Laboratori Nazionali di Legnaro – INFN

Work Package 2: activities and prospects

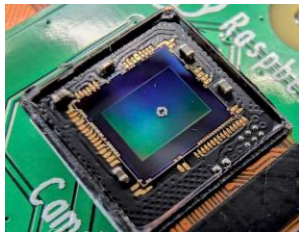
M. Lunardon and D. Serafini on behalf of the ADMIRAL WP2

June 18th, 2025

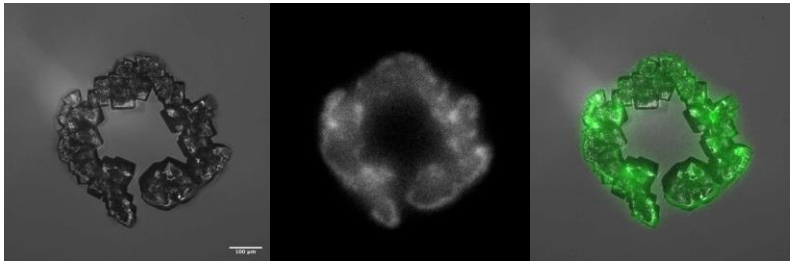
Outline

- Beta detection state of the art
- DUMBO explained
- Updates of the ADMIRAL WP2
  - Mechanics status
  - Electronics status
  - Simulation status and scaffolds
- Experiments

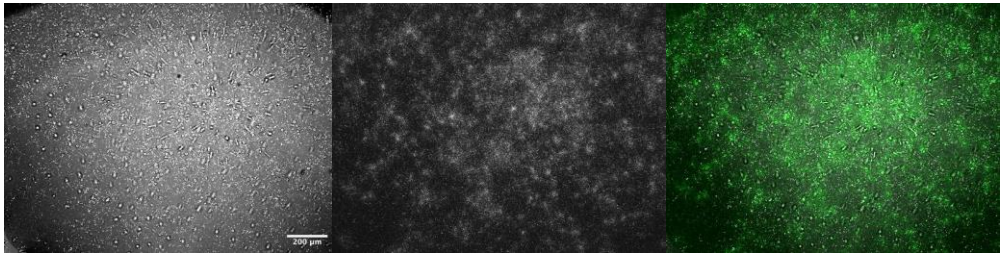
State of the art of beta imaging



- Beta detector of INFN-Pisa



- Test with 18F-FDG

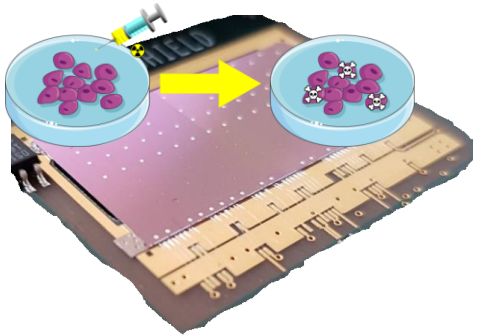


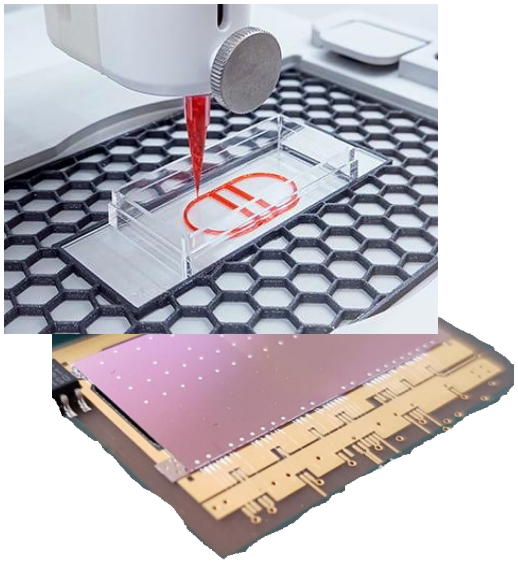
- Test with cells taking up 18F-FDG

- Test at CAPiR in June with cells uptaking Ag-111

Why DUMBO?

