LGADs-based (outer) tracker for ECCE
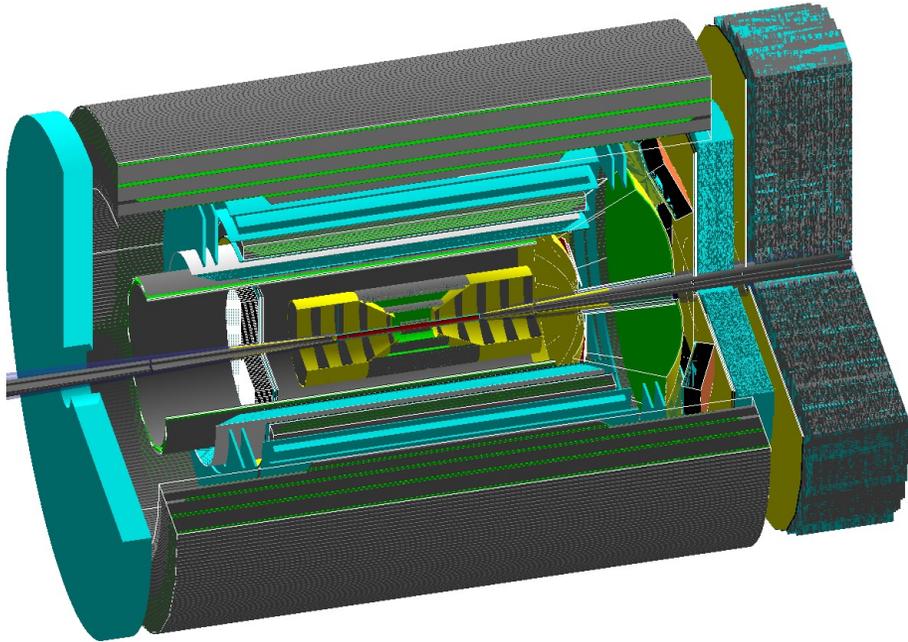
- status of simulations in Fun4All

Wei Li (Rice University)

ECCE Tracking WG meeting
May 21, 2021

# LGADs TOF simulation in Fun4All

- Silicon layers with timing and position smeared to expected resolution

- Timing and path length of each track stored for calculating the velocity

- Material budget is dummy for now but will update soon

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https://github.com/eic/fun4all_eicmacros/blob/master/common/G4_TTL_EIC.C

	Default	R_{barrel}	Length	z location	$R_{endcap,in}$	$R_{endcap,out}$	η coverage	Area (m²)
Backward	$ETTL_0$			-1.555	0.077	0.632	[-3.7,-1.6]	1.23
	$ETTL_1$			-1.585	0.078	0.62	[-3.7,-1.6]	1.19
Central	$CTTL_0$	0.92	3.6				[-1.34,1.34]	20.8
	$CTTL_1$	1.147	3.6				[-1.11,1.11]	25.9
Forward	$FTTL_0$			2.87	0.116	1.527	[1.3,3.9]	7.28
	$FTTL_1$			2.89	0.117	1.538	[1.3,3.9]	7.39
	$FTTL_2$			3.4	0.138	2.185	[1.1,3.9]	14.94
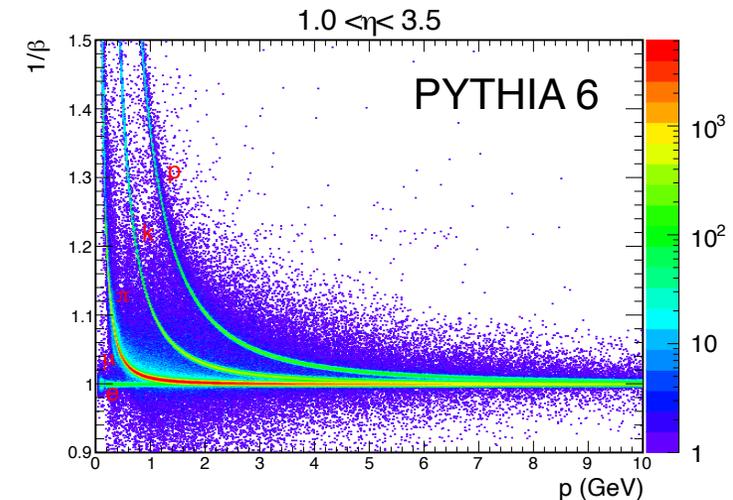
Position resolution

Pitch size: 1.3 mm – 700 (500) μm
(mainly limited by ASICs)

