$\psi(2S)/J/\psi(1S)$ ratio in photoproduction: proton dissociative fraction

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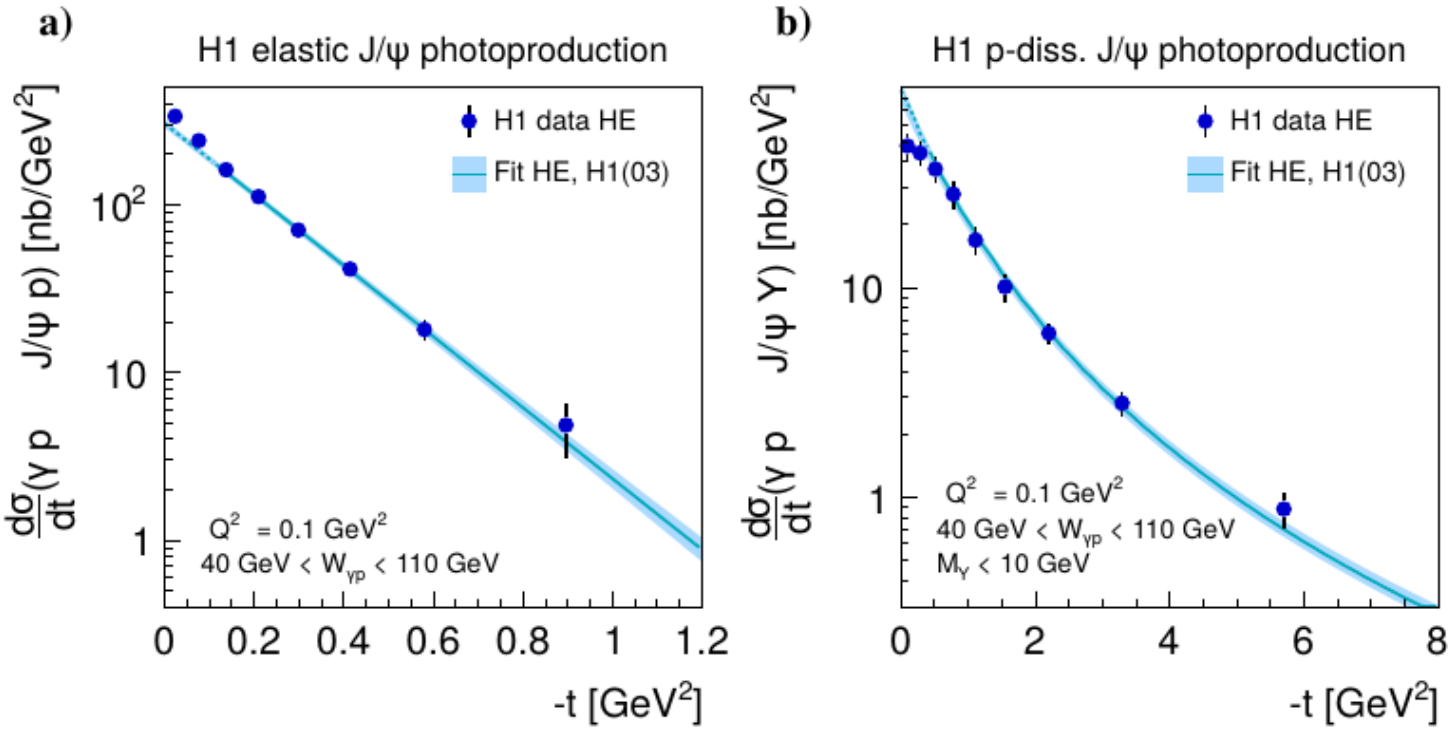
Outlook

- JPSI t-distribution
- PSI2S: 2-PRONG
- PSI2S: 4-PRONG

- all plots with $|t| < 4.0$ GeV^2, longer "lever arm" for p.diss fits
- (final analysis with $|t| < 1.0$ GeV^2 (or similar) to reduce p.diss BG)

Example t-spectra: H1 plots



- two features common for many VM analyses:
- excess of elastic events for very small $|t|$
- deficit of p-diss. events for very small $|t|$

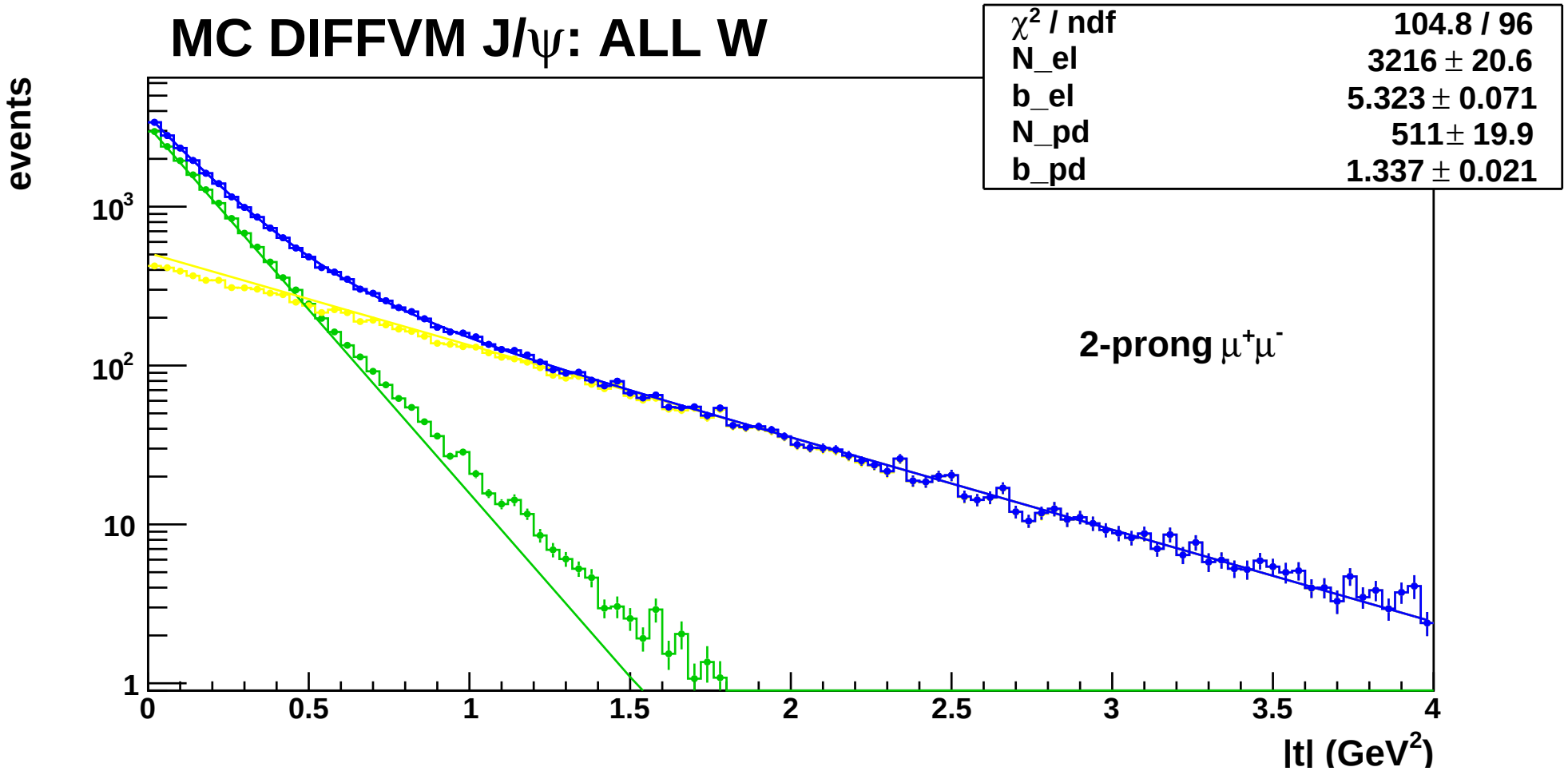
Parameterization of t-distributions

- exponential form $\sim \exp(-b|t|)$ for small |t|
- different slopes for elastic (b_{el}) and p.diss (b_{pd}) processes
- different slopes for J/psi and ψ'
- splitting of p.diss sample (?), different slopes for:
  - resonant component ($N*$, etc.)
  - non-resonant component (M_Y)
- **this analysis is not about determination of t-slopes, we need them to tune the MC and calculate acceptance/efficiency and estimate fraction of p.diss events**

JPSI: DIFFVM MC study

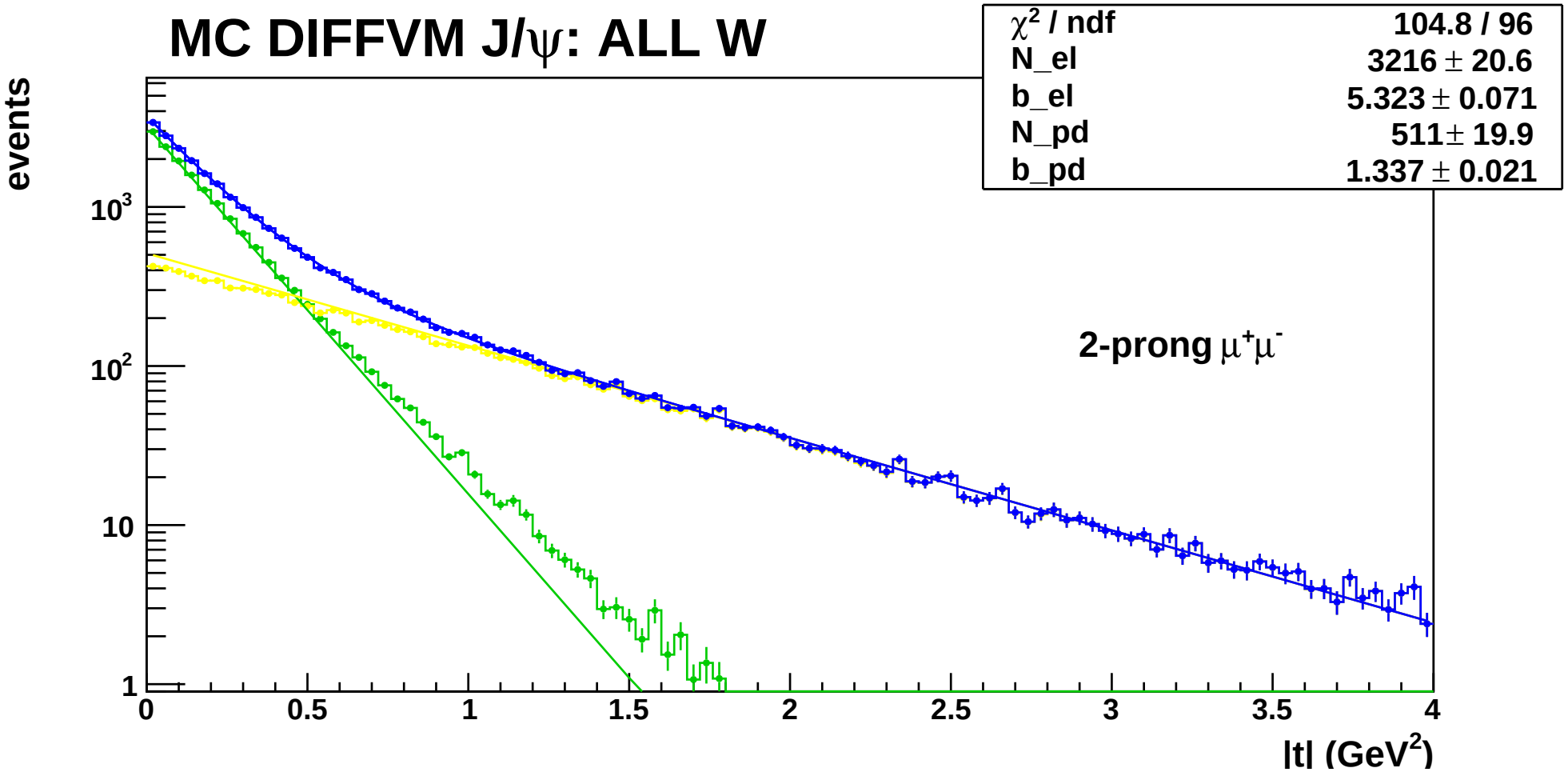
- MC exercise
- to gain some experience how to interpret data
- instead of “guessing” the t-slopes try to fit them

