TBA low emittance lattice for the Beijing APS

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Topics

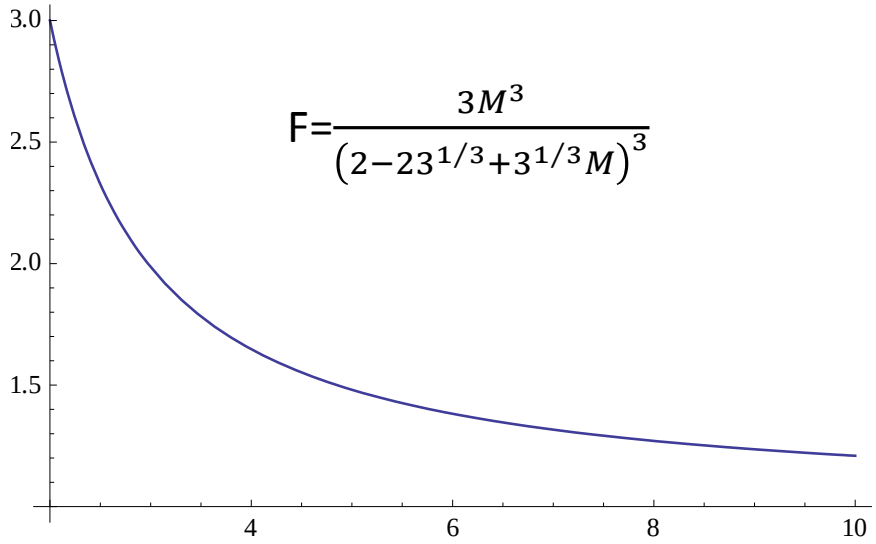
- Background
- A special TBA with a TME mid bending magnet
- Lattice deign For BAPS
- Main parameters
- High beta insertion for pulse sextupole Injection
- Chromaticity correction and Dynamic aperture
- The ERL or USR in the same tunnel
- Summary

Background

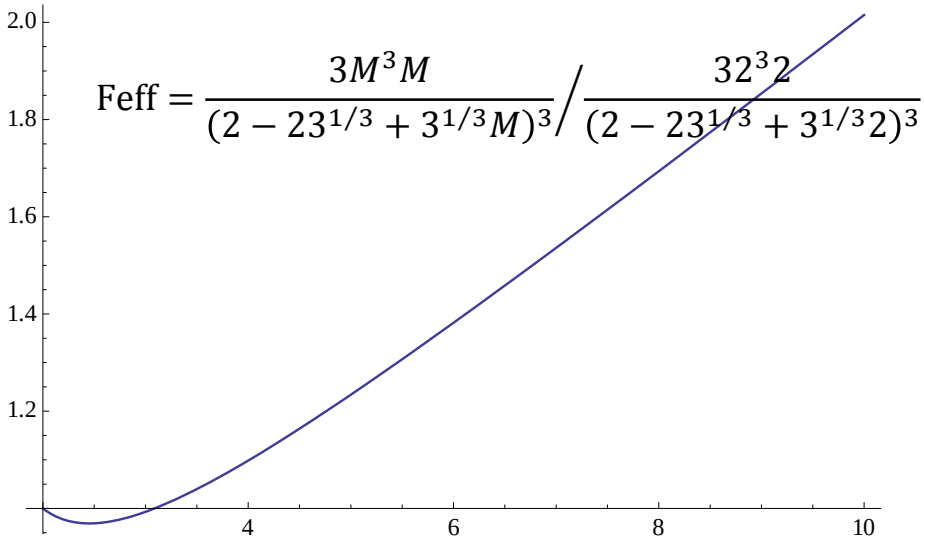
- 48 DBAs lattice For BAPS
  circumference is about 1200m
  about 1.5nm emittance for the bare lattice
  it is too conservative
- 36 7BAs lattice For BAPS
  circumference is about 1370m
  about 50pm for the bare lattice
  10pm need 60m length damping wigglers
  it is a big challenge both technology and budget

$$\varepsilon_{MBA\min} = \frac{C_q \gamma^2}{4\sqrt{15}(2 - 2 * 3^{1/3} + M * 3^{1/3})^3}\left(\frac{2\pi}{n}\right)^3 = \frac{C_q \gamma^2}{4\sqrt{15}\left(\frac{2-2*3^{1/3}}{M} + 3^{1/3}\right)^3}\left(\frac{2\pi}{Mn}\right)^3$$

Where M is number of bending magnets in one period of achromat, n is the number of the periods



emittance vs. M



Consider no. of users, the effective emittance

M=2, F=3(Double bends achromat)
M=3, F=1.98(TBA)
M=7, F=1.32(7BA)
M → ∞, F→1(no achromat)

M=2, Feff=1
M=3, Feff=0.99(TBA)
M=7, Feff=1.54(7BA)
M → ∞, Feff→ ∞(no achromat)

- So, for TBA, althrough the users will decrease but the emittance also decrease. It is worth comparing with DBA
- Traditionally, the emittance ratio to the TME for TBA is about 5~6(ALS, TLS, PLS), and for DBA the value is near 2(NSLSII)
- Can we get the factor near 2 For TBA?

