DCH:

Cell Layout FastSim Studies

G. Finocchiaro, M. Rama
INFN LNF

XII SuperB General Meeting

DGWG-II parallel session
Annecy, 17 March 2010

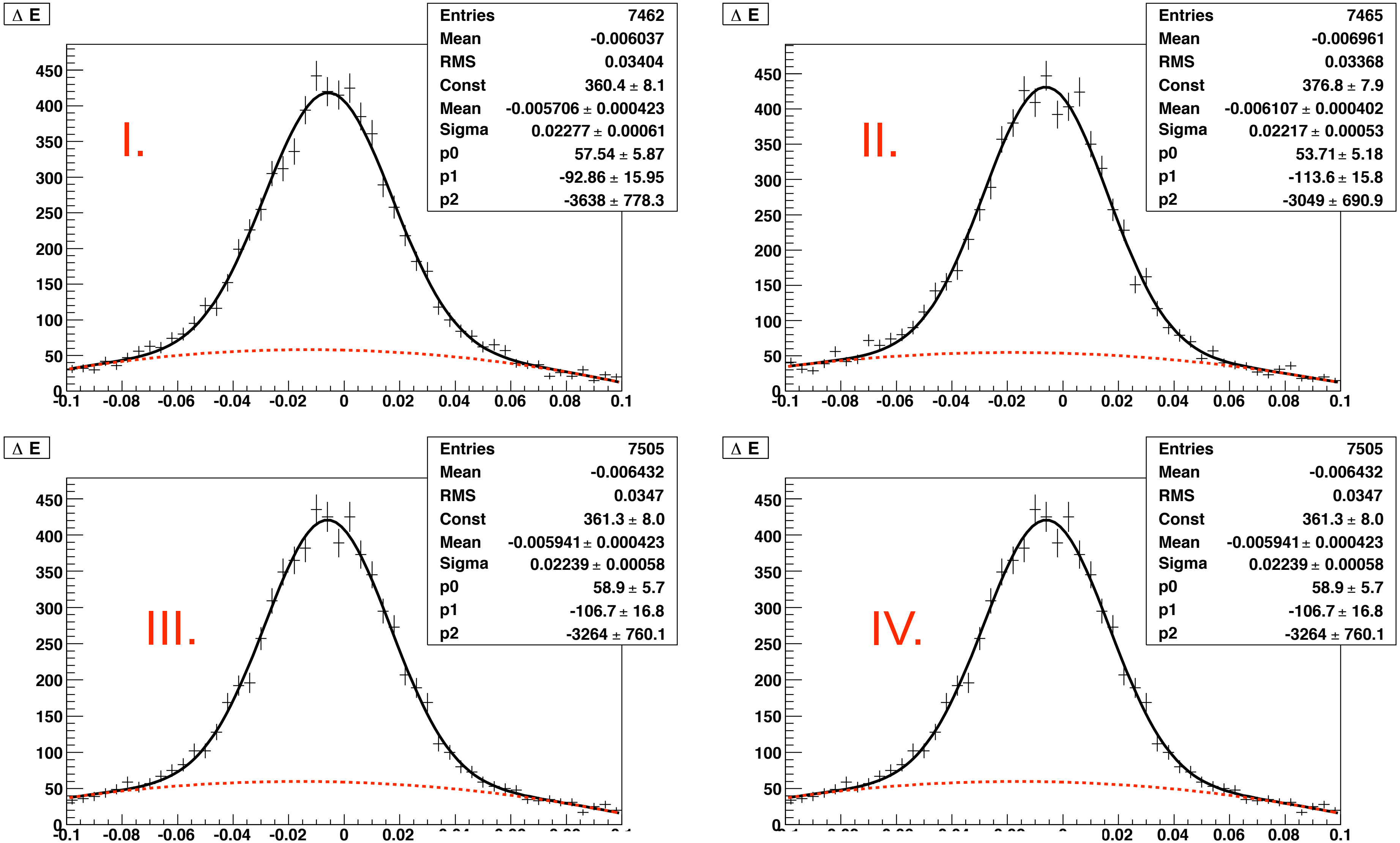
Cell and Layer Layout Optimization

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

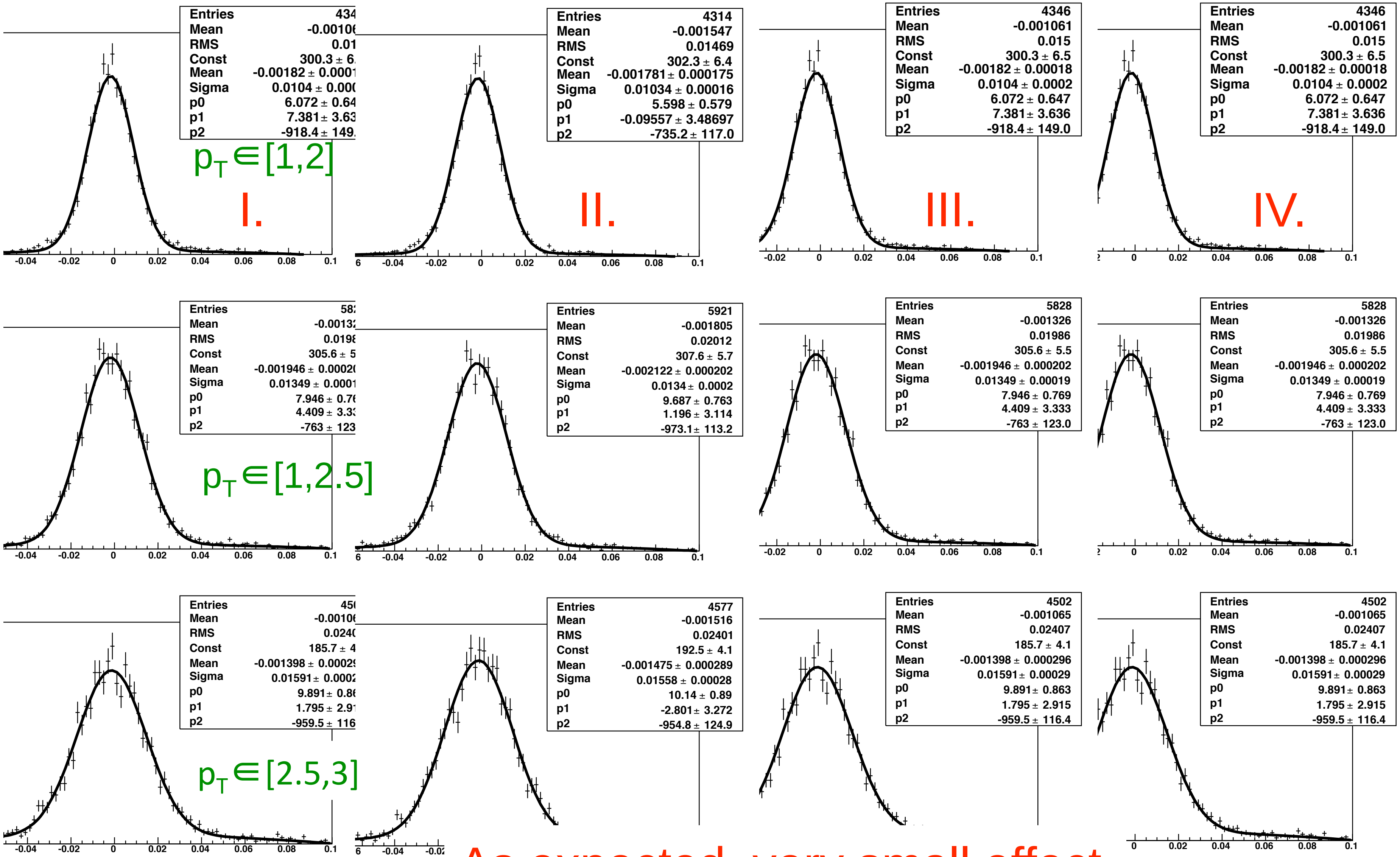
- Theta measurement largely dominated by vertex detector
- Study effect on tracking of stereo/axial measuring layers comparing (BToPiPi and BToDstarK) four different configurations:
  I. “Nominal”: AUVAUVAUVA
  II. “Axial”: AAAAAAAAAA
  III. “Stereo SL” : AUVUVUVUVA
  IV. “Stereo layers” Auvuv…..uvuvA

