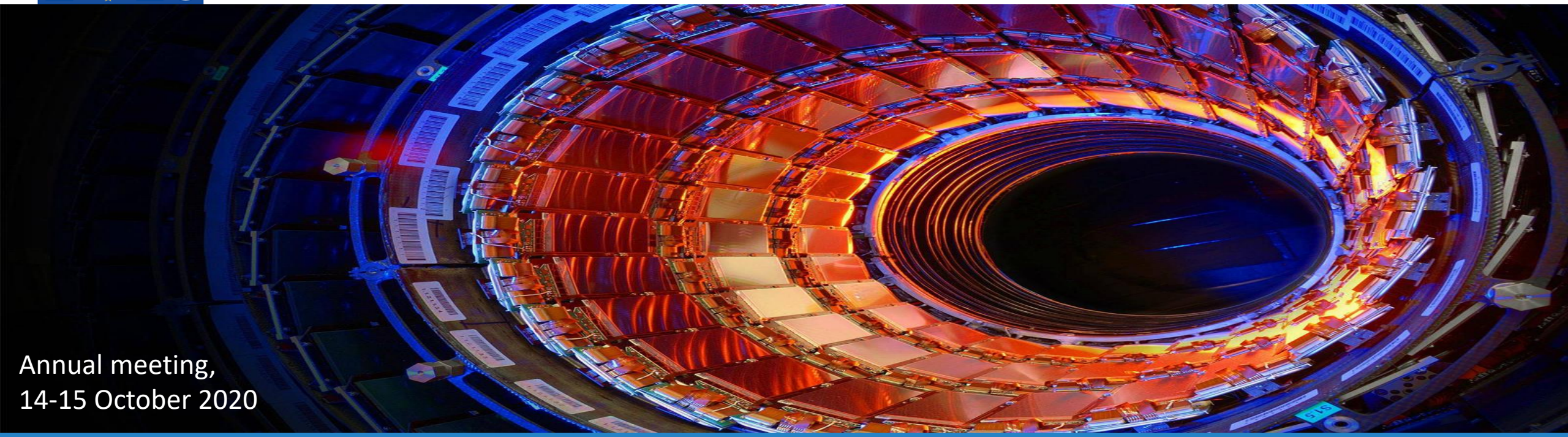
Jerome BAUDOT
for the JRA9 group



Annual meeting,
14-15 October 2020

JRA9-Tracking and Ions Identifications with Minimal Material budget: TIIMM

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 824093

Outline

- Context = combining Tracking & Identification
- Schedule overview / sensor prototypes
- First prototype: requirements & status
- Current activities: tests & second prototype

JRA9 WP27 team

- DKFZ, Heidelberg
- INFN, Bari
- GSI, Darmstadt
- INFN, Trento
- IPHC, Strasbourg
- LNF / INFN, Frascati

