Low-mass WIMP search challenges with the **TREX-DM** experiment

Álvaro Ezquerro Sastre

on behalf of the TREX-DM team

IDM2026 @Zaragoza

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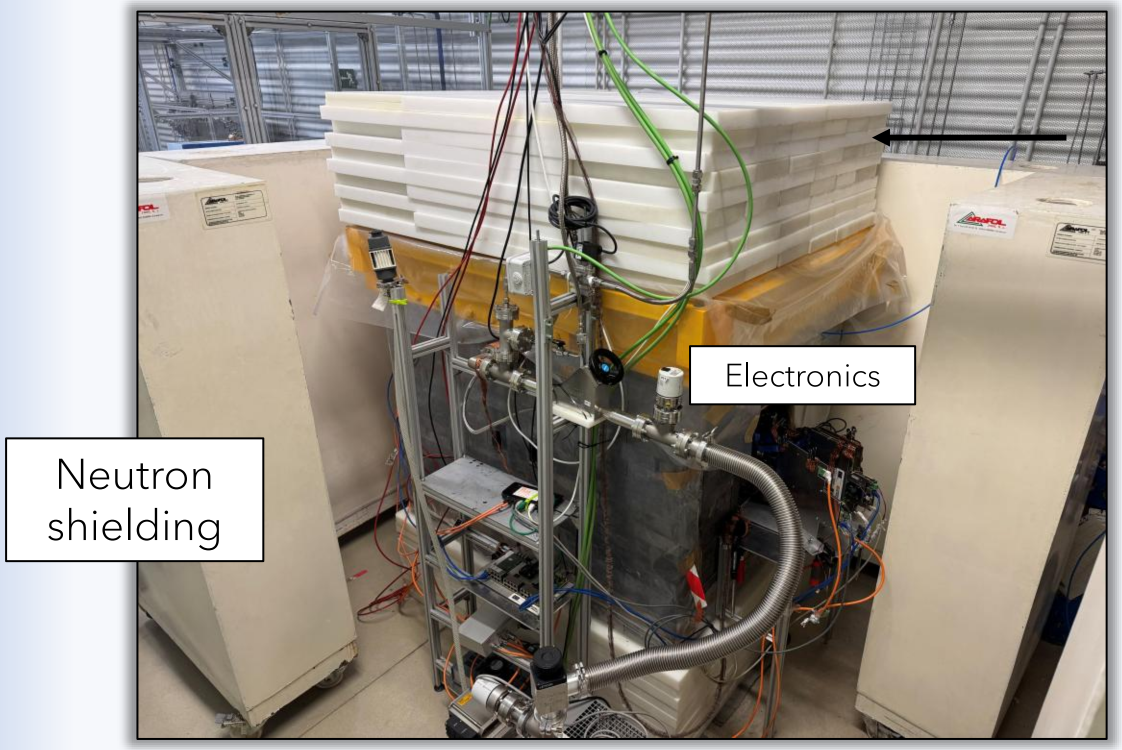
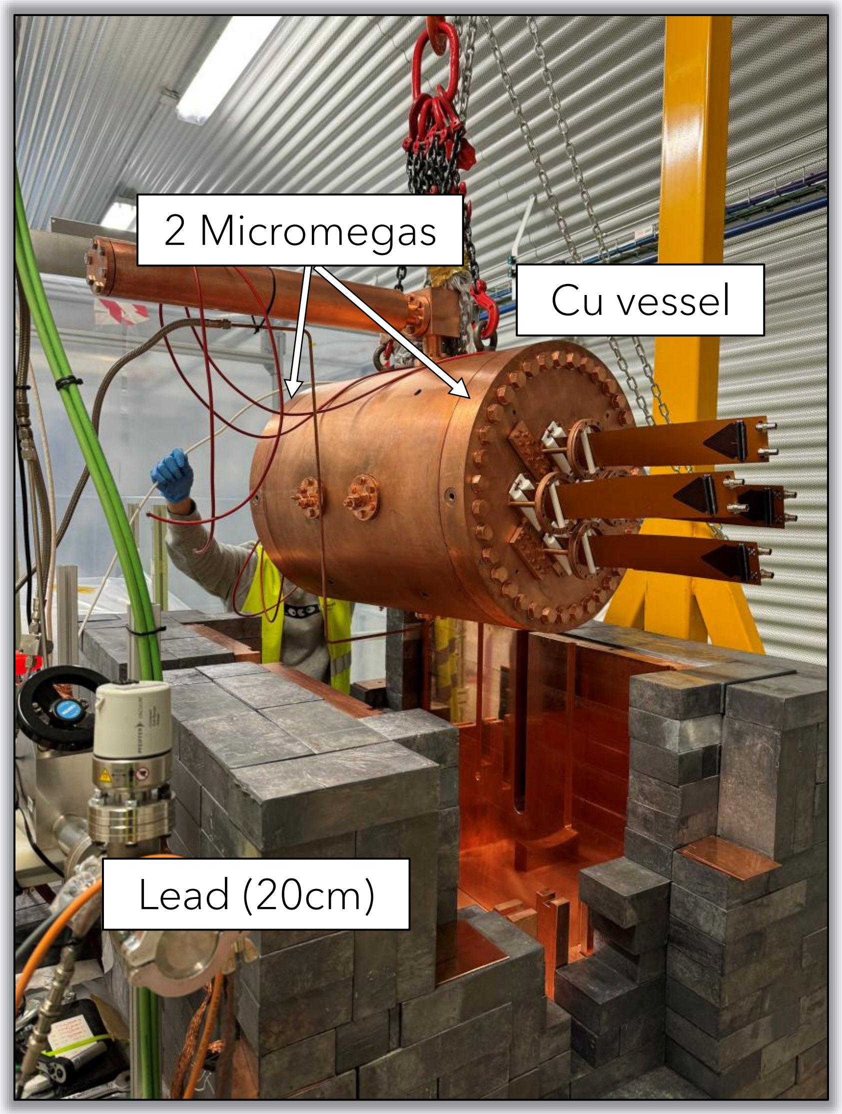
Universidad Zaragoza 1542

TPC for Rare Event eXperiments-Dark Matter

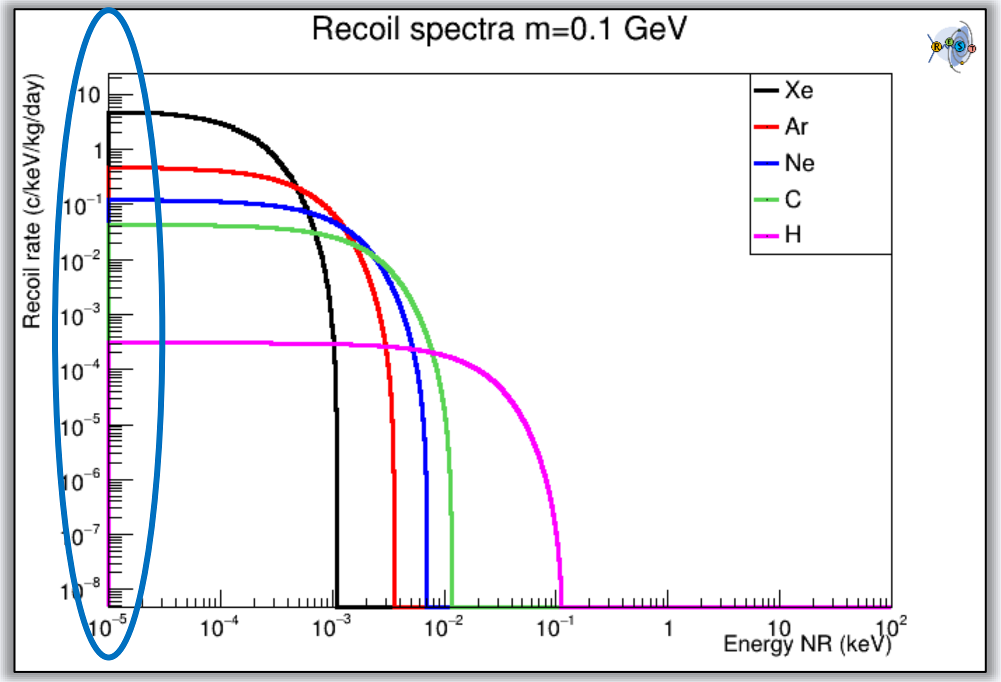
- Direct detection of low-mass WIMPs
- High pressure (up to 10bar) gaseous TPC
- Copper, lead and water/PE shielding

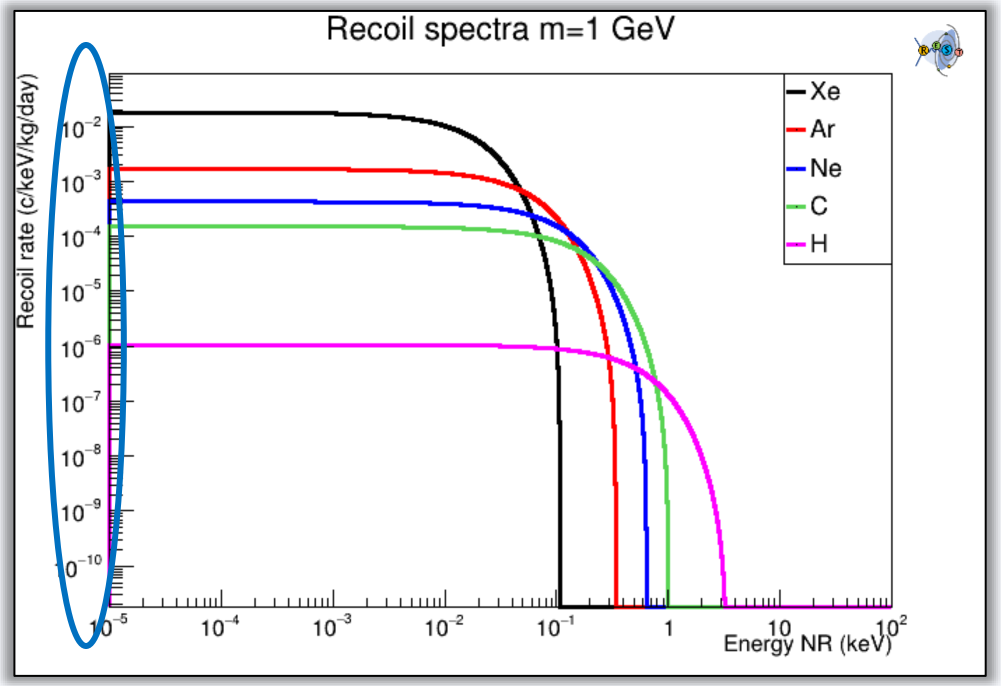




Low-mass WIMP search challenges

- Low Background
- Exposure (mass × time)
- Low energy threshold
- Light nuclei targets





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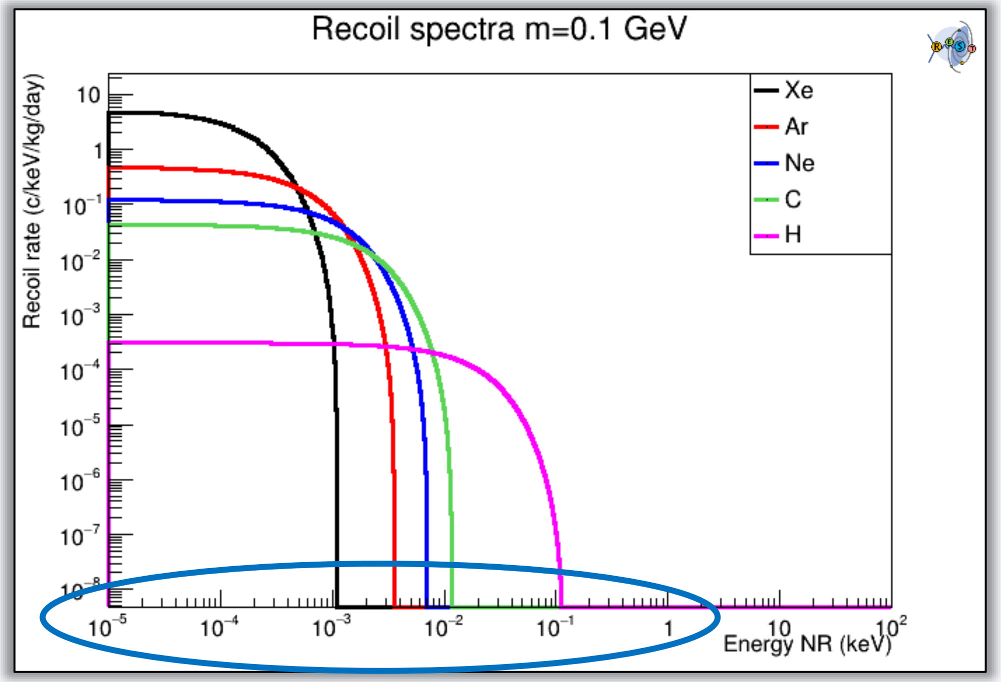