A special TBA with a TME mid bending magnet

- In order to get lower emittance, we directly set the mid bend to the TME case, so the achromat condition just depend on the side bends.
- At the meantime, taking a larger bending radius of the side bends can decrease its contribution to I5. For fabricating simply the bending magnets have the same length, the radius of side bends is double the mid one

Lattice deign For BAPS

- Design goal

  energy 5GeV

  circumference 1200~1300

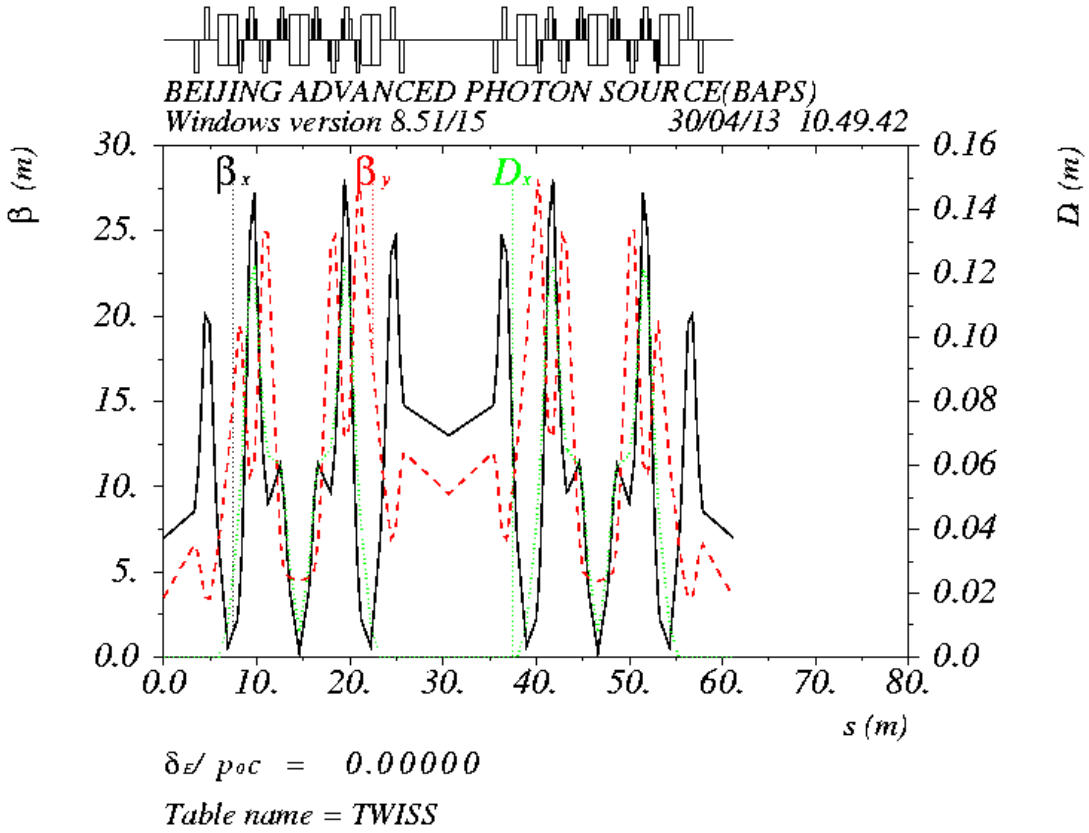
  emittance <0.5nm

  Insertion straight>36*6.5m

- Our design

