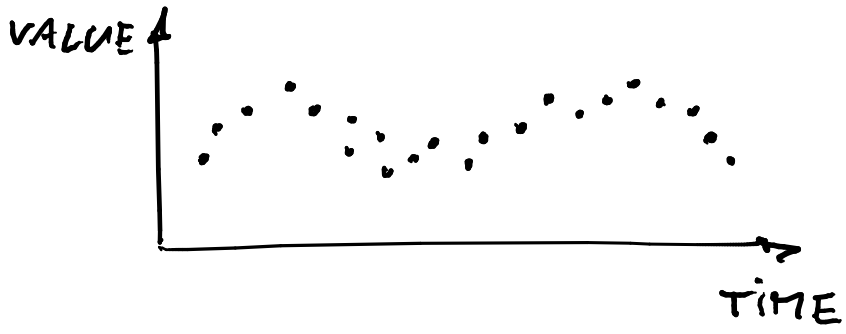
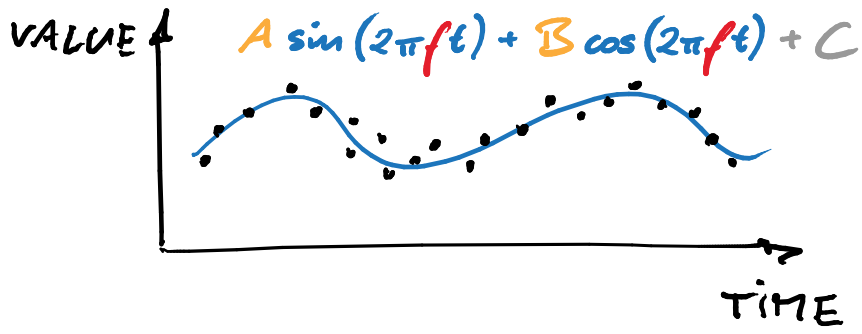
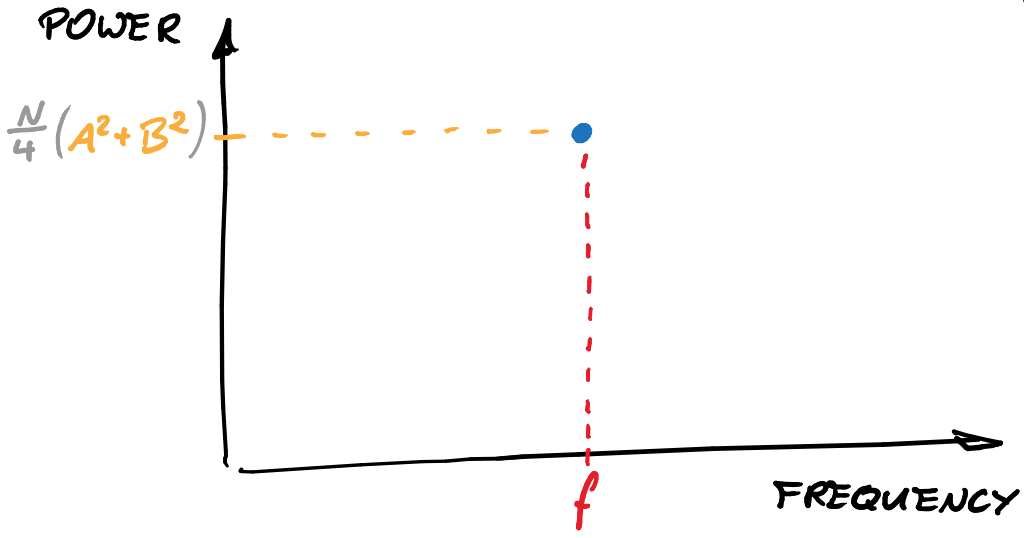
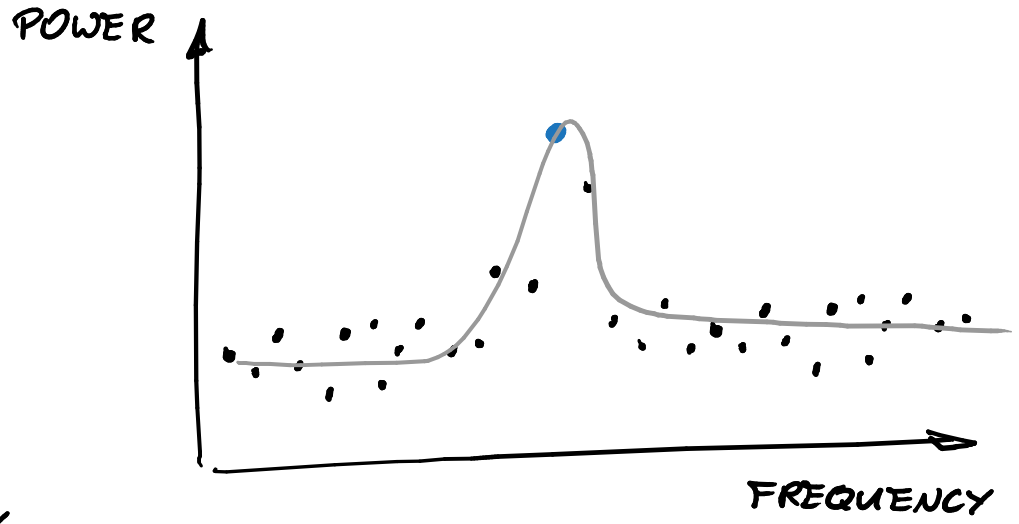

VALUE
TIME


VALUE
$A \sin(2\pi f t) + B \cos(2\pi f t) + C$
TIME

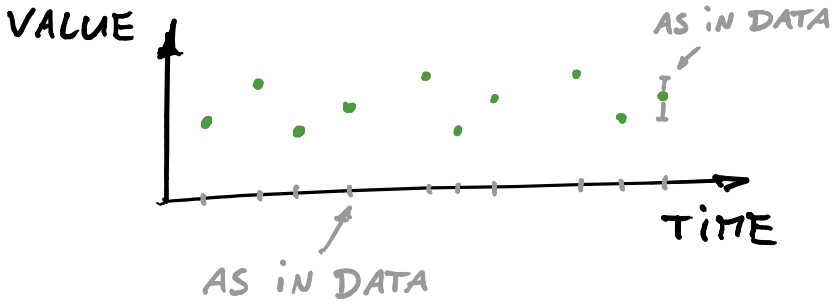

POWER
$\frac{N}{4}(A^2+B^2)$
f
FREQUENCY

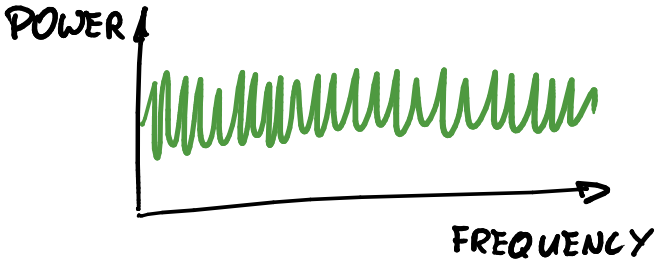

POWER
FREQUENCY

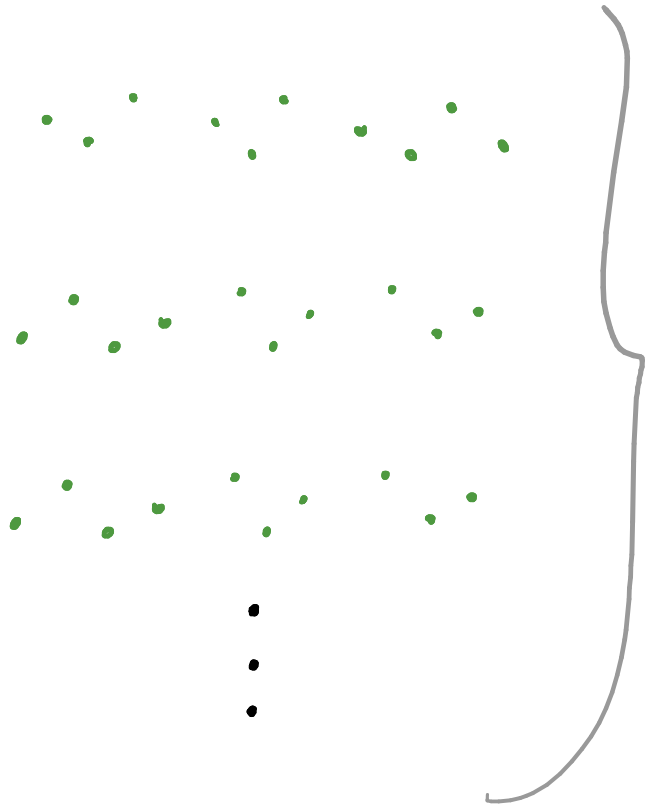
IS THERE AN OSCILLATION?

