Future Experiments

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Overview

- Review of the activities this year
- Hot topics for new intensity frontier experiments
- Topics for discussion

Activities of the GDRI

Two main activities relevant for future experiments (i.e. WG5) this year:

- Workshop on “The future of the Intensity Frontier” at CERN, 1-2 February.
- Lectures and Workshop on “The strong CP problem and axions” in Grenoble, 14-16 May. This was actually organised by convenors of WG1 and WG2.

We would like to organise another workshop soon: the experimental situation is evolving rapidly!

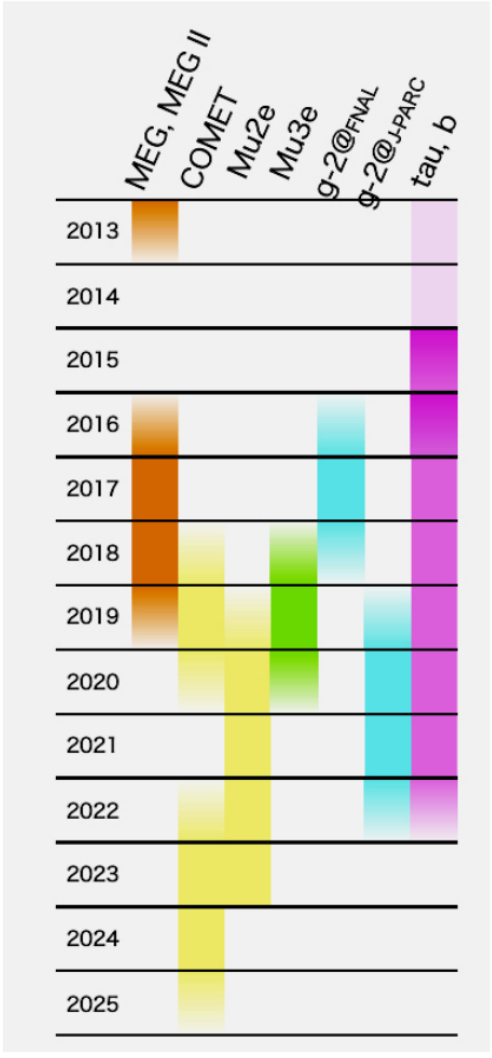
CERN workshop

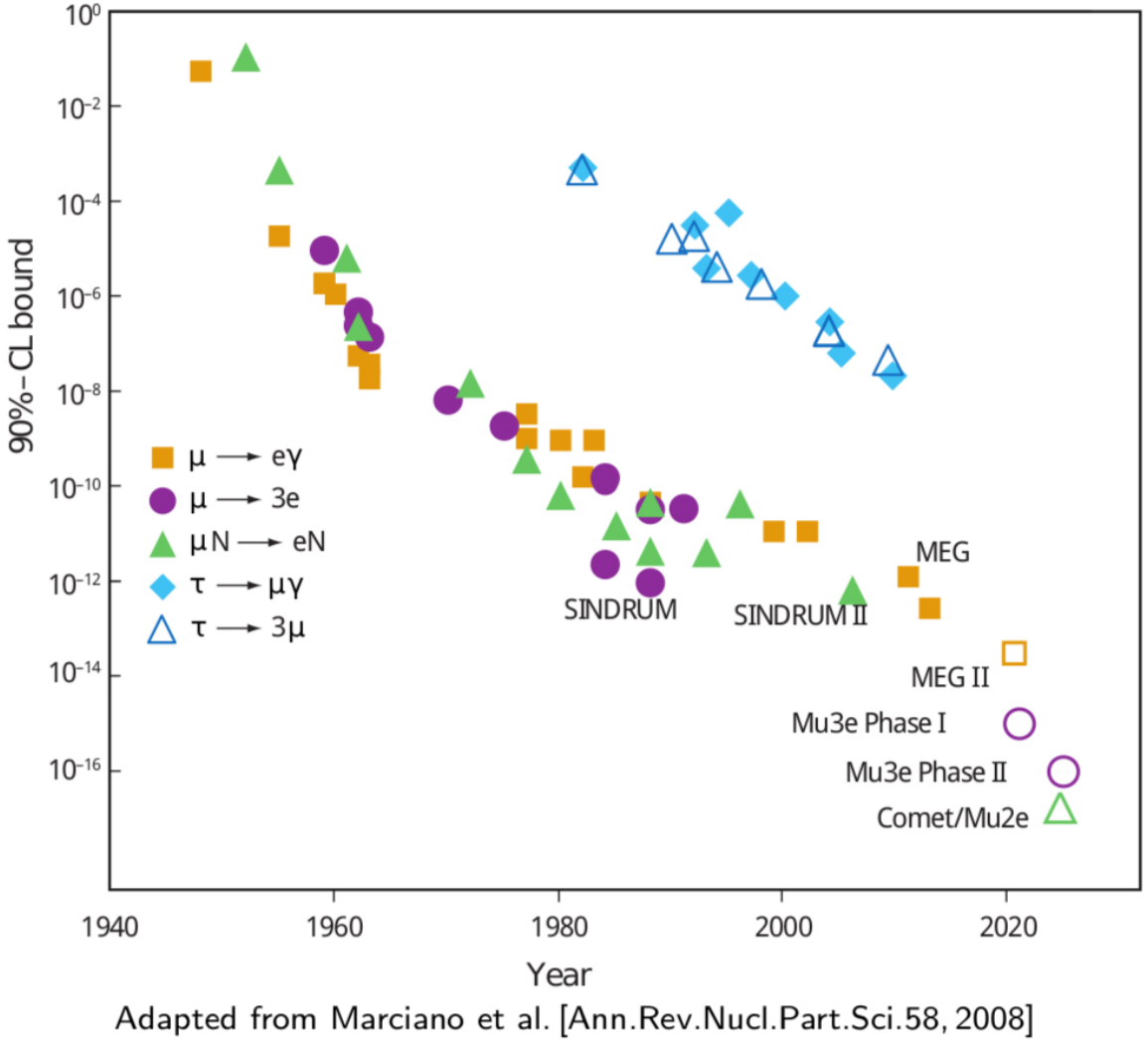
Highlights from the CERN workshop:

- 40 participants, mixture of theorists and experimentalists
- Theory talks on day one, experiments and round table on day two
