

Update on ϕ generator

Simulation objectives :

- Estimate the expected number of ϕ with

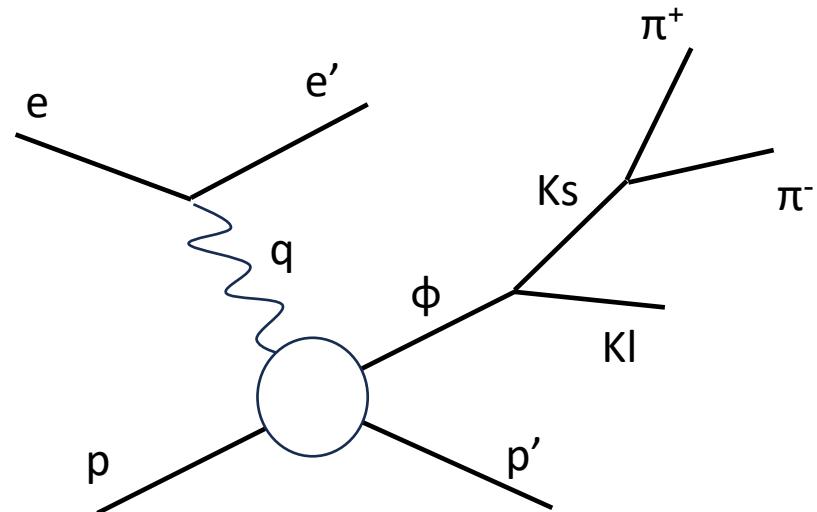
$$N_{expected} = \frac{\sum w_{rec}}{N_{gen}} * \mathcal{L}$$

- Find interesting cuts

Previously with **TGenPhasespace** (root module) :

- Generate automatically quadri-impulsion in the phasespace
- But problems with the weight associated with the phasespace

→ In the next slides the generator that we implemented without **TGenPhaseSpace**



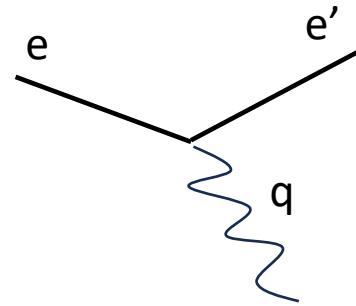
Update on ϕ generator

1. Initially :

$Target = (0, 0, 0, Mp)$

$Beam = (0, 0, Eb, Eb)$

Q^2 generated in $[1, 6.5]$ GeV



2. Scattering electron kinematics :

- Find W_{min}^2 and W_{max}^2 . Formula in *Byckling, E., and Kajantie, K. (1973b). Particle kinematics. Wiley-Interscience.*
- Find xb_{min} and xb_{max} (which depend on $W_{min/max}^2$ and Q^2)
- Generate xb in $[xb_{min}, xb_{max}]$
- Find $E' = E - \nu$ with $\nu = \frac{Q^2}{2*Mp*xb}$
- Find $\theta_{e'} = 2 * \arcsin(\sqrt{\frac{Q^2}{4EE'}})$
- Generate $\phi_{e'}$ in $[0, 2\pi]$

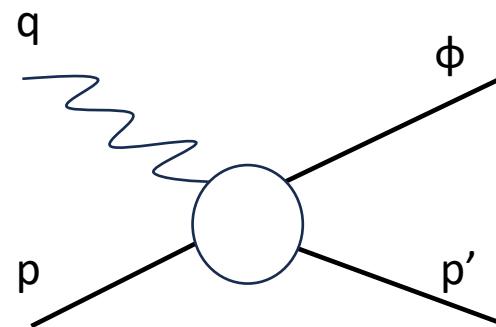
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3. Virtual photon kinematics :

$$q = e - e'$$

4. Scattering proton kinematics :

- Find t_{min} and t_{max}
 - Generate t in $[t_{min}, t_{max}]$
 - Find $E_{p'} = \frac{-t+2*Mp^2}{2Mp}$
 - Find $\theta_{\gamma p}$ between proton and photon
 - Generate ϕ_p (relative to the photon axis) in $[0, 2\pi]$
- Formula for $t_{min/max}$ and $\theta_{\gamma p}$ in *Byckling, E., and Kajantie, K. (1973b). Particle kinematics. Wiley-Interscience.*



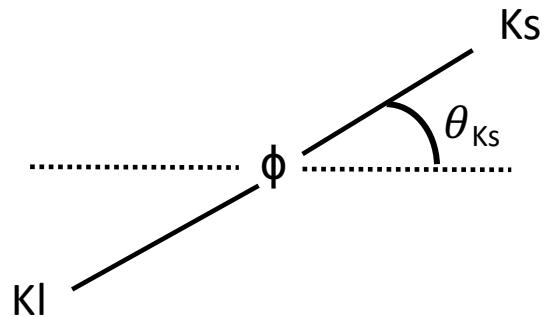
5. Meson ϕ kinematics :

$$\phi = p + q - p'$$

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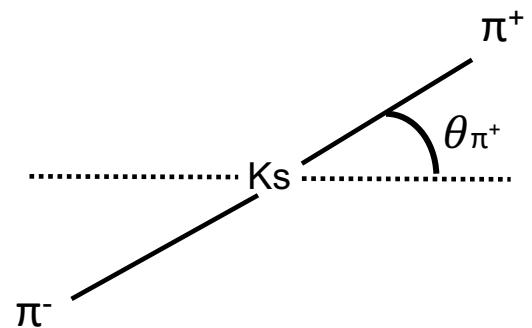
6. Kinematics of second decay $\phi \rightarrow K_s K_l$:

- Uniform decay in θ (and ϕ) in first approximation (in CM)
- Generate $\cos(\theta_{K_s})$ in $[-1, 1]$
- Generate ϕ_{K_s} in $[0, 2\pi]$
- Find $E_{K_s} = m_\phi/2$ and $p_{K_s} = \sqrt{E_{K_s}^2 - m_{K_s}^2}$
- $p_{K_l} = -p_{K_s}$ in CM
- Boost in order to find K_s and K_l in the lab



7. Kinematics of thrid decay $K_s \rightarrow \pi^+ \pi^-$:

- Same method than in step 6.
- V_x V_y V_z shifted by 2.8 cm in the direction of K_s emmision to simulate the flight of K_s



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$$weight_{PhaseSpace} = |Q_{max}^2 - Q_{min}^2| * |xb_{max} - xb_{min}| * |t_{max} - t_{min}|$$

$$\frac{d^3\sigma}{dQ^2dx_Bdt} \quad \text{From Proposal to Jefferson Lab PAC39 Exclusive Phi Meson Electroproduction with CLAS12}$$

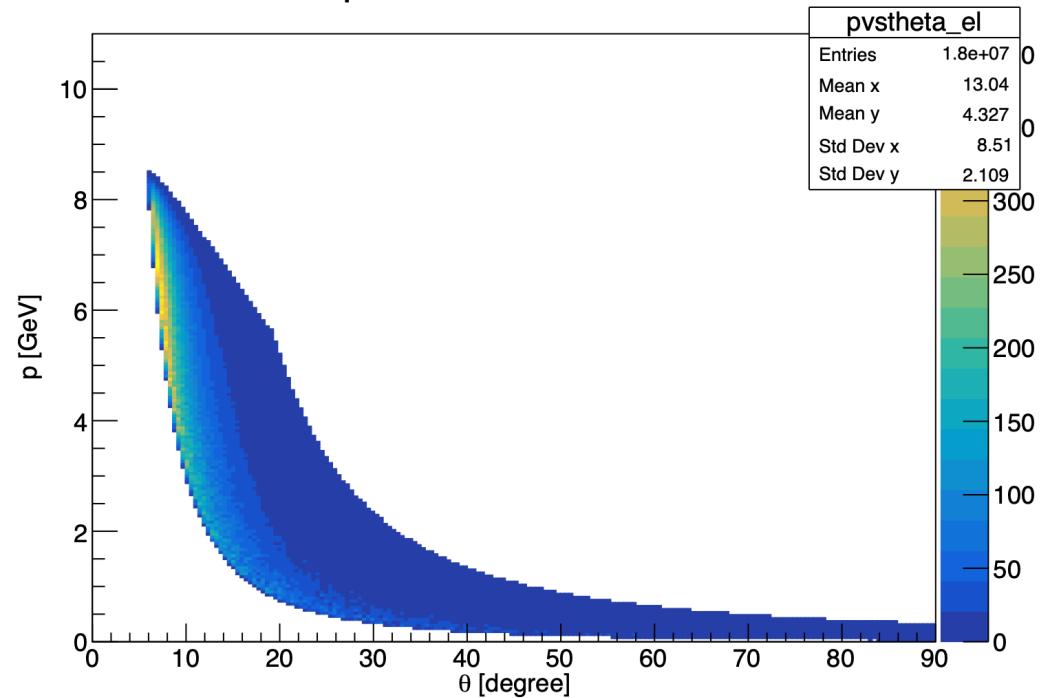
Branching ratio $Ks \rightarrow \pi^+ \pi^- = 69\%$

