# Optical Design of the Energy Recovery Linac FEL at Peking University

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# Outline

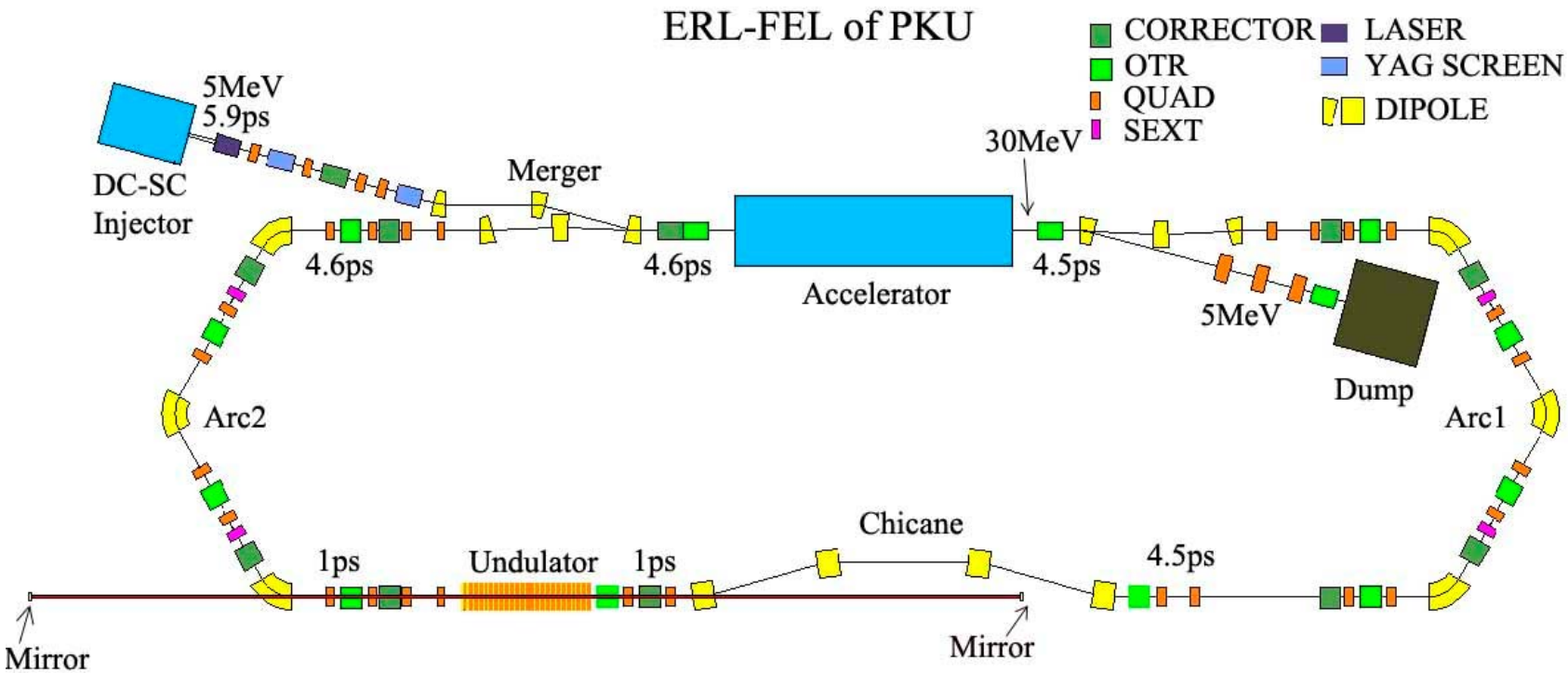
- Description of PKU-ERL-FEL
- Design consideration
- Results of the optical design
- Further work

# I

# Description of PKU-ERL-FEL

- Aims:
  - provide IR-FEL for users,
  - study ERL technology
- Components:
  - DC-SC injector
  - Rossendorf Type linac (TESLA 9-cell cavity)
  - Undulator with mirrors
  - Beam transmission system

