

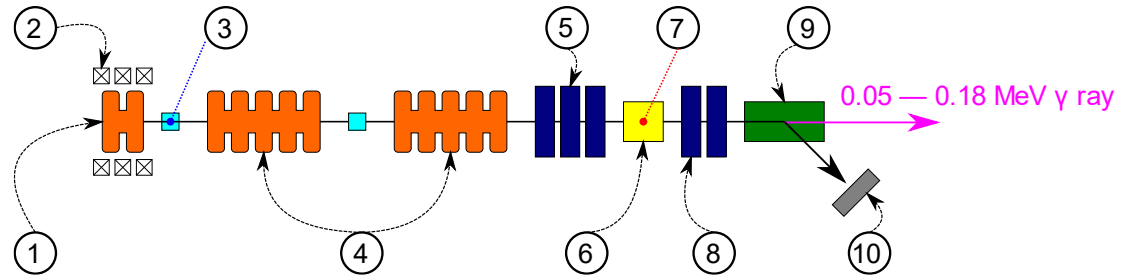
Commissioning of a photocathode and interaction laser system at RadiaBeam

Compact Inverse Compton Light Source

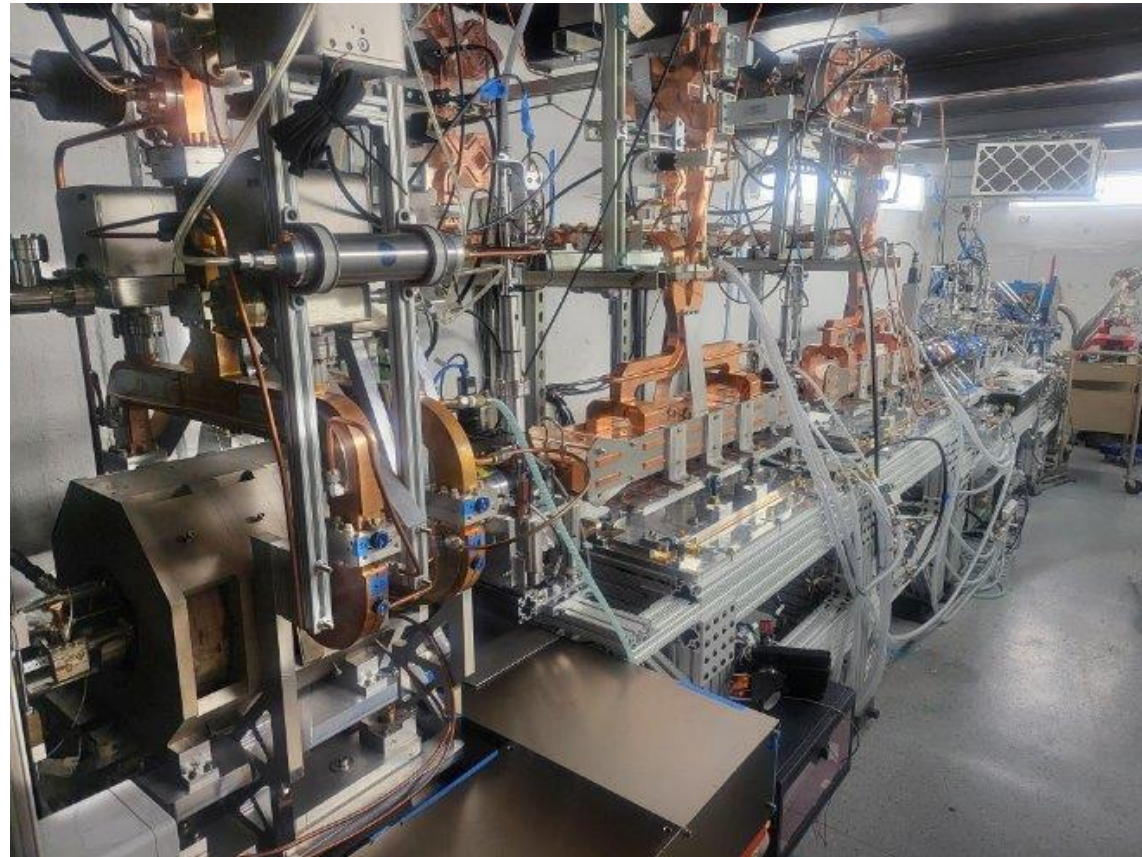
Loic Amoudry, Maksim Kravchenko, Robert Berry, Nathan Burger, Amirari Diego, Jonathan Edelen, Marcos Ruelas, Ronald Agustsson, Gerard Andonian, Yung-Chuan Chen Osvaldo Chimalpopoca, Luigi Faillace, Dmitriy Gavryushkin, Tara Hodgetts, Sergey Kutsaev, Alex Murokh, James Rosenzweig, Alexander Smirnov, Seiji Thielk, Kathryn Wolfinger

22nd – July – 2024

This work was supported by DARPA project HR001120C0072

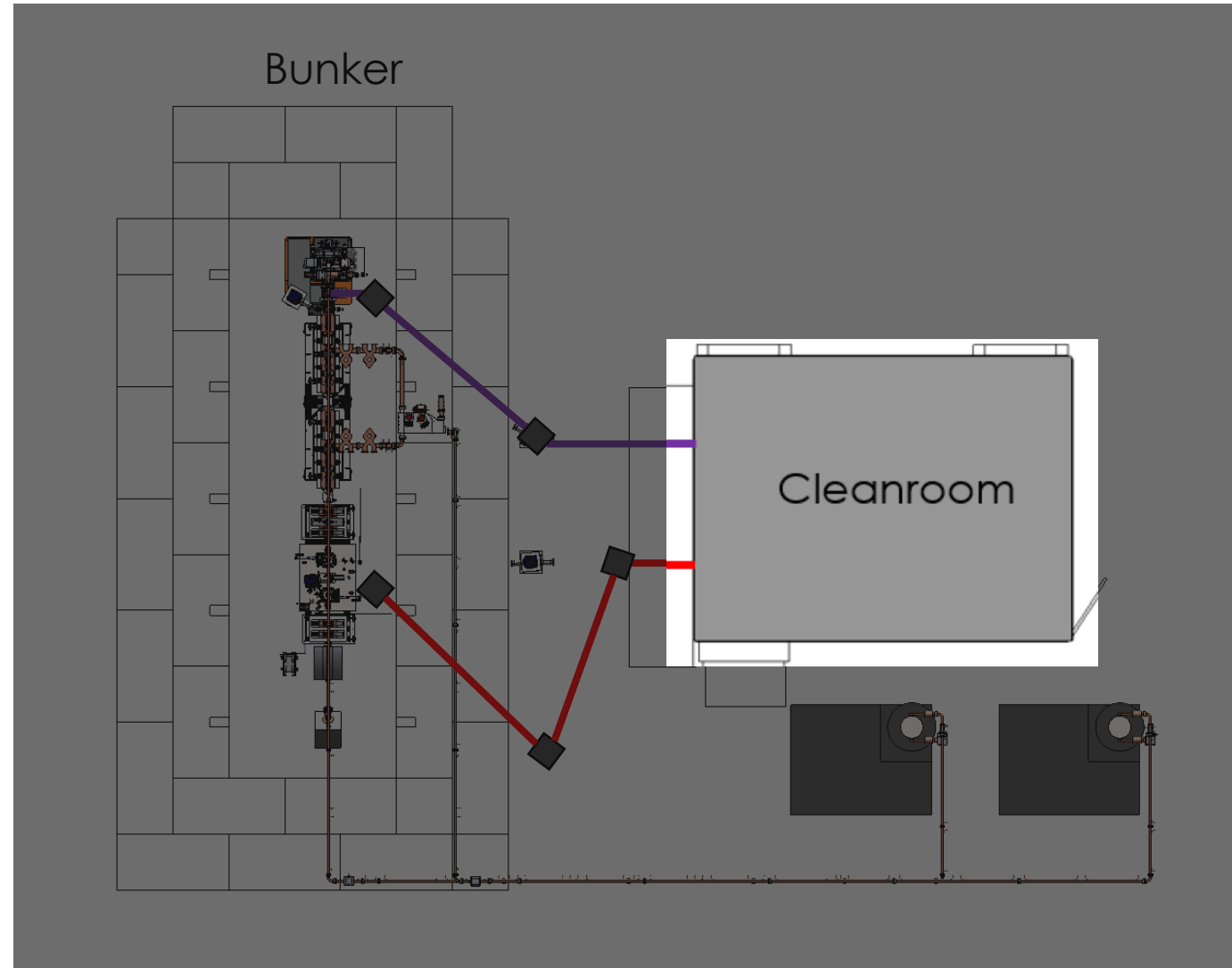


- C-band hybrid RF photoinjector for a compact 100 MeV-class source for inverse Compton scattering
- Photoinjector accelerates electrons up to 4.5MeV, <math><0.8\text{mm.mrad}</math> transverse emittance, >200A peak current
- Two C-band linacs (5.712GHz)



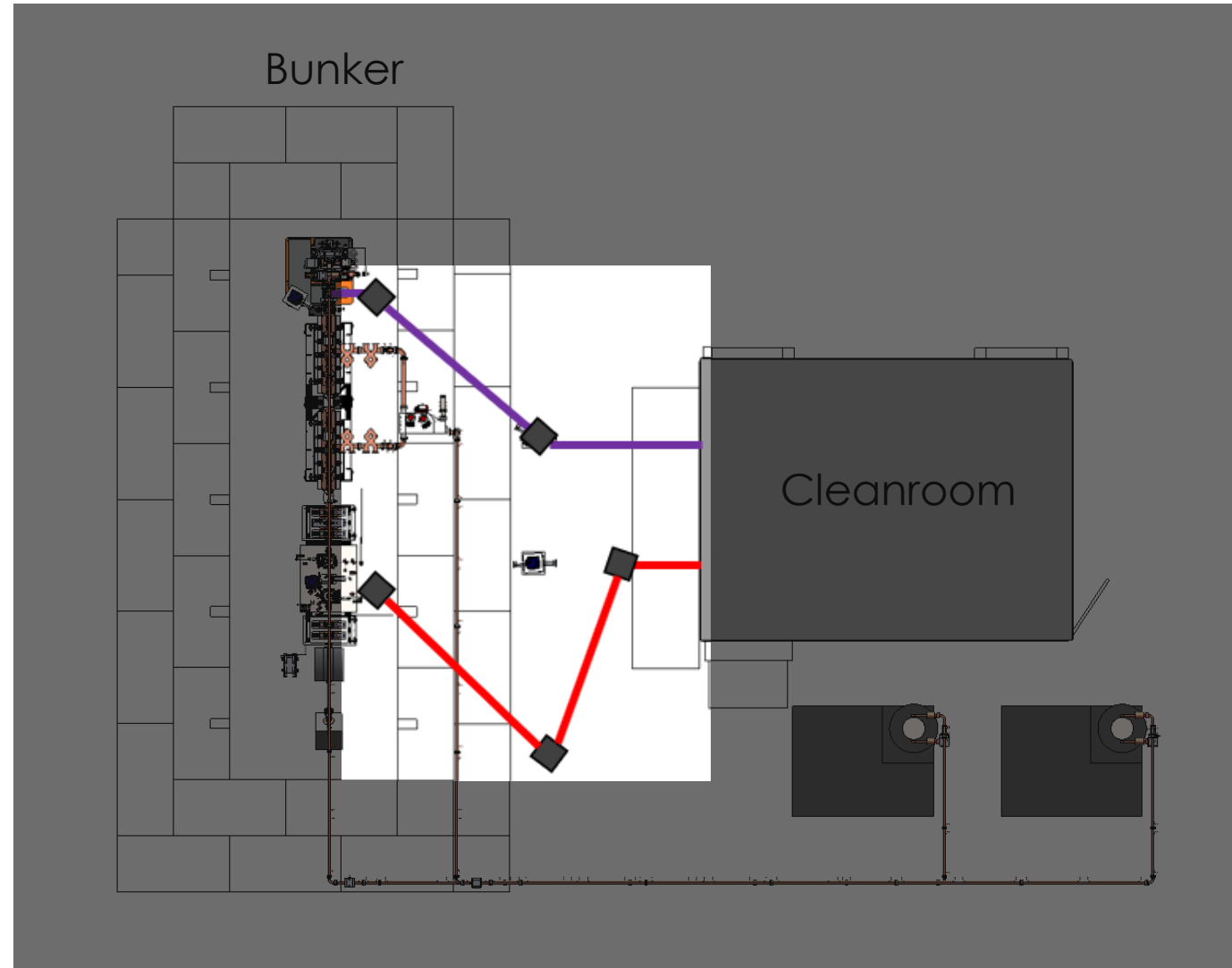
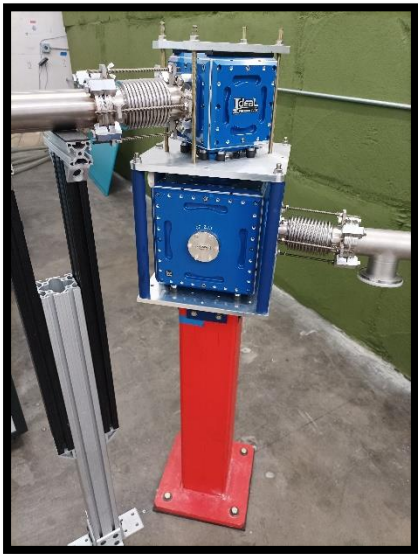
Laser system in three parts:

The laser cleanroom, where the source of both UV and IR laser is installed.



