The trigger for the New Electromagnetic Calorimeter NewCal

Feasibility studies (4th version)

Charles F. Perdrisat

September 12,2012

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 defining: 150Vx40H cm at 3.25+0.7 m: 39 msr proton-detector, Jacobian 1.66x1.58, for BigCal solid angle ~110 msr: ~6.4 m to the back of NewCal.

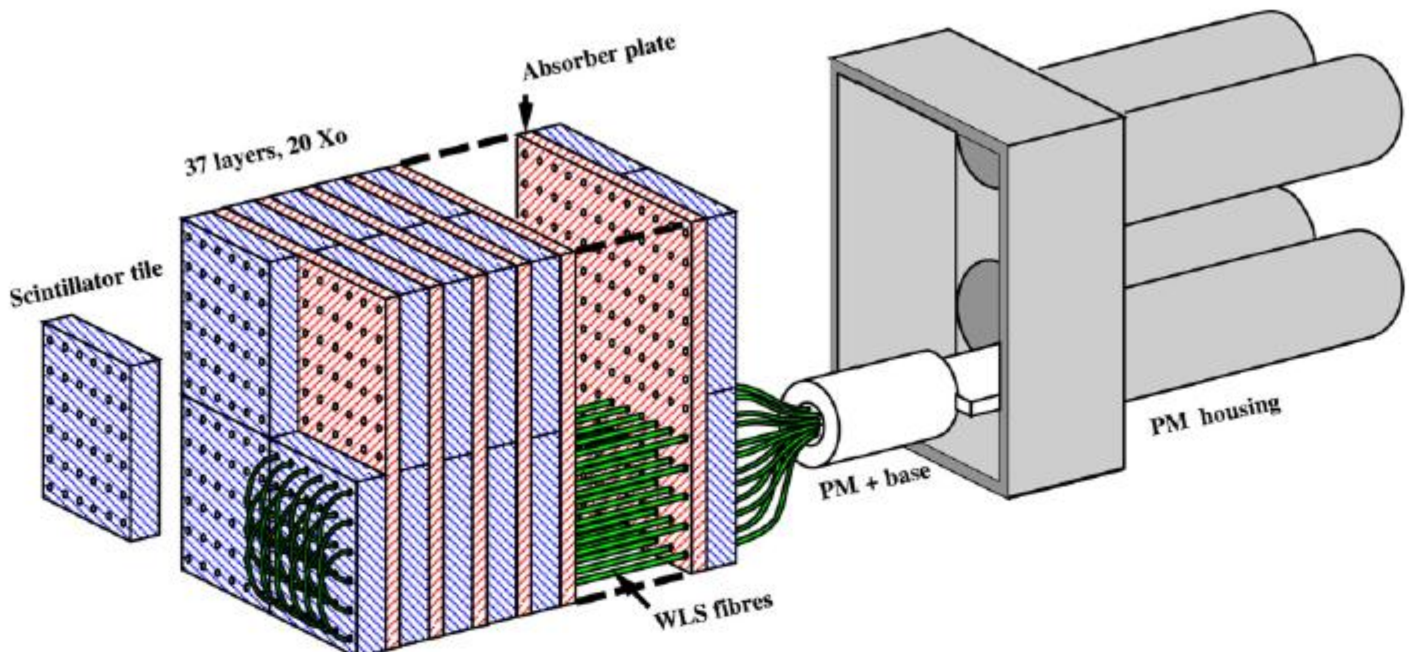
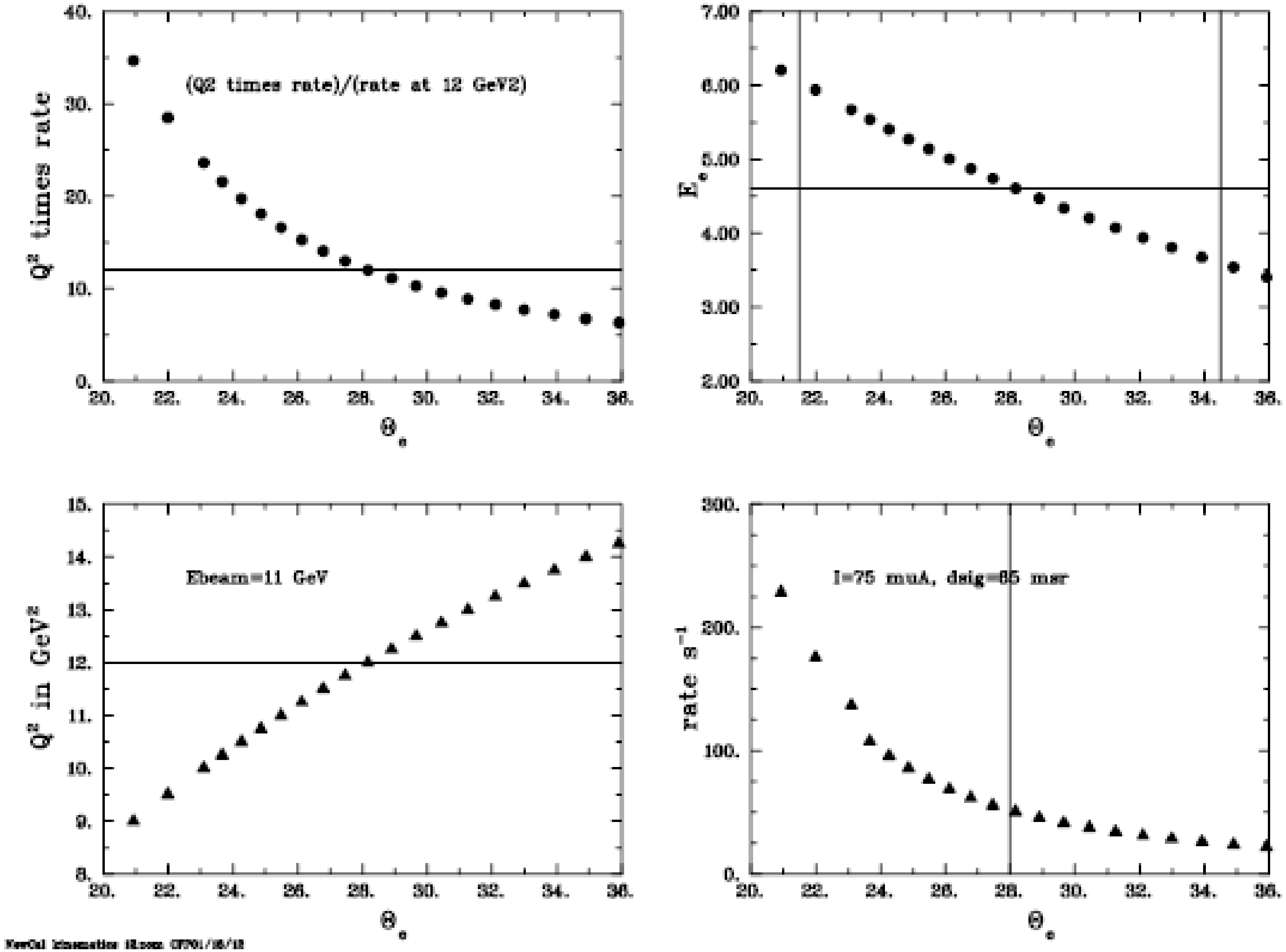
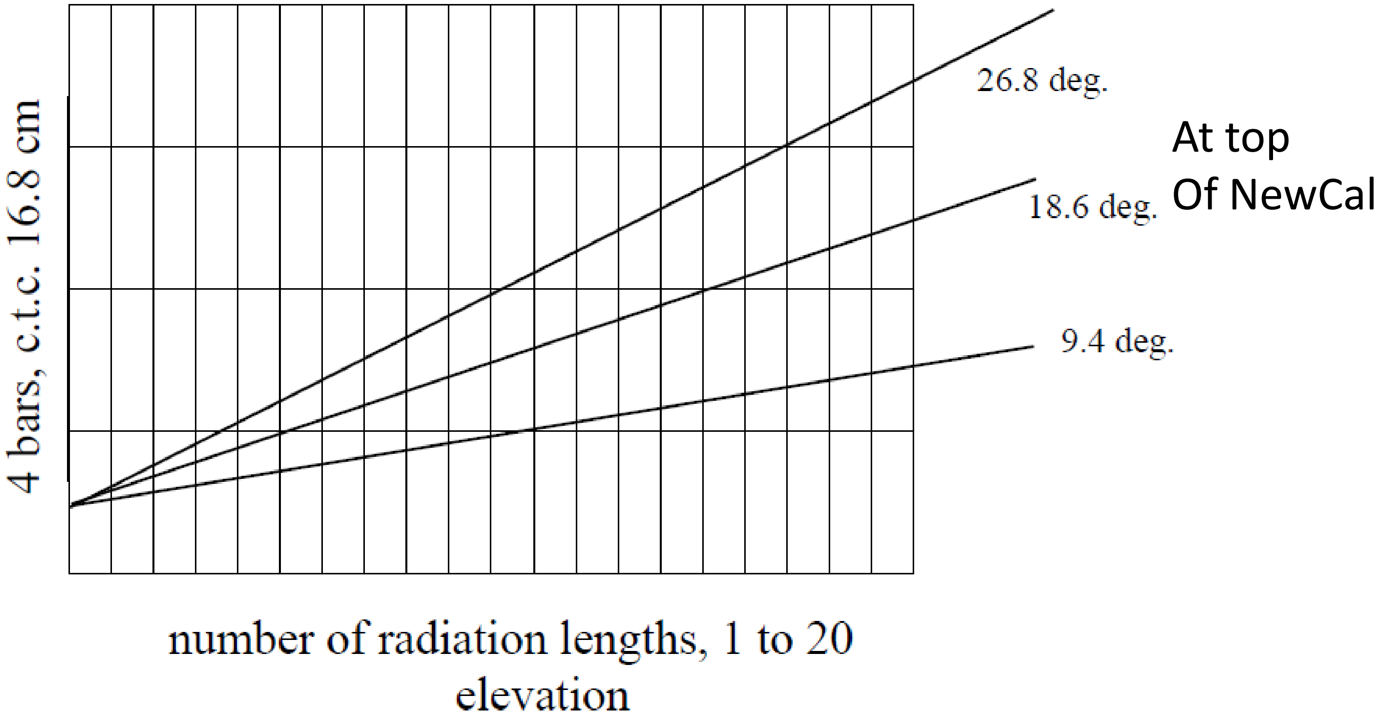