JPSI: MC DIFFVM reconstructed t-distribution



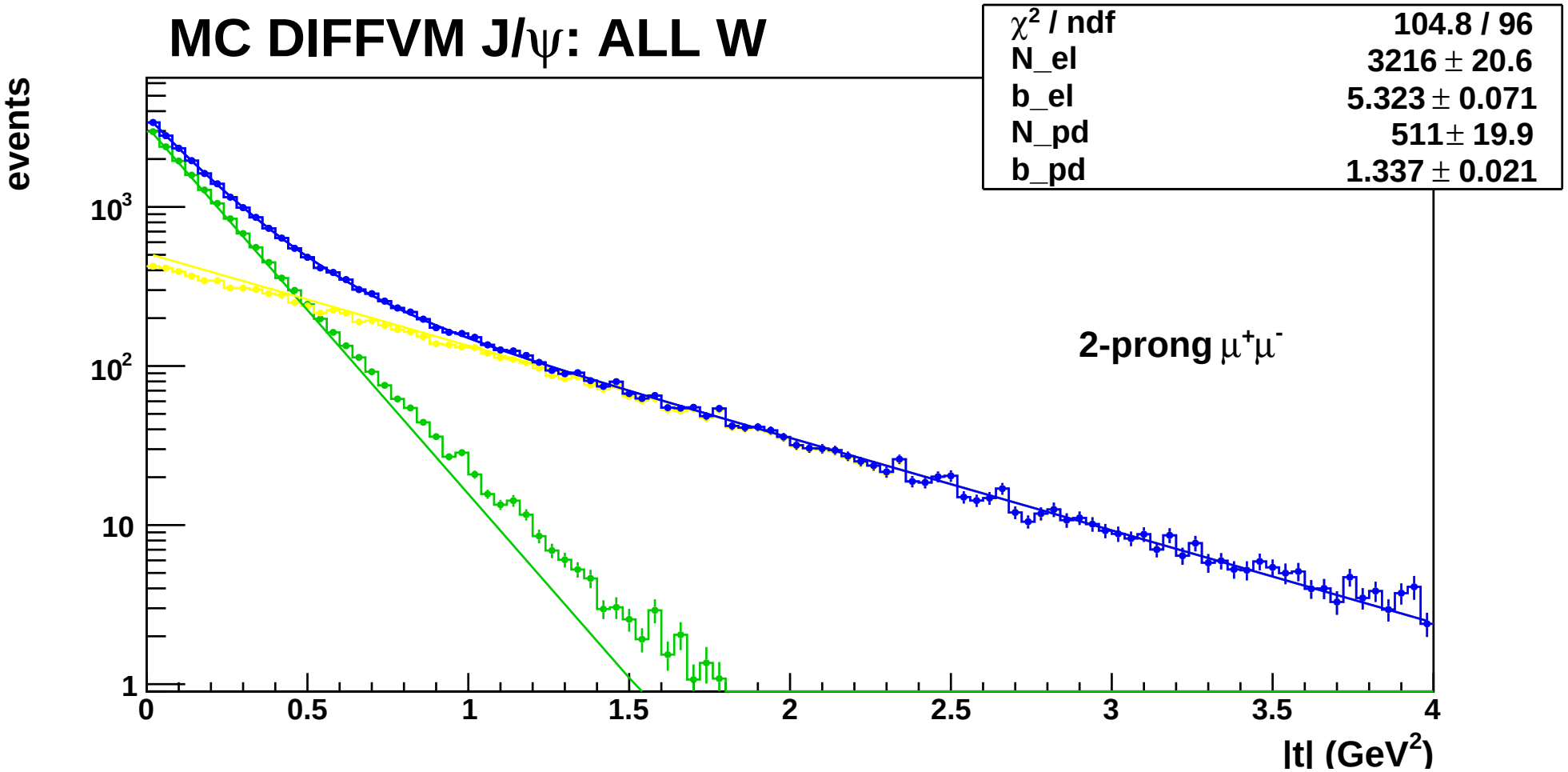
- reconstructed t, after all cuts, smeared by detector resolution
- using approximation: $|t| = p_T^2$, (p_T of VM, neglecting scattered e')
- $f_{p.diss} \approx 0.35$ (realistic value, suggested by data)

JPSI: MC DIFFVM reconstructed t-distribution



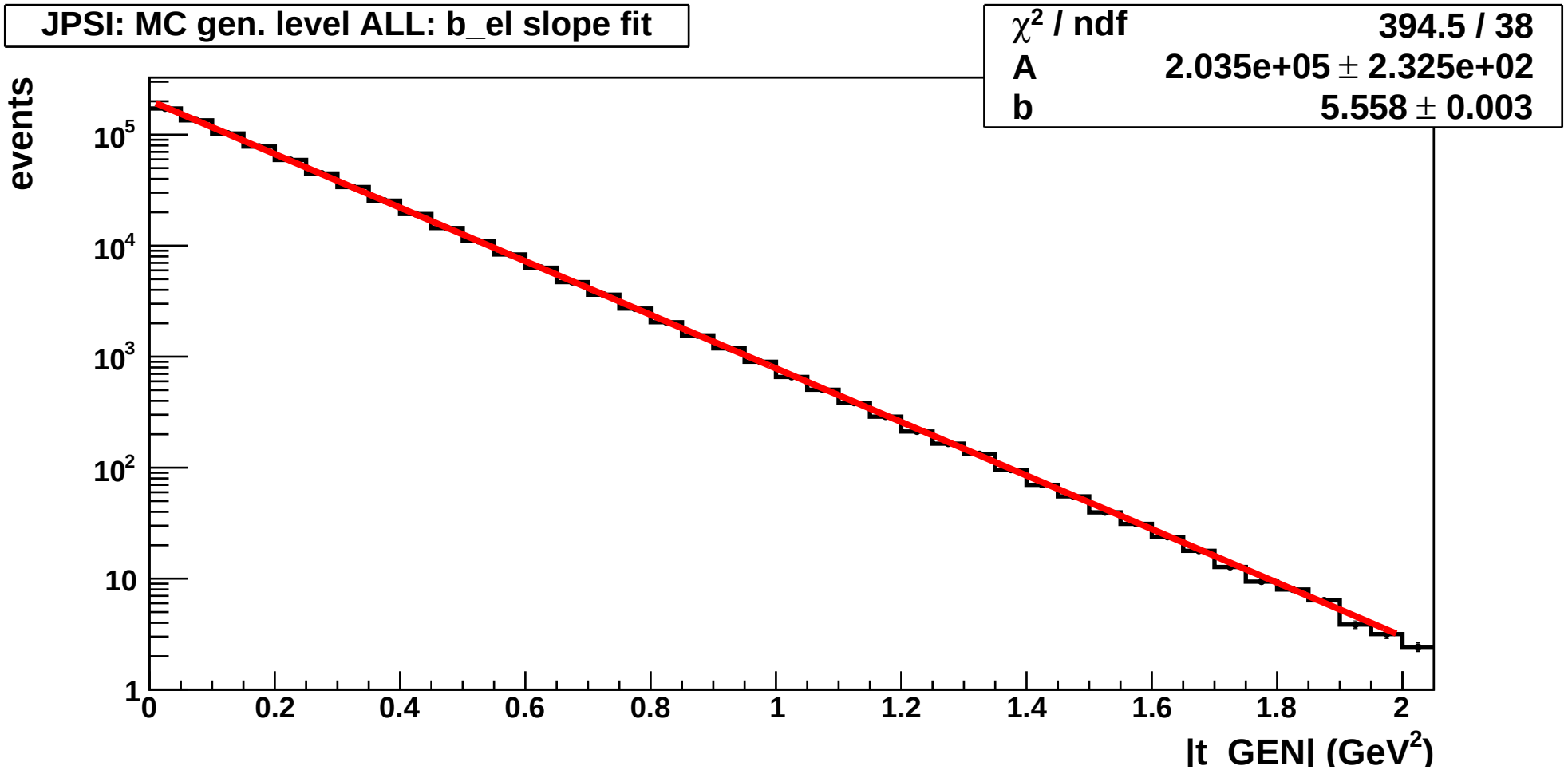
- double exp() fit: $N_{el}\exp(-b_{el}|t|) + N_{pd}\exp(-b_{pd}|t|)$
- elastic, fitted: $b_{el} = 5.3$ GeV^{-2} (generated with $b_{el} = 5.6$ GeV^{-2})
- some bias of reconstructed elastic slope

JPSI: MC DIFFVM reconstructed t-distribution



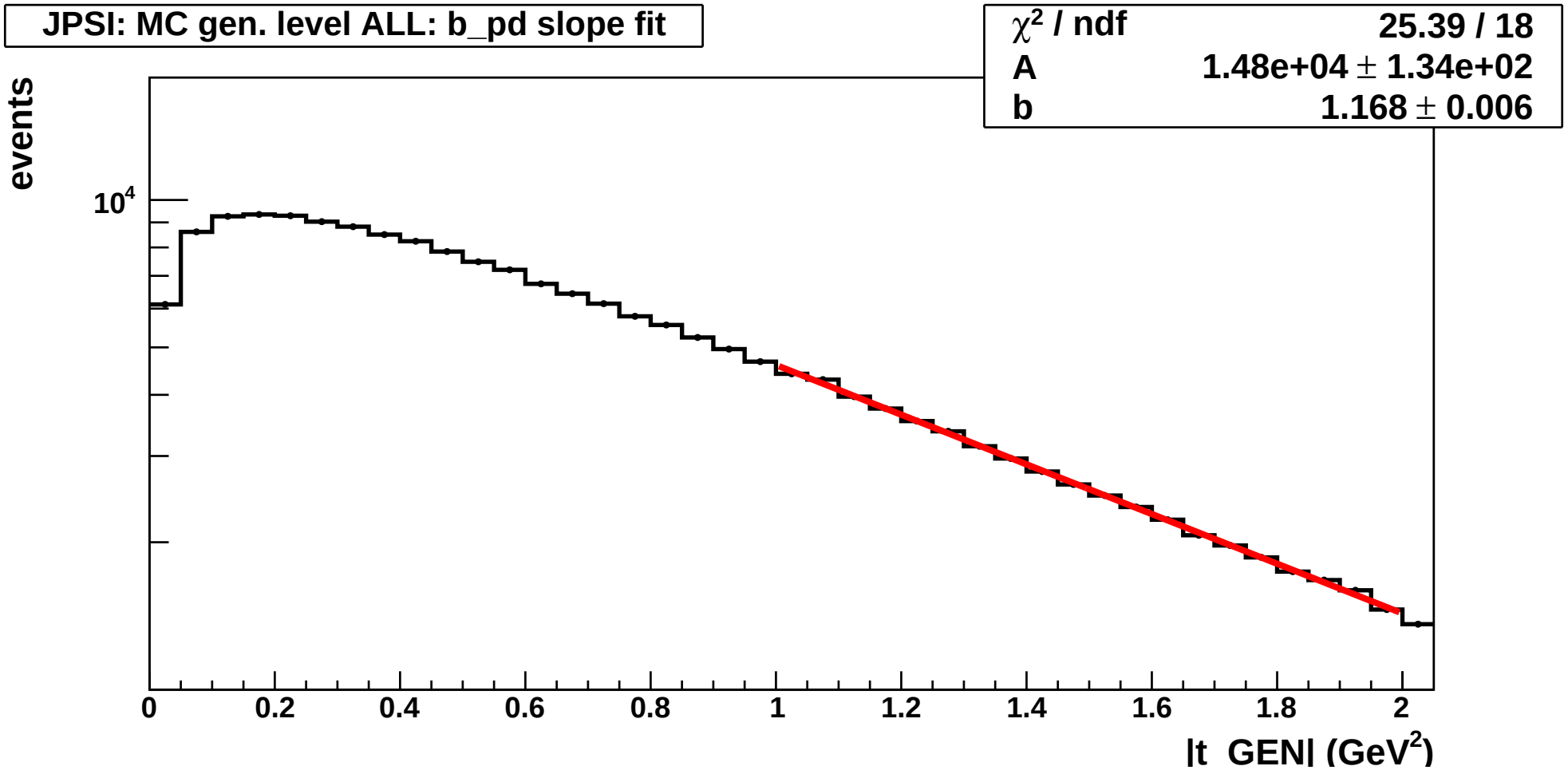
- double exp() fit: $N_{el}\exp(-b_{el}|t|) + N_{pd}\exp(-b_{pd}|t|)$
- p.diss, fitted: $b_{pd} = 1.3$ GeV^{-2} (generated with $b_{pd} = 1.3$ GeV^{-2})
- non-exponential p.diss MC template for p.diss at low $|t|$

