IPHC-Strasbourg Group in CREMLINplus

M.Winter / ex IPHC-Strasbourg, 4 Septembre 2020

- **IPHC $\equiv$ one out of $\sim$ 20 subatomic physics laboratories**

  belonging to IN2P3/CNRS

- **IPHC-Group: activity driven by future electron-positron collider**

  experiments (e.g. ILC/Japan)

- **IPHC-Group track: pionnered CMOS Pixel Sensors (CPS)**

  for subatomic physics

CREMLIN P LUS
Connecting Russian and European Measures
for Large-scale Research Infrastructures

# IPHC-Strasbourg Group in CREMLINplus

- **PERSONNEL CONCERNED:**

  - **Particle Physicists:** 3 staff physicists, 1 staff instrumentation physicist, 2 post-docs

  - **ASIC designers (6 PhD):** 10 staff engineers, 2 PhD students

  - **Electronicians :** 4 staff engineers

  - **Technical support from IPHC services:** micro-technics & mechanics workshops
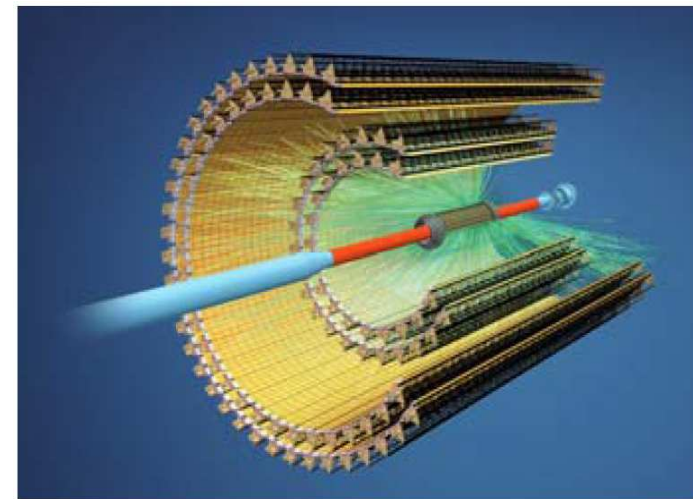
- **MAIN ACTIVITIES:**

  - **Activities mainly instrumental, targetting future e+e- colliders:** (supported by phys. studies)

    ↪ R&D on highly granular and thin CMOS pixel sensors (+ 2-sided ladders):

    design, electronic tests, characterisation, detection performance evaluation

    ↪ full prototyping until final production

  - **Domains of application: predominently subatomic physics and some spin-off domains**