Context

For more details ⇒ E.Spiriti talk at 2019 kick-off

Tracking | **Identification**

TIIMM target =

Precision tracking
$\sigma_{pos.} \leq 10$ µm

+

Low material budget << % X_0

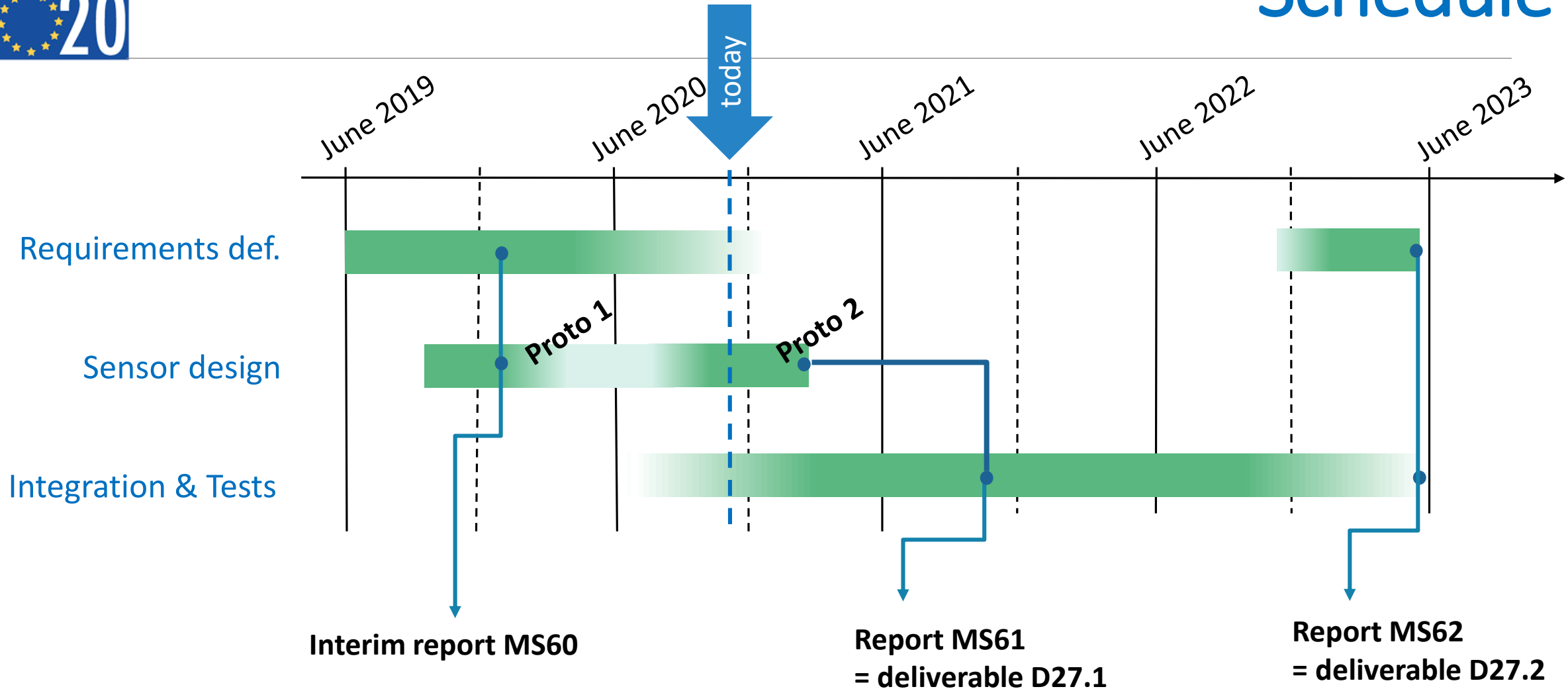
+

Energy loss measurement
1-10^3 MIPs

Current achievements

	Precision tracking	Low material budget	Energy loss measurement
Hybrid detectors	◦ At the limit of feasibility	◦ Limit around 1 % X_0	◦ Strong point ◦ Thick substrate 300-1000 µ m
Monolithic sensors	◦ ~5 µm ALICE – ITS2 ◦ with 1-10 MIPs ◦ 5-10 µm FIRST, hadrontherapy ◦ Ions 150-300 MeV/u	◦ 0.3 to 0.8 % X_0 ◦ ALICE – ITS2 over 10 m^2 ◦ ~0.2 % X_0 ◦ FOOT prototype over 30 cm^2	◦ Available for MIP level ◦ σ_E not investigated ◦ Initial work for >> MIPs ◦ Indirect estimation of ΔE

Schedule


June 2019
June 2020
today
June 2021
June 2022
June 2023
Requirements def.
Sensor design
Integration & Tests
Proto 1
Proto 2
Interim report MS60
Report MS61
= deliverable D27.1
Report MS62
= deliverable D27.2

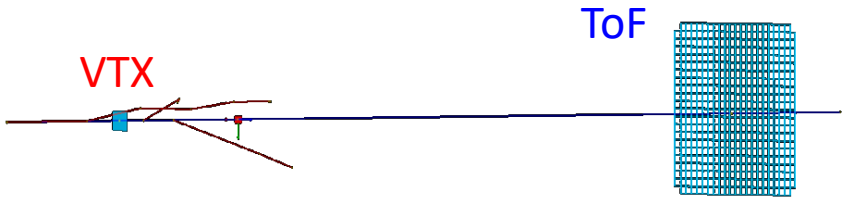
First glimpse on requirements

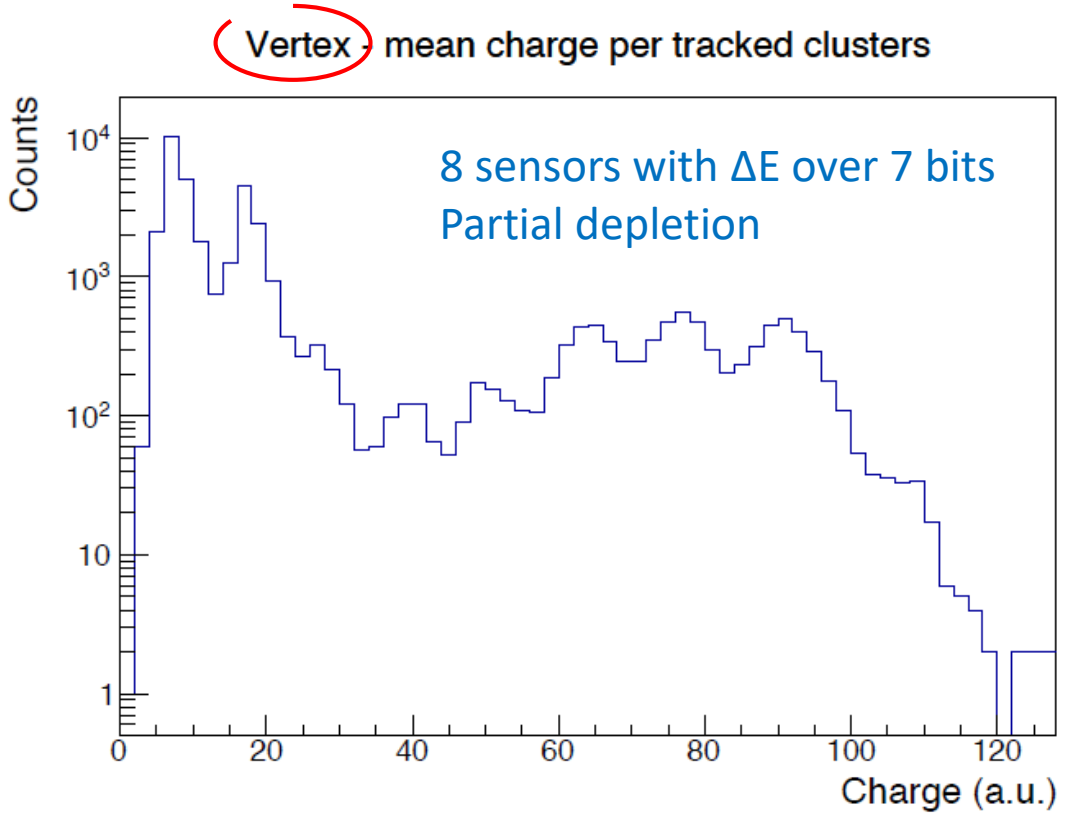
Identification of low Z fragments (1-8)?

- Produced in ^{18}O + ^{12}C @ 200 MeV/u
- Set-up =
  - 4-8 stations of thinned (20 m) pixel sensors (VTX)
  - Time Of Flight from plastic scintillator σ ~ 60 ps
- Simulation by Christian Finck @ IPHC

Assumptions

- Sensing layer partially to fully depleted
- Charge spread model tuned from previous sensors
- ΔE digitisation from simulation of TIIMM-0 prototype
- Average ΔE over all pixel sensors





