

Dark Matter and Axions

direct searches

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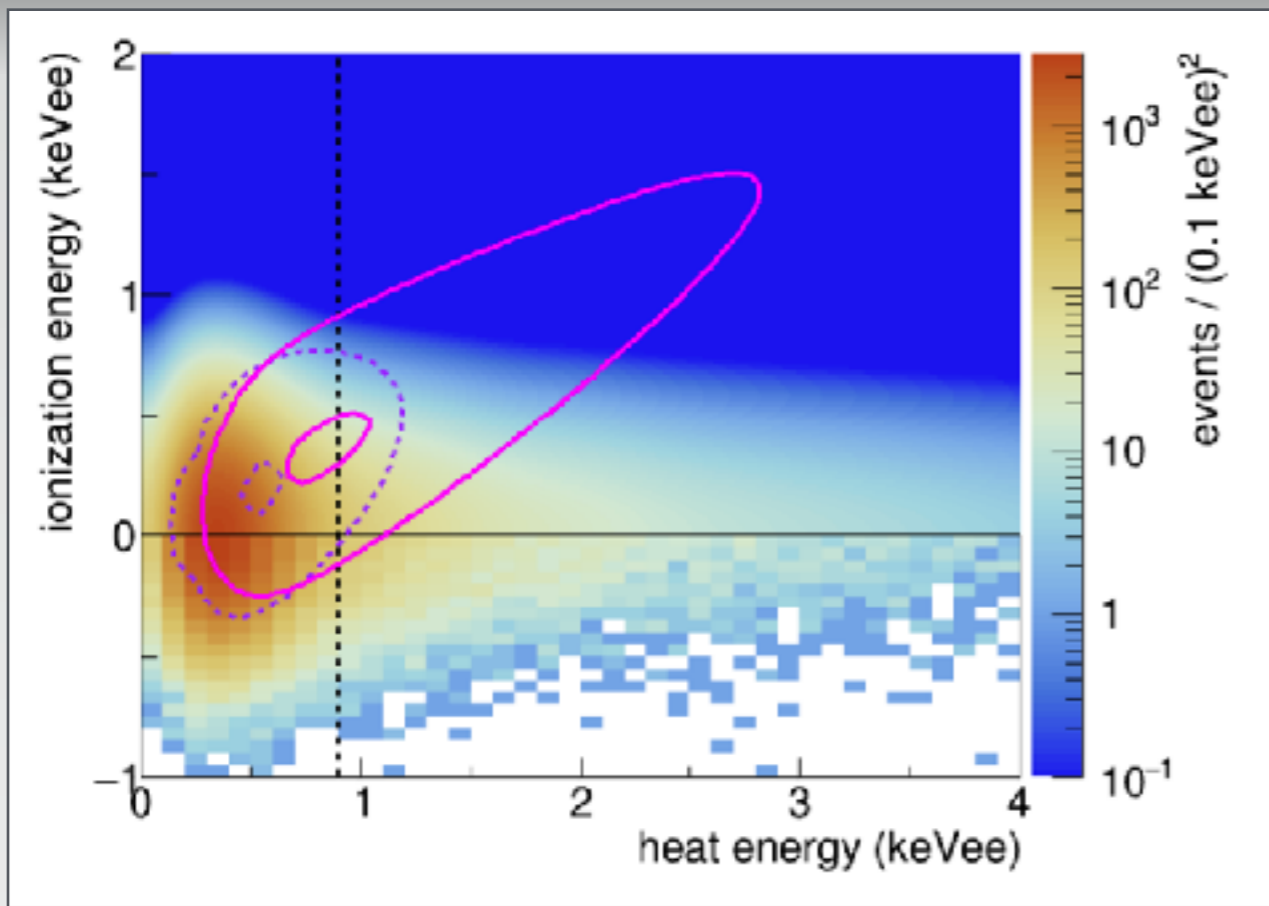
Prospectives 2017-2027 DPhP - 16 octobre 2017

Outline

- ★ Direct searches for WIMPs w/ bolometers
- ★ Direct searches for WIMPs w/ spherical TPC
- ★ Search for solar axions
- ★ Radio searches for QCD axion dark matter
- ★ Discussion and other experiments