Branching ratio $\phi \rightarrow Ks Kl = 34\%$

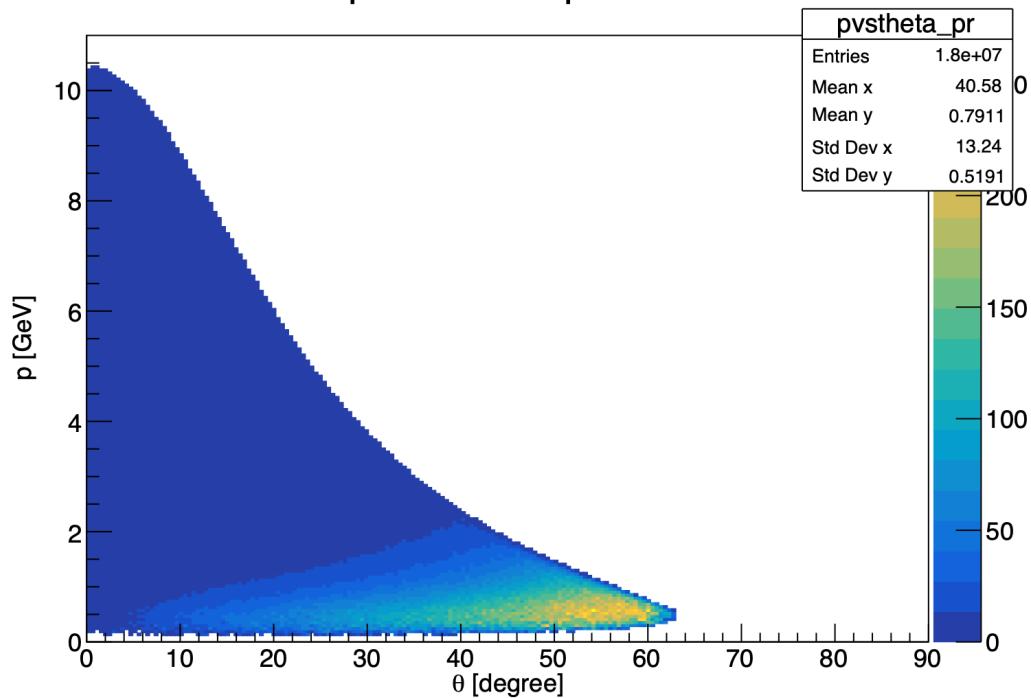
$$totalweight = weight_{PhaseSpace} * weight_{crosssection} * BR_{KsKl} * BR_{\pi^+ \pi^-}$$

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p vs theta for electron

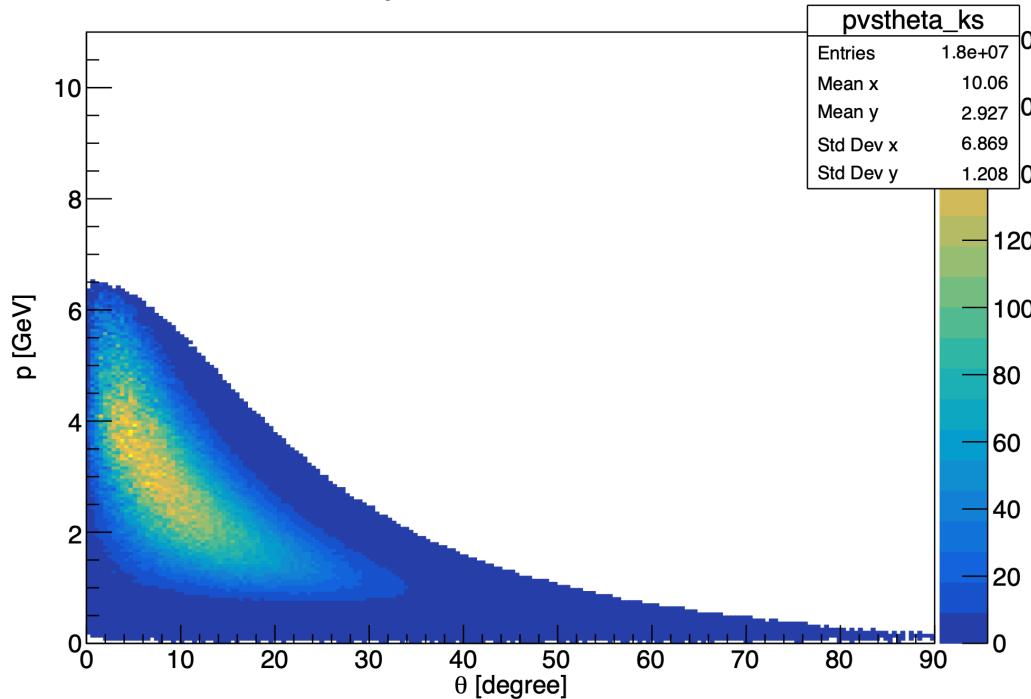


p vs theta for proton

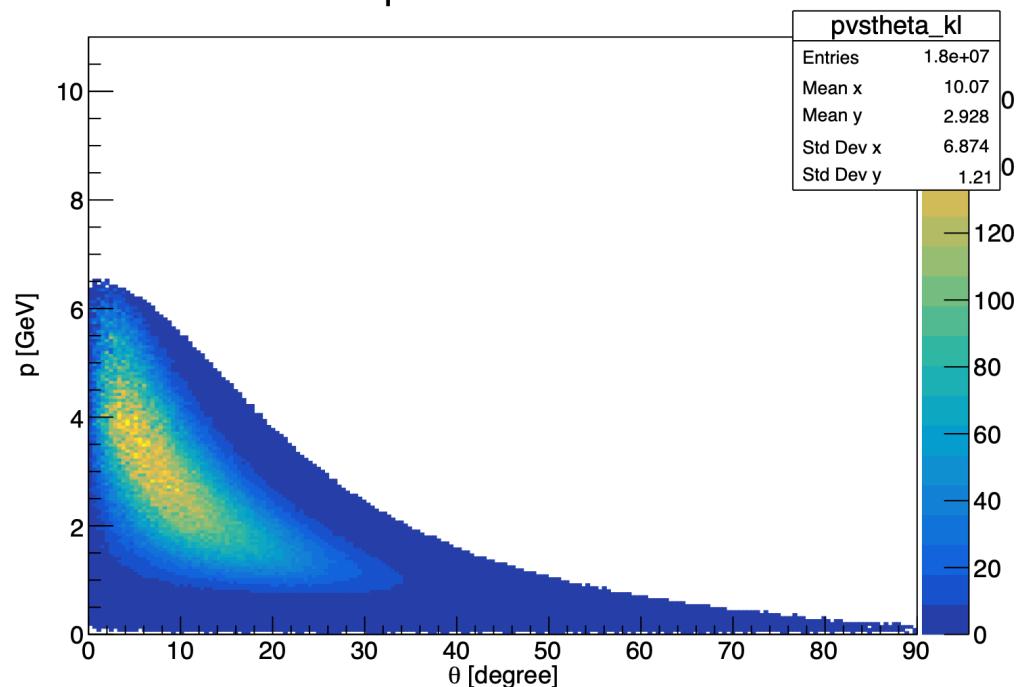


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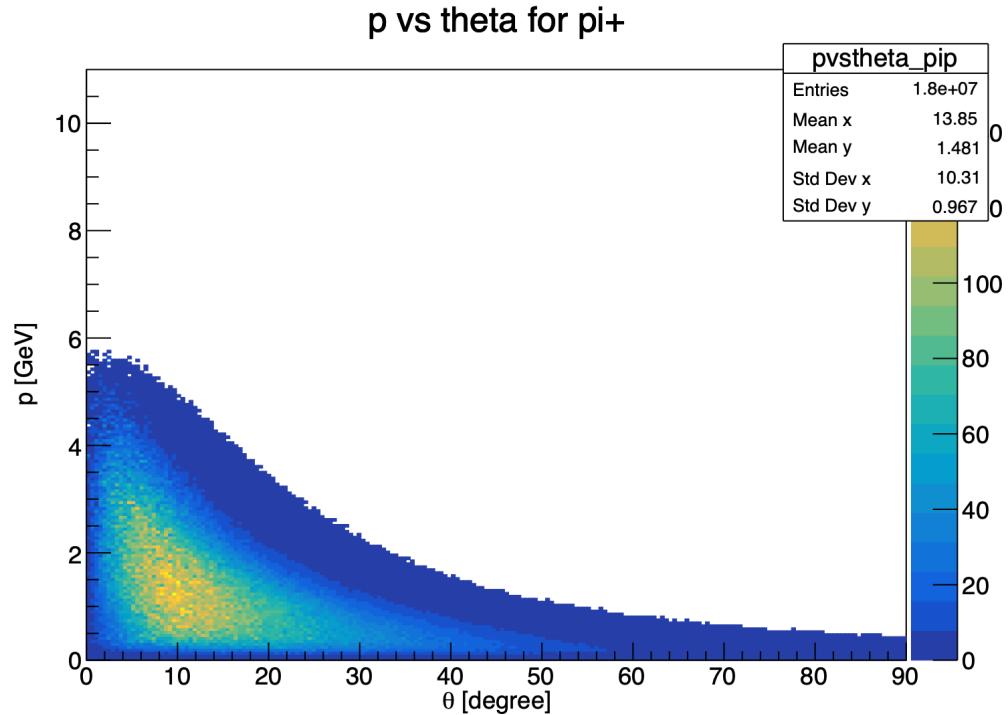
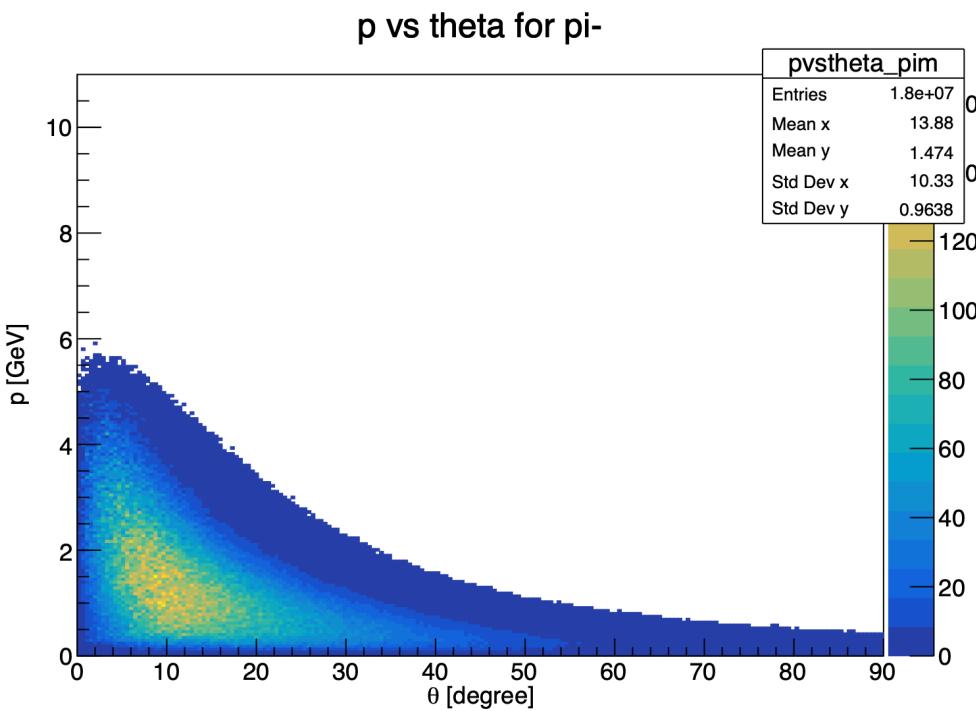
p vs theta for ks



