EIC FST Fun4All Simulation

Cheuk-Ping Wong
On Behalf of LANL EIC Team
Los Alamos National Laboratory
10-08-2020

Outline

- Motivation: summary table for the detector performance of the LANL FST design

- Parameters of the momentum and DCA resolutions
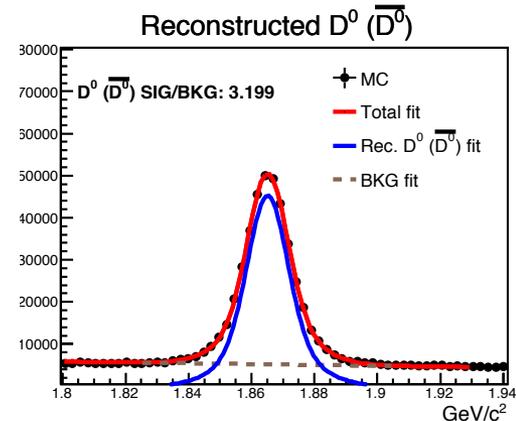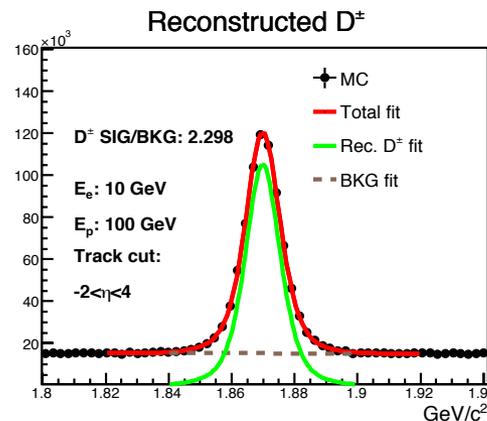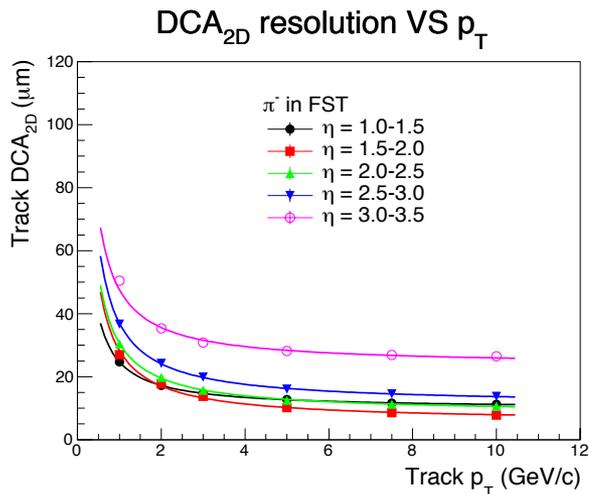
- Summary and Plan

Motivation

- 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

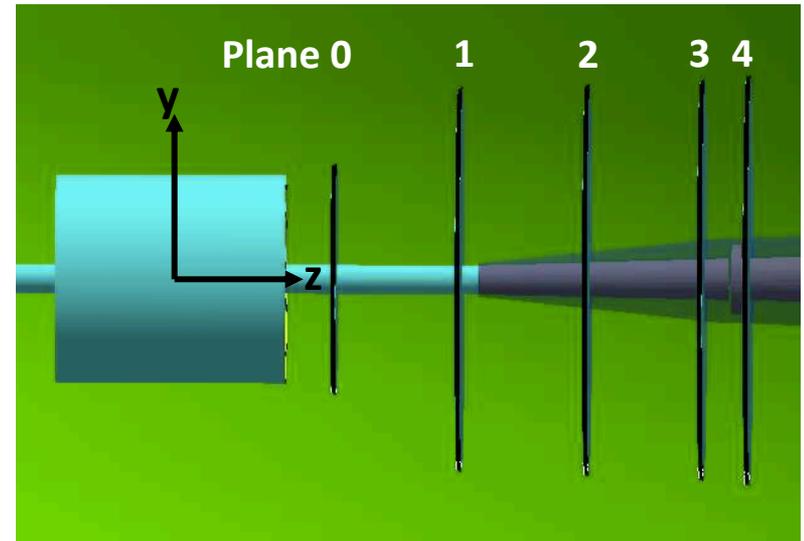Detector performance → physics requirements

arXiv:2009.02888

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: 1-4 in lab frame
  - Hit efficiency at 95%
  - Pseudorapidity correction for ion beam angle

