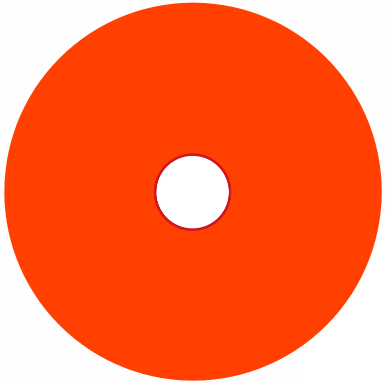
UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Effects of disk tiling on acceptance, tracking performance with larger pixel pitch

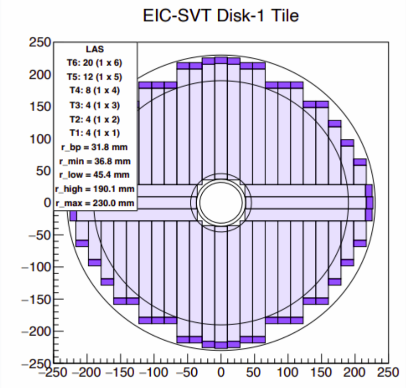
L. Gonella, P. G. Jones, S. Maple, P. R. Newman

Acceptance of Disks around beampipe

- Disks consist of tiles of ITS3-like sensors, with length and width determined by the ITS3 reticle
  - The result is that the inner opening of the disks is not perfectly circular → instead they are squared off
  - This means that there isn't full azimuthal acceptance at the inner radii we've been using (beampipe radius +5mm)



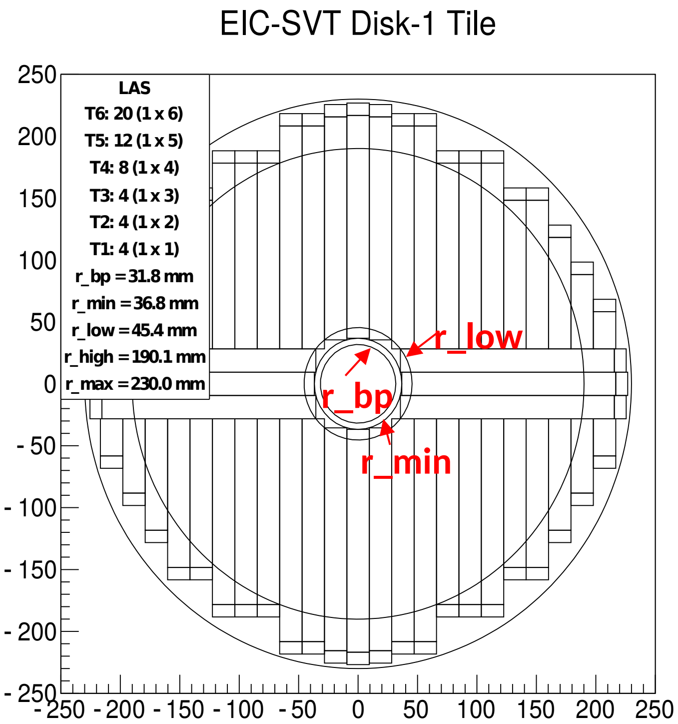
Disks in simulations



Realistic disks

* P. G. Jones
https://indico.bnl.gov/event/15486/contributions/62590/attachments/40656/67919/EIC-Sensors-Jones.pdf

- Studies of how to tile disks with EIC LAS sensor ongoing in the EIC SC.
  - For full details, see talk by Peter Jones at https://indico.bnl.gov/event/17073/



z = +/- 250 mm

Cruciform = 3 x 3 sensors

The algorithm

- Aim to keep periphery to larger radii
- Two designs, each based on a central cross pattern smaller than the inner diameter of the disk
- Design #1 = vertical tiles (shown)
- Design #2 = herringbone (alternating vertical and horizontal tiles)
- Limits on the max and min sensor length can be applied
- Study the number of sensor variants that are needed
- **The minimum radius (r_min) is 5 mm larger than the beam pipe (r_bp) for bake out purposes**
- Sensor and periphery must be contained within the min and max radii of the disk (r_min and r_max).
- **For each disk, the algorithm calculates the smallest and largest radii with full acceptance (r_low and r_high)**
- The algorithm does not permit any sensor overlap
- Acceptance at small radii could be improved by allowing some sensor overlap; placing overlapping sensors on the reverse side of the disk (in progress)

