Non-Prompt J/psi Analysis

PbPb @ 5.02 TeV

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Apr 28th, 2020

IFJ - ALICE Meetings

Activites:

- **Progress on Fitting for Non-prompt Fraction**

Procedure

- X = pseudo-proper decay length
- m=invariant mass reconstructed from pairs
- Observing either signal or bkg J/psi
-

- Basic Idea to maximize

$$lnL = \sum_{i=1}^{N} lnF(x^i, m^i_{e^+e^-}) \qquad (1)$$

$F(x^i, m^i_{e^+e^-}) \rightarrow$ Likelihood Function
$\rightarrow$ Probability of observing a J/Ψ, given x^i and $m^i_{e^+e^-}$
$\sum \rightarrow$ Sum over all the J/ψ candidates

- Unbinned 2-dim likelihood fit function

$$F(x, m_{e^-e^+}) = f_{sig}.F_{sig}(x).M_{sig}(m_{e^+e^-}) + (1 - f_{sig}).F_{bkg}(x).M_{bkg}(m_{e^+e^-})$$

$$F_{sig} = f'_B.F_B(x) + (1 - f'_B).F_{Prompt}(x)$$

X-distribution for Prompt-Jpsi

- Function to Fit :

$$F(x, m_{e^-e^+}) = f_{sig}.\left[f'_B.F_B(x) + (1 - f'_B).F_{Prompt}(x)\right].M_{sig}(m_{e^+e^-}) + (1 - f_{sig}).F_{bkg}(x).M_{bkg}(m_{e^+e^-})$$

f'_B & $f_{sig}(=\frac{S}{(S+B)})$ are free parameters.

All the PDFs are defined in the Ana-note.

Fitting Templates

According to the previous slide (last bullet)

- We need 5 templates PDFs for the 2-dim (m_{ee}, x) fitting of the Likelihood function.

  - $M_{sig}(m_{ee})$: template for Invariant Mass of J/Ψ-Signal (taken from MC)
  - $M_{bkg}(m_{ee})$: template for Inv. Mass Combinatorial Background.
  - R(x) : Resolution function – depends on p_T, Hits on SPD's Ist layer (taken from MC) ~ $F_{Prompt}(x)$
  - $F_B(x)$: template for Non-prompt J/Ψ (from MC)
  - $F_{bkg}(x)$: template for fitting x-Background (on data)

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$M_{sig}(m_{ee})$ Signal

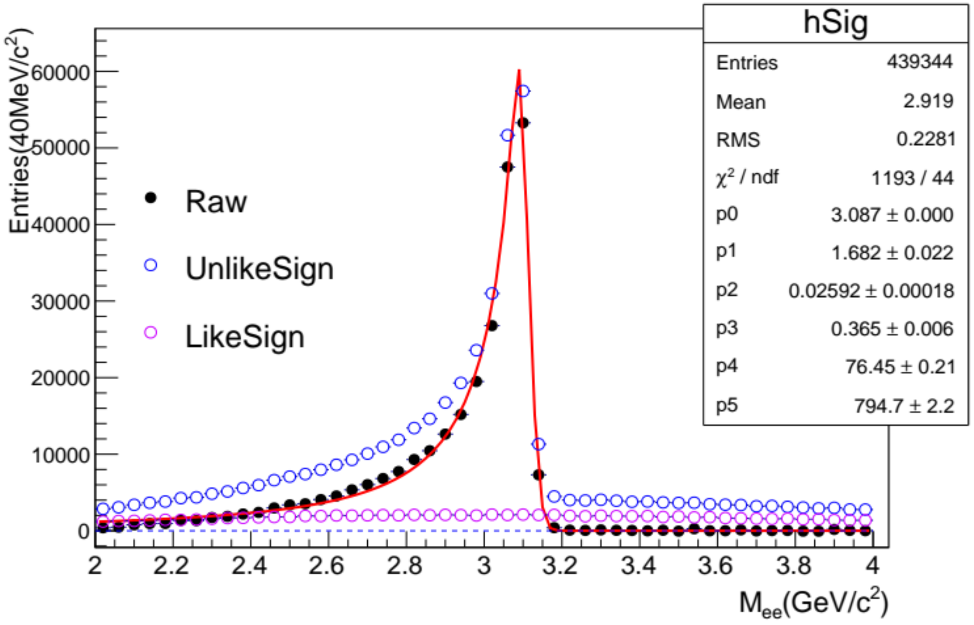
- **Fit on MC sample (with Injected Jpsi)**

  p0: Mean, p1: Sigma, p2: Alpha, p3: Norm, p4: Norm of Exp = n

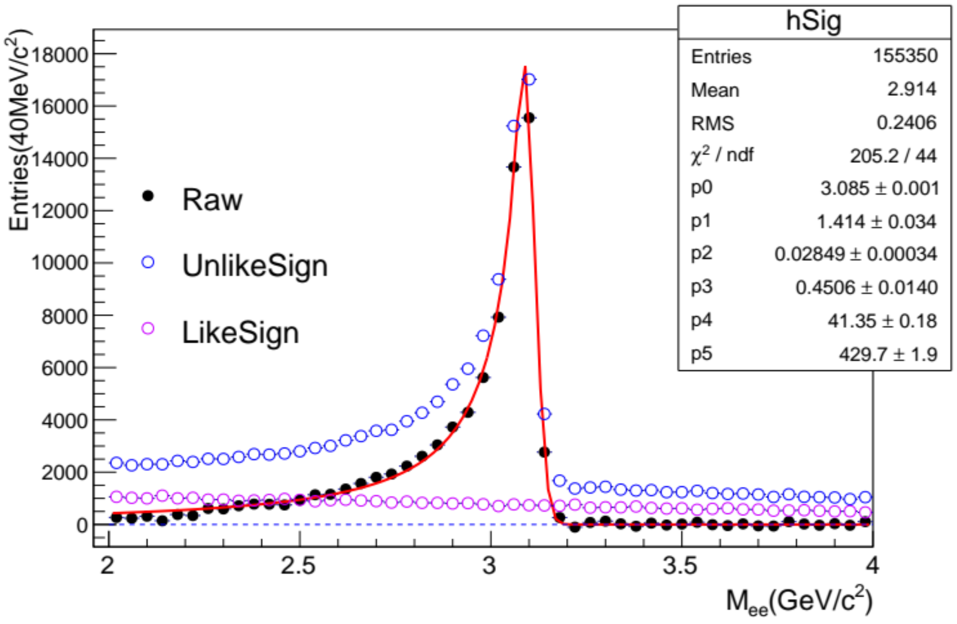
$$f(m^{e^+e^-};\alpha,n,\bar{m},\sigma,N) = N\cdot\begin{cases}\exp\left(-\frac{(m^{e^+e^-}-\bar{m})^2}{2\sigma^2}\right) & \text{for } \frac{m^{e^+e^-}-\bar{m}}{\sigma} > -\alpha \\ A\cdot\left(B-\frac{m^{e^+e^-}-\bar{m}}{\sigma}\right)^{-n} & \text{for } \frac{m^{e^+e^-}-\bar{m}}{\sigma} \leqslant -\alpha\end{cases}$$