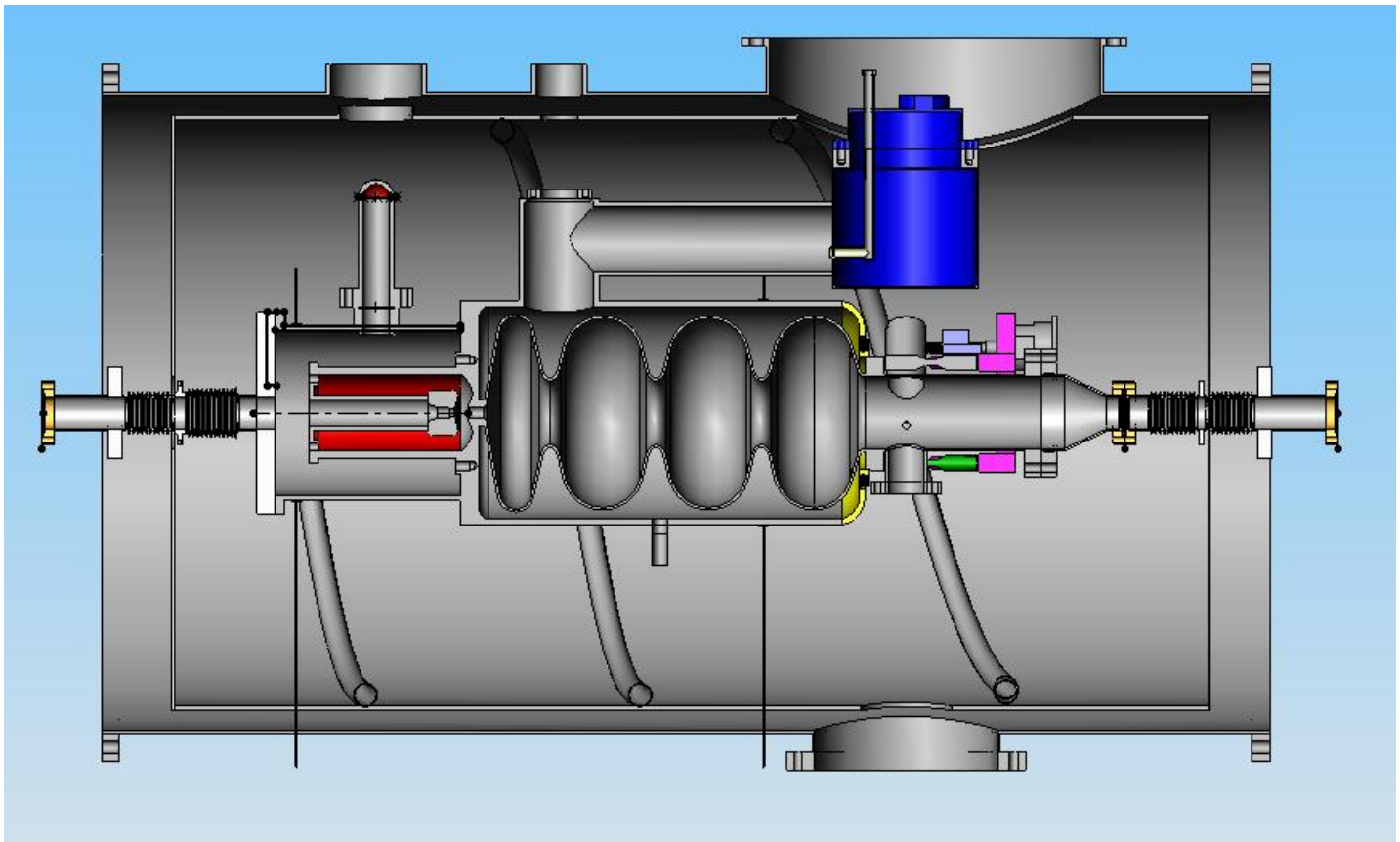
# ERL-FEL of Peking University (PKU-ERL-FEL)