Los Alamos
NATIONAL LABORATORY
EST.1943

Cheuk-Ping Wong

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

Cheuk-Ping Wong

Momentum Resolution of FST with BeAST / Babar Magnet
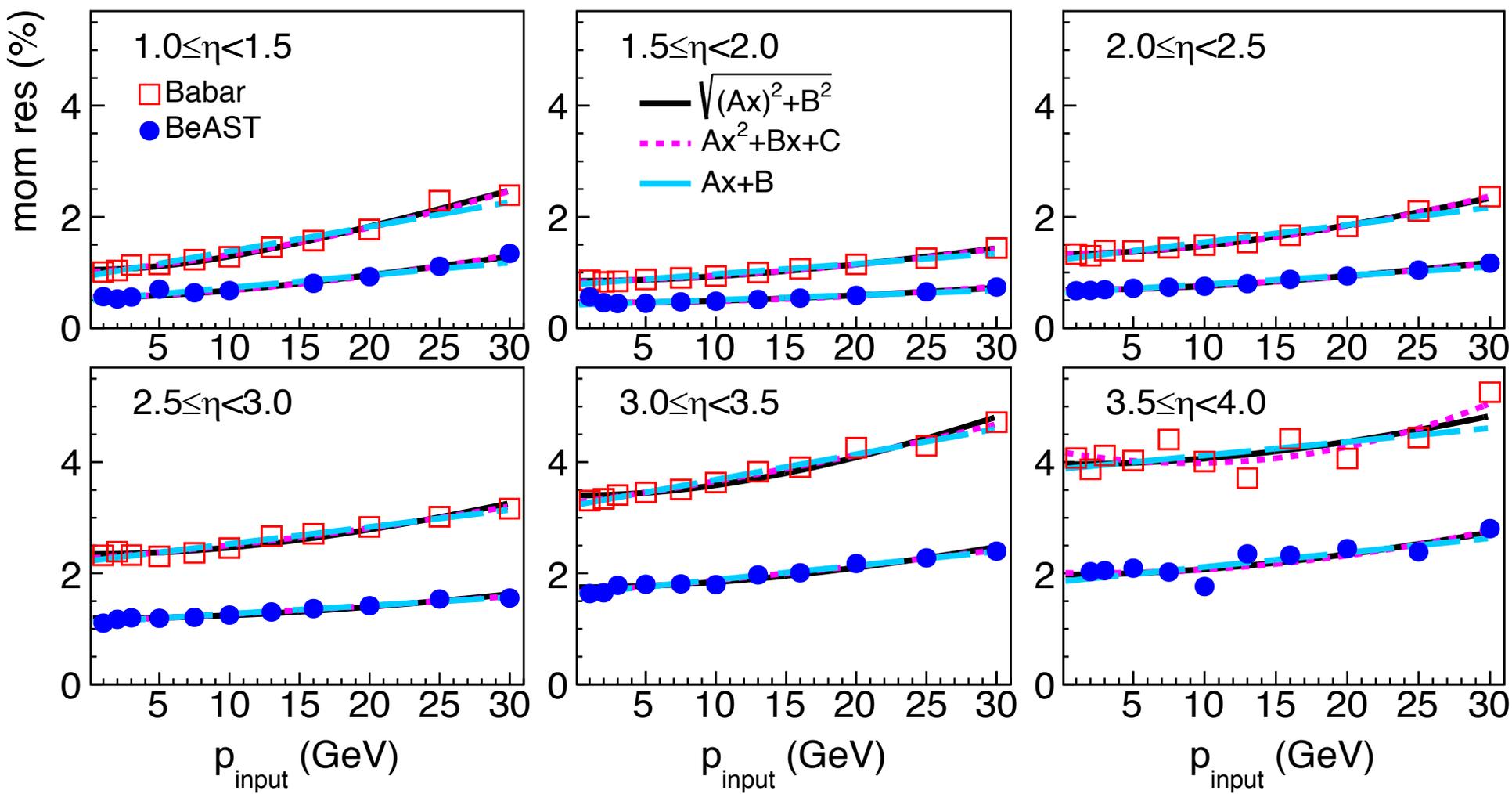
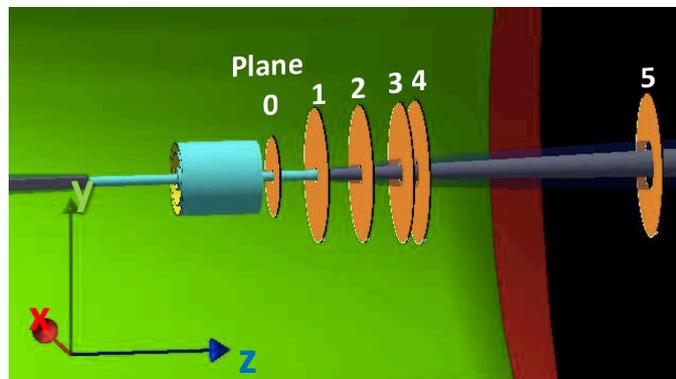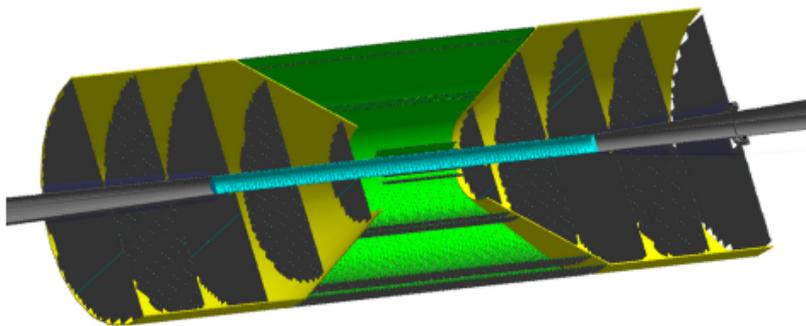# Momentum Resolution Comparison

