Proposal for the calibrations of CYGNO04

Distributed events: Kripton

Xenon /Darkside experiments uses gaseous 83mKr decay for calibration

Kr is produced in ^{83}Rb decay. Kr is diffusing into the experimental volume

Kr decays by gamma and Internal Conversion

Monochromatic gamma and **electrons** from the sources.

Increase of monochromatics electrons (30 keV and 9 keV)
(on top of Compton electrons) compared
to same energy gamma ray source.

Half life of Kr is about 2hours (it disappears quickly)

Can be procured from **Nuclear Physics Institute of the [Czech Academy of Sciences]**

(20 kBq costs about 6k euro, can be shared with Ptolemy)

Ptolemy RF antenna setup at LNGS

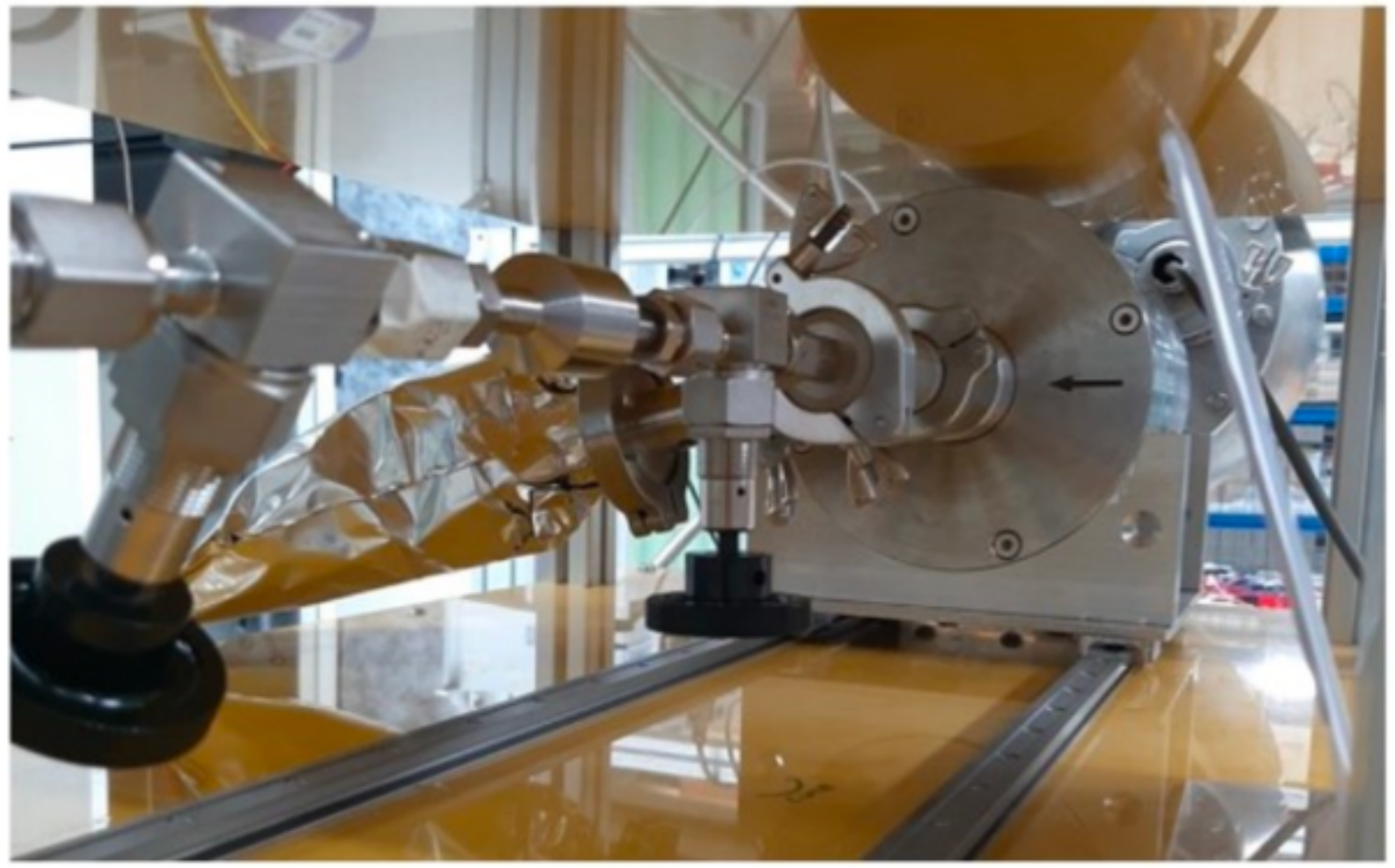


Figure 3.3. Photo of the Krypton source. The second valve opens a tap permitting the injection of the ^{83m}Kr gas. In the background the magnet is visible, too. The black arrow indicates the direction of the magnetic field inside the permanent magnet.