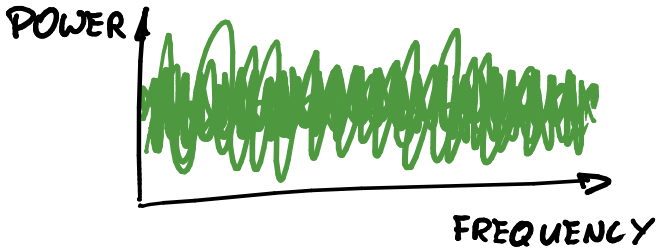
TEST NULL HYPOTHESIS COMPATIBILITY WITH DATA

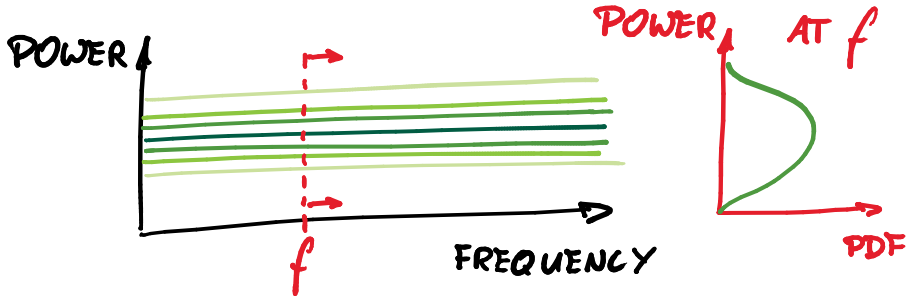
ASSUME H_0





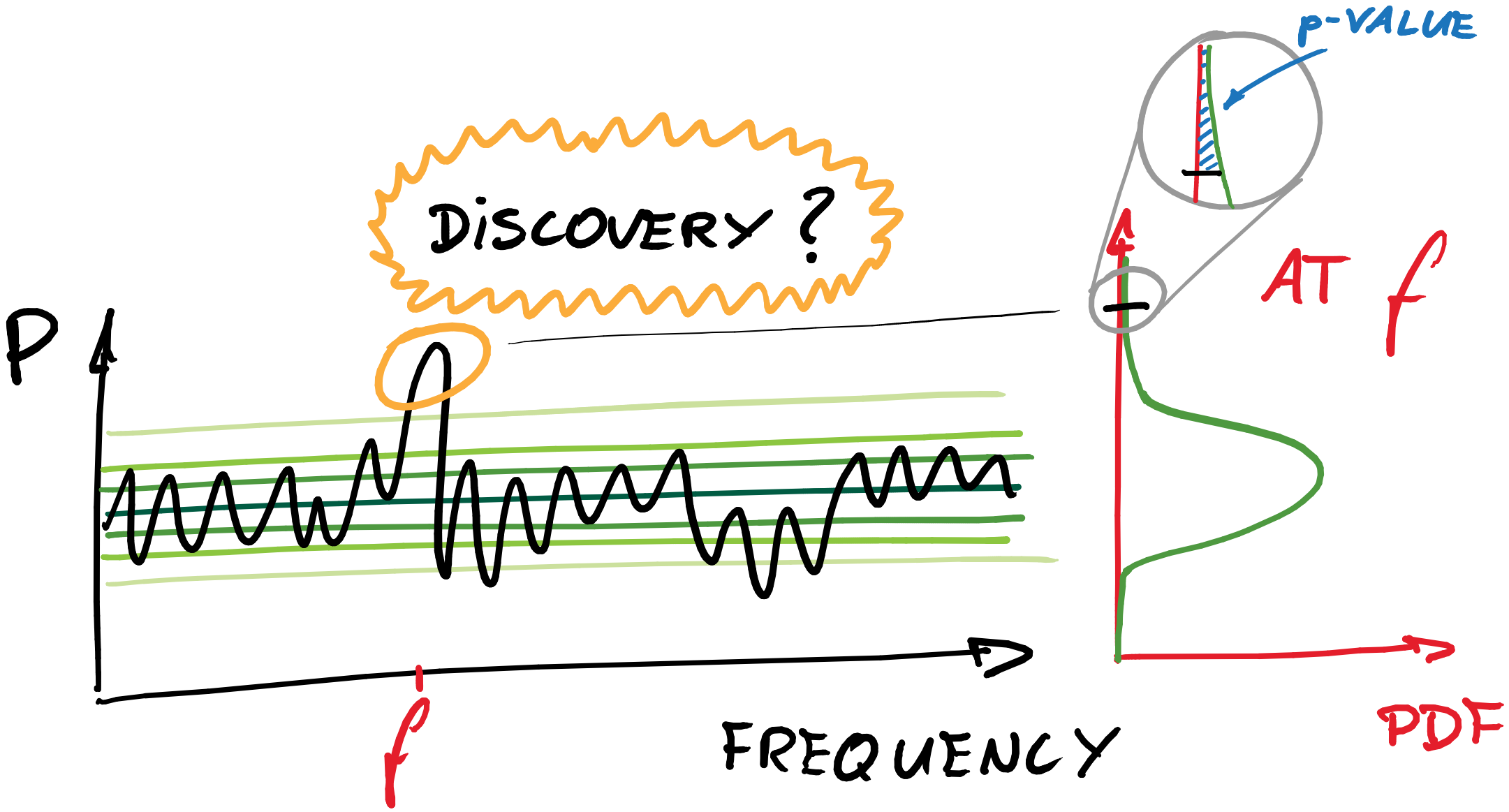


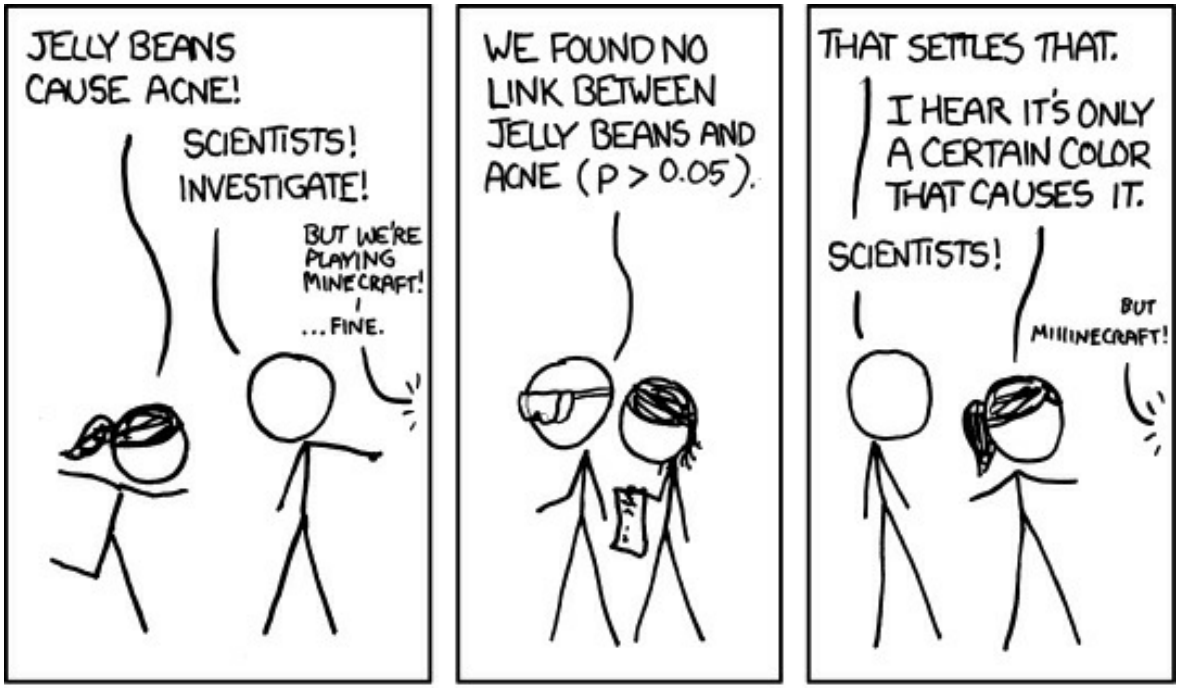


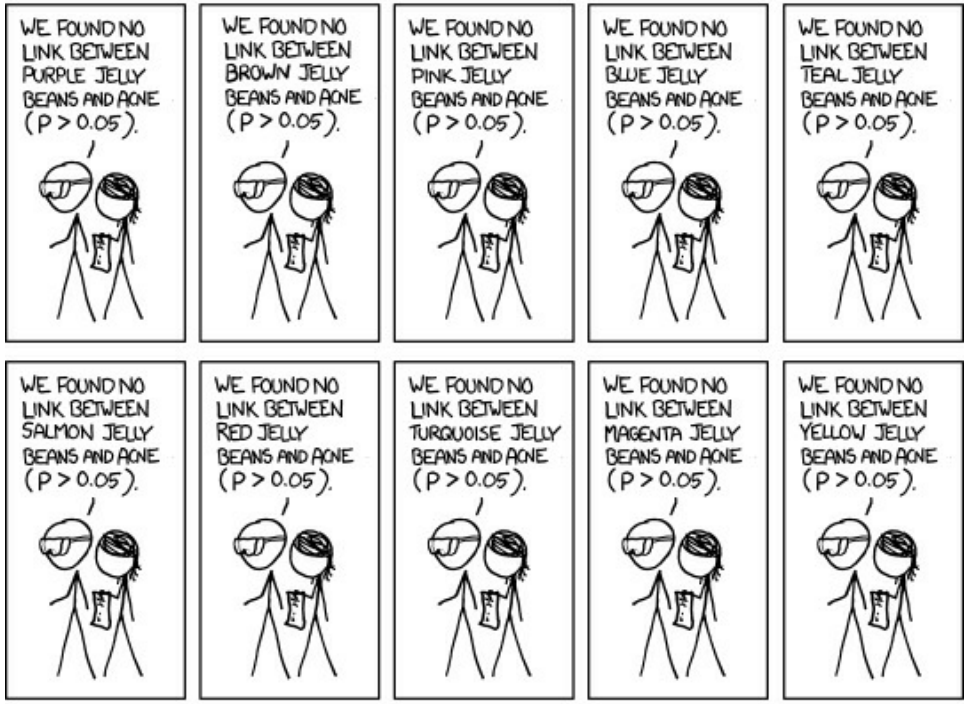


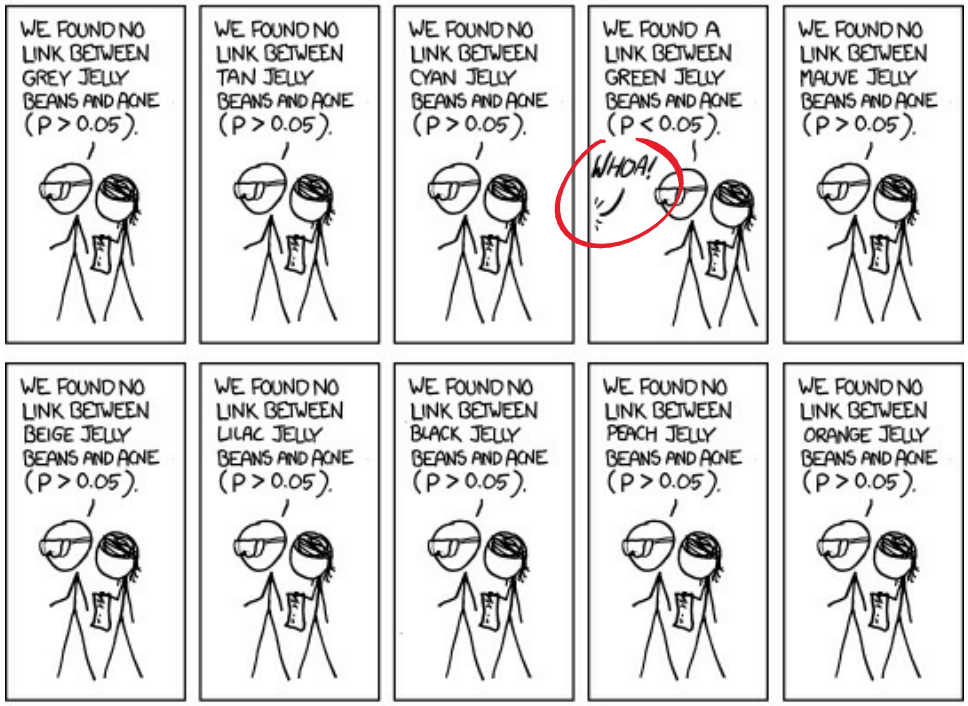
IS THERE AN OSCILLATION?

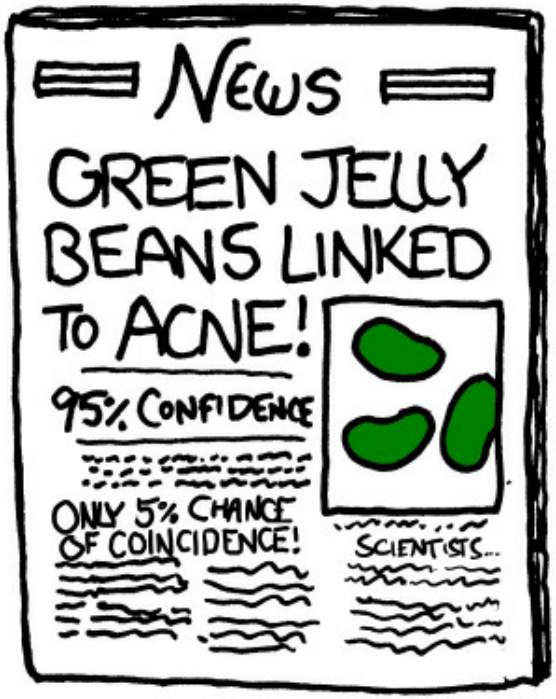
TEST NULL HYPOTHESIS COMPATIBILITY WITH DATA




JELLY BEANS CAUSE ACNE!
SCIENTISTS! INVESTIGATE!
BUT WE'RE PLAYING MINECRAFT!
...FINE.
WE FOUND NO LINK BETWEEN JELLY BEANS AND ACNE (P > 0.05).
THAT SETTLES THAT.
I HEAR IT'S ONLY A CERTAIN COLOR THAT CAUSES IT.
SCIENTISTS!
BUT MILLINECRAFT!

