LumiCal, BeamCal and GamCal

William Morse - BNL

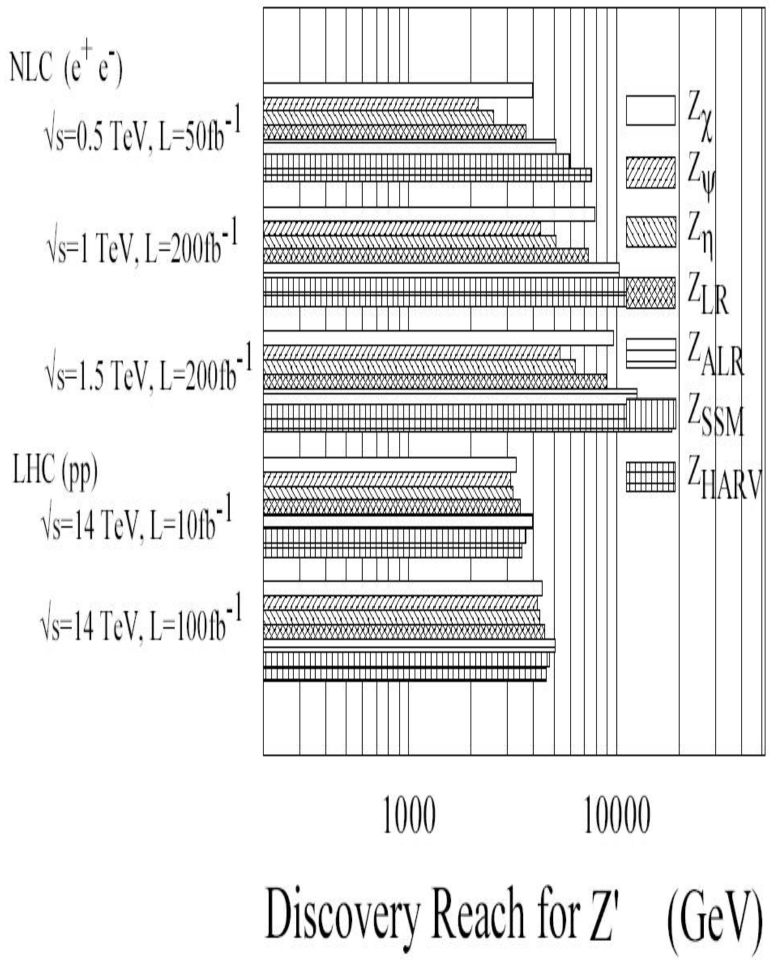
LumiCal

- SiD DoD: $0.02 < \theta < 0.14$rad
- $0.998 < \cos\theta < 0.99$
- Probably will be changed to about $.03<\theta<.14$
- Vetoes ee→ee ee events (SUSY search)
- Integrated *L* to better than 0.1% ($\sqrt{s}$=0.5TeV)
- *L* fiducial region probably $0.04 < \theta < 0.08$ rad
- 10^6 fermion anti-fermion, gauge boson evts/yr

Precision Tests of the SM: Indirect Signals of New Physics

- Common feature of many models is a contact interaction type signature

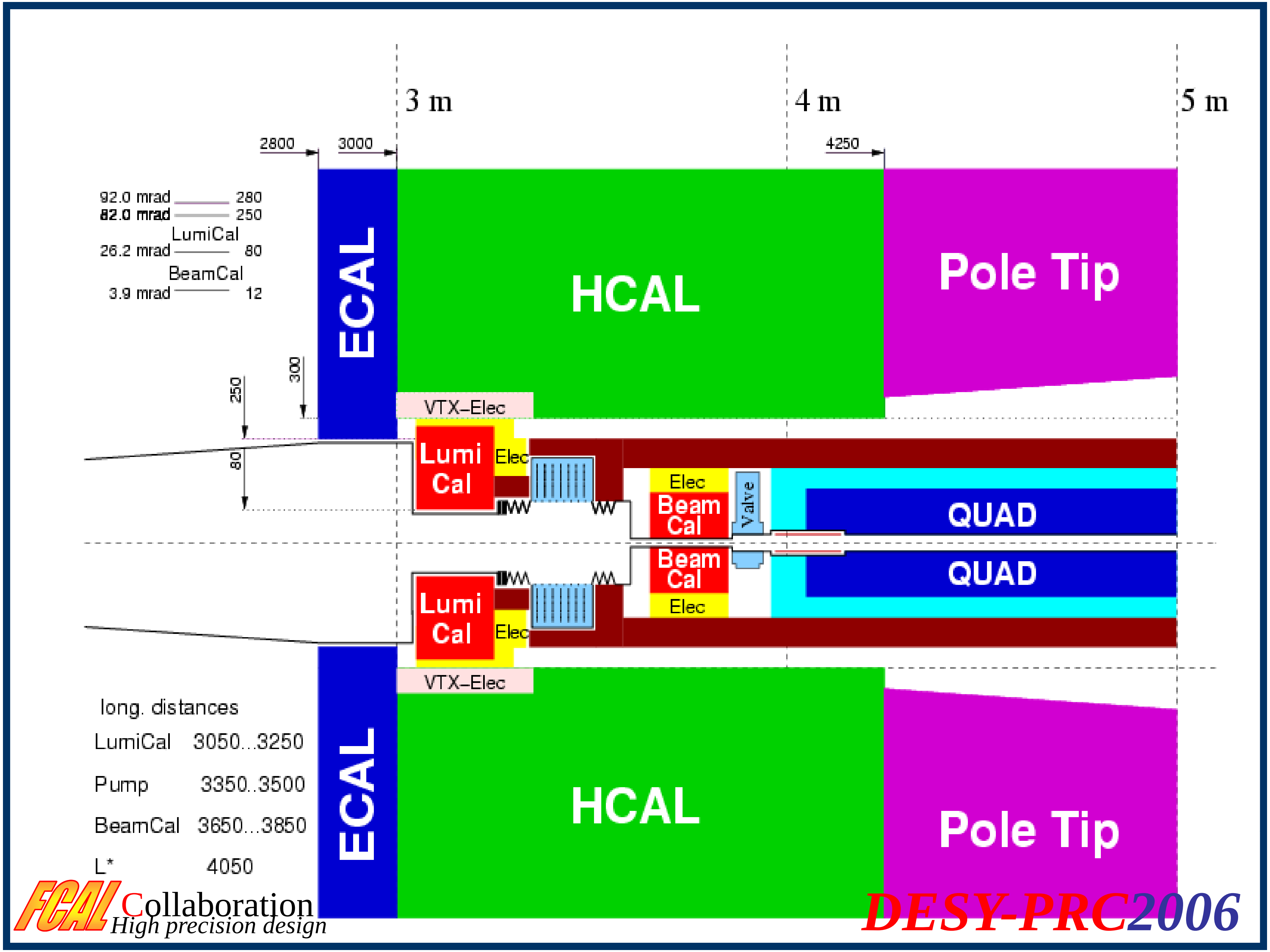
  New gauge bosons, Large extra dimensions, Compositness, Leptoquarks, String excitations..



