The trigger for the New Electromagnetic Calorimeter NewCal

Feasibility studies (2d version)

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Assumptions:

HERA-B midsection shashlik detectors available, 2128 channels in clusters of 2x2, original 4 FEU-84-3 PMs in each cluster not available

2) The cross section size of one midsection detector is 5.59x5.59 cm^2, container not included

3) The proposal NewCal front was ~110x312 cm^2 =3.43 m^2; can be achieved with 20x56 =1280 HERA-blocks, neglecting the unknown gap between elements.
Can make a larger NewCal with 24x72=1728 blocks, 134x402 cm^2=5.4 m^2.

With BigCal lead glass, same area of 5.4 m^2 requires 3366 bars. As far as I know, we have 1744+1000 bars available at Jlab (or BNL); corresponds to 4.4 m^2. Requires 2744 electronic channels, rather than 1728 for HERA blocks; not negligible difference! And then there is the question of radiation hardness which strongly favors HERA-B shashliks.
Estimate that with lead-glass, need annealing 3 times a day, for 1 hour each.

Assume Hera-B middle section blocks, max. number 2128, 5.59x5.59 cm2 each, in groups of 4 with 4 PMs.

solution	Blocks HxV=number	Area m2	Distance/169 msr
min	20x60=1200	3.63	3.63
reasonable	24x72=1728	5.39	5.6
max	28x84=2352	7.62	6.7

Solid angle matching for 65 msr proton-detector, Jacobian 1.66x1.58 at 12 GeV^2. 166 msr for NewCal.

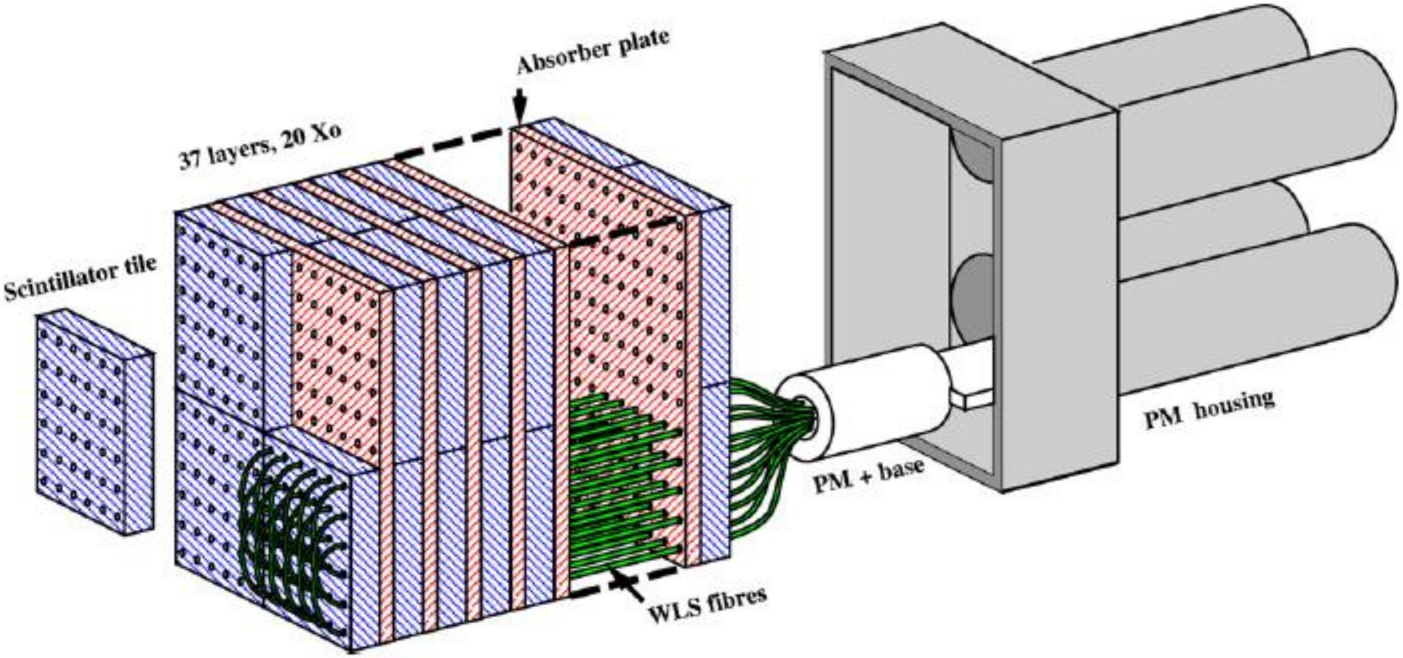
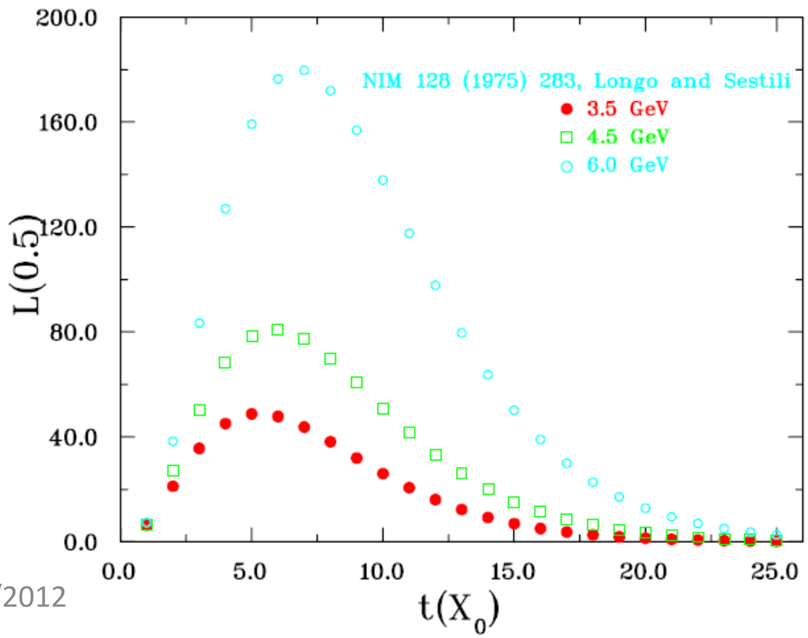