BToPiPi: ΔE vs. Stereo Angle Layout



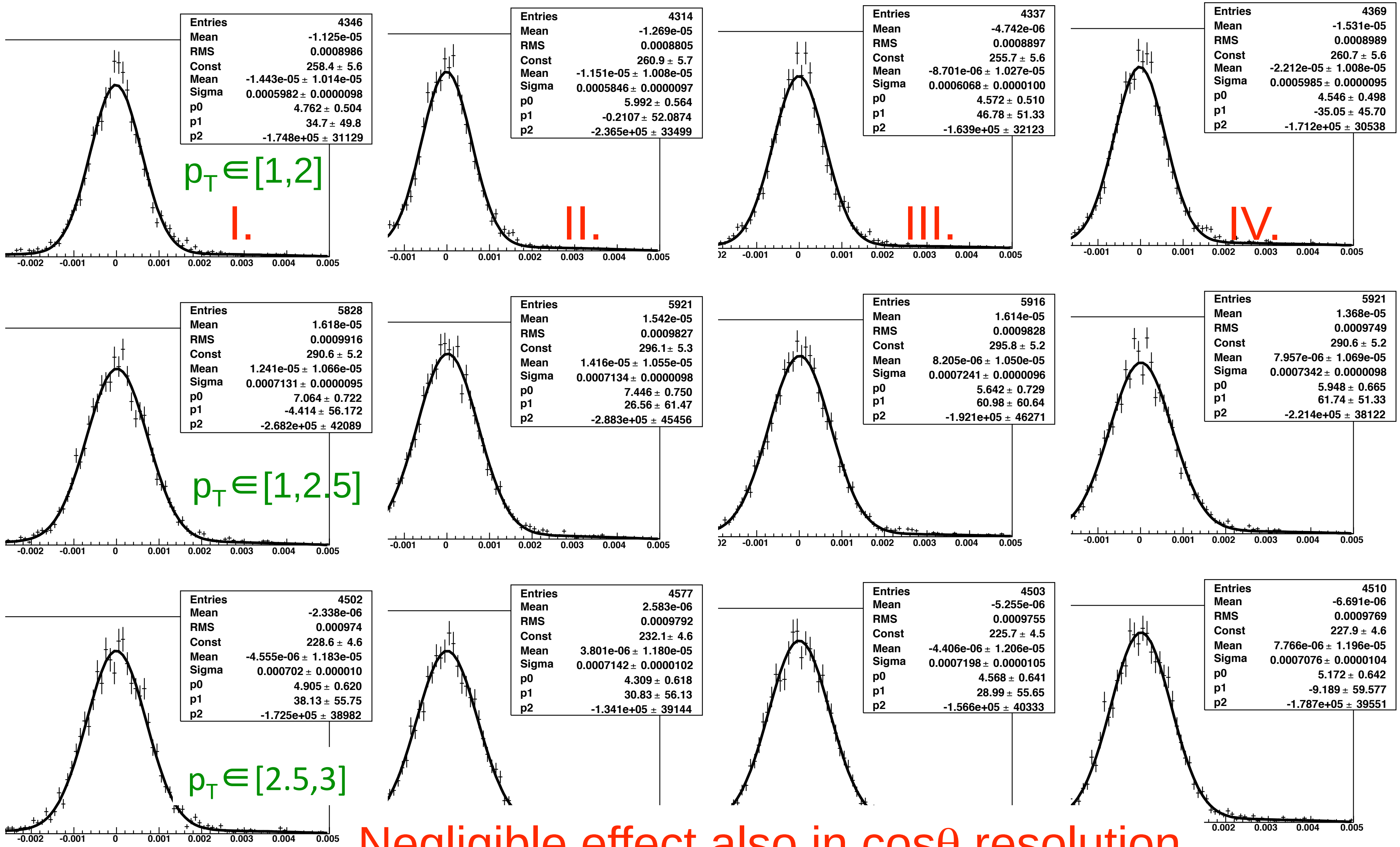
As expected, very small effect

BToPiPi: p_T vs. Stereo Angle Layout



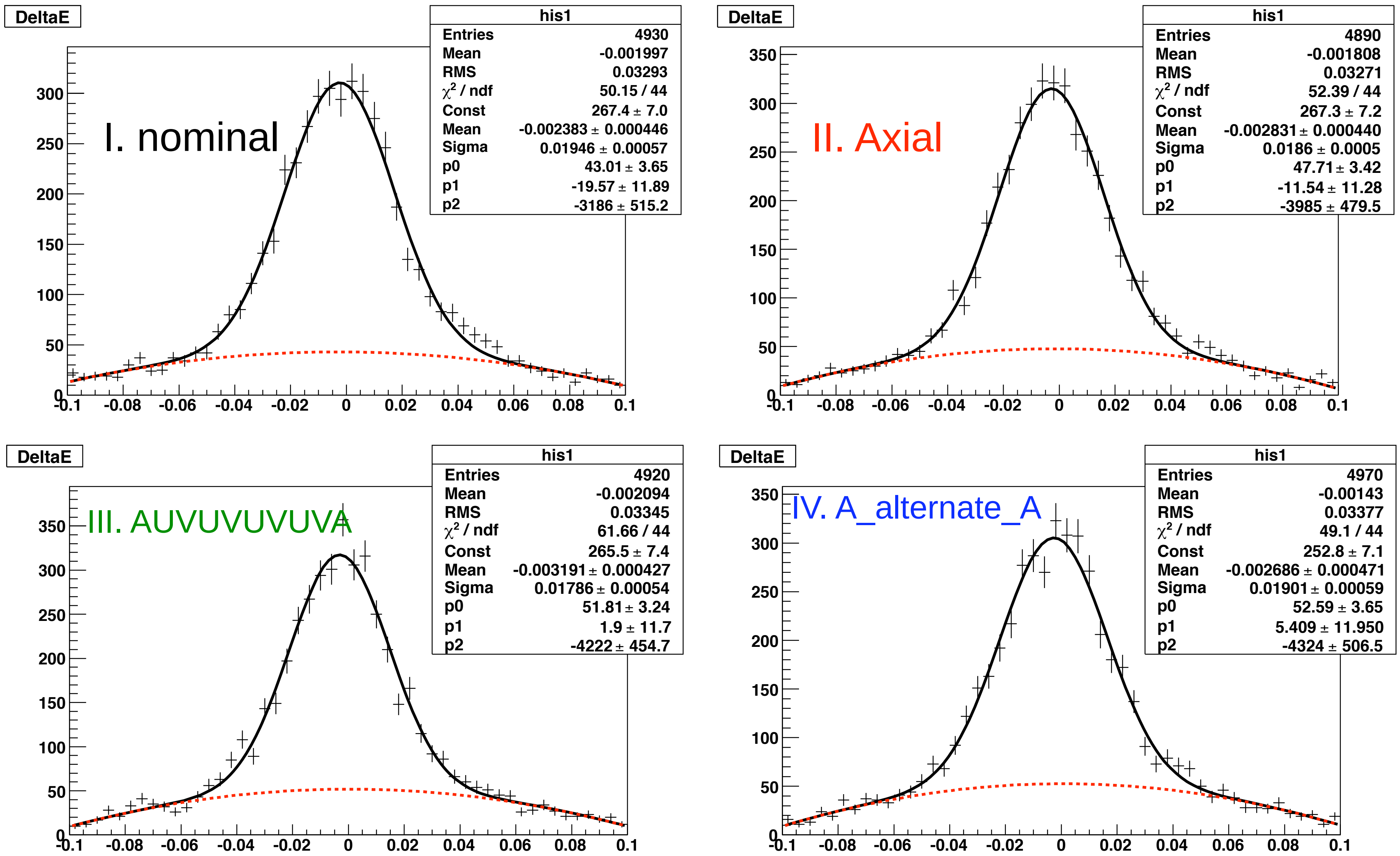
As expected, very small effect

BToPiPi: cosθ vs. Stereo Angle Layout



Negligible effect also in cosθ resolution

BToDstarK: ΔE vs. Stereo Angle Layout



Small effects also in events with softer tracks

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 ≥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 20μm∅ wires, 704 clearing 120μm∅ wires, 6400 guard 80μm∅, 14560 field 120μm∅
  - 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

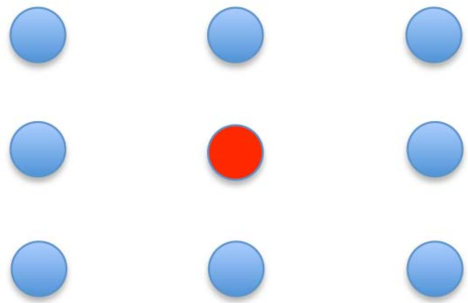
2 specifics square-cell layouts – 44 measuring layers

- ✓ AA UV UV UV UV A (11 SL with 4 layers each)
- ✓ h=12mm; w=π×6mm (in first 8 A layers w=π×3mm) $R_{cylinder}$=21.2cm (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 20μm∅ wires, 1554 guard 80μm∅ wires, 25150 field 80μm∅(*) wires
