CLAS12 Pre-shower

Project overview

S. Stepanyan (JLAB)

Collaborating institutions:

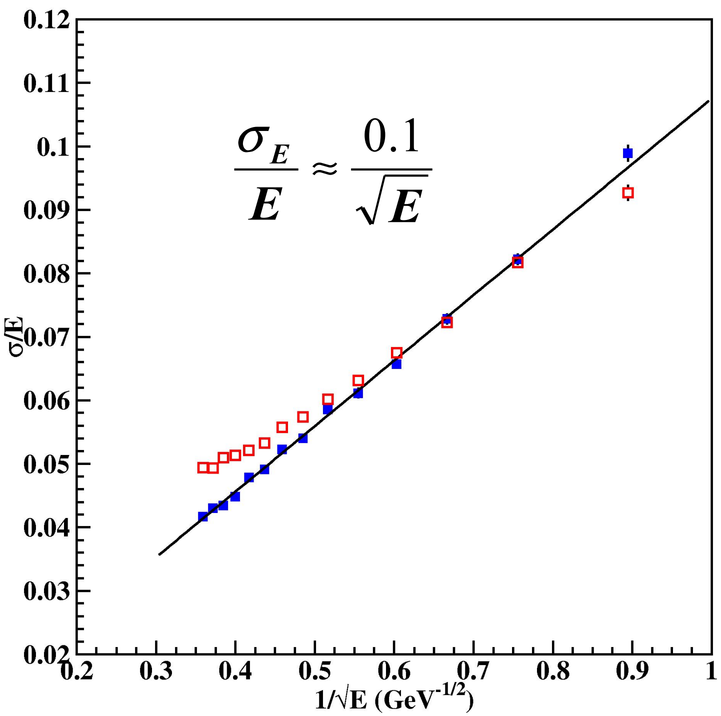
YerPhI, JMU, OU, NSU, W&M, Orsay-IPN, JLAB

CLAS12 TWG meeting, February 21, 2008 , JLAB

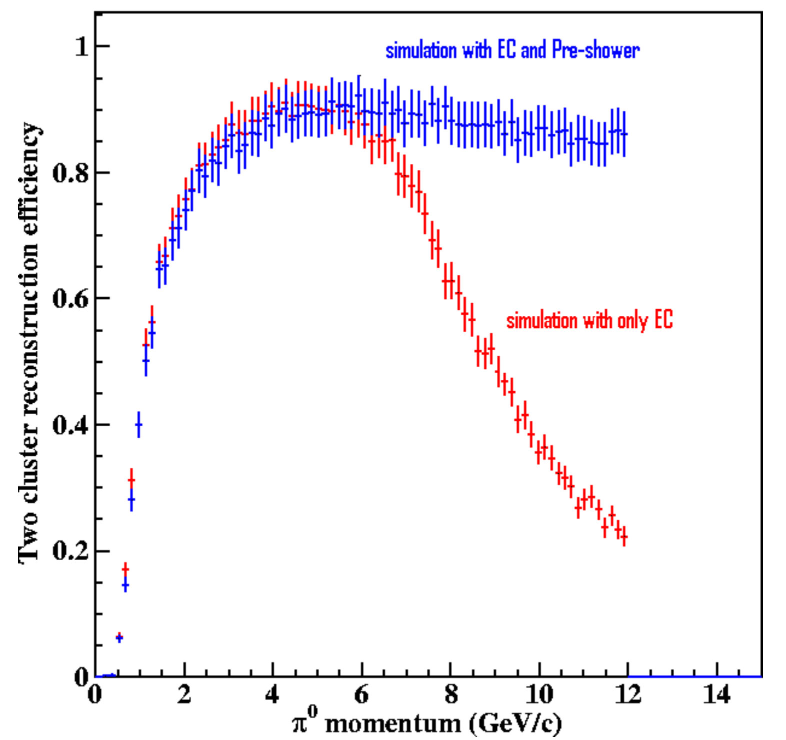
Electromagnetic shower reconstruction at high energies

PCAL+EC simulations (15 layers and 108 strips)

Energy resolution for electrons thrown in the center of the of the calorimeter

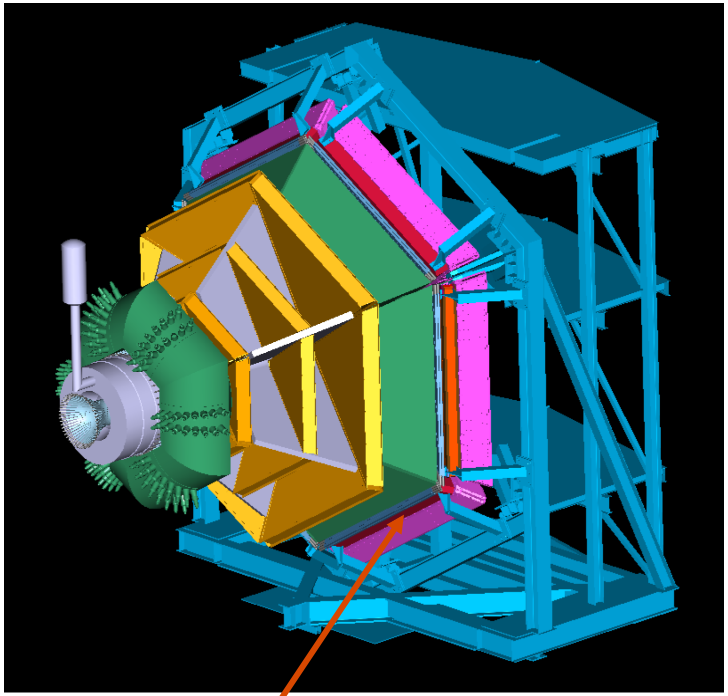


Efficiency of two photon reconstruction from high energy p0’ gg decays



CLAS12 PCAL project [WBS 1.4.2.2.2.3]

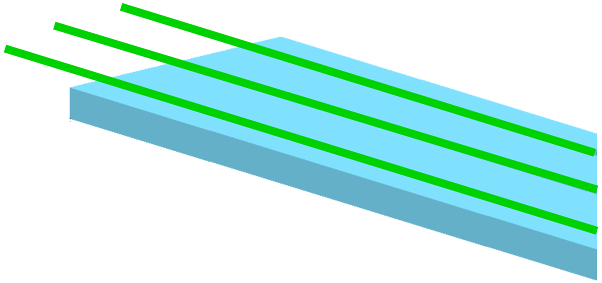
CLAS12 detector



Pre-shower calorimeter

Proposed configuration for the pre-shower:

- lead and scintillator sandwich with three stereo readout views, UVW (5 layers per readout view)
- fine segmentation of scintillator layers in the forward region for all three UVW views
- light transport from scintillator to PMT via green wave-shifting fibers embedded in grooves on the surface of the scintillator strips



Does not require high performance, high transparent scintillators. Low cost extruded scintillators can be used. No optical contact inside the box.

