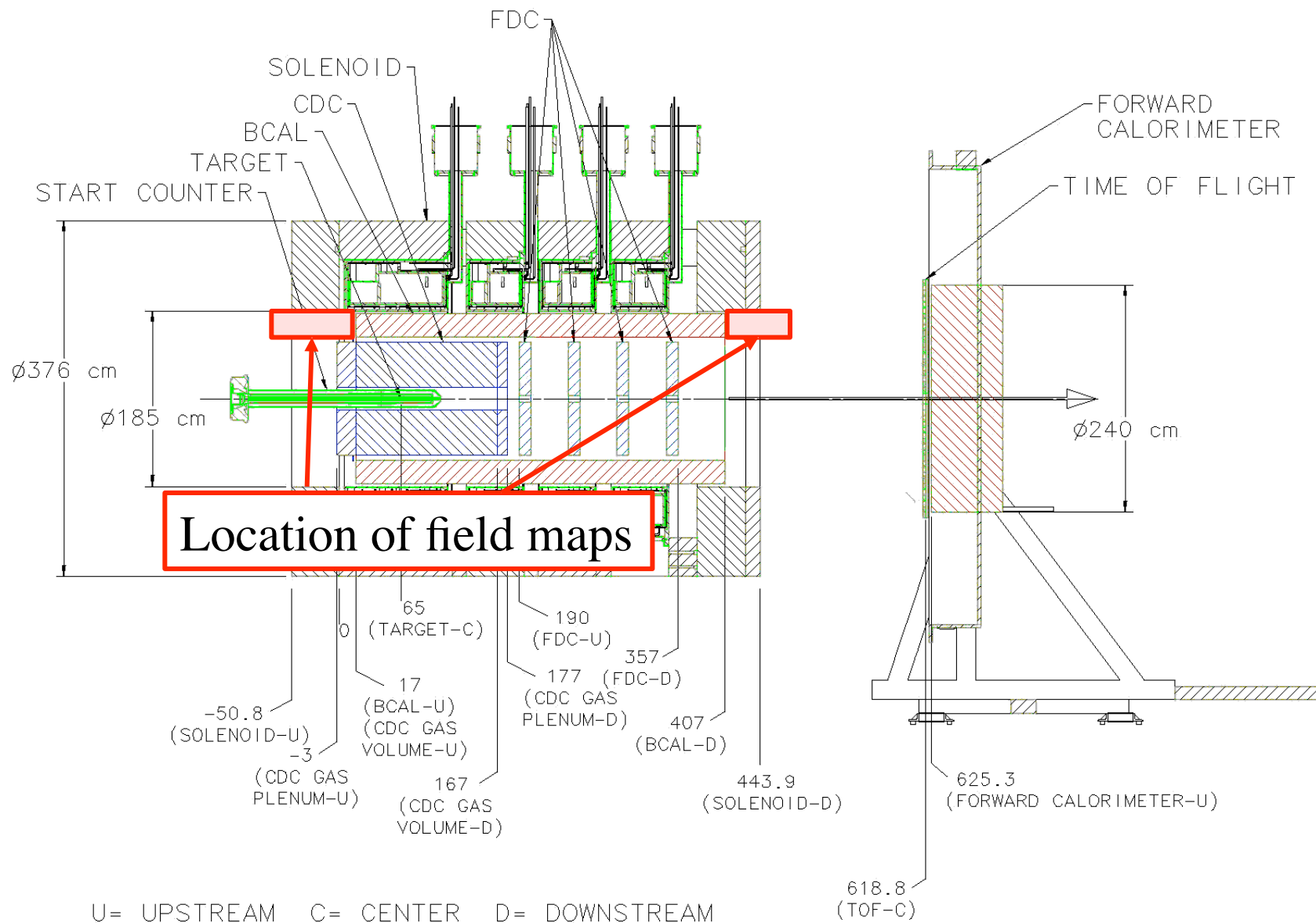

Status - Bcal Readout
draft considerations

Elton Smith

Hall D Collaboration Meeting

May 11-13, 2009

Hall D elevation



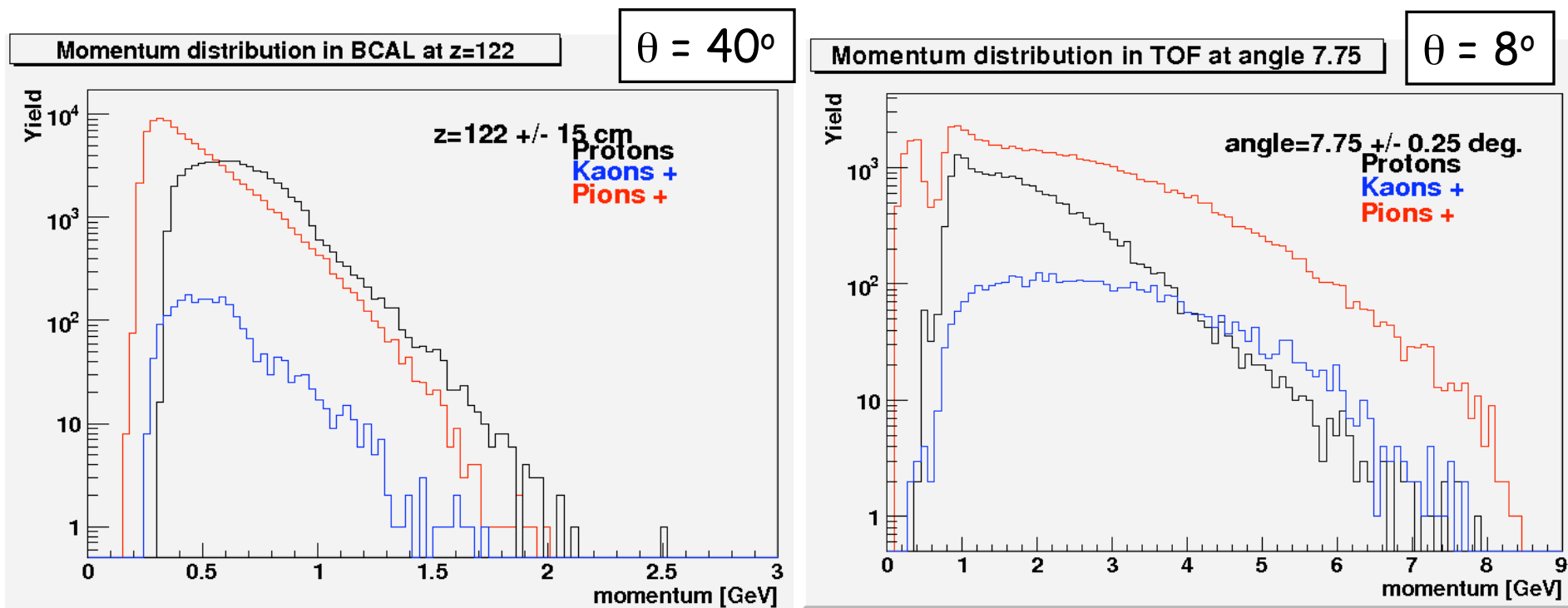
Kinematics

$E_\gamma = 9 \text{ GeV}$

PYTHIA event generator

Bcal

TOF



Working toward specifications

$$N_\gamma = 2 \times 10,500 / \text{GeV}$$

$$N_{\text{tubes}} = 2 \times 10$$

$$\Delta = 100 \text{ ns}$$

$$\frac{\sigma}{E} = \sqrt{\left(\frac{\sigma_{\text{sampl}}}{E}\right)^2 + \left(\frac{\sigma_{pe}}{E}\right)^2 + \left(\frac{\sigma_{ped}}{E}\right)^2}$$

