BCAL Signal Timing Resolutions

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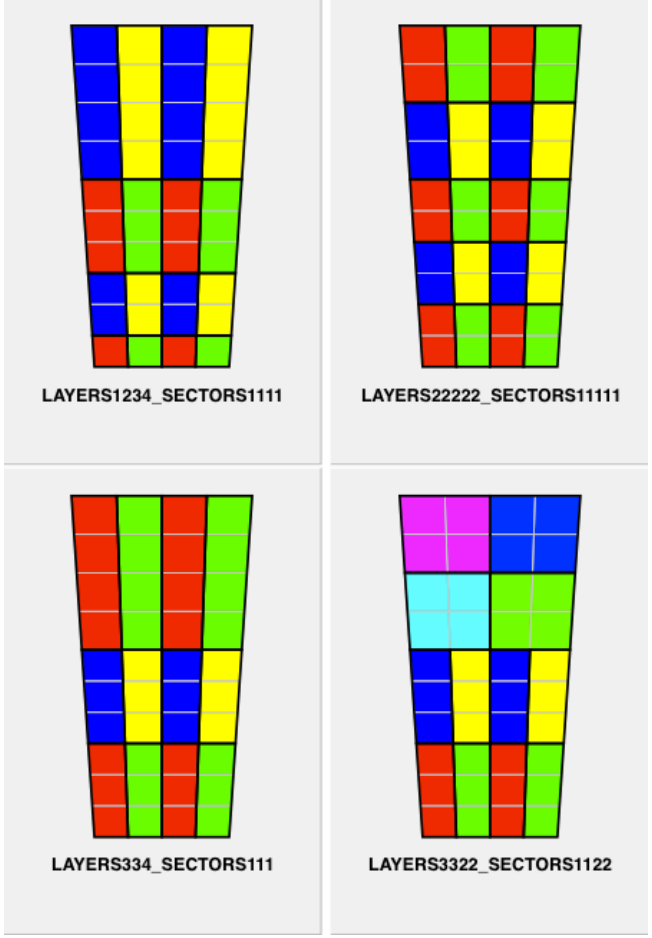
M.C. Simulation study

- The current study was done using 3 datasets generated at θ=12^o, 20^o, and 90^o
- Each data set contained 10k events
- $0 \leq E_\gamma \leq 2.0GeV$
- 5 different segmentation schemes, including “fine”
- Detailed effects:
  - Sampling Fluctuations - dark pulses
  - Photo-statistics - electronic pulse shape
  - Photo-detector jitter - threshold
  - Timewalk calibration
- No reconstruction code from *sim-recon* tree has been used. Analysis starts with individual shower steps generated by *hdgeant*



New BCAL Pulse Shape

New electronics design leads to a “5ns” rise time

Sharper-edged pulse is being incorporated into current study

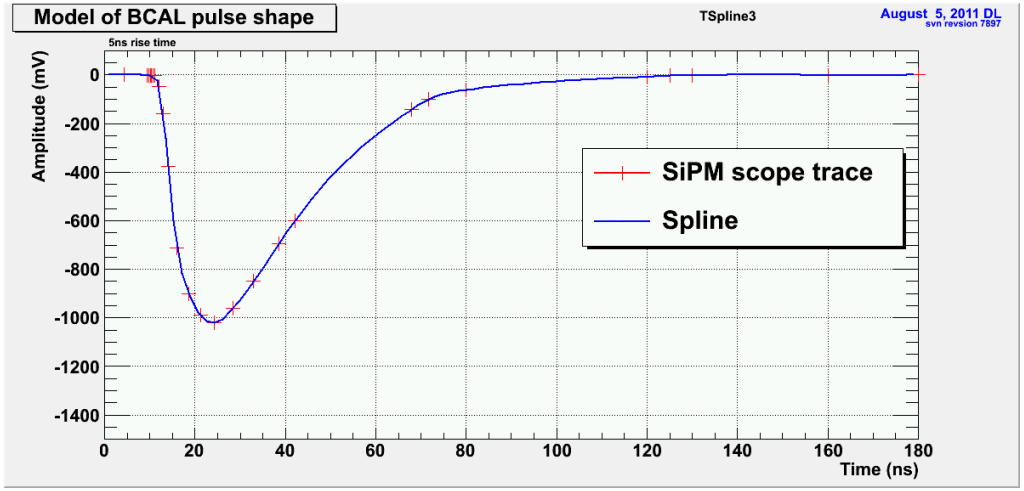
Top (magenta) waveform in scope capture on right is for BCAL_T (the one used)

