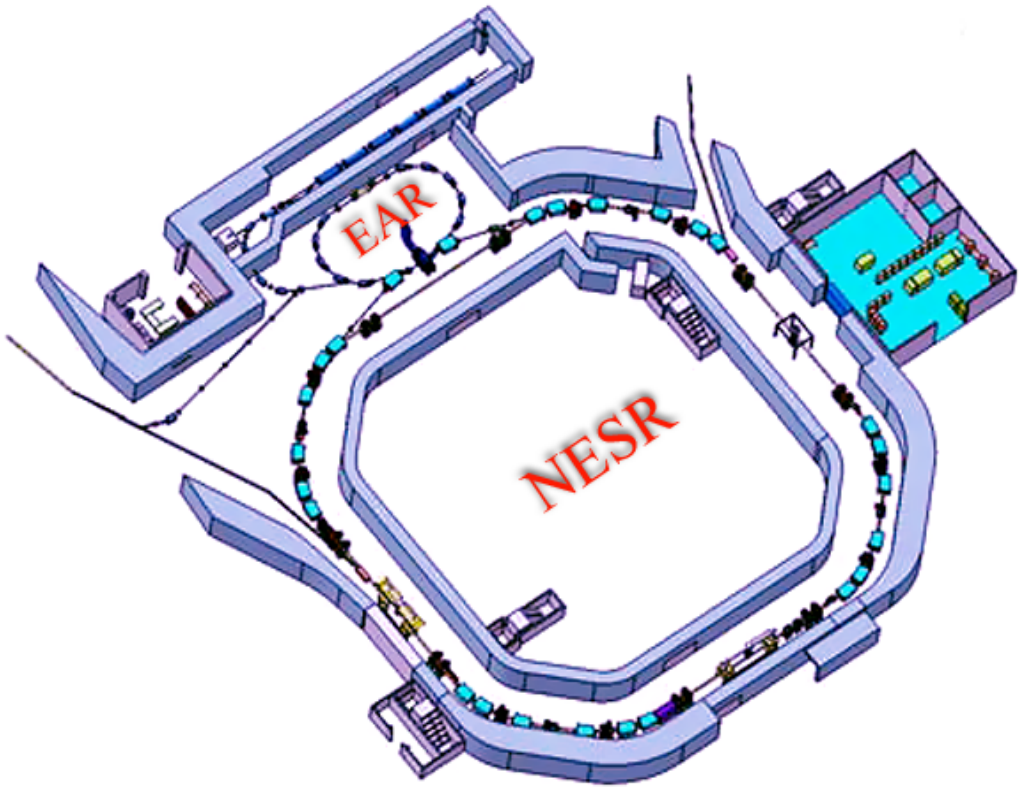
Electron - Ion Collider Project

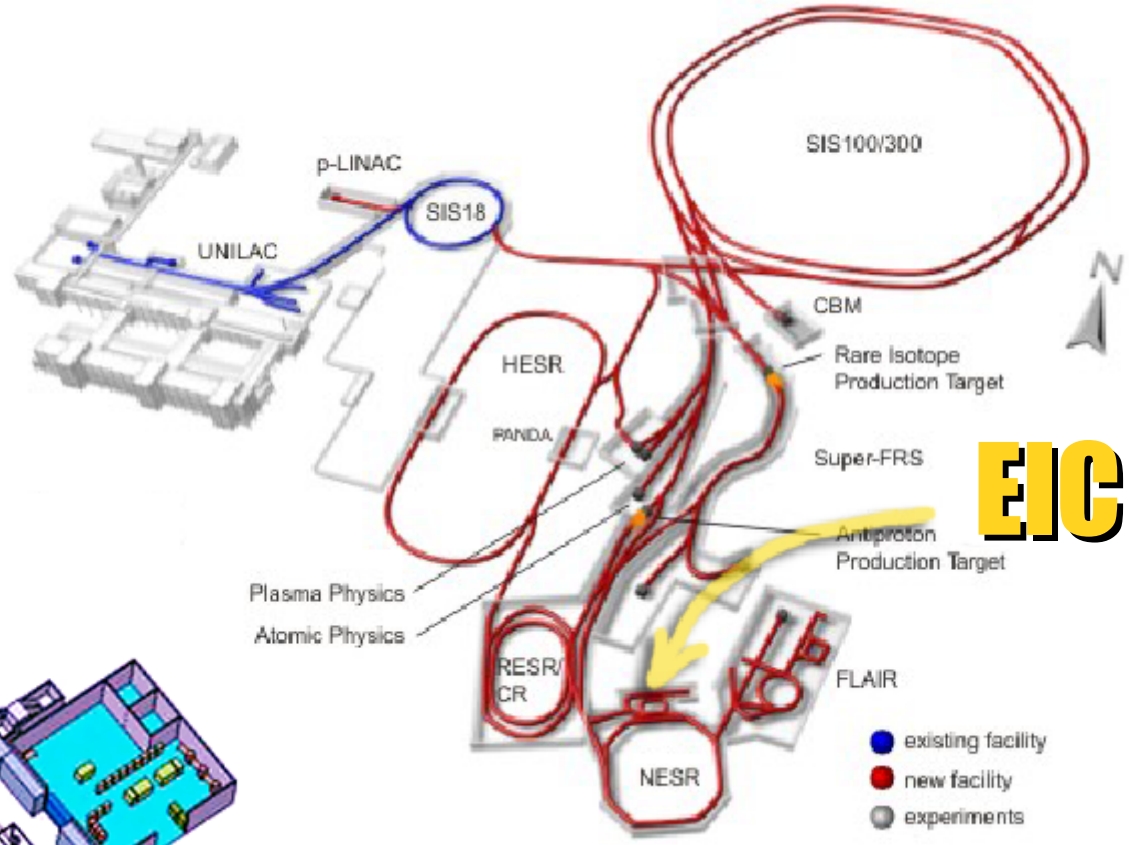
The Present State of development

Petr Shatunov, BINP, Novosibrsk

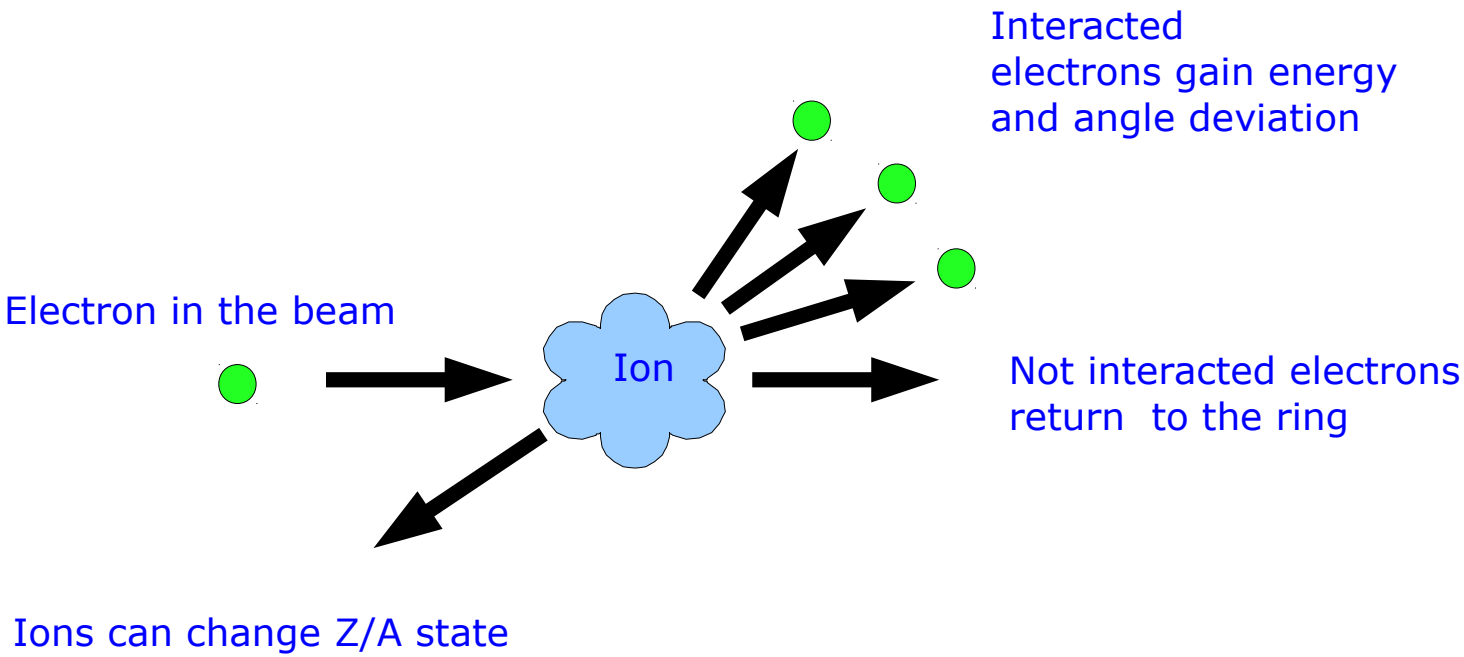
Moskow, 21-22, June, 2011

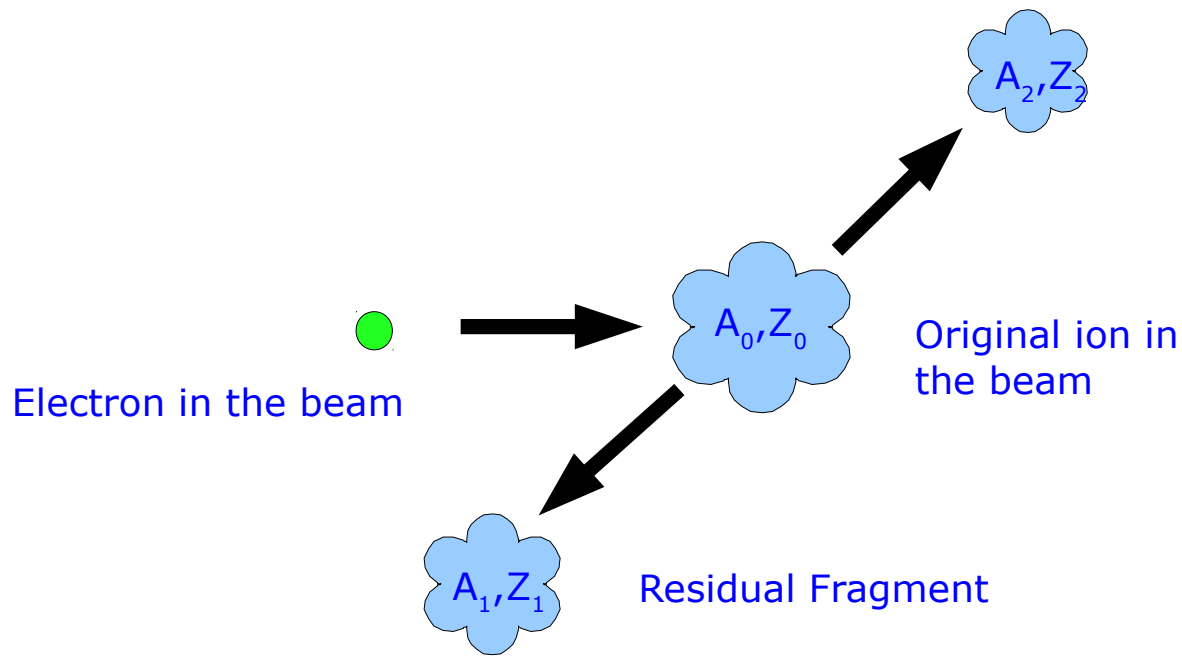
Main view of the facility



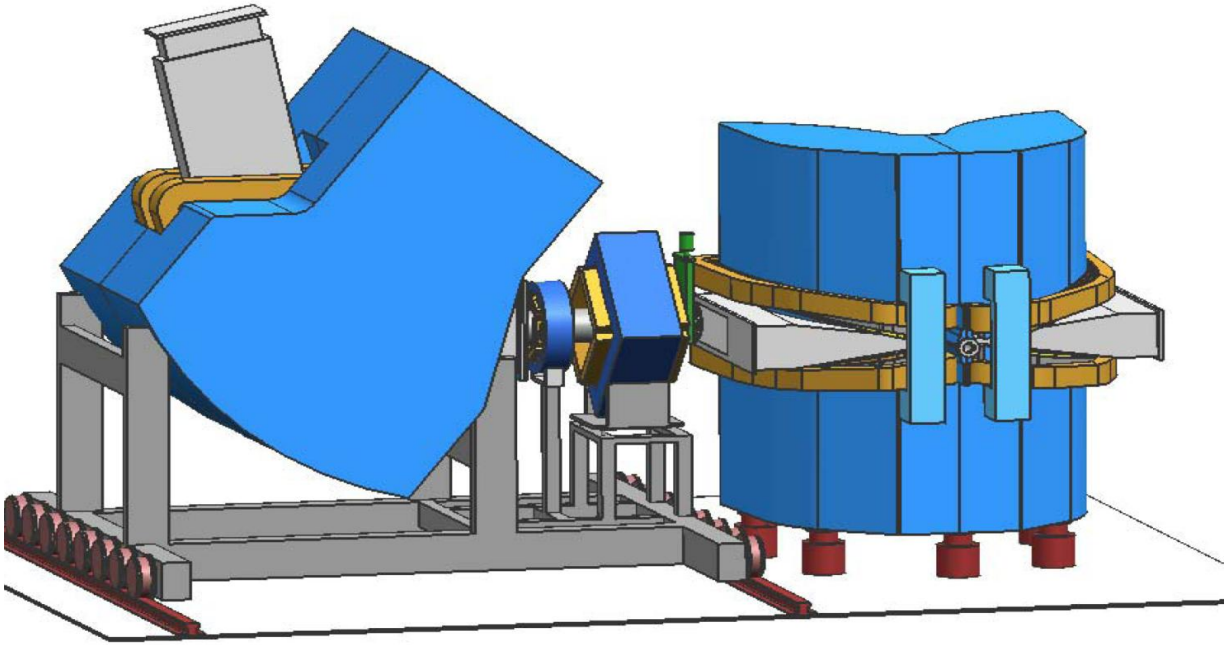


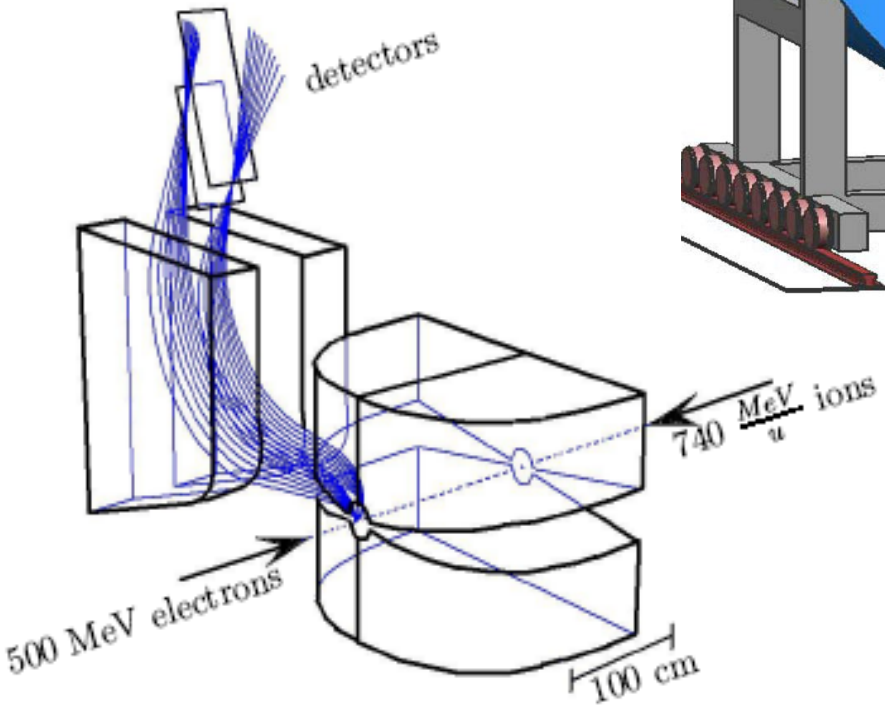
What happens at the IP?