LumiCal

- Measures *L* to 10^{-4} for Giga Z
- OPAL Luminometer

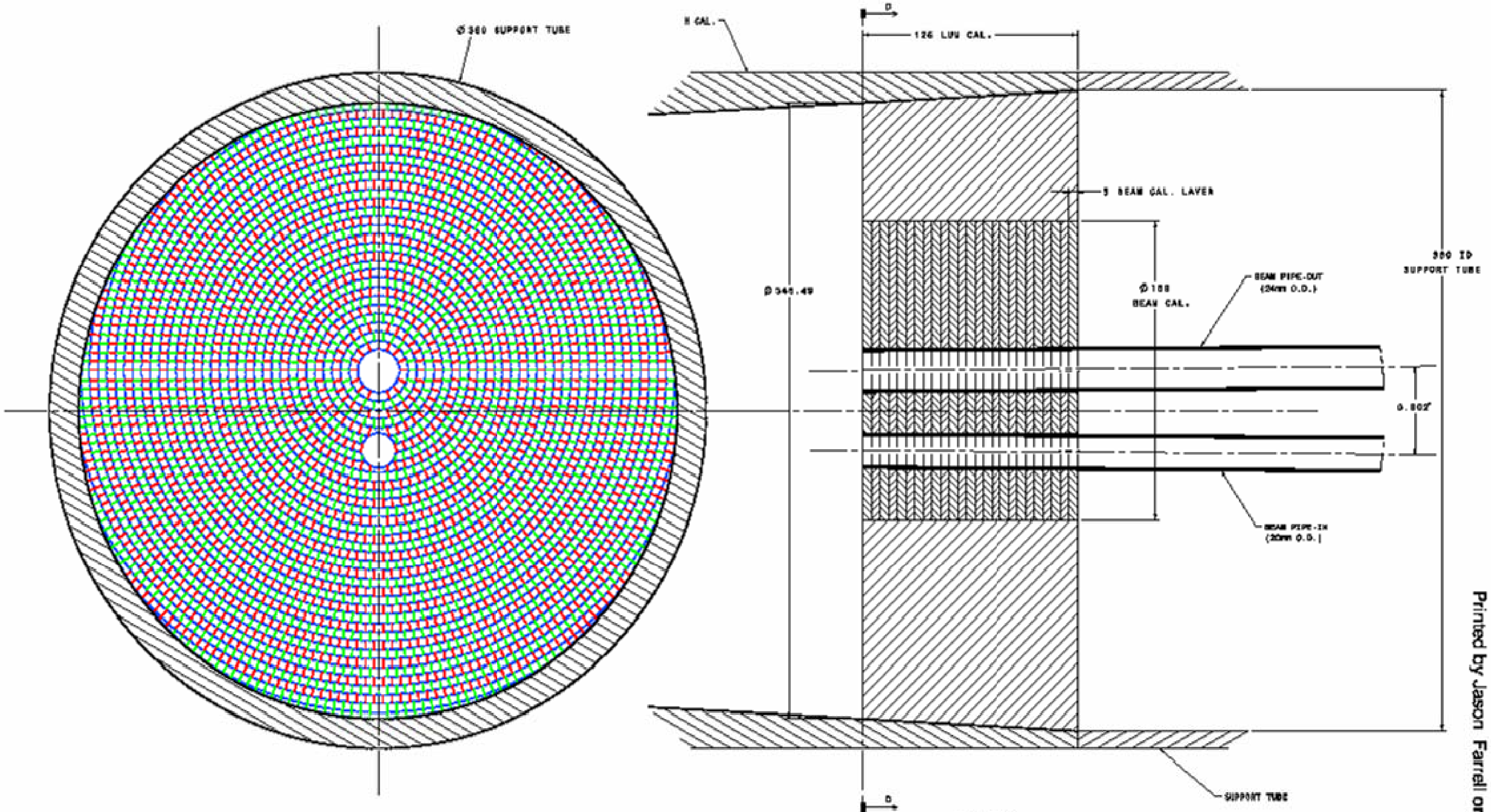
1999 Bhabha syst error	5.4×10^{-4}
dL/L systematic error	3.4×10^{-4}
Energy response dL/L	1.8×10^{-4}
Radial metrology dL/L	1.4×10^{-4}
Distance measurement dL/L	0.5×10^{-4}



3 m
4 m
5 m
2800
3000
4250
92.0 mrad 280
82.0 mrad 250
LumiCal
26.2 mrad 80
BeamCal
3.9 mrad 12
ECAL
HCAL
Pole Tip
300
250
80
VTX–Elec
Lumi Cal
Elec
Beam Cal
Valve
QUAD
QUAD
Beam Cal
Elec
Lumi Cal
Elec
VTX–Elec
ECAL
HCAL
Pole Tip
long. distances
LumiCal 3050...3250
Pump 3350..3500
BeamCal 3650...3850
L* 4050
FCAL Collaboration
High precision design
DESY-PRC2006

BeamCal

- $.003 < \theta < .02$ rad
- Veto ee $\rightarrow$ ee ee events with 99.9% efficiency
- Measure the 10^4 beam-strahlung e^+e^- pairs/BX for beam diagnostics
- 2-10MGy/year



Section view D-D
Scale: 1:1

Detail A(2)
Scale: 1:1

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FCAL R&D Collaboration

- W. Lohmann (DESY Zeuthen) spokesman
- W. Morse (BNL) beam diagnostics (BeamCal/GamCal) coordinator
- B. Pawlik (Cracow) simulations coordinator
- W. Lange (DESY) sensors coordinator
- TBD electronics coordinator
- W. Wierba (Cracow) LumiCal laser alignment coordinator

U.S. Forward (SiD)

- G. Haller, A. Abusleme, M. Breidenbach, D. Freytag (SLAC): BeamCal readout design
- Z. Li (BNL): BeamCal radiation damage issues
- B. Parker (BNL): machine interface issues
- M. Zeller, G. Atoian, V. Issakov, A. Poblaguev (Yale): GamCal design issues
- Y. Nosochkov (SLAC): Extraction line issues
- U. Nauenberg (Colorado): SUSY studies

Luminosity Feedback Detectors: BeamCal and GamCal

- Reference Desgin Report:

2.7.4.2.3 Luminosity feedback Because the luminosity may be extremely sensitive to bunch shape, the maximum luminosity may be achieved when the beams are slightly offset from one another vertically, or with a slight nonzero beam-beam deflection. After the IP position and angle feedbacks have converged, the luminosity feedback varies the position and angle of one beam with respect to the other in small steps to maximize the measured luminosity.

