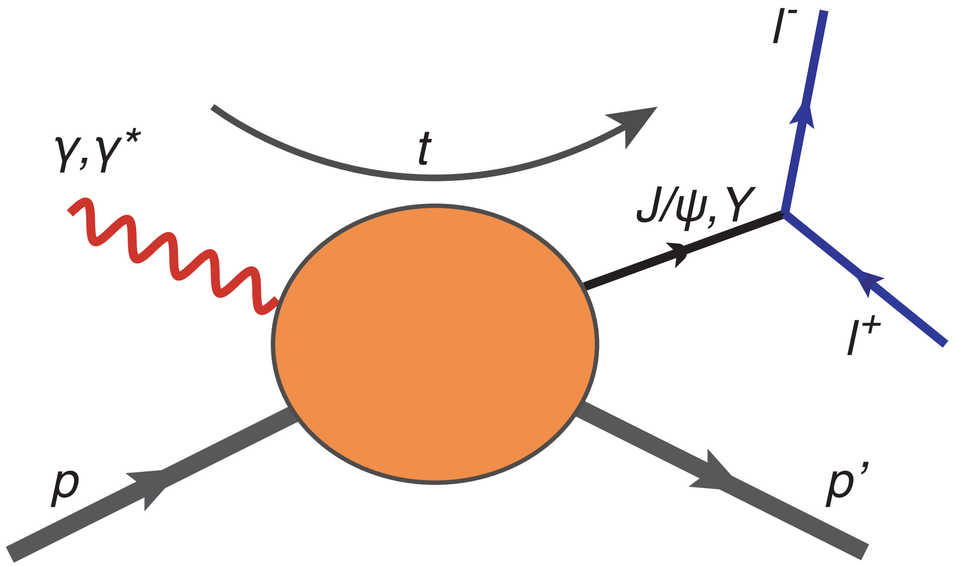
EVALUATION OF THE MATRIX DETECTOR

Argonne NATIONAL LABORATORY

REQUIREMENTS FOR DVMP



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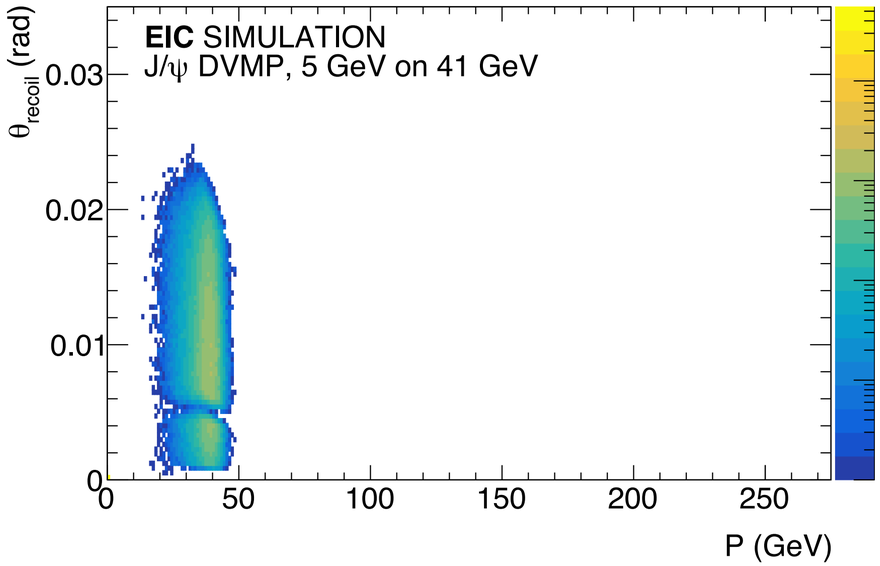
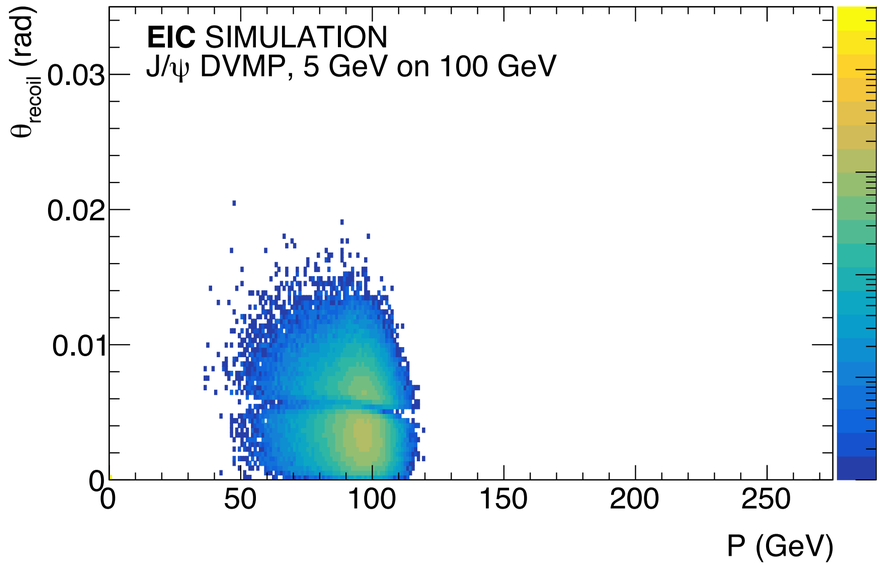
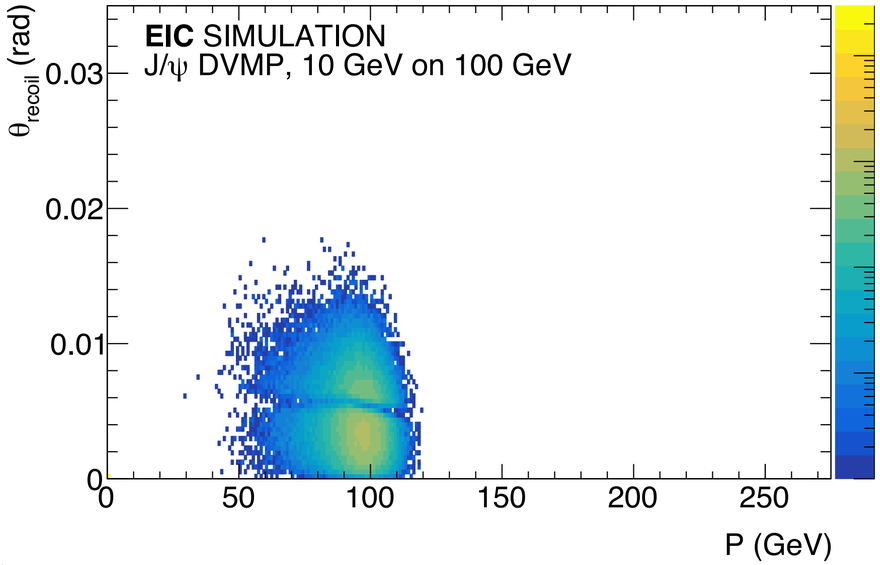
Exclusive WG Meeting
August 31, 2020

