Run 15 TSSA of Open Heavy Flavor Electrons at Midrapidity (5)

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PHENIX

Reminder

Last update -- 04/29/2020

- Progress on open heavy flavor electron transverse single spin asymmetry was presented for the inclusive electron spectrum **(before background asymmetry/fraction corrections)**
  - $A_N(p_T)$ - square root formula (yellow, blue)
  - $A_N(p_T)$ - relative luminosity formula (yellow (left, right), blue(left, right))
  - Comparisons between results and extraction of systematic error from difference of sqrt and lumi formulas

For This Talk:

- Background fraction calculation -- procedure and results
  - Closely follows procedure outlined in an1340 corresponding to PPG223

Reminder

- Currently have A_N^{S+B} for different formulas and independent data samples
  - [sqrt(yellow, blue), lumi(yellow left, yellow right, blue left, blue right)]
- Need to calculate background fractions and calculate/aggregate background asymmetries such that A_N^S can be extracted as shown here
  - Here $A_N^S = A_N^{OHF \to e}$

$$A_N^S = \frac{A_N^{S+B} - rA_N^B}{1-r}$$

$$\sigma_{A_N^S} = \frac{\sqrt{(\sigma_{A_N^{S+B}})^2 + r^2(\sigma_{A_N^B})^2}}{1-r}$$

More generally:

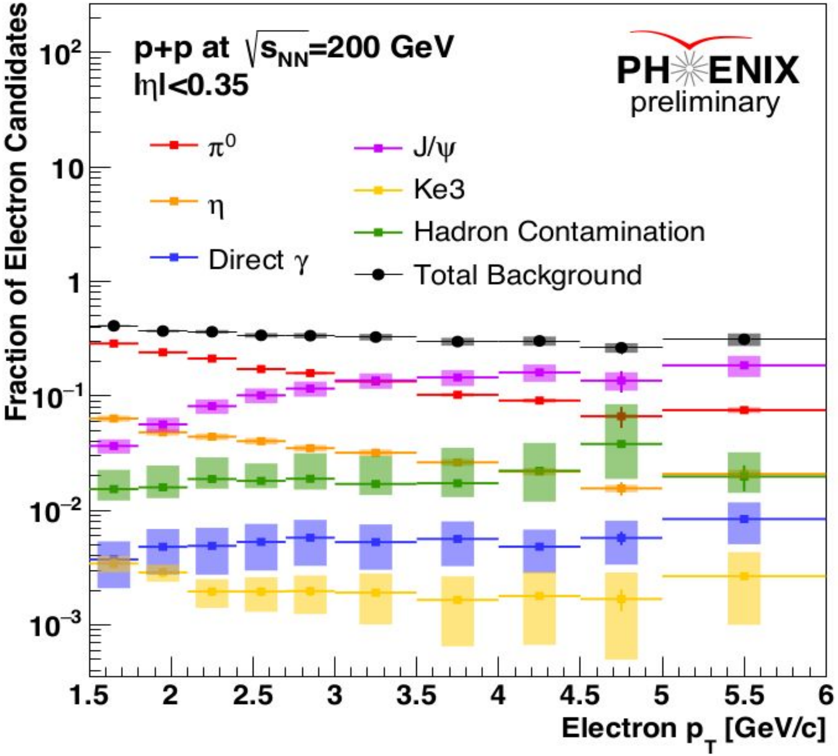
$r \to \Sigma_i f_i^{norm}$

and

$rA_N^B \to \Sigma_i f_i^{norm} A_N^i$

Background Fractions from PPG223

- Background sources for this analysis and PPG223 are shown here
- Need to recalculate background fractions using my binning and curated electron candidate sample
- Consider the following backgrounds:



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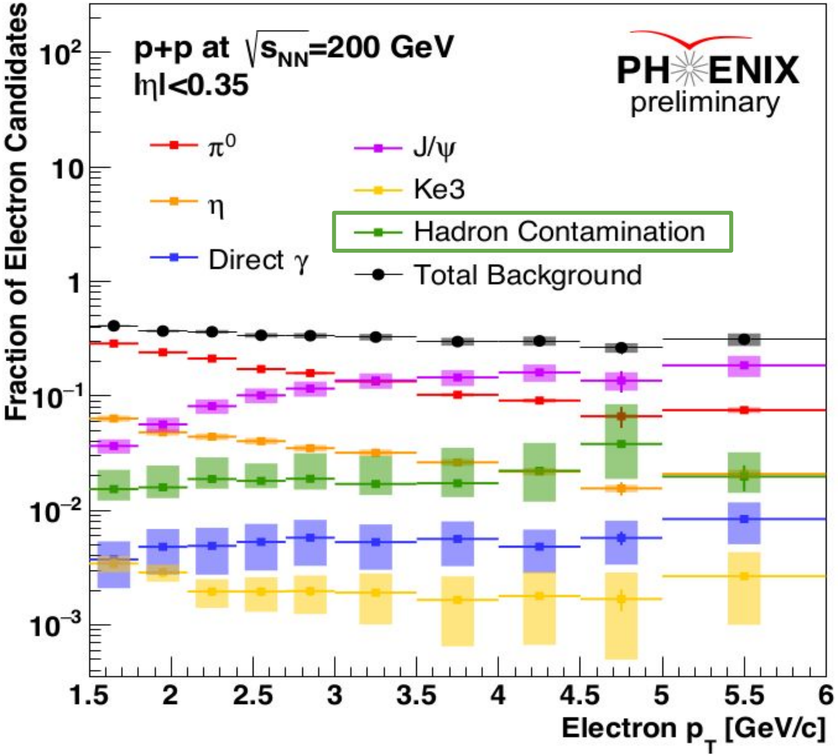

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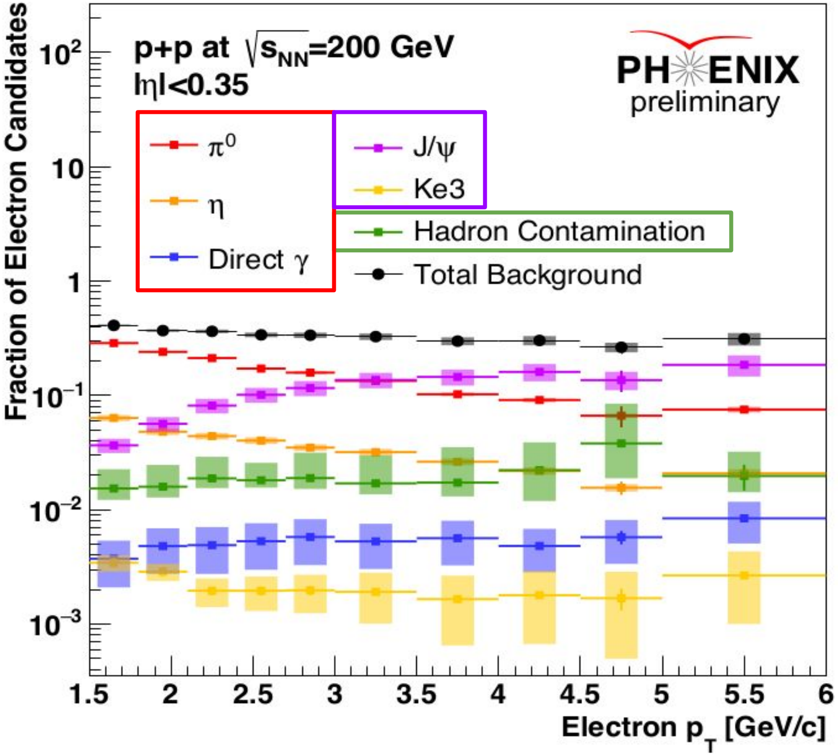
- Need to recalculate background fractions using my binning and curated electron candidate sample
- Consider the following backgrounds:
  - Hadron contamination (misidentified hadrons)
  - Photonic and non-photonic electrons -- create an electron cocktail from simulation



Highest pT Bin -- Back to my binning…

Variable	Cut	Kinematic Range
| emcdφ |	$< 3\sigma$	1.5 GeV < p_T < 6.0 GeV
| emcdz |	$< 3\sigma$	1.5 GeV < p_T < 6.0 GeV
| (E/p-μ) = dep * σ|	$< 2\sigma$	1.5 GeV < p_T < 6.0 GeV
| zed |	< 75	1.5 GeV < p_T < 6.0 GeV
disp	< 5	1.5 GeV < p_T < 6.0 GeV
χ^2/ndf	< 3	1.5 GeV < p_T < 6.0 GeV
nhits	> 2	1.5 GeV < p_T < 6.0 GeV
quality	== (63 or 31)	1.5 GeV < p_T < 6.0 GeV
conversion veto	✔	1.5 GeV < p_T < 6.0 GeV
n0	> 1	1.5 GeV < p_T < 5.0 GeV
prob	> 0.01	1.5 GeV < p_T < 5.0 GeV
n0	> 3	5.0 GeV < p_T < 6.0 GeV
prob	> 0.2	5.0 GeV < p_T < 6.0 GeV

