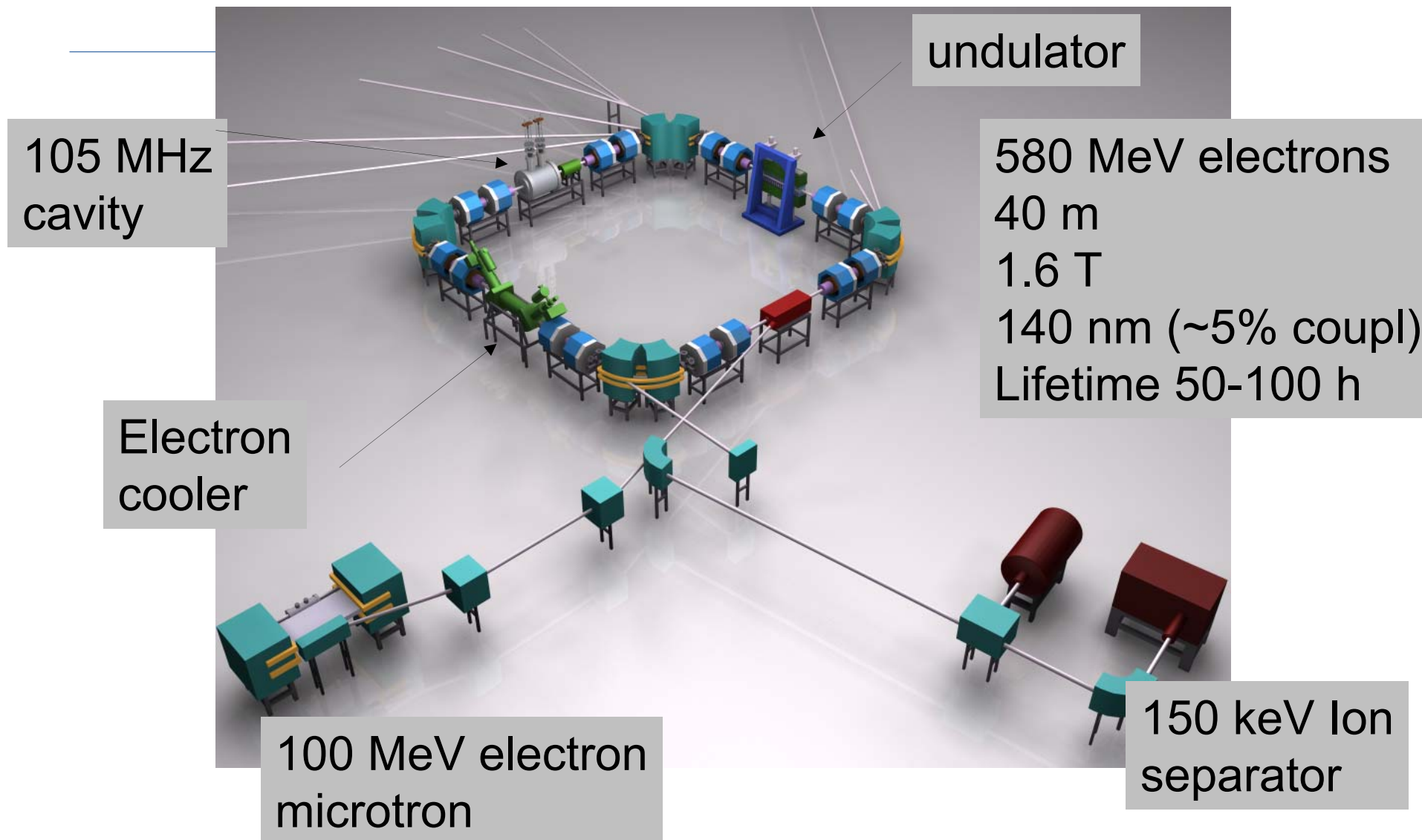


ASTRID2, a new 580 MeV low-emittance light source in Århus

- › Brief introduction to ASTRID, ISA and Aarhus University
- › Other accelerator activities during recent years
- › Pre-history of ASTRID2
- › Our new grant for ASTRID2
- › ASTRID2
- › Time plan
- › Future?

ASTRID

- › ASTRID was built as a heavy-ion storage ring and a Synchrotron Radiation source
- › Operating with ions in 1990
- › Since then many ion experiments have been performed including ions like
 H_2^+ , Mg^+ , $^{13}\text{CO}^{++}$, C_{60}^+
 H^- , O^- , Al_{12}^- , C_{70}^-
studying laser-cooling, electron-cooling, photo-detachment, electron-recombination and dissociation ...
- › Inaugurated with electrons in 1993
- › For ~10 years 50%/50% operation with ions and electrons
- › Last ion run in 2006



