U.S. FCAL Efforts

William Morse - BNL

U.S. Interests

- BNL – BeamCal, GamCal
- Yale – GamCal
- Colorado – SUSY studies
- Morse is the SiD forward coordinator
- Have submitted GamCal R&D Proposal to DOE
- Preparing BeamCal R&D Proposal to DOE

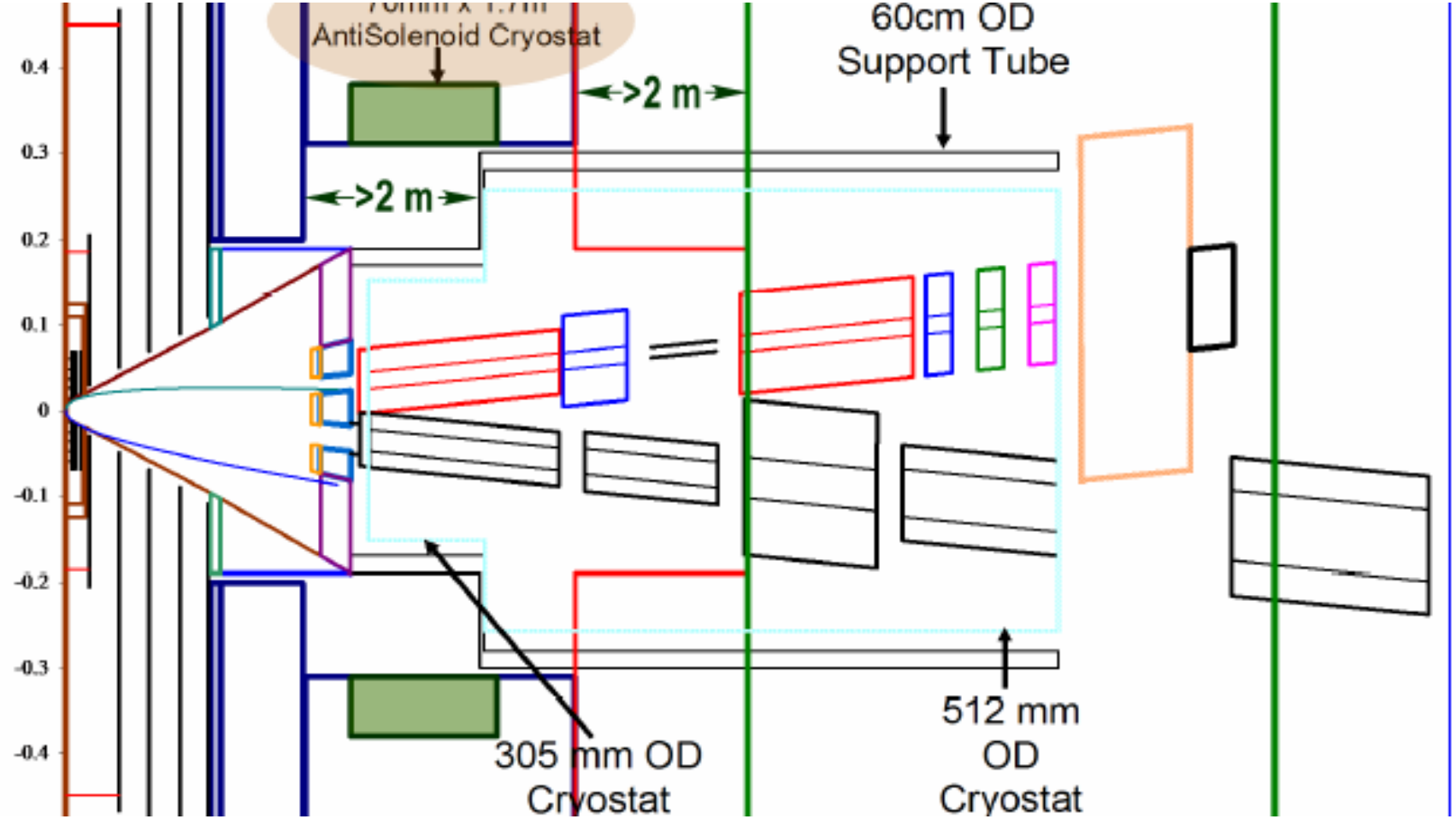
U.S. Interests

- BNL PI: W. Morse
- F. Lanni, D. Lissauer: BeamCal readout issues
- Z. Li: radiation damage issues
- B. Parker: machine interface issues
- Yale PI: M. Zeller
- G. Atoian, V. Issakov, A. Poblaguev: GamCal design issues
- Colorado PI: U. Nauenberg: SUSY studies

BeamCal Radiation Damage

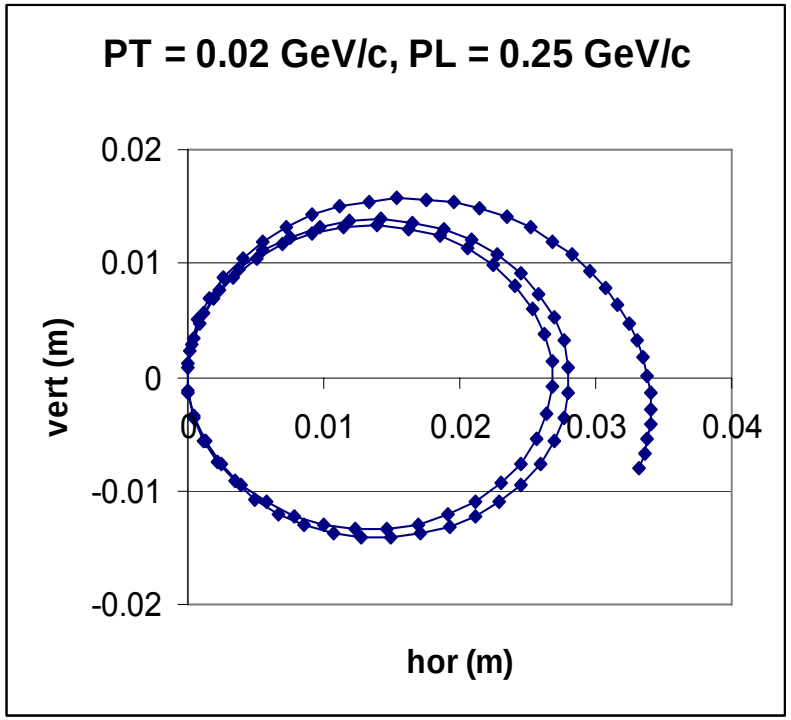
- 10MGy/yr from electrons
- 2×10^{14} n/cm^2 per yr, mainly from giant dipole resonance (10-40 MeV $\gamma N \rightarrow nN^*$)
- Zheng Li (BNL Instrumentation) recommends high resistivity MCZ Si cooled to -10C

