





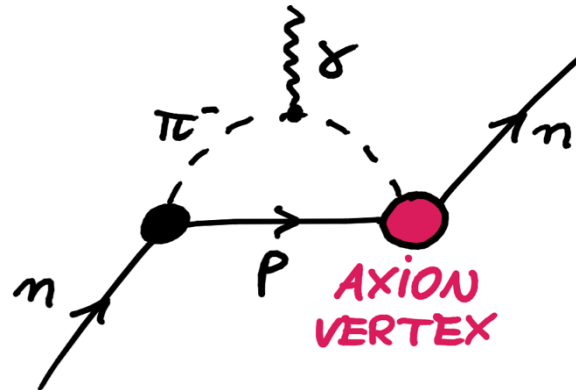
# Looking for axions with nEDM experiments

**Michał Rawlik** on behalf of the nEDM collaboration

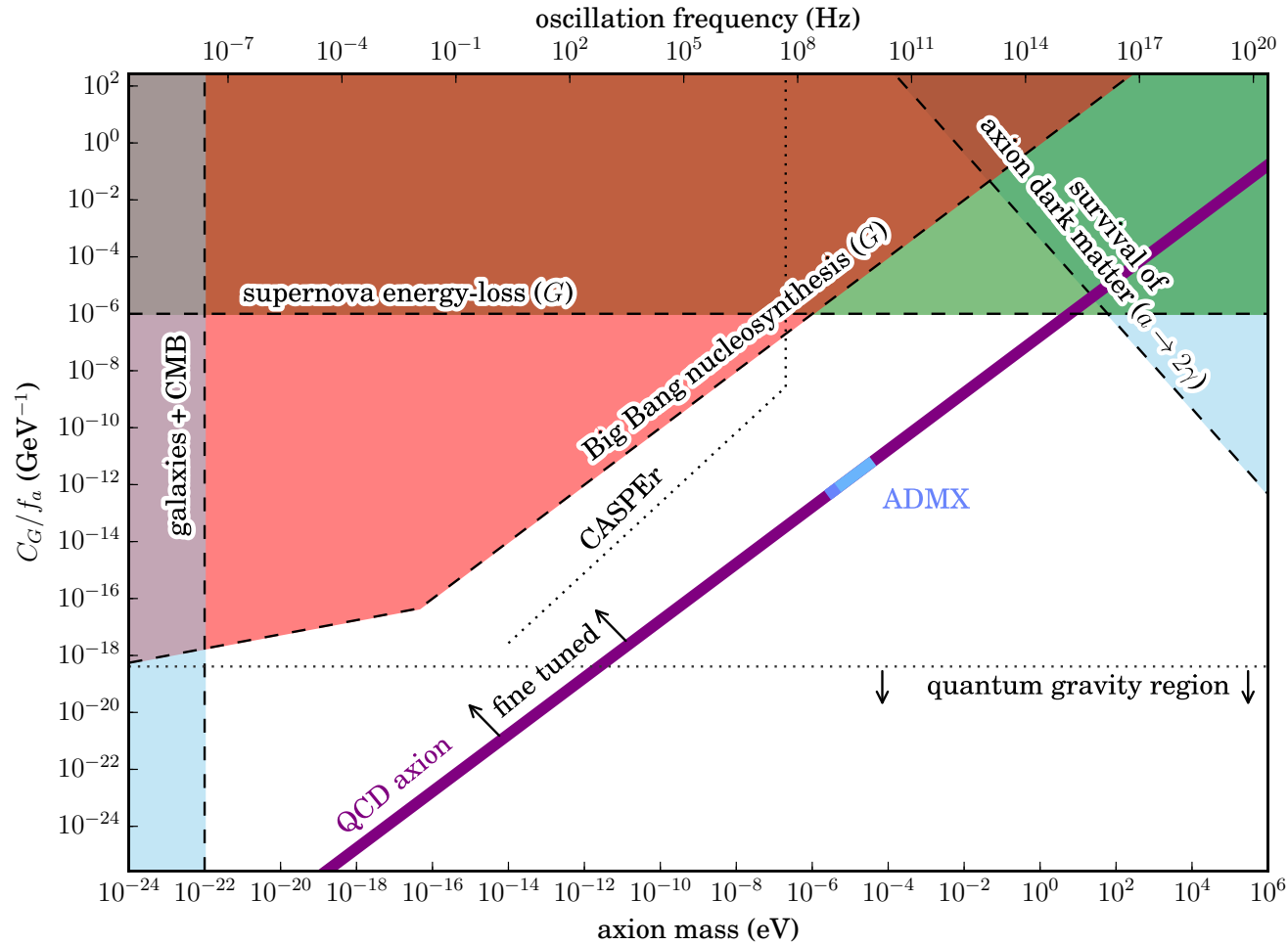
*with:* N. Ayres, M. Fairbairn, V. V. Flambaum, D. J. E. Marsh, Y. V. Stadnik

# What is an axion?

- Axions tackle two problems of the modern physics:
  - The **strong CP problem** of QCD.
  - **Dark matter**, being a candidate therefor.
- Most searches focus on an axion coupling to photons.
- Recently, searching for a **gluon coupling** has been proposed:

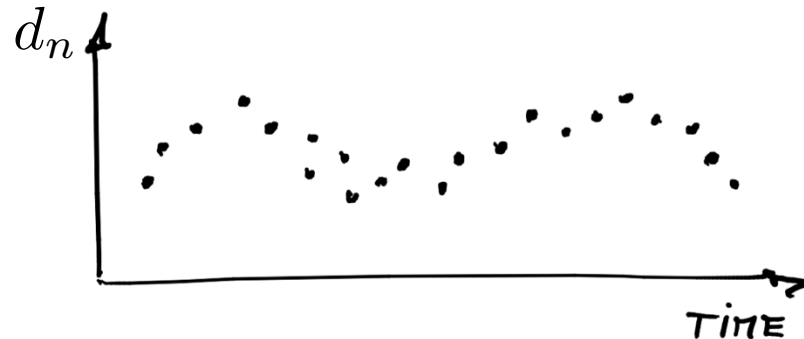


# Current situation

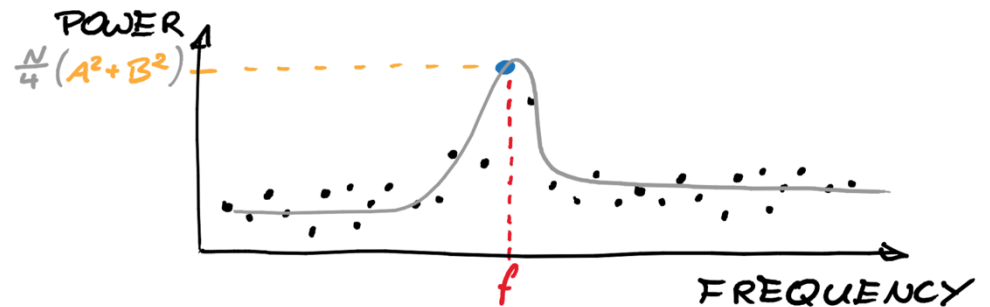
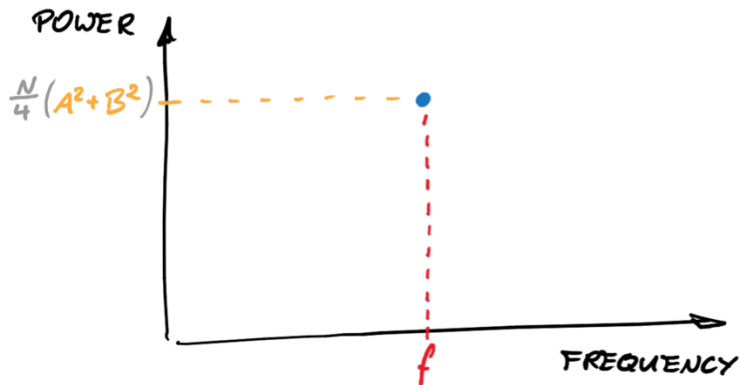
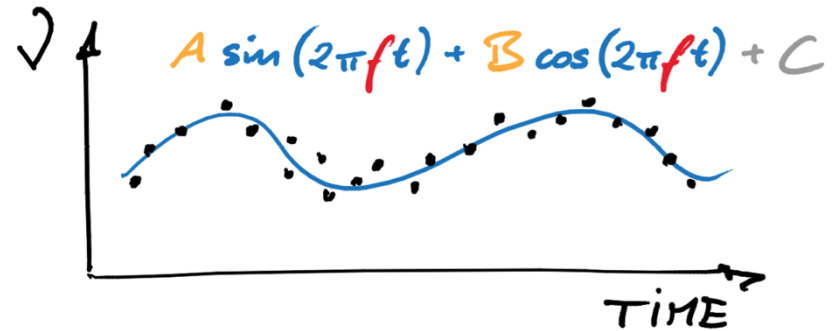
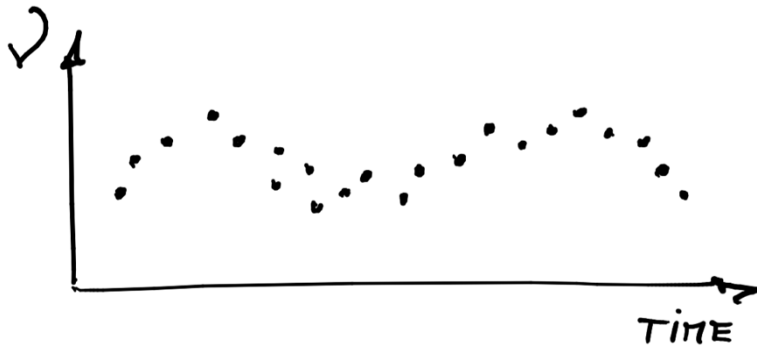


