Supersonic Gas Jet Target

JENSA

K.A. Chipps

March 25th, 2011

JENSA Gas Jet Workshop, Friday, March 25th

9:45am Coffee

10:00am Welcome and introductions

Chipps: overview of Gas Jet Target

Couder: recent results and lessons from the Notre Dame gas jet

11:00am Discussion: general project issues (locations, funding, requirements, specifications, resources, delegation of responsibility)

12:30pm Working lunch (provided)

1:30pm Presentations: technical issues

Schatz/Montes: ReA3 updates, timelines, specifications, etc

Erikson: low cost gamma array for the gas jet

Bardayan/Pain/Blackmon: charged particle and recoil detection

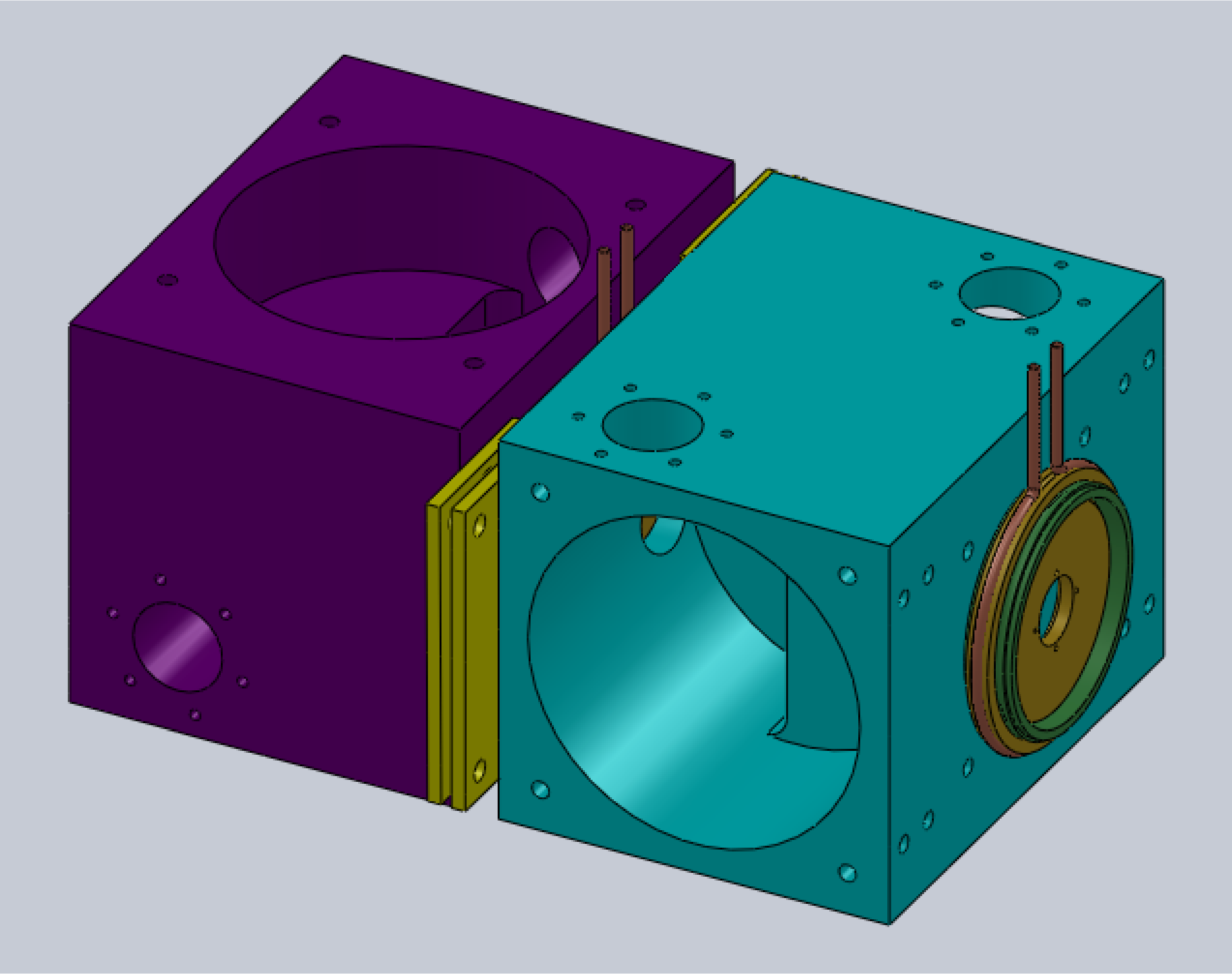
2:30pm Discussion: technical issues (infrastructure, gases, detection systems, diagnostics, experimental campaigns)

4:00pm Summary, AOB (like beer!)

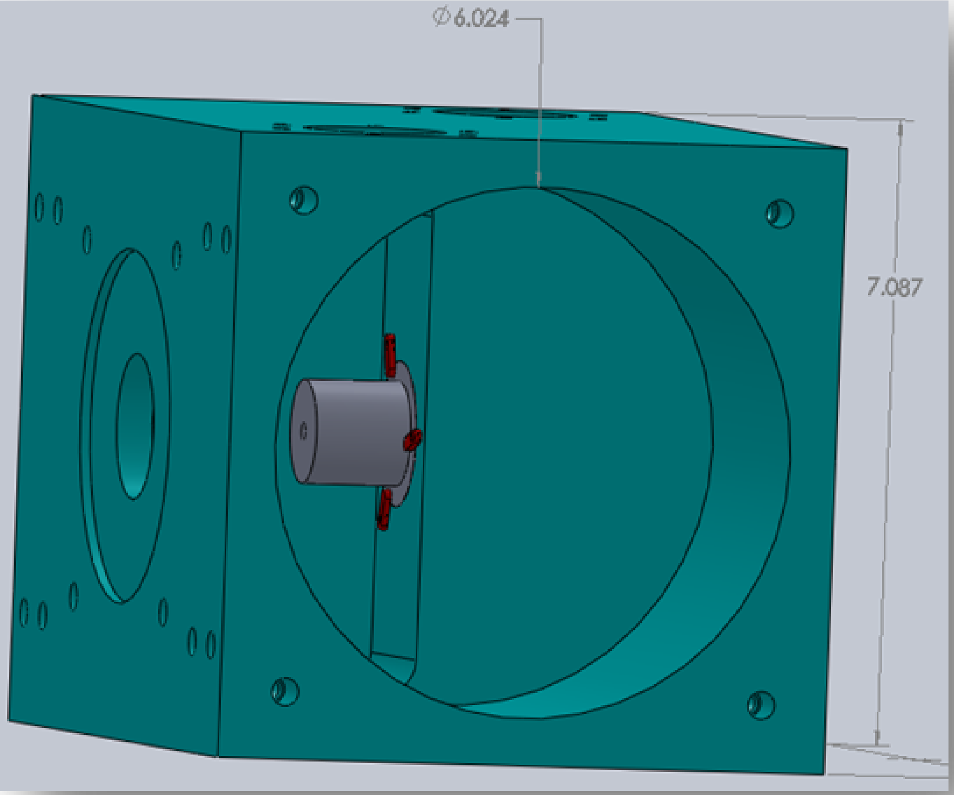
5:30pm Dinner

Preliminaries

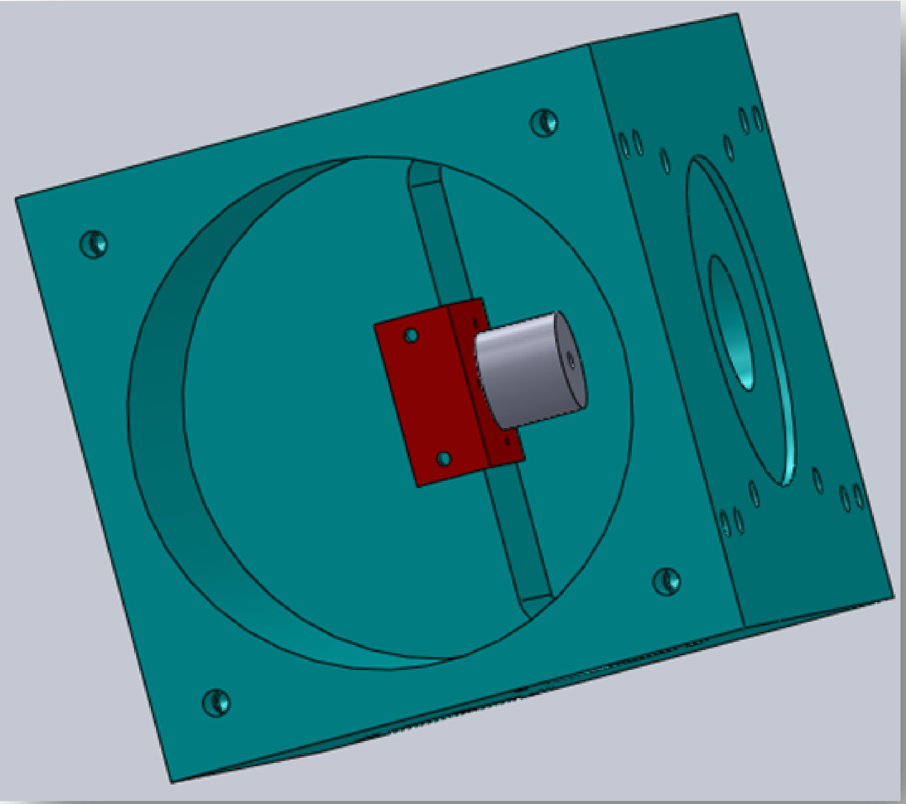
- General design
- Pumping scheme
- Calculations



