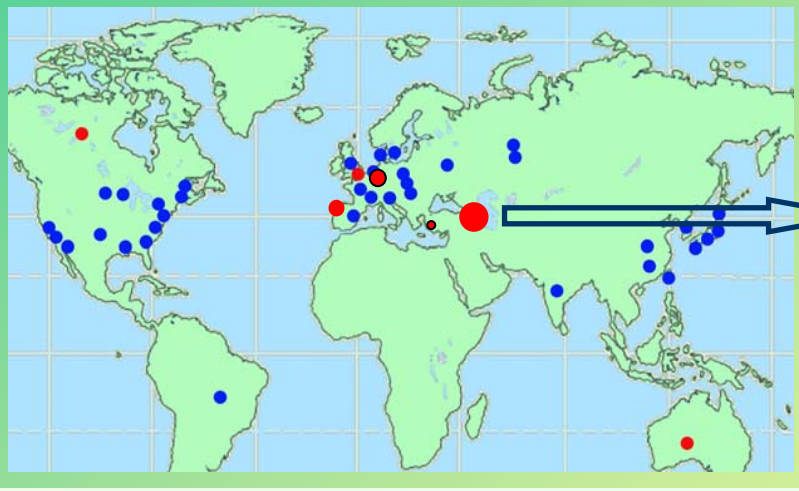
Center for the Advancement of Natural Discoveries using Light Emission



CANDLE

Armenia

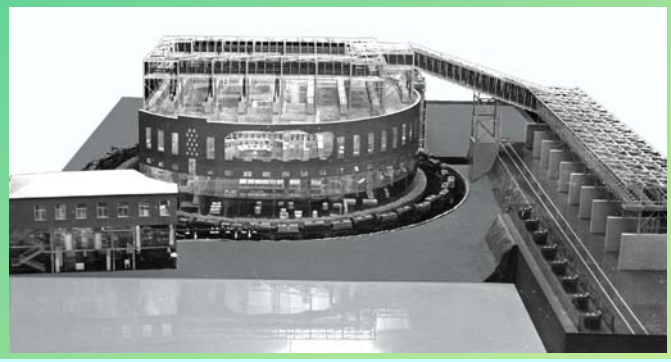
Beam Physics Issues in CANDLE Project

M. Ivanian, Yu. Martirosyan, V.Tsakanov
CANDLE, Yerevan, Armenia

ICFA FLS,15-19 May,2006, DESY,Hamburg

Pre-History

A.I. Alikhanian



Construction of 6 GeV synchrotron (1967)

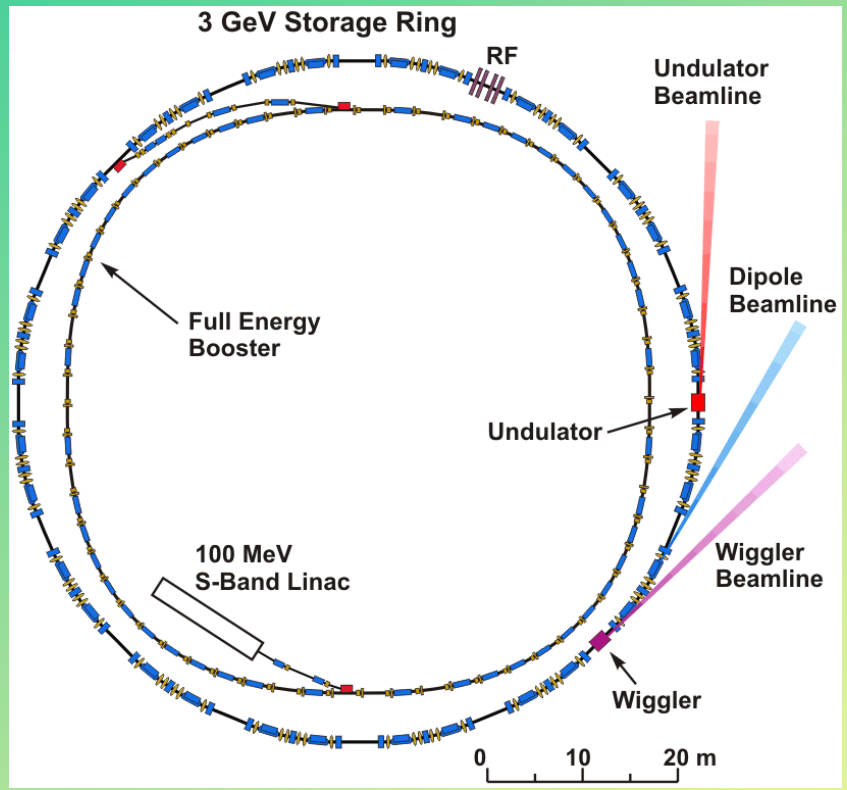
A.I. Alikhanov

01 Ihe1#2002

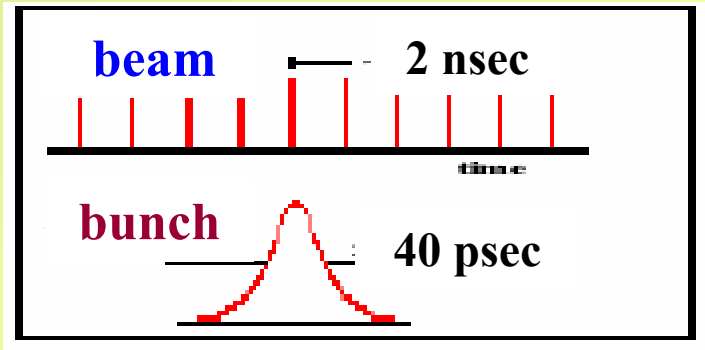
01 Mxo| 2002

Review Panel, NSF,
14-15 Aug 2002

3 GeV CANDLE Light Source



Energy	3 GeV
Current	350 mA
Circumference	216 m
Frequency	499.65 MHz
Harm. Number	360
Periods No	16
Straight section	4.8m
Lattice type	DBA
Emittance	*8.4 nm*
Beam lifetime	*18.4 hours*



Time structure

Storage Ring – Figure of Merit

Brightness

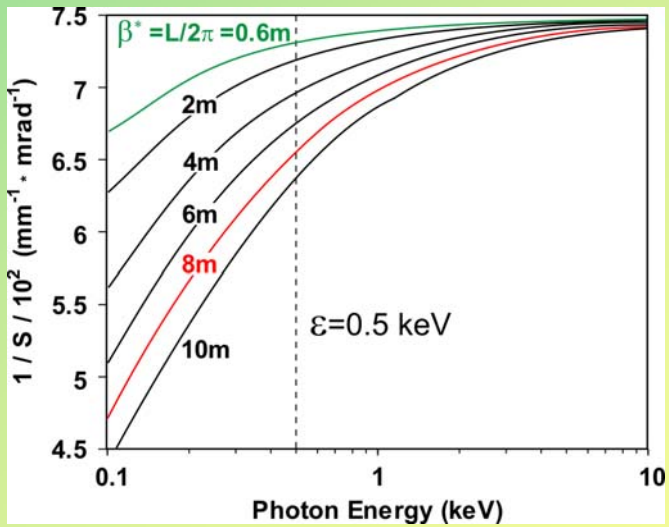
$$B = \frac{N_{ph}}{4\pi^2 \varepsilon_{px} \varepsilon_{py}}$$

