SPPC Overview

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for the SPPC study group

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Outline

- Ongoing SPPC study
- Collider accelerator physics
- Technical issues
- Injector chain
- Plan for CDR writing
- Summary

Ongoing SPPC Study

- CEPC CDR final version published on web
  - IHEP-CEPC-DR-2018-01/IHEP-AC-2018-01
  - SPPC as one chapter (Ch.8) and contributes one section (Sec.11.16, HFM)
- Ongoing studies
  - Almost no budget available for continuing the SPPC study, except HFM R&D supported by the CAS Pioneering Program; Chen Yukai obtained a NSFC Youth Fund
  - Weaker manpower since this year, mainly some students working on accelerator physics studies
  - R&D efforts on high-field magnets maintain

SPPC main parameters (no update)

Parameter	Unit	Value		
		PreCDR	CDR	Ultimate
Circumference	km	54.4	100	100
C.M. energy	TeV	70.6	75	125-150
Dipole field	T	20	12	20-24
Injection energy	TeV	2.1	2.1	4.2
Number of IPs		2	2	2
Nominal luminosity per IP	$cm^{-2}s^{-1}$	1.2e35	1.0e35	-
Beta function at collision	m	0.75	0.75	-
Circulating beam current	A	1.0	0.7	-
Bunch separation	ns	25	25	-
Bunch population		2.0e11	1.5e11	-
SR power per beam	MW	2.1	1.1	-
SR heat load per aperture @arc	W/m	45	13	-

Collider Accelerator Physics

-Parameter list (no update since 2017.5)

Parameter	Value	Unit
Main parameters		
Circumference	100	km
Beam energy	37.5	TeV
Lorentz gamma	39979	
Dipole field	12.00	T
Dipole curvature radius	10415.4	m
Arc filling factor	0.780	
Total dipole magnet length	65442.0	m
Arc length	83900	m
Total straight section length	16100	m
Energy gain factor in collider rings	17.86	
Injection energy	2.10	TeV
Number of IPs	2	
Revolution frequency	3.00	kHz
Revolution period	333.3	μs
Physics performance and beam parameters		
Nominal luminosity per IP	1.01E+35	$cm^{-2}s^{-1}$
Beta function at initial collision	0.75	m
Circulating beam current	0.73	A
Nominal beam-beam tune shift limit per	0.0075	
Bunch separation	25	ns
Bunch filling factor	0.756	
Number of bunches	10080	
Bunch population	1.5E+11	
Accumulated particles per beam	1.5E+15	
Normalized rms transverse emittance	2.4	μm
Beam life time due to burn-off	14.2	hour
Turnaround time	3.0	hour
Total cycle time	17.2	hour

Total / inelastic cross section	147	mbarn
Reduction factor in luminosity	0.85	
Full crossing angle	110	μrad
rms bunch length	75.5	mm
rms IP spot size	6.8	μm
Beta at the 1st parasitic encounter	19.5	m
rms spot size at the 1st parasitic encoun	34.5	μm
Stored energy per beam	9.1	GJ
SR power per ring	1.1	MW
SR heat load at arc per aperture	12.8	W/m
Critical photon energy	1.8	keV
Energy loss per turn	1.48	MeV
Damping partition number	1	
Damping partition number	1	
Damping partition number	2	
Transverse emittance damping time	2.35	hour
Longitudinal emittance damping time	1.17	hour

