PBC technology WG

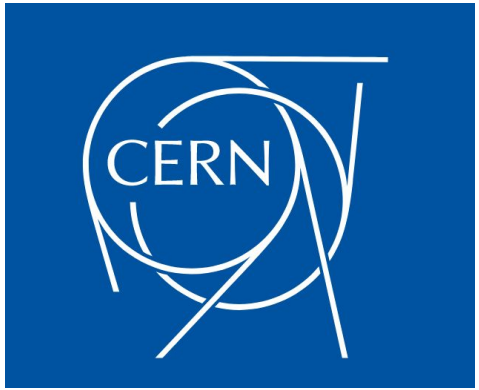
Babette Döbrich and Andrzej Siemko for the Working Group

March 2021

Initiatives/Experiments
(possibly outside CERN)
with technological challenge/expertise

(old?) PBC
Technology WG

Facilitate connection,
Discussion forum
identify mutual benefit



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List of technologies (past mandate/ new mandate):

- High field magnets
- Cryo
- RadioFrequency (RF)
- optics/photon detection
- Vacuum (large-scale/UHV)
- new : high-T superconductors (HTS)

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PHYSICS :-)

- New particles (Dark Matter etc)
- Low-energy fundamental physics (vacuum magnetic birefringence)

From past WG report (2018: https://cds.cern.ch/record/2652165)

Technology concerned	benefit from CERN	benefit to CERN	how facilitate?	Exps concerned
Magnet, concretely: high-field, large-bore	availability of strong fields, CERN expertise to build custom magnets	make optimal physics use of magnet resources (spares)	advertise magnet usage times, provide expertise in magnet design, PBC-fellow for IAXO	IAXO, JURA, STAX, VMB@CERN
Optics/Optics sensing, concretely: Fabry Perot, membranes	surface coating, possibility to combine magnet with optics	add local expertise on cavity optics technologies	"optics hub", as described in the document	aKWISP, VMB@CERN, JURA
Radiofrequency cavities, concretely: design for axion searches	experience in design and production	new cavity designs for various physics purposes, tuning and characterization in cryogenic environment	mandate for cavity experts to aid in design	Grenoble initiative, & other Haloscope initiatives operating already at CERN, STAX
Cryogenics, concretely: large-scale: helium, argon, krypton from 120K to mK	availability of cryogenic facilities	participate in research beyond collider	mandate through TE-CRG	DarkSide, aKWISP, VMB@CERN, IAXO
Vacuum, concretely: large-scale leak testing	experience & availability	participate in research beyond collider	mandate through TE-VSC	DarkSide, JURA, aKWISP, CNT

From past WG report:

Two highlights of the past mandate:

- **VMB@CERN** proposed and presented to SPSC
- **babyIAXO** magnet design finalized

↕

Described in dedicated talks!
-> will flash through news of all initiatives now

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Relevant techno: VACUUM/
Photon detection, cryo

DarkSide (input from Livio Mapelli)

-> purify UAr from Ar39, leaving only Ar40 by exploiting slightly different volatility

-> 350m Aria high column

-> excellent results on prototype column (26m)

-> first Aria paper. Leak checks carried out at CERN

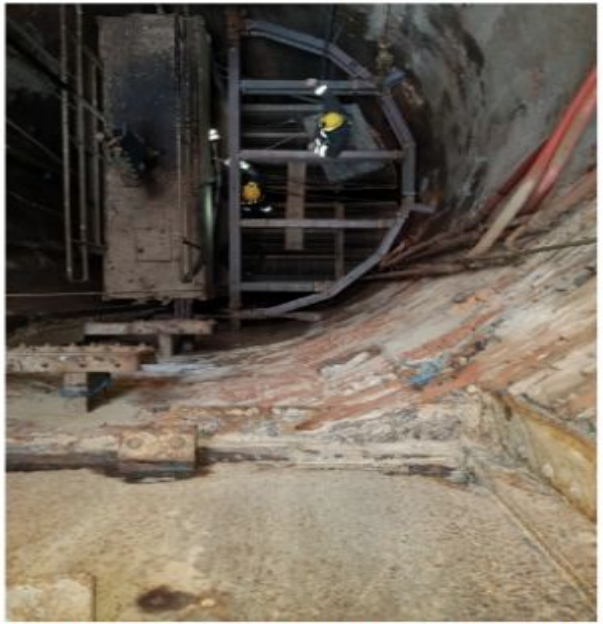


Fig. 7 Installation of the first support structure in the shaft of the Carbosulcis mine, Seruci site.

