J/ψ @ SoLID

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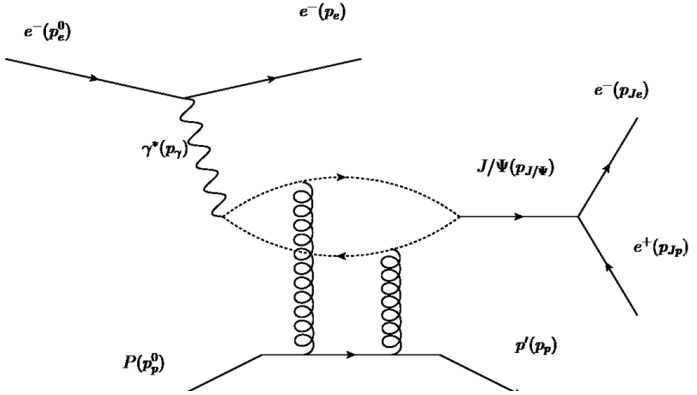
2015/5

PID

$$e\,p \rightarrow e'\,p'\,J/\psi(e^-\,e^+)$$

$$\gamma\,p \rightarrow p'\,J/\psi(e^-\,e^+)$$

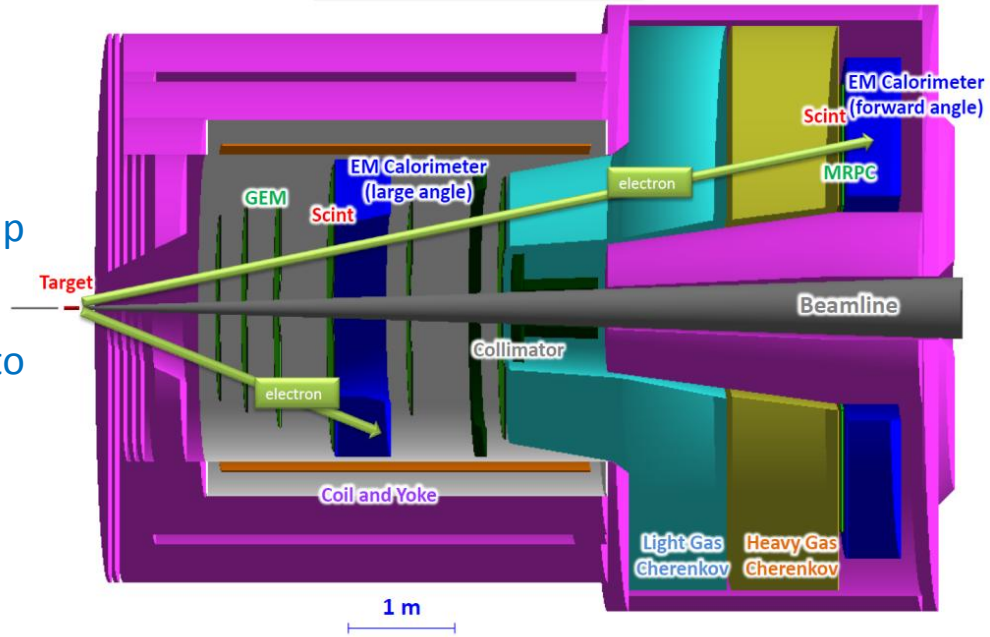
$$\gamma^* + N \rightarrow N + J/\psi$$



- electroproduction detect decay e^- e^+ pair and scattered e^-
- photoproduction
  detect decay e^- e^+ pair and recoil p

SoLID (J/ψ)

- Scattered e^- and Decay e^-/e^+:
  - EC + SPD + CC @ forward angle
  - EC + SPD @ large angle
- Recoil p:
  - 100 ps TOF(MRPC): 4 σ separation p/K up to 4.5 GeV and p/pi up to 5GeV @ forward angle
  - 150 ps TOF(SPD): 4 σ separation p/K up to 2GeV and p/pi up to 2.5 GeV @ large angle (new)



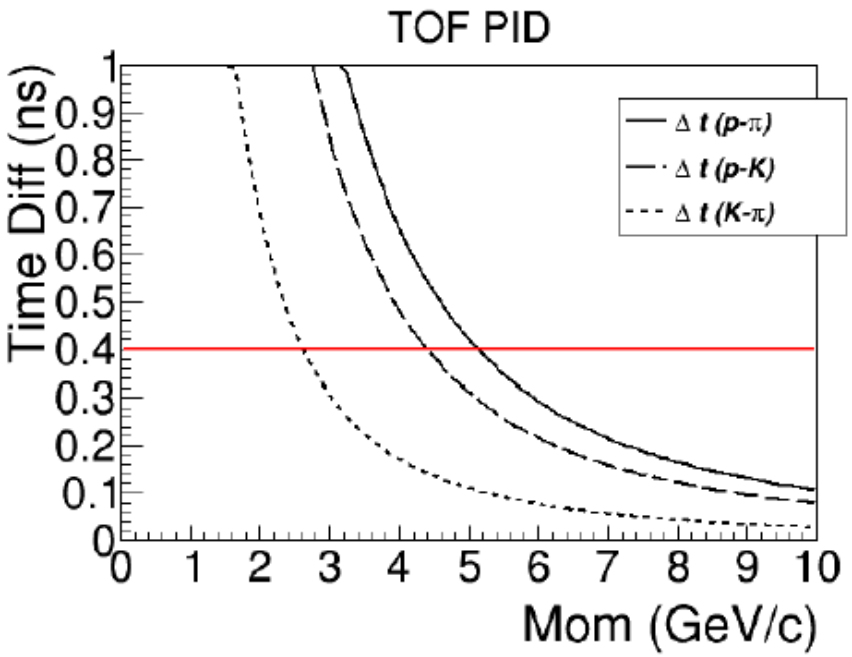
TOF

Recoil p:

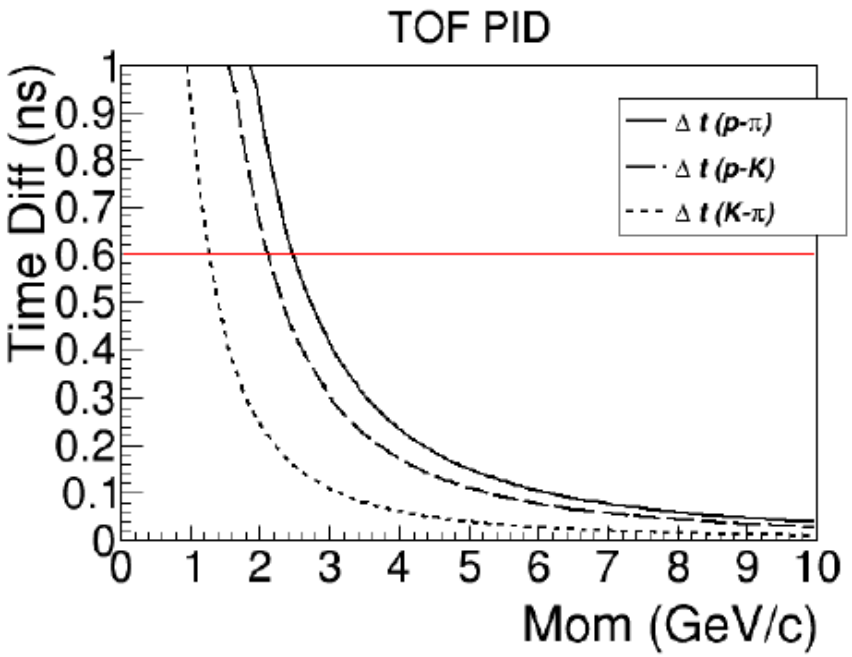
100 ps TOF(MRPC): 4 σ separation p/K up to 4.5 GeV and p/pi up to 5GeV @ forward angle

150 ps TOF(Scint): 4 σ separation p/K up to 2 GeV p/pi up to 2.5GeV @ large angle

FA



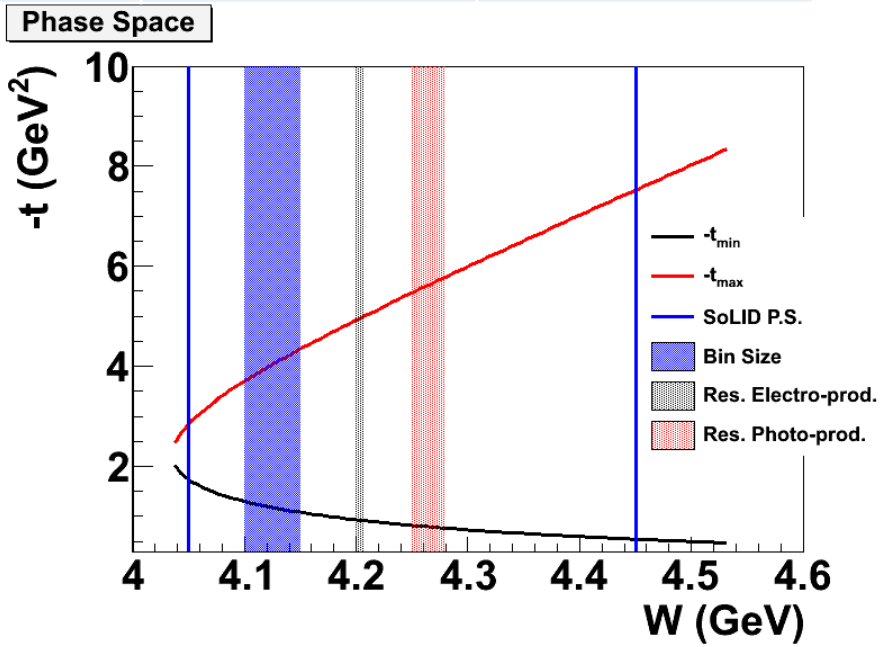
LA



Electroproduction vs. Photoproduction

production	Energy resolution	W reach	Background	Statistics
Electro-	better	lower	less	less
Photo-	worse	higher	more	more

- Electroproduction
  - virtual photon energy solely determined by detection of scattered e^-, like a tagged virtual photon beam
  - non-zero Q2 gives lower W reach
  - More final particle detection can have less background
- Photoproduction
  - photon energy derived from detection of recoil p, decay e-, decay e+
  - more statistics

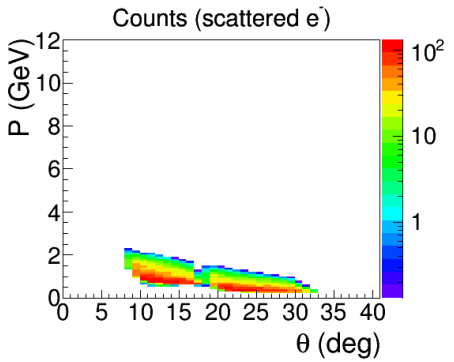


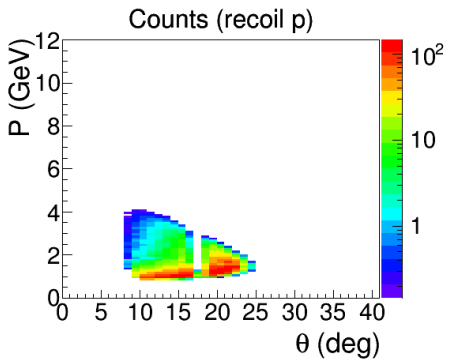
$$W^2 = 2\nu \cdot M_p + M_p^2 - Q^2$$
$$= 2E_\gamma^{eff} \cdot M_p + M_p^2$$

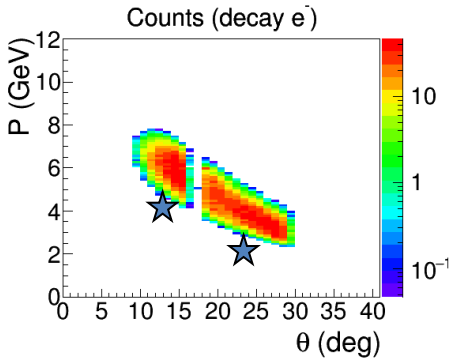
Trigger on decay e^- and decay e^+ to include both channels

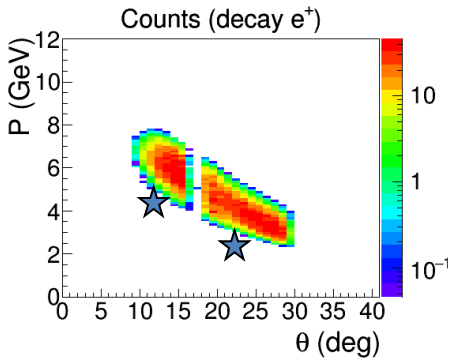
Acceptance (Electroproduction)

