LUXE GEANT4 ECAL Simulation.

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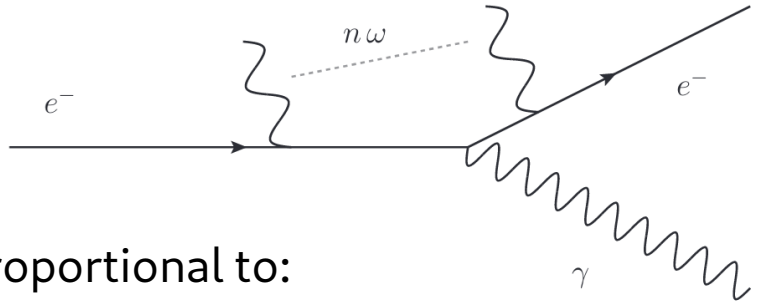
LUXE Calorimetry Meeting
November 05, 2020

High Intensity Compton Scattering

$$e^- + n\omega \rightarrow e^- + \gamma$$



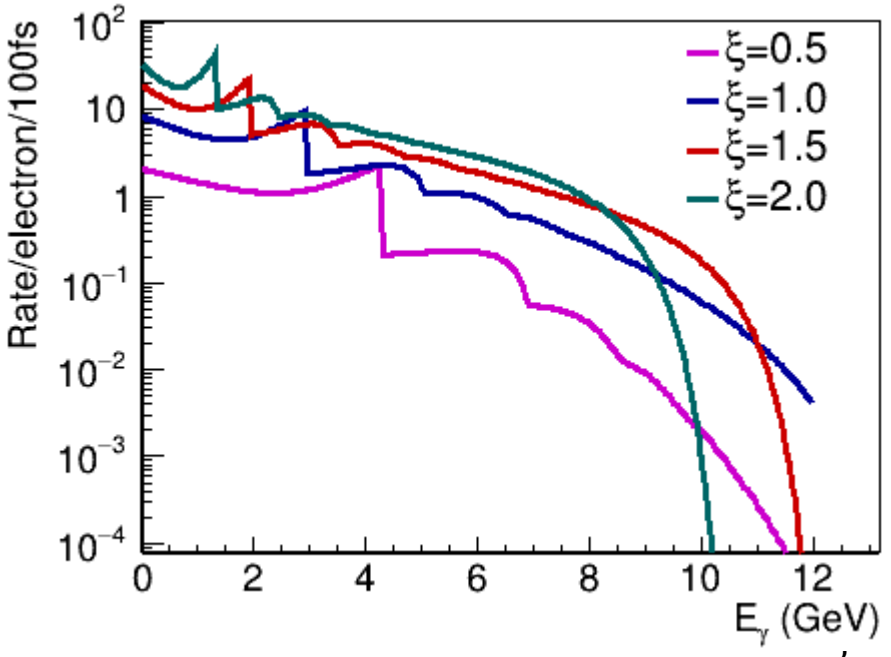
The rate of High Intensity Compton Scattering (HICS) is proportional to:

$$\sum_{\mathrm{n}} \delta^{(4)} \left[p_{\mathrm{i}} + k\frac{\xi^3}{2\chi_{\mathrm{i}}} + nk - p_{\mathrm{f}} - k\frac{\xi^3}{2\chi_{\mathrm{f}}} - k_{\mathrm{f}} \right]$$

Momentum conservation is a sum over external field photon contributions, *nk*

Even for *n=0* there is an irreducible contribution:

$$p_{\mathrm{i}} + k\frac{\xi^3}{2\chi_{\mathrm{i}}} \rightarrow p_{\mathrm{i}}^2 = m^2(1+\xi^2)$$

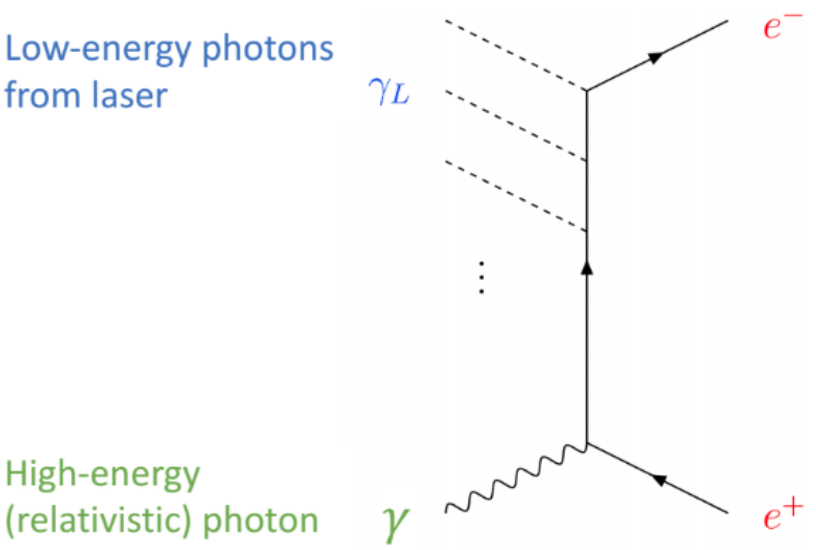


- Strong field leads to increase in electron rest mass.
- Observation of Compton edge shift.