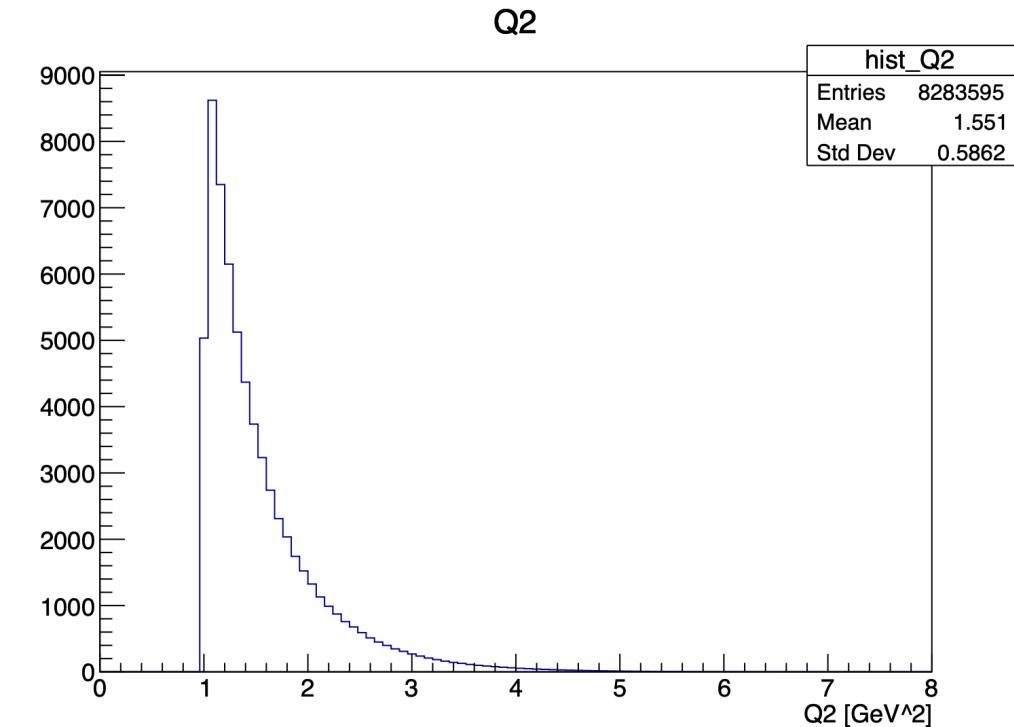
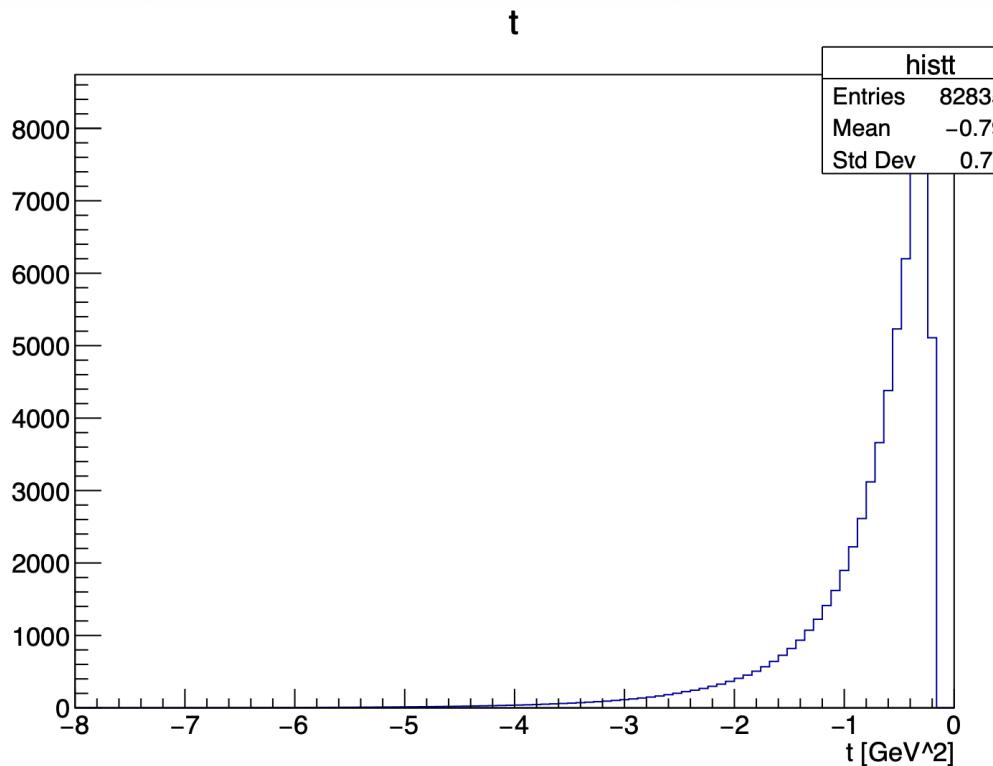
p vs theta for kl