  TBA with TME mid bend

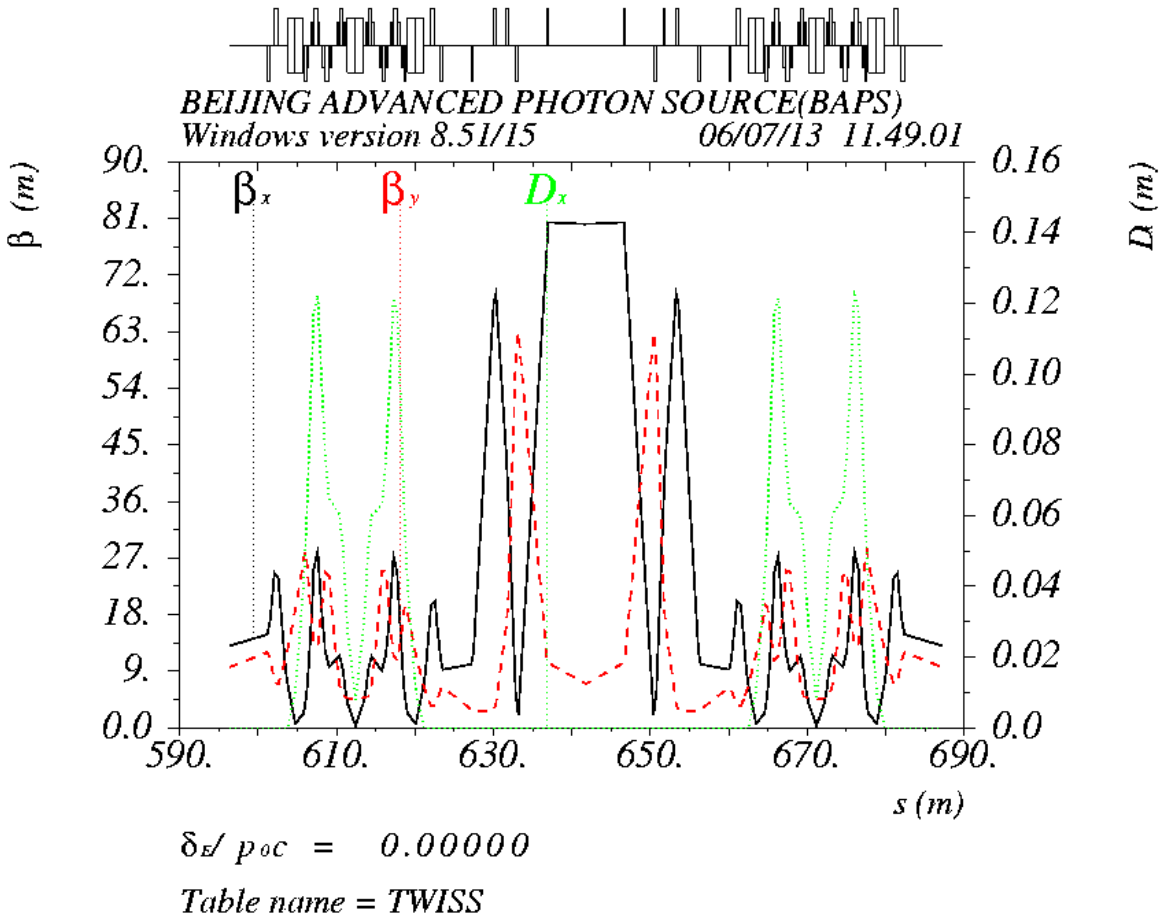
  20*9.6m+20*6.6m mixed TBA



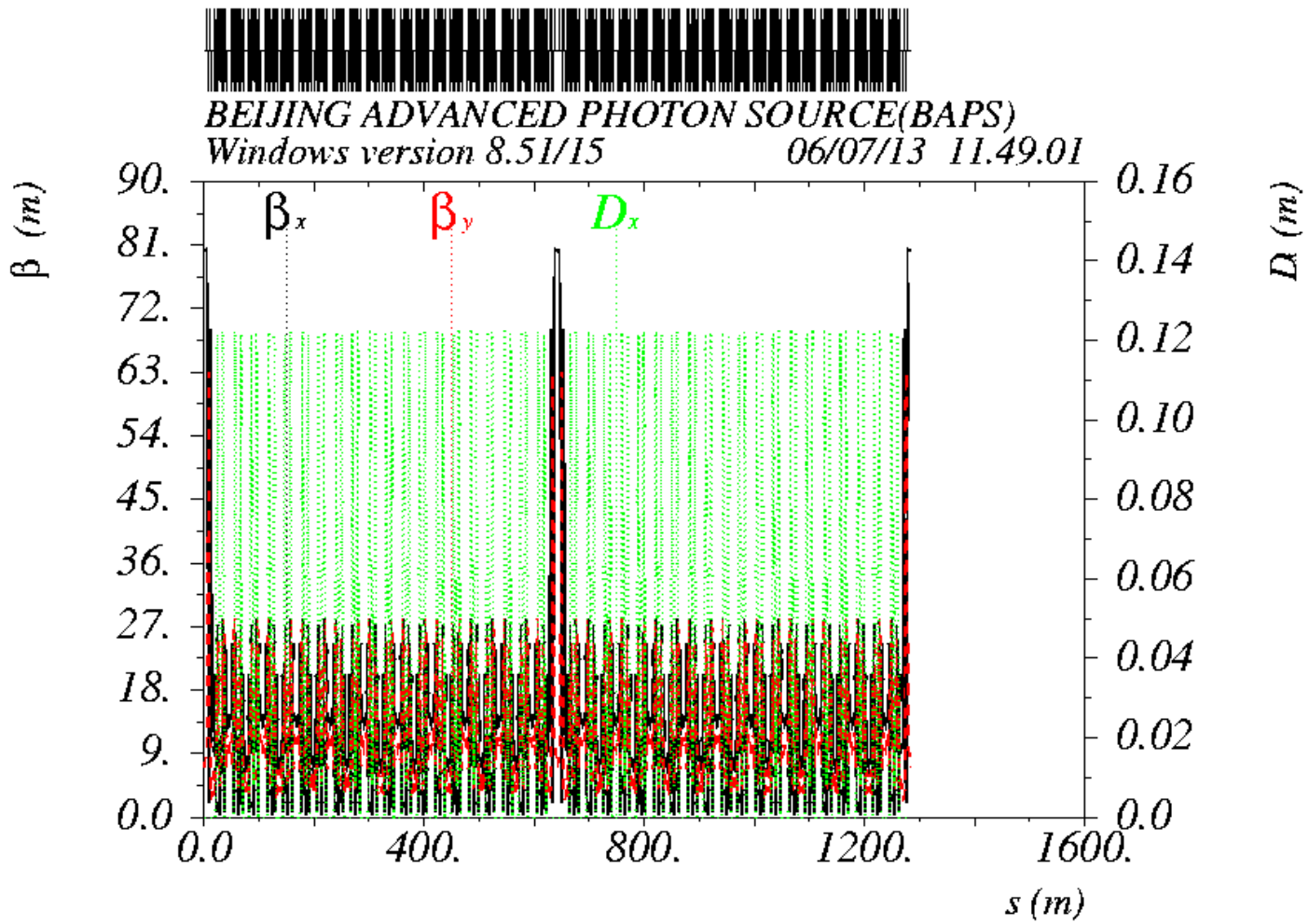
Main parameters

parameter	Unit	Value	parameter	Unit	Value
Energy	GeV	5	U0 of bends	MeV	1.6
circumference	m	1284	Rf voltage	MV	6
Beam current	mA	200~300	Rf frequency	MHz	499.8
Emittance H/V	nm	0.46/0.005(bare) 0.15/0.002(with ID & damping wiggler)	Energy spread	10^{-3}	0.77
Working point H/V/L		66.28/26.31/0.005 2	Momentum compaction	10^{-3}	0.75
Chromaticity H/V		-246.4/-101.9	Bunch length	ps/mm	6.9/2.1
Super-period		20	Damping time	ms	26.8/26.8/13.4
β function at ID	m	7/3.5 6.6m 13/9.6 9.6m	Critical energy	keV	10.66(mid) 5.33(side)

High beta insertion for pulse sextupole Injection



In order to increase the dynamic aperture, a high beta insertion replaces the short straight insertion, the phase advance for this injection insertion are standard value+1 for both H/V


BEIJING ADVANCED PHOTON SOURCE(BAPS)
Windows version 8.51/15
06/07/13 11.49.01
β (m)
D (m)
βx
βy
Dx
90.
81.
72.
63.
54.
45.
36.
27.
18.
9.
0.0
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.0
0.0
400.
800.
1200.
1600.
s (m)
δE/ p0c = 0.00000
Table name = TWISS