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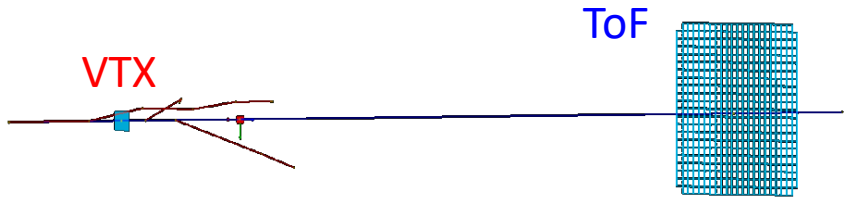
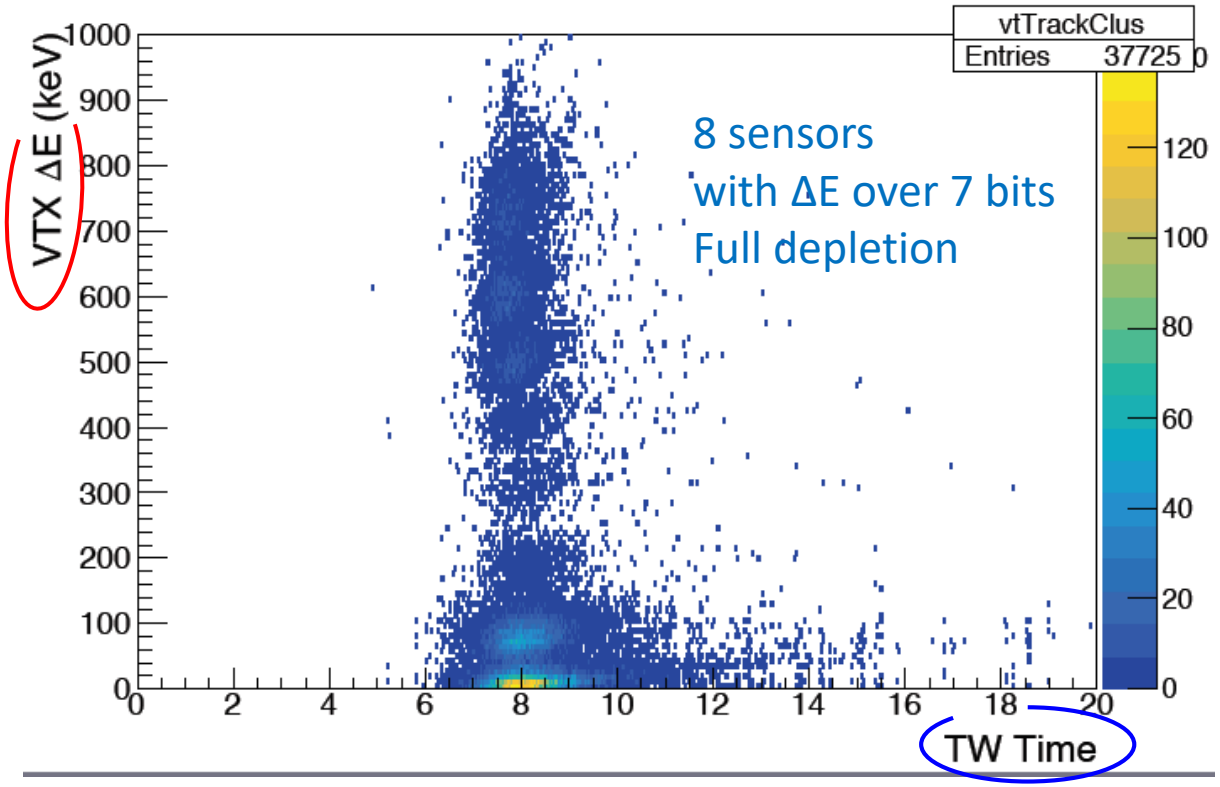
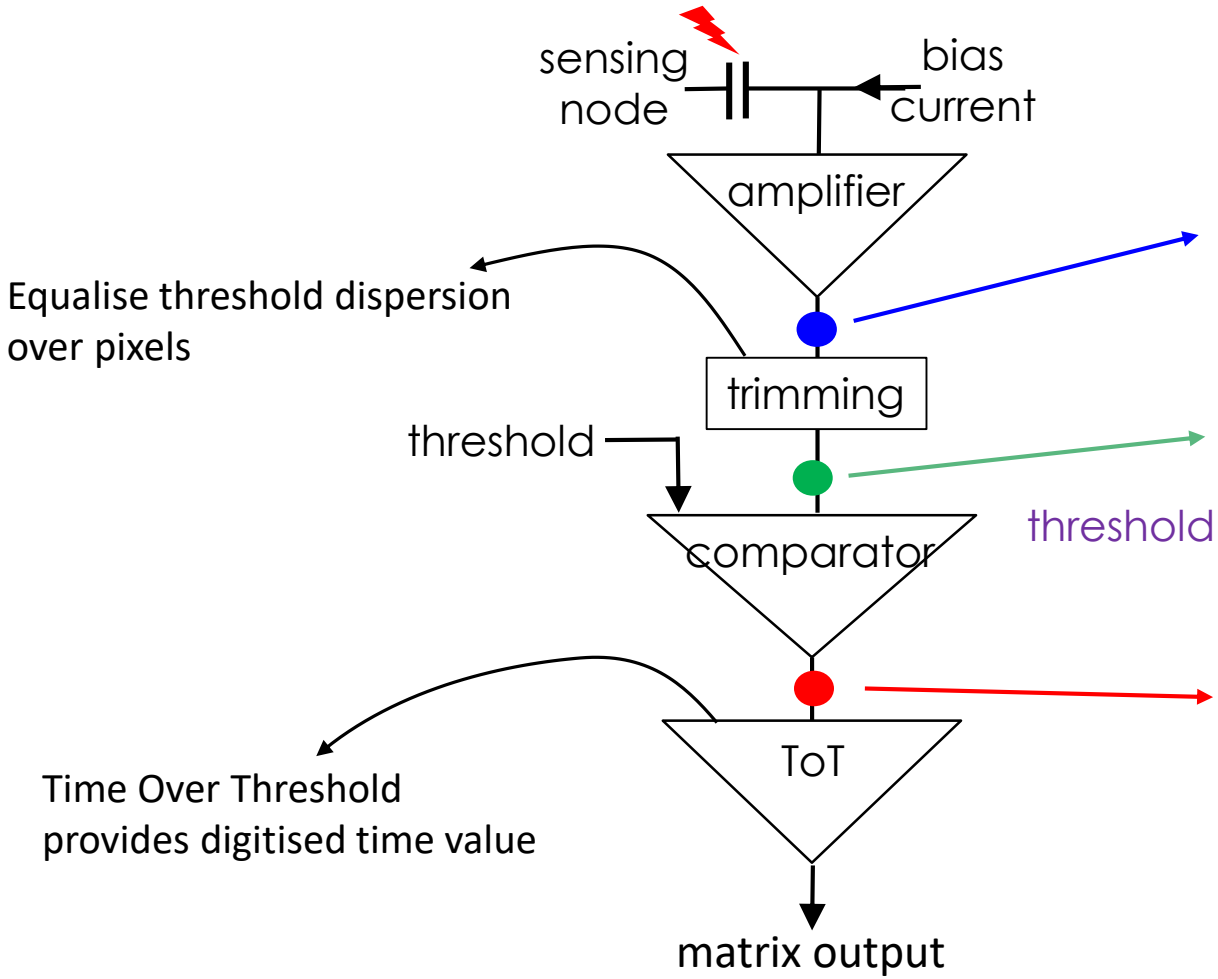
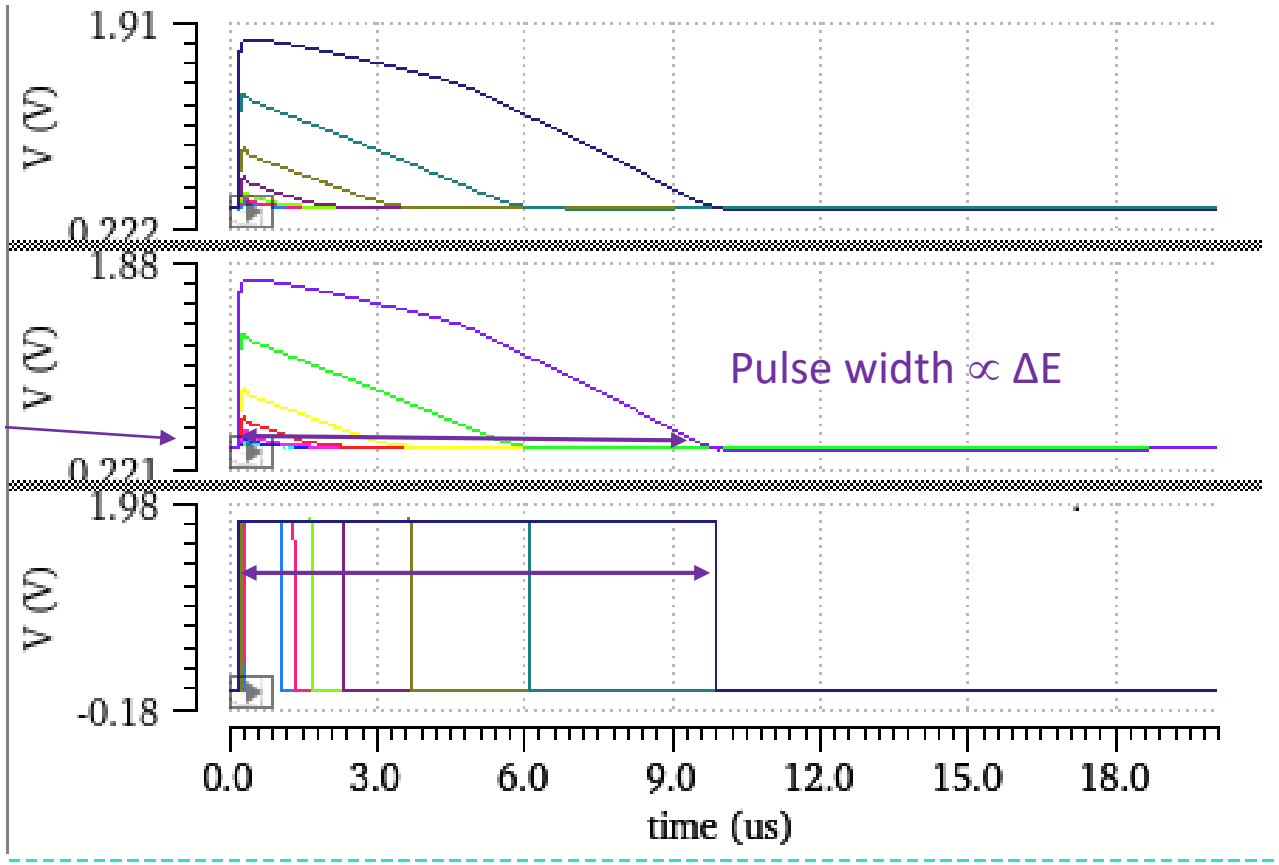