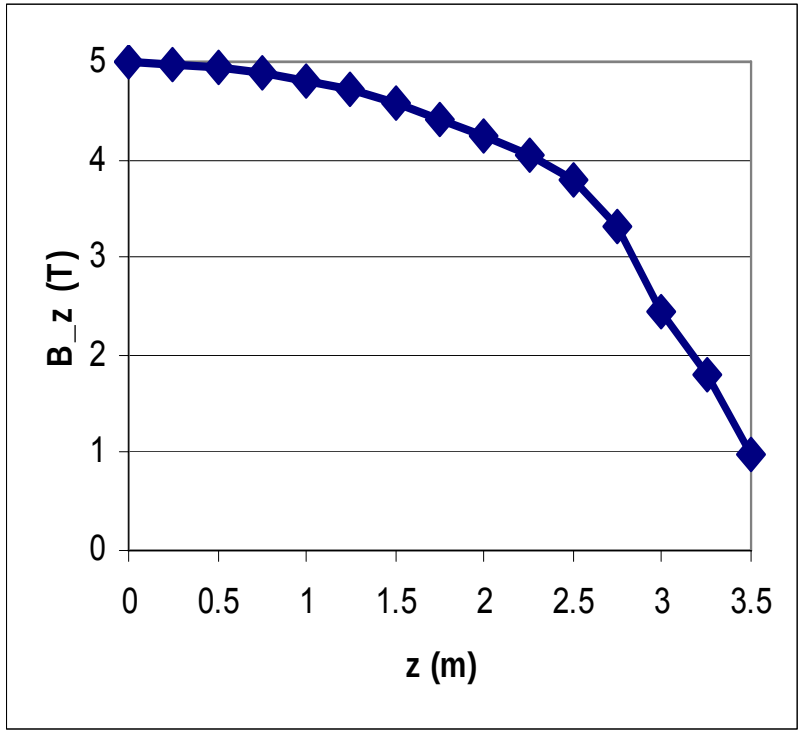
SiD 14mr with anti-solenoid



SiD Anti-Solenoid Magnet

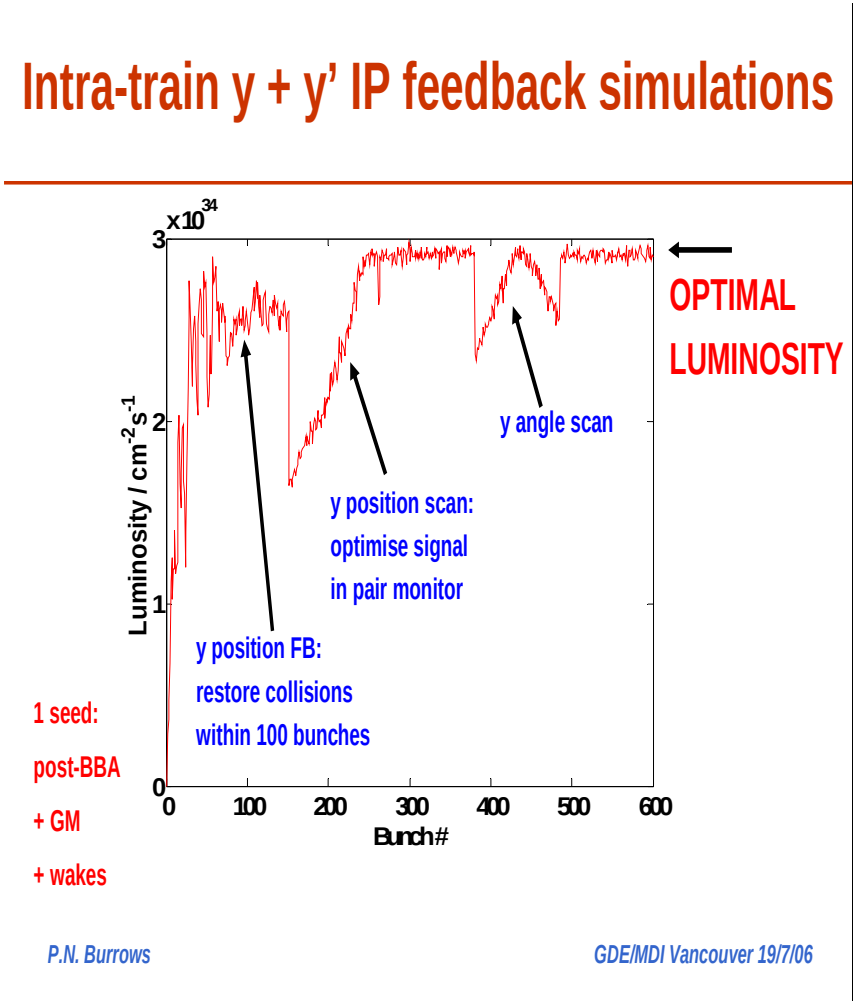
- Brett Parker (BNL) design – see VLCW06 talk
- Lower B affects pairs and also backsplash to vertex detector





Fast Feedback

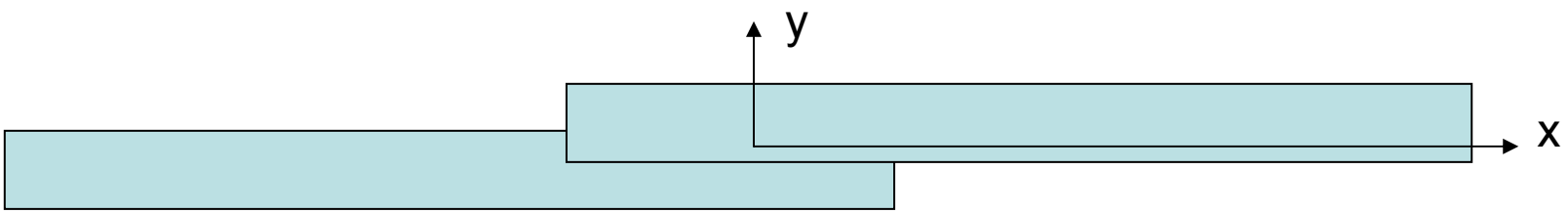
- The ILC fast feedback team requests a signal at 3MHz with low latency almost proportional to actual luminosity for fast optimization
- Comprehensive info at 5Hz to a data base (still to be defined)



Achieving the Design Luminosity Will Be a Challenge

- Bunch $P_-(t)$ $\{N, E, x, y, z, \sigma_x, \sigma_y, \sigma_z, \sigma_{xy}, \psi_x, \psi_y\}$
- Bunch $P_+(t)$ $\{N, E, x, y, z, \sigma_x, \sigma_y, \sigma_z, \sigma_{xy}, \psi_x, \psi_y\}$
- Instantaneous Luminosity:

$$L(t) = \frac{N_+^o N_-^o}{4\pi \sigma_x^o \sigma_y^o}$$



Run Time Measurements

- Beam-beam deflections (pickup electrodes)
- Beam-strahlung gammas (GamCal)
- Beam-strahlung pairs (BeamCal)
- We need robust and complementary information

Beam-strahlung

- F = e(E + cβ×B). $B_{max} \approx$ 1KT
- Instantaneous power radiated:
- $P_\gamma \approx 3\% P_e$ $N_\gamma \approx 1.5 N_e$
- Bethe-Heitler: $\gamma e \rightarrow e\, e^+e^-$
- $\sigma_{BH} \approx$ 38 mb
- <E> ≈ 1GeV
- Landau-Lifshitz: $ee \rightarrow ee\, e^+e^-$
- $\sigma_{LL} \approx$ 19 mb
- <E> ≈ 0.15GeV
- Other processes much smaller
- C. Rimbault et al., Phys Rev ST AB 9,034402 (2006).