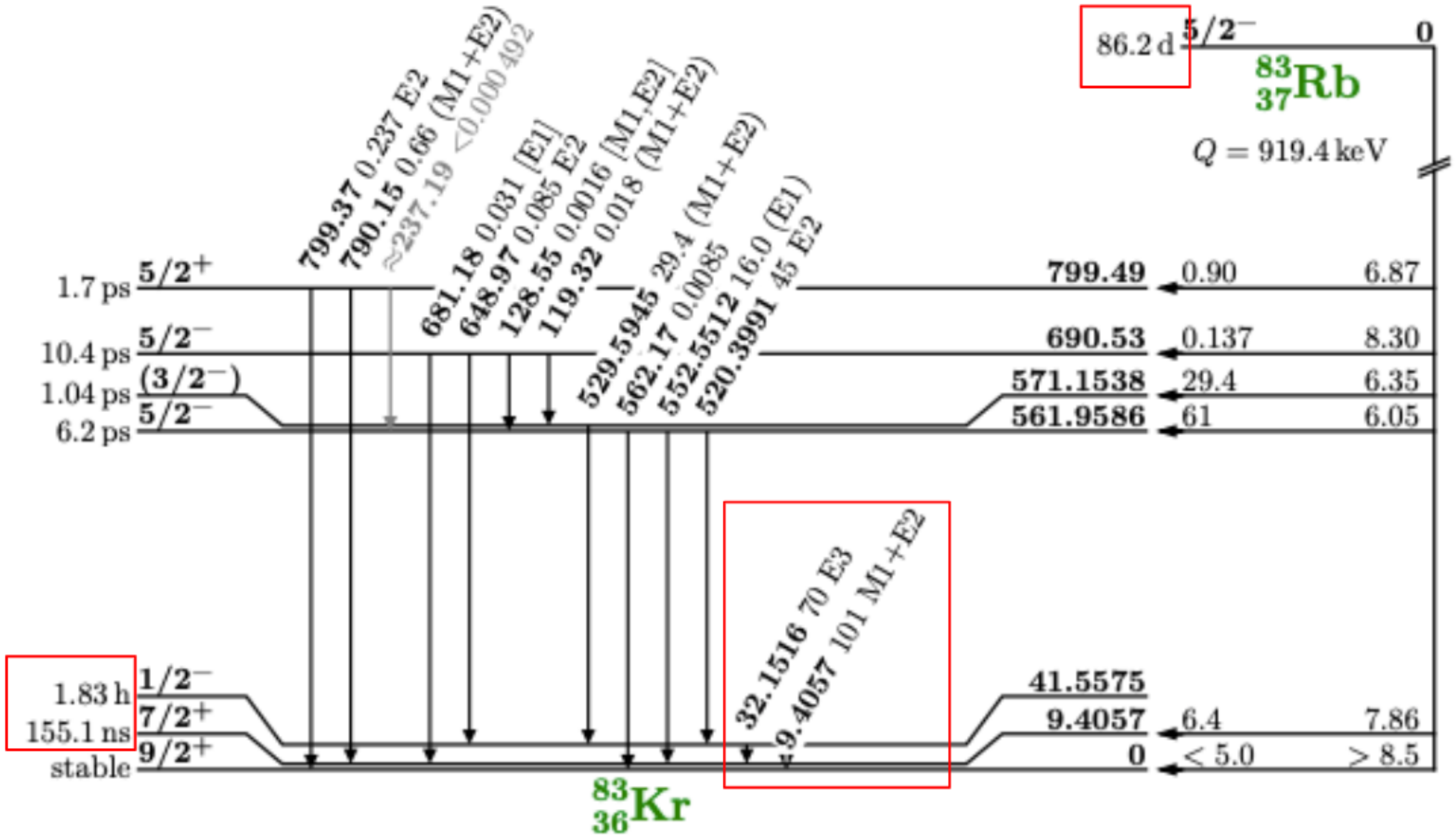
Distributed events: Kripton

Rb has an half life of 3 months

Produces 83Kr that emits 32 keV and 9.4 keV

photons 155 ns apart with an half life

of about 2 hours



Distributed events: Kripton

Rb has an half life of 3 months

Produces 83Kr that emits 32 keV and 9.4 keV

photons 155 ns apart with an half life

of about 2 hours

By Internal Conversion, these will produce electrons

The 9.4 keV photon provides mainly a 7.5 electron (90%) and electrons of 9.1 keV (10%), while the other makes 17.8 keV (25%) and around 30 keV (75%)

Line	Energy E_{ce} (eV)	ICC,[a]	Intensity I_{ce},[b] per decay (%)	Natural line width Γ (eV) [32]	[33]
γ 9405.7					
L_1	7481.1(10)	12.1(1)	66.8(13)	3.75(93)	3.72(19)
L_2	7673.7(6)	1.34(1)	7.47(15)	1.25(25)	1.29(14)
L_3	7726.4(6)	1.03(1)	5.70(11)	1.19(24)	1.58(16)
M_1	9112.9(7)	2.00(2)	10.8(3)	3.5(4)	3.123(4)
M_2	9183.5(6)	0.220(2)	1.19(3)	1.6(2)	0.63(39)
M_3	9191.1(6)	0.166(2)	0.897(21)	1.1(1)	1.1(4)
M_4	9310.6(6)	0.00324(3)	0.0175(4)	0.07(2)	—
M_5	9311.9(6)	0.00290(3)	0.0156(4)	0.07(2)	—
N_1	9378.1(6)	0.247(2)	1.11(3)	0.40(4)	0.288(93)
N_2	9391.0(6)	0.0197(2)	0.0881(21)	—	0,[c]
N_3	9391.6(6)	0.0146(1)	0.0655(16)	—	0,[c]
γ 32151.6					
K	17824.2(5)	478.0(50)	24.8(5)	2.71(20)	2.70(6)
L_1	30226.8(9)	31.7(3)	1.56(2)	3.75(93)	—
L_2	30419.5(5)	492.0(50)	24.3(3)	1.25(25)	1.165(69)
L_3	30472.2(5)	766.0(77)	37.8(5)	1.19(24)	1.108(13)
M_1	31858.7(6)	5.19(5)	0.249(4)	3.5(4)	—
M_2	31929.3(5)	83.7(8)	4.02(6)	1.6(2)	1.230(61)
M_3	31936.9(5)	130.0(13)	6.24(9)	1.1(1)	1.322(18)
M_4	32056.4(5)	1.31(1)	0.0628(9)	0.07(2)	—
M_5	32057.6(5)	1.84(2)	0.0884(12)	0.07(2)	—
N_1	32123.9(5)	0.643(6)	0.0255(4)	0.40(4)	4.0,[c]
N_2	32136.7(5)	7.54(8)	0.300(4)	0.03,[d]	0,[c]
N_3	32137.4(5)	11.5(1)	0.457(6)	0.03,[d]	0,[c]

Distributed events: Kripton

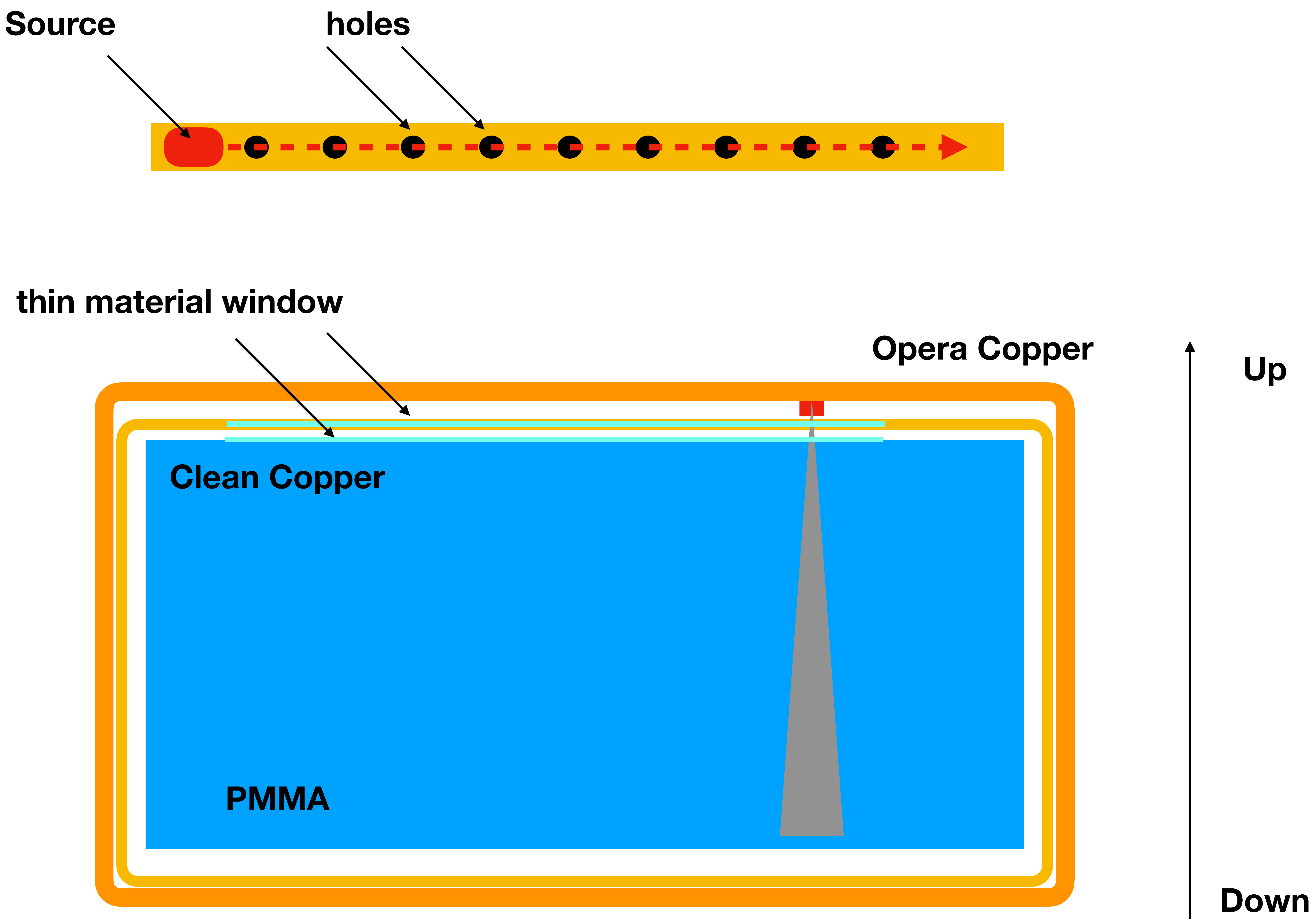
The use of a source producing diffused interactions will allow to make a “tomography” of the response of CYGNO-04 and produce a cumulative mask to correct the response of the detector for disomogeneities in:

- Drift Field
- GEM gain
- Transfer field
- Sensor and lens

A corrective map that can then be used to correct the images of each camera;

These tests can be performed once for ever or once every long intervals, to cross check their stability;

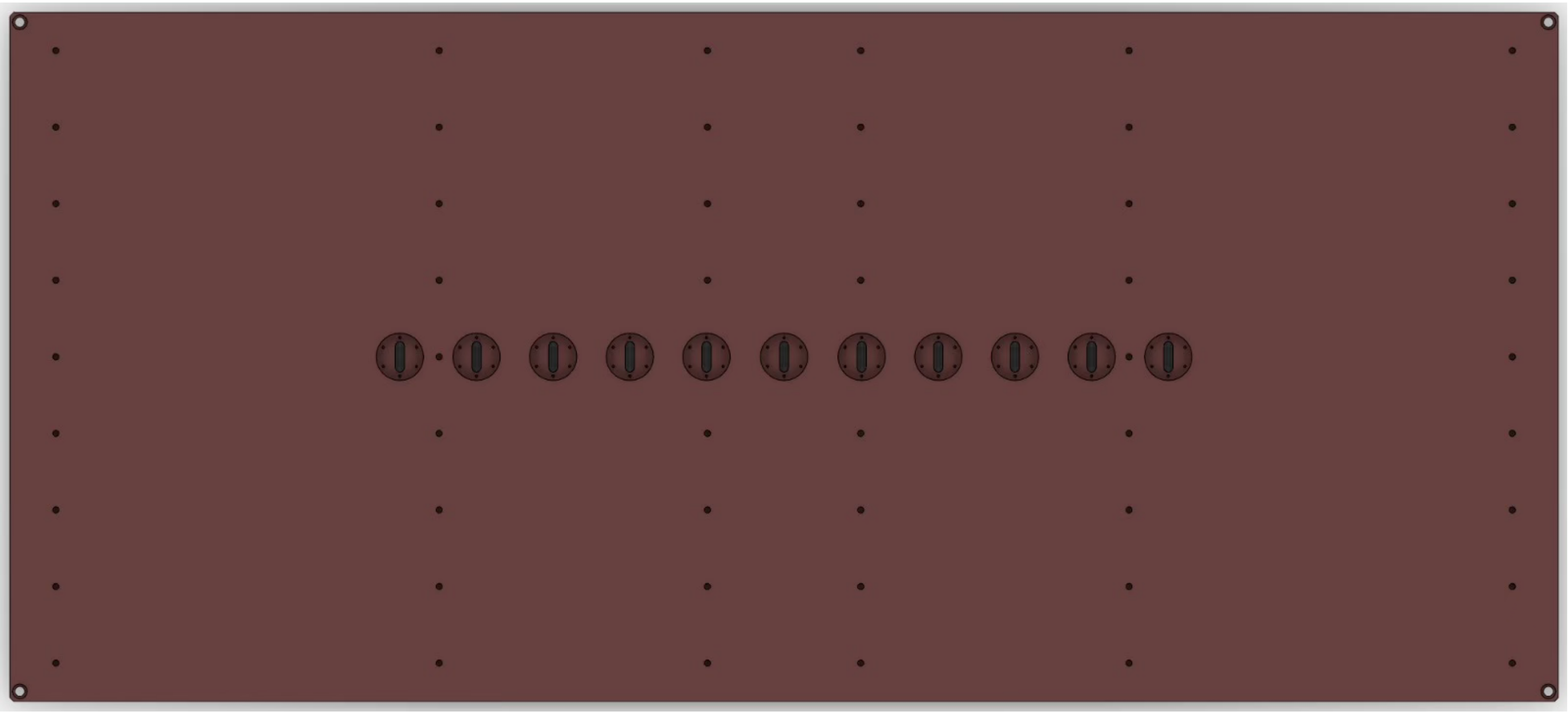
Technically they require an inlet in the gas system to connect the Ru source;



Source
holes
thin material window
Opera Copper
Clean Copper
PMMA
Up
Down

In the pure copper there will be 14 (11 in the picture) slits, where the source will be exposed

62.5 mm apart each other



In the pure copper there will be 14 (11 in the picture) slits, where the source will be exposed