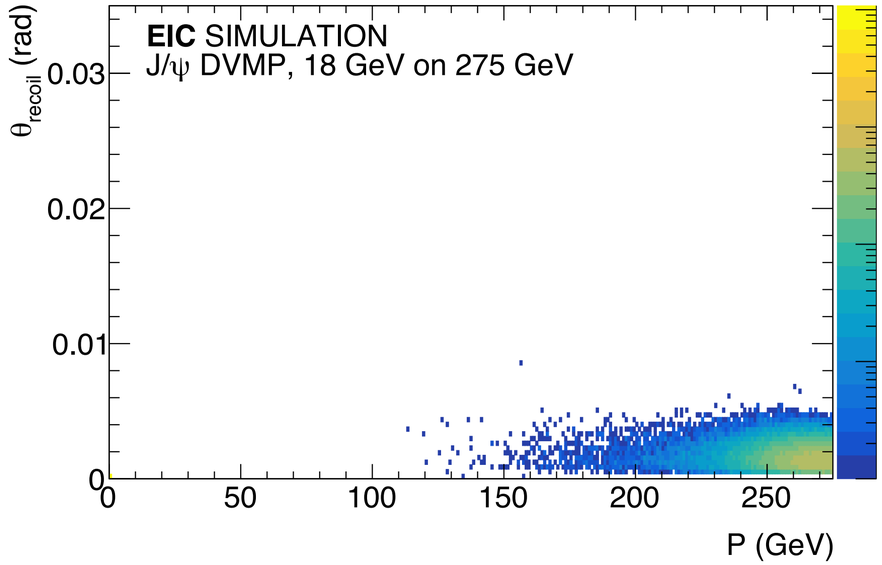
FAR FORWARD DETECTION SYSTEM

Sufficient for *J/ψ* DVMP at all nominal energies



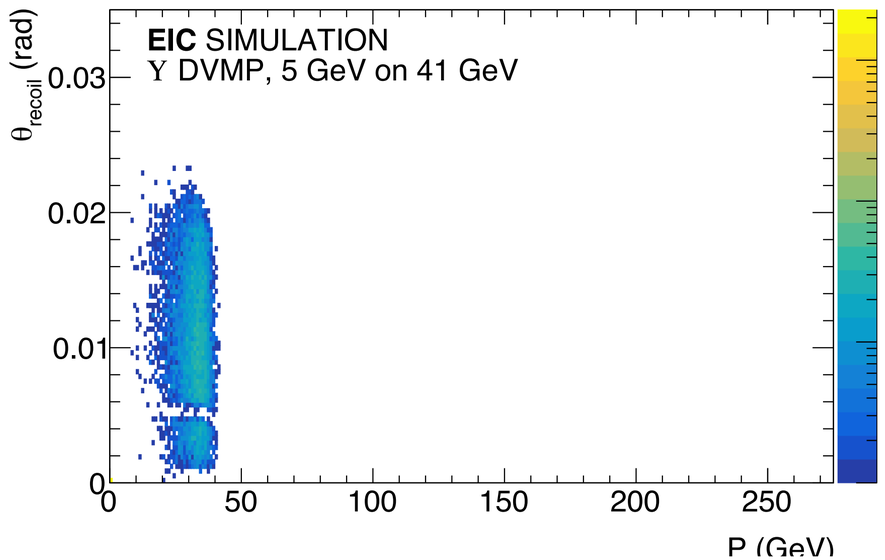


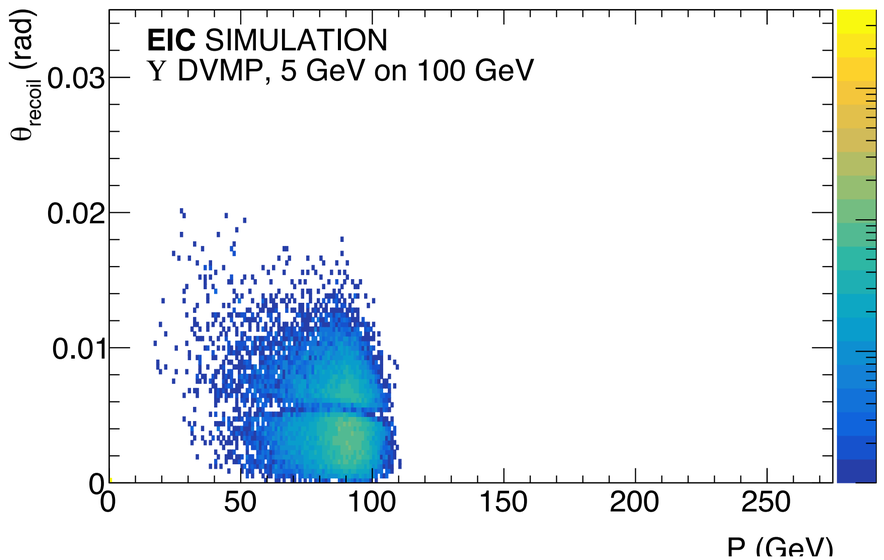


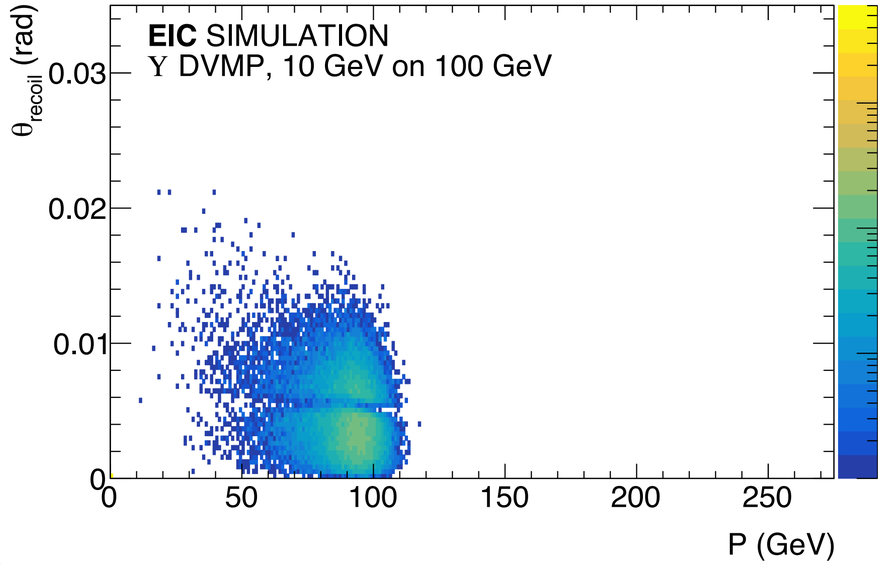


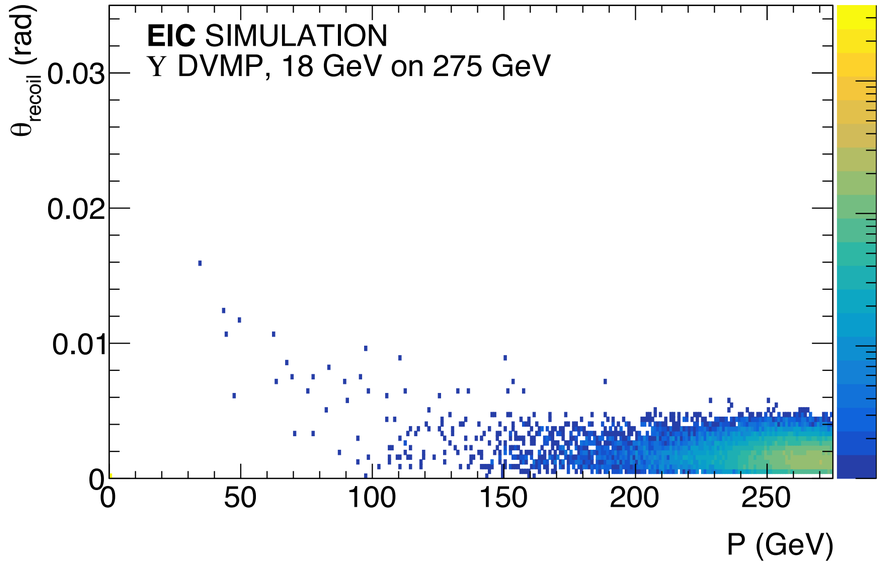
FAR FORWARD DETECTION SYSTEM

Same for *Y* DVMP



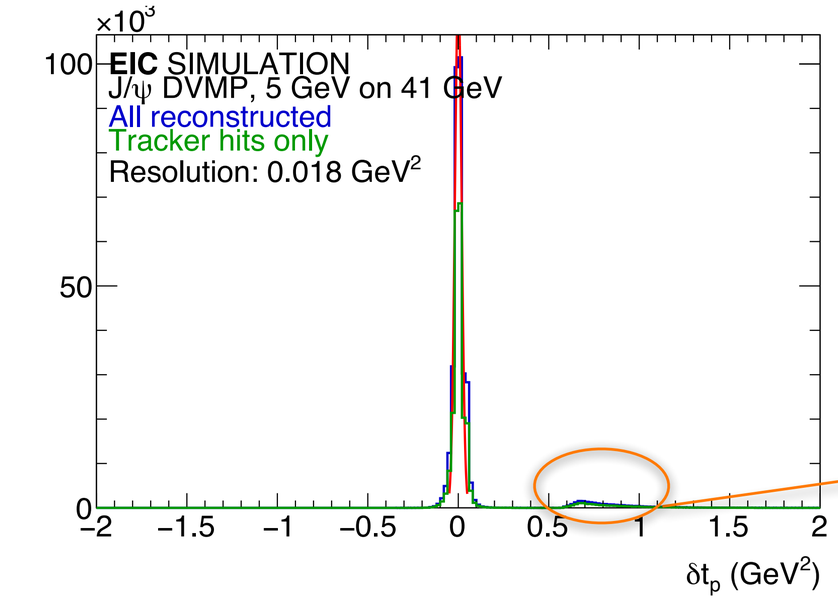


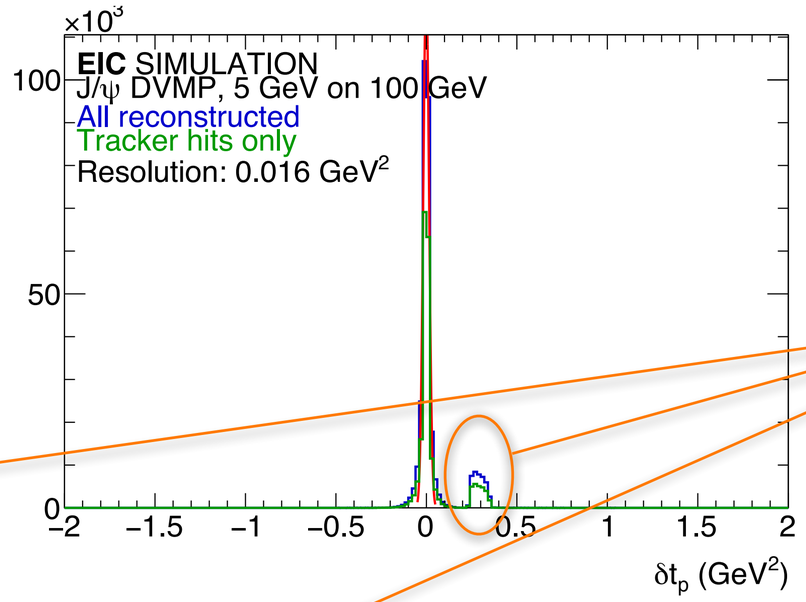


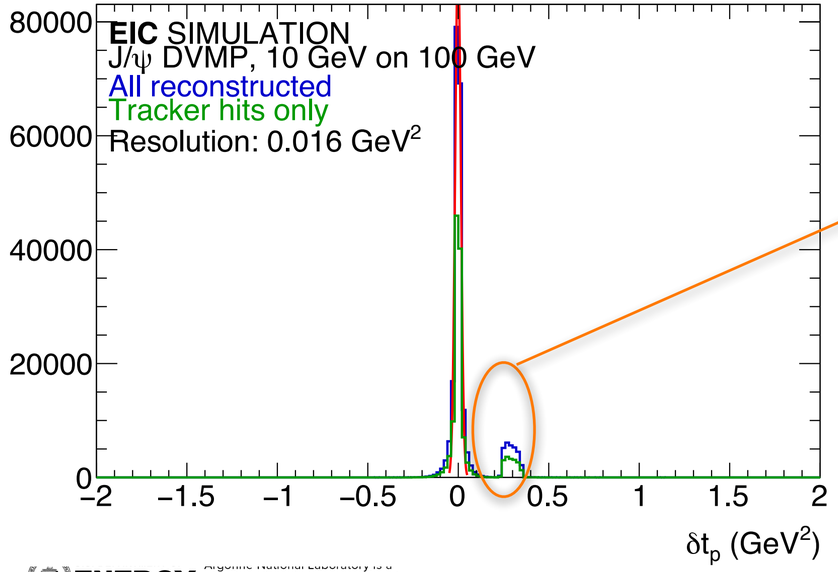


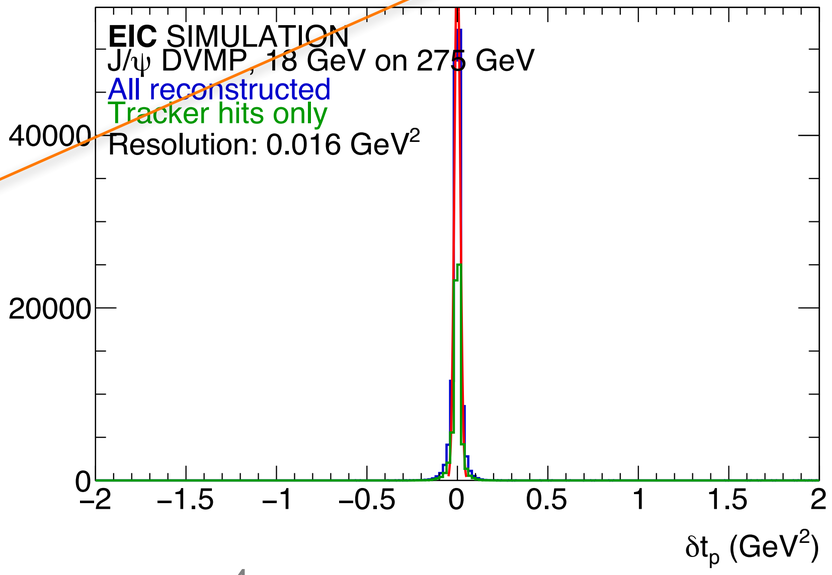
FAR FORWARD DETECTION SYSTEM

Good *t*-resolution using B0 & Roman pot system





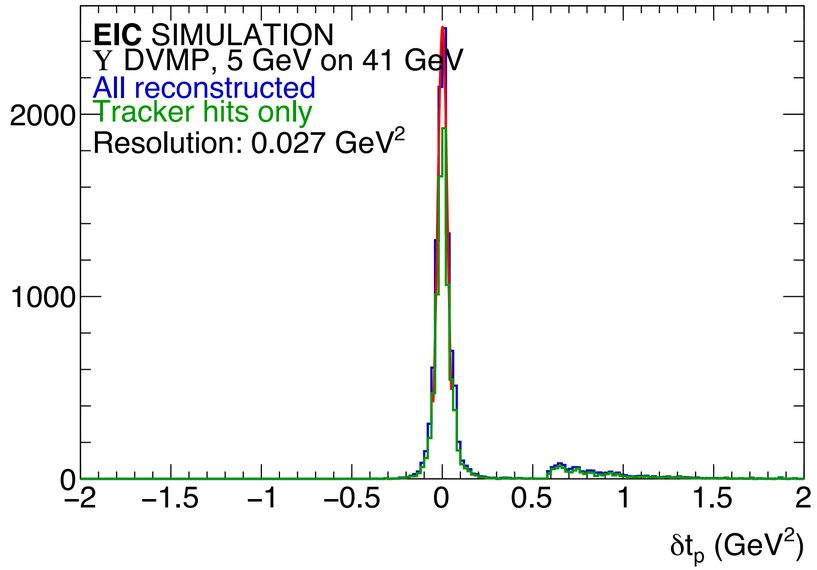


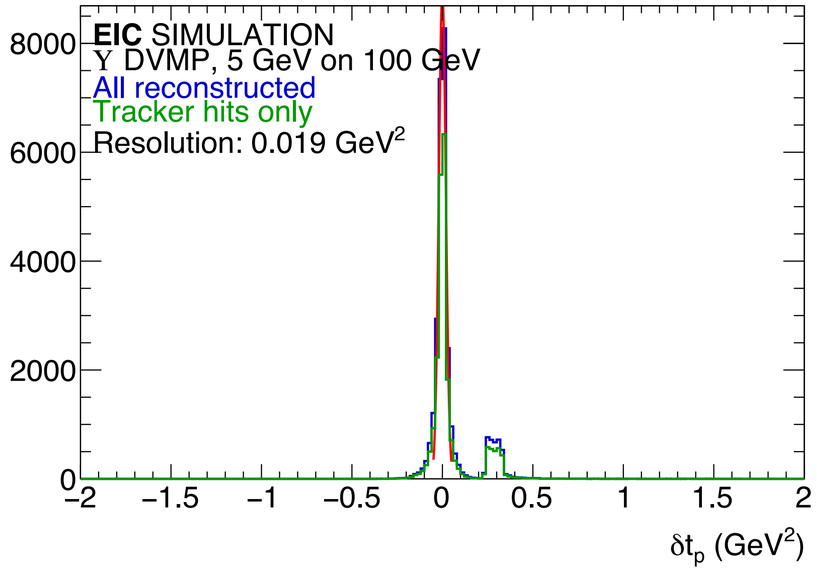


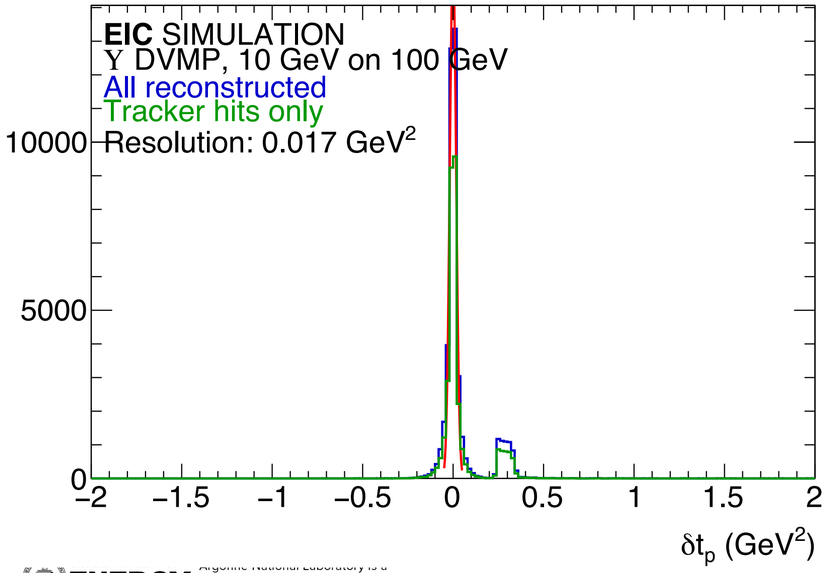
- Possible issue in eicsmear FF detector implementation?
- TODO: track down source of this issue

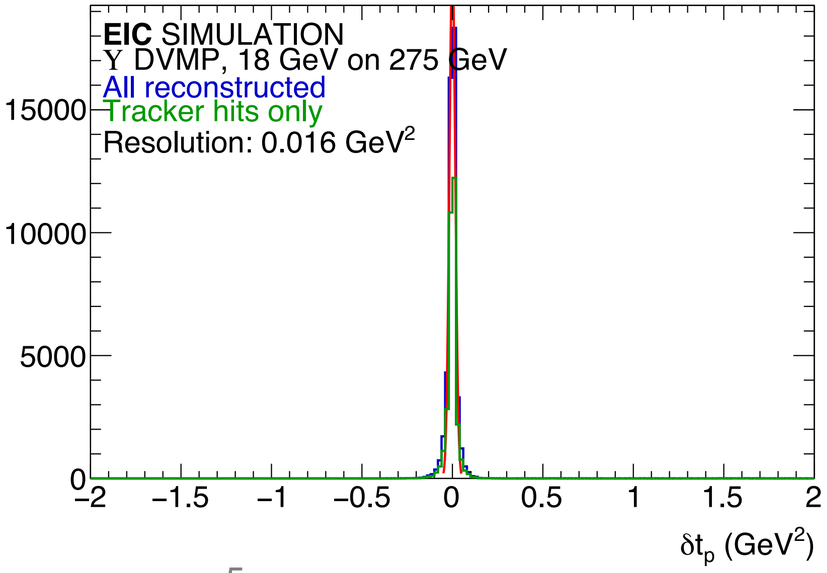
FAR FORWARD DETECTION SYSTEM

Same situation for *Y* production





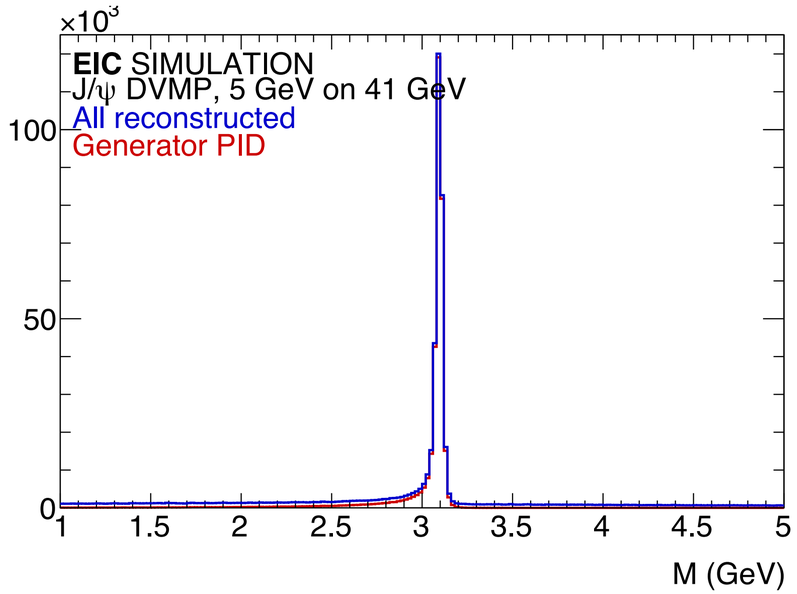


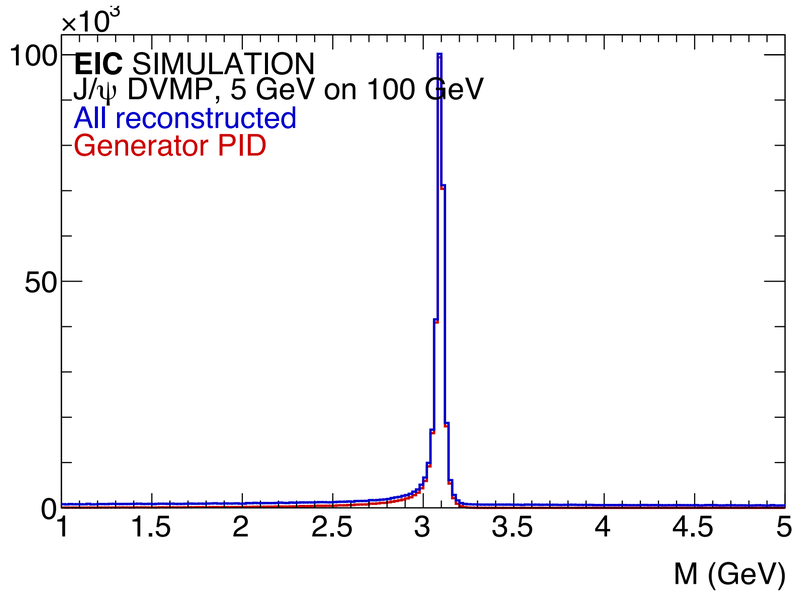


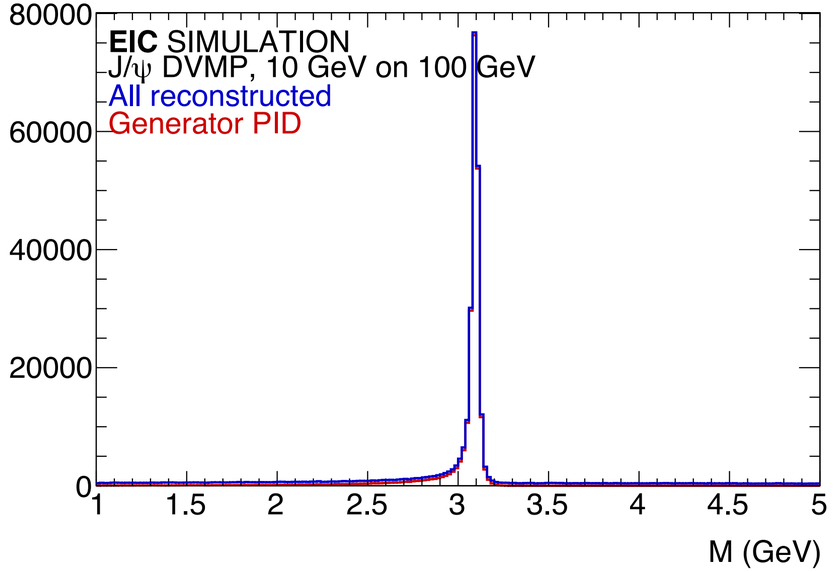
- Possible issue in eicsmear FF detector implementation?
- TODO: track down source of this issue

