Electromagnetic calorimeter for GEp(5): status report

Charles F. Perdrisat

August 21, 2013

@ SBS weekly meeting

General overview

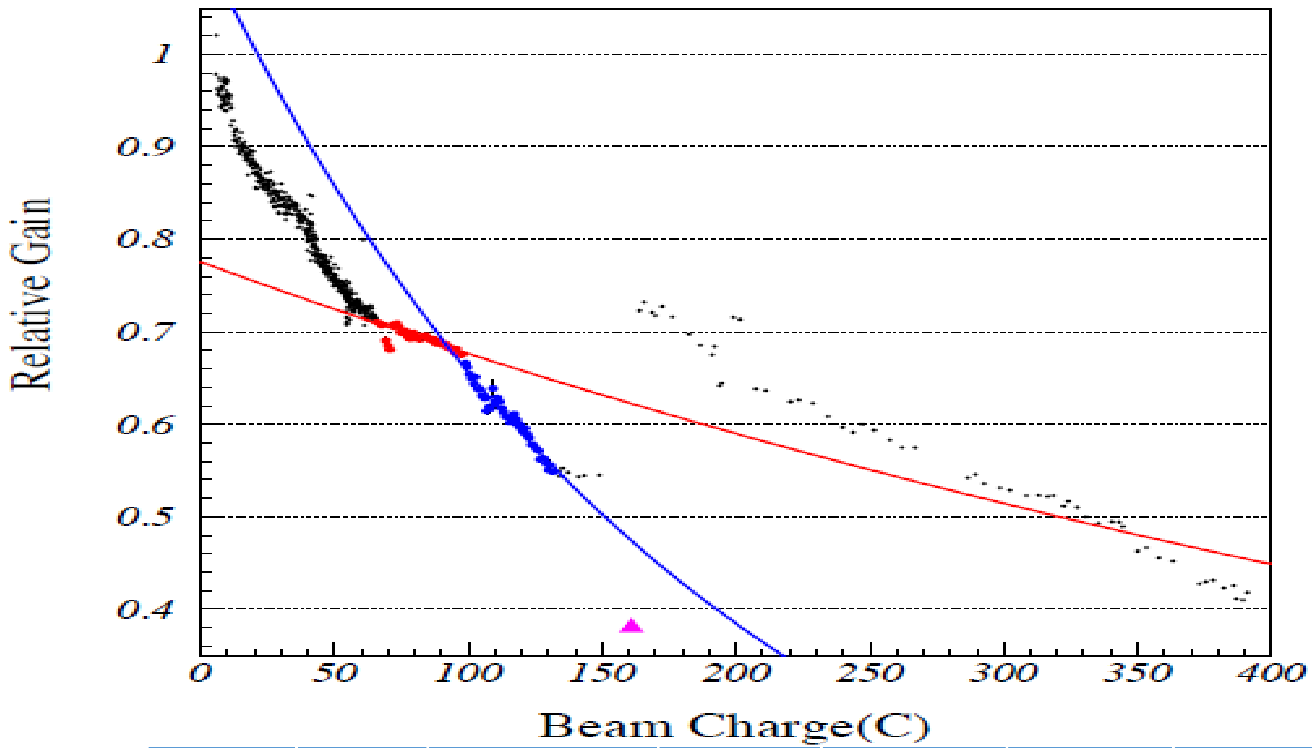
GEp(5) is a coincidence experiment, requiring characterization of both the proton and the electron energy and angles. Currently approved max Q^2 is 12 GeV^2.

As documented several times in the recent past, the required electromagnetic calorimeter (Ecal) does not exist currently; neither is it funded within the SBS project.

In the original proposal, as well as the DOE funding proposal, it was assumed that the leadglass from BigCal of GEp(3) would be re-configured and reused. The major flaw of this approach comes from the much more intense radiation level in GEp(5), and the poor radiation hardness of leadglass; this has been documented several times by Mark Jones.

