US Cosmic Visions roundup

new ideas in dark matter

Christopher McCabe

DMUK, Bristol - 17th January 2018

What is Cosmic Visions?

US Cosmic Visions: New Ideas in Dark Matter 2017 : Community Report

Marco Battaglieri (SAC co-chair),[1] Alberto Belloni (Coordinator),[2] Aaron Chou (WG2 Convener),[3] Priscilla Cushman (Coordinator),[4] Bertrand Echenard (WG3 Convener),[5] Rouven Essig (WG1 Convener),[6] Juan Estrada (WG1 Convener),[3] Jonathan L. Feng (WG4 Convener),[7] Brenna Flaugher (Coordinator),[3] Patrick J. Fox (WG4 Convener),[3] Peter Graham (WG2 Convener),[8] Carter Hall (Coordinator),[2] Roni Harnik (SAC member),[3] JoAnne Hewett (Coordinator),[9,8] Joseph Incandela (Coordinator),[10] Eder Izaguirre (WG3 Convener),[11] Daniel McKinsey (WG1 Convener),[12] Matthew Pyle (SAC member),[12] Natalie Roe (Coordinator),[13] Gray Rybka (SAC member),[14] Pierre Sikivie (SAC member),[15] Tim M.P. 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- *workshop in Maryland*
- *white paper*
- *grand vision for the future (in US, worldwide?)*

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- *I didn't write this*
- *I didn't attend the workshop*
- *US vision… Is it relevant for the UK DM community?*

How to summarise 113 page white paper in 15 minutes?

Big picture summary

A lot of time and effort spent looking for WIMPs

new particles around the weak scale

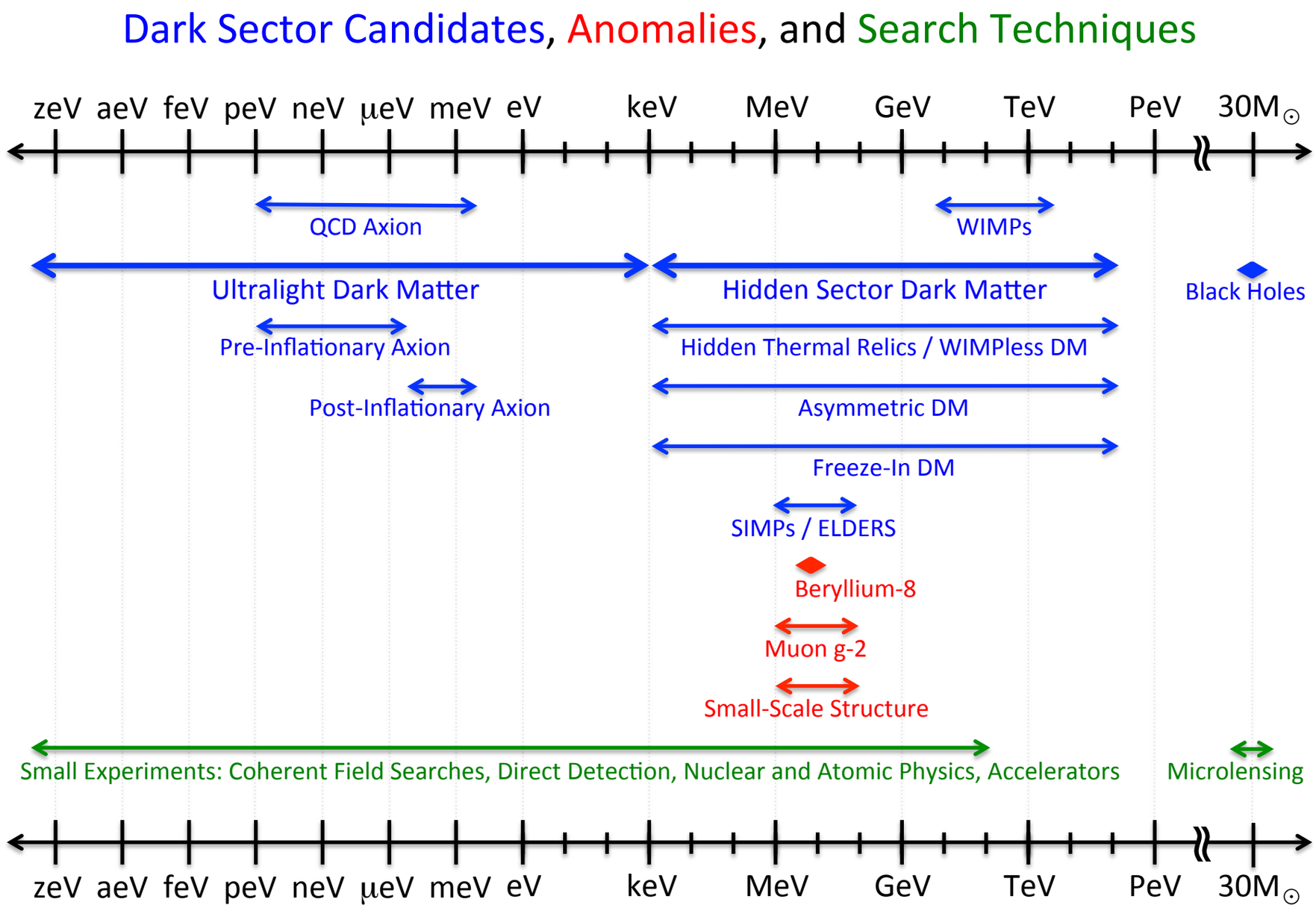
that {are/are not} connected to the electroweak hierarchy problem*