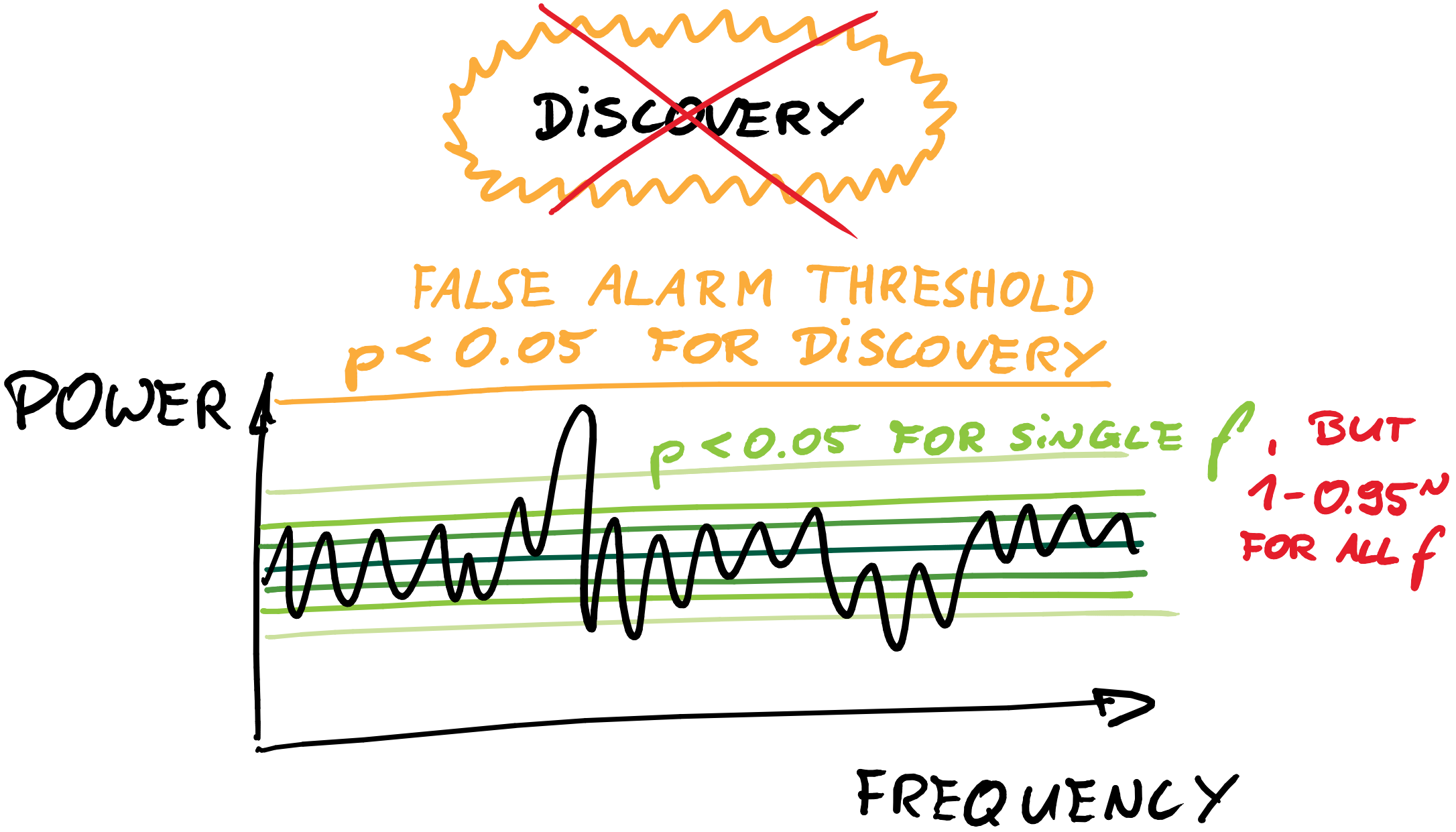

WE FOUND NO LINK BETWEEN PURPLE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BROWN JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN PINK JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BLUE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN TEAL JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN SALMON JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN RED JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN TURQUOISE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN MAGENTA JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN YELLOW JELLY BEANS AND ACNE (P > 0.05).


