GAGG Veto Studies

BULLKID Meeting Pisa 26/03/2025

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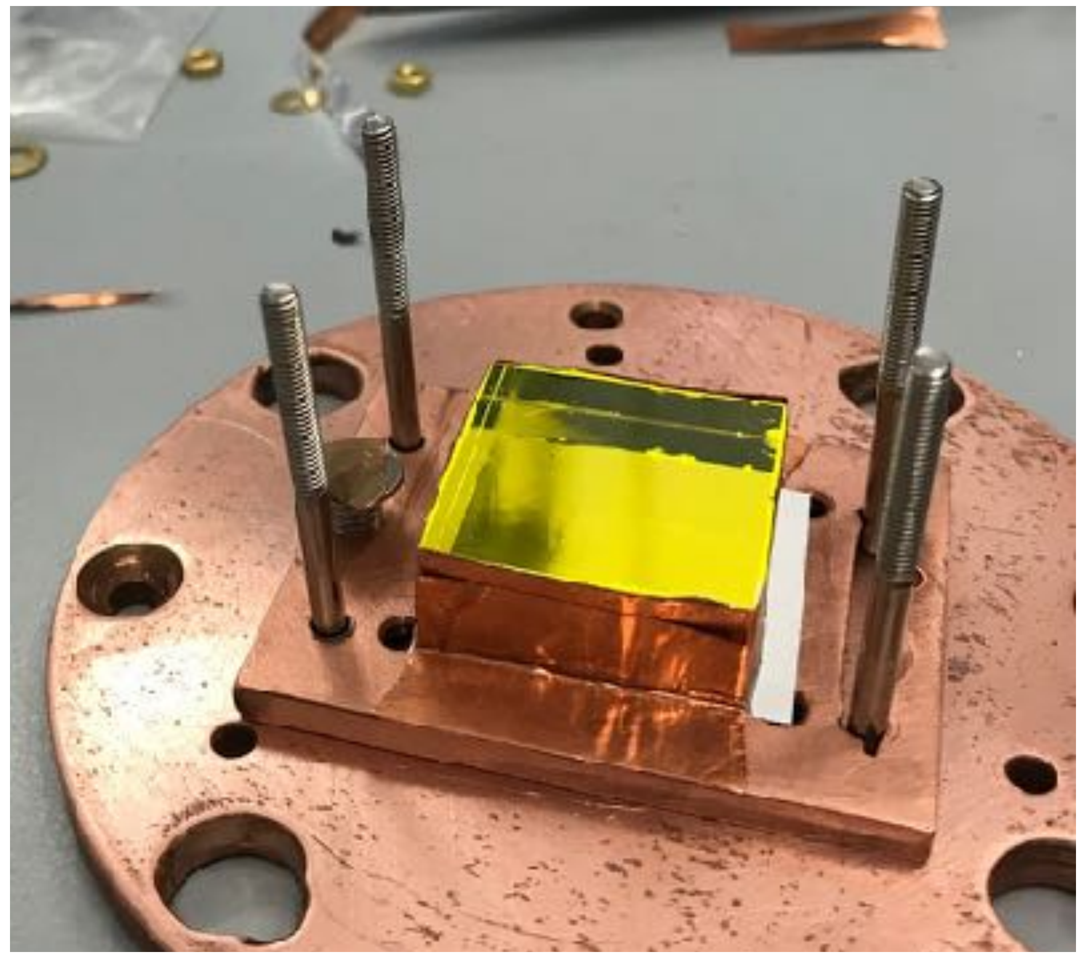
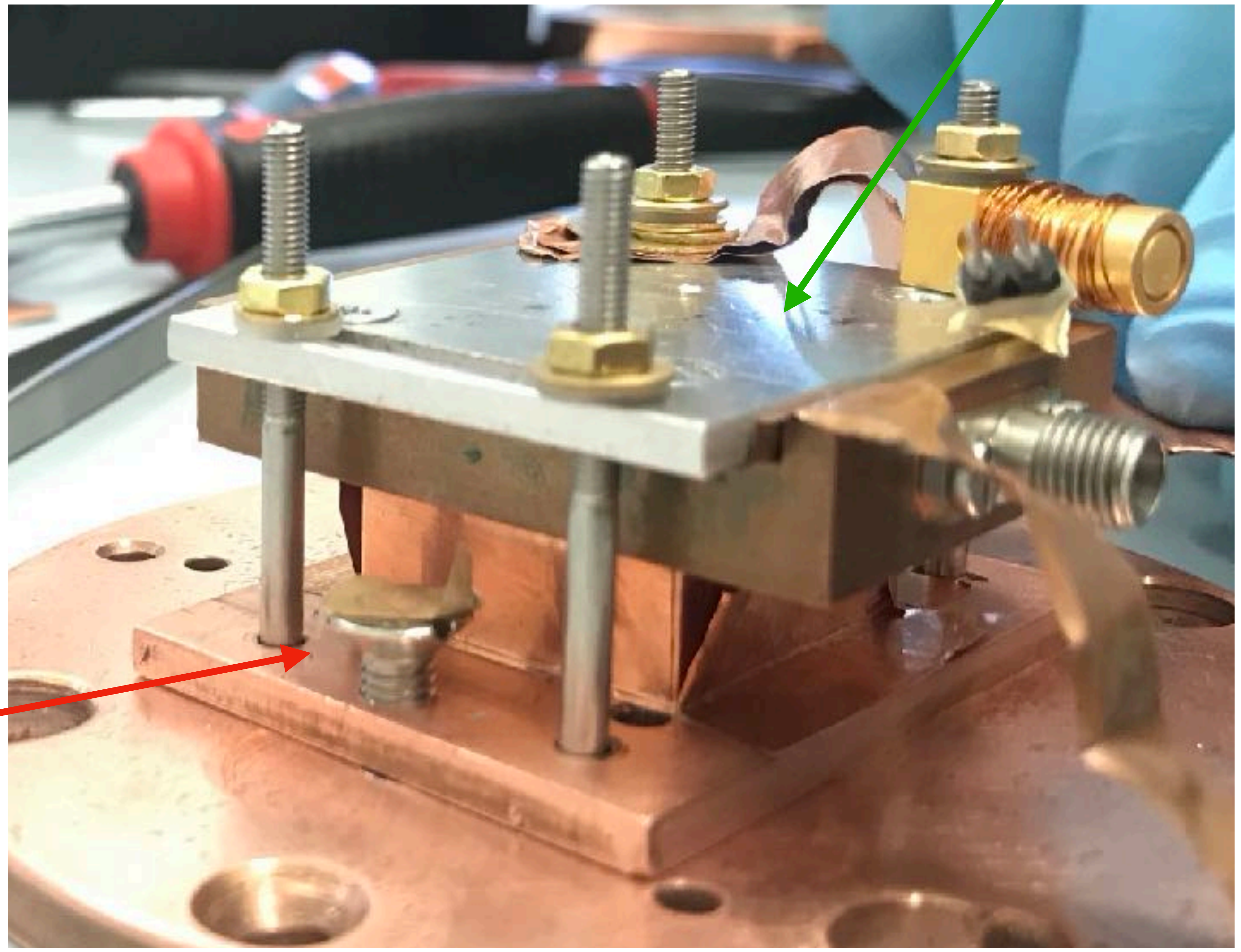
Test of GAGG crystal coupled to MKID:

- 2.5x2.5x1 cm GAGG crystal
- 2X2 cm “Calder” KID photon detector
- Reflective tape-> better photon collection
- Crystal supported by Cu plate for better thermalization
- 241 Am source
- External 137 Cs source

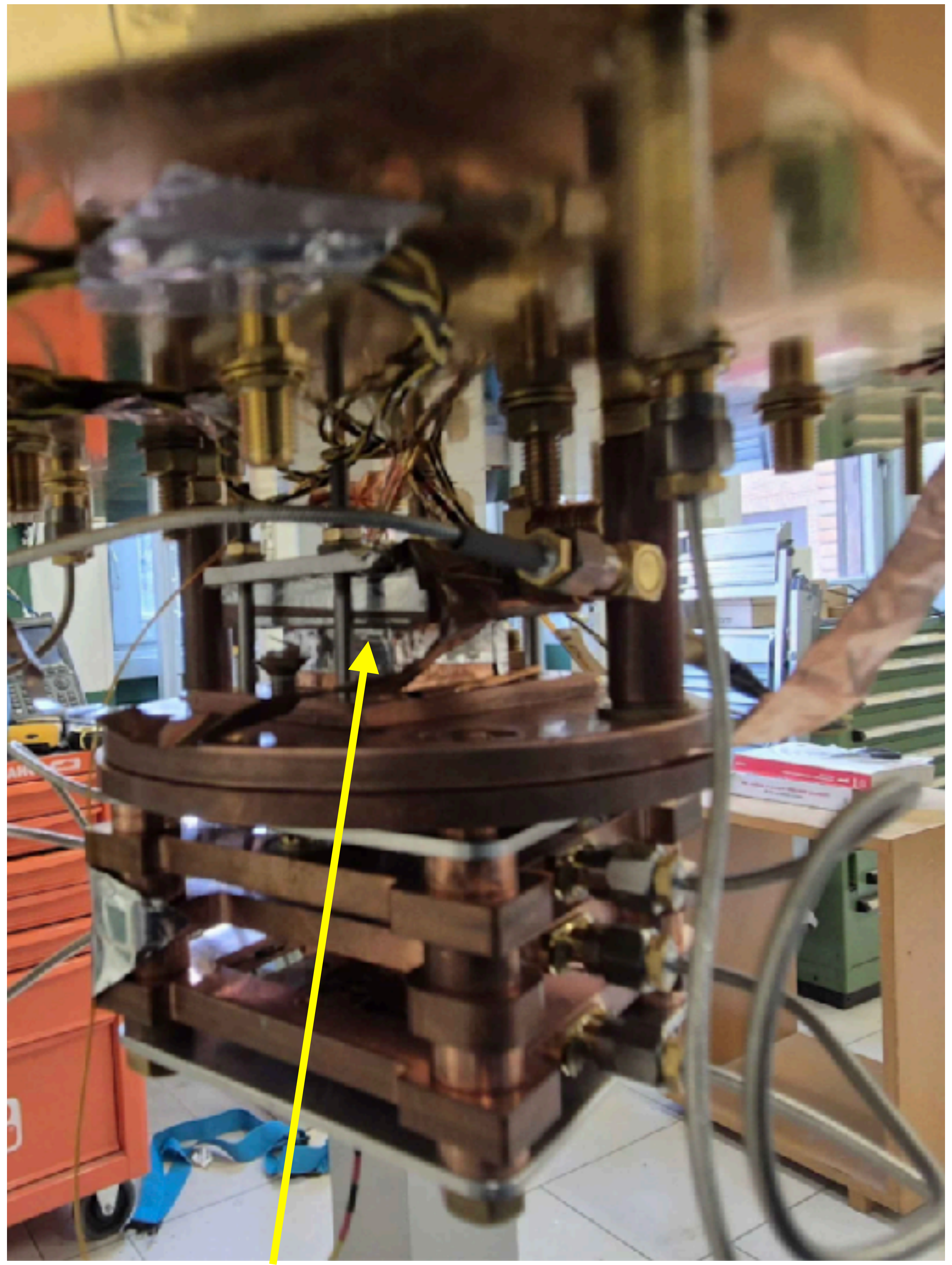
(Test in Roma Sapienza)