- Lots of theory and experimental interplay in France for cLFV and B anomalies
- LHCb arguing with muon $g-2$ about who will get to 5σ first

A bright future for muons

From F. Kapusta's talk:





from Ann-Kathrin Perrevoort NuFACT2017

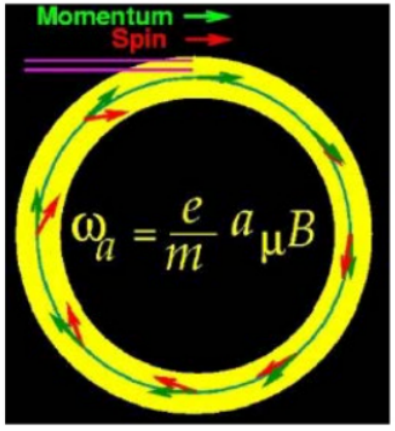
From F. Kapusta's talk:

$g-2$

g-2 measurements

- **Spin precession in a uniform B-field**

$$\vec{\omega} = -\frac{e}{m}\left[a_\mu \vec{B} - \left(a_\mu - \frac{1}{\gamma^2 - 1}\right)\frac{\vec{\beta}\times\vec{E}}{c} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B} + \frac{\vec{E}}{c}\right)\right]$$



- **Two alternative methods**
  - **Magic momentum : BNL E821 and FNAL E989**
    - Eliminate the 2nd term by setting p=3.09 GeV/c (γ=29.3)
    - Can use E-field for beam focusing

$$\vec{\omega} = -\frac{e}{m}\left[a_\mu \vec{B} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B} + \frac{\vec{E}}{c}\right)\right]$$