21 APRIL, 2009





ASTRID acceleratorlaboratory

21 APRIL, 2009

35.000 students
5 Gkr.
2/3 on CAMPUS

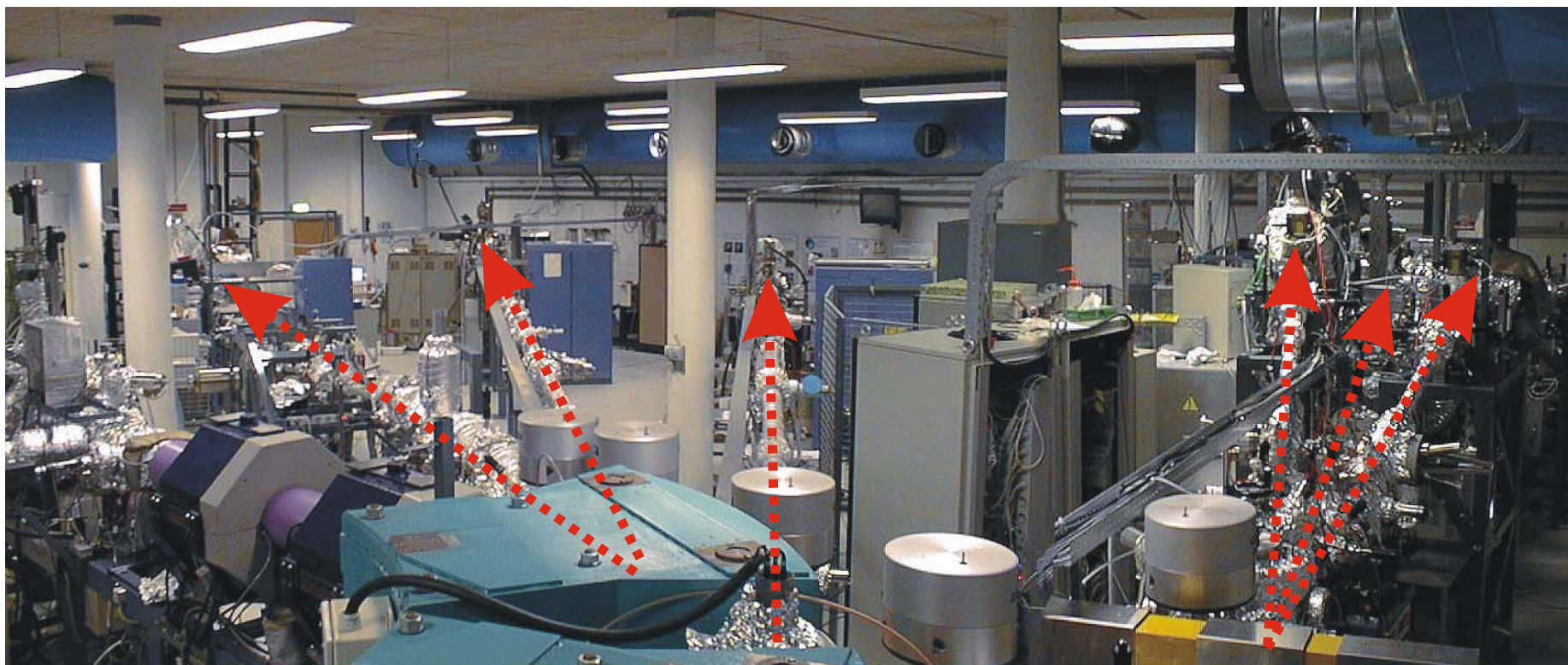
ASTRIDs below parking place



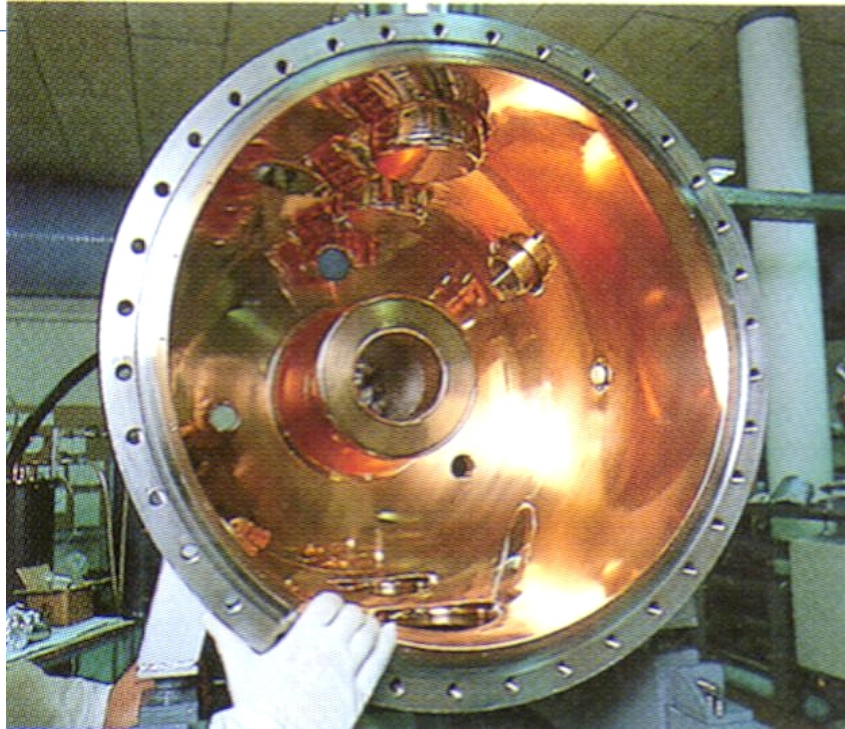
ASTRID as a virgin



Synchrotron-radiation beamlines at ASTRID



ASTRID RF cavity

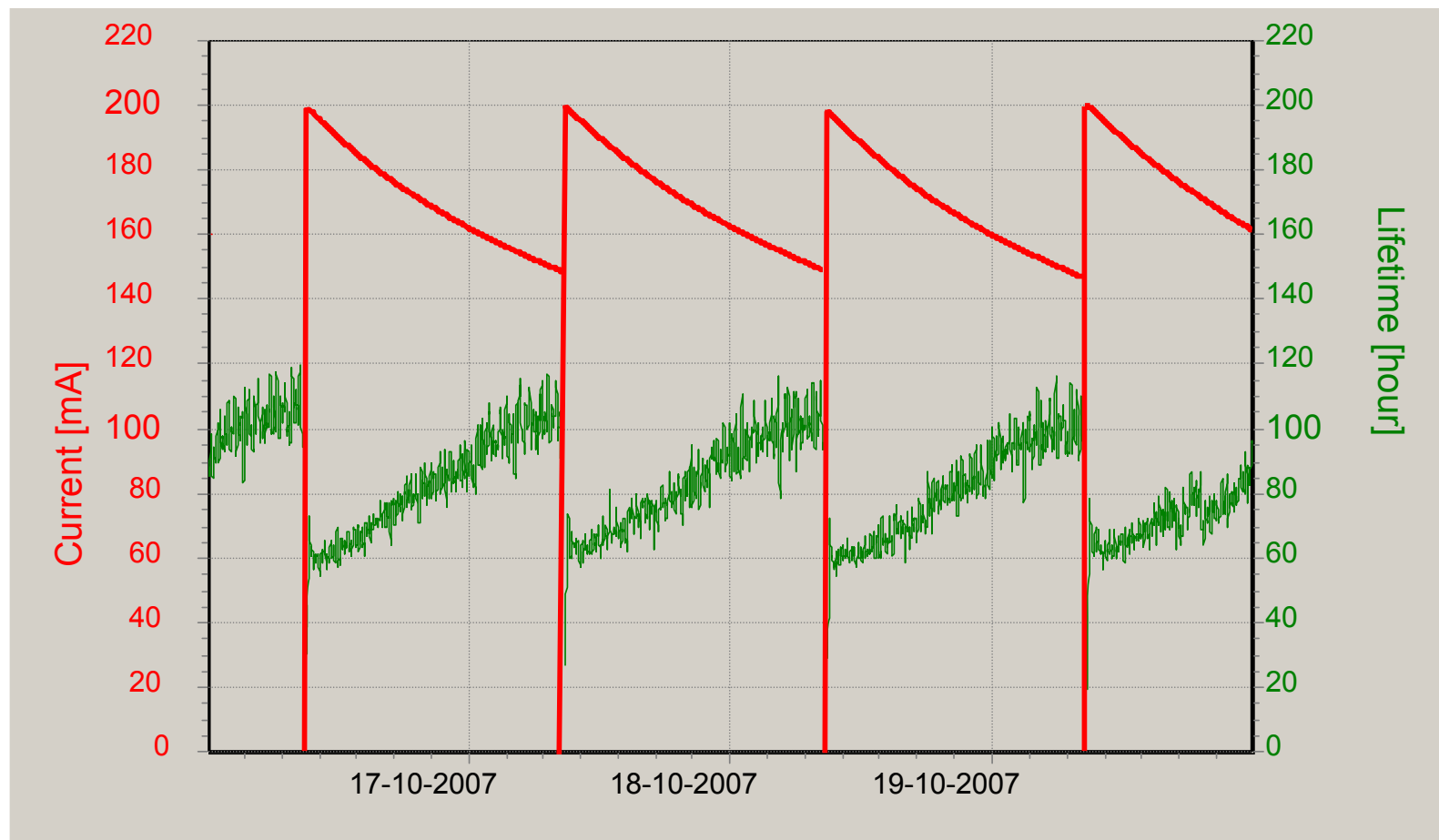


105 MHz cavity ($Q \sim 1.37 M\Omega$)
20 kW transmitter



ASTRID undulator





ASTRID beamlines

Beamline	Spectral range	Performance	Research area
SGM 1	30 to 600 eV	Resolving power 5 to 14,000 Typical flux $2 \cdot 10^{11}$ ph/sec	Condensed matter and nanoscale physics
SX 700	6 to 700 eV	Resolving power typically 1000 Typical flux $1 \cdot 10^{11}$ photons/sec	Condensed matter and nanoscale physics
X-ray Microscope	1.5 to 3 nm 400-800 eV	Resolving power 2,000 Typical flux $2 \cdot 10^{11}$ ph/sec	X-ray Microscopy, Medical Research
MIYAKE	15 to 180 eV	Resolving power 2,000 Flux $2 \cdot 10^{12}$ photons/sec	Atomic and Molecular Physics
SGM 2	12 to 40 eV	Resolving power up to 24,000 Typical flux $2 \cdot 10^{11}$ ph/sec	Atomic and Molecular Physics
SGM 3	8 to 150 eV	Resolving power up to 23,000 Typical flux $2 \cdot 10^{11}$ ph/sec	Condensed matter and nanoscale physics
UV 1	1.5 to 12 eV	Resolving power 1,000 to 5,000 Typical flux $2 \cdot 10^{11}$ ph/sec	Photobiology, UV Spectroscopy
CD 1	1.5 to 12 eV	Typical resolving power 200 Flux $> 10^{12}$ photons/sec	Biology: circular and linear ₁₂ dichroism spectroscopy

USE of ASTRID

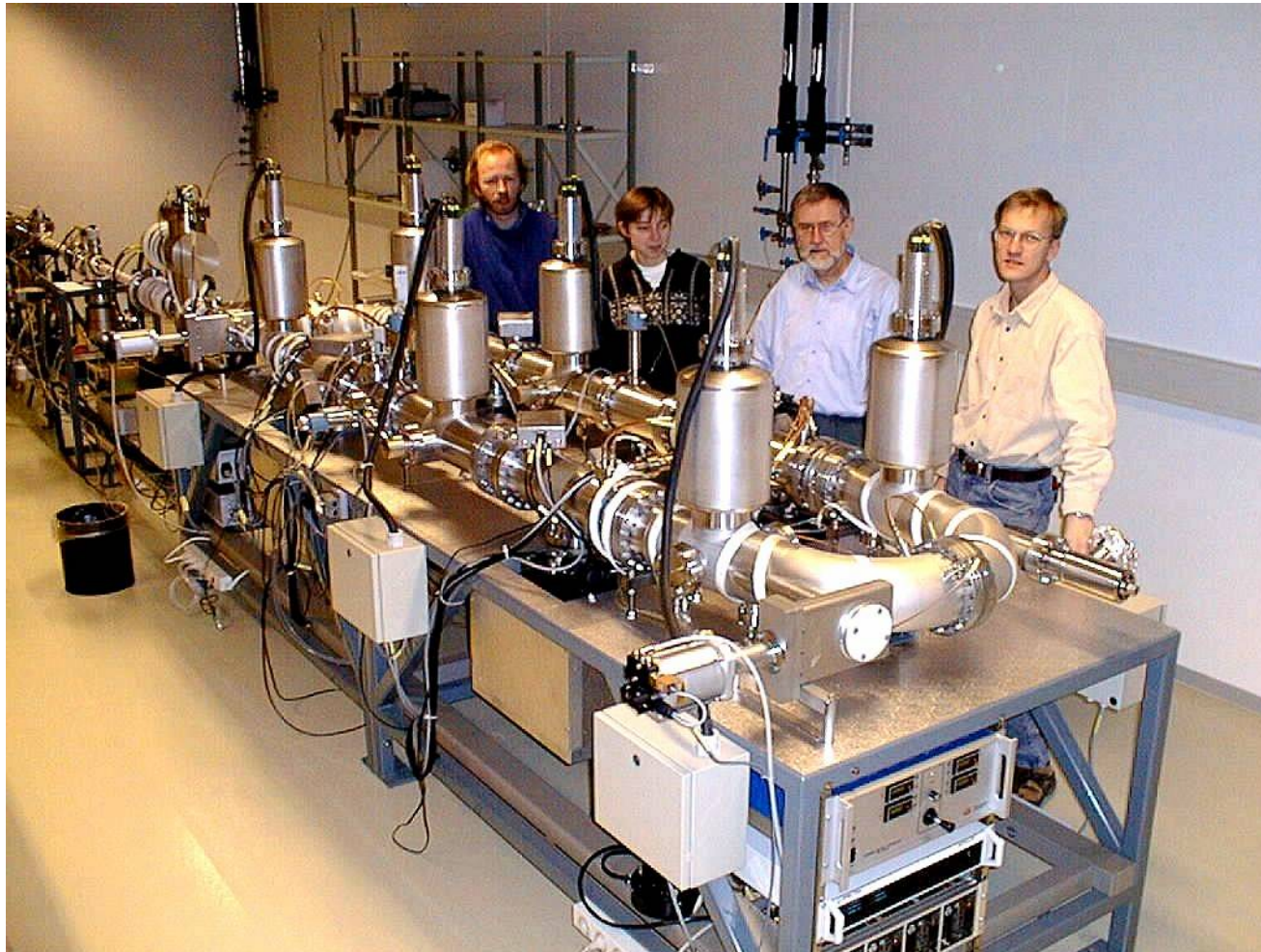
- ASTRID operates > 40 weeks per year, 6½ days x 23.5 hours
- ~150 users per year
- ~50 % from abroad – partly financed from IA-SFS (transnational access)
- ~25% from Aarhus
- ~25 % from elsewhere in DK

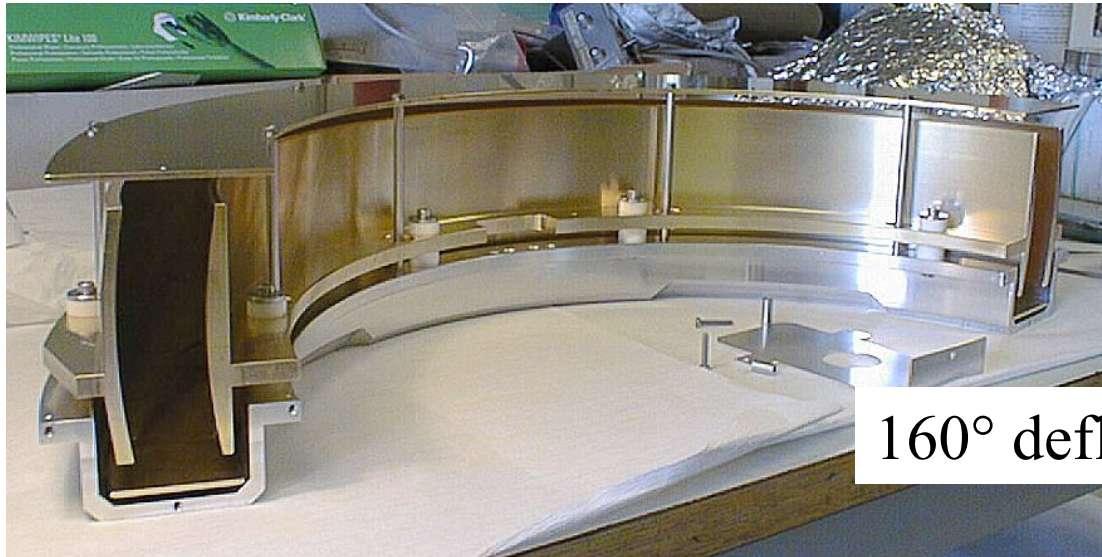
Other accelerator activities during recent years

- ELISA
- ANKA microtron and booster
- CLS booster
- ASP booster
- FLASH bypass
- PT facilities