Outcome of R&D efforts

Design parameters of the pre-shower are established

15 layers of the lead and scintillator, 2.2mm lead, 10mm scintillator
4.5 cm segmentation of the scintillator layers in forward region

Choice for the scintillator, WLS fiber, and PMT

Fermi Lab extruded scintillators, 4.5x1 cm^2 with 3 grooves

Kuraray, 1mm diameter Y11 single clad

HAMAMATSU R6095 selected with Q.E.>16% @ 500 nm

Expected photo-electron yield ~11p.e./MeV for 3 fibers (yield for EC readout from the test measurements was ~8.4p.e./MeV)

Final price tag for the construction of 6 modules of PCAL is set

PCAL Construction

Construction of the PCAL consists of several quasi-independent processes:

- processing of scintillators and gluing of fibers (W&M)
- assembly of PMTs and dividers (JMU)
- stacking of scintillator-lead layers (JLAB)
- mounting PMTs and testing (JLAB)
- storage of ready modules before moving to the Hall B (JLAB)

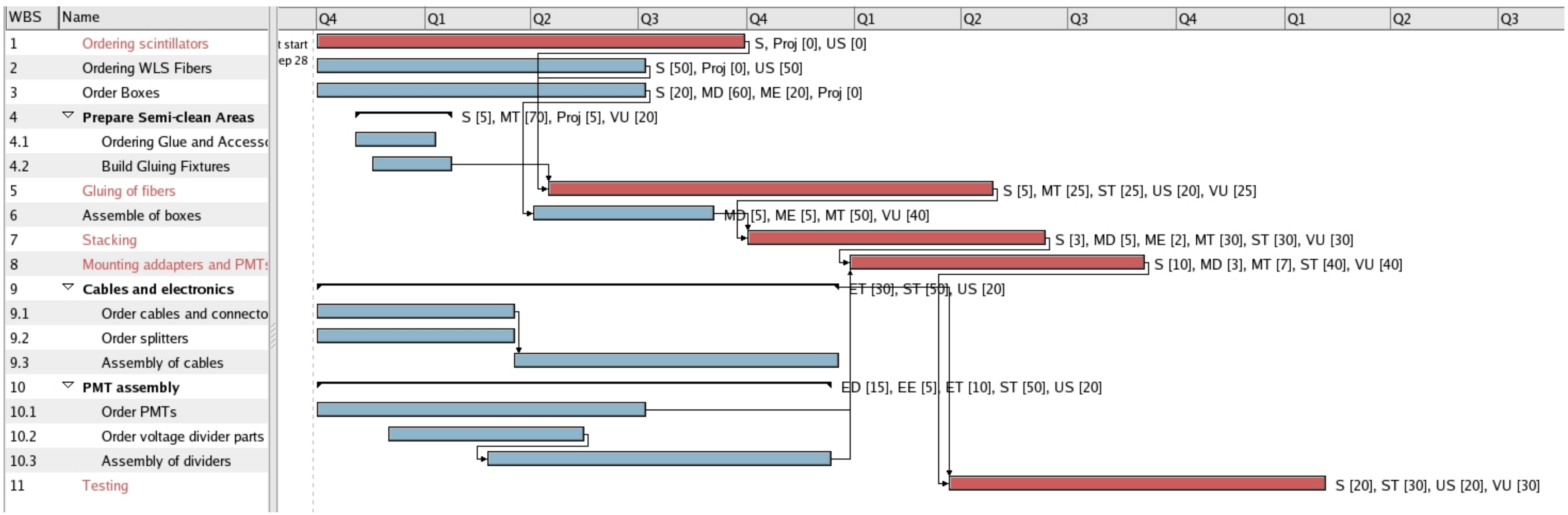
Each process requires independent man power and work space

Most of these processes require clean environment, climate controlled areas

Few details of construction must be worked out before construction starts:

- type of glue to use
- gluing procedure and QC
- fiber channeling during the stacking
- polishing of fiber ends on after assemble
- PMT dividers – active vs. passive

Construction time line and manpower



		Technicians		Engineers		Designers		Scientists			Student	
Amount	Costs (k$)	MT	ET	ME	EE	MD	ED	VU	S	US		Comm.
42000m		4		1				54	4	54	54	3 days/layer (CLAS+prototype), VU with student and post.doc.
6		12		2		1			1			2 weeks/box (CLAS), only mechanical work
90		36		4				36	4	36	36	2 days/layer (CLAS), VU with student oand post.doc., MT for lead
1152		12		1		2		36	6	36		2 weeks/side(CLAS), VU with student or post.doc.
		4						12	6	12		2 weeks/module (CLAS), VU with student or post.doc.
	0	68	0	8	0	3	0	138	21	138	90	376

Plans for R&D in FY08

Must -

1. Continue testing of different optical glues - will require about $1000 to purchase glues, work will be done either at JMU
2. Testing of different voltage dividers for PMTs - will require about $2000 for a design and assembly of the dividers, work will be done at JLAB?
3. Continue testing new scintillators from FNAL - will require about $2000 to order fibers. Work will be done at JLAB
4. Develop scintillator cutting technology – will require test samples. Work will be done at JLAB/W&M
5. Continue tests of the small prototype (using beam) - Work will be done at JLAB

