Compton Calorimeter at 11 GeV

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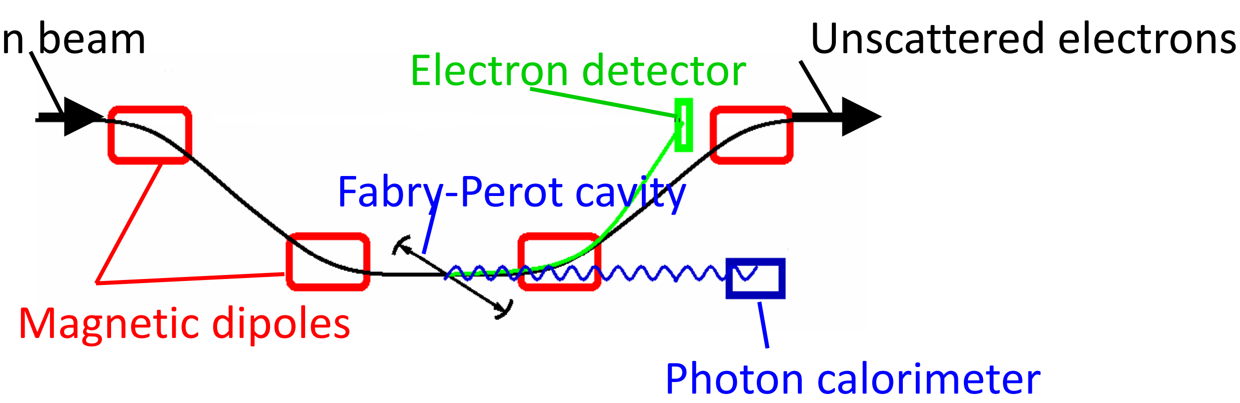
1) Compton Scattering at 11 GeV
   - Compton energy scaling
   - Asymmetries
   - Calorimeter crystal resolution
2) Synchrotron Light
   - Scaling with energy
   - Dependence on fringe field and aperture
   - Possible beamline modifications for 11 GeV



Compton Edge: $$k_{max} = a4\gamma^2 k_0$$

$$\begin{aligned} k_0 &= photon\ energy \\ \gamma &= E_e/m_e \\ a &= 1/(1 + 4\gamma k_0/m_e) \end{aligned}$$

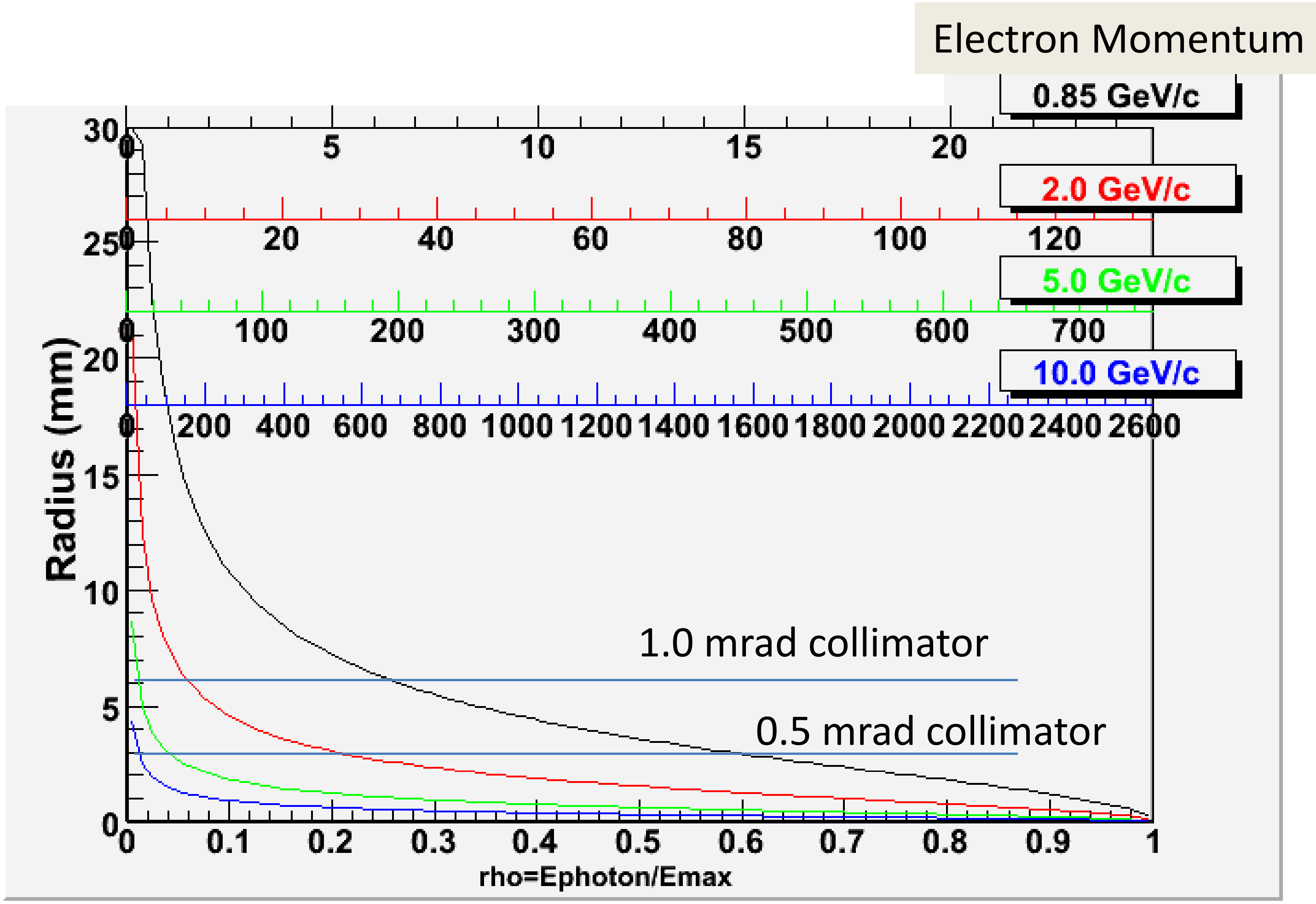
Asymmetry: $$A_{max} = A(k = k_{max}) = \frac{1-a^2}{1+a^2} = \eta \frac{1+\eta^2/2}{1+\eta+\eta^2/2}$$

