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ICS Simulation Results

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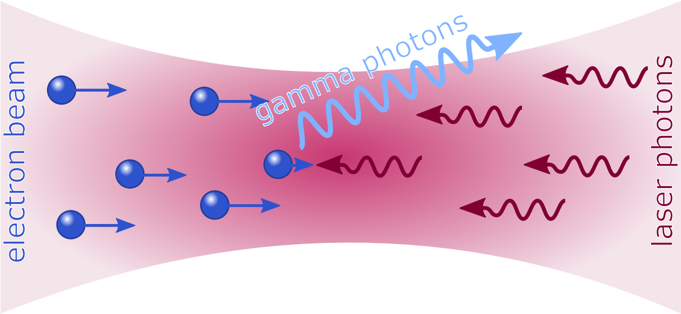
Inverse Compton Scattering Principle



parameter	value
ω_L	4.1 eV
γ	32290
ξ	< 0.1
η	0.518
$\gamma\theta$	$\ll 0.1$
ω	≈ 8.4 GeV
E_L	100 mJ

$$\omega \approx \frac{4\gamma^2\omega_L}{1 + \frac{\xi^2}{2} + \gamma^2\theta^2 + 2\eta}, \qquad \eta \approx \frac{2\gamma\omega_L}{m}$$

Simulations: `https://github.com/danielseipt/luxeics`

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ICS Bandwidth

$$\left(\frac{\Delta\omega}{\omega}\right)^2 = \left(\frac{\Delta\omega_L}{\omega_L}\right)^2 + \left(\frac{\xi^2}{2}\right)^2 + \left(2\frac{\Delta\gamma}{\gamma}\right)^2 + \left(\frac{\gamma^2\Delta\theta_e^2}{\#}\right)^2 + (\lceil N_{sc} - 1\rceil\eta)^2 + \dots$$

- Bandwidth contribution small: $< 1 \times 10^{-3}$
- $\xi < 0.1$: 2.5×10^{-5}
- $\Delta\gamma/\gamma = 0.1\%$: 4×10^{-6}
- Angular spread: dominant contribution for tight beam focusing
- Number of scatters $N_{sc} = \mathrm{rate} \times \mathrm{pulse\ duration} < 1$: ≈ 0

Curatolo et al,PRAB 20, 080701 (2017)

Various Constraints

- Need $\chi_\gamma \sim 1$ at IP for efficient NBW pair production $\Rightarrow \omega_\gamma$ as large as possible
- Maximize photon flux at IP to optimize pair yield
- Gamma-profile at IP always $\gg$ strong-laser spot size
- Minimize γ-rays bandwidth for vertex reconstruction?
- given machine emittance ϵ, γ-bandwidth is dominated by ebeam angular spread $\Delta\theta \propto \epsilon/\sigma_T$

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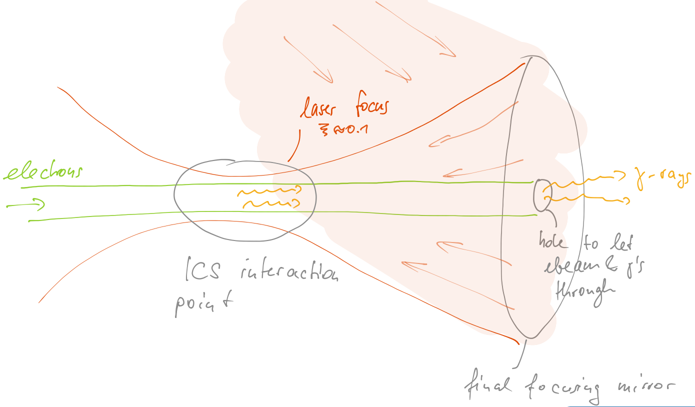
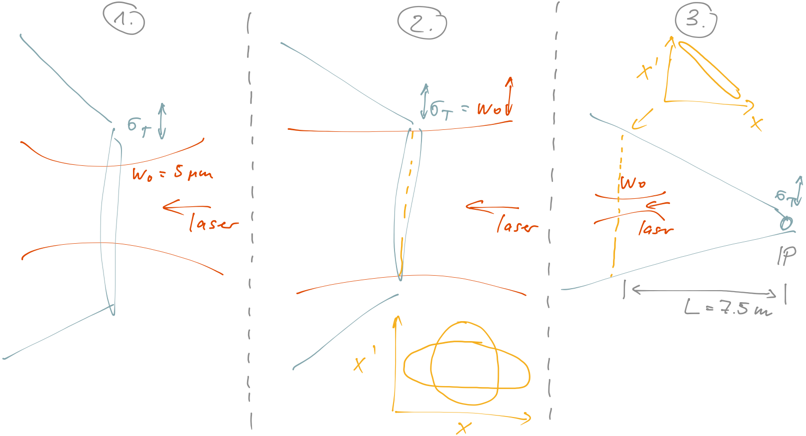
ICS Parameters

