

Direct dark matter detection of light particles at the GeV-scale and below

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XVIII International
Conference on Topics in
Astroparticle and
Underground Physics

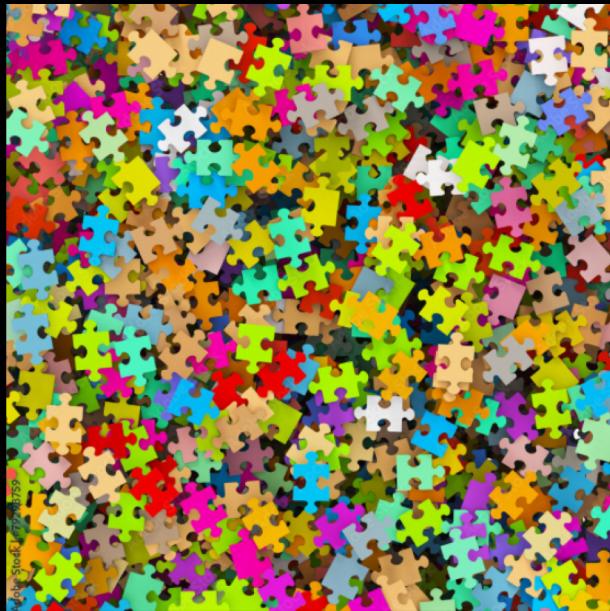
Aug, 28 to Sep, 1
University of Vienna

Aug, 30 2023



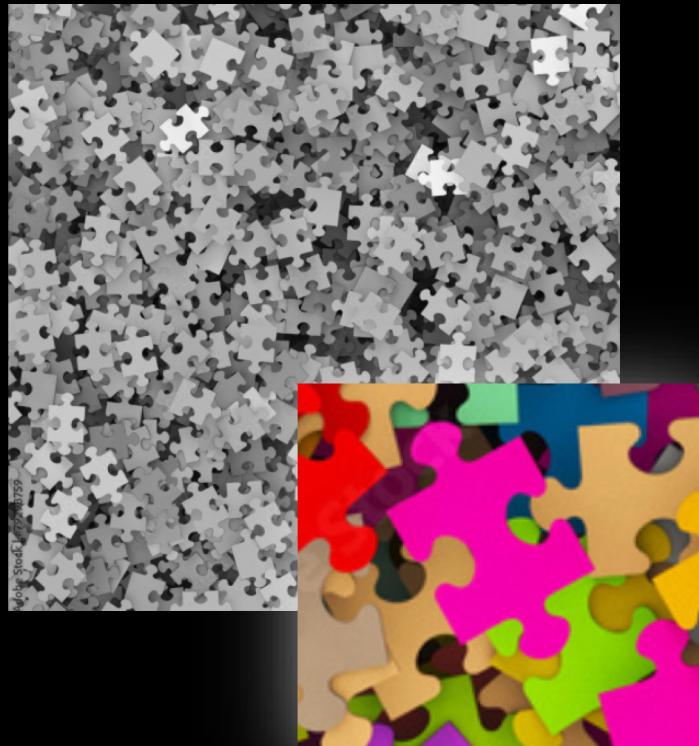
MAX-PLANCK-INSTITUT
FÜR PHYSIK

Direct dark matter detection of light particles at the **GeV-scale and below**



$\mathcal{O}(100)$ papers in the past 5 years
different detection technologies
active and growing community with various
R&D programs and small-scale projects

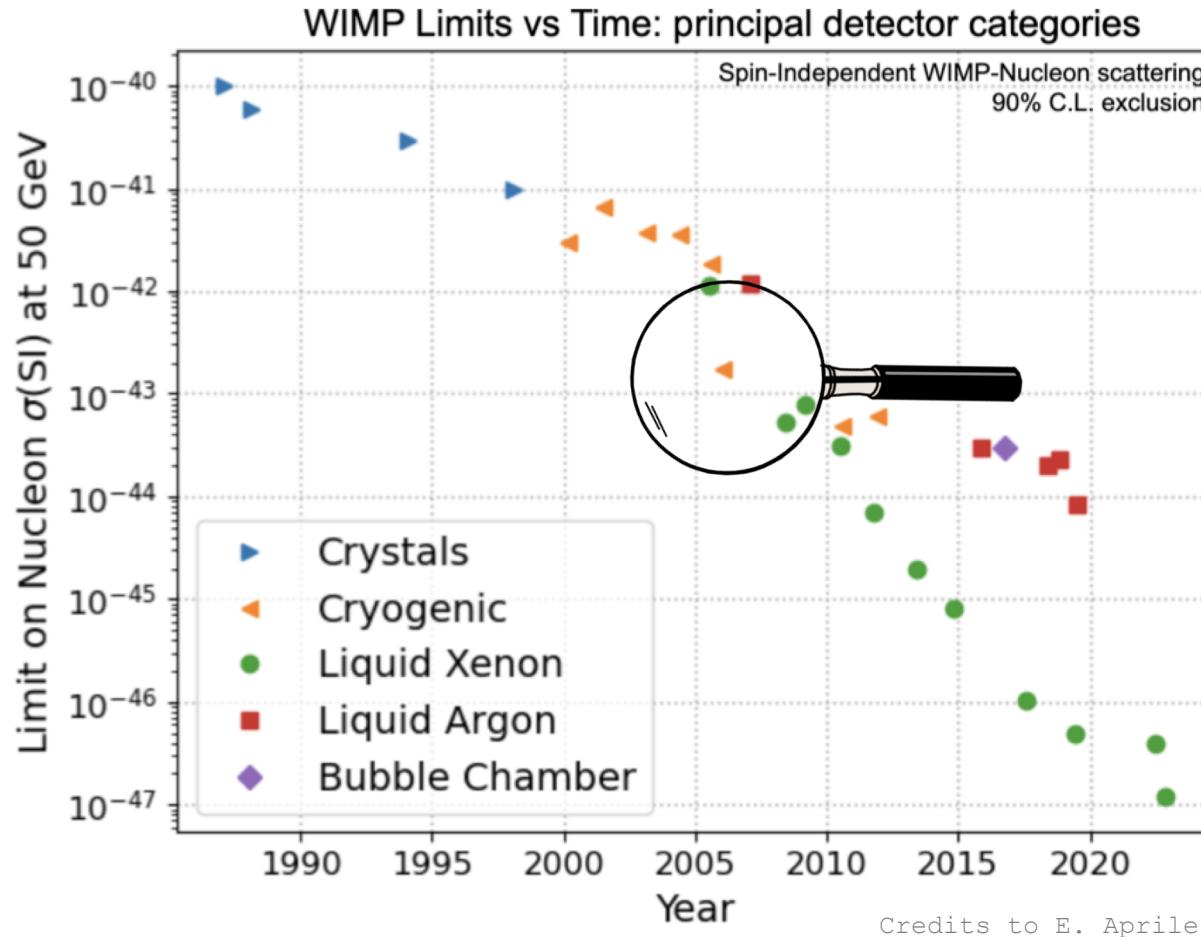
Direct dark matter detection of light particles at the GeV-scale and below



$\mathcal{O}(100)$ papers in the past 5 years
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active and growing community with various R&D programs and small-scale projects

Sorry if I missed your favorite topic or R&D project

SEARCHING for “the” WIMP



Protagonists: 1990 - 2000

scintillators and **cryogenic detectors** proof technological feasibility and are the “**starters**” of the WIMP hunt

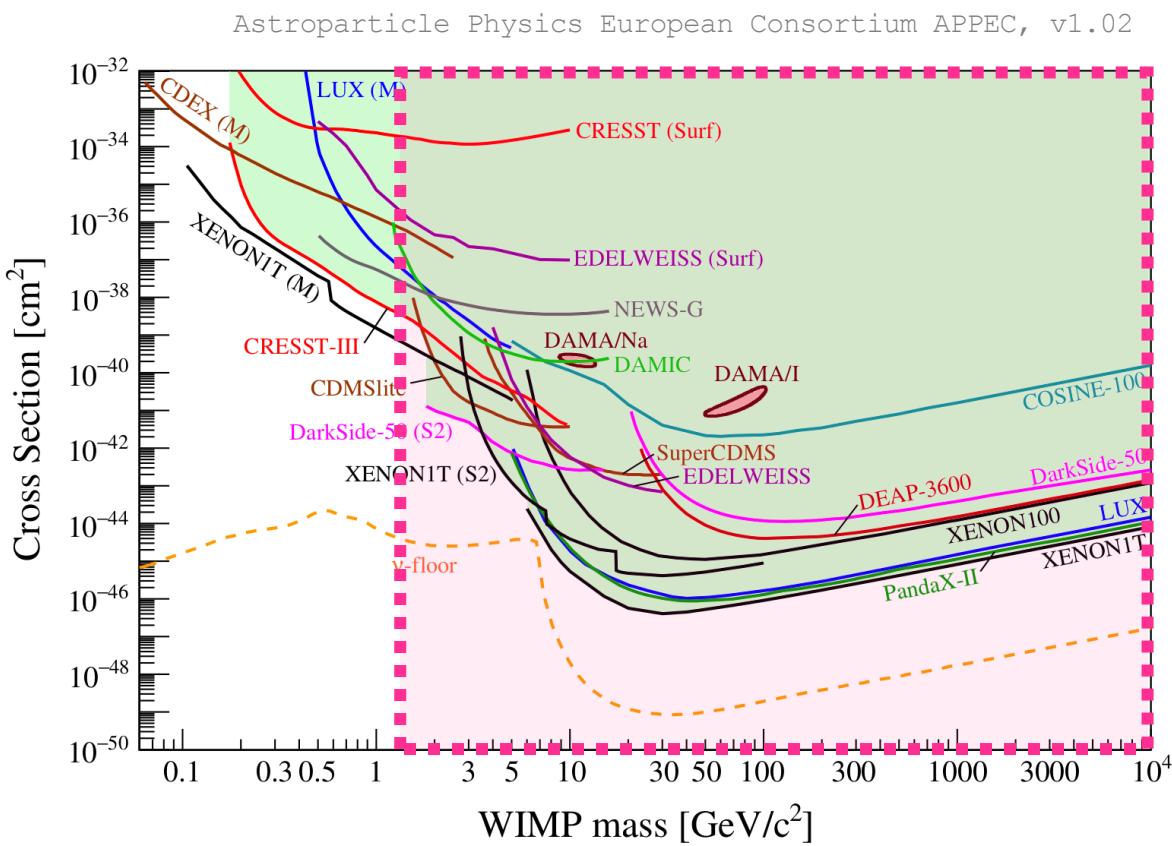
Background discrimination: 2005-2007

cryogenic detectors **provide particle identification** → a breakthrough!
Liquid noble gas detectors enter the field

Scalability: > 2010

liquid noble gas detectors take the lead in the run for the classical WIMP

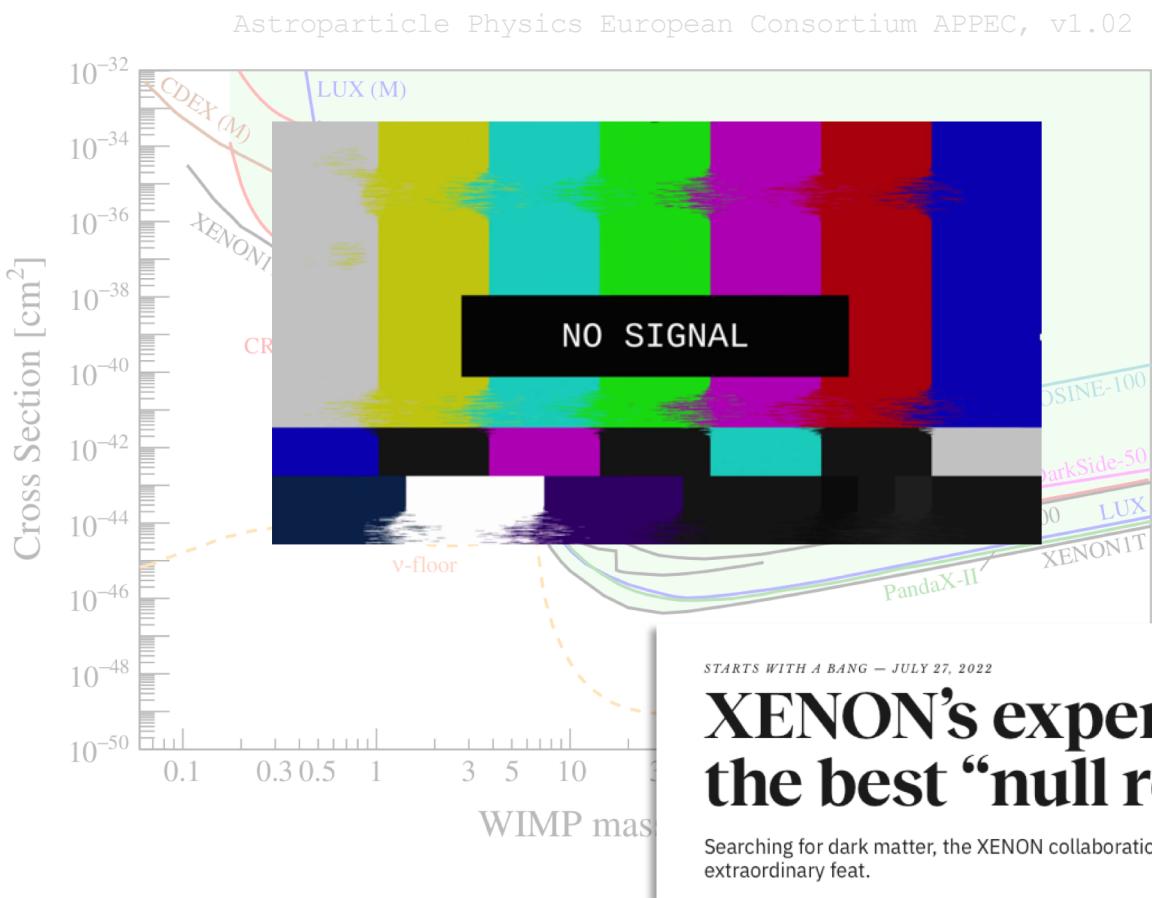
CURRENT STATUS of the WIMP SEARCH



~ 1 – 1000 GeV/c^2 with liquid nobles

- world-wide effort with enormous technological progress in last decades
- tonne-scale experiments with extremely rare interaction rate
current limit: $\mathcal{O}(0.01)$ cts/(keV tonne year)

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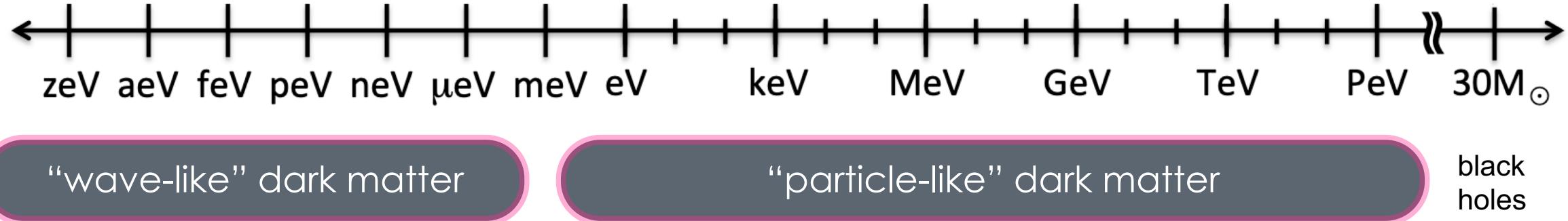
→ no discovery !

XENON's experimental triumph: No dark matter, but the best “null result” in history

Searching for dark matter, the XENON collaboration found absolutely nothing out of the ordinary. Here's why that's an extraordinary feat.