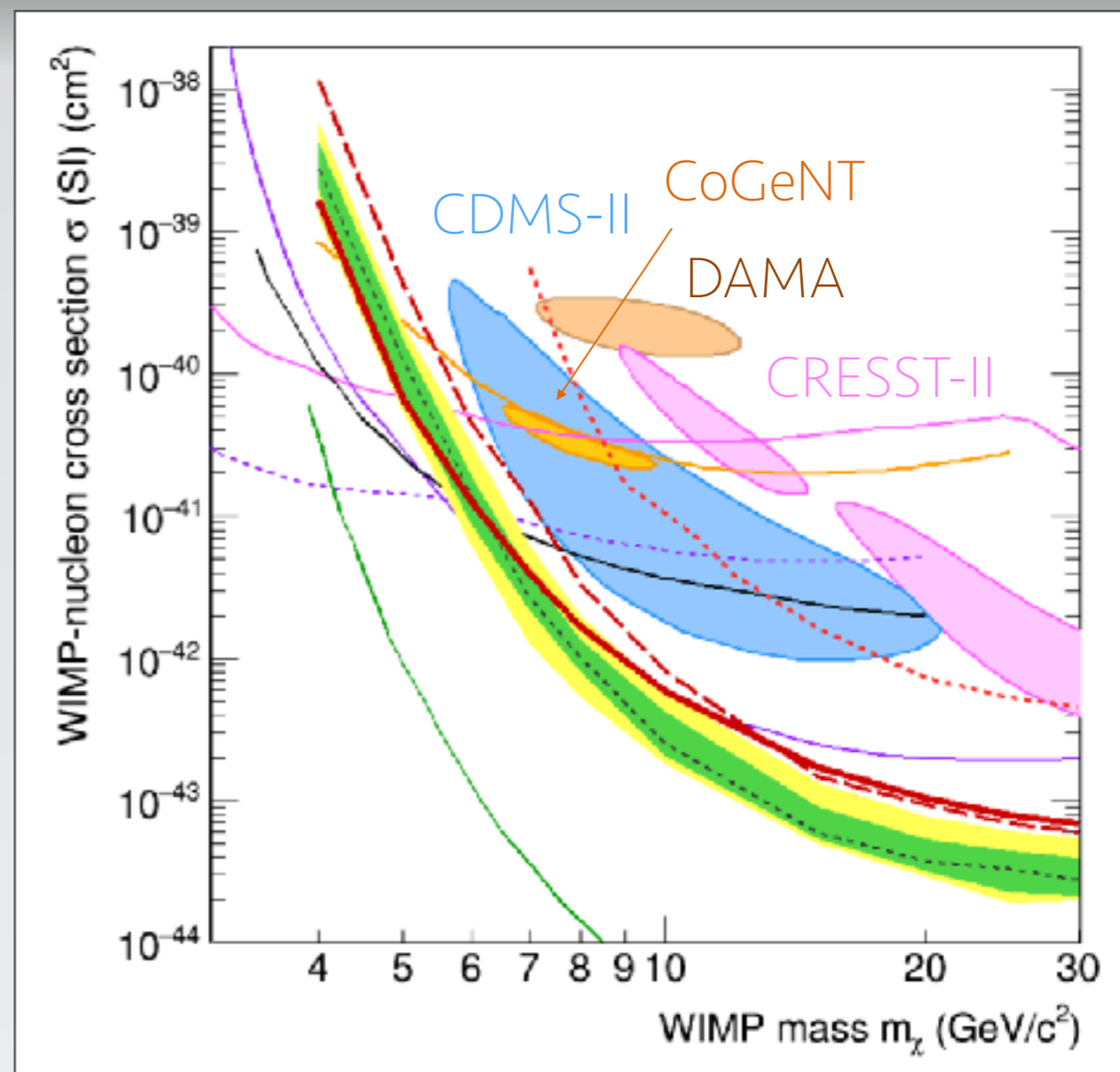
WIMPs

EDELWEISS



Focus on low-mass WIMPs
500 MeV- 5 GeV

Heat-only events limit sensitivity
Dedicated run ongoing



○ Hints

— Limits

EDELWEISS-III

CoGeNT

EDELWEISS-II

XENON100

Super-CDMS

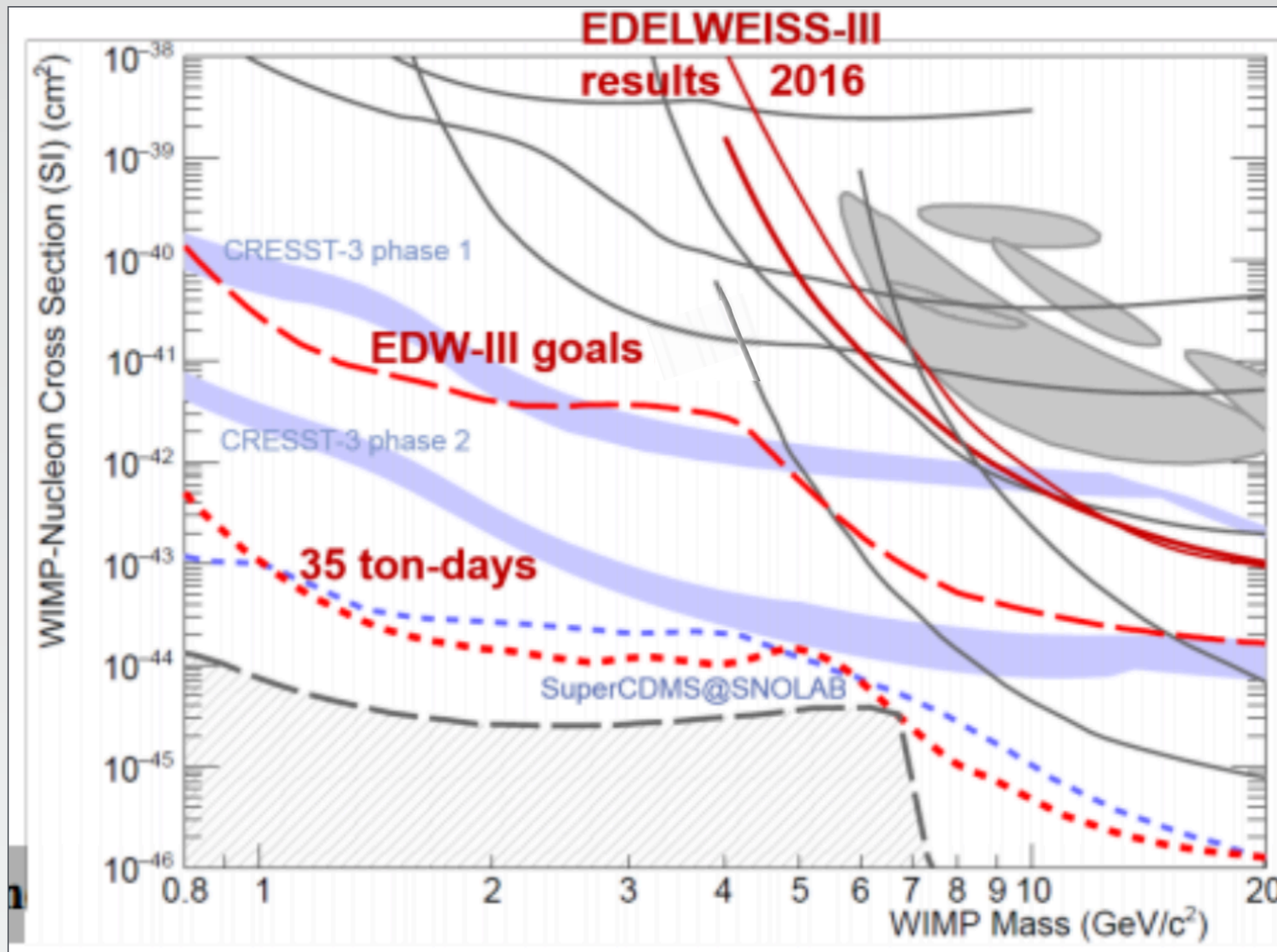
CDMSlite

LUX

EDELWEISS

- ★ Masses $>$ few GeV dominated by Xe
- ★ Future TBD by outcome of current run