During GEp(3) the energy resolution of BigCal went from , $\Delta E/\sqrt{E}$ of an initial 12% to 28% at the end of the experiment, totally unacceptable for GEp(5), which requires a threshold cut at 80-90% of the electron energy of elastic **ep**. The remedy originally proposed was frequent leadglass "cleaning" with UV light.

Radiation damage in lead glass major problem in GEp(5). Gain loss/Cb of beam in the Hall ~13 times larger than in worse kinematics of GEp(3). Slide shown before at SBS meetings.



- Expect 9x increase in time rate of gain loss for GEp(5) at 12 GeV^2; 13x at 14 GeV^2
- For 75uA beam and 12 GeV^2 point
- ~9% gain loss/8 hrs beam on target

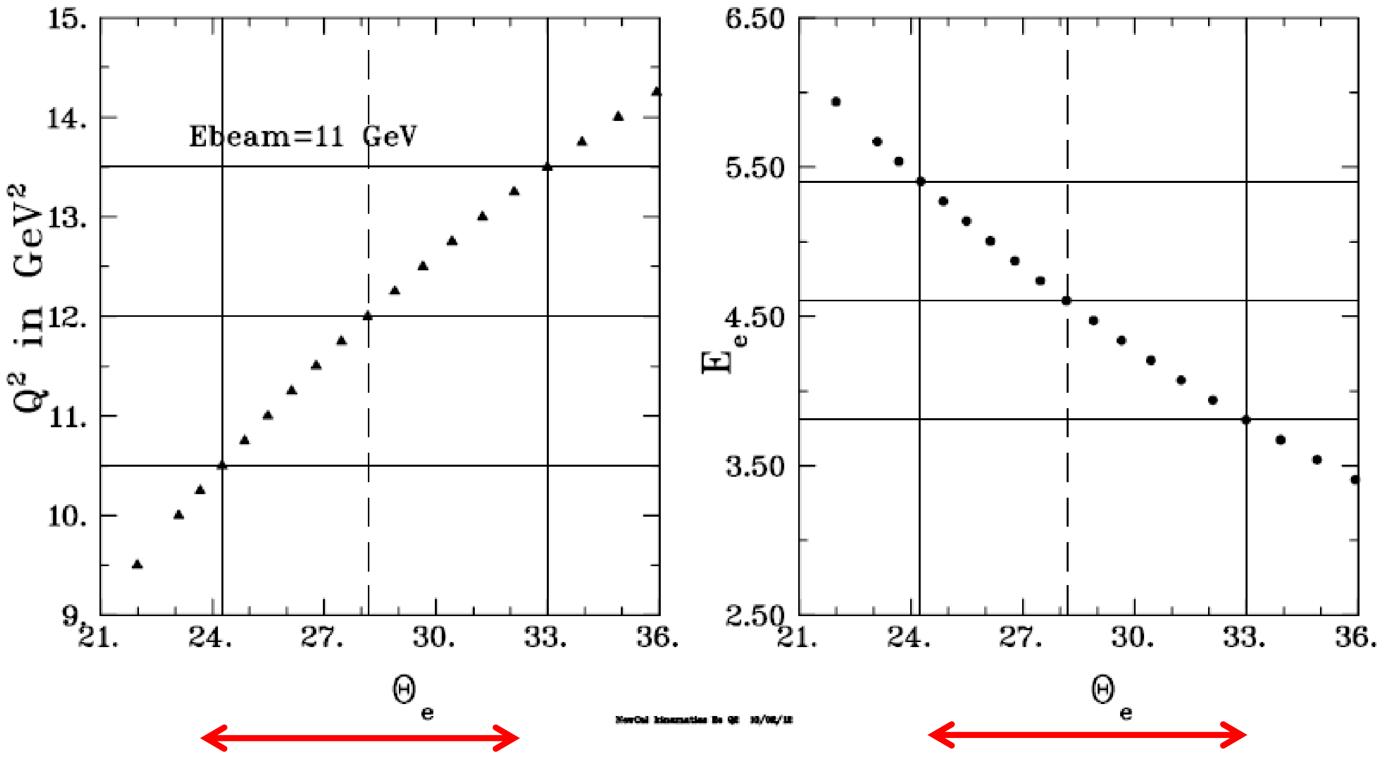
Source: Mark Jones
plots and work by Wei Luo
Lubomir Pentchev

