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Non-prompt J/ψ analysis in proton-proton collisions at √s=5.02TeV

2022.9.30

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Motivation

There are three different processes that contribute to the inclusive J/ψ yield measured at the LHC:

- Direct production: a $c\bar{c}$ pair produced in the hard partonic scattering process combines to form a J/ψ state
- Decay from higher excited charmonium states: a produced $c\bar{c}$ pair hadronizes in a higher mass state than J/ψ, for example χ_c or $\psi(2S)$ state and then decays into a J/ψ state

} prompt

- Decay from beauty-flavored hadrons: a $b\bar{b}$ pair from the initial hard scattering processes, hadronizes and produces a beauty flavored hadron, h_B, which decays weakly to a J/ψ state → Non-prompt

- In order to gain an accurate knowledge of the prompt charmonium production mechanisms, the adequate measurement and subtraction of the non-prompt J/ψ component from the inclusive one is mandatory
- the study of beauty hadrons decaying into J/ψ allows to accurately measure the beauty hadron cross-section down to very low transverse momentum

Datasets

- Data：LHC17p、LHC17q
  - NINT7 is 631.8M
- MC：LHC18a11

- Event cuts：
  - $|V_z| < 10$ cm
  - Physics selection
  - MinVtxContributors > 1
  - Minimum bias trigger

Analysis cuts：

Task	Action
p_T	> 1 GeV/c
$\|\eta\|$	< 0.9
$\|\mathrm{DCA}_{xy}\|$	< 0.5 cm
$\|\mathrm{DCA}_z\|$	< 2.0 cm
kITSrefit	request
TPCrefit	request
kink daughters	reject
matching with SPD	SPDany
ITS χ^2 per cluster	< 36
number of ITS shared clusters	At most 1
number of TPC clusters	>70
TPC χ^2 per cluster	< 4
Pre-filter cuts:	
p_T of conversion partner	< 300 MeV/c
invMassPair	< 50 MeV/c^2
electron inclusion	-2,3 σ
p and π rejection	-3,3 σ

Fit Function

- Mass: Crystal ball function
- Pseudoproper decay length:
  - Prompt:

$$R(x) = \omega_1 \cdot G_1(x;\mu_1,\rho_1) + \omega_2 \cdot G_2(x;\mu_2,\rho_2) + \omega_3 \cdot f(x;\alpha,\lambda)$$

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

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

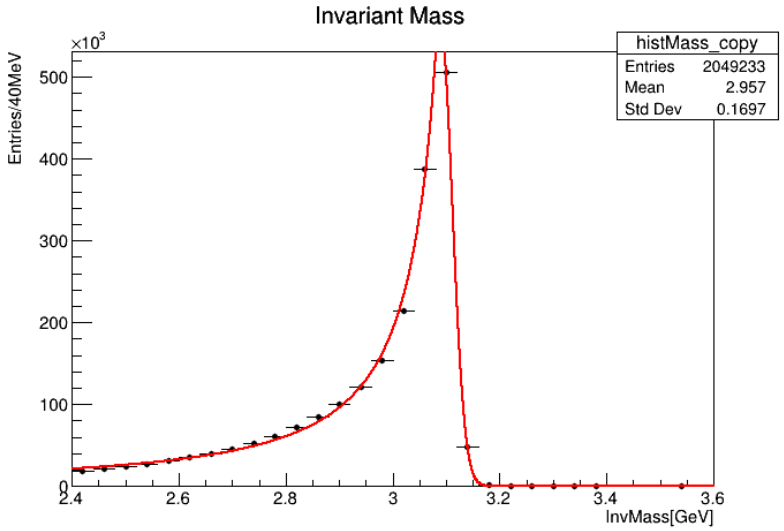
  - Non-prompt:

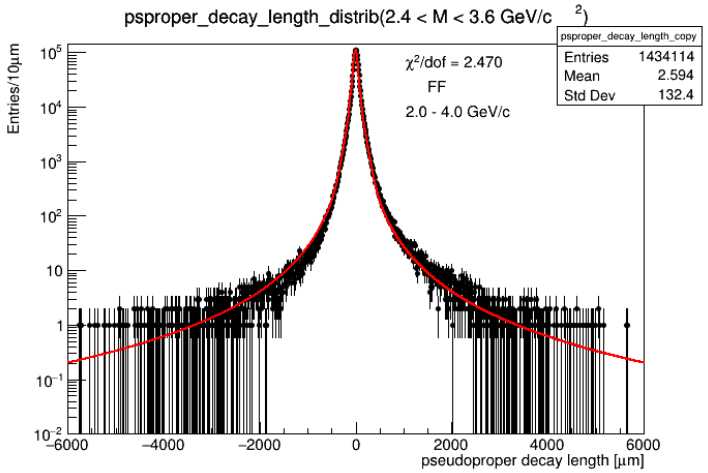
$$F_{B[p_T,type]}(x) = \chi_B(x) \otimes R_{p_T,type}(x)$$

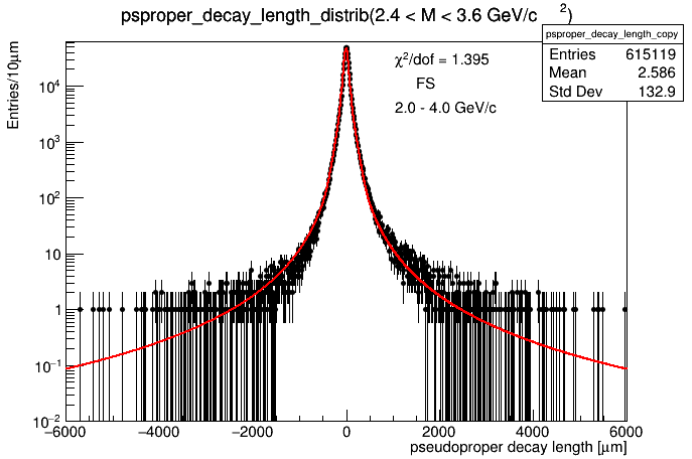
- Background :

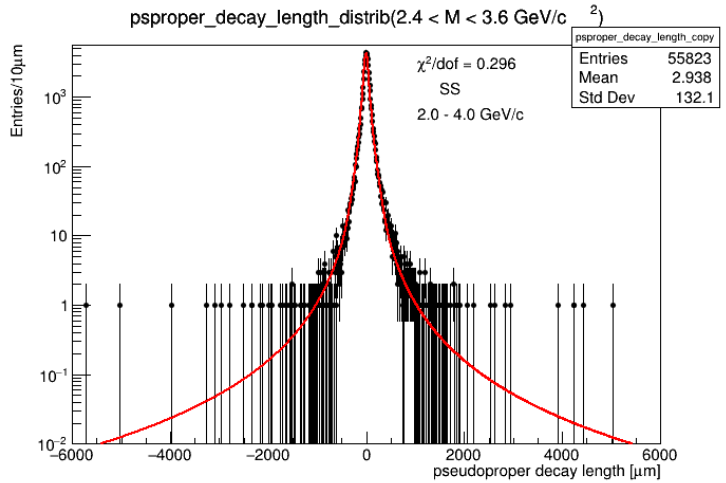
$$\begin{aligned} F_{Bkg[m_{inv},p_T,type]}(x) &= [\frac{f_+}{\lambda_+} e^{-\frac{x'}{\lambda_+}} \cdot \theta(x') + \frac{f_-}{\lambda_-} e^{\frac{x'}{\lambda_-}} \cdot \theta(-x') + \frac{f_{Sym}}{2\lambda_{Sym}} e^{-\frac{|x'|}{\lambda_{Sym}}} \\ &+ (1 - f_+ - f_- - f_{Sym}) \cdot \delta(x')] \otimes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

