

DCH:

Cell Layout FastSim Studies

G. Finocchiaro, M. Rama
INFN LNF

XII SuperB General Meeting

DCH-I parallel session
Annecy, 16 March 2010

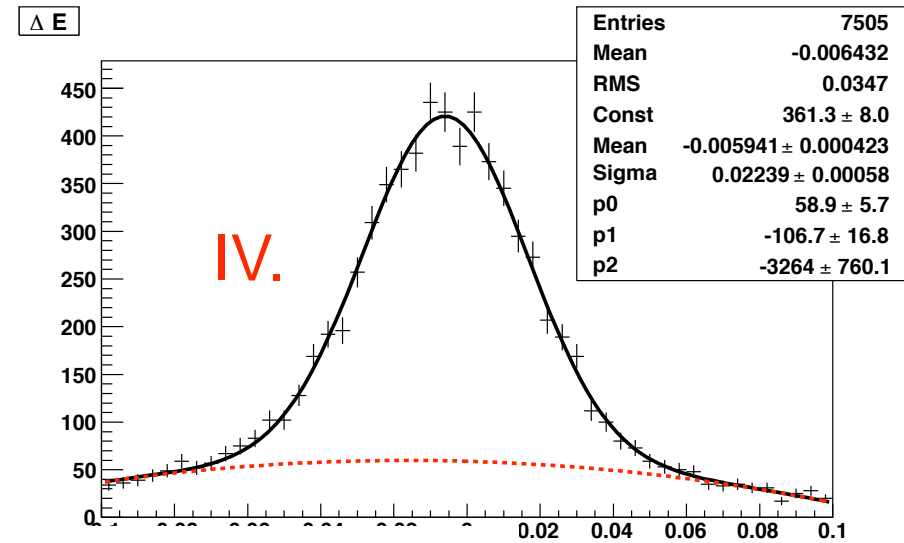
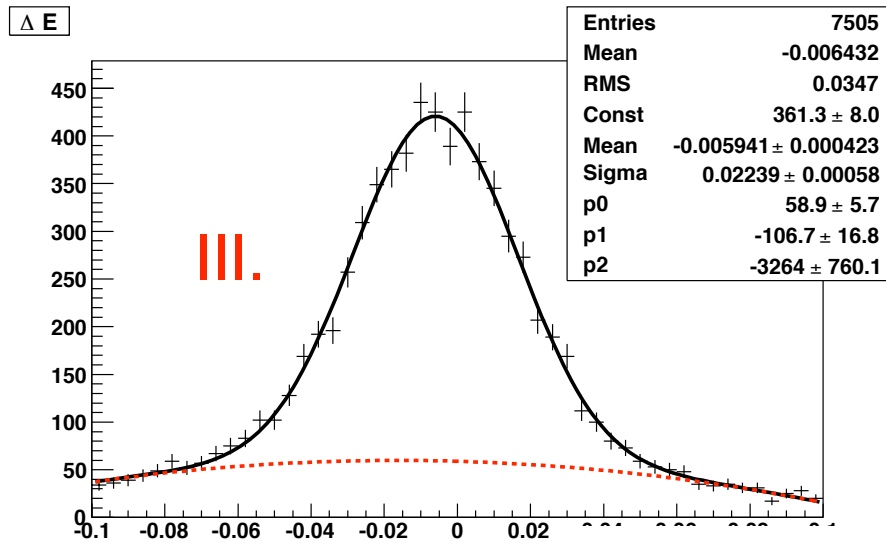
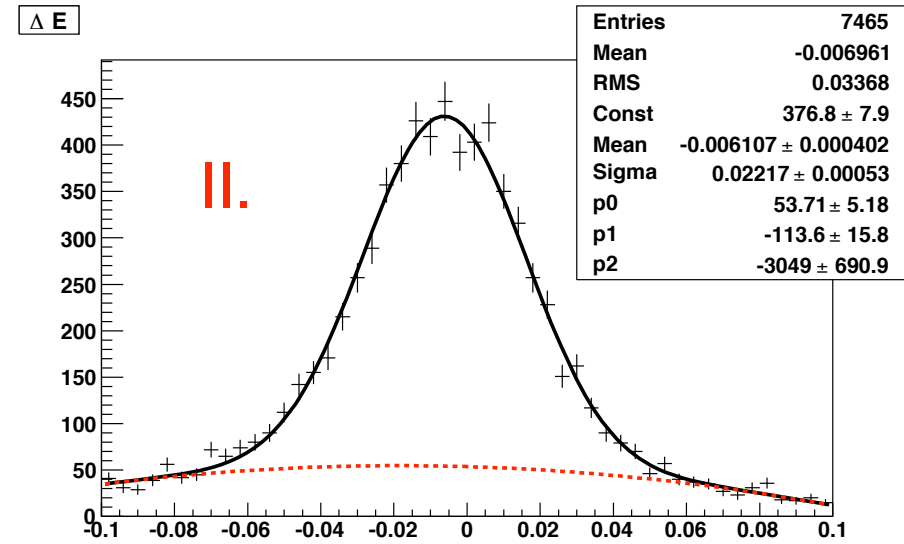
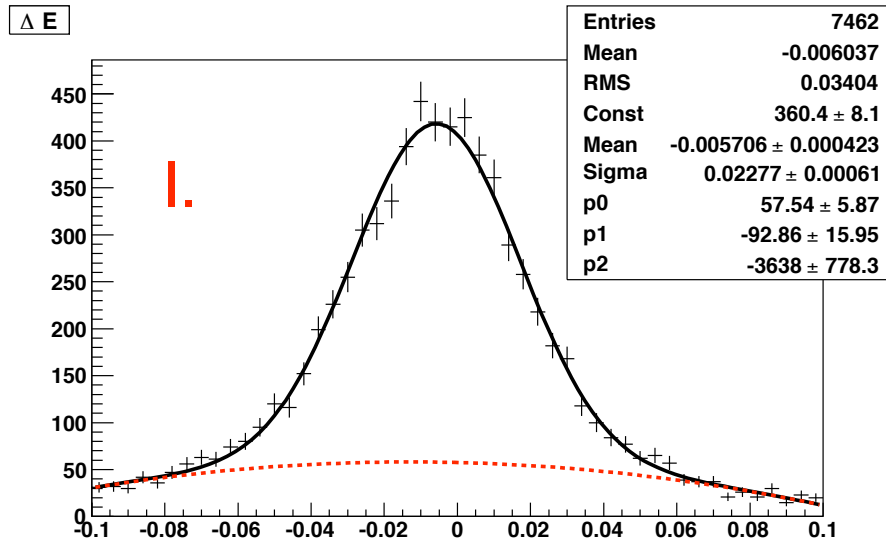
Cell and Layer Layout Optimization

