Miniworkshop difrakce a ultraperiferálních srážek
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The photon flux of a fast lead ion

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Where do the photons come from?

- Take the electric field of a particle at rest.
- Boost it to high velocity.
- Take the square of the Fourier transform.

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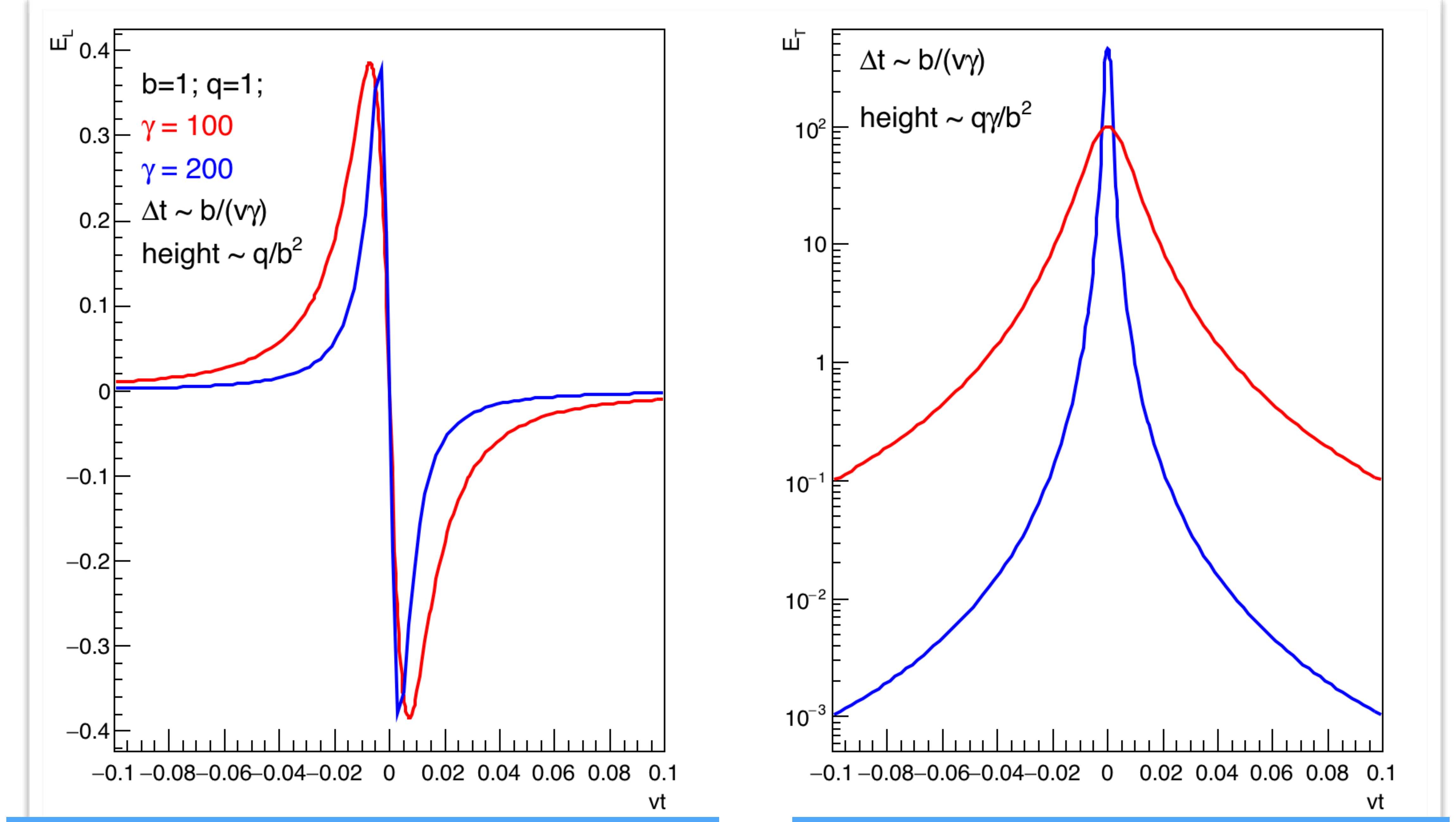