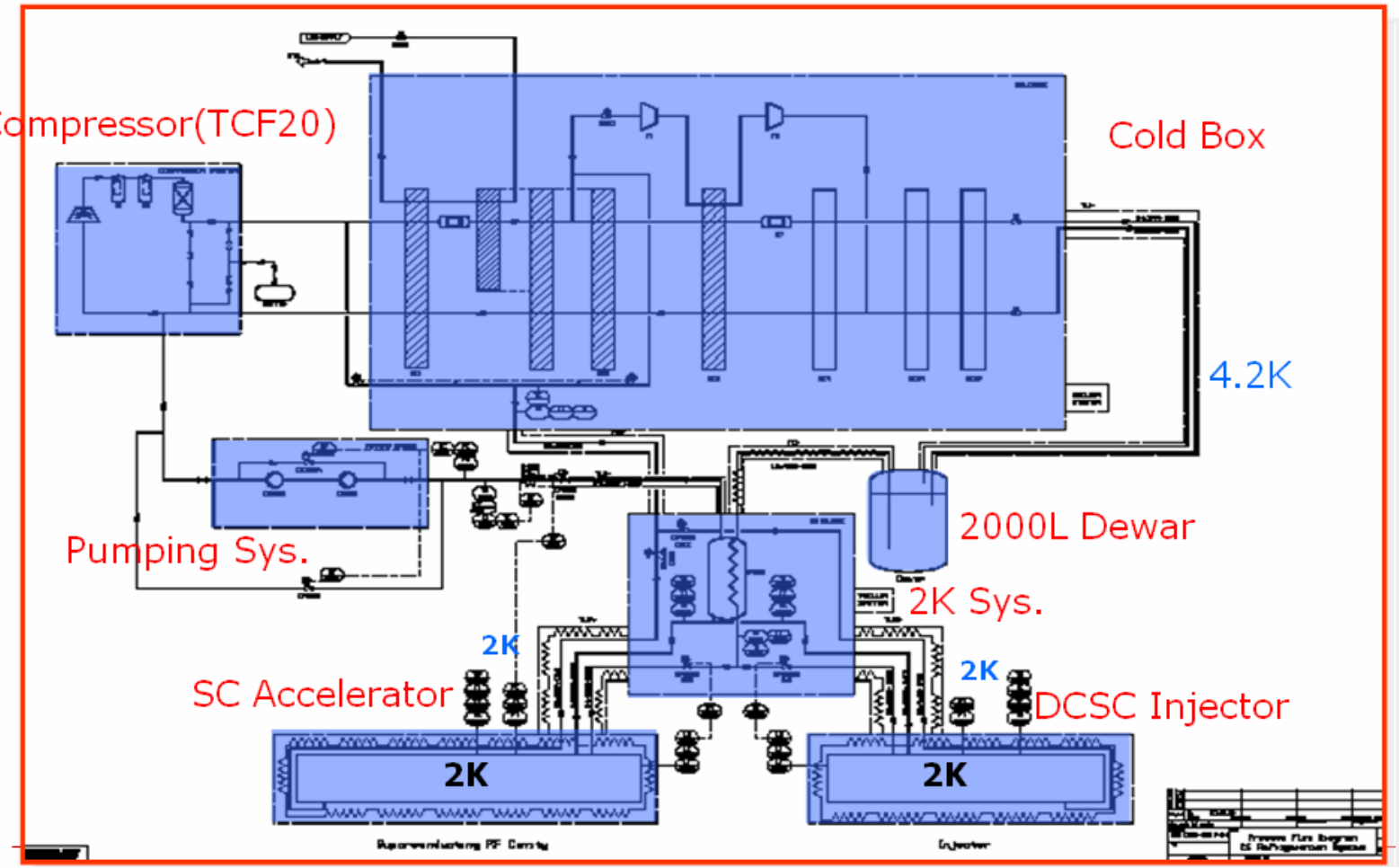
# PKU-ERL-FEL parameters

| | |
|---|---|
| Inject Energy | 5MeV |
| Maximum Energy | 30MeV |
| Bunch Frequency | 26MHz |
| Bunch Charge | ~60pC |
| Bunch length at Entrance of Undulator | ~1ps |
| Macro Pulse Length | 2ms |
| Rep. Frequency of Macro Pulse | 10Hz |
| Energy Spread (rms) | 0.24% |
| Transverse Emittance （rms, n.） | ~3 μ m |
| Length of Undulator | 1.5m |
| $\lambda_u$ of Undulator | 3cm |
| K of Undulator | 0.5-1.4 |
| Optical Cavity Length | 11.52m |
| Wavelength of FEL | 4.7-8.3 μ m |