and where the coefficients are:

$$A = \left(\frac{n}{|\alpha|}\right)^n\cdot\exp\left(-\frac{|\alpha|^2}{2}\right) \qquad B = \frac{n}{|\alpha|} - |\alpha|\ .$$



0 <pT< 3



3 <pT< 5

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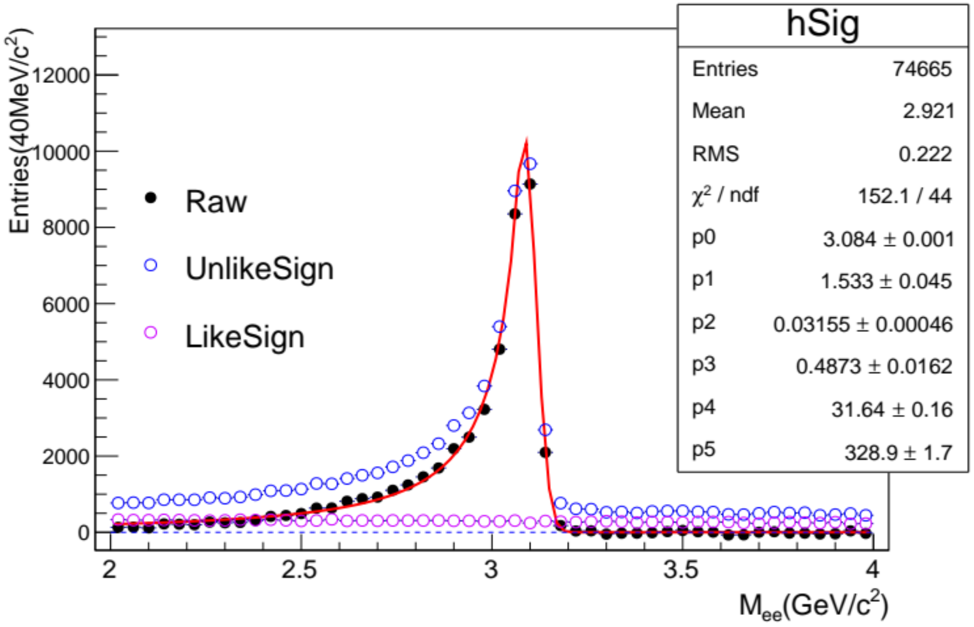
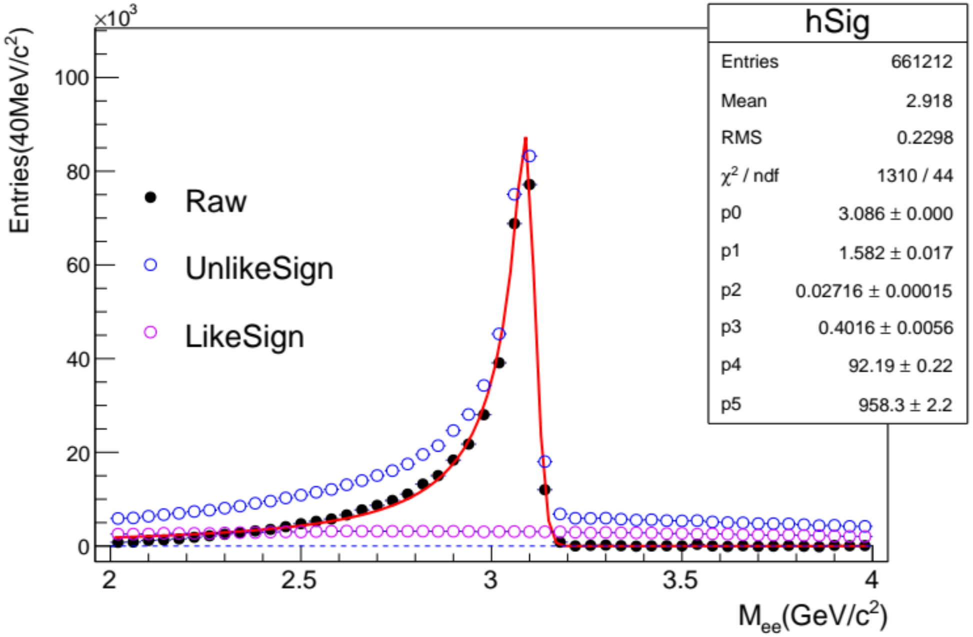


5 <pT< 15



0 <pT< 15

Fitting the Resolution Function R(x)

- R(x) is measured as a function of pT(Jpsi) and type of J/psi.

  - Transverse Impact parameter d_0(r,phi) resolution depends on the pT. (see backup)

- Therefore, RMS of R(x) depends strongly on the pT of J/psi.
  - Going from higher to lower pT, it increases
  - In lower pT, the d0 (r,phi) resolution is worse than high-pT.

- Significantly, the hits in SPD layers varies the precision of tracking the daughters.

- Fitted on the x-distribution Reconstructed Prompt Jpsi in MC, In different pT regions.

- Fitted using BtoJPSI classes.