Longitudinal electric field

Transversal electric field

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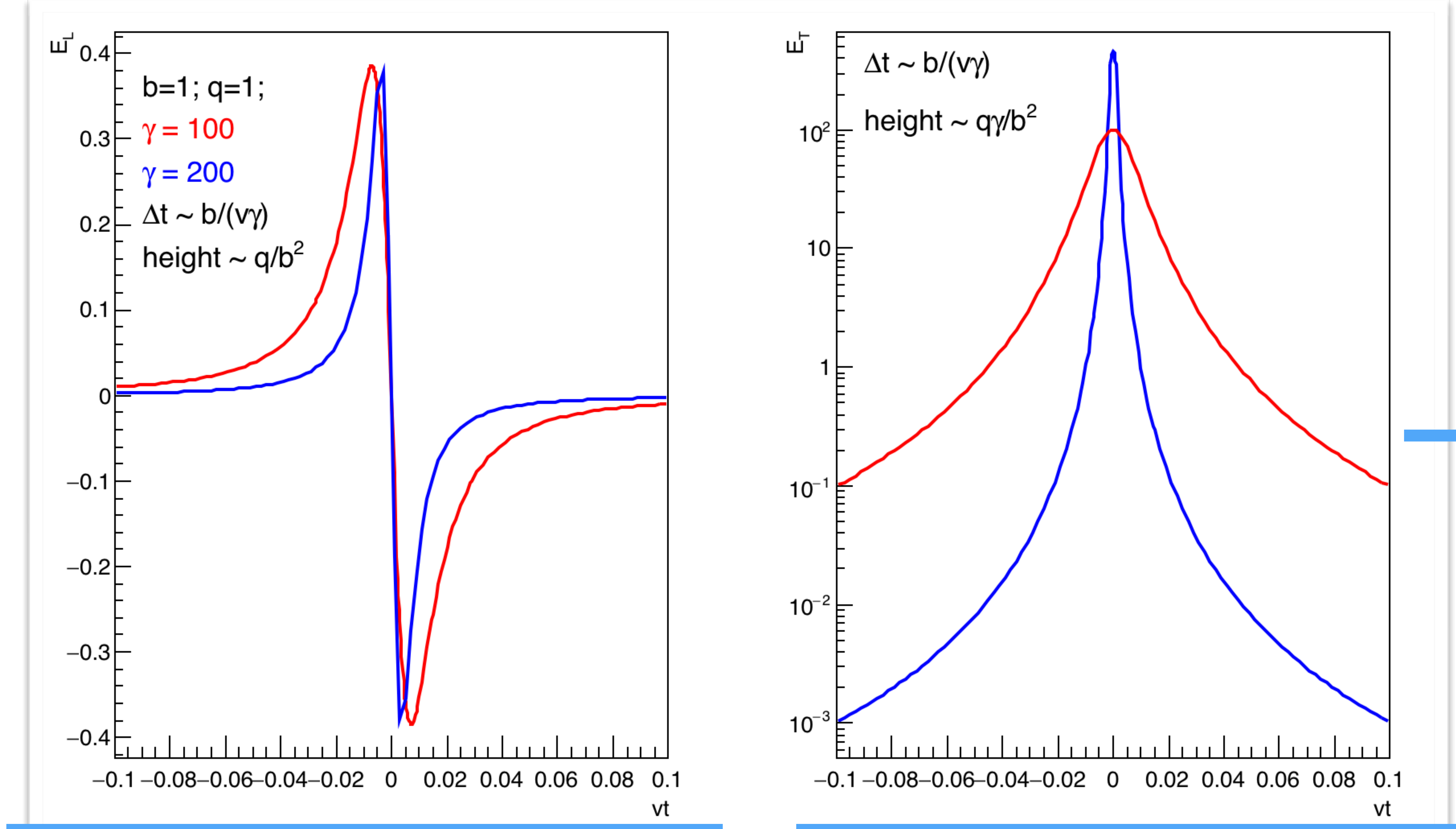
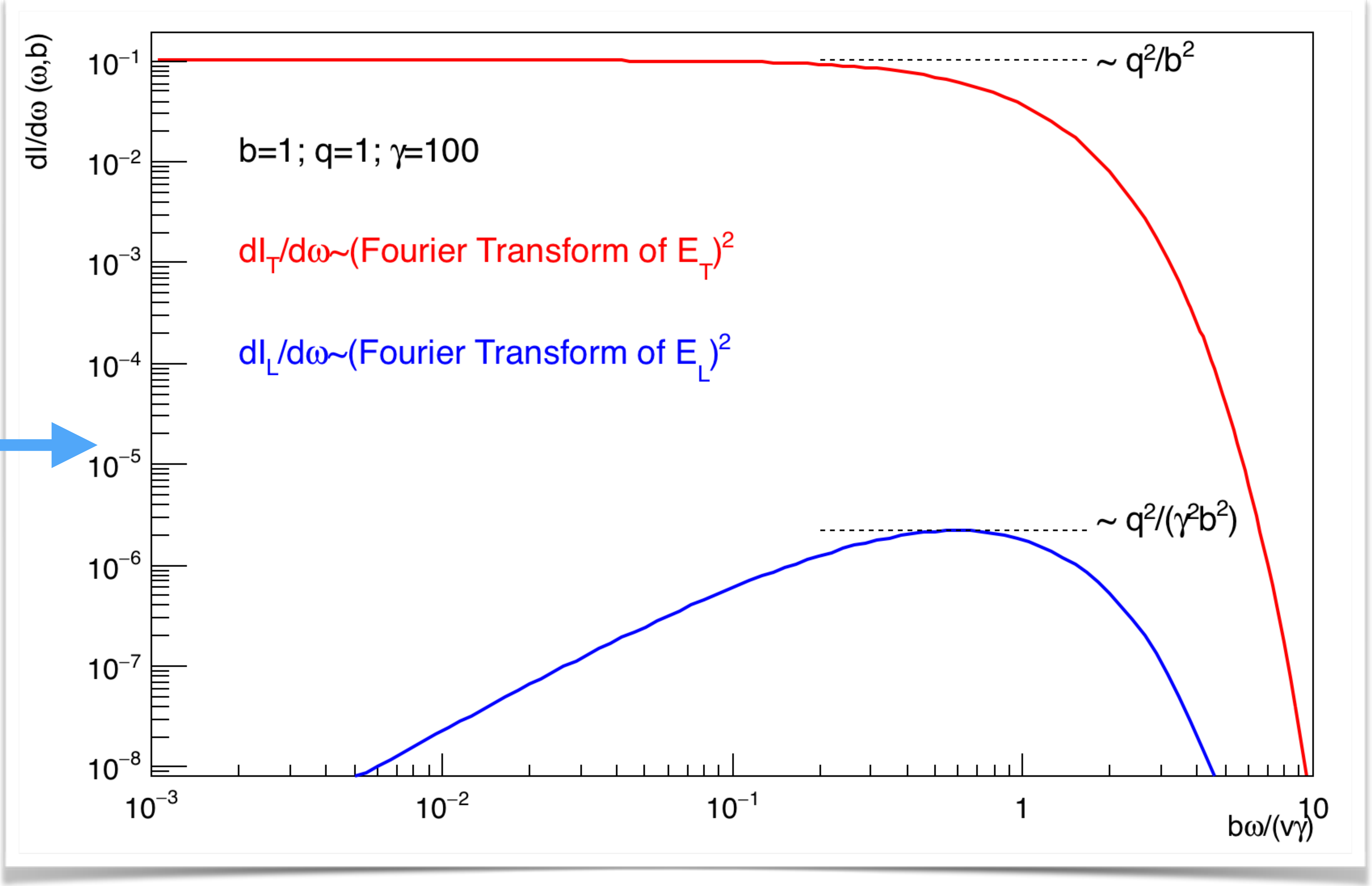