Physics > Instrumentation and Detectors

[Submitted on 21 Jan 2021 (v1), last revised 23 Jan 2021 (this version, v2)]

Separating ^{39}Ar from ^{40}Ar by cryogenic distillation with Aria for dark matter searches

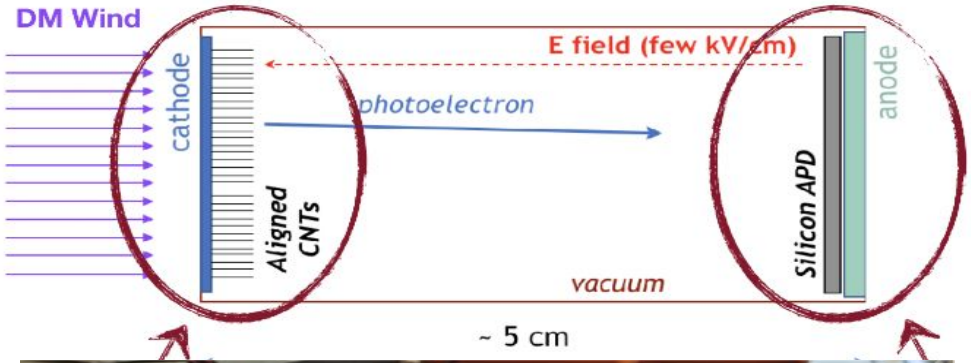
Acknowledgements

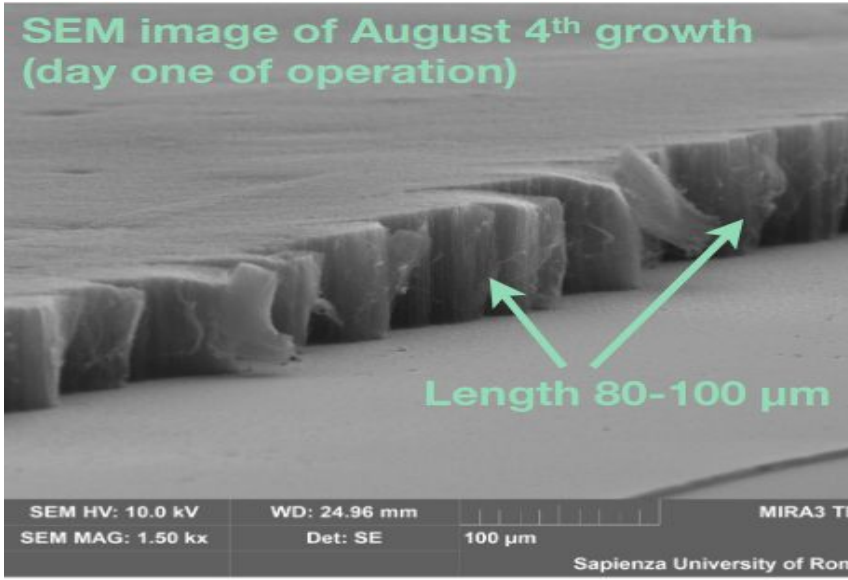
The second phase of the leak checks, carried out at CERN, was performed under service agreement KN3155/TE. We

CNTs for DarkPMTs (input by G. Cavoto)