Require all 4 particles

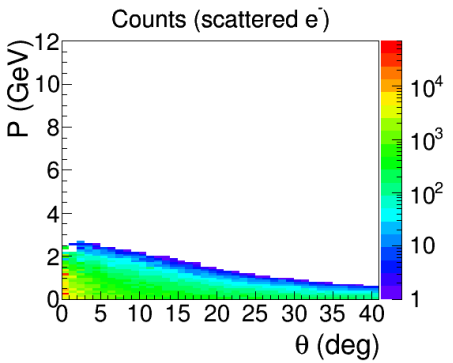


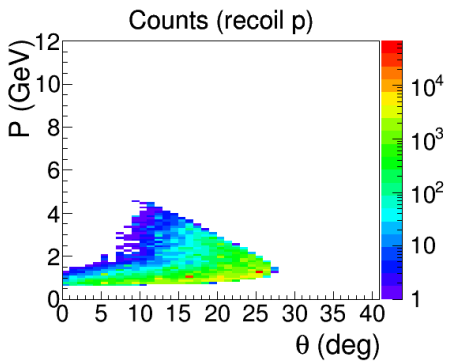


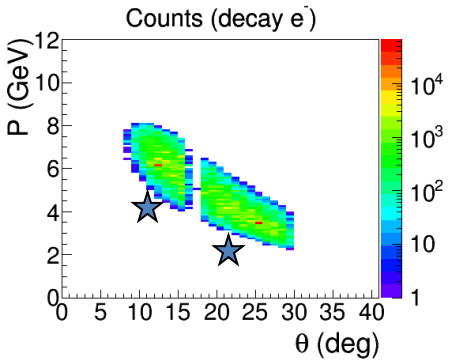


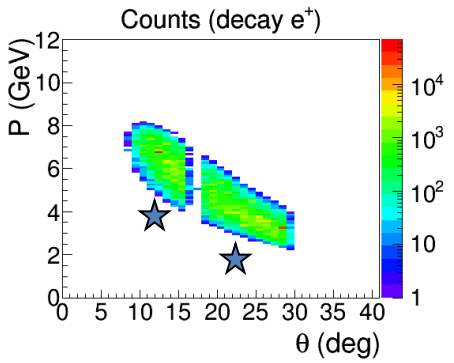


Require decay pair only









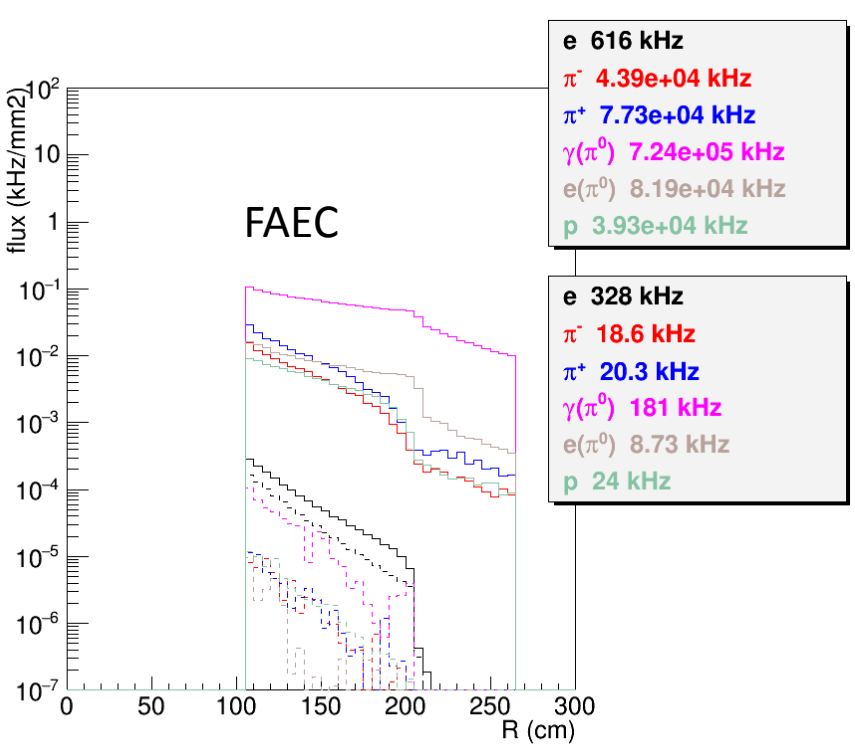
Possible Trigger 1 (flat): electron trigger by EC with 4GeV threshold at forward angle and 2GeV at large angle to detect decay pair (stars shows trigger energy)
This allows both electroproduction and photoproduction in data collection

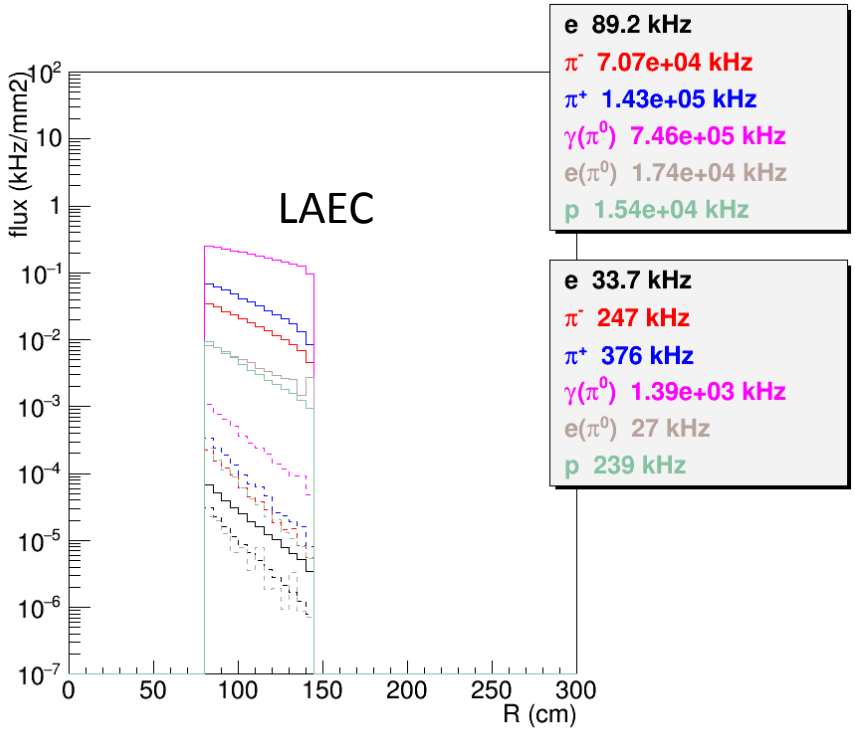
Acceptance for photoproduction needs further study