# DC-SC Injector

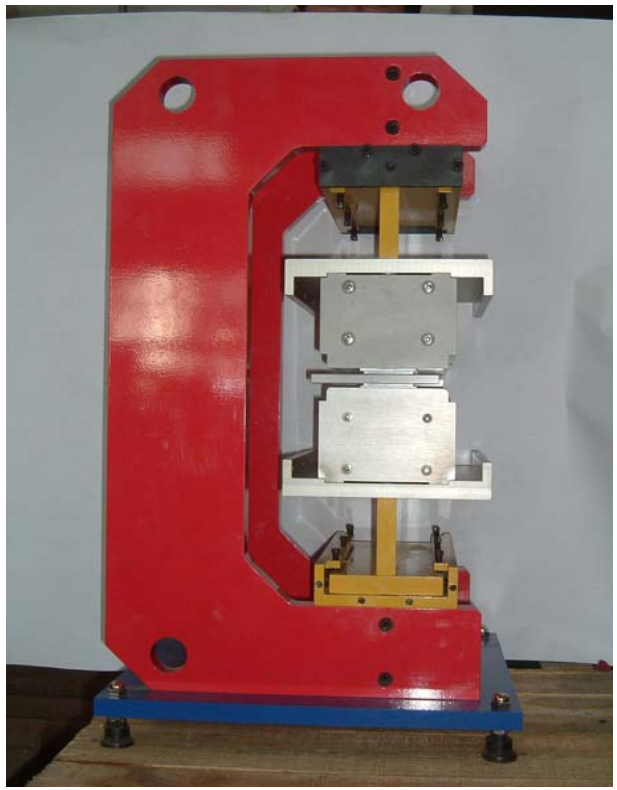


# The cryogenic system

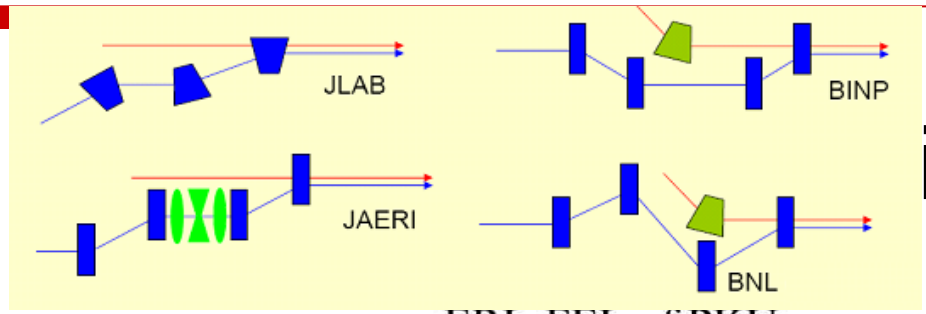


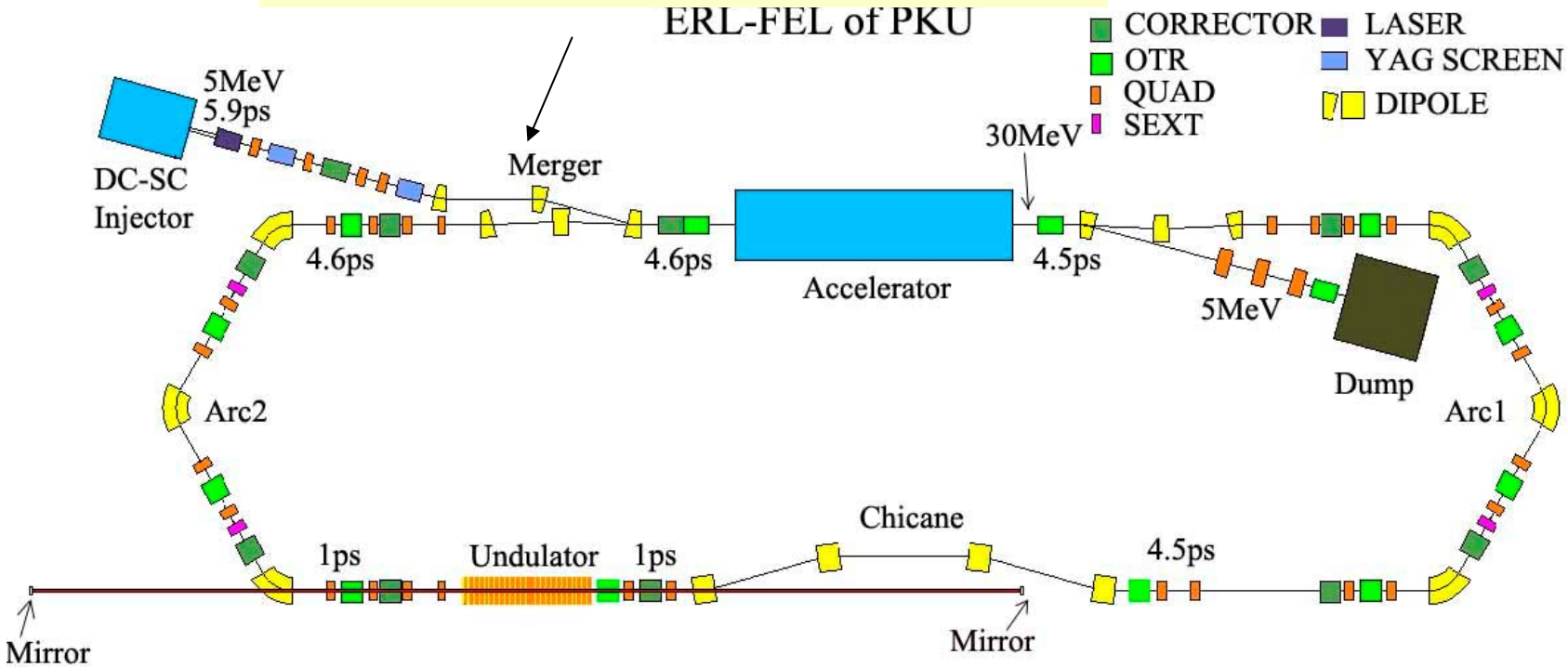
# Undulator

Undulator will be manufactured in China.



# ine


JLAB
BINP
JAERI
BNL


ERL-FEL of PKU
CORRECTOR
OTR
QUAD
SEXT
LASER
YAG SCREEN
DIPOLE
5MeV
5.9ps
DC-SC
Injector
Merger
30MeV
4.6ps
4.6ps
Accelerator
4.5ps
5MeV
Dump
Arc2
Arc1
Chicane
1ps
Undulator
1ps
4.5ps
Mirror
Mirror

# II

# Design Consideration

- Achromatic ($R_{16}$=$R_{26}$=0)
- Isochronous ($R_{56}$=0)
- Small bending angle (15 degree)
- Energy spread acceptance of undulator
- Small beta function in undulator
- Large energy spread acceptance in the second arc (7% at full width from the experience of JAREI and Jlab )

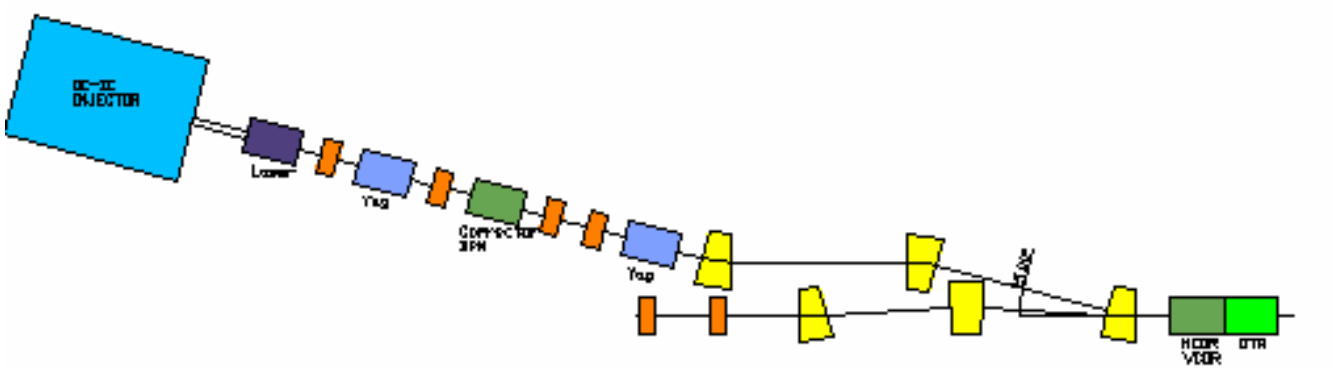
- Compensation of the second order matrix term
- Trajectory length of the loop is variable
- Space for installation of facilities
- Space charge and CSR