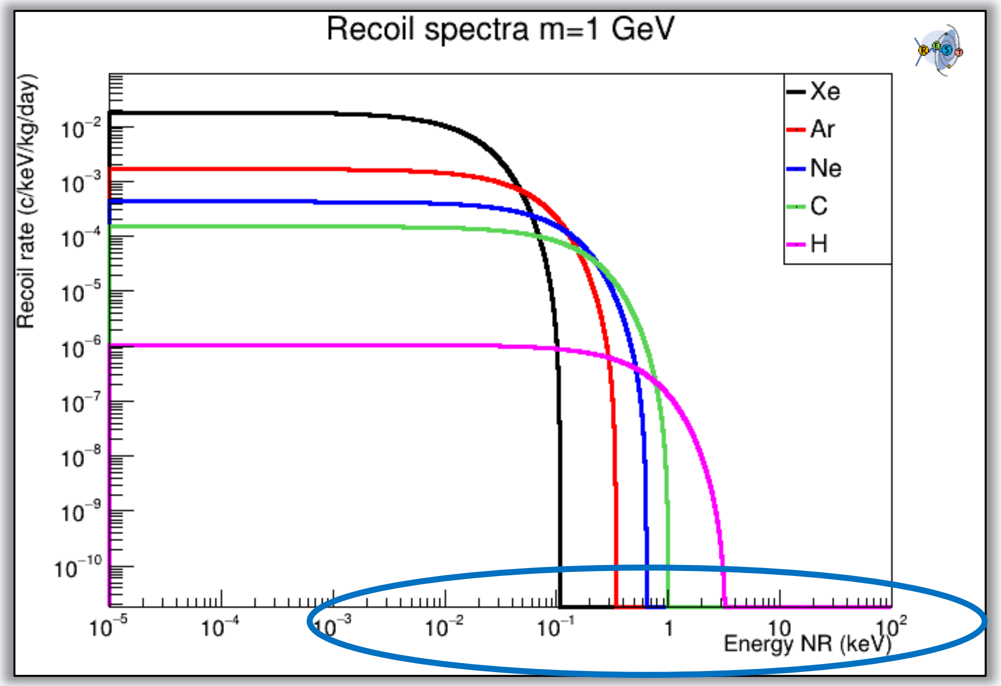

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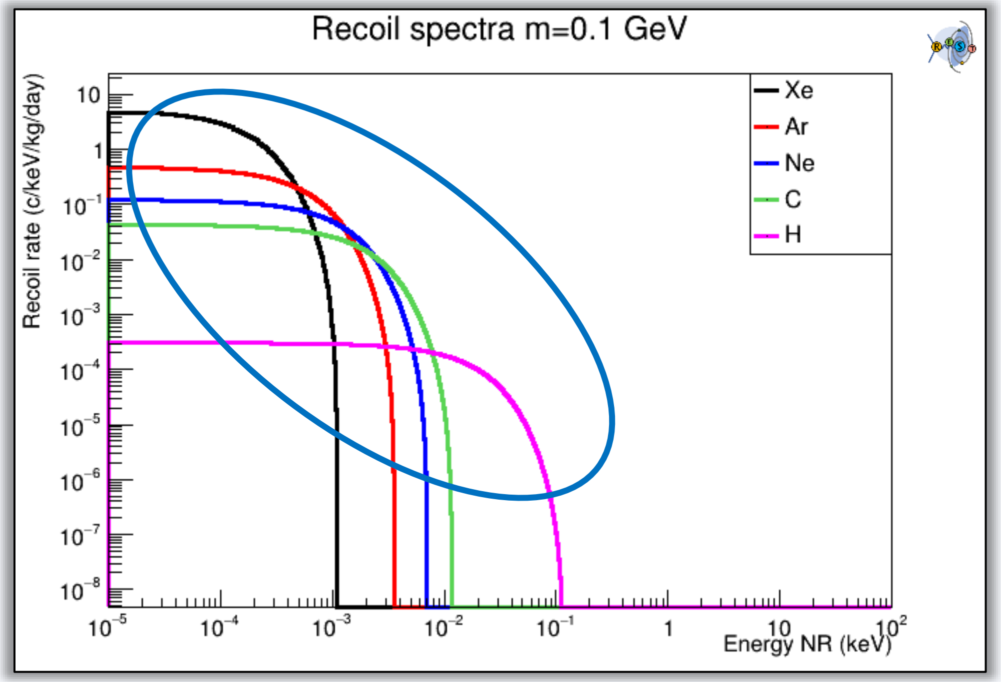
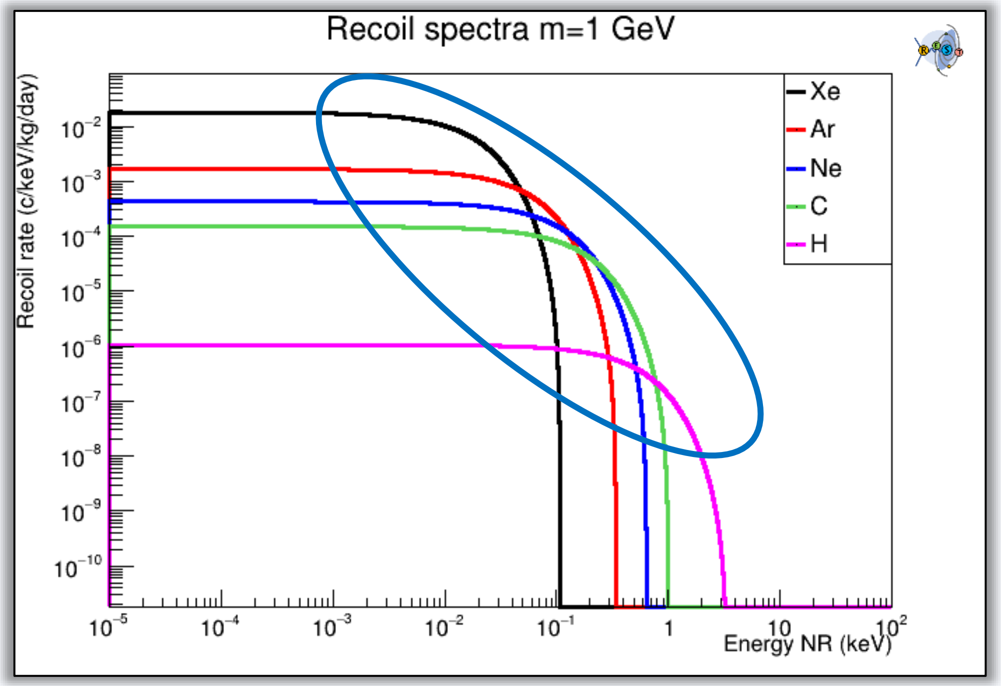
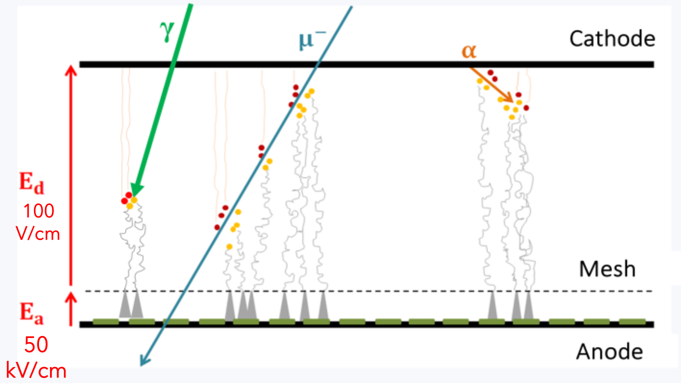
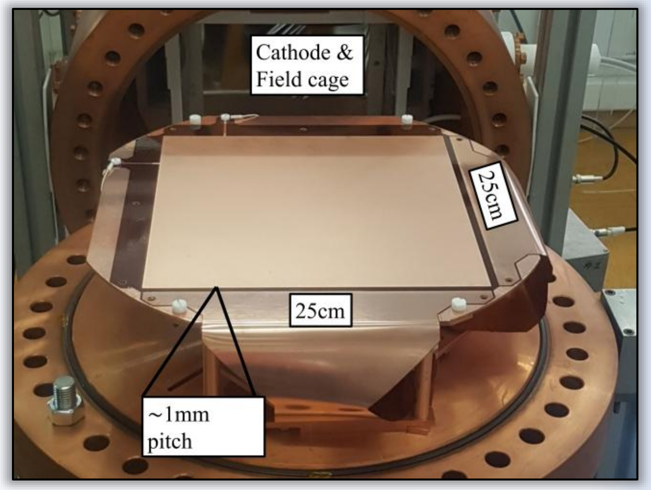


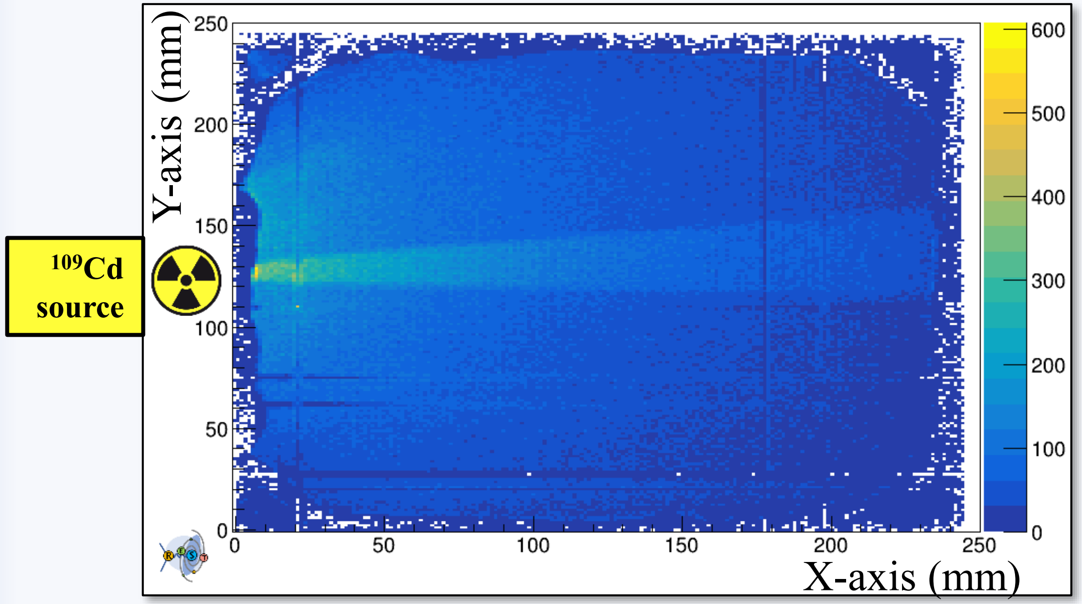


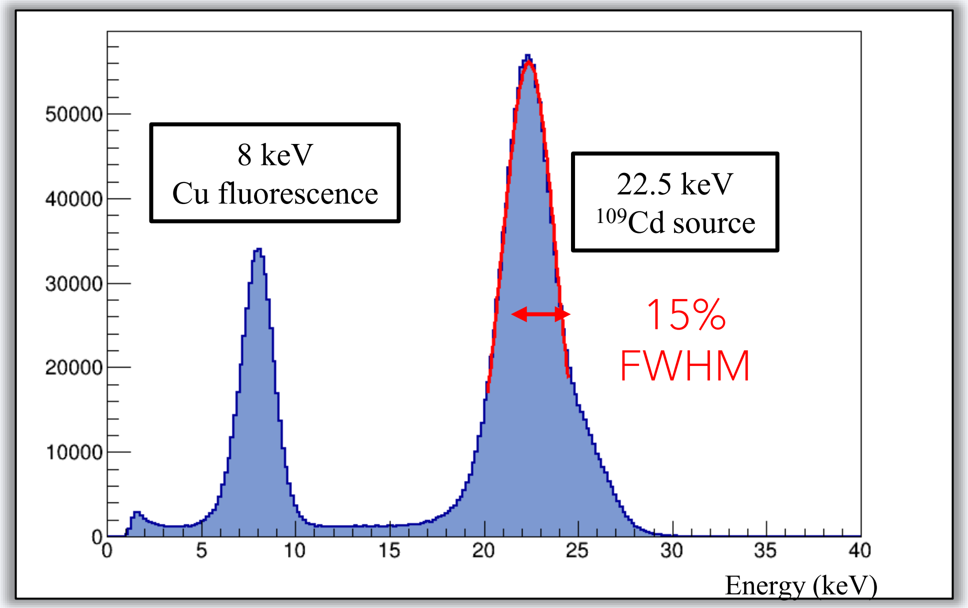
TREX-DM Micromegas

- 2 readout planes sharing 1 cathode
- Largest Surface produced (*microbulk*) Micro-Mesh Gaseous Structure (**Micromegas**)
  - 512 channels: 256 X strips, 256 Y strips