1. Number of axial vs. stereo measuring layers
2. Material in hexagonal vs. “square” (or rectangular) cell layouts, for different gas mixtures

1. Stereo Angle Layout

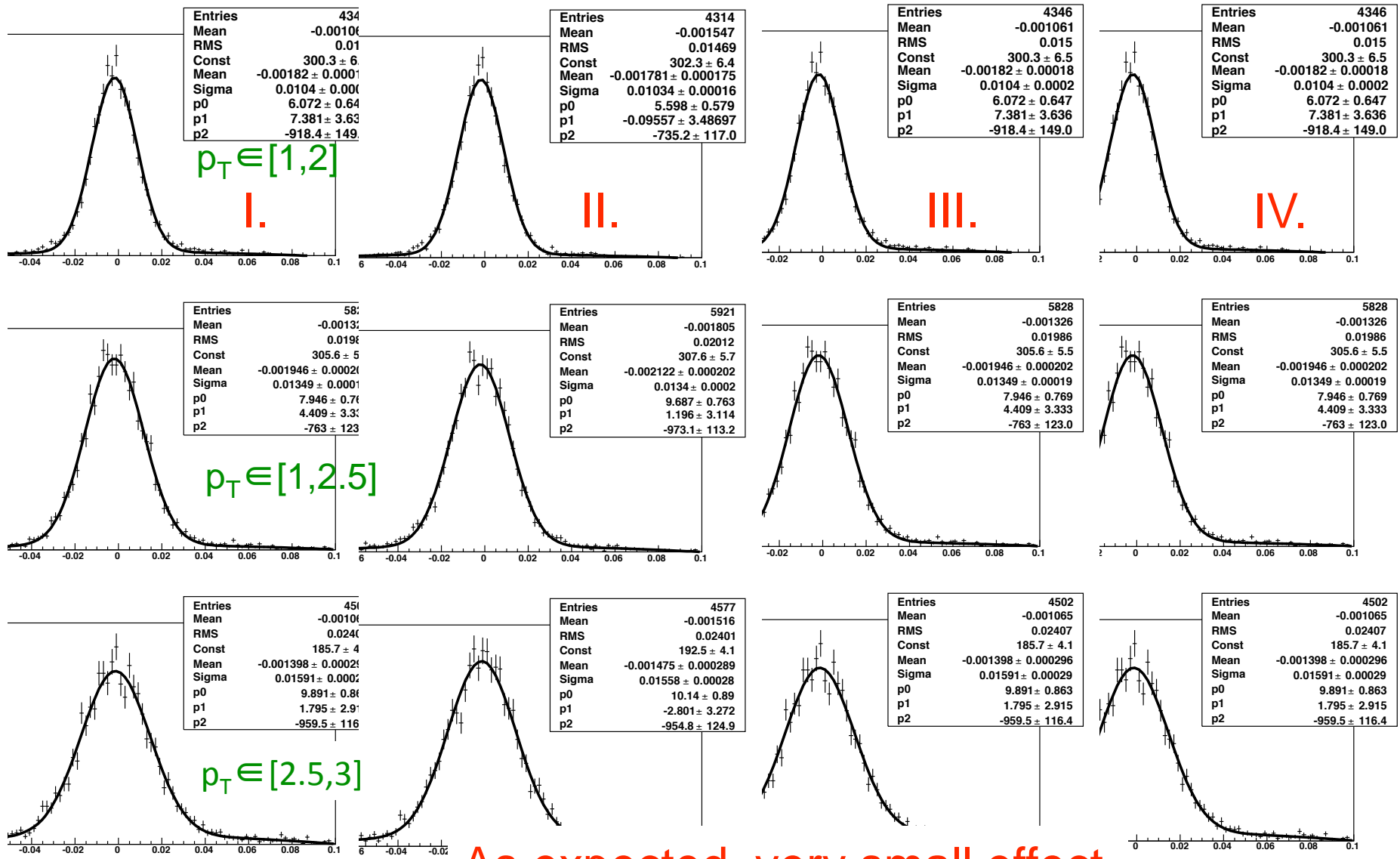
- Theta measurement largely dominated by vertex detector
- Study effect on tracking of stereo/axial measuring layers comparing (BToPiPi and BToDstarK) four different configurations:
 - I. “Nominal”: AUVAUVAUVA
 - II. “Axial”: AAAAAAAAAA
 - III. “Stereo SL” : AUVUVUVUVA
 - IV. “Stereo layers” Auvuv.....uvuvA

