

# ORIGAMIX



DE LA RECHERCHE À L'INDUSTRIE

cea



## CURRENT STATE OF A TECHNOLOGY TRANSFER PROJECT FROM SPACE GRADE HIGH ENERGY SPECTRO-IMAGER TO COMMERCIAL GRADE GAMMA CAMERA



[www.cea.fr](http://www.cea.fr)

*Pierre-Anne BAUSSON*

*CEA Saclay – DRF/Irfu*

*B. 709 p. 27 – B. 141 p. 104*

MAY 24TH 2016 – CEA SACLAY

## ORIGAMIX

- ✓ Personal & project introduction
- ✓ Existing CALISTE technology
- ✓ Project tasks & organization
  - ✓ Compton-effect based algorithm development
  - ✓ Embedded modular system design
  - ✓ Space technology downgrading
- ✓ Tests, results and current state of project
- ✓ Remaining steps & Perspectives
- ✓ Conclusion

- ❖ 25 years old INSA Lyon electronics engineer
- ❖ 1 year finished term contract @SAp, finished 3 weeks ago
- ❖ Now : Permanent position @SEDI, same research institute but a more technical department



ANR : French **N**ational funding **A**gency for **R**esearch



RSNR : **R**adioprotection & **N**uclear **S**afety **R**esearch projects call

## ORIGAMIX

Stands for :

**I**ocalisation de la **R**adioactivité par **I**mageurs **GAM**ma **piX**ellisés

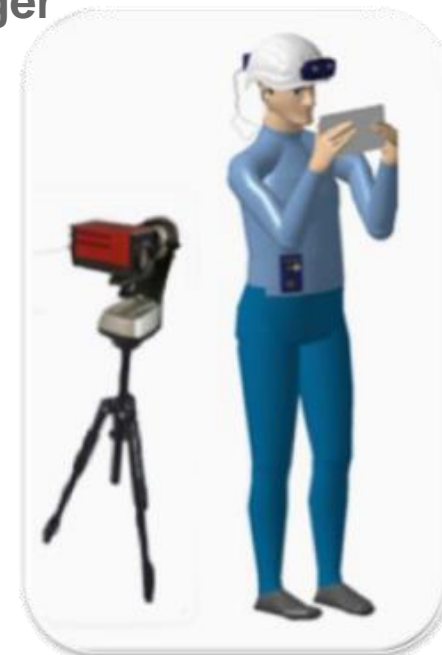


**piX**elated **GAM**ma **I**mager for **R**adioactivity **I**ocation

**Main goal** : Design a new generation of gamma imager

**Specifications** :

- Smaller / Easier-to-use system
- Better spectroscopic resolution
- Higher energy range
- Innovative Compton effect-based source location algorithm



Consortium : CEA : DRF/Irfu – DRT/LIST – DEN/MAR  
3Dplus – Areva Canberra – IRSN – GIE INTRA

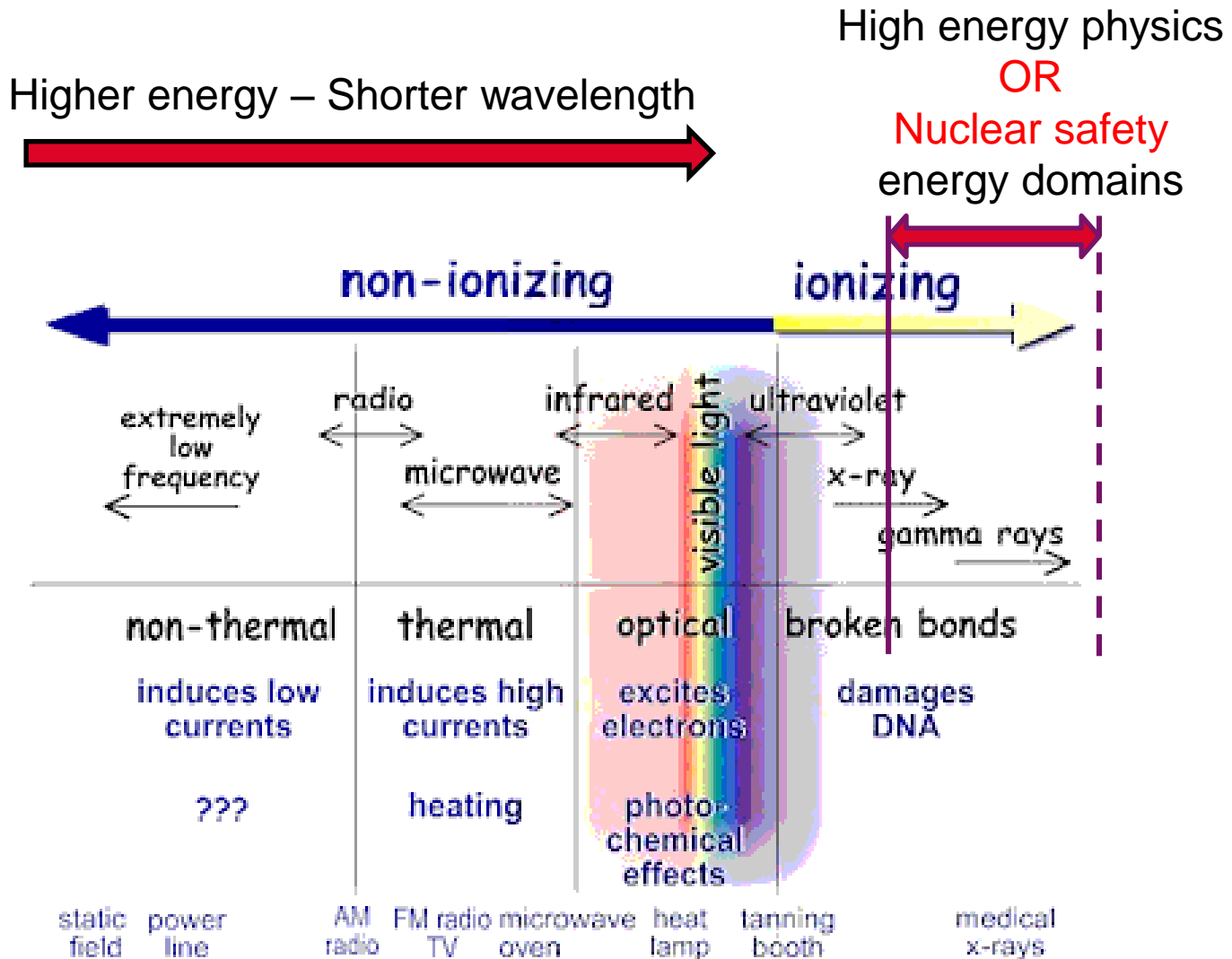


CEA DRF/Irfu roles :

- Third generation “3G” gamma camera prototype development
  - Embedded modular system design
  - Acquisition chain electronics design
  - Compton effect based location algorithm
- CALISTE space technology “downgrading” / cost optimization

## So how to do this ?







## Compact Objects

Point sources  
Continuum spectra

## Gamma Ray Bursts

Point sources  
Light curves  
Continuum spectra

- Space applications
- Wide field imaging
- High angular resolution
- Wide energy band
- High energy resolution
- Time resolution

## Supernovae remnants

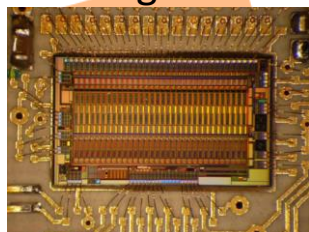
Line spectra  
Point or diffuse sources  
( $^{44}\text{Ti}$ ,  $^{57}\text{Co}$ ,  $^{56}\text{Fe}$ , )

## Diffuse Emission

Fine spectroscopy  
( $^{26}\text{Al}$ , 511 keV)  
Extended sources

## IDEF-X HD ASIC

32 analog channels



Mounting on PCB

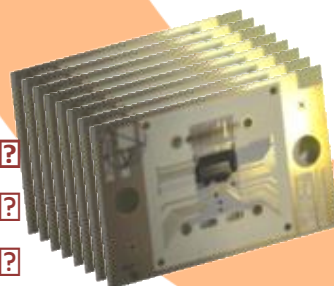
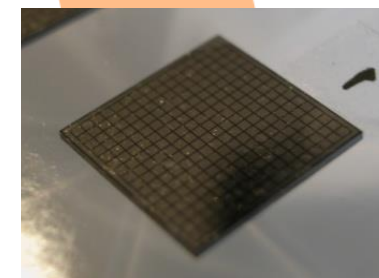


## CdTe 256-pixel detector

(625 μm pitch, 1.0 or 2.3 mm thick, Al Schottky)

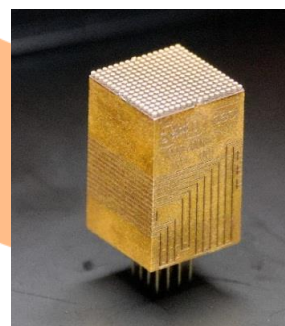
+

(Pt entrance electrode)



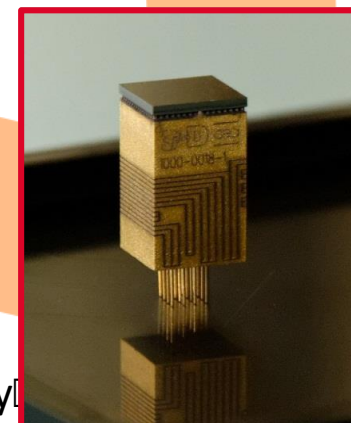
8 ASIC stacking  
perpendicular to the  
detection surface