WE FOUND NO LINK BETWEEN GREY JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN TAN JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN CYAN JELLY BEANS AND ACNE (P > 0.05).
WE FOUND A LINK BETWEEN GREEN JELLY BEANS AND ACNE (P < 0.05).
WHOA!
WE FOUND NO LINK BETWEEN MAUVE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BEIGE JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN LILAC JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN BLACK JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN PEACH JELLY BEANS AND ACNE (P > 0.05).
WE FOUND NO LINK BETWEEN ORANGE JELLY BEANS AND ACNE (P > 0.05).


News
GREEN JELLY BEANS LINKED TO ACNE!
95% CONFIDENCE
ONLY 5% CHANCE OF COINCIDENCE!
SCIENTISTS...

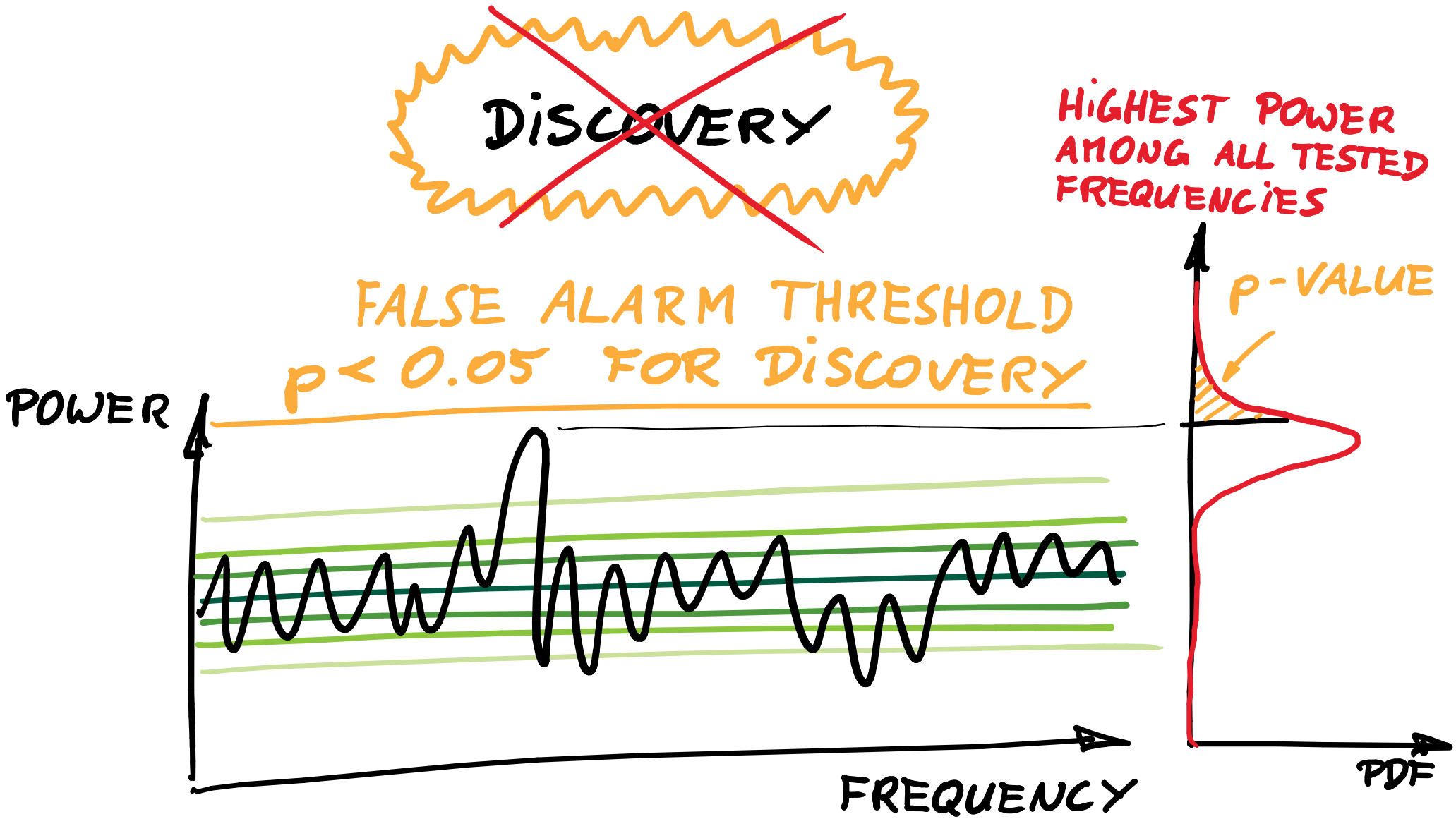
IS THERE AN OSCILLATION?

TEST NULL HYPOTHESIS COMPATIBILITY WITH DATA

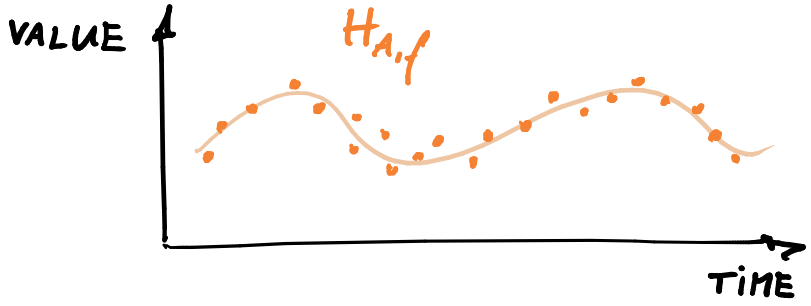


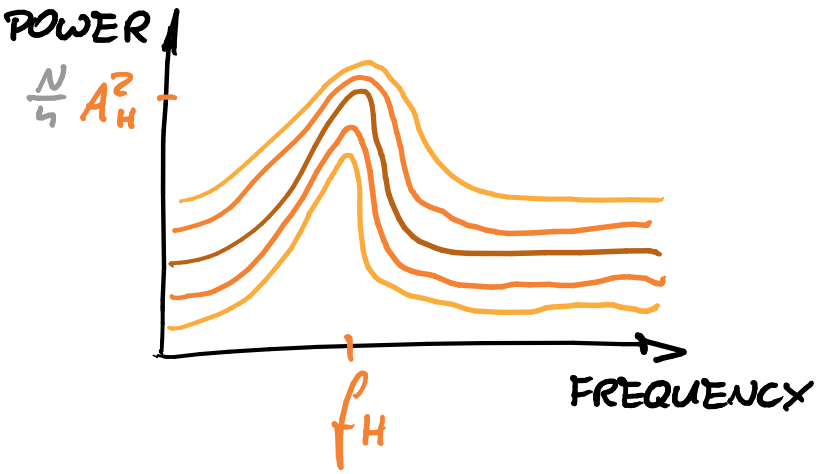
IS THERE AN OSCILLATION?