KID light detector





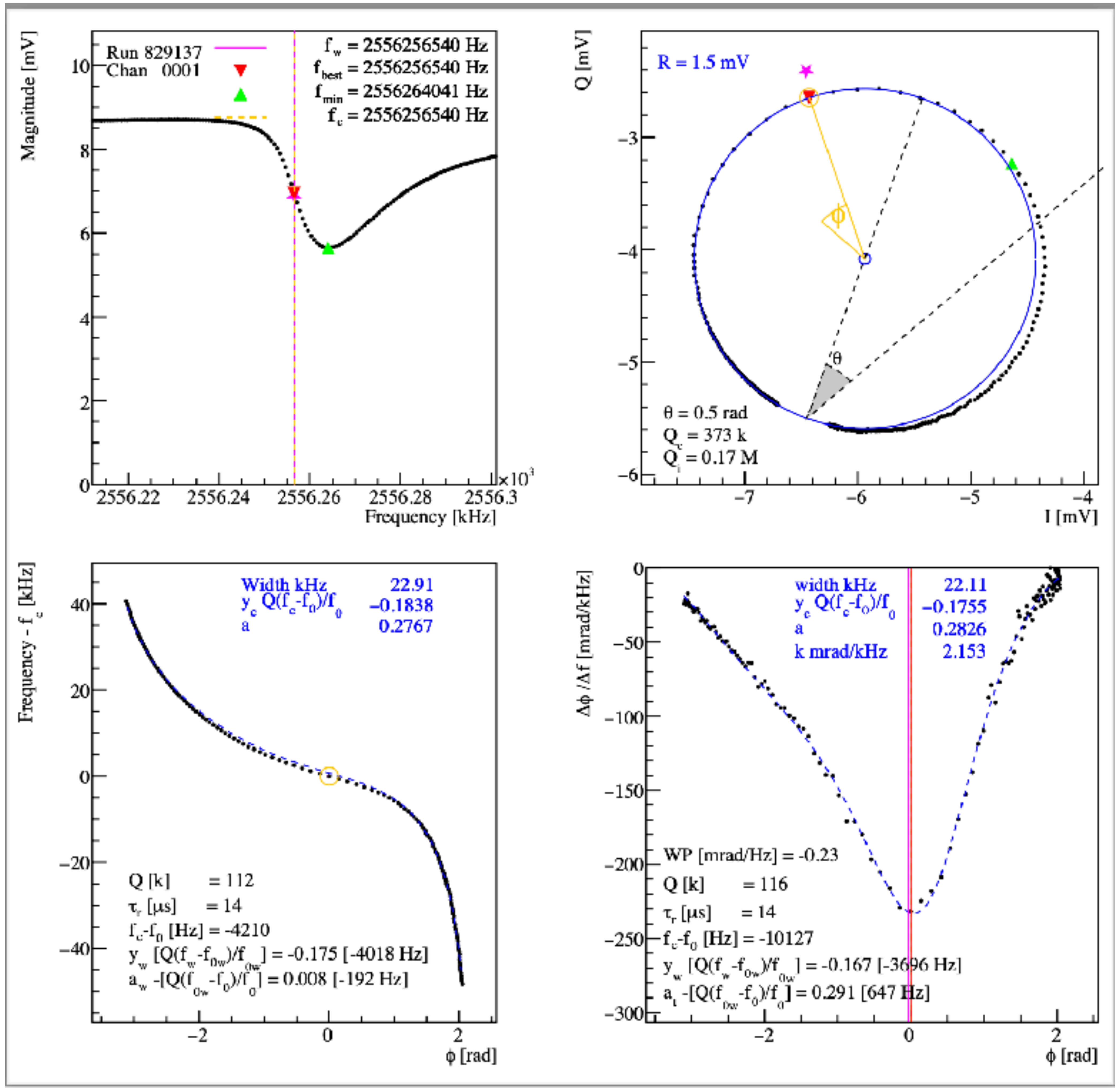
241Am



GAGG

Test of GAGG crystal coupled to MKID:

VNA Scan:



- **The detector parameters at the operating point are worse than expected:**

Measured	**Expected**
f0=2.556 GHz Q=116 k Qi=0.17 M Qc=373 k	f0=2.556 GHz Q=175 k Qi=0.55 M Qc=256 k

- **Possible issue in thermalization?**
- **Heat capacity of GAGG? (Doi: 10.1063/1.1681634)**

Test of GAGG crystal coupled to MKID:

- Peak at low energy (Am? Threshold effect?)
