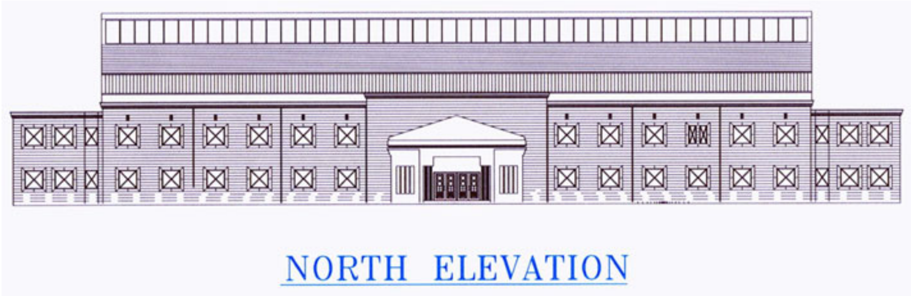
SESAME

Synchrotron Light for **E**xperimental **S**cience and **A**pplications in the **M**iddle **E**ast

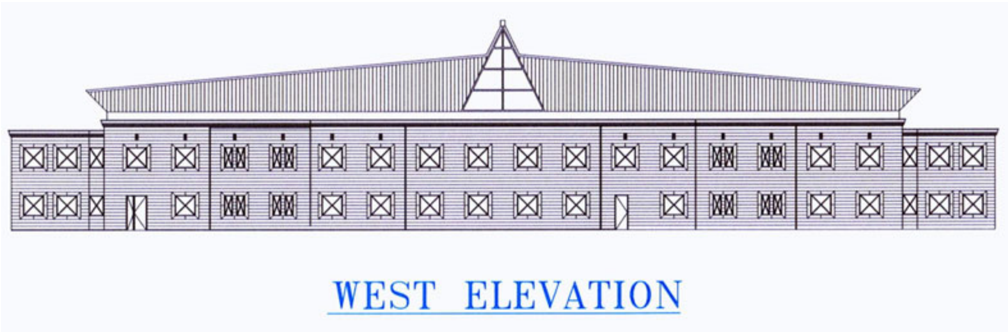


JSPS Asien Science Seminar

Synchrotron Radiation Science

Dieter Einfeld

Amman, October 2002



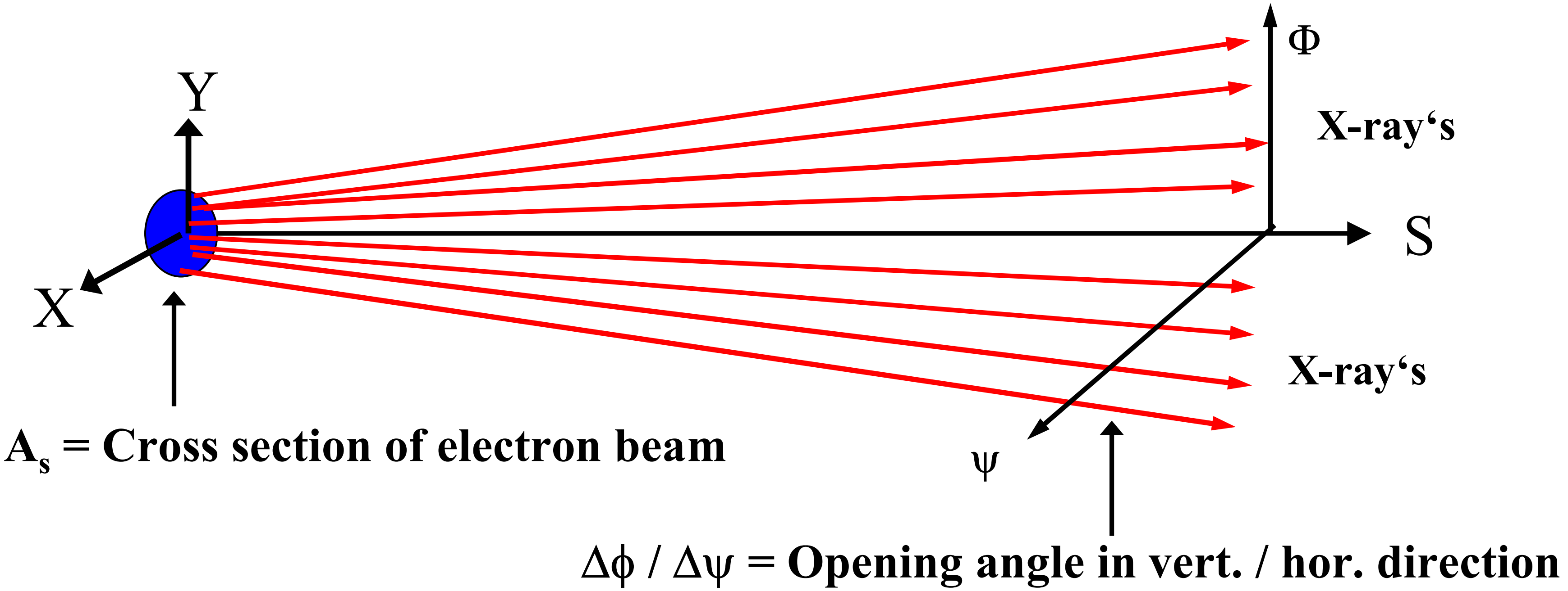
Introduction

Based on the workshops held in the Middle East Region and other activities of the SESAME Scientific Committee, the scientific program for SESAME includes:

- **Structural molecular biology**
- **Molecular environnemental science**
- **Surface and interface science**
- **Micro mechanical devices**
- **X-ray imaging**
- **Archaeological microanalysis**
- **Material characterization**
- **Medical applications**

Most of these applications require hard x-rays up to 20 keV photons.

Characterization of Synchrotron Radiation



Flux = Photons / (s • BW)

Fluxdensity = Flux / A_s , [Photons / (s • mm^2 • BW)]

Brilliance = Flux / (A_s • ΔΦ •∇ψ) , [Photons / (s • mm^2 • mrad^2 • BW)]

Performance of a Light Source

The performance of a synchrotron light source is given by:

- **the brilliance of the emitted radiation**
- **the overall length of the straight sections**
- **the emitted photon spectrum**

The brilliance:

The brilliance is proportional to the photon flux per area of the source size, and opening angle of the radiation. Both factors are proportional to the emittance of the stored electron beam.

To increase the brilliance further more one introduces wigglers and undulators to enlarge the number of source points.

Performance of a Light Source

Length of the straight sections:

According to the attraction of the synchrotron radiation, a light source should provide the radiation simultaneously to a lot of users. Hence the performance of a synchrotron light source is proportional to the number of useable long straight sections.

The photon spectrum:

The different users are asking for a special spectrum range. The highest photon energy of the spectrum from the bending magnet, the wiggler and the undulator is proportional to the square of the energy of the stored electrons. So, the performance of the machine should also proportional to the energy.

The following parameters of the machine determine the performance of a synchrotron light source:

- ➔ **the emittance**
- ➔ **the overall length of the straight sections**
- ➔ **the energy**

History of SESAME

- Idea to upgrade BESSY I (1997)
- Proposal for SESAME to UNESCO DG (1999)
- Establishment of Interim Council
- Setting up of Advisory Committees (international)
- Green Book (Technical Proposal) (1999)
- Site Decision Al-Balqa Applied Universit
- Training Programme initiated (Oct. 2000)
- Financing of BESSY I dismantling (Aug 2000)
- Appointment of Technical Director (Sept. 2001)
- New Advisory Committees (from region)(Dec. 2001)
- Shipping of BESSY I components (May 2002

History of SESAME

Green Book Design:

- ➡ Photon energies of 20 KeV are required
- ➡ 7.5 Tesla super conducting wiggler is available
- ➡ To reach 20 keV photons, the energy has to be increased to 1 GeV
- ➡ The bending magnets have to be modified (from 1.5 to 1.87 Tesla)
- ➡ All magnets (quadrupoles and sextupoles) from BESSY I should be used
- ➡ The number of straight sections have to be increased

Solution:

- ➡ New arrangement of magnets (Circumference = 100.4 m)
- ➡ Energy = 1 GeV, emittance = 50 – 100 nm rad,
- ➡ Number of straight sections = 6 (only 3 for wigglers)

Conclusion:

The design of the „Green Book“ has to make a lot of compromises. With the result, that the specifications can not compete with other synchrotron light sources.

➡ **New design, White Book**

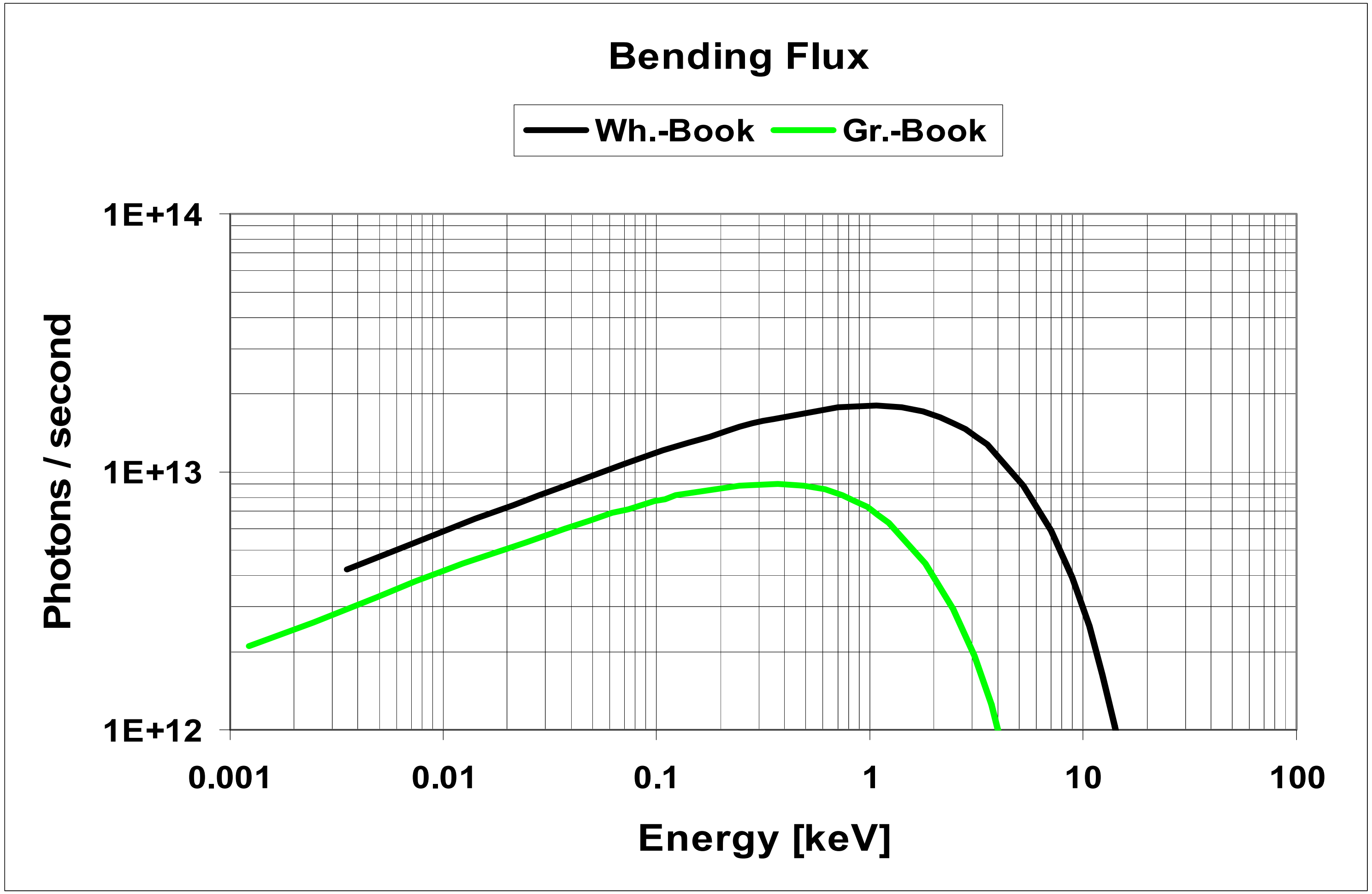
History of SESAME

White Book Design:

- Design of building based upon ANKA
- Building: ANKA plus annexes
- Lengths of beam lines around 30 meter
- Maximum circumference of the storage ring is 126 meter
- The energy was fixed to 2 GeV
- New arrangements of magnets (TME – optic)
- 16 straight sections (8 long & 8 small)
- Emittance is around 17 nmrad
- Radiation spectrum from bendings goes up to 12 keV
- Radiation spectrum from wiggler goes up to 24 keV
- Repetition frequency of booster will changed to 1 Hz

Machine

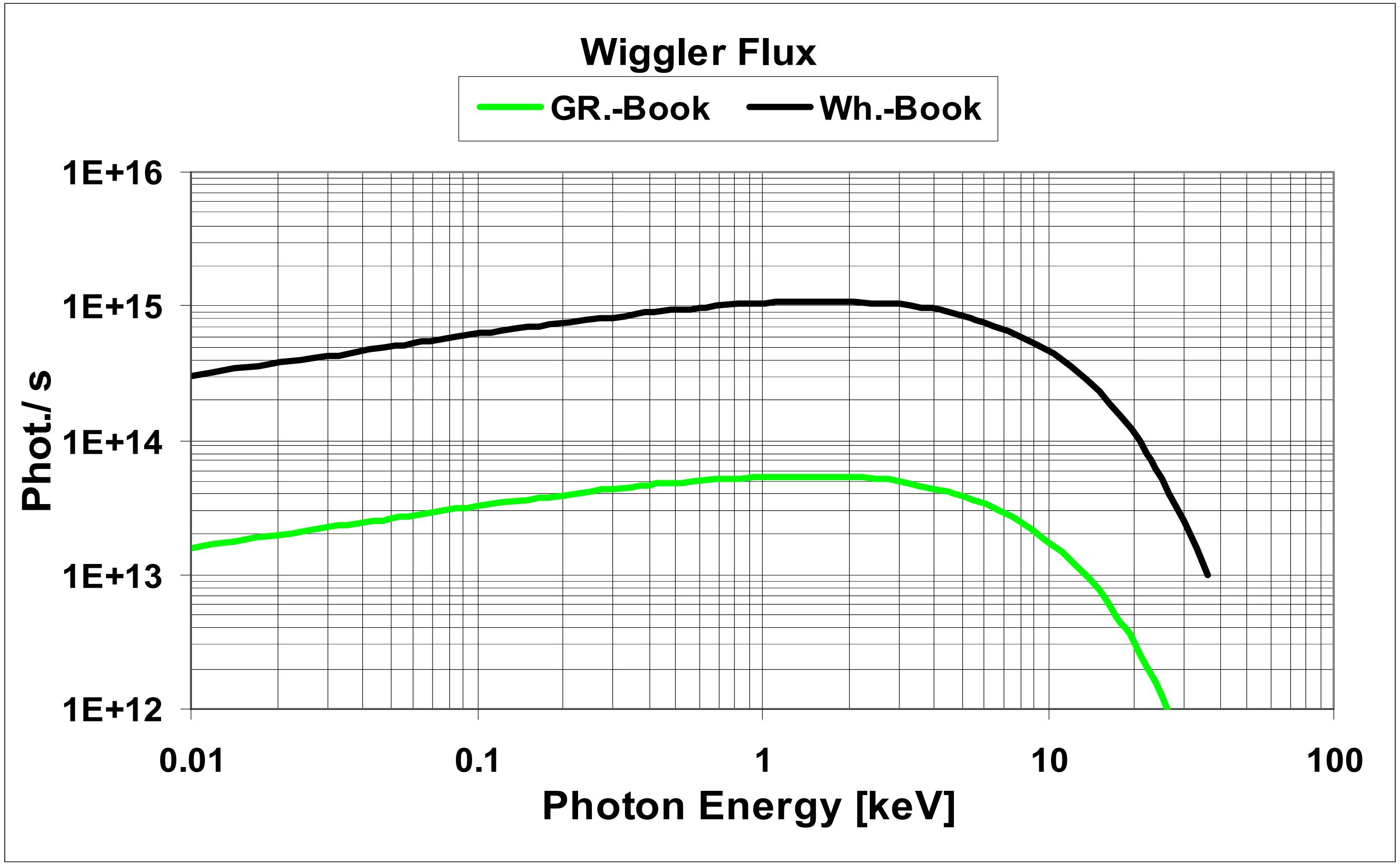
Radiation Characteristics



Flux of the synchrotron radiation from the bending magnets:
Version SES_1_1: Green book, 1GeV, 1.87 Tesla, 400 mA;
version SES_4_2: 2GeV, 1.35 Tesla, 400 mA