Laser-assisted pair production

$$\gamma + n\omega \rightarrow e^+e^-$$

One photon pair production (OPPP) at ultra high intensity - non-perturbative physics



The rate of laser-assisted (OPPP) rate:

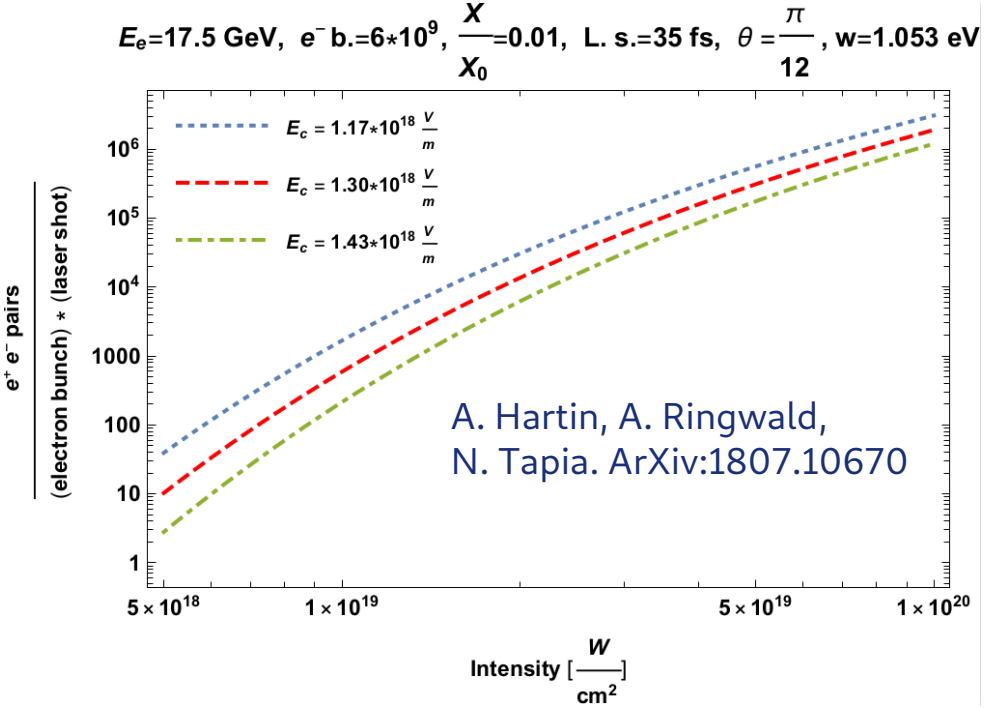
$$\Gamma_{\mathrm{OPPP}} = \frac{\alpha m_e^2}{4\,\omega_{\mathrm{i}}} F_\gamma(\xi, \chi_\gamma)$$

$$\xi \equiv \frac{e\,|\mathbf{E}|}{\omega m_e} = \frac{m_e}{\omega}\frac{|\mathbf{E}|}{\mathrm{E}_c}, \quad \chi_\gamma \equiv \frac{k\cdot k_i}{m_e^2}\xi = (1+\cos\theta)\,\frac{\omega_i}{m_e}\,\frac{|\mathbf{E}|}{\mathrm{E}_c}$$