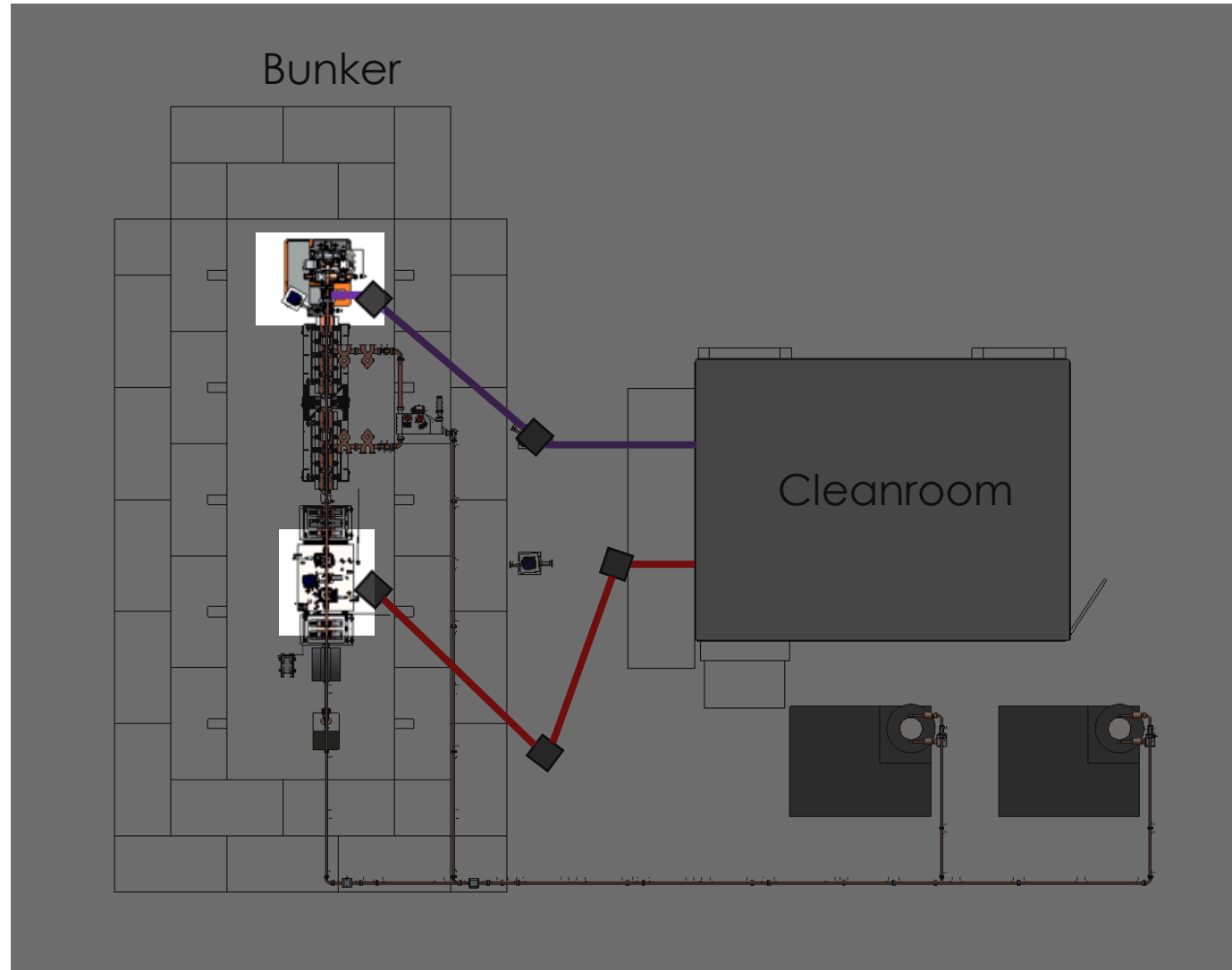
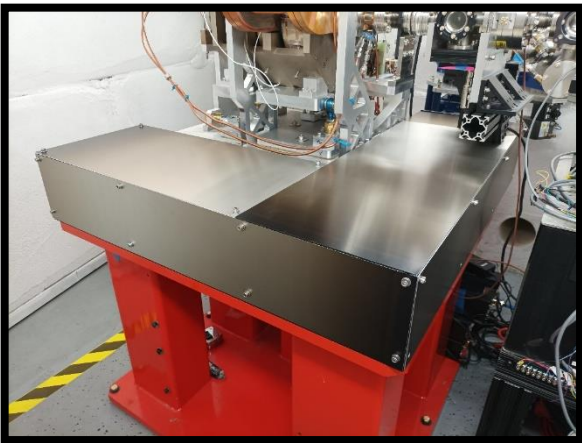
Laser system in three parts:

The low vacuum transport at $\sim 10^{-3}$ mbar, only composed of 3" mirrors.

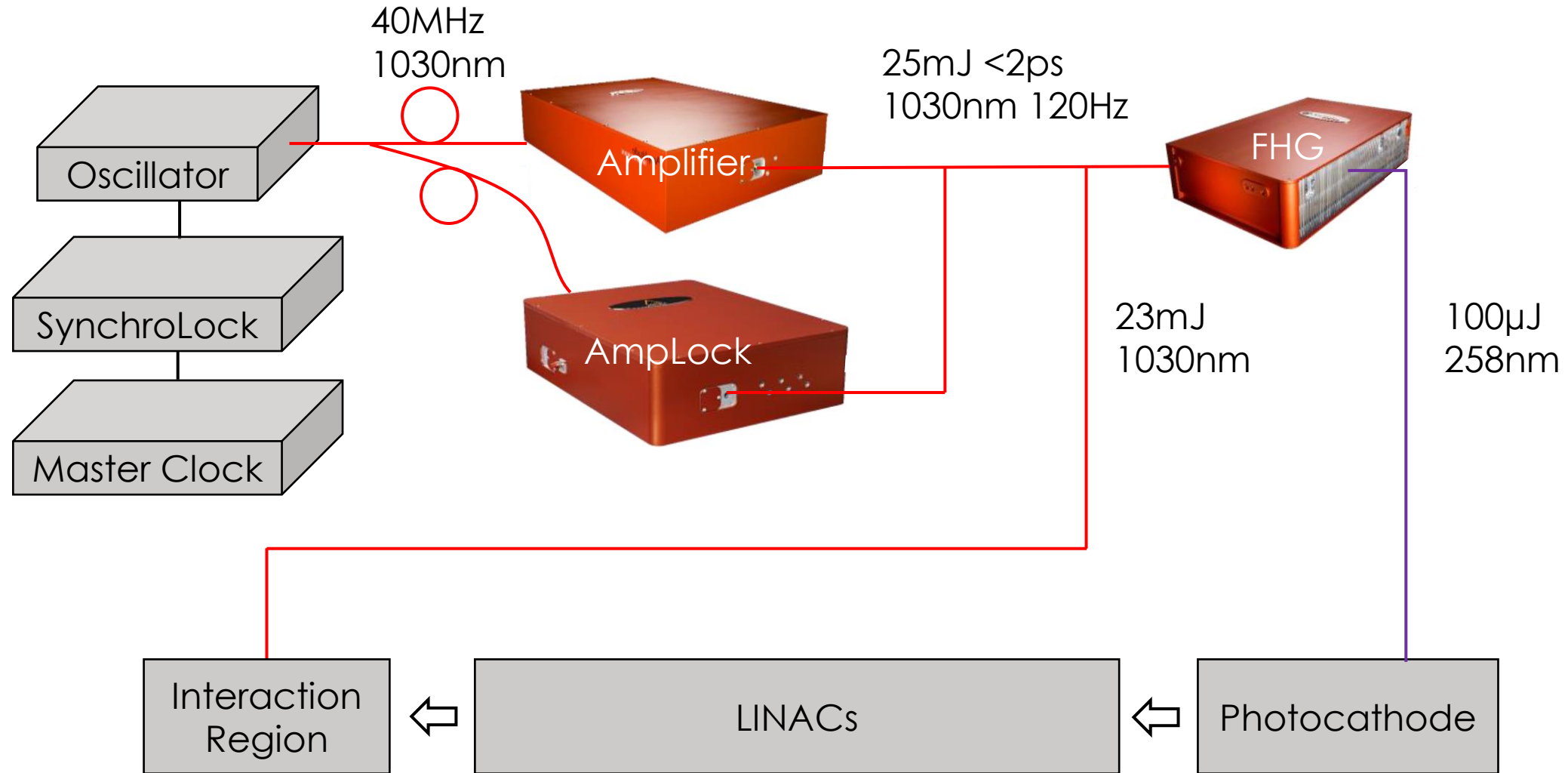


Laser system in three parts:

The bunker, where laser breadboard, imaging setup and diagnostics are installed.

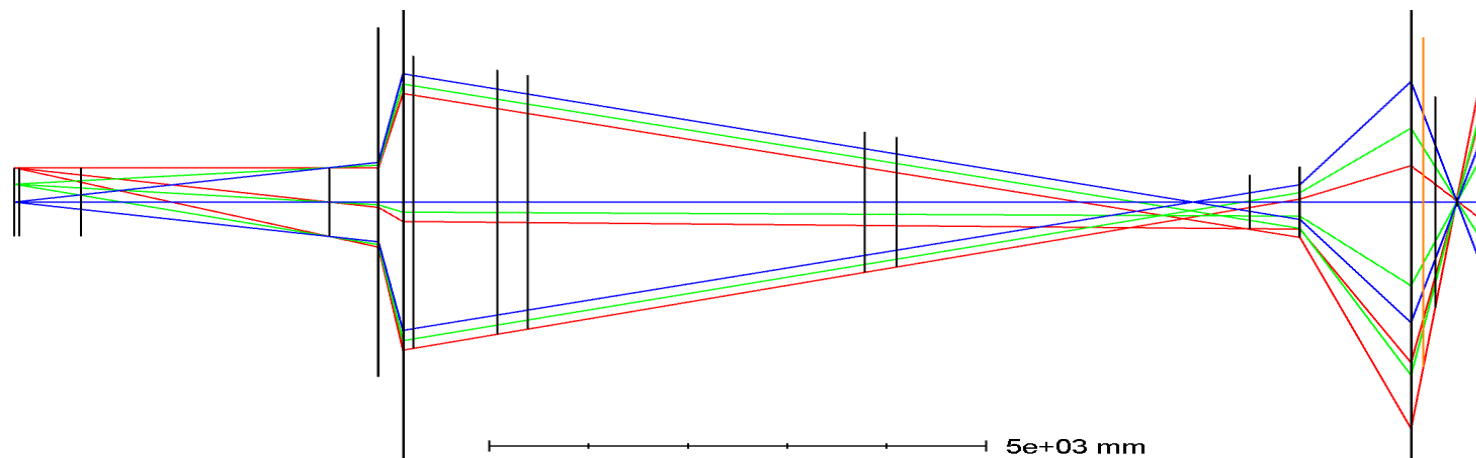


IR and UV lasers



Laser simulations done with Zemax OpticStudio.