*delete as appropriate

Great - keep looking for WIMPs…

…but also look elsewhere

Big picture summary



WIMPs are only a small part of the interesting parameter space

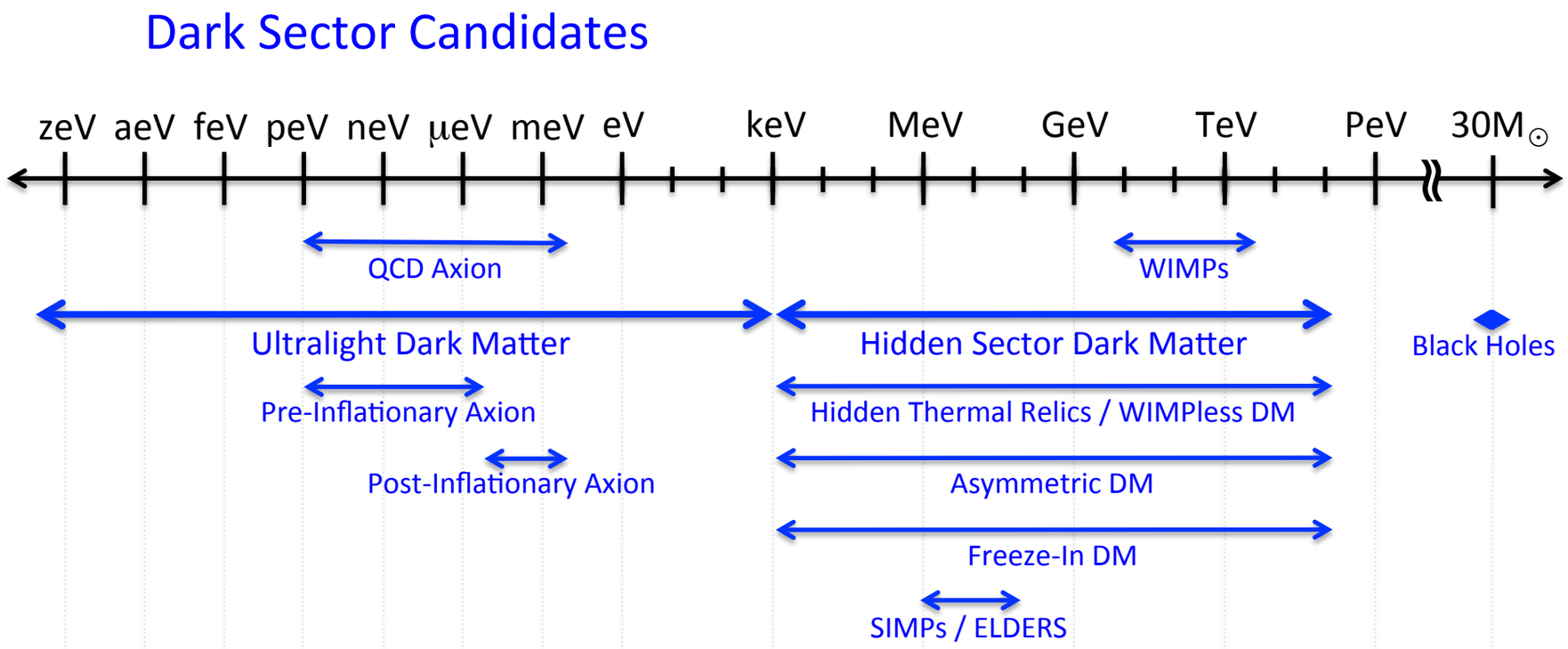
More closely: 5 main themes

1. Theory
2. Low threshold direct detection
3. A suite of axion-like searches
4. Searches with particle accelerators
5. Resolution of current anomalies

1. theory

Why is theory needed?

- motivates new models and regions of parameter space
- suggests new experiments
- and draws connections between disparate phenomena

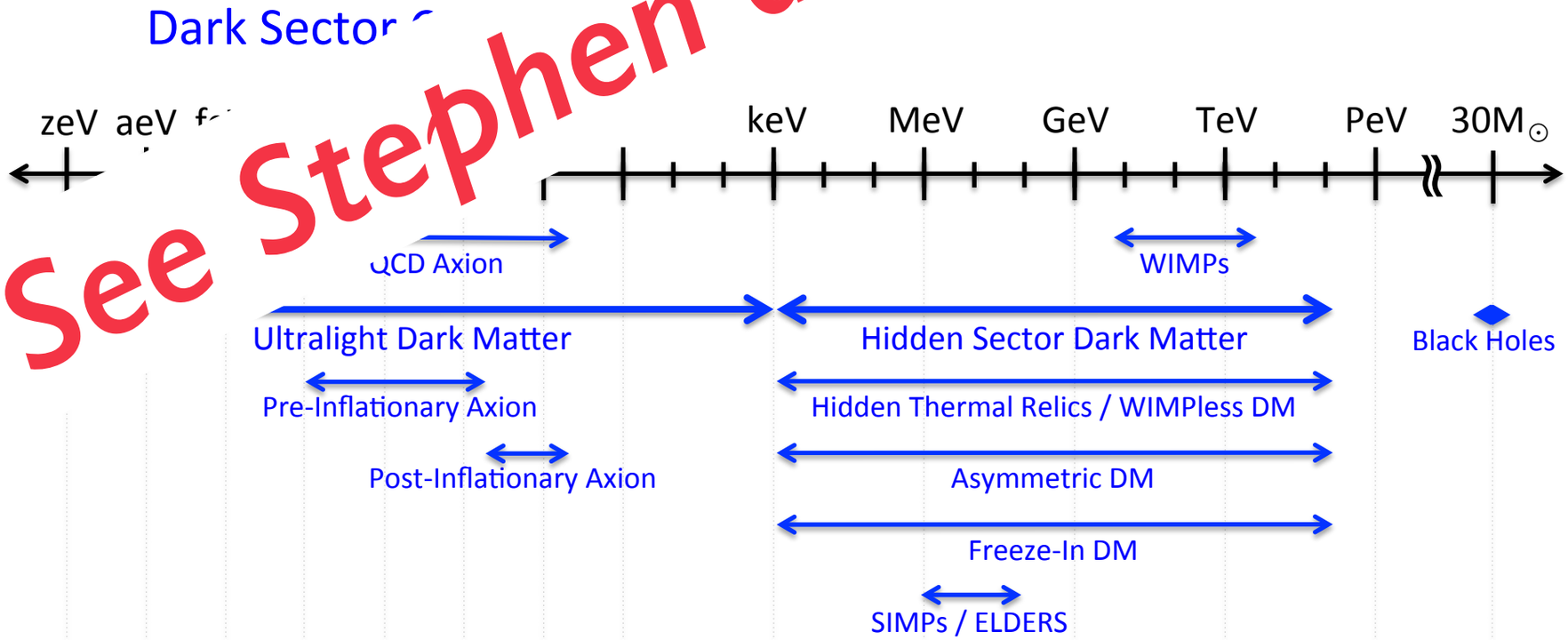


I. theory

Why is theory needed?

- motivates new models and regions of para ace
- suggests new experiments
- and draws connections be ace phenomena