  - **Zero E-field : J-PARC E34**
    - Separation of a_μ and η_μ
    - A new technology is necessary.
      - Muon beam w/o E-focusing

    ⇨ **Ultra-cold muon beam**

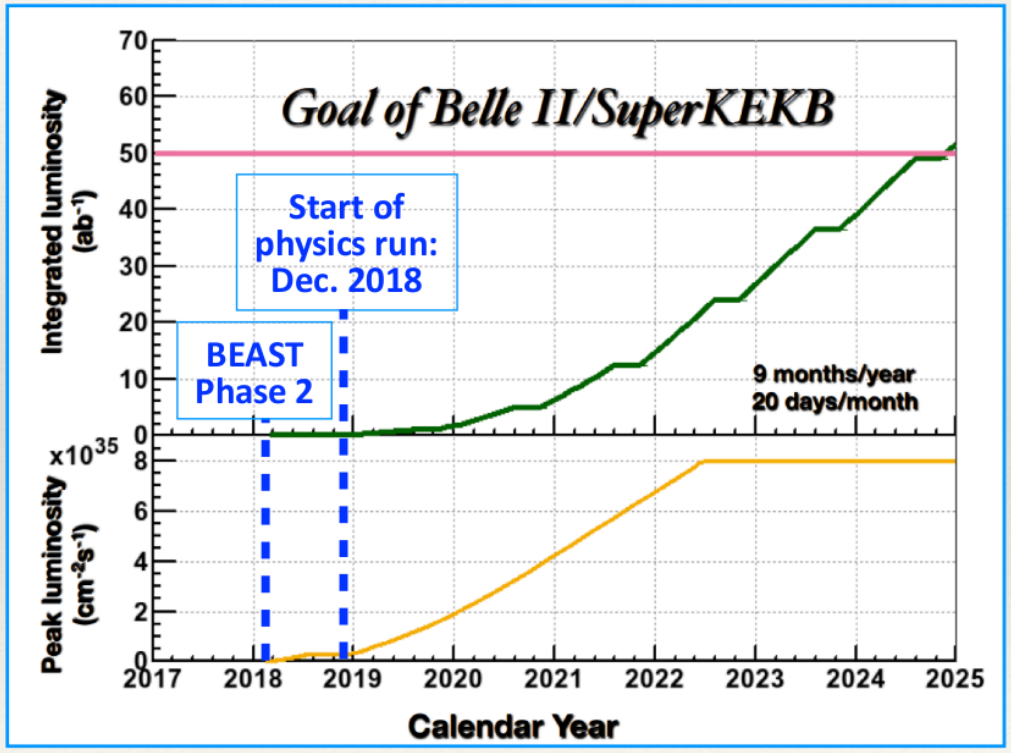
$$\vec{\omega} = -\frac{e}{m}\left[a_\mu \vec{B} + \frac{\eta}{2}\left(\vec{\beta}\times\vec{B}\right)\right]$$

Exciting times for B physics

Belle-II has begun. From talk by I. Ripp-Baudot:

- SuperKEKB started in January 2016: circulation of single beams (BEAST Phase 1).
  First collisions will be delivered in Spring 2018 (BEAST Phase 2).
  Start of physics run scheduled in December 2018.

- Target integrated luminosities:
  - 2019: 1 ab^{-1} > present dataset.
  - 2021: 10 ab^{-1}.
  - 2024: 50 ab^{-1}
    - ➛ 55×10^9 $B\bar{B}$,
      45×10^9 $\tau^+\tau^-$,
      65×10^9 $c\bar{c}$.



LHCb upgrade to come in the future – we'll know soon if the B-anomalies are confirmed!