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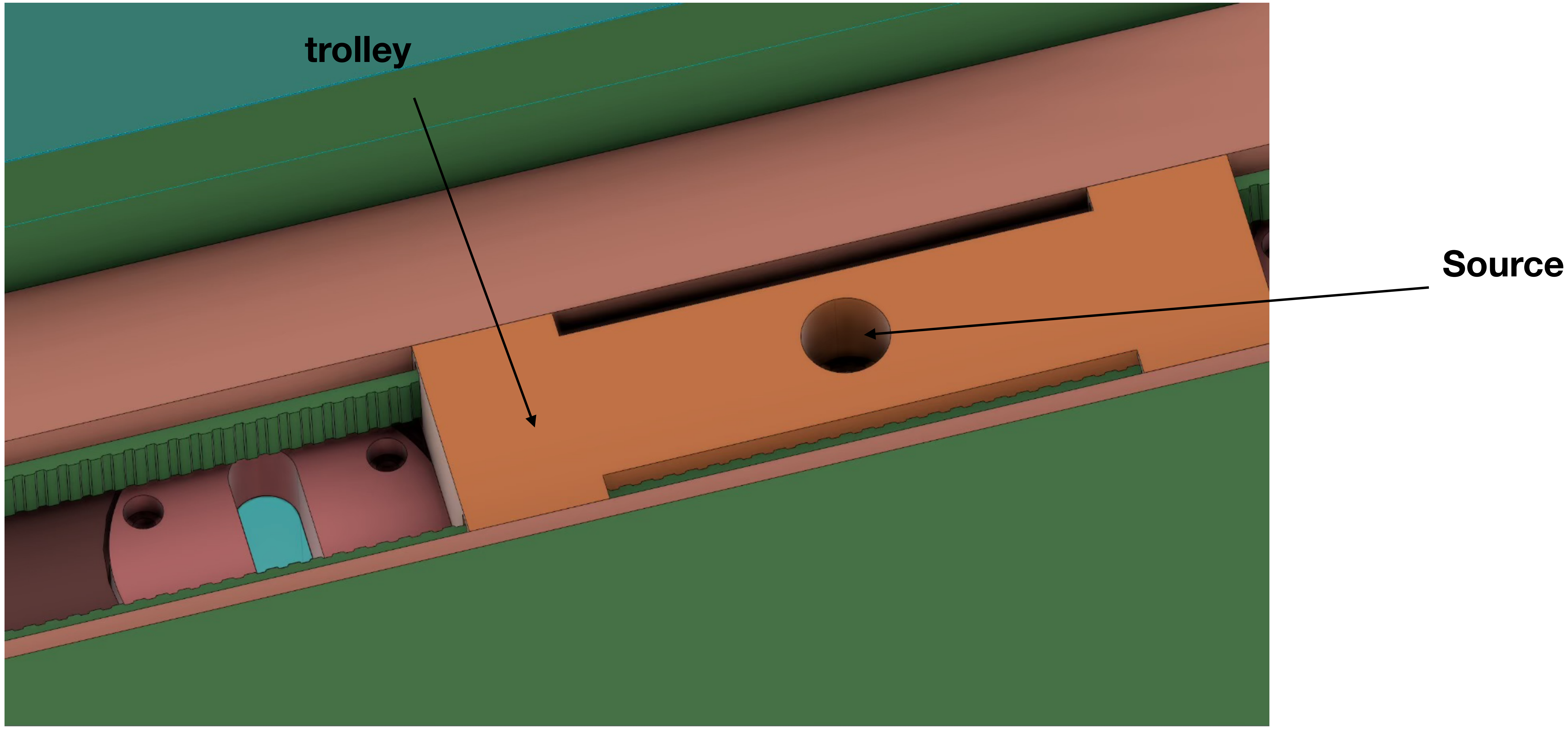
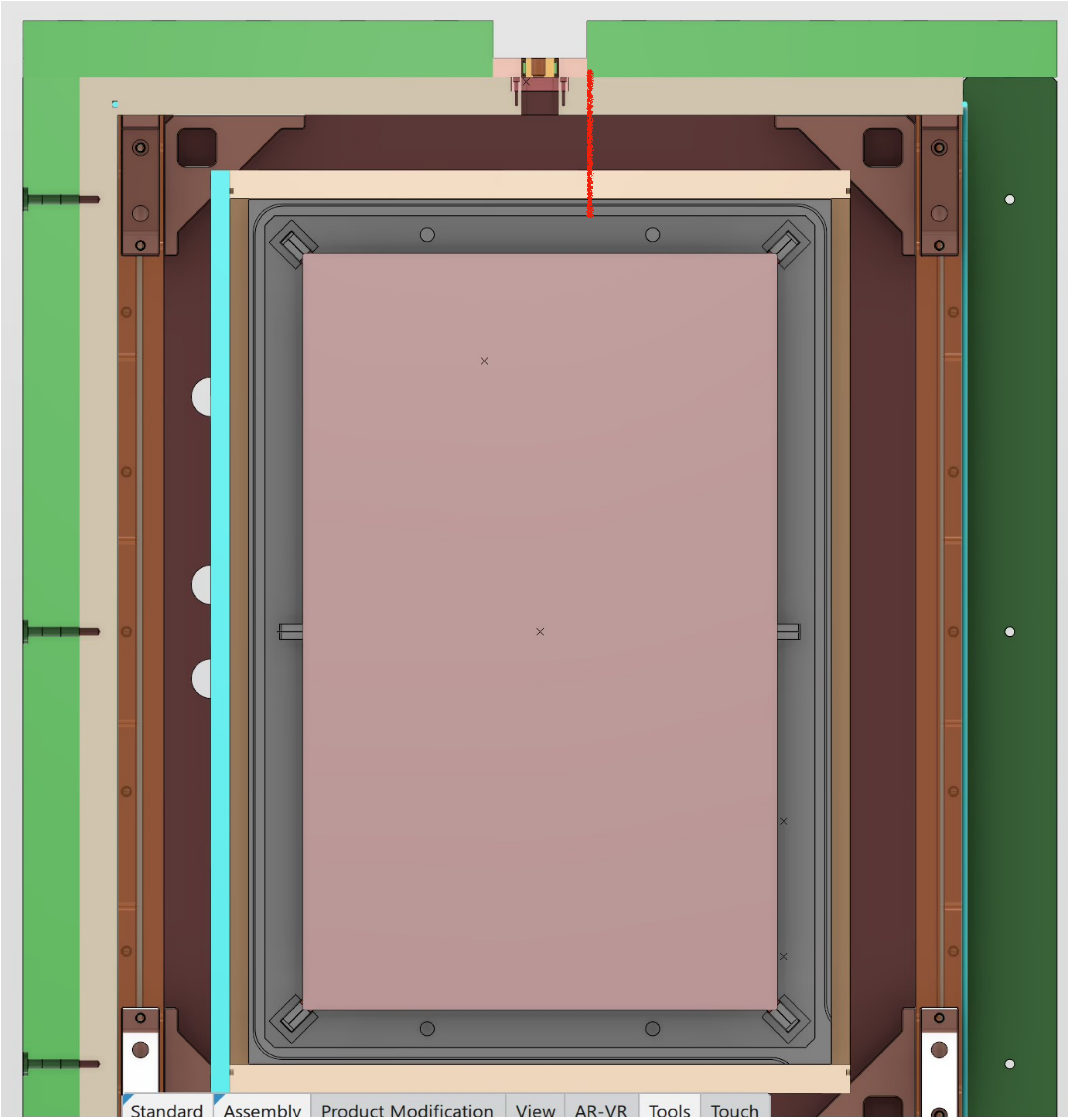
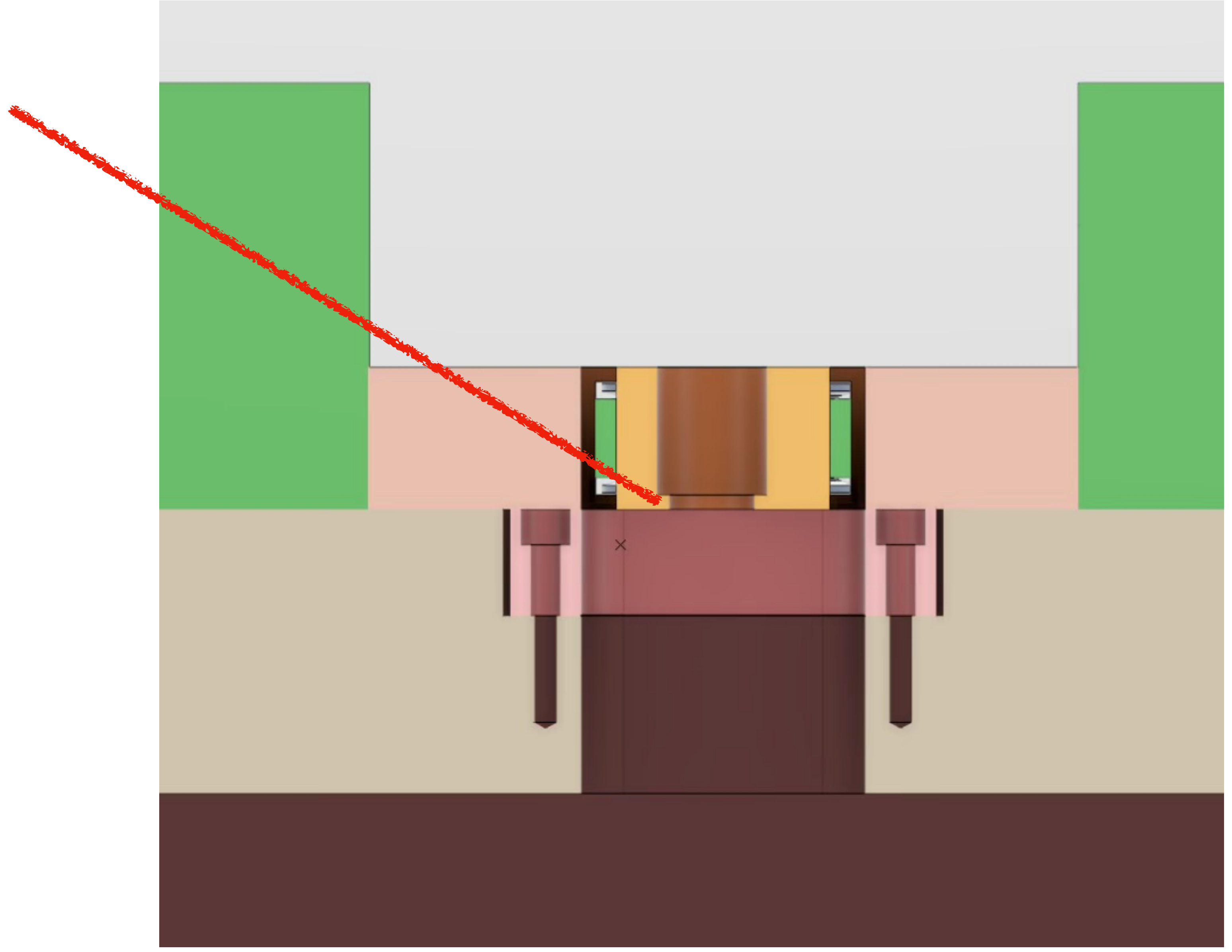