$$\eta = 4\gamma k_0/m_e$$

Cross Section: $$\sigma = \pi r_0^2 a(1 + higher\ order\ in\ \eta)$$

E_e (MeV)	$k_0 = 1.165eV$ (IR) a	k_{max} (MeV)	A_{max}	$k_0 = 2.33eV$ $(green)$ a	k_{max} (MeV)	A_{max}
1,375	.976	33	.024	.953	64	.048
2,750	.953	129	.047	.911	246	.093
5,500	.911	492	.093	.836	903	.177
11,000	.817	1,806	.177	.718	3,101	.320

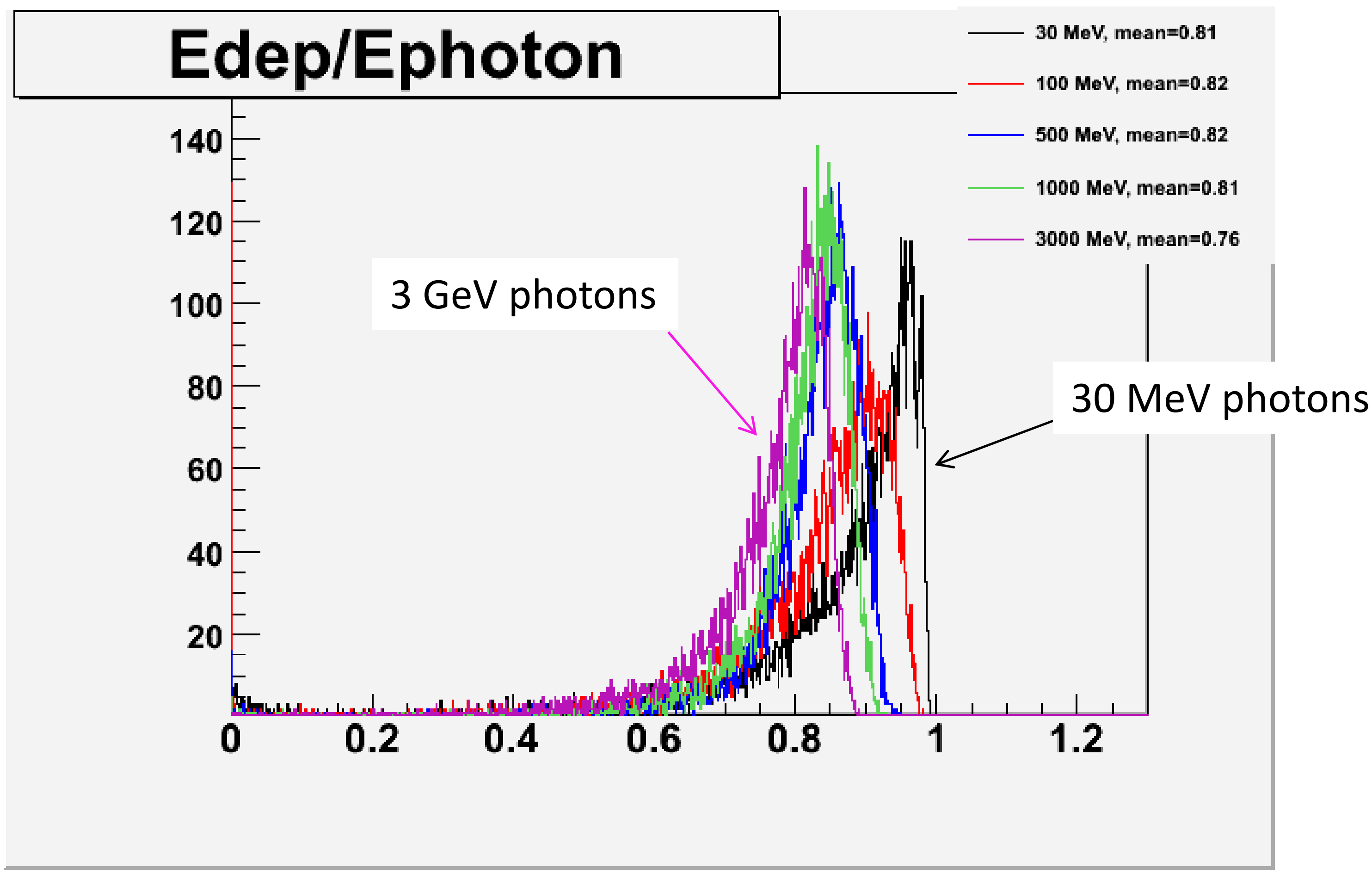
Angular cone of Compton photons



Compton Photon Radius at 6 meters vs Photon Energy

GSO Crystal Resolution

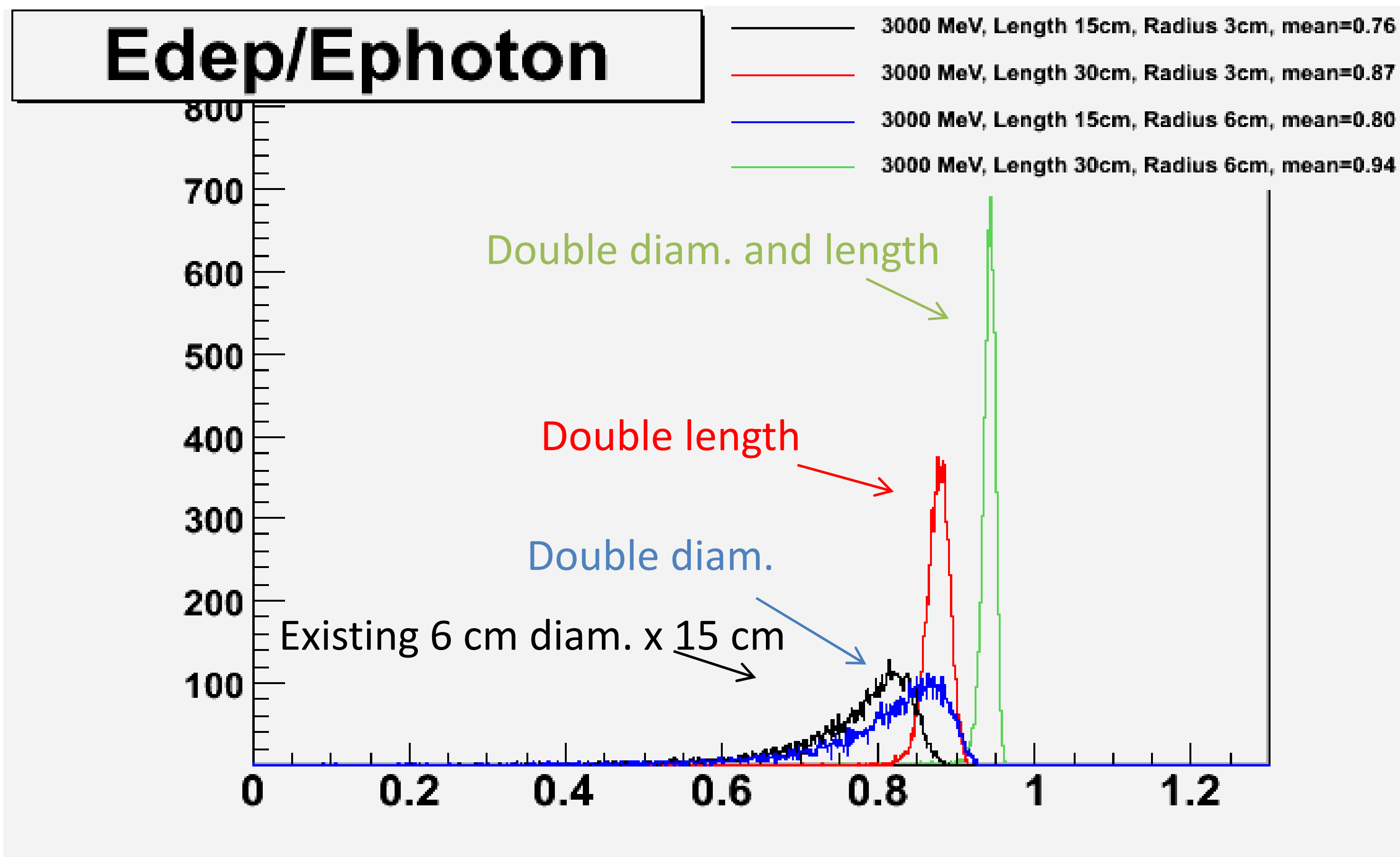
GEANT4 simulations for 5 photon energies
existing Hall A GSO Crystal (6 cm diam x 15 cm)



