Photon Position Resolution Requirement for Lumi Pair Spectrometer

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Procedure to estimate required photon position (X_γ , Y_γ) resolution

Need for X_γ and Y_γ resolution:

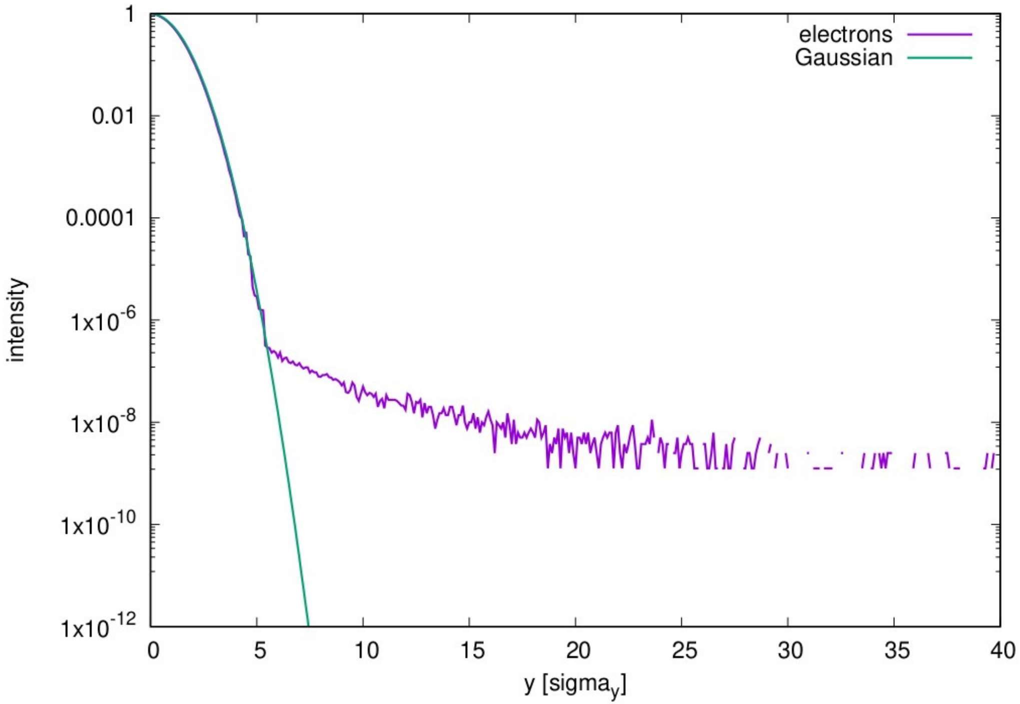
- With a sufficiently wide aperture, we would capture full Brem photon flux → no need to determine X_γ and Y_γ.
- Finite aperture due to, in particular, lumi diplole magnet bore diameter.
- Also electron beam not guaranteed to be steered along ePIC -Z axis.
- Photon beam will be clipped. Need to reliably extrapolate.
- To do that we need resolution on X_γ , Y_γ. How much depends on how much is clipped.

Procedure to determine needed X_γ and Y_γ resolution:

- Determine the extrapolation error of photon population vs clipped Nσ and X_γ resolution.
- Want δL <~ 1%, so we want δAcceptance < 1%.
- Determine the needed δX_γ for a reasonable maximum clipped Nσ.

What will the ESR electron beam profile look like?

Christoph Montag's studies



Longest tails expected in y direction

- Beam-gas scattering and beam-beam interactions yield very long tails.
- Tails are important for calculations of beam lifetime and SR loads.
- For the lumi PS program, the photon yield coming from the tails is totally negligible: << 1%.
- We can assume Gaussian beams.