In collaboration with DESY, DANFYSIK, Siemens, MAXLAB and others

ELISA as a virgin

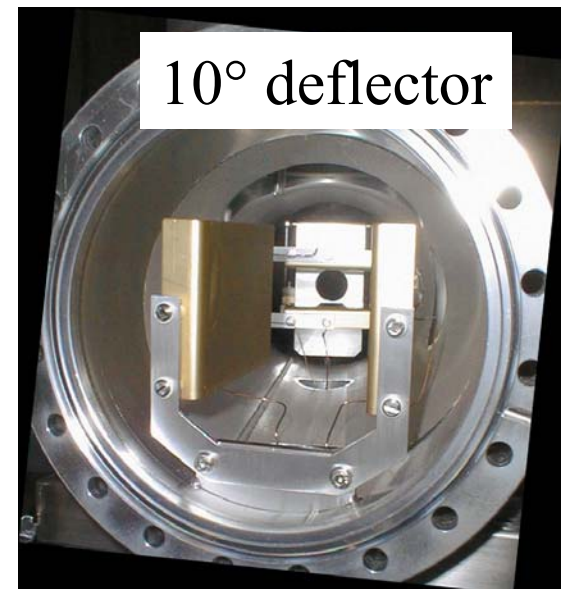




160° deflectors

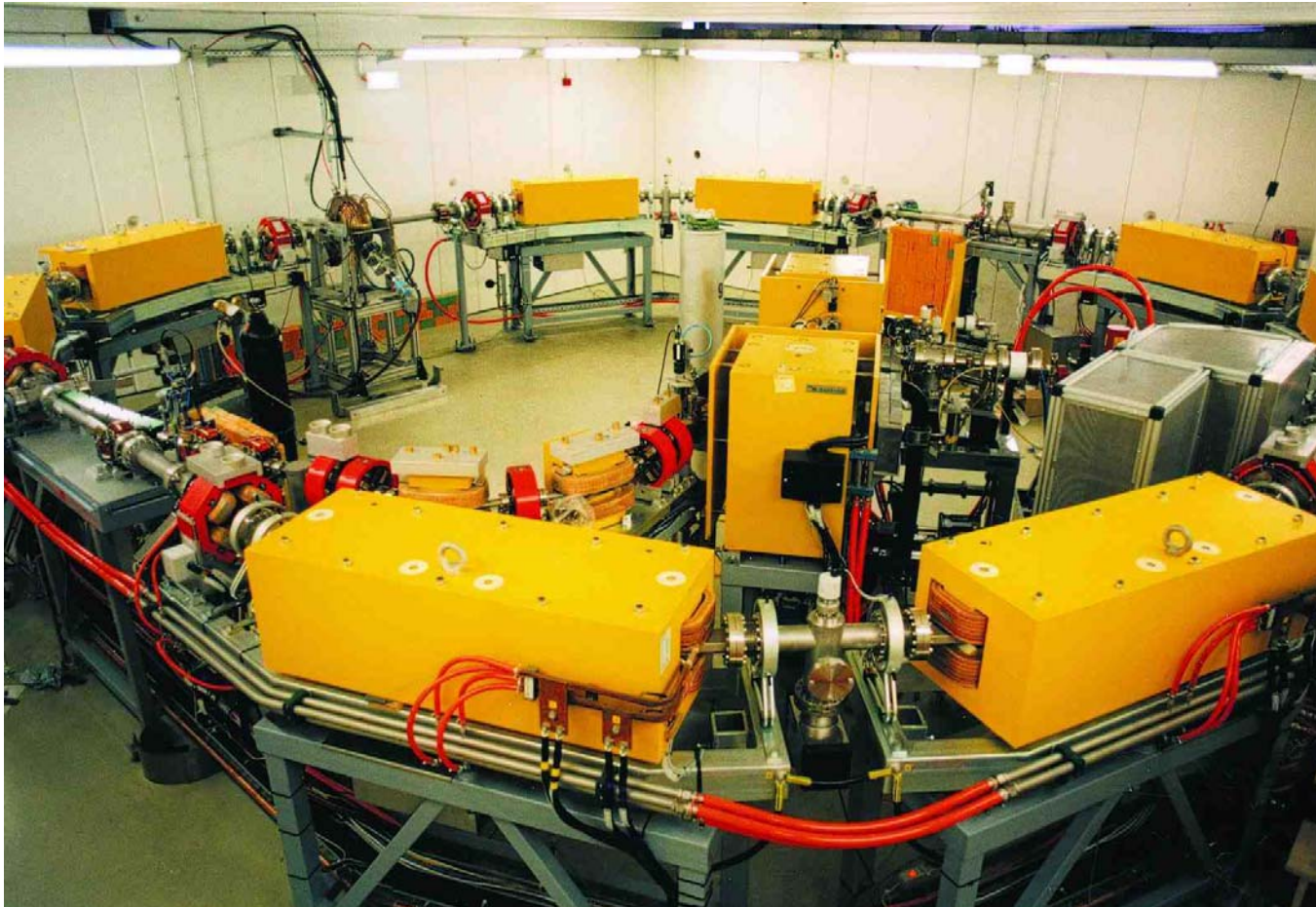


quadrupoles

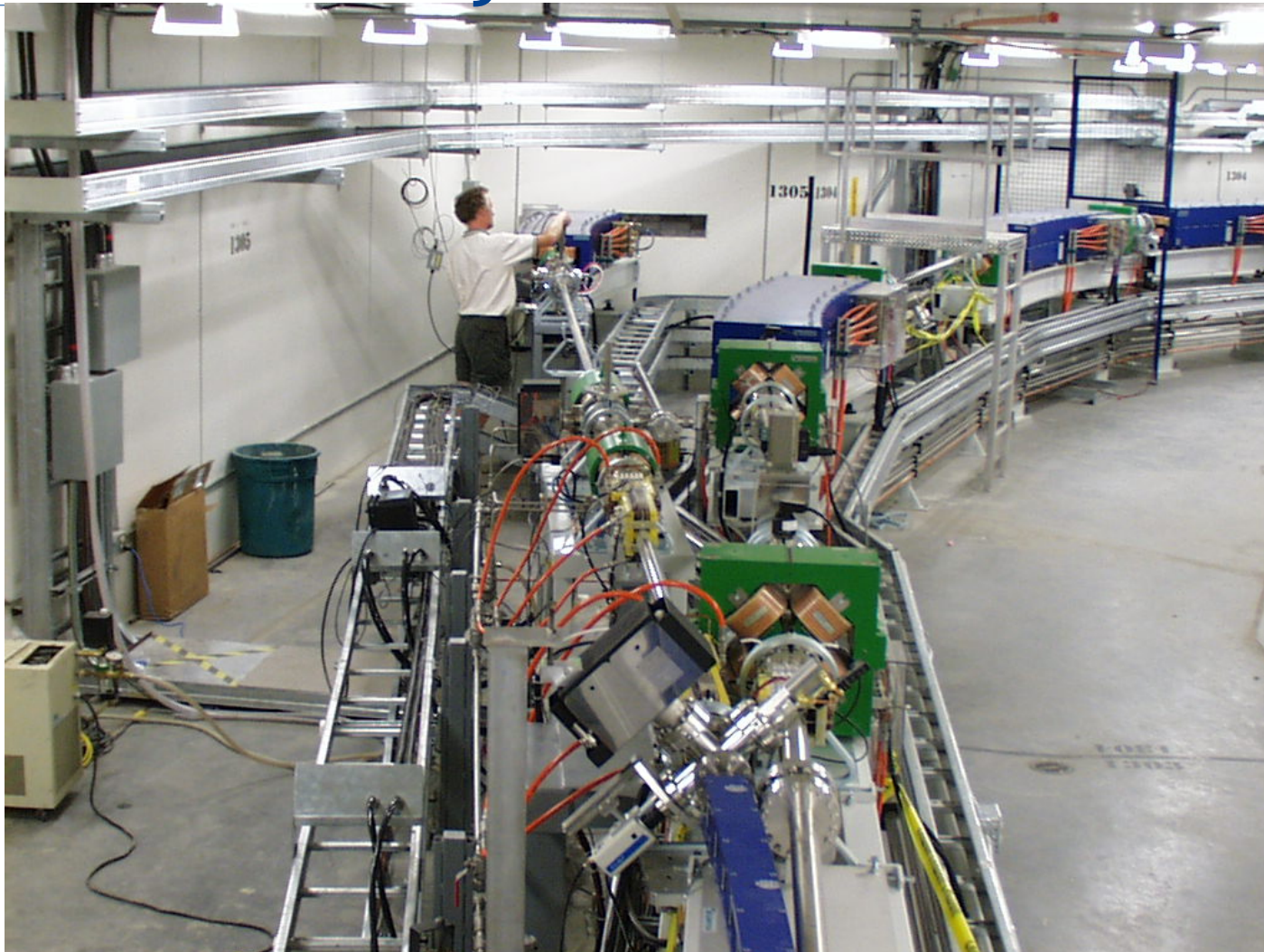


10° deflector

50 MeV microtron and 500 MeV booster synchrotron for ANKA



3 GeV booster synchrotron Canadian Light Source,



3 GeV booster synchrotron for Australian Synchrotron Project

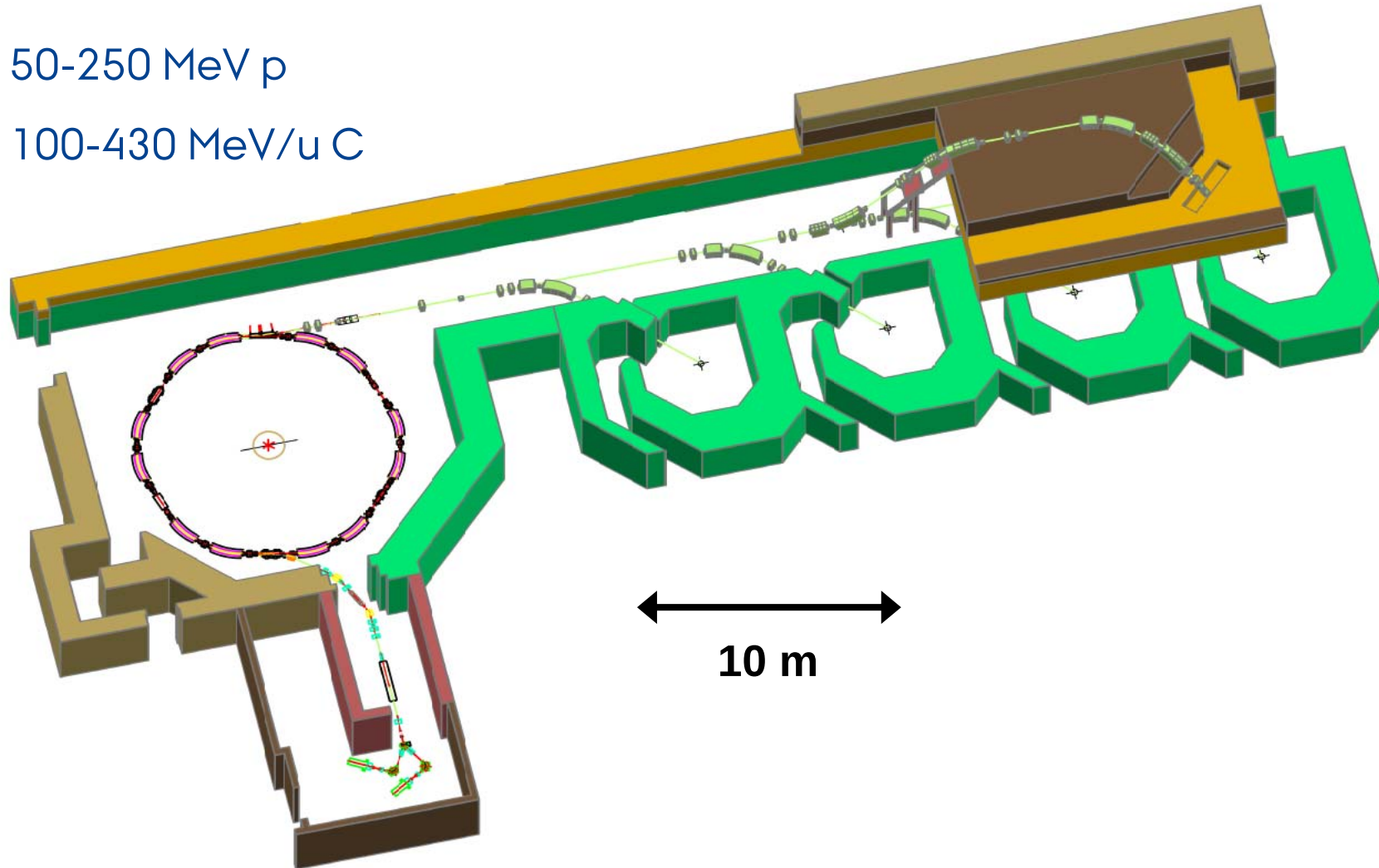


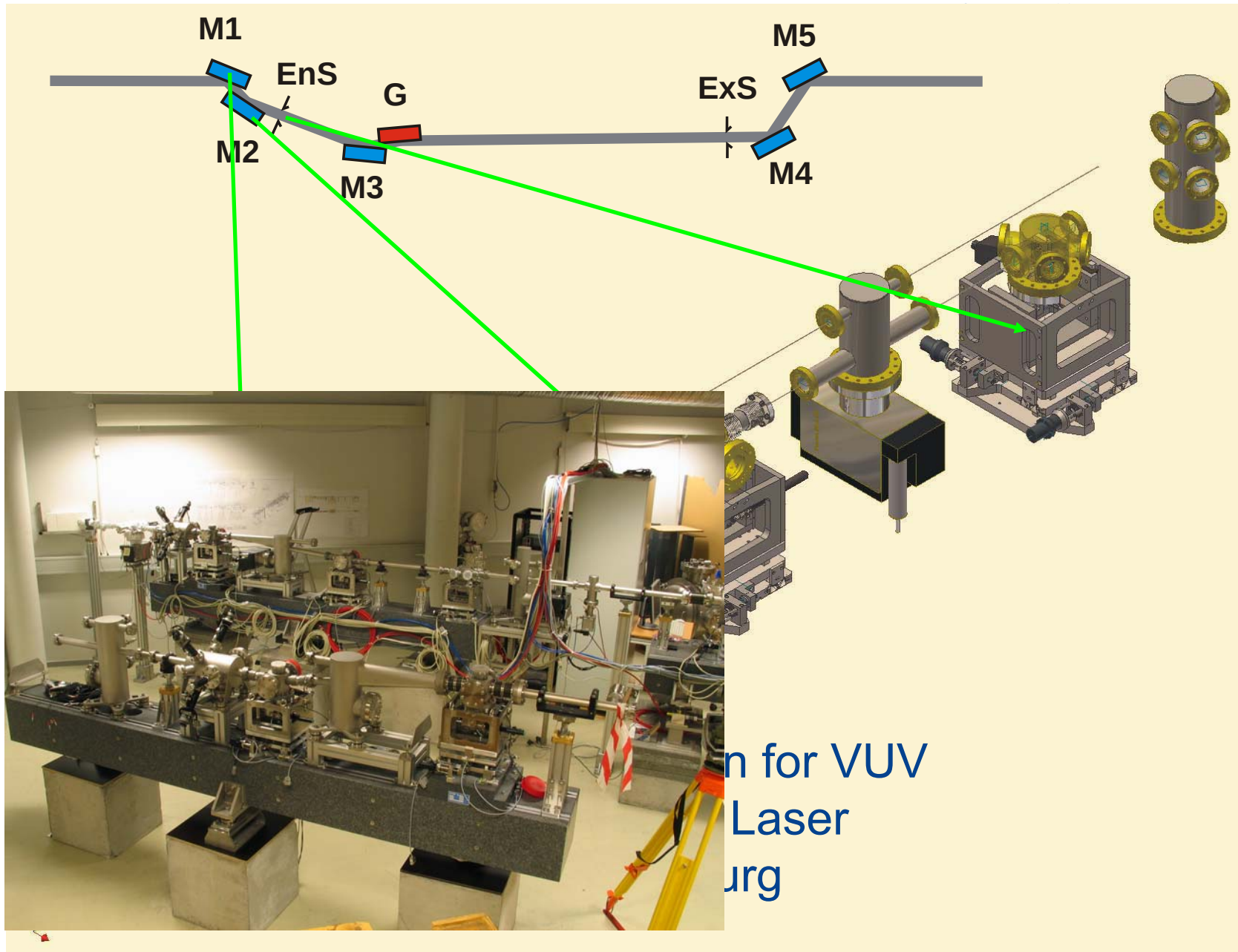
100 MeV - 3 GeV
Ø 130.2 m
1 Hz, 5 mA
 $\epsilon_H = 33$ nm

Particle Therapy facility (Marburg)