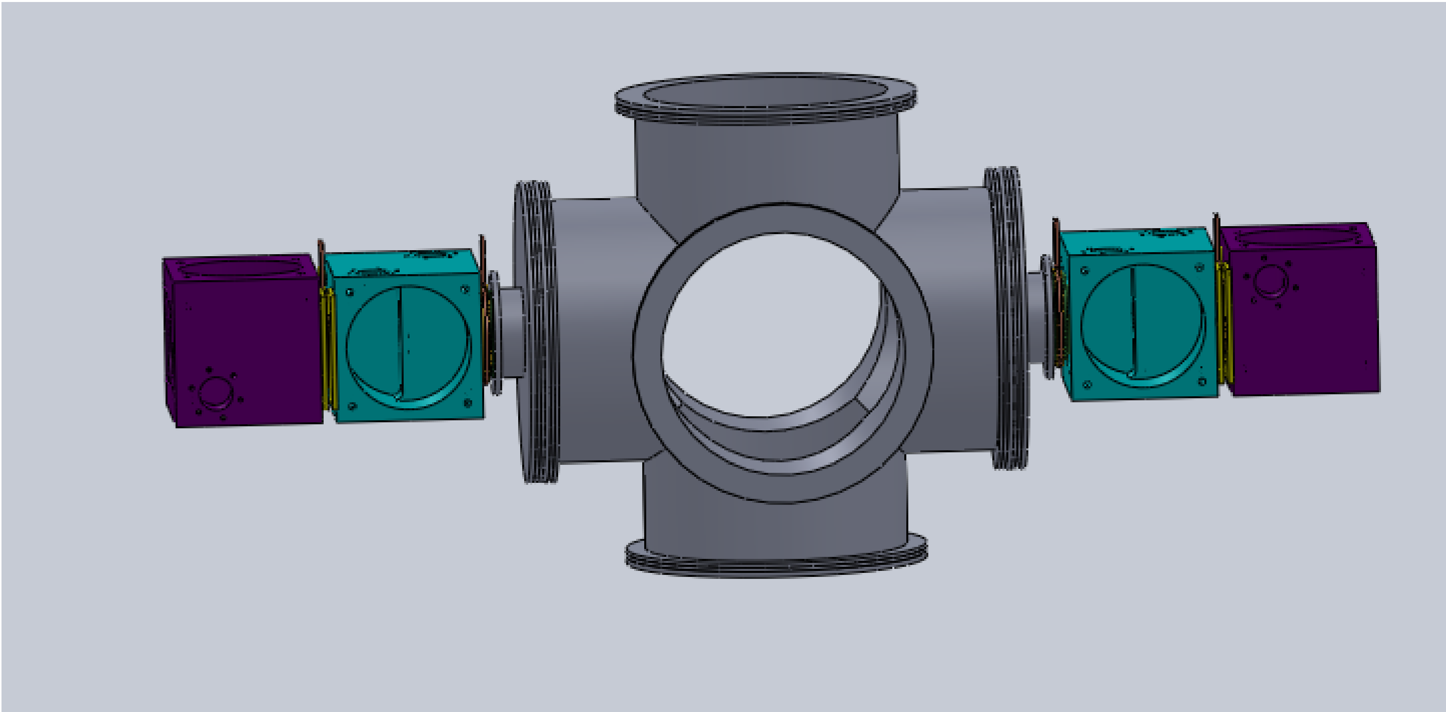
CAD drawings courtesy of L. Linhardt, LSU



