CLAS Collaboration Meeting: J/ψ Photoproduction Near Threshold

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Overview

- Theoretical Model
- Previous Measurements
- Projected Results
- Event Selection and Particle Identification
- First Look At Run Group A Data
- Preparation For Further Higher Level Analysis

Experiment E-12-12-001(A)

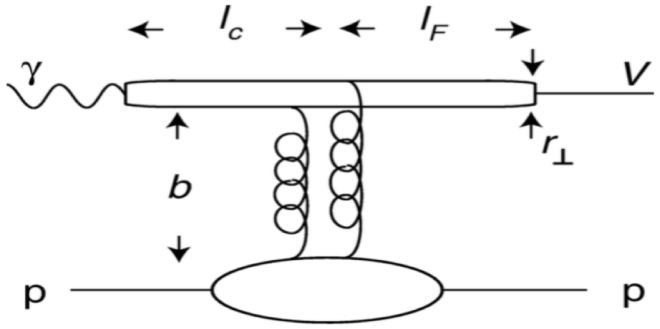


Fig. Vector Meson Dominance Model for photoproduction of a vector meson through gluon exchanges in the proton

- The photon couples to the gluon field through intermediate virtual charm-anti-charm pair according to the Vector Dominance Model (VDM)
- Near threshold, momentum transfer becomes large and all three valence quarks must exchange energy in the form of gluons for the elastic production of J/ψ. This will allow the study of gluonic form factors of the proton.

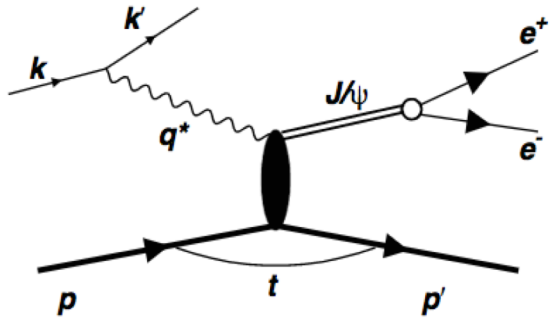


Fig. T-channel production of J/Psi and its decay into an electron and positron, used for probing the gluons in proton

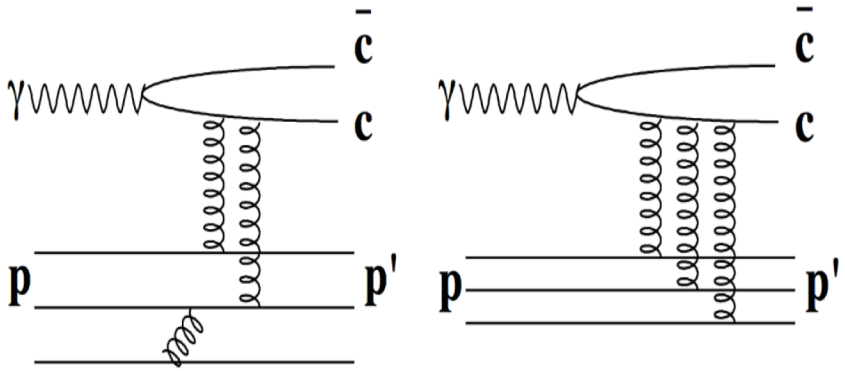


Fig. These are the pathways for the transfer of proton momentum to the creation of the J/ψ

Two-gluon exchange differential cross section

$$\frac{d\sigma}{dt} = N_{2g}\frac{(1-x)^2}{R^2M^2}F_{2g}^2(t)(s-m_p^2)^2$$

Three-gluon exchange differential cross section

$$\frac{d\sigma}{dt} = N_{3g}\frac{(1-x)^0}{R^4M^4}F_{3g}^2(t)(s-m_p^2)^2$$

Current and Past Measurement Regions

- Data exists in the higher energy region, but, there is no published data at E < 11 GeV
- Old data fits well with two-gluon exchange model, data near threshold may end up following three-gluon exchange model
- If the pentaquarks exist, we will see them as s-channel resonances
- Without the pentaquarks, assuming the two-gluon exchange mechanism, we expect to see 45 J/ψ per day in CLAS12, according to FASTMC data