elastic JPSI: MC DIFFVM generator level



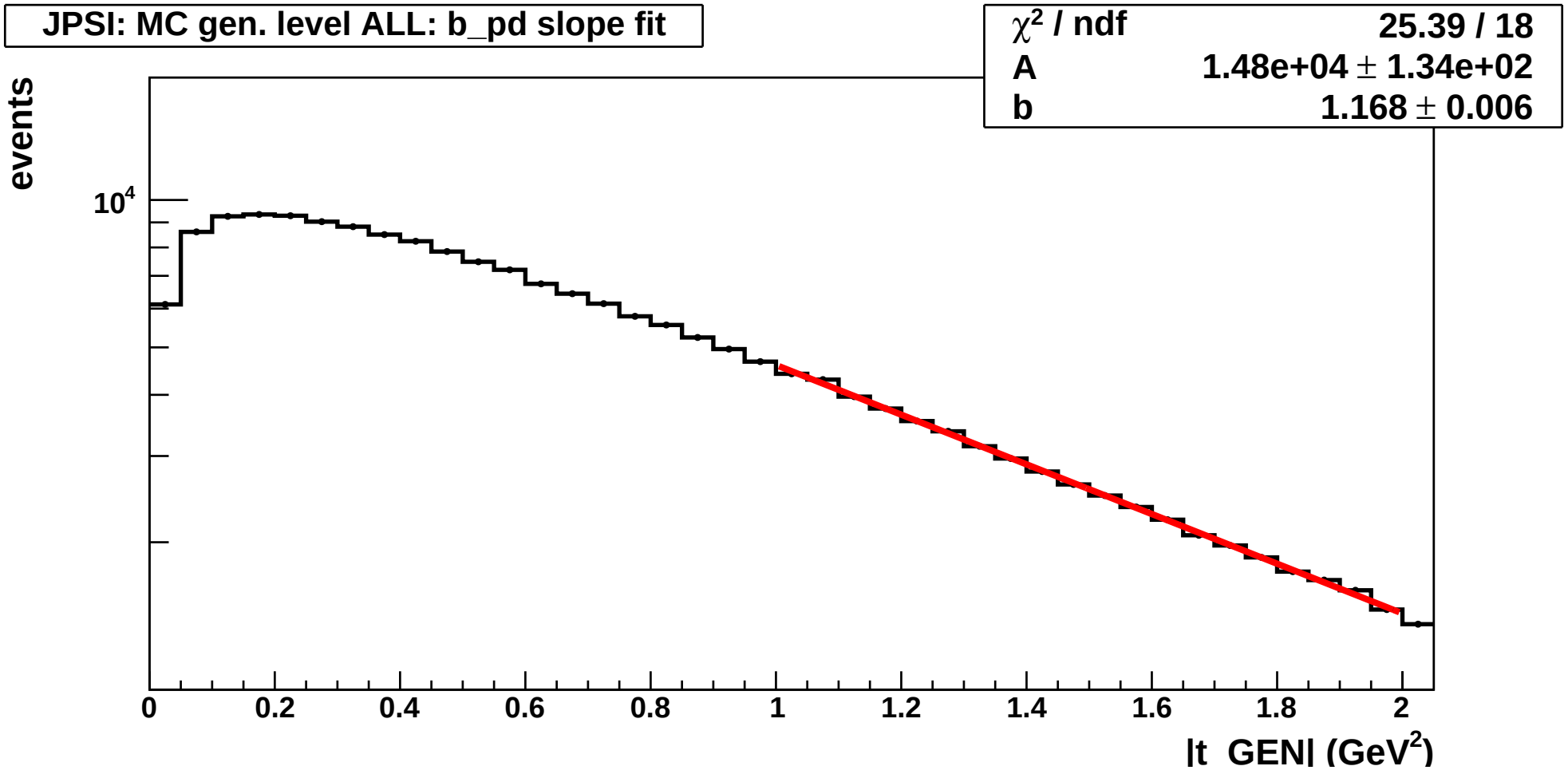
- elastic JPSI: generator level "true" $|t|$-distribution before cuts, (calculated using gen-level 4-vectors including scattered e')
- reweighted to: $b_{el} = 5.6$ GeV^{-2} (realistic example)

p.diss JPSI: MC DIFFVM generator level



- p.diss JPSI: generator level "true" $|t|$-distribution before cuts, (calculated using gen-level 4-vectors including scattered e')
- reweighted to: $b_{pd} = 1.3$ GeV^{-2} (realistic example)

p.diss JPSI: MC DIFFVM generator level



- p.diss t-distribution is non-exponential already at generator level !
- kinematical threshold effect
  (minimal 4-momentum transfer needed to excite the proton)

p.diss JPSI: MC DIFFVM generator level

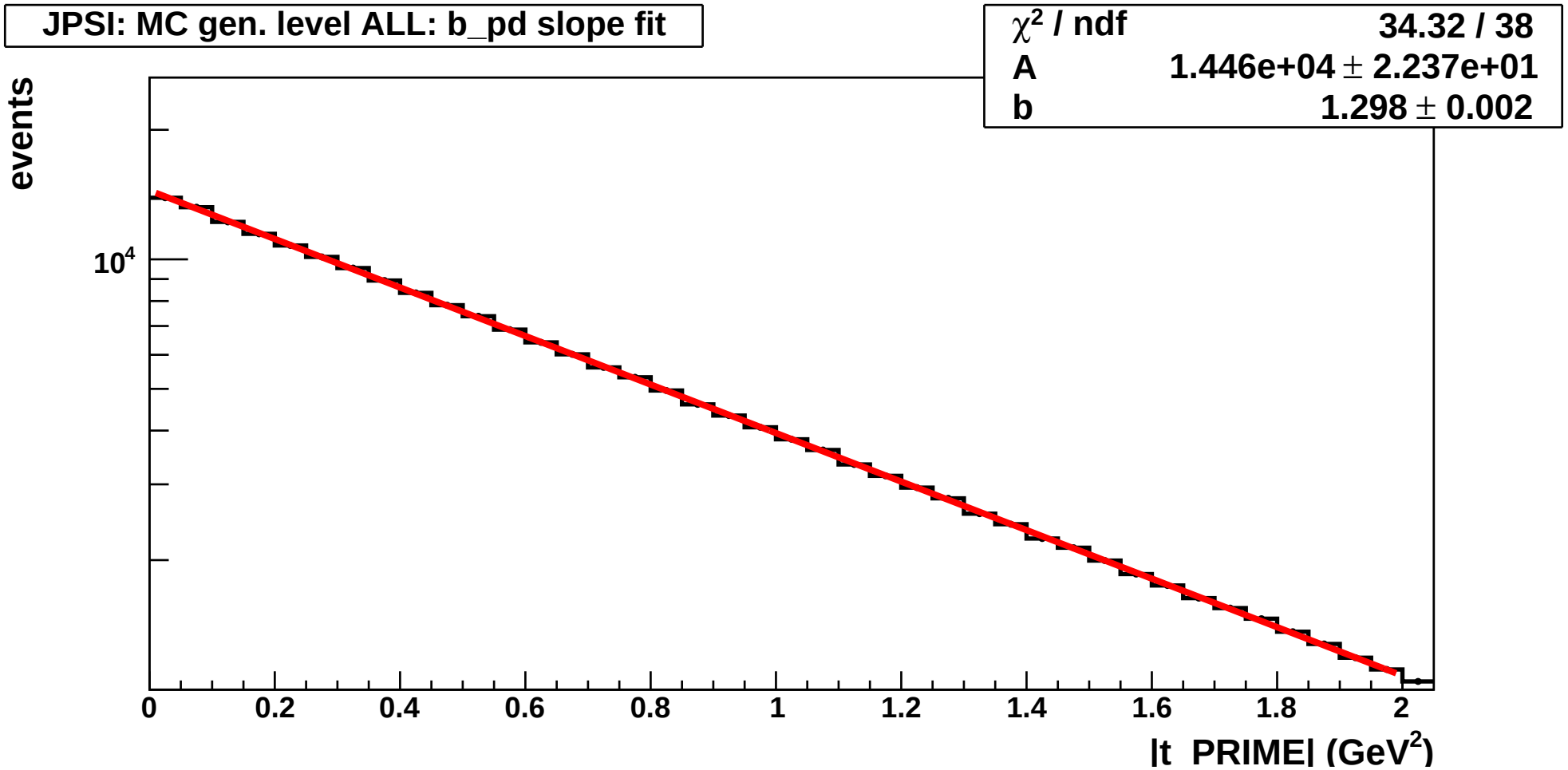
- t' variable corrected for threshold effect:

```
amprot = PMASS;
mdiff  = M_Y_gen;
q2g    = Q2_gen;
mppg   = mass_VM_gen;
Wg     = W_gen;

t_min = ((amprot*amprot-mdiff*mdiff+q2g+mppg*mppg)/(2*Wg))*
        ((amprot*amprot-mdiff*mdiff+q2g+mppg*mppg)/(2*Wg))
       -(sqrt(((Wg*Wg + amprot*amprot+q2g)/(2*Wg))*
        ((Wg*Wg + amprot*amprot+q2g)/(2*Wg))-amprot*amprot)
       -sqrt(((Wg*Wg+mdiff*mdiff-mppg*mppg)/(2*Wg))*
        ((Wg*Wg+mdiff*mdiff-mppg*mppg)/(2*Wg))-mdiff*mdiff))*
        (sqrt(((Wg*Wg + amprot*amprot+q2g)/(2*Wg))*
        ((Wg*Wg + amprot*amprot+q2g)/(2*Wg))-amprot*amprot)
       -sqrt(((Wg*Wg+mdiff*mdiff-mppg*mppg)/(2*Wg))*
        ((Wg*Wg+mdiff*mdiff-mppg*mppg)/(2*Wg))-mdiff*mdiff));

t_prime = t_gen - abs(t_min);
```

p.diss JPSI: MC DIFFVM generator level

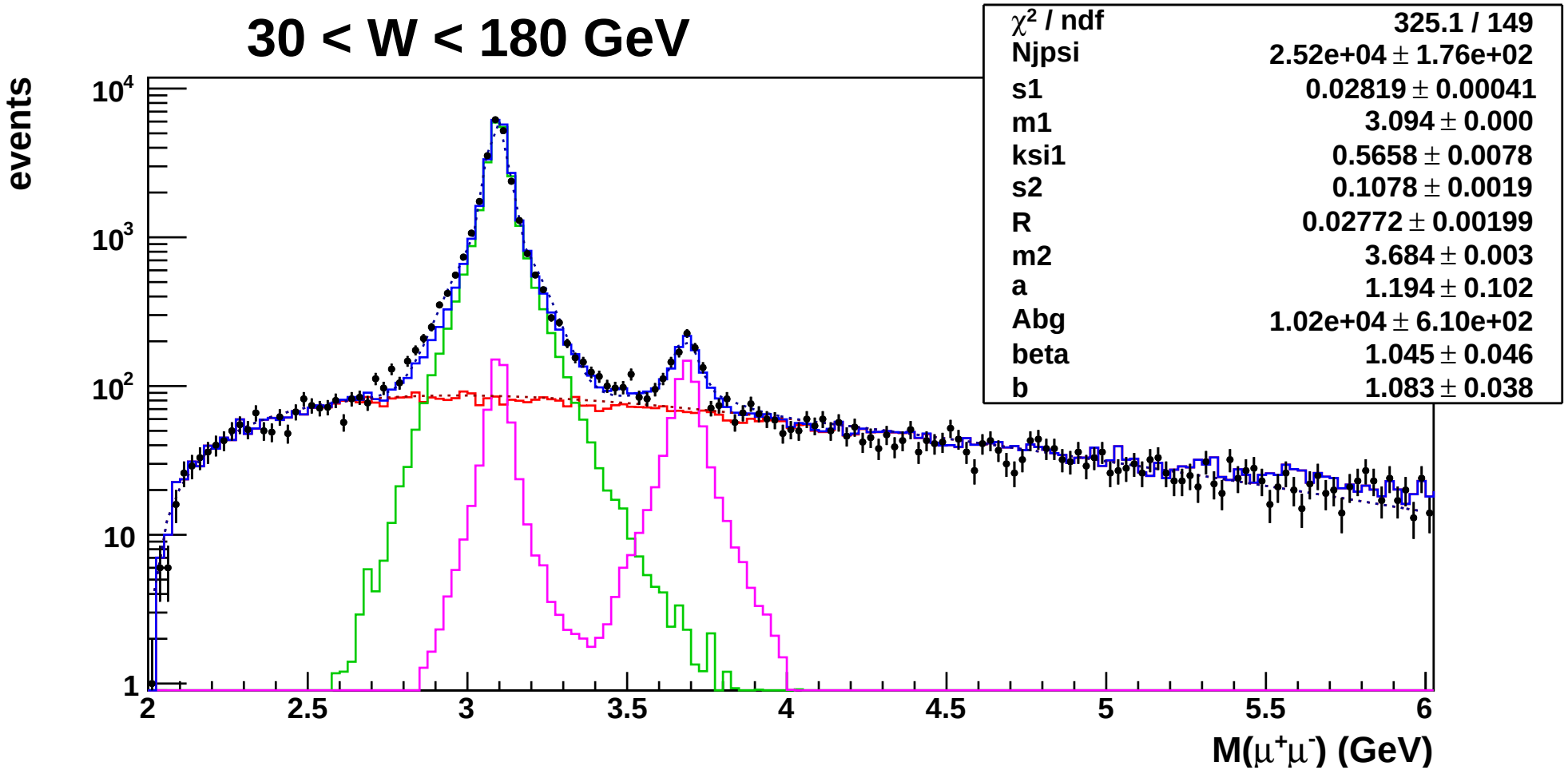


- p.diss t'-distribution is exponential !
- lesson learned (1): reweight p.diss MC using t' !
- lesson learned (2): correct fitted b_{el} slope for detector level bias