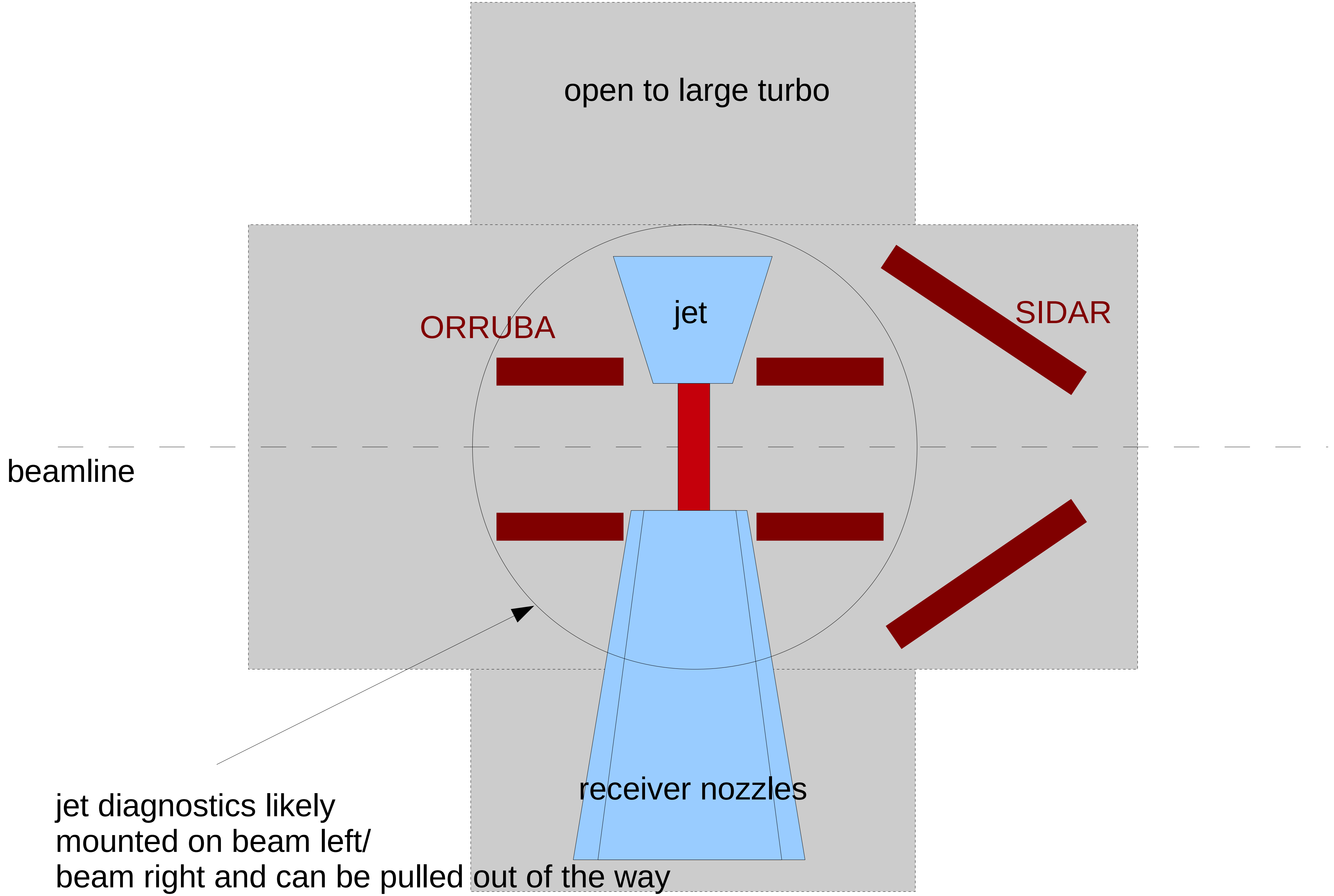
“tab” design



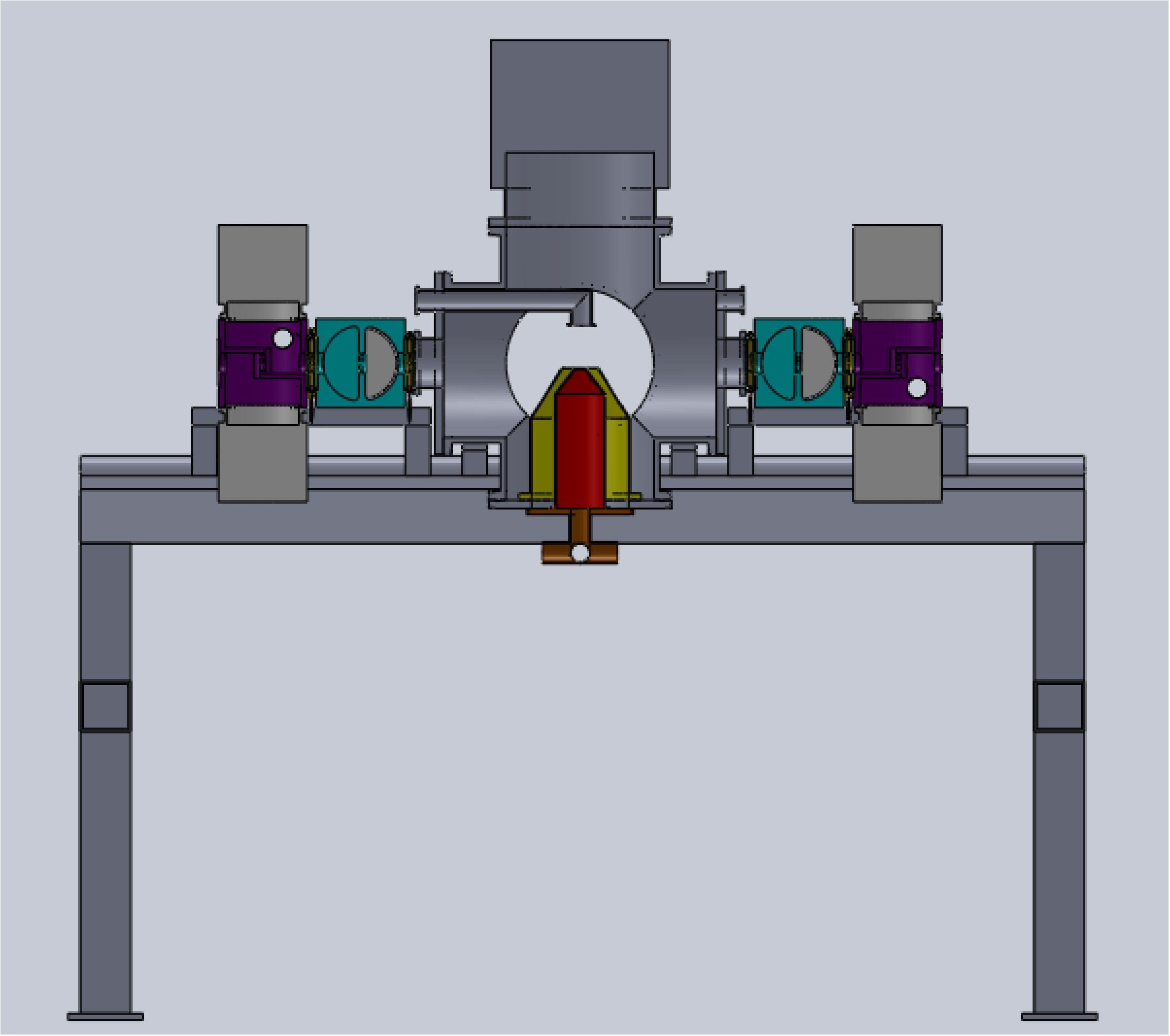
“bracket” design

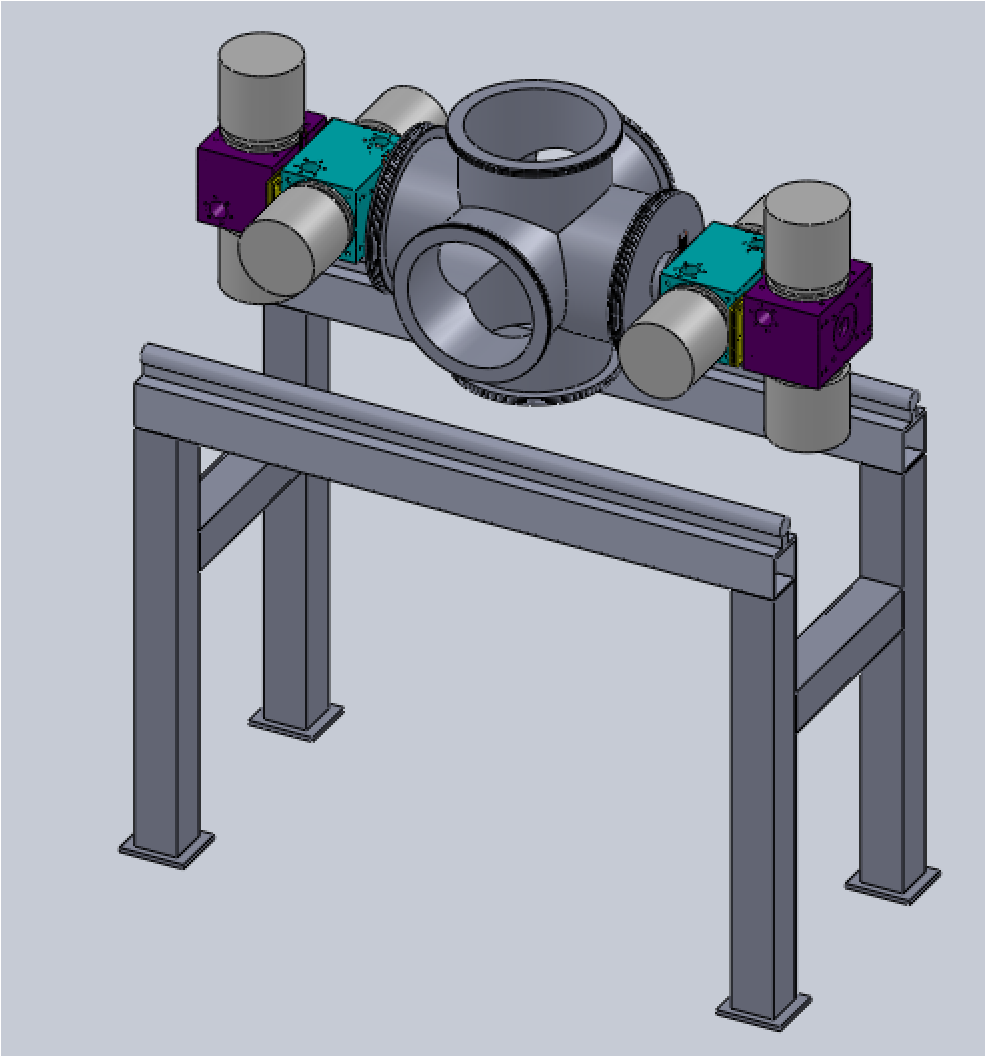


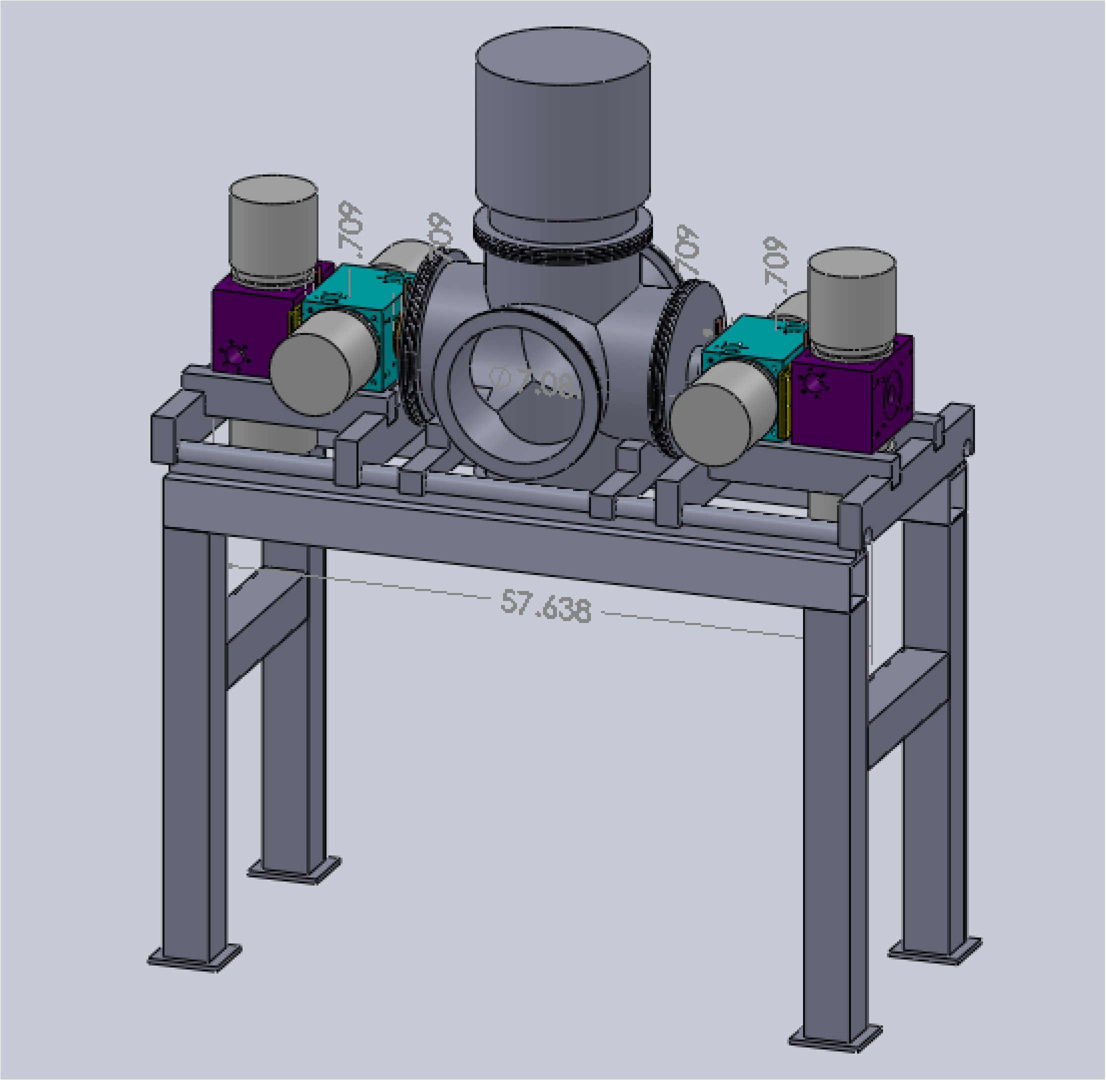