BToPiPi: ΔE vs. Stereo Angle Layout



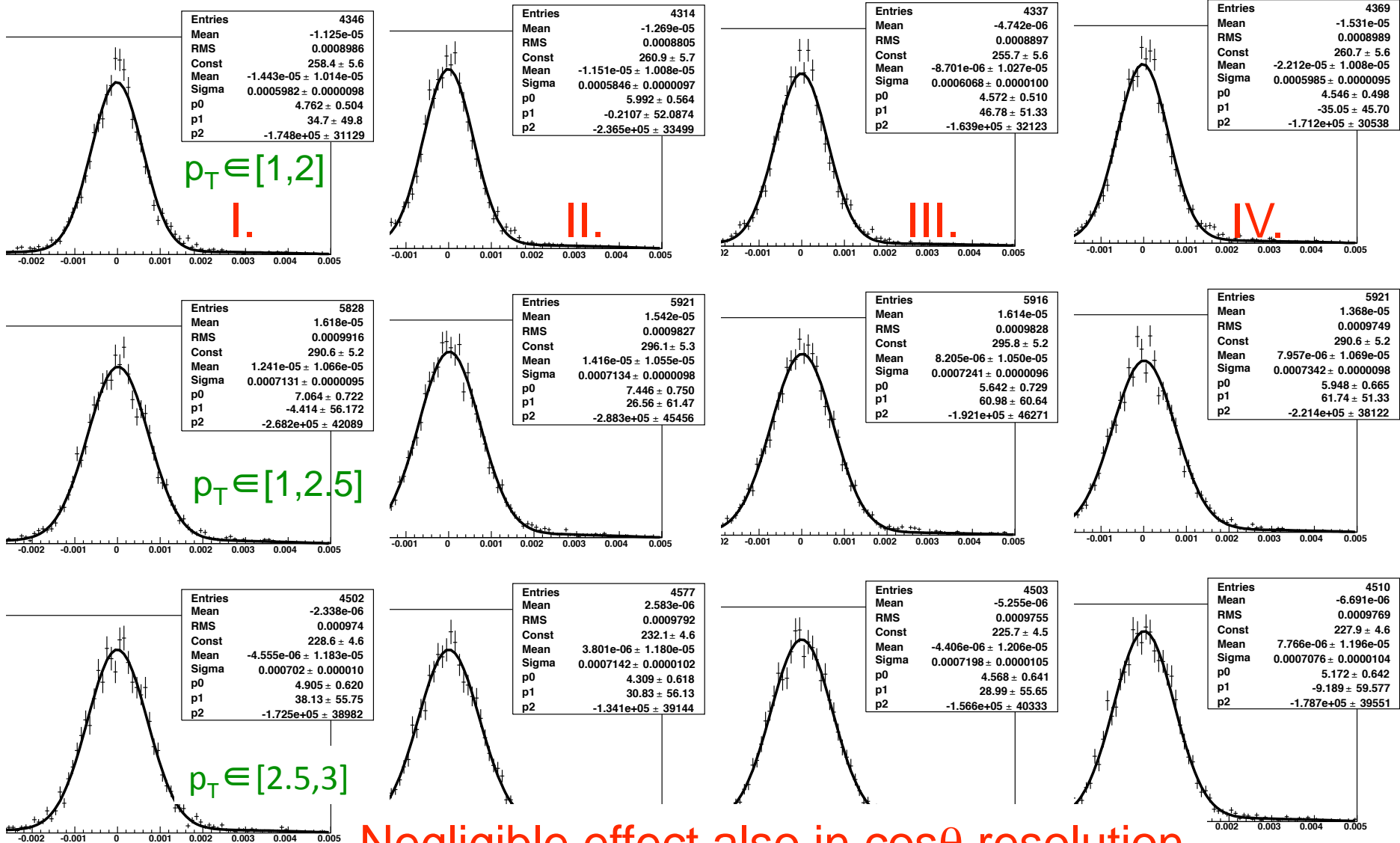
As expected, very small effect

BToPiPi: p_T vs. Stereo Angle Layout



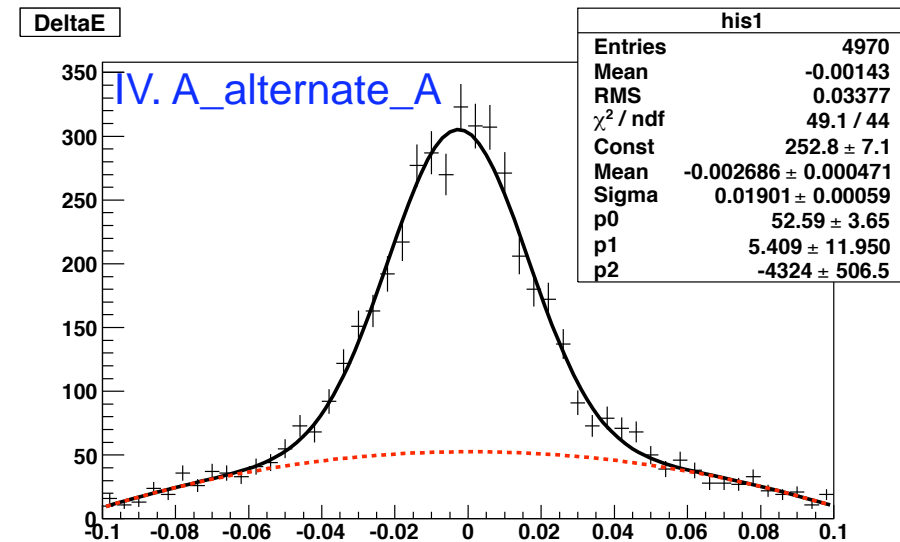
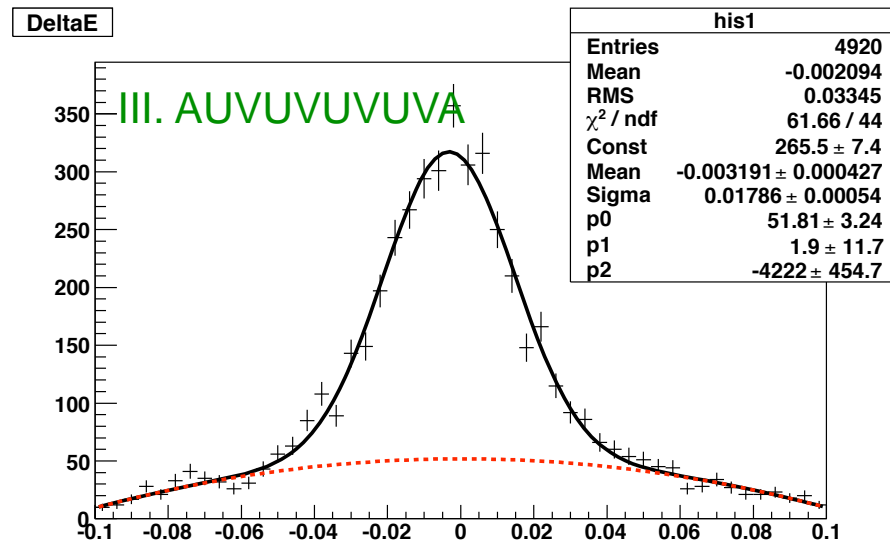
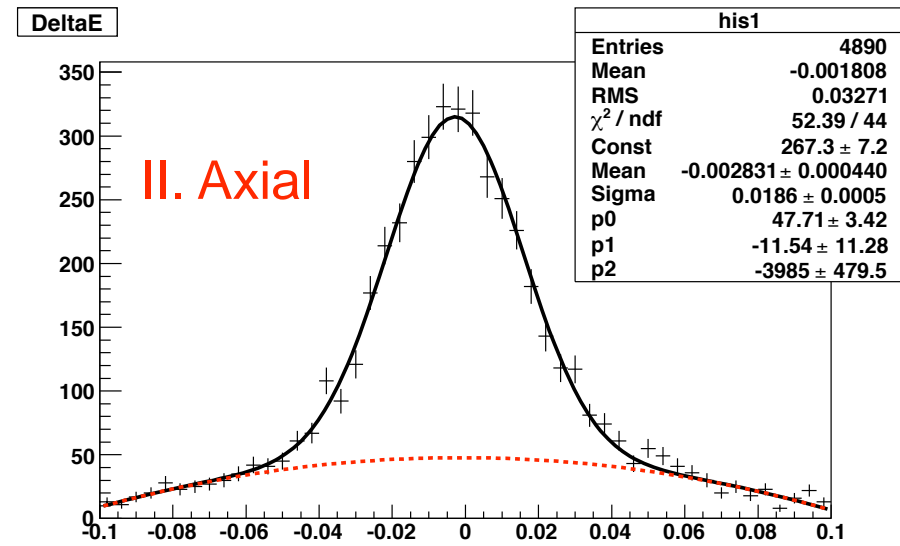
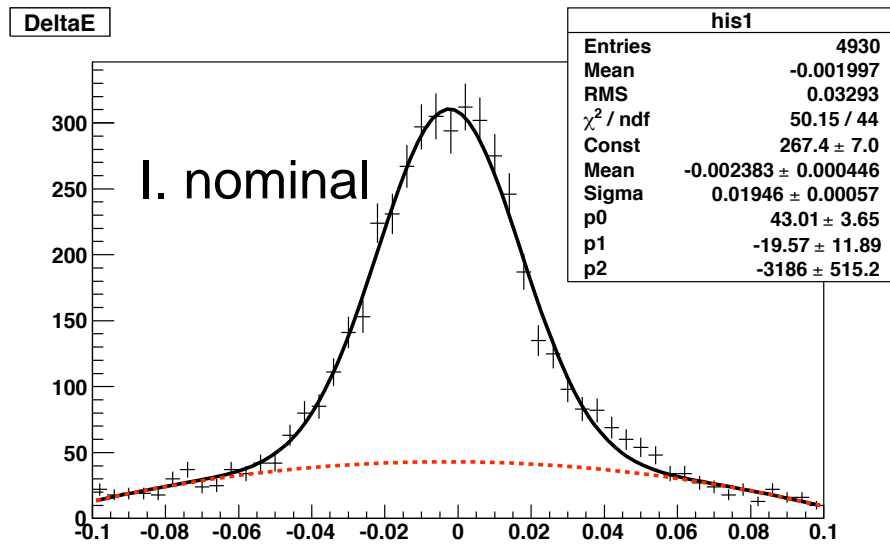
As expected, very small effect

