Discussion topics

1. Preparation for nTMM measurements in 2024 with CO2 gas with 2 magnets inside the GP-SANS guide box
2. Update on ESS developments
3. Correction for how large Δm can be
4. UCN paper plot with $\tau_{nn'}$ limits. Could it include Serebrov's B=0 limit?

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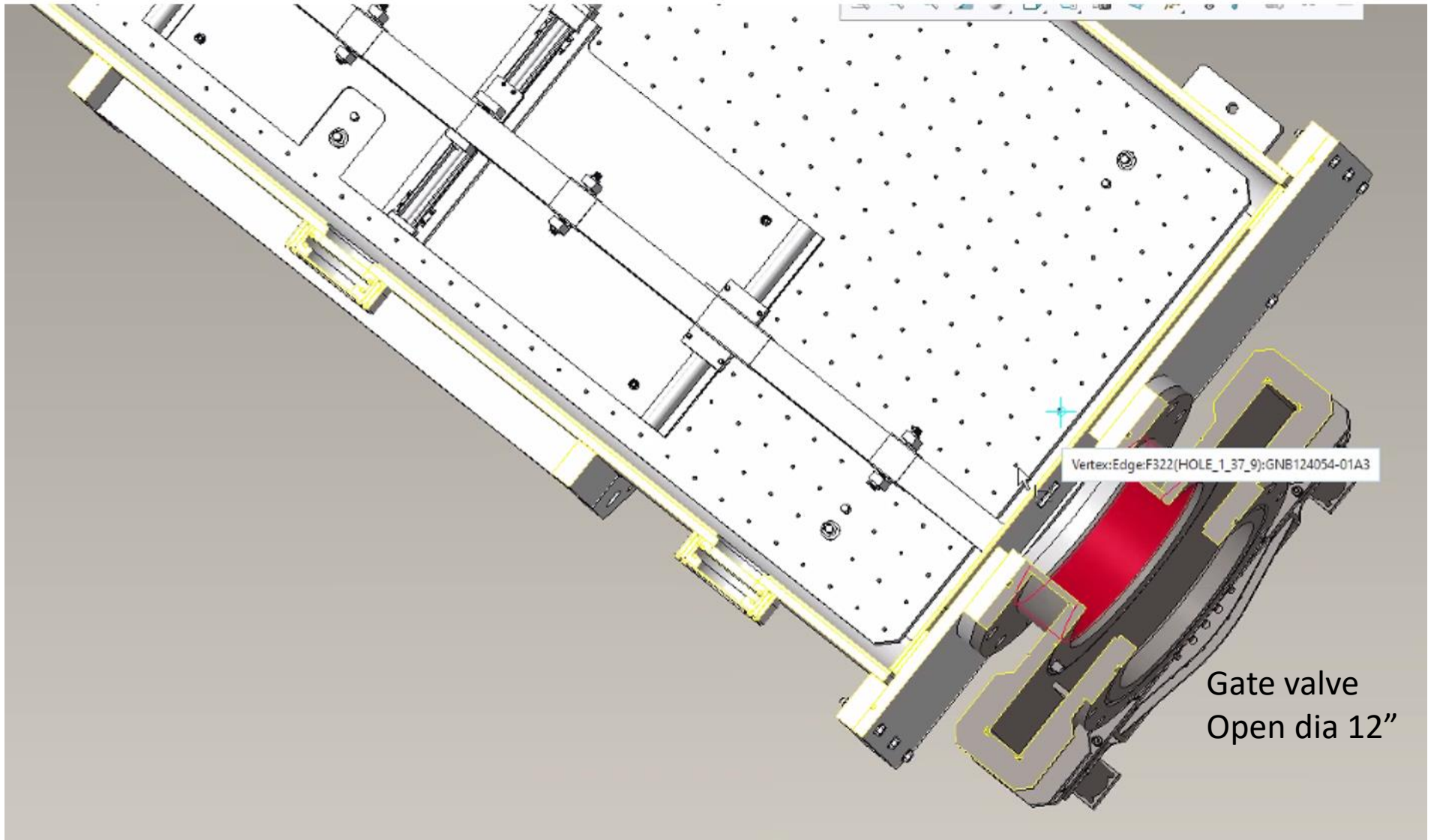
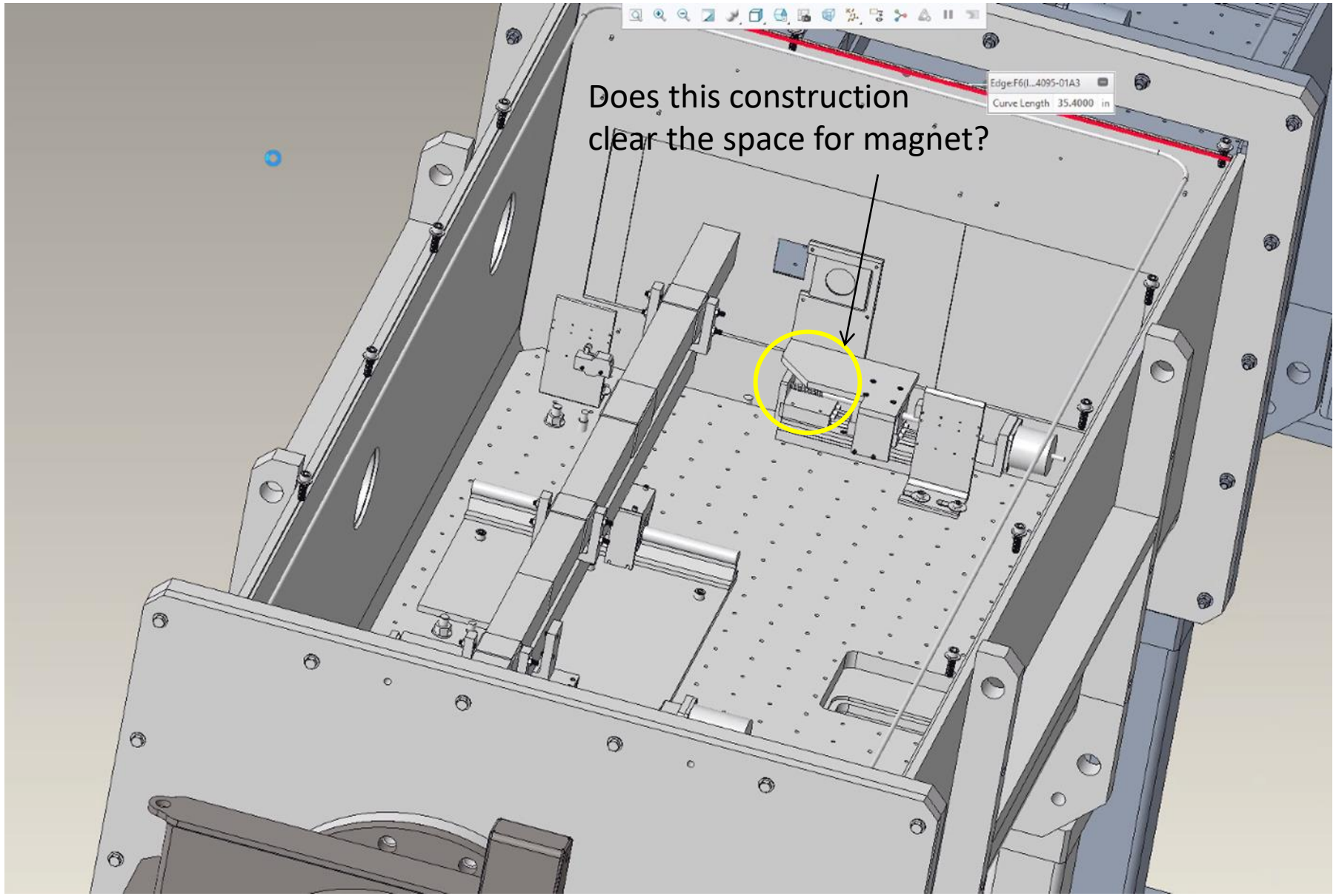
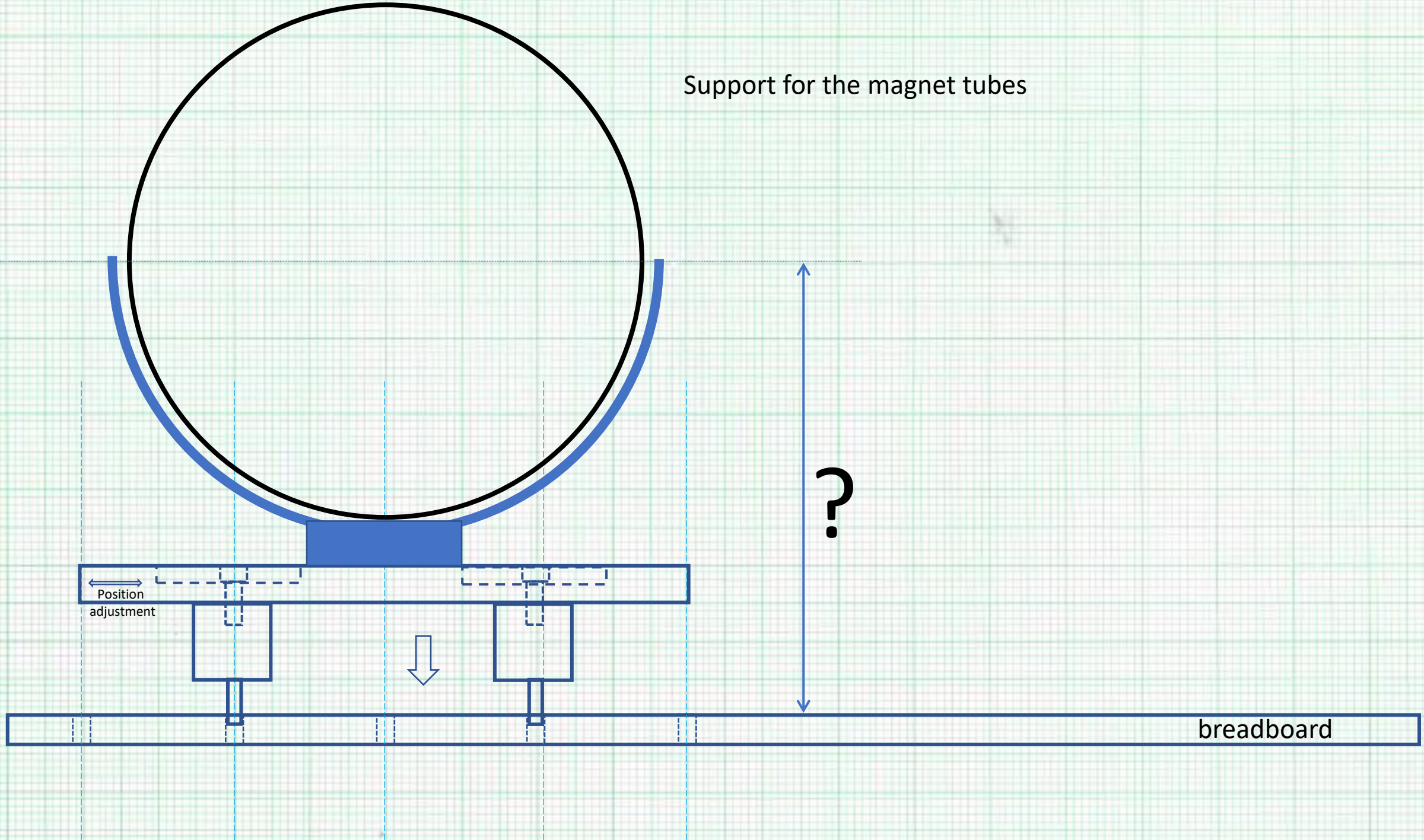
1