- In Cs137 more event in the shield

```
Rate Bkg1= 1.50 Count/s
Rate Bkg2= 1.57 Count/s
Rate Cs= 2.24 Count/s
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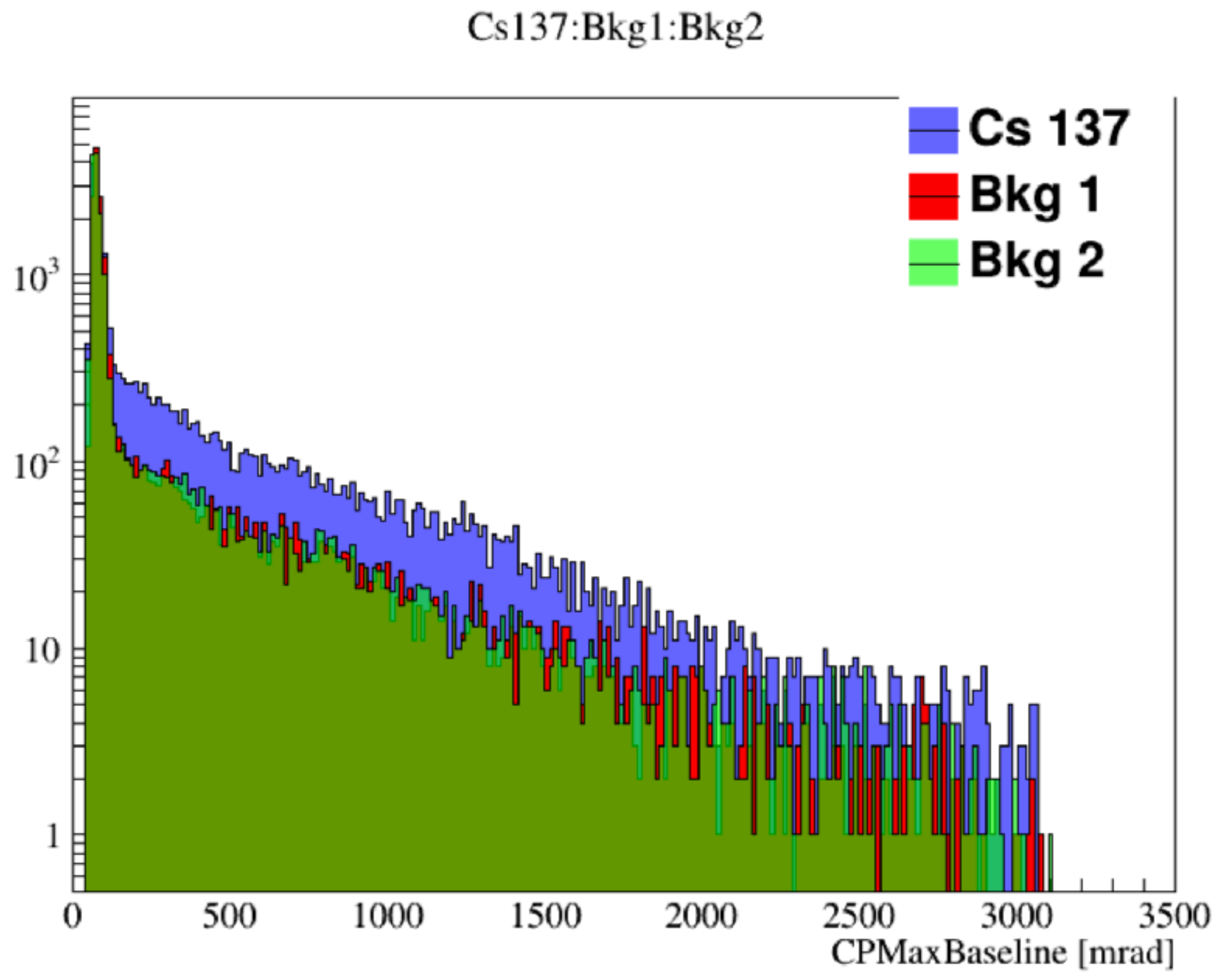
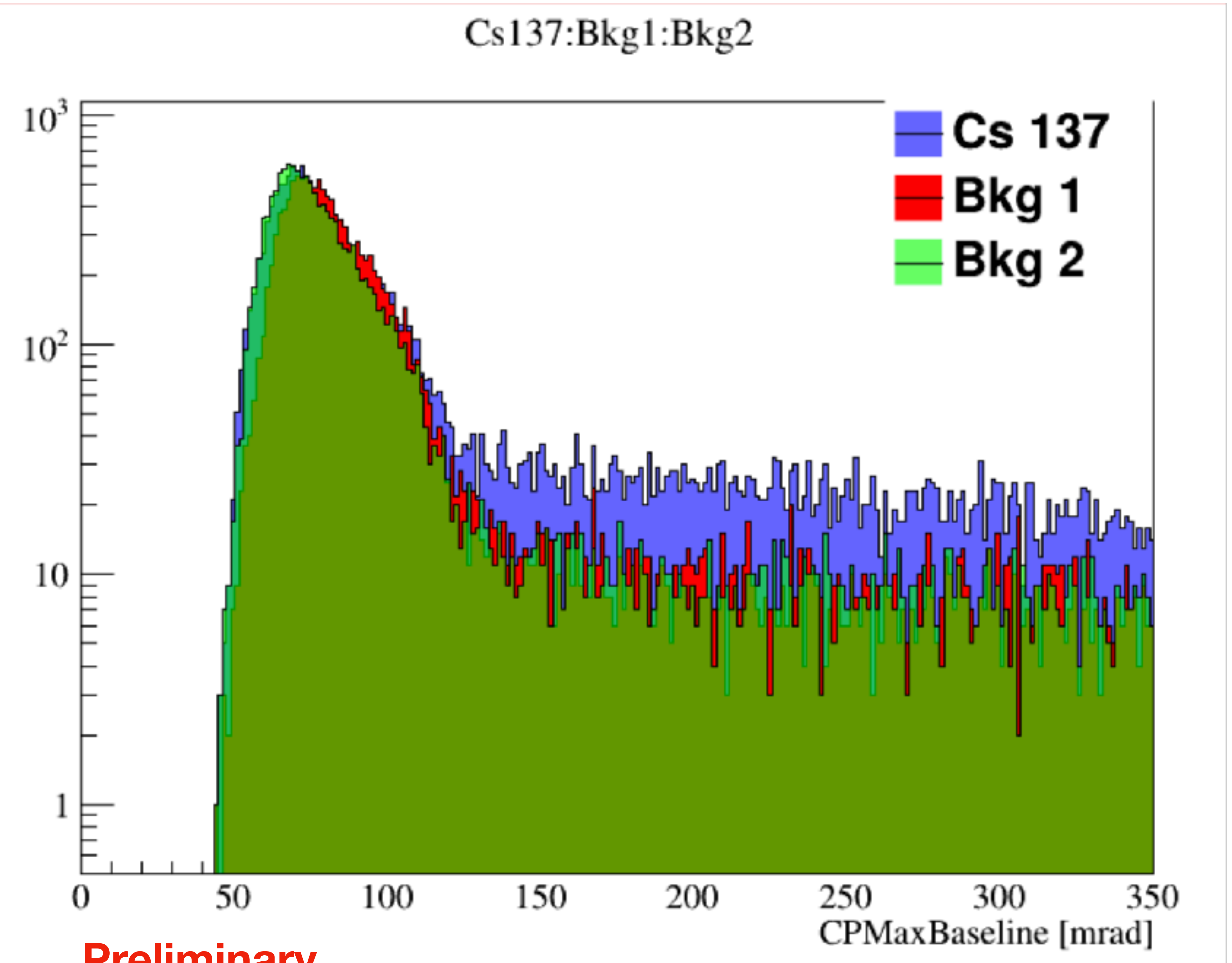
- CP Max Baseline
- No cuts



Preliminary

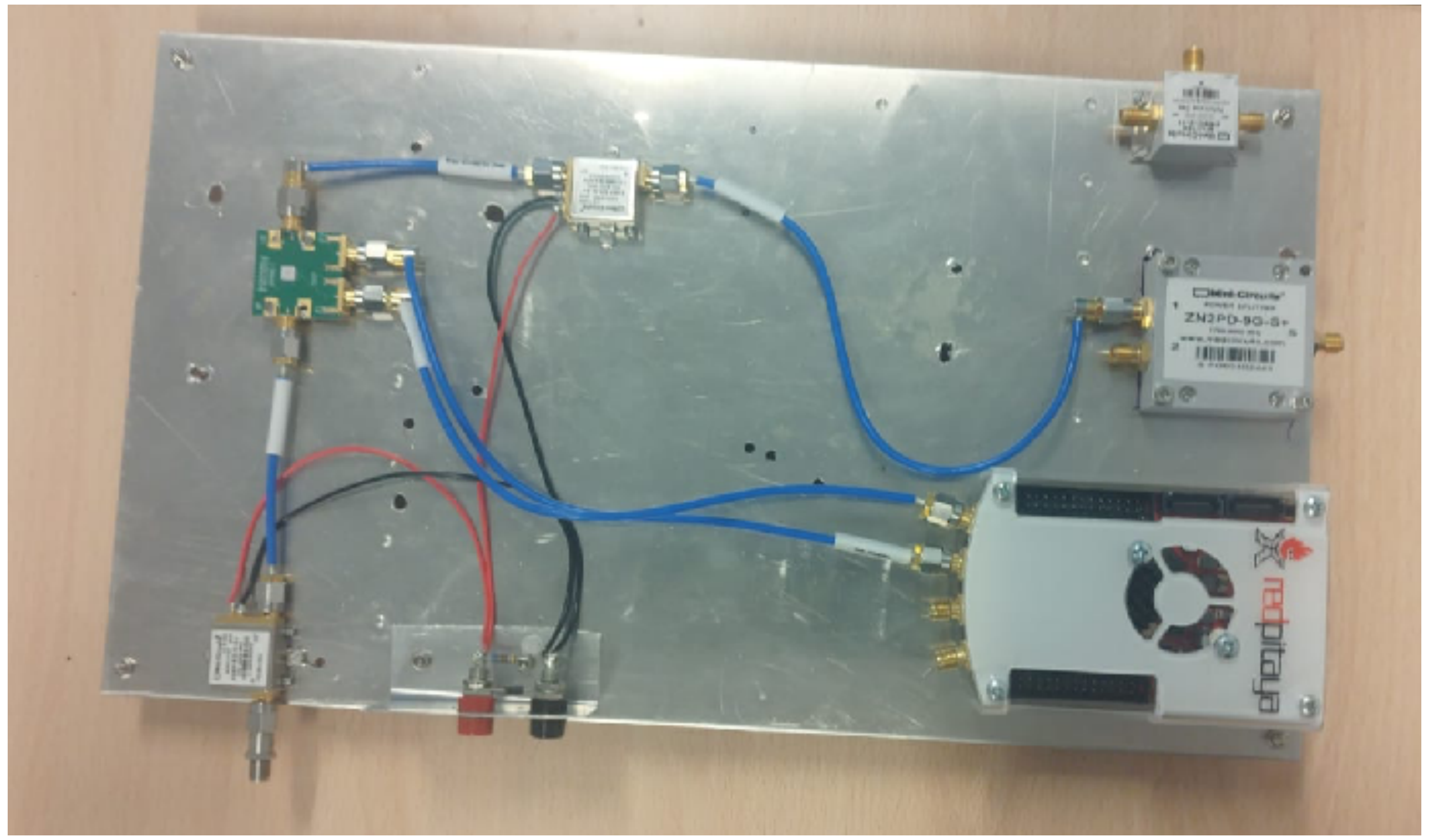


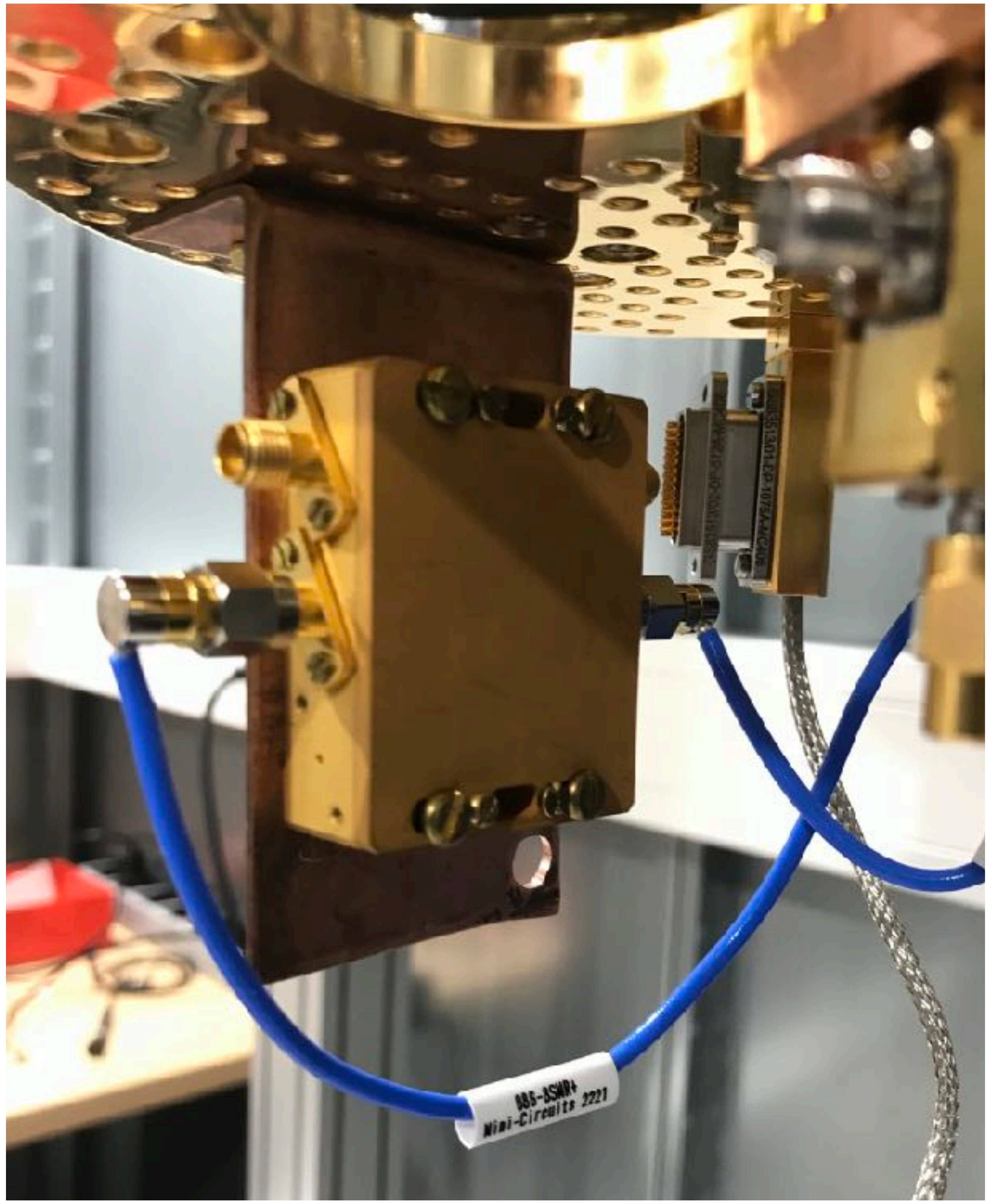
Preliminary

Test of GAGG crystal coupled to MKID:

KID setup in PISA:

- **RF superconductive lines installed at ~ 20 mK and tested**
- **HEMT amplifier installed and tested**
- **Minimal KID readout: mixer + redpitaya**

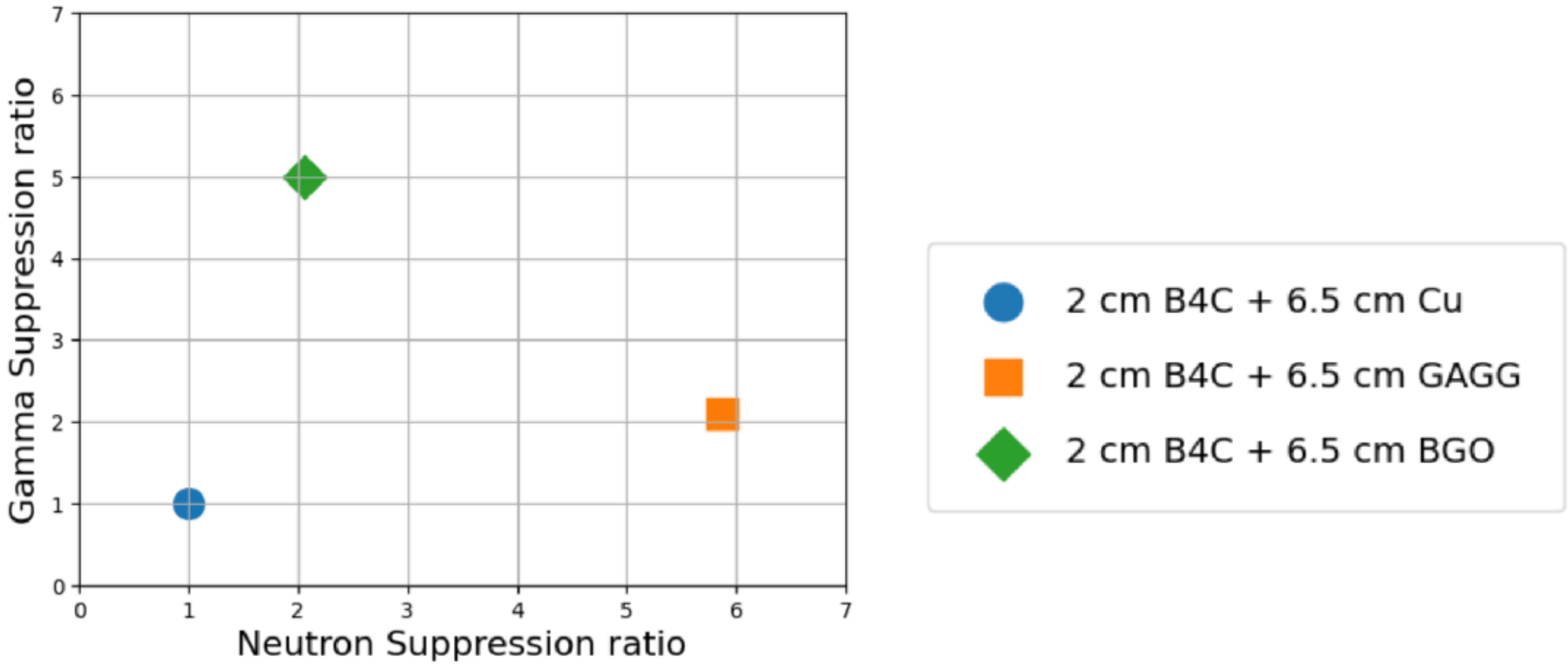


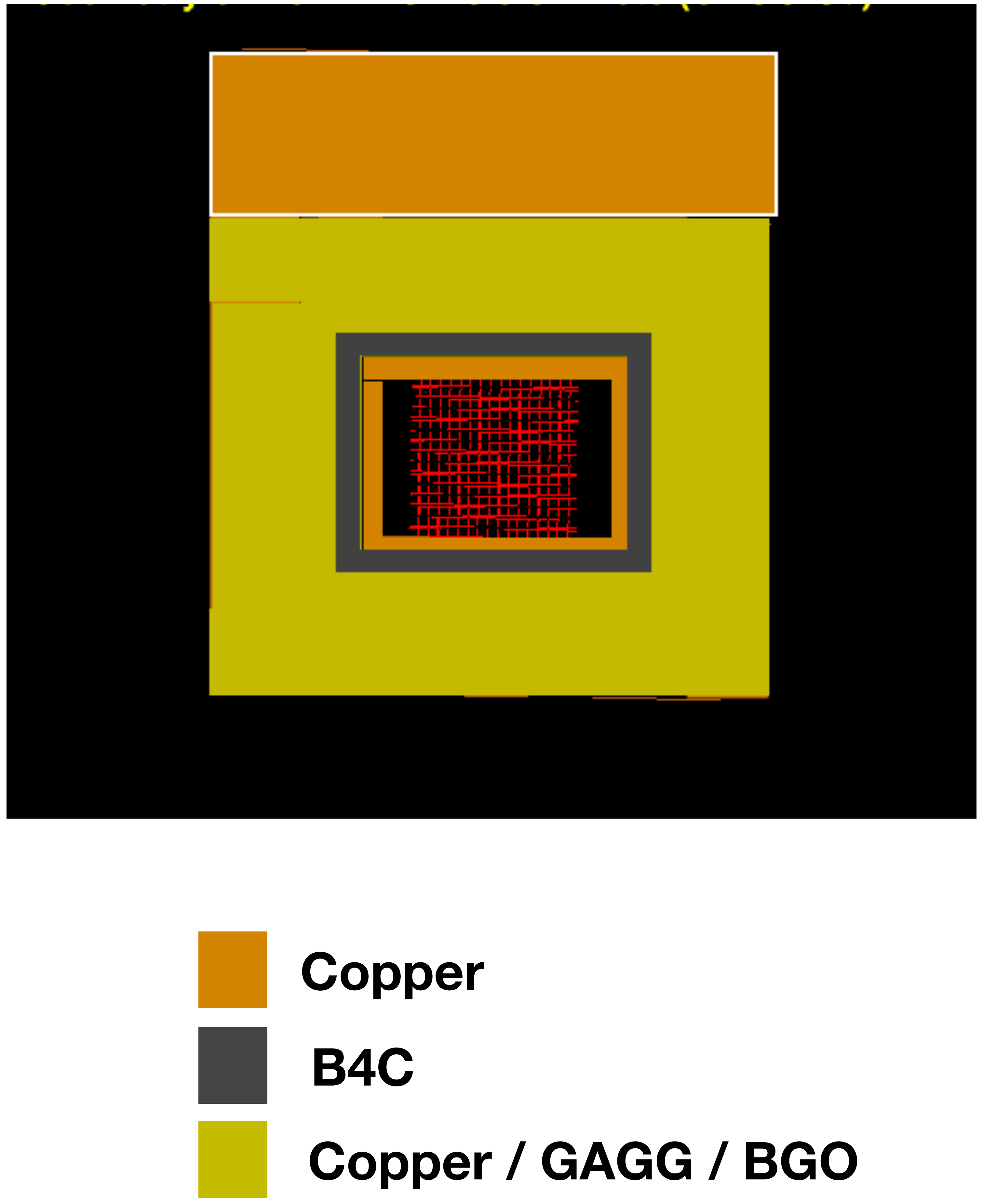


Testing on the GAGG+KID setup (including crystal thermalization, KID resonances, etc.) will continue in Pisa.

Veto simulation:

- **Baseline configuration of internal shields:**
  - **1 cm copper**
  - **2 cm B4C**
  - **6.5 cm Copper**
- **Active veto:**