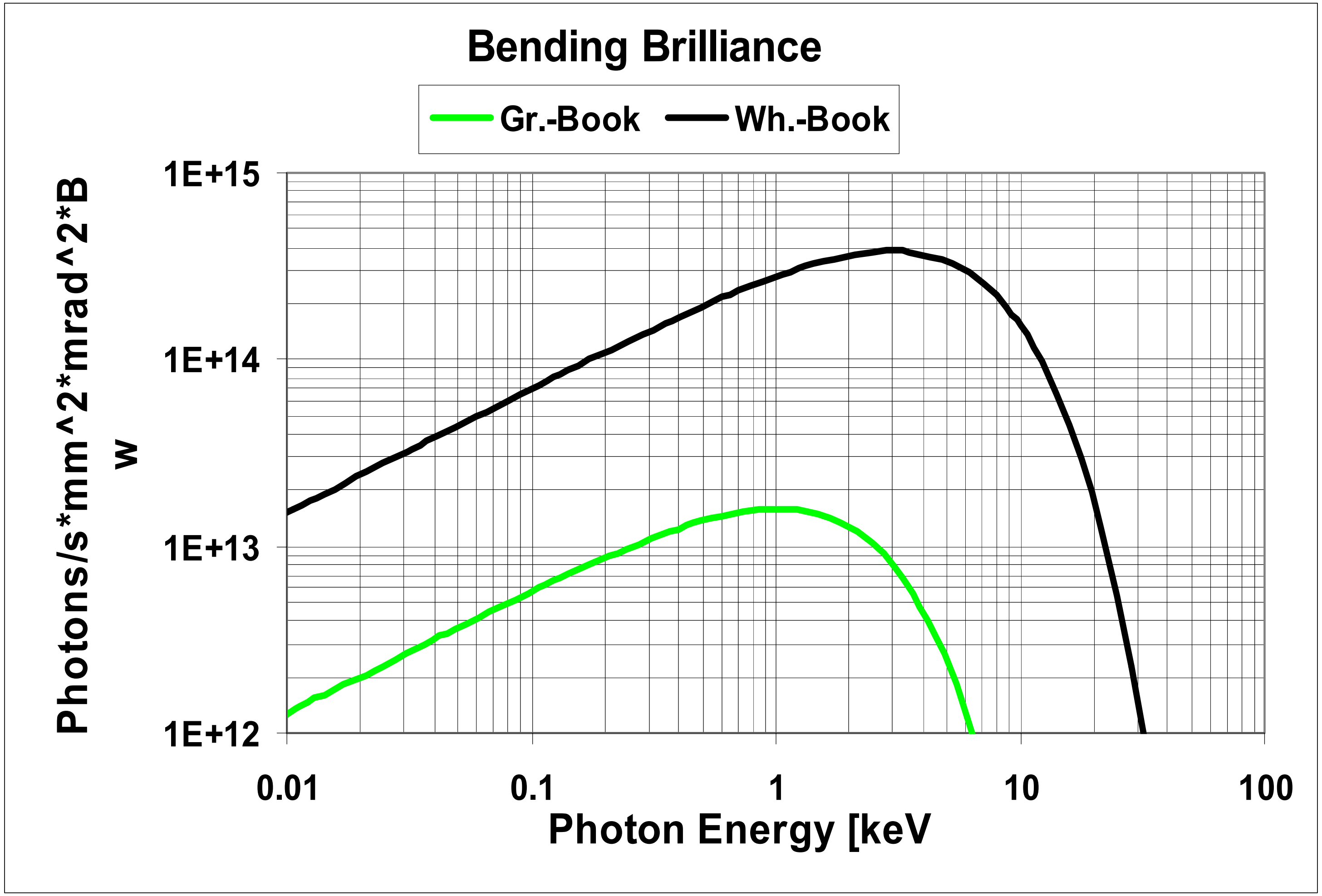
Machine

Radiation Characteristics



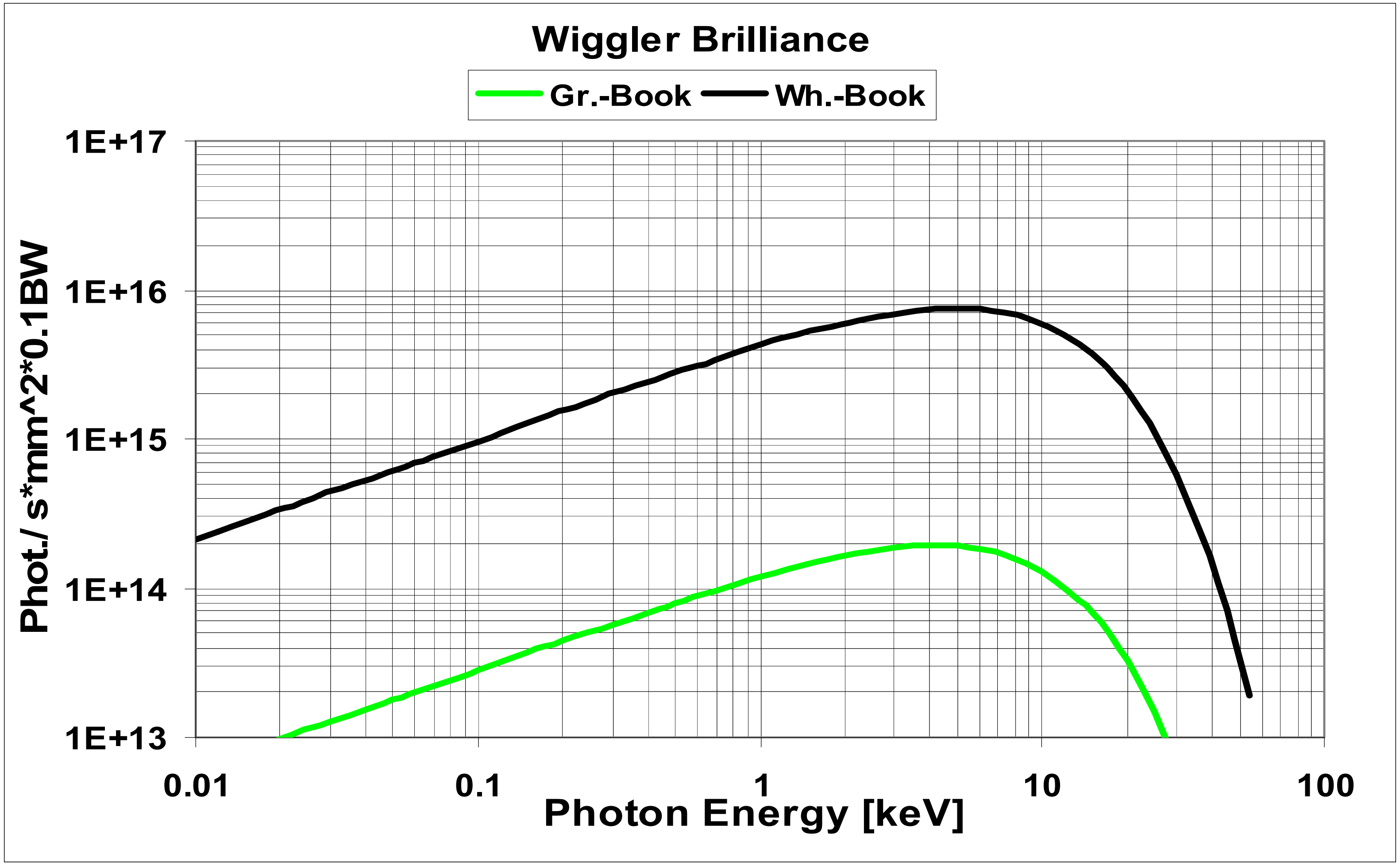
Flux of the synchrotron radiation from the wiggler for the versions: SES_1_2 and SES_4_1.

Radiation Characteristics



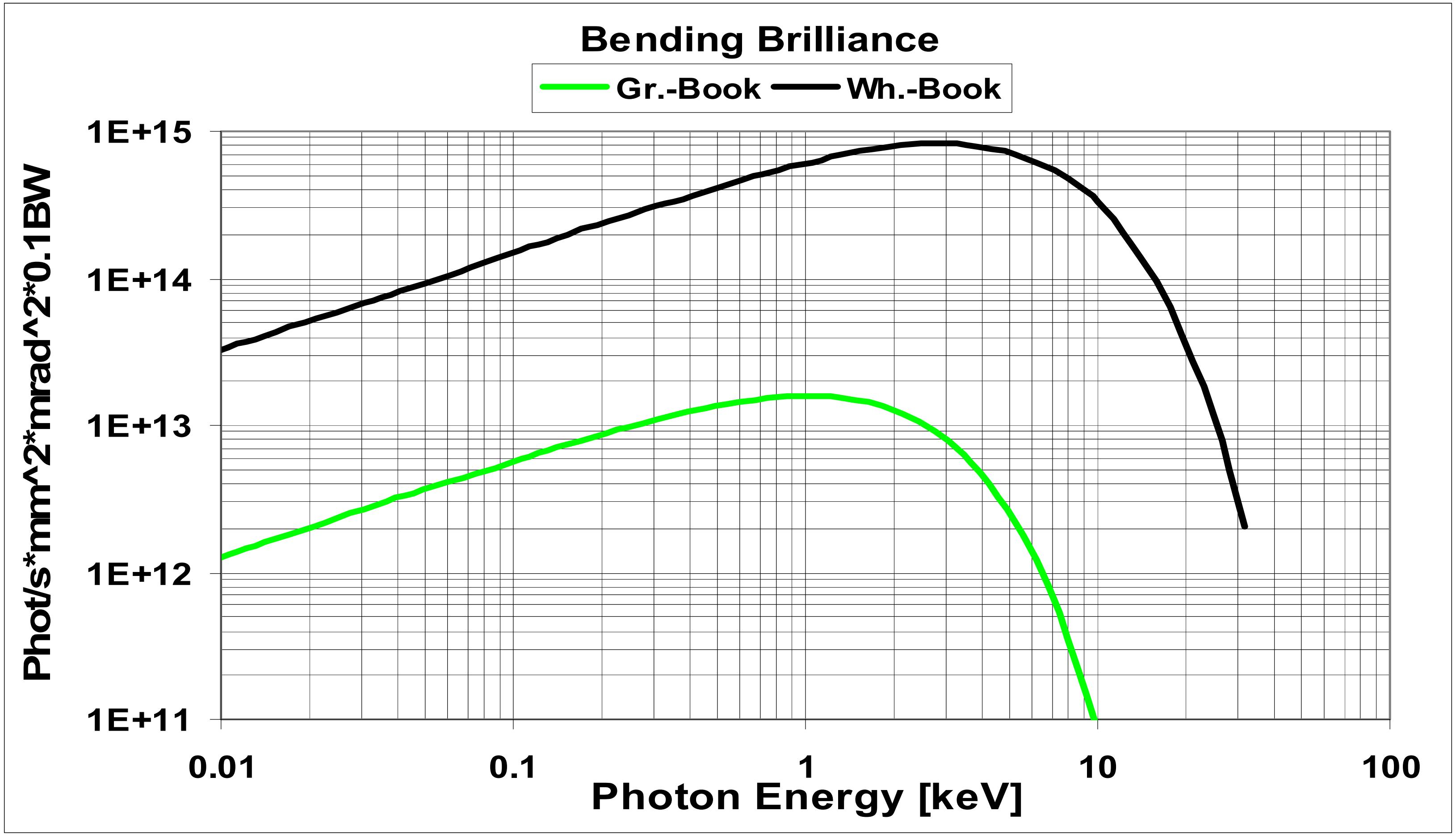
Brilliance of the synchrotron radiation from the bending magnets for the versions SES_1_2 and SES_4_1

Radiation Characteristics



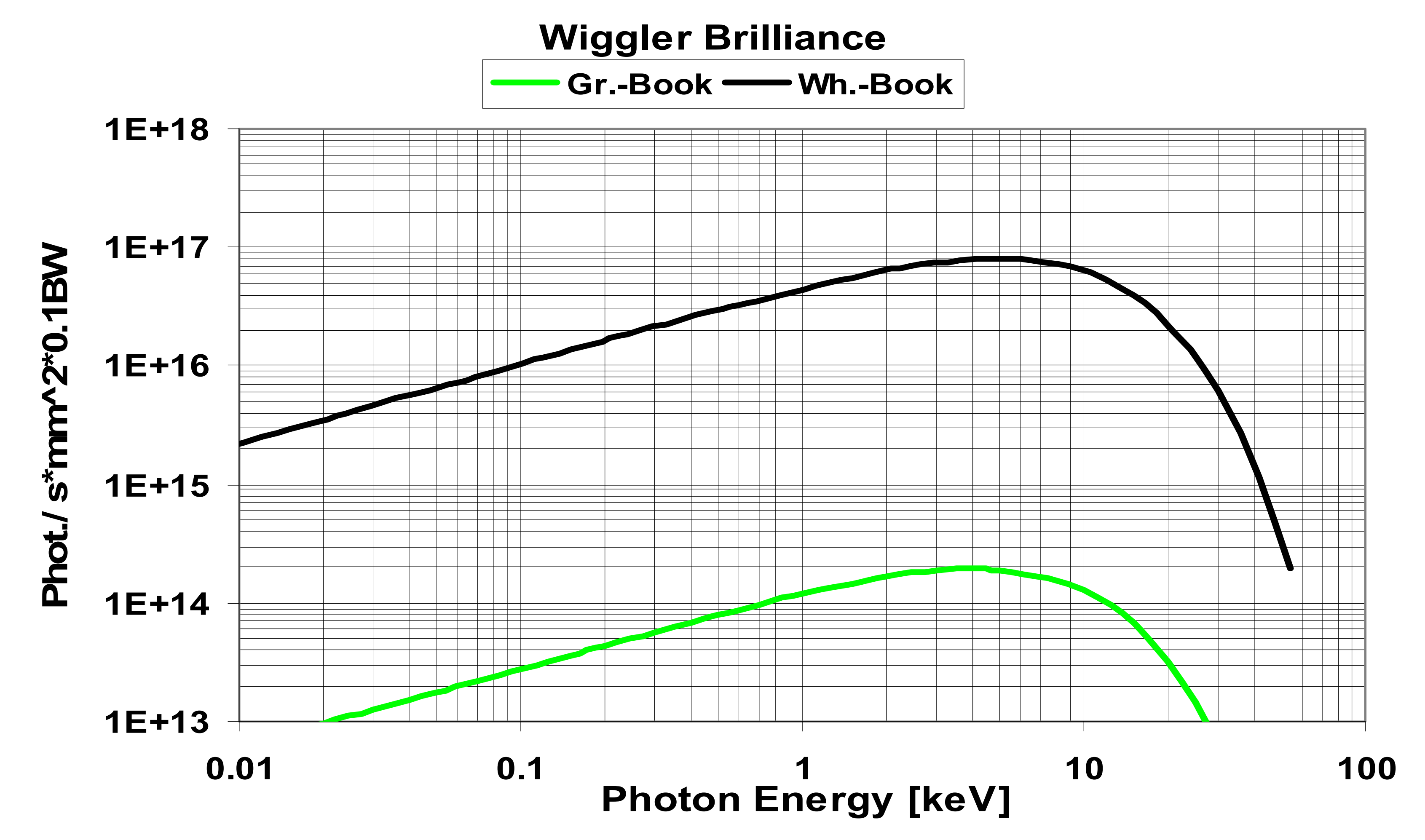
Brilliance of synchrotron radiation from the wigglers of the versions SES_1_2 and version SES_4_1

Radiation Characteristics



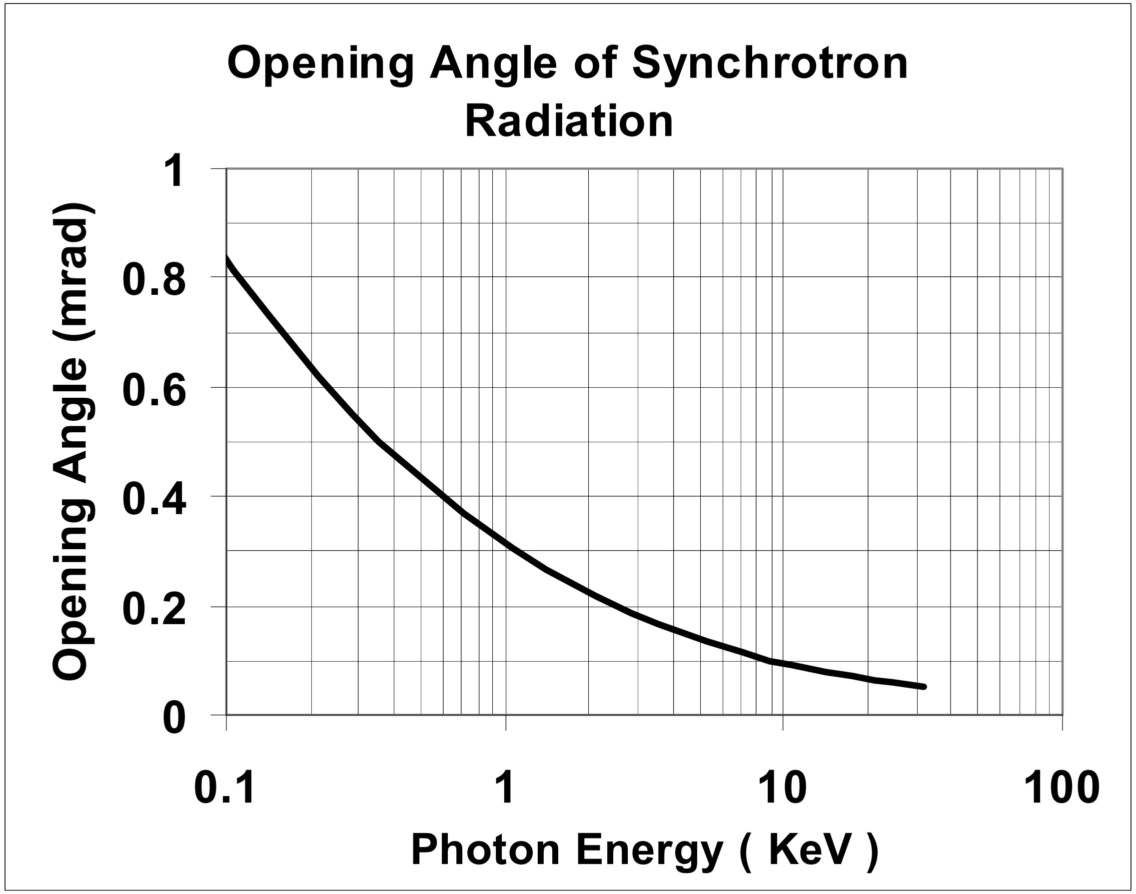
Brilliance of the synchrotron radiation from the bending magnets for the versions SES_1_2 and SES_4_2

Machine *Radiation Characteristics*

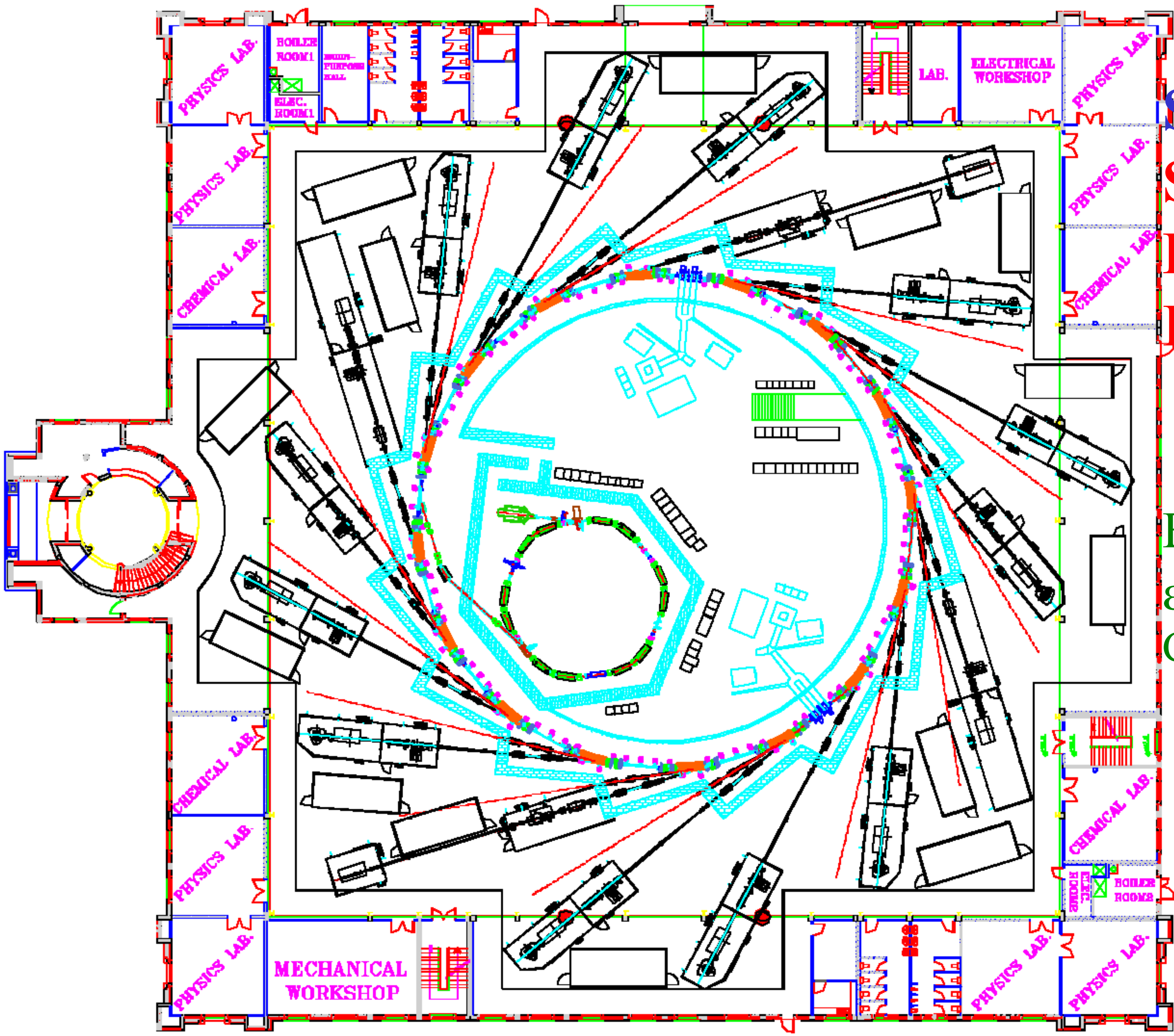


Brilliance of the synchrotron radiation from the wigglers for the versions SES_1_2 and SES_4_2