Back to DATA

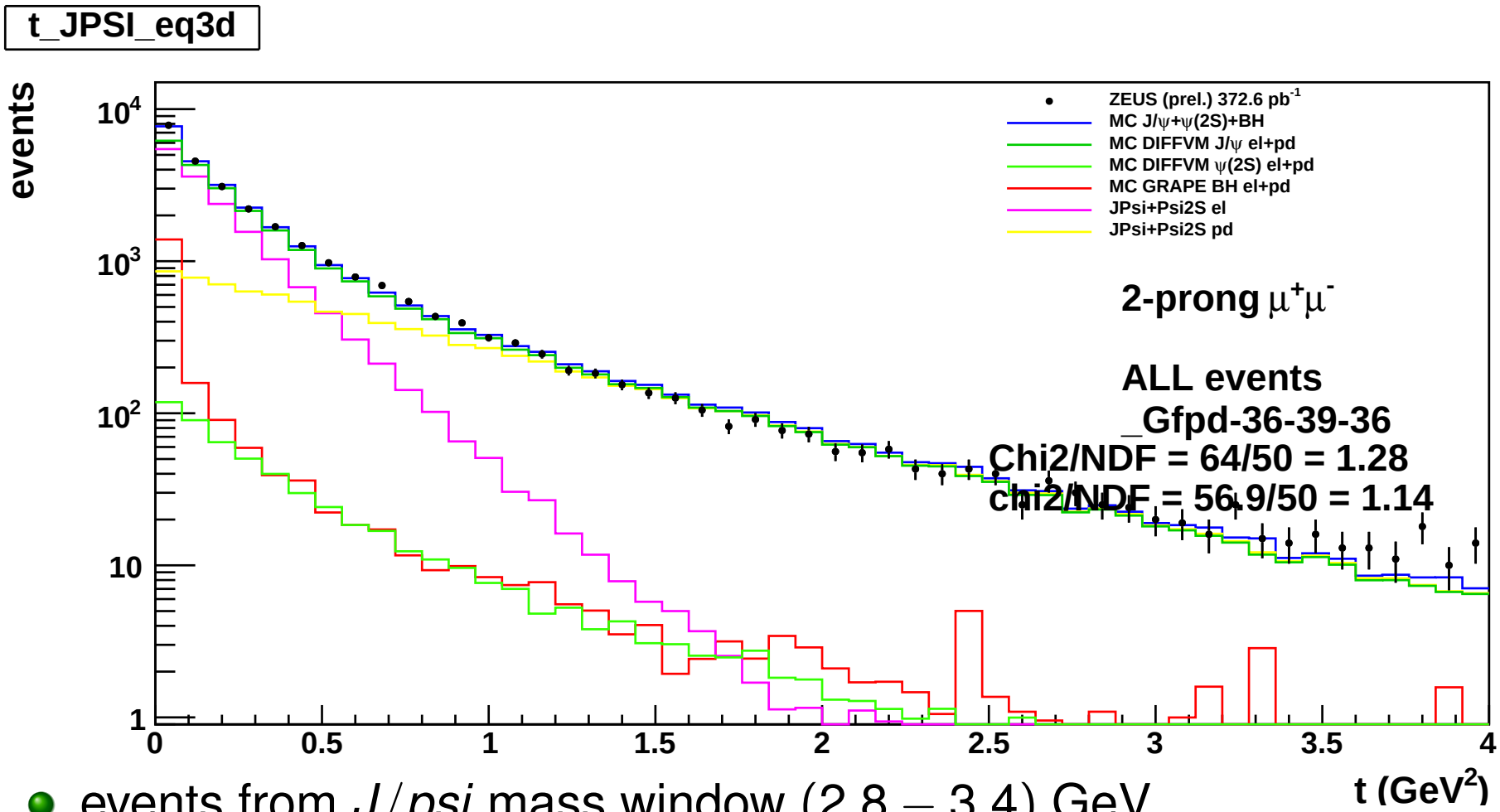
- Back to DATA

Di-muon mass distribution



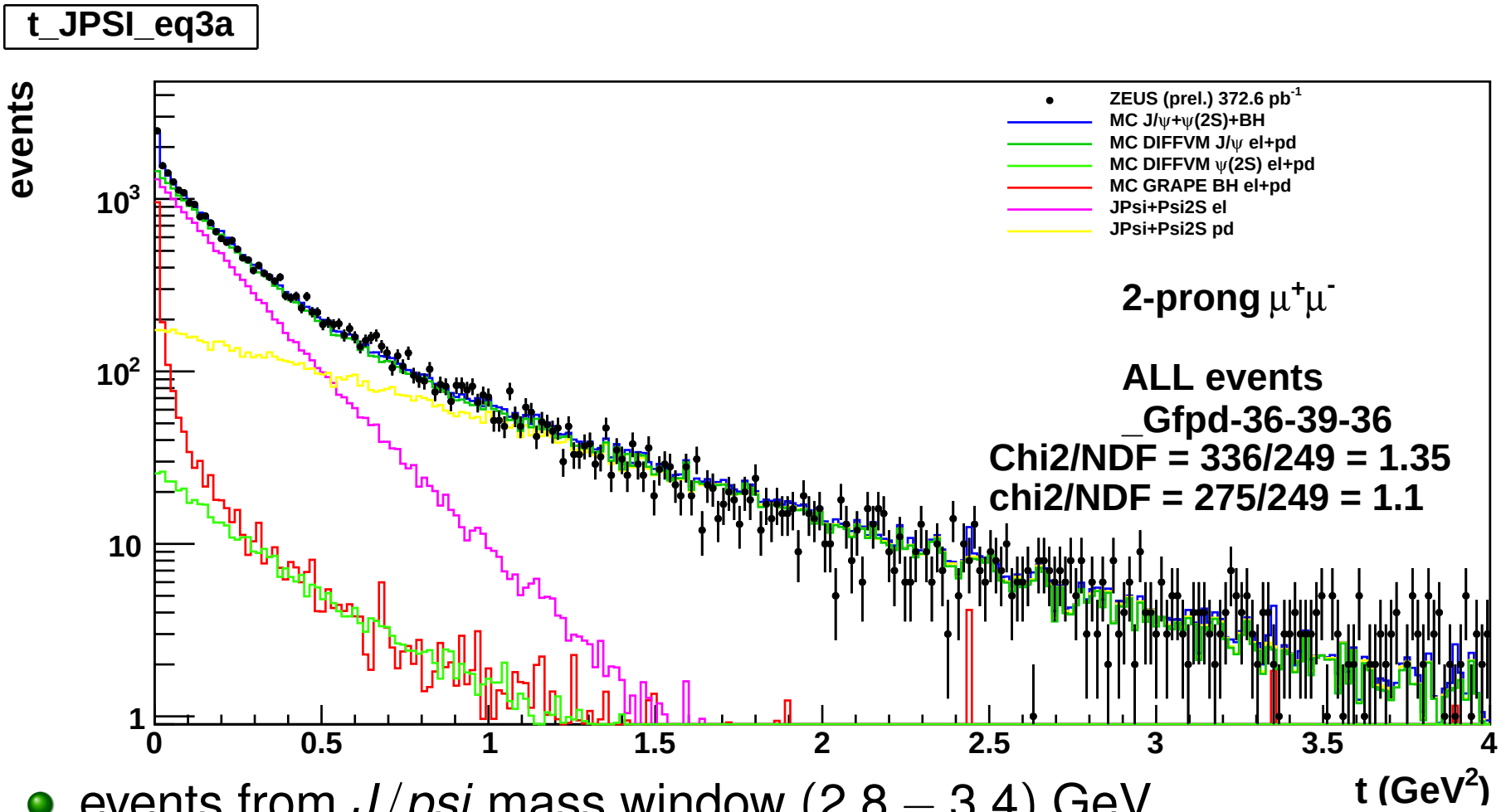
- full phase space, double Gaussian fit to VM peaks
- BG to JPSI: BH and cascade decay of $\psi' \to J/\psi + \pi^+\pi^-$

JPSI mass window: *t*-distribution



- events from J/psi mass window $(2.8 - 3.4)$ GeV
- elastic and p.piss components (magenta, yellow)
- BH and ψ' background (red, light-green)
- fractions from di-muon mass plot

