FROM RESEARCH TO INDUSTRY

WP2: SUMMARY

EuroCirCol kick-off meeting 3-4 June 2015 | Antoine CHANCE

www.cea.fr

TECHNICAL WP2 MEETING
WEDNESDAY JUNE 3, 2015

- **14:00 - 15:30 Work for the Extended Straight Section**
  - 14:00 Welcome (Antoine CHANCE, CEA)
  - 14:15 Collimation (Maria FIASCARIS, CERN)
  - 14:30 Review on the collimation optics (Antoine LACHAIZE, IPNO)
  - 14:45 Extraction section optics (Wolfgang BARTMANN, CERN)
  - 15:00 Discussions
- **16:00 - 17:30 Common session, basic parameters**
  - 16:00 Status and needs for the dynamic aperture calculations (Barbara DALENA, CEA)
  - 16:20 WP3 (Experimental Insertion Region Design)
  - 16:40 WP5 (High Field Accelerator Magnet Design)
- **18h30 Welcome drink at the restaurant 1 (Glass box)**

TECHNICAL WP2 MEETING
THURSDAY JUNE 4, 2015

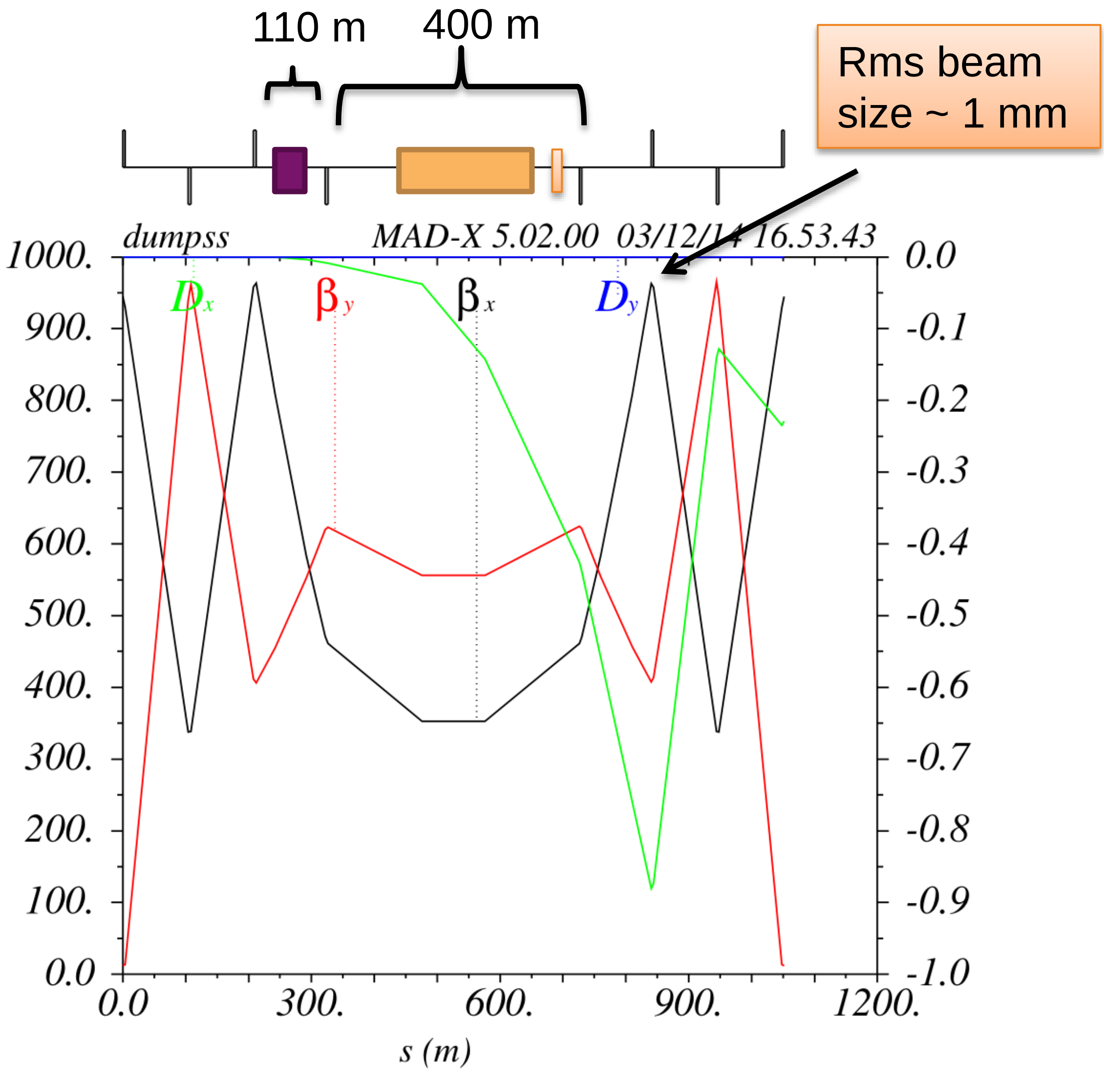
- **09:00 - 10:30 Common session, WP2 WP4**
  - 09:00 Aperture definition of the beam pipes (TBD)
  - 09:20 Electron cloud status (Lotta METHER, CERN)
  - 09:40 Impedance status (Oliver BOINE-FRANKENHEIM, TUD)
  - 10:00 Discussions
- **11:00 - 12:30 Common session, WP2 WP3**
  - 11:00 Status of the IR optics (TBD)
  - 11:20 Collimation in the IR (TBD)
  - 11:40 Interface between the DIS and the IR (Antoine CHANCE, CEA)
  - 12:00 Discussions
- **14:00 - 15:30 WP2, 2nd session**
  - 14:00 Status and plans of the arc and of the optics integration (Antoine CHANCE, CEA)
  - 14:20 Work repartition
  - 15:00 Tentative planning
- **16:00 - 17:30 Plenary discussion**
  - 16:00 WP2 summary
  - 16:15 WP3 summary
  - 16:30 WP4 summary
  - 16:45 WP5 summary