- Ability to create lenses corresponding to catalogues
- Compute beam size as a function of the beam parameters and optics used
- Generate a cross-section view of the optical system



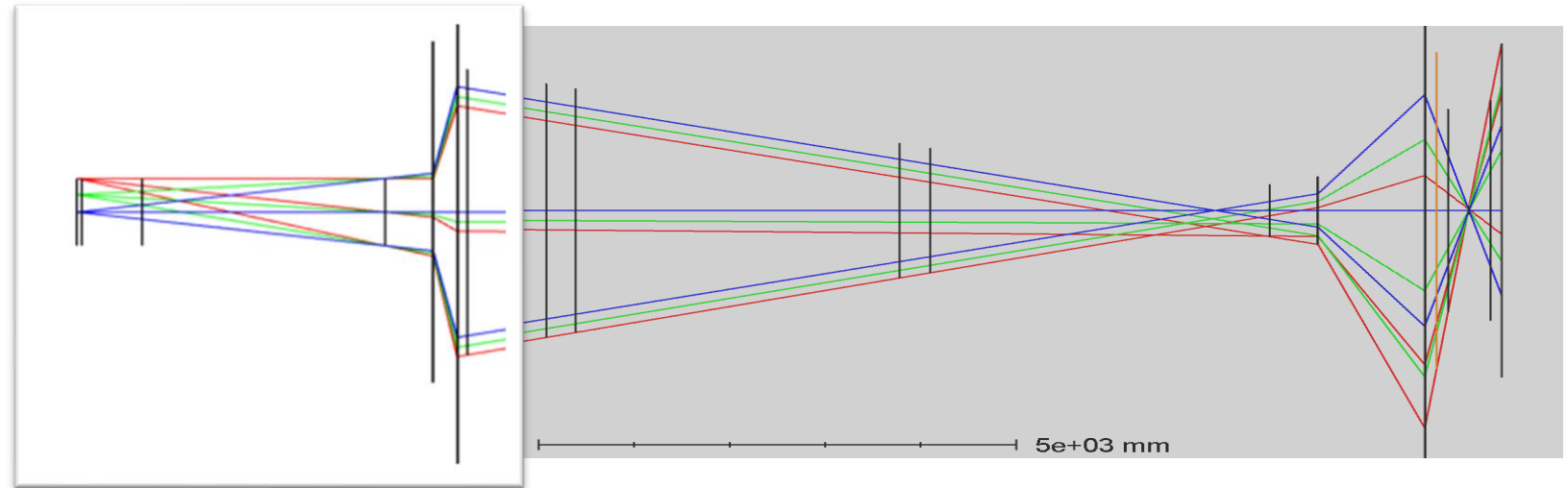
Sur	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia
0	Stan	Infinity	50.000			2.500	0.000	2.500
1	Stan	Infinity	624.160			2.500 U	0.000	2.500 U
2	Stan	Infinity	2500.000			2.500 U	0.000	2.500 U
3	Stan	Delay line	488.700			2.500 U	0.000	2.500 U
4	Stan	Front div lens	100.000	3.000	F_SILICA	12.700 U	0.000	12.700 U
5	Stan	Beam expander length	33.700	248.749		3.242	0.000	12.700
6	Stan	Front conv lens	100.100	5.100	F_SILICA	25.400 U	0.000	25.400 U
7	Stan	End of table	279.100	100.000		22.860 U	0.000	25.400
8	Stan	Vacuum input	Infinity	846.100		10.635	0.000	10.635
9	Stan	1st mirror	Infinity	304.800		9.605	0.000	9.605
10	Stan	2nd mirror	Infinity	3390.900		9.234	0.000	9.234
11	Stan	3rd mirror	Infinity	317.500		5.108	0.000	5.108
12	Stan	4th mirror	Infinity	3556.000		4.722	0.000	4.722
13	Stan	Iris	Infinity	0.000		1.984	0.000	1.984
14	Stan	Iris to telescope	Infinity	500.000		1.984	0.000	1.984
15	Stan	Front div lens	100.000	3.000	F_SILICA	2.564	0.000	2.564
16	Stan	Beam expander length	50.200	1119.235		2.542	0.000	2.564
17	Stan	Front conv lens	100.100	5.100	F_SILICA	22.000 U	0.000	22.000 U
18	Stan	Conv to injection	279.100	120.000		22.000 U	0.000	22.000
19	Stan		Infinity	0.000		11.972	0.000	11.972
20	Stan	Accelerator window	Infinity	118.560		11.972	0.000	11.972
21	Stan	Mirror	Infinity	221.250		7.679	0.000	7.679
22	Stan	Interaction region 20 µm	Infinity	221.250		0.333	0.000	0.333
23	Stan	Mirror	Infinity	118.560		8.344	0.000	8.344
24	Stan	Output window	Infinity	0.000		12.637	0.000	12.637
25	Stan	Diagnostics	Infinity	-		0.000 U	0.000	0.000 U

Mixed Mode results for M2 = 1.1800:

Sur	Size	Waist	Position
OBJ	2.49845E+00	2.49844E+00	-5.00000E+01
1	2.49844E+00	2.49844E+00	0.00000E+00
2	2.50031E+00	2.49844E+00	6.24160E+02
STO	2.54484E+00	2.49844E+00	3.12416E+03
4	2.56031E+00	3.36715E-02	-3.23094E+02
5	2.53654E+00	1.72821E-02	1.13307E+02
6	8.10495E+00	2.75283E-02	-8.36256E+02
7	8.05553E+00	3.63162E-01	-7.55411E+03
8	7.94911E+00	3.63162E-01	-7.45411E+03
9	7.04882E+00	3.63162E-01	-6.60801E+03
10	6.72457E+00	3.63162E-01	-6.30321E+03
11	3.12364E+00	3.63162E-01	-2.91231E+03
12	2.78798E+00	3.63162E-01	-2.59481E+03
13	1.08644E+00	3.63162E-01	9.61190E+02
14	1.08644E+00	3.63162E-01	9.61190E+02
15	1.59840E+00	6.27959E-02	-3.75917E+02
16	1.58566E+00	4.79802E-02	1.96564E+02
17	1.06097E+01	9.76035E-03	-3.88131E+02
18	1.04702E+01	1.70023E-02	-4.60144E+02
19	7.73974E+00	1.70023E-02	-3.40144E+02
20	7.73974E+00	1.70023E-02	-3.40144E+02
21	5.04201E+00	1.70023E-02	-2.21584E+02
22	1.86277E-02	1.70023E-02	-3.34450E-01
23	5.02679E+00	1.70023E-02	2.20916E+02
24	7.72452E+00	1.70023E-02	3.39476E+02
IMA	7.72452E+00	1.70023E-02	3.39476E+02

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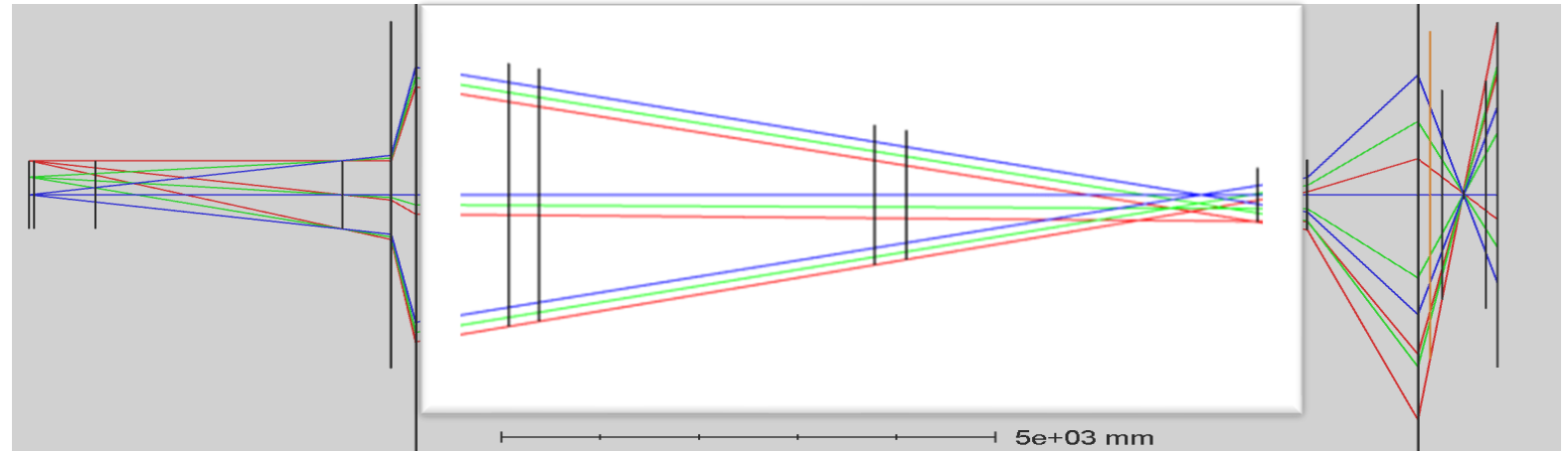
Sur	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia
0	Stan	Iris	Infinity	50.000		2.500	0.000	2.500
1	Stan		Infinity	624.160		2.500 U	0.000	2.500 U
2	Stan		Infinity	2500.000		2.500 U	0.000	2.500 U
3	Stan	Delay line	Infinity	488.700		2.500 U	0.000	2.500 U
4	Stan	Front div lens	100.000	3.000	F_SILICA	12.700 U	0.000	12.700 U
5	Stan	Beam expander length	33.700	248.749		3.242	0.000	12.700
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7	Stan	End of table	279.100	100.000		22.860 U	0.000	25.400
8	Stan	Vacuum input	Infinity	846.100		10.635	0.000	10.635
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19	Stan		Infinity	0.000		11.972	0.000	11.972
20	Stan	Accelerator window	Infinity	118.560		11.972	0.000	11.972
21	Stan	Mirror	Infinity	221.250		7.679	0.000	7.679
22	Stan	Interaction region 20 µm	Infinity	221.250		0.333	0.000	0.333
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Sur	Size	Waist	Position
OBJ	2.49845E+00	2.49844E+00	-5.00000E+01
1	2.49844E+00	2.49844E+00	0.00000E+00
2	2.50031E+00	2.49844E+00	6.24160E+02
STO	2.54484E+00	2.49844E+00	3.12416E+03
4	2.56031E+00	3.36715E-02	-3.23094E+02
5	2.53654E+00	1.72821E-02	1.13307E+02
6	8.10495E+00	2.75283E-02	-8.36256E+02
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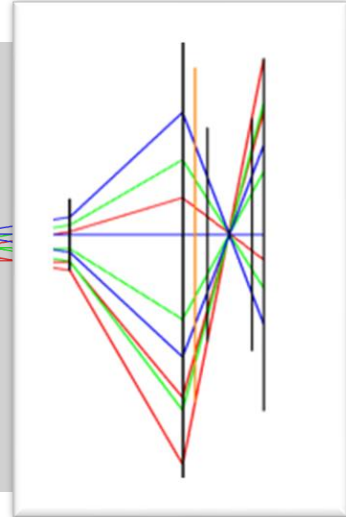
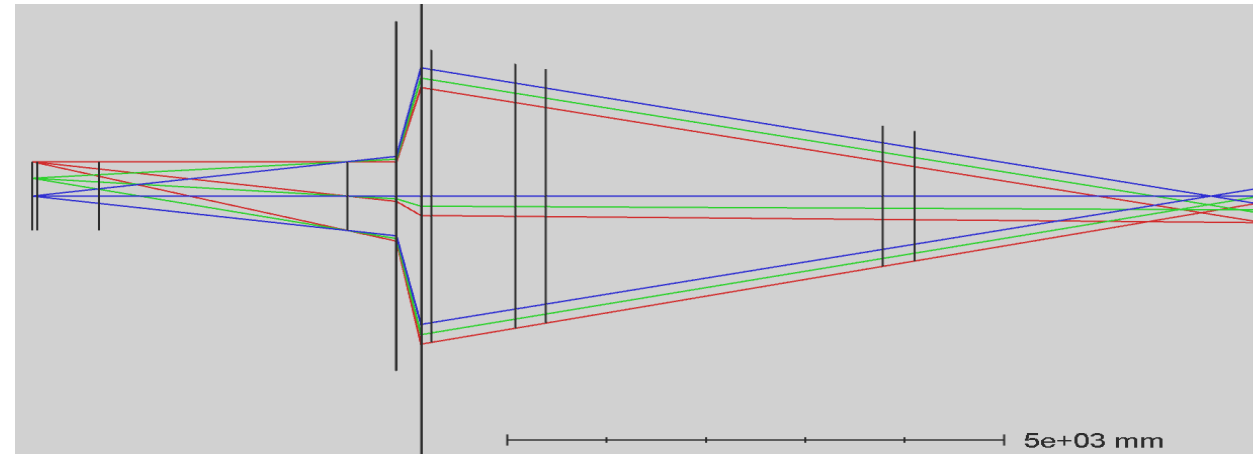
Sur	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia
0	Stan	Iris	Infinity	50.000		2.500	0.000	2.500
1	Stan		Infinity	624.160		2.500 U	0.000	2.500 U
2	Stan		Infinity	2500.000		2.500 U	0.000	2.500 U
3	Stan	Delay line	Infinity	488.700		2.500 U	0.000	2.500 U
4	Stan	Front div lens	100.000	3.000	F_SILICA	12.700 U	0.000	12.700 U
5	Stan	Beam expander length	33.700	248.749		3.242	0.000	12.700
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7	Stan	End of table	279.100	100.000		22.860 U	0.000	25.400
8	Stan	Vacuum input	Infinity	846.100		10.635	0.000	10.635
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21	Stan	Mirror	Infinity	221.250		7.679	0.000	7.679
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24	Stan	Output window	Infinity	0.000		12.637	0.000	12.637
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Sur	Size	Waist	Position
OBJ	2.49845E+00	2.49844E+00	-5.00000E+01
1	2.49844E+00	2.49844E+00	0.00000E+00
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18	1.04702E+01	1.70023E-02	-4.60144E+02
19	7.73974E+00	1.70023E-02	-3.40144E+02
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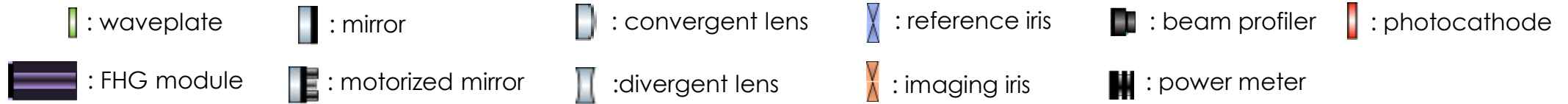
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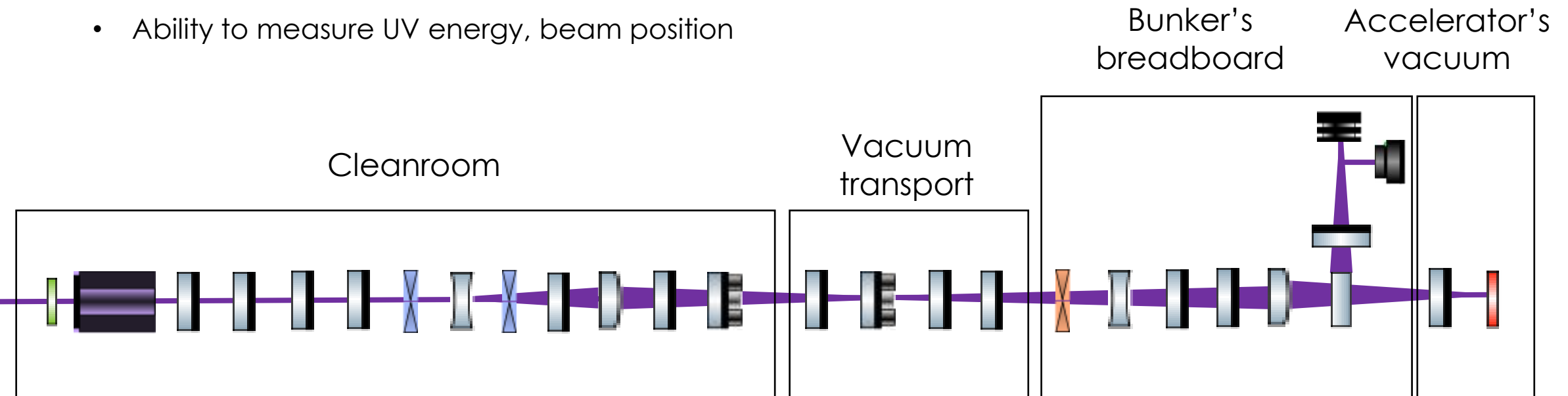
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24	Stan	Infinity	0.000			12.637	0.000	12.637
25	Stan	Infinity	-			0.000 U	0.000	0.000 U