- Compared with the analysis pp 5TeV, 13TeV by Fiorella (pp Analysis-note)

$$R(x) = w_1 \cdot G_1(x;\mu_1,\sigma_1) + w_2 \cdot G_2(x;\mu_2,\sigma_2) + w_3 \cdot f(x;\alpha,\lambda) \ ,$$

where the two functions G_1 and G_2 are gaussian functions:

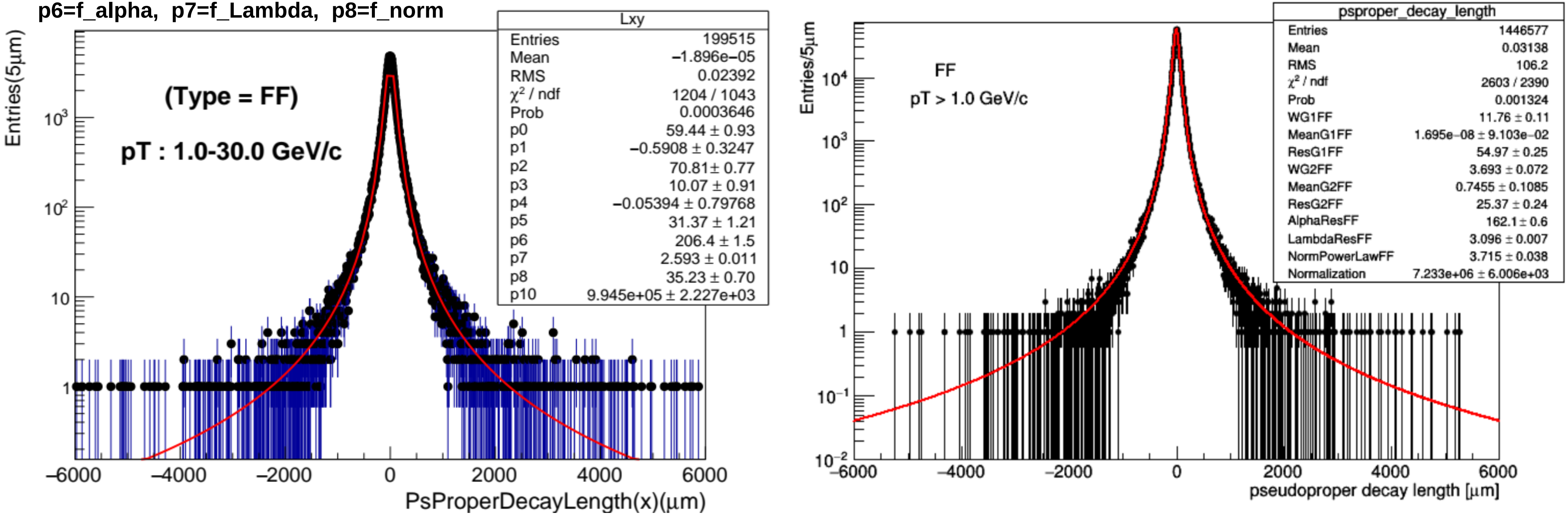
$$G(x;\mu,\sigma) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

while the symmetric power law term has the stepwise form:

$$f(x;\alpha,\lambda) = \begin{cases} \frac{\lambda-1}{2\alpha\lambda} & |x| < \alpha \\ \frac{\lambda-1}{2\alpha\lambda}\alpha|x|^{-\lambda} & |x| > \alpha \end{cases}$$

Resolution Function R(x) fitting to Prompt Jpsi x-distribution:

p0=G1norm, p1=G1Mean, p2=G1rms,
p3=G2norm, p4=G2Mean, p5=G2rms,
p6=f_alpha, p7=f_Lambda, p8=f_norm



Fiorella pp-5-13TeV

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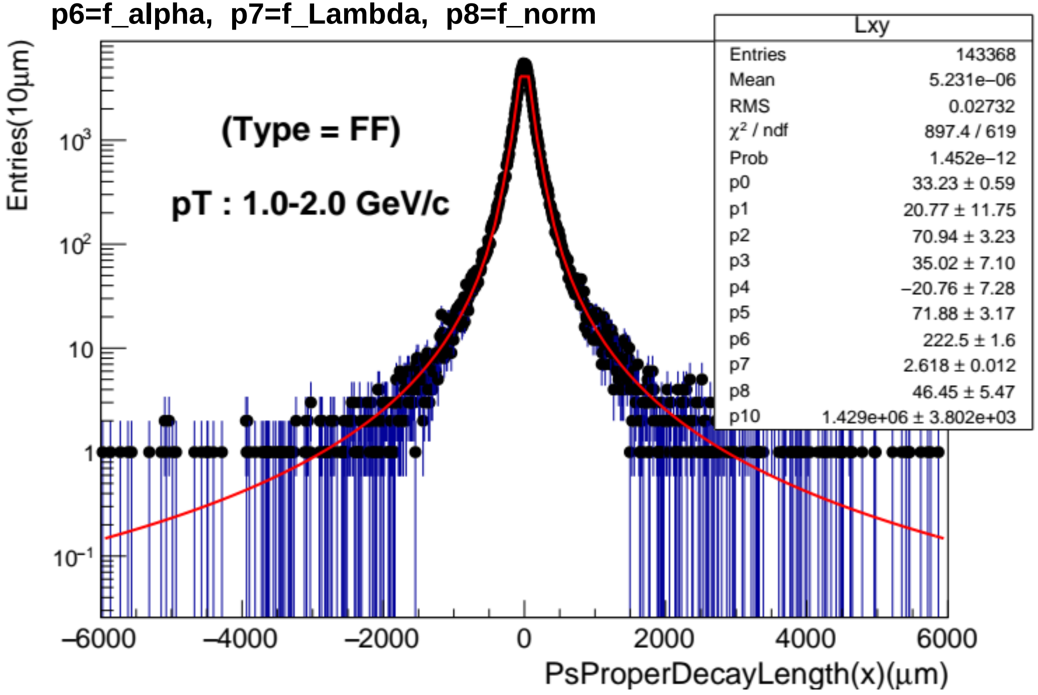