JPSI mass window: *t*-distribution, different binning



- events from J/psi mass window $(2.8 - 3.4)$ GeV
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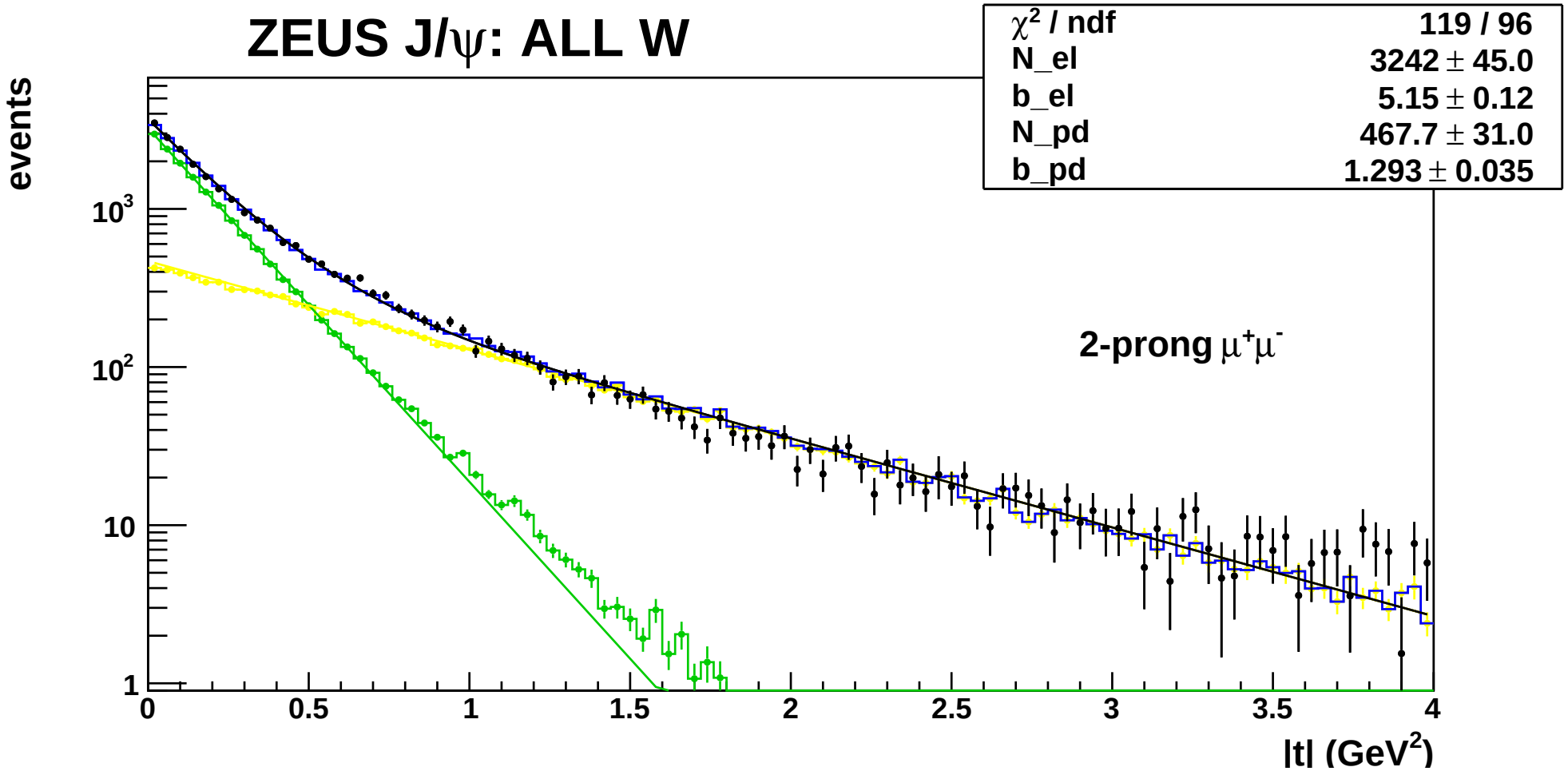
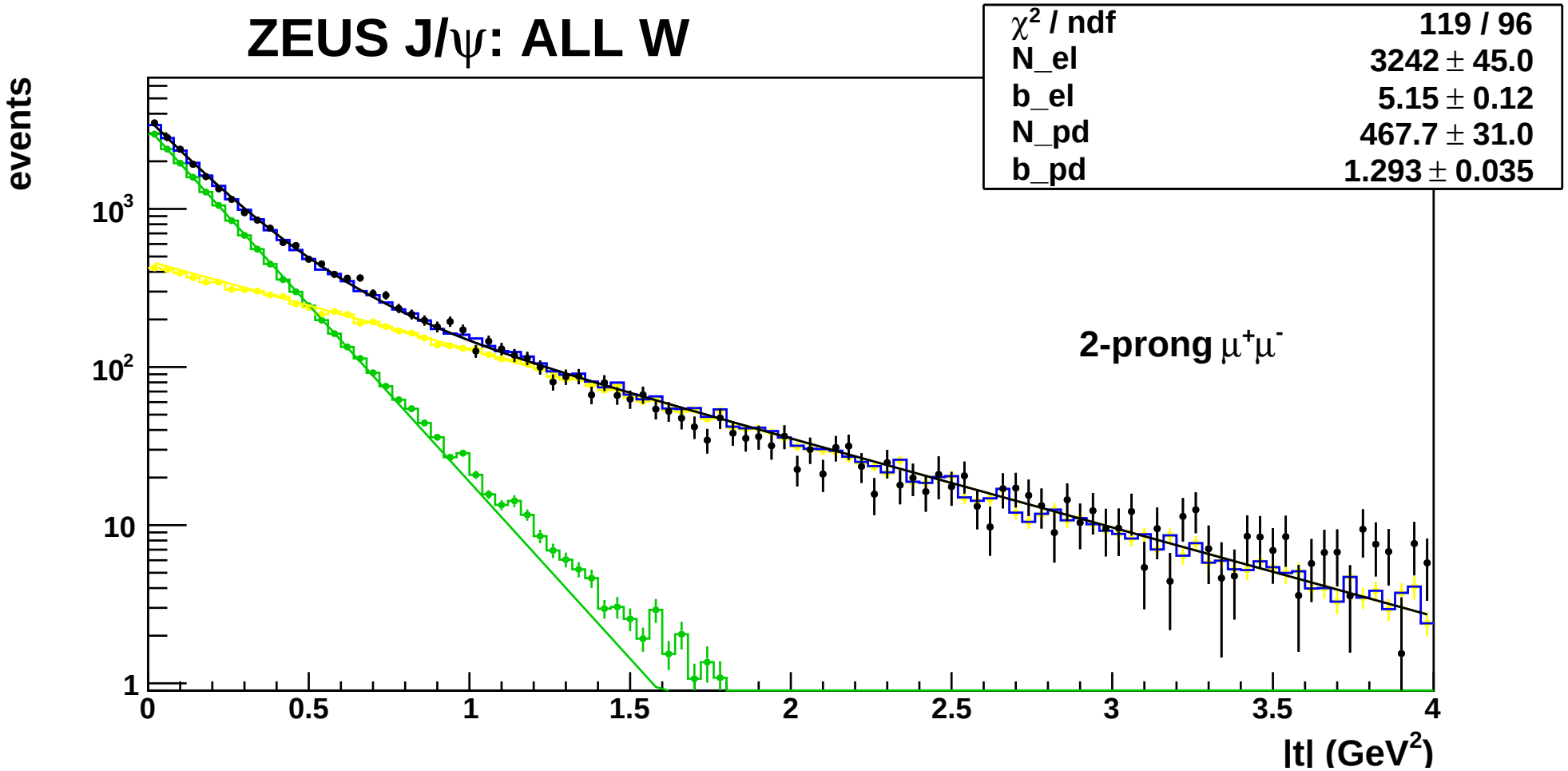
- BH and ψ' background (red, light-green)
- fractions from di-muon mass plot

JPSI mass window: t-distribution, BG subtracted



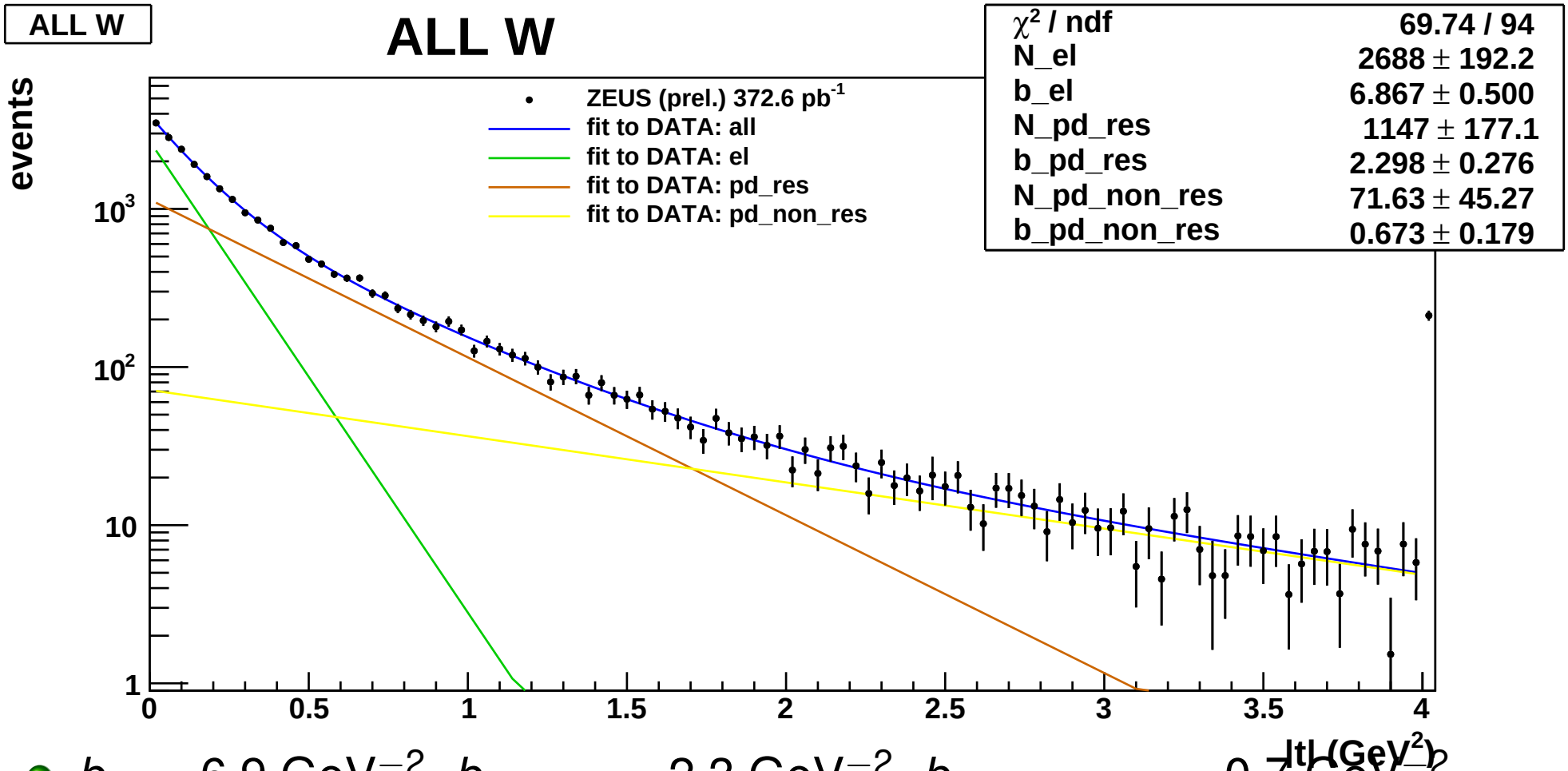
- BH and ψ' subtracted using MC templates
- double exp() fit to data: $b_{el} = 5.1$ GeV^{-2}, $b_{pd} = 1.3$ GeV^{-2}
- $f_{pdiss} = 0.36$ (from exp() fit and from `root TFracFitter`)

JPSI mass window: t-distribution, BG subtracted



- good description of data using two component exp() fit
- no excess at very low $|t|$ (BH properly subtracted)
- no need to introduce 3rd exp() component (see next page)

JPSI mass window: t-distribution, triple exp() fit

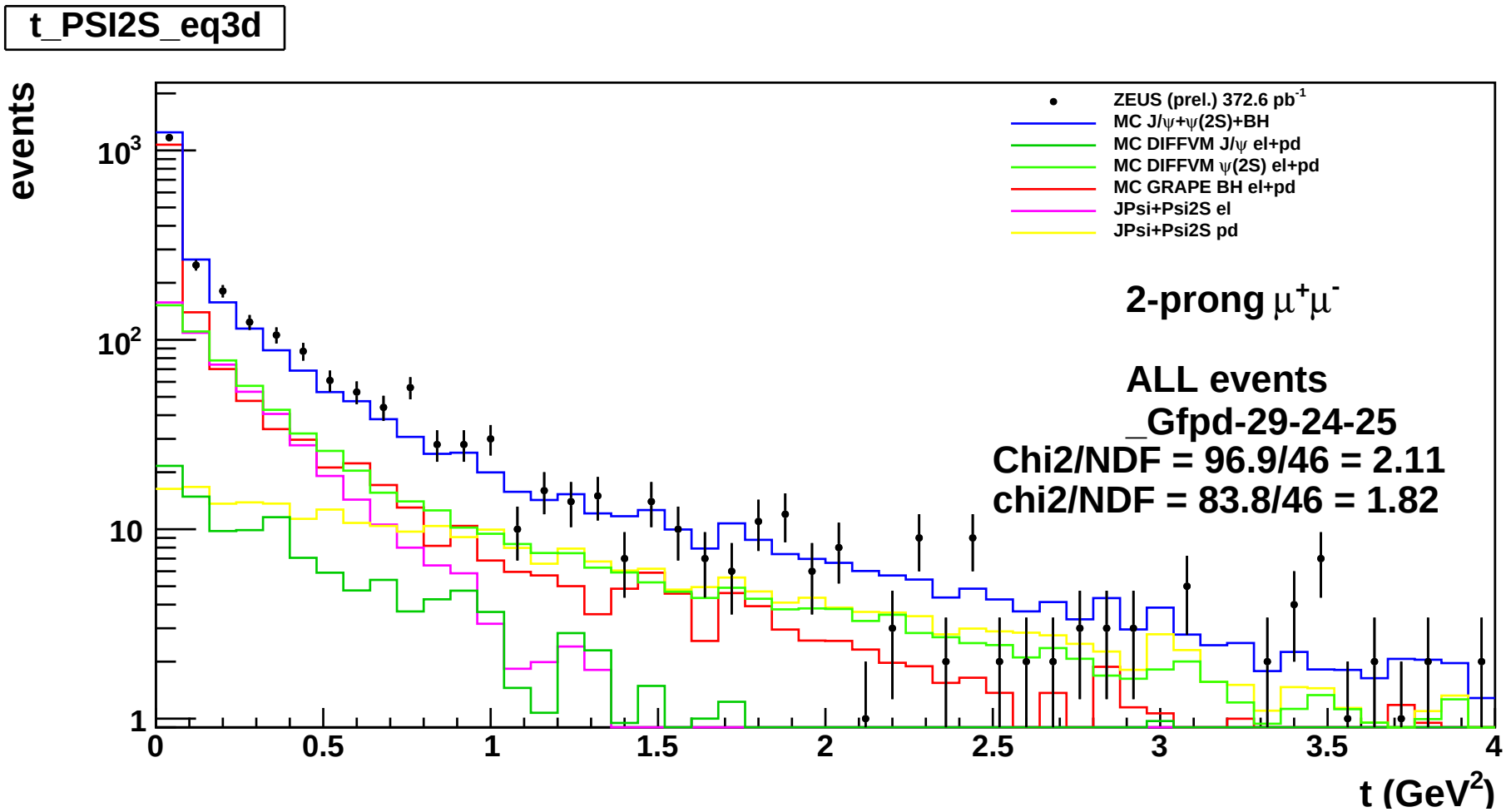


- $b_{el} = 6.9$ GeV^{-2}, $b_{pd-res} = 2.3$ GeV^{-2}, $b_{pd-non-res} = 0.7$ GeV^{-2}
- very large b_{el} (?), if $b_{el} \leftrightarrow b_{pd-res}$ then b_{el} very small...
- resonant and non-resonant component interpolates between single p.diss fraction...