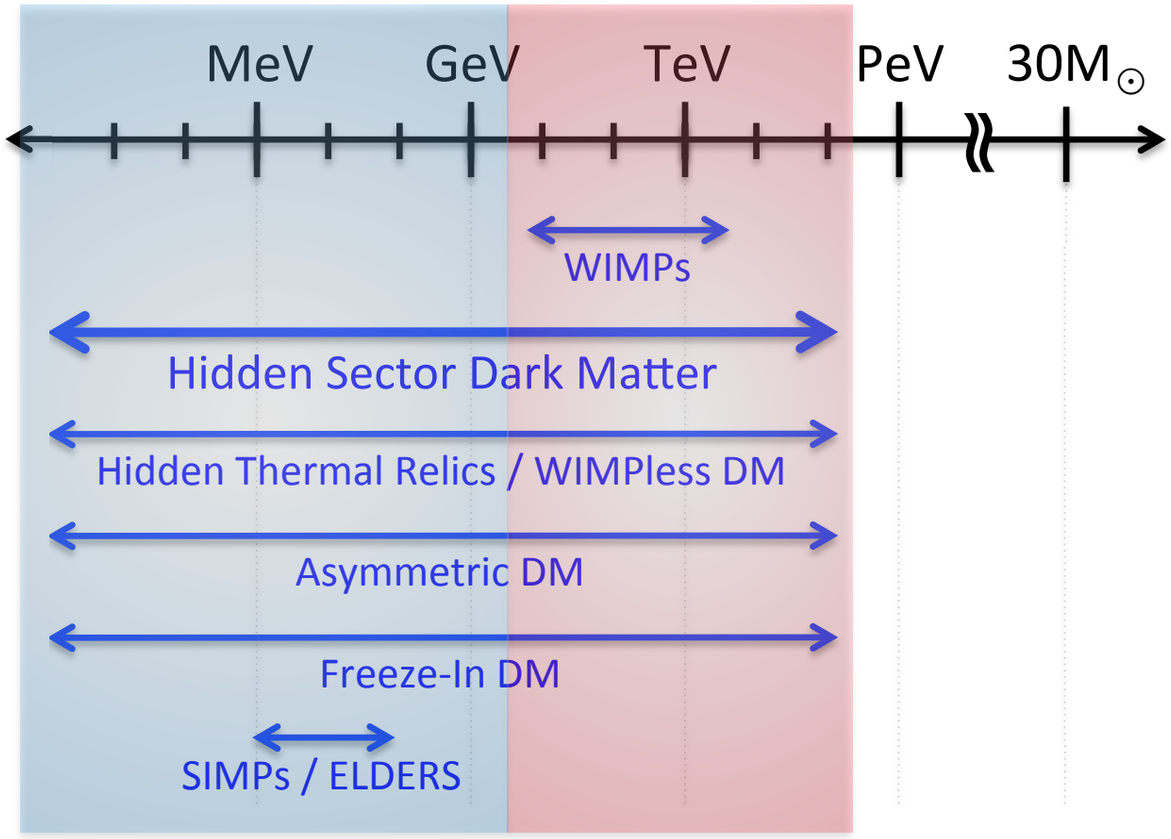
See Stephen and John's talks



2. low threshold direct detection

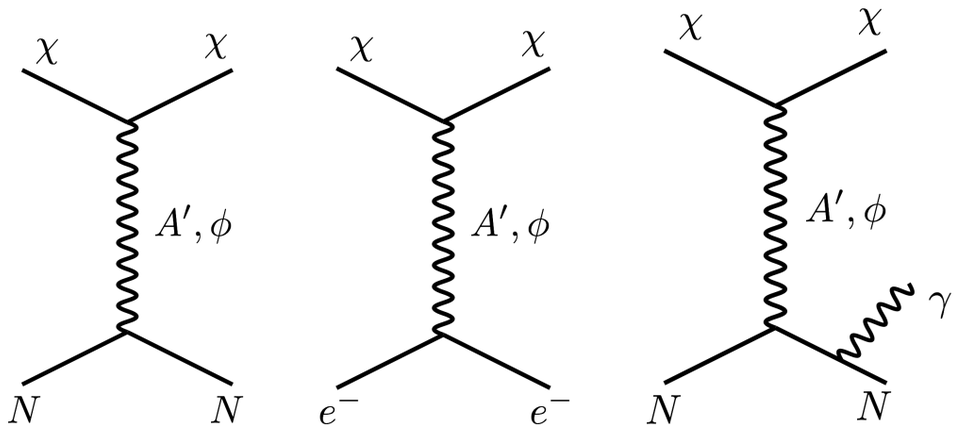
More than WIMPs

how can we probe them?