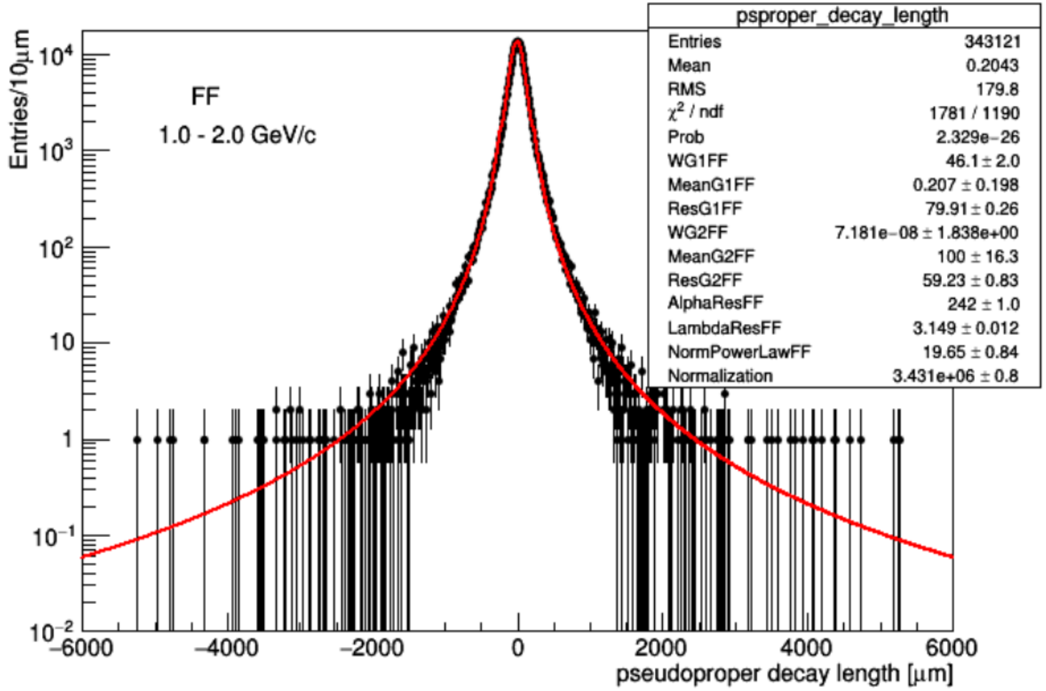

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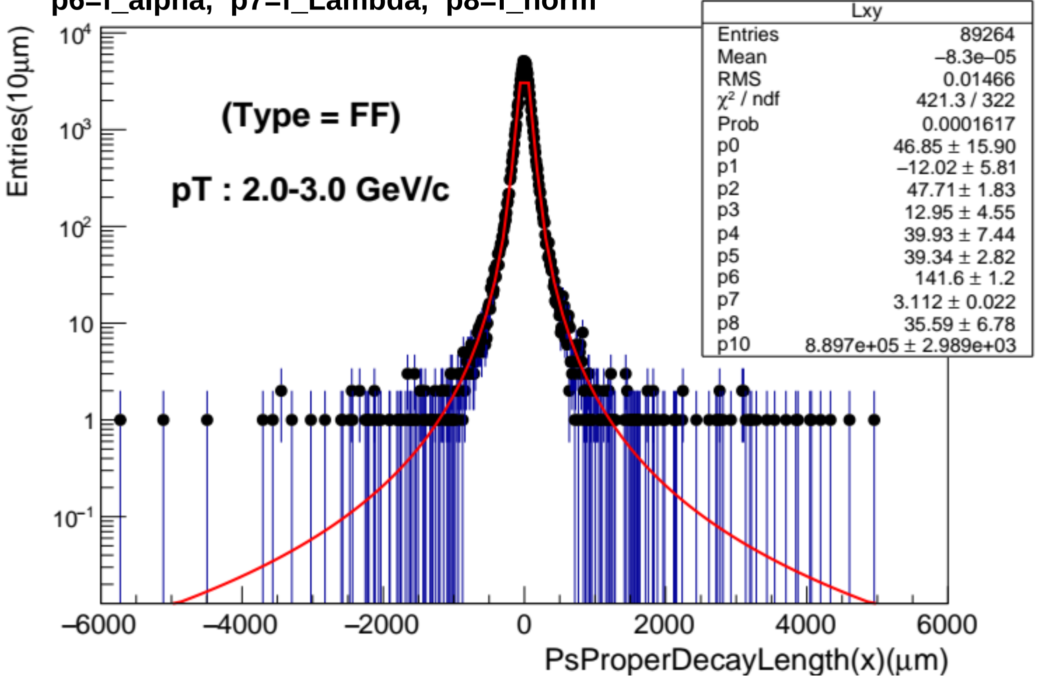

