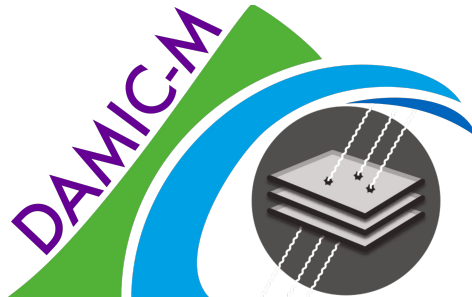
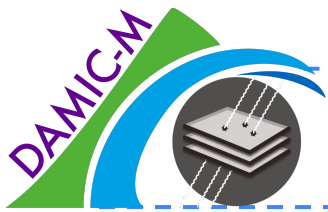


*GDR Duphy, Aussois, 21st- 23rd June 2023*

# The DAMIC-M Experiment: Background budget and Compton measurement

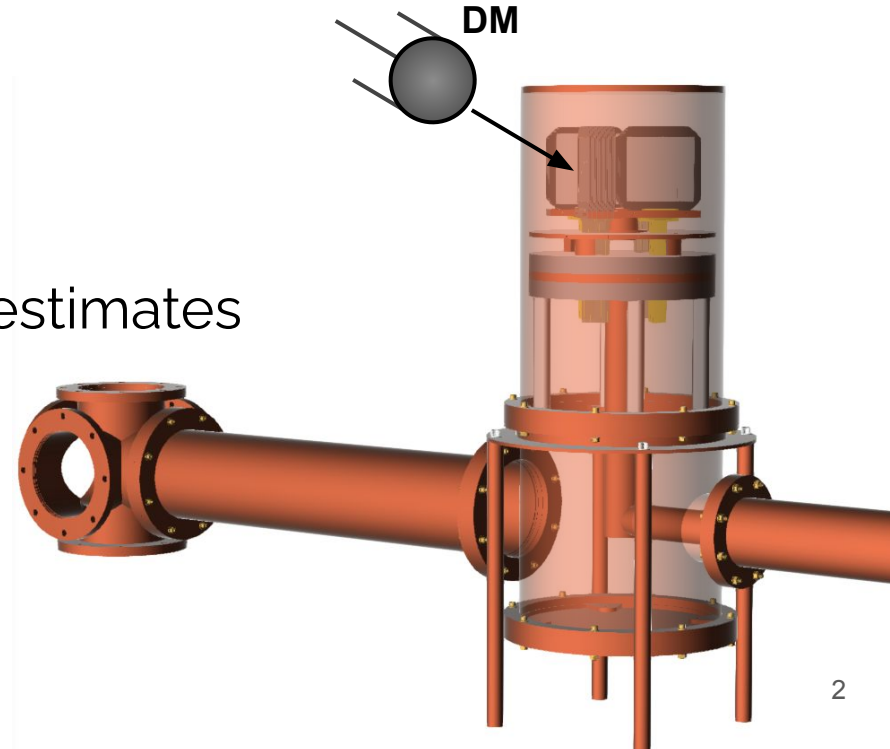
Claudia De Dominicis on behalf of the DAMIC-M Collaboration  
*LPNHE (Paris), CNRS-IN2P3*





# Outline

- The DAMIC-M experiment:
  - Physics reach
  - Status of the experiment
- DAMIC-M design & background estimates
- Calibration measurements:  
the Compton measurement



# DARk Matter In CCDs at Modane

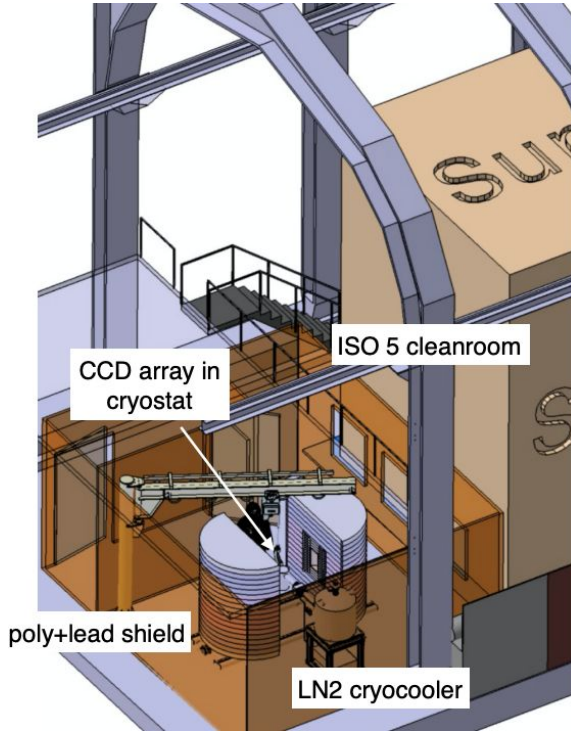


DAMIC experiment  
at SNOLAB (Canada)