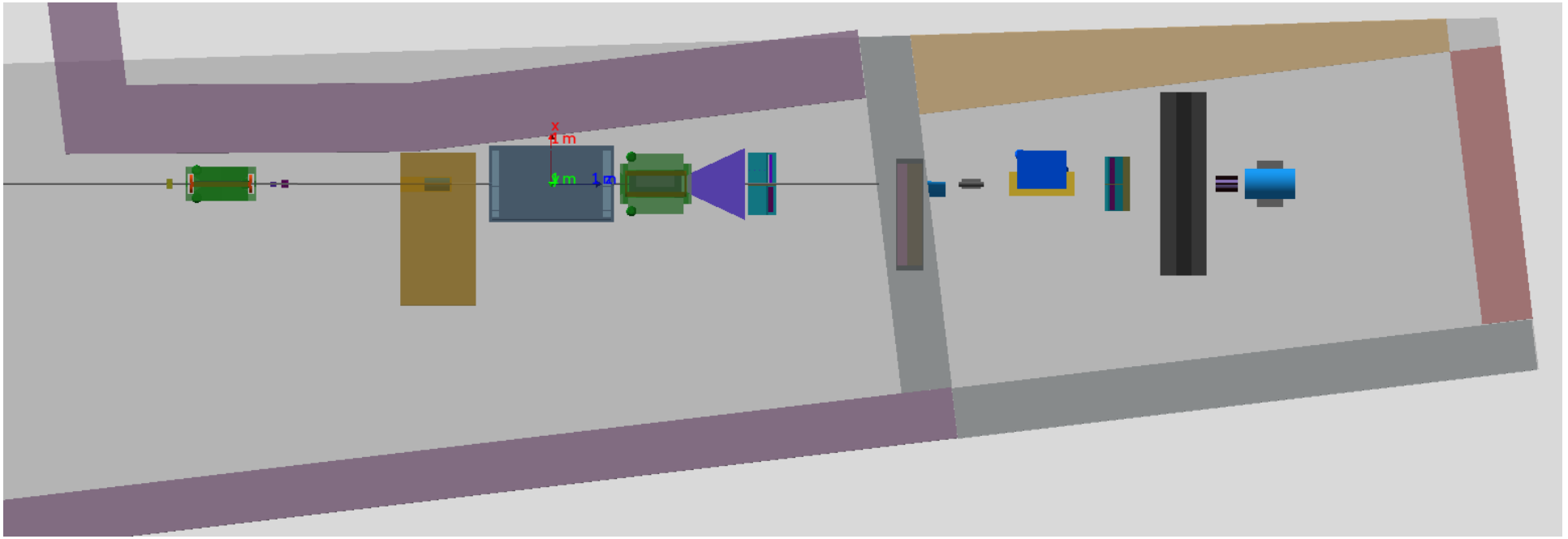
Use bremsstrahlung photons produced by XFEL beam hitting tungsten target.

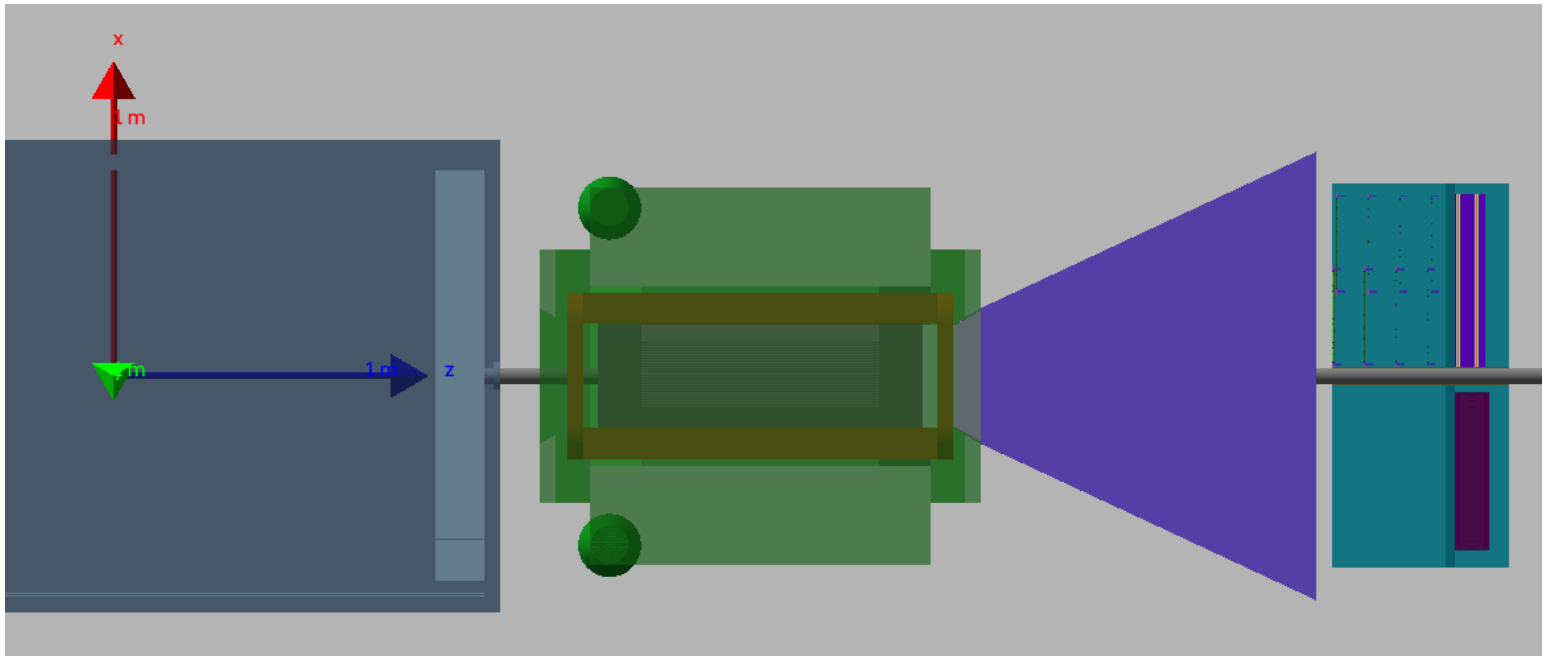
$$\Gamma_{\mathrm{BPPP}} = \frac{\alpha\, m_e^2}{4}\int_0^{E_e}\frac{\mathrm{d}\omega_i}{\omega_{\mathrm{i}}}\frac{\mathrm{d}N_\gamma}{\mathrm{d}\omega_i}F_\gamma(\xi,\chi_\gamma(\omega_i))$$