Kin6. 8	Q^2	Angle (degree)	Dist (m)	Tgt (cm)	E GeV	gainloss rate %/C	Soft photon flux $J/cm^2/C$
1	2.5	44.9	12	20	2.84	0.14	0.004
2	2.5	32.0	11.2	20	3.54	0.53	0.013
GEp5	12	28.2	6.3	40	4.61	4.3	0.11
GEp5	14	34.9	4.8	40	3.54	6.8	0.17

(75 μA for 8 hours is 2.1 C).

Basic facts for Q^2=12 GeV^2

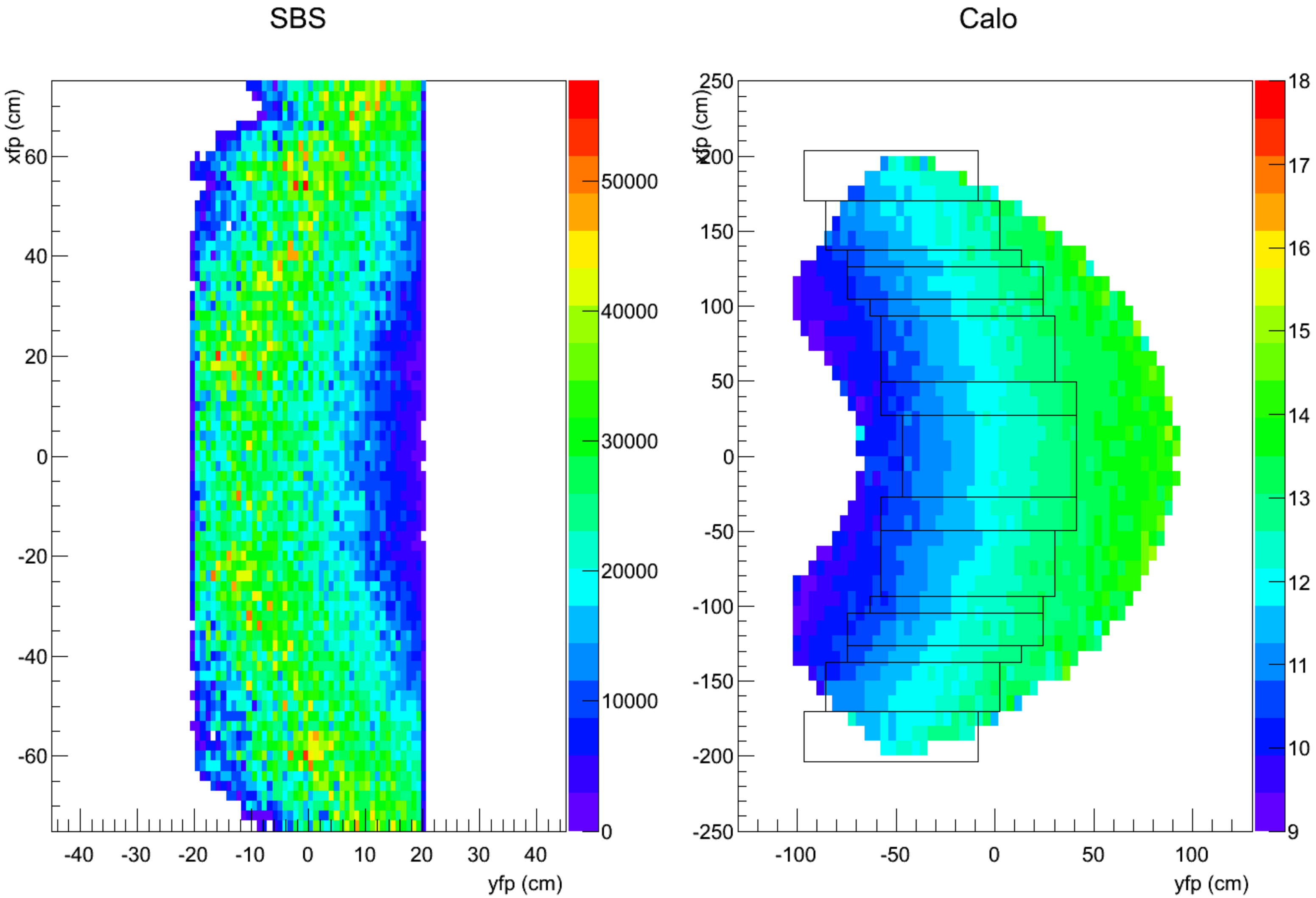
1. Electron energy varies strongly over face of detector (as does Q^2).
To define a trigger at 80-90% of electron energy everywhere on face of detector, will require summing signals from a number of detectors, following the constant energy (or Q^2) pattern.