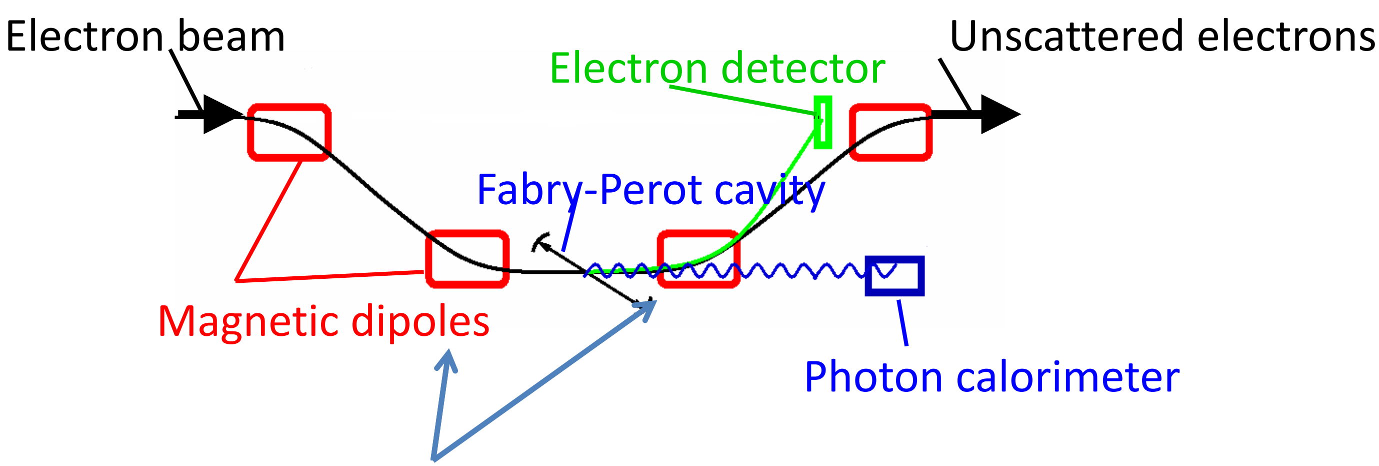
GSO Crystal Resolution

Simulations of larger crystals
3.0 GeV incident photons
~150 photo electron/ MeV deposited

Better to use cheaper, bigger crystal? Lead-glass?



Synchrotron Radiation



Photon calorimeter sees synchrotron light from dipoles #2 and #3

Synchrotron Radiation

Synch. radiation for 1 electron bent thru angle $\Delta\,\theta$:

$$\frac{dE}{d\theta}\Delta\theta = \frac{2}{3}\alpha\frac{\hbar c}{R}\gamma^4\Delta\theta$$

For 11 GeV running: R = 22.8 m, γ= 2.2 $\times$ 10^4, γ^4=2 $\times$ 10^{17}

Energy radiated by an electron for $\Delta\,\theta$ = 0.001

$$E = 4\times 10^{-17} MeV \gamma^4 \Delta\theta = .008 MeV$$

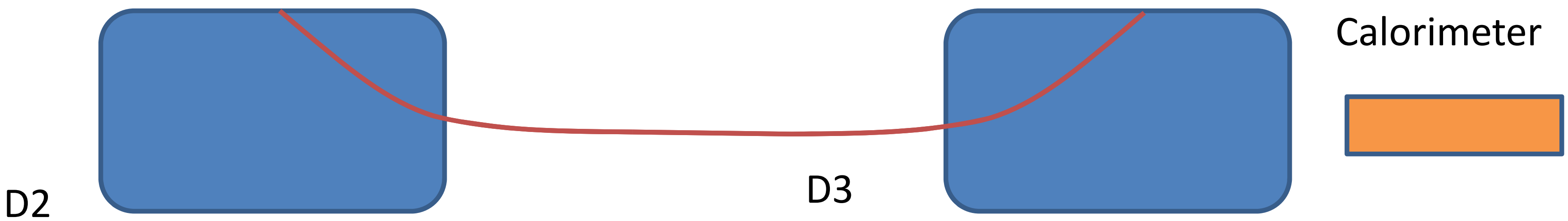
For 100 μ A beam

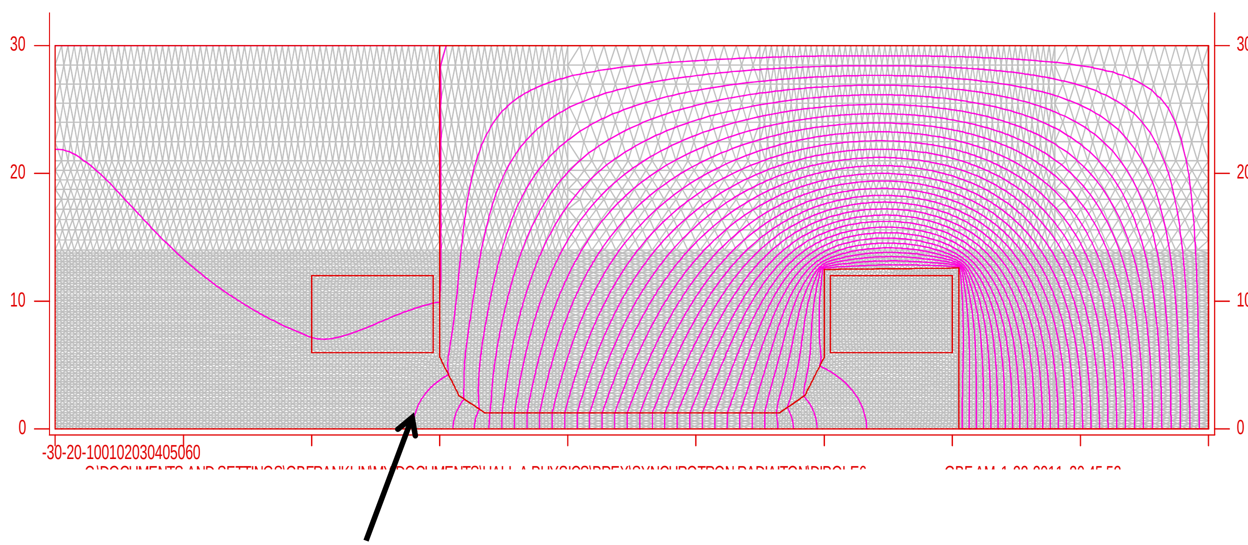
$$P = .008 MeV/electron \times 6.2\times 10^{14} electron/s = 5\times 10^{12} MeV/s$$