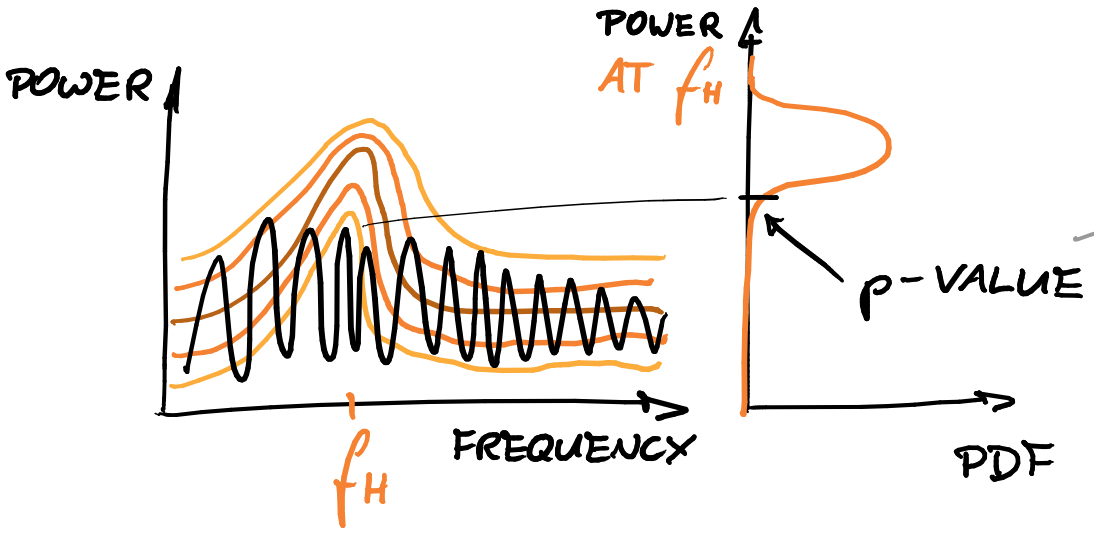
TEST NULL HYPOTHESIS COMPATIBILITY WITH DATA

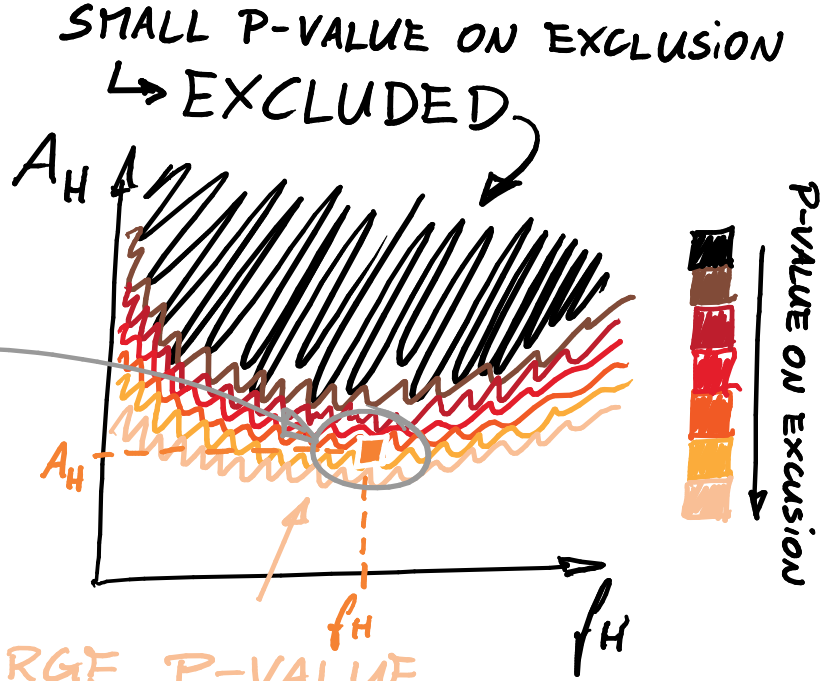


WHAT CAN BE EXCLUDED?

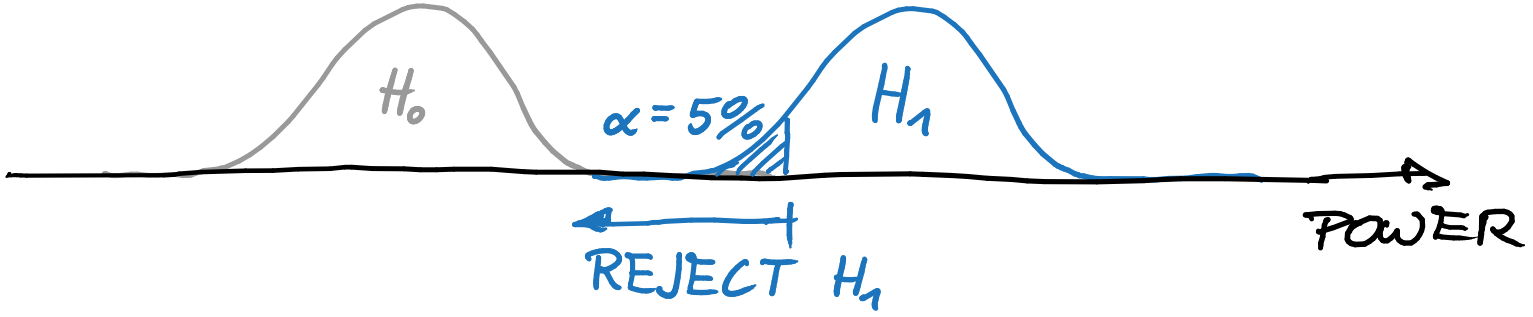




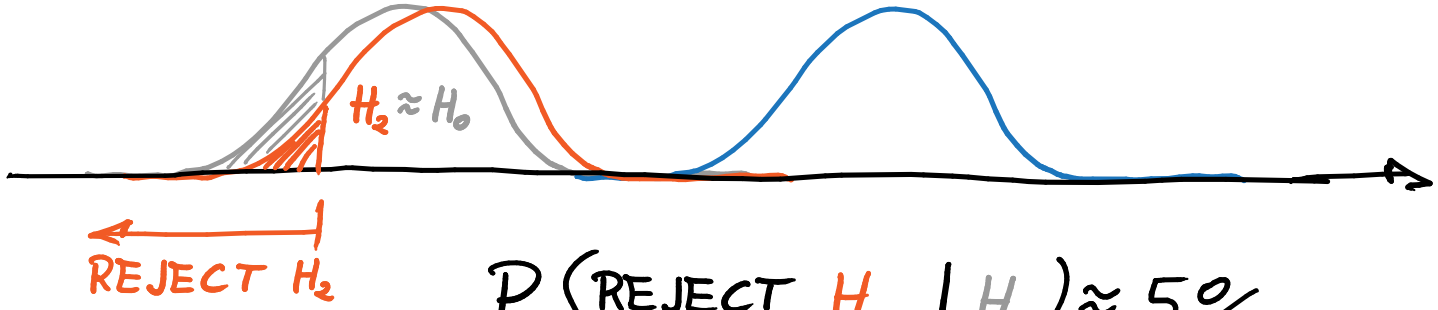




LARGE P-VALUE
↳ CAN'T EXCLUDE



$$P(\text{REJECT } H_1 \mid H_0) \approx 1$$



$$P(\text{REJECT } H_2 \mid H_0) \approx 5\%$$
$$P(\text{REJECT } H_0 \mid H_0) = 5\% \quad (\text{C.L. } 95\%)$$

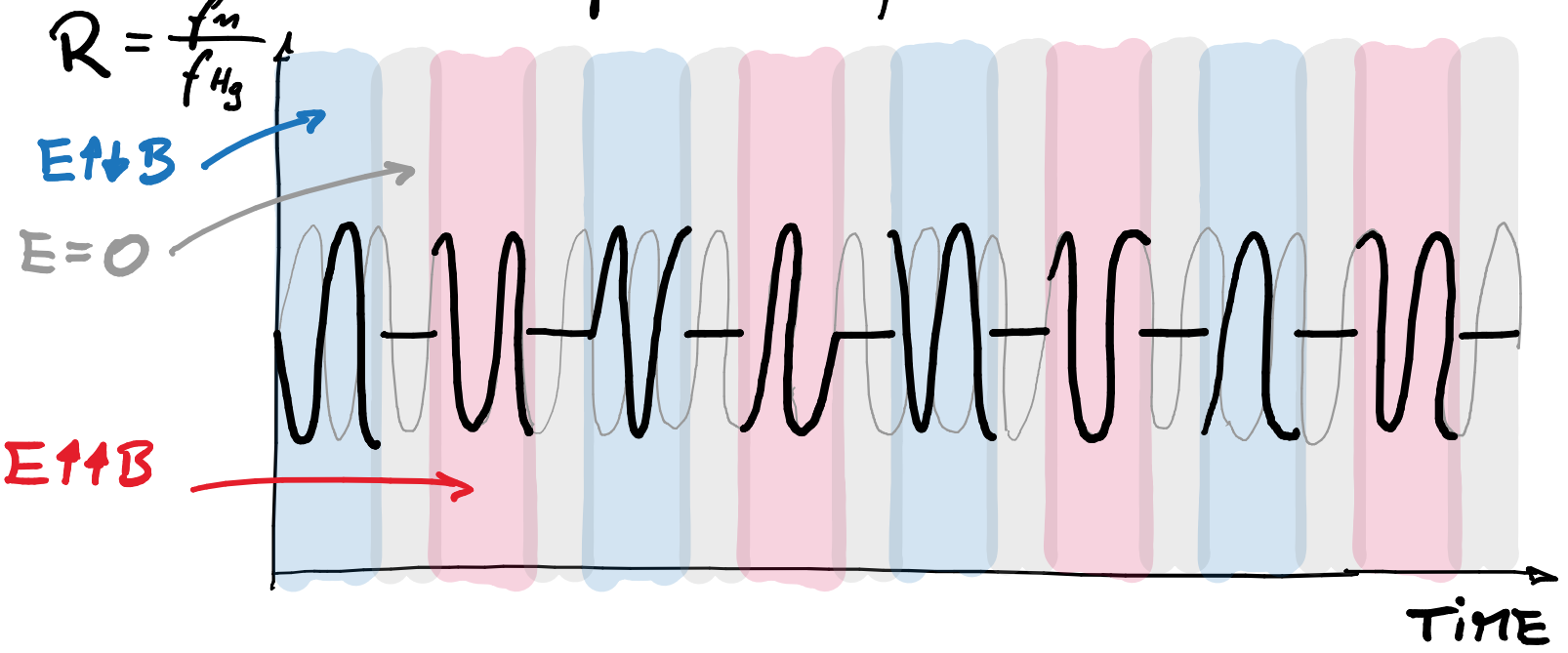
$$p_{H_1} \rightarrow CL_S^{H_1} := \frac{p_{H_1}}{p_{H_0}} = \frac{0.05}{\approx 1} \approx 0.05$$