Point source

$$\varepsilon_p = \sqrt{\left(\varepsilon\beta + \sigma_r^2\right)\left(\varepsilon/\beta + \sigma_{r'}^2\right)}$$

Optimal beta for diffraction limited case

$$\beta_{opt} = L_{und} / 2\pi$$



$$\varepsilon_x = 8.4\ \text{nm} \cdot \text{rad}$$

$$L_{und} = 4\text{m}$$

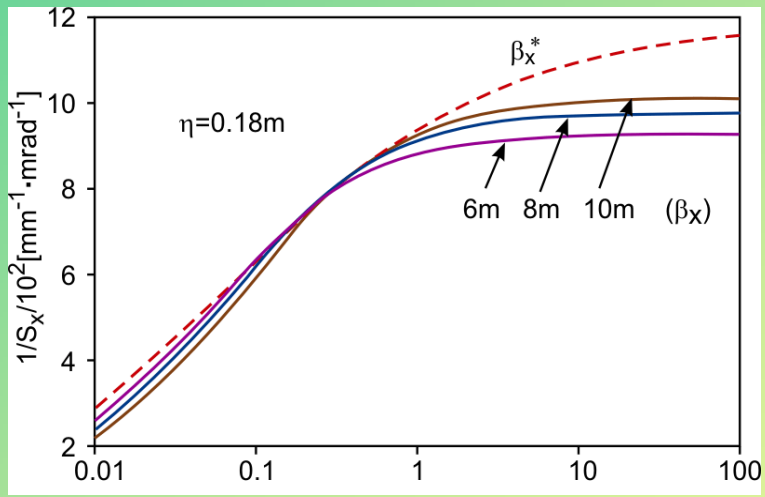
Real Beam

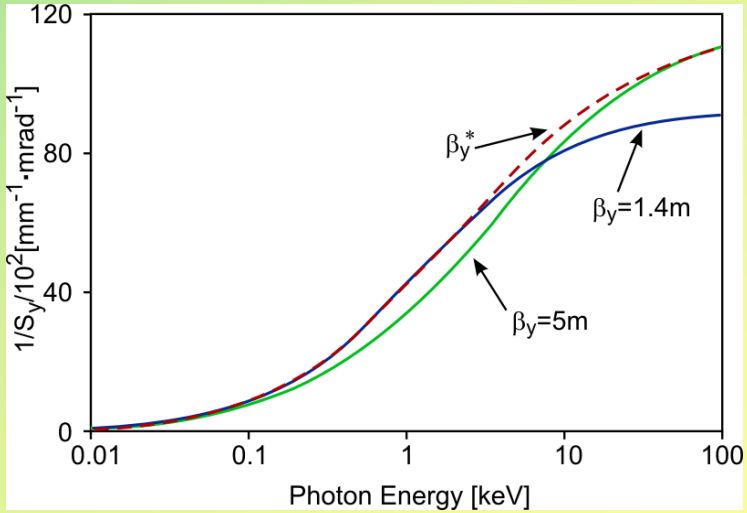
- Oscillating e-beam trajectory
- Beam size variation along undulator

H. Wiedemann, SSR, 2000.

$$\varepsilon_{ph}^2 = \varepsilon_u^2\left(1 + L^2/12\beta_u^2\right) + \varepsilon_u\sigma_{r'}^2\beta_u + \varepsilon_u\sigma_{r'}^2 p_u/\beta_u + d_u^2\sigma_{r'}^2$$

