Large Angle Beamstrahlung Monitor

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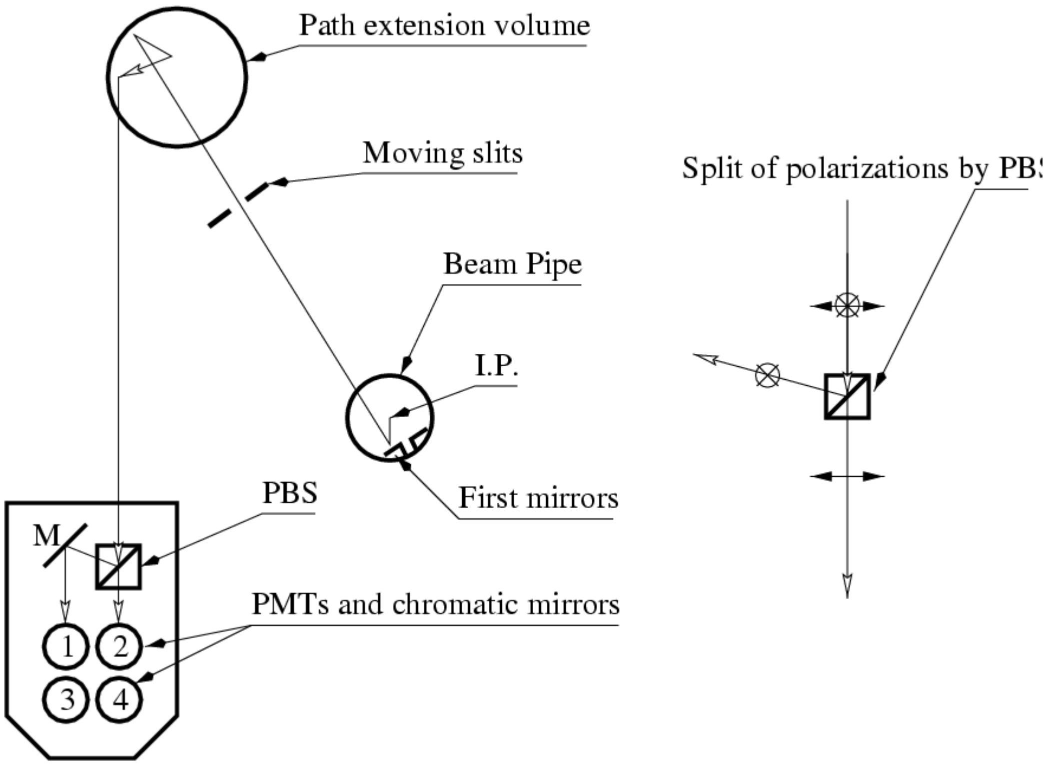
National Science Foundation — Where Discoveries Begin

With:

- several REU students over the years (E. Luckwald, N. Detgen, N. Powell, M. West)
- … and much help from many LEPP people
- I will discuss both visible (incoherent) and microwave (coherent) beamstrahlung (IB and CB)
- By now we have taken about 100 data runs (each 8 hrs) since March 2006. Detector is complete since Sept. 2006

¼ Set-up principal scheme

- Transverse view
- Optic channel
- Mirrors
- PBS
- Chromatic mirrors
- PMT numeration



