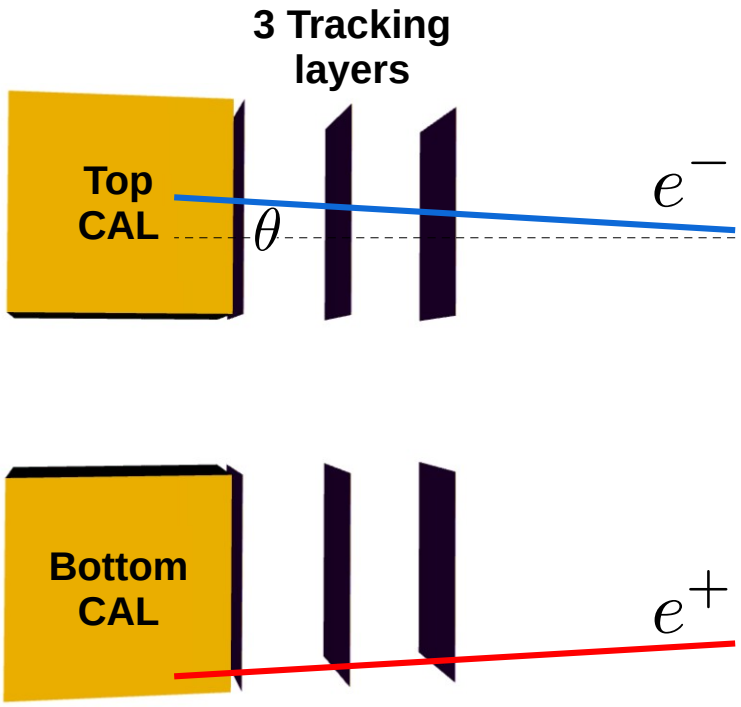
Pair Spectrometer Tracker Technology



We need trackers for the pair spectrometer

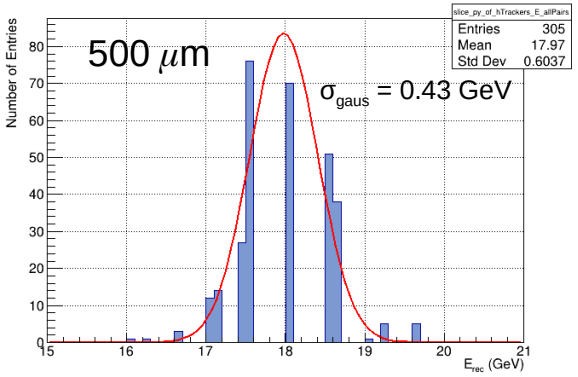
- They provide superior energy resolution compared to the CALs (θ proportional to E)
- No fuzzy edges that CALs suffer from
- Provides measurements of electron beam divergence

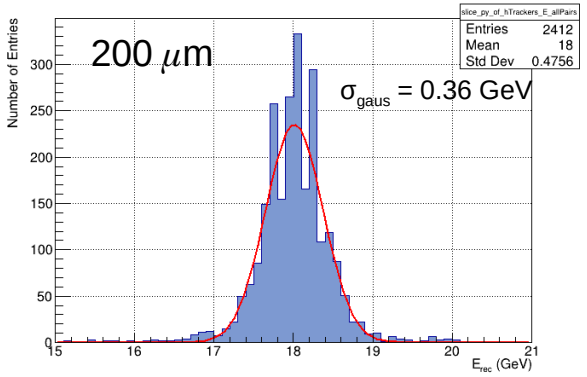
Supporting slides here:

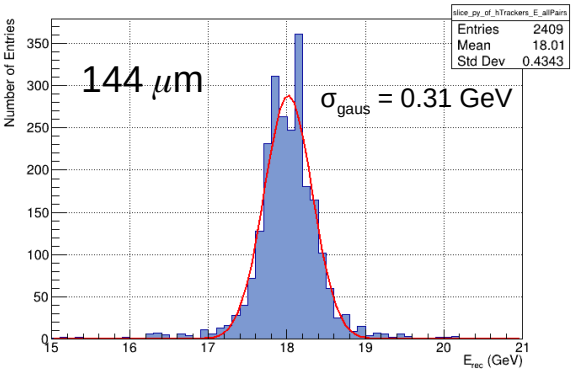
Presentation at June 26th TIC meeting

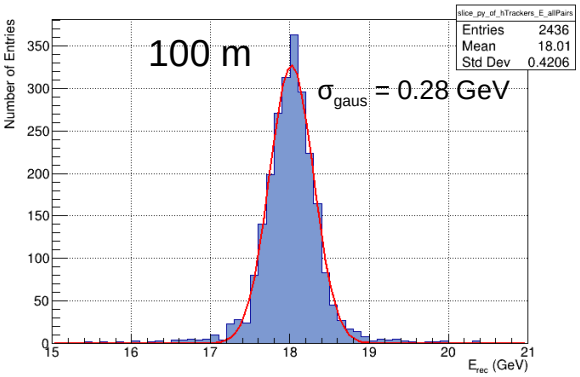
Dhevan Gangadharan (University of Houston)
FF/FB Cross cutting meeting July 18th 2023

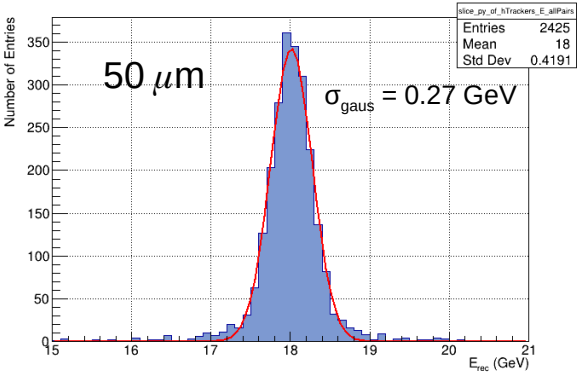
Trackers - Pixel Size and Energy Resolutions

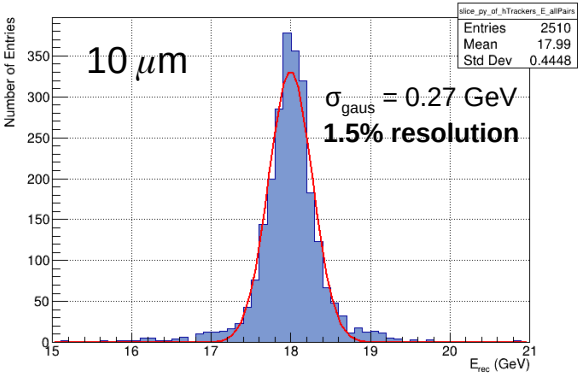






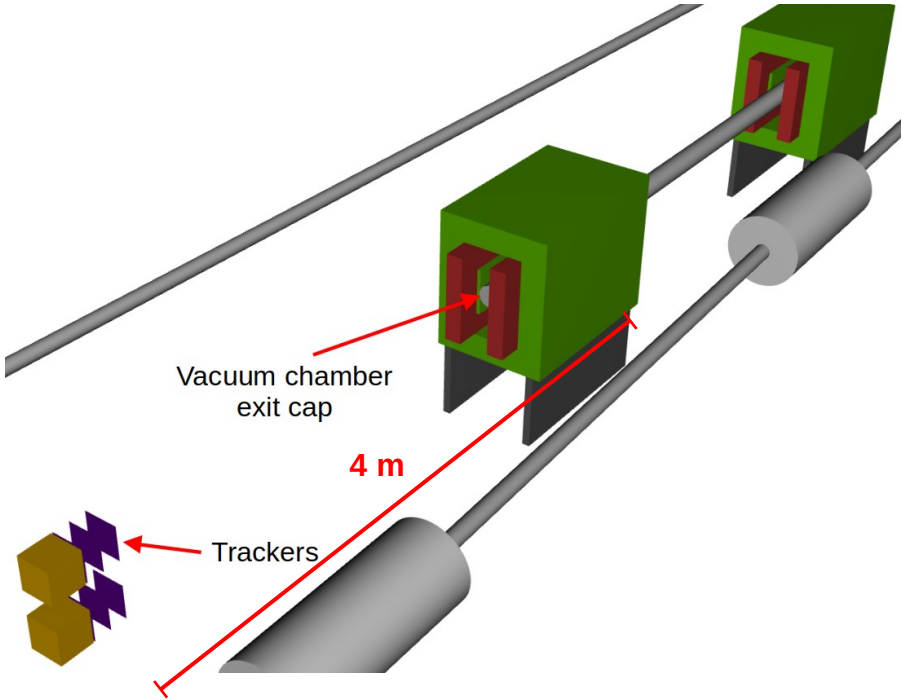






- Clear discretization effects visible for “large” pixels, due to small angular range of tracks: ~0.7° to ~4°. Note, charge-sharing effects would improve E resolutions somewhat.