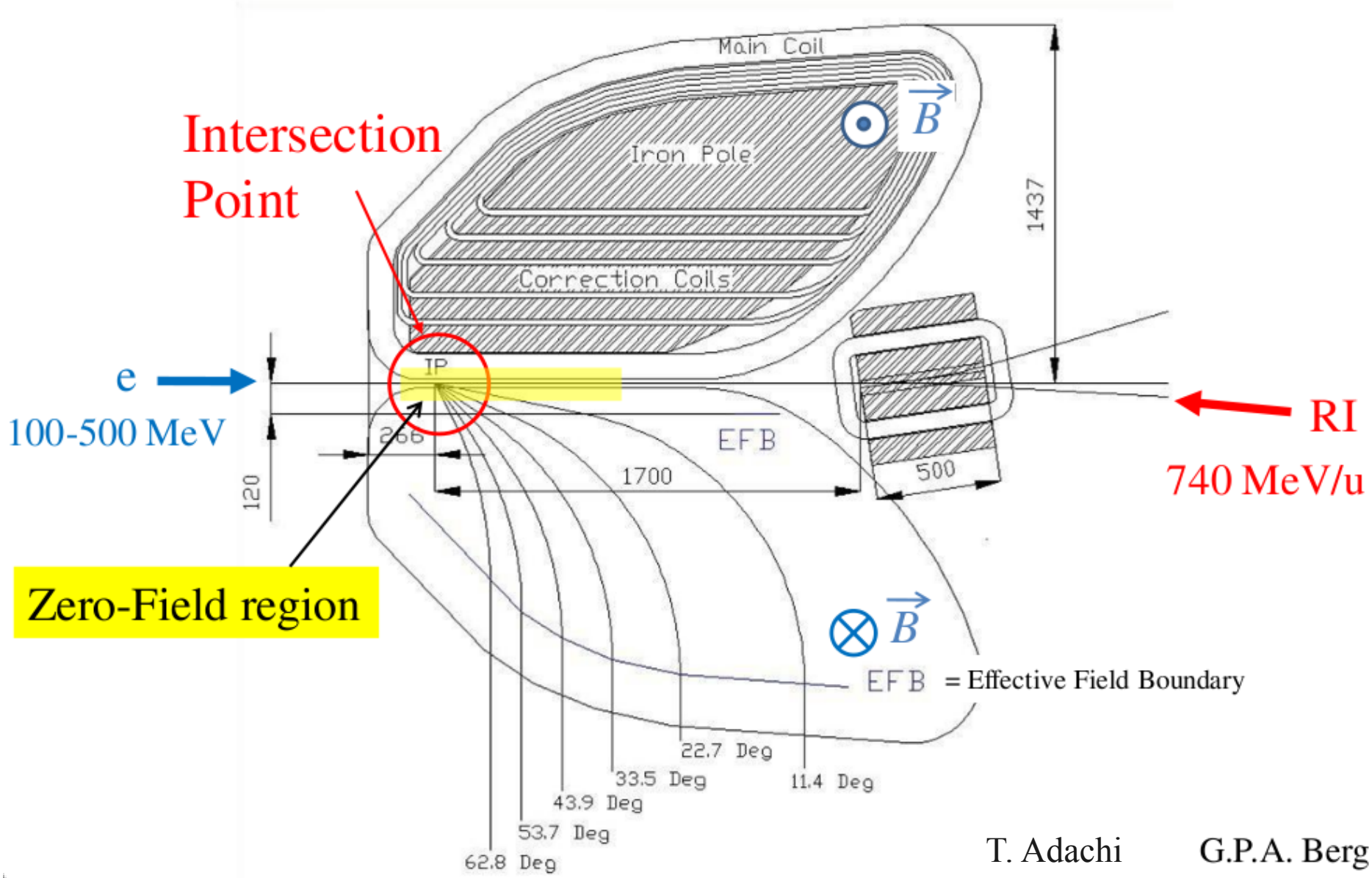


Electron Spectrometer



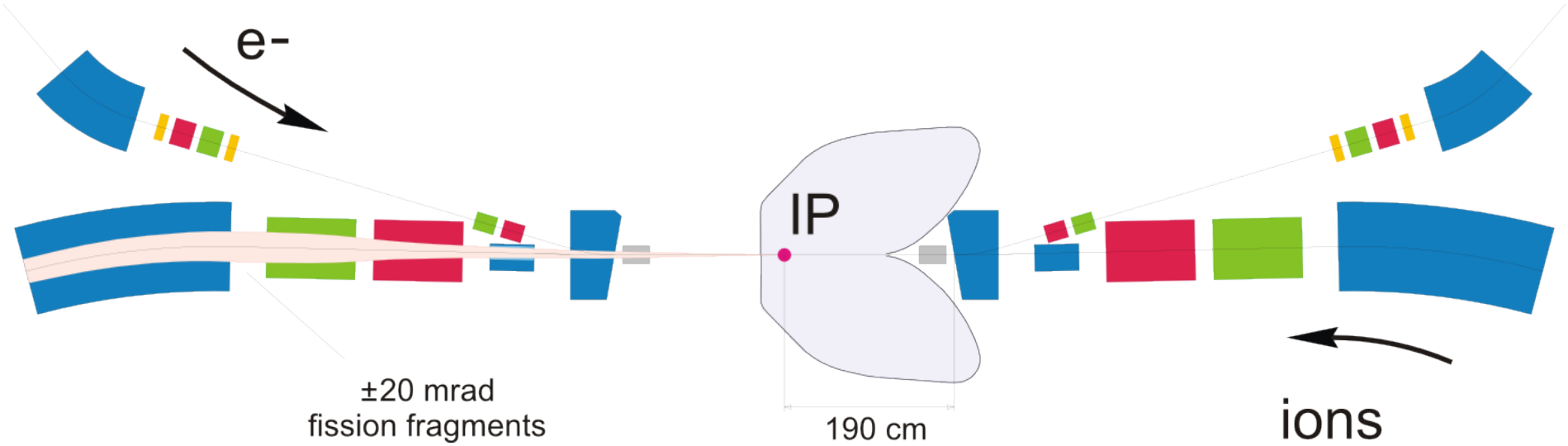


Pre-deflector in Midplane

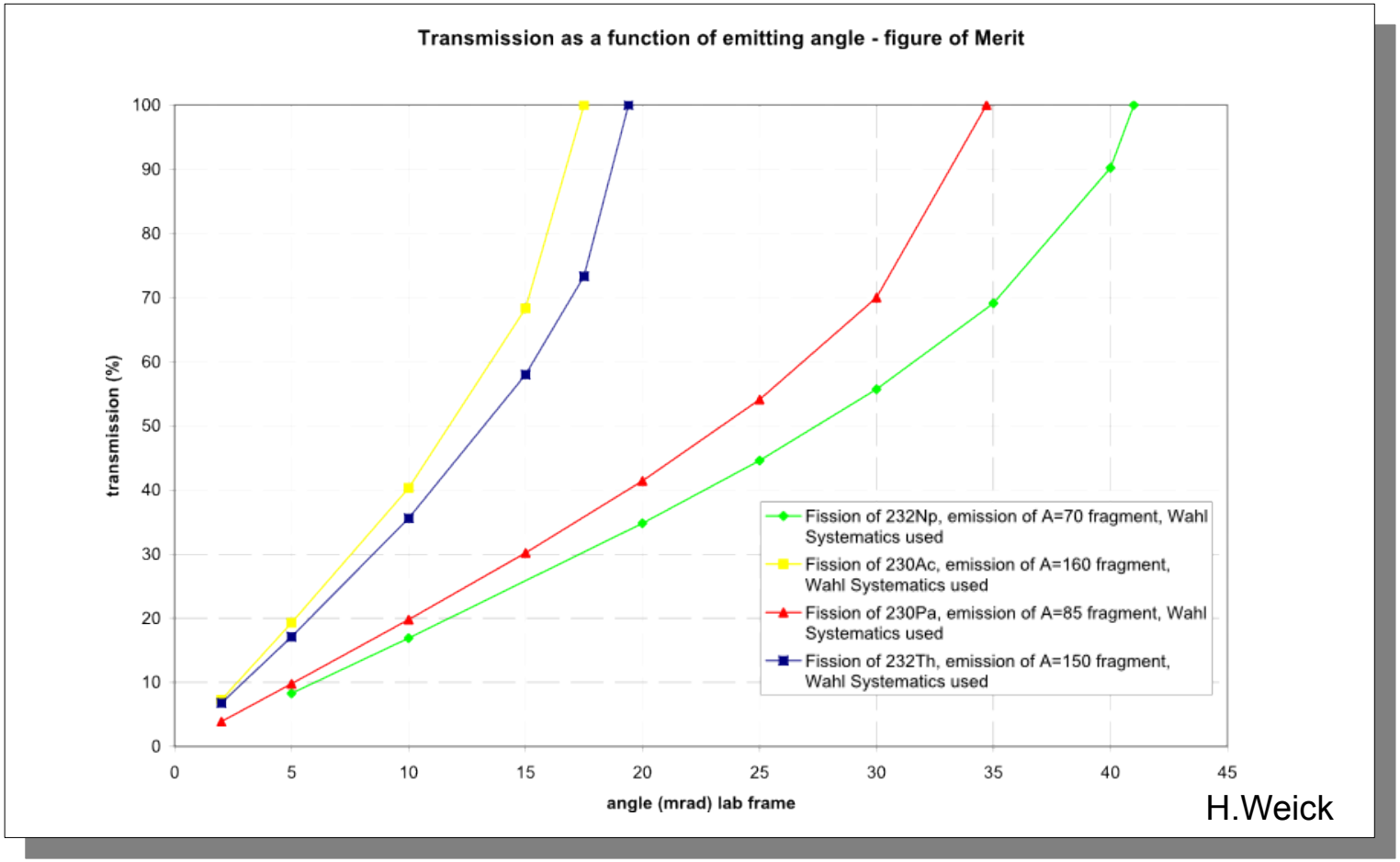


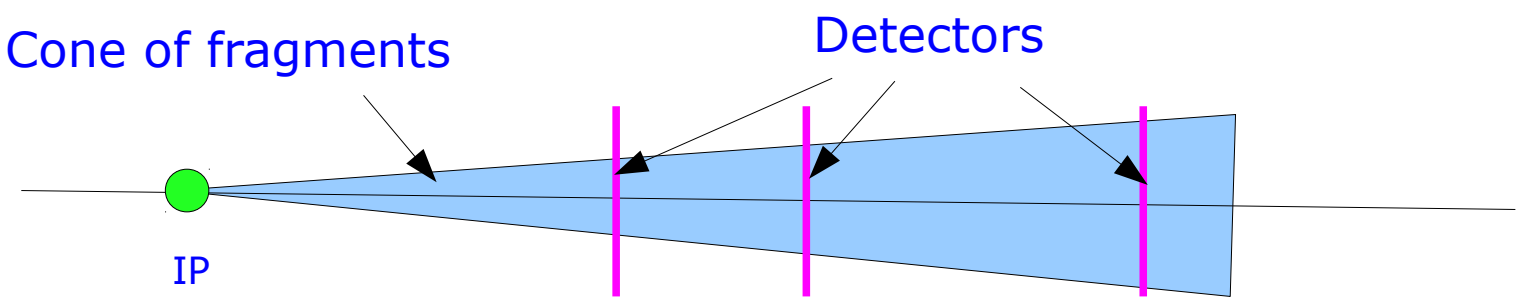
T. Adachi G.P.A. Berg

IP Region with fission option

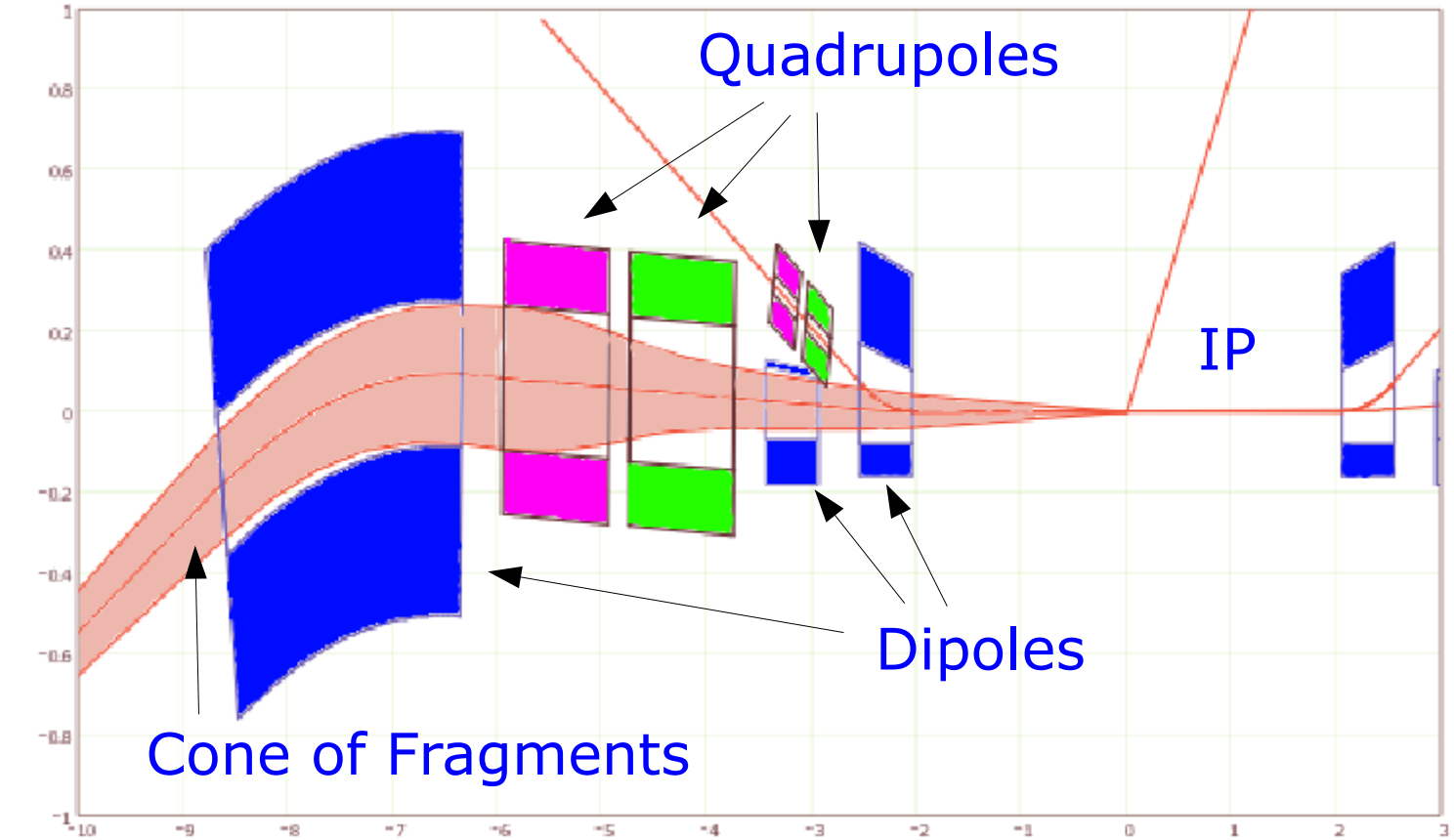


Demands for open angle

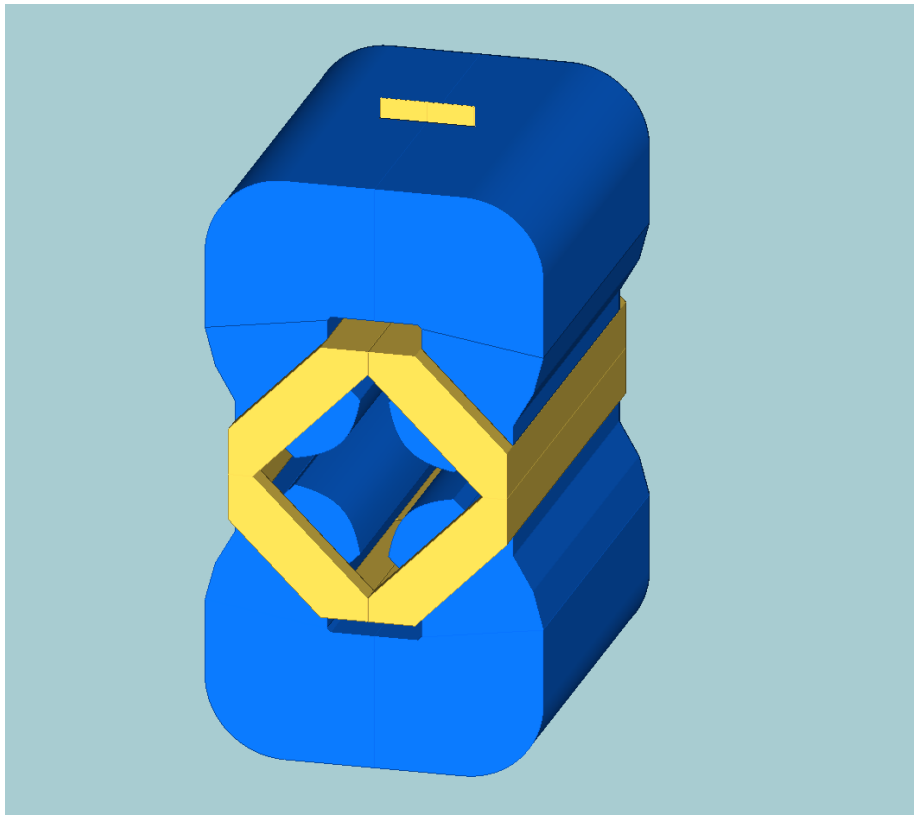


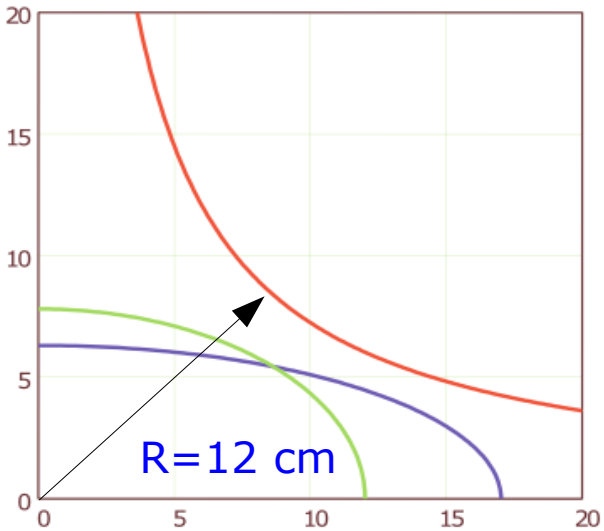


Fragments with angle deviation passing through the structure



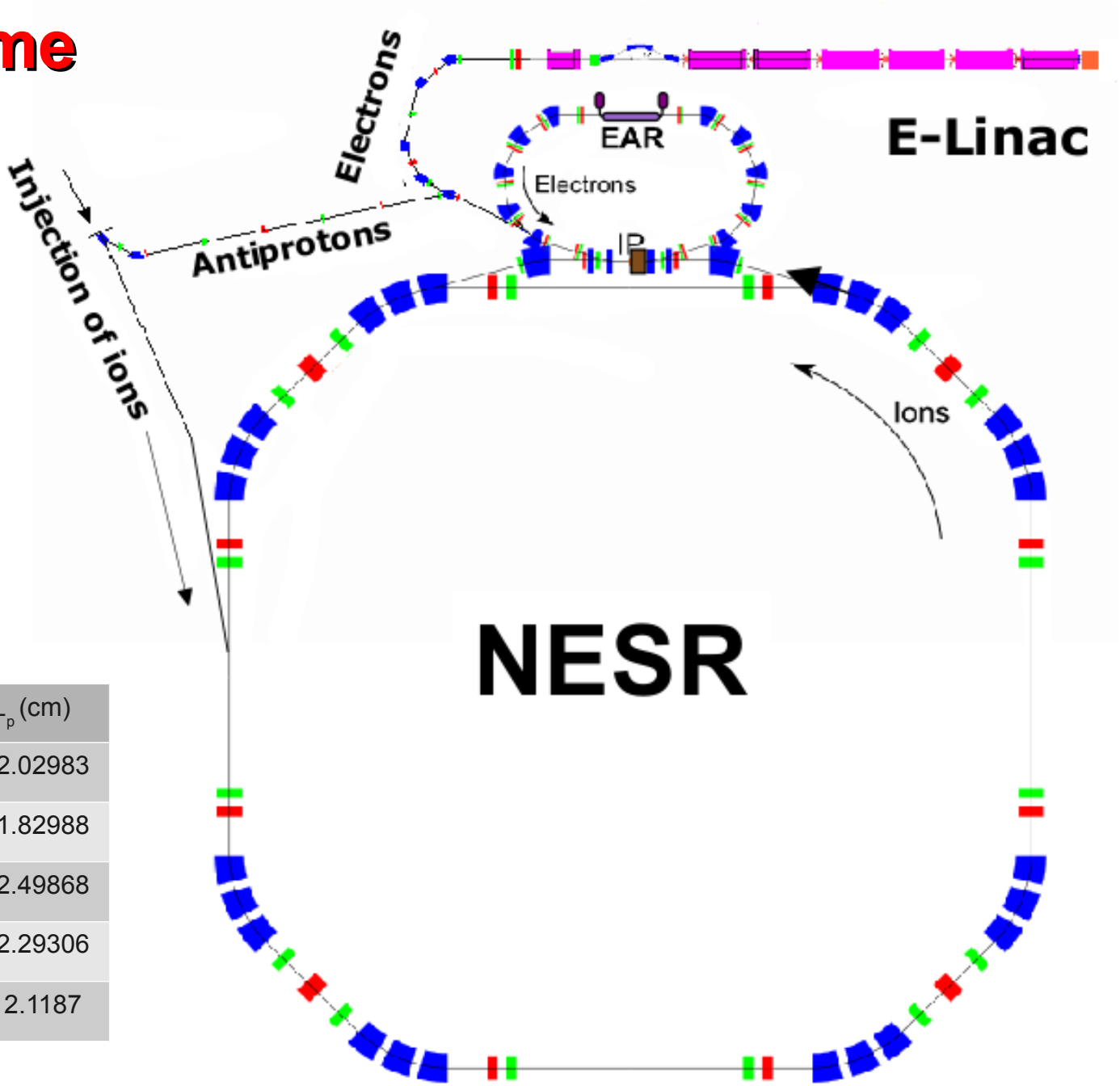
NESR final focusing quadrupole





Inner Radius	12 cm