Relevant techno: (hv in) **vacuum,** secondary e^- emission in **vacuum**

Prototype INFN Roma, coupled to UV source





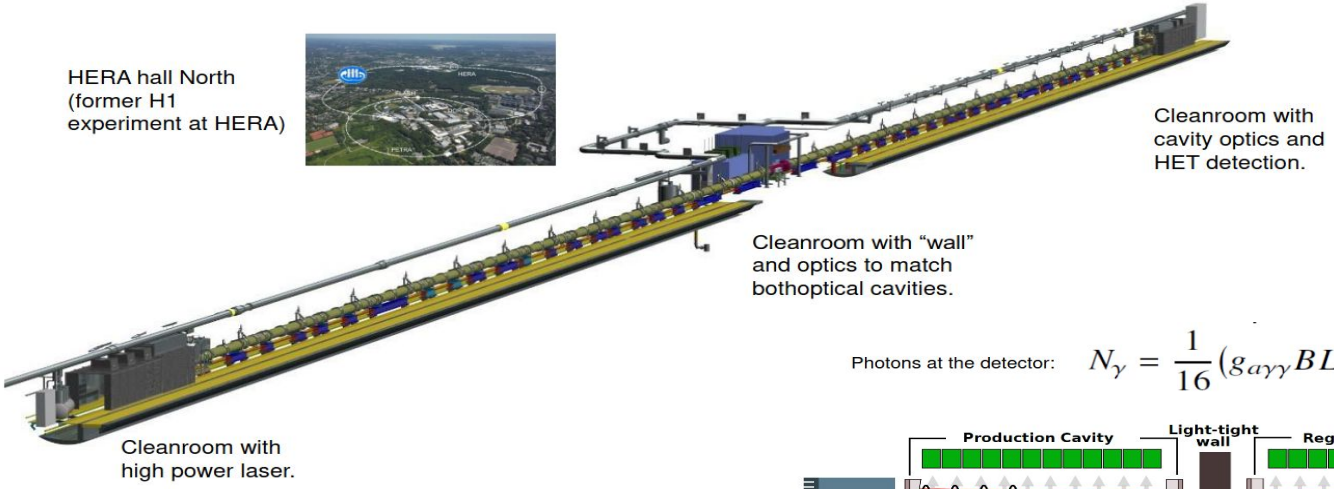
ATTRACT

NanoUV, P.I.: Francesco Pandolf

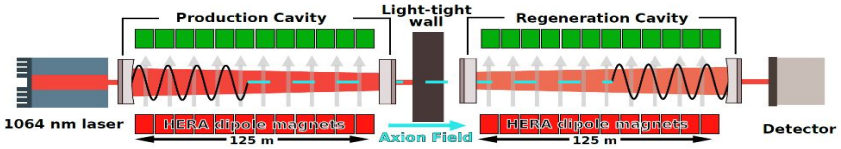
Relevant techno:
MAGNET/optics

JURA (input by Jörn Schaffran)

- JURA could be the ``ultimate'' optical LSW experiment on a long time-scale, combining forces of ALPS-II and OSQAR using current/future accelerator magnets



Photons at the detector: $N_\gamma = \frac{1}{16}(g_{a\gamma\gamma}BL)^4 \eta \beta_R P_c \tau, \quad (m^2 << 2\omega/L)$



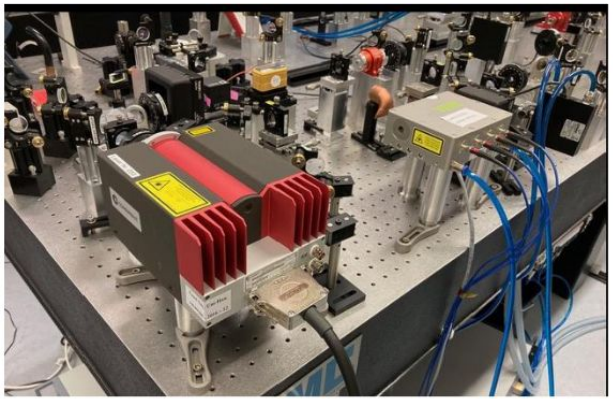
$g = 2.0 \times 10^{-11}$ GeV^{-1}
$B = 5.3$ T
$L = 106$ m
$P_c = 150$ kW
$\beta = 16{,}000$

$N_\gamma = 1$ photon per day!

Relevant techno:
MAGNET/optics

JURA (input by Jörn Schaffran)

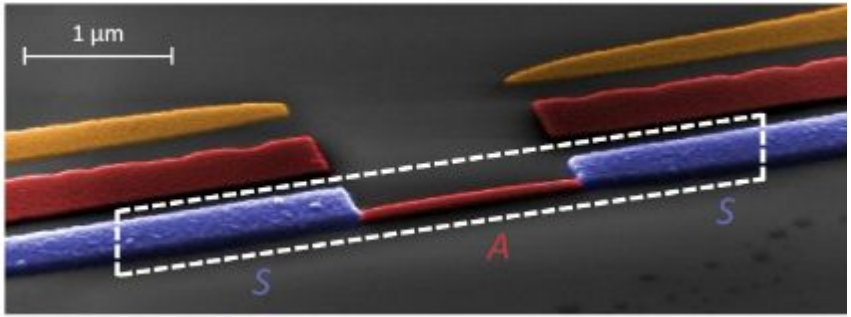
- JURA could be the ultimate optical LSW experiment on a long time-scale, combining forces of ALPS-II and OSQAR
- ALPS-II: first light expected in 2021, cryogenic magnet operation planned for fall 2021