# Axion-induced nEDM oscillation

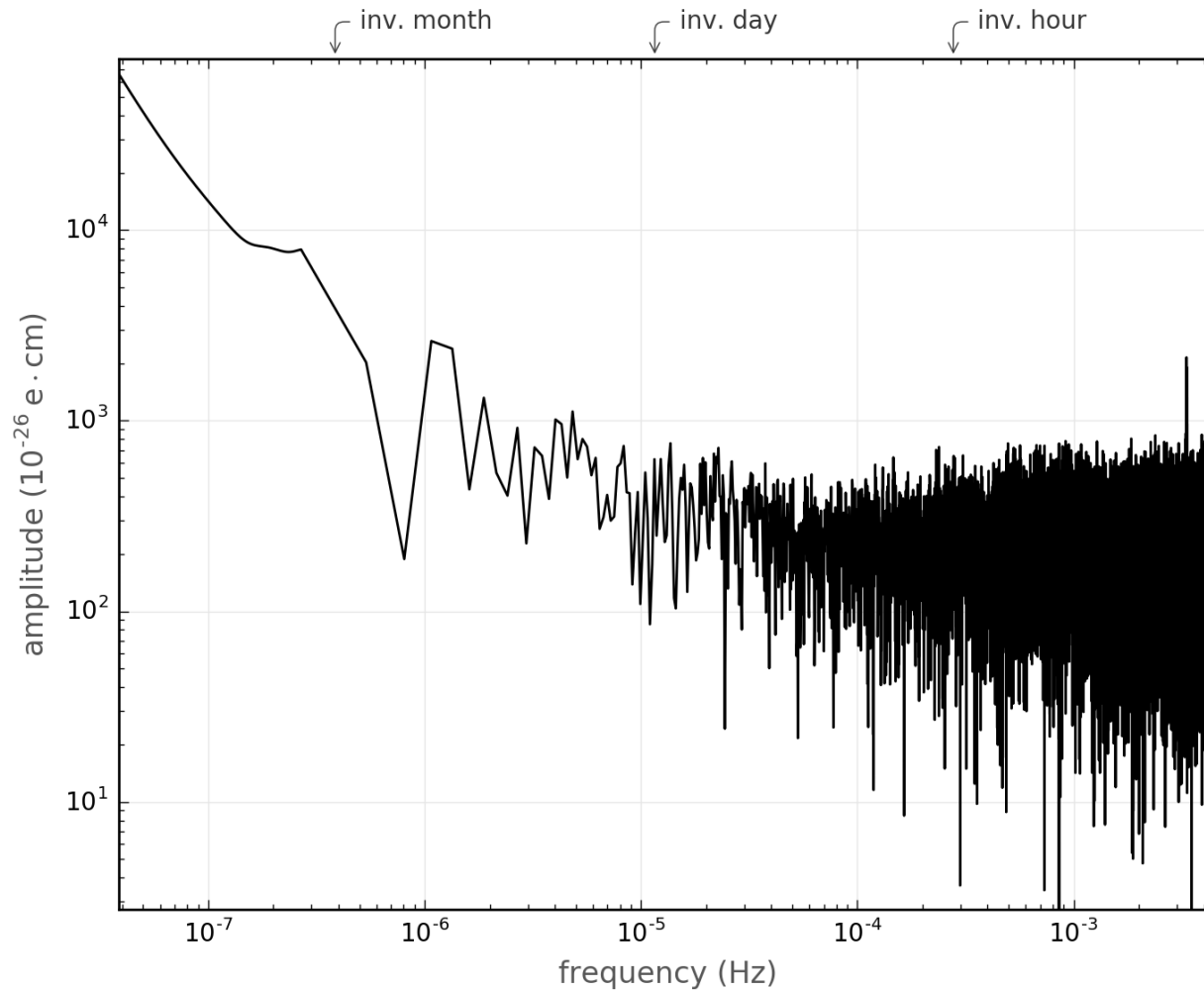
$$d_n(t) \approx 5.9 \times 10^{-22} C_G \left( \frac{10^{-22} \text{eV}}{m_a} \right) \left( \frac{10^{16} \text{GeV}}{f_a} \right) \cos(m_a t) e \cdot \text{cm}$$



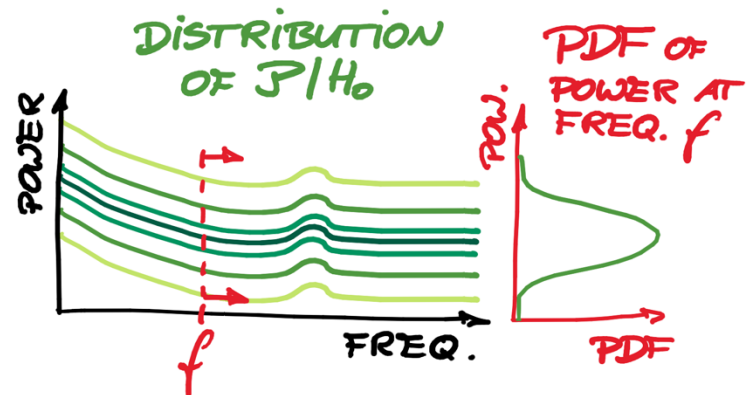
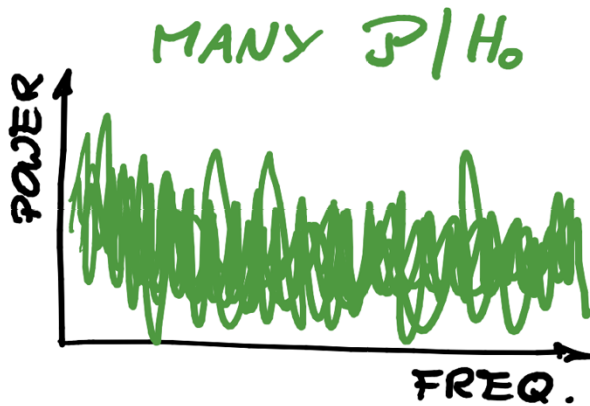
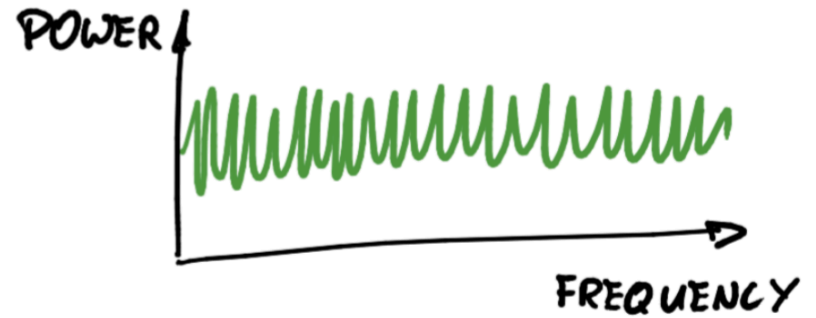
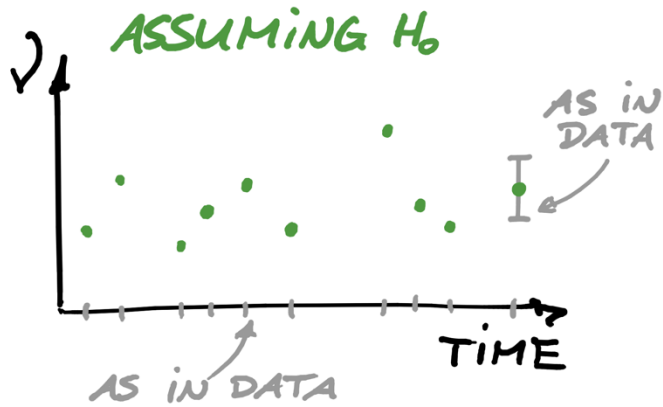
# Least Squares Spectral Analysis (LSSA)