Current	60kA*turns
Magnetic field gradient	8.5 T/m
Length	90 cm
Height	155cm
Width	100cm

NESR scheme



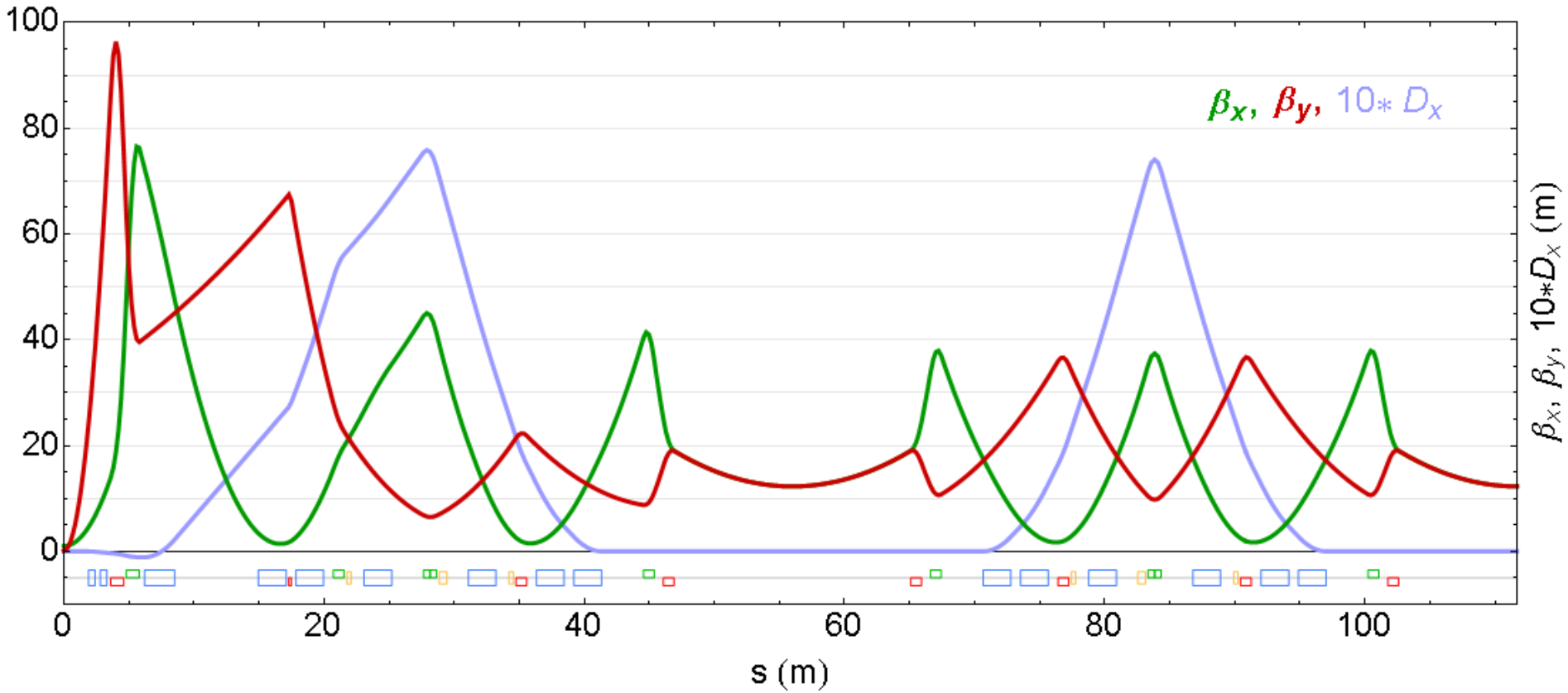
Fi·ni = Fe·ne

β_i	T(MeV/u)	n_i	n_e	L_p (cm)
0.8303	740.0	40	12	2.02983
0.6919	358.7	48	12	1.82988
0.5931	225.4	56	8	2.49868
0.5190	158.2	64	8	2.29306
0.4613	118.4	72	8	2.1187

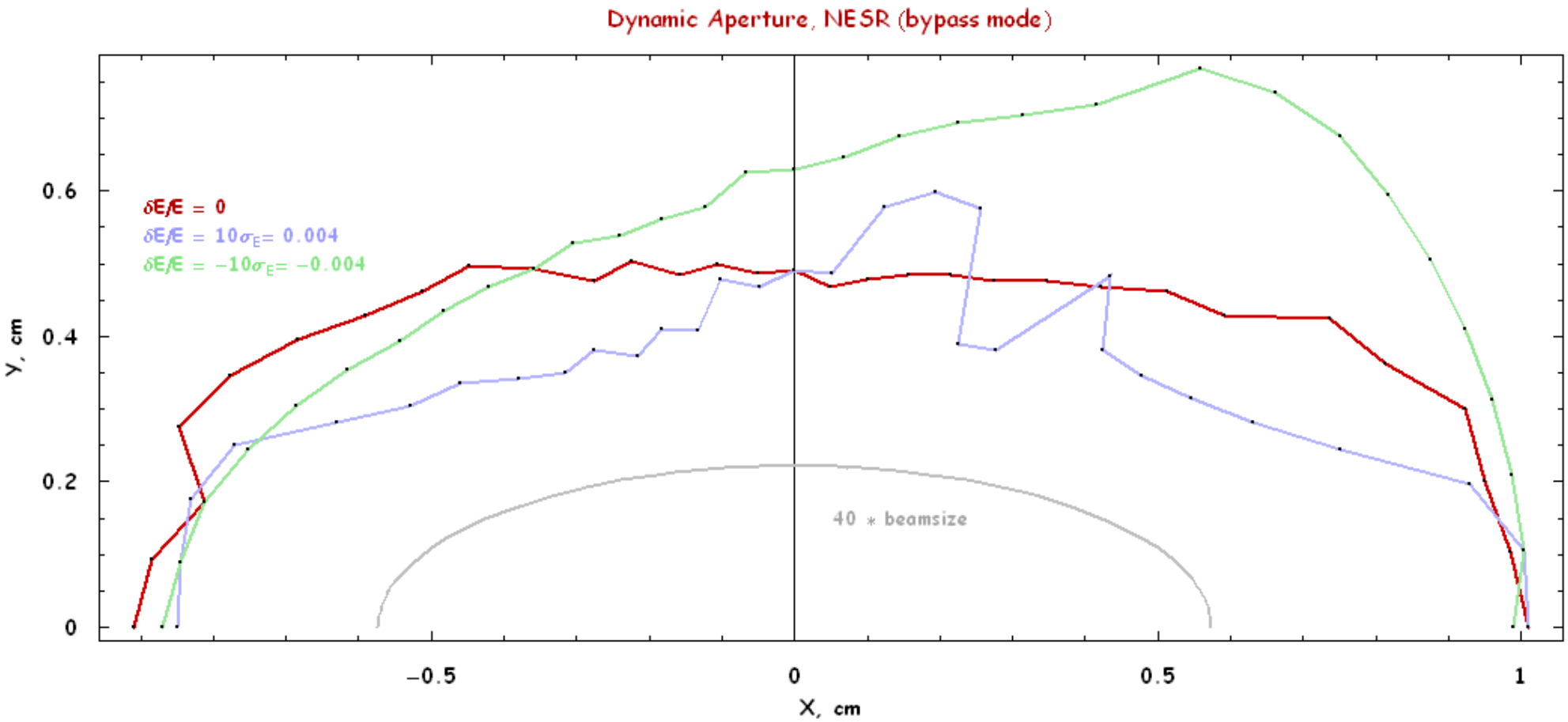
General parameters of the elecron-nucleus collider

	Units	Electon ring	Ion ring
Circumference	*m*	53.693	222.916
Energy	*GeV,GeV/u*	0.500	0.740
Revolution frequency	*MHz*	5.583	1.117
Betatron tunes, ν_x, ν_z		4.2,3.2	3.55,2.55
Compaction factor, α		0.049	0.036
Bending Radius	*m*	1.75	8.125
Number of bunches		8	44
Bunch to bunch spacing		6.7	5.58
Bunch population		$5\cdot10^{10}$	$0.86\cdot10^{7}$
Beam currents	*mA*	358	5.65
Damping time, τ	*ms*	73	20
Beam emittances, $\varepsilon_{x,z}$	*μm·mrad*	47.6	50
Beta functions at IP, $\beta_{x,z}$	*cm*	100,15	100,15
Beam size at IP, $\sigma_{x,z}$	*μm*	210,85	220,87
Momentum spread, $\sigma_{\Delta p/p}$		0.00036	0.0004
Bunch length, σ_s	*cm*	4	15
Beam-beam parameters, $\xi_{x,z}$		0.005,0.002	0.044,0.017
Laslett tune shift, Δu			0.08
Luminosity	$cm^{-2}s^{-1}$	$1\cdot10^{28}$	