Top surface preparation



Electrical body  
with a 24x24 pin grid array

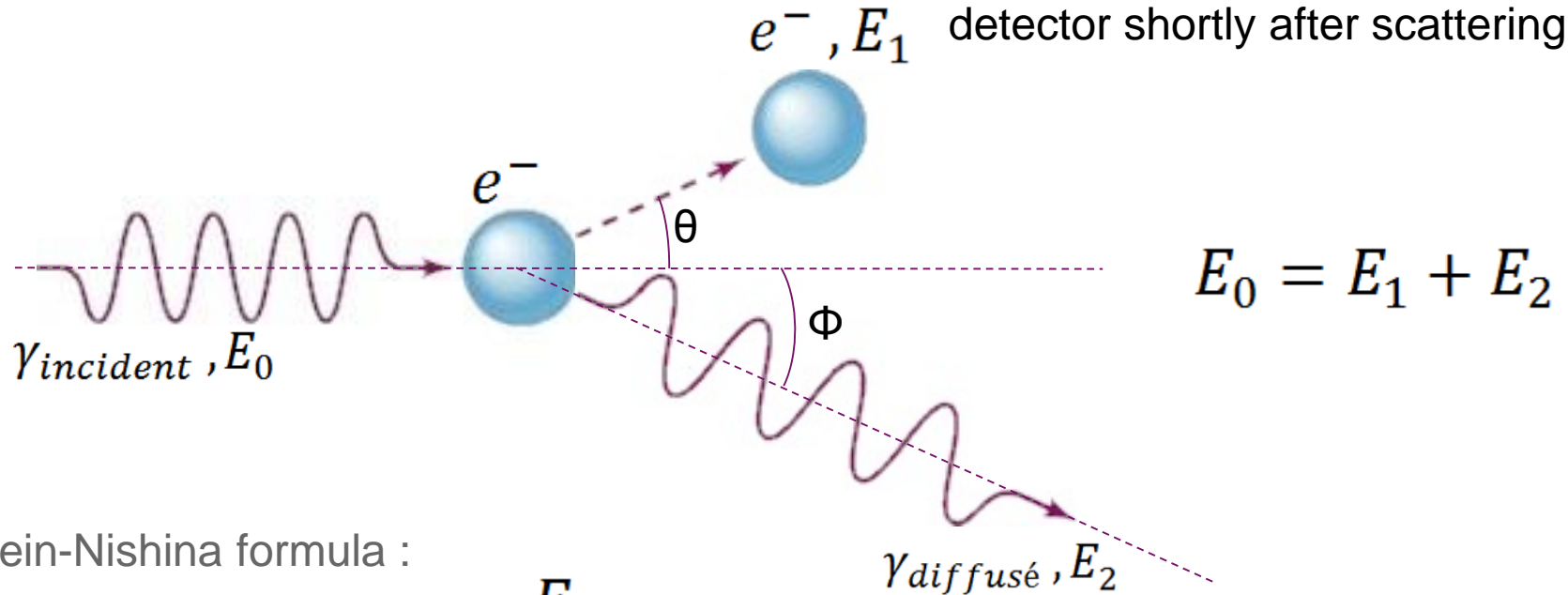
## Caliste-HD camera



## The Compton effect :

Significant effects for  $E_0 > 100 \text{ keV}$

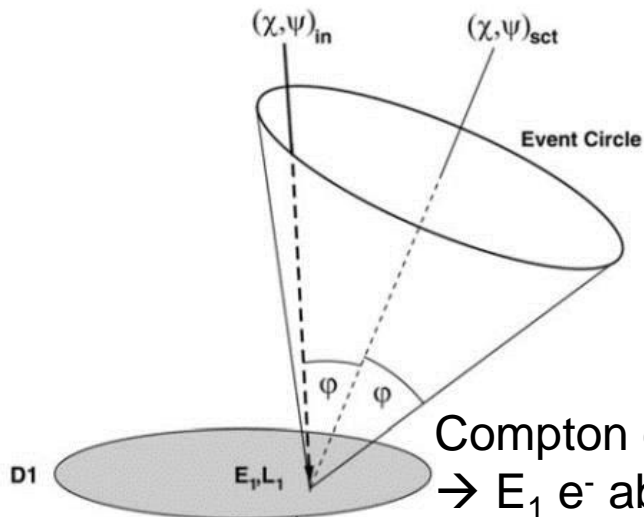
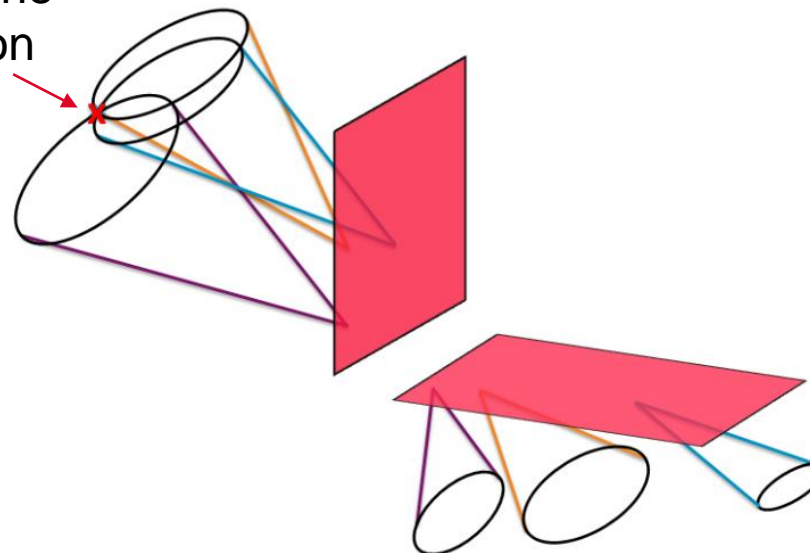
Deposited entirely inside the detector shortly after scattering



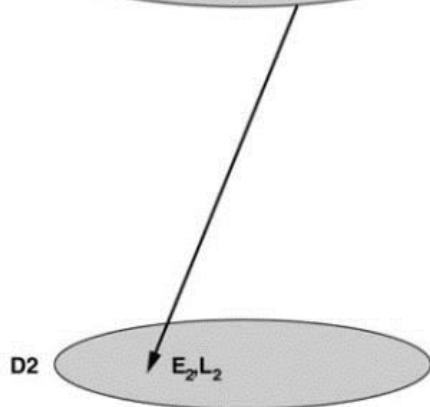
Klein-Nishina formula :

$$\cos(\theta) = 1 - m_e c^2 \frac{E_1}{E_2 E_0}$$

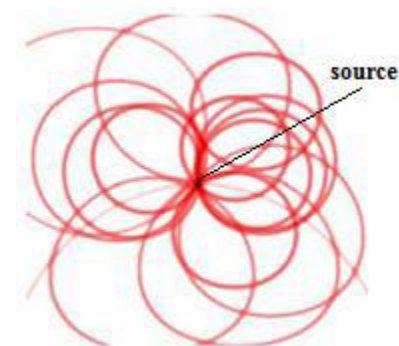
Source is at the circles junction

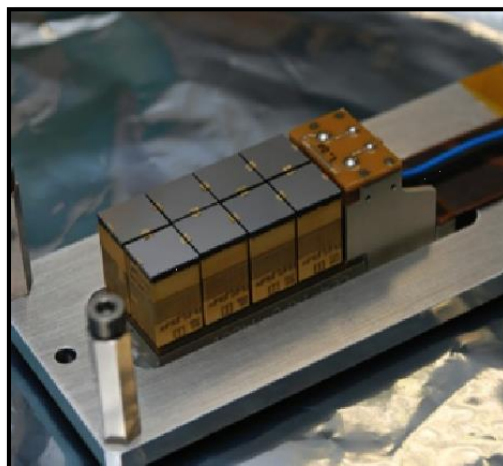
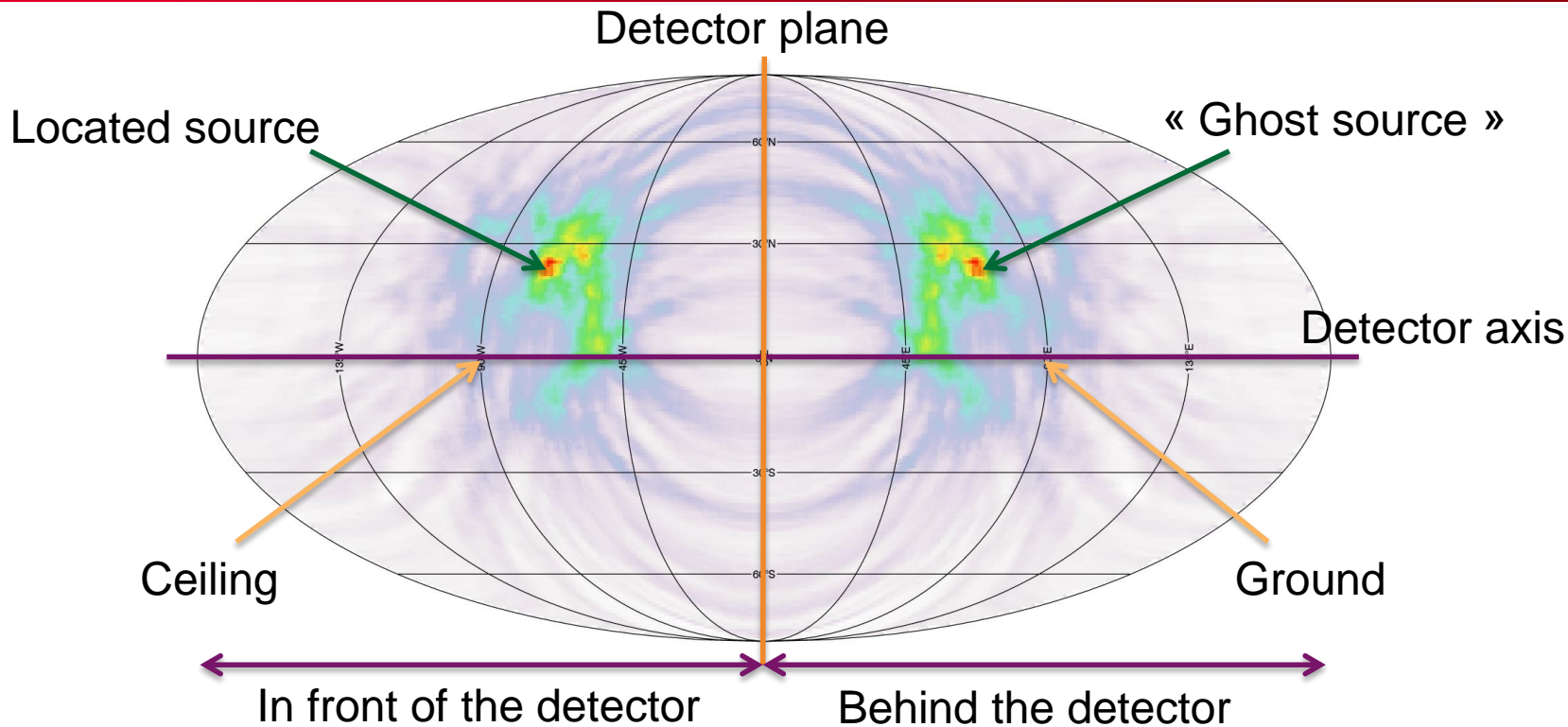


Compton diffusion  
→  $E_1$   $e^-$  absorption in CdTe



Scattered lower-energy  $\gamma$  photon  
 $E_2$  photoelectric absorption in CdTe