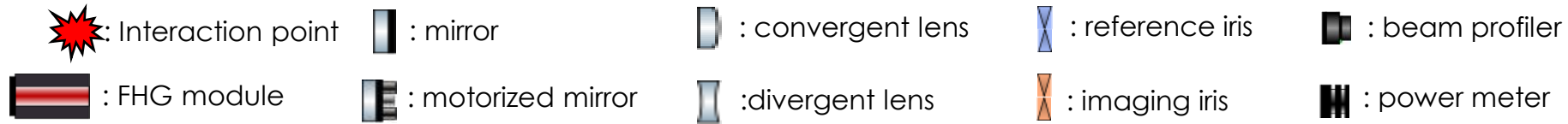
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24	7.72452E+00	1.70023E-02	3.39476E+02
IMA	7.72452E+00	1.70023E-02	3.39476E+02

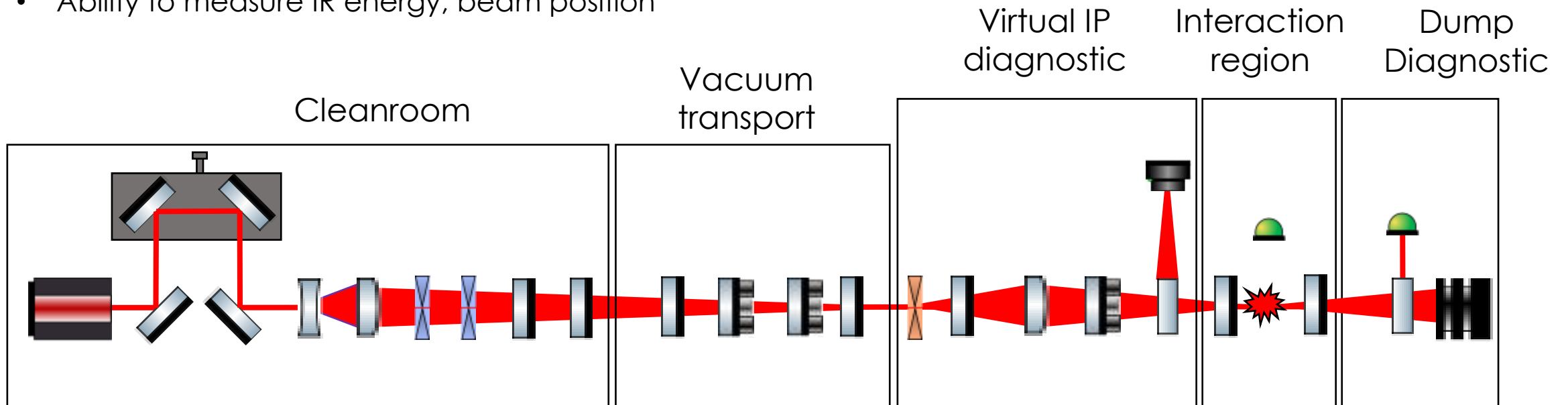


- From the FHG module to the photocathode, we are going through 14 mirrors, 4 lenses, 2 beam sampler and a total of ~10.5m of distance
- Most of the transport under vacuum
- Ability to measure UV energy, beam position





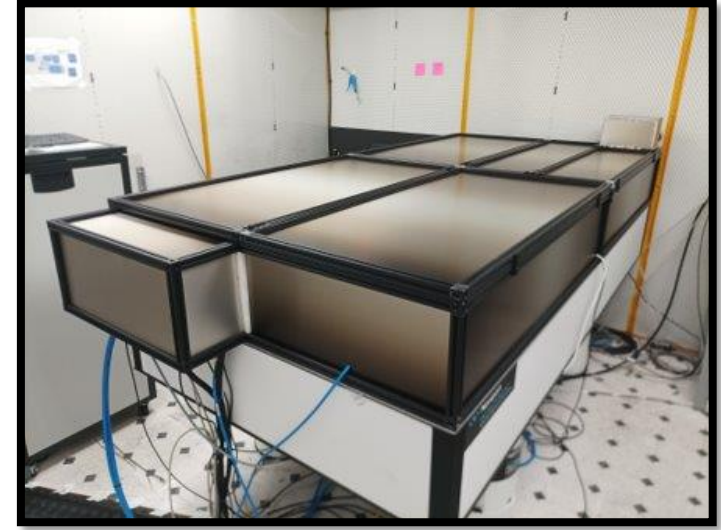
- From the split between IR and UV to the interaction point, we will be going through 18 mirrors, 4 lenses, 1 beam sampler and a total of ~15m of distance (UV + 4365.5 mm +/- 5 mm)
- Half of the transport is the vacuum transport
- Ability to measure IR energy, beam position



Laser cleanroom

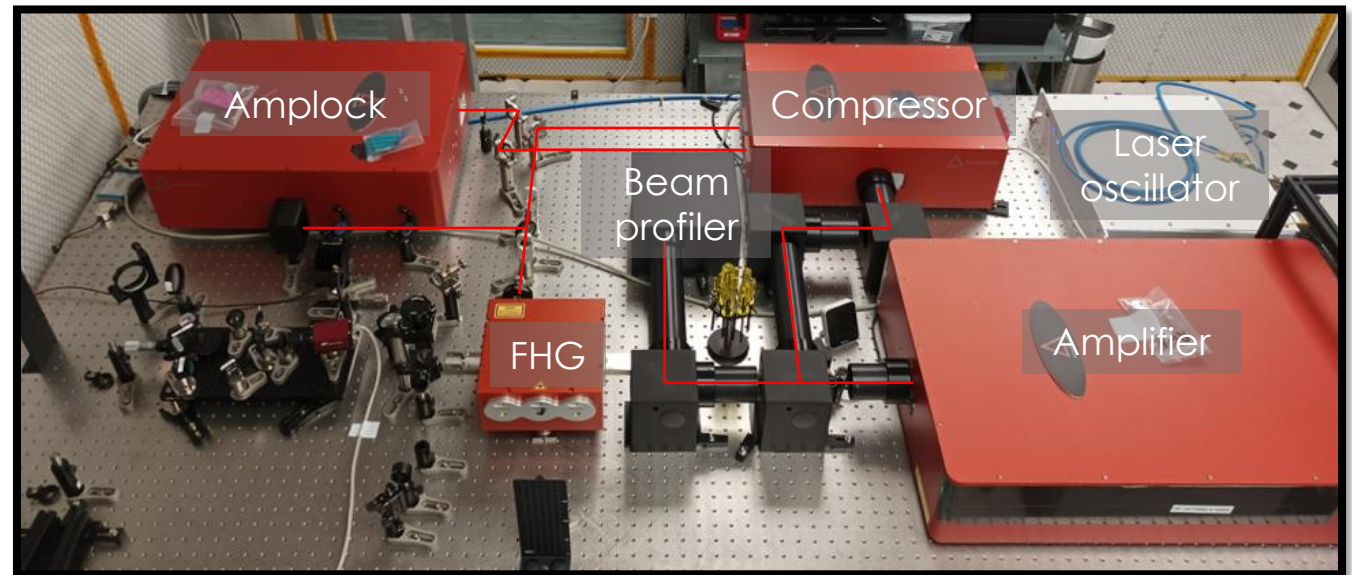
Laser cleanroom ISO5, 5x4m:

- Temperature controlled environment
- Low dust presence and laminar flow
- 8'x4' Optical damped table
- Laser enclosure