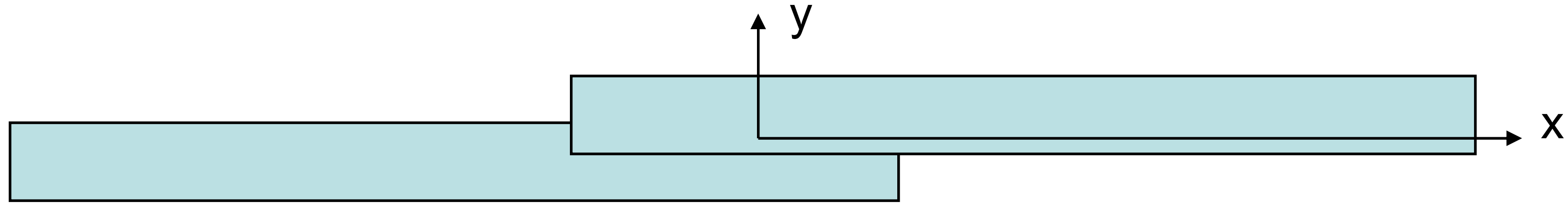
Nominal ILC Parameters

Parameter	ILC	SLC
L ($cm^{-2}\ s^{-1}$)	2×10^{34}	2×10^{30}
σ_y	5nm	500nm
σ_x	500nm	1500nm

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:

$$L(t) \propto \frac{N_+^o \, N_-^o}{\sigma_x^o \, \sigma_y^o}$$



Beam-strahlung

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

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

Bethe-Heitler Pairs

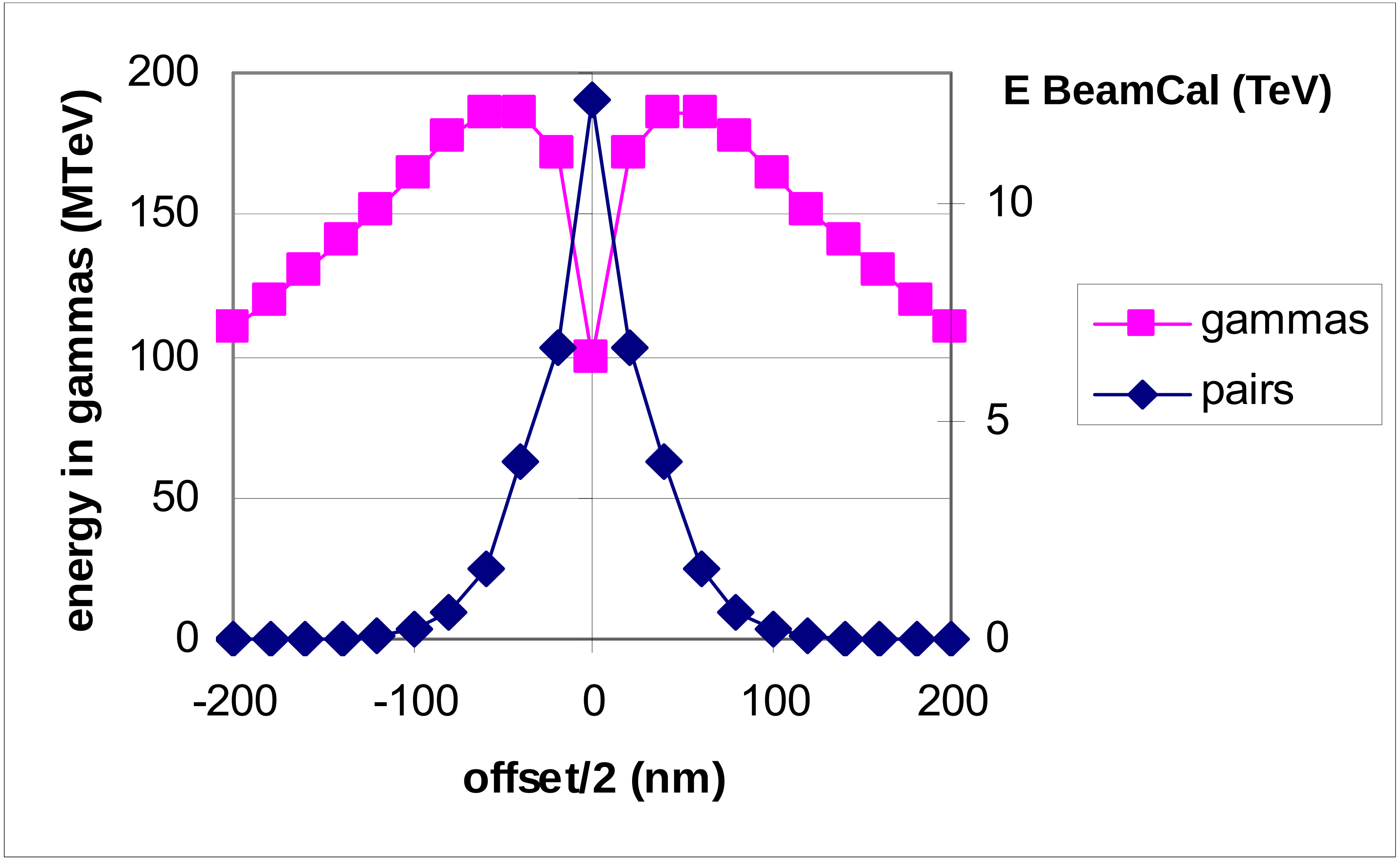
- $\gamma e \rightarrow e\, e^+ e^-$

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

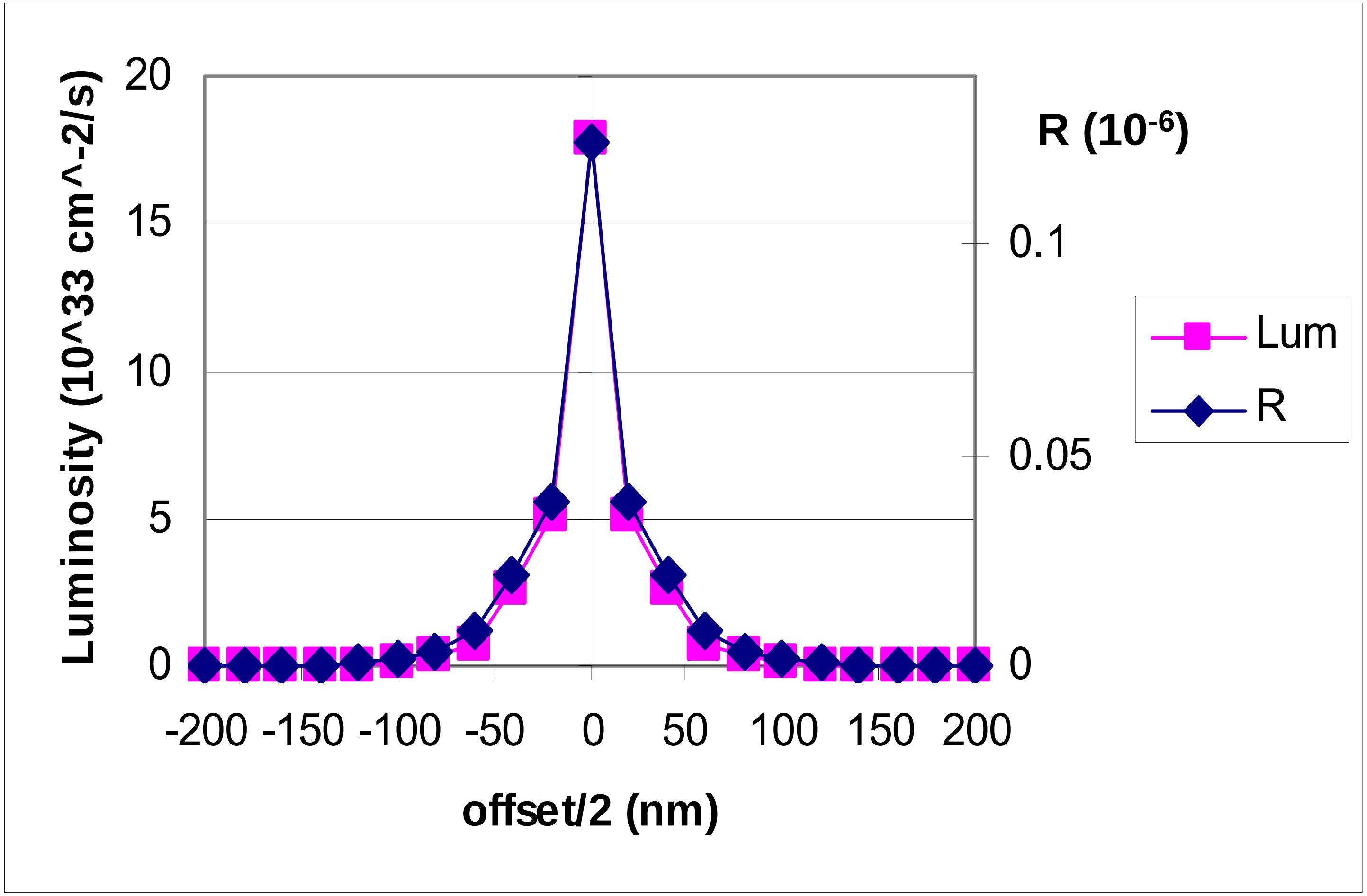
$$\frac{E_{ee}}{E_\gamma} \propto \frac{N_e^o}{\sigma_x^o \sigma_y^o}$$

