Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI LEGNARO

Laboratori Nazionali di Legnaro – INFN

Work **P**ackage **2**

Status of **b**eta-**i**maging **d**etector

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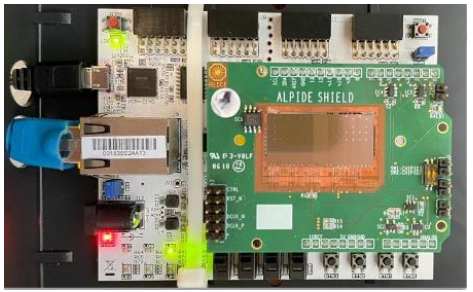
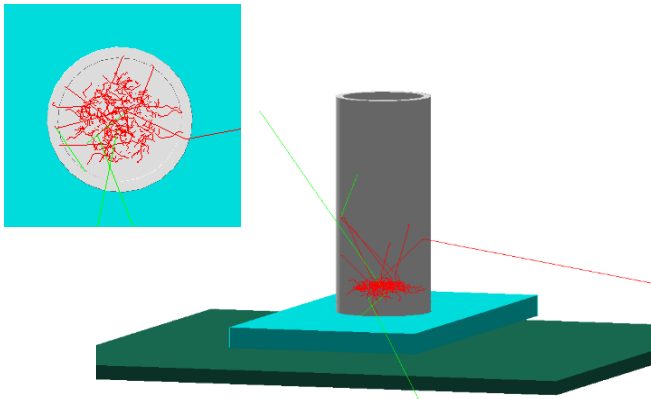
June 20th, 2024

Preliminary simulation

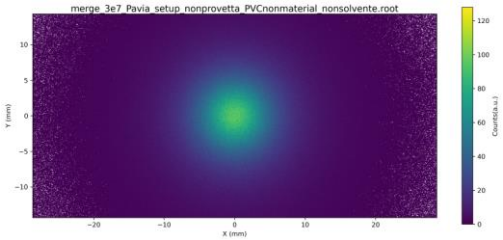
- Preliminary simulation before measurement at Pavia using Geant4
- Selection of the vial containing the ^{111}Ag
  - Glass vial
  - Plastic vial with solvent
- 1 Alpide chip
- Total **number** of simulated events $3x10^7$
- **Source shape**: cylinder thickness 0.5 mm and radius 4mm, attached to the base of the vial
- **Tubes shapes**: radius 0.75 cm. Thickness 0.7 mm (plastic), 1mm (glass)
- **Materials** tubes: Pyrex_Glass and Polystyrene
- PVC board (air material), but the distance of 5 mm taken into account





Preliminary simulation

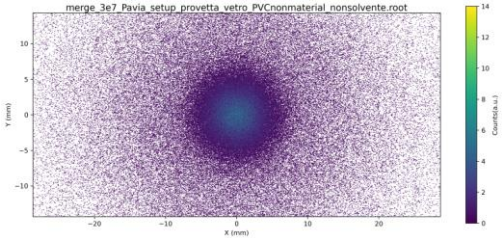
Non tube non solvent



Number of events resgistered= 9227264 **Eff_abs=30.75%,** with respect to $3x10^7$

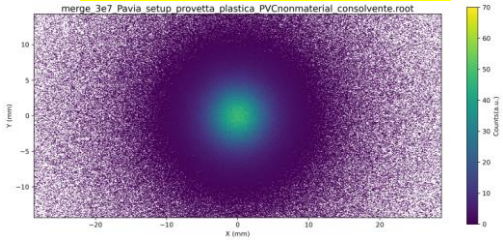
Conclusion: Glass tube attenuates more than the plastic tube with the solvent.

Glass tube without solvent



Number of events resgistered= 227737 **Eff_int=2.47%**

Plastic tube with solvent

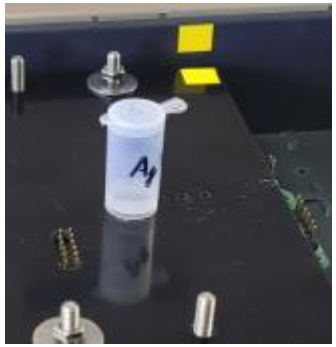


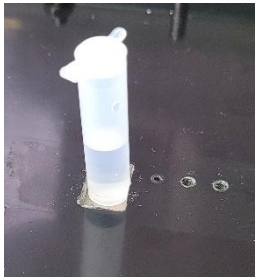
Number of events resgistered= 2144987 **Eff_int=23.24%**

Measurements at Pavia

Measurement performed with different quantities of ^{111}Ag and different test vial at LENA (Pavia) April 2024.

