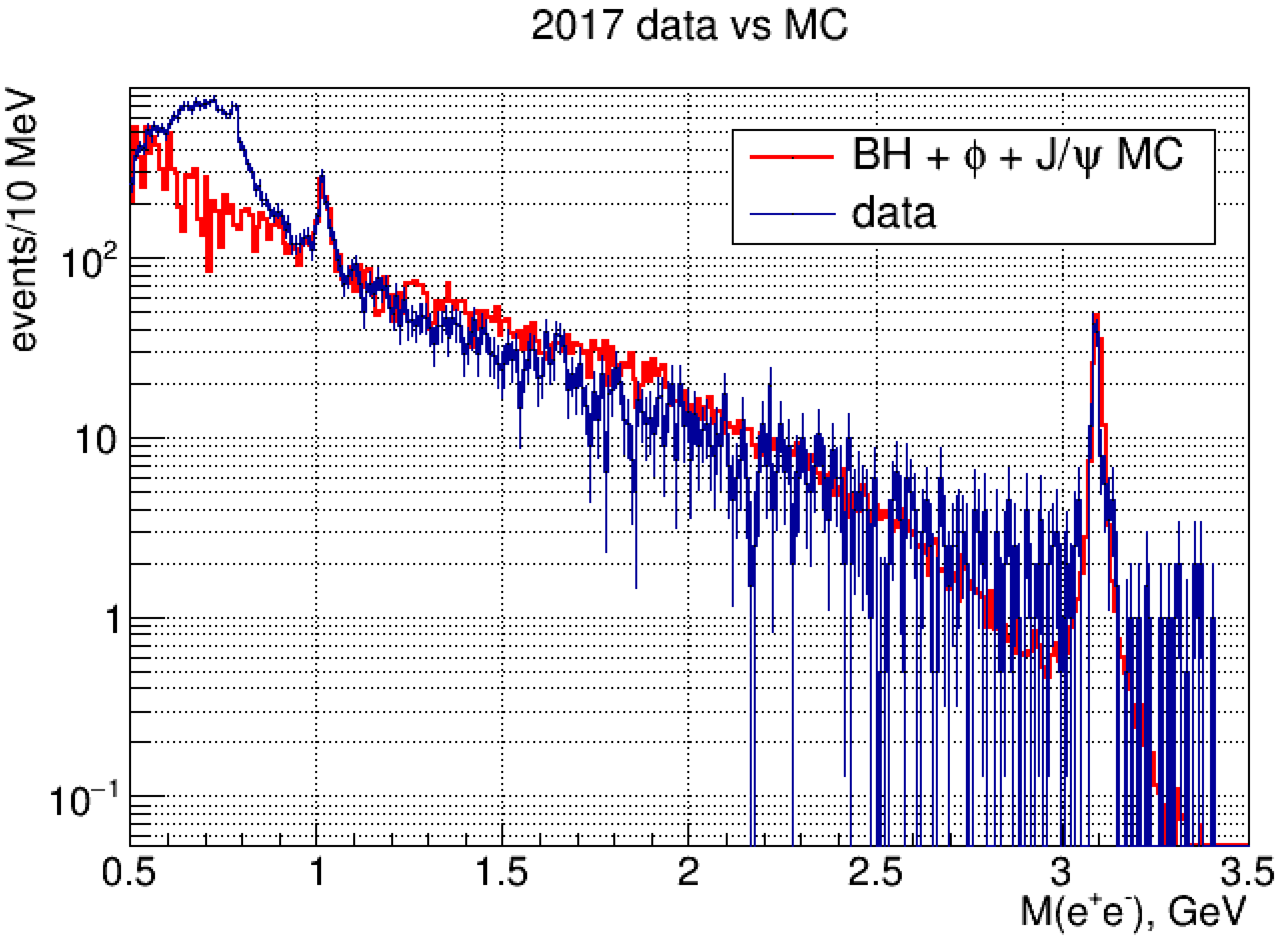
J/ψ analysis status

- Exclusive reaction: $\gamma p \rightarrow e^+e^-p$
- Only 2017 (both LI and HI) data in this presentation
- New reconstruction/analysis:
  - Default analysis cuts
  - Kinematic fit with loose χ^2 cut (<5000)
  - Initial $E/p>0.7$ cut for electrons
  - Accidentals subtracted using one bunch peak on each side (so far)
  - All other cuts are discussed
  - Identical cuts used for data and MC

- Same version used for MC with random hits included
- Only Bethe-Heitler and J/ψ so far (using old ϕ MC)
- In this presentation MC means: simulation results times cross-section times luminosity – NO NORMALIZATION to data

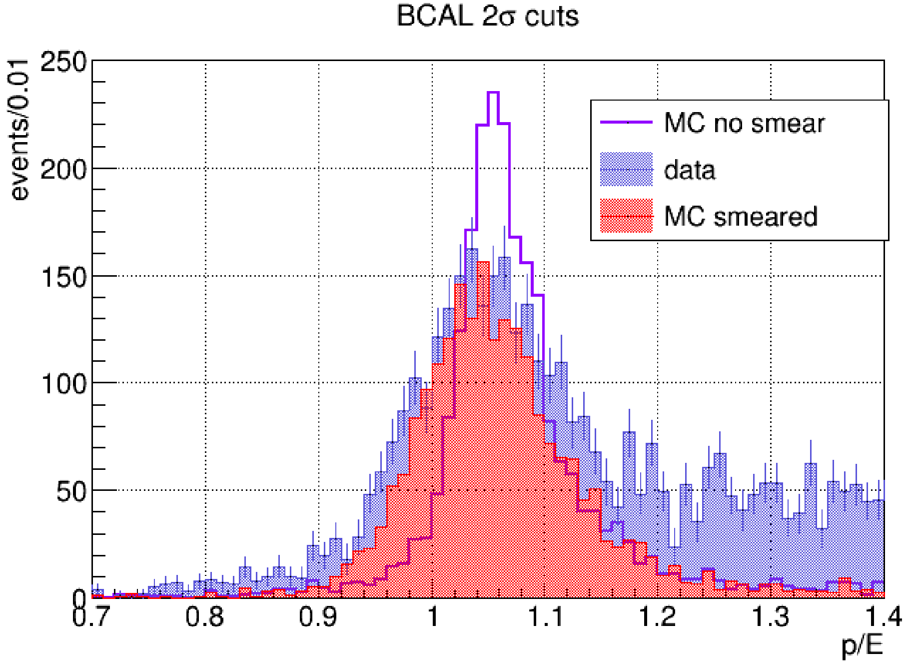
Data vs MC: $M(e^+e^-)$

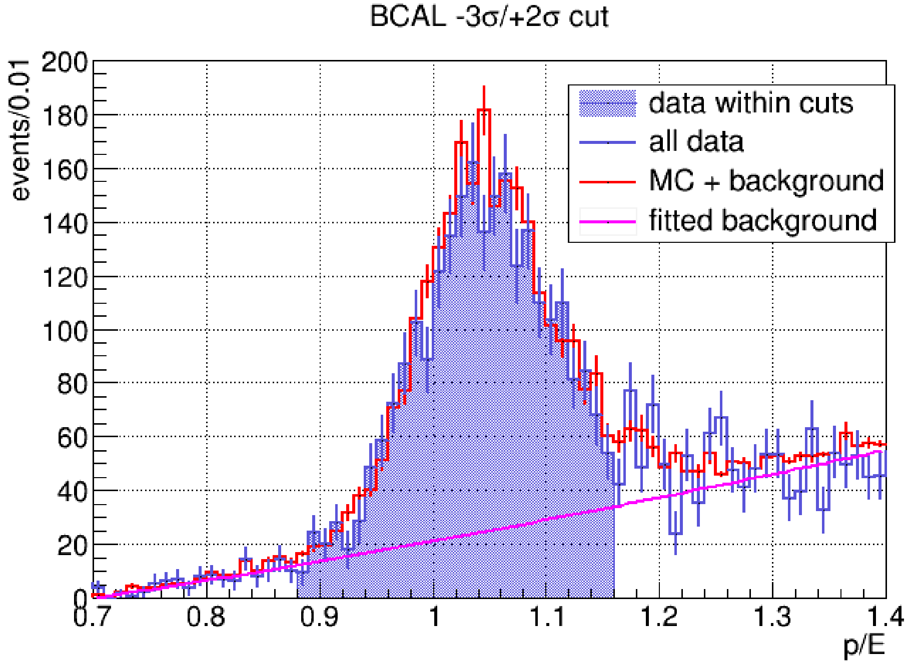
- Good agreement for $M(e^+e^-)>1$ GeV, over two magnitudes
- Only J/ψ cross-section fitted to the data
- $\sigma(\phi)=550\pm70$ nb
- BH calculated (discussed later)