2. low threshold direct detection

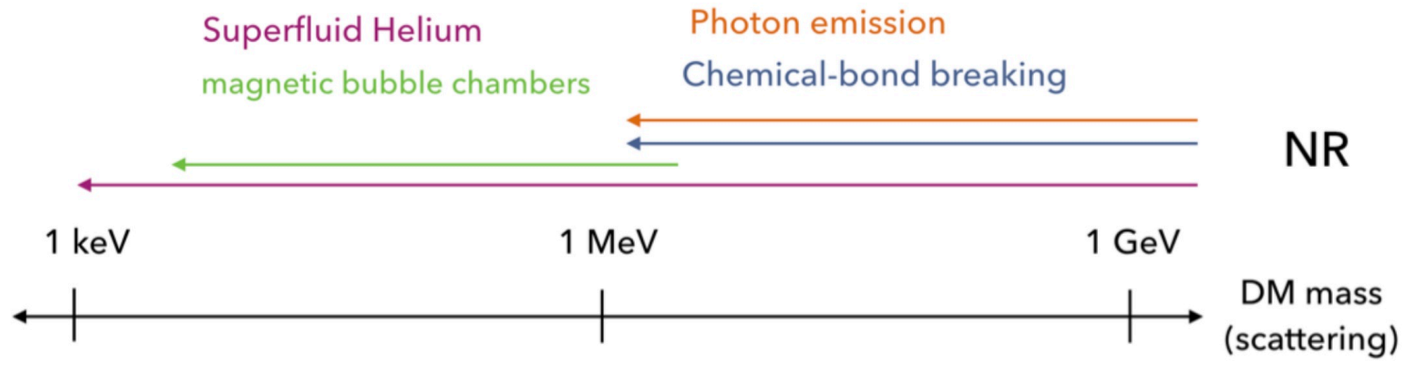
Direct detection still important

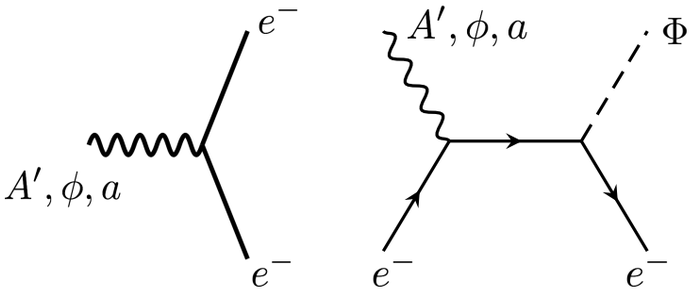


Nucleon scattering

Electron scattering

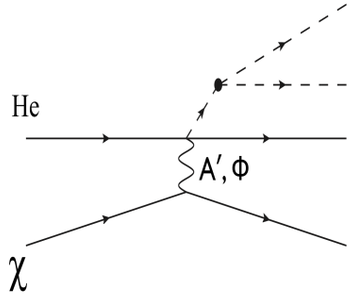
Nucleon scattering ++



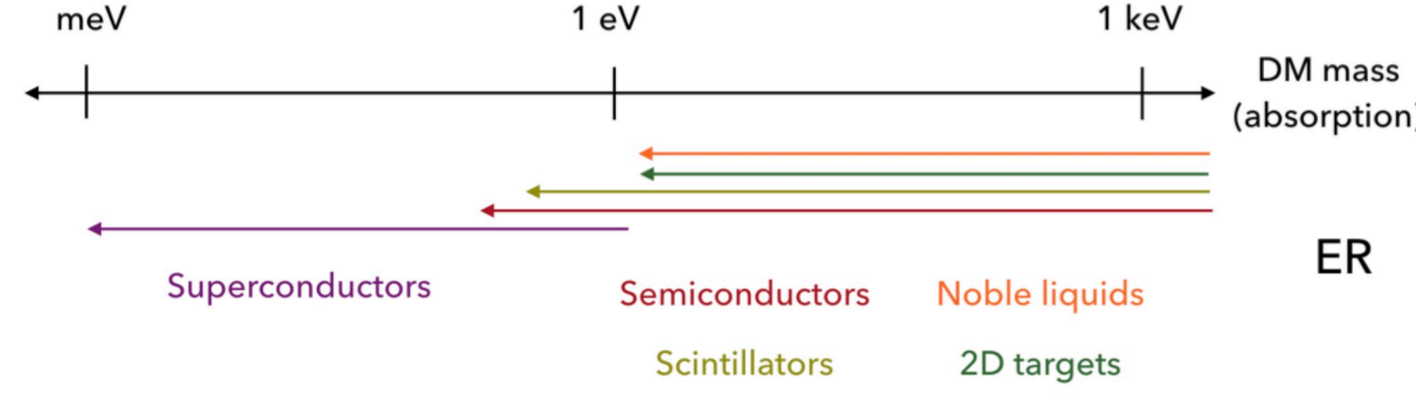


absorption

absorption & phonons



scatter & phonons

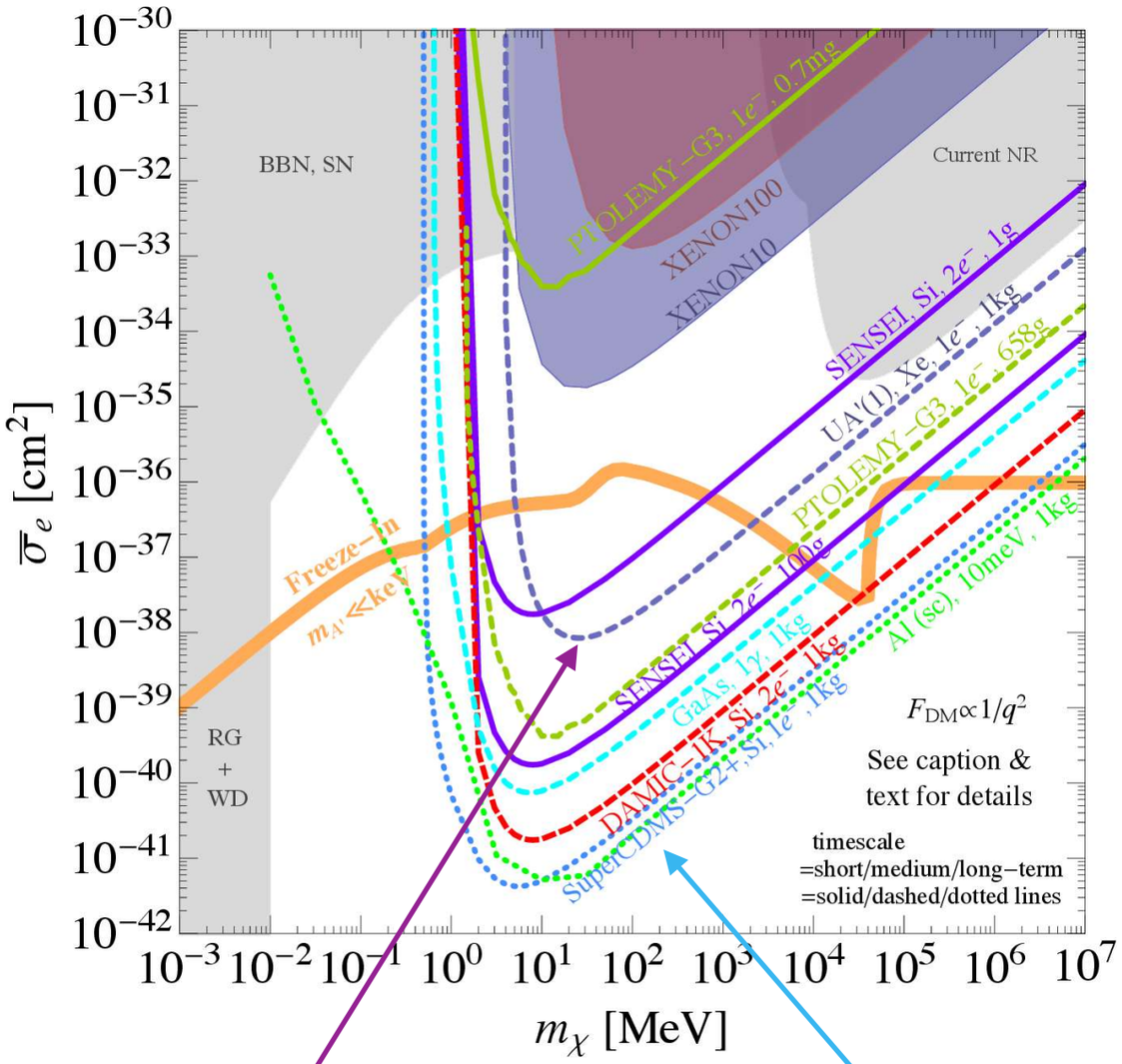


Old and new technology

See talks after lunch

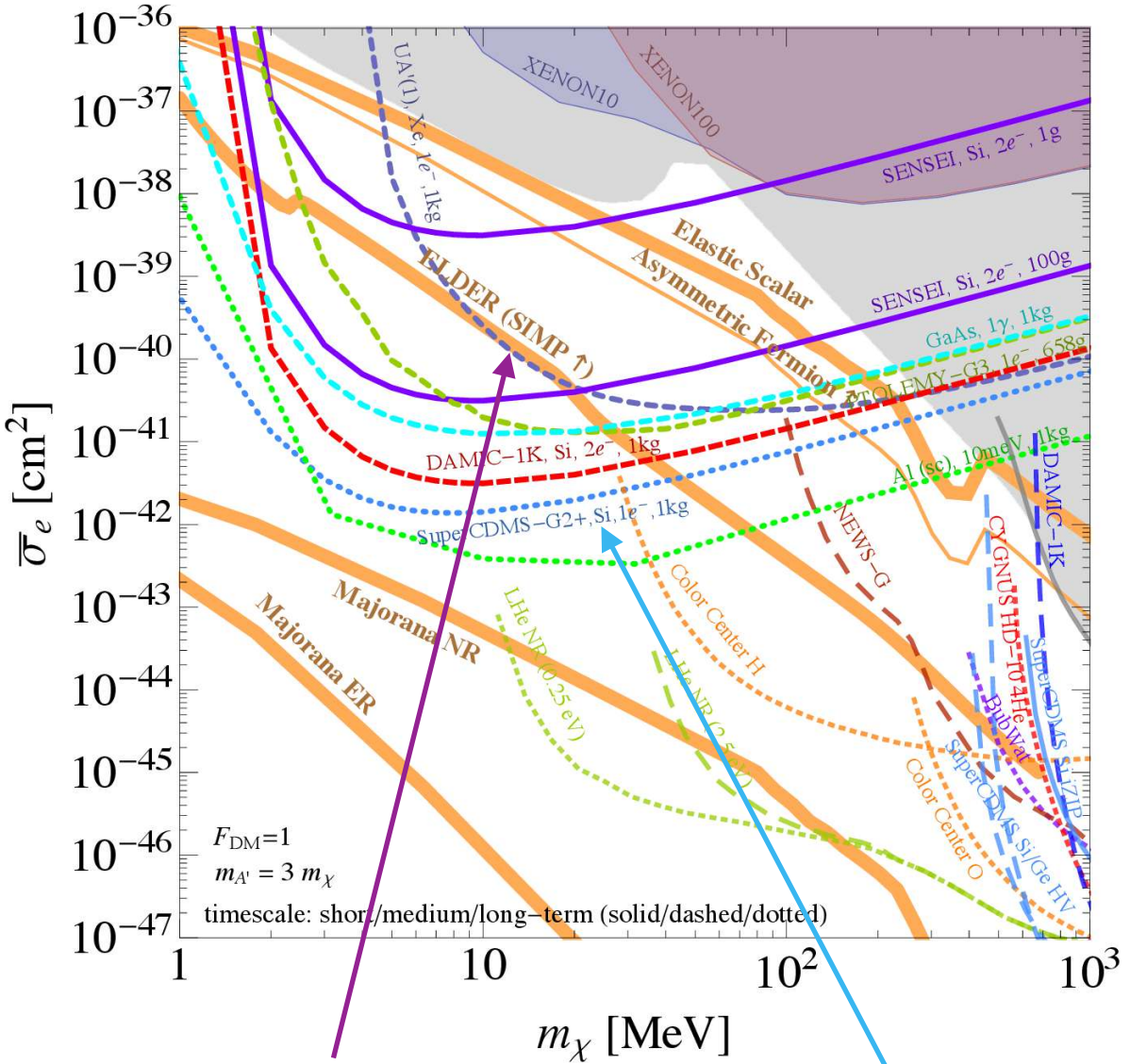
Main Science Goal	Experiment	Target	Readout	Estimated Timeline
Sub-GeV Dark Matter (Electron Interactions)	SENSEI	Si	charge	ready to start project (2 yr to deploy 100g)
	DAMIC-1K	Si	charge	ongoing R&D 2018 ready to start project (2 yr to deploy 1 kg)
	UA′(1) liquid Xe TPC	Xe	charge	ready to start project (2 yr to deploy 10kg)
	Scintillator w/ TES readout	GaAs(Si,B)	light	2 yr R&D 2020 in sCDMS cryostat
	NICE; NaI/CsI cooled crystals	NaI CsI	light	3 yr R&D 2020 ready to start project
	Ge Detector w/ Avalanche Ionization Amplification	Ge	charge	3 yr R&D 1 yr 10kg detector 1 yr 100kg detector
	PTOLEMY-G3, 2d graphene	graphene	charge directionality	1 yr fab prototype 1 yr data
	supercond. Al cube	Al	heat	10+ yr program
Sub-GeV Dark Matter (Nucleon Interactions)	Superfluid helium with TES readout	He	heat, light	1 yr R&D; 2018 ready to start project; 2022 run
	Evaporation & detection of He-atoms by field ionization	superfluid helium, crystals with long phonon mean free path (e.g. Si, Ge)	heat	3 yr R&D; 2020 ready to start project R&D
	color centers	crystals (CaF)	light	R&D effort ongoing
	Magnetic bubble chamber	Single molecule magnet crystals	Spin-avalanche (Magnetic flux)	R&D effort ongoing
Searches down to Neutrino Floor for $\mathcal{O}$(GeV) Dark Matter	SuperCDMS-G2+	Ge	heat, ionization	3 yr R&D; 1 yr fabrication; 2022 start running
	NEWS-G	H, He	charge	140cm sphere installed at SNOLAB in 2018
	NEWS-dm emulsions	Si, Br, I, C, O, N, H, S	charge directionality	R&D phase complete. Now technical test
	CYGNUS HD-10	SF_6, He flexible	charge directionality	1 yr R&D; 1 yr 1 m^3; 2 yr 10 m^3
	Scintillating bubble chamber	Xe, Ar C_6F_6, H_20	light heat(bubble)	2 yr program; test 10kg Xe chamber with CENNS
Spin-Dependent (Proton) Interactions	PICO bubble chambers	wide range	heat(bubble)	40 l chamber now PICO 500 l next