not to scale



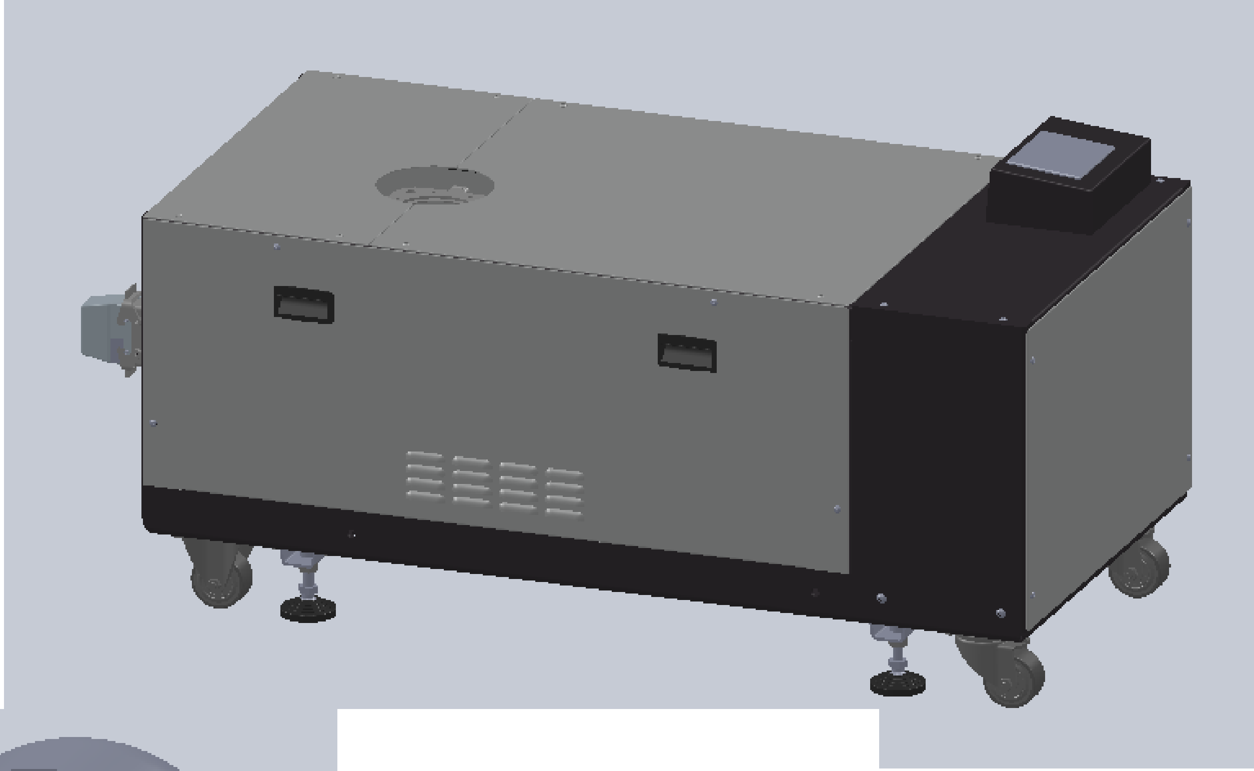
jet diagnostics likely
mounted on beam left/
beam right and can be pulled out of the way
(jet piping could come in from the side or upstream...)