p/E cuts - BCAL

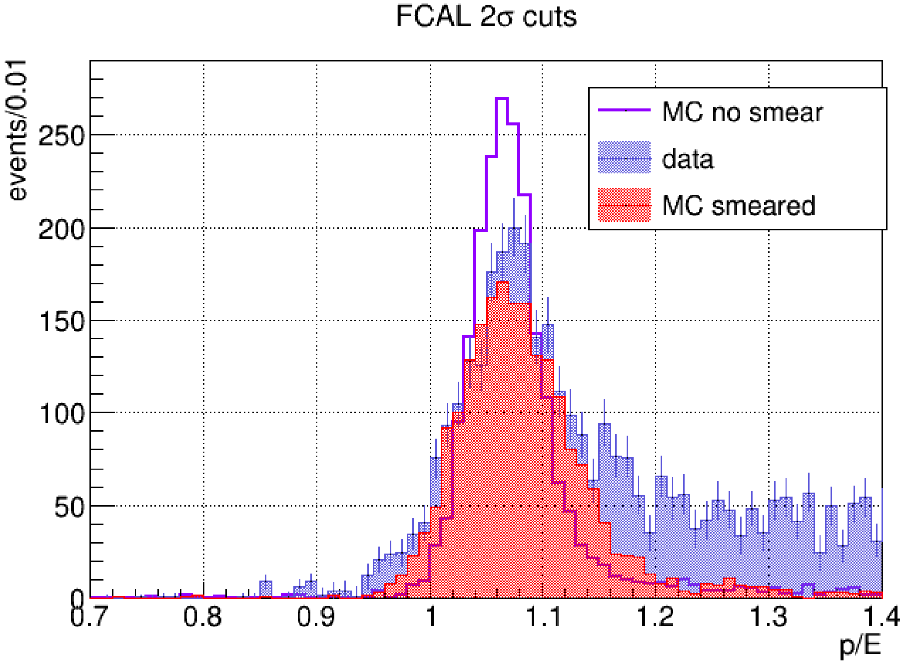
- Data vs BH MC simulations (M(e+e-)>1.5 GeV)
- Additional smearing (from 4.3 to 5.8%) applied to MC to match data width and mean
- All other cuts applied (discussed later)
- Background fitted with polynomial (quadratic)
- Estimated background contribution for -3σ/+2σ cut: 26%

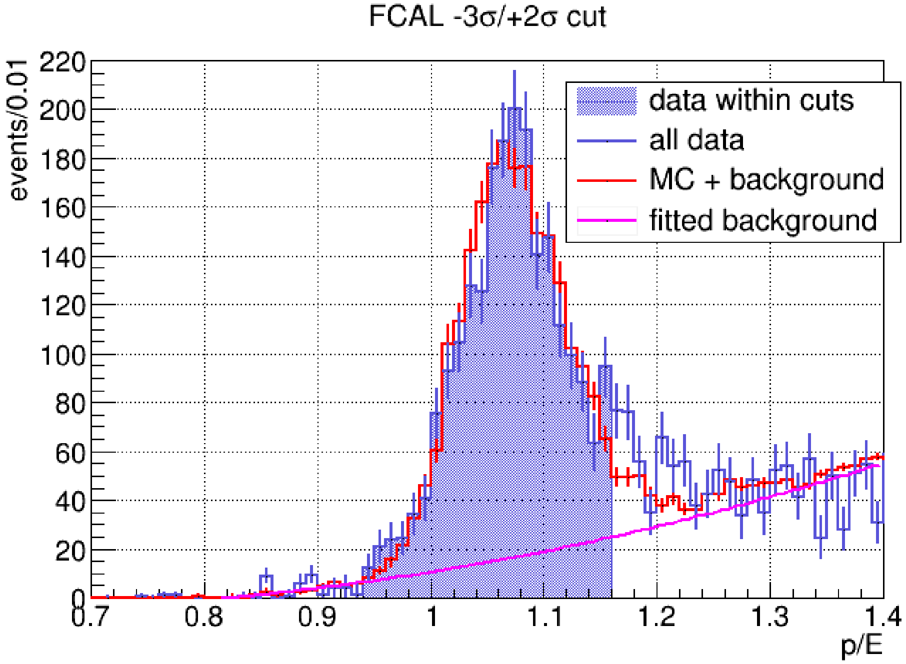




p/E cuts - FCAL

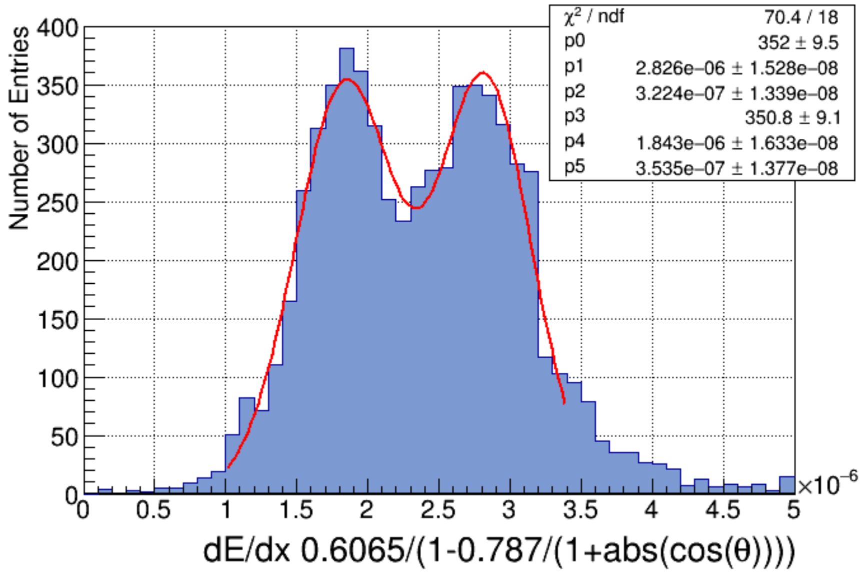
- Data vs BH MC simulations (M(e+e-)>1.5 GeV)
- Additional smearing (from 3.2 to 4.5%) applied to MC to match data width and mean
- All other cuts applied (discussed later)
- Background fitted with polynomial (quadratic)
- Estimated background contribution for -3σ/+2σ cut: 16%