Pixel concept





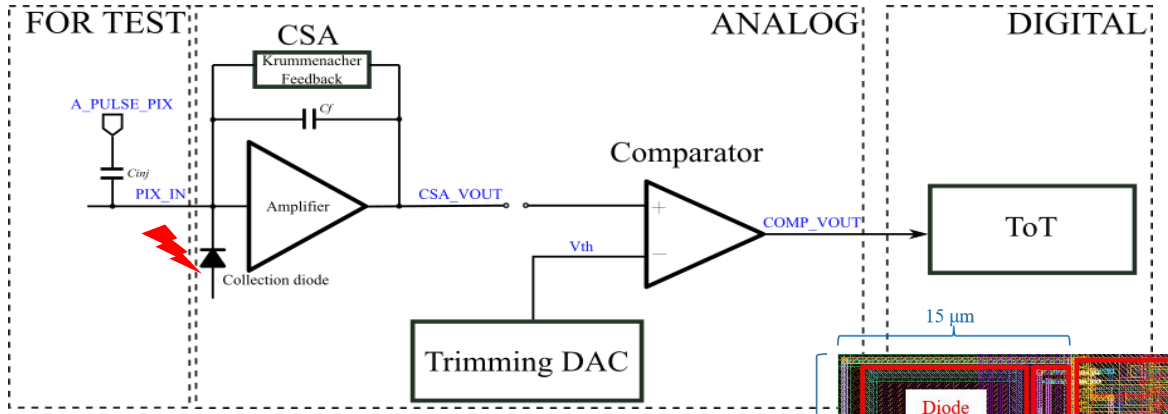
First prototype TIIMM-0

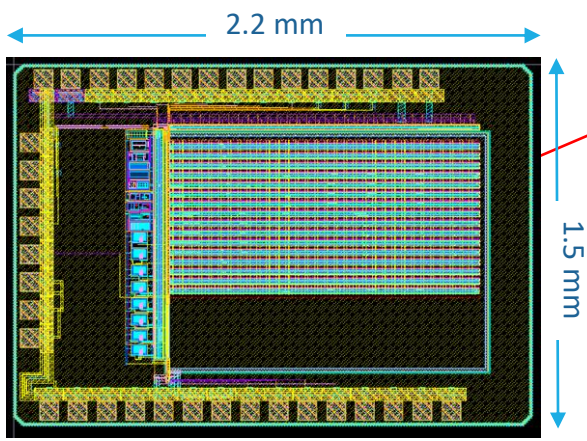
Features

- Pixel pitch 40 µm
- Matrix: 32 rows x 16 columns
- ToT output over 6 bits
  - +1 column with analogue out
- Trimming DAC with 4 bits

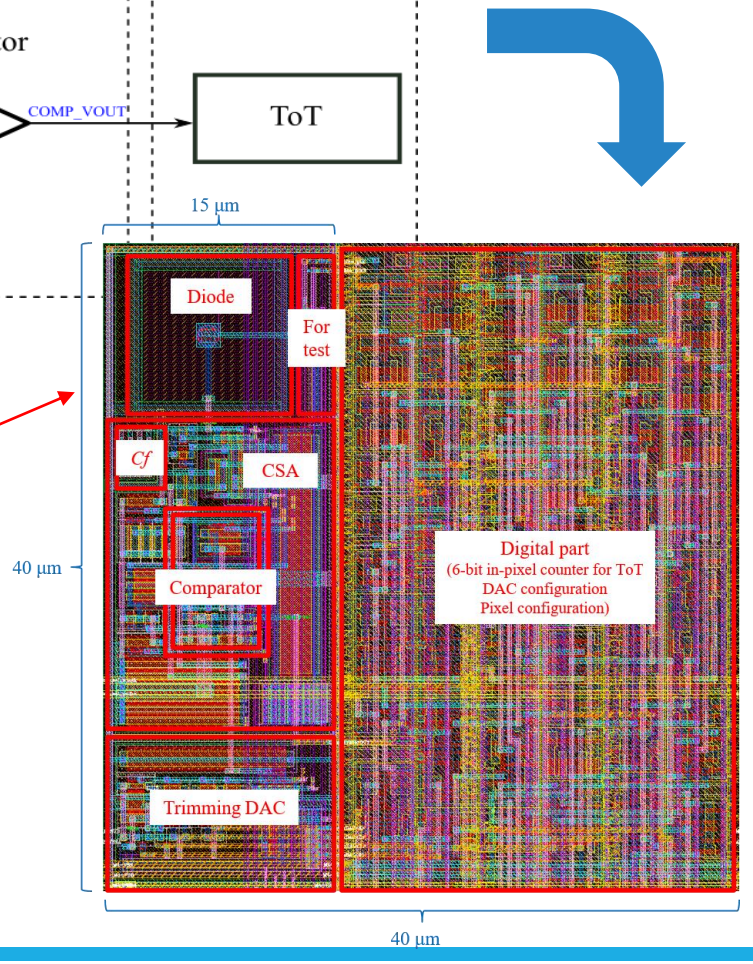
Design & Fabrication

- Maciej KACHEL & Weiping REN @ IPHC
- Submitted March 2020
- 180 nm technology
- 4 sensing layer variants
  - Thickness ~ 20 µm, from partial to full depletion
- Back from foundry July 2020





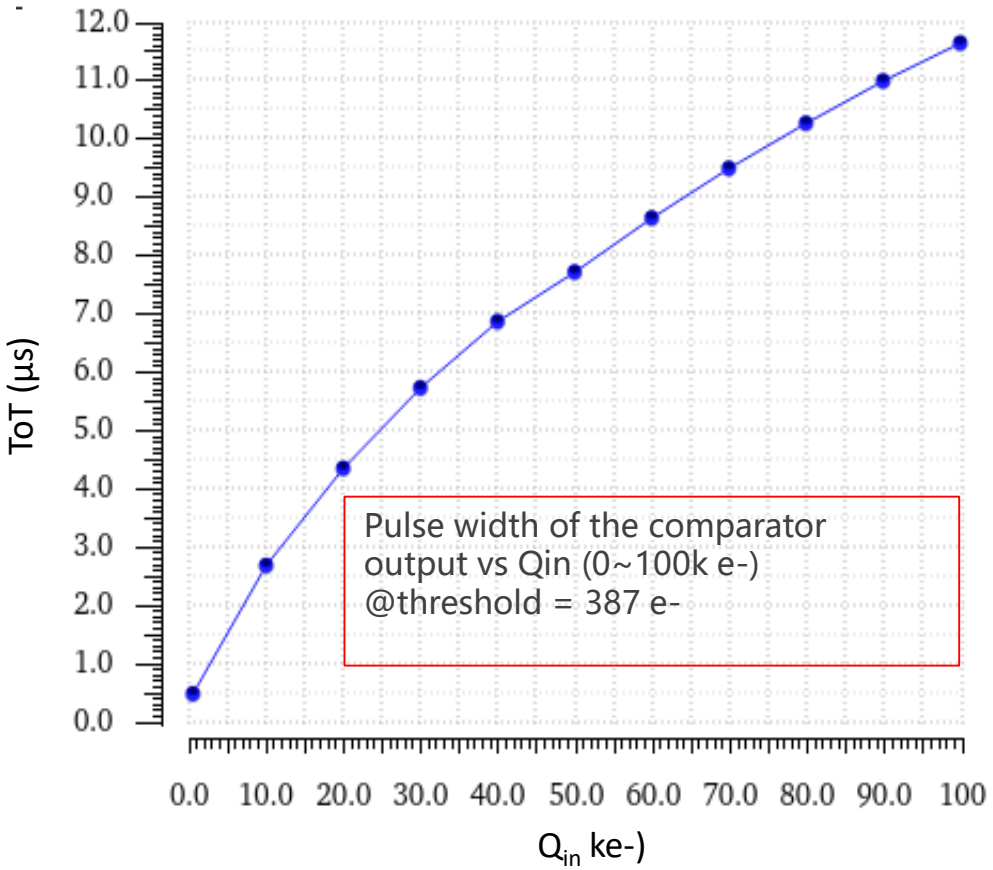
TIIMM-0 sensor layout



First prototype TIIMM-0

Expectations (from circuit simulation)