TASK 2.2 ARC OPTICS STATUS

- Lattice integration similar to what was presented in FCC week 2015
  - Realisation of the arc cells with some input parameters.
  - Realisation of the optics of the whole machine with the existing lattice files.
  - The naming convention is under application.
- Extraction optics: already 3 options. Lattice files already existing. Some refinement is nder study. These lattices are already matched to the arc opticla functions.
- Some second order schemes are under tudy to correct the chromaticity.
  - The first results are promising with small variation of the betatron functions with momentum.
  - More investigation is needed.

EXTRACTION SECTION STATUS
3 CONCEPTS

- **LHC scaled**
- SSC like
- Asymmetric



Courtesy: Wolfgang BARTMANN

TASK 2.2 ARC OPTICS WORKING PLAN

- For September 2015:
  - Checking that the element names are conform to the naming convention.
  - Adding the dipole and multipole correctors (setupole and decapole to correct. the b3 and b5 components in the dipoles) in the lattice.
  - Adding some methods to adjust the global tune.
    - Matching the Qpoles of the arcs.
    - Using a dedicated section.
- For December 2015:
  - Integrating the collimation lattice files (momentum collimation).
  - Integrating a first aperture model (MAD-X model).
  - Making the first calculations for obit correction.
  - Refining the chromaticity correction scheme.
  - Introducing the the coupling correctors.

Arc dipole's field quality

- First table for dipole's multipole errors provided (*E. Todesco FCC-hh design meeting 28/05/2015*) →

- Needs:
  - full integration of insertion optics and trims for total tune ?
  - will assume LHC collision tune, which seems a good point for beam-beam (*X. Buffat FCC-hh design meeting 28/05/2015*)
  - what about quadrupole field quality ?