Fig. 4. MIDDLE ECAL module structure.

Characteristics of HERA-B mid-section blocks

Each element consists of 37 square lead plates (3 mm thick), alternating with scintillator plates (6 mm thick), total thickness $20X_0$. Total length hence 33.3 cm ($0.6X_0$ per Pb-scint.unit).
Scintillator light brought to PM with 18 U-shaped WLS fibers, inserted in the 36 holes in lead and scintillator.
Groups of 4 elements in one box (material?), PM and power supply in steel tubes. Light from LED injected by 1 fiber into center of each element.



Number of electrons with energy larger than 0.5 MeV versus thickness in units of X_o.
At 4.5 GeV, 99.5% of electrons produced are contained in $20X_0$.

Geometry of the detector

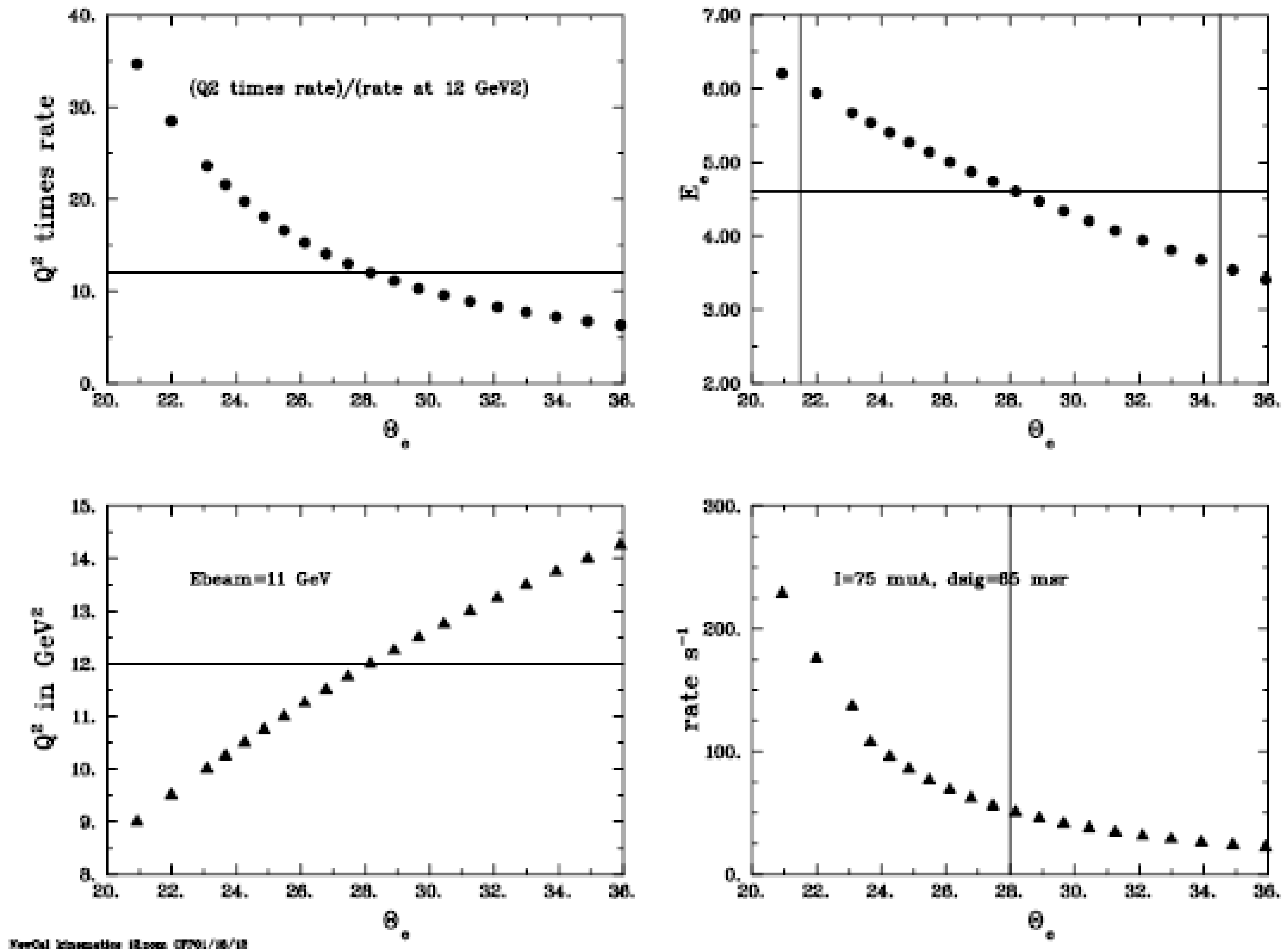
At least 2 considerations are most important, to form an efficient trigger with threshold at ~90% of elastic electron energy (4.5 GeV for Q^2 =12 GeV^2).