- Known overshoot (limited) issue of CSA
- Equivalent Noise Charge ~ 42 e-
- Comparator offset stdev sizeable
  but within trimming trimming-DAC range
- Non-linearity for Qin > 6 ke- (ΔE for few MIPs)
- But still useful relation Qin – Time Over Threshold ⇒



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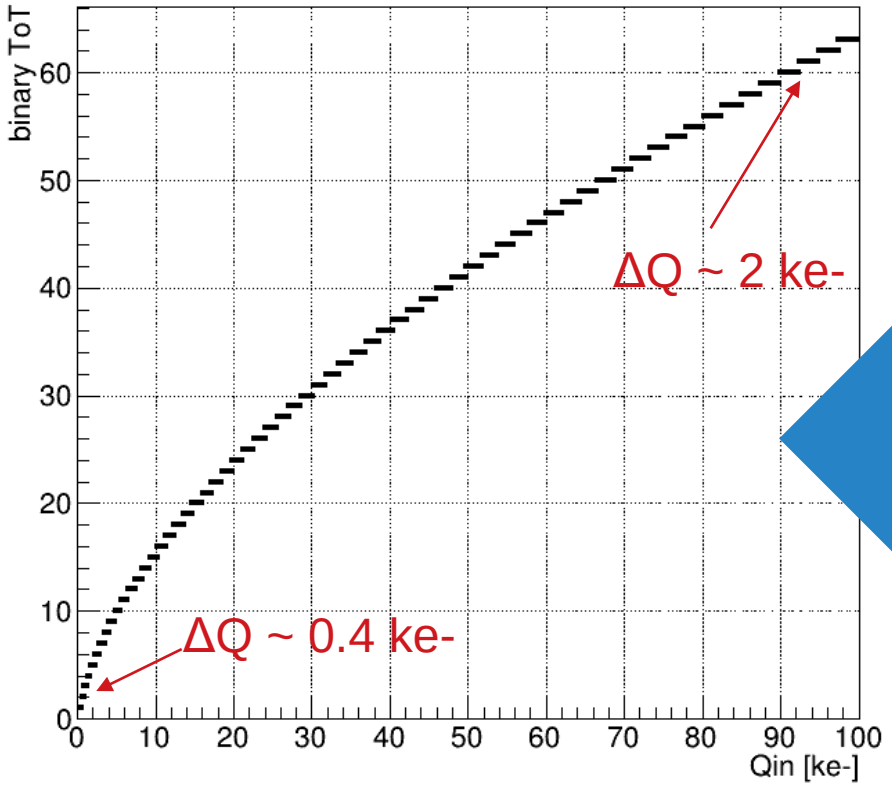
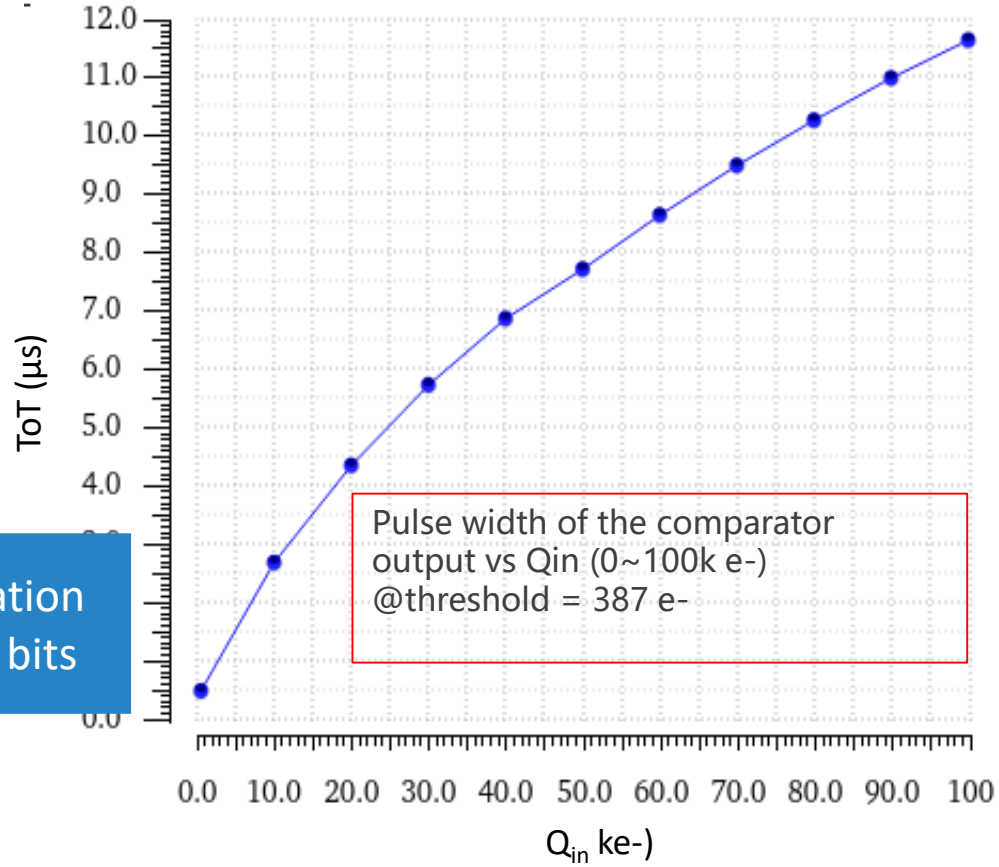