 - Understand heat-only events
 - Use high voltage
- ★ If understood, competitive w/ CDMS, CRESST
- ★ Maintain presence at LSM
 - Keep R&D running, use cryostat as R&D facility
 - Seize opportunities: low recoils, axions, MeV, hidden sector..

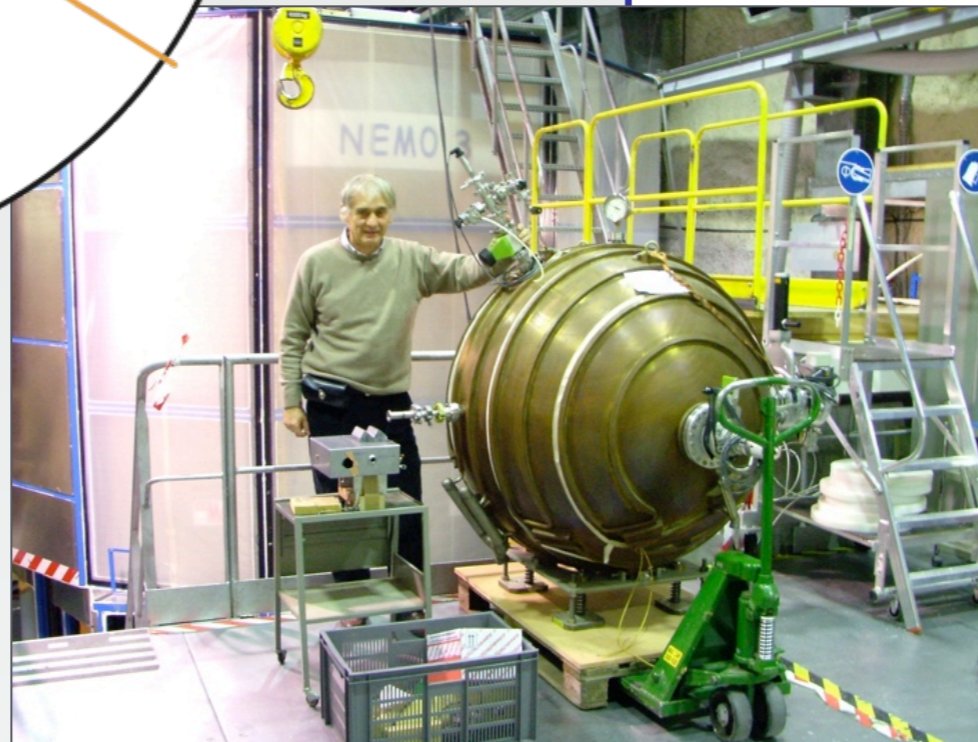
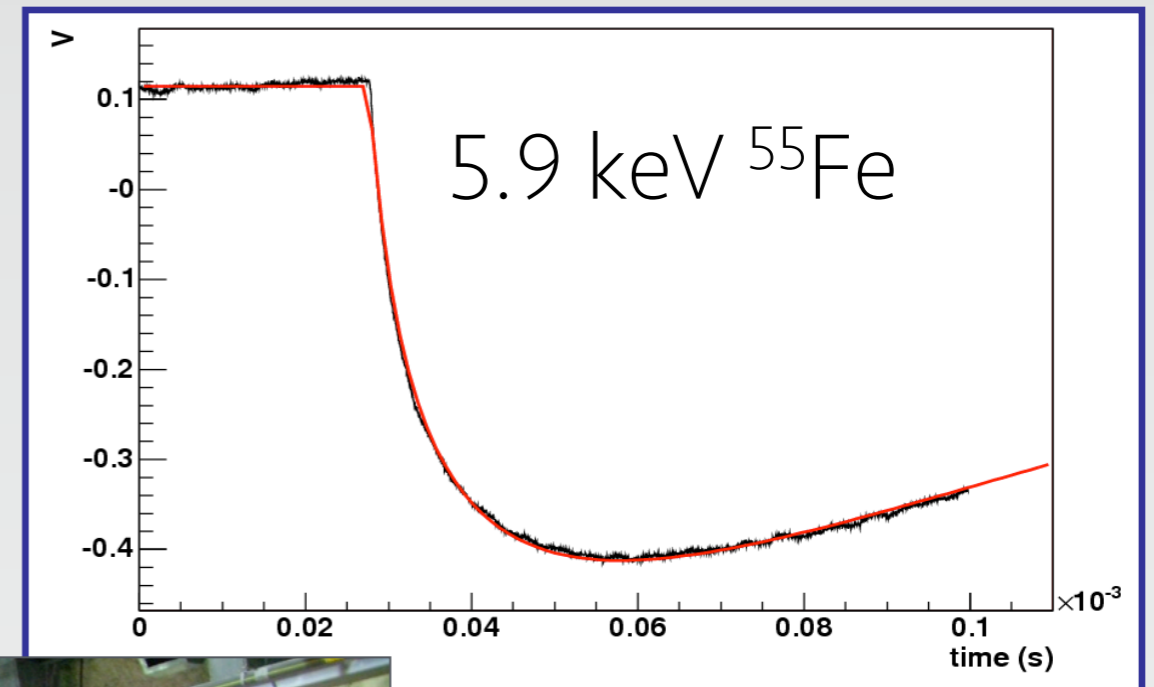
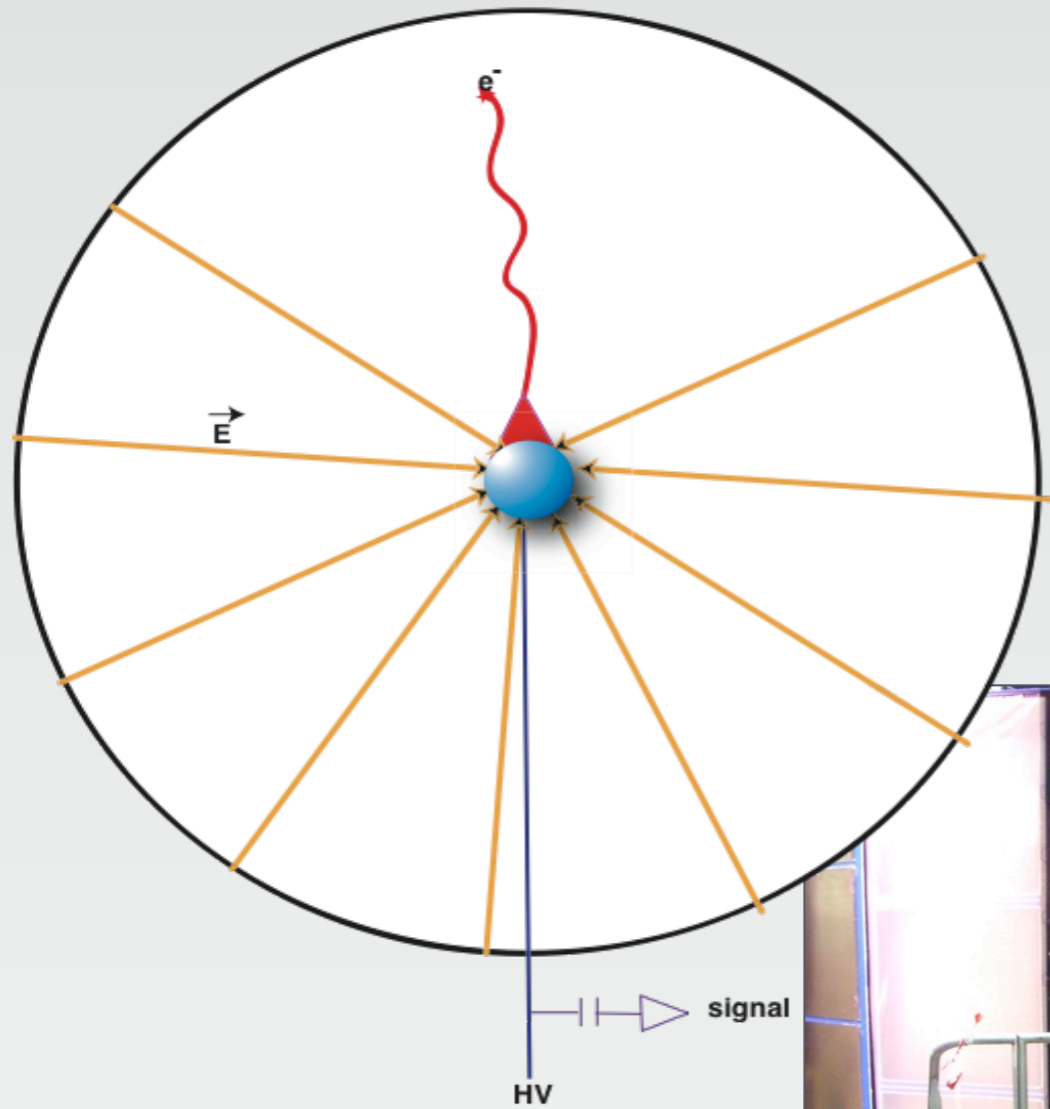
EDELWEISS : prospects