BToPiPi: $\cos\theta$ vs. Stereo Angle Layout



Negligible effect also in $\cos\theta$ resolution

BToDstarK: ΔE vs. Stereo Angle Layout



Stereo Angle Layout: (Preliminary) Conclusions

- Since SVT dominates the θ measurement, Tracking does not seem to impose serious constraints to number and arrangement of stereo layers
 - possibly will repeat study
 - varying SVT inefficiencies (FastSim default $\geq 95\%$ used here)
 - on different channels (reco efficiency of long-lived particles?)
- This is good news: more freedom to cope with bkg occupancies from low pt curling tracks (which fire many stereo layers)
- Stricter requirements probably imposed by θ measurement in L1 trigger (to be investigated)

2. Drift Cell Optimization

- Drift cell design guidelines: **field uniformity** ↑
material ↓
- (As well-known) *BABAR* uses **hex** cells
 - “**symmetric**” and with **low F:S ratio** (2:1) but...
 - **mandatory Super-Layer structure**, with guard wires
 - 7104 sense $20\mu\text{m}\varnothing$ wires, 704 clearing $120\mu\text{m}\varnothing$ wires, **6400 guard $80\mu\text{m}\varnothing$** , 14560 field **$120\mu\text{m}\varnothing$**
 - Overall material budget relatively high
- With **square** cells, guard wires only needed at stereo-axial transitions (not at UV or VU ones)

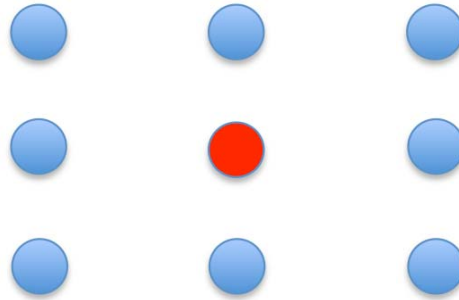
Drift Cell Layout Study

More attempts at specific square-cell layouts – 44 measuring layers

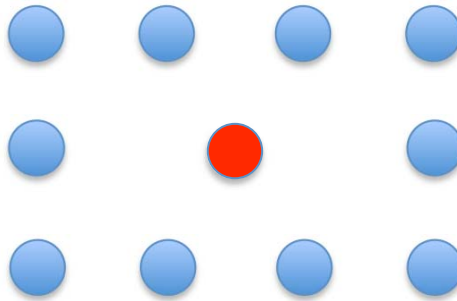
- ✓ AA UV UV UV UV A (11 SL with 4 layers each)
- ✓ $h=12\text{mm}$; $w=\pi\times 6\text{mm}$ (in first 8 A layers $w=\pi\times 3\text{mm}$)
 $R_{\text{cylinder}}=21.2\text{cm}$ (still waiting for final number)
 - `_r_first[11]={24.0,28.8,35.4,40.2,45.0,49.8,54.6,59.4,64.2,69.0,74.7};`
 - `_nSense[11]={160,192,118,134,150,166,182,198,214,230,249}`
- ✓ Guard layers: 1) after inner cylinder; 2) at A-U and V-A transitions; 3) before outer cylinder.
- ✓ 3:1 field:sense ratio - 7972 sense $20\mu\text{m}\varnothing$ wires, 1554 guard $80\mu\text{m}\varnothing$ wires, 25150 field $80\mu\text{m}\varnothing$ wires
- ✓ 4:1 field:sense ratio - 7972 sense $20\mu\text{m}\varnothing$ wires, 2331 guard $80\mu\text{m}\varnothing$ wires, 33739 field $60\mu\text{m}\varnothing$ wires

Drift Cell Layout Study (cont.)