Lower energy electron detection needs further study

Possible Trigger 1 (flat)

- Done in the way similar to the trigger study for SIDIS_He3
- Single electron trigger by flat EC > 4GeV at FA and flat EC>2GeV at LA
- Histograms showing rate before and after trigger cut
- Using SIDIS_He3 EC trigger response for now, but luminosity (1e37/cm2/s) are similar for both and background has no big effect on EC trigger for this level of luminosity)





Possible Trigger 1 (radial)

- MRPC+FASPD can reduce trigger rate from pi0 photon by factor 20
- LASPD can reduce trigger rate from pi0 photon by factor 5
- LGCC can reduce photon background by 40 and hadron backgroud by 40(rand. Coin.) and 55 (corr. Coin.)
- Single electron trigger including both FA and LA is about 1.54MHz
- Coincidence of two electron trigger within 30ns time window is 1.54e6*1.54e6*30e-9 = 71kHz, which is below 100kHz SIDIS Setup limit

Single electron trigger

FA (4GeV flat)

335kHz

=328+4+4/40+181/20/40+(18+20+24)/40+(18+20+24)/55

=328(e) + 4(e(π^0) front) + 0.1(e(π^0) back) +0.23(γ(π^0)) + 1.6(hadron rand. coin.) + 1.1(hadron corr. coin.)

LA (2GeV flat)

1200kHz

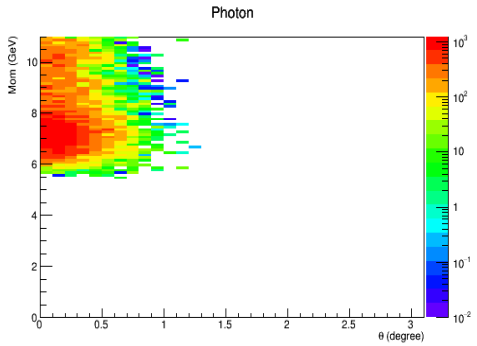
= 33+27+1390/5+(247+376+239)

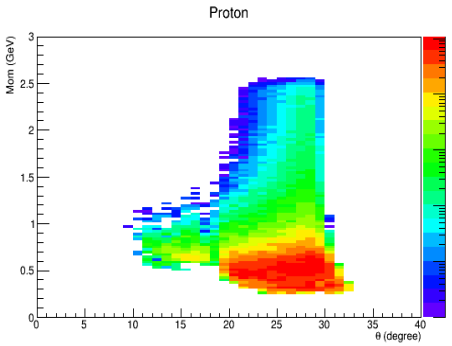
= 33(eDIS) + 27(e(π^0))+ 270(γ(π^0))+862(hadron)

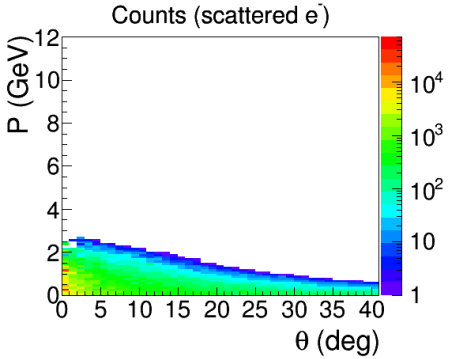
Acceptance comparison

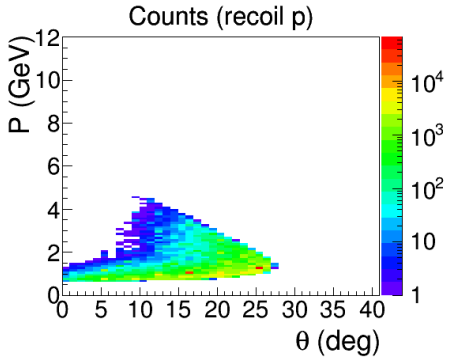
TCS/BH (photo + quasi-photoproduction)
Require proton and decay pair

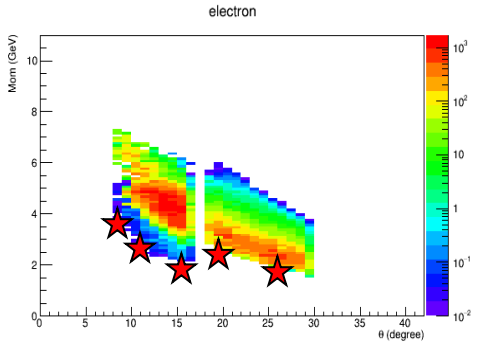
Jpsi (Electroproduction)
Require decay pair only