PSI2S: 2-PRONG

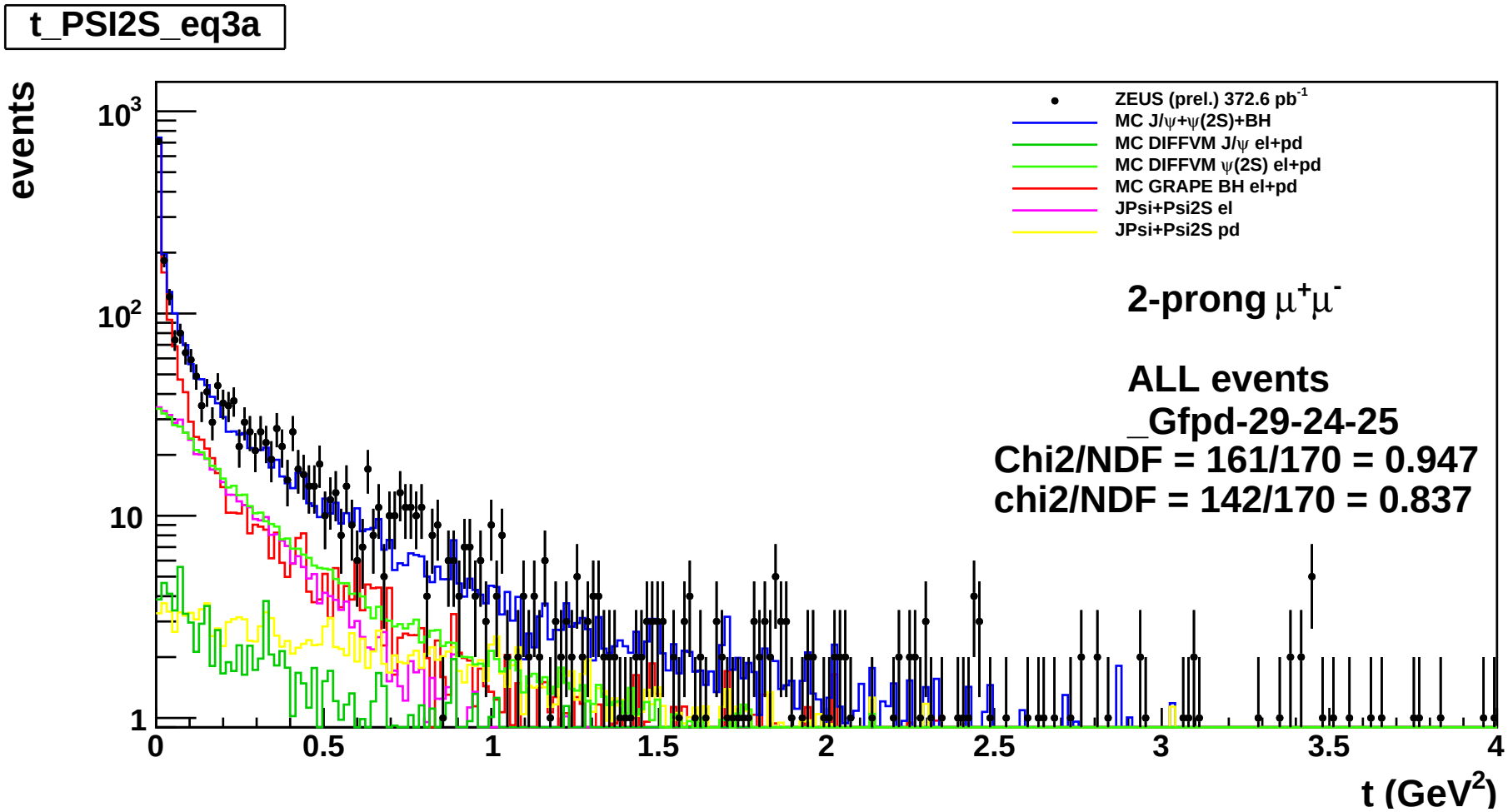
- ψ' : 2-PRONG channel

PSI2S mass window: t-distribution



- very high BH background (plus some J/ψ leakage)
- sharp (non-exponential) BH peak around $|t| = 0$
- background subtraction more sensitive to MC model

PSI2S mass window: t-distribution (different binning)



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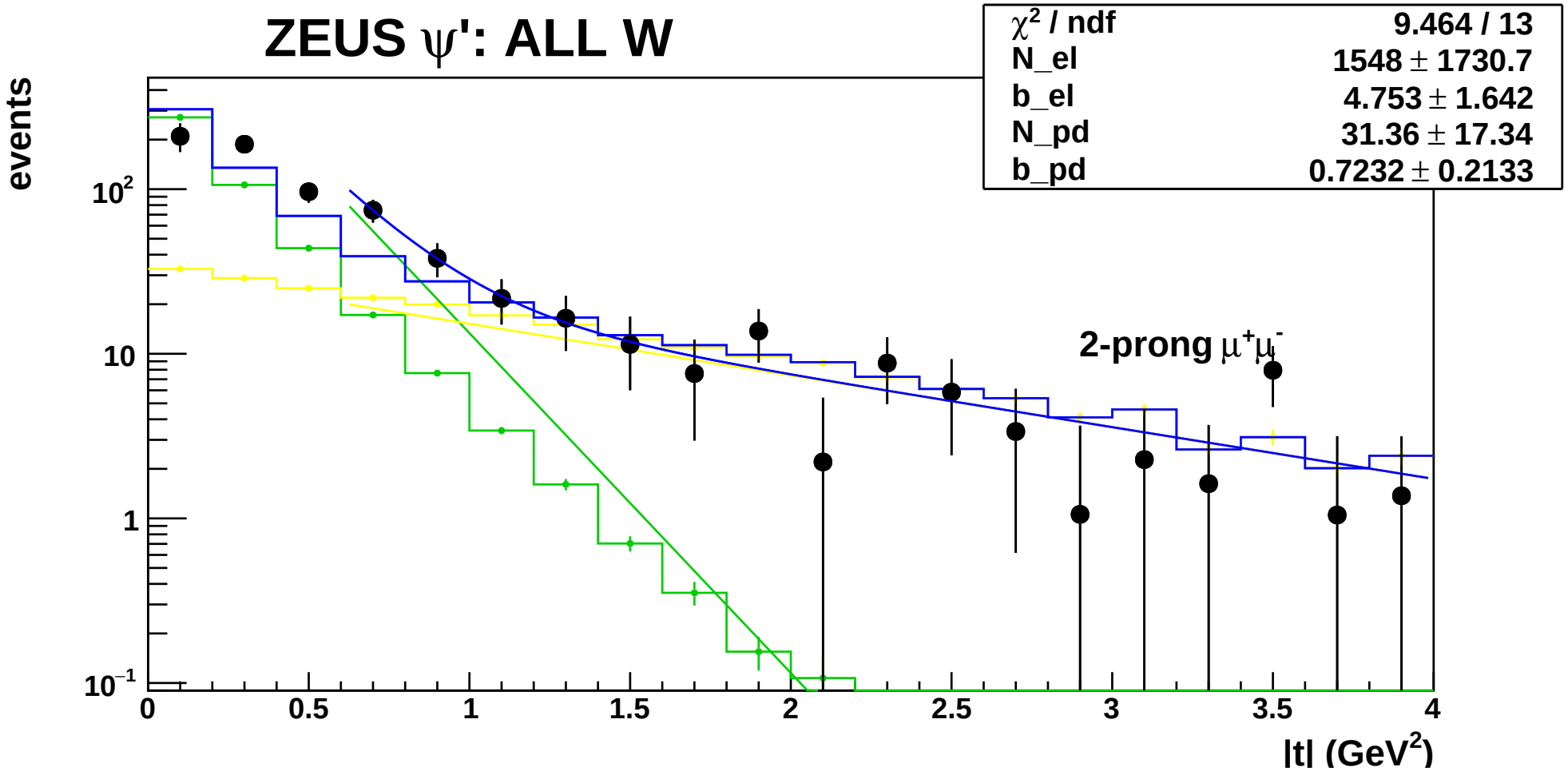
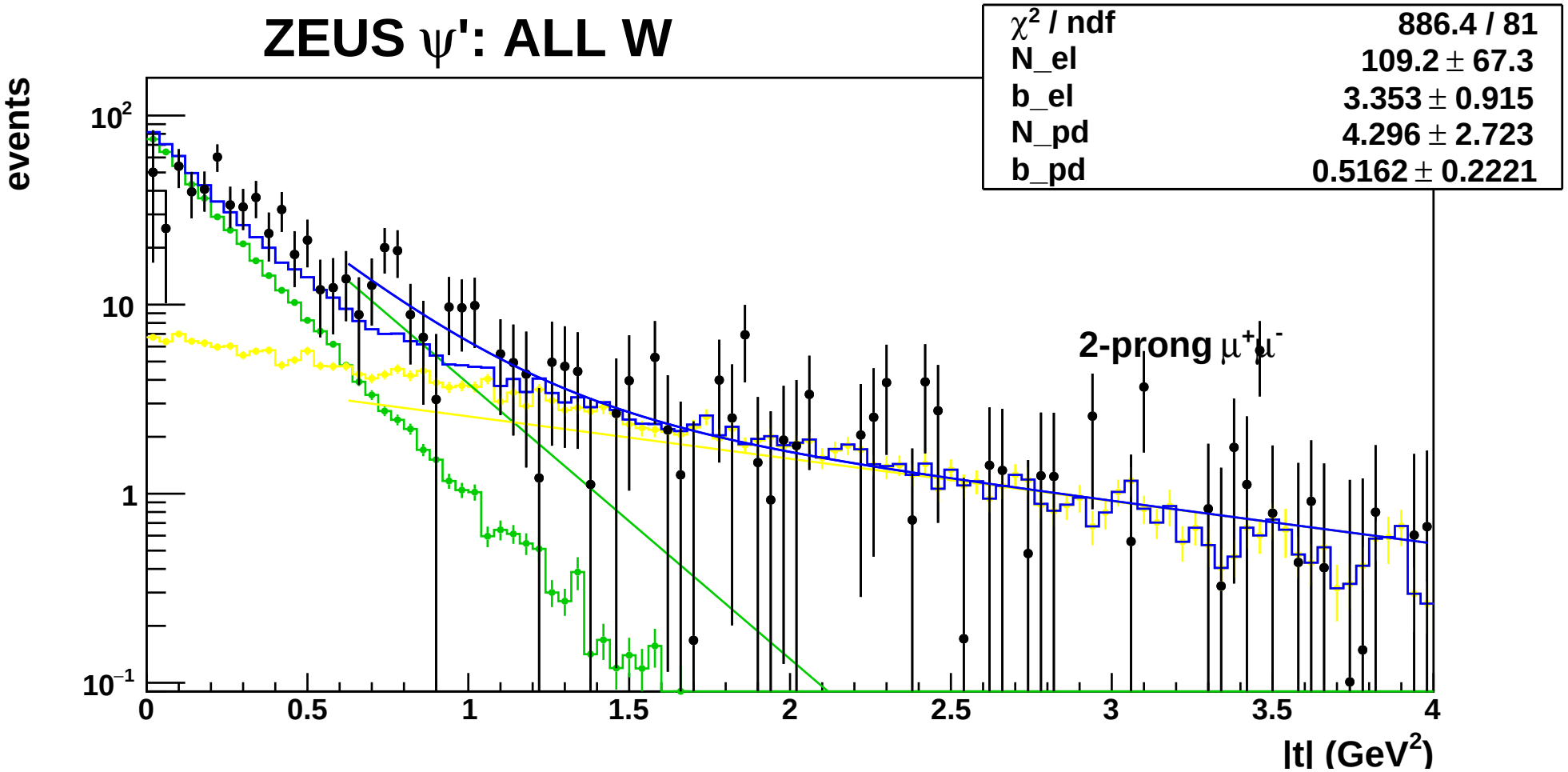
PSI2S mass window: t-distribution (BG subtracted)



