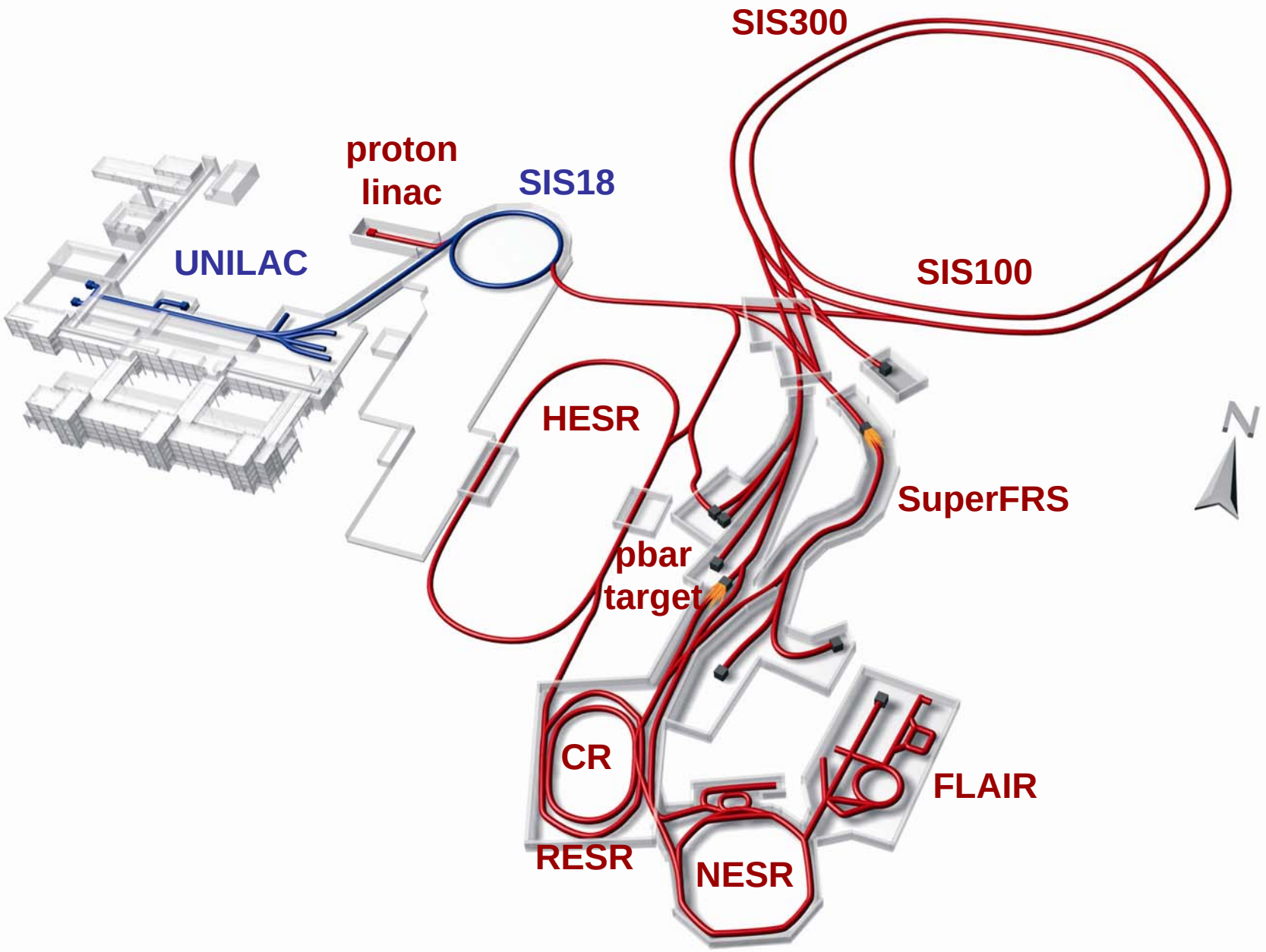
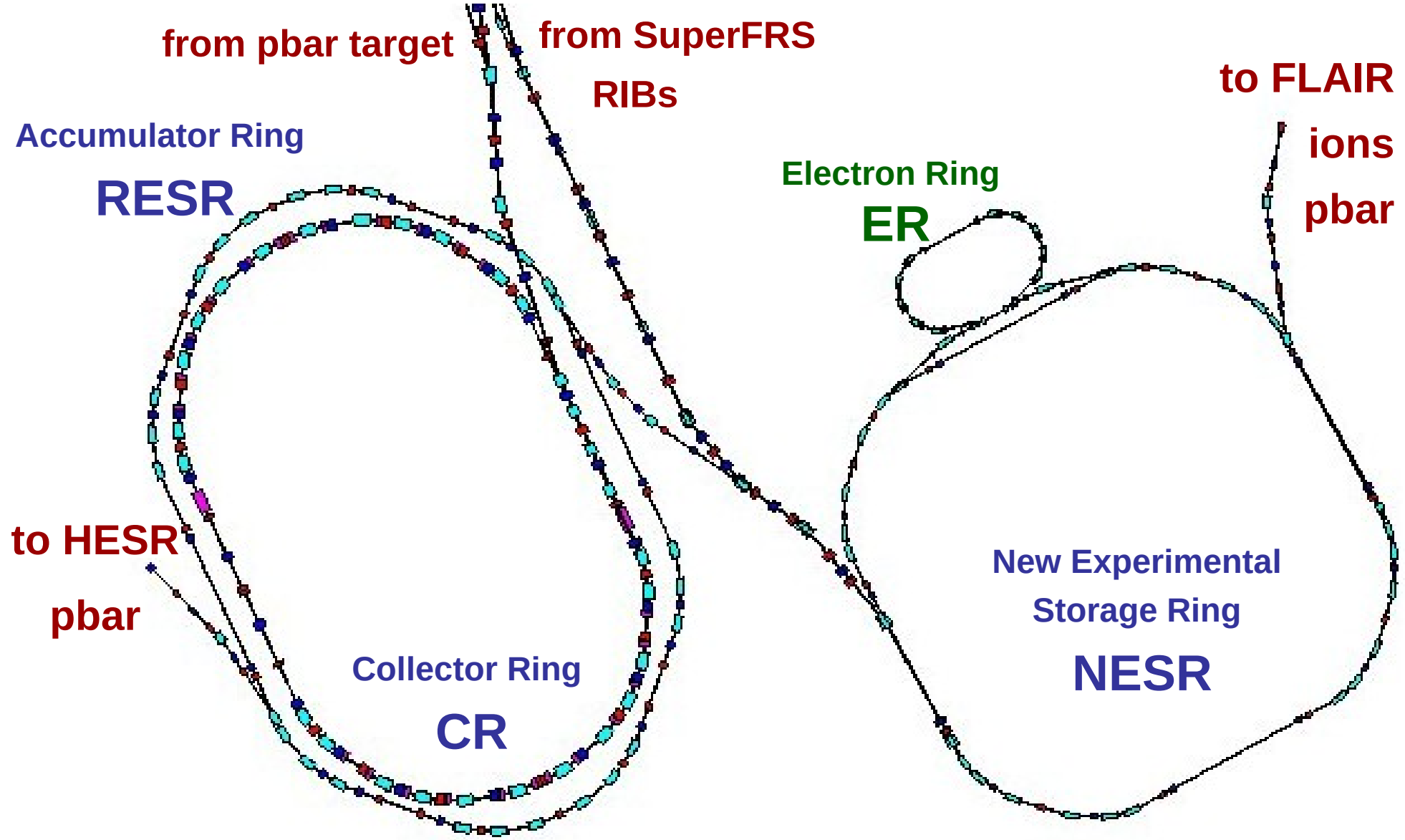
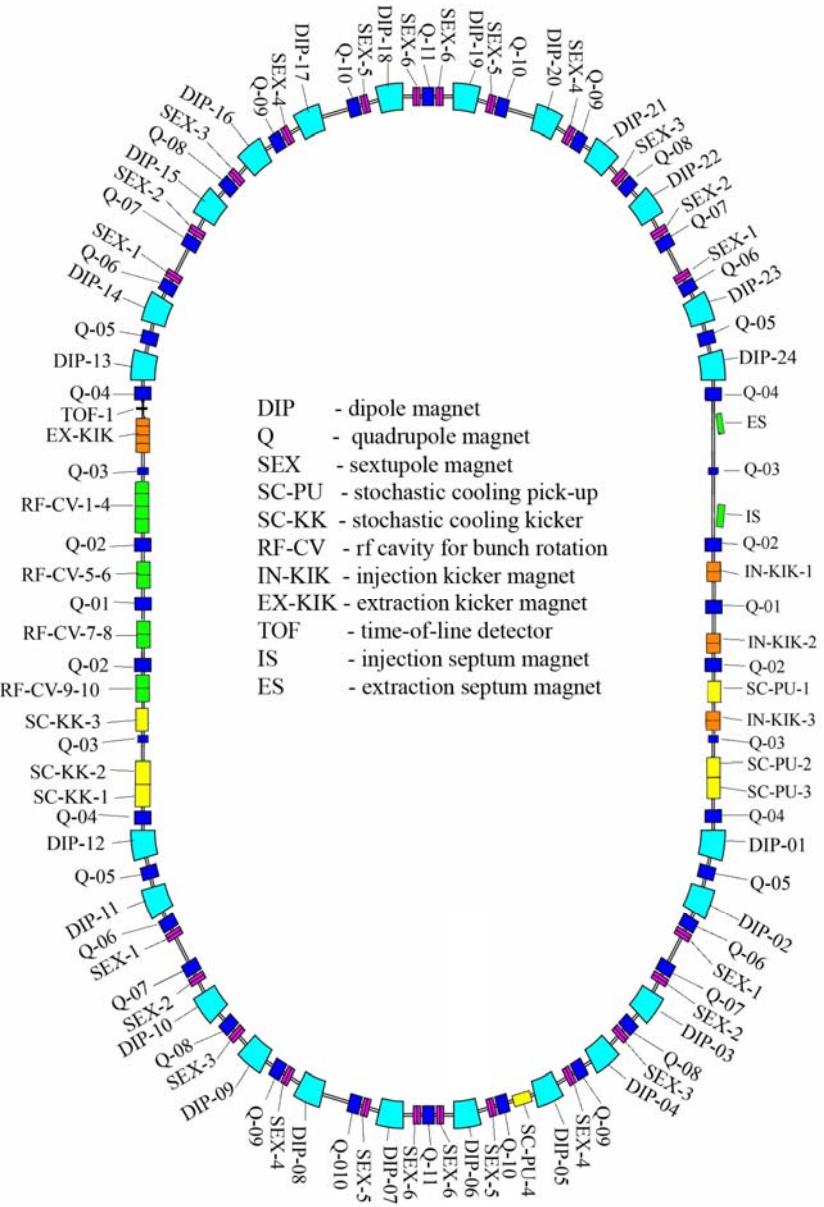
The FAIR Accelerator Facility