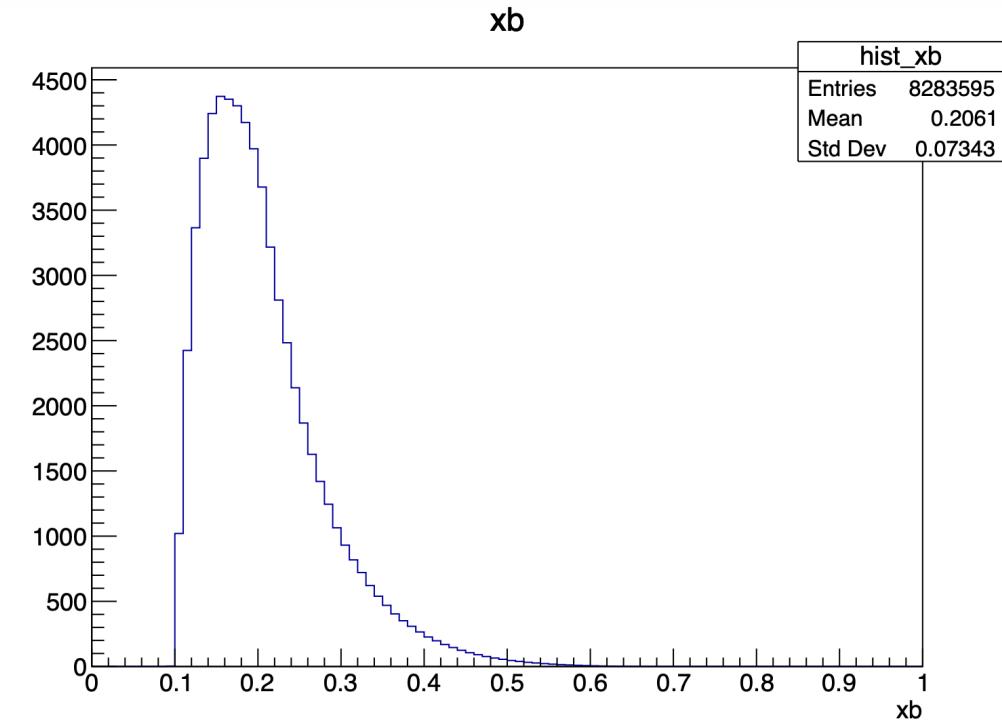
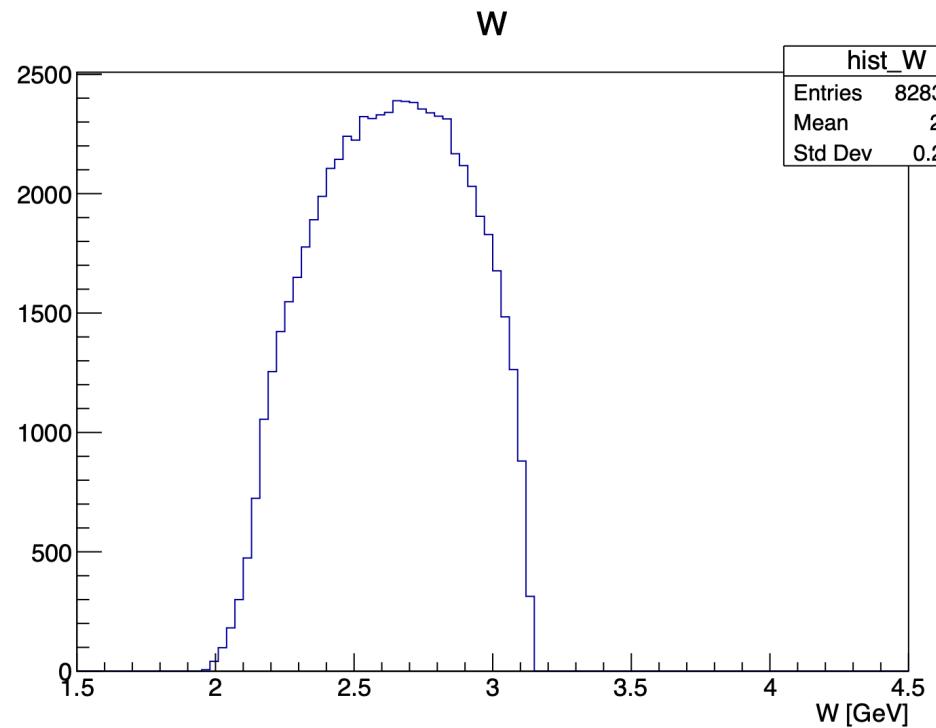
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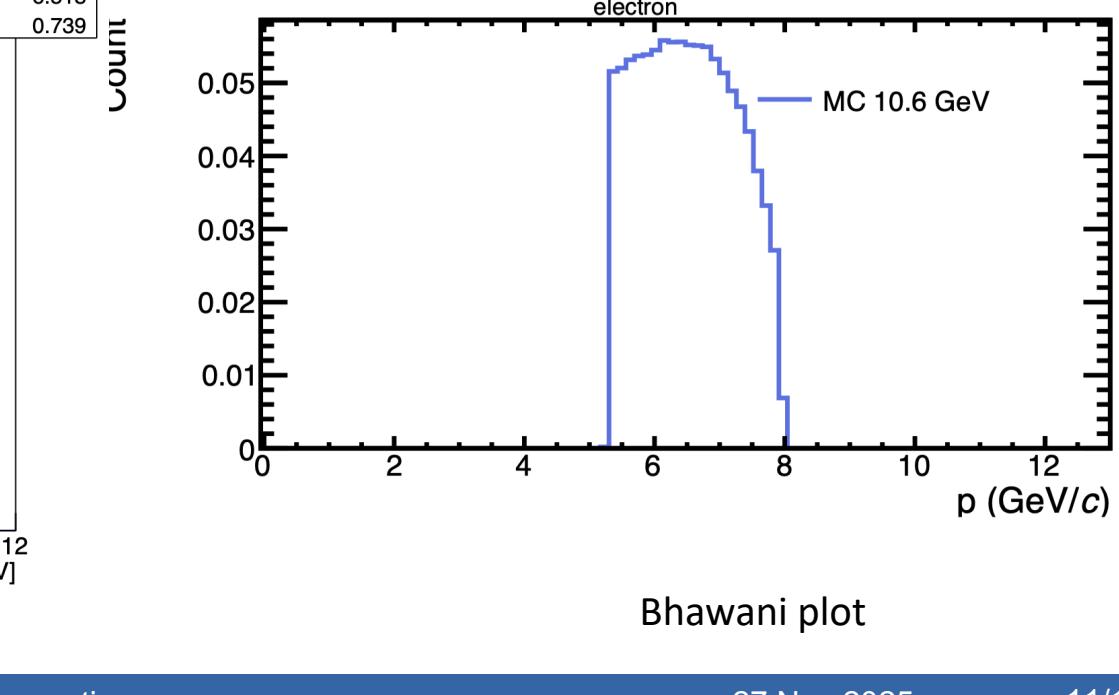
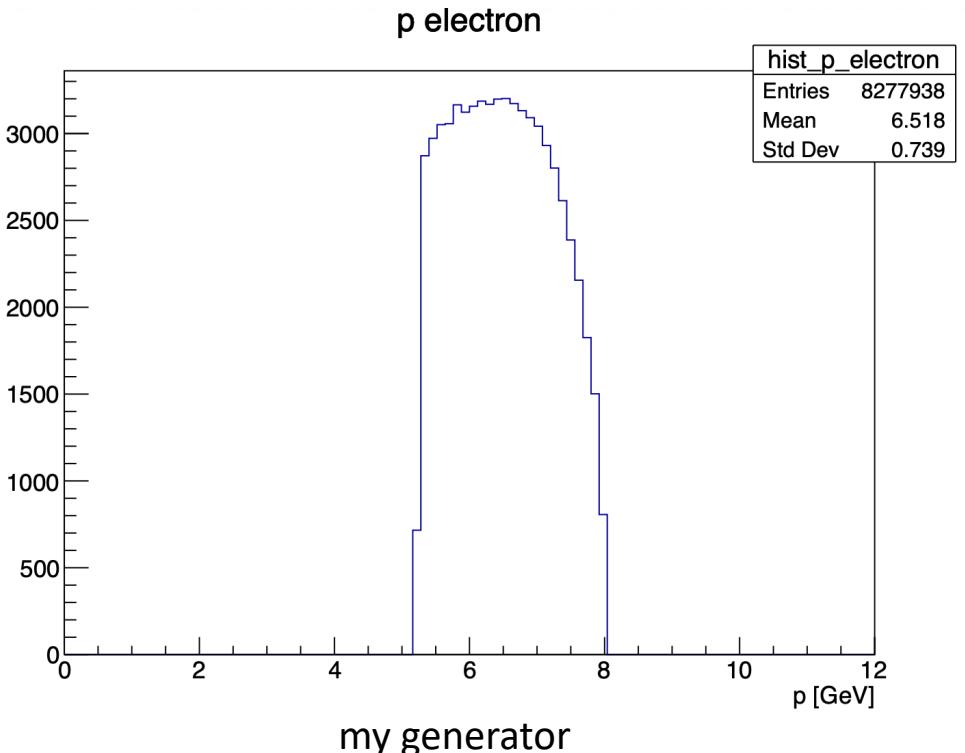


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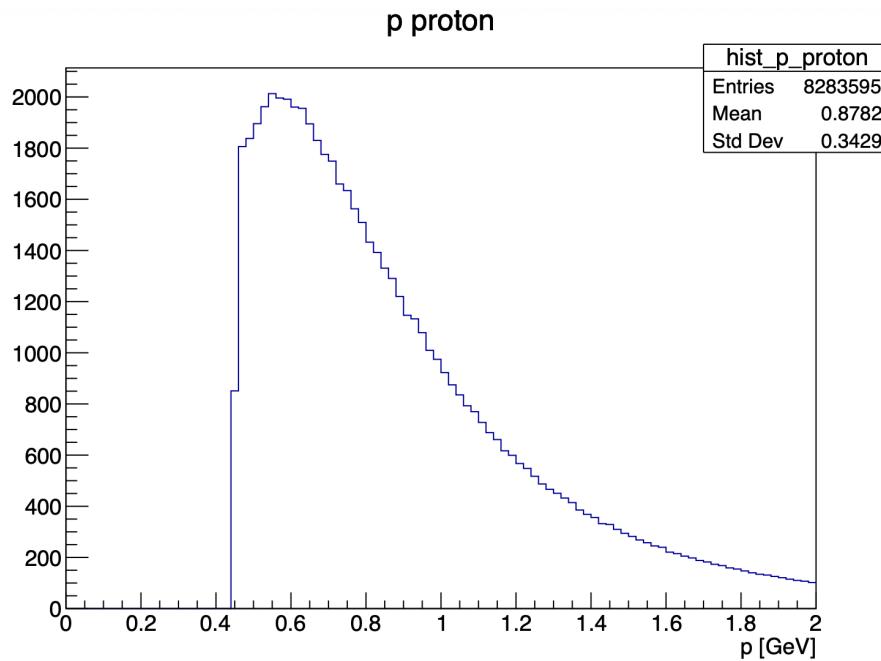
Update on ϕ generator

With this cuts : $5.25 < P_{\text{electron}} < 8 \text{ GeV}$ and $P_{\text{proton}} > 0.45 \text{ GeV}$