1) limit the range of Q^2 accepted to decrease large counting rate from low Q^2 events.

2) limit the number of elements in which the energy is shared, to attain large energy collection, even so the angular acceptance of the detector is very large. Adapt structure of trigger to accommodate this number of elements.

The geometric considerations required are different for these 2 requirements.

For 12 GeV^2 with 11 GeV beam

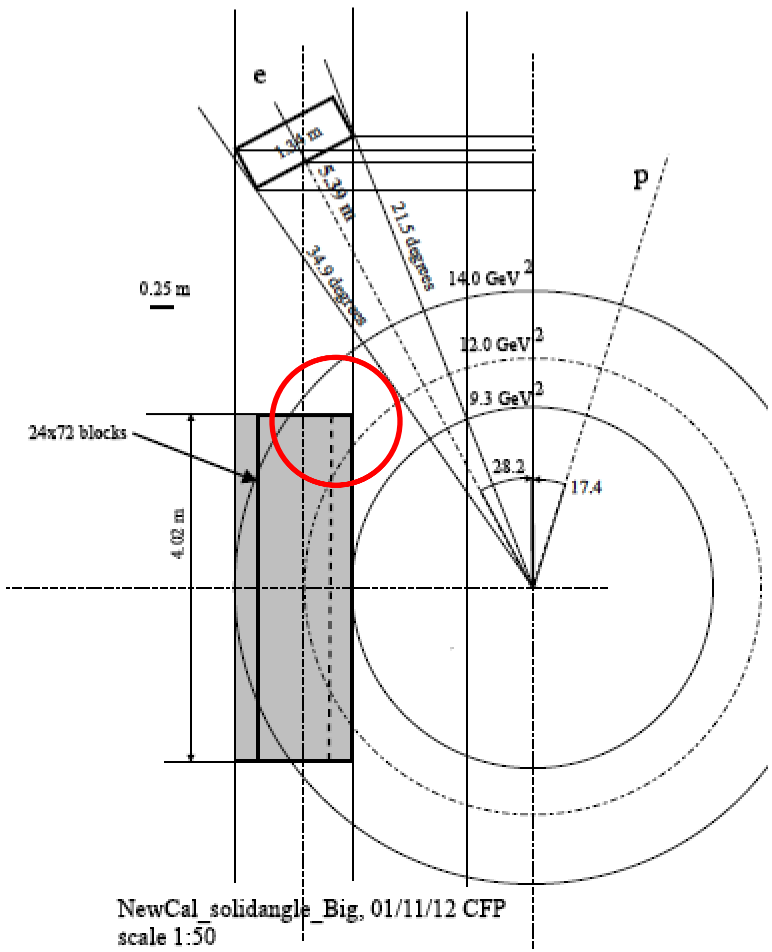


Combined top view (upper part), and side view looking down the beam pipe (Lower part).

NewCal assumed to be monolithic vertical 4.02 m high.

Circles are constant Q^2, illustrating the mismatch of this geometry.

However, note that acceptance for 9.3 GeV^2 is minimal, but acceptance for 14 GeV^2 is maximum.

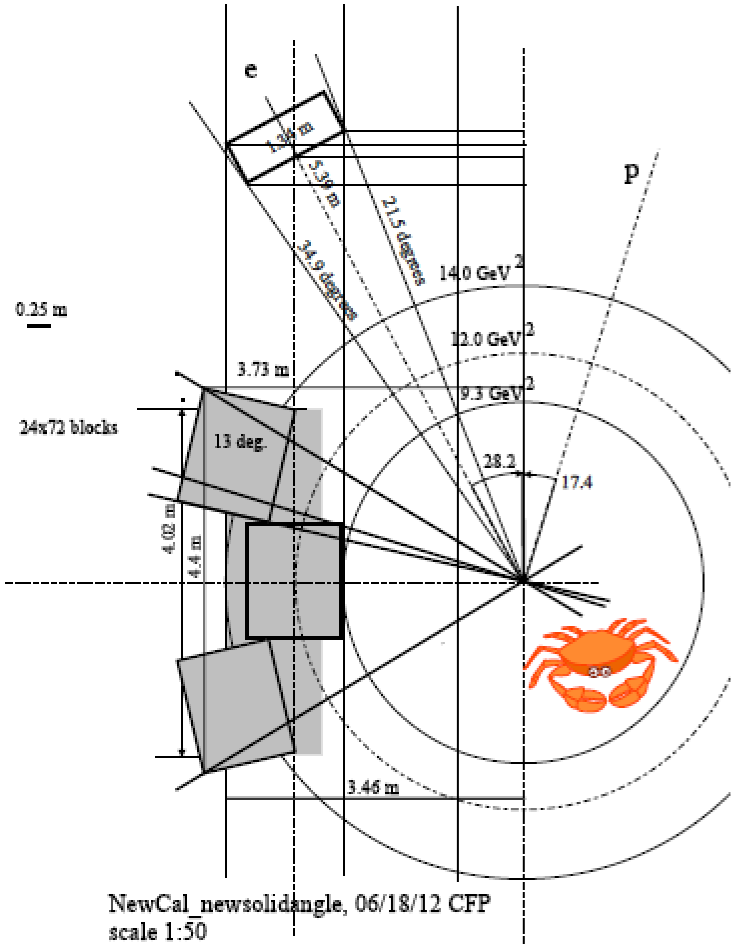


Illustrating how to "wrap" the 3 modules around circle of constant Q2.