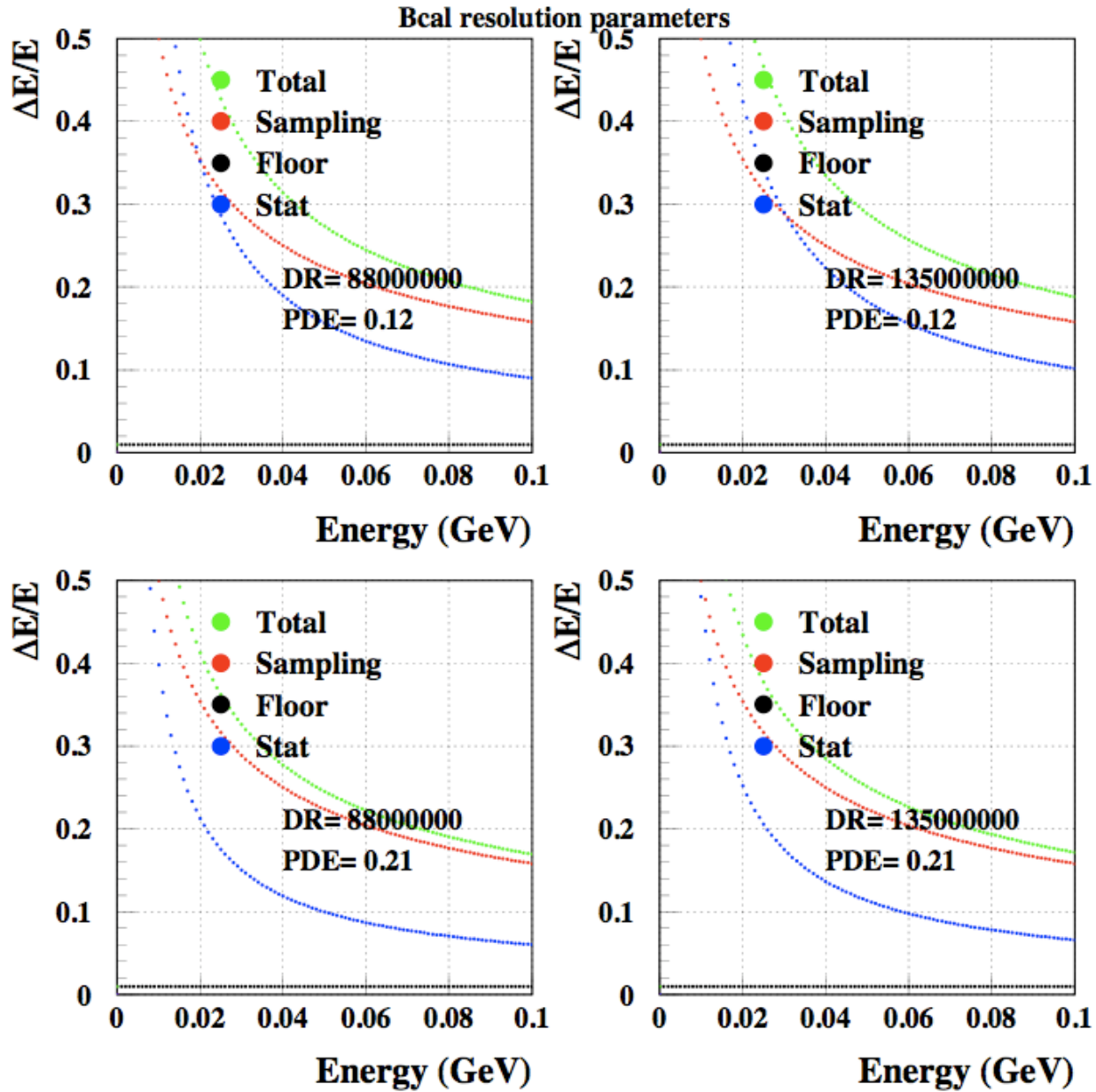
$$\frac{\sigma_{\text{sampl}}}{E} = \frac{5\%}{\sqrt{E}}$$