2. low threshold direct detection



UK expertise

UK expertise



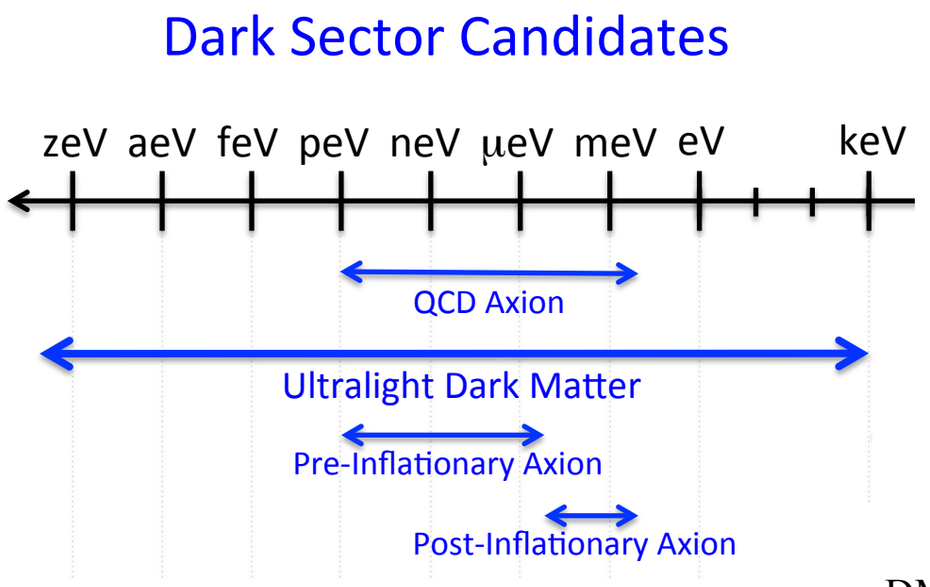
UK expertise

UK expertise

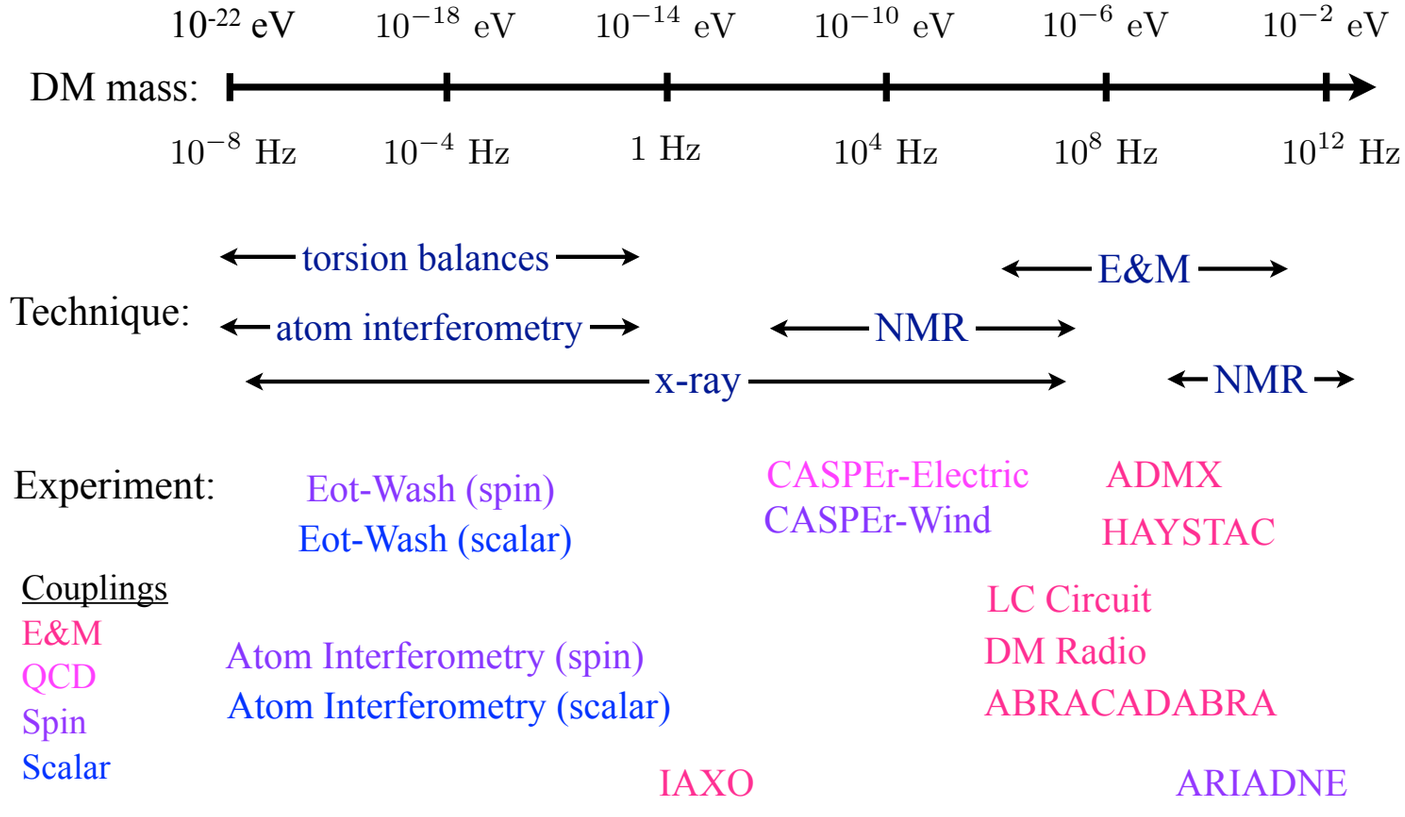
$$\sigma_e^{\rm FI} \sim \frac{1}{(q \sim {\rm keV})^4} \rightarrow \text{observable signal}$$