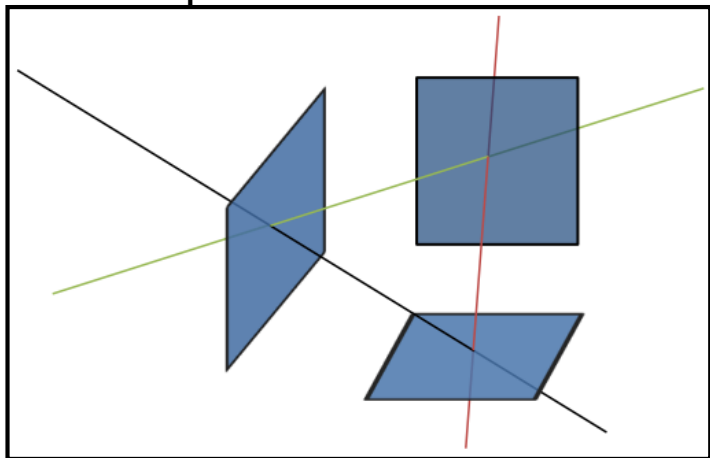




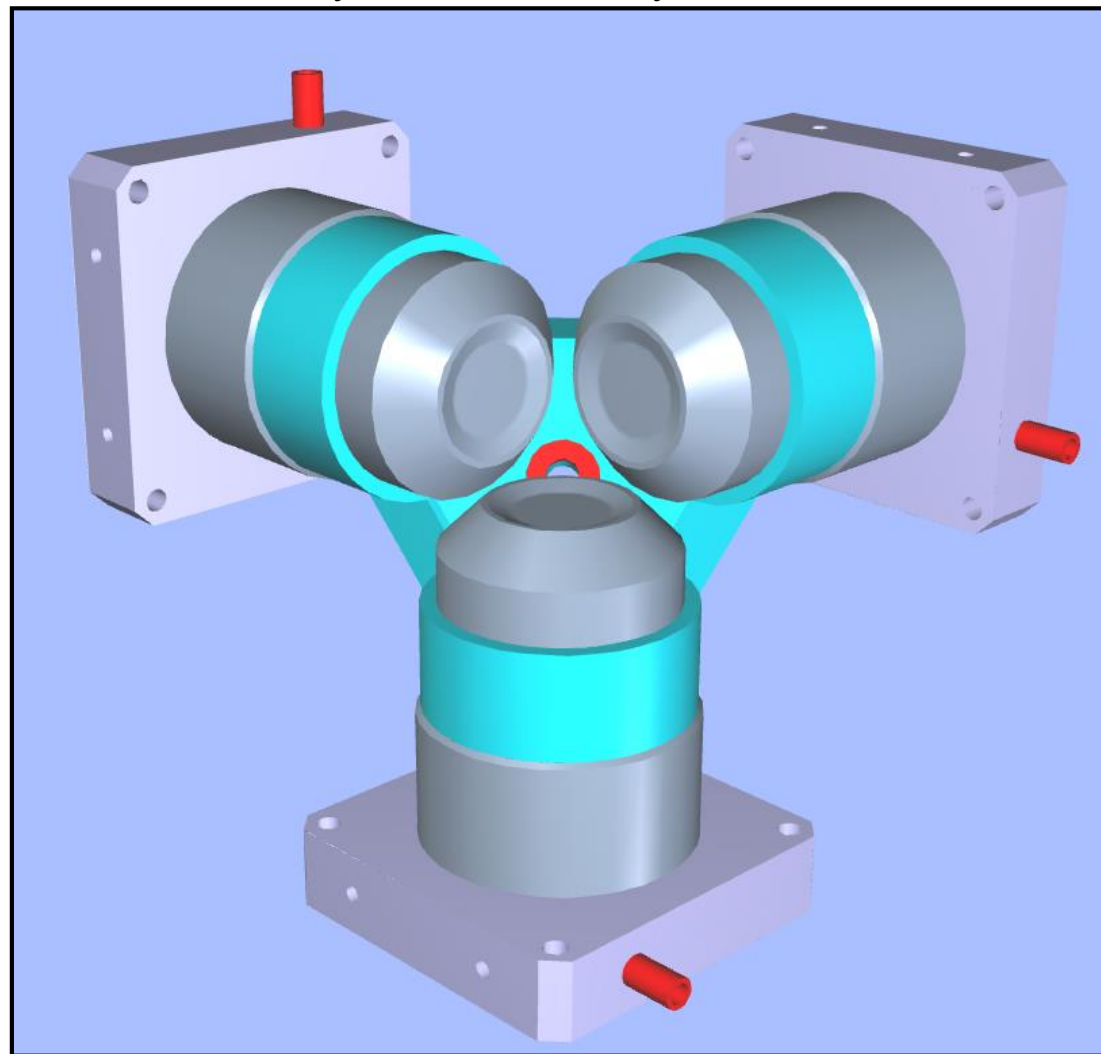
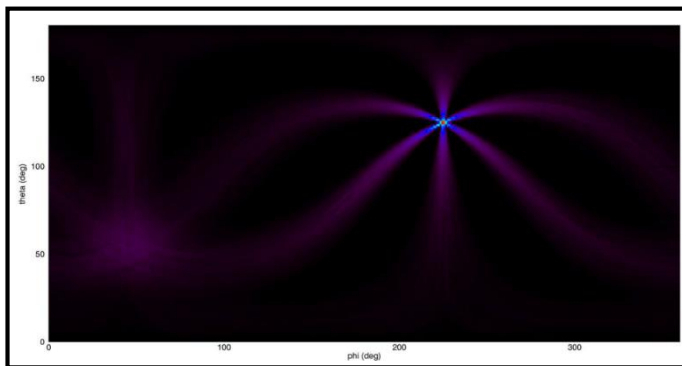


Corner cube system assembly:

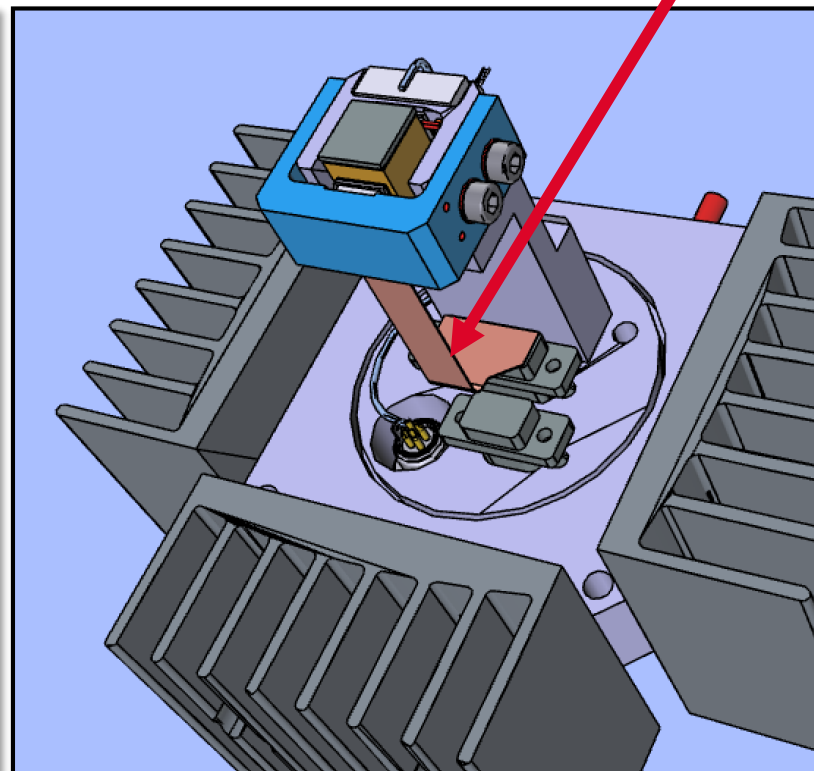
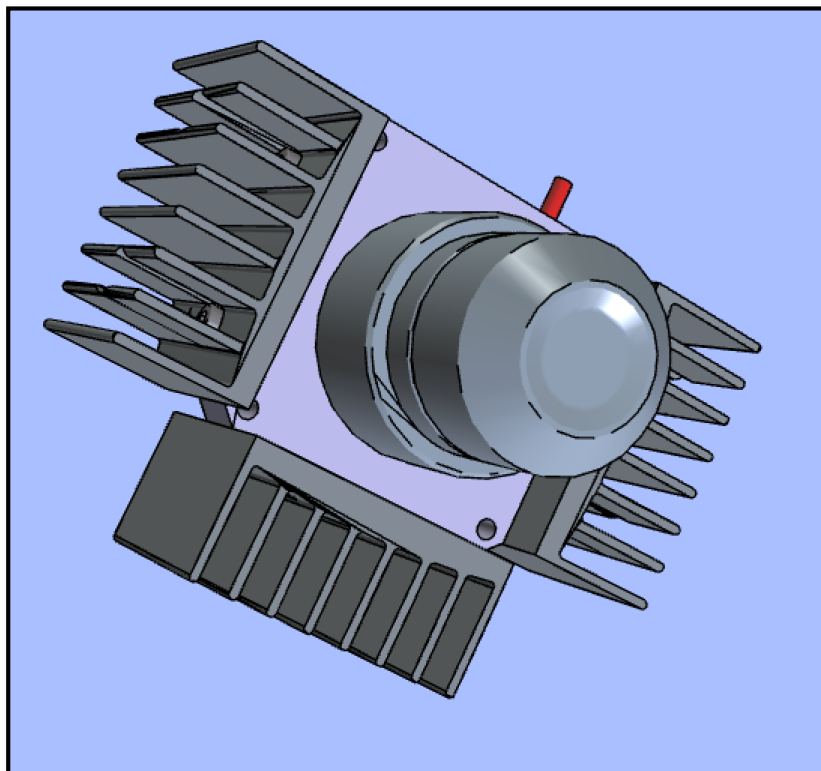
Detector planes in corner cube :

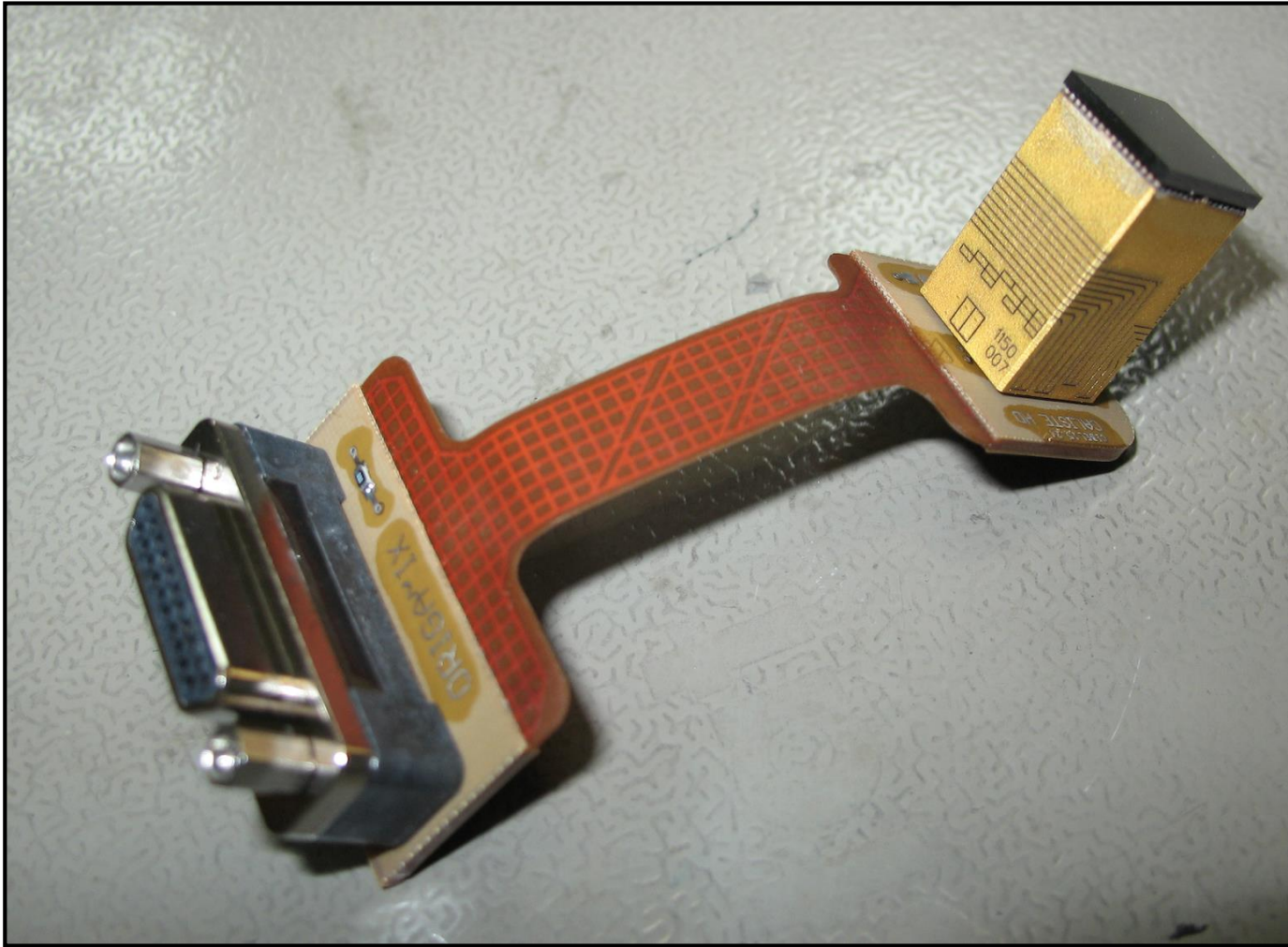


Simulation results :