Bin #	1	2	3	4
Pt Range (GeV)	(1.5, 1.8)	(1.8, 2.1)	(2.1, 2.7)	(2.7, 6.0)

- Differing n0 and prob cuts above 5 GeV implemented to suppress hadron contamination to the few percent level in the 5-6 GeV bin of PPG223
- Spin sorting decreases statistics, 5-6 GeV bin is not viable… So currently have differing cuts within a single bin (2.7 - 6 GeV)
  - Proposal to limit range to 5 GeV in pT? $n_{2.7\text{-}5}/n_{2.7\text{-}6}$ ~ 98%

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Pt Bins

The following Pt bins are used for this analysis -- chosen by combining bins used in PPG223:

Bin #	1	2	3	4
Pt Range (GeV)	(1.5, 1.8)	(1.8, 2.1)	(2.1, 2.7)	(2.7, 5.0)

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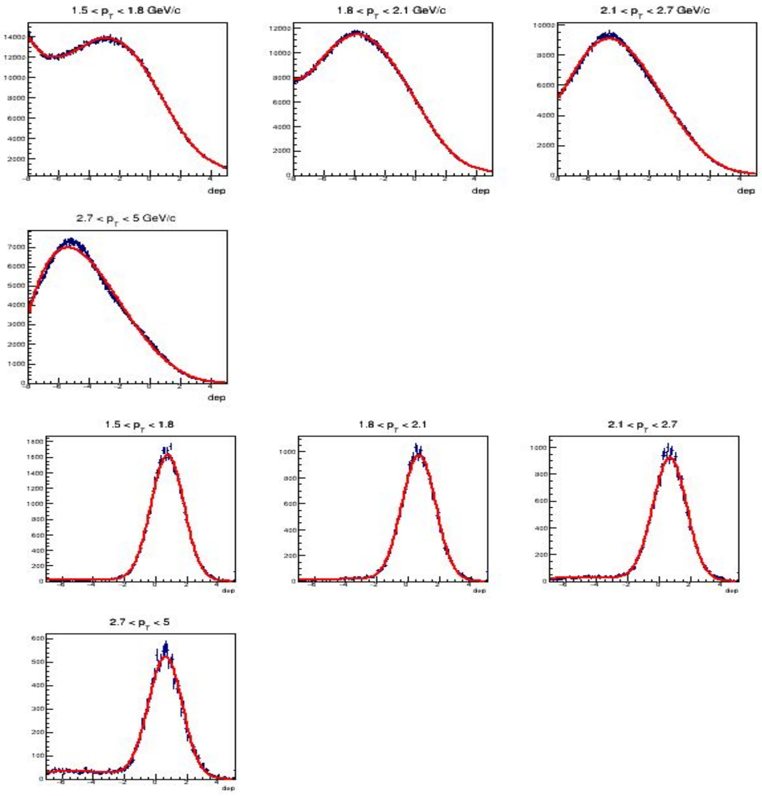
Hadron Contamination

- Two methods used to calculate fraction of candidates attributed to charged hadrons misidentified as electrons
  - Dep fitting method
  - Algebraic calculation with n0 survival rate
- Weighted average of both methods is used to calculate hadron contamination fraction
  - Difference between average value and values from either method are considered for systematics

Hadron Contamination -- dep Fitting

- True electrons have Gaussian dep distribution with σ ~ 1 and μ ~ 0
- Hadron dep distribution has different characteristics
  - Accessed in data via n0 < 0 cut
  - Fit extracted for template in fitting the electron candidate distribution (normalization is the only free parameter)
- Electron candidate dep distribution fit with Gaussian + hadron dep template
  - Allows for extraction of both electron and hadron contribution
  - Hadron contamination fraction determined by ratio of the contributions in the dep cut region |dep| < 2