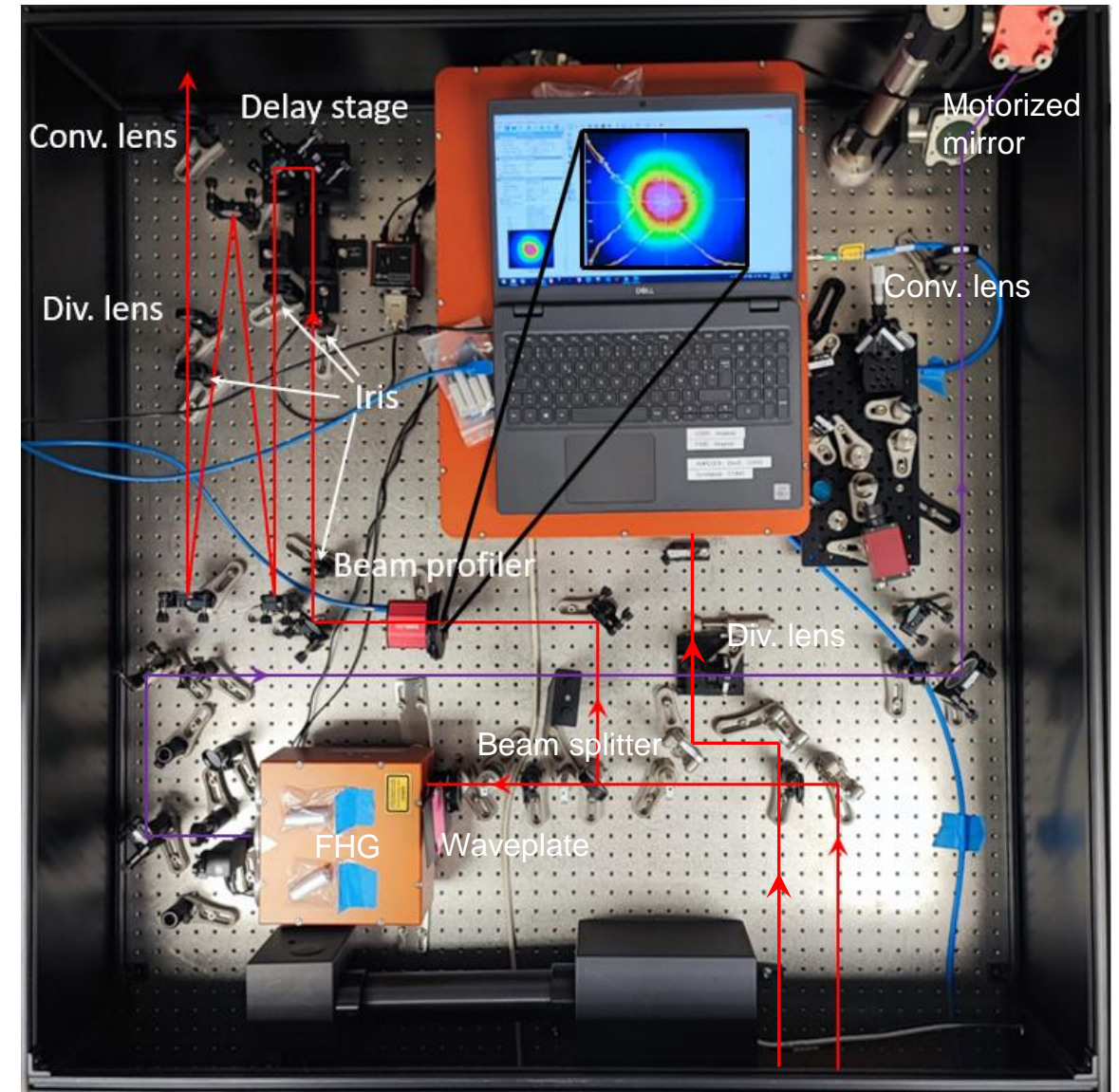


Picosecond Yb:YAG amplifier:

- Up to 23mJ delivered at 1030nm
- Up to 100 μ J delivered at 257nm
- Repetition rate adjustable from 1 to 120Hz
- < 2ps pulse width
- < 10 μ rad rms pointing stability
- Full synchronization capabilities

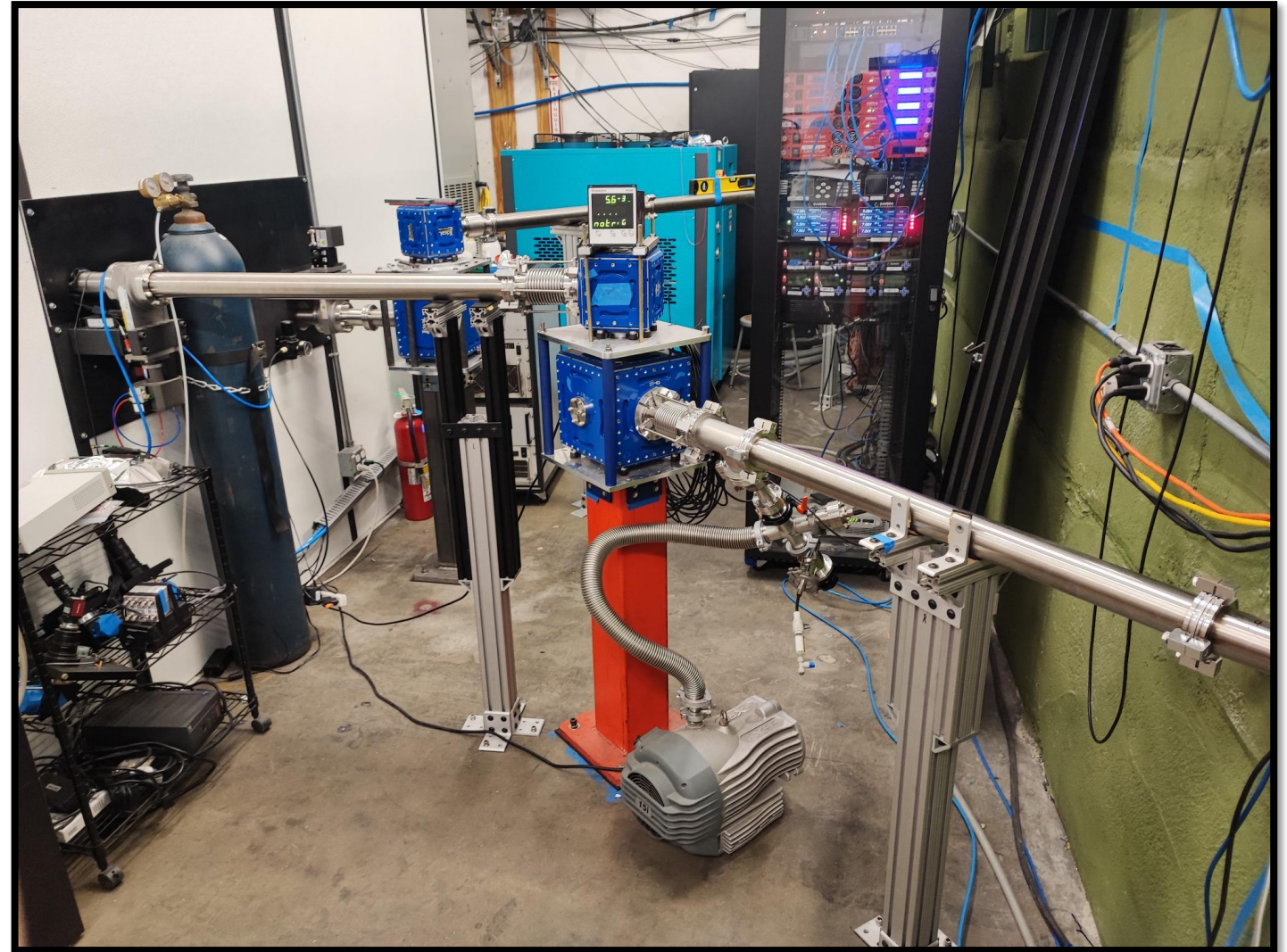
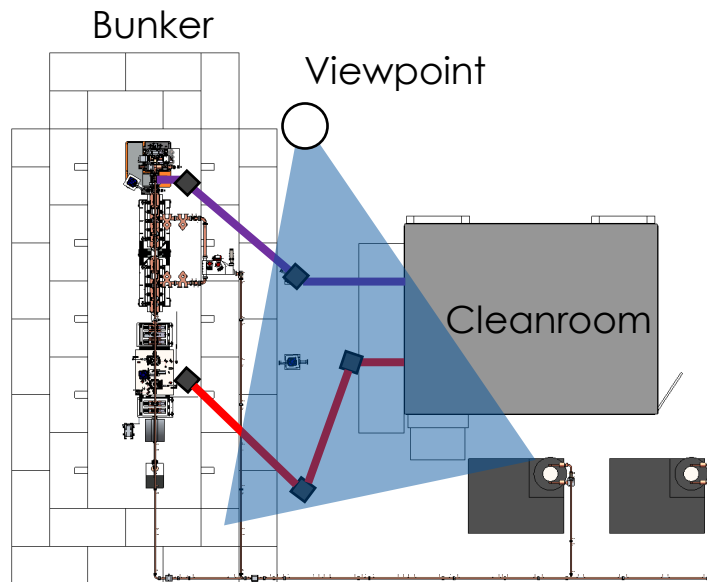


- UV beam expanding for transport
- UV motorized mirror for real time beam position correction
- IR beam expanding for transport
- IR long path travelled and delay stage to adjust the transport length



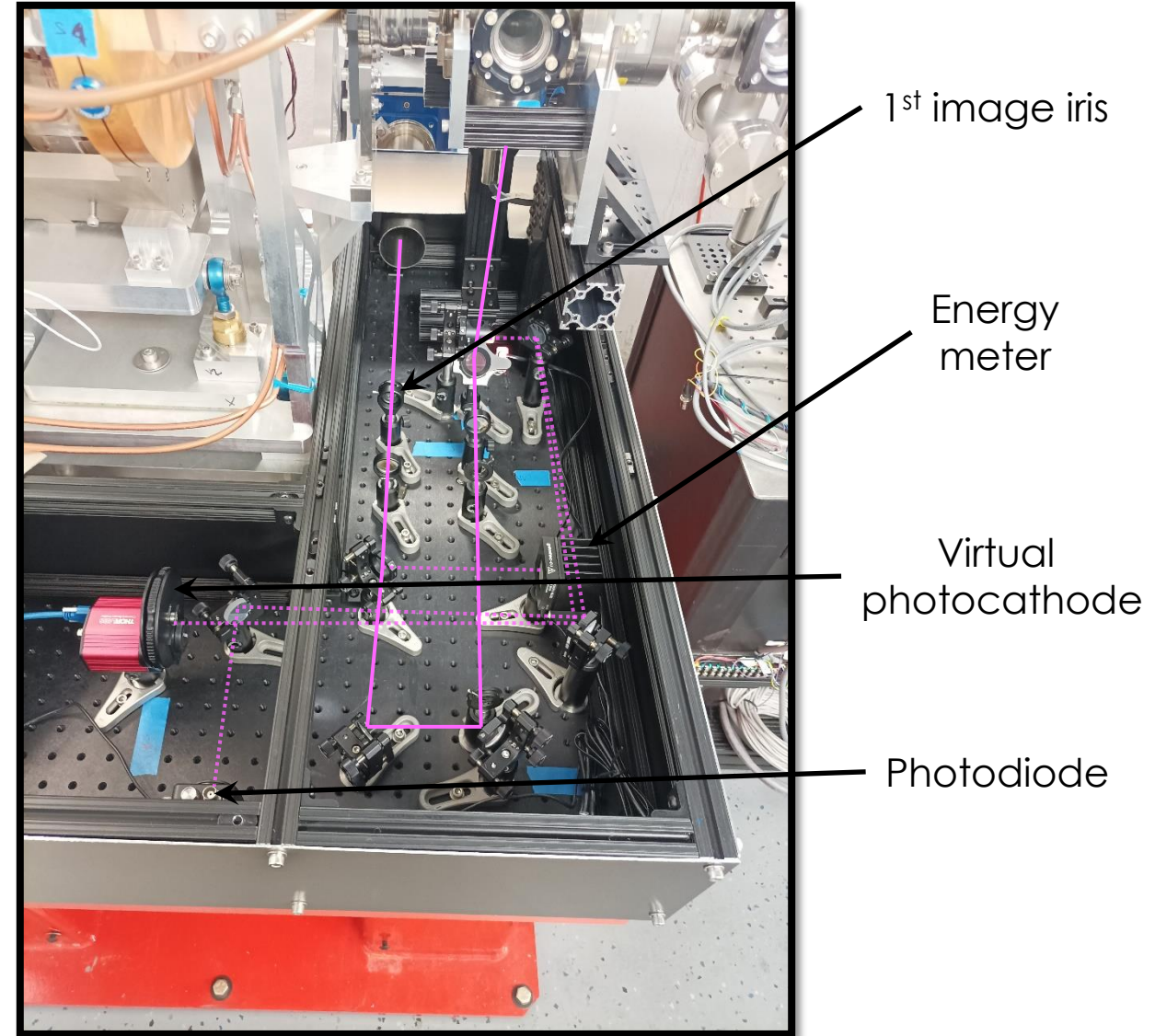
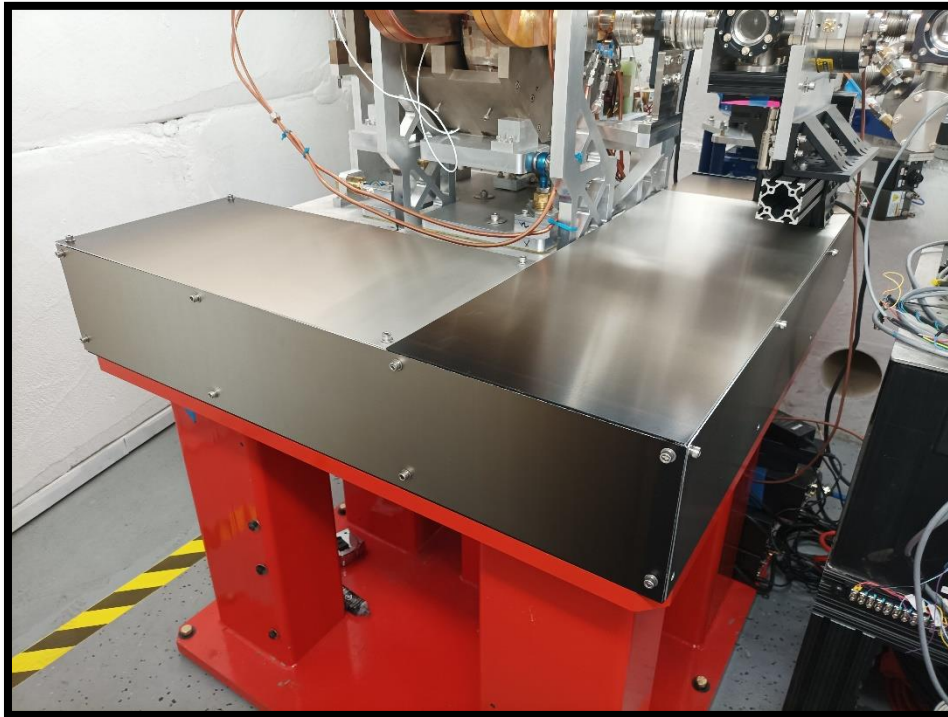
Laser transport