M. Lindner, EPS 2017, DM review

Spherical TPC

Principle: radial TPC w/ proportional counter

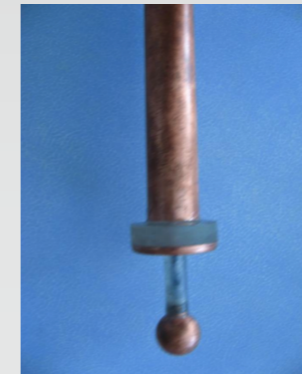


Spherical TPC

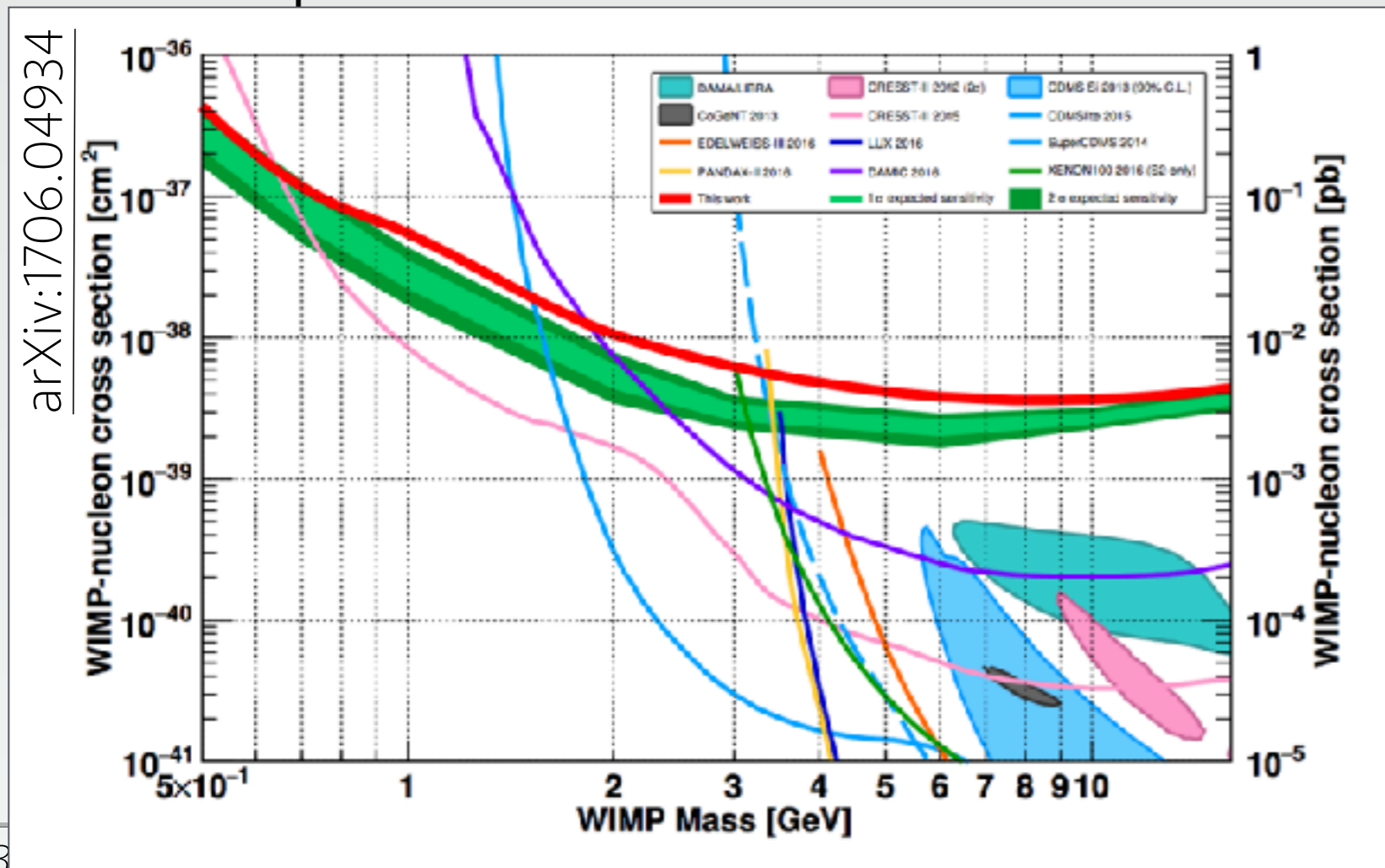
★ NEWS-G setup at LSM



60 cm



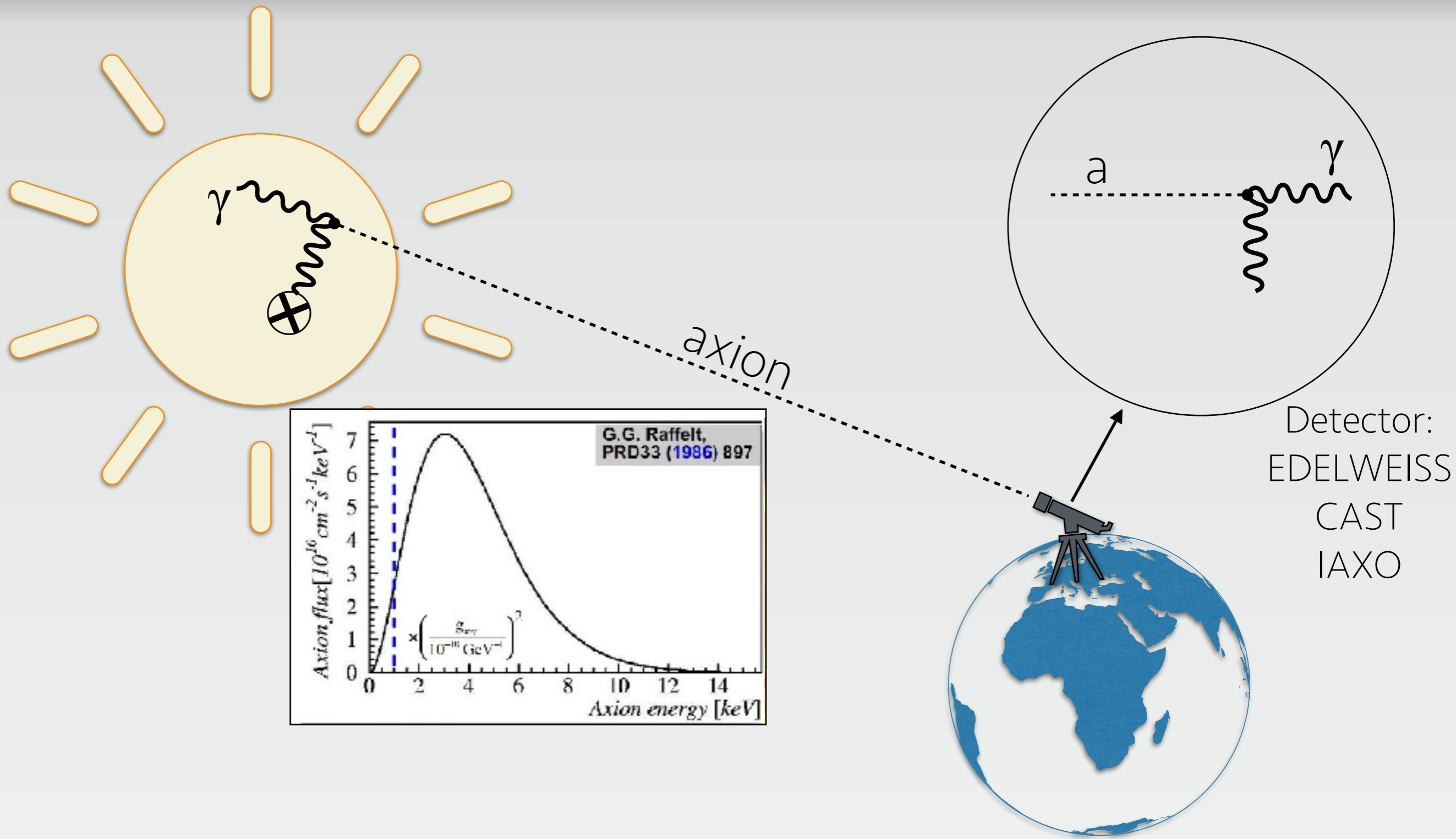
★ Competitive < 1 GeV



On going:
Quenching factor meas.
Different gas & P

Solar Axions

Production & detection

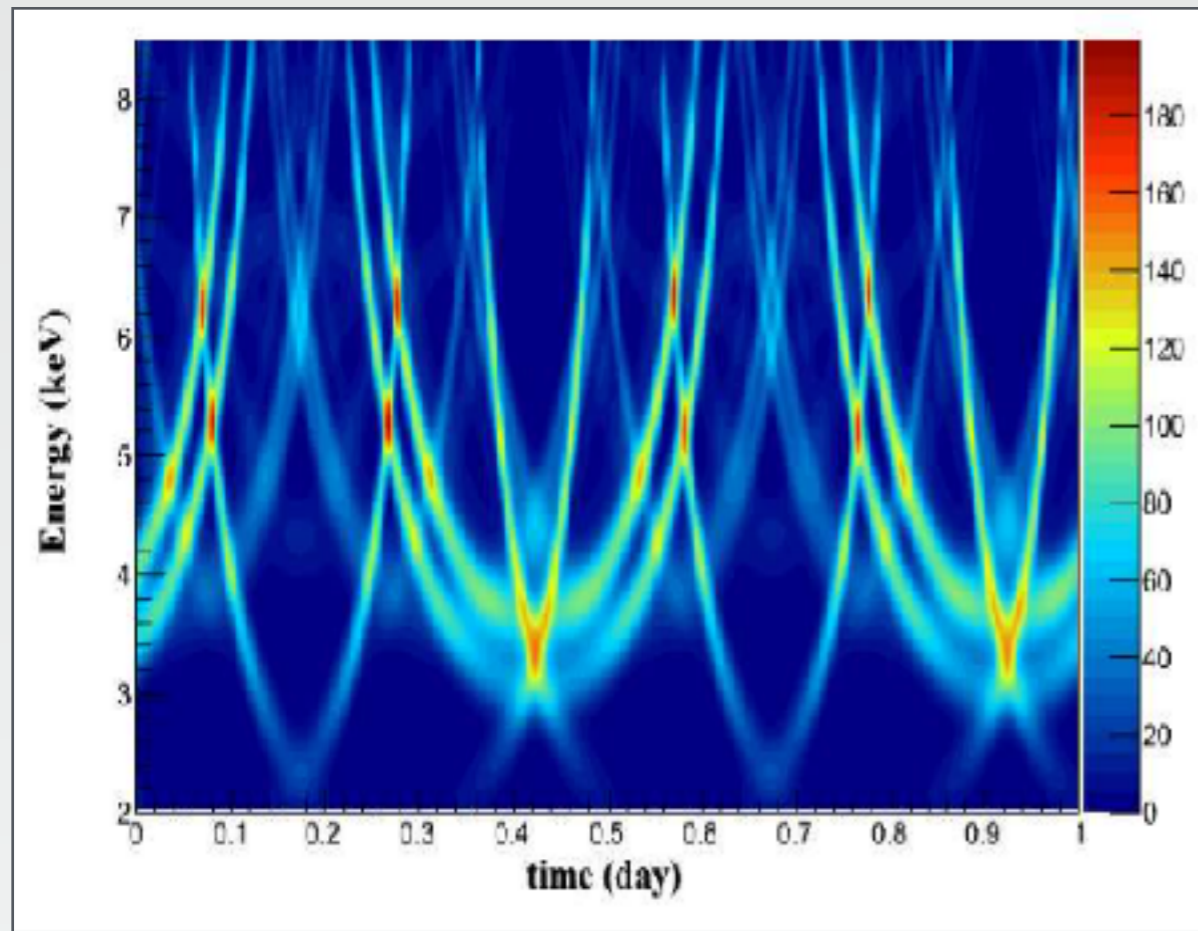


Axions in EDELWEISS

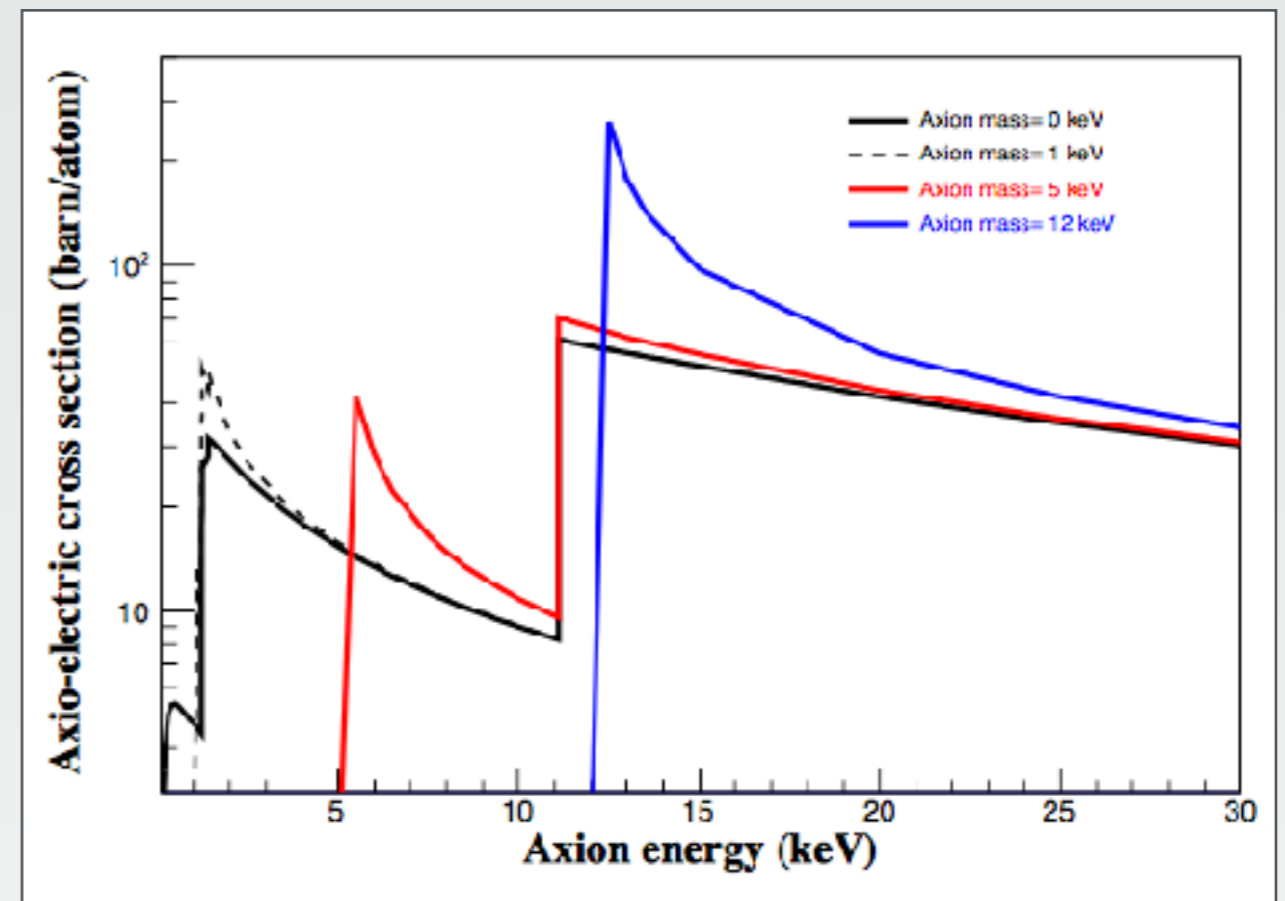
★ Bragg diffraction

- Primakoff in E-field of Ge

