# Lead Glass Damage

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# Need For Radiation Hardened Glass(RHG)

- Previous experiments indicate F8 lead glass darkens with radiation dosage
  - RadPhi
- How much is needed?
- Cost and resolution necessitate balance
- Need to simulate damage in FCAL

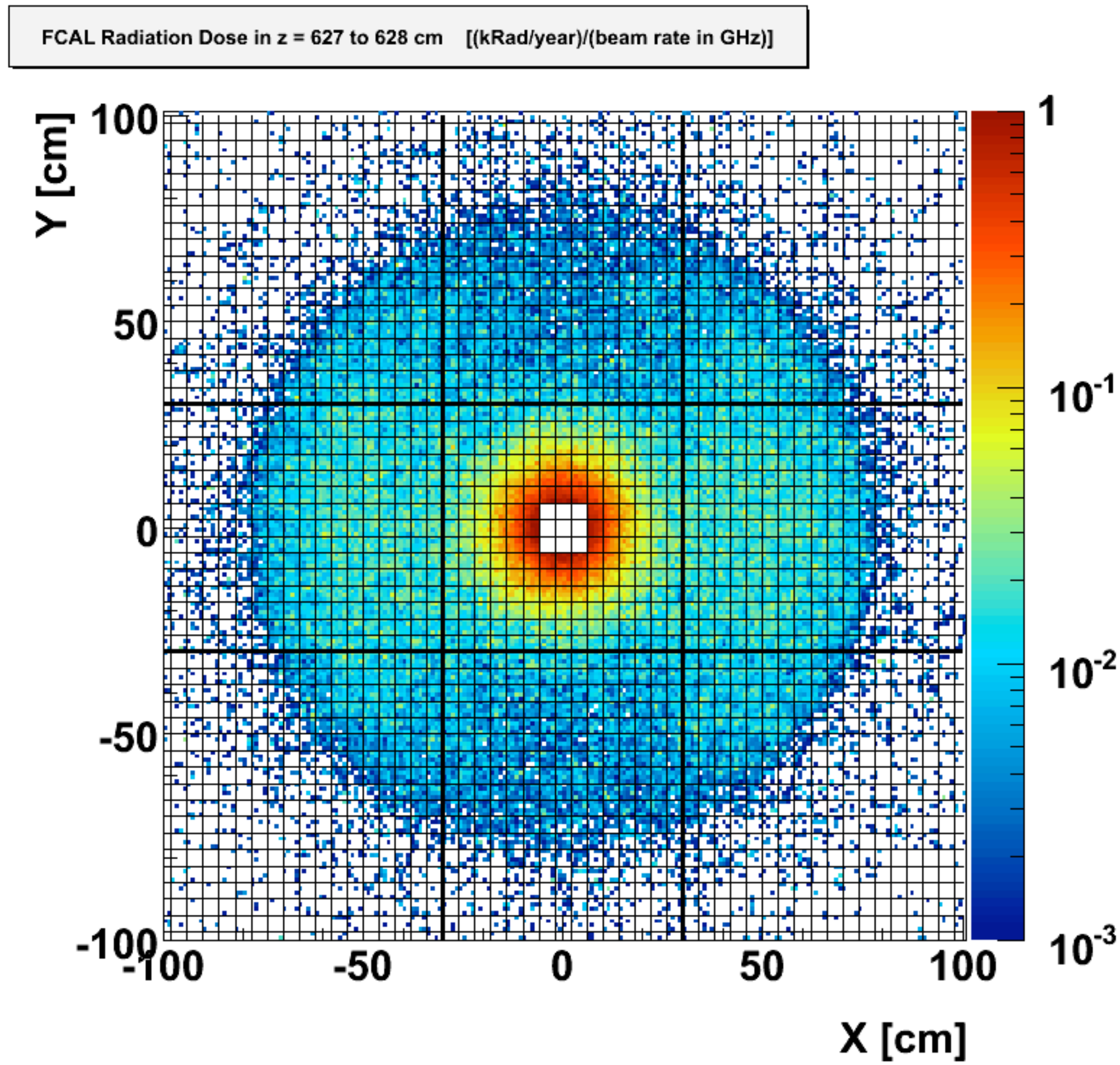
# Outline

- 1: Calculate electromagnetic background within FCAL for standard GLUEX run
- 2: Damage the standard F8 block at IUCF with 20MeV electrons and describe how radiation dosage affects the transmission
- 3: Insert radiation damage model into HDGEANT
- 4: Run simulations to determine the effect on energy resolution of radiation damage of the lead glass