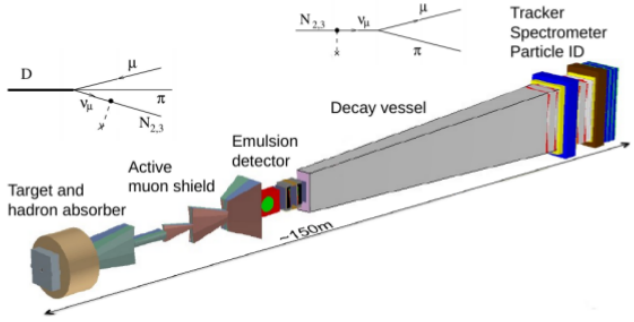
Hot topics

- Beam dumps
- Searches for axions picking up pace
- Future colliders – FCC,
- Machine learning

Future beam dumps

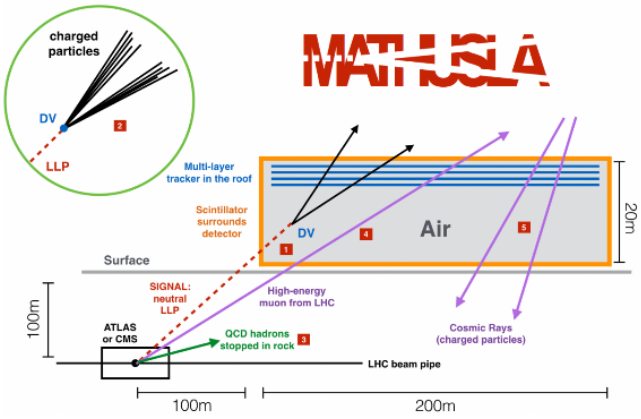
From a talk elsewhere by S. Trojanowski:

Proposed experiments: CODEX-b, FASER, MATHUSLA, SHiP



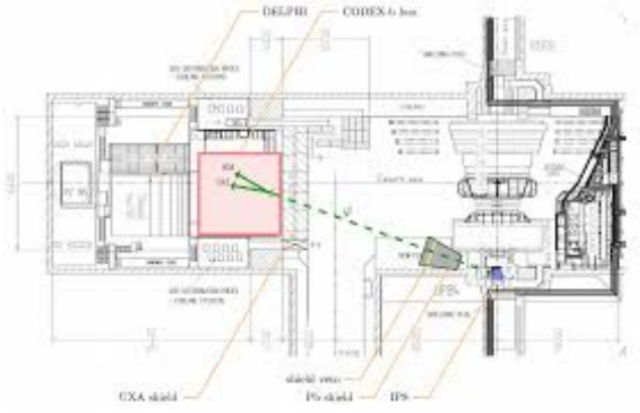
SHiP, Alekhin et al. (2015)

$\sim 1000\ \mathrm{m}^3$, a few hundred million \$



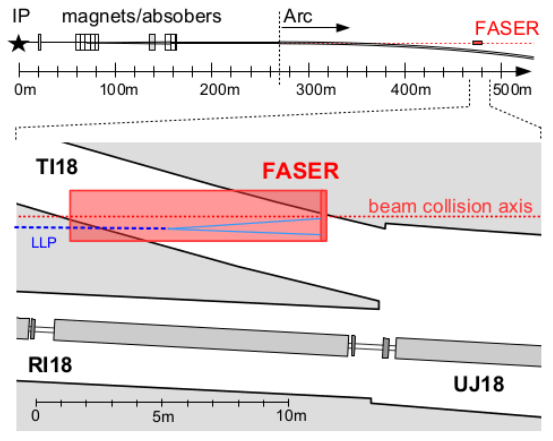
MATHUSLA, Chou, Curtin, Lubatti (2016)

$\sim 10^6\ \mathrm{m}^3$, $\sim 50\mathrm{M}\$$



CODEX-b, Gligorov, Knapen, Papucci, Robinson (2016)

$\sim 1000\ \mathrm{m}^3$



FASER, Feng, Galon, Kling, Trojanowski (2016)