- 1kBq + Glass vial(d=0.96cm) (very low rate).
- 247kBq +Plastic vial(d=1.2cm) + solvent (0.4 ml) (low rate)
- 222kBq + Plastic vial(d=0.6cm) + solvent (0.4 ml) (low rate)
- 27.5MBq + Plastic vial(d=1.2cm) + solvent (0.4 ml) (high rate – measurement crashed)
- 3.5MBq + Plastic vial (d=1.2cm) + solvent (0.3 ml) (measurement crashed after two minutes). Vial used for the rest of the measurements.





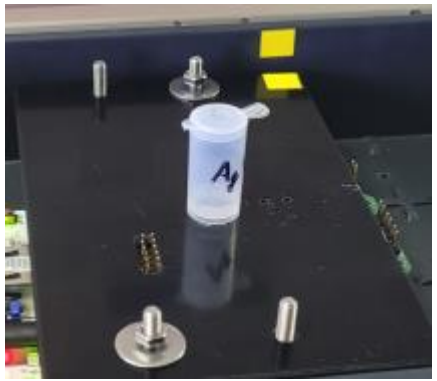
d=0.96cm

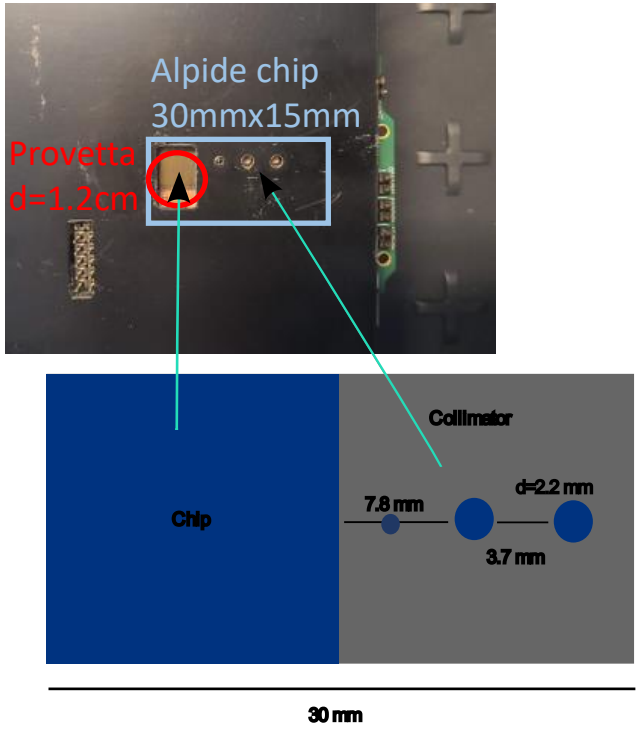
d=1.2cm

d=0.6cm

Measurement at Pavia

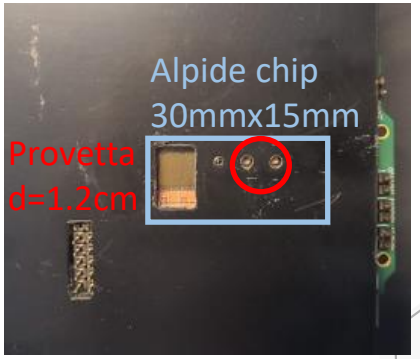
- Measurement performed with ^{111}Ag A=3.5 MBq, inside a plastic vial with d=1.2cm, and solvent solution 0.3ml.
- PVC was cut in order to have an idea of the spatial resolution of the detector:
  1. Two holes d=2.2mm
  2. Large slot 7.8mm x 12.2mm, almost half of the chip exposed
  3. Small and big holes, d=1mm and d=2.2mm

