

Detector induced assymetry in CP violation measurements

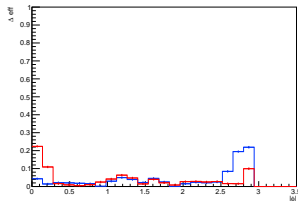
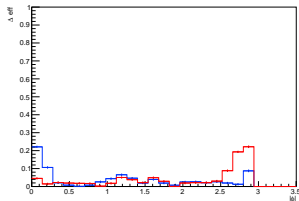
Eugenia Spedicato, Lina Maria Ortiz Parra, Jonah Blank

March 23, 2020

- normalization ($N_{tot} = 3 \cdot 10^6$) has no measurable effect
- mean origin vertex:
 - UP: $(0.84 \pm 0.03, -0.18 \pm 0.03, -2.64 \pm 44.56)$
 - DOWN: $(0.84 \pm 0.03, -0.18 \pm 0.03, -3.14 \pm 37.46)$
- x and y many σ from 0
→ asymmetric distribution of particles flying into the detector

Idea 1

- form of detector: difference in eff. of different charges with $\pm\phi$
- for $|\phi| < 0.5$ & $|\phi| > 2.5$ big differences in reconstruction for both charges
→ cut these out



Total Efficiencies - before cut

| Polarity | ϵ_{π} | ϵ_K | $\epsilon_{\pi,s}$ | ϵ_{D^0} | ϵ_{D^*} |
|-------------|------------------|------------------|--------------------|------------------|------------------|
| <i>UP</i> | 86.65 ± 0.01 | 84.63 ± 0.01 | 76.65 ± 0.02 | 73.34 ± 0.02 | 56.31 ± 0.02 |
| <i>DOWN</i> | 86.68 ± 0.01 | 84.67 ± 0.01 | 76.66 ± 0.02 | 73.39 ± 0.02 | 56.35 ± 0.02 |

Total Efficiencies - after cut

| Polarity | ϵ_{π} | ϵ_K | $\epsilon_{\pi,s}$ | ϵ_{D^0} | ϵ_{D^*} |
|-------------|------------------|------------------|--------------------|------------------|------------------|
| <i>UP</i> | 86.65 ± 0.01 | 84.63 ± 0.01 | 50.23 ± 0.02 | 73.34 ± 0.02 | 36.61 ± 0.02 |
| <i>DOWN</i> | 86.68 ± 0.01 | 84.67 ± 0.01 | 50.25 ± 0.02 | 73.39 ± 0.02 | 36.58 ± 0.02 |

Charge: +

Numbers - before cut

| UP | π | K | $soft\ \pi$ | D^0 | D^* |
|-------------------|-----------|-----------|-------------|-----------|-----------|
| N_{reco} | 2 669 990 | 2 620 280 | 2 352 910 | 2 249 370 | 1 720 940 |
| N_{tot} | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 |
| DOWN | π | K | $soft\ \pi$ | D^0 | D^* |
| N_{reco} | 2 674 000 | 2 626 350 | 2 374 360 | 2 253 370 | 1 737 460 |
| N_{tot} | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 |

Numbers - after cut

| UP | π | K | $soft\ \pi$ | D^0 | D^* |
|-------------------|-----------|-----------|-------------|-----------|-----------|
| N_{reco} | 2 669 990 | 2 620 280 | 1 546 670 | 2 249 370 | 1 121 530 |
| N_{tot} | 3 000 000 | 3 000 000 | 1 961 330 | 3 000 000 | 1 961 330 |
| DOWN | π | K | $soft\ \pi$ | D^0 | D^* |
| N_{reco} | 2 674 000 | 2 626 350 | 1 552 010 | 2 253 370 | 1 125 280 |
| N_{tot} | 3 000 000 | 3 000 000 | 1 963 510 | 3 000 000 | 1 963 510 |