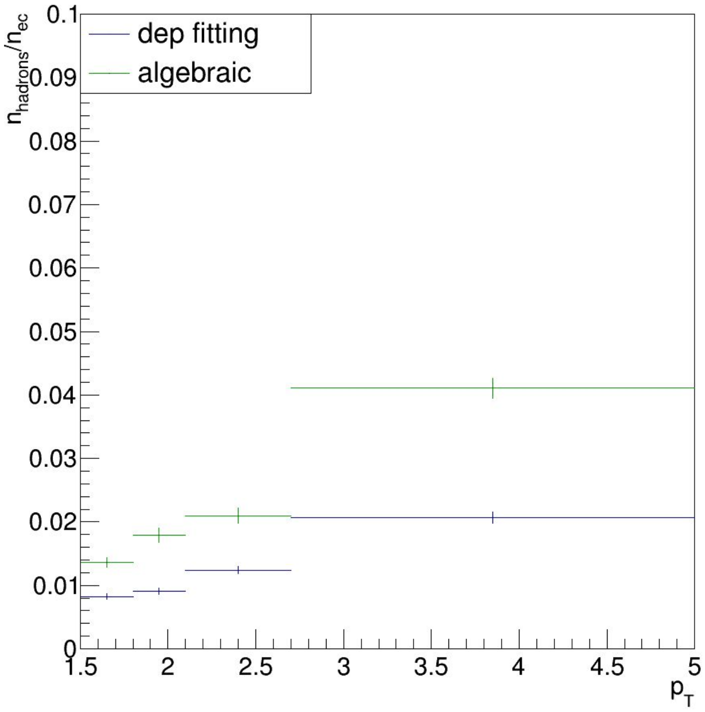
Hadron Contamination -- Algebraic Method

- Provides estimate that is independent of dep shape by using the survival rate of the n0 cut (accessed via electron candidate sample with dep<-6)
  - Electrons fire the RICH differently than charged hadrons, and therefore have a different survival rate
- The following system of equations can then be used to isolate the number of hadrons in our electron candidate sample:

$$n_{non0} = n_e + n_h$$

$$n_{n0} = \epsilon_e n_e + \epsilon_h n_h$$

$$\boxed{n_{h,n0} = \epsilon_h(n_{n0} - \epsilon_e n_{non0})/(\epsilon_h - \epsilon_e)}$$



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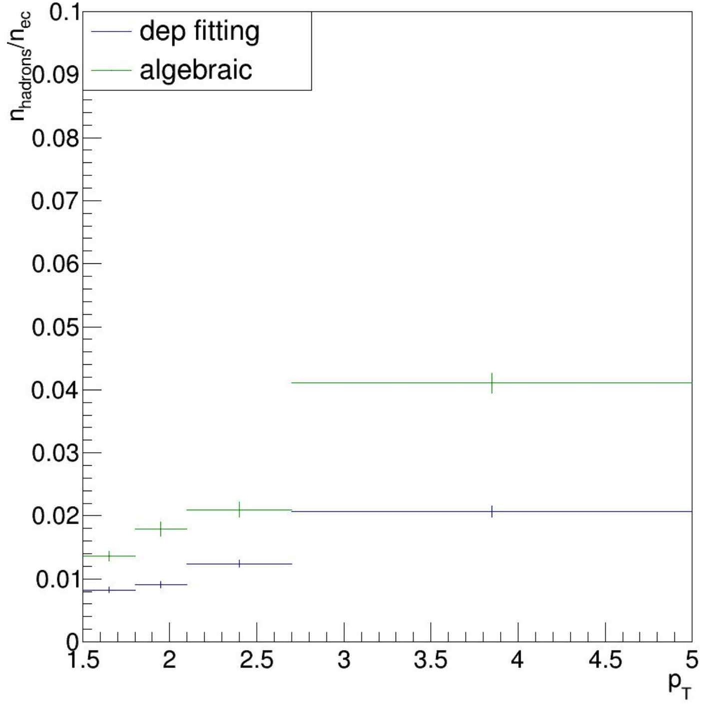
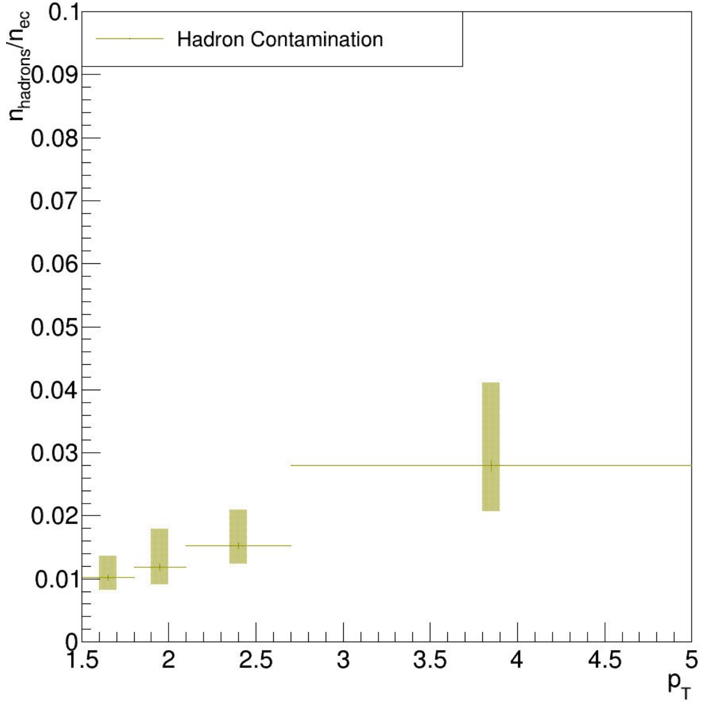
Hadron Contamination