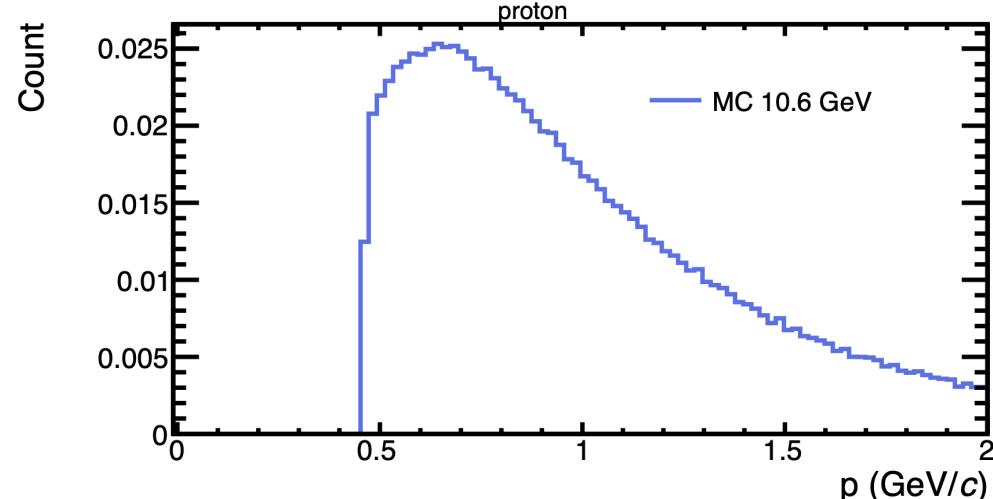


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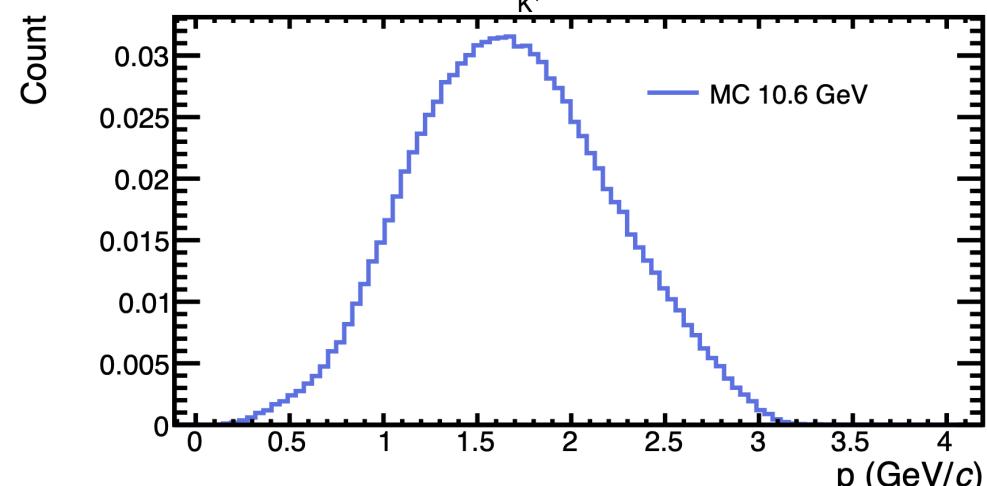
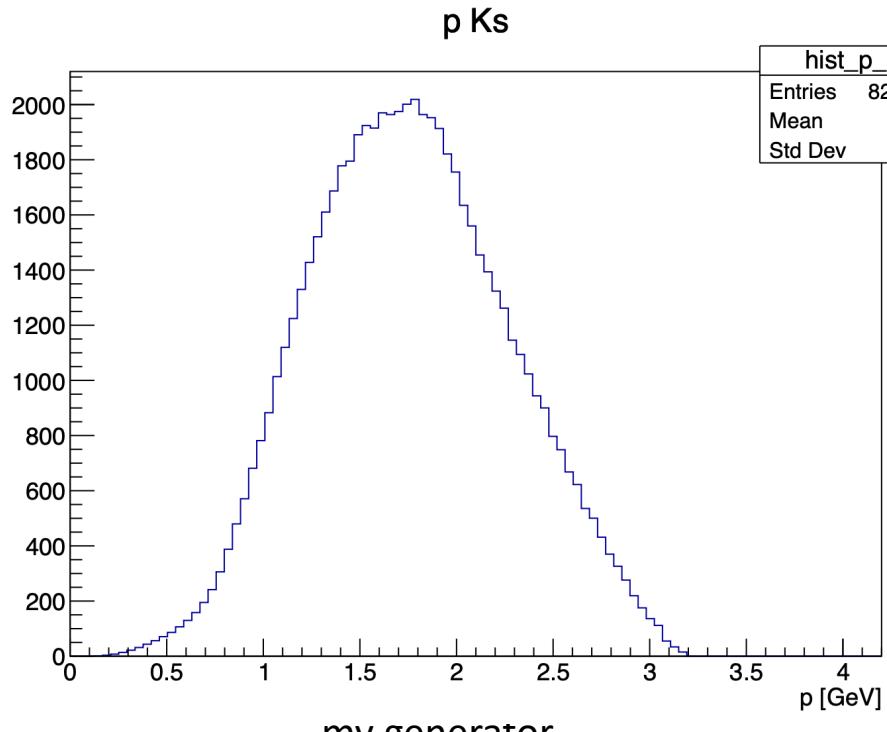
my generator



Bhawani plot

Update on ϕ generator

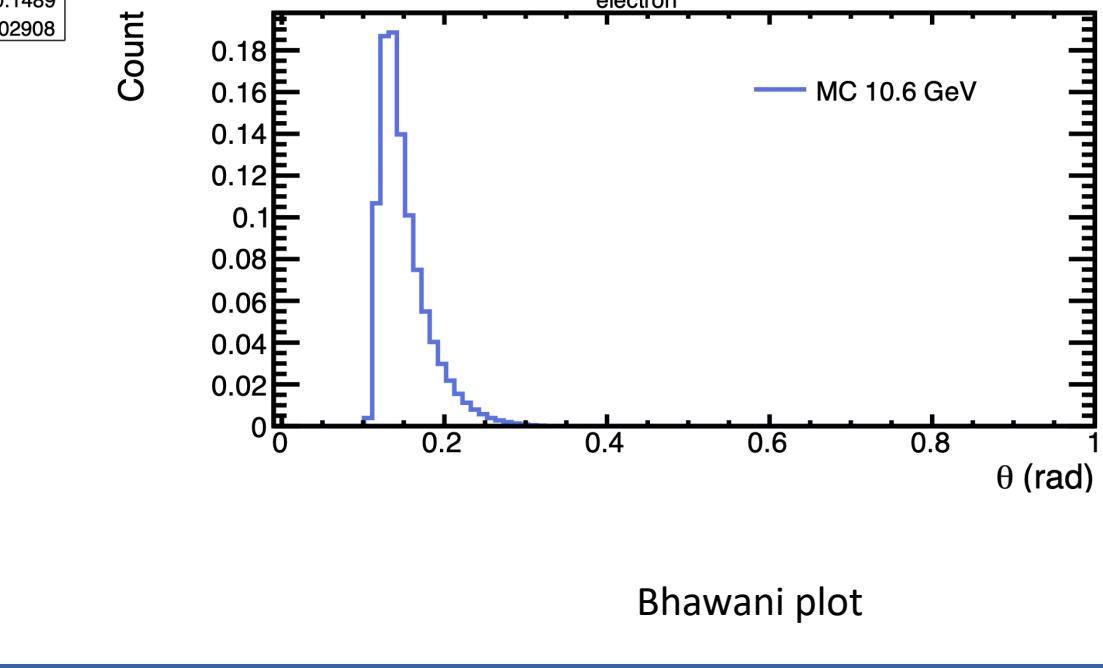
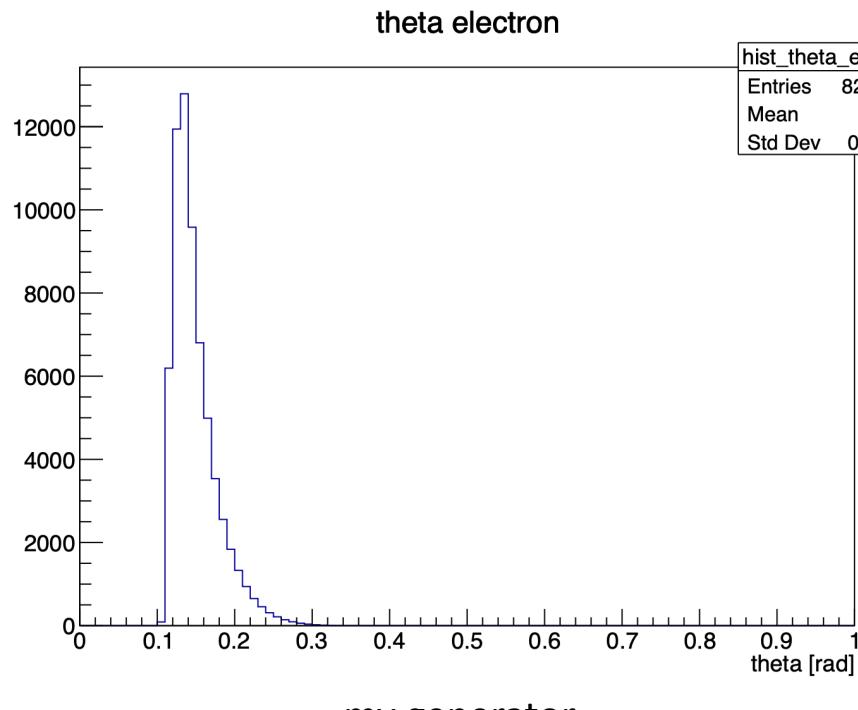
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Bhawani plot