3. axion

Axions as/more motivated than WIMPs



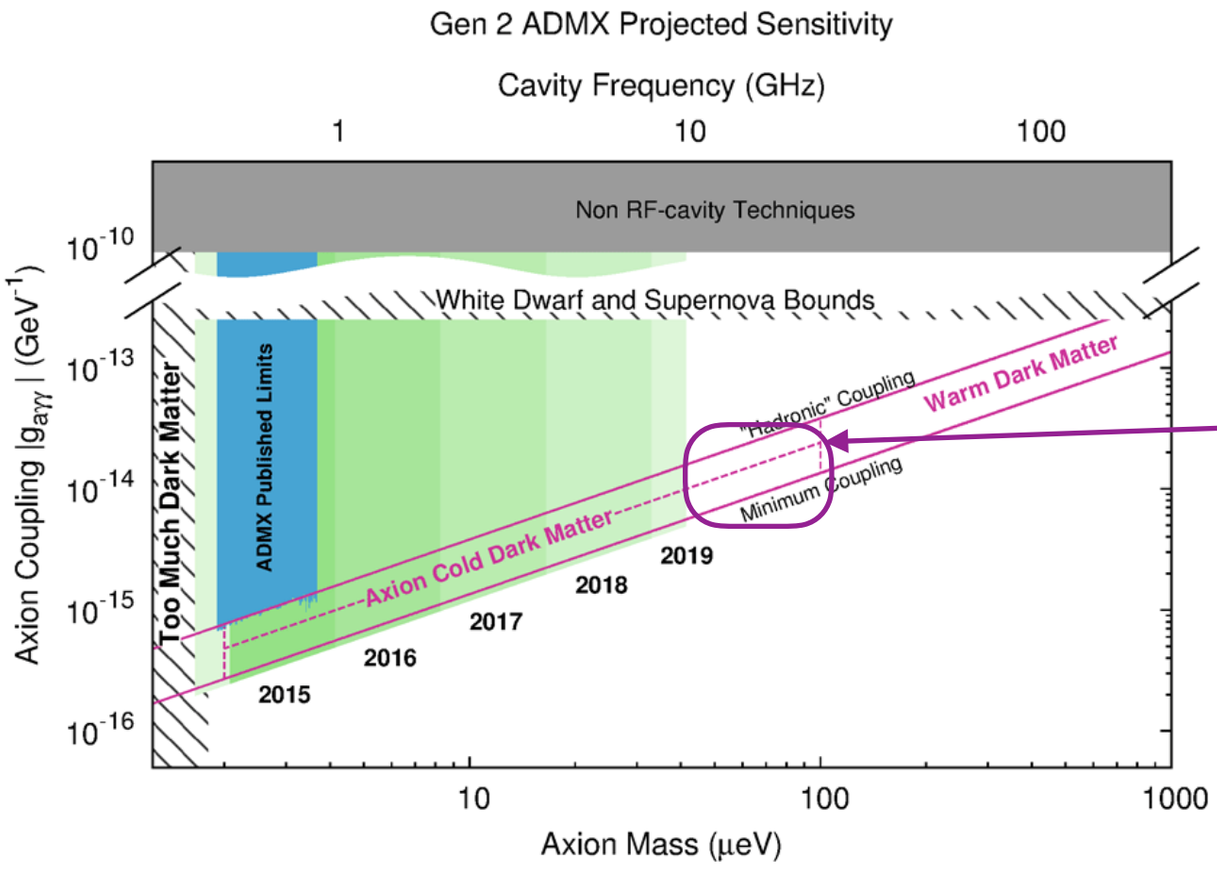
plethora of ideas:



3. axion

Fantastic searches already running: ADMX
Call for R&D to extend the reach

See Edward Daw talk after lunch



eg HAYSTAC (R&D): extend further

3. axion

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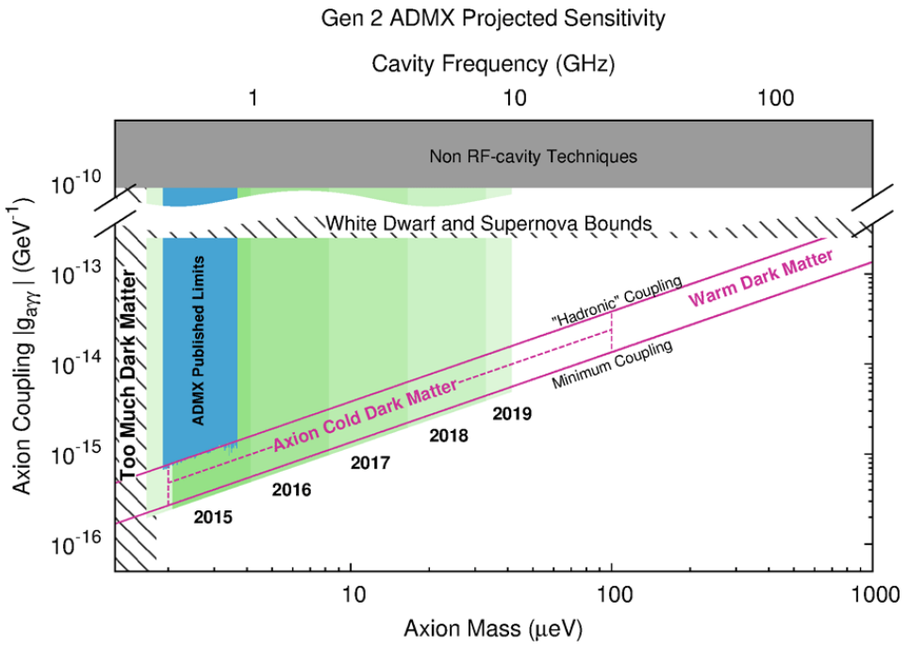
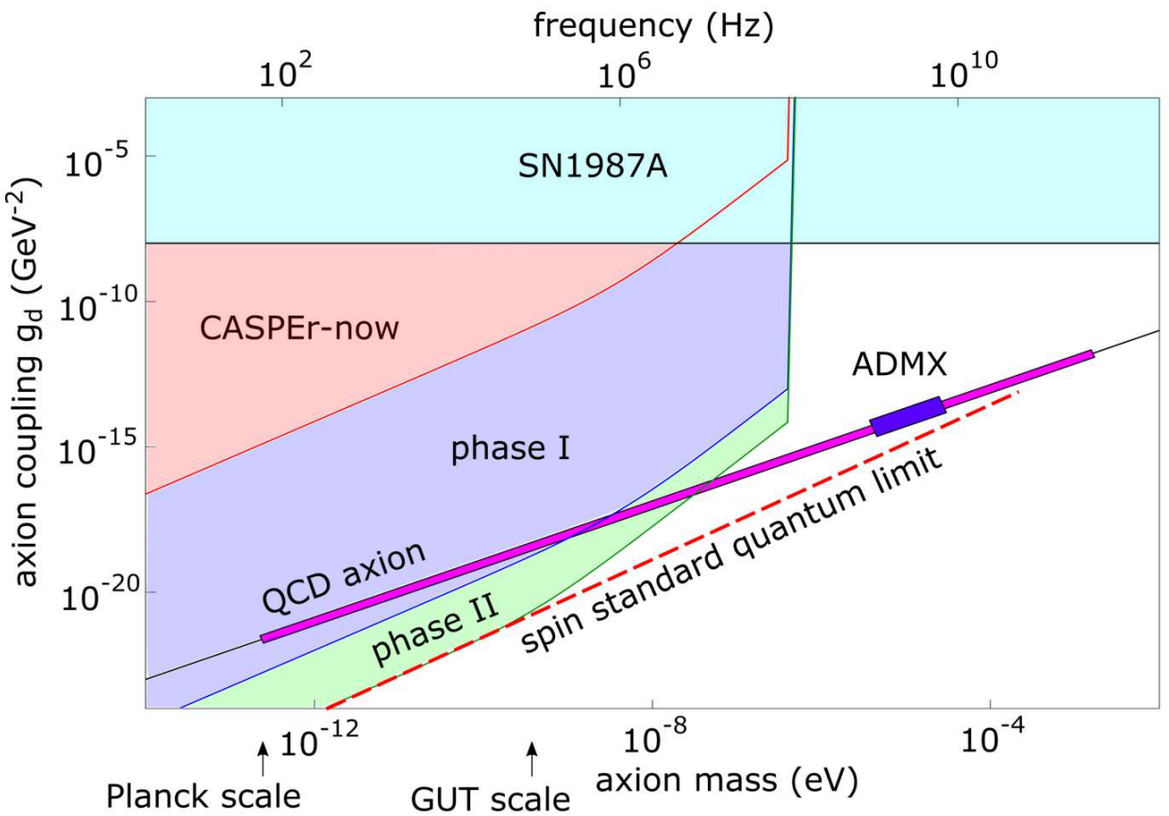
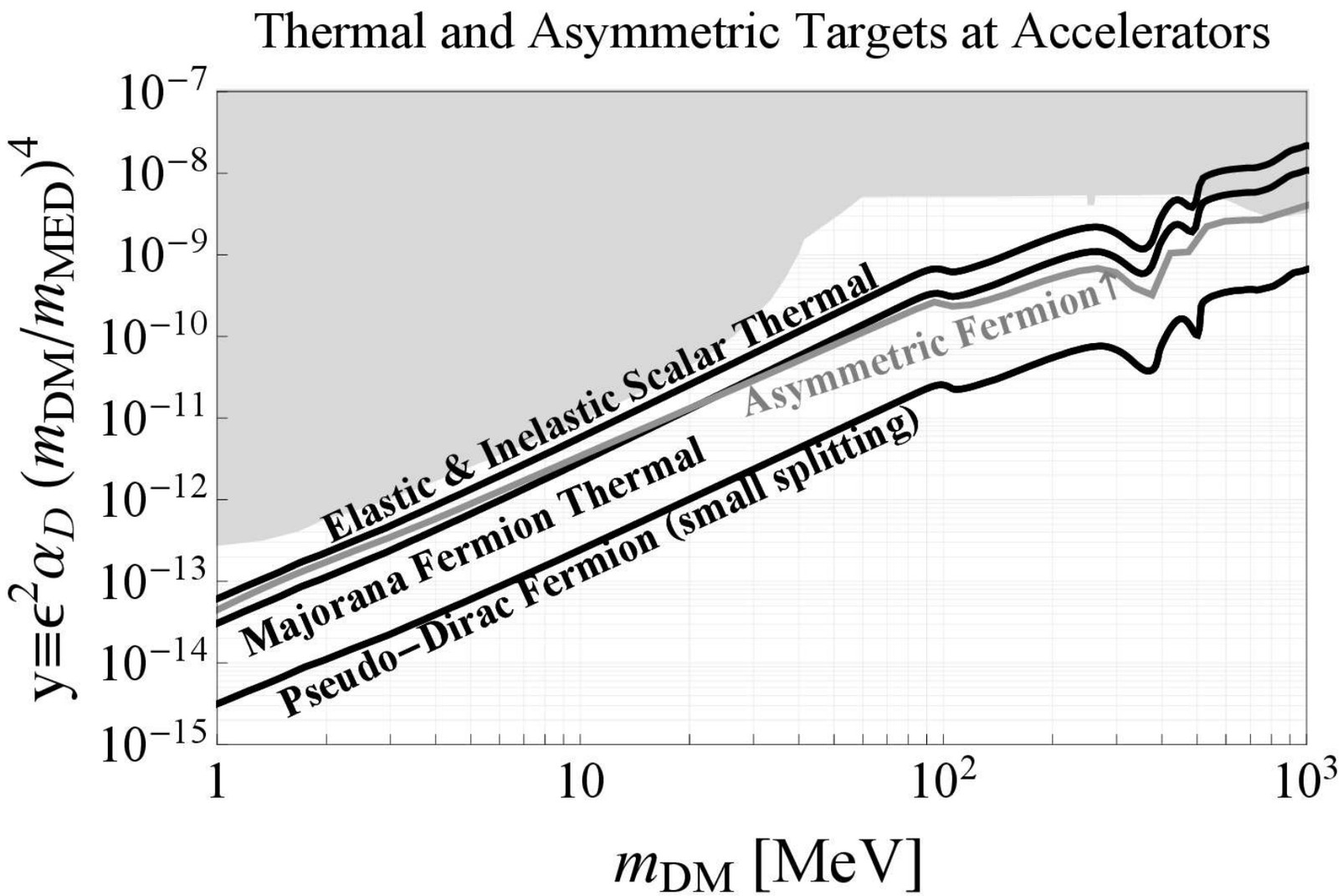




4. Searches with particle accelerators

Henning told us about the ATLAS/CMS/LHCb searches

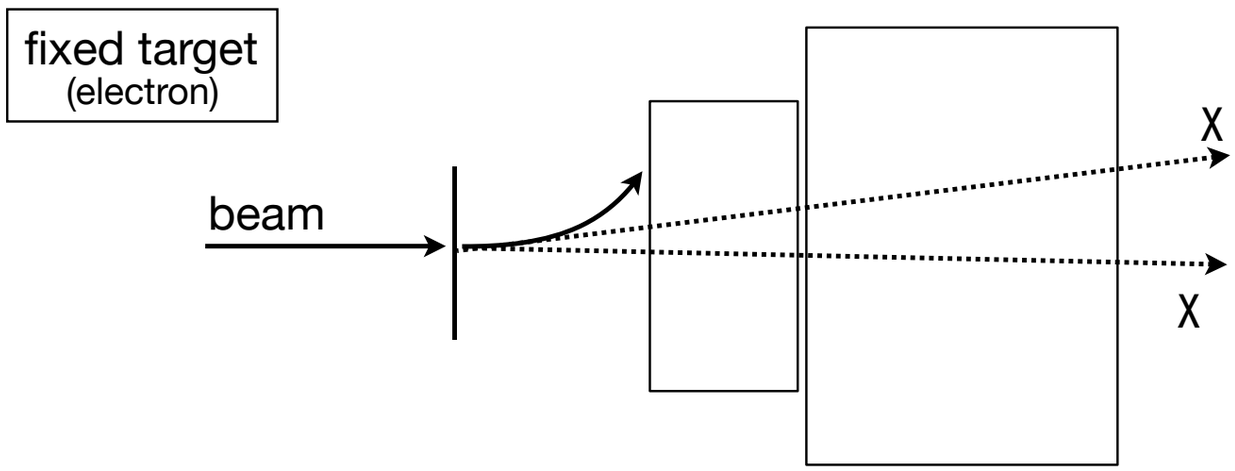
How can we probe low mass region with small portal couplings?