LBNL Silicon tracker + support structure

10um pixel pitch

		$\delta p/p = Ap \oplus B$	
		A [%/GeV]	B [%]
$1.0 < \eta < 1.5$	B = 3.0T	0.016	0.427
	B=1.4T	0.035	0.921
$1.5 < \eta < 2.0$	B = 3.0T	0.012	0.462
	B=1.4T	0.026	0.997
$2.0 < \eta < 2.5$	B = 3.0T	0.018	0.719
	B=1.4T	0.041	1.548
$2.5 < \eta < 3.0$	B = 3.0T	0.039	1.336
	B=1.4T	0.088	2.830
$3.0 < \eta < 3.5$	B = 3.0T	0.103	2.428
	B=1.4T	0.217	5.234
$3.5 < \eta < 4.0$	B = 3.0T	0.295	4.552
	B=1.4T	0.610	9.797

LANL FST $\quad \frac{\Delta p}{p}(p) = Ap + B$

| η	B field	A (%/GeV)	B (%)
$1.0 \leq \eta < 1.5$	BeAST	0.023	0.499
	Babar	0.044	0.940
$1.5 \leq \eta < 2.0$	BeAST	0.009	0.420
	Babar	0.018	0.787
$2.0 \leq \eta < 2.5$	BeAST	0.016	0.630
	Babar	0.031	1.234
$2.5 \leq \eta < 3.0$	BeAST	0.015	1.120
	Babar	0.031	2.224
$3.0 \leq \eta < 3.5$	BeAST	0.025	1.630
	Babar	0.046	3.228
$3.5 \leq \eta < 4.0$	BeAST	0.026	1.855
	Babar	0.024	3.878

https://indico.bnl.gov/event/7913/contributions/41704/attachments/30564/47972/200924_Parametrizations.pdf