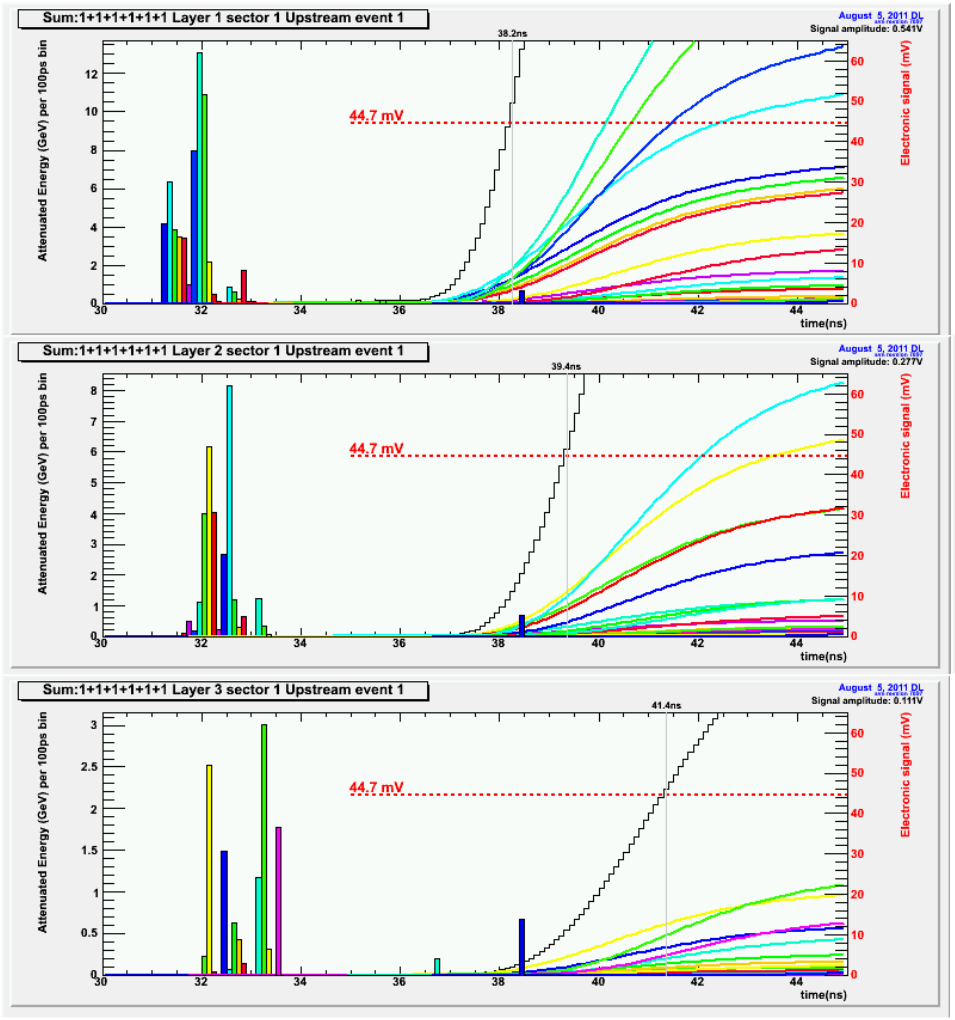
Middle (green) waveform is for BCAL_A

Bottom (yellow) waveform is for fast laser Sync output (L-Trig)