Procedure (Fun4All simulations)

- Uniformly generate single particles in ranges $-4 < \eta < -2.5$ and $2.5 < \eta < 4$
  - Pions forward, electrons backward
  - Disks of 100% and 95% efficiency
- Measure “Acceptance” of disks as implemented in simulation

$$Acceptance = \frac{Num\,3\,hit\,tracks}{Total\,num\,tracks}$$

- Initially use disks with perfectly circular openings of radius r_min and r_low, opening centred around x_offset

	Z - ePIC	R_bpipe	x_offset	R_min	R_outer	R_low	R_high
5n	-1350	41.08	-5.3	46.1	430	56.5	386.7
4n	-1000	35.76	-1.81	40.8	430	53.3	386.7
3n	-700	31.76	0	36.8	430	45.4	389.3
2n	-450	31.76	0	36.8	430	45.4	389.3
1n	-250	31.76	0	36.8	230	45.4	190.1
1p	250	31.76	0	36.8	230	45.4	190.1
2p	450	31.76	0	36.8	430	45.4	389.3
3p	700	32.86	0.56	37.9	430	46.3	389.3
4p	1000	40.58	7.85	45.6	430	56.1	386.7
5p	1350	49.12	16.02	54.2	430	67.8	389.2

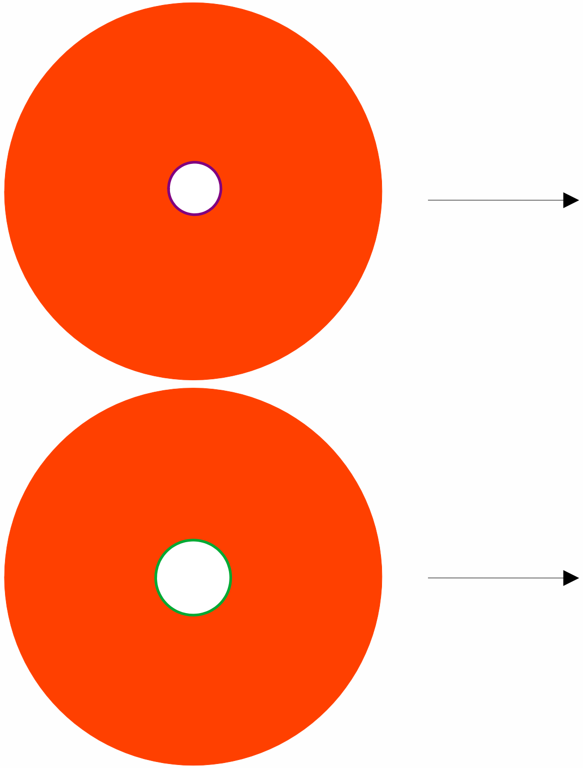
Acceptance with circular openings

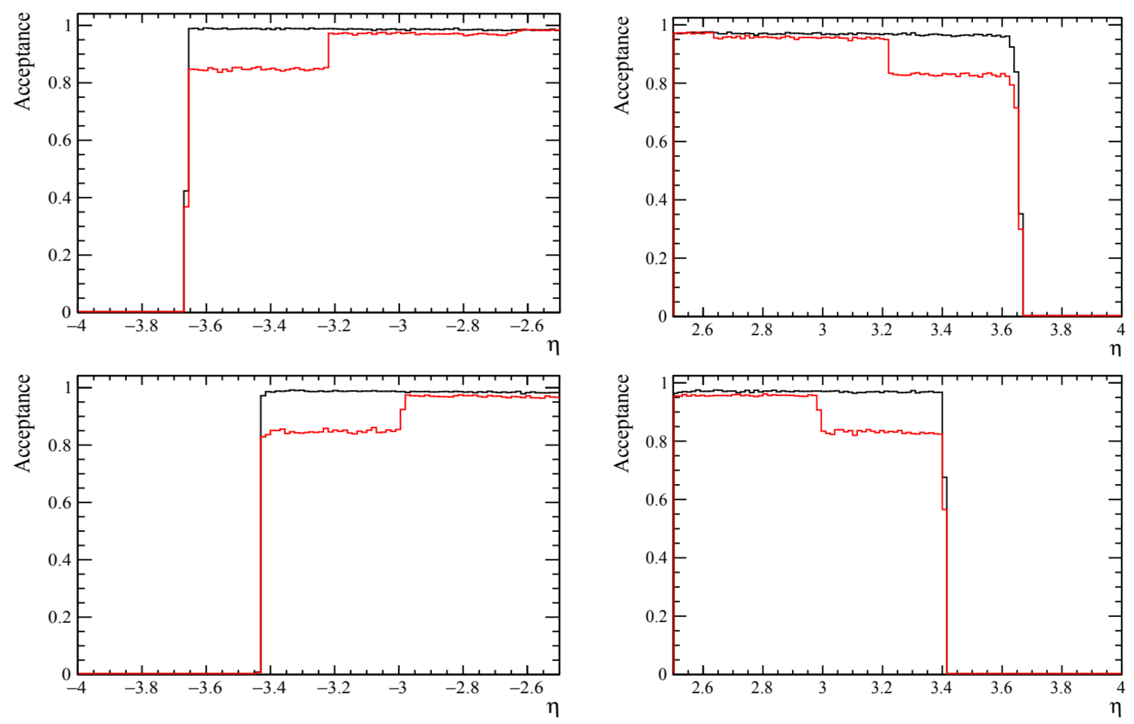
100% efficient disks

95% efficient disks

"r_min"

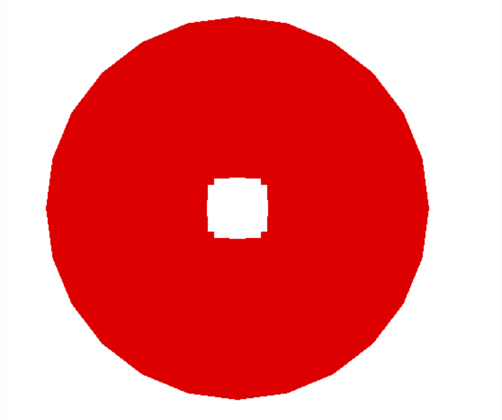
"r_low"



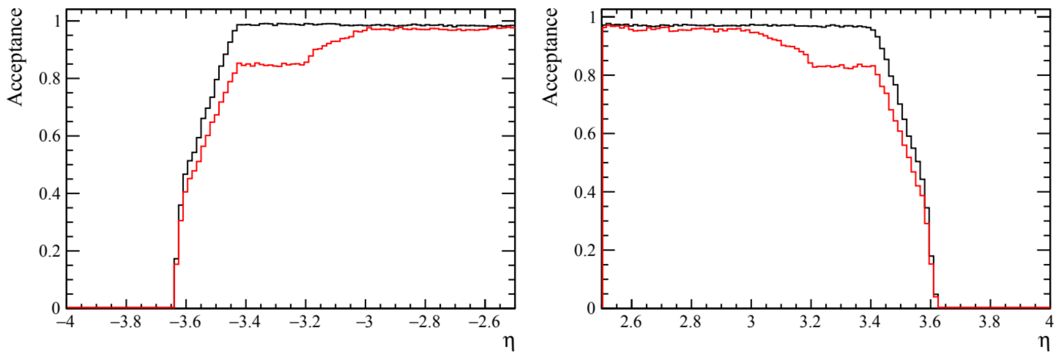


“Realistic” disk acceptance

- The studies with circular openings give an idea of the upper and lower limits of the disk acceptance – however to get a better idea of this, we need to use disks with partial acceptance in this region
  - Implemented disk modules with inner cutouts in the same shape as the disks as produced by the tiling algorithm:



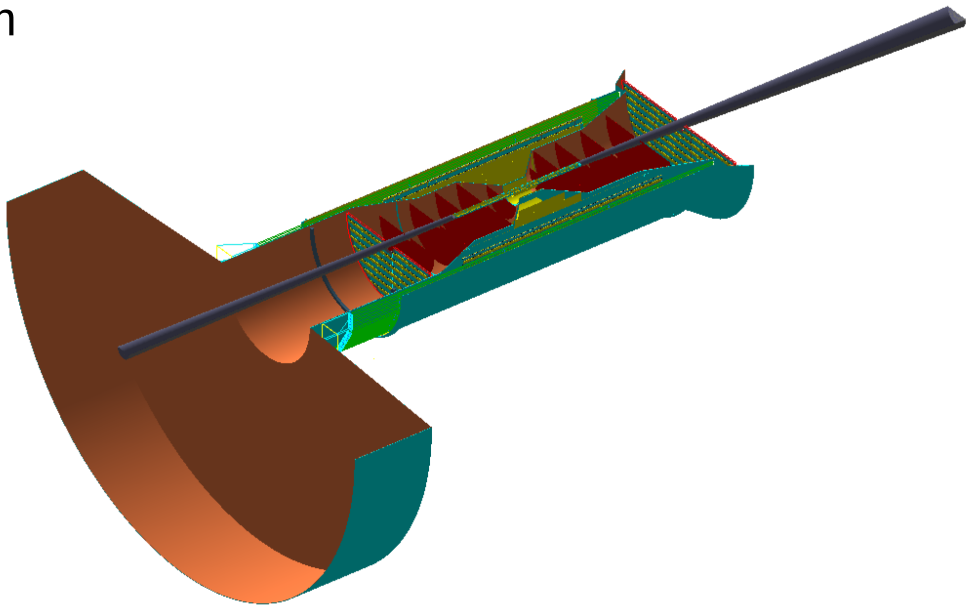
We instead see a gradual decrease in acceptance at disk edges