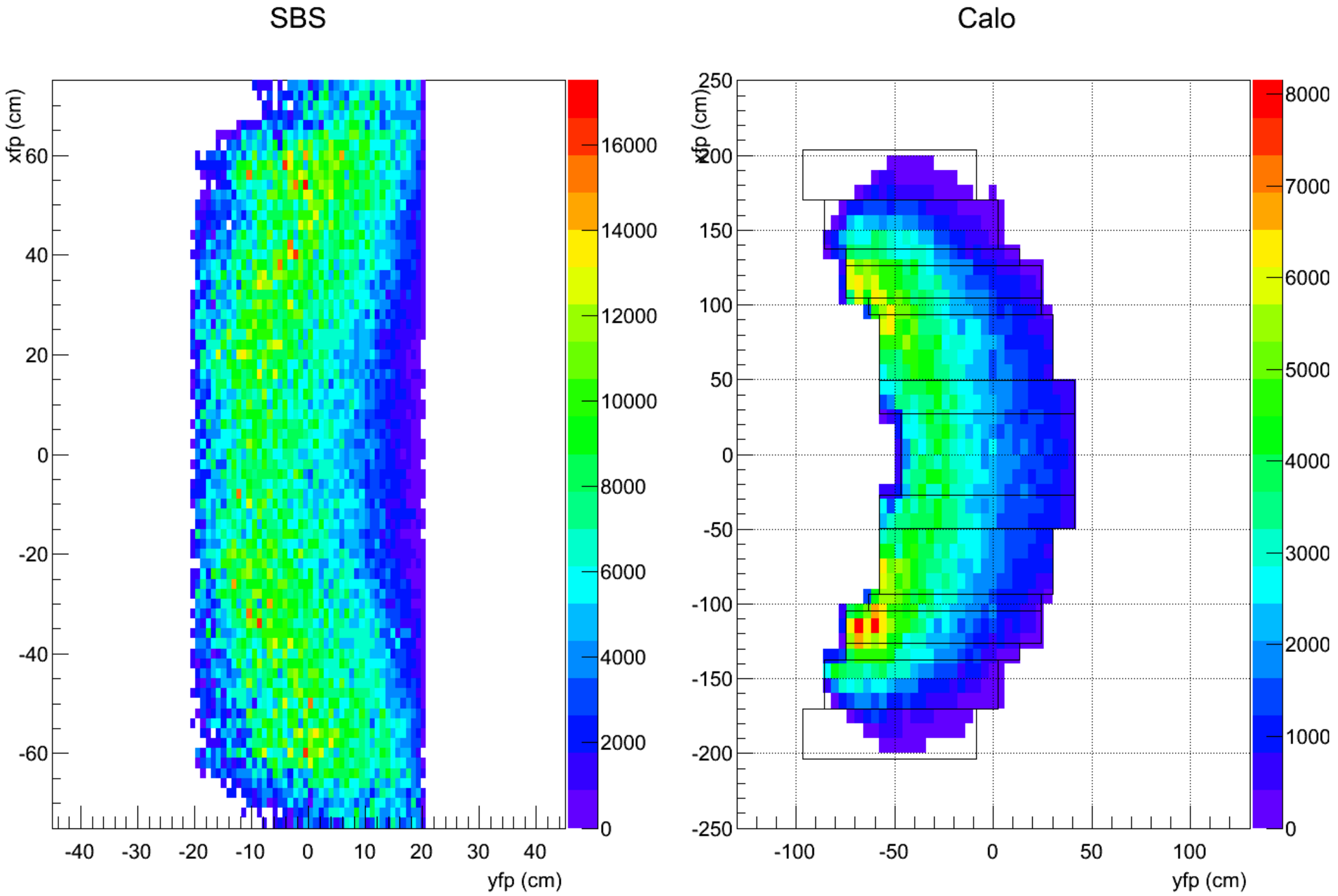
Ratio E_e^{max}/E_e^{min}>1.75

2. Wide distribution of constant Q^2 profile on face of Ecal

Left, number of events on SBS side, **Right**, Q^2 on Ecal side. Boxes proposed coverage by new Ecal. Follow the green area, which is 11.5 to 13.5 GeV^2. Electron energy is then 5.5 to 3.3 GeV. Figures from Mark Jones, SIMC simulation.



2. continued, same as previous, but with acceptance cut on ECal enforced.
The detector configuration shown contain 304 11.2x11.2 cm^2 detector bars.
The distance to the back of Ecal is 6.35 m.
Other Q^2 (5, 8 and 14.5 GeV^2) require no re-stacking, only change of distance and angle.



What are the elements of NewCal (or what should they be)?

Increasingly common in high energy physics are electromagnetic calorimeters of the sampling kind. They consist of *n* identical layers of material, alternating smallest X_0 , and scintillator: Pb common, X_0=0.56 cm, W better (0.35 cm), Pt best (0.305 cm), Fe not good (1.56 cm), but chosen for hadron calorimeters.
Energy resolution goes like 1/√n. Empirical optimum ratio for energy resolution Pb/scintil. ≈1/2 (thickness, not weight).

Typical energy resolution ΔE/E=[(10-12)/√**E**+(few)**/E**+(1-2)]%.): statistics1/√E; noise1/E.

The test at SLAC for OUTER HERA-B module gave **ΔE/E=(10.4/√E+8.3/E+0.00)%,** close to HERA-B published value ΔE/E =10.8(±0.1)//√E+1.4((±0.2)]% (G. Avoni et al, NIM in PR A580 (2007) 1209).