- ✓ **3:1** field:sense ratio - 7972 sense $20\mu\text{m}\varnothing$ wires, **1554** guard $80\mu\text{m}\varnothing$ wires, **25150** field $80\mu\text{m}\varnothing$ wires



- ✓ **4:1** field:sense ratio - 7972 sense $20\mu\text{m}\varnothing$ wires, **2331** guard $80\mu\text{m}\varnothing$ wires, **33739** field $60\mu\text{m}\varnothing$ wires



Wire Diameter & Coating

- ✓ Sense wire diameter should guarantee high fields and gas amplification
 - e.g. BABAR $20\mu\text{m}$, KLOE $25\mu\text{m}$
 - in practice, limited by ease of handling
- ✓ Field wire diameter chosen to avoid field emission and gas amplification near the cathode ($E \leq 20\text{kV/cm}$)
 - $\varnothing \sim 120\mu\text{m}$ for 2:1 field:sense wire ratio
 - $\varnothing \sim 80\mu\text{m}$ for 3:1 field:sense wire ratio
 - $\varnothing \sim 60\mu\text{m}$ for 4:1 field:sense wire ratio
- ✓ 4:1 should also provide more uniform field for rectangular cells (to be confirmed by Garfield)
- ✓ Gold coating necessary on sense wire, not clear (at best) for field wires
 - Substantial increase in material

Drift cell-Gas mixture

Material Budget Comparison

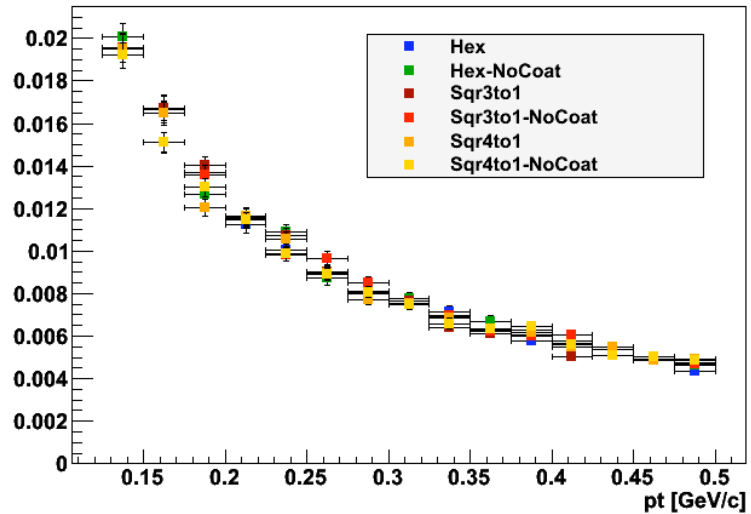
	$\rho(\text{g/cm}^3) \times 10^4$ coating/nocoating	$X0(\text{g/cm}^2)$ coating/nocoating	$X0(\text{m})$ coating/nocoating
80%He-20%iC ₄ H ₁₀	6.3	50.8	805
80%He-20%iC ₄ H ₁₀ -hex	10./9.5	27.3/33.3	270/350
80%He-20%iC ₄ H ₁₀ -sqr3:1	9.0/8.5	27.9/34.4	310/400
80%He-20%iC ₄ H ₁₀ -sqr4:1	8.5/8.1	27.9/35.1	320/430
90%He-10%iC ₄ H ₁₀	4.0	56.2	1410
90%He-10%iC ₄ H ₁₀ -hex	7.7/7.2	24.5/30.9	320/430
90%He-10%iC ₄ H ₁₀ -sqr3:1	6.7/6.2	24.8/31.8	370/510
90%He-10%iC ₄ H ₁₀ -sqr4:1	6.3/5.8	24.6/32.5	390/560
80%He-20%CH ₄	2.7	62.0	2340
80%He-20%CH ₄ -hex	6.4/5.9	22.3/28.7	350/490
80%He-20%CH ₄ -sqr3:1	5.4/4.9	22.2/29.3	410/600
80%He-20%CH ₄ -sqr4:1	5.0/4.5	21.8/30.0	440/660

BABAR

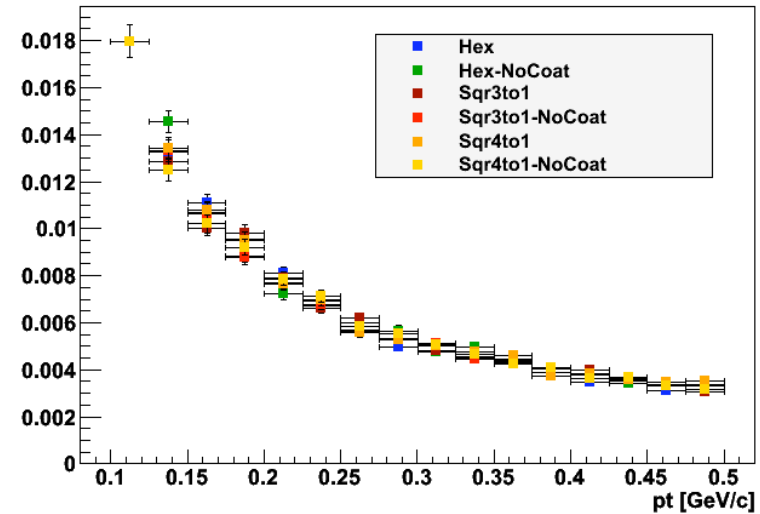
Tracking Performance vs. Cell Layout – “low” p_T

single π^+ $p \in [0.05, 4.5] \text{ GeV}/c$; $\cos\theta \in [-1, +1]$; $\phi \in [0, 360]^\circ$

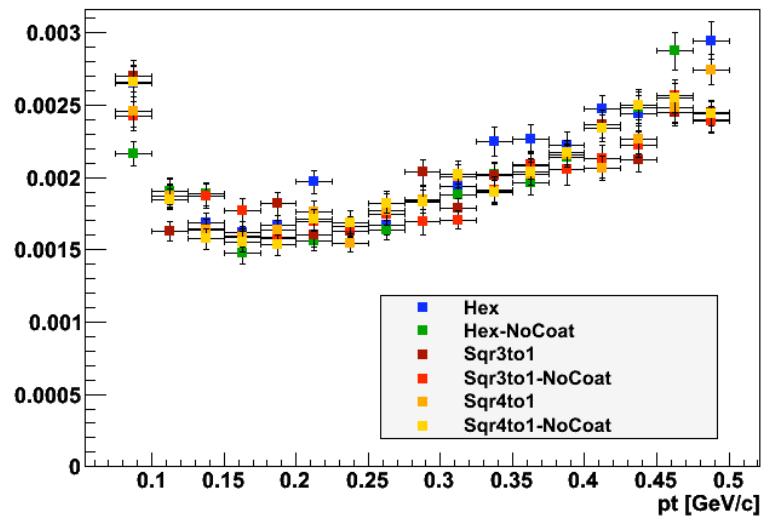
phi reso. [rad]



