Report on the Informal mini-review of the CEPC-SppC Pre-CDR, 13-17 October 2014

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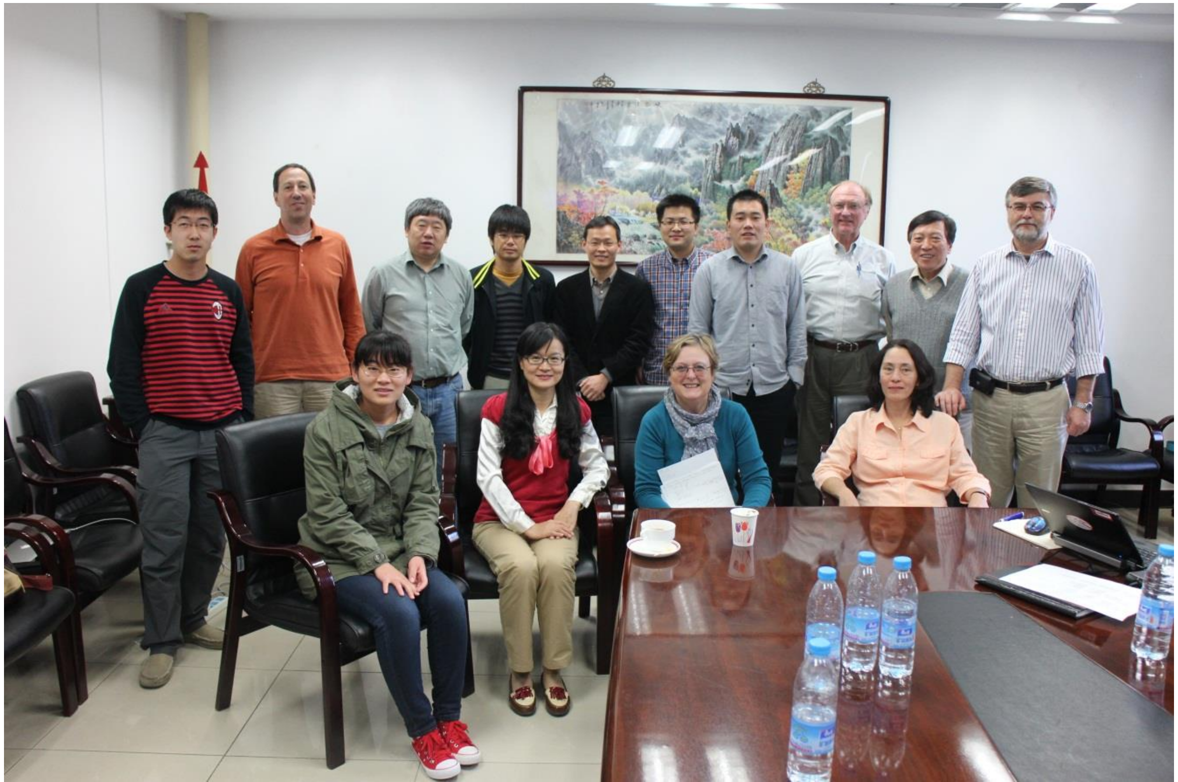
FCC-ee ACC meeting,

3/11/2014

Mini-review

- Following the HF2014 workshop
- ~10 reviewers, 3 intense days of talks about all aspects of CEPC (and SppC!)
- From CERN: Frank, MK
- All talks can be found at http://indico.ihep.ac.cn/conferenceTimeTable.py?confId=4606#20141013



Major design points

- Goal is 250fb-1 per year
- 50MW/beam SR power consumption
- Emittance ratio 330
- Horizontal beam-beam parameter sqrt(2) larger than the vertical beam-beam parameter! This is not what we do at CERN.