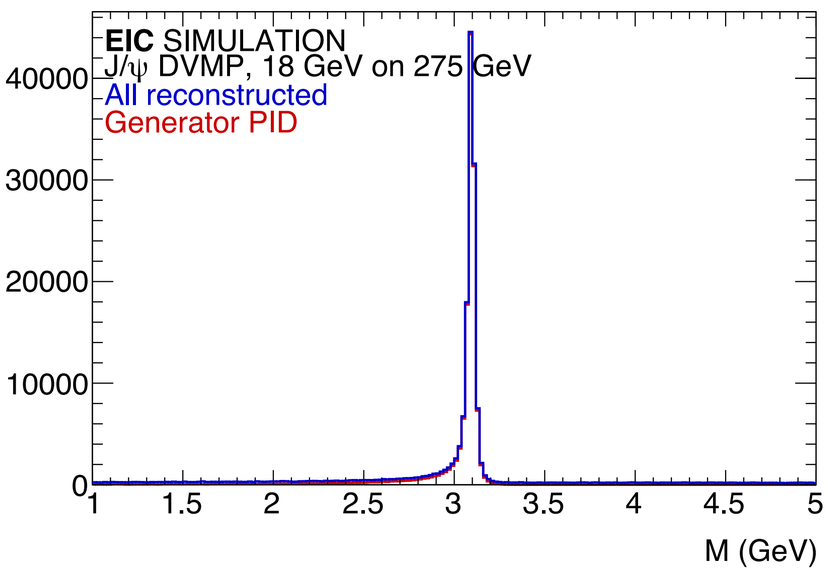
EVENT RECONSTRUCTION AND AMBIGUITY

Effect of scattered/decay electron ambiguity seems minimal for DVMP





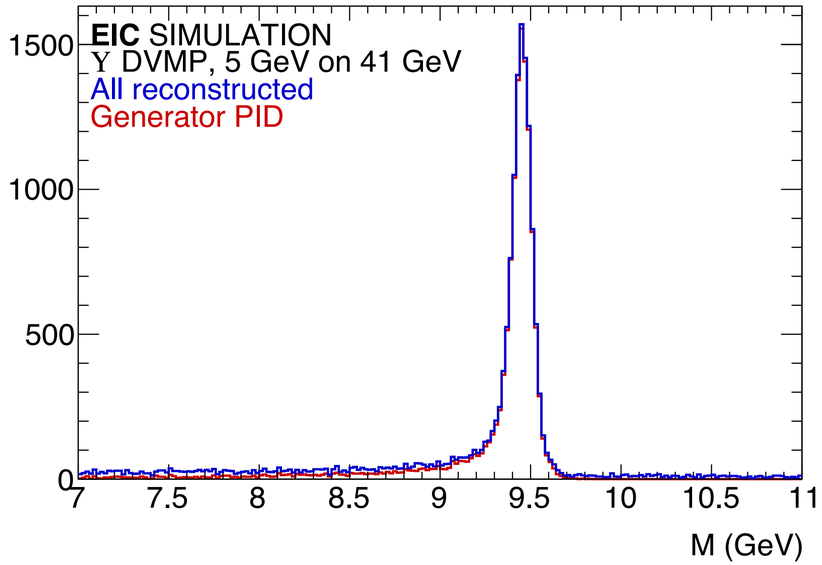


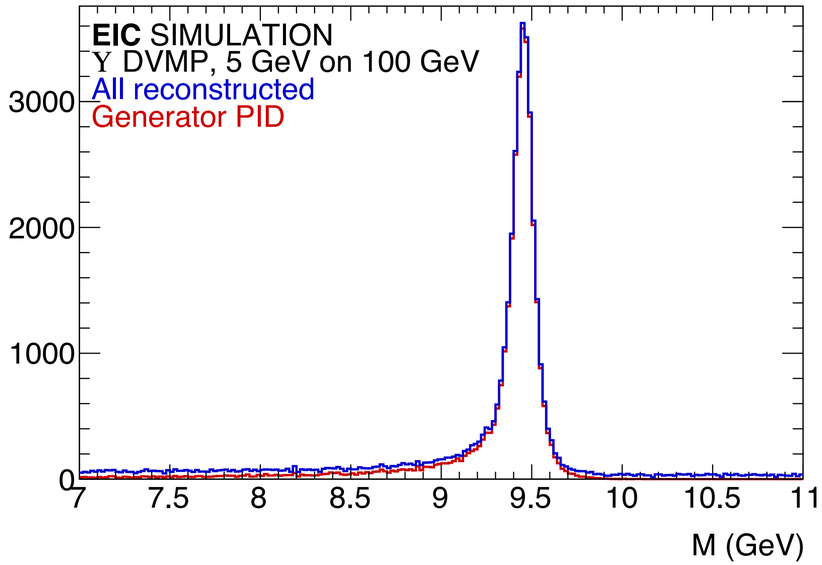


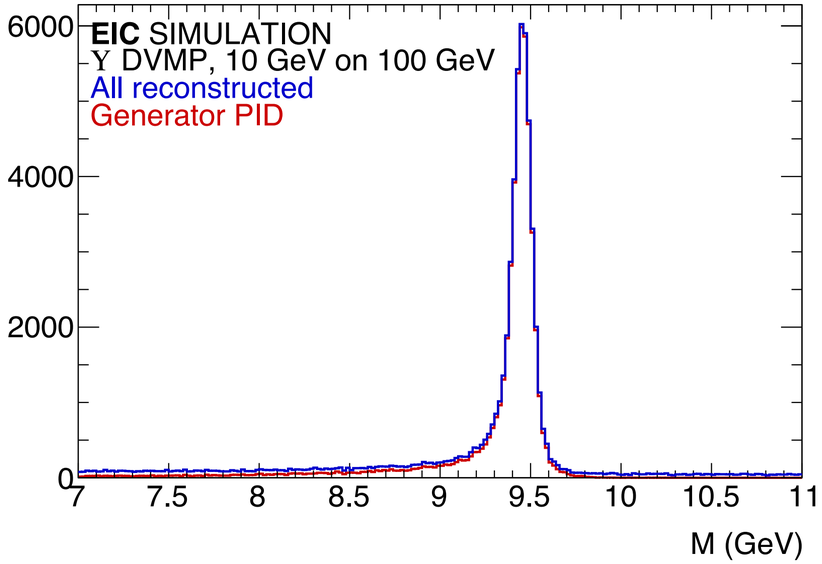
- Momentum resolution in matrix detector sufficient for *J/ψ* invariant mass reconstruction
- Evaluated effects of finite angular resolution
  - theta: 1mrad
  - phi: 4mrad
- Does not noticeably impact any reconstructed quantities
- Note: fast simulation includes radiative effects at the *vertex*, but does not include (potentially significant) effects of radiative effects in the tracker.

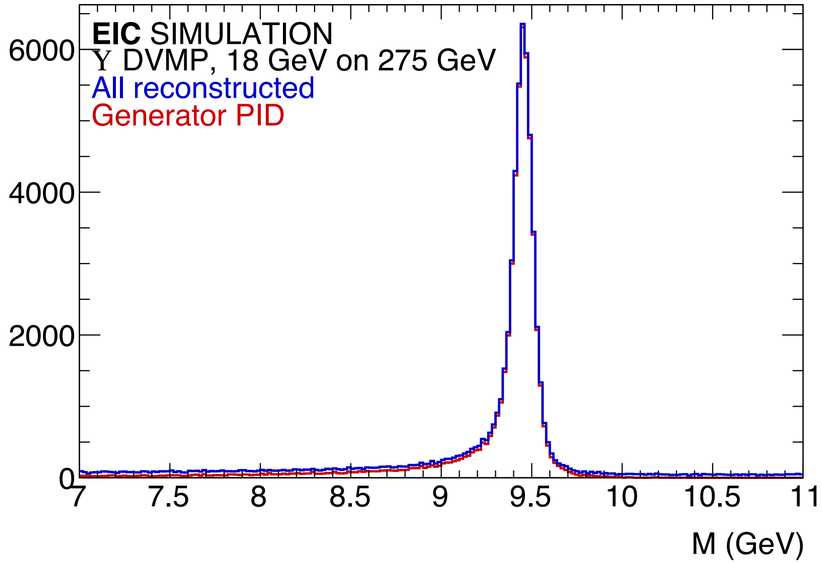
EVENT RECONSTRUCTION AND AMBIGUITY

Invariant mass resolution for *Y* reasonable





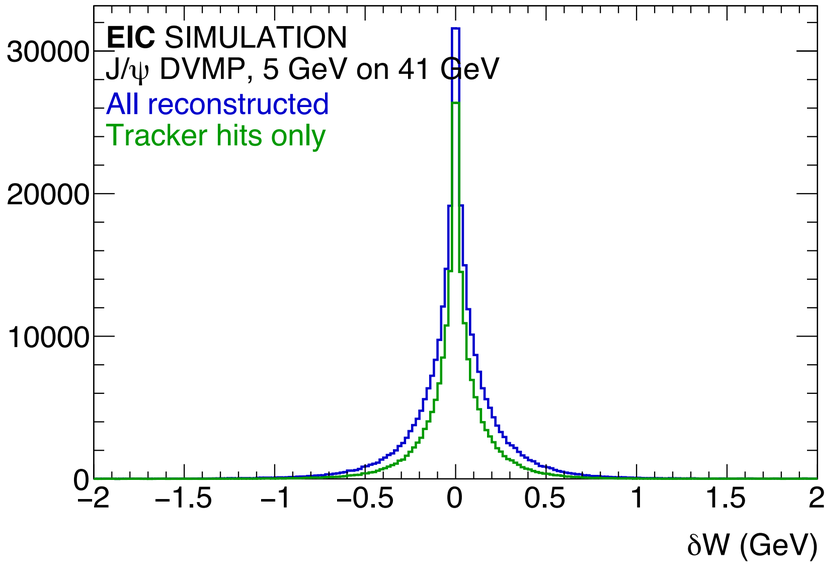


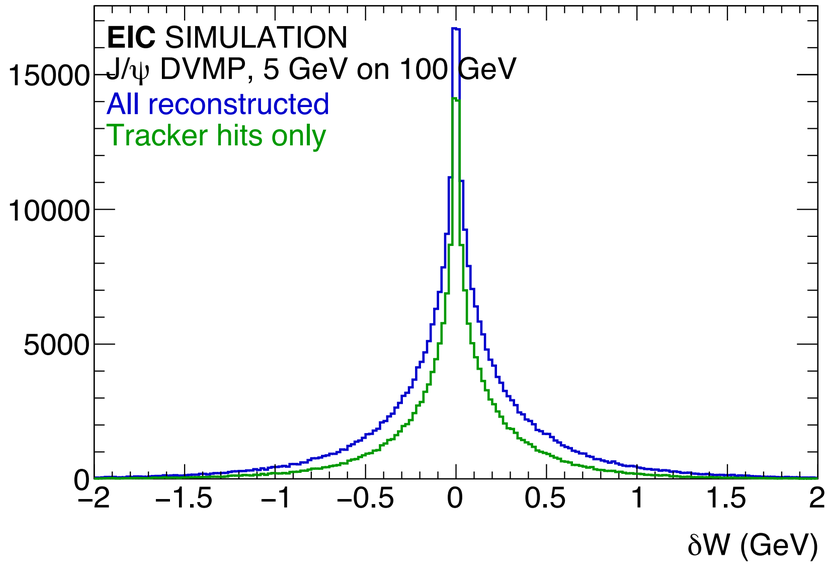


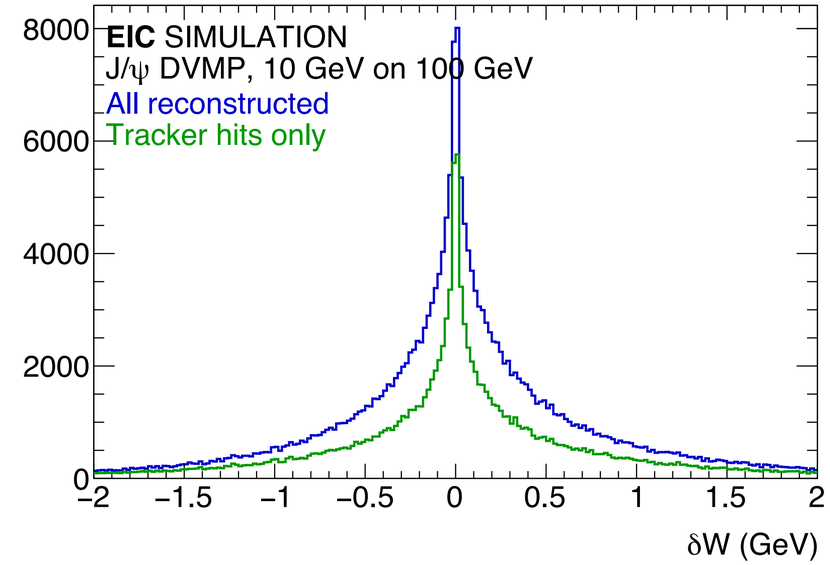
- Invariant mass resolution for *Y* slightly worse than for *J/ψ,* but overall fine.

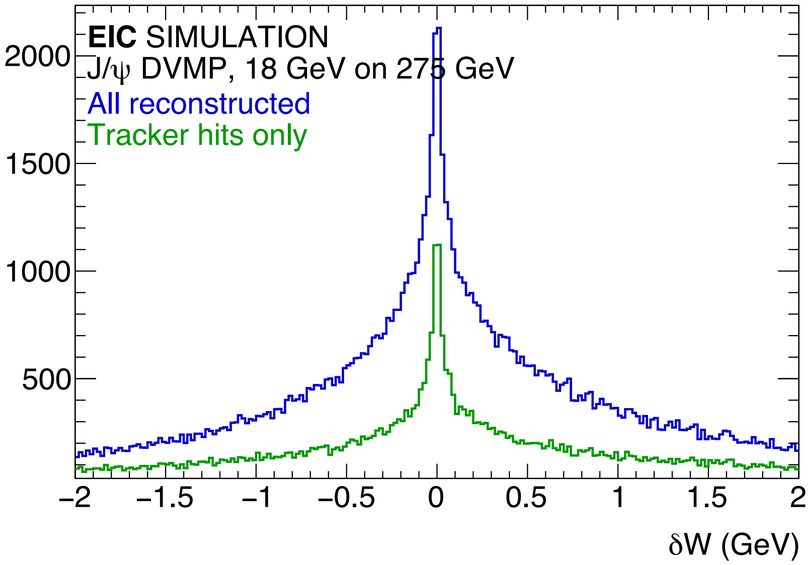
EVENT KINEMATICS

Heavy tails on reconstructed *W* could be problematic?