Longitudinal electric field

Transversal electric field

|FT|²



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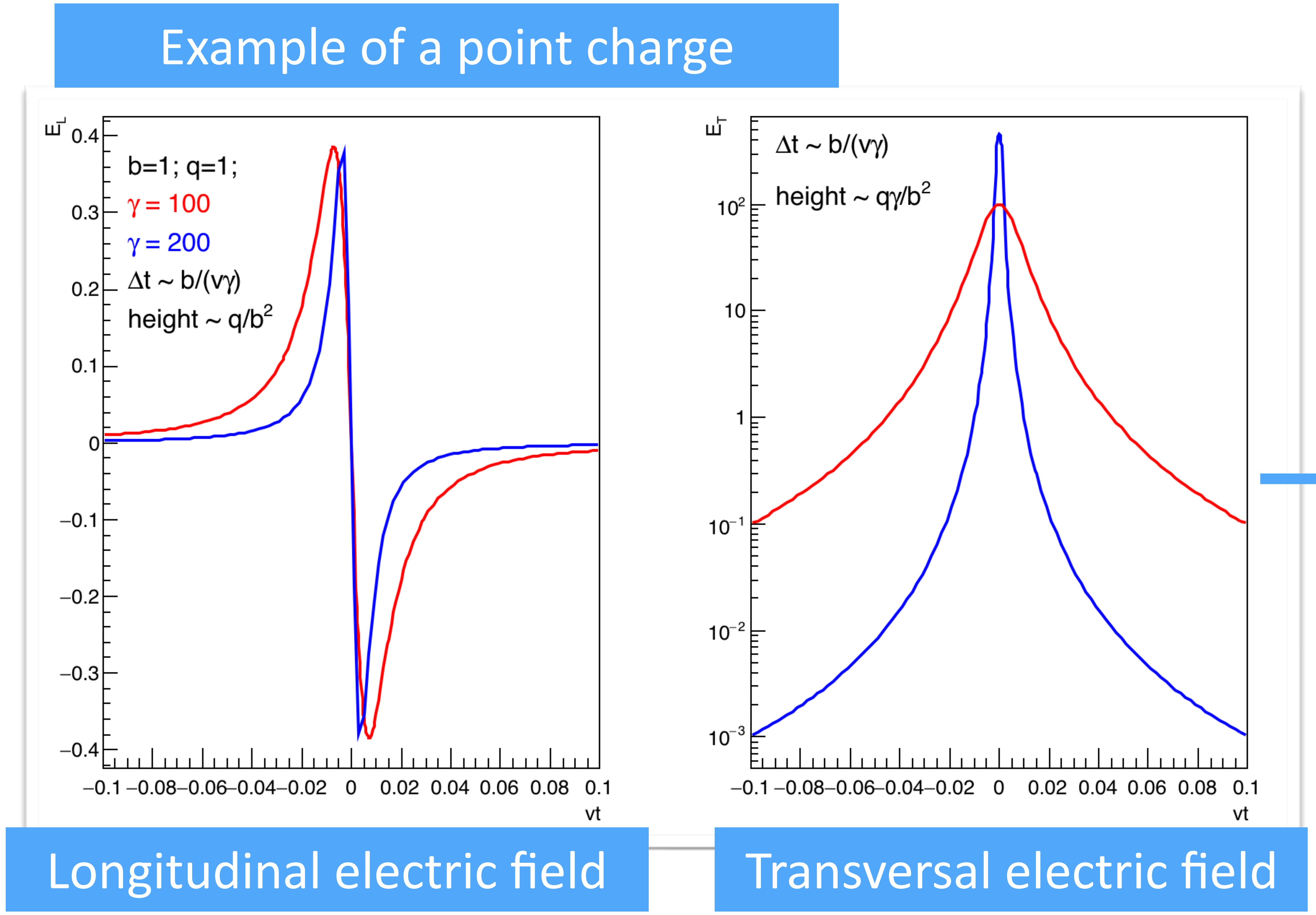