- 100 mJ laser energy in 300 nm light (3rd harmonic of 900 nm) in 1 ps duration
- head-on collision
- minimal available electron beam spot size at target ≈ 5 micron
- All fluxed normalized to 1 BX (100 pC beam charge, 1.4 mm mrad emittance, 16.5 GeV, 0.1% energy spread, $\sigma_L = 20$ micron)

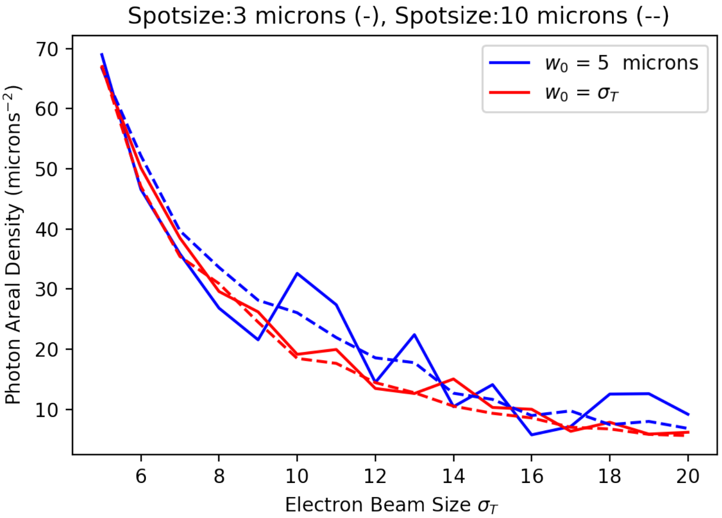


Collision Geometries

1. laser focus 5 micron, electron focus variable
2. laser focus = electron focus variable
3. electrons focused to IP (not target) location