# III

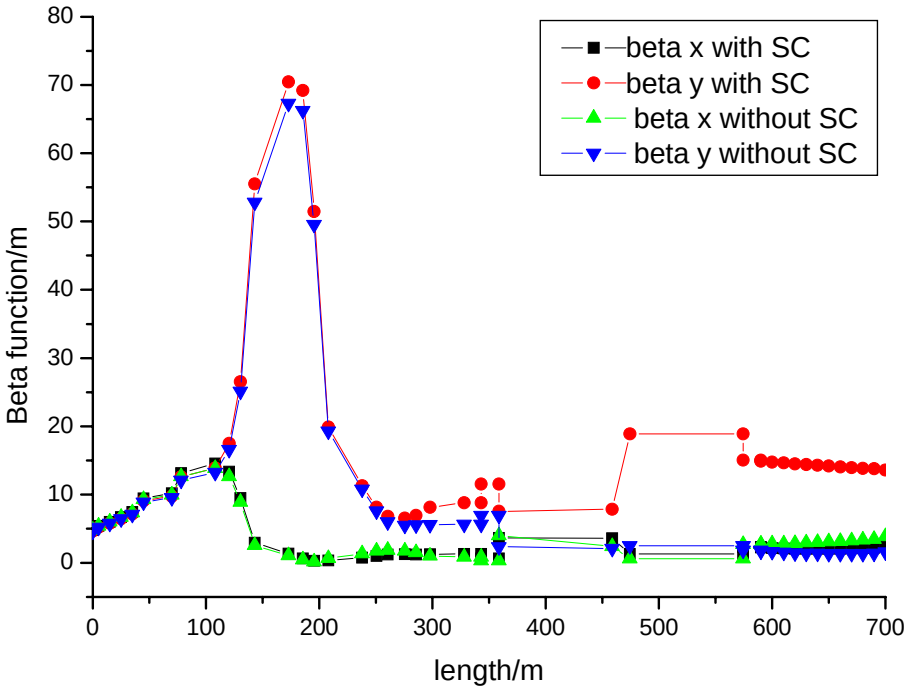
# Results of the optical design

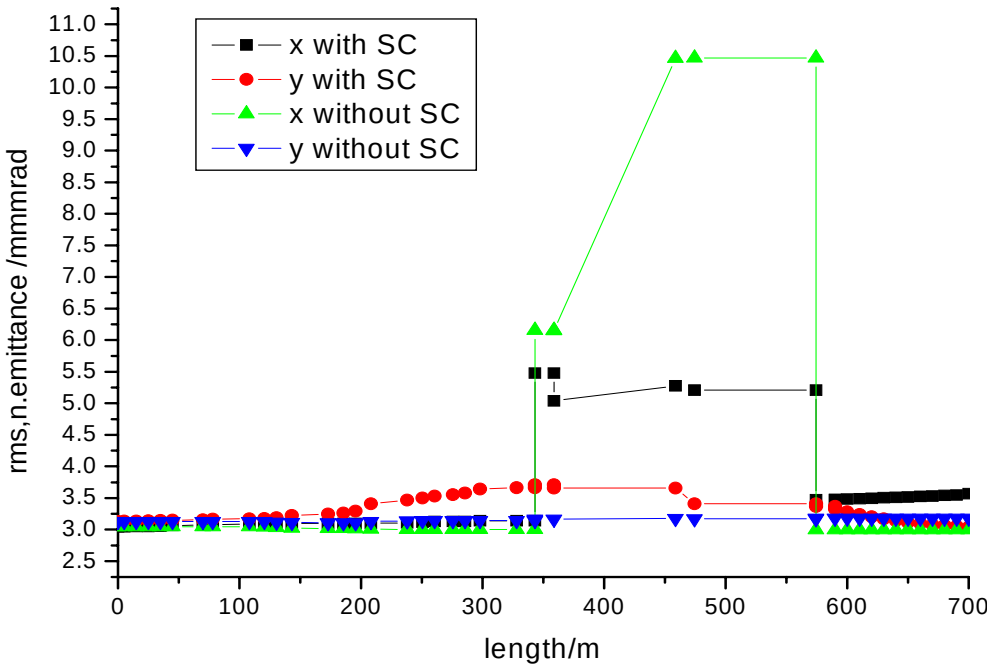
# Merger

- Achromatic
- Adequate $R_{56}$
- Reduce the influence of space charge
- Fit the need of linac
- Good transmission for the return beam

