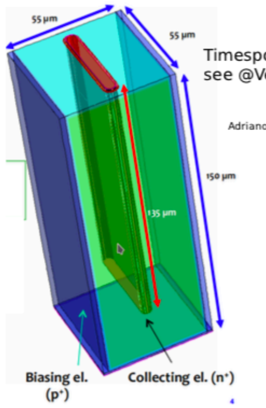
Hybrid fast timing sensor developments
(EP R&D WP 1.1)
Sensor R&D and telescope plans

Hybrid silicon sensors

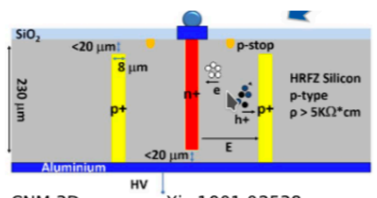
Drive hybrid silicon pixel R&D towards proof-of-concept prototypes.

Time resolution
aiming at <50ps

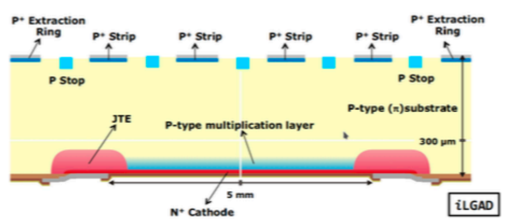


Timespot 3D sensor
see @Vertex2019

+ thin planar (50-100um)