Compare to Compton signal

$$P = \frac{1}{2}(3100\ MeV)(10^5 Compton\ events/s) = 1.6\times 10^8\ MeV/s$$

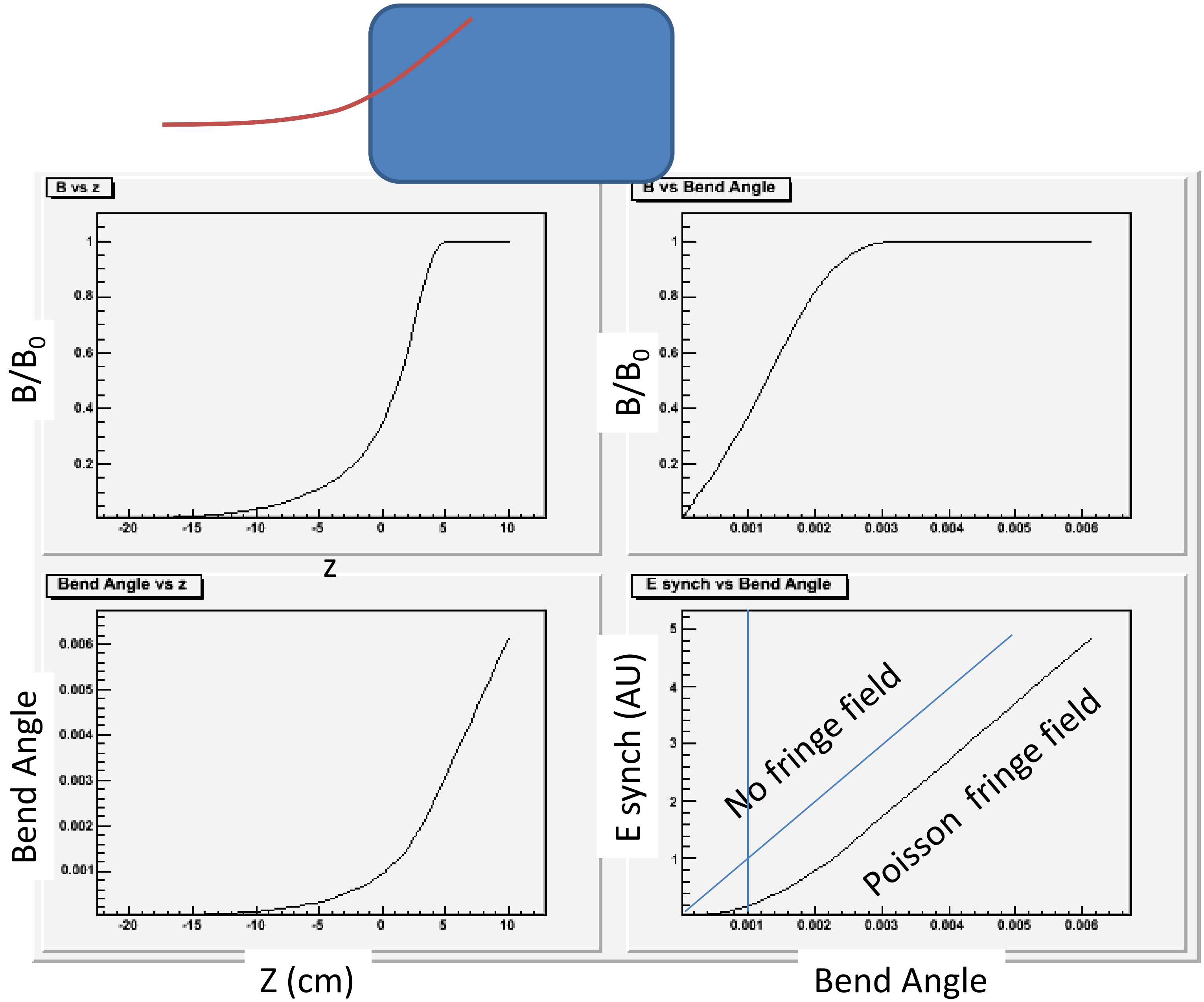
Only exit of Dipole 2 and entrance of Dipole 3 contribute