NESR structure funtions with fission option

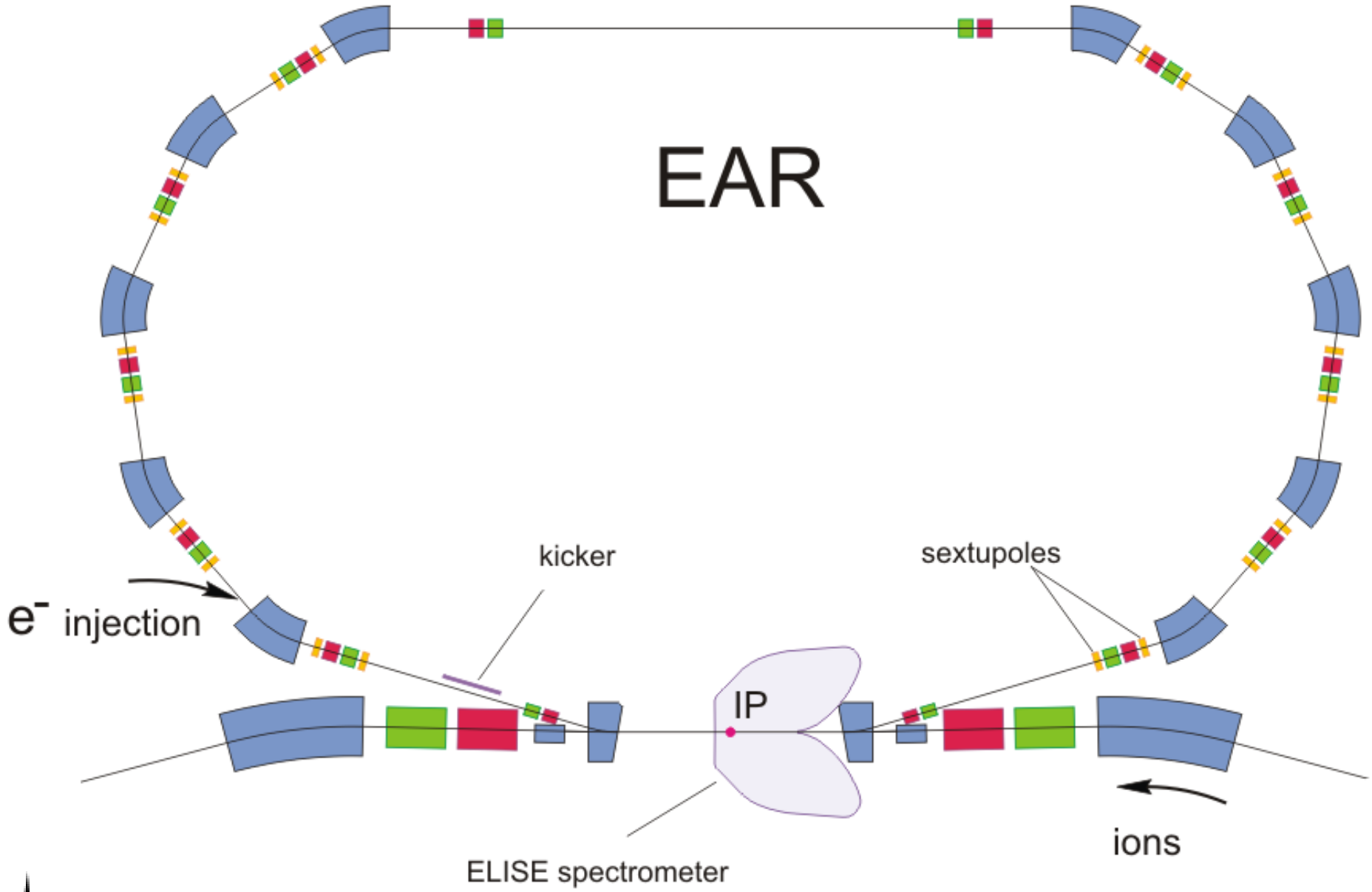


Dynamic aperture simulations



D.Shwartz

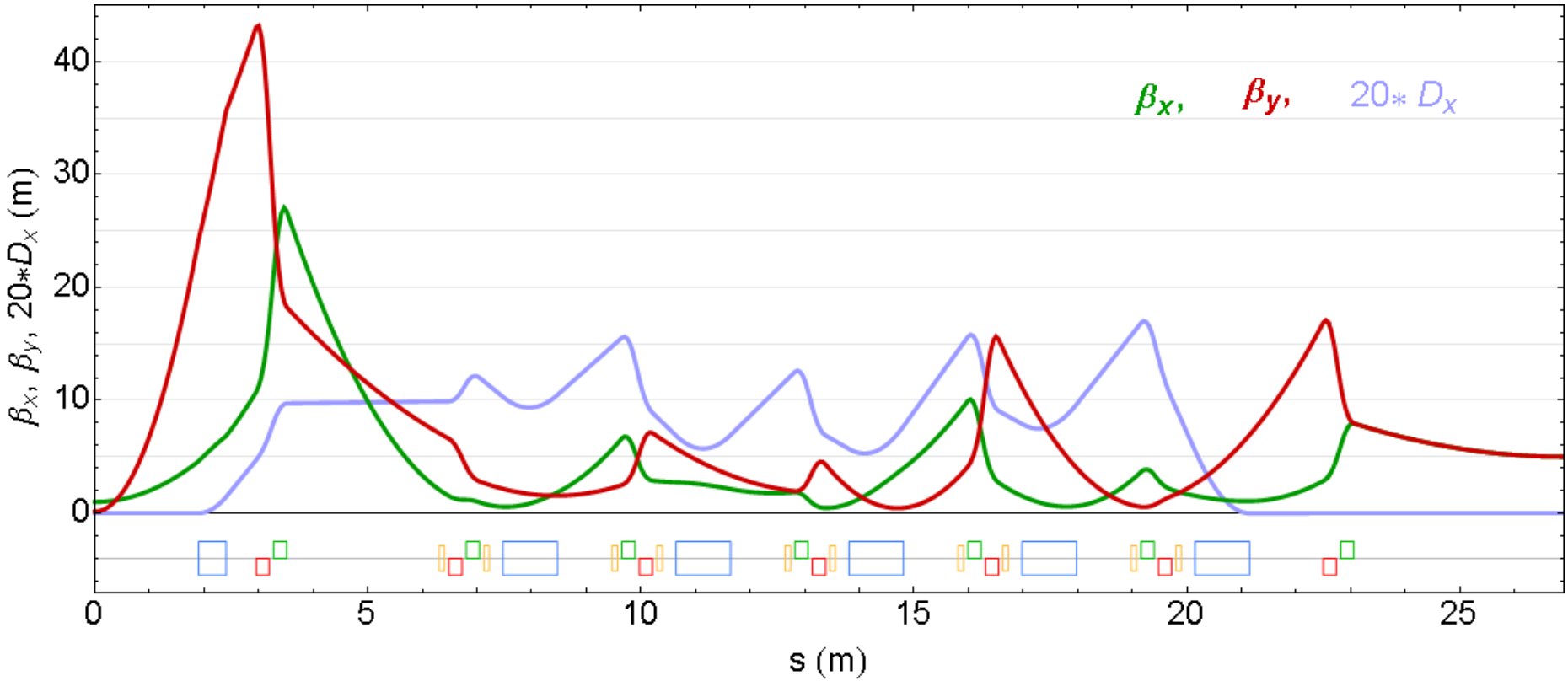
The Electron Ring



Parameters of ER

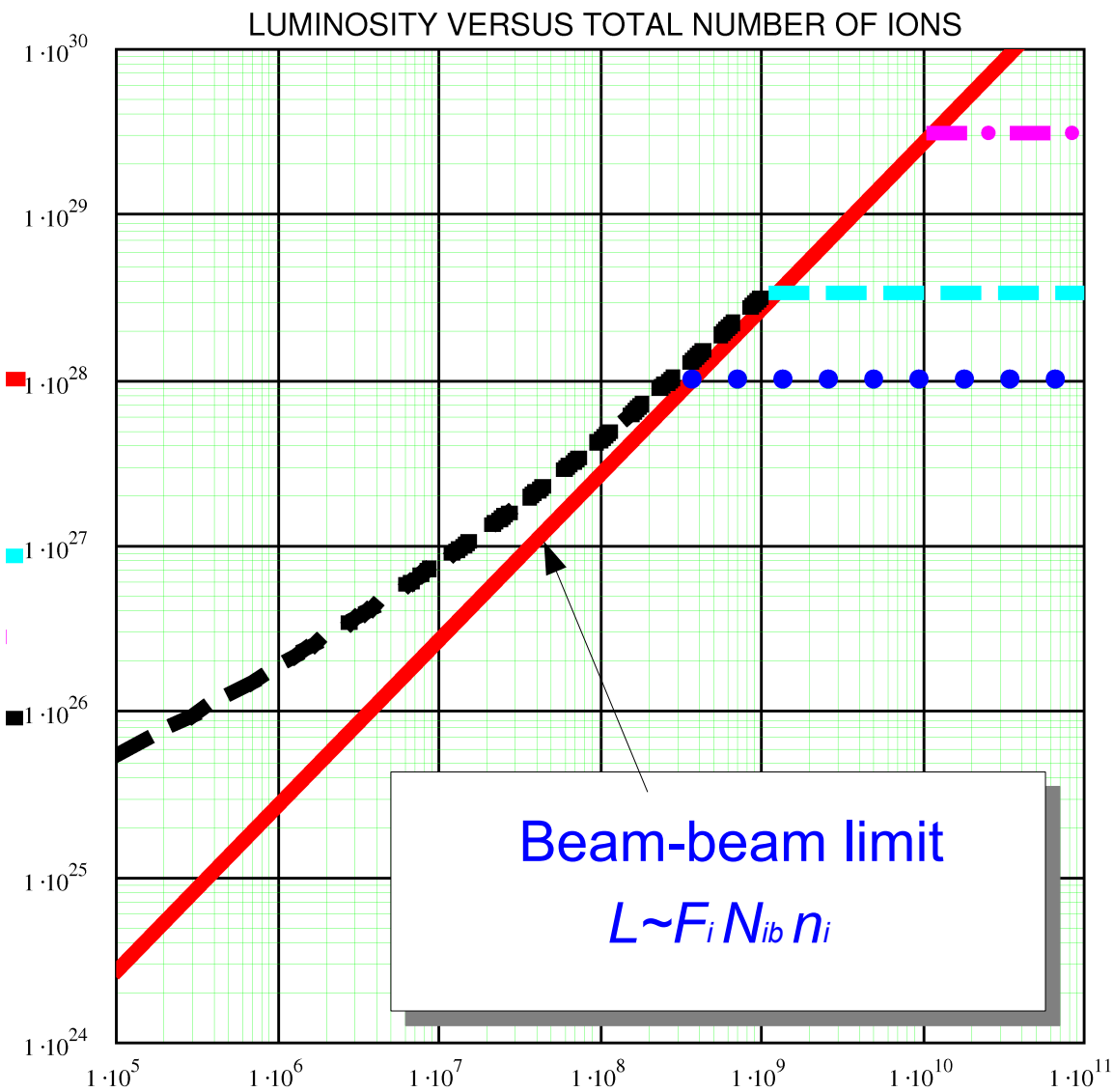
Energy, E	125 - 500 MeV
Revolution frequency, f_0	5.5717 MHz
RF harmonic number, q	24
Number of bunches	8
Bunch population	$5 \cdot 10^{10}$
Betatron tunes, ν_x, ν_y	4.2, 3.2
Beta functions in IP, β^*_x, β^*_y	100 cm, 15 cm
Beam emittances, $\varepsilon_{x,y}$	$2.4 \cdot 10^{-6}$ cm·rad
Beam sizes in IP, σ_x, σ_y	0.15mm, 0.06mm
Bunch length, σ_s	4 cm
Momentum compaction, α_p	0.034
Momentum spread, $\sigma_{\Delta p/p}$	$3.2 \cdot 10^{-4}$
Damping time, τ_x	70 ms