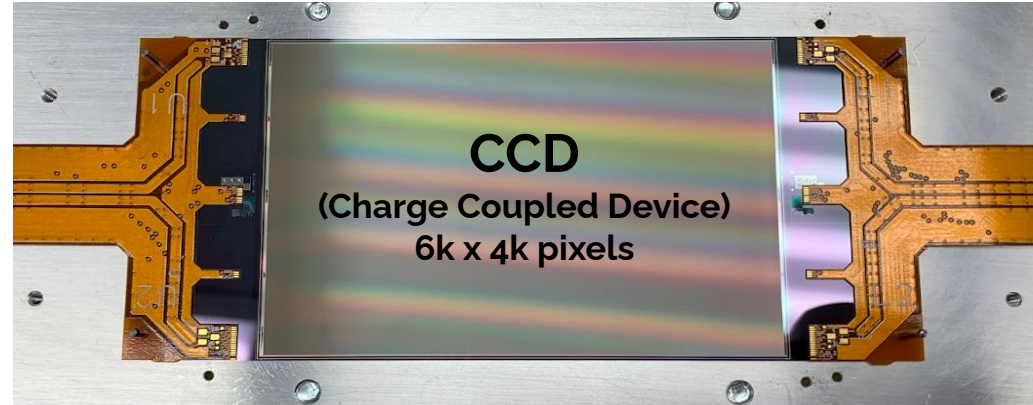
**DAMIC-M experiment**  
at LSM (France)

2017  2024

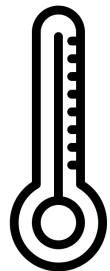
**Aim:** detect **Light DM** (WIMP, Hidden Sector) signals via interaction with Si nucleus or e- in the bulk of **CCDs**



**DAMIC-M@LSM**  
(conceptual design)

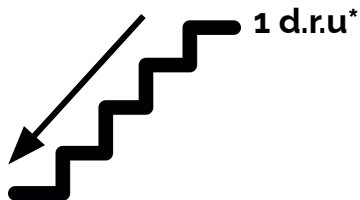


# DAMIC-M detector features



~100 K

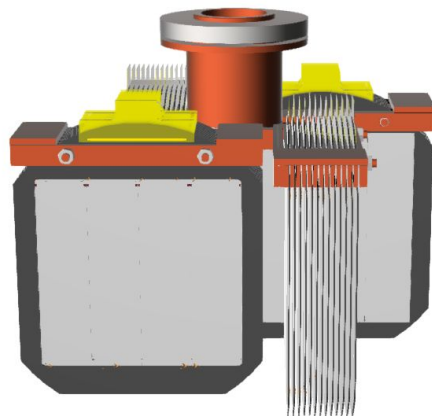
Temperature



1 d.r.u.\*

Background Level  
< 1 d.ru

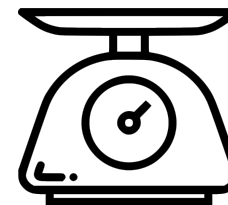
DAMIC-M CCD stack



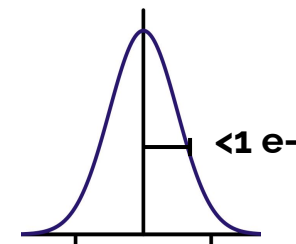
~200 SKIPPER CCDs

6000 pix x 1500 pix

~1 kg



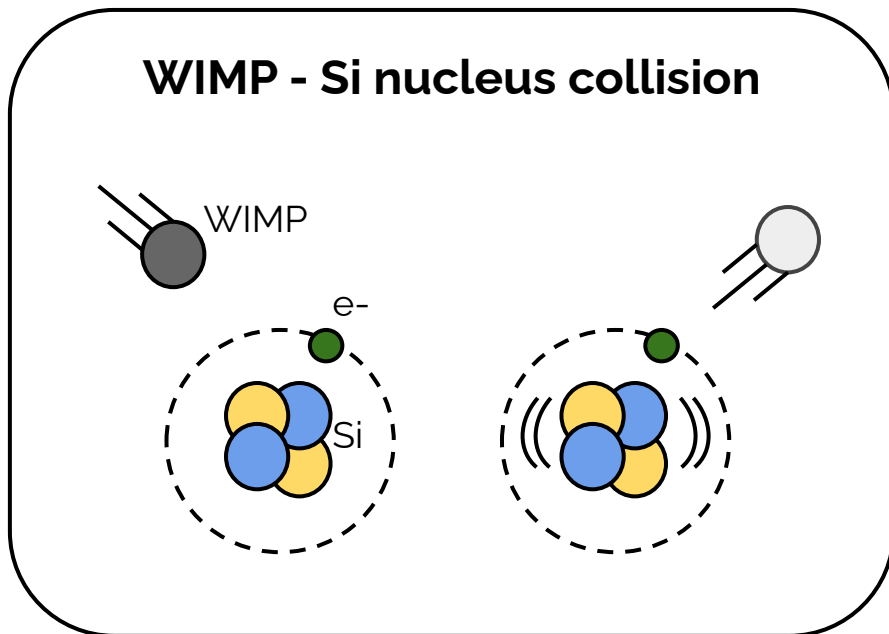
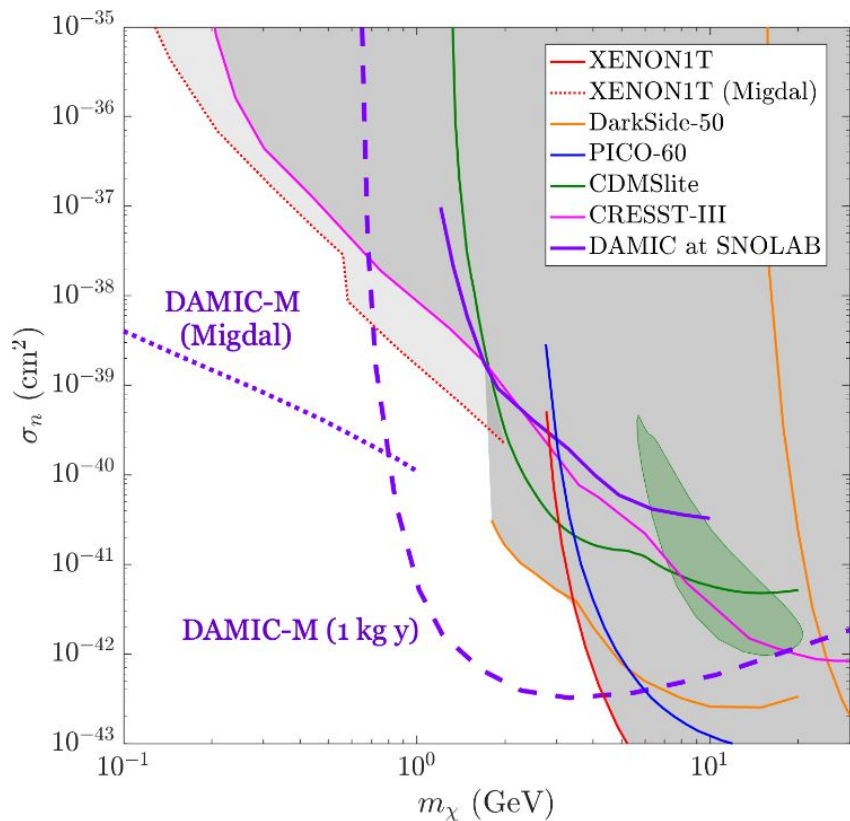
Sensitive Mass