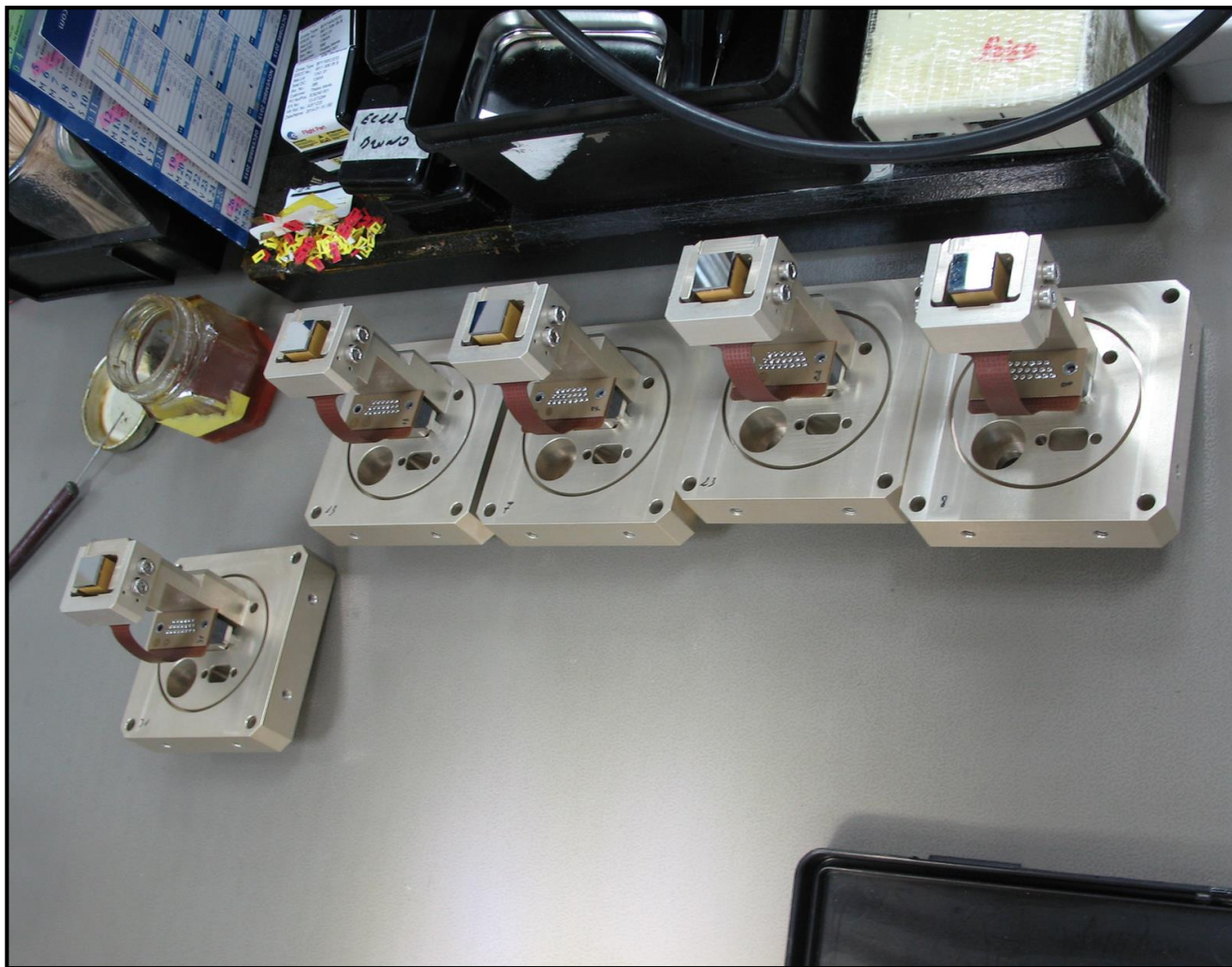


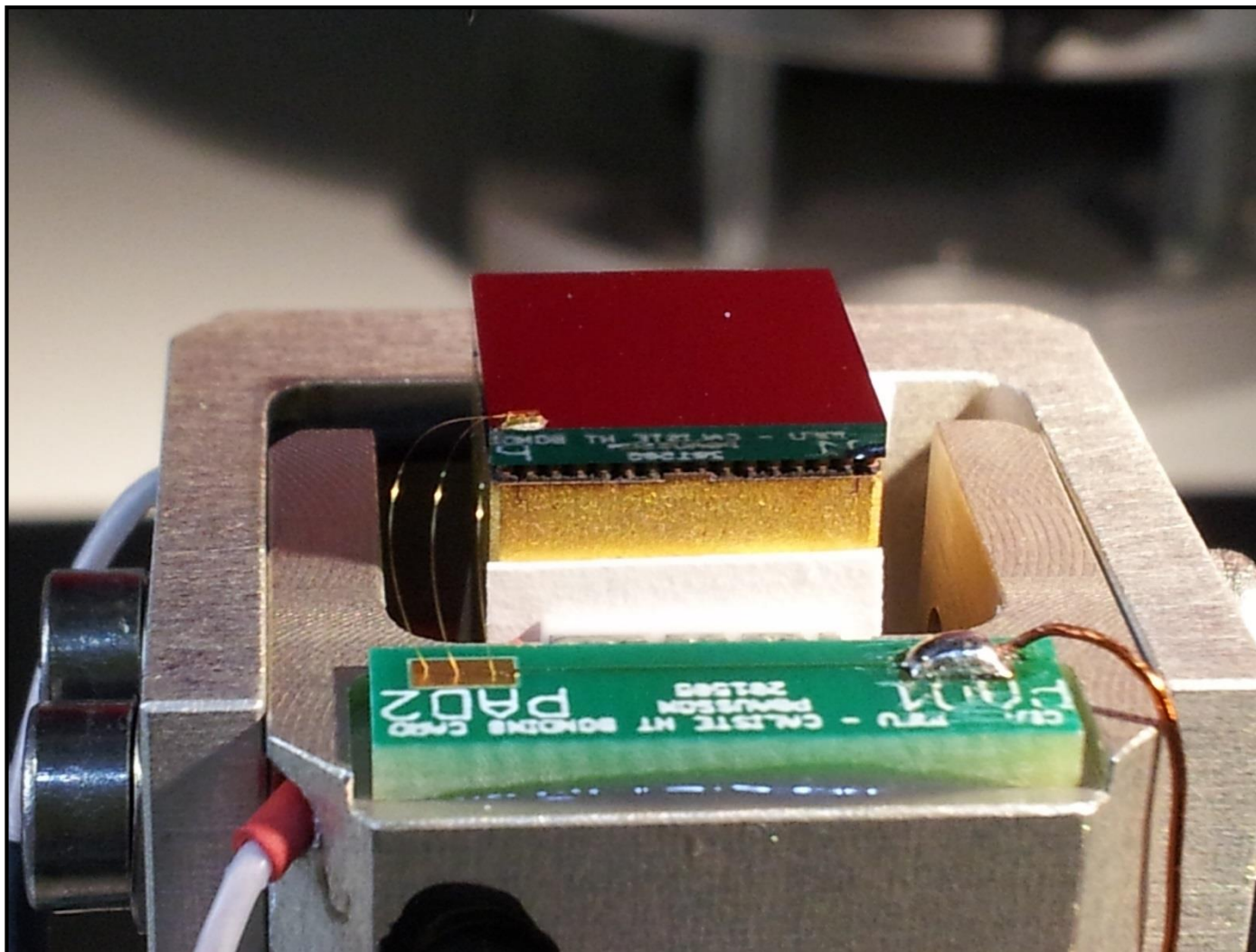
Flexible PCB





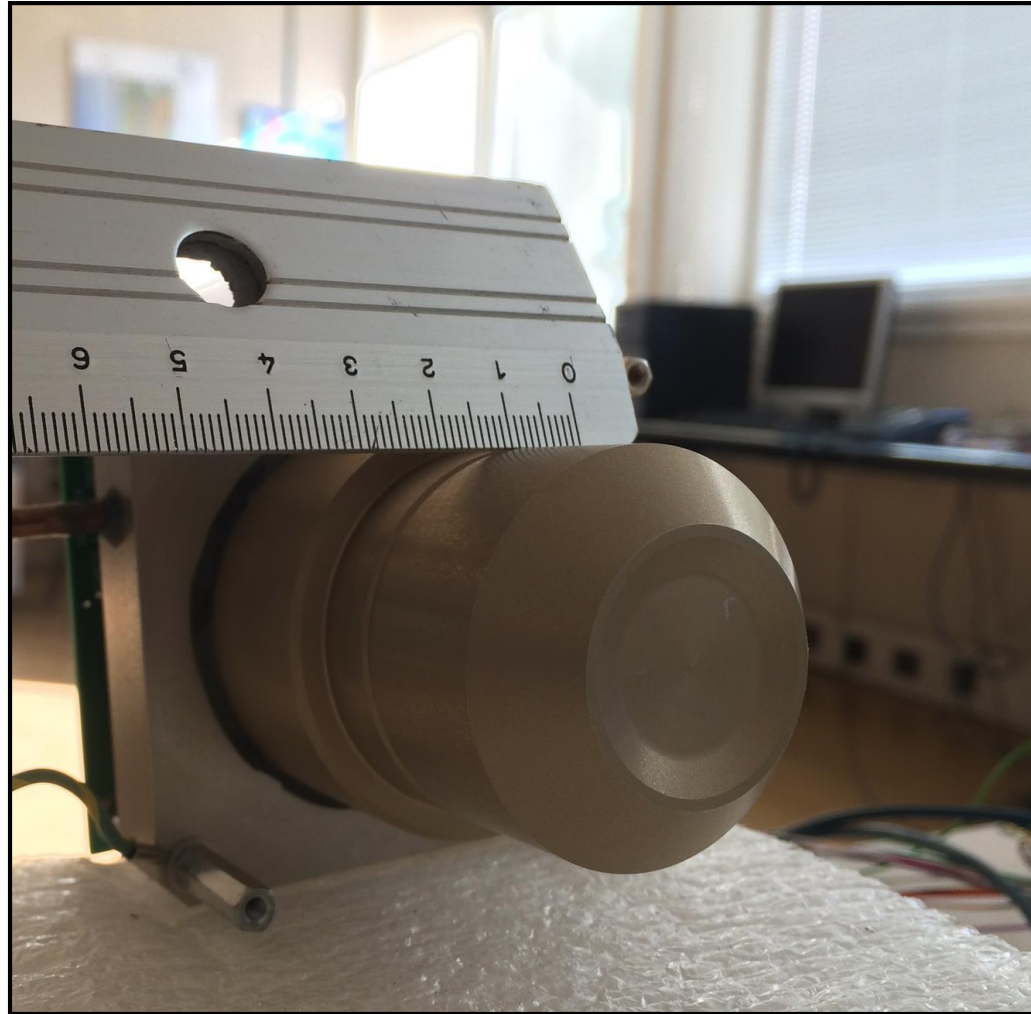