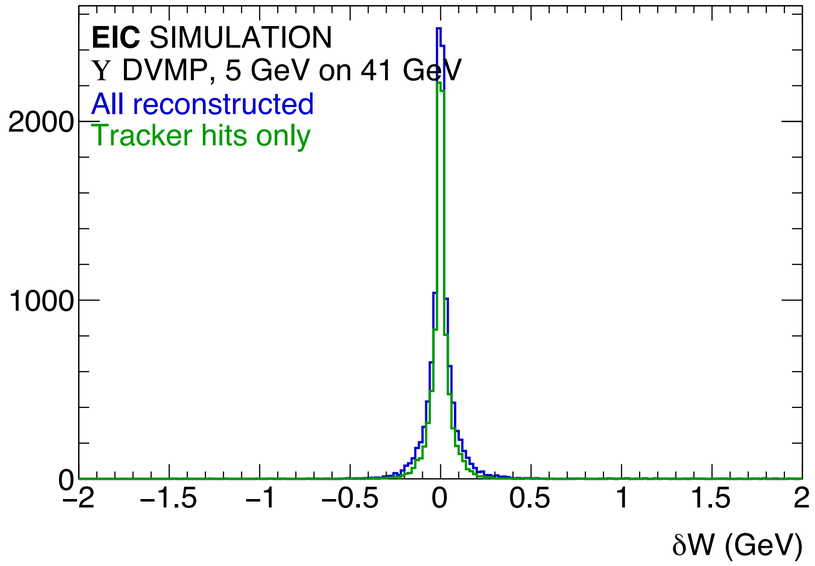


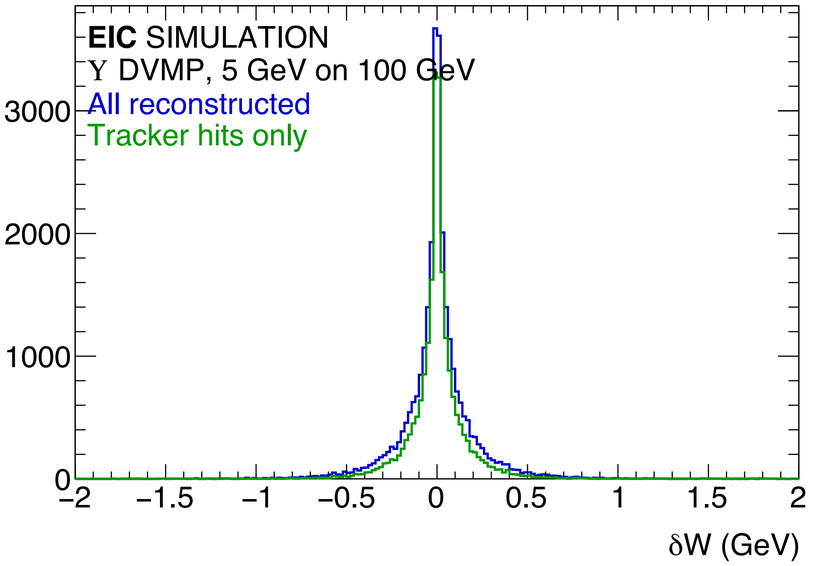


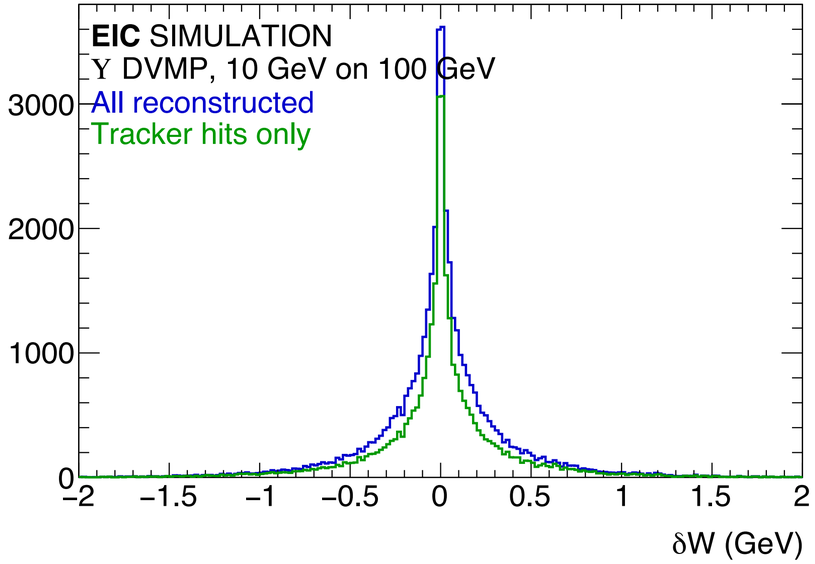


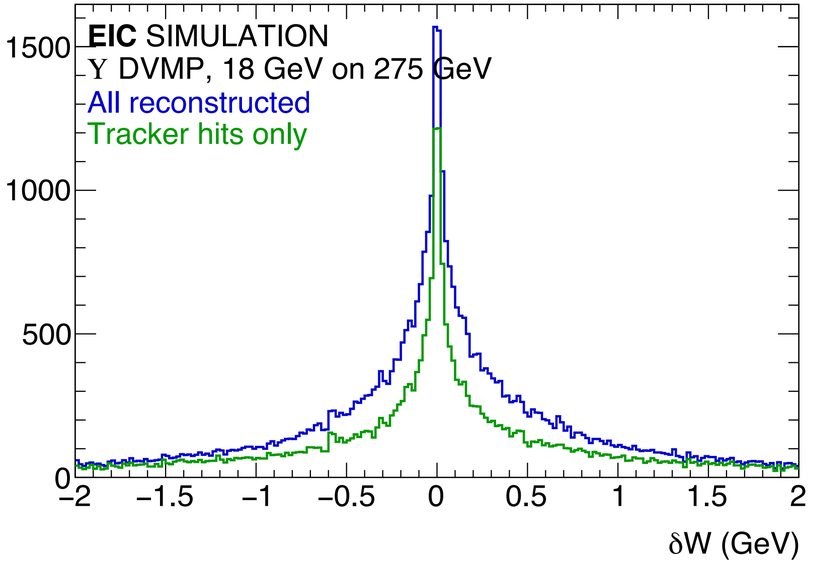
EVENT KINEMATICS

Situation similar (slightly better maybe?) for *Y* kinematics



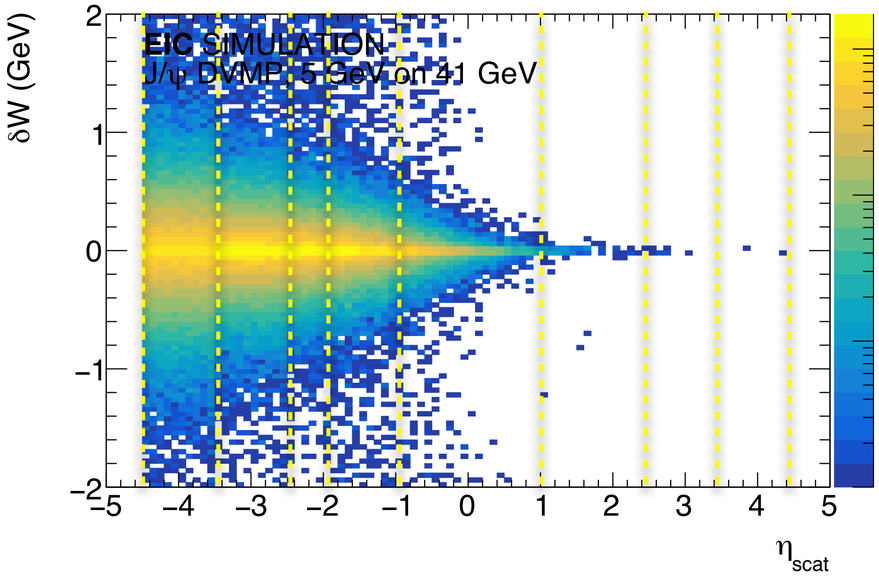


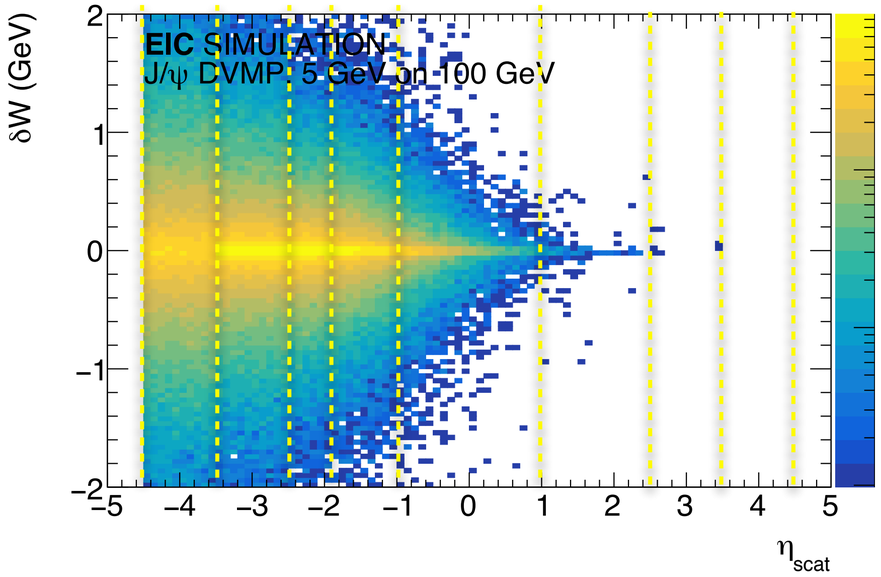


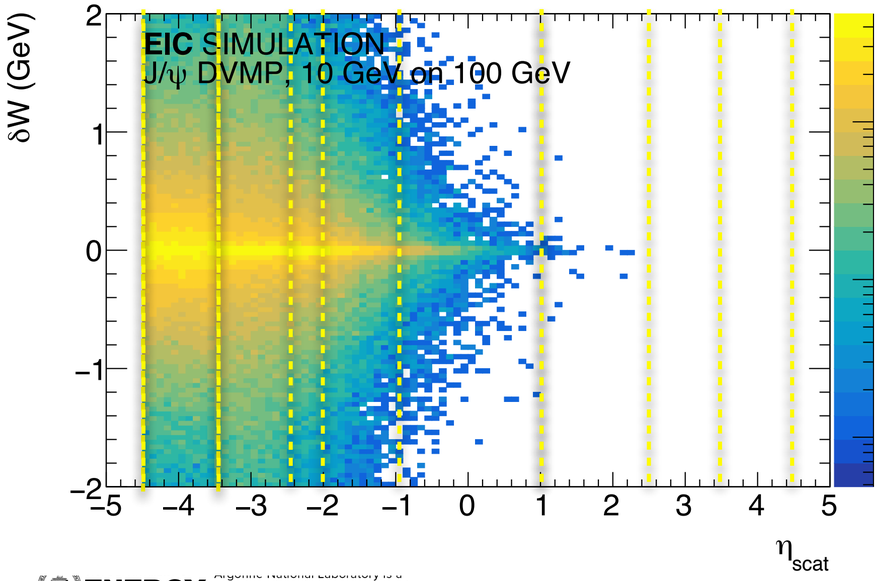


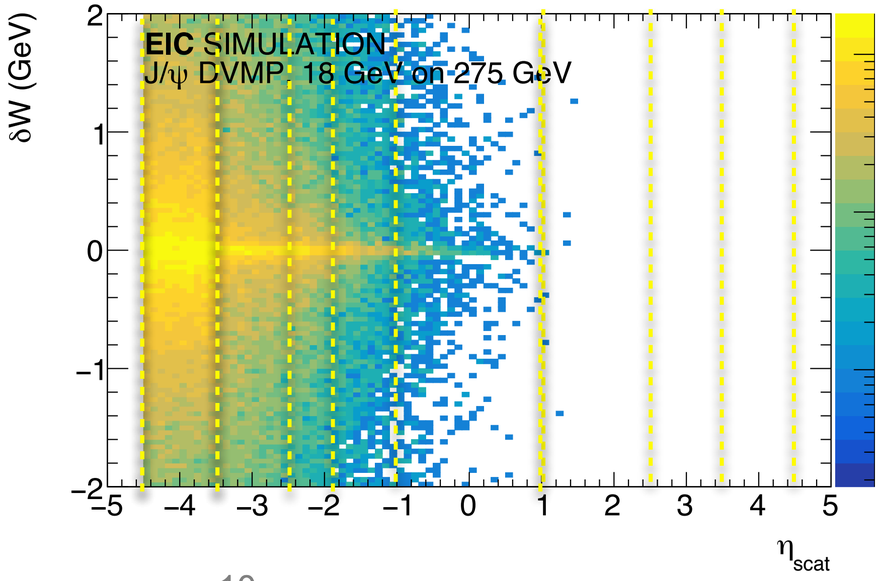
UNDERSTANDING THE W RESOLUTION

W resolution versus pseudo rapidity of the scattered lepton





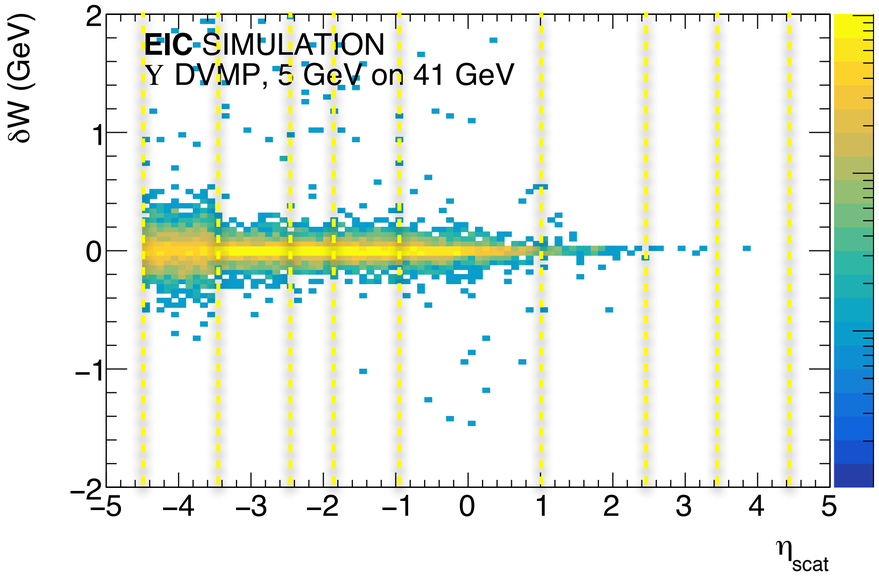


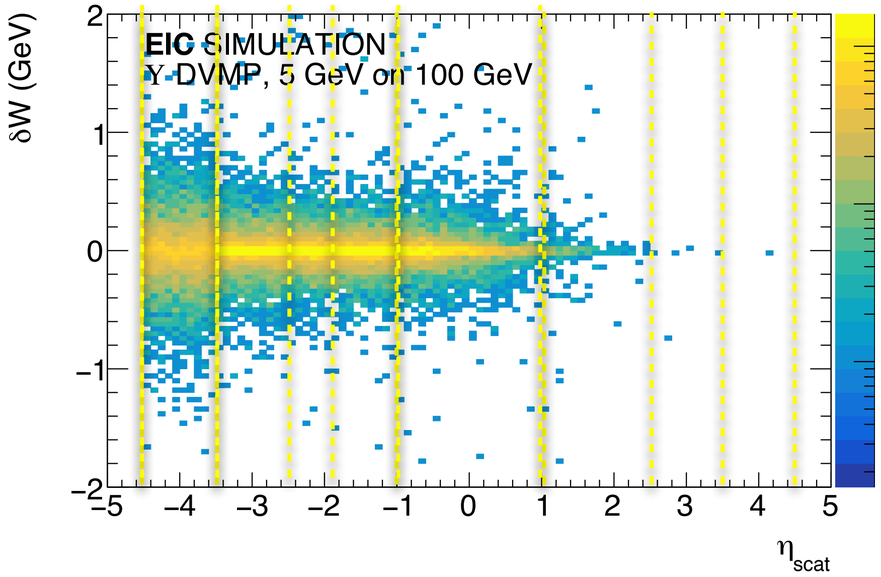


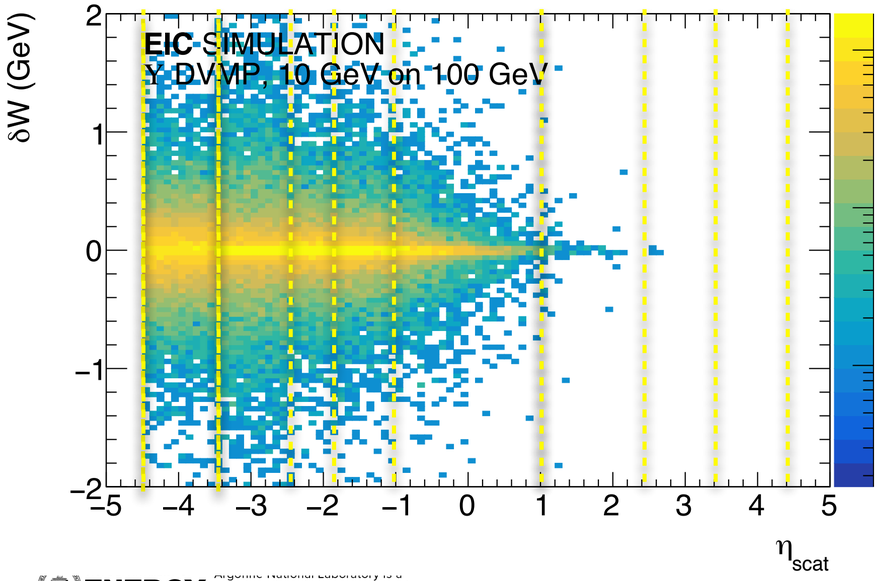
- η < -3.5 region (where we only have ECAL) not really usable to get a precise *W* spectrum
- -1 < η < -3.5 (backward region) also has very heavy tails.
- *This could be problematic for physics in certain kinematic areas.*