Optimal beta → $\beta_{opt} = F(\varepsilon, L, \lambda)$

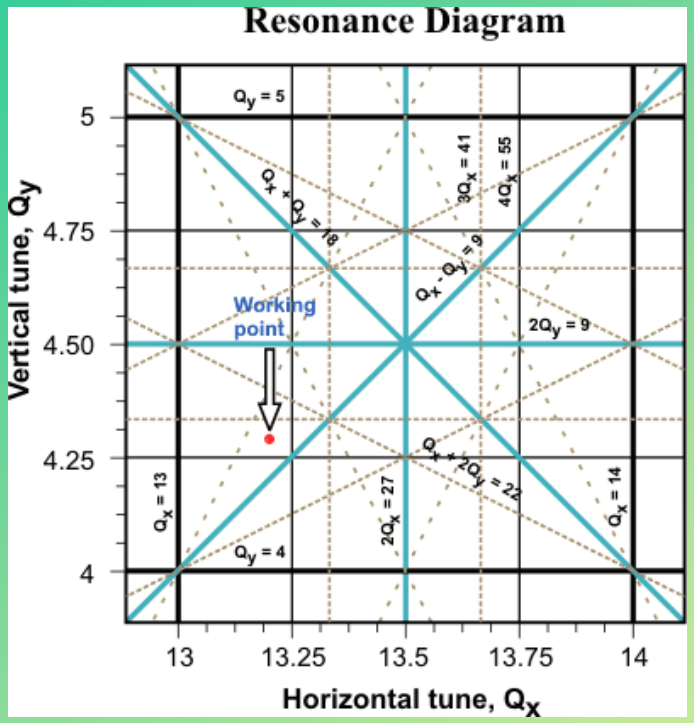


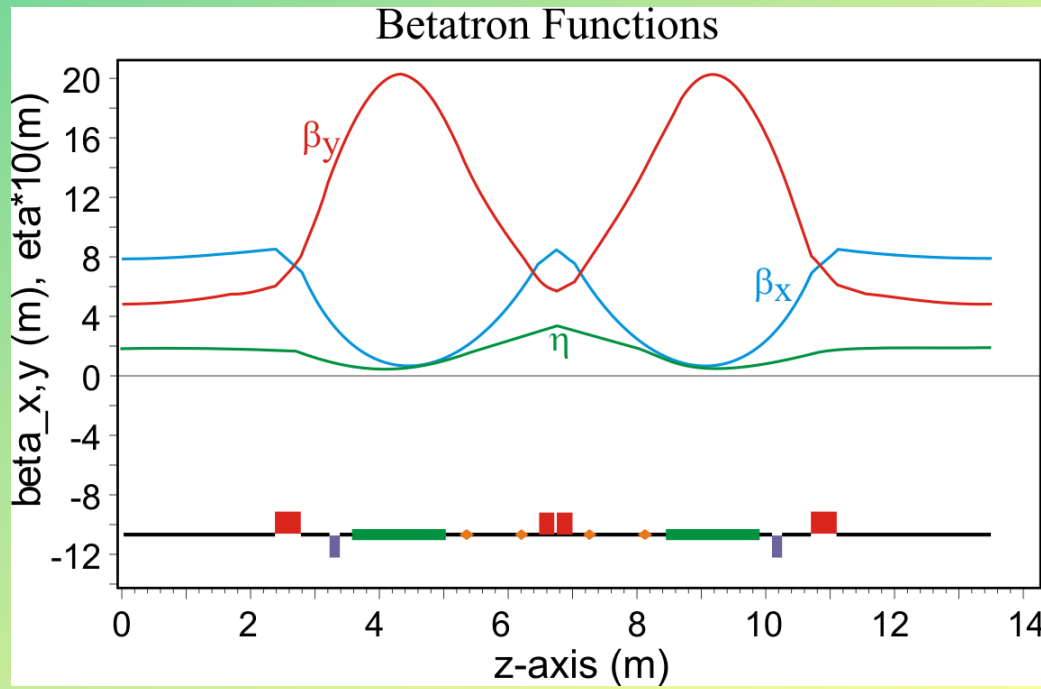


In X-Ray region: large Beta → High Brilliance

M. Ivanian et al, NIM (A) 2004

Storage Ring- Optics





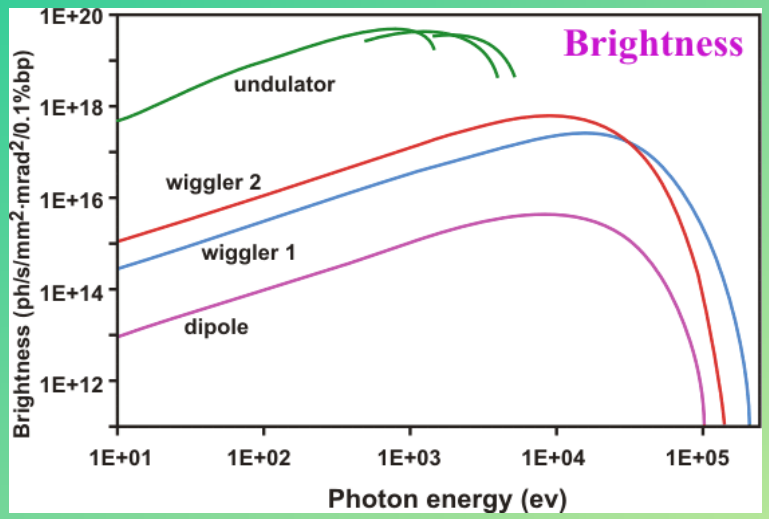
$$Q_x = 13.22 \quad Q_y = 4.26$$

$$\eta = 0.18\ m$$

$$\beta_{x,y} = 7.9m\ /\ 4.8m$$

Emittance → $\varepsilon_x = 8.4\ nm \cdot rad$

High Brightness & Stable Beams



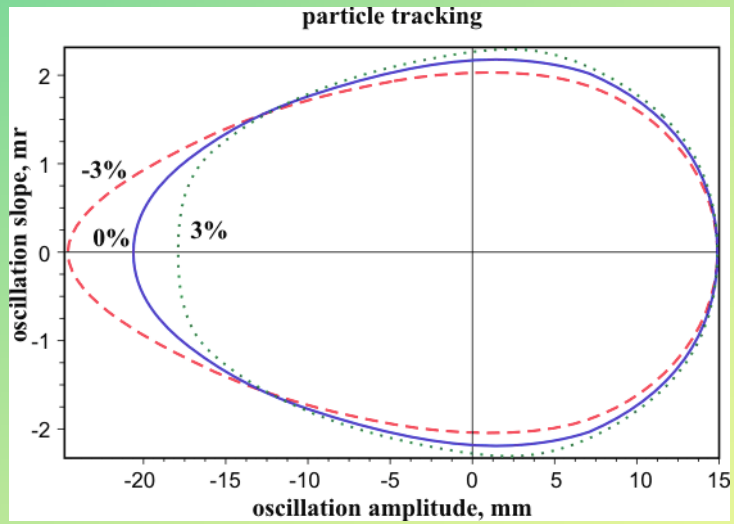
Wiggler type I

Magnetic field (T)	1.98
Period length (cm)	17
Critical ph. energy (keV)	11.97

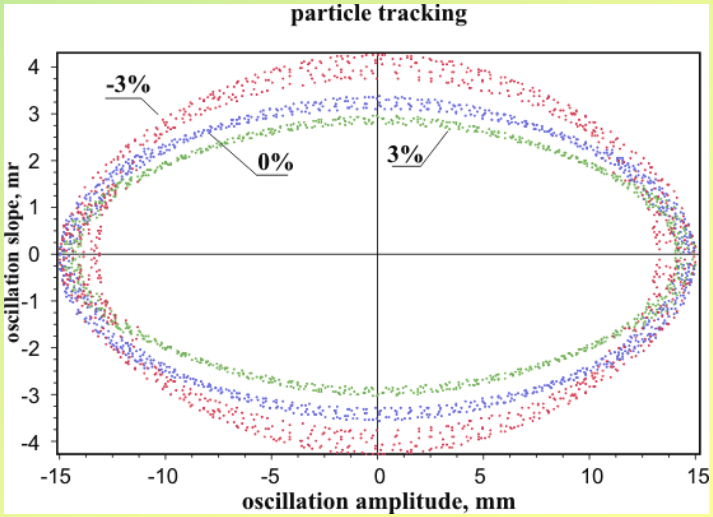
Undulator

Magnetic field (T)	0.3
Period Length (cm)	5
Photon energy n=1,3,5 (keV)	0.85/ 2.6 /4.3