Fig 6. from GlueX-doc-1795

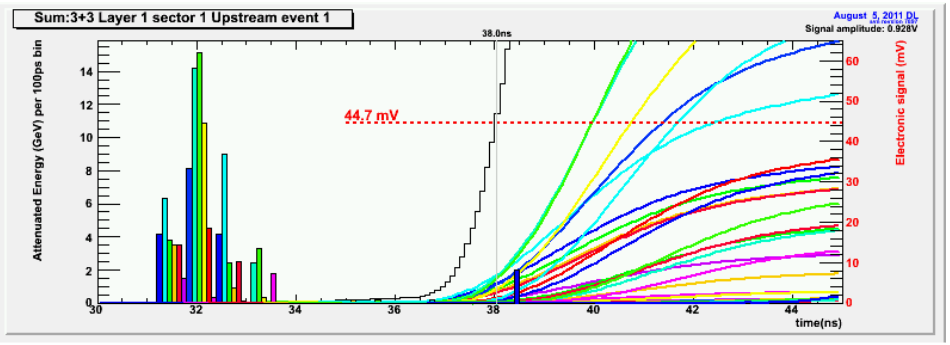
TSpline3 using points harvested from above image





Individual cells: sector 1; layers 1,2,3

Times: 38.2ns, 39.4ns, 41.1ns



Summed cell: sector1l layer 1

Time: 38.0ns

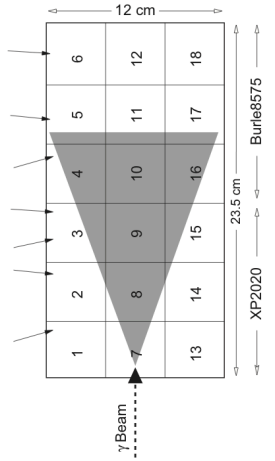
Comparison to 2006 Beam Test

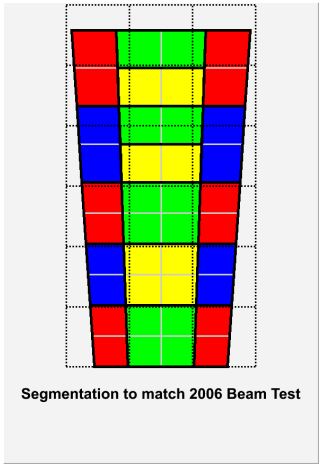
To tie the current M.C. technique into the results of the 2006 beam test, a set of data was produced with photons in the range:

150MeV - 650MeV

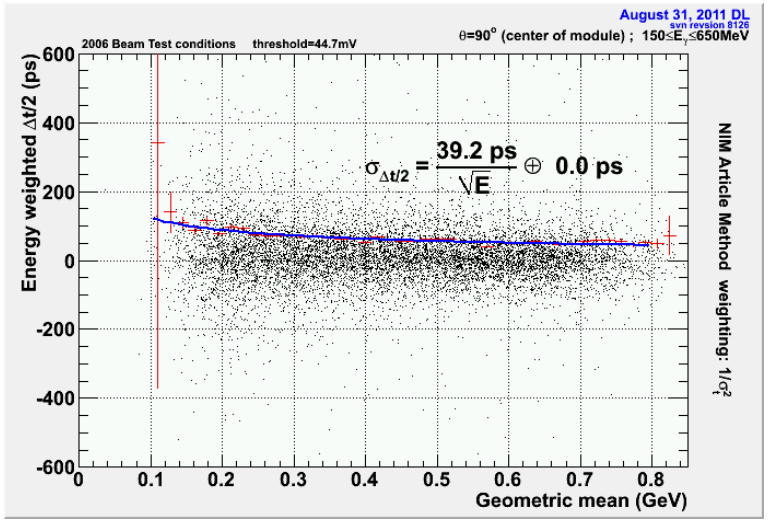
At normal incidence to the center of the BCAL module.

A segmentation was chosen that matched that of the 2006 beam test (see plots to the left).