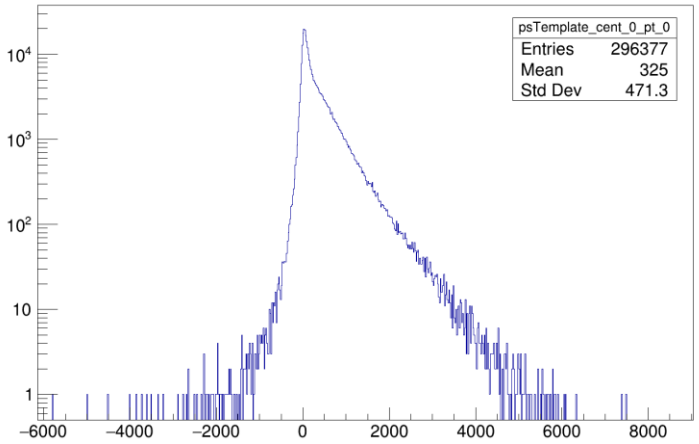
Components of the Likelihood function



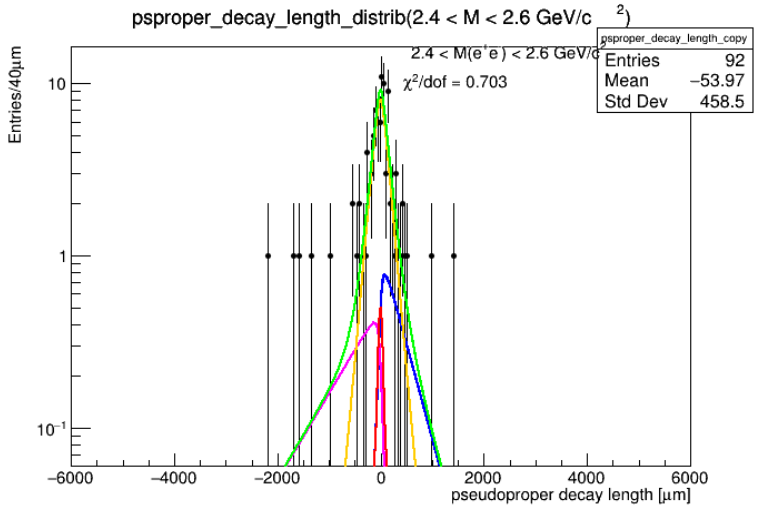


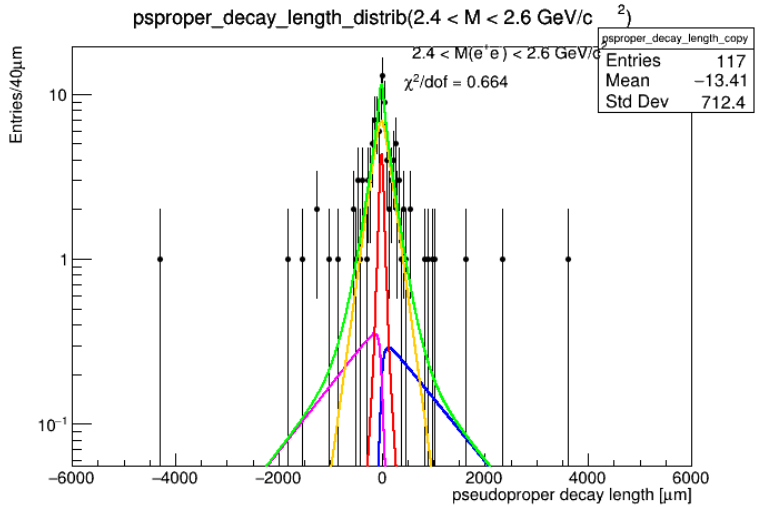


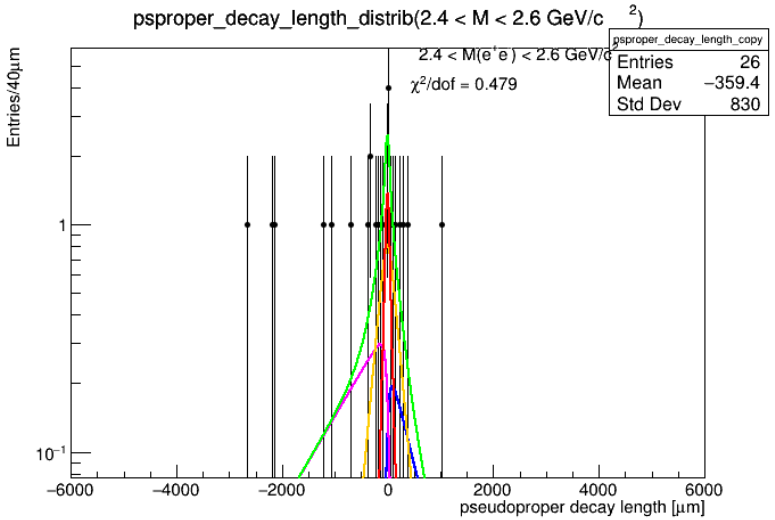