Digitisation over 6 bits



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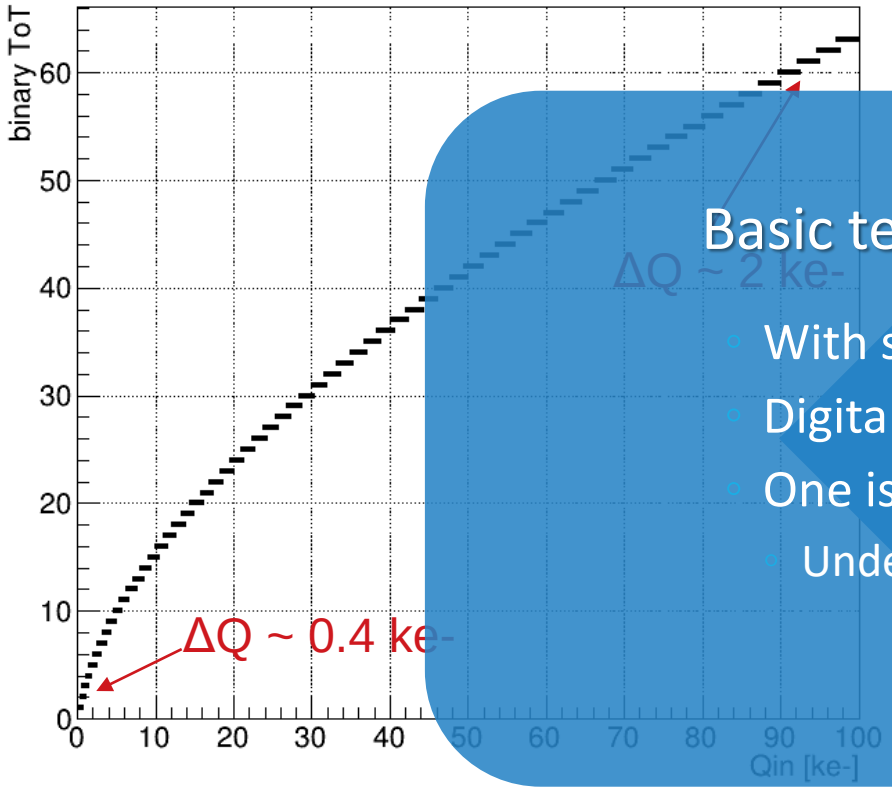
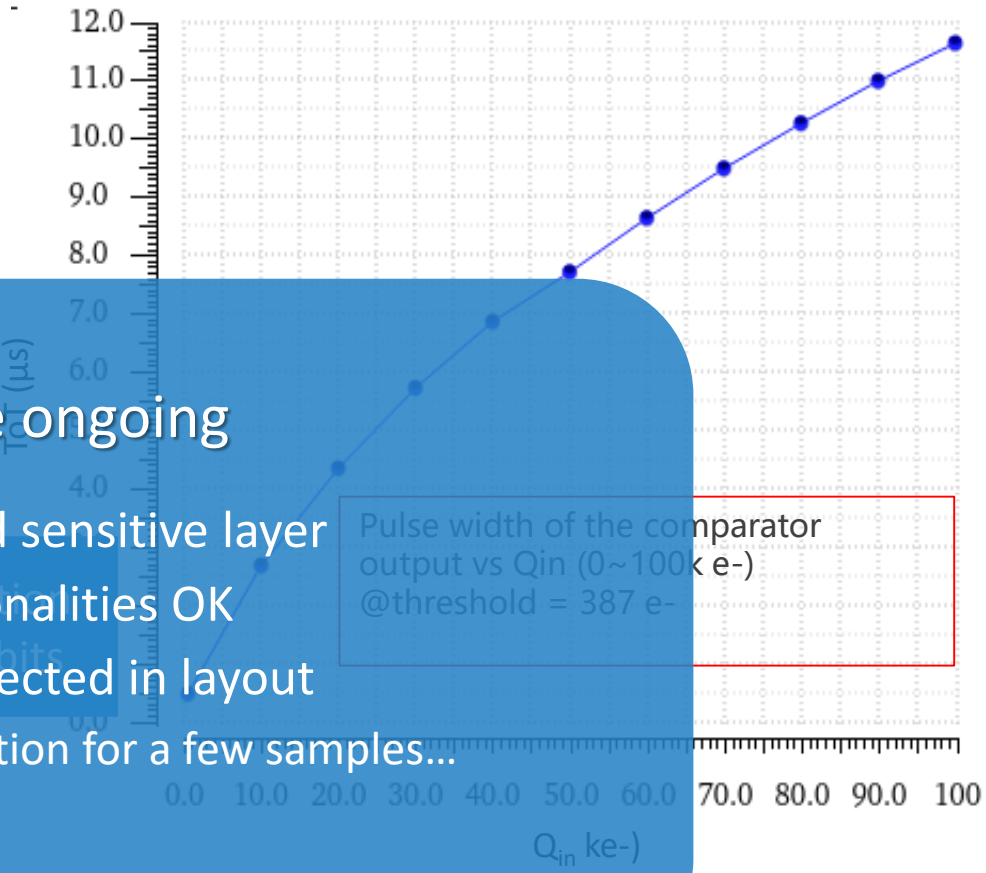




Basic tests are ongoing

- With standard sensitive layer
- Digital functionalities OK
- One issue detected in layout
  - Under correction for a few samples…