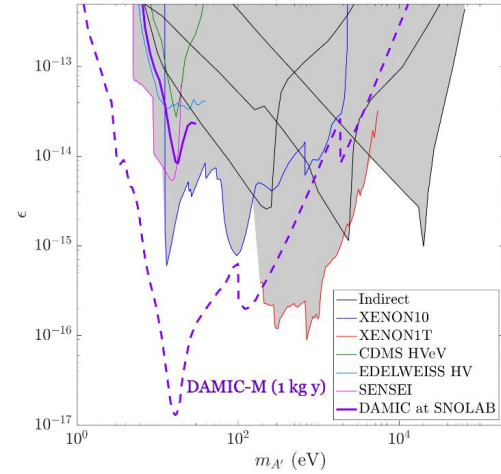
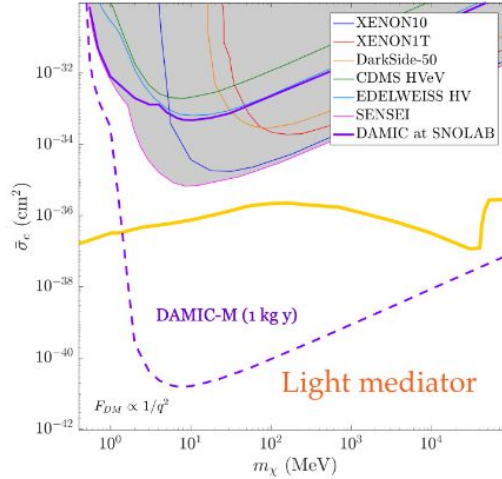
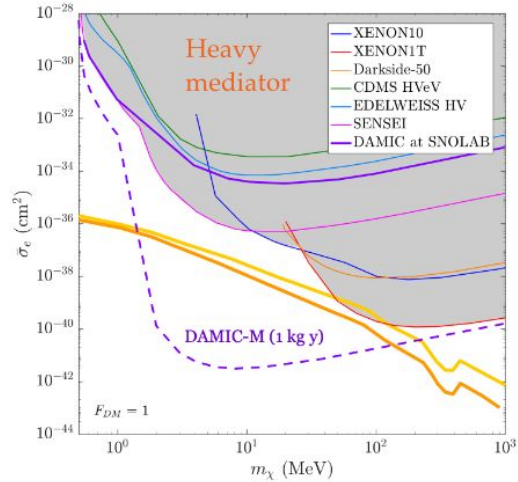
Resolution (readout noise)  
< 1 e-