- provide first estimate of impact of dipole's errors for September
  ⇒ no magnets mis-alignment and no multipole correction considered
  (? see next slide)

	Average		Uncertainty		Random	
Normal	Injection	High Field	Injection	High Field	Injection	High Field
2	0.000	0.000	0.484	0.484	0.484	0.484
3	-5.000	20.000	0.781	0.781	0.781	0.781
4	0.000	0.000	0.065	0.065	0.065	0.065
5	-1.000	-1.500	0.074	0.074	0.074	0.074
6	0.000	0.000	0.009	0.009	0.009	0.009
7	-0.500	1.300	0.016	0.016	0.016	0.016
8	0.000	0.000	0.001	0.001	0.001	0.001
9	-0.100	0.050	0.002	0.002	0.002	0.002
10	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000
Skew						
2	0.000	0.000	1.108	1.108	1.108	1.108
3	0.000	0.000	0.258	0.258	0.258	0.258
4	0.000	0.000	0.252	0.252	0.252	0.252
5	0.000	0.000	0.050	0.050	0.050	0.050
6	0.000	0.000	0.040	0.040	0.040	0.040
7	0.000	0.000	0.007	0.007	0.007	0.007
8	0.000	0.000	0.007	0.007	0.007	0.007
9	0.000	0.000	0.002	0.002	0.002	0.002
10	0.000	0.000	0.001	0.001	0.001	0.001
11	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000

Impact of IR field quality

To be coordinated with **WP3**

- Definition of lattices to be studied: nominal, ultimate, flat, injection…
- Integration of the different lattices
- Study the impact of interaction region magnets w or w/o arcs errors ?
- IR insertion at the injection energy.

- What about inner triplet fringe fields ?

Conclusion

- Tools for FCC-hh Dynamics Aperture calculation have been developed (makethin.madx) and adapted starting from the (HL-)LHC ones.
- Further development and optimization possible and needed…
- Needs:
  - Optics for the different specific studies (injection, ….)
  - Trims for tune scan
  - Local correctors for b3
  - …

Comparison with round pipe impedance → Horizontal

Courtesy: Uwe NIEDERMYER

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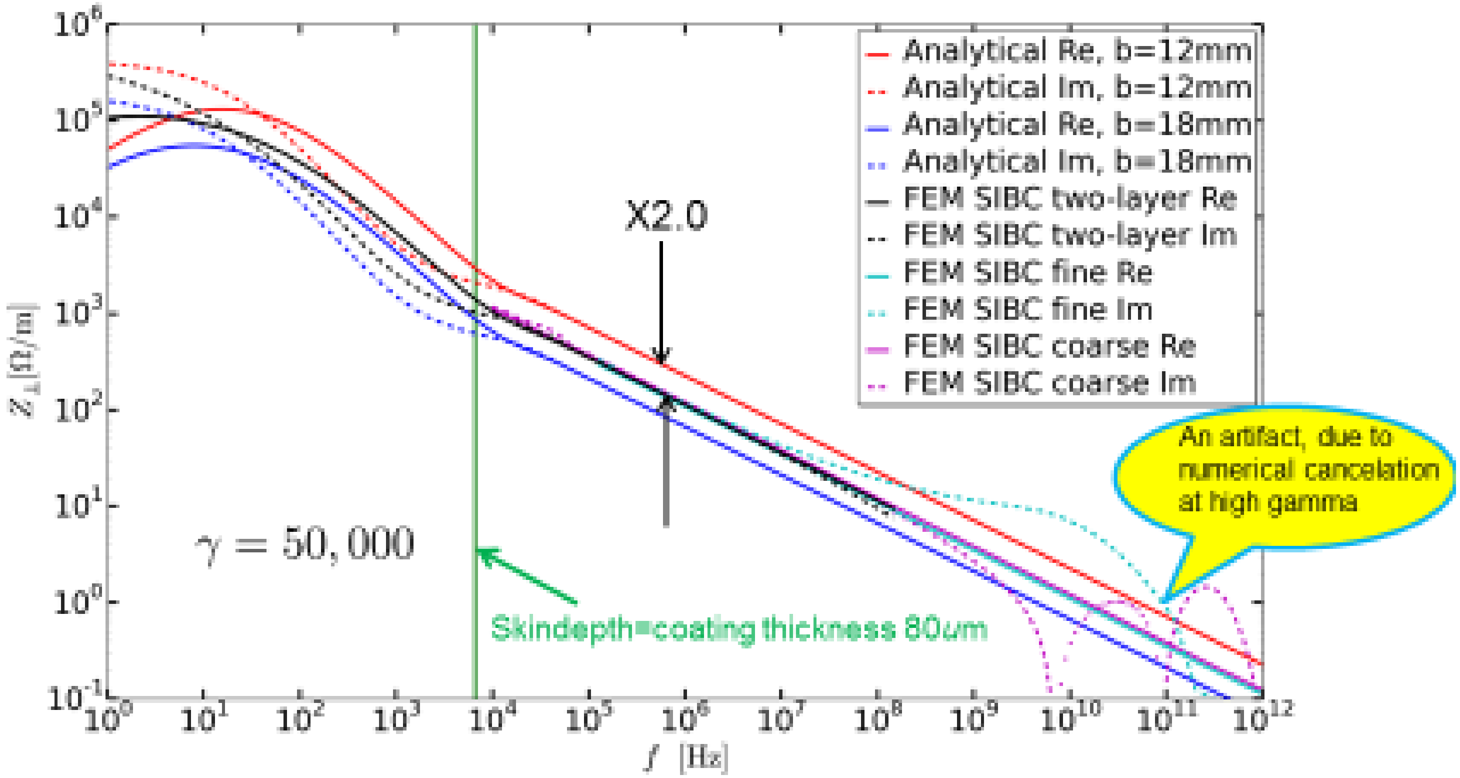
(1 meter pipe)