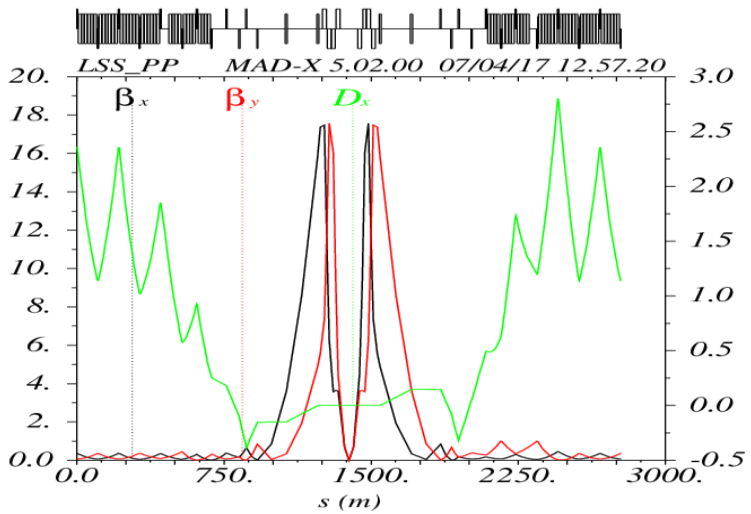
Accelerator Physics

- Lattice, layout, dynamics aperture: Chen Yukai
- Collimation: Yang Jianquan, Zou Ye (Uppsala U.), Tang Jingyu, A. Faus-Golfe (LAL)
- Beam-beam, Luminosity leveling: Lijiao Wang, K. Ohmi (KEK), T. Sen (FNAL)
- Longitudinal dynamics (collider and injector chain): Zhang Linhao
- Instabilities: Liu Yudong, Zhang Linhao
- Injector chain AP: Hong Yang (MSS), Wang Xiangqi and Liu Tao (USTC, SS), Zhang Linhao (p-RCS)

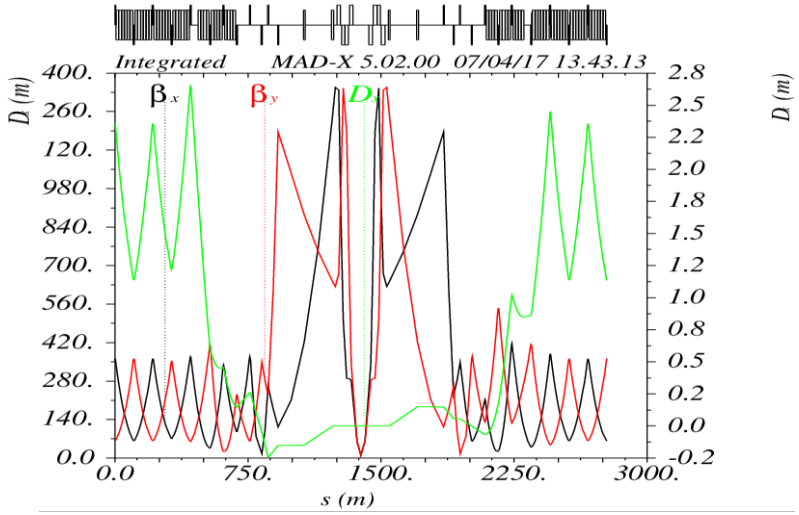
Lattice design

Chen Yukai

- Some work focusing on
  - Lattice optimization
  - Dynamics tracking
  - Some kind of interaction with the CEPC lattice, about how to keep the CEPC machine and detector when SPPC will be built. Some complicated detouring methods were studied.