Fig. 4. MIDDLE ECAL module structure.

For 12 GeV^2 with 11 GeV beam



Number of blocks involved for extreme hits. In vertical direction approximately 4, with most of energy in first and second, buty need At least third included in trigger for 80-90% threshold.



Trigger configuration

The signals of all elements included in one shower must be added and subjected to a threshold with level 80-90% of the elastic electron energy.
Electron energy varies from 3.5 to 6 GeV (4.6 GeV for 12 GeV^2).
Revised to reduced acceptance, 10.5 to 13.5 GeV^2, energy range still 6.5 GeV to 4.5 GeV. Individual PM gain control scheme yet to be invented!

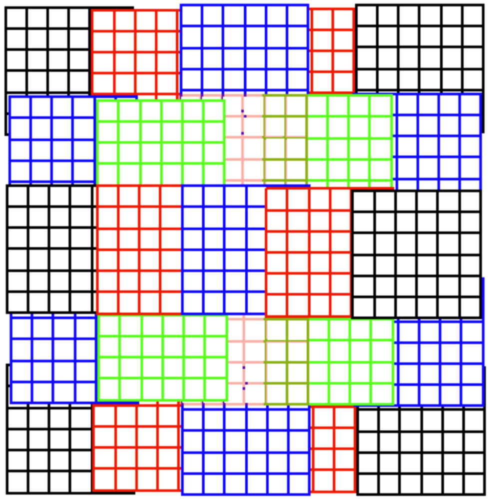
The maximum spread due to non-perpendicular incoming particles in vertical direction is 3 elements, and 2 elements in horizontal direction.

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

PrimeX 36-channel adders

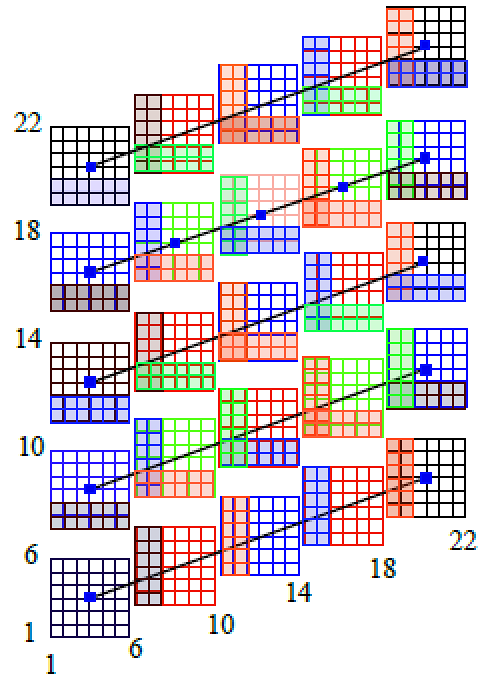
Using existing 50 units could work as follows: 1 adder has 36 channels, so make 6x6 matrices.
Provide 2-channel overlap H and V would require 25 units for 24x24 elements, 75 units would cover 3 elements or 1728 channels.
Would provide 75 triggers signals for discriminators and FPGAs.
Comparison to number of Hcal triggers follows.

Sept. 7 update on 36-channel adders.
Were built by Bill Stephens of UVa.
Now independent business in Earlysville (VA).
Hall B has 36 such adders, will not use them anymore. I contacted Cole Smith.



For NewCal, assumed to consist of 3 identical sections, each 24 times 24 Hera-B blocks.

Overlap pattern: 2 horizontally and 2 vertically; suggested by shaded 2x6 areas



21E				25E
16E				
11E				
6E				
1E				5E

Labels for 5x5 pattern after 36-adders.

4	4	2	2	4	4
4	4	2	2	4	4
2	2		1	2	2
2	2	1	1	2	2
4	4	2	2	4	4
4	4	2	2	4	4

Number of PM outputs required depending on position in 6x6 adder.

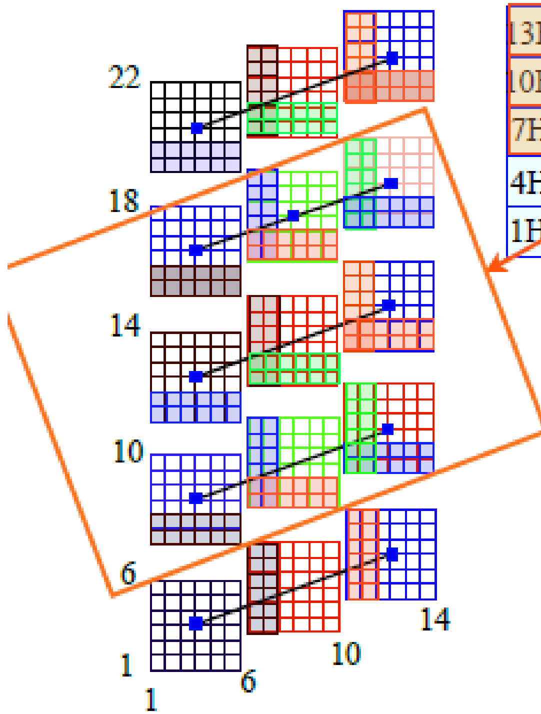
Add 1 output per PM for ADC to each channel

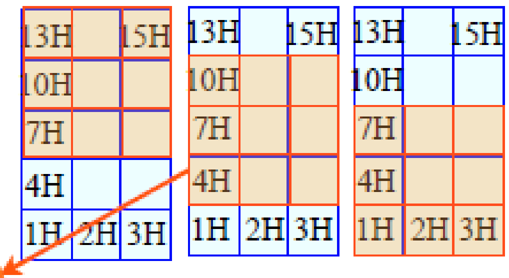
newcal_6by6_next062912 /CFP

Requires 25 adders, but leaves out one row/column all around. To cover that go to 6x6 adders per section (not available at this time)

For HCAL,
one of several possible solutions:

Using adders of 36 channels
In both NewCal and HCal





4	4	2	2	4	4
4	4	2	2	4	4
2	2	1	1	2	2
2	2	1	1	2	2
4	4	2	2	4	4
4	4	2	2	4	4

Number of PM outputs required for PM connected
to given input of 36-adder
Add 1 output per PM for ADC to each channel

Likewise, to cover all bars should go to 3x6 adders.