Set-up general view

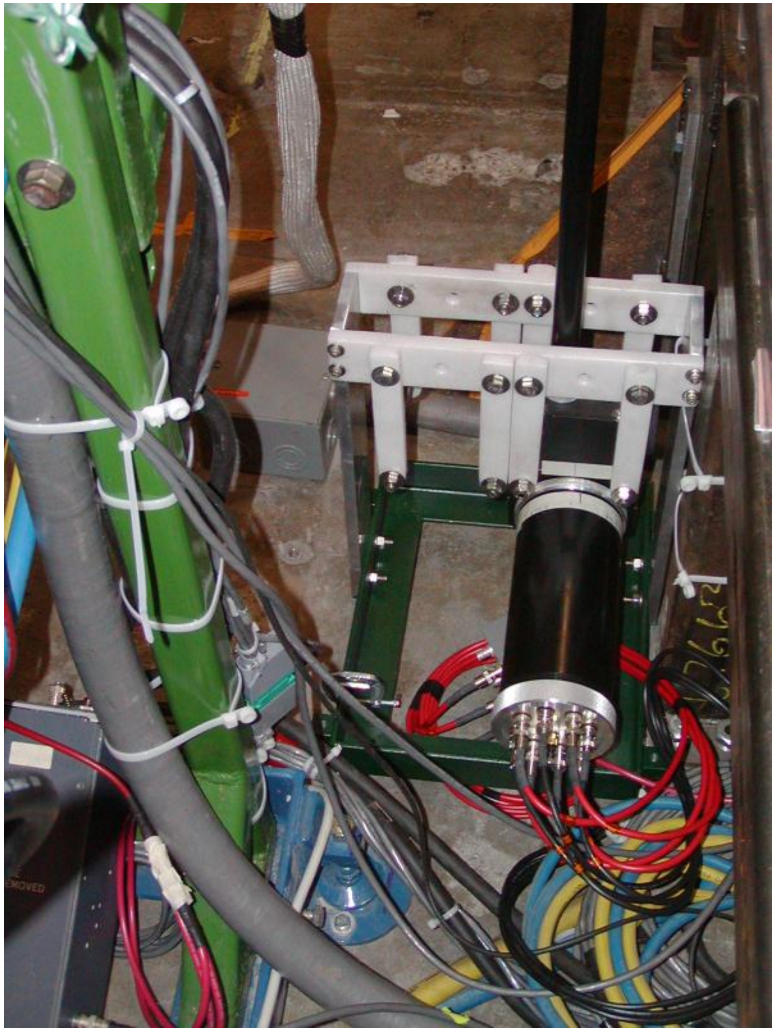
- East side of CLEO
- Mirrors and optic port ~6m apart from I.P.
- Optic channel with wide band mirrors
- Fully installed detector, but 50 degrees ports abandoned

On the top of set-up

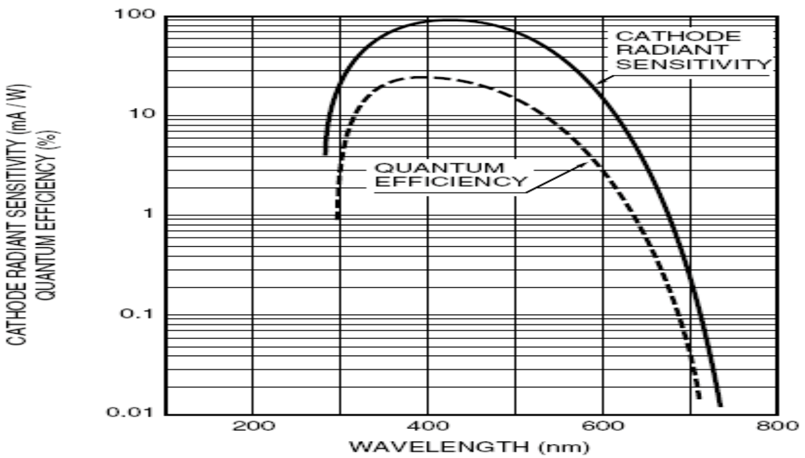
- Input optics channel
- Radiation profile scanner
- Optics path extension volume