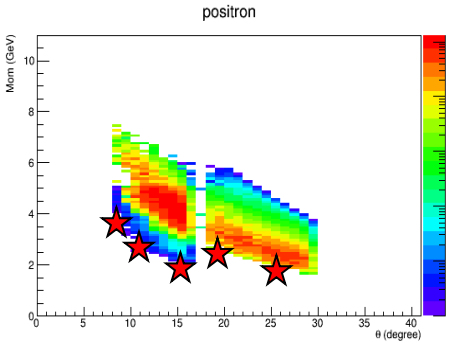


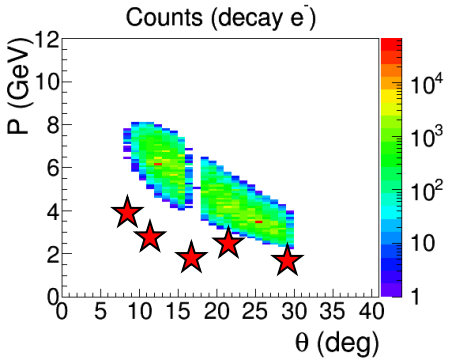


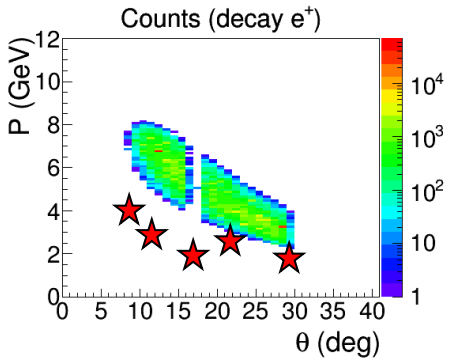










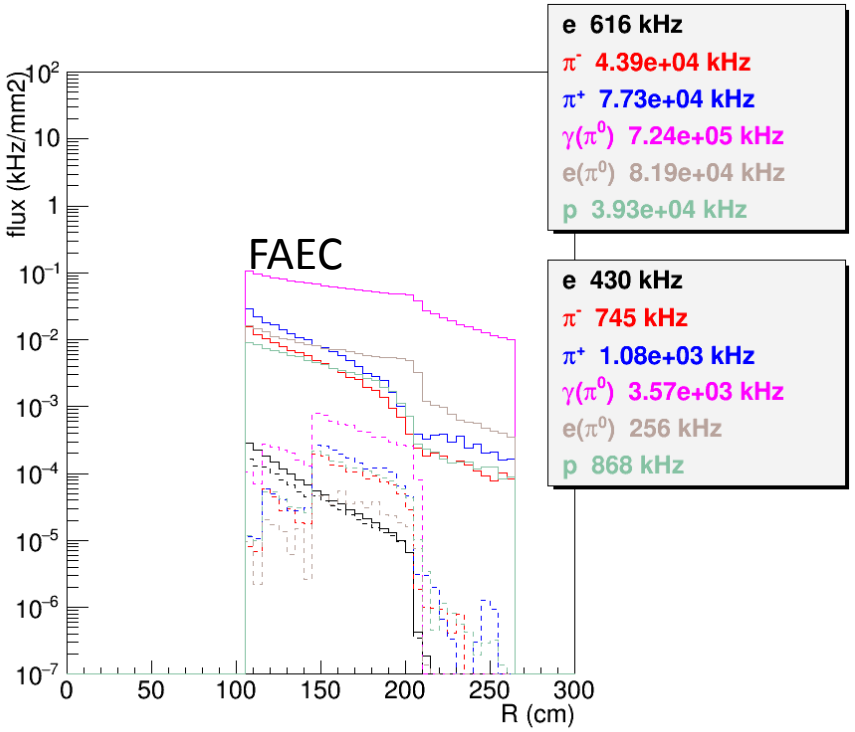


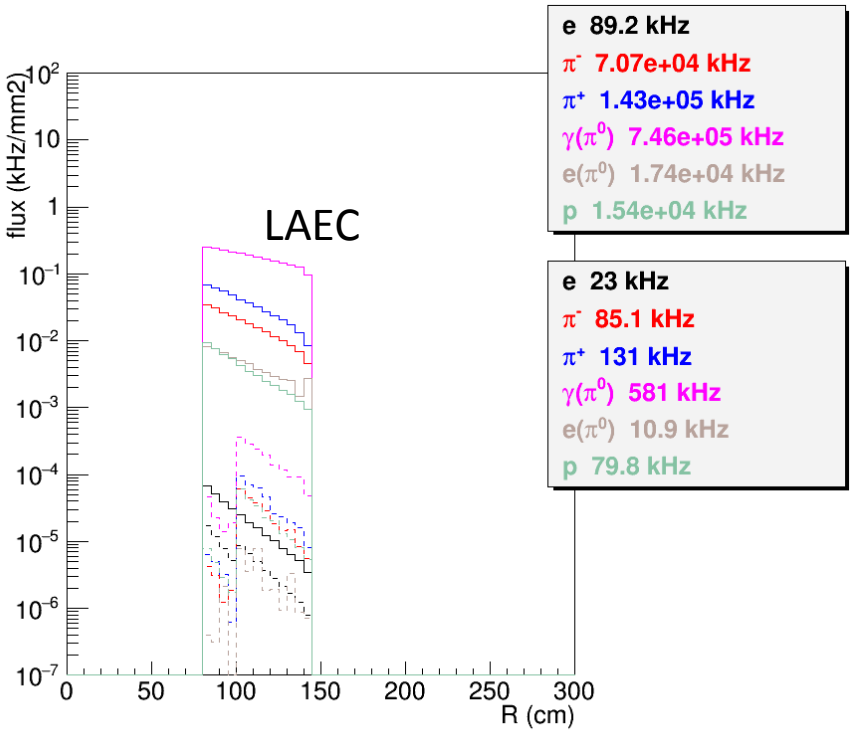
Possible Trigger 2 (radial): electron trigger by FAEC with 4GeV (r=105-115cm), 3GeV (r=115-145cm) and 2GeV (r=145-235cm), by LAEC with 3GeV (r=80-100cm) and 2GeV (r=100-140cm) (stars shows trigger energy)

This allows both TCS and JPsi electroproduction and photoproduction in data collection

Possible Trigger 2 (radial)

- Done in the way similar to the trigger study for SIDIS_He3
- Single electron trigger by EC radial
- Histograms showing rate before and after trigger cut
- Using SIDIS_He3 EC trigger response for now, but luminosity (1e37/cm2/s) are similar for both and background has no big effect on EC trigger for this level of luminosity)





Possible Trigger 2 (radial)

- MRPC+FASPD can reduce trigger rate from pi0 photon by factor 20
- LASPD can reduce trigger rate from pi0 photon by factor 5
- LGCC can reduce photon background by 40 and hadron backgroud by 40(rand. Coin.) and 55 (corr. Coin.)
- Single electron trigger including both FA and LA is about 1.13MHz
- Coincidence of two electron trigger within 30ns time window is 1.13e6*1.13e6*30e-9 = 40kHz, which is below 100kHz SIDIS Setup limit

Electron trigger

FA (radial)

682kHz

=430+128+128/40+3570/20/40+(745+1080+868)/40+(745+1080+868)/55

= 430(e) + 128(e(π^0) front) + 3(e(π^0) back) +4.5(γ(π^0)) + 67(hadron rand. coin.) + 49(hadron corr. coin.)