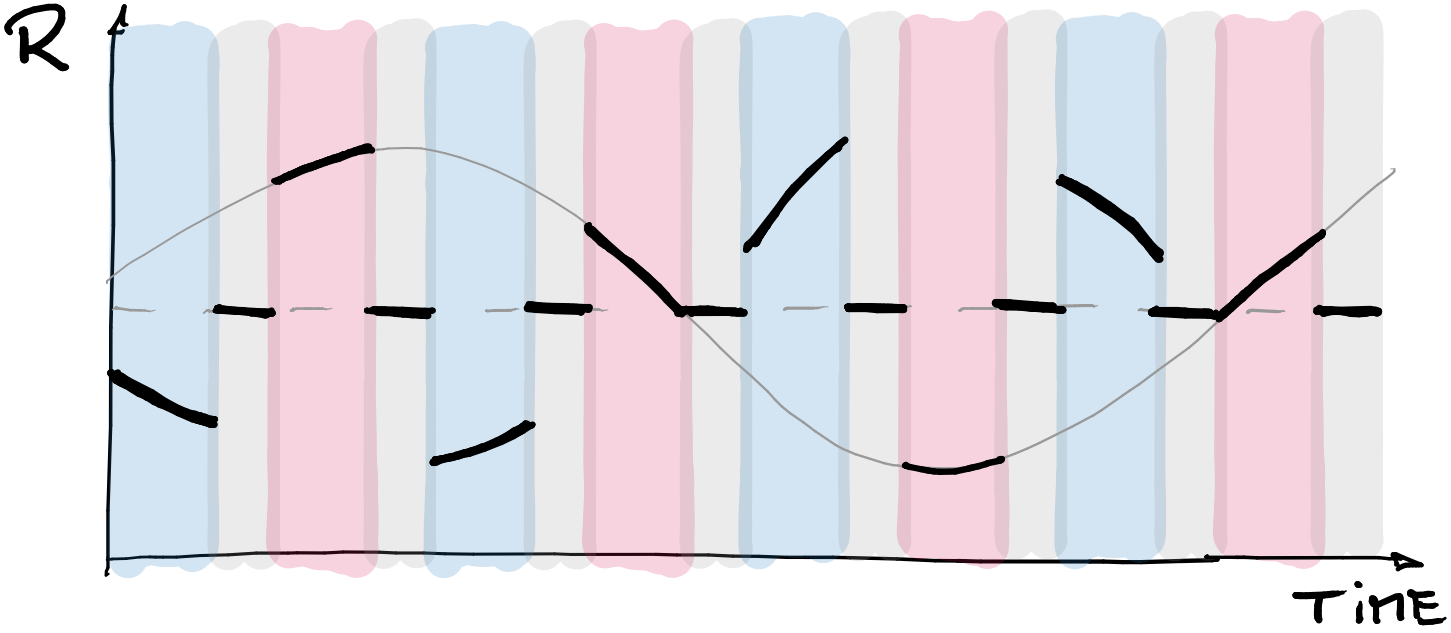
$$p_{H_2} \rightarrow CL_S^{H_2} = \frac{p_{H_2}}{p_{H_0}} = \frac{0.05}{\approx 0.05} \approx 1$$

NEVER SMALL

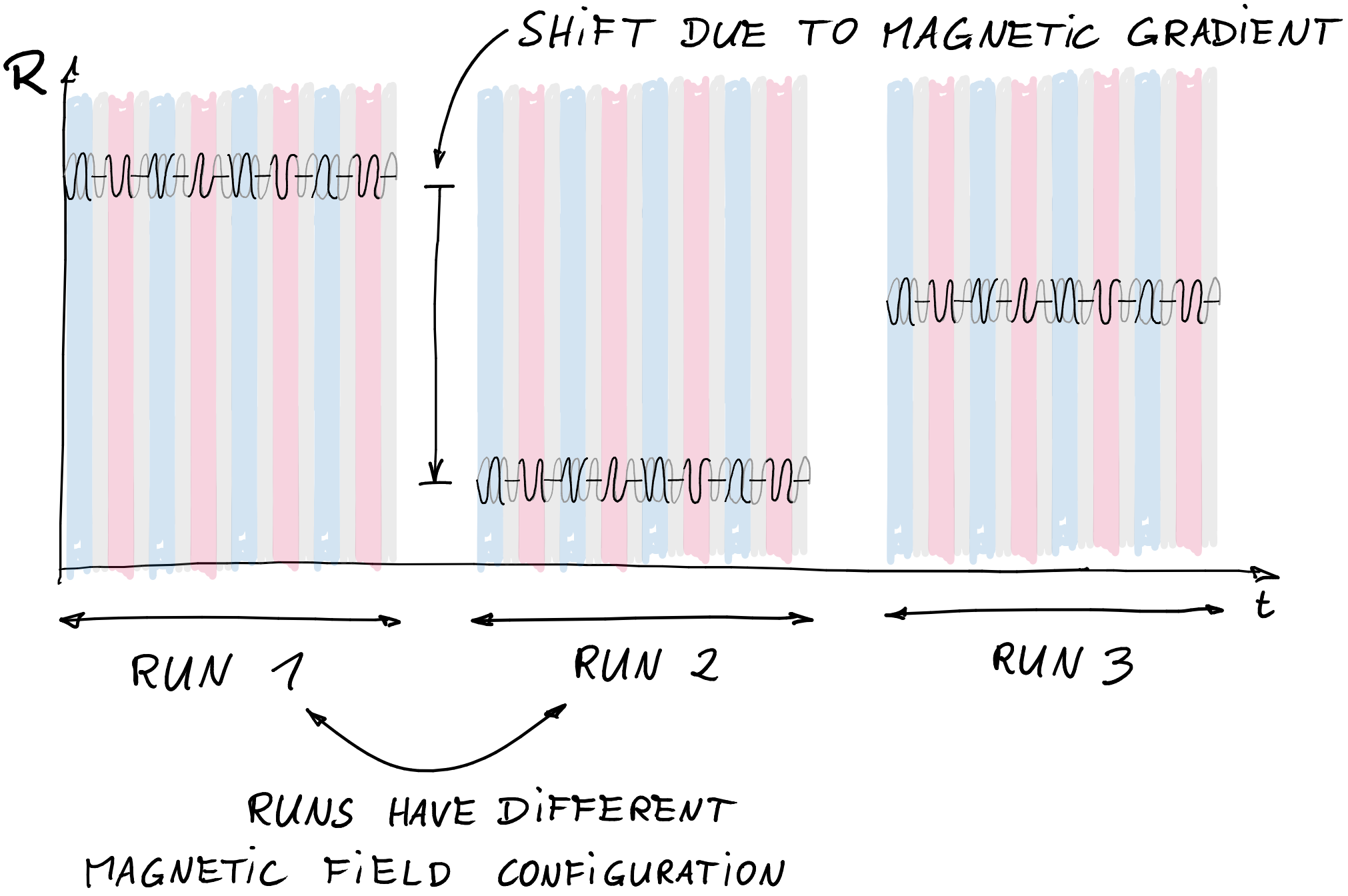
HOW WOULD THE SIGNAL LOOK?

$$h f_m^{\uparrow\downarrow/\downarrow\uparrow} = 2\left|\vec{\mu}_m \cdot \vec{B} \pm \vec{d}_m \cdot \vec{E}\right|$$