IP: at collision

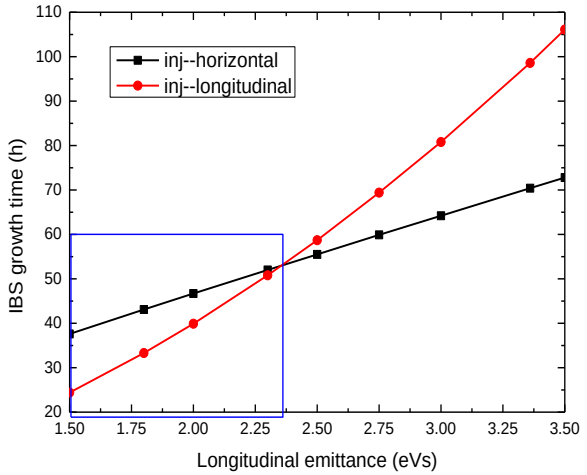


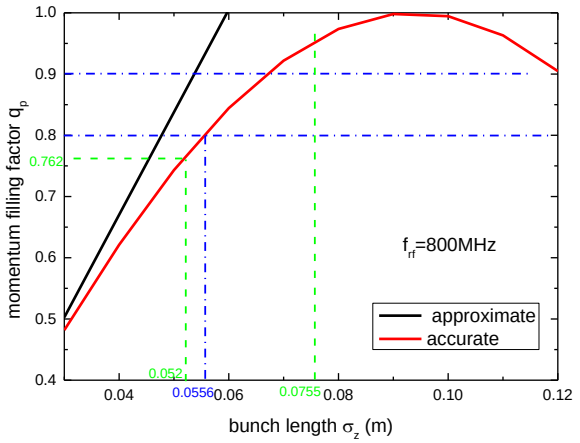
IP: at injection

Longitudinal beam dynamics

Zhang Linhao

- The work concerning long. Dynamics in both Collider and injector chain
- Concerns:
  - Bunch filling schemes
  - Luminosity leveling schemes
  - Instabilities
  - Requirement to the RF systems
  - Global study with the injector accelerators
- Recent study focusing on:
  - RF frequency choice (collider) with relation to instabilities (200+ 400 + 800 MHz)
  - Bucket matching between different accelerator stages



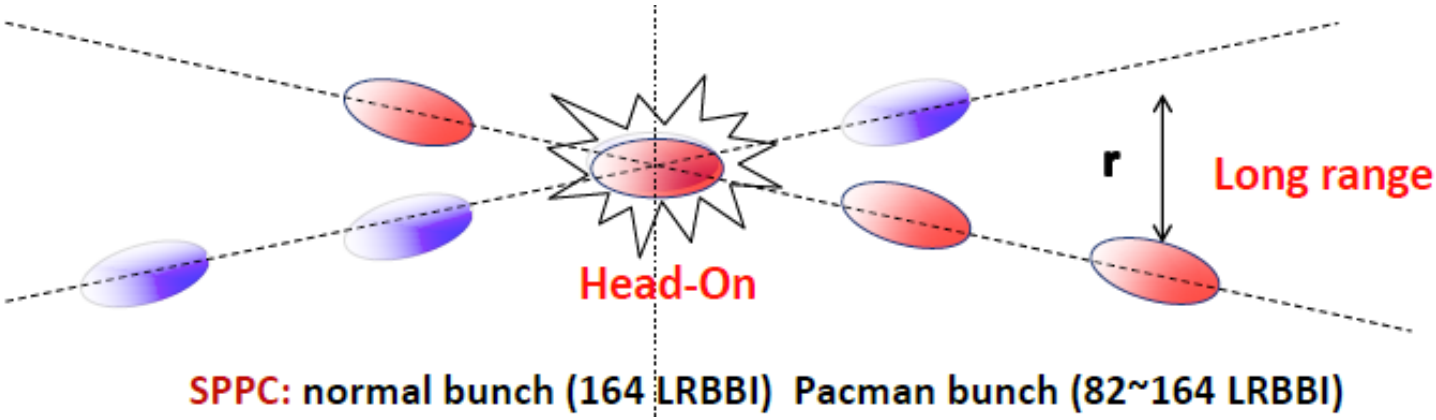


Beam-beam effects

Lijiao Wang, collaborating with K. Ohmi and T. Sen

- Beam-beam effect has direct impact to the luminosity
- The work continues with detailed simulations and calculations, with different factors and effects.
  - Head-on interaction
  - Long-range interaction
  - Pacman effects
  - Orbit effects
  - Coherent beam effects
  - BB compensation methods (Electron lens, Compensation wires)
- Wang Lijiao just went to Fermilab to work with T. Sen for one year

$$\mathcal{L} \propto \xi \frac{1}{\beta_y} N n_b f_r$$



Beam Collimation

Jianquan Yang, Ye Zou (Uppsala U.), collaborating with LAL and LHC

- This important work continues with detailed simulations
- Yang Jianquan just went to LAL for six months (Faus-Golfe)
- Requirements