Plane 0 1 2 3 4 5

DCA$_{2D}$ Resolution of FST with BeAST Magnet
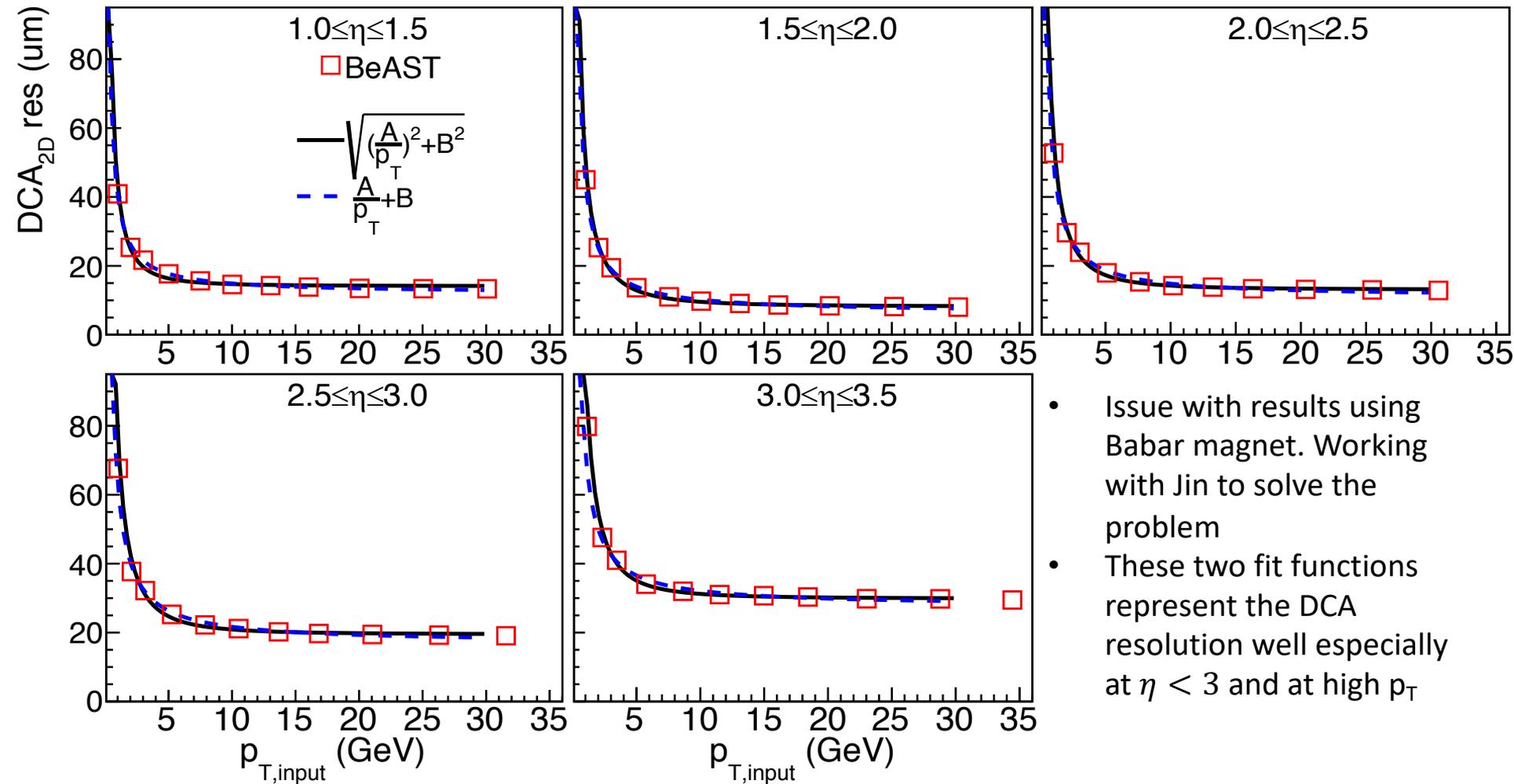
- Issue with results using Babar magnet. Working with Jin to solve the problem
- These two fit functions represent the DCA resolution well especially at $\eta < 3$ and at high p_T

Cheuk-Ping Wong

DCA$_z$ Resolution of FST with BeAST Magnet
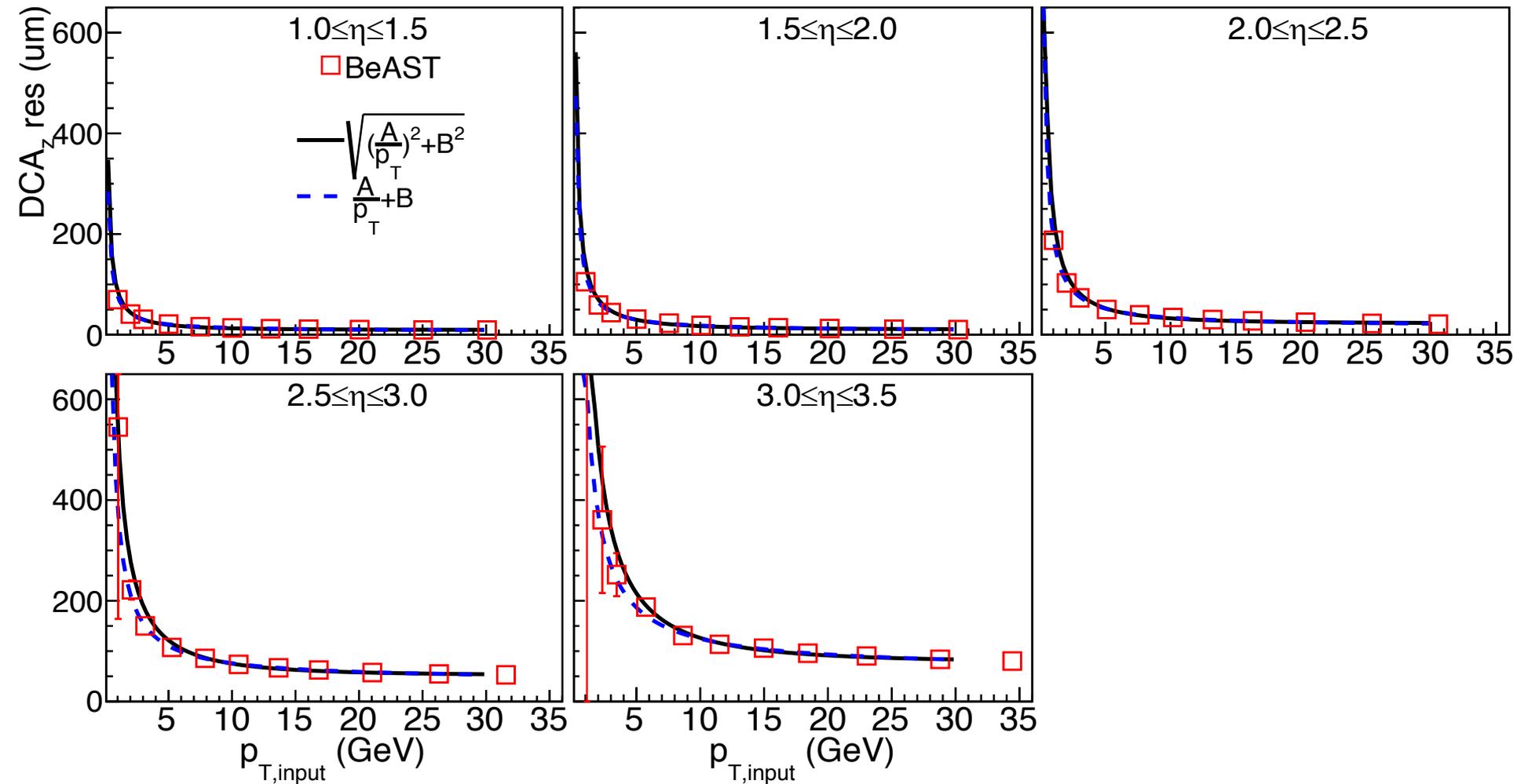
DCA Resolution Comparison