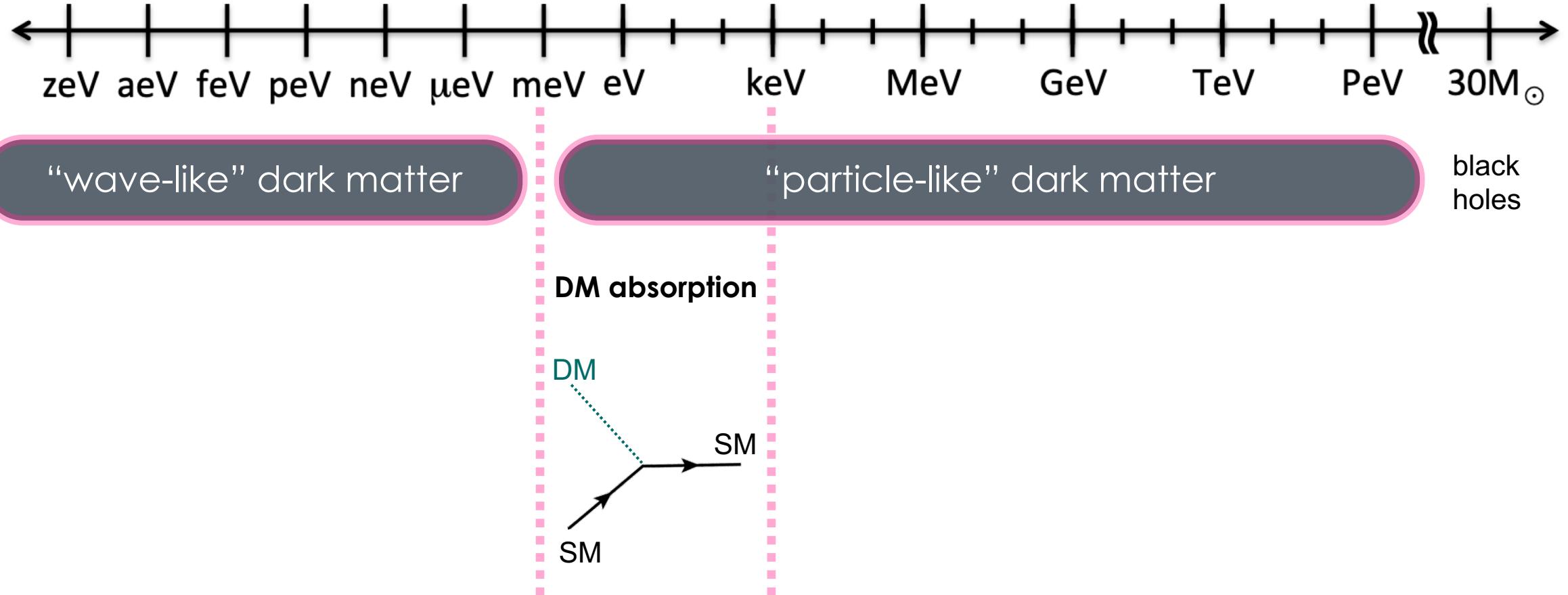
THE “ALLOWABLE” MASS RANGE



→ see talk of A. Ringwald

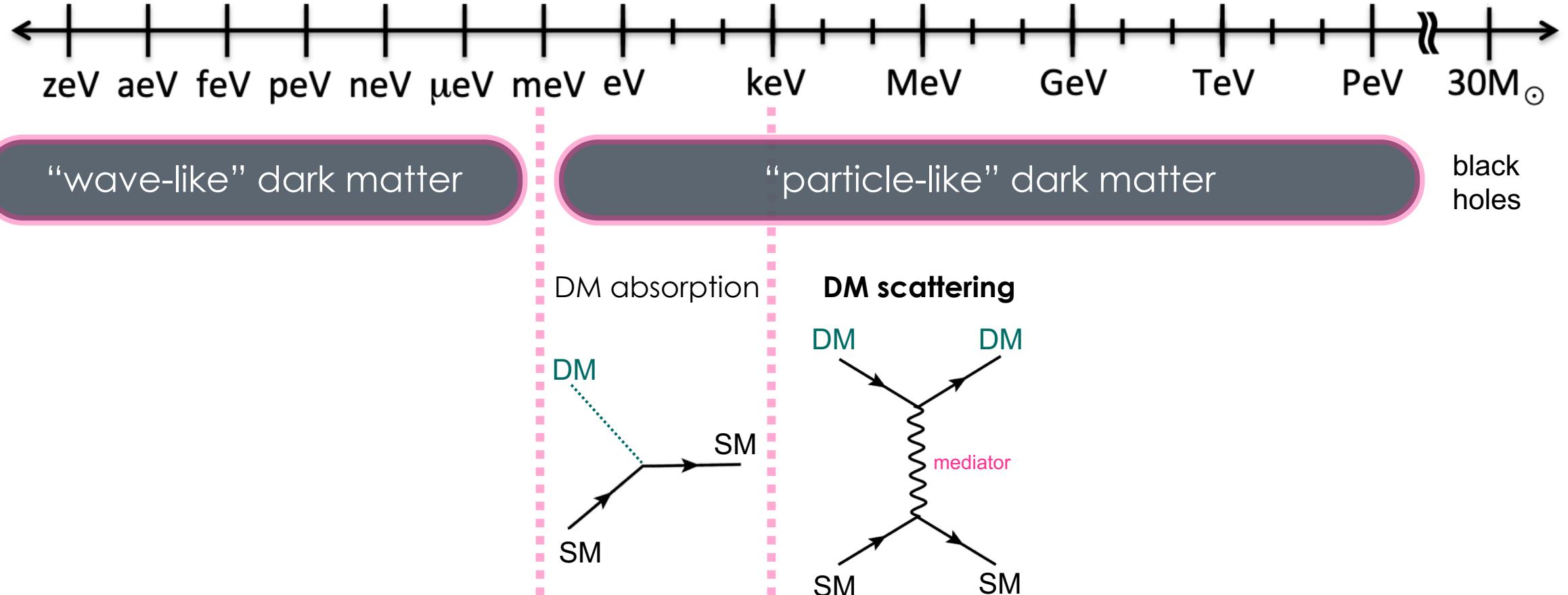


THE “ALLOWABLE” MASS RANGE





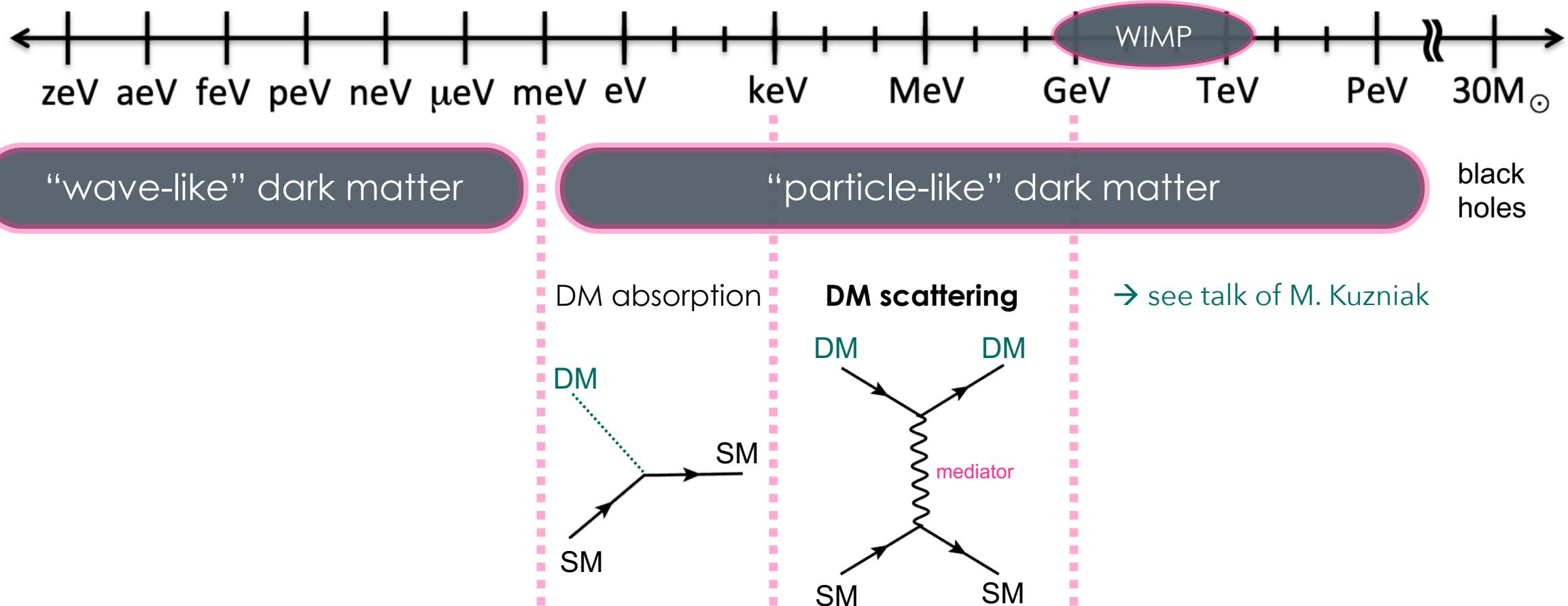
THE “ALLOWABLE” MASS RANGE



→ Possible production scenarios discussed before by **M. Cirelli**



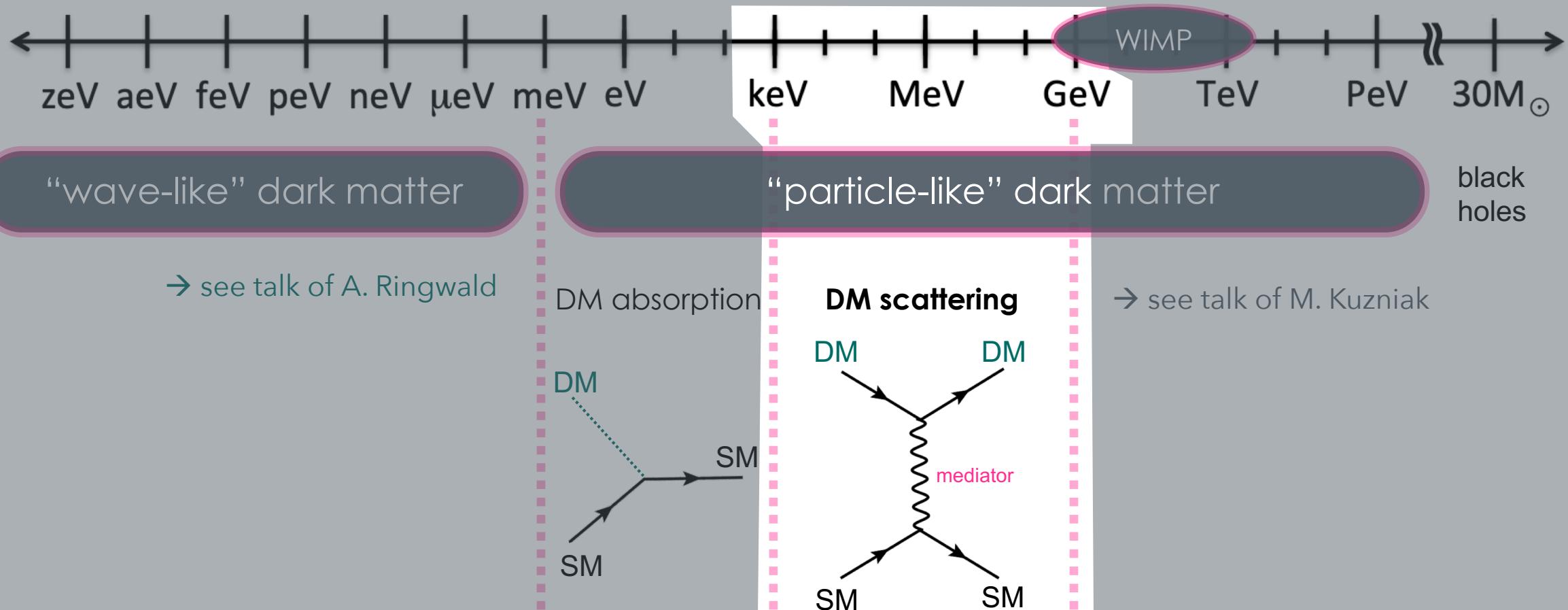
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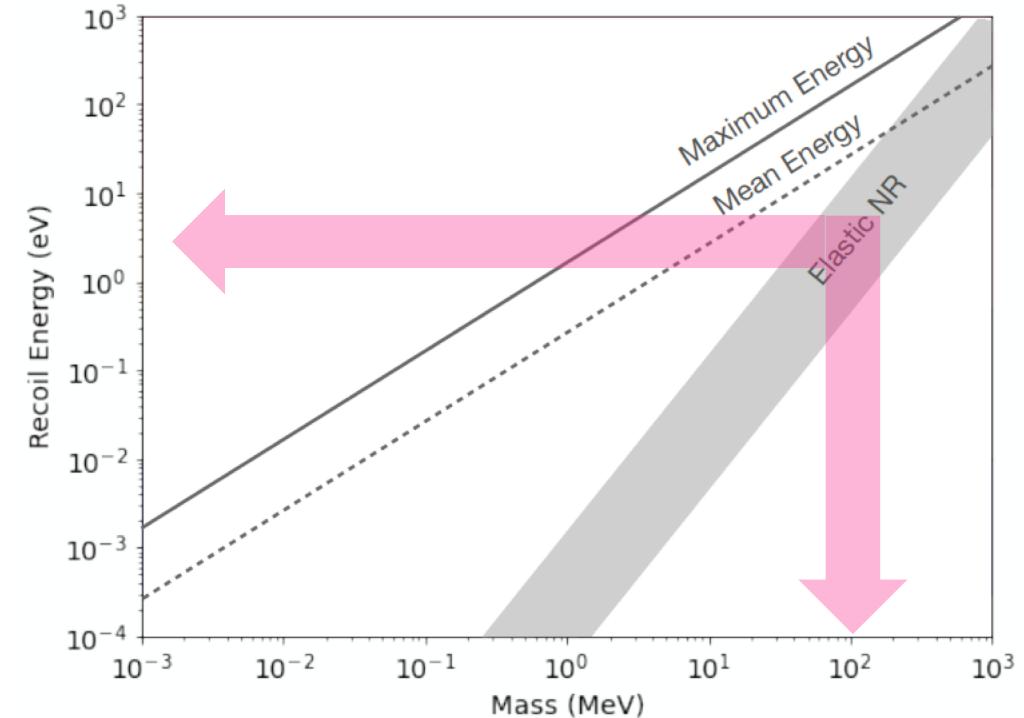
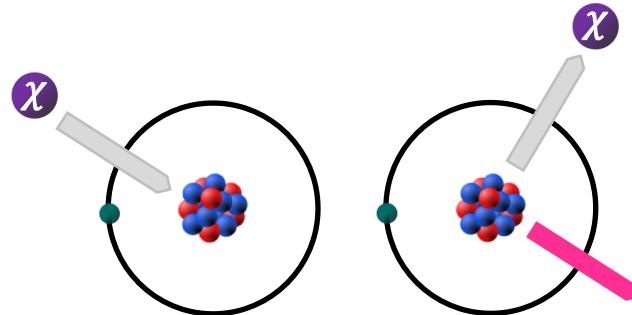
THE “ALLOWABLE” MASS RANGE



DARK MATTER INTERACTIONS AND SIGNALS



- elastic DM – nucleus scattering (NR)

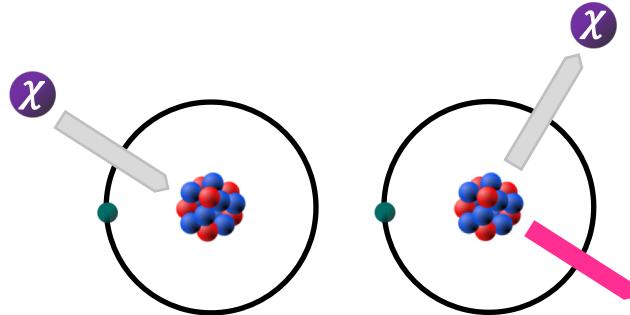


Elastic NR for H and Xe

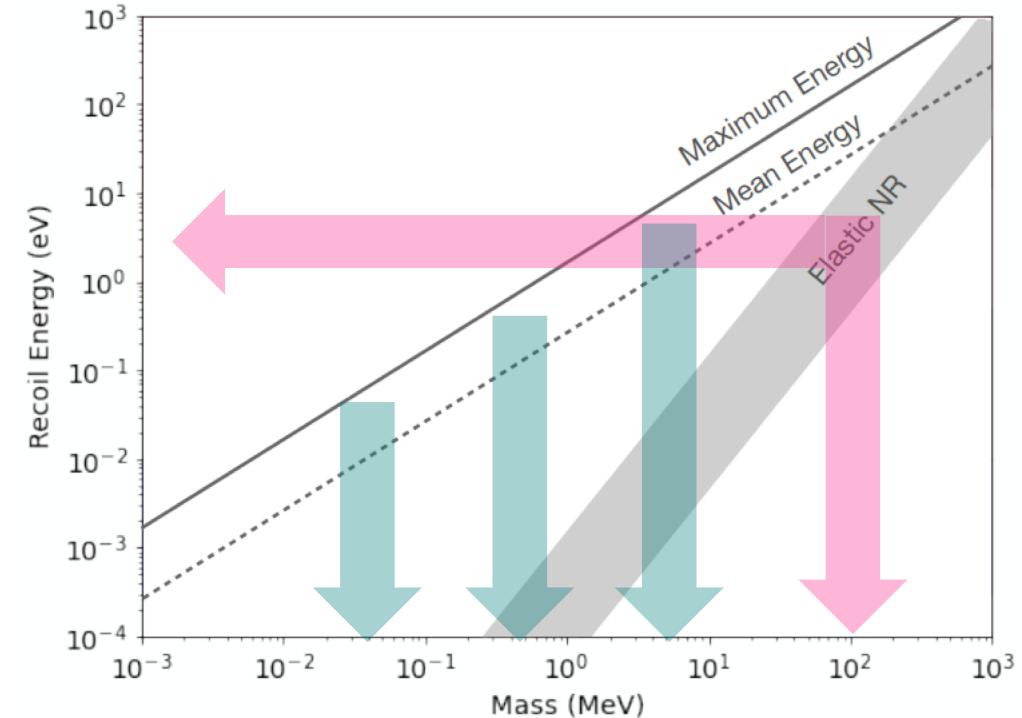
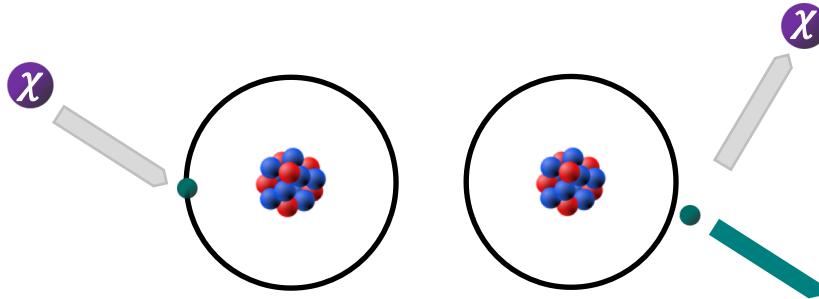
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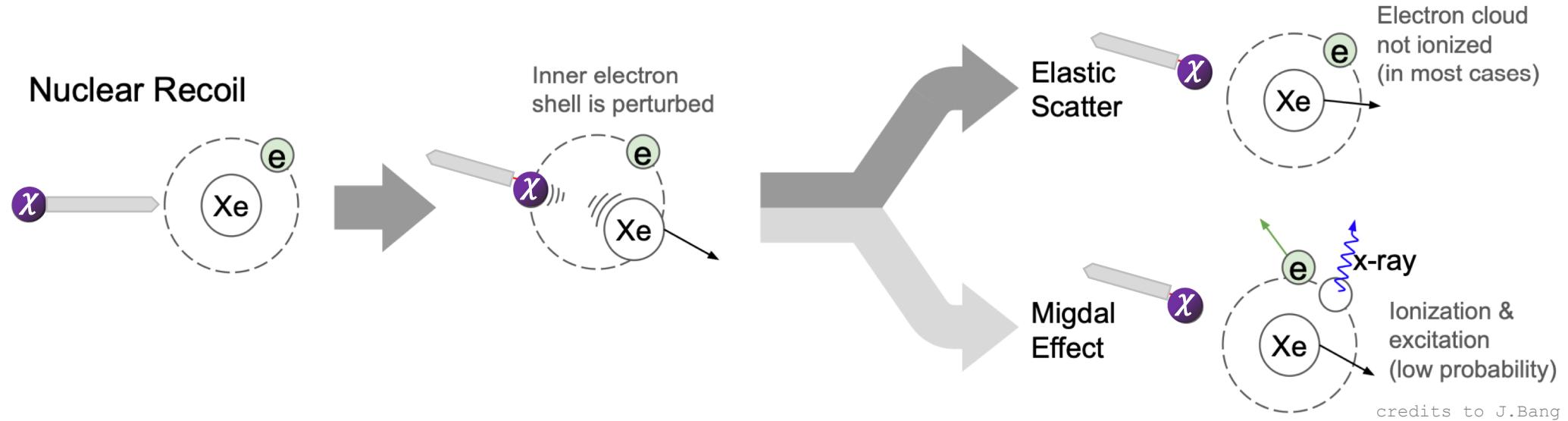


- DM – electron – scattering (ER) (inelastic)



Elastic NR for H and Xe

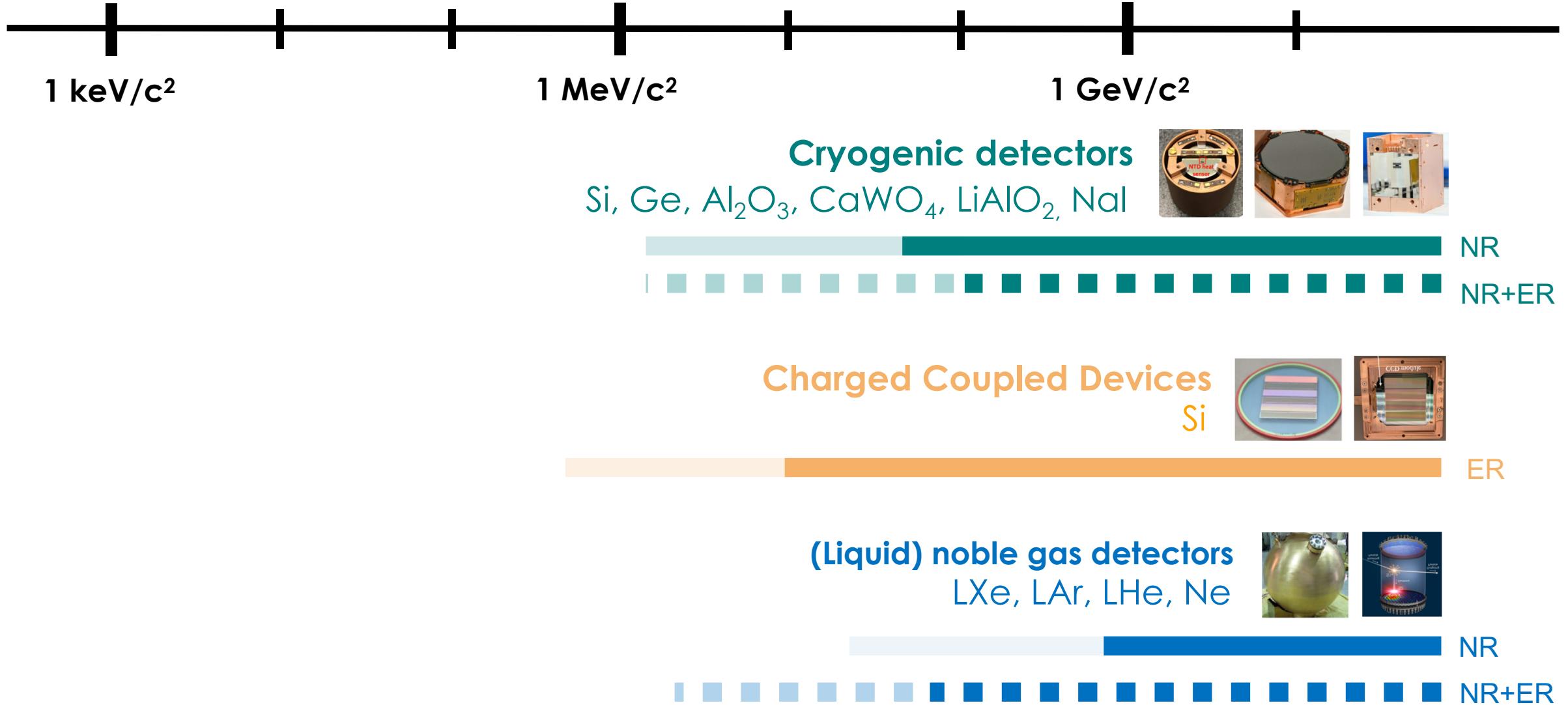
MIGDAL EFFECT – promising avenue



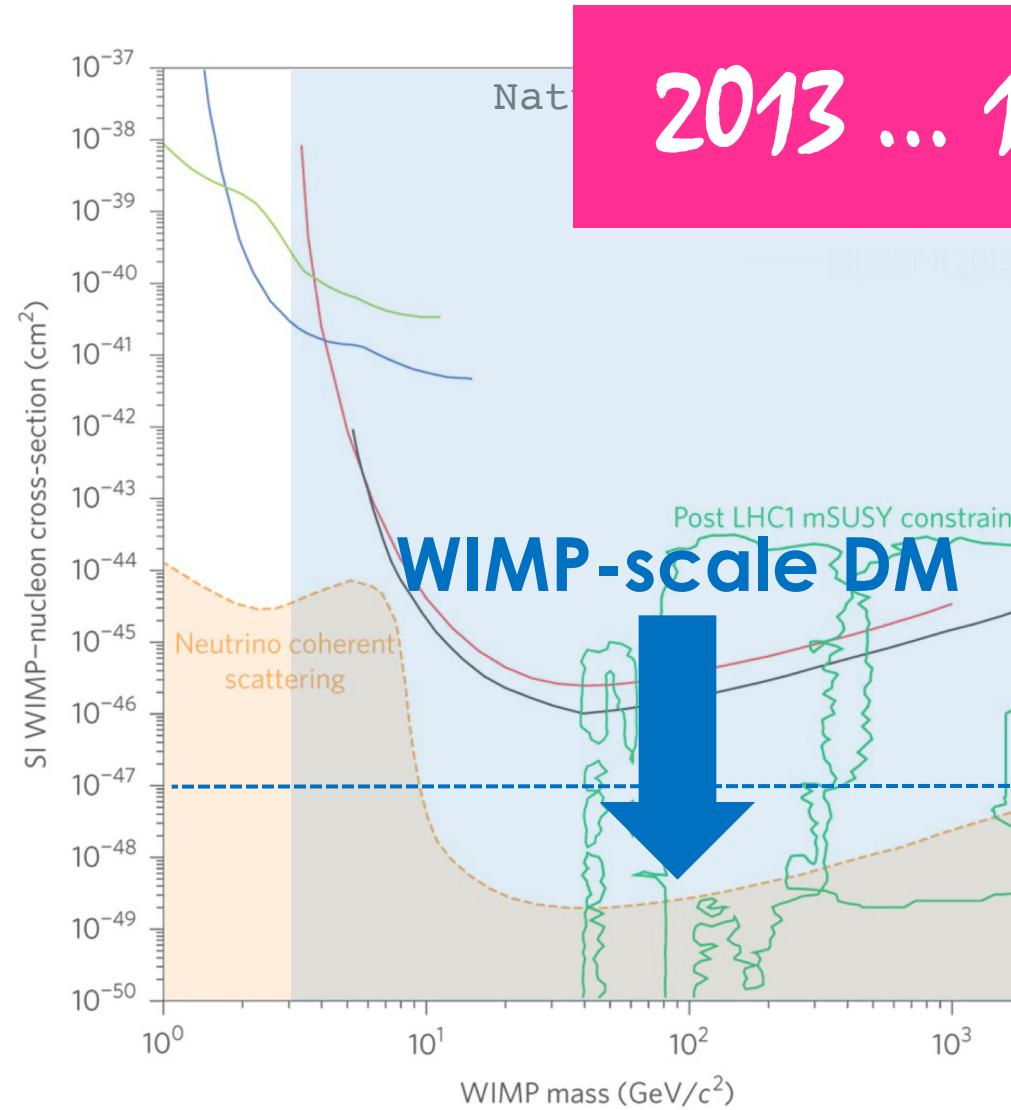
change in the Coulomb field felt by the electrons results in an energy transfer from DM to the electrons
→ readjustment of the electron cloud can spit out an electron of a few hundred eV = **ionisation signal**

BUT there is a penalty to pay → signal rates are suppressed

DETECTION TECHNIQUE and TARGETS



CRYOGENIC DETECTORS – the Renaissance



2013 ... 10 years ago !