Dynamical Aperture

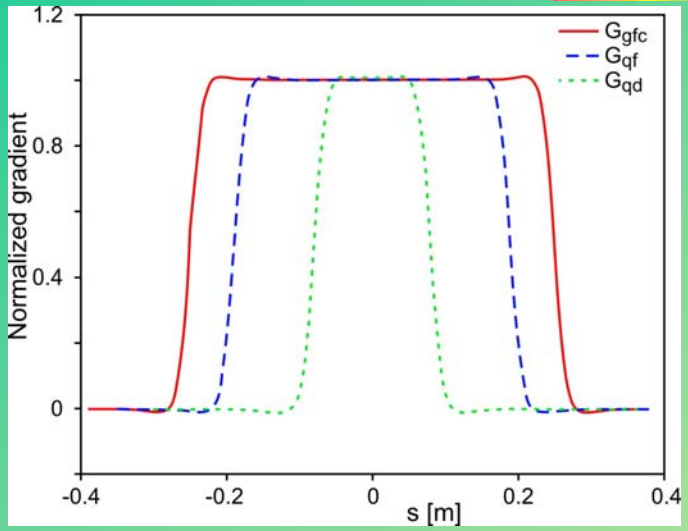


Horizontal



Vertical

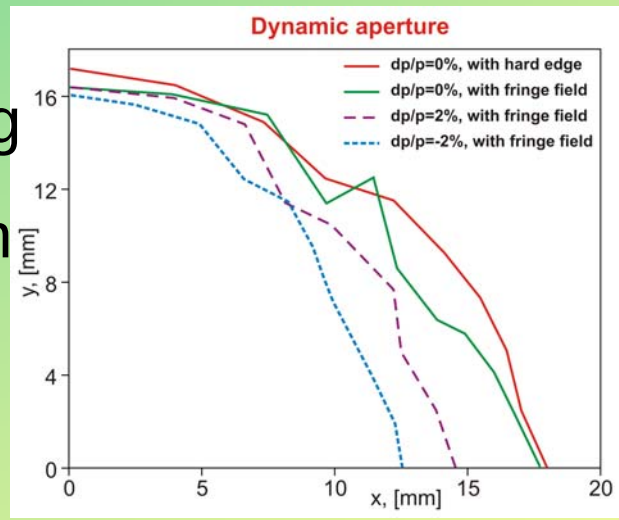
Fringe Field Effects

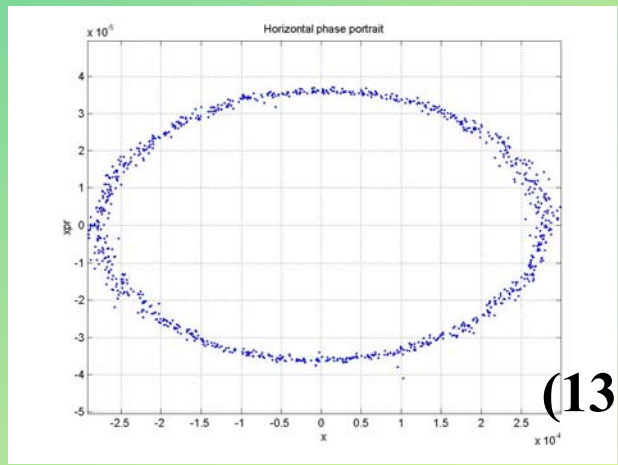


Field profile fitting

Direct integration

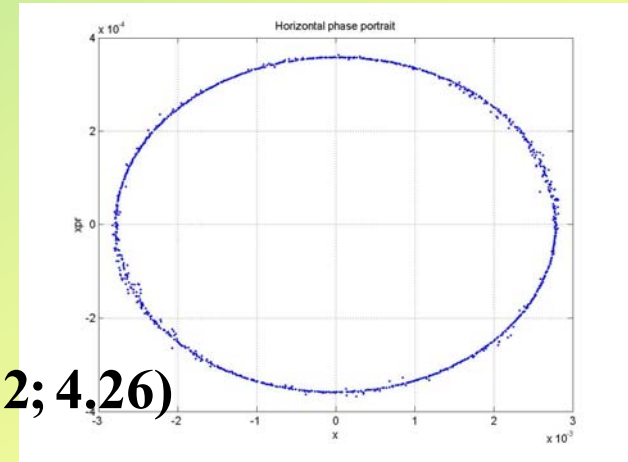
(MATLAB)





Tunes adjustment

(13.08; 4.11) ⇔ (13.22; 4.26)