$\sim 1 - 10\ \mathrm{m}^3$

SHiP

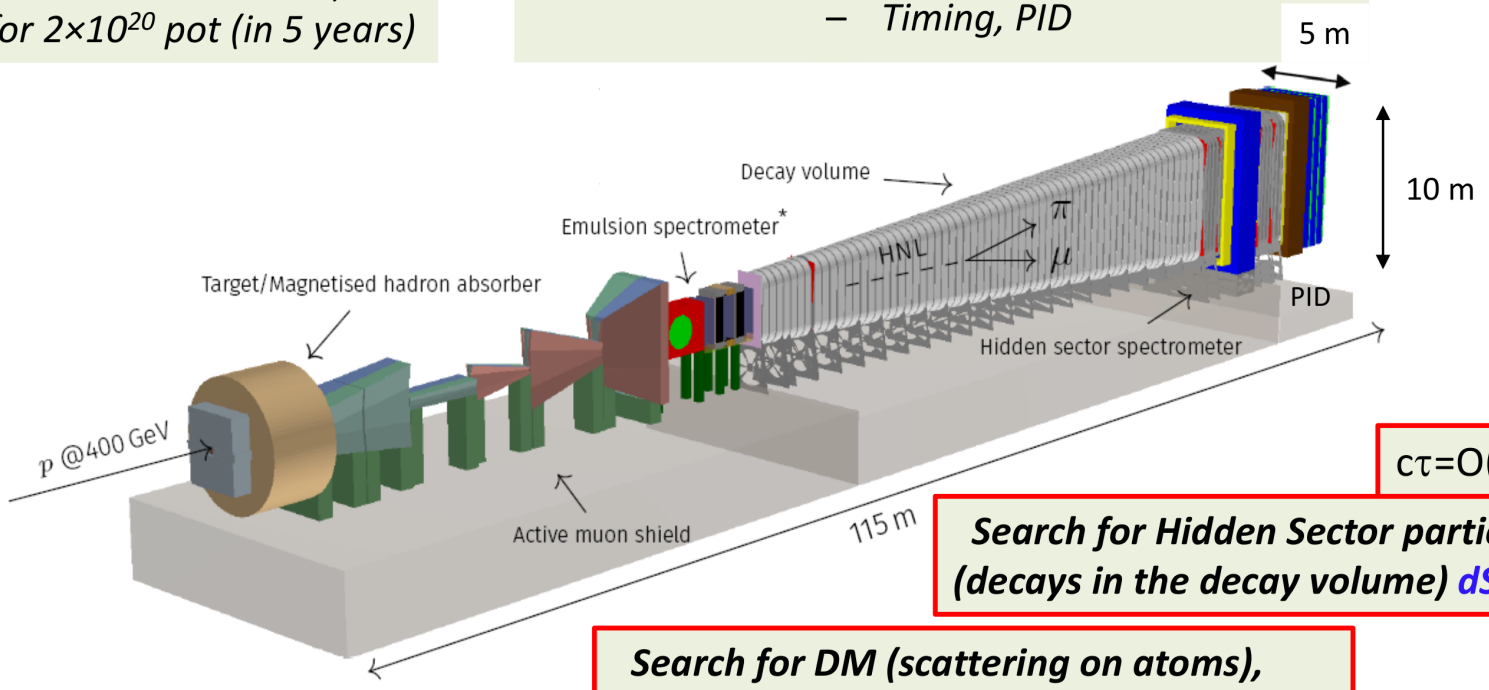
From talk by J. Chauveau:

SHiP
Search for Hidden Particles

« Zero-background experiment »

- *Dump*
- *Muon Shield*
- *Surrounding Veto detectors*
- *Vacuum*
- *Timing, PID*

$>10^{18}$D, $>10^{16}$ τ, $>10^{20}$ γ for 2×10^{20} pot (in 5 years)



cτ=O(km)