Charge: -

Numbers - before cut

| UP | π | K | $soft\ \pi$ | D^0 | D^* |
|-------------------|-----------|-----------|-------------|-----------|-----------|
| N_{reco} | 2 669 990 | 2 620 280 | 2 352 910 | 2 249 370 | 1 720 940 |
| N_{tot} | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 |
| DOWN | π | K | $soft\ \pi$ | D^0 | D^* |
| N_{reco} | 2 674 000 | 2 626 350 | 2 374 360 | 2 253 370 | 1 737 460 |
| N_{tot} | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 | 3 000 000 |

Numbers - after cut

| UP | π | K | $soft\ \pi$ | D^0 | D^* |
|-------------------|-----------|-----------|-------------|-----------|-----------|
| N_{reco} | 2 669 990 | 2 620 280 | 1 549 090 | 2 249 370 | 1 132 970 |
| N_{tot} | 3 000 000 | 3 000 000 | 1 960 630 | 3 000 000 | 1 960 630 |
| DOWN | π | K | $soft\ \pi$ | D^0 | D^* |
| N_{reco} | 2 674 000 | 2 626 350 | 1 549 160 | 2 253 370 | 1 134 370 |
| N_{tot} | 3 000 000 | 3 000 000 | 1 964 560 | 3 000 000 | 1 964 560 |

Deviation before & after cut

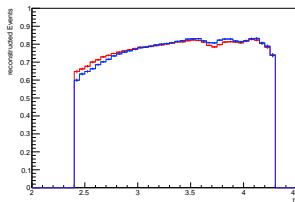
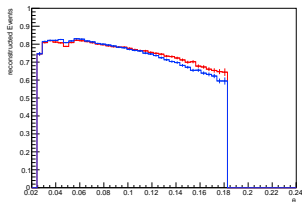
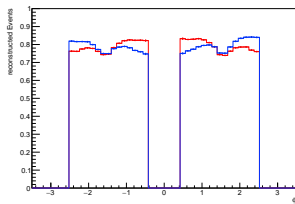
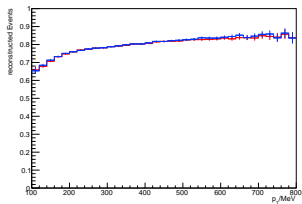
Table: The deviation $\frac{N_+ - N_-}{N_+ + N_-} / 10^{-3}$

| Polarity | π | K | $soft\pi$ | D^0 | D^* |
|-------------|----------------|---------------|----------------|----------------|----------------|
| <i>UP</i> | -0.1 ± 0.4 | 4.7 ± 0.4 | -3.8 ± 0.5 | -4.7 ± 0.5 | -8.2 ± 0.5 |
| <i>DOWN</i> | -0.3 ± 0.4 | 5.2 ± 0.4 | 3.7 ± 0.5 | -5.0 ± 0.5 | -0.8 ± 0.5 |

| Polarity | π | K | $soft\pi$ | D^0 | D^* |
|-------------|----------------|---------------|----------------|----------------|----------------|
| <i>UP</i> | -0.1 ± 0.4 | 4.7 ± 0.4 | -0.8 ± 0.6 | -4.7 ± 0.5 | -5.1 ± 0.7 |
| <i>DOWN</i> | -0.3 ± 0.4 | 5.2 ± 0.4 | 0.9 ± 0.5 | -5.0 ± 0.5 | -4.0 ± 0.7 |

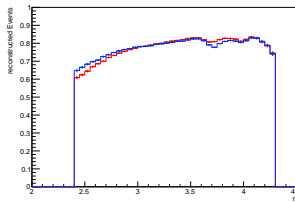
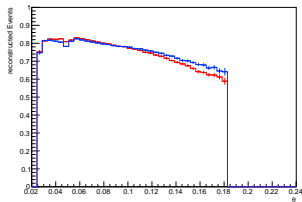
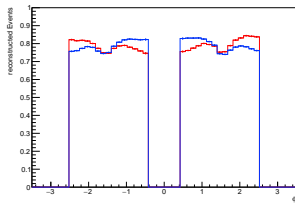
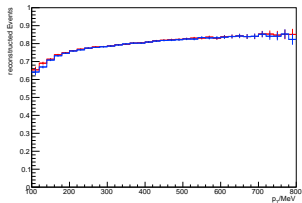
- deviation in π gets smaller, in D^* equals out
- $\approx 35\%$ of events is rejected