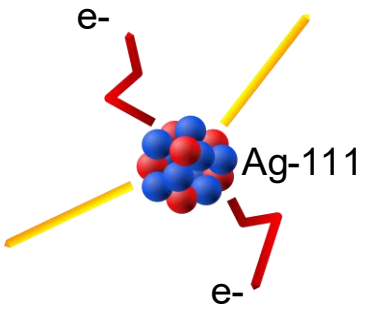
- Features of DUMBO
  - Sample isolated from the detector
  - Spatial resolution of about 1 mm at 500 um distance
  - Large sensitive area (15x30 mm²)
  - Scanner function using motors to increase FoV
  - Easy to use
- Applications
  - Cell clusters imaging in-vitro for uptake
  - Imaging of 2.5D scaffolds

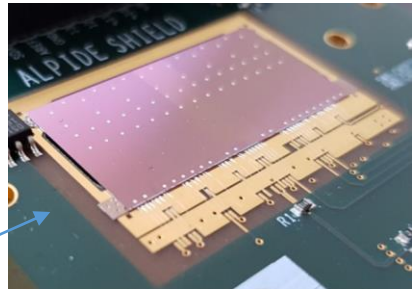




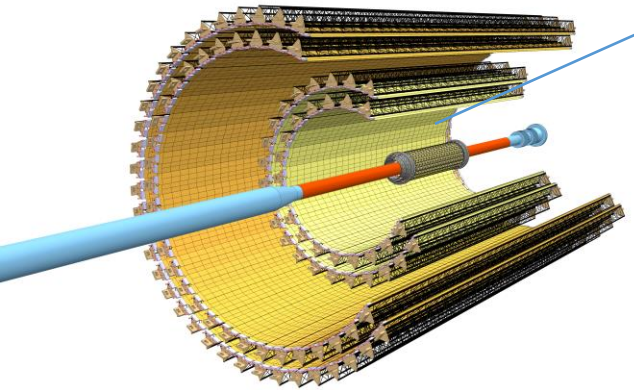
DUMBO

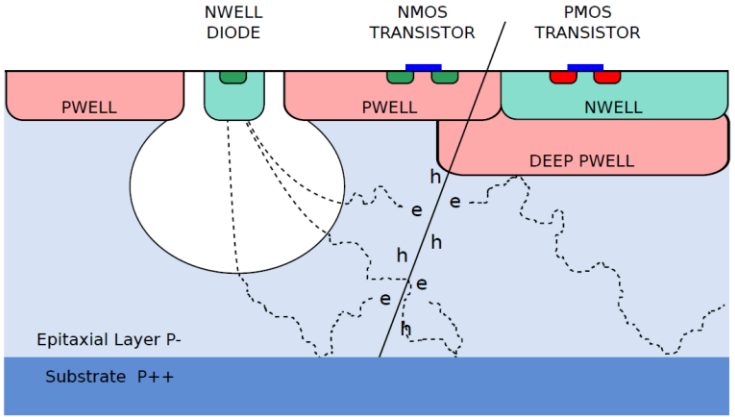
Detector
Using
Maps for
Beta-rays
Observation