$$\Gamma_{\mathrm{BPPP}} \rightarrow \frac{\alpha\, m_e^2}{E_e}\frac{9}{128}\sqrt{\frac{3}{2}}\,\chi_e^2\, e^{-\frac{8}{3\chi_e}\left(1-\frac{1}{15\xi^2}\right)}\frac{X}{X_0}$$

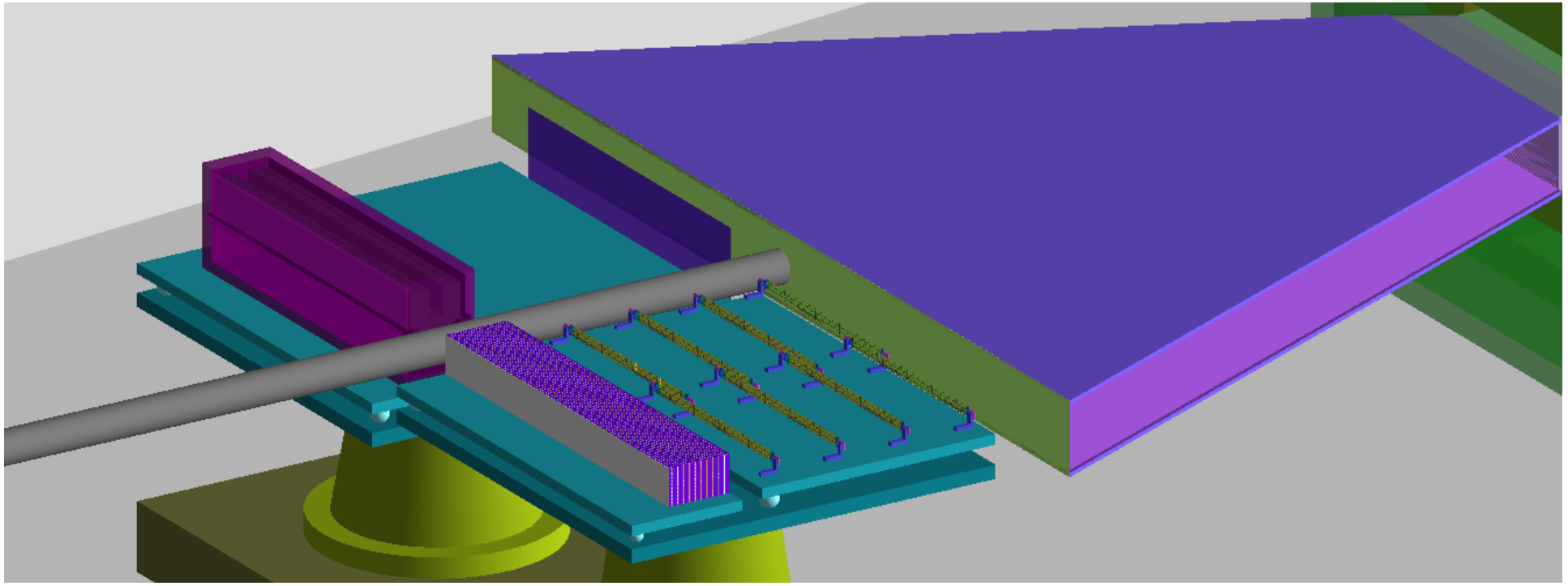


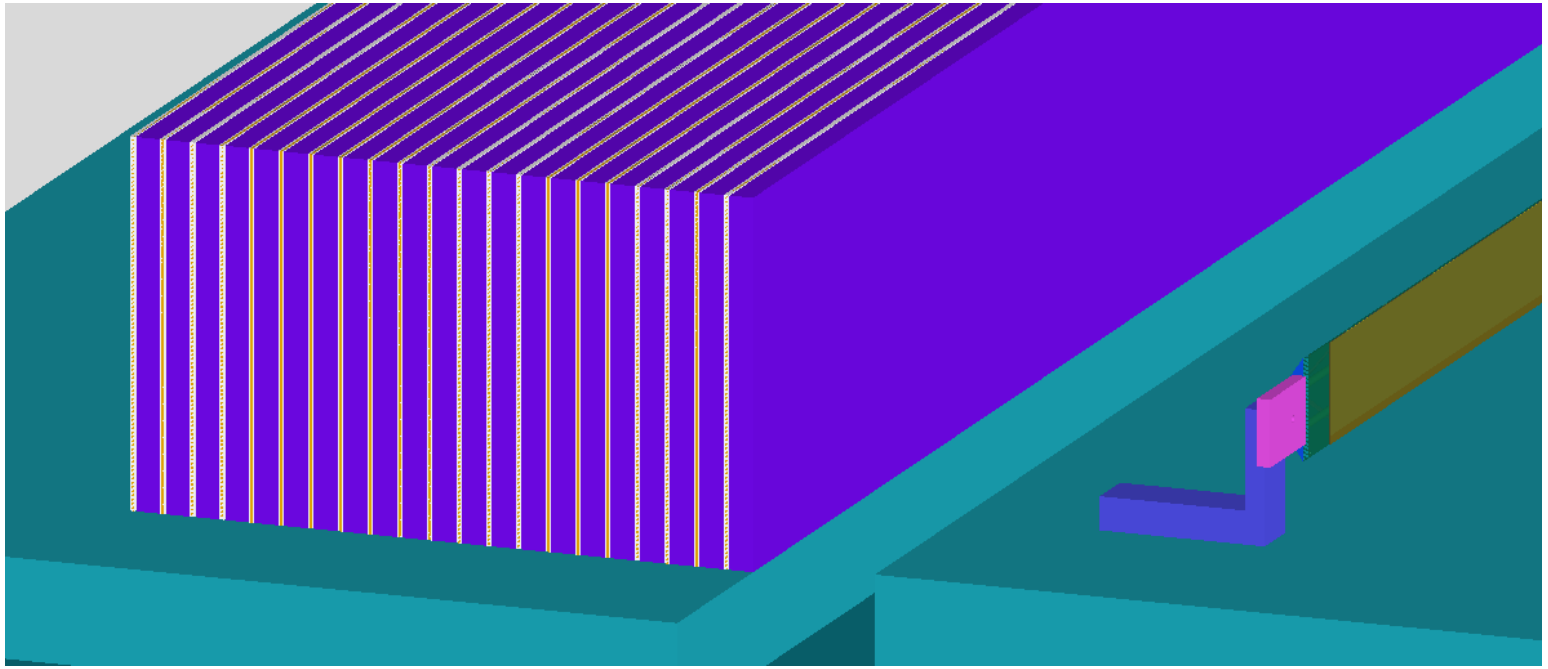
LUXE geometry





Positron arm and ECAL





MC

https://confluence.desy.de/display/LS/GEANT4+MC

GEANT4 MC

Oleksandr Borysov posted on 13. Oct. 2020 13:40h - last edited by Oleksandr Borysov on 05. Nov. 2020 08:00h

IPstrong_V1.1.00
JETI40
e_laser 16.5 GeV

MC	# MC out (BX)	Processed (BX)	Location	Notes
w0_100000nm	474	474	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_100000nm.txt	
w0_50000nm	4764	4764	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_50000nm.txt	
w0_20000nm	468	468	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_20000nm.txt	
w0_20000nm	468	468	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_20000nm_mag2t.txt	IP magnet 2T, electrons above 16.2 GeV excluded
w0_20000nm	468	468	/nfs/dust/ilc/user/oborysov/hics_list /list_root_hics_165gev_w0_20000nm_mag2t_all_particles.txt	IP magnet 2T, all primary particles are simulated
w0_10000nm	675	675	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_10000nm.txt	
w0_8000nm	9479	9479	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_8000nm.txt	
w0_3000nm	9508	9508	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_3000nm.txt	
w0_3000nm	9508	9113	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_3000nm_mag2t.txt	IP magnet 2T, electrons above 16.4 GeV excluded
w0_50000nm	4764	4720	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_165gev_w0_50000nm_mag2t.txt	IP magnet 2T, electrons above 16.4 GeV excluded