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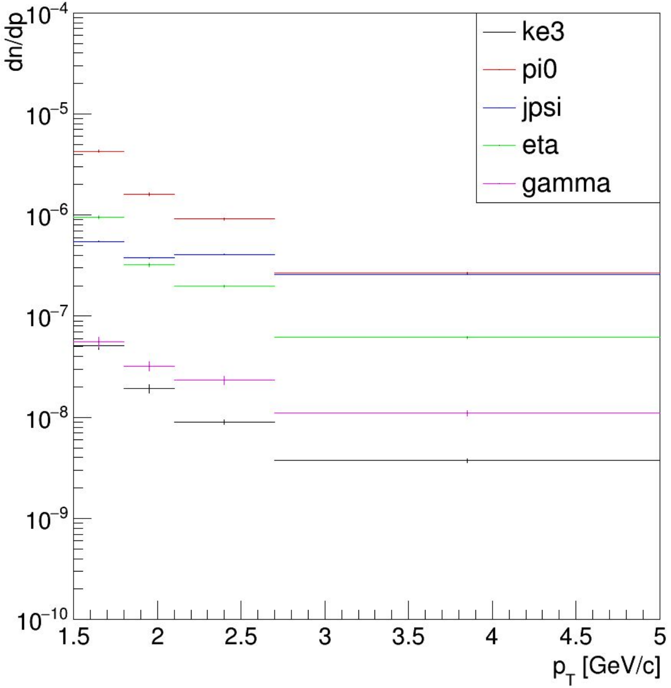
Electron Cocktail Simulation



- Electron cocktail created from single particle electron simulations
    - Simulation details outlined extensively in an1340
- pT weighting based on measured PHENIX cross sections
    - Still needs to be normalized w.r.t. Inclusive electron spectrum!
    - We have a handle on the photonic vs. non-photonic fraction of electrons in our sample via the survival rate of the conversion veto cut, and can use this fact for normalization