$$\rho(r) = e^{-\frac{r^2}{2\sigma_r^2}} + K_r\, r^{-3}$$

$$K_r <= 0.0006$$

Toy MC simulation

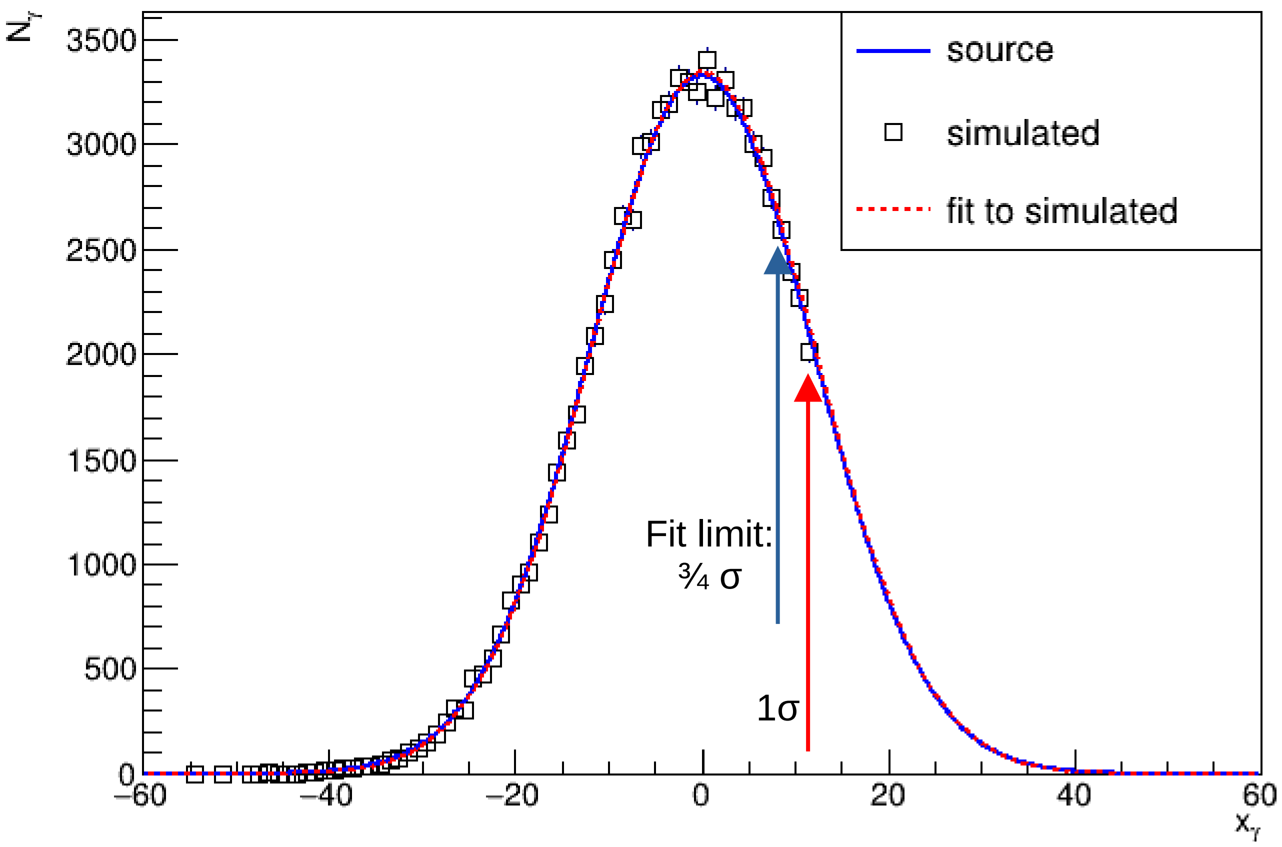
Source photon X_γ distribution taken as a Gaussian with
$\sigma = \delta\theta * Z = (211e\text{-}6 \text{ rad}) * (58 \text{ m}) = 12 \text{ mm}$

1) Randomly sample X_γ from the source
2) Clip one side by $N\sigma$
3) Smear X_γ by resolution
4) Fill a histogram with smeared X_γ
5) Fit the histogram with Gaussian and compare it's yield to that of the source

This is done for truncated $N\sigma$ between 0 and 5 from center of Gaussian, and for X_γ resolutions from 0 to 20 mm.