Radiation Characteristics



Machine



SESAME

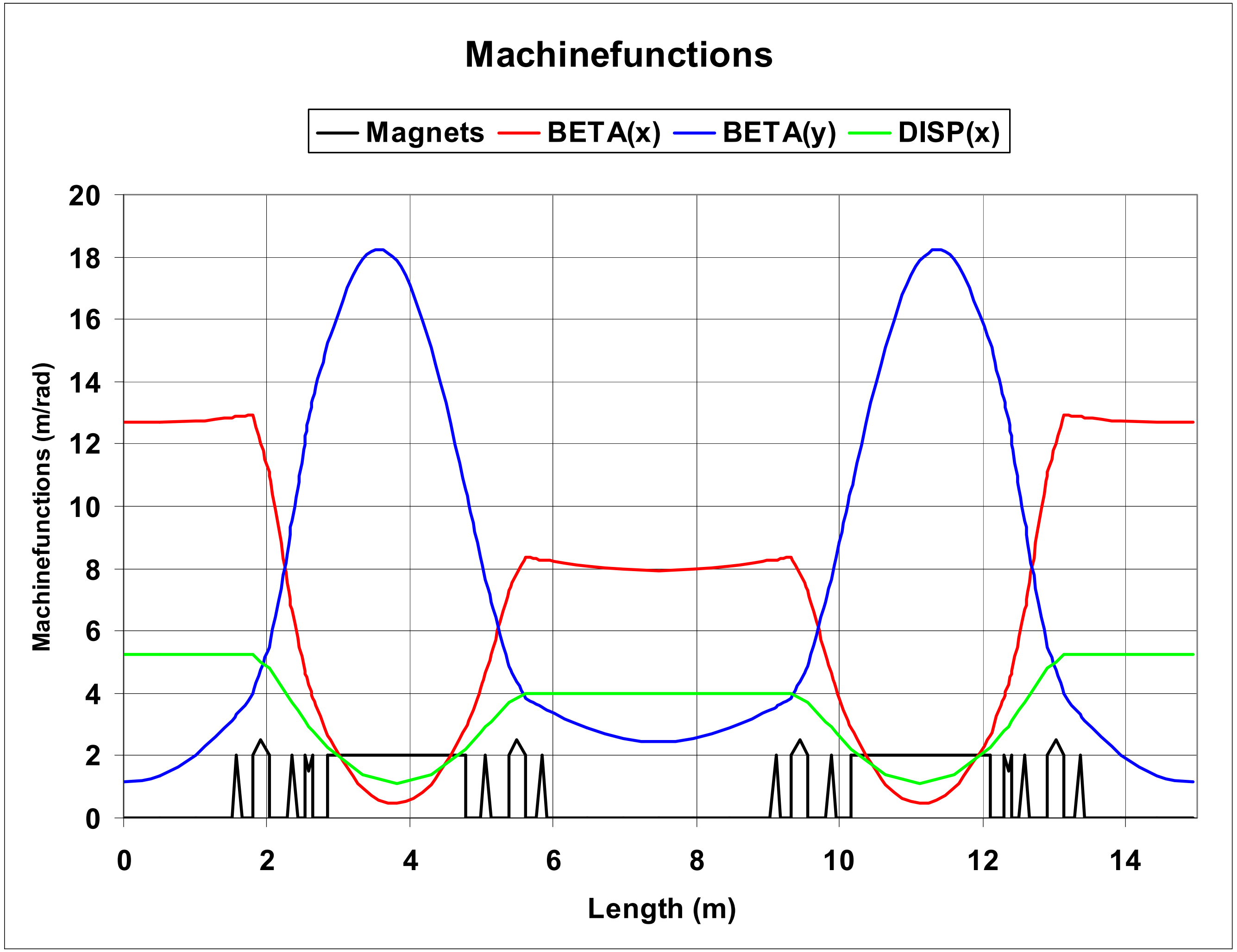
Synchrotron Radiation Facility

E= 2.0 Gev

ε= 17.3 nm.rad

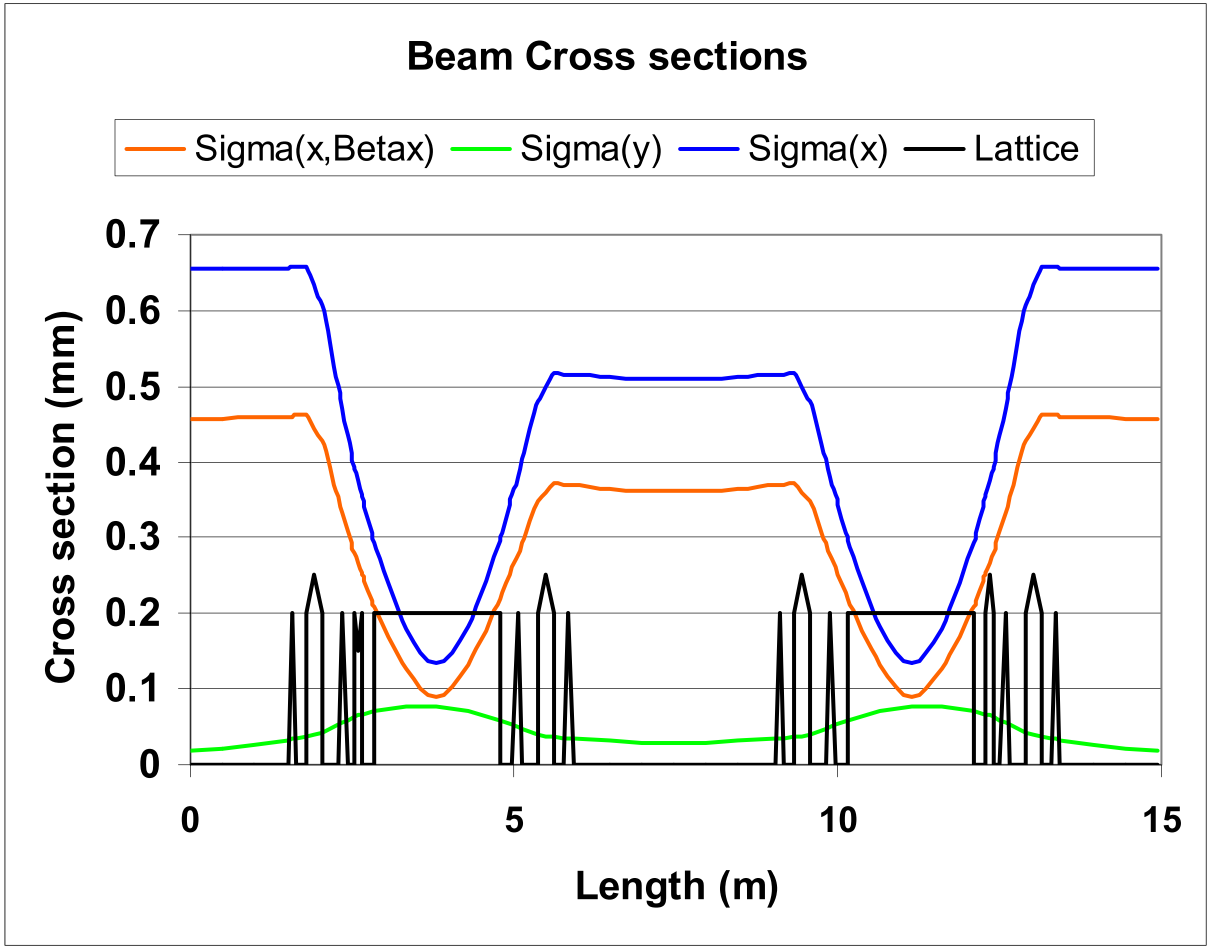
C= 126 m

Machine

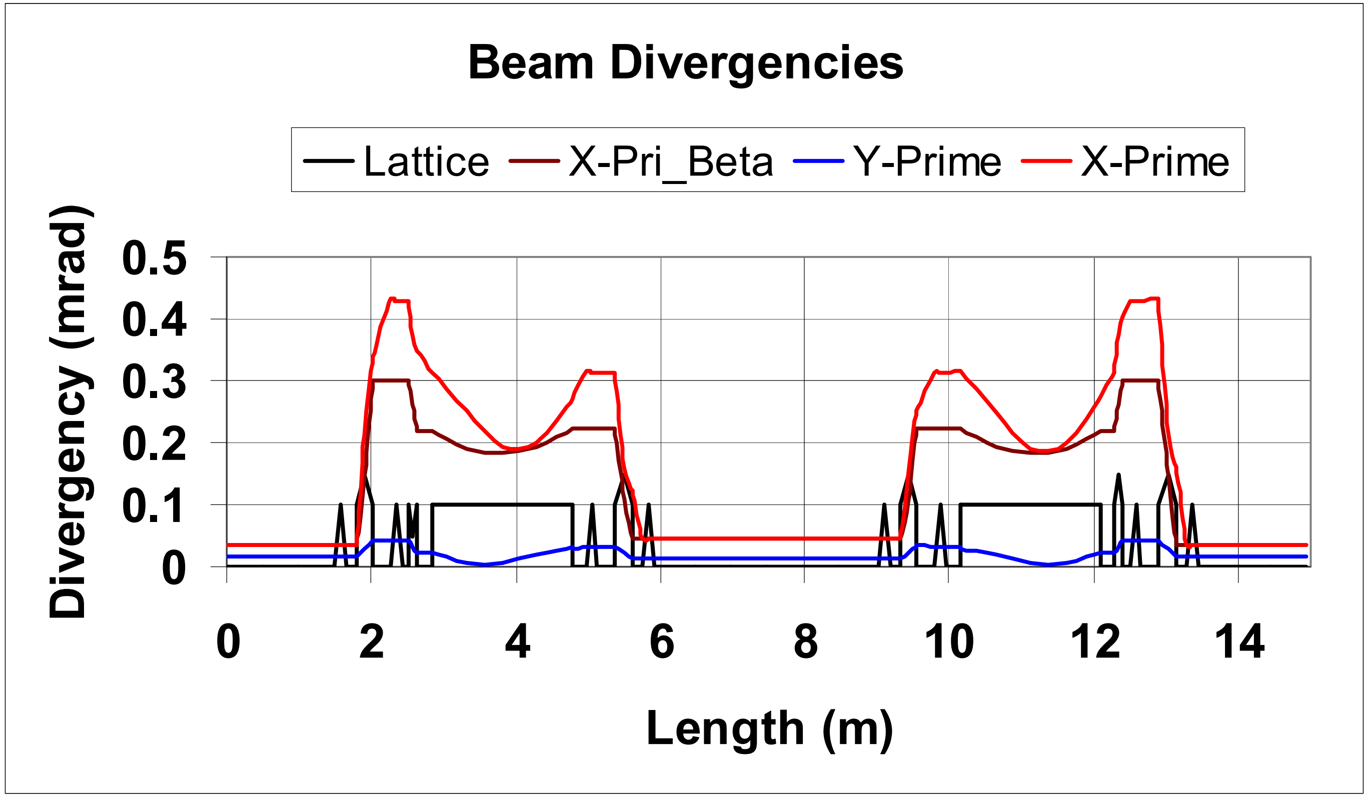


Machinefunctions
Magnets
BETA(x)
BETA(y)
DISP(x)
Machinefunctions (m/rad)
20
18
16
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
Length (m)

Machine


Beam Cross sections
Sigma(x,Betax)
Sigma(y)
Sigma(x)
Lattice
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Cross section (mm)
0
5
10
15
Length (m)

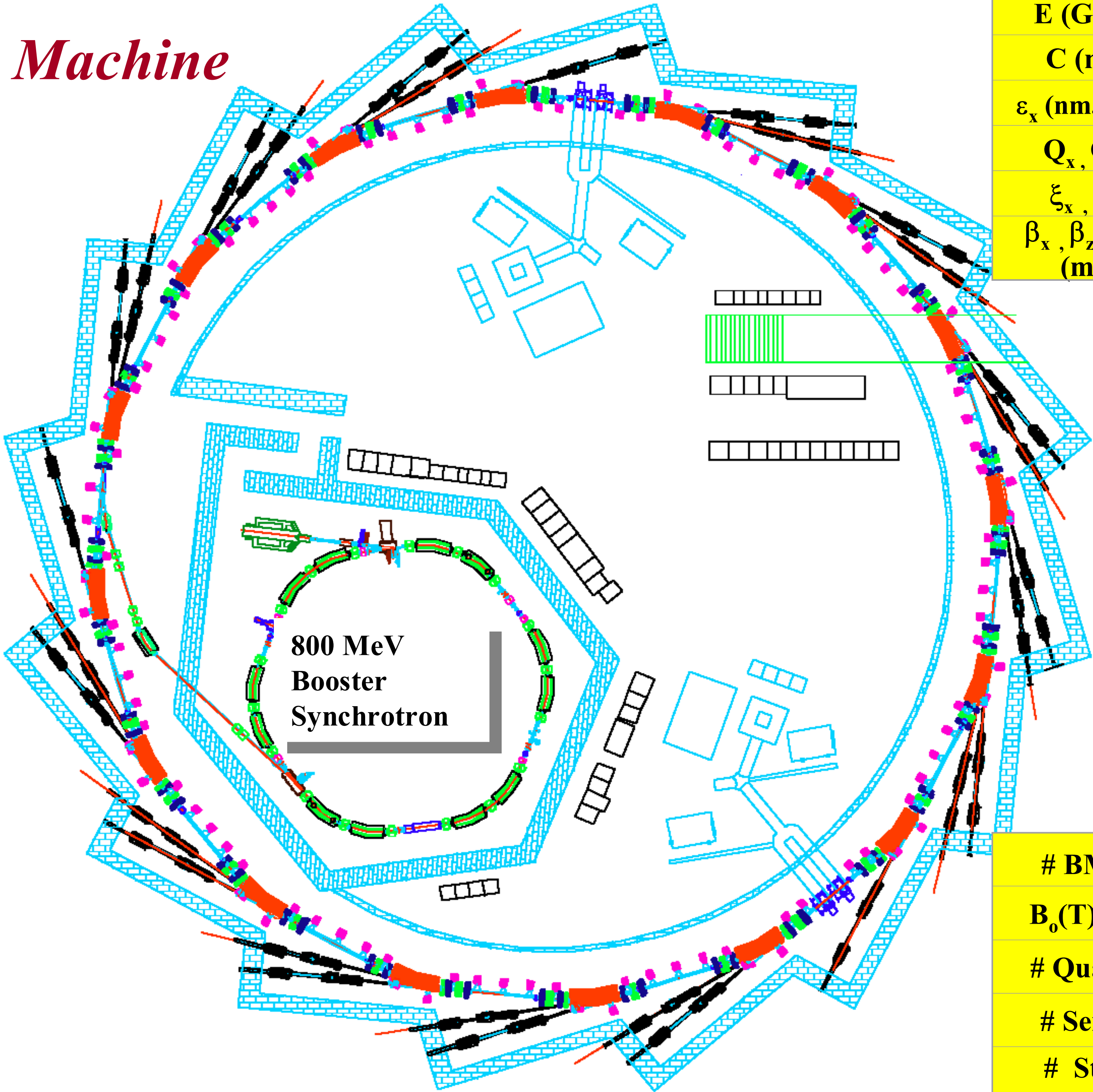
Machine



Beam Divergencies
Lattice
X-Pri_Beta
Y-Prime
X-Prime
Divergency (mrad)
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
Length (m)

Machine

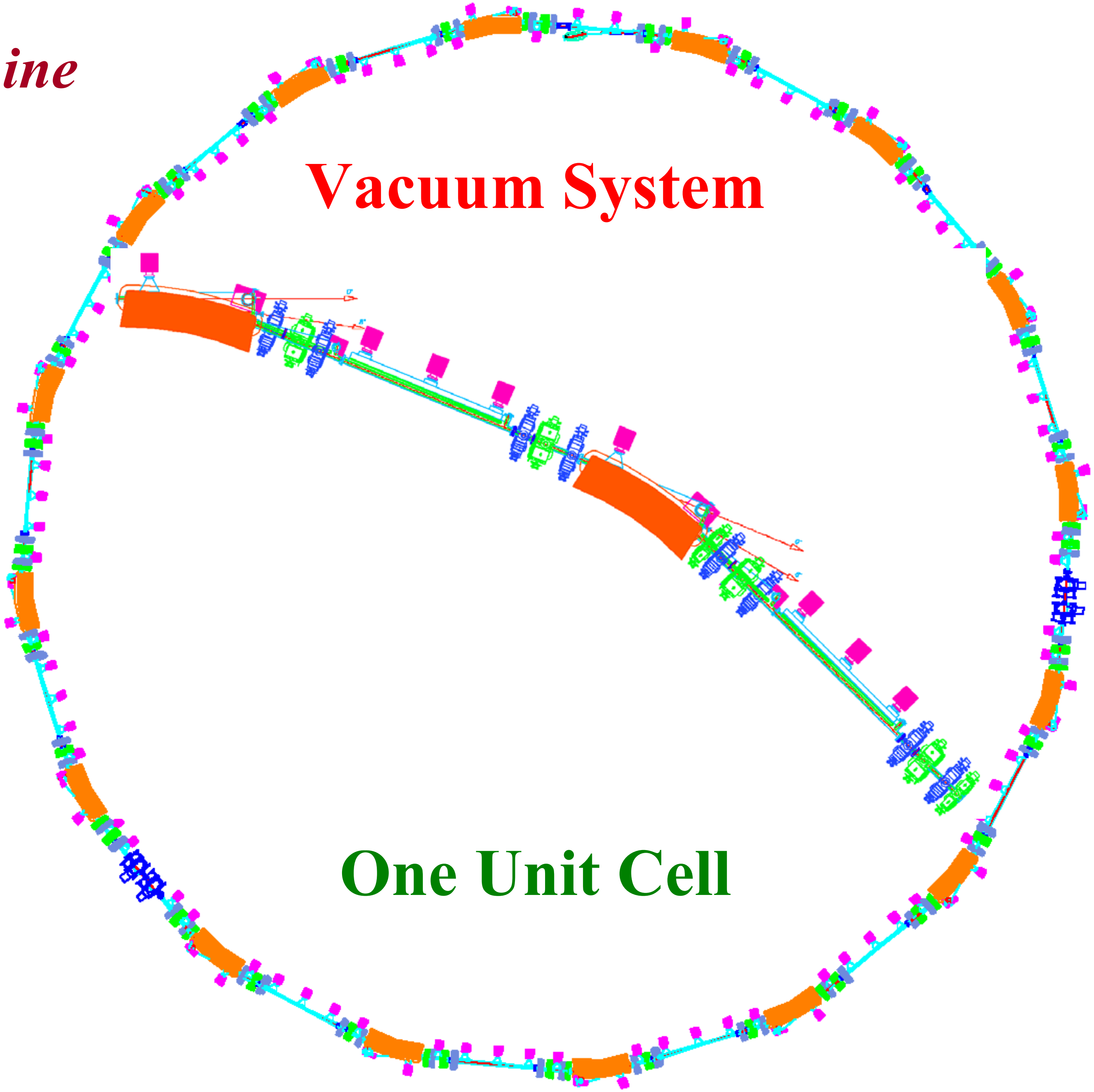
Parameters of the SESAME Storage Ring



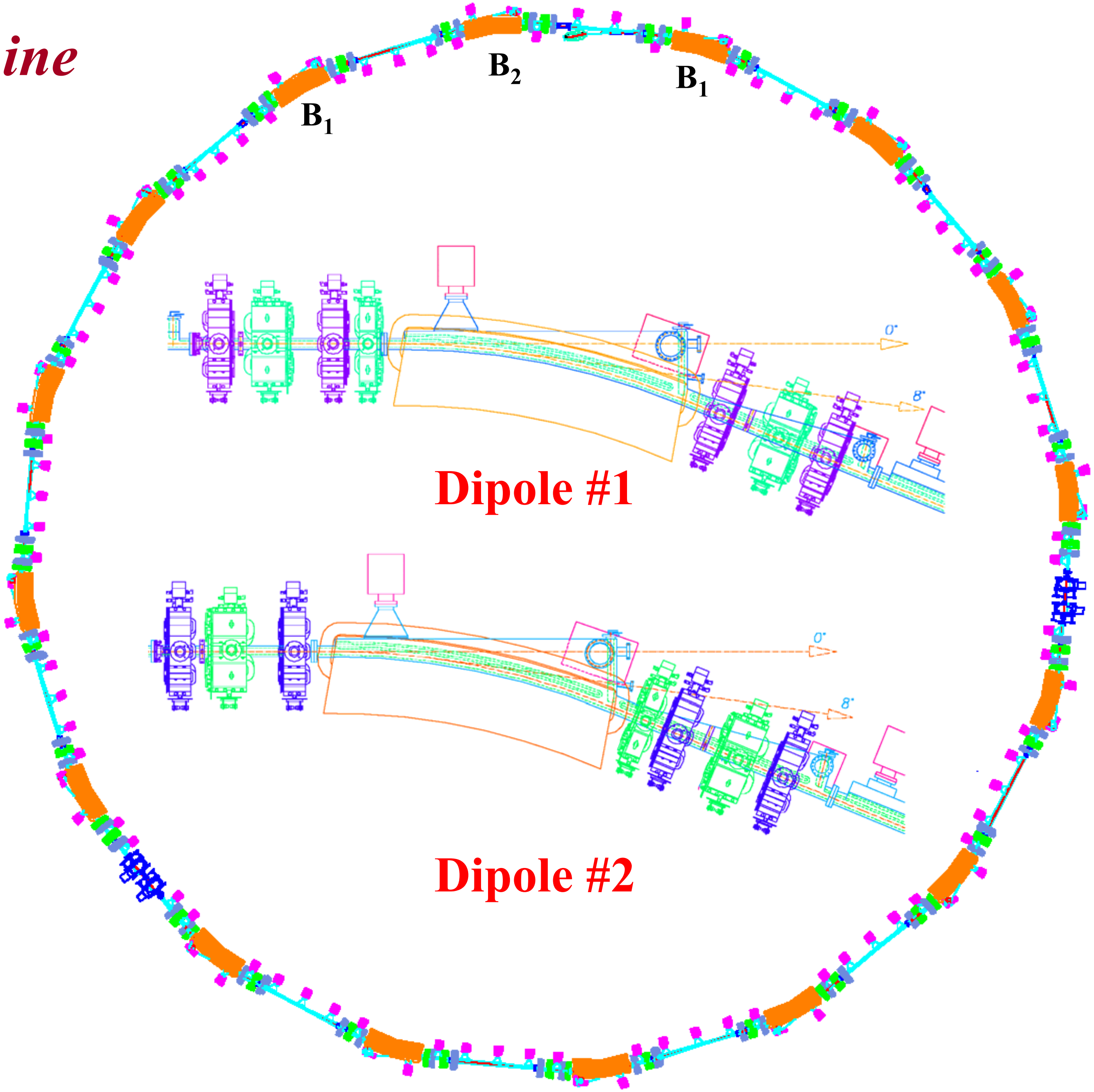
E (Gev)	2
C (m)	119.51
ε_x (nm.rad)	17.3
Q_x , Q_z	7.272, 5.216
ξ_x , ξ_z	-13.608, -14.889
β_x , β_z , η_x (m)	12.6, 1.14, 0.52 (in 8 Sec.) 8, 2.47, 0.4 (in the others)