LA (radial)

446kHz

= 23+11+581/5+(85+131+80)

= 23(eDIS) + 11(e(π^0))+ 116(γ(π^0))+296(hadron)

Summary

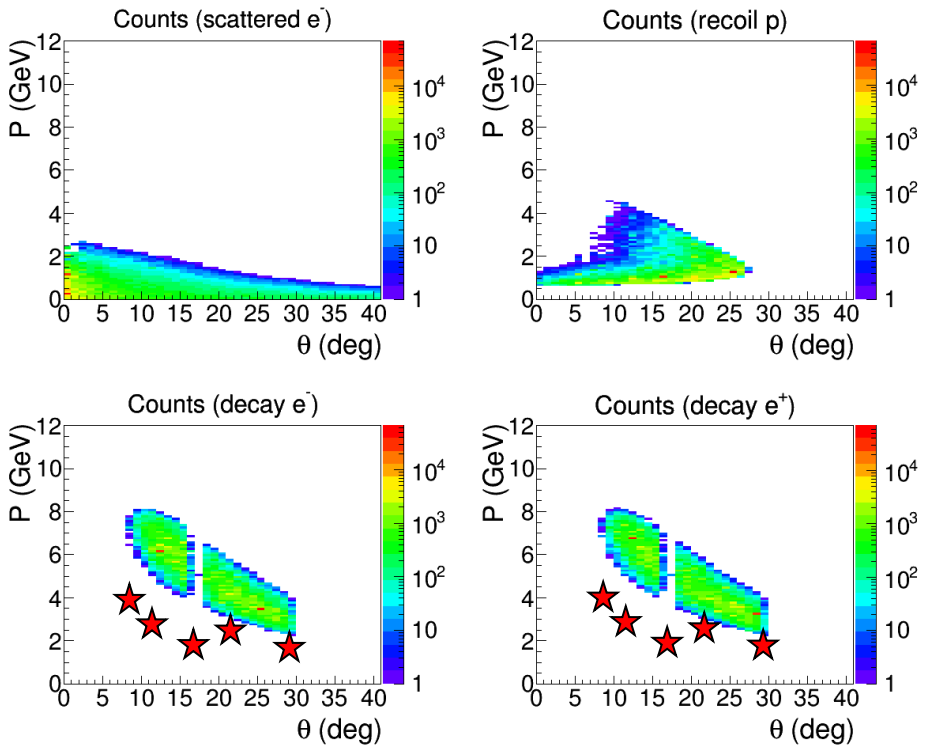
- LASPD(TOF) will help proton detection for JPsi
- By triggering on electron decay pair, JPsi can do both electro and photoproduction
- Radial dependent trigger (40kHz< 100kHz limit) is not only help Jpsi reducing trigger rate, but also allow TCS running in parallel
- TCS physics is dominant by BH process which in turn will be helpful for Jpsi normlization

SoLID JPsi Trigger

- Trigger on decay electron and positron
- Allow both electroproduction and photoproduction in data
- EC has radial dependent trigger threshold from 4 – 2GeV (stars)
- LGCC, MRPC, SPD help reject other hadrons and photons
- Same trigger works for Jpsi and TCS as run group

- Study was done in the way similar to PVDIS and SIDIS trigger rate
- Using SIDIS_He3 EC trigger response for now, luminosity (1e37/cm2/s) is similar for both and background has no big effect on EC trigger for this level of luminosity)

Jpsi (Electroproduction)
Require decay pair only



Single electron trigger including both FA (682kHz) and LA(446kHz) is about 1.13MHz

Coincidence of two electron trigger within 30ns time window is 1.13e6*1.13e6*30e-9 = 40kHz, which is below 100kHz SIDIS Setup limit

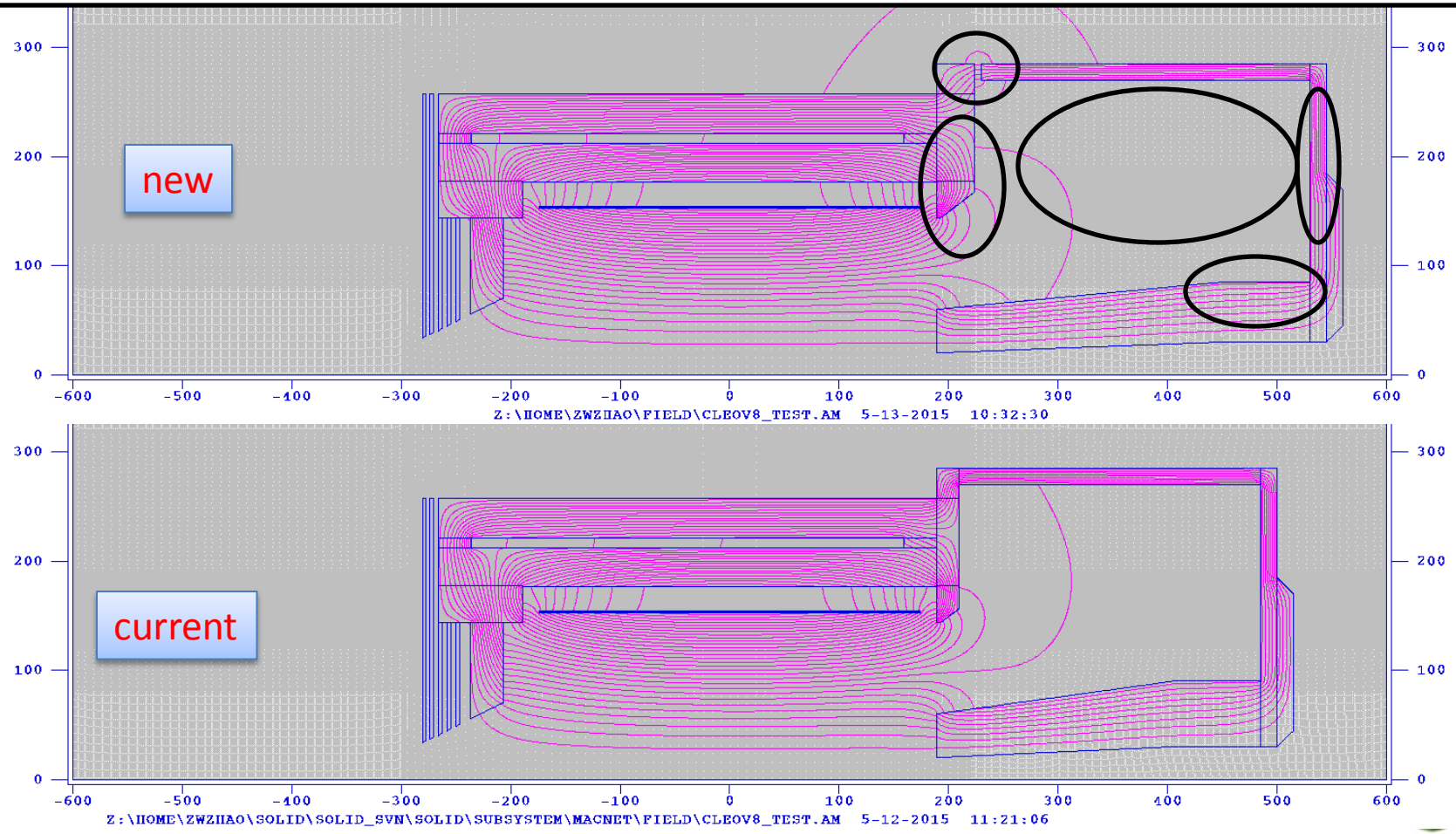
Just ideas, but changes are definitely needed