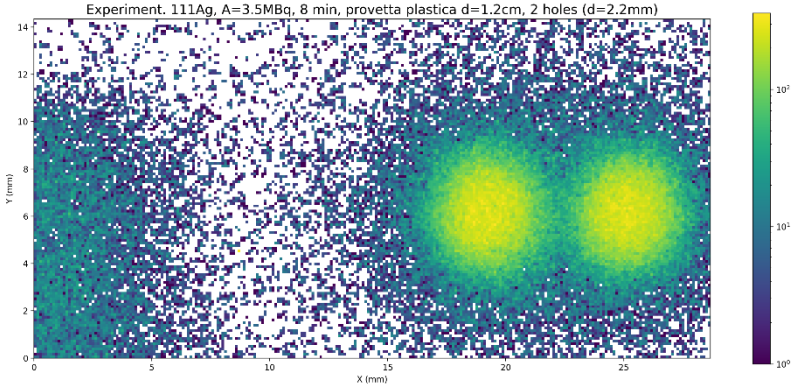


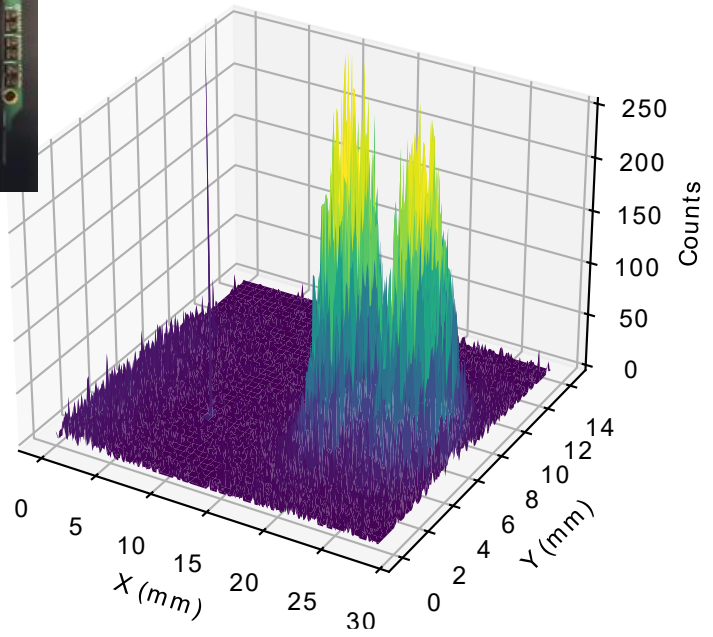


Measurement 2 holes collimator

- Measurement performed with ^{111}Ag A=3.5 MBq, inside a plastic vial with d=1.2cm, and solvent solution 0.3ml.
- Collimator of two holes each hole with d=2.2mm
- 8 min measurement
- Good separation

