EIC FST Simulaiton using Fun4All

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10-22-2020

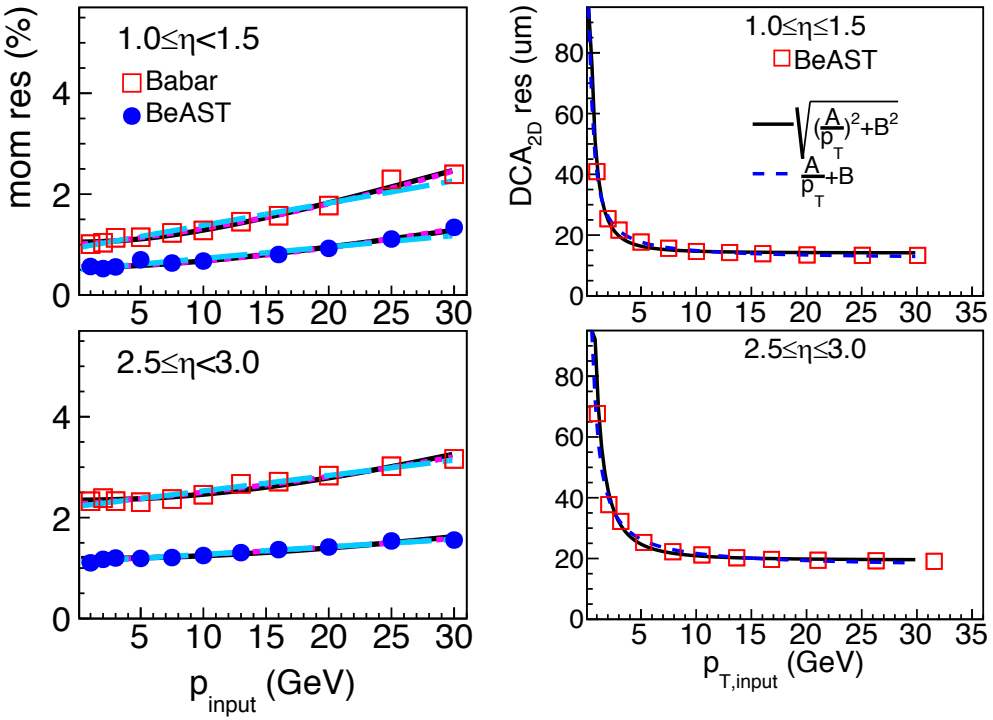
Outline

- Motivation: summary table for the detector performance of the LANL FST design in the integrated detector systems
- Material Budgets
- Parameters of the momentum and DCA resolutions
- Summary and Plan

Motivation

Last Update

- Summary table for the detector performance of the LANL FST design
- To check whether the performance can meet the associated heavy flavor and jets physics requirements



Feedback from Tracking Group: Gas RICH need to be included in detector performance study

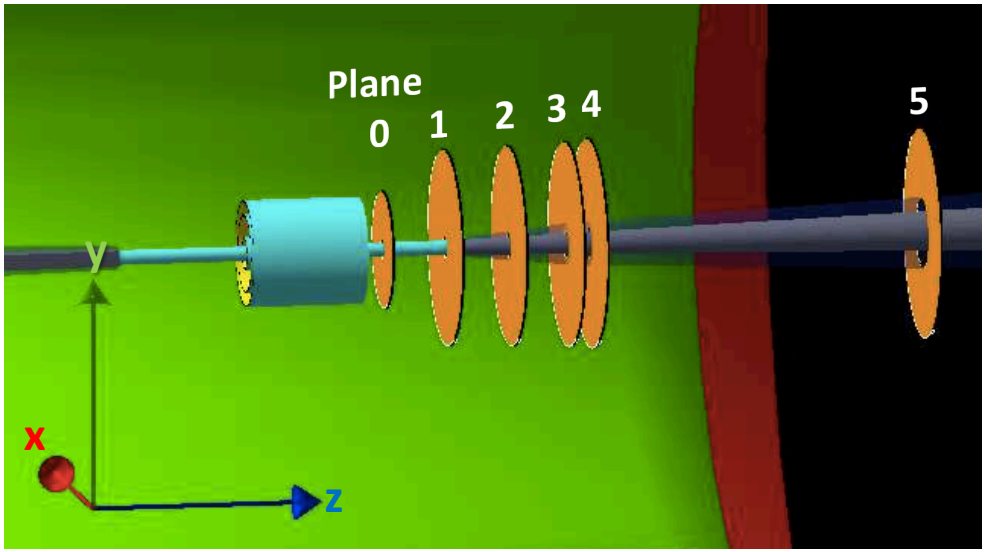
Simulation Setup

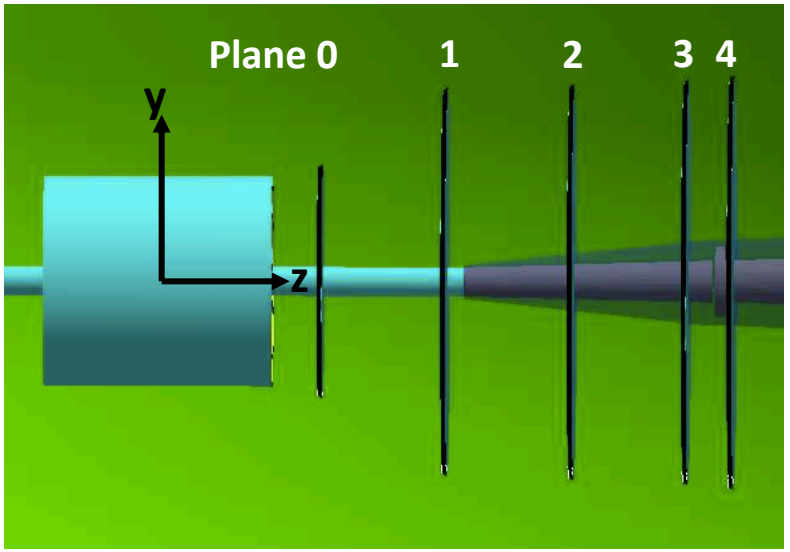
- Event configuration:
  - single (10) π- per event for momentum (vertex) reconstruction
  - Vertex (0,0,0)
    - no smearing for vertex reconstruction
    - 20um smearing in x and y direction for track reconstruction
  - 7.5M events in each p_T bin
- Track configuration:
  - p_T: 1-30 GeV with varying increments
  - Pseudorapdity: **0-3.5** w.r.t. to the beam pipe
  - Hit efficiency at 95%
  - Pseudorapidity correction for ion beam angle