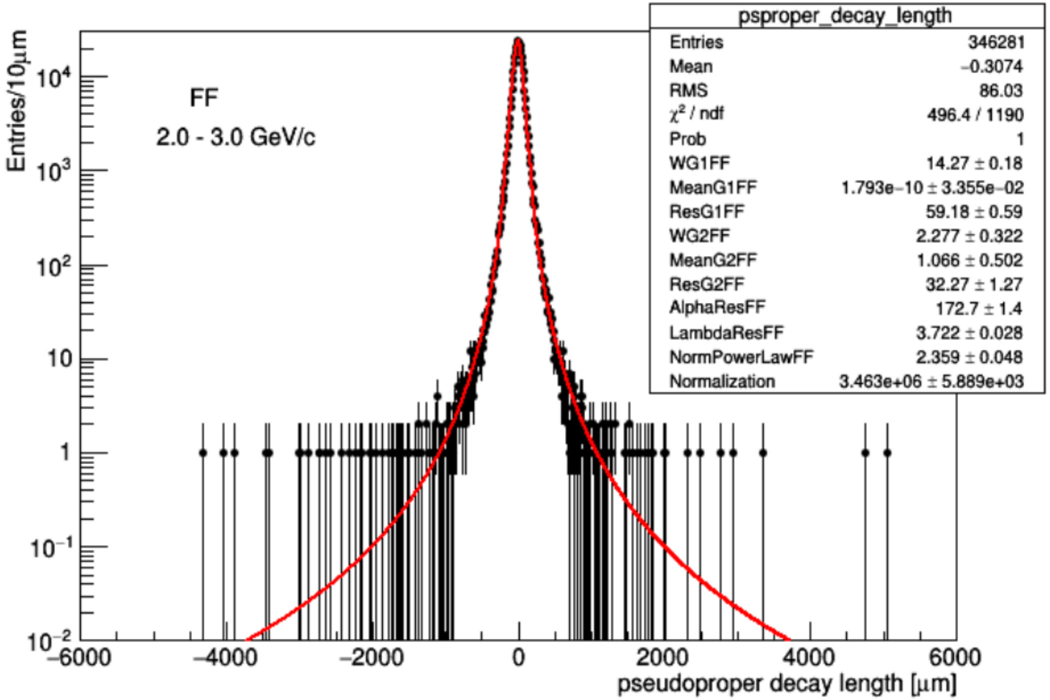

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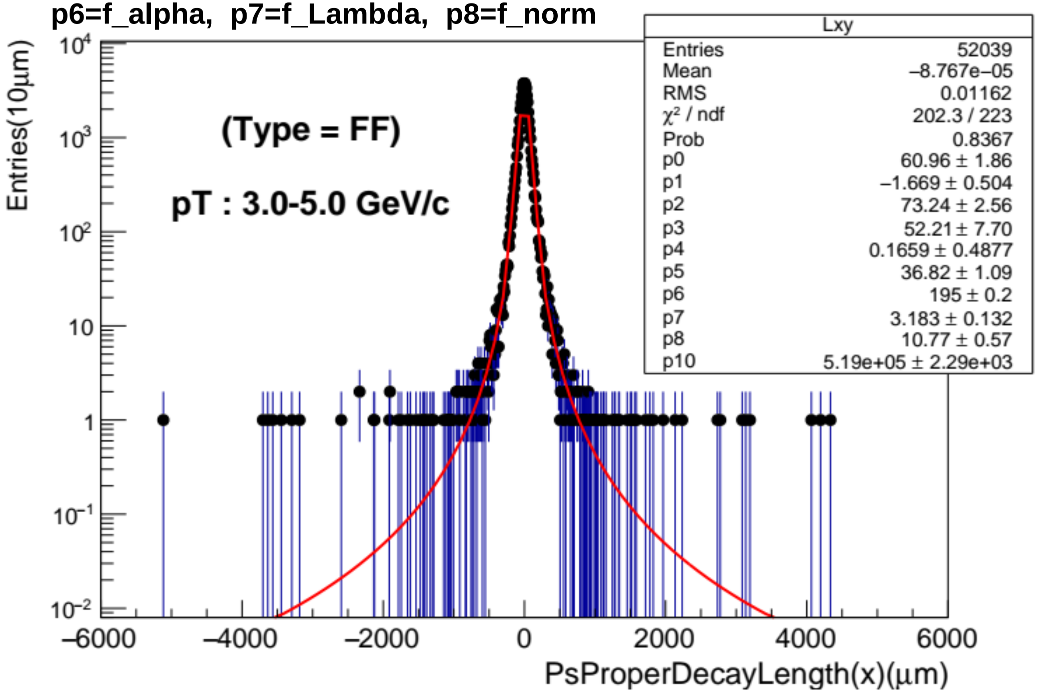

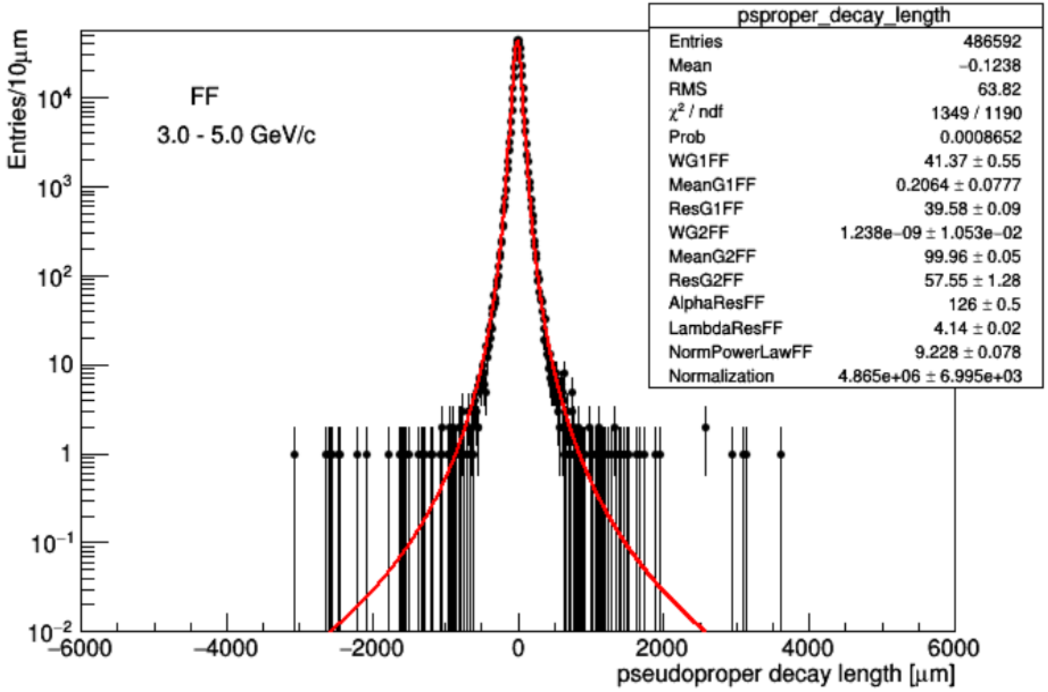

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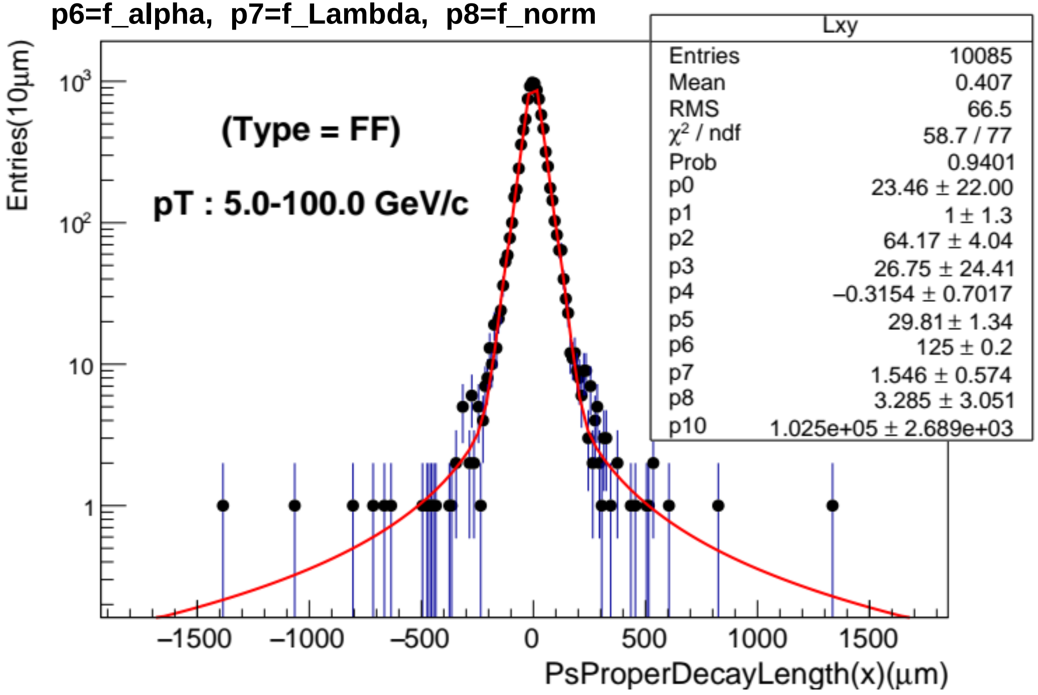