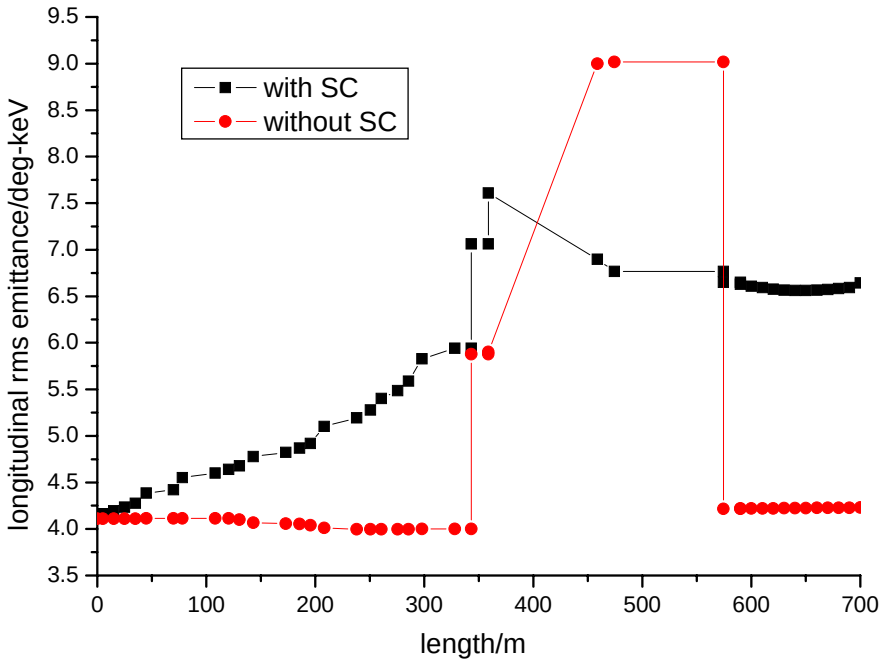


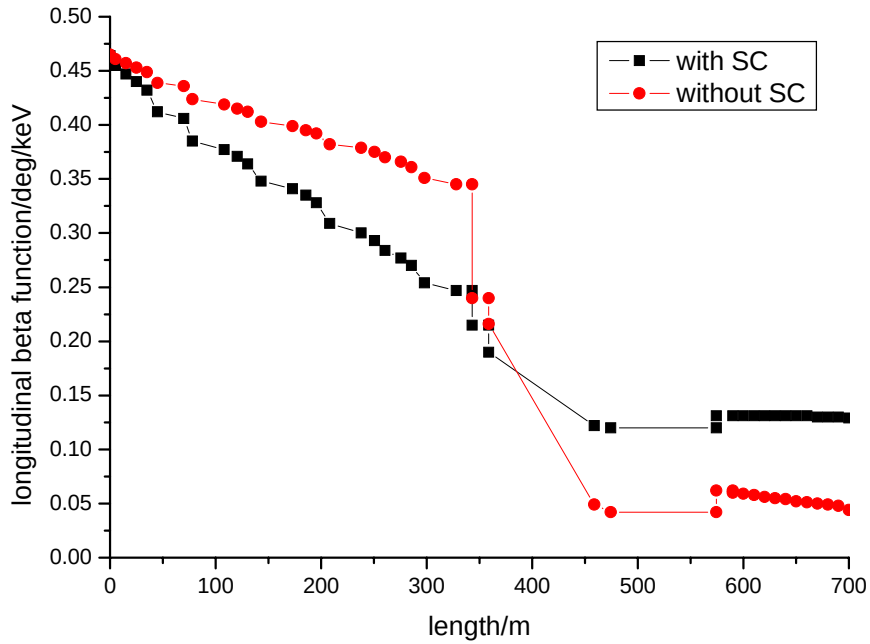
# Transverse beta function and emittance



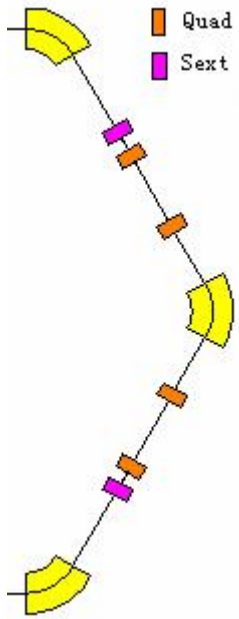
# Longitudinal beta function and emittance