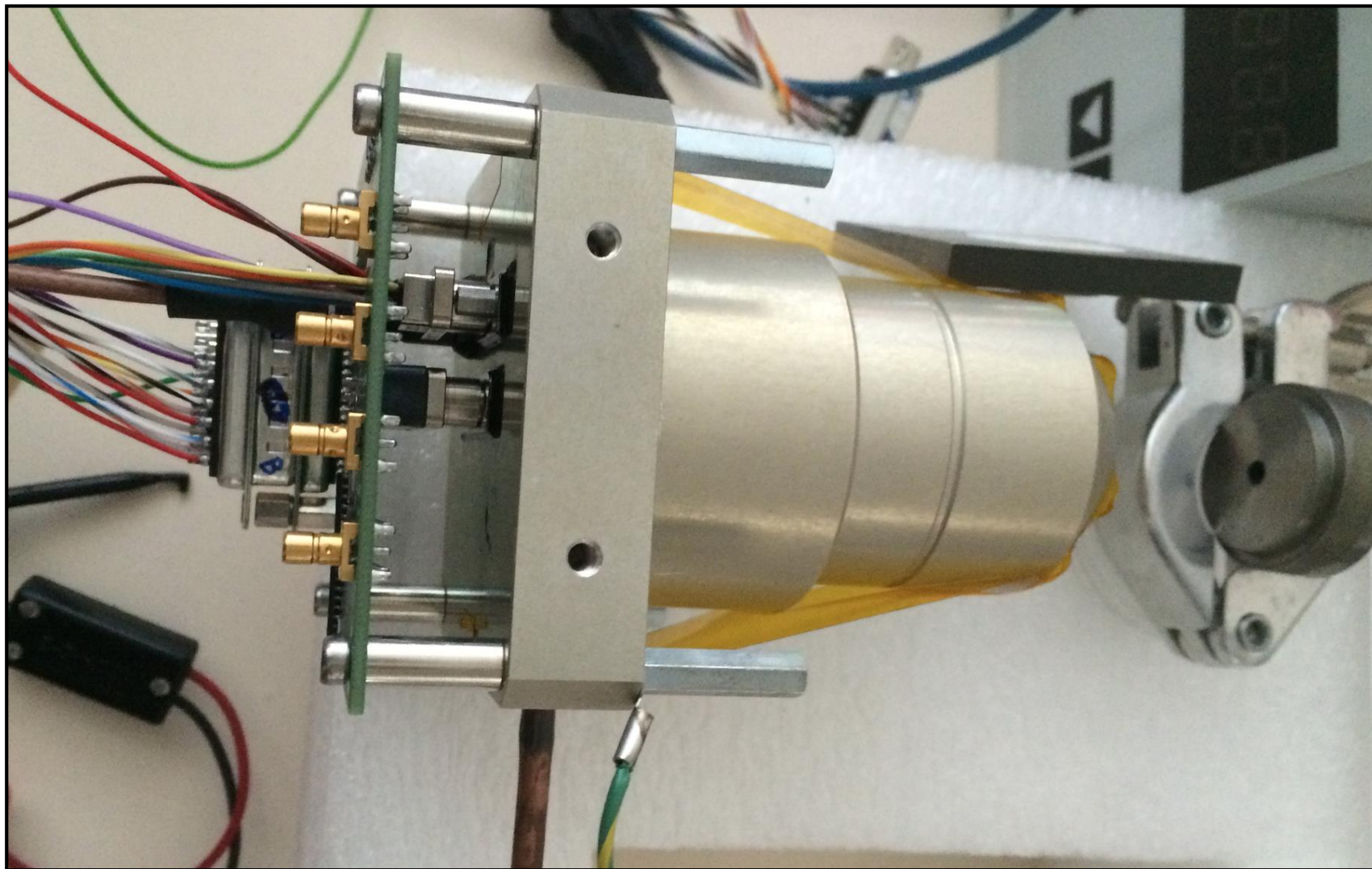




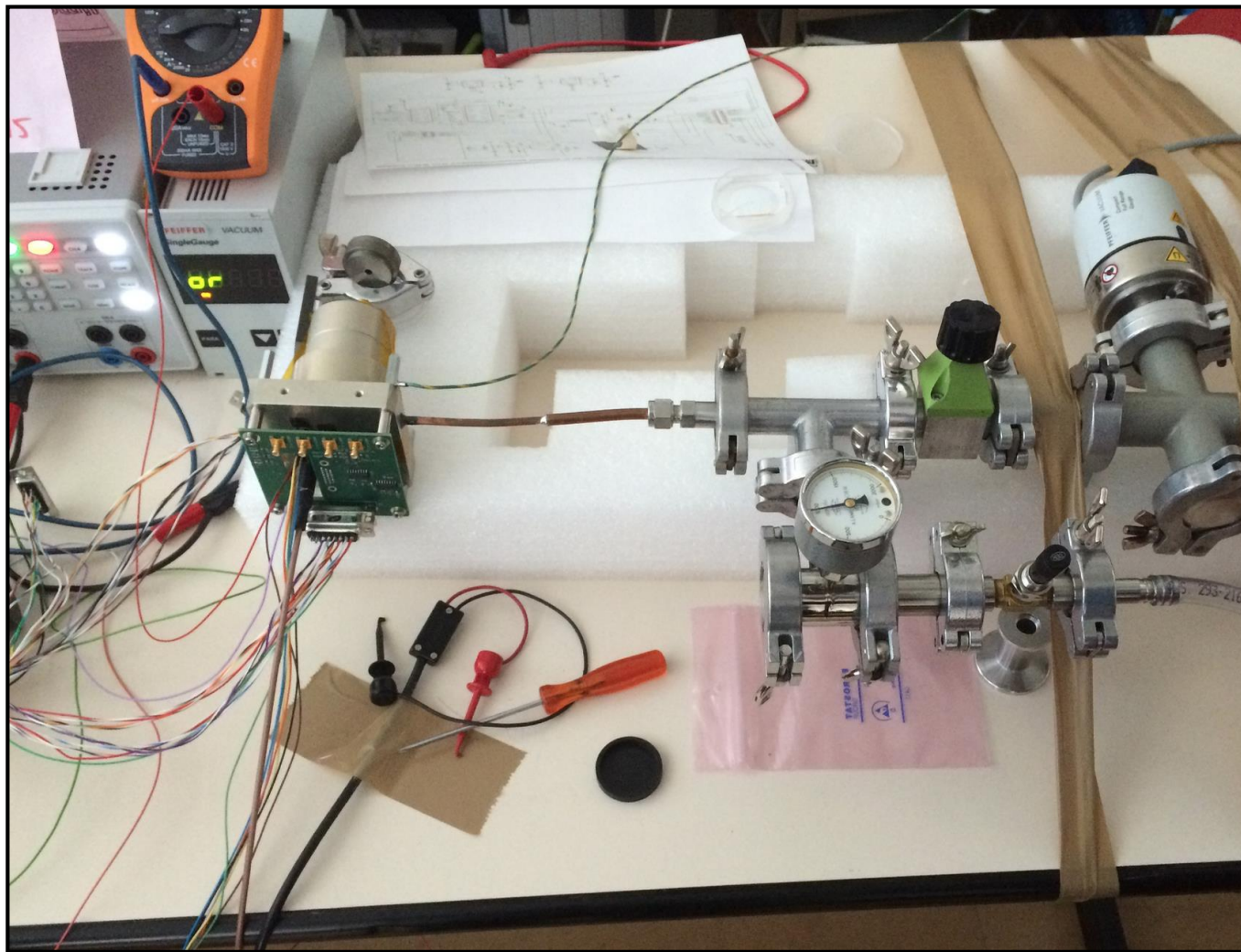






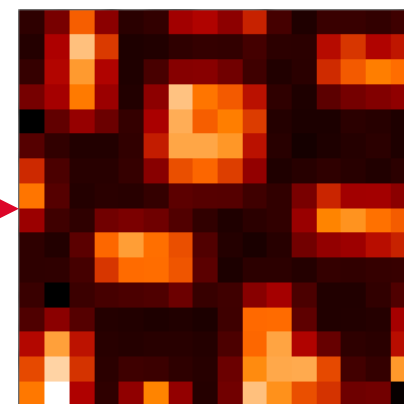
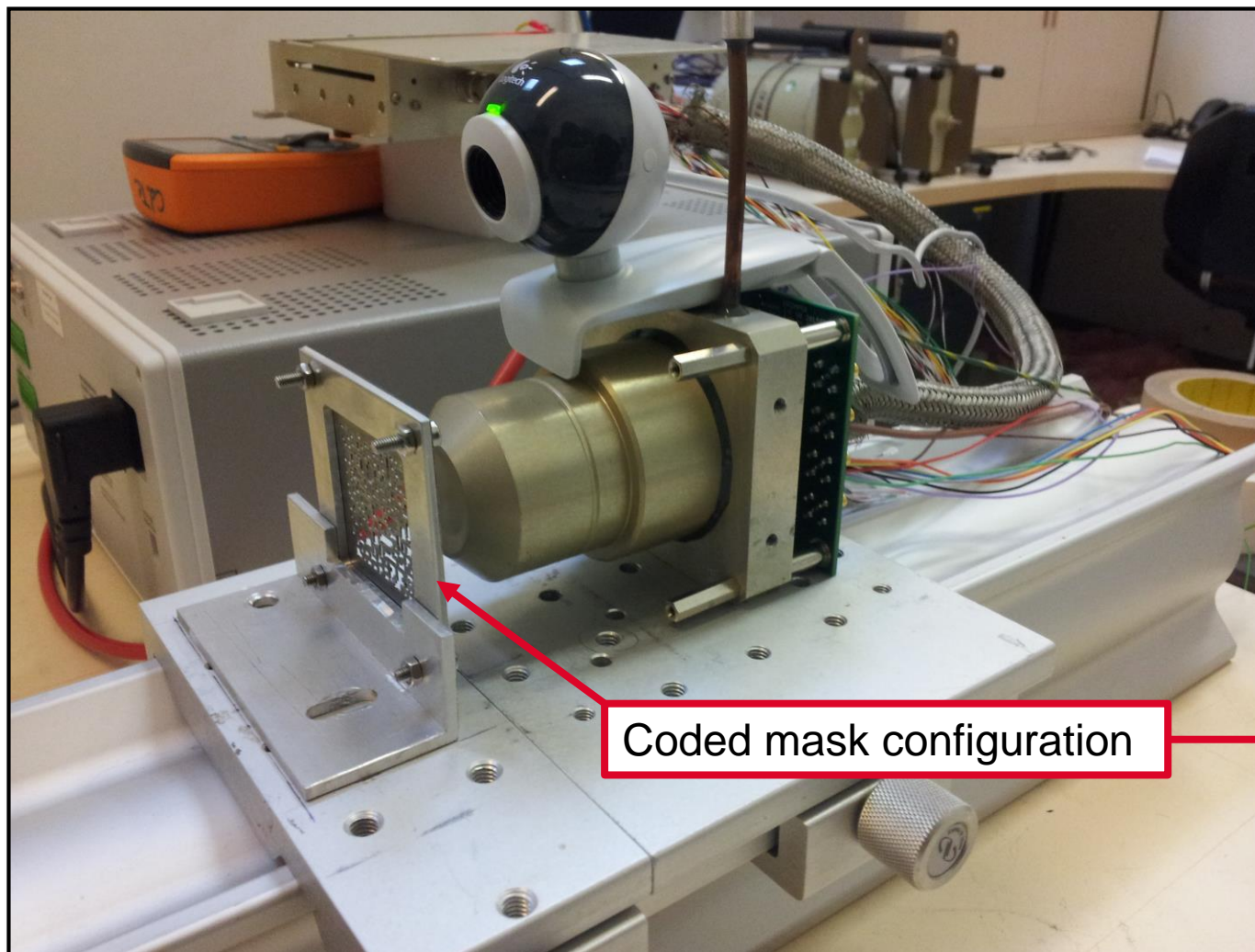