Design Considerations - **Trackers**

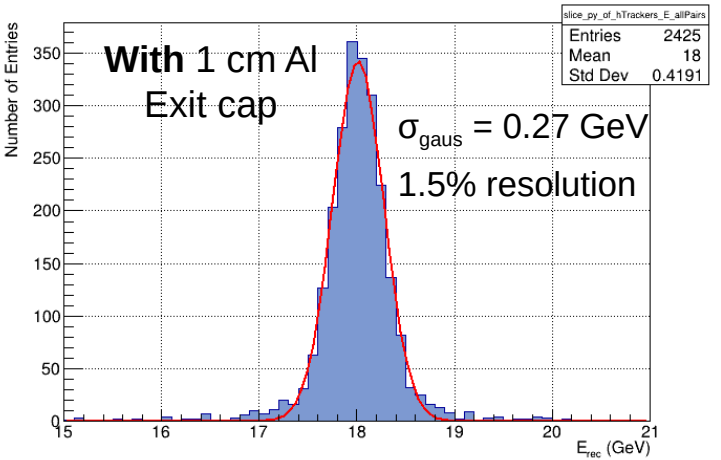


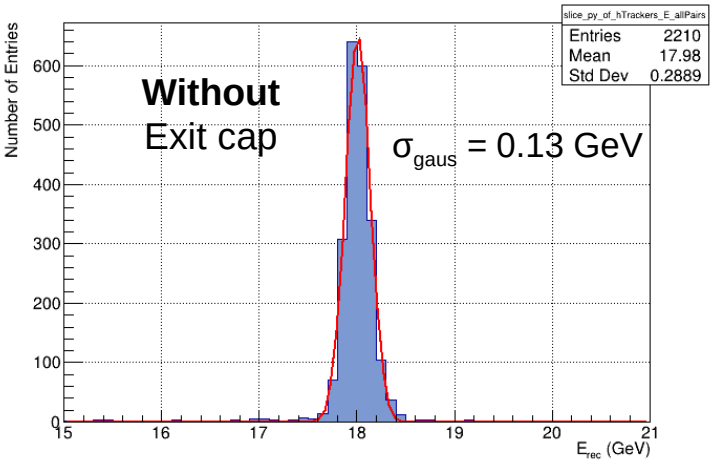
3 Tracking planes in front of each CAL.
Benefits from Tracking:

- Better energy resolutions attainable than from CALs.
- Well defined acceptance, no “fuzzy” edges as with CALs.
- Pile-up easily identified and treated.
- Tracks allow rejection of background particles (beam-gas) and assessment of electron beam divergence.