(\*) 1 d.ru = 1 decay/kg/day/keV

# Physics reach - Light WIMPS

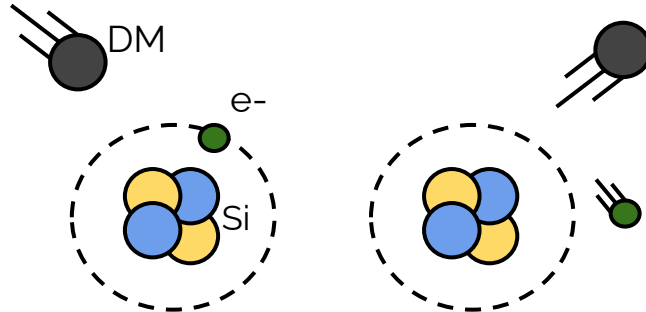


# Physics reach - Hidden sector



Hidden dark photon

DM - valence e- collision

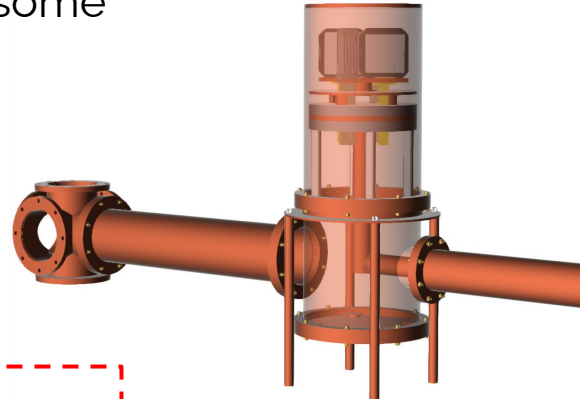


# Status of DAMIC-M

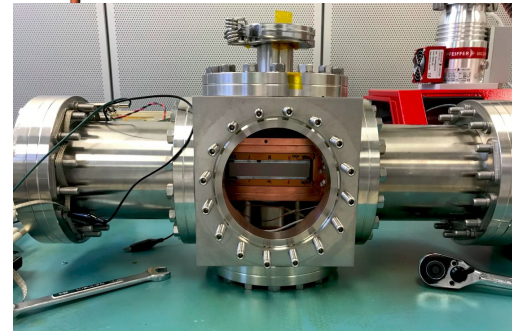
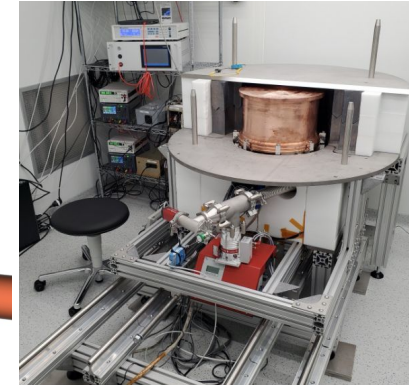


- Detector design almost finalized and some part prototypes are tested
- CCD production ongoing
- Electronics designed, under test
- Calibration with radioactive sources:
  - gamma source: [Phys. Rev. D 106, 092001](#)
  - neutron source: ongoing
- Low Background chamber operating at LSM (see J.P. Zopounidis's presentation)
- Installation in 2024

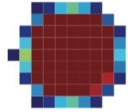
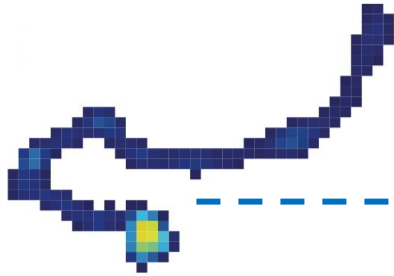
Preliminary design DAMIC-M