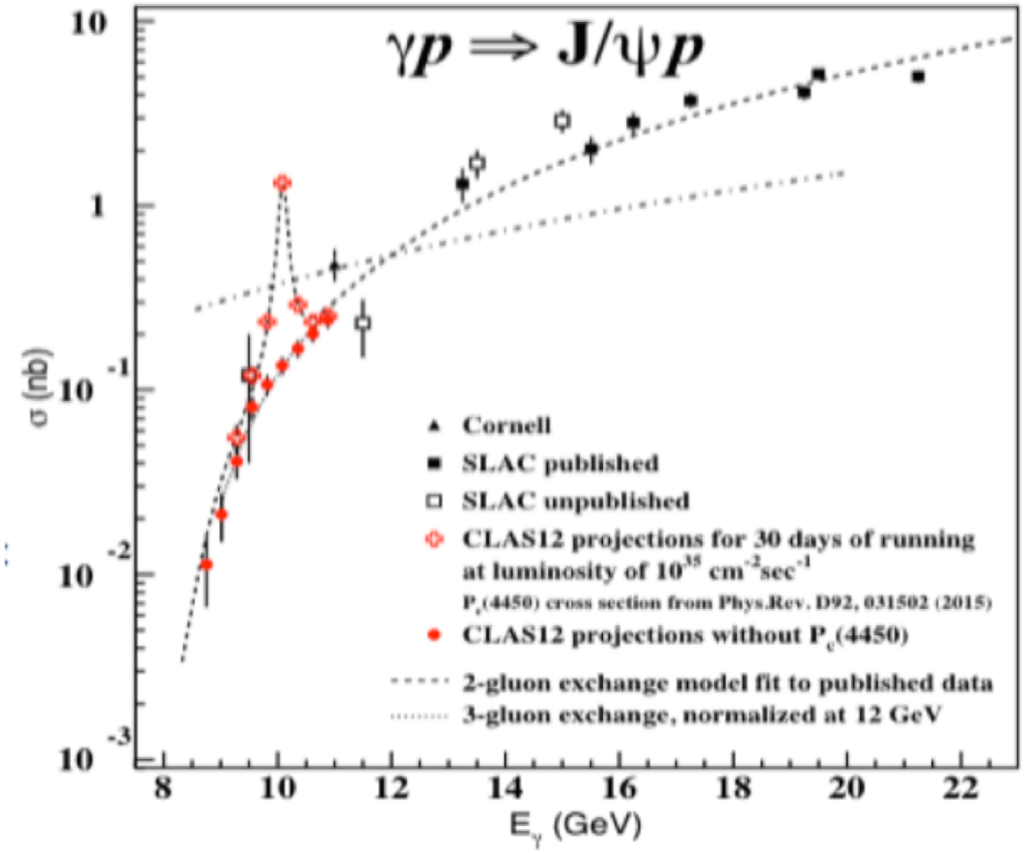


Fig. Past results at SLAC and Cornell and future results for CLAS12 for two-gluon exchanges, three-gluon exchanges, and possible observation of the P(4450) pentaquark.

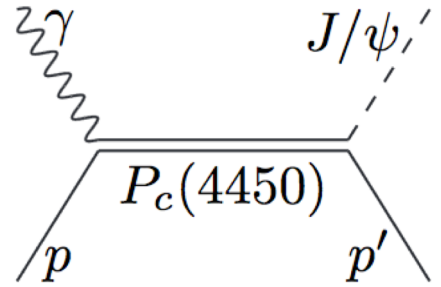
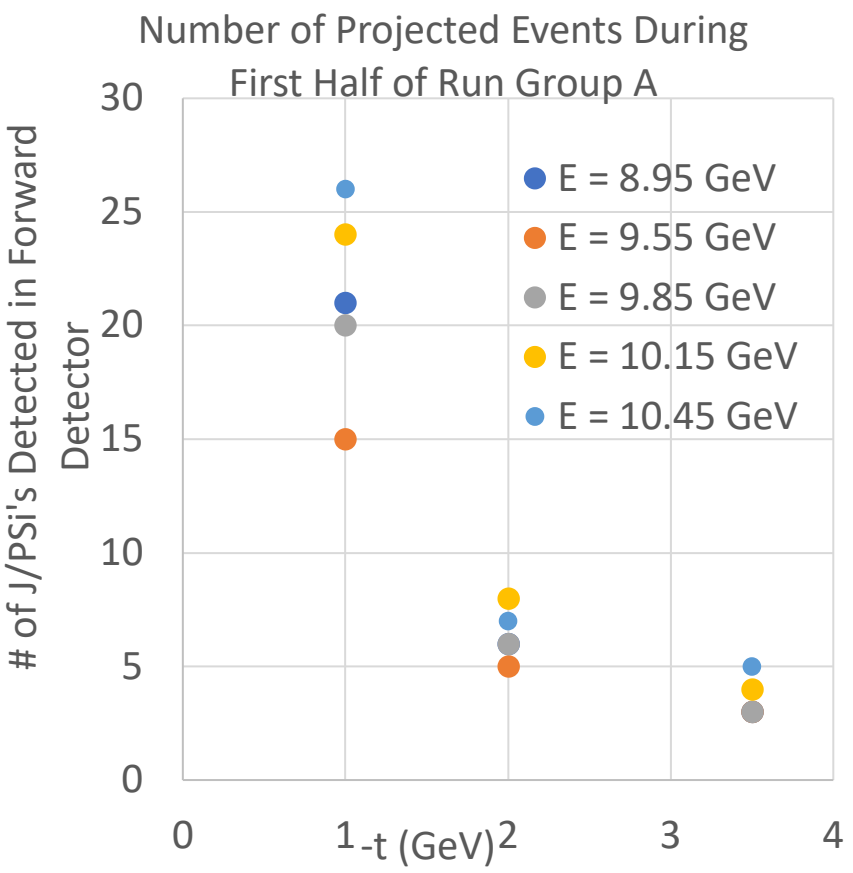


Fig. S-channel production of P(4450) and its decay into J/ψ and the struck proton