$$\frac{\sigma_{pe}}{E} = \frac{1}{\sqrt{N_\gamma f_{PDE} E}}$$

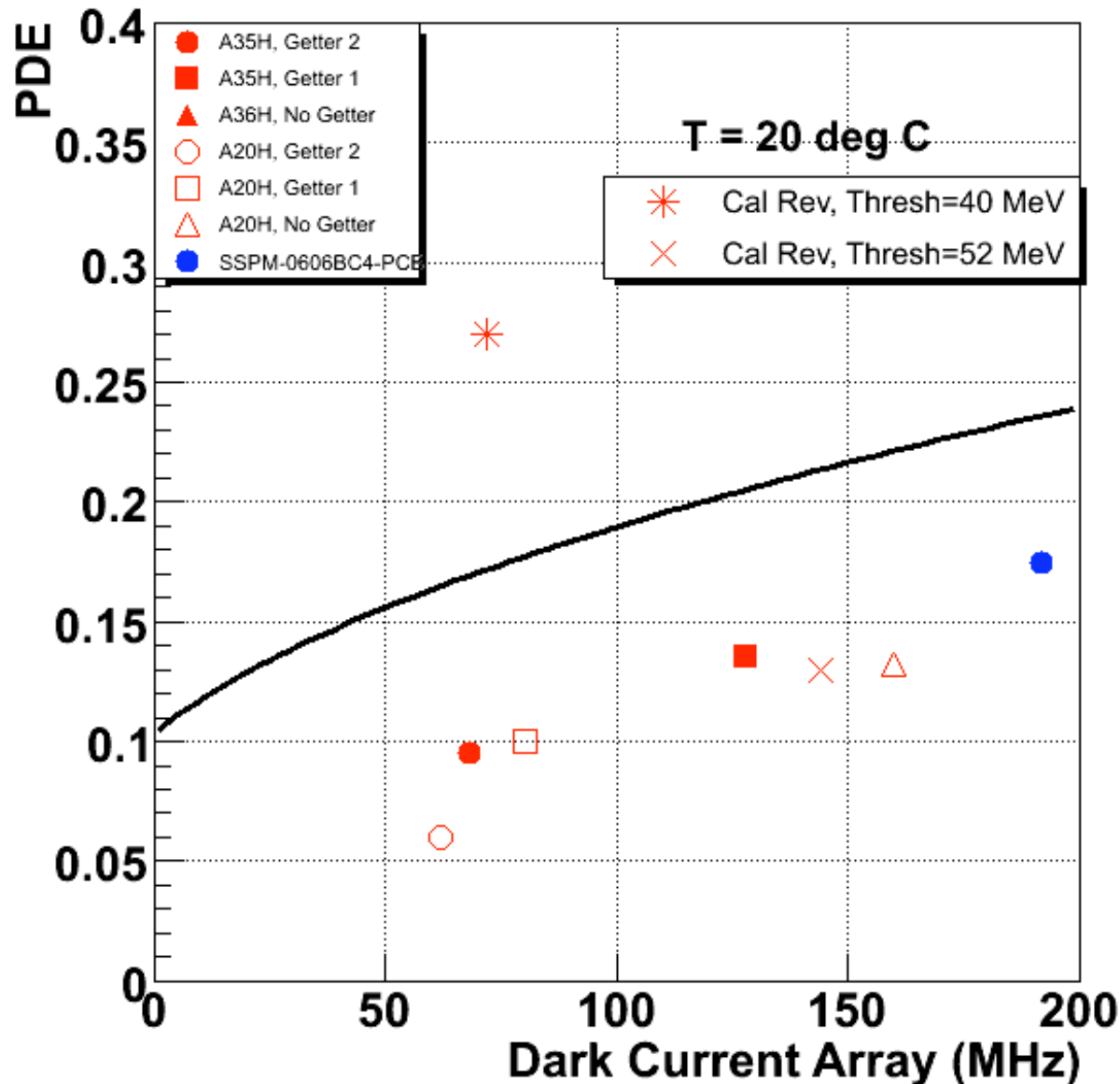
$$\frac{\sigma_{ped}}{E} = \frac{\sqrt{\Delta N_{\text{tubes}} R_{\text{dark}}}}{N_\gamma f_{PDE} E}$$

$$\frac{\sigma_{\text{stat}}}{E} = \sqrt{\left(\frac{\sigma_{pe}}{E}\right)^2 + \left(\frac{\sigma_{ped}}{E}\right)^2}$$