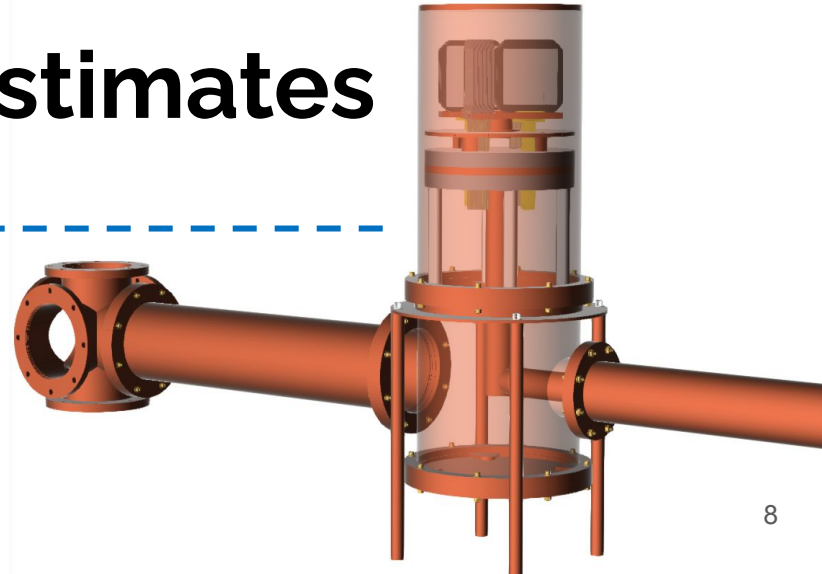
LBC @LSM



Compton measurement setup @UChicago

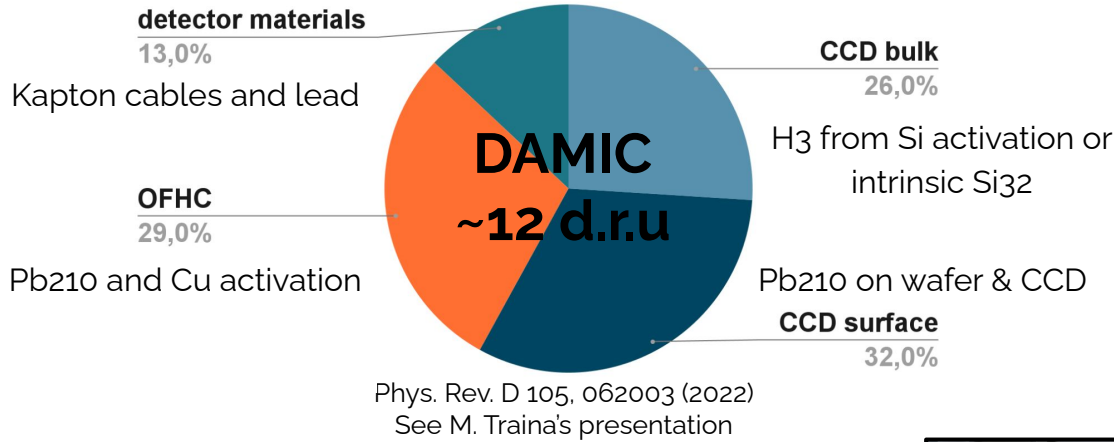


# DAMIC-M design & background estimates





# DAMIC and DAMIC-M background



**for DAMIC-M (goal: < 1 d.r.u)**  
**better material selection and handling:**

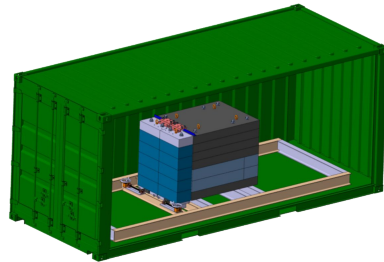
- Limit exposure time to cosmic rays (mostly Cu and Si)
- Limit the detector surfaces' exposure to radon (also of Si wafers prior CCD fabrication)
- Remove Si wafer surface (to reduce surface Pb210)
- Chemical treatments of Cu, Pb components to remove surface Pb210
- New materials: Electro-Formed copper, [low-background cables](#)



Rn free storage



Rn free clean-room



shielded transportation (activation rate/20)




shield during CCD production (act. rate /7)

# DAMIC- M background estimate and design optimization



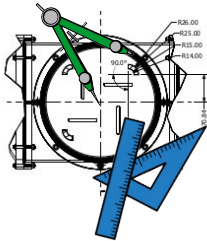
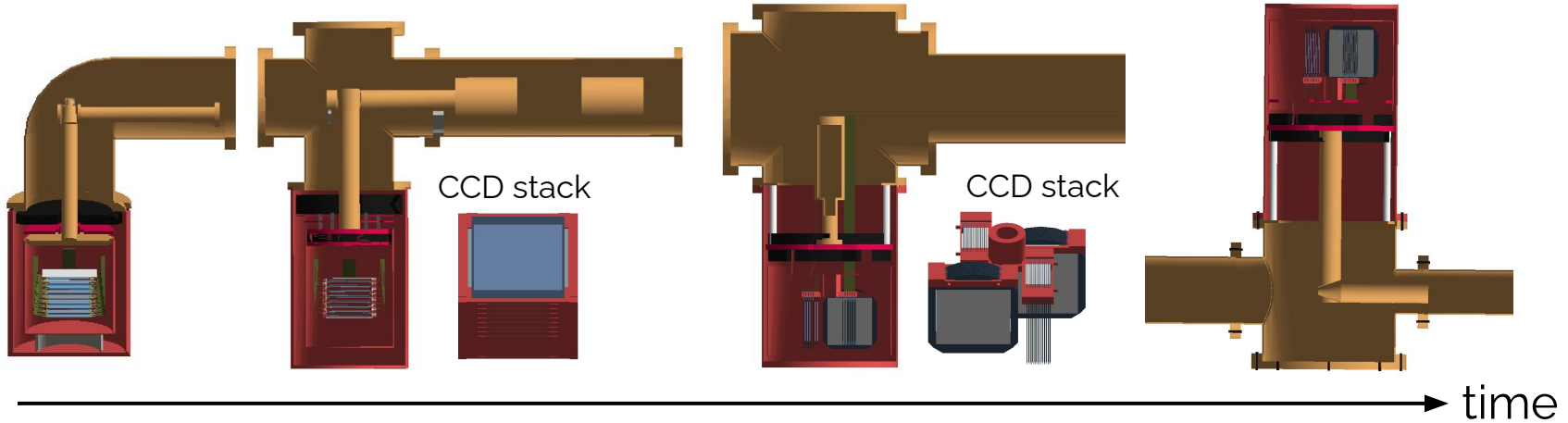
 OFHC *Oxygen-Free High thermal conductivity Copper*