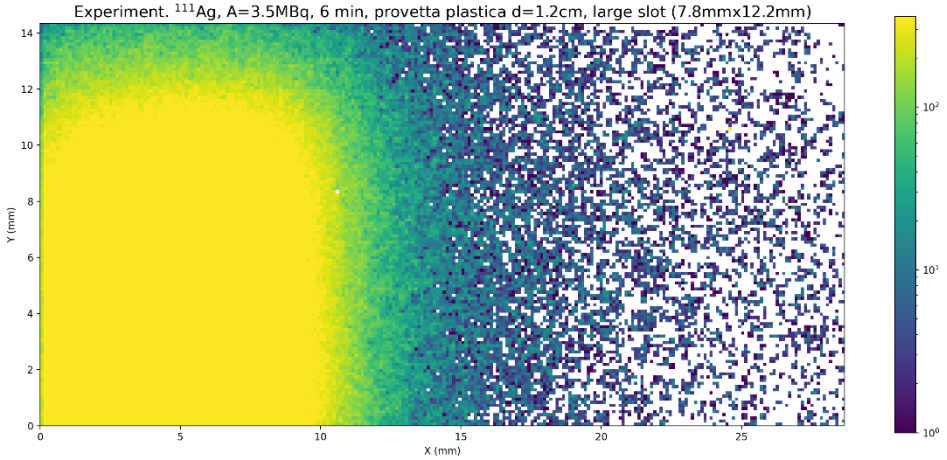


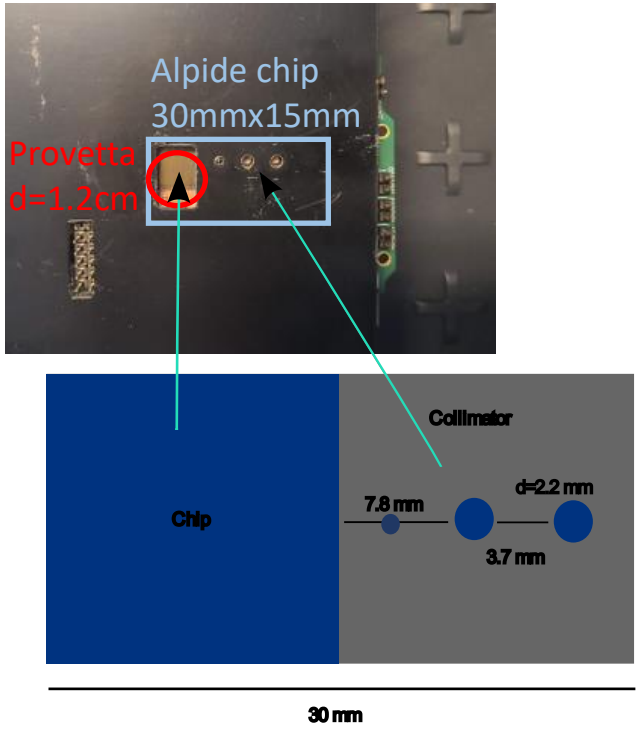




Measurement large slot

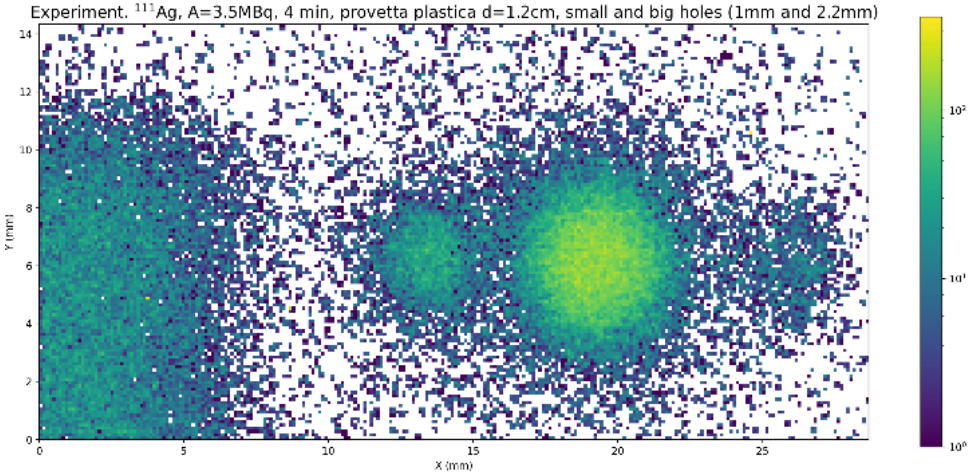
- Measurement performed with ^{111}Ag A=3.5 MBq, inside a plastic vial with d=1.2cm, and solvent solution 0.3ml.
- Large slot (7.8mm x 12.2mm)
- 6 min measurement

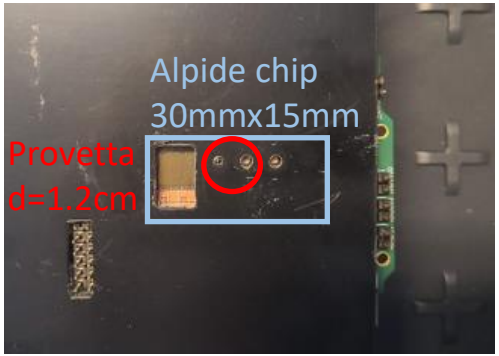




Measurement small and big holes

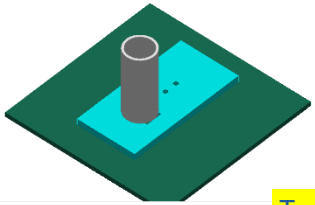
- Measurement performed with ^{111}Ag A=3.5 MBq, inside a plastic vial with d=1.2cm, and solvent solution 0.3ml.
- Small and big holes (d=1mm and d=2.2mm)
- 4 min measurement
- Possible to differentiated the 1 mm hole.