Background Fraction Calculation

$$n_e = n_{np} + n_p + n_{hc}$$

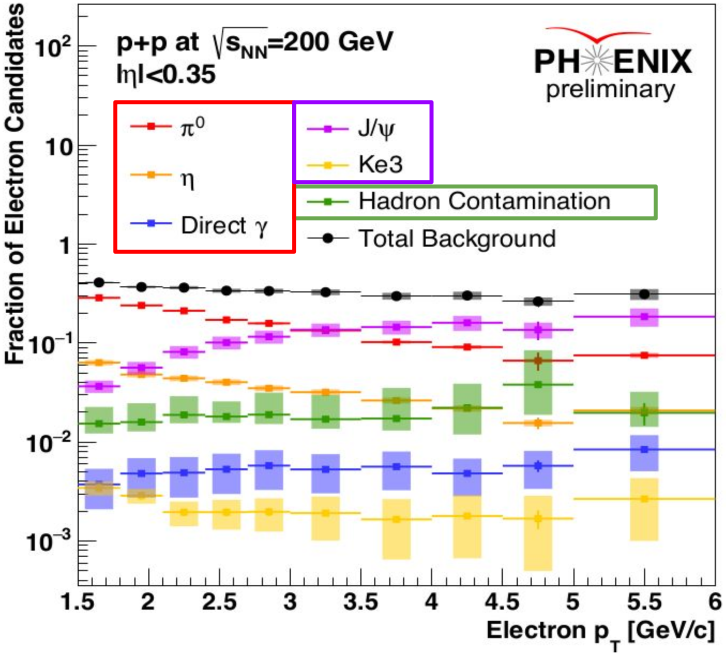
$$\tilde{n}_e = \tilde{n}_{np} + \tilde{n}_p + \tilde{n}_{hc} = \epsilon_{uc} n_{np} + \epsilon_{uc}\epsilon_p n_p + \tilde{n}_{hc}$$

$$F_{np} = \frac{n_{np}}{n_{np} + n_p}$$

no ~ = without conversion veto

~ = with conversion veto

$$F_{np} = \frac{\epsilon_{uc}\epsilon_p n_e - \tilde{n}_e - \epsilon_{uc}\epsilon_p n_{hc} + \tilde{n}_{hc}}{(\epsilon_p - 1)(\tilde{n}_e - \tilde{n}_{hc})}$$



$$f_i^{\text{norm}} = (1 - \tilde{f}_{hc})(1 - F_{np}) \frac{\tilde{n}_i}{\tilde{n}_{\pi^0} + \tilde{n}_\eta + \tilde{n}_\gamma}$$

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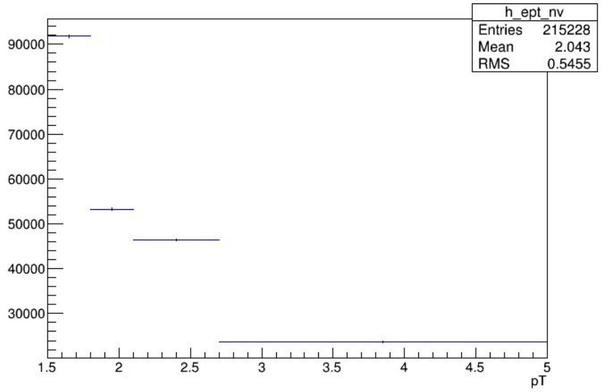
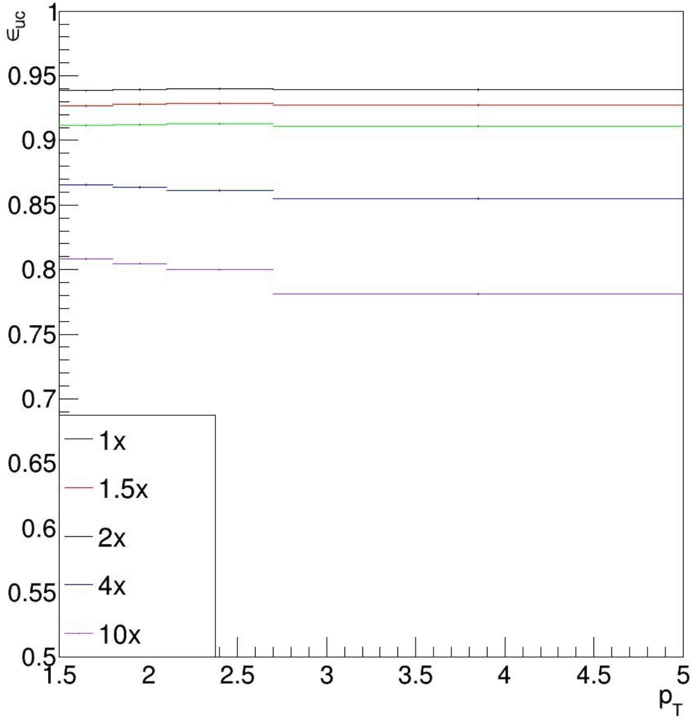
Conversion Veto Survival Rates

- 2x conversion veto window size (green) was used in PPG223
- ϵ_{uc} extracted from survival rate histo (hadrons in data)
- ϵ_p extracted from simulation (not shown here)
- n_e and $\tilde{n}_e$ extracted from e p_T spectrum with and without conversion veto cut