Search for Hidden Sector particles (decays in the decay volume) dSHiP

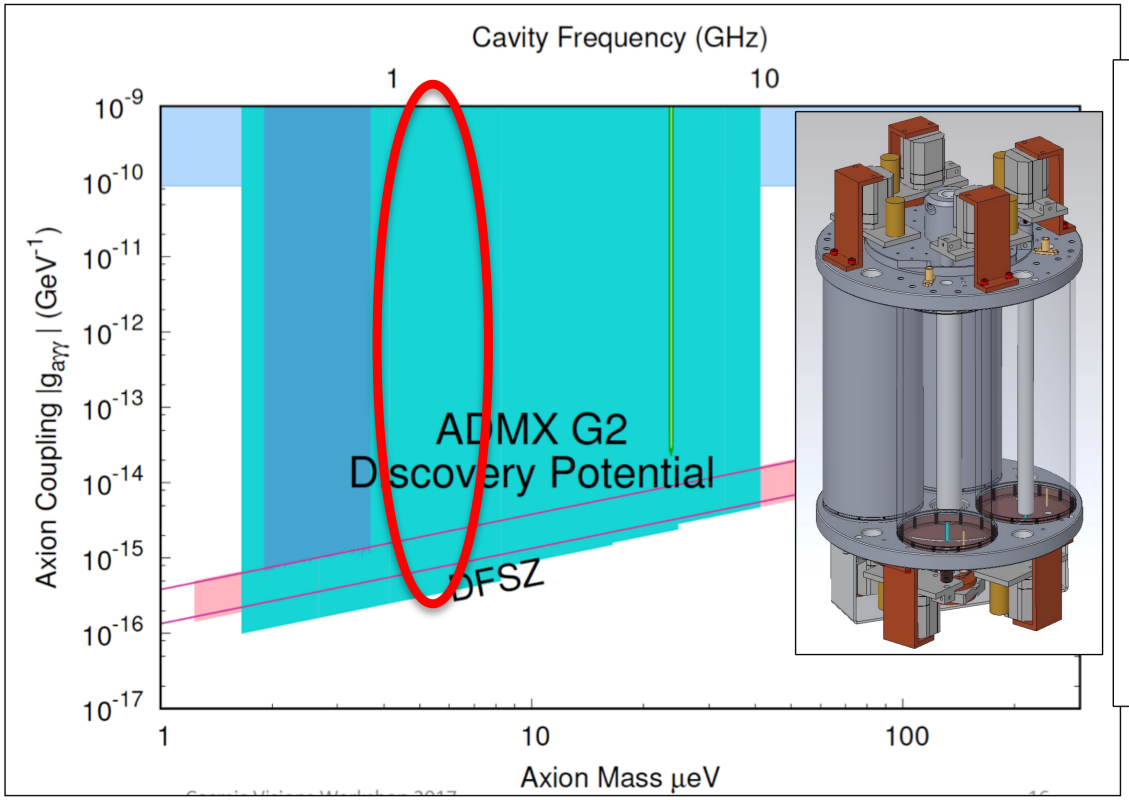
Search for DM (scattering on atoms), ν_τ physics (specific event topology) iSHiP

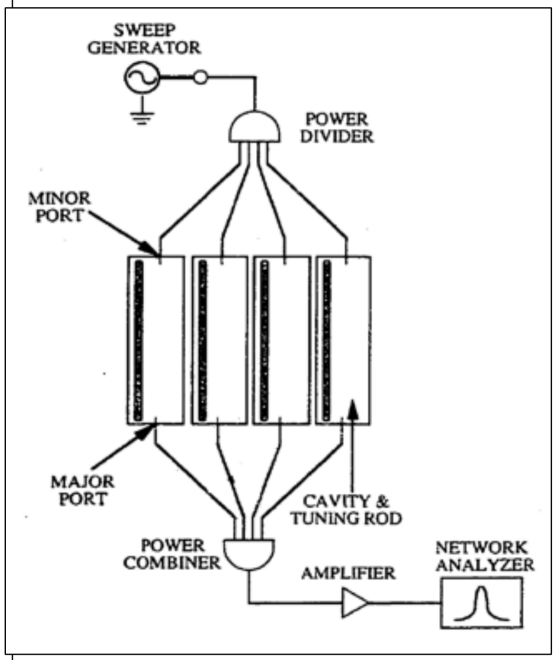
ADMX

ADMX-G2 is ongoing! Recall classic axion window has mass $26 \rightarrow 1500\,\mu\text{eV}$