Latest FST Detector Setup

Design by Xuan

Plane	z (cm)	r_{in} (cm)	r_{out} (cm)	Pixel pitch (um)	Silicon thickness (um)
0	35	4	25	20	50
1	62.3	4.5	42	20	50
2	90	5.2	43	20	50
3	115	6	44	36.4	100
4	125	6.5	45	36.4	100
5	270	15	45	36.4	100



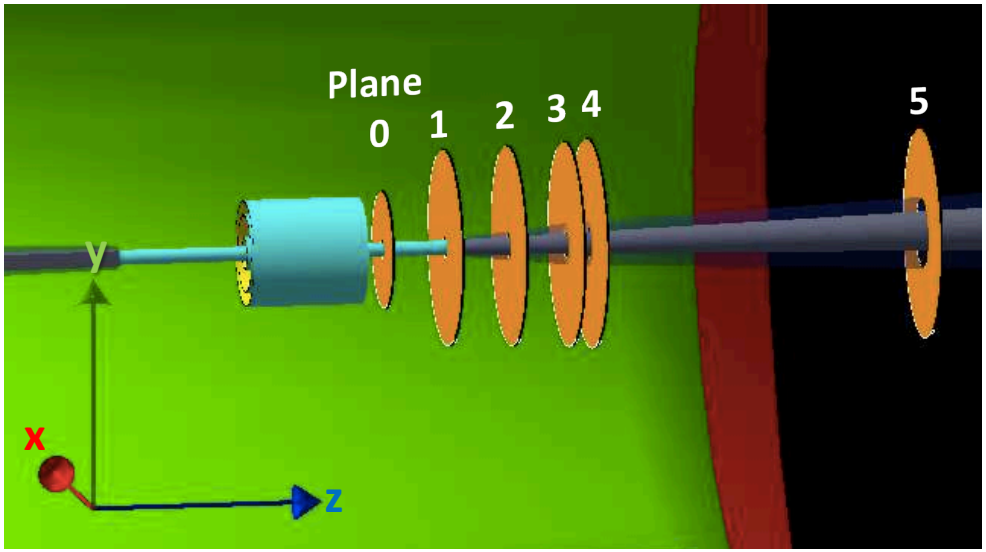


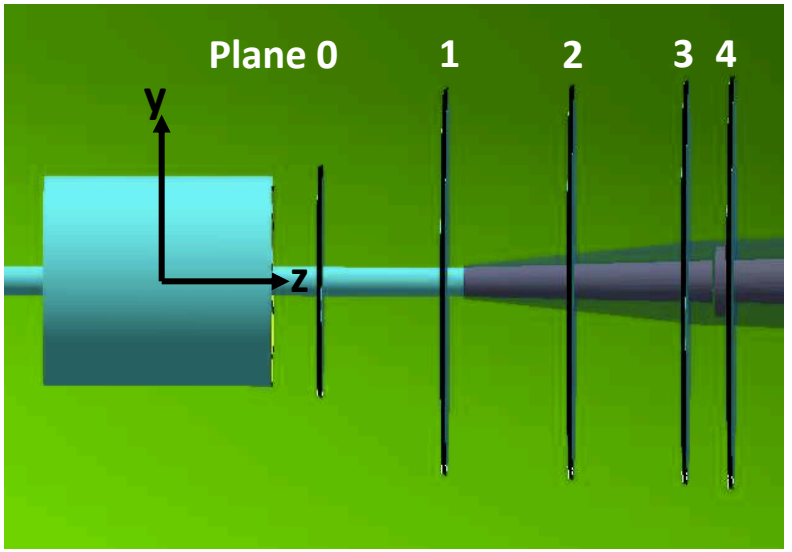
Latest FST Detector Setup

To accommodate the Gas RICH

Design by Xuan

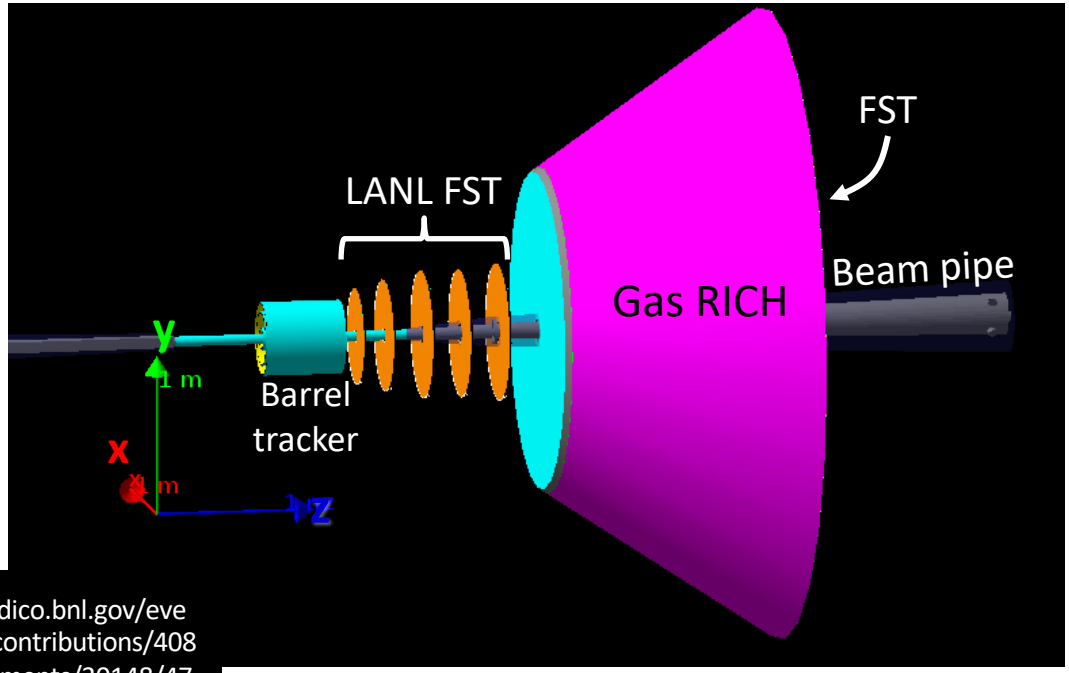
Plane	z (cm)	r_{in} (cm)	r_{out} (cm)	Pixel pitch (um)	Silicon thickness (um)
0	35	4	25	20	50
1	62.3	4.5	42	20	50
2	90	5.2	43	20	50
3	115	6	44	36.4	100
4	125	6.5	45	36.4	100
5	**300**	15	45	36.4	100