Comparison of different charges with UP polarity - soft π

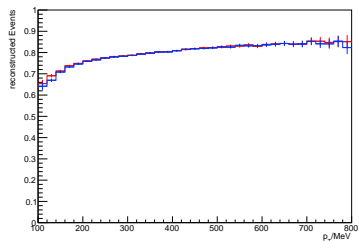
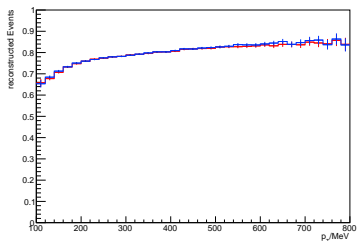


Comparison of different charges with *DOWN* polarity - soft

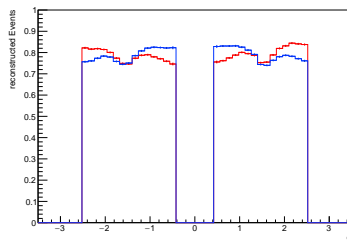
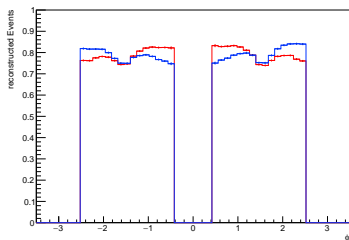
π



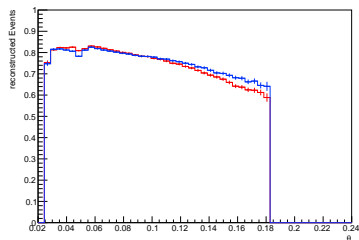
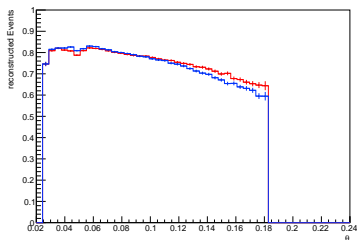
Comparison - soft πp_T



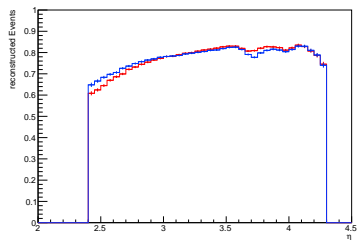
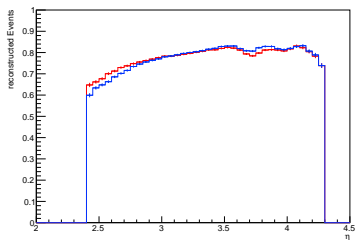
Comparison - soft $\pi\phi$



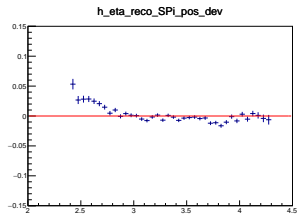
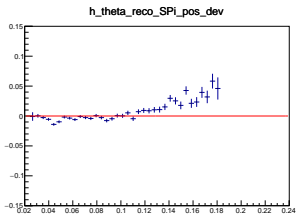
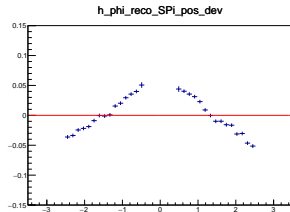
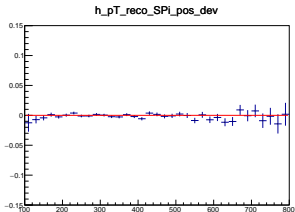
Comparison - soft $\pi\theta$