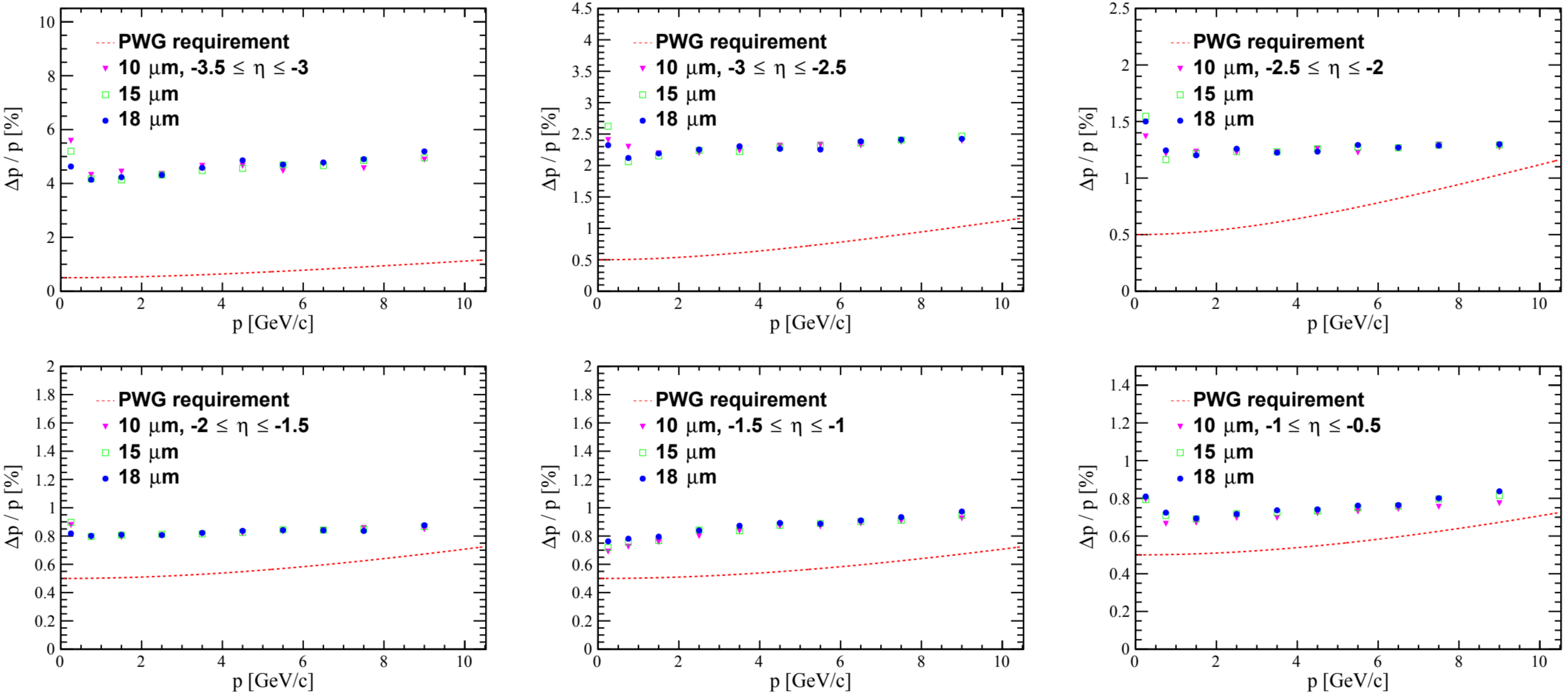
Only 3 disks at |η| > ~3.2

Pixel pitch comparisons

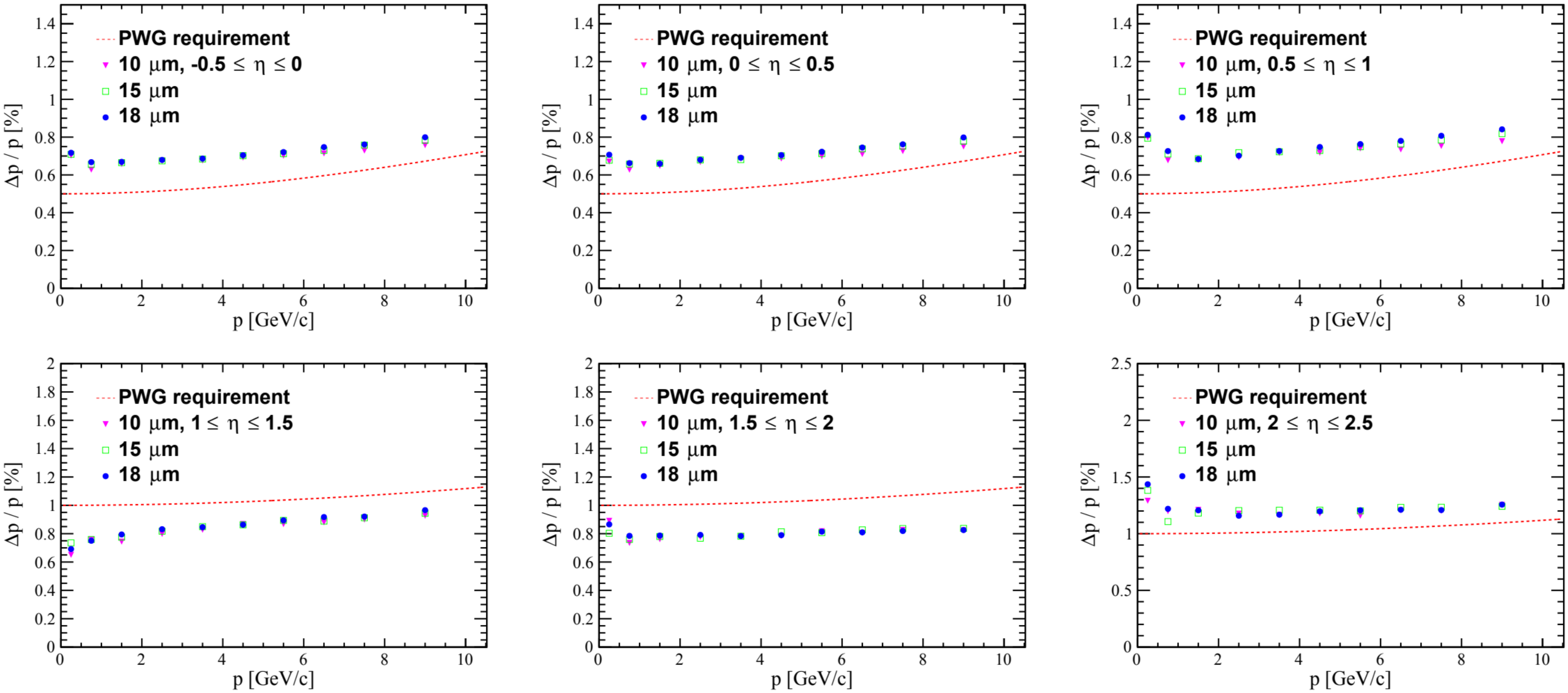
- ITS3 aims at 10μm pixel pitch
  - Currently working with 15μm and 18μm
- To see effect of this in simulation, implement setup as shown:
  - 5 disks from +-25cm to +-135cm
  - 5 silicon barrel layers
  - Complemented by AC-LGADs and MPGDs
- Run simulations with single pions with silicon layers of pitch 10, 15, 18μm