AC-coupled LGAD

$$\sigma_x < \frac{\text{Pitch}}{\sqrt{12}}$$

ETROC1 Single Pixel Layout
1.3mm x 1.3mm

σ_x: 20-30 μm
for pitch of ~ 500 μm
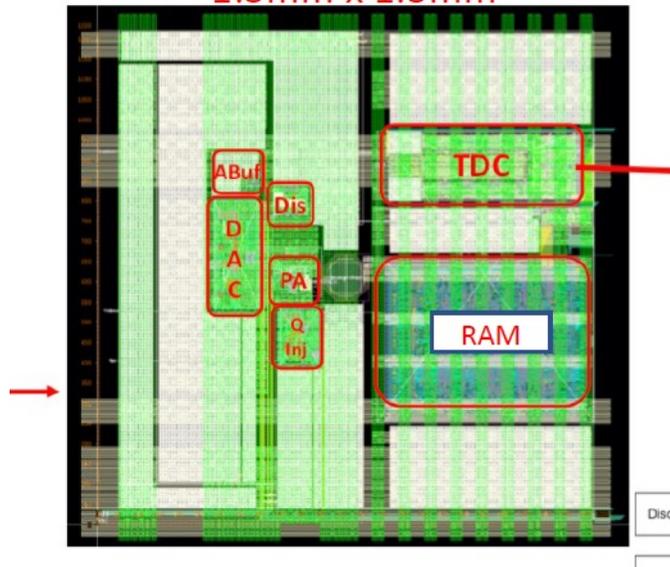
arXiv:2003.04838

LGADs consortium meeting on electronics:
https://indico.bnl.gov/event/11717/
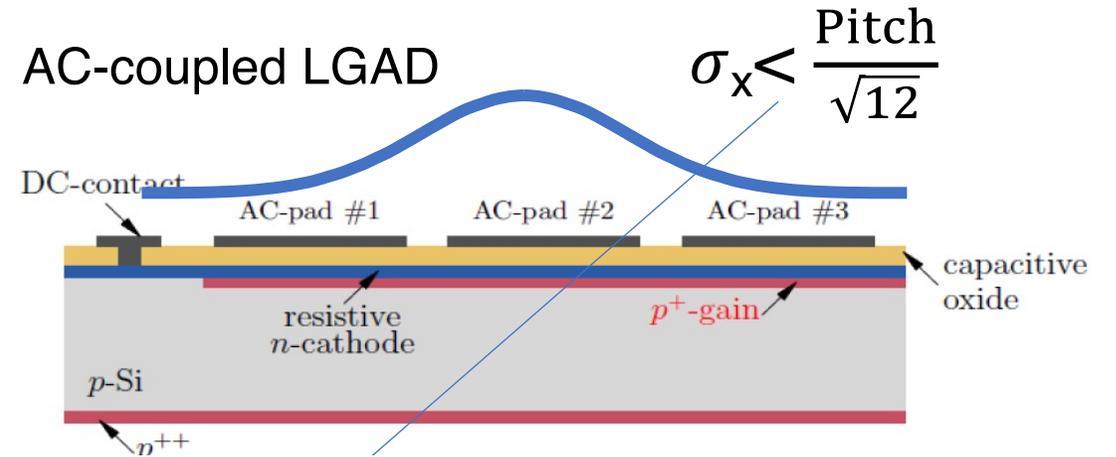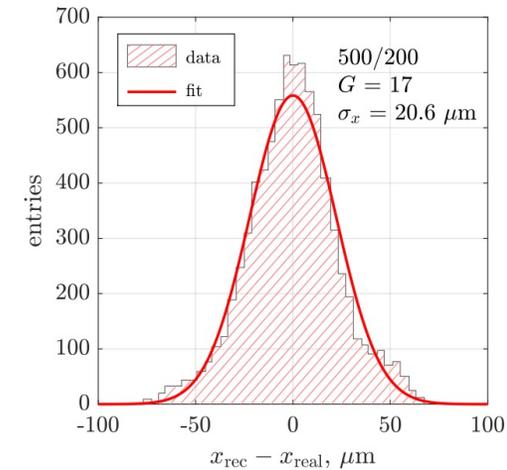
Small pitch → more channels (~ 2 mW/ch)
→ more power consumption