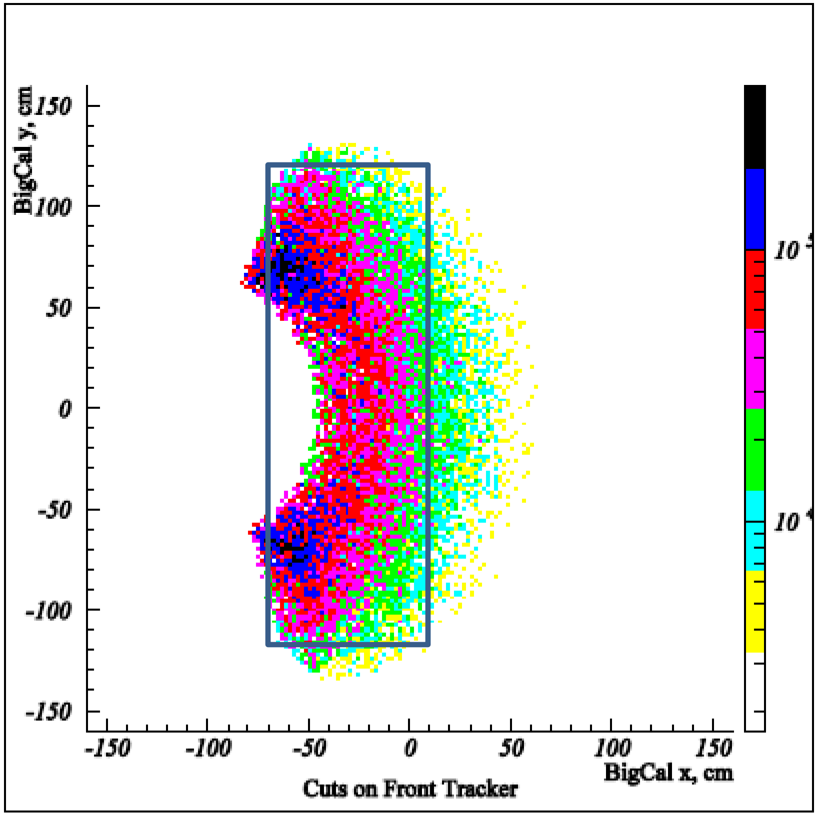
This is rotation in the plane of a circle perpendicular to the beam.

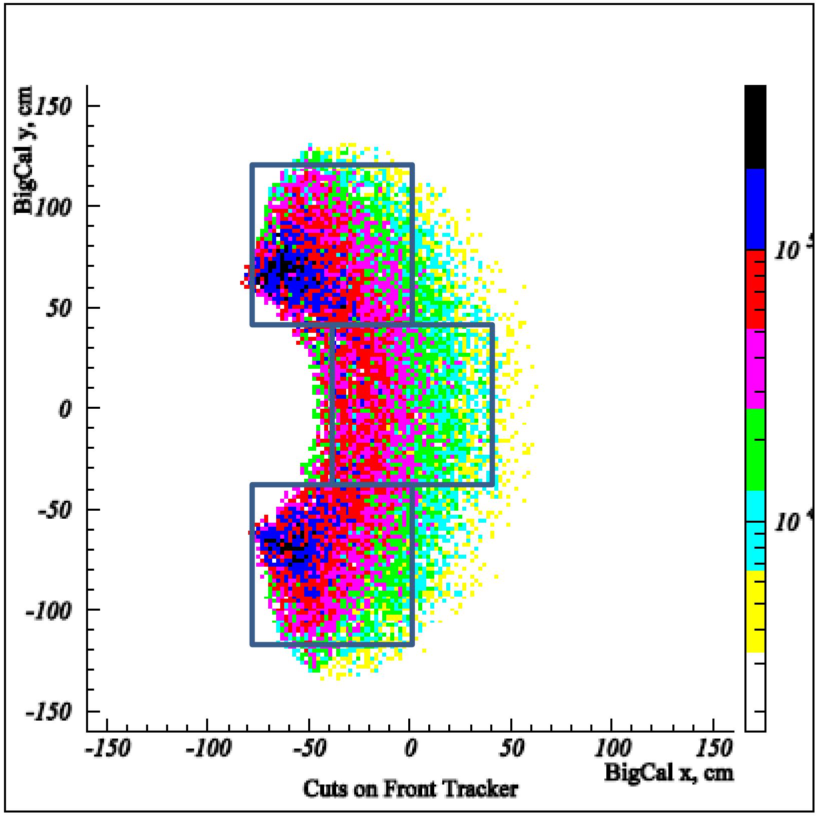
Doable, but difficult. Does solve partially problem of energy spread and trigger level accuracy.