- ✓ 4:1 field:sense ratio - 7972 sense 20μm∅ wires, 2331 guard 80μm∅ wires, 33739 field 60μm∅(*) wires

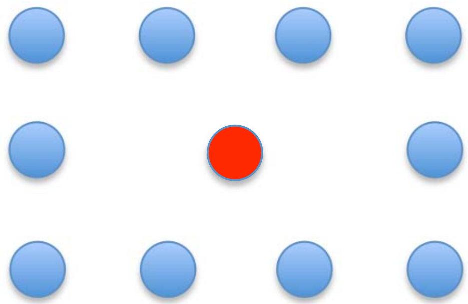
(*) True for square cells. Calculation to be repeated for rectangular cells

Drift Cell Layout Study (cont.)

✓ 3:1 field:sense ratio - 7972 sense 20μm∅ wires, 1554 guard 80μm∅ wires, 25150 field 80μm∅ wires



✓ 4:1 field:sense ratio - 7972 sense 20μm∅ wires, 2331 guard 80μm∅ wires, 33739 field 60μm∅ wires



Wire Diameter & Coating

- ✓ Sense wire diameter should guarantee high fields and gas amplification
  - e.g. BABAR 20μm, KLOE 25μm
  - in practice, limited by ease of handling
- ✓ Field wire diameter chosen to avoid field emission and gas amplification near the cathode (E≤20kV/cm)
  - ∅ ~ 120μm for 2:1 field:sense wire ratio
  - ∅ ~ 80μm for 3:1 field:sense wire ratio
  - ∅ ~ 60μm 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