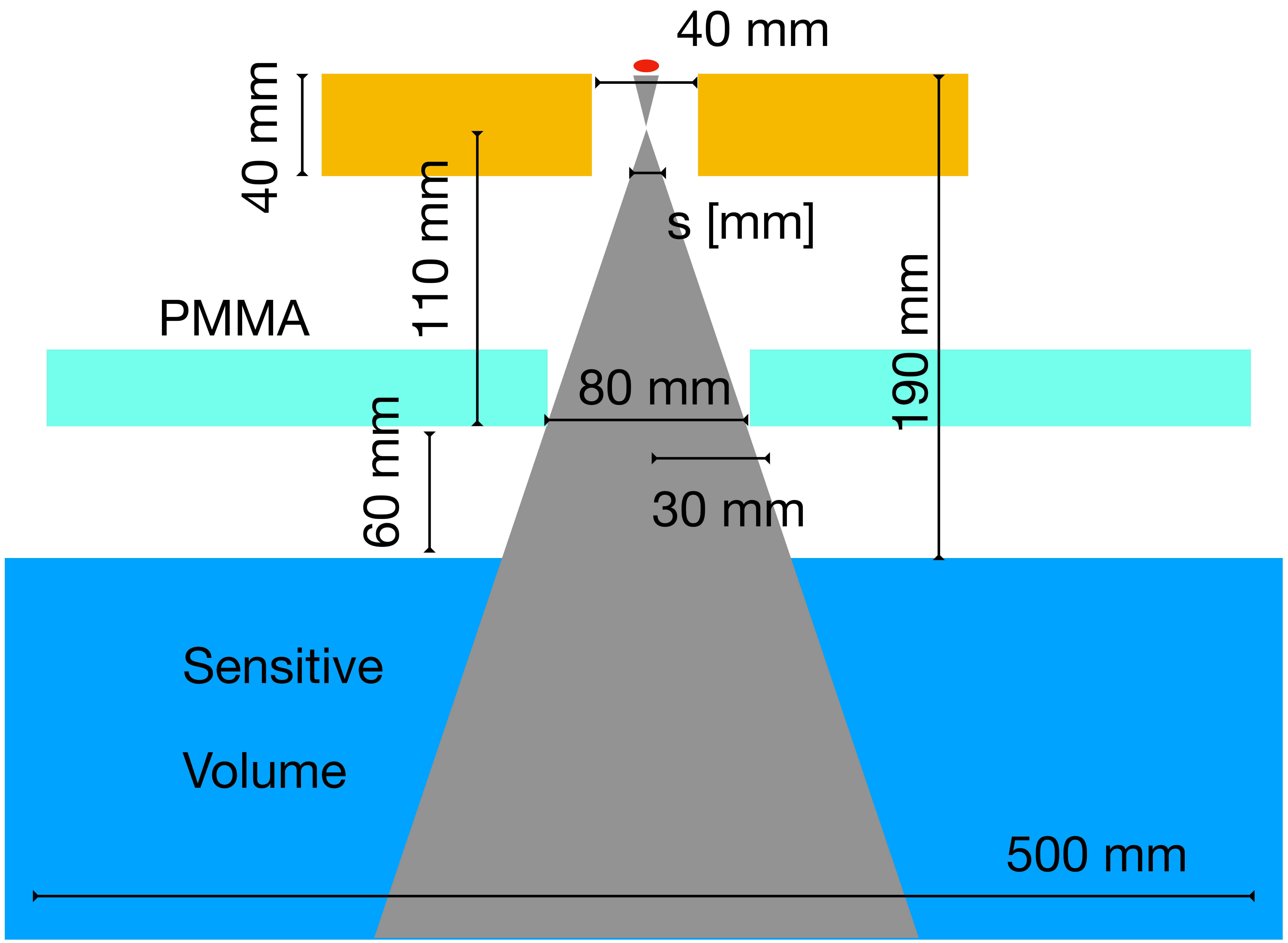
- Distance source - sensitive volume is 190 mm
- Distance source - PMMA is 101 mm
- 30 mm of PMMA
- 60 mm PMMA base to sensitive volume