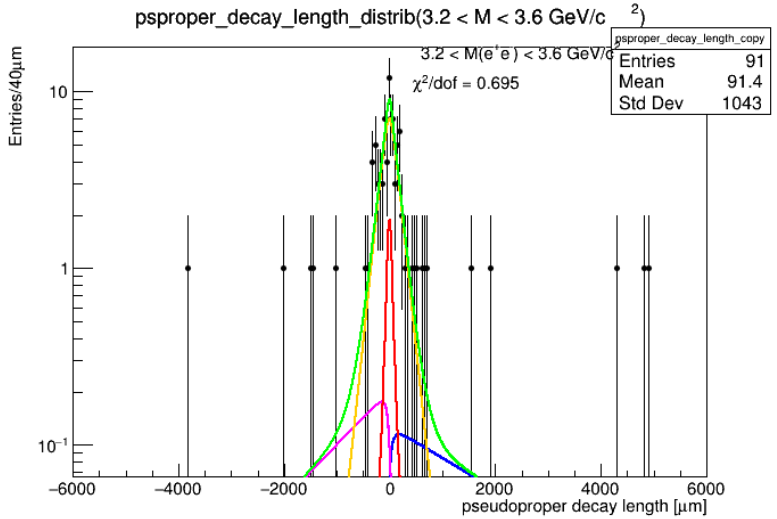


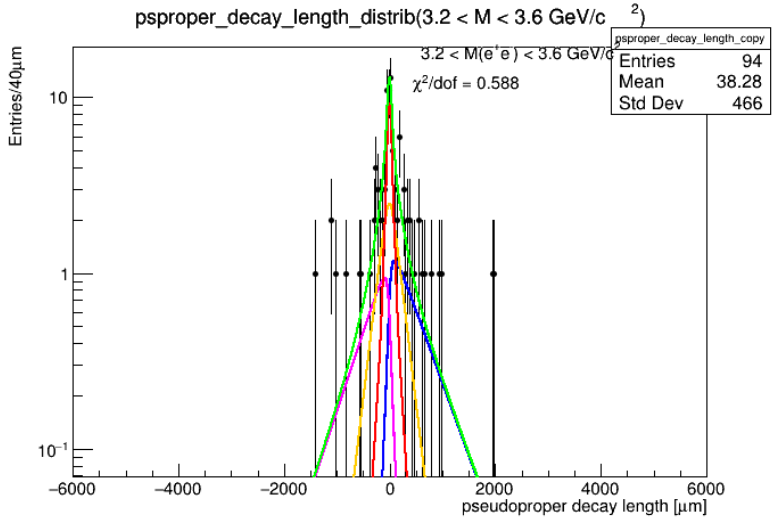
Components of the Likelihood function

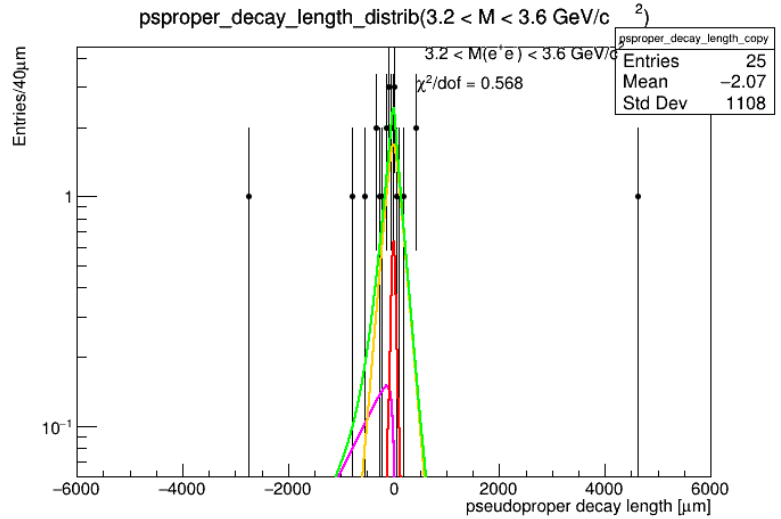




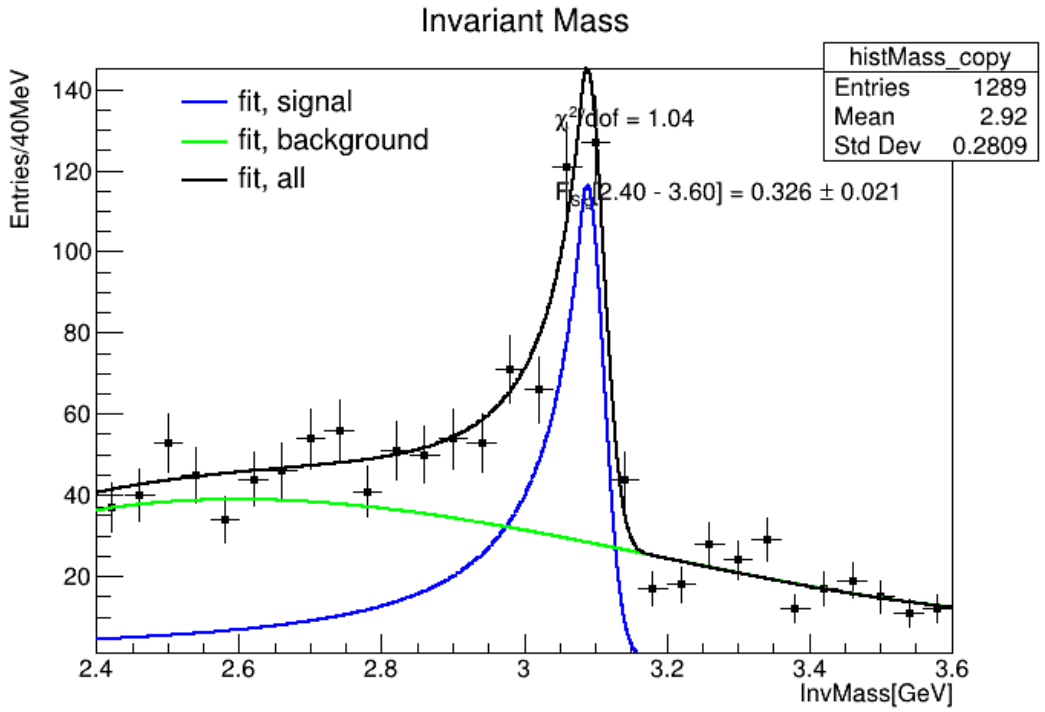


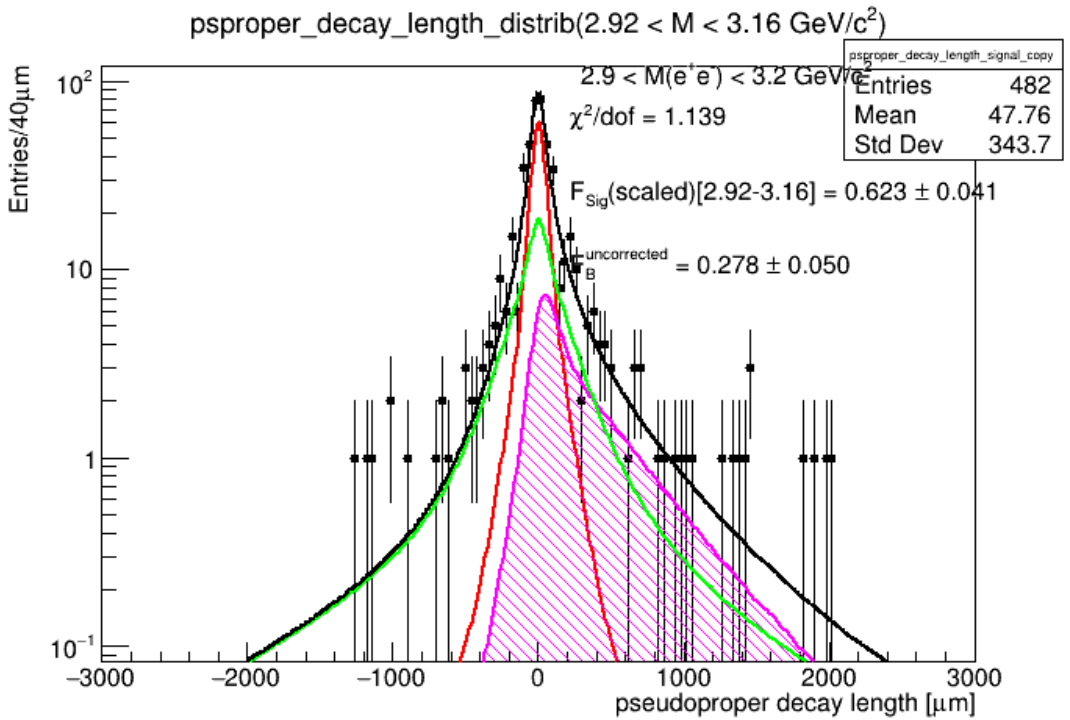