Most importantly, it limits max angle (H and V) to 8^0, instead of 26^0 with one unit detector.
Difficult to change Q^2 (for ex. to 14 GeV^2)

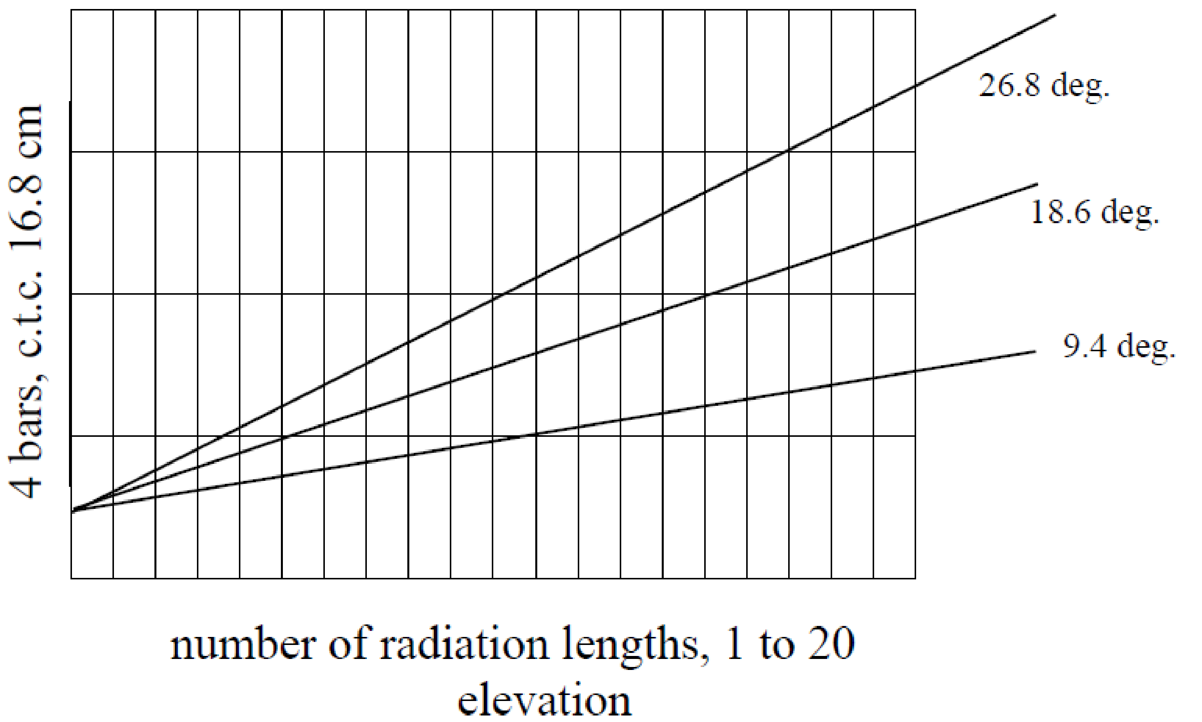


From Lubomir's toy Monte Carlo: distance 3.5 m (BigCal); not NewCal (5.4 m); cuts of front tracking on proton side applied.





My previous considerations were wrong, electrons coming to top/bottom of calo will be contained in 4 elements (not 8 as previously believed). Rays at extreme left and right will be contained in 2 elements.
This remove need to rotate elements of calo around horizontal axis to minimize largest angle of impact.



Trigger configuration

The signals of all elements included in one shower must be added and subjected to a threshold with level 90% of the elastic electron energy.

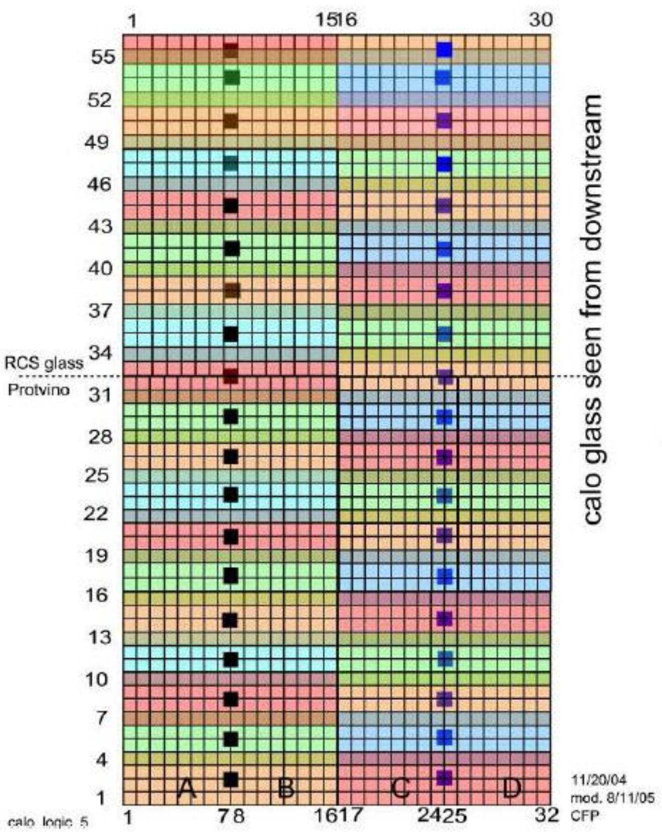
The elastic electron energy varies from 3.5 to 6 GeV (4.6 GeV for 12 GeV2).