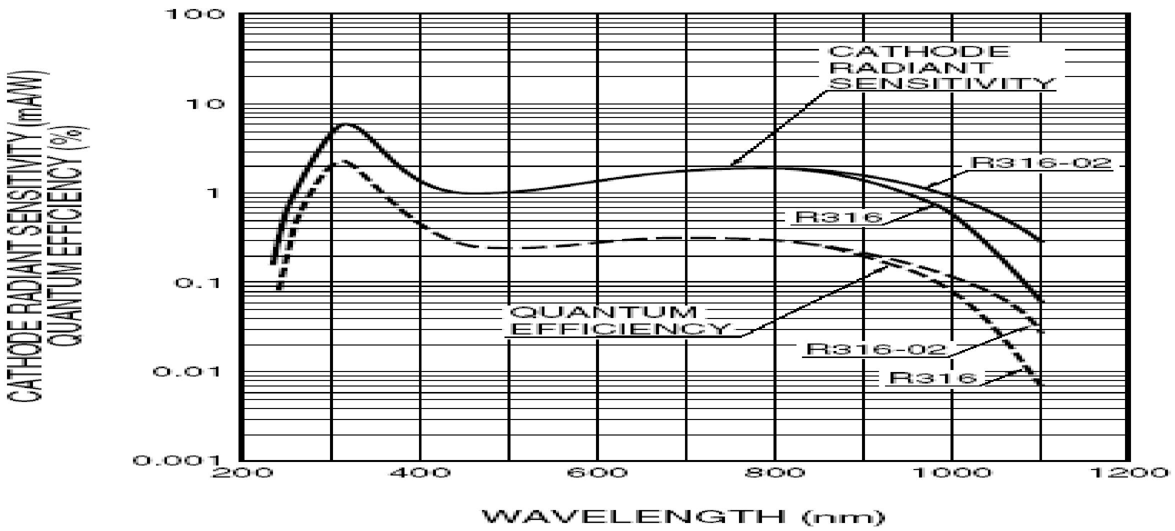
The ¼ detector

- Input channel
- Polarizing Beam Splitter
- Dichroic filters
- PMT's assembly
- Cooling…