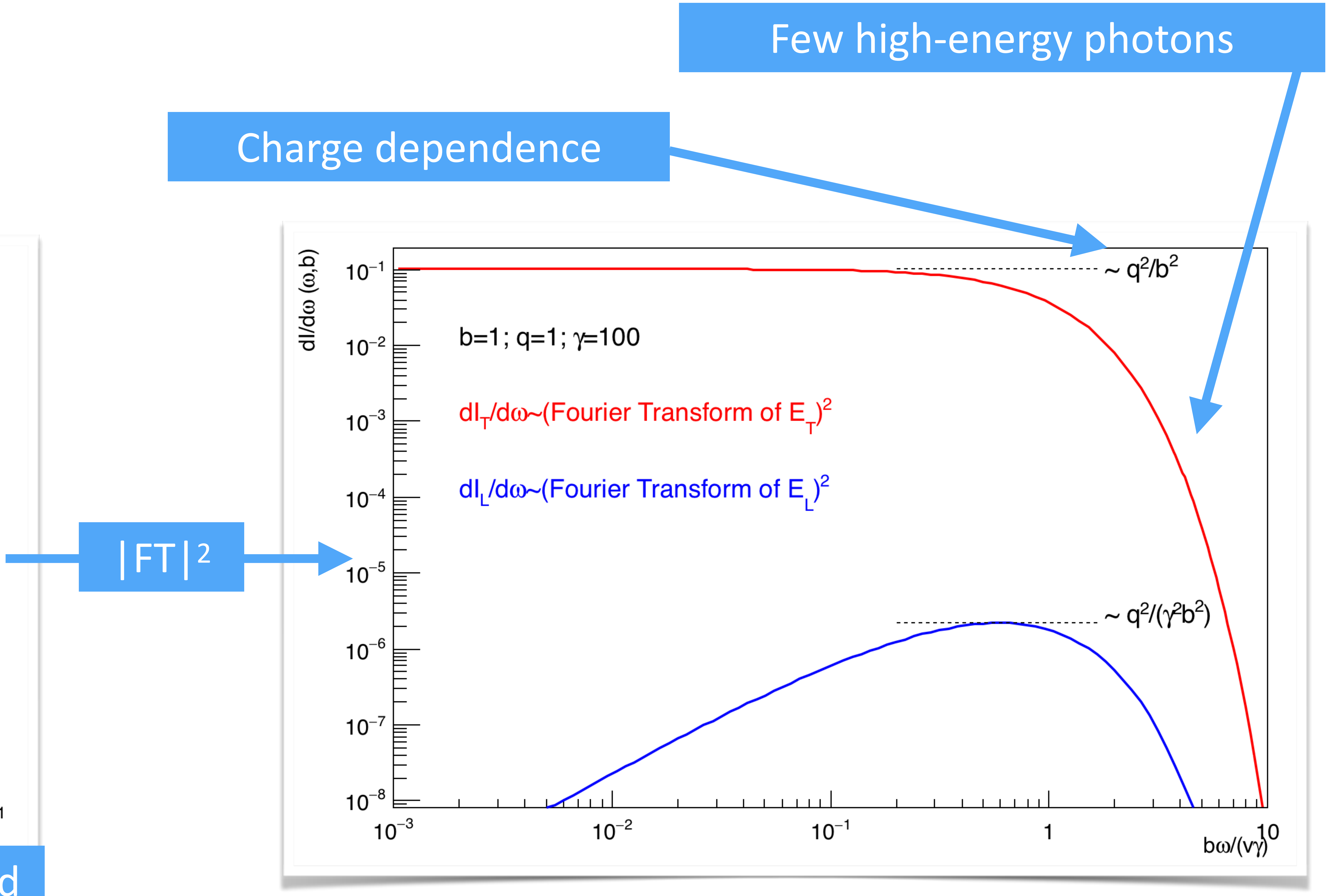

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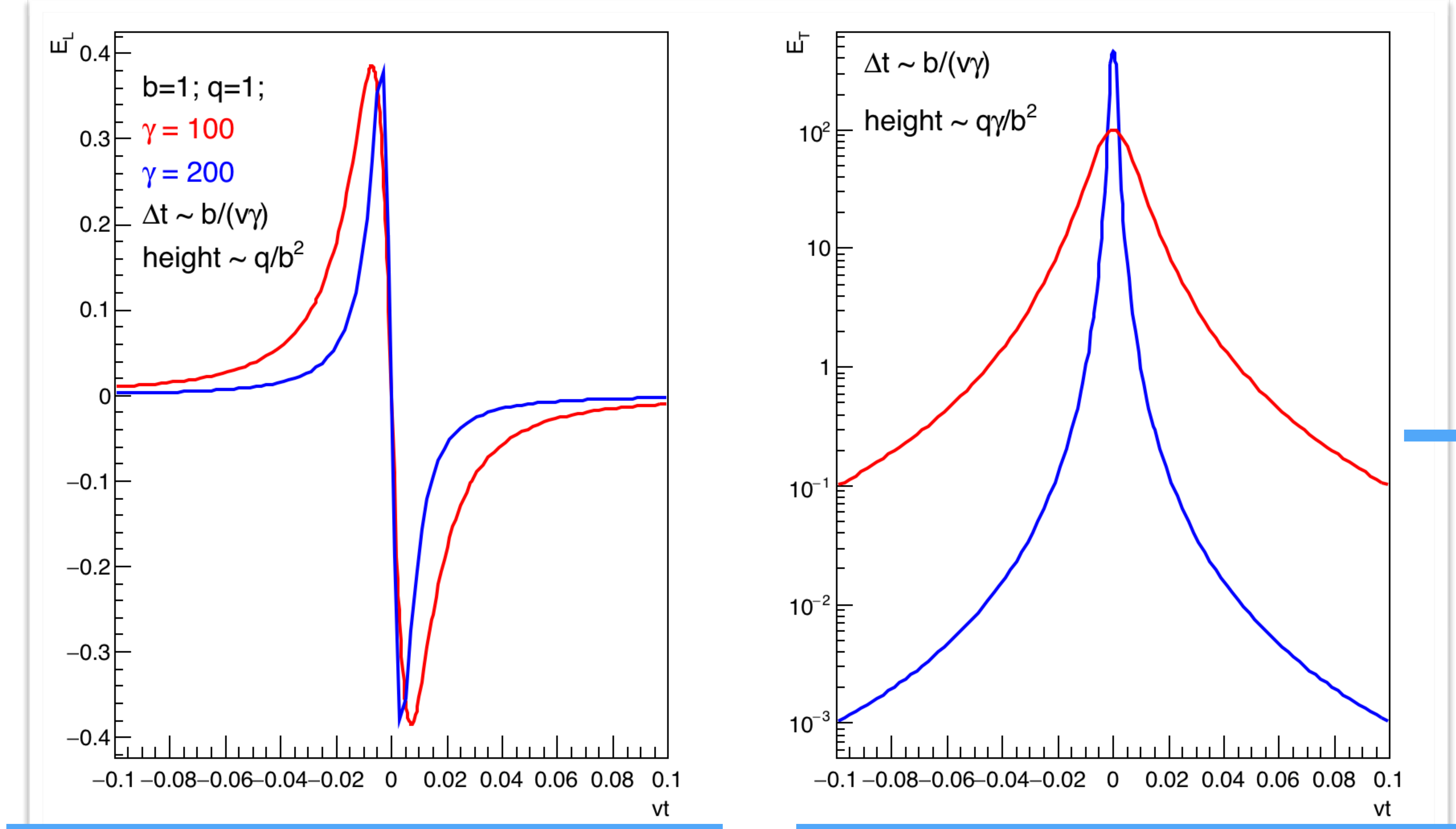