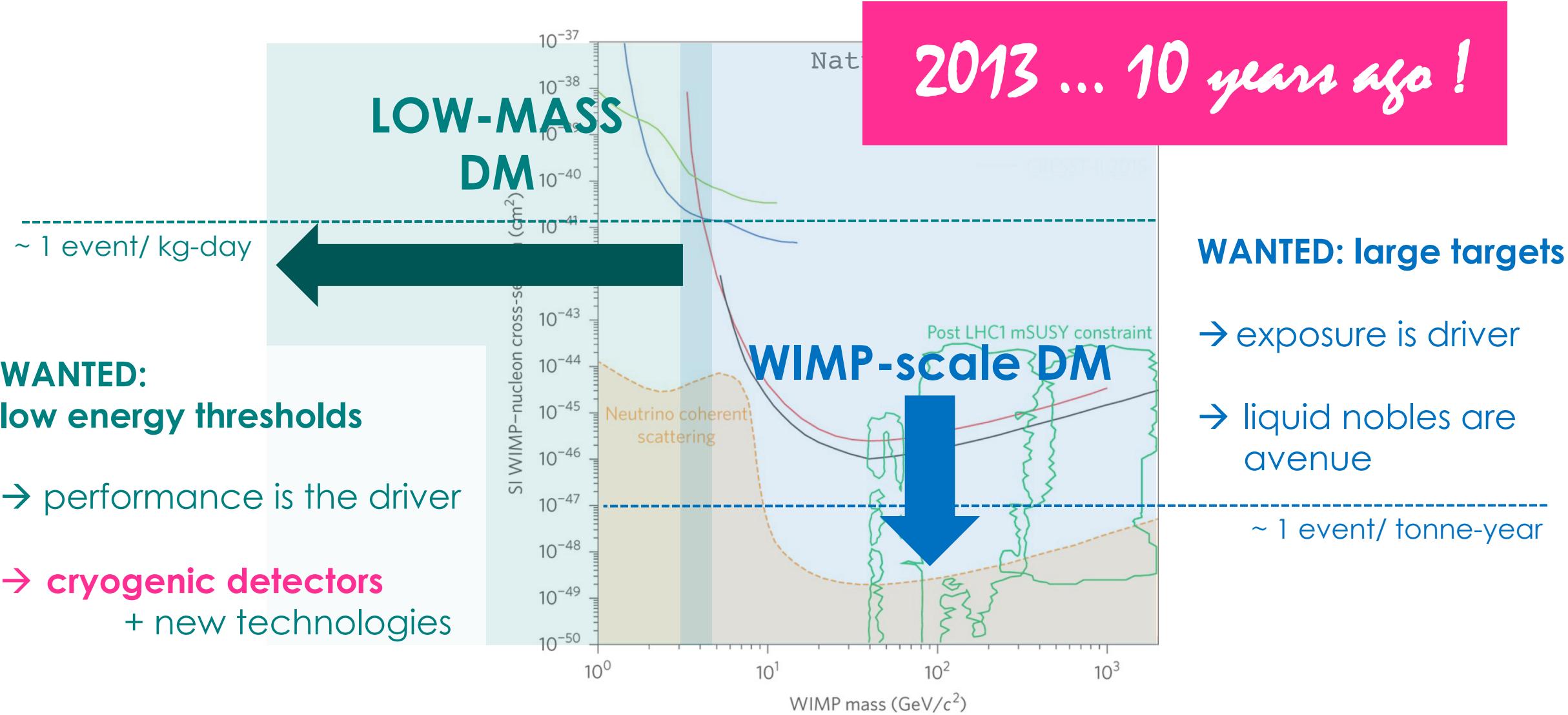
WANTED: large targets

→ exposure is driver

→ liquid nobles are avenue

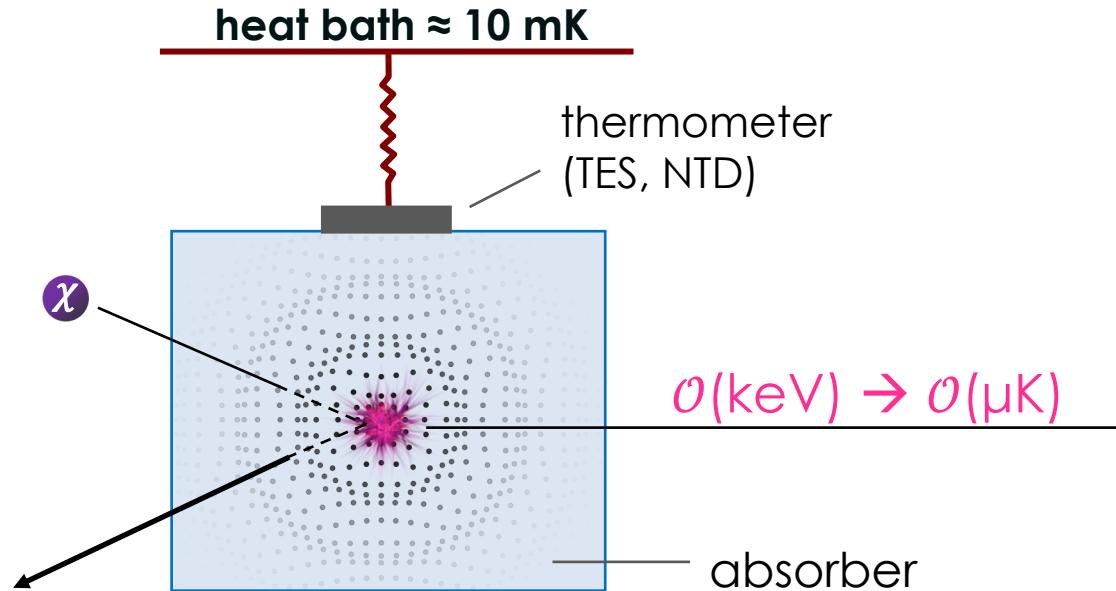
~ 1 event/ tonne-year

CRYOGENIC DETECTORS – the Renaissance





CRYOGENIC DETECTORS

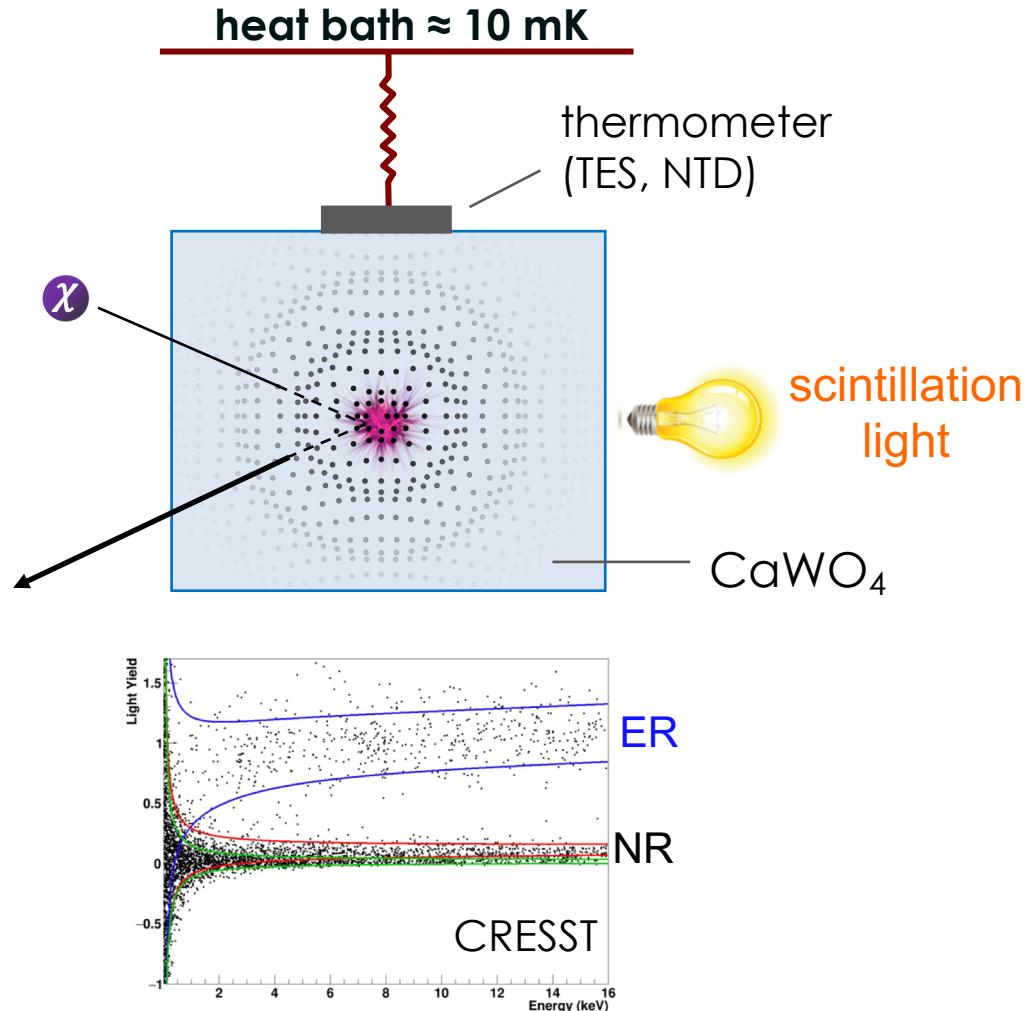


Primary signal:

dark matter creates **phonons / heat**
→ temperature increase measured by thermometer
→ precise measurement of (almost) full deposited energy



CRYOGENIC DETECTORS



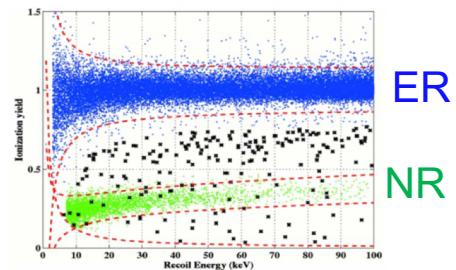
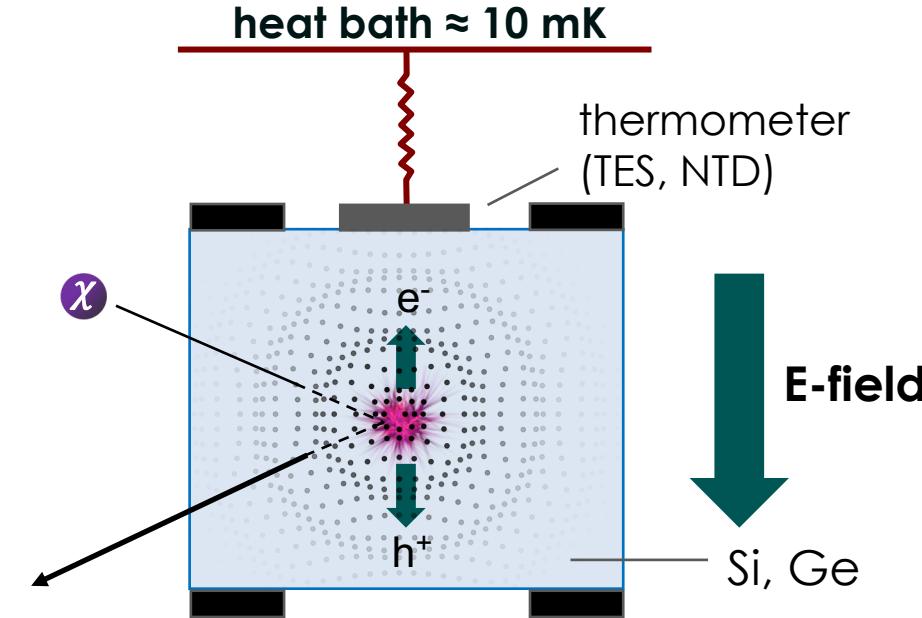
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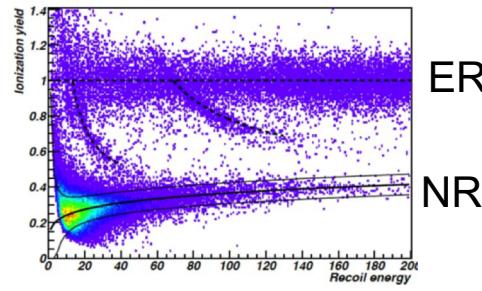
Secondary signal: scintillating target

- separate cryogenic detector for light signal
- particle identification via ratio of light to primary phonon

CRYOGENIC DETECTORS



SuperCDMS



EDELWEISS

Primary signal:

- dark matter creates **phonons / heat**
- temperature increase measured by thermometer
- precise measurement of (almost) full deposited energy

Secondary signal: scintillating target

- separate cryogenic detector for light signal
- particle identification via ratio of light to primary phonon

Secondary signal: semiconducting target

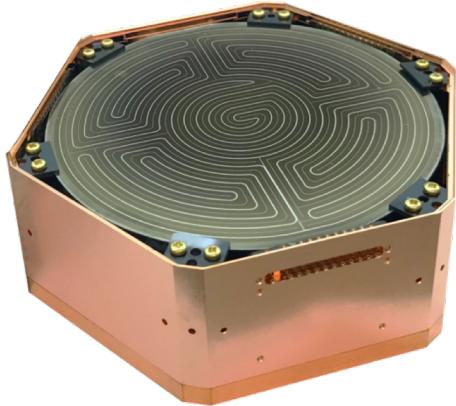
- phonon and charge sensors on target
- particle identification via ratio of ionization to primary phonon
- surface event rejection via ID electrodes

SuperCDMS @ SNOLAB

→ see: S. Zatschler, B. Zatschler, S. Das ←

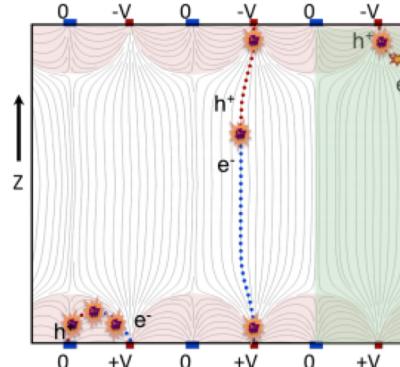


iZIP detector (6 V): Ge of 1.4 kg with TESs

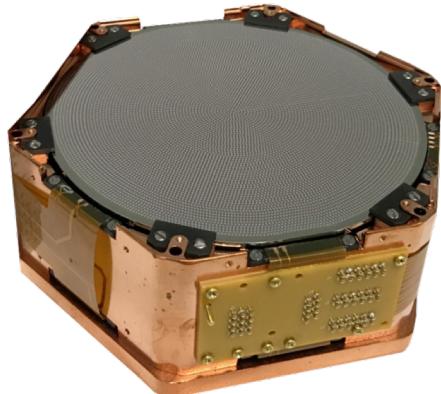


double-sided readout
with E-field-shaping
provides z-dependence
and surface rejection

$$E_{\text{th}} \sim 150 \text{ eV}_{\text{nr}}$$

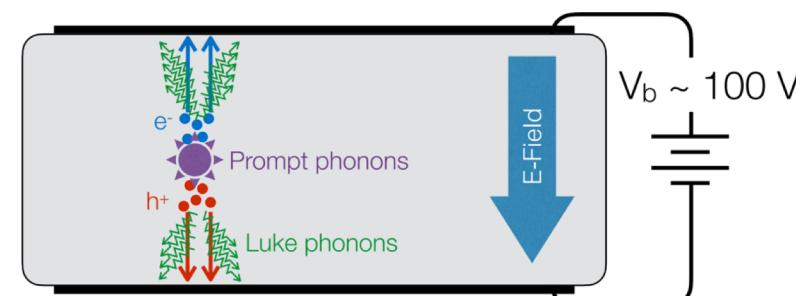


HV detector (100 V): Si of 0.6 kg with TESs

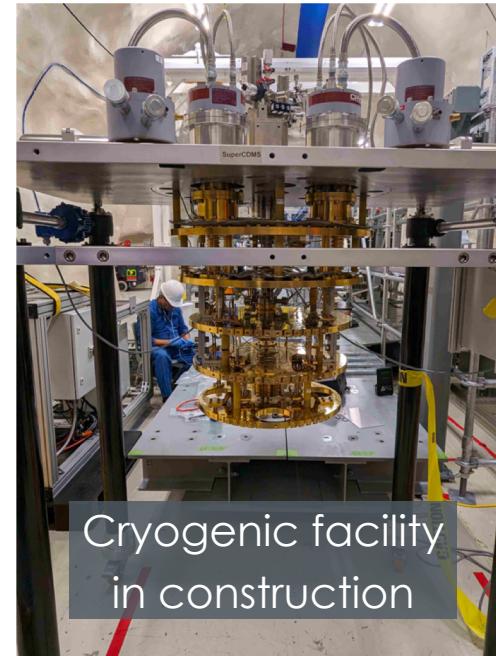


no charge readout;
Optimized for phonon
resolution and collection
efficiency

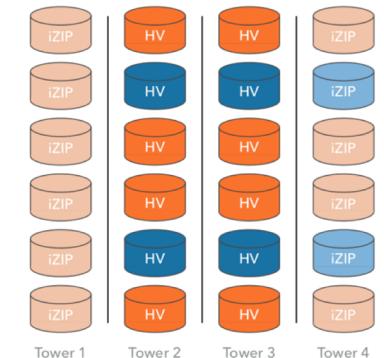
$$E_{\text{th}} \sim 60 \text{ eV}_{\text{nr}}$$



Credits: P. Cushmann, S. Zatschler



Detector
tower

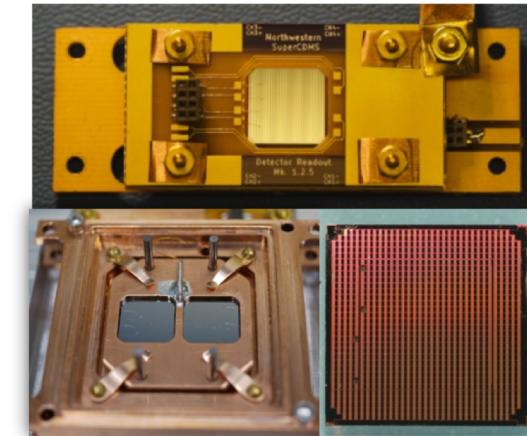


SuperCDMS @ SURFACE

→ see: S. Zatschler, B. Zatschler, S. Das ←



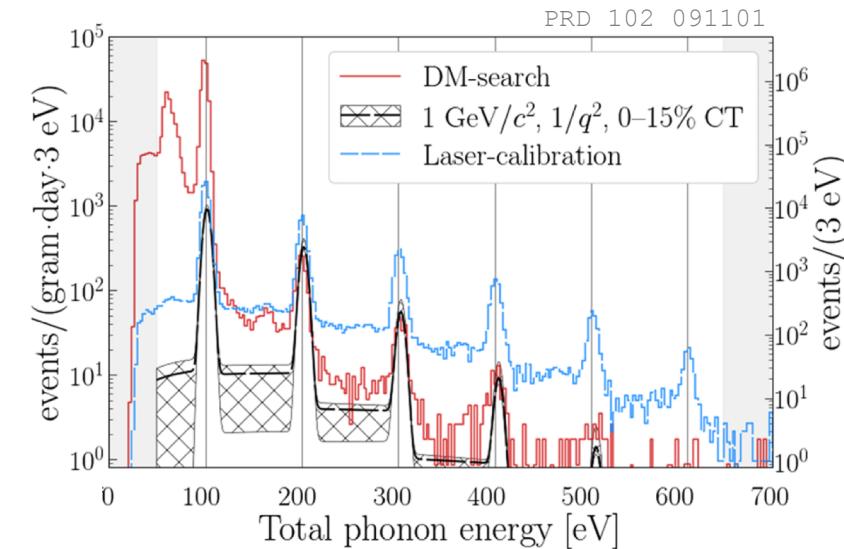
Credits: P. Cushman



HVeV detector Run 1-4: Si wafer of 1cm² x 4 mm

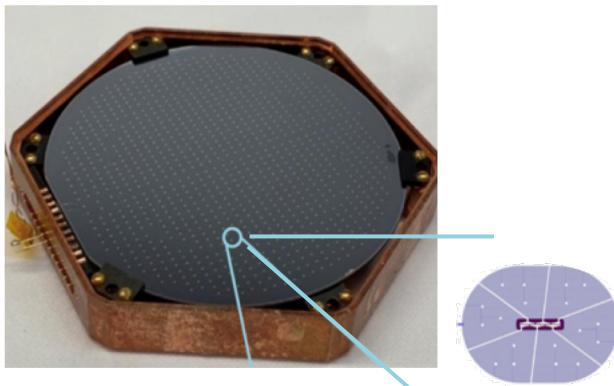
Single e-h resolution
Si wafer with 0.93 g

$$\sigma = 2.7 \text{ eV}_{ee}$$
$$E_{th} = 9.2 \text{ eV}$$

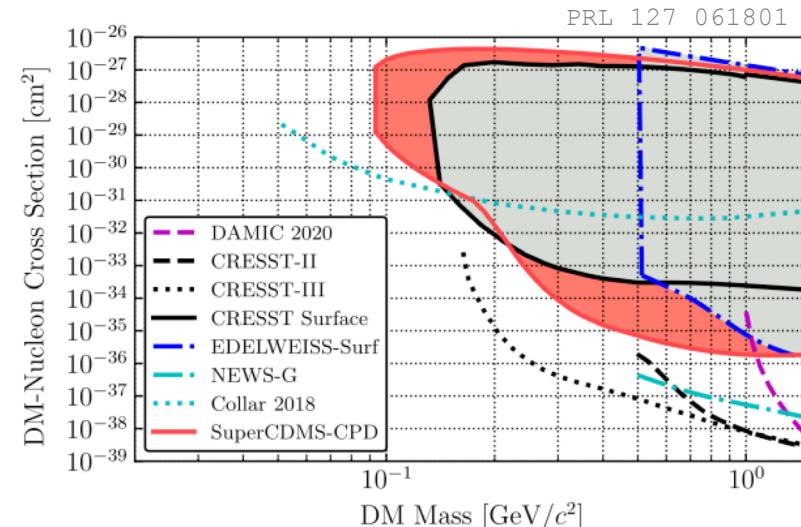


@NEXUS
at Fermilab
(300 m.w.e.)