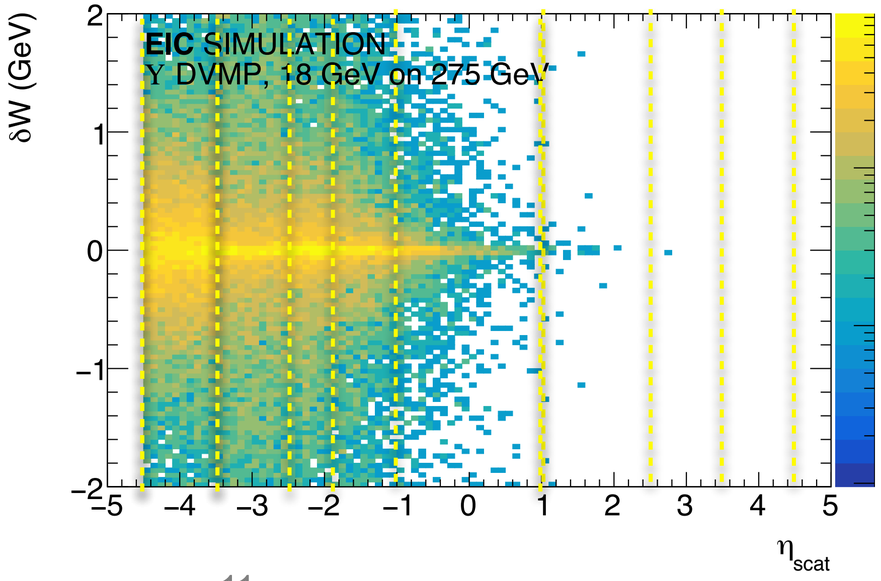
UNDERSTANDING THE W RESOLUTION

Situation seems better for *Y*. This could imply a *W (or y)*-dependence





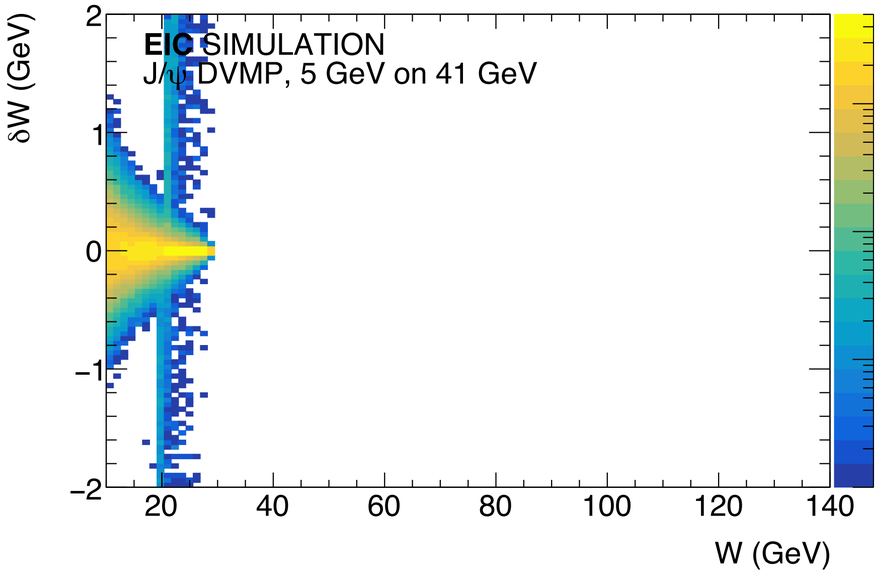


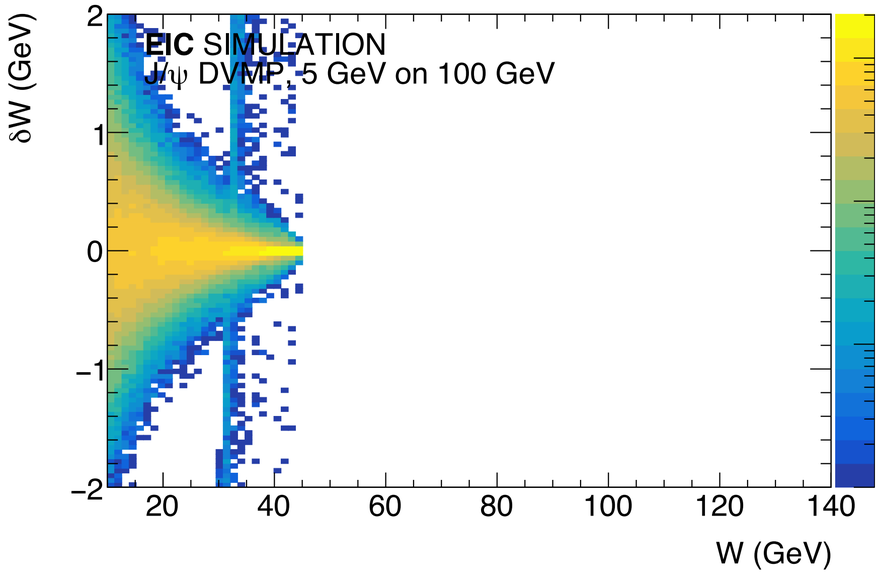


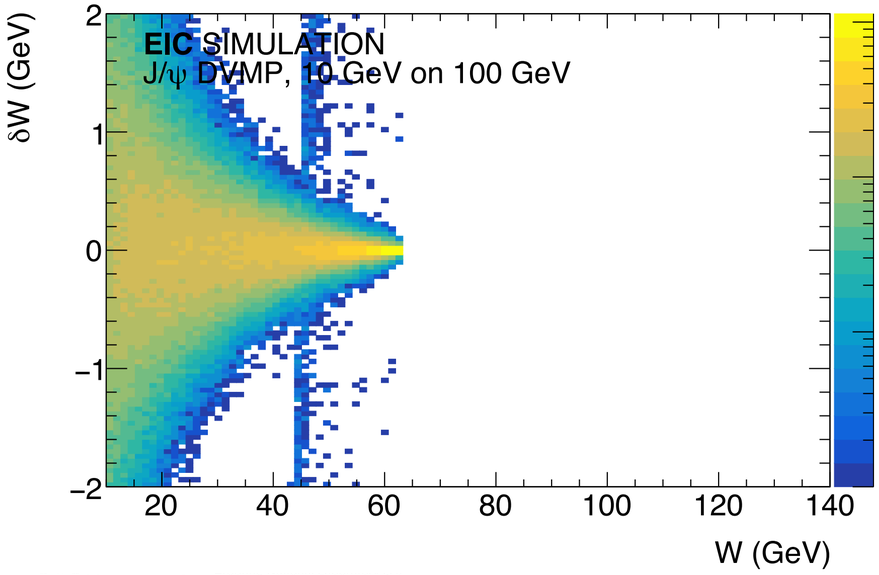
- η < -3.5 region (where we only have ECAL) looks actually usable with the low-energy setting
- -1 < η < -3.5 (backward region) looks fine for the two lower-energy settings.
- The only kinematic difference between *J/ψ* and *Y* production is the higher threshold, meaning *Y* sample sits at higher average *W*

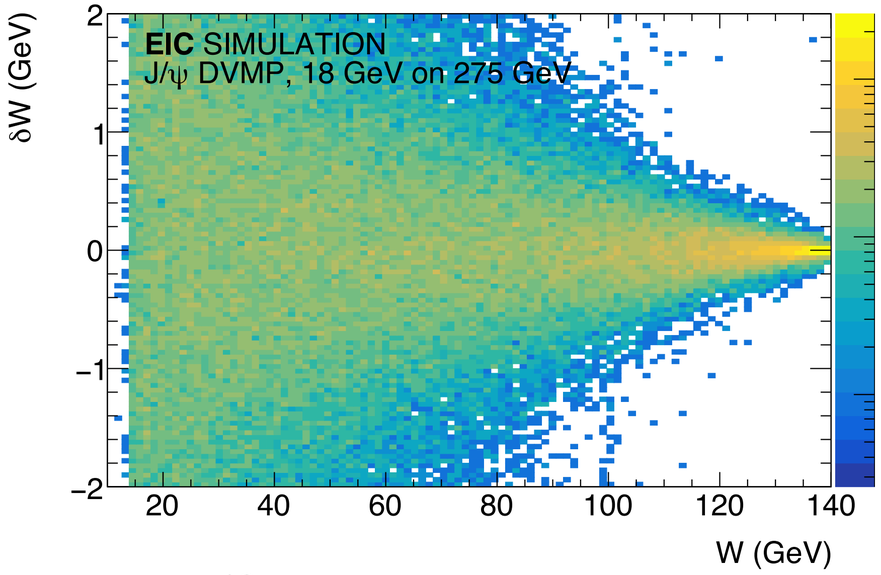
IMPACT OF THE W RESOLUTION

Let's look at the *W* resolution versus *W*





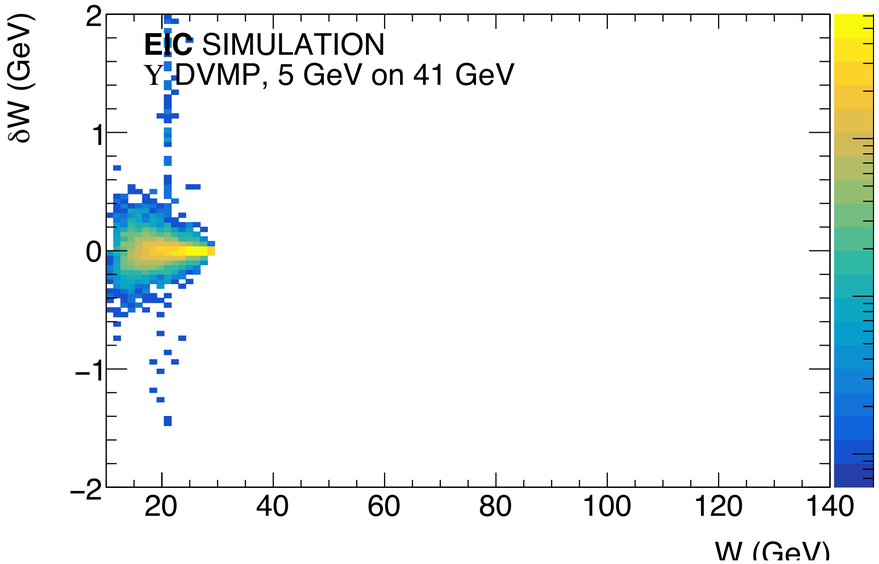


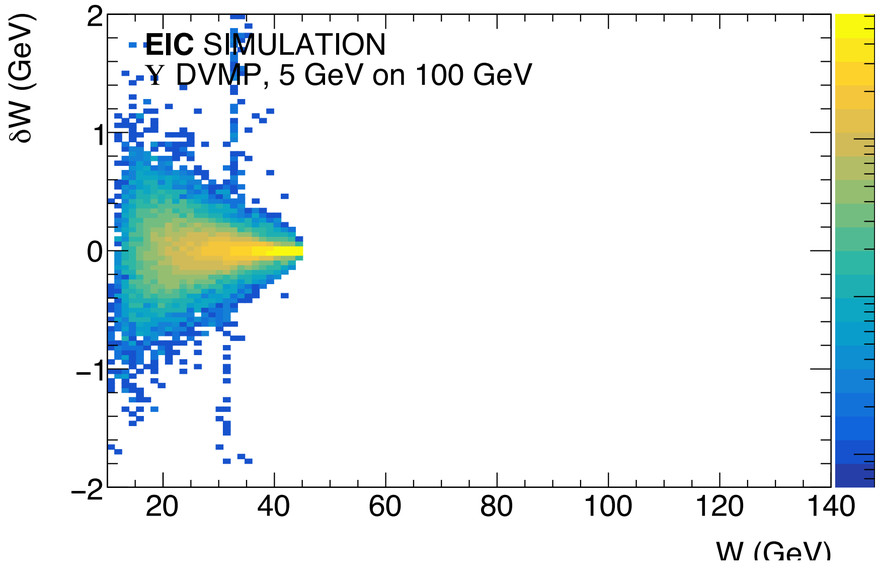


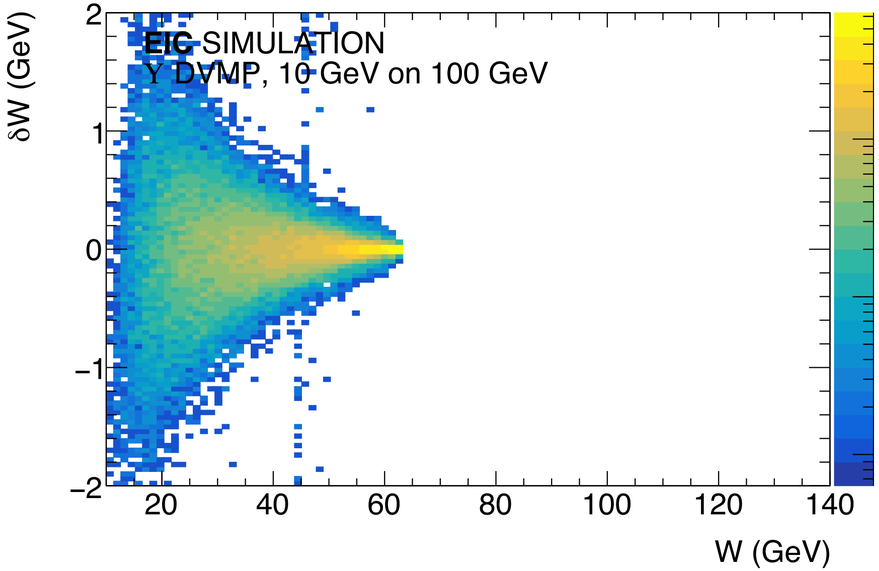
- As expected, the *W* resolution gets much worse at lower *W*.
- With the current setup we can only reliably measure *W* in a narrow range near the maximum energy
- This could definitely be problematic for *Y* near threshold…