  - **Subsitute Copper with active material (GAGG, BGO)**
  - **Assuming veto threshold 50 keV**

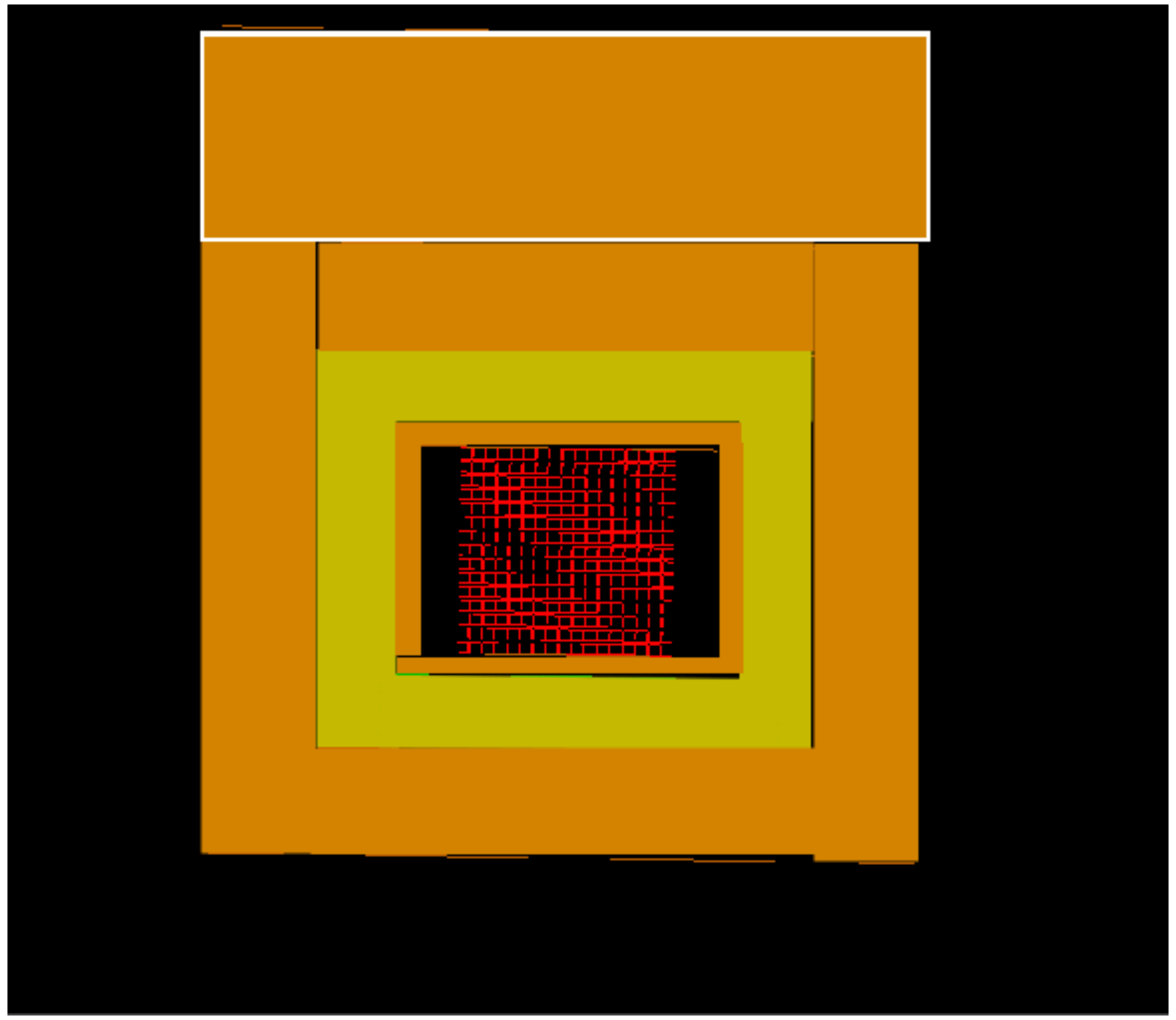




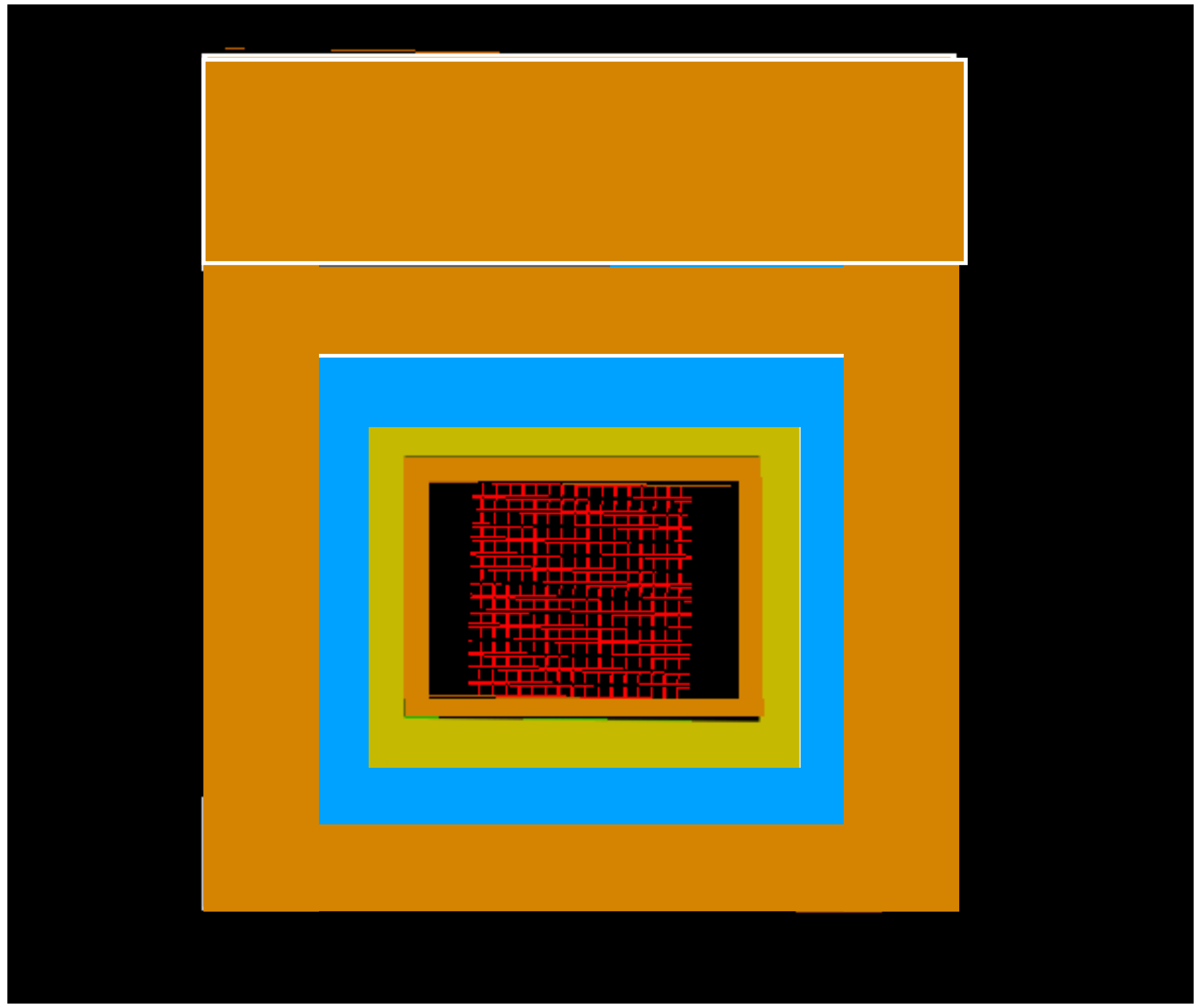
Veto simulation:

- **Exploring different configurations:**

2 .5 cm ative veto (GAGG/BGO)+6 cm Cu



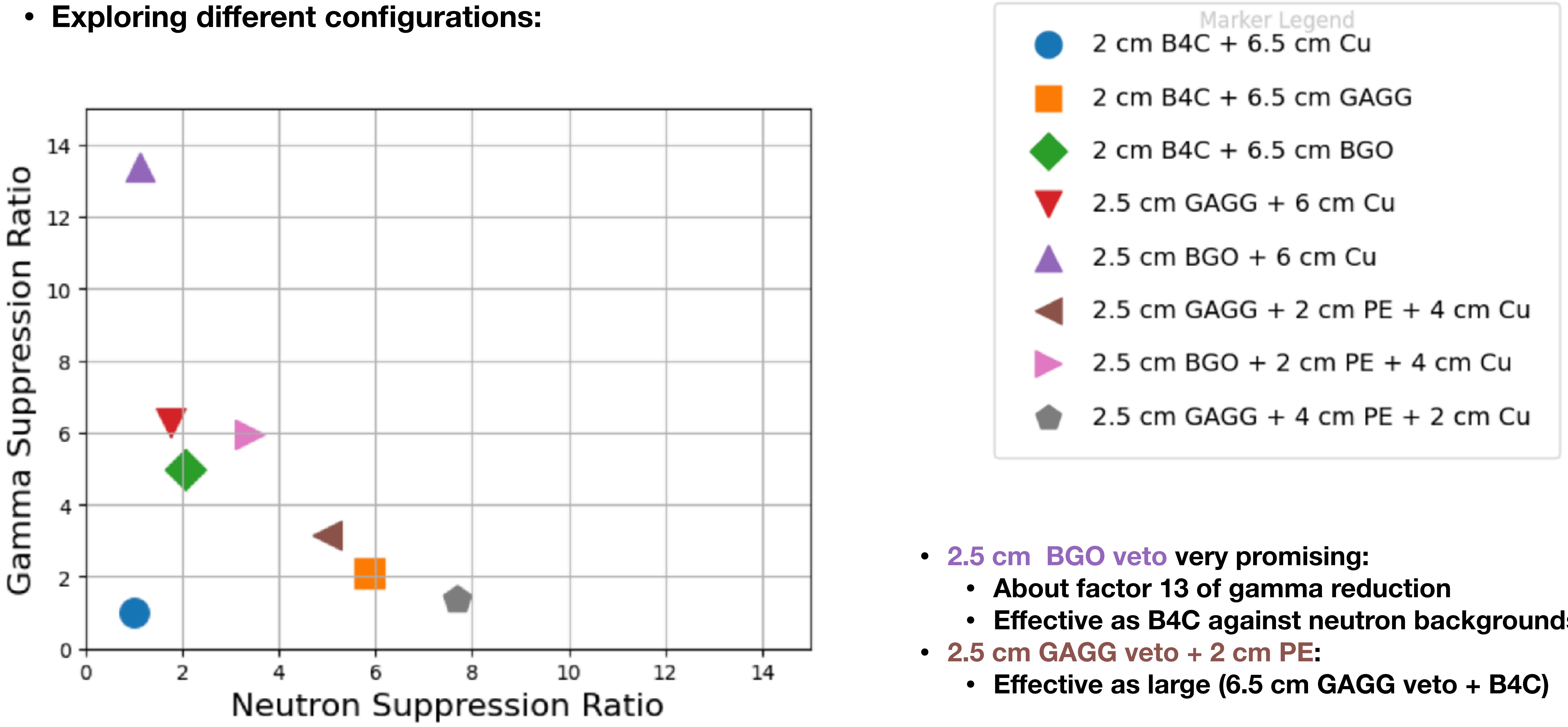
2 .5 cm ative veto (GAGG/BGO)+2 cm PE +4 cm Cu



Copper **GAGG / BGO** **PE**

Veto simulation:

- **Exploring different configurations:**