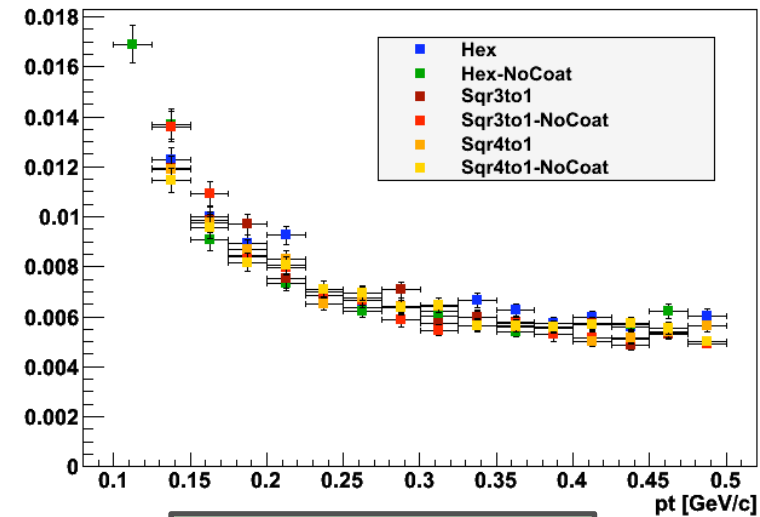
theta reso. [rad]



pt reso. [GeV/c]



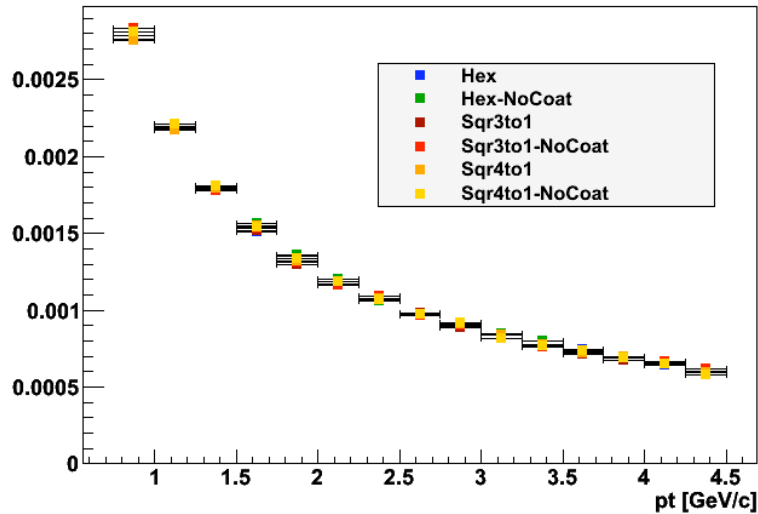
$\sigma(pt)/pt$ reso.



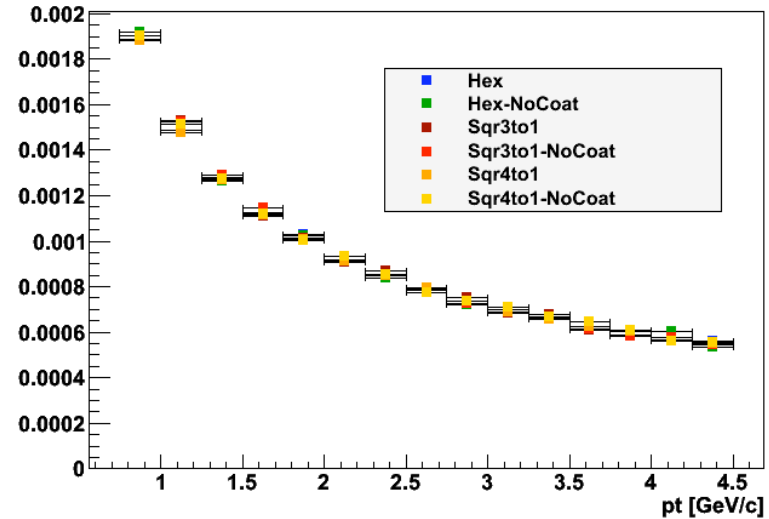
Tracking Performance vs. Cell Layout – “high” p_T

single π^+ $p \in [0.05, 4.5] \text{ GeV}/c$; $\cos\theta \in [-1, +1]$; $\phi \in [0, 360]^\circ$

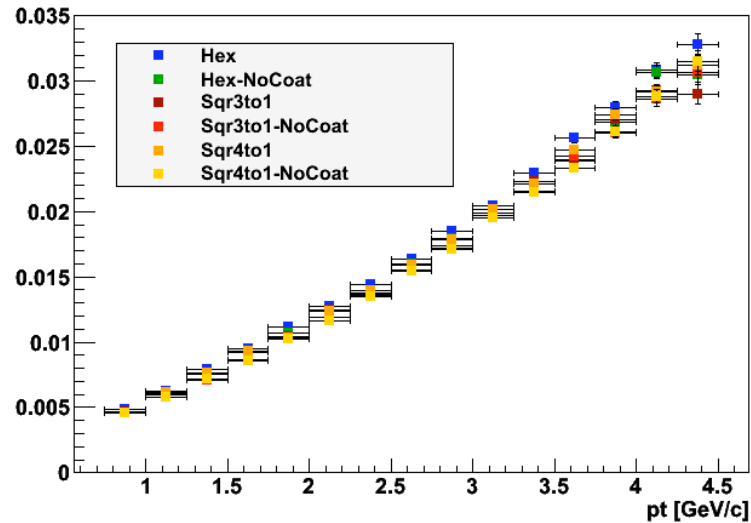
phi reso. [rad]