    ↪ exploiting synergy between tracking devices for heavy-ion and lepton-collider expts
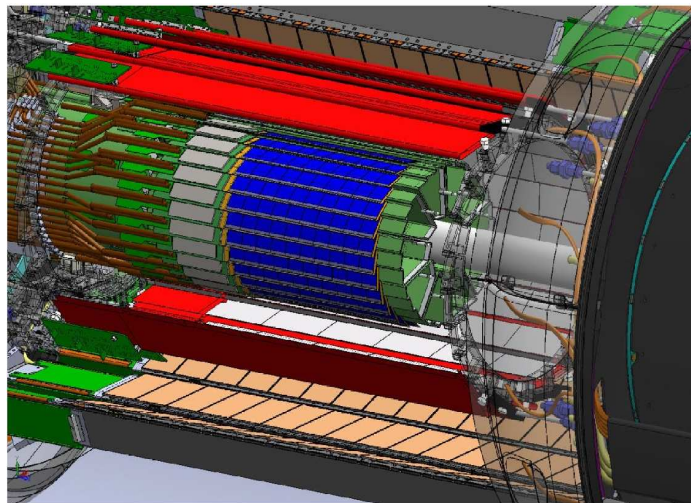
Emblematic Devices Equipped with CPS
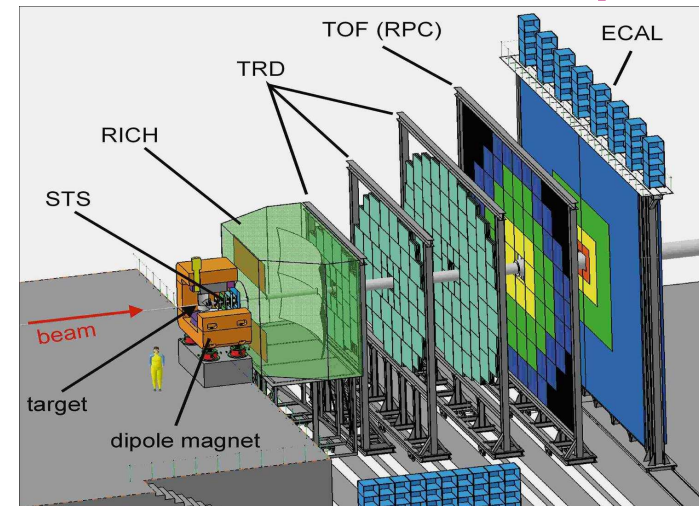
EUDET BT: running since 2009
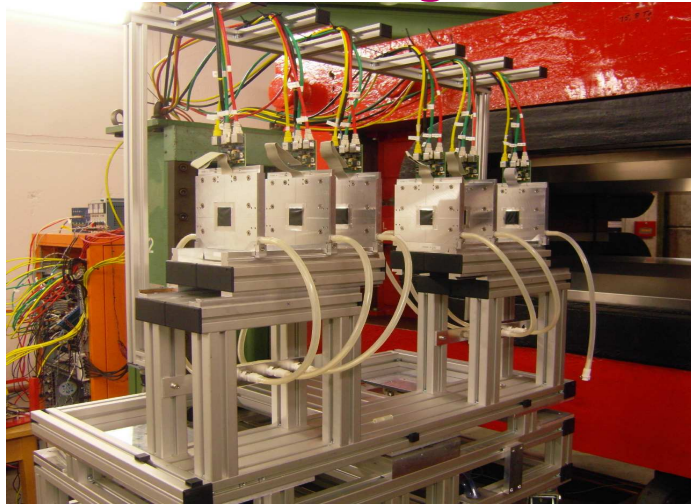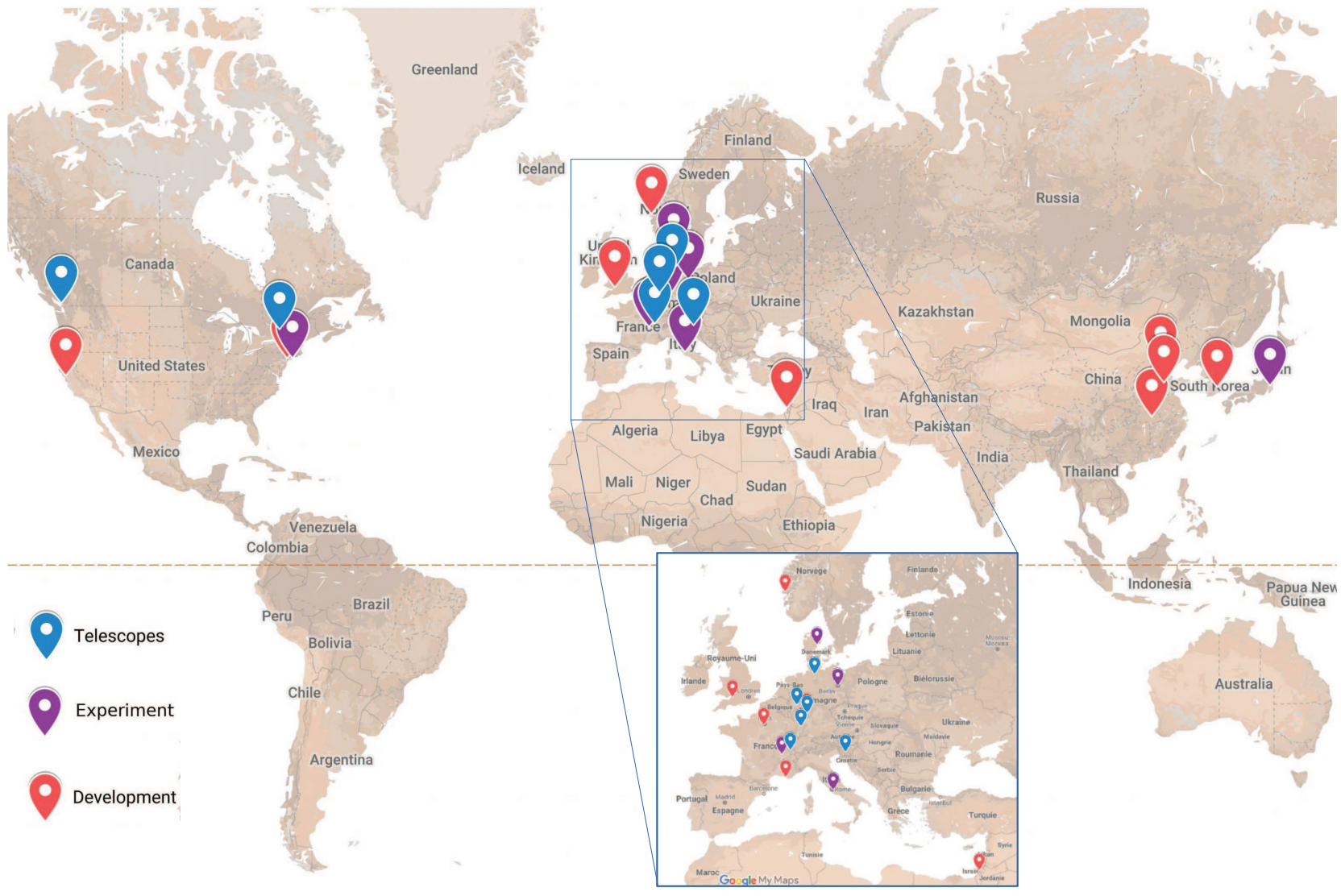
ALICE-ITS2: in construction