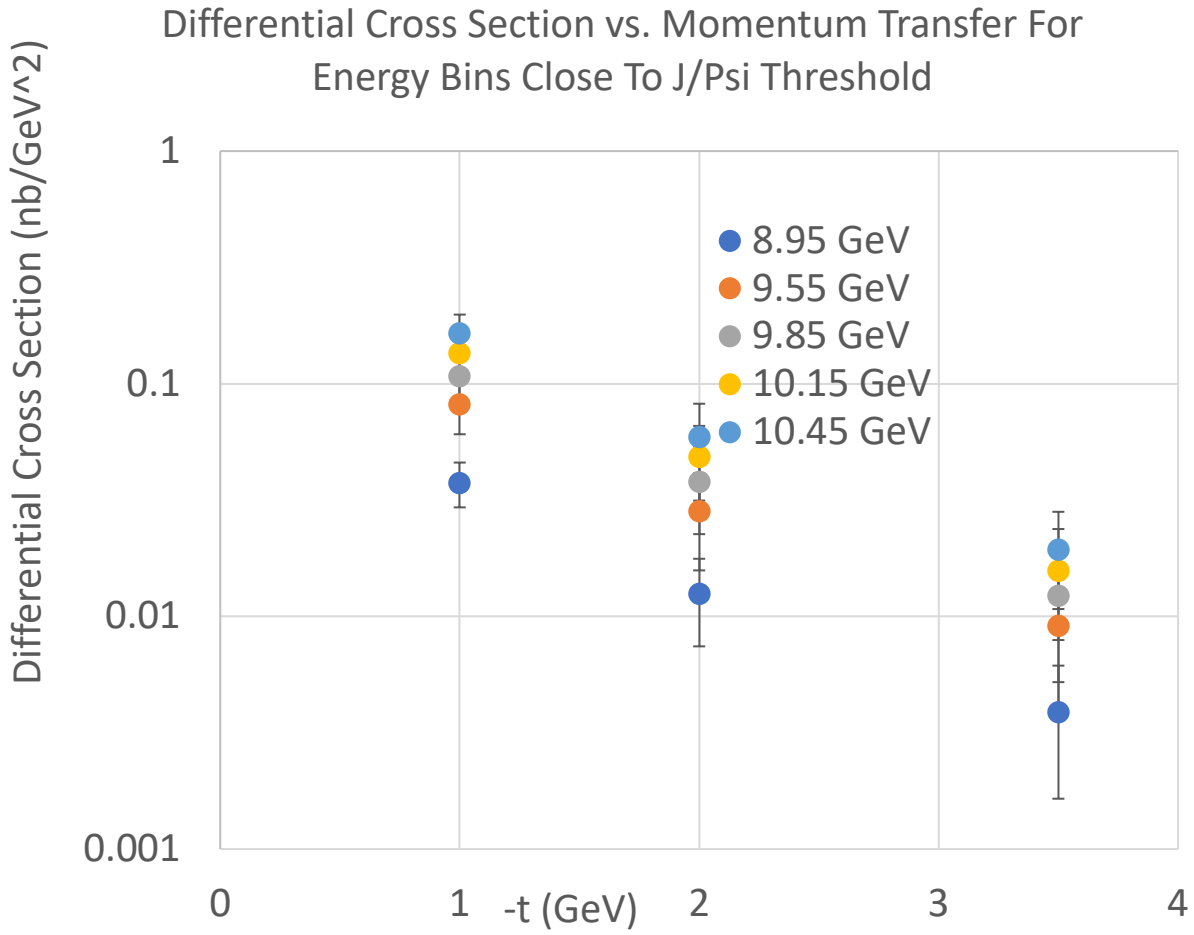
Acceptance	8.5 < E < 9.1	9.1 < E < 9.4	9.4 < E < 9.7	9.7 < E < 10.0	10.0 < E < 10.3	10.3 < E < 10.6
0.5 < -t < 1.5	0.16	0.18	0.19	0.20	0.21	0.22
1.5 < -t < 2.5	0.14	0.16	0.17	0.18	0.19	0.20
2.5 < -t < 3.5	0.11	0.14	0.14	0.15	0.17	0.18
3.5 < -t < 4.5	0.084	0.11	0.13	0.14	0.16	0.17

Fig. Acceptance at various energies and momentum transfers in phase space

Projections for J/ψ from RG-A Spring 2018 Run



***Bin sizes for photon energy…**
8.5 < E < 9.4
9.4 < E < 9.7
9.7 < E < 10.0
10.0 < E < 10.3
10.3 < E < 10.6
***Bin sizes for -t…**
0.5 < -t < 1.5
1.5 < -t < 2.5
2.5 < -t < 4.5



***A total of 184 J/Psi events from e+e- detection for the time period corresponding to the first half of Run Group A are projected based off acceptances from simulation and tracking efficiency from data**

*45 J/psi events are from the combined e+e- and mu+mu- decays. For the diagram on the left, energy dependence is only for e+e-, estimated to be 25 J/psi per day