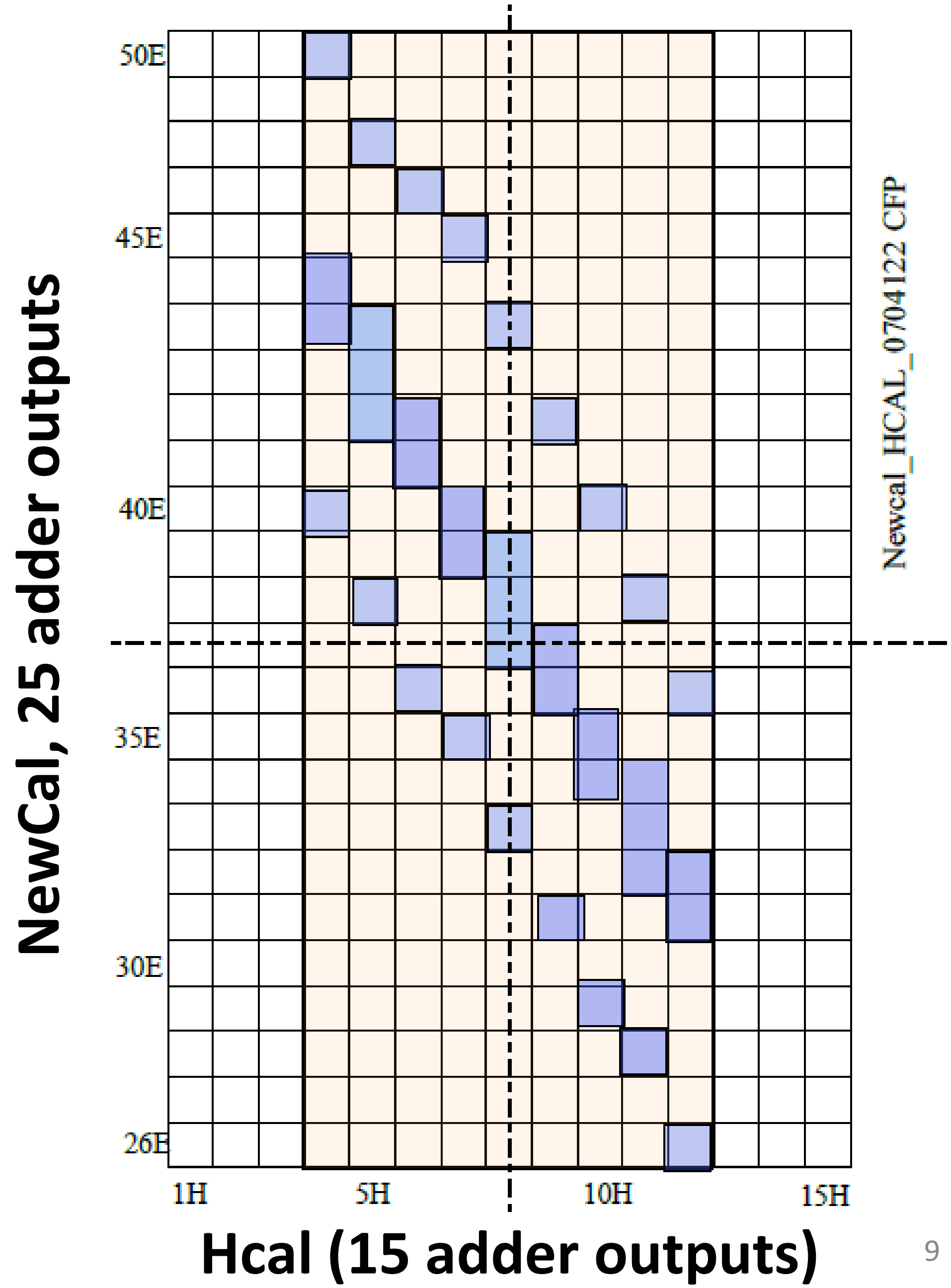
HCAL_6by6_070412 /CFP

Table of correspondence for the FPGA (Field Programmable Gate Array, CAEN 1495) <u>central region only</u> of NewCal in figure.

Horizontally 9 of the 15 adder outputs for the central region of HCAL

Vertically the 25 adder outputs of the central region of NewCal

Will use 90 of the 160 inputs for the complete calorimeters (1E to 75E, plus 1H to 15 H). Requires 3 FPGAs for whole calorimeter?



So how many 36-channel adders would we need?

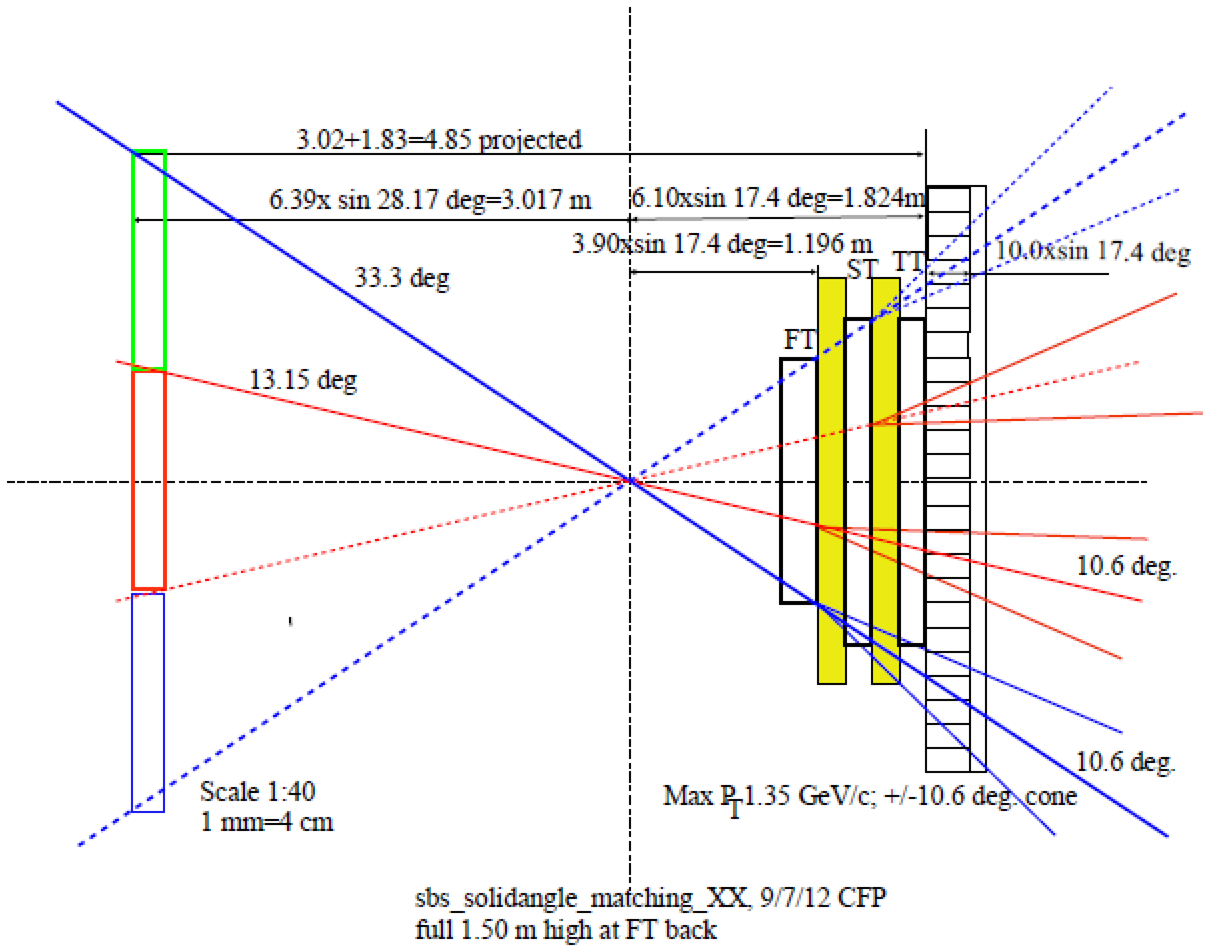
Minimum plan, include 3x(22x22) PMs in New Cal and 11x22 in Hcal
Requires 90 adders. If hall B and PrimeX adders all available: 86