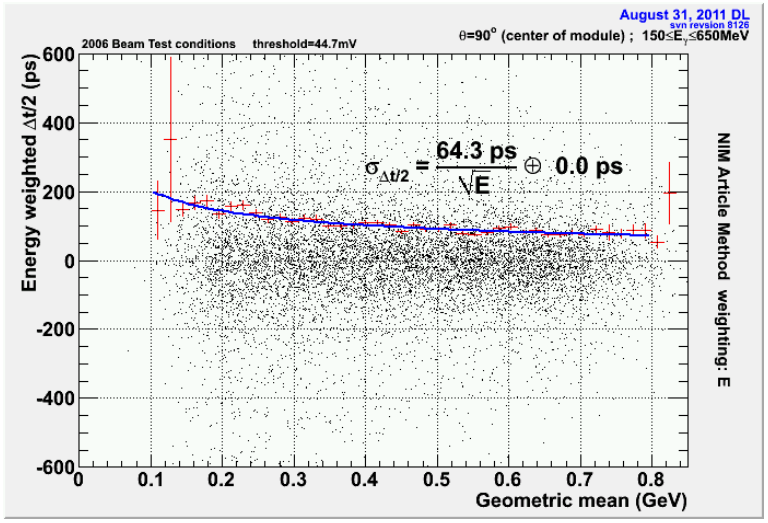




NIM A596, 327(2008) reported 70ps/sqrt(E)



Uncertainty derived from data (see next slide)



Uncertainty fixed at 1/sqrt(E)

Uncertainty dependence on Energy

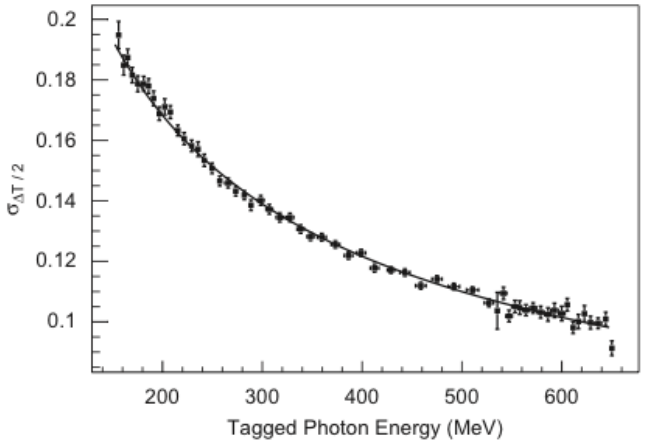
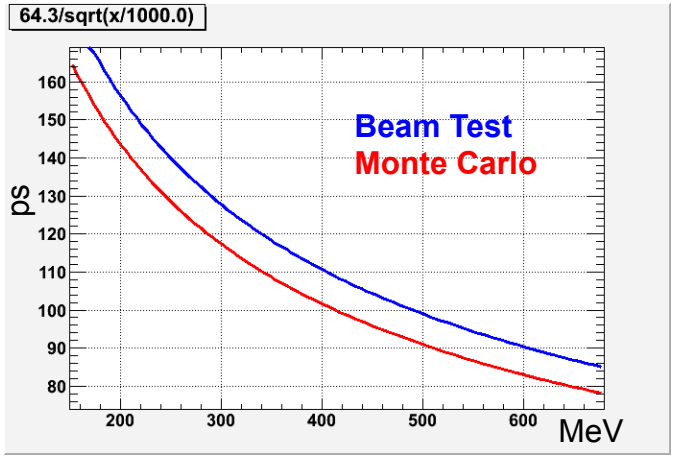
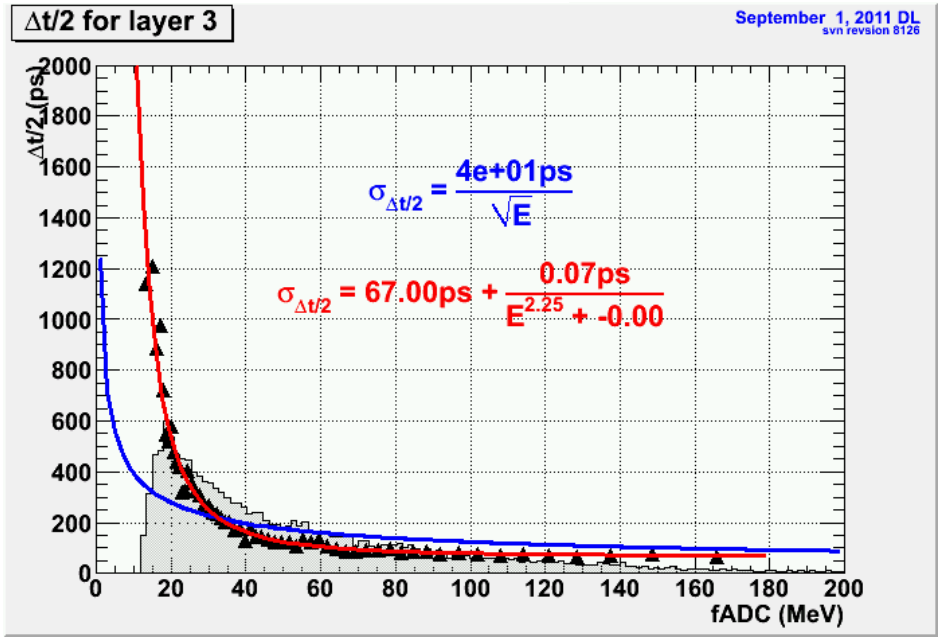


