Mini-report on status of medical physics projects with ALPIDE chip

PRIN 2022 - 2022LJT55R (Pixel Chamber)
PRIN PNRR 2022 - P2022XX7F7 (RGS probe)

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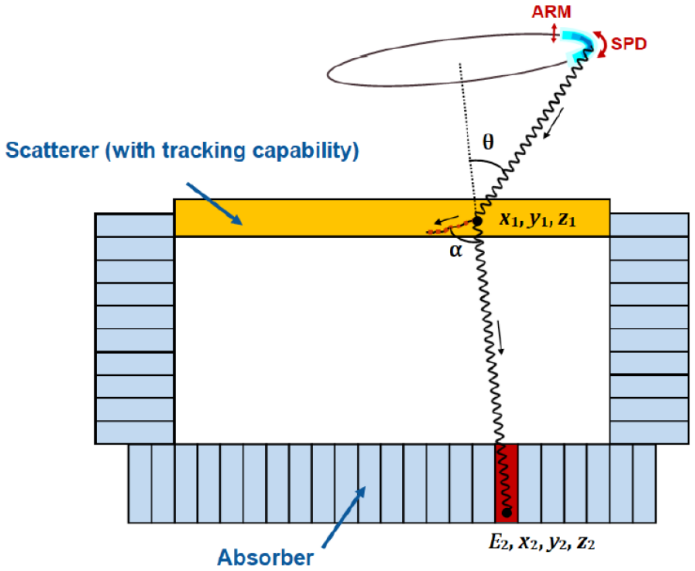
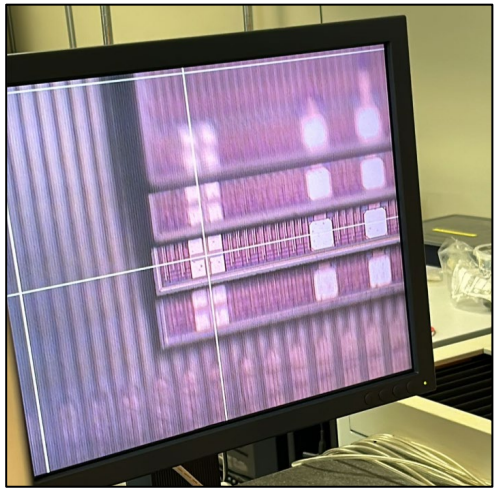
PIXEL CHAMBER – SCIENTIFIC GOALS

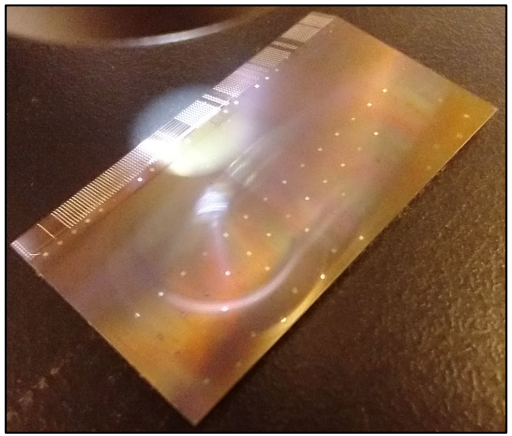
- Compton Chamber consists of two position- and energy-sensitive sub-detectors: scatterer and absorber
- A γ undergoes a Compton scattering in the first detector and is then absorbed in the second detector
  - Direction of the γ is not univocally determined (cone)
  - Many γ from the same source point are needed to reconstruct the source position
- New concept: use a Pixel Chamber as the scatterer
  - The Pixel Chamber is a stack of thin pixel detectors
  - It can determine the direction of the emitted electron
  - This can constrain the original direction using a single γ
- A first prototype of Pixel Chamber is proposed considering state-of-the-art monolithic active pixel sensors, the ALPIDE sensor developed for the ITS of the ALICE experiment at the CERN LHC