To include all PMs both in NewCal and Hcal requires 126 adders. Would have to build 50 additional ones.

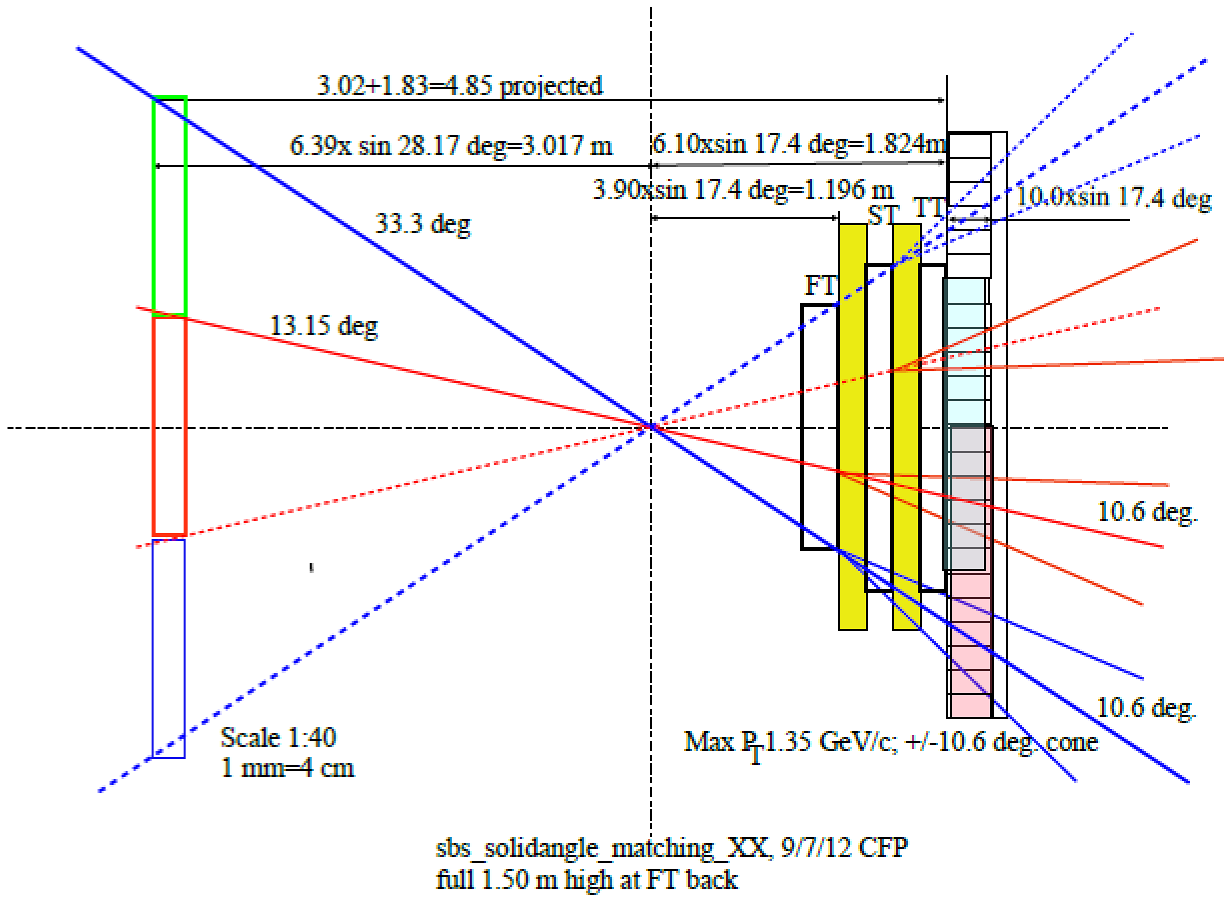
Another problem is number of PM outputs required: 4 to go to adders, plus 1 or 2 for ADC and or TDC: 6 outputs. How? Unless TFC/ADC on FPGA outputs only

One more frugal solution is to go to single overlap, instead of double overlap solution. We have done single overlap in one direction only in GEp(V); with considerable success!

With 1 row/column overlap, we still need 25 adders per section, but now we cover all 24 bars either way in NewCal (26x26). Same for Hcal, with 15 adders we now cover all channels (14x26).



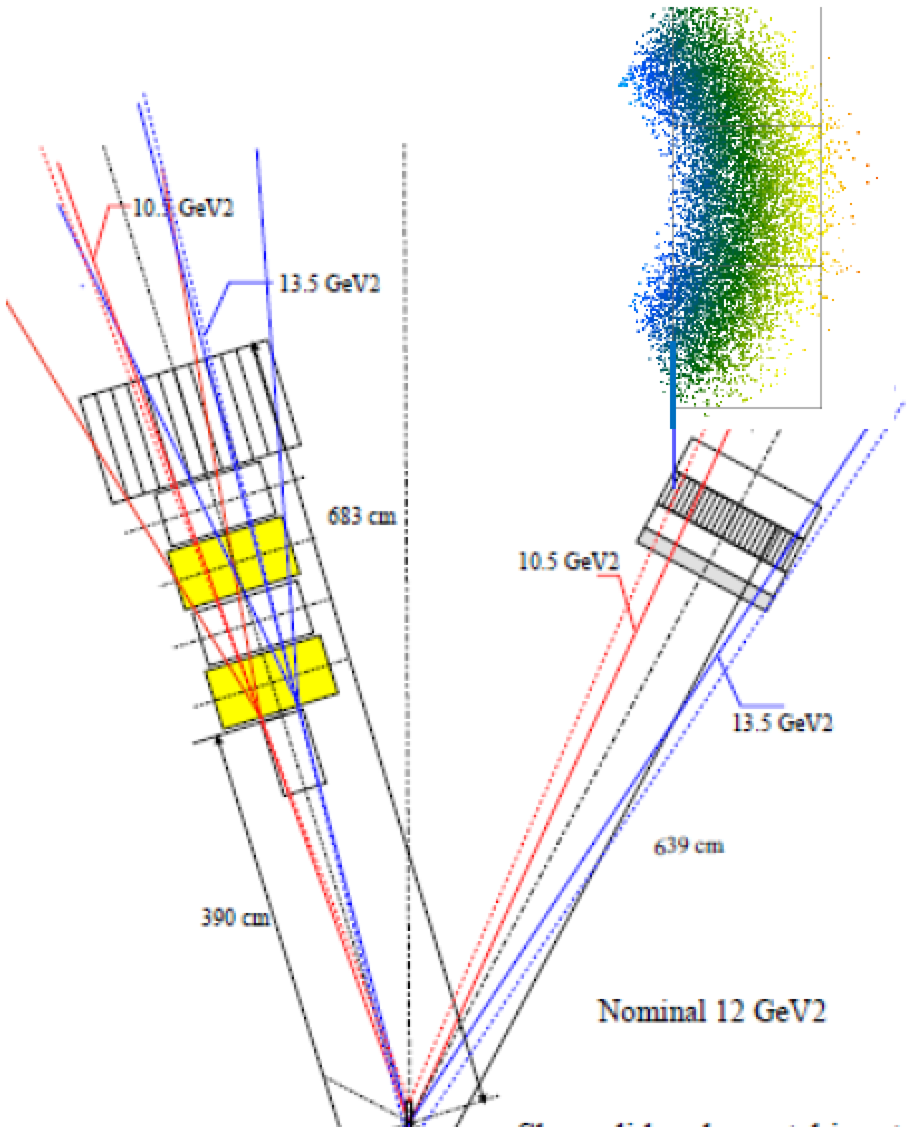
3.02+1.83=4.85 projected
6.39x sin 28.17 deg=3.017 m
6.10xsin 17.4 deg=1.824m
3.90xsin 17.4 deg=1.196 m
10.0xsin 17.4 deg
33.3 deg
ST
TT
FT
13.15 deg
10.6 deg.
10.6 deg.
Scale 1:40
1 mm=4 cm
Max P T 1.35 GeV/c; +/-10.6 deg. cone
sbs_solidangle_matching_XX, 9/7/12 CFP
full 1.50 m high at FT back