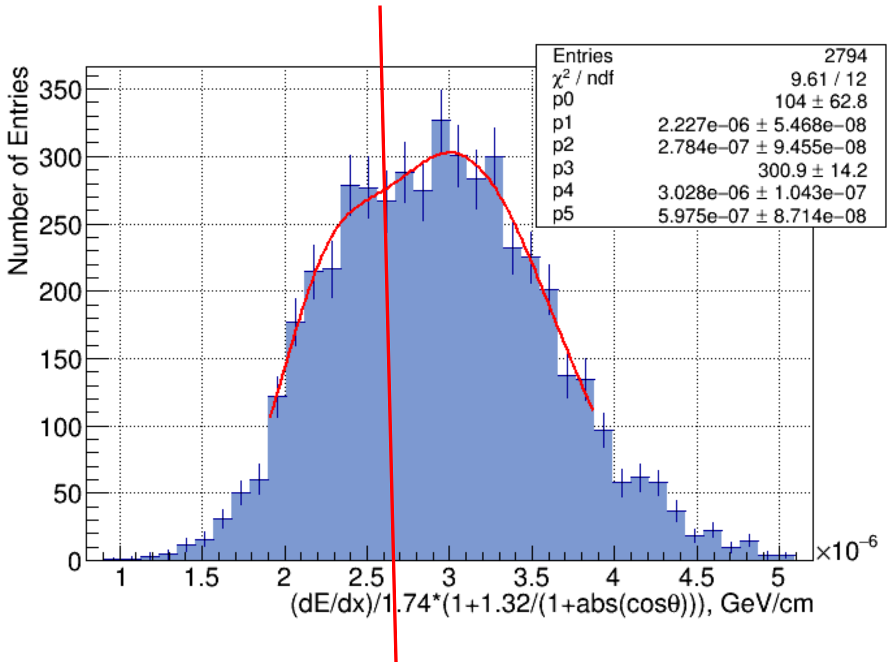


CDC dE/dx cut

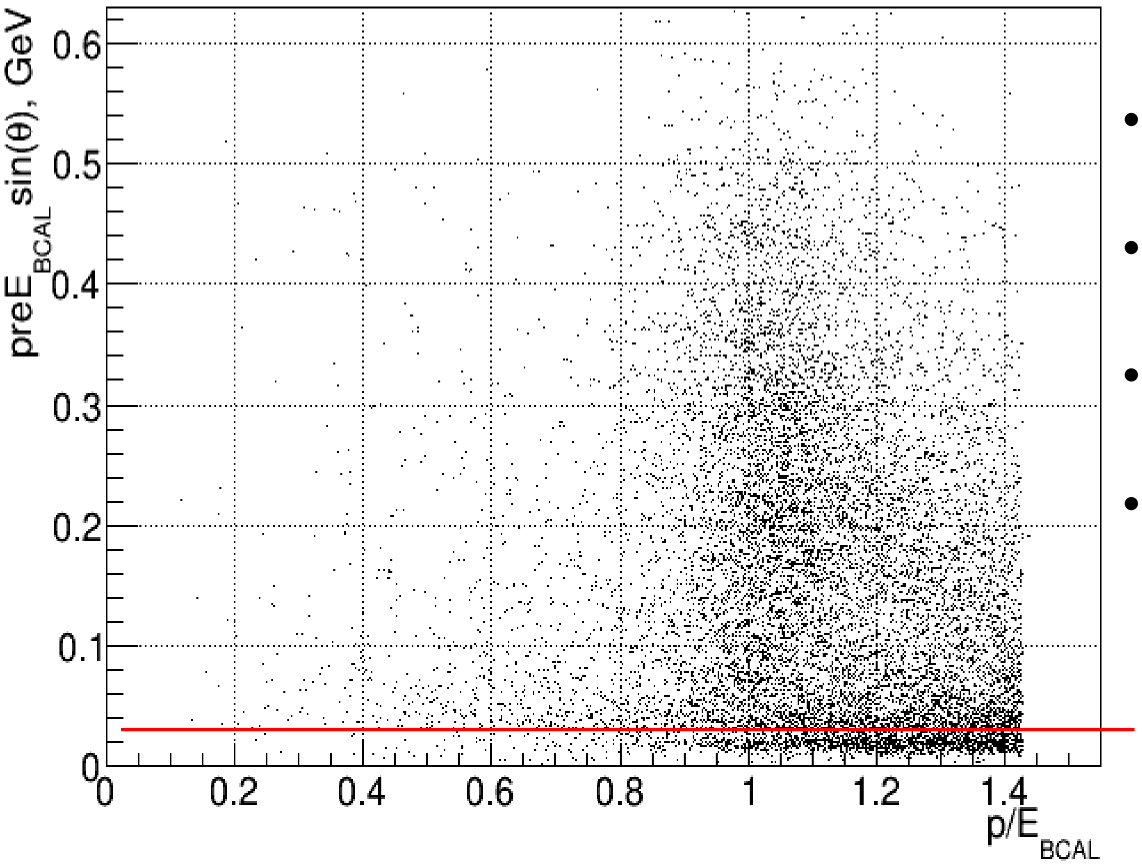
- Old analysis and using integral



New analysis and using peak amplitude

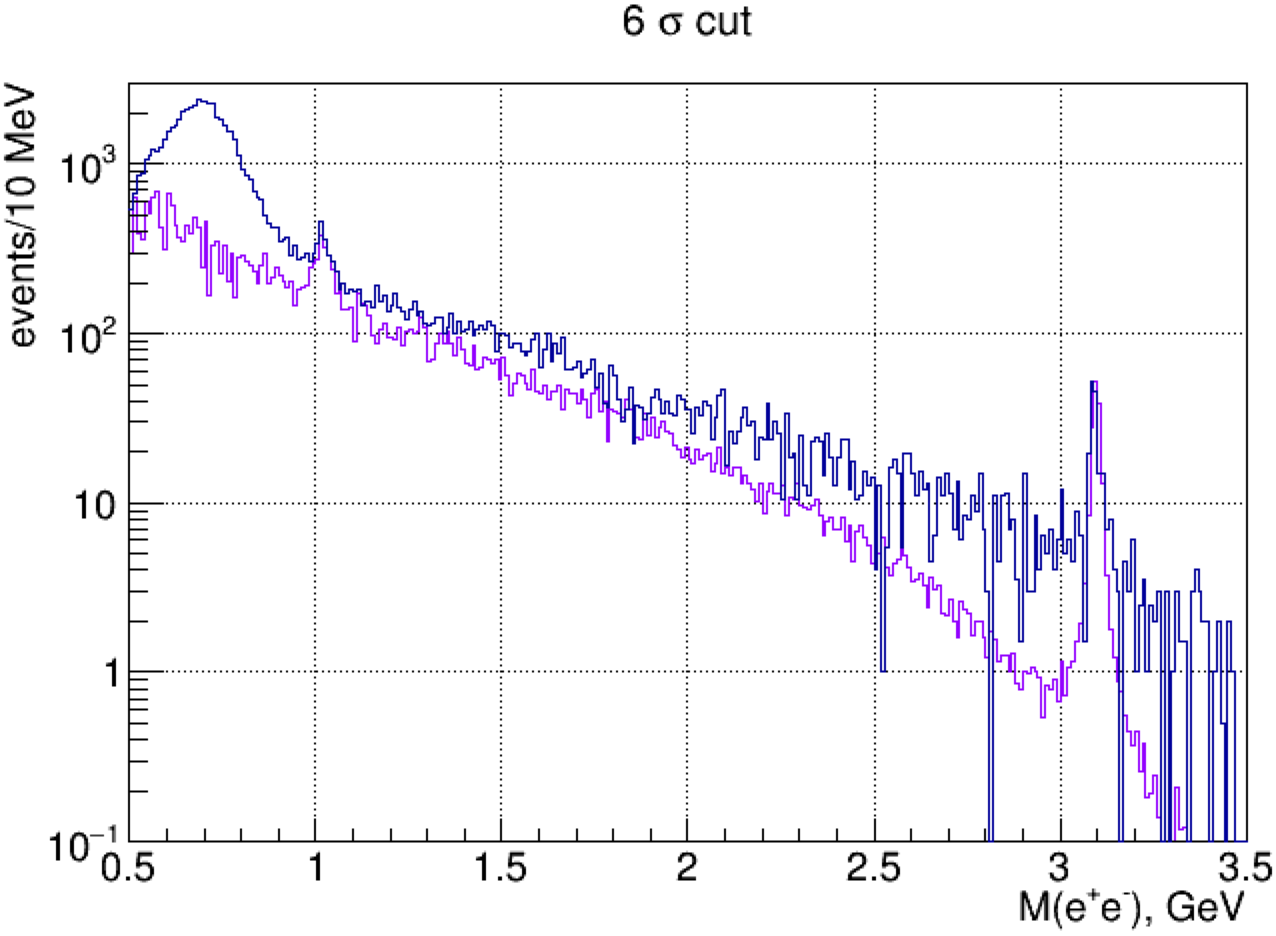


BCAL pre-shower and other cuts

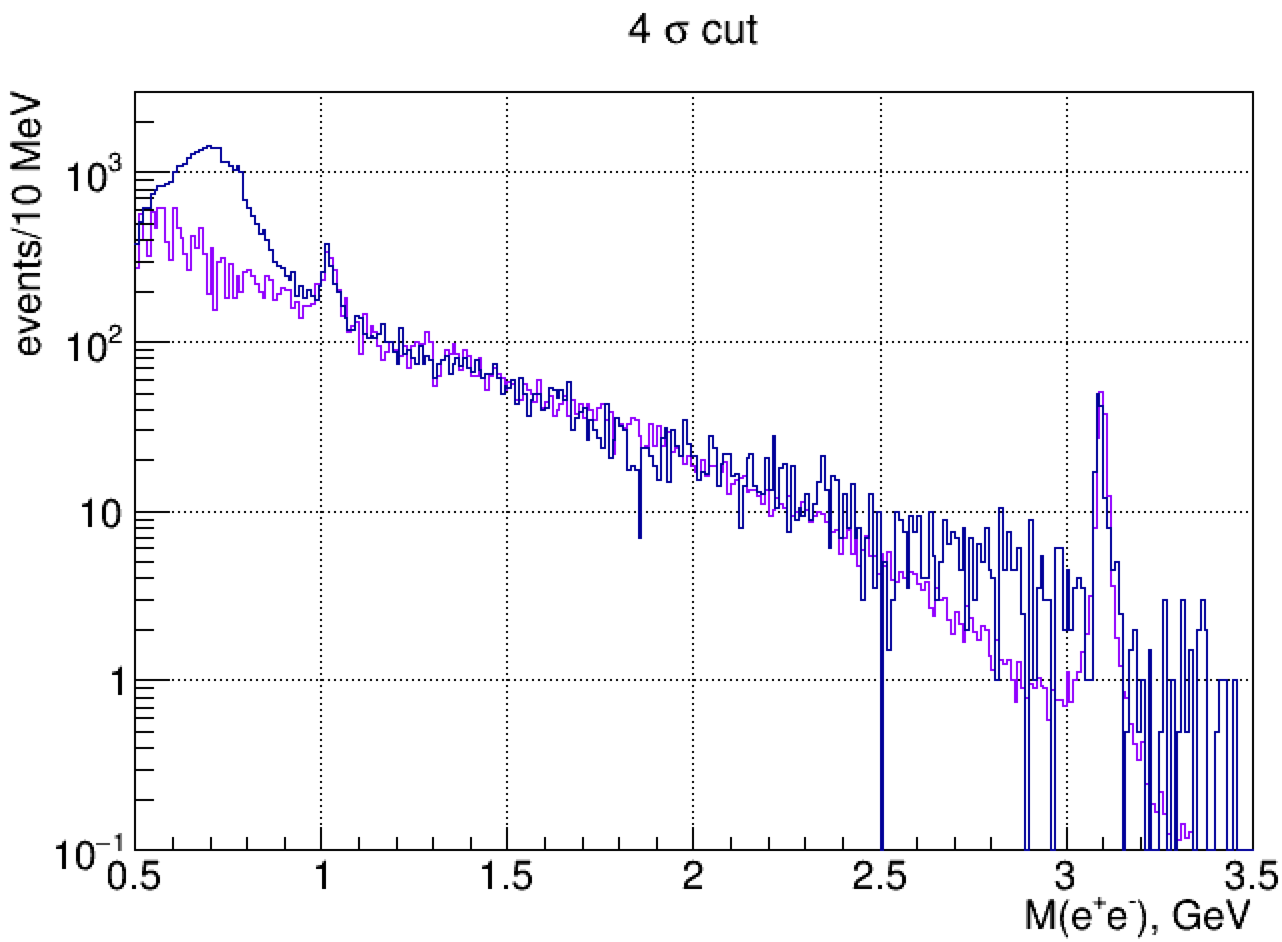


- BCAL presh. * sin(θ)> 30 MeV
- θ(e+,e-)>2 deg
- p(e+,e-)>0.4 GeV
- abs(M(p,π+/π-)-1.23)>0.1 GeV