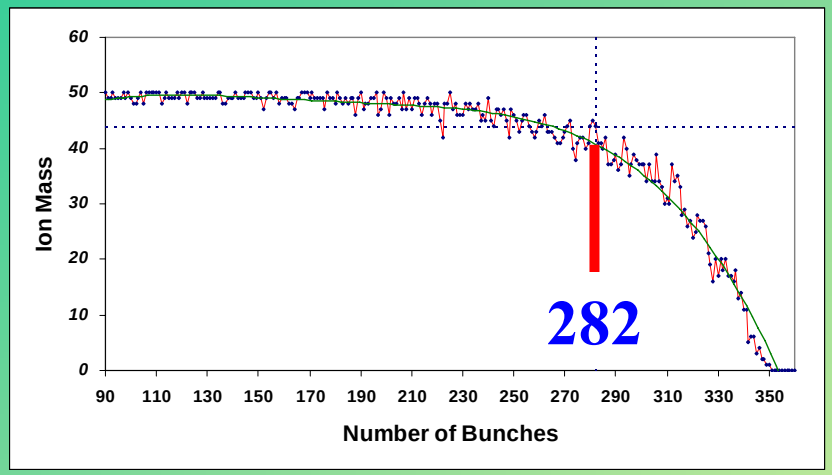
Effect

Yu. Martirosyan , NIM(A)-2004

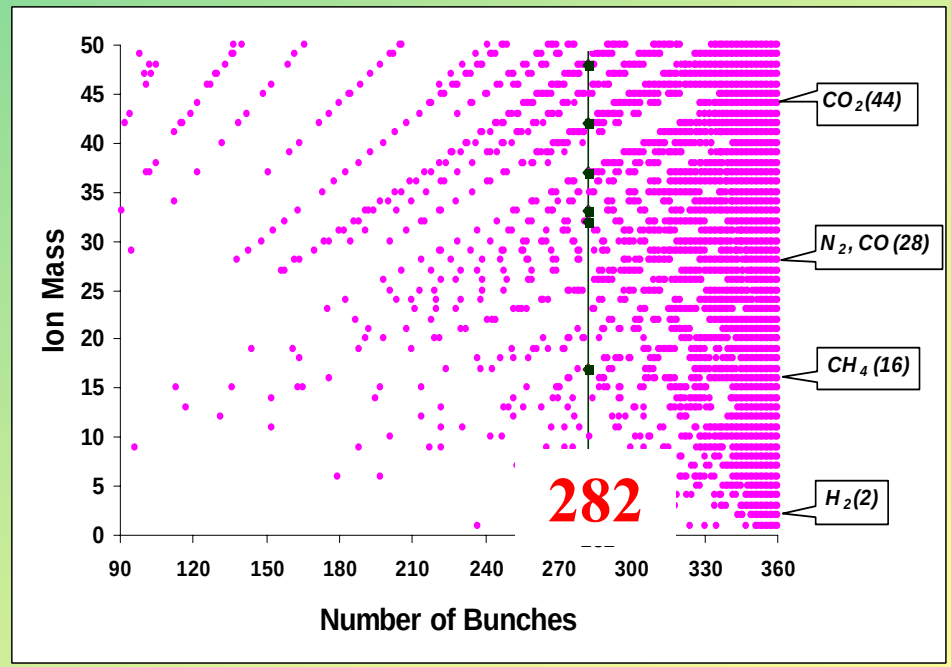
Tunes re-adjustement

Vwrudjh#Ulqj# Irq#Wuds lqj

Non-stable ions

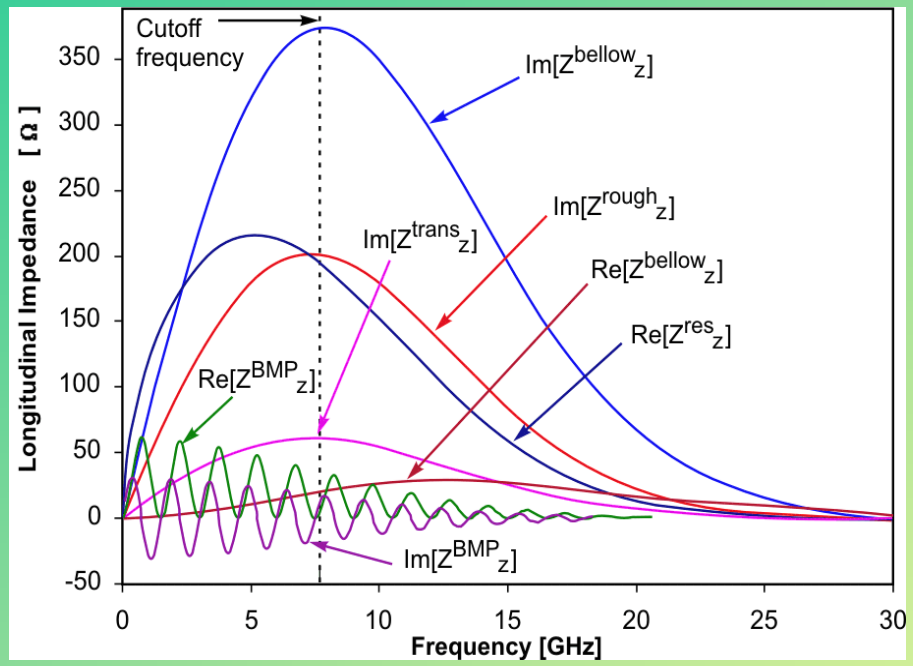


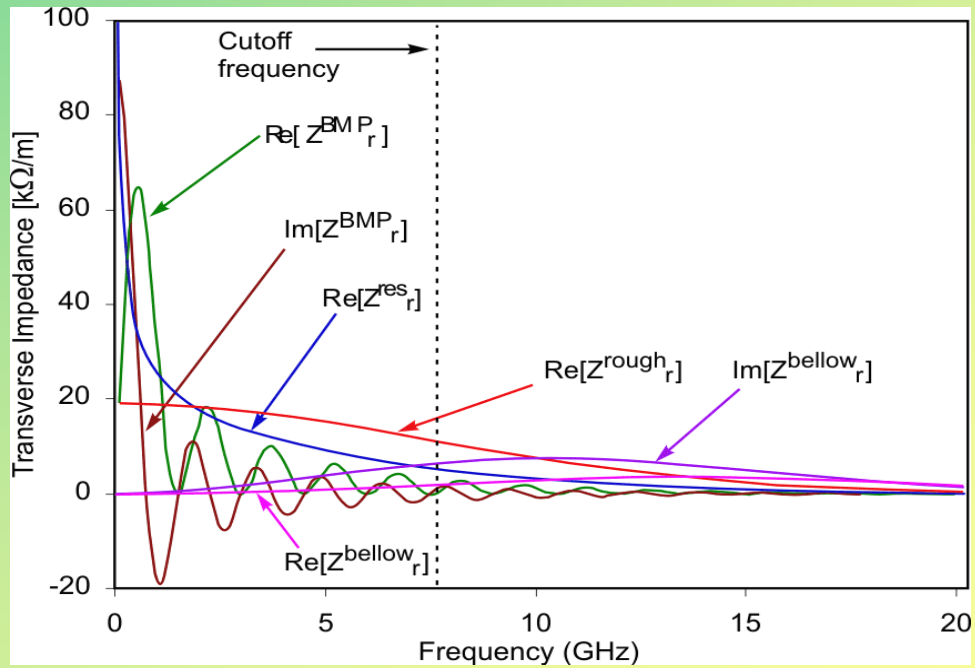
Stable ion mass	Residual gas species
-	2, H_2
-	16, CH_4
17	-
-	28 , N_2 , CO
32	-
33	-
37	-
42	-
-	44, CO_2
48	-



Trapped ions

Ring impedance

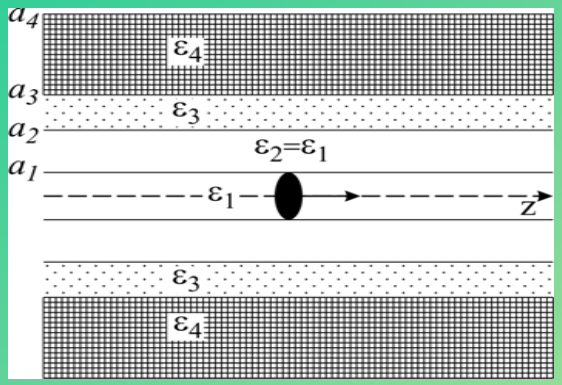




Longit. Impedance - 0.314 Ω

Trans. Impedance - 12.5 kΩ/m

Impedance of Laminated Vacuum Chamber



Stainless- steel- Copper (reduce imped.)

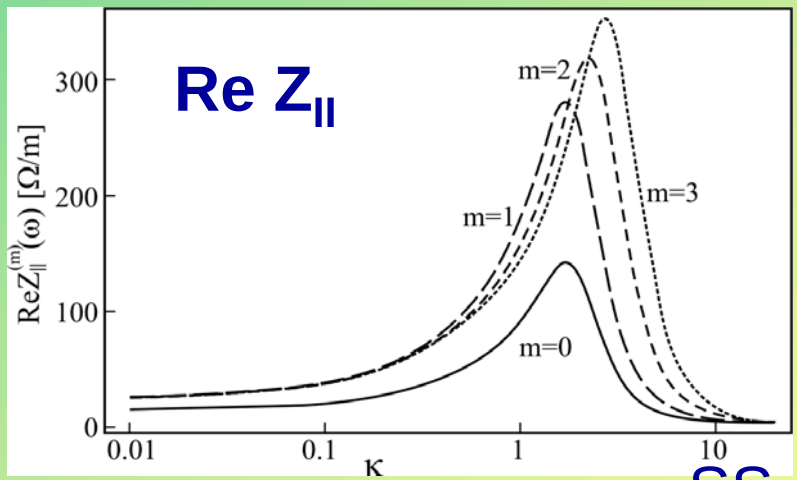
Copper – NEG (high vacuum)