The FAIR 13 Tm Storage Rings



The Collector Ring CR



circumference **216 m**
magnetic bending power **13 Tm**
large acceptance $\varepsilon_{x,y}$ **= 240 (200) mm mrad**
$\Delta p/p = \pm$ **3.0 (1.5) %**

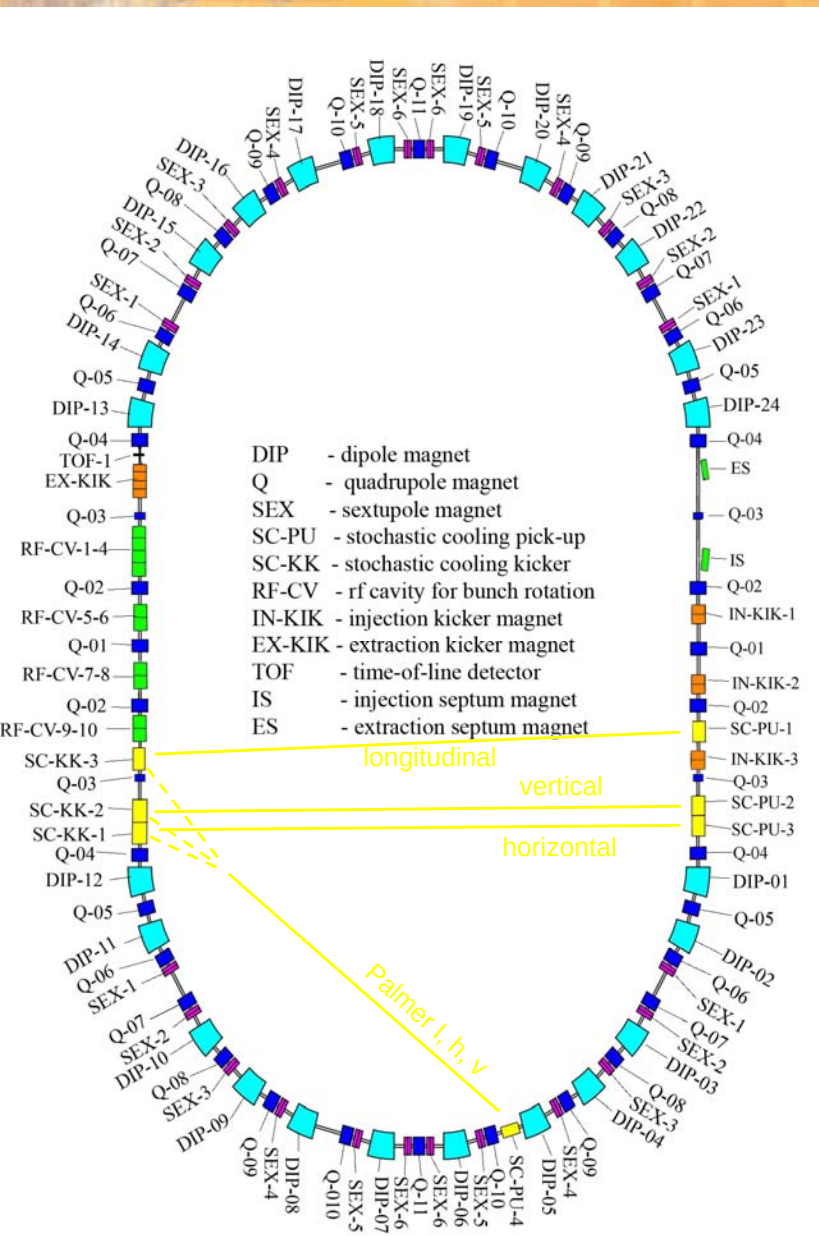
fast stochastic cooling (1-2 GHz) of antiprotons (10 s) and rare isotope beams (1.5 s)

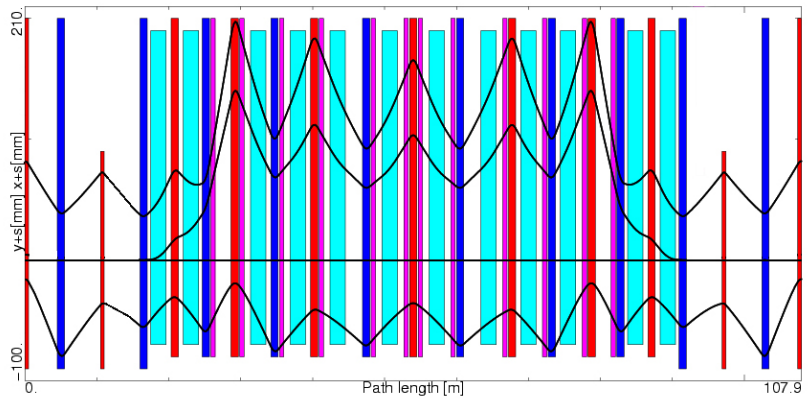
fast bunch rotation at h=1 with rf voltage 200 kV adiabatic debunching

optimized ring lattice (slip factor) for proper mixing large acceptance magnet system