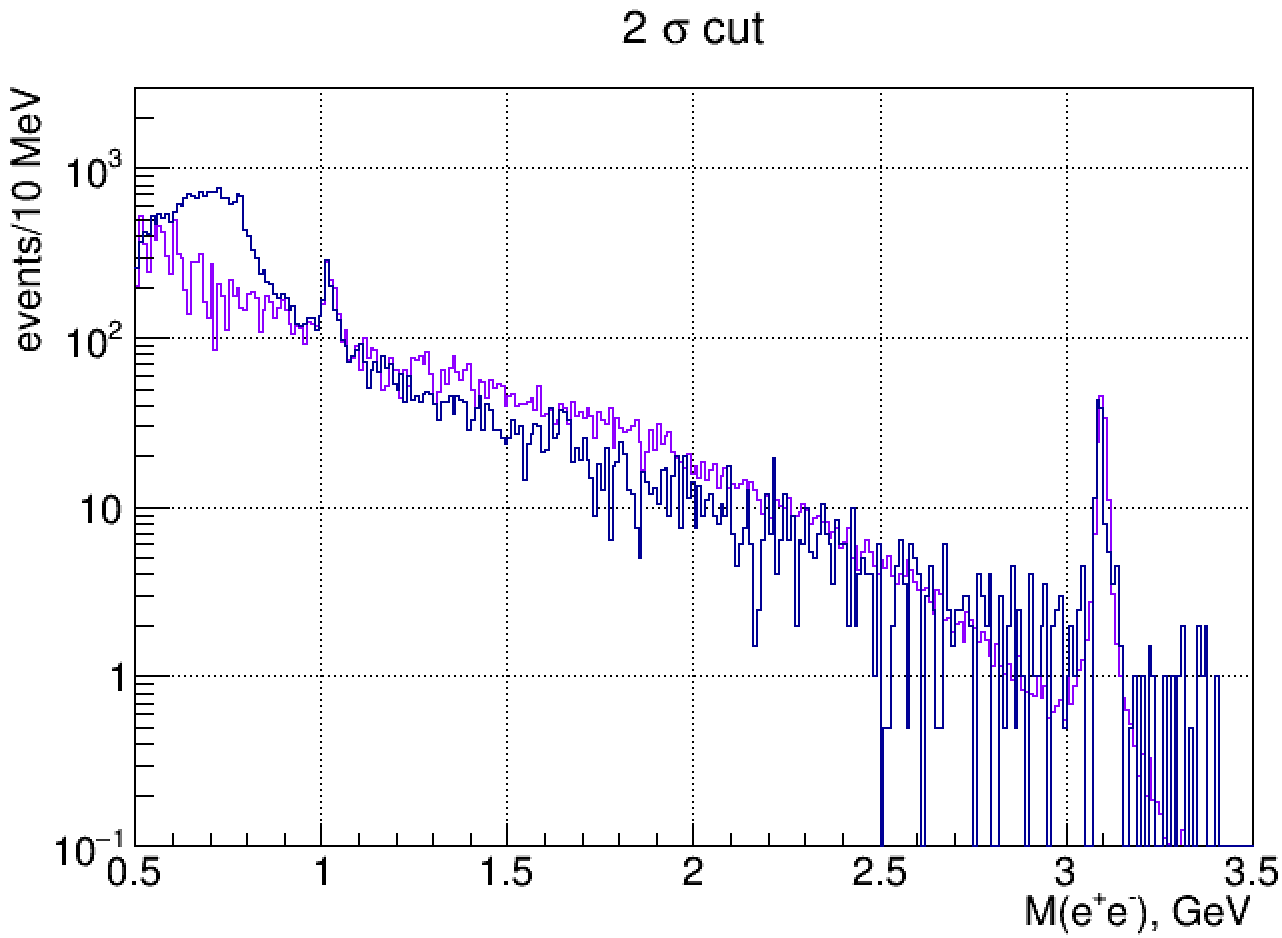
Data vs MC for different p/E cuts



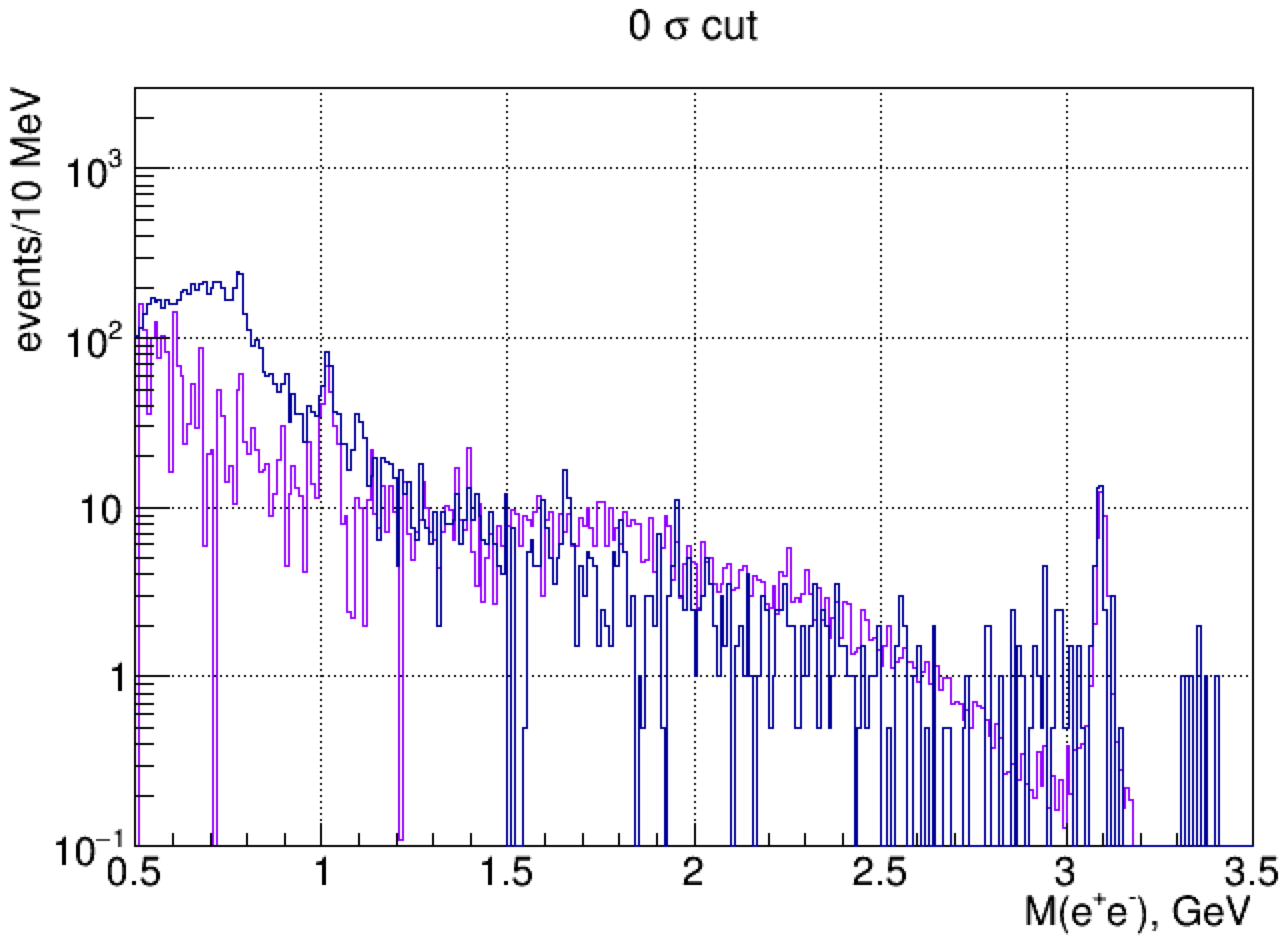
Data vs MC for different p/E cuts



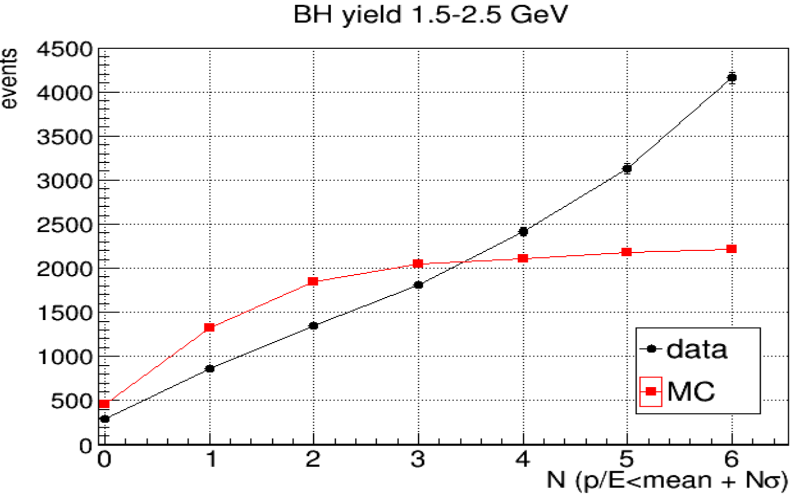
Data vs MC for different p/E cuts

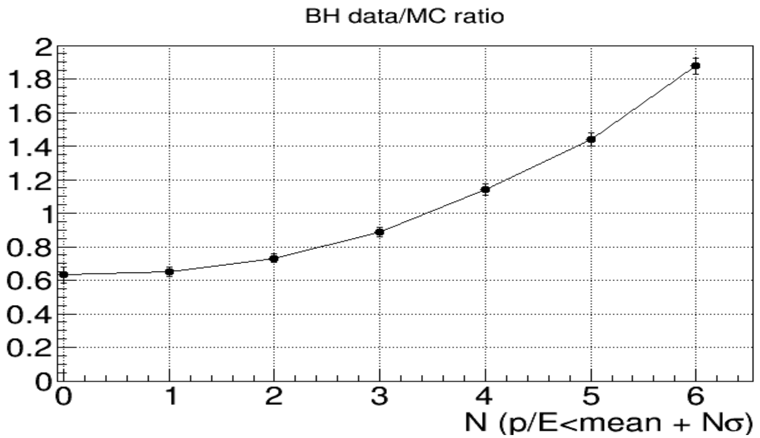


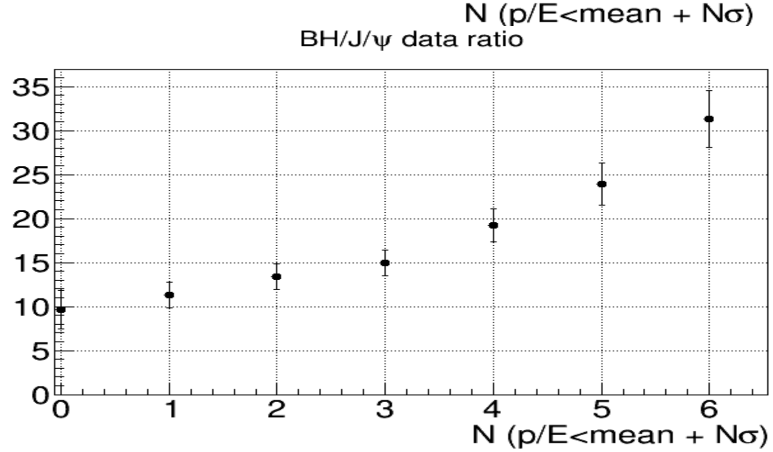
Data vs MC for different p/E cuts