# 1:Calculating the EM background

- Ryan Mitchell's simulation of expected dose in FCAL from electromagnetic background
  - Radiation dose in slices of z (along length of bars)
  - Units in kRad per year per beam rate (photons from radiator) in GHz

So red is 10kRad per year at $10^8$ photons on target per second

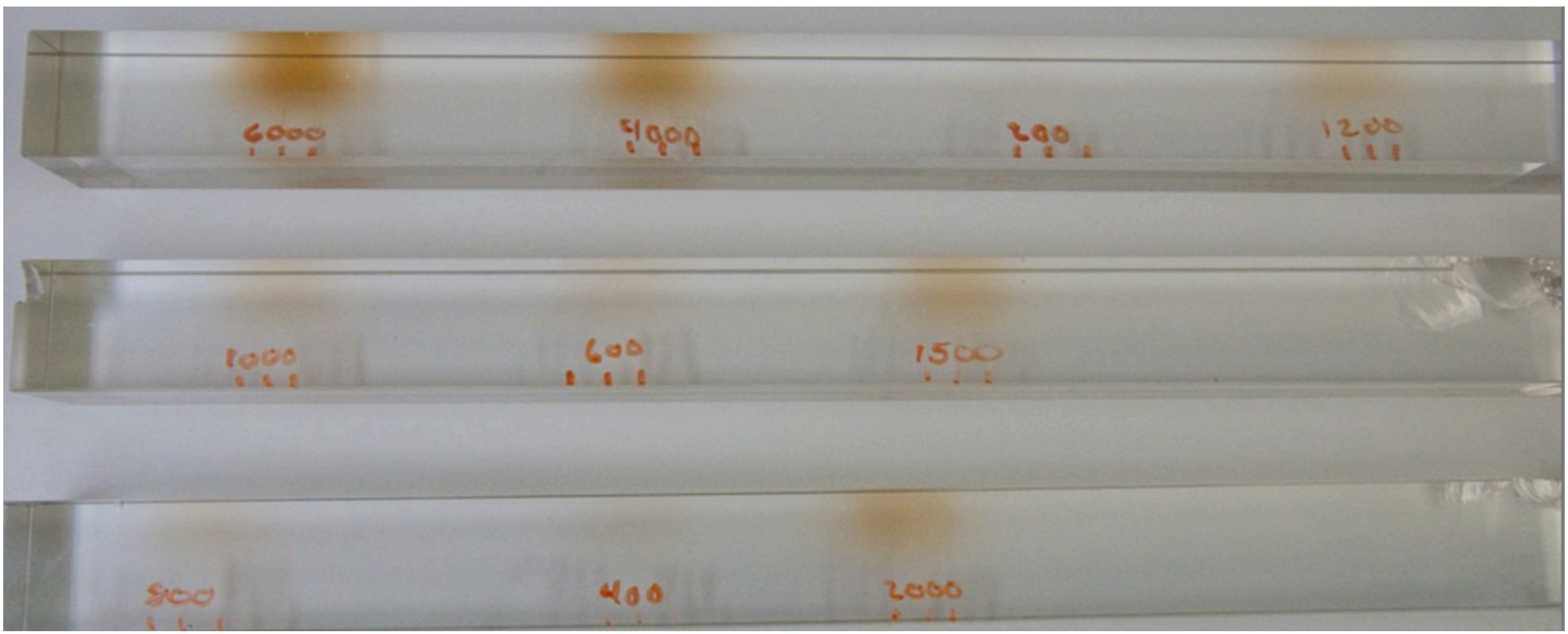


# 2:Damaging the F8 Block

- Used a Medical Linear Accelerator at IUCF
  - 20MeV electrons at 2 cm X 2 cm section
  - Dosed blocks 200 to 6000 “Monitor Units”