STAX (input py P. Spagnolo)

Relevant techno:
MAGNET/optics, photon detection/MW

-> idea to exploit higher photon flux from Gyrotrons (10s of GHz). To detect:

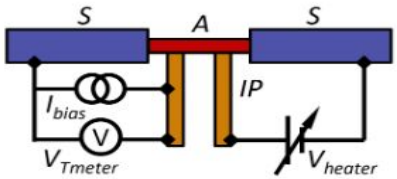


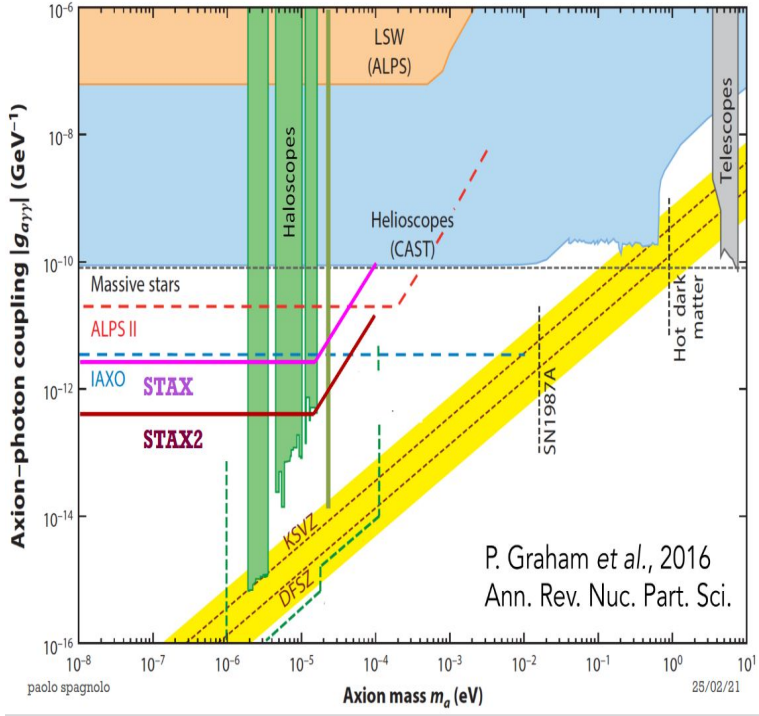
TES Nanowire

F. Paolucci et al arXiv:2007.08320

A (Red) TiAu
B (Blue) Al electrode
IP (Yellow) Al-O tunnel probe

T_c suppression by vertical inverse proximity effect
Superconductivity Of Metals And Alloys, Advanced Books Classics (Westview Press, 1999)



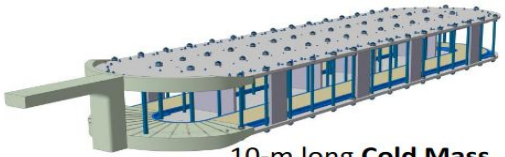


Relevant techno: magnet, cryo

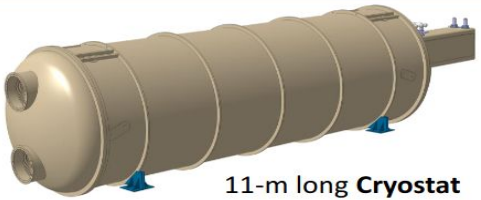
babyIAXO (input by H. ten Kate)

Tendering design complete - next step: manufacturing, assembly & installation design

