**IMIC - Needle-Shaped Low-Power Monolithic Active Pixel Sensor for Molecular Neuroimaging on Awake and Freely Moving Rats**

**MAPSSIC PROJECT**

- **Motivation**
  - Neuroimaging on awake and freely moving animals
  - Localization of β+ radiotracers close to the pixelated sensor

- **Requirements**
  - **Sensor**
    - Small size
    - Immunity to the 511keV γ-rays background
    - Low power
  - **System**
    - Compact system → rat behavior not influenced

**IMIC SENSOR DESIGN**

- **Size:** 610 x 12000 µm² (Needle-shape)
- **Sensitive area** 16 x 128 pixels → 480 x 6400 µm²
- **Technology:** 0.18 µm CMOS process on Hi-resistivity 18 µm epitaxial layer

- **Pixel design**
  - Dissipated power for the sensitive region : 115 µW
  - Detection efficiency → small pitch - 30 x 50 µm²
  - Based on a front-end amplifier of ALPIDE (ALice Pixel DEtector) [5]
    - Low power (55 nW/pixel)
    - Asynchronous operation
    - Memory to store the binary information of the hit until the readout
    - Synchronization

- **Readout**
  - Column parallel rolling shutter readout
  - Serialization to the output (16 columns → 1 output)
  - Complete matrix readout in 128 µs
  - Output bandwidth fixed by integration time not hit rate
    - Bandwidth ~ 2048 pixels / integration time
  - Digital power over matrix ~ 1-3 µW averaged over the integration time
  - Chip configuration : SPI protocol to steer on-chip DACs → polarization of the front-end

**SENSOR VALIDATION**

- **Laboratory tests**
  - Power consumption of the whole sensor : 161 µW
  - On-chip DACs fully operational

- **Measurements with 90Sr source**
  - Integration time between 10 ms and 1 s
  - Room temperature operation
  - β source activity regulated with shield thickness

**Results translated to a mean activity in the matrix over 1000 frames vs the integration time**

**Detection performances**

- For long integration time (~1 s)
  - Dark count rate → 1.15 hits/matrix/s
- For short integration time (~< 20 ms)
  - Maximum activity ~ 80 000 hits/matrix/s
  - Dark count rate ~ 2.3 hits/matrix/s
- For expected activity (~< 100 hits/matrix/s)
  - No hit loss with long integration time (~1s)

**CONCLUSIONS**

- Specifications reached : Operational full-scale needle-shaped CMOS active pixel sensor
  - Low power dissipation for the whole probe : 161 µW
  - Suitable for the expected low activity

**REFERENCES**