Tracking Efficiency With Latest Version Of Reconstructed Code

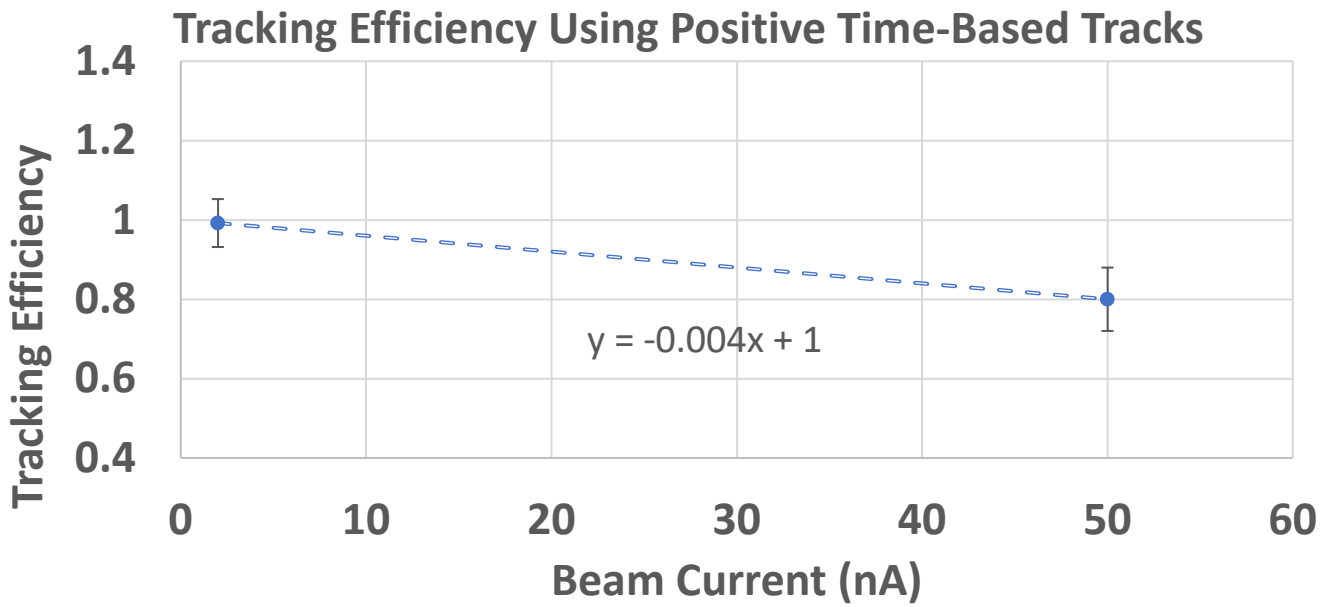
- Rate of positively and negatively charged tracks per electron, normalized to 1 at 0 nA , from the fit

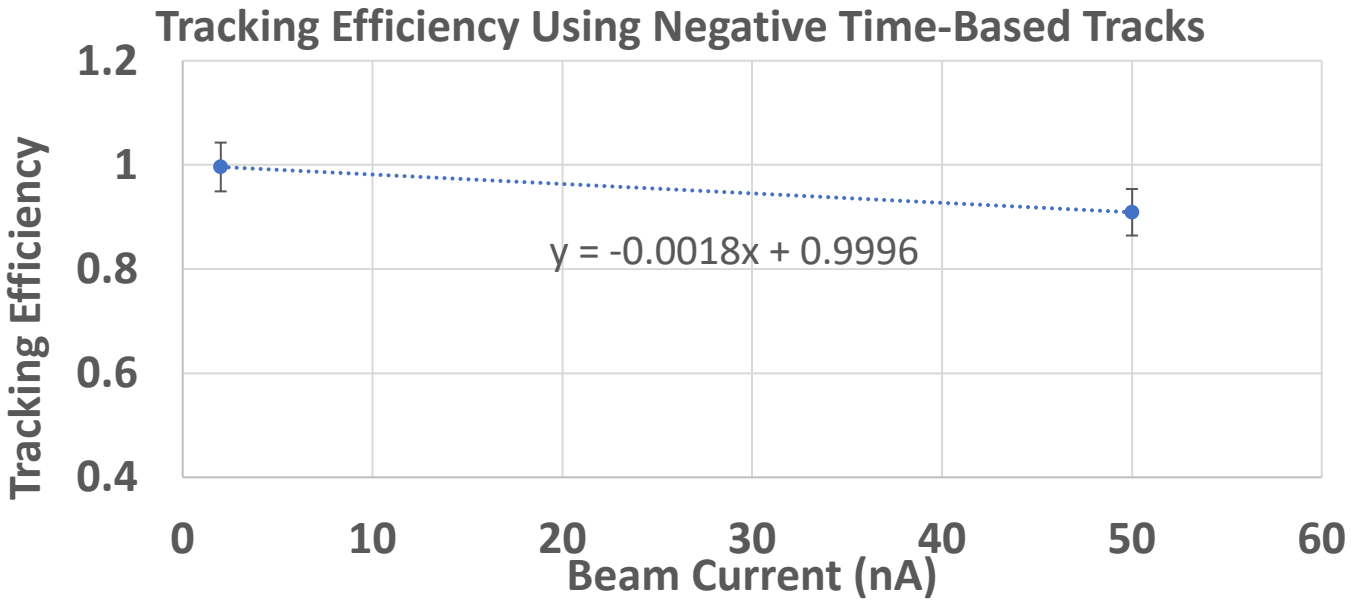
$$n_i = \frac{N_i}{N_e};$$

$$n_i(I) = a + b \times I;$$

$$Trk.efficiency = \frac{n_i}{a};$$

i $-$ $positively\ or\ negatively\ charged\ tracks$





Event Selection and Particle Identification

Event Selection: J/ψ is produced through the exchange of a quasi-real photon, in which the kinematics are constrained to a very low Q^2 and transverse missing momentum components that give the signature of a very forward scattered electron