# The Data Periodogram

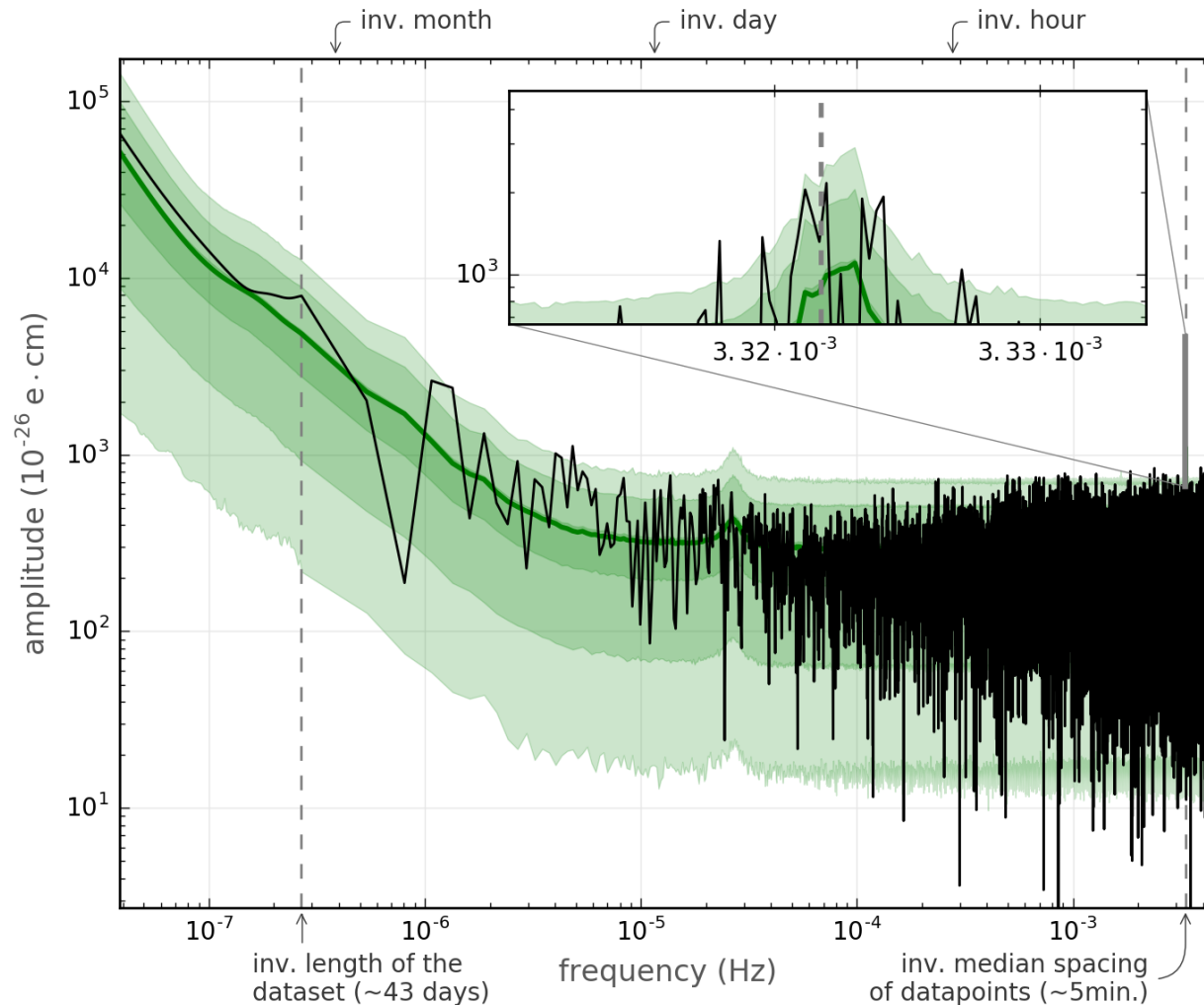


# The Periodogram Under the Null Hypothesis

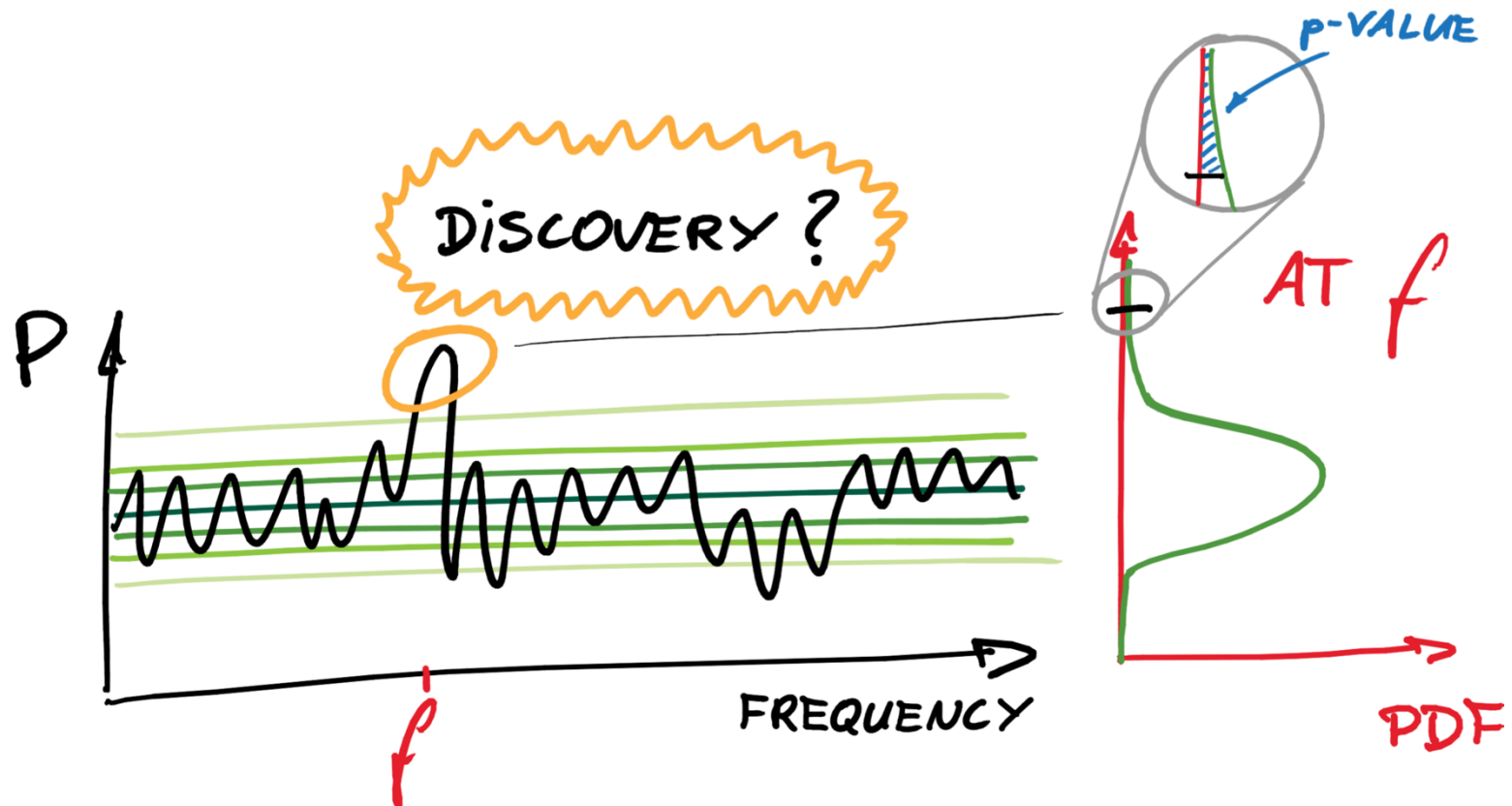




# The Data Periodogram vs. the Null Hypothesis



# The Null Hypothesis Test



# The Look-Elsewhere Effect

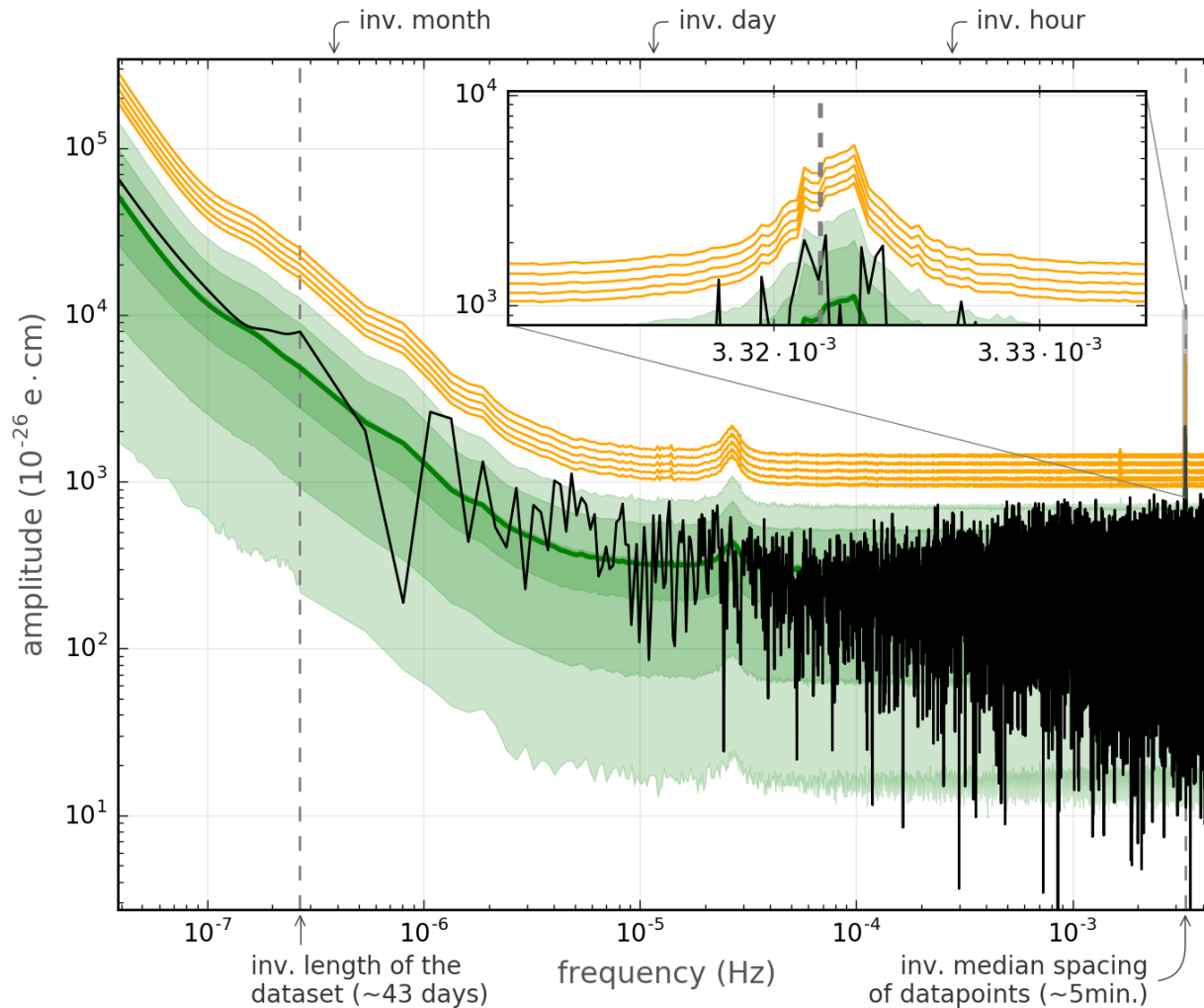
$$p_{\text{global}} = 1 - (1 - p_{\text{local}})^{\text{number of frequencies}}$$