LBNL Silicon tracker + support structure

10um pixel pitch

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

DCA$_{2D}$

		A [μm GeV]	B [μm]
$1.0 < \eta < 1.5$	B = 3.0T	33.1	5.46
	B = 1.4T	35.2	5.10
$1.5 < \eta < 2.0$	B = 3.0T	39.1	5.46
	B = 1.4T	39.8	5.21
$2.0 < \eta < 2.5$	B = 3.0T	45.1	9.54
	B = 1.4T	46.3	9.31

DCA$_z$

		A [μm GeV]	B [μm]
$1.0 < \eta < 1.5$	B = 3.0T	55.9	5.89
	B = 1.4T	56.2	5.41
$1.5 < \eta < 2.0$	B = 3.0T	108.2	8.74
	B = 1.4T	106.3	8.36
$2.0 < \eta < 2.5$	B = 3.0T	207.3	19.77
	B = 1.4T	201.8	21.50

LANL FST

Using BeAST Magnet

$$\frac{A}{p_T} + B$$

η	DCA_{2D}	
	A (μm·GeV)	B (μm)
$1.0 \le \eta < 1.5$	28.43	12.04
$1.5 \le \eta < 2.0$	37.97	6.38
$2.0 \le \eta < 2.5$	39.05	10.93
$2.5 \le \eta < 3.0$	46.88	16.99
$3.0 \le \eta < 3.5$	44.70	27.64

η	DCA_z	
	A (μm·GeV)	B (μm)
$1.0 \le \eta < 1.5$	69.24	6.92
$1.5 \le \eta < 2.0$	116.60	6.64
$2.0 \le \eta < 2.5$	178.45	16.17
$2.5 \le \eta < 3.0$	342.90	41.67
$3.0 \le \eta < 3.5$	622.09	62.34

Summary

- Extracted detector performance parameters

- Different functions are tried in fitting the momentum and DCA resolutions. All these fit functions describe the resolution very well.

