I. MAPSSIC PROJECT

Motivation
- Neuroimaging on awake [1] and freely moving animals
- Localization of β−/γ-emitter clusters close to the pixelated sensor
- Implantiation of a pixelated needle-shaped sensor in the brain

Requirements
- Small size
- Limitation of the impact on the brain tissue
- Immunity to the 511 keV/γ-rays background
- Low power
- Limited heat dissipation
- Compact with wireless data transmission
- Autonomous
- Limitation of the discomfort that may alter normal behavior

II. IMIC SENSOR DESIGN

Strategy for low power dissipation
- Very low readout rate (~ Hz)
- Information of the hit stored in the pixel between two readouts

Pixel design
- Detection efficiency: Small pixel pitch: 30 x 50 µm
- Based on a front-end amplifier of ALPIDE (ALice Pixel DEctor) [5]
- Low power (55 nW/pixel)
- Asynchronous operation
- Memoryization (on 1 bit) of the information of the hit until the readout

Readout
- Column parallel rolling shutter readout
- Complete matrix readout in 128 µs
- Typical bandwidth: few kHz/s

Chip configuration: SPI protocol to steer on-chip DACs

III. BACK-TO-BACK INTEGRATION

Concept
- Two sensors back to back
- Robustness for manipulation and implantation
- Large two-sided sensitive area
- Easy connection between the sensors and the backpack containing the microcontroller with wireless transmission and the battery

Realization
- Diced and thinned sensors glued back to back
- Successful tests with individual sensors thinned to 150, 200, and 250 µm
- Total volume of the needle: 610 x 1200 x 580 µm

IV. SINGLE SENSOR VALIDATION

Laboratory tests
- Power consumption of the whole sensor: 161 µW
- Integrated DACs fully operating

Measurements with β− source (29Si)
- Integration time between 10 ms and 1 s
- Room temperature operation
- β source activity regulated with various shield thickness

Measurements with β+ emitter (18F)
- 18F: β− and γ emitter in aqueous solution
- Produced at the Cerny cyclotron (IPHC)

Detection performances
- For long integration time (~ 1 s)
  - Dark Count Rate = ~1.15 hits/matrix/s
  - For short integration time (~ 20 ms)
  - Max. activity = ~6 000 hits/matrix/s
  - Dark Count Rate = ~2.3 hits/matrix/s
- For expected activities (~ 100 hits/matrix/s)
  - No hit losses with longer integration times (~1 s)

Sensitivity to γ-rays
- γ source with low activity close to the sensor: majority of positrons measured
- γ source with high activity (~100 MBq) - 20 cm away from the sensor (head-localizer distance): γ-rays only
- The γ-ray contribution increases the mean #clusters/frame from positions by 3.5 % only
- The beta-gamma measurement with the two sources at a time is 300x higher than for gamma only
- IMIC is immune to 511 keV γ-rays

18F decay
- 6 hours - 3 periods
  - Starting activity = 24 MBq
  - Ending activity = 2.5 MBq
- Integration time: 500 µs
- Pickup for high activity (counting limited to 1 bit)
- Exponential decay measured at the expected operation activity

V. CONCLUSIONS & PERSPECTIVES

- Requirements reached:
  - Low power: 161 µW
  - Compatible to the awaited activities of the radiotracers
  - Immune to the 511 keV γ-rays

Outlook
- Tests of the double-sided probe
- System integration (backpack)
- Coating with biocompatible polymer (Parylene)
- In-situ experiments
- Tests and characterization of IMIC-LF: DMAPS version of IMIC (CPPM)

REFERENCES