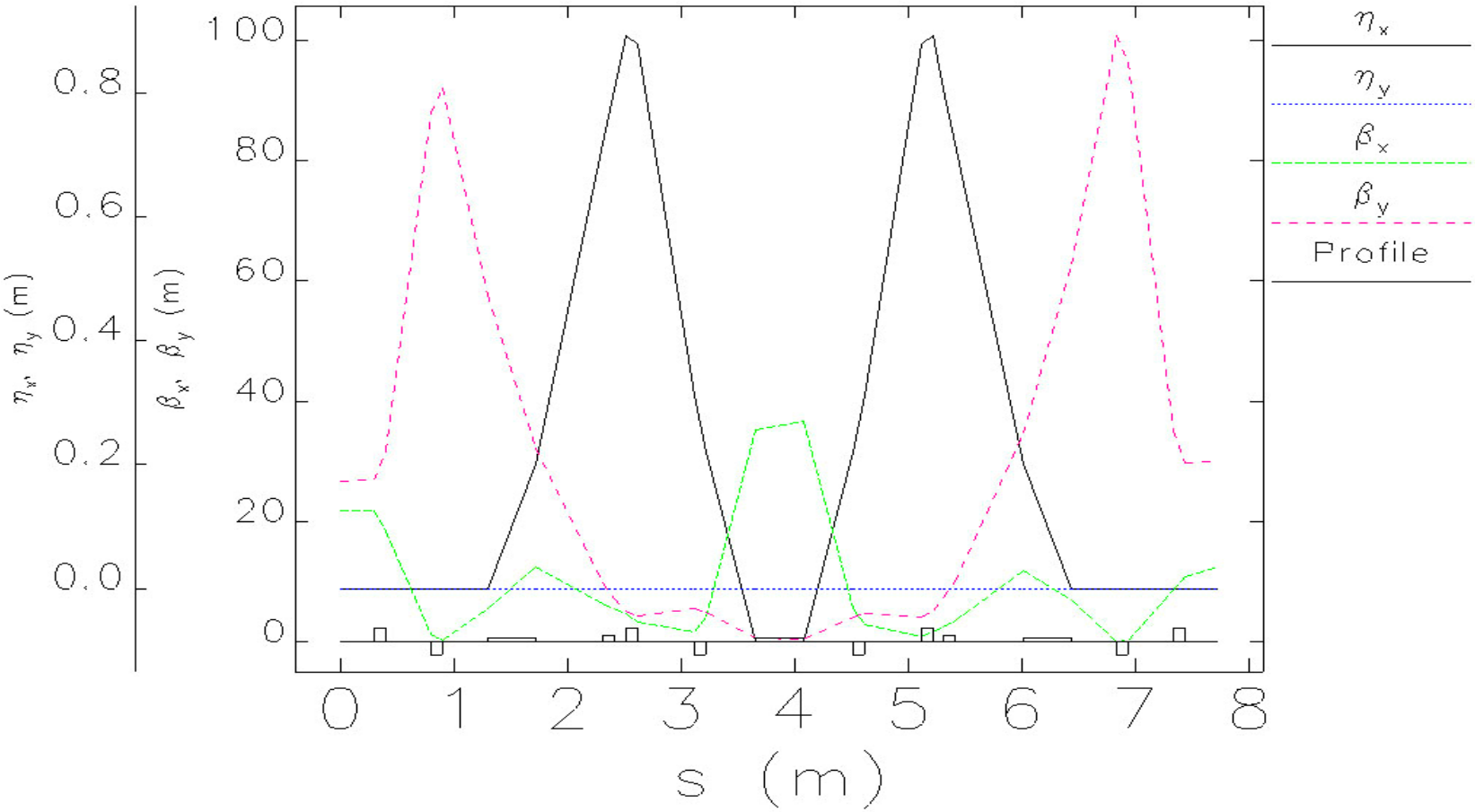



# Arc1

- TBA arc, turning 180 degree
- Isochronous
- Achromatic
- Compensation of $T_{166}$,$T_{266}$ and $T_{566}$

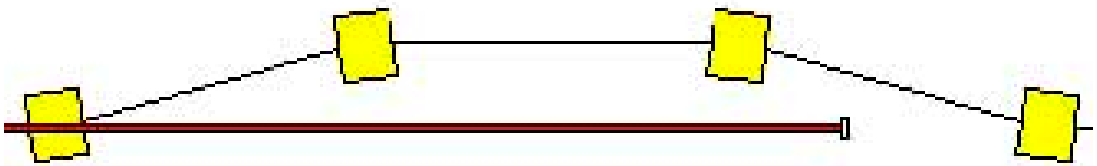


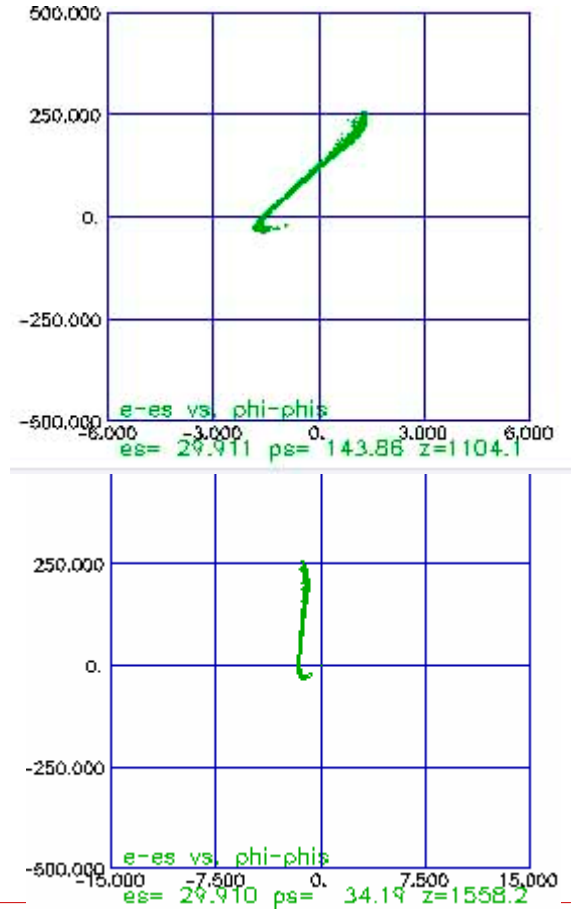
# Beta function and dispersion



# Bunch Compression

- Four dipole chicane
- $R_{56}$=-0.2m
- Compress the bunch to 1ps (FWHM)
- CSR takes a little influence

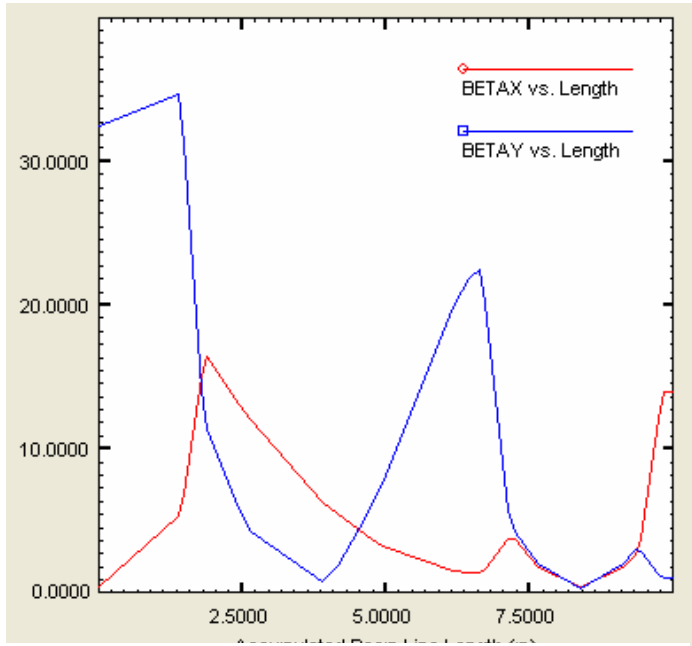




# Undulator

$\beta_x$=0.4m in the undulator center

(without the effect of undulator field on the beam)