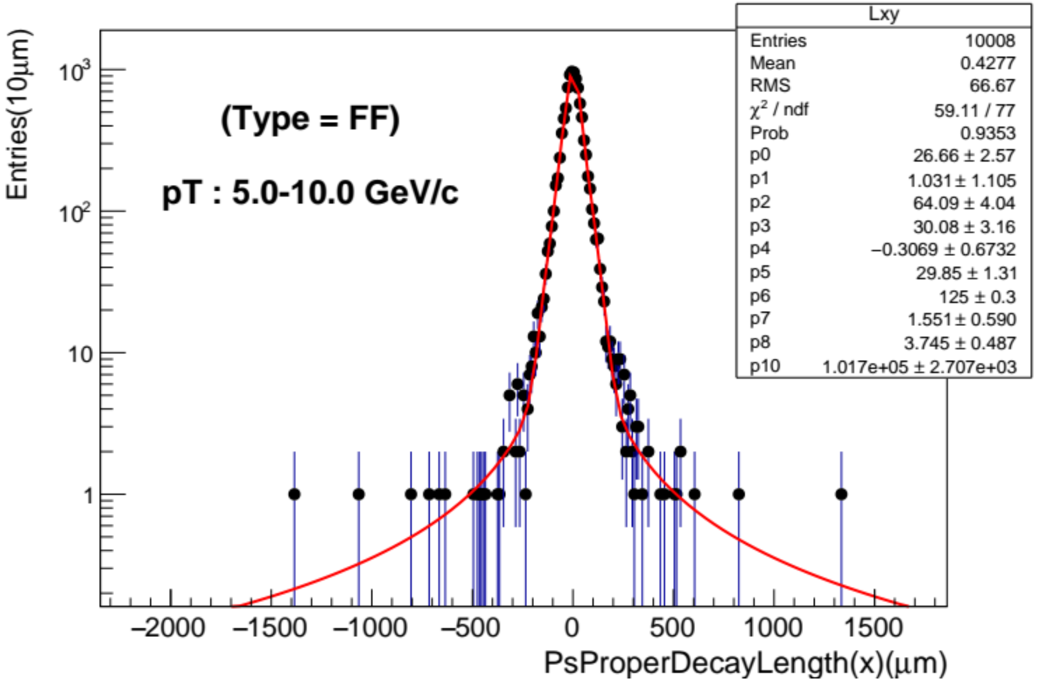

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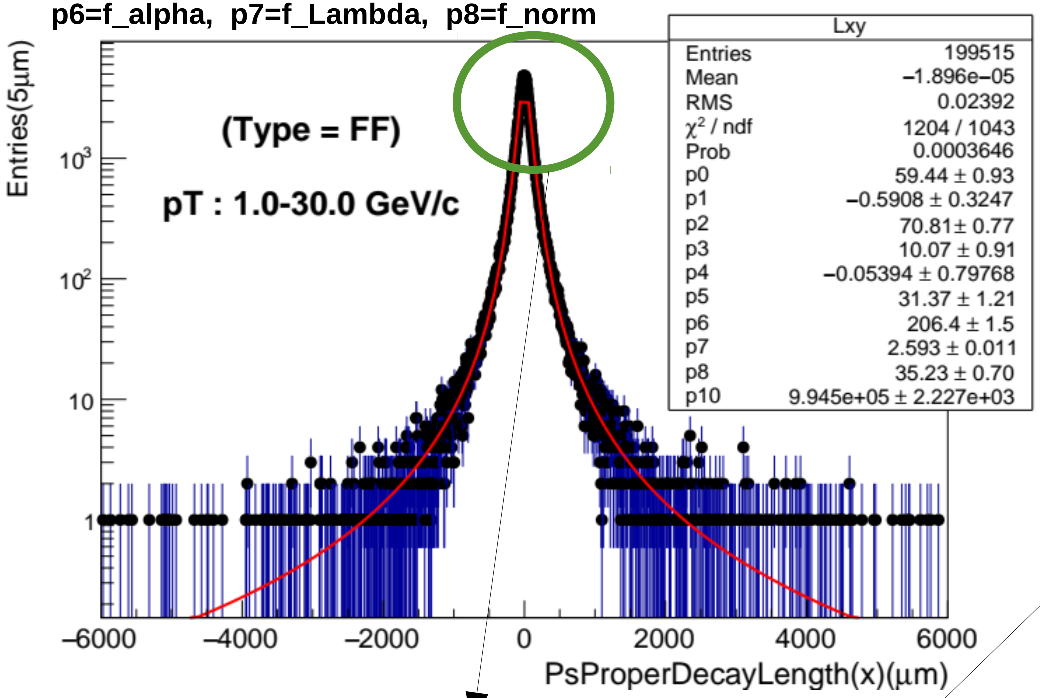
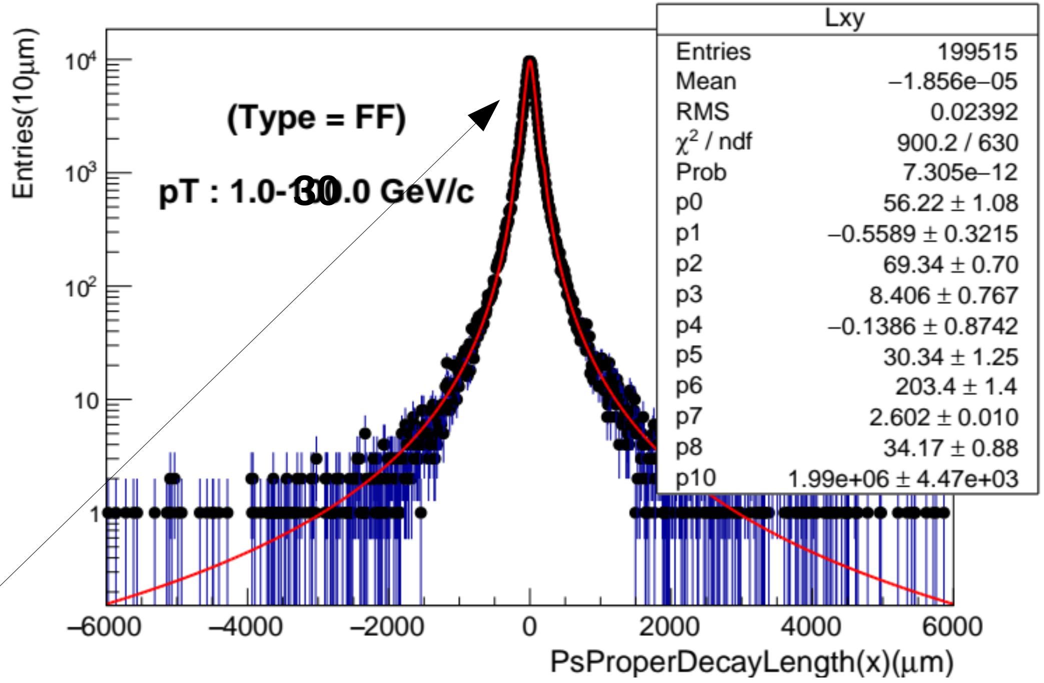