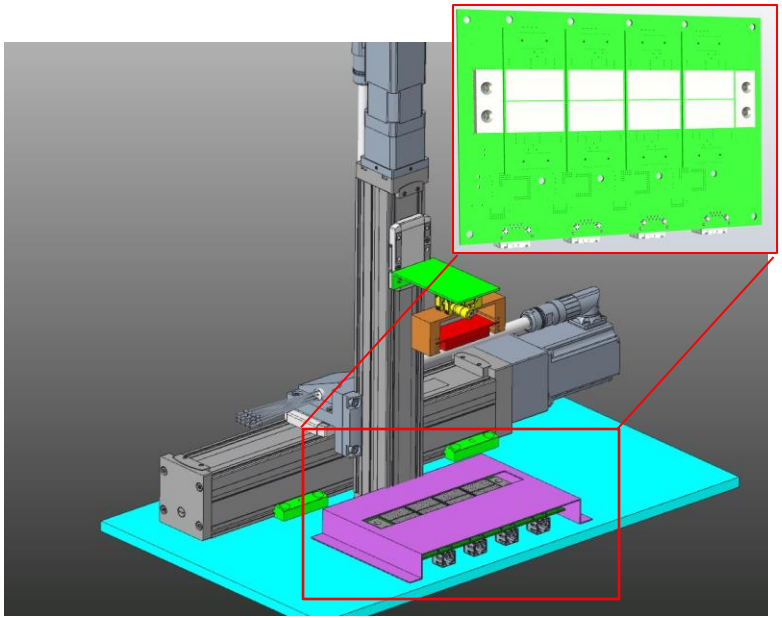


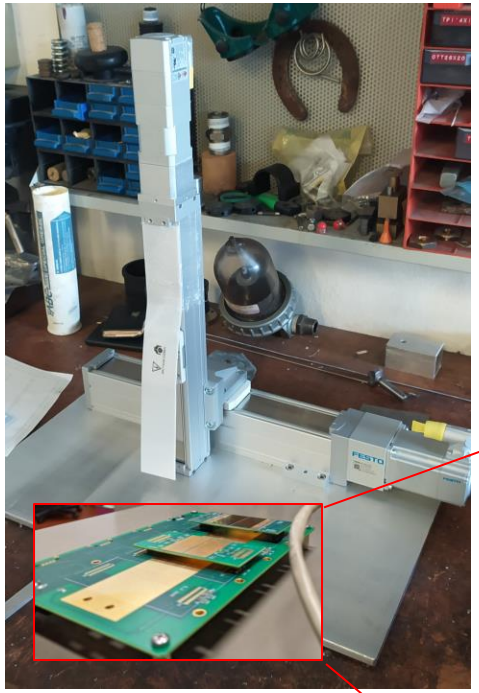
- MAPS -> ALPIDE
- ALice PIxel DEtector



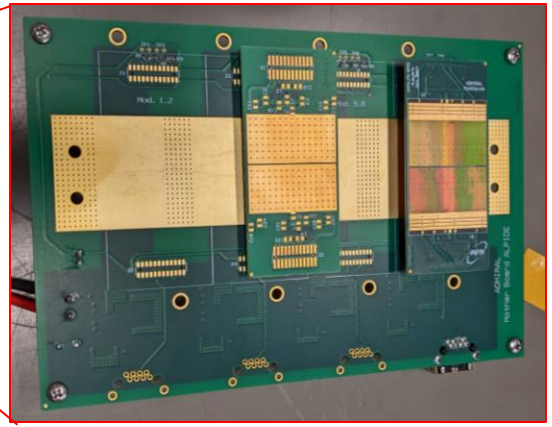


DUMBO





- 8 ALPIDE chips are the sensitive elements
- Mechanics system to place the sample
  - x-y movement



WP2 ADMIRAL GANTT

		Year 1				Year 2				Year 3				Notes
		M3	M6	M9	M12	M15	M18	M21	M24	M27	M30	M33	M36	Required for
	WP1 - Radiopharmaceutical production													
MS1.0	Optimization of Ag-111 production and Ag/Pa separation	→			●									MS1.1
MS1.1	Routine production of Ag-111 at the LENA facilities, purification and quality control					→	○		●					MS1.2
MS1.2	Synthesis of improved stable Ag chelators and radiochemical characterization	→	○		○		○		●					MS1.3, MS2.3, MS3.3, MS4.1, MS4.2
MS1.3	Development of the macromolecule for active targeting									→	○		●	MS4.2, MS4.4
MS1.4	Bioengineering of 3D scaffolds for in vitro tissue mimicking					→	○		○		○		●	MS4.2
	WP2 - β-Imaging													
MS2.0	Development of the detector control firmware prototype	→			●									MS2.3
MS2.1	Preliminary Monte Carlo simulations for mechanics and detector design	→		○				●						MS2.3
MS2.2	Electronics and mechanics design	→			○		○		●					MS2.3
MS2.3	β-detector characterization							→	○		●			MS2.4, MS4.4
MS2.4	β-imaging test with Ag-111							→	○				●	MS4.4
	WP3 - γ-Imaging													
MS3.0	Sizing of the detector components according to the required spatial resolution	→	●											MS3.1, MS3.2
MS3.1	Preliminary Monte Carlo simulations for detector design	→	○		●									MS3.2
MS3.2	Planar imaging detector construction for Ag-111 γ detection					→	○		●					MS3.3
MS3.3	Characterization of the planar system for γ-imaging							→			●			MS3.4
MS3.4	γ-imaging test with Ag-111							→					●	
	WP4 - Targeted Radiobiology													
MS4.0	Evaluation of the cellular dose as function of the injected activity via Monte Carlo simulations	→			●									MS4.4
MS4.1	Cell survival tests in 2D Petri dishes					→	○		●					MS4.4
MS4.2	Cell survival tests in 3D scaffold dynamic cultures							→	○		○		●	MS4.4
MS4.3	Comparison between different Monte Carlo codes (Geant4, MCNPX, PHITS)	→			●									MS4.4
MS4.4	Dose computation in cell cultures using Monte Carlo codes and cell survival prediction					→			○				●	MS4.1, MS4.2