BAPS ultralow emittance design and optimization

Linear optics

Analyzer based on Lie Algebra and Hamiltonian analysis

Analytical expressions of non. driving terms

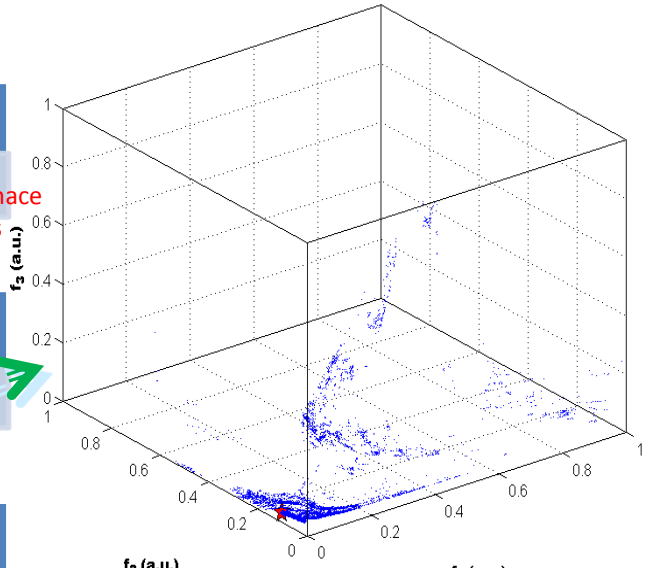
MOGA

Pareto-optimal solutions

Numerical tracking | Frequency map analysis

Final optimal solution