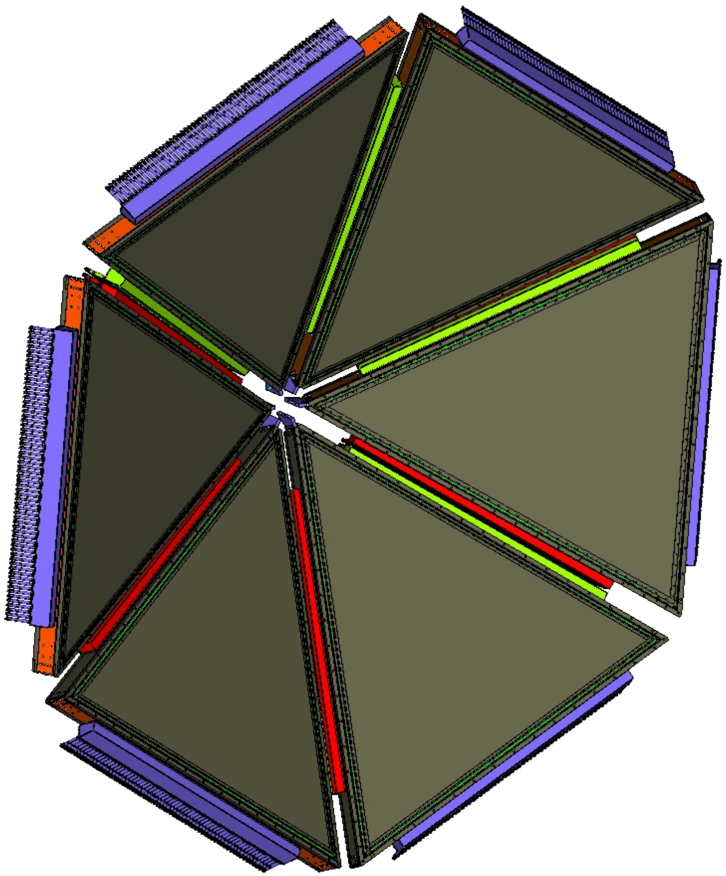
Overall the estimate ~$7000 for purchases and money for a visitor for 6 months.

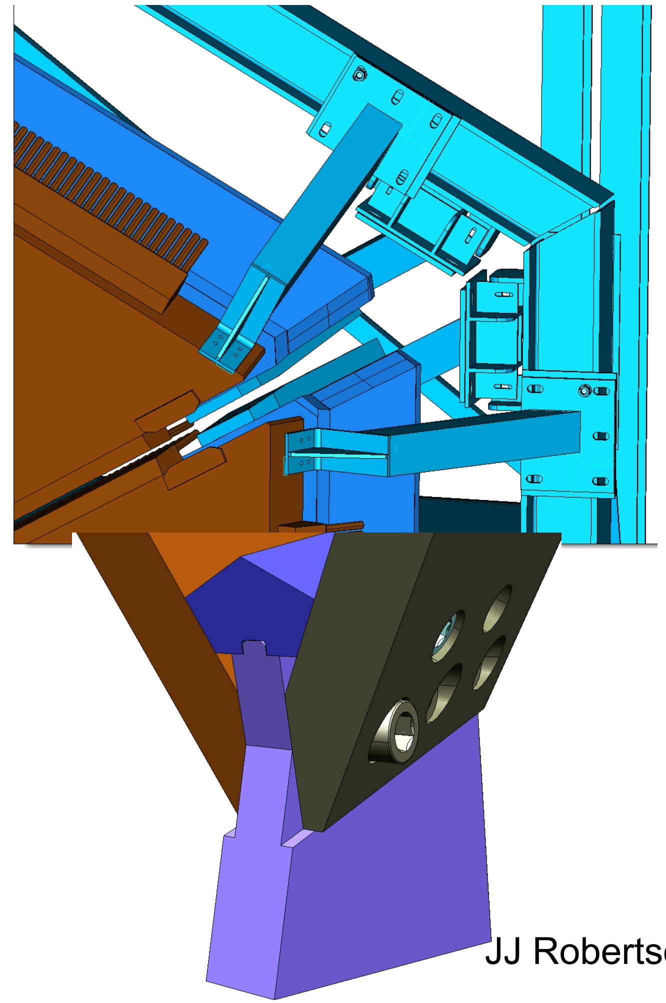
Should

1. Continue die development with FNAL, requires about $10000
2. Disassemble and reassemble the small prototype with new (latest) FNAL scintillators. Work will be done at JLAB. Will require some machine shop time, stock room items, electronic lab time, etc., about $1000

PCAL PED

Most of critical details are worked out!

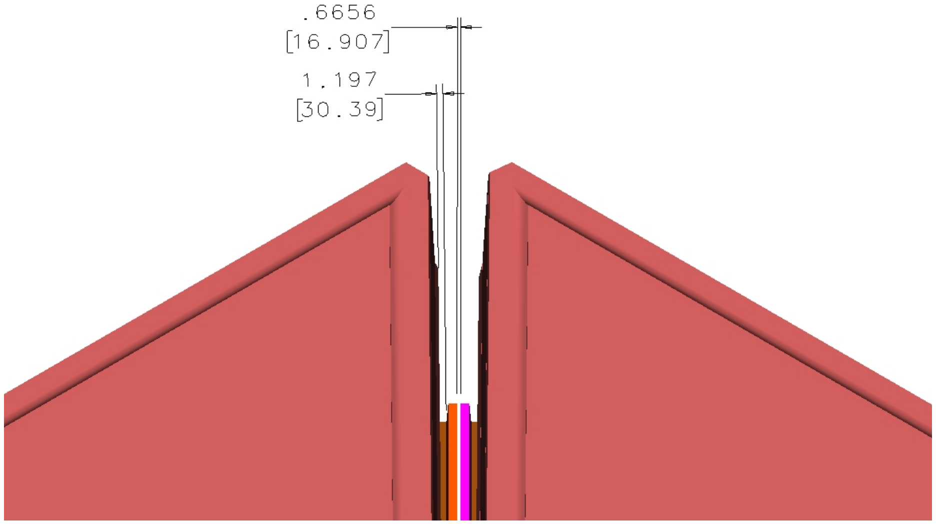




JJ Robertson

PCAL design issues

PMTs along sides of modules from adjacent sectors are very close to each other. On the top of modules, where the distance is largest, the gap is only ~15mm wide.