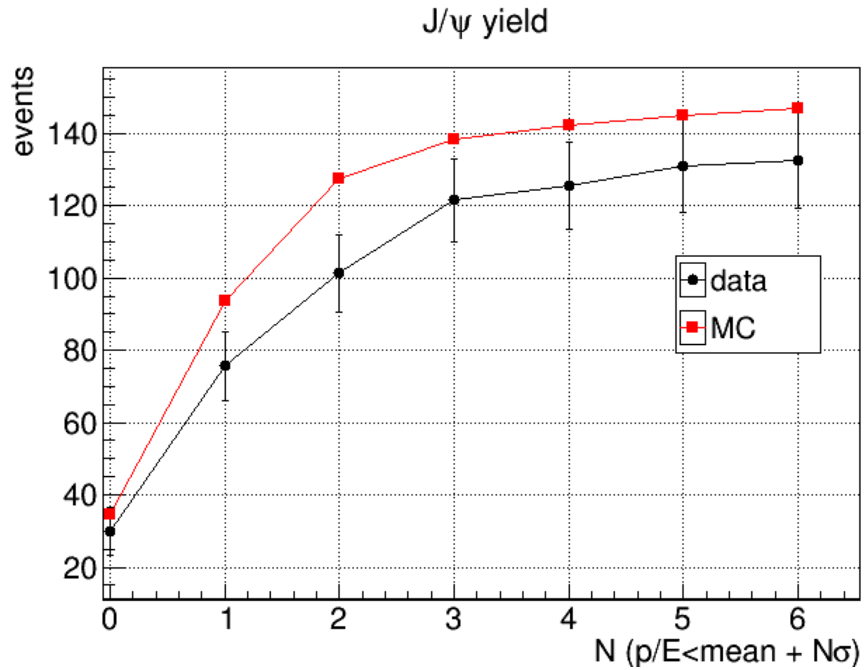


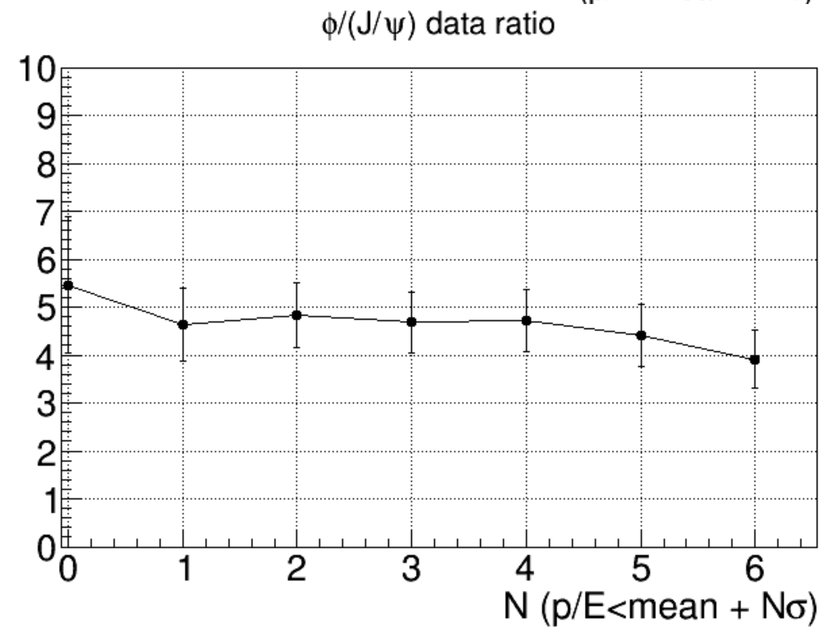
Varying p/E cut



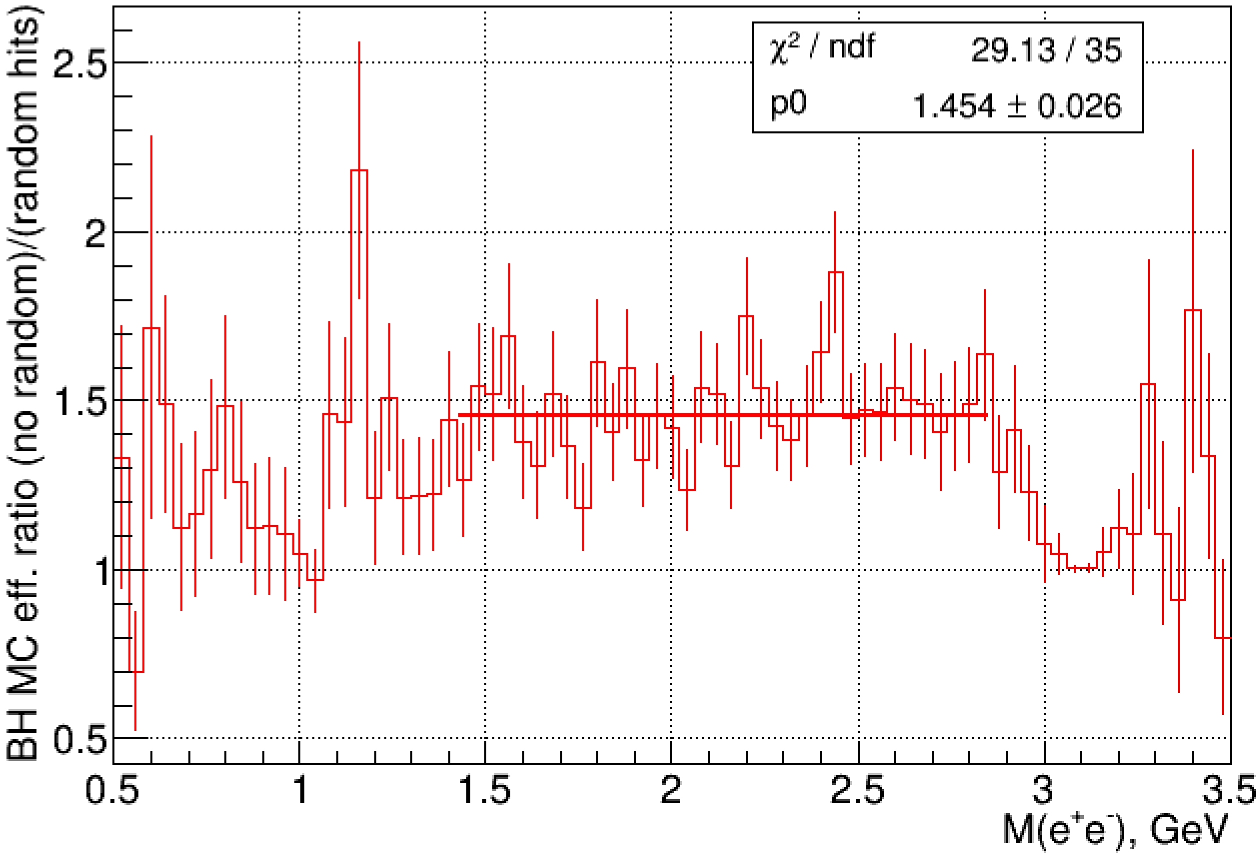








BH MC without/with random hits



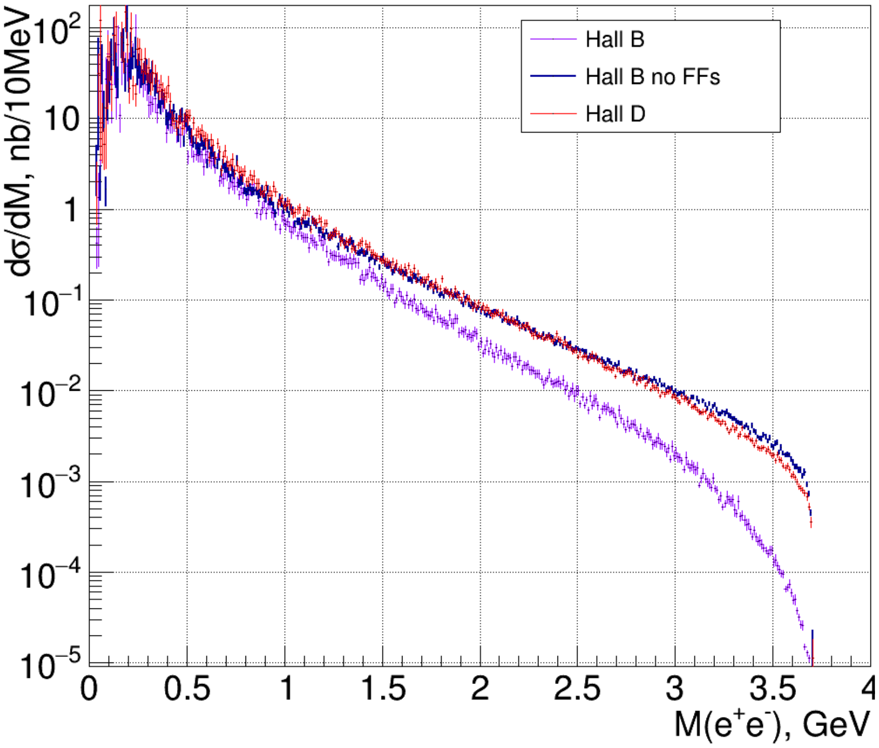
Bethe-Heitler Simulations

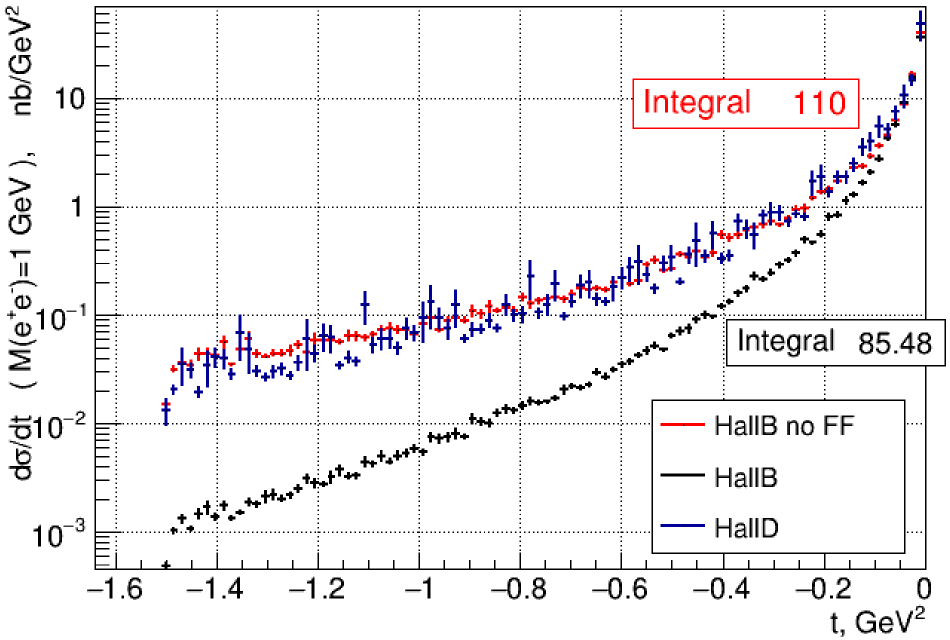
Generator /author	Based on	Proton FFs	Phase space	Singularities	Implemeted for HallD
Rafayel Paremuzyan	Berger et.al* formulas	yes	flat	Acceptance cut	yes
Mike Dugger	Feynman diag. (numerical)	no	weighted	Propagator cut	yes
Richard Jones	Feynman diag. (numerical)	yes	weighted	Propagator cut	no
Marie Boer	Berger at.al* formulas?	yes	flat	Acceptance cut	no