# BMs	16
B_o(T) , k	1.35, 8.327 (k=-0.341)
# Quads	48 (3 families)
# Sext.	64 (4 families)
# Str. Sections	16 (8 x 3 m + 8 x 3.12 m)

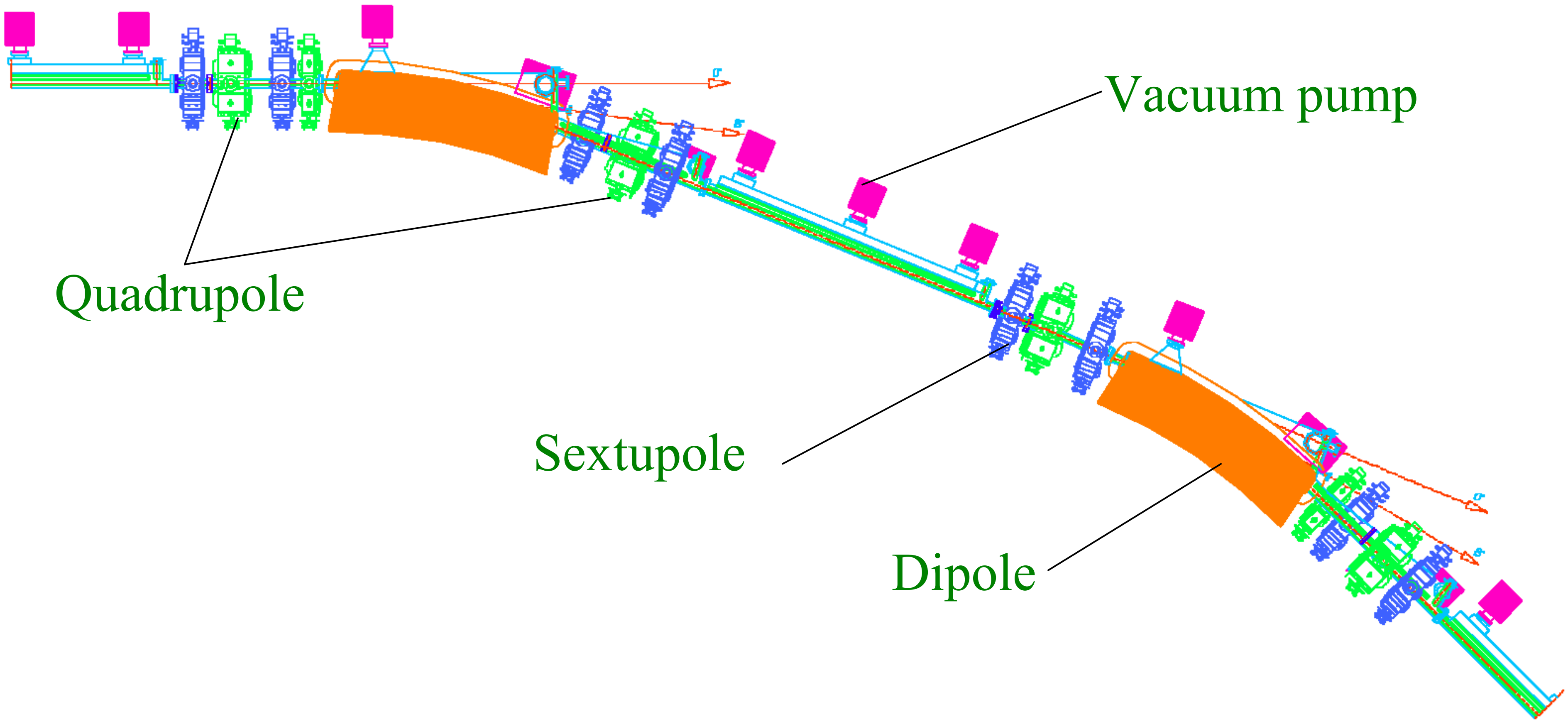
Machine



Machine

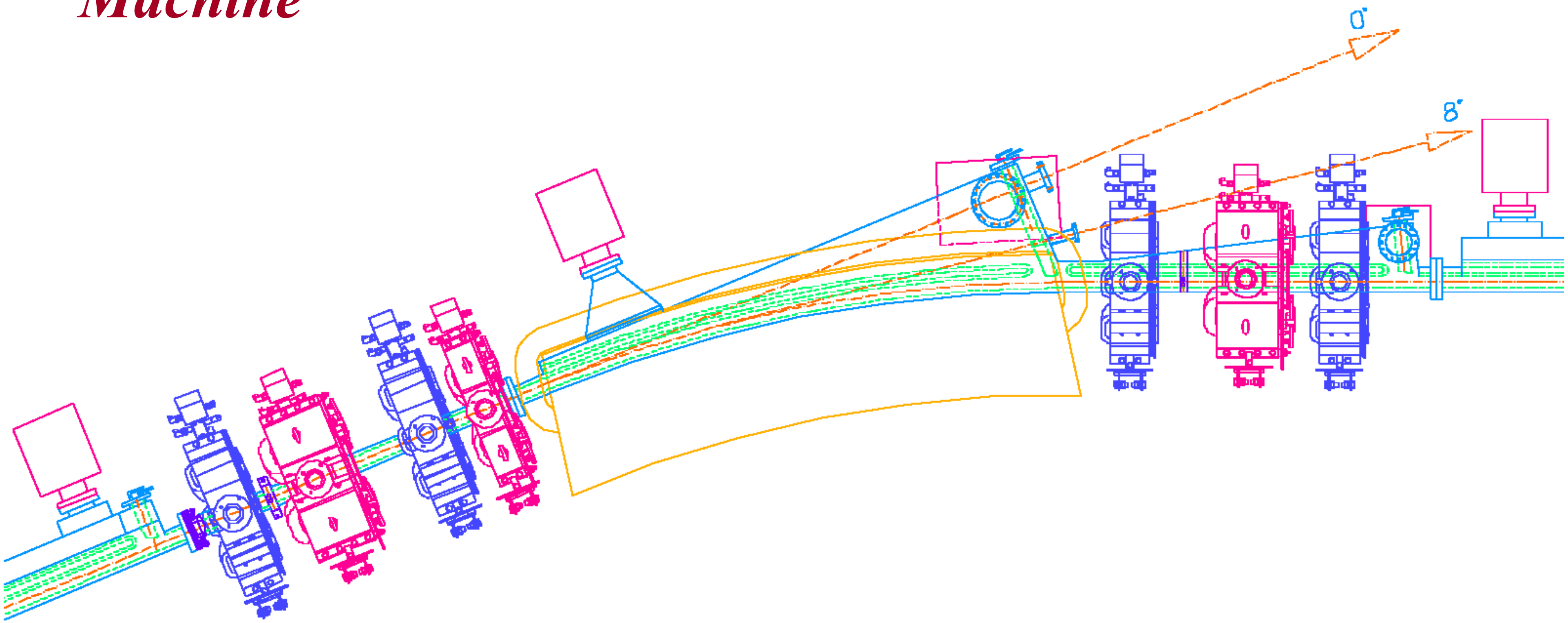


Machine



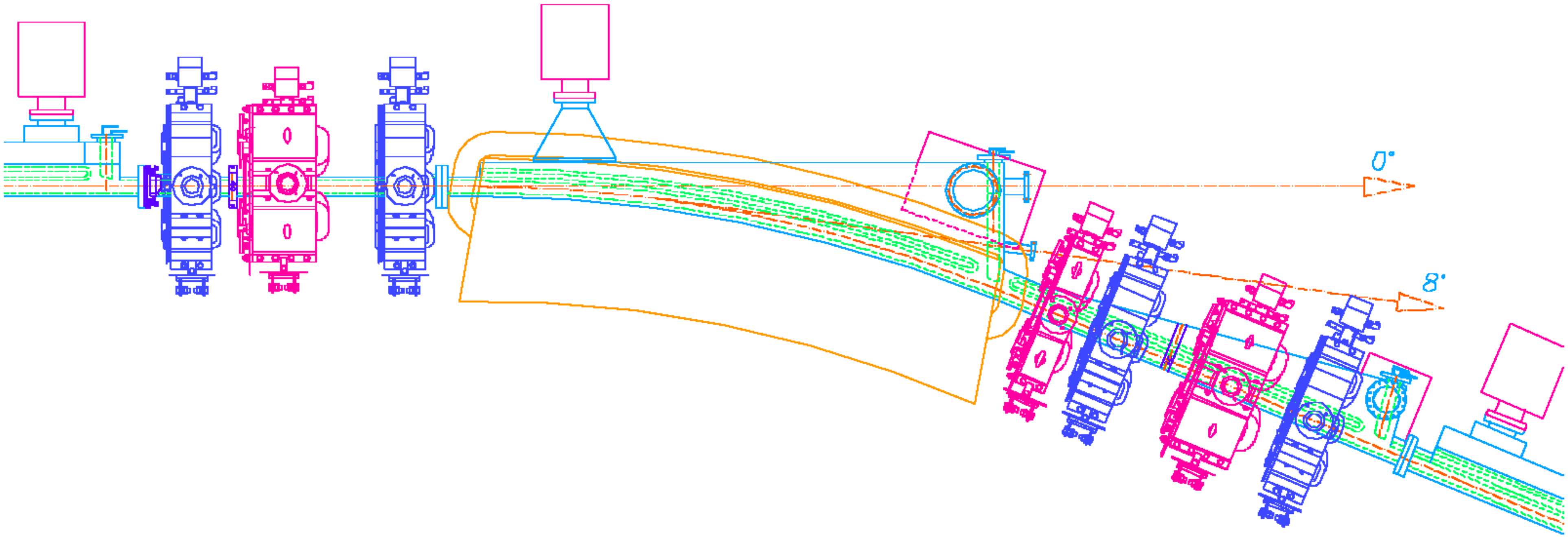
One unit Cell

Machine



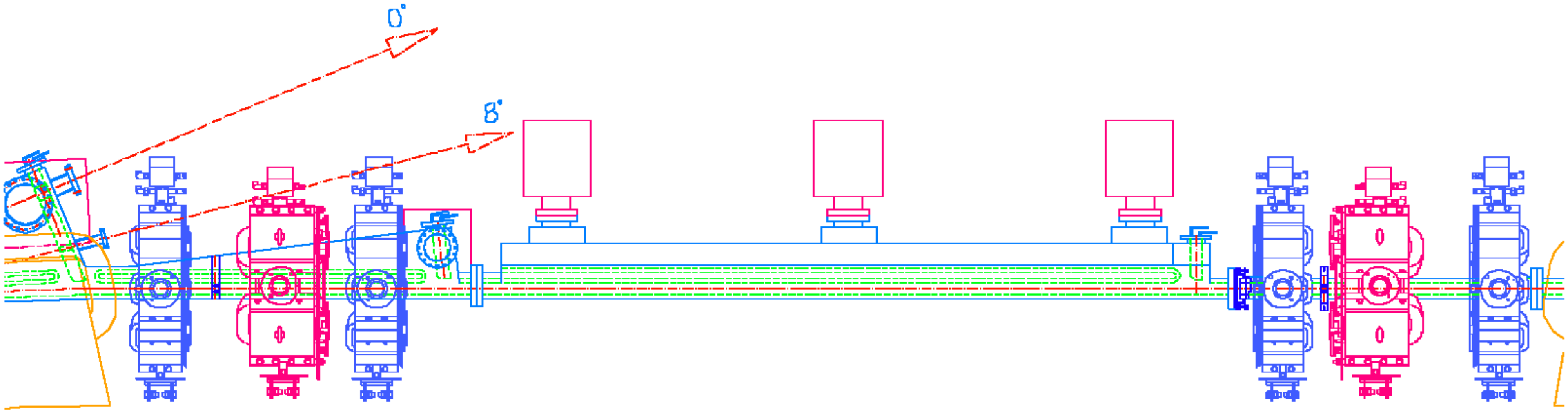
Arrangement of Magnets adjacent to Dipole Number One