number of frequencies = 1 000 000

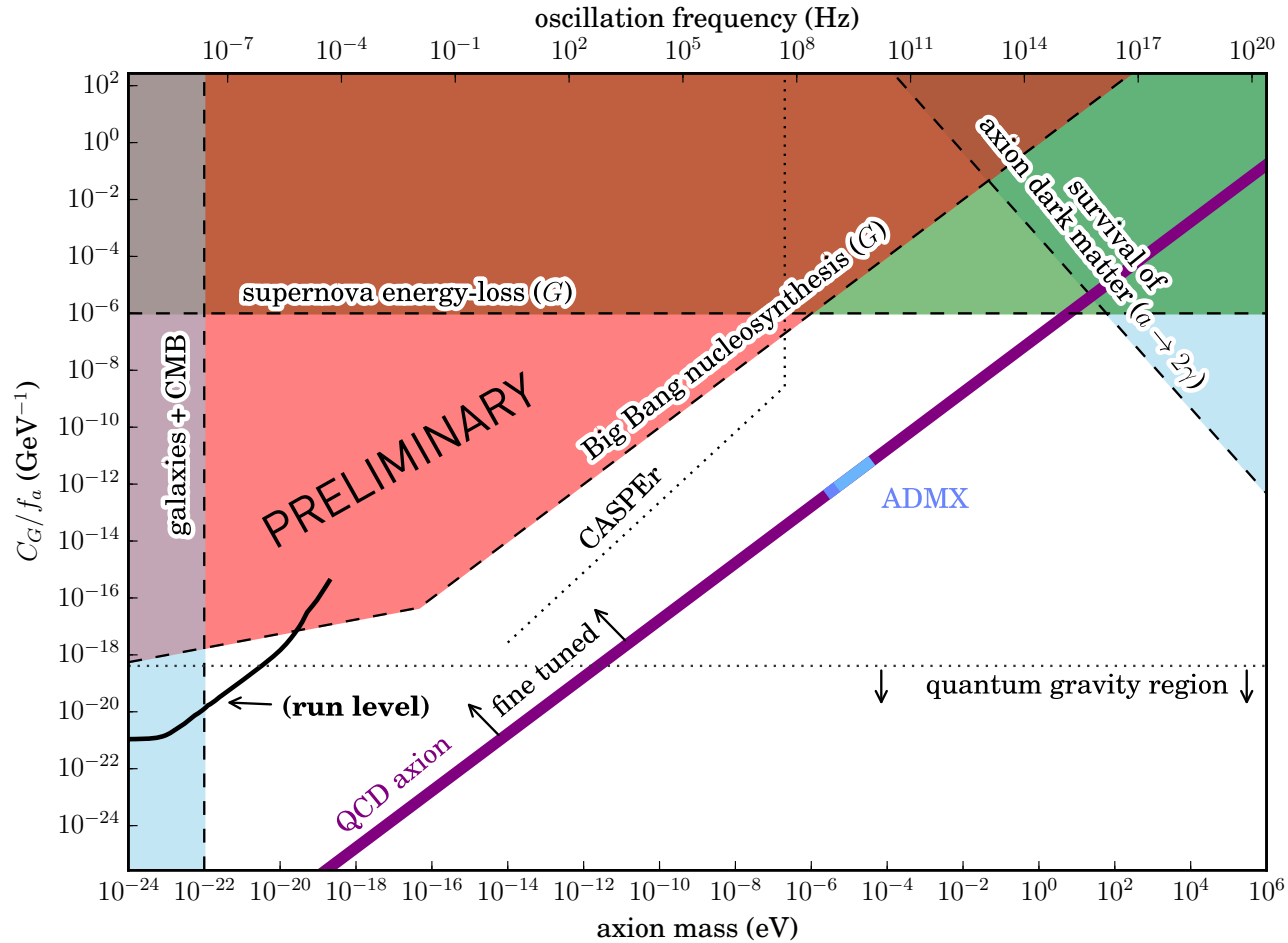
$p_{\text{global}}$  = 3-sigma level

$p_{\text{local}}$  = 6-sigma level

# False-Alarm Thresholds



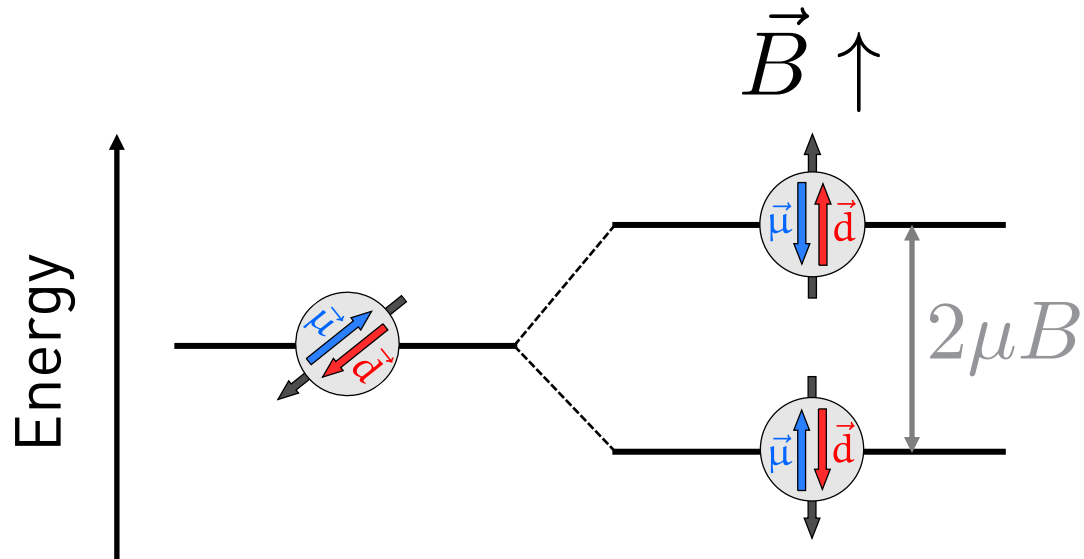