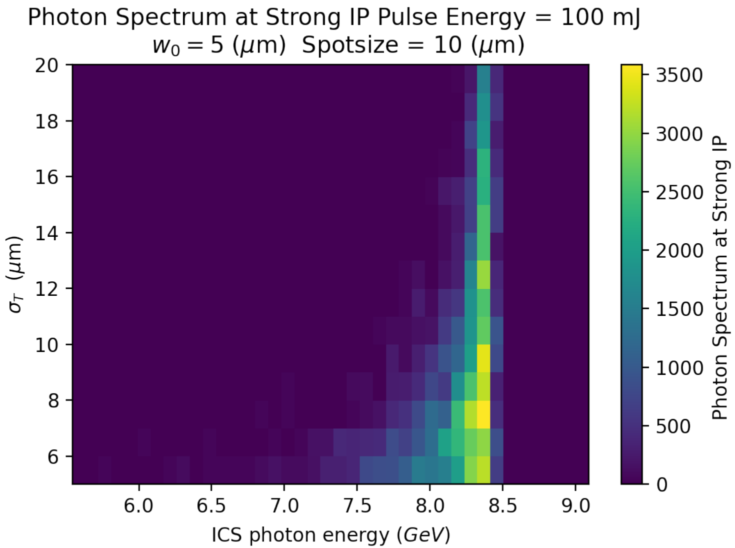


Photon Flux spatially homogeneous at IP

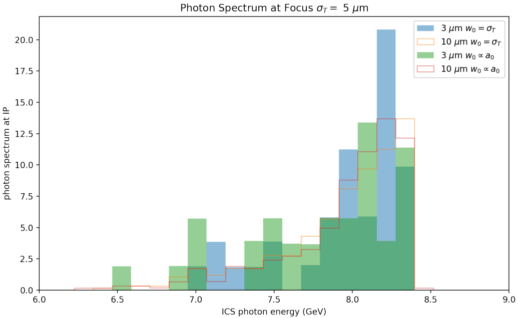


Largest photon flux ($\approx 65/\mu m^2$) for 5 micron target spot size

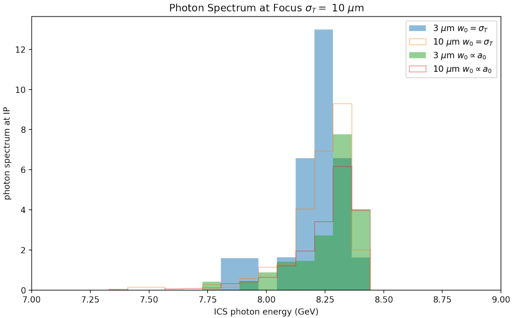
Spectra at IP



small ebeam

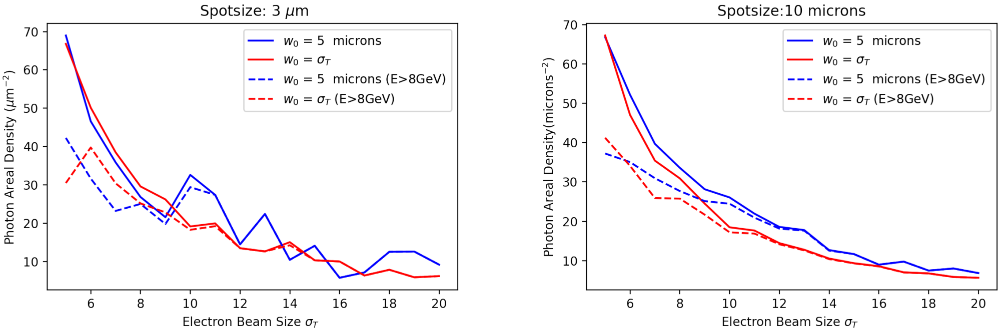


large ebeam



Photon Flux with Cuts

For strongest electron focusing the gamma spectrum becomes broadband.



Cut in photon energies above 8 GeV: flux drops to $\approx 40/\mu m^2$
but flux less sensitive to beam focusing σ_T, w_0

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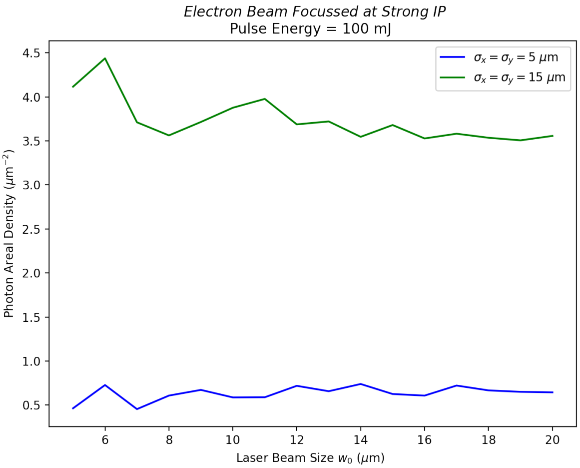
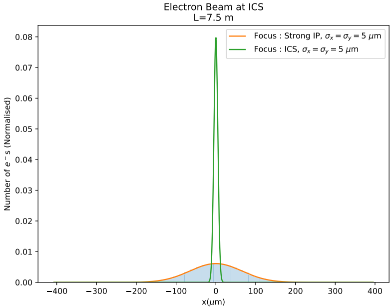
Ebeam focus at strong IP (Scenario 3)





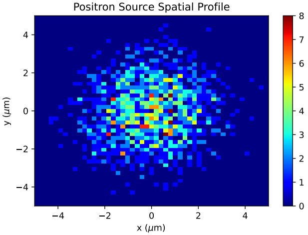
Not reliable

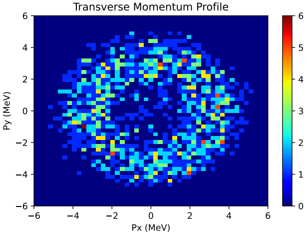
e^+e^- Production Sims: PTARMIGAN config