Structure functiond of ER



D.Shwartz

Luminosity considerations



$$L = F_e n_e \frac{N_{eb} N_{ib}}{4\pi\sigma_x\sigma_z} \qquad (1)$$

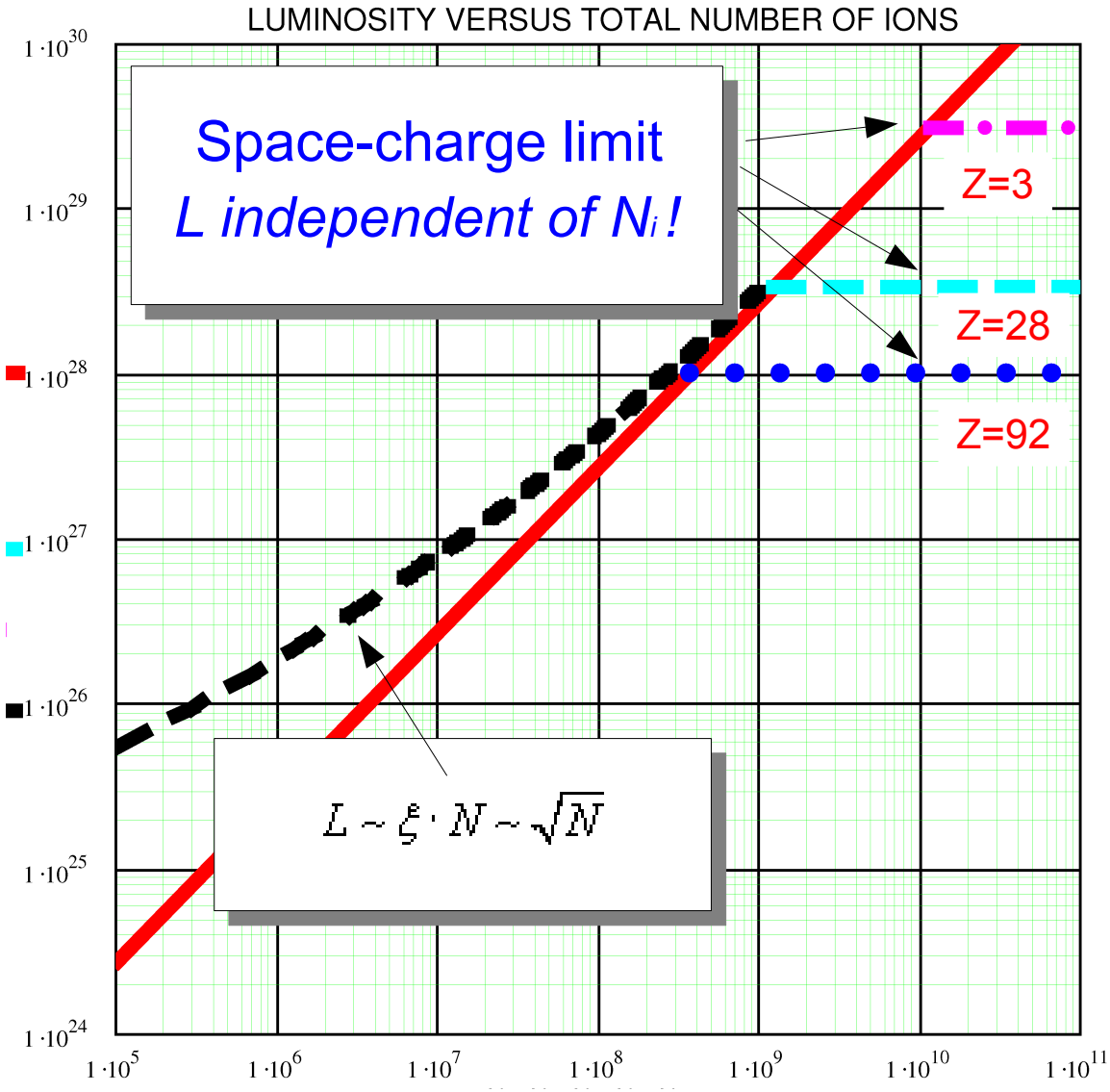
$$\xi_{ix} = \frac{Z}{A}\cdot\frac{N_{eb} r_p \beta_x}{2\pi\gamma_i \beta_i (\sigma_x+\sigma_z)\sigma_x}$$
$$\xi_{iz} = \frac{Z}{A}\cdot\frac{N_{eb} r_p \beta_z}{2\pi\gamma_i \beta_i (\sigma_x+\sigma_z)\sigma_z} \qquad (2)$$

$$\xi_{max} = (3\div 5)\cdot\lambda^{1/3} \qquad \xi_{ix} = 0.05 \qquad (3)$$

$$\frac{N_{eb}}{2\pi\sigma_x\sigma_z} = \frac{A}{Z}\cdot\frac{\xi_{ix}\gamma_i\beta_i}{\sqrt{\beta_x\beta_z}}\cdot\left(1+\frac{\sigma_z}{\sigma_x}\right) \qquad (4)$$

$$L_t = F_i n_i \cdot \frac{A}{Z}\cdot\left(1+\frac{\sigma_z}{\sigma_x}\right)\cdot\frac{N_{ib}\xi_{ix}\gamma_i\beta_i}{2r_p\sqrt{\beta_x\beta_z}} \qquad (5)$$

Luminosity considerations



$$\Delta\nu = \frac{Z^2}{A} \cdot \frac{N_{ib} r_p}{\gamma_i^3 \beta_i^2 \varepsilon} \cdot \frac{R}{2\sqrt{2\pi}\sigma_s} \qquad (6)$$

$$\varepsilon = \frac{Z^2}{A} \cdot \frac{N_{ib} r_p}{\gamma_i^3 \beta_i^2 \Delta\nu} \cdot \frac{R}{2\sqrt{2\pi}\sigma_s} \qquad (7)$$

$$L_{Ne} = F_e n_e \cdot \frac{A}{Z^2} \cdot \frac{N_{eb} \Delta\nu \gamma_i^3 \beta_i^2}{4\pi r_p \sqrt{\beta_x \beta_z}} \cdot \frac{2\sqrt{2\pi}\sigma_s}{R}$$

$$\xi_{xi} = \frac{1}{Z} \cdot \frac{N_{eb}}{N_{ib}} \cdot \frac{\Delta\nu \gamma_i^2 \beta_i}{2\pi\left(1 + \frac{\sigma_z}{\sigma_x}\right)\sqrt{\beta_x \beta_z}} \cdot \frac{2\sqrt{2\pi}\sigma_s}{R} \qquad (8)$$

Luminosity considerations

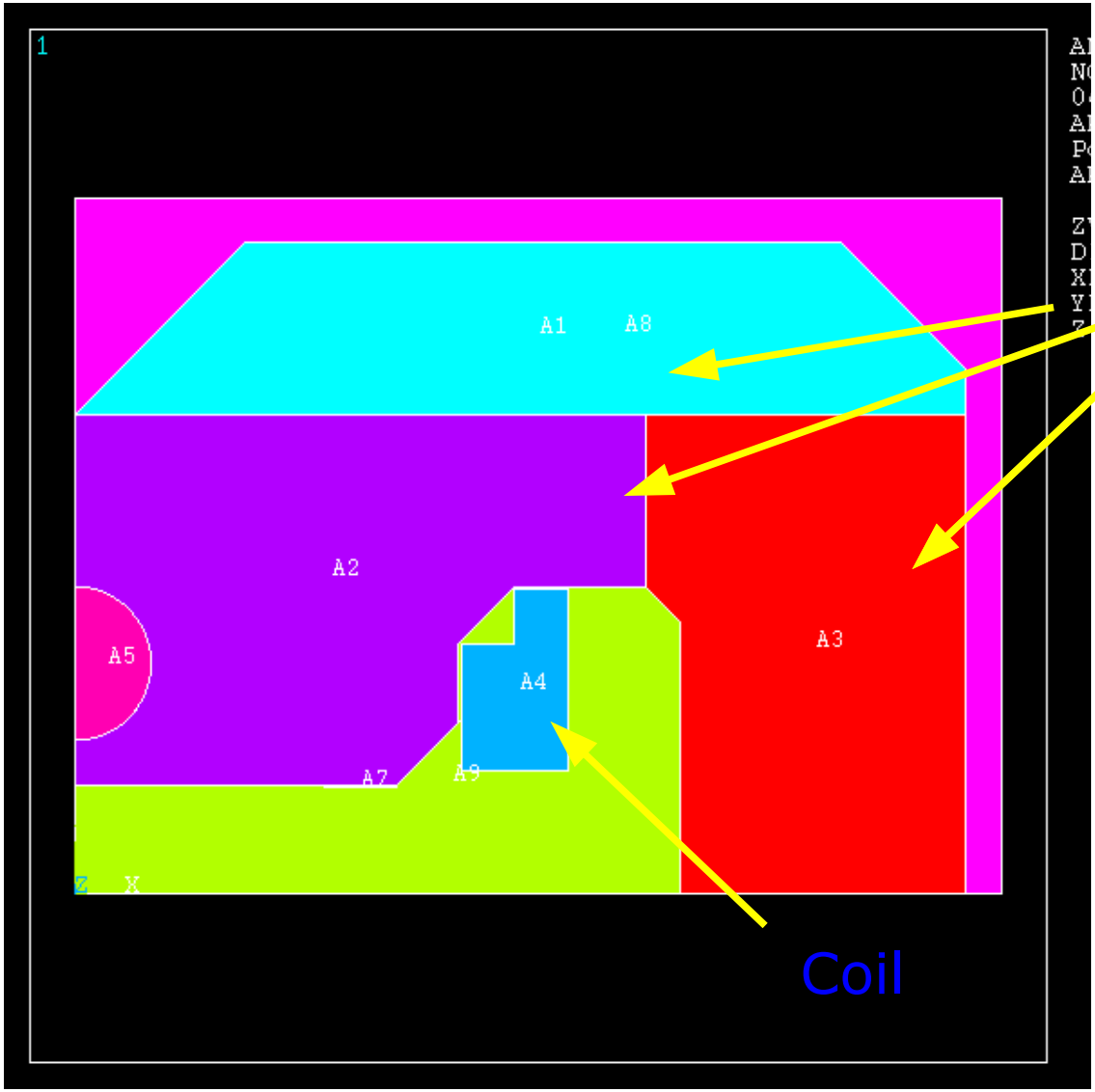
Element	$T_{1/2}$, s	N_{shot}	$\langle N \rangle$	$L, cm^{-2}s^{-1}$
$^{11}Be^{4+}$	13.8	$6\cdot10^{8}$	$2.1\cdot10^{10}$	$2.4\cdot10^{29}$
$^{35}Ar^{18+}$	1.75	$1.9\cdot10^{7}$	$8.5\cdot10^{7}$	$1.7\cdot10^{27}$
$^{55}Ni^{28+}$	0.2	$3.9\cdot10^{7}$	$2.0\cdot10^{7}$	$4.0\cdot10^{27}$
$^{71}Ni^{28+}$	2.56	$6.6\cdot10^{6}$	$4.3\cdot10^{7}$	$1.1\cdot10^{27}$
$^{93}Kr^{36+}$	1.29	$2.0\cdot10^{6}$	$6.6\cdot10^{6}$	$1.8\cdot10^{28}$
$^{132}Sn^{50+}$	39.7	$1.8\cdot10^{7}$	$1.2\cdot10^{9}$	$1.9\cdot10^{28}$
$^{133}Sn^{50+}$	1.4	$2.1\cdot10^{6}$	$7.3\cdot10^{6}$	$2.0\cdot10^{26}$
$^{224}Fr^{87+}$	198	$5.4\cdot10^{6}$	$3.2\cdot10^{8}$	$8.6\cdot10^{27}$
$^{238}U^{92+}$	10^{7}	$1.0\cdot10^{6}$	$6.0\cdot10^{10}$	$1.0\cdot10^{28}$

Thank You!