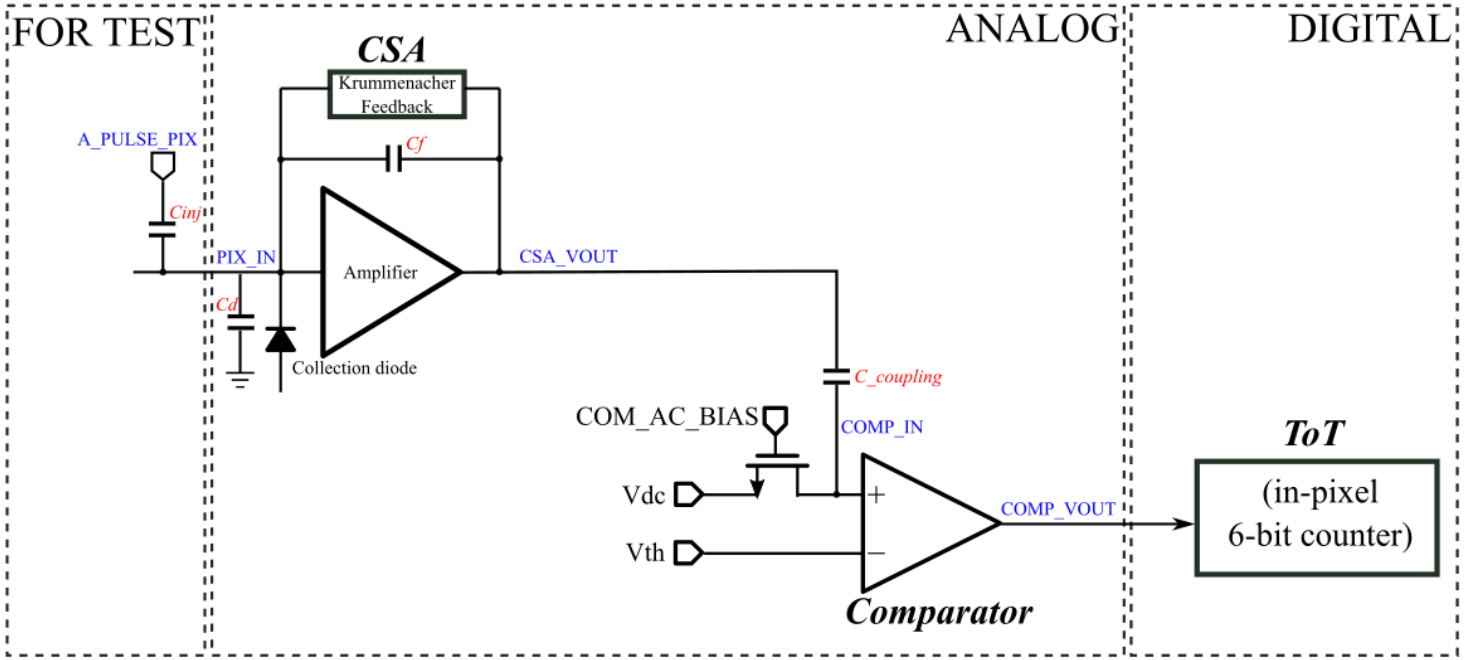
Second prototype TIIMM-1

Strategy

- Keep TIIMM-0 overall structure
  - same size & communication protocol
- Basic plan = keep same digital part

Current work = analogue optimisation

- Mitigate CSA overshoot
- Better offset compensation
  - Stdev decreased 15 mV ↘ 2 µV
- New balance between noise & dynamic
  - ENC 42 e- ↗ 52 e-
  - Extended pulse width duration



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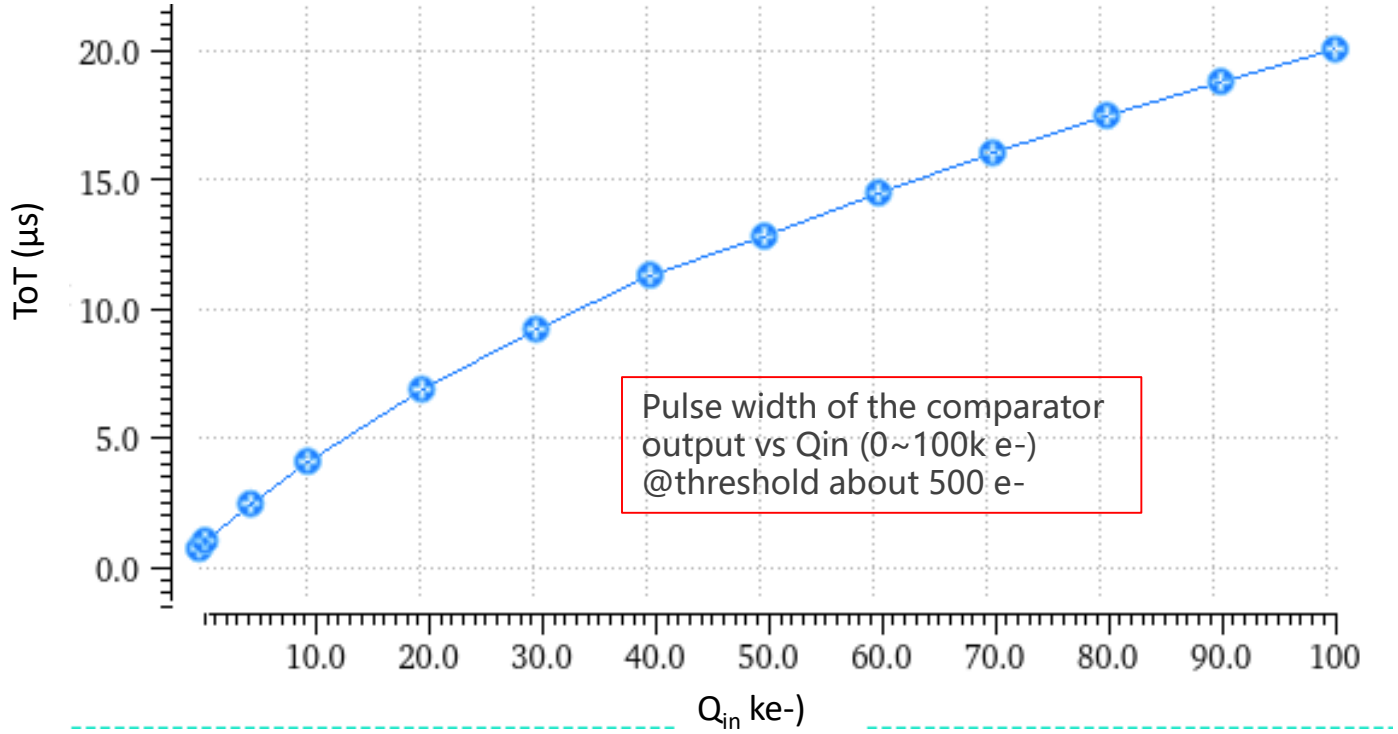

Summary / Outlooks

Project on time / sensor design

- First prototype fabricated & currently on test
- Second prototype well on track
  - Still need test outcome to be finalized

More difficult with testing due to pandemic situation

- Lab test more or less OK
- Beam tests not easy to plan …

Simulation activities / tracking & identification

- Excellent early start
- Need test results for further developments