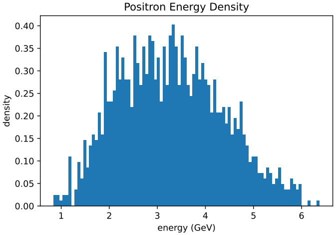
- NBW positron produciton using PTARMIGAN
- Initial plan was to directly import LUXEICS output to PTARMIGAN, but that was not feasible with limited time
- Instead model γ-beam as Gaussian with flux, mean ω and std fitted to LUXEICS data

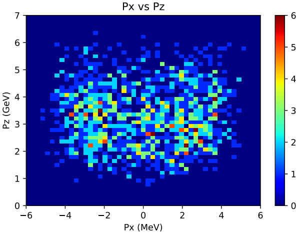
```
laser:
  a0:           10
  waist:        5.0 * micro
  wavelength:   0.8 * micro
  fwhm_duration: 25 * femto

beam:
  ne:       100000
  species:  photon
  gamma:    7.898 * GeV / (m * c^2)
  sigma:    0.438 * GeV / (m * c^2)
  radius:   [5.0 * micro, normally_distributed]
```

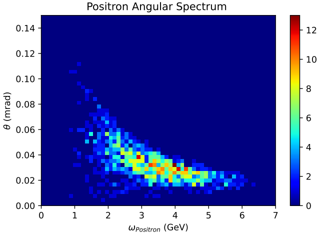
Positron distributions (PTARMIGAN)



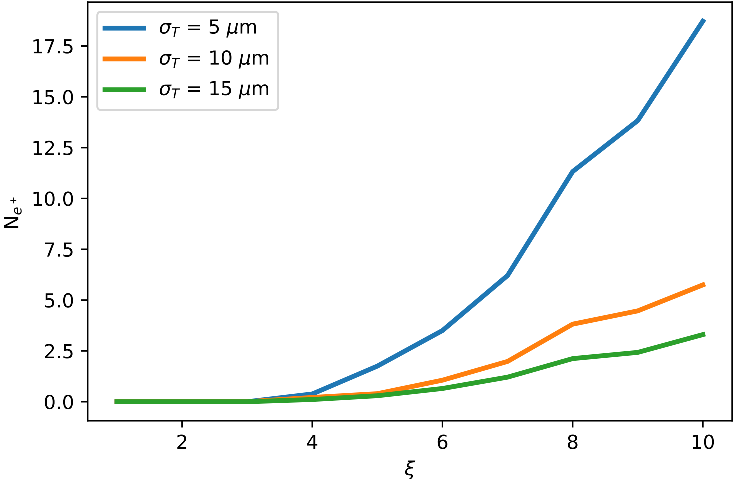








Positron Yield per BX



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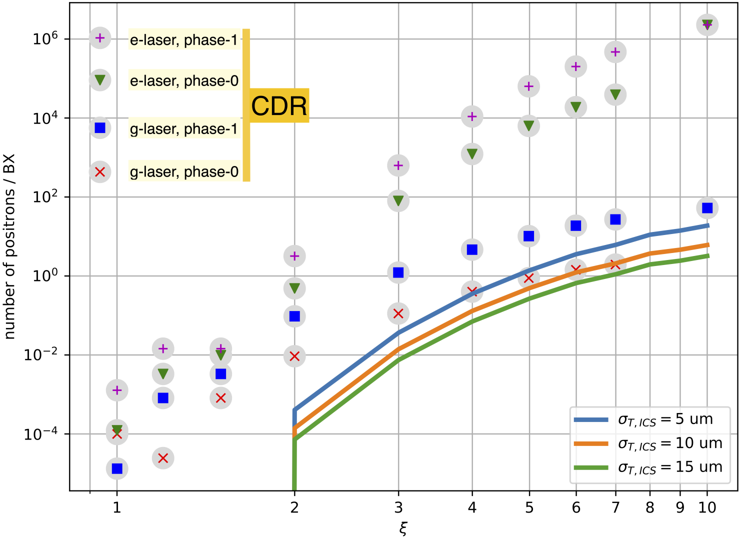
Positron Yield Comparison



Conclusions & Future Work

Summary:

1. Best to focus ebeam as hard as possible (5 micron), but 10 micron might be acceptable
2. Photon fluxes as high as $40 - 65/\mu m^2$
3. Positron yield comparable to Bremsstrahlung source

Outlook:

1. Include γ-ray polarization in ICS sims
2. Background studies ...
3. More detailed technical design of the ICS layout