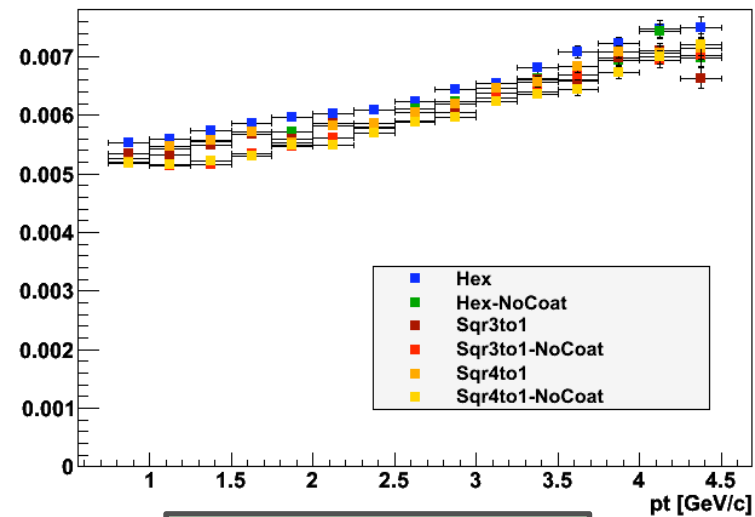
theta reso. [rad]



pt reso. [GeV/c]



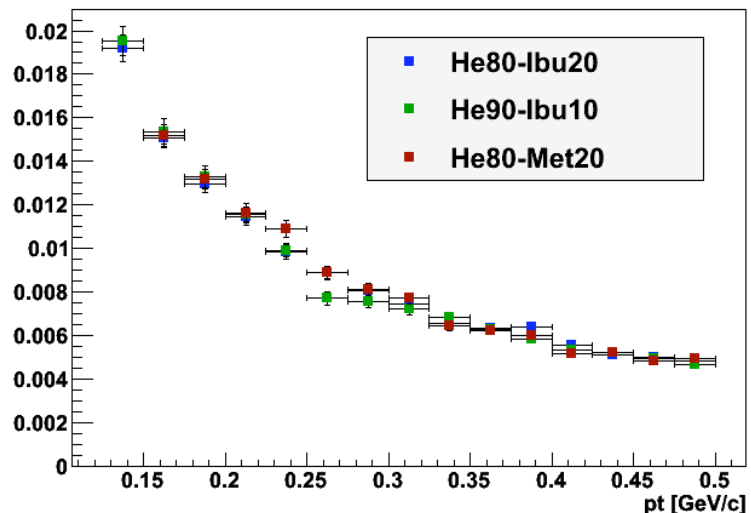
$\sigma(pt)/pt$ reso.



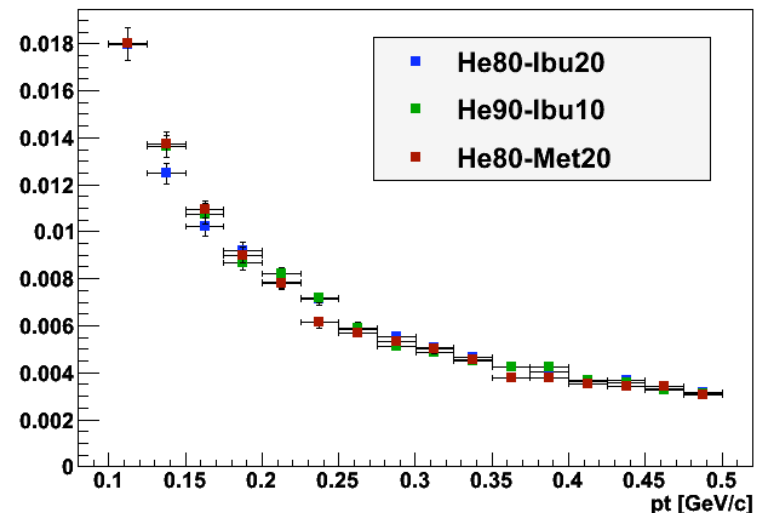
Tracking Performance vs. Gas Mixture – “low” p_T

single π^+ $p \in [0.05, 4.5] \text{ GeV}/c$; $\cos\theta \in [-1, +1]$; $\phi \in [0, 360]^\circ$

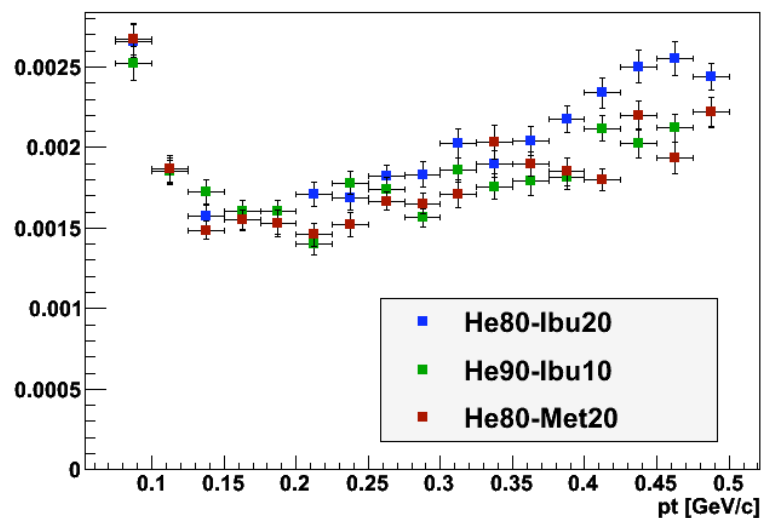
phi reso. [rad]



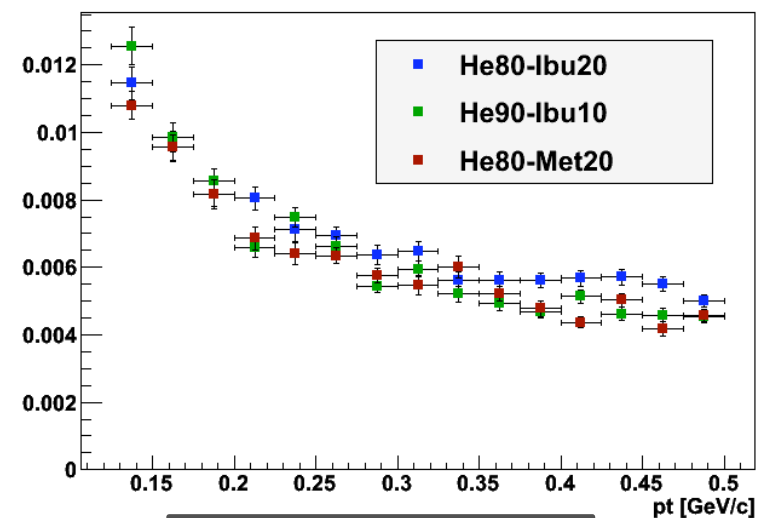
theta reso. [rad]



pt reso. [GeV/c]