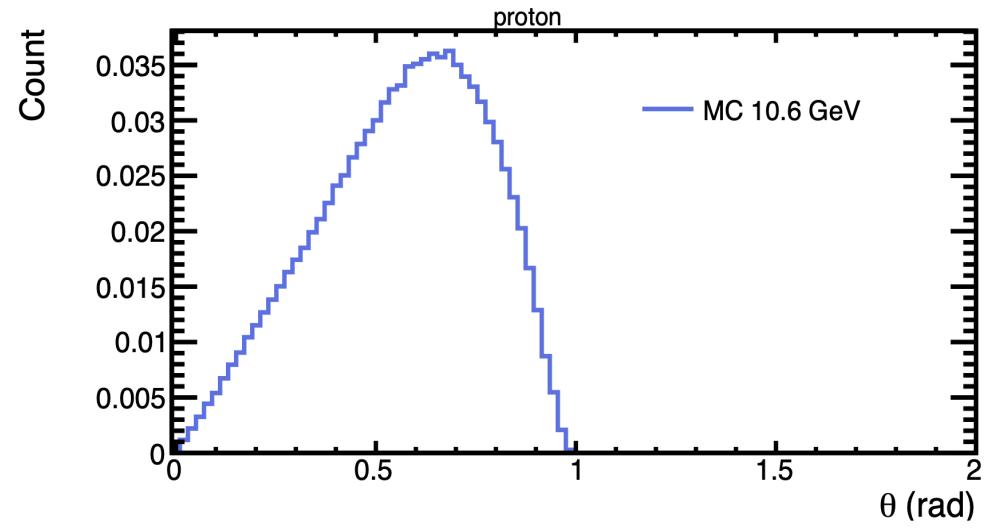
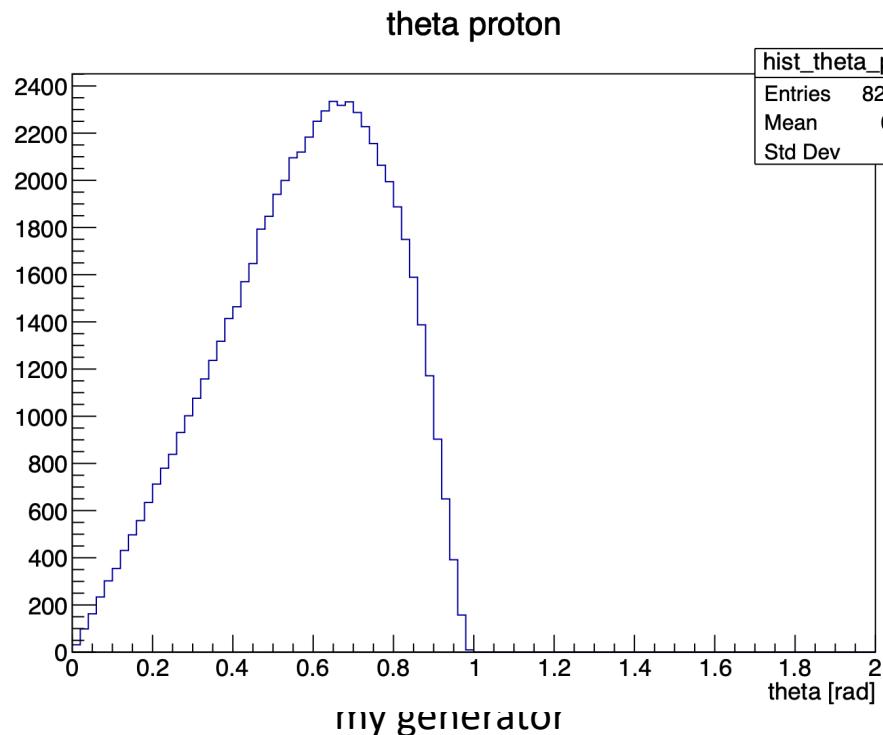
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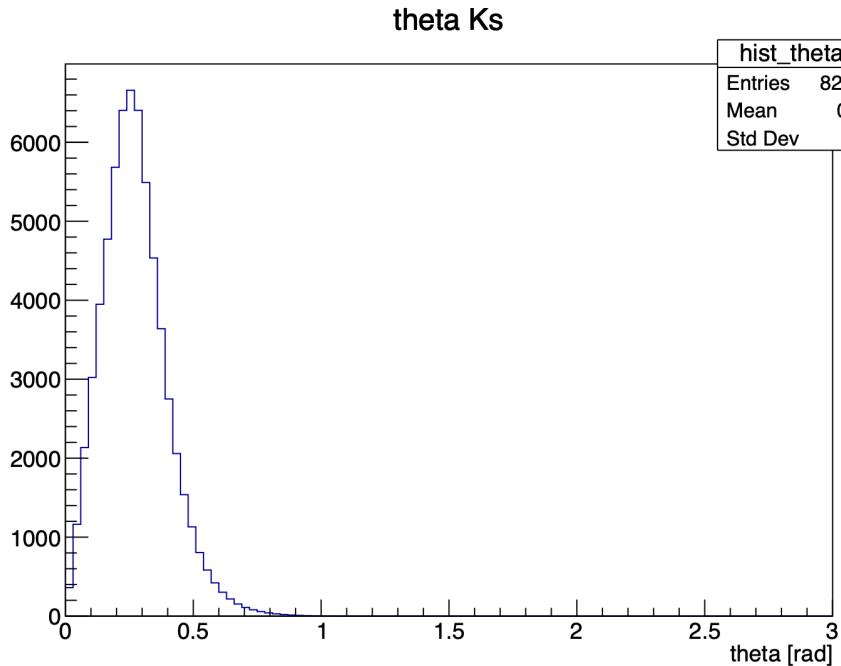
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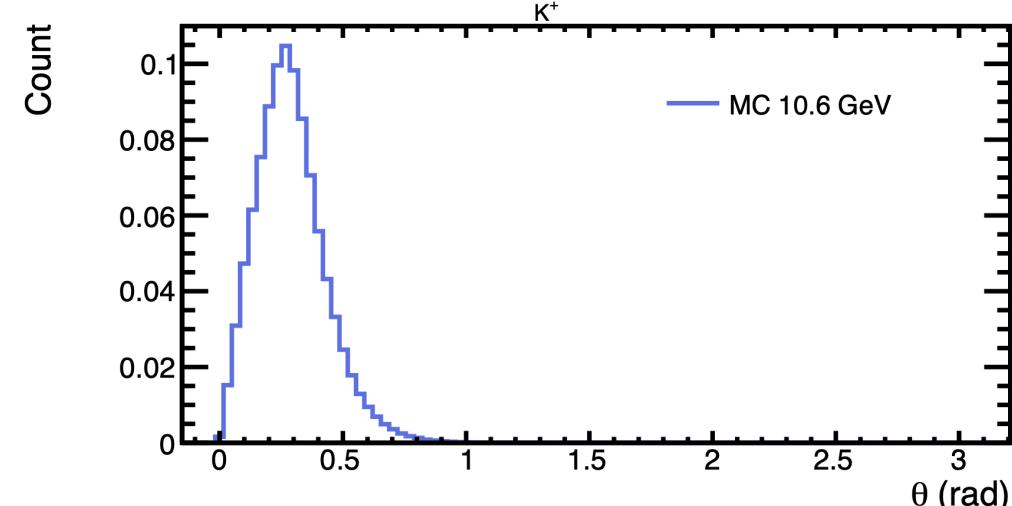
Bhawani plot

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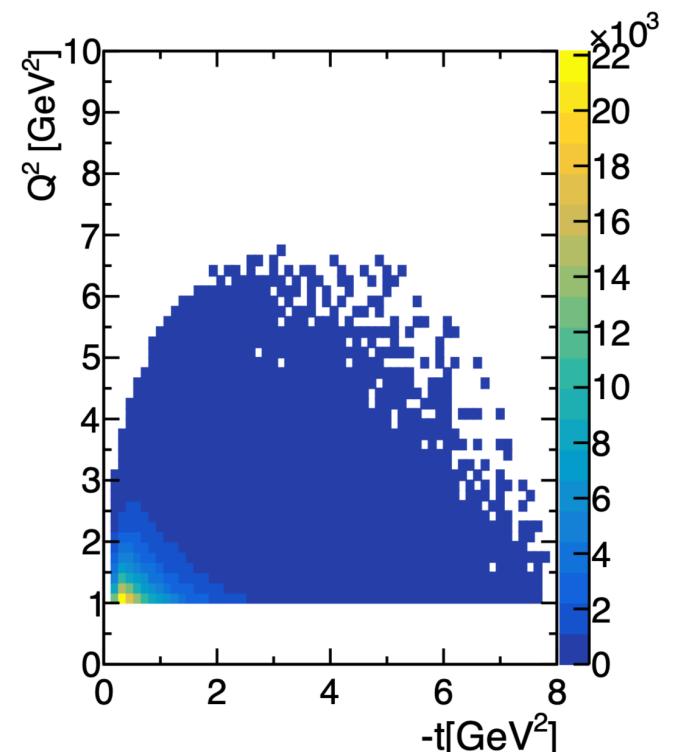
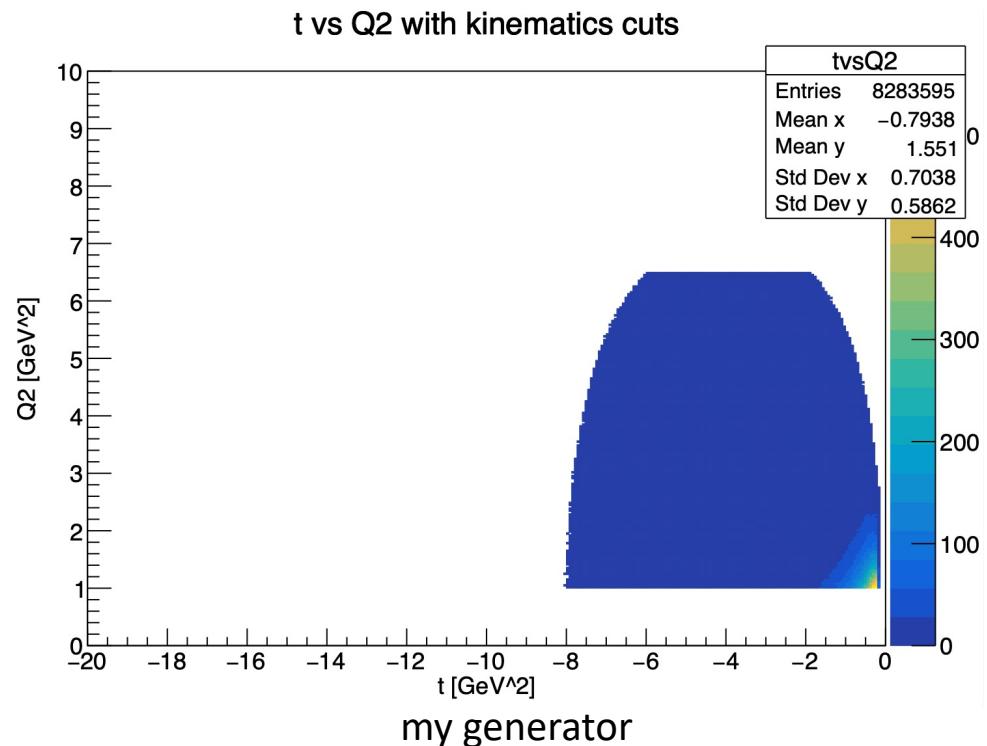
my generator



Bhawani plot

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With this cuts : $5.25 < P_{\text{electron}} < 8 \text{ GeV}$ and $P_{\text{proton}} > 0.45 \text{ GeV}$



Bhawani plot

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Next steps :

- Analysis of REC data with GEMC (find interresting cuts and the number of ϕ expected)
- Improve the generator with radiatives corrections
- Improve the generator with θ dependance in $\phi \rightarrow K_S K_L$ and $K_S \rightarrow \pi^+ \pi^-$

Thanks!