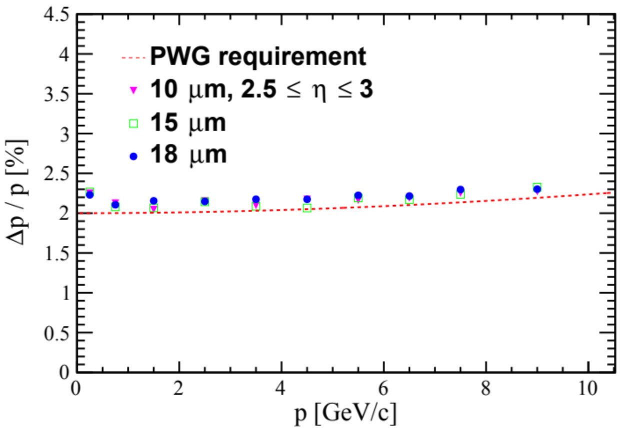
EPIC – Symmetric disks – 1.7T – Momentum Resolution

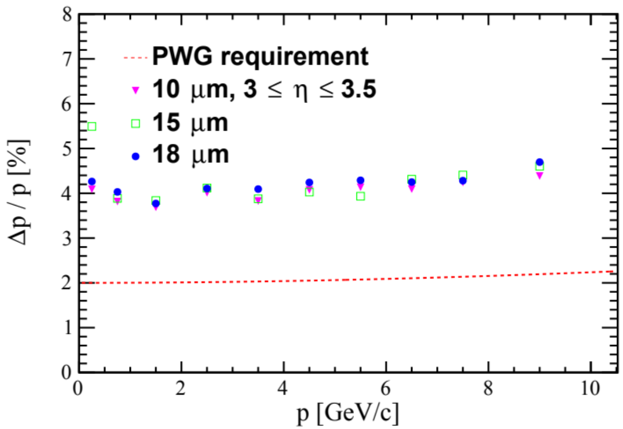


EPIC – Symmetric disks – 1.7T – Momentum Resolution

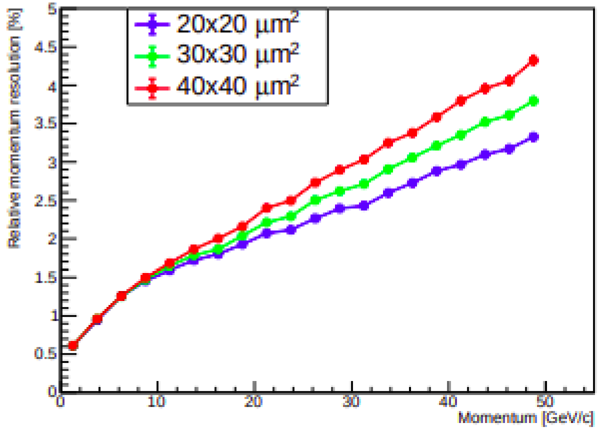


EPIC – Symmetric disks – 1.7T – Momentum Reso





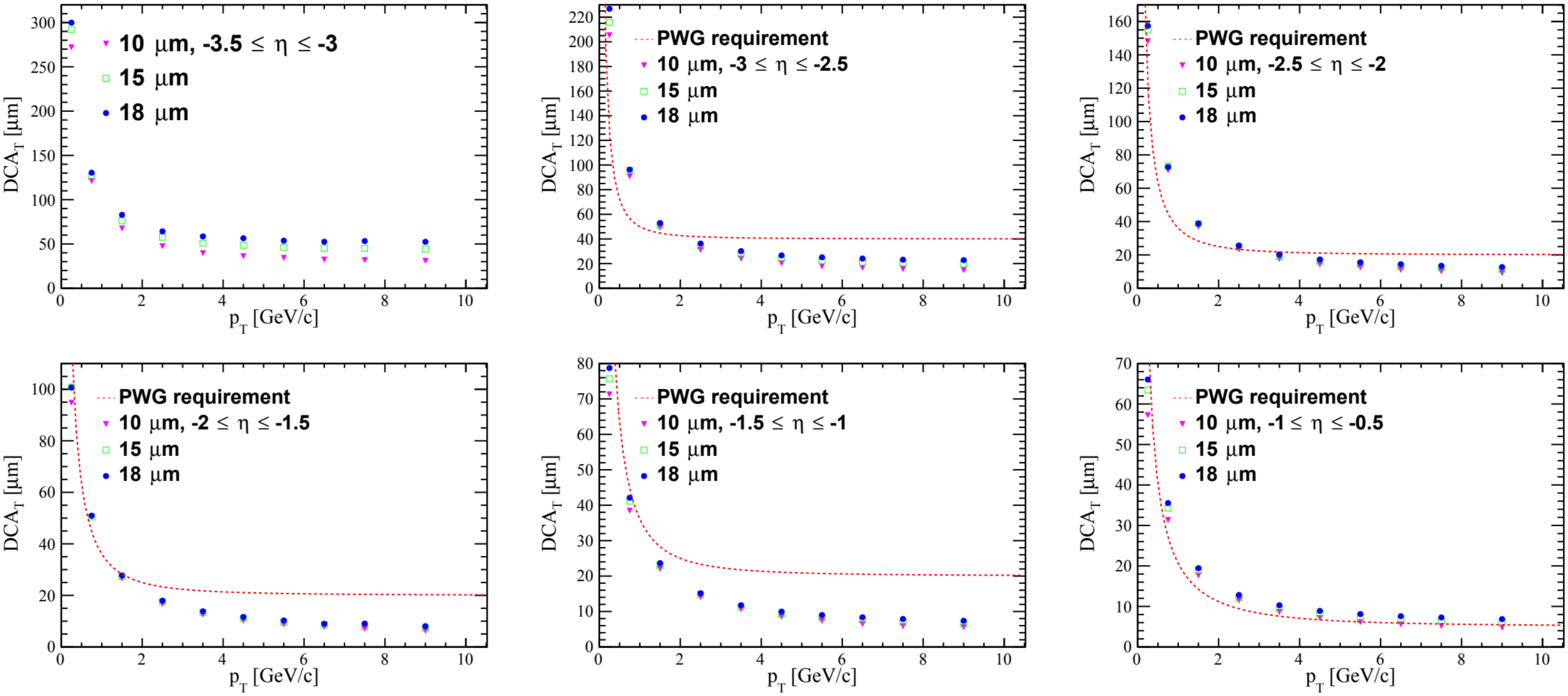
- Don’t see significant degradation in momentum reconstruction performance for momentum range studied
  - Expect performance to remain similar until higher momenta