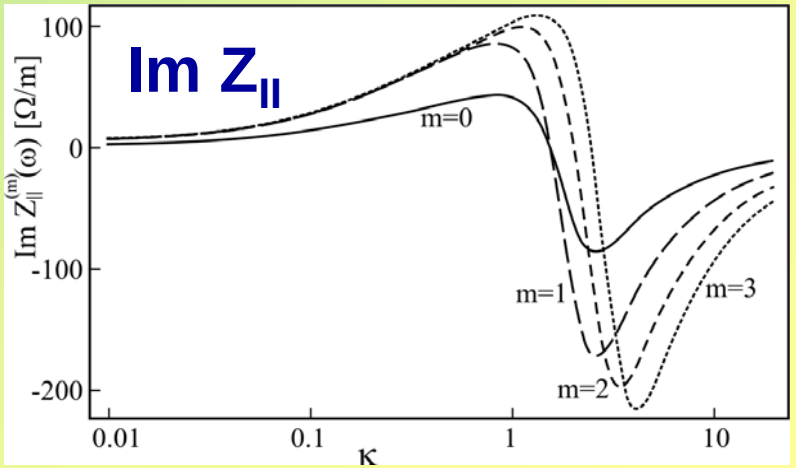
Ceramic –metal (static charge)

Exact analytical solutions for **long. and trans. impedances**

$$\overline{Z}_{z\,m}(r,\omega) = -\left(\frac{r}{a_2}\right)^m \left(\frac{a_1}{a_2}\right)^m \frac{jZ_0}{\pi k U_m(k)}$$

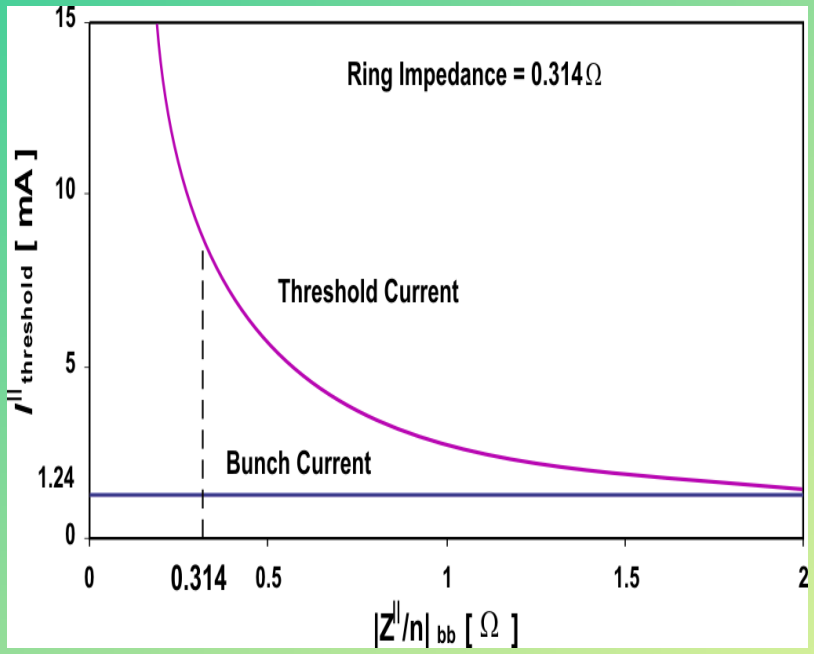
M. Ivanian et al, Phys. Rev STAB-2004
M. Ivanian et al, Phys. Rev STAB-2006

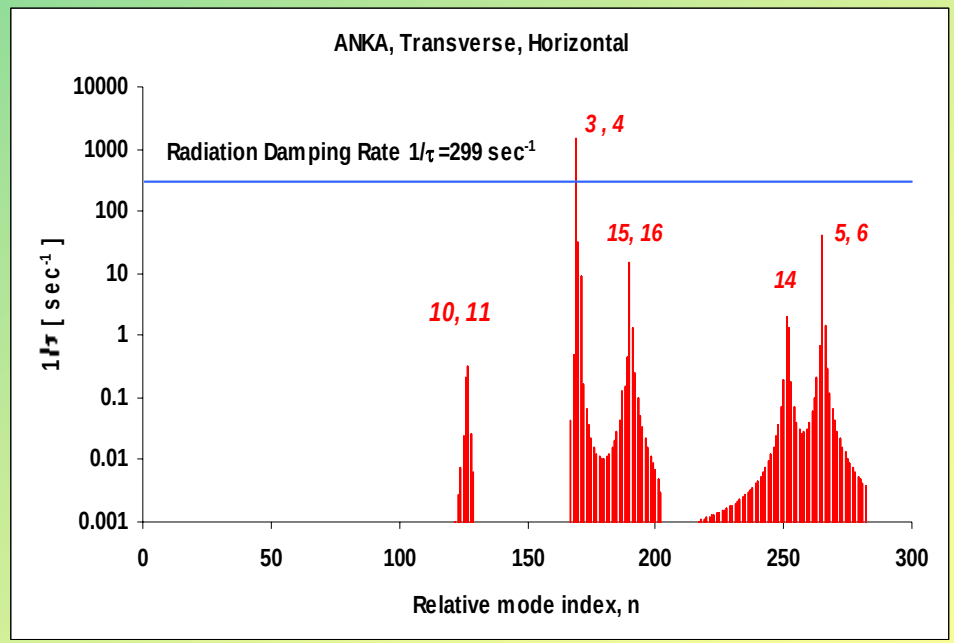




SS-copper

Storage Ring – Instabilities



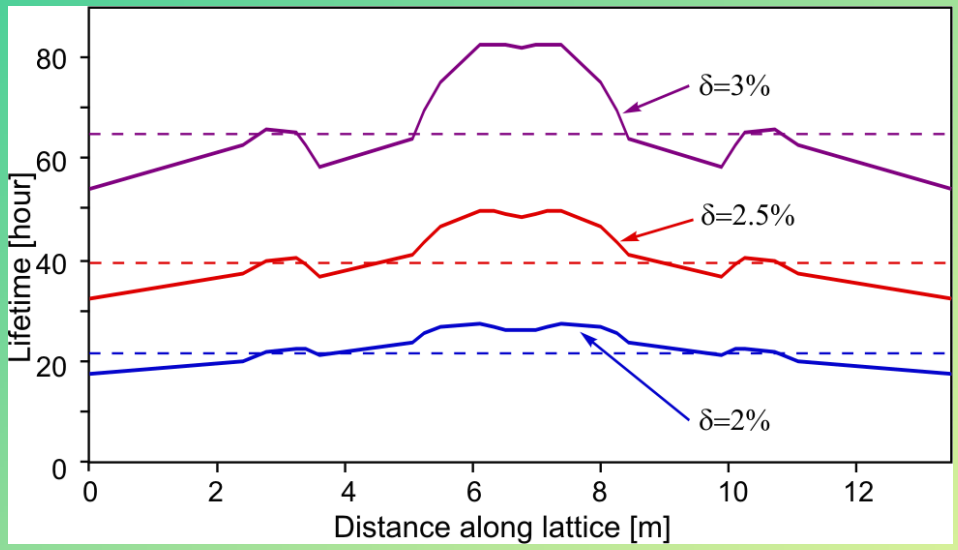


Single bunch Instability (long.)