 EFC *Electro-formed Copper*

 Ancient Pb

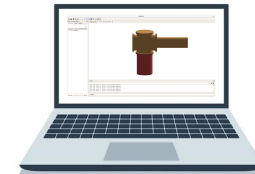
 Kapton

DAMIC-M  
DESIGN

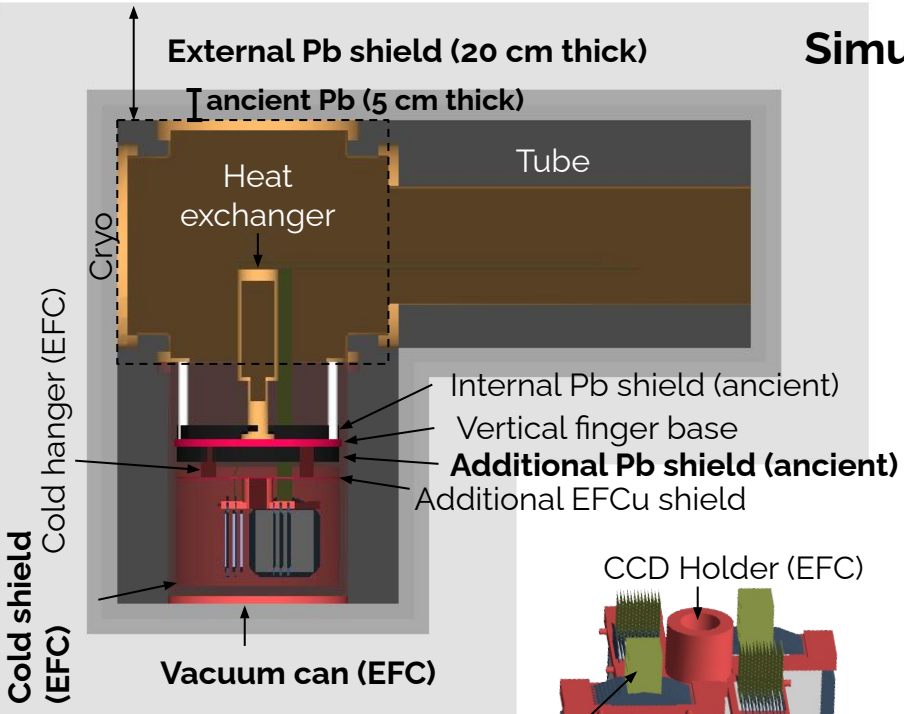


Detector  
design

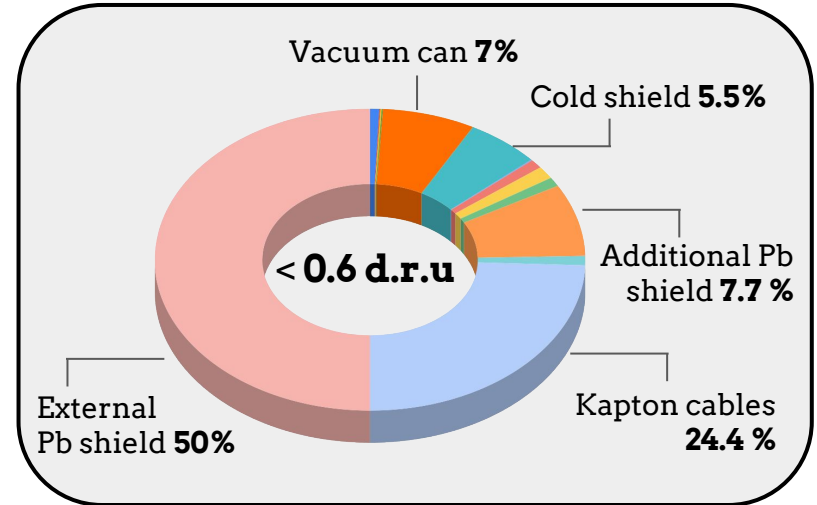
Simulations



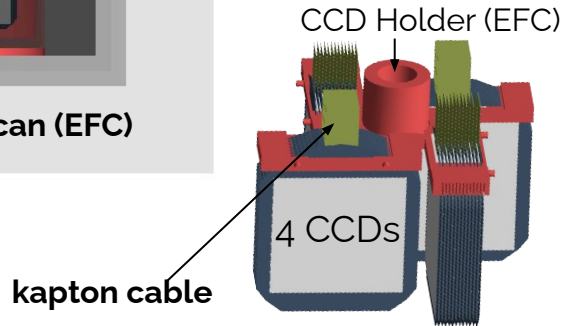
# DAMIC- M background estimate and design optimization



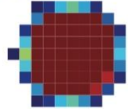
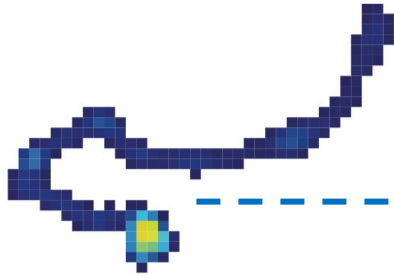
**Simulations to estimate design background level:**  
**Geant4 + custom detector response simulation**



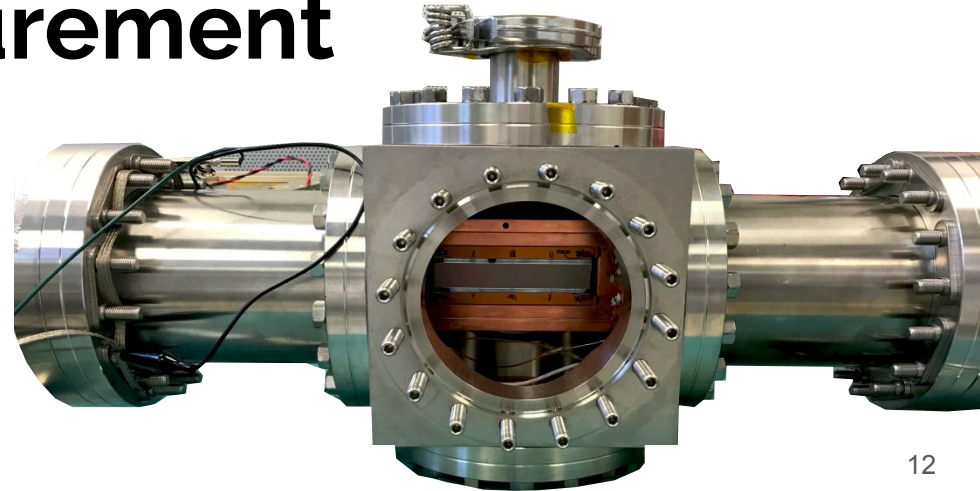
cosmogenic isotopes in Electro-Formed Cu assuming:  
exposure time= 10 d, cooling time underground = 180 d,  
 experiment running time = 1 yr