This will lead to

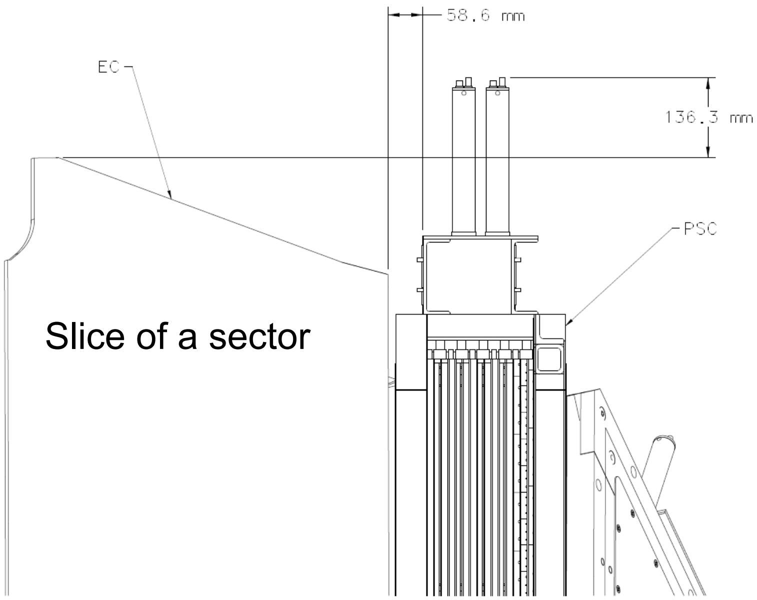
a) Difficulties during the installation - requires positioning of individual modules with better than few mm accuracy

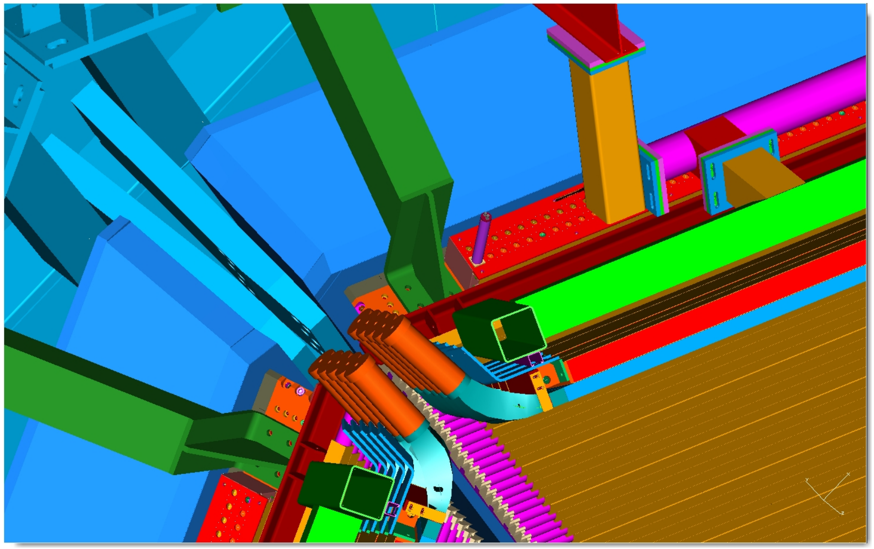
b) Could result in damaging of fiber enclosures, if measured dimensions on forward carriage will change due to the load change

c) Makes maintenance of modules (replacing PMTs) very hard, some spots may become inaccessible

Solution to the tight space for PCAL PMTs

Change the read out of the W-view to be from the same side where V-view readout is located (at the back side of a module). It will create a second row of PMTs on the V-side. There will be no interference to any detector or structure, that part is wide open.



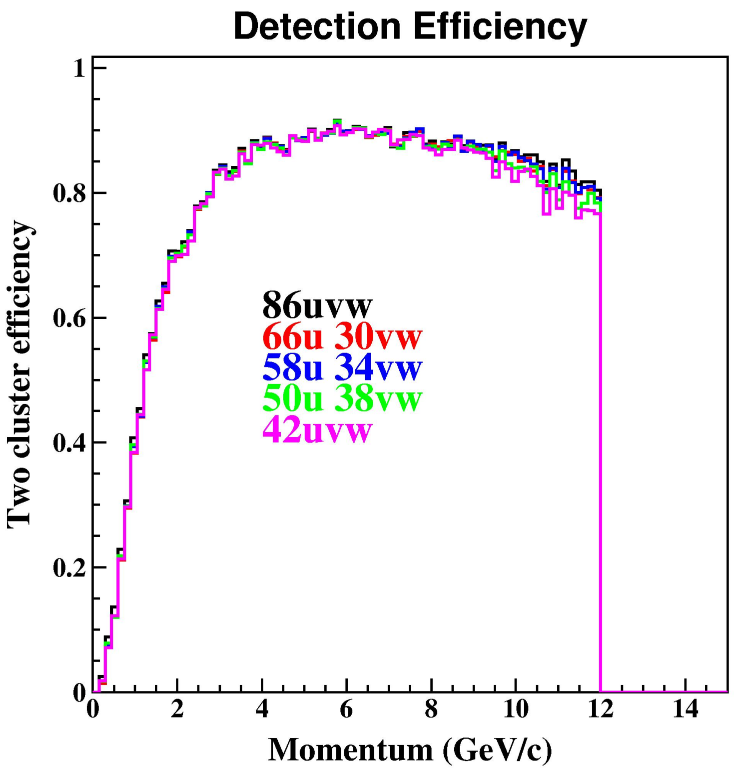


Possible impact of moving W-view readout will be some what larger non-uniformity of energy sampling at the trigger level, *if the trigger for CLAS12 EC&PCAL will be the same as it is done for EC*. Simulations are needed in order to estimate the magnitude of the impact. However, use of fADCs (as planned for CLAS12 DAQ) eliminates the issue with trigger non-uniformity.