For left and right detectors separately: $N^+/\sigma_x\sigma_y$ and $N^-/\sigma_x\sigma_y$.

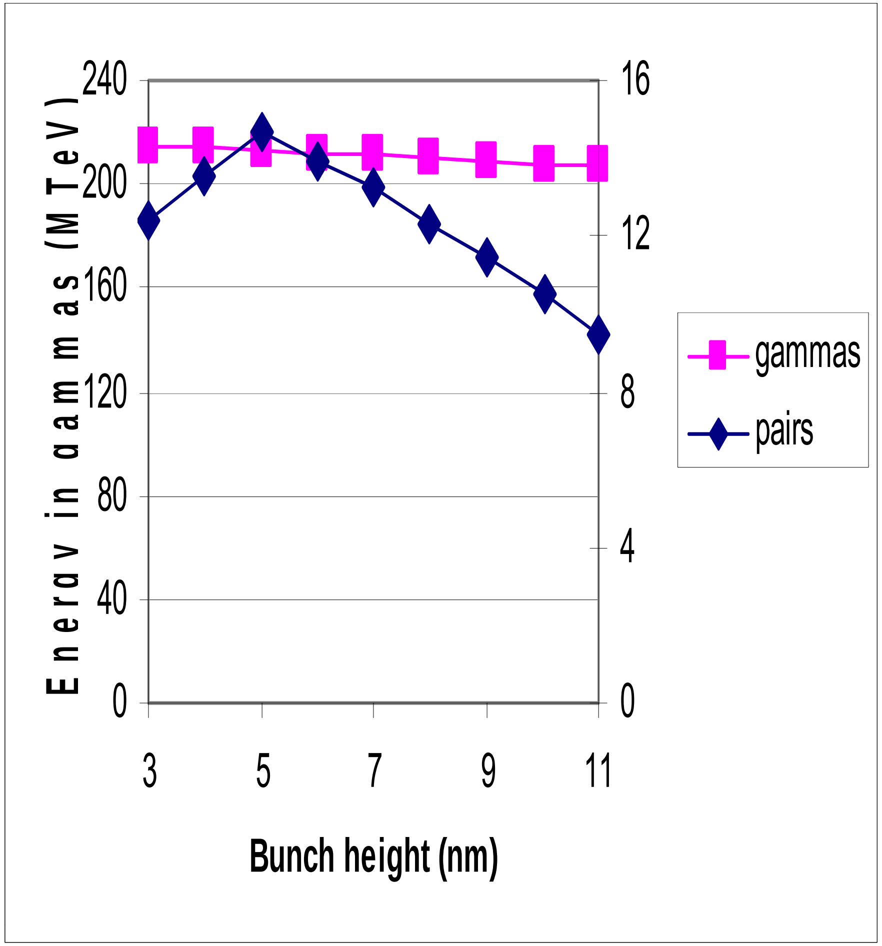
Vertical offset

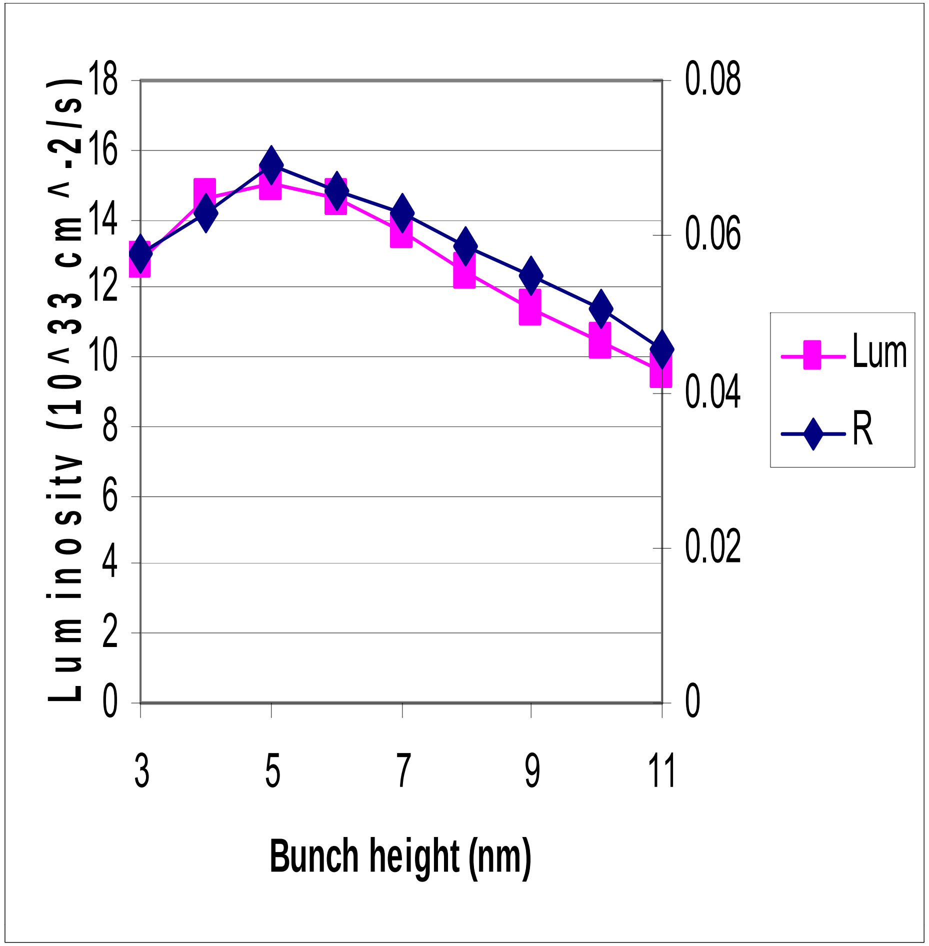


Vertical Offset

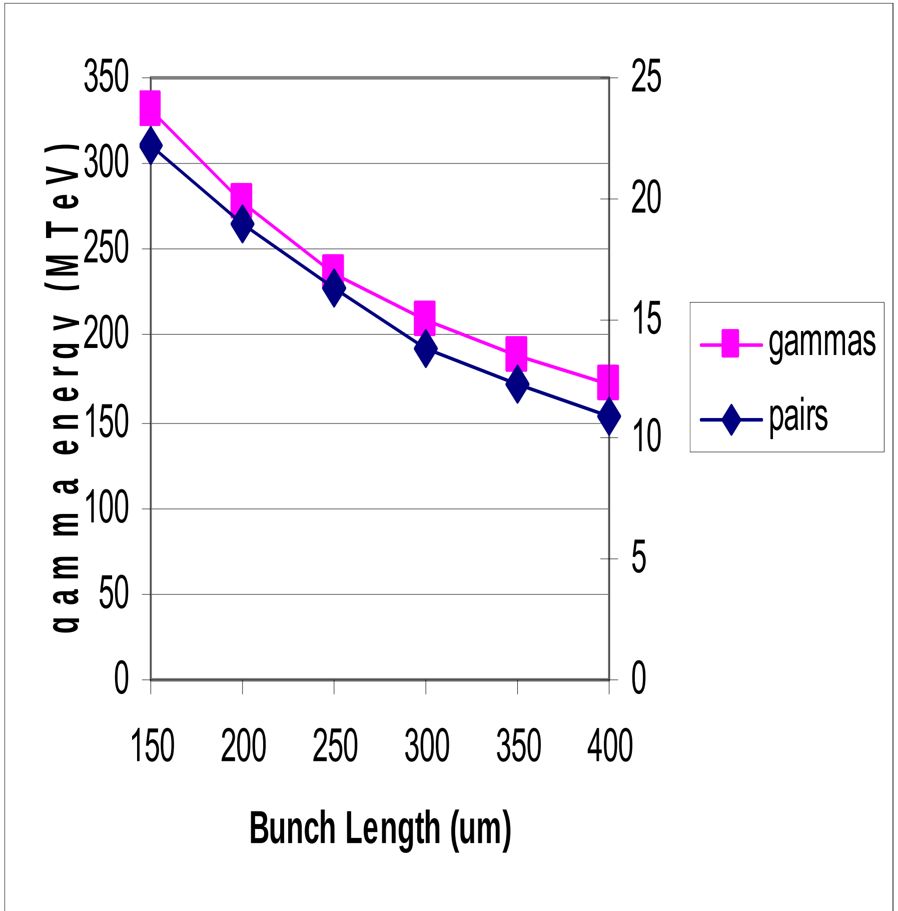