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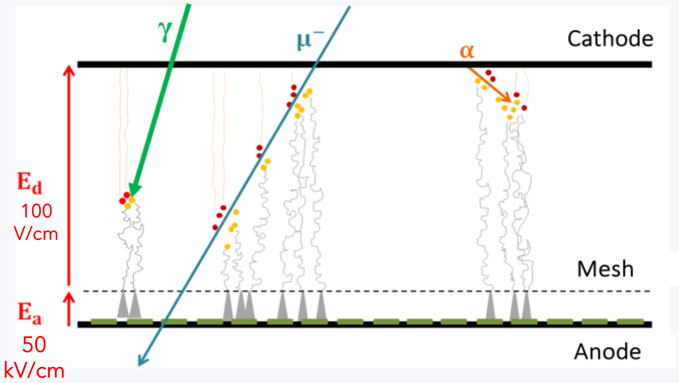
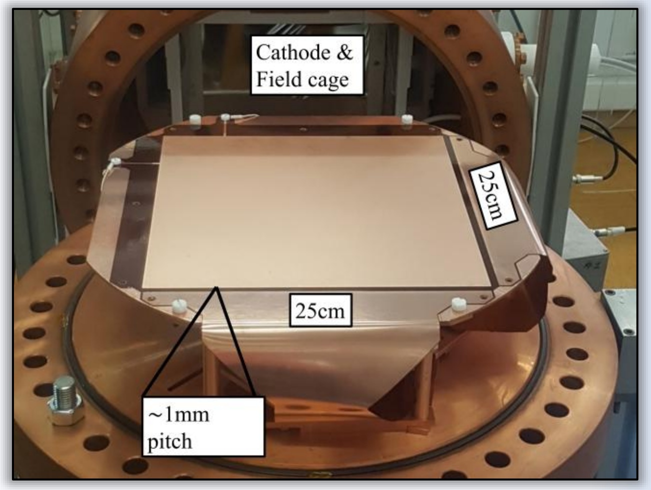
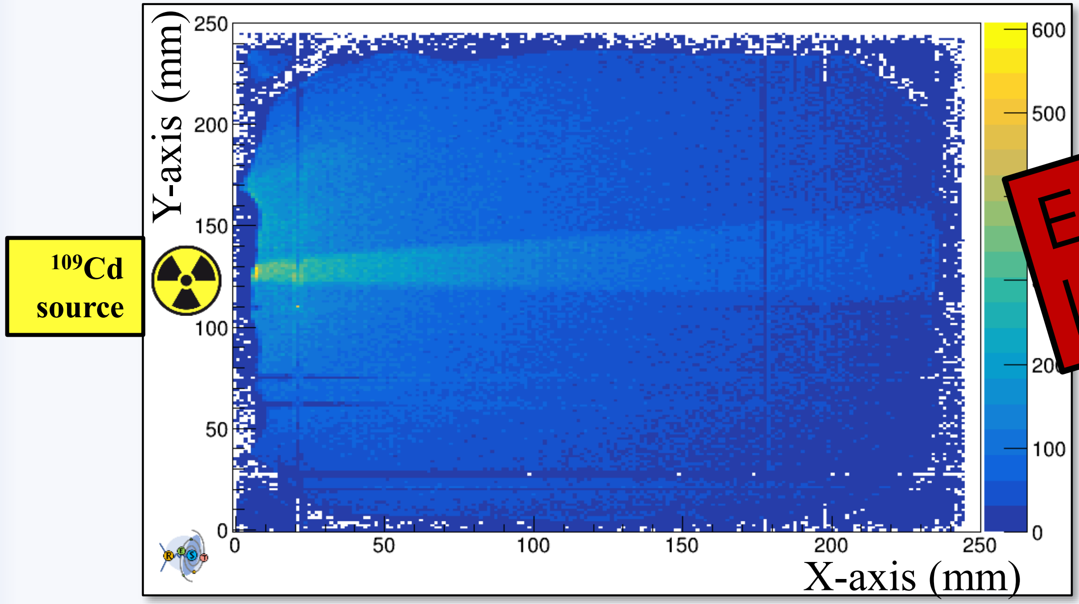
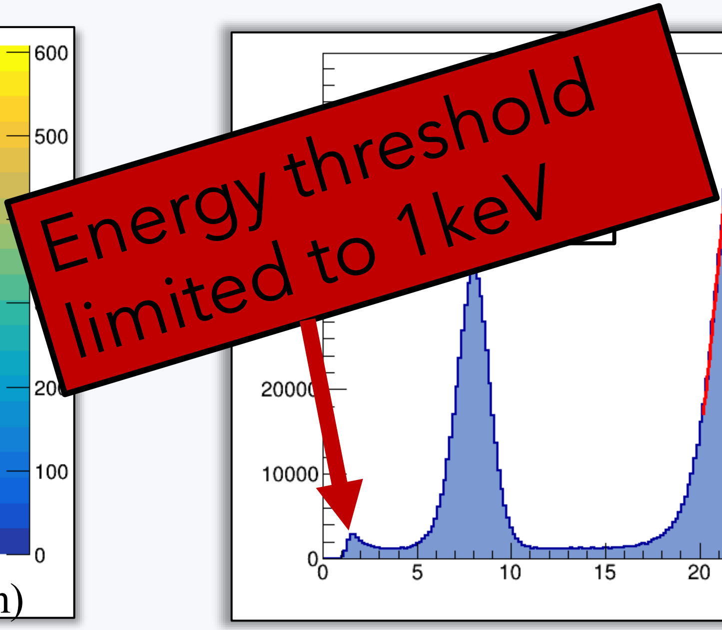




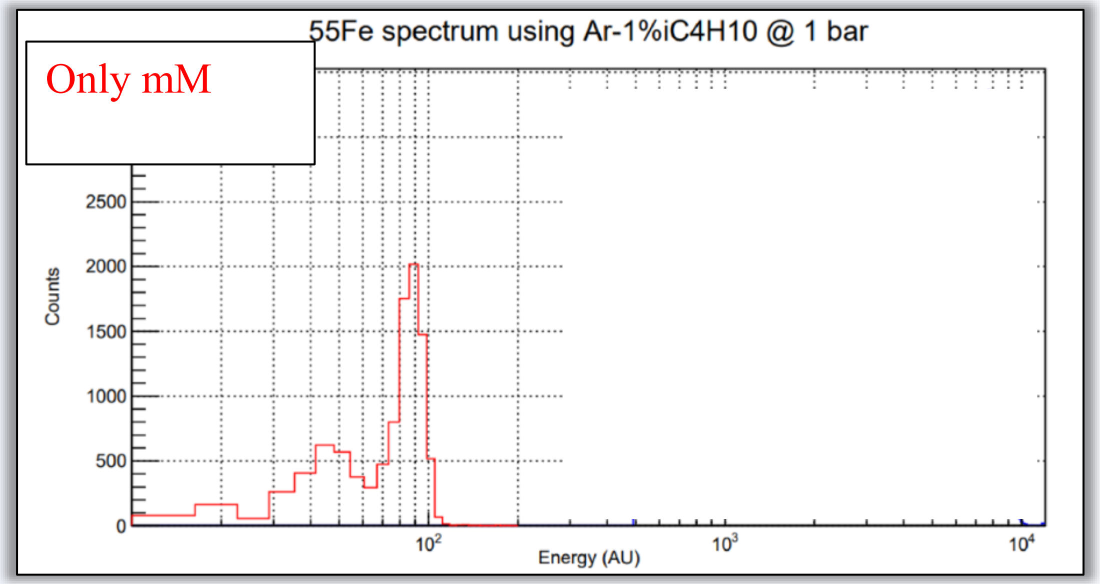


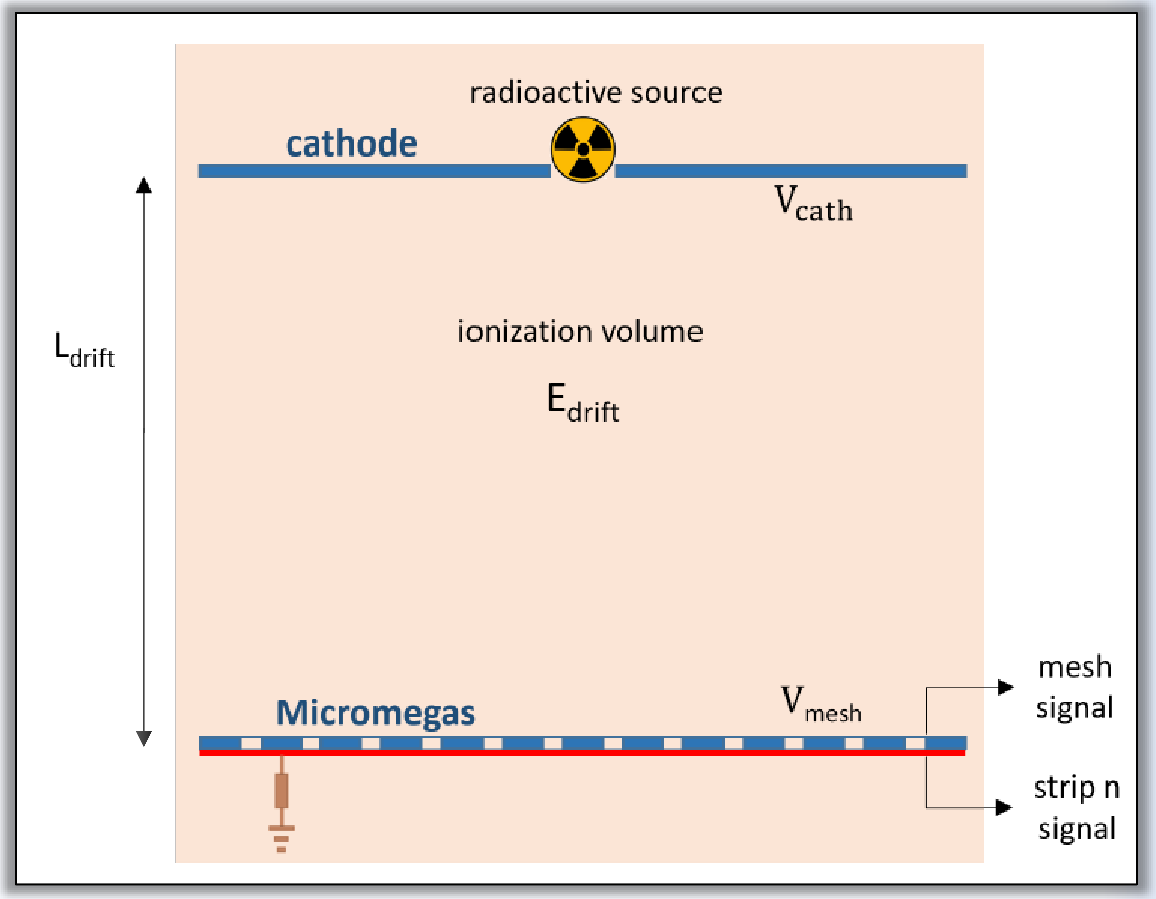


TREX-DM Micromegas + GEM

- Improve gain by adding a GEM as a pre-amplification stage on top of the Micromegas

DOI: 10.12688/openreseurope.19258.2





TREX-DM Micromegas + GEM

- Improve gain by adding a GEM as a pre-amplification stage on top of the Micromegas
  - Increase signal-to-noise ratio
  - ×10-100 extra amplification factor

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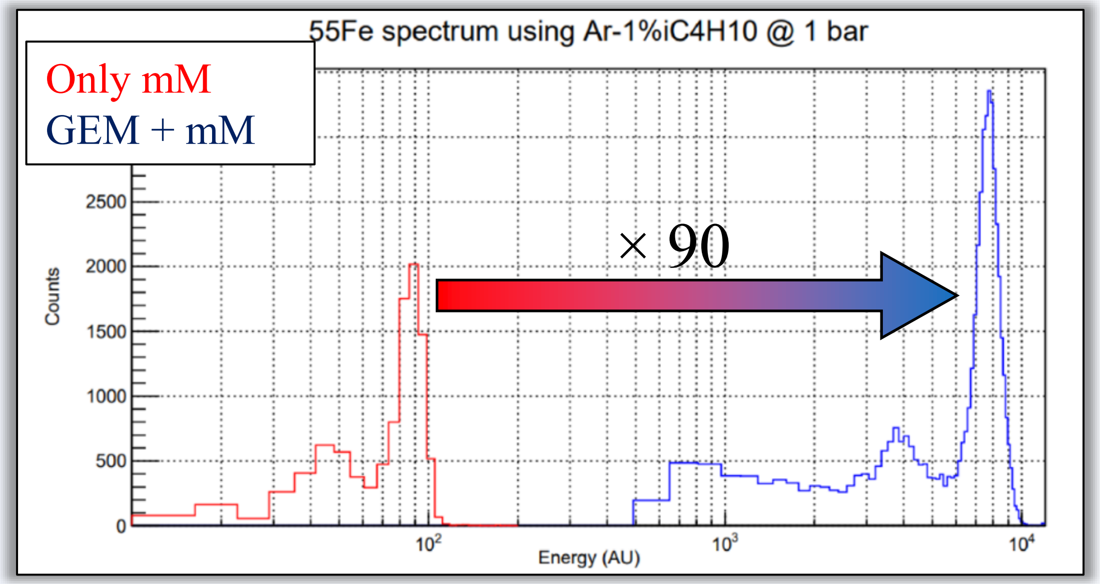
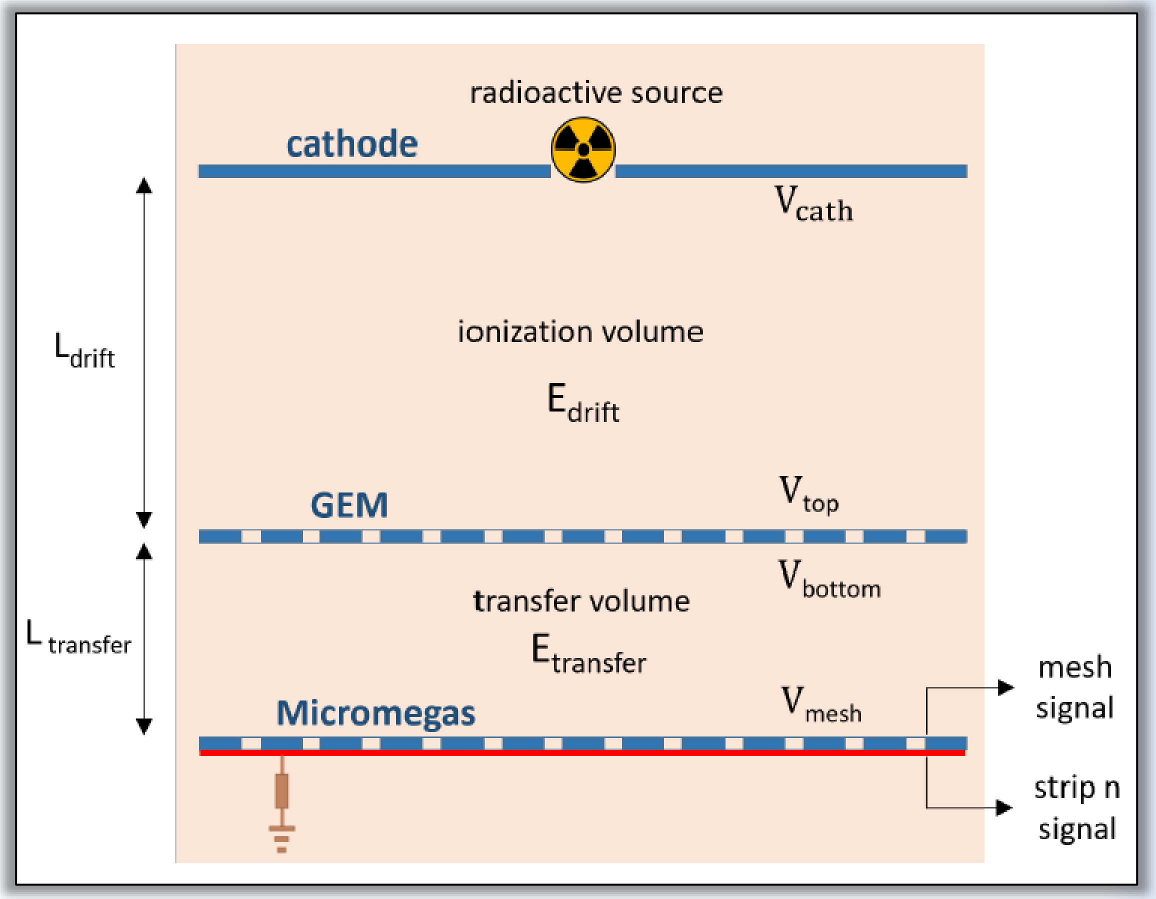