From talk by N. Cresoto:

Run 2





ADMX
AXION DARK MATTER EXPERIMENT

Other axion searches

Gauge Fields

$$\frac{a}{f_a} F_{\mu\nu}\tilde{F}^{\mu\nu} \qquad \frac{a}{f_a} G_{\mu\nu}\tilde{G}^{\mu\nu}$$

Fermions

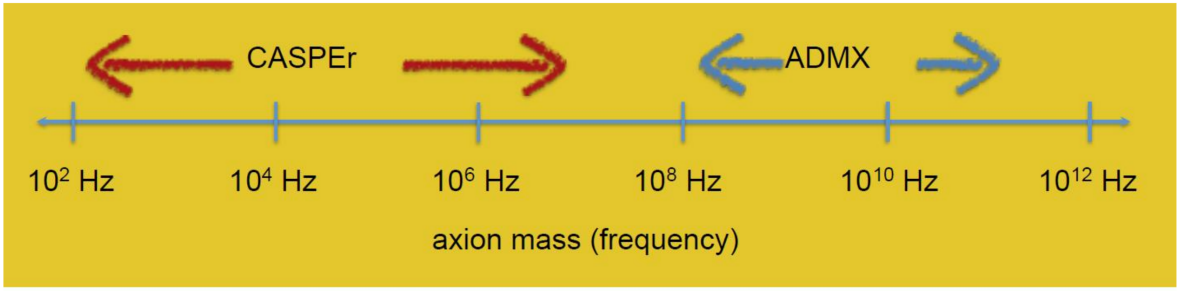
$$\frac{\partial_\mu a}{f_a} \bar{\Psi}_f \gamma^\mu \gamma_5 \Psi_f$$

Most Searches

(CASPEr-E)

(CASPEr-Wind, GNOME, QUAX)

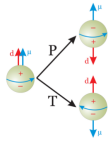
E.g. GNOME and CASPEr

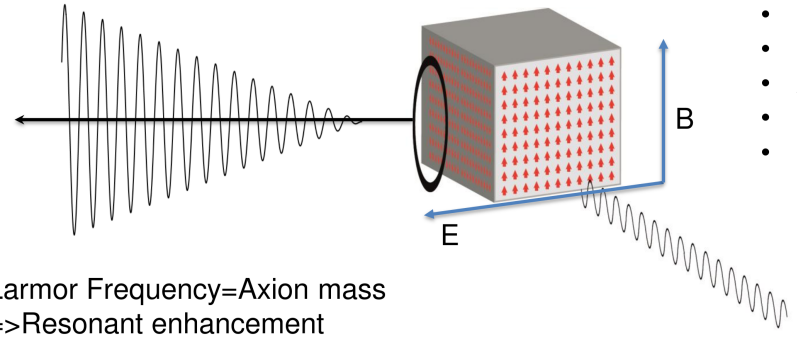


Talks by Wickenbrock, Roig and Smiga:

CASPEr – Electric idea

Detecting oscillating induced electric dipole moment with NMR





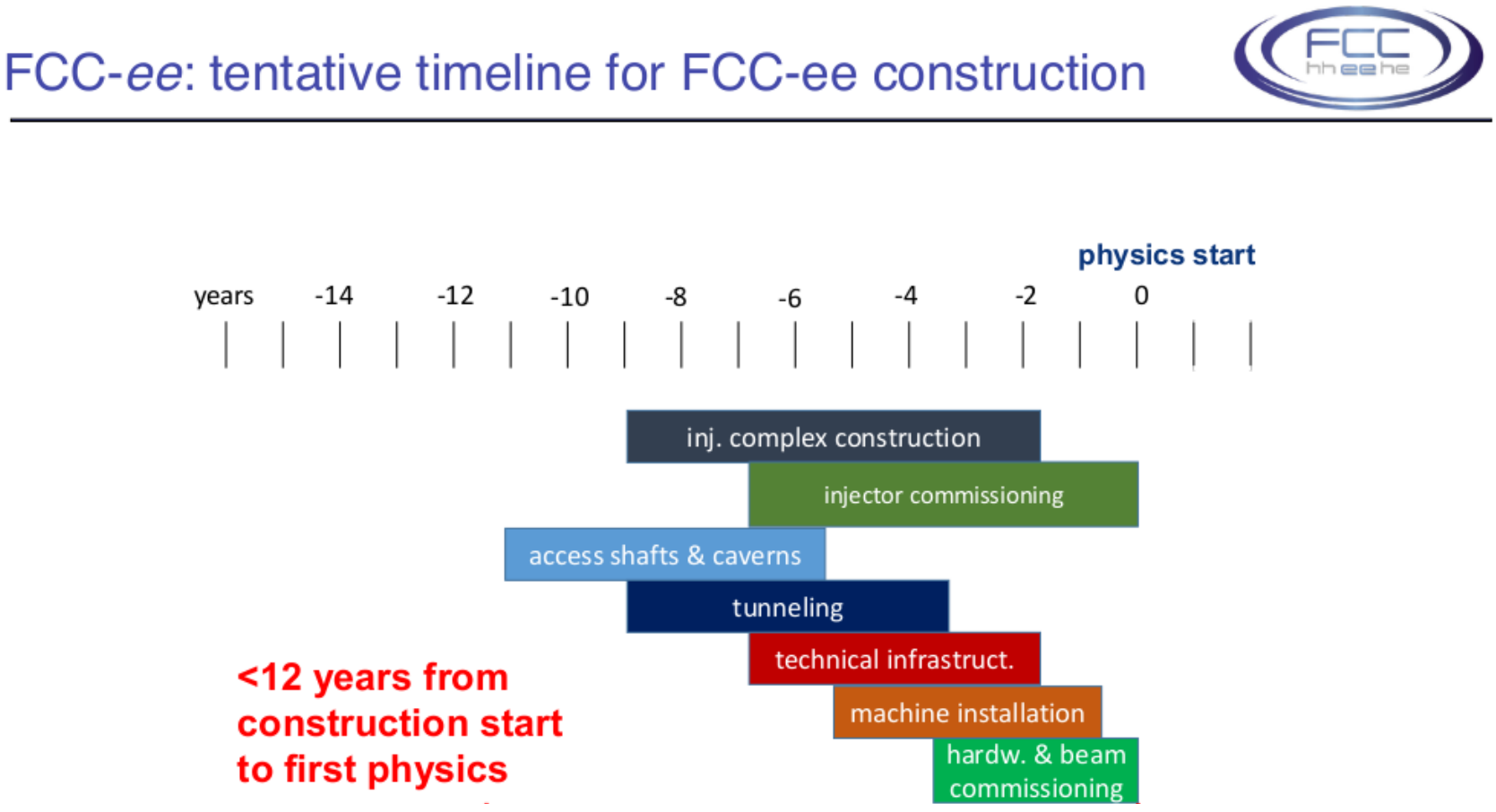
- Polarized nuclear spins
- B field
- E field perp to B
- Axion induces EDM
- ->Oscillating torque on spins
- Pickup with SQUIDs

$$\frac{a}{f_a} G_{\mu\nu}\tilde{G}^{\mu\nu}$$

Larmor Frequency=Axion mass
=>Resonant enhancement

Future colliders

Lots of activity on future colliders with significant French input. Timeline from talk by S. Monteil:



Topics for discussion

- French involvement is significant in SHiP. But what about other beam dumps?
- French involvement in EDM searches, e.g. PanEDM at ILL in Grenoble. But Axion searches?
- How can machine learning help get the most from current experiments?
- Physics reach of a gamma factory?