IPstrong_V1.1.00
Phase II
e_laser 16.5 GeV

MC	# MC out (BX)	Processed (BX)	Location	Notes
w0_8000nm	941	941	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_phase2_165gev_w0_8000nm.txt	
w0_9000nm	951	951	/nfs/dust/ilc/user/oborysov/hics_list/list_root_hics_phase2_165gev_w0_9000nm.txt	

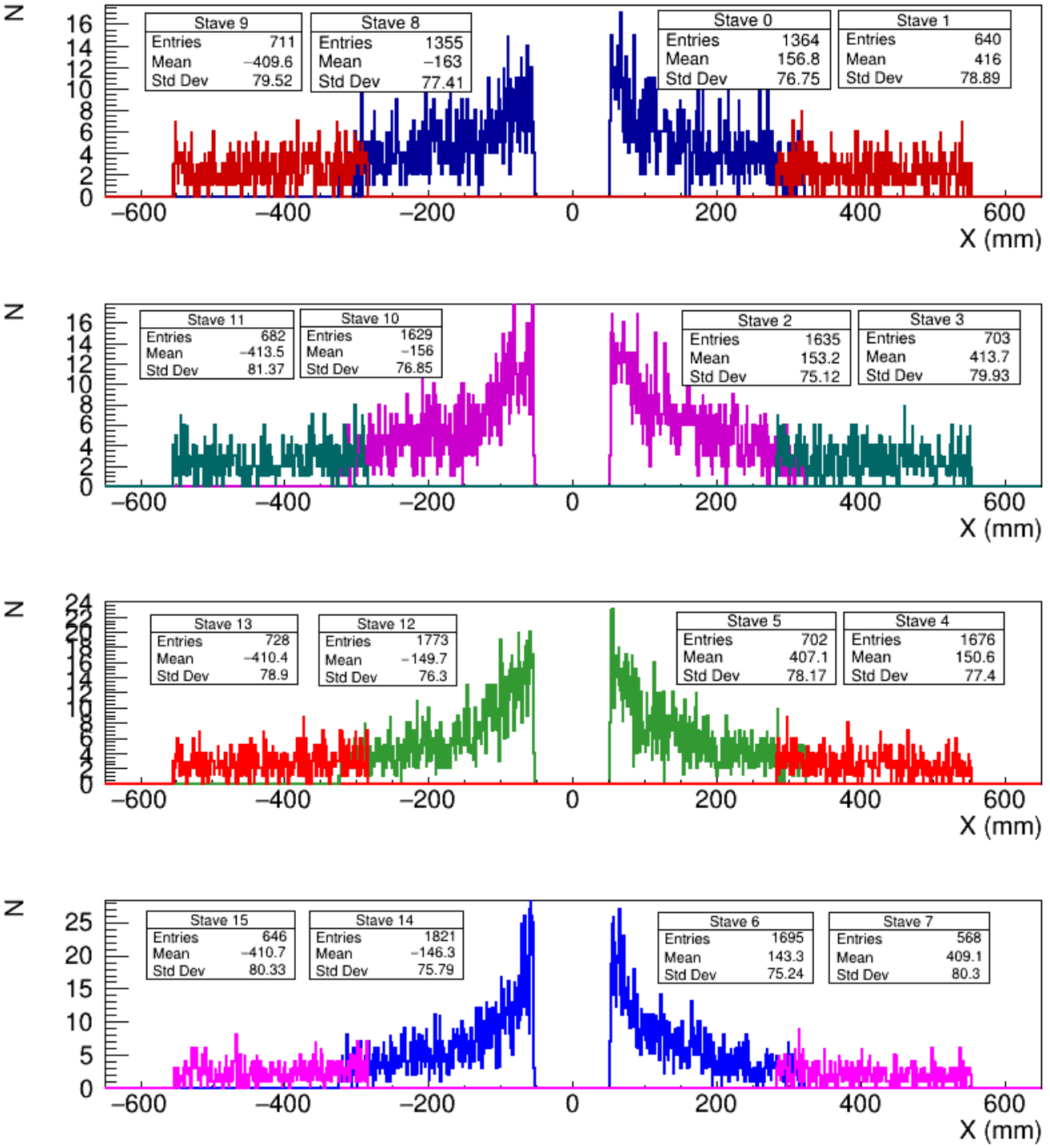
Background 16.5 GeV

Simulation	# particles	Processed (BX)	Location	Notes
Electron background for electron-laser setup	1.89e9	1.259	/nfs/dust/luxe/group/MCProduction/Background/elaser/29102020_lx86a1/Merged /Files/	Setup corresponds to commit 86a153 (hics branch)