My take:

- Here is my personal opinion of the CEPC design:
  - Impressive progress in short period of time
  - (nearly) everything to be done in-house
  - Design delivers a luminosity of ~50% of the scaled down luminosity of FCCee

Where the design can be improved

- There are two fundamental problems with the CEPC design:
  - The inherent (SR dominated) bunch length is too long (around 2.5mm) compared to beta*_y.
  - The vertical emittance is not small enough to avoid being in an BS-dominated machine
- Strategy for improvement:
  - Reduce the vertical emittance by reducing the horizontal emittance by using stronger focusing (90^o optics) and/or shorter FODO cell
  - Reduce the momentum compaction factor using the two above techniques.
  - Find a way to accommodate more bunches (more than 100 for the H running

Emittance

- The ratio of emittances is a (conservative) 330 and it is a matter of strategic choice
- Horizontal emittance is 7 times larger than FCCee (which in turn is a factor of 2 larger than what comes out of MAD)
- Why? Because the ring is twice shorter and FODO cell length about the same.
- Remedy: go from 60 to 90 degree optics to gain a factor of 3
- Go from 48.7m to 38m FODO cell to gain another factor of 2
- This implies some cost increase

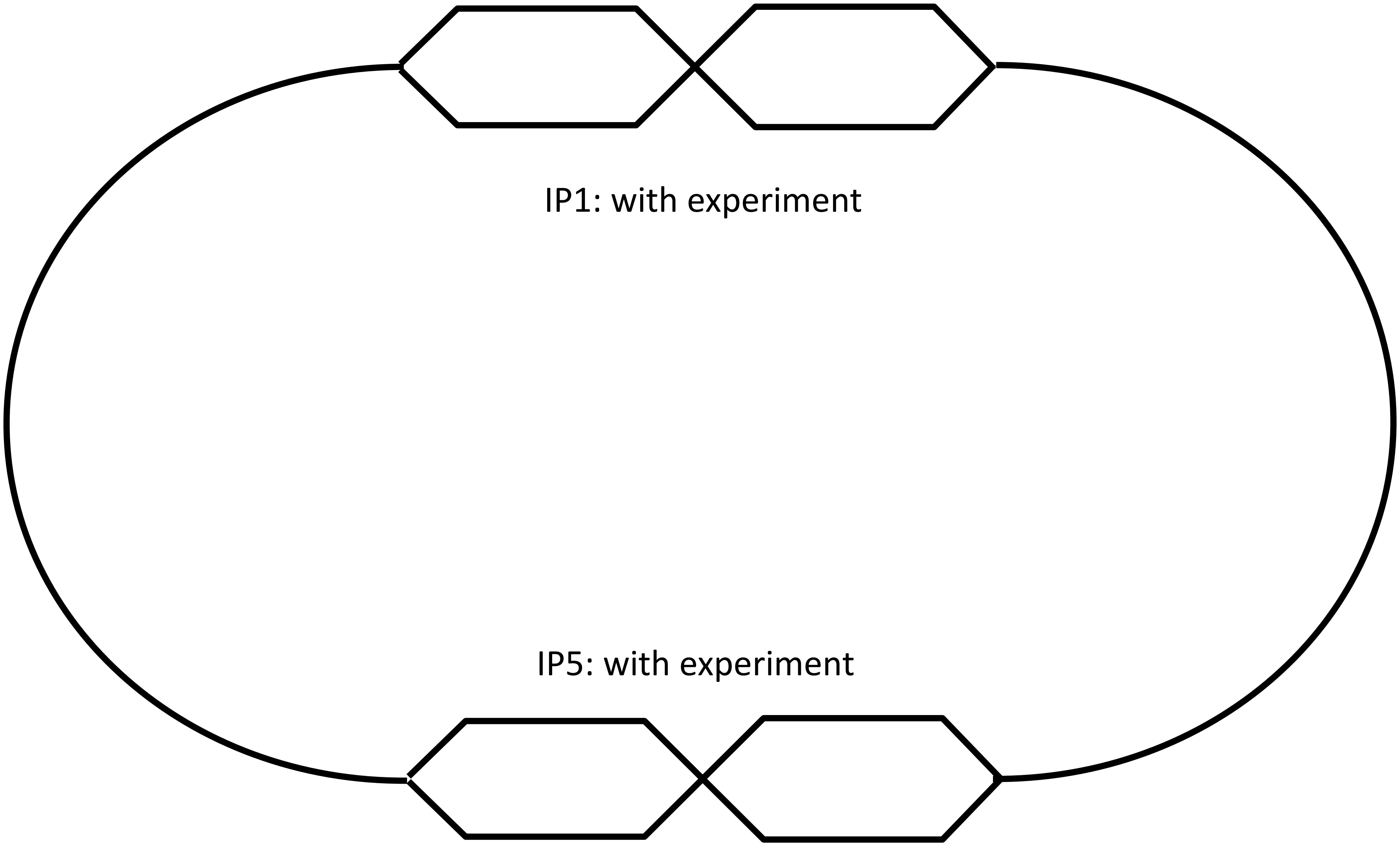
Momentum compaction factor

- A factor of 7 higher than FCCee.
- Need to reduce by a factor of 3
- Can be achieved by
  - going to 90 degree optics (factor of 2)
  - Going to 38m FODO cell length gives another factor of 1.5