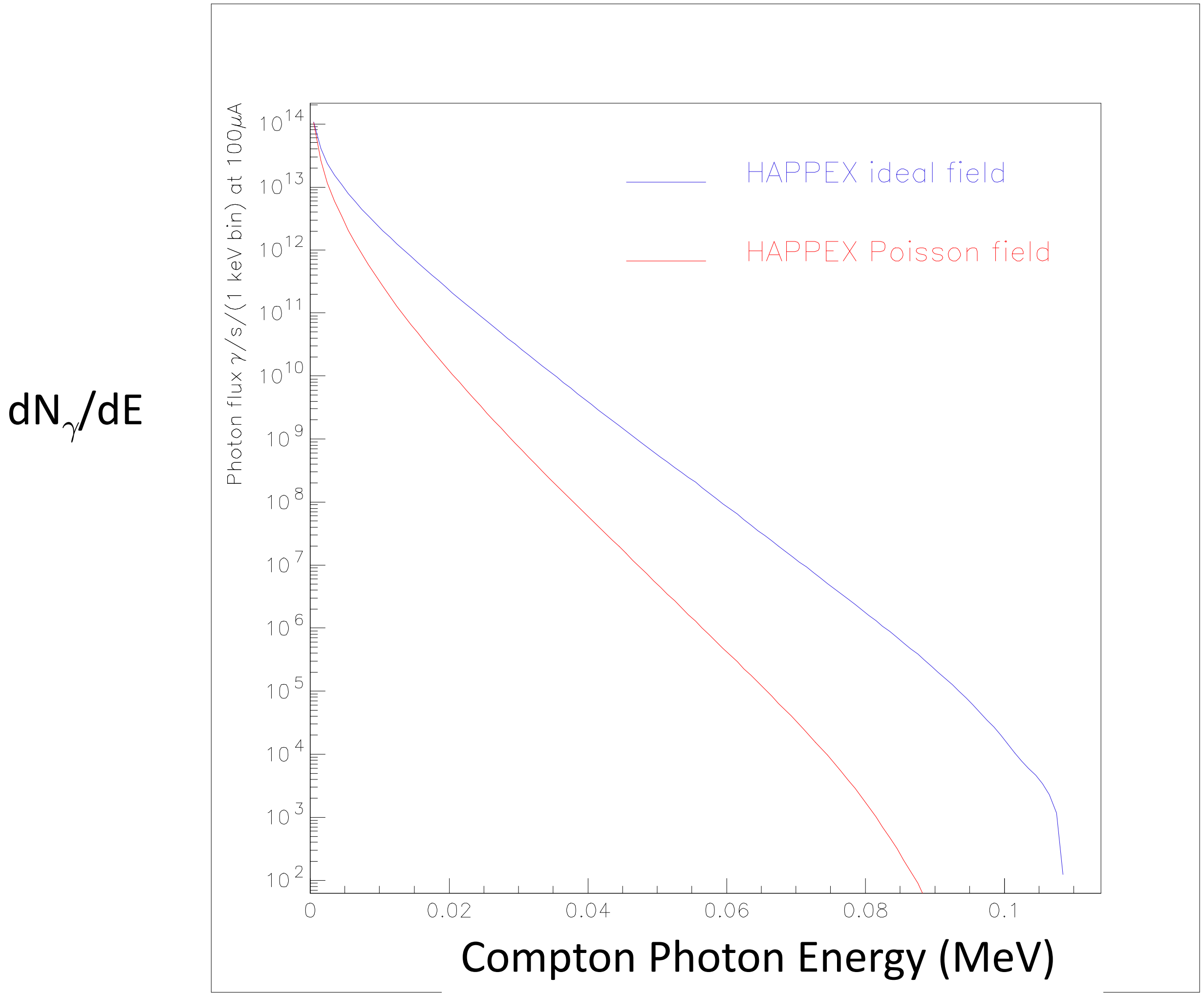


Poisson 2D simulation of fringe field

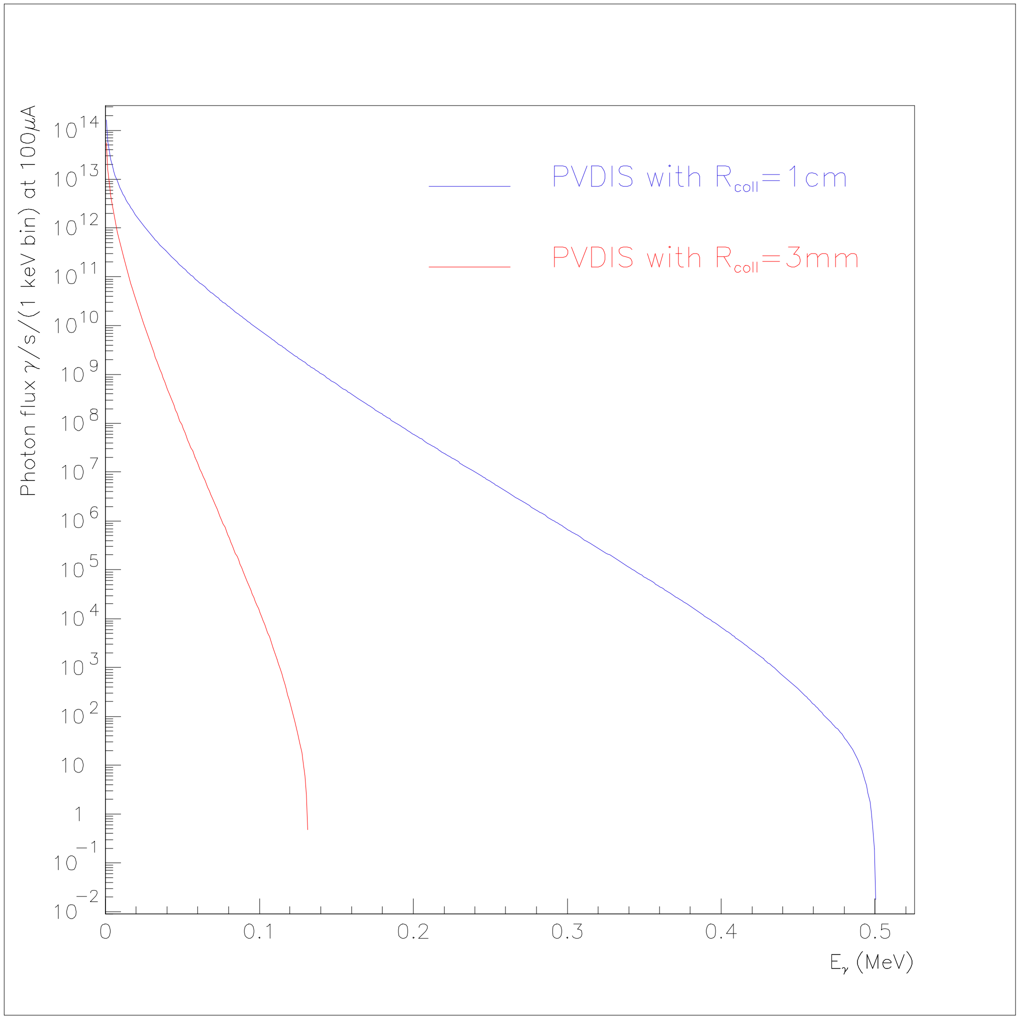
Results using Poisson fringe field



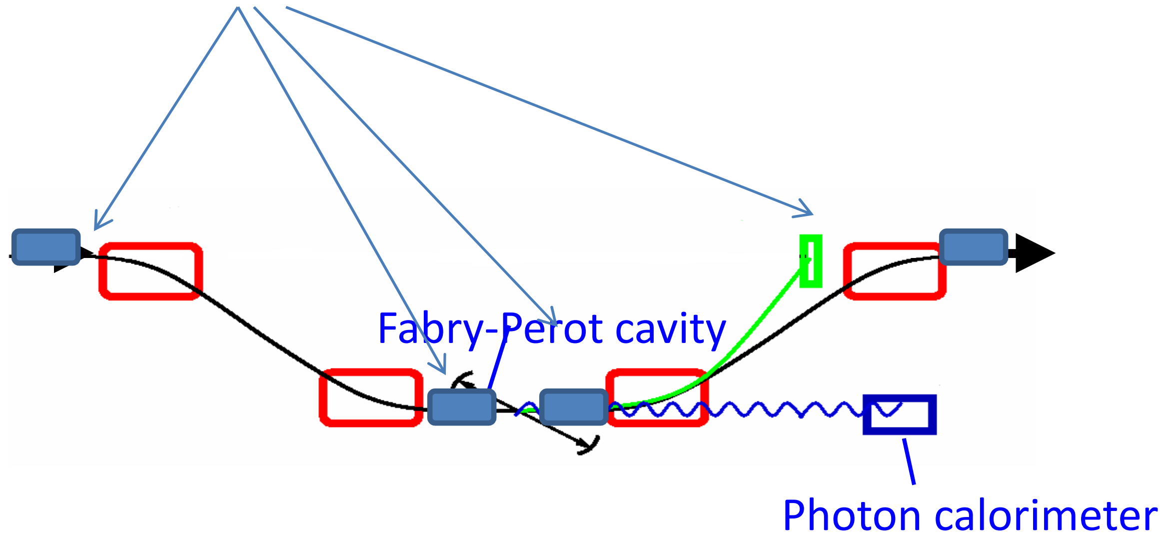