STAR-PXL: Physics 2014 $\longmapsto$ 2016

CBM-MVD: under development

Telescopes

Experiment

Development

Activities Foreseen within CREMLINplus

- **Development of the CMOS Pixel Sensor (MIMOSIS) for the CBM-MVD at FAIR:**

  - MIMOSIS-1 expected to be available within consortium $\lesssim$ Q4/'21

  - MIMOSIS-2 expected to be available within consortium $\lesssim$ Q4/'22 (?)

- **Development of CPS for an expt at the International Linear Collider (ILC):**

  - Main objective: vertex detector and inner trackers composed of double-sided layers

  - R&D goals: squeeze time resol. & power consumption while keeping achieved spatial resol. (few μm)

  - Starting point: improve time resolution of MIMOSIS

- **Explore newly available products of CMOS industry:**

  - Exploit stitching possibilities (multireticle sensors) within ALICE-ITS3 project (tbc)

  - Develop CPS in 65 nm CMOS technology within CERN-ALICE R&D project

- **Develop ultra-light double-sided ladder equipped with MIMOSIS:**

  - Follow-up of PLUME ladder concept (2x6 MIMOSIS-26 sensors)

  - ?????????????

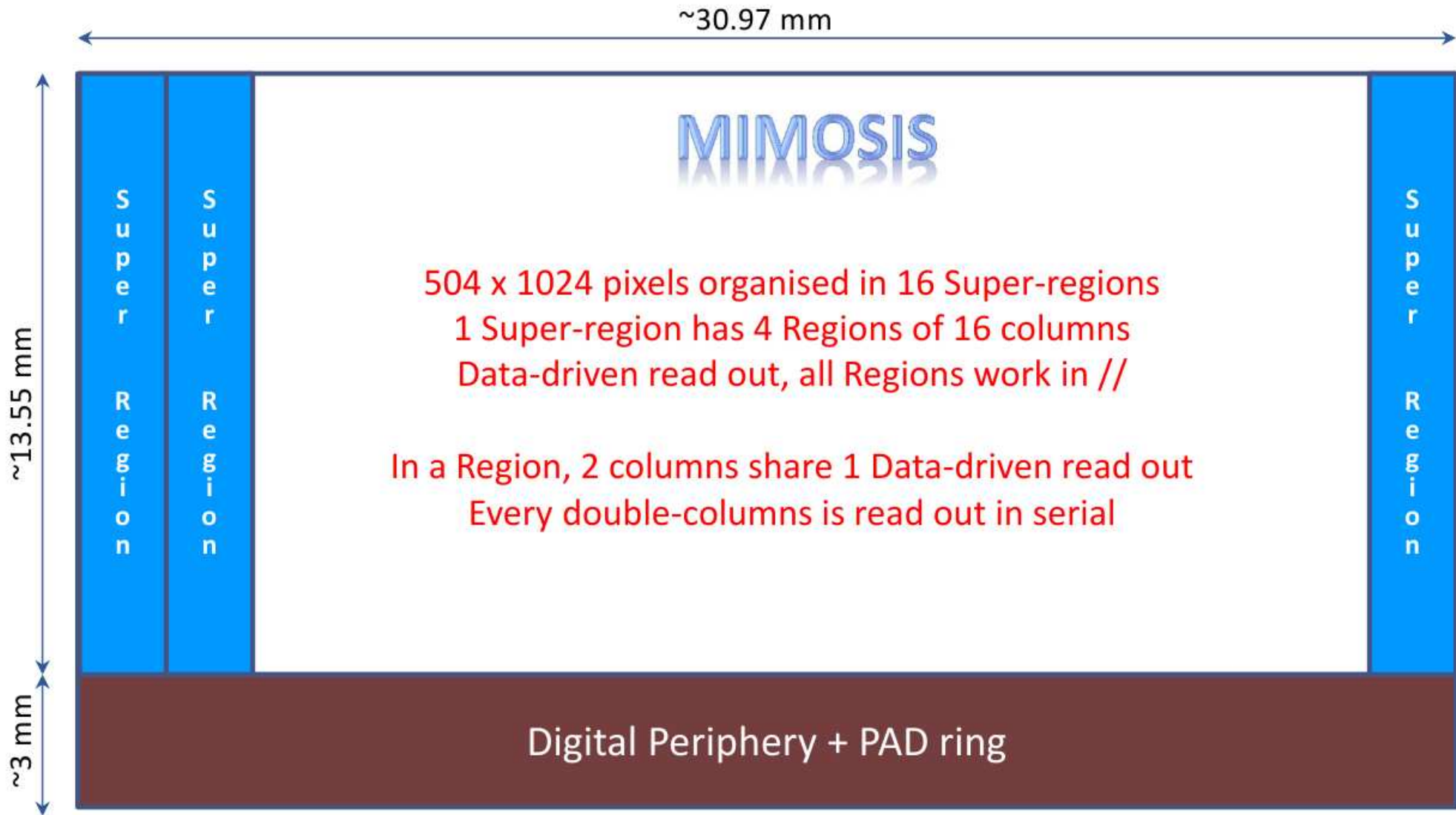- **Others:** CPS in CMOS-SoI, 2-tier CPS, ...

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CPS Design Required for the MVD: MIMOSIS Sensor

- **MIMOSIS derived from ALPIDE pixel array read-out architecture (ITS, MFT)**

- **Required radiation tolerance significantly higher than ALPIDE**

    ($\gtrsim$ 10 times higher locally)

- **Required data throughput $\sim$ 10 times higher than ALPIDE**

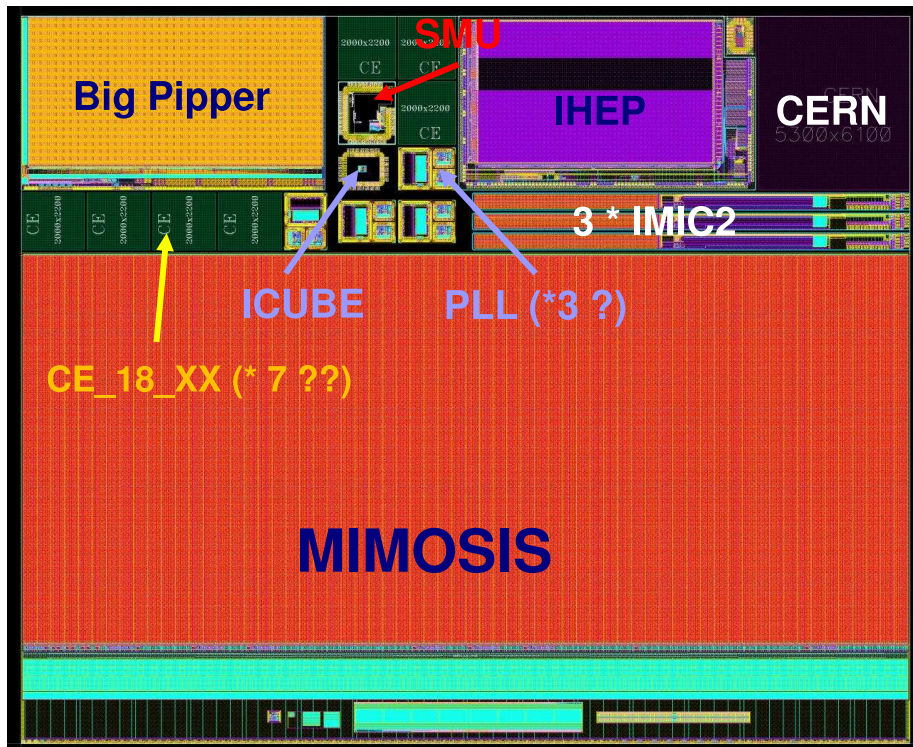   *(hit density actually up to $\sim 10^2$ times higher locally)*