Gamma laser setup background: /nfs/dust/luxe/group/MCProduction/Background/gammalaser/09102020_lxb18e/Merged/Files

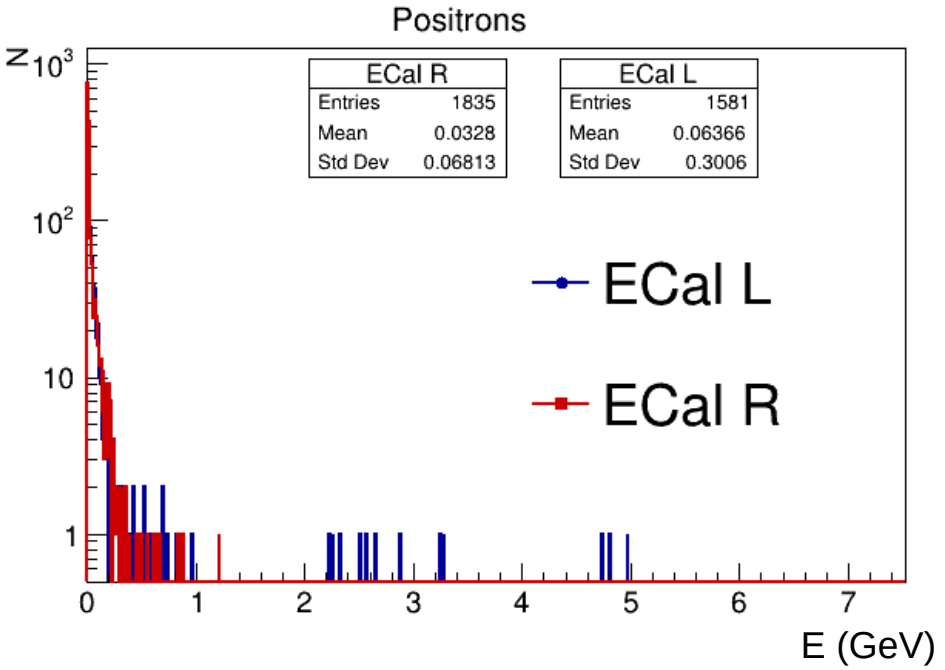
Electrons in tracking planes

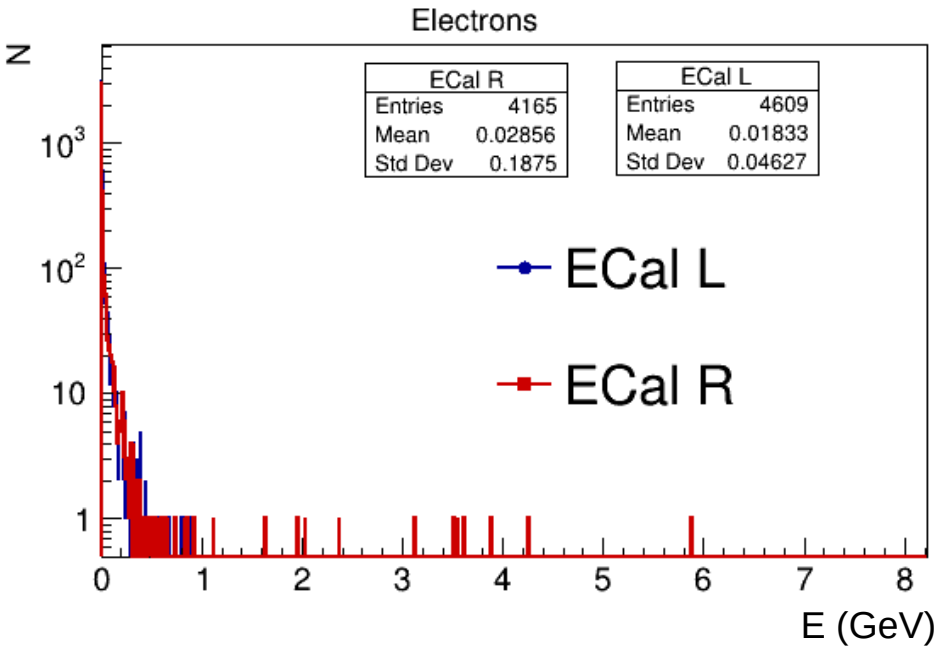
Background in gamma laser setup

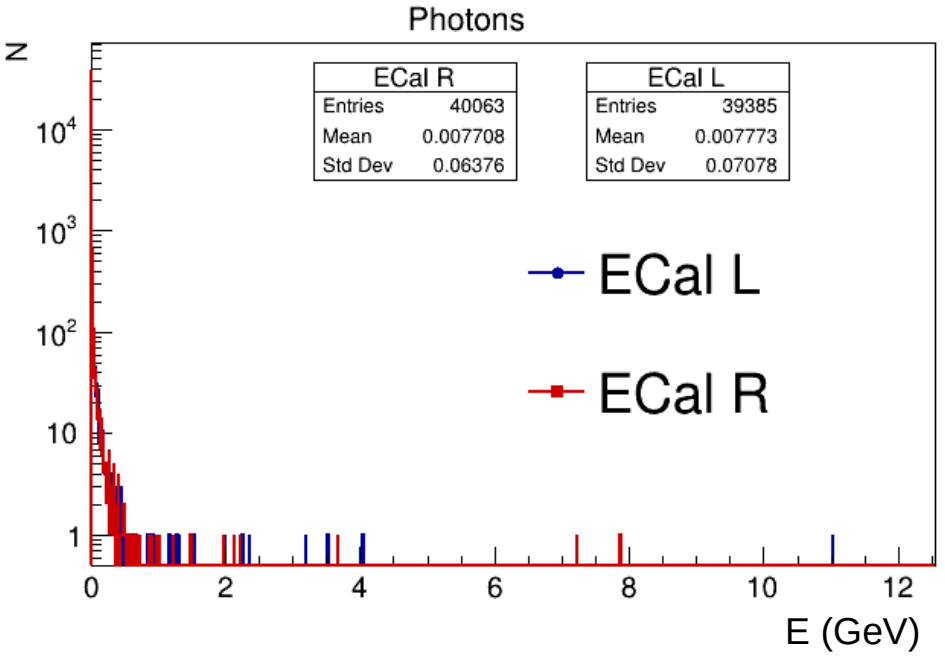


Spectra of particles crossing calorimeters volumes