Coating with Copper at 50K, *k*=6e9 S/m



Coupled bunch resistive instability

Courtesy: Uwe NIEDERMYER

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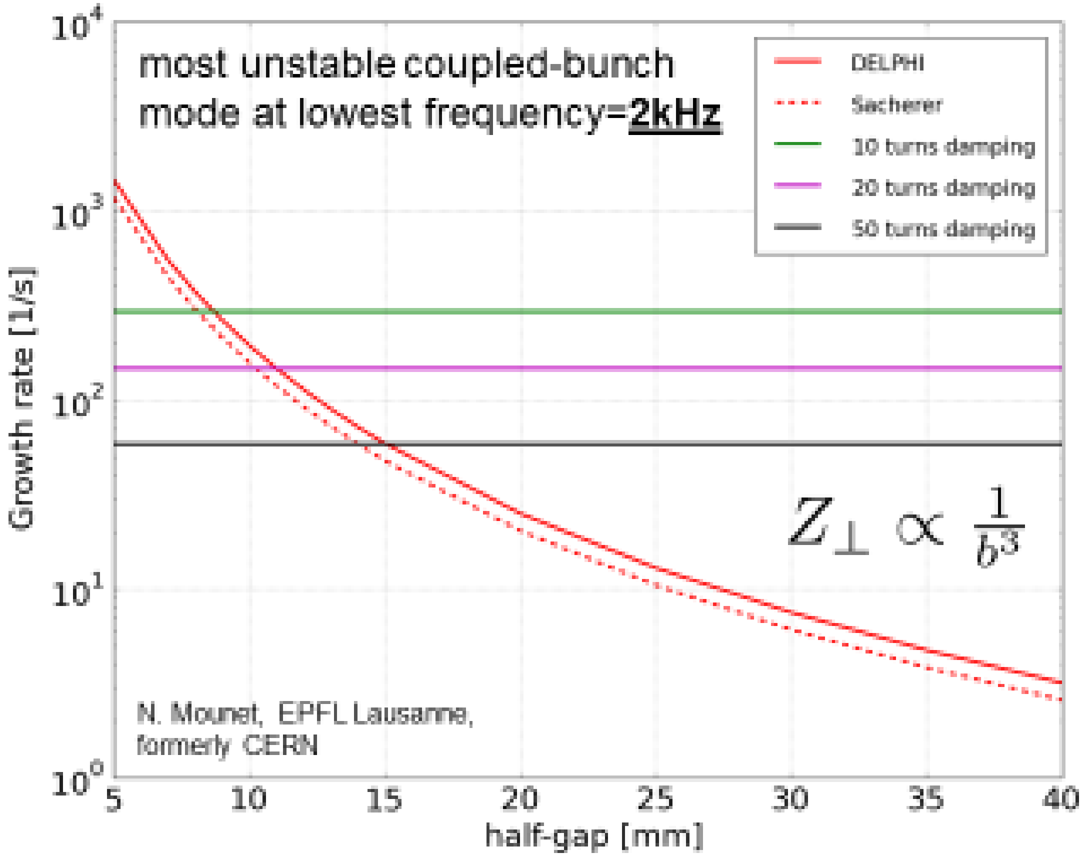