# Expected limits



# Can one do better?

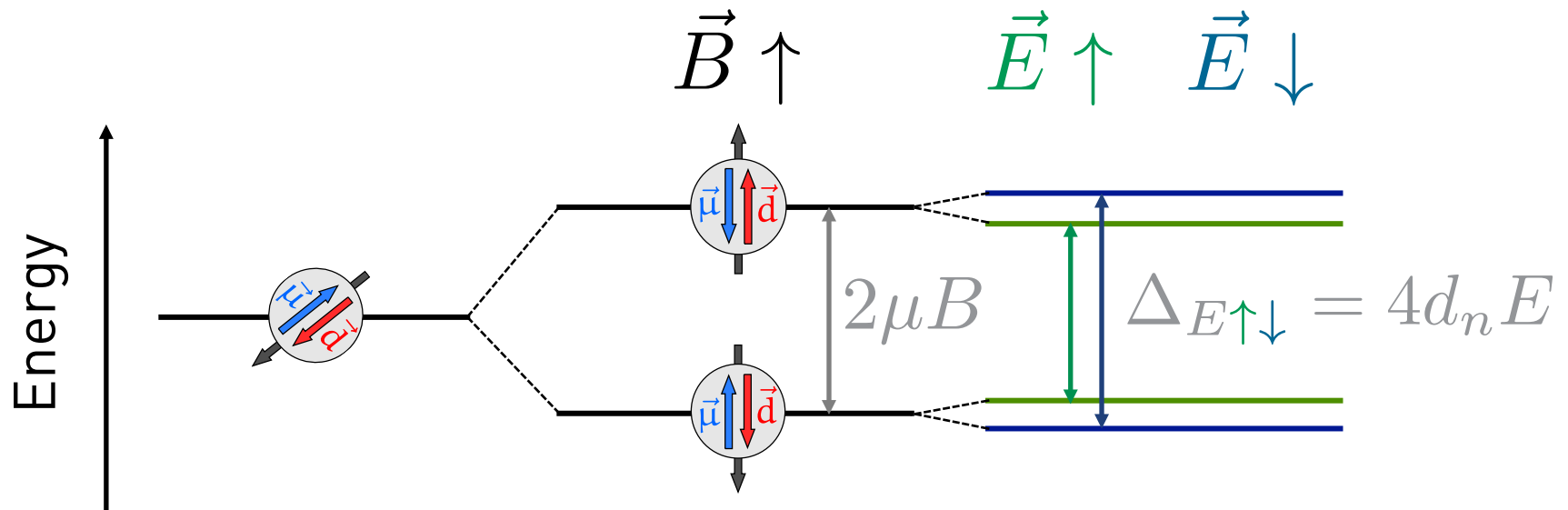
# How to measure the nEDM

$$\mathcal{H} = -\vec{\mu} \cdot \vec{B}$$



# How to measure the nEDM

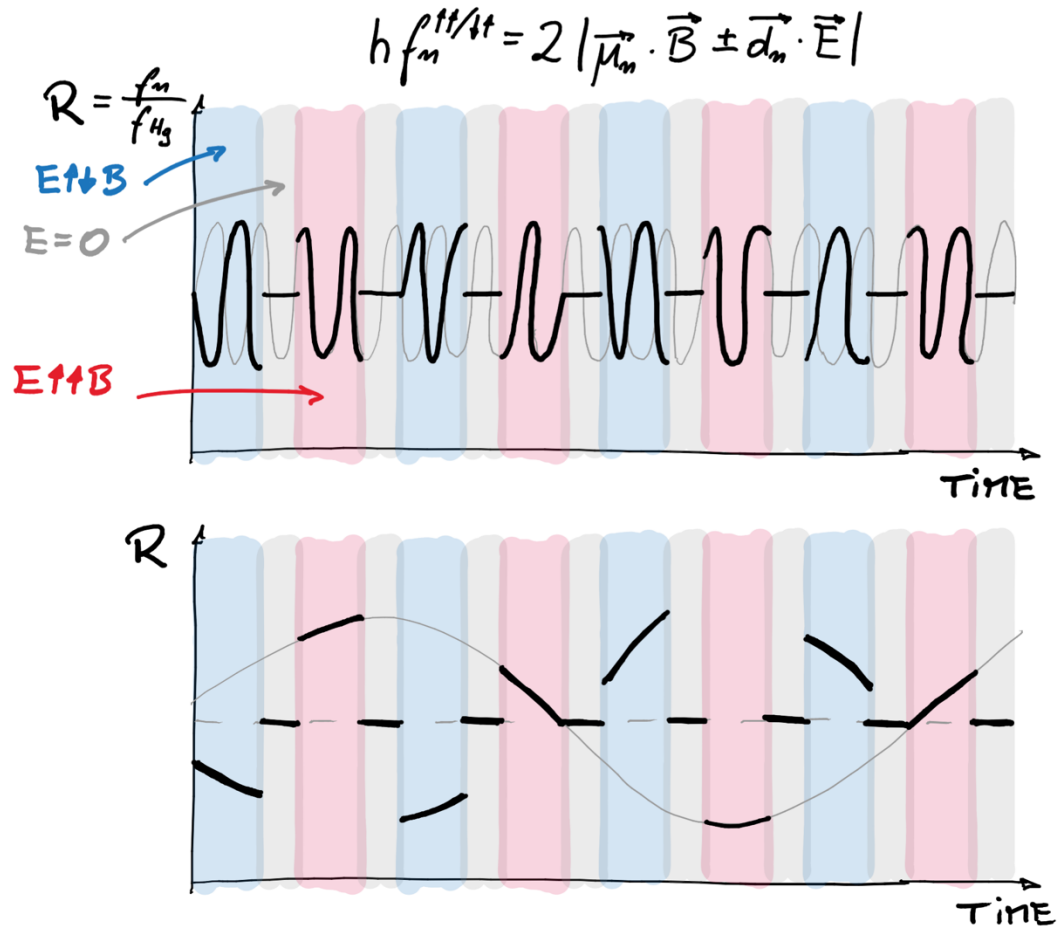
$$\mathcal{H} = -\vec{\mu} \cdot \vec{B} - \vec{d}_n \cdot \vec{E}$$