Study of drawings of GP-SANS guide boxes with Matt Frost




Does this construction
clear the space for magnet?
Edge:F6(I...4095-01A3
Curve Length 35.4000 in

Support for the magnet tubes

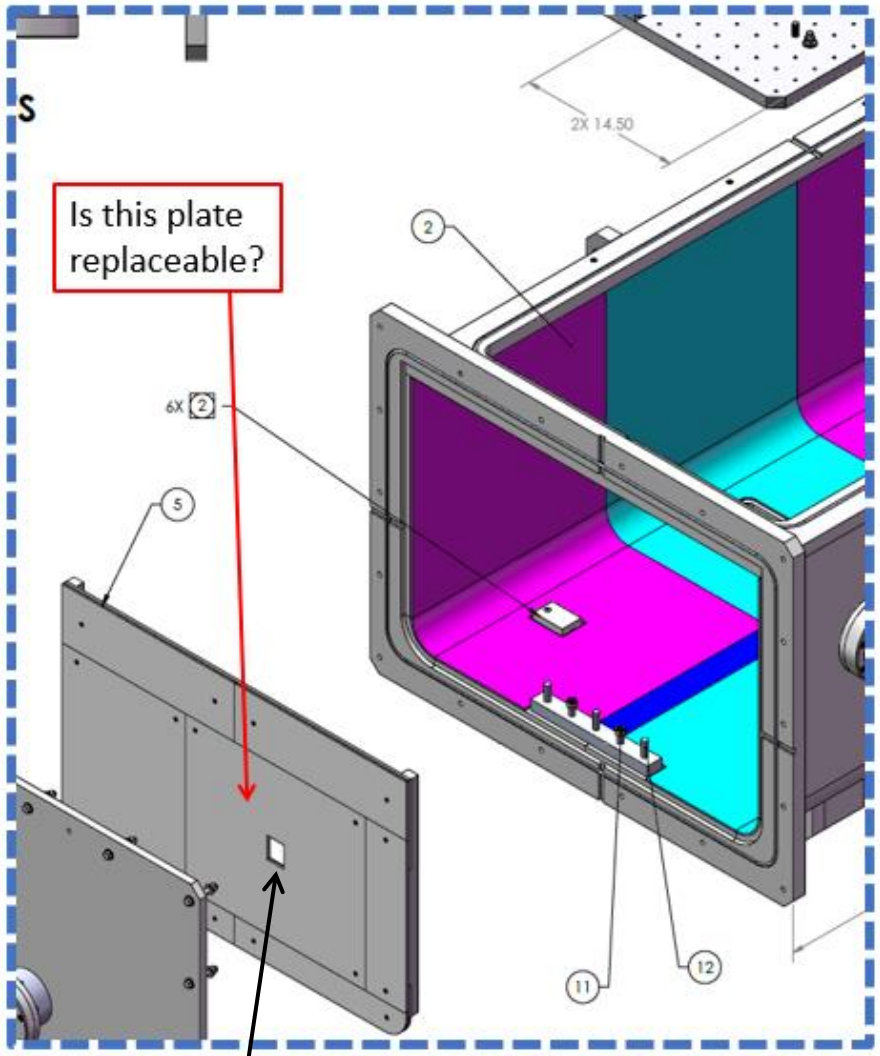


Question that is not yet understood for beam passing

There is a beam scraping hold in Cd(?) plate between Sections of guide box, even in front of rge exit gate valve in section 8 (with 12” opening)

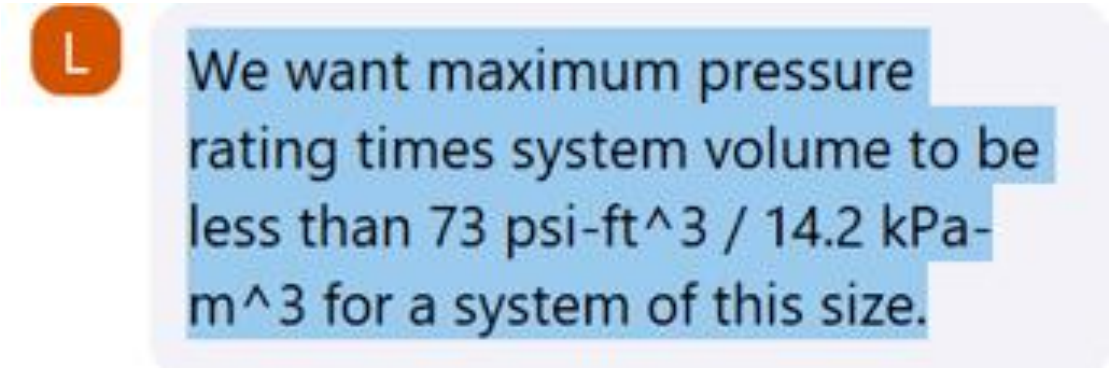
At the end of guide section 7:
Calculated x-y beam size: 6.4 x 7.6 cm2
Available beam scraper hole: 4.4 x 5.2 cm2