Multi-bunch Instability (trans.)

ELETTRA type cavity

Beam Lifetime



Touschek Lifetime

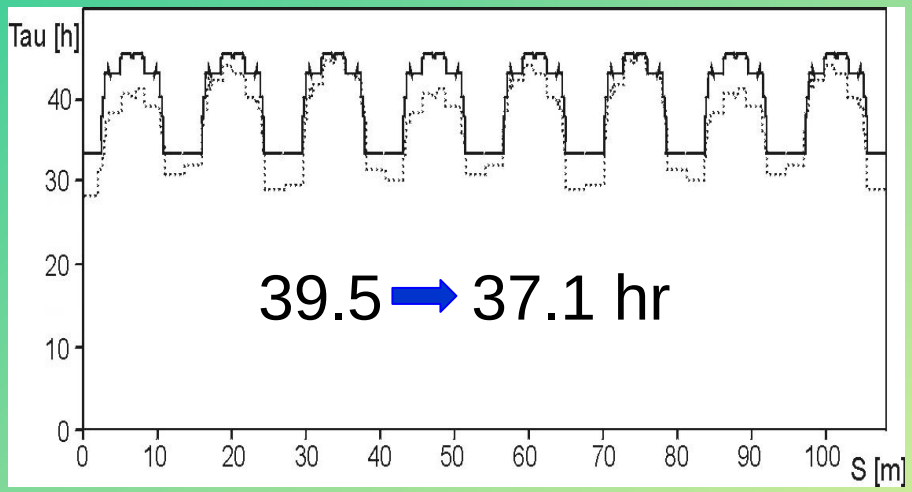
Coupling	1%
Gap Voltage	3.3 MV
Energy Accept.	2.4%
Vacuum	1 nTorr

- Elastic scattering 91.4
- Inelas. Scattering 55.4
- Tousch. Lifetime 39.5
- Quant. Lifetime $43^{6;}$

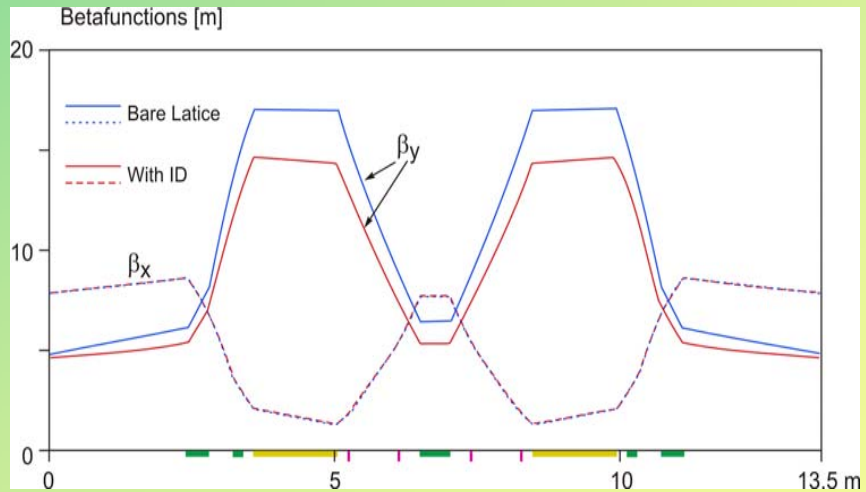
Total - 18.4 hours

Effects from insertion devices

Touschek lifetime



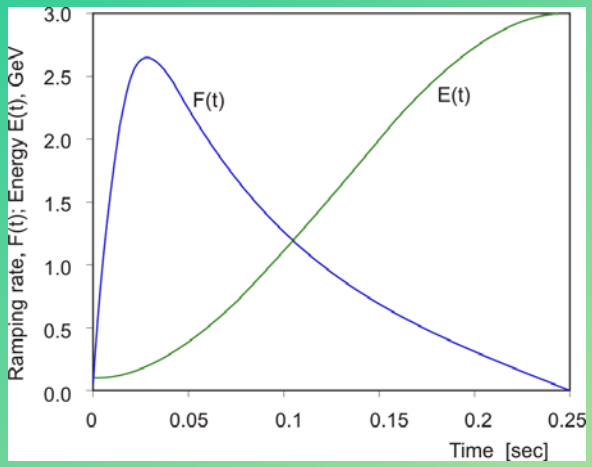
Beta beating



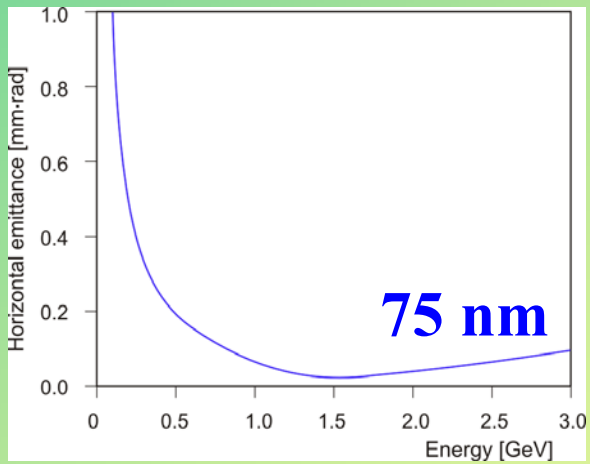
ID's	Wig.I	Undul
$\Delta U/U_0$,%	9	0.21
$\Delta\sigma_E/\sigma_E^0$, %	0.16	-0.11
$\Delta\varepsilon_x/\varepsilon_x$, %	0.56	-0.13

ID's	Wig.I	Undul
ΔQ_y	0.063	0.0015
$\Delta\beta_y/\beta_y$%	39.6	0.92
ΔQ_y^{oct} (10^{-8})	3.73	1.0