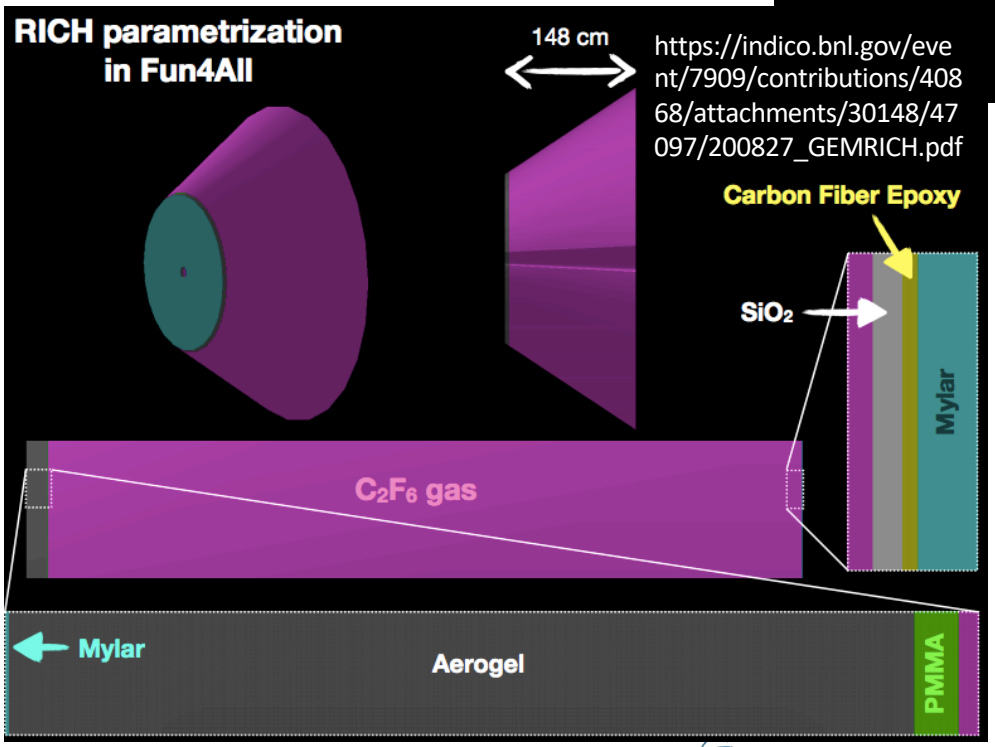


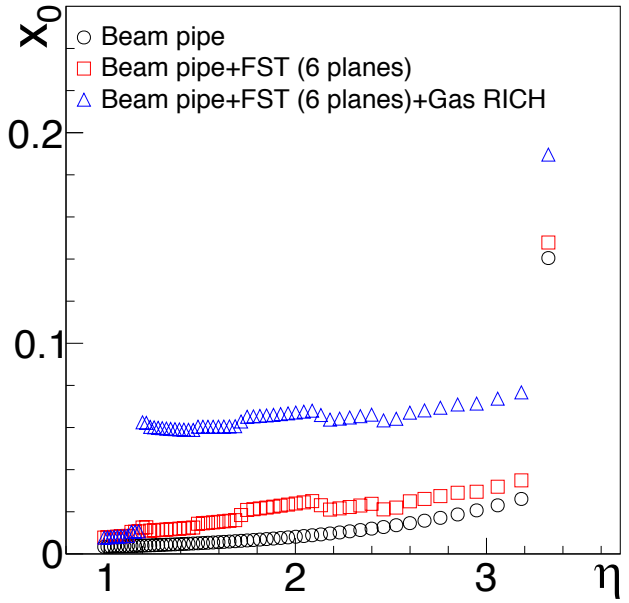


Material Budget of
FST (6 Planes) + Gas RICH

- Mockup Gas RICH by LBNL: same materials used by PID consortium, but simplified geometry
- Total material budget (blue) is <8% at $\eta < 3.3$