At the end of guide section 8:
Calculated x-y beam size: 9.2 x 11.6 cm2
Available beam scraper hole: 4.4 x 5.2 cm2



Beam scraper hole

Comment from Leah about pressure safety:



Let's calculate this limit for the proposed vessel:

Pressure 1.25 atm. Say, max pressure is 2 atm. → 203 kPa

Volume ID =6.75" and length 2 m → V=0.0462 m^3

$P \times V = 9.4\ kPa \cdot m^3 < 14.2\ kPa \cdot m^3$

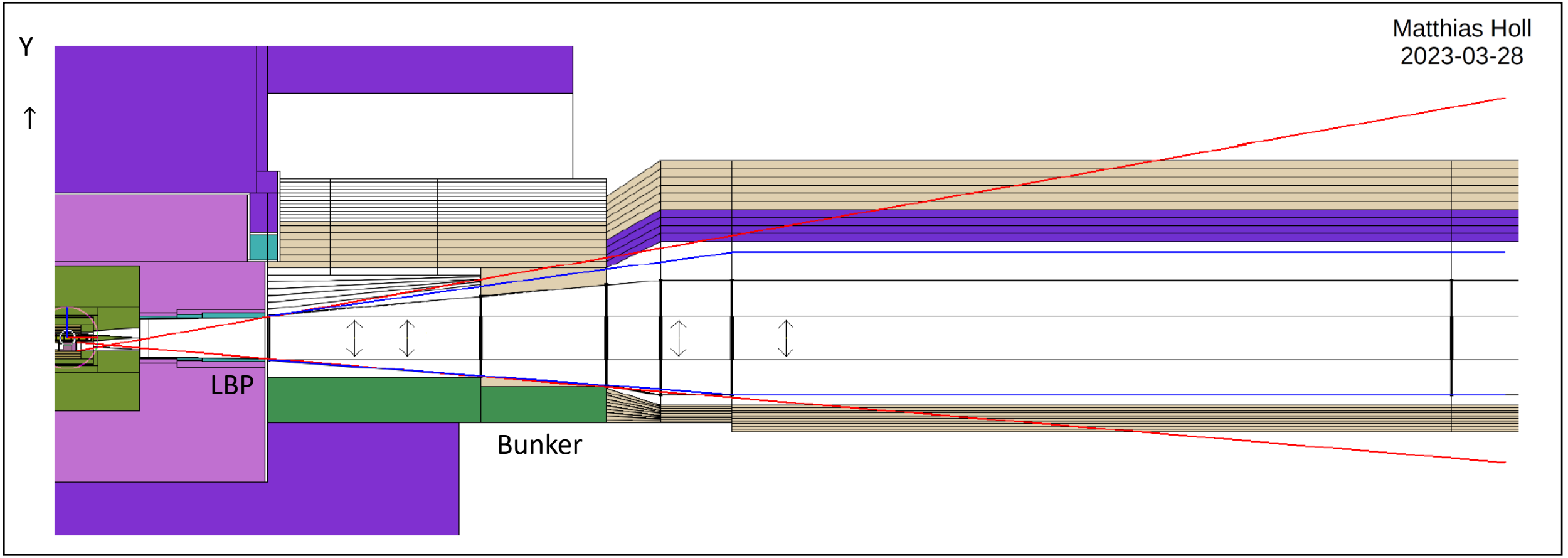
- With anticipated overpressure $\Delta p = 1.25\ atm$ at what excess pressure vessels should be tested?
- Since vessel is not a vacuum vessel, filling with CO_2 should be by long blowing through

Discussion with Chris Crawford today

- He is interested to participate in nTMM measurement at GP-SANS
- He might have better ideas how to make magnets
- It seems that he have resources for construction of 2 mags
- He has a lot of undergraduate students to build it

- We should invite Chris to one of our regular meetings dedicated to nTMM measurement at GP-SANS

2 ESS NNbar update

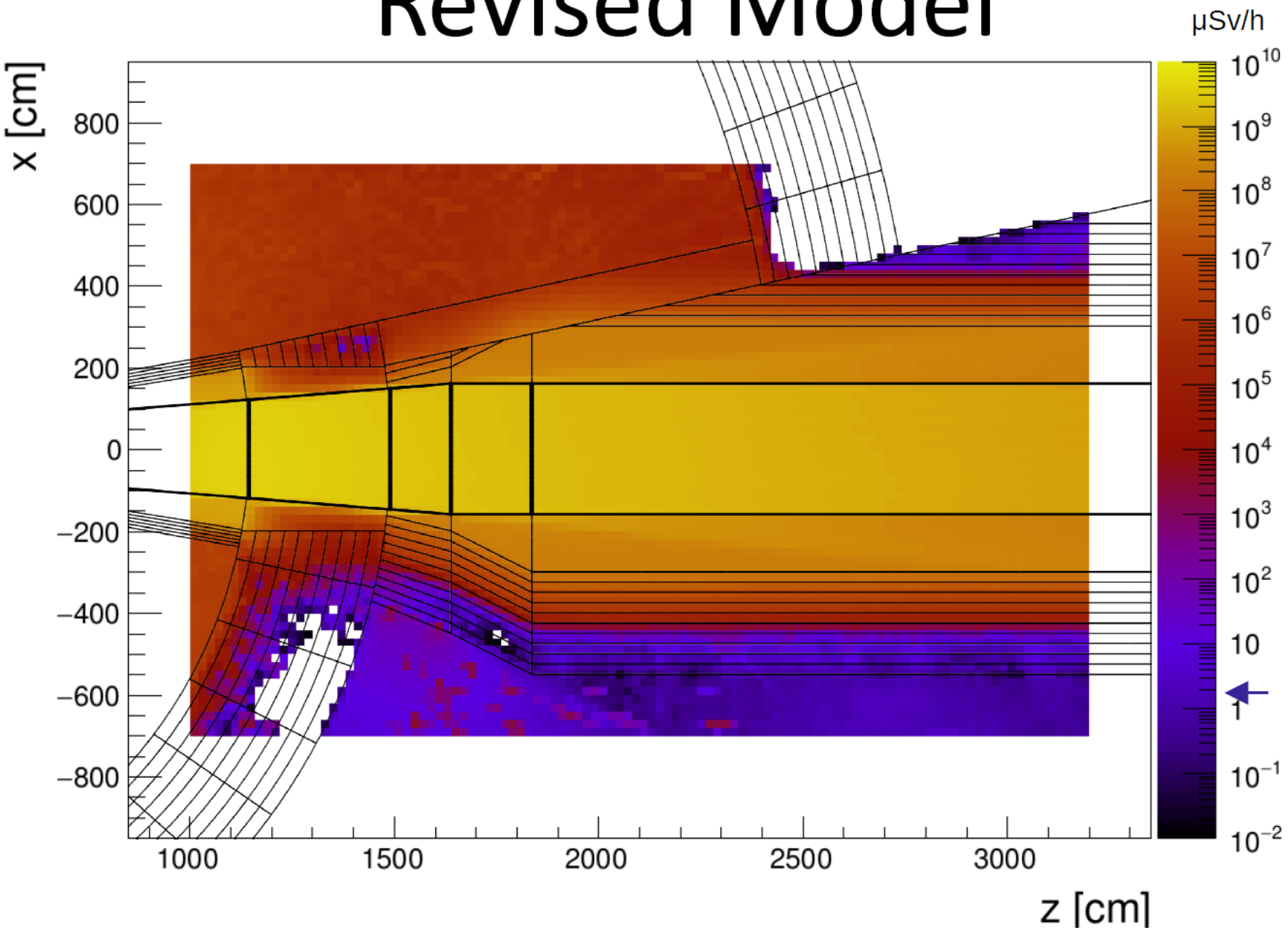


Recent developments

- Square x-section vacuum tube become round after bunker wall at 15 m
- main tube diameter 3m (tube + vacuum system cost might be approx. 7M€
- Reflector: Venetian Blinds (no access during ESS operation)
- Problem: Standard beam shutter is approx. 3 m long. Beam off needed for detector access at 200 m