$$P = \frac{2r_0\gamma^2 F^2}{3mc}$$

Bethe-Heitler Pairs

- $\gamma e \rightarrow e\, e^+ e^-$

$$N_{ee} \propto \frac{\sigma_{BH} N_\gamma^o N_e^o}{\sigma_x^o \sigma_y^o} \qquad \frac{N_{ee}}{N_\gamma} \propto \frac{\sigma_{BH} N_e^o}{\sigma_x^o \sigma_y^o}$$

$$\frac{E_{ee}}{E_\gamma} \propto \frac{N_e^o}{\sigma_x^o \sigma_y^o}$$

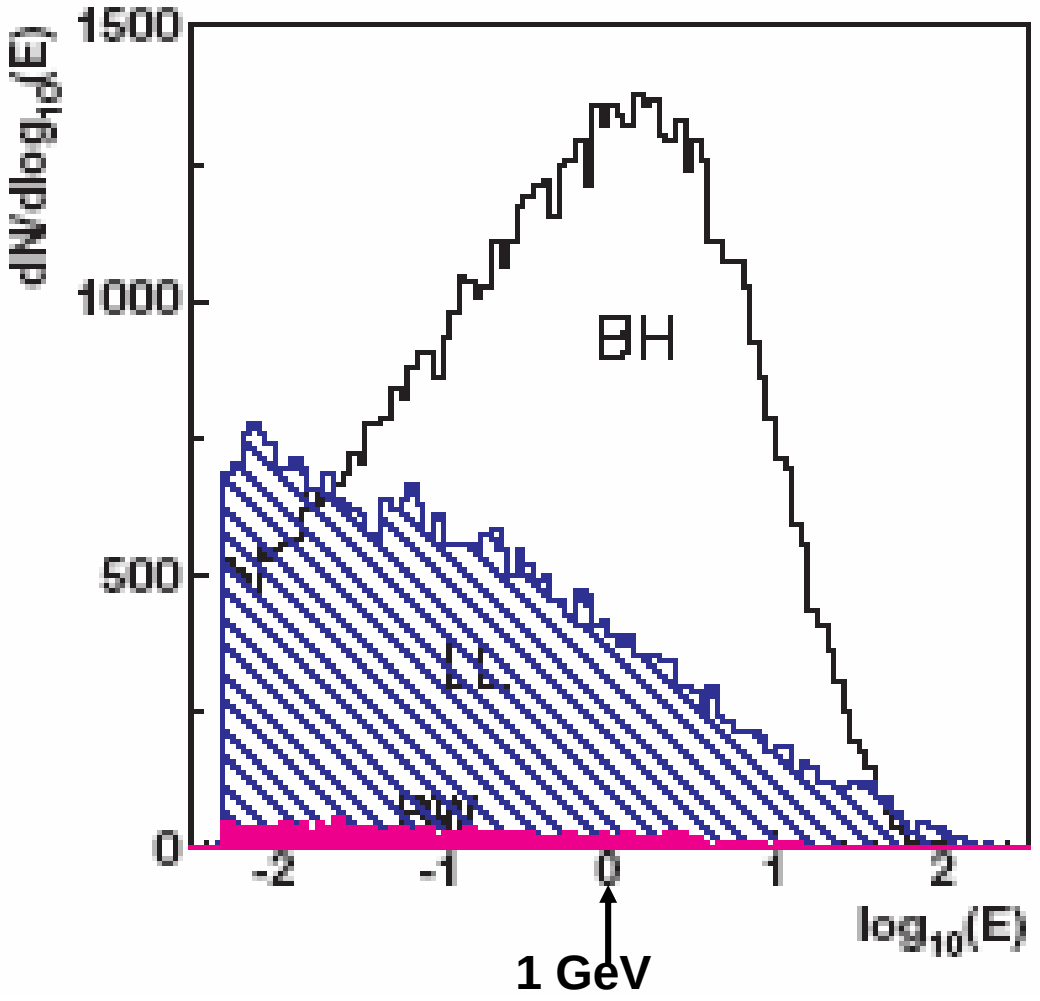
For left and right detectors separately: $N^+/\sigma_x\sigma_y$ and $N^-/\sigma_x\sigma_y$. Question: How well does this really work? Answer: Needs simulation.