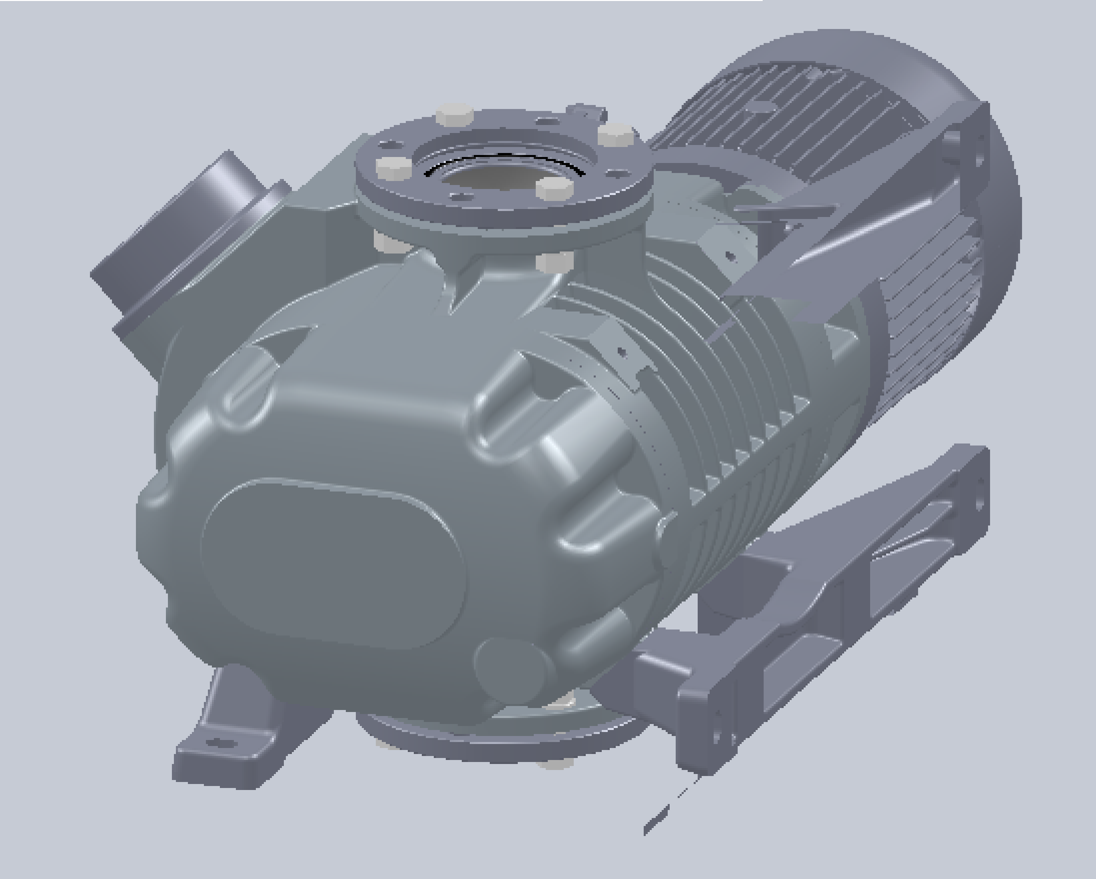


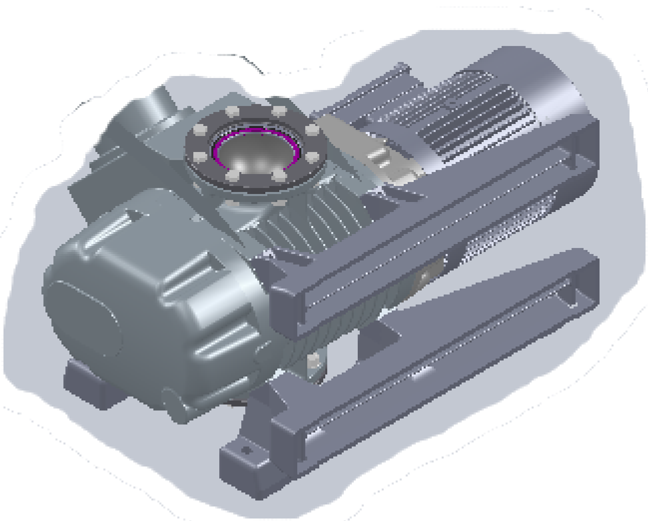


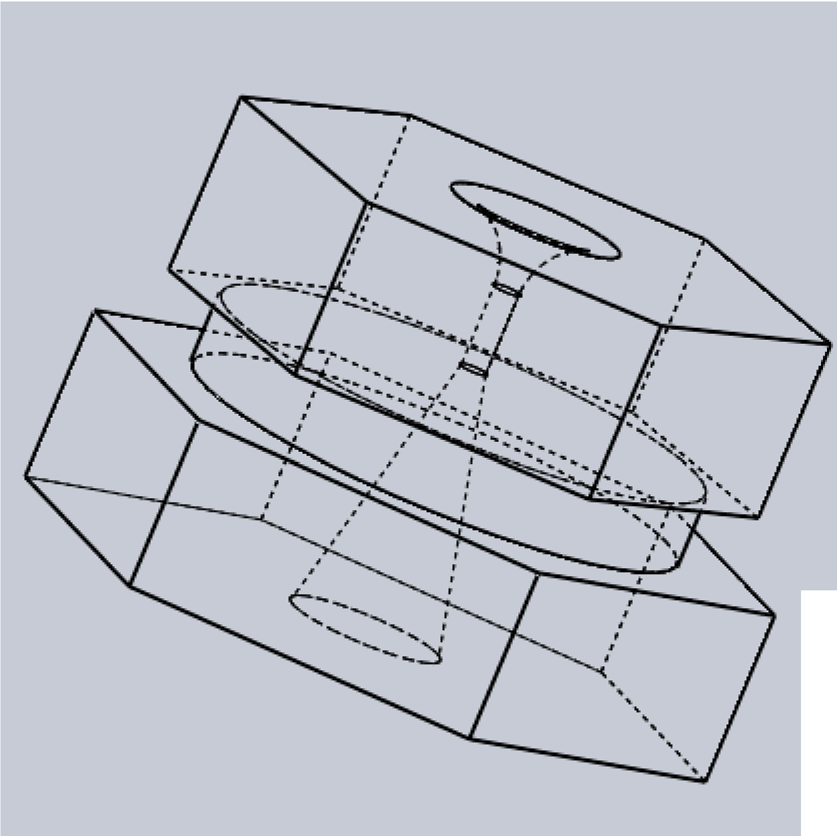

.709
.709
.709
.709
Ø7.09
57.638

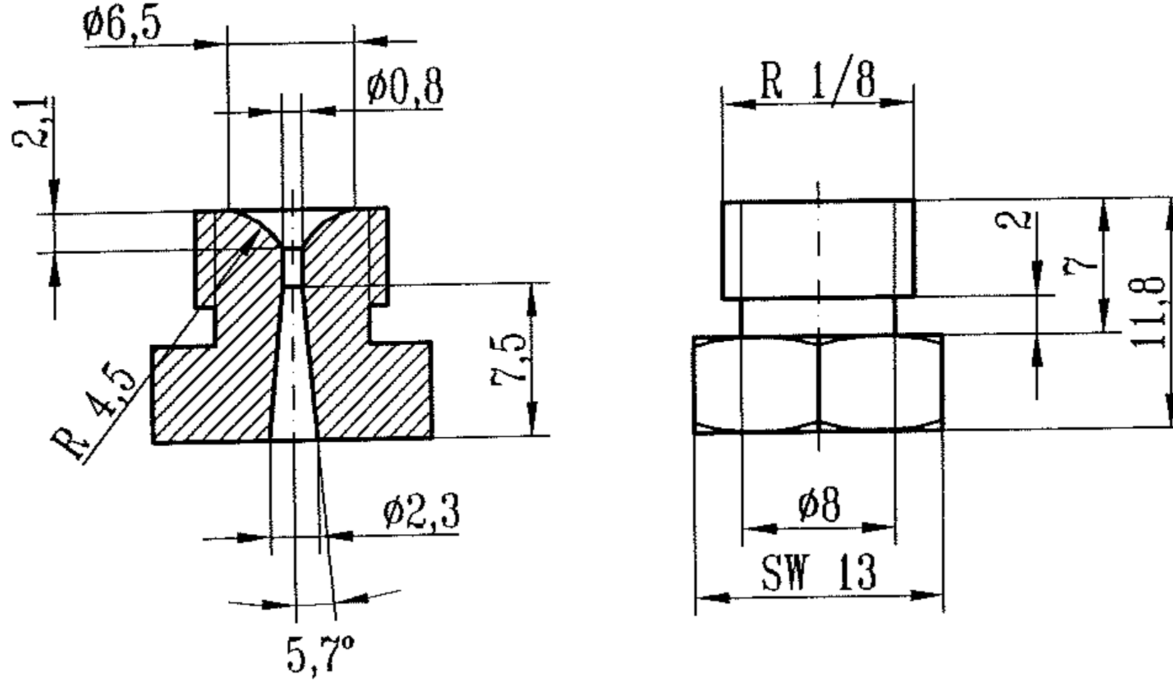
drawings courtesy of
W. Jenkins, Oerlikon-Leybold





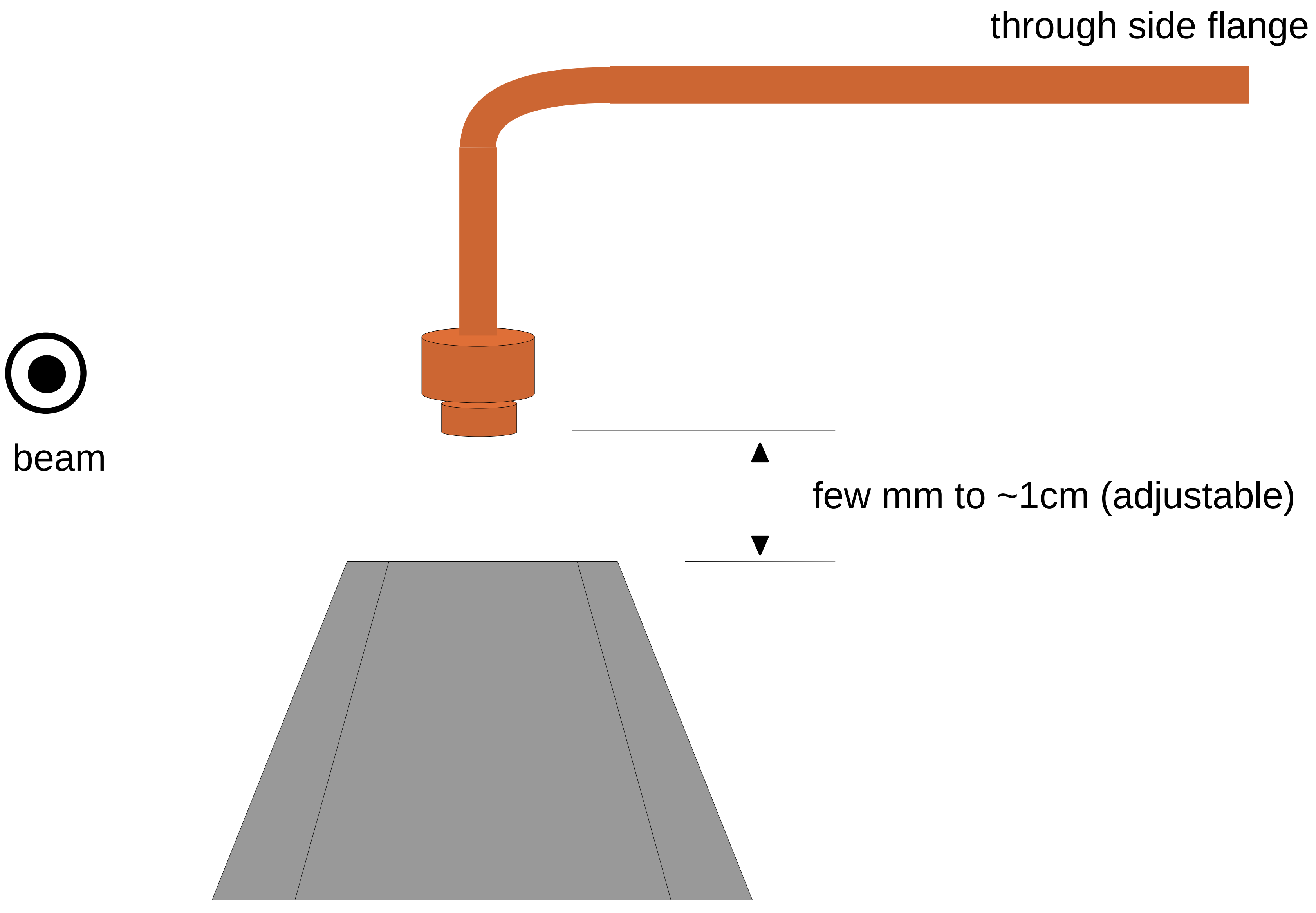






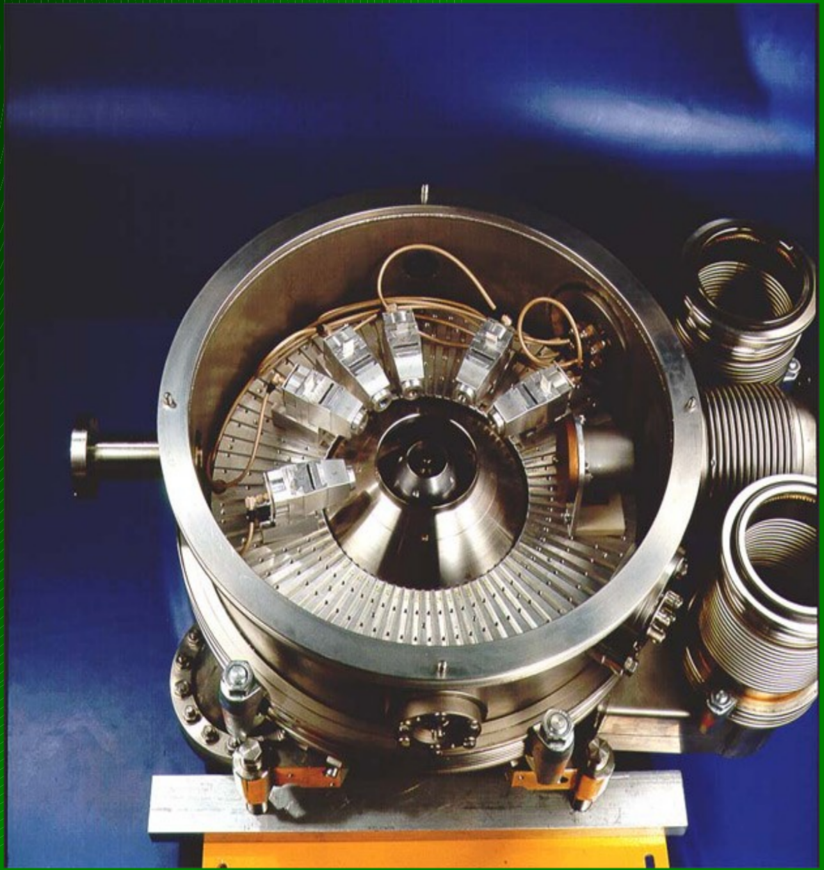
laval nozzle (common design)