Material budgets

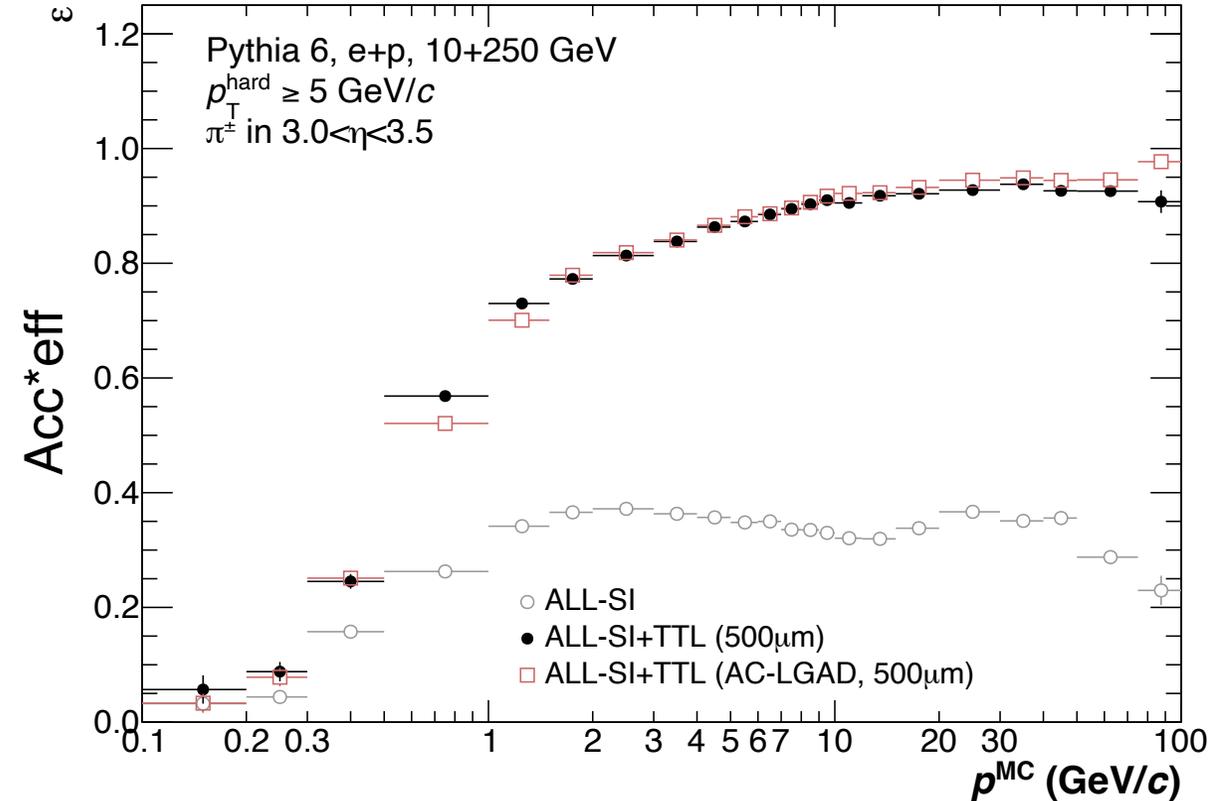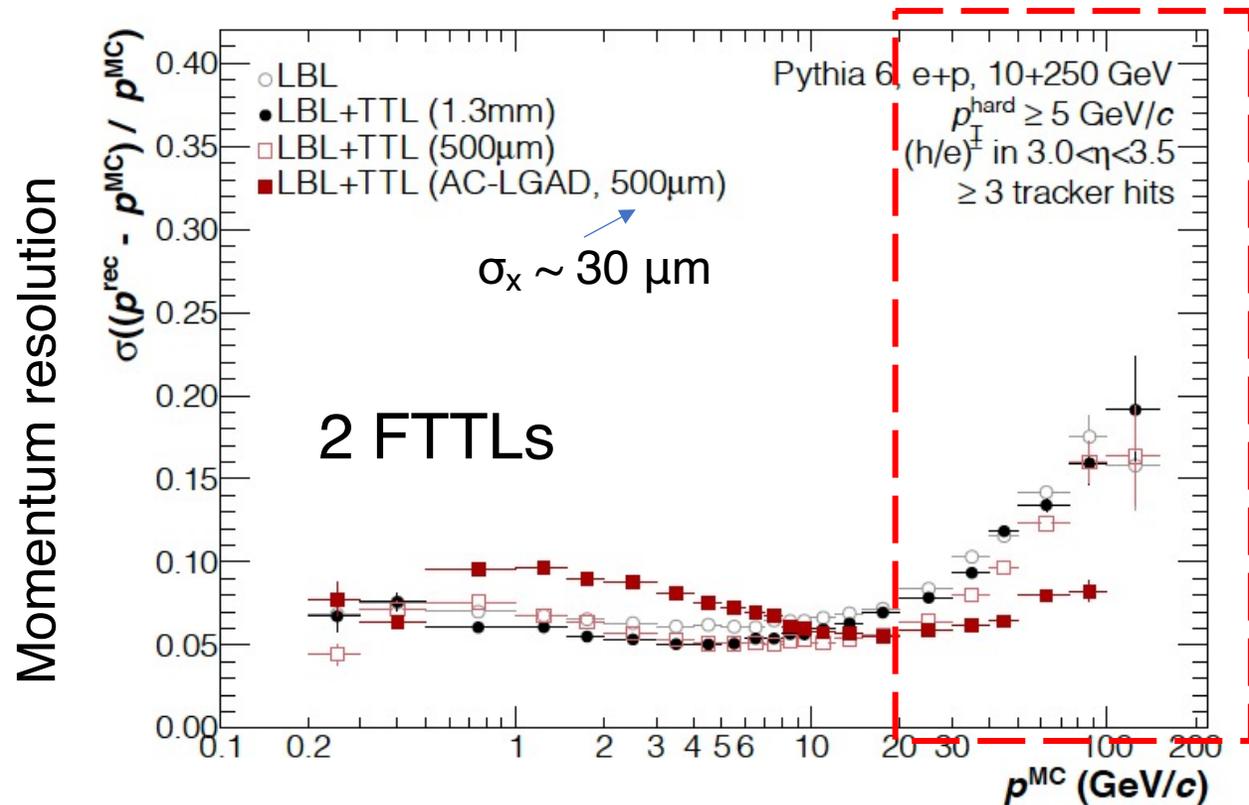15% X_0 for two layers, dominated by support (Al), electronics