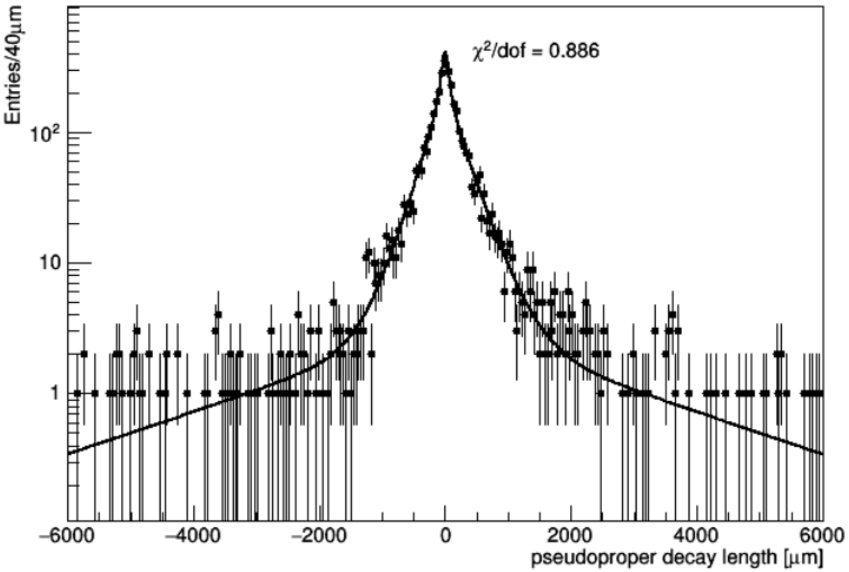


This is due to less # of points in function to draw, after increasing the # of points it is corrected.!!!

$F_{bkg}(x)$: for x-Background description

- To obtain a good description of the data outside the signal region.
- We fit the x-distribution on both side of signal-mass region (LB, RB).
- Components:
  - Exp(+ve slope) λ_+ : describes the bkg from other long-lived b-hadrons producing ep-em pairs.

    b $\longrightarrow$ c e- X   c $\longrightarrow$ e+ X
  - Exp (-ve slope) λ_- and symmetric part: describes the remaining bkg from other sources.
  - Zero-life time components : same as resolution function.
  - f's are constants to normalize the distribution.



$$F_{Bkg[m_{inv,p_T},type]}(x) = \left[\frac{f_+}{\lambda_+}e^{-\frac{x'}{\lambda_+}}\cdot\theta(x') + \frac{f_-}{\lambda_-}e^{\frac{x'}{\lambda_-}}\cdot\theta(-x') + \frac{f_{Sym}}{2\lambda_{Sym}}e^{-\frac{|x'|}{\lambda_{Sym}}}\right.$$
$$\left. + (1-f_+-f_--f_{Sym})\cdot\delta(x')\right]\otimes R_{p_T,type}(x-x')$$

Example figure taken from
AnaNote-957

Backup

M_{Bkg} (m_{ee}) : Exponential function

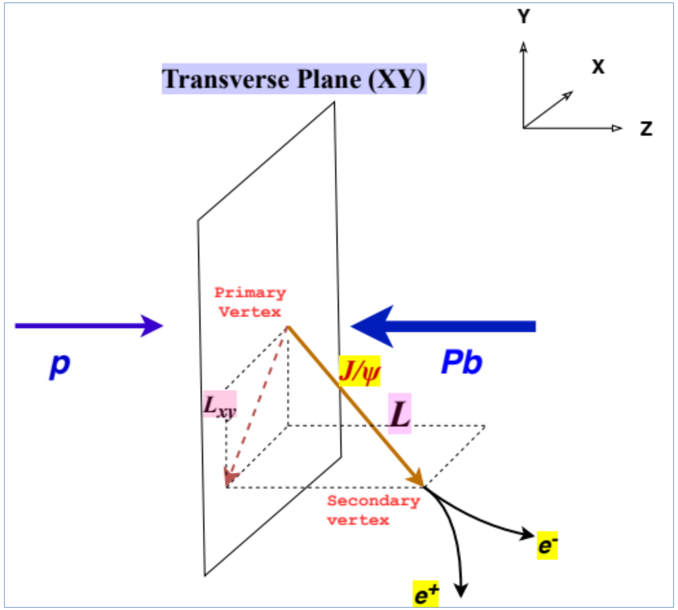
$$M_{Bkg}(m_{e^+e^-};\lambda,A) = A \cdot e^{-\frac{(m^{e^+e^-})}{\lambda}} + B \ ,$$