Update on ϕ generator

Details on cross section :

σ_T and $\sigma_L(\gamma^* p \rightarrow \phi p)$:

$$\sigma_T(W, Q^2) = \frac{c_T(W)}{(1 + Q^2/m_\phi^2)^{\nu_T}}$$

$$R = \sigma_L(W, Q^2)/\sigma_T(W, Q^2)$$

$$R(W, Q^2) = \frac{c_R Q^2}{m_\phi^2}$$

t-dependence (dipole) :

$$\frac{d\sigma_{L,T}}{dt} = \frac{\sigma_{L,T} F(t)}{F_{\text{int}}}$$

$$F(t) = \frac{m_g^8}{(m_g^2 - t)^4}$$

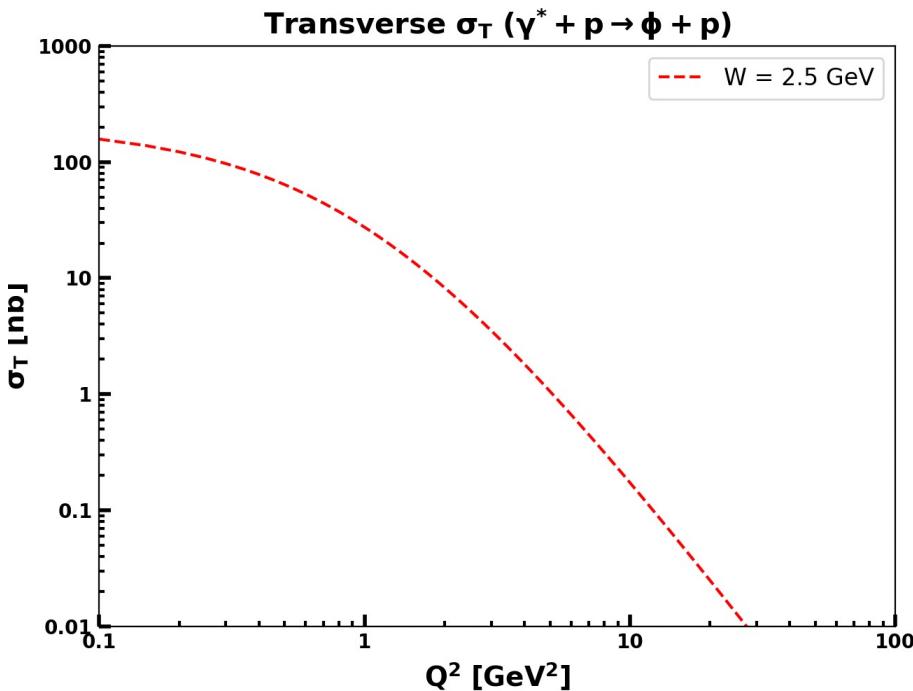
Update on ϕ generator

Cross section (ep $\rightarrow \phi$ p) :

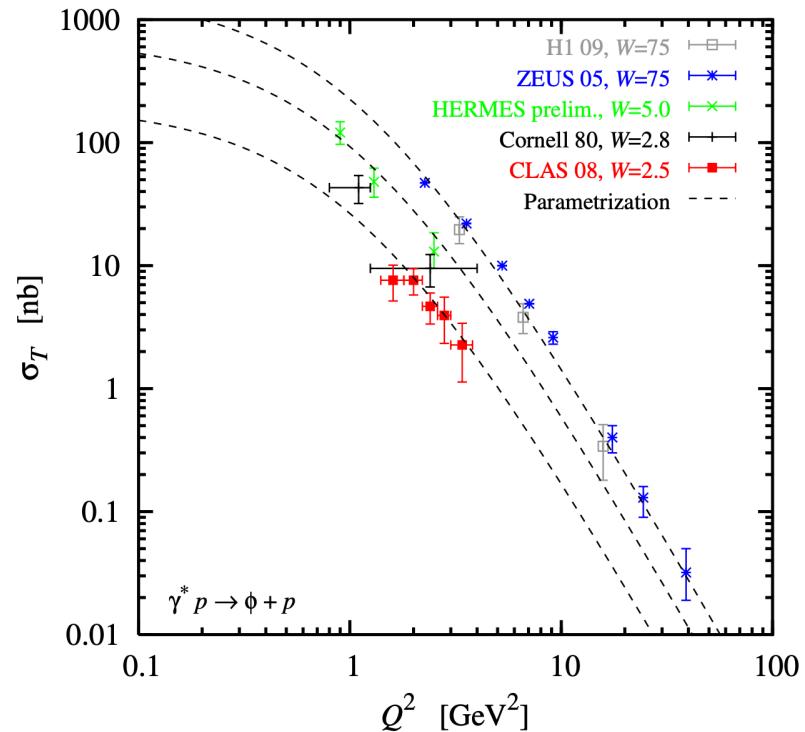
$$\frac{d^3\sigma}{dQ^2dx_Bdt} = \Gamma(Q^2, x_B, E) \left[\frac{d\sigma_T}{dt}(Q^2, x_B, t) + \epsilon \frac{d\sigma_L}{dt}(Q^2, x_B, t) \right]$$

The virtual photon flux : $\Gamma \equiv \frac{\alpha}{8\pi} \frac{Q^2}{m_N^2 E^2} \frac{1-x_B}{x_B^3} \frac{1}{1-\epsilon}$

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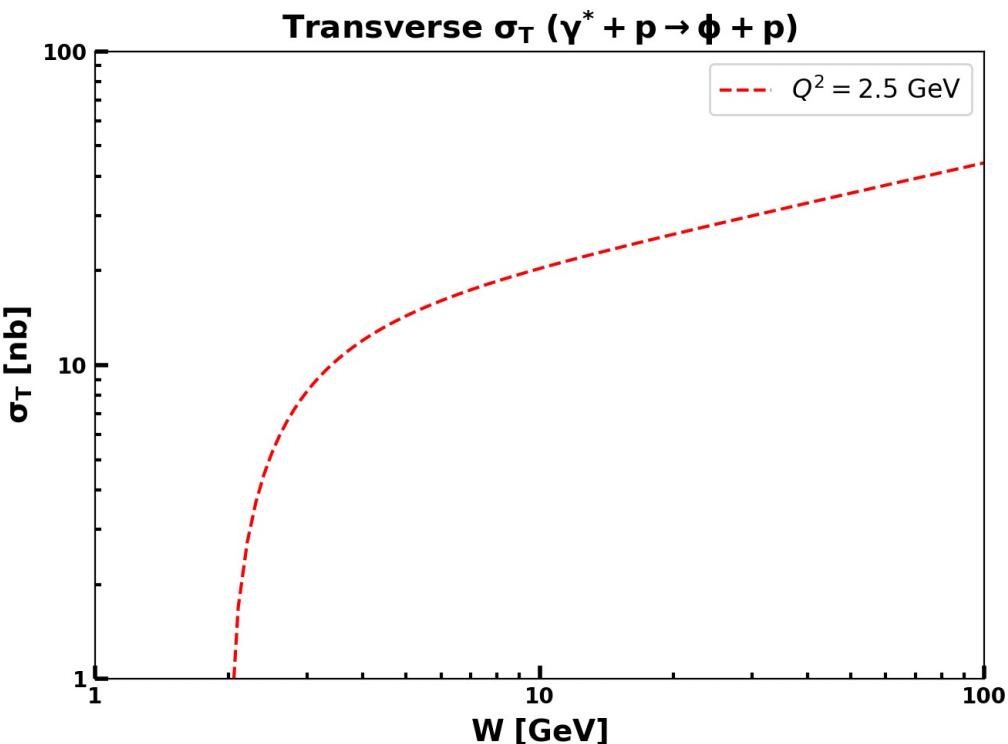


