Nonlinearity corrections

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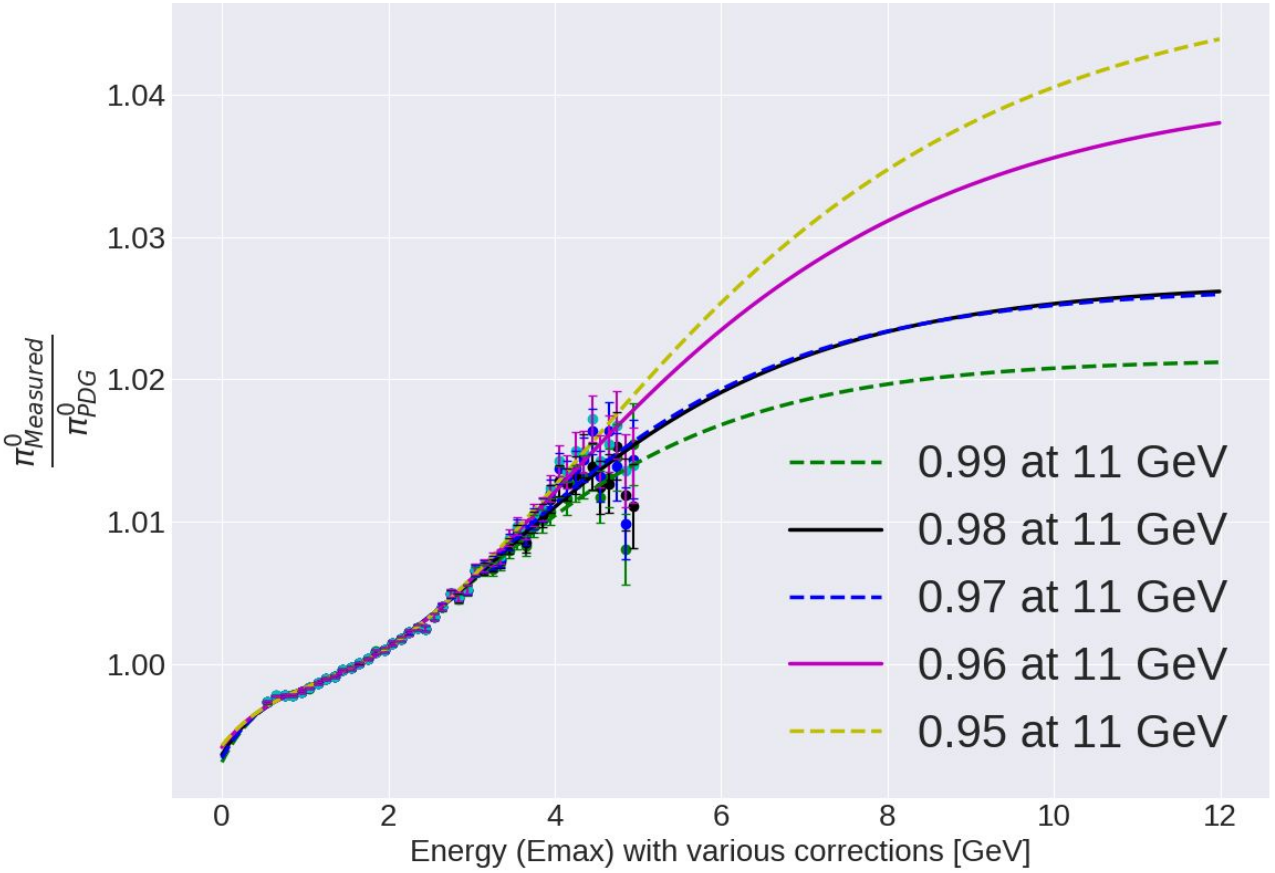
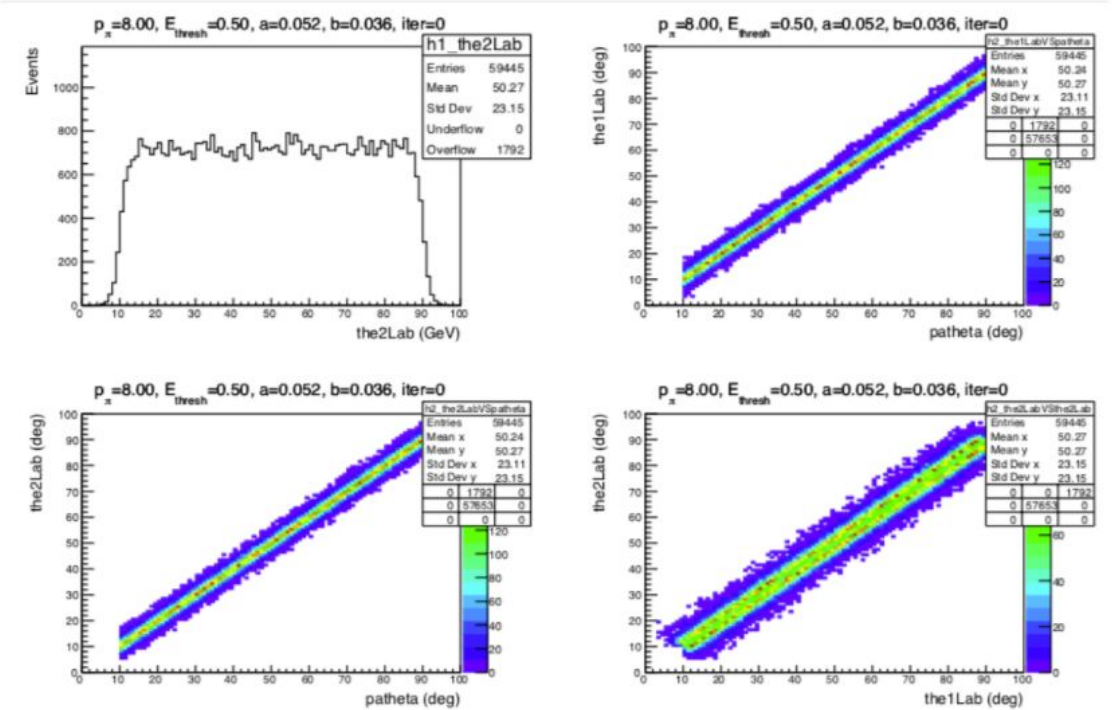
Ratio as a function of E1 (Emax) [GeV] with varying correction functions (Fitting the Emax plots)