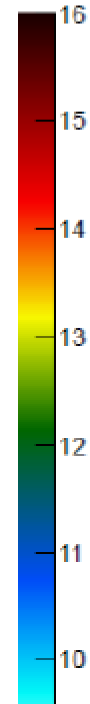
Looking down t

Indicates that 6x6 blocs in Hcal are crude, 4x4 better

Blue (brown) areas indicate bars in bottom, and central region included in red/green regions.



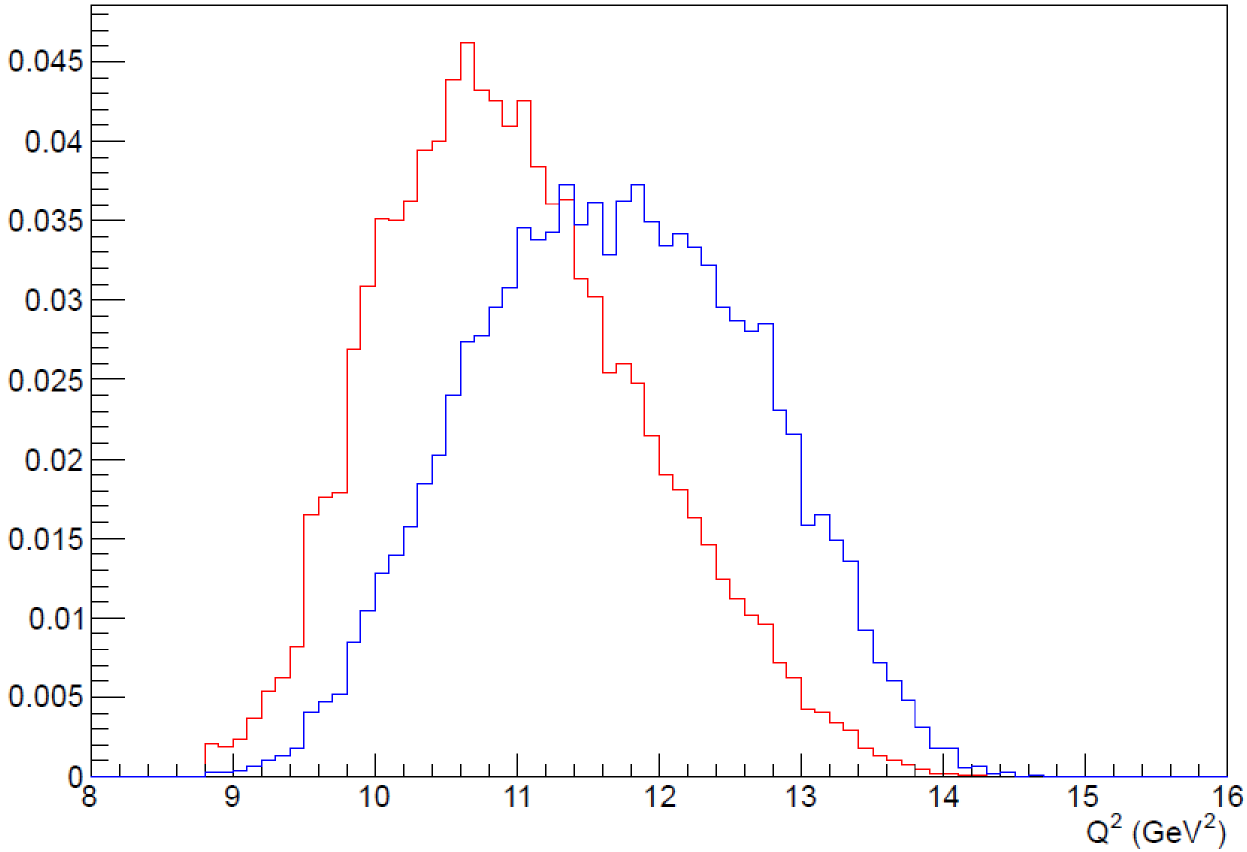
Front face of NewCal: 12 GeV^2 is dark green.



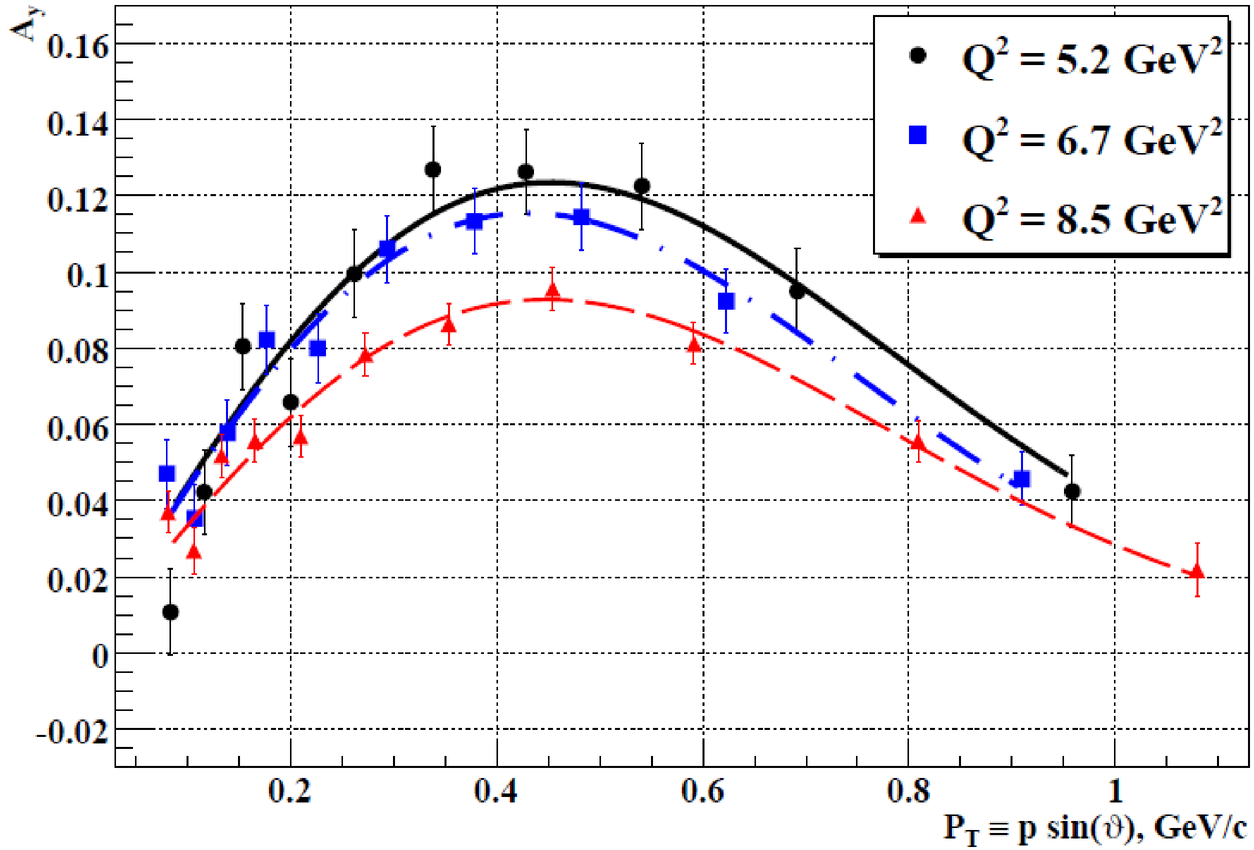
Blue: transmission for Q^2-12 GeV^2 kinem. Arbitrary units