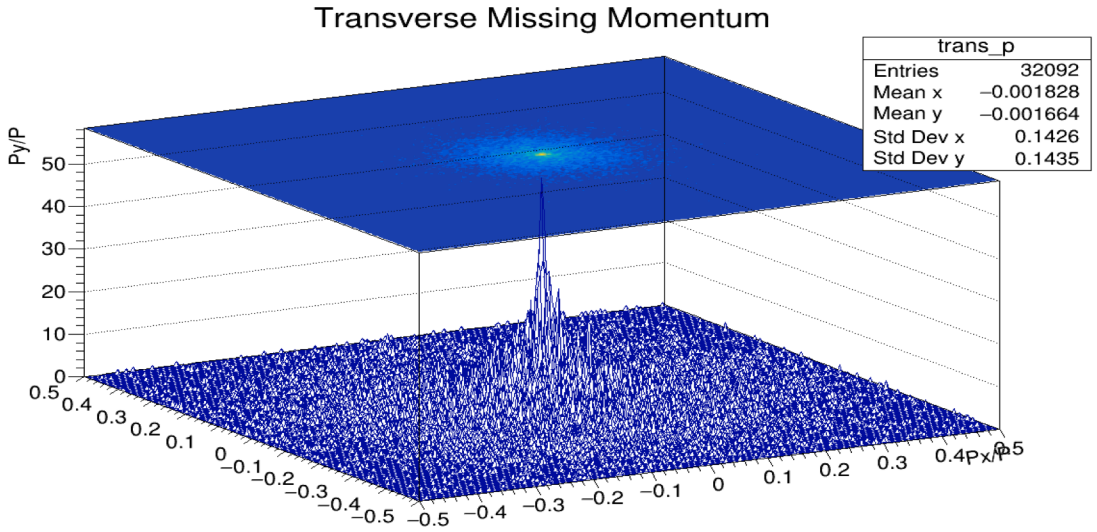


Fig. Transverse Missing Momentum Components in X and Y

Leptons and Protons: Muons are detected from the presence of energy deposition in all layers of the calorimeter. Electrons have cuts on sampling fraction and Cherenkov photoelectrons. The standard EB particle ID is used for protons.

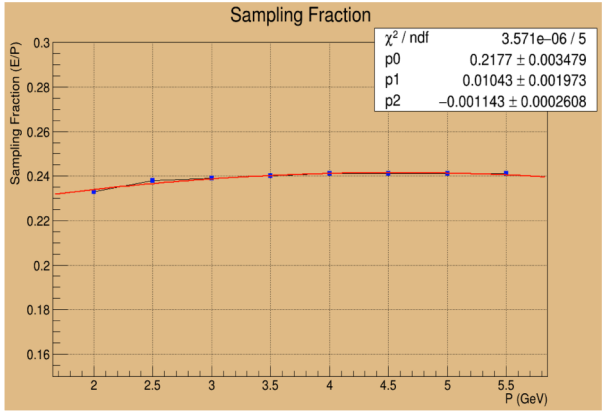


Fig. Parametrization of energy deposition in bins of momentum relevant to kinematic range of experiment

Fig. Low Q^2 events

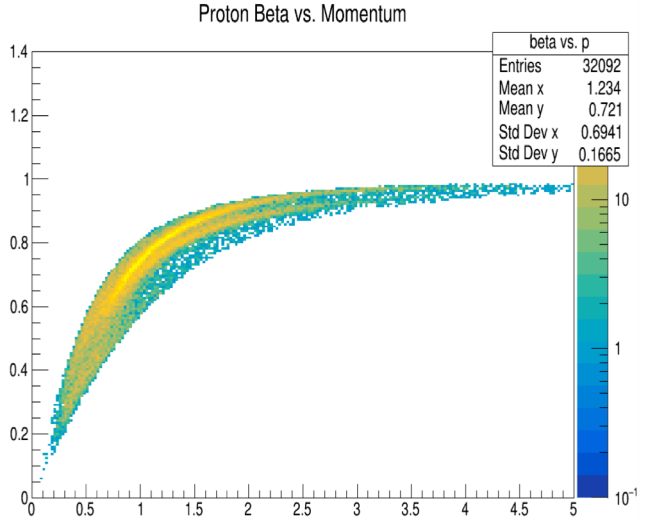


Fig. Protons were identified by event builder's PID algorithm. The resulting beta vs. momentum plot is displayed.