* Berger, E., Diehl, M. & Pire, B. Eur. Phys. J. C (2002) 23: 675.
https://doi.org/10.1007/s100520200917

Bethe-Heitler Simulations – proton FFs

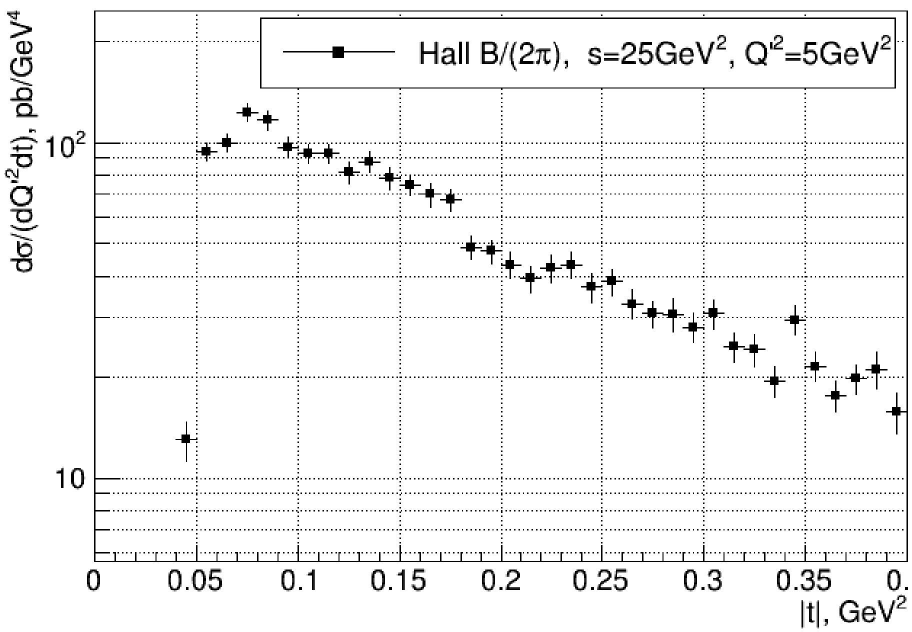
- Hall B (Rafayel) vs Hall D(Mike) E_γ = 11 GeV, θ_e>0.01
- Proton FFs explain differences
- Right plot: t dependence at M(e+e-)=1 GeV
- t_{min} increases with M(e+e-)