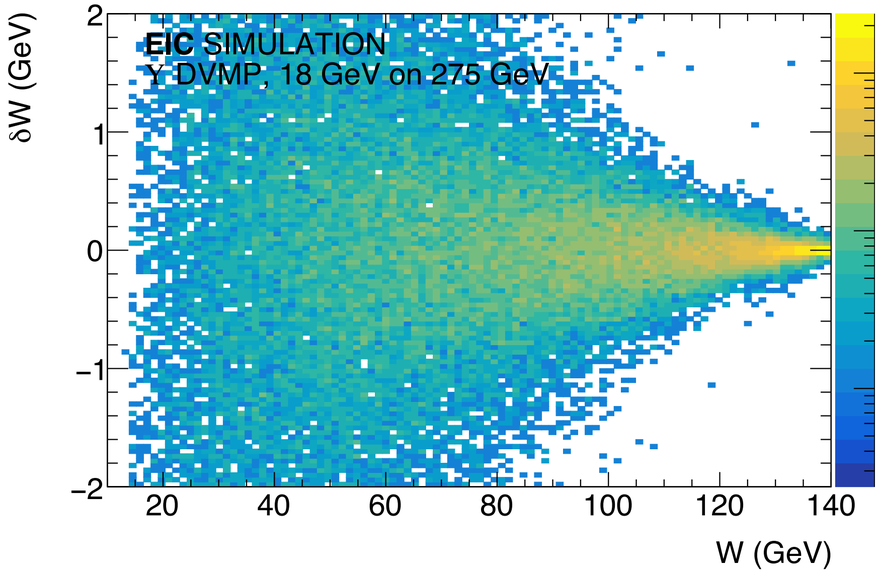
IMPACT OF THE W RESOLUTION

W-resolution versus *W* for near-threshold *Y* production





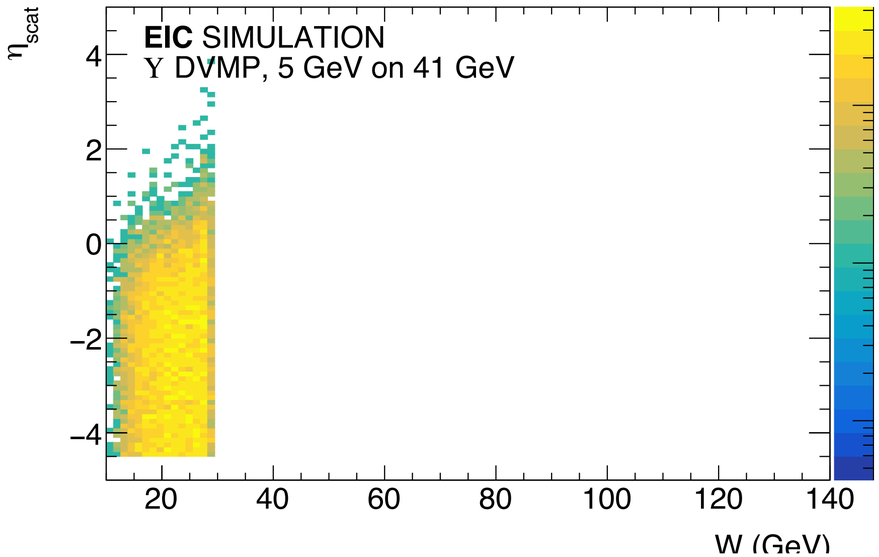


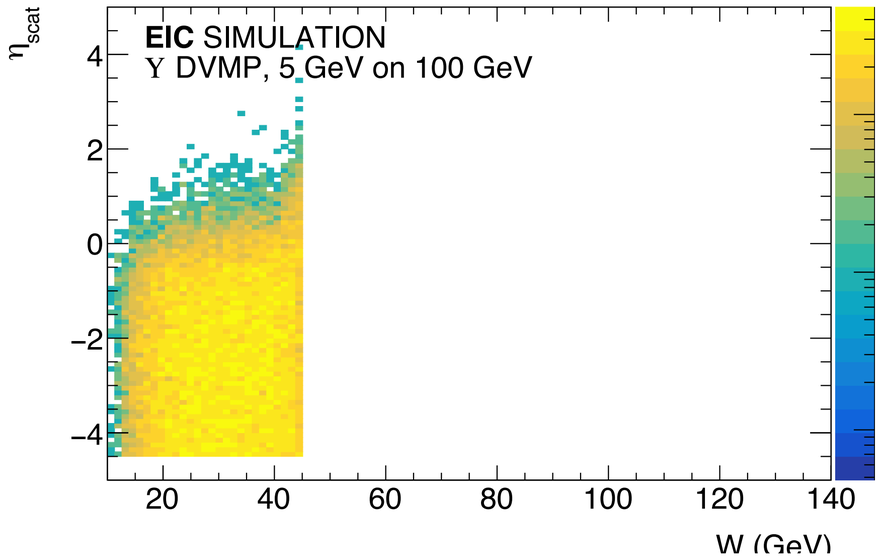


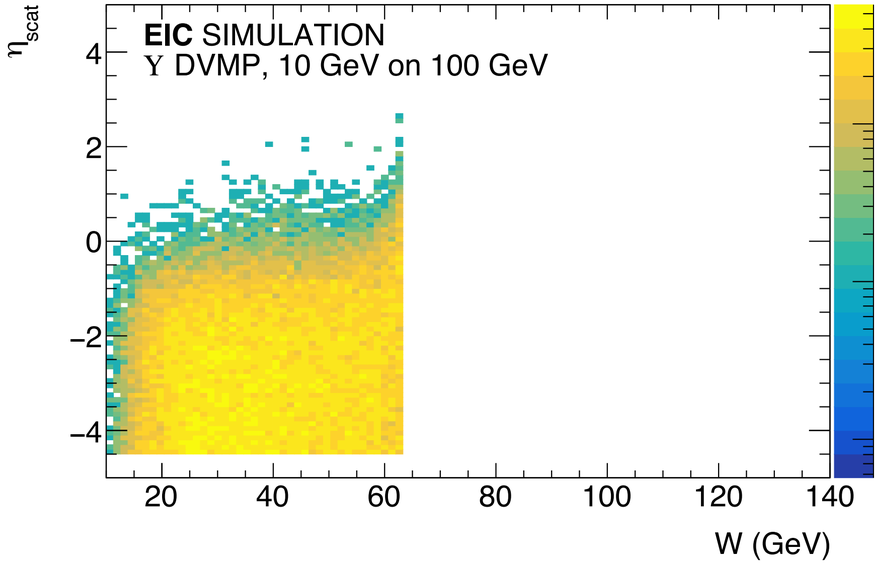
- Situation identical to what we saw for *J/ψ* production, modulo the *Y* cross section near threshold.
- **Improved resolution for scattered electron reconstruction would strongly enhance the threshold *Y* program, one of the key processes to study the origin of the proton mass**

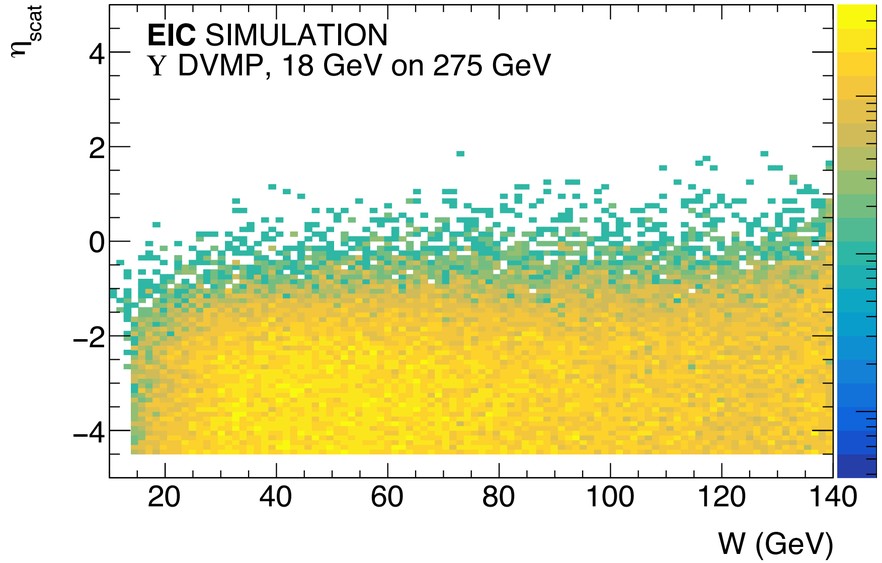
CAN WE IMPROVE WITH STRICT CUTS?

Scattered lepton pseudo-rapidity versus *W* for *Y* production





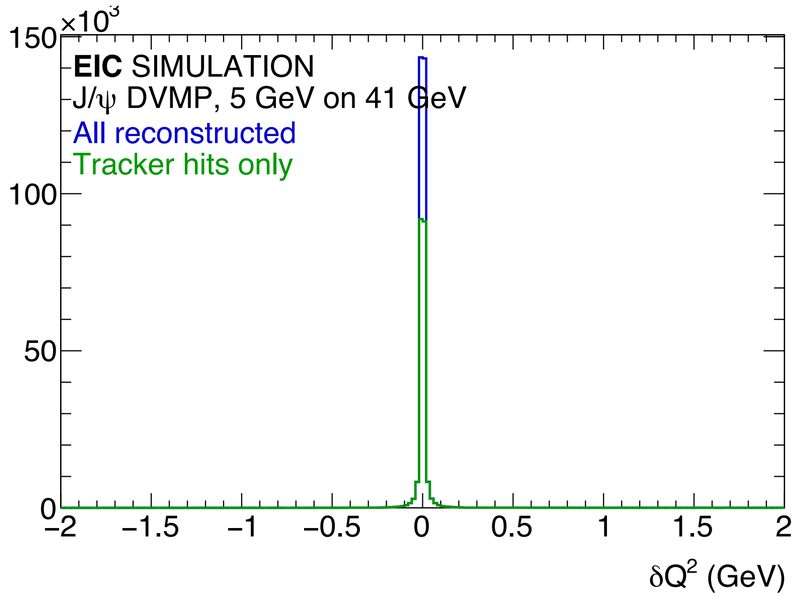


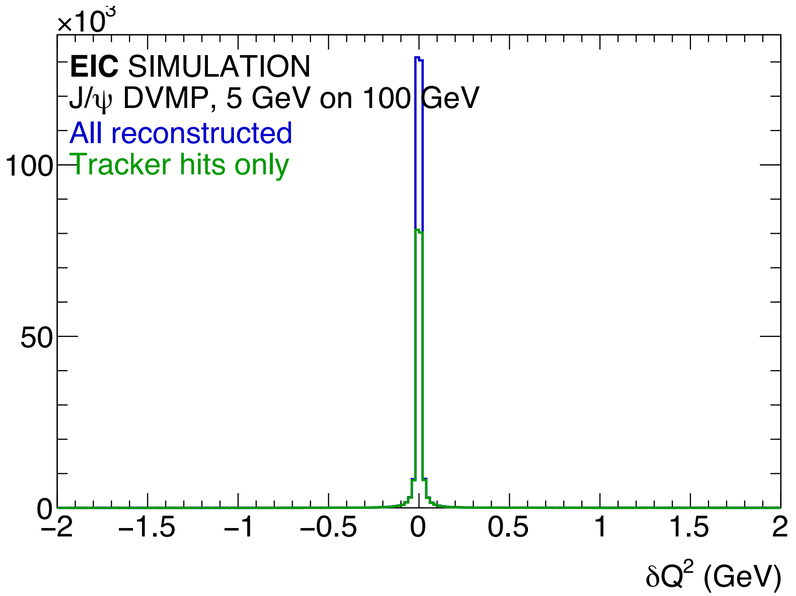


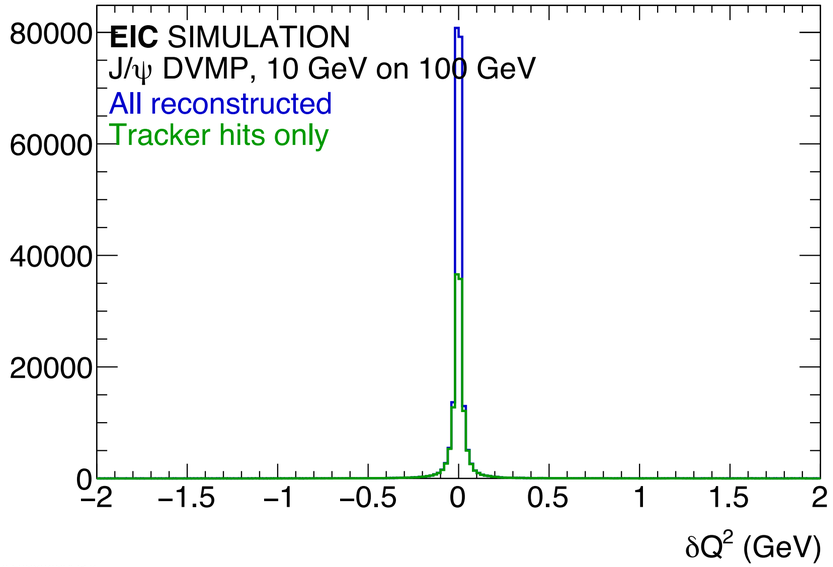
- Scattered lepton acceptance and *W* seem relatively independent
- **Can in principle cut on *η* to improve resolution at low *W*, but that will kill statistics…**

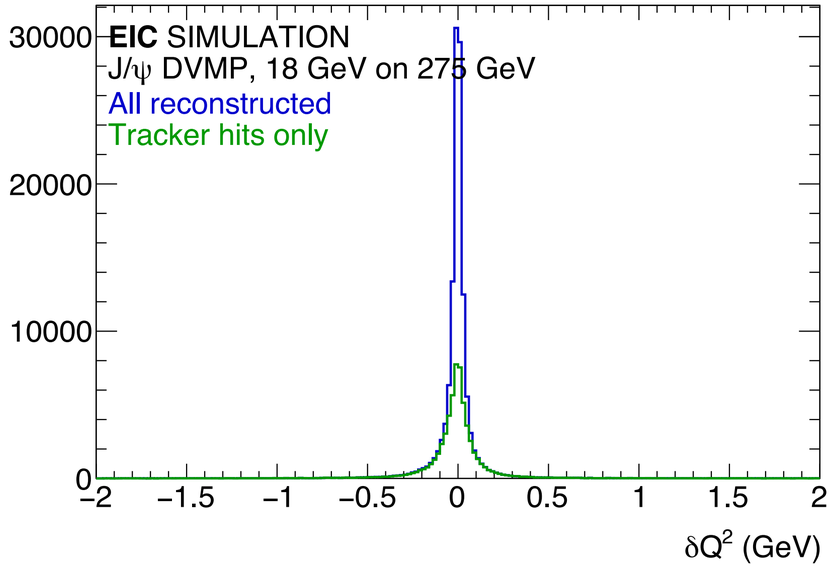
OTHER SCATTERED LEPTON-BASED KINEMATICS

Situation for Q2 is much better



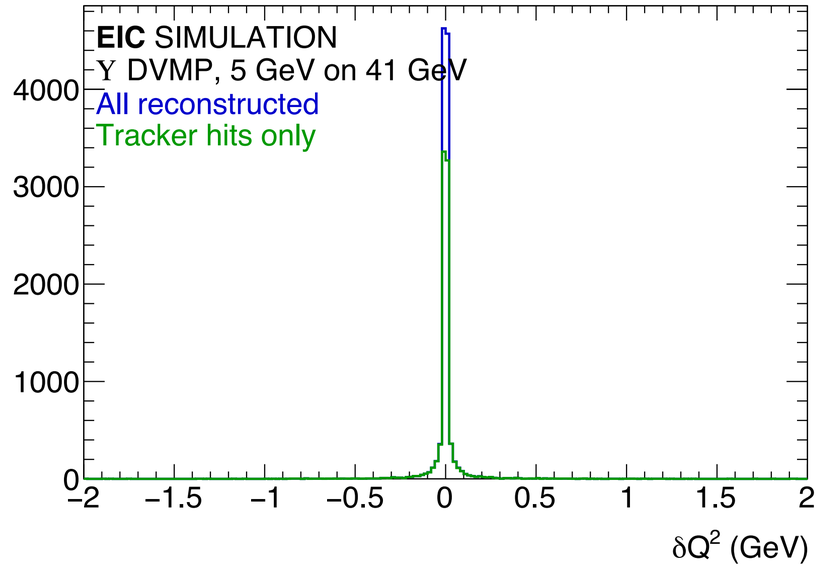


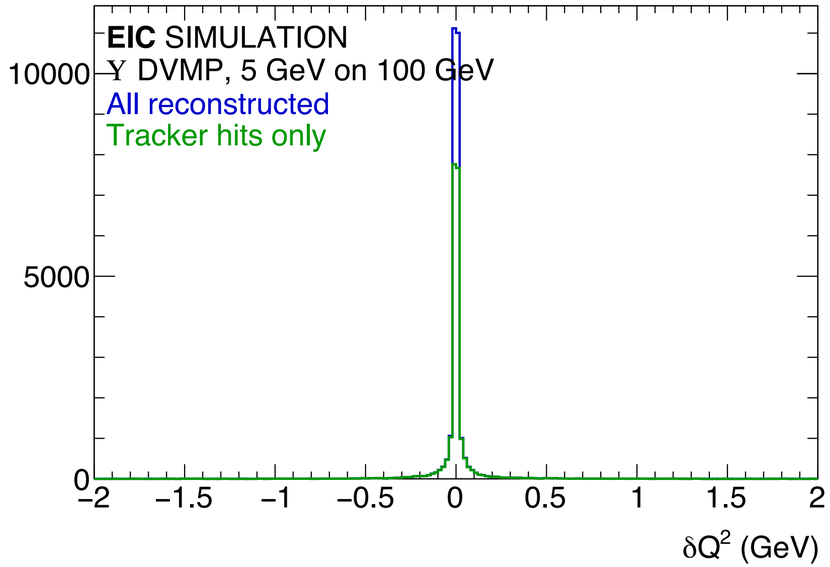


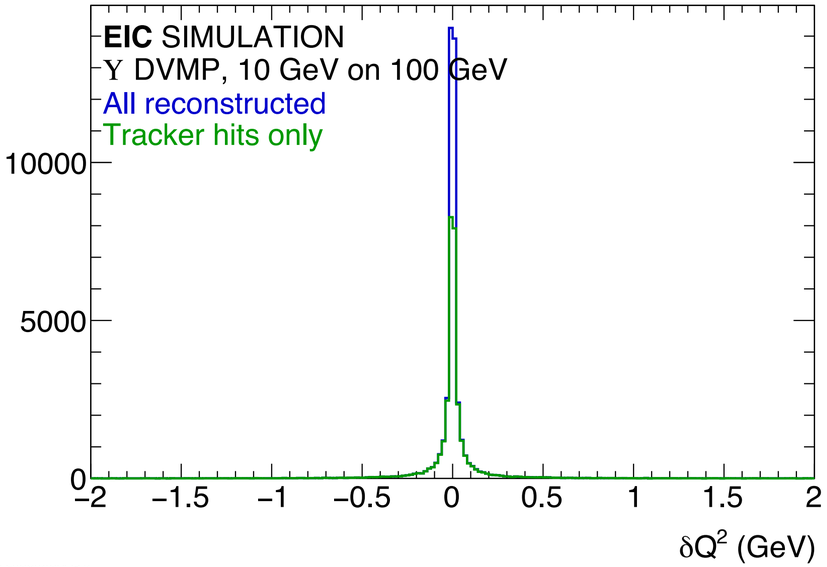


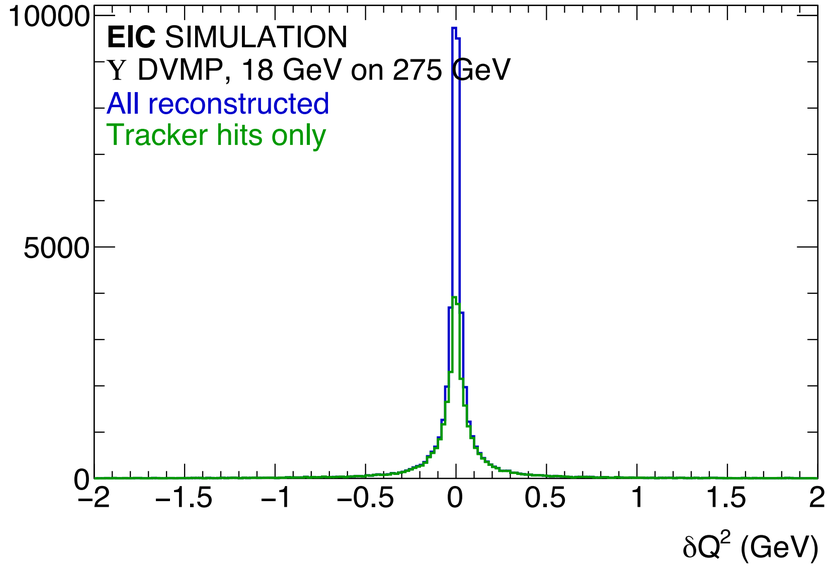
OTHER SCATTERED LEPTON-BASED KINEMATICS

Situation for Q2 is much better (same for *Y*)