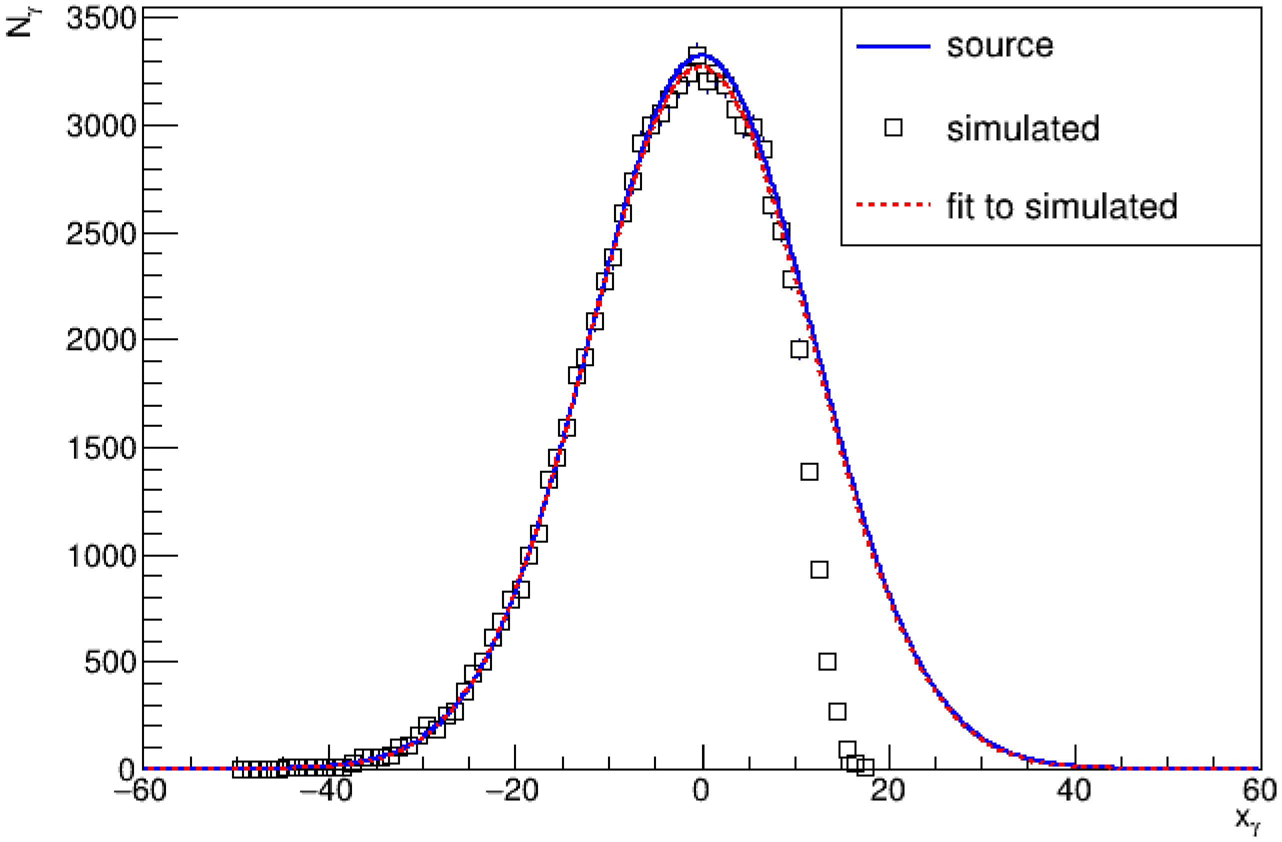
Fitting the clipped & smeared distribution causes non-Gaussian features.
Best fits obtained by fitting from -5σ to ¾ $N\sigma_{clipped}$