For 4.5 GeV electron energy (12 GeV^2) the two results are similar. (6.7% from our test, versus 6.3% from Avoni).
With twice the number of samplings, our test values: ΔE/E=5.3% at 4.5 GeV.

Current situation with search for radiation hard modules

1. Original idea to borrow modules from the HERA-B facility at DESY at a stand-still. According to Yuri Zaitsev at ITEP (Moscow), responsible of the MIDDLE and OUTER modules of the EM calorimeter, current budget uncertainty preclude lending us modules; kept as fall-back for FAIR. He lent us 10 modules, tested locally on cosmics, and at SLAC (see Carlos' talk).

2. Contacts with Sasha Vasiliev at IHEP (Protvino) interesting, but too expensive for us

3. Contacts with Oleg Gavrishchuk at JINR(Dubna) ongoing. Rough estimate of cost of 304 modules in range 250 to 400K$. What is being discussed is: 74 layers, 1.5 mm Pb, 3 mm scintillator, WLS fibers through whole volume , cross section 11x11 cm^2, 20 X_o.

4. Collaboration with SoLID, to prepare proposal for ~400 modules as part of their need; hence multi-use. Protvino design: 200 Pb/scint, 0.6 mm/1.5 mm, 20X_0. Hexagonal cross section, 100 cm^2; requires ~380 modules for same frontal area; estimate $1400 per module: cost ~k$540+fiber connectors add k$100. Add 30% contingency: k$700?