- Pneumatic valves
- Low vacuum
- Nitrogen purge

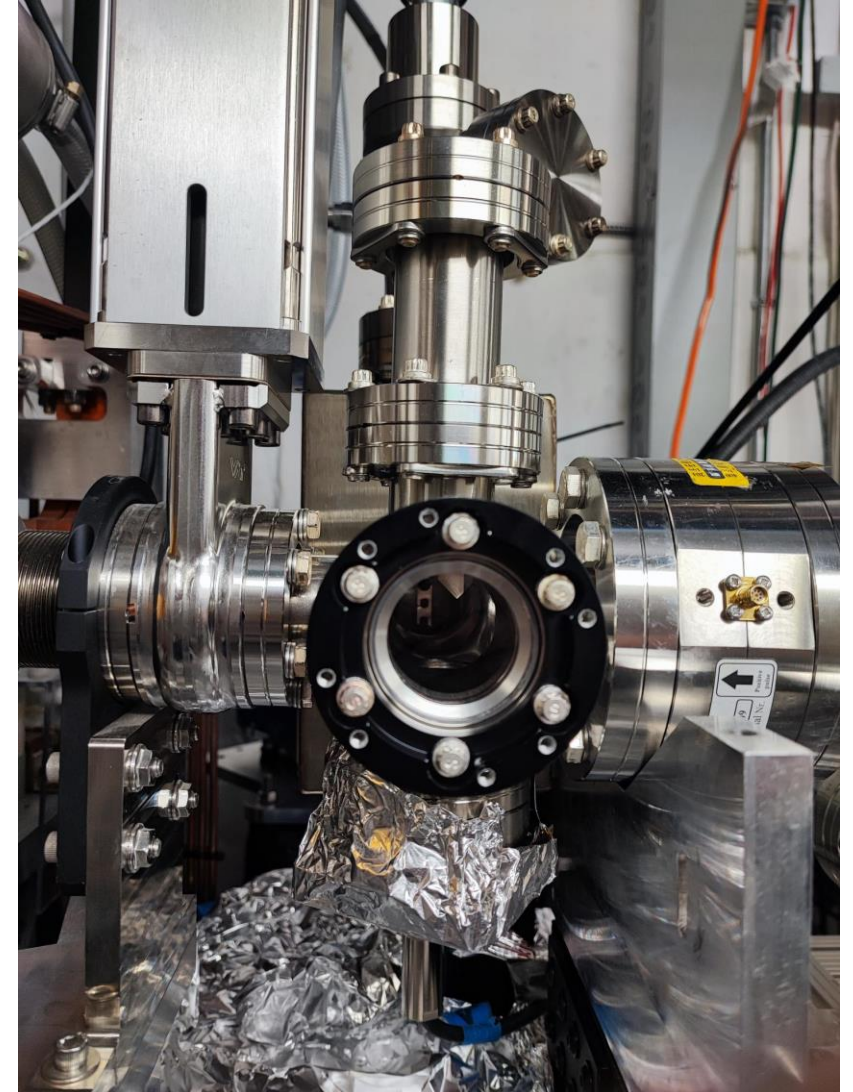
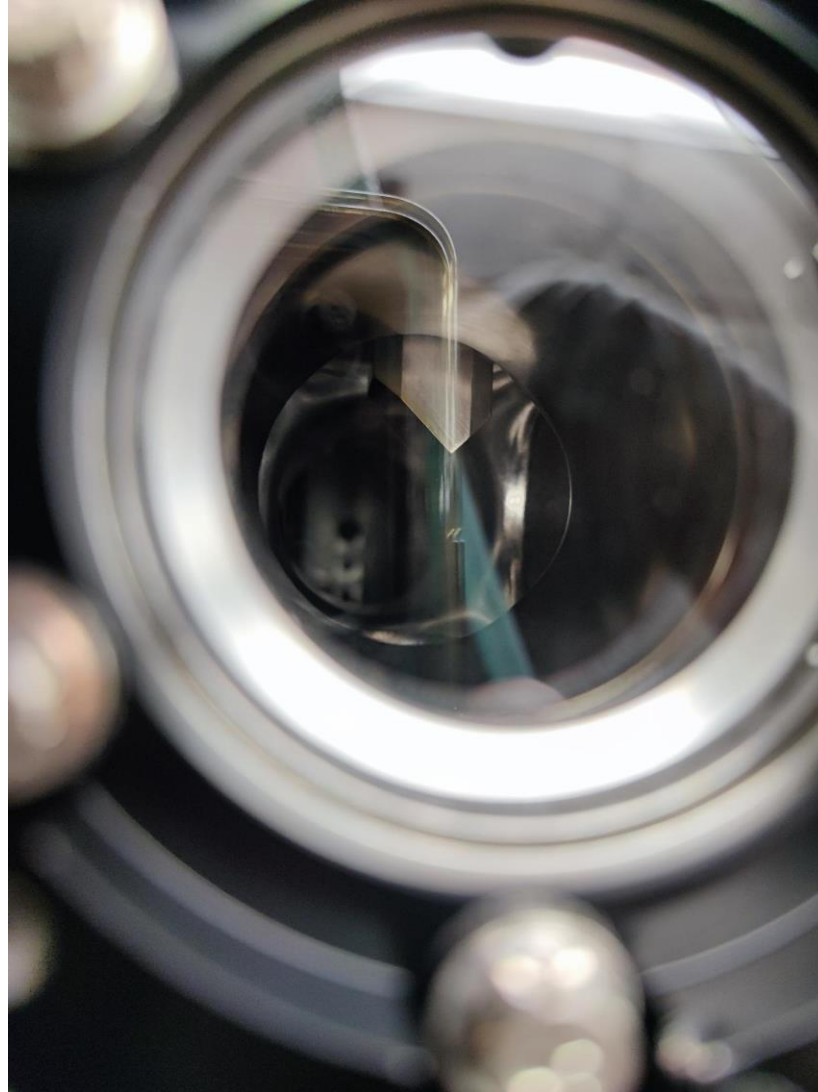


Bunker's setup

- Cover has been mounted
- Beam aligned
- UV beam injected in accelerator

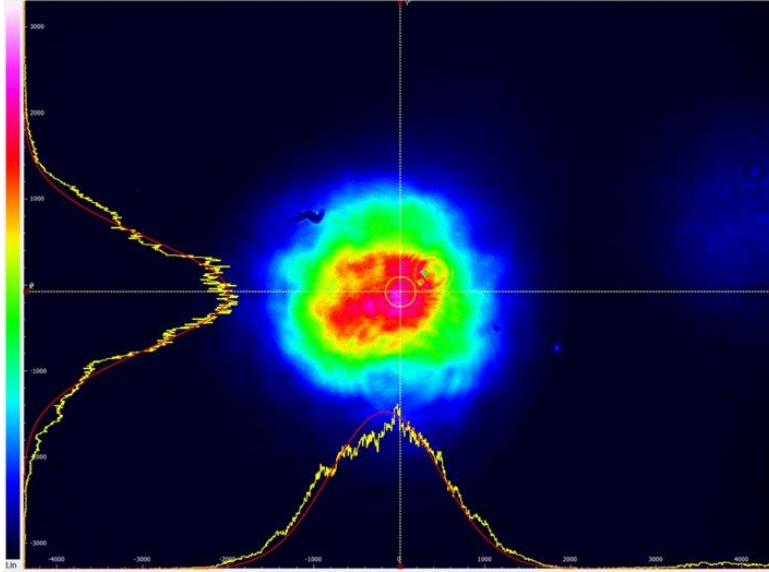


- Injection polished aluminum mirror 45degree angle
- Only horizontal reflection angle adjustable

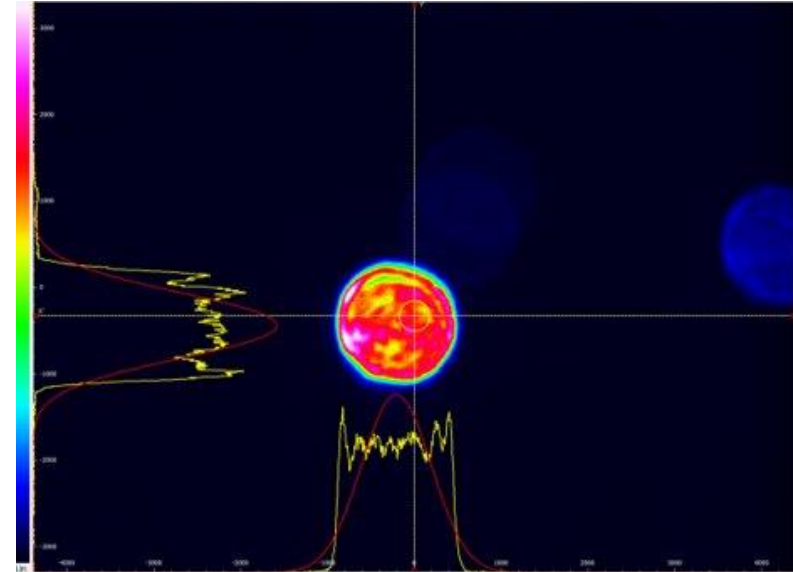


1st iris image (UV laser - bunker)