1σ truncation, perfect position resolution



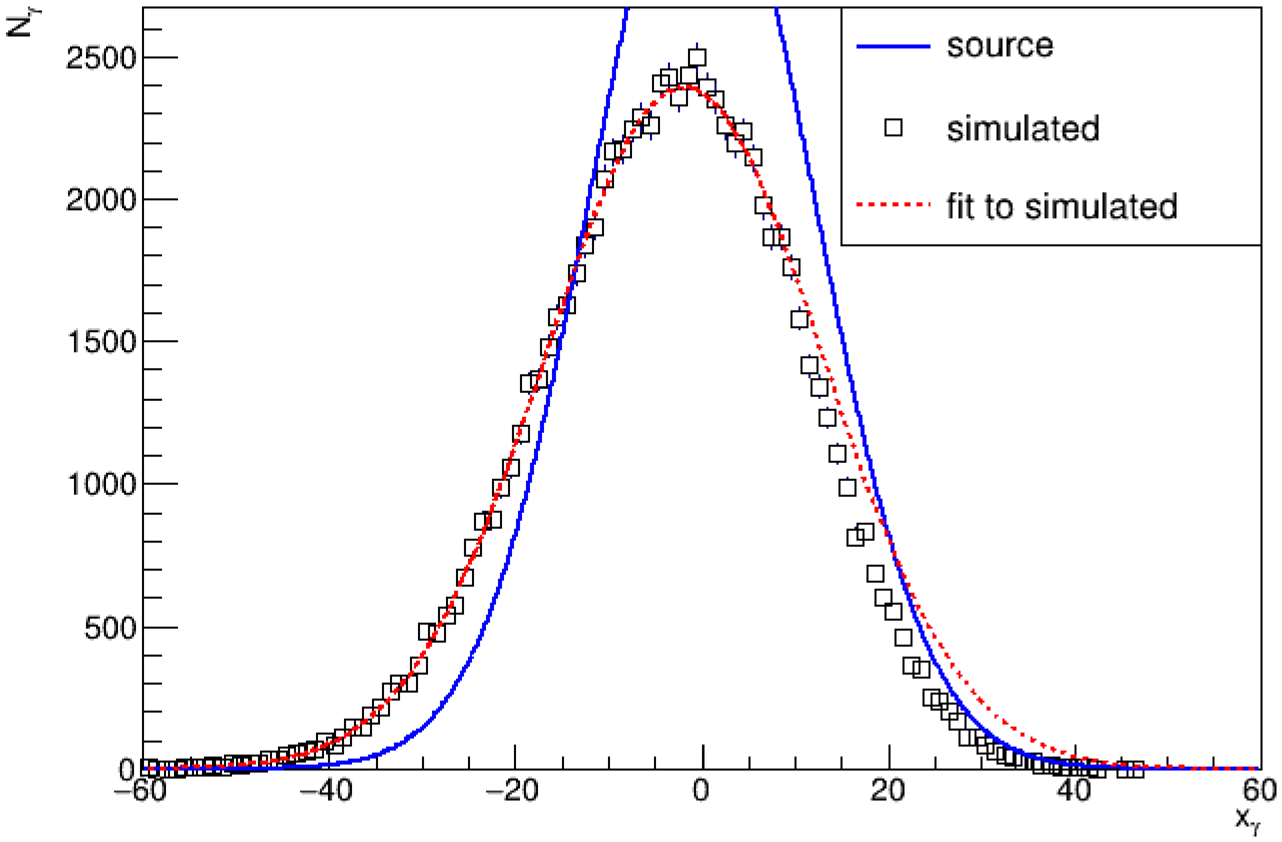
Acceptance error = 0.4%

1σ truncation,
2 mm position resolution



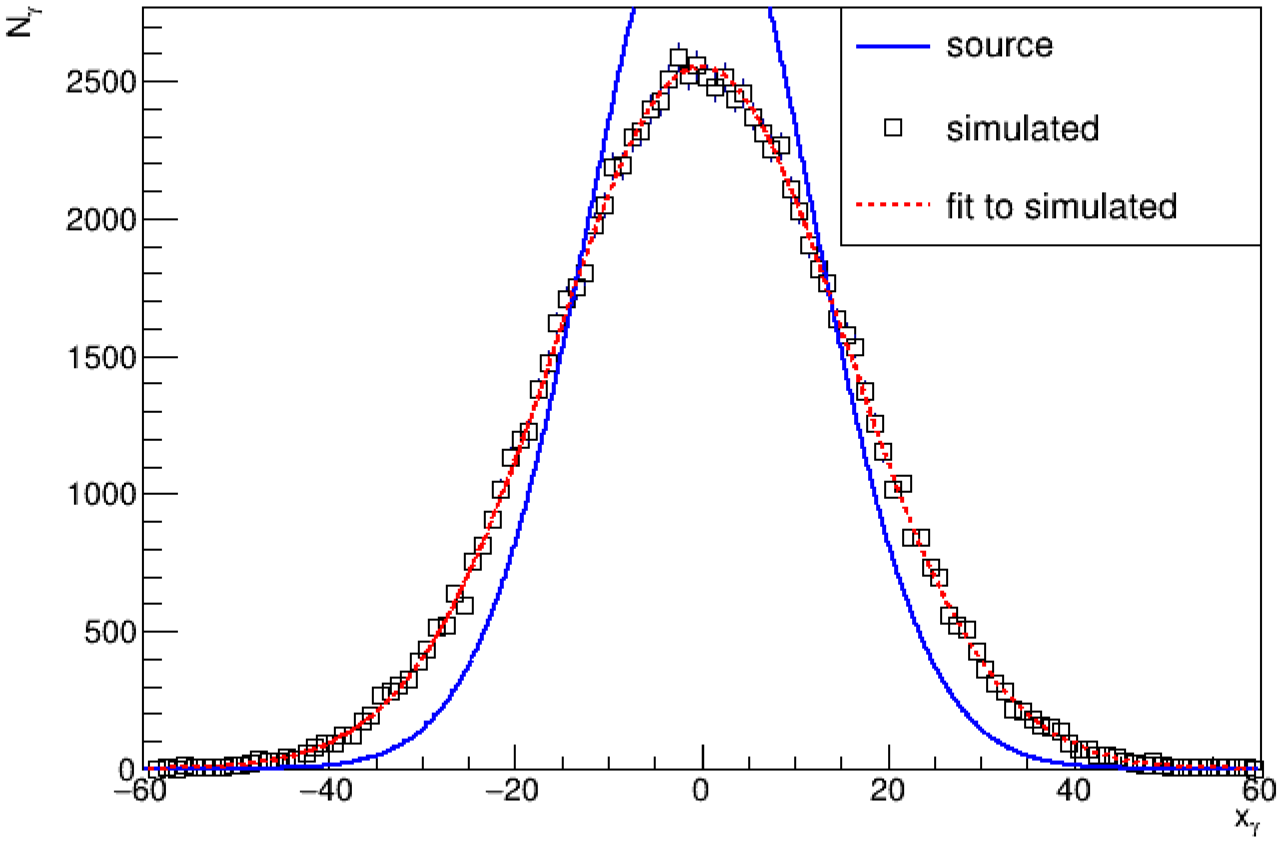
Acceptance error = 0.6%

1σ truncation,
10 mm position resolution



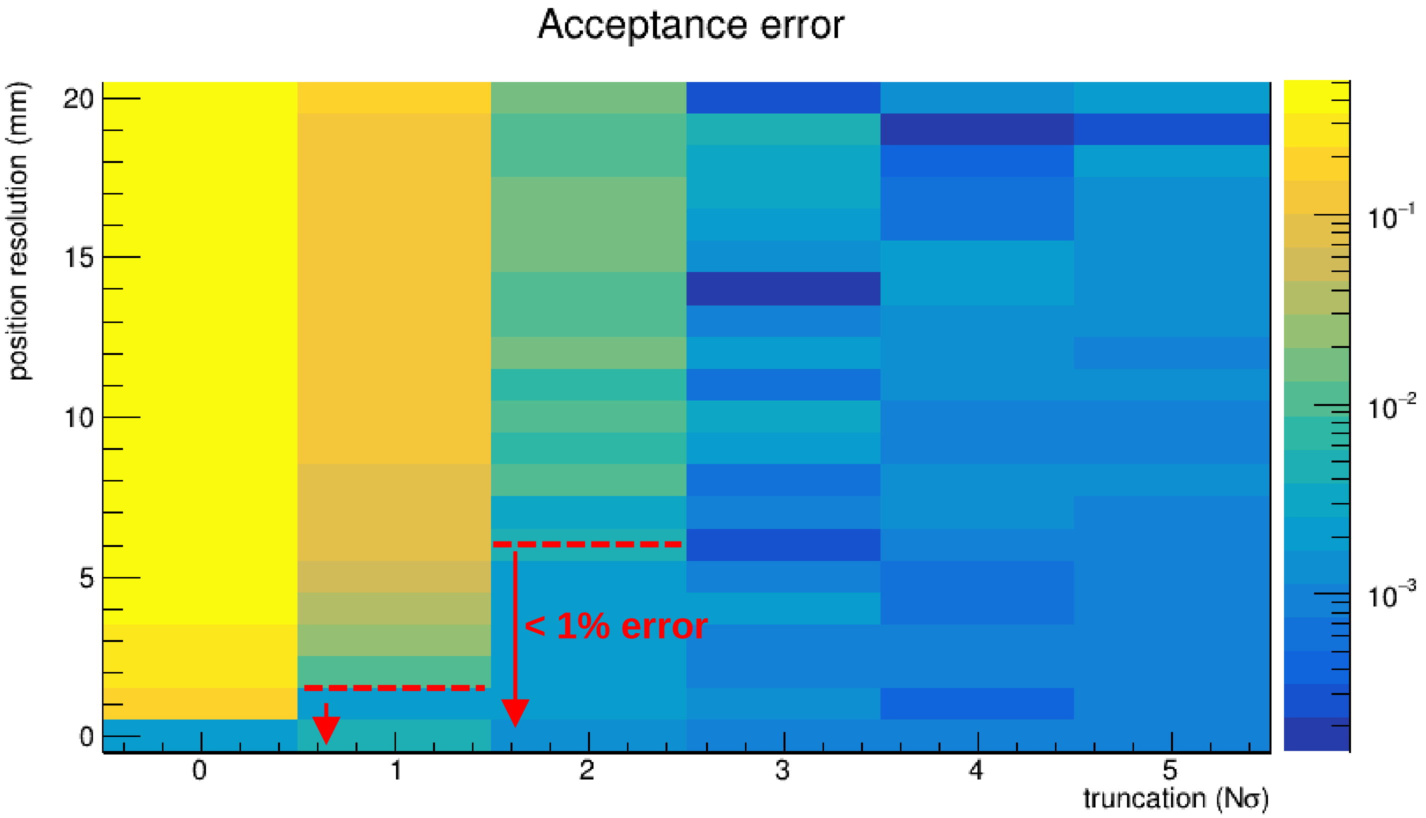
Acceptance error = 11%

3σ truncation,
10 mm position resolution



Acceptance error = 0.2%

Putting it all together



Acceptance error depends on truncation and position resolution.

How much truncation to expect??

Difficult to answer, but discussions with Christoph Montag suggest that Nσ=2 might be a reasonable max. Corresponds to a 630 urad angle of electron beam at IP.

- To achieve < 1% error, we need a X_γ resolution of **< 6 mm**.

Summary

- If ~600 urad is a reasonable maximum electron angle to expect at IP,
  we need a photon transverse position resolution of at least 6 mm.
- Previous studies of a 2-layer ACLGAD tracker yield a 2 mm resolution.
- Need to estimate the resolution obtained from the PS CALs alone. This needs the CAL position resolution and energy resolution.