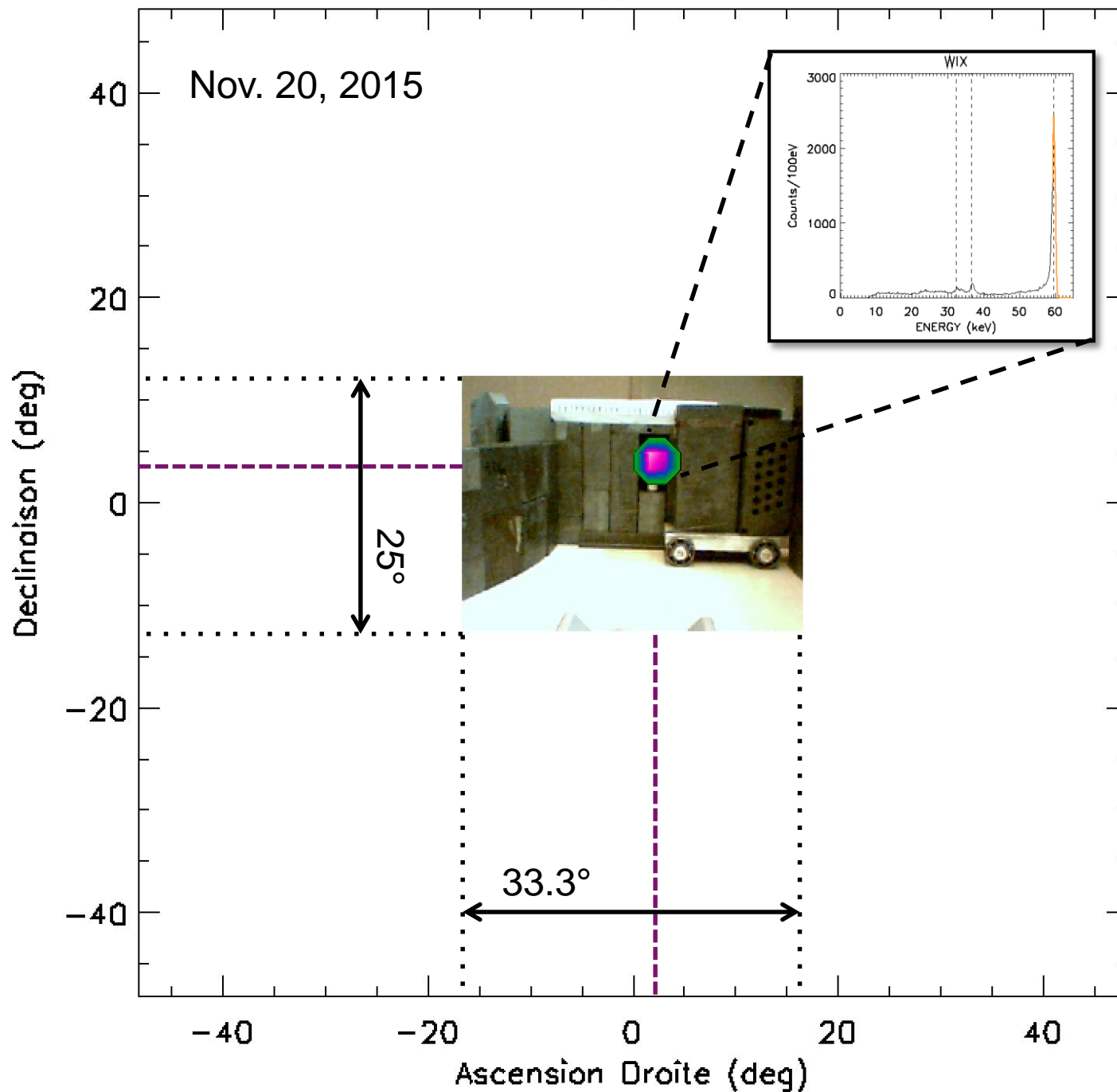


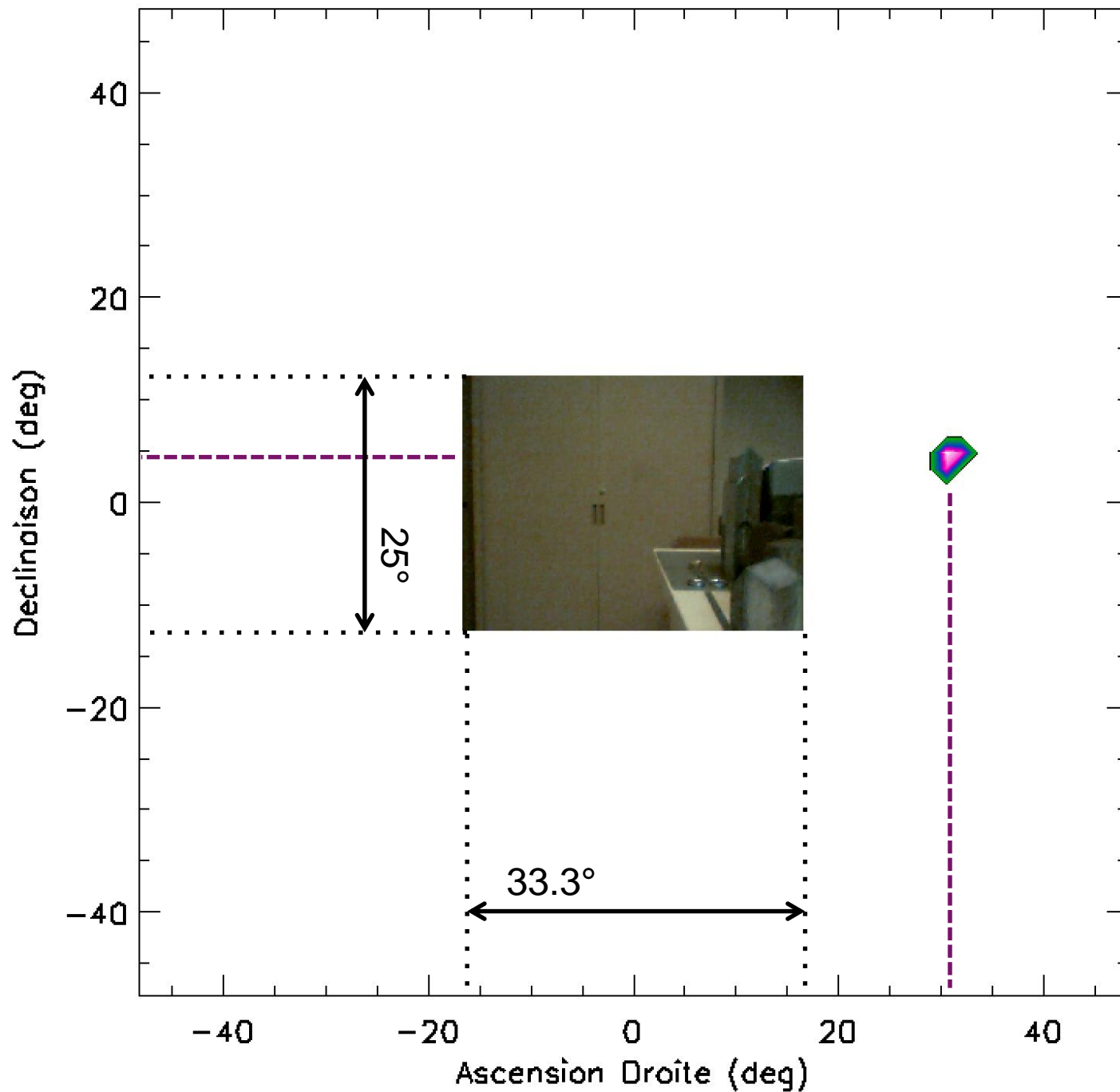




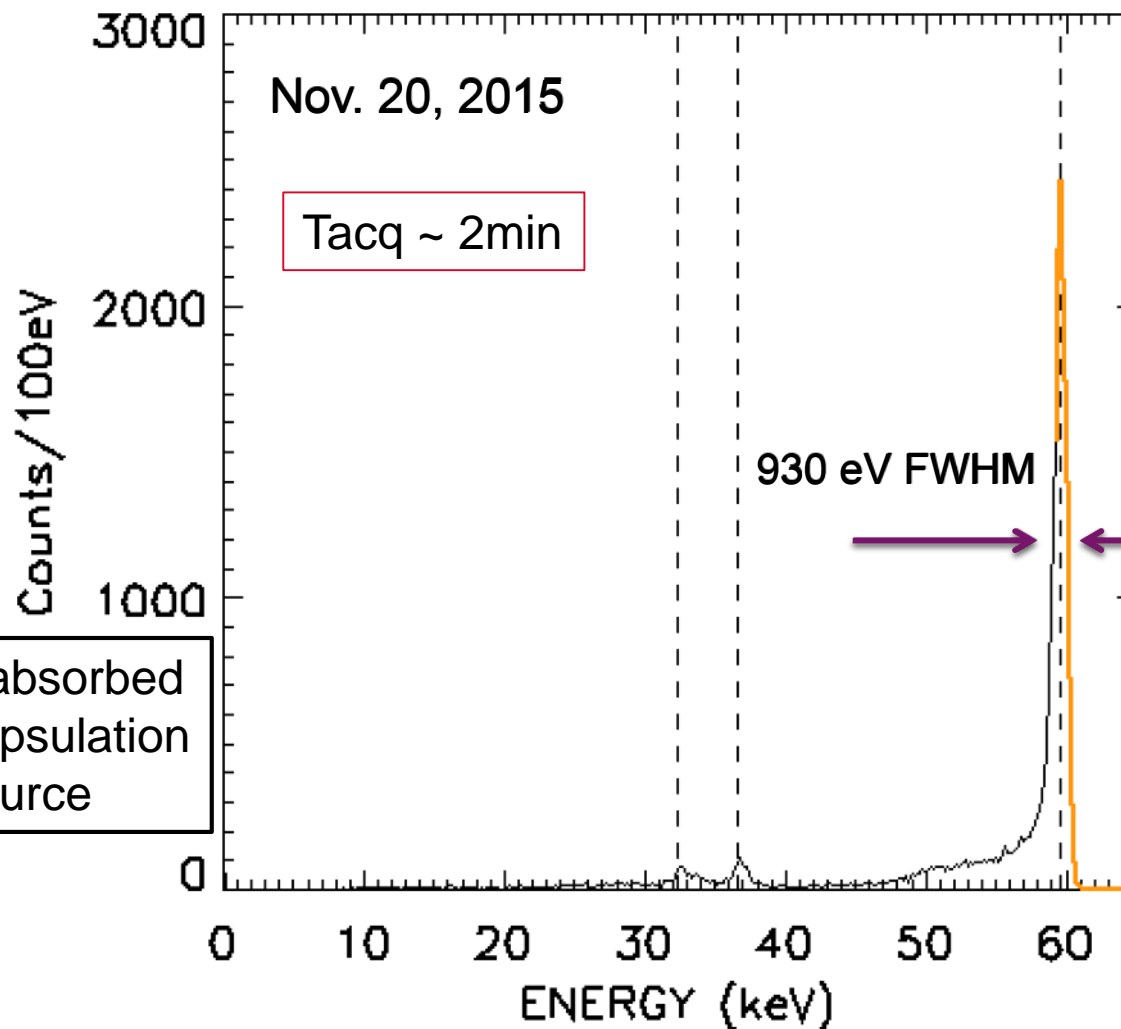


WIX



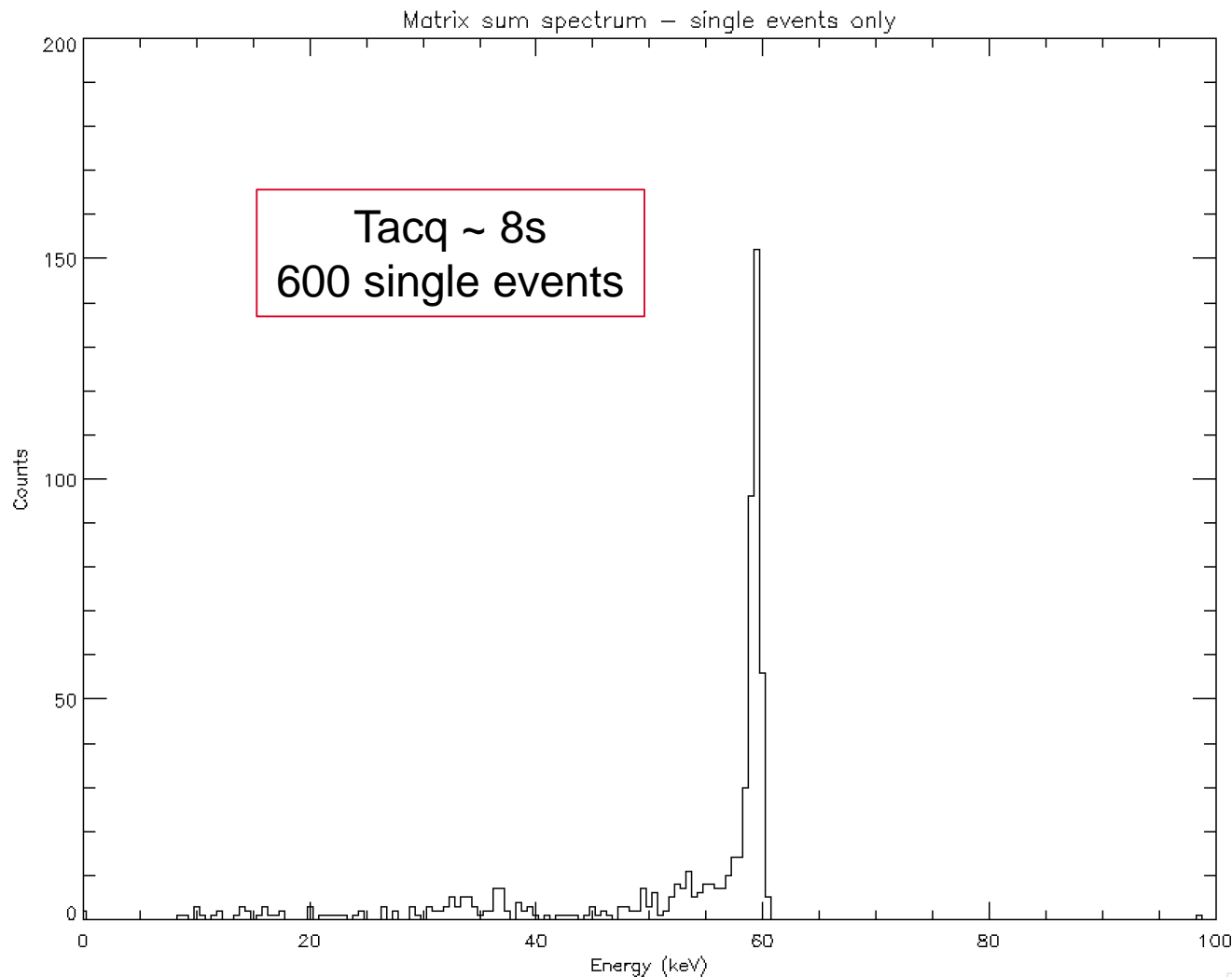