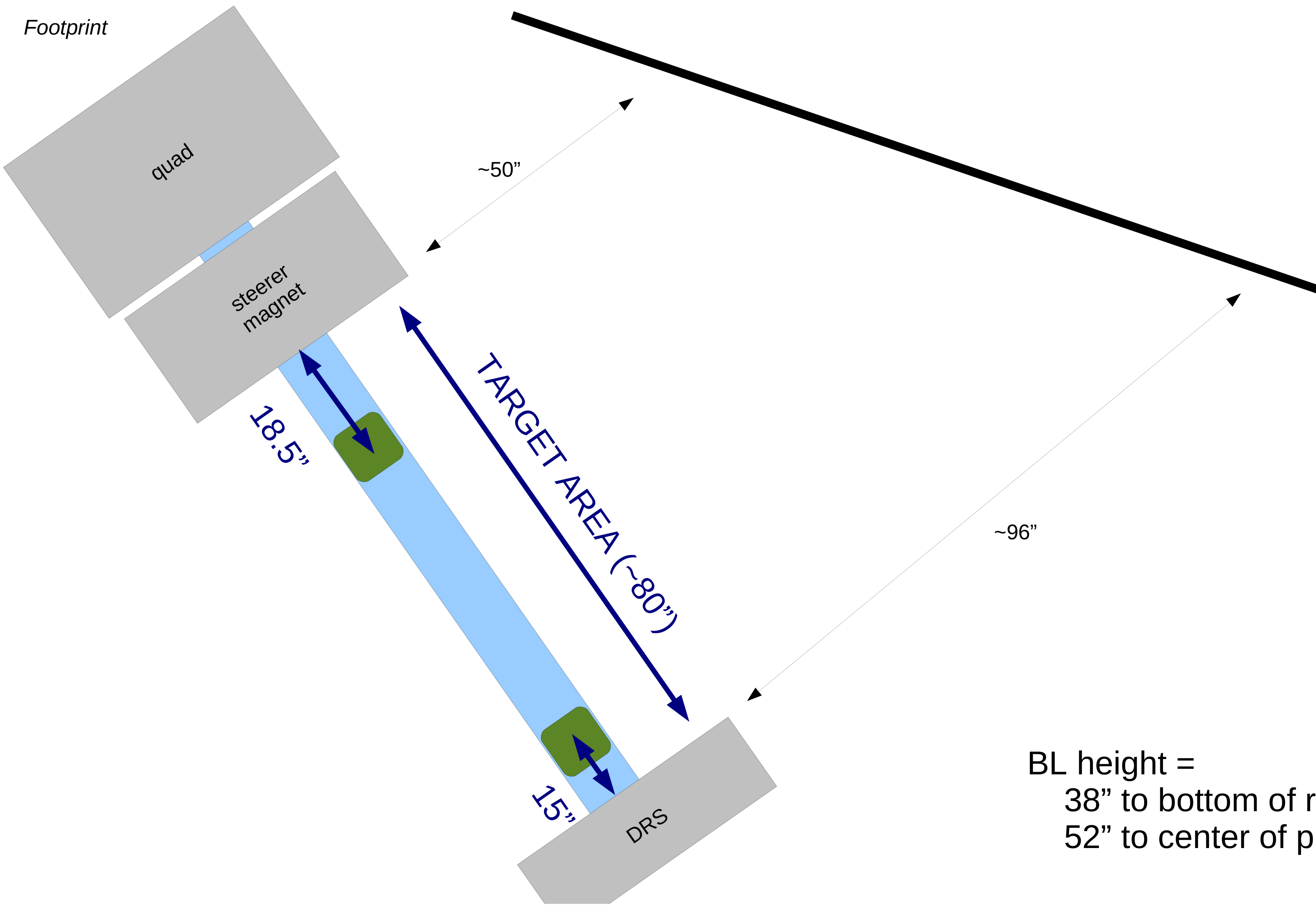
inside target chamber



What are we talking about (scale):