6 mm

CMS MTD TDR
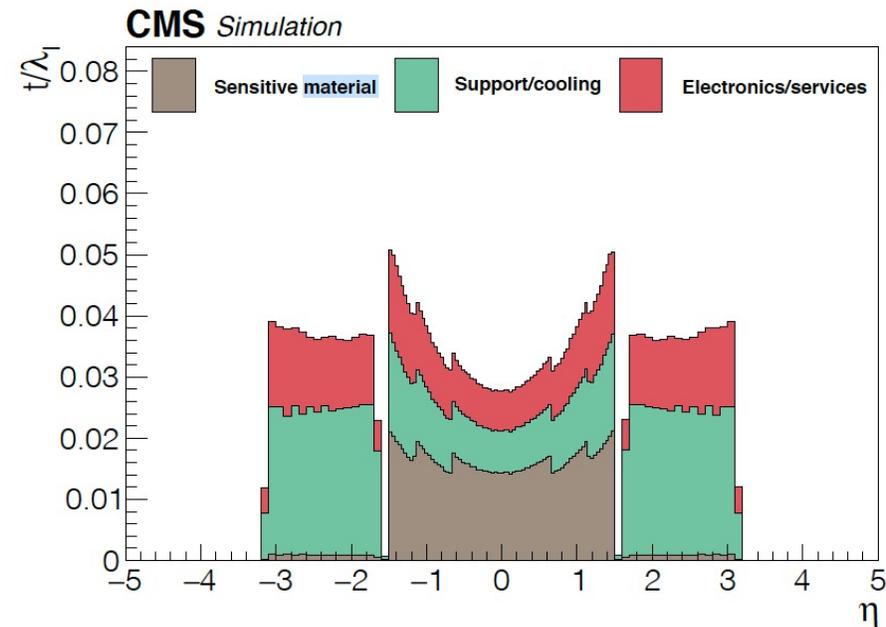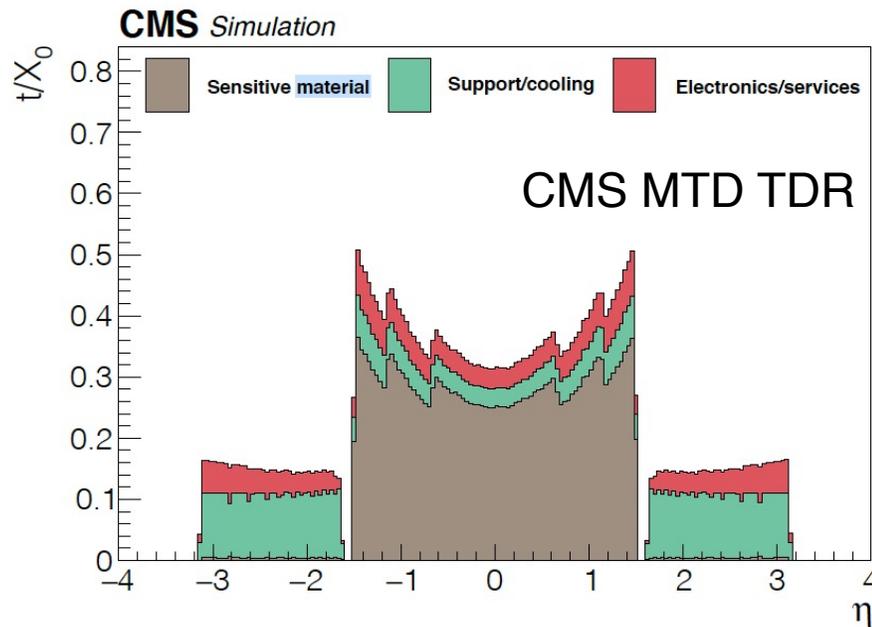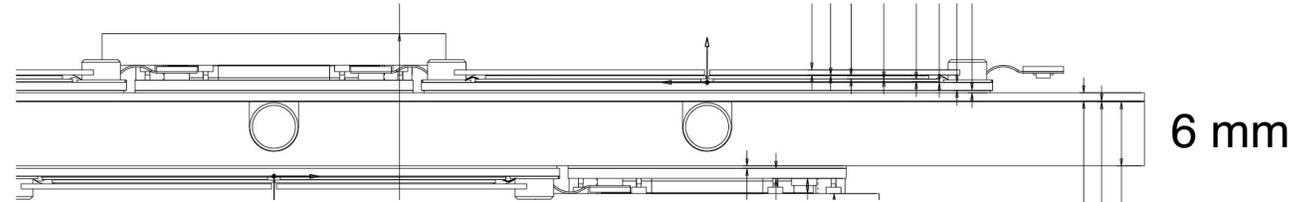
Plan to implement 6mm thick Al for each layer in Fun4All