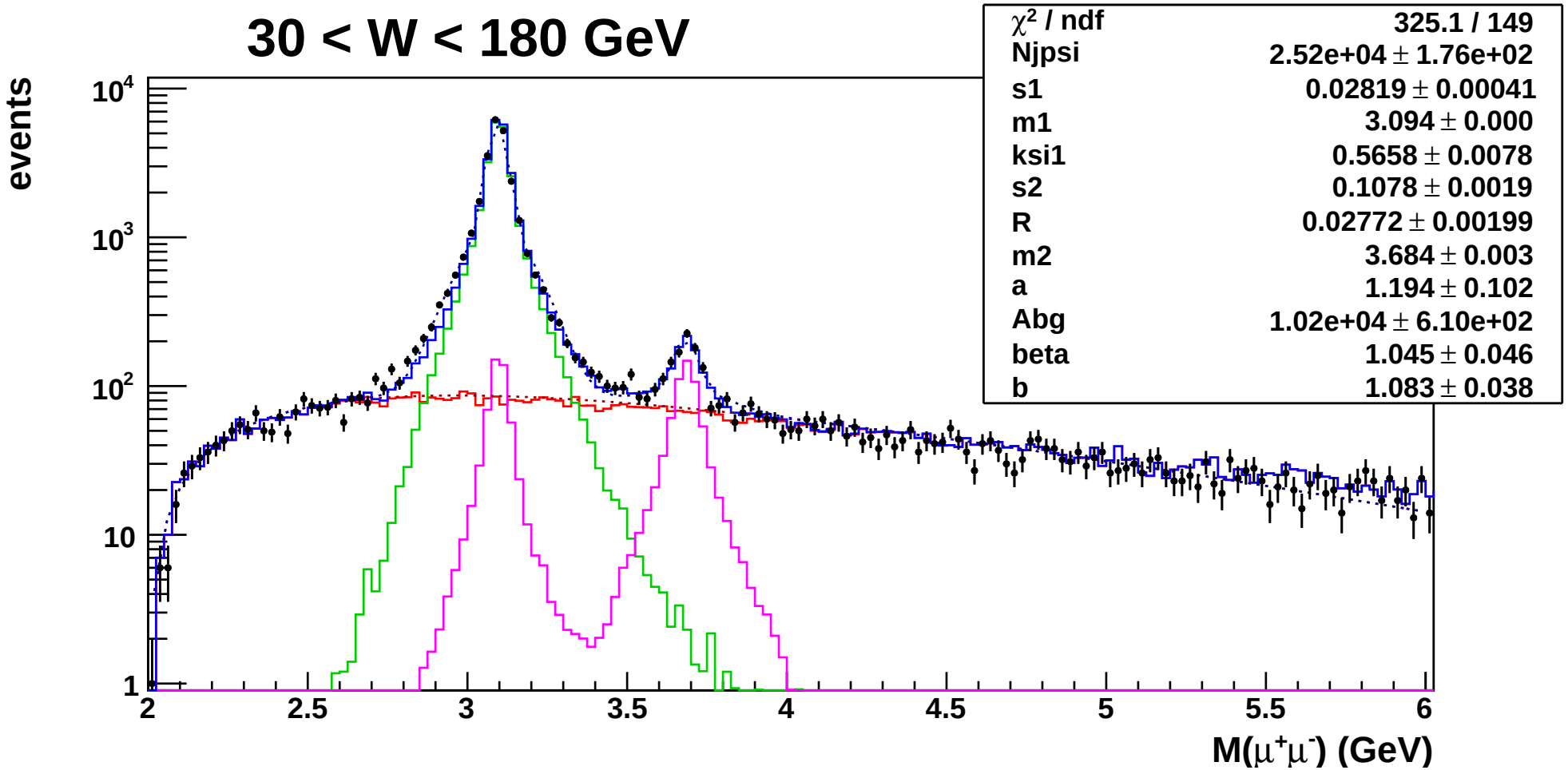
- BH (and JPSI) background subtracted
- non-exponential shape
- deficit of low $|t|$ events (not p.diss enhanced sample !)

PSI2S mass window: t-distribution (different binning)



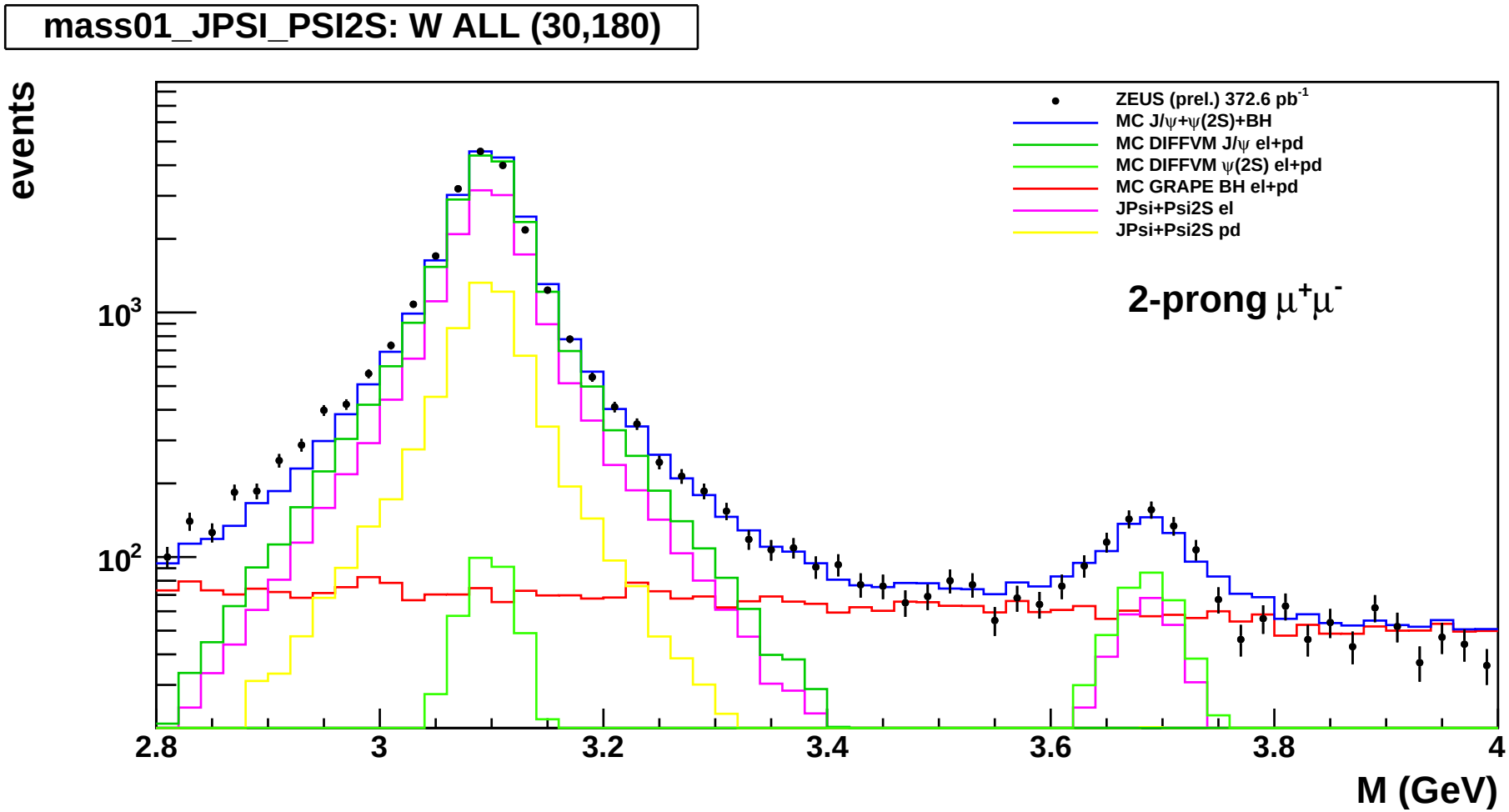
- BH (and JPSI) background subtracted
- non-exponential shape
- deficit of low $|t|$ events (not p.diss enhanced sample !)

Di-muon mass distribution (once again)



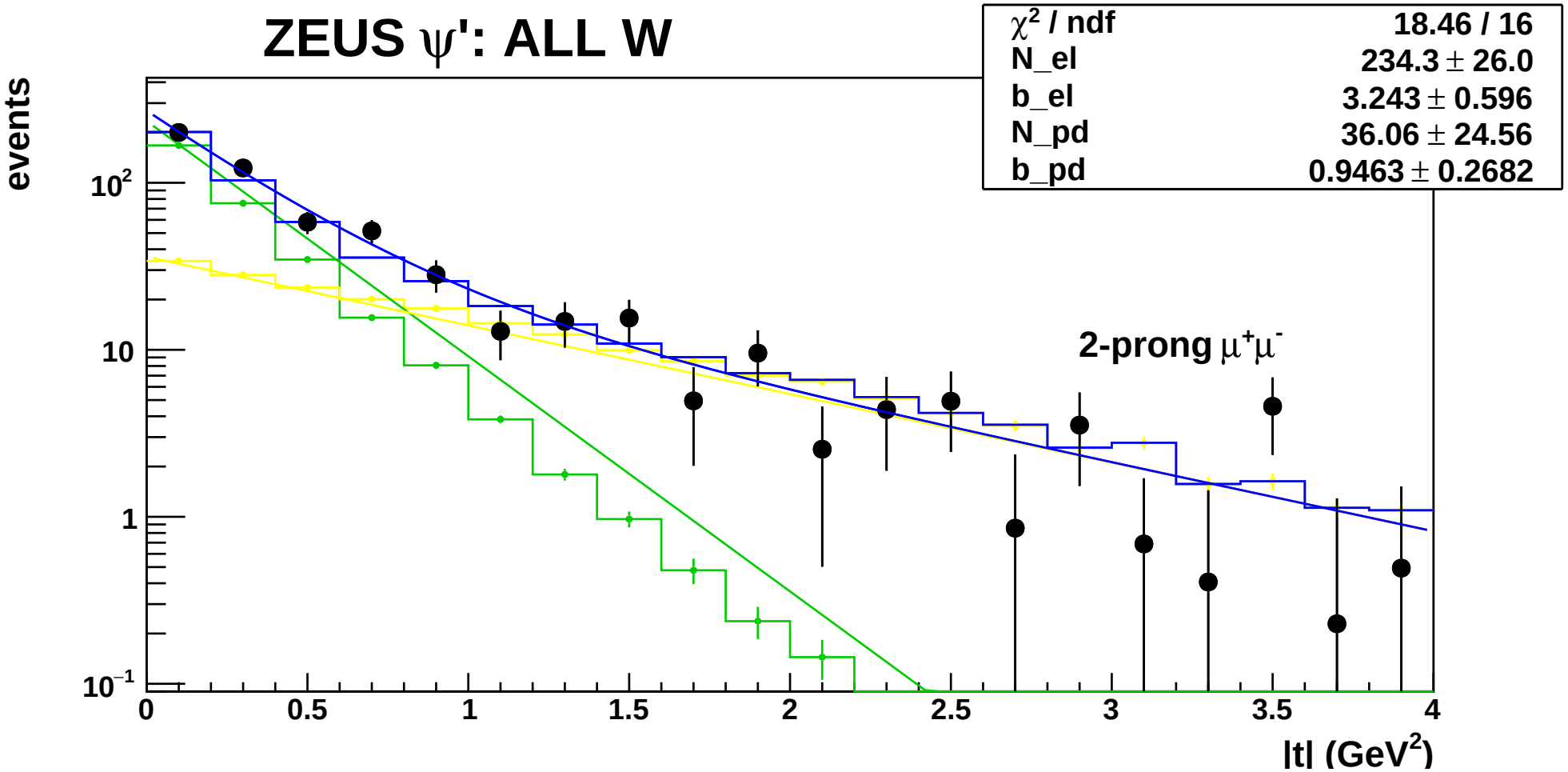
- full phase space, double Gaussian fit to VM peaks
- BG to JPSI: BH and cascade decay of $\psi' \to J/\psi + \pi^+\pi^-$

Di-muon mass distribution (zoom around VM peaks)