Separating magnet

B_y=10kGs

I_c=52kA



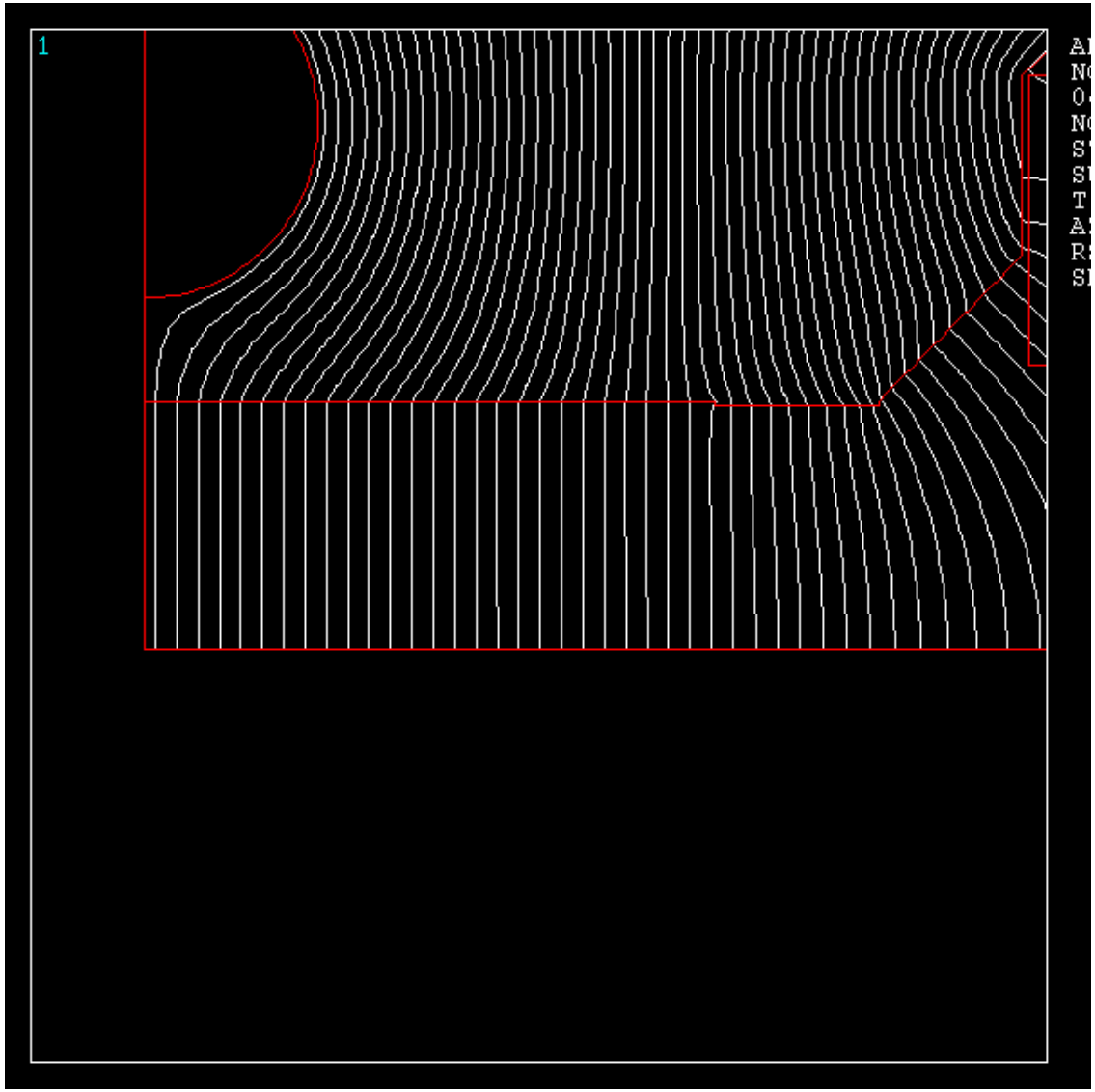
Yoke

Coil

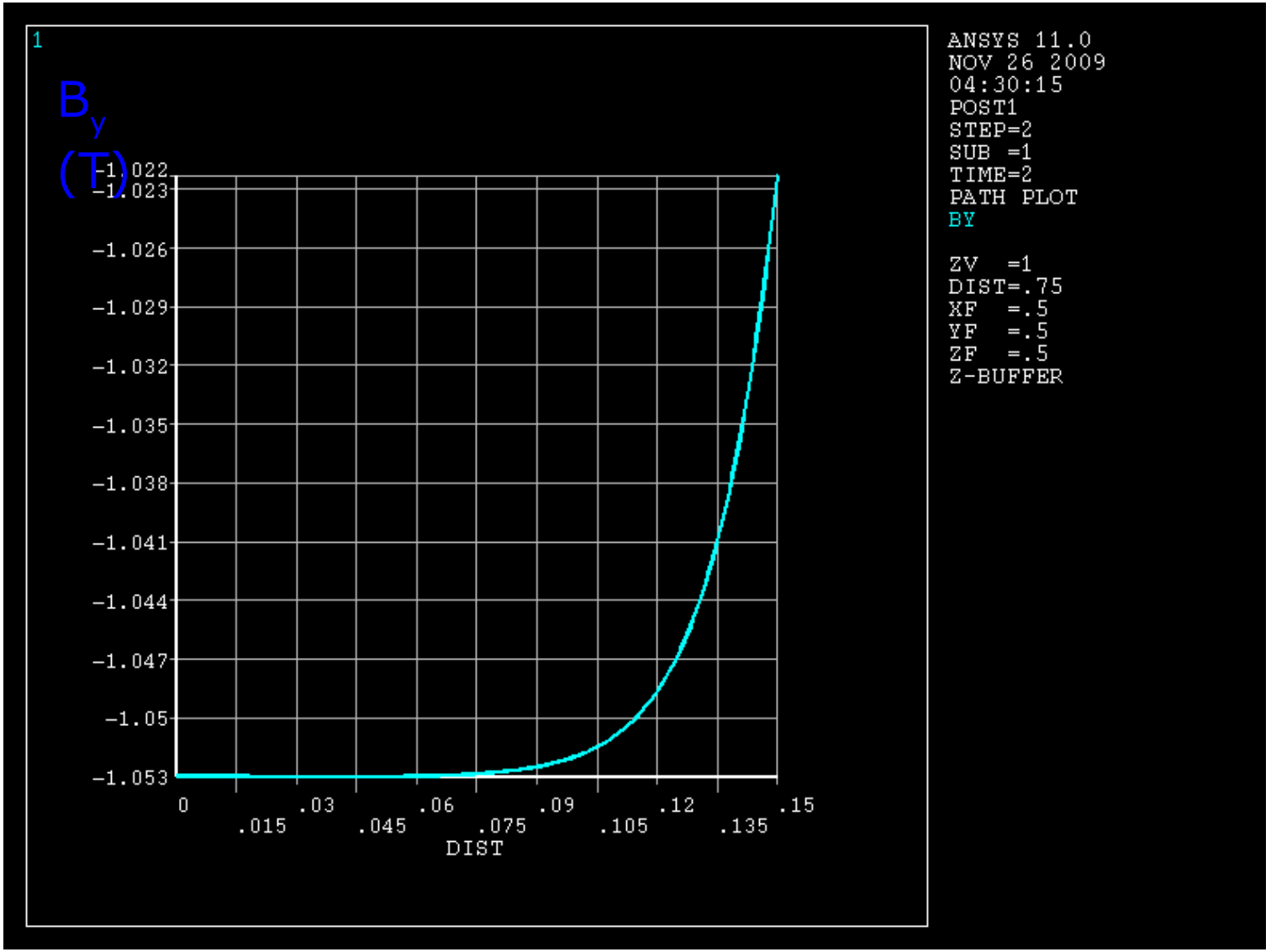
8 cm

50 cm

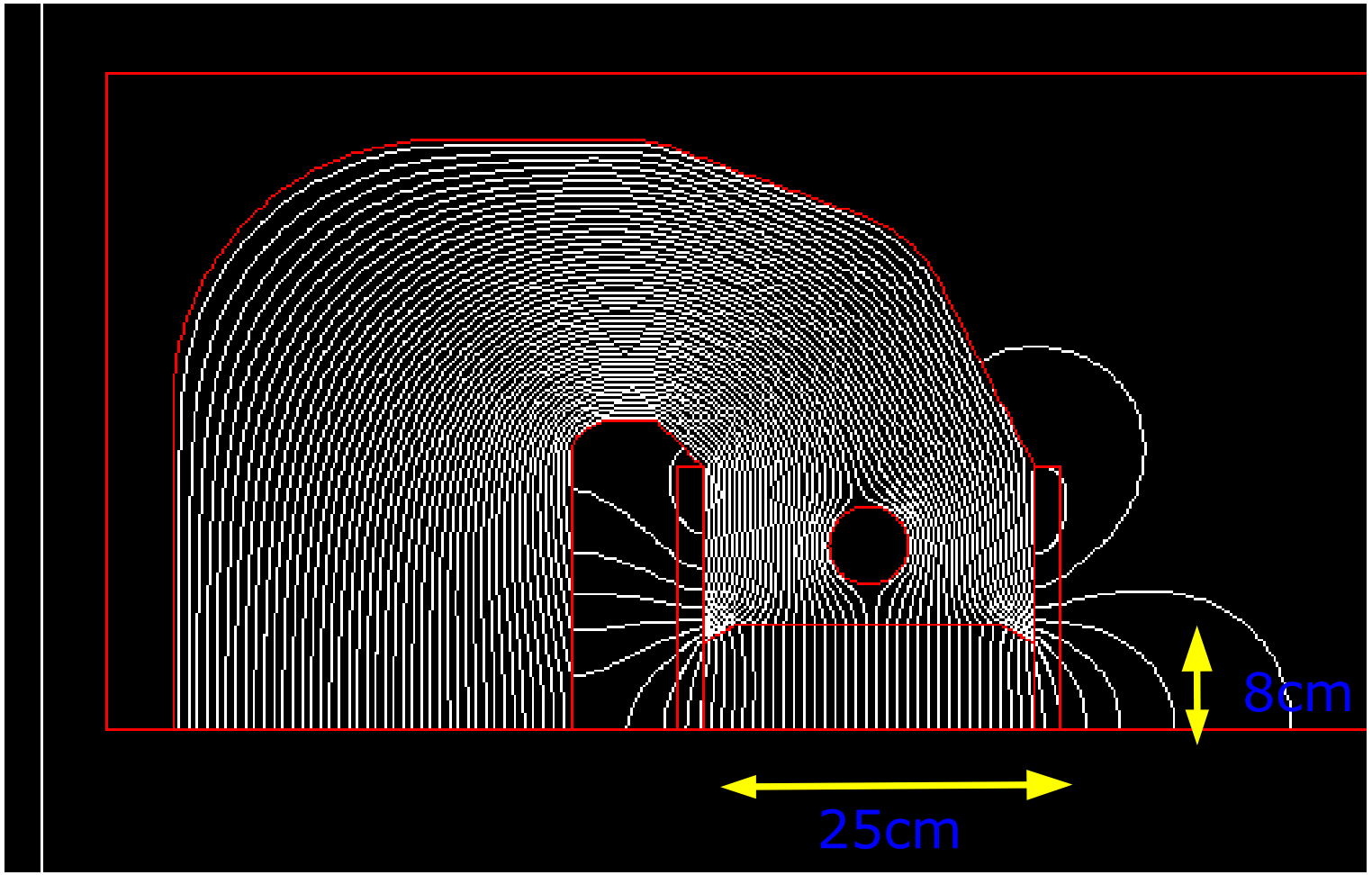
Separating magnet



Separating magnet

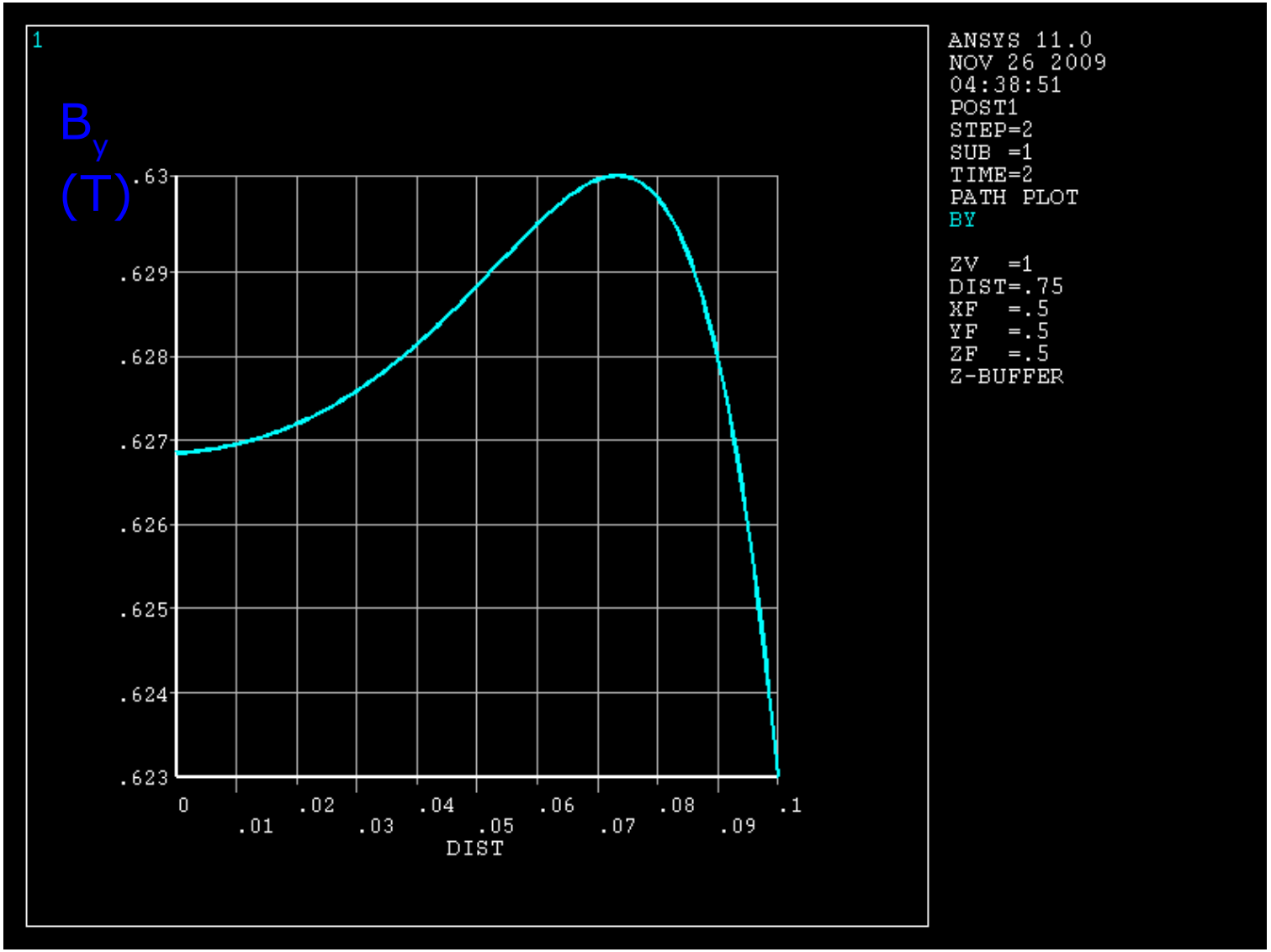


Steering magnet