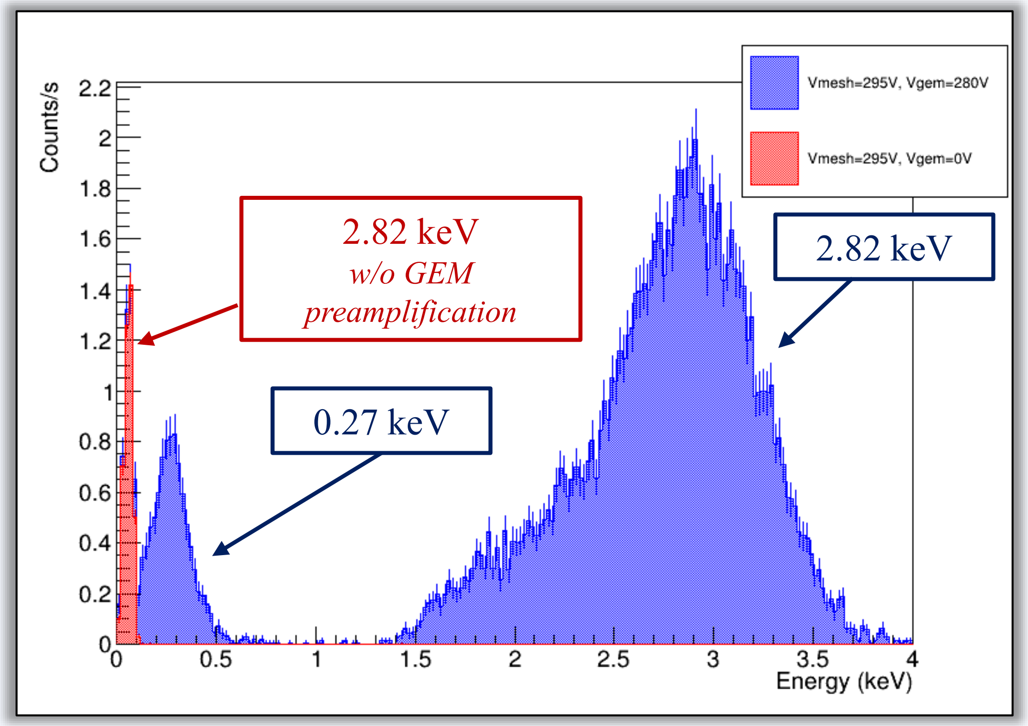


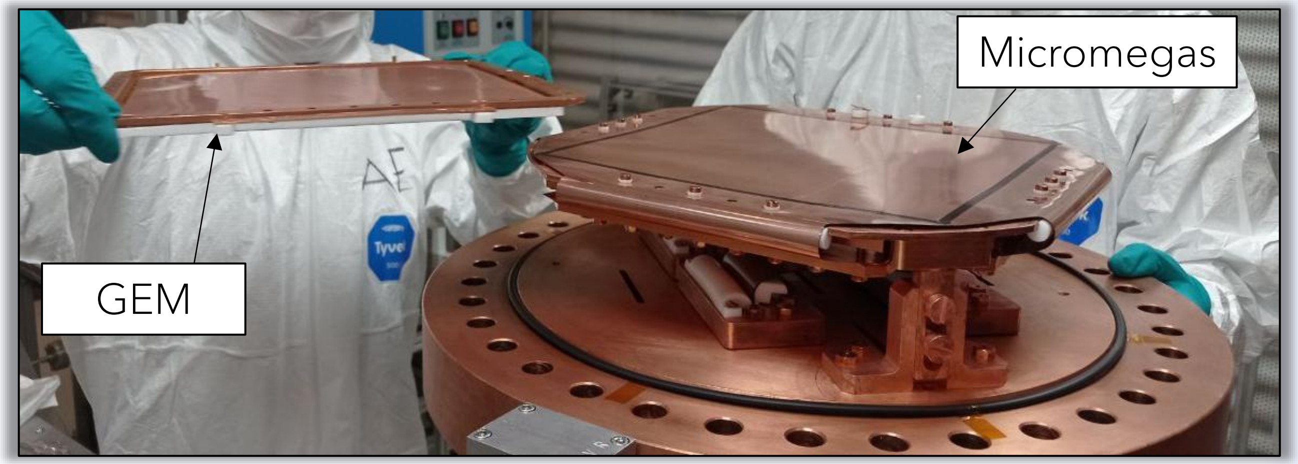
Energy threshold

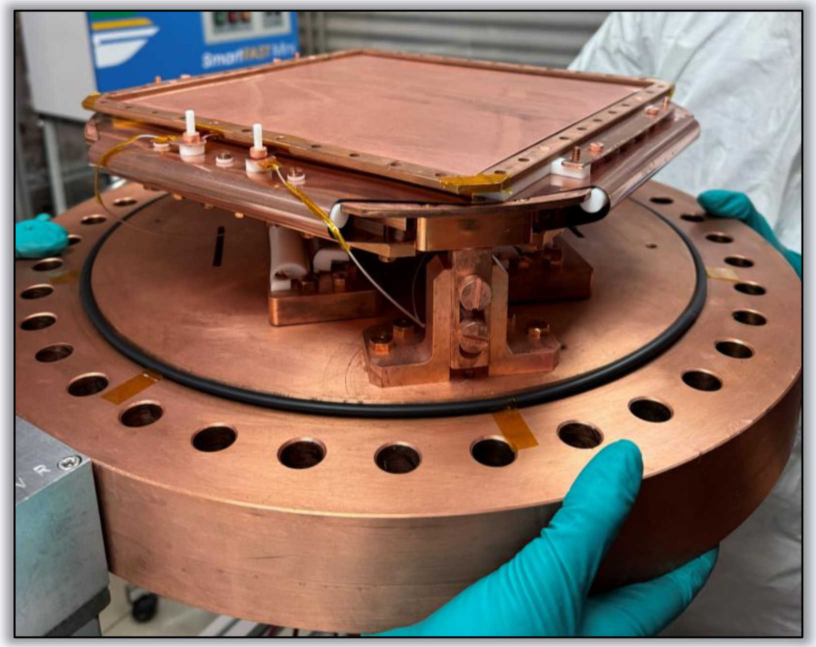
- Low energy calibration with ^{37}Ar
  - X-rays: 2.8 keV (90%), 0.27keV (9%)
  - Homogeneous illumination

DOI: 10.1088/1475-7516/2026/04/072

- Show single-electron capability







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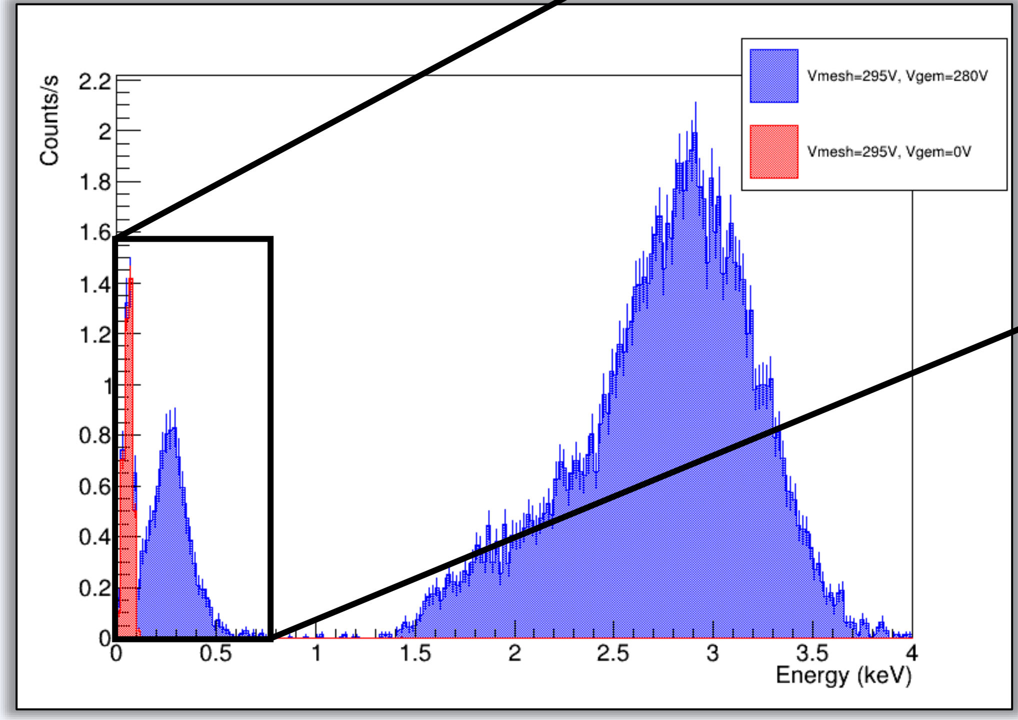