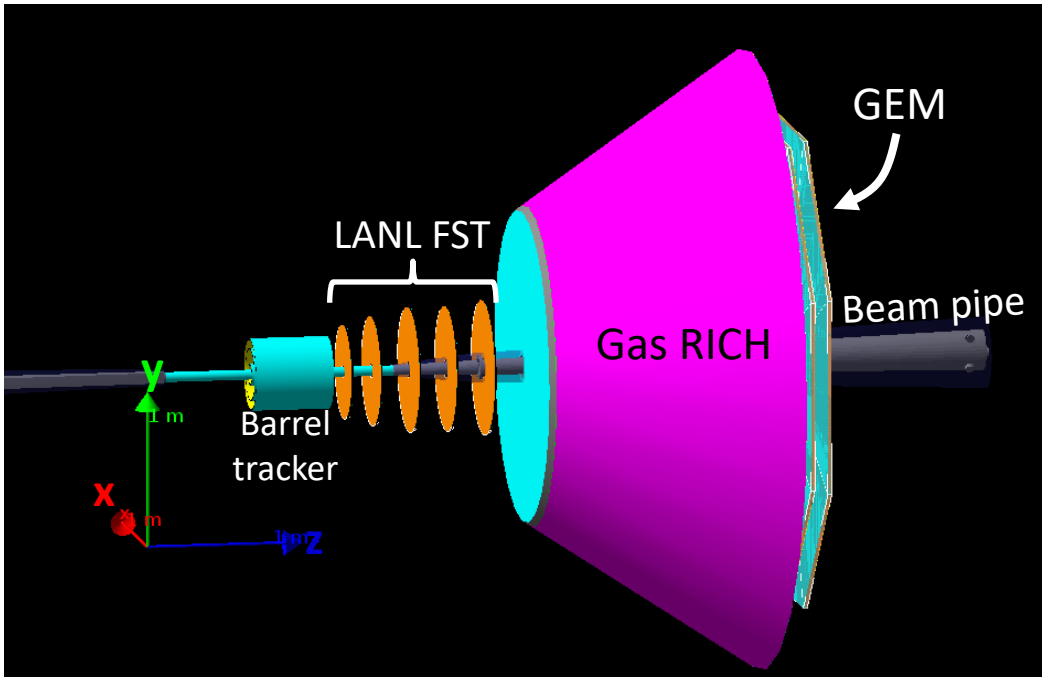




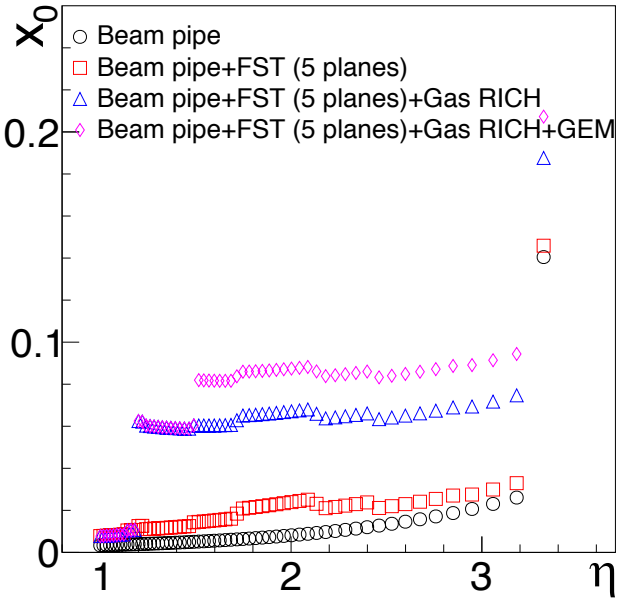


Material Budget of

FST (5 Planes) + Gas RICH+GEM



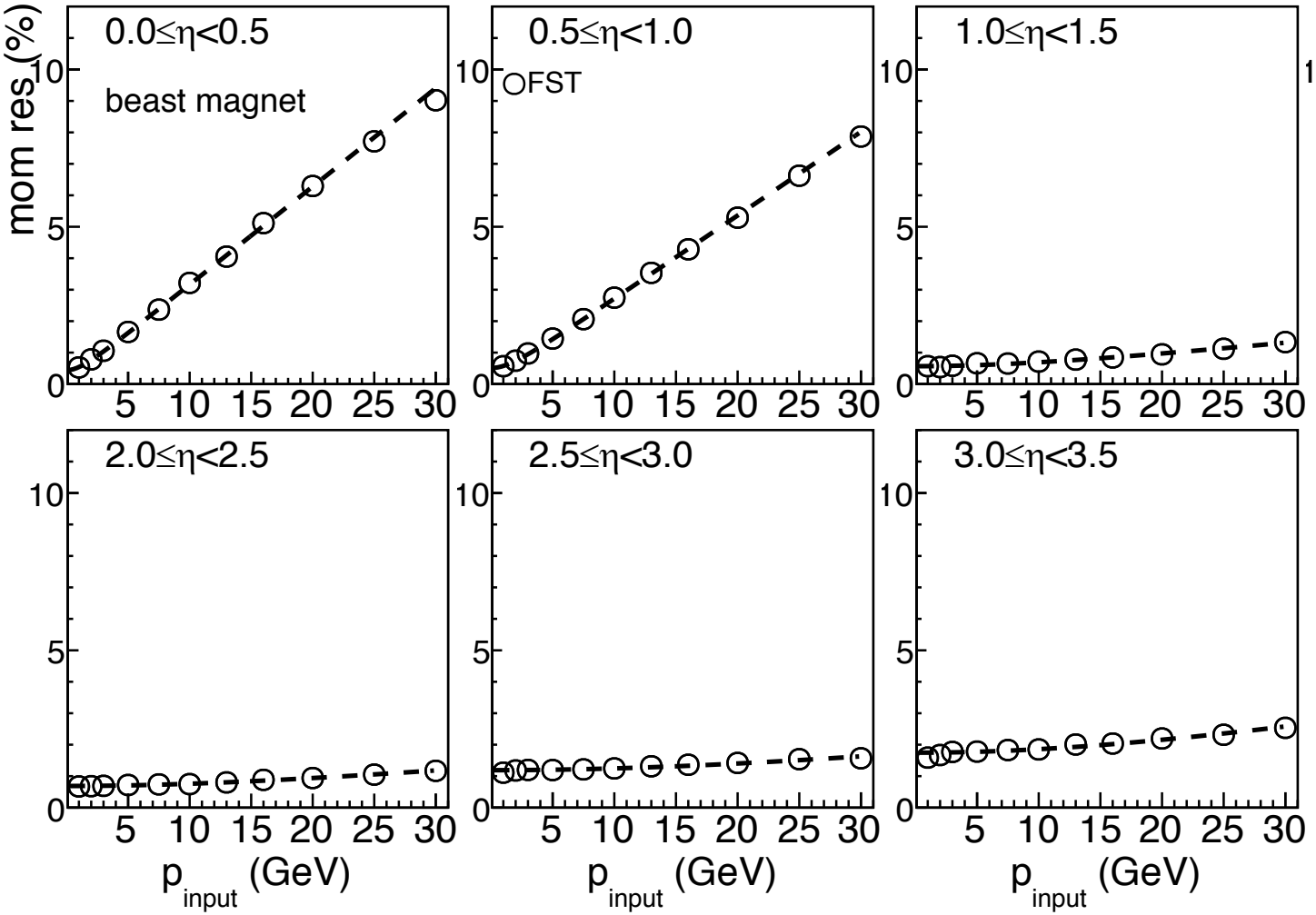
- Replacing the last plane (z=300cm) of FST by 3-plane GEM tracker, which is modified from sPHENIX design
- Waiting for the GEM group for a more realistic GEM setup
- Total material budget (blue) is ~10% at $\eta < 3.3$, and <8% at $\eta < 1.5$