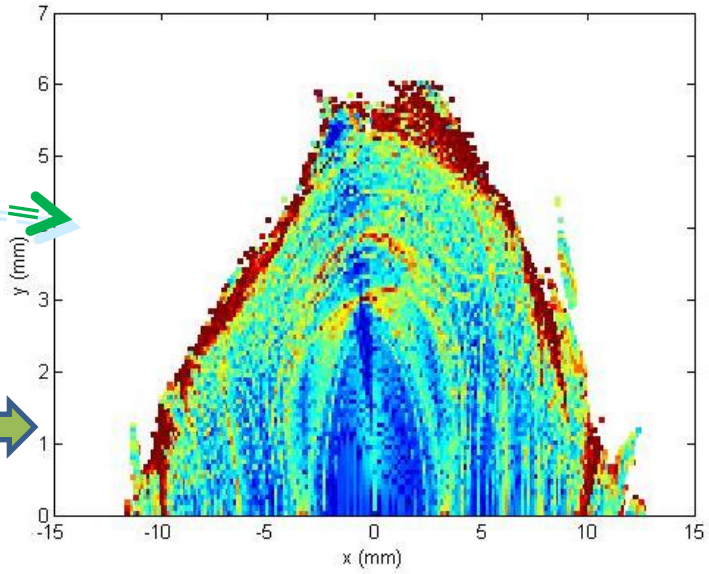
Resonace terms



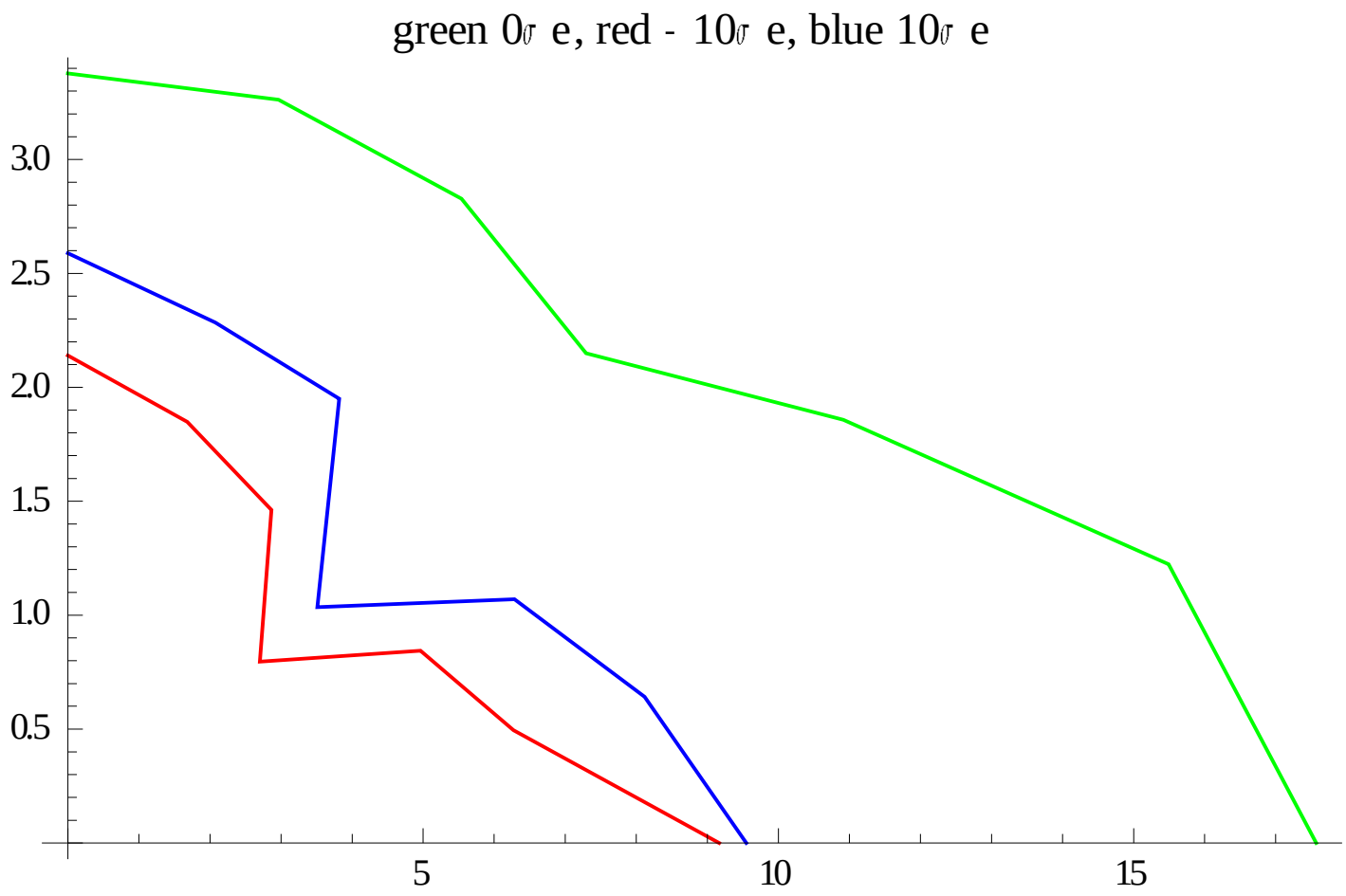
chromaticity

detune

On-momentum DA at the center of the inj. Straight.



G. XU, Y. JIAO, Chinese Physics C, 37(5), 057003, 2013.



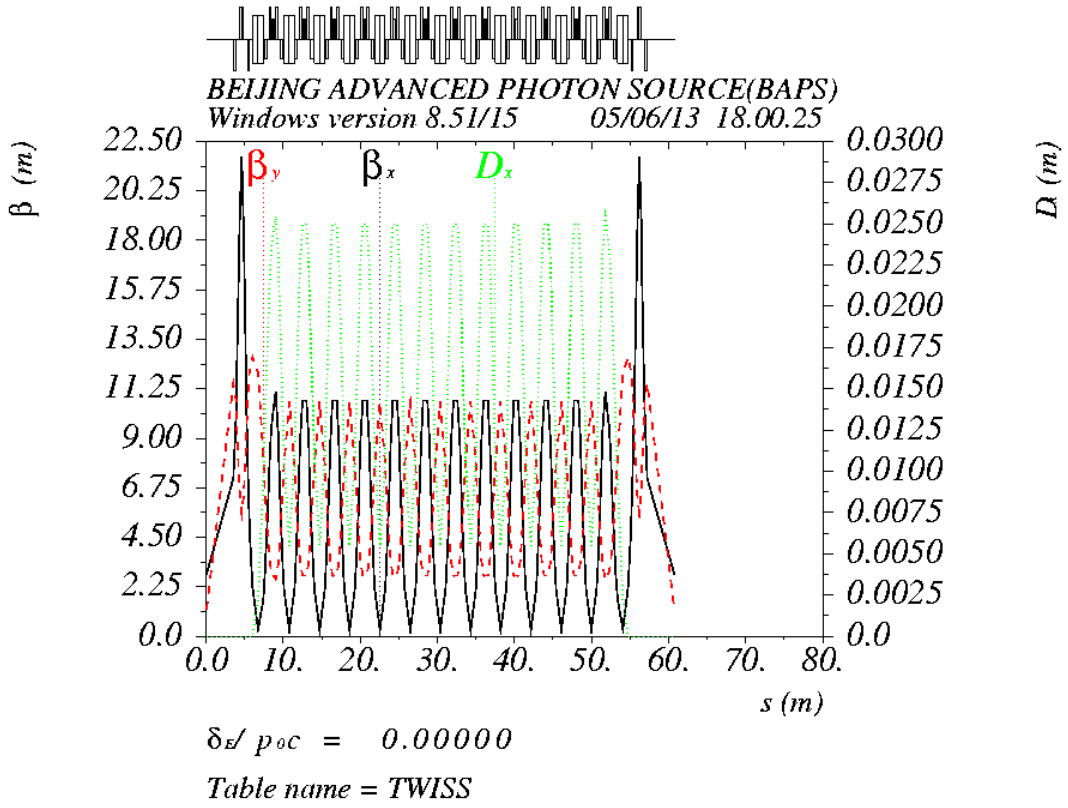
Dynamic aperture(mm)