OV detector (aka CPD) : Si wafer of 10.6 g



$$E_{th} = 16.3 \text{ eV}_{nr}$$





HV detector @ LSM: Ge of 200 g



NbSi TES to read
the phonon signal
 $E_{th} \sim 20 \text{ eV}_{ee}$
 $E_{th} \sim 400 \text{ eV}_{nr}$

HV detector @ LSM: Ge of 33.4 g



NTD
 $\sigma = 0.53 \text{ e}^-$
towards single
 e^-/h^+ sensitivity for
DM- e^- interaction

LV @ surface: Ge of 40 g

FET replaced by HEMT
→ RED20
collab. with Ricochet

$$\sigma_{ion} = 30 \text{ eV}_{ee}$$

arXiv: 2306.00166

CRYOSEL

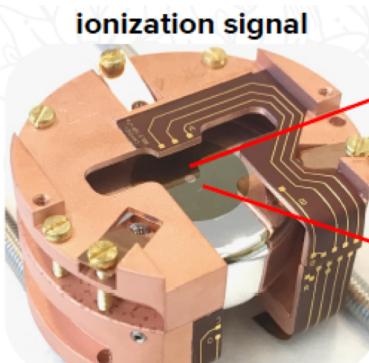
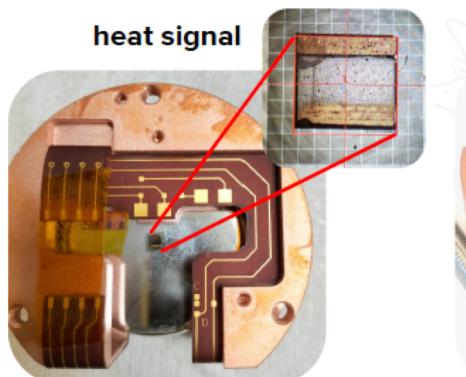
→ NEW program for sub-GeV searches

40 g Ge HV detectors (200 V)

→ NTD for heat signal: goal $\sigma_{phonon} = 20 \text{ eV}$

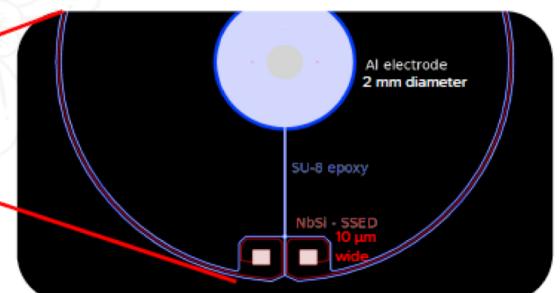
→ identify athermal phonons from heat-only
events using the NbSi TES

PRD 108 022006



Superconducting Single Electron Device

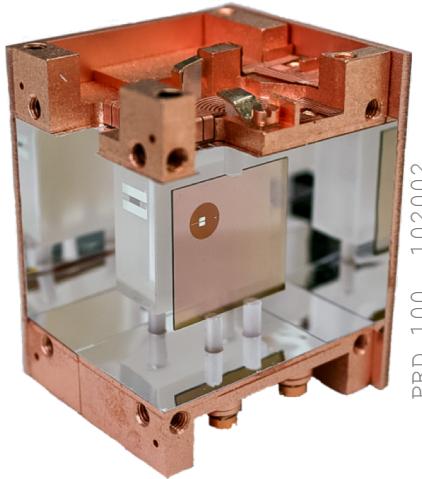
SSED signal



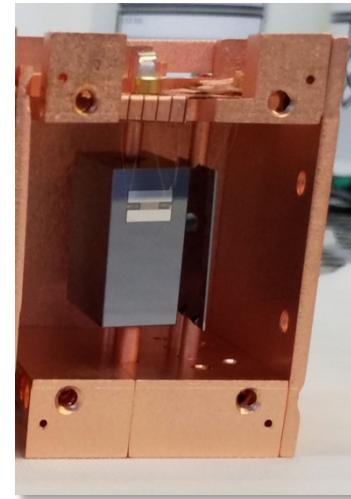
Credits: J. Gascon, E. Guy

CRESST-III @ LNGS

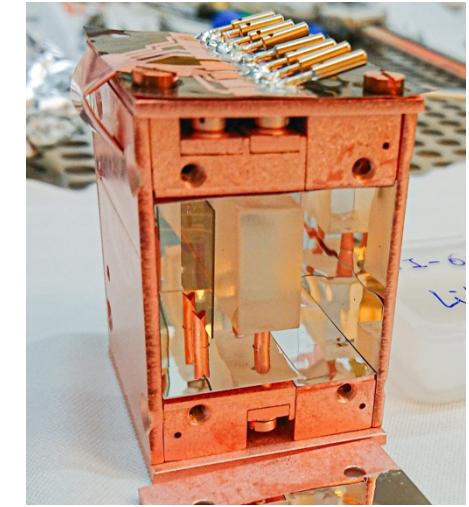
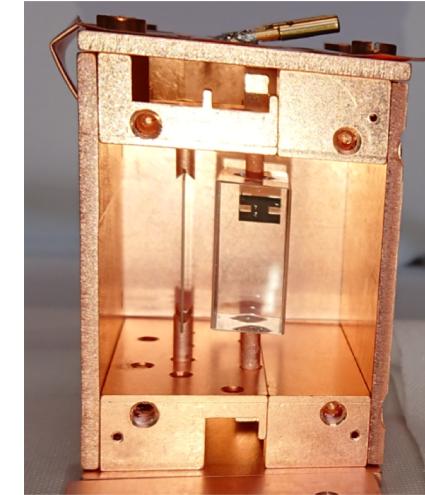
→ see: S. Banik, J. Burkhart, D. Fuchs, R. Kaznacheeva ←



PRD 100, 102002

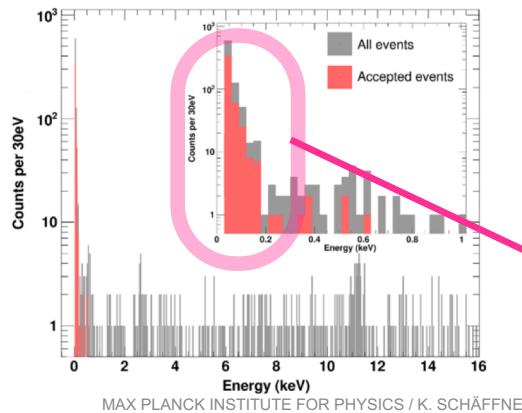


PRD 107, 122003



PRD 106, 092008

Detector A - CaWO₄:
23.6 g
exposure: 5.698 kgd
 $E_{th} = 30.1 \text{ eV}_{NR}$



Si wafer detector:
0.35 g
exposure: 55.06 gd
 $E_{th} = 10.0 \text{ eV}_{NR}$

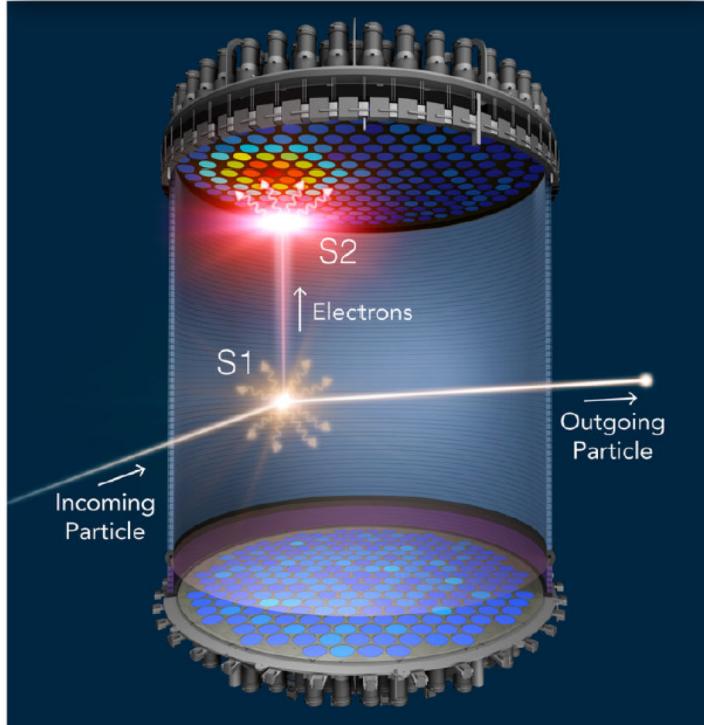
Al₂O₃ wafer detector:
0.6 g
exposure: 0.14 kgd
 $E_{th} = 6.7 \text{ eV}_{NR}$

LiAlO₂ detector:
10.5 g
exposure: 1.161 kgd
 $E_{th} = 83.6 \text{ eV}_{NR}$

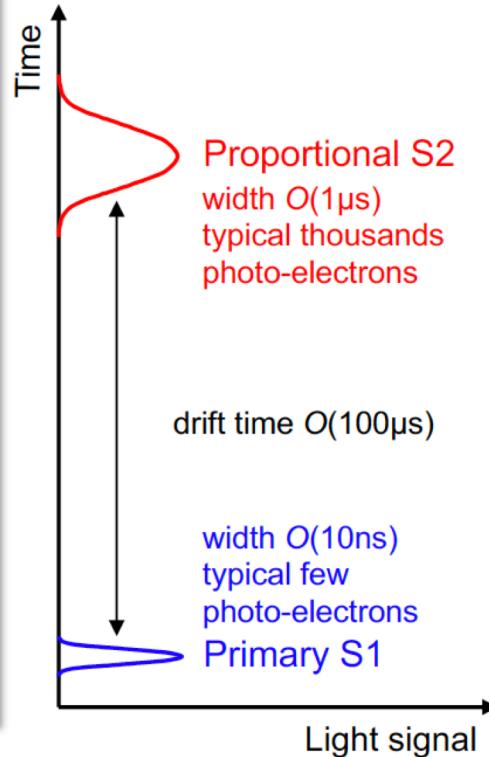
excess of events at low energies (LEE) observed in all detectors below $\mathcal{O}(100 \text{ eV})$

- various target materials
- different holders → LEE related?
- scintillating parts removed

LIQUID NOBLE GAS TPCs for Xe, Ar



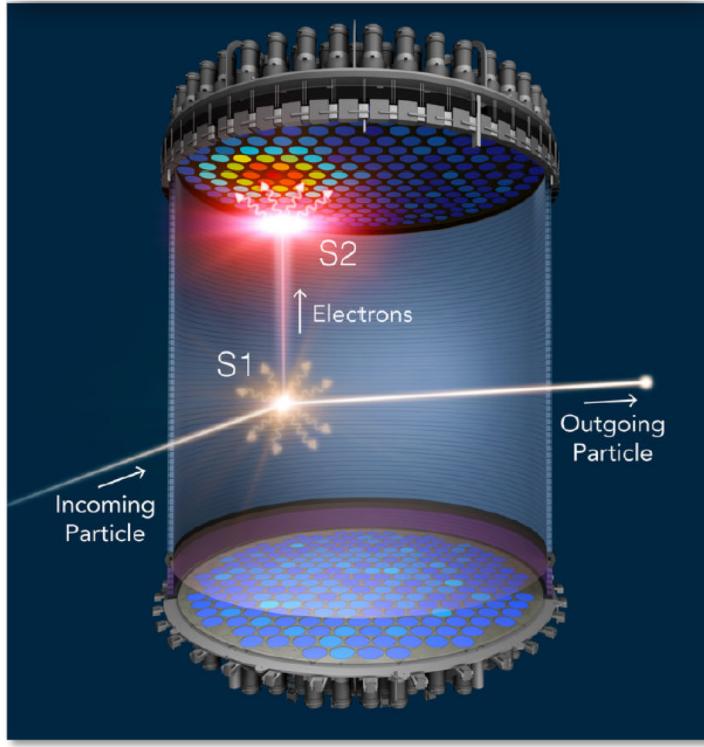
Credit: LZ collaboration SLAC



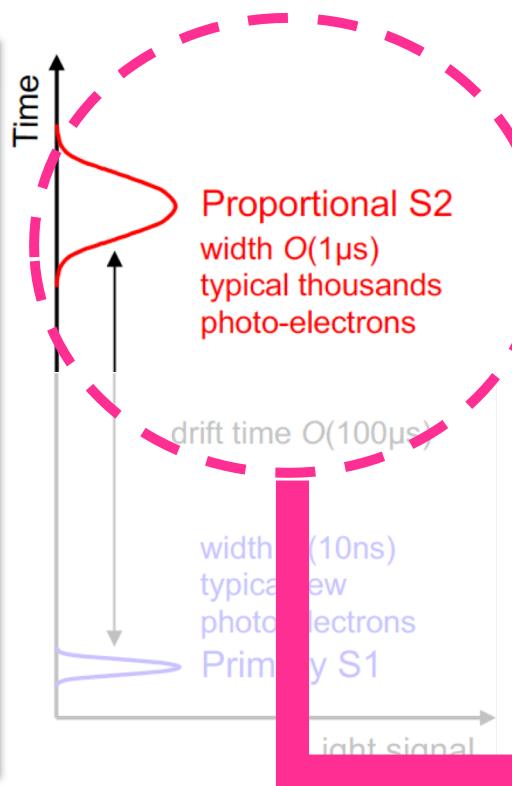
Dual-phase time projection chambers

- primary scintillation signal S1
- ionisation electrons via secondary scintillation S2 in the gas
- particle identification via ratio S2/S1
- position reconstruction
- multi-scatter rejection
- + in Ar: pulse shape discrimination

LIQUID NOBLE GASE TPCs for Xe, Ar



Credit: LZ collaboration SLAC



Dual-phase time projection chambers

- primary scintillation signal S1
 - ionisation electrons via secondary scintillation S2 in the gas
 - particle identification via ratio S2/S1
 - reconstruction of the interaction position
 - multi-scatter rejection
- + in Ar: pulse shape discrimination

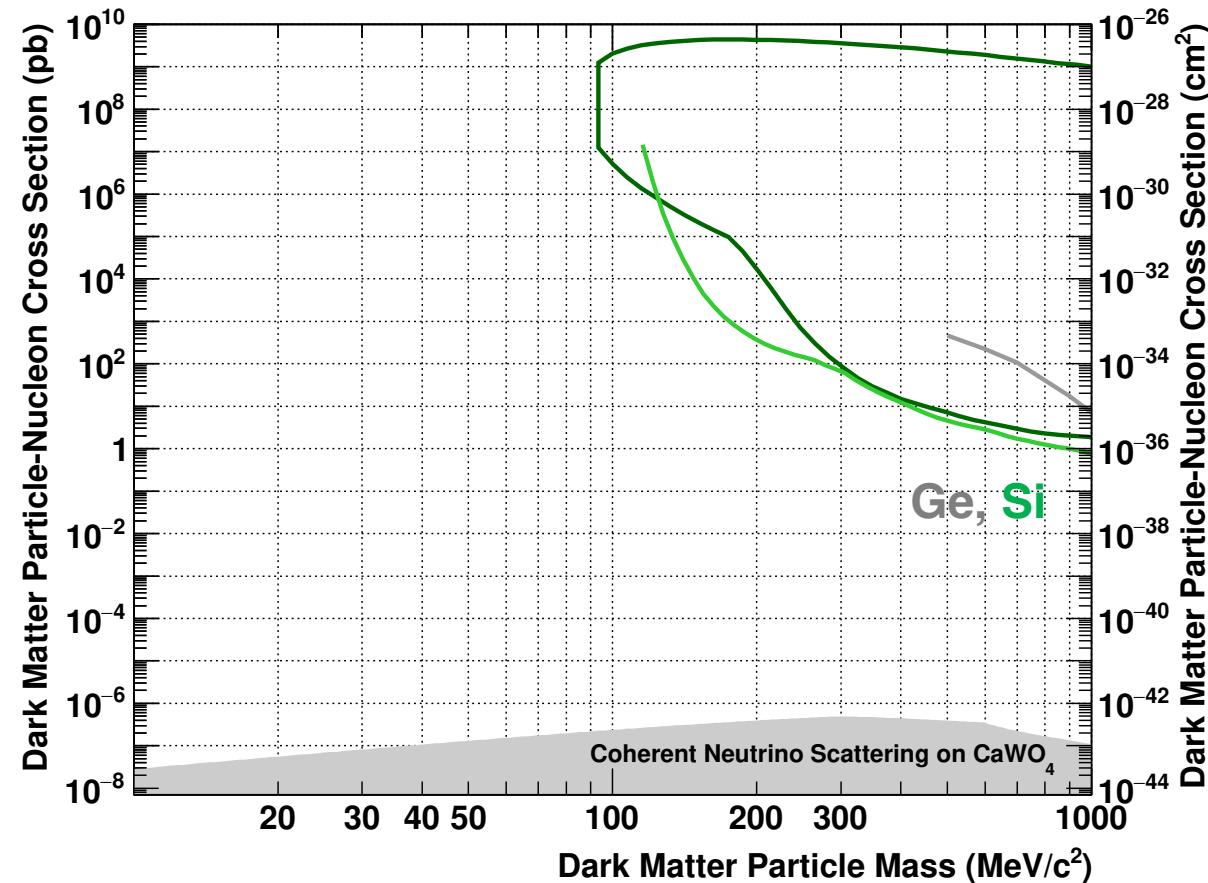
Light production less efficient than ionization
S2 only-mode

- sensitive to single extracted electrons
- lower energy thresholds
- e.g. XENON1T: $\sim 5 \text{ keV}_{\text{nr}}$ versus $\sim 1.5 \text{ keV}_{\text{nr}}$

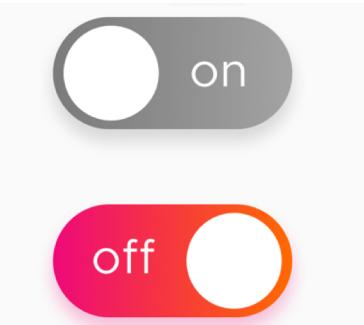
DM-NUCLEUS SCATTERING LANDSCAPE



— SuperCDMS-CPD 2020 — CRESST-III 2023 — EDELWEISS surf. 2018



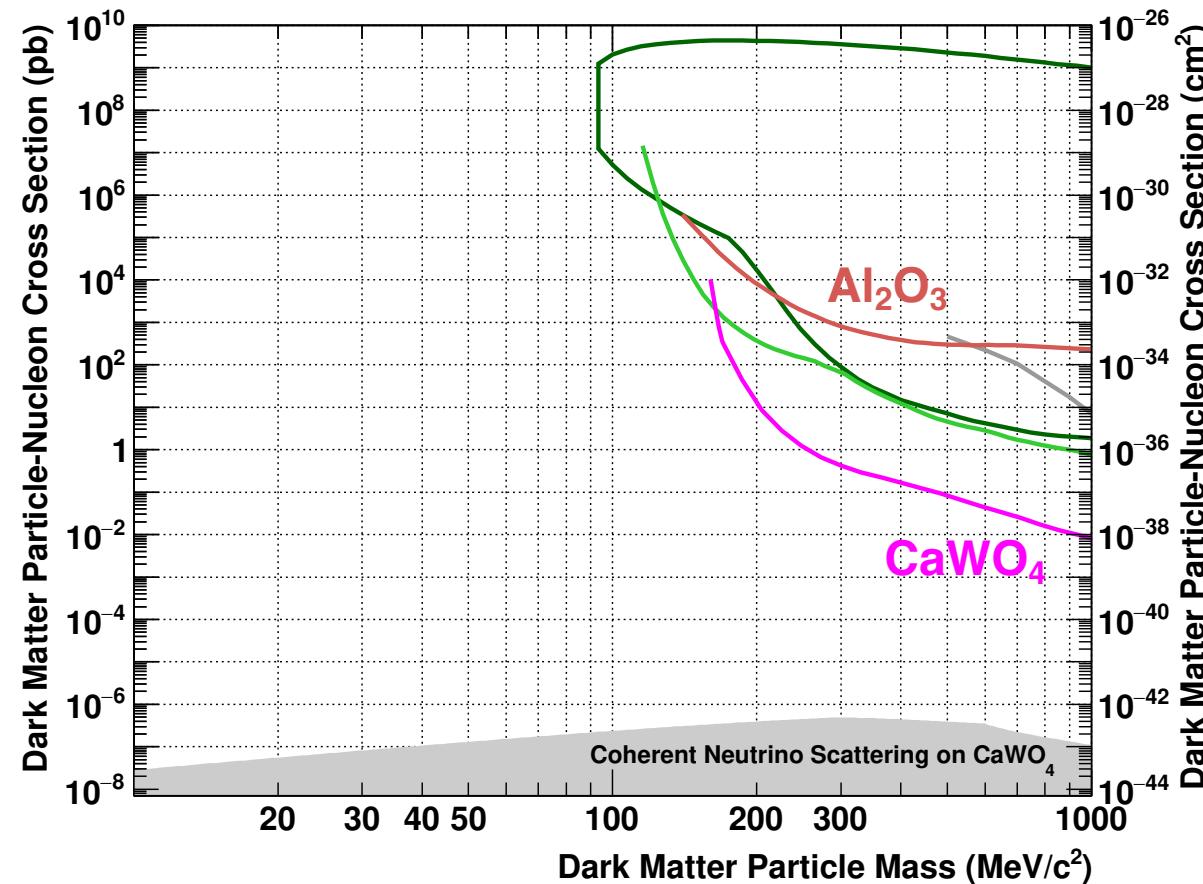
MIGDAL



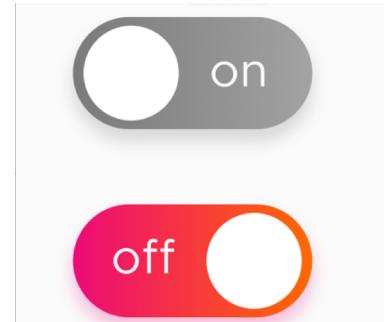
DM-NUCLEUS SCATTERING LANDSCAPE



— SuperCDMS-CPD 2020 — CRESST-III 2023 — EDELWEISS surf. 2018 — CRESST-III 2019
— CRESST surf. 2017



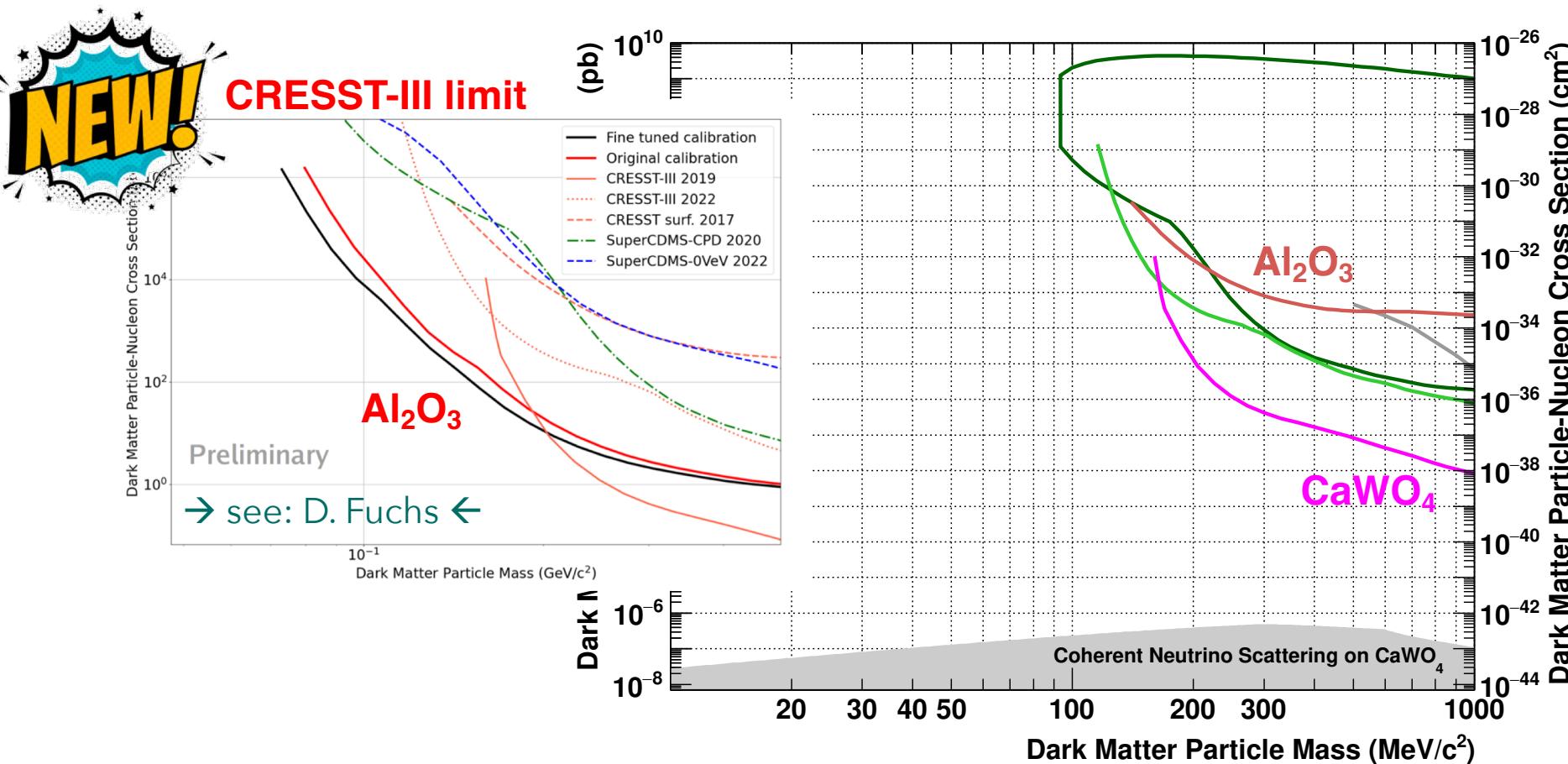
MIGDAL



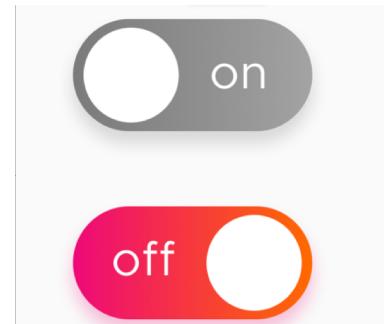
DM-NUCLEUS SCATTERING LANDSCAPE



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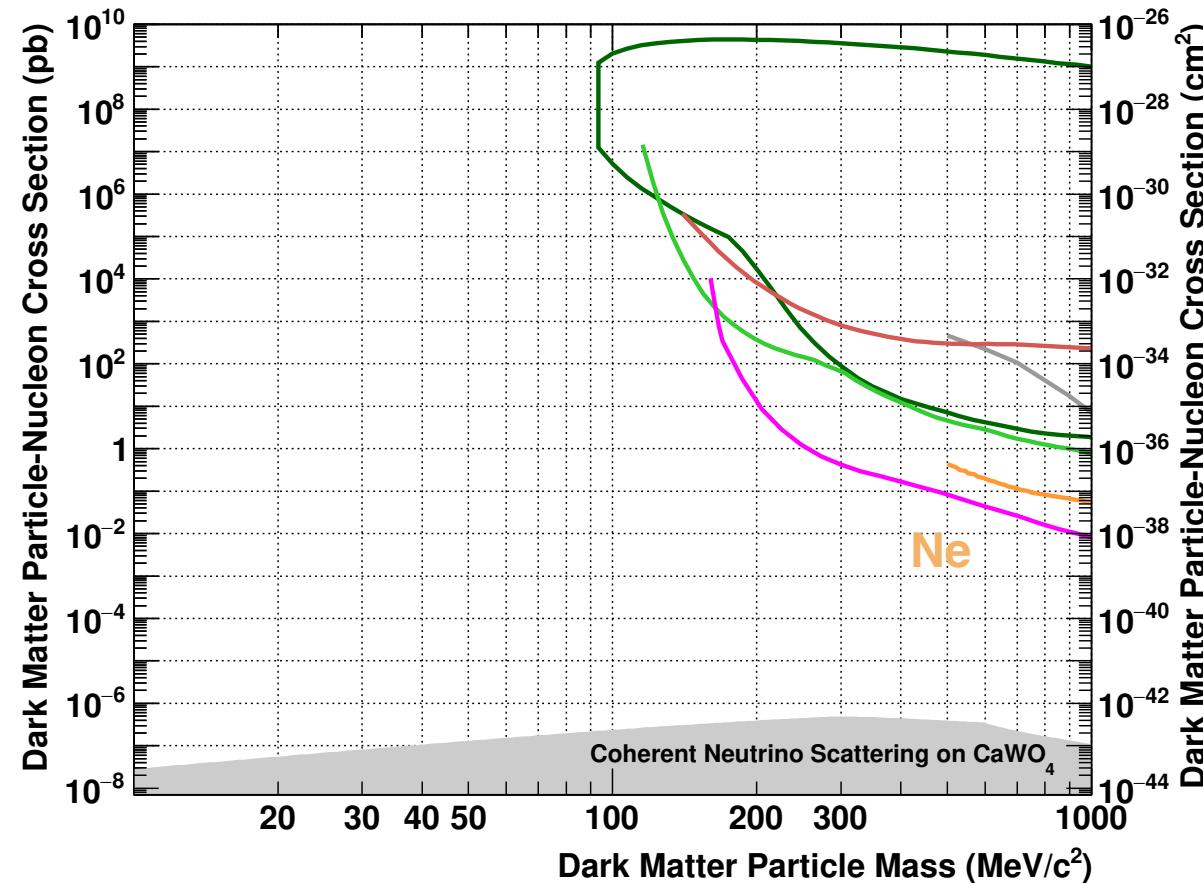
MIGDAL