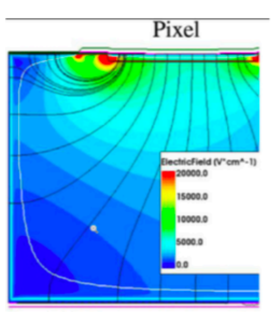


CNM 3D sensor arXiv:1901.02538



CNM iLGAD arXiv:1904.02061

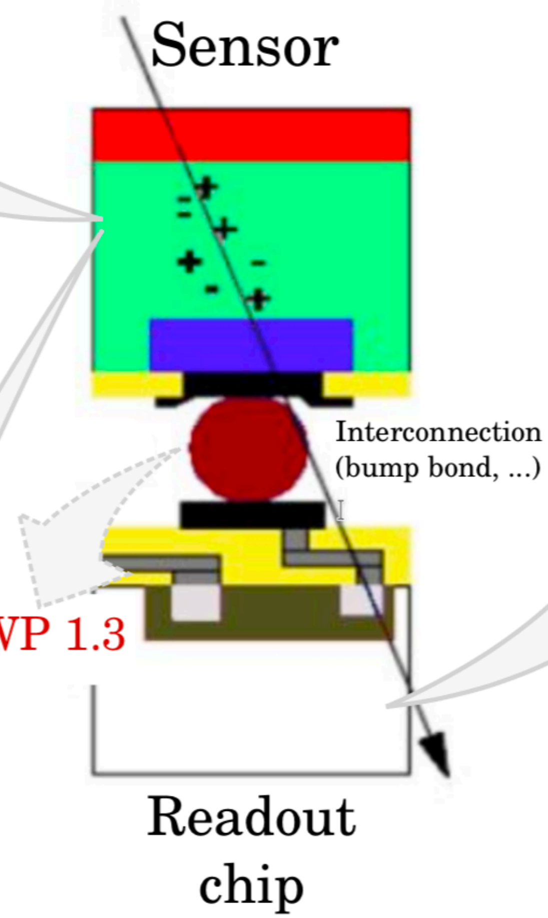
Spatial resolution



(a) No GR

Thin - Active Edge planar sensors
CLIC arXiv:1904.09953

+ fine pitch (25um)
planar sensors



Available ROC

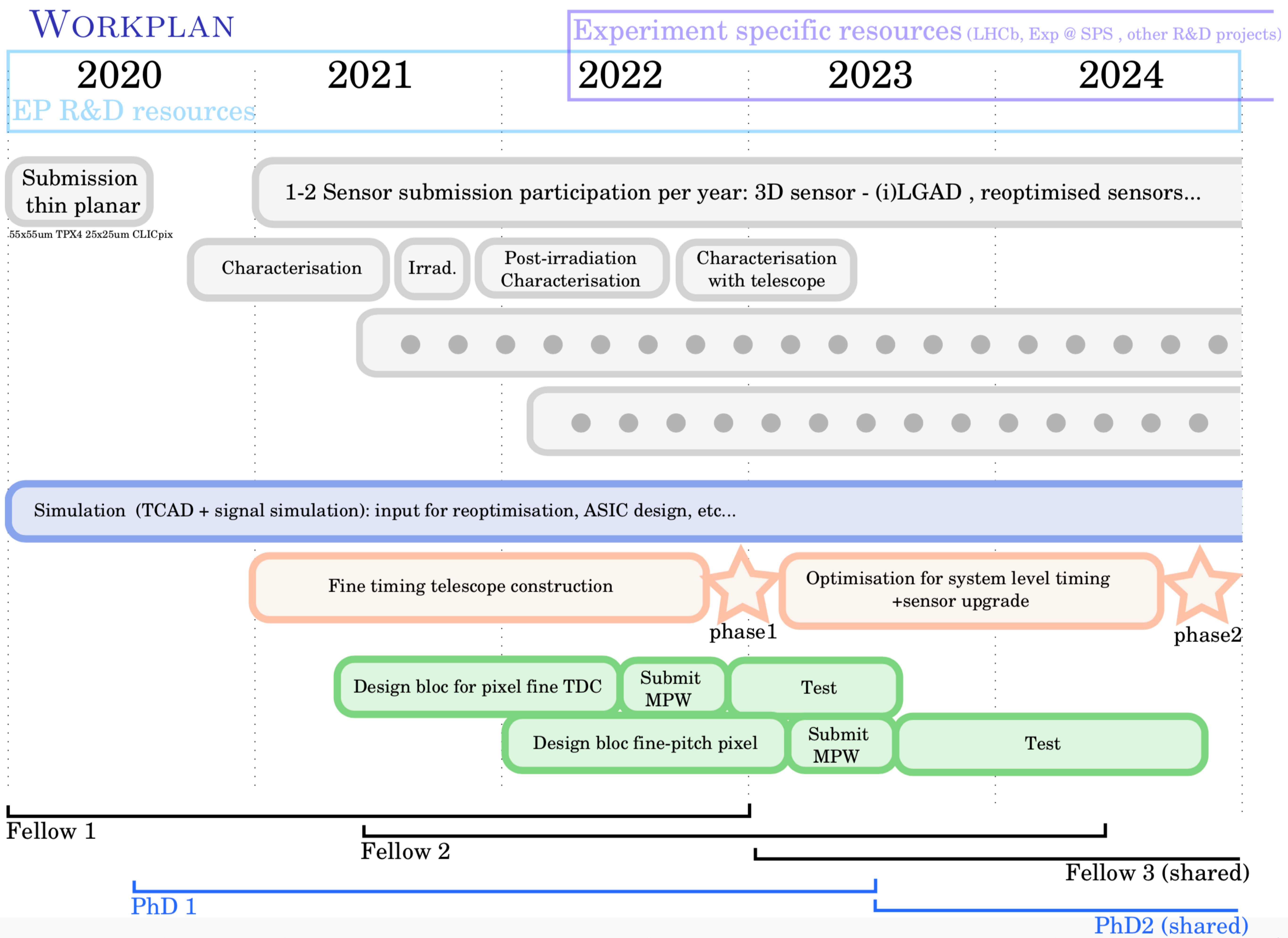
R/O Chip	TFS (nm)	Pitch (µm)	Size (cm^2)	time bin (ns)	Data rate (Gbit/s)
Timepix3	130	55	2	1.56	5
Velopix	130	55	2	25	19
CLICpix2	65	25	0.1	10	0.1
RD53-A/B	65	50	2/4	25	5
Timepix4	65	55	7	0.2	82

ROC block developement

Specific ASIC development related to fine timestamp or fine-pitch covered here.

Ideally targetting 28nm, possibly prototyping in 65nm.

Links to IC and High Speed links work package


WORKPLAN
Experiment specific resources (LHCb, Exp @ SPS , other R&D projects)
2020
2021
2022
2023
2024
EP R&D resources
Submission thin planar
55x55um TPX4 25x25um CLICpix
1-2 Sensor submission participation per year: 3D sensor - (i)LGAD , reoptimised sensors...
Characterisation
Irrad.
Post-irradiation Characterisation
Characterisation with telescope
Simulation (TCAD + signal simulation): input for reoptimisation, ASIC design, etc...
Fine timing telescope construction
phase1
Optimisation for system level timing +sensor upgrade
phase2
Design bloc for pixel fine TDC
Submit MPW
Test
Design bloc fine-pitch pixel
Submit MPW
Test
Fellow 1
Fellow 2
Fellow 3 (shared)
PhD 1
PhD2 (shared)

Performances @ SPS, FERMILAB and DESY beam lines

	$\sigma_{t\ tel}$ [ps] tel./single plane	$\sigma_{x\ tel}$ [μm] SPS/FERMIL./DESY	rate @SPS [kHz/cm^2]	rate @FERMIL. [kHz/cm^2]	rate @DESY [kHz/cm^2]	Avail.
AIDA	-	2/2/2	1.6[(1)]	0.6[(1)]	9[(1)]	Now
TPX3	270/646	2/2/10[(2)]	400[(3)]	3000[(1)]	100[(3)]	Now
AIDA-ALPIDE 2-TPX4	60/85	2/2/2	9[(1)]	3.5[(1)]	50[(1)]	**2022**
AIDA+ALPIDE 2-LGAD	35/50[(4)]	2/2/2	9[(1)]	3.5[(1)]	50[(1)]	2024(?)[(5)]
AIDA+MALTA 2-TPX4	60/85	2/2/2	400[(3)]	700[(1)]	100[(3)]	2024[(6)]
AIDA+MALTA 2-LGAD	35/50[(4)]	2/2/2	90[(3)]	35[(1)]	100[(3)]	2024(?)[(5)][(6)]
AIDA-TPX4 ϕ_1	30/85	2/2/10[(2)]	400[(3)]	25000[(1)]	100[(3)]	**2022**
AIDA-TPX4 ϕ_2	22/70[(7)]	2/2/10[(2)]	400[(3)]	25000[(1)]	100[(3)]	2024