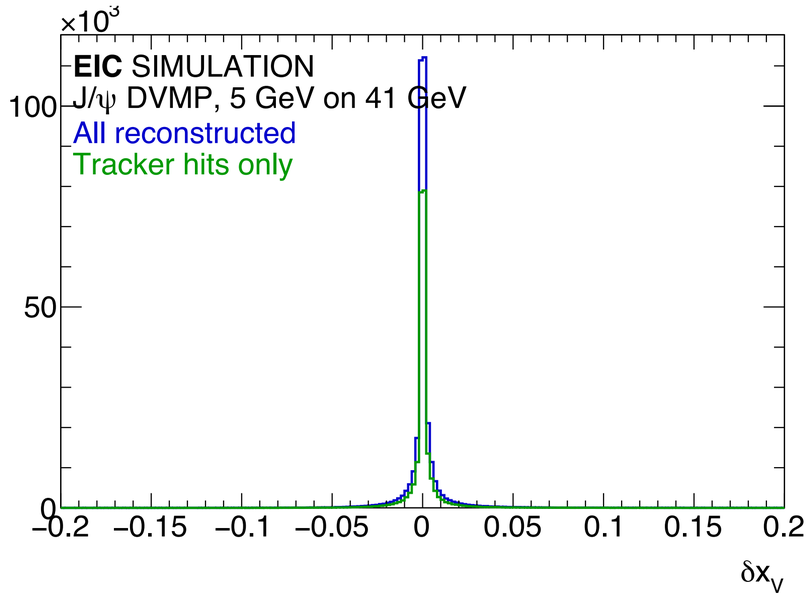


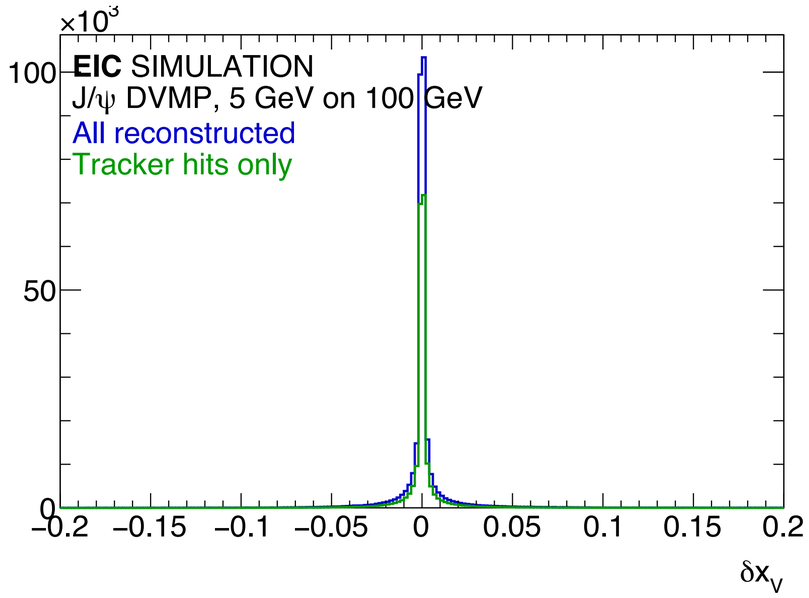


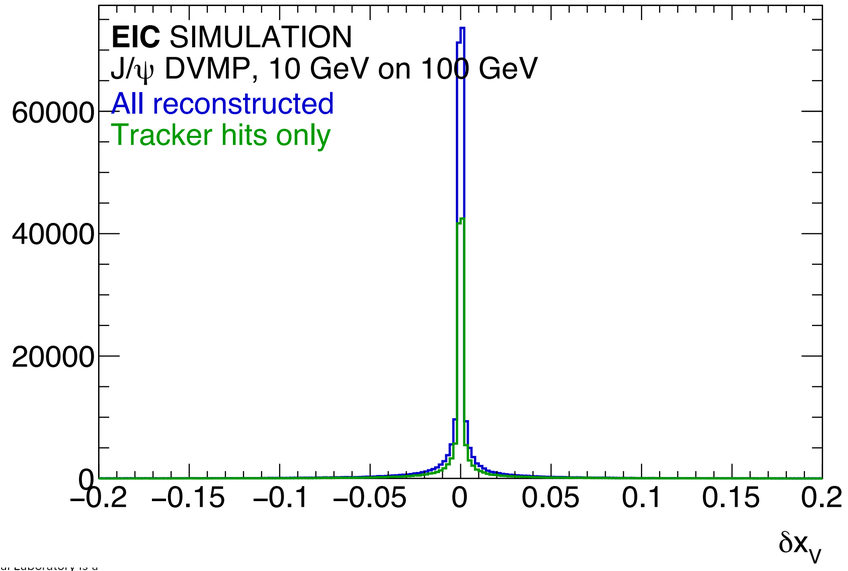


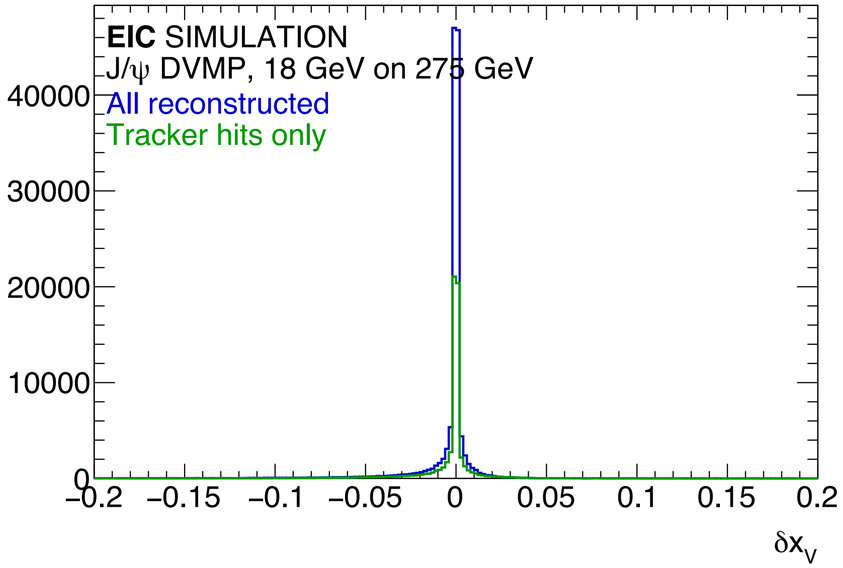
OTHER SCATTERED LEPTON-BASED KINEMATICS

Situation for x_v is also fine



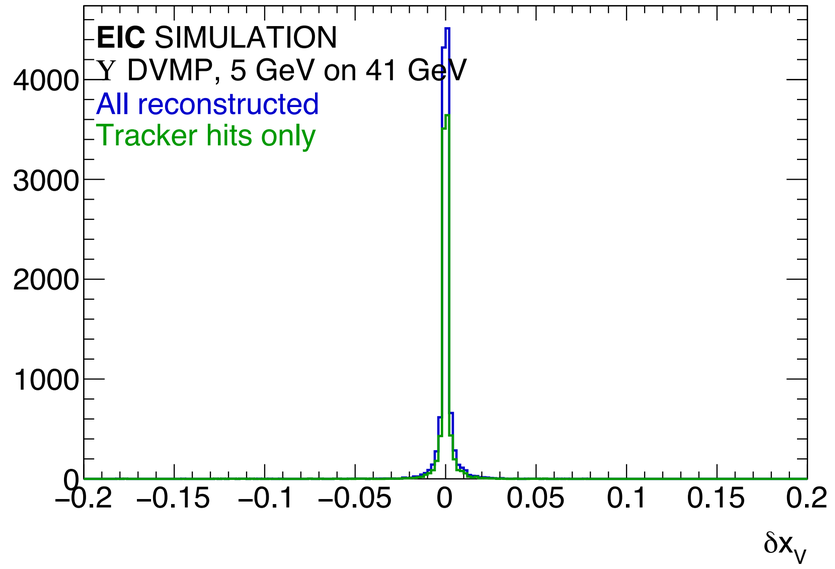


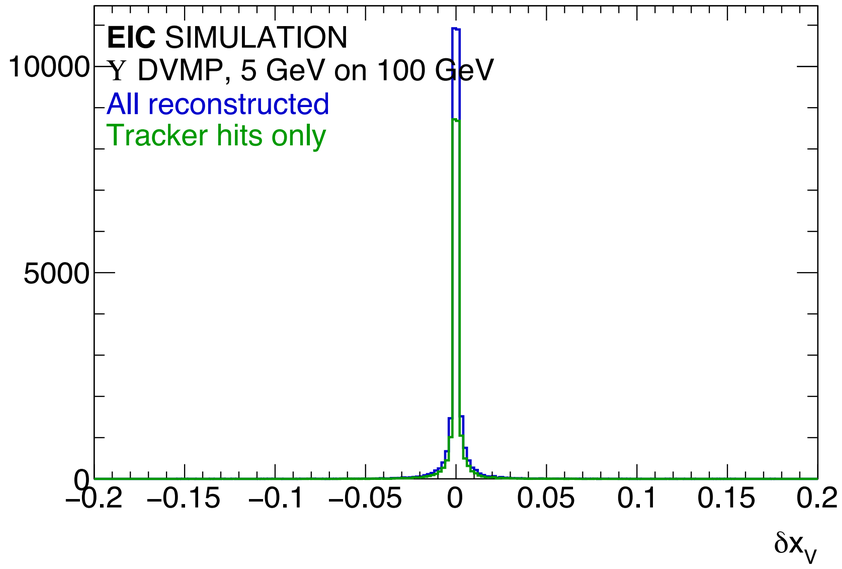


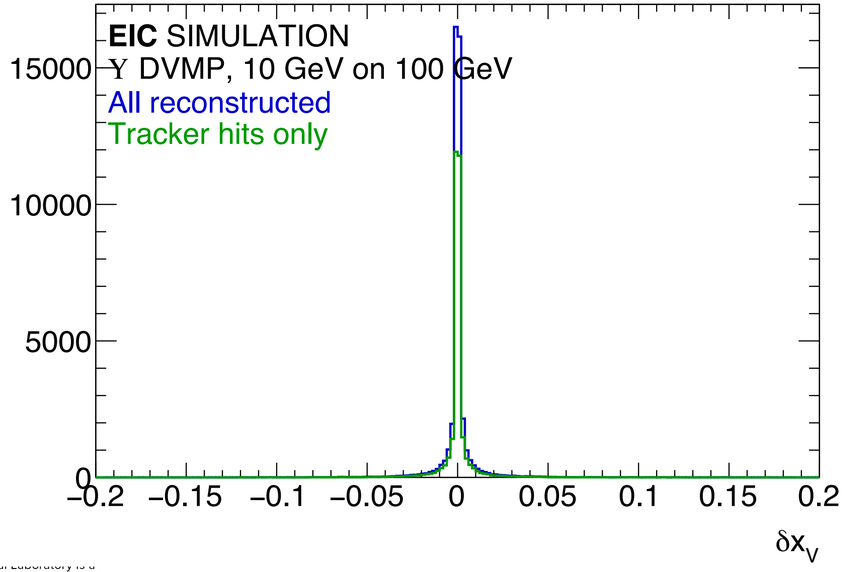


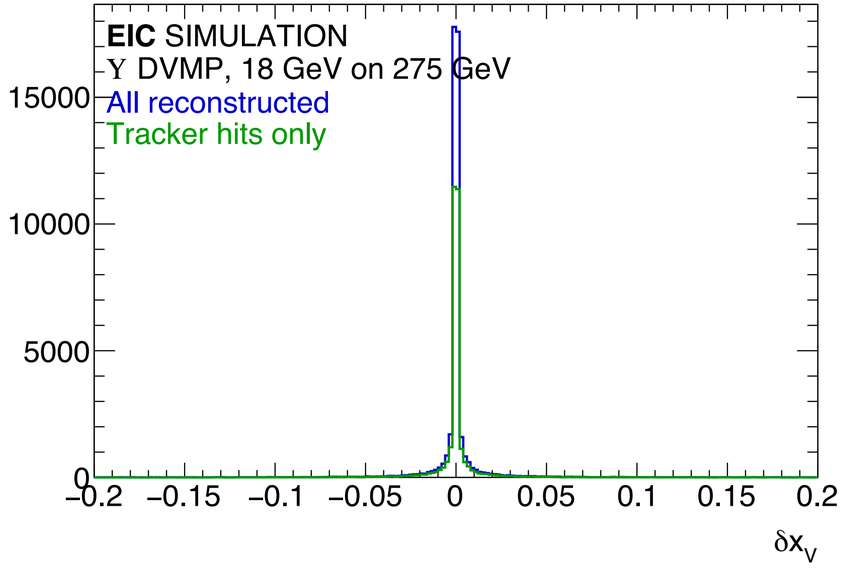
OTHER SCATTERED LEPTON-BASED KINEMATICS

Same for x_v for *Y* DVMP.