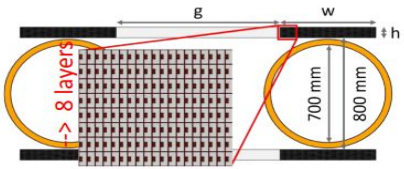
55 km **Conductor**



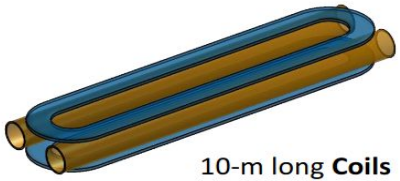
10-m long **Cold Mass**



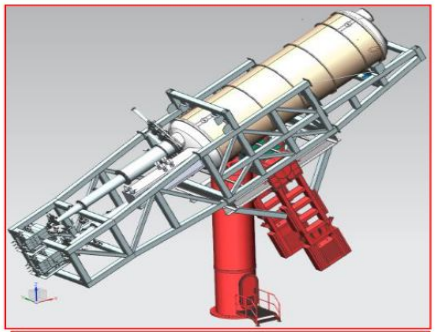
11-m long **Cryostat**



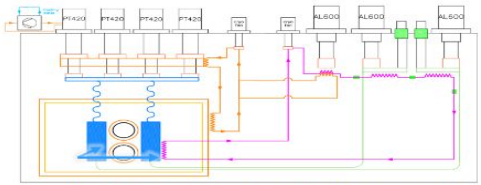
---> 130 turns



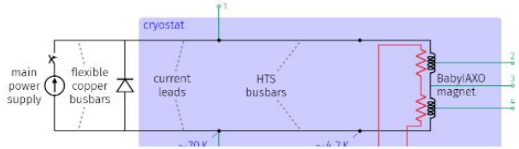
10-m long **Coils**



BabyIAXO on drive system installed at DESY



Conduction cooled with 7 **Cryocoolers**



Direct-drive **Electrical circuit**

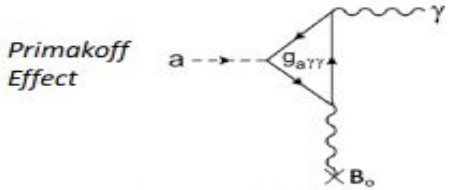
GrAHal (input by P. Pugnat)

Relevant techno: RF, magnet, vacuum

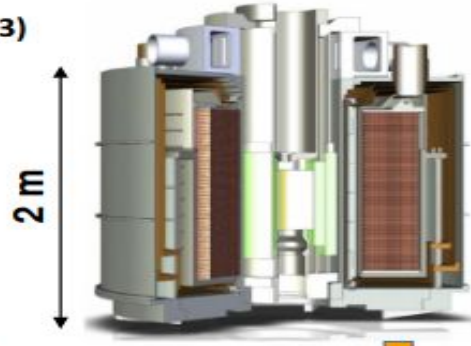
-> hybrid magnet in Grenoble:

43T/34mm, steps to 9T/800mm

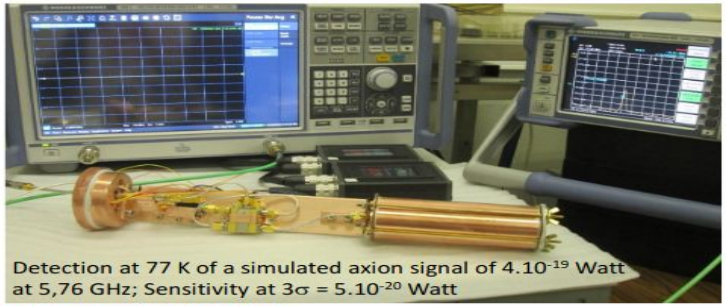
Axion & ALPs Haloscope (Sikivie 1983)



$P \alpha g_{a\gamma\gamma}^2 B_o^2 V < 10^{-21} W$



RF Cavity developments at NÉEL institut



⇒ **RF cavities (0.3-30 GHz) at 20 mK & quantum amplifiers SQUID & JPA (IN) in strong magnetic field (LNCMI)**

Large & small scale dilution fridges

First data taking in 2021 at 2 K & 16 T in 55 mm dia. sc coil

Ref. (p.77) : http://lncmi.cnrs.fr/wp-content/uploads/2021/02/LNCMI_AR2020vwBD.pdf

RADES-HTS (Input by J.Golm)

Relevant techno: RF, magnet, vacuum

-> synergy with groups studying e.g.

FCC beamscreen

-> measurements slot via ARIES in May 2021

$$\mathcal{F} \sim g_{A\gamma}^4 \, \boldsymbol{Q} \, T_{sys}^{-2} V^2 G^4 m_A^2 \, \boldsymbol{B^4}$$

Increase Q
copper coating → superconducting coating

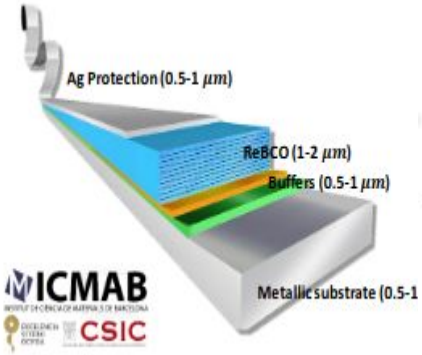
Requirement:
High quality factor in a high magnetic field