Expected resolution



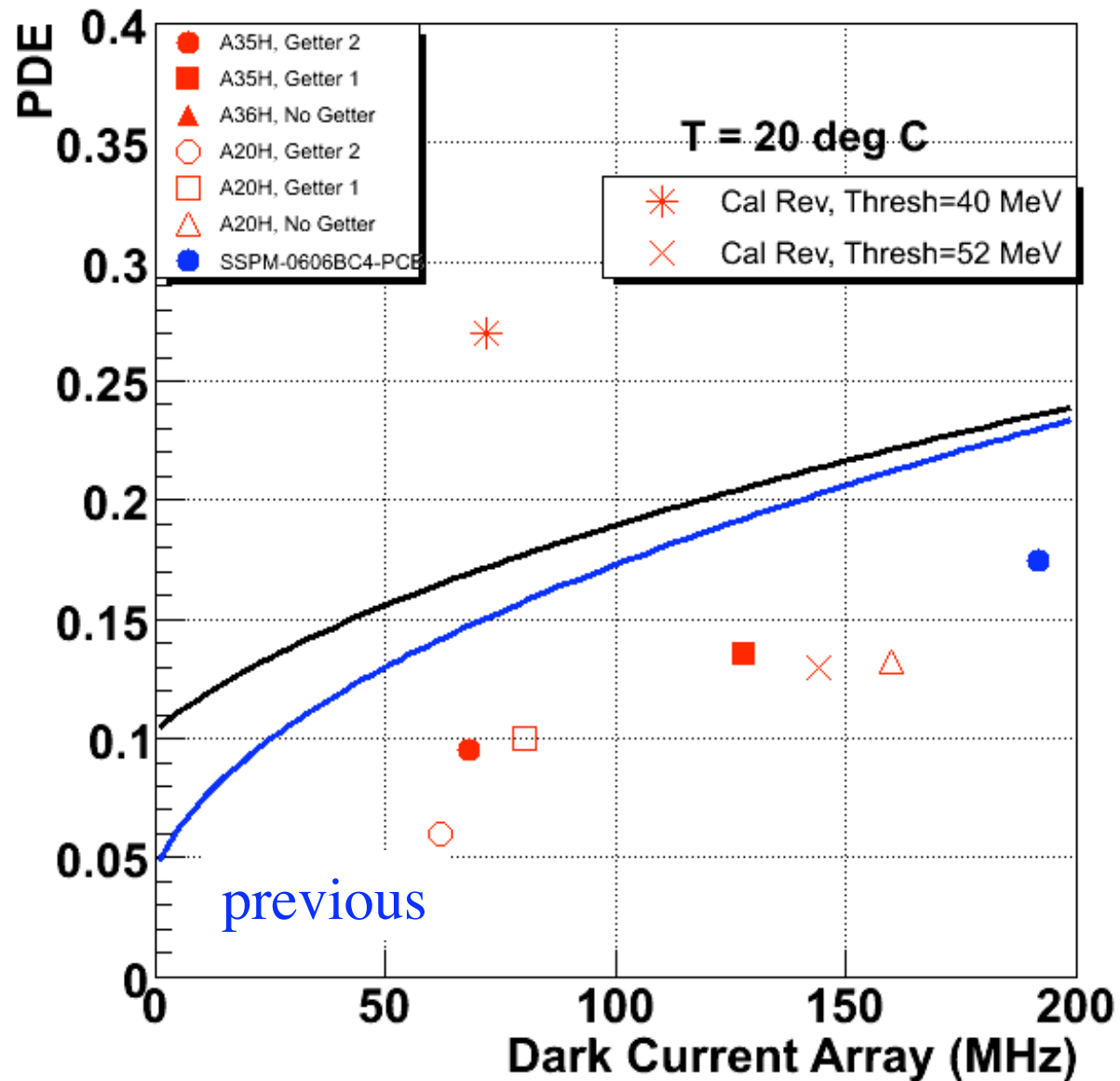
Requirements on R_{dark} and f_{PDE}



Set requirements on R_{dark} and PDE at $E = 60$ MeV.