	ITS (IB)	CBM (1st station)
Radiation Load TID	~270 krad	3 Mrad @ -20°C, 1 Mrad @ +30°C
Radiation Load NIEL	~1,7x10^{12} 1MeV n_{eq}/cm²	3x10^{13} n_{eq}/cm² @-20°C, 1x10^{13} n_{eq}/cm² @+30°C
Peak hit rate	~1,25x10^6/cm²/s → 1,25x10^4/mm²/s	7x10^5/mm²/s (x 56 times than ITS)
Trigger	yes	no
Heavy Ion Effect		

- **Fully revisited digital circuitry (data sparsification & transfer logic)**

MIMOSIS Overview

~30.97 mm

~13.55 mm

~3 mm

Super Region | **Super Region** | **Super Region**

MIMOSIS

504 x 1024 pixels organised in 16 Super-regions
1 Super-region has 4 Regions of 16 columns
Data-driven read out, all Regions work in //

In a Region, 2 columns share 1 Data-driven read out
Every double-columns is read out in serial

Digital Periphery + PAD ring

- Dimensions :
  X = 31 100.16 µm
  Y = 25 500 µm

- Around 25 to 27 reticle / wafer

- For all chips, a first version have been provided by the collaboration

- Need to adjust the dicing plan

19/09/2019   gregory.bertolone@iphc.cnrs.fr
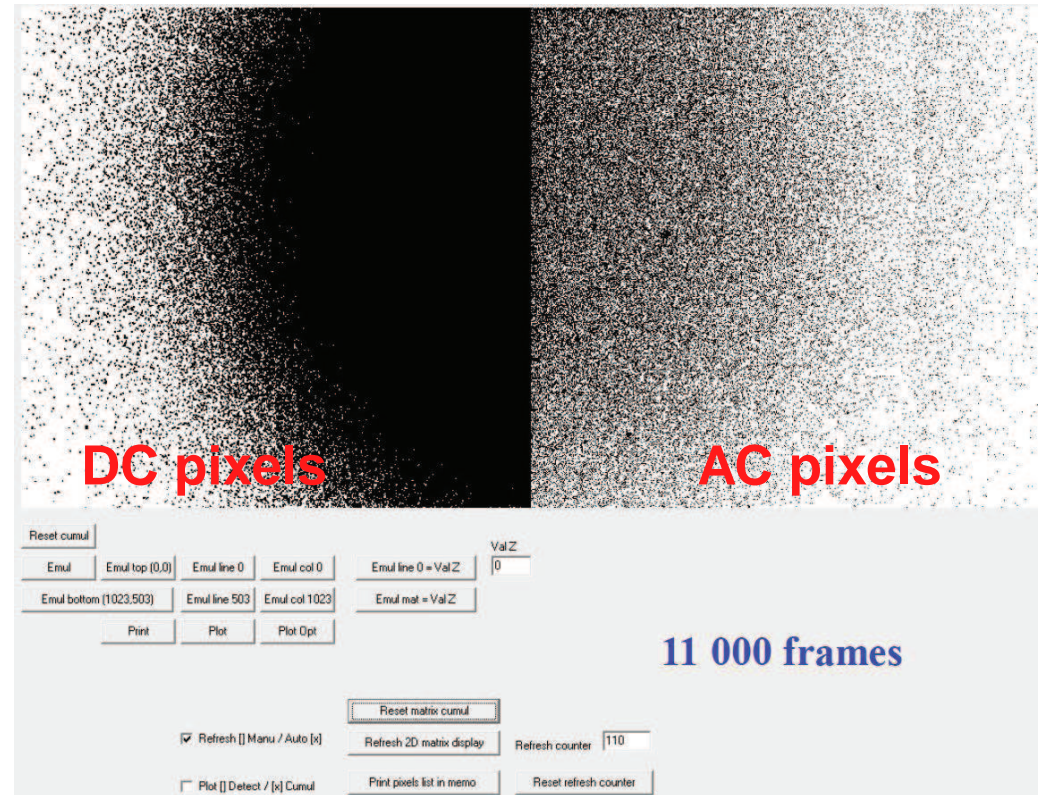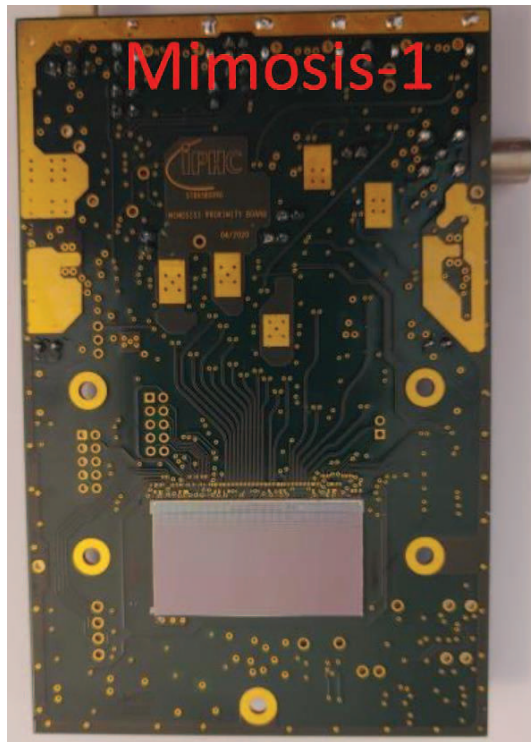
6 variants of epi-layer to achieve $T^Q_{coll} < 1$ **ns**