Most critical at injection due to less stiff beam!

Pipe only, solid Cu 50K E=3TeV

Growth rate by factor 1.6 higher for 80 *um* coating

Required thickness for "thick wall"
150 *um* for 50K
450 *um* for 140K

TASK 2.4: SINGLE BEAM STABILITY

Conclusion

Courtesy: Uwe NIEDERMYER

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- FCC-hh already on the edge of stability only with resistive pipe

- 50 turns feedback possible but maybe insufficient
- 10 turns feedback possible?

- Kickers not yet considered
- Landau damping and Octupoles not yet considered

- Impedance should play an important role in collimator design

TASK 2.5: ELECTRON CLOUD

Electron cloud studies so far

Courtesy: Lotta METHER

Build up (CERN)

- Simulation studies
- Initial estimates for LHC-type beam screen
  - Dipole, quadrupole, drift
  - 25 ns and 5 ns beam
- Estimated
  - Threshold SEY for multipacting
  - Heat loads on beam screen
  - Electron density around beam
- Parameter scans

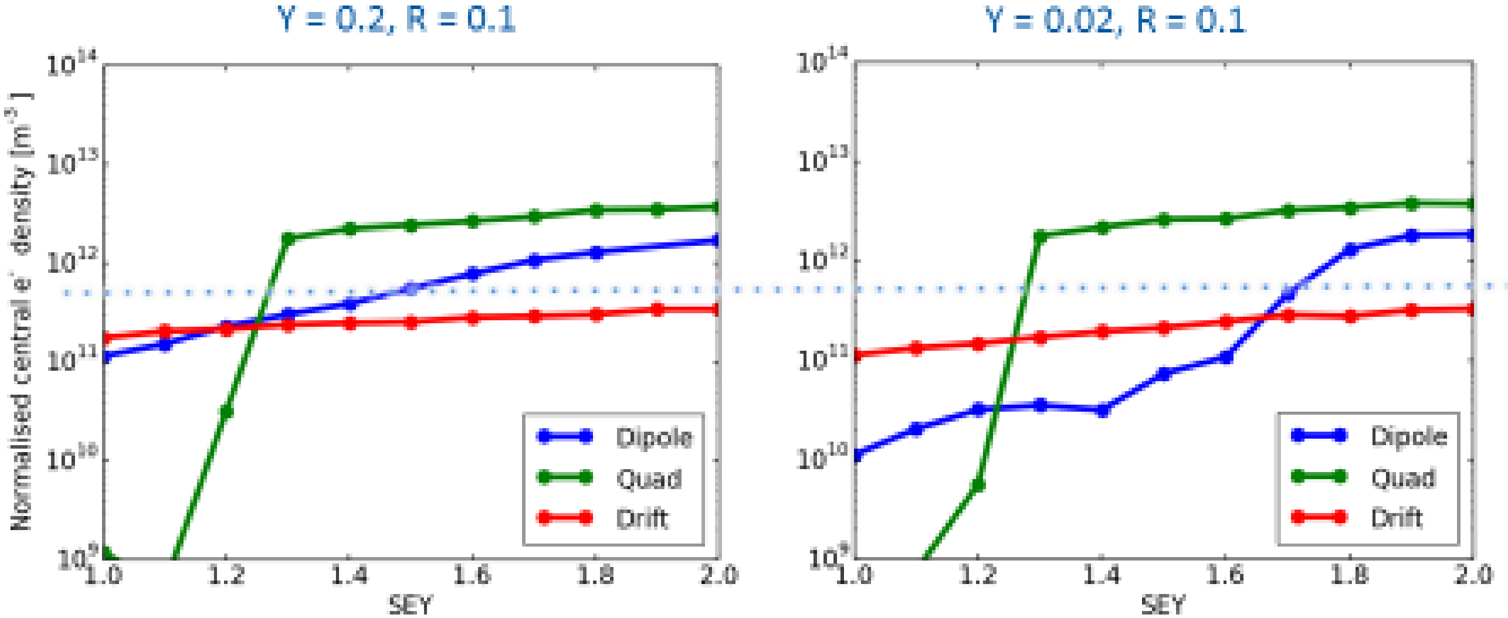
Instabilities (KEK)