**Background level goal within reach**



# The Compton measurement



# Calibration: Compton measurement



## Aim:

- Parametrize Compton spectrum at low energy (main source of background for DM search)
- Provide detector calibration

## Setup:

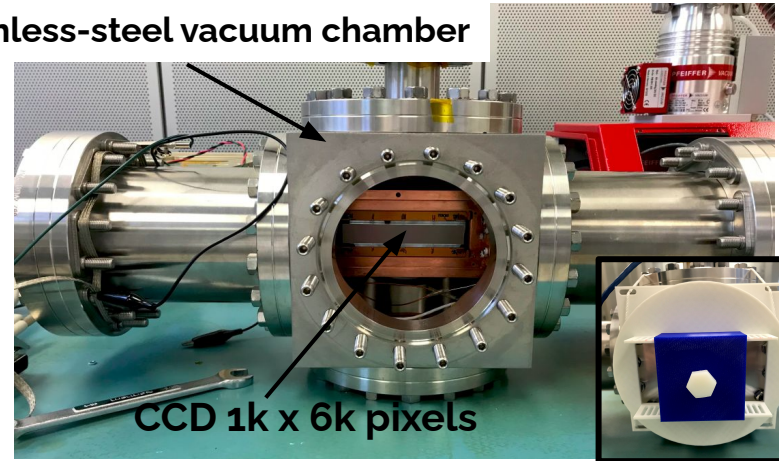
- Temperature: 126 K
- $\gamma$  source: Am241 ( $\gamma$  Energy: 26.3 keV & 59.5 keV)
- 1 skipper CCD (1k x 6k pixels)

## Readout:

- 64 skips
- 0.7 e- readout noise ( $\sim 2.6$  eV)
- binning: 4 pixels x 4 pixels

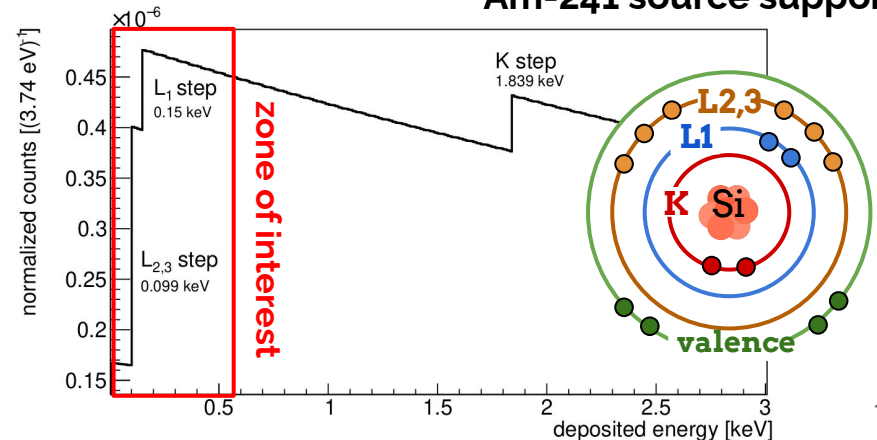
**Publication:** [Phys. Rev. D 106, 092001](#)