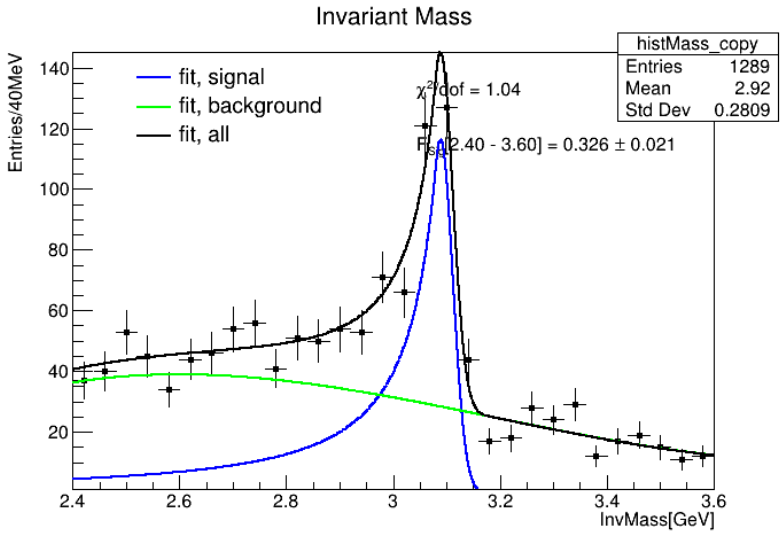


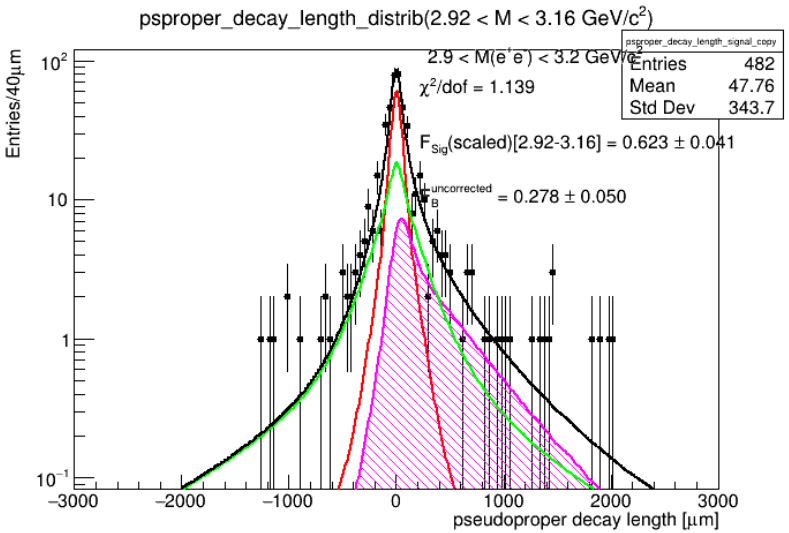
Fit results

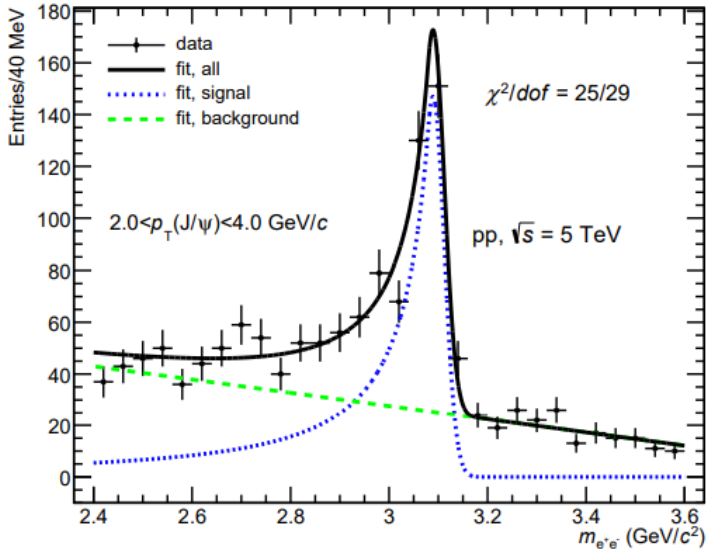

Invariant Mass
histMass_copy
Entries 1289
Mean 2.92
Std Dev 0.2809