PCAL design issues (cont.)

2. Current design assumes equal number of PMTs for each U, V, and W-views (64 PMTs per view, total of 192 PMTs per module). This requires double tower readout with single PMT at large angles.

   Having U-view with finer segmentation farther to large angles might be beneficial for overall detector performance. Simulations are needed to test different configurations of the readout segmentation.



3. There are few solutions for the top and bottom plates (composite plates, foam with SS skins mounted in a SS or Aluminum frame). For the final choice more FEA and tests are needed.

Other issues

For construction:

- type of glue to use
- gluing procedure and QC
- fiber channeling during the stacking
- polishing of fiber ends on after assemble
- PMT dividers – active vs. passive

Reconstruction software issues: fADC – pulse width and energy resolution

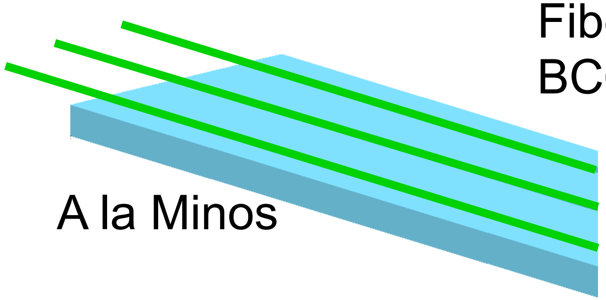
Summary

- Pre-shower R&D and PED are in progress
- Main design parameters are established using the full GEANT simulations, but there are still few issues to resolve before the design is completed
- Key components of the PCAL (scintillator-fiber-PMT) are selected, but there are few details for construction to be worked out
- Cost estimate for the whole project is completed
- MRI proposal for amount of $780K ($630K) is submitted to NSF – total of 60% of whole PCAL procurement
- Contingency and risk analysis are performed
- Stages and required resources for construction of the main detector are identified

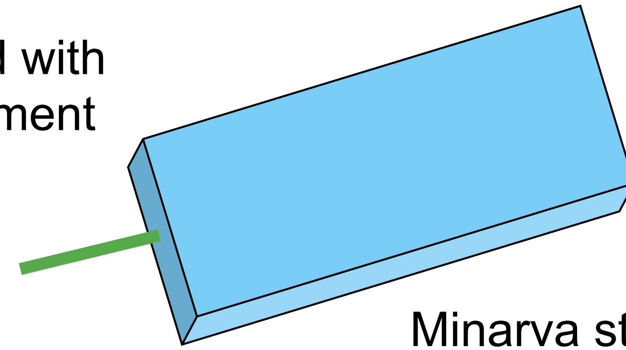
Surface mount vs. through hole mount

3 grooves with 1 mm diameter single clad Y11, 4.5 cm wide scintillator

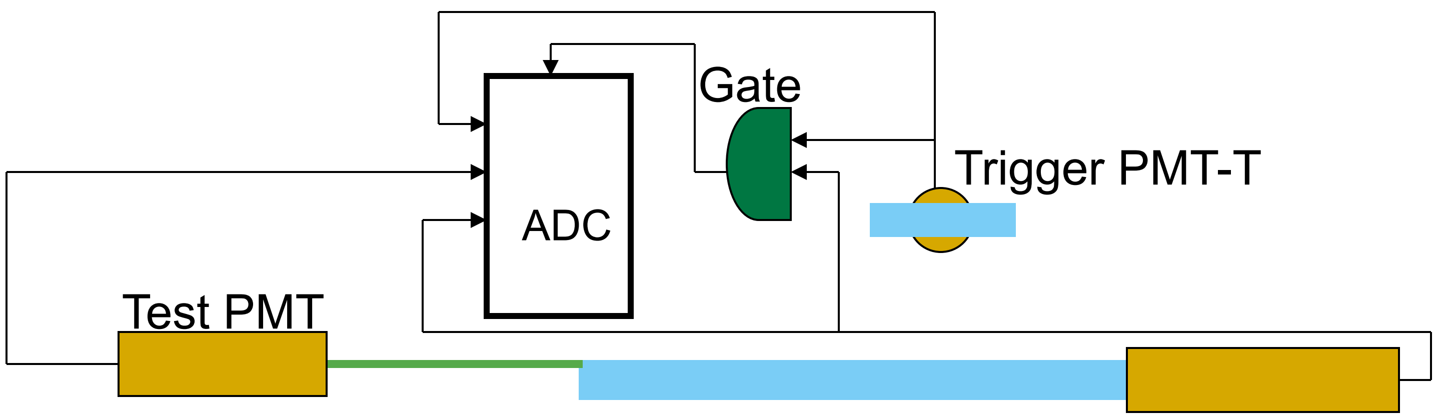
1 through hole with 1.5 mm diameter single clad Y11, 4 cm wide scintillator