GEM Setup

Plane	z (cm)	η_{min}	η_{max}	r res (um)	ϕ res (um)	Gas
0	300	1.5	3.5	100	70	methane
1	310	1.5	3.5	100	70	methane
2	320	1.5	3.5	100	70	methane

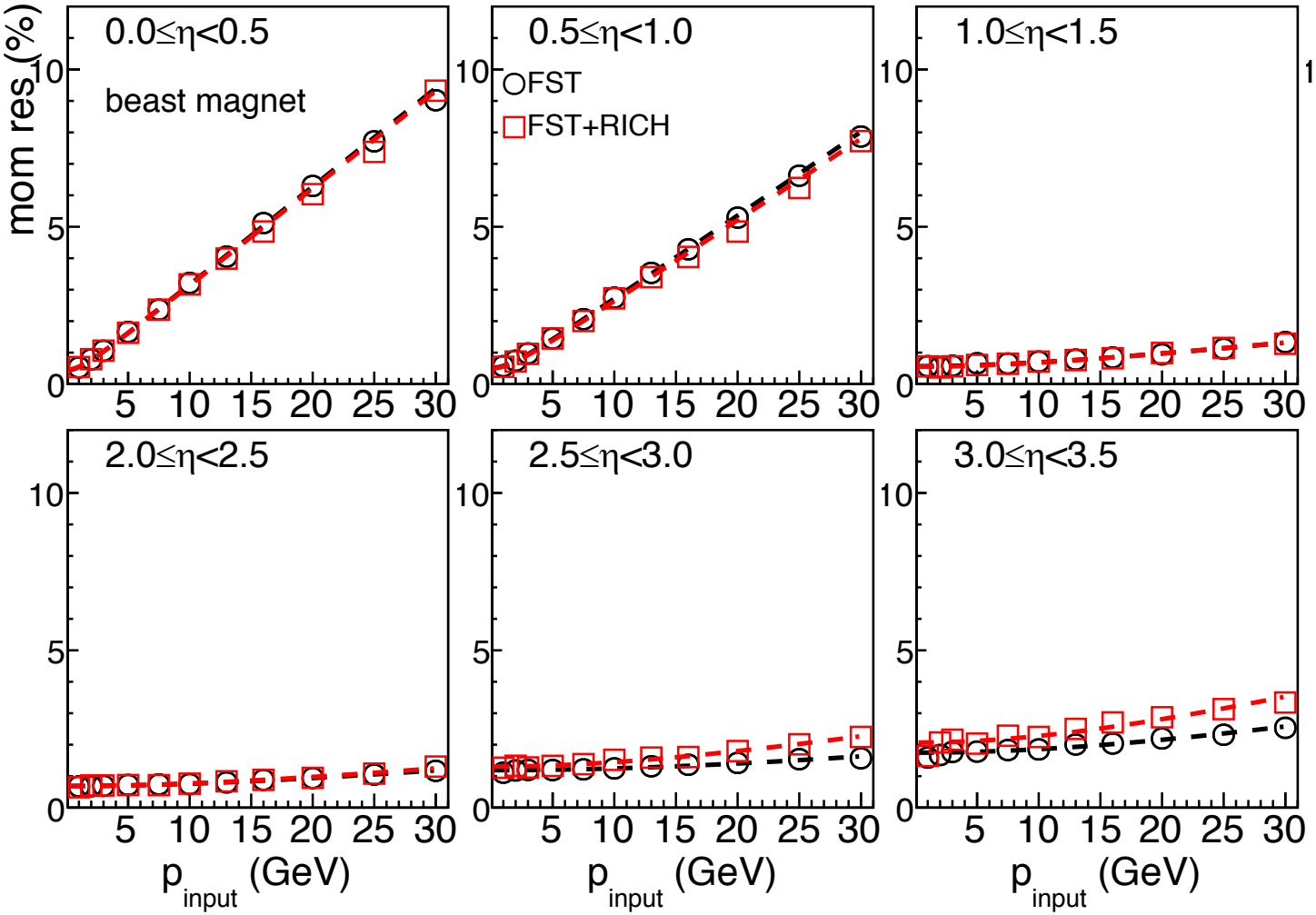
Momentum Resolution of FST with BeAST Magnet



$$\frac{\Delta p}{p}(p) = \sqrt{(Ap)^2 + B^2}$$

- Momentum resolution <10% at $\eta < 1$, and <4% at p<10GeV
- Momentum resolution <3% $\eta > 1$