Huge stored energy: 9.1 GJ/beam

  - SC magnet quench prevention:

$$\tilde{\eta}_c = \frac{\tau_{\min} \cdot R_q}{N_{tot}^q}$$

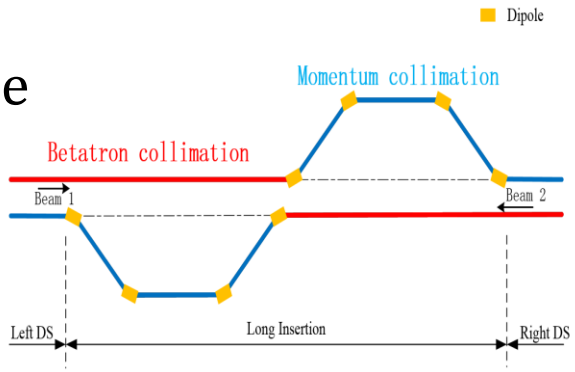
Rq: ~10^6 protons/m/s

N_{tot}^q : 1.5×10^{15}

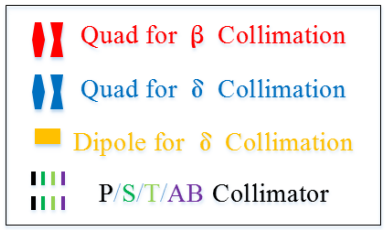
$\tau_{\min}$: 0.2 h (10s) /5 h

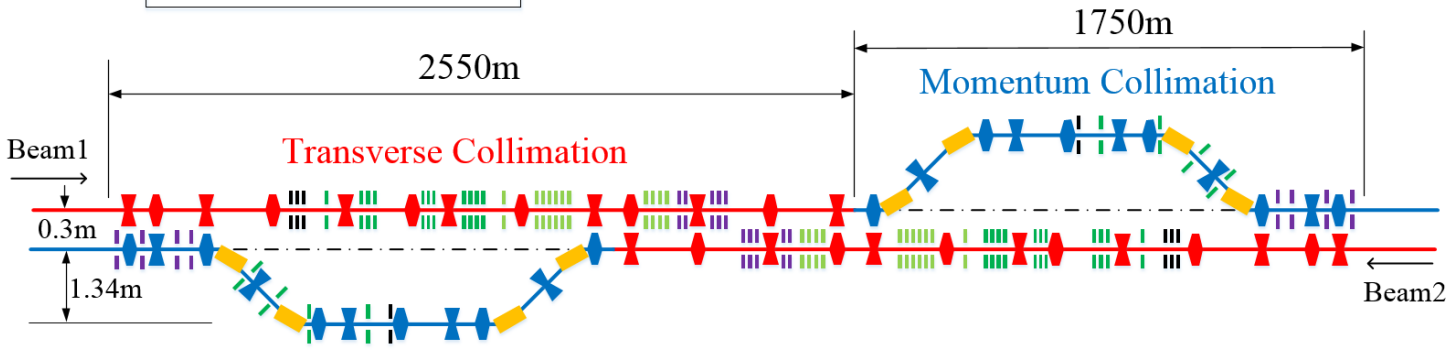
$$\tilde{\eta}_c < 3.5 \times 10^{-7}\ \mathrm{m}^{-1}$$