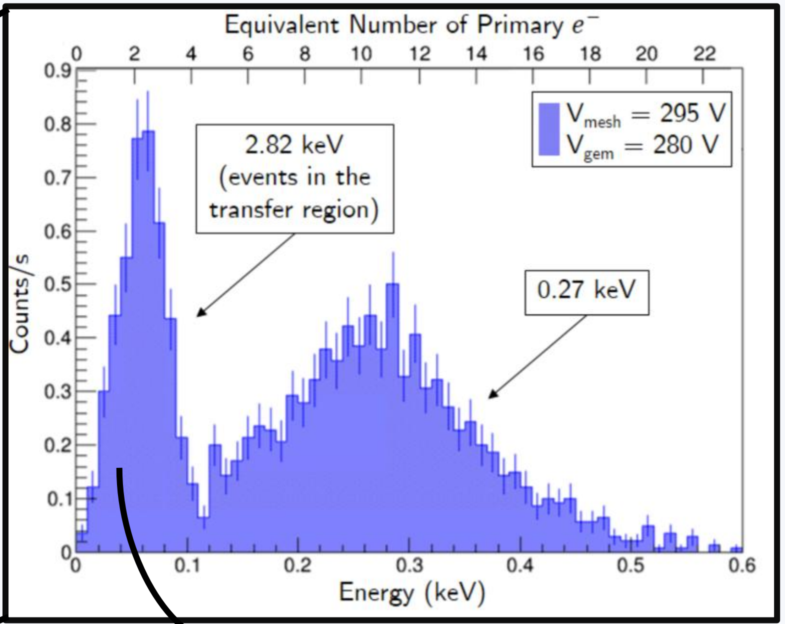

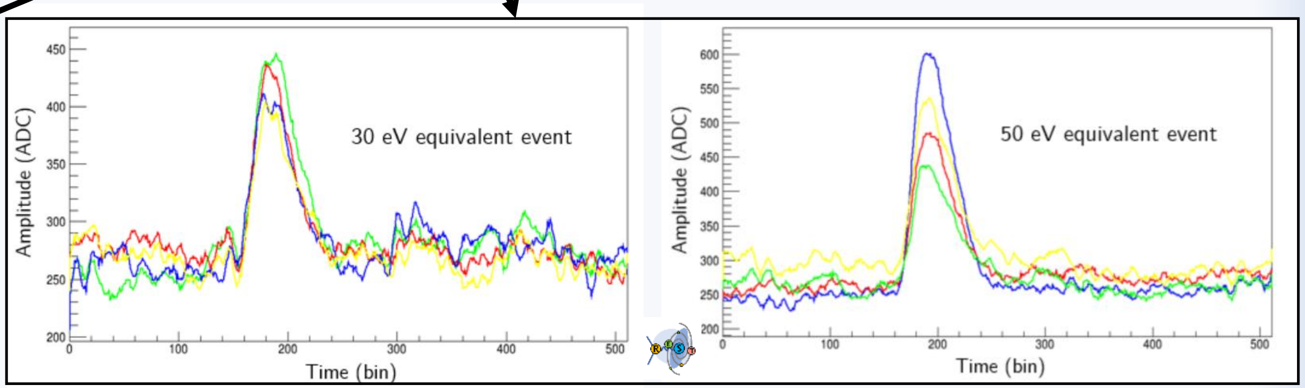

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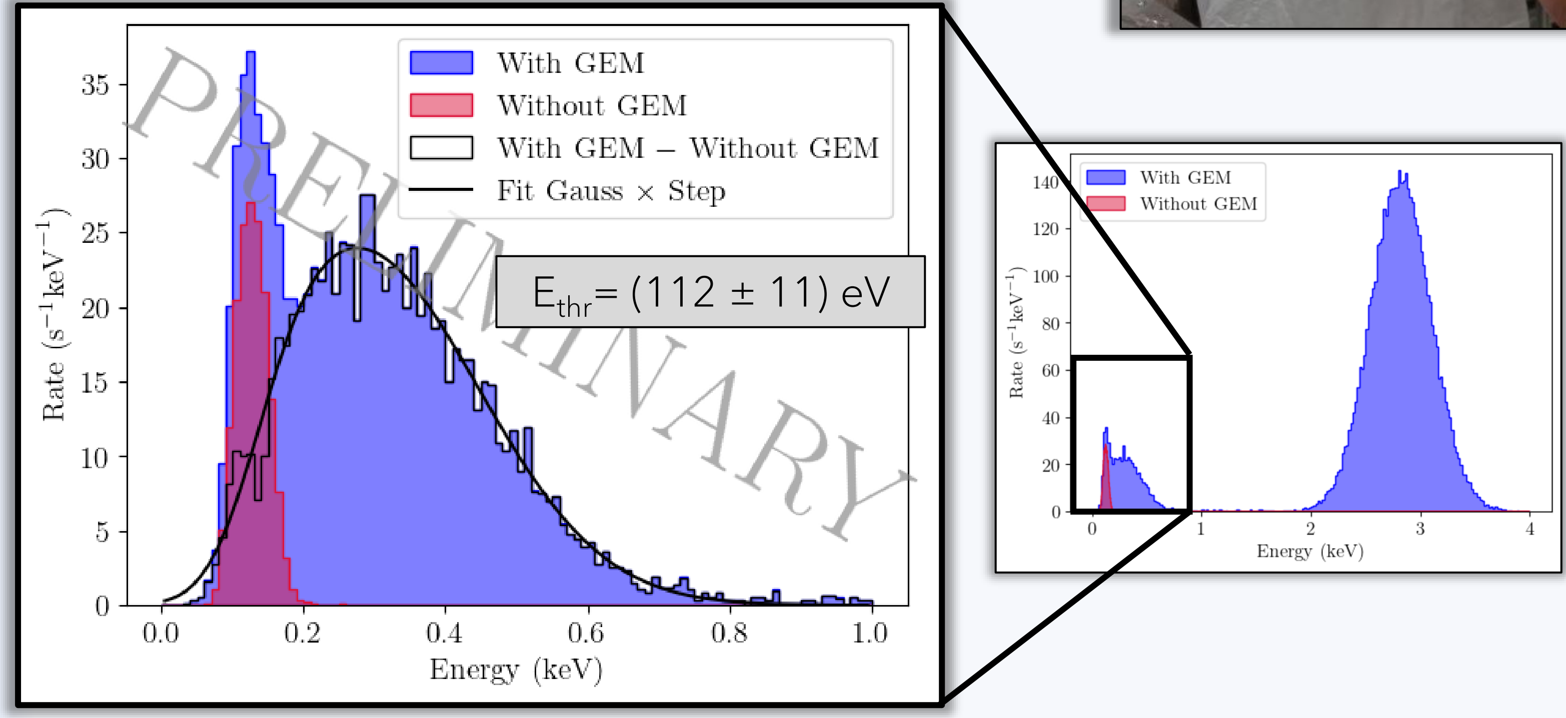
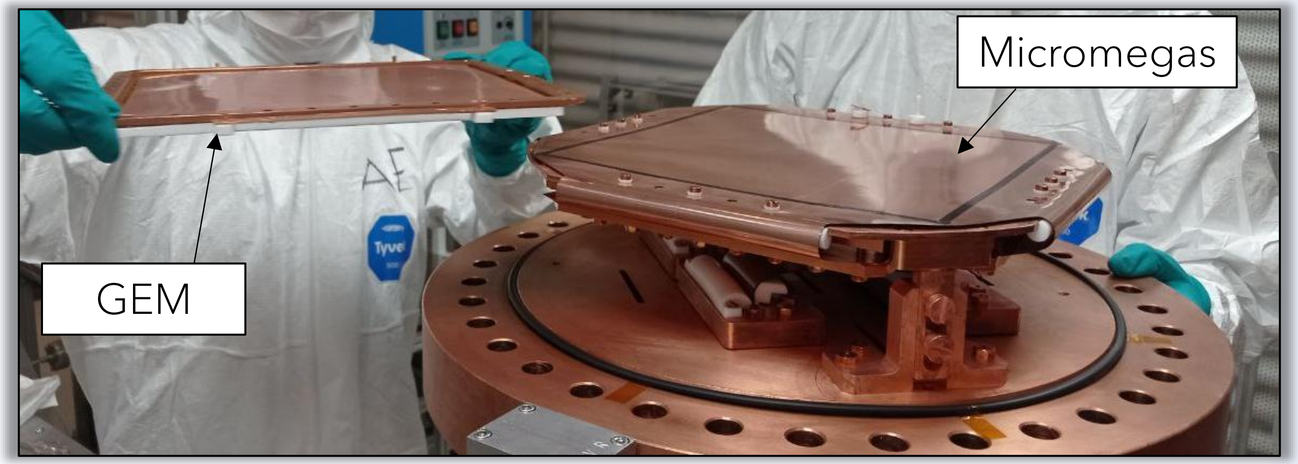
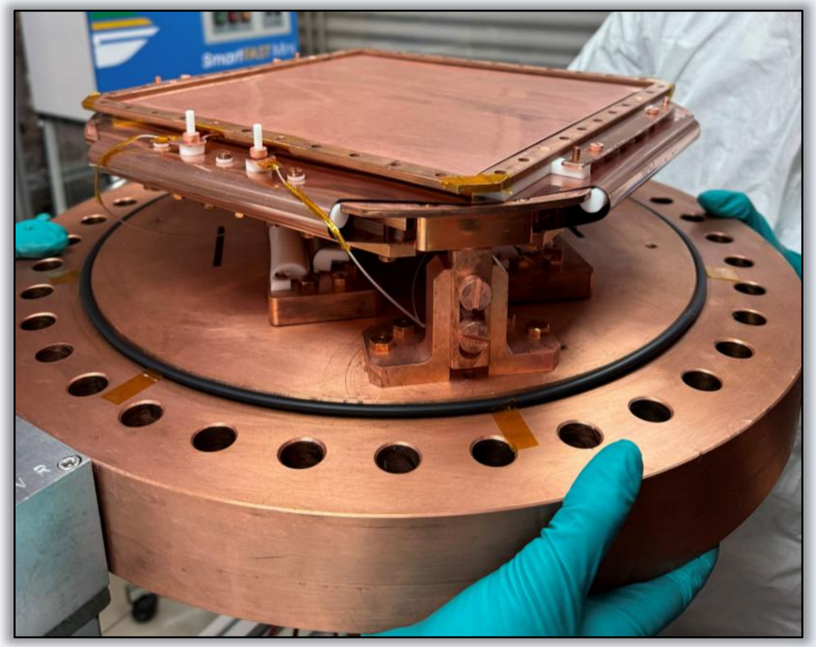
- Background data taking conditions
  - Ne+2%iso







Background level

Background model | First measurements | Rn issue | Surface contamination | Field cage & cathode

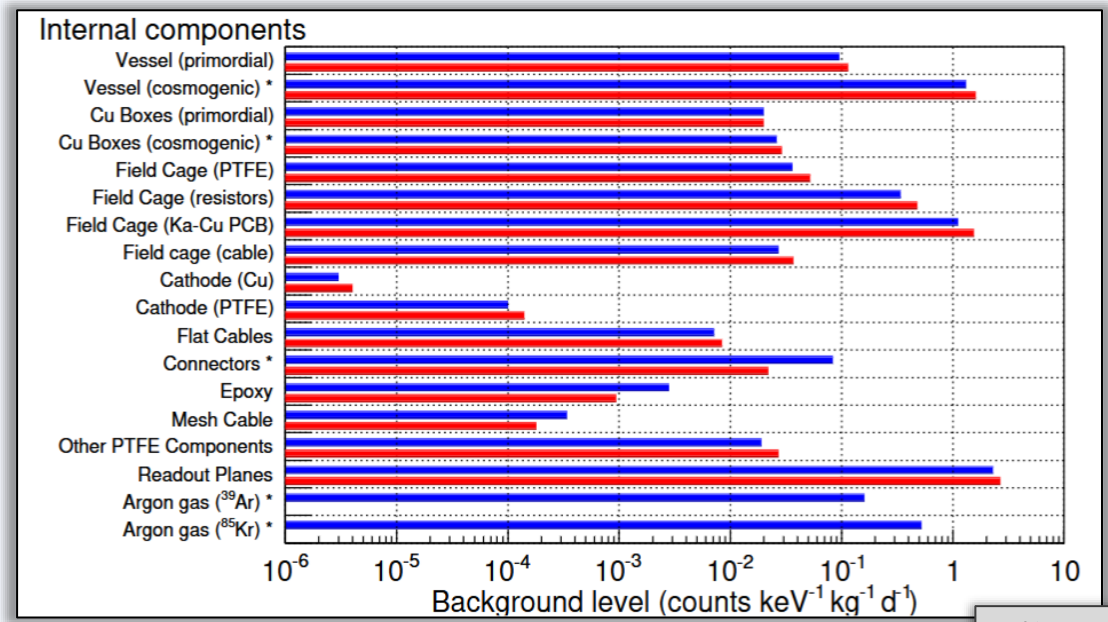
- Total background level in (0.2-7)keVee: ~10 dru
- Dominated by internal components

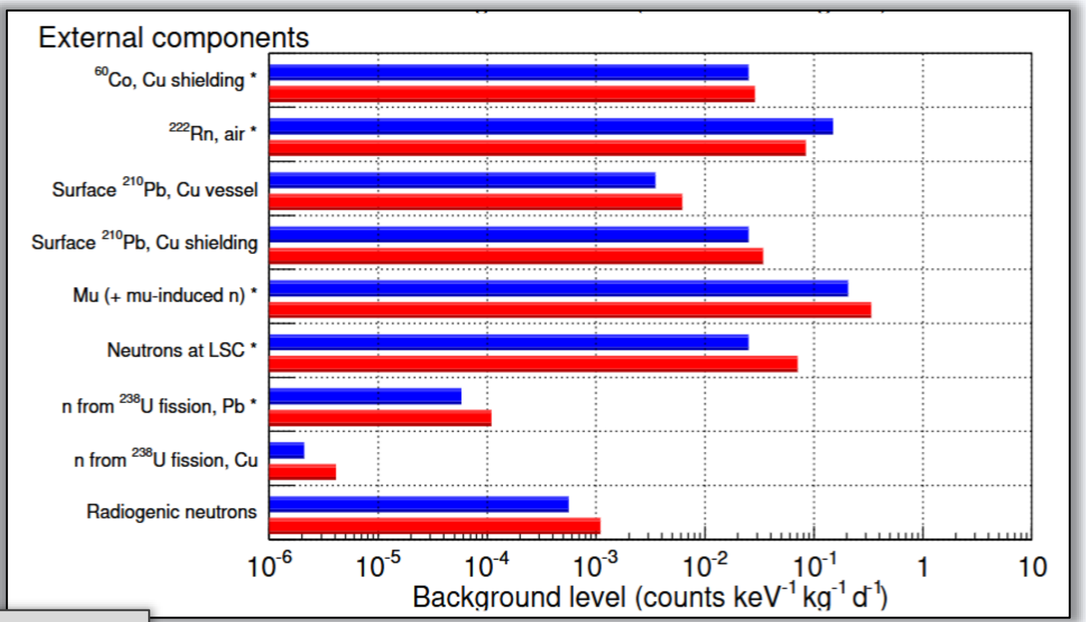
- High LE background: 600 dru
- LE and HE runs in seal mode

- After Rn decay: 80 dru
- Rn + constant component

- Operate in open loop to avoid the filters
- Surface contamination

- Explore different cathodes: mylar, Cu-Kp-Cu and wired Cu
- Replace full field cage





DOI: 10.1140/epjc/s10052-019-7282-6

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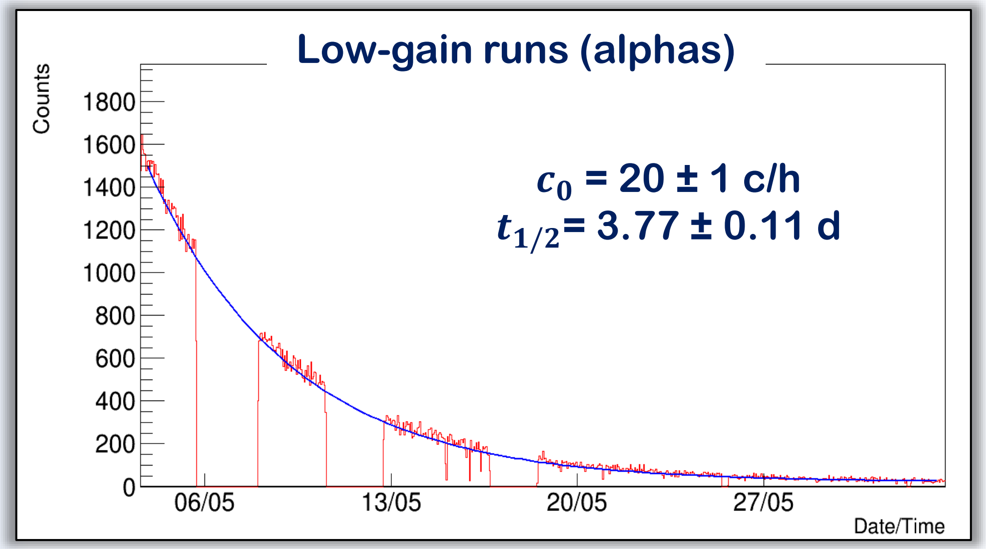