B. Quinn's simulation of energy distribution
Fringe field reduces flux AND softens energy distribution



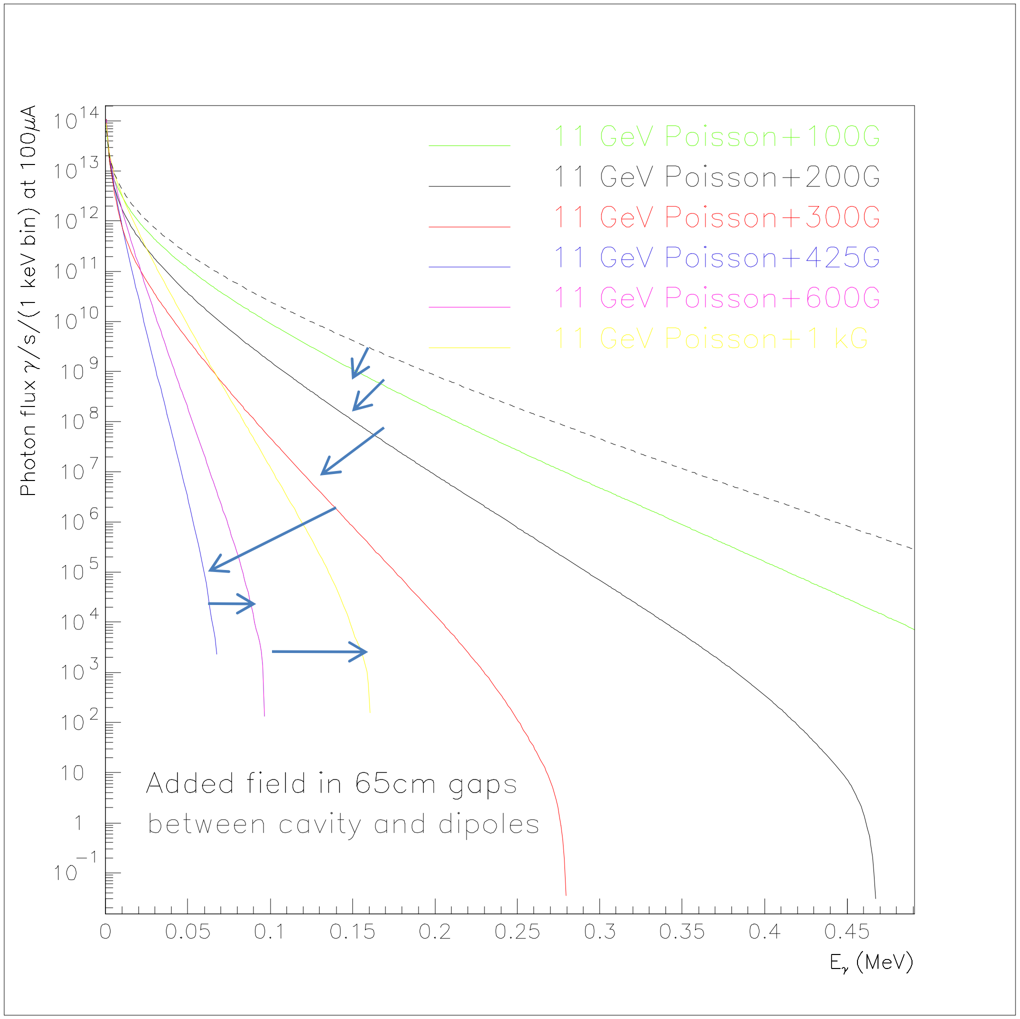
Wide collimator used at start of PVDIS produced hard synchroton beam