The ERL or USR in the same tunnel

- The emittance for Our TBA design is 0.46nm or 0.15nm with ID and damping wiggler, in order to keep the possibility to 10pm, we just keep the tunnel wider to insert the other ring ERL or USR
- For ERL, TBA structure is enough
- For USR, we have a preliminary design:

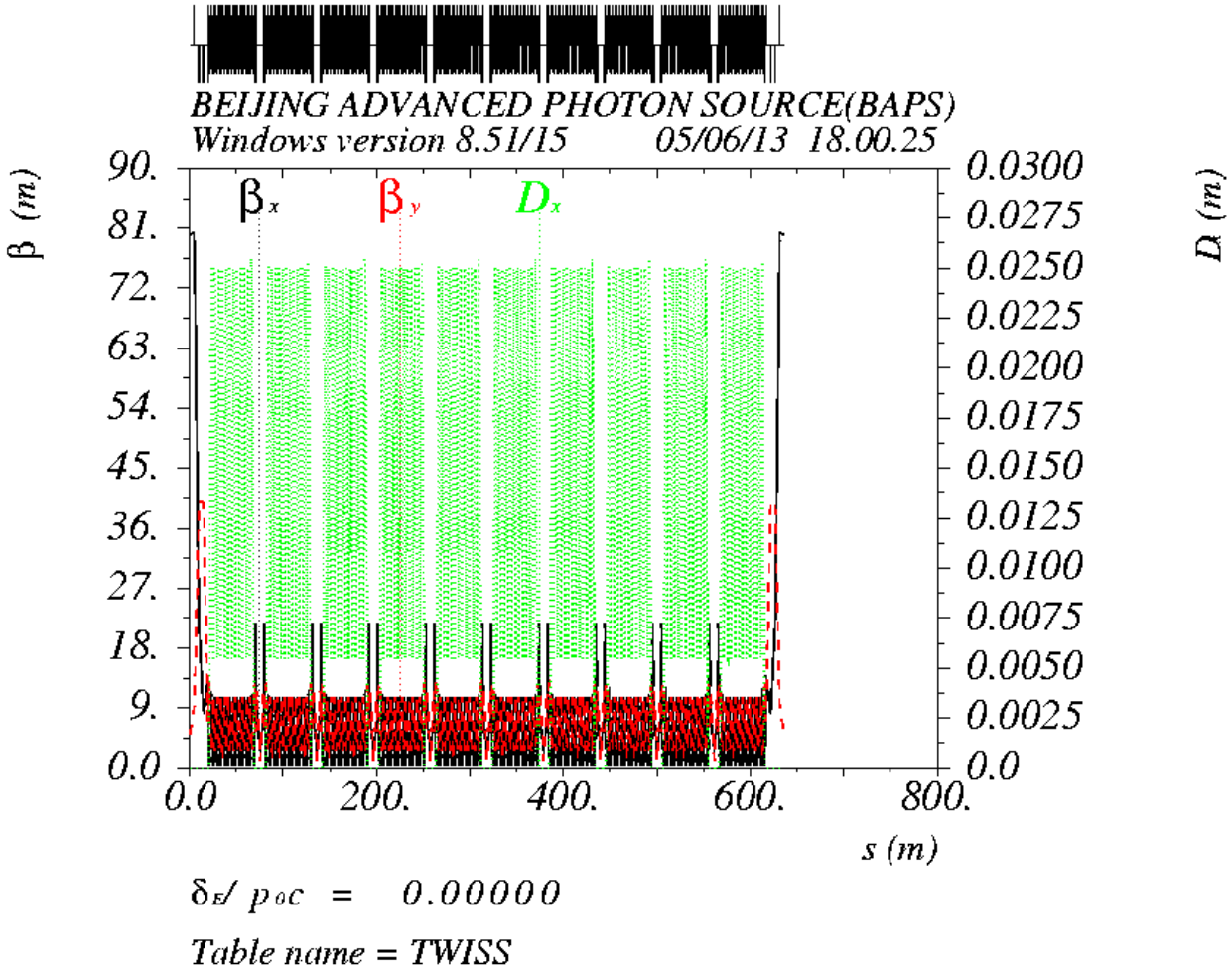
  20*13BA with high beta insertion for pulse sextupole injection