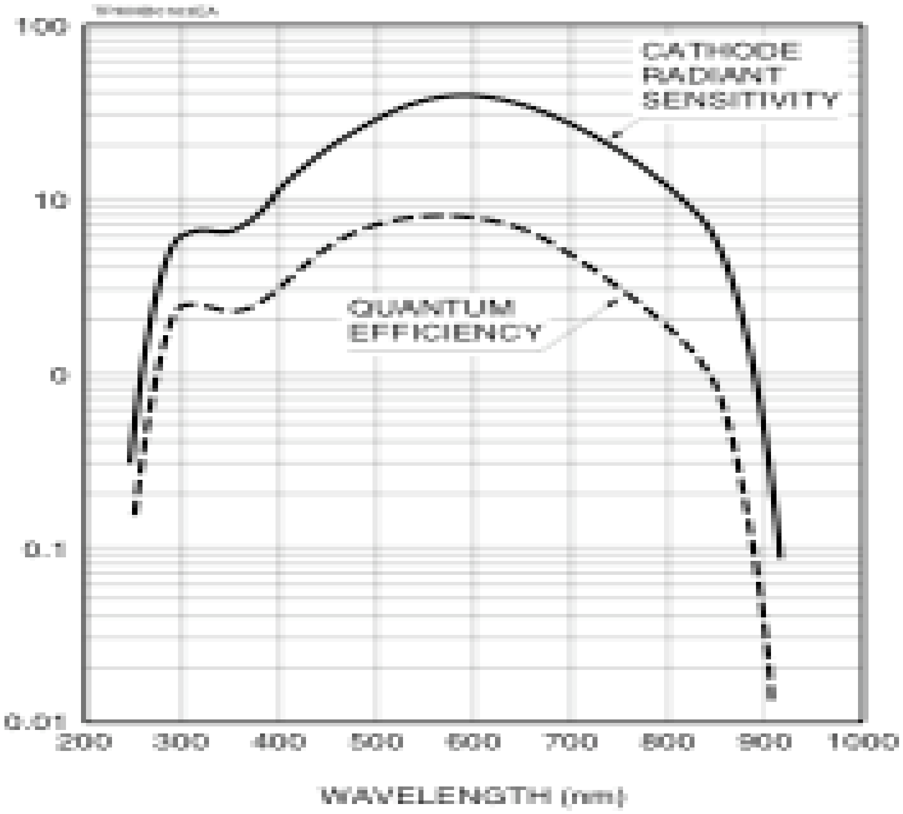


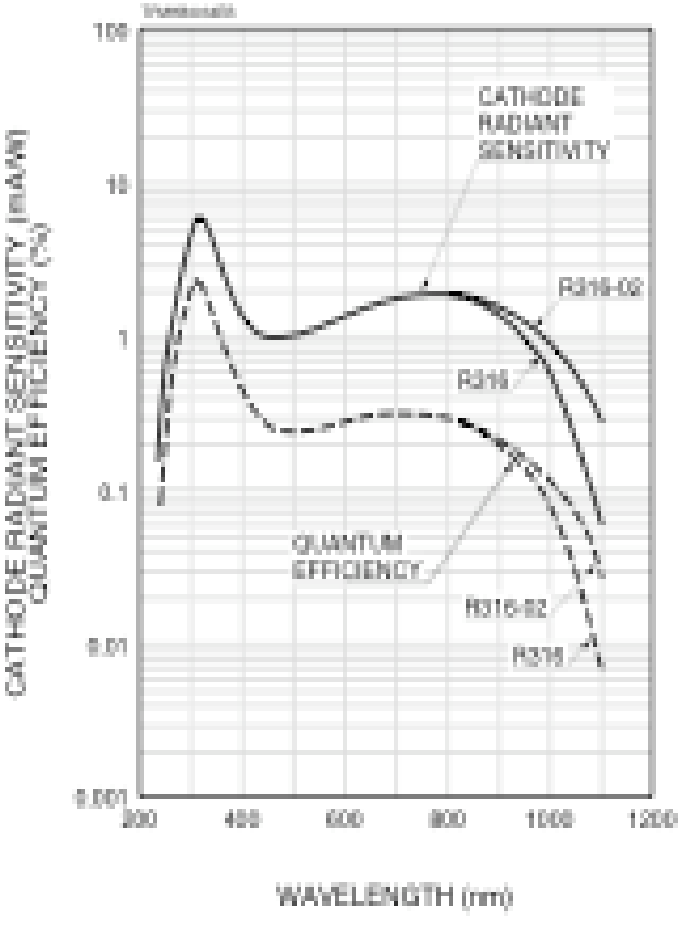
Sensitivity of R6095 vs R316-02





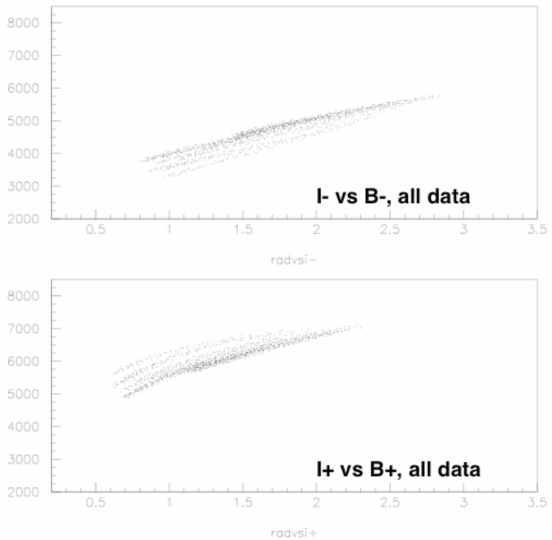
Sensitivity of R2228 vs R316-02





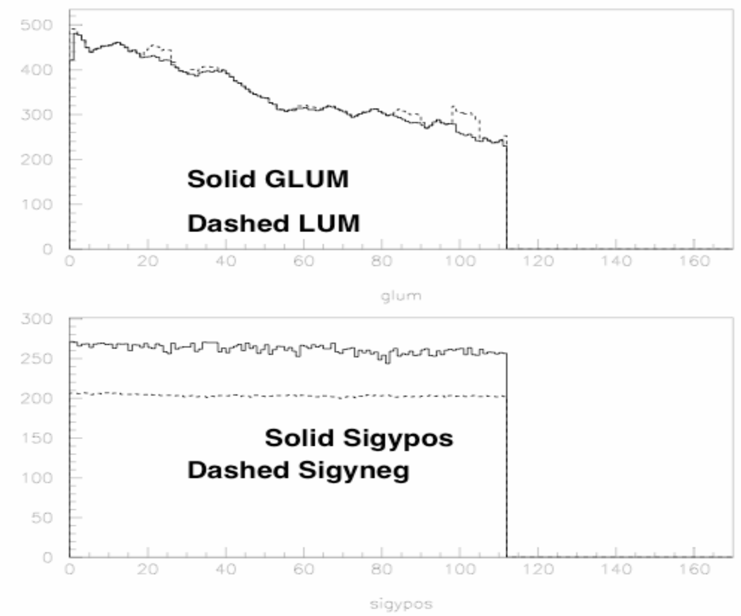
Beamstrahlung strength vs current

- On West side signal is stronger and background is weaker
- Due to pretzel scheme, on East side angle is smaller



Data selection

- At least 700 continuous data points ($1\text{-}5X10^8$ cts for VIS PMTs, $1\text{-}2X10^6$ for IR PMTs)
- $|GLUM/LUM-1|<0.02$
- $-0.001<\delta I<0.0005$ continuously
- Numerous other CESR quantities are acquired for monitoring