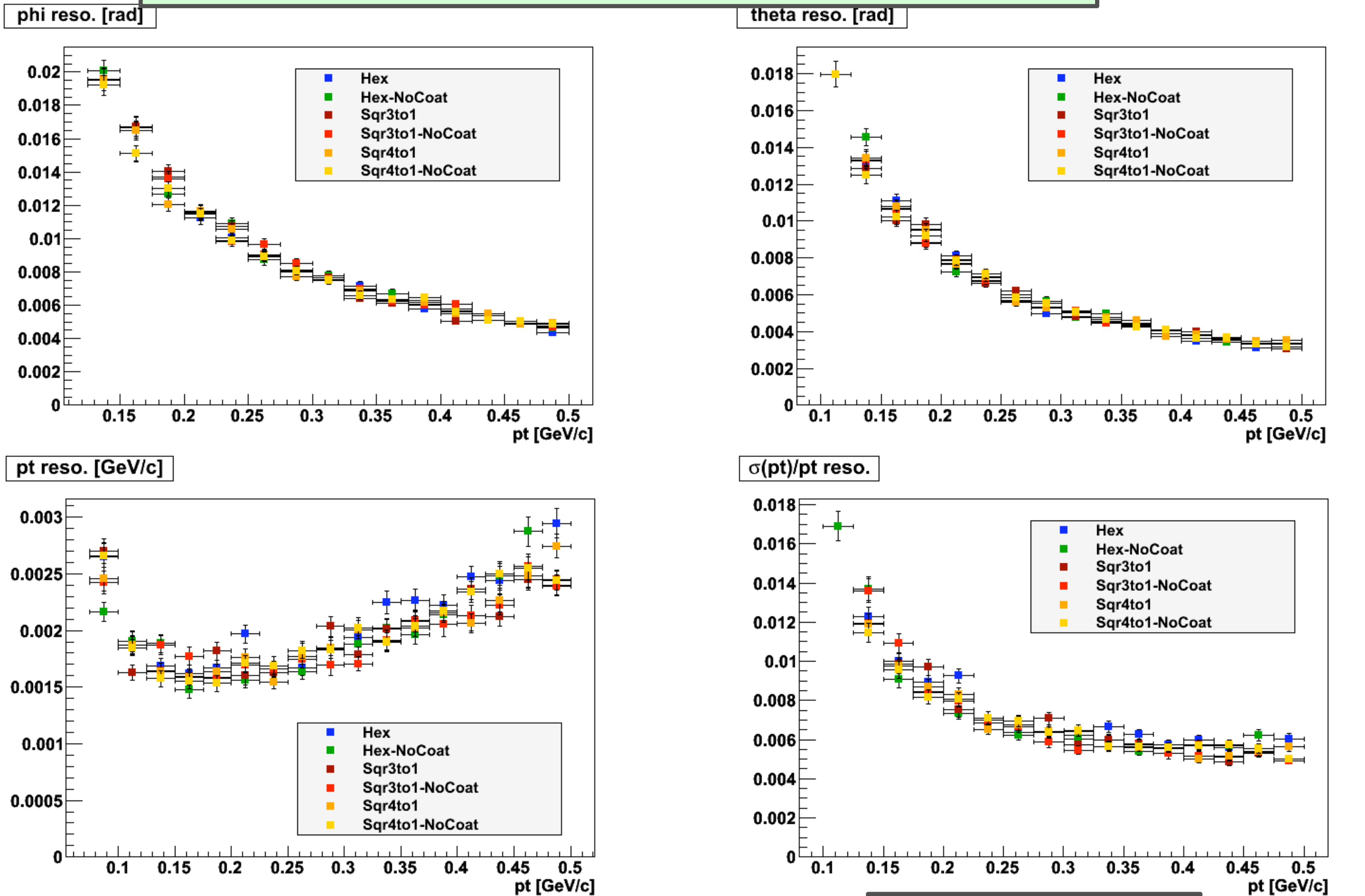
Drift cell-Gas mixture
Material Budget Comparison

	ρ(g/cm^3) x1 0^4 coating/nocoating	X0(g/cm^2) coating/nocoating	X0(m) coating/nocoating
80%He-20%iC_4H_{10}	6.3	50.8	805
80%He-20%iC_4H_{10}-hex	10./9.5	27.3/33.3	270/350
80%He-20%iC_4H_{10}-sqr3:1	9.0/8.5	27.9/34.4	310/400
80%He-20%iC_4H_{10}-sqr4:1	8.5/8.1	27.9/35.1	320/430
90%He-10%iC_4H_{10}	4.0	56.2	1410
90%He-10%iC_4H_{10}-hex	7.7/7.2	24.5/30.9	320/430
90%He-10%iC_4H_{10}-sqr3:1	6.7/6.2	24.8/31.8	370/510
90%He-10%iC_4H_{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