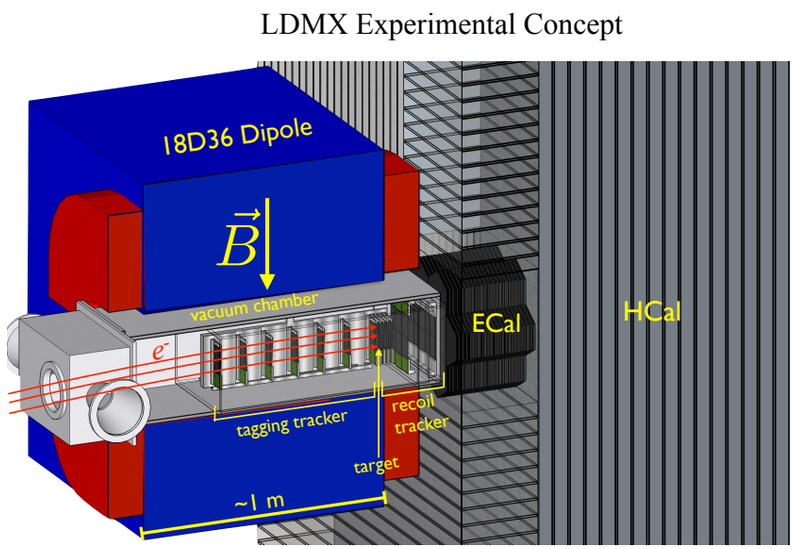


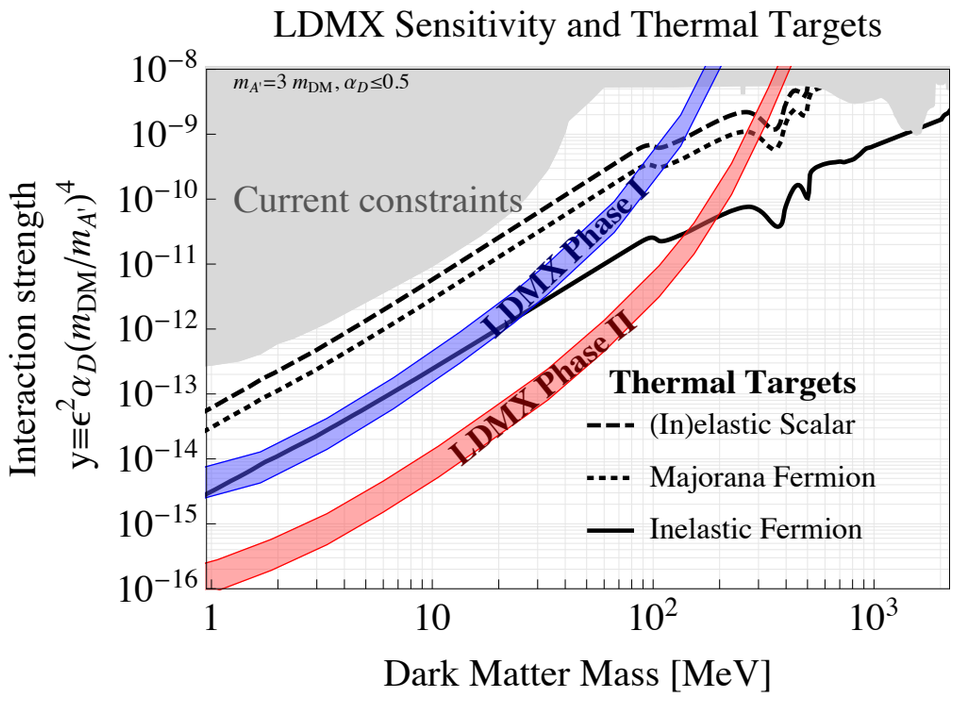
4. Searches with particle accelerators

Example: LDMX

$$eZ \rightarrow eZ(A' \rightarrow \chi\bar{\chi})$$

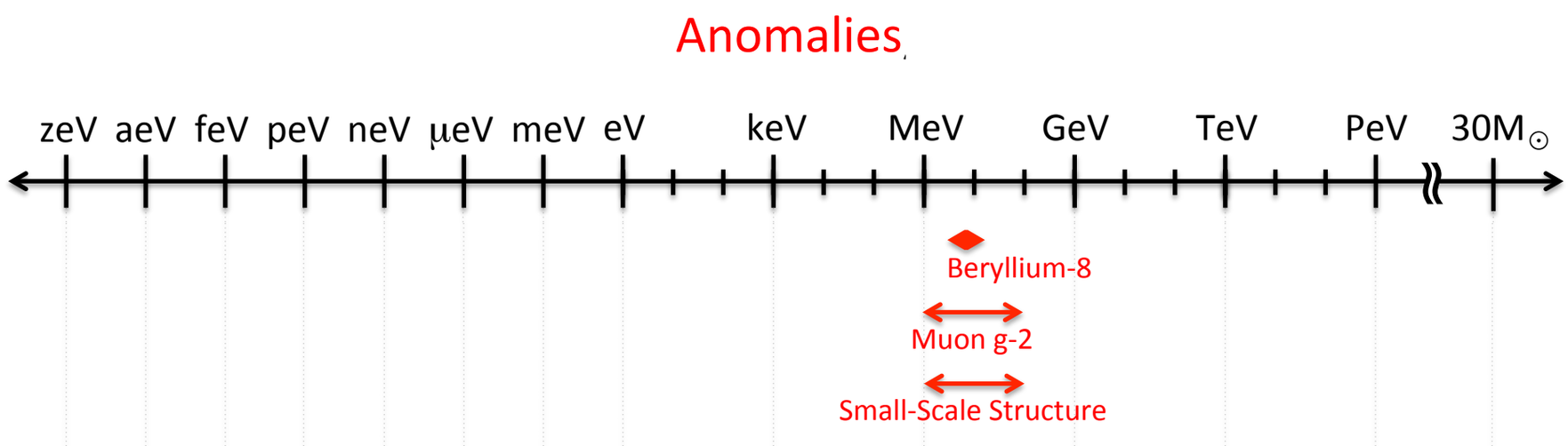






Make sense for the USA (particle physics again at SLAC)
Does it make sense for UK to focus on…?

5. Resolution of current anomalies



Excess in the distribution of e^+e^- opening angles in: $^8\mathrm{Be}^* \rightarrow ^8\mathrm{Be} + e^- + e^+$

Evidence for

$$^8\mathrm{Be}^* \rightarrow ^8\mathrm{Be} + X, \quad X \rightarrow e^- + e^+ \ (m_X = 17\ \mathrm{MeV})$$ **??**

Test with new nuclear experiments eg @Purdue, @Notre Dame or Isotope Shift Spectroscopy (Yb^+ transitions)

Summary

We should search for dark matter along every feasible avenue

[New experiments] exploit unique US-based facilities and/or expertise, and represent natural opportunities for US leadership in the field.

UK already contributing much - see talks after lunch

Can/should UK community look for other opportunities?
Xe experiments can probe low mass: lessons from Zeplin I, II, III?

Can/should theory &experiments community work more closely?
(particularly important if funding is squeezed?)

Thanks