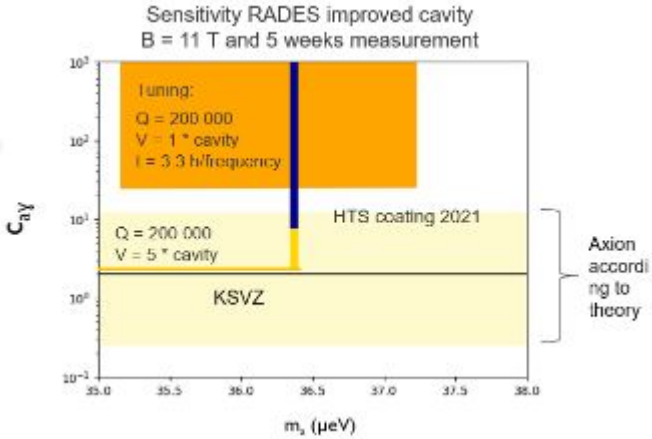
Coating material/ methods:

Nb_3Sn coating

ReBCO coating
→ first buffer layer successful applied

ReBCO tape → scalable
ICMAB technology to strip of Cu and Ag layers
REBCO layer is exposed to the RF fields



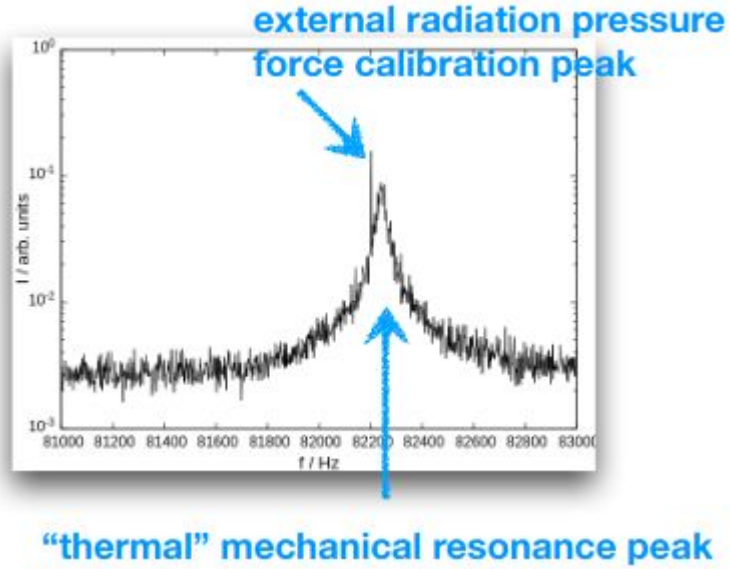


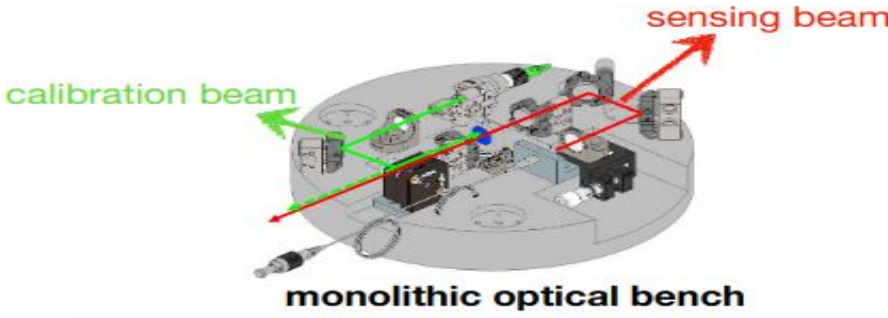
Relevant techno: optics/cryo

aKWISP (input by G. Cantatore)