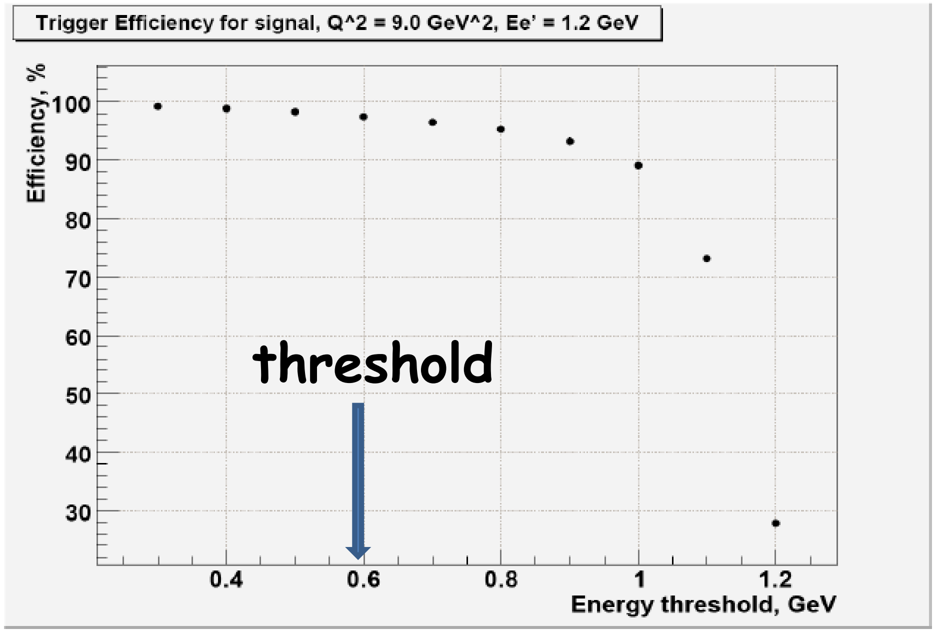
The maximum spread in vertical direction is 4 elements, and 2 elements in horizontal direction.

The address of the subgroup which identified a shower above threshold will be correlated with the address of the identified proton from hcal.

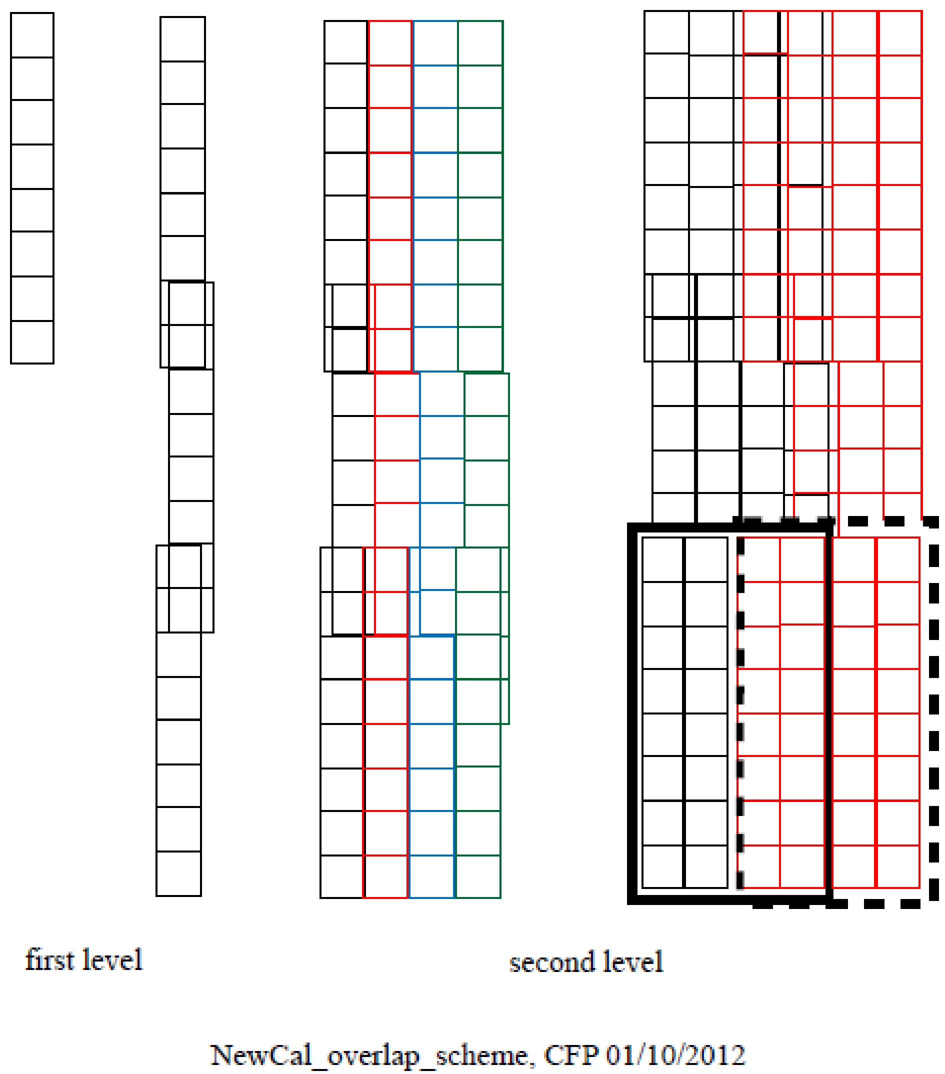
Size of matrix unknown to me at this point.

How was it done with Gep(III)?





First the easiest and cheapest solution, from February. Vertical groups of 8, overlapping vertically by 2 at first level. Four such group added at second level, with horizontal overlap of 2.



Problems that need to be addressed next

1) The simplest scheme requires two parallel PM outputs from 432 of the 1728 PMs.

2) It also requires 4 outputs from the first level adder octets; these currently have 3 outputs.

We have 112 first level adder modules ,
and 21 second level modules, total 266 octets plus spares?
compare to the need of 264 first level adder modules.

But the existing adders need to be modified

Considerations about "Bogdan's best scheme"

first level, add blocks of 4x4 bars (1 element)
second level sum of these with 2 rows and 2 columns overlap.