fit, signal
fit, background
fit, all
χ²/dof = 1.04
F_Sig[2.40 - 3.60] = 0.326 ± 0.021
Entries/40MeV
InvMass[GeV]

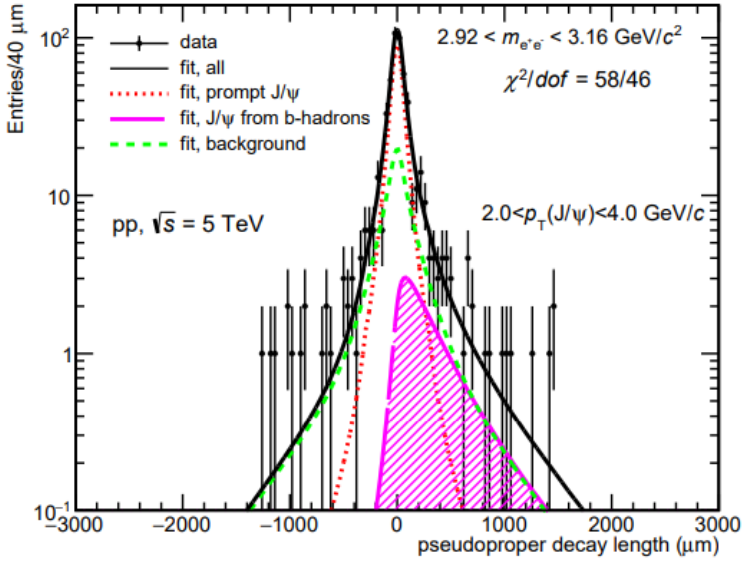

psproper_decay_length_distrib(2.92 < M < 3.16 GeV/c²)
psproper_decay_length_signal_copy
Entries 482
Mean 47.76
Std Dev 343.7
2.9 < M(e⁺e⁻) < 3.2 GeV/c²
χ²/dof = 1.139
F_Sig(scaled)[2.92-3.16] = 0.623 ± 0.041
F_B^uncorrected = 0.278 ± 0.050
Entries/40μm
pseudoproper decay length [μm]