Distance source - slit is 2 mm



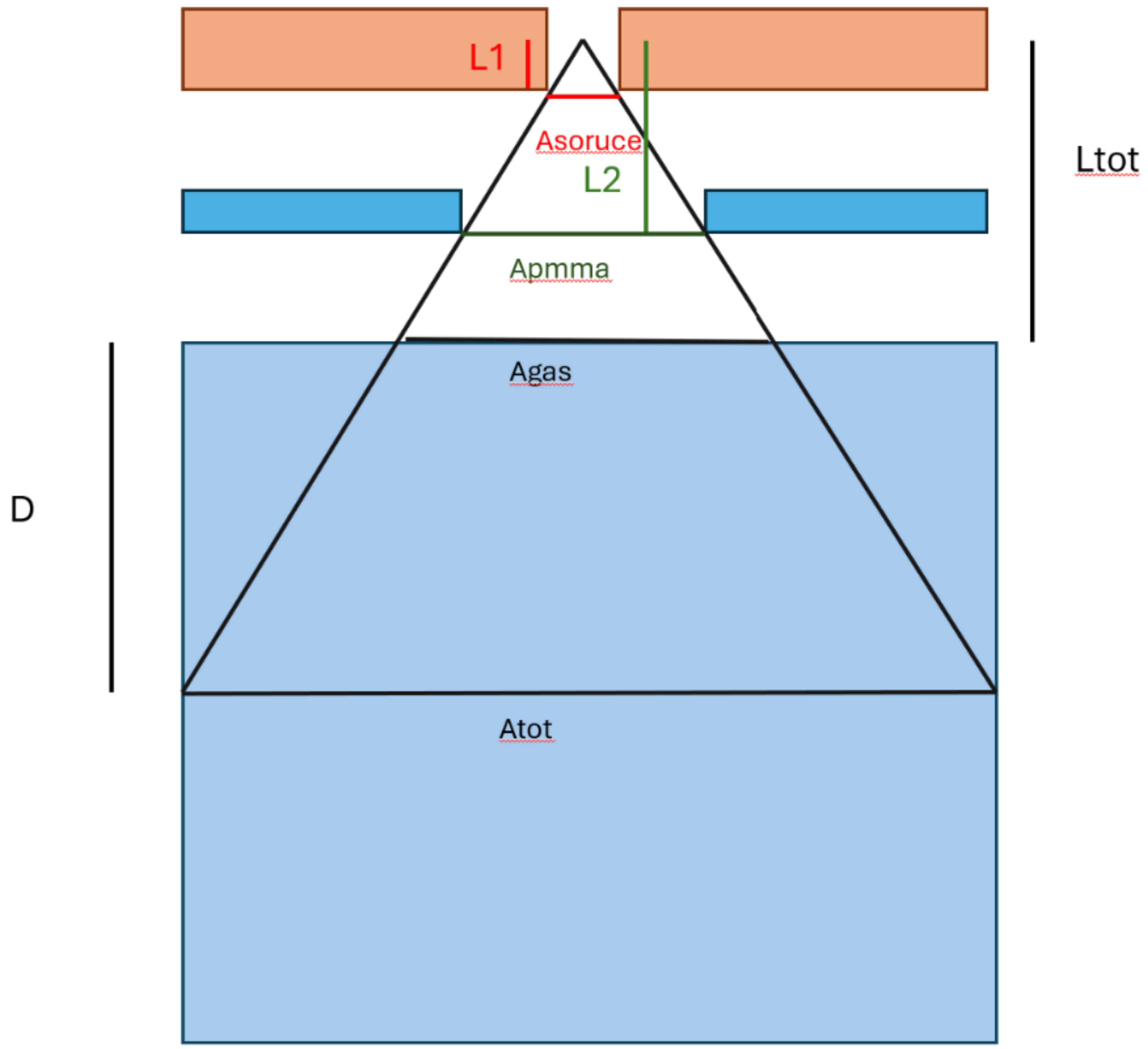
Front view

- Distance source - sensitive volume is 190 mm
- Distance source - PMMA is 101 mm
- 30 mm of PMMA
- 60 mm PMMA base to sensitive volume
- $$s[mm] = \frac{20 \cdot 80}{110} = 14.5\ mm$$



Source window Constraints - GEM view

Constrain set as PMMA window A_gas == 8mm (+ L2==110mm)



$$\frac{A_{source}}{L_1} = \frac{A_{pmma}}{L_2} = \frac{A_{gas}}{L_{tot}} = \frac{A_{tot}}{D+L_{tot}} = R$$

A_source = 15mm

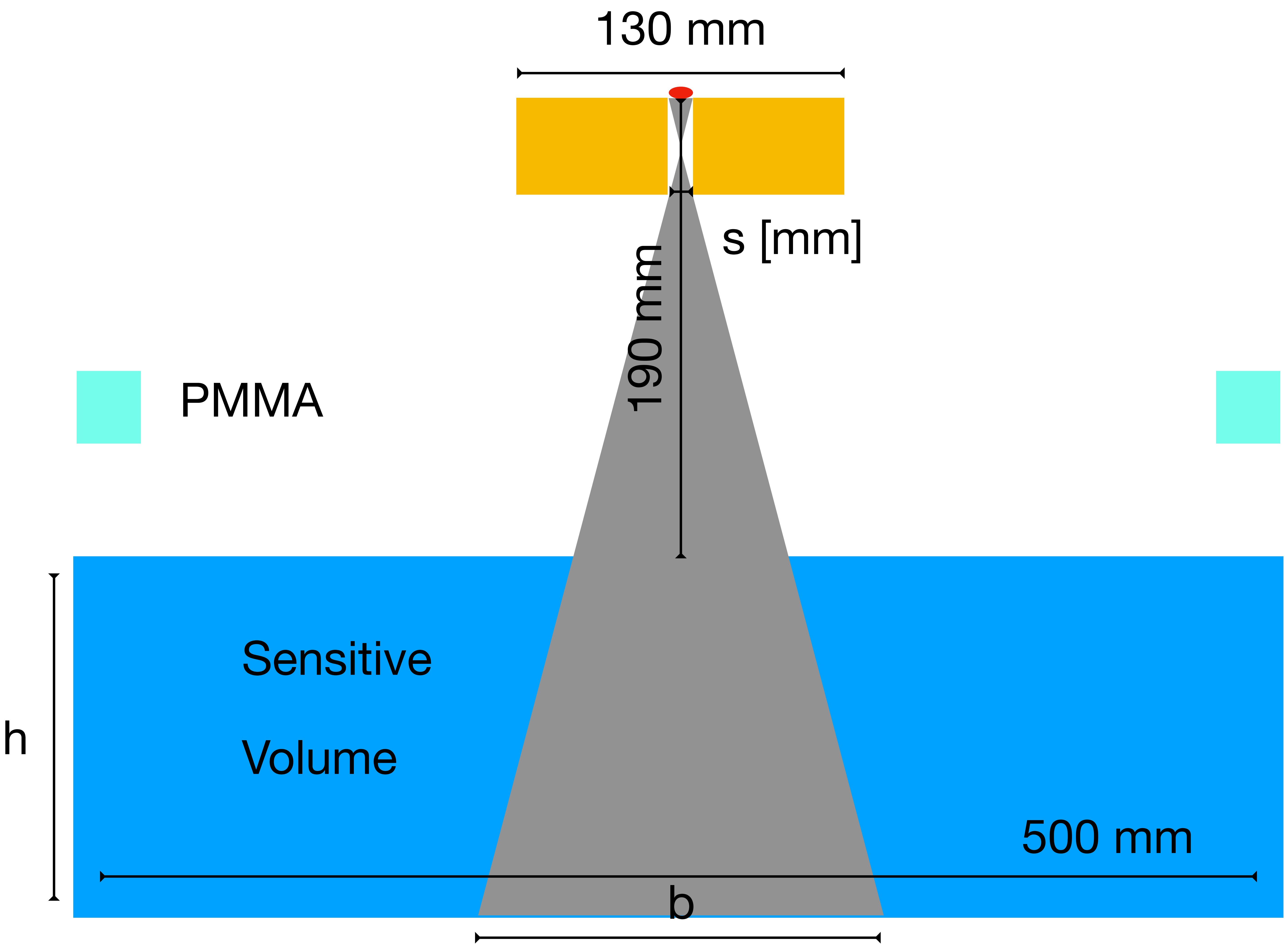
$$S_{dead} = \frac{D(800mm - A_{gas})}{4}$$