→	Activity started
○	Checkpoint (preliminary/partial results required to start other subsequent activities)
●	Milestone reached

Active WP2 personnel

Staff:

- Marcello Lunardon -> WP leader
- Piero Giubilato -> Resources
- Sandra Moretto -> Resources
- Devis Pantano -> ALPIDE electronics
- Lorenzo Castellani -> ALPIDE electronics
- Roberto Michinelli -> mechanics designer

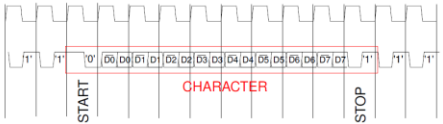
PhD students:

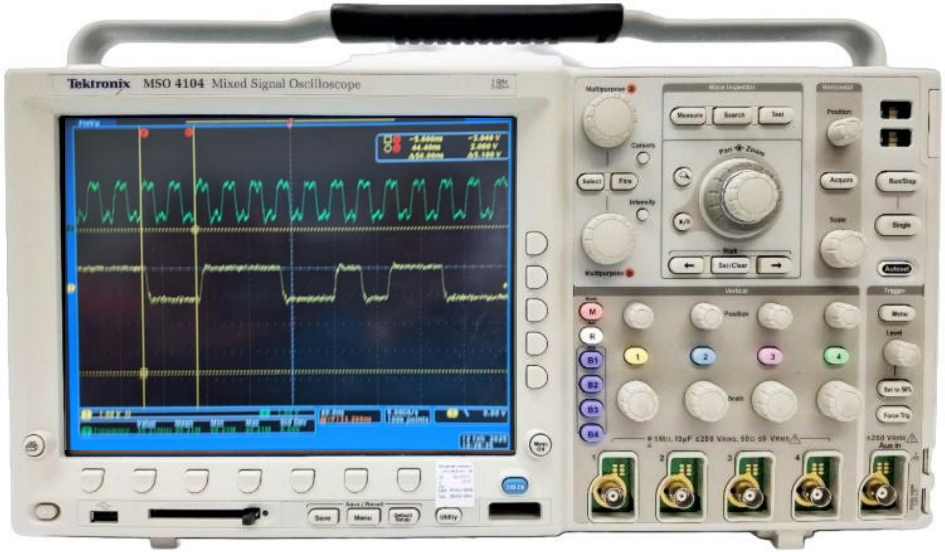
- Aurora Leso -> Geant4 simulation
- Davide Serafini -> experimental setup

Bachelor students:

- Sofia Busatto -> Geant4 simulation
- Tommaso Coppelli -> movement tests and phantoms
- Edoardo Cervi Gambaro -> ALPIDE tests

ALPIDE communication





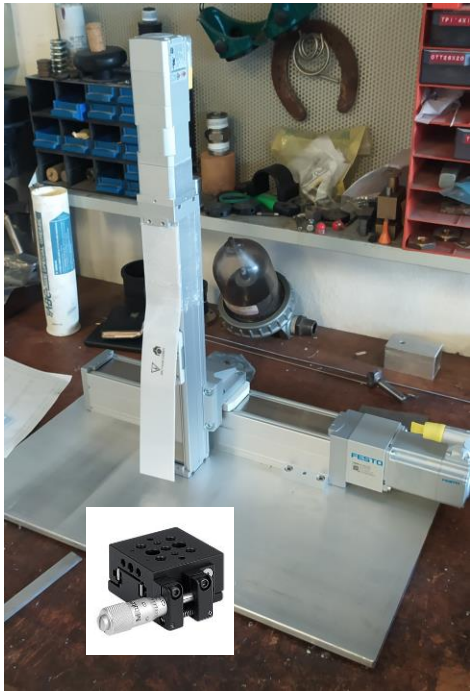
- Communication with the ALPIDE
- Bachelor thesis of Edoardo Cervi Gambaro