Fibers were glued with BC600 optical cement



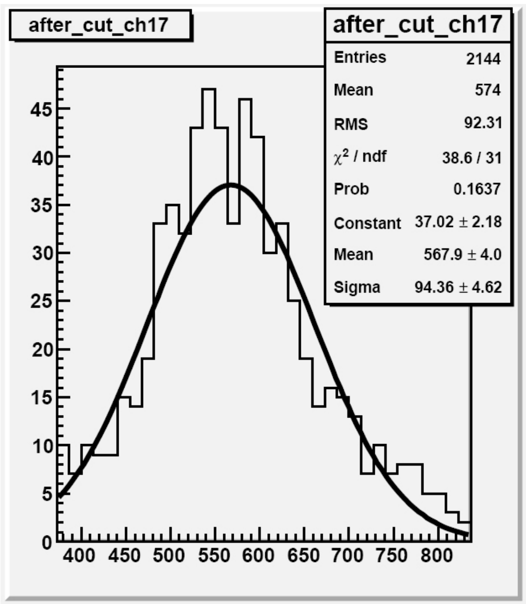
Test Setup



Test PMT ADC distributions

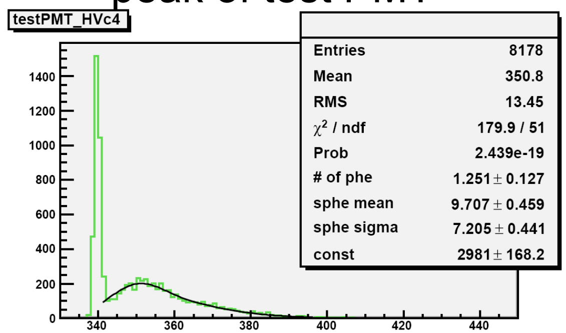
3-fibers, 1 mm in diameter

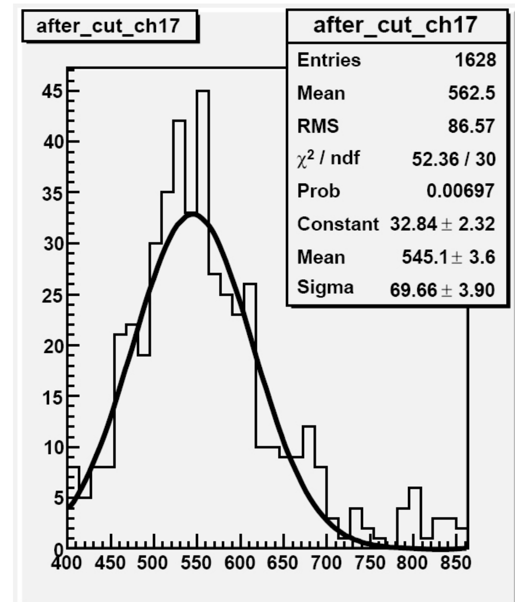
1 fiber, 1.5 mm in diameter



Pedestal is at 341

Single photoelectron peak of test PMT





4 cm wide scintillator with 1 through hole for a single 1.5 mm diameter fiber

- has ~25% less light per unit of width than current PCAL design
- 1.5 mm diameter fibers are ~2.5 times more expensive than 1mm fibers
- will require ~10% more readout channels
- broken fiber will have much bigger effect
- may be easy to assemble

Current activities

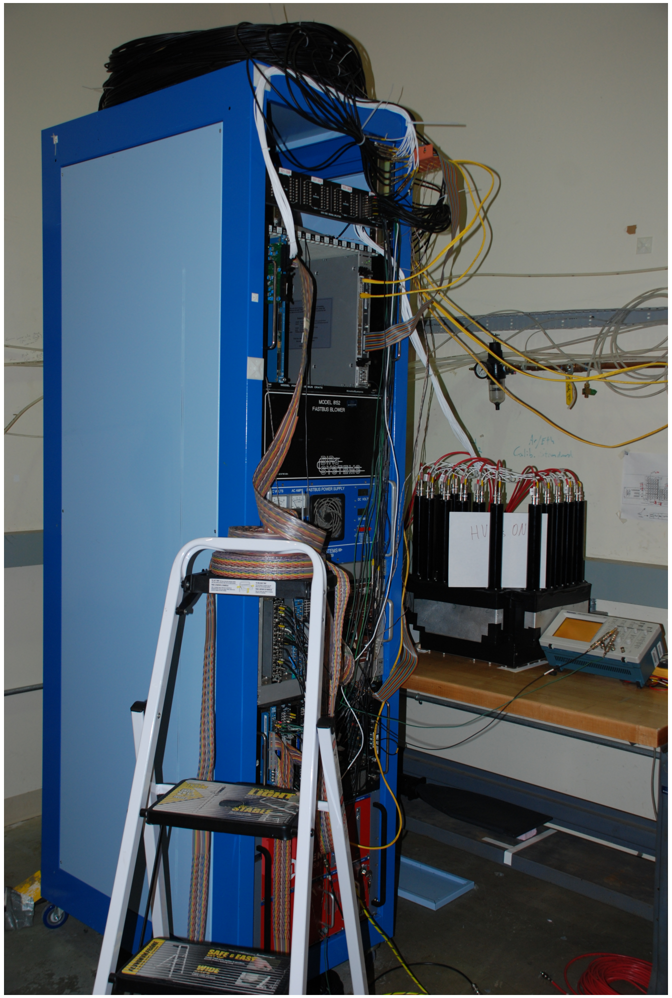
Prototyping

- a small scale prototype, rectangular 5x5 matrix (XXY), total of 15 layers
- absolute light yield and time characteristics (MIP)
- shower reconstruction (energy, position) and time characteristics (in the beam)

Data taking is in progress in EEL *(see Mikhail's presentation).*

Simulation of the prototype in GEANT and cluster reconstruction are in progress (N. Dashyan and D. Keller)