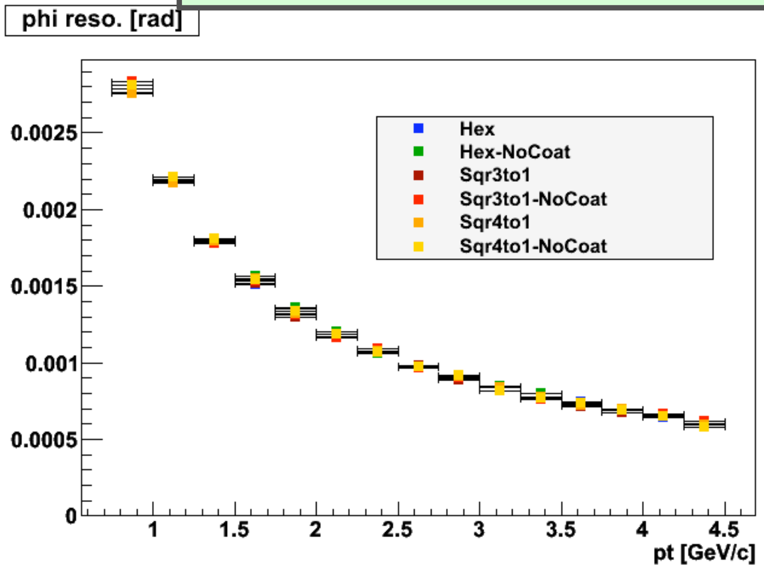
single π^+ $p\in[0.05,4.5]$GeV/c ; $\cos\theta\in[-1,+1]$; $\phi\in[0,360]^o$