Plan

## Momentum resolution using Pythia6 events
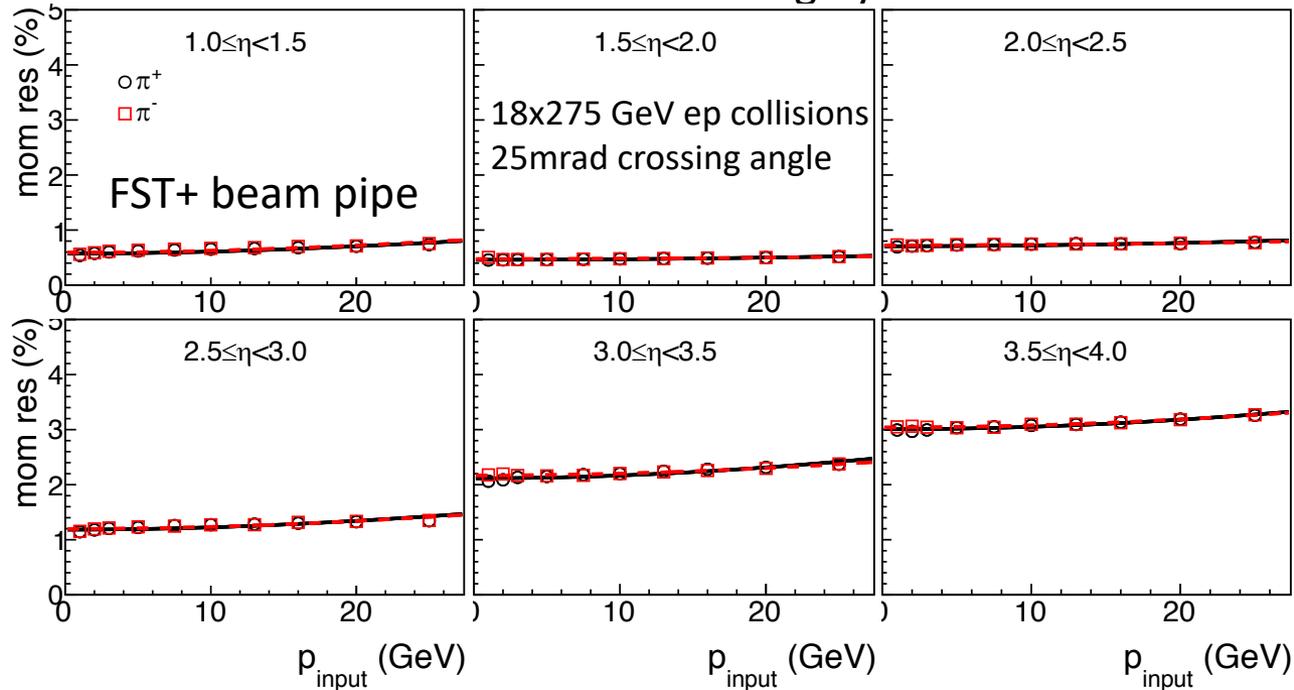
Detector simulation:
- Single track reconstruction performance with Pythia6 events
- Compare results to Geant single tracks events
- Running Pythia6 events with the integrated detector setup
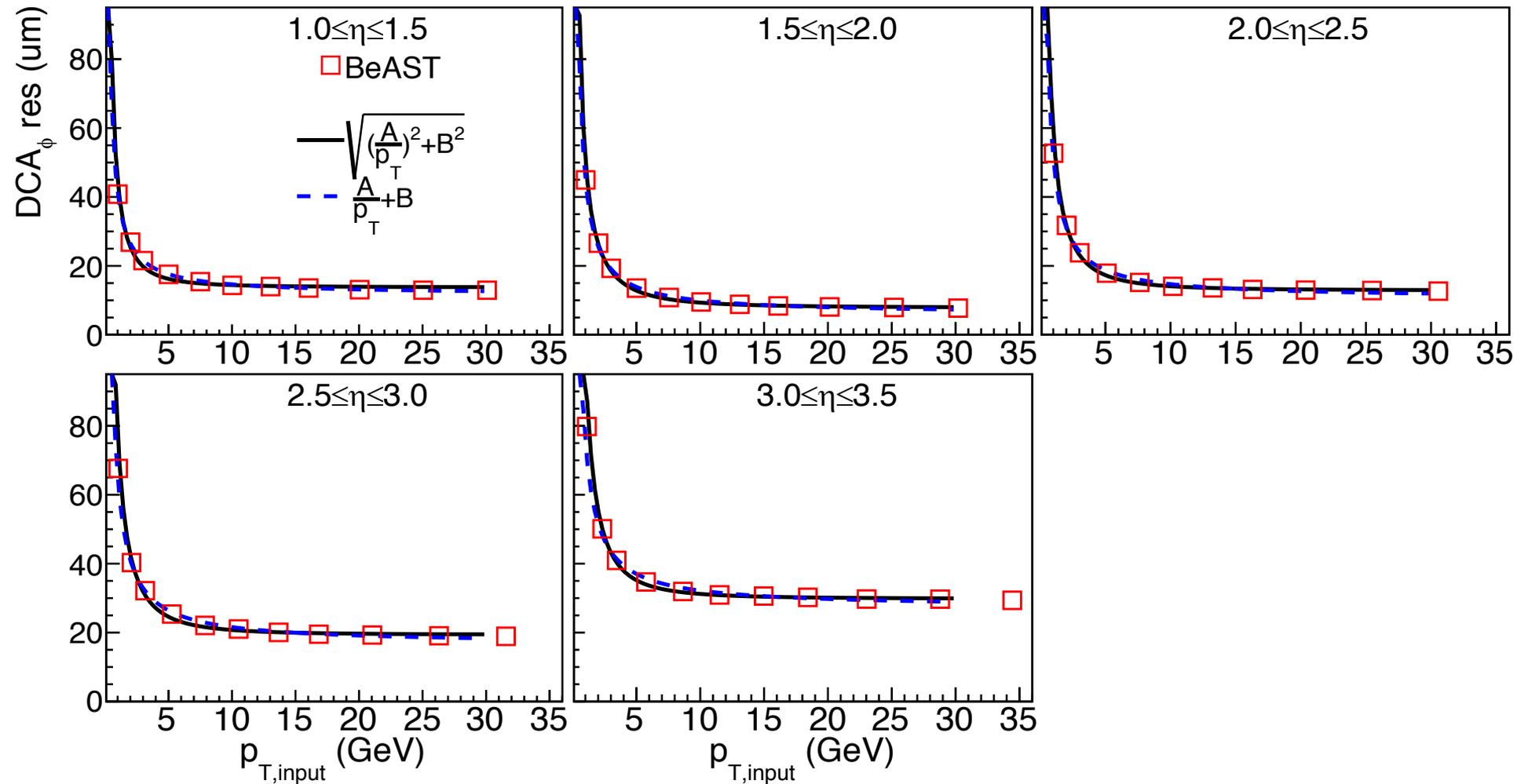
Implement detector performance in heavy flavor jets study
- Heavy flavor and jets reconstruction