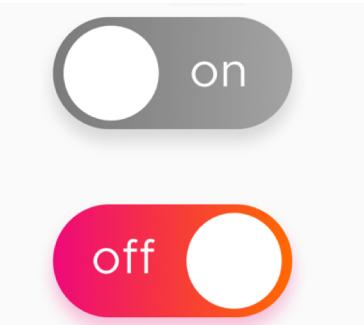
DM-NUCLEUS SCATTERING LANDSCAPE



— SuperCDMS-CPD 2020 — CRESST-III 2023 — EDELWEISS surf. 2018 — CRESST-III 2019
— CRESST surf. 2017 — NEWS-G 2018



MIGDAL

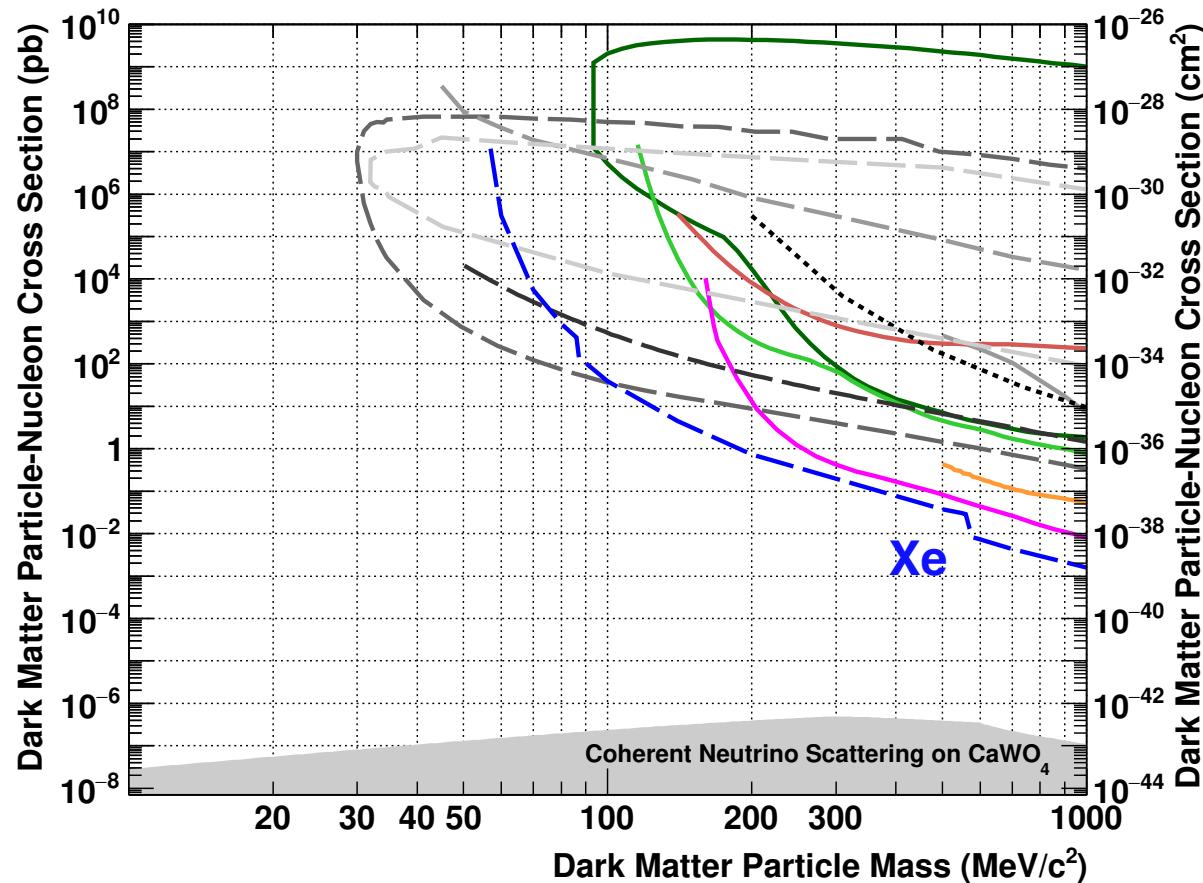


DM-NUCLEUS SCATTERING LANDSCAPE

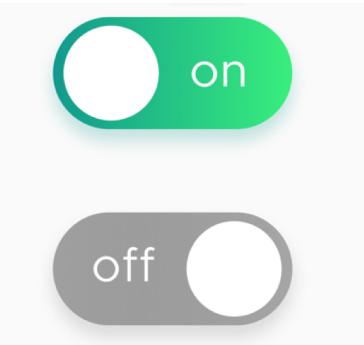


Legend:

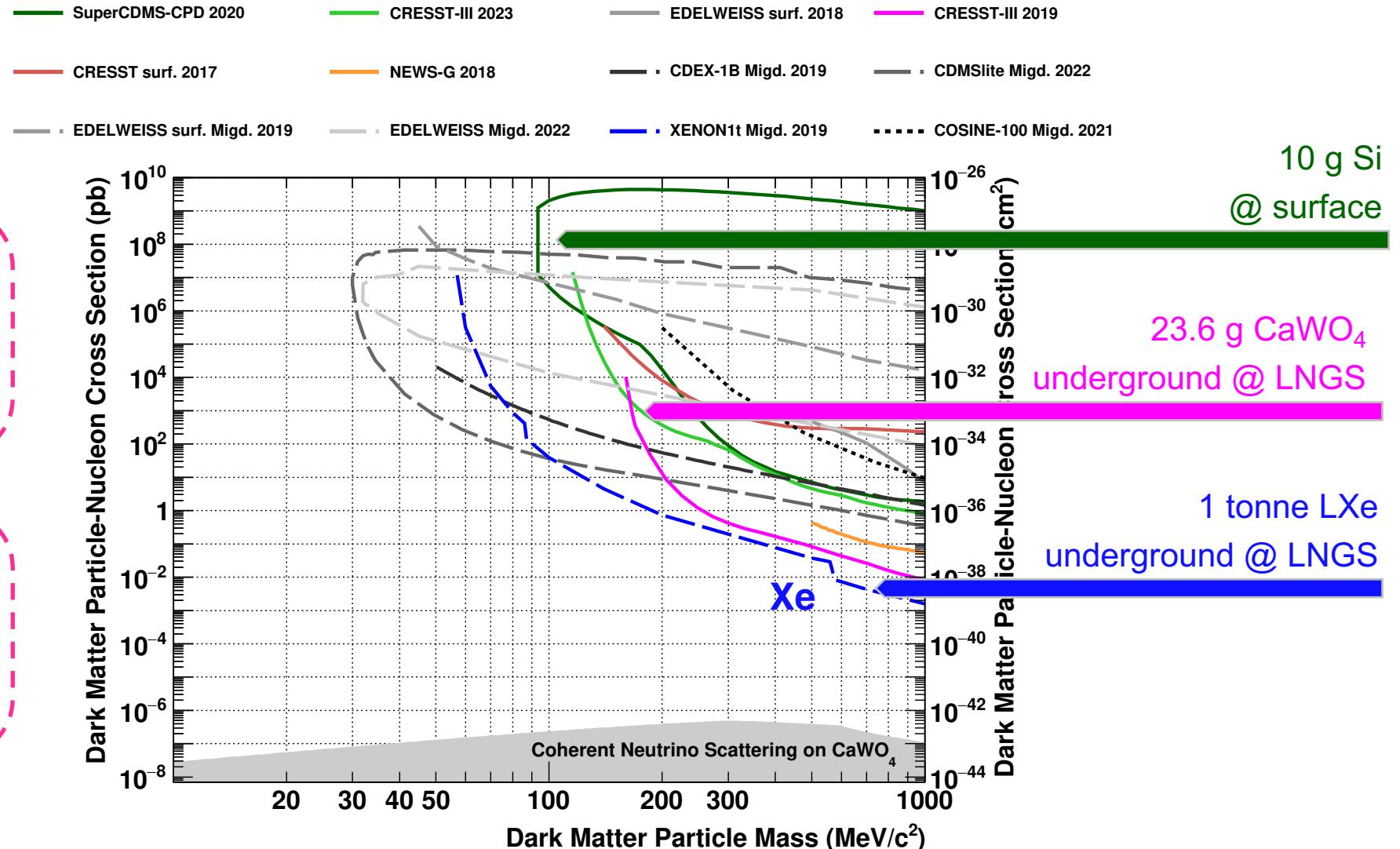
- SuperCDMS-CPD 2020
- CRESST-III 2023
- EDELWEISS surf. 2018
- CRESST-III 2019
- CRESST surf. 2017
- NEWS-G 2018
- CDEX-1B Migd. 2019
- CDMSlite Migd. 2022
- EDELWEISS surf. Migd. 2019
- EDELWEISS Migd. 2022
- XENON1t Migd. 2019
- COSINE-100 Migd. 2021



MIGDAL



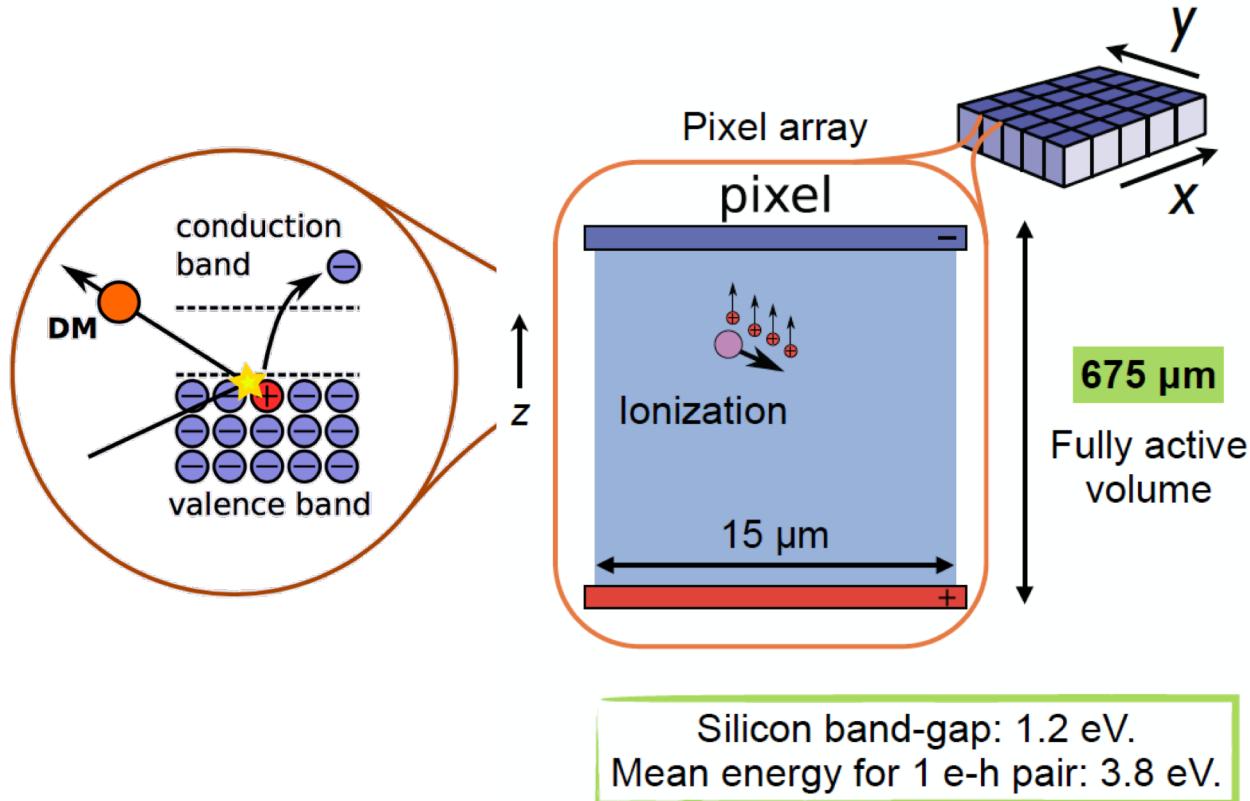
DM-NUCLEUS SCATTERING LANDSCAPE





Silicon-Charged Coupled Devices (CCDs)

Credits: A. Botti, P. Privitera

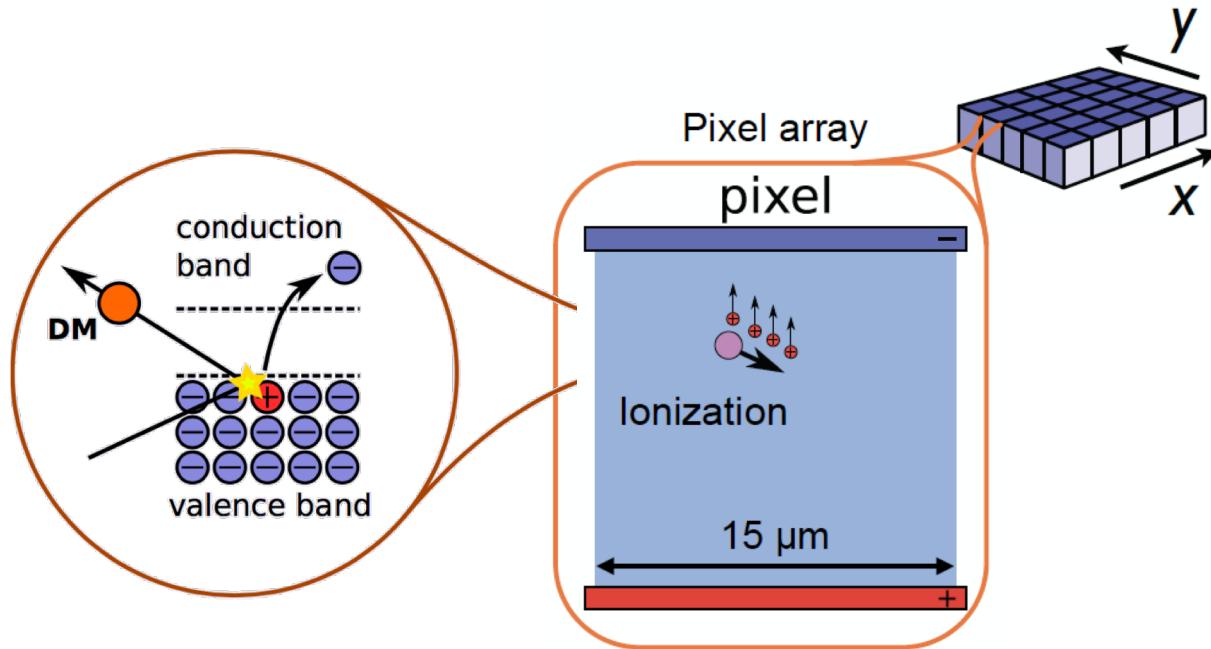


Dark matter creates **one or a few electrons** in a pixel

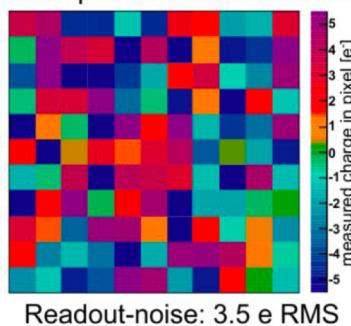


Silicon-Charged Coupled Devices (CCDs)

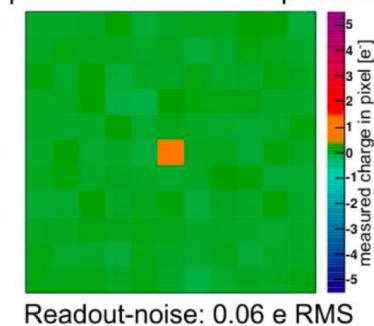
Credits: A. Botti, P. Privitera



Standard CCD mode: charge in each pixel is measured once



Skipper CCD: charge in each pixel is measured multiple times



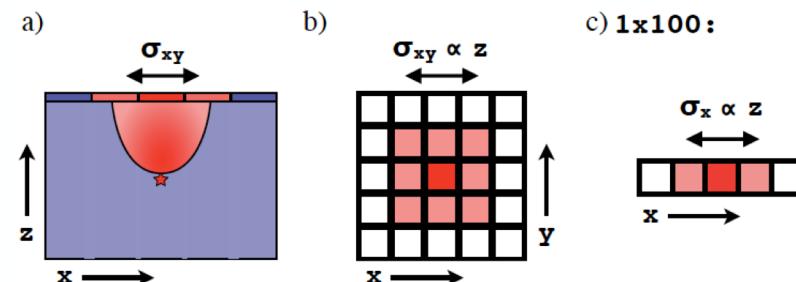
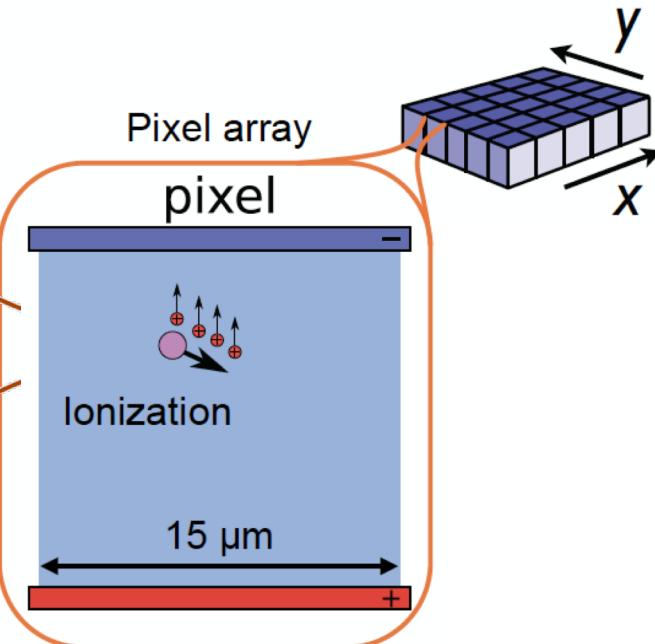
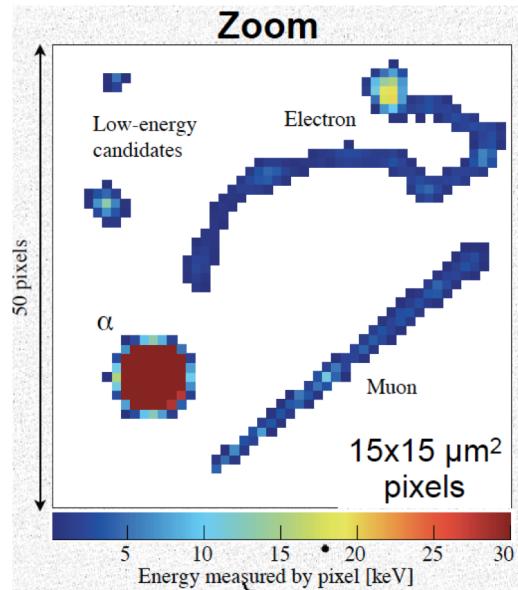
Dark matter creates **one or a few electrons** in a pixel

- repeatedly measure charge
- sub-electron readout noise



Silicon-Charged Coupled Devices (CCDs)

Credits: A. Botti, P. Privitera



Dark matter creates **one or a few electrons** in a pixel

- repeatedly measure charge
- sub-electron readout noise

Excellent spatial resolution:

SENSEI: $\sim 20 \text{ mm} \times 100 \text{ mm}$, 5.4 Mpixel



- particle identification
- surface background rejection
- background measurements



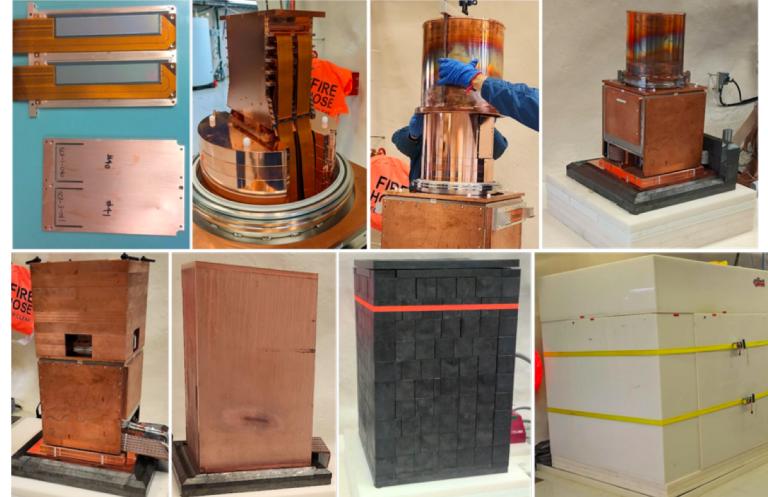
SENSEI @ MINOS



PRI 125, 171802 (2020)