## Stainless-steel vacuum chamber

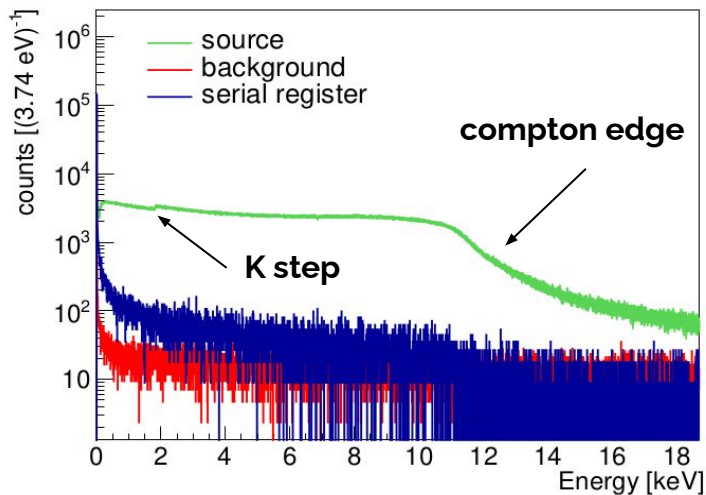


CCD 1k x 6k pixels

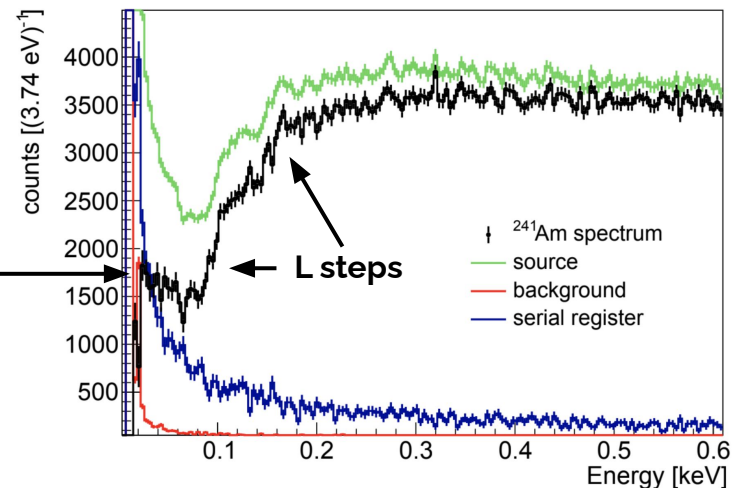
## Am-241 source support



# Compton measurements - Data taking



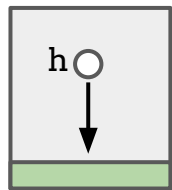
Compton spectrum measured down to 23 eV!



Source: 113.5 days



Am Source

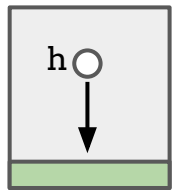


serial reg.

Background: 48.2 days



NO Source

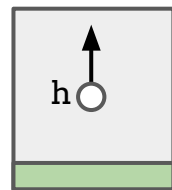


serial reg.

Serial register: 12.7 days



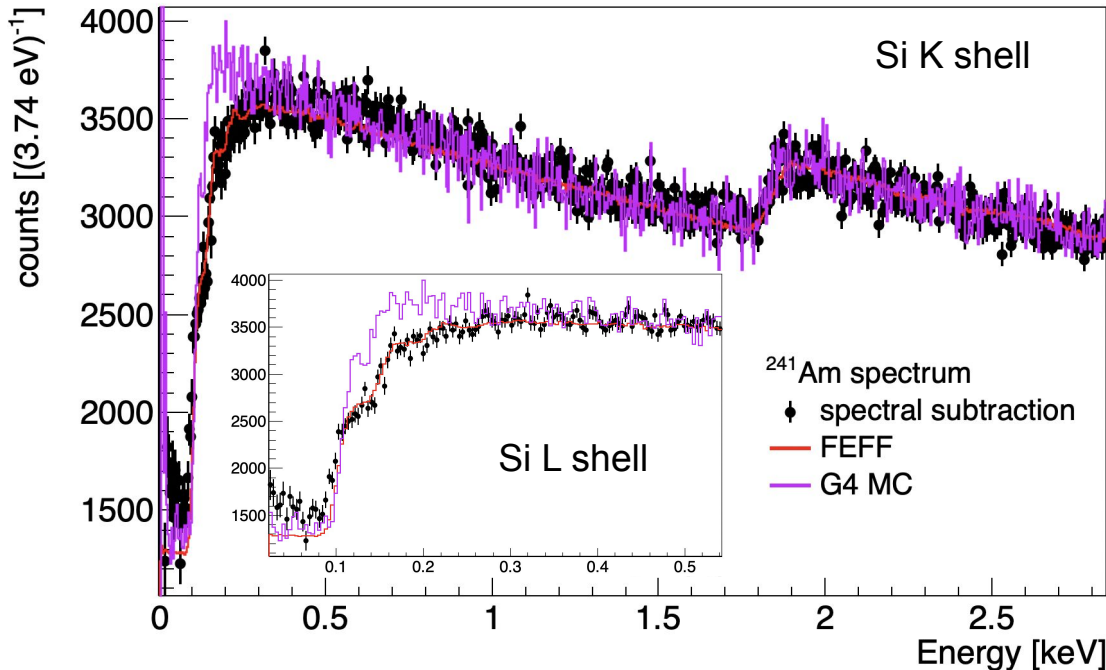
Am Source



serial reg.

Am241 spectrum  
= Source - Bkg - Serial register

# Compton measurements - Data vs model



Data vs Models:

- **agreement in the K-shell region with Relativistic Impulse Approximation**
- **disagreement at L shell with RIA:**
  - softening of the spectrum below 250 eV is observed
  - confirmation of the previous DAMIC measurement [Phys. Rev. D 96, 042002 (2017)]
  - Better agreement with FEFF code

### Geant4:

full Geant4 (with RIA) simulation of the experiment + custom detector response simulation

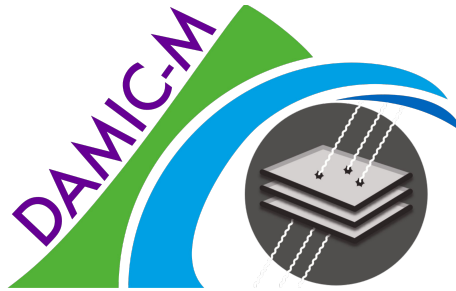
### FEFF:

ab initio calculation (full quantum treatment) + detector resolution

## On our way towards DAMIC-M:

- CCDs are being fabricated and tested right now
- Calibration measurements:
  - **Compton measurement** (Phys. Rev. D 106, 092001):
    - validation of skipper CCD performances
    - characterization of important background source for DM search down to 23 eV (unexplored region)
  - Photo-nuclear scattering measurement: ongoing
- **Design optimization and finalization**
- Electronics being designed and tested
- Low Background Chamber: World leading exclusion limits on DM-electron interactions (see J.P. Zopounidis's presentation)





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# Thank you for the attention!

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