additional feature:
isochronous mass measurements of rare isotope beams

Ion Optical Modes of the CR



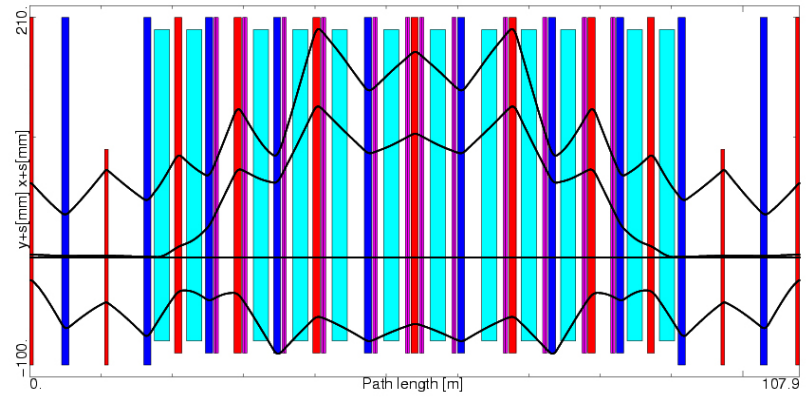


antiprotons

Q_x= 4.26, Q_y= 4.84

γ_t = 3.7

η = - 0.016

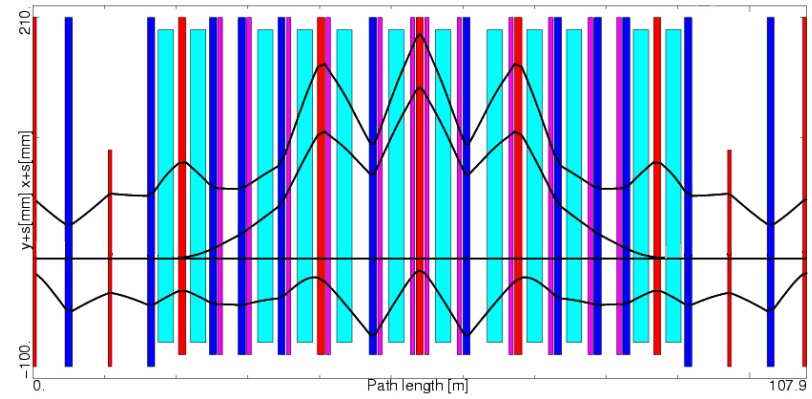


RIBs

Q_x= 3.21, Q_y= 3.71

γ_t = 2.8

η = + 0.185



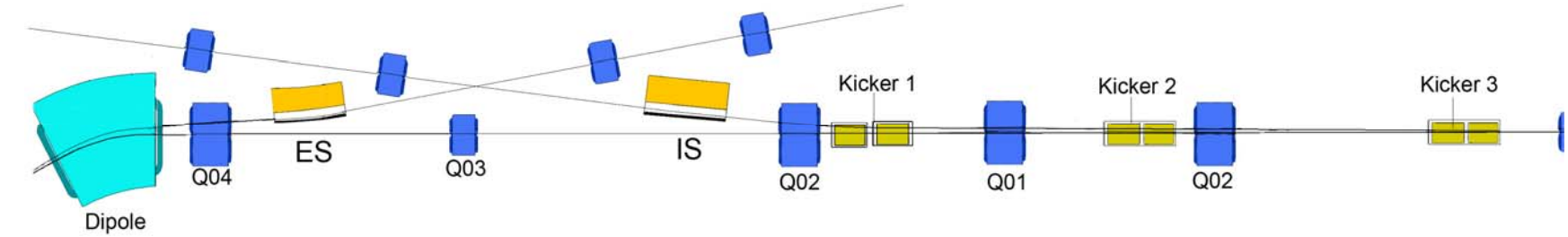
isochronous

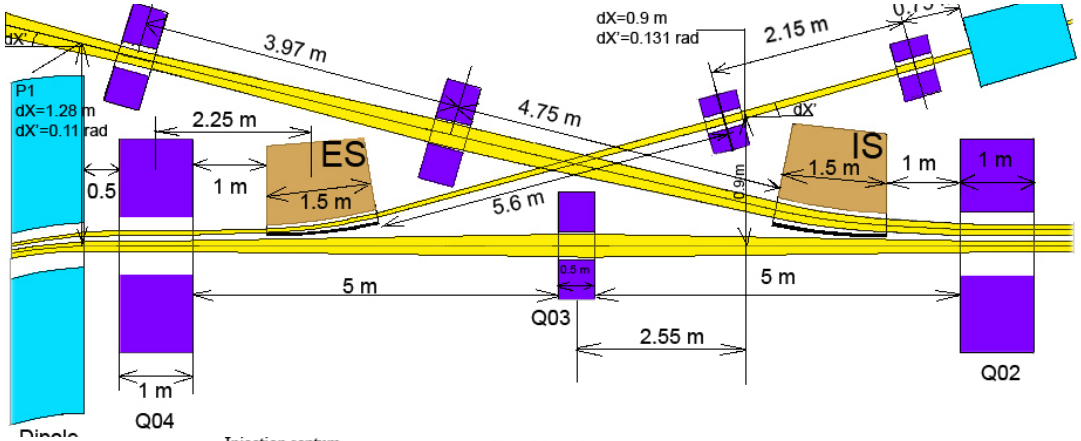
Q_x= 2.33, Q_y= 4.64

γ_t = 1.67-1.84

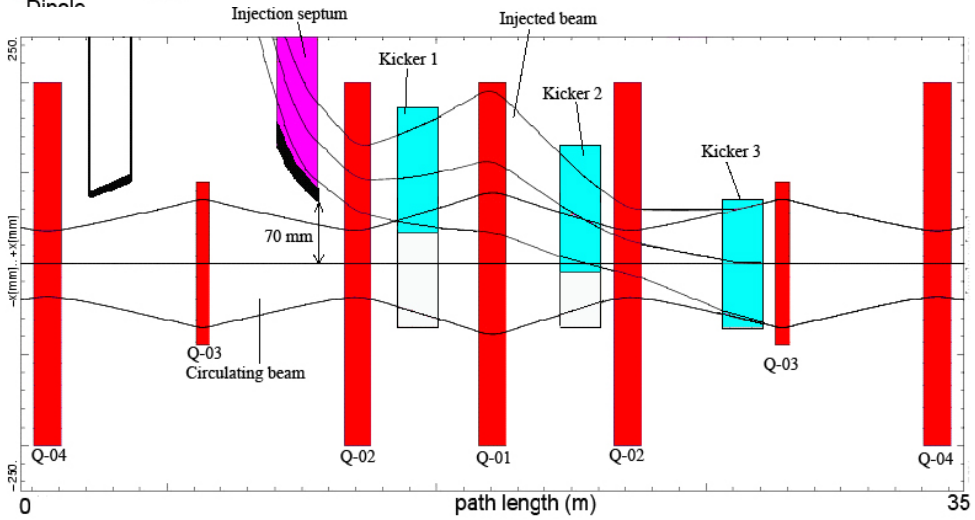
η = 0

Injection/Extraction CR





matching to pbar separator has been optimized ⇒ rotation - 5.6º



Septum magnets (pulsed, curved):

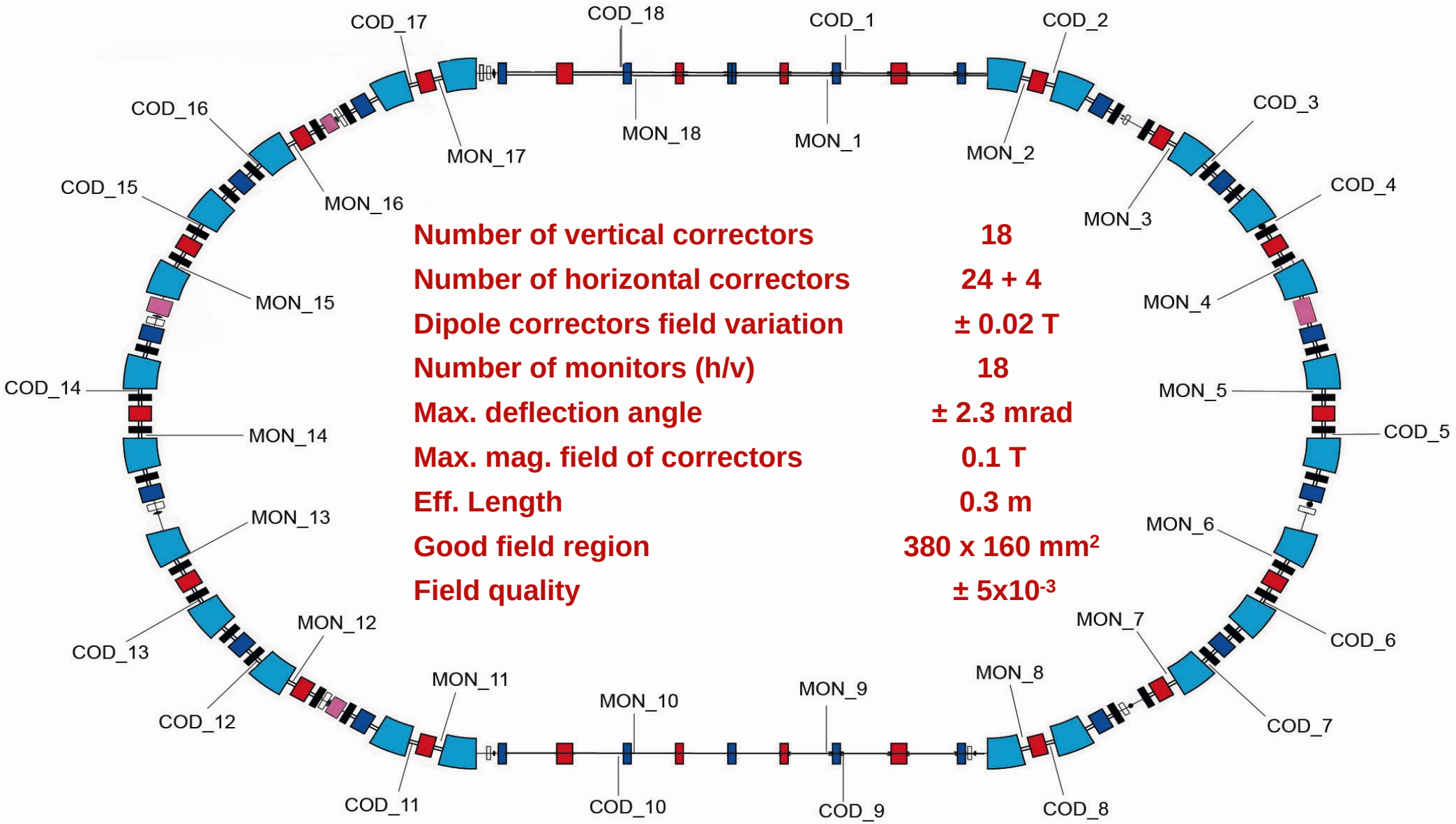
injection: 82 mrad, 0.8 T

extraction: 110 mrad, 1.1 T

Injection kicker magnets (±6 mrad):
3 units of the same type with 2 modules on different horizontal positions