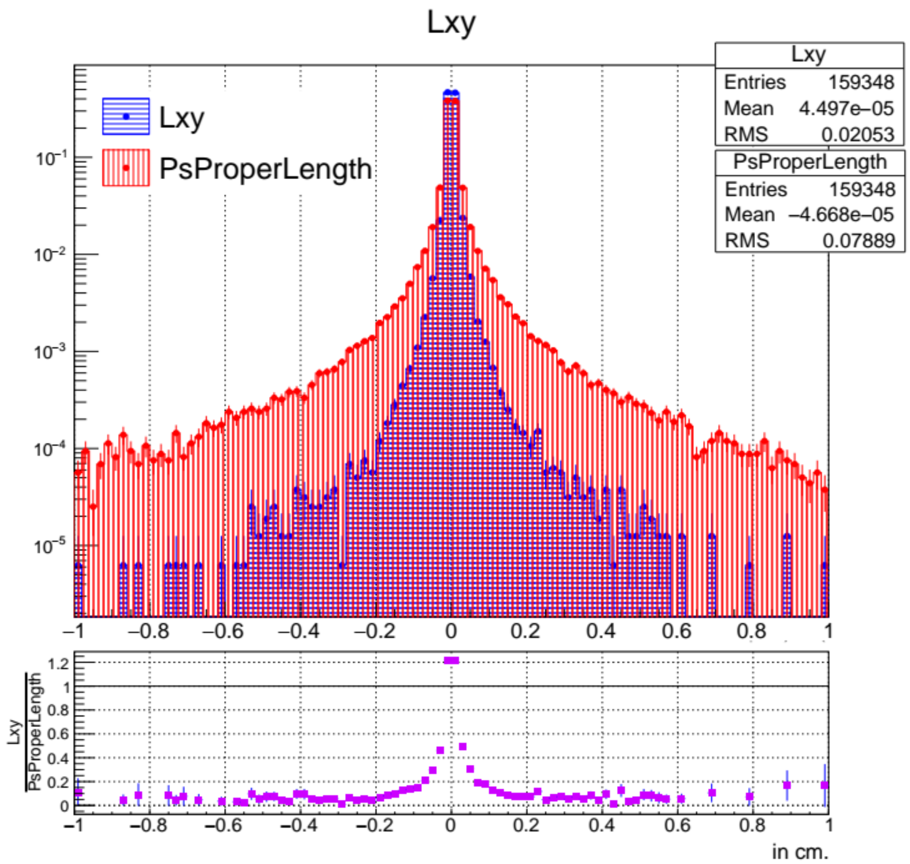
A & Lambda are free parameters

L_{xy} to PsProper Decay Length (x)

$$L_{xy} = \vec{L} \cdot \vec{p}_T^{\,J/\psi} / p_T^{J/\psi}$$

$$x = \frac{c \cdot L_{xy} \cdot m_{J/\psi}}{p_T^{J/\psi}}$$





Comparision of Lxy and x-distributions for Reconstructed true Prompt J/psi

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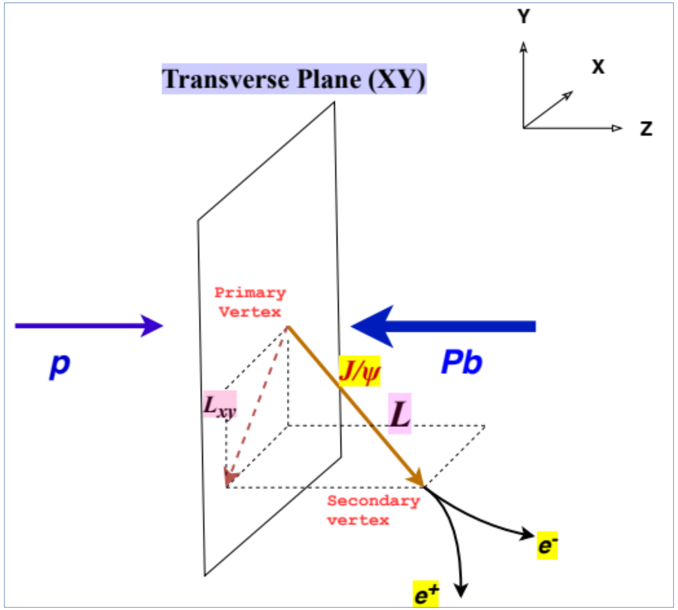

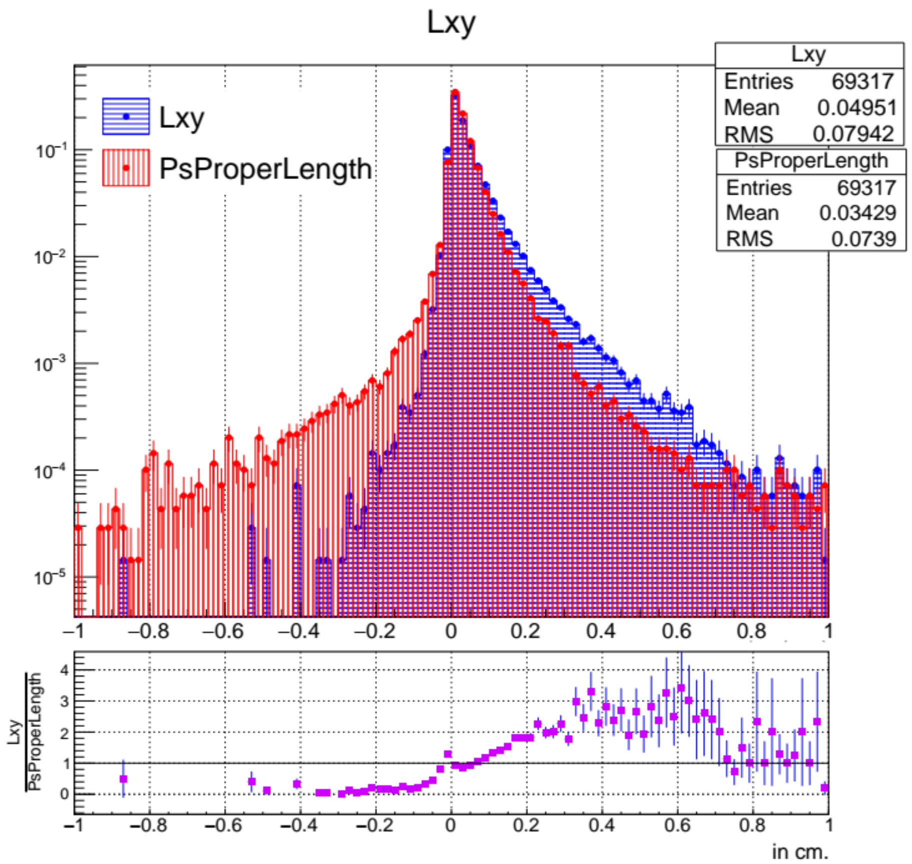

Comparision of Lxy and x-distributions for Reconstructed true NonPrompt J/psi

d0(r,phi) resolution