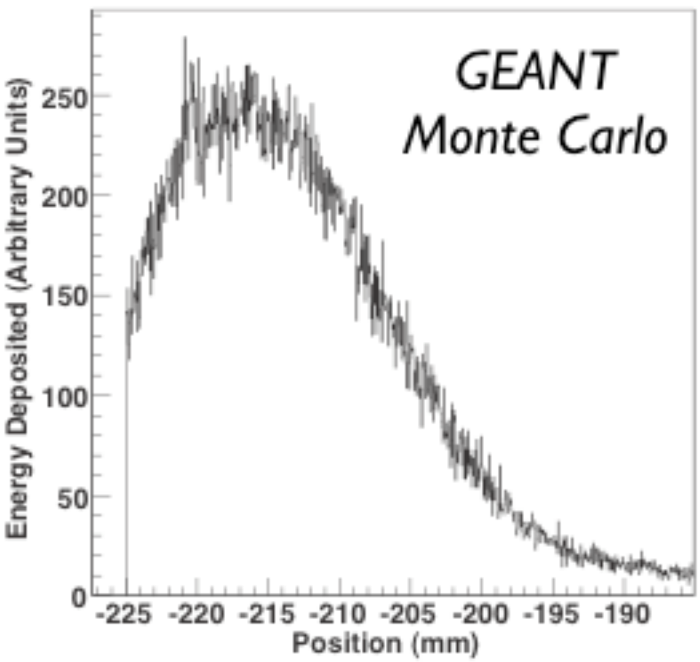
    (~3kRad to 80kRad in 2cm X 2cm X 2cm volume, needs verification)