What is the impact on electron energy resolution?

Forward tracking with LGADs

Tracking w/o vs. w/ LGADs layers

LGADs layers will serve as both TOF and outer tracker (behind RICH) to improve *p* resolution by up to 50% at 100 GeV/c and efficiency at forward y
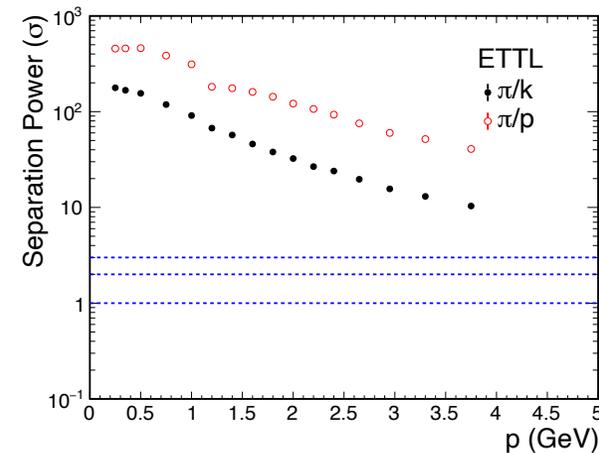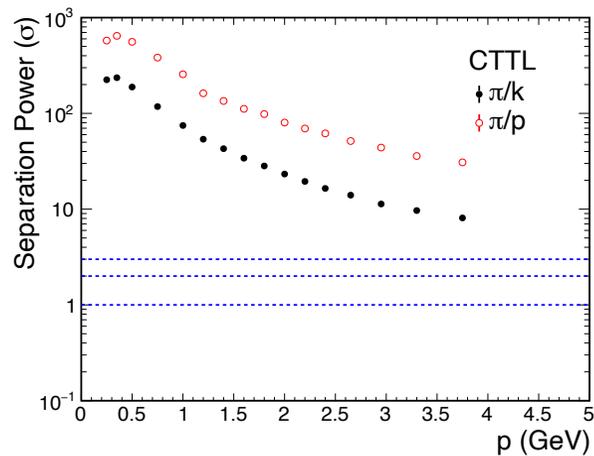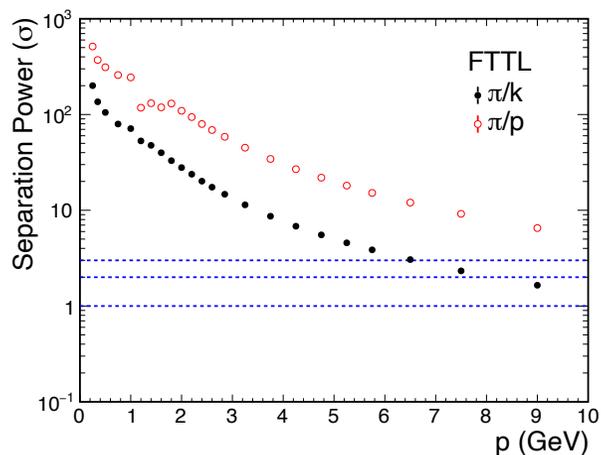
Backups

PID performance

Forward (1<η<3.5):   Central (|η|<1):   Backward (-3.5<η<-1):