Machine



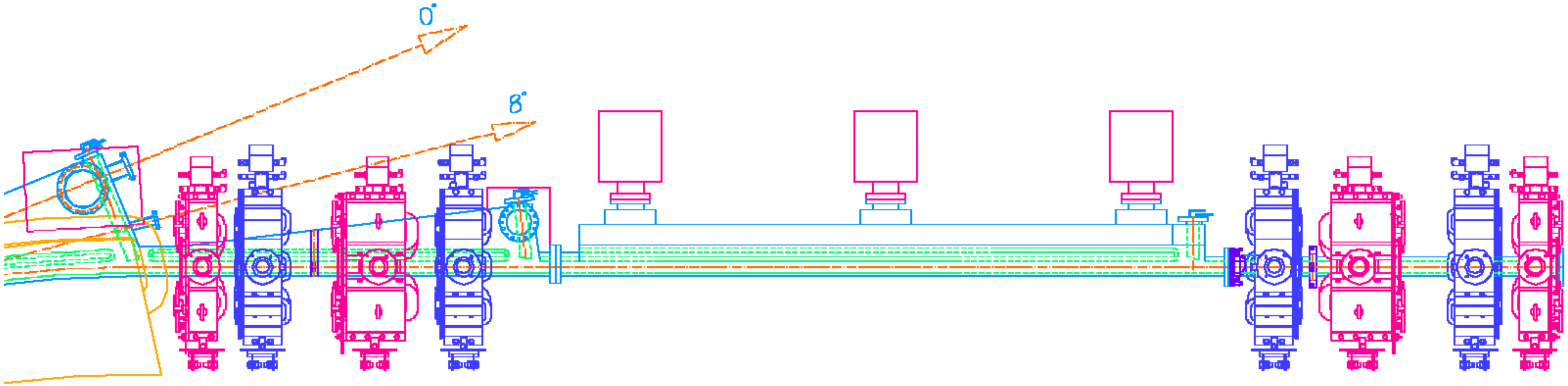
Dipole Number Two

Machine

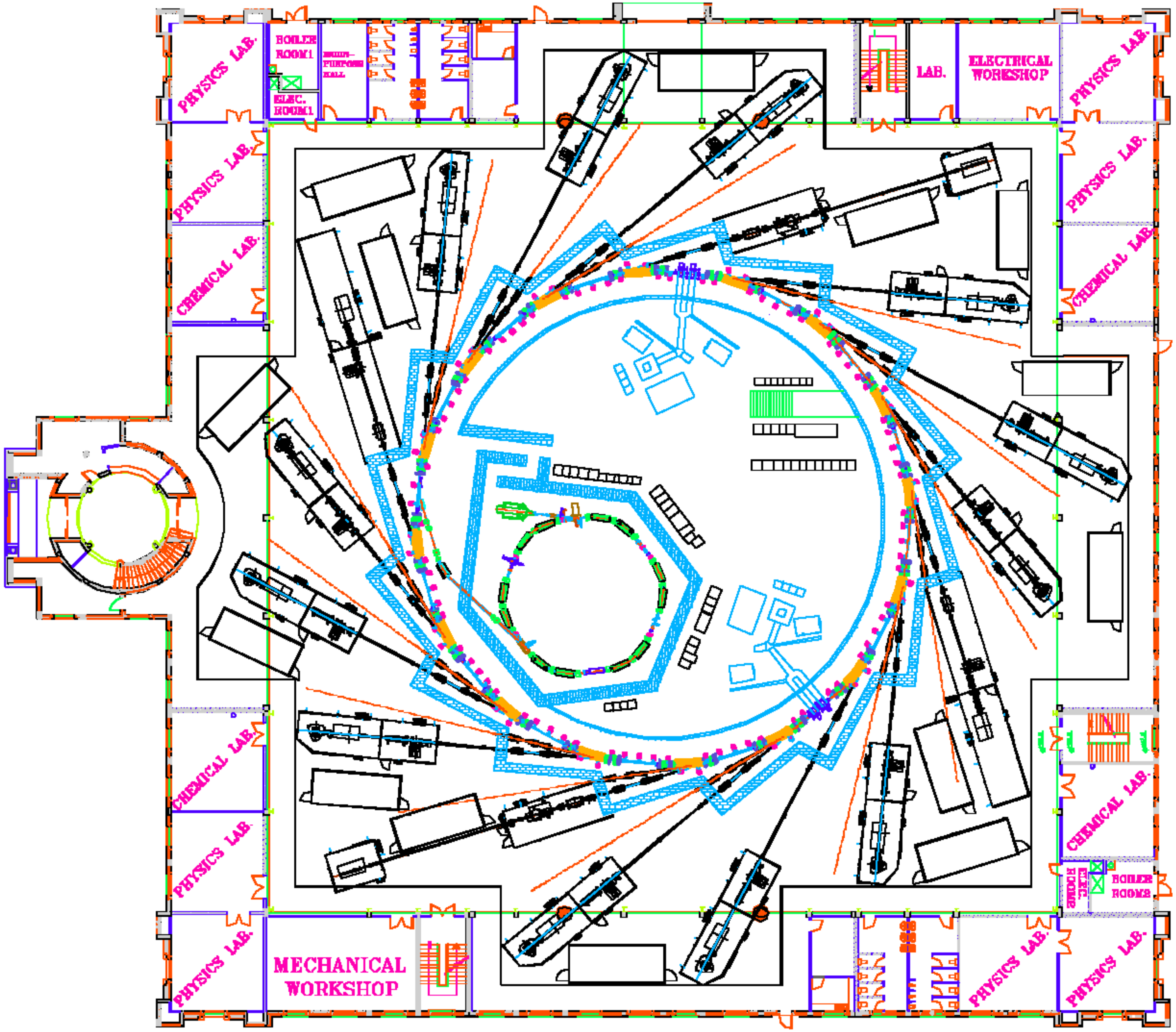


Long Straight Section of the SESAME Storage Ring

Machine

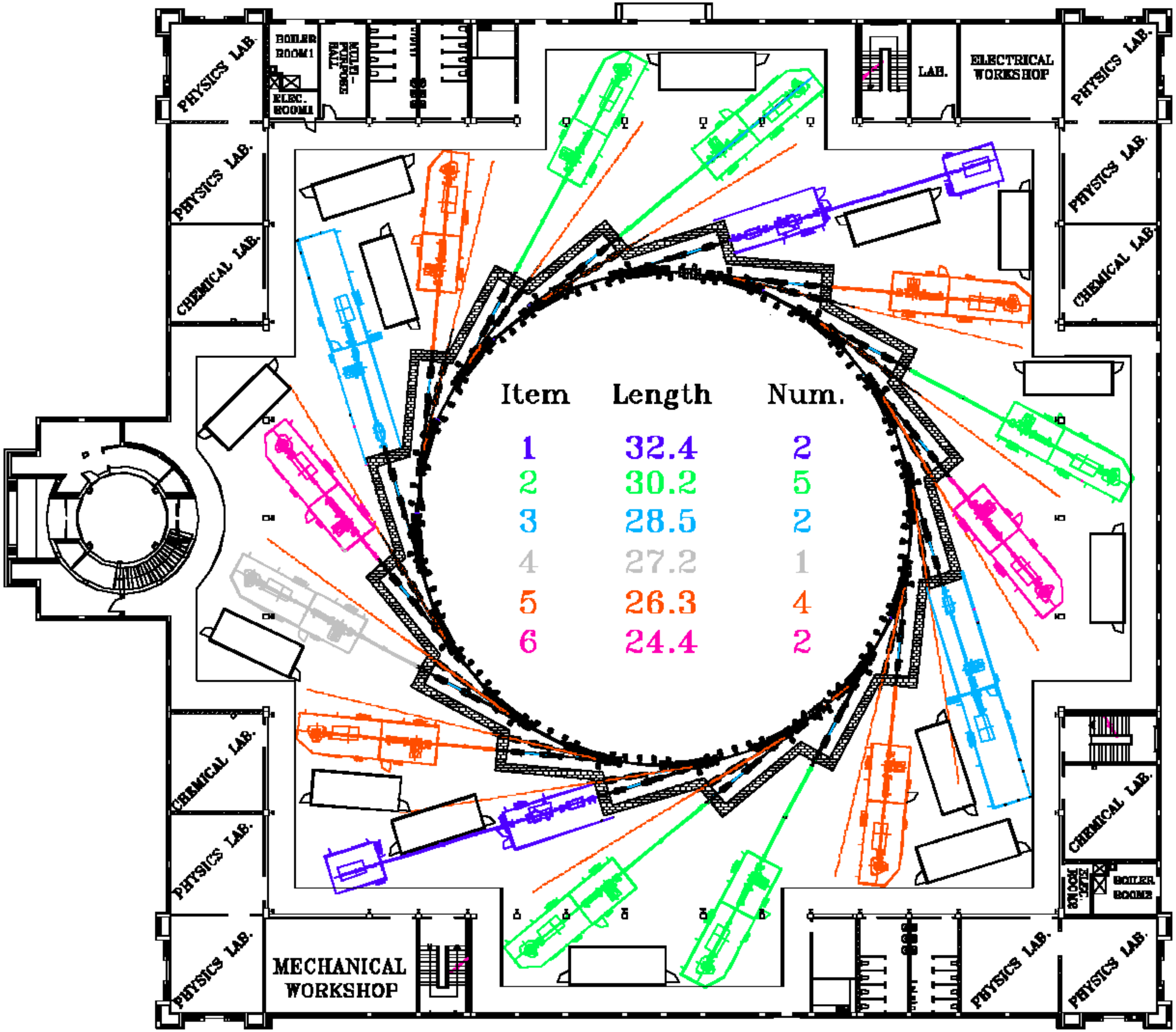


Short Straight Section of the SESAME Storage Ring



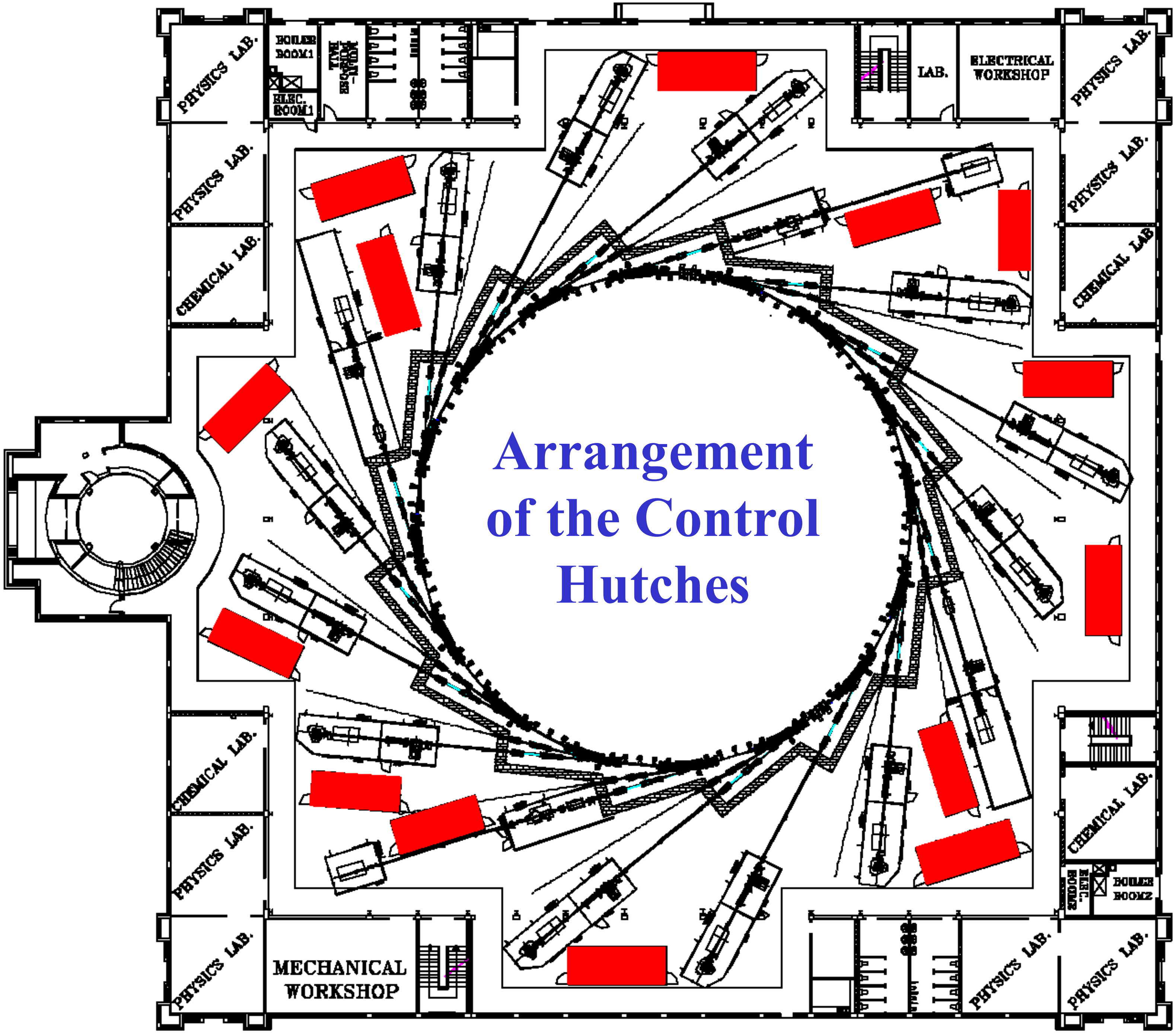
A possible arrangement of the beam lines within the experimental hall

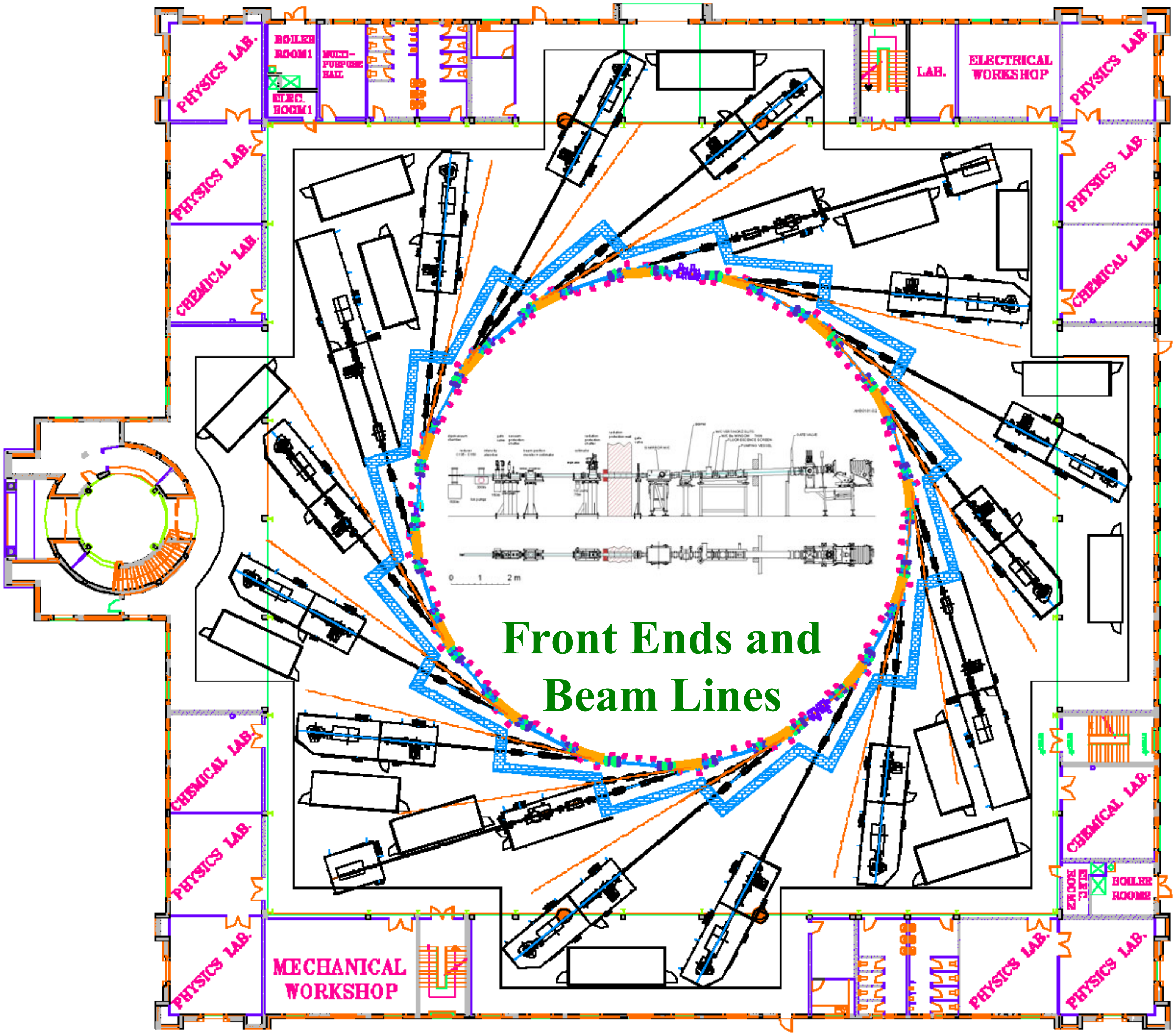
Beam Lines and there Lengths



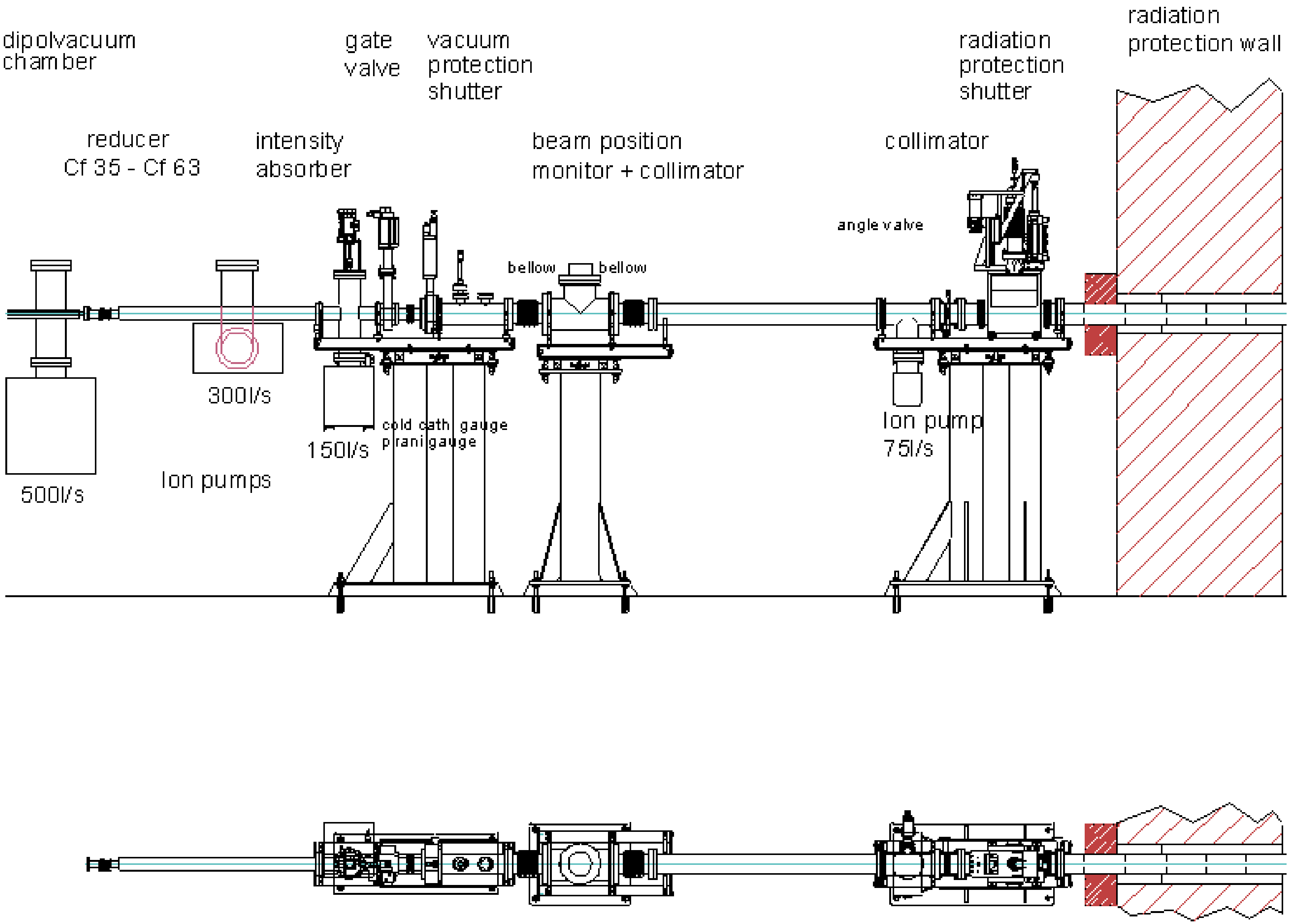
Item	Length	Num.
1	32.4	2
2	30.2	5
3	28.5	2
4	27.2	1
5	26.3	4
6	24.4	2