50-250 MeV p

100-430 MeV/u C





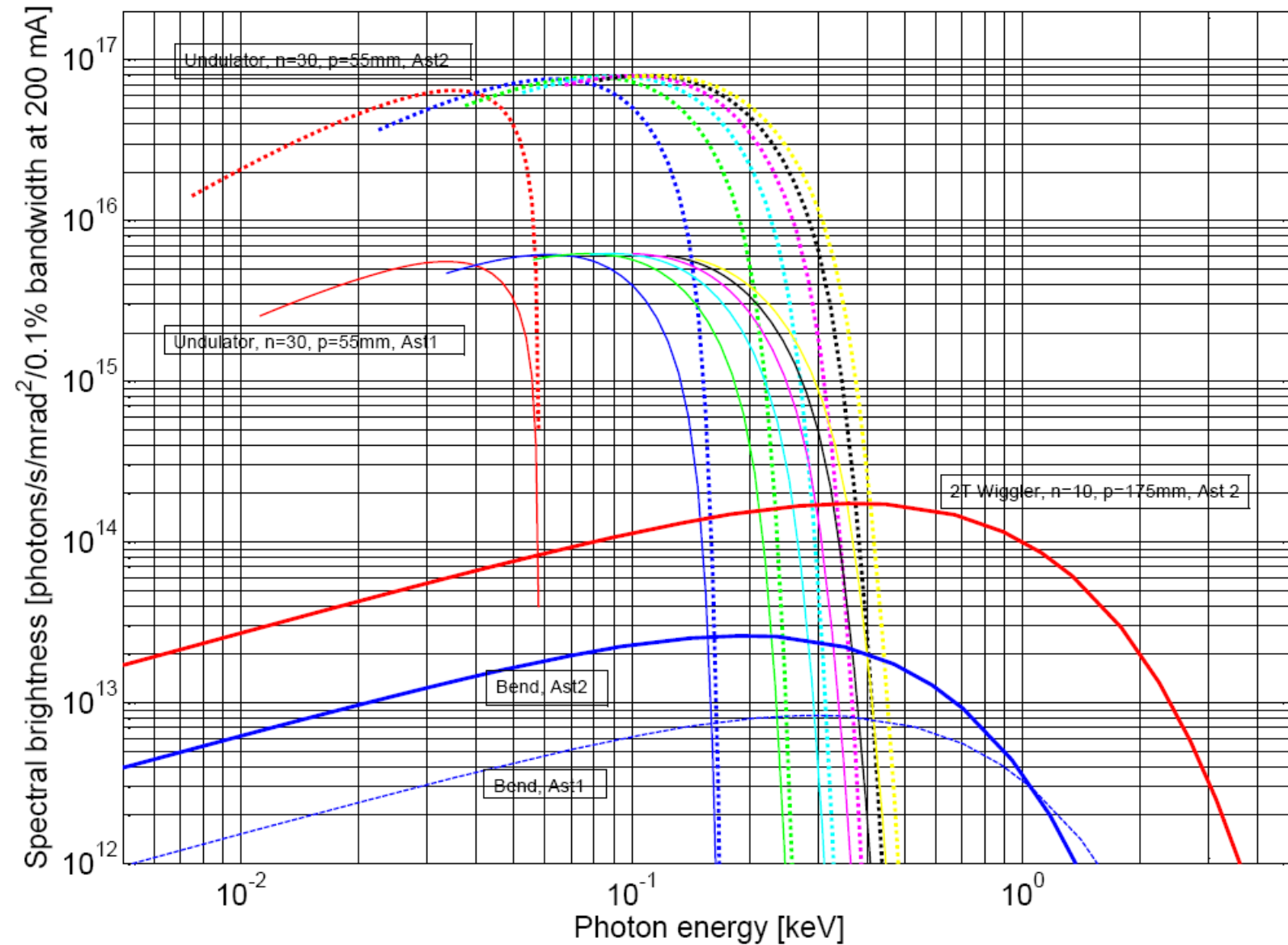
ASTRID2

- Funding for ASTRID2 has been sought for several years
- 2007-2009 Research Infrastructure Fund
- Dec. 2008 37 Mkr. (we applied for 42 Mkr) over 4 years
- Funds for ASTRID modifications, transfer beamline, ASTRID2, 2 ID's, some adaptations/improvements to ASTRID beamlines

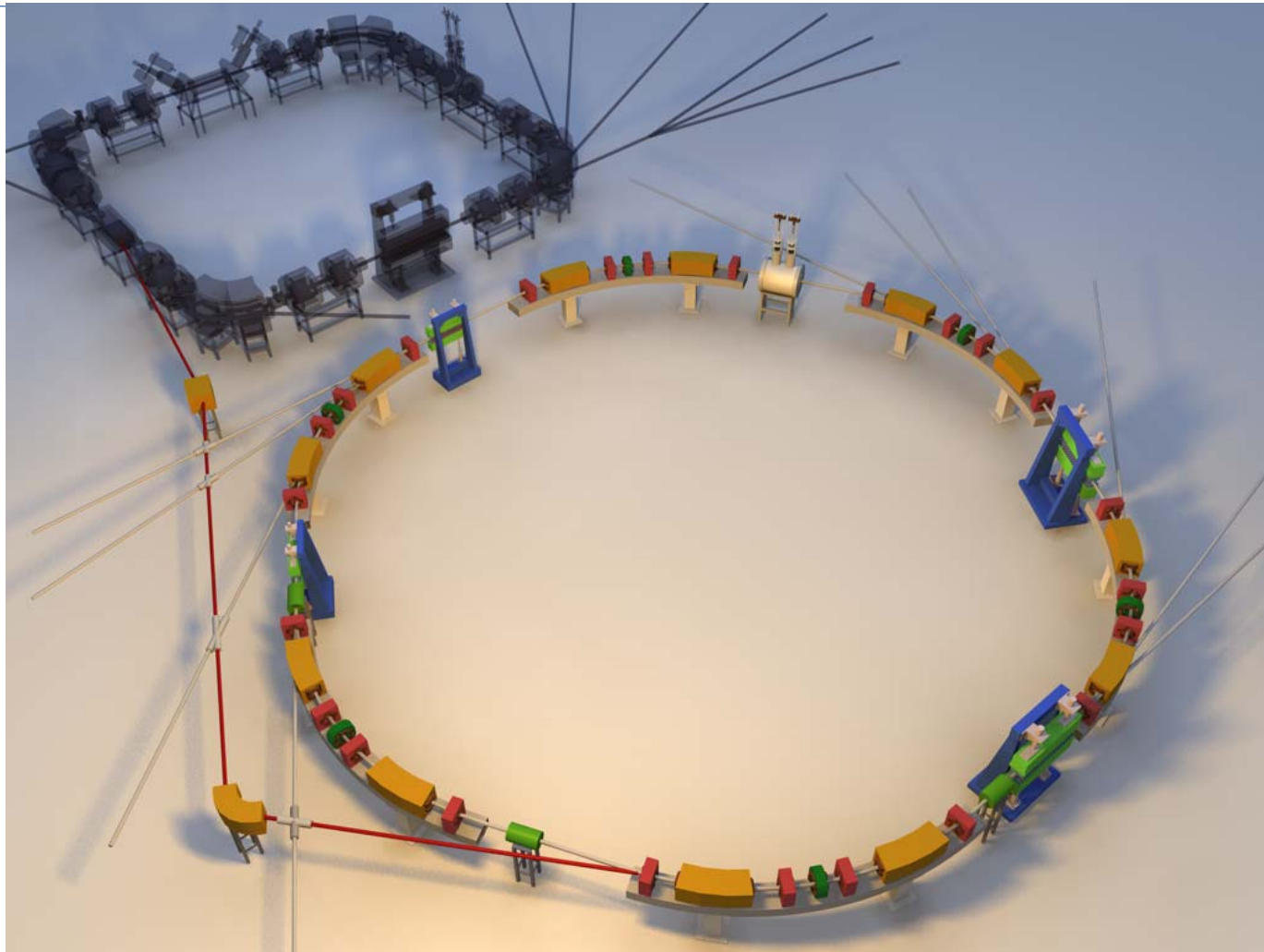
- ASTRID2: low-emittance ($<10\text{nm}$) 580 MeV SR source
- Top-up from ASTRID
- undulator radiation up to $\sim 100\text{ eV}$
- MPW radiation up to 600 eV (O edge)

- Research:
 - condensed matter/surfaces/nanoscale
 - atomic and molecular physics
 - BIO