Signal rates

- Strongly dependent on θ, σ_z
- σ_z measured with CLEO data to better than 1%. Has varied by 10% between Apr. 2006 and Sept. 2007 (+40%-50% signal cmp. to median point)

θ min (mrad)	R6095(VIS)	R6095(VIS) w/CAD	R2228(NIR)	R2228(NIR) w/CAD
9.0	833	2003	24446	39646
9.2	444	1201	15646	26683
9.4	230	695	9855	17565
9.6	115	390	6074	11335
9.8	56	213	3633	7170
10.0	25	113	2071	4433
10.2	11	58	1075	2666
10.4	4	29	496	1549
10.6	1	14	188	862
10.8	0	6	46	456
11.0	0	3	14	227

CLEO data for August

- Sigma x as measured
- Sigma z equal to 1.414 times the luminous spot length
- Sigma y from CESR phas lock data
- Sigma z is constant within period but does change after shutdowns

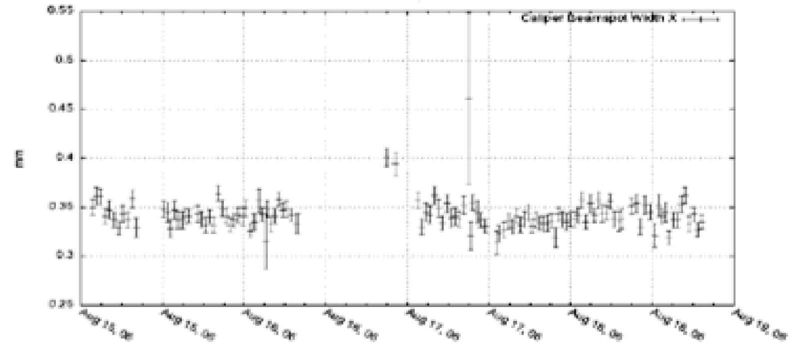


Figure 1: Caliper Beamspot Width x, August

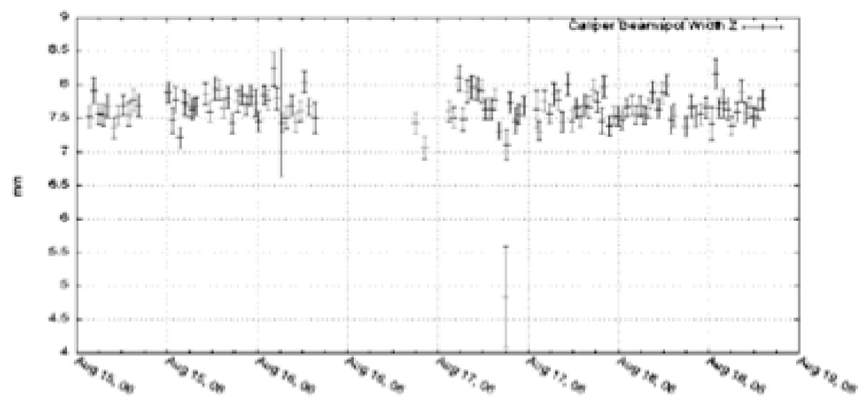
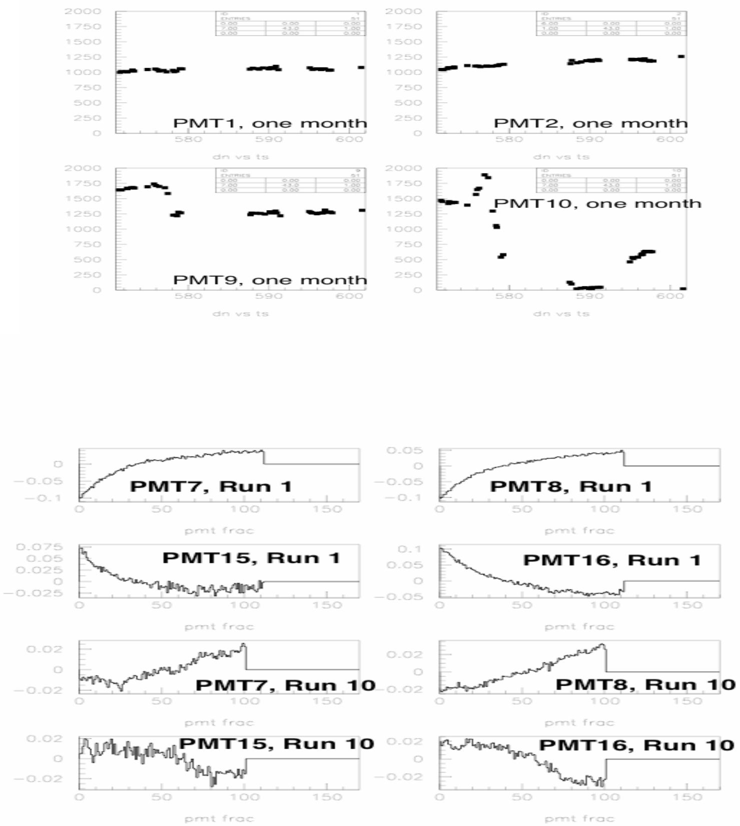