ALPIDE Operations Manual

ALICE ITS ALPIDE development team

July 25, 2016
Version: 0.3
Status: DRAFT

Festo motors control

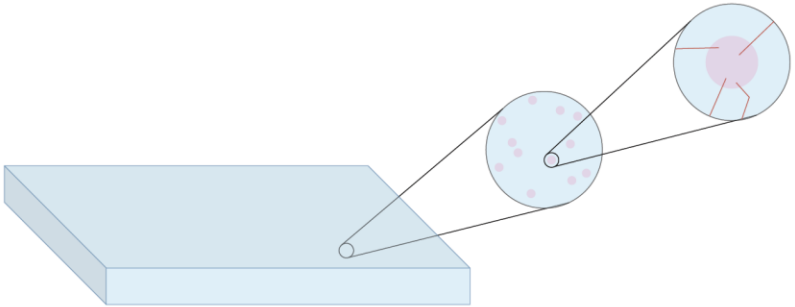


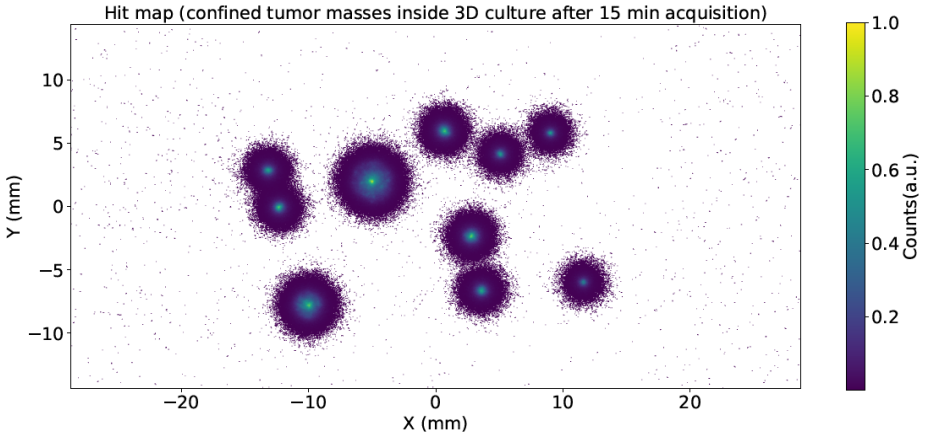
- Two motors for two axes
- One micrometric manual traslator on the 3rd axis

- Festo automation suite can be be used for manual and automatic control
- Festo-edcon python library for modbus communication with the motors
- Python scripts with several target positions
  - Integration with ALPIDE communication python script
- Bachelor thesis of Tommaso Coppelli