Beam Direction



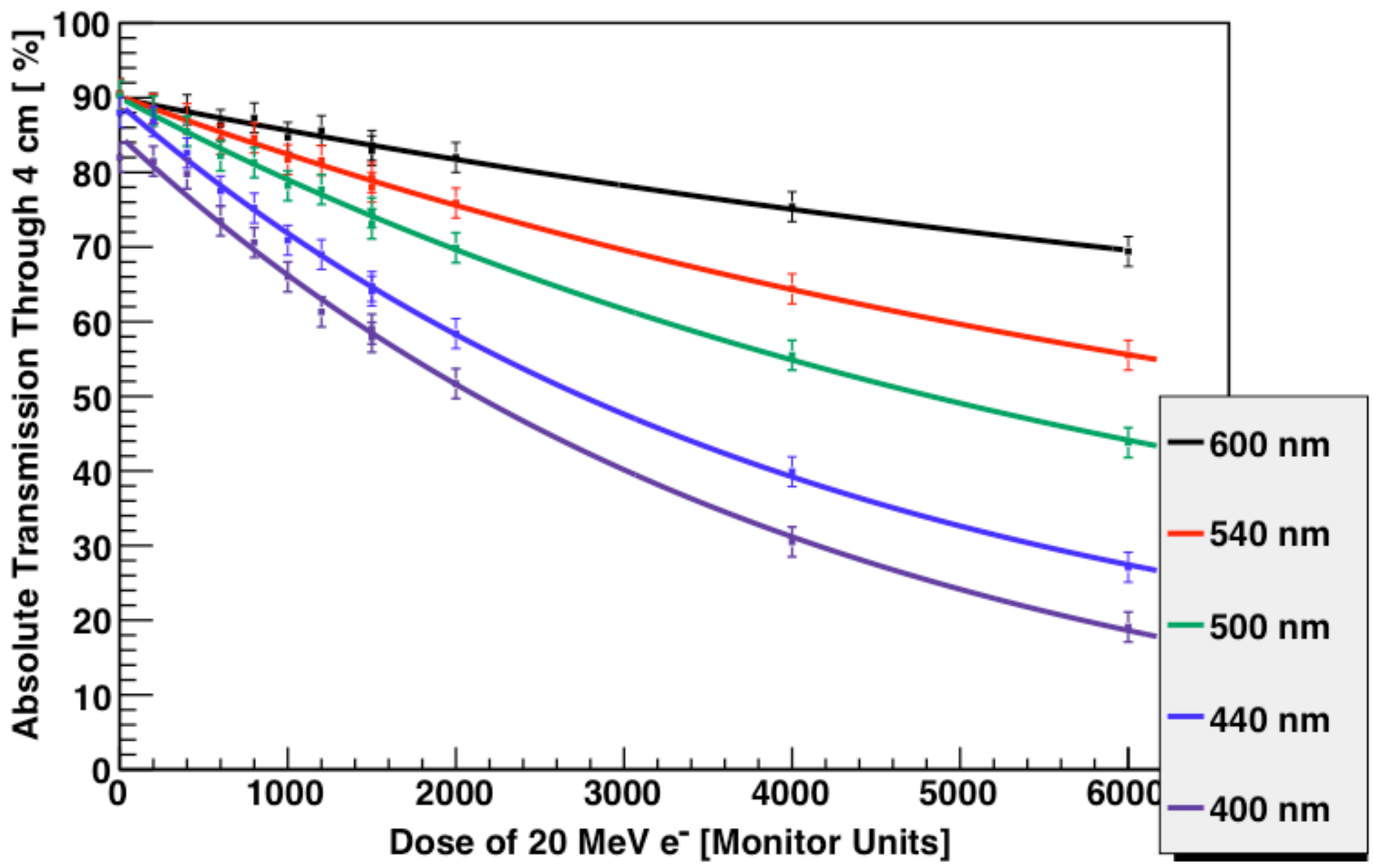
# Damage Profile

6000 Monitor Units
(80kRad)



# Analyzing Lead Glass Damage

- Used spectrophotometer to analyze transmission through damaged
  lead glass section
- Plotted absolute transmission vs. dosage
- Determined a relationship between dosage (damage) and transmission




440 nm used in Simulations because it is close to the Cherenkov wavelength

$$T_2 = A \cdot exp(B \cdot E_{MU}) + C$$

# 3:HDGEANT

Currently, HDGEANT uses attenuation length, lambda, to attenuate the energy of a photon that enters the FCAL

$$E_{final} = E_{initial} \cdot exp(-z/\lambda)$$

Where z is the distance from the end of the block

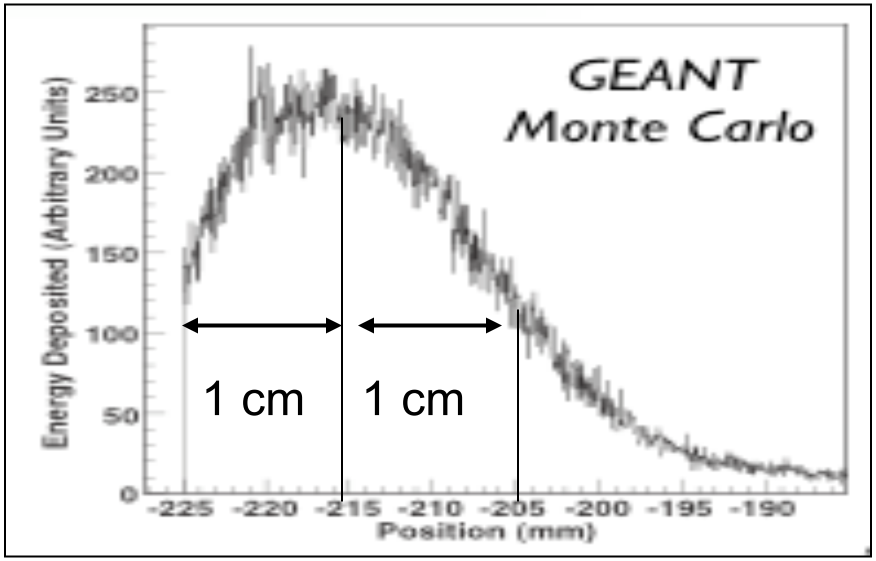
We want to use transmissions, instead of the exponential above, to attenuate the energy

$$T_2 = A \cdot exp(B \cdot E_{MU}) + C$$

The goal is to multiply the transmission successively along the block to calculate the attenuated energy

Both methods provide the same result for no damage

# Damage profile




Almost all of the energy is in the first two cm. So we can say $T_2$ is valid over 2 cm of lead glass

$$T_2 = A \cdot exp(B \cdot E_{MU}) + C$$

Where A, B, and C are coefficients from before (slide 7).

