Production line in SIC is active, can produce 4k modules/year. Price range $2.5 to $5 per cc
Summary:
Excellent energy and position resolution
Compact shower size
Fast signals
Excellent radiation hardness
4000 modules can be delivered by SIC within 1 year.
Radiation damage: seems to depend on the rate, not the integrated dose that affects PbWO.

Ashot Gasparian, *HYCAL*
Experiment ran at 18° C, stability .2 degree C, complications not worth reducing temp.
Wrap with VM-2000 and tedlar 38.1 micron. Resolution 2.3% @ 1 GeV.
LSO has much higher light output. Price? Radiation hard, about same Moliere radius as PbWO, made in China.

Alexandre Camsonne, *PbF2*
11 x 12 blocks. Pure Cherenkov detector, not sensitive to charged hadronic background. Using PMT gains of 10^4. Digital summing trigger to generate coincidence trigger, Flash ADC type readout to deal with high energy pileup. Use active base and lower gain PMTs to reduce effect of low energy background.

Eugene Chadakov, Calorimeter ***options for a large acceptance PVDIS experiment***
Uses BaBar solenoid, suppress pions to 1% of electrons
SpaCal detector: KLOE 5.7%/sqrt(E)
Shashlyk detector: Pb + scint. Sandwich, photo detector surface,
HERA B 0.12/sqrt(E) + .014 with PMT's, NIMA 580, 1209 (2007)
KOPIO .03/sqrt(E) + .02 with APT, NIMA 584, 291 (2008)
1.5 cm/sqrt(E) position resolution for KOPIO.

Erik Johnson, RMD, ***Review of SSPM's for Primex***
Solid state photomultiplier (SSPM) technology was presented. Detection efficiency is well matched to PbWO spectral response. Parameters such as detection efficiency, dark counts, cross talk and after-pulsing have been measured, as well as the temperature dependence of these processes. There is good matching of SSPM and PMT responses for a 22Na source on CsI crystal. The production costs of 1,330 SSPM-ADC units, with 50k pixels/device and integrated 250 MSPS 12-bit ADC, are estimated at $50 to $150 per unit.

Rory Miskimen, ***Using SSPM's on HYCAL***
Simulation studies of SSPM's with PbWO. Need approx. 50,000 pixels per block, cooling to around 0° C, excess bias around 4 V. Energy resolution is typically 1%. We have approved SBIR phase I proposal for developing a SSPM detector with integrated 250 MSPS 12-bit ADC. Triggering will allow for multi-cluster triggers, triggering on shower energy and position. A Phase II SBIR will be submitted March 2009.
Elke comment: energy resolution is degraded at low energy compared to PMT
RM reply:Need to run simulations to determine required resolution. Can't expect to have good resolution at low energy using PbWO with any readout. Better energy resolution at lower energies can be obtained by reducing the clustering size from 5 x 5; more simulation studies are needed.

Ashot Gasparian, ***Organization***
12 GeV beam in Hall A,B,C in 2015.
Group decided to focus on a 1.2 m x 1.2 m high resolution (PbWO) detector.
Steering committee: Ashot will function as the leader of the SC. Each experiment will suggest a couple of people to add to the group.
Important deadlines:

- Mid-December 2008: PAC deadline
- March 2009: SBIR Phase I report and Phase II proposal due
- Late 2009: Prepare NSF MRI proposal for submission