Extraction kicker magnets (±12 mrad):
1 unit with 5 modules

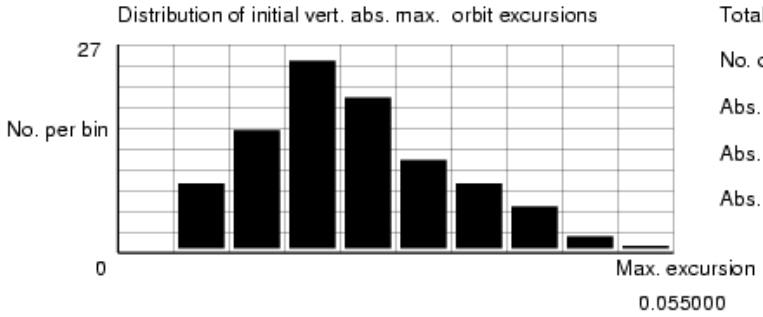
CR Closed orbit correction



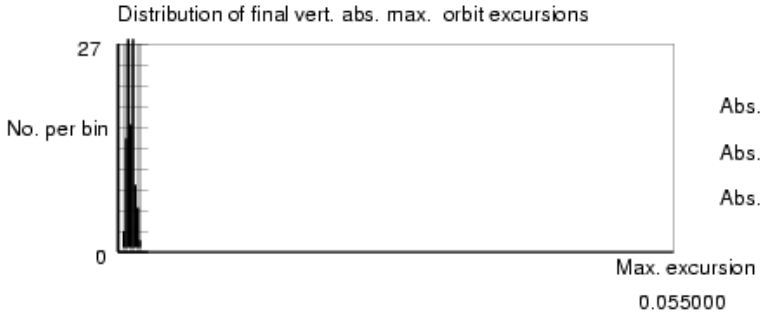
Number of vertical correctors	**18**
Number of horizontal correctors	**24 + 4**
Dipole correctors field variation	**± 0.02 T**
Number of monitors (h/v)	**18**
Max. deflection angle	**± 2.3 mrad**
Max. mag. field of correctors	**0.1 T**
Eff. Length	**0.3 m**
Good field region	**380 x 160 mm²**
Field quality	**± 5x10⁻³**

CR Closed orbit correction

MAD and WINAGILE simulations



Total no. of orbits in sample	100
No. of correction failures	0
Abs. max. initial excursion [m]	0.051265
Abs. av. initial excursion [m]	0.023751
Abs. RMS initial excursion [m]	0.009816



Abs. max. final excursion [m]	0.002722
Abs. av. final excursion [m]	0.001632
Abs. RMS final excursion [m]	0.000432

Alignment rms errors used in tracking studies

Element	Δx [mm]	Δy [mm]	Δz [mm]	Roll [mrad]
Dipole	0.2	0.2	0.5	0.5
Quadrupole	0.2	0.2	0.3	0.5
Sextupole	0.2	0.2	0.3	0.5

Closed orbit excursions before correction

	PBAR		RIB		ISO	
	hor	ver	Hor	ver	hor	ver
ΔX_{max} [mm]	17.22	20.93	42.17	51.06	17.07	15.19
$\Delta X_{average}$ [mm]	9.76	11.57	14.71	23.75	10.71	8.64

Before correction
The most probable COD ≈ 20 mm

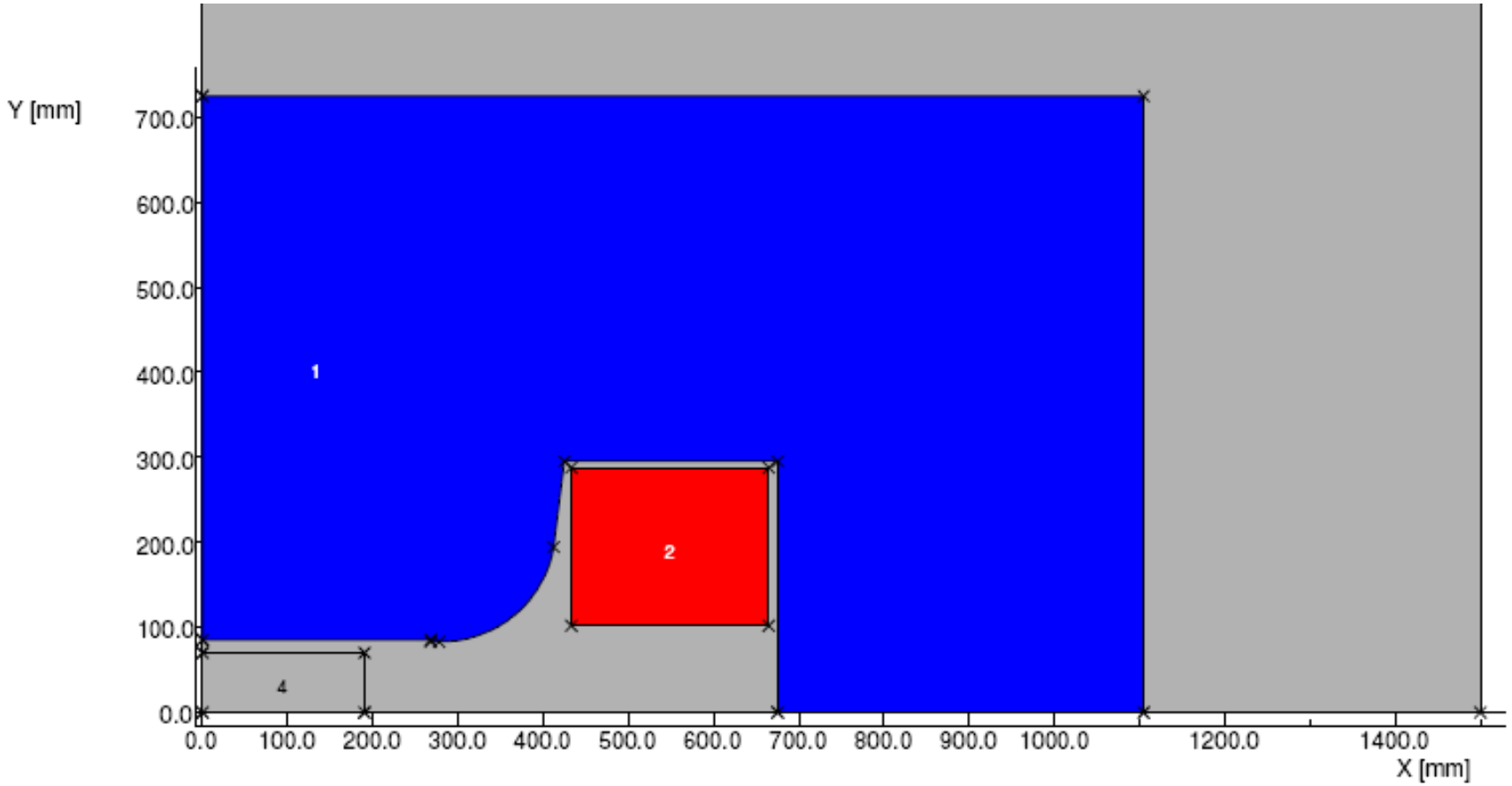
After correction
The most probable COD ≈ 1 mm

Closed orbit excursions after correction

	PBAR		RIB		ISO	
	hor	ver	hor	ver	hor	ver
ΔX_{max}[mm]	3.07	2.52	1.40	2.64	0.45	0.92
$\Delta X_{average}$ [mm]	1.10	1.20	0.81	1.34	0.25	0.46

Orbit corrections are important for optimum stochastic cooling

CR Dipole Magnet



field range 1.2- 1.6 T
ramp rate 0.054 T
maximum current 1448 A
maximum power 112 kW

H-Type sector magnet
bending angle 15 degrees

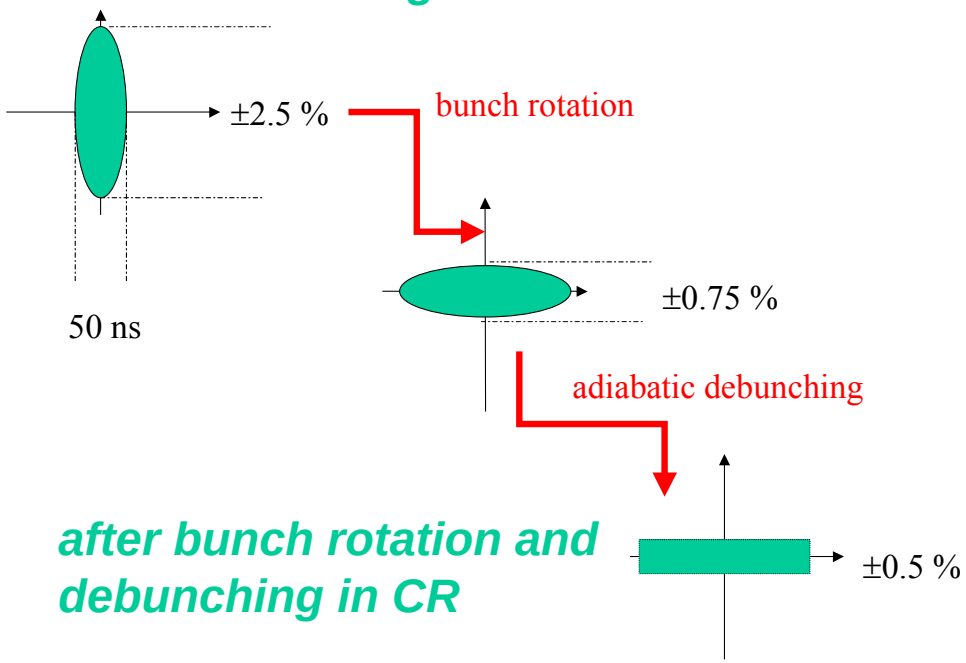
effective length 2.126 m
usable gap 380 × 140 mm²

technical design ??