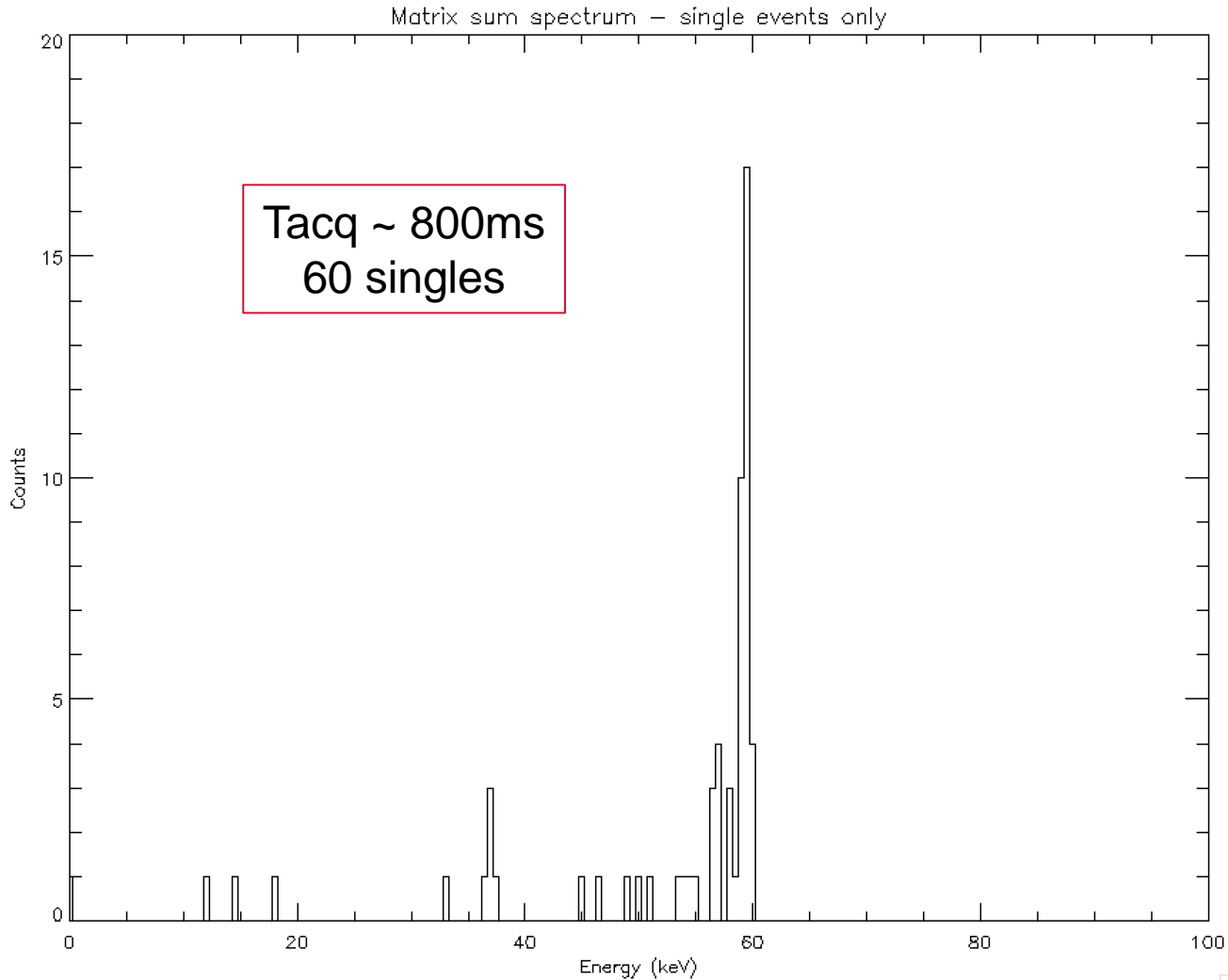
74 MBq  $^{241}\text{Am}$

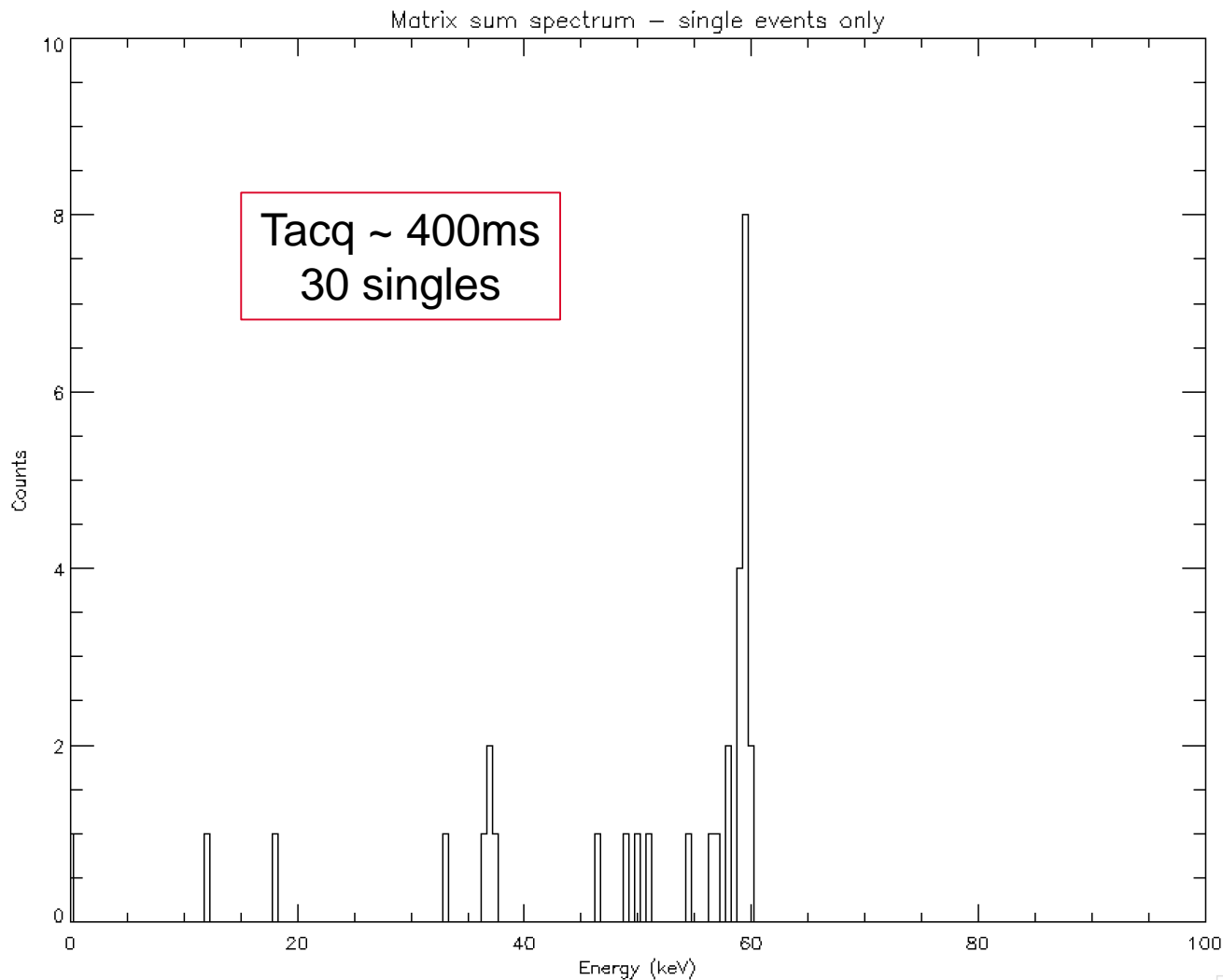


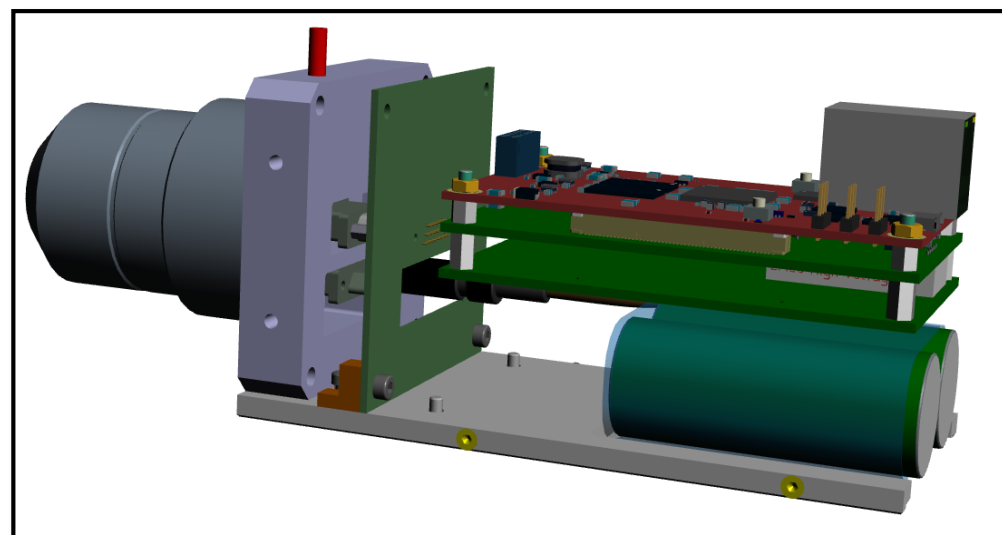
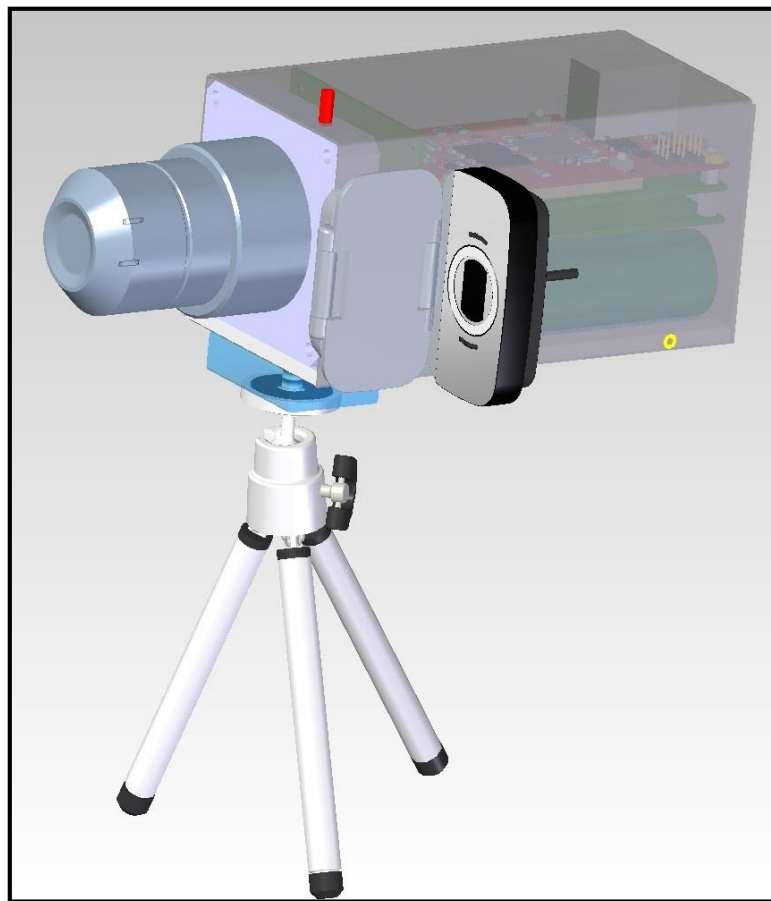
1,5% @ 60keV  
In 2 minutes