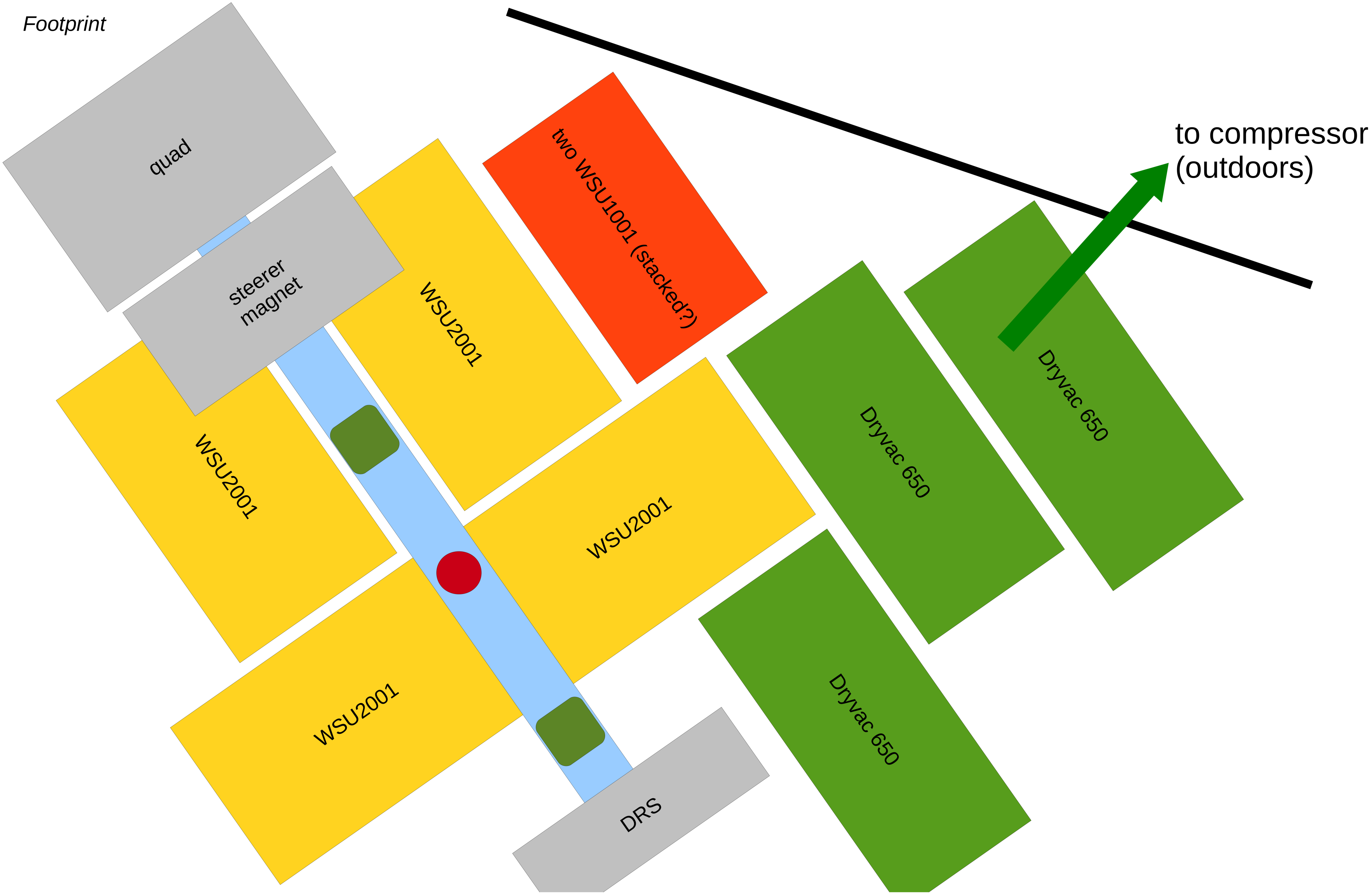
RHINOCEROS
Gas jet at Stuttgart

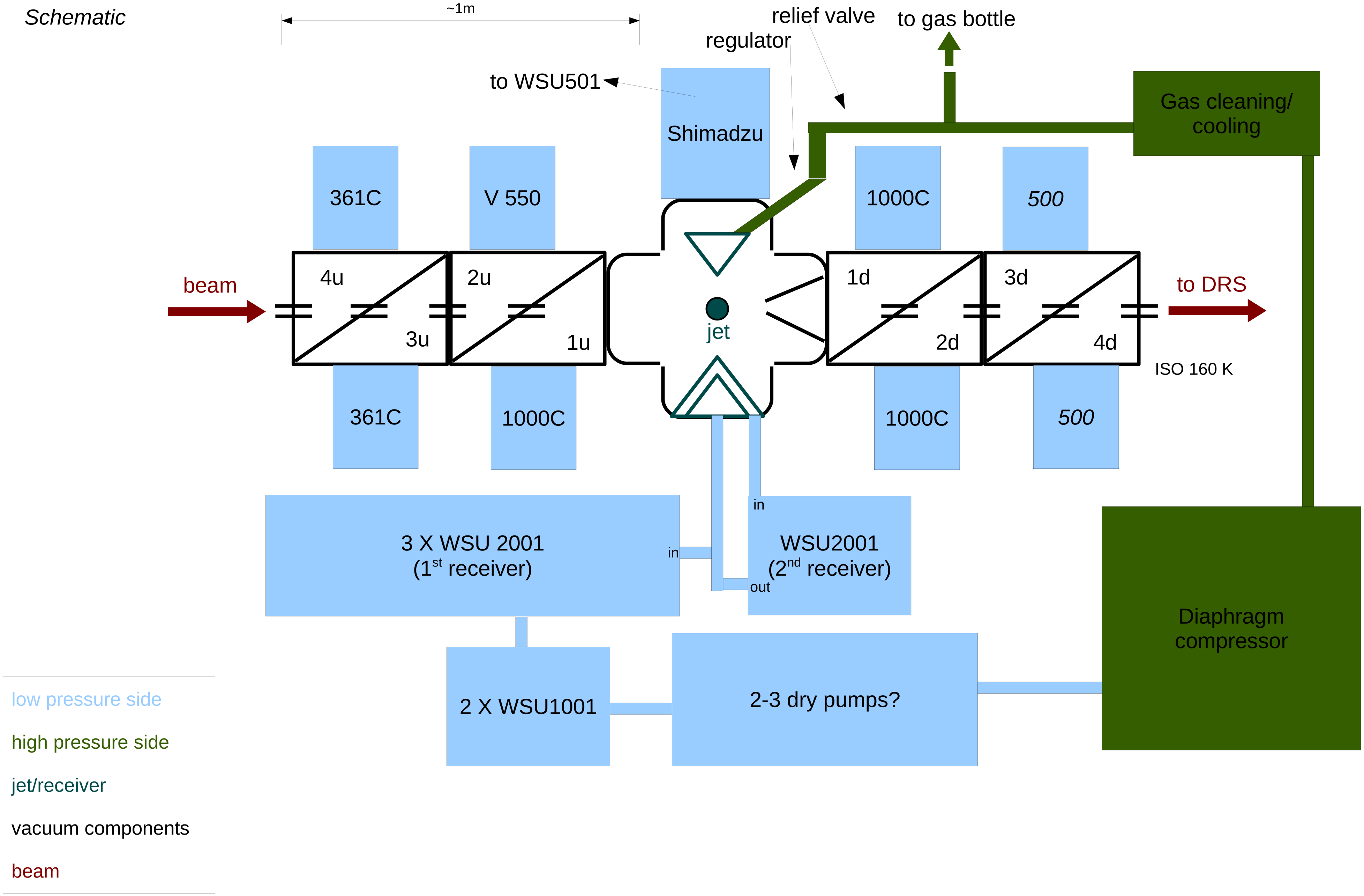




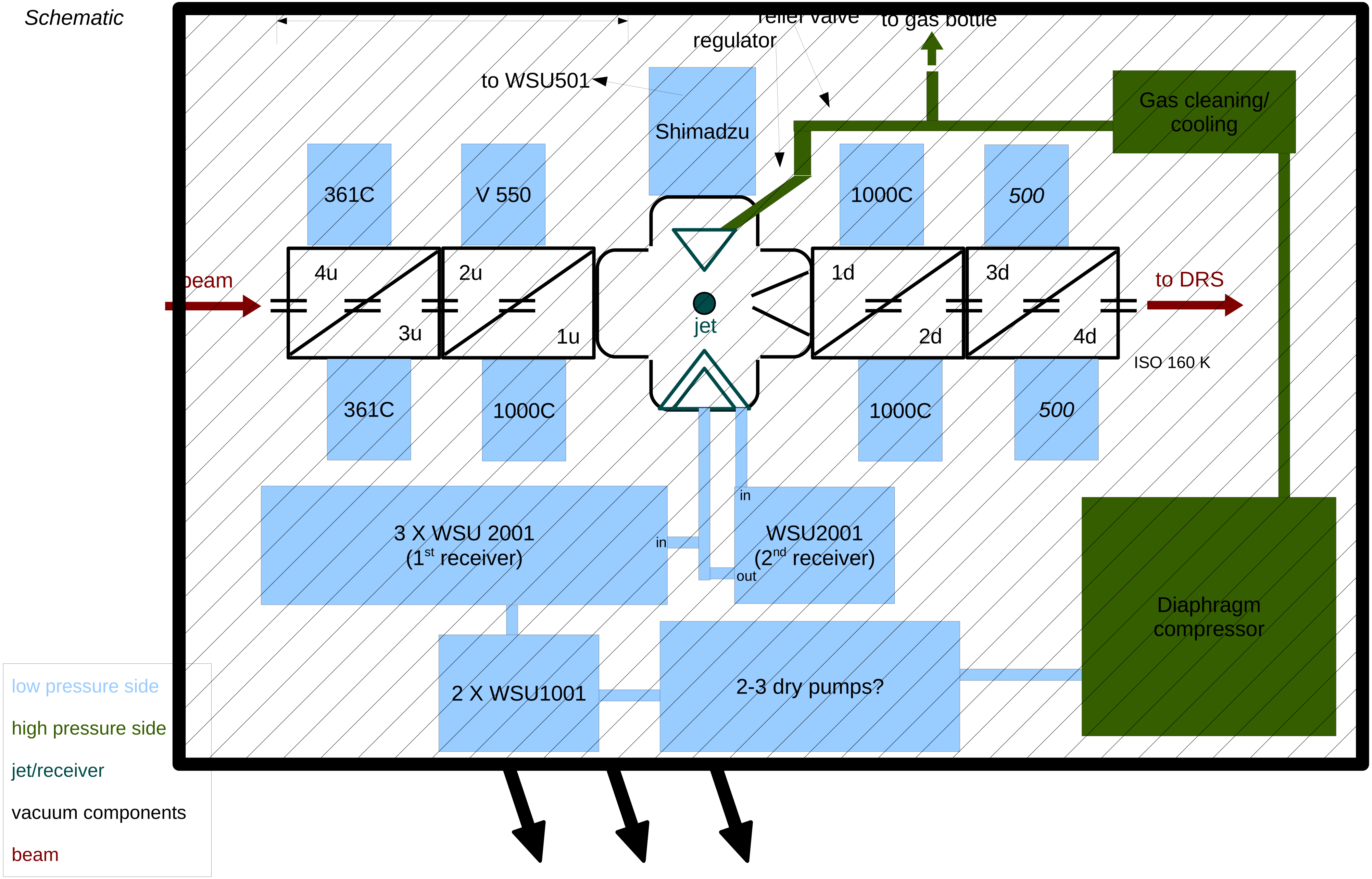
BL height =
38" to bottom of rail
52" to center of pipe

Footprint

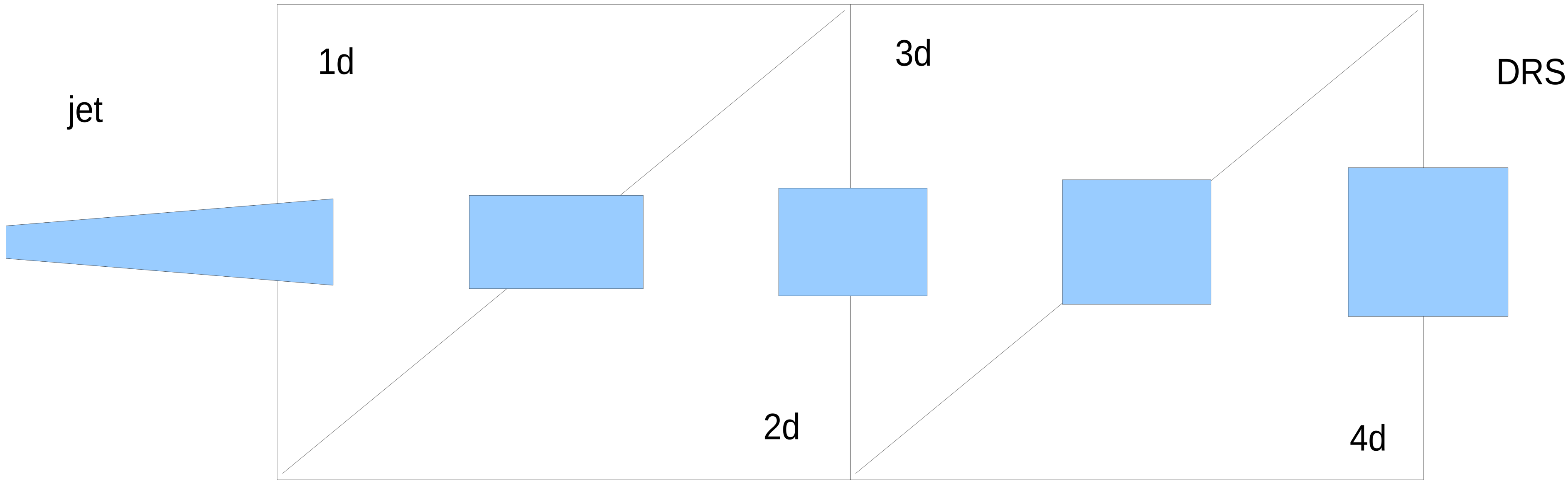

quad
steerer magnet
WSU2001
WSU2001
WSU2001
WSU2001
two WSU1001 (stacked?)
Dryvac 650
Dryvac 650
Dryvac 650
to compressor (outdoors)
DRS


Schematic
~1m
relief valve
to gas bottle
regulator
to WSU501
Shimadzu
Gas cleaning/ cooling
361C
V 550
1000C
500
beam
4u
3u
2u
1u
jet
1d
2d
3d
4d
to DRS
ISO 160 K
361C
1000C
1000C
500
in
3 X WSU 2001
(1st receiver)
in
WSU2001
(2nd receiver)
out
Diaphragm compressor
2 X WSU1001
2-3 dry pumps?
low pressure side
high pressure side
jet/receiver
vacuum components
beam

Schematic



one connection to power, one to water, one (possibly) to gas bottle...



first aperture is conical and “re-entrant” (cone defined by DRS acceptance)
remaining apertures can be tubes (diam. equal to DRS acceptance at largest distance)

336.01	14.46	A1d (avg)
435.01	18.73	A2d (avg)
534.01	22.99	A3d (avg)
633.01	27.25	A4d (avg)
723.01	31.12	A5d (avg)
x (to jet,mm)	diameter (mm)	