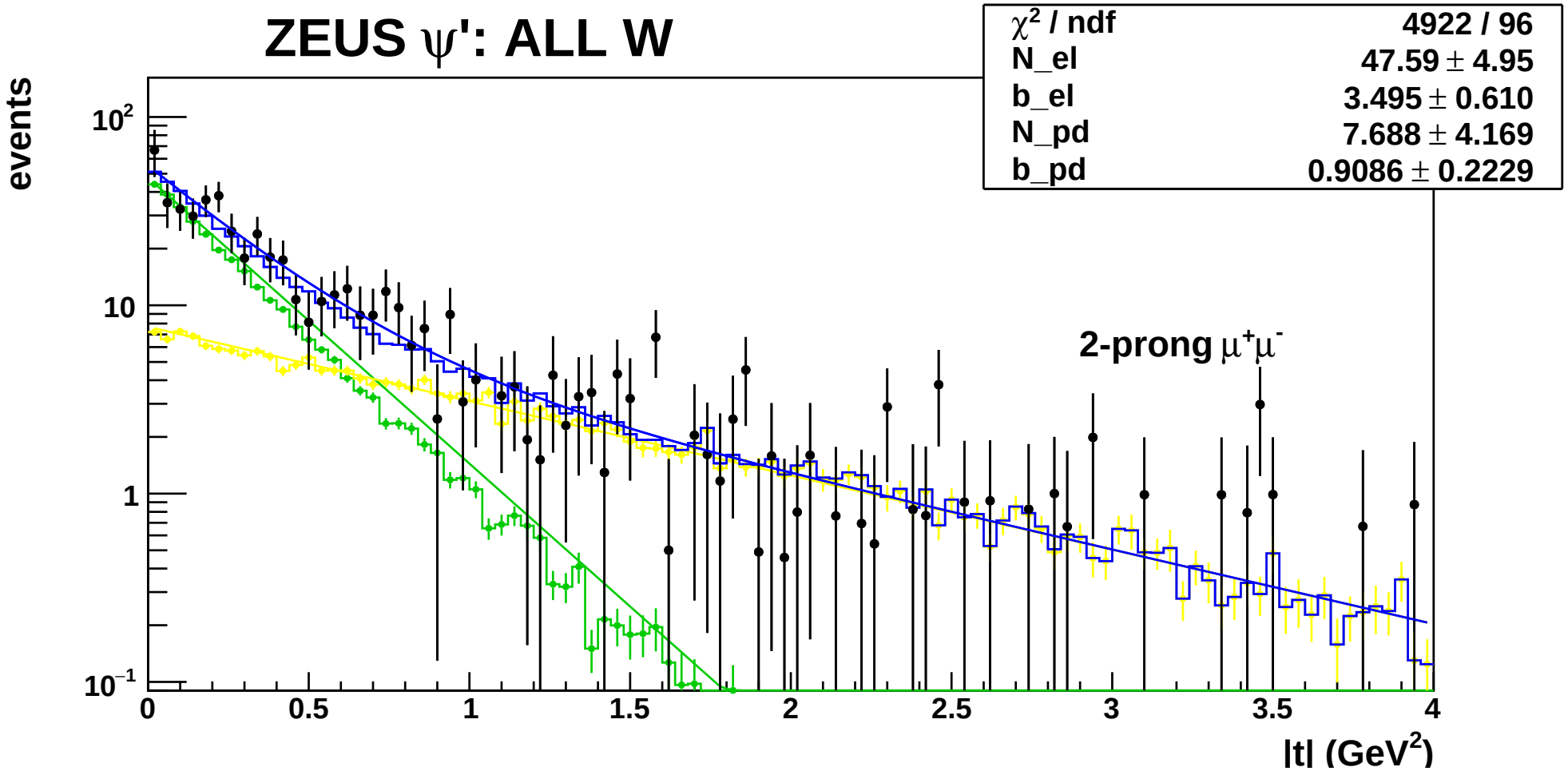
- full phase space, different binning
- strange fluctuation on the falling edge of ψ' peak (?)

PSI2S: $|t|$-distribution, narrow window around ψ' peak



- only events from di-muon mass $(3.6 - 3.75)$ GeV
- $|t|$-spectrum is exponential (!)
- $f_{p.diss} = 0.39$

PSI2S: $|t|$-distribution, narrow window around ψ' peak

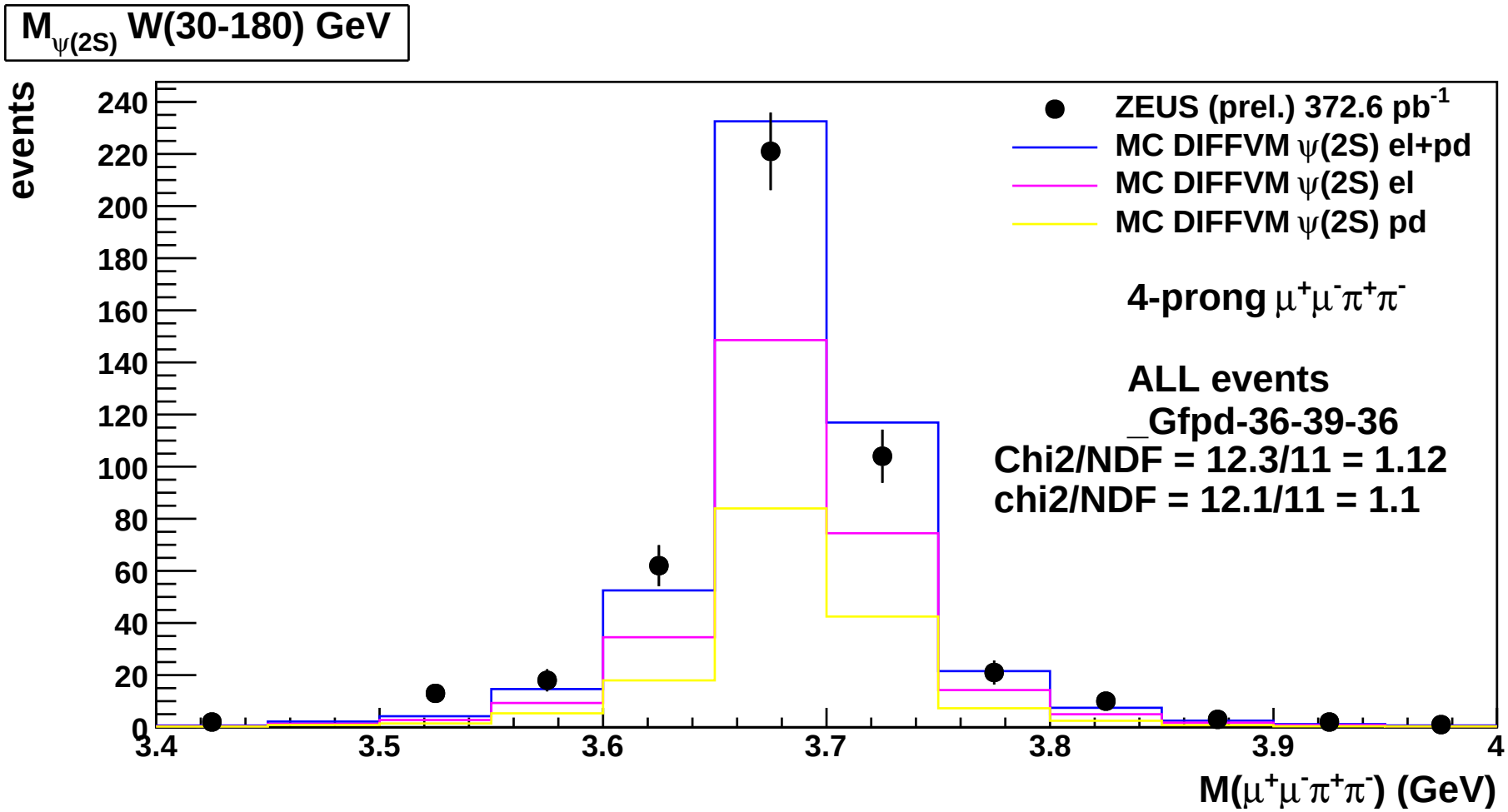


- only events from di-muon mass $(3.6 - 3.75)$ GeV (different binning)
- $|t|$-slopes at generator level (for histogram templates): $b_{el} = 4.2$ GeV^{-2} and $b_{pd} = 1.0$ GeV^{-2}

PSI2S: 4-PRONG

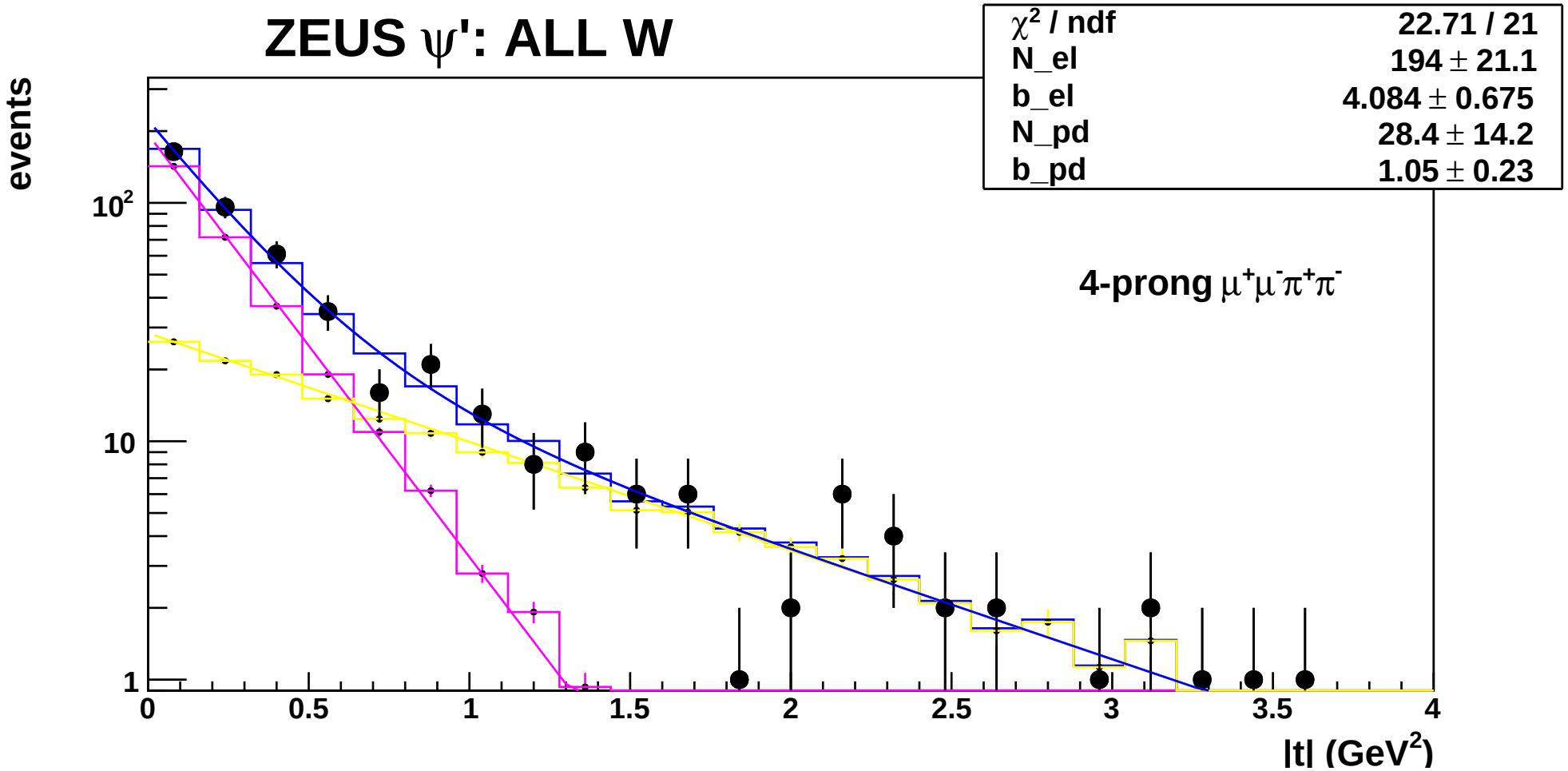
- ψ' : 4-PRONG channel

PSI2S: 4-PRONG: mass distribution



- $M(\mu^+\mu^-\pi^+\pi^-)$
- very clean channel, no BG

PSI2S: 4-PRONG: $|t|$-distribution



- t-spectra are exponential (!)
- fits prefer a bit higher b_{el} comparing to 2-PRONG channel
- $f_{p.diss} = 0.36$

Conclusions

- two components exp() fits provide consistent description of data
- p.diss fractions for JPSI and PSI2S are very similar ($\sim 35 - 40\%$)
  (when using the fitted t-slopes, $|t| < 4.0$ GeV^2)

- to do:
- check the W and t dependence of p.diss fractions (2- and 4-PRONG)
- check the stability of fits:
  (bin size dependence)
  (log-L vs. bin integrated least-squares)
- select final t-slopes, reweight MC
- calculate final acceptance/effic and p.diss fractions
- systematics
- plot theory predictions