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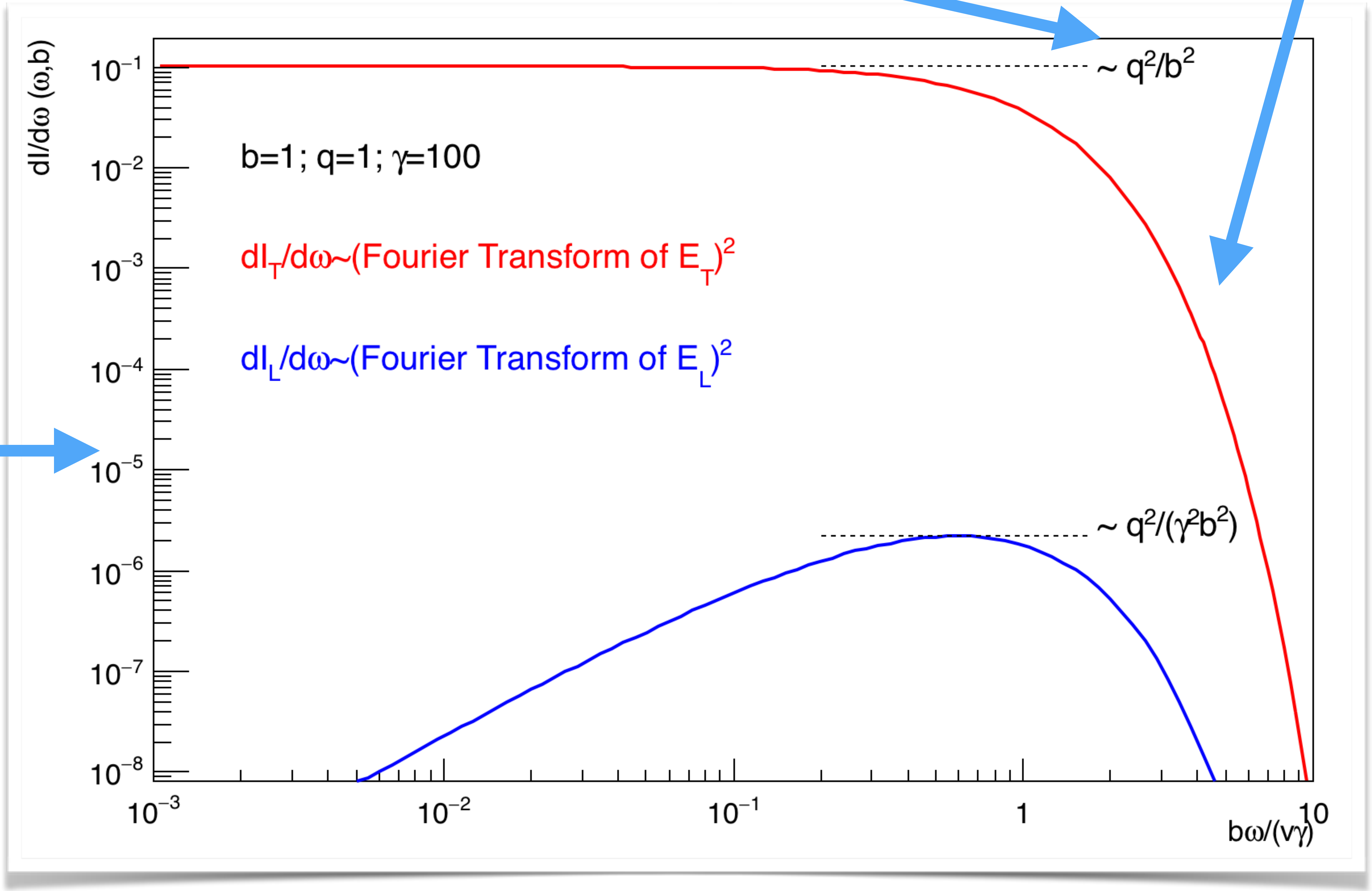
Charge dependence

Few high-energy photons



This intensity is interpreted as the number of photons with a given energy and at a given transverse distance from the charge.

Photon flux from a fast particle

Photon energy

Flux of photons

$$n(k, \vec{x}_\perp) = \frac{Z^2 \alpha_{\rm QED}}{\pi^2 k} \left| \int_0^\infty dk_\perp k_\perp^2 \frac{F(k_\perp^2 + (k/\gamma)^2)}{k_\perp^2 + (k/\gamma)^2} J_1(x_\perp k_\perp) \right|^2$$

Distance from centre of particle to point of emission

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EM Form factor

Distance from centre of particle to point of emission

Lorentz factor

Photon flux from a fast particle

Flux of photons

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EM Form factor

- Point charge
- Convolution of Yukawa and hard sphere potentials
- Fourier Bessel transform of Woods-Saxon distribution

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Distance from centre of particle to point of emission

Lorentz factor

Form factor for a point charge

$$\boxed{F_{pc}(q) = 1}$$

Integral can be done analytically

$$\boxed{n_{pc}(k, \vec{x}_\perp) = \frac{Z^2 \alpha_{\mathrm{QED}} k}{\pi^2 \gamma^2} K_1^2(k x_\perp / \gamma)}$$

Other form factors for Pb

$$F_{hsY}(q) = \frac{4\pi d_0}{Aq^3}\left[\sin(qR_A) - qR_A\cos(qR_A)\right]\left(\frac{1}{1+a^2q^2}\right)$$