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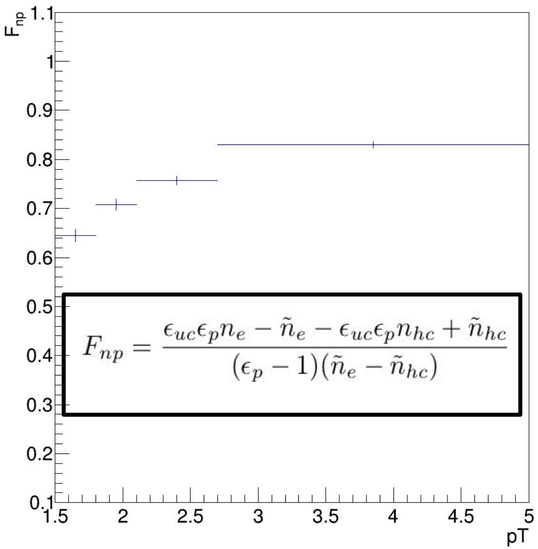
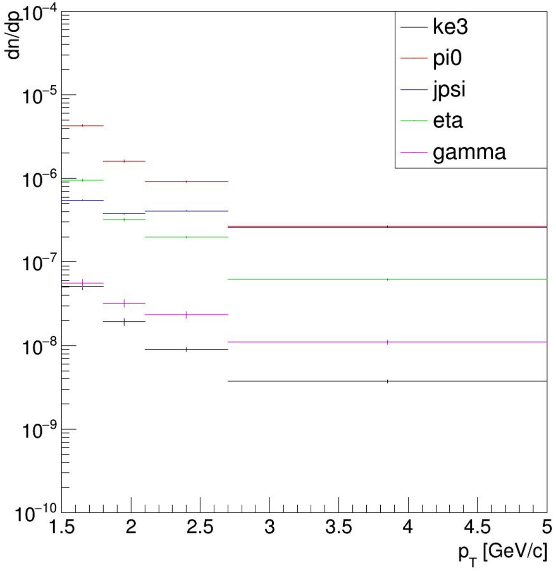
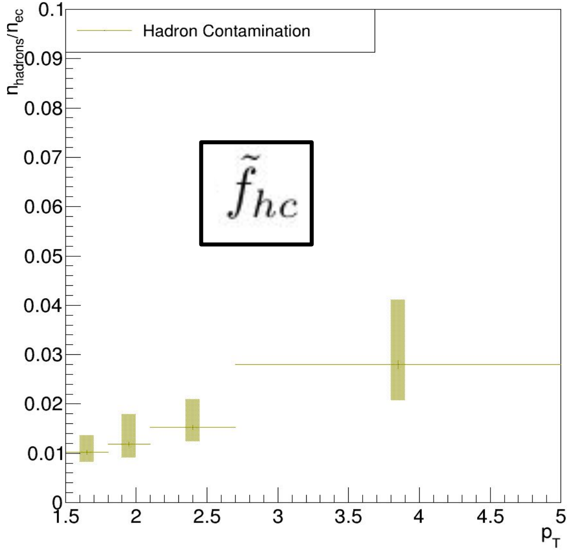


$$F_{np} = \frac{\epsilon_{uc}\epsilon_p n_e - \tilde{n}_e - \epsilon_{uc}\epsilon_p n_{hc} + \tilde{n}_{hc}}{(\epsilon_p - 1)(\tilde{n}_e - \tilde{n}_{hc})}$$





$$\tilde{f}_{hc}$$

$$f_i^{\text{norm}} = (1 - \tilde{f}_{hc})(1 - F_{np}) \frac{\tilde{n}_i}{\tilde{n}_{\pi^0} + \tilde{n}_\eta + \tilde{n}_\gamma}$$

$$f_i^{\text{norm}} = f_{\pi^0}^{\text{norm}} \frac{\tilde{n}_i}{\tilde{n}_{\pi_0}}$$