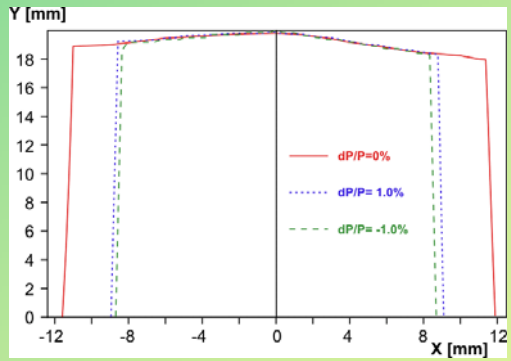
Booster



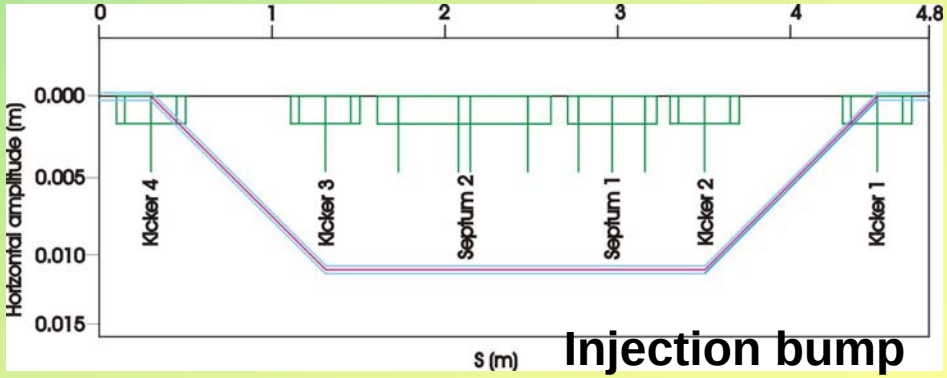
Dipole ramping rate and energy gain



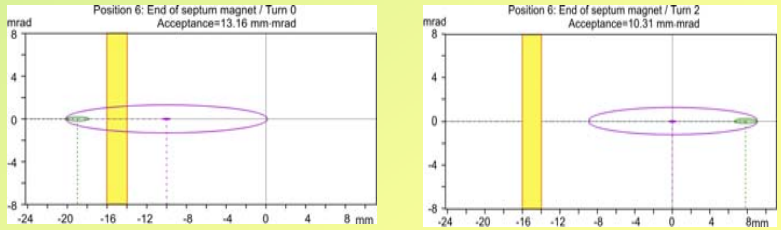
Emittance vs energy



Dynamic aperture

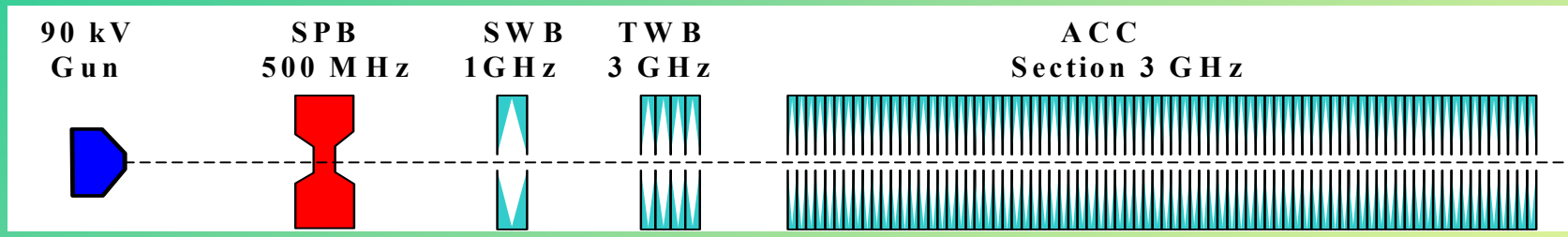


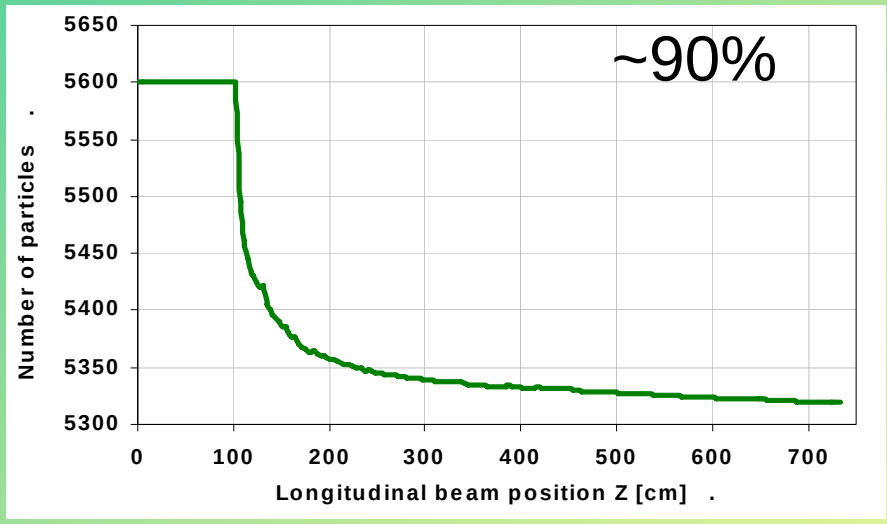
Injection bump



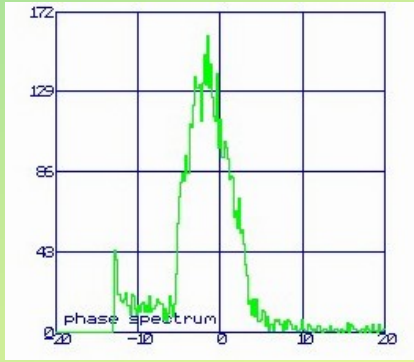
Injected beam: 1 and 3 turns

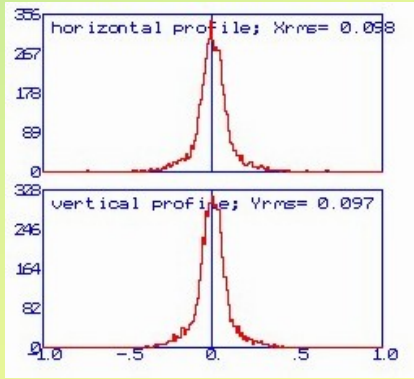
Linac





16^{o} of 3GHz





Energy 100 MeV
Current 1- 20 mA
Pulse length 2-600 nsec
Frequency 3 GHz
Energy Spread < 1%
Emittance < 1 mm-mrad

Welcome to ARW06

NATO Advanced Research Workshop

Brilliant Light Facilities and Research in Life and Material Sciences

17 - 21 July 2006, Yerevan, Armenia

CANDLE

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- **Instrument. and Exper. Technique**
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