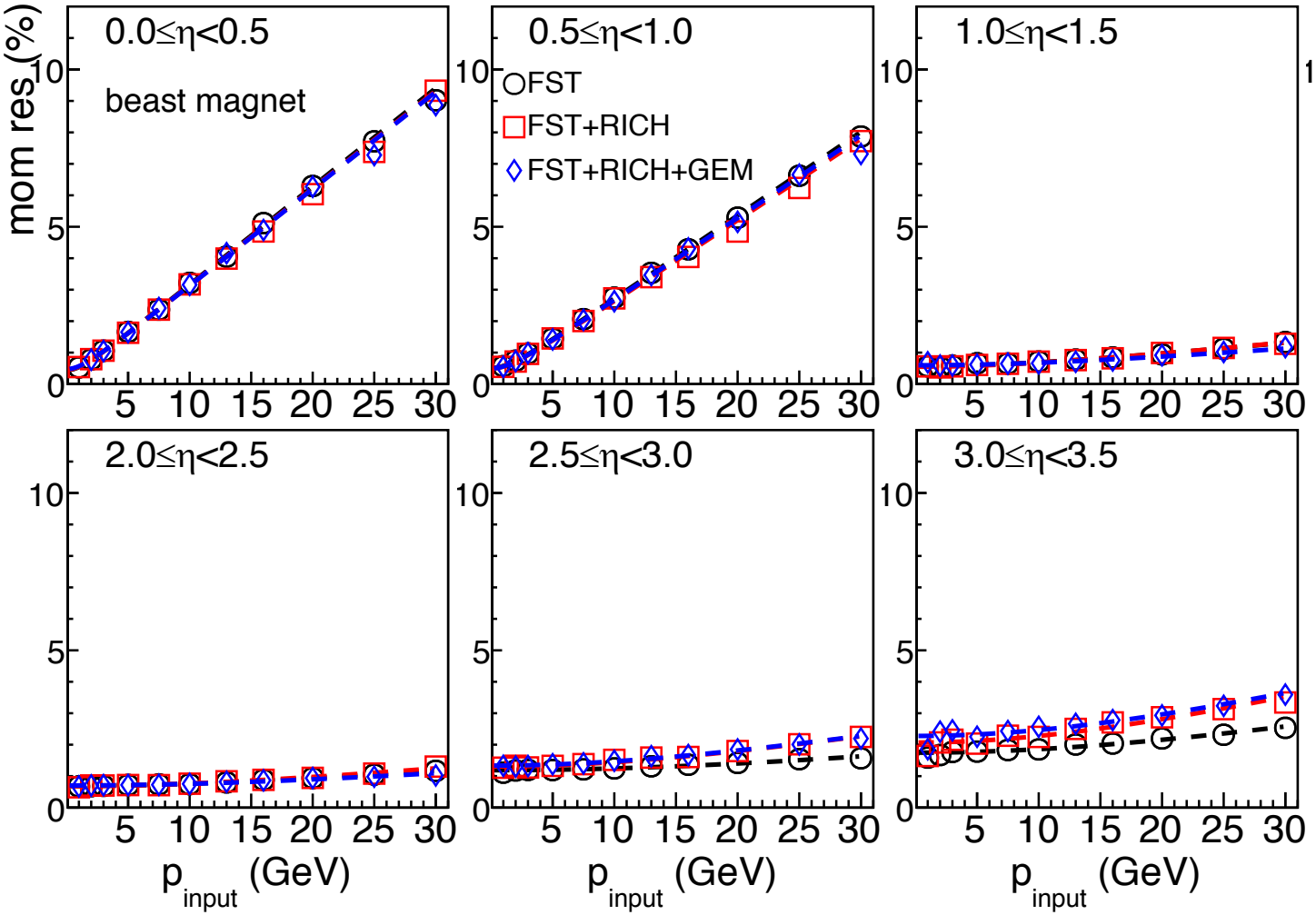
Momentum Resolution of Tracking System with BeAST Magnet



$$\frac{\Delta p}{p}(p) = \sqrt{(Ap)^2 + B^2}$$

The Gas RICH worsen the momentum resolution by ~1% at high momentum and at $\eta > 2.5$

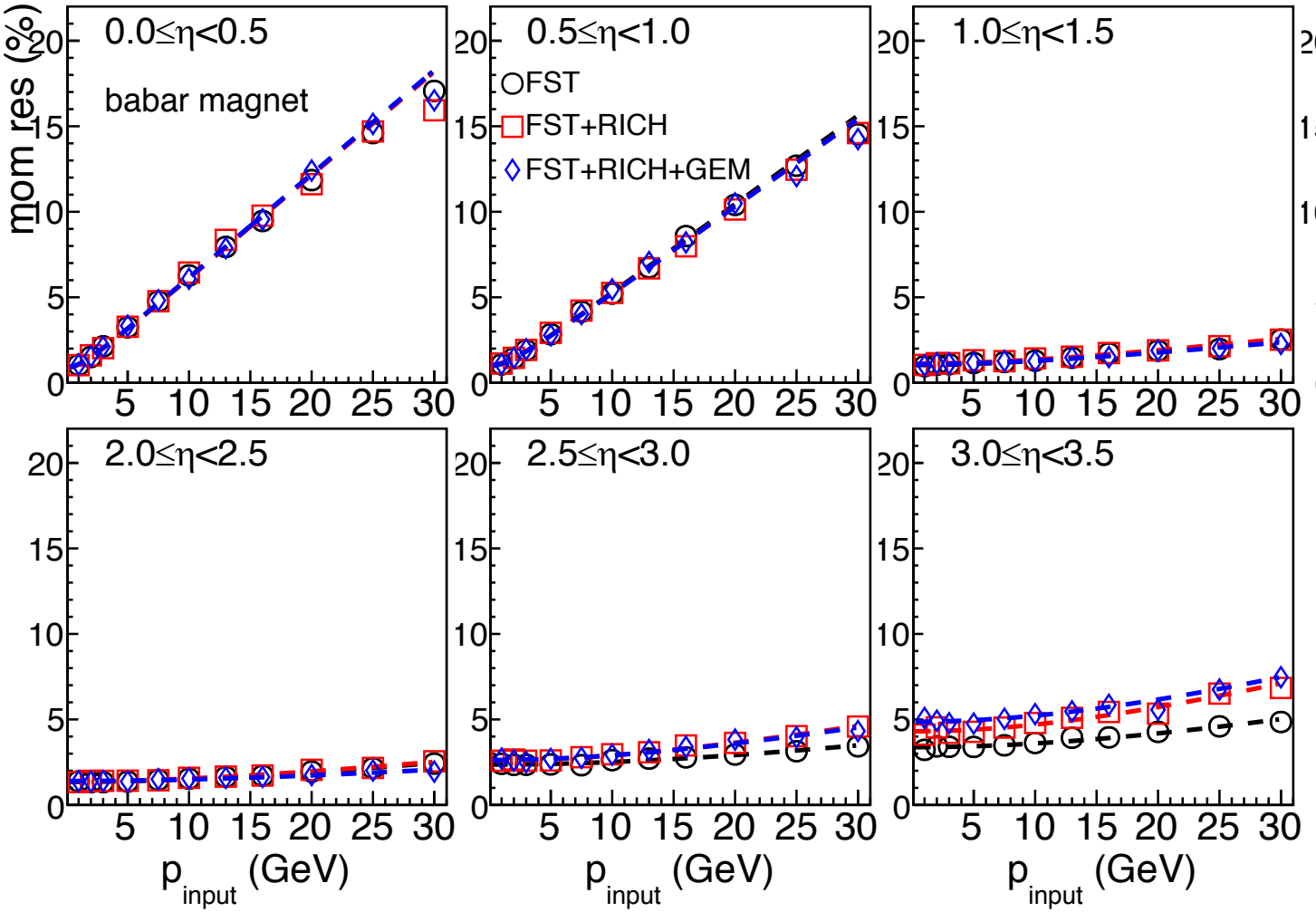
Momentum Resolution of Tracking System with BeAST Magnet



$$\frac{\Delta p}{p}(p) = \sqrt{(Ap)^2 + B^2}$$

The momentum resolutions with the addition of GEM agrees with the results without GEM