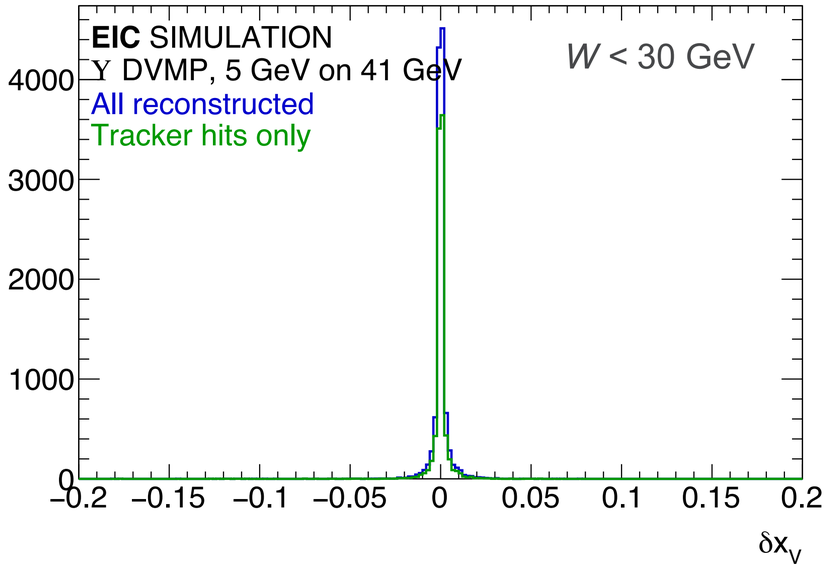


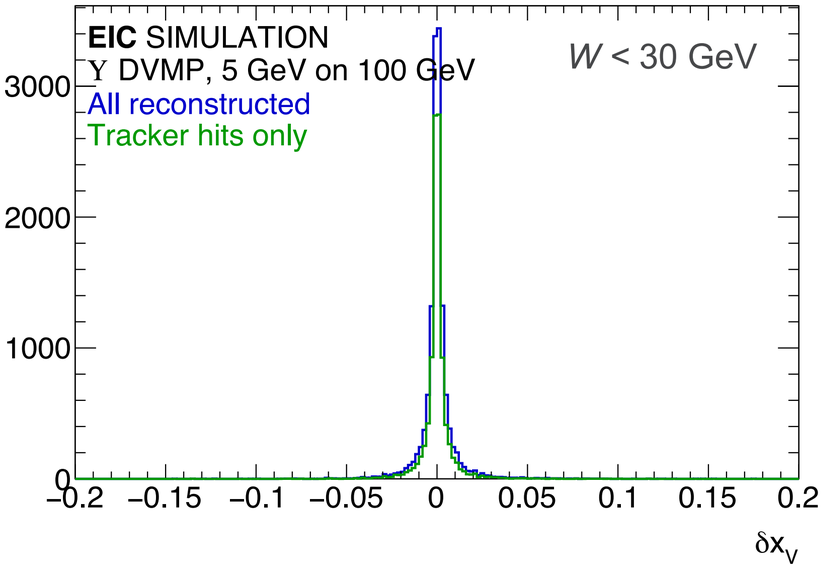


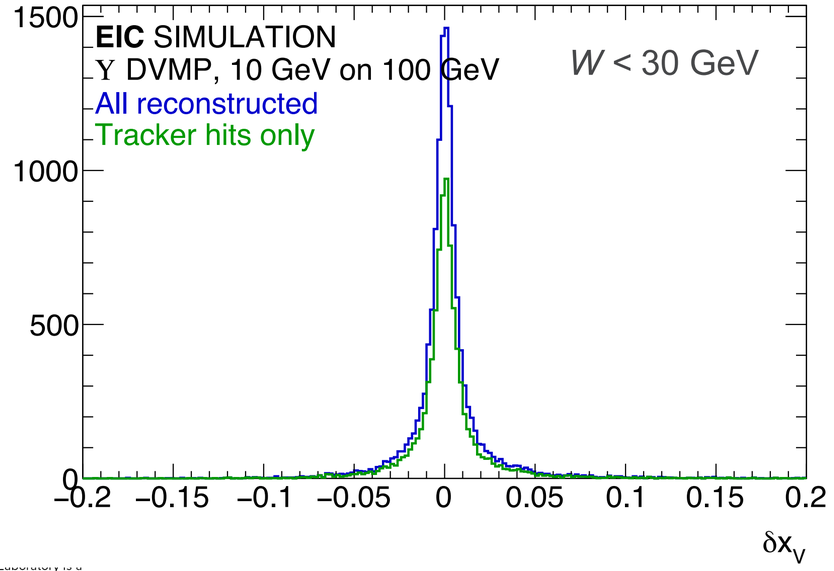


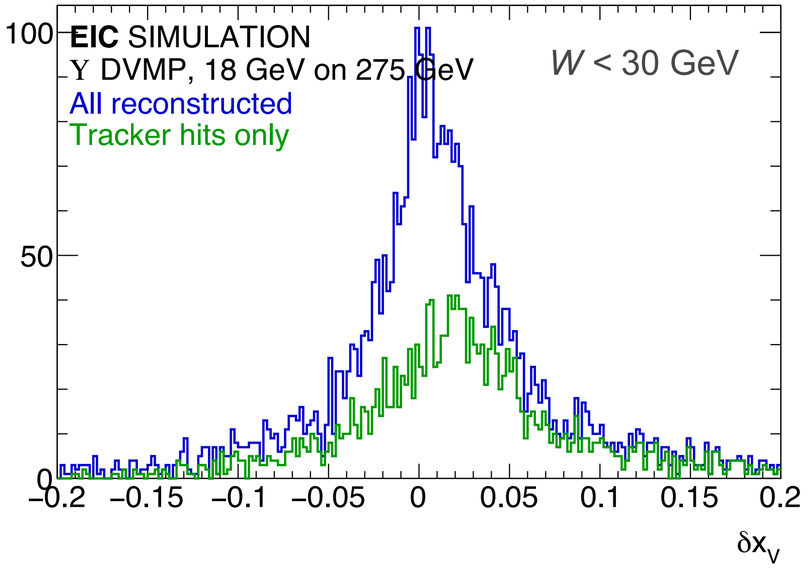
OTHER SCATTERED LEPTON-BASED KINEMATICS

However, much worse performance near *Y* threshold (*W* < 30 GeV)



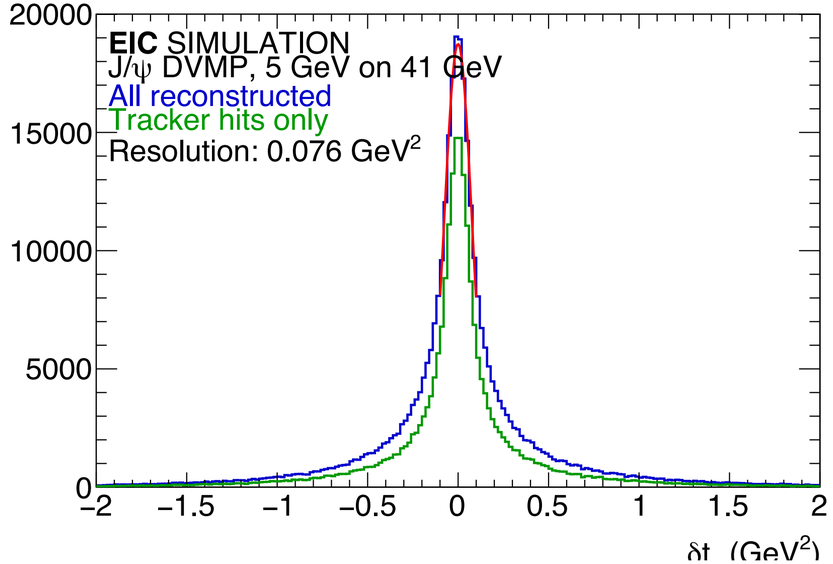


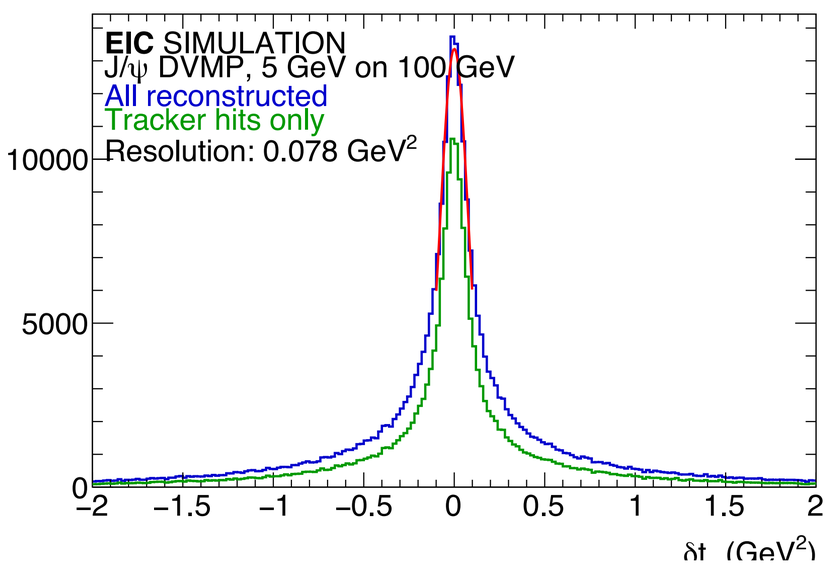


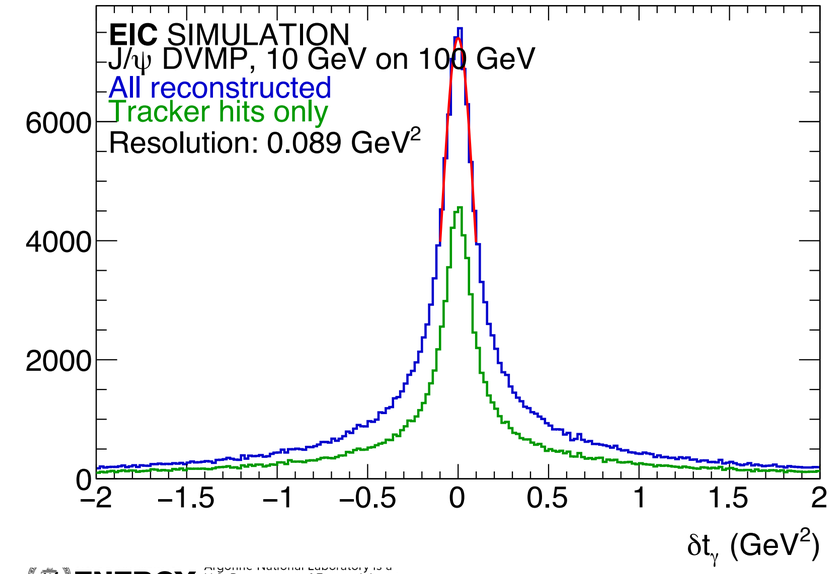


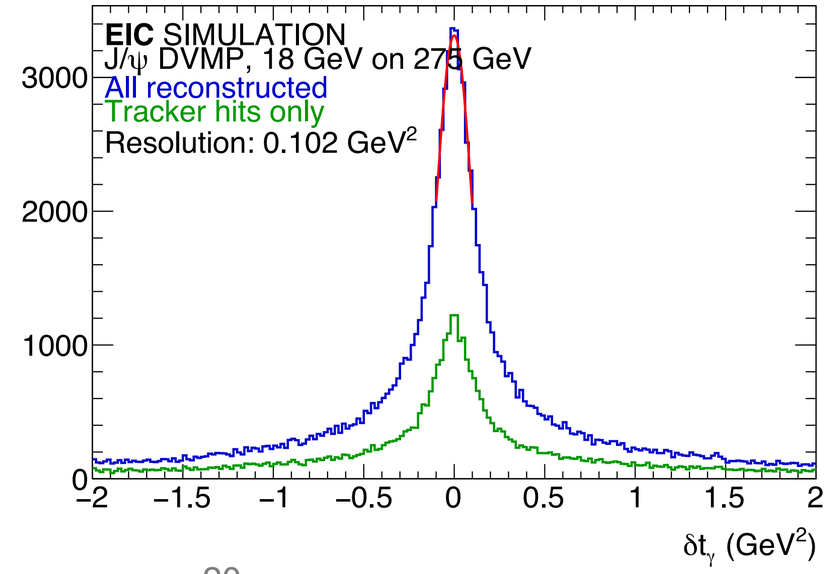
DVMP KINEMATICS

How well can we reconstruct *t* from the lepton+decay kinematics?





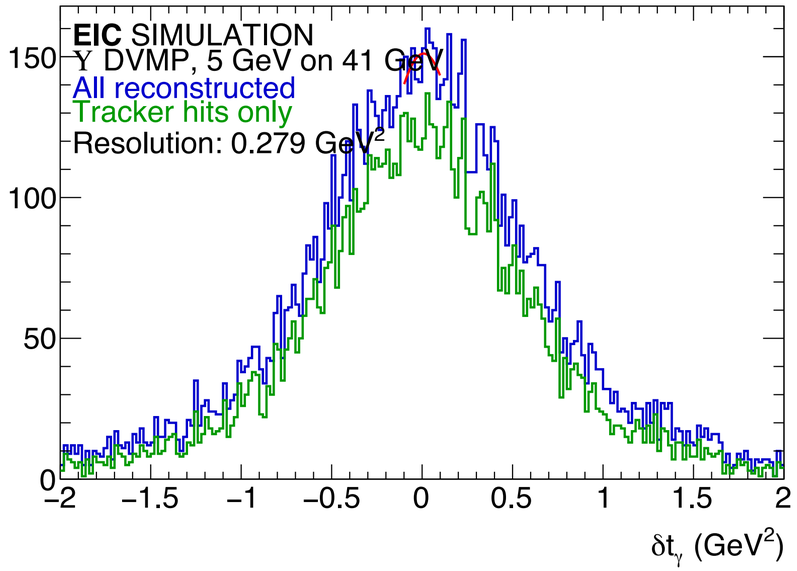


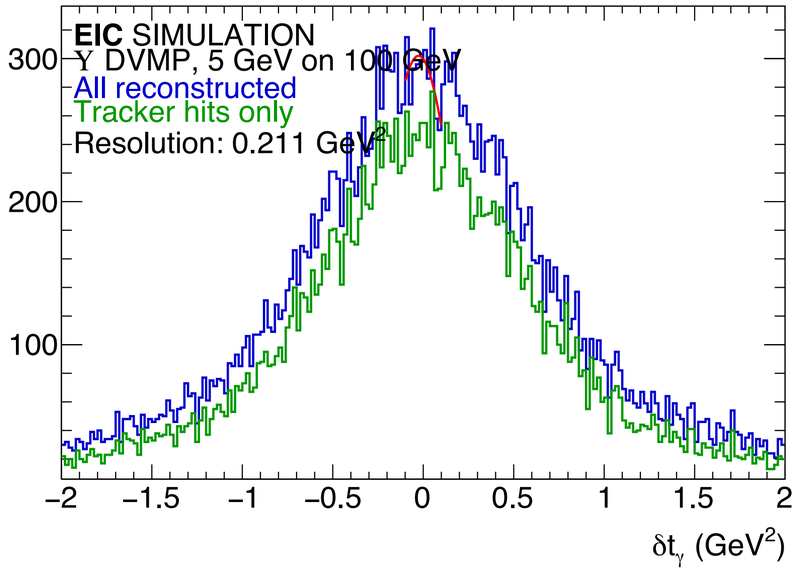


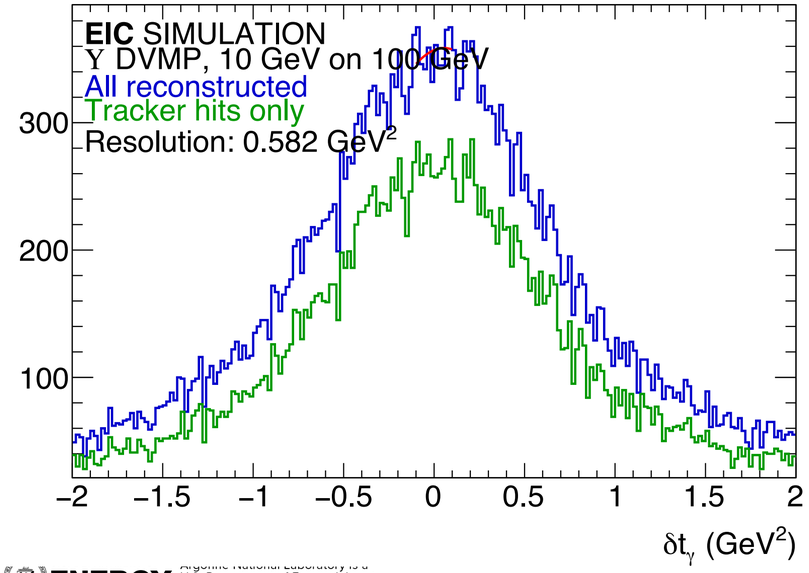
- Significantly worse resolution than with the recoil!
  - *cf. page 4, where the resolution is < .02*
- Heavy tails make this avenue to constrain *t* less attractive.
- **Might be possible to improve situation with strict cuts on the event kinematics, but that will drastically lower the statistics.**

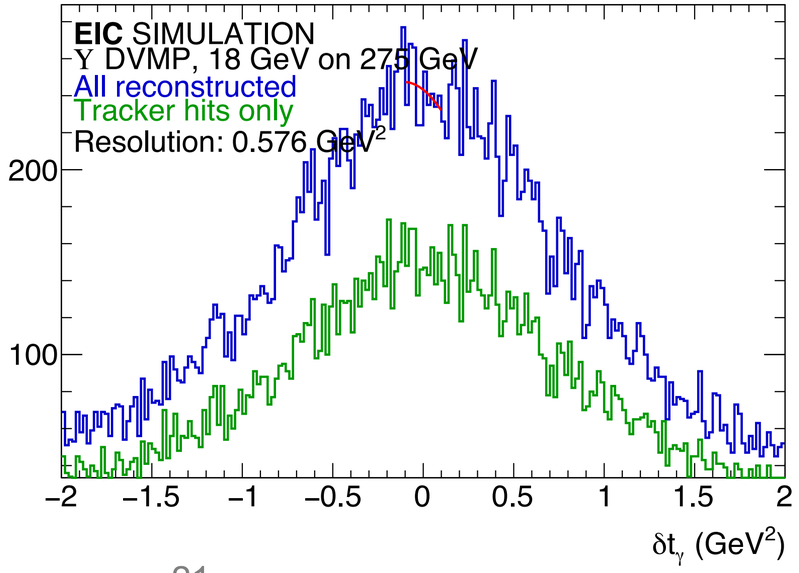
DVMP KINEMATICS

t from lepton+decay kinematics problematic for *Y*









- Orders of magnitude worse than same calculation using the recoil kinematics (*cf. page 5)*
- **Overall very much limited by lepton resolution in the end-caps**
- **As things are right now, precision DVMP measurements only possible leaning on the FF system!**

CONCLUSIONS ON DVMP WITH THE MATRIX DETECTOR

Insufficient precision in the end-caps for lepton reconstruction

- Current iteration of FF system sufficient to precisely constrain *t* from recoil end
- Ambiguity decay lepton with scattered lepton minimal for DVMP. May be worse for other (lower-statistics) channels).
- Tracker precision sufficient for exclusive DVMP event selection
- Heavily limited in *W* resolution by resolution in backward endcap. This significantly hurts the near-threshold program to study the origin of mass in QCD.
- No current estimate of radiative effects in the detector, but can be significant in a system already hurting for resolution.
- Muon identification in the barrel + endcaps would enhance DVMP program and mitigate the stricter event selection required to get to reasonable resolutions at lower *W.*
- Any improvements to tracking resolution in the end-caps will have large impact in DVMP