Matthias Holl
2023-03-28

Revised Model



HIBEAM E6 beamline update

Two elliptic guides

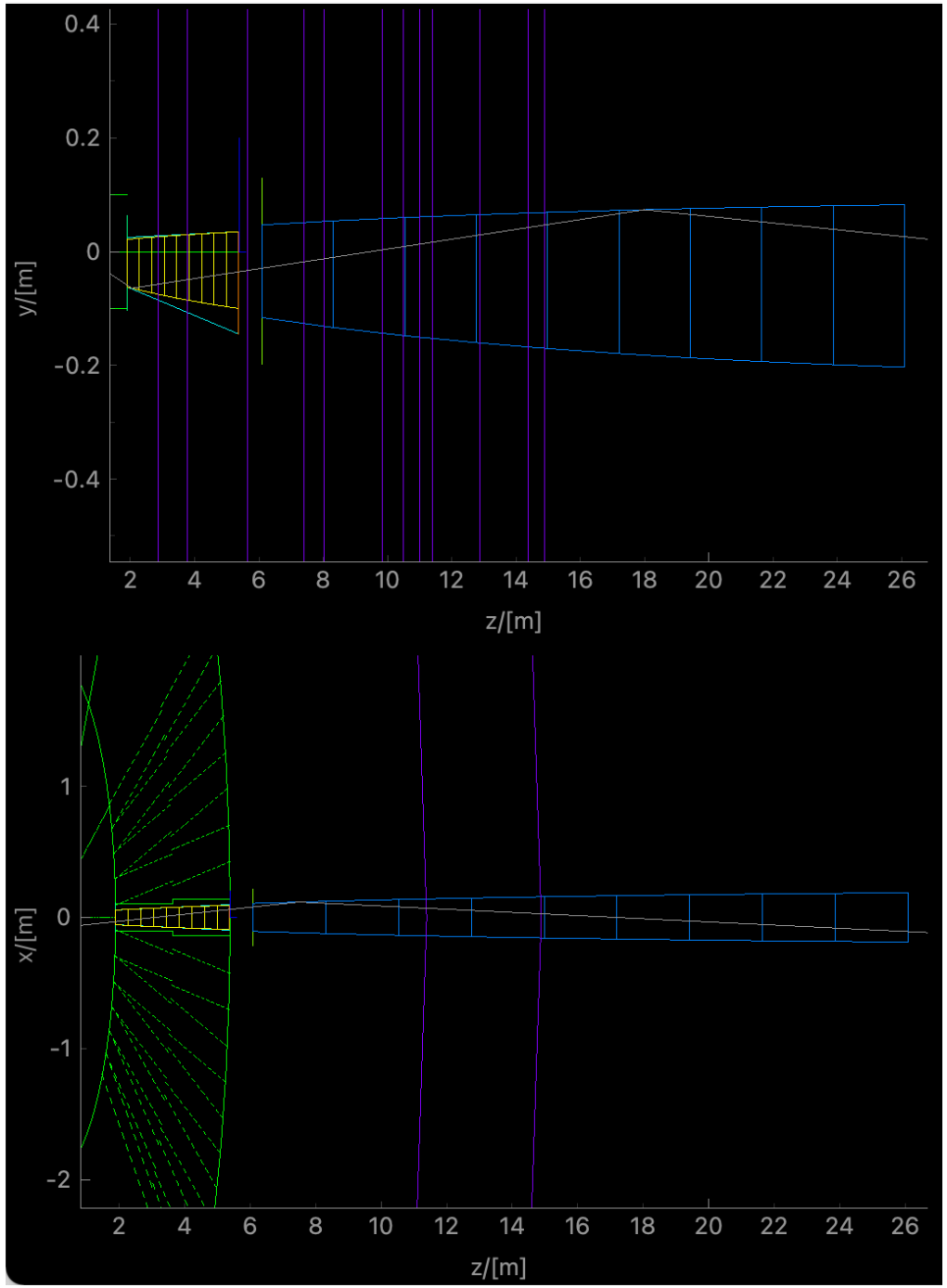
Monolith guide:

	Entry [mm]	Exit [mm]
x	[-57, 57]	[-92, 92]
y	[-62, 22]	[-100, 35]

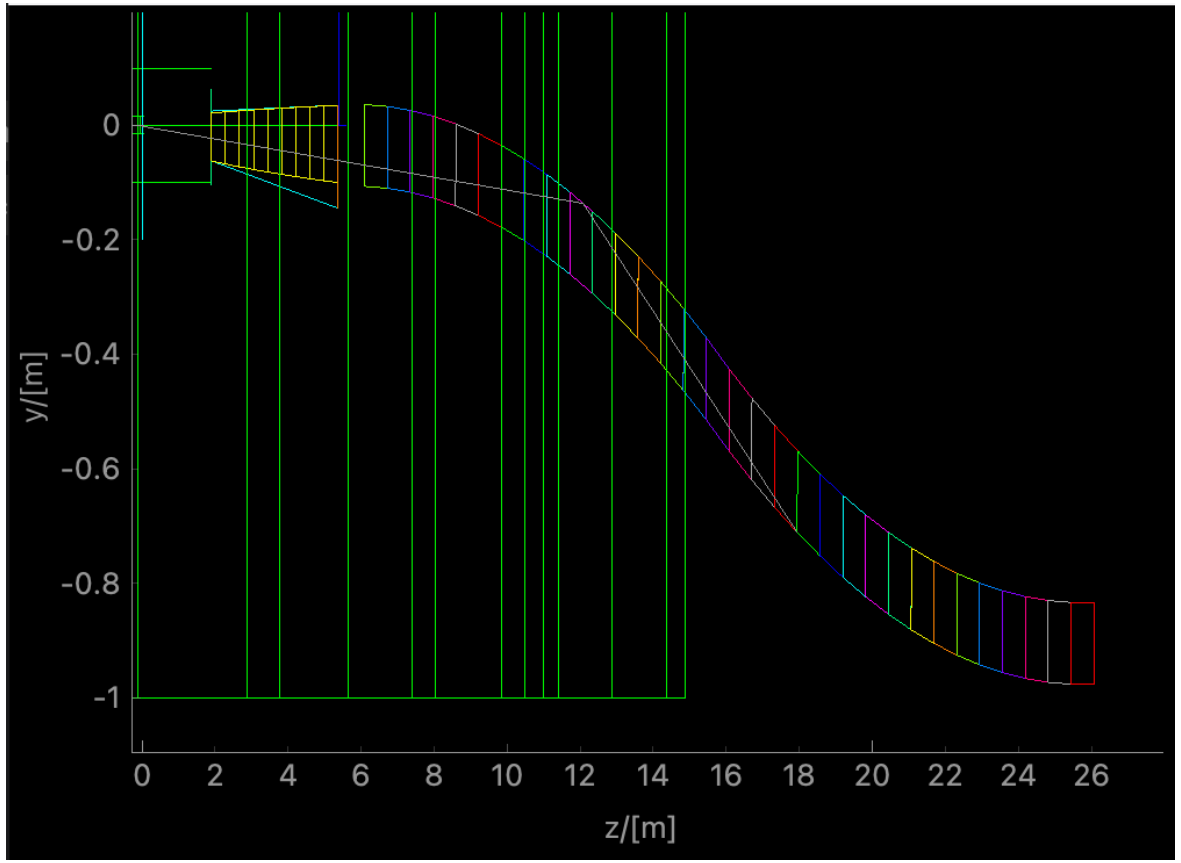
Second 20-m guide:

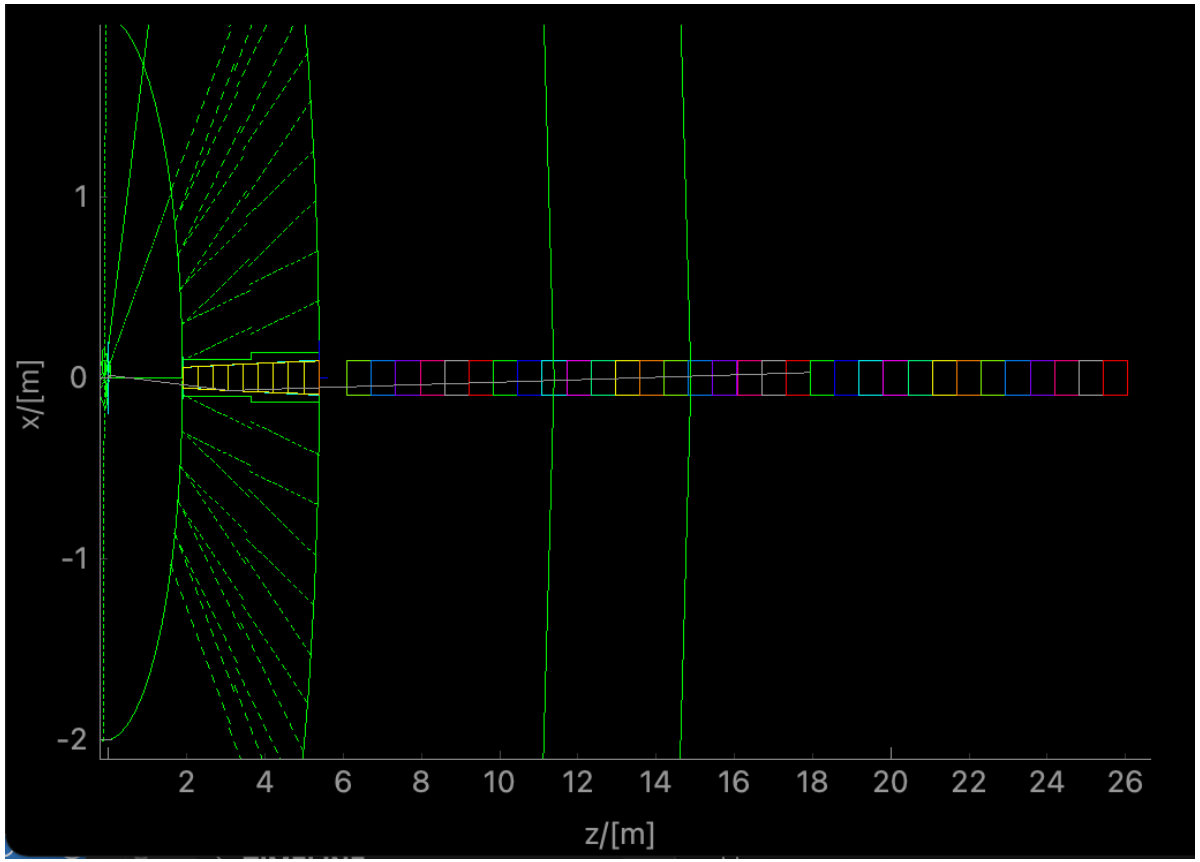
	Entry [mm]	Exit [mm]
x	[-110, 110]	[-190, 190]
y	[-120, 48]	[-200, 83]