$\sigma_t = 0$ ps
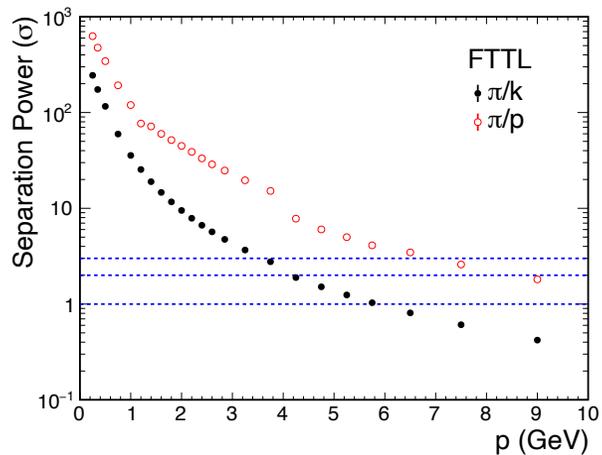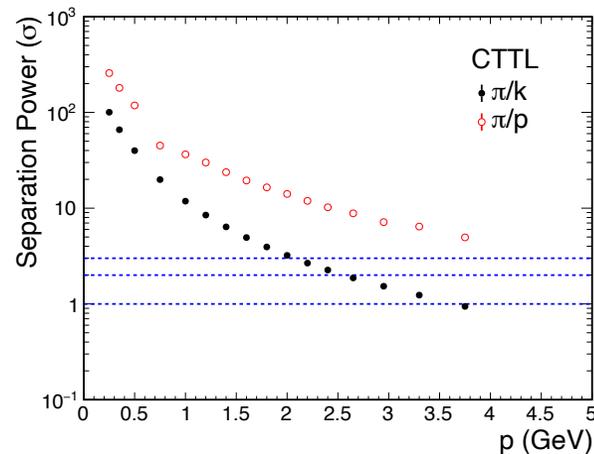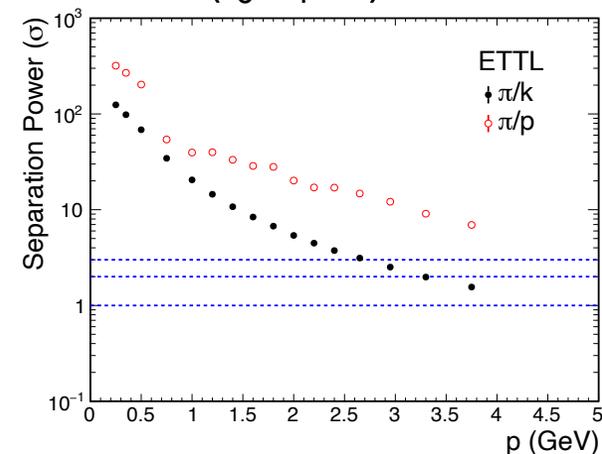
all uncertainties (t_0, t_f, L) included

$\sigma_t = 20$ ps

0.2-4 GeV   0.2-2.5 GeV   0.2-3 GeV

PID performance
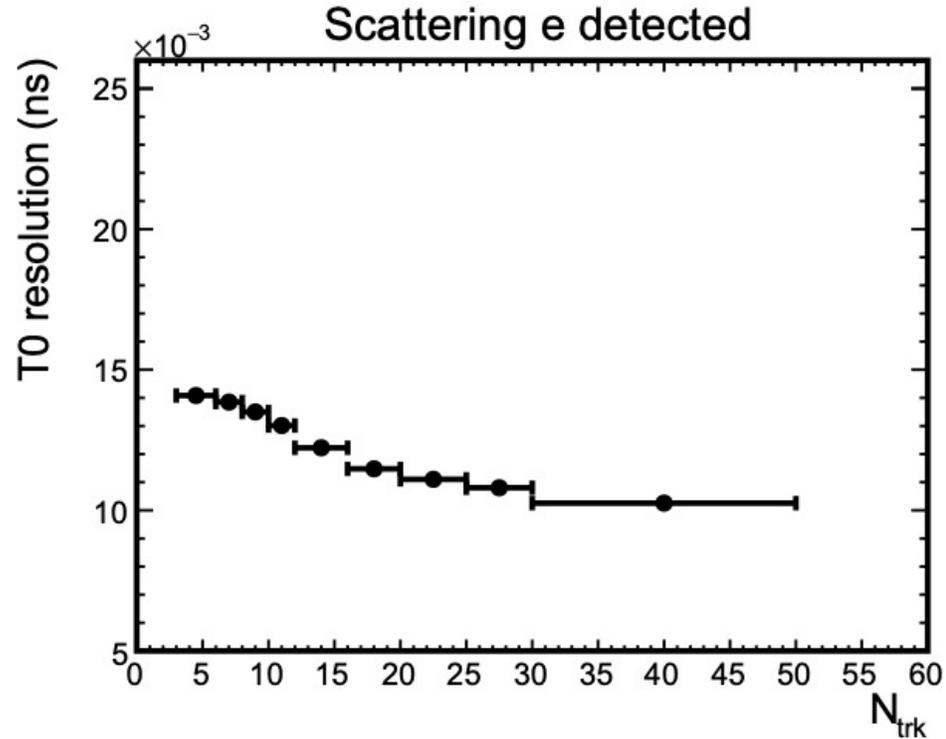
Iterative procedure to determine T_0:

- Assume scattered e is detected by TOF
- Start with pion assuming for all other particles to fit T_0
- Update mass assumption for outliers in next iterations