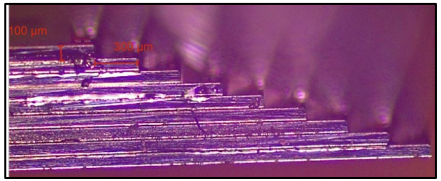


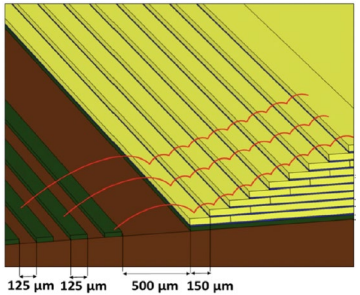
PIXEL CHAMBER – STATUS

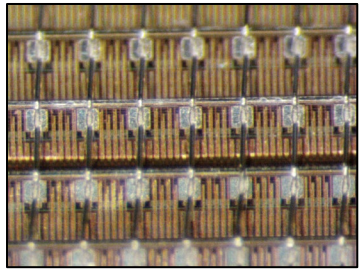
- **A9 (→ A8) prototyping**
  - Four mechanical assemblies, using (dummy) ALPIDE sensors, 100 µm thick
  - Sensors alignment by Mitutoyo, long curing time glue, relative sensor alignment ~5-10 µm
  - Wedge wire-bonding investigations: multiple welding without wire cutting (cascade bonding), loop shape, welding strength, welding failures
  - 150 µm shift among sensors not feasible, minimum distance being studied (hopefully < 500 µm)







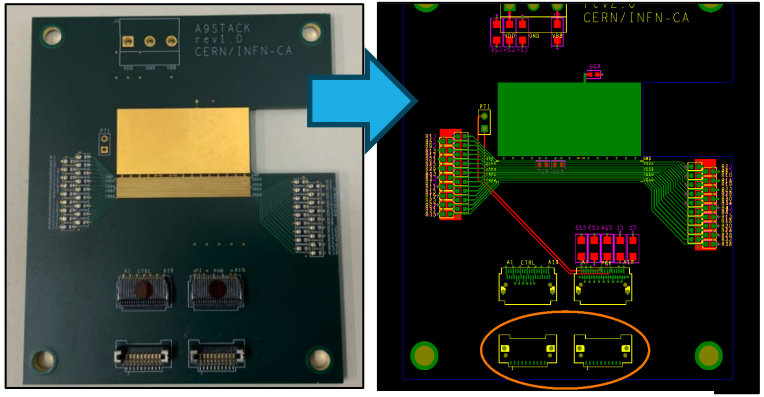


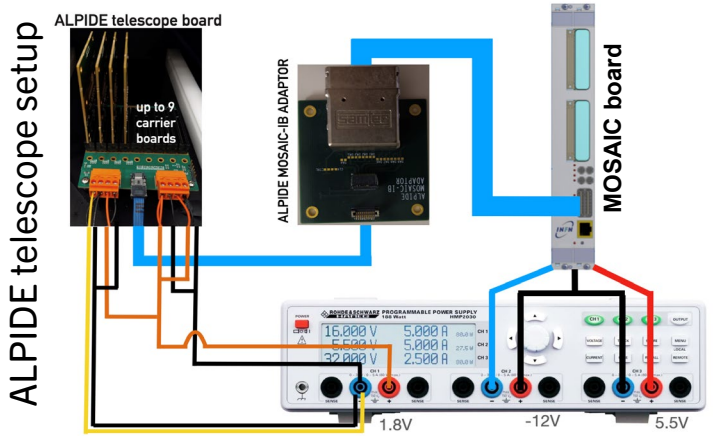


PIXEL CHAMBER – STATUS

- **Carrier board production**
  - Modified design of the original INFN Cagliari A9 carrier
  - A9 configured as OB stave, 1 master + slave chips
  - Independent power supply lines for each chip
  - Cascade bonding for serial lines: clock (x2) + slow control (x2) + master-slave 4-bit control (x4) + busy (1 line)
  - Production of 10-15 boards on PRIN funds is starting right now

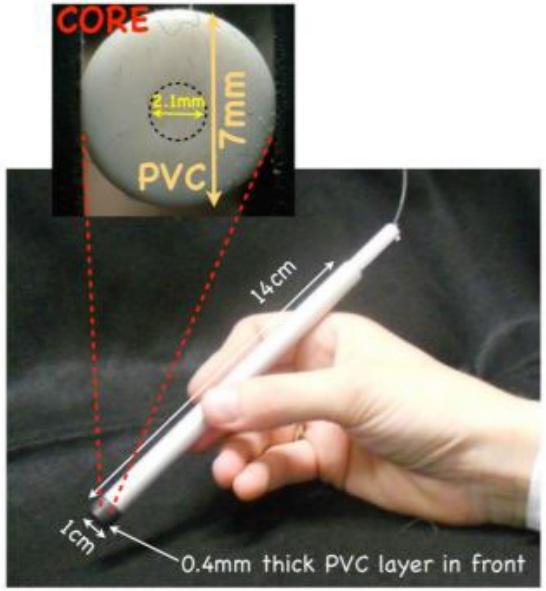
- **Readout software**
  - Readout to be performed via MOSAIC board
  - Code for the simultaneous readout of multiple ALPIDE ready
  - Same as that developed for the ALPIDE telescope (already tested)
  - Electron tracking software to be developed