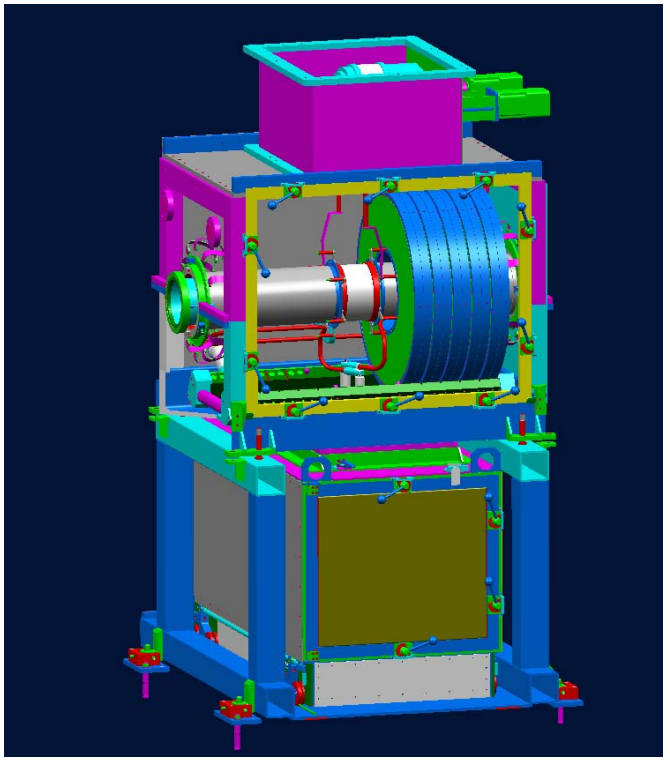
Fast Bunch Rotation in CR

Fast bunch rotation of SIS100 bunch
to provide optimum initial parameters
for stochastic cooling
total rf voltage 200 kV at h=1 reduces
the momentum spread (2.5→ 0.5 %)
after passage of production target

SIS100 bunch after target



after bunch rotation and debunching in CR



bunch rotation cavity
filled with magnetic alloy
(*SIS18 bunch compressor*)

voltage 40 kV
length 1 m
frequency range 1.18 – 1.38 MHz
rotation time ~ 100 μs

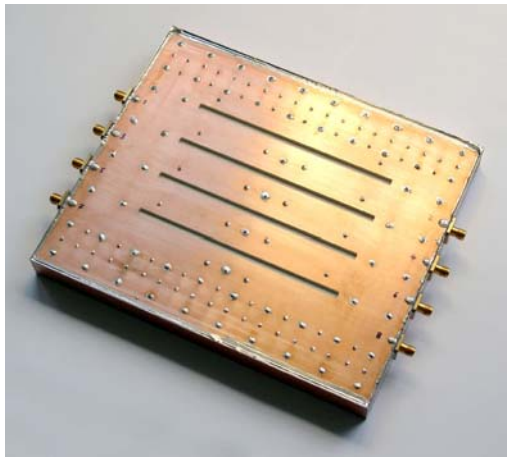
CR Stochastic Cooling Electrodes

Fast Stochastic Pre-cooling

system band width 1-2 GHz

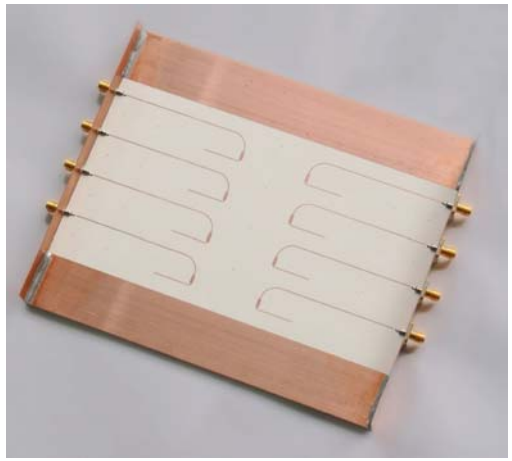
matched to velocities β = 0.83 - 0.97

rf power ~ 1-2 kW per system



electrode prototype (slotline type)

front side



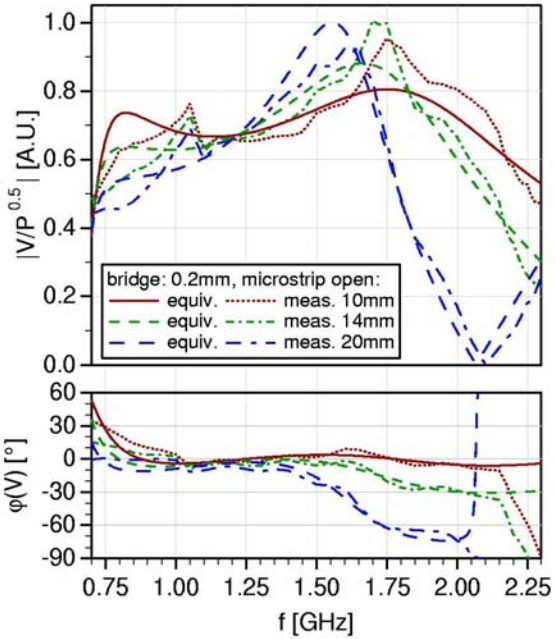
back side

flatness of

voltage

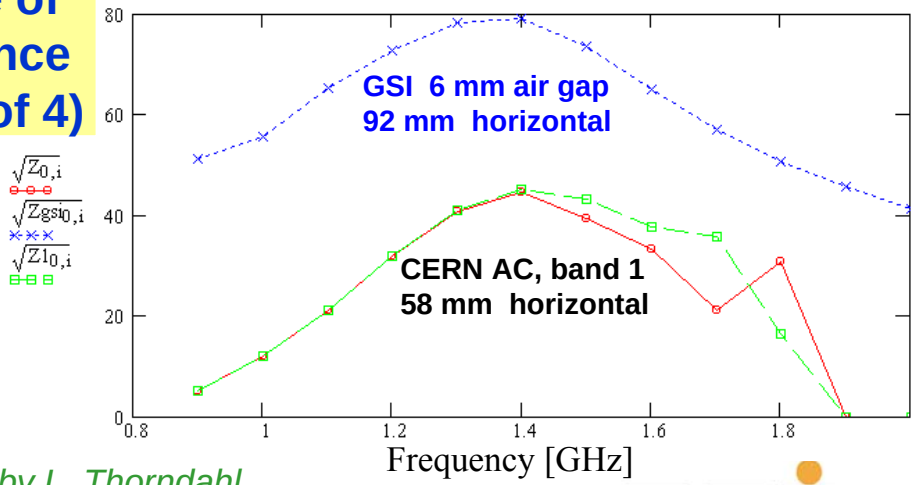
and

phase



increase of impedance (factor of 4)

Square root of longitudinal impedance (circuit convention, beta=0.97 and valid at centre of chamber with half aperture 53 mm)