Implemented in the generator

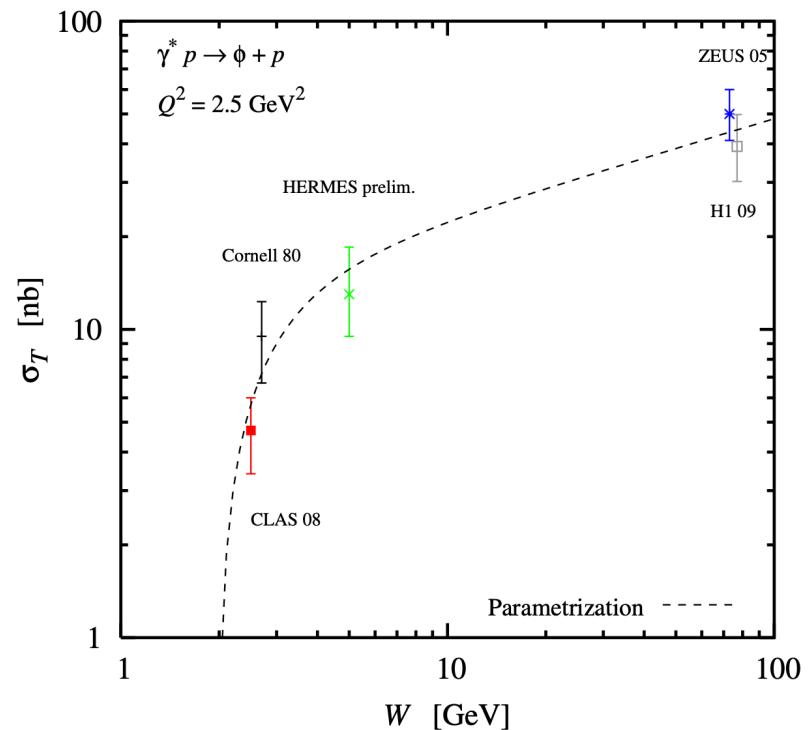


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Update on ϕ generator

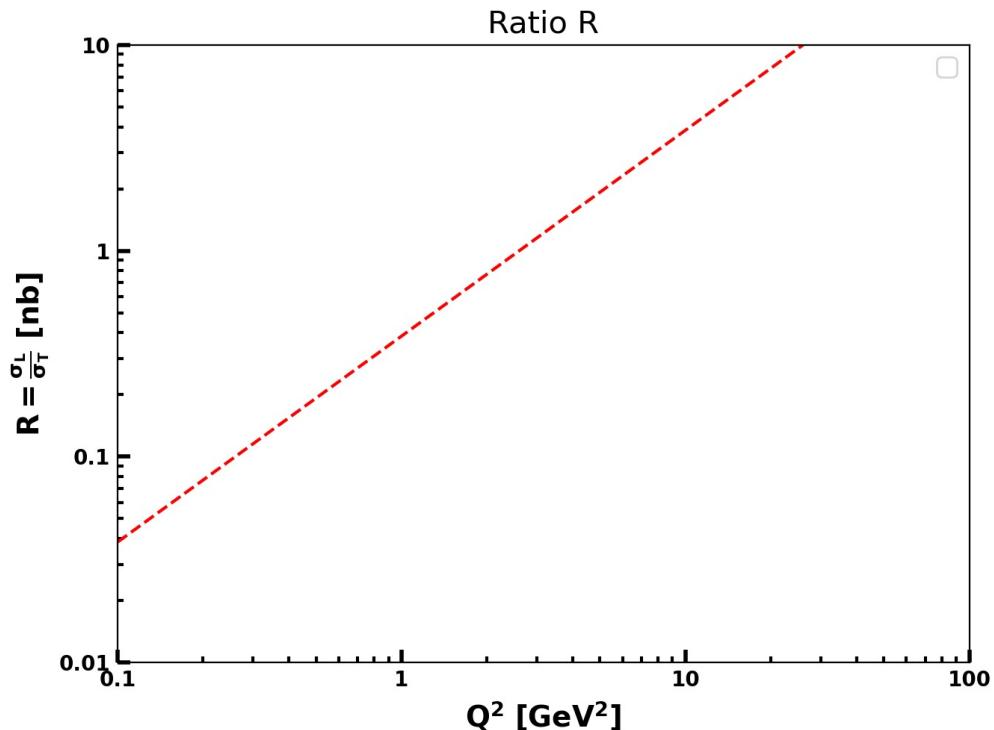


Implemented in the generator

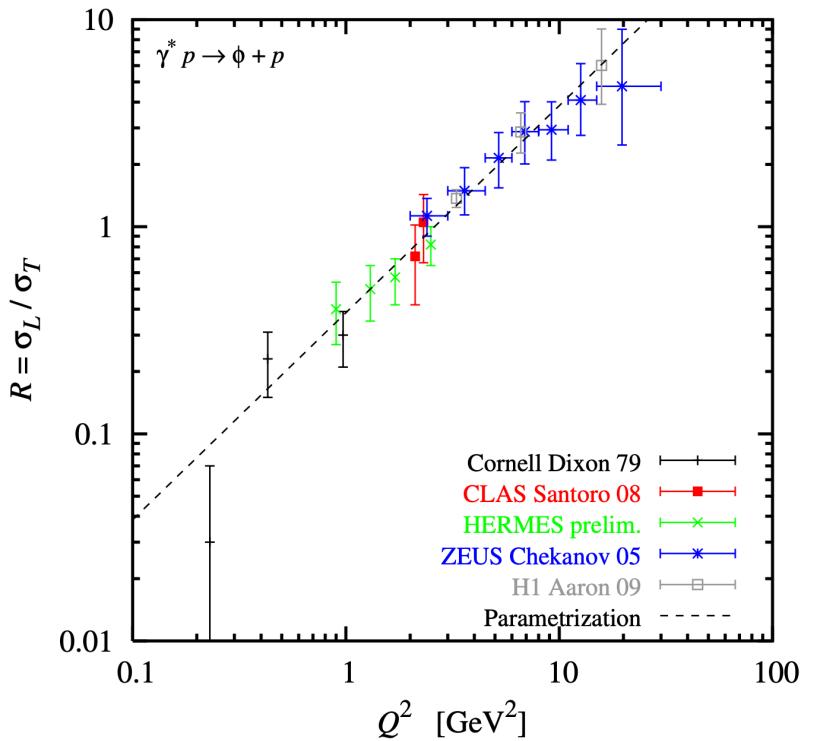


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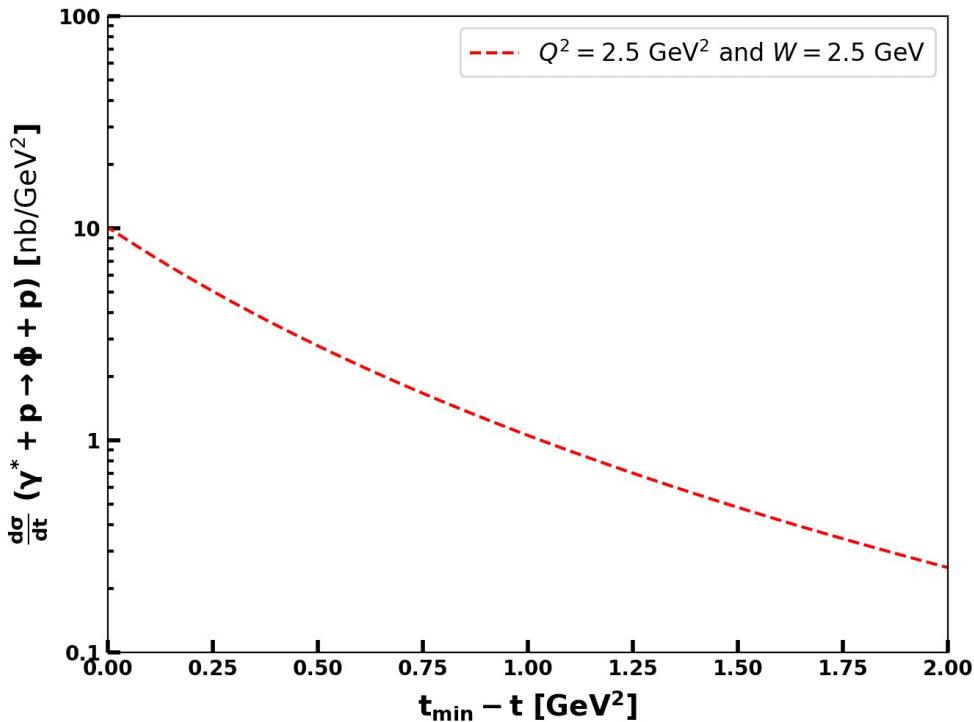


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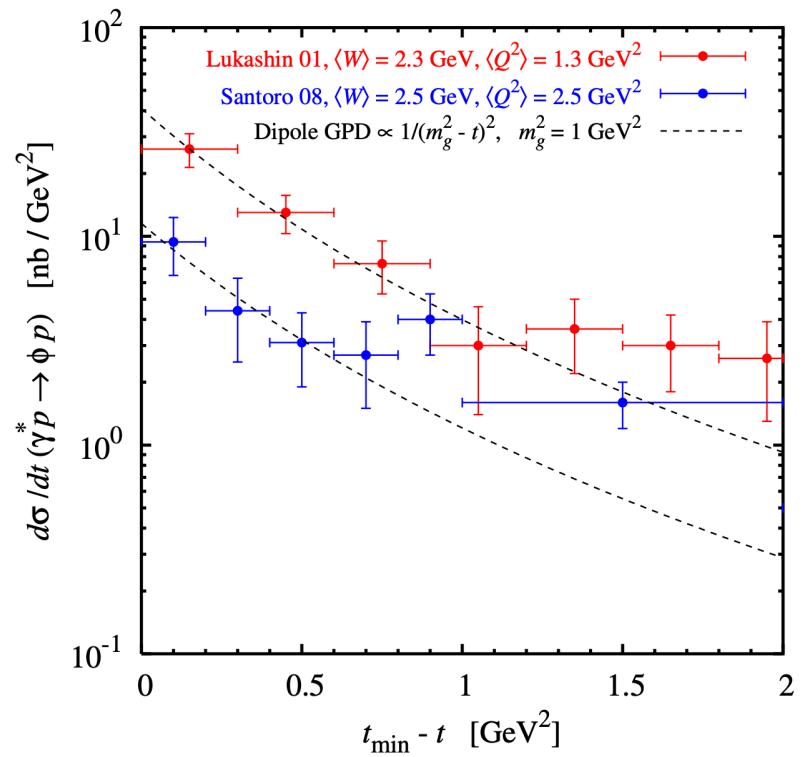


From Proposal to Jefferson Lab PAC39

Update on ϕ generator



Implemented in the generator



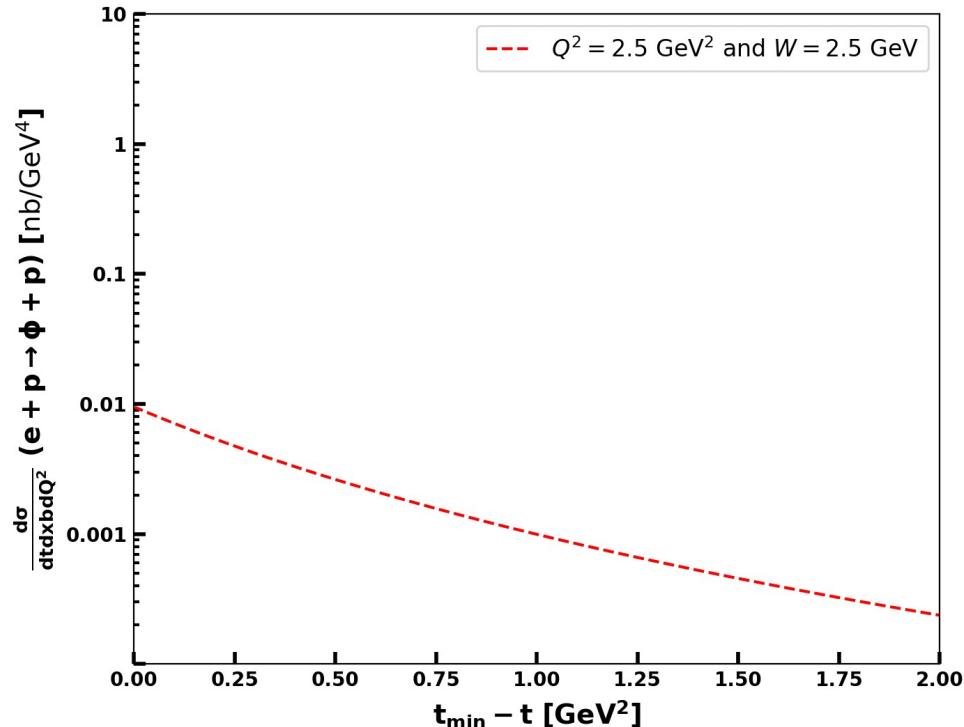
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Update on ϕ generator

Cross section ($e p \rightarrow \phi p$) (with the virtual photon flux) :

$$\frac{d^3\sigma}{dQ^2 dx_B dt} = \Gamma(Q^2, x_B, E) \left[\frac{d\sigma_T}{dt}(Q^2, x_B, t) + \epsilon \frac{d\sigma_L}{dt}(Q^2, x_B, t) \right]$$

$$\Gamma \equiv \frac{\alpha}{8\pi} \frac{Q^2}{m_N^2 E^2} \frac{1-x_B}{x_B^3} \frac{1}{1-\epsilon}$$



Implemented in the generator