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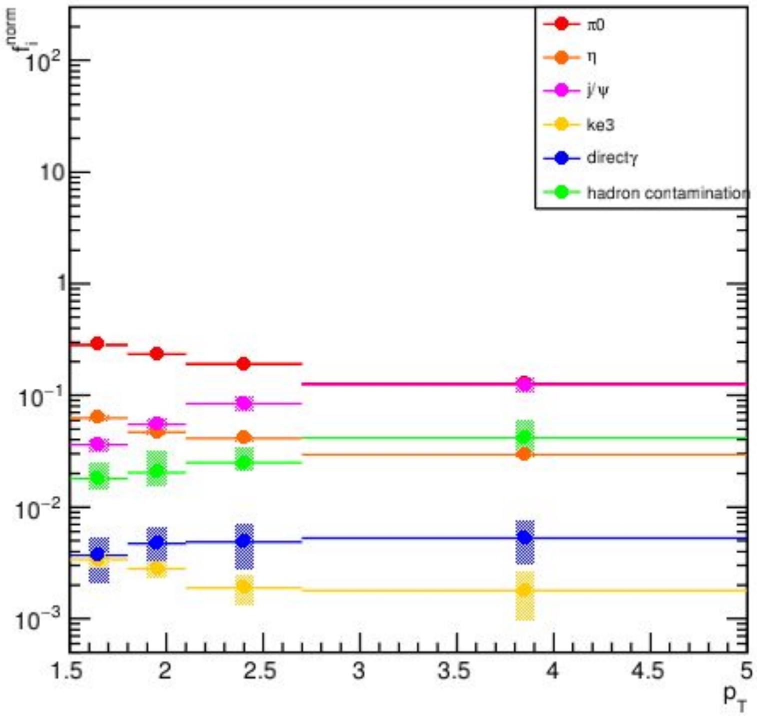
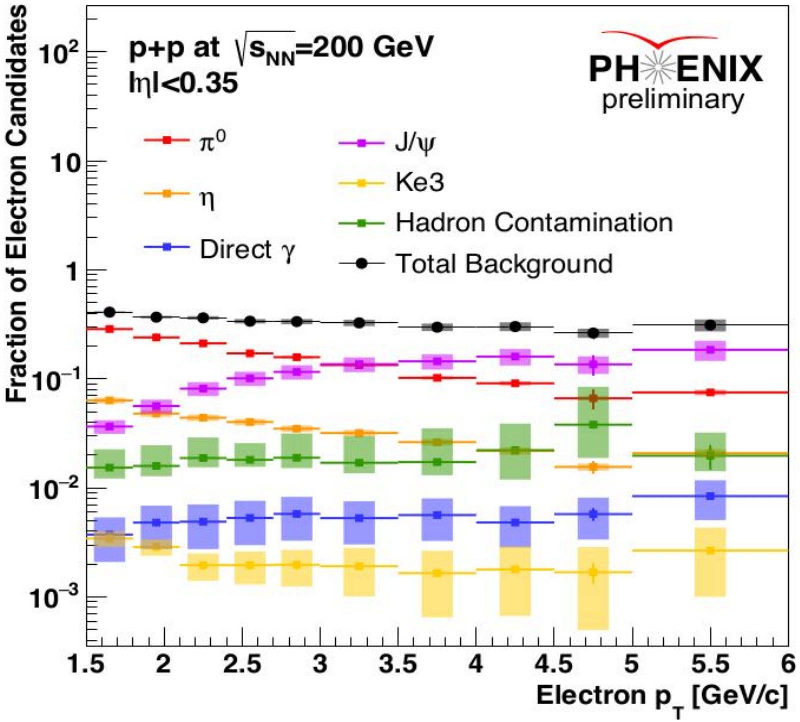
Background Fraction Calculation





Next Steps

- Bunch shuffling cross check
- $A_N \sin\varphi$ modulation cross check
- Background Correction
- Gather systematics

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- Bunch shuffling cross check
- $A_N \sin\varphi$ modulation cross check
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Does the order in which these are completed matter?

For Your Information

I have been tracking my analysis progress on the web:

http://www-personal.umich.edu/~dillfitz/PHENIX_Analysis/index.html

$A_N(p_T)$ plots can be found at (see various subdirectories for formula comparisons):

http://www-personal.umich.edu/~dillfitz/PHENIX_Analysis/Asymmetry_Ana/1.5GeV_6GeV/pTBins/

For electron ID selection requirements and motivating histograms, see:

http://www-personal.umich.edu/~dillfitz/PHENIX_Analysis/Open_Heavy_Flavor_Ana/electronID_and_spectra/lin_y/