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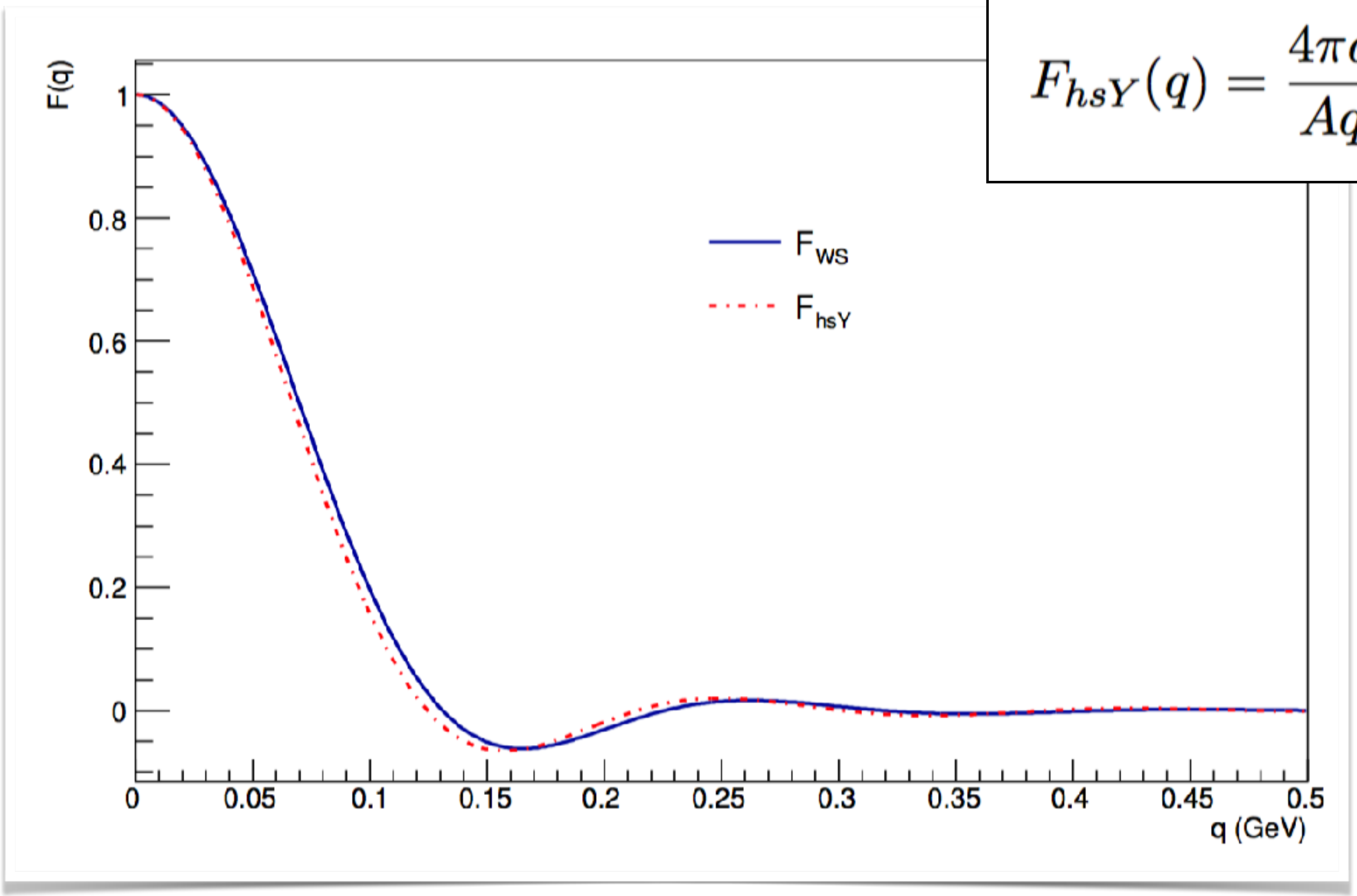