Determination of Cuts For Invariant Mass

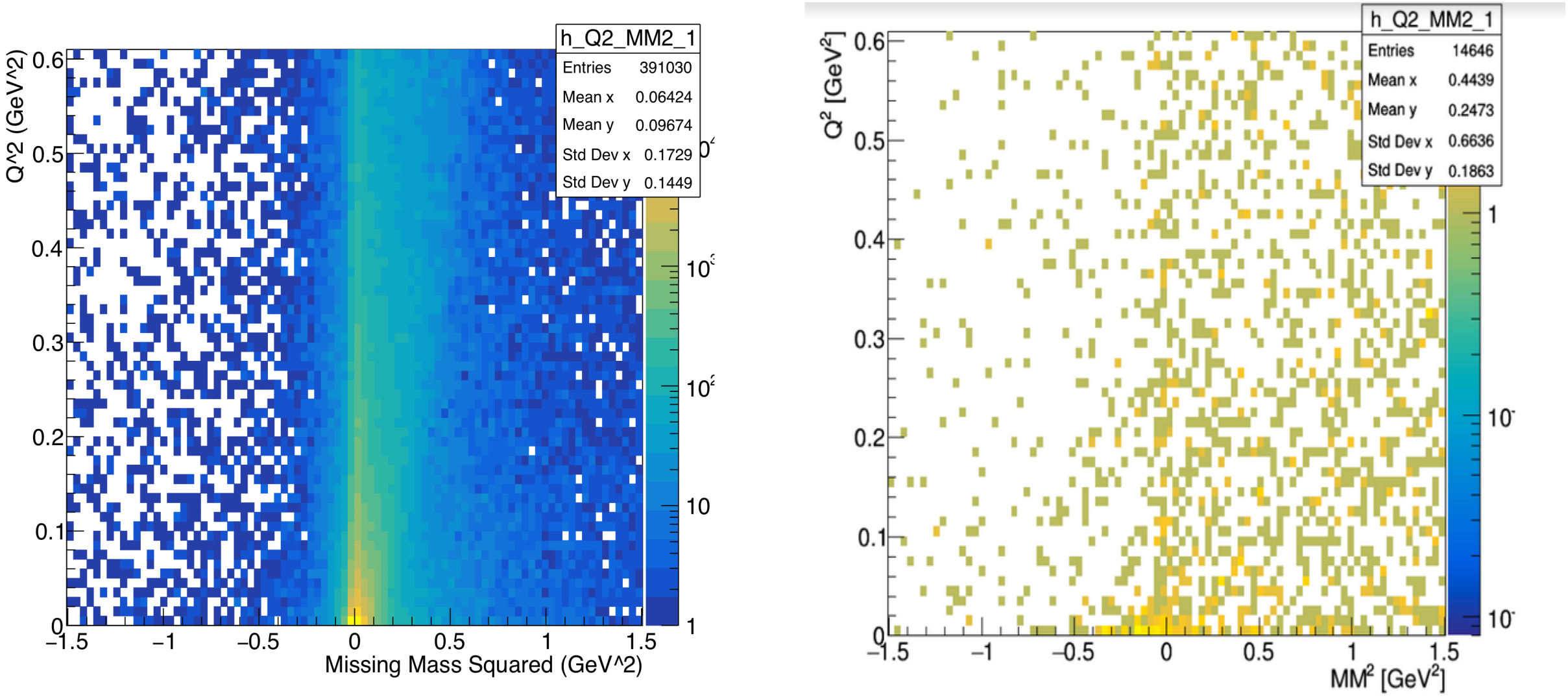