- Simulations and analytical estimates for single bunch instability
- LHC-type beam screen
  - Dipole
  - 25 ns and 5 ns beam
- Estimated
  - Threshold electron densities for instability

Central electron densities along FODO cell

Courtesy: Lotta METHER

- Central electron density, scaled to fraction of element in FODO cell, 50 TeV 25 ns



- Instability threshold estimate ρ ~ $5x10^{11}/m^3$ (for dipole)
- Length of arc elements
  - FODO: 208.14 m, Dipole: 170.40 m, Drift: 26.40 m, Quadrupole: 10.34 m

TASK 2.5: ELECTRON CLOUD

Further studies

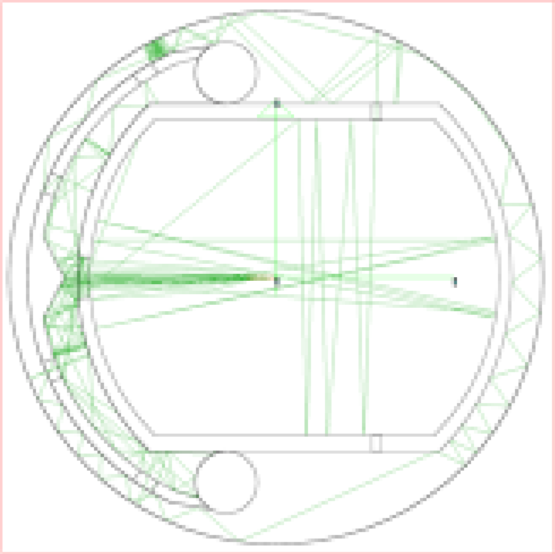
Courtesy: Lotta METHER

- Refine studies on LHC type beam screen
  - Study electron cloud build-up using accurate boundary
  - Cross-check of codes between KEK and CERN
  - Instability thresholds for all components
  - Details of instability
  - Better input for build-up simulations may play bigger role

- Intermediate bunch spacings
  - 12.5 ns?

- Study beam screen with SR chamber
  - Requires detailed knowledge on where photoelectrons will be produced

- Electron cloud in injectors



R. Kersevan

TASK 2.5: ELECTRON CLOUD

- Risk: a lack of people (12 person.months from KEK and less from CERN).

⇒ More people needed

- September 2015: meeting beween Task 2.4 and 2.5
- Strong synergy between both expertises

Electron Cloud effects

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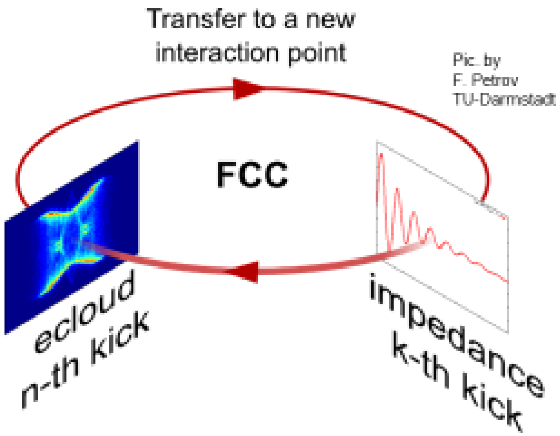
Electron clouds lead to

- Tune shift / spread
- Synchronous phase shift
- Instabilities

Difference to LHC

- Syncr. Rad.
- Asymmetry
- Small aperture



- 3D and 2D particle in cell codes for electron cloud simulations
- community supported beam tracking codes (e.g. PyOrbit)
- working on coupling the electron cloud simulations to the beam tracking including impedances.