COMPONENTS LIST

Component	quantity	buy?	nom speed	eff speed	power (kW)*	water	footprint	weight (lbs)	cutoff p	max delta p
large Shimadzu turbo pump (TMP-3203LM or LMC)	1	y	~10000 m3/hr	(helium)	0.96	4L/min			1.5 Torr	4 Torr outlet p
RUVAC WSU2001 roots pump	4	y (2)	2000 m3/h		7.61	air cooled	1.5x0.75m	1007.6	25 mbar	50 mbar
RUVAC WSU501 roots pump (backing the turbo)	1	n	500 m3/hr		2.16	air cooled	1x0.5m	286	80 mbar	80 mbar
RUVAC WSU1001 roots pump	2	n	1000 m3/hr		5	air cooled			80 mbar	80 mbar
dry pump (likely Leybold Dryvac Champion 650S)	3	y	650 m3/hr	86 m3/hr	7	450L/hr	2x1.5m	992	~atm	4/3 atm
Pdc diaphragm compressor (skidded package)	1	y	54 m^3/hr (with blower)		15	7.5gpm	2x2m	8000		30 atm
~10 psi blower	1	y								
Polycold PFC-1102HC gas chiller	1	y	200,000 l/s		19.2	3.6gpm	2x1m	1000		
Leybold Turbovac 1000C	3	y (2)	3240 m3/hr		0.8					
Varian Turbo-V 550	1		1863 m3/hr		0.6					
Leybold Turbovac 361C	2		1224 m3/hr		0.54					
~500 l/s turbos	2	y (2)	1800 m3/hr		0.3					
			total power consumption (rough)		103	kW		*total weight (not beamline supported)*		
		**power ratings have all been converted to kW (some listed as HP or kVA)*						16292.4	lbs, or	
								8.15	tons	

Important totals:

- 103 kW total power consumption (most pumps can use 208-220V, some 480V requirements; pumps alone are about 70% of this consumption)
- 8.6 tons total weight (not beamline supported)
- < 28 gpm cooling water
- ~ 100 dB noise level

(c) Oerlikon Leybold Vacuum LeyCaT™ 1.2.2 (.841)

C O M P U T E R S I M U L A T I O N

Project No.:	**Super Sonic Gas Jet**
Customer:	**Kelly Chips**
Facility:	**Colorado School of Mines**

Ambient temperature:	**20**	°C
Type of gas:	**Helium (He)**	
Temperature of gas:	**20**	°C
Molar mass:	**4**	kg/kmol

Set of pumps:
3*WSU2001 + 1*WSU2001 + 3*DryVac Champion 650S (H2) @ 60 Hz, Helium (He)

Calculation of working point
(Target parameter: Pressure)

Pressure (set value):	**10**	torr
Pressure (calculated)	**10**	torr
Pumping Speed (calculated)	**1943**	m^3/h
Flow (calculated)	**23.84**	Nm^3/h
Power consumption	**68.15**	kW

Leybold calculations show bottleneck is at dry pumps (from ~50mT to atm)

Roots pump stage:

State:	**ON**

** PDC Machines Inc. **

Suction: 10 Psig (Z: 1.001) [0.689 Barg][0.703 Kg/cm2] | Discharge: 420 Psig (Z: 1.019) [28.938 Barg][29.526 Kg/cm2] | Flow: 33.79 SCFM [54.34 Nm3/hr]

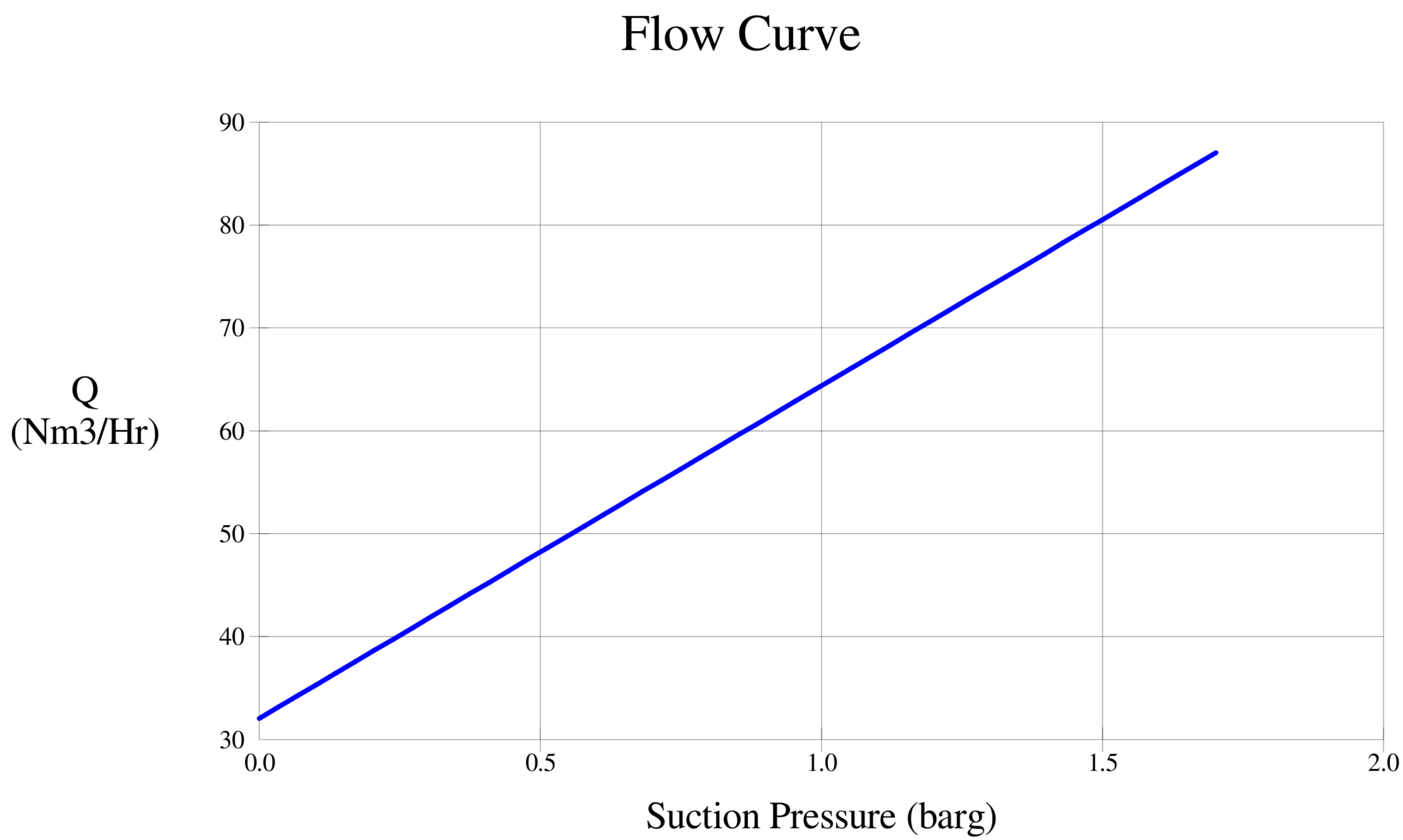
Max. Str.: 25000 Psi | Gas: Hydrogen | Temperature: 70 Deg F [21 Deg C] | Stages: 2

Stage1: PDC-4-100 (100) Full Cavity Dis: 98Psig [7Barg] [7Kg/cm2] Speed: 400 Rpm

Eff.= 119.2398 Cav.= 123.5311 Z= 0.8734 Y0 = 0.3276 Dia = 23.375 St = 23,912 Pl.dia= 5.8124

Stage2: PDC-4-500 (100) Full Cavity Dis: 420Psig [29Barg] [30Kg/cm2]

Eff.= 26.4447 Cav.= 28.1245 Z= 0.8137 Y0 = 0.2029 Dia = 14.625 St = 24,379 Pl.dia= 2.7439



compressor throughput a function of inlet pressure (thus jet density is a function of inlet pressure): roughly,

$\#/cm^2 = (0.29\, P_i + 4.16)\times10^{18}$

Costs

- Pdc Machines diaphragm compressor, with aftercooler, motor starters, gauges, controllers, etc: $200k (+$5k “installed”)
- Leybold Dryvac 650S (3): $24,400 ea (with discount)
- Leybold WSU2001 (2): $19,931.20 ea (with discount)
- Blower...? (if we can achieve 10psi at the compressor inlet, we can get 54 m^3/hr flow)

TAKE HOME MESSAGE

- Equipment $315k + previous equipment + labor/ raw materials
- 105kW 3ph power (avg), mostly 208V
- 25-30gpm cooling water at $<65^0$
- 8.65 tons on the floor + about 300 pounds beamline-supported
- apertures can be easily swapped out
- large central chamber necessary for detectors (not jet)

Objectives

- **Locations**
  - How many jet targets ultimately need to be built, and where (HRIBF, TRIUMF, ReA3+SECAR, DIANA...)? Funding?
- **Infrastructure**
  - Each location isn't likely to need, or provide, the same things. Requirements, costs, etc.
- **Gases**
  - Who needs what target gas? Should design be flexible for many gases or optimized for one? Also, procurement of rare/expensive gases (like 3He): we don't want to be competing for the same supply.
- **Detector systems**
  - What do we want to measure, and how? Charged particle, gamma, recoil detection, logistics of placement, electronics, DAQ, etc.
- **Experimental campaigns**
  - What do we hope to achieve, both separately and collaboratively? LOI to NSCL PAC, etc.
- **General design issues**
  - Who needs what, and to what specifications. Not all the jets need be identical. Beam and jet diagnostics. Resource needs.
- **Delegation of responsibility**
  - Students, postdocs, etc. Who buys what? Who updates the JENSA webpage? etc