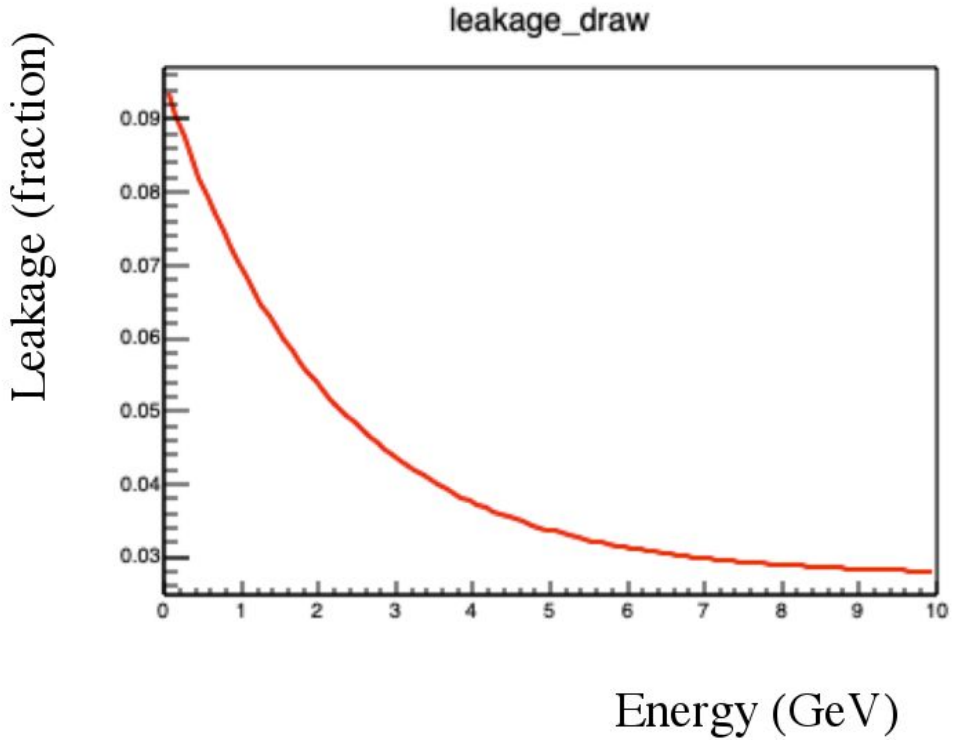
Elton's Toy MC (Study on Nonlinearity)