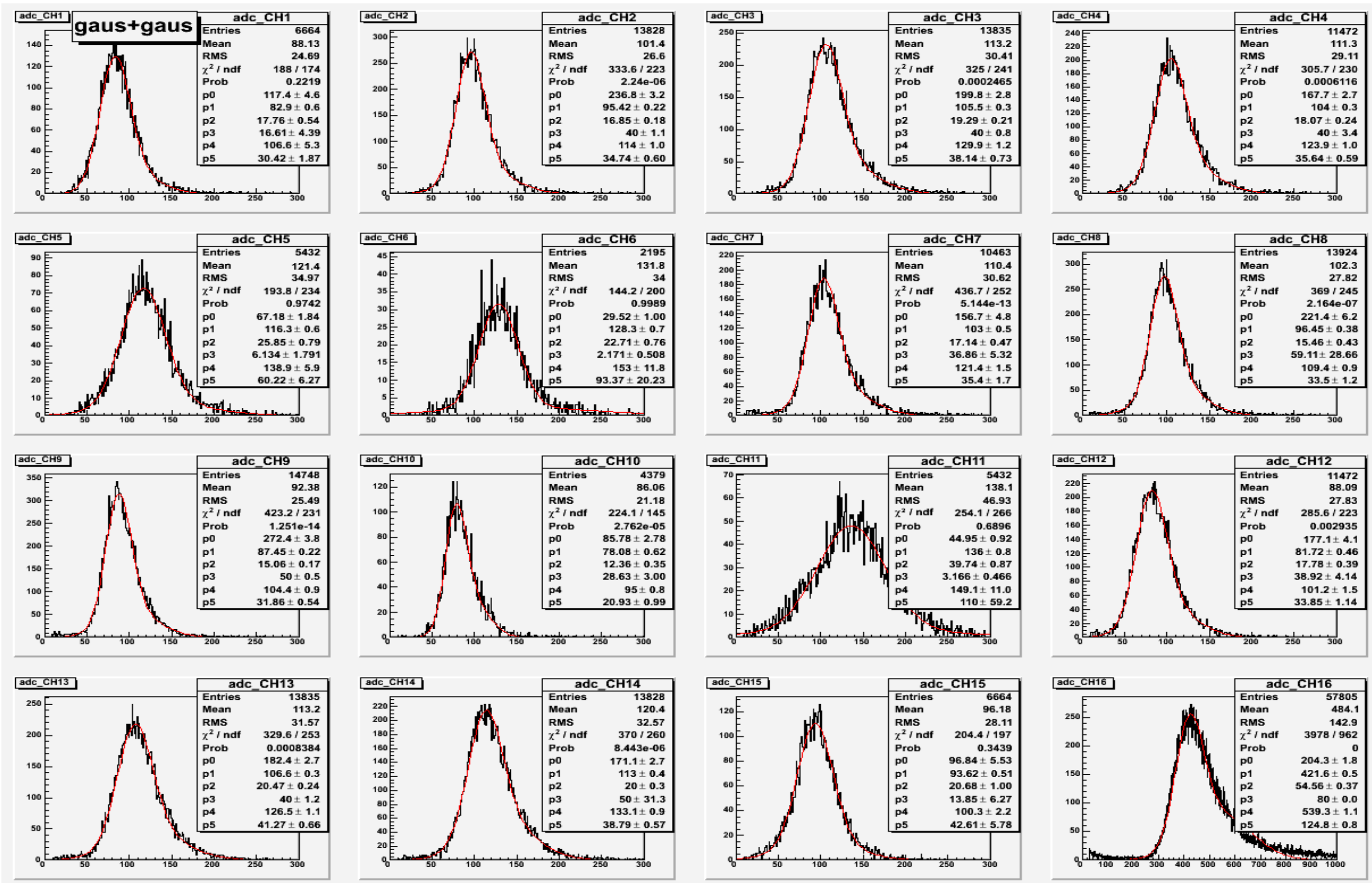
After cosmic tests are completed (this week) Prototype will be moved to the Hall for tests with electrons on the Hall B pair spectrometer.



Testing of different optical glues started at JMU *(see Kevin's presentation)*

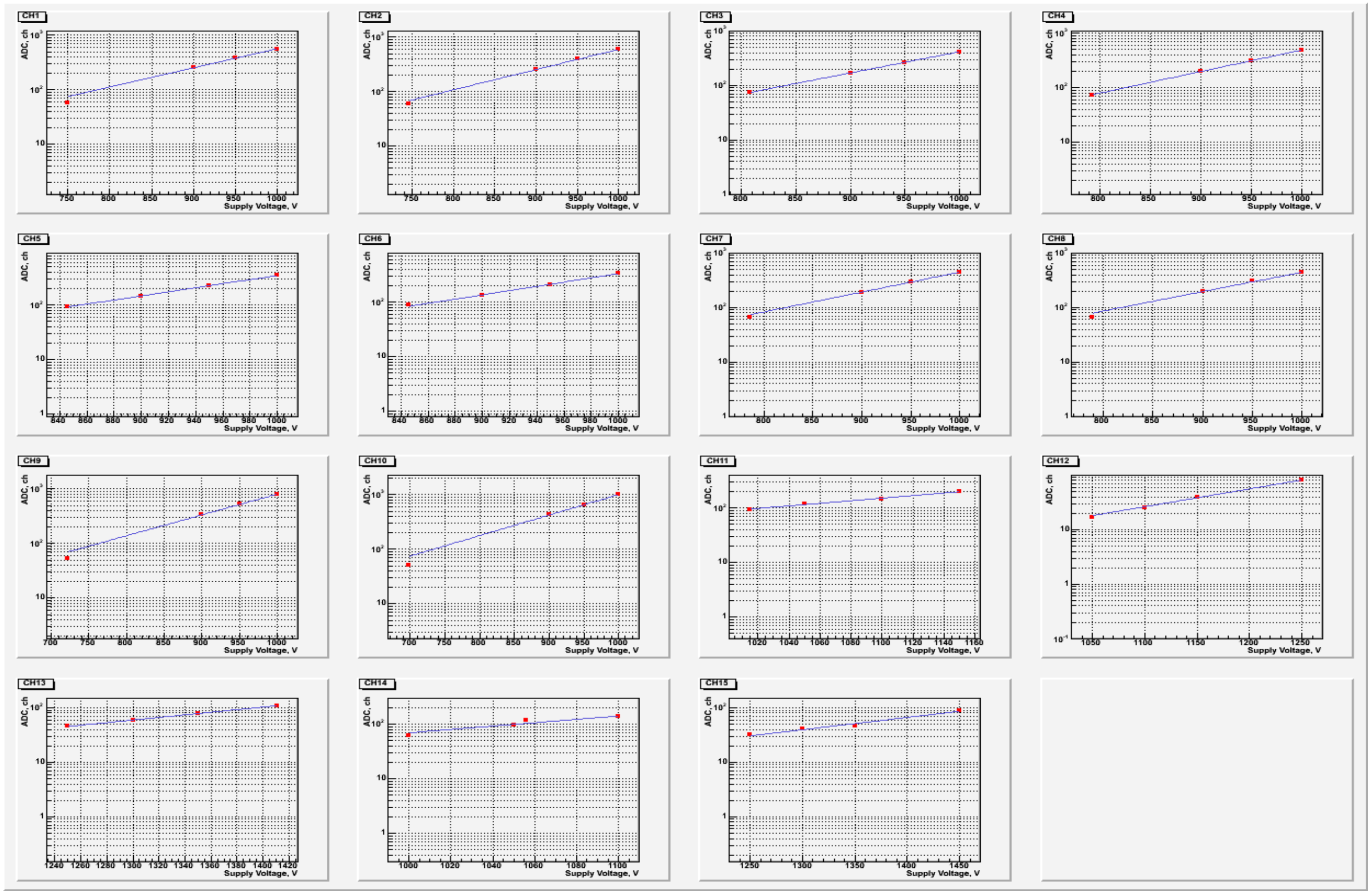
ADC signals for 10 MeV energy deposition (M. Yurov)

For each PMT, a MIP's peak position, at given HV, was determined using two Gaussian fit to the ADC distribution.