'Dead' area around 12% of the total area

D. Fiorina

Lateral view

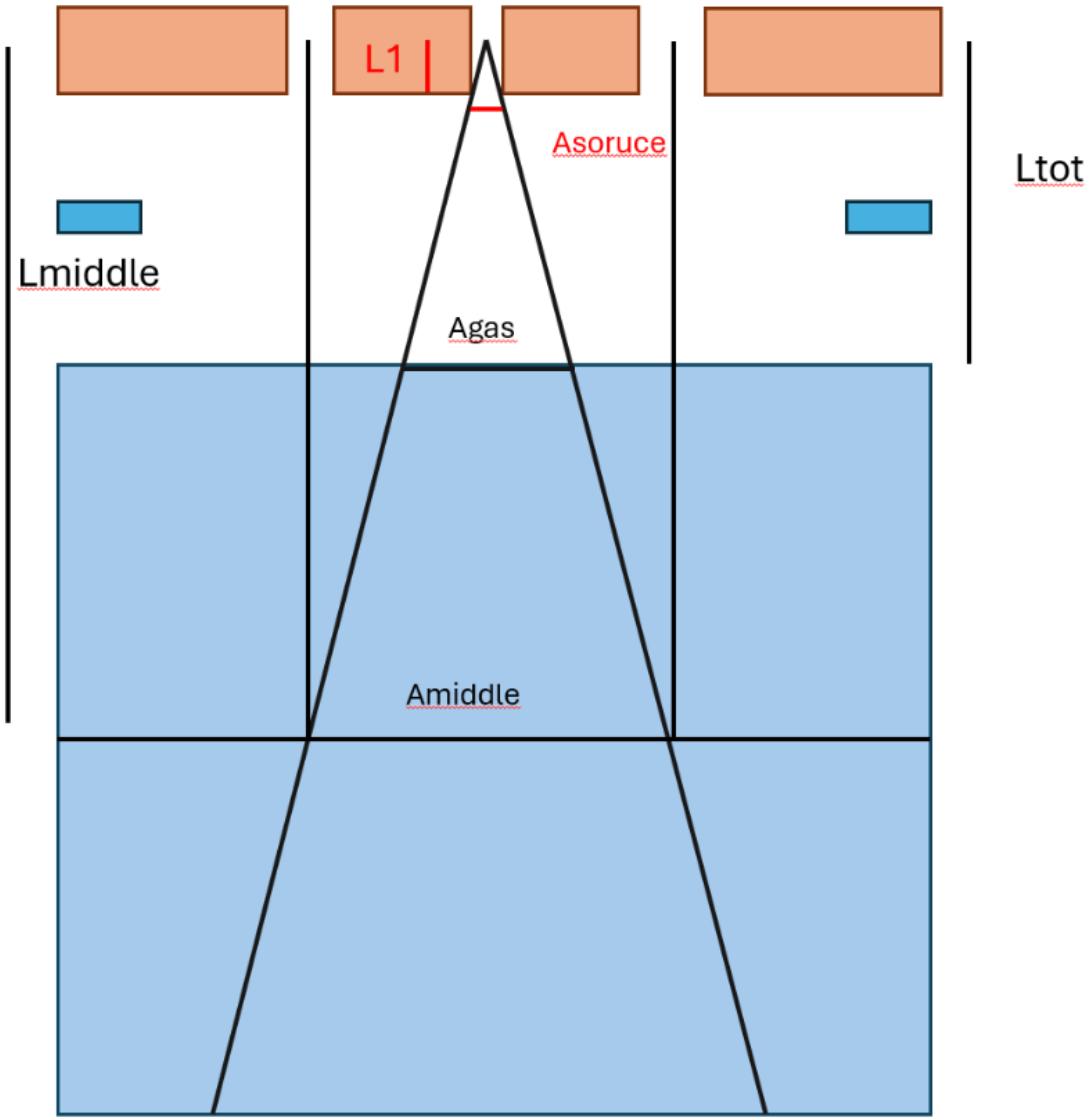
- Distance source - sensitive volume is 190 mm
- Distance source - PMMA is 101 mm
- 30 mm of PMMA
- 60 mm PMMA base to sensitive volume
- in general $b[mm] = s\ \frac{h + 170}{20}$
- if we want b = 130 mm at half heigh (h=400mm) -> s = 4.5 mm -> we loose 55% of source activity
- So a slit 4.5 x 14.5 = 62 mm^2 at a distance of 40 mm -> 4% of solid angle



2% of photons reach the gas

Source window Constraints - z view

Constrain set as: beam aperture at detector center equal to the window pitch A_middle == 125mm



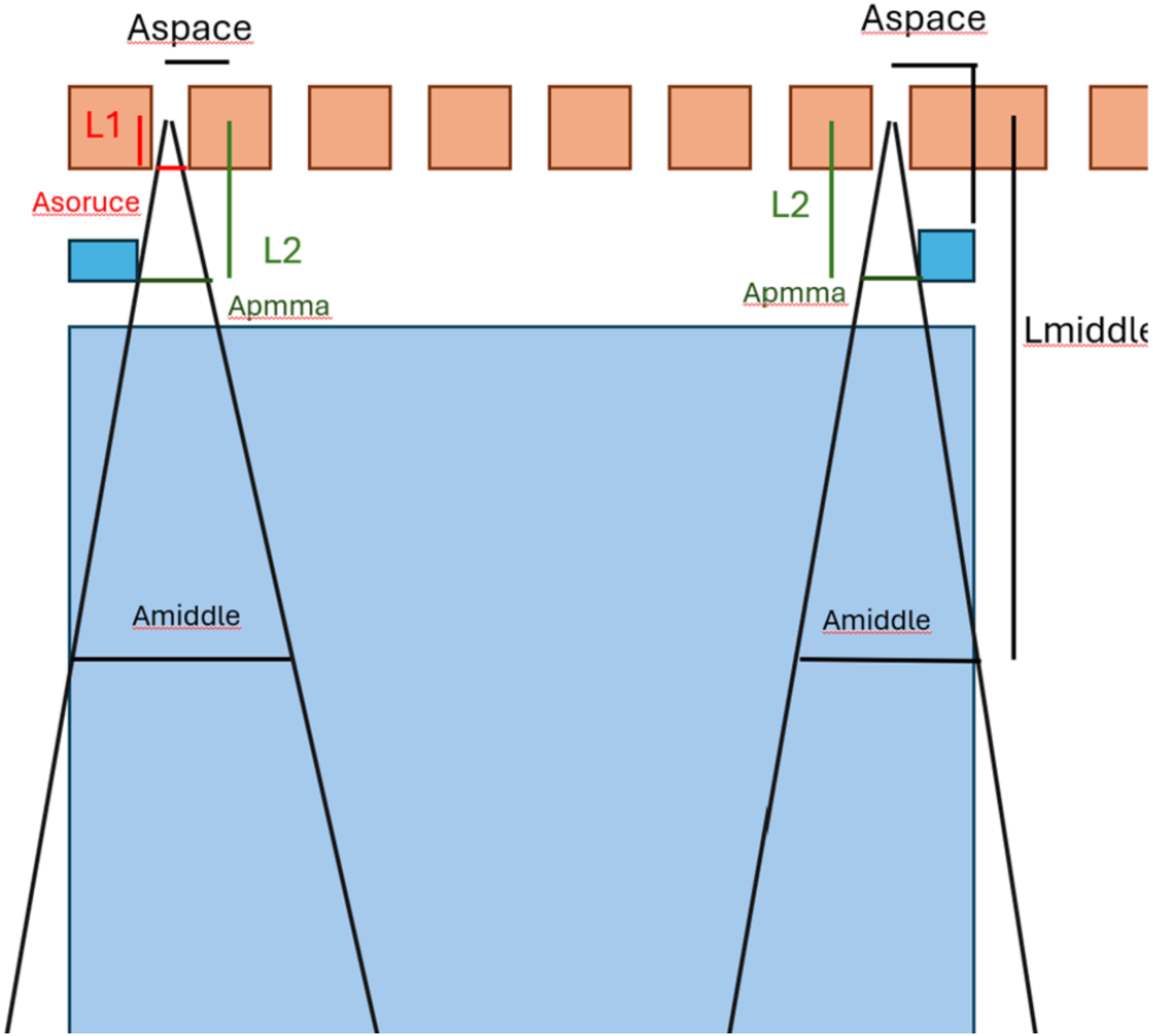
$$\frac{A_{source}}{L_1} = \frac{A_{gas}}{L_{tot}} = \frac{A_{middle}}{L_{middle}} = R$$