- Downstream collar enlarge by by 15cm in z (engineering need for support)
- Endcap move 15cm downstream and enlarge 30cm (SIDIS setup needs room)
- Endcap nose back reduce 5cm in r (EC hexagon module needs room)
- 6cm gap between downstream collar and endcap (let cable out, more cable out at back needed)
- Main impact, PVDIS EC large angle performance

Need design with full 3D model and satisfy both physics and engineering requirement

needed by all subsystems to fix their design, must be a coherent effort

More realistic design now, More saving of man power, effort, cost, maybe even physics



backup

Comments: SoLID Director Review

- During review
  - How does SoLID JPsi comparing to other JPsi programs?

The committee seems like our answer in the next slide, so they didn't mention it in the final review conclusion

J/Ψ@JLab Comparison

Setup	E_{e^-} GeV	I_{e^-} μA	RL eff	N_γ Hz	E_{e^-} meas	target cm	BR	Accept	J/ψ /day
Hall C	11	50	0.09	$1.4 \cdot 10^{12}$		20	0.12	0.03%	40
Hall B	11	0.03	0.02	$2.2 \cdot 10^{8}$	MM	10	0.06	10%	0.4
Hall D	12			$1 \cdot 10^{7}$	tag	30	0.06	50%	0.3
SoLID	11	1.0	0.04	$1.4 \cdot 10^{10}$	MM	40	0.06	20%	240

Eugene Chudakov, JPsi workshop at Temple in 2012

The estimation assumed luminosity ~1e^{37}/cm^2/s similar to the approved SoLID experiment.

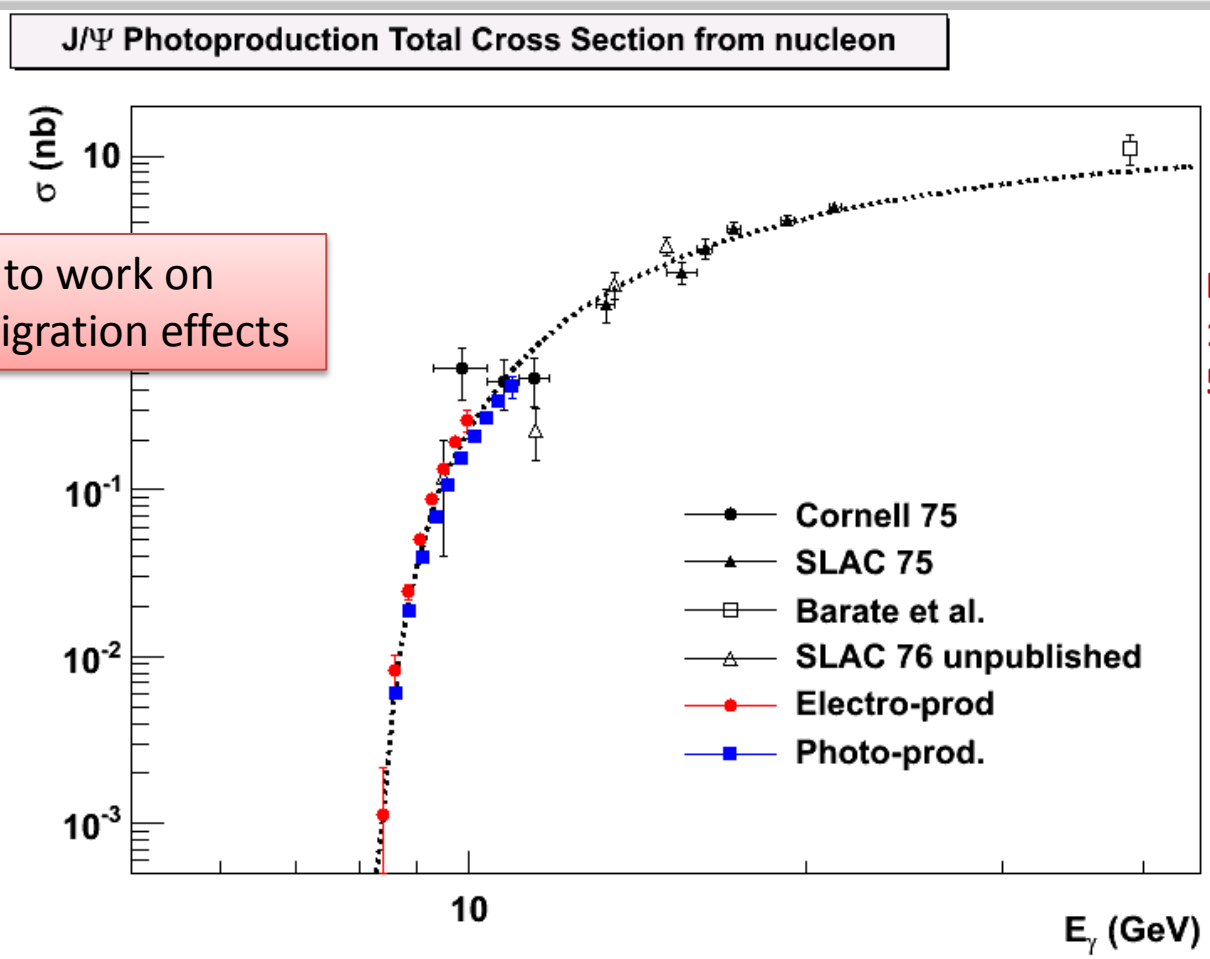
The estimation assumed J/ψ cross section 0.01nb at 8.4<E< 9GeV.
The cross section could rise to 0.1nb at 9<E<12GeV, but it won't change acceptance much, so the comparison will be similar.
In Hall D case, for photon intensity of 10^8, the production would change to 3/day.