5. Use the material of the Hall B large angle calorimeter, to make shashliks.

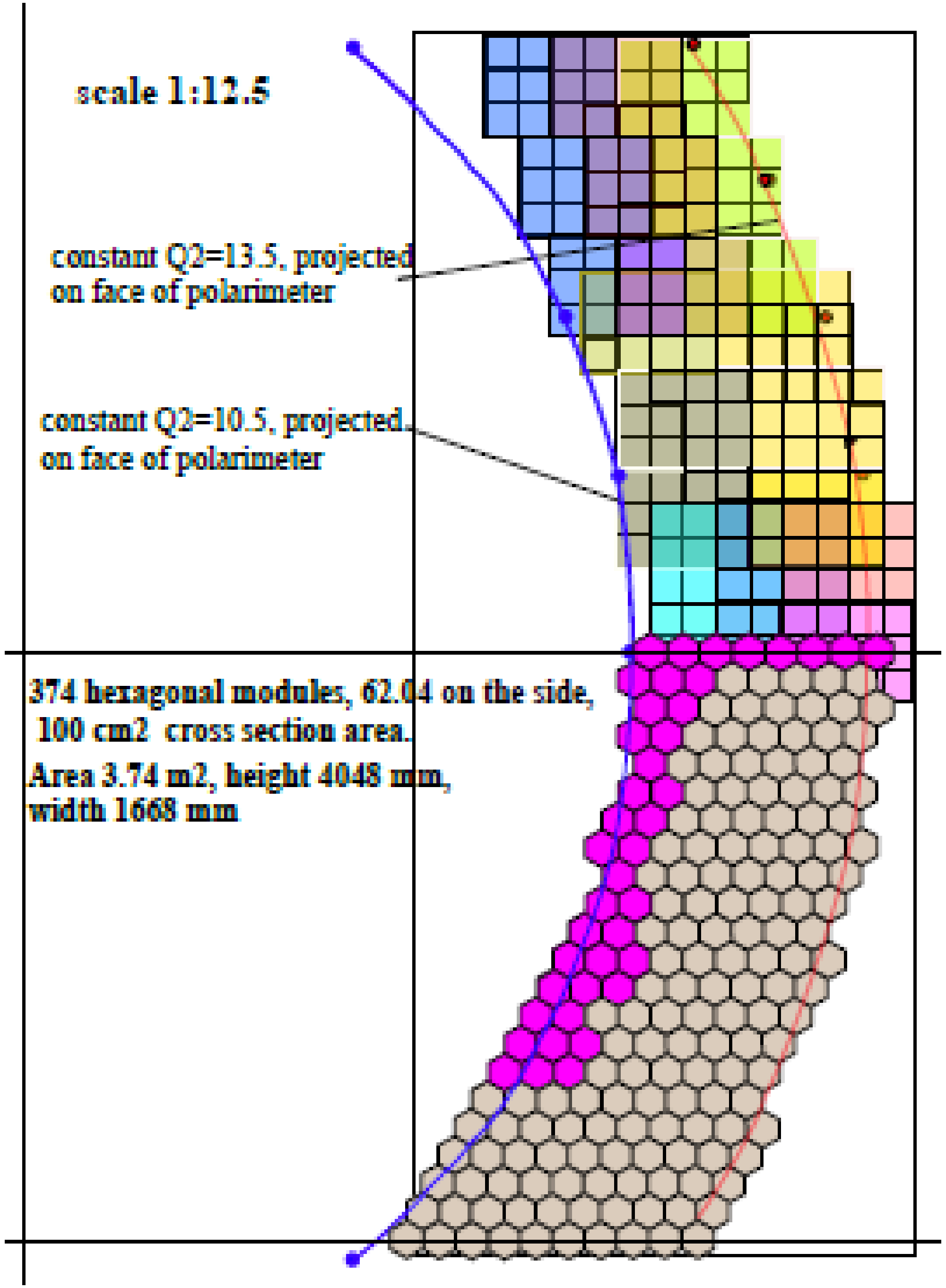
Main problem is scintillator thickness: 1.5 cm, but lead only 0.2 cm*. Could reuse the lead, but machining the scintillators does not make sense (tremendous work). Would still have to get fibers. Side or central single WLS rod not good enough with 10x10 cm^2 shashliks. Best might be to get scintillators from Dubna or FermiLab, and assemble the detectors here. No obvious cost advantage. Why destroy a perfectly good calorimeter just to re-use the Pb?