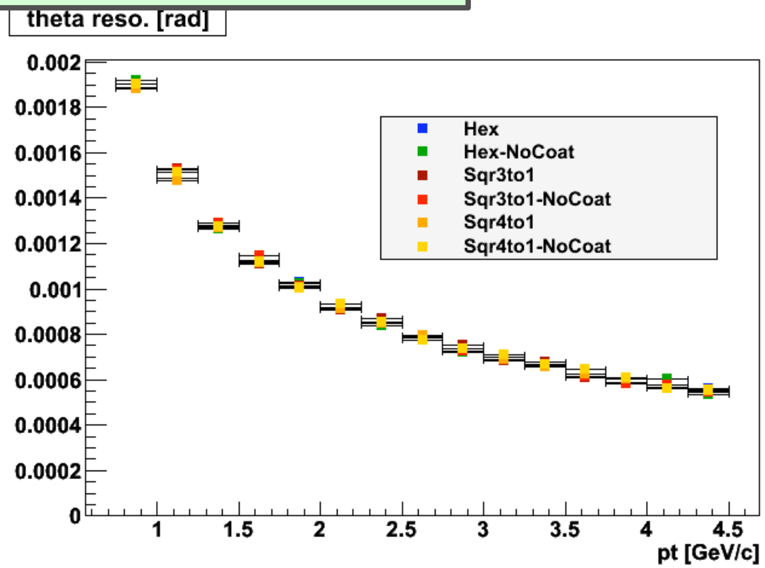


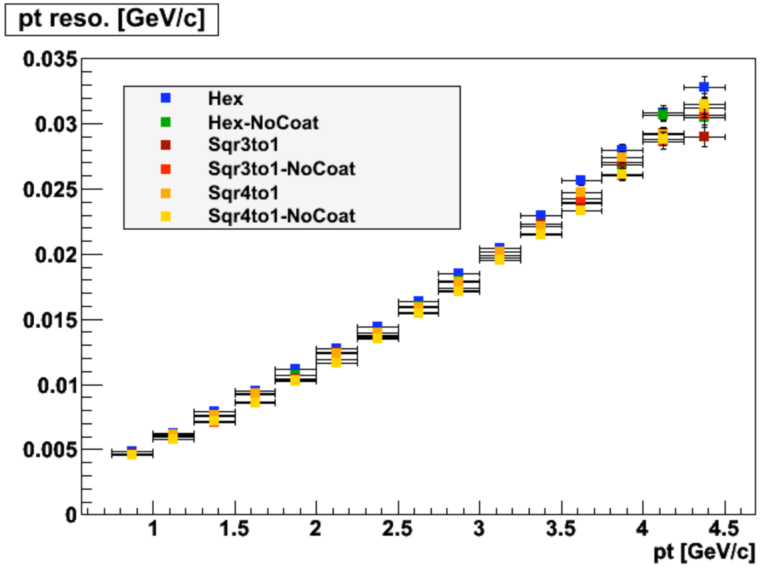
$80\%He-20\%iC_4H_{10}$

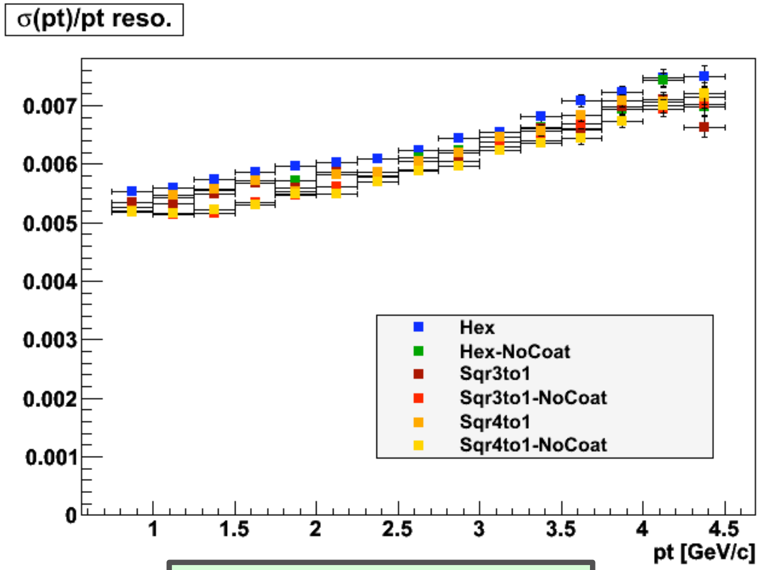
Tracking Performance vs. Cell Layout – “high” p_T