Length of second guide 20 m



New test: break line of sight at HIBEAM

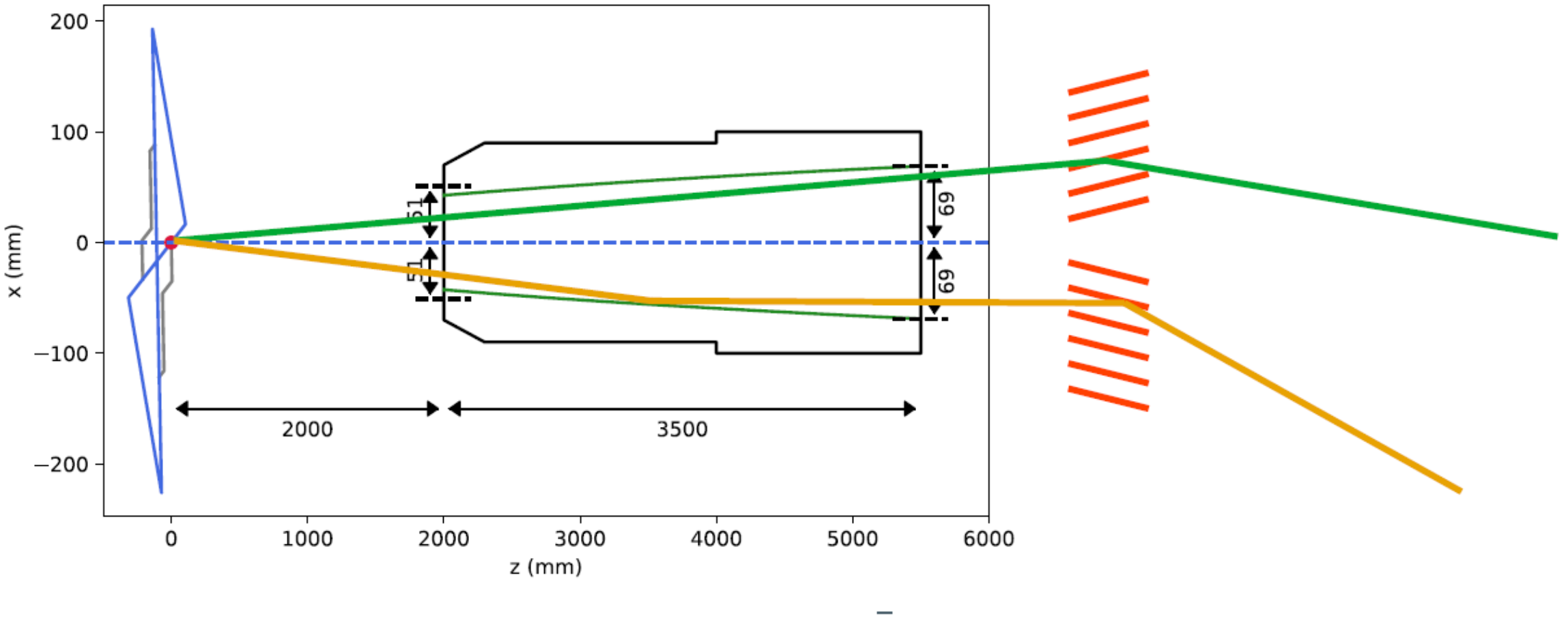




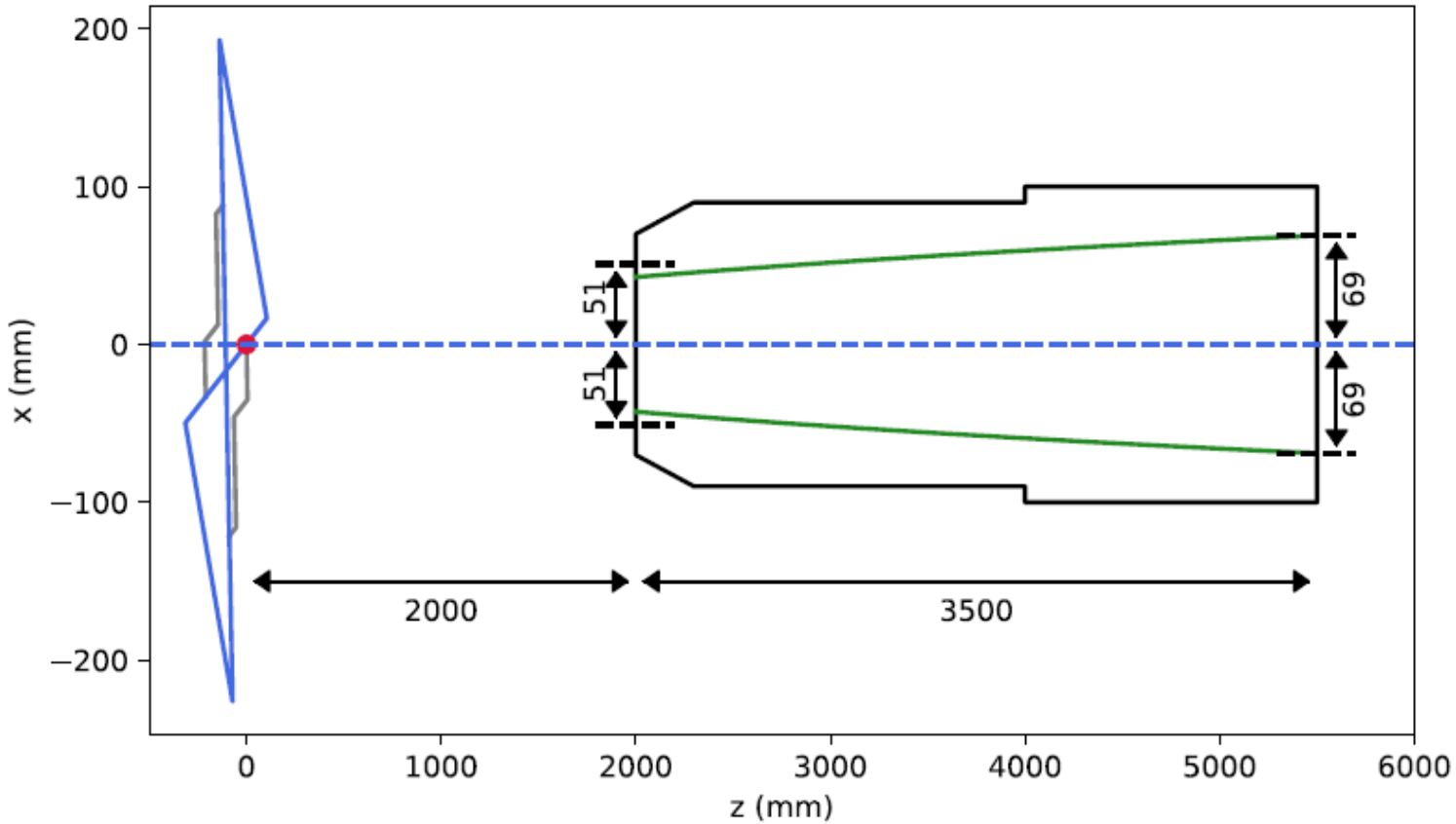
Inspired by ANNI. Parameters set to break line of sight twice for every neutron

Elliptic Monolith Guide + Venetian Blinds

Destructive “interference”



Simulation with Monolith guide only [1]: 2.7 x 10^9 ns
Simulation without Monolith guide : 1.1 x 10^9 ns

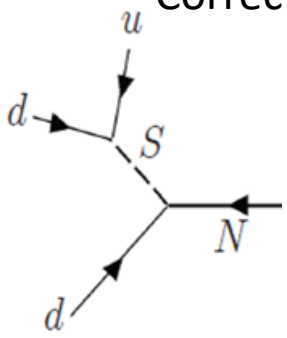


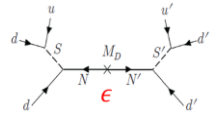
Can Venetian blinds replace the large elliptic guide AND gain an additional factor of ~2.5 in FOM?

3

Correction to my previous understanding on

How large can be $\Delta m_{nn'}$?



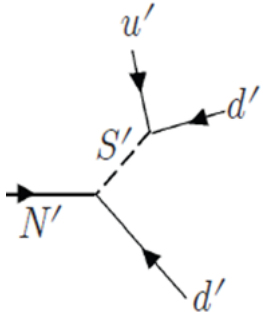


4-fermion process, like n-decay

$$M_S \in (> 1\ TeV; 7.2\ TeV\ in\ E_6\ models)$$

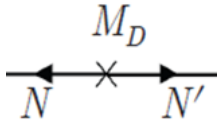
$n \to N$ $\qquad \epsilon_{nN} = \mathcal{O}_6 = \dfrac{uddN}{M_x^2} = \dfrac{\Lambda_{QCD}^3}{M_S^2} \cong \dfrac{(0.25\ GeV)^3}{(1000\ GeV)^2} = 1.56 \cdot 10^{-8}\ GeV \to$ $\approx 16\ eV$

Would be process of production of N

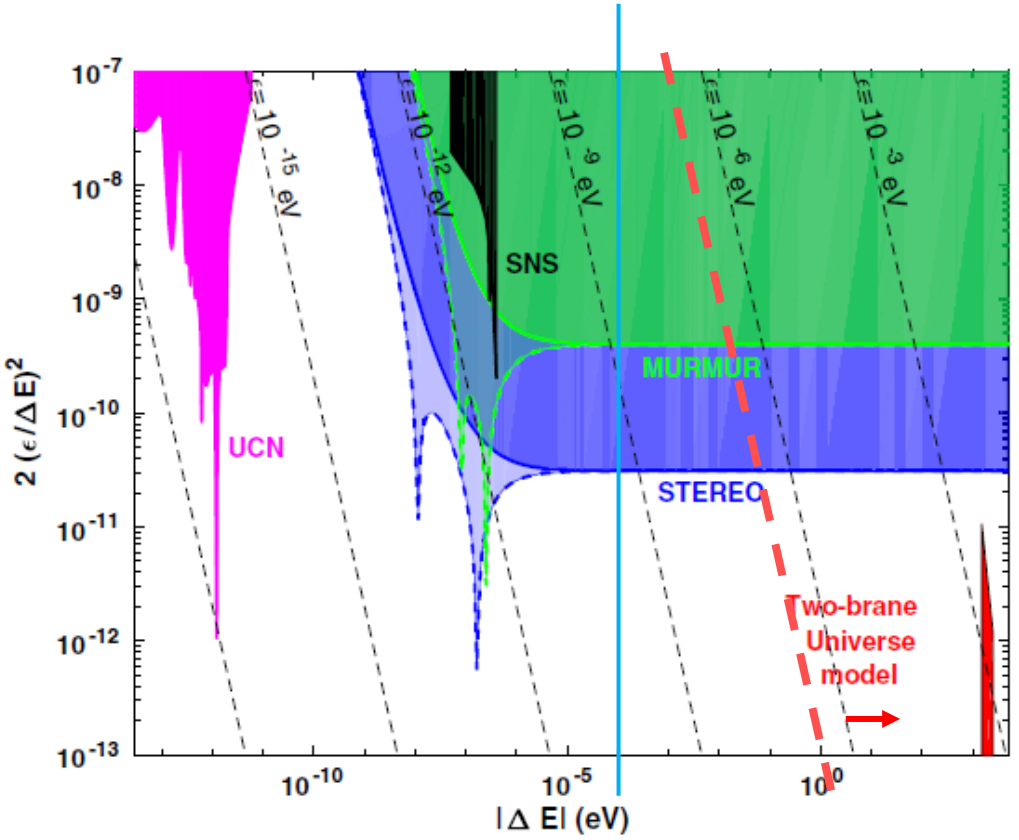


$$\epsilon_{nN} = \epsilon_{n'N'}$$

$$M_x^5 = M_S^2 \cdot M_{S'}^2 \cdot M_D$$



$M_D \bar{N} N'$ Dirac fermion mass term



$$\epsilon_{nn'} = \frac{\Lambda_{QCD}^6}{M_S^2\ M_{S'}^2 M_D} = \frac{\epsilon_{nN} \times \epsilon_{n'N'}}{M_D} = \frac{256\ eV^2}{10^9\ eV} = 256\ neV$$