Spectral brightness for Astrid 2 at 580MeV, 200 mA

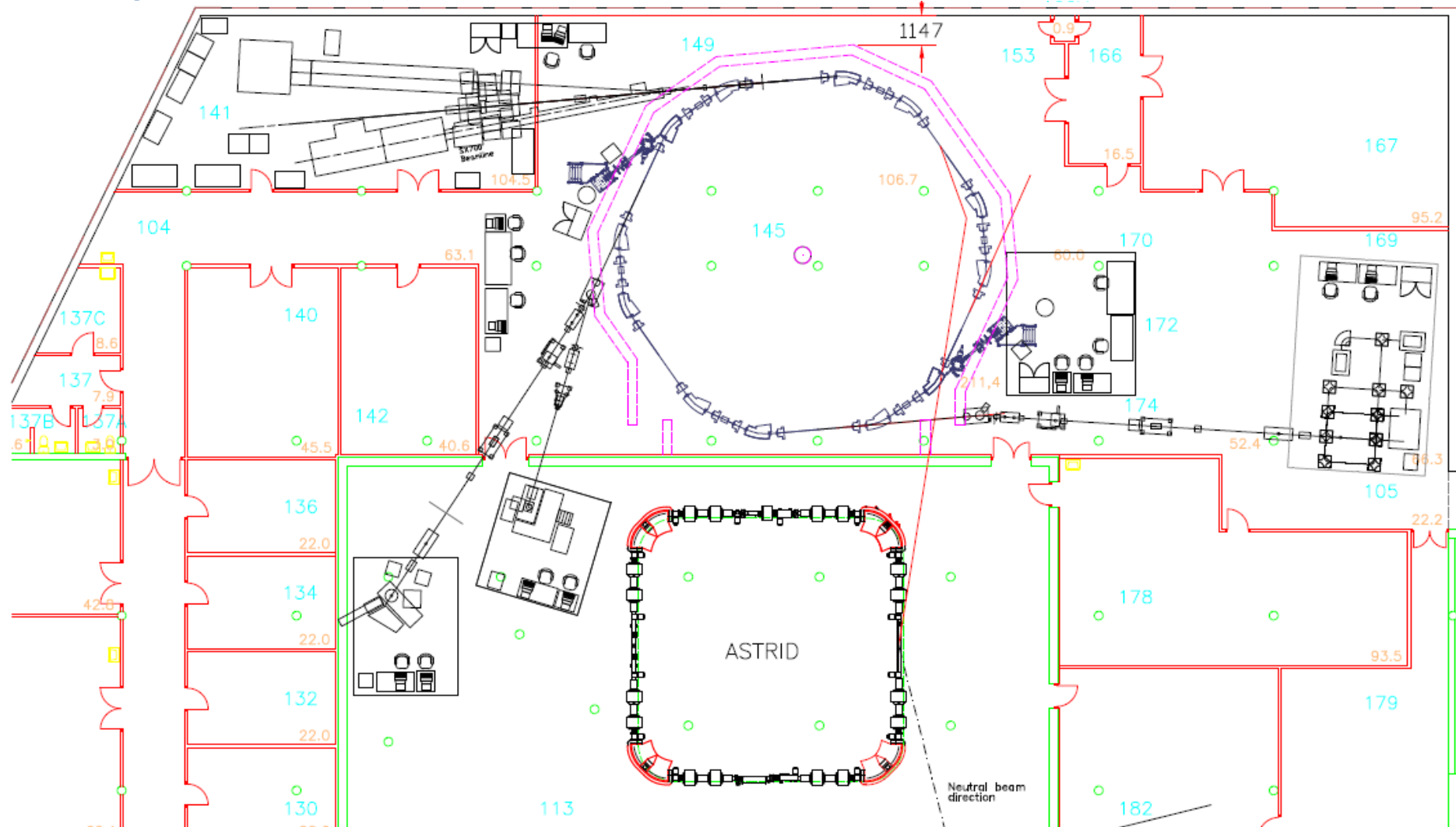


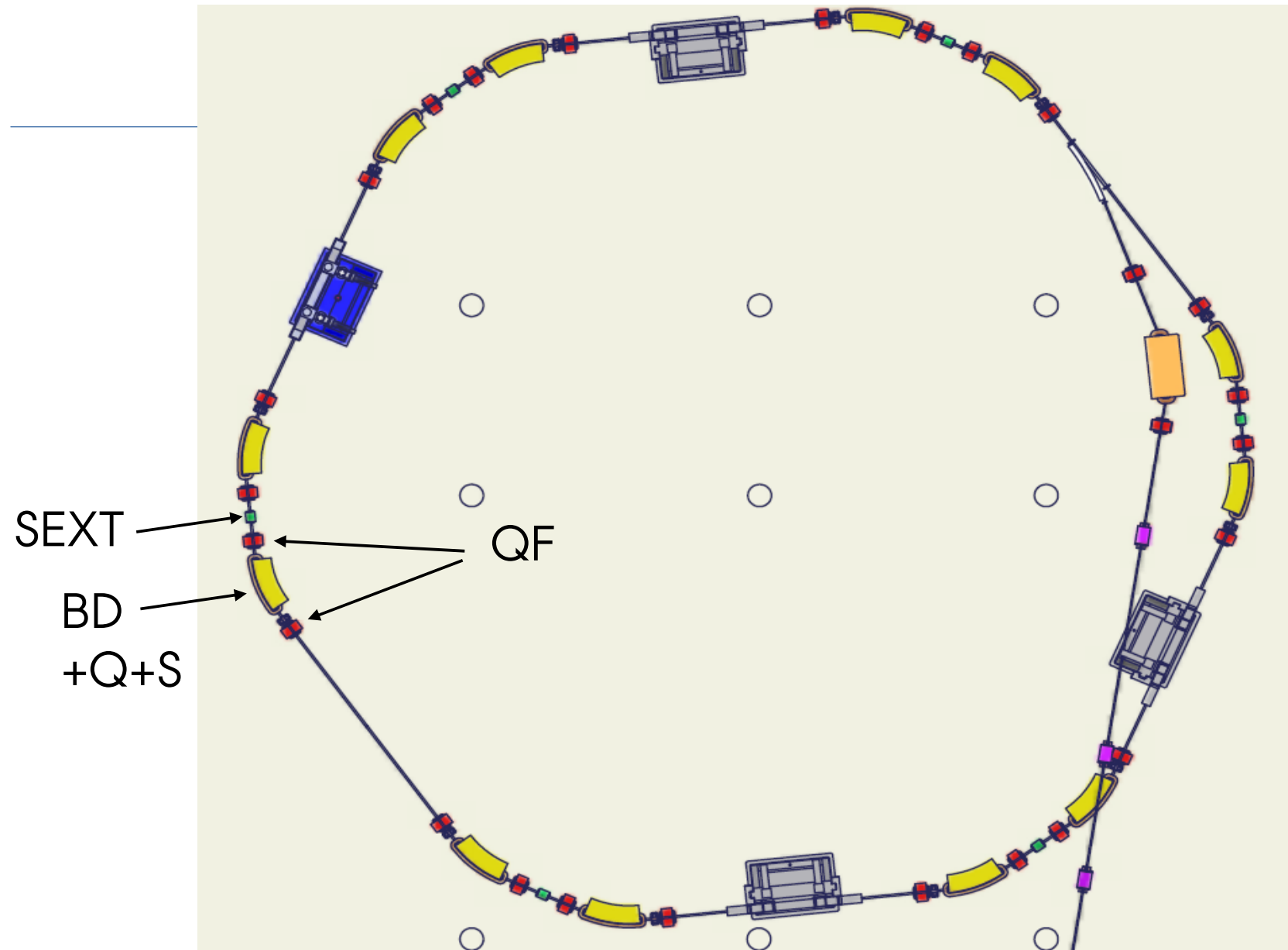
ASTRID2



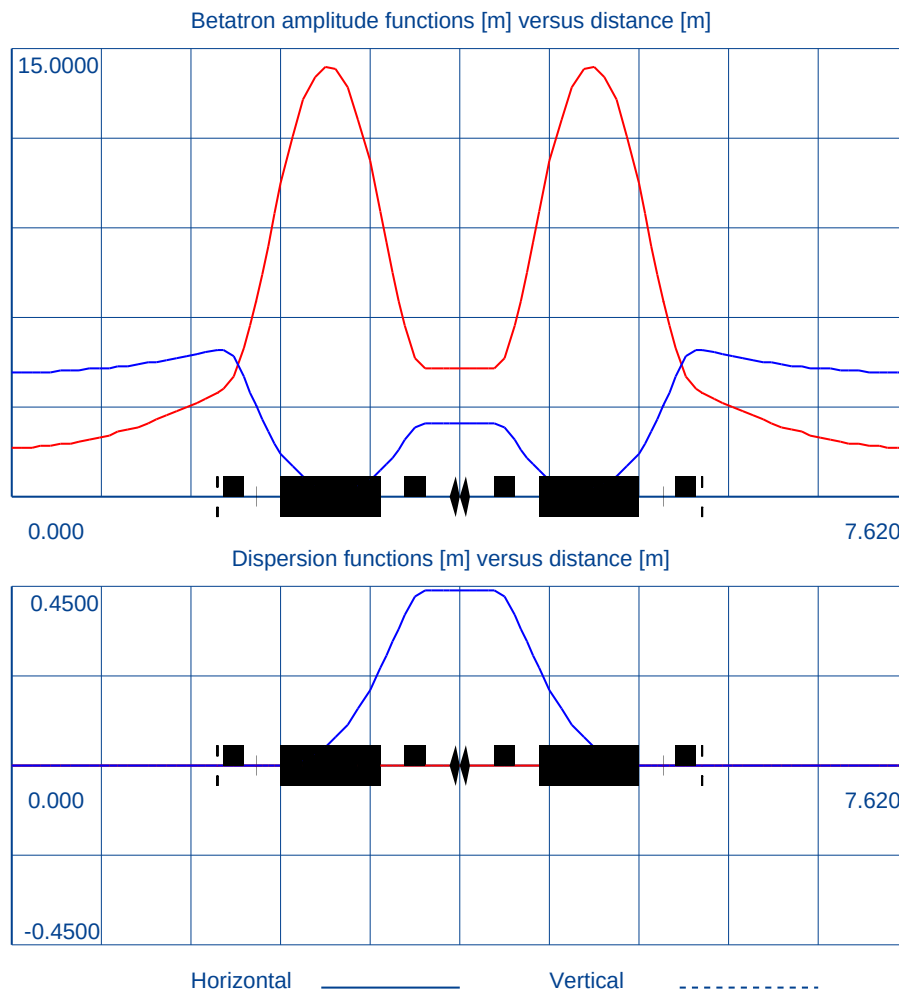
ASTRID2 parameters

Parameter		ASTRID2	ASTRID
Energy	MeV	580	580
Circumference	m	46	40
Current	mA	200	200
Lifetime	Hours	Infinite (top-up)	50-100
Horizontal emittance	nm	<10	140
Characteristic energy	eV	238	358
Characteristic wavelength	nm	5.2	3.5
Straight sections (number and length)	#×m	4×3.?	1×2.0





ASTRID2 lattice



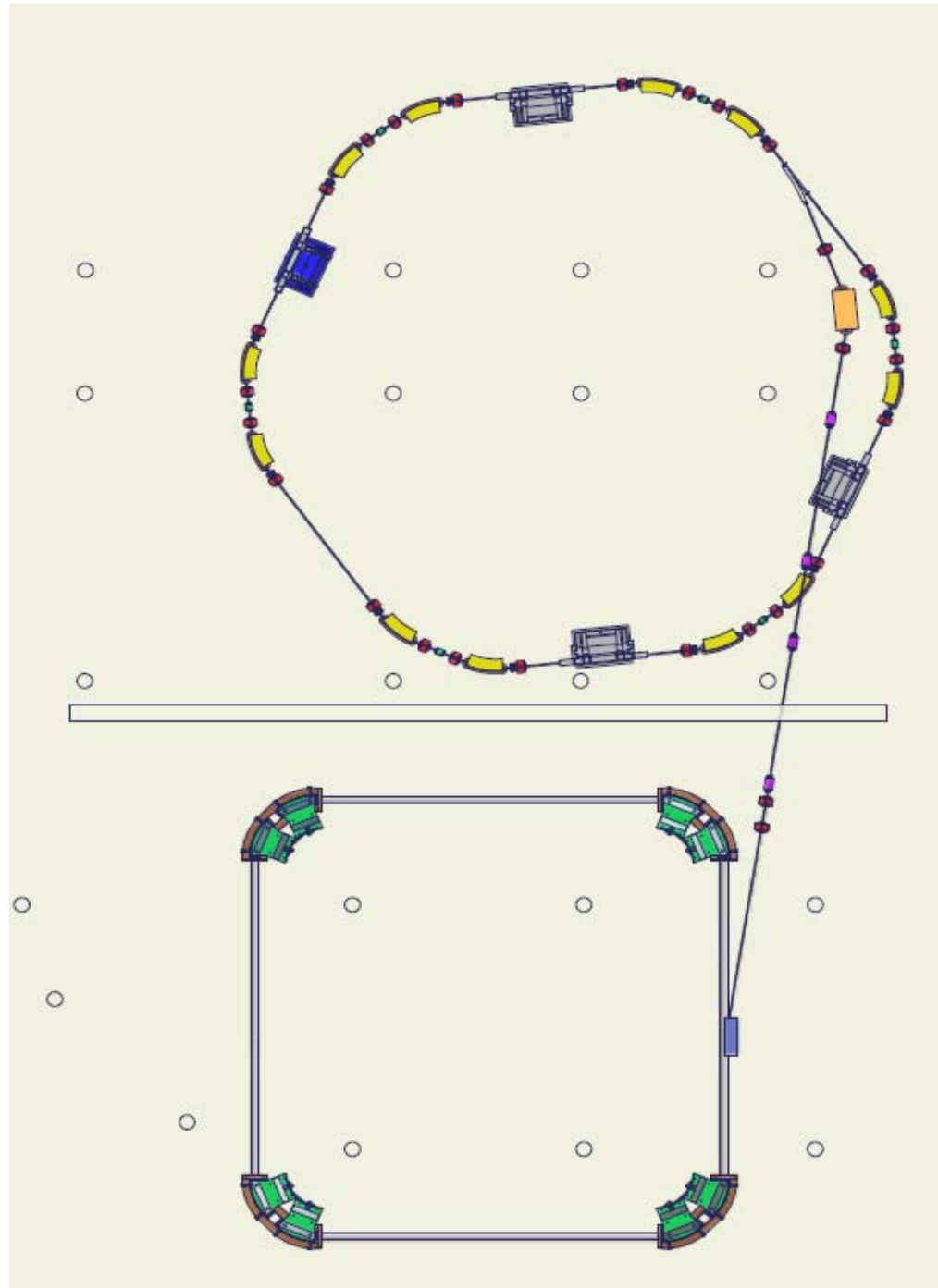
6×2 combined-function magnets
(dipole, quadrupole, sextupole)