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





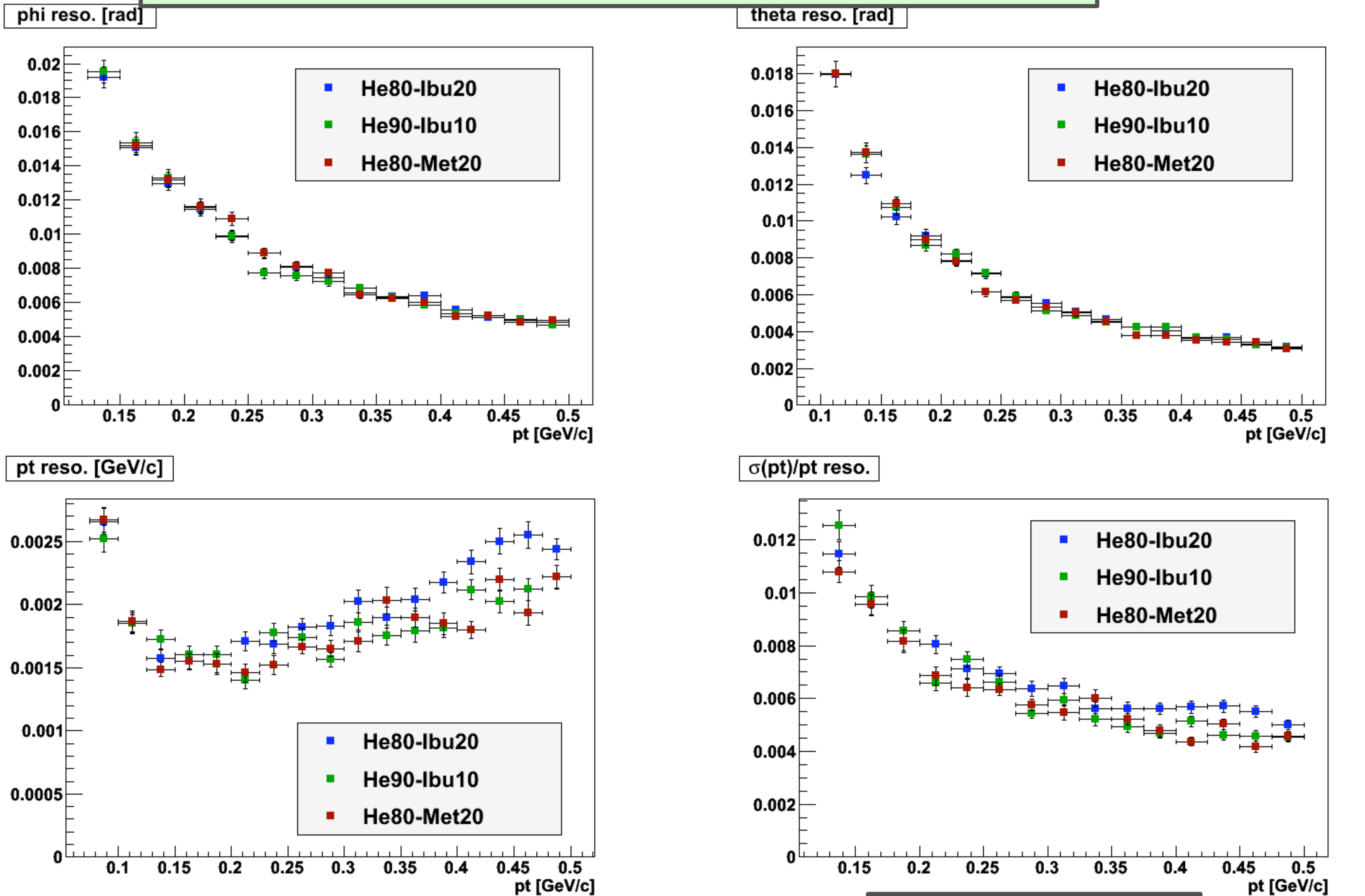




80%He-20%iC_4H_{10}

Tracking Performance vs. Gas Mixture – "low" p_T

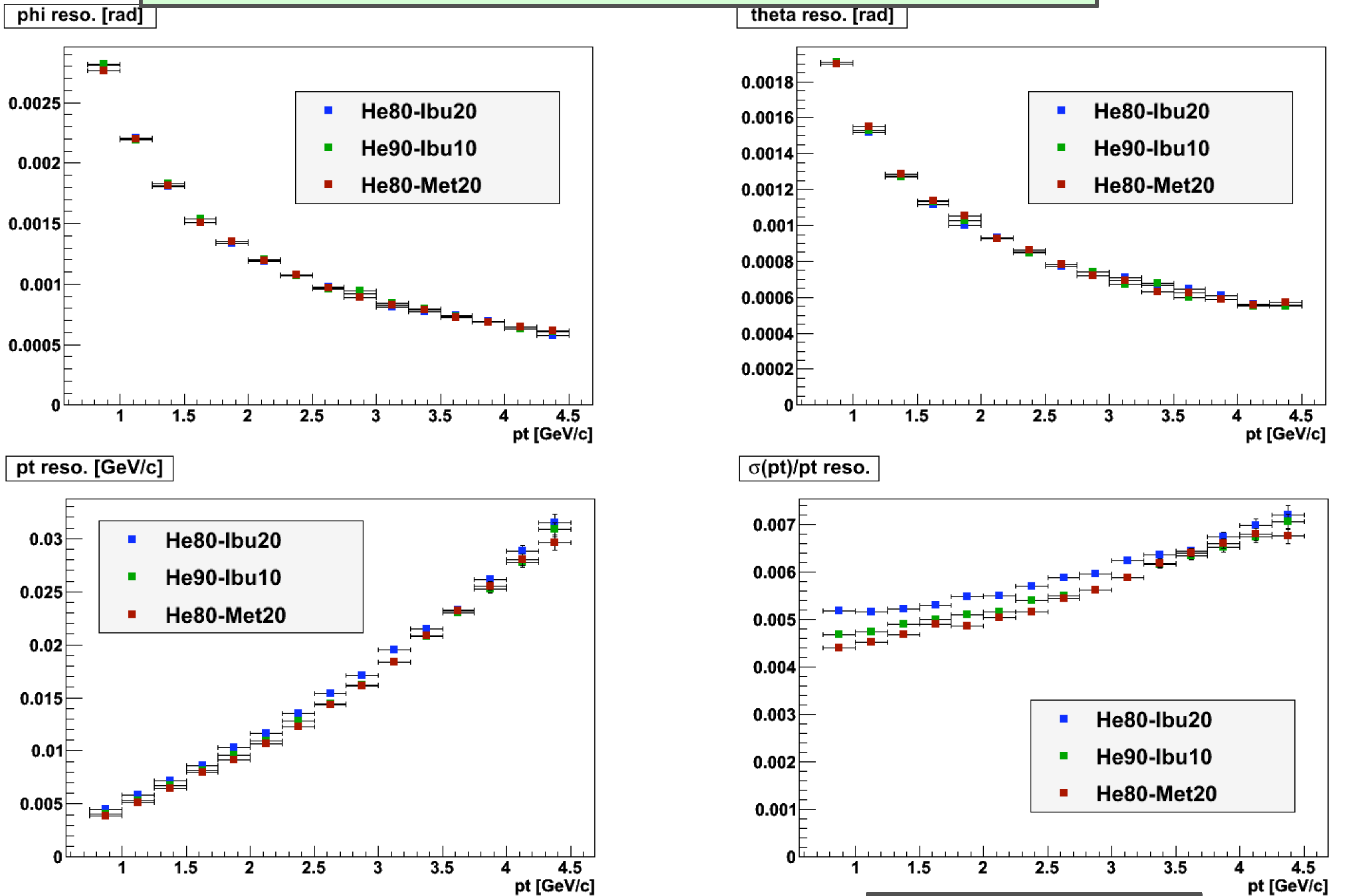
single π^+ $p \in [0.05,4.5]$GeV/c ; $\cos\theta \in [-1,+1]$; $\phi \in [0,360]^o$



Sqr 4:1 No Coating

Tracking Performance vs. Gas Mixture – "high" p_T

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



Sqr 4:1 No Coating

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%iC_4H_{10} *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