If $M_S > 1\ TeV$ and/or $M_D \gg 1\ GeV$ then $\epsilon_{nn'} \ll 256$ neV or $\tau_{nn'} \gtrsim 2 \times 10^{-9}\ s$

$$\Delta m = \frac{\epsilon}{\theta_0}$$

4 Is B=0 limit (Serebrov, 2009) has visible exclusion tails?

A. Serebrov et al., NIM A611 (2009) 137-140 paper
"Search for neutron–mirror neutron oscillations in a laboratory experiment with ultracold neutrons"
Best limit on nn' in zero mag. field (assuming $B' = 0, V'_F = 0, \Delta m = 0$)

At B=0 (B < 100 nT) $\tau_{osc} \geq 448\ s\ (90\%\ CL)$ in the UCN trap with $\langle t_f^2 \rangle = 0.012\ s^2$, t_f wall-to-wall-flight

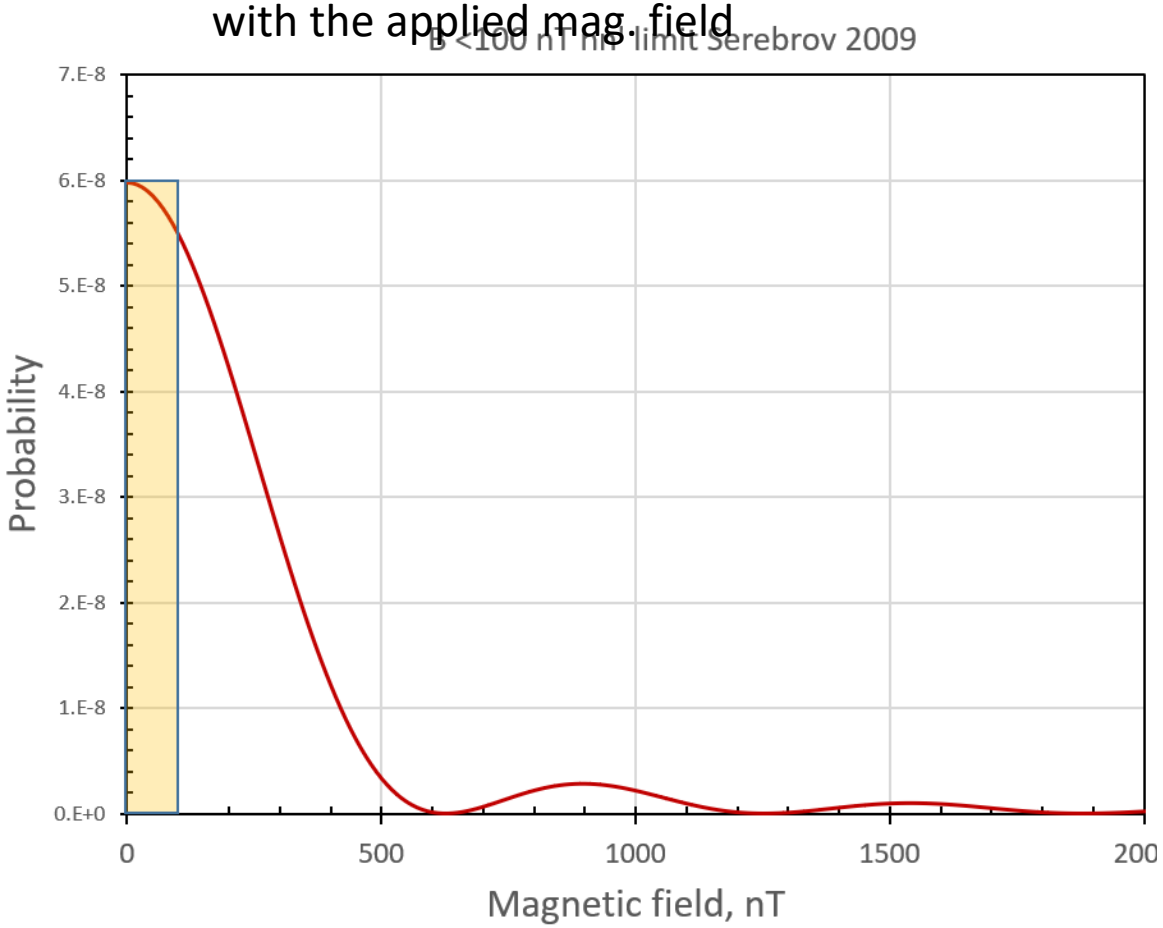
Per one flight in the UCN trap with t_f $$P_{nn'} = \frac{\epsilon^2}{\omega^2} sin^2\left(\frac{\omega t_f}{\hbar}\right),$$ where $$\omega = \sqrt{\left(\frac{\Delta m}{2}\right)^2 + \epsilon^2}$$

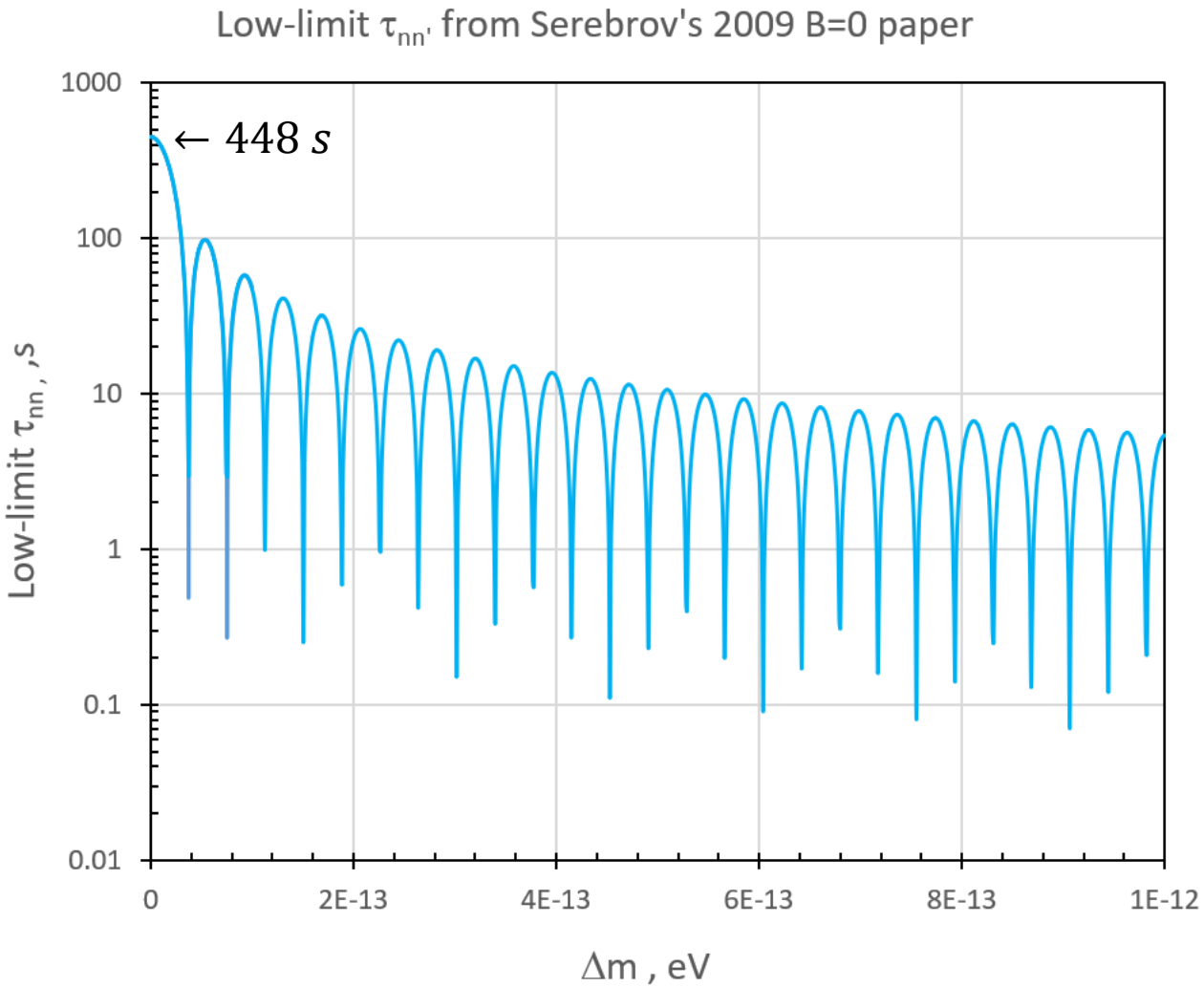
Limit $\tau_{osc} \geq 448\ s$ corresponds to $\epsilon\ (B = 0, \Delta m = 0)$ $\epsilon \leq 1.4692 \times 10^{-18}$ eV and

the probability of conversion per flight $P_{nn'} \cong 6 \times 10^{-8}$. Fixing this measured probability

one can find for any desired Δm the corresponding limit of τ_{osc}

How measured probability would change with the applied mag. field





This should be a continuous line after averaging over UCN velocity spectrum and/or mag. field non uniformity