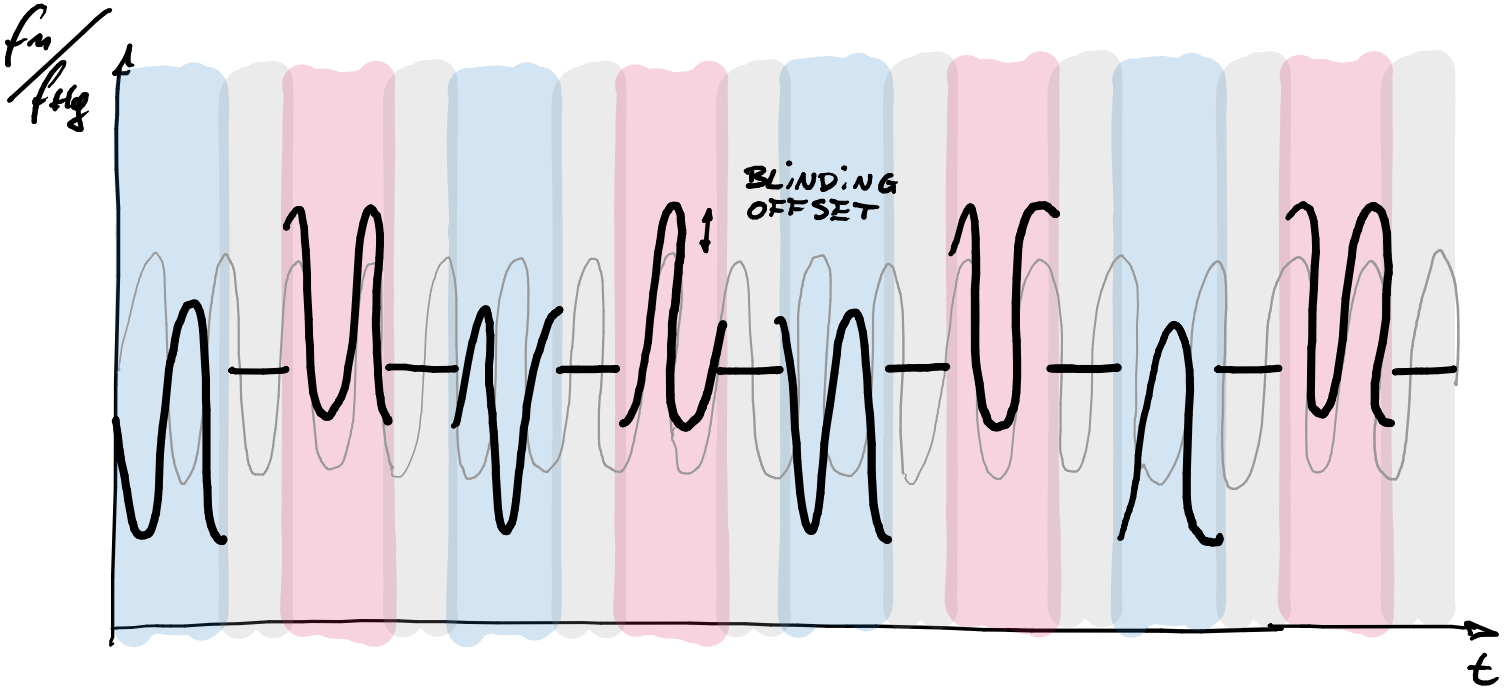


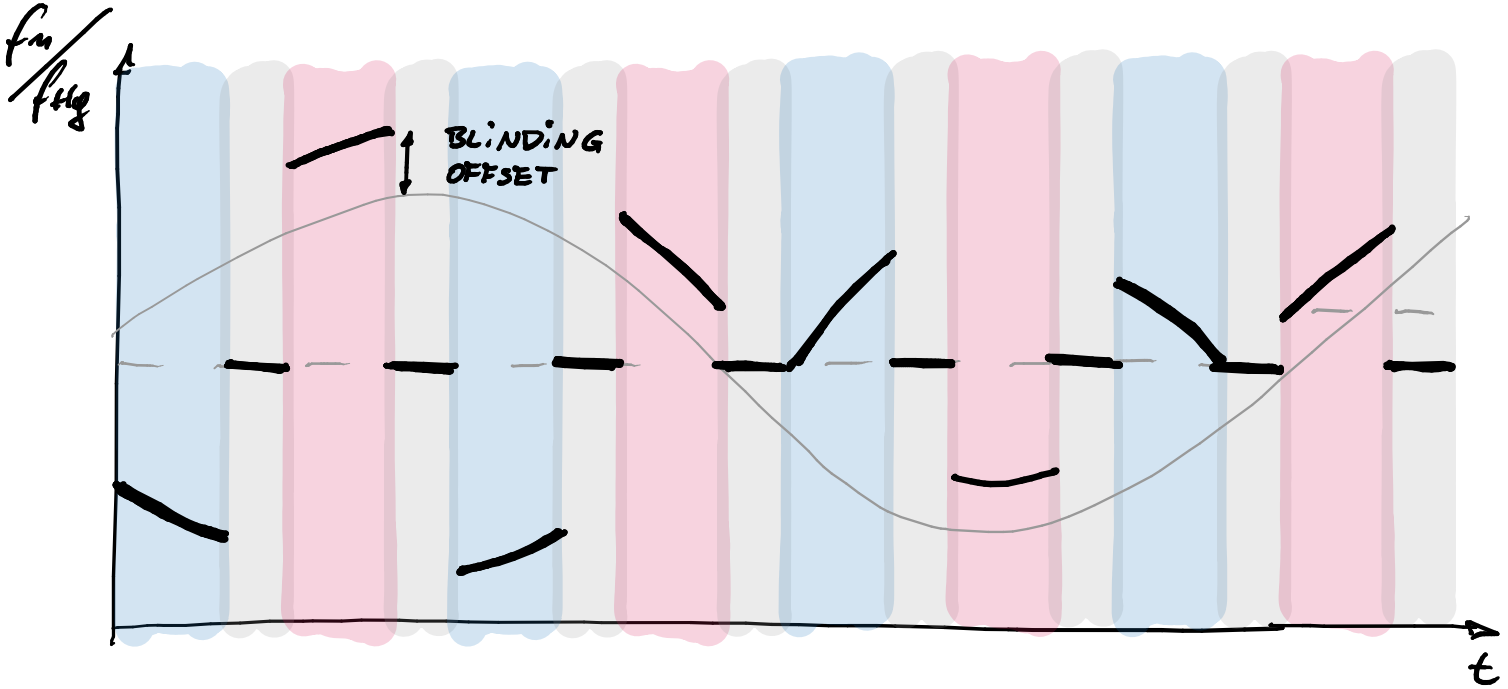


HOW WOULD THE SIGNAL LOOK?



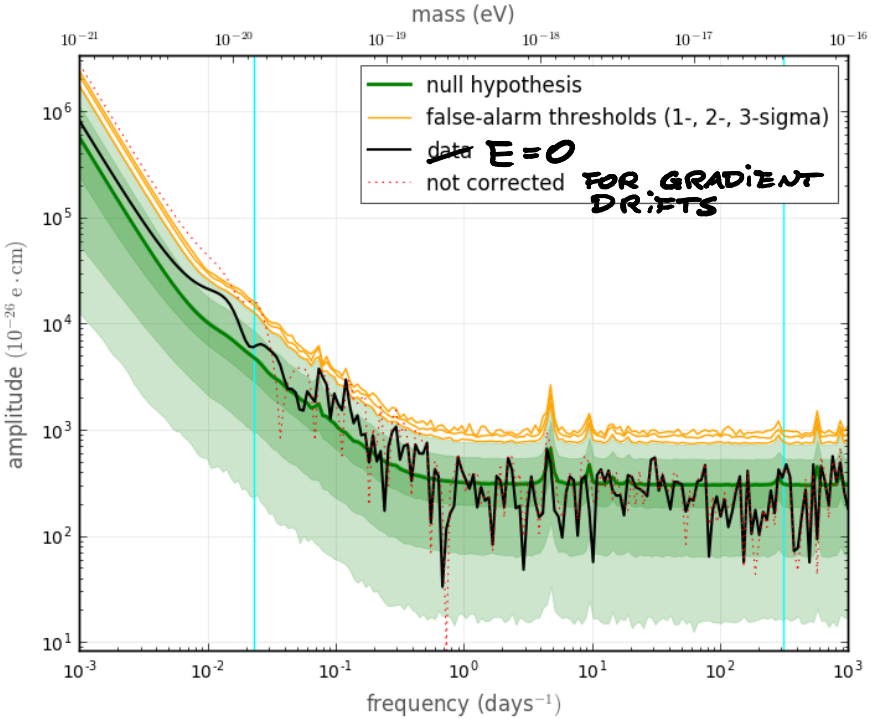
HOW WOULD THE SIGNAL LOOK?