Momentum Resolution of Tracking System with Babar Magnet



$$\frac{\Delta p}{p}(p) = \sqrt{(Ap)^2 + B^2}$$

- The momentum resolution is <18% at $\eta < 1$, and <8% at p<10GeV
- At $\eta > 1$, the momentum resolution is <9%

Fitting Parameters of Momentum Resolution

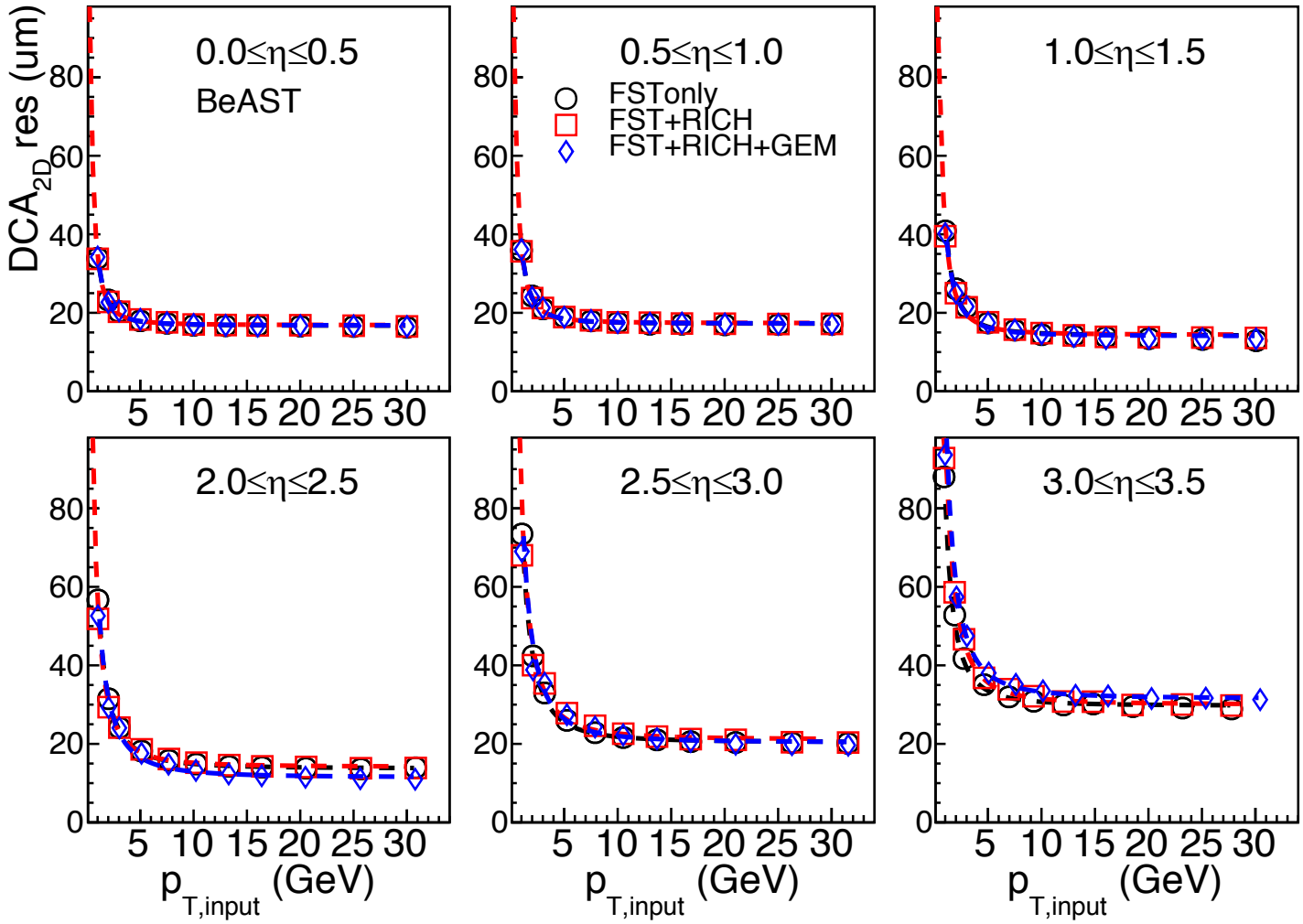
$$\frac{\Delta p}{p}(p) = \sqrt{(Ap)^2 + B^2}$$

η	B field	FST (6 planes)		FST (6 planes) + RICH		FST (5 planes) + RICH + GEM	
		A (%/GeV)	B (%)	A (%/GeV)	B (%)	A (%/GeV)	B (%)
0.0–0.5	BeAST	0.313	0.440	0.310	0.457	-0.309	0.475
	Babar	0.608	0.880	0.605	0.892	0.608	0.915
0.5–1.0	BeAST	0.267	0.510	0.259	0.494	0.263	0.494
	Babar	0.520	0.971	0.513	1.035	0.513	1.010
1.0–1.5	BeAST	0.039	0.568	0.040	0.551	0.032	0.597
	Babar	0.076	1.039	0.077	1.120	0.070	1.088
1.5–2.0	BeAST	0.019	0.454	0.018	0.448	0.013	0.445
	Babar	0.039	0.839	0.039	0.882	0.026	0.876
2.0–2.5	BeAST	0.032	0.687	0.035	0.682	0.028	0.704
	Babar	0.068	1.346	0.070	1.374	0.051	1.402
2.5–3.0	BeAST	0.037	1.190	0.062	1.306	0.062	1.336
	Babar	0.086	2.362	0.127	2.607	0.123	2.629
3.0–3.5	BeAST	0.063	1.746	0.095	2.069	0.095	2.278
	Babar	0.124	3.378	0.189	4.305	0.189	4.868

- BeAST vs Babar: Fitting parameters with the use of Babar magnet are about double of the use of BeAST magnet
- $\eta < 2.5$: Comparable values between different detector systems
- $\eta > 2.5$: Fitting parameters increases with the more integrated detector systems