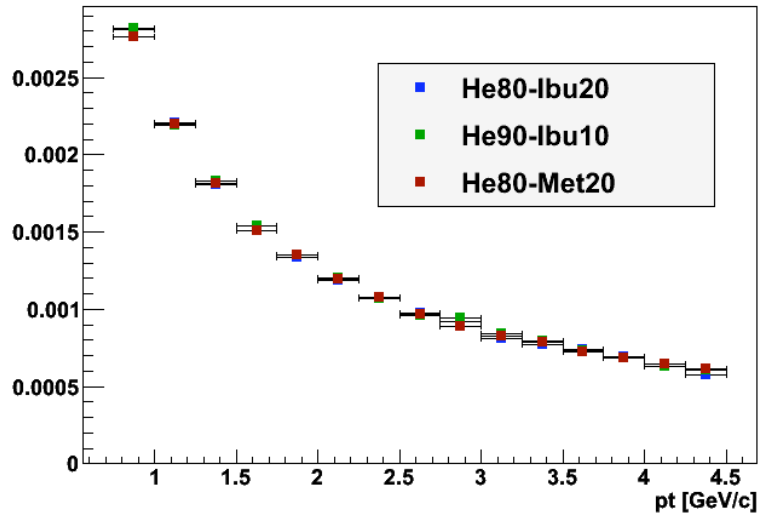
$\sigma(pt)/pt$ reso.



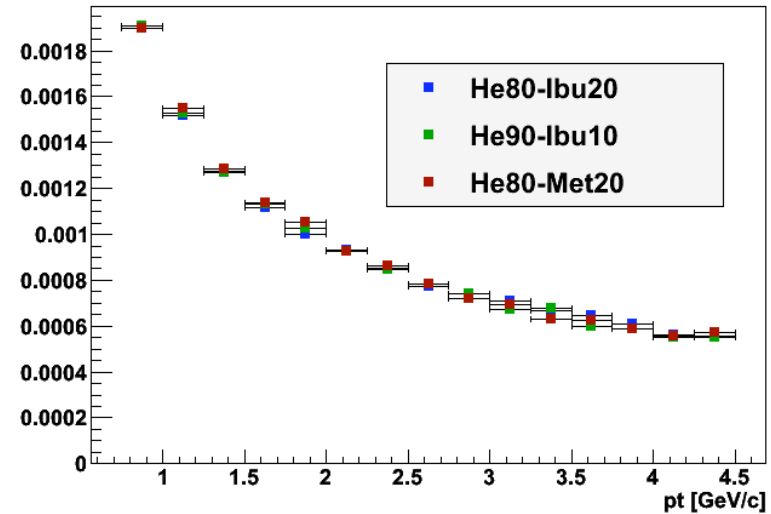
Tracking Performance vs. Gas Mixture – “high” p_T

single π^+ $p \in [0.05, 4.5] \text{ GeV}/c$; $\cos\theta \in [-1, +1]$; $\phi \in [0, 360]^\circ$

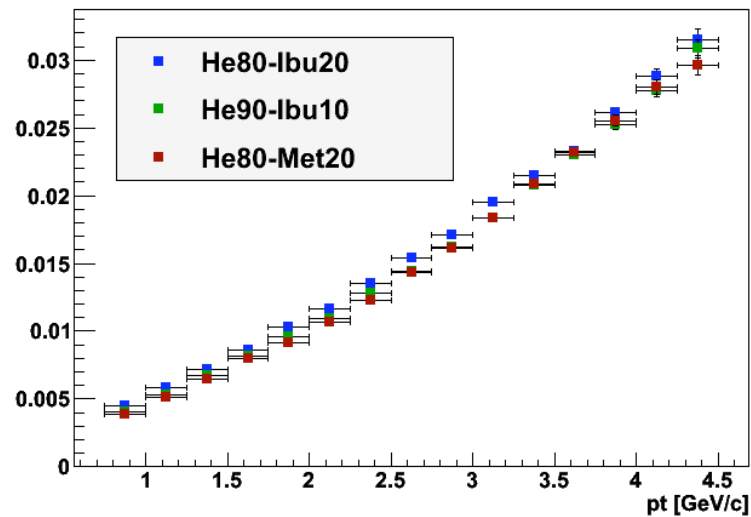
phi reso. [rad]



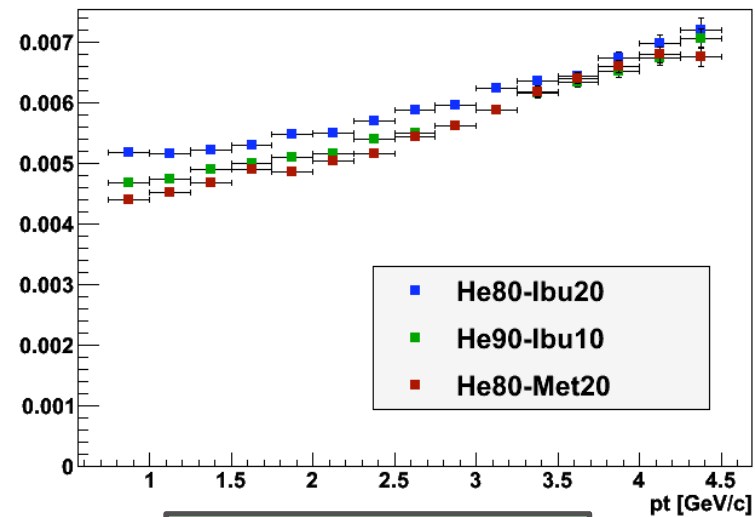
theta reso. [rad]



pt reso. [GeV/c]



$\sigma(pt)/pt$ reso.



Drift Cell Layout: (preliminary) Conclusions

- Square cells with 3:1 or 4:1, and the use of un-plated Al5056 field wires allow substantial reduction of the DCH material.
- First FastSim comparative study of the various configurations using single pions
 - important limitation of this study: the same cell resolution was used for all configurations
- 15-20% improvement in momentum measurement at lower momenta
 - larger statistics needed to understand finer details
- Gas mixtures lighter than *BABAR*'s 80%He-20% i C₄H₁₀ *might* be used to further reduce overall DCH material
- Delicate trade-off with achievable spatial and dE/dx resolutions (integrated charge vs. cluster counting), and stability of operation
 - See first preliminary results in tomorrow's talk @DCH-II