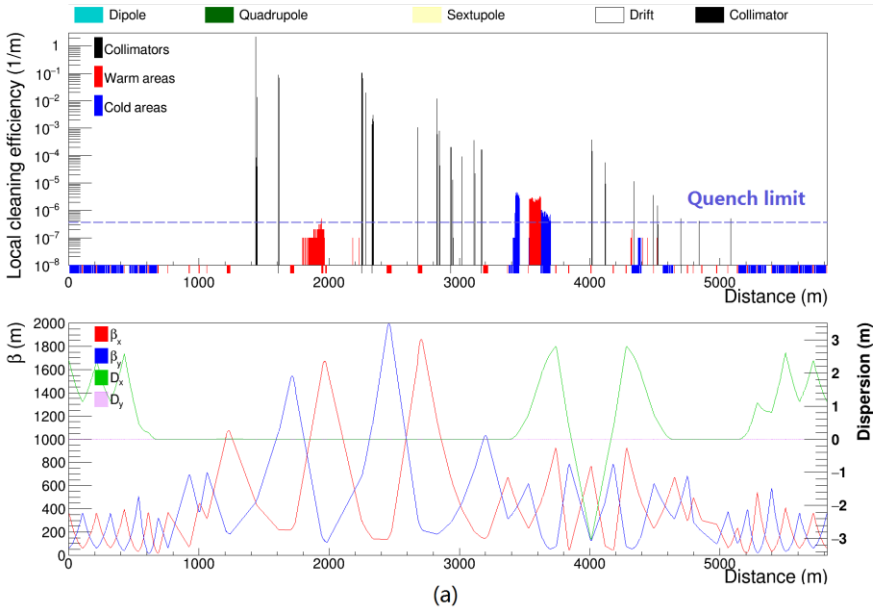
  - Machine protection: prevent damaging radiation-sensitive devices
  - Radiation localization: hands-on maintenance
  - Halo particles cleaning
  - Cleaning physics debris: collision products
  - Optimizing background: in the experiments



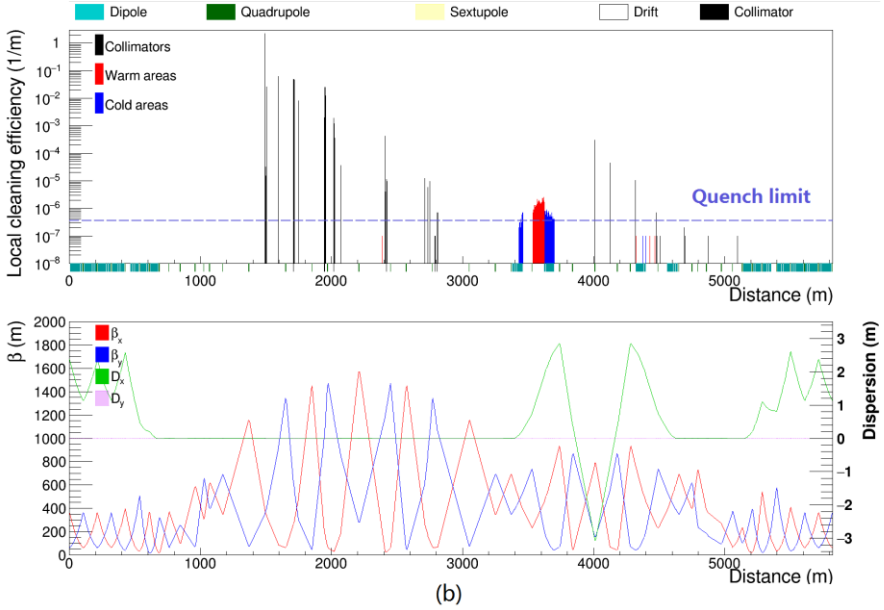
- Detailed simulations on: collimation performance for different schemes, energy deposit pattern and protection of the SC magnets
- A paper submitted to PRAB under revision