Partners of the submission besides IKF-GSI-IPHC:

- IHEP-Beijing: CEPC
- CERN: ATTRACT & LHC
- IMNC-Orsay: β imaging
- SMU-TX: PLL/MIMOSIS
- CPPM-Marseille: β imaging
- ICUBE-Strasbourg (CNRS): ultra-fast imaging

Back from foundry and diced in July 2020

First Functionnal Tests of MIMOSIS-1

- Reacts to I2C Slow Control commands, gets configured as expected

- Data flow properly acquired by DAQ and decoded (header, data information, trailer)

- Various hit pixel patterns generated, which get all faithfully encoded and read

- The whole pixel array reacts appropriately to ^{55}Fe source illumination

Exploration of TJsc 65 nm CMOS Technology

- Newly accessible 65 nm imaging CMOS technology via ALICE-ITS coll. and CERN-EP

- Submission for fabrication of exploratory structures & chips foreseen at "end of Septembre" (MLR-1)

- IPHC: small pixel arrays ($15\mu m$, $25\mu m$, possibly $20\mu m$, pitch; DC & AC); in-pixel VFE variants; analog DACs contributions to O(100) ps in-pixel amplification circuitry (AC/DC input node)

CE65 VARIANTS

IPHC
Institut Pluridisciplinaire
Hubert CURIEN
STRASBOURG

➢ Variant A
- pixel pitch: 15um
- matrix size: 64x32
- 3 sub-matrices: Amp (AC)/ Amp (DC)/SF (DC)
- provides space for DACs
  (fully separated from matrix)
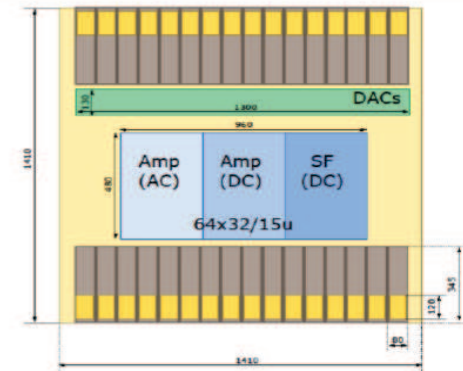
➢ Variant B
- pixel pitch: 25um
- matrix size: 32x32
- 2 sub-matrices: Amp (AC)/SF (DC)