Fig. 15. The time difference resolution, in nanoseconds, for segments 7, 8, 9 and 10 as a function of energy. The fit gives $\sigma_{\Delta T/2} = 75\,\mathrm{ps}/\sqrt{E(\mathrm{GeV})} \oplus 30\,\mathrm{ps}$. The fit of Fig. 14 corresponds to the 40th datum from the right (19th from the left) in this figure.





Simulation seems to match well with beam test result. However, better resolutions were achieved by using non-E weighting for cell times

$$\frac{\Delta T}{2} = \frac{1}{2}\frac{\sum_i E_i (T_{N,i} - T_{S,i})}{\sum_i E_i}$$

NIM article used energy weighted mean

tavg

12 degrees

Segmentation	p0	p1	E=500MeV	E=1GeV	% better 500MeV	% better 1GeV
FINE	56.3	30.6	85.30	64.08	35.5%	37.2%
1234	60.9	43.6	96.53	74.90	27.0%	26.6%
22222	75.2	64	124.12	98.75	6.1%	3.2%
322	80.5	79.7	138.97	113.28	-5.2%	-11.0%
334	84	57.9	132.15	102.02	0.0%	0.0%

20 degrees

Segmentation	p0	p1	E=500MeV	E=1GeV	% better 500MeV	% better 1GeV
FINE	50.1	36	79.47	61.69	36.7%	41.1%
1234	69.9	46.4	109.20	83.90	13.0%	19.9%
22222	79.4	42.2	119.96	89.92	4.5%	14.2%
322	60.1	91.5	124.89	109.47	0.6%	-4.5%
334	69.2	78.7	125.58	104.80	0.0%	0.0%

90 degrees

Segmentation	p0	p1	E=500MeV	E=1GeV	% better 500MeV	% better 1GeV
FINE	45	0	63.64	45.00	41.6%	41.6%
1234	74.3	0	105.08	74.30	3.5%	3.5%
22222	73.1	0	103.38	73.10	5.1%	5.1%
322	75.6	0	106.91	75.60	1.8%	1.8%
334	77	0	108.89	77.00	0.0%	0.0%

tdiff

12 degrees

Segmentation	p0	p1	E=500MeV	E=1GeV	% better 500MeV	% better 1GeV
FINE	68.4	61.4	114.57	91.92	38.8%	38.0%
1234	91	49.6	137.92	103.64	26.4%	30.1%
22222	98.2	96.5	169.11	137.68	9.7%	7.1%
322	119.1	96.9	194.32	153.54	-3.7%	-3.6%
334	114.6	94	187.36	148.22	0.0%	0.0%

