Context of the TIIMM+Monopix=TIIX project

Jerome

Genesis of TIIMM

- <u>Tracking and Ion Identification with Minimal Material budget</u>

TIIMM target $=$

Precision tracking
$\sigma_{pos.} \leq 10\ \mu m$

$+$

Low material budget $<< \% X_0$

$+$

Energy loss measurement
$1\text{-}10^3$ MIPs

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
  ∘ With <u>binary output</u> sensor
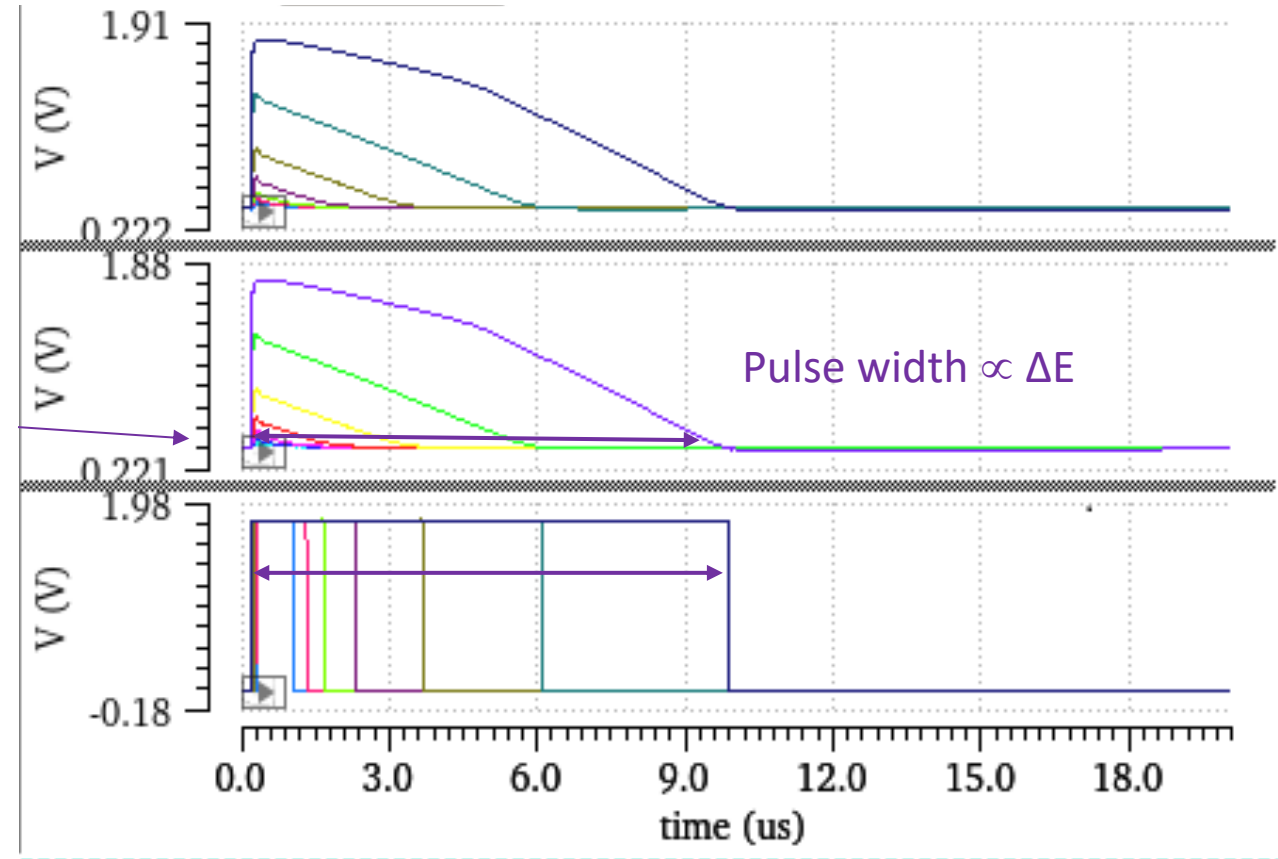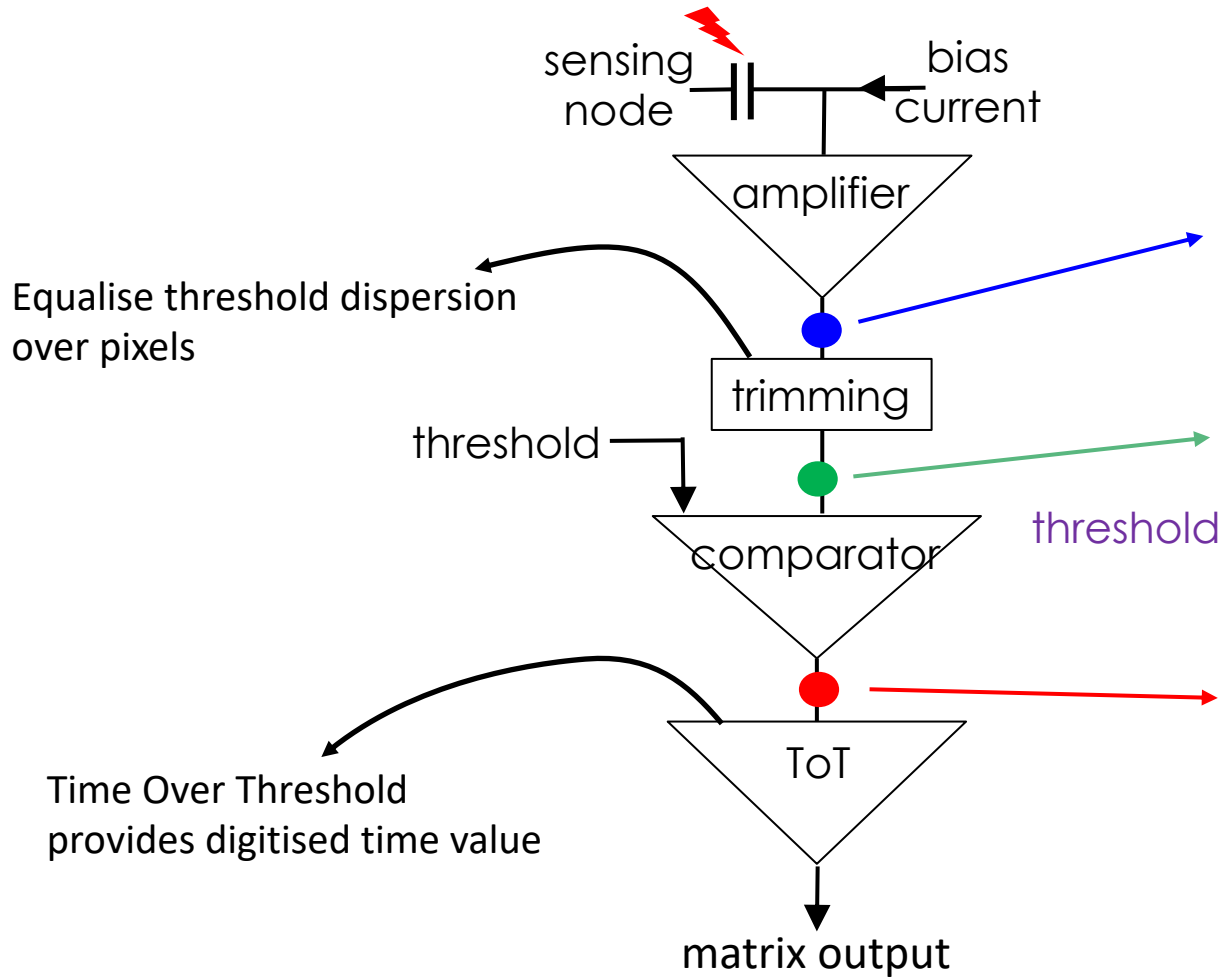 ∘ Indirect estimation of ΔE