Figure 2: Caliper Beamspot Width z, August

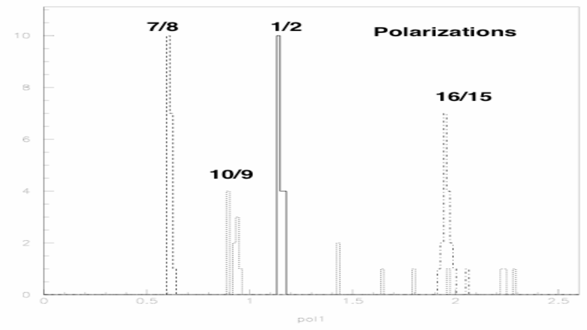
Data taking procedure

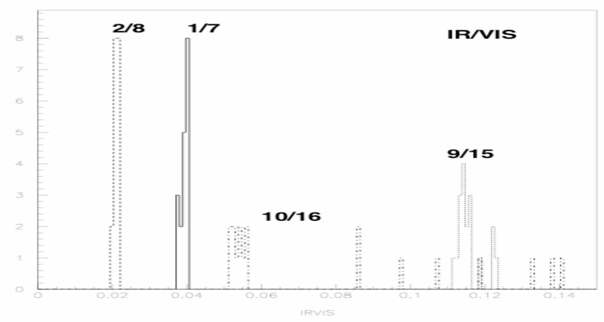
- Major improvement in accuracy by taking dark noise data before and after every 8-hr data taking period (600 pts each) and fixing dark noise par. in fits



Some ratios of rates

- Data are now substantially smooth except for some residual el. Noise
- Apparent spread explained later in "flashlight calibration"