$$\frac{\sigma_{stat}}{E} \leq 0.3\sqrt{2} \frac{\sigma_{sampl}}{E}$$

Change in tradeoff curve

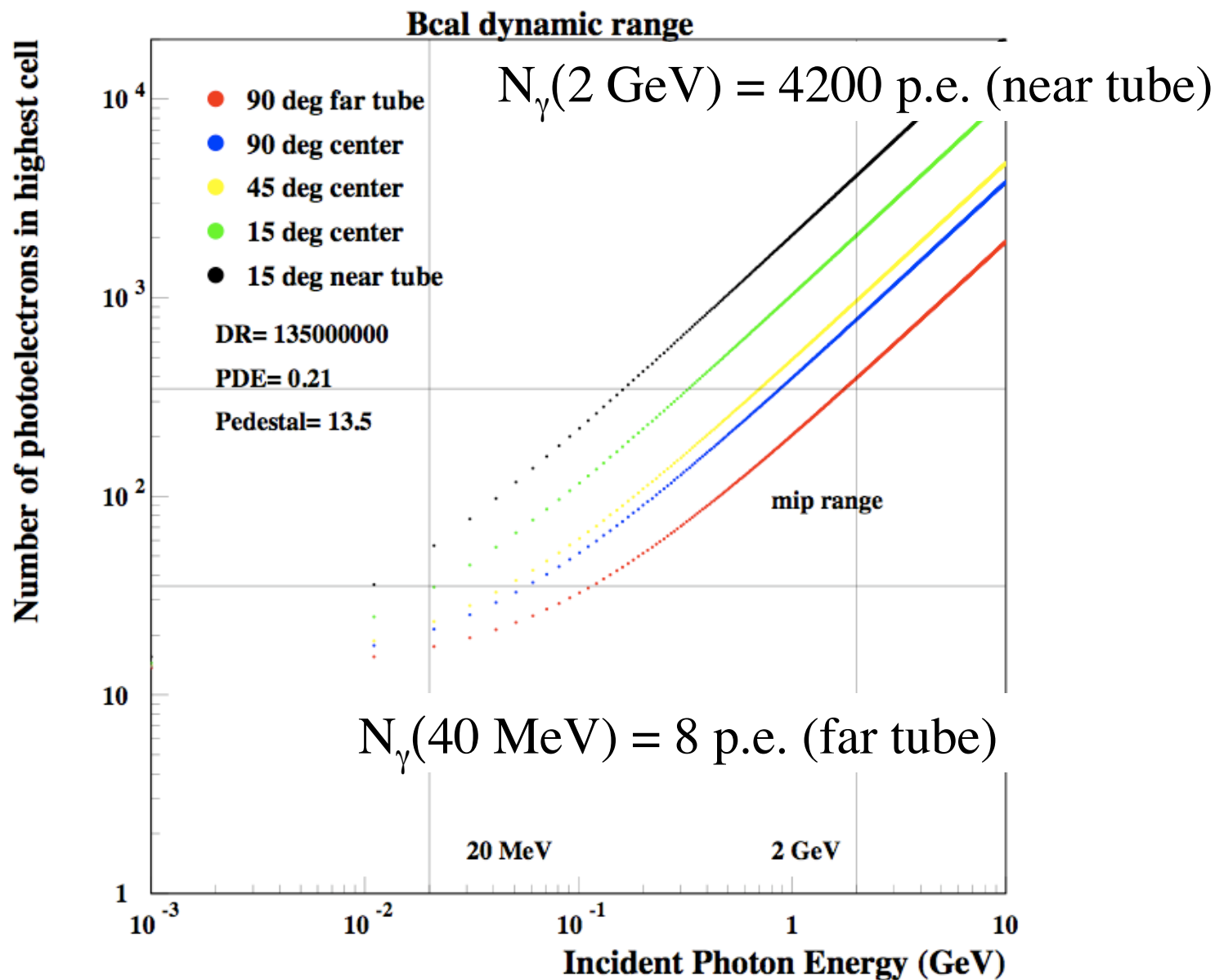


Dynamic range

Table 2: Range of number of photoelectrons expected for a 1 GeV photon and $f_{PDE}=\mathbf{0.21}$ for the 2×2 cm² cell with maximum energy deposited under various conditions [2] renormalized by a factor of four. The total number of photoelectrons deposited by a 1 GeV electron (normal incidence) is **2223** per side. The last two rows refer to the energy deposited in the inner layers for minimum ionizing tracks. Note that several rows correspond to non-physical geometric correlations between angle and position as viewed from the target.