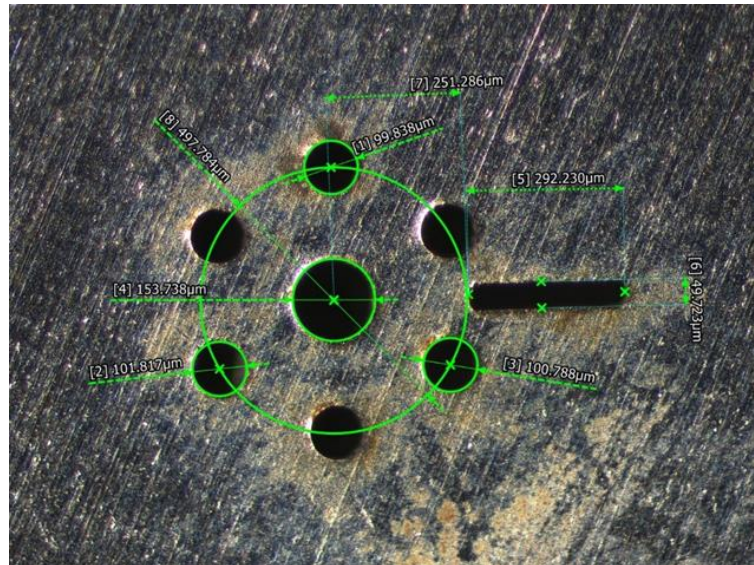
FHG output imaged



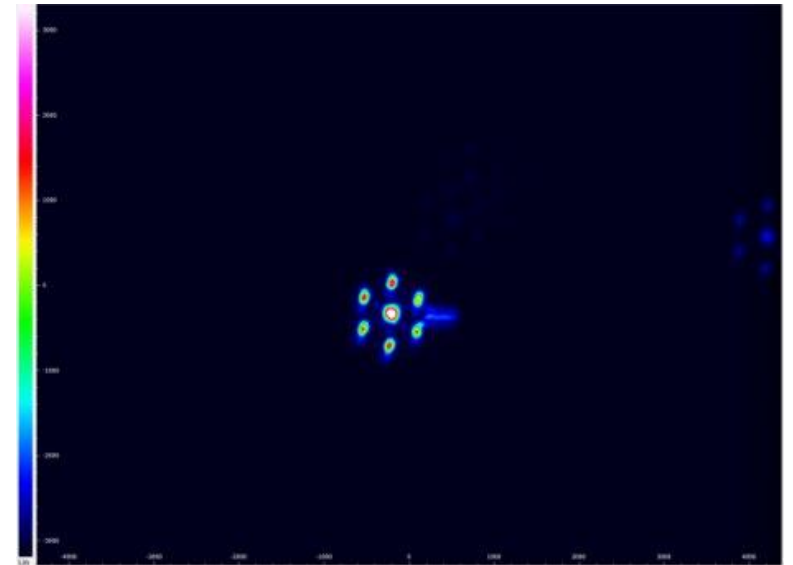
1 mm iris imaged



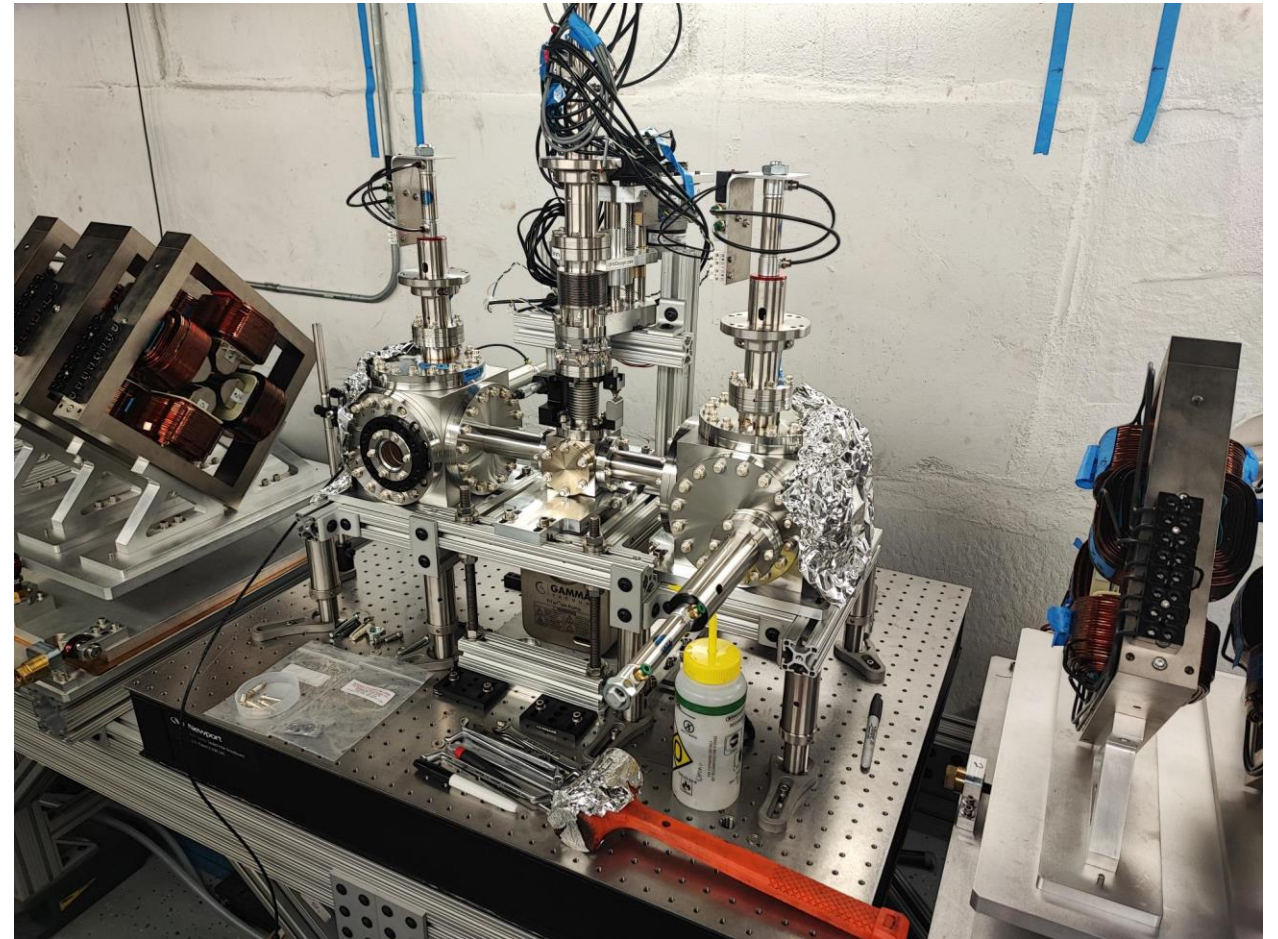
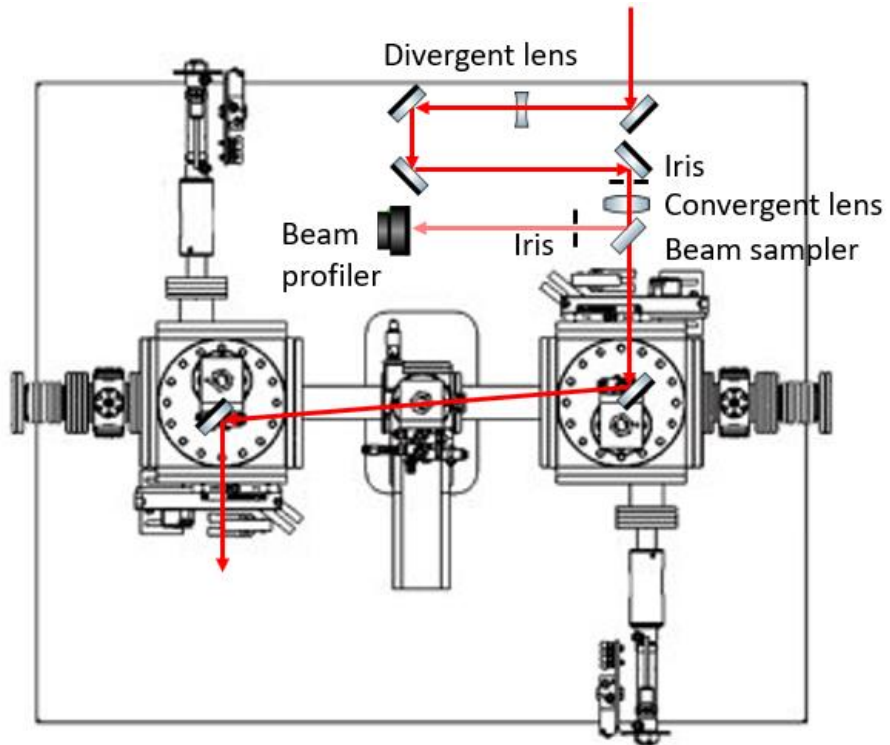
Imaging mask



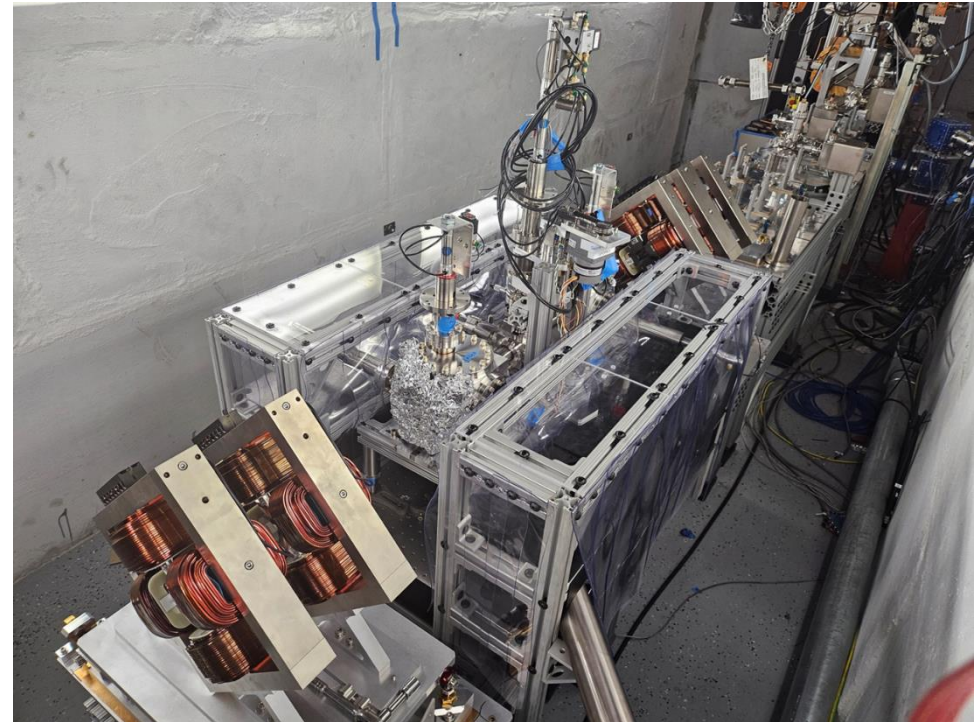
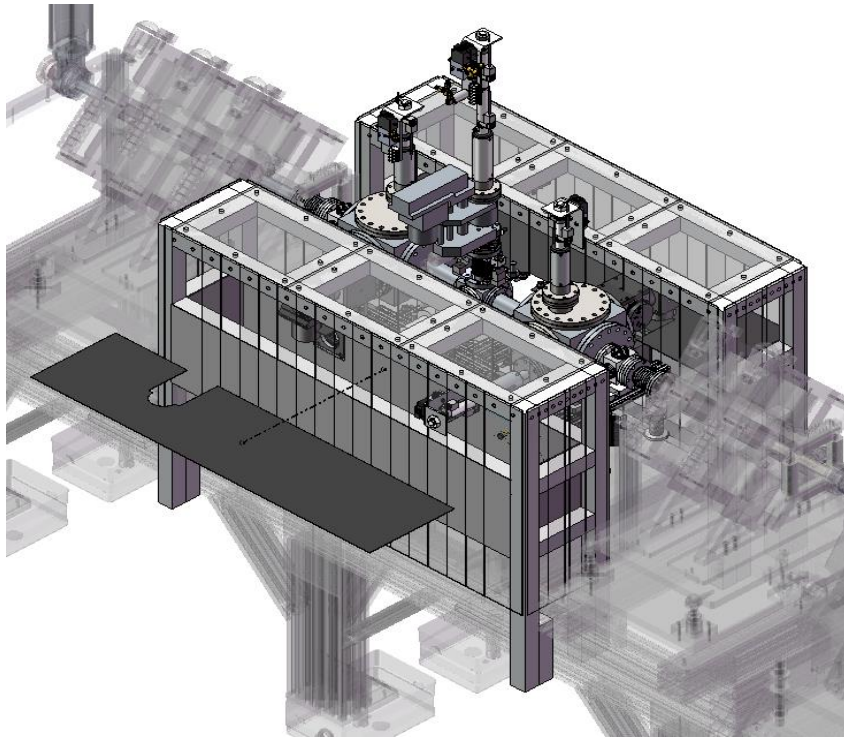
Mask imaged