Red: number of events For same kinem. Arbitrary units

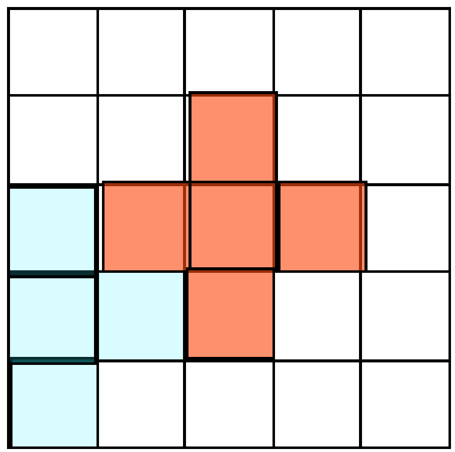
From Carlos Ayerbe



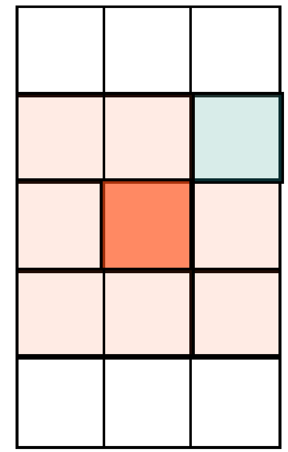
From Andrew Puckett thesis, p. 256



Middle section, NewCal



HCAL, pink region to be correlated with midsection NewCal Middle



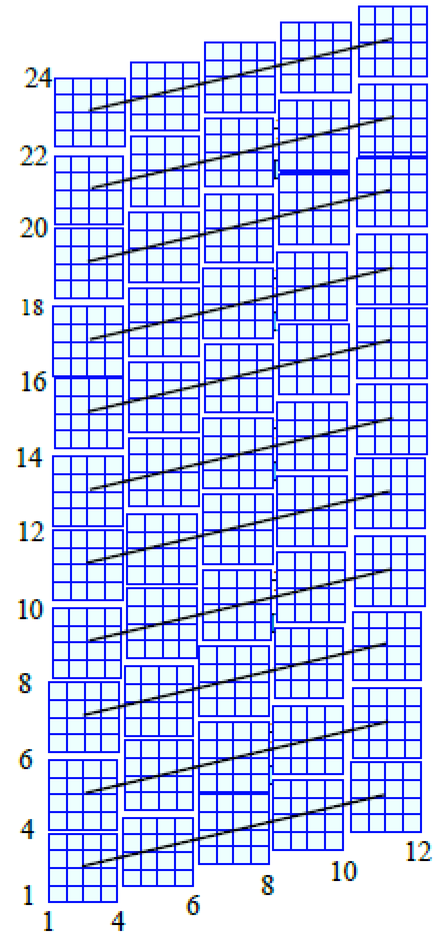
All HCAL adders containing PM touching the boundary (up/down, left/right) have a pattern like BLUE
All HCAL adders not touching boundary have a star pattern like RED.

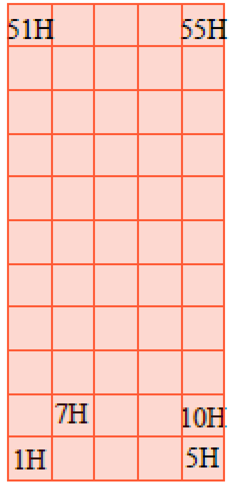
Newcal_HCAL_correlation_070512 CFP

A 4x4 pattern, with 2 rows and 2 columns overlap, could be obtained redesigning the PrimeX 36-adders so as to add two independent 16 channels in one unit. The number of 36-adders will then be 55/2=28 (instead of the 15 required for the 6x6 pattern). To be decided on base of simulation and availability.

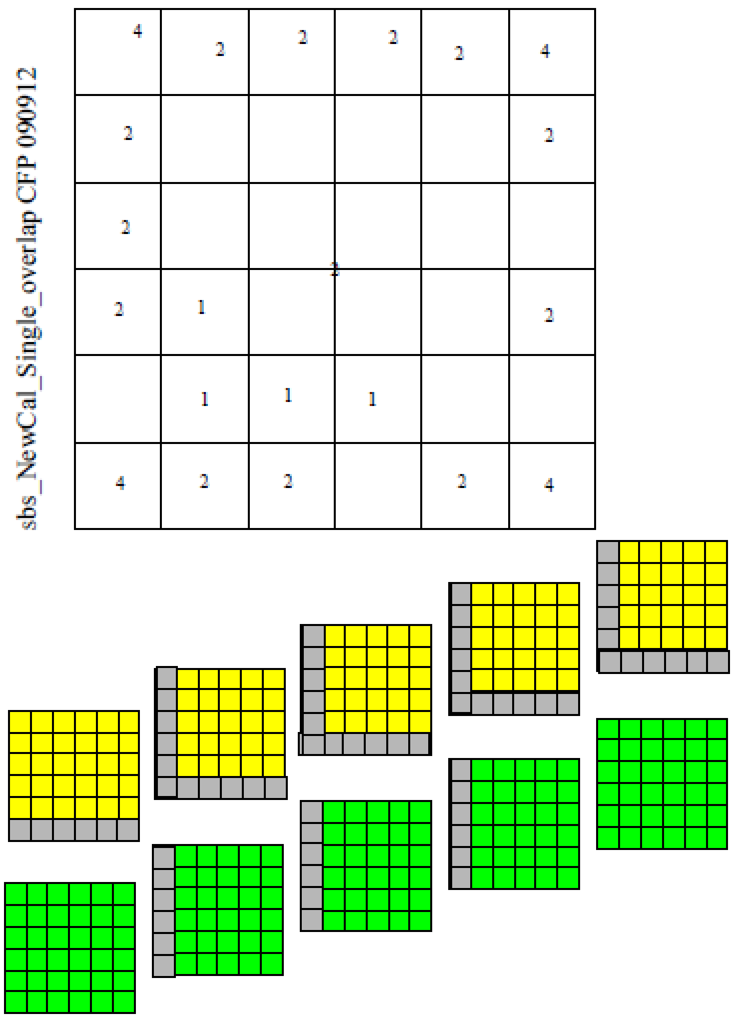
Note: overlaps not shown, but similar to the ones for 6x6.;

Constructor not interested in redesign.