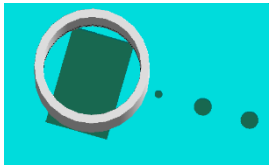


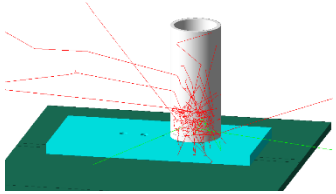


Simulations

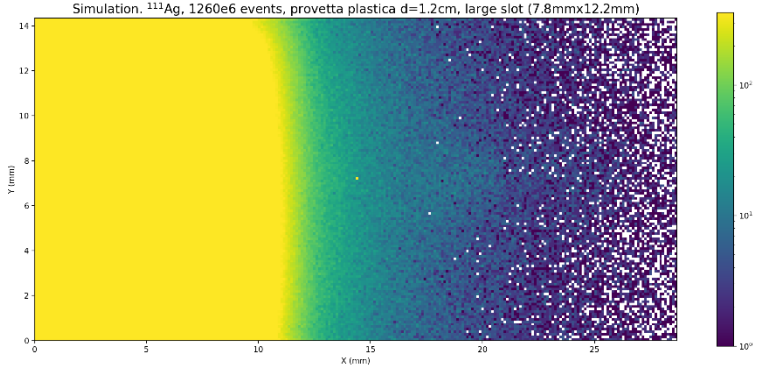
- Simulations on the same condition of the experimental measurements.
- Simulation of the beta spectrum emitted by the ^{111}Ag.
- Number of events simulated equivalent to the number of decays during the measurement



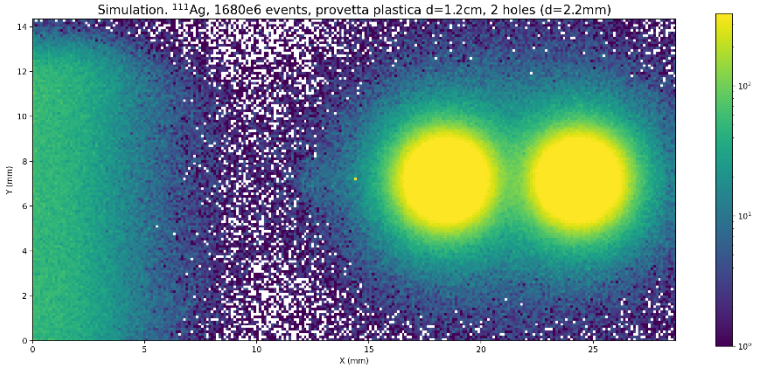




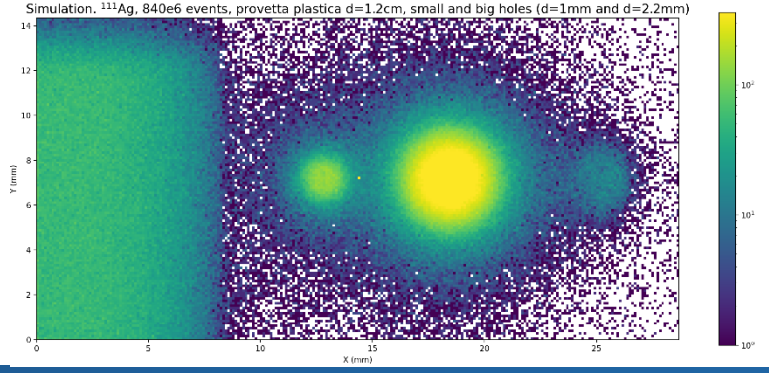
Large slot (7.8mm x 12.2mm)



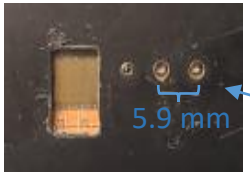
Two holes (d=2.2mm)