Details described in https://wiki.bnl.gov/conferences/images/0/01/ERD29_progress_report_March2021.pdf
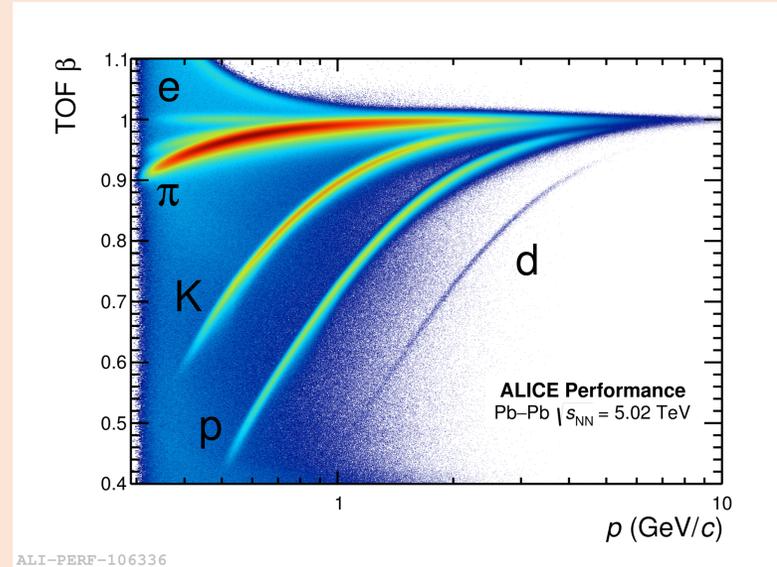(still optimizing)

Concept of LGADs sensors
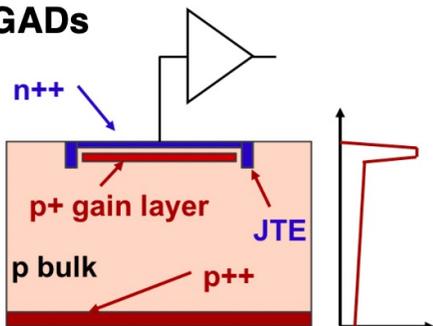
Precision position detectors:
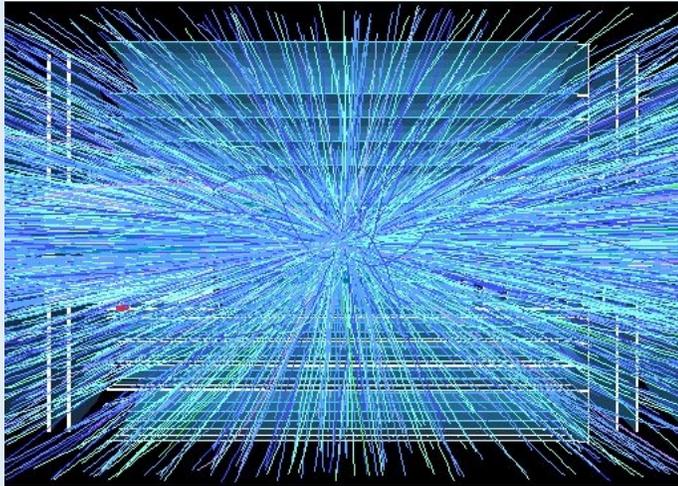
e.g., silicon:

Thin & Light
Segmented
B tolerant
Rad-hard

Precision timing detector:
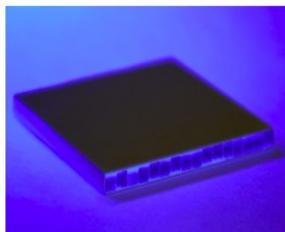

Scintillation
Ionization
+
High gain

LGADs

n++

p+ gain layer

JTE

p bulk

p++

Ultra Fast Silicon Detector E field

LGADs sensors:
precision **position** and **timing**

LGADs at the HL-LHC (2028)