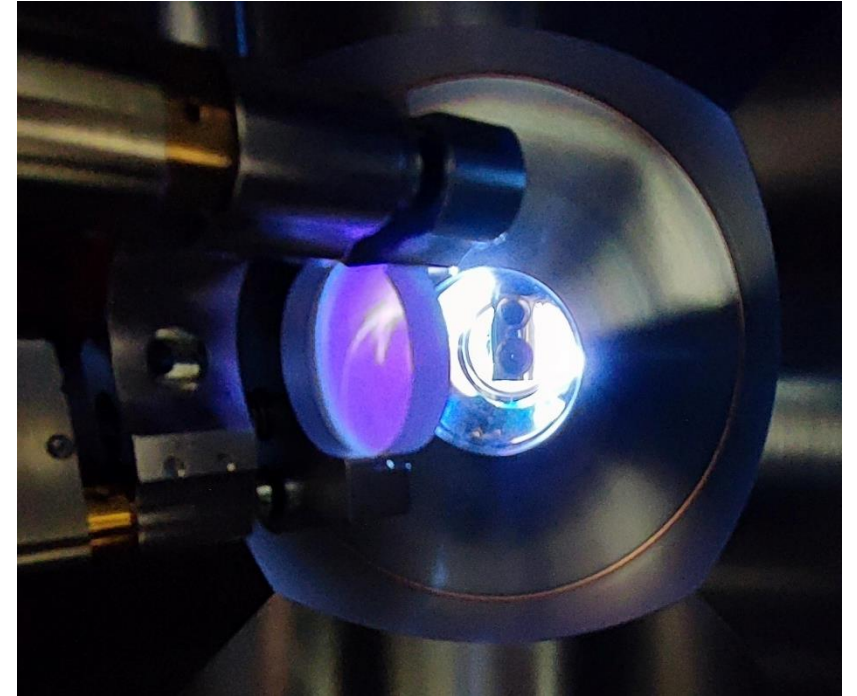
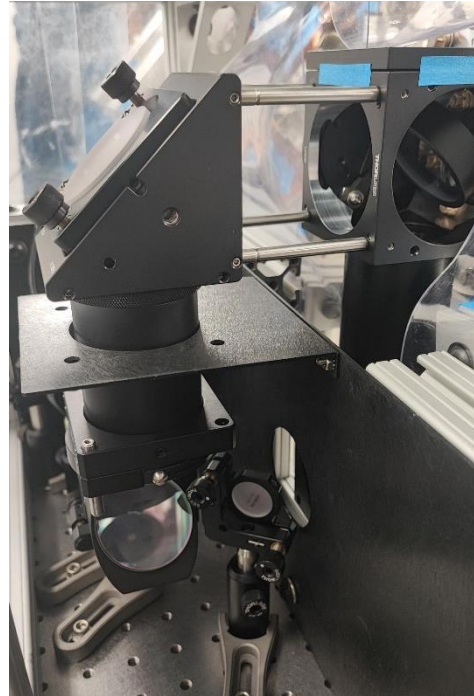
- IP chamber in three parts
- Insertable mirrors
- Insertable and motorized alignment iris (30 μ m)

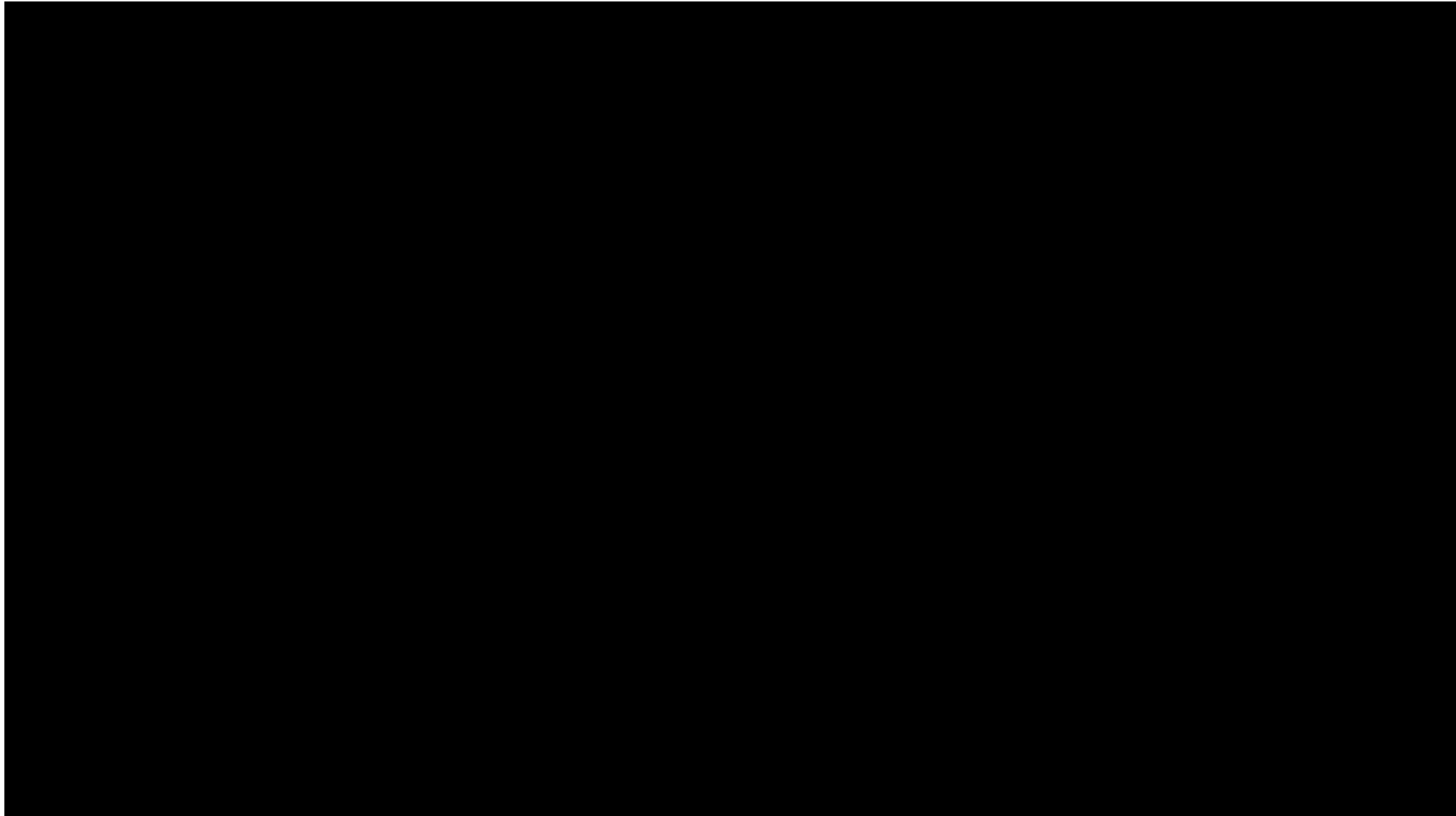


- Aluminum enclosure
- Acrylic top
- Flexible PVC curtains

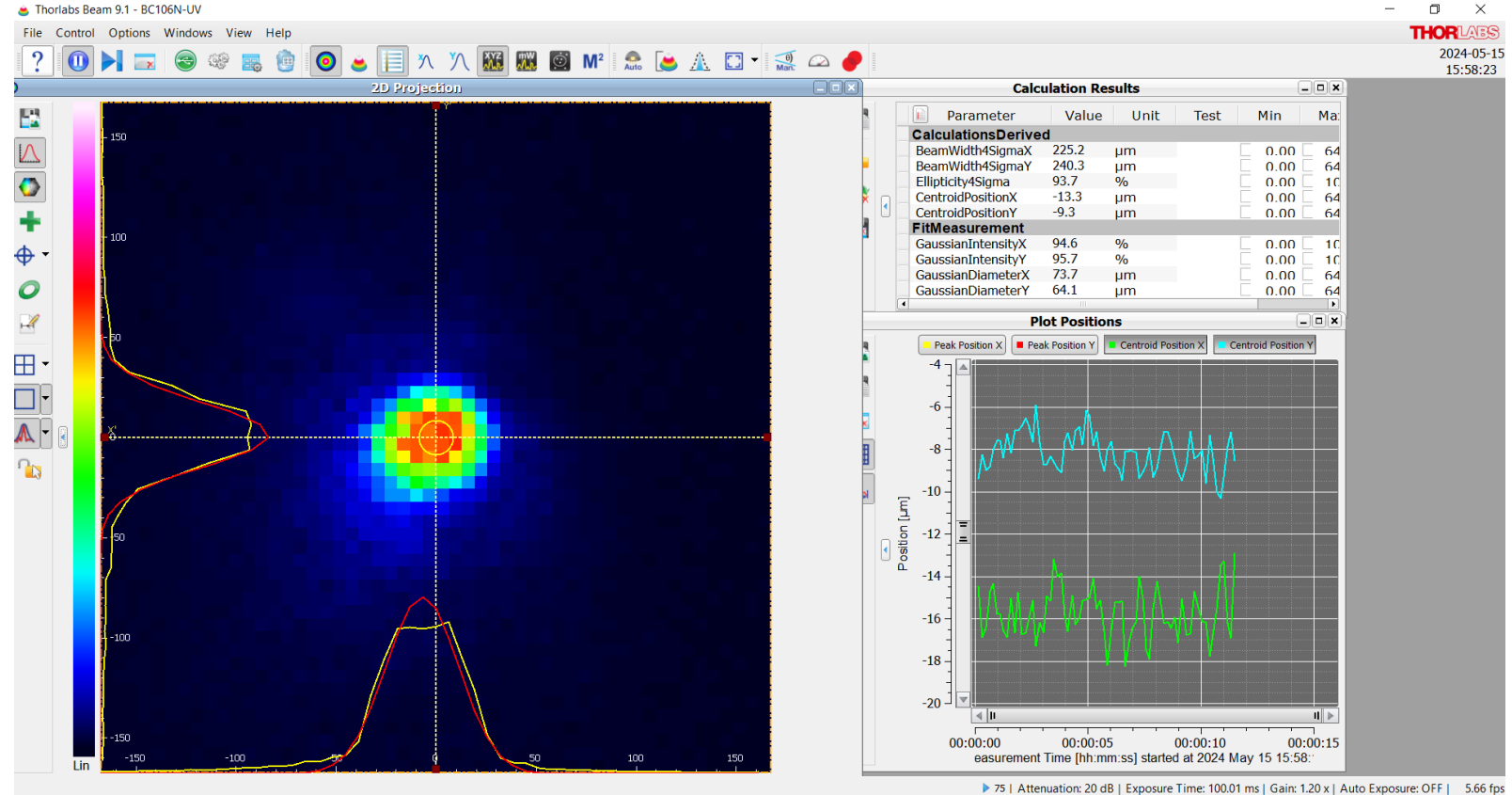


- IR beam aligned through the IP chamber
- Beam profiler installed at the virtual interaction point and after the IP chamber
- Interaction point lenses mounted and aligned in respect with the initial beam
- ❖ Goal 40-48 μm beam diameter ($1/e^2$)
- Achieved 64.1 μm vertically and 73.7 μm horizontally



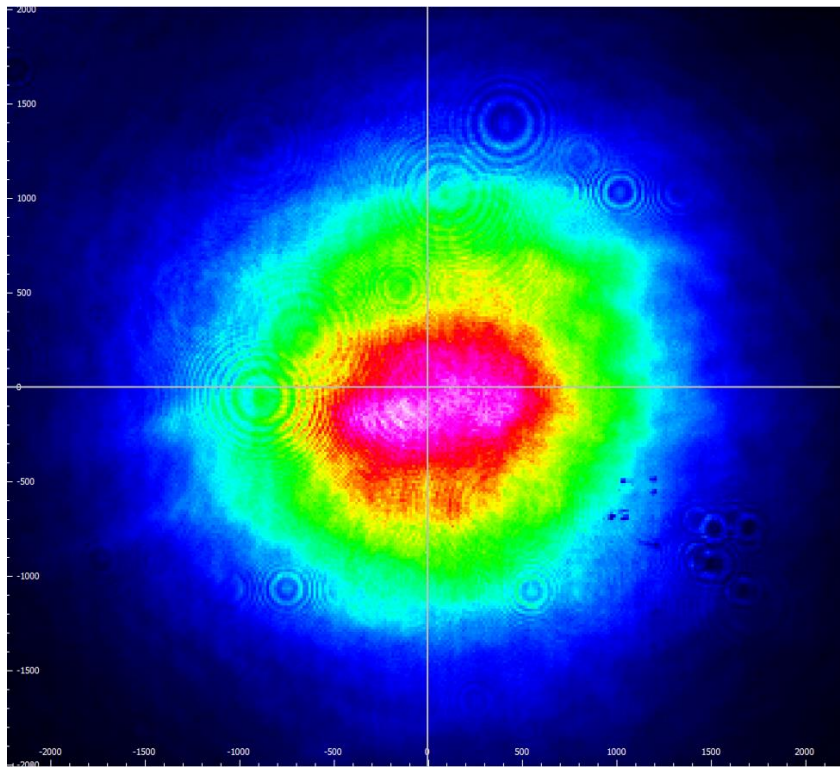


- Goal 40-48 μm beam diameter ($1/e^2$) or 10-12 μm (σ)
- Achieved 64.1 μm vertically and 73.7 μm horizontally or $\sigma = 17.26\mu\text{m}$



Thank you

Infra-red beam



Ultra-violet beam (after FHG)