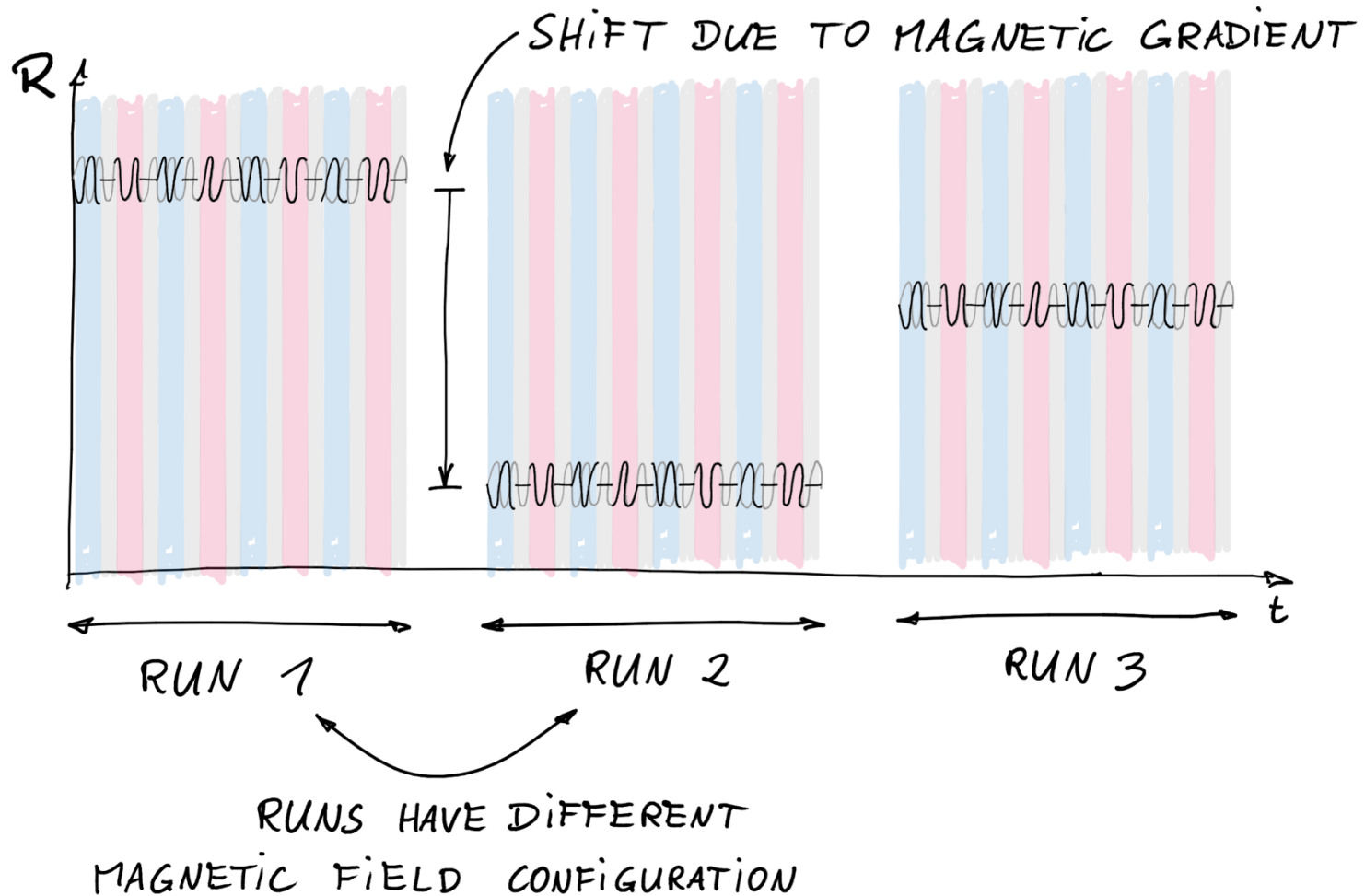
Measure a change in the transition frequency in a presence of an electric field.



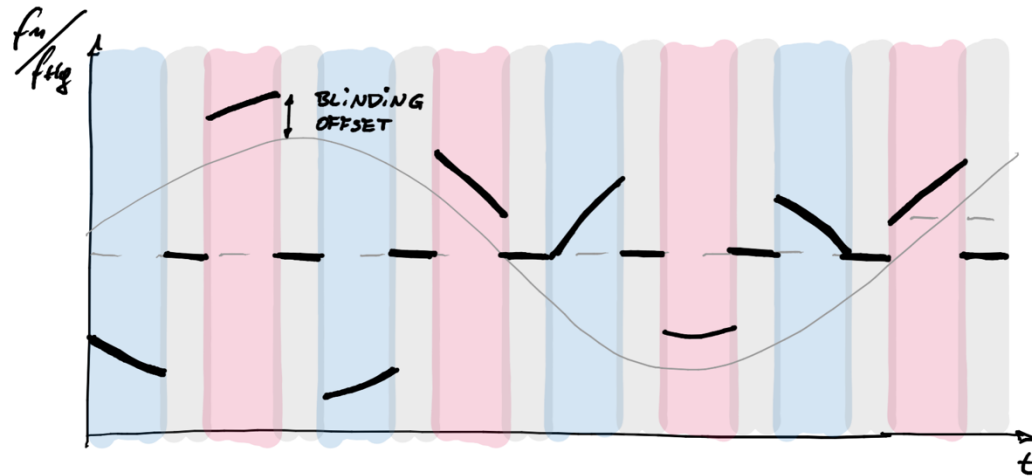
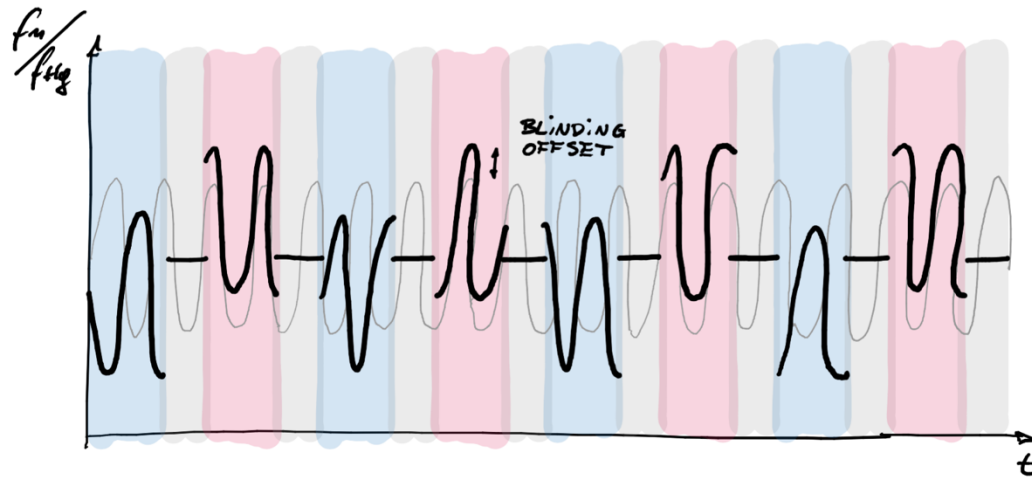
# Cycle-level analysis



# Cycle-level analysis

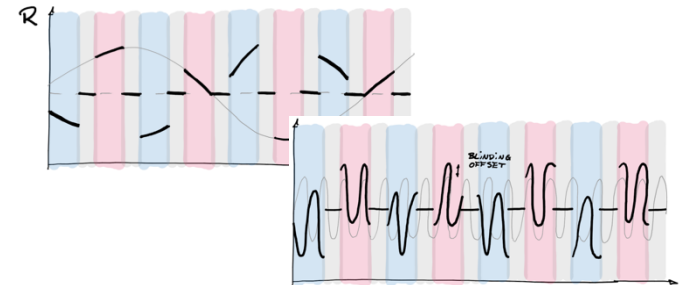


# Cycle-level analysis

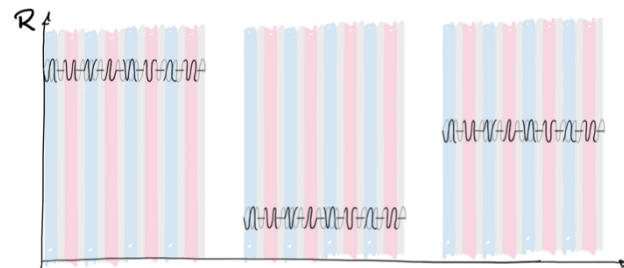
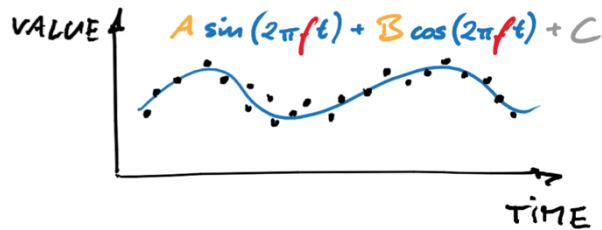