$$\lambda_a \sim \text{few } \text{\AA}$$

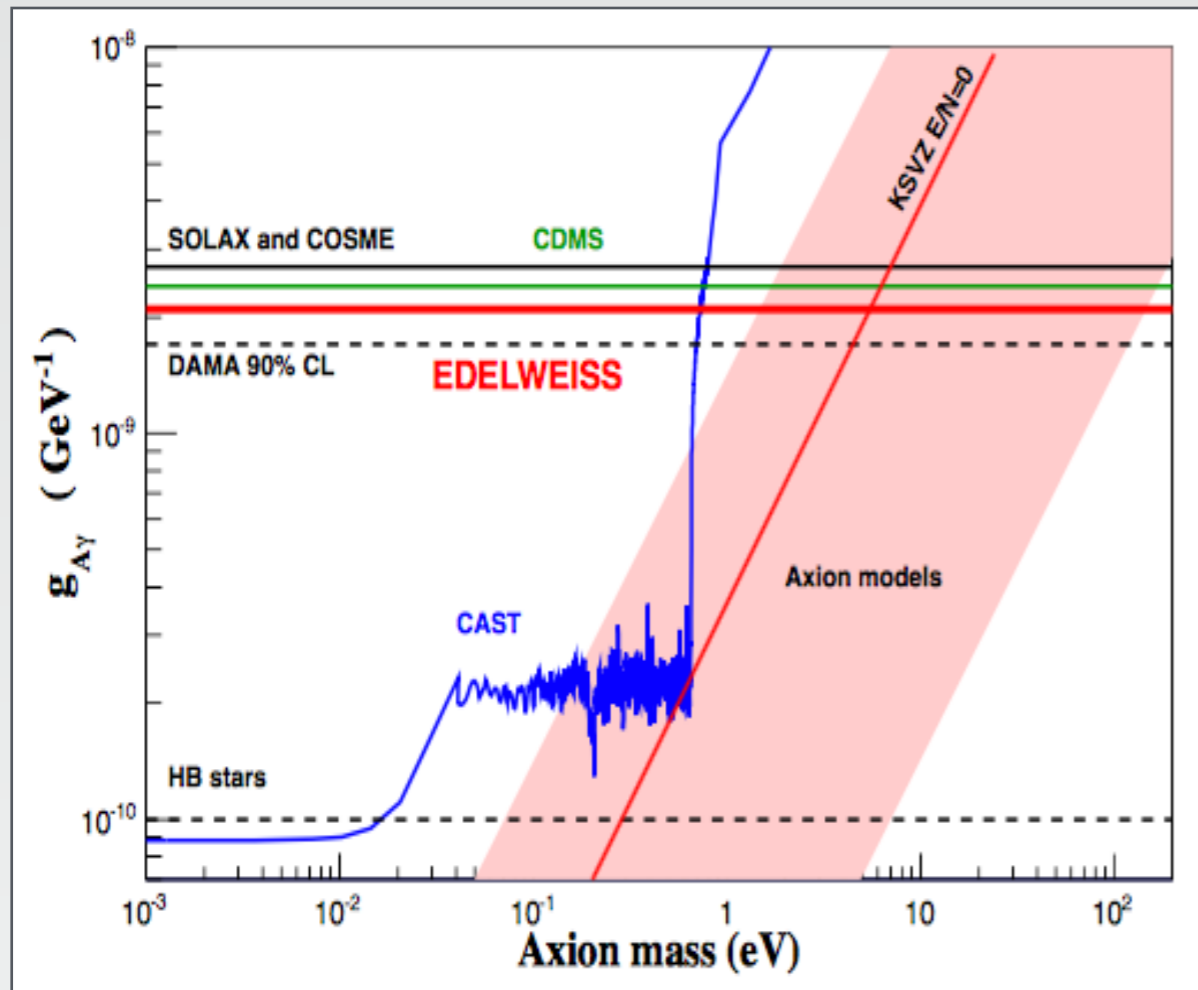


★ Axio-electric effect

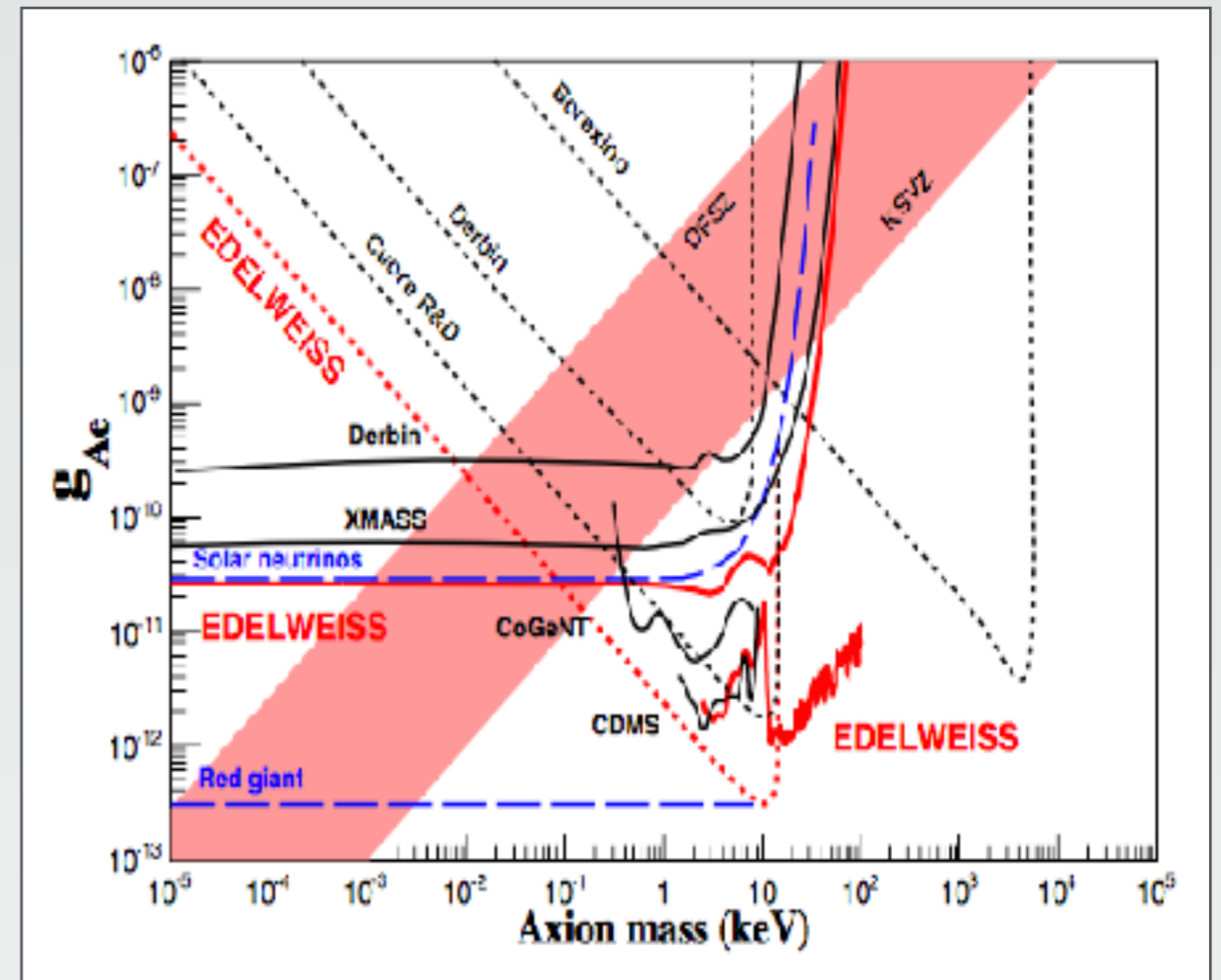


Axions in EDELWEISS

photon-axion coupling



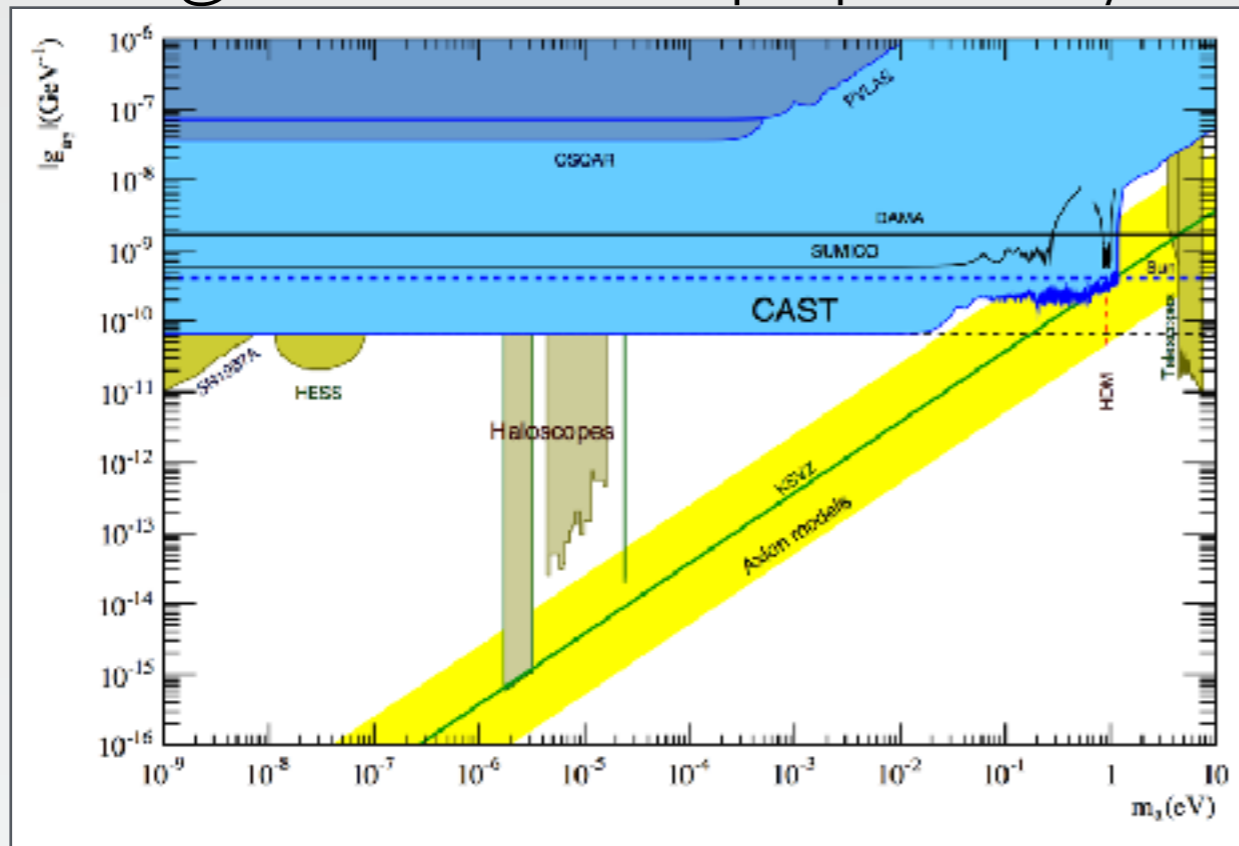
electron-axion coupling



Could be improved if EDELWEISS carries on

CAST

- ★ 2003-2015 : DEDIP
- ★ 2015 : Active
- ★ Since 2016 : Irfu out
- ★ 2017: Signed Nature paper anyway



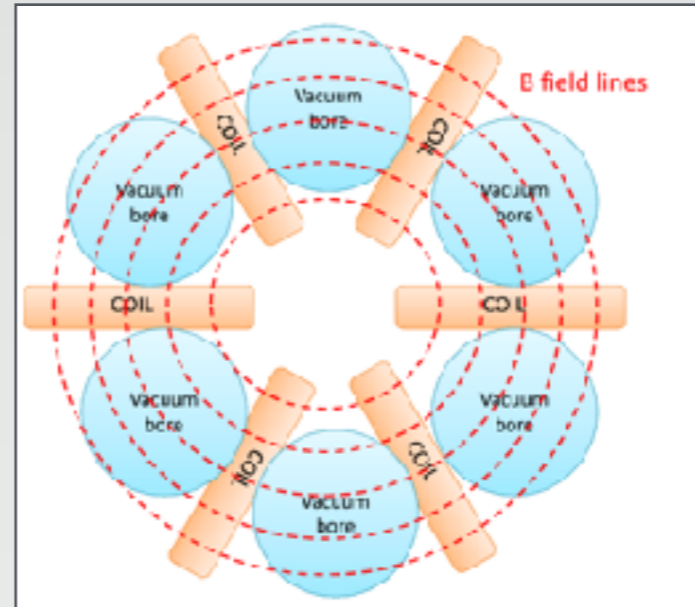
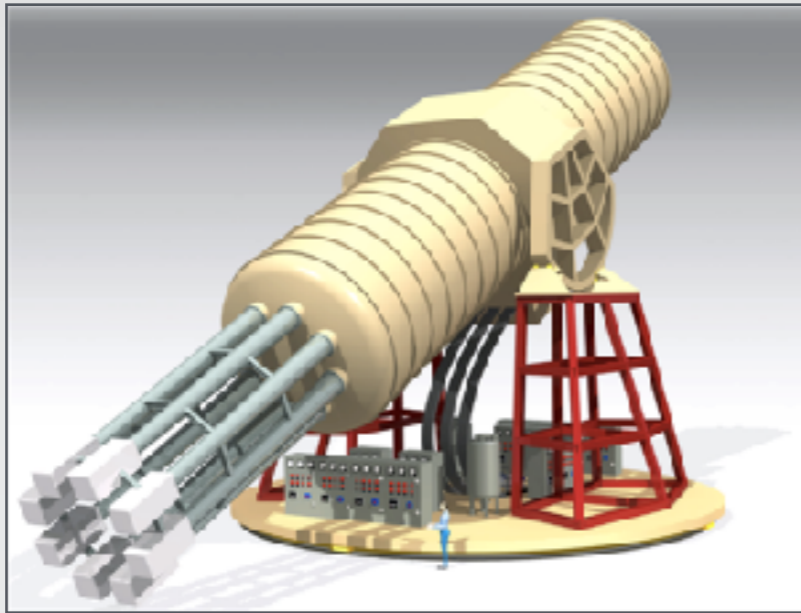
2016 analyses use
X-ray telescope
and Micromegas detectors

CAST