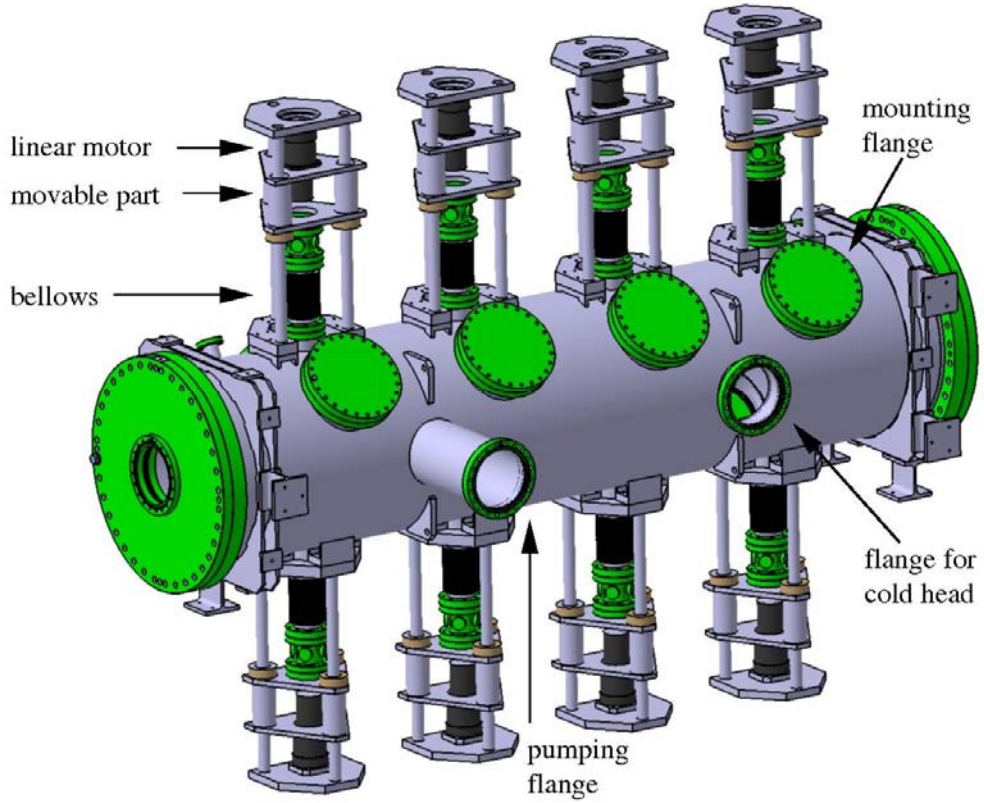


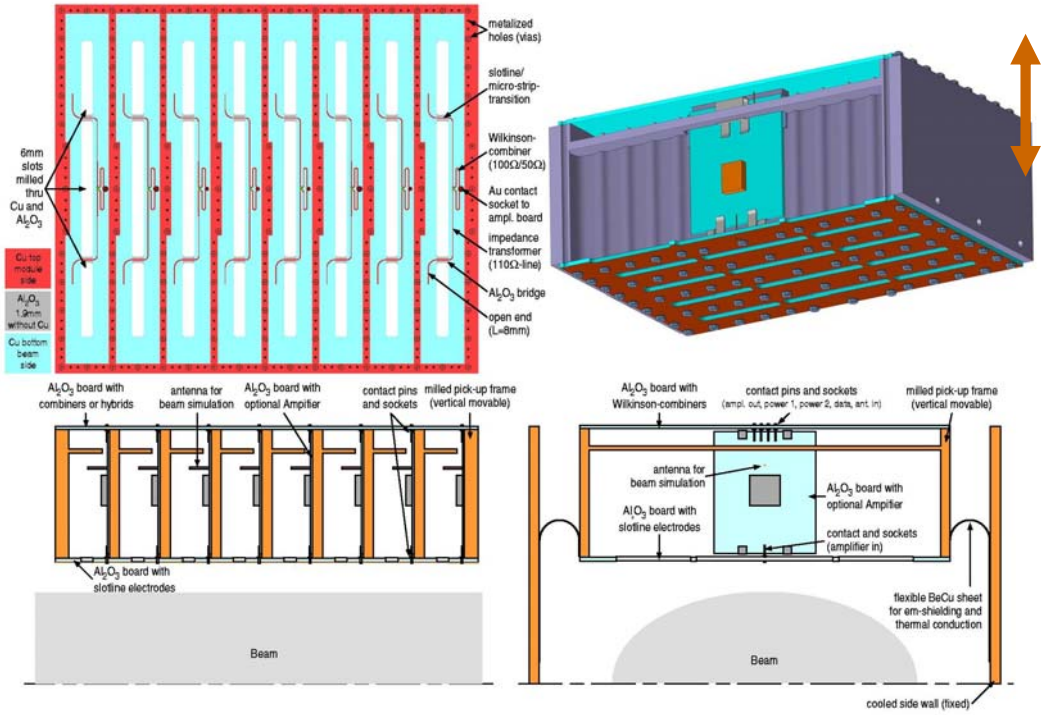
analysis by L. Thorndahl

CR Stochastic Cooling

vacuum tank
with actuators for electrode movement including cold heads (20 K) and cooled pre-amplifiers

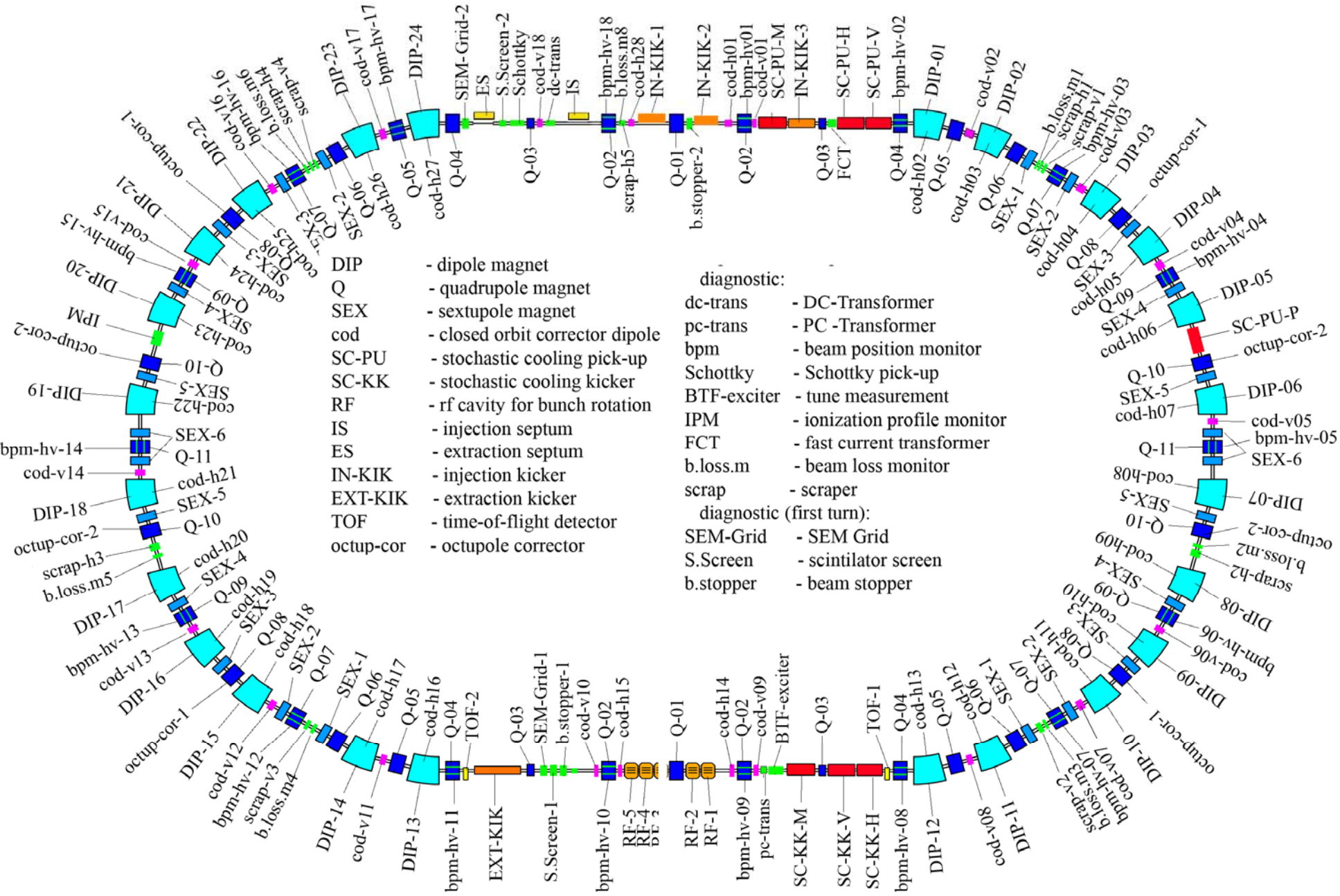
electrodes and amplifiers installed in the vacuum tank cooled to 20 K