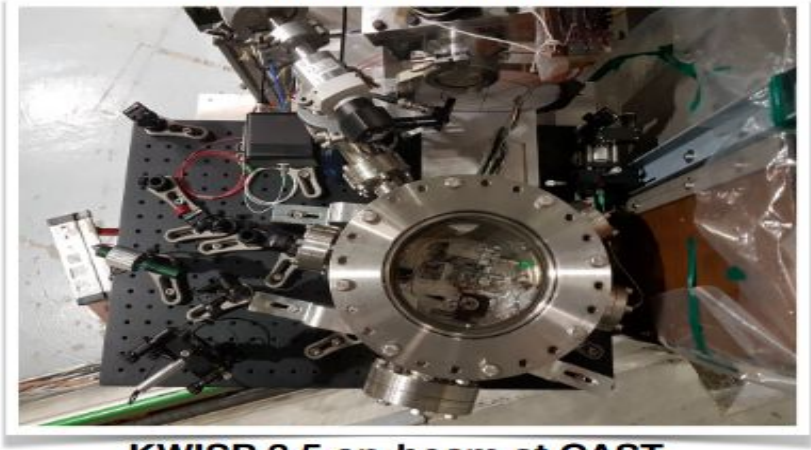
Detection of membrane displacements

by novel particles, wish to upgrade to 4K





monolithic optical bench

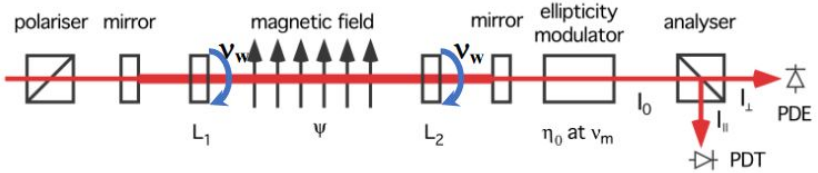


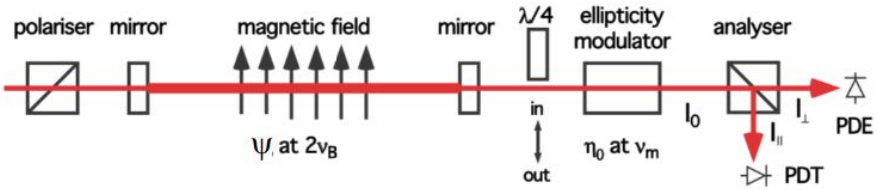
KWISP 3.5 on-beam at CAST

Relevant techno: magnet

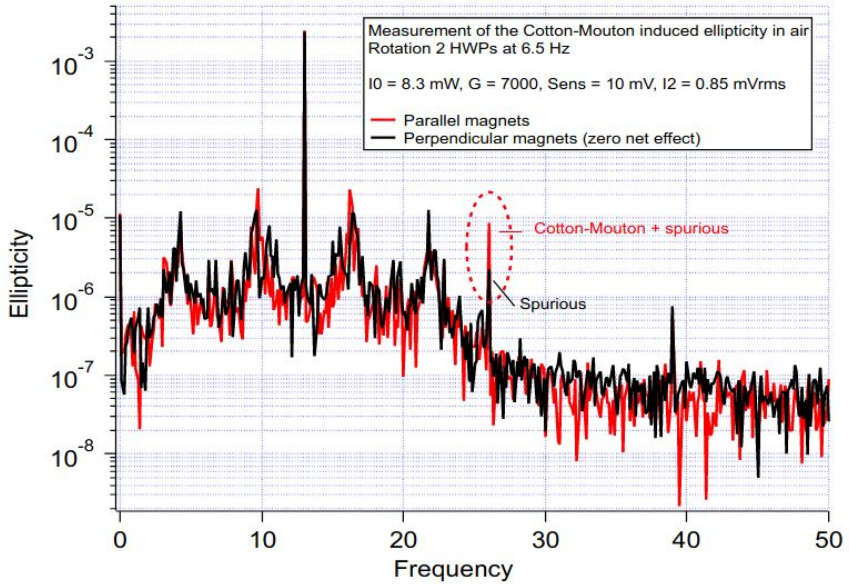
VMB@CERN (input by G. Zavattini)

-> measure vacuum magnetic birefringence using
A macroscopic external magnetic field





The PVLAS experiment was limited by the intrinsic noise coming from the Fabry-Perot mirrors.



That was … a lot! What to take away?

Nota bene: Our exact mandate for the `new PBC' to be sharpened: All the following statements potentially subject to update (e.g. experiments followed up in SPSC vs PBC, interplay with CERN quantum initiative? etc...)

-> In principle this was/is an open working group, contact the PBC coordinators if you think you fit (we wish to cross-fertilize communities)

-> work to establish contacts to CERN technological expertise for initiatives where appropriate

-> work to connect experiments with common/complementary expertise

-> enjoy discussing some physics

-> ~ monthly to bi-monthly meetings https://indico.cern.ch/category/8816/ (need to request mailing-list membership)