- The NE110A scintillators bars are 4 m and 2.4 m long, 10 cm wide.

6. Current plan of action: Wait for more details from Oleg, then decide between Dubna and SoLID, then start process of gaining support/authorization(?) from Jlab administration. Currently in discussion with Xiaochao and J.P. Chen.

Using the hexagonal modules of SoLID.

Their cross section being 100 cm^2, rather than the standard shashlik cross section of $11x11=121cm^2$, increases the number modules necessary to ~374, as shown.



CONCLUSION

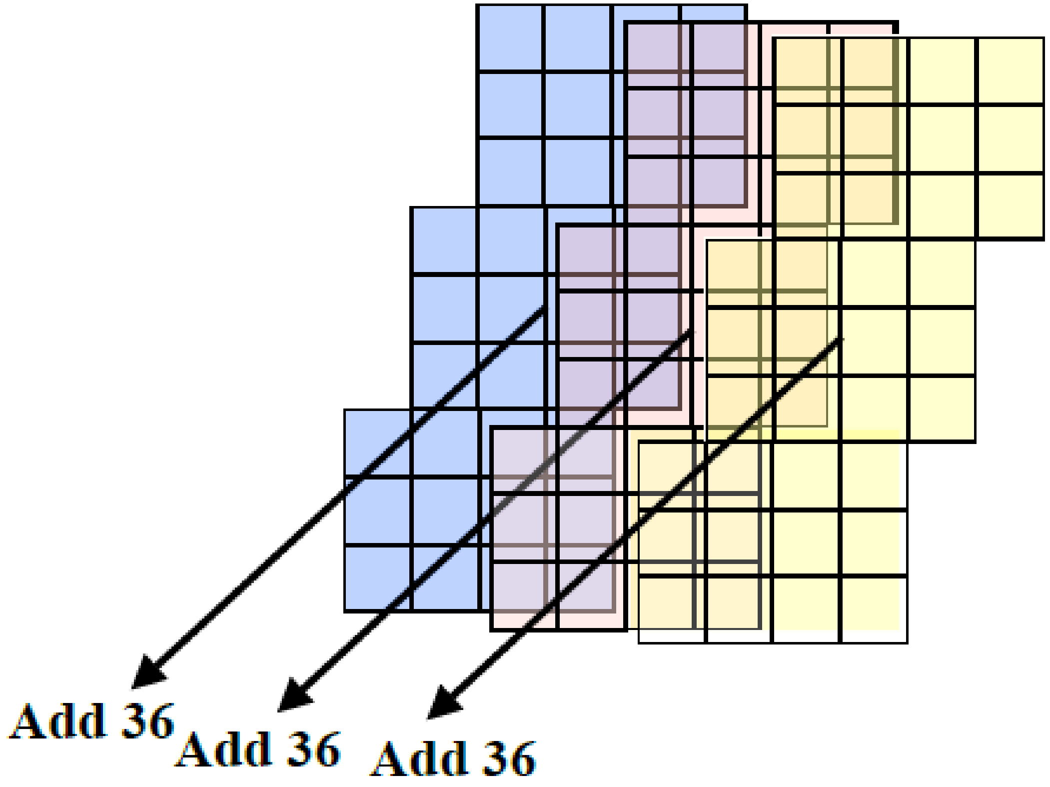
It is clear to us that re-using the lead glass of GEp(3) is not a solution.
Too much time to be spent on regenerating the transparency of the glass every shift,
with a time loss of 1-2 hours per shift; in 45 days run this is equivalent to 5-10 days
of data acquisition days lost.