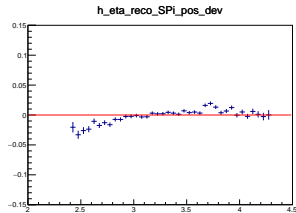
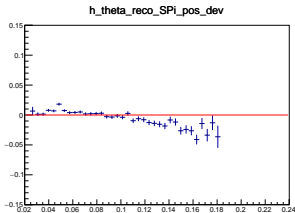
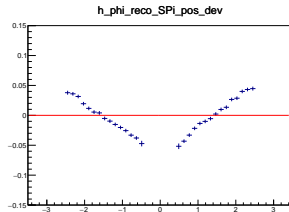
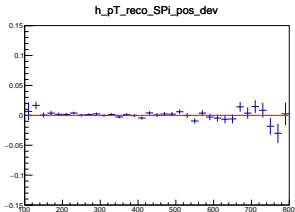
Comparison - soft $\pi\eta$



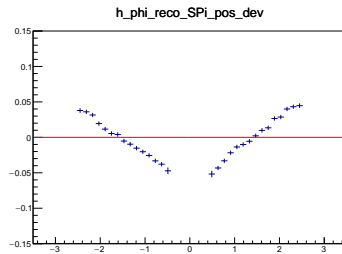
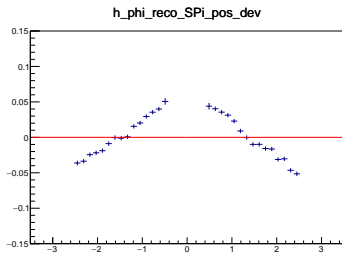
soft π deviation dependencies - UP polarity



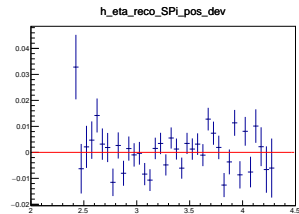
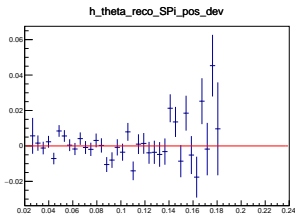
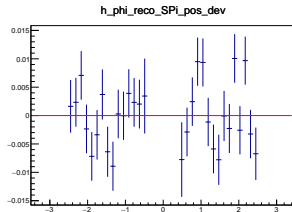
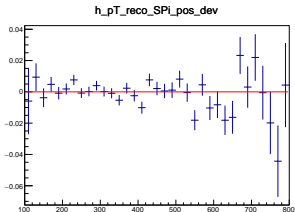
soft π deviation dependencies - *DOWN* polarity



soft π deviation - ϕ

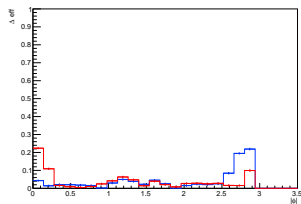
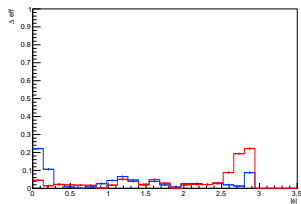


soft π deviation UP+DOWN



Idea 2

■ $|\phi| < 0.3 \& |\phi| > 2.5 \& \eta > 3$



Deviation before & after cut

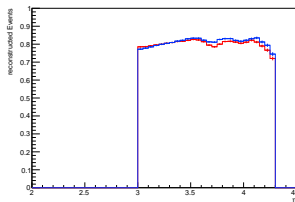
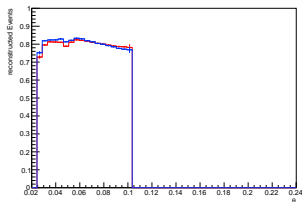
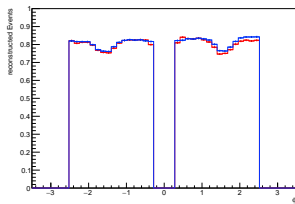
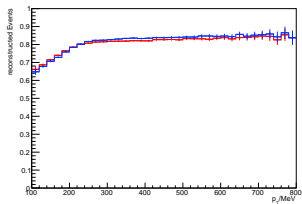
Table: The deviation $\frac{N_+ - N_-}{N_+ + N_-} / 10^{-3}$