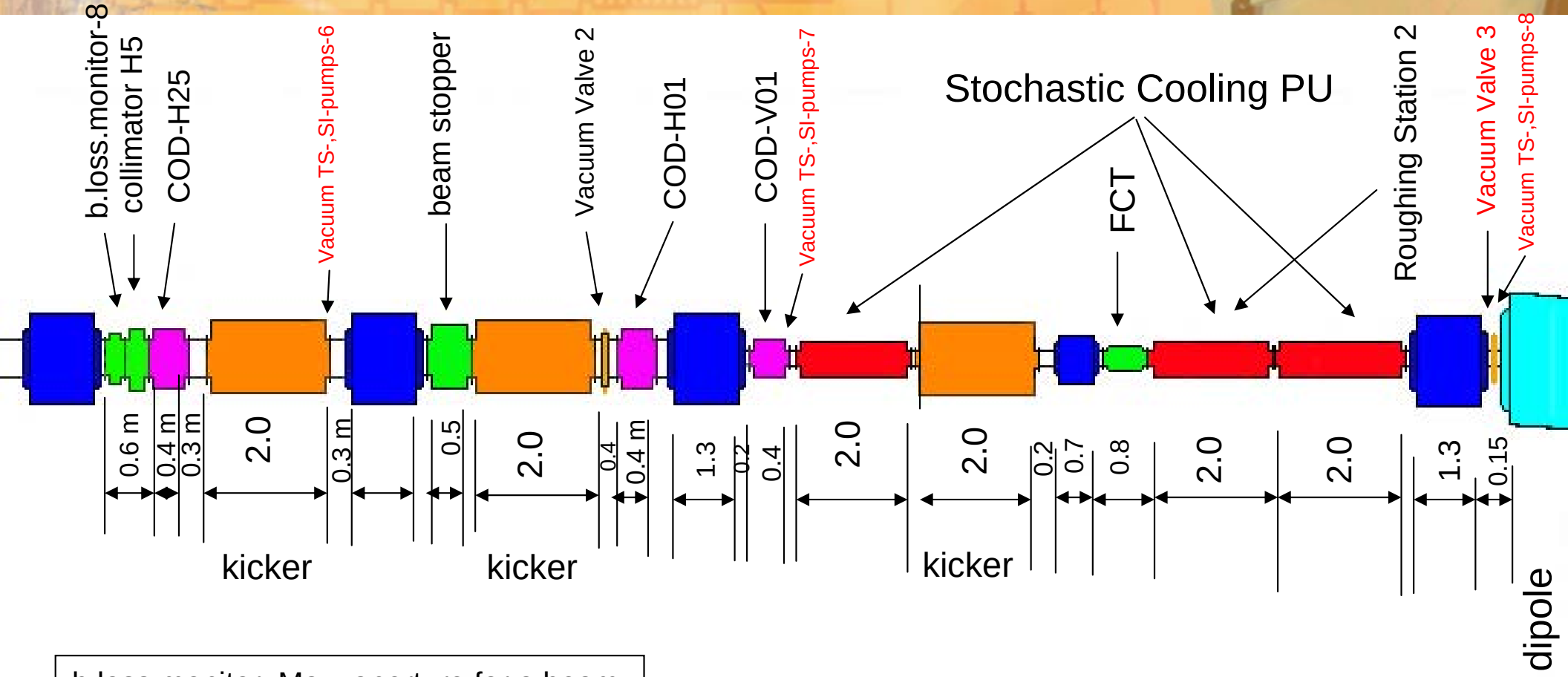


Prototype development supported in the framework of EUFP6 design study

Detailed Ring Design



CR Straight Section 1

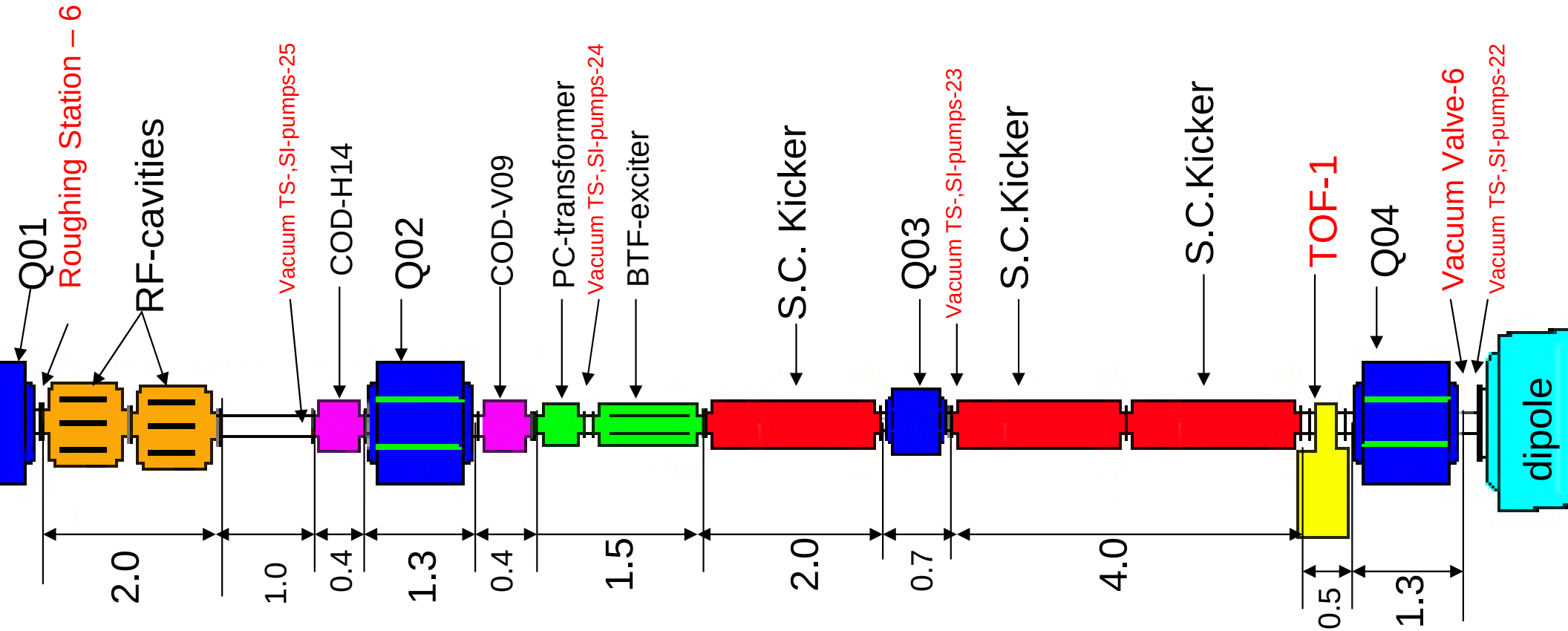


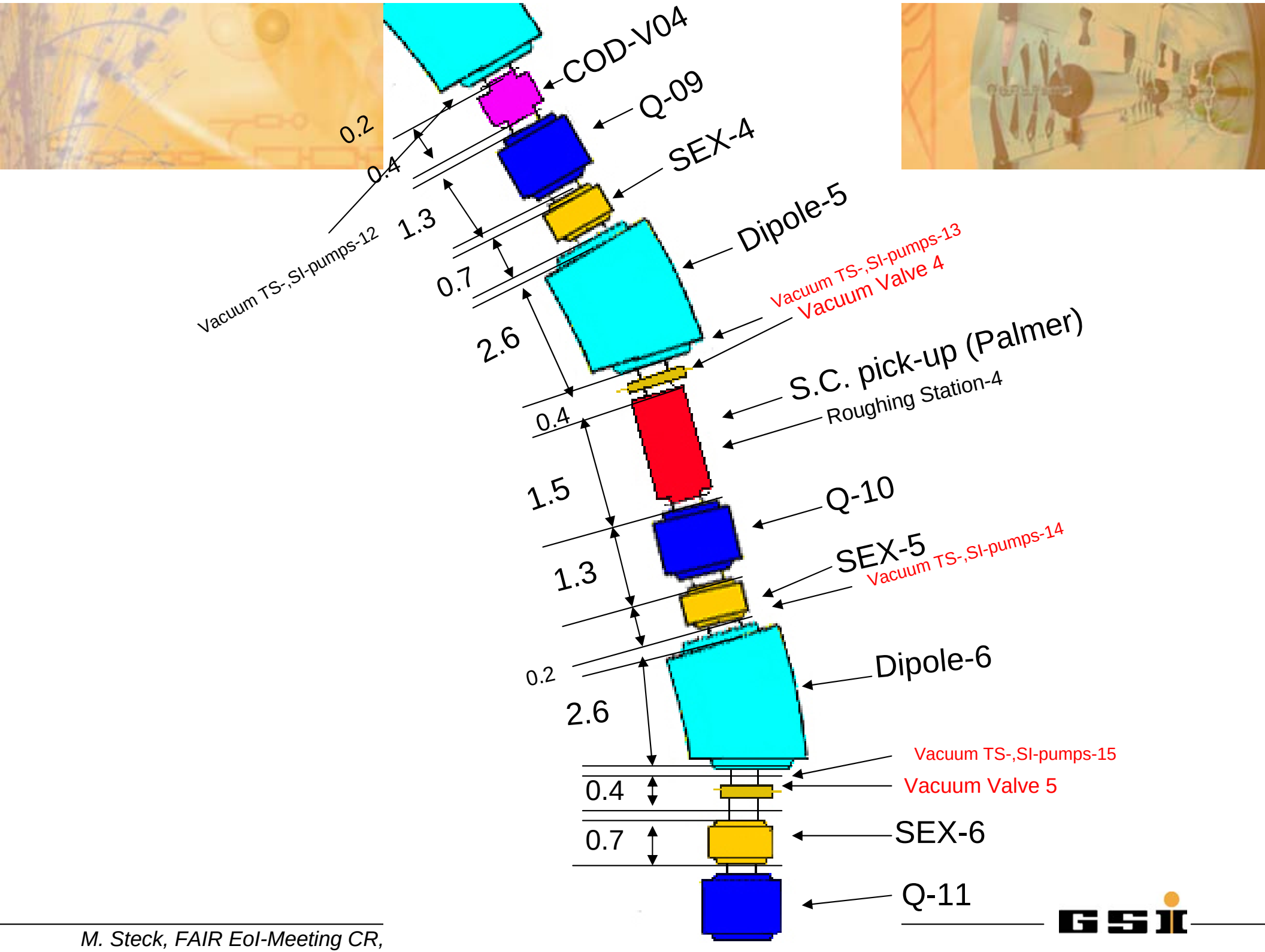
b.loss monitor: Max. aperture for a beam
Hor. ±200 mm
Ver. ±90 mm