Background in gamma laser setup







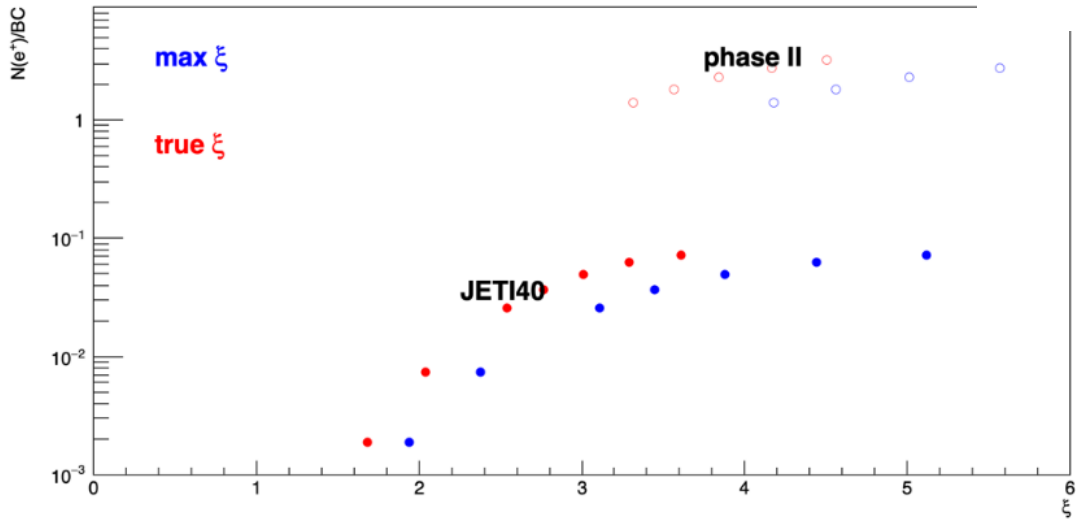
Signal in gamma laser setup

Plots of new gamma-laser files

B. Heinemann

Oct. 20th 2020

Positron rate vs xi



- Rather similar to previous files
- Large difference between phaseII and JETI40 => normalize by area (pi*R^2)
- Red shows the mean of the true underlying xi distribution

HICS spectra of e+ e-