6×2×2 QF quadrupoles

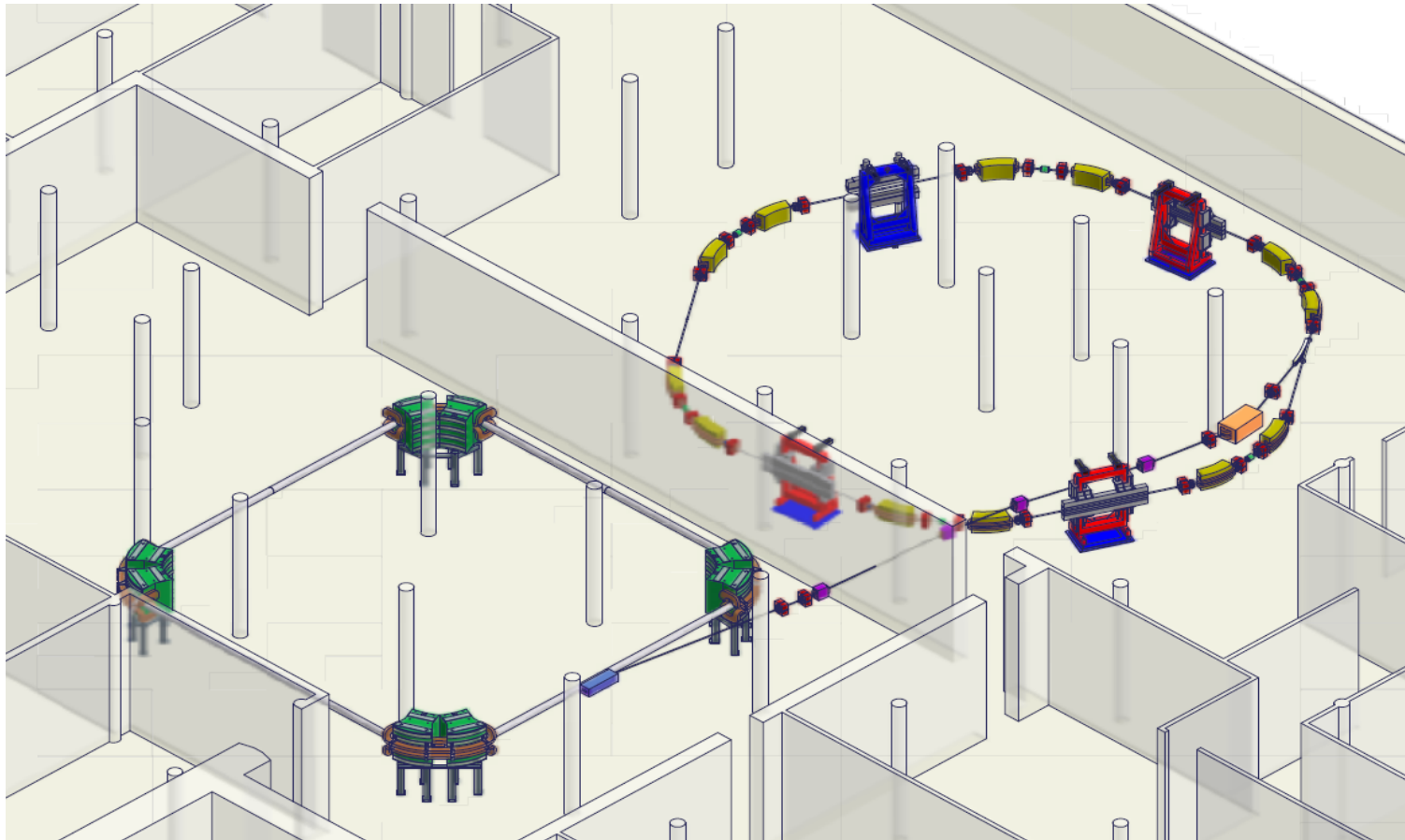
6×1 sextupoles

6×2 x-y correctors

Transfer beamline



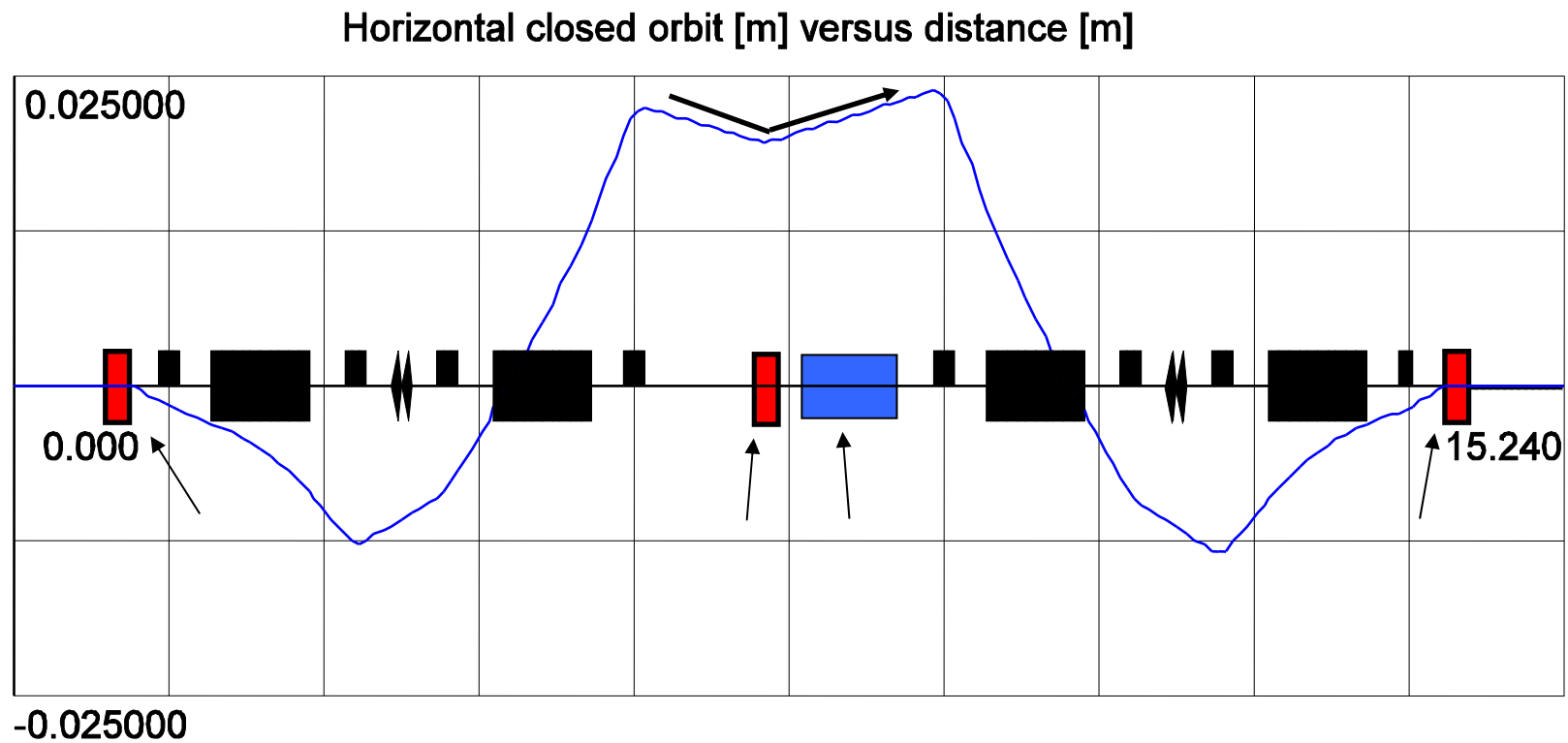
ASTRIDs with undulators and transfer beamline



Some ASTRID2 parameters

General parameters		ASTRID2	ASTRID
Energy	E [GeV]	0.58	0.58
Dipole field	B [T]	1.192	1.6
Circumference	L [m]	45.713	40.00
Current	I [mA]	200	200
Number of ID's		4	1
Lattice parameters			
Straight S dispersion	[m]	0	2.7
Horizontal tune	Q_x	5.73	2.29
Vertical tune	Q_y	2.23	2.69
Horizontal chromaticity	$dQ_x/d(\Delta p/p)$	-9.0	-4.0
Vertical chromaticity	$dQ_y/d(\Delta p/p)$	-13.9	-7.1
Coupling factor		5 %	5 %
SR parameters			
Energy loss per turn	U_0 keV/turn]	6.2	8.3
SR power	P_0 [kW]	1.2	1.6
Natural emittance	ϵ_H [nm]	8	140
Characteristic energy	ϵ_c [eV]	267	358
Damping times	τ_h, τ_v, τ_s [ms]	18.9, 28.6, 19.2	29.1, 18.7, 7.9
RF parameters			
Damped energy spread	σ_E/E [0/00]	0.0452	0.416
RF frequency		105	105
Harmonic number	h	16	14
RF voltage	[kV]	50	30

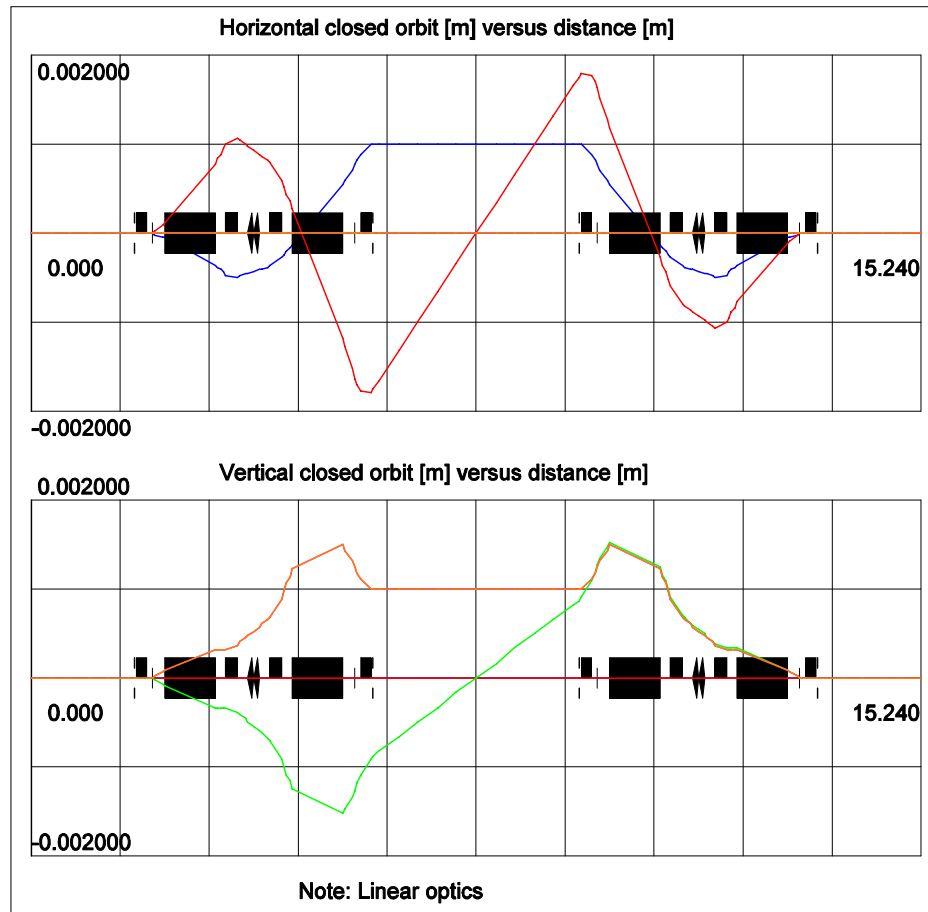
3 bumper pulsed-septum injection



ASTRID2 Magnet parameters

Name of magnet	BD	Qf3	Qf2	Sf	
Type of magnet	Defocusing combined-function magnet	Quadrupole	Quadrupole	Sextupole	HxV steerer
Number of magnets	12	12	12	6	12
Magnet length [m]	0.85	0.18	0.18	0.18	0.1
Aperture [mm]	44x28	Ø44	Ø44	Ø44	45x45
Good field region [mm]	36x22	Ø36	Ø36	Ø36	35x35
Dipole field [T]	1.192	-	-		0.03
Radius of curvature [m]	1.623	-	-	-	-
Quadrupole field [T/m]	4.201	20 nom. 13.84	20 nom.16.65	-	-
Sextupole field [T/m ²]	64.71	-	-	250 Nom. 195	-

Closed-orbit correction

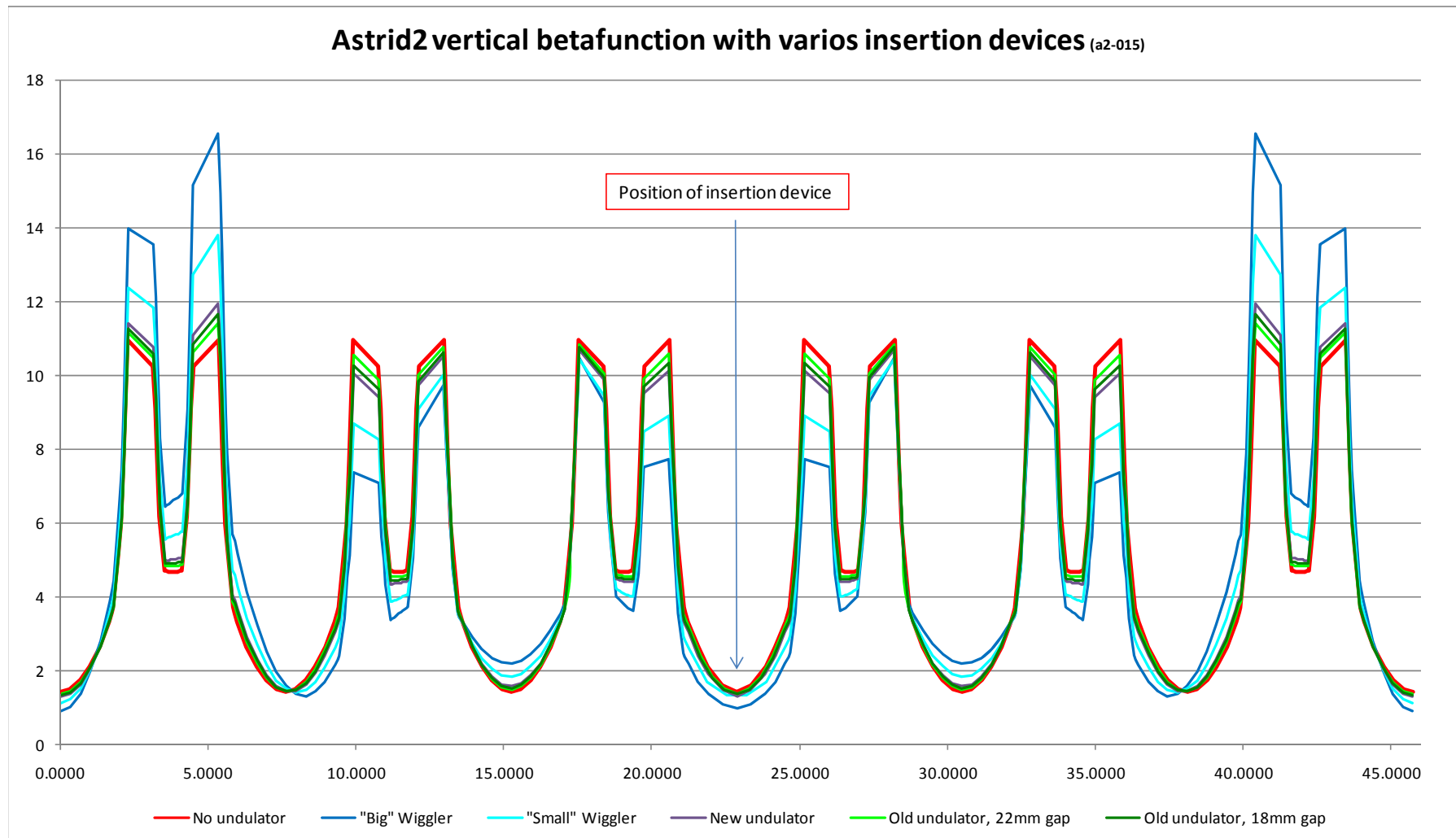


- 12 H/V BPM's and 12 H/V correctors for closed-orbit correction (24/12?)
- position and angular bumps in SS
- Quadrupole shunts

ASTRID2 insertion devices

Insertion device	Present ASTRID undulator	New undulator	Multipole Wiggler
Period length (mm)	55	65	175 / 116
Number of periods	24	30	11 / 6
Peak magnetic field (T)	0.558	0.80	2.0
Gap (mm)	22-240	18	18 / 12
Inner vacuum gap (mm)	19		14 / 8
K (max)	2.87	4.89	32.7 / 21.7
Max. deflection angle (mrad)			28.8 / 19
Max. deflection angle (°)			1.6/1.1
Width after 2 m (mm)			±58 / ±38
Length (mm)		1950	1925 / 700
Total power radiated (W)	18	54	328 / 119