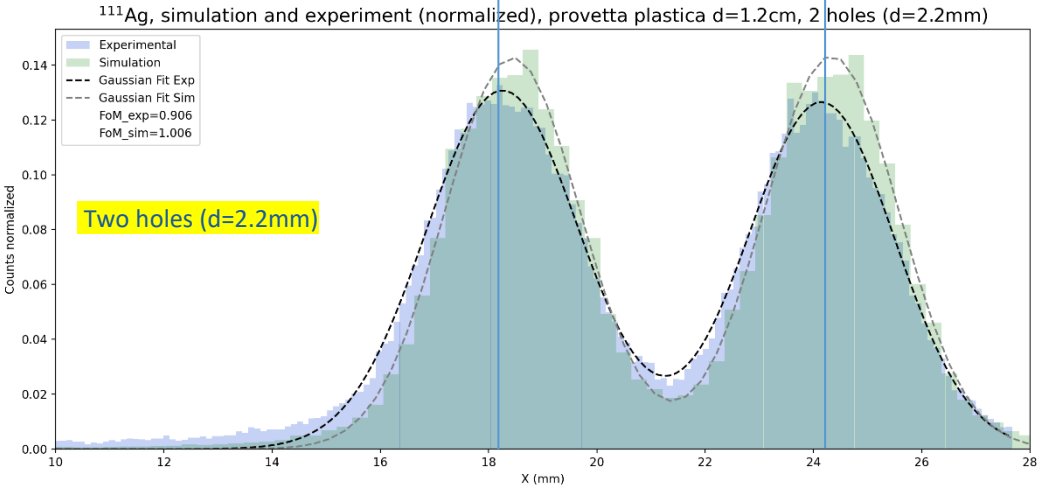
Small and big holes (d=1mm and d=2.2mm)

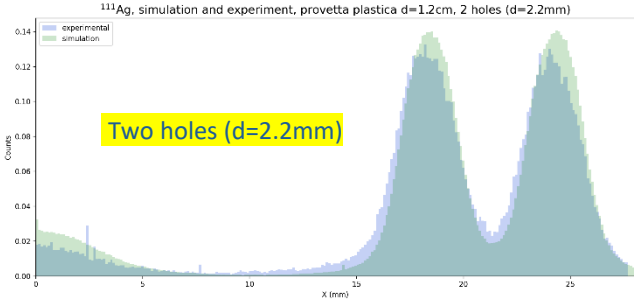


Exp. and Sim. comparison



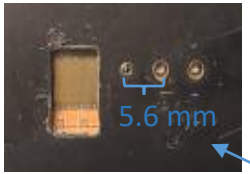
Δx≈6 mm



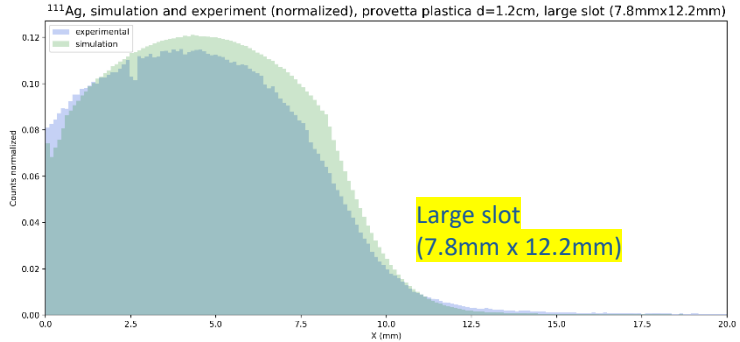


- Good agreement of the spatial distribution between the experimental and simulations results.
- FoM_Sim=1.006 and FoM_Exp=0.906
- Discrepancy=10%