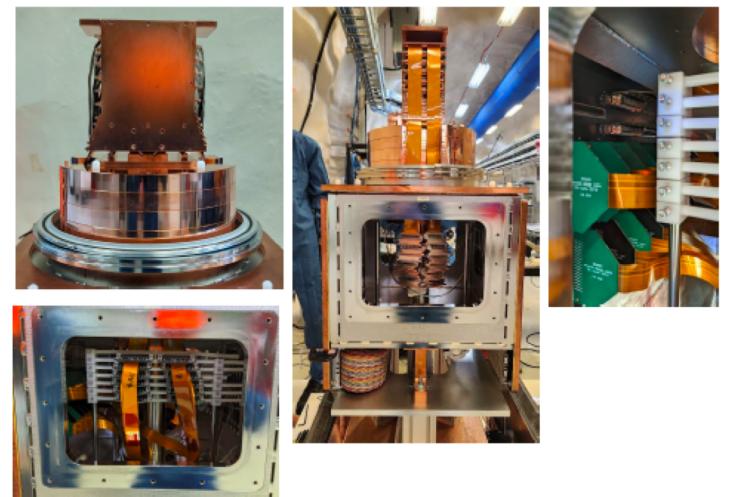
- 5.5 Mpix of $15\text{ }\mu\text{m}$
- active mass $\sim 2\text{ g}$
- $T \sim 135\text{ K}$
- 3000 dru with shield

SENSEI @ SNOLAB – RUN1, 20h



- 6.3 Mpix of $15\text{ }\mu\text{m}$
- 6 CCDs: mass $\sim 13\text{ g}$
- low background shielding
- $T \sim 140\text{ K}$

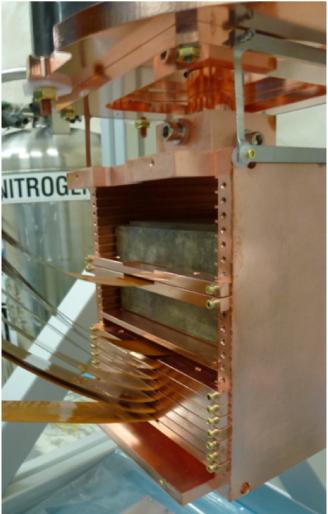
SENSEI @ SNOLAB – RUN2



- 19 CCDs: mass $\sim 40\text{ g}$
- shield fully deployed
- data acquisition starting soon
- goal: 5 dru for 100 g



DAMIC @ SNOLAB



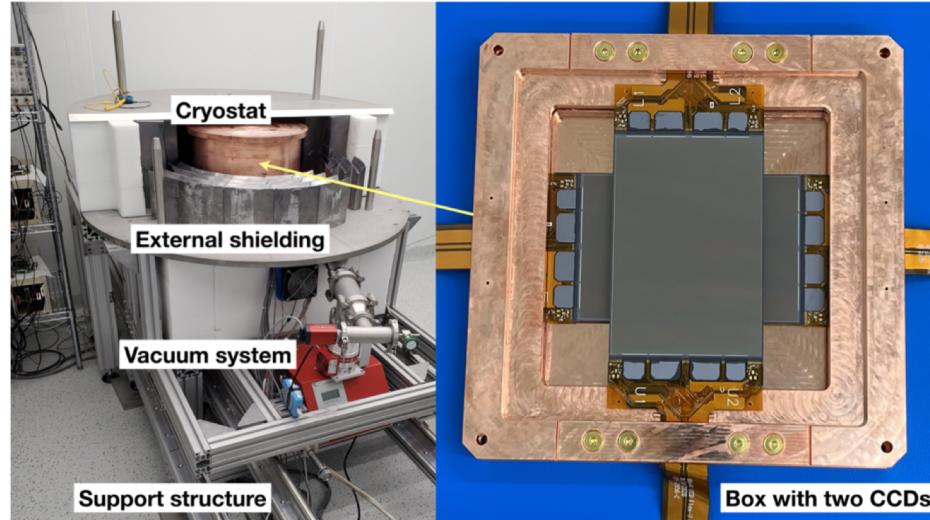
- 16 Mpix of $15\text{ }\mu\text{m}$
- 7 CCDs: mass $\sim 6\text{ g}$
- ~ 200 CCDs for 1kg
- background shielding
- $T \sim 140\text{ K}$
- ~ 10 dru

PRL123 181802 (2019)

PRL125 241803 (2020)

PRD105 062003 (2022)

DAMIC-M @ LSM

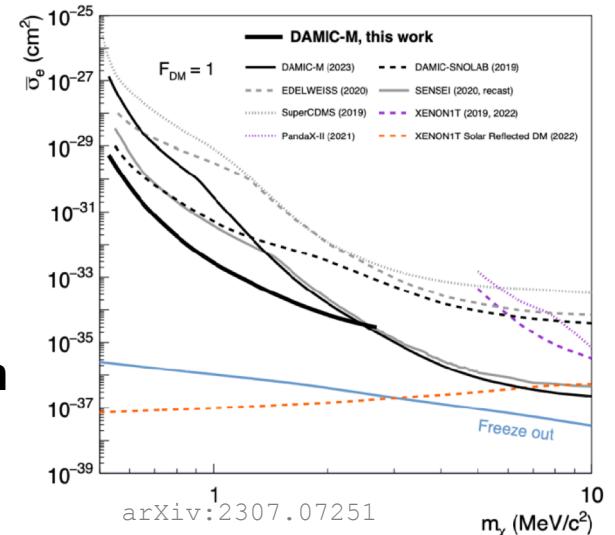
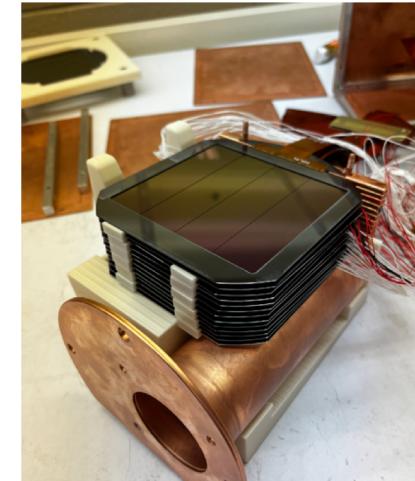


- 9 Mpix of $15\text{ }\mu\text{m}$
- 1 CCDs: mass $\sim 13\text{ g} \rightarrow 2$ CCDs for first run
- goal: ~ 200 CCDs for 1kg
- low background shielding
- $T \sim 140\text{ K}$



**Search for daily modulation
of MeV DM signals**

PRL 130, 171003 (2023)

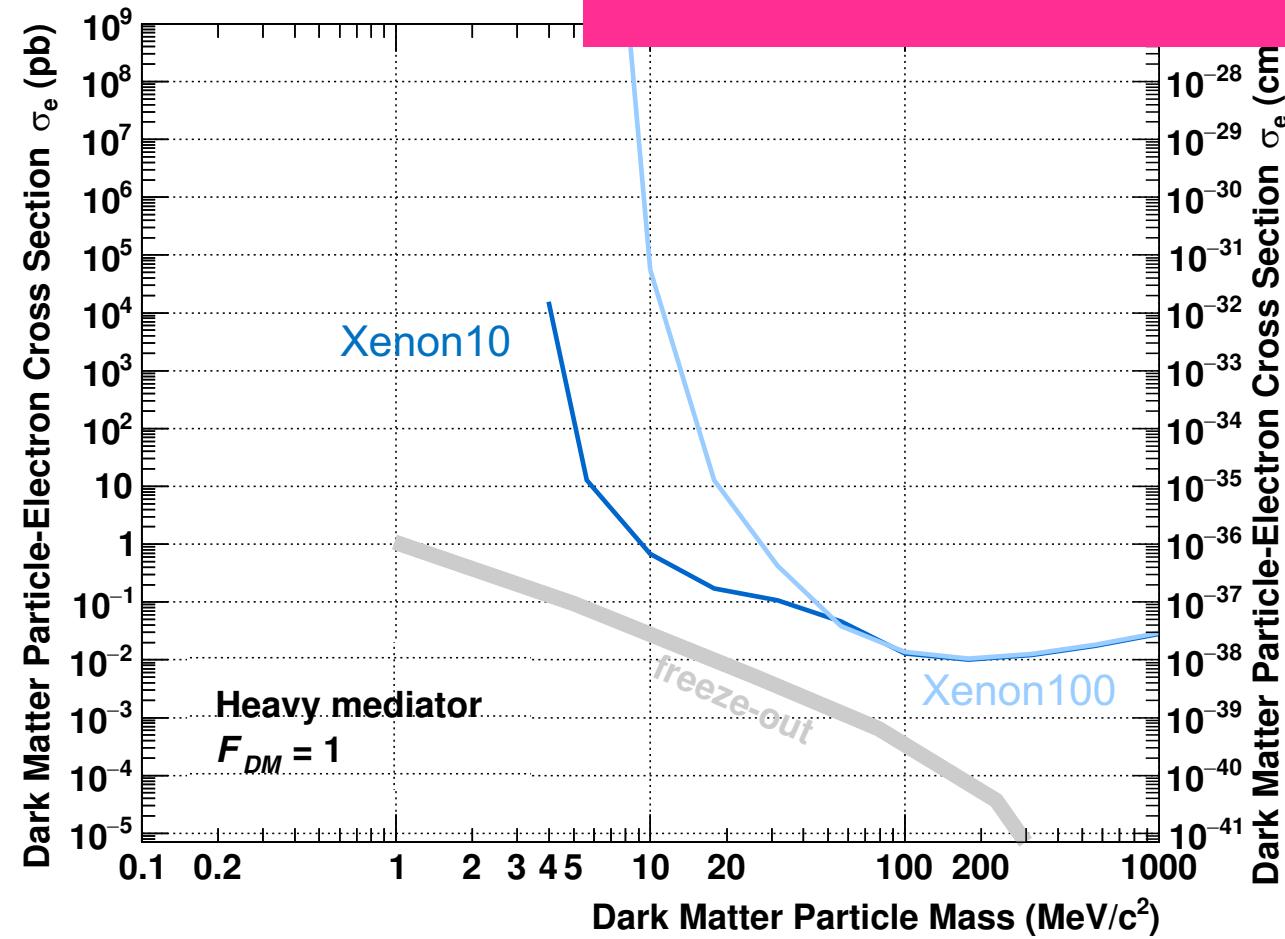


DM-ELECTRON SCATTERING LANDSCAPE



12.06.2012 ... 11 years ago !

PRL 109, 021301



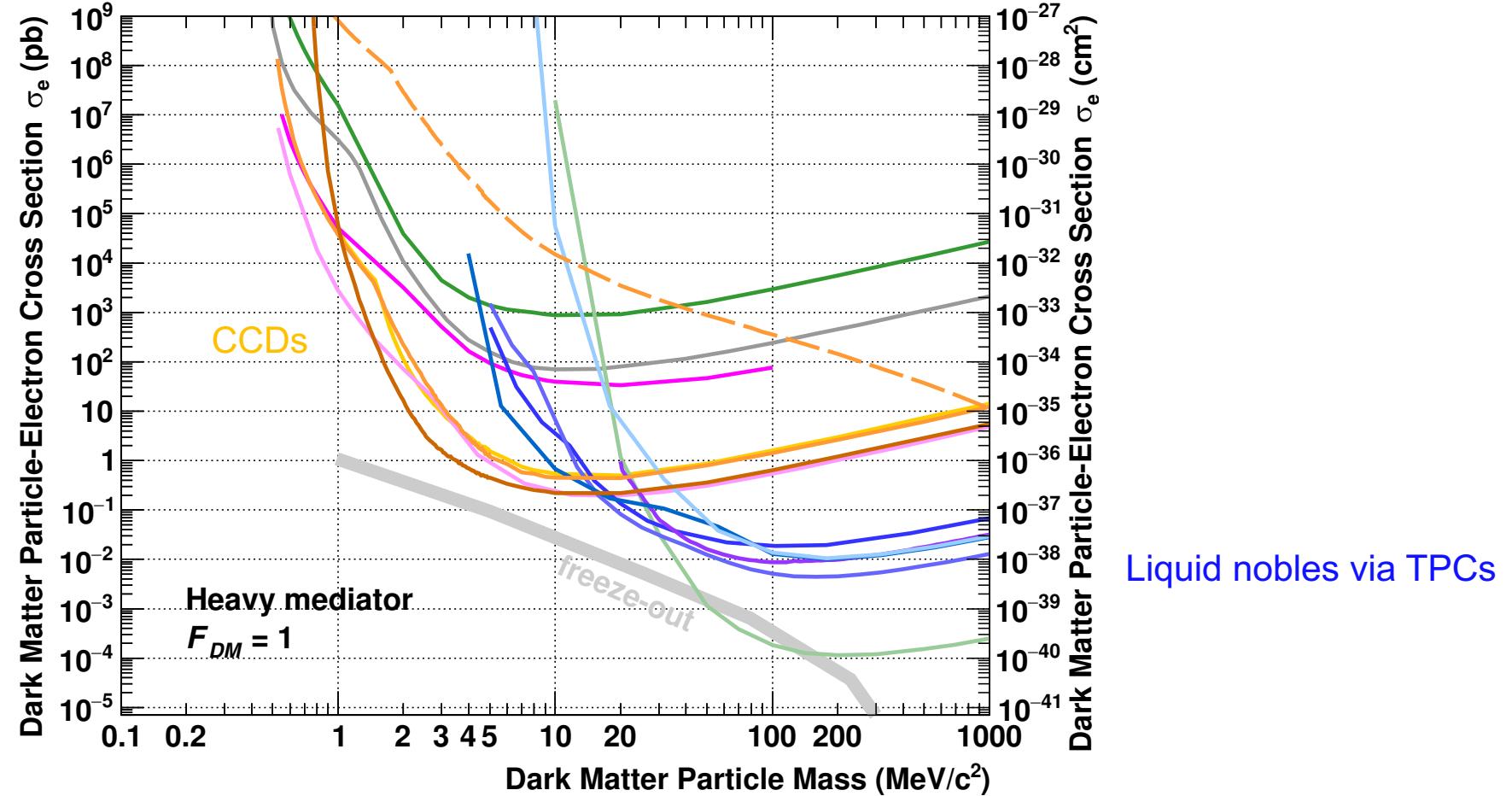
DM-ELECTRON SCATTERING LANDSCAPE



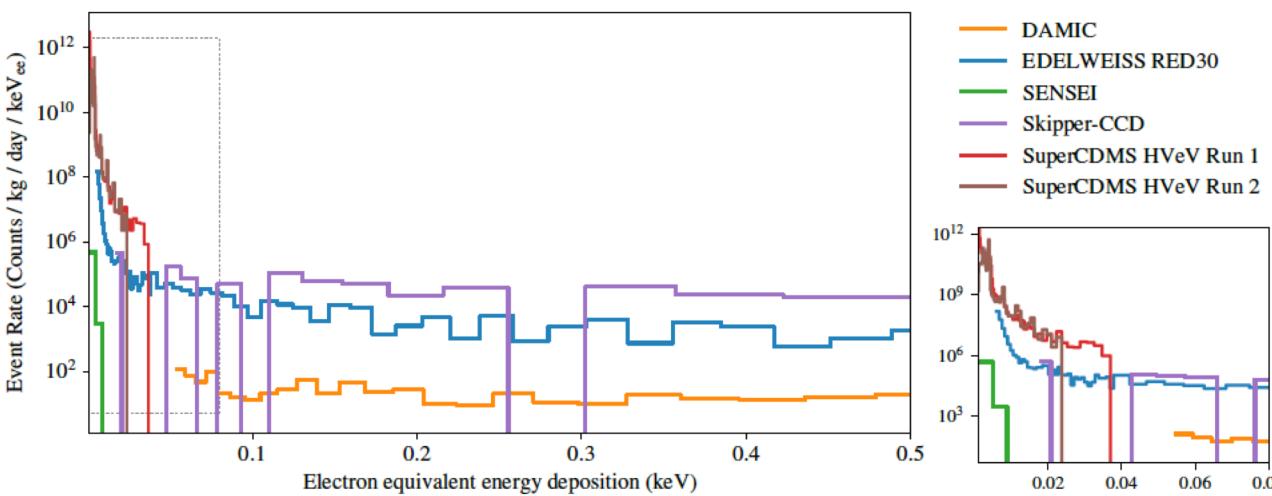
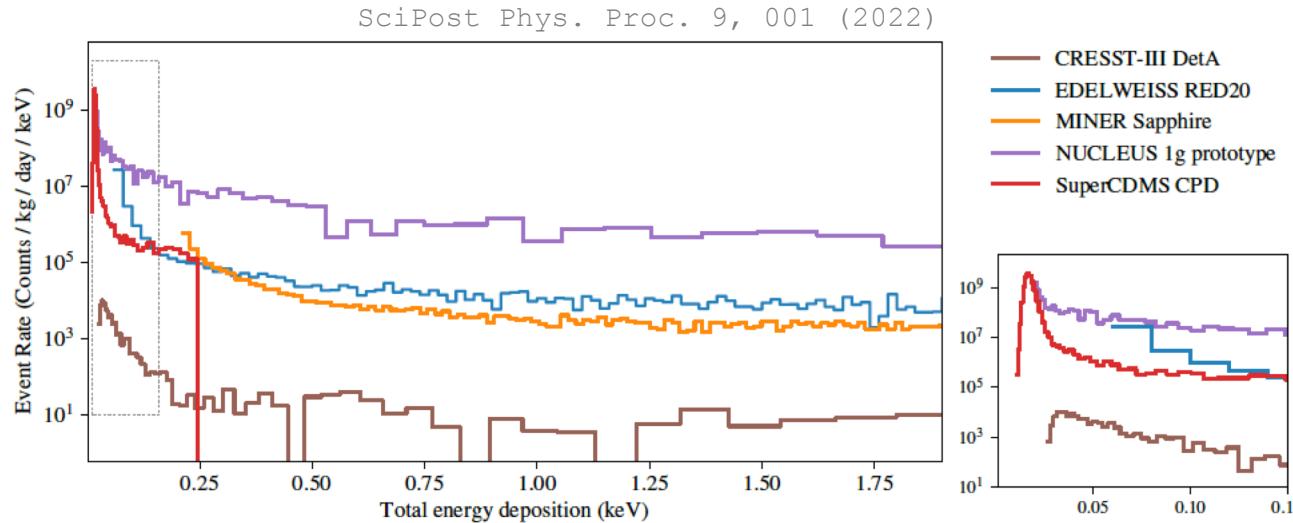
CCD technology very active and takes the lead at masses below 10 MeV/c²

S2-only analysis gives excellent sensitivity to liquid nobles TPCs

DAMIC 2019	DAMIC 2023	EDELWEISS 2020	SENSEI 2020
SENSEI@MINOS 2020	SENSEI@SNOLAB 2022	SENSEI@MINOS Migd. 2020	SuperCDMS HVeVR2 2020
DarkSide-50 2018	PandaX-II 2021	XENON10 2017	XENON100 2017
XENON (S2-only) 2019	XENON (SE) 2022		



CHALLENGE 1 – LOW ENERGY EXCESS (LEE)



- steeply rising background towards lower energies
- Low Energy Excesses are globally limiting the sensitivity in this community