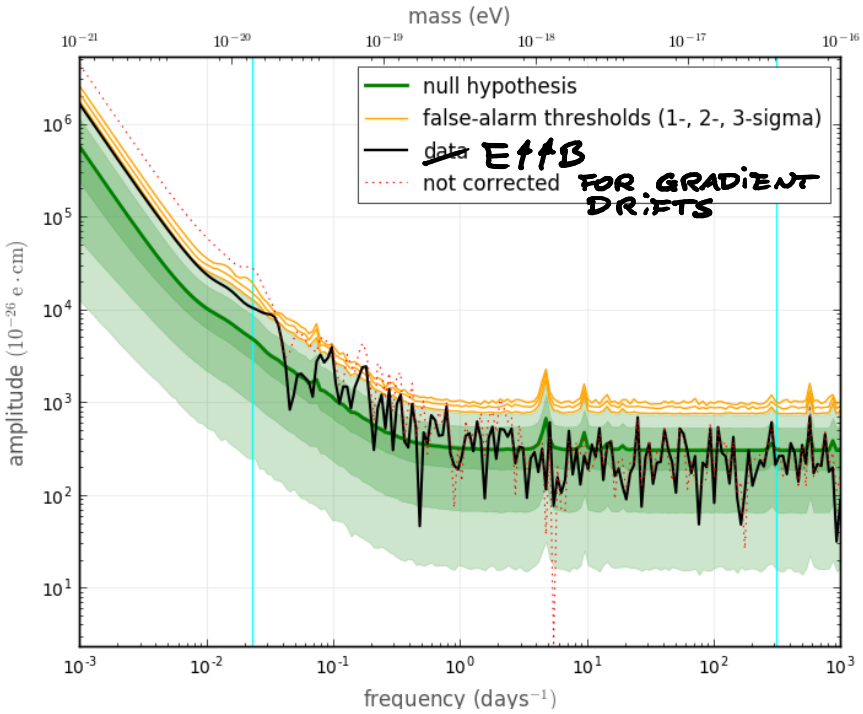


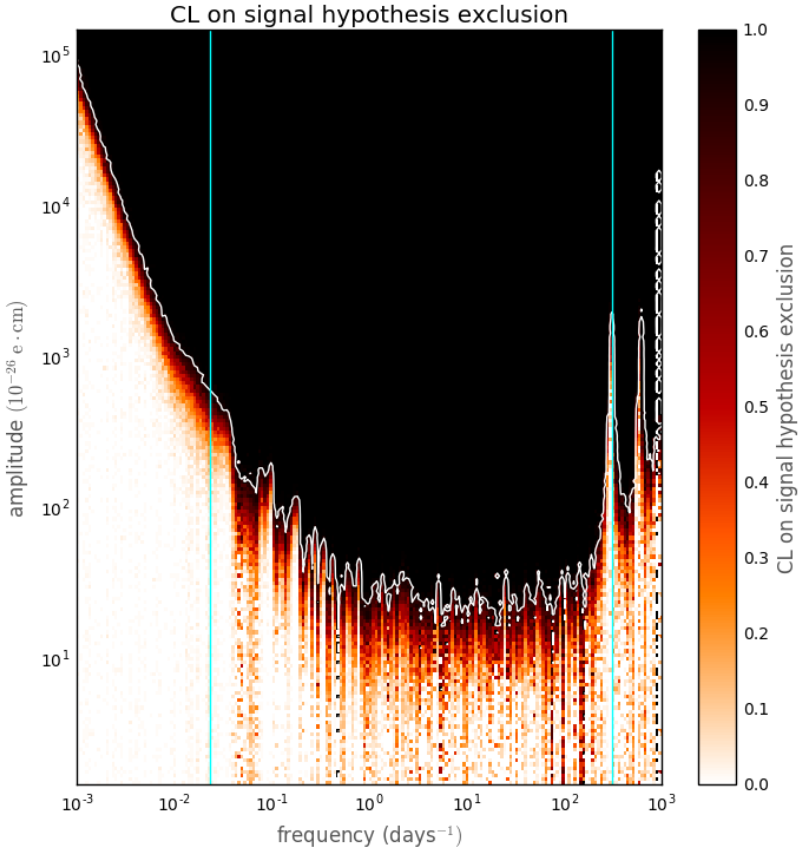


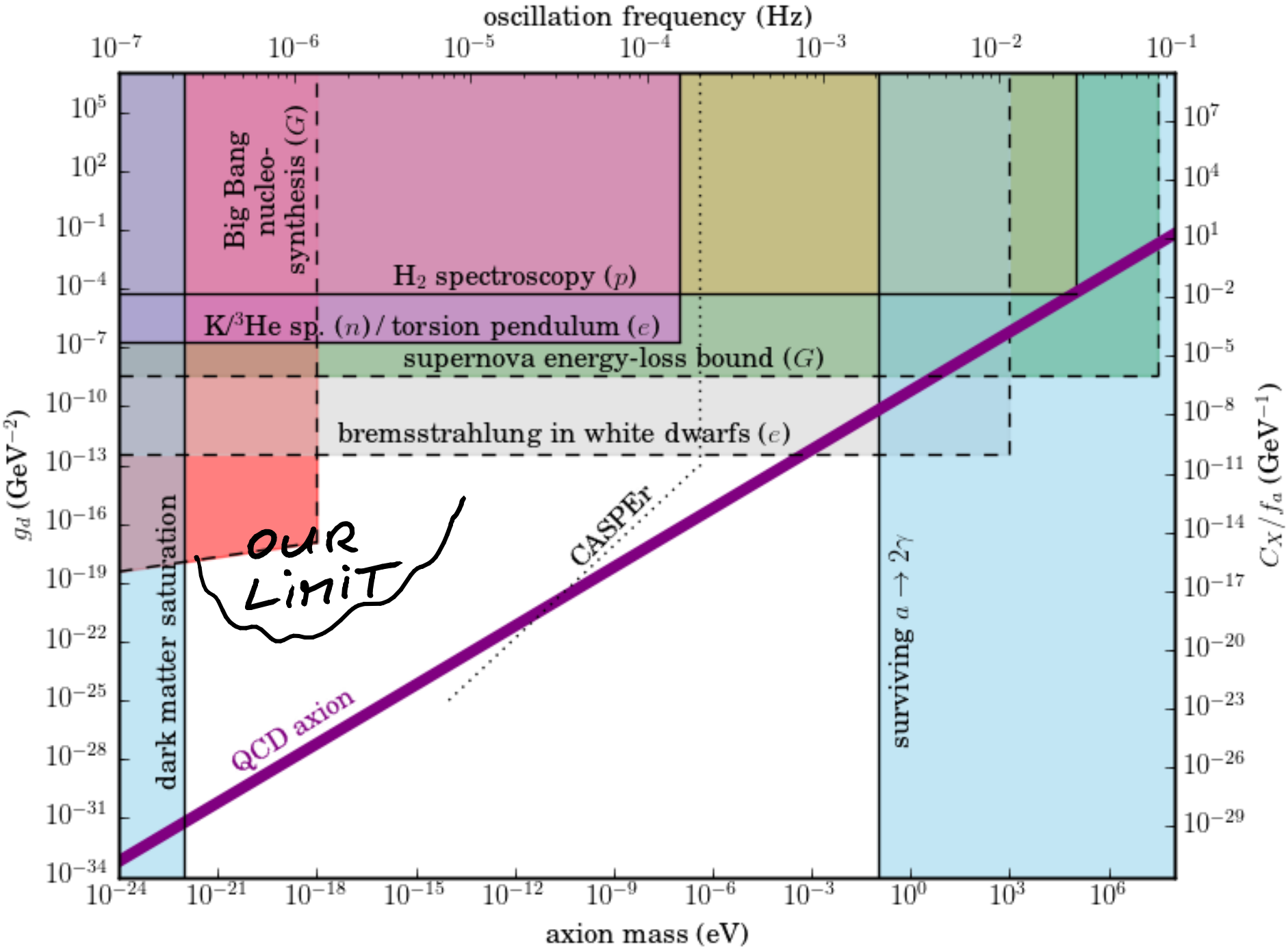
- ANALYSE $E=0$, $E \uparrow\downarrow B$, $E \perp B$ SEPARATELY
- IN FIT HAVE A SEPARATE OFFSET IN EACH RUN
- CORRECT FOR IN-RUN GRADIENT FLUCTUATIONS WITH CESIUMS DATA
- OSCILLATION AVERAGED OVER TIME BETWEEN $\pi/2$ PULSES

40 DAYS OF DATA ANALYSED








oscillation frequency (Hz)
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
Big Bang nucleo-synthesis (G)
H_2 spectroscopy (p)
K/^{3}He sp. (n) / torsion pendulum (e)
supernova energy-loss bound (G)
bremsstrahlung in white dwarfs (e)
dark matter saturation
OUR LIMIT
CASPEr
QCD axion
surviving $a \to 2\gamma$
g_d (GeV^{-2})
C_X/f_a (GeV^{-1})
axion mass (eV)
10^{-24}
10^{-21}
10^{-18}
10^{-15}
10^{-12}
10^{-9}
10^{-6}
10^{-3}
10^{0}
10^{3}
10^{6}

TO DO:

- REFINEMENT: USE REAL TIMES OF π/2 PULSES
- ALALYSE WHOLE DATASET
- MERGE RUNS (NEED INPUT FROM nEDM ANALYSIS)

AXION WIND