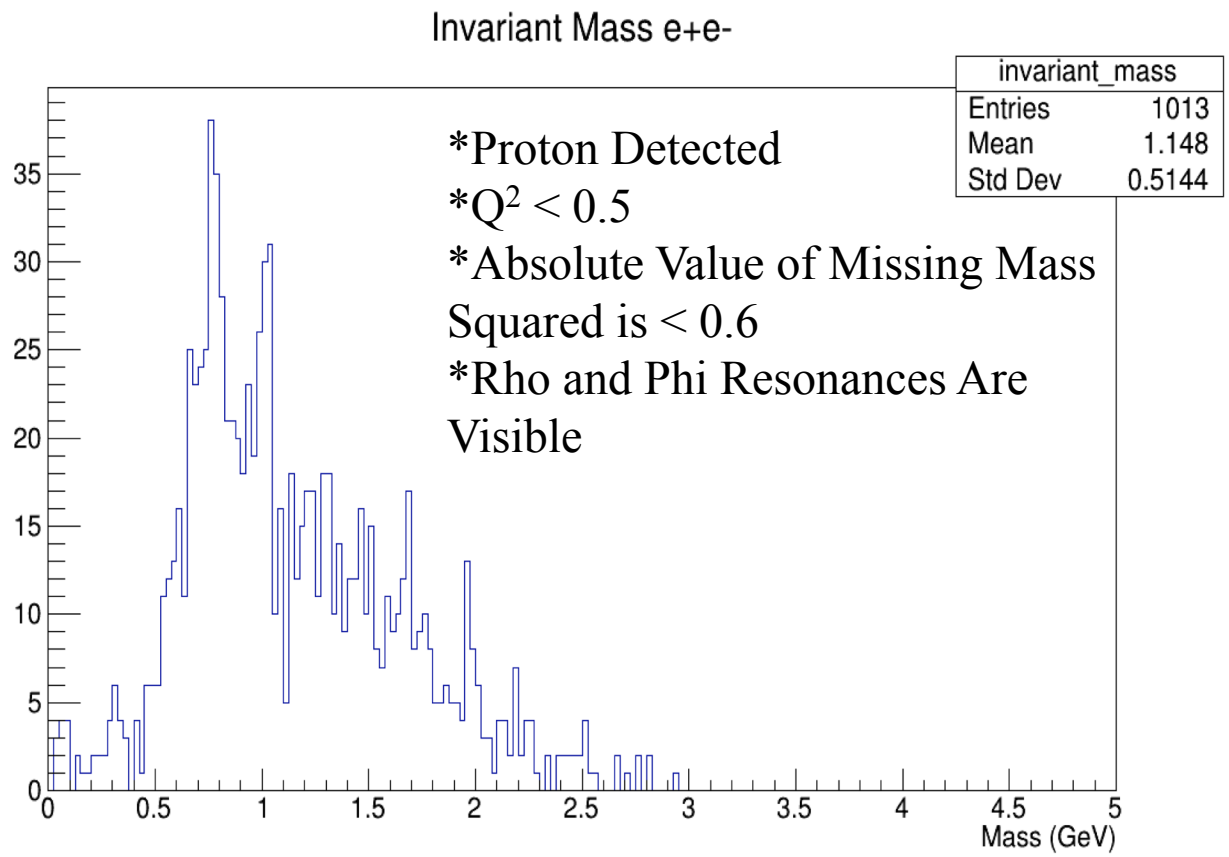
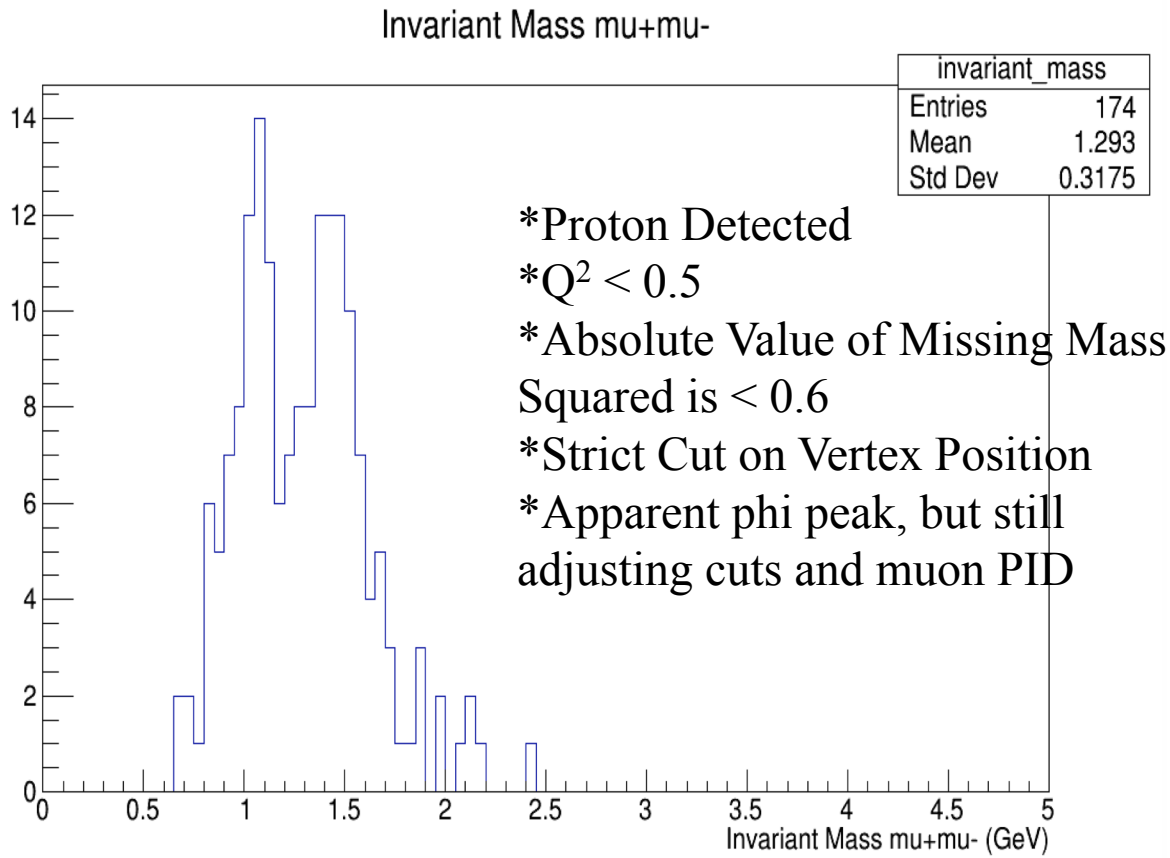