Angle	Position	Number of p.e. Max Inner cell	Number of p.e. Total per side	Ratio (%)
Normal (90°)	far pmt	191	1100	17
Normal (90°)	center	381	2224	17
45°	center	474	2194	22
15°	center	1022	2081	49
15°	near pmt	2042	4162	49
Normal (90°) mip	center	44	380	8.8
15° mip	center	166	1460	8.8
15° mip	far pmt	84	730	8.8

Dynamic range





Backup Slides

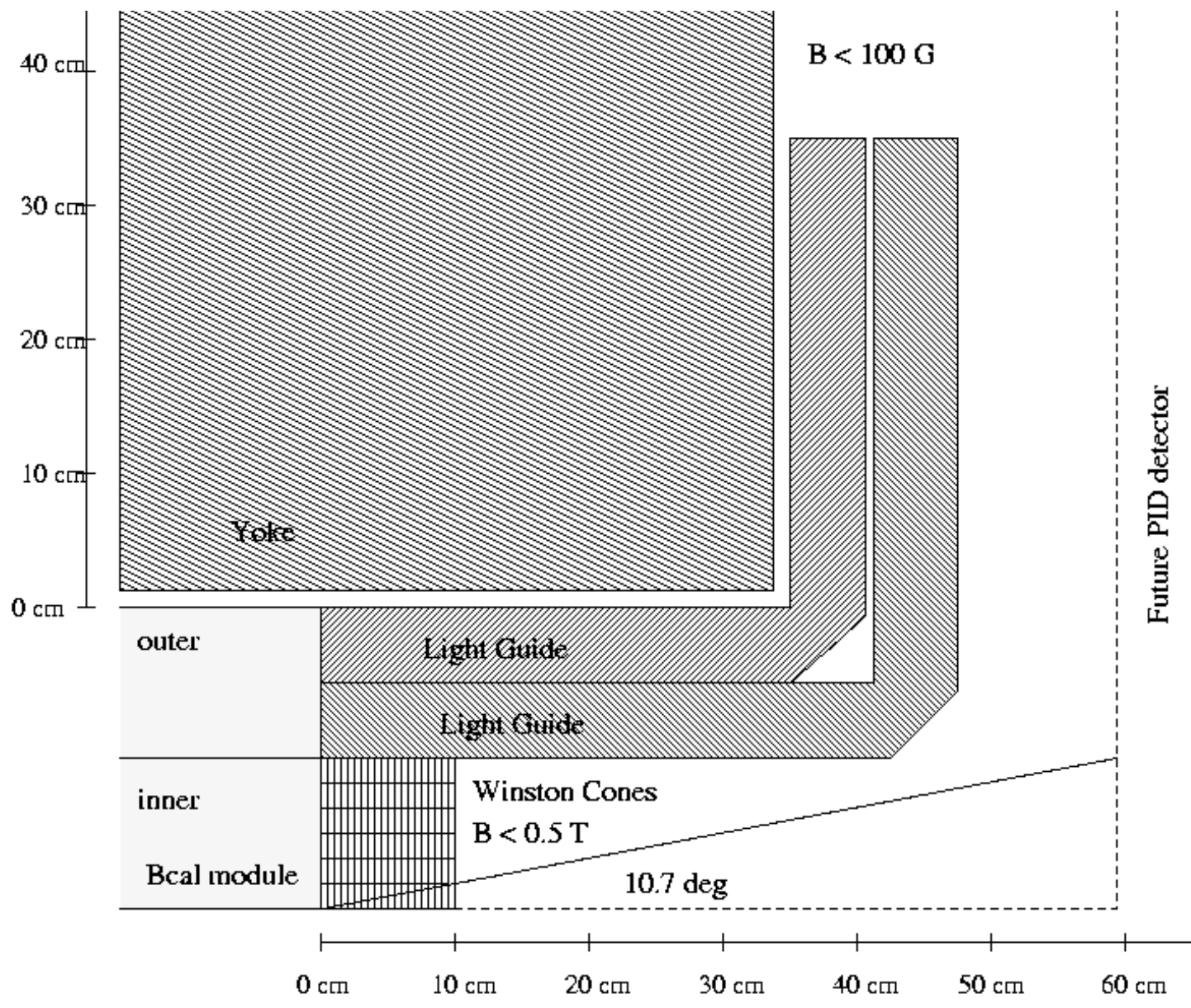
Bcal Readout Possibilities

Characteristic	Design Goal	Planacon Burle 85011-501	SiPM SensL 4x4 array at 1.2 Vbr	Fine Mesh Hamamatsu R5924-70
Gain		10^5	10^6	10^7
Single p.e.	desirable	2:1 peak-to-valley	with amplification	no single p.e
Area		5.08x5.08 cm ²	1.2x1.2 cm ²	11.9 cm ²
Channels / area		16 channels	1 channel	1 channel
B-field sensitivity	none	Insensitivity to Bpar 2-3x loss Bperp=100 G	Unaffected by 20kG	Gain loss 2-3x at 0.5 T and 45deg
Dark rate	< 32MHz (E=20MeV and PDE=12%)	50-300kHz	110 MHz per 16 x 16 area Notes: 5x lower at 0deg 40 MHz is "pure thermionic"	30 nA
PDE at 490 nm	> 12%	10%	C20: 4.5% A20L: 10%	> 13%
Threshold Energy	40 MeV			
Cost (sensor only)		\$240	\$400	\$3000
Cost / BCAL - Ch.		\$140	\$400	\$3000
Cooling	<50% of FDC goal	outside magnet	room temp	outside magnet
Gain Uniformity	~ 5-10%	1:1.5 (max)	1:1.1 Delta Vbr=0.1V	standard pmt
Onboard electr	yes	Required amplifier/shaper	N/A	
High voltage		Individual control	N/A	2000V
Low voltage		N/A	Granularity?	N/A
Lifetime	> 10 years	Less than standard PM due to vacuum leakage	Collect information	standard pmt
Access	open	outside magnet	inside magnet	outside magnet
Dynamic range	> 10^4	> 10^4	non-linear above 10^3	> 10^4
Linearity	10^3	10^3	non-linear above 10^3	