RGS PROBE – SCIENTIFIC GOALS

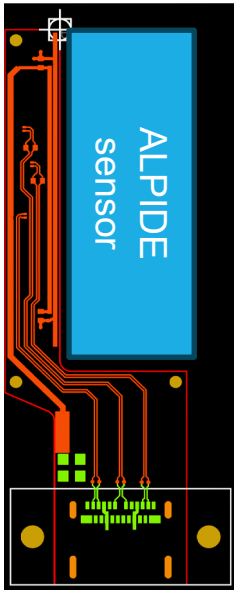
- Radioguided oncological Surgery (RGS): real-time localization (during the excision of the tumor mass) based on detection of β+/ β– emitted by radiotracers absorbed by tumor tissues.
- Compared to the γ tracers (commonly used), β+/ β– radiotracers allow to reduce background emission from healthy tissues and administered dose.
  - **β^+**: γ background at 511 KeV, wide range of use (typical case, ^{18}F-FDG, also used for PET)
  - **β^-**: no γ background but still few tracers available (^{90}Y-DOTATOC) and limited applications
- Currently available probes based on scintillators + SiPM only with counting applications
- The ALPIDE chip has much better potential for usage as a probe:
  - High detection efficiency, high γ rejection, low electronics noise, compactness.
  - Usable, not only for counting, but potentially also for real-time 2D imaging



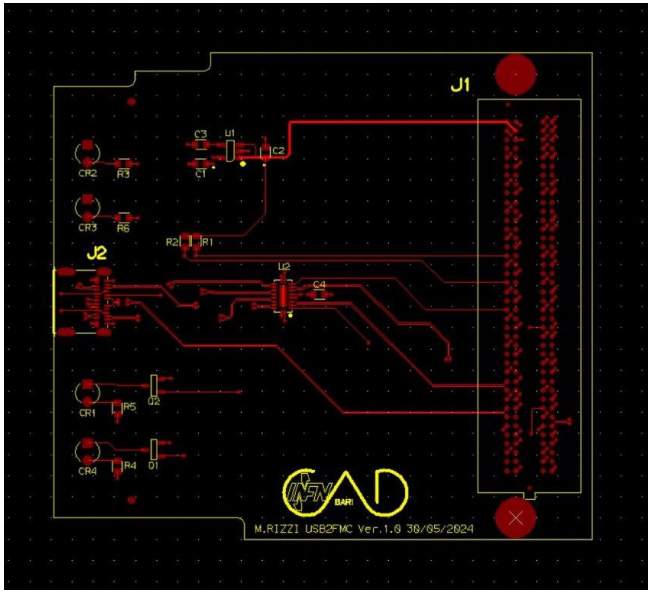
RGS PROBE – STATUS

- Design of a thin FPC for to keep the horizontal size to <2.5 cm completed
  - Develops along the short direction of the chip, with about 5mm thickness for bonding and tracks
  - The bonding to ALPIDE will exploit the pads on the periphery
  - The signal connector is a USB-C type
- Design of an interface PCB for the connection to the MOSAIC board also ready
- Production of both boards is currently ongoing, expecting to receive them in early December
  - Next step: start the bonding, assembly & readout testing

FPC for ALPIDE connection



Interface to MOSAIC board



RGS PROBE – STATUS

- Very first design for light and rigid cover case for the sensor also completed
  - Total width of 26 mm including ALPIDE chip (15 mm) + FPC (5 mm width), with a small gap to allow for optimal bonding
  - Total length of 55 mm, including the ALPIDE chip, the FPC, and the USB-C connector
  - Thickness of 2.5 mm for the region embedding the chip and 6 mm for the region holding the USB-C connector
  - Case open on the top side, used for data acquisition, to minimize material between the chip and tissues
  - Chip will be positioned at a 1 mm depth from the case, protected by a 100 μm thick kapton film.
- First mockup with ONYX with carbon fiber filaments has been prepared
- Final choice of the material under discussion