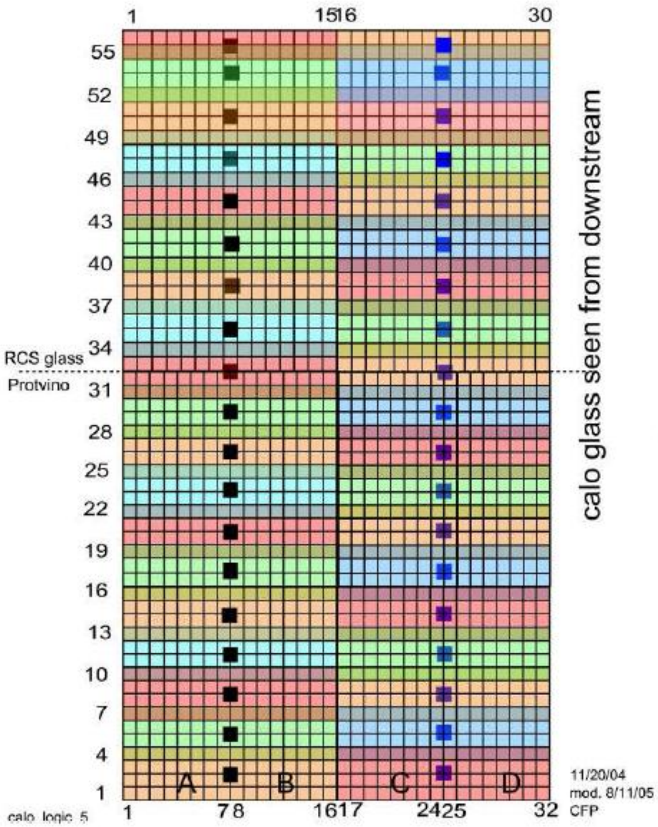


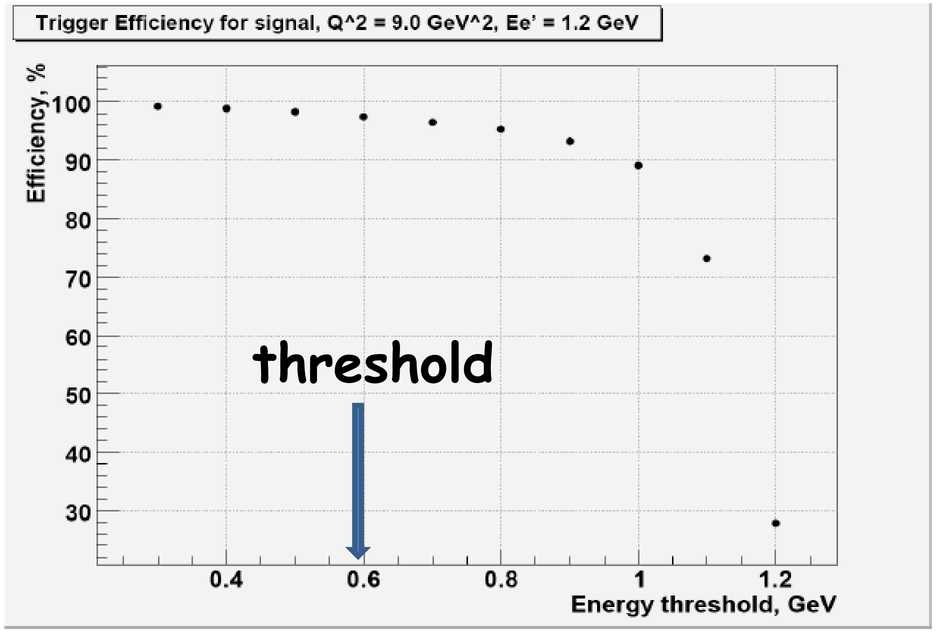
HCAL_4by4_070612 /CFP


sbs_NewCal_Single_overlap CFP 090912

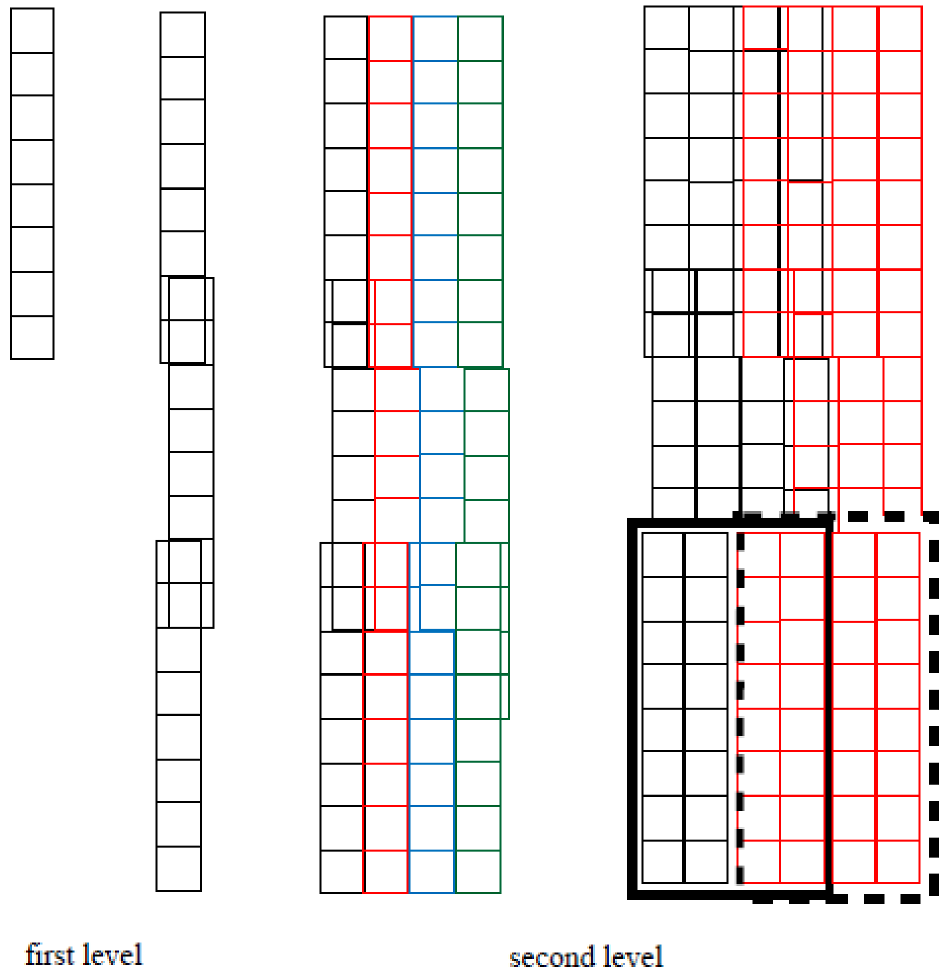
The end for now

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.



NewCal_overlap_scheme, CFP 01/10/2012

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.