10 π^- events

DCA_{2D} Resolution of Tracking System with BeAST Magnet

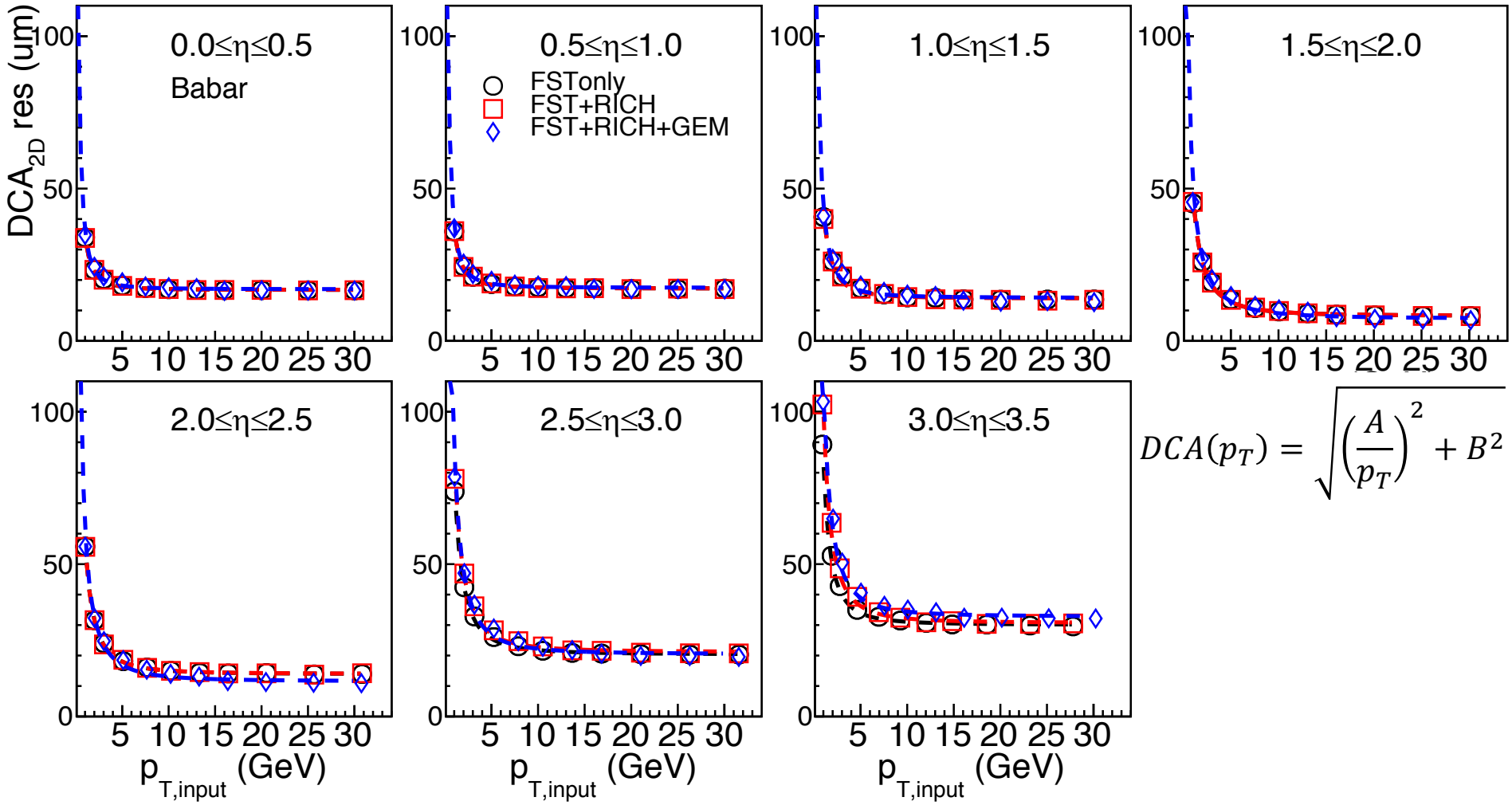


$$DCA(p_T) = \sqrt{\left(\frac{A}{p_T}\right)^2 + B^2}$$

- DCA_{2D} <50um at $\eta < 2$
- DCA_{2D} <100um at $\eta > 2$

10 π^- events

DCA_{2D} Resolution of Tracking System with Babar Magnet



$$DCA(p_T) = \sqrt{\left(\frac{A}{p_T}\right)^2 + B^2}$$

Fitting Parameters of DCA_{2D} Resolution

$$DCA(p_T) = \sqrt{\left(\frac{A}{p_T}\right)^2 + B^2}$$

η	B field	FST (6 planes)		FST (6 planes) + RICH		FST (5 planes) + RICH + GEM	
		A (μm·GeV)	B (μm)	A (μm·GeV)	B (μm)	A (μm·GeV)	B (μm)
0.0–0.5	BeAST	30.73	16.71	30.17	16.86	30.84	16.78
	Babar	30.80	16.74	30.56	16.75	32.55	16.97
0.5–1.0	BeAST	32.80	17.22	32.14	17.37	32.83	17.28
	Babar	32.98	17.22	32.99	17.21	34.76	17.46
1.0–1.5	BeAST	41.54	14.19	39.47	14.39	40.73	14.06
	Babar	41.40	14.01	40.92	13.93	42.62	14.15
1.5–2.0	BeAST	49.57	8.24	48.49	8.43	51.56	7.36
	Babar	49.20	8.18	49.30	8.21	53.72	7.32
2.0–2.5	BeAST	57.87	13.73	54.79	14.16	59.58	11.48
	Babar	57.21	13.91	57.00	13.97	61.83	11.54
2.5–3.0	BeAST	76.78	20.42	81.63	21.13	83.90	20.35
	Babar	77.10	20.37	84.77	21.15	86.97	20.45
3.0–3.5	BeAST	77.79	29.71	95.90	30.01	104.95	31.55
	Babar	78.50	30.08	96.37	30.68	105.17	32.77

- BeAST vs Babar: comparable fitting parameters
- $\eta < 2.5$: Comparable values between different detector systems
- $\eta > 2.5$: Fitting parameters increases with the more integrated detector systems

Summary & Plan

Summary

Parameterized detector performance with different detector setups:

The additional RICH and GEM tracker worsen detector performance at large η>2.5

Plans

Pythia 6 events in Fun4All for heavy flavor & and jet reconstructions