Arrangement of the Control Hutches

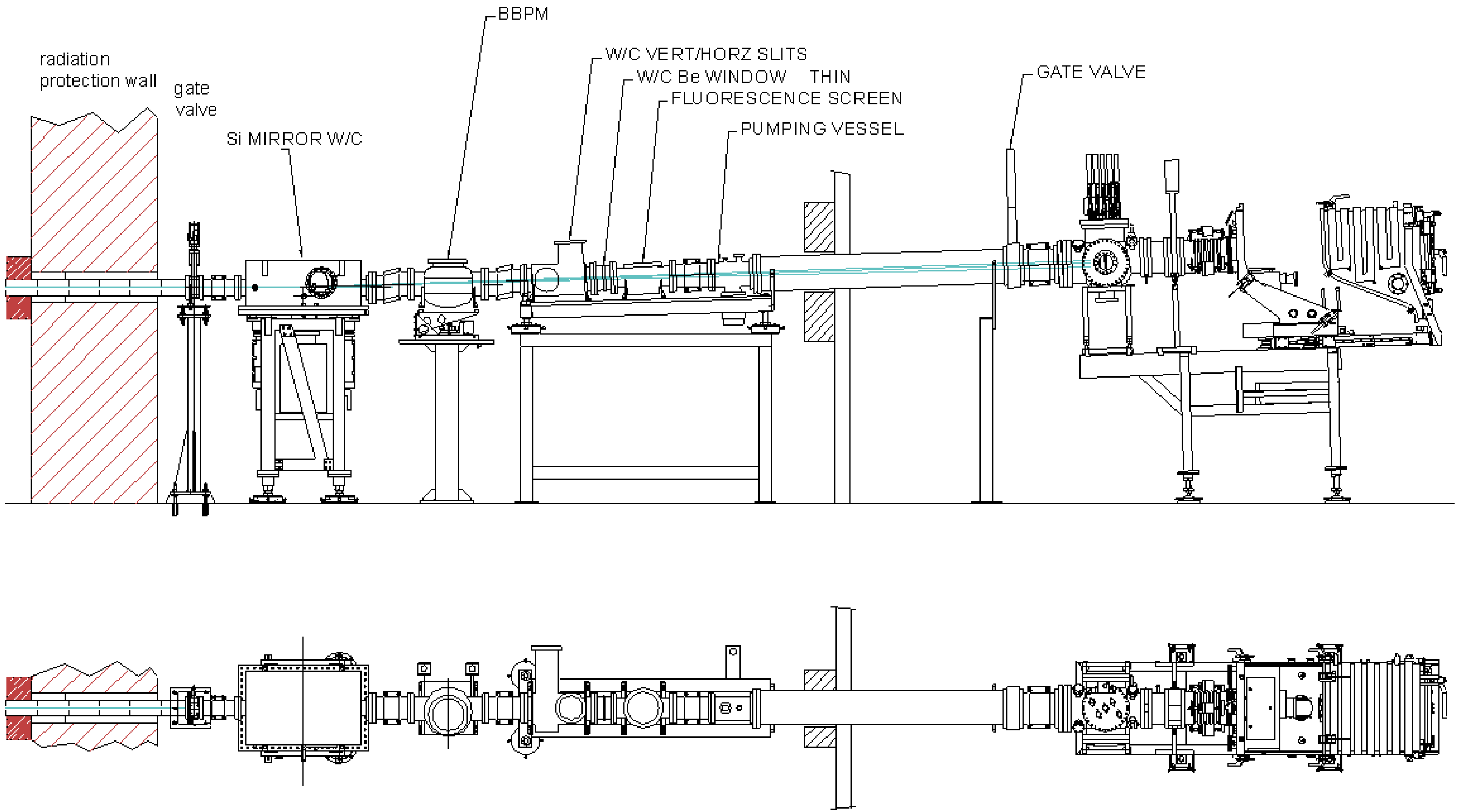




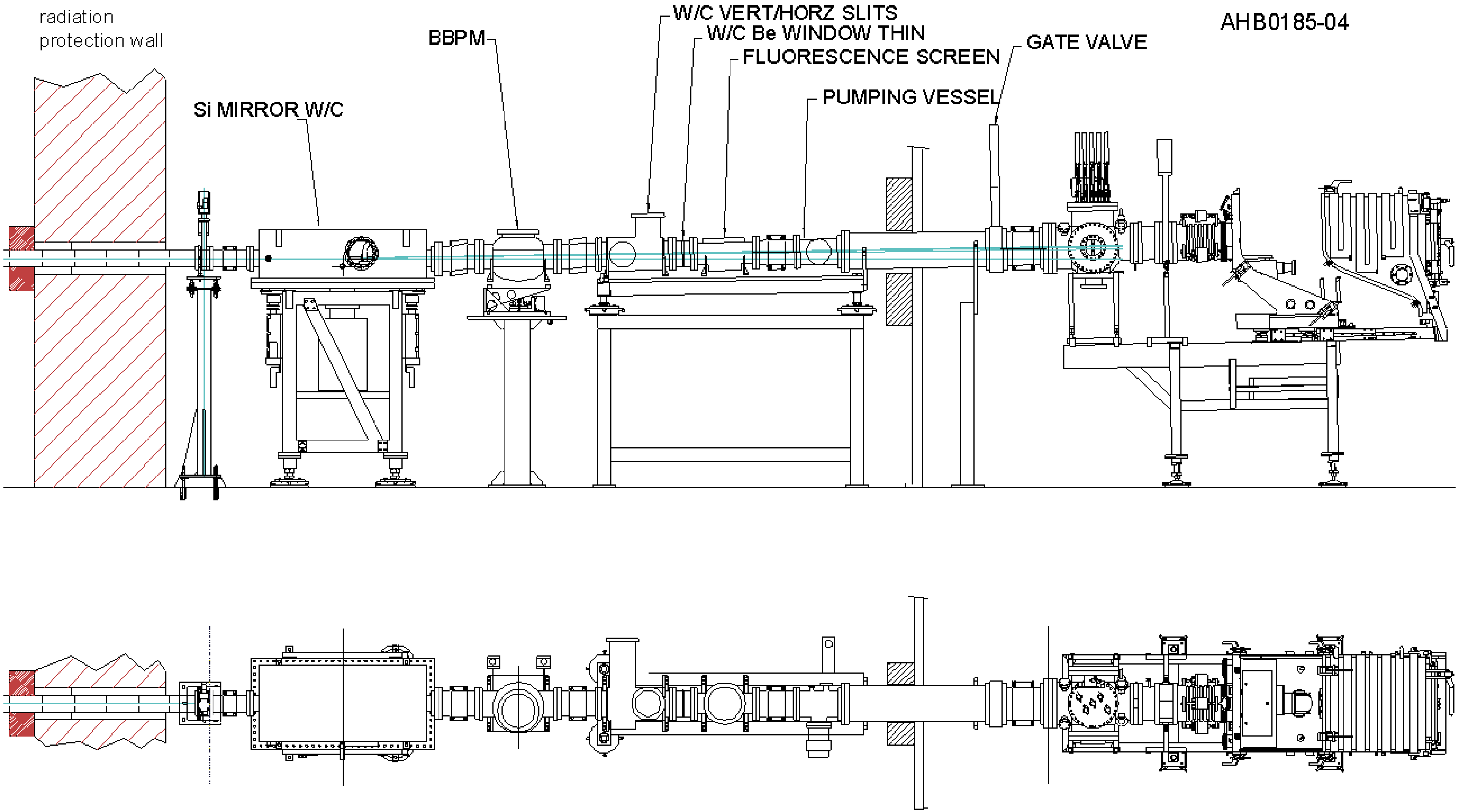
Front Ends and Beam Lines
PHYSICS LAB.
BOILER ROOM1
MULTI-PURPOSE HALL
ELEC. ROOM1
LAB.
ELECTRICAL WORKSHOP
CHEMICAL LAB.
MECHANICAL WORKSHOP
BOILER ROOM2



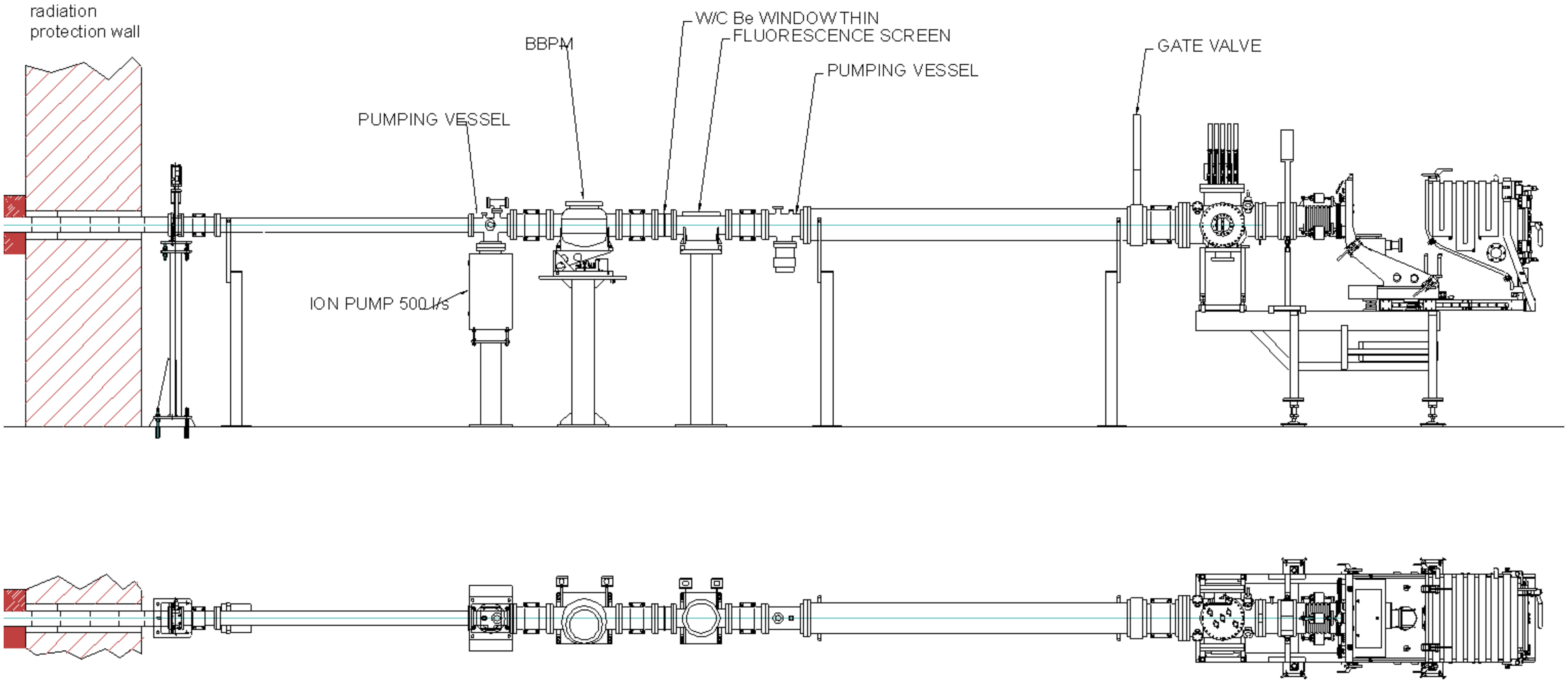
Front End of the Beam Lines at ANKA



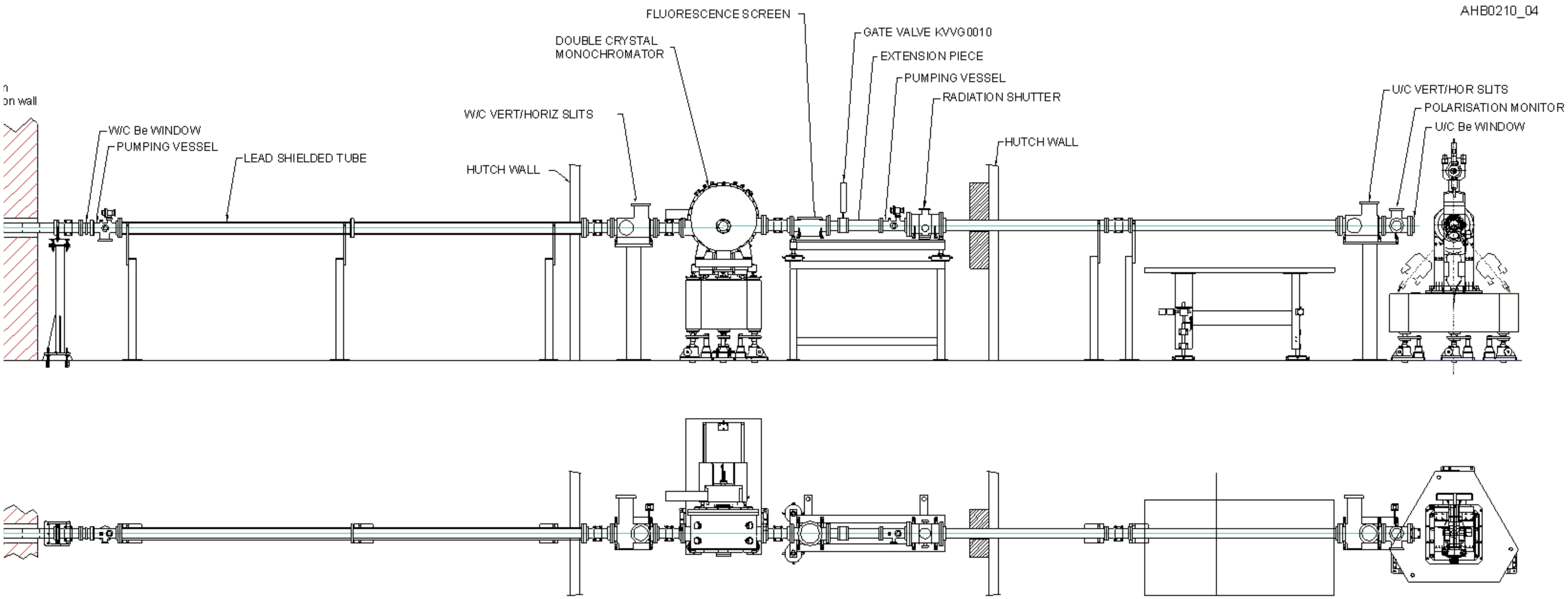
LIGA-I Beam Line at ANKA



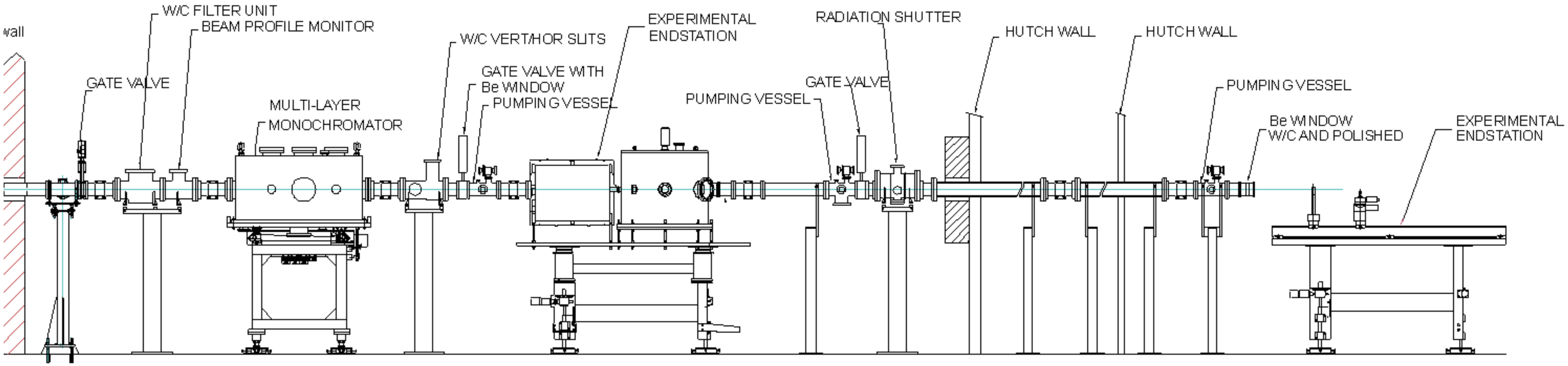
LIGA-II Beam Line at ANKA

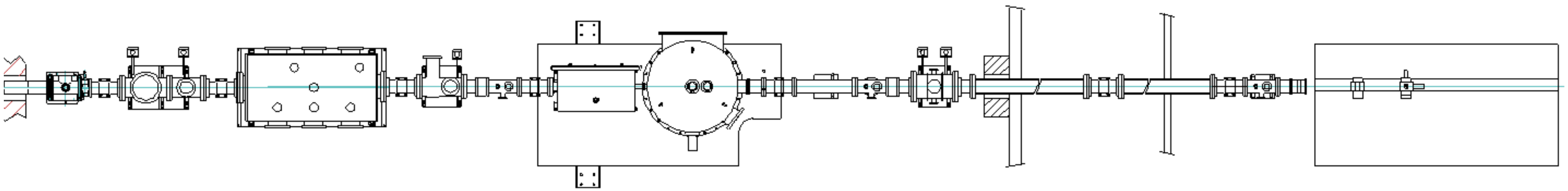


LIGA-III Beam Line at ANKA

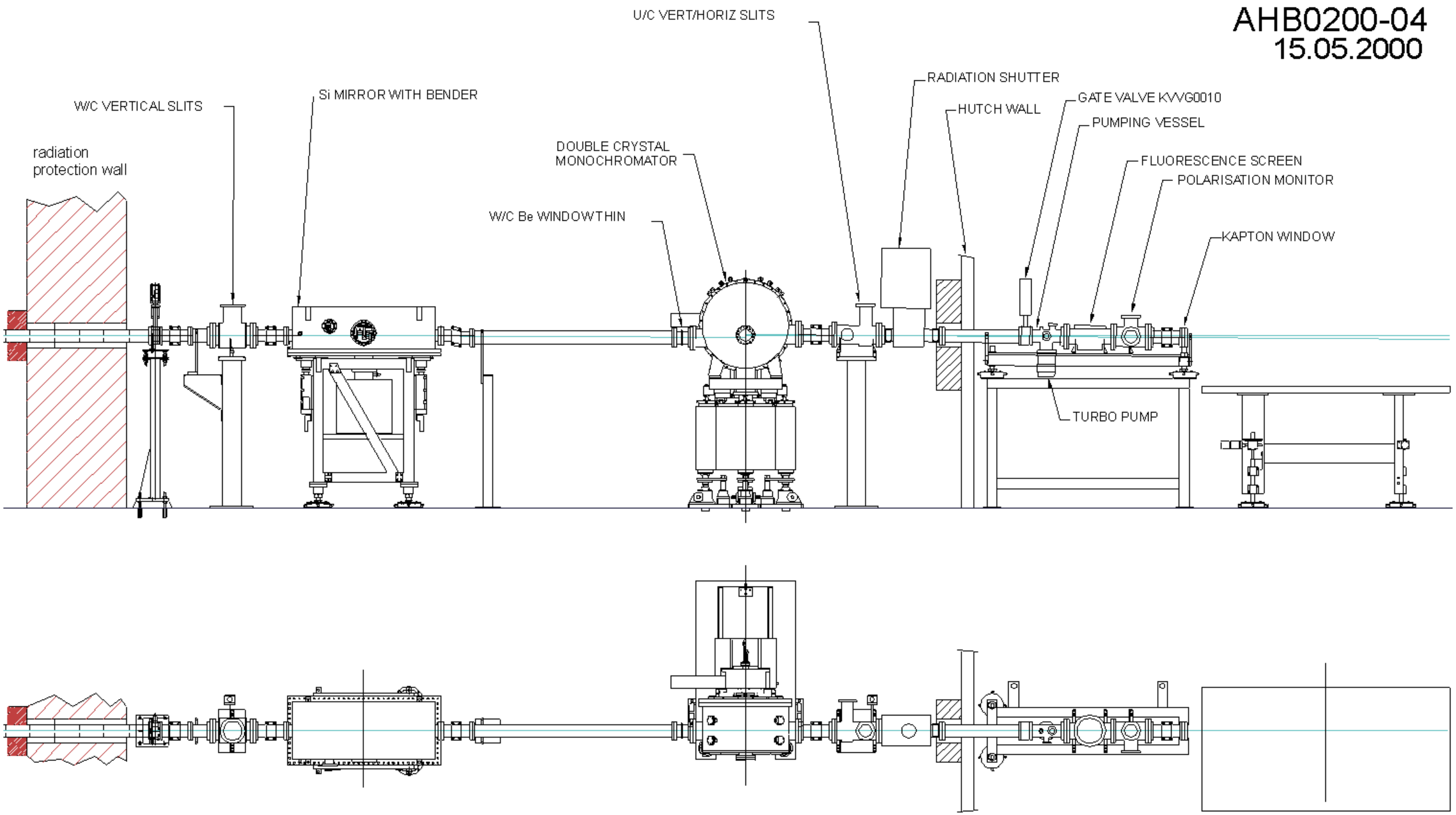


Diffraction Beam Line at ANKA

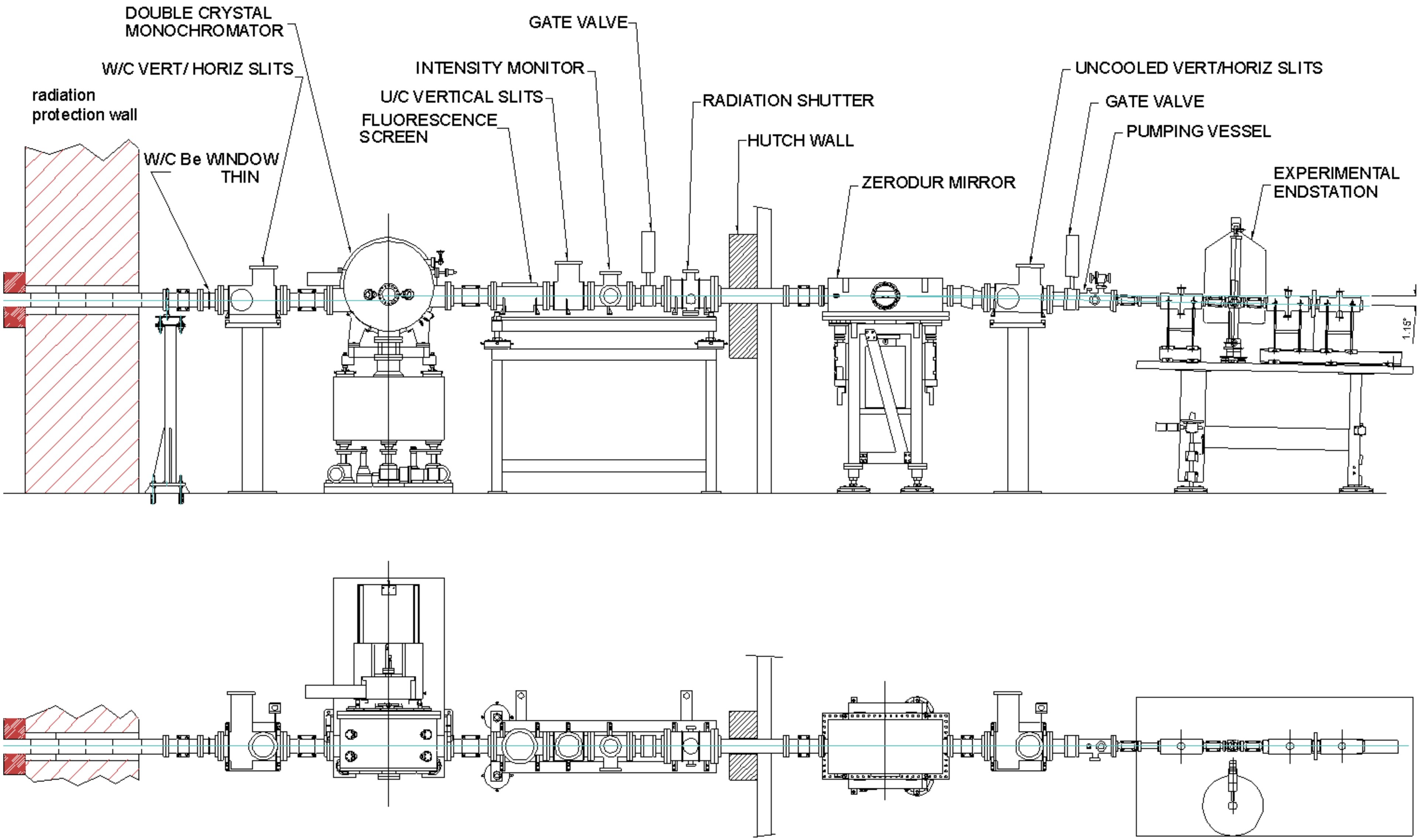




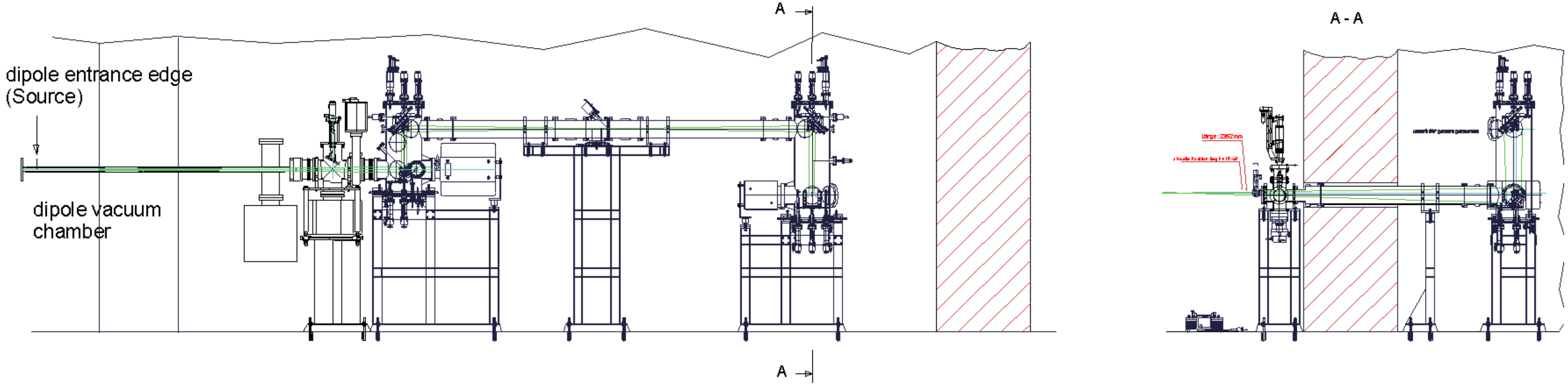
Fluorescence and Topography Beam Line at ANKA