- ★ Only DEDIP involved
 - Continuous request for DPhP support (phys. involved)
- ★ since 2015 : no use of Micromegas
- ★ Proposal to install back the detectors
 - 3 years from 2018 on
 - Discussed at the Oct. '17 collaboration meeting
 - SPSC late October

IAXO

- ★ Same principle as CAST w/ dedicated magnet



- ★ Magnet too expensive: start small (baby IAXO)

- ★ Important to keep contact for DACM

- ★ From Irfu & IPhT:

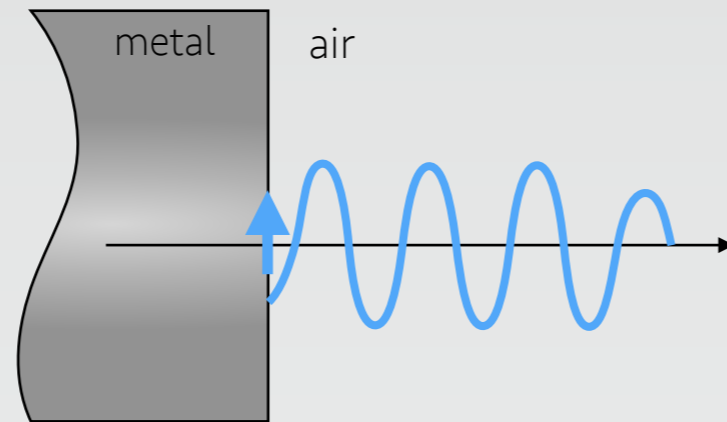
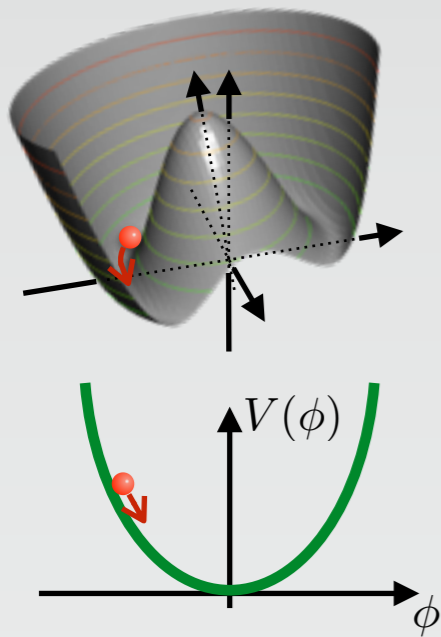
E. Armengaud, P. Brun, E. Ferrer-Ribas, C. Nones, P. Brax