- $\pi^0 \rightarrow \gamma\gamma$ decay isotropically in the pi0 rest frame
- The 4-momenta of the gammas are transformed to the lab



Slides from Elton's Study

Leakage example (exaggerated)

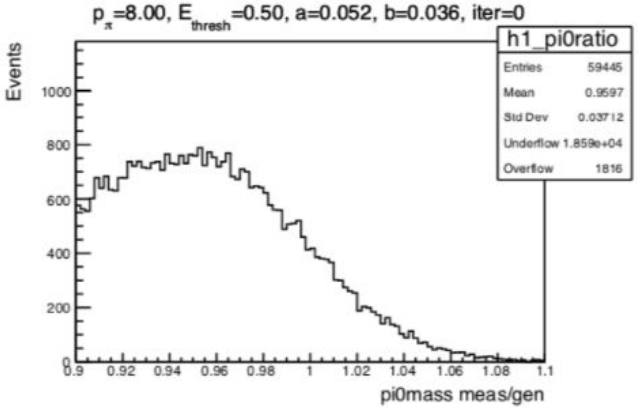


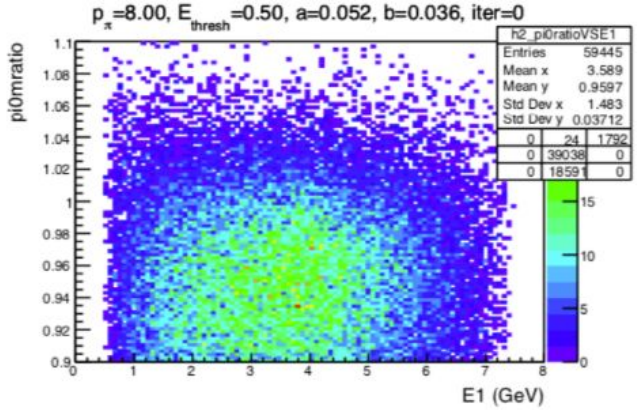
Slides from Elton's Study

Elton’s MC in a nutshell

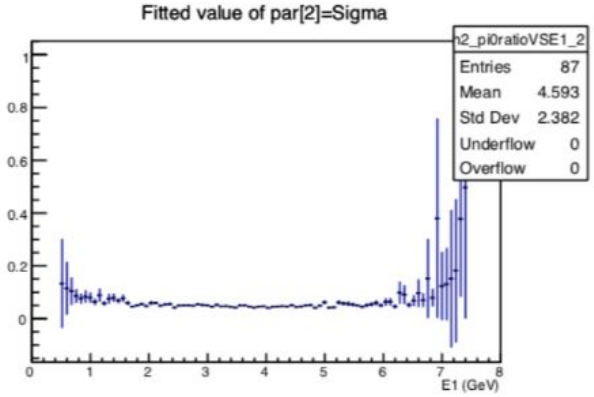
- Shoot π^0 gun in the BCAL from 0° to 90 ° with respect to the z axis
- $\pi^0 \rightarrow 2\gamma$ isotropically
- Smear the photon showers based on
  - Usual smearing effect
  - Additionally included the leakage as described in previous slide
- Looked into the reconstructed invariant mass of π^0