# Cycle-level analysis

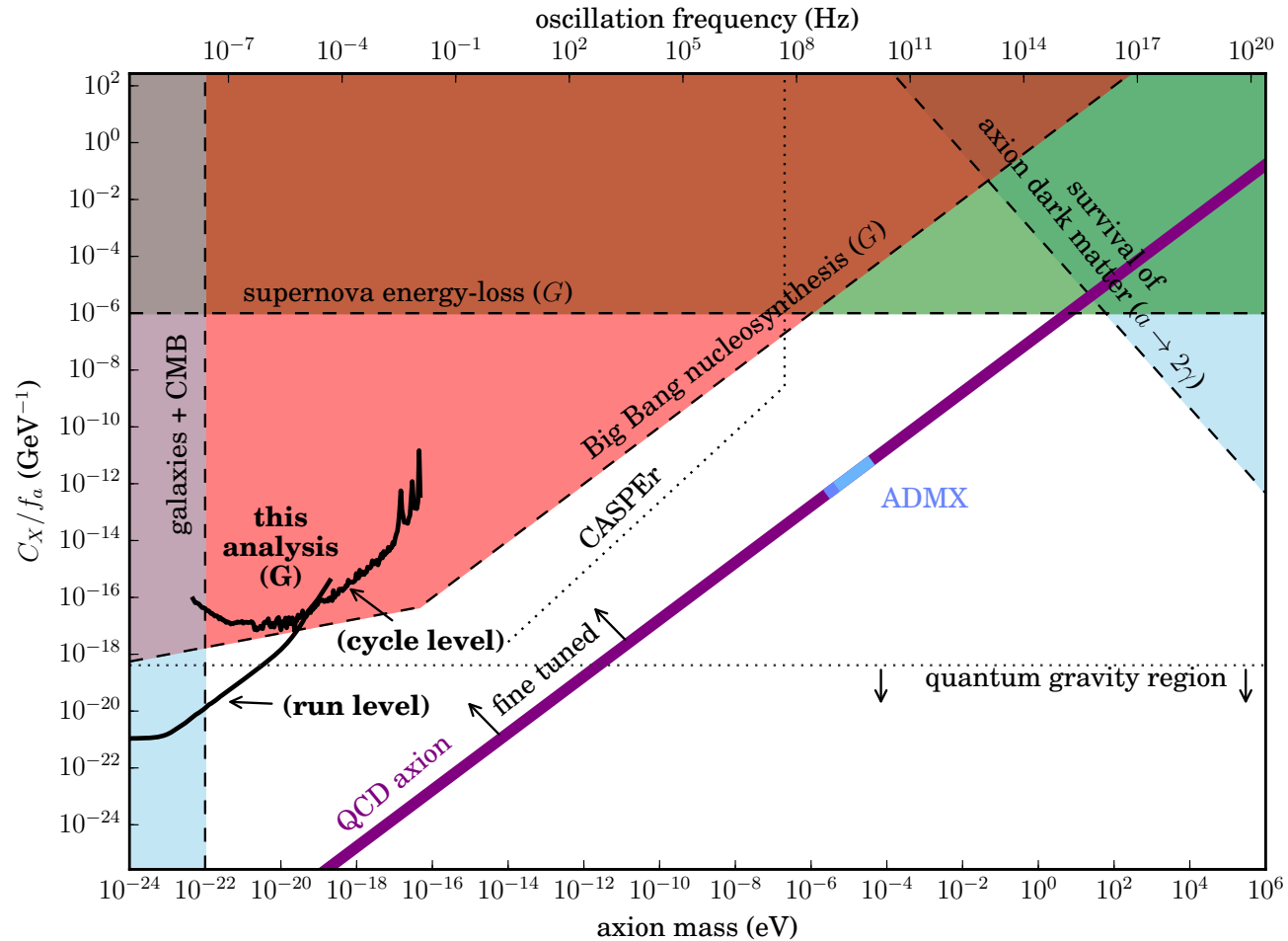
- Analyse  $E=0$ ,  $E \uparrow B$ ,  $E \downarrow B$  separately



- In fit have a separate offset  $C$  in each run



# Expected limits





# Thank you for your attention!

## Further reading:

D. J. E. Marsh, Phys. Rep. **643**, 1 (2016)

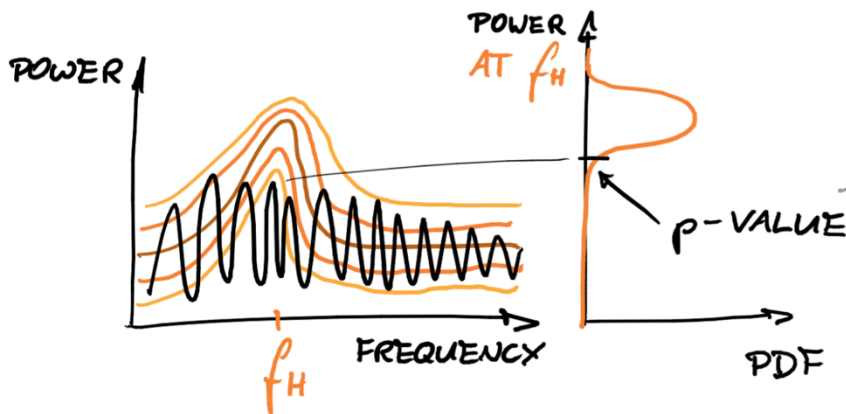
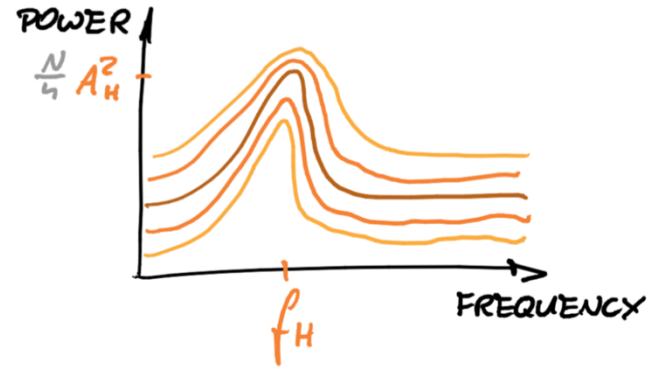
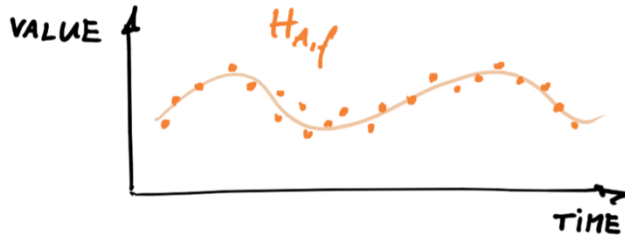
Y. V. Stadnik, V. V. Flambaum, Phys. Rev. D **89**, 043522 (2014)

J. D. Scargle, Astrophys. J. **263**, 835 (1982)

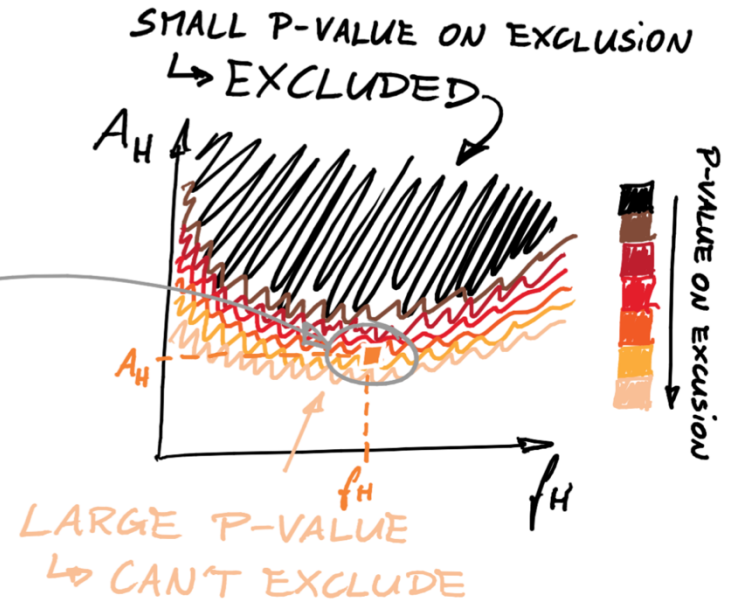
S. Algeri, J. Conrad, D. A. van Dyk, B. Anderson, arXiv:1602.03765 (2016)