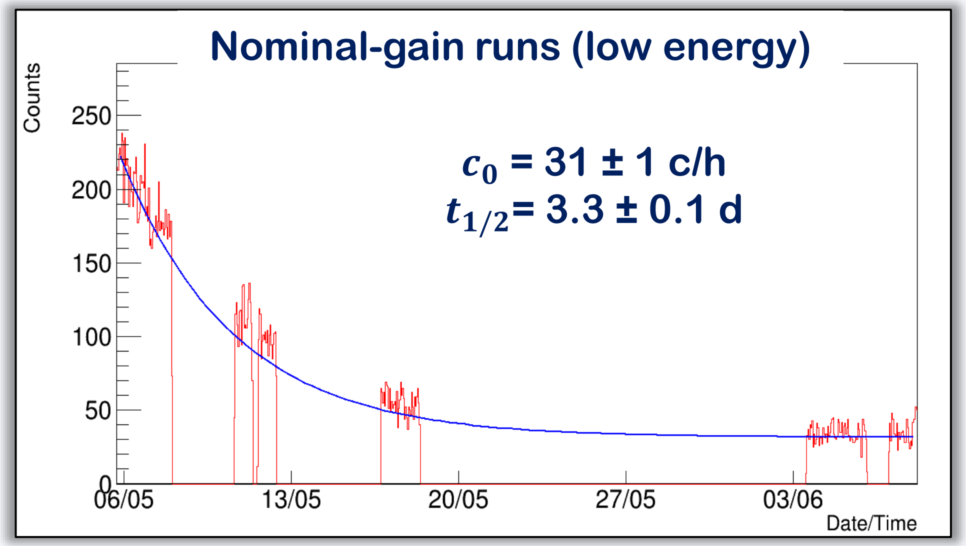

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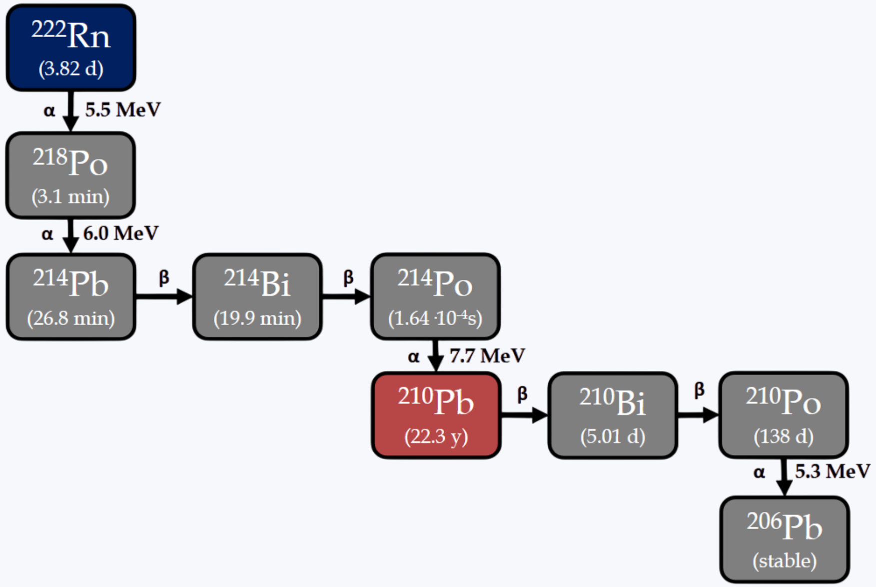

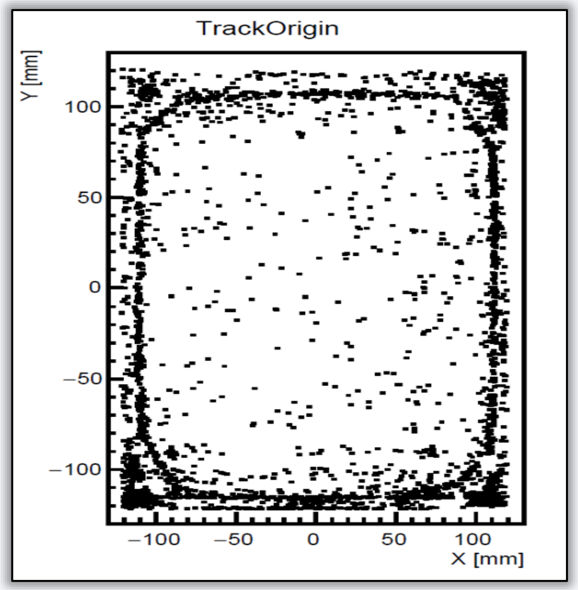

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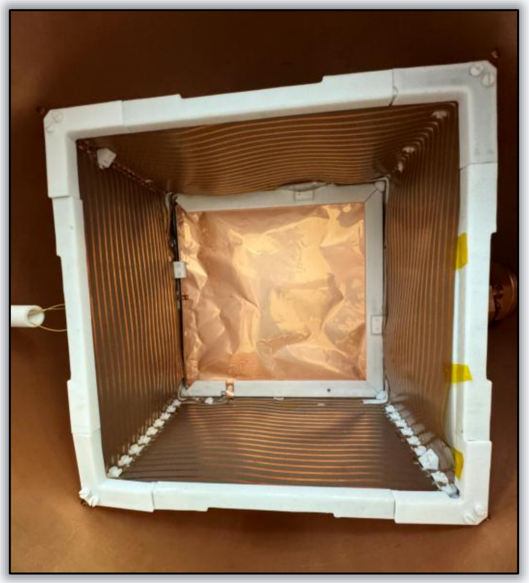
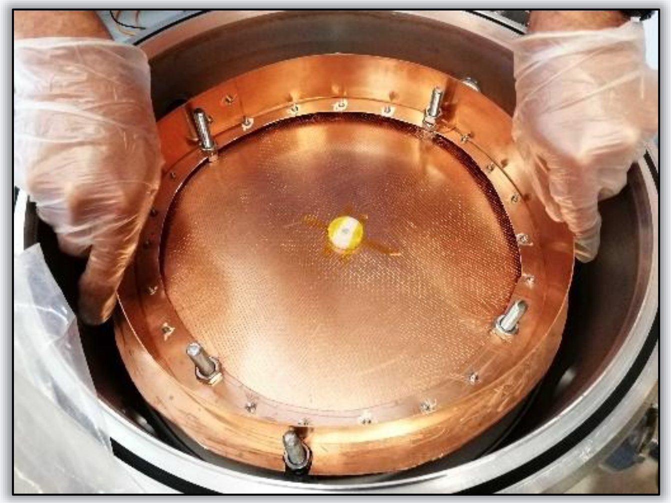
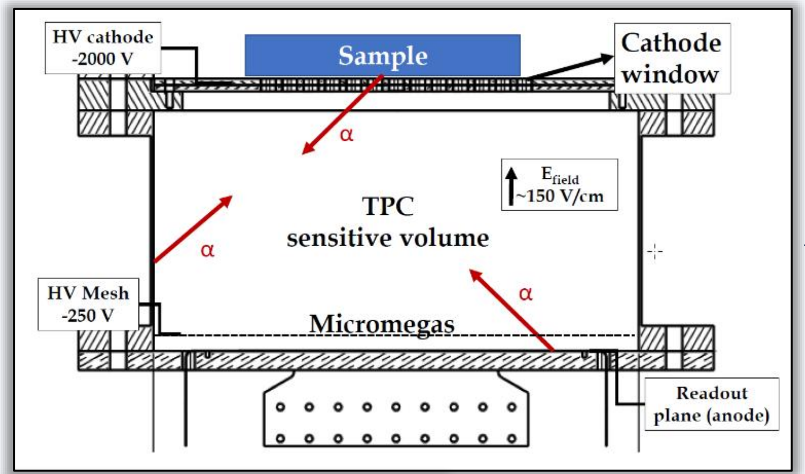


AlphaCAMM (Alpha CAMera Micromegas)

- Gaseous TPC with a segmented mM (25cm x 25cm)
- Measure ^{210}Pb surface contamination of flat samples down to 100 nBq/cm^2
- Track reconstruction (origin and end) allows to identify the alphas coming from the sample





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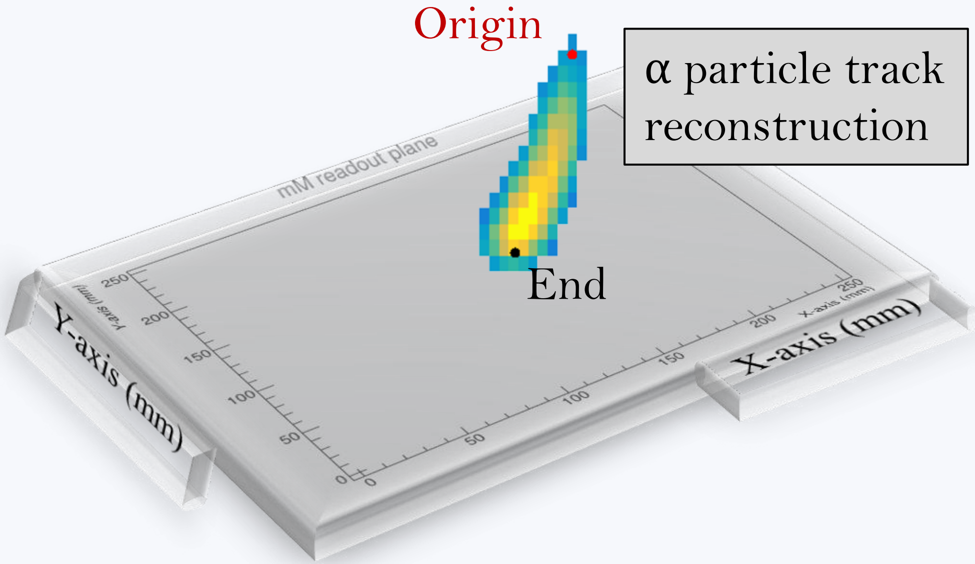
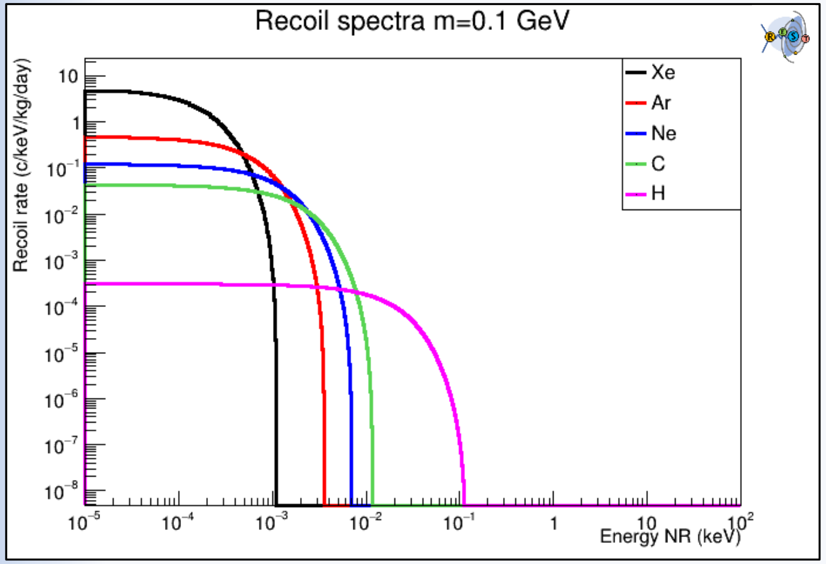
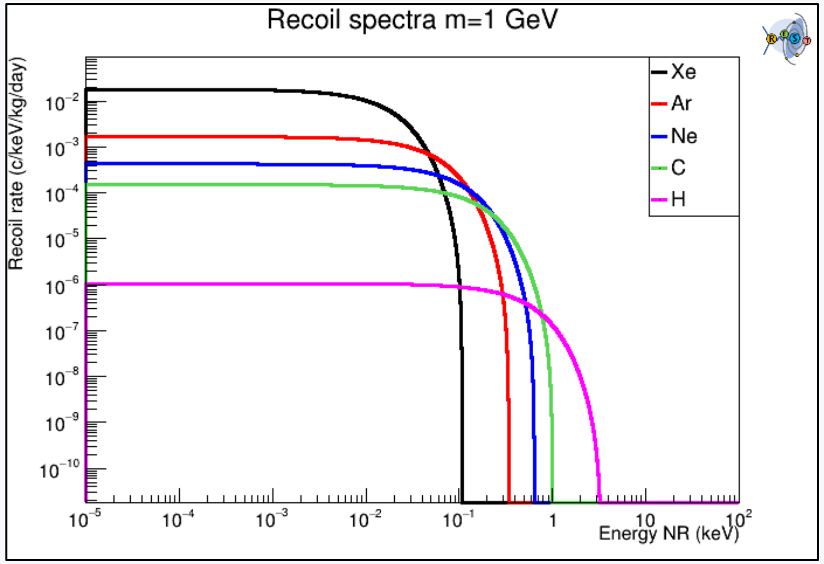