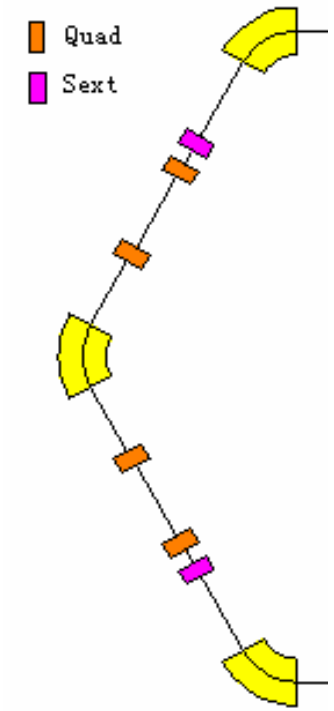



# Arc2

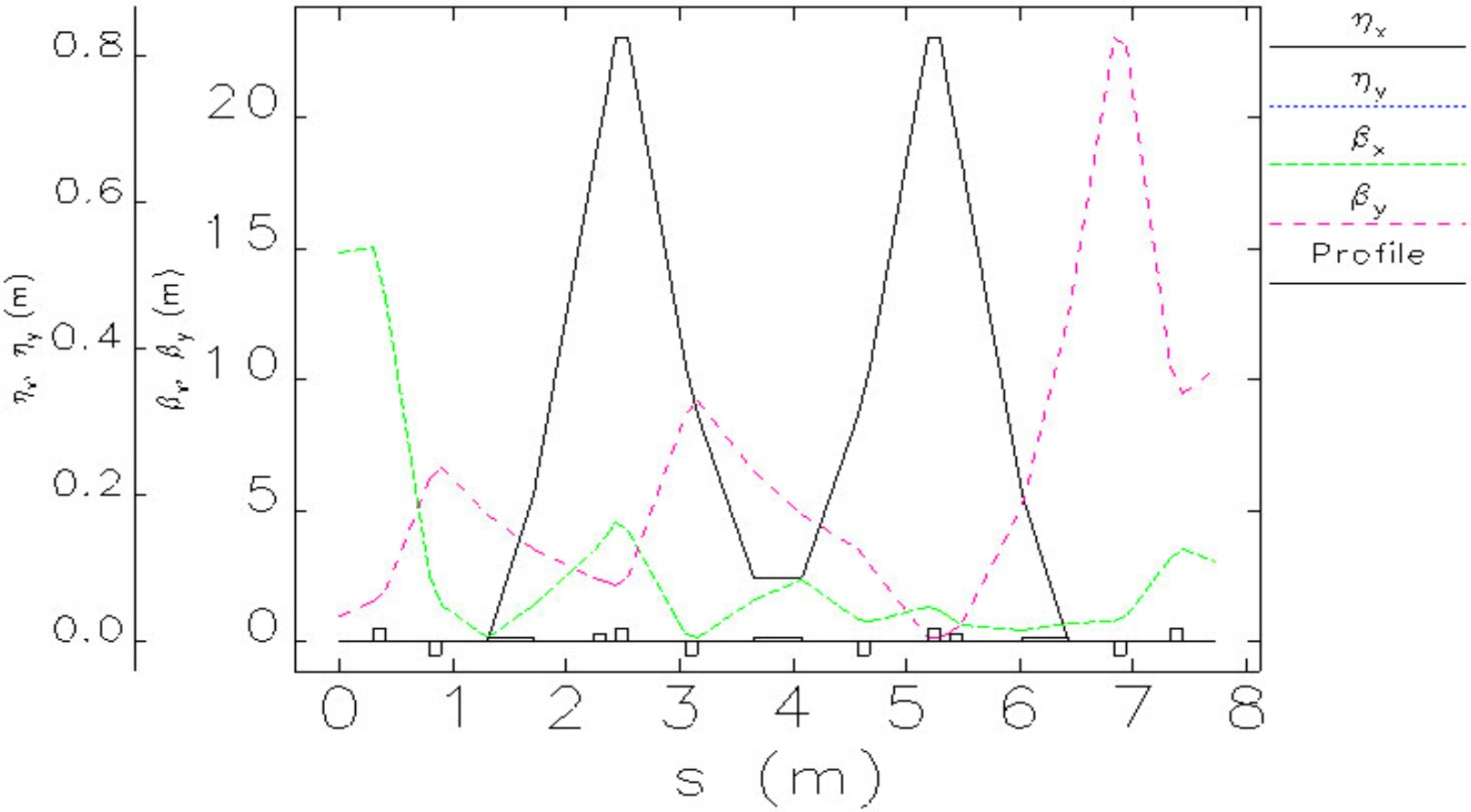
- TBA arc, turning 180 degree
- $R_{56}$ is variable
- Achromatic
- Energy spread acceptance is 7% (full width)
- Lengthening the return bunch and making the whole loop isochronous

$$R_{56,arc2} = -(R_{56,chicane} + R_{56,other})$$

- Compensation of $T_{166}$,$T_{266}$ and $T_{566}$



# Beta function and dispersion



# Further Work

- The parameters of the whole loop will be further optimized with other codes and compared with present results.
- Beam behavior in undulator will be simulated and the beta function within and after this part will be optimized


Thanks !