# determining the exclusion region

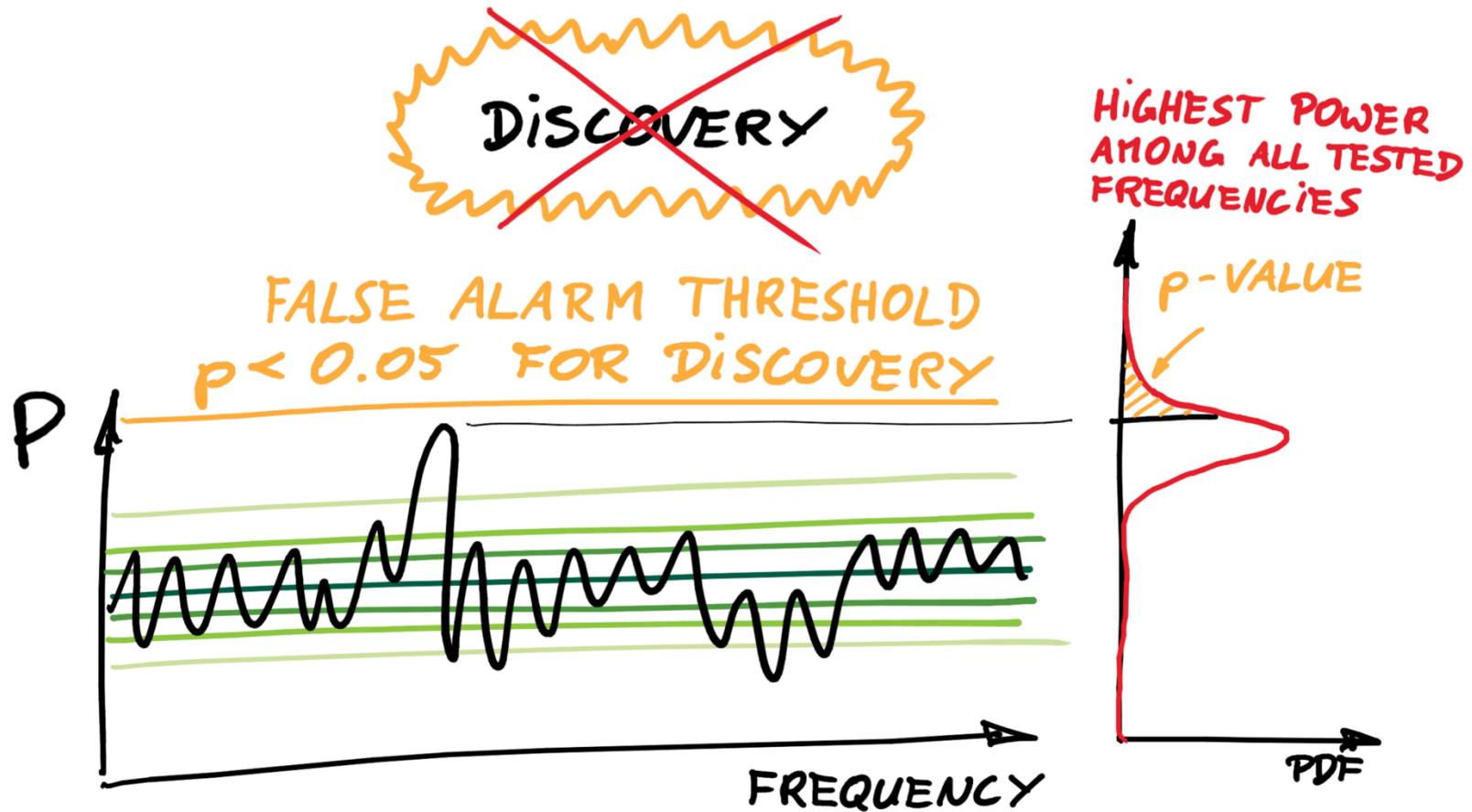


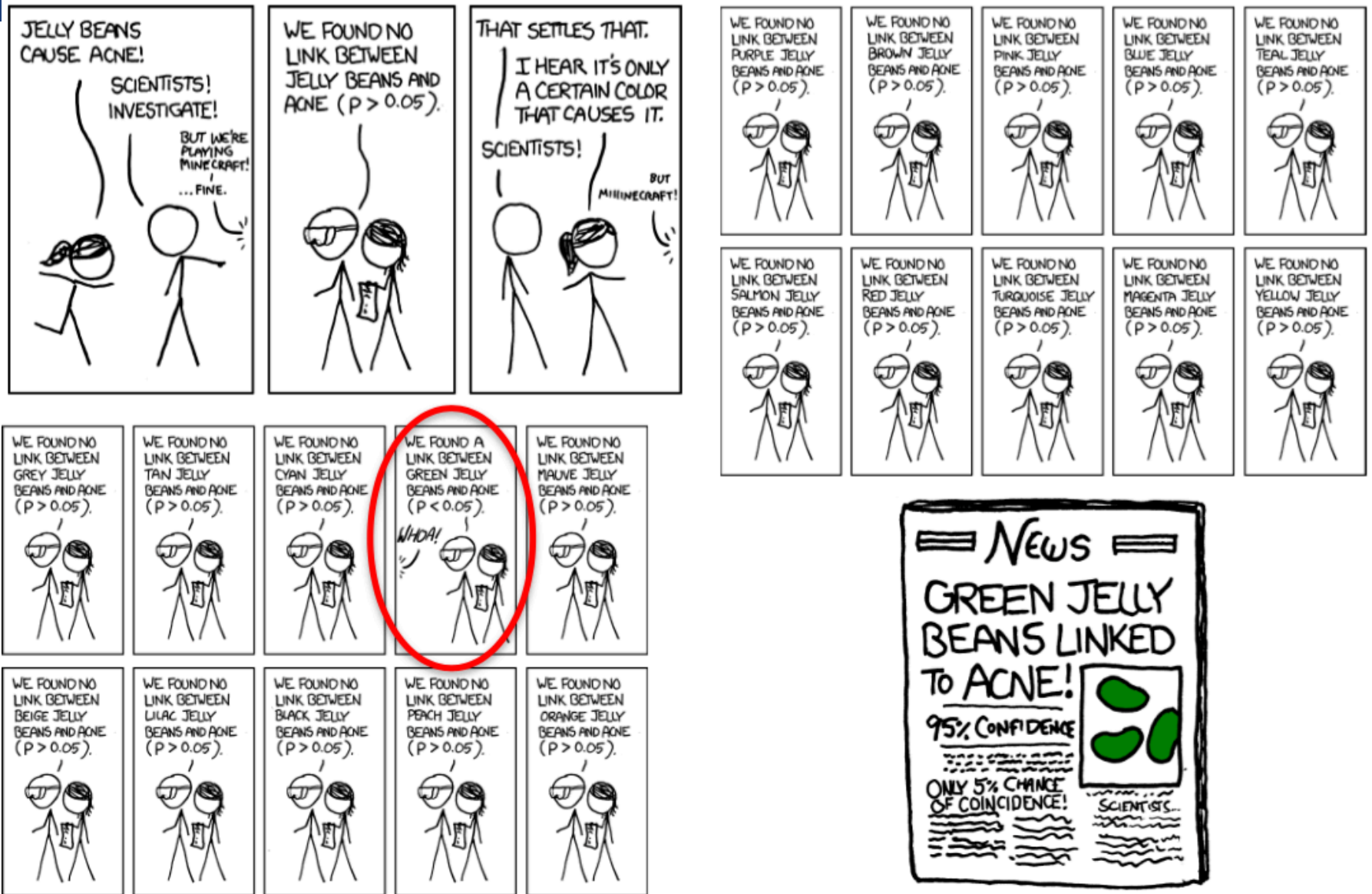
PDF





# the look-elsewhere effect





# the exclusion region