A_source = 4.5mm

D. Fiorina

Source window length Constraints - z view

Constrain set as: beam aperture at detector center equal to the window pitch A_middle == 125mm



$$\frac{A_{PMMA}}{L_2} = \frac{A_{middle}}{L_{middle}} = R$$

$$L_{window} = 6A_{space} + A_{pmma}$$

Lwindow=402mm

Wwindow=80mm (set as constraint)

D. Fiorina

Rate estimation

- Rate of interactions $4\ 10^6 \cdot (1/4) \cdot 0.02 \cdot 0.98 \cdot (0.75)^2$ **11 kHz**

2 half lives

4 absorption lengths

Nominal activity in 2021

collimation

2 windows

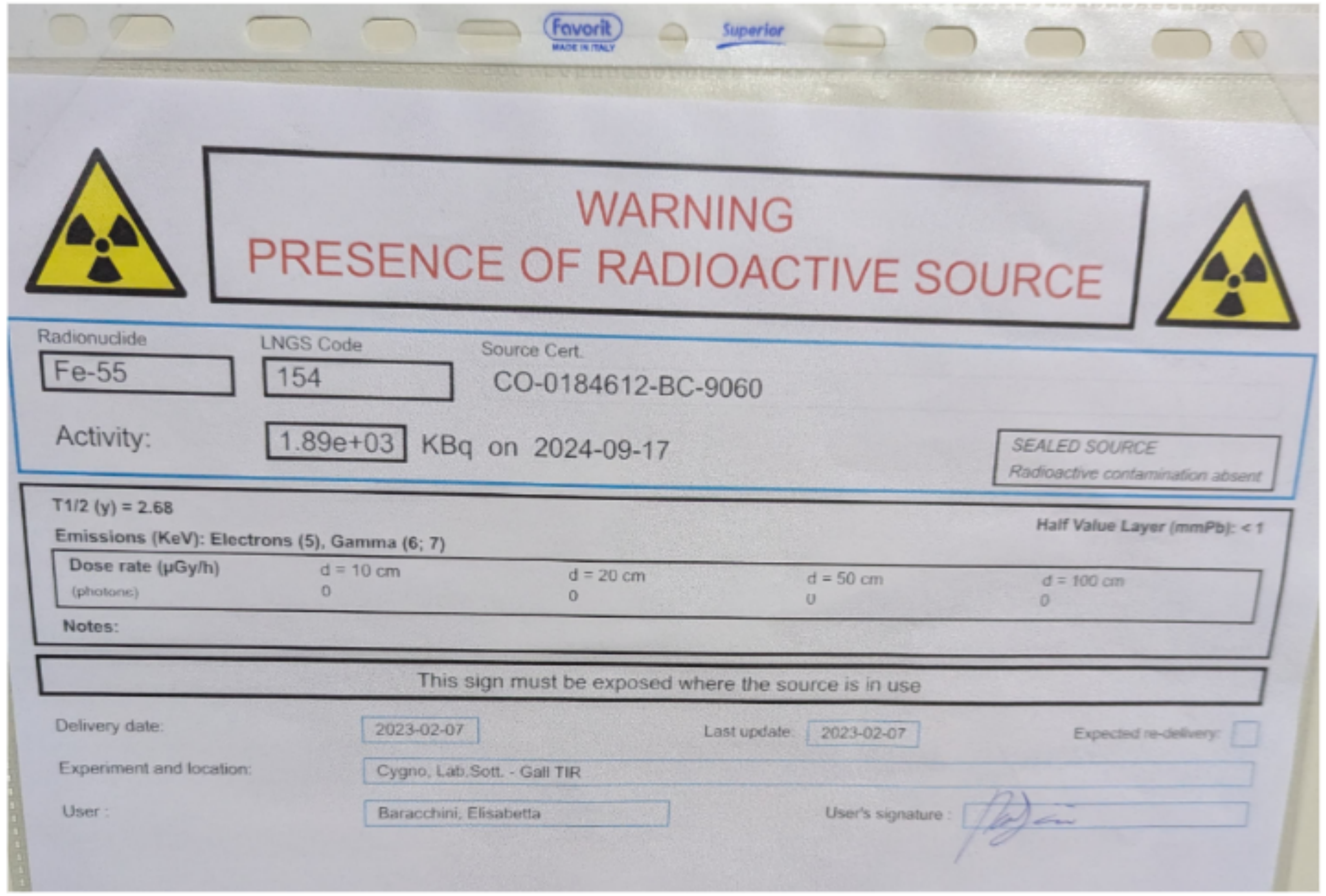
Rate estimation

1- Source activity estimated in 2025: 1.5MBq

$$A = e^{-\mu x}$$

μ_EFTE = 3.5cm-1
μ_HeCF4 = 0.05cm-1

$$A_{tot} = A_{gas} A_{EFTE} = 0.33$$



2- Solid angle under a rectangle

$$\Omega = 4 \cdot \arctan\left(\frac{a \cdot b}{2 \cdot d \cdot \sqrt{a^2 + b^2 + 4 \cdot d^2}}\right)$$

Cooper window: 4.5x15mm2 d=21mm

Solid angle fraction (2pi): 0.023

3- Interaction Probablity in 800mm of He/CF4 i.e. the detector 98%

Expected rate around 10kHZ i.e. 2.5Hz/cm2

$$Rate = Activity \cdot A_{tot} \cdot \Omega_{fraction} \cdot P_{interaction}$$

Conclusion

For the Ru source, we should foresee a inlet to inject the Kr in the gas;

For the ^{55}Fe, our proposal is to have:

On the COPPER

- 14 slits 62.5 mm apart each other;
- 4.5 x 14.5 mm^2 and 40 mm deep (the whole clean copper layer)

On the `PMMA

- 2 windows (1 per half volume)
- 80 x 402 mm^2 windows

This setup should allow 10 kHz of events (about 2 Hz/cm^2)