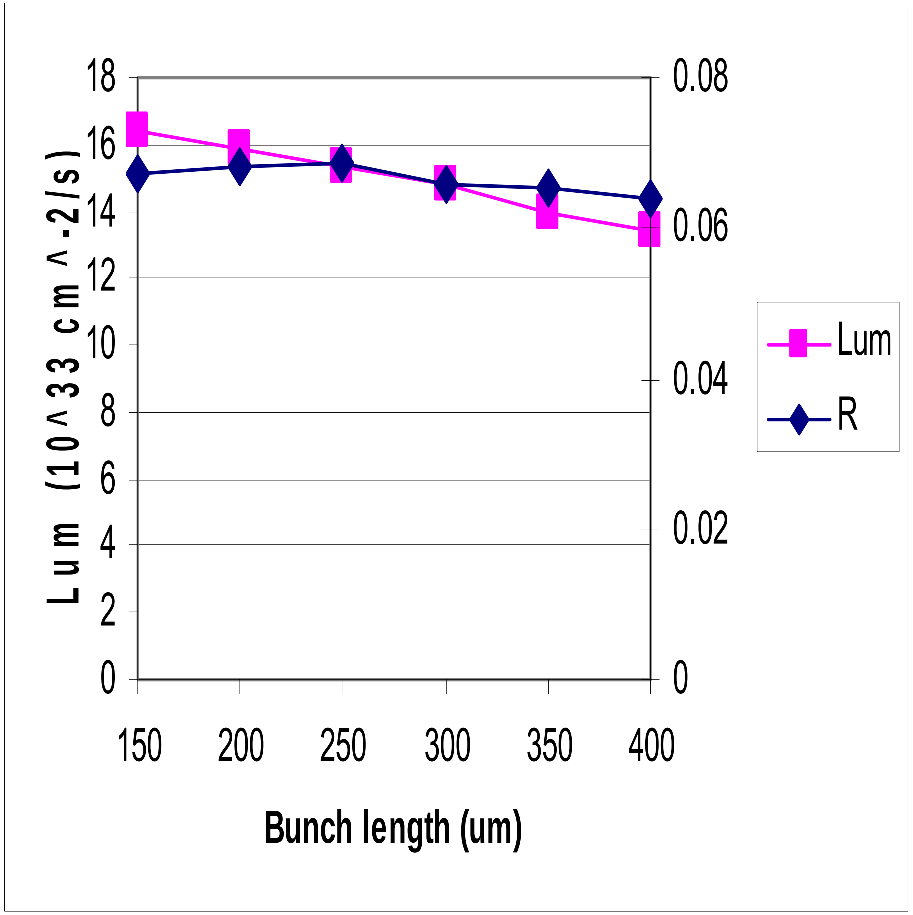
Bunch Height





Bunch Length

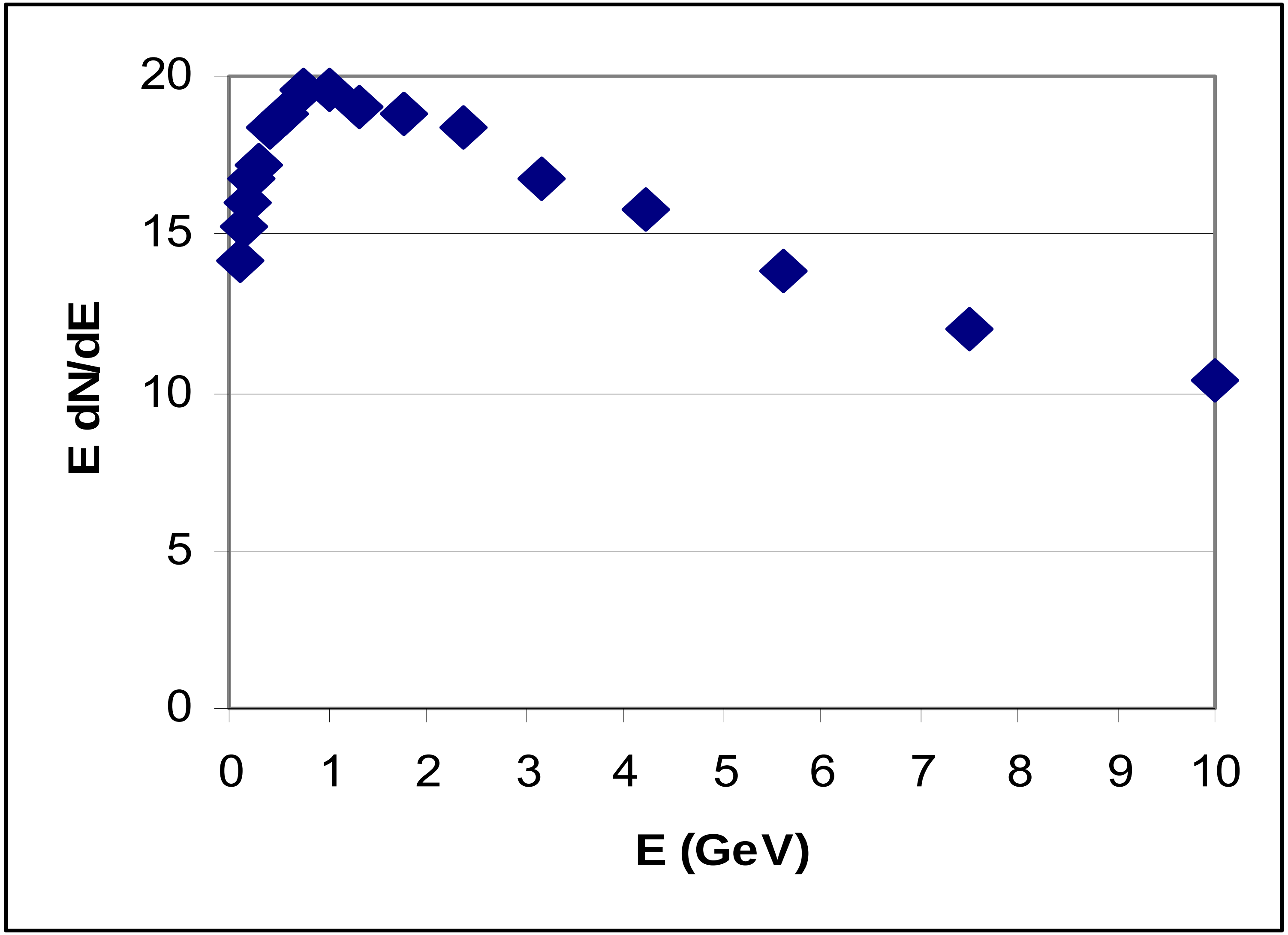




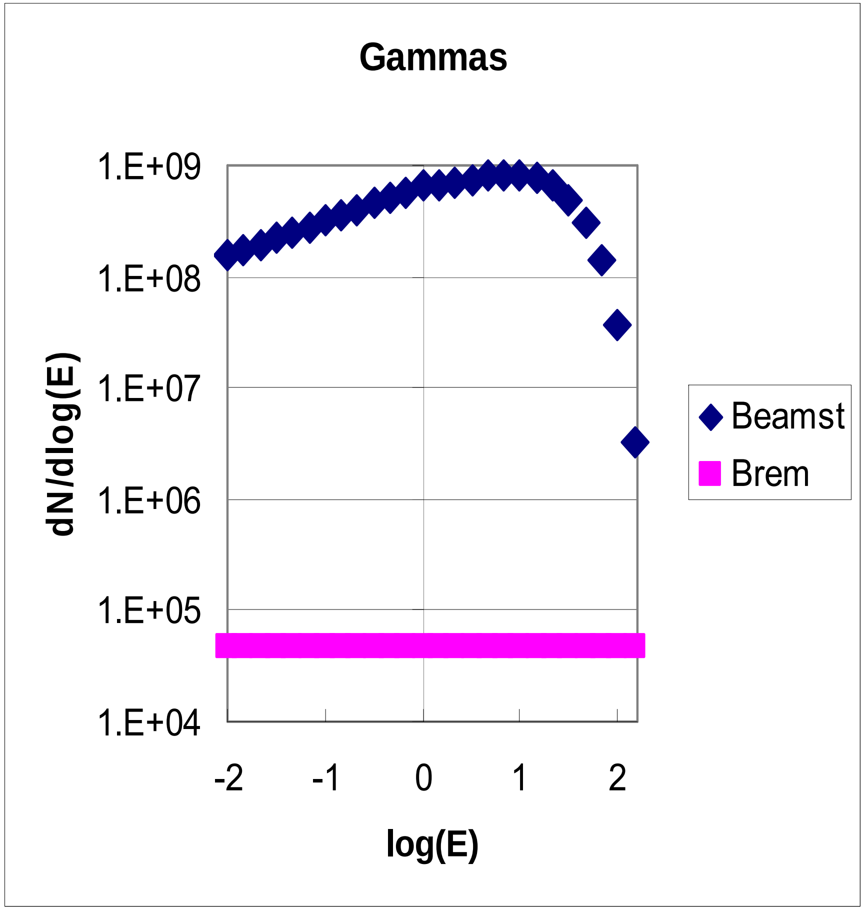
GamCal Detector Concepts

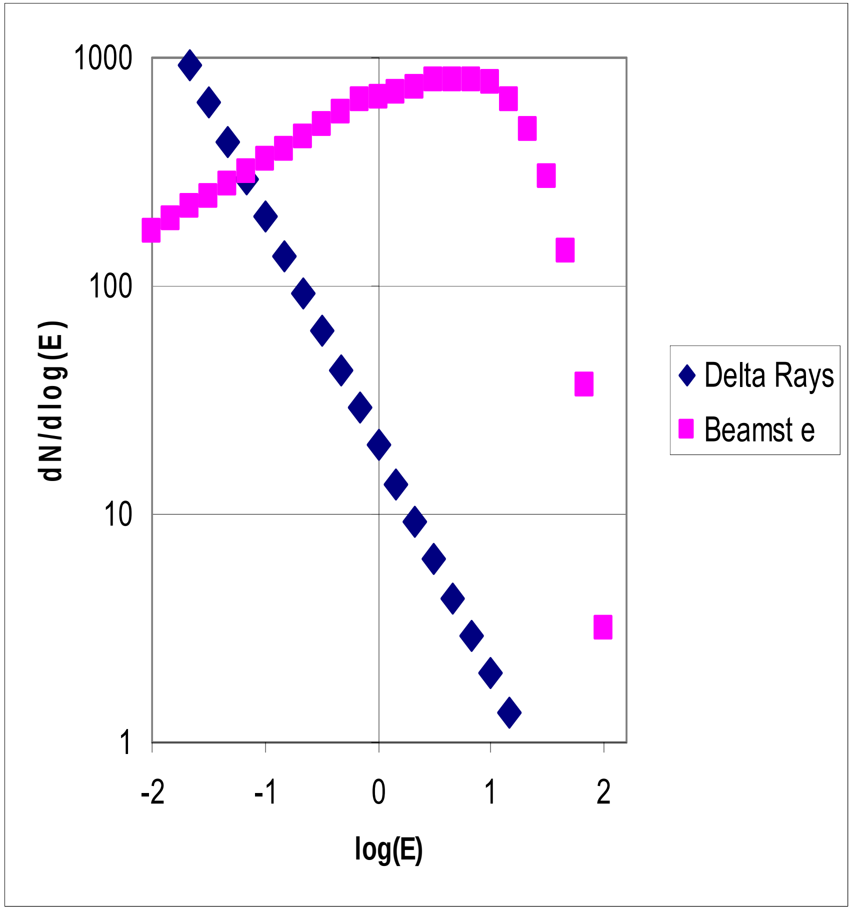
- 14mrad crossing angle
- ≈180m downstream of IP
- 10^{-4} - 10^{-6} X_0 to convert beam-strahlung gammas into e^+e^- pairs
- Converter could be gas jet or a thin solid converter
- Magnet to separate pairs from beam electrons