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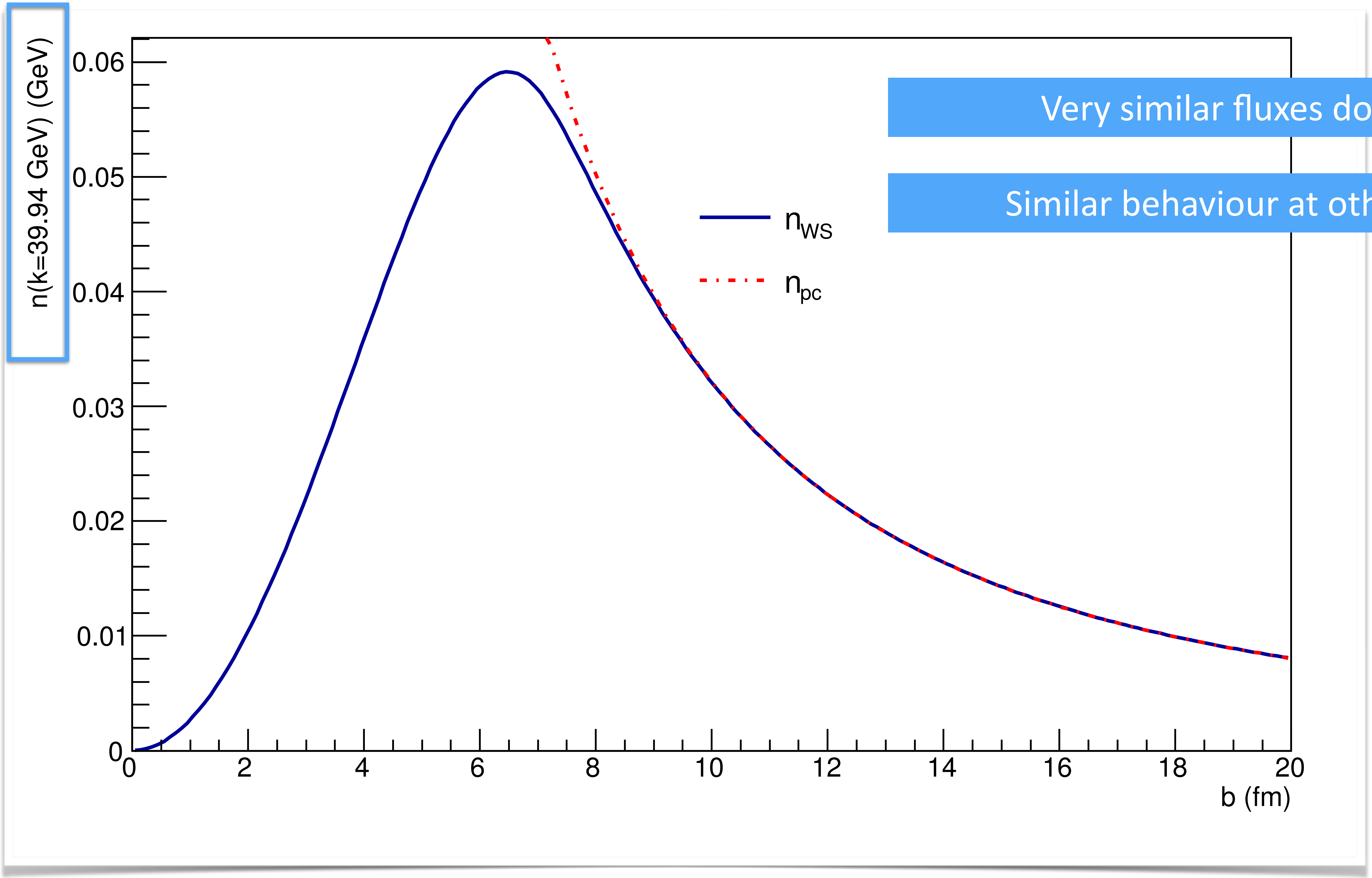
Very similar … convolution of hard sphere and Yukawa potential numerical easier to use …

Fluxes from Pb for different form factors



Very similar fluxes down to about 9 fm

Similar behaviour at other photon energies

Flux in UPC collisions

- One way of computing the flux in UPC is:
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Probability of no hadronic interaction

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$$T_A(\vec{r}) = \int dz \rho(\sqrt{|\vec{r}|^2 + z^2})$$

Nuclear thickness

$$T_{AA}(|\vec{b}|) = \int d^2\vec{r} T_A(\vec{r}) T_A(\vec{r} - \vec{b})$$

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$$P_{NH}(b) = \exp(-T_{AA}\sigma_{NN})$$

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For coherent interactions:
Average over target surface

Code

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  Original code not by me. I modified it slightly.
  Computes ρ, T_A and T_{AA}
  Uses Global.h, where constants are defined.

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- **ProbNoInt.C**
  Computes P_{NH} for different systems/energies.
  Uses results from glauber.C and needs Global.h.
  It includes two different computations for σ_{NN}

$$P_{NH}(b) = \exp(-T_{AA}\sigma_{NN})$$

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- **FluxSL.C**
  Computes flux for different systems and impact parameter ranges
  Integrates up to a bmax, then uses exact result to integrate up to infinity.
  Uses results from ProbNoInt.C and needs Global.h.
  Call directly Flux or for example Make_Table.

$$n^U(y) = k \int_0^\infty db 2\pi b P_{NH}(b) \int_0^{r_A} \frac{rdr}{\pi r_A^2} \int_0^{2\pi} d\phi n(k, b + r\cos(\phi))$$

$$n^P(y) = k \int_{b_{\min}}^{b_{\max}} db 2\pi b (1 - P_{NH}(b)) \int_0^{r_A} \frac{rdr}{\pi r_A^2} \int_0^{2\pi} d\phi n(k, b + r\cos(\phi))$$