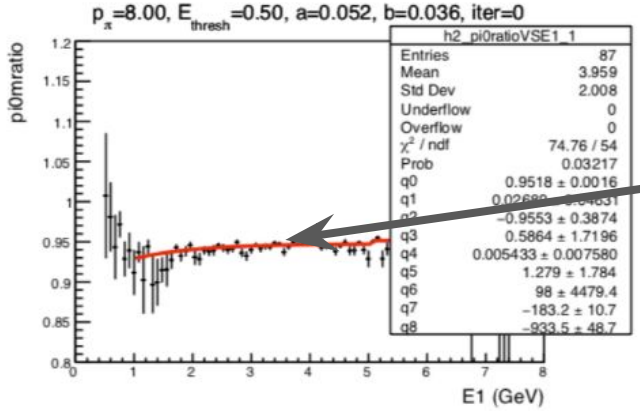
Pi0 mass(E1meas,E2meas)/true





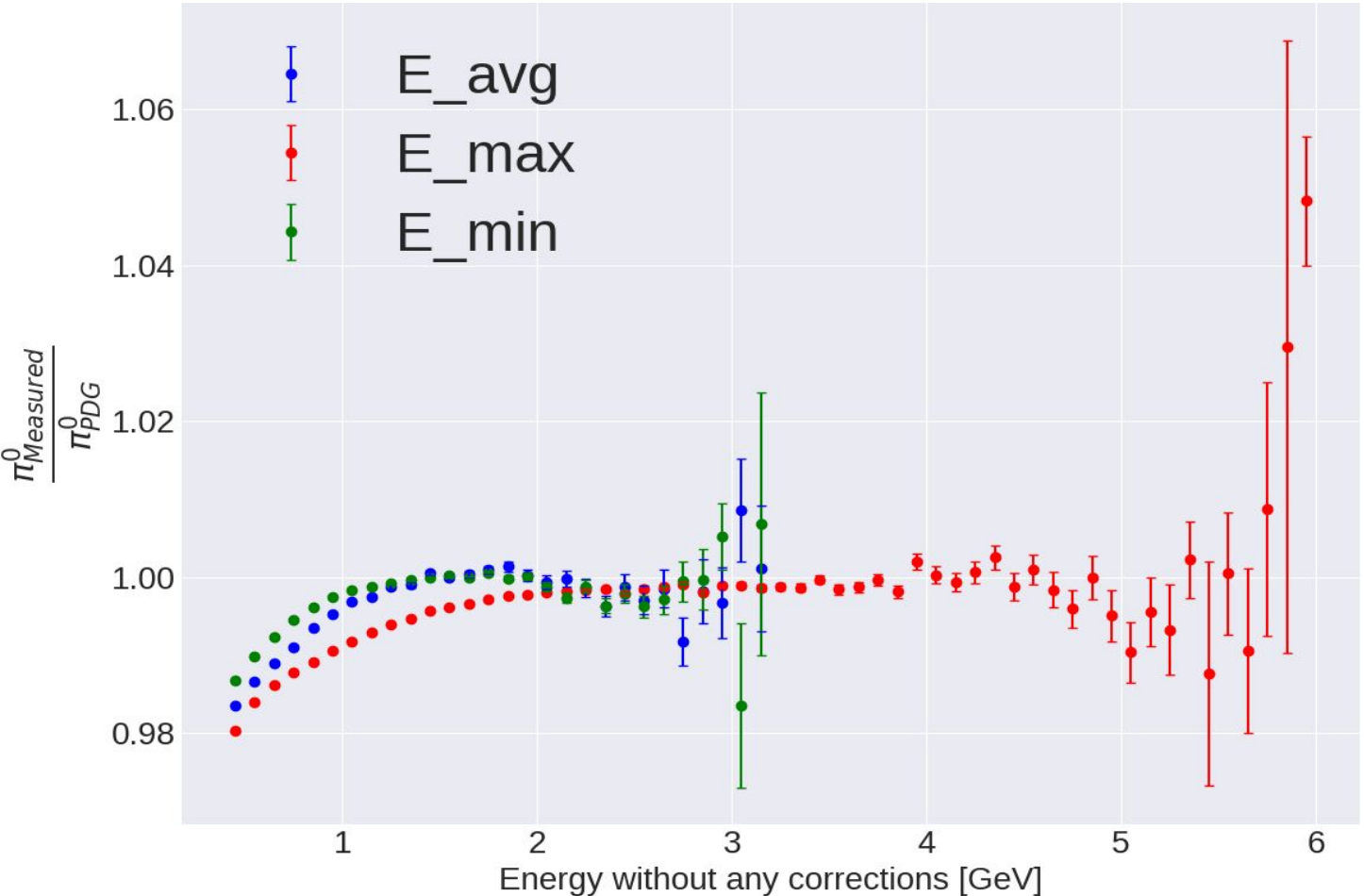
[Slides from Elton's Study]