Beam-strahlung $\gamma Z \to eeZ$



GamCal Backgrounds



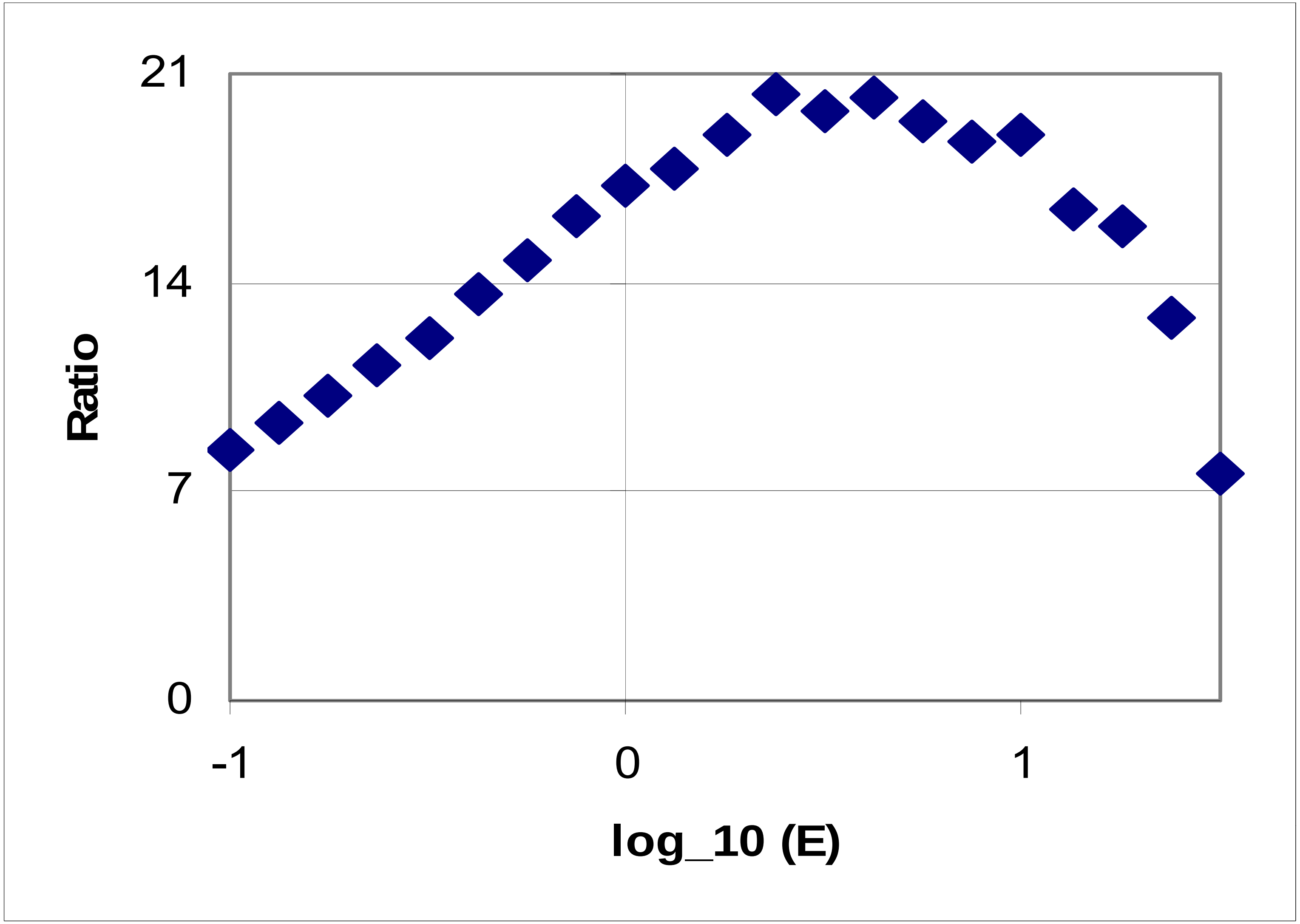


$\gamma Z \rightarrow eeZ$ vs. $eZ \rightarrow eZee$

- Electron carries virtual gammas
- Landau Lifshitz conversion of virtual gammas

$$\frac{dN}{d\omega} = \frac{2\alpha}{\pi}\frac{1}{\omega}\left[\ln\frac{1.1\gamma c}{\omega b_{\min}} - \frac{1}{2}\right]$$

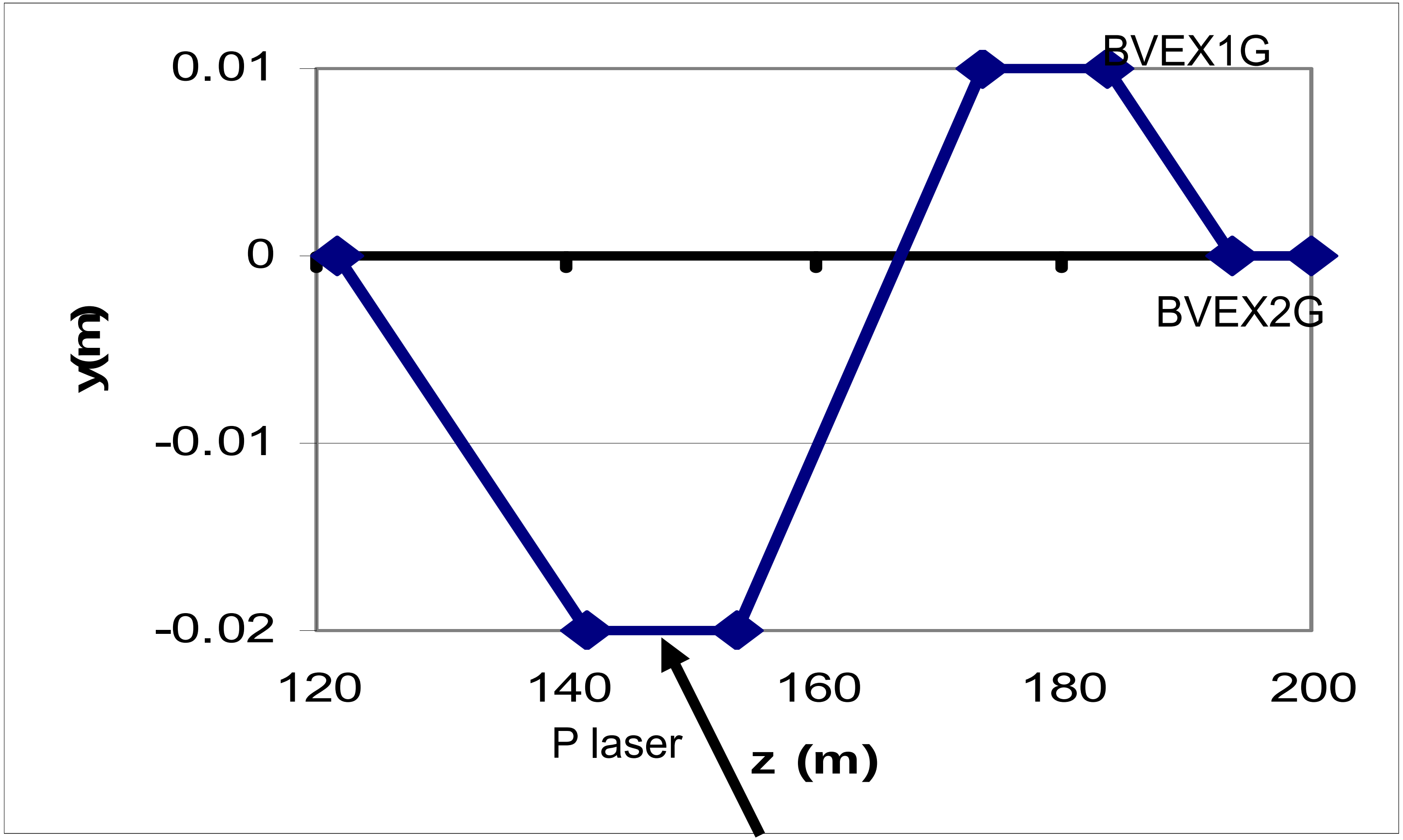
Ratio of $\gamma Z \rightarrow eeZ$ vs. $eZ \rightarrow eZee$