| Polarity | π | K | $soft\pi$ | D^0 | D^* |
|-------------|----------------|---------------|----------------|----------------|----------------|
| <i>UP</i> | -0.1 ± 0.4 | 4.7 ± 0.4 | -3.8 ± 0.5 | -4.7 ± 0.5 | -8.2 ± 0.5 |
| <i>DOWN</i> | -0.3 ± 0.4 | 5.2 ± 0.4 | 3.7 ± 0.5 | -5.0 ± 0.5 | -0.8 ± 0.5 |

| Polarity | π | K | $soft\pi$ | D^0 | D^* |
|-------------|----------------|---------------|----------------|----------------|----------------|
| <i>UP</i> | -0.1 ± 0.4 | 4.7 ± 0.4 | -4.4 ± 0.6 | -4.7 ± 0.5 | -8.7 ± 0.7 |
| <i>DOWN</i> | -0.3 ± 0.4 | 5.2 ± 0.4 | 4.1 ± 0.6 | -5.0 ± 0.5 | -0.2 ± 0.7 |

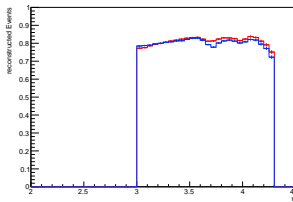
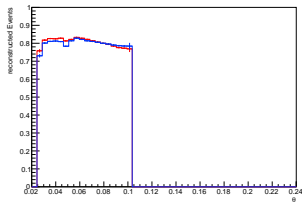
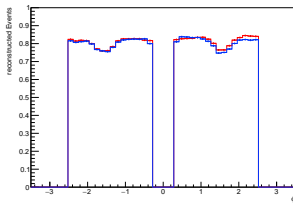
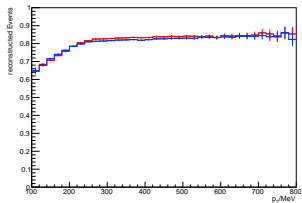
- deviation is even worse than before
- $\approx 50\%$ of events is rejected

Comparison of different charges with UP polarity - soft π

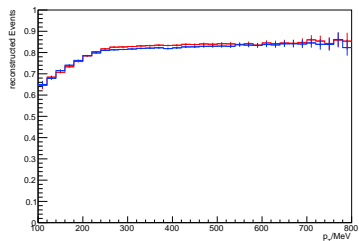
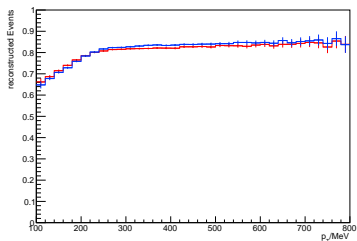


Comparison of different charges with *DOWN* polarity - soft

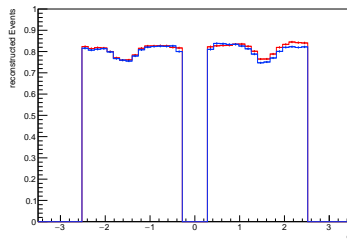
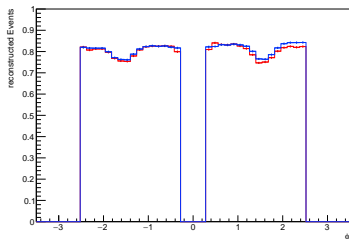
π