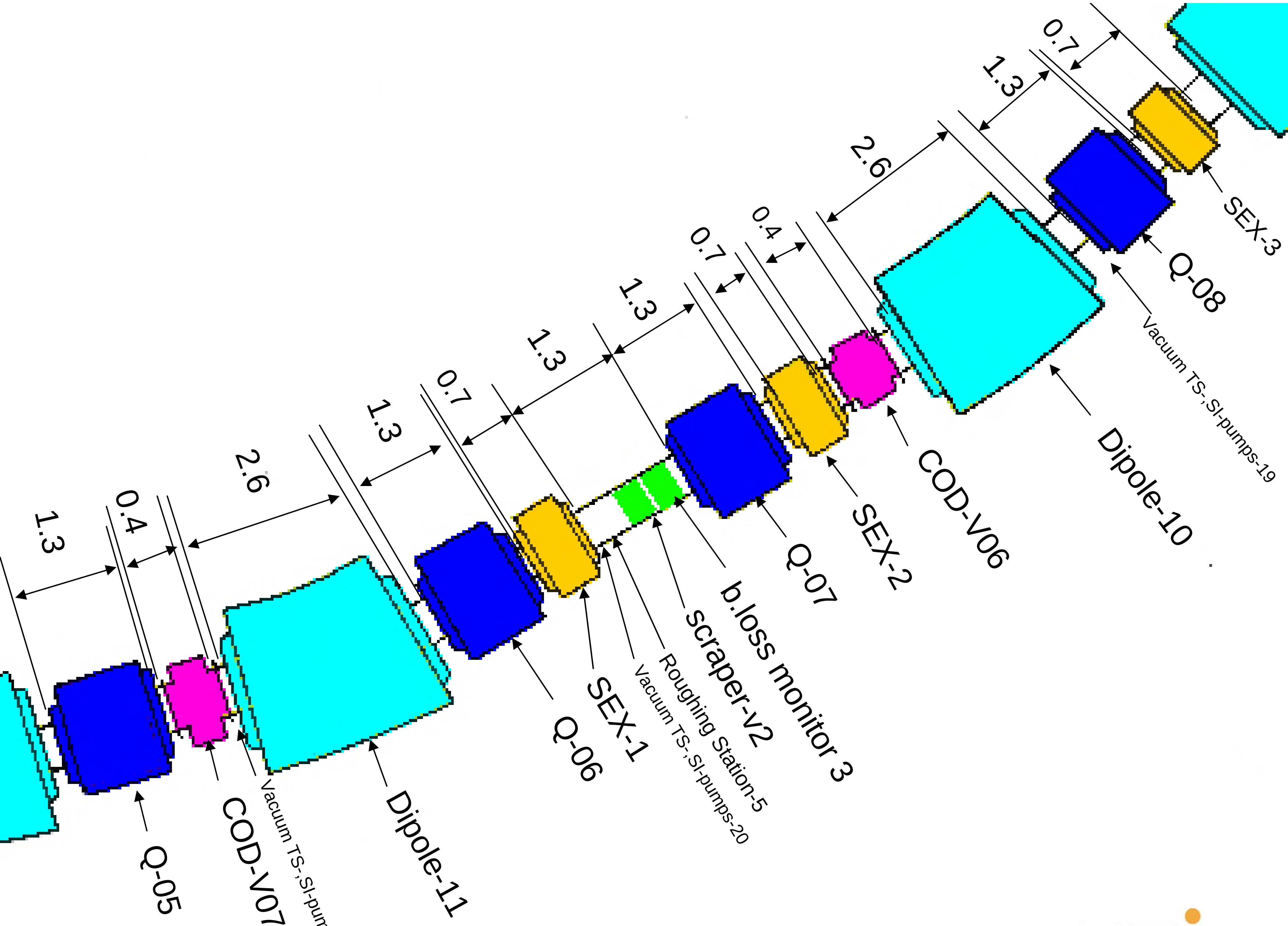
Fast current transformer FCT: Aperture for a beam
Hor. ±90 mm
Ver. ±90 mm

H5 collimator: Max. aperture for a beam
Hor. ±200 mm
Ver. ±90

CR Straight Section 2

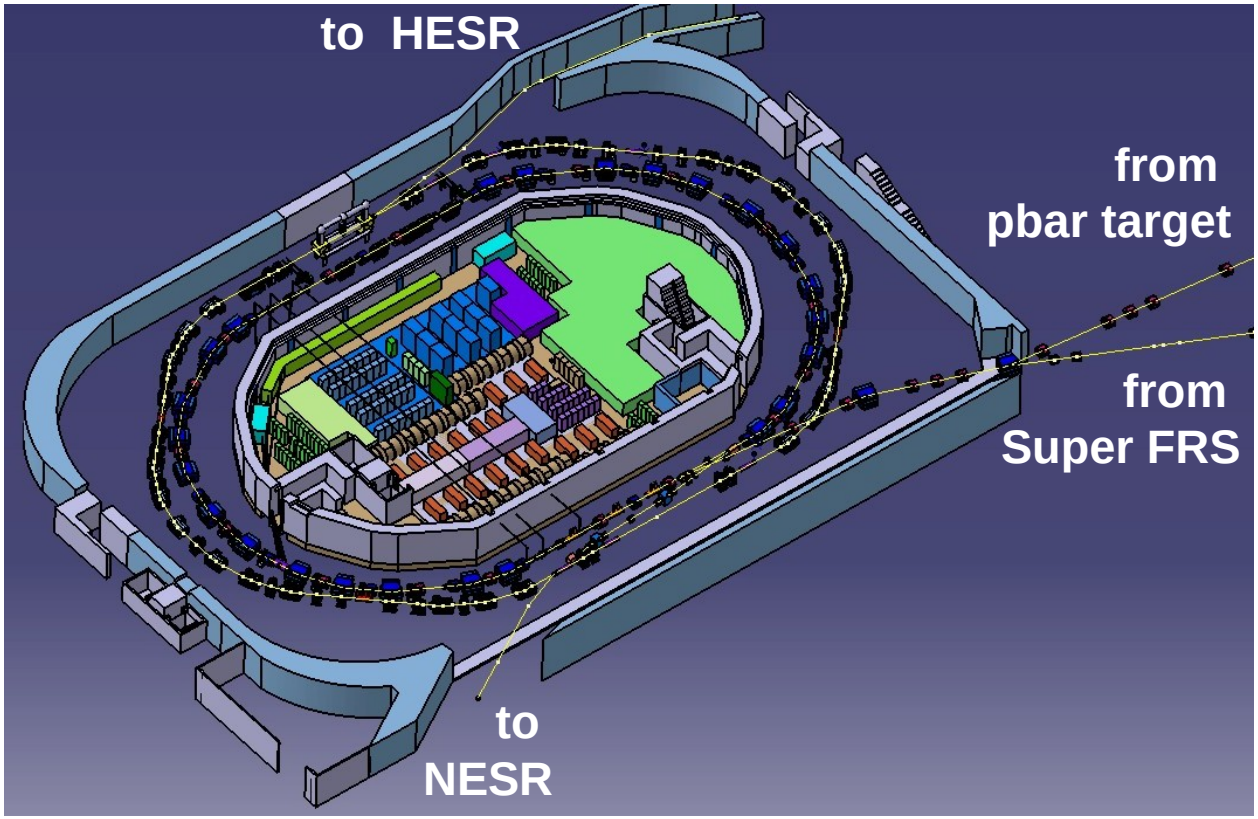



COD-V04
Q-09
SEX-4
Dipole-5
Vacuum TS-,SI-pumps-13
Vacuum Valve 4
S.C. pick-up (Palmer)
Roughing Station-4
Q-10
SEX-5
Vacuum TS-,SI-pumps-14
Dipole-6
Vacuum TS-,SI-pumps-15
Vacuum Valve 5
SEX-6
Q-11
0.2
0.4
1.3
0.7
2.6
Vacuum TS-,SI-pumps-12
0.4
1.5
1.3
0.2
2.6
0.4
0.7

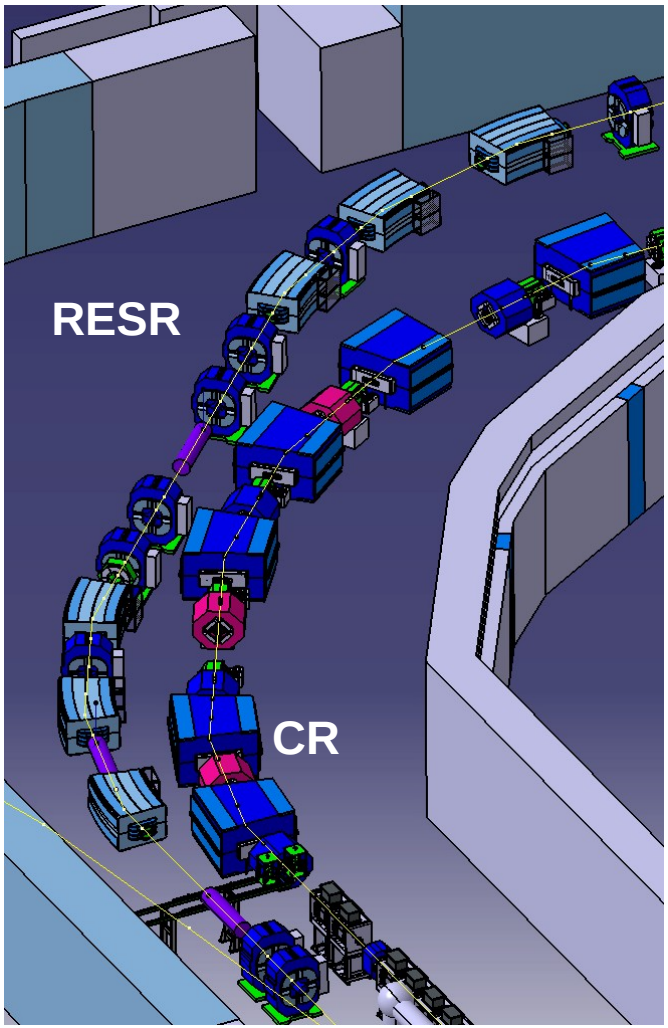

0.7
1.3
2.6
0.4
0.7
1.3
1.3
0.7
1.3
2.6
0.4
1.3
SEX-3
Q-08
Vacuum TS-,SI-pumps-19
Dipole-10
COD-V06
SEX-2
Q-07
b.loss monitor 3
scraper-v2
Roughing Station-5
Vacuum TS-,SI-pumps-20
SEX-1
Q-06
Dipole-11
COD-V07
Q-05

Civil Construction of CR/RESR

Building



Ring Tunnel



- common tunnel for CR and RESR
- inner part of ring building (two stories) accommodates the technical systems

Time Schedule CR

2009	**Prototypes, Pre-Series Production** **manufacturing and testing**
2010-2012	**Series Production** **preparation and manufacturing**
2013	**Preparation for Installation**
2014	**Commissioning**
2015	**Start of Ring Operation**

Next steps: technical design of components urgently needed to finish ring design and to start production