Light guides	minimal	square + WC	designed	WC + cyl rod
Rise Time	4 ns	~ 4 ns typical	~ 10 ns	~ 4 ns typical
Fall Time	30 ns	~ 30 ns typical	400 ns	~ 30 ns typical

mechanically not possible

nominal design

alternative design



Various light configuration studies

Configuration Outer	Atten μ (cm)	R	pmt type	Area Matching	θ_{max}	Collection Eff. (%)
Nominal, 2" cyl	240	0.85	2"	0.61	27.4	21.3
Nominal, WC	240	0.85	2"	0.61	27.4	31.1
Long μ , WC	1000	0.85	2"	0.61	27.4	45.0
Max with 2" cyl	24000	0.99	2"	0.61	21.3	53.3
Max with 3" cyl	24000	0.99	3"	0.99	21.3	86.4
Max with planacon	24000	0.99	planacon	0.25	21.3	21.7

Configuration Inner	Top (cm)	Side (cm)	Bottom (cm)	Length (cm)	LG Eff (%)	WC Radius In (cm)	WC Radius Out (cm)	Length (cm)	WC Eff (%)	Total Eff (%)
In top side SiPM	2.525	2.0	2.4026	2+6	92.2	1.0	0.6	2.13	88.1	81.2
In top center FM 1" 8°	3.37	4.0	3.016	2+10	74.3	1.35	0.875	2.61	86.7	64.4
Out top side FM 1.5"	5.75	5.25	5.4	2+10	94.2	2.625	1.3	6.89	73.8	69.5
In top side SiPM square	2.0	2.0	2.0	2+8	95.7	1.0	0.6	2.13	95.7	91.4
In top side SiPM short	2.525	2.0	2.4026	2+2	74.7	1.0	0.6	2.13	90.0	67.2
In top side FM 1"	3.37	4.0	3.016	2+10	79.7	1.35	0.875	2.61	87.5	69.7
In top side FM 1" upstr	3.37	4.0	3.016	2+50	71.9	1.35	0.875	2.61	86.1	61.9
In top side FM 1" wide	3.37	4.0	3.016	2+10	92.9	1.685	0.875	4.21	75.9	70.5
In top outs FM 1" wide long	3.37	4.0	3.19	2+20	87.6	1.685	0.875	4.21	78.5	68.7
Out top side FM 2"	5.75	5.75	5.4	2+10	94.6	2.875	1.95	5.23	96.1	90.6
Out top side FM 2" short	5.75	5.75	5.4	5+5	84.5	2.875	1.95	5.23	97.0	82.0
Out top side FM 2" short	5.75	5.75	5.4	0+5	86.6	2.875	1.95	5.23	97.0	84.0