Fig. MC data is shown on the left and Run Group A data is shown on the right.

Invariant Mass





Analyzed Runs: 3432, 3817, 3877, 3967, 3975, 3985, 4169, 4203, 4250, 4295, and 4296

Forward Detector Reconstruction Of Decayed Electron-Positron Pair and the Struck Proton

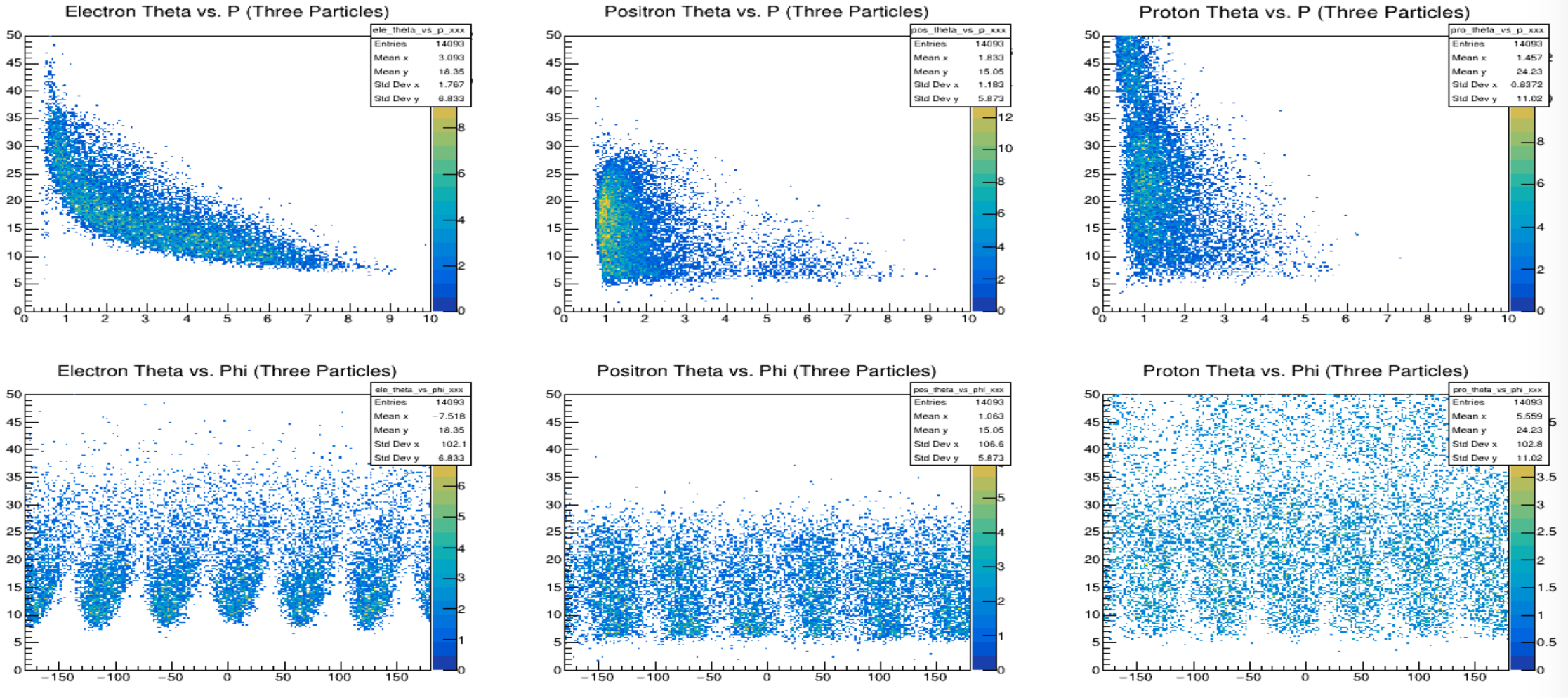
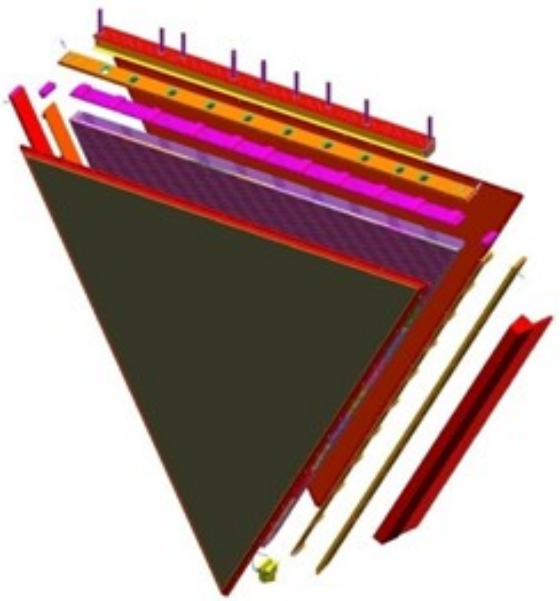


Fig. The six plots show kinematics for three particles (e+e-p) detected with cuts on transverse missing momentum. The amount of pion contamination ($p > 4.9$ GeV) is displayed.

Further Studies Needed For Higher-Level Analysis

- Understanding of Bethe-Heitler background in all relevant regions of phase space for a visible J/ψ peak
- Understanding of lepton and hadron lateral energy deposition for higher-momentum particle identification using shower moments
- Development of fiducial cuts for the PCAL and ECAL layers for optimal longitudinal energy deposition



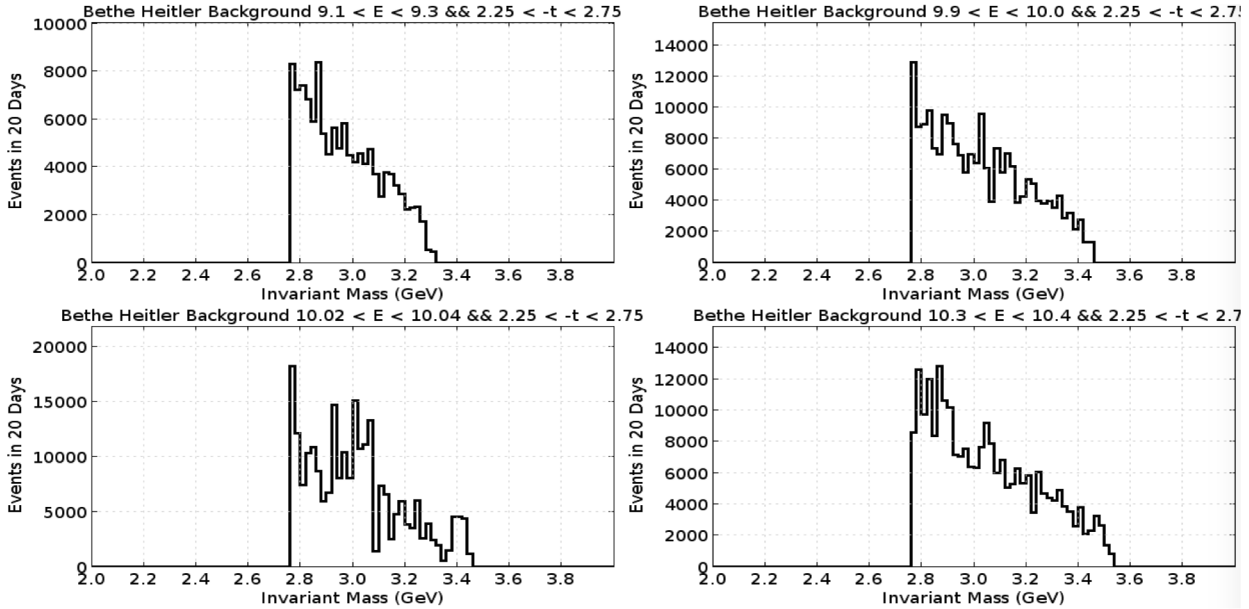


Fig. Study of Bethe-Heitler background using normalized simulation results