Consider adding low-field dipoles

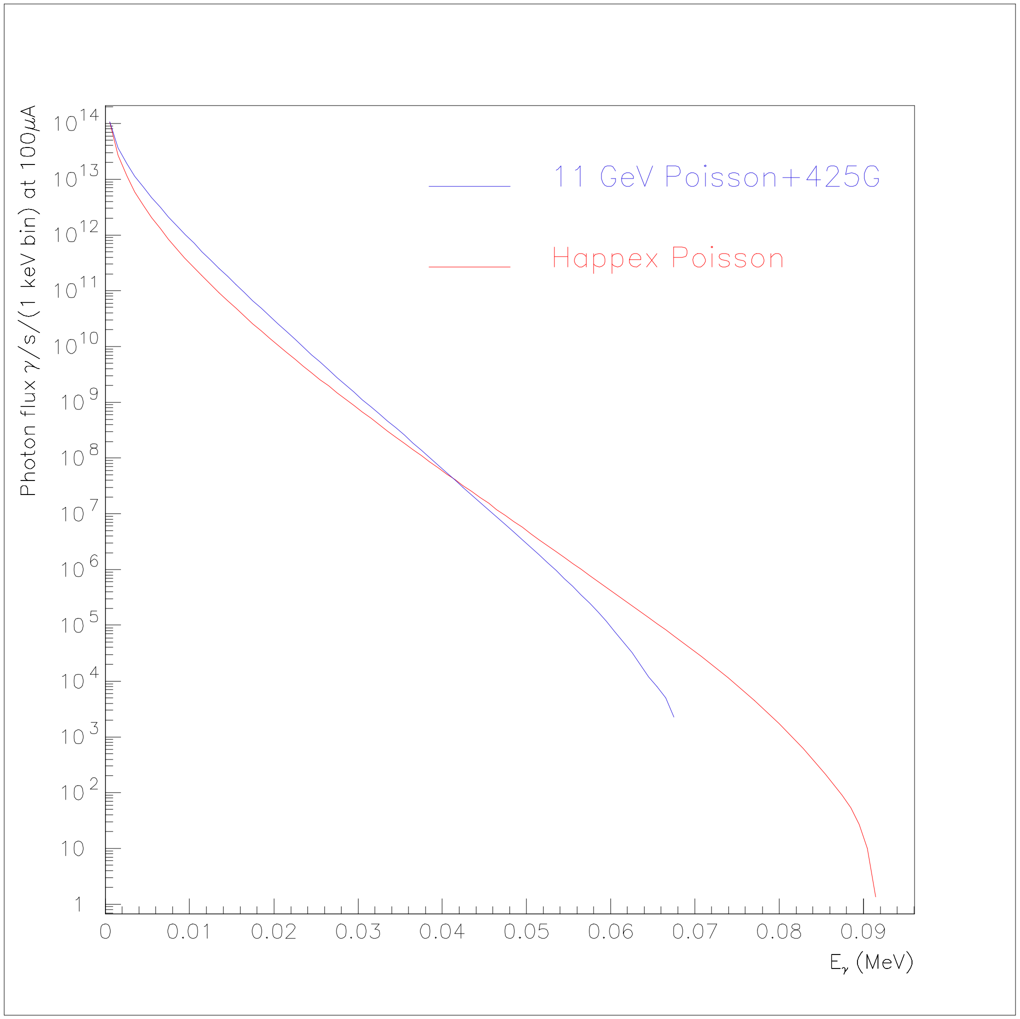


Consider adding 65 cm low-field coils before and after interaction point



Bottom Line

Added low-field dipoles can reduce 11 GeV/c synchrotron radiation to levels encountered during Happex



Conclusions

Crystal

- GSO not optimal
- Bigger crystal would improve resolution
- Less photo electrons OK?
- Maybe use Lead Glass?

Synchrotron Radiation

- Important to model fringe field and collimator correctly
- Adding low B-field regions greatly reduces background

- Crystal Properties

	PbWO4	BGO	GSO	CeF_3	BriLanCe 380	PreLude 420
Density (6/cm^3)	8.30	7.13	6.70	6.16	5.29	7.1
Rad Length (cm)	0.90	1.12	1.39	1.68	~1.9	1.2
Moliere Radius (cm)	2.0	2.3	2.4	2.6	?	?
Decay time (ns)	50	300	56:60	30	16	41
Light output (% NaI)	0.4%	9%	45%	6.6%	165%	84%
photoelectrons (# / MeV)	8	170	850	125	3150	1600
					$$$ 4 in max	Natural decay