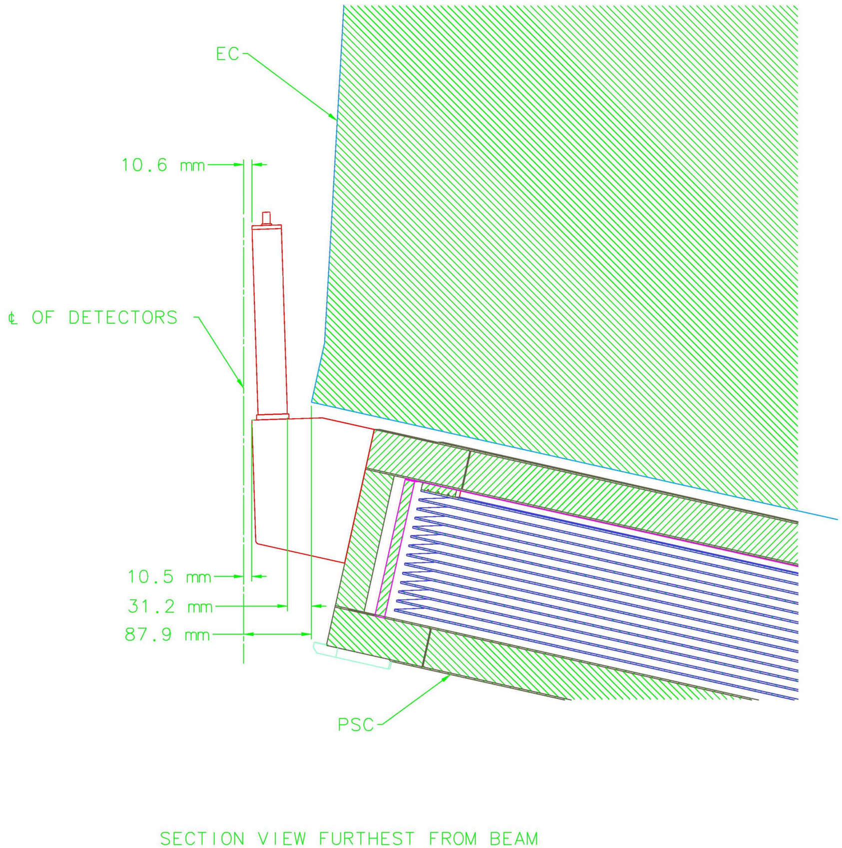
Gain Curve based on MIP data (M. Yourov)

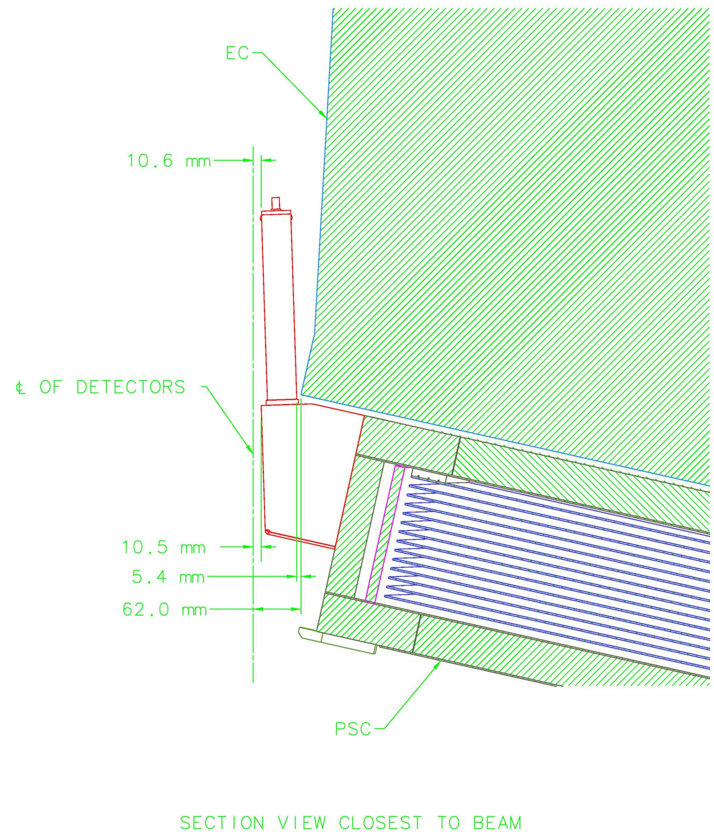
In order to have approximately 10ADCch/MeV, measurements with different HV settings have been performed .



- Full scale prototype (not necessary to have all PMTs and readout electronics)
  - workout design details (fiber routes, PMT holders, light guides …)
  - techniques for the fiber gluing and the quality control
  - work out details of the assembly procedure
  - establish a technique for fiber-adapter-PMT assembly
  - attenuation and light yield measurements (MIP)

PCAL PMT locations relative to EC





R&D FY06 & FY07

Goals:

- establish optimal design parameters of the pre-shower
- determine characteristics of electromagnetic shower and p^{0}’ gg reconstruction in the CLAS12 forward electromagnetic calorimeter
- determination of the light read out configuration
- selection of final components
- test measurements and prototyping

GEANT implementation and simulation of the pre-shower

N. Dashyan (YerPhI), K. Whitlow (SULI)

CLAS-NOTE 2007-001 & CLAS-NOTE 2007-002

Test readout system, component selection and protyping

G. Asryan, H. Voskanyan

CLAS-NOTE 2007-007

H. Viskanyan, M. Yurov, D. McNulty

CLAS-NOTE 2007?