Number of bunches

- The lower emittance allows us to run with higher luminosity BUT with a larger number of bunches
- BUT the pretzel scheme does not allow more than O(100) bunches.
- In any case, the pretzel scheme gives a lot of headaches.
- Can we avoid it?
- Proposal to replace ~10% of the ring with a double beam pipe.

Proposal for bunch train scheme



Bunch train scheme

- Electrostatic separators separate the beams in 2 or 4 straight sections.
- If total length of double beam pipe is 4kms, and bunch separation is 2m, then 2000 bunches can be accomodated
- This gives the option to collide at the experiments with a crab waist scheme
- Increase in cost more than compensated by increase in performance

My suggestion

Parameter	Unit	Value 10/10/2014	Value – this suggestion
Beam energy [E]	GeV	120	120
Circumference [C]	m	54752	54752
Number of IP[N_{IP}]		2	2
SR loss/turn [U_0]	GeV	3.11	3.11
Bunch number/beam[n_B]		50	**120**
Bunch population [Ne]		3.79E+11	**1.5E+11**
SR power/beam [P]	MW	51.7	50
Beam current [I]	mA	16.6	16.6
Bending radius [r]	m	6094	6094
momentum compaction factor [a_p]		3.36E-05	**1.1E-05**
Revolution period [T_0]	s	1.83E-04	1.83E-04
Revolution frequency [f_0]	Hz	5475.46	5475.46
emittance (x/y)	nm	6.12/0.018	**2/0.006**
b_{IP}(x/y)	mm	800/1.2	800/1.2
Transverse size (x/y)	mm	69.97/0.15	40/0.085
$\xi_{,y}$/IP		0.118/0.083	**0.146/0.104**
Bunch length SR [$s_{s.SR}$]	mm	2.14	**1.24**
Bunch length total [$s_{s.tot}$]	mm	2.65	**1.55**
Lifetime due to Beamstrahlung	min	47	**68/360**
lifetime radiative Bhabha scattering [t_L]	min	51	34
RF voltage [V_{rf}]	GV	6.87	6.87
RF frequency [f_{rf}]	MHz	650	650
Harmonic number [h]		118800	118800
Synchrotron oscillation tune [n_s]		0.18	0.10
Energy acceptance RF [h]	%	5.99	5.99
Damping partition number [Je]		2	2
Energy spread SR [$s_{d.SR}$]	%	0.132	0.132
Energy spread BS [$s_{d.BS}$]	%	0.096	0.099
Energy spread total [$s_{d.tot}$]	%	0.163	0.165
n_g		0.23	0.17
Transverse damping time [n_x]	turns	78	78
Longitudinal damping time [n_e]	turns	39	39
Hourglass factor	Fh	0.68	**0.81**
Luminosity /IP[L]	$cm^{-2}s^{-1}$	2.04E+34	**3.07E+34**
FODO length	m	48	**38**
FODO phase advance (horiz./vertical)	degrees	60/60	**90**/60

Other points

Injector chain

- Linac gives 6GeV electrons!
- No damping ring is envisaged – is this feasible?
- Ingenious design to operate the booster at low energies and a giant wiggler, increasing the field in the magnets.
- SLAC has available two damping rings and one Linac going for a small price, buyer to incur shipping costs

Staging

- superZ does not need full RF. Could start with that (used as a staging option)
- superZ option becomes viable from the moment than many bunches can be accommodated in the machine

175GeV running

- Cuurently, not considered at all
- Although not a priority, important to be able to have it as an upgrade
- Design the booster to go up to 900 gauss (not 600)

Magnet design

- They say that iron-only magnets will be 20% cheaper!
- I believe that concrete magnets is the cheapest option
- Main magnet power consumption: 68MW! This is a lot higher than what was assumed for the ring-ring option of the LHeC
- Every effort should be made to reduce this (use copper instead of aluminium? – trade-off between initial cost and running costs
- We need to have a first reliable figure for our design as well!
- Power supplies at the surface – advantages/disadvantages?