Energy Resolutions

For 18 GeV electrons

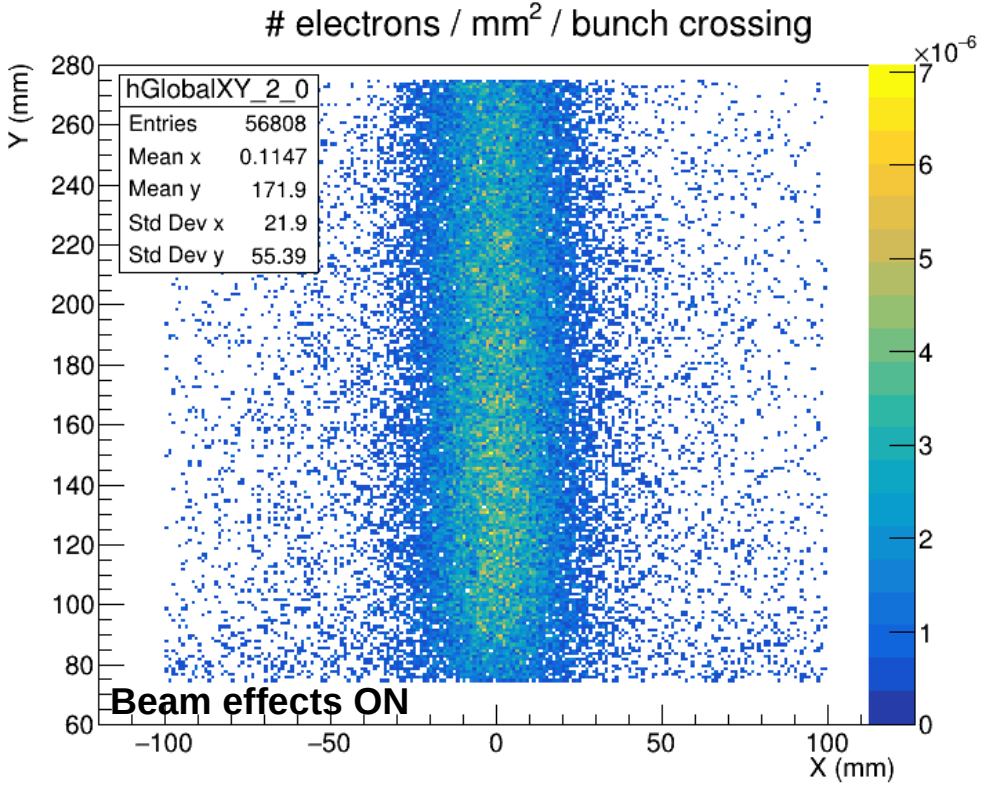




Effective pixel size 50 μm

Tracker Occupancies

ep 18x275 (44 ns bunch spacing)



~ 10^{-5} electrons per mm^2 per bunch crossing.

~ 10^{-5} electrons per 55 um pixel per bunch crossing in the “brightest” eA setting.

Large pixel integration times are not necessarily a problem (even μsec level).

Summary of Tracker Requirements

Total sensor Area	2 sets * 3 layers * 20 cm * 20 cm = 2,400 cm2
Pixel size	~ 50 um
Material budget	no stringent requirements
Integration times	no stringent requirements
Time resolution	~nsec, to distinguish bunch crossings

Considered technologies for the Trackers:

- **Timepix4 (preferred option so far)**
- Microstrips (quote from a company on next slide)
- AC-LGAD
- AstroPix
- MAPS

Microstrip sensors

For what its worth...here is a price quote I obtained for microstrips that might suite our needs

Product Catalogue

Micron Semiconductor Limited

Units 1-5 Royal Buildings
85 Marlborough Rd
Lancing
West Sussex
United Kingdom
BN15 8SJ
Tel: +44 1903 755252

Company Registration No: 1694255 England
VAT No: GB 376 8710-14
EORI No: GB 376 8710 14000

E-Mail: sales@micronsemiconductor.co.uk
www.micronsemiconductor.co.uk

Description	Quantity	Unit Price	VAT	Amount USD
DDD5 (DS) 300 2M/2M AC coupled chip only detectors	120.00	5000.00	Zero Rated	600000.00
NRE custom dedicated test and shipping trays for sample testing, shipping and storage	120.00	175.00	Zero Rated	21000.00
NRE masks	2.00	1850.00	Zero Rated	3700.00
NRE probe cards; 128 channels	2.00	1250.00	Zero Rated	2500.00
NRE copy masks	12.00	650.00	Zero Rated	7800.00
NRE Silicon 5K - 10K N Type <1-0-0> 6 inch	100.00	150.00	Zero Rated	15000.00
Prices US dollars FOB destination				
			Subtotal	650000.00
			Total Zero Rated	0.00
			TOTAL USD	**650000.00**

DDD5 dual sided Si microstrips

- 50 um pitch
- orthogonal dual sided strips
  not sure if readouts from both sides could be read out from one end
- 2 cm x 12 cm chips (need 120 of them)

This price doesn't include ASICs, assembly, etc. Appropriate total could be well over $1M.

Thoughts on Pair Spectrometer Tracker Technology options

- Timepix4 to be used for the low-Q2 taggers and would satisfy all of the requirements for the Pair Spectrometer trackers. The total sensor areas are about the same for the taggers and pair spectrometer. Assuming no shared expenses, cost would be about $2M for the Pair spectrometer.
- Microstrip detectors, at least the one from previous slide, might also satisfy our requirements but would cost over $1M. Close to Timepix4 costs. Might not be worth introducing a new technology…
- AC-LGAD and Astropix have “huge” 500 um pixels and likely won’t suite our needs (tracks with small angular differences need to be distinguished).
- MAPS have large integration times but that might not be a problem given the low occupancies.