Within one 24x24 sub-calorimeter,
at first level, to make blocks of 2x2 elements will need to add the PM outputs of 2 horiz. neighbors and their corresponding 2 vertical neighbors,
producing 144 analog 4-fold sums with adders (24x24/4=596/4=144).
Will need 4 copies of each of the 144 sums, **432 sums for complete NewCal.**

At second level, summing 4 outputs of the first level, 2 horiz. X 2 vert.,
Requires 12x12 4-fold summing circuits. i.e. 144 sums. This is also the number of discriminators per sub-calorimeter, **if we don't add a third level**.

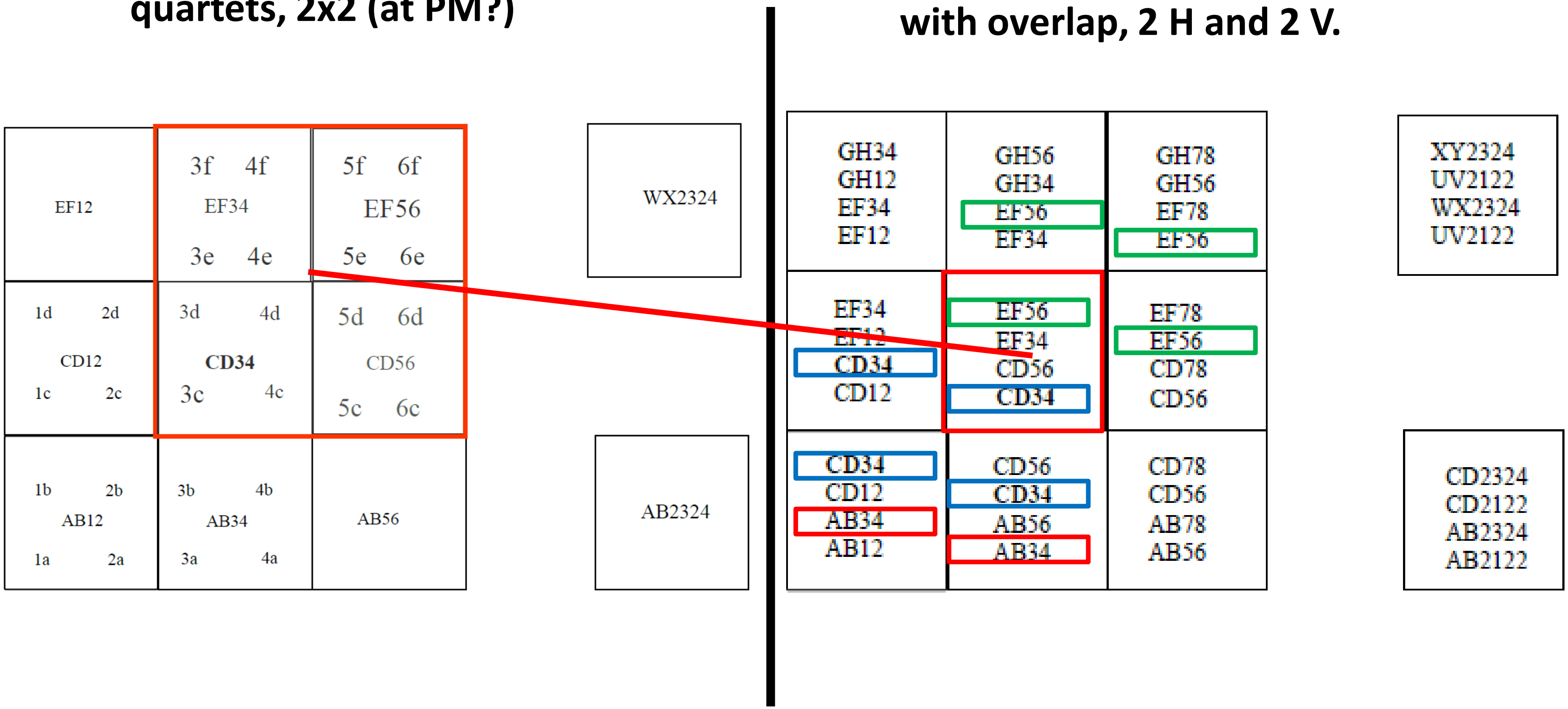
So for the complete NewCal would have 432 second level outputs to send to the same number of discriminators.

Third level sums: one simple solution, sums of 4 second level outputs in a square pattern without overlap (as the overlap is done in second level); reduces number of discris to 144 (still 18 units at 8 channels each).

Bogdan’s best idea?

First level: produce 144 quartets, 2x2 (at PM?)

Second level, add quartet with overlap, 2 H and 2 V.



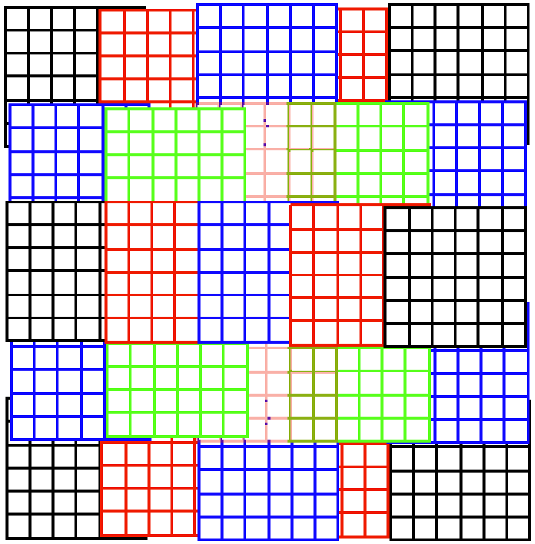
First level adders
Requires 144 4-fold analog adders

Second level adders:
Requires 144 4-fold analog adders

for one 24x24 calorimeter element

PrimeX 36-channel adders

Using existing 48 units would work as follows (are there more around?):
1 adder has 36 channels, 6x6
Providing 2-channel overlap H and V would require 25 units for 24x24.
elements, 75 units would cover 3 elements or 1728 channels.
Would provide 75 triggers signals for discriminator.
Compare to number of Hcal triggers?