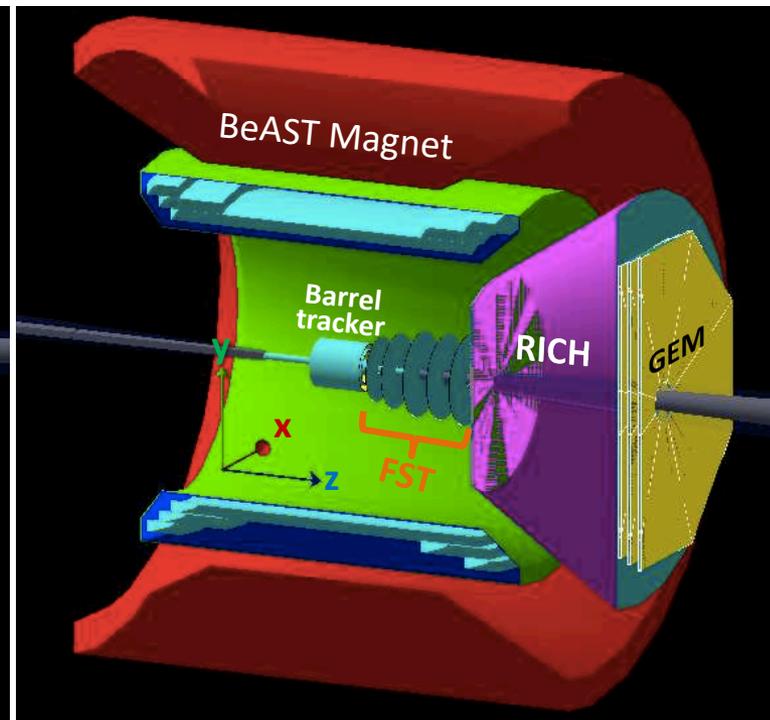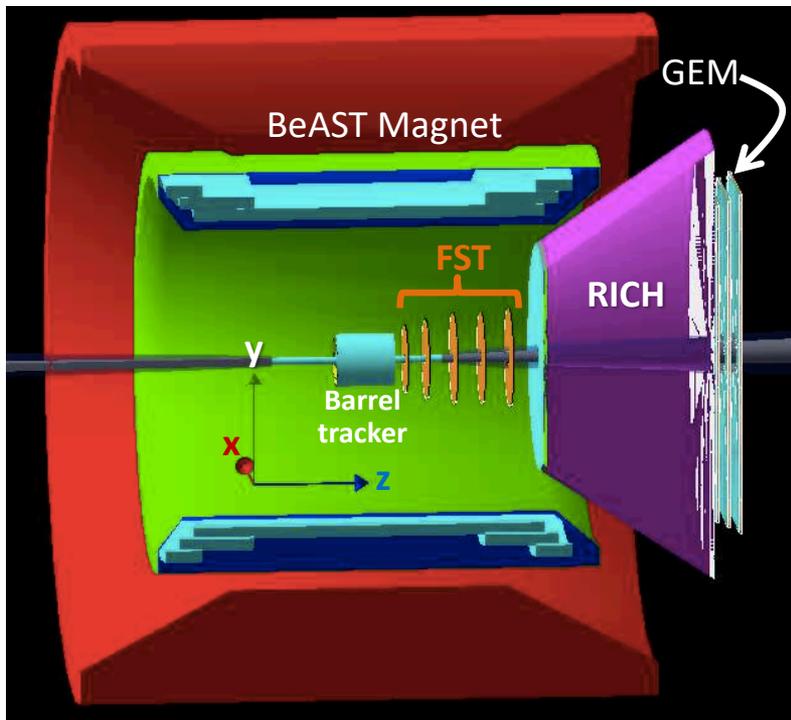# Back Up