If $T_1$ is the transmission in one cm then due to the symmetry of the first and second cm, we can say $T_1^2 = T_2$ so:

$$T_1 = \sqrt{A \cdot exp(B \cdot E_{MU}) + C}$$

# Combining it all together in GEANT

- Use Ryan's simulation to determine damage in 2cm X 2cm X 1cm volume for various FCAL radii

- With equation

$$T_1 = \sqrt{A \cdot exp(B \cdot E_{MU}) + C}$$

- Now we can use 1 cm steps along the block to attenuate the energy

$$T = \prod_i T_1(E(z_i))$$

# 4:HDGEANT Simulations

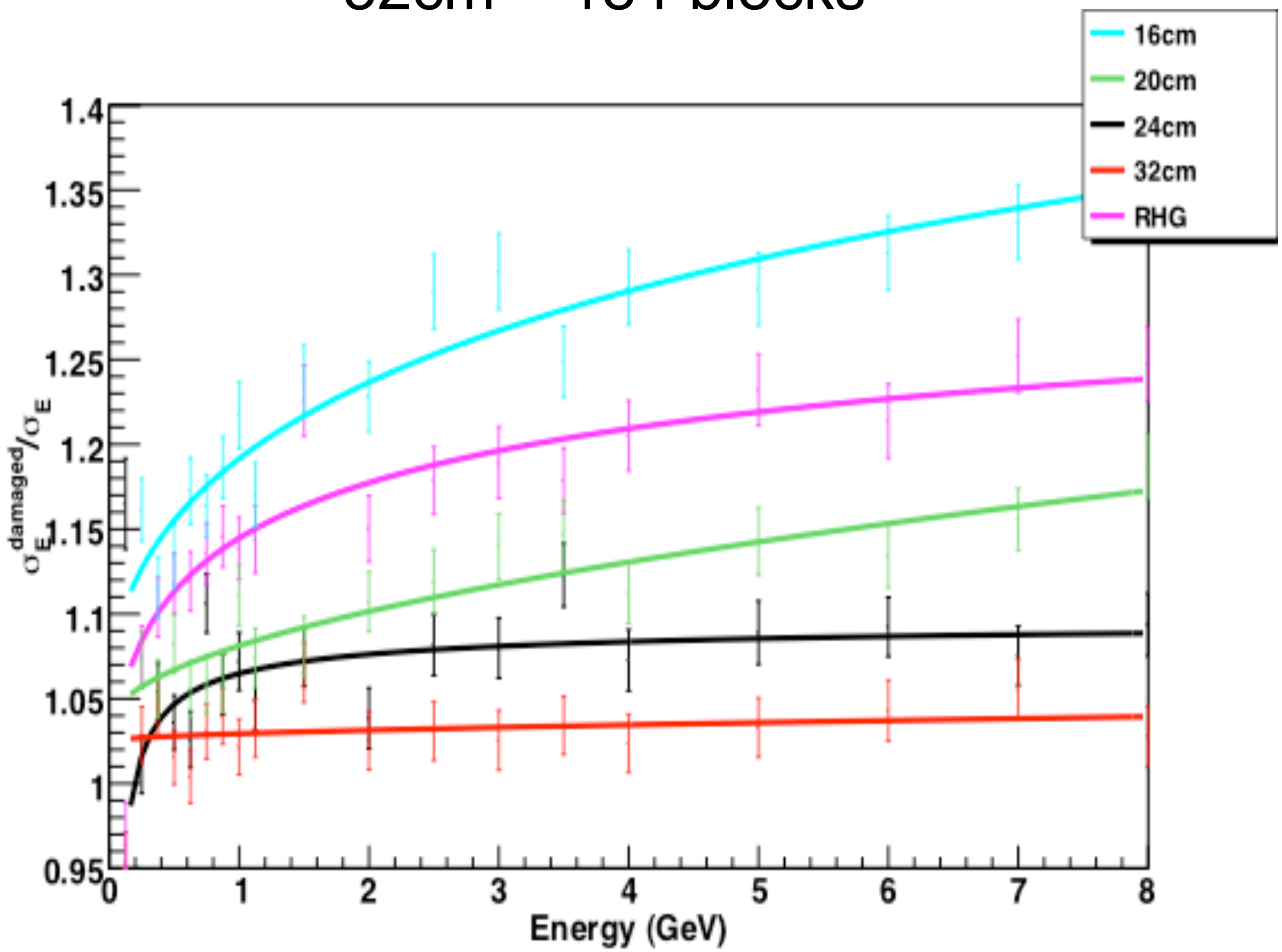
- Ratios of Energy resolution of damaged to undamaged
  - 1 year of running at 10^8 Hz
  - Various radii of blocks in FCAL
  - RHG is undamaged radiation hardened glass