Other design considerations:

Assuming again HERA-B mid-section shashliks, the lead weight of 1 element consisting of four 5.59x5.59 cm bars, is ~18 kg, 40 lbs.

1728 bars in the calorimeter is 8,200 kg, 18,000 lbs.

OK with crane, but must add overall container(s). Design challenge (?).

Propose building 3 identical units, each 24x24 bars. Details to follow.

The end for now

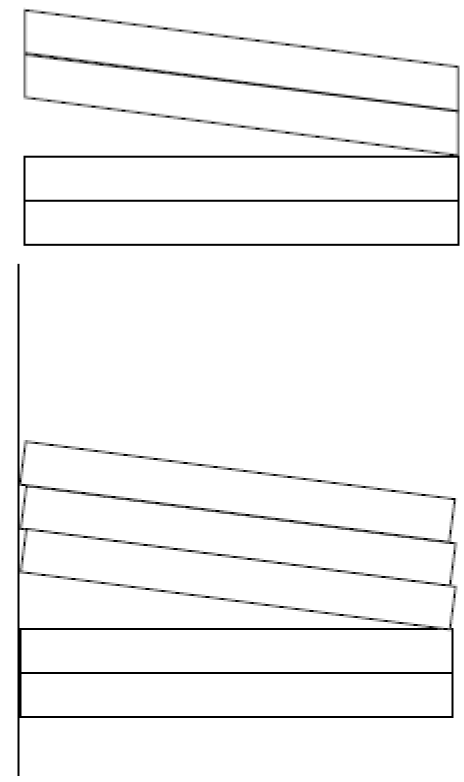
use solid angle 65 msr of p in SBS

0.700000

Ebeam	q2	pmom	Escat	th(e)	t(p)	th(p)	pt	pl	dp3_dp4
11.0	8.000	5.1161	6.737	18.91	4.263	25.263	-0.027	0.531	-0.984
11.0	8.500	5.3867	6.470	19.90	4.530	24.133	-0.024	0.562	-0.985
11.0	9.000	5.6570	6.204	20.92	4.796	23.057	-0.022	0.593	-0.987
11.0	9.500	5.9269	5.938	21.99	5.062	22.028	-0.019	0.623	-0.988
11.0	10.000	6.1965	5.671	23.10	5.329	21.039	-0.017	0.653	-0.989
11.0	10.250	6.3313	5.538	23.67	5.462	20.559	-0.016	0.667	-0.989
11.0	10.500	6.4659	5.405	24.26	5.595	20.086	-0.015	0.682	-0.990
11.0	10.750	6.6005	5.271	24.86	5.729	19.622	-0.014	0.696	-0.990
11.0	11.000	6.7350	5.138	25.49	5.862	19.164	-0.013	0.711	-0.990
11.0	11.250	6.8695	5.005	26.13	5.995	18.713	-0.012	0.725	-0.991
11.0	11.500	7.0039	4.872	26.79	6.128	18.268	-0.011	0.739	-0.991
11.0	11.750	7.1383	4.739	27.47	6.261	17.828	-0.010	0.752	-0.991
11.0	12.000	7.2727	4.605	28.17	6.395	17.394	-0.009	0.766	-0.992
11.0	12.250	7.4070	4.472	28.90	6.528	16.963	-0.008	0.779	-0.992
11.0	12.500	7.5413	4.339	29.65	6.661	16.537	-0.008	0.792	-0.992
11.0	12.750	7.6755	4.206	30.44	6.794	16.115	-0.007	0.805	-0.993
11.0	13.000	7.8097	4.072	31.25	6.928	15.696	-0.006	0.817	-0.993
11.0	13.250	7.9439	3.939	32.10	7.061	15.279	-0.005	0.829	-0.993
11.0	13.500	8.0780	3.806	32.99	7.194	14.865	-0.005	0.841	-0.993
11.0	13.750	8.2121	3.673	33.92	7.327	14.452	-0.004	0.852	-0.994
11.0	14.000	8.3462	3.540	34.89	7.460	14.040	-0.003	0.864	-0.994
11.0	14.250	8.4802	3.406	35.92	7.594	13.629	-0.003	0.874	-0.994
11.0	14.500	8.6142	3.273	37.00	7.727	13.219	-0.002	0.885	-0.994
11.0	14.750	8.7482	3.140	38.14	7.860	12.807	-0.001	0.895	-0.994

The “new” coordinate detector in front of NewCal

NC_coord_detail CFP arb. Scale 5/7/2012



Now 3 layers of 3x30x1350 mm scintillator slats. (possibly 5 mm thick instead of 3 mm).

To be read by multi anodes Hamamatsu PM tubes (4 by 4)

Outside size of 1 PM is 30x30 mm.

16 slats of 3 mm requires 1 PM every 48 mm. So no problem of spacing.

Inclining slats in upper and lower region may be easy and improve resolution.