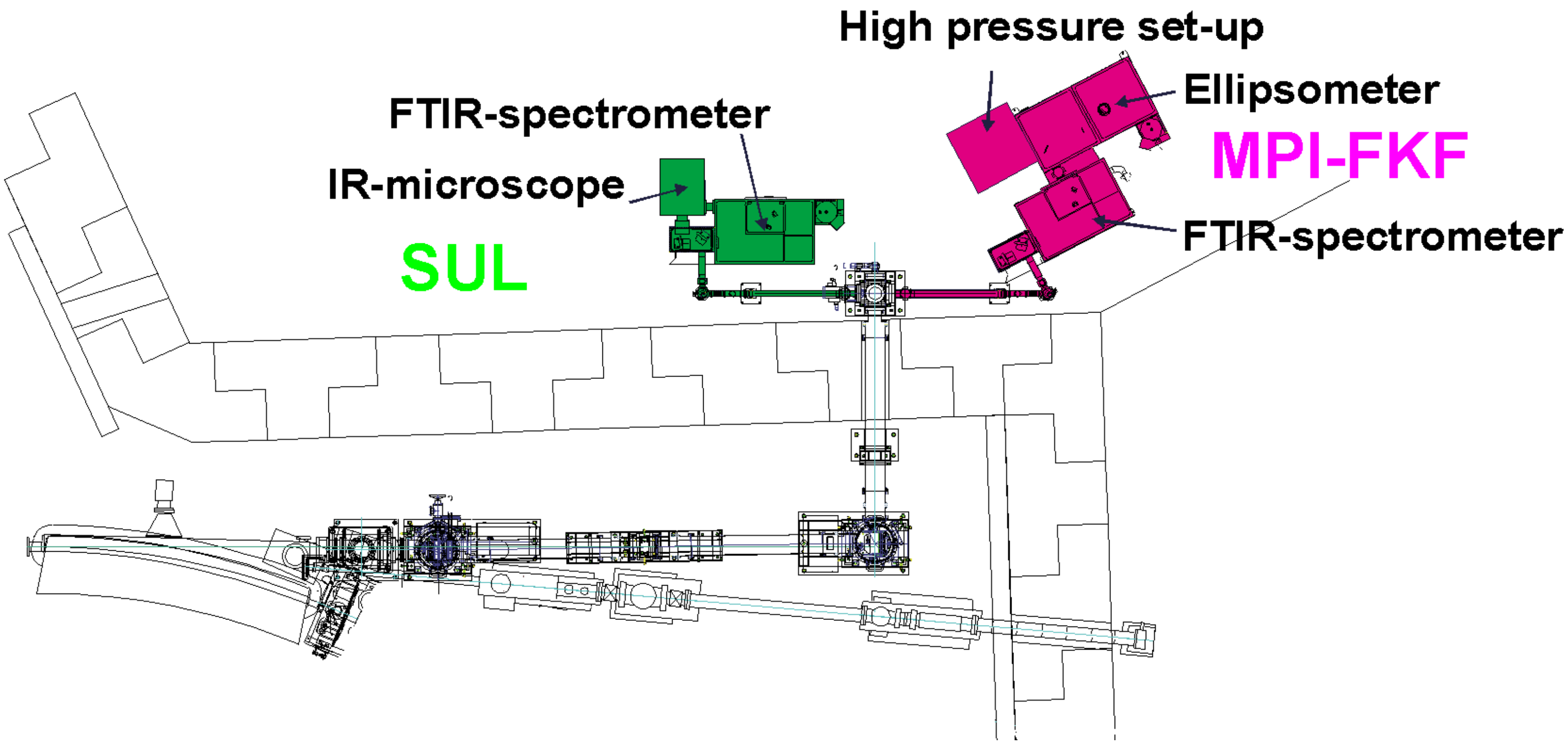


Protein Crystallography Beam Line at ANKA

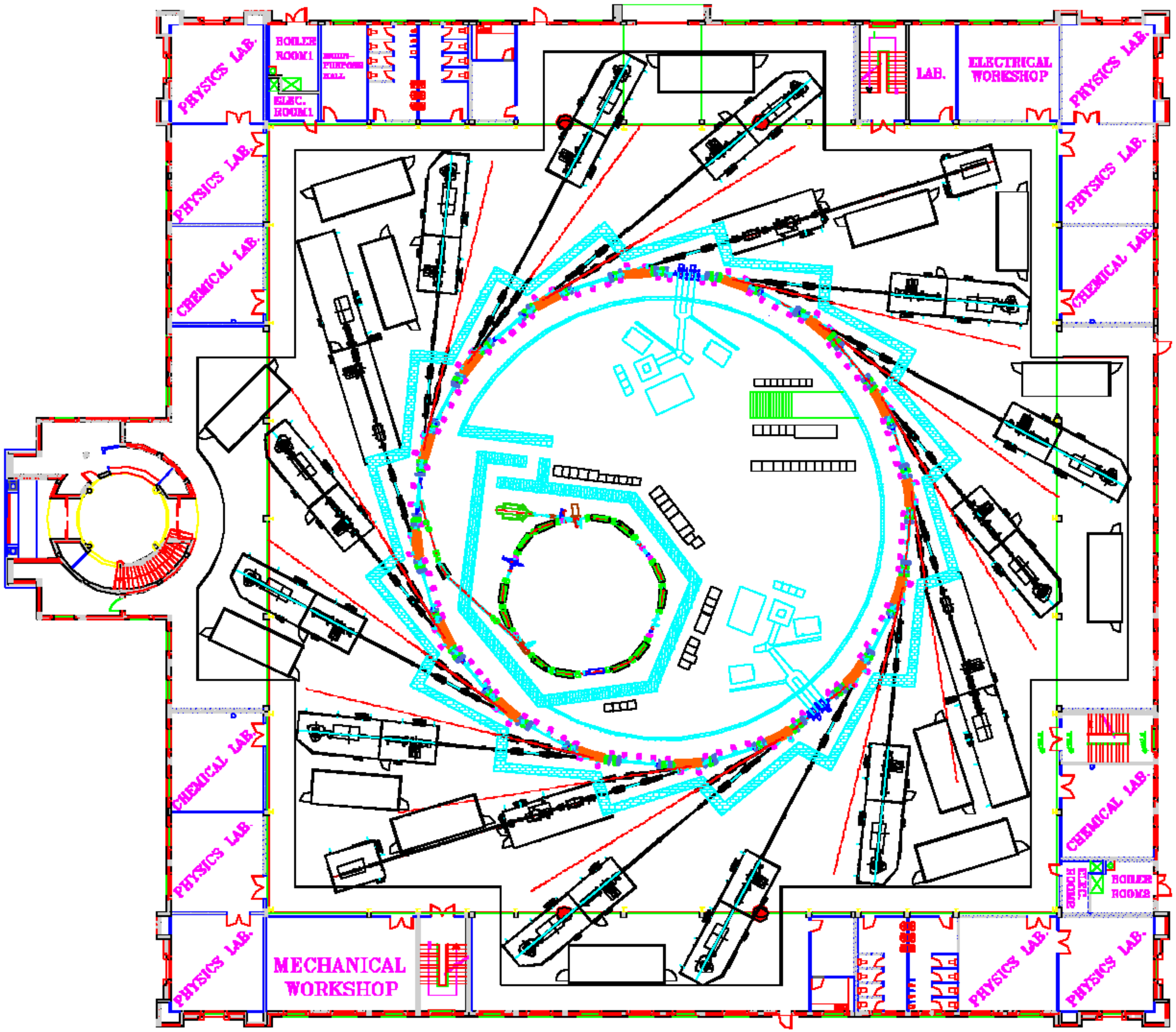


X-Ray Absorption Beam Line at ANKA





Infrared Beam Line at ANKA



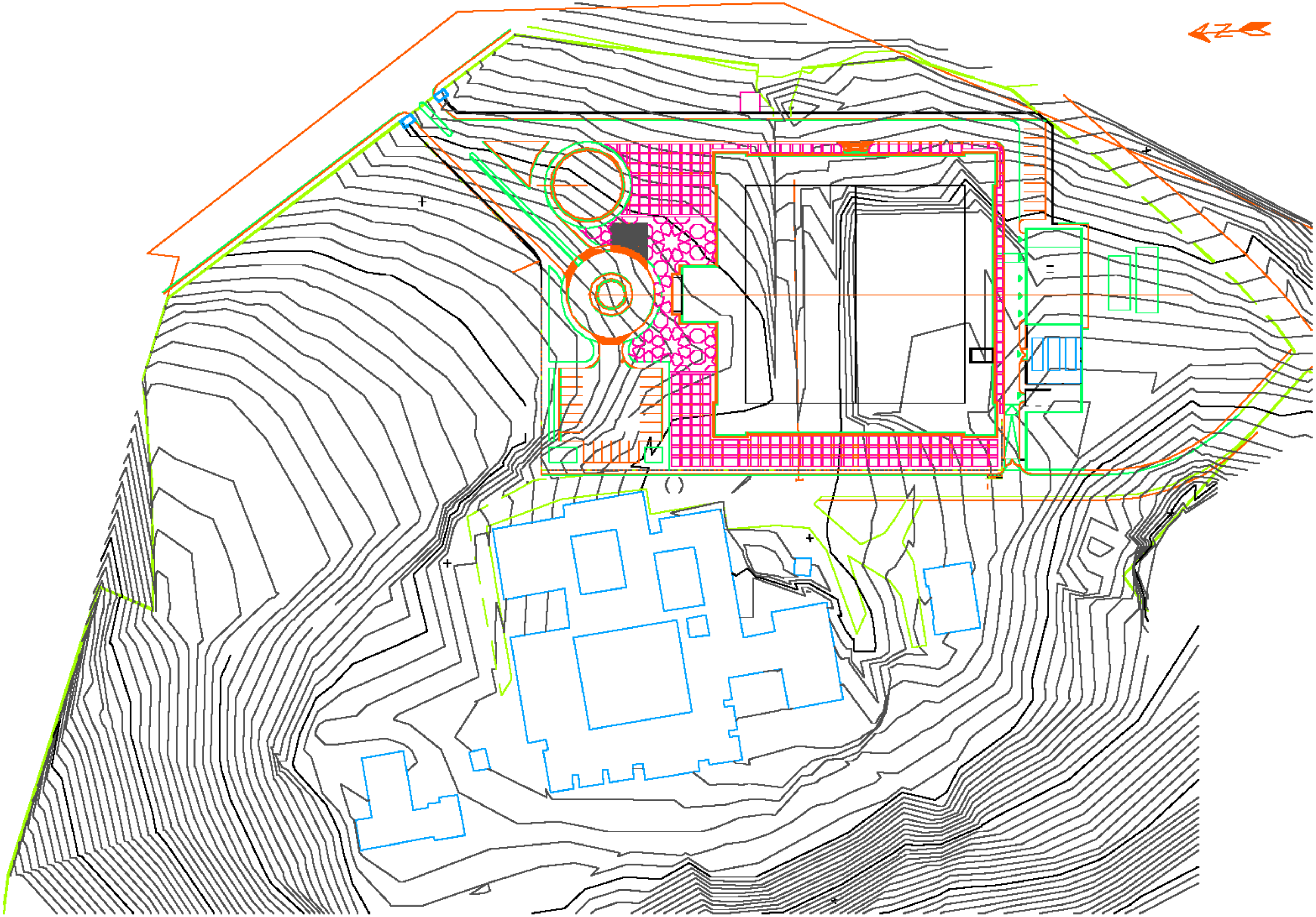
SESAME

Synchrotron Radiation Facility

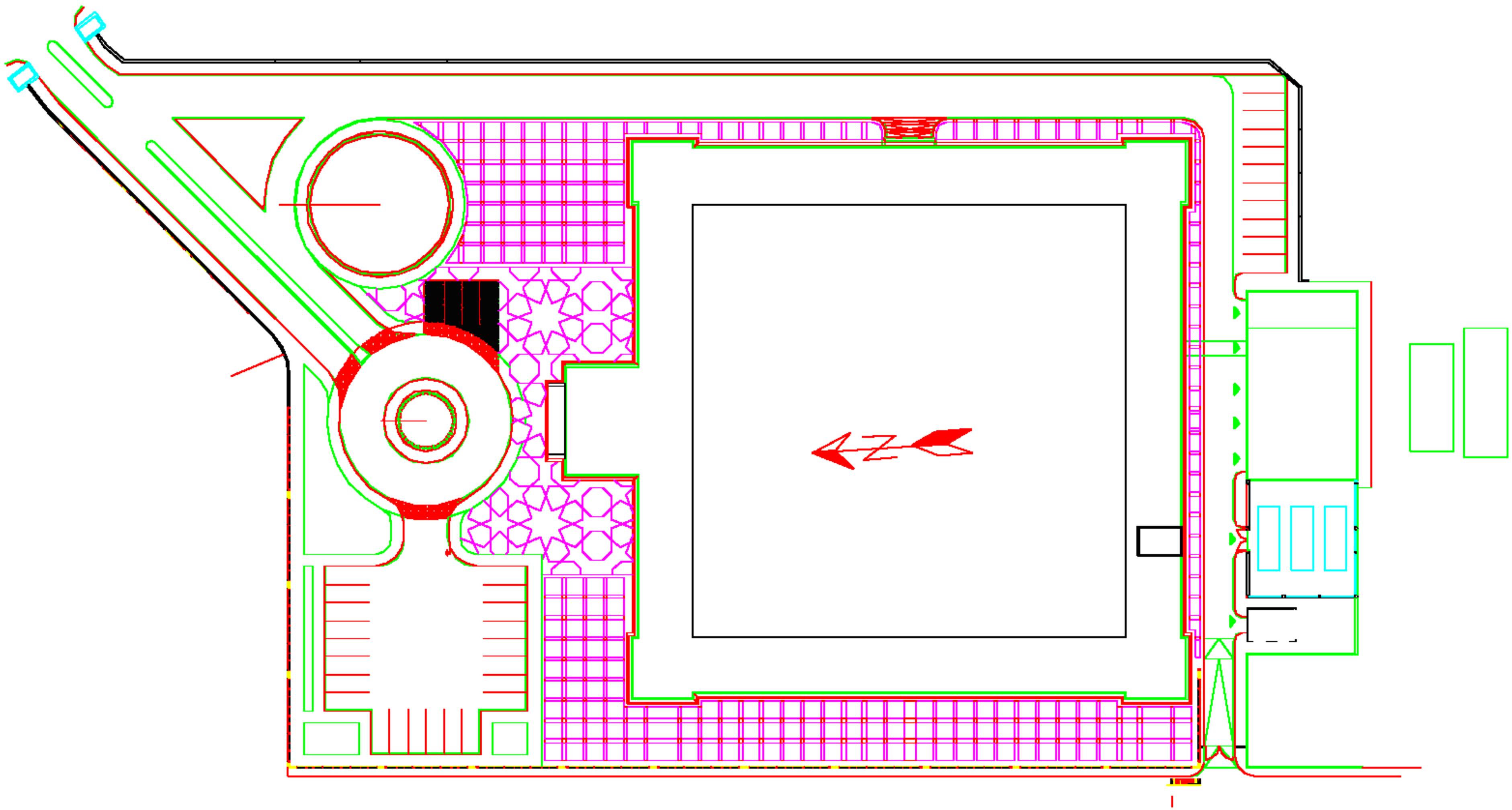
E= 2.0 Gev

ε= 17.3 nm.rad

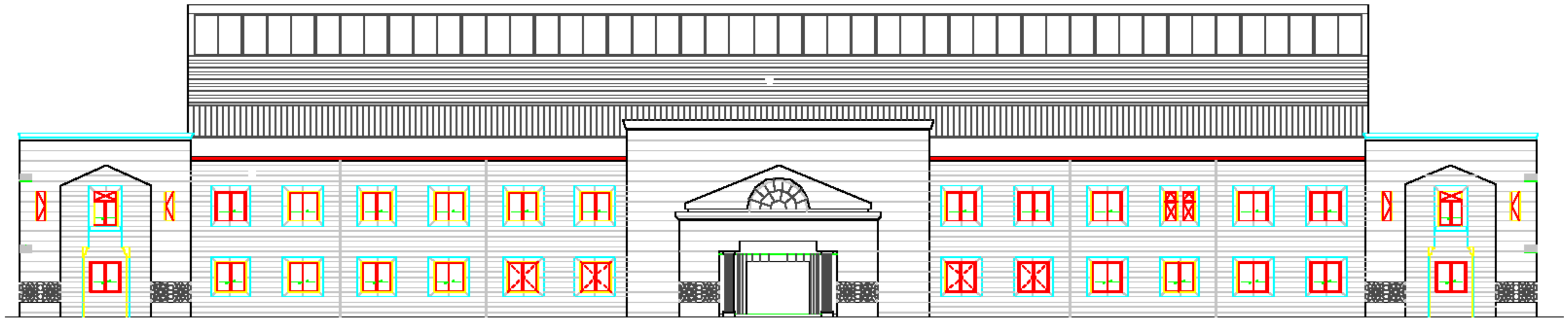
C= 126 m



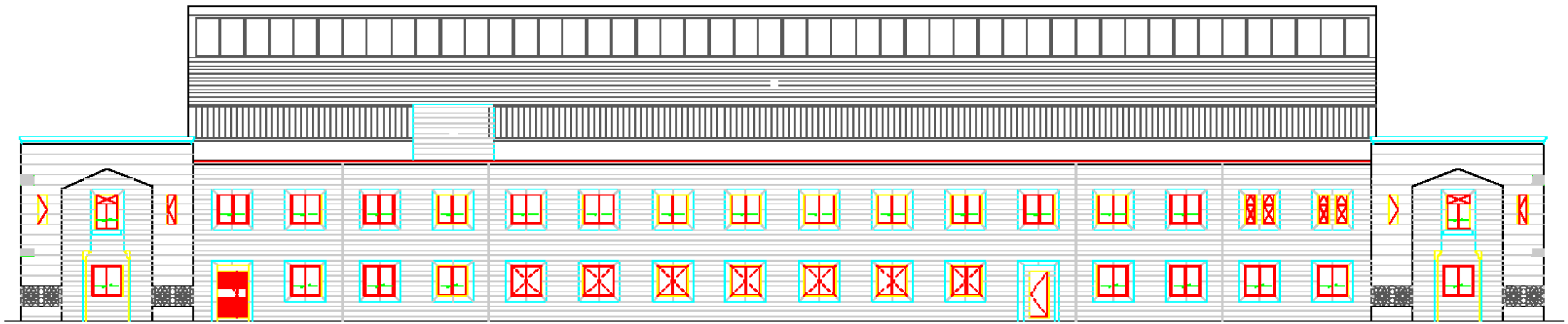
General View of the Building and the college