Low energy absorbed  
by steel encapsulation  
of the source

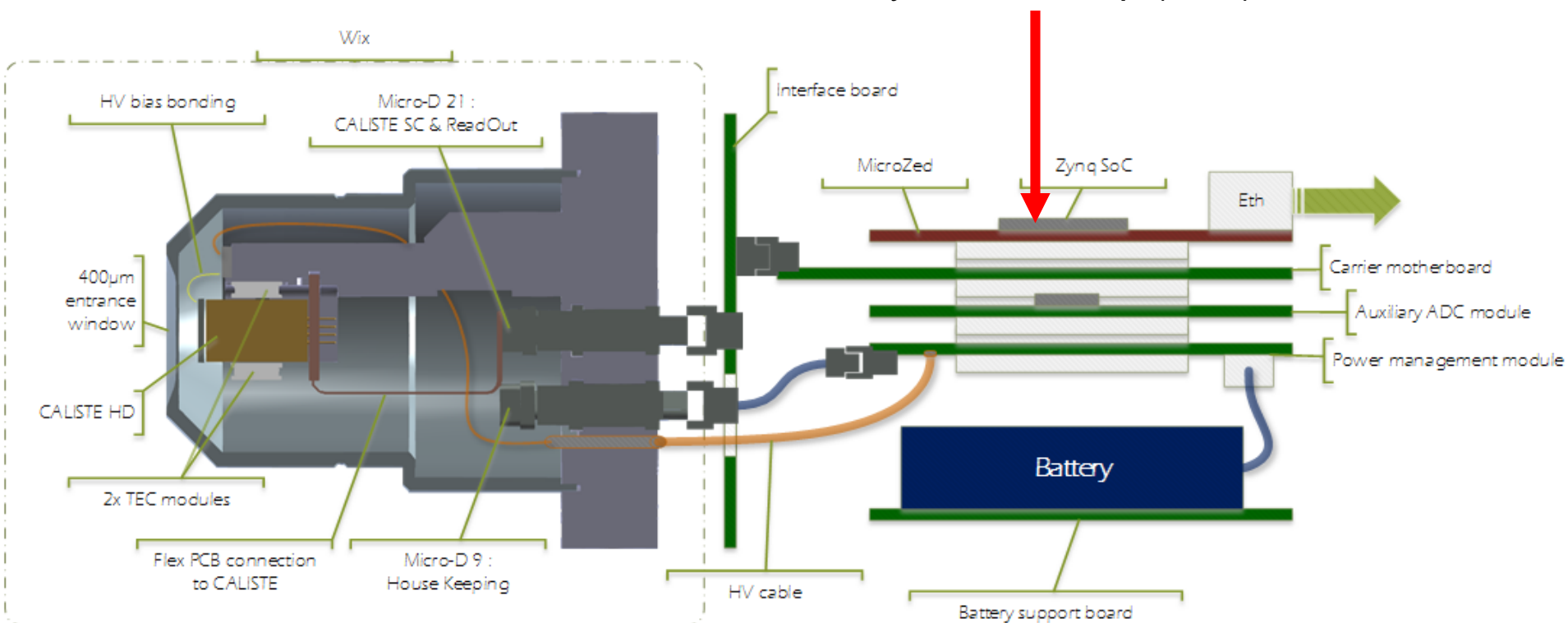




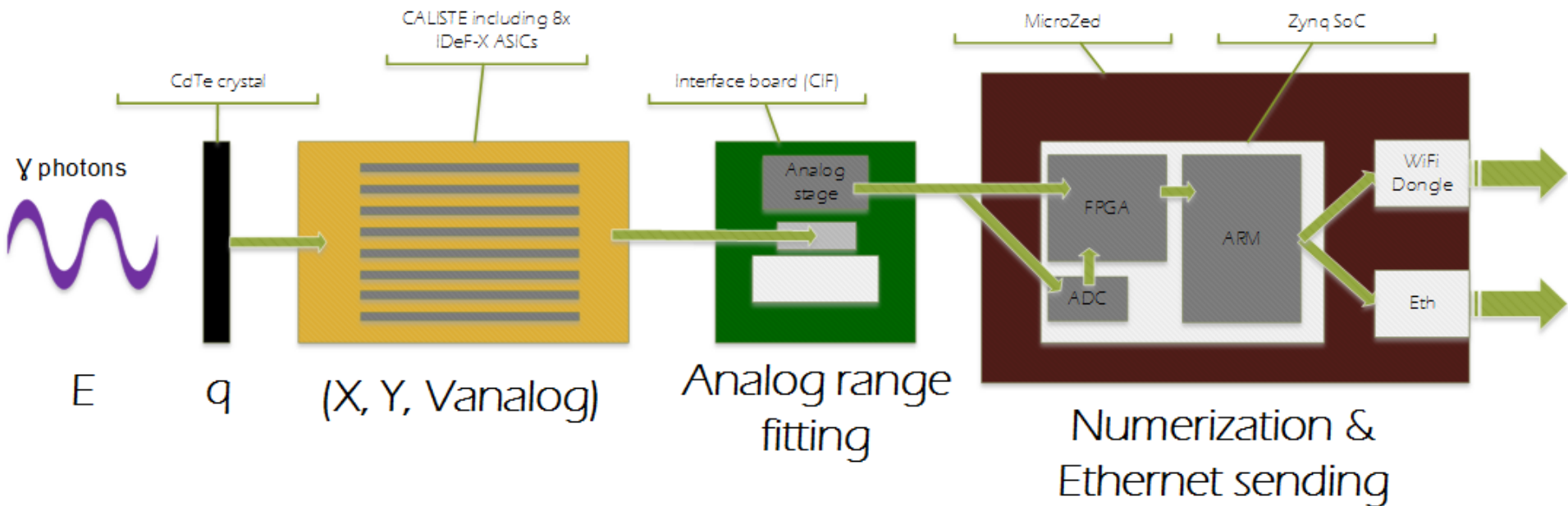




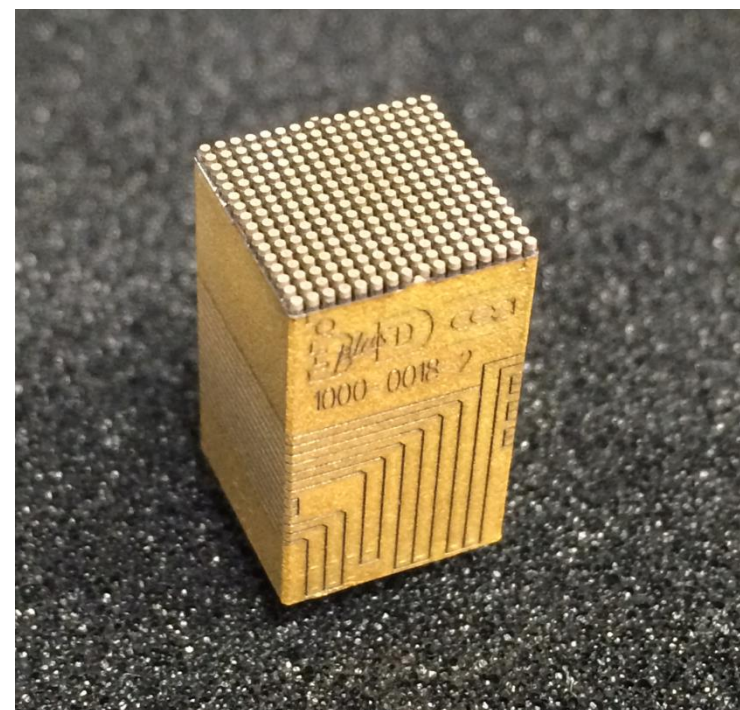
## Xilinx Zynq System on Chip (SoC)







- 800 $\mu$ m pixel pitch
- 400 $\mu$ m between two pixel  $\approx$  pixel size
- 16x16 physical pixels
- Same IDeF-X HD ASIC use inside
- Optimization of industrial manufacturing process
- Use of non-space qualified industrial technologies and parts when possible
- New CALISTE-O detector design's response validated by simulation

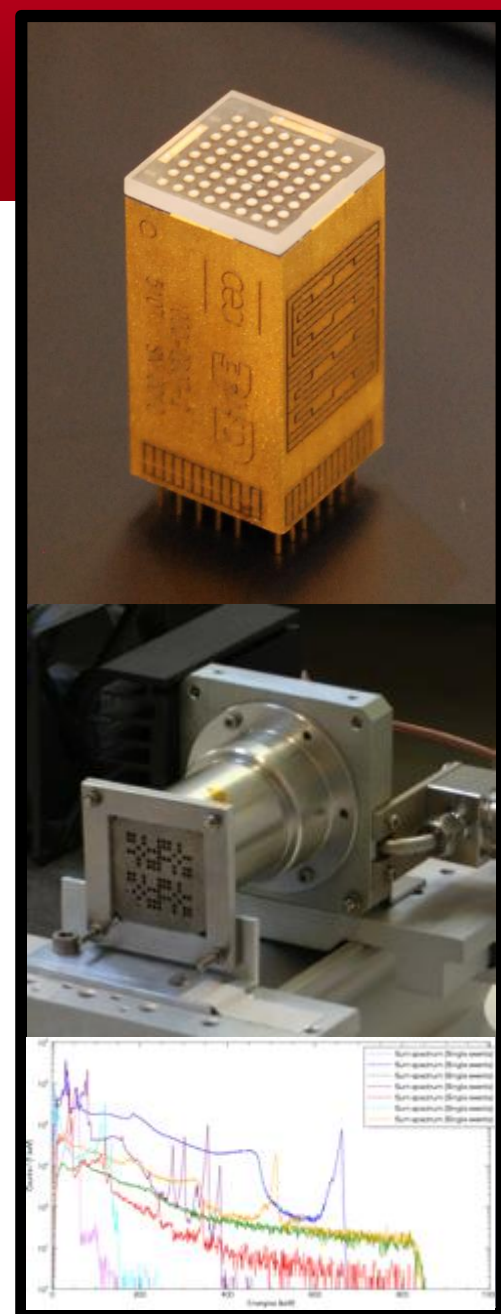


## ORIGAMIX

- ✓ First modules are ready and functional
- ✓ First tests are a good proof of concept
- ✓ Compton configuration tests coming soon
- ✓ Caliste-O : Cost optimized CALISTE design in progress
- ✓ Final system design and acquisition chain releases soon!

## What's next ?

- Modular and flexible Hardware & Software architectures are ready for further developments and optimizations!
- On site demonstration campaign at CEA Marcoule nuclear center planned during this September.



Thank you to all the ORIGAMIX project team :

- H. Bervas *DRF/Irfu/SEDI*
- C. Blondel *DRF/Irfu/SAP*
- F. Bouyjou *DRF/Irfu/SEDI*
- F. Carrel *DRT/LIST/DM2I*
- G. Daniel *DRF/Irfu/SAP*
- C. Delisle *DRF/Irfu/SAP*
- L. Dumaye *DRF/Irfu/SAP*
- C. Force *DRT/LIST/DM2I*
- O. Gevin *DRF/Irfu/SEDI*
- A. Gros *DRF/Irfu/SAP*
- S. Herve *DRF/Irfu/SEDI*
- D. Huynh *DRF/Irfu/SAP*
- P. Laurent *DRF/Irfu/SAP*
- H. Lemaire *DRT/LIST/DISC*
- O. Limousin *DRF/Irfu/SAP*
- J. Martignac *DRF/Irfu/SAP*
- Y. Menesguen *DRT/LIST/DM2I*
- A. Meuris *DRF/Irfu/SAP*
- T. Orduna *DRF/Irfu/SAP*
- F. Pinsard *DRF/Irfu/SAP*
- D. Renaud *DRF/Irfu/SAP*
- S. Schanne *DRF/Irfu/SAP*
- V. Schoepff *DRT/LIST/DM2I*
- MC. Vassal *3Dplus*
- *And many curious people*