Landau-Lifshitz Pairs

- $ee \rightarrow eee^+e^-$

$$N_{ee}^{LL} = \frac{\sigma_{LL} N_-^o N_+^o}{\sigma_x^o \sigma_y^o}$$

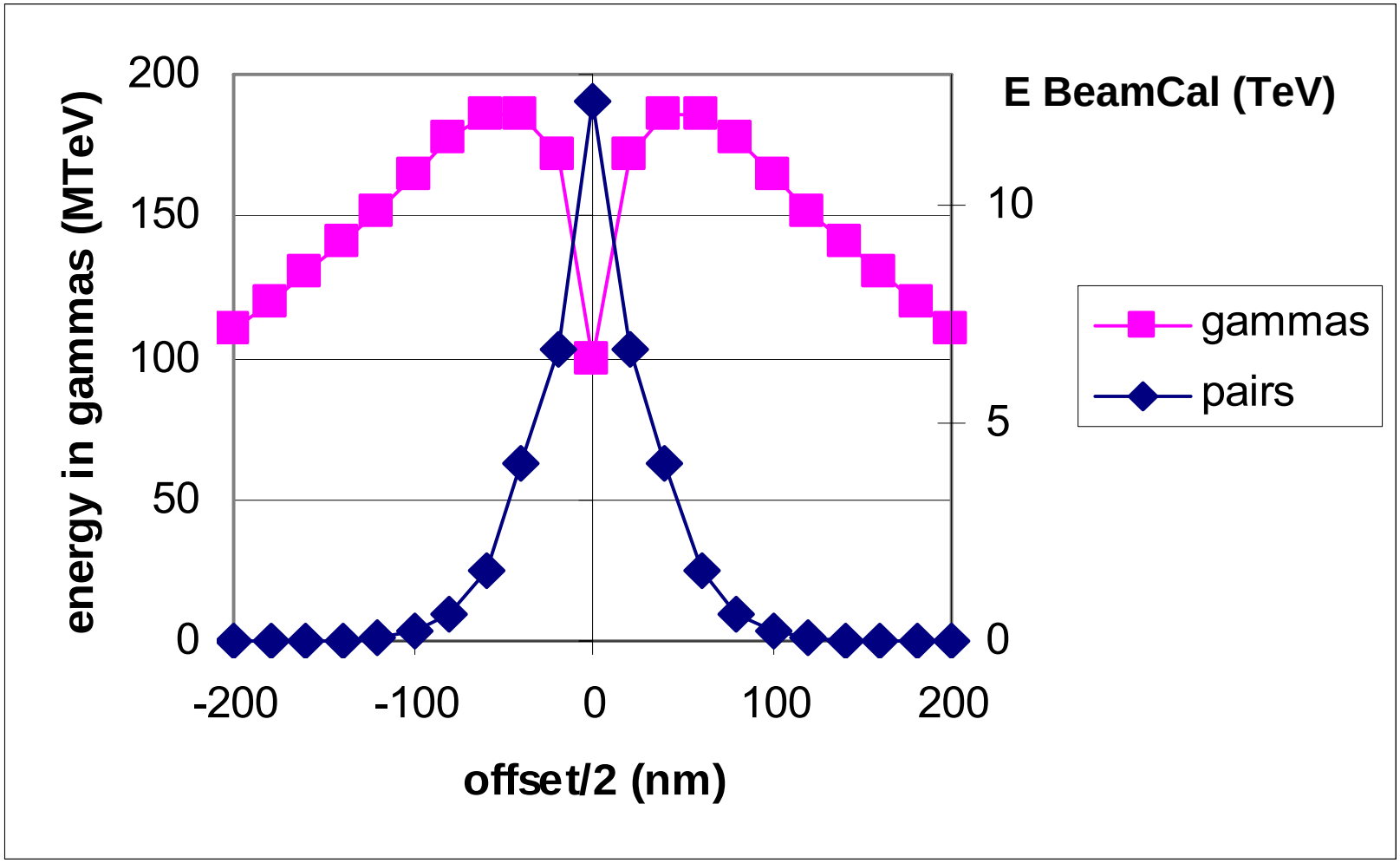
For left and right detector equally



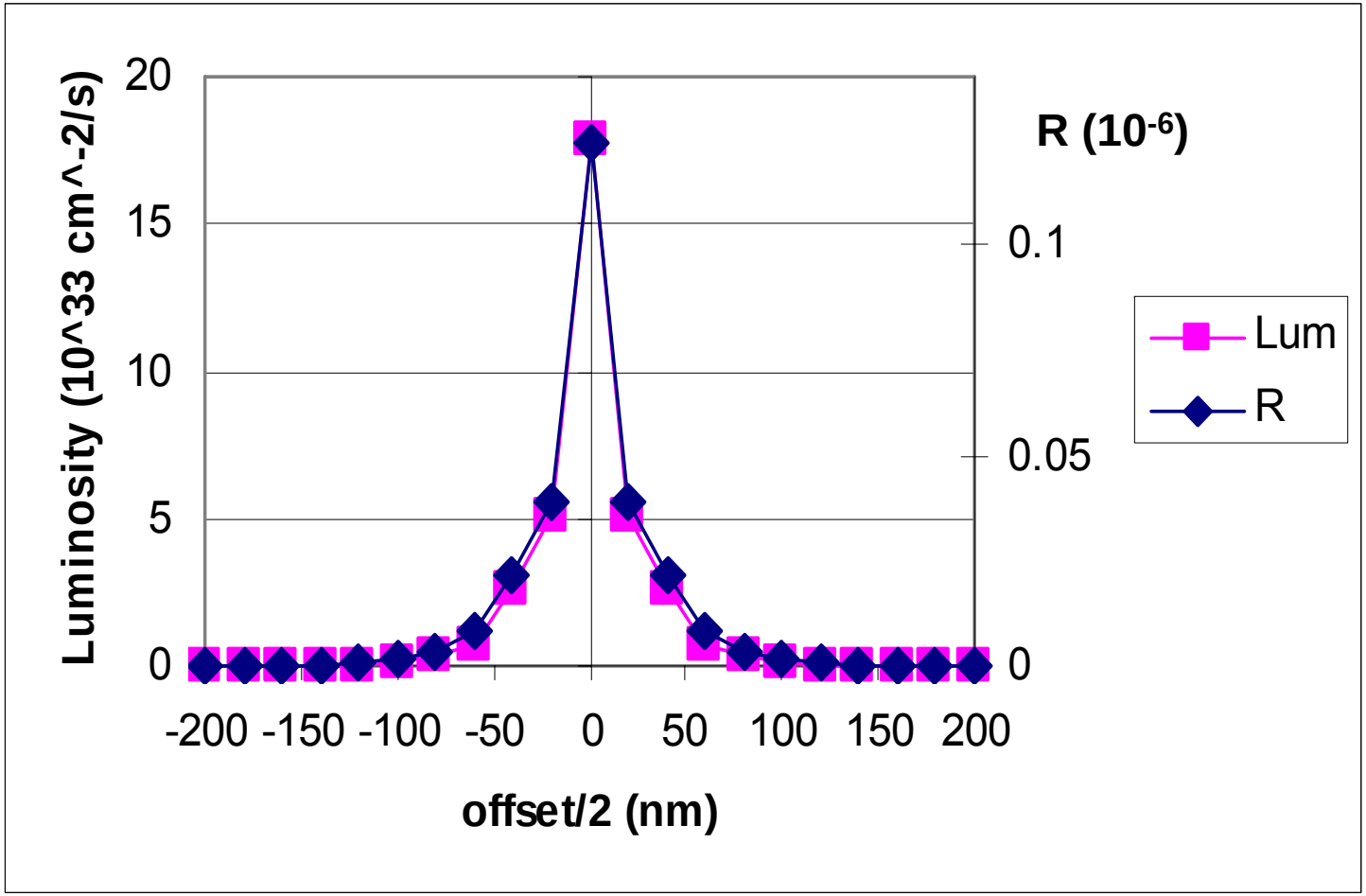
Simulations

- W. Morse (BNL)
- W. Lohman, E. von Oelson, and M. Ohlerich (DESY Zeuthen)
- To Be Submitted as an ILC Note
- Guinea Pig simulations varying some of the 500 GeV ILC bunch parameters around nominal values