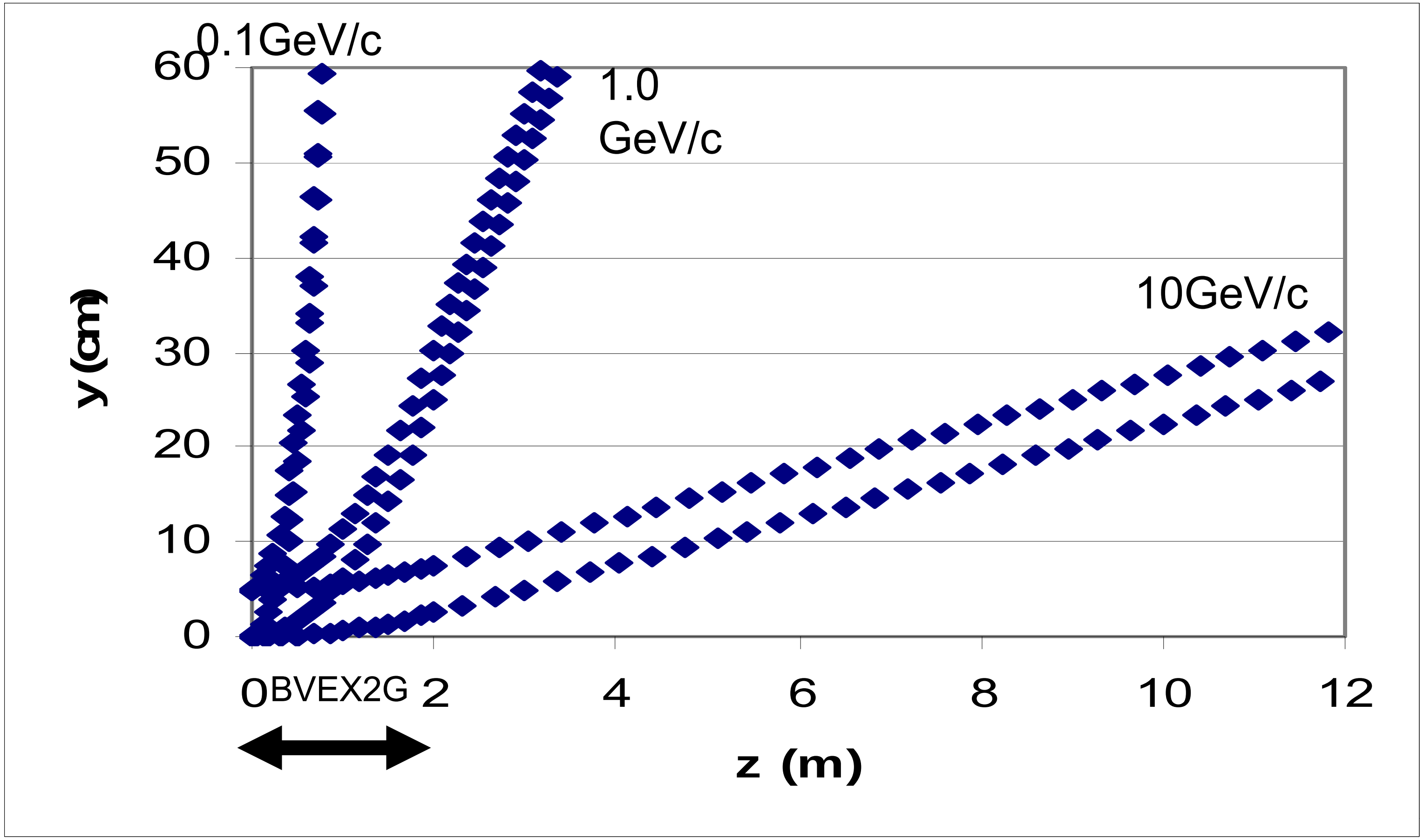
π Production Compared to ee

- $\gamma p \rightarrow eep \quad \sigma \approx 10$ mb
- $\gamma p \rightarrow \pi N \quad \sigma \approx 0.5$ mb in resonance region
- $\gamma p \rightarrow \pi N \quad \sigma \approx 0.1$ mb $\quad E > 4$GeV
- $ep \rightarrow e \pi N \quad \sigma \approx 10^{-3}$ mb
- Thus $ep \rightarrow e \pi N$ is negligible

Polarimeter/Gamma Chicane



BVEX2G Magnet Works Well



FY07 LCDRD R&D Request

- Univ. of Colorado $76K
- BeamCal Physics Simulations
- Yale University $40K
- GamCal Design Studies
- BNL $390K
- MCZ Si for BeamCal, Integration of Detectors and Beamline, GamCal
- Collaborators: SLAC, DESY Zeuthen

Milestones

- **FY07 Project Activities and Deliverables**

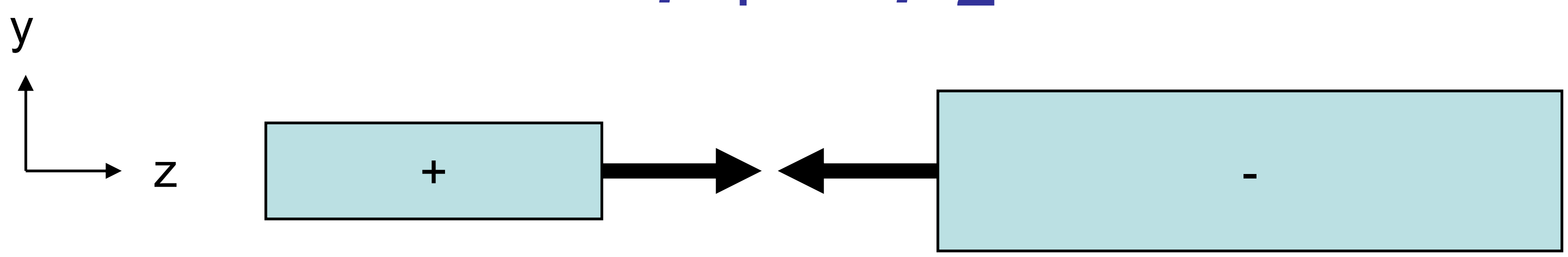
1. Concept for detectors integrated with extraction
2. Radiation hardness studies completed
3. Concept for readout

- **Project Activities and Deliverables FY08-9**

1. Prototypes in test beam
2. Efficiency detecting 2 photon processes in SiD
3. Final conceptual design

Extra Slides

$\rho_1 \neq \rho_2$



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

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

Perfect Collisions

$$E_\gamma \propto \frac{N^2}{\sigma_x^2 \sigma_z}$$

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