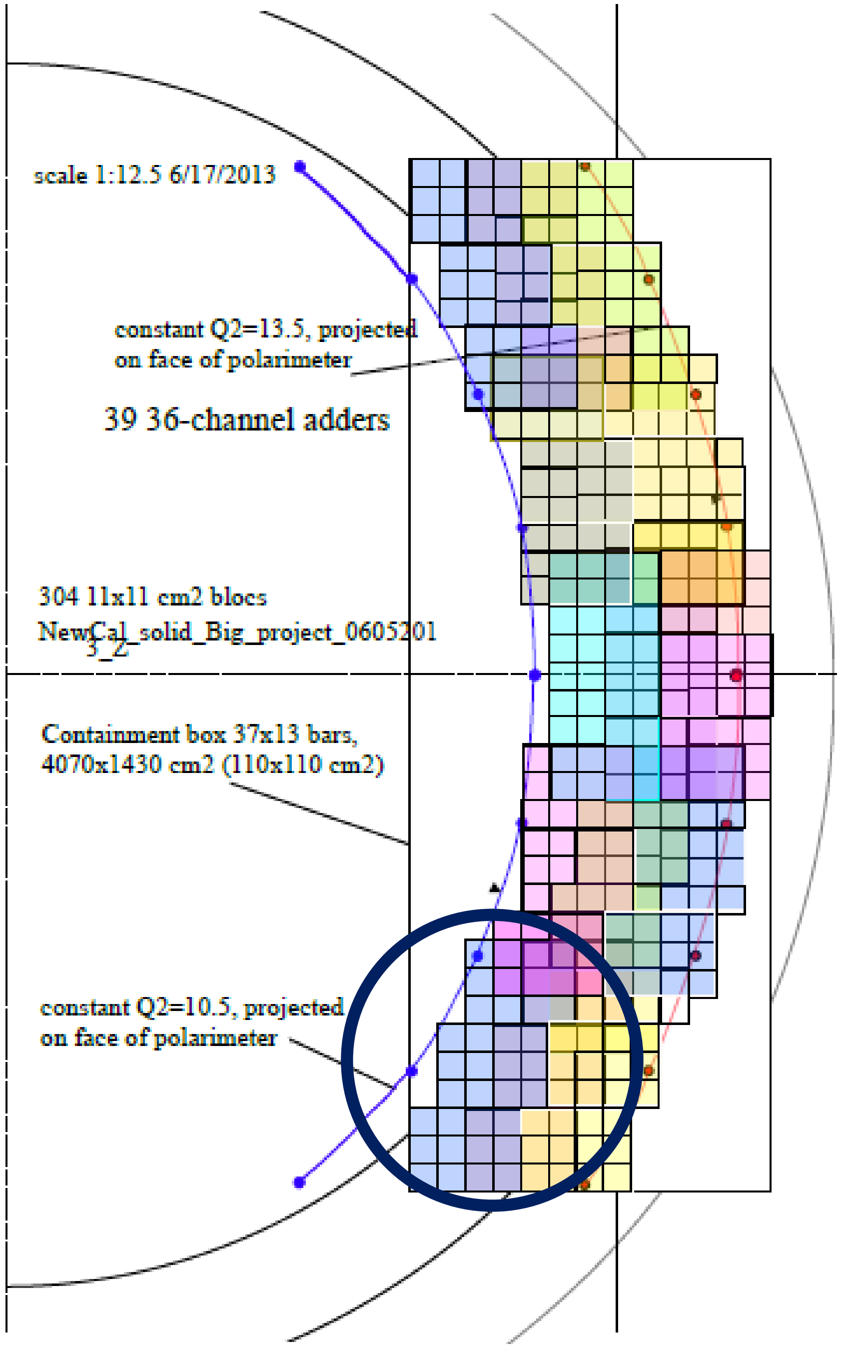
Using some of the material of the Large Angle Hall B calorimeter is not a solution either;
cutting and polishing 28,000 plates of scintillators is not economical and not a worthwhile
activity.

We will need to come to a decision: new shashliks of HERA-B type built in Dubna,
or SoLID shashliks built in Protvino in collaborative proposal.

Additional Transparency

How to make an Ecal





Difficulty is number of outputs per module required:
One (132), two(264), three(48), four(96): total 540.
Two row/column overlap may be overkill (MonteCarlo)