Dark Matter

Axions

Search principles

- ★ Local oscillations of axion field = dark matter



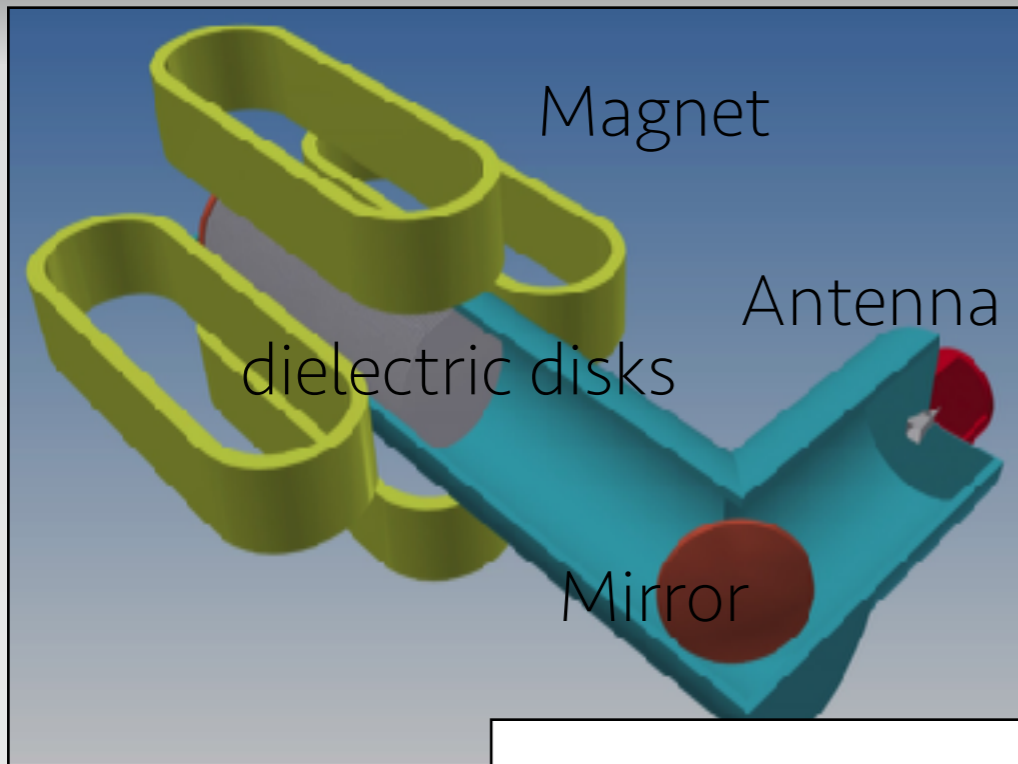
Conductor-air interface
in B field emit EM waves

$$f = 2.4 \text{ GHz} \times \frac{m}{10 \mu\text{eV}}$$

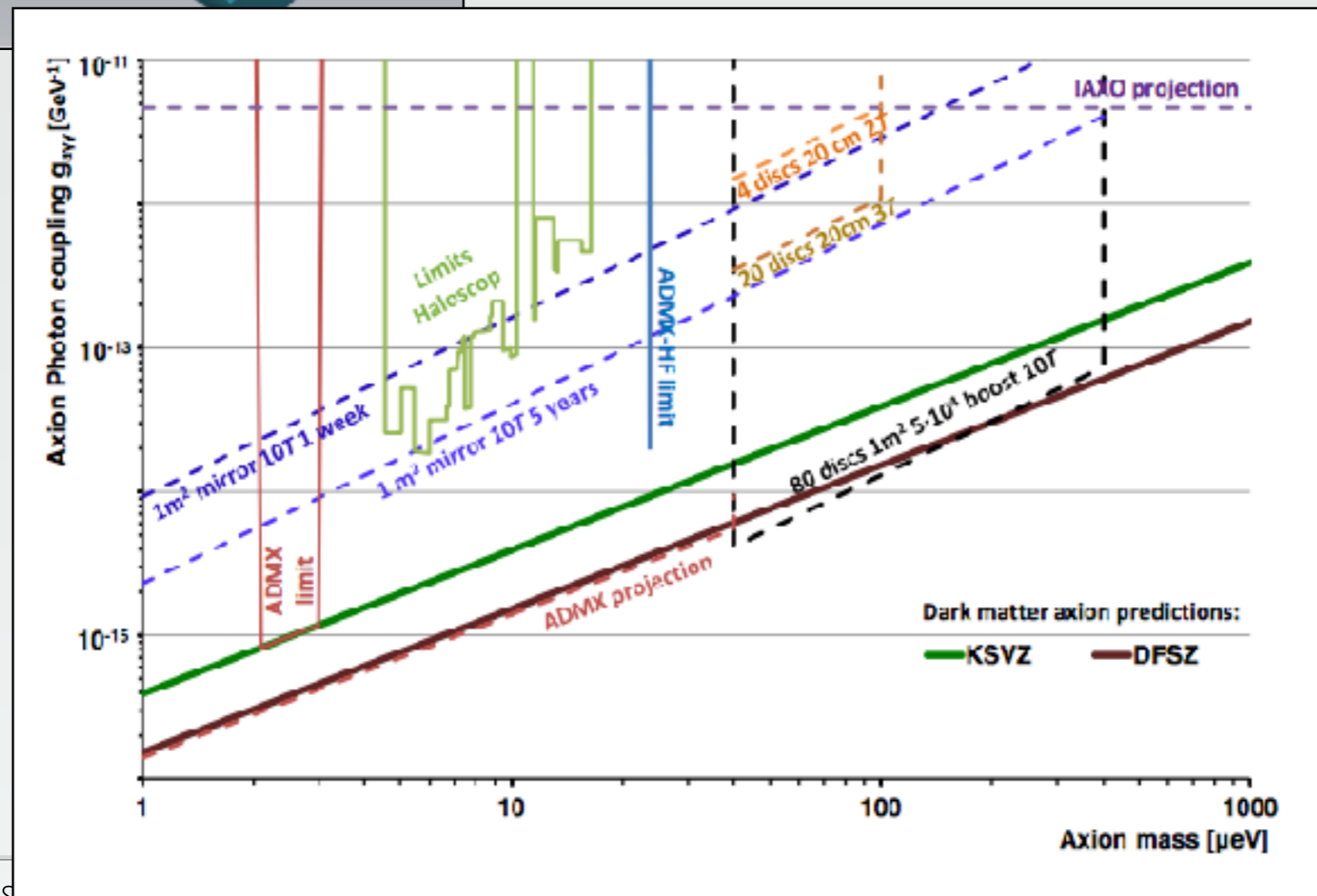
- ★ Two ways to seek this signal

- Enhance w/ multiple conversions : MadMax
 - + Stronger signal
 - Challenging mechanics, narrow band
- Use modular, scalable emitters : Saclay attempt
 - + Broadband
 - Limited sensitivity

MadMax



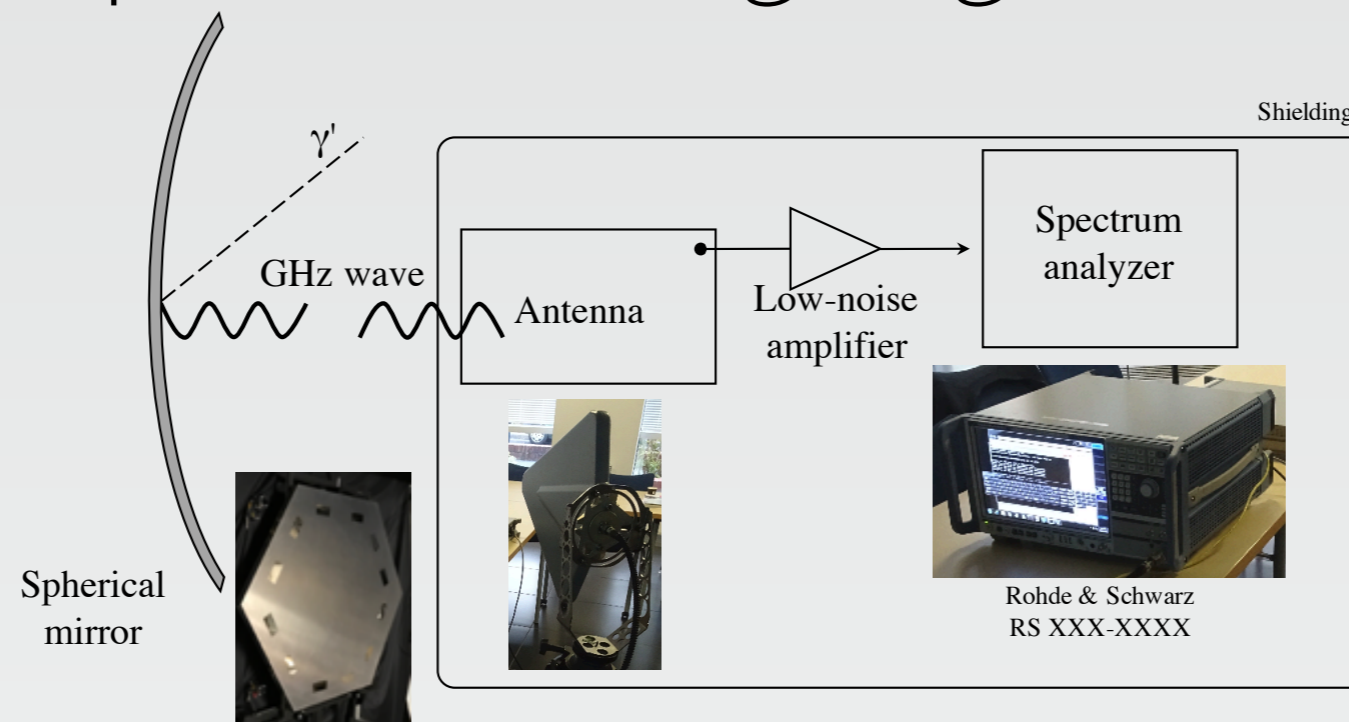
- ★ DPhP signed white paper
 - Interesting physics
 - Things to learn instrumentation-wise
 - Strengthen DACM proposal for magnet
- ★ Participation in first phase