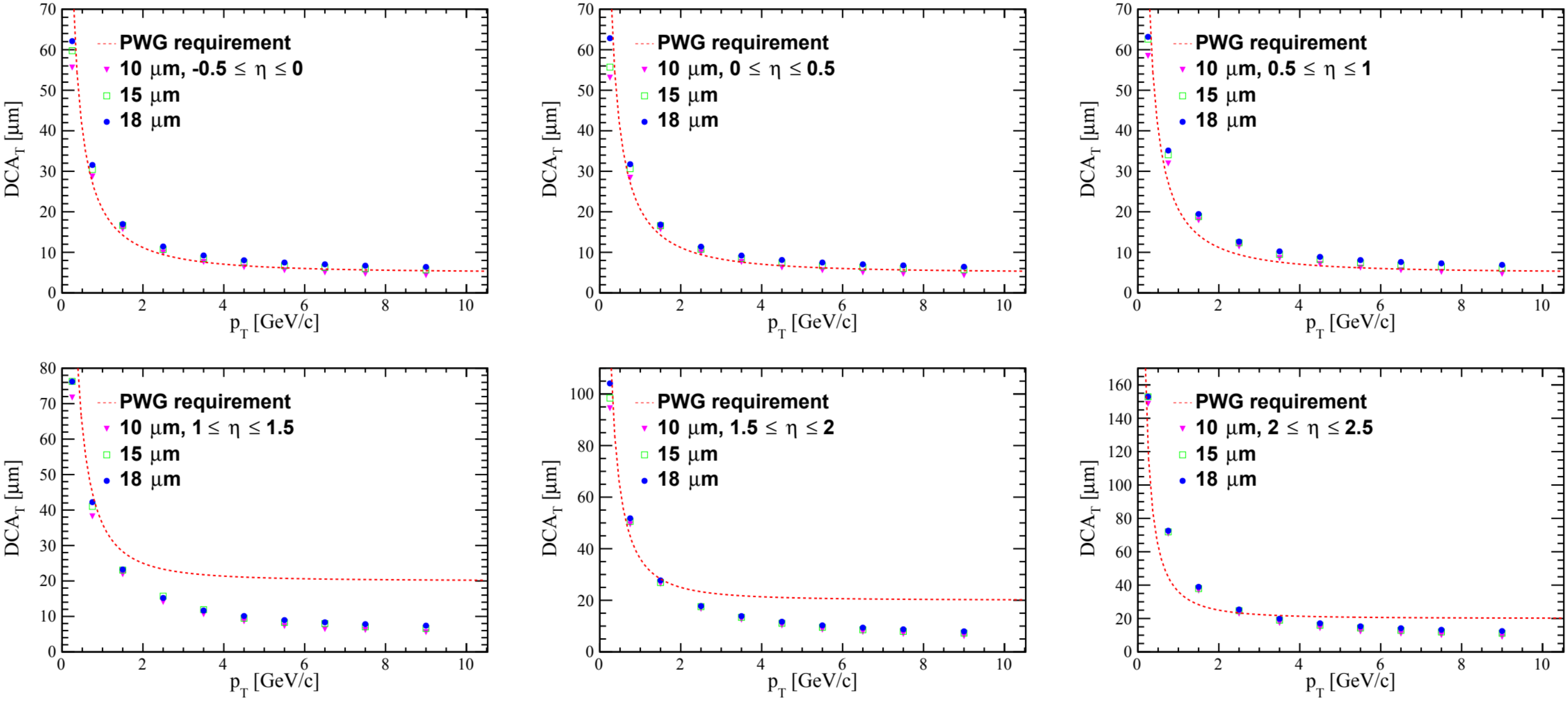
H. Wennlof
PhD thesis

Figure 5.5: Relative momentum resolution for different pixel sizes in the silicon vertex tracker barrel, for momenta between 0 and 50 GeV/c.

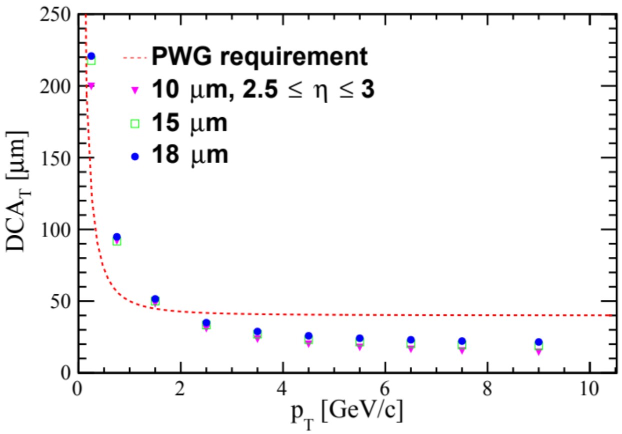
EPIC – Symmetric disks – 1.7T – Pointing Resolution

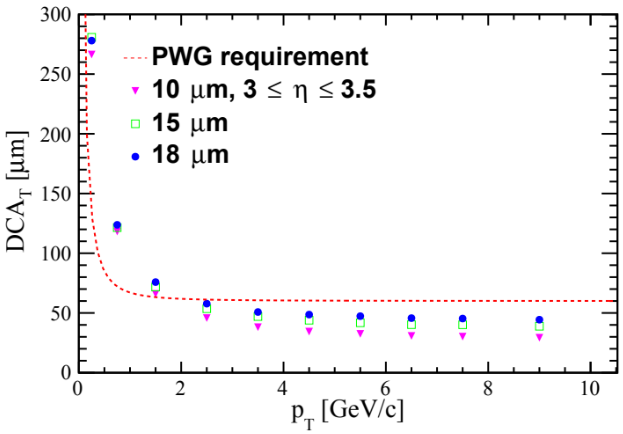


EPIC – Symmetric disks – 1.7T – Pointing Resolution



EPIC – Symmetric disks – 1.7T – Pointing Resolution





- Loss in performance seen at higher momenta as expected
- Position of points with relation to requirement line mostly unchanged

Summary

- Acceptance of disks around the beampipe measured as a function of η and compared for 95% vs 100% efficiency
  - Only 3 disks hit for $|\eta| > \sim 3.2$ → reduces acceptance to ~80% if disks are 95% efficient
- Compared 10, 15, and 18μm pixels in terms of momentum and pointing resolution
  - Losses are minimal for (transverse) Momenta in the range 0 to 10 GeV

Next Steps

- Look at acceptance in terms of one of the measured quantities (such as $Q^2_{electron}$)
- Investigate effect of beam spot on performance