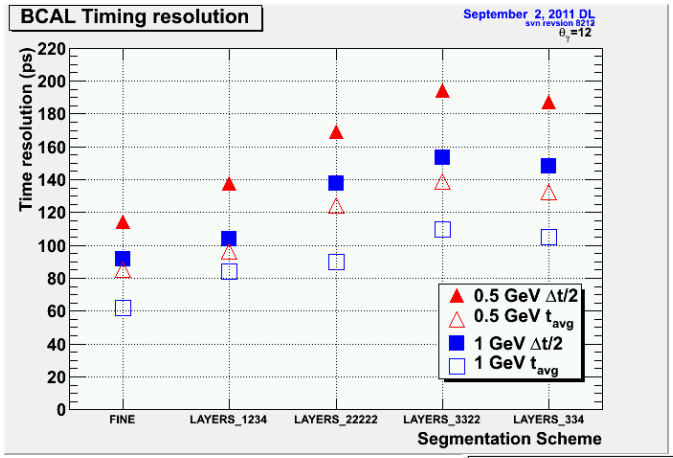
20 degrees

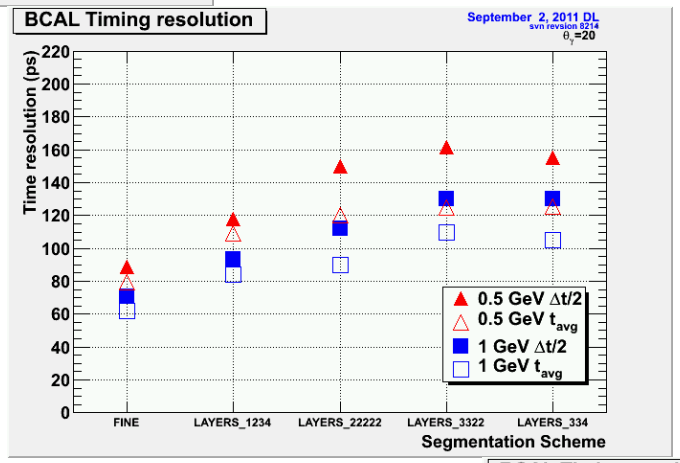
Segmentation	p0	p1	E=500MeV	E=1GeV	% better 500MeV	% better 1GeV
FINE	53.8	45.8	88.81	70.65	42.8%	45.6%
1234	71.3	60.7	117.69	93.64	24.1%	28.0%
22222	99.2	52.5	149.79	112.24	3.5%	13.7%
322	96.3	87.4	161.82	130.05	-4.3%	0.0%
334	84.7	98.6	155.15	129.98	0.0%	0.0%

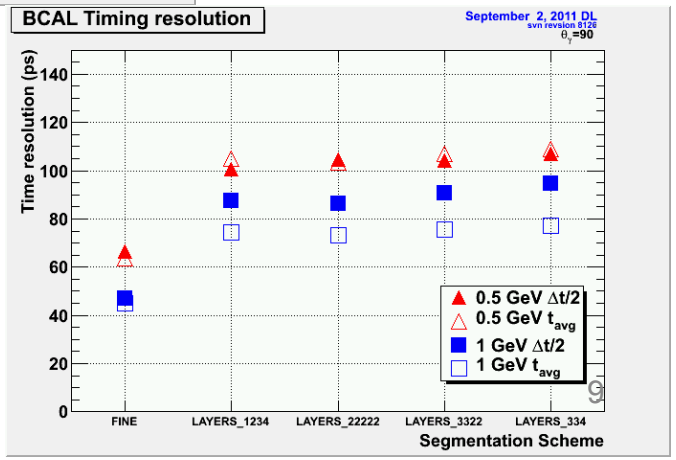
90 degrees

Segmentation	p0	p1	E=500MeV	E=1GeV	% better 500MeV	% better 1GeV
FINE	47.1	0	66.61	47.10	37.8%	50.2%
1234	49	72.7	100.44	87.67	6.3%	7.3%
22222	58.7	63.4	104.46	86.40	2.5%	8.6%
322	51.1	74.9	104.08	90.67	2.9%	4.1%
334	50.4	80	107.15	94.55	0.0%	0.0%

Timing resolution







Summary

- Time jitter effect added to simulation
- Data set and segmentation generated to match (reasonably close) 2006 beam test conditions
  - 64ps/sqrt(E) MC
  - 70ps/sqrt(E) beam test data
- 20-30% improvement in timing resolution seen for “1234” segmentation scheme relative to “334” segmentation scheme