- **2.5 cm BGO veto very promising:**
  - **About factor 13 of gamma reduction**
  - **Effective as B4C against neutron backgrounds**
- **2.5 cm GAGG veto + 2 cm PE:**
  - **Effective as large (6.5 cm GAGG veto + B4C)**

Crystal Price Quotations:

3 quotations:

- **EPIC CRYSTAL**
- **SCIONIX**
- **ADVATECH**

50 units, GAGG(Ce) crystal, all sides polished, 35x35x100 mm:
US$11,300/each ——--> 92 USD/cm^3

50 units, GAGG(Ce) crystal, all sides polished, 35x35x51 mm:
US$5,450/each ———--> 88 USD/cm^3
50 units, BGO crystal, all sides polished, 35x35x100 mm: US$1700/each
————-->>14 USD/cm^3
50 units, BGO crystal, all sides polished, 35x35x51 mm: US$860/each

Veto thickness cm	Volume cm3	GAGG (88 USD cm3)	BGO (14 USD cm3)
2.5	3330	**306** K USD	**46** K USD
3.5	5266	**484** K USD	**73** K USD
6.5	17734	**1631** K USD	**284** K USD

1. **Price excluding VAT**
2. **Assuming no waste of material**

Conclusions:

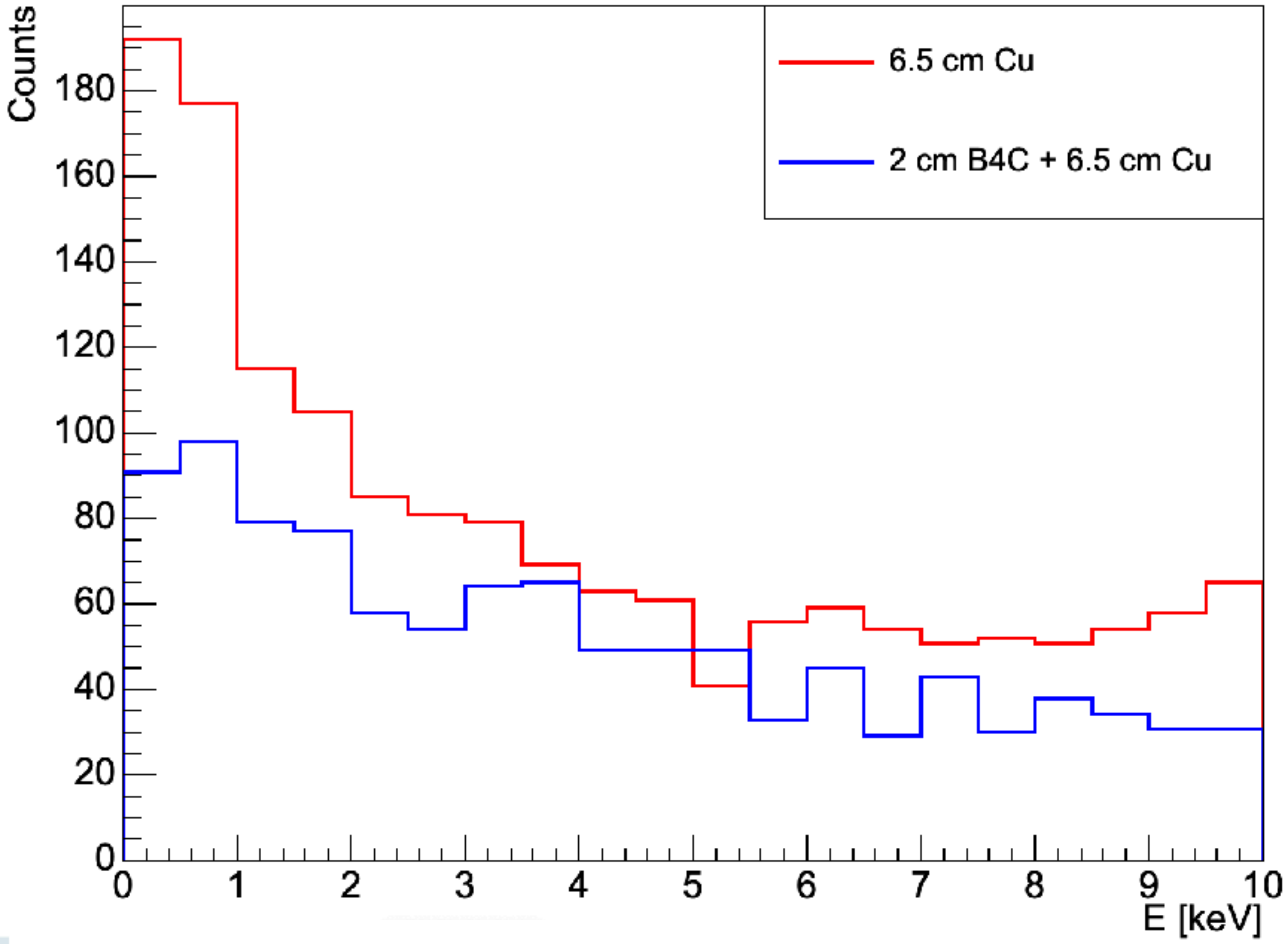
- Tests of a benchmark detector, representing a single veto module, have started.
- A small (2.5 cm thick) active veto effectively reduces backgrounds (factor ~ 13 of gamma reduction) while remaining cost-effective

NEXT STEPS:

- Study of KID + GAGG setup including: thermalization of KID and thermalization of GAGG. (Will continue in Pisa)
- Simulate a realistic veto module including: crystal support, KID sensor, photon transport.

Backup:

B4C vs NO B4C



Optimal detector parameters