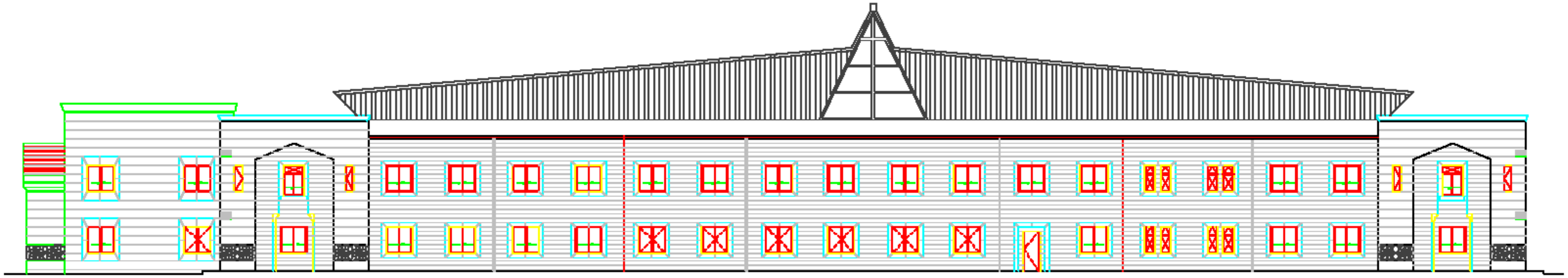
General layout of the SESAME Site



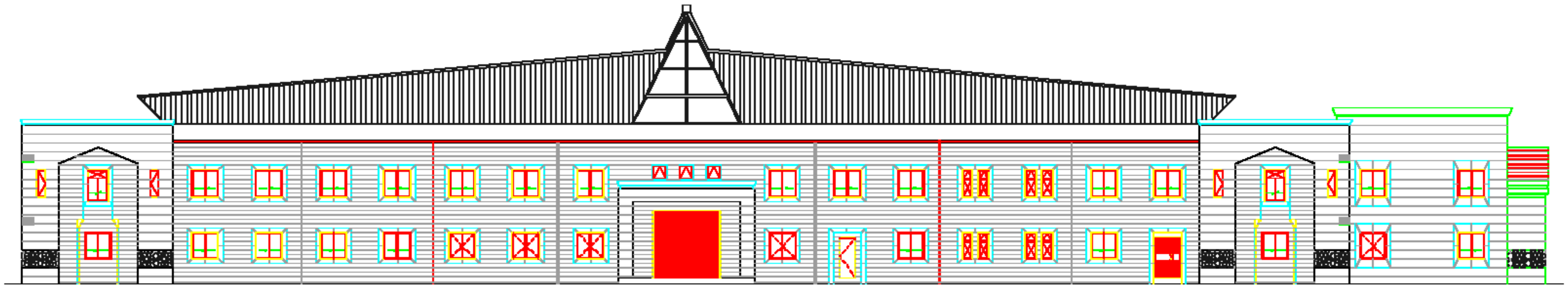
North Elevation



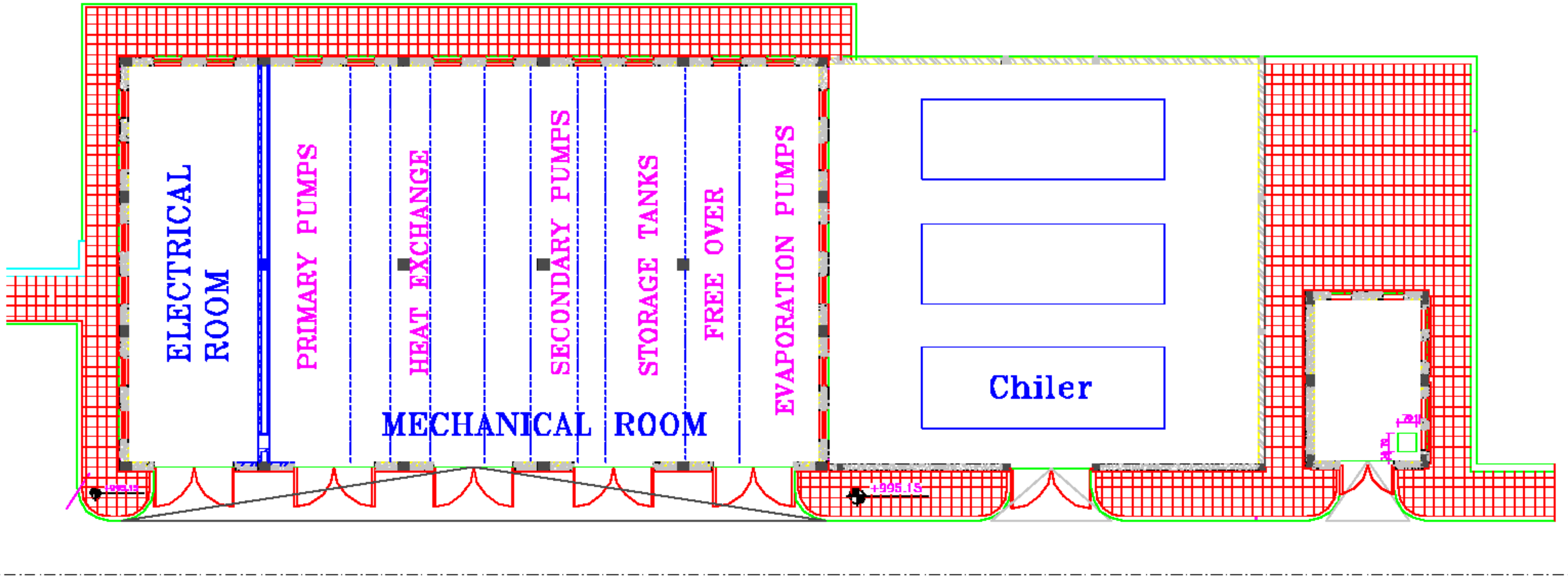
South Elevation



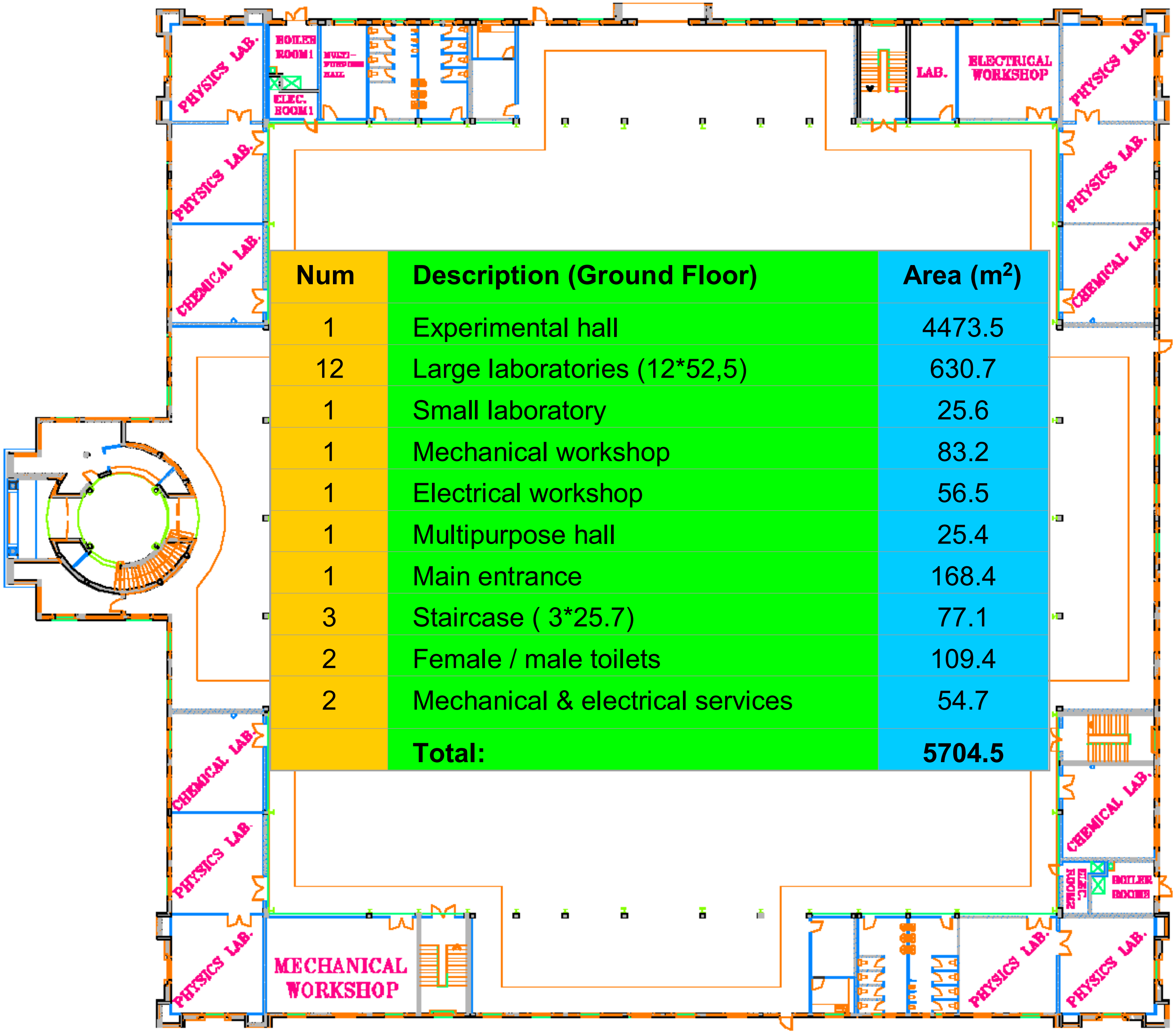
West Elevation



East Elevation

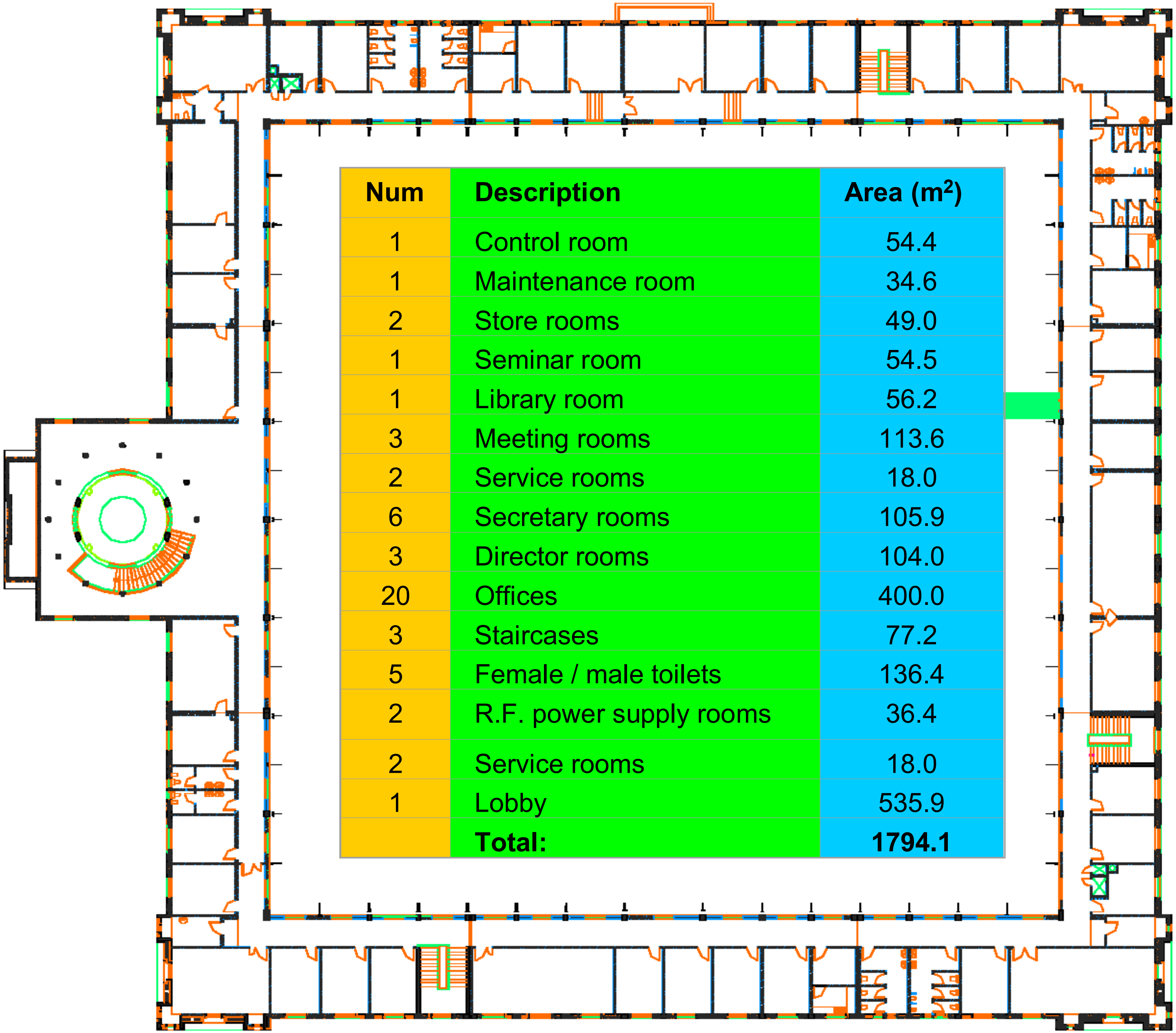


Technical Building



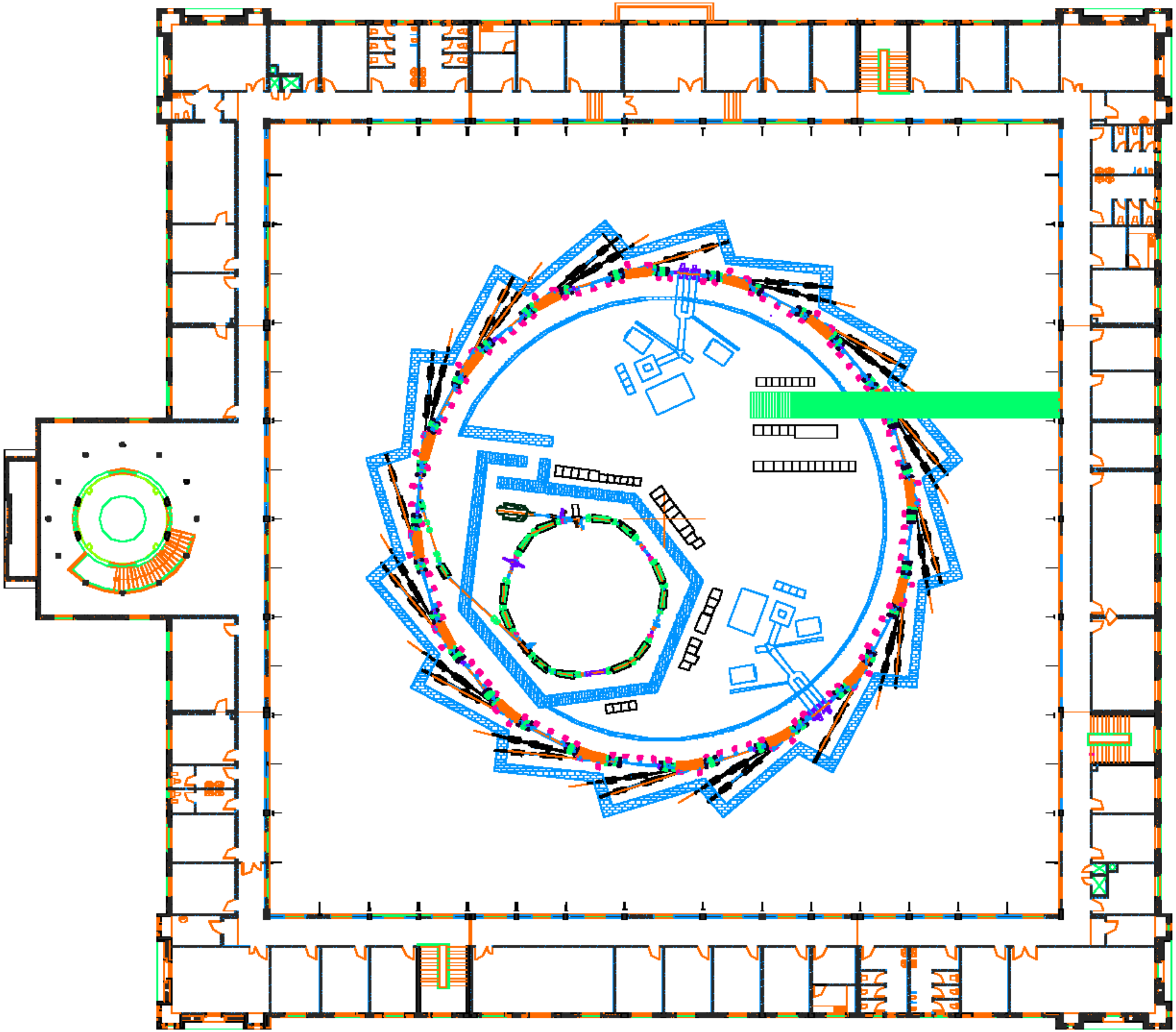
Num	Description (Ground Floor)	Area (m^2)
1	Experimental hall	4473.5
12	Large laboratories (12*52,5)	630.7
1	Small laboratory	25.6
1	Mechanical workshop	83.2
1	Electrical workshop	56.5
1	Multipurpose hall	25.4
1	Main entrance	168.4
3	Staircase (3*25.7)	77.1
2	Female / male toilets	109.4
2	Mechanical & electrical services	54.7
	Total:	**5704.5**

Space within the Ground Floor



Num	Description	Area (m^2)
1	Control room	54.4
1	Maintenance room	34.6
2	Store rooms	49.0
1	Seminar room	54.5
1	Library room	56.2
3	Meeting rooms	113.6
2	Service rooms	18.0
6	Secretary rooms	105.9
3	Director rooms	104.0
20	Offices	400.0
3	Staircases	77.2
5	Female / male toilets	136.4
2	R.F. power supply rooms	36.4
2	Service rooms	18.0
1	Lobby	535.9
	Total:	**1794.1**

Space within the First Floor



First floor with the bridge from the control room to the inner side