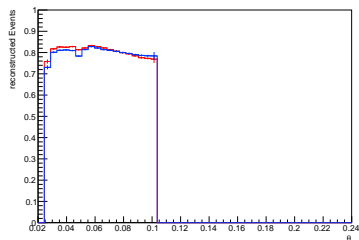
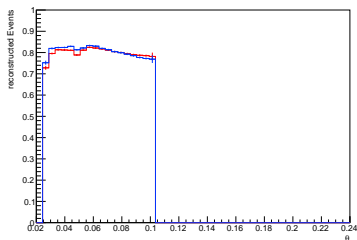
Comparison - soft πp_T



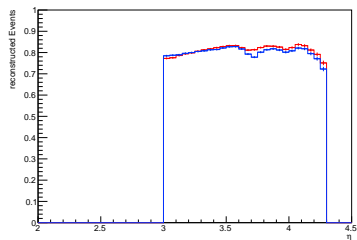
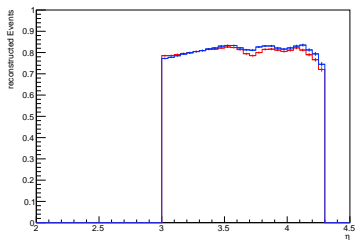
Comparison - soft $\pi\phi$



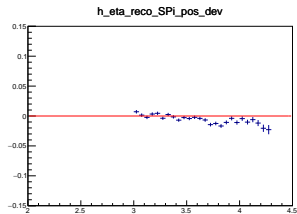
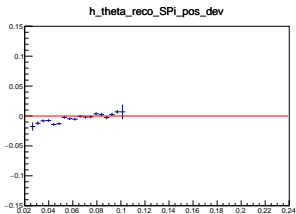
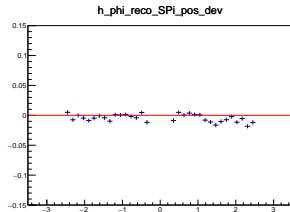
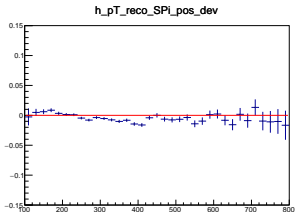
Comparison - soft $\pi\theta$



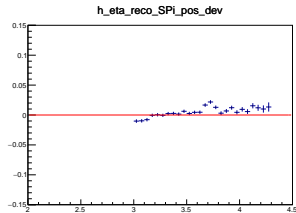
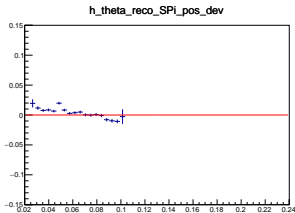
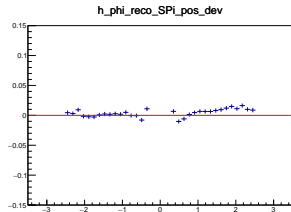
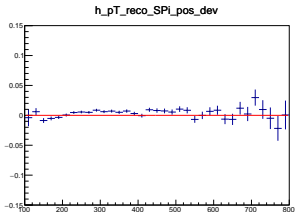
Comparison - soft $\pi\eta$



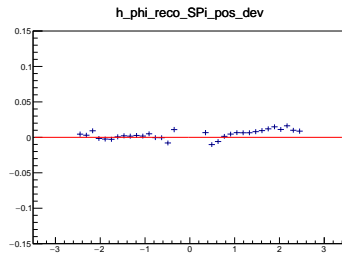
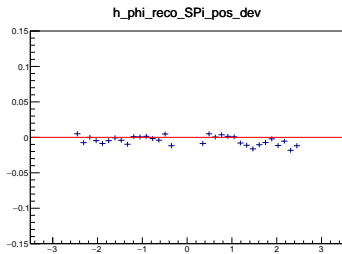
soft π deviation dependencies - UP polarity



soft π deviation dependencies - *DOWN* polarity



soft π deviation - ϕ



soft π deviation UP+DOWN