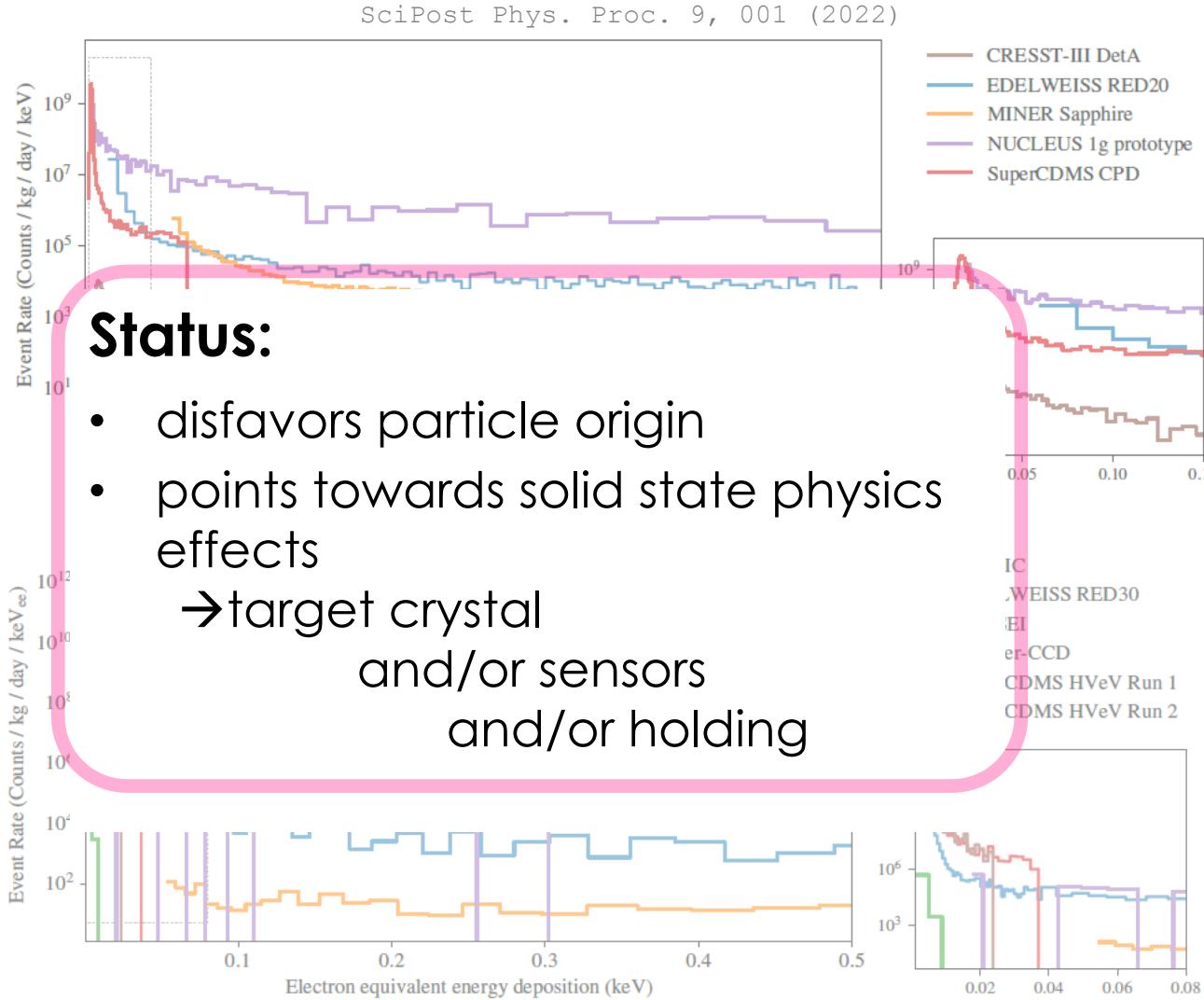
Origin(s) still unknown

very active field of research



Workshop series:
Jun 2021
Feb 2022
Jul 2022 @ IDM
Aug 2023 @ TAUP

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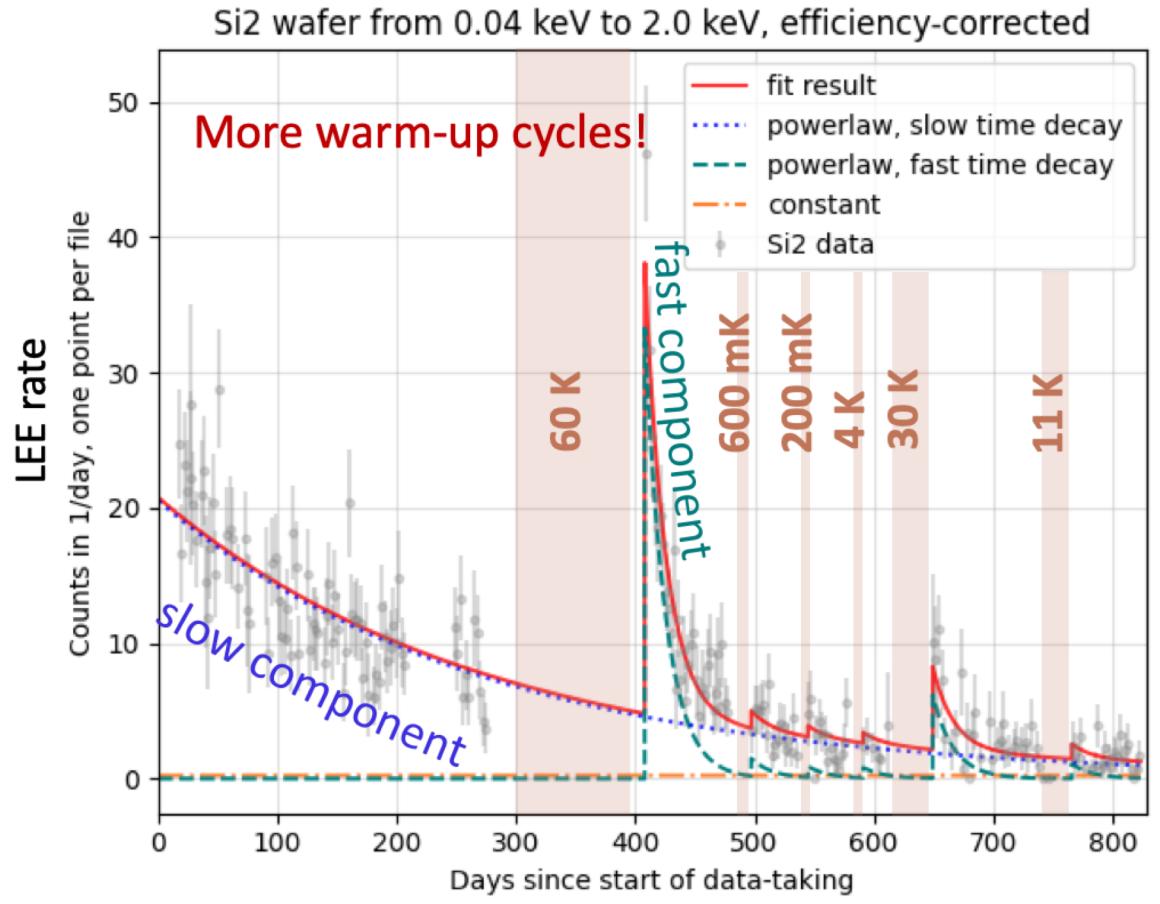
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Jun 2021
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CHALLENGE 1 – LEE in CRESST-III

→ see: M. Kaznacheeva ←



credits: M. Kaznacheeva arXiv: 2207.09375

LEE rate increases prominently after warm-ups:

- excludes radioactivity
- excludes DM explanation

Origin(s):

- Mechanical stress?
- thermal expansion?

→ → REDUCE STRESS LEVEL

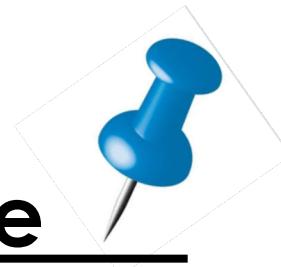


CHALLENGE 2 – ENERGY CALIBRATION



→ see: V. Wagner ←

Energy scale



Electronic recoils:

low energy X-rays

LED sources

lasers

target material activation

Nuclear recoils:

neutron capture reaction

→ the CRAB project



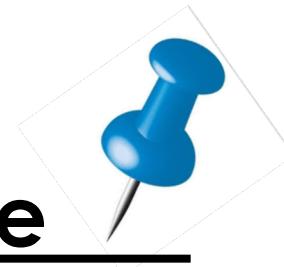
JINST 16 P07032

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→ see: V. Wagner ←

Energy scale



Electronic recoils:

low energy X-rays
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lasers
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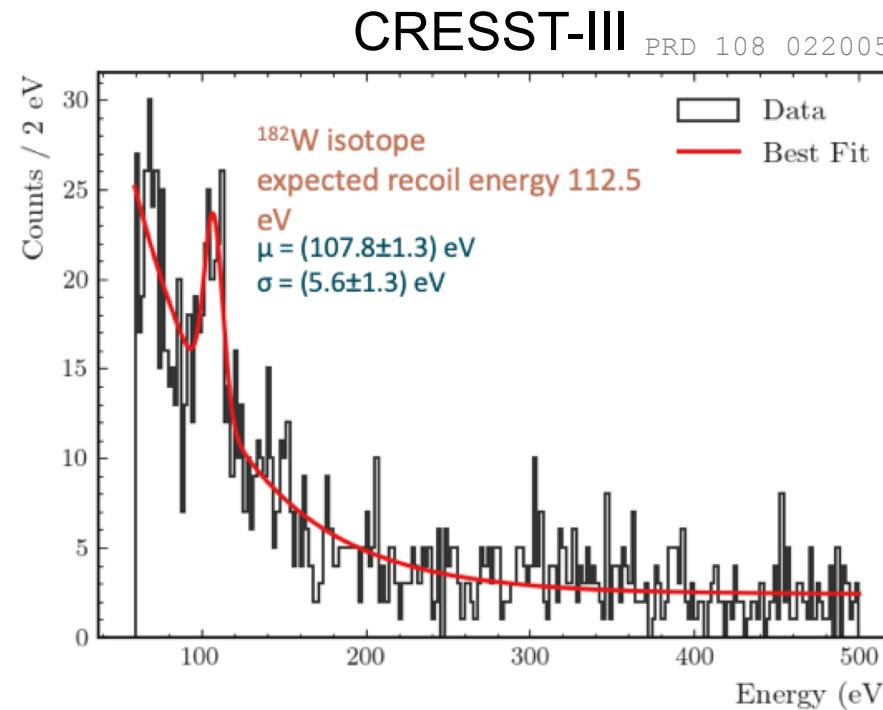
Nuclear recoils:

neutron capture reaction

→ the CRAB project



JINST 16 P07032



Thermal neutron capture
on ^{182}W

→ de-excitation with a
single gamma

→ mono-energetic
nuclear recoil

CHALLENGE 3 – MIGDAL EFFECT

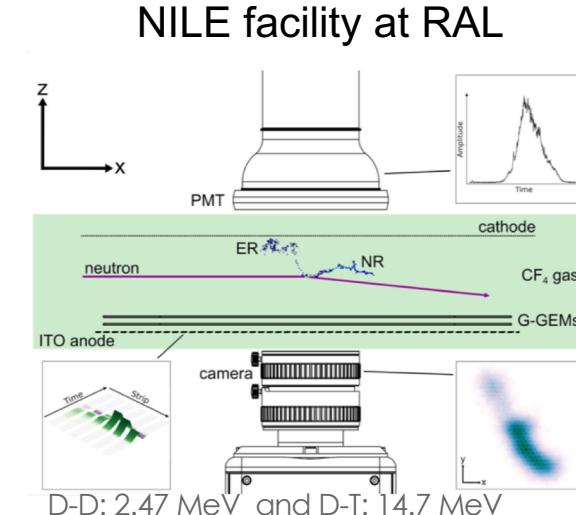
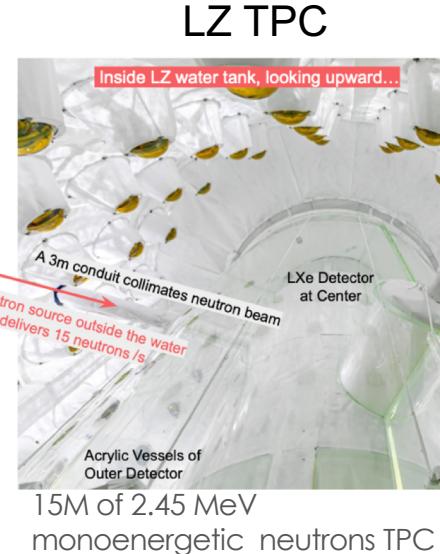
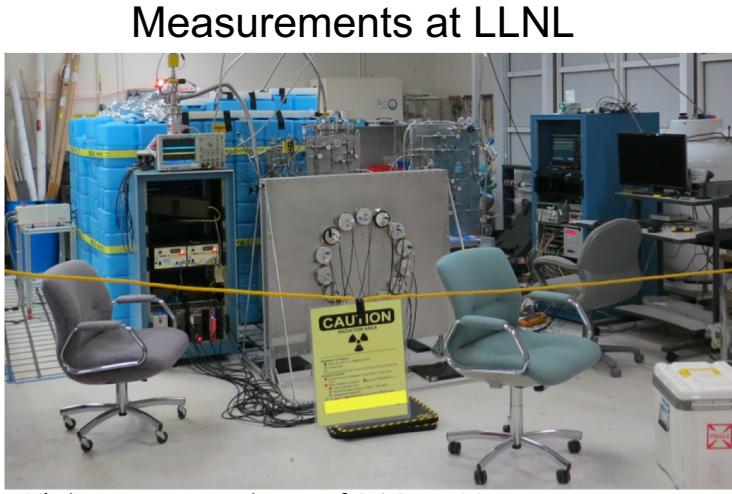
→ see: J. Xu, P. Majewski ←



Potential enhancement of low-mass DM sensitivity for existing experiments, in particular **liquid nobles (LXe, LAr)**

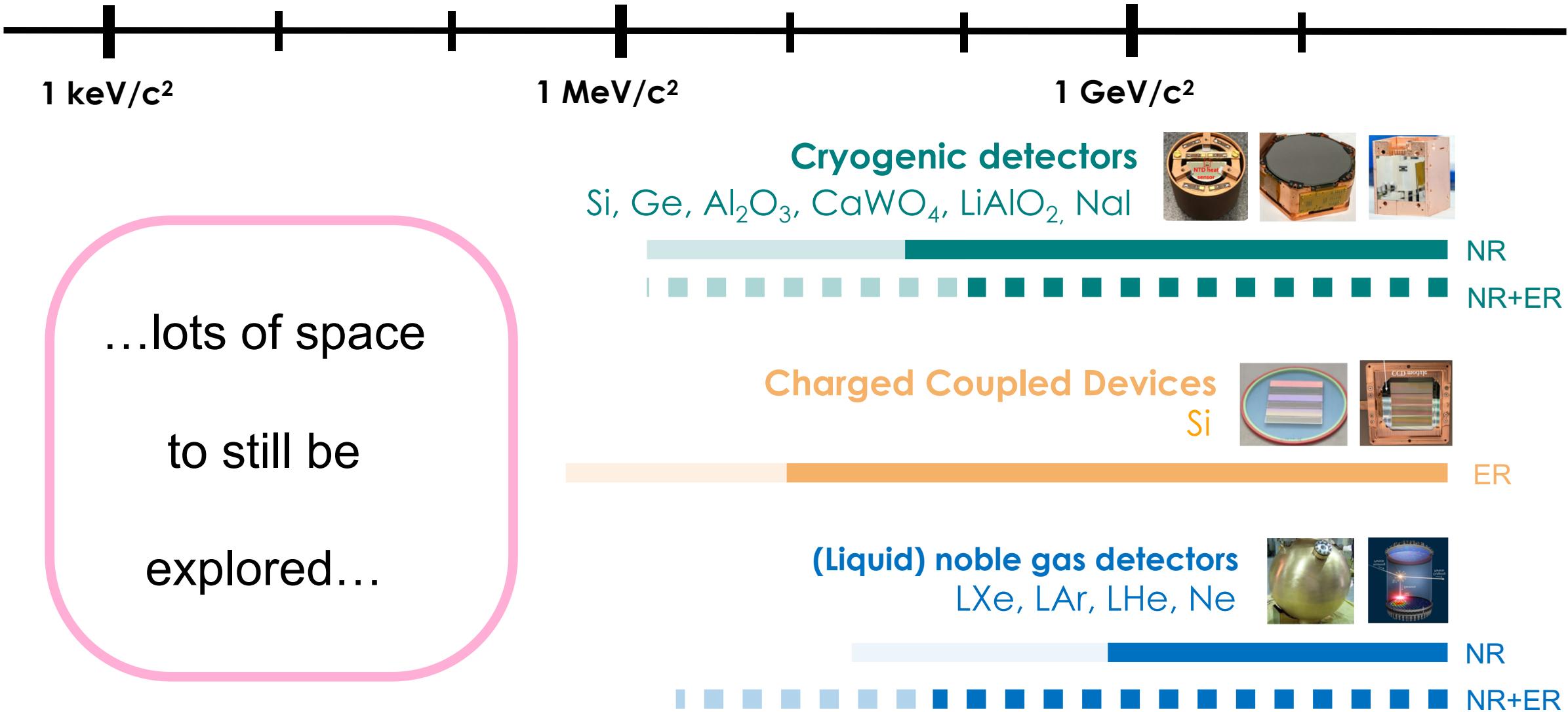
- actively used to set some of the strongest bounds:
- theory set and (almost) straight forward **BUT** laboratory measurement missing and mandatory

XENON1T, PRL 123, 241803 (2019); XENONnT, PRD 106, 022001 (2022)
LUX, PRL 122 131301 (2019); DarkSide50, PRL 130, 101001 (2023)
EDELWEISS, PRD 106, 062004 (2022); SuperCDMS, PRD 107, 112013 (2023)
CDEX-1B, PRL 123, 161301 (2019)



first science on
the way;
stay tuned for
robust results in
the near future!

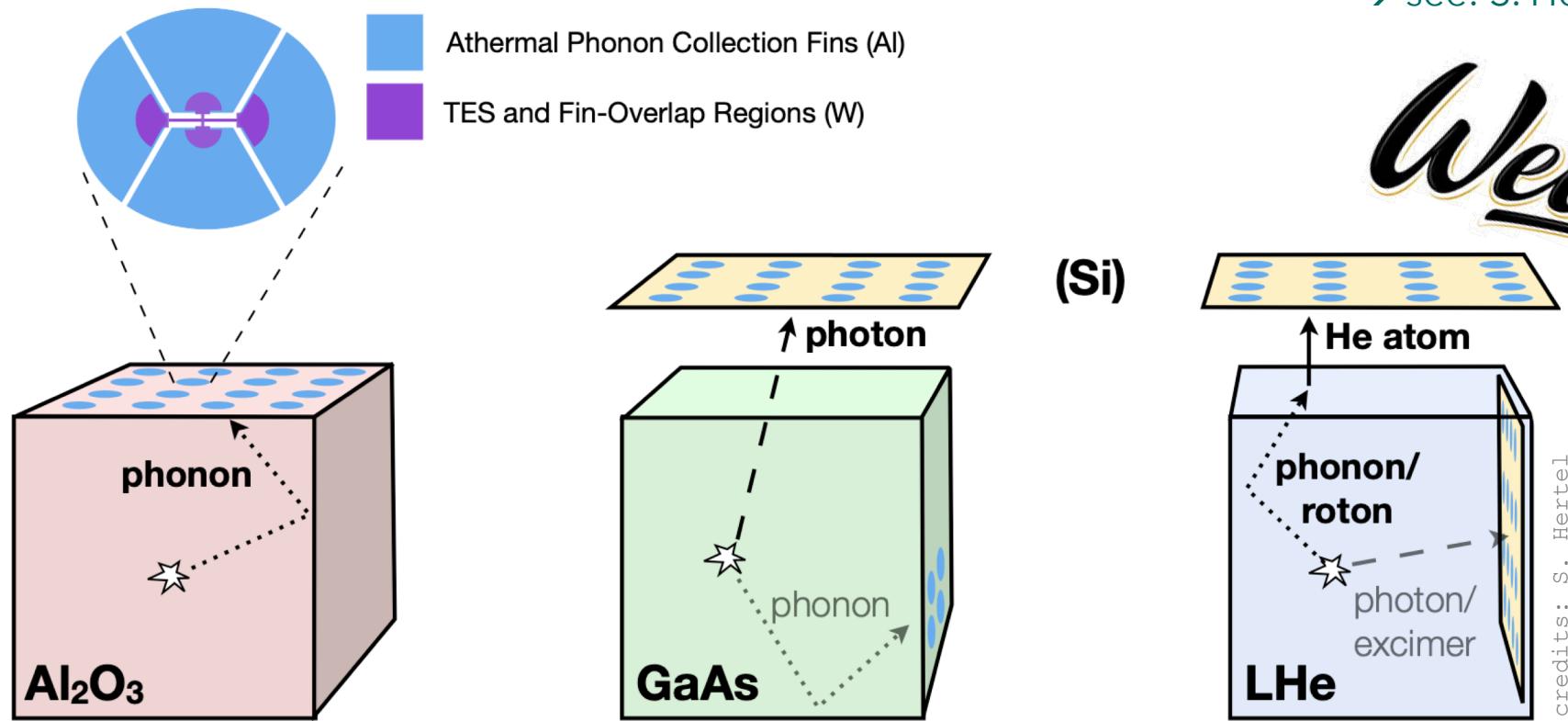
DETECTION TECHNIQUE and TARGETS





A new player – the TESSERACT project

→ see: S. Hertel, R. Romani ←



Goal: use multiple target materials (GaAs, sapphire, ...)
+ advances in TES sensor technology

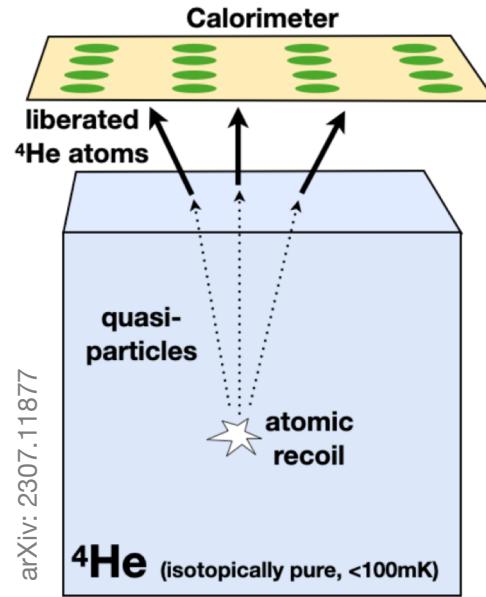
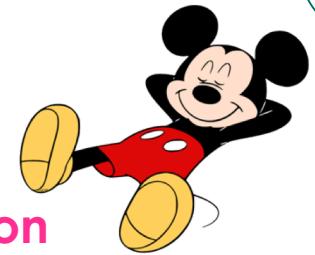
HeRALD – superfluid ^4He

→ see: S. Hertel

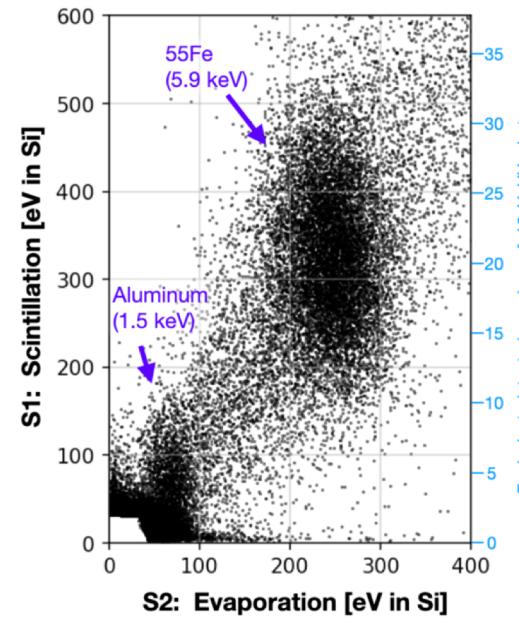


LEE may have spontaneous relaxation of detector materials as origin

→ ^4He target is in superfluid state = close to quantum ground state → **stress-free region**



arXiv: 2307.11877



First key measurement: evaporation channel ‘gain’ aka ‘efficiency’

→ gain of 0.15 (1eV of energy deposited in the ^4He phonon/quasiparticle system appears at 0.15eV)
→ work in progress

NEW technologies entering the field



- MKIDS with BULLKID → M. Vignati
- Qubits → R. Linehan
- Magnetic sensors with MAGNETO → G. Kim
- Narrow-gap Semiconductors with SPLENDOR → S. Watkins
- Polar crystal with SPICE → R. Romani
- ^3He with QUEST-DMC → E. Leason
- ^4He with DELight → F. Toschi

... apologies if I missed your favorite topic !