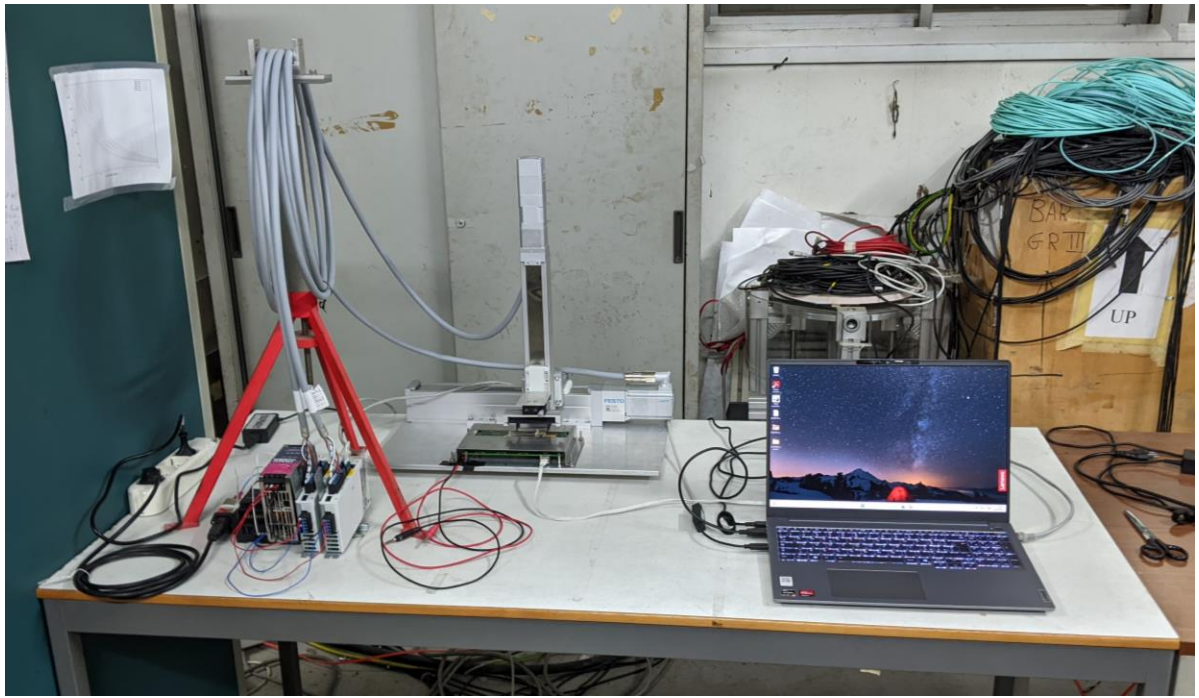
Simulation

- Simulation framework developed by Vittoria Pavanello
- Different experimental conditions can be simulated
- Thesis of Sofia Busatto





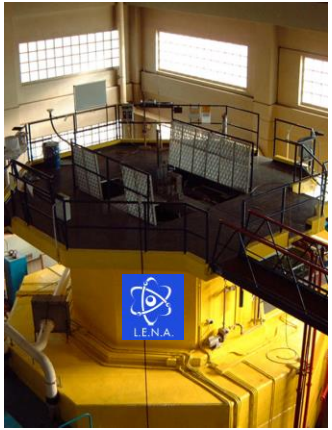
Debugging setup

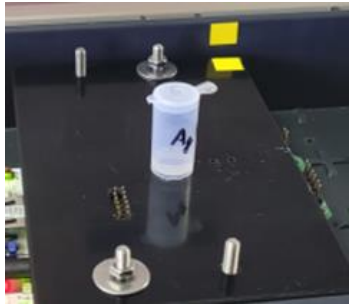


One python script:

- Motors movement
- Chip communication

Last experiment in 2024

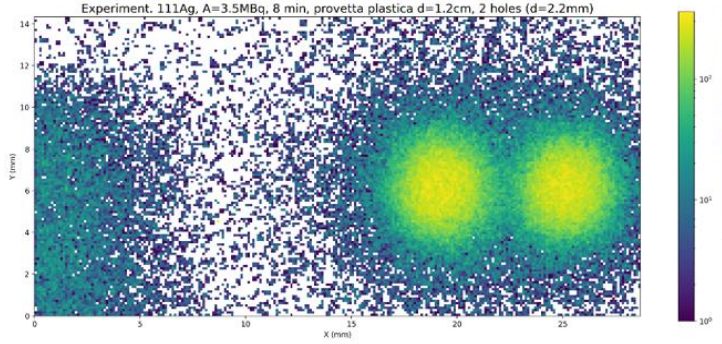


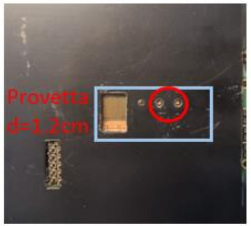


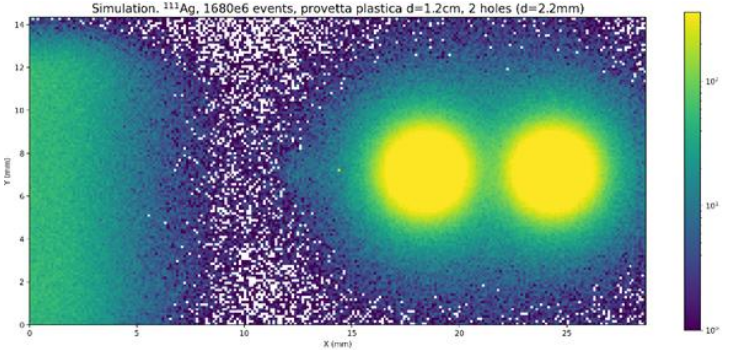
Beta detector tests at LENA:

- Characterized the ALPIDE sensor
  - No mechanics
- Validated the Geant4 simulations
- Ag-111 solution in big vials (diameter 12.5 mm)
  - With collimator