USR design



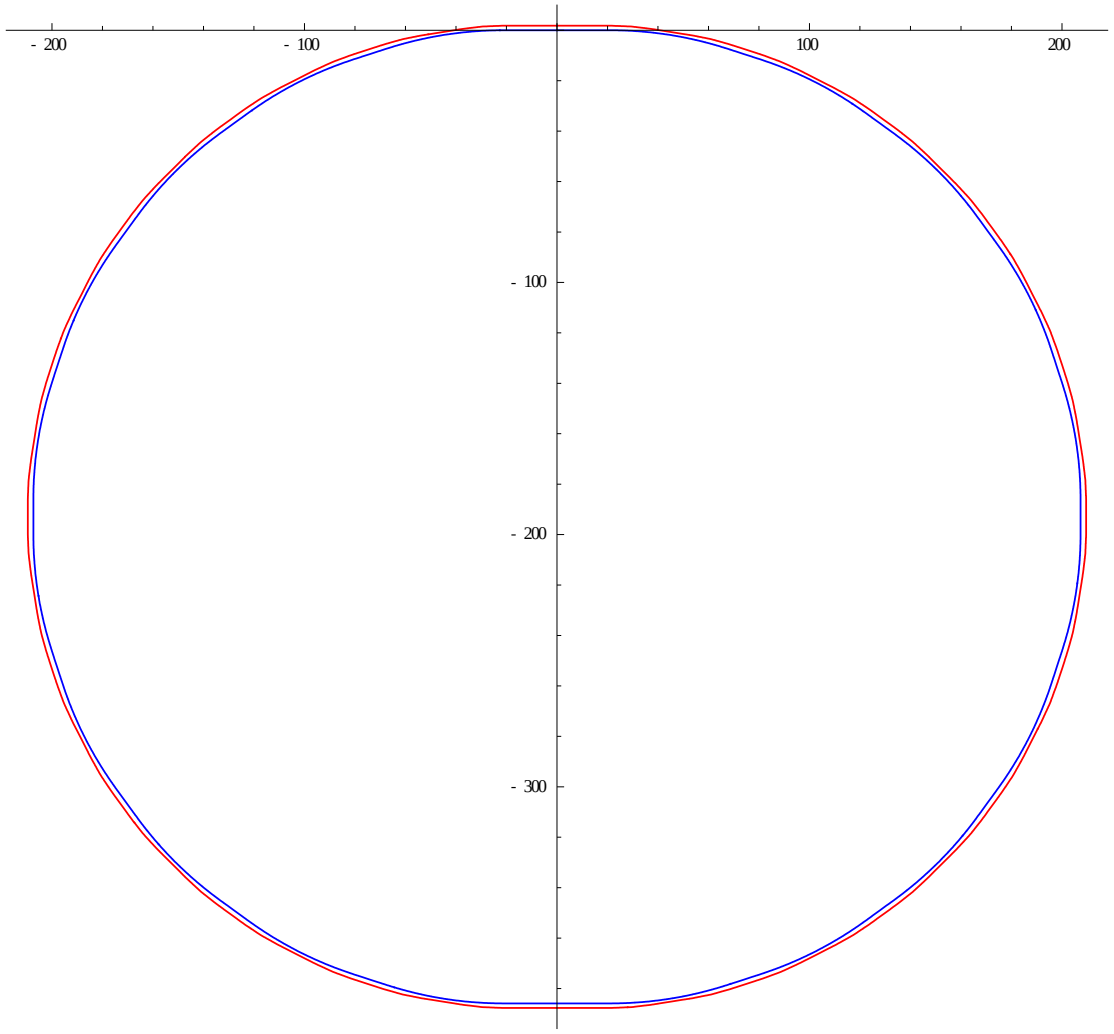
Circumference 1272m Emittance 36pm(bare)

Use damping wiggler and full coupling the emittance get down to 10pm/10pm



Half ring optics function for USR

Two rings tunnel



Distance of two rings
Is 1.78m
Outer ring is TBA
Inner ring is 13BA

Summary

- With TME mid bend, the ratio of emittance to TME is 2.04(the TME of 40*TBA for 5GeV is 0.225nm)
- With ID and several damping wiggler(<20m), the emittance can decrease to about 0.15nm
- Dynamic aperture large enough for the pulse sextupole injection
- The tunnel can insert another ring for ERL or USR

Thanks for attention!