SoLID has higher photon intensity than HallD

Comments: SoLID Director Review

- After review, in the final review conclusion
  - The signal and background trigger rates should be simulated for the J/ψ measurements. (try to answer this time)
  - Bin migration effects should be simulated for the measurements of the sharply rising J/ψ production cross section near threshold. (need to think about it, will try to answer in near future)

Projection of Total Crossection



Need to work on
Bin migration effects

Lumi 1.2e37/cm^2/s
11GeV 3uA e- on 15cm LH2
50 Days

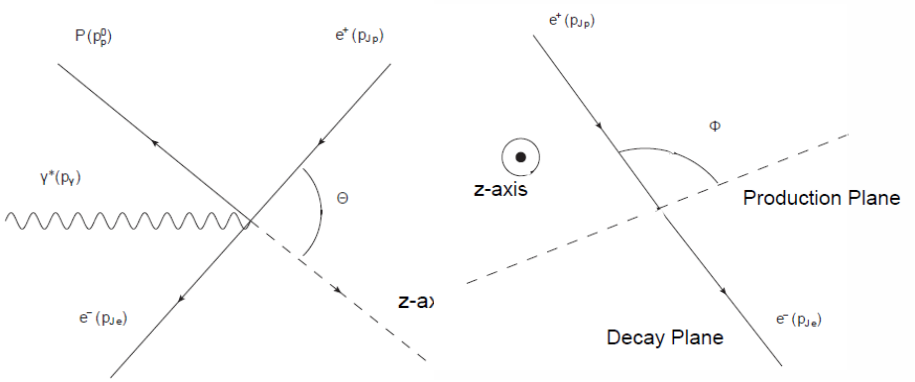
With ~ 0.02 GeV energy resolution for E_γ and small binning to study the threshold behavior of cross section

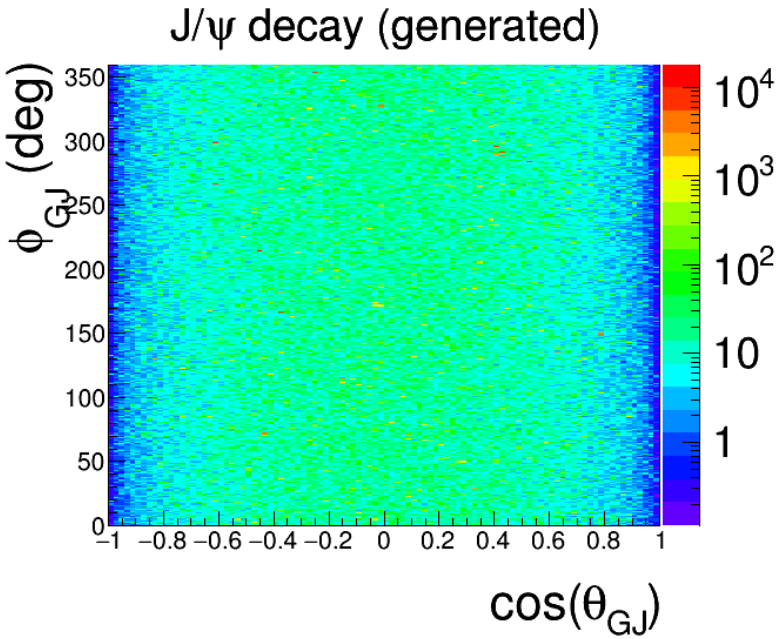
Decay

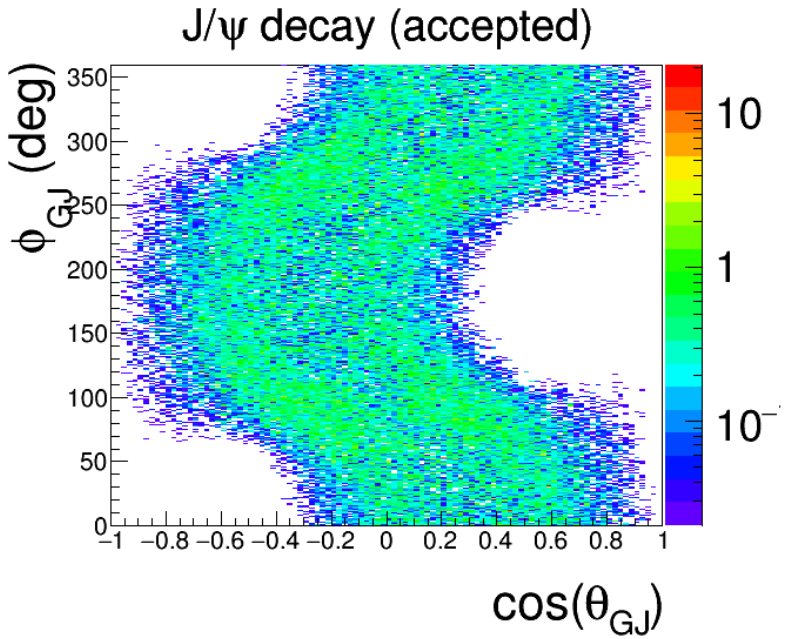
Look into decay model

- What we can learn from decay of J/ψ provide about its production?

$$W(\cos\theta) = \frac{3}{8\pi}(1 - r + (3r - 1)\cos^2\theta)$$







Electron trigger

FAEC (2GeV flat)

1115kHz

=509+315+315/40+7300/20/40+6300/40+6300/55

=509(e) + 315(e(π^0) front) + 8(e(π^0) back) +9(γ(π^0)) + 159(hadron rand. coin.) + 115(hadron corr. coin.)

LAEC (2GeV flat)

1200kHz

= 33+27+1390/5+(247+376+239)

= 33(eDIS) + 27(e(π^0))+ 270(γ(π^0))+862(hadron)