16cm = 36 blocks

20cm = 60 blocks

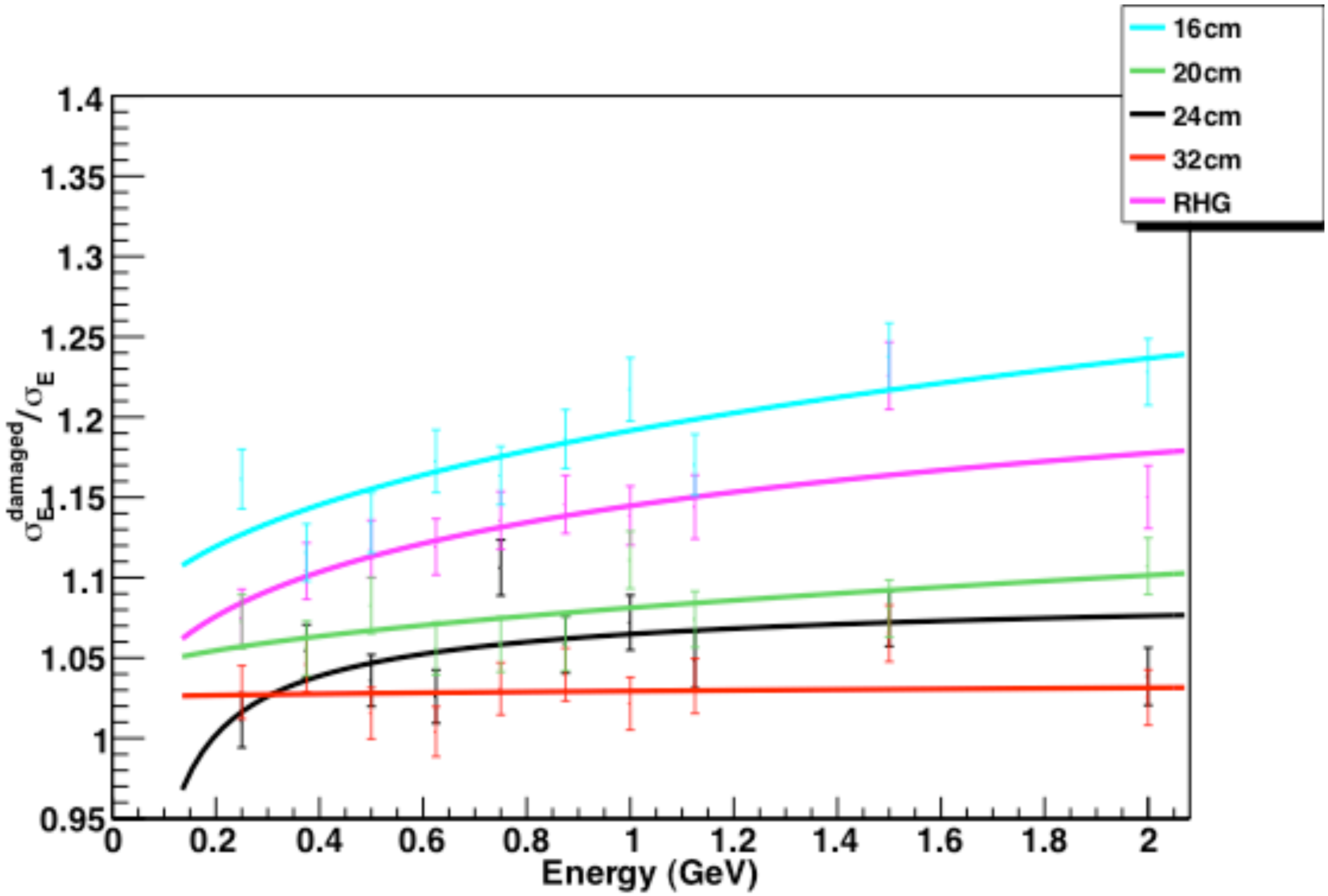
32cm = 184 blocks

$$\sigma_E^{Damaged} / \sigma_E^{Undamaged}$$



# 1 Year Dosage
# 0 to 2 GeV

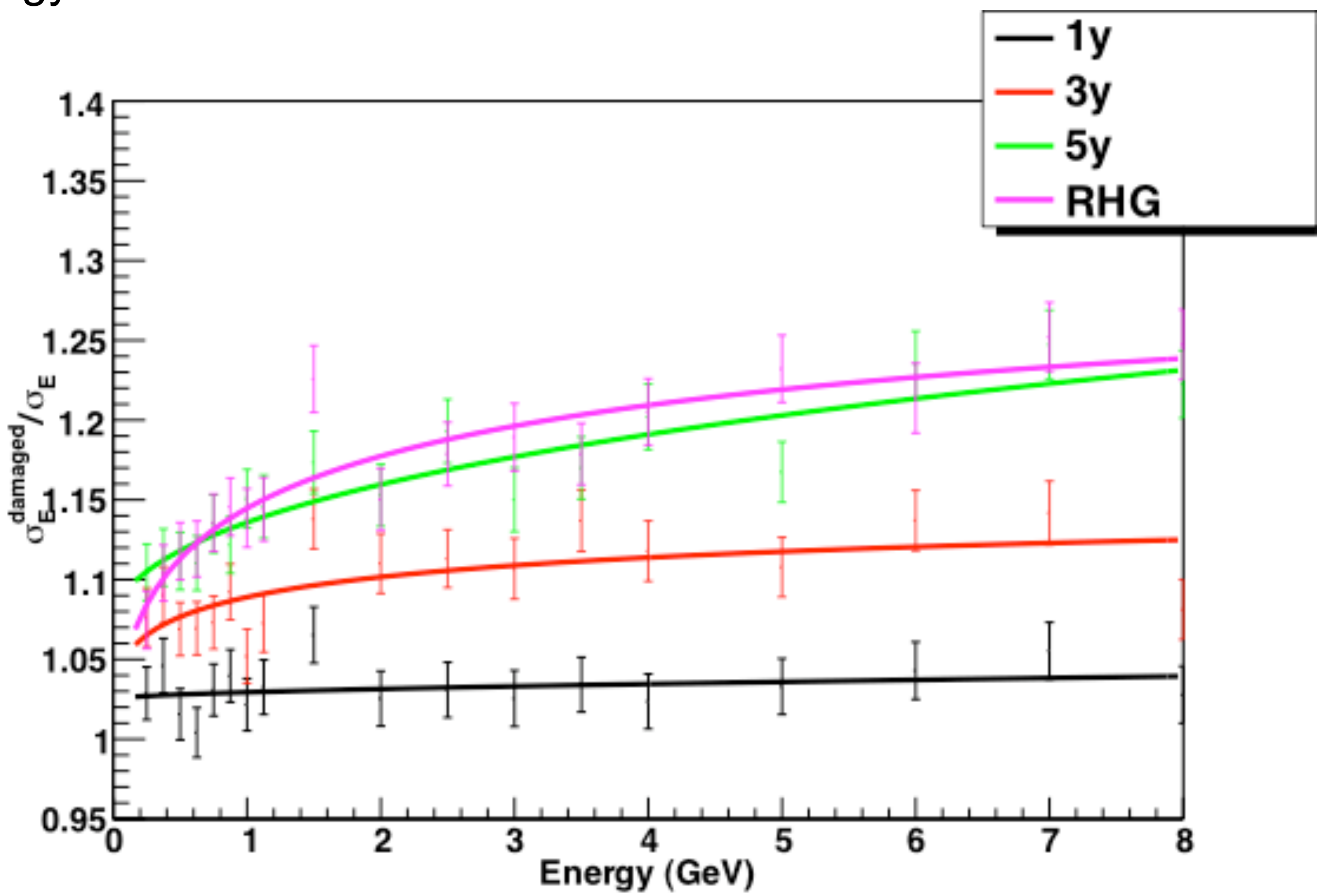
So the blocks at 16 cm are worse than RHG while the block at 20 is better than RHG after one year



- Different beam durations
- All resolutions are at radius of 32cm on the FCAL
- Varying from 1 year to 5 years
- Attenuation Length curve relates attenuation length method to stepping method for attenuating the energy

So it will take 5 years of running for the glass at 32 cm to have the same energy resolution as RHG