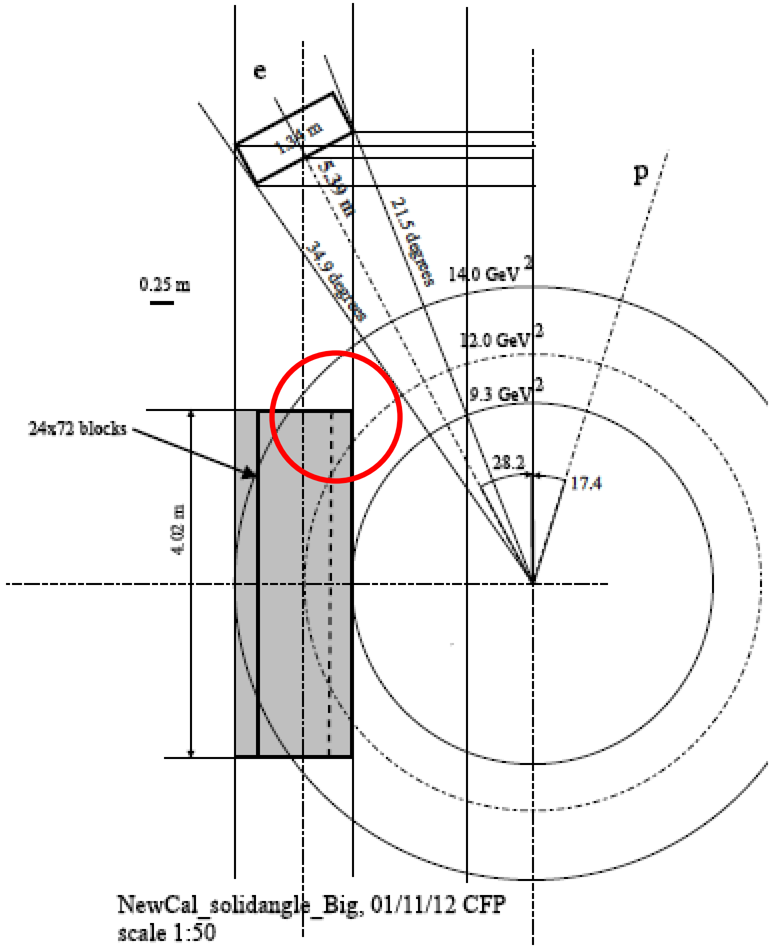
But the existing adders need to be modified

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.



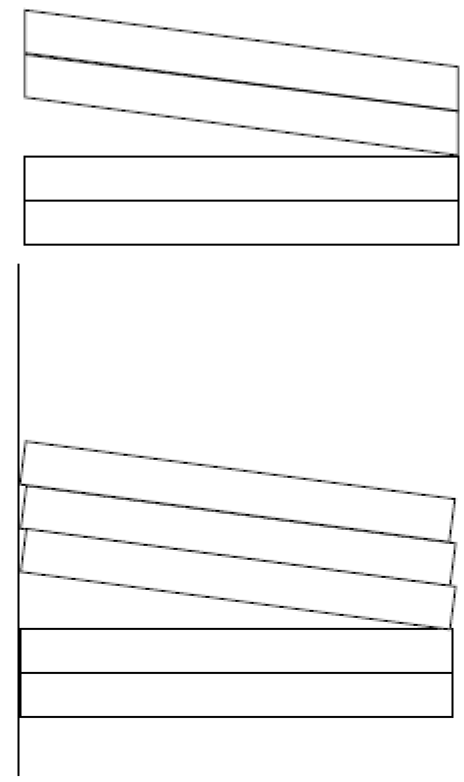
use solid angle 65 msr of p in SBS

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).

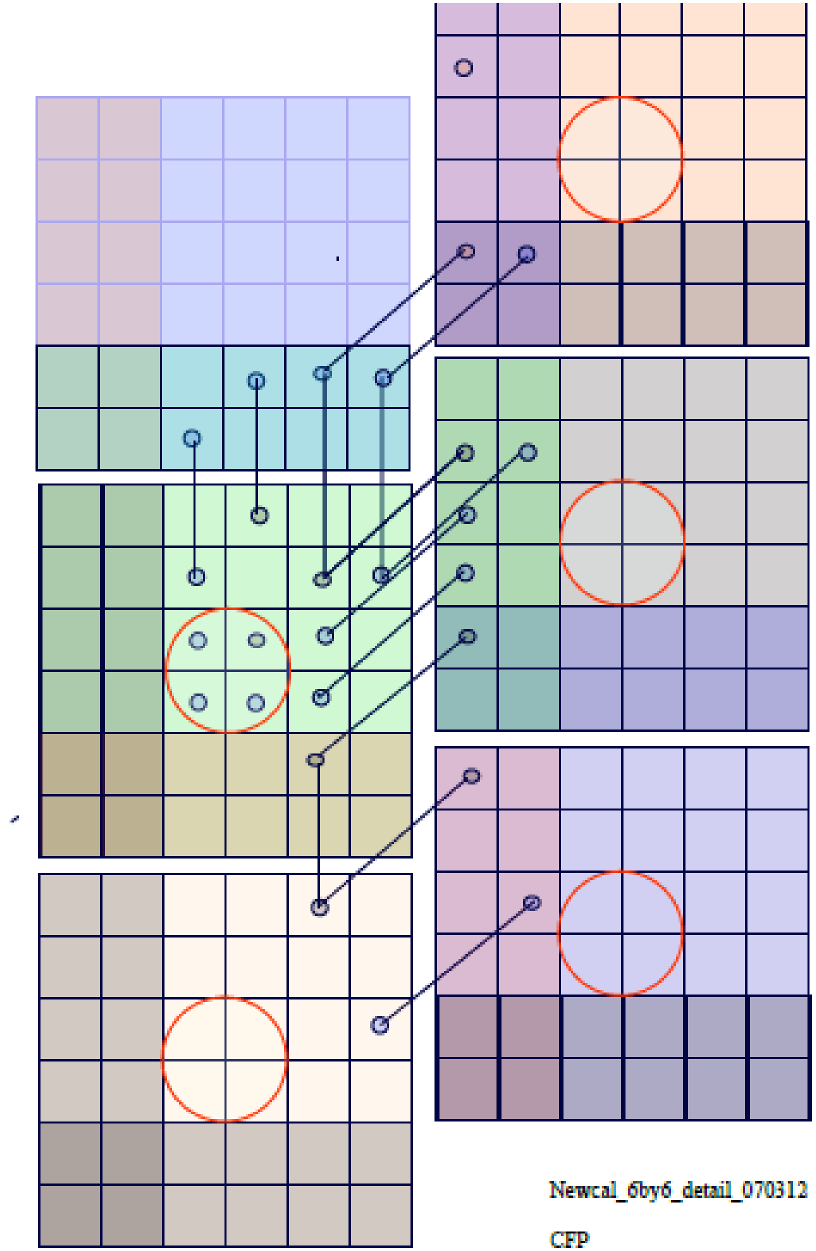
To be read by multi anodes Hamamatsu PM tubes (4 by 4)

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.

Just counting the number of PM outputs required according to position in the 6x6 matrices.



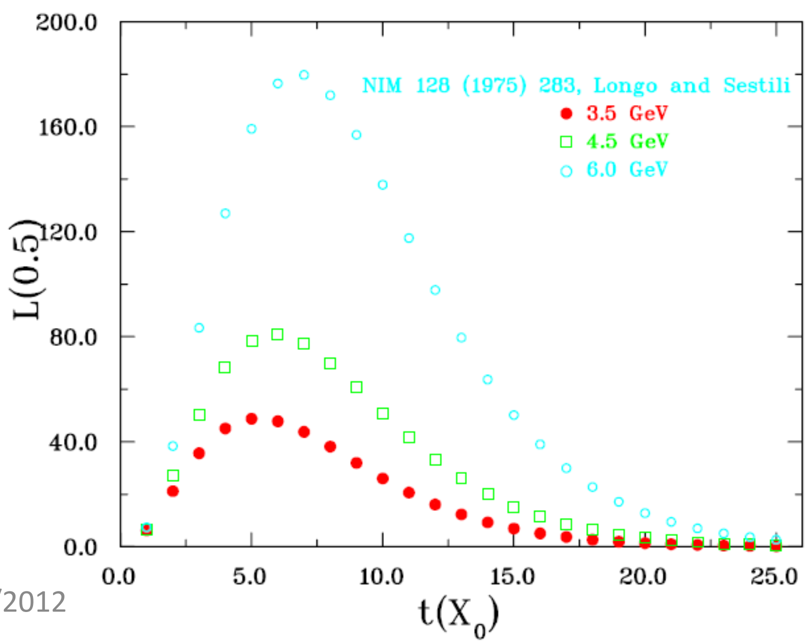
Newcal_6by6_detail_070312

CFP

(Not showing all connections)

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.