Compare



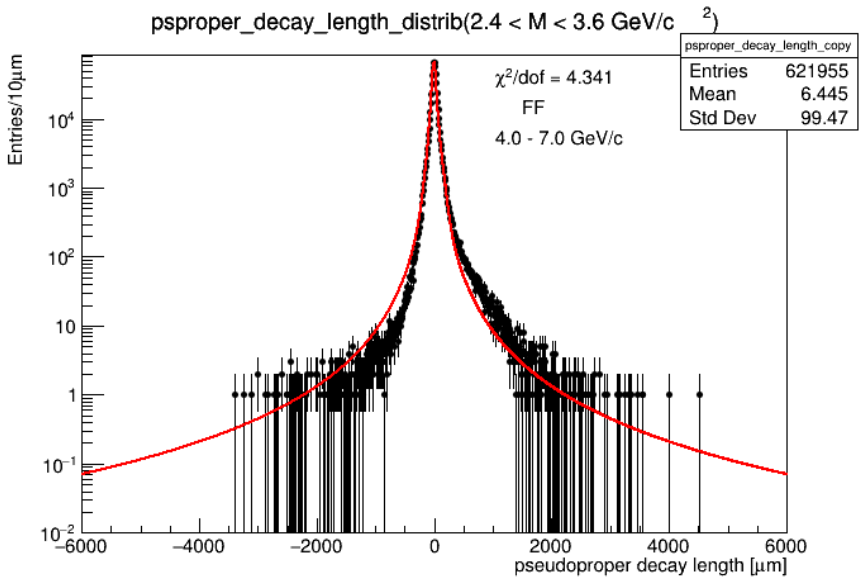


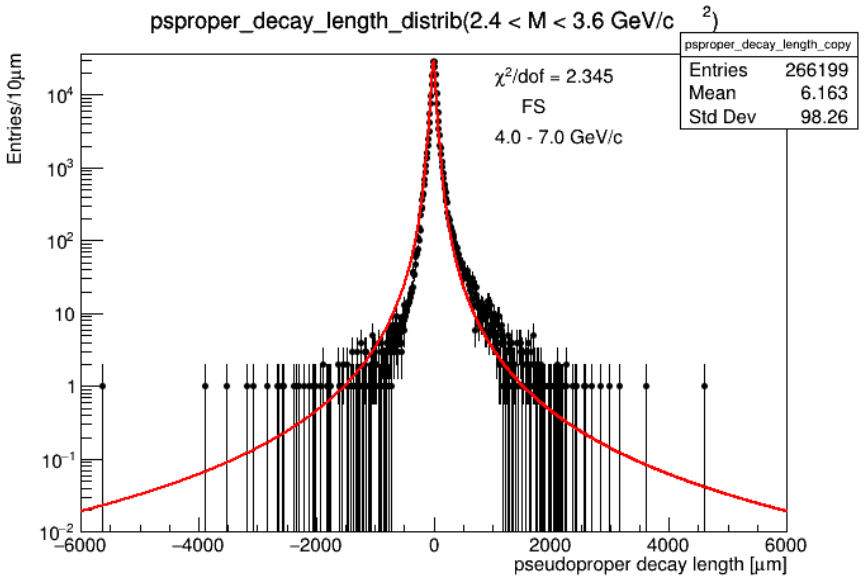


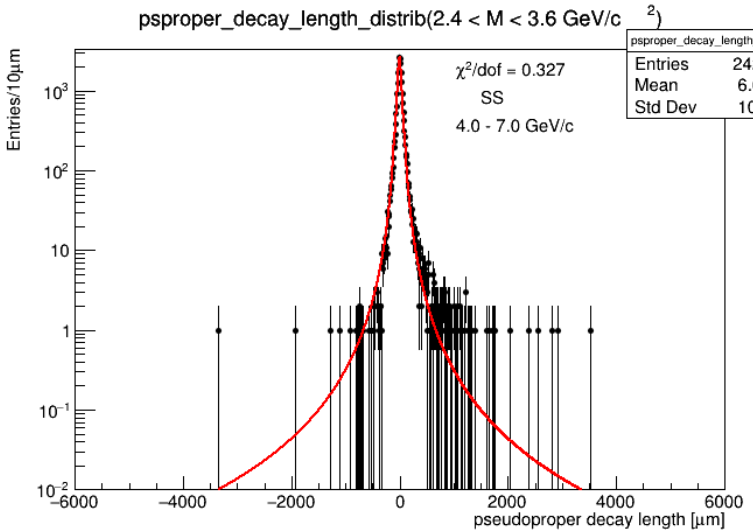


0.139 ± 0.032

Problem


psproper_decay_length_distrib(2.4 < M < 3.6 GeV/c 2)
psproper_decay_length_copy
Entries 621955
Mean 6.445
Std Dev 99.47
χ2/dof = 4.341
FF
4.0 - 7.0 GeV/c
Entries/10μm
pseudoproper decay length [μm]


psproper_decay_length_distrib(2.4 < M < 3.6 GeV/c 2)
psproper_decay_length_copy
Entries 266199
Mean 6.163
Std Dev 98.26
χ2/dof = 2.345
FS
4.0 - 7.0 GeV/c
Entries/10μm
pseudoproper decay length [μm]


psproper_decay_length_distrib(2.4 < M < 3.6 GeV/c 2)
psproper_decay_length_copy
Entries 24257
Mean 6.628
Std Dev 103.8
χ2/dof = 0.327
SS
4.0 - 7.0 GeV/c
Entries/10μm
pseudoproper decay length [μm]