There is no nonlinearity seen in the plot

Explanation to see no nonlinearity in the above plots

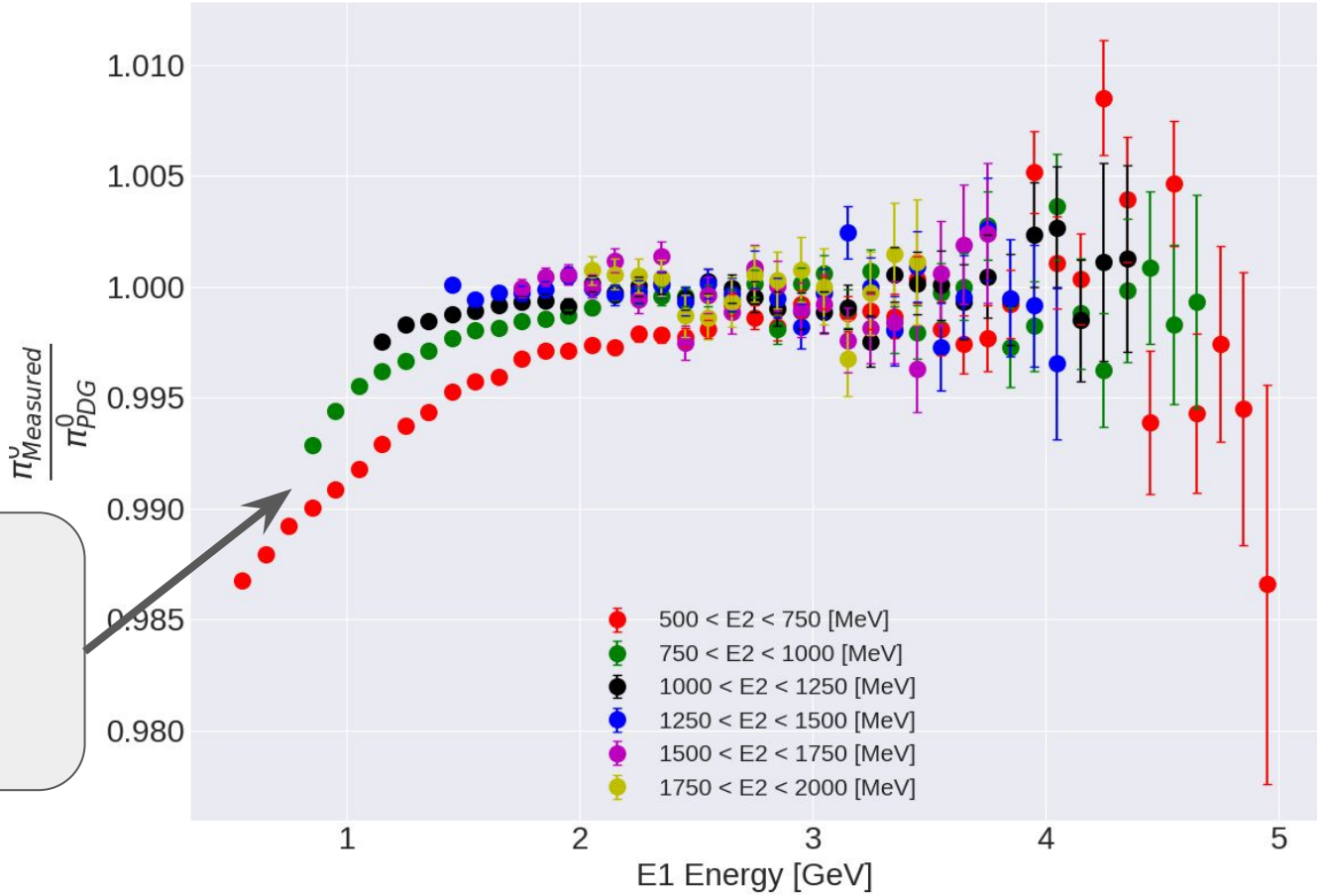


The effect of one shower nullifies the effect the other shower

A study on systematics caused due to Energy in nonlinear corrections

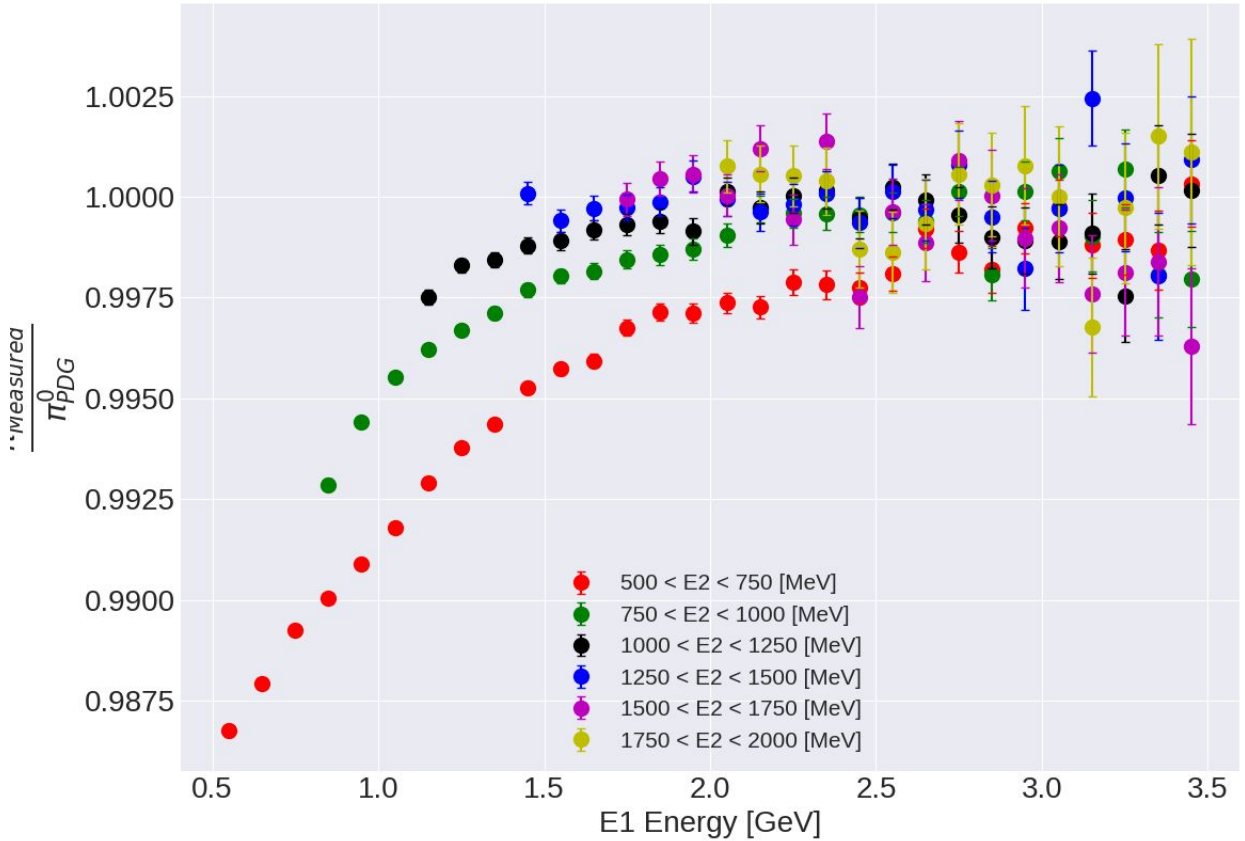
- Fix E2 (Emin) in bins of 250 MeV and start scanning in E1 and look into **invariant mass as a function of E1.** Systematically vary E2 in bins of 250 MeV (from 750 MeV to 3000 MeV), and look for systematics. This will probe the systematics caused due to low energy photons
- Fix E1 (Emax) in bins of MeV and start scanning in E2 and look into **invariant mass as a function of E2** Systematically vary E1 in bins of 250 MeV (from 2750 MeV to 4250 MeV), and look for systematics. This will probe the systematics caused due to high energy photons

Ratio as a function of E1 (Emax) by fixing the E2 (Emin)