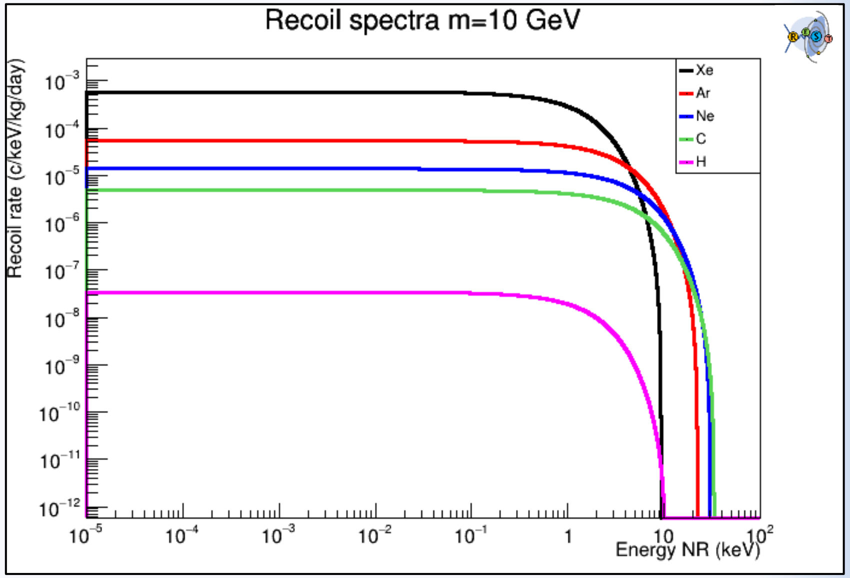
Gas as target

- For low-mass WIMP, the lighter targets are more efficient

- Increase the quencher (C_4H_{10}) fraction to enhance the sensitivity



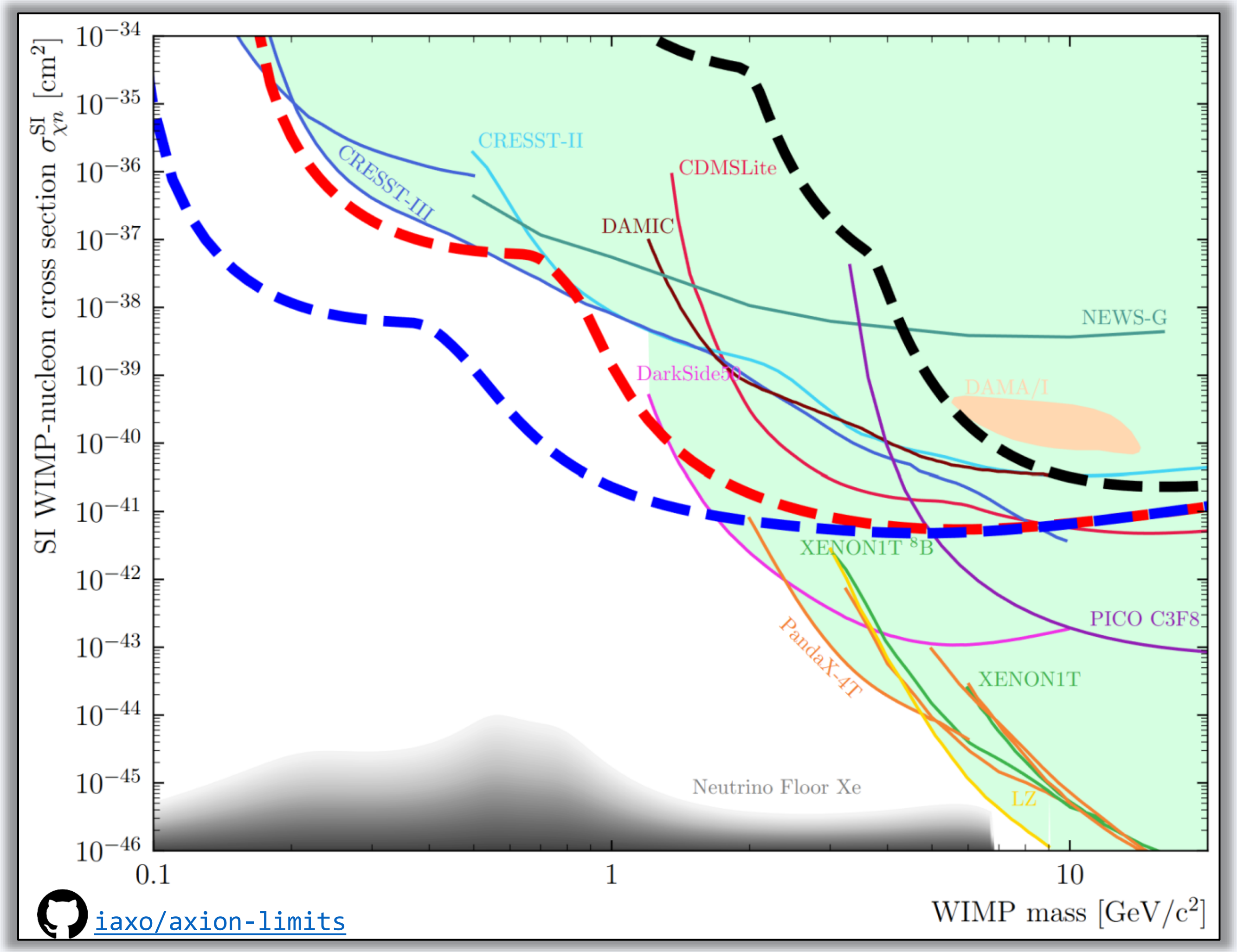




Decreasing WIMP mass

TREX-DM sensitivity prospects

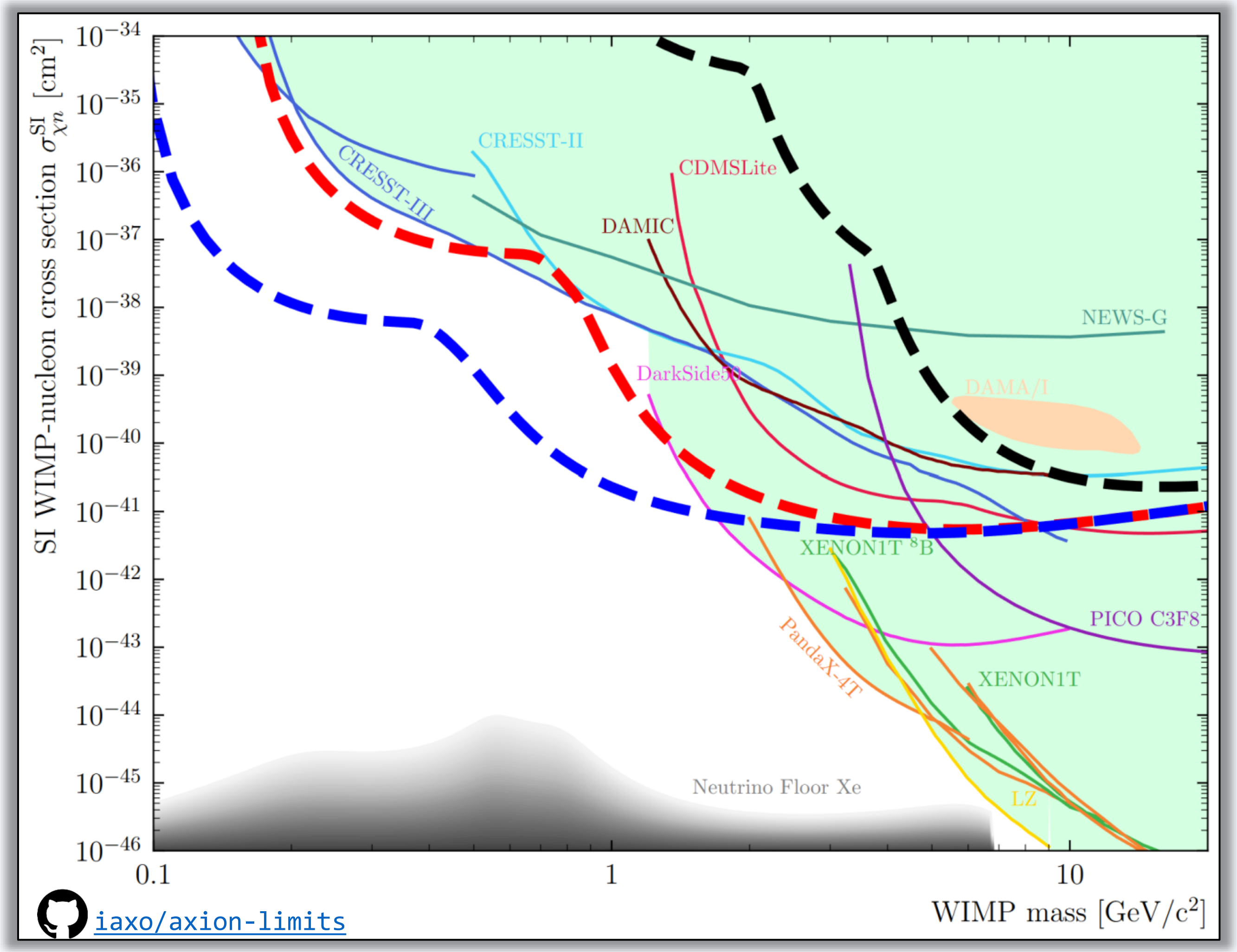
E_{th} (eV$_{ee}$)	B(dru)	Gas
1000	80	Ar-1%Iso



TREX-DM sensitivity prospects

E_{th} (eV_{ee})	B(dru)	Gas
1000	80	Ar-1%Iso
100	80	Ne-2%Iso

Improve E_{th} and use of Ne

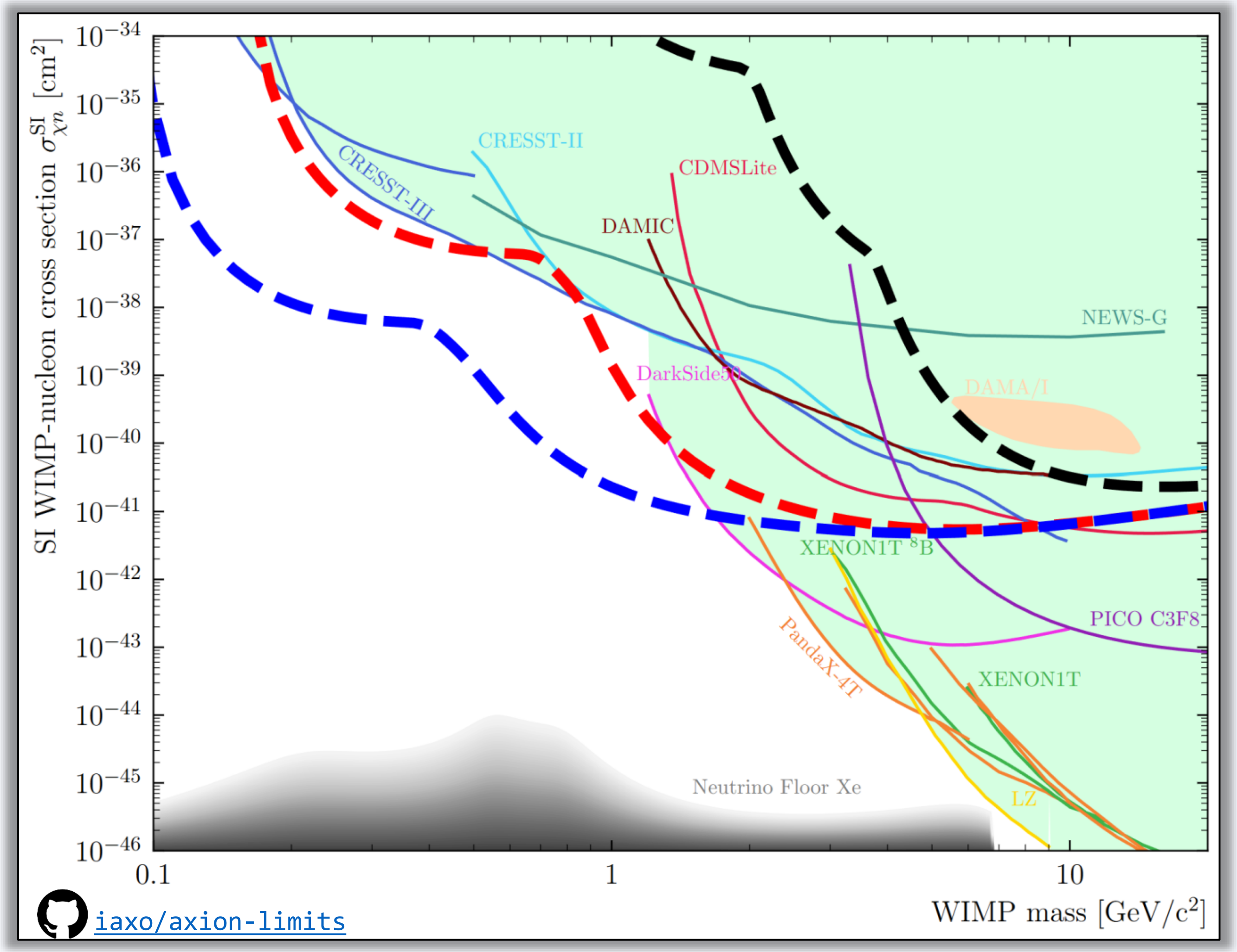


TREX-DM sensitivity prospects

E_{th} (eV_{ee})	B(dru)	Gas
1000	80	Ar-1%Iso
100	80	Ne-2%Iso
30	1	Ne-10%Iso

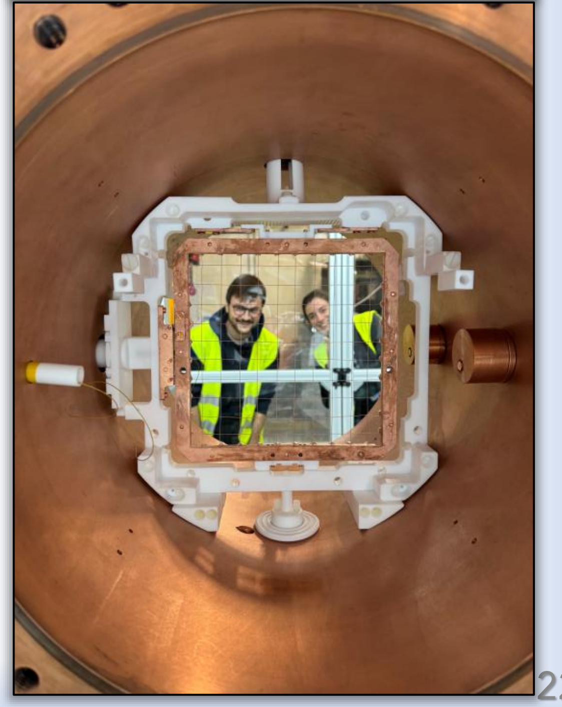
Improve E_{th} and use of Ne

Improve E_{th}, background and more isobutane



Conclusions

- **TREX-DM** is a high pressure gaseous TPC experiment for direct detection of **low-mass WIMPs** with **Micromegas** technology
  - High radiopurity
  - Topology information → background discrimination
- We succesfully implemented the **GEM+mM** in one of TREX-DM sides, allowing to reach **energy thresholds around single electron ionization** O(10eV)
  - Working in a dedicated UV laser set-up to study the efficiency at this such low energies
- Stable **background** data taking has been carried out with **E_{th}~100eV at 1.1bar**
  - Work on-going to identify and remove the events of the transfer gap
- Currently taking background at higher pressure of 2.0bar
- Near future plans to increase the pressure and isobutane fraction




THANKS!