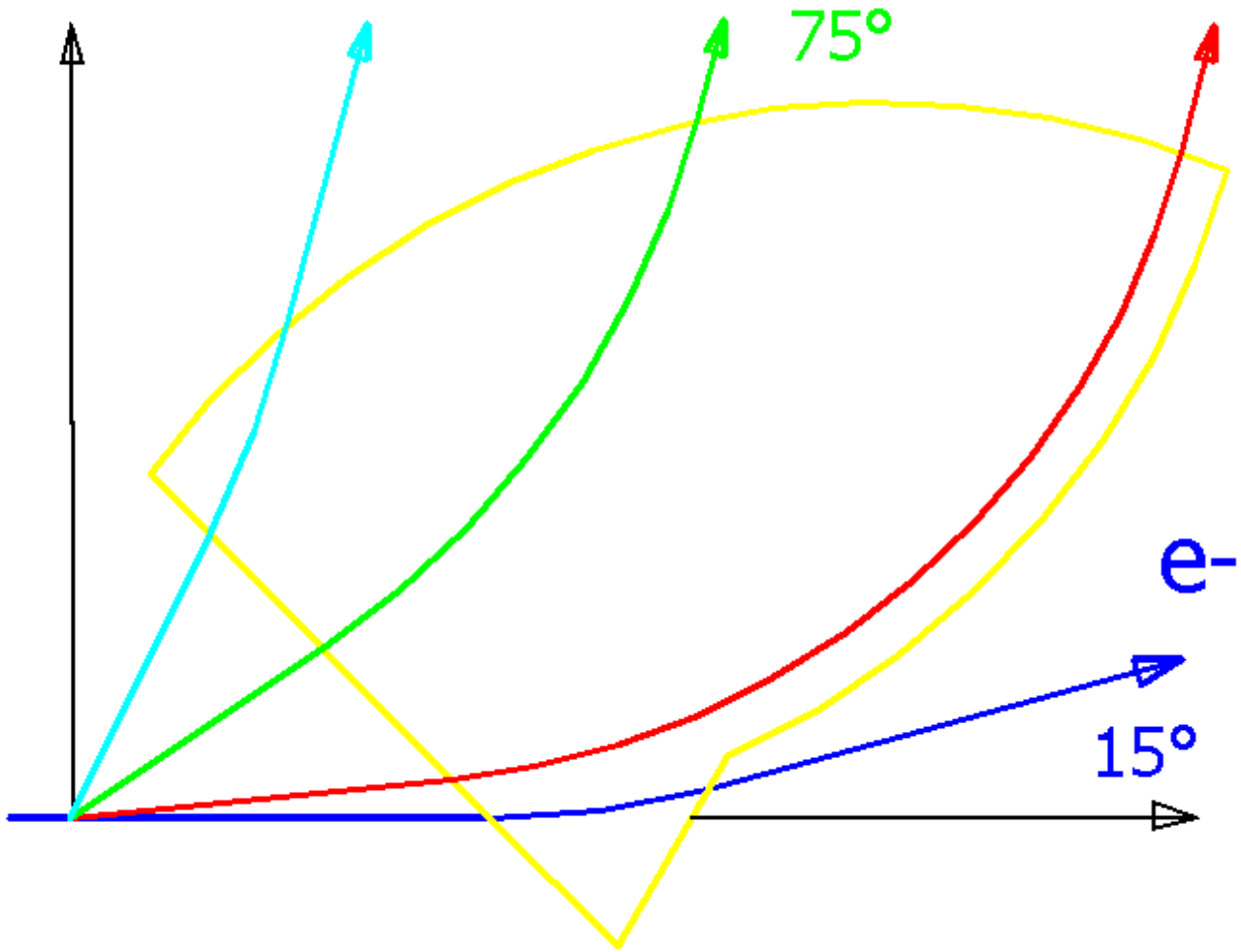


B_y=5.5kG I_c=40kA

Steering magnet



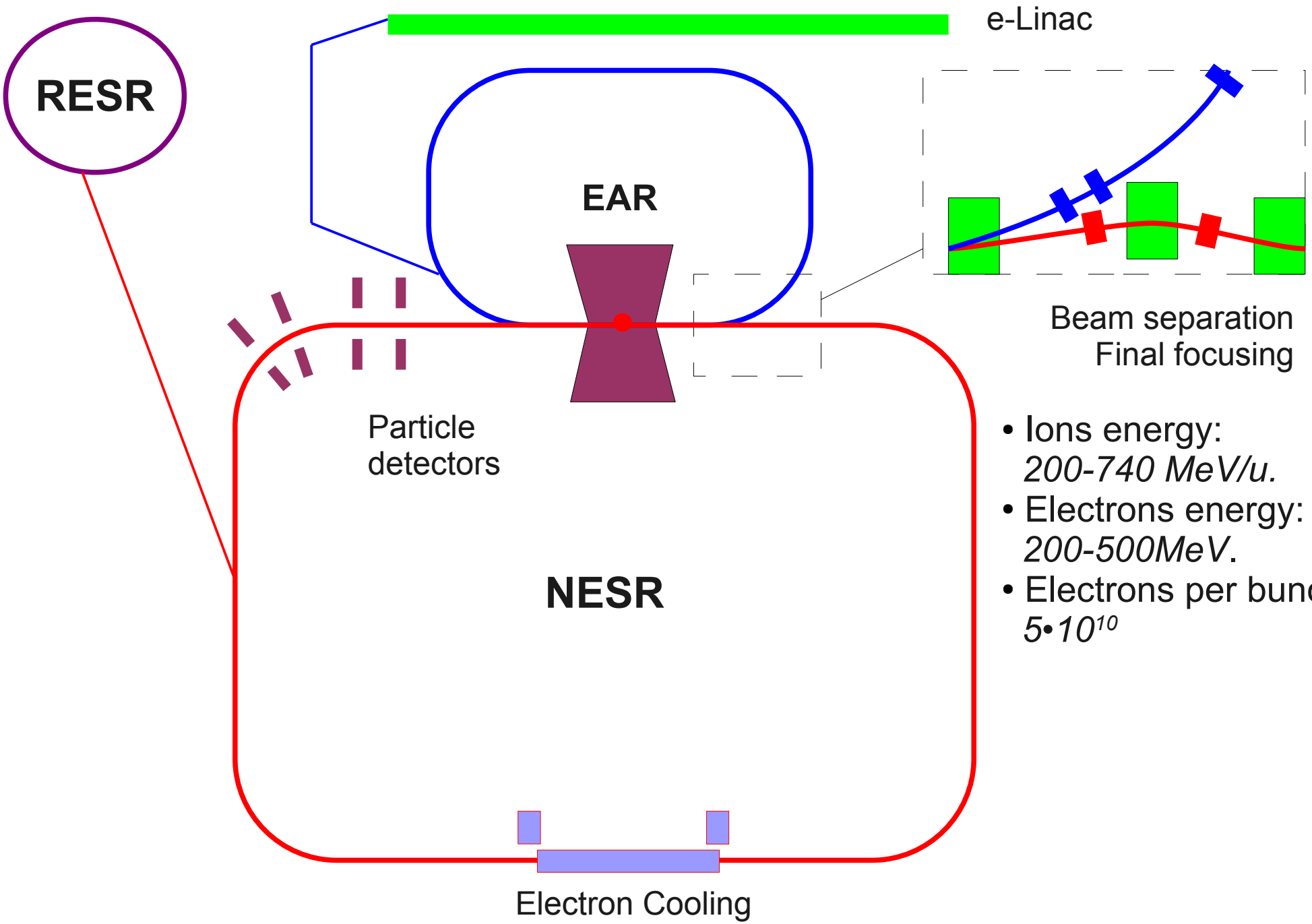
Alternatives



I.Koop

Combined deflection-separation magnet

What do we need to create a Collider?



- Ions energy: *200-740 MeV/u.*
- Electrons energy: *200-500MeV*.
- Electrons per bunch: $5 \cdot 10^{10}$