The TIIMM project

- A Joint Research Action (WP27) from the STRONG EU-infraia project
  - June 2019 – June 2023 (6 months extension under discussion)
  - Project leader: Eleuterio Spiriti INFN-Frascati

- Goal
  - Demonstrate feasibility of an **in-pixel front-end** for~40µm pixel with large input dynamic 1:10^5

- Deliverables
  - Only reports

- Partners
  - INFN Frascati: Eleuterio, Luca (2021-22)
  - CNRS IPHC: **Maciek, Rachid, Luca**(2022-), Weiping Ren (PhD finished in 2022), Jérôme
  - GSI Biophysik:

- Timeline
  - 1st submission 2020 → TIIMM-0
    - Only electrical measurements
  - 2nd submission 2022 → TIIMM-0bis , TIIMM1 , TIIMM-1A , TIIMM-1B
    - **Current electrical tests => goal is reached**
    - Next come in-beam measurements

- Budget for submissions
  - 60 k€ already used
  - **40 k€ still for a new submission**

Pixel concept

sensing node

bias current

amplifier

Equalise threshold dispersion over pixels

trimming

threshold

comparator

threshold

Pulse width $\propto \Delta E$

ToT

Time Over Threshold provides digitised time value

matrix output

Next step ?

- Current matrix readout logic suited for small matrix (32x24 pixels) => not scalable !
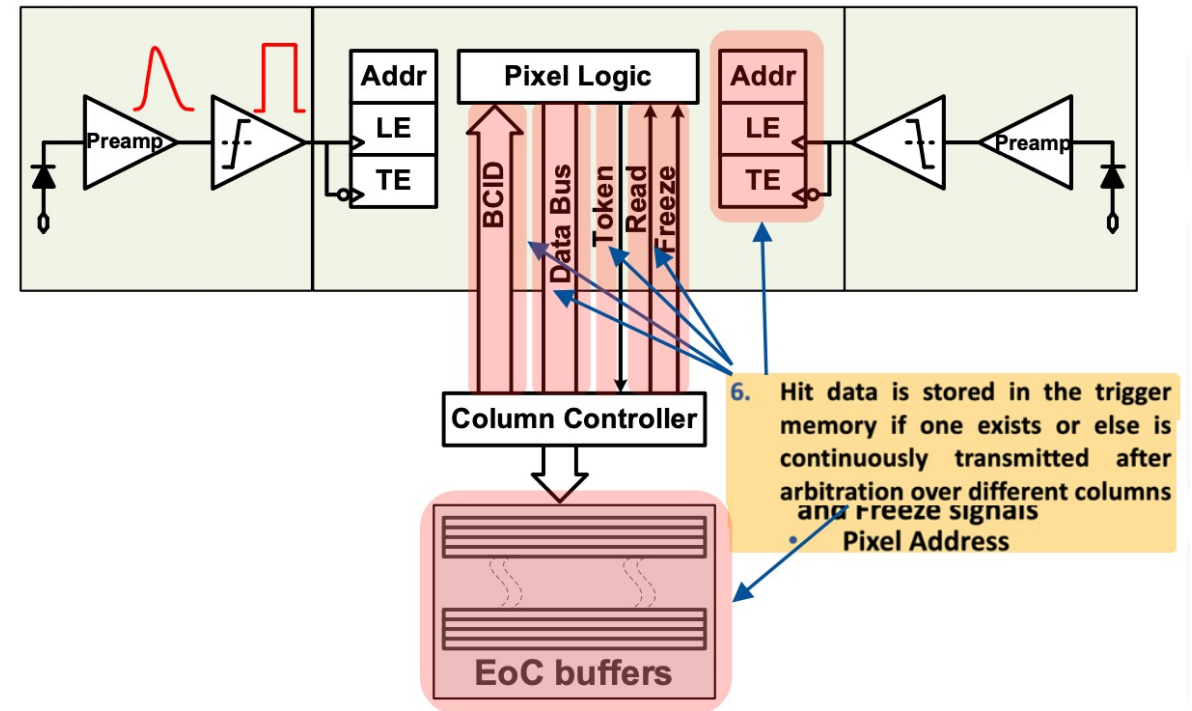
■ <u>Candidate architecture = column-drain read-out</u>

- Developed for ATLAS hybrid pixel (FE-I3):
  - 25 ns frequency,
  - Pulse leading & trailing edges stored over ~7 bits = ToT
  - Scalable
- Implemented in MAPS prototypes for ATLAS-ITK
  - TJ-Monopix1 (2019) & TJ-Monopix2 (2021)
  - Main partners: Uni.Bonn + CERN
- Re-used in MAPS for Belle II = OBELIX
  - IPHC + CPPM + HEPHY + Uni.Bonn + IFIC

■ <u>TIIMM + TJ-Monopix = TIIX</u>

- TIIX-0 goal = small but fully scalable digital matrix
- TIIX-0 dimension = anything matching the goal
- To be discussed: simple serialisation in periphery
  - There is no constraint on hit-rate

Synchronous readout => time stamping in matrix

6. Hit data is stored in the trigger memory if one exists or else is continuously transmitted after arbitration over different columns and Freeze signals
- Pixel Address

Process & Submission opportunities

- **Tower Jazz 180 nm**
  - Well known at IPHC, used for TIIMM & OBELIX
  - Currently best established MAPS process: ALPIDE (ITS-2), MIMOSIS (CBM), OBELIX(Belle II), MALTA/Monopix (ATLAS)
  - Good link with next process: TPSCo 65 nm

- **Options**
  - QUARTPIC-2 ER organised by C4Pi in 2023
    - Summer?