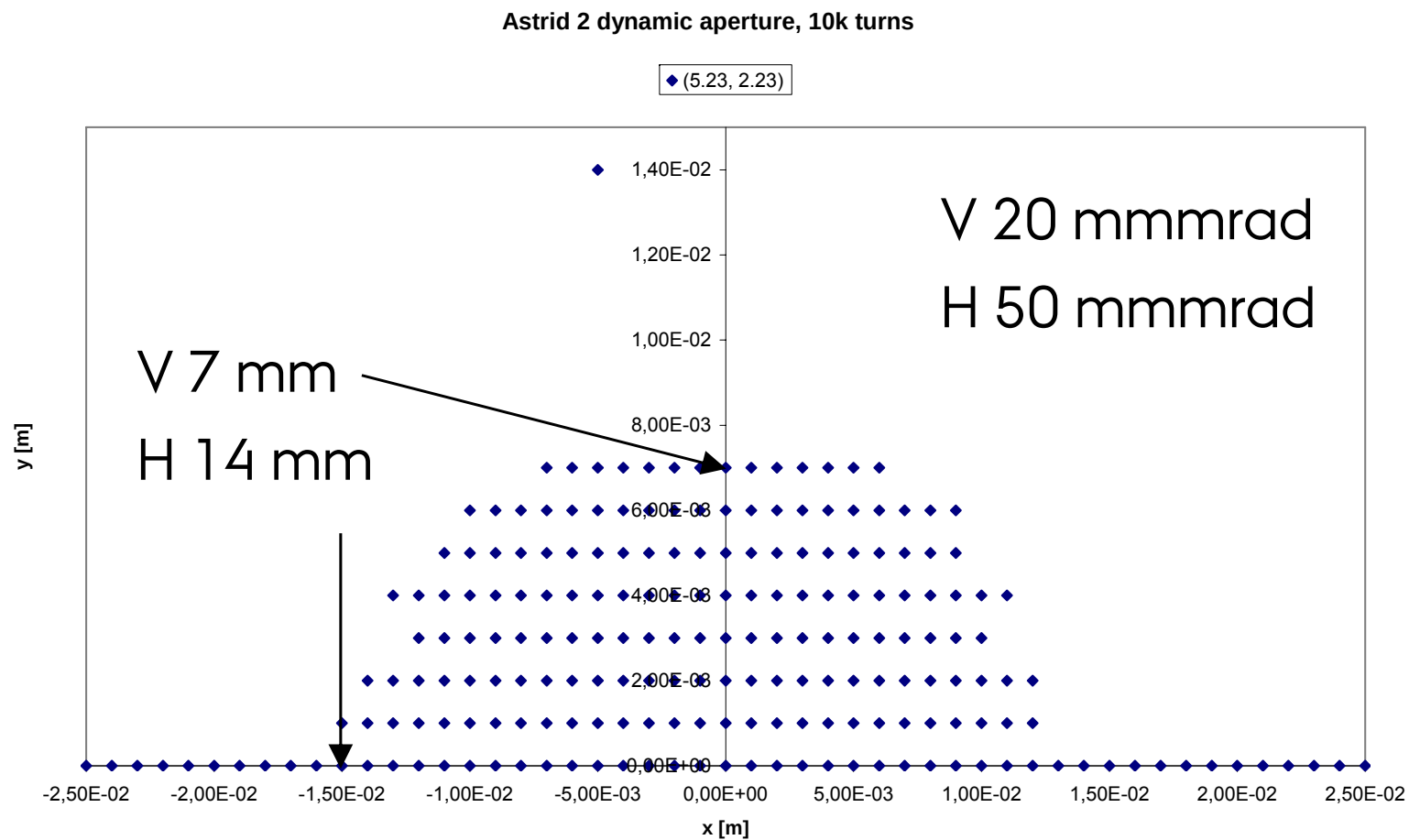
Influence of ID's



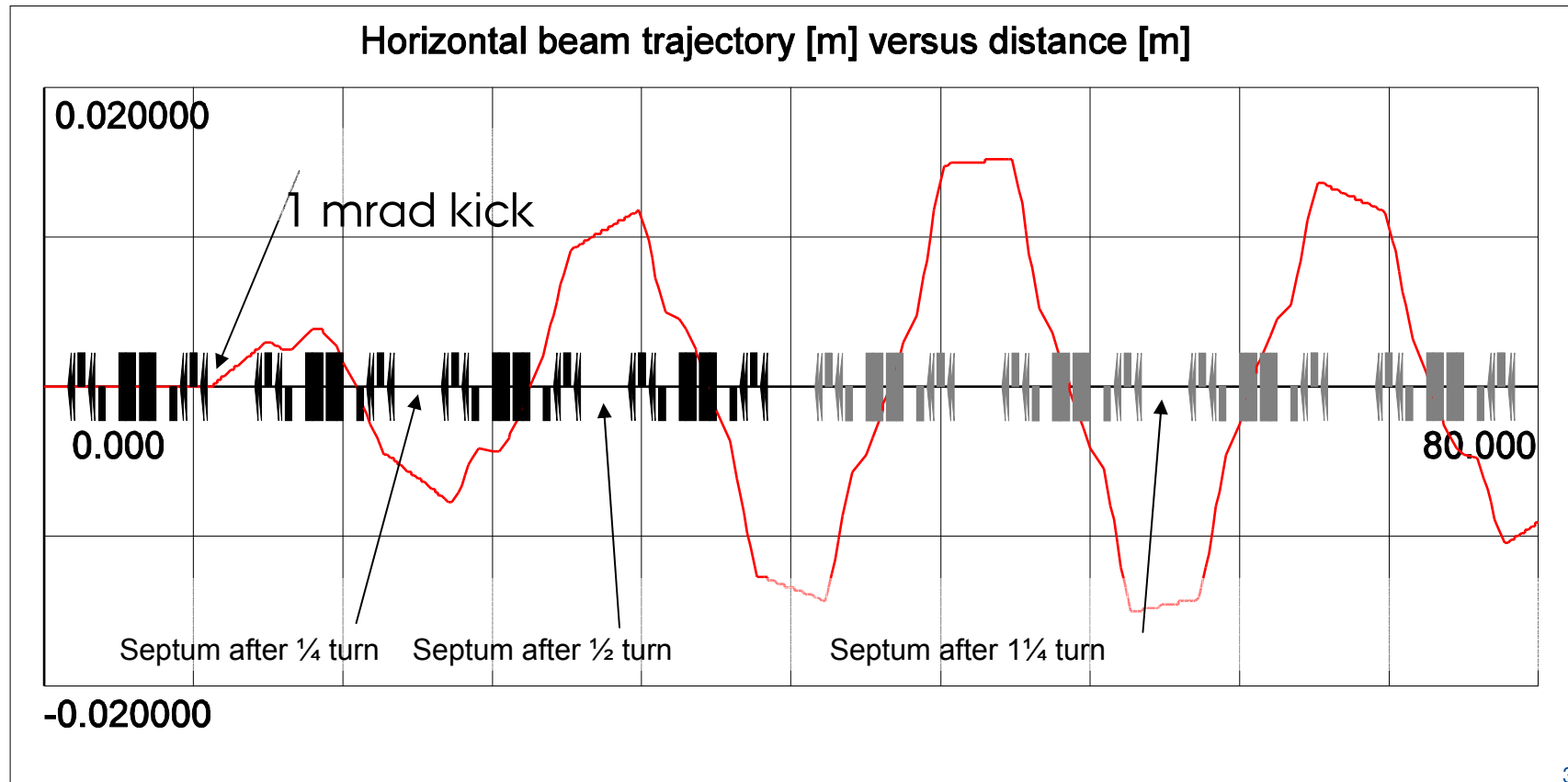
Tune shifts from the various insertion devices

Insertion device	K	L_period [m]	L [m]	N	Tune Shift (V)
"big" MPW	32.7	0.175	1.925	11	0.109
"small" MPW	21.7	0.116	0.700	6	0.042
new undulator	4.89	0.065	1.950	30	0.021
Old undulator, 22 mm gap	2.87	0.055	1.650	30	0.009
Old undulator, 18 mm gap	3.66	0.055	1.650	30	0.014