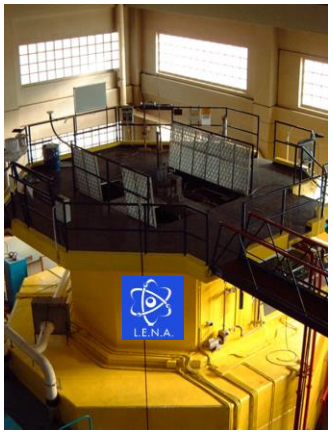
Due fori di d=2.2 mm

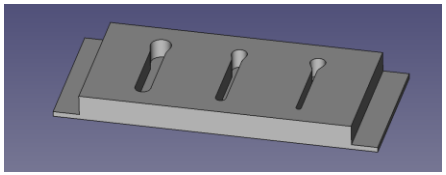






Next experiment in July 2025





Designed by Tommaso Coppelli

DUMBO tests at LENA:

- Characterize the whole device
  - ALPIDE chip (still temporary)
  - Movement system

Preliminary tests

- Study of diffusion of Ag-111 ions
  - In GelMA scaffolds prepared ad the radiolab of Pavia in collaboration with the BIOtech of Trento

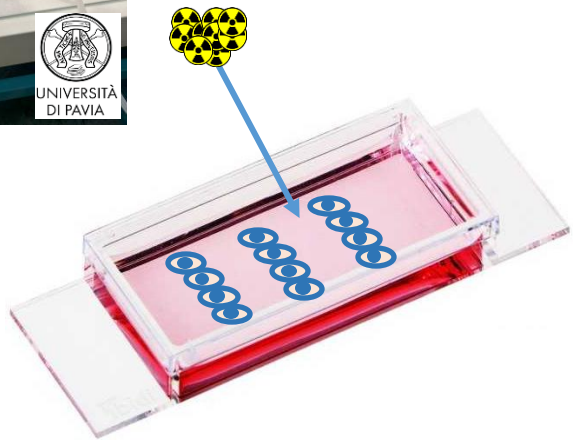
BIOtech
Biomedical Technologies

- Evaluation of the spatial resolution
  - In plastic phantoms

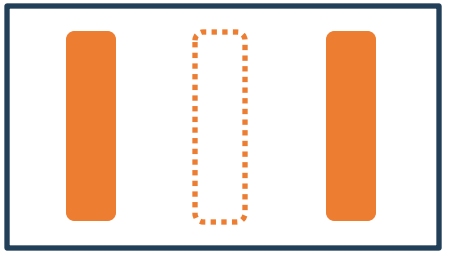
Future experiments

Experiments with cells:

- Estimate uptake of different cell lines in the same culture
  - Uptake of Ag-111 ions
  - Uptake of Ag-111 radiopharmaceutical



DUMBO imaging



Thanks

Back-up

Differences

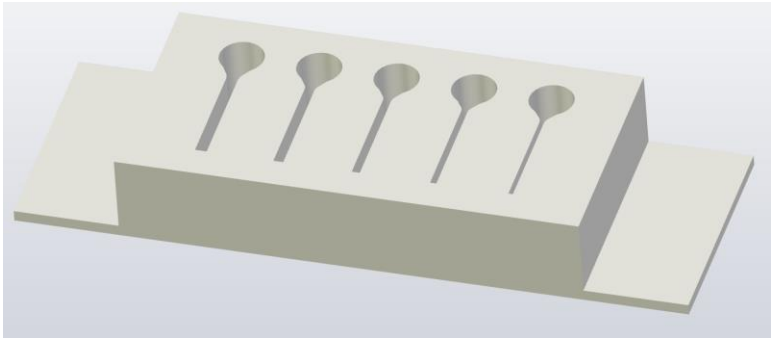
Beta detector with CMOS:

- Spatial resolution

DUMBO:

- Spatial resolution

Phantoms



- μ-slide 1 well coverslips used for 2.5D scaffolds
- Phantoms realized with:
  - Same external geometry
  - Same bottom layer thickness: 180 um
  - Lines with well-defined thicknesses
- Design of Tommaso Coppelli

Experiments

- Future experiments with cells:
  - Image the radioactive cells clusters in 3D scaffolds
  - Estimate the cellular radiopharmaceutical uptake