BTL: LYSO bars + SiPM readout:
- TK / ECAL interface: $|\eta| < 1.45$
- Inner radius: 1148 mm (40 mm thick)
- Length: ±2.6 m along z
- Surface ~38 m^2; 332k channels
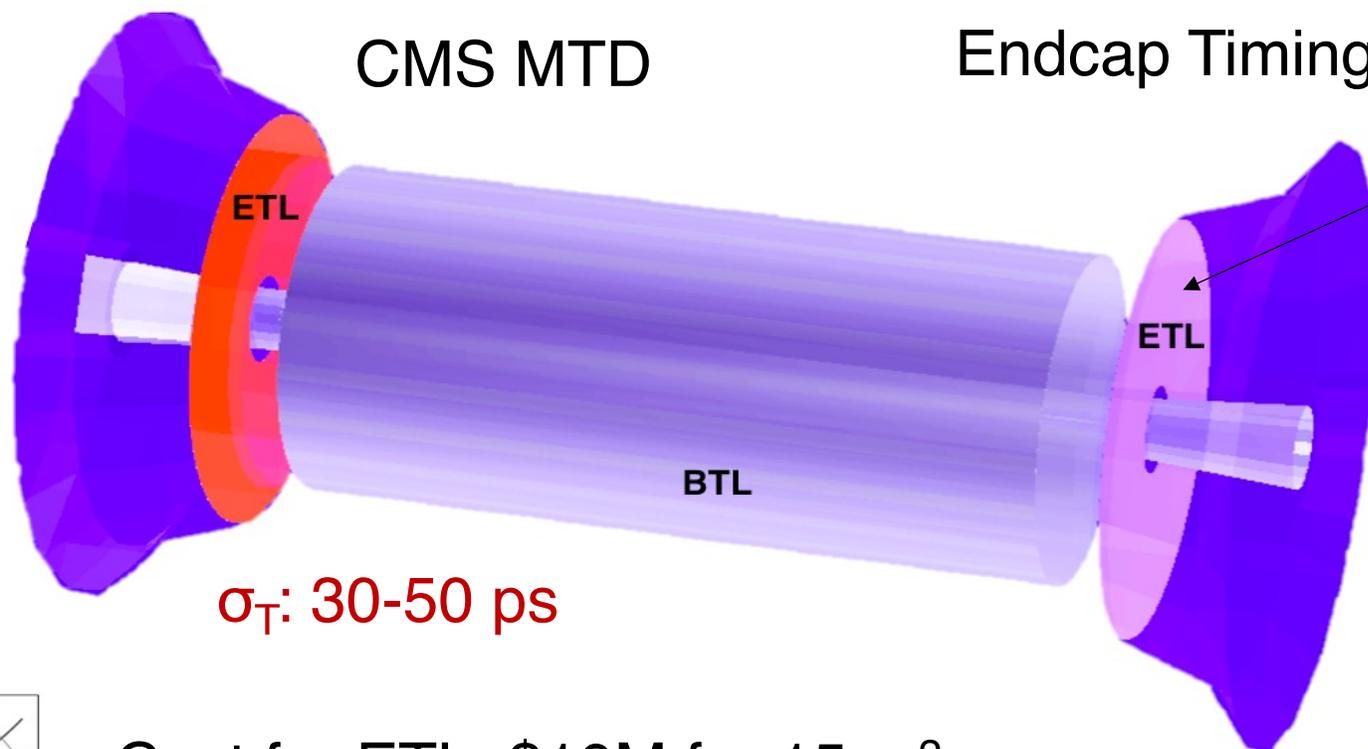- Fluence at 4 ab^{-1}: 2×10^{14} n_{eq}/cm^2

ETL: Si with internal gain (LGAD):
- On the CE nose: $1.6 < |\eta| < 3.0$
- Radius: $315 < R < 1200$ mm
- Position in z: ±3.0 m (45 mm thick)
- Surface ~14 m^2; ~8.5M channels
- Fluence at 4 ab^{-1}: up to 2×10^{15} n_{eq}/cm^2
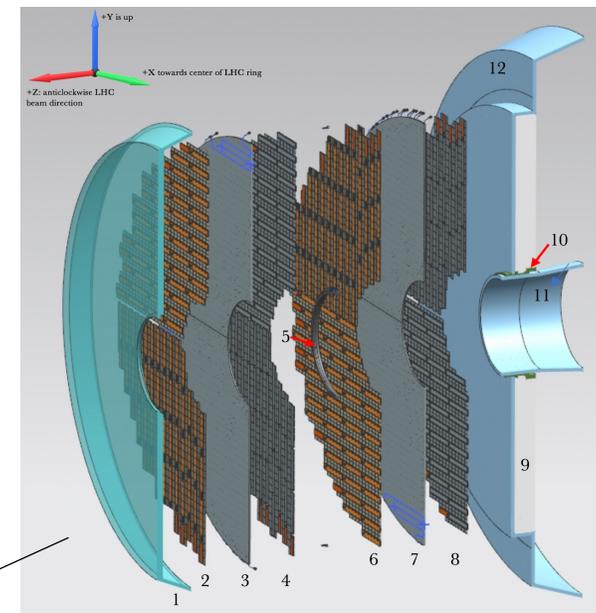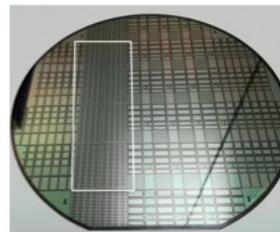
CMS MTD

Endcap Timing Layer

Particle ID in HI

σ_T: 30-50 ps

Cost for ETL: $10M for 15 m^2
(possible to optimize for low radiation)