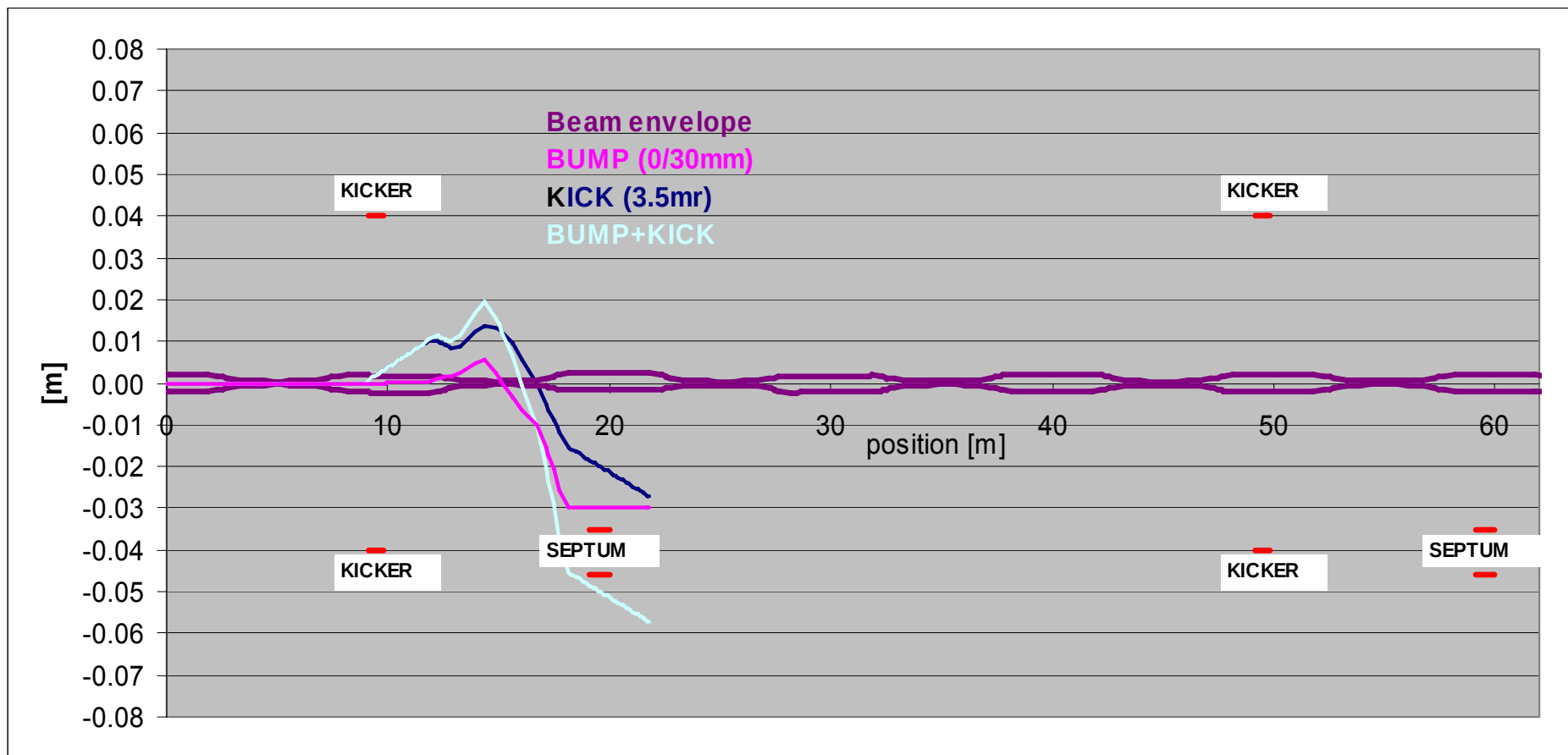
Dynamic aperture



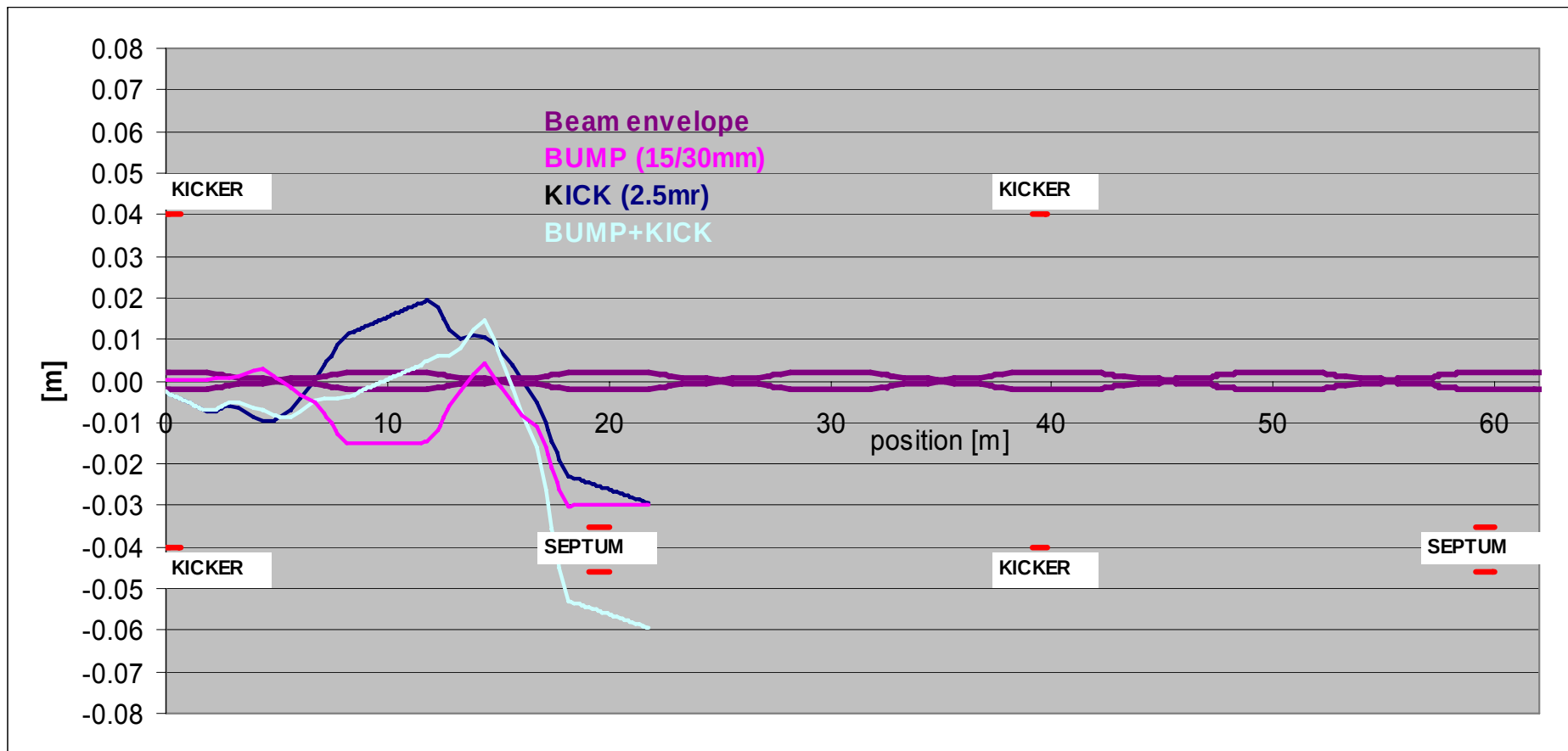
ASTRID fast extraction



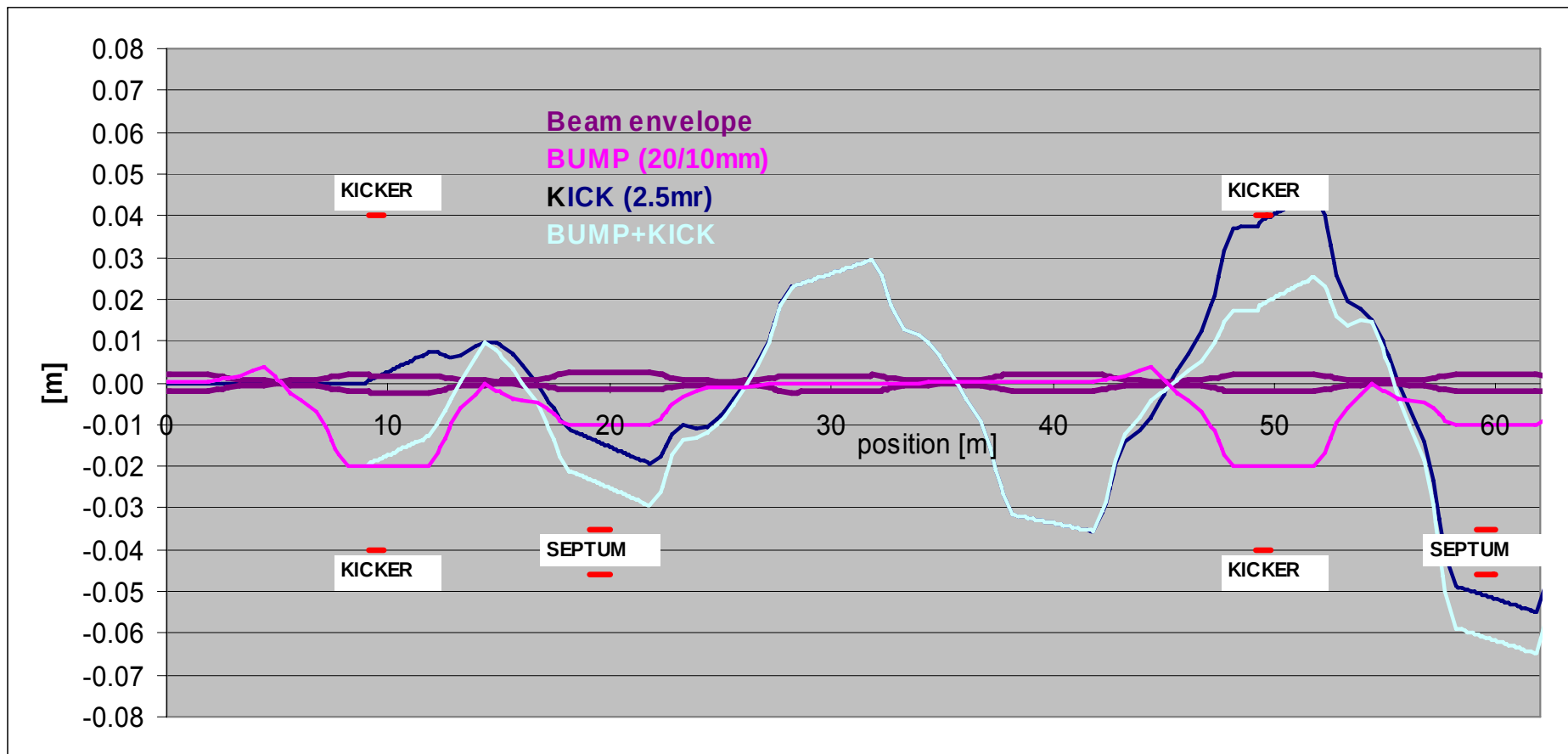
ASTRID $\frac{1}{4}$ turn extraction



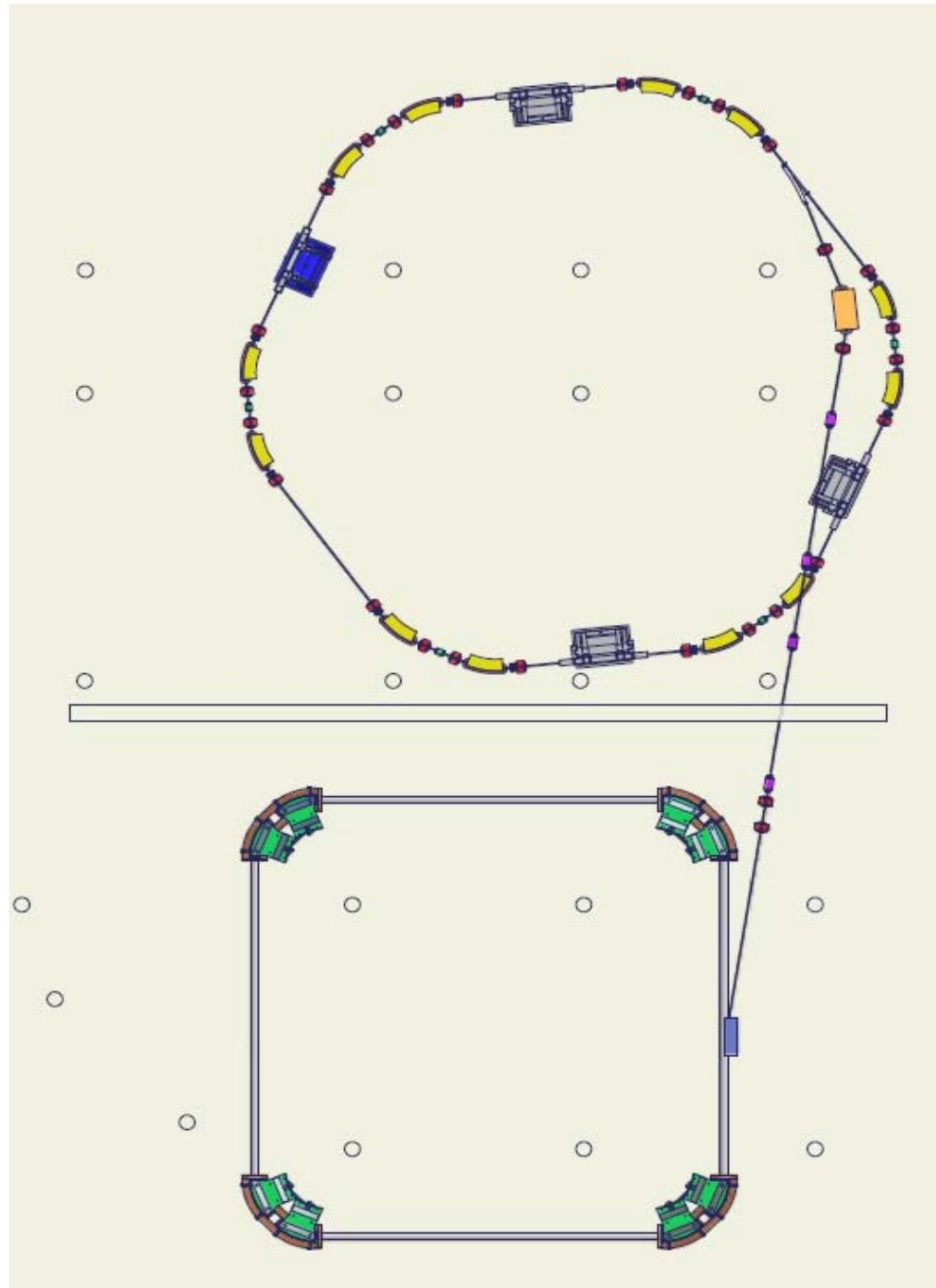
ASTRID $\frac{1}{2}$ turn extraction



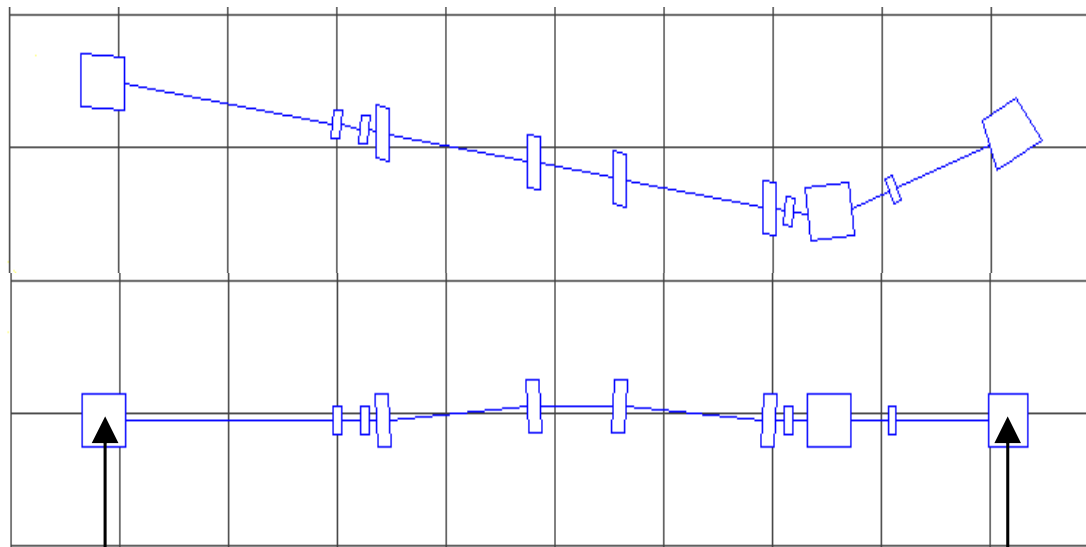
ASTRID 1 ¼ turn extraction



Transfer beamline

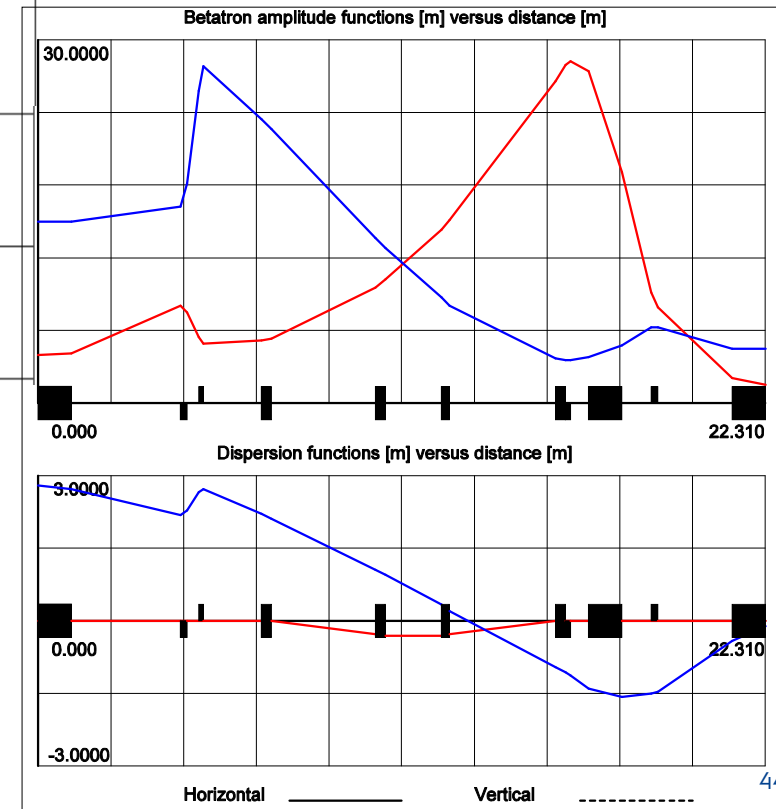


ASTRID → ASTRID2 transfer line



ASTRID septum

ASTRID2 Septum



Other technical aspects

- › Ex-situ bake-out of Arcs
- › 105 MHz RF – LLRF analog/digital
- › 5 kW RF power
- › Vertical betatron excitation (as at ASTRID) for large lifetime
- › Gradual transition from ASTRID → ASTRID2 to minimize “dark period”

Time line

- › September 2009: order most accelerator components
- › Beginning 2011 first injection in ASTRID2
- › 2012 First beamline on ASTRID2
- › 2013 All beamlines transferred to ASTRID2

Future

- › We will be busy over the next 4 years
- › Additional funding for two new beamlines (ID, mono, end-stations) are being prepared
- › We appreciate the always good relations to MAXLAB!!

Thank you for your attention!

Questions and comments?