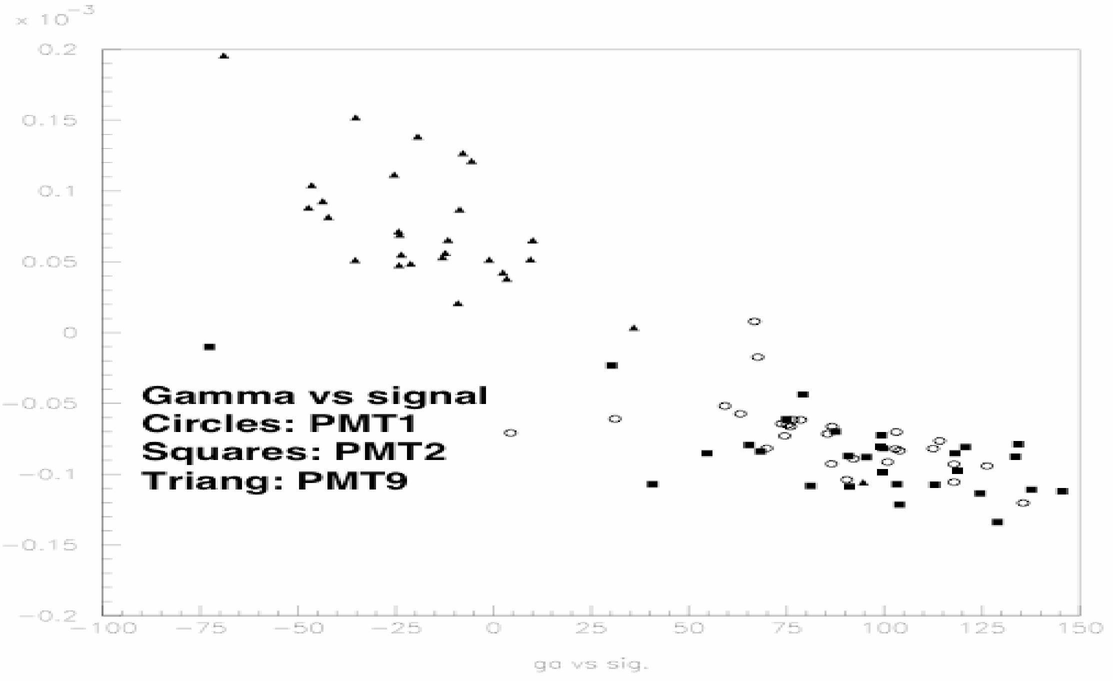




Description of low energy beamstrahlung MC

- Final quadrupole radiation simulation
- Use CESRV output provided by M. Forster and D. Sagan, containing Twiss matrix and B-Field map at every step in quads
- Extract 4-D (x,x',y,y') Gaussian distribution
- Using B-Field map, radiate incoherently according to radiation model (classical or short-magnet)
- Benchmarks are VIS rates (now in agreement to 20% w. MC), IR and VIS polarization (not in agreement, 1.0 in MC, 1.3-1.4 in data), IR/VIS ratios (30% agreement for R-316-02, 50% for R-2228), and relative variation (factor of 3)
- All models agree that $\delta R_{vis}/\delta\theta << \delta R_{IR}/\delta\theta$

… but the data to do not bear that out



Flashlight calibration

- Over four accesses we re-calibrated the PMTs using a flashlight
- PMTs measured and then swapped to measure relative efficiencies, which are now known to better than 5%

Current (mA)	PMT	ϵ_2/ϵ_1 8/28	ϵ_2/ϵ_1 9/11
100.	2	1.9220± 0.0014	-
100.	6	1.9193± 0.0043	1.933± 0.003
100.	8	1.8326± 0.0013	-
90.	2	1.9187± 0.0021	1.932± 0.002
90.	6	1.9102± 0.0068	1.932± 0.005
90.	8	1.8439± 0.0024	1.688± 0.001
80.	2	1.9101± 0.0039	1.927± 0.003
80.	4	1.8087± 0.0013	-
80.	6	1.9008± 0.0124	1.934± 0.008
80.	8	1.8382± 0.0044	1.679± 0.002
70.	2	1.8975± 0.0113	1.903± 0.005
70.	4	1.8011± 0.0033	1.630± 0.001
70.	6	1.9027± 0.0330	1.924± 0.017
70.	8	1.8290± 0.0105	1.669± 0.005
60.	2	1.7878± 0.0824	1.918± 0.018
60.	4	1.7814± 0.0240	1.616± 0.004
60.	6	-	1.891± 0.061
60.	8	1.9017± 0.0779	1.632± 0.015
80.	10	0.969± 0.004	-
80.	12	0.856± 0.004	-

Table 3: Relative IR/IR and VIS/VIS efficiencies measured at various flashlight currents. The last block of data is the East side data, taken on 9/25.

The good/The bad

- PMT spectral efficiency was found to be similar to 1%
- Relative efficiencies could be corrected to a few percent

- Because of our continuing noise problems, someone had moved the thresholds too high
- The reflected efficiency of the polarimeters (90% according to manufacturer) is closer to 50%

Future work

- We may have to go back to R-316-02, due to longer wavelength efficiency and noise resistance
- This requires new hardware (a LN2 line to our detector)

- We would like to get dedicated runs with one bunch per beam and/or min. σ_z
- This may be helped by gating electronics
- Because these are serious requests, we wait to get a consistent set of MC results

Coherent beamstrahlung

- Coherent synchrotron radiation has been observed many times for very short beams
- A first coherence condition is given by $\lambda > \sigma_z$
- A similar situation arises when beams are separated - coherent beamstrahlung
- Coherent enhancement is in principle proportional to N

CB coherent enhancement (vacuum, no angular divergence)

- C=P(CB)/P(IB)
- $C(\lambda)=N \exp(-(2\pi\sigma_z / \lambda)^2)$ (G. Bonvicini, unpublished)
- Angular spread reduces C

Beam pipe shielding

- Beam pipe effects are important for long magnets (Heifets, Mikhailichenko, SLAC-AP-083)

$$\lambda < d\sqrt{d/R}$$

- However in the case of beamstrahlung the magnet is shorter than the beam. This needs to be computed. ILC CB is probably there