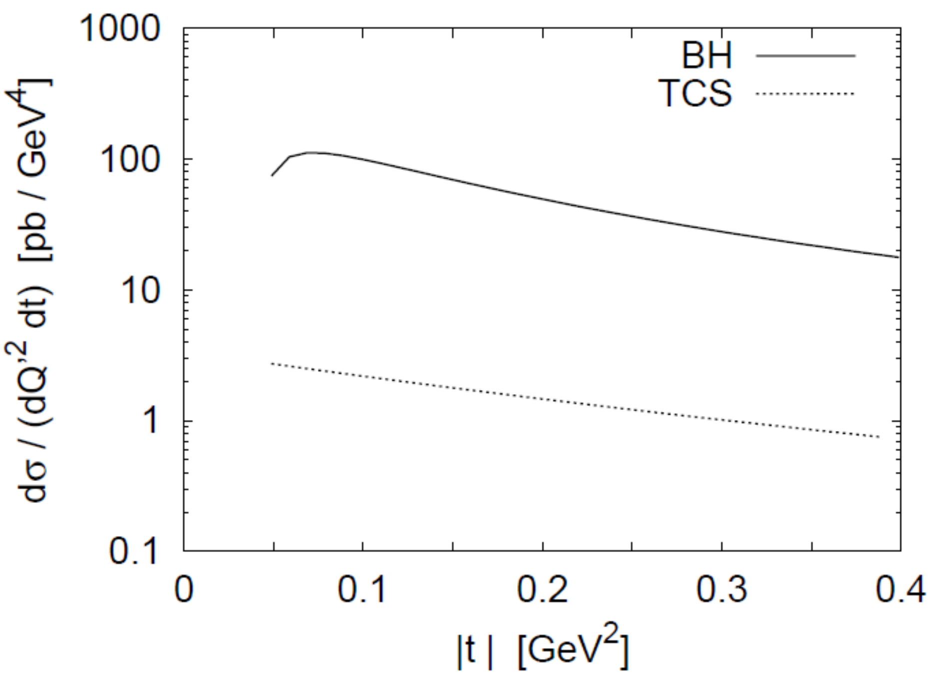




Bethe-Heitler Simulations

- Hall B vs Berger et.al paper

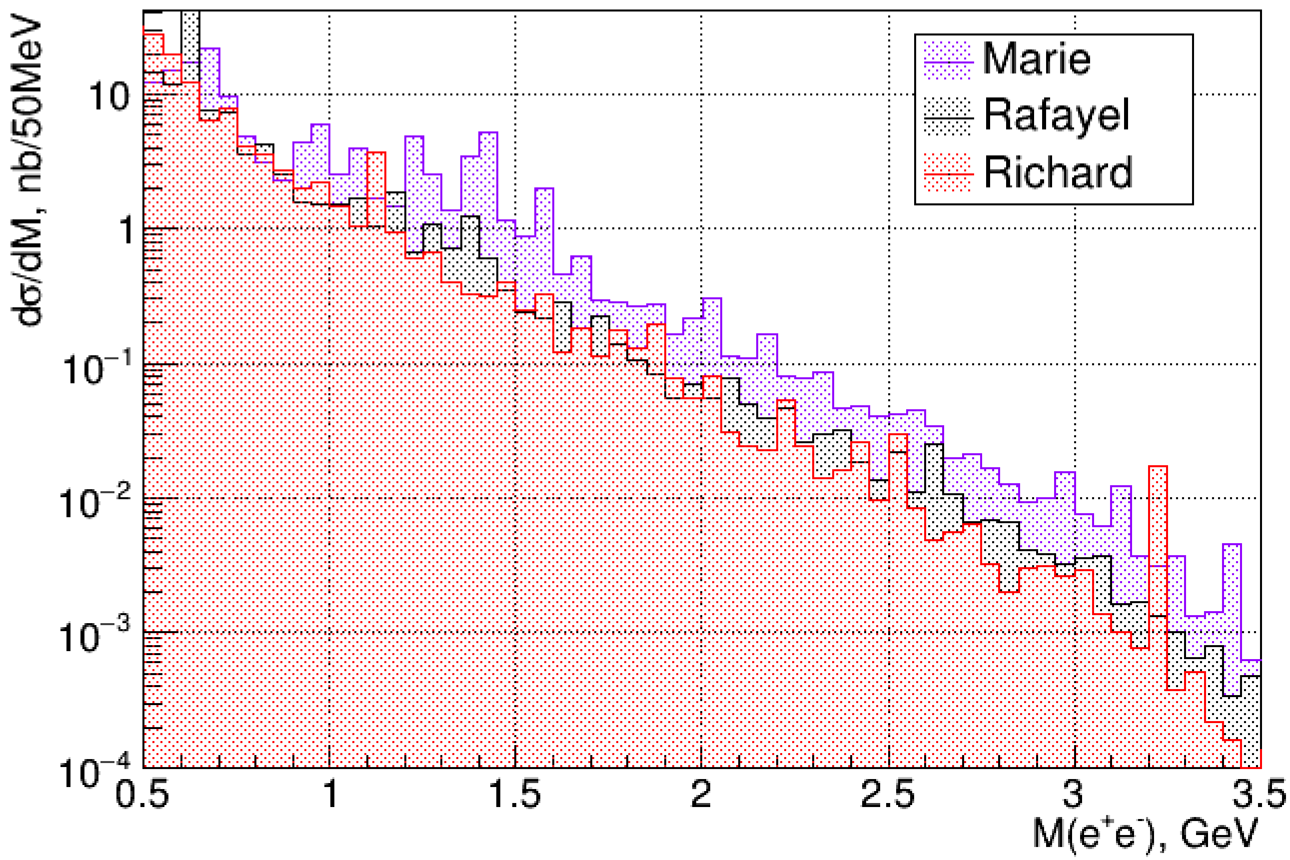




- s = 25 GeV^2 Q'2 = 5 GeV^2

Bethe-Heitler Simulations

- Three BH generators: using dipole FFs

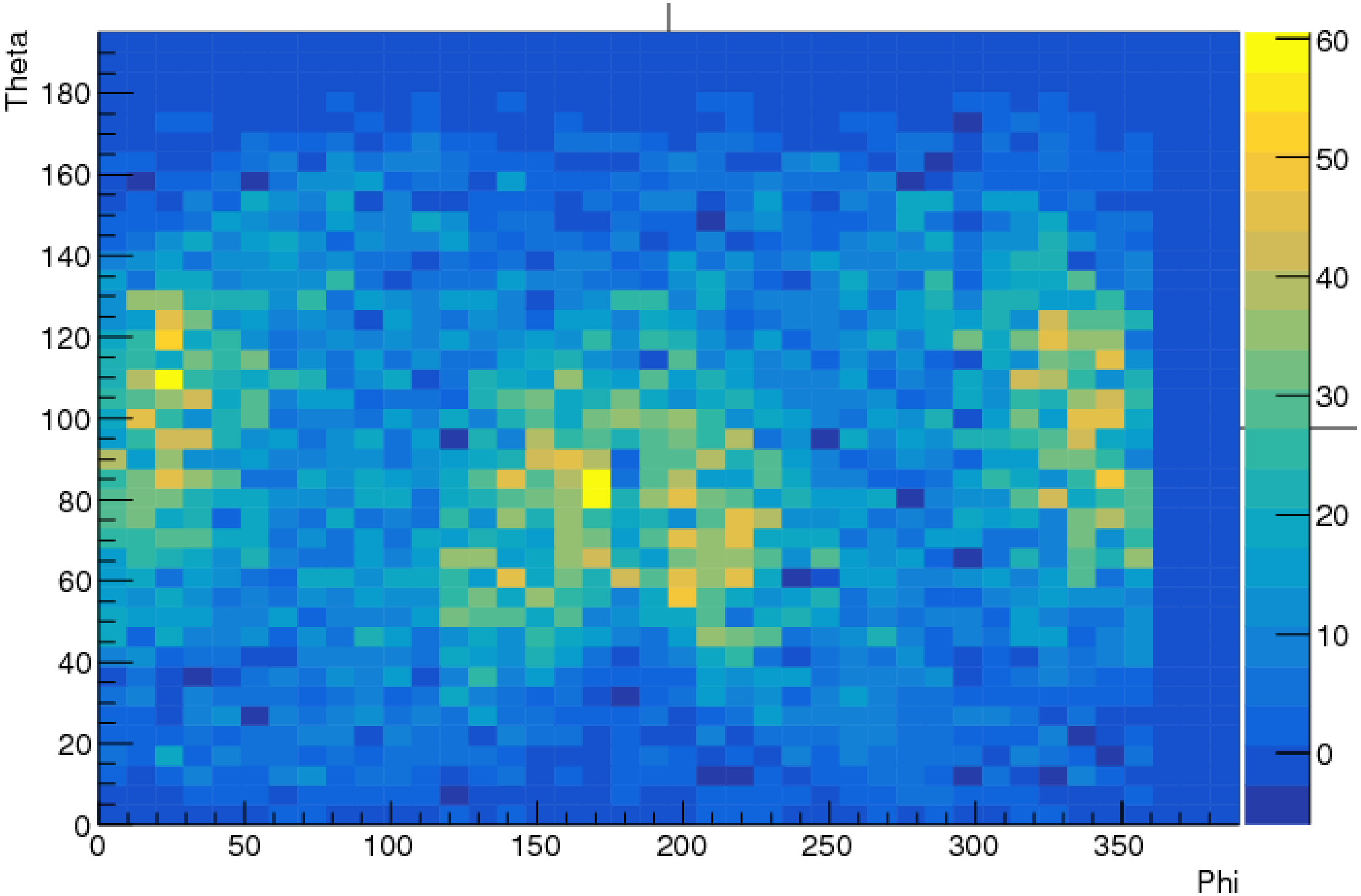


E_γ = 11 GeV   40<θ<140   0.04<|t|<3.5 GeV^2

Bethe-Heitler Simulations - uncertainties

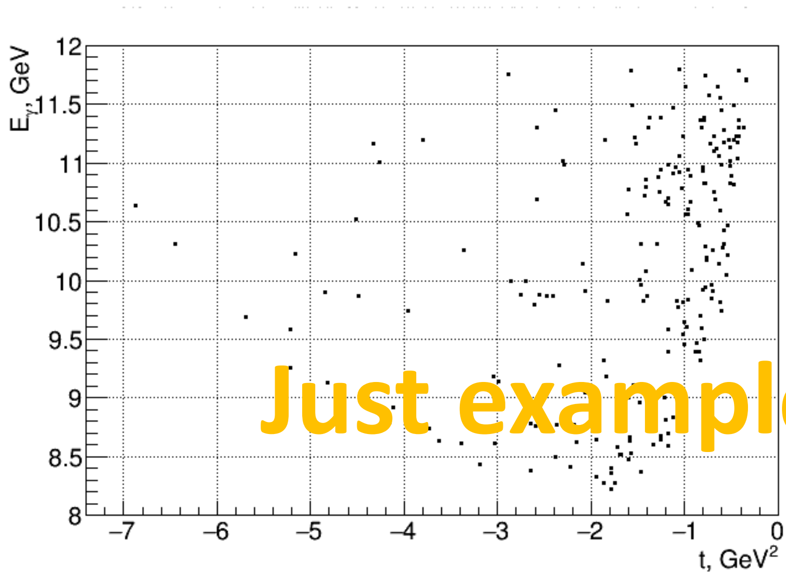
From Marie B.:

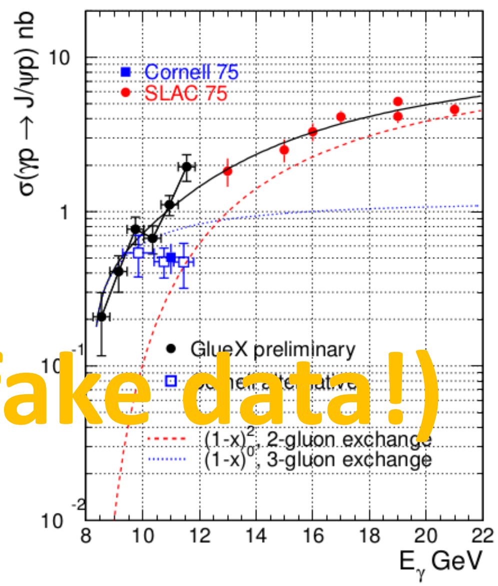
- Singularities for $\theta_{cm(e+e-)} \rightarrow 0$ and π
- Additional uncertainties from TCS contribution
- Estimated ~20%(?) uncertainties



Outlook

- BH is the only option we can do normalization in bins of energy (needed for the highest energy point!)
- Need to finalize cuts
- Run reconstruction/analysis over 2016 data
- Expect something like this:





Just examples (fake data!)

- Estimate the pentaquark BR limits
- Estimate systematics

From Sean

Model Fitting

- Want to test different production models and provide accurate determination of the confidence intervals of their parameters
- Implementing unbinned fitter
  - Performing toy MC tests to verify accuracy
- Plan: Finalize fitting code and extract expected limits before applying to data

$$\frac{d\sigma}{dt} \propto \frac{1}{E_\gamma^2} A^2 e^{2b(t-t_0)} \left(\frac{s-s_{\text{thr}}}{s_0}\right)^{2\alpha(t)}$$

with

$$\begin{aligned} \alpha(t) = \alpha_0 + \alpha' t \quad &: \quad \text{Pomeron} \\ A \quad &: \quad \text{Normalization} \\ b \quad &: \quad t - \text{Slope} \end{aligned}$$

Total cross section:

$$\sigma = \int_{t_{\text{max}}}^{t_{\text{min}}} \frac{d\sigma}{dt} dt$$

JPAC Model via A. Austregeslio

From Sean

Model Fitting

- Example: JPAC model
  - $N(J/\psi) = 300$
  - $M(P_c) = 4.45$ GeV
  - $\Gamma(P_c) = 0.039$ GeV
  - $spin(P_c) = 5/2$
  - $Br(P_c \rightarrow J/\psi + p) = 3\%$
  - Statistical uncertainties only