  - TJ MPW in 2024
    - May, August, November

The figure shows a treemap-style diagram with the following blocks:

- C4PI R&D (2,6 x 2 mm²)
- C4PI R&D (2,6 x 2 mm²)
- USTC (5,4 x 3,15) mm²
  Price 1: 6,8 k€
  Price 2: 50 k€
  USTC 15 k€
- C4PI R&D (5,4 x 3,15) mm²
- C4PI R&D (5,4 x 3,15) mm²
- C4PI R&D (5,4 x 3,15) mm²
- Projet 1 (7,5 x 10,4 mm²)
  Price 1: 31,2 k€
  Price 2: 156 k€
  30 k€?
- Projet 2 (8,8 x 10,4 mm²)
  Price 1: 36,6 k€
  Price 2: 183 k€
  40 k€?
- IHEP (15 x 20 mm²)
  Price 1: 300 mm² x 400 €/mm² = 120 k€
  Price 2: 300 mm² x 2000 €/mm² = 600 k€
  IHEP has 150 k€
- PICMIC2 (16,4 x 15 mm²)
  Price 1: 246 mm² x 400 €/mm² = 98,4 k€
  Price 2: 246 mm² x 2000 €/mm² = 492 k€
  Imad has 70 k€

Proposal to IP2I

- Ultimate mid-term objective: design together state-of-the-art MAPS for FCCee
  - Most probably in TPSCo 65 nm process and within a large collaboration under ECFA roadmap implementation

- Current short-term prospect
  - TPSCo 65 nm will not be widely open (outside ALICE-ITS3) before…2024?
  - => need intermediate goal useful to learn

Let's design TIIX-0 together!

- IPHC provides in-pixel front-end + expertise on digital-on-top design
- IP2I implements in-pixel digital logic

Benefits

- Well controlled project:
  - limited duration, budget granted
- Excellent for learning:
  - all aspects of pixel matrix & proper design technique
- Not directly matching FCCee requirement BUT
  - solution to transmit timing information through matrix, there are very few other proposals
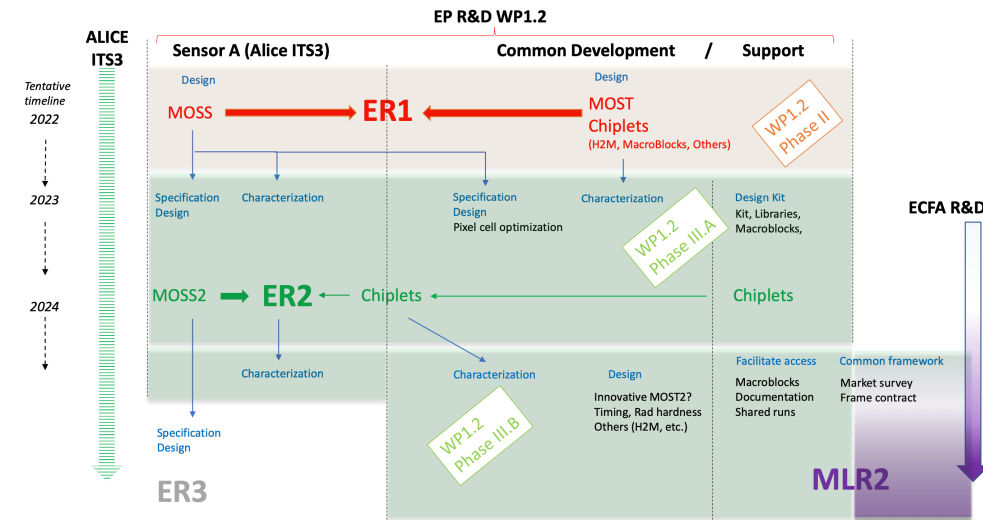
Needed discussion

- Technical details (←the devil is here!)
- Task sharing
- Milestones