With RT magnets in beta-collimation

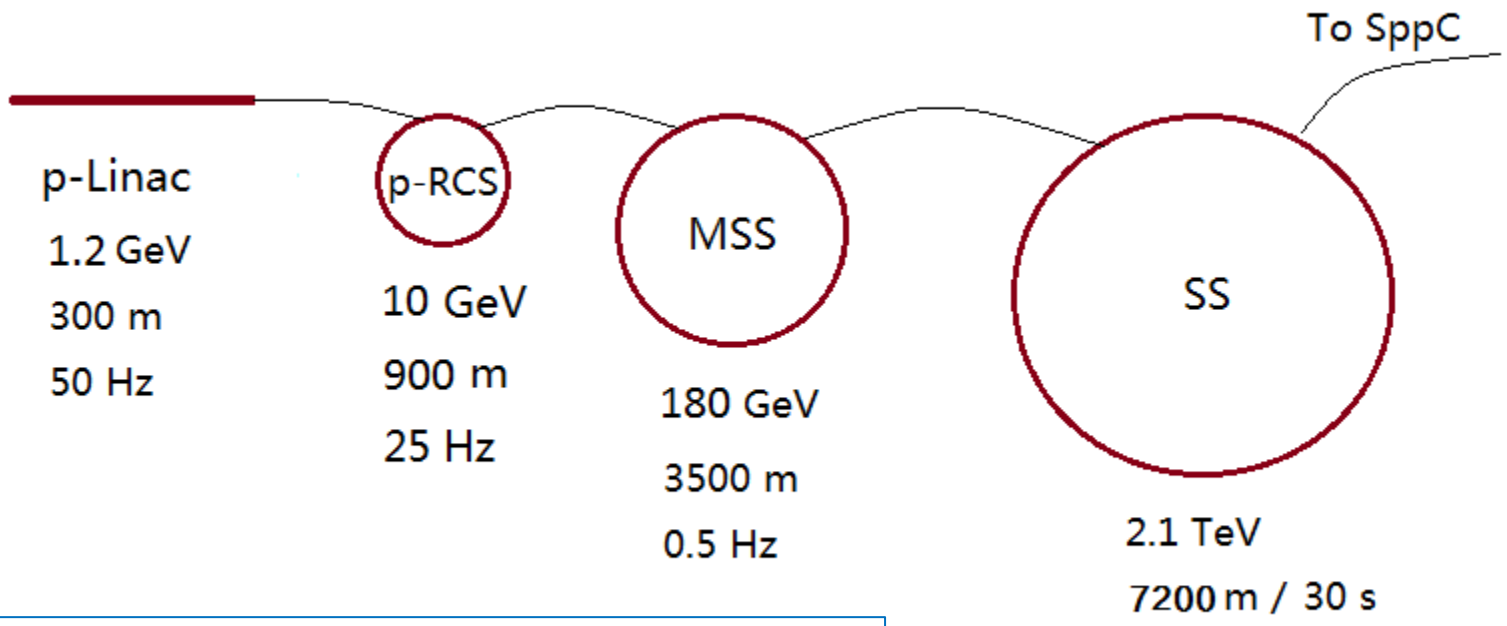


With SC magnets in beta-collimation

Technical Challenges

- R&D efforts for high field SC magnets
  - See yesterday's talk and the incoming talk by Xu Qingjin
- Beam screen
  - Zhu Kun and his student did good paper work, but no continuing with R&D due to lack of funding
- High-Q RF cavities
  - Still looking for fund to do the R&D

Injector chain
(for proton beam)



p-Linac: proton superconducting linac

p-RCS: proton rapid cycling synchrotron

MSS: Medium-Stage Synchrotron

SS: Super Synchrotron

Ion beams have dedicated linac (I-Linac) and RCS (I-RCS)

Major parameters for the injector chain (no update)

	Value	Unit		Value	Unit
p-Linac			MSS		
Energy	1.2	GeV	Energy	180	GeV
Average current	1.4	mA	Average current	20	uA
Length	~300	m	Circumference	3500	m
RF frequency	325/650	MHz	RF frequency	40	MHz
Repetition rate	50	Hz	Repetition rate	0.5	Hz
Beam power	1.6	MW	Beam power	3.7	MW
p-RCS			SS		
Energy	10	GeV	Energy	2.1	TeV
Average current	0.34	mA	Accum. protons	1.0E14	
Circumference	970	m	Circumference	7200	m
RF frequency	36-40	MHz	RF frequency	200	MHz
Repetition rate	25	Hz	Repetition period	30	s
Beam power	3.4	MW	Protons per bunch	1.5E11	
			Dipole field	8.3	T

Summary

- SPPC contributed one chapter and one section in the CEPC CDR report
- SPPC general study will continue with a low profile, and efforts to seek NSFC funds are encouraged
- R&D efforts on high-field SC magnets will remain as the main activity within SPPC in the next few years
- We will follow the CEPC evolution in the TDR design phase

THANK YOU!