Acknowledgements

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In particular, we acknowledge the support from

- The **Spanish Agencia Estatal de Investigación AEI** under grant PID2019-108122GB-C31 funded by MCIN/AEI/10.13039/501100011033
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Financiado por la Unión Europea NextGenerationEU

Plan de Recuperación, Transformación y Resiliencia

AGENCIA ESTATAL DE INVESTIGACIÓN

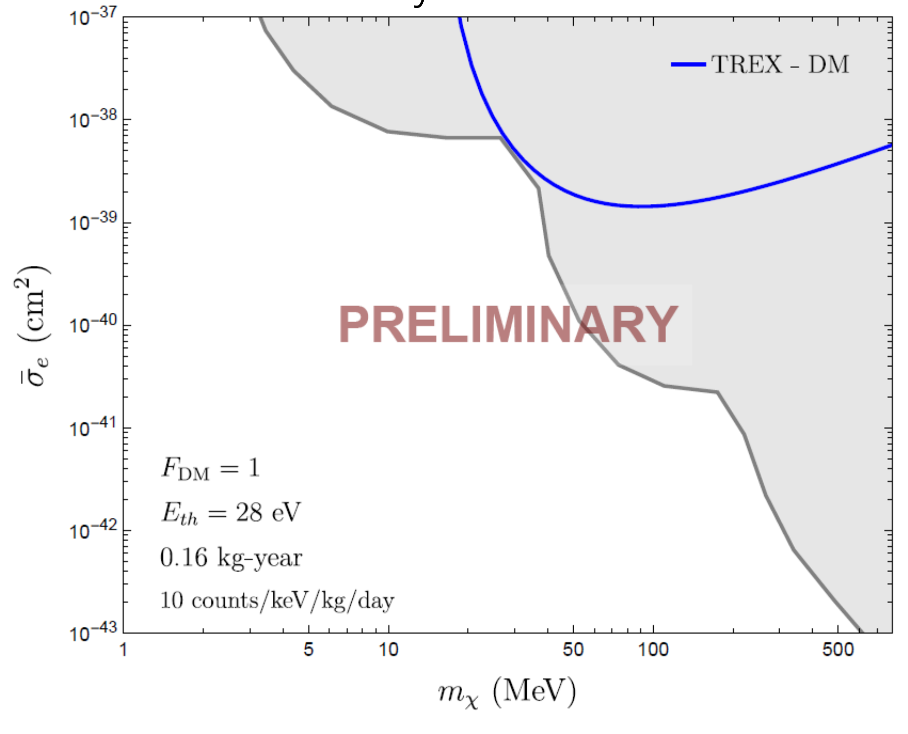
GOBIERNO DE ARAGON

TREX-DM sensitivity prospects

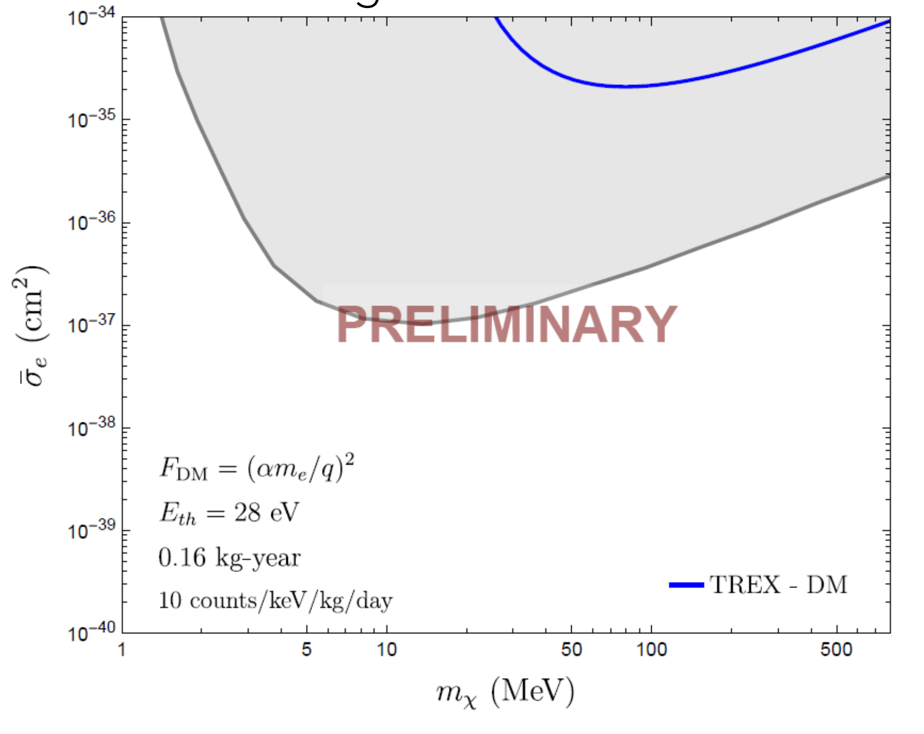
- WIMP-electron channel

Work of Pablo Figueroa & Camilo García Cely

Heavy mediator



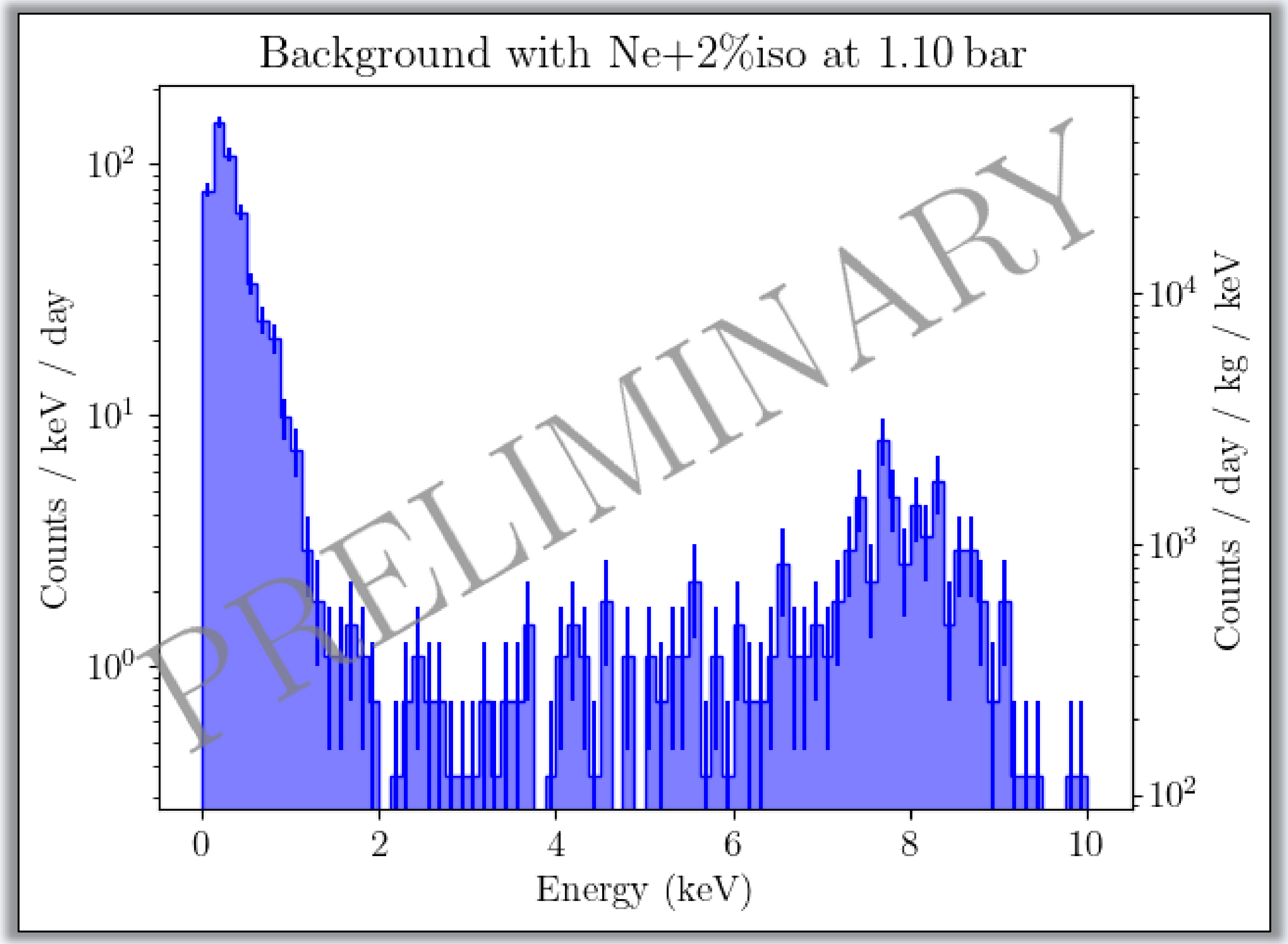
Light mediator



Background at low energies

- Background with Ne+2%iso at 1.10bar
- 22 days of data

- Expected peak from the copper fluorescence (8keV)
- Background rapidly increases below 2keV



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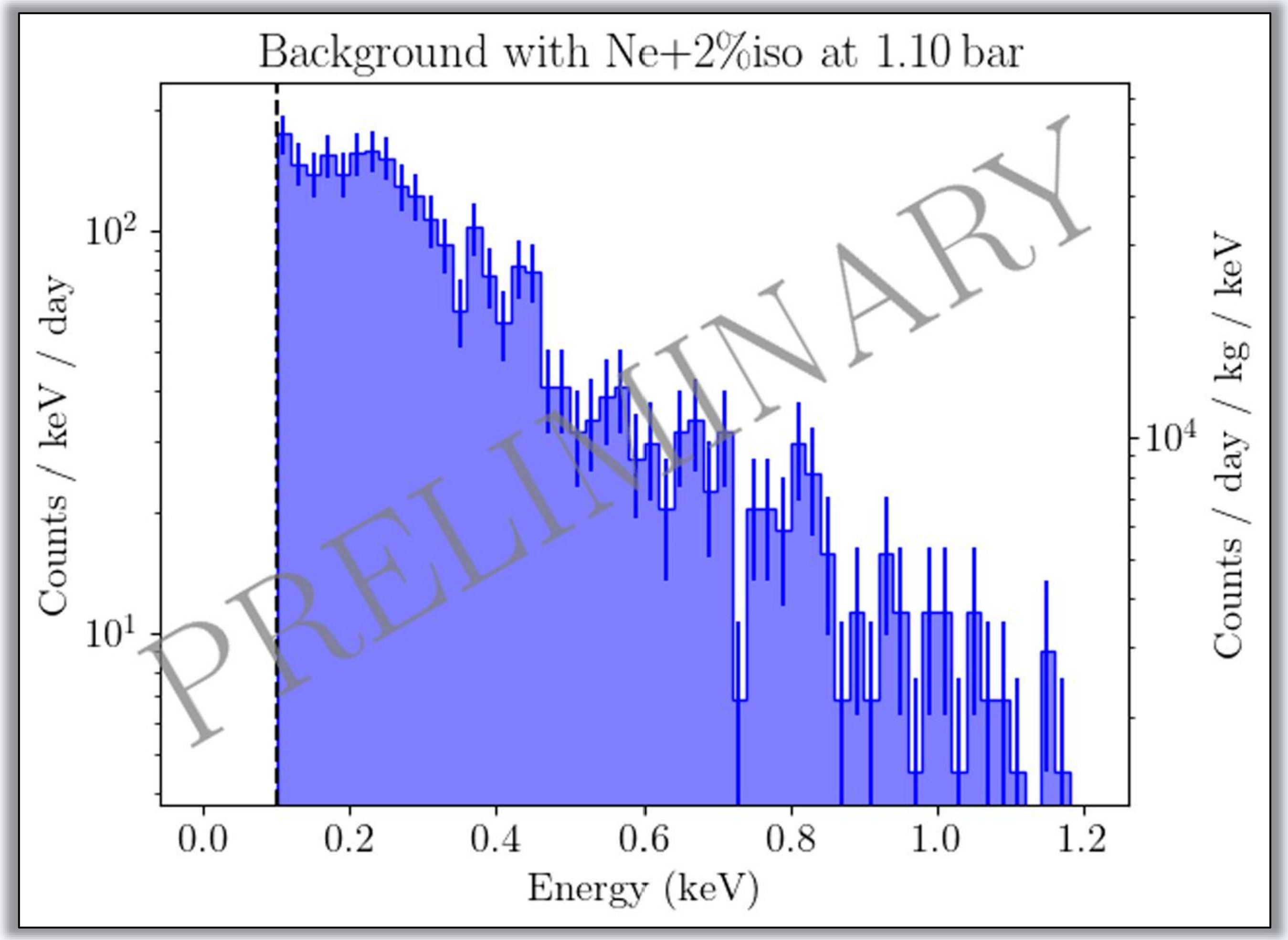
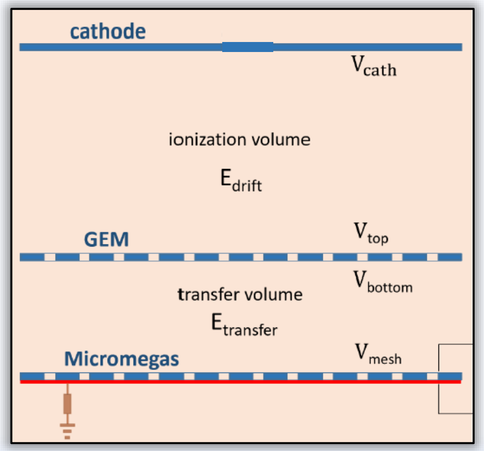


- E_{th}~100eV
- Perhaps dominated by transfer region events



Background comparison with other experiments

- Data from https://github.com/fewagner/excess

Please, let me know if there is a more updated repository !!!