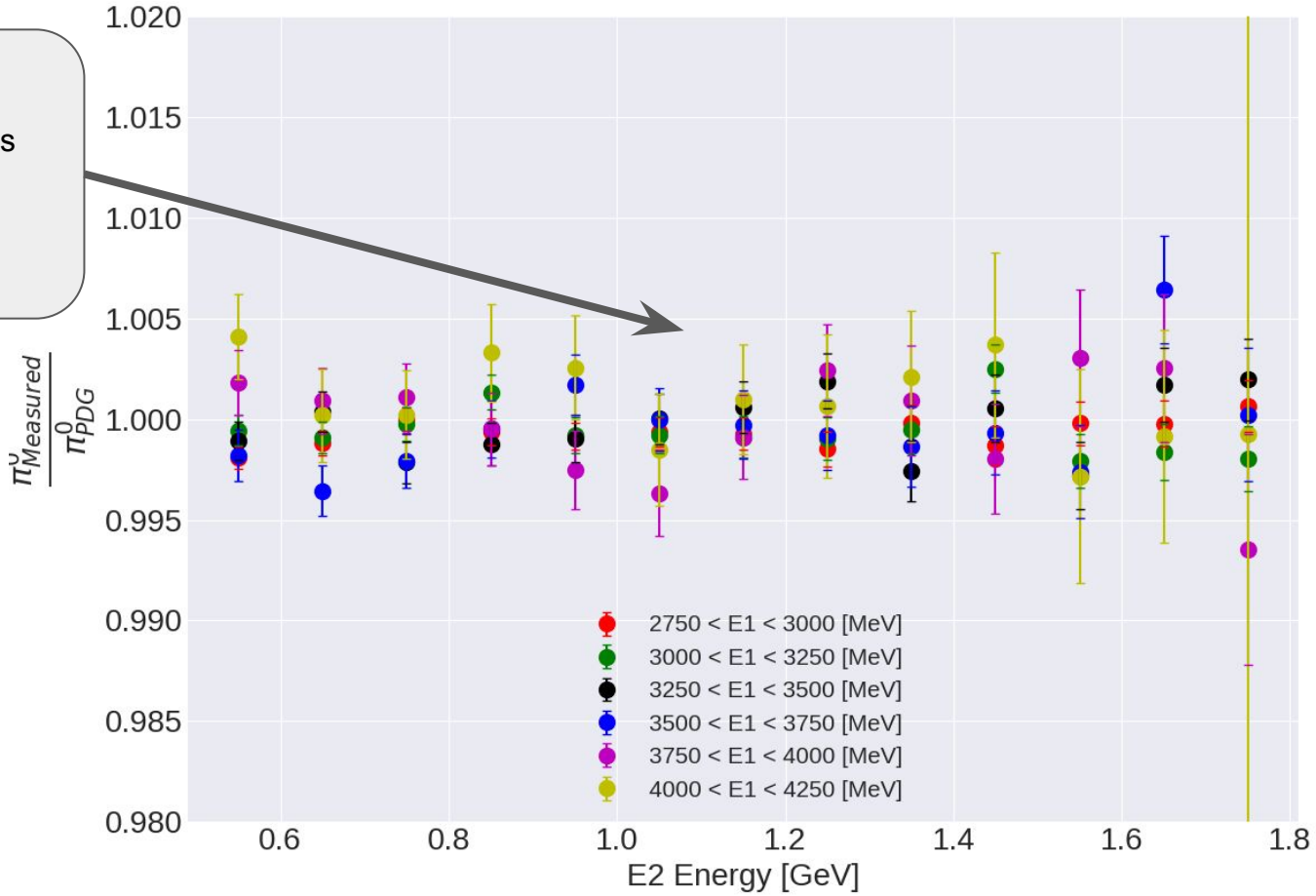
There is systematics due to low energy photons

Ratio as a function of E1 (Emax) by fixing the E2 (Emin) Zoomed



Ratio as a function of E2 (Emin) by fixing E1 (Emax)

The Points are linear within a percent. There is no significant nonlinearity caused due to high energies