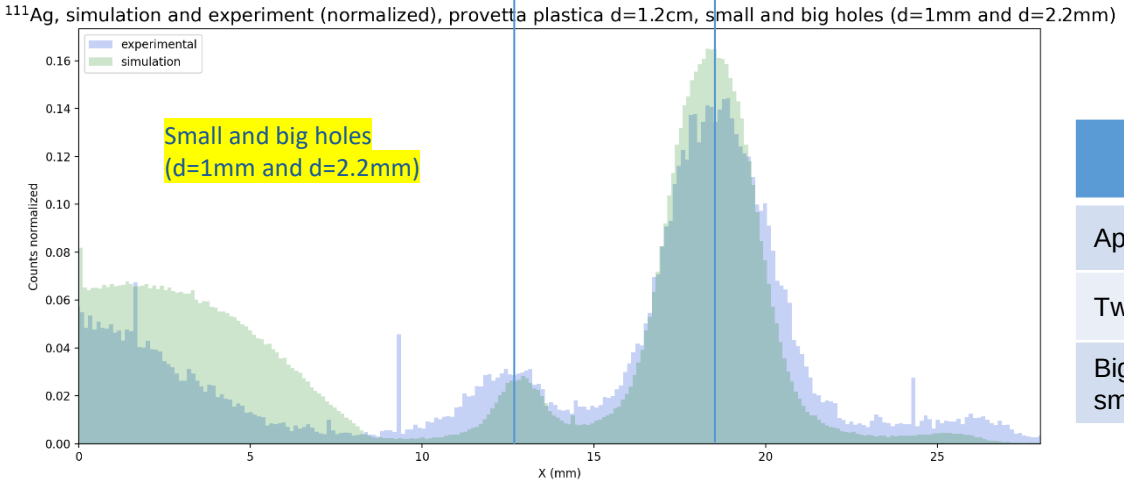
Exp. and Sim. comparison



- Good agreement of the spatial distribution between the experimental and simulations results.



Δx≈6 mm



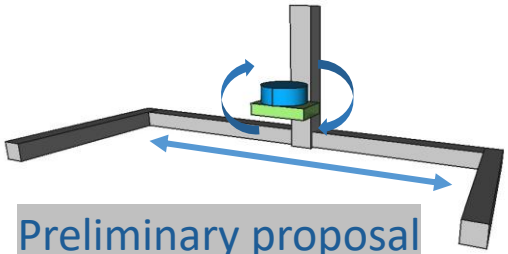
	Exp (counts)	Sim (counts)	Eff (%)
Aperture	6768623	39037992	17.33
Two holes	688339	1990557	34.58
Big and small holes	294995	842104	35.03

Higher rate

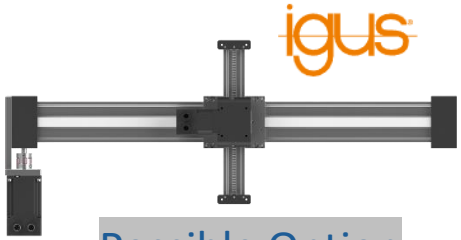
Lower rate

Mechanical support

- Guidance and help from Roberto Michinelli, personnel from the Mechanical Design Service at INFN Bologna.
- Some difficulties related to the payment method.
- Options found: linear gantry two-dimensional movement, parameters can be customized by the user. Produced by IGUS and FESTO (German companies).
- Waiting for the budget proposal.



Preliminary proposal



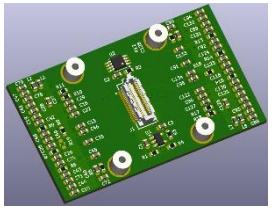
Possible Option

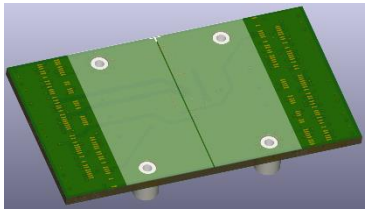
Possible Option

Design of the PCB for the chips

- Michele Giorato, a technician from the Physics department (UNIPD), has already designed the PCB where two of the ALPIDE chips will be mounted.
- However, the design of the mezzanine board is still pending.
- Followed by the connection to an embedded board.

PCB design





PCB for chip mounting

mezzanine board

FPGA board

connection from commercial FPGA (standard connectors) to custom PCB with ALPIDE chips

Raspberry Pi Pico

Following steps

- Perform measurement tests using ^{111}Ag with one ALPIDE chip at various rates (adjusting distance or varying the activity of ^{111}Ag) to analyze the system's dead time as a function of the rate, alongside simulations.
- Conclude with the acquisition of mechanical support.
- Construct the PCB already designed for the two chips, followed by connecting them and designing the mezzanine board.

Thank you ..!!