$\sigma_E^{Damaged} / \sigma_E^{Undamaged}$

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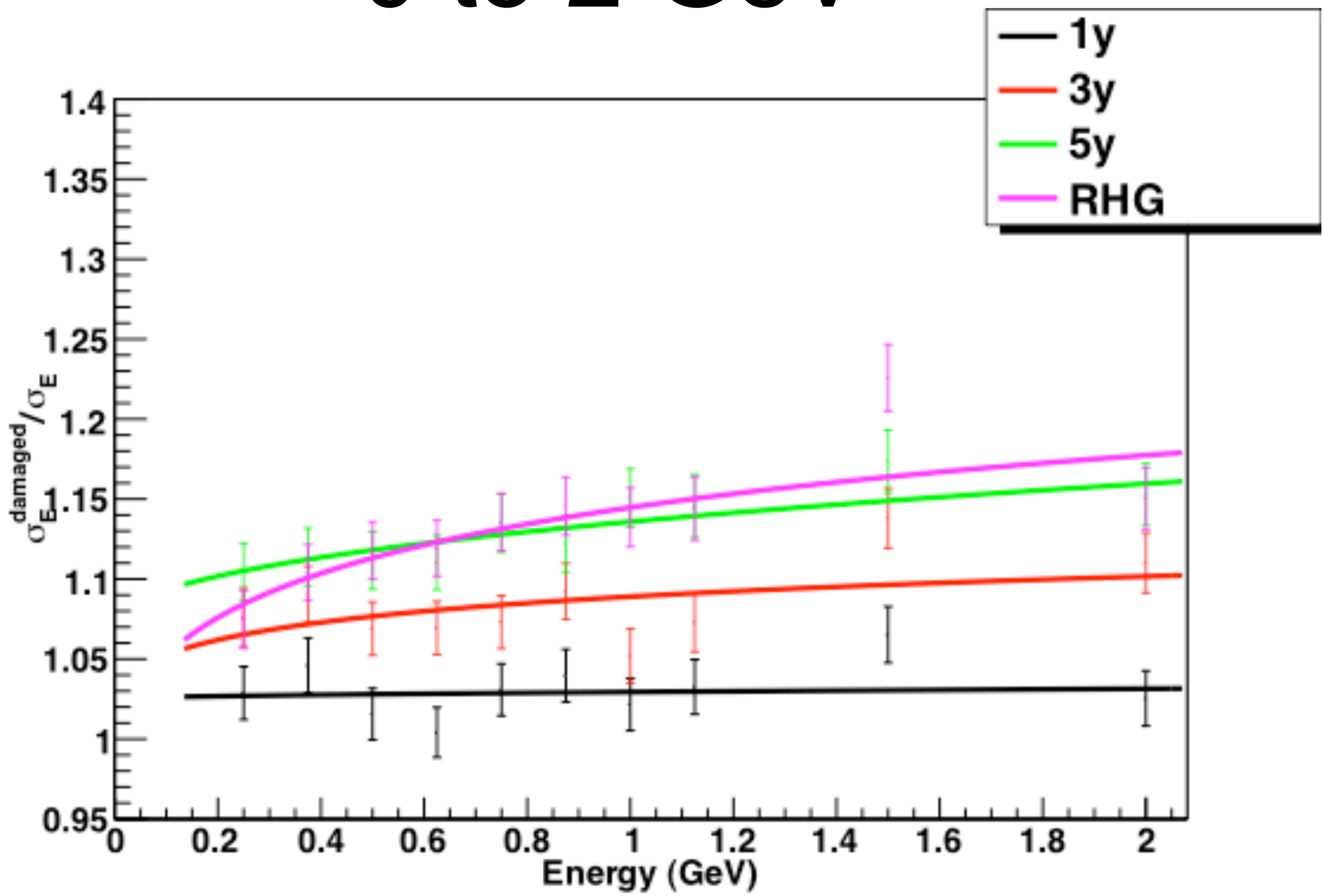
# Time plot zoomed in 0 to 2 GeV



# Conclusions

- After one year of running between 16 cm and 20 cm yields the same energy resolution as undamaged radiation hardened glass
- It takes 5 years of running for the radius of 32 cm to be damaged enough to yield the same energy resolution as undamaged radiation hardened glass
- Going to try to damage test the RHG and probably retest F8 at IUCF this spring
- Another goal is to compare our model to previous lead glass papers on radiation damage