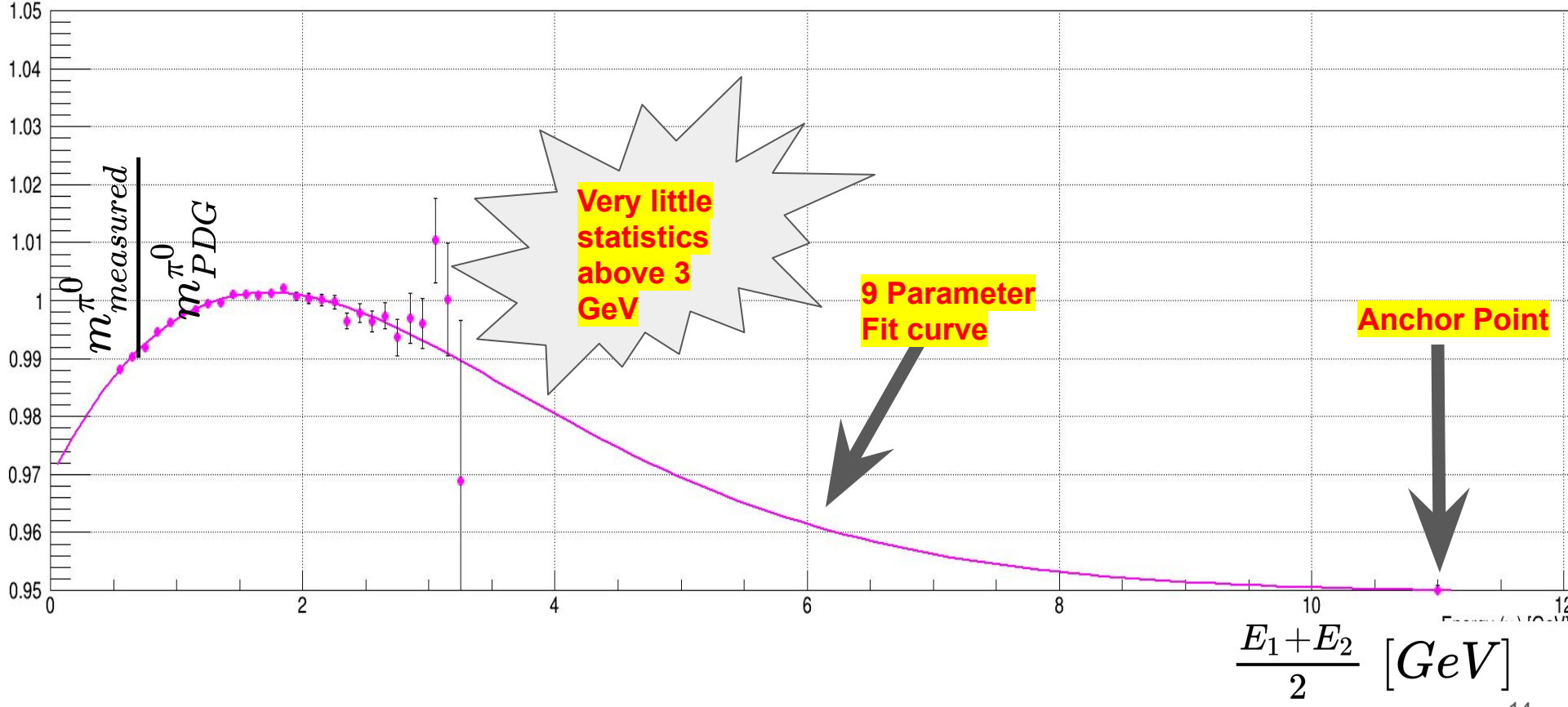
Conclusions

- We did a systematic study on nonlinearity as a function of photon energies
- We did find that there exist significant nonlinearity caused due to low energy photons and need to be corrected
- We find that there exist no significant nonlinearity caused due to high energy photons

Nonlinear corrections (Current algorithm):

- After gain calibrations, select out $\pi^0 \rightarrow 2\gamma$ inclusive events with symmetric photon decays (|E1 - E2| < 0.1)
- Reconstruct the invariant mass of the events, and plot the Ratio of reconstructed invariant mass to PDG invariant mass (~0.135 GeV) as a function of E_{avg} = (E1 + E2)/2
- Put an anchor of 5 % offset at 11 GeV. This is to make the curve pass through 95% at 11 GeV. Follows from J/psi analysis
- Fit an empirical nonlinear function to fit the above distribution.

Nonlinear corrections



Nonlinearity correction (an alternative method)

- The main drawback is there are no events beyond 3 GeV and there is no way to validate the fitted curve due to huge statistical fluctuations in the 3 GeV range
- As a first step the symmetric condition for photon showers are modified.

$$|E_1 - E_2| < 0.1 \rightarrow \frac{|E_1 - E_2|}{E_{avg}} < 0.1$$

- This amounts to variation between E1/E2 to about 90%
- This will give more statistics at higher energies
- Also explicitly sort E1 and E2 such that E1 > E2 (refer backups)

Nonlinearity Study

Fix anchor Point 0.95,0.96,0.97,0.98,0.99,1	fit Ratio_vs_E_avg and correct for nonlinearity	Look Ratio_vs_Emax (E1)	Fit for nonlinearity in Ratio_vs_Emax and apply nonlinearity	Look at Ratio_vs_Emax after correction
Fix an anchor point at 11 GeV to apply for nonlinear corrections	Use the new symmetric condition to produce ratio of measured π^0 mass to PDG value as a function E_avg energy. Fit the distribution along with the anchor point with a 9 parameter fit function. Apply the corrections using fit parameters	After correcting for nonlinearity plot ratio of measured π^0 mass to PDG value as a function Emax (E1) energy. Check for any nonlinearity in the plot (check for over-corrections)	If there exist a nonlinearity in the plot (Ratio_v_Emax), fit the distribution with a nonlinear function, and apply corrections.	Once again look at the plot of measured π^0 mass to PDG value as a function Emax energy with the new corrections applied from previous step. Check for any nonlinearity