Cheuk-Ping Wong

DCA$_r$ Resolution of FST
with BeAST Magnet

Cheuk-Ping Wong
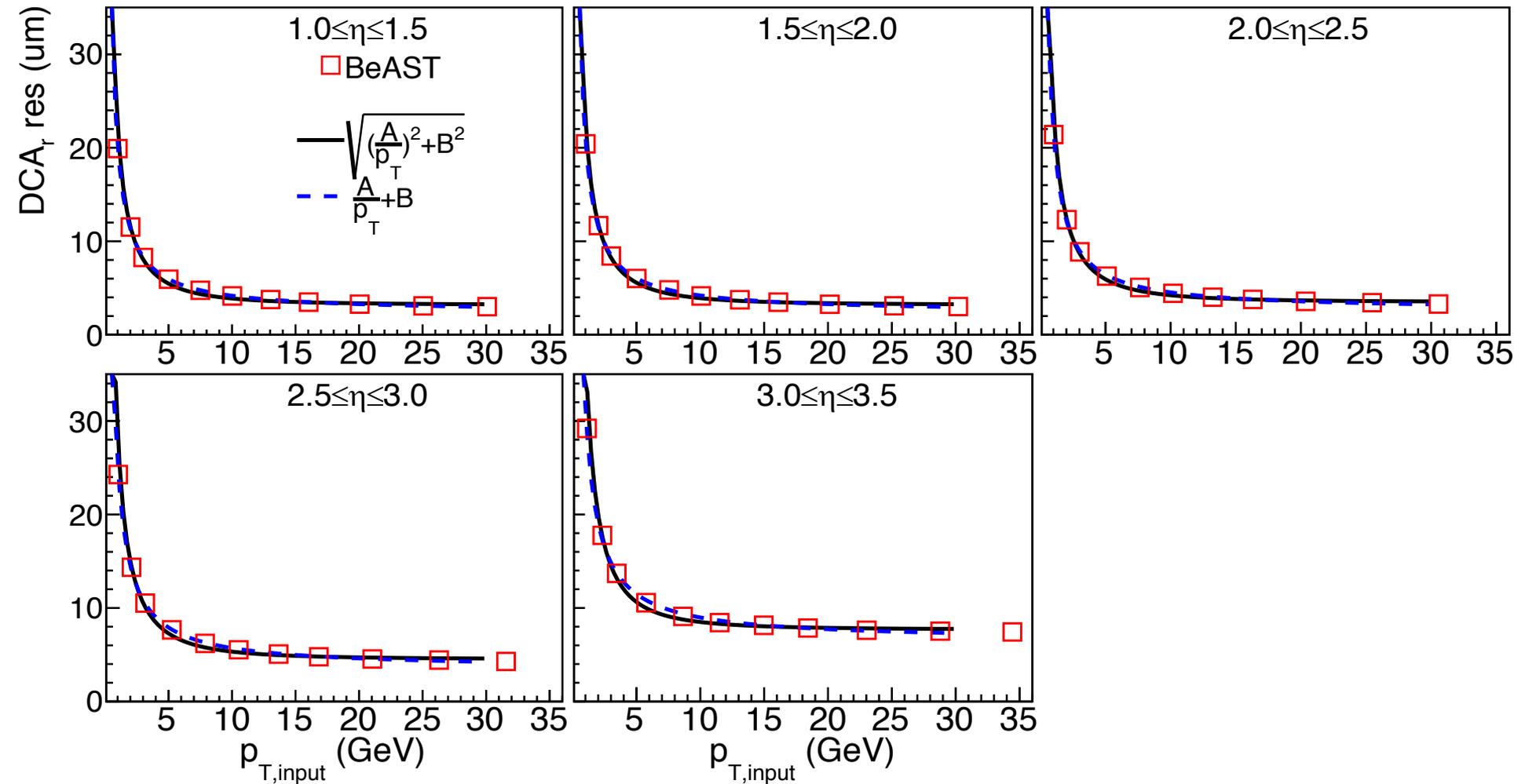
DCA$_\phi$ Resolution of FST with BeAST Magnet

Cheuk-Ping Wong

Integrated Detector Setup in Fun4All

FST Version 5 Parameters

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

Detector Design in Fun4all

Material sublayers of the plane detectors
(arbitrary scale)

Silicone wafer | Aluminum | Kapton | Cooling water | Supporting graphite

**Air gap
1 cm**

Supporting graphite

50 / 100   20   100   50   **50** (μm)

Cheuk-Ping Wong