Our attempt at Irfu

- ★ Use CTA-like mirrors

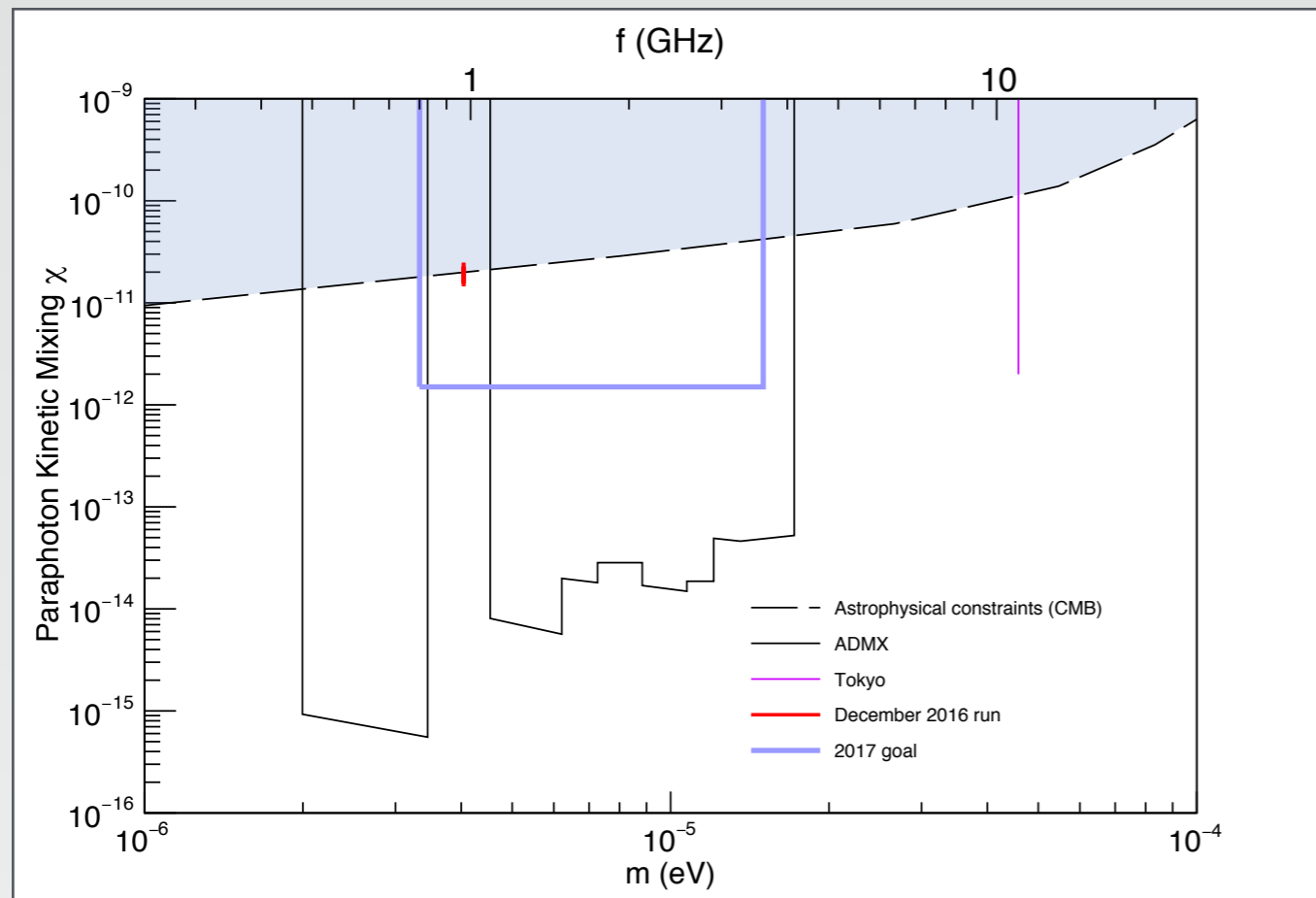
- ★ Pathfinder experiment on-going : SHUKET



- ★ All detection instrumentation borrowed from firms

SHUKET sensitivity & future

- ★ Current constraints: tiny spot



No magnetic field :
constraints on paraphotons

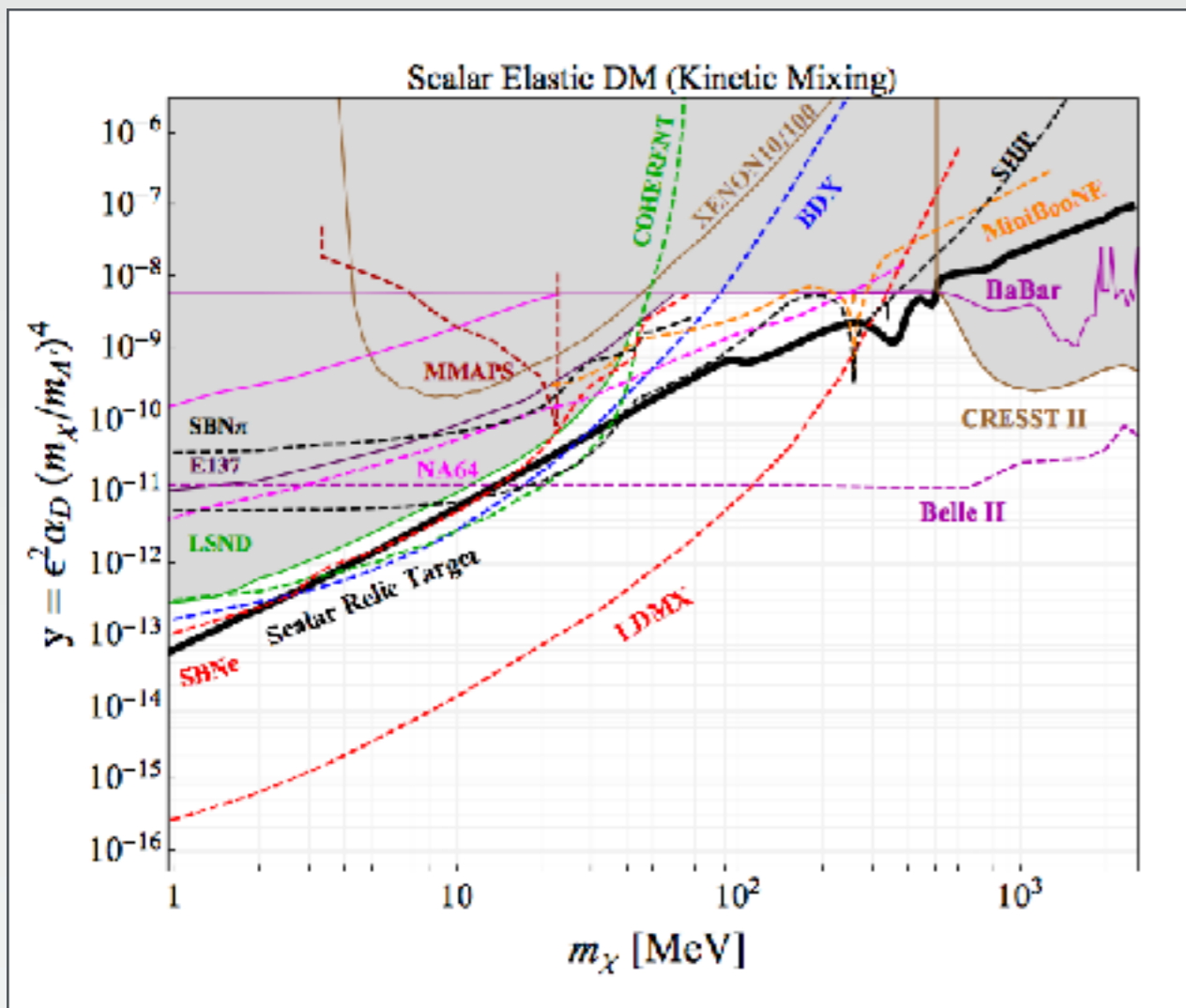
- ★ New run in November

- ★ Add magnetic field and go bigger : need funding

Hidden Sector

SHiP at CERN

- ★ Fixed-target experiment a CERN SPS
- ★ Search for long-lived exotic particles < 10 GeV
- ★ Could benefit from Micromegas detectors



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

- ❖ Irfu is not an official member of the SHiP project and did not sign the SHiP TP (2014)
→ contributions from Irfu SPP/SEDI people have been acknowledged in the TP
- ❖ Some R&D activity can be envisaged for optimization of MM for the SHiP tracker
→ no major financial investment is possible before the SHiP TDR (~ 2021)
- ❖ Opportunities to contribute on projects of common interest (jointly with LN2P3)
has to be investigated and would be highly desirable

M. Titov, Journée SHiP, Oct 2017

Summary

★ WIMPs

- EDELWEISS
- Spherical TPC

★ Solar axions

- EDELWEISS
- CAST
- IAXO

★ Dark matter axions

- MadMax
- Saclay/SHUKET

★ Hidden sector dark matter

- SHiP