[(1)]limited by ASIC rate
[(2)]reduced resolution for 6.3GeV electrons
[(3)]limited by beam rate
[(4)]performances at Vertex 2019
[(5)]not clear when it ALTIROC/ETROC would be available for this use, nor if it is even feasible to integrate them
[(6)]MALTA is still prototype, not clear when available
[(7)]assuming we improve on thin planar sensors: ex. 3D sensors, iLGADs

Results

Example 1 by ~2022

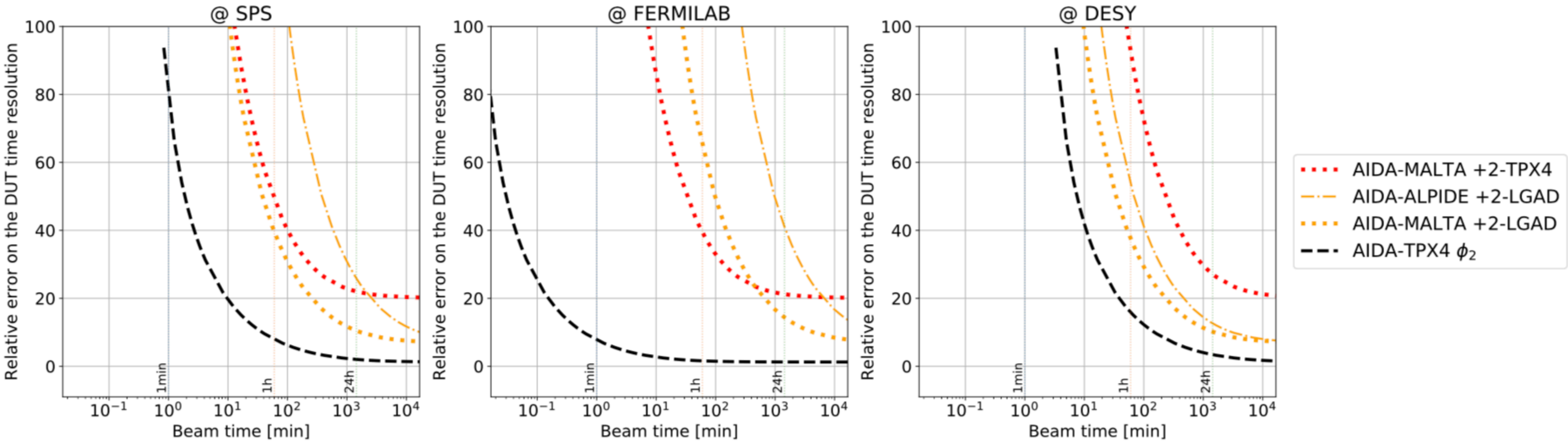
- Evaluate variation of timing resolution depending on intra-pixel position in LGAD for ATLAS HGTD/CMS MTD as function of ten track angle values.
- $\mathcal{A}_{feature} = 1 \times 1\ \mu m^2$, $\sigma_{t\ DUT} = 30\ ps$, $\mathcal{A}_{pixel} = 1 \times 1\ mm^2$, $\mathcal{A}_{DUT} = 1 cm^2$, 5% systematic uncertainty on telescope timing resolution

	time to reach 30%			time to reach 10%		
	SPS	FERMILAB	DESY	SPS	FERMILAB	DESY
TPX3	-	-	-	-	-	-
AIDA	-	-	-	-	-	-
AIDA-ALPIDE +2-TPX4	8d	20d	1.4d	-	-	-
AIDA-TPX4 ϕ_1	12m	$<$1m	50m	2h	2m	8h

- **AIDA-TPX4 is the only short term option**

Results
Example 1 by $\gtrsim$2024

- Evaluate variation of timing resolution depending on intra-pixel position in LGAD for ATLAS HGTD/CMS MTD as function of ten track angle values.
- $\mathcal{A}_{feature} = 1 \times 1\ \mu m^2$, $\sigma_{t\ DUT} = 30\ ps$, $\mathcal{A}_{pixel} = 1 \times 1\ mm^2$, $\mathcal{A}_{DUT} = 1 cm^2$, 5% systematic uncertainty on telescope timing resolution



- **AIDA-TPX4 is the best long term option too**