04 June 2015 | TU Darmstadt | Fachbereich 18 | Institut Theorie Elektromagnetischer Felder | Uwe Niedermayer | 19

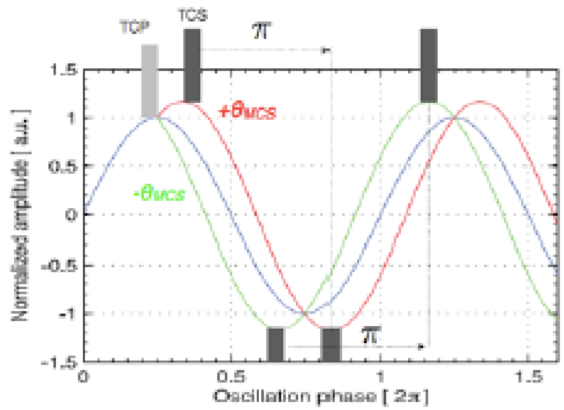
Where we are

Baseline available for a first FCC betatron collimation layout, based on a scaled-up version of the present system

- Standard optics for multi-stage cleaning
- Beta functions scaled to have similar collimator gaps as in the LHC
  → push until later technological developments beyond present state-of-the-art
- Initially, keep current collimation system layout (same number of collimators, positioned at same phase advance, based on C-reinforced-C material for primary and secondary stages)
  → to be optimized later (more collimators for secondary and tertiary stages, new materials...)

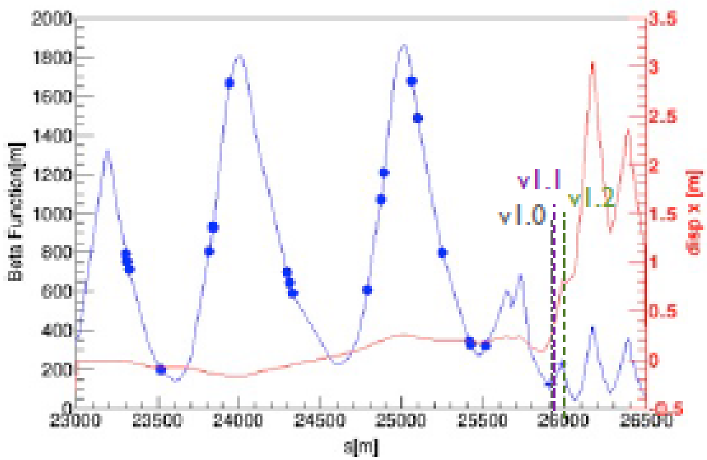
Secondary collimators must be placed at optimum phase locations to catch secondary halo

see *Phys. Rev. Spec. Top. Accel. Beams 1 (1998) 081001*

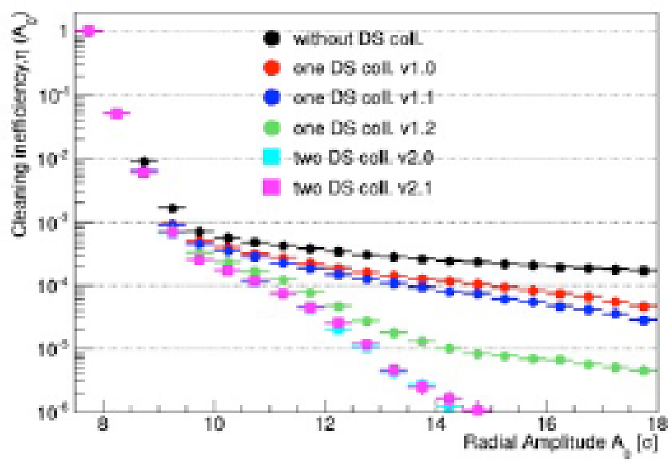