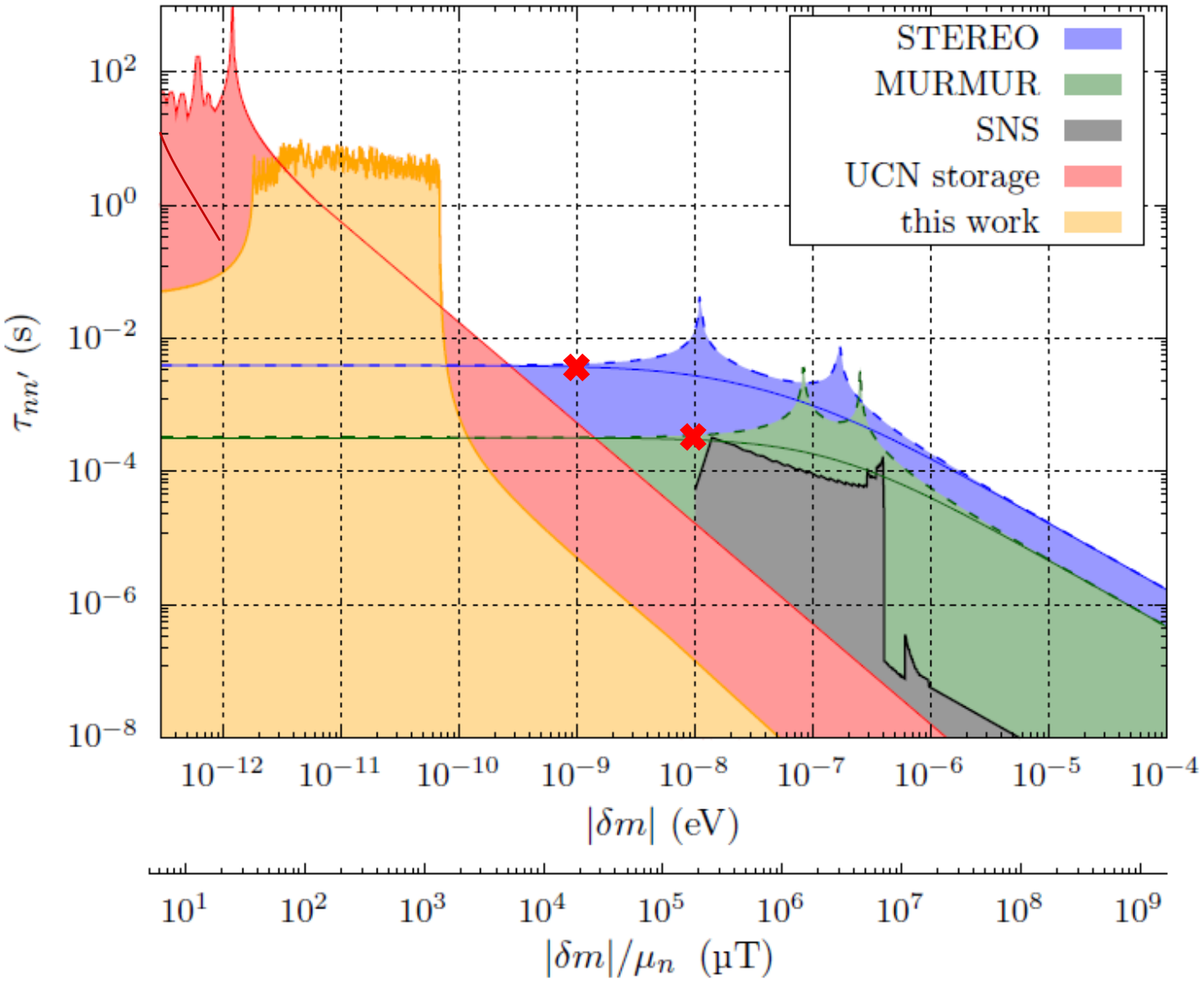
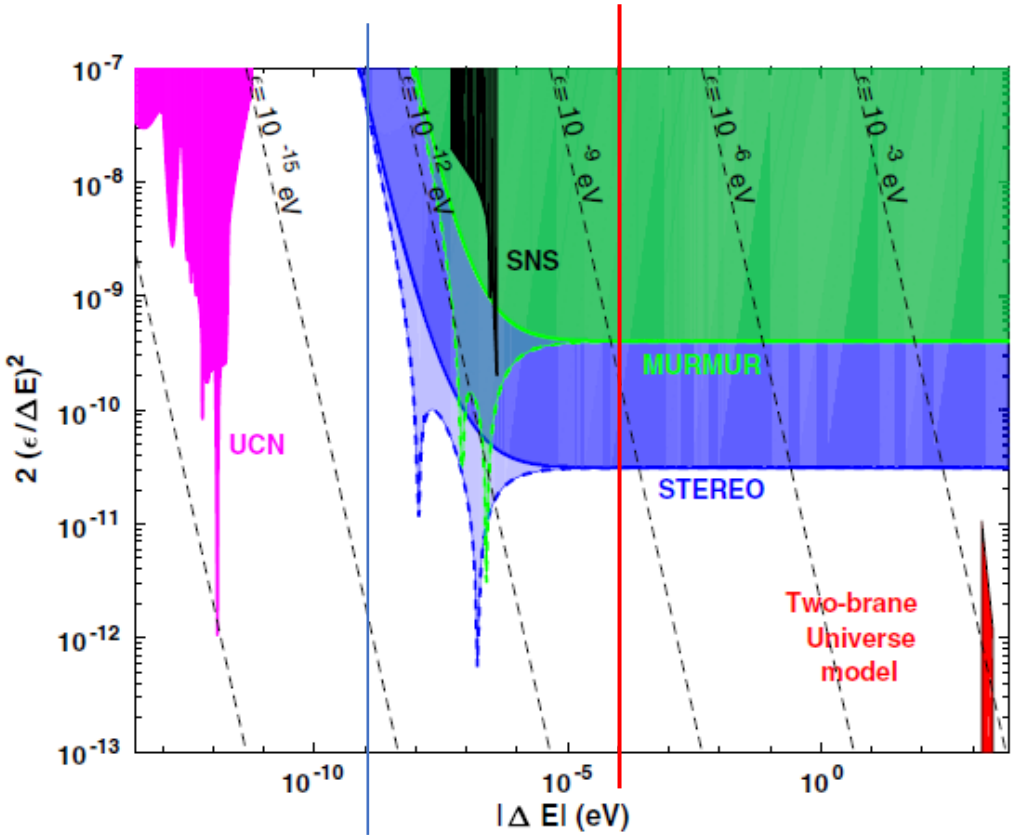


FIG. 3. Exclusion of the $n - n'$ parameter space including all experimental results up to August 2022.



Last ΔE $(or\ \Delta m\ in\ SNS\ or\ \delta m\ in\ UCN)$ in STEREO is ~1E-9 , and in MURMUR ~1E-8
Why it is extended to smaller δm in UCN paper?
Why STEREO and MURMUR lines are extended to smaller values of δm?