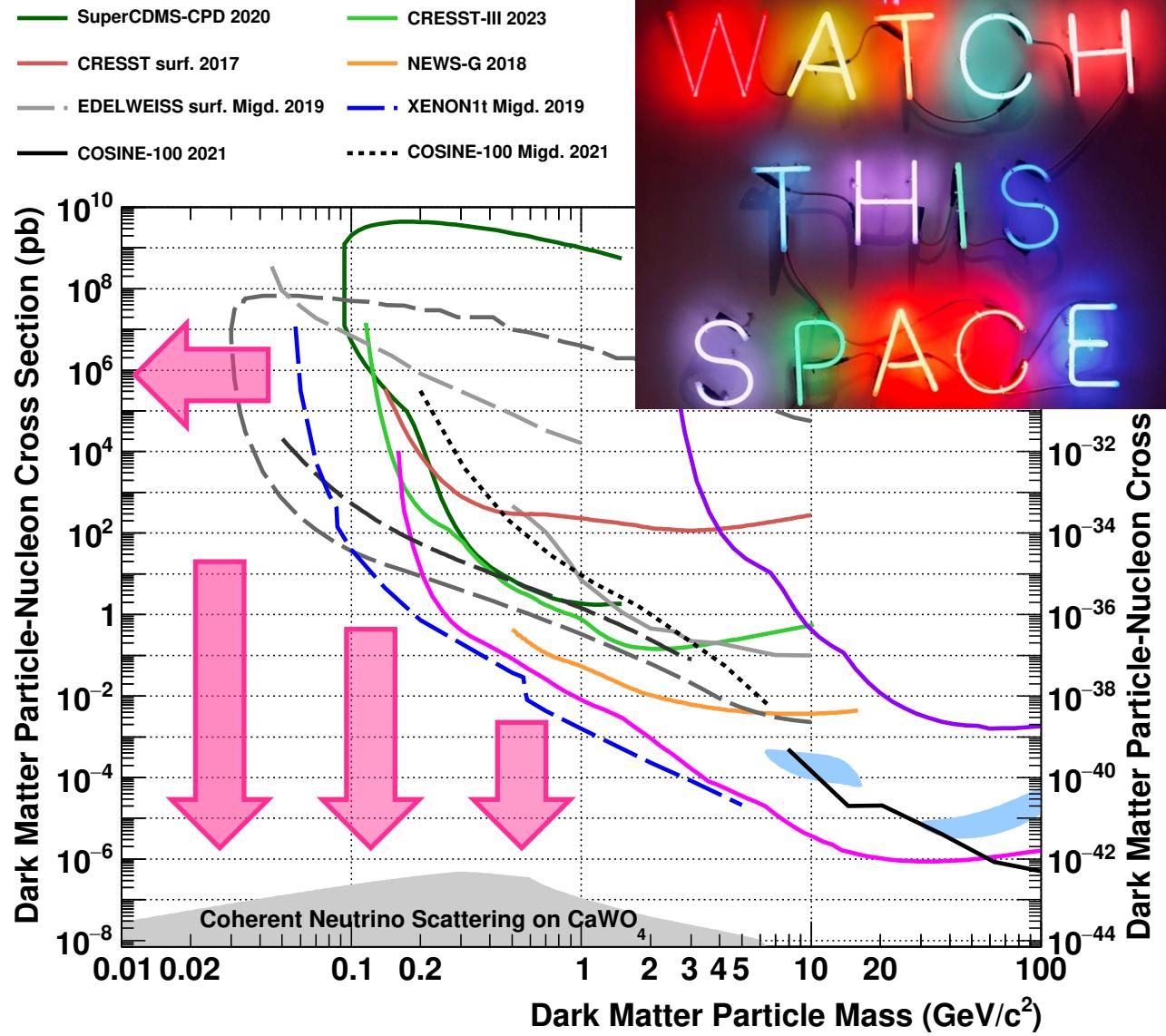
OVERALL PICTURE

improved detection techniques
+ EXCESS solved
+ calibration done, incl. Migdal
+ new players optimized for sub (sub) GeV



exploration of the full low-mass
parameter space!

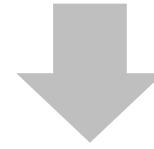
AND: exposure needed
at $\mathcal{O}(\text{tonne-years})$



SUMMA SUMARUM



improved detection techniques
+ EXCESS solved
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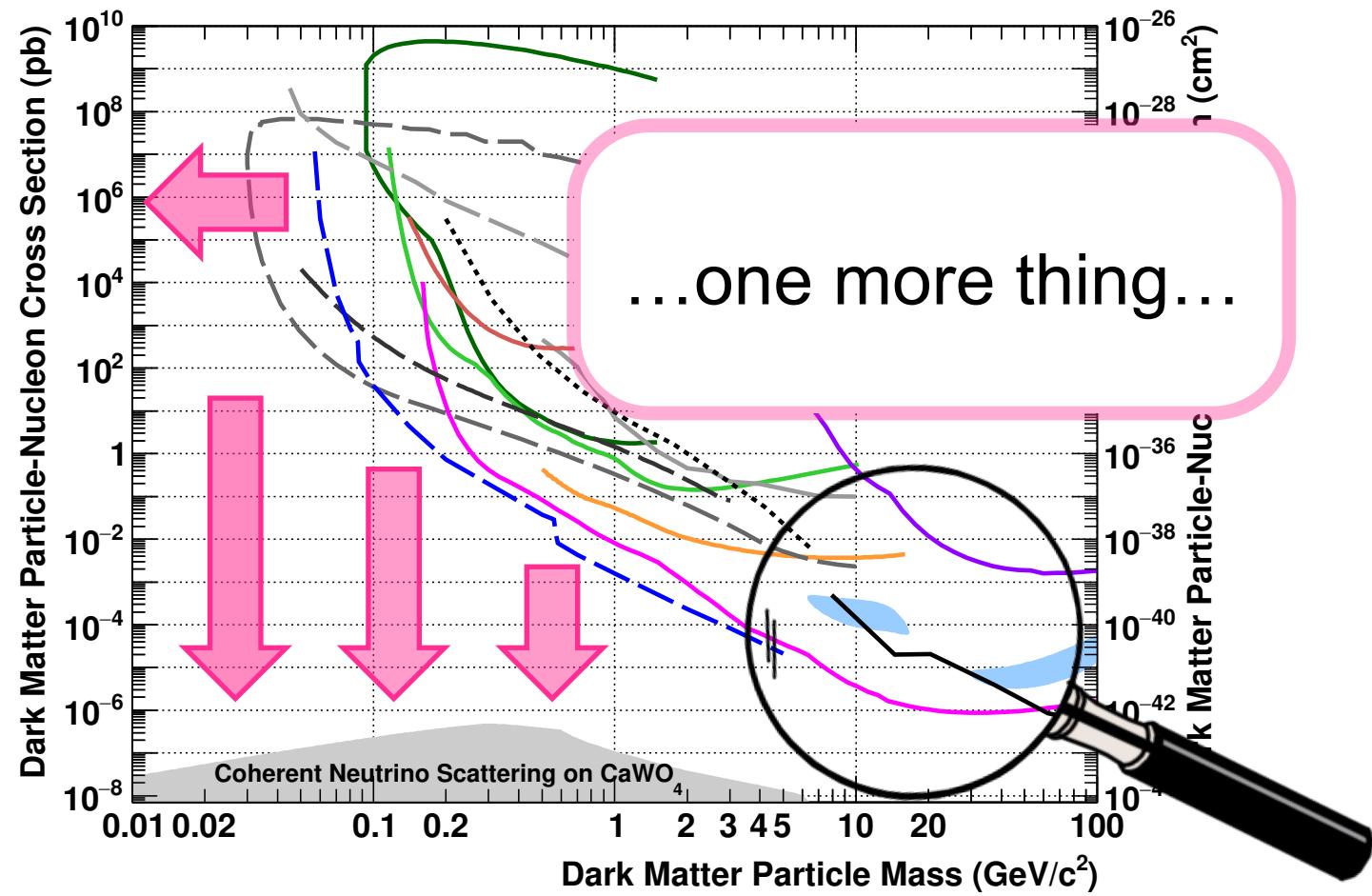
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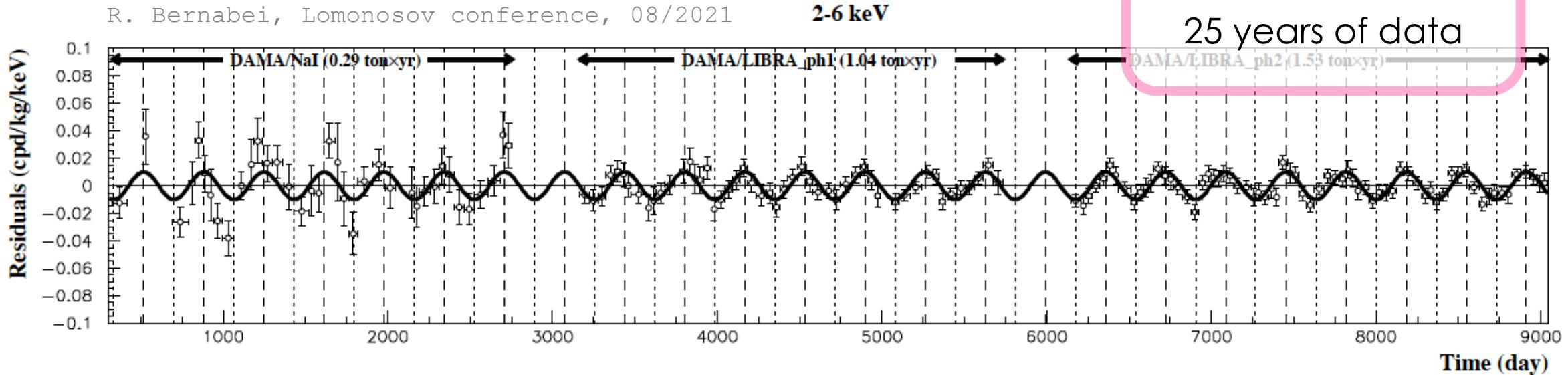


Legend for experimental sensitivities:

- SuperCDMS-CPD 2020
- CRESST-III 2023
- EDELWEISS surf. 2018
- CRESST-III 2019
- CRESST surf. 2017
- NEWS-G 2018
- CDEX-1B Migd. 2019
- CDMSlite Migd. 2022
- EDELWEISS surf. Migd. 2019
- XENON1t Migd. 2019
- DAMA/LIBRA (3 σ)
- COSINUS 2023
- COSINE-100 2021
- COSINE-100 Migd. 2021



DAMA's LONG STANDING DM CLAIM



Total exposure: 2.86 tonne years
Statistical significance: 13.7 σ
Energy region: 2-6 keV_{ee}

Claim: positive evidence for the presence of DM particles in the galactic halo

NaI community using room temperature scintillators → lots of effort

SABRE	→ G. D'Imperio
ANALIS-112	→ T. Yanguas, I. Casas
COSINE-100	→ H. Su Lee
PICOLON	→ Y. Urano

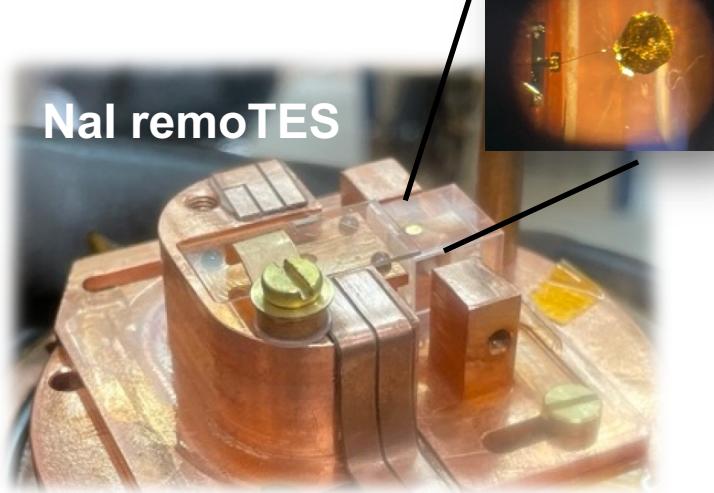
COSINUS – the “cold” DAMA-check



→ see: V. Zema, M. Bharadwaj, R. Maji ←

remoTES readout for NaI

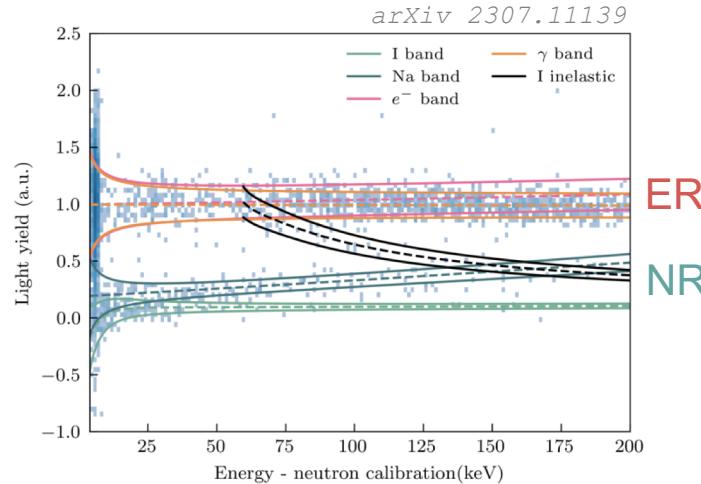
NIM A1045 167532



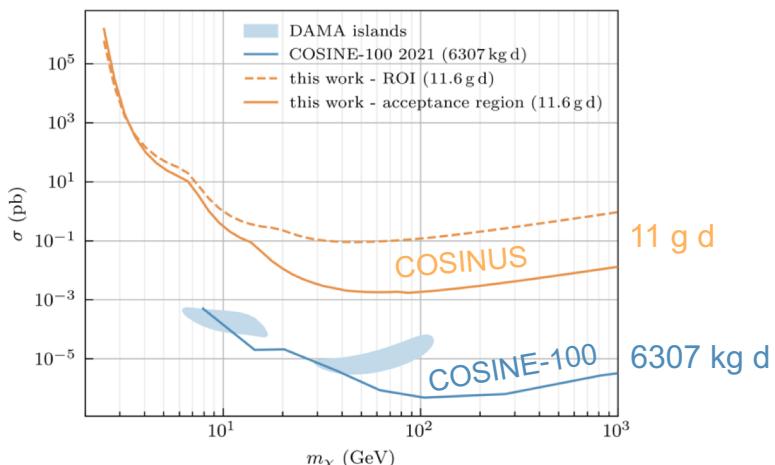
NaI remoTES

MAX PLANCK INSTITUTE FOR PHYSICS / K. SCHÄFFNER

first physics results



$$\sigma(\text{NaI}) = (0.441 \pm 0.011) \text{ keV}$$



cryogenic low background facility in hall B @ LNGS



53



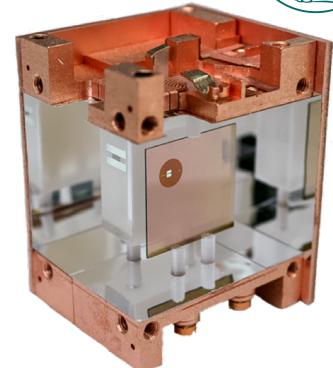
CONCLUSION

CRYODETECTORS

probe new parameter space with small-scale detectors for both NR and e^- - DM interactions



Low Energy Excess (LEE) is *limiting sensitivity*



CCDs

remarkable technological progress and most stringent limits below $10 \text{ MeV}/c^2$ for e^- -DM (heavy mediator)



further overall background reduction

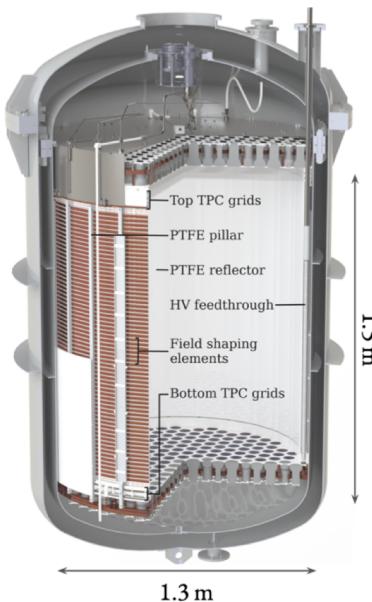


LIQUID NOBLE GAS TPCs

Migdal effect brings sensitivity $< 1\text{GeV}/c^2$

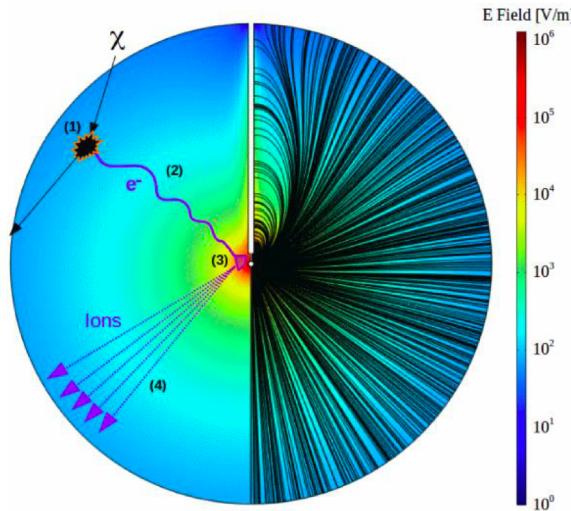


experimental proof of Migdal effect



THANK YOU FOR YOUR ATTENTION

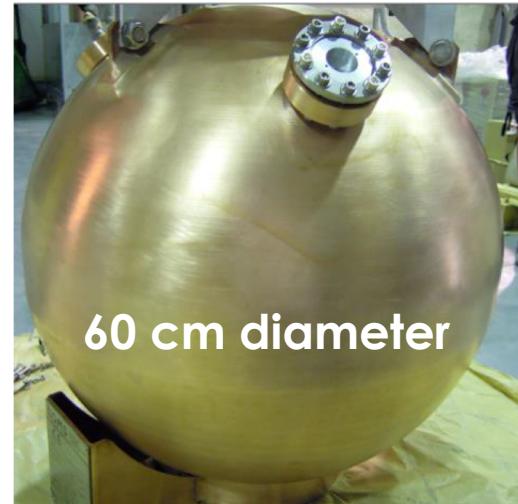
Spherical proportional counters – NEWS-G



SPCs are metallic spheres filled with gas, with a central anode producing a radial electric field

- different gases (Ne, He, H)
- low threshold (single-ionization)
- sphere provides optimal volume/surface ratio

SEDINE @ LSM



Ne + CH₄ (0.7%) at 3.1 bar
exposure: 9.6 kgd
 $E_{th} = 150 \text{ eV}_{ee}$ (analysis threshold)

→ see: J.-M. Coquillat ←

S140 / SNOGLOBE @ SNOLAB



10 days of data taken at LSM with CH₄ before shipping to SNOLAB

Data taking ongoing



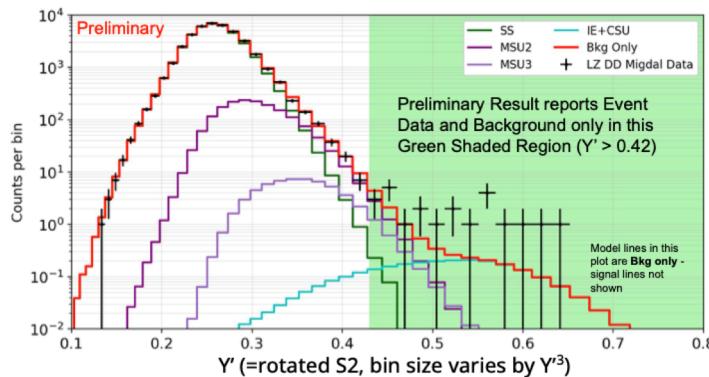
LZ – MIGDAL

Preliminary Result: Background-Only Comparison

In Background-only model:

- Count total background events in $Y' > 0.42$
- Determine significance of excess in model over data
 - Systematic uncertainties of background components incorporated in full calculation via poisson pdf:
 $P(n \geq N_{\text{obs}} | \mu_{\text{pred}} * (1+k)) = (\text{sys. unc.})/\mu_{\text{pred}}$

Observe a 3.4σ excess in data in Y' in region of high S/B



Source	Number of events in $Y' > 0.42$
Observed Data Events	23
BG Model Prediction	SS 0.3 +/- 0.1 (sys.)
	MSU2 4.9 +/- 0.1 (sys.)
	MSU3 2.4 +/- 0.1 (sys.)
	IE+CSU 2.0 +/- 0.2 (sys.)
Total BG Model Predicted	9.6 +/- 0.5 (sys.)
Significance versus BG-only Model Poiss($n \geq 23 \mu = 9.6 + 0.5$)	3.4 σ

Conclusion

- Direct search of L and M-shell Migdal effect is performed for LZ experiment using 15M neutrons into LXe TPC at 2.45 MeV
- Compare results with expected Migdal signals in S1-S2 space calculated based on Ibe et al. and Cox et al.
 - Sensitive to Migdal Events with Nuclear Recoils in energy 10-74 keVnr
 - Cox predicts rates ~1.2x those of Ibe
- In preliminary high-S2 region analysis, observing 23 events on a background $9.6 \pm 0.5(\text{sys})$
 - Observed excess consistent with Migdal signal predicted by Ibe and Cox
 - The background models are well-constrained and are dominated by:
 - Unresolved Neutron Multiple Scattering (MSU) being consistent with simulations and well constrained by data (MSU-only region)
 - Inelastic Nuclear Recoil + local Compton Scattering of Emitted Gamma-Ray (IE+CSU) highly suppressed/evaluated with simulation and calculation.
 - All other backgrounds are subdominant
- Profile Likelihood Ratio (PLR) analysis using more observables that contains an expected 6 L-shell and 152 M-shell (if Ibe et al., 1.2x higher if Cox et al.) is being finalized

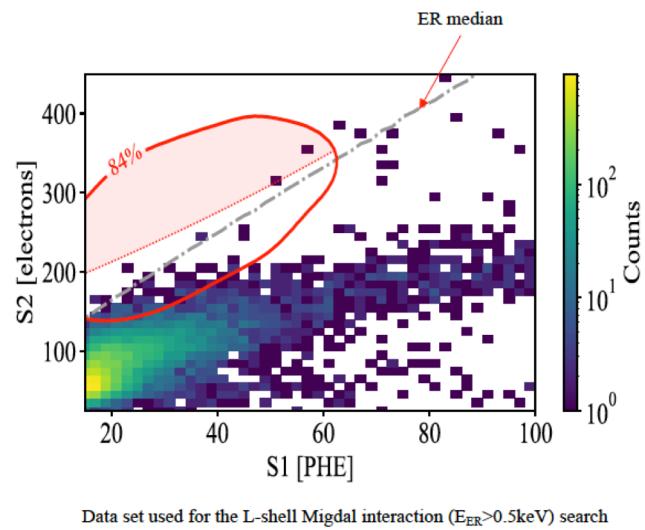
Jeanne Bang, Austin Vaitkus, Chen Ding
On behalf of the LZ Collaboration

UCLA Dark Matter 2023
03/31/2023



L-shell (>3keV) Migdal search

- ~410k NRs for L-shell search
 - Larger S1 signals → less stringent S1 cleanliness cut → increased event statistics
- Signal ROI defined as within 84% contour ($E_{ER}>3\text{keV}$) and above signal median
 - Well separated from NR population
- $5.7^{+/-1.2}$ signals expected
- 2 events observed
- $2.1^{+0.9}$ backgrounds expected



Summary

- The Migdal effect can substantially improve the sensitivity of existing experiments to low-mass dark matter interactions
- Tagged scatters of neutrons with liquid xenon is a promising approach to search for the Migdal effect directly
- We carried out a direct search for the Migdal effect in liquid xenon and achieved a lower background rate than the expected signal rate
- Analysis of experimental data suggests that we do not observe events at the predicted rate in our expected signal region
- Xenon recombination physics may explain the null result
- Low-mass dark matter search could still benefit from the Migdal effect since the NR component would be negligible (no significant recombination enhancement)
- Additional experimental efforts are being planned to more definitively test the Migdal effect predictions

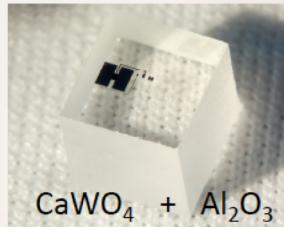
NEW OPPORTUNITIES – CEvNS

→ see: M. Vignati ←

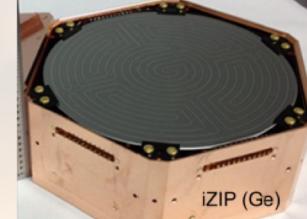


The CEvNS Spin-Offs

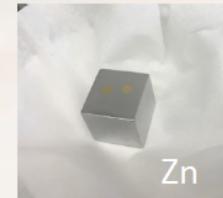
CRESST



SuperCDMS



EDELWEISS



ILL
France

Credits: R. Strauss

Nail-down CEvNS cross-section

What's the point for DM searches?

Boost for detector R&D

Calibration of detectors via CEvNS(!)