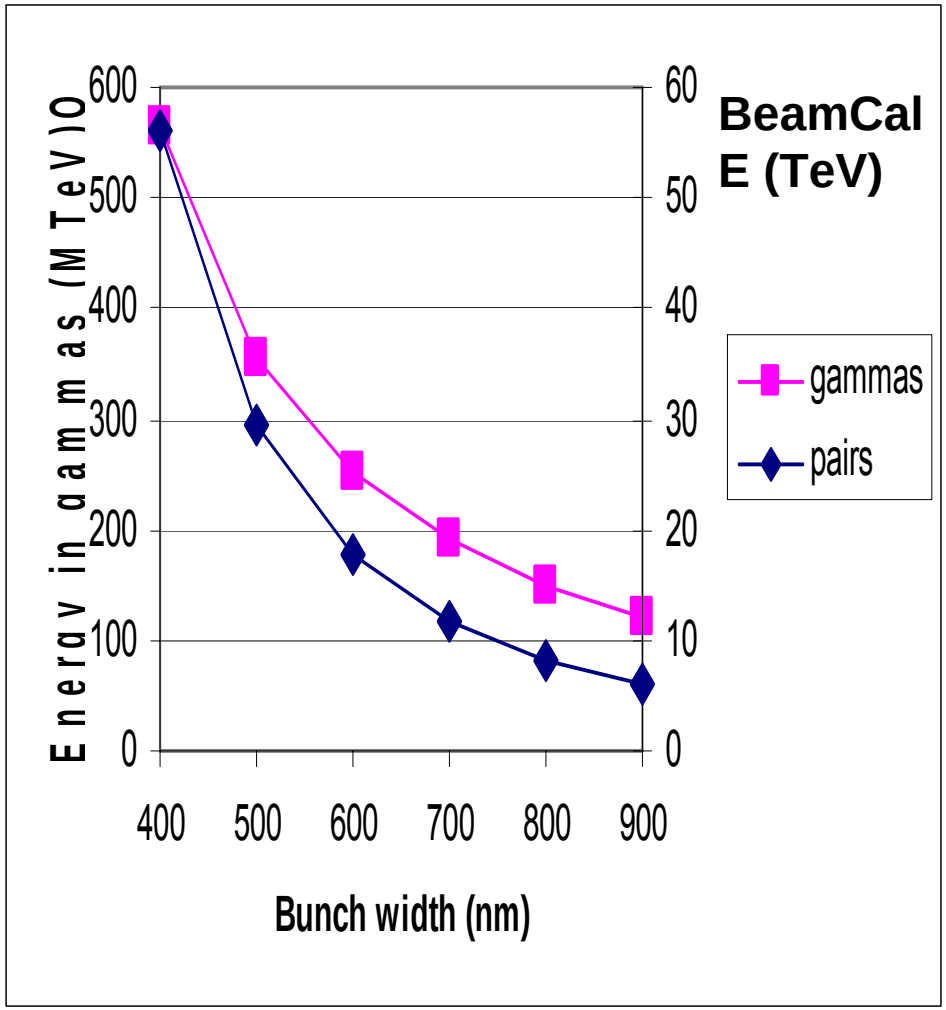
Vertical offset

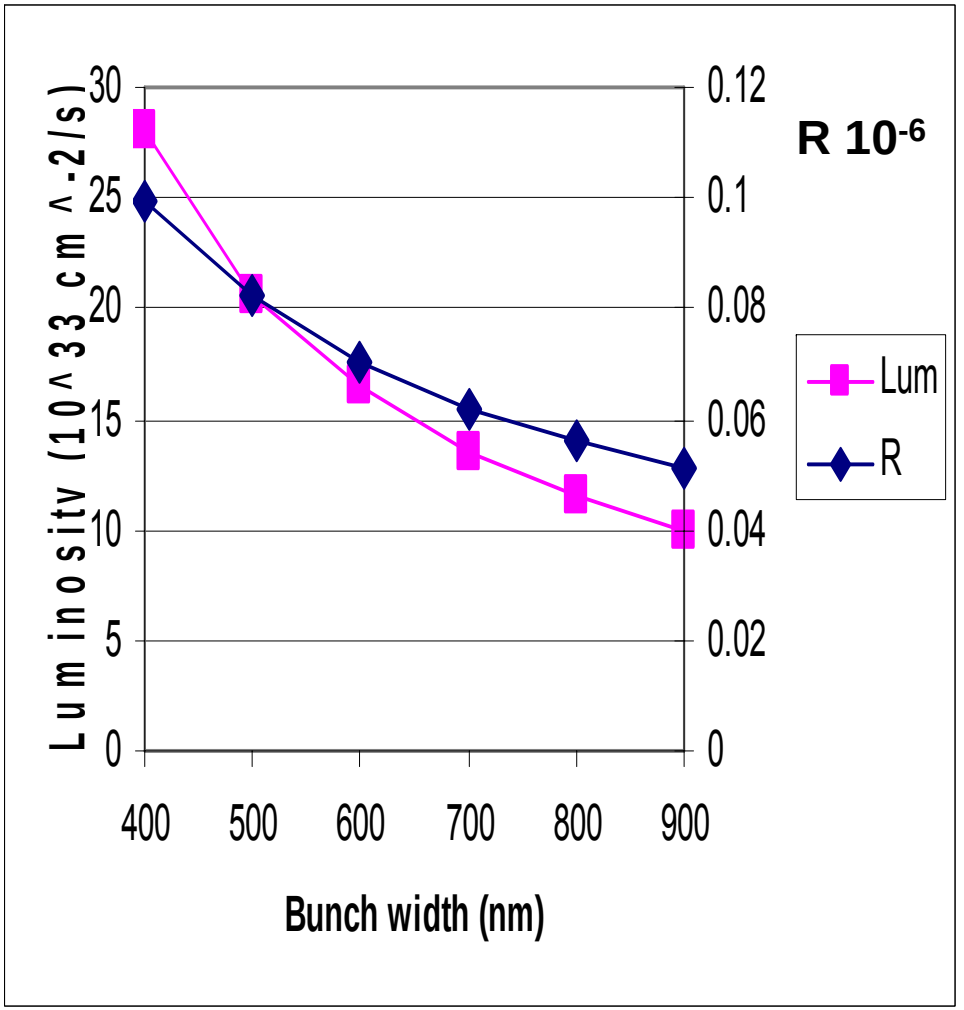


Vertical Offset



Bunch Width


Energy in gamma (MTeV)
600
500
400
300
200
100
0
60
50
40
30
20
10
0
400
500
600
700
800
900
Bunch width (nm)
BeamCal
E (TeV)
gammas
pairs

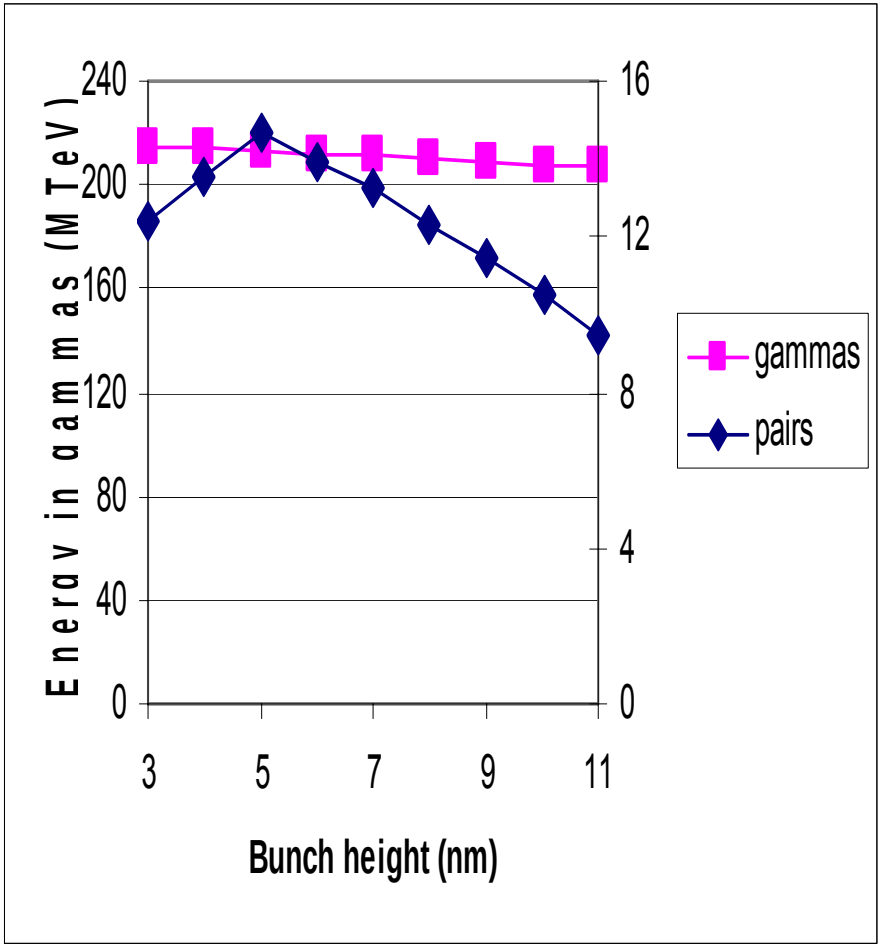

Luminositv (10^33 cm^-2/s)
30
25
20
15
10
5
0
0.12
0.1
0.08
0.06
0.04
0.02
0
400
500
600
700
800
900
Bunch width (nm)
R 10-6
Lum
R

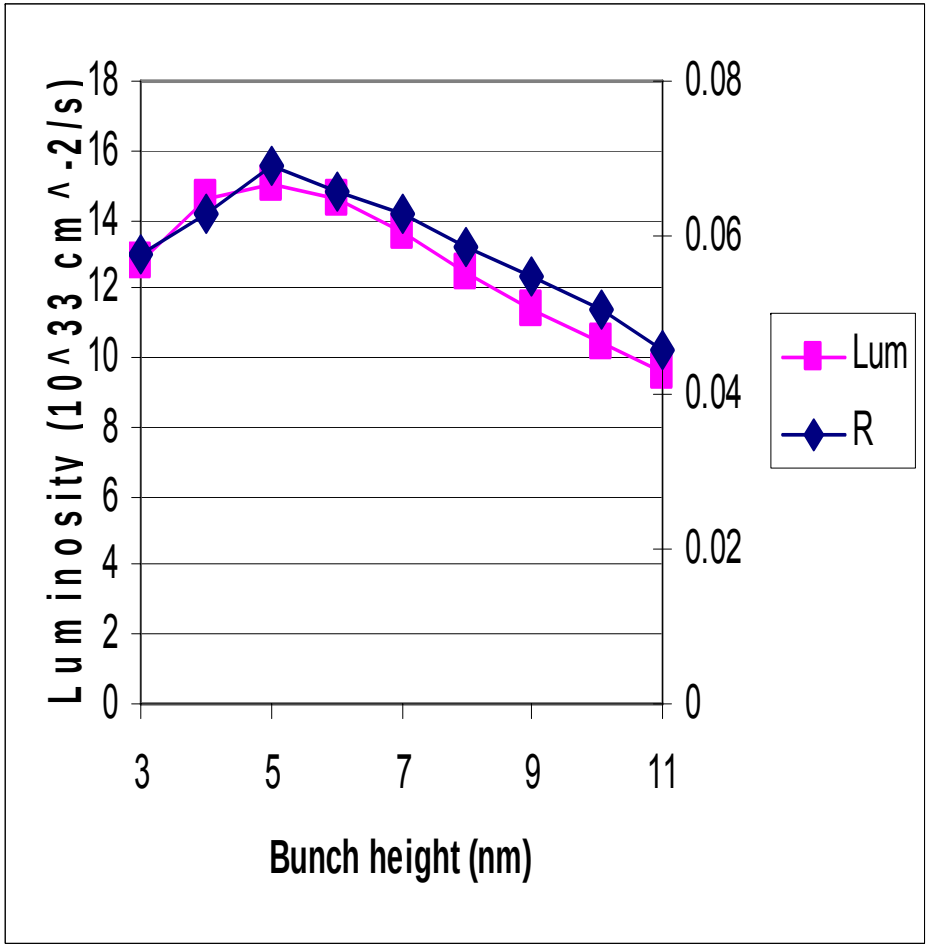
Comparison

- Sign of dE/d(bunch characteristic) at design values. Note that all five lines are different, which means complementary information.

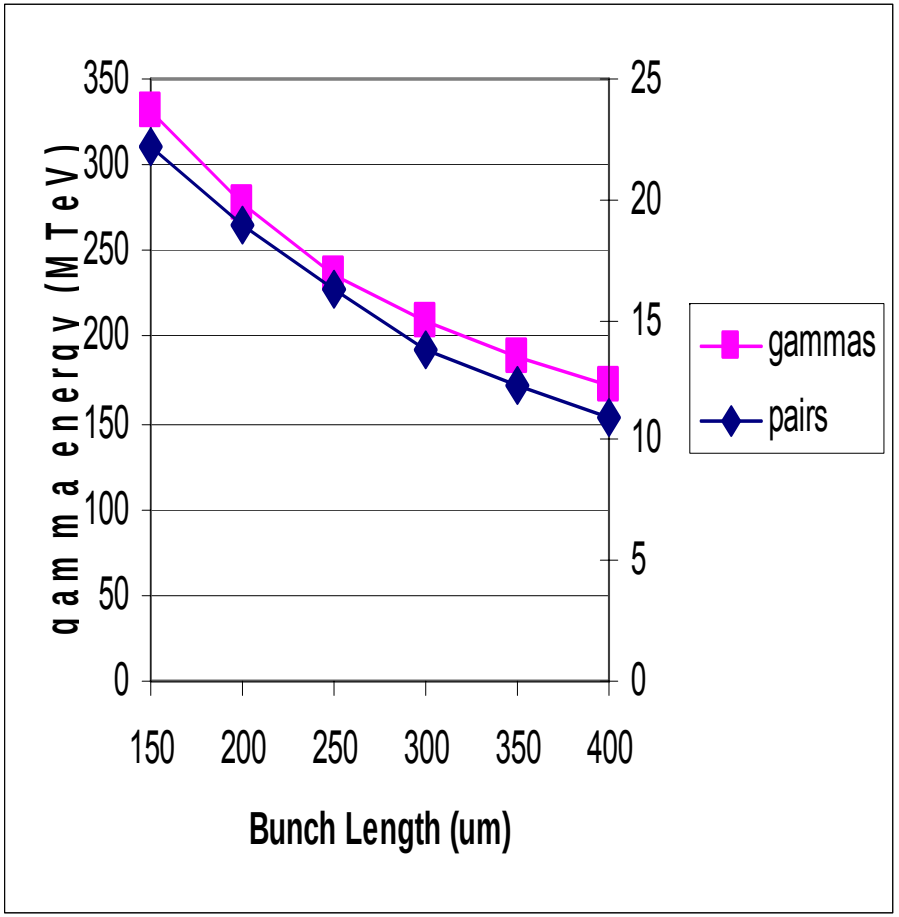
Parameter	Pairs	Gammas	Ratio
X offset	0 (max)	0 (max)	0 (max)
σ_z	-	-	≈ 0
σ_y	0 (max)	≈ 0	0 (max)
σ_x	-	-	-
Y offset	0 (max)	0 (min)	0 (max)

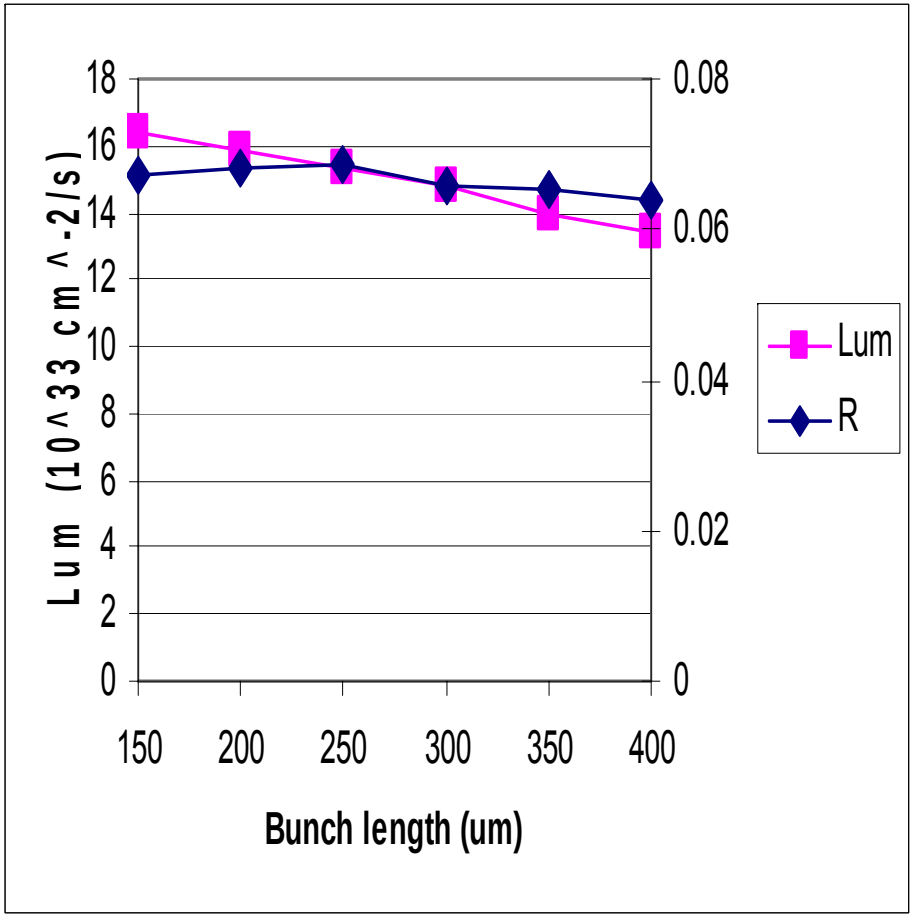
Bunch Height





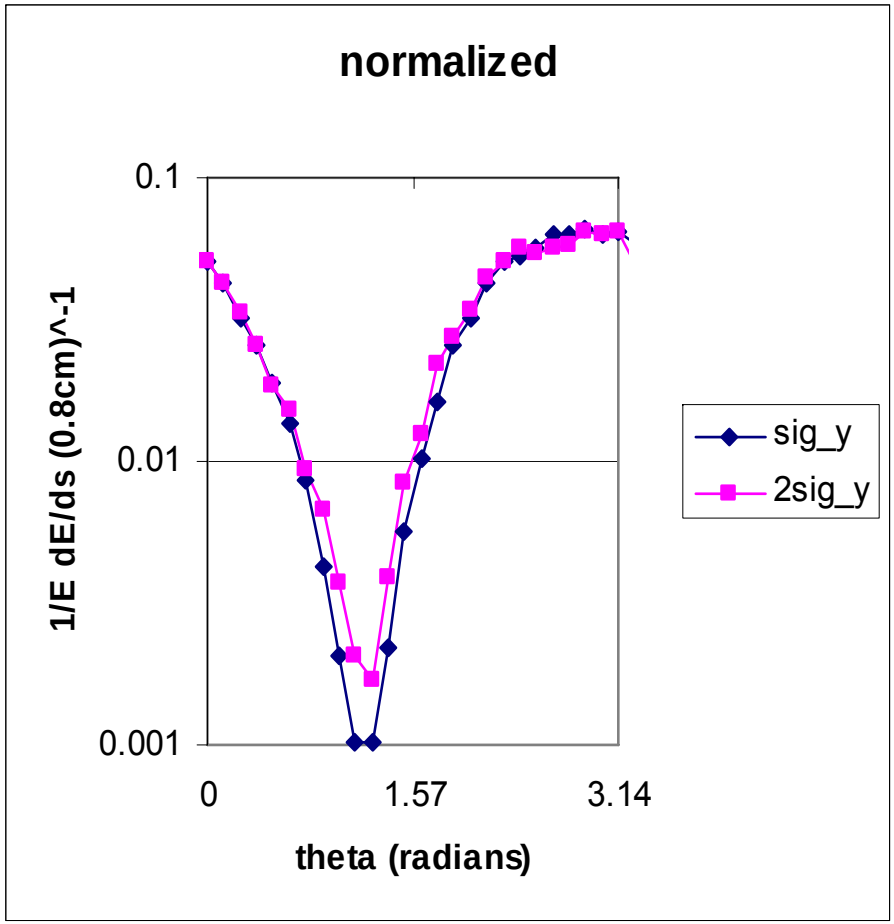
Bunch Length





Is There More Info in BeamCal?

- T.Tauchi,K.Yokoya
- Phys Rev E51,6119(95)
- 6<*r*<7cm azimuthal dist
- But, Moliere dia. ≈2cm!
- Also, ≈1 Bhabha/BX!
- Thus we need more simulation to show that it is robust enough.

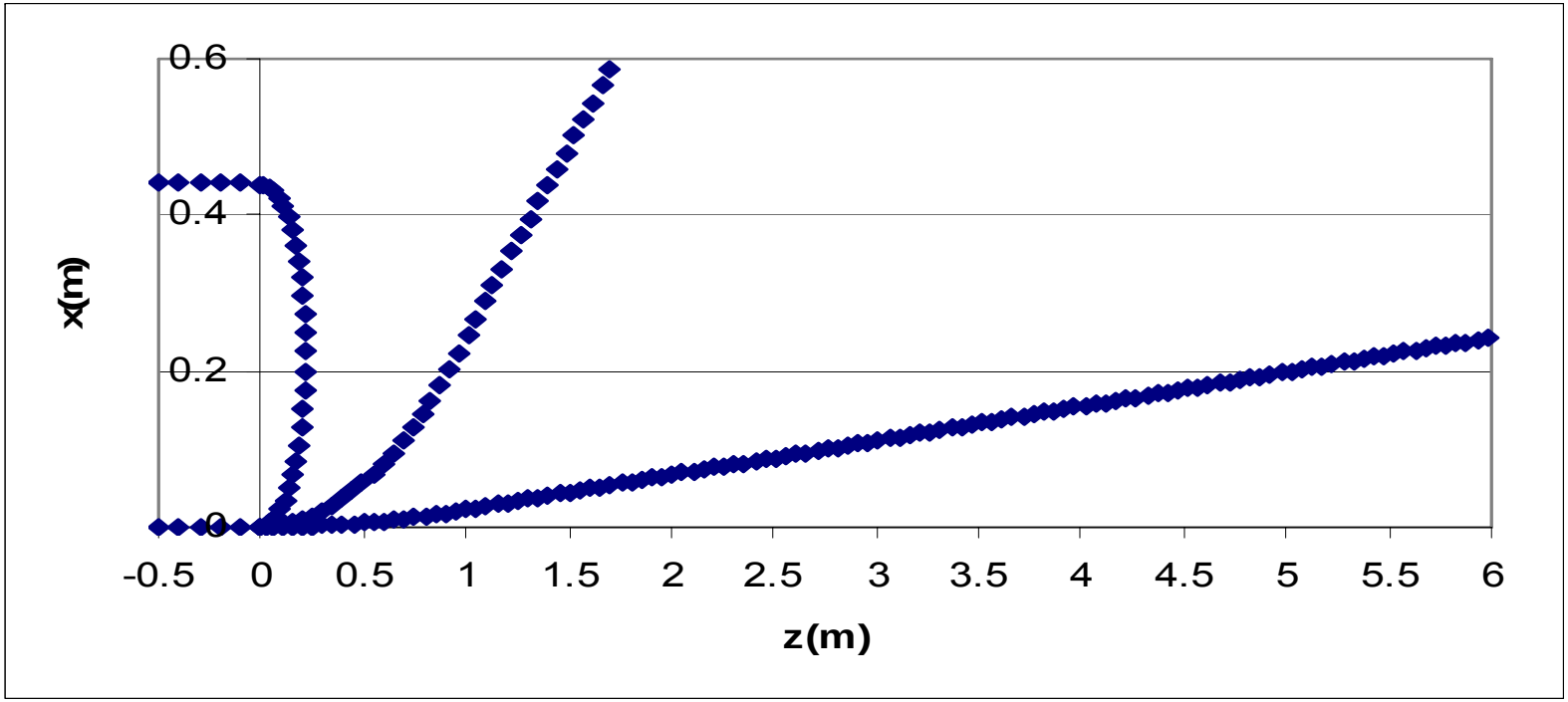


Robust and Complementary

Luminosity, ie. R, is low. Note that all columns are different, ie. complementary information.

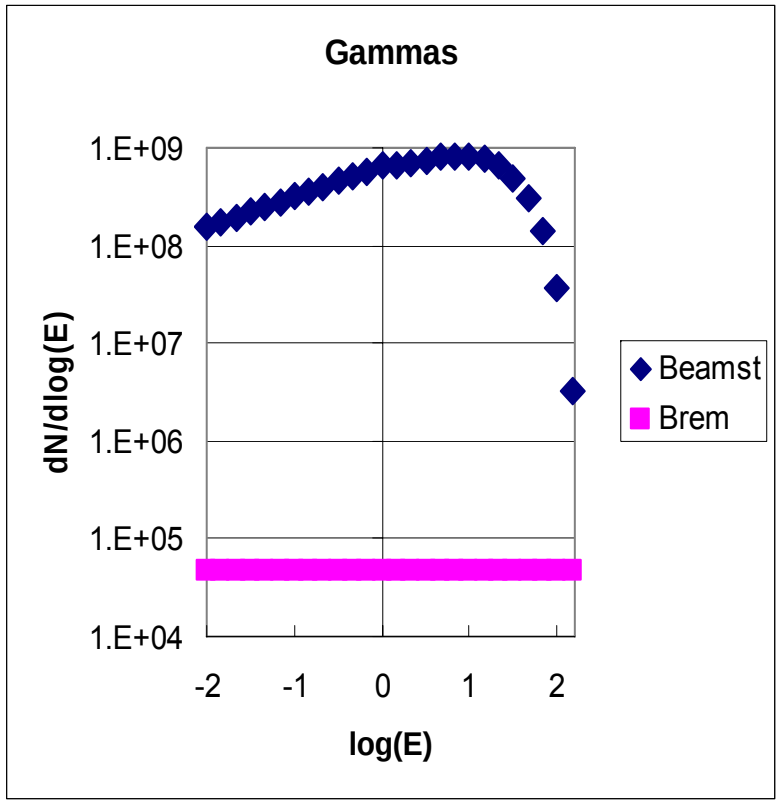
Detector	X offset	Y offset	σ_x	σ_y
PUE	$\pm x$	$\pm y$	Normal	Normal
E GamCal	Low	High	Low	Normal
E BeamCal	Low	Low	Low	Low

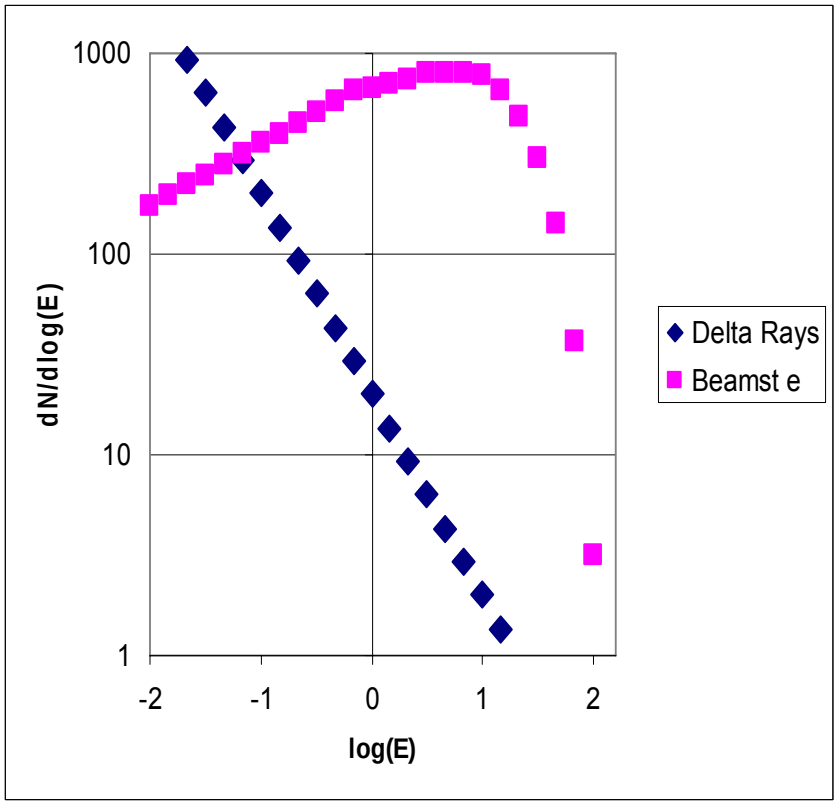
Large Crossing Angle GamCal



Gas jet followed by a 1m long 1.5T dipole magnetic field. Trajectories of positrons of momentum 0.1, 1, and 10 GeV/c are shown.

GamCal Backgrounds



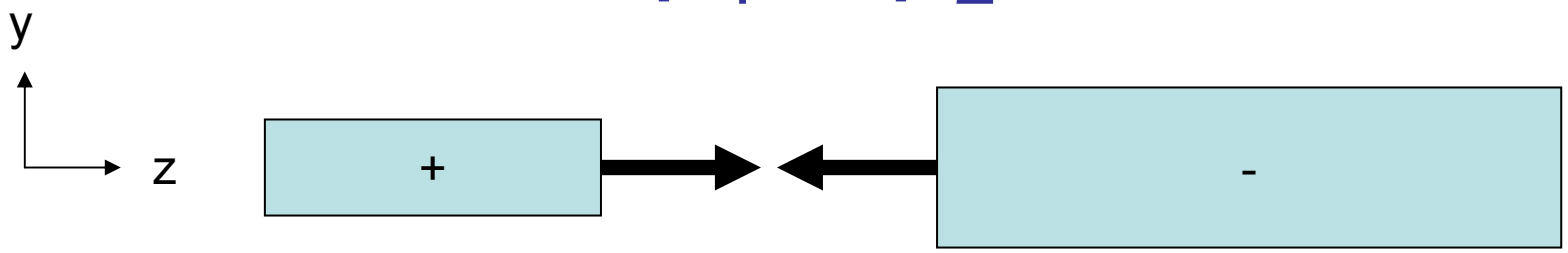


Conclusions

- We need robust, redundant information:
- Beam-beam deflections
- Beam-strahlung gammas
- Beam-strahlung pairs
- E(pairs)/E(gammas) particularly valuable
- Largely proportional to instantaneous luminosity

Extra Slides

$\rho_1 \neq \rho_2$



$$F_1 = \frac{ey}{\varepsilon_0}\left(\rho_2 - \rho_1 + \beta^2\left(\rho_1 + \rho_2\right)\right) \approx \frac{2\rho_2 ey}{\varepsilon_0}$$

$$E = \frac{\left(\rho_1 - \rho_2\right)y}{\varepsilon_0} \qquad B = \frac{\beta\left(\rho_1 + \rho_2\right)y}{\varepsilon_0}$$

Perfect Collisions

$$E_\gamma \propto \frac{N^2}{\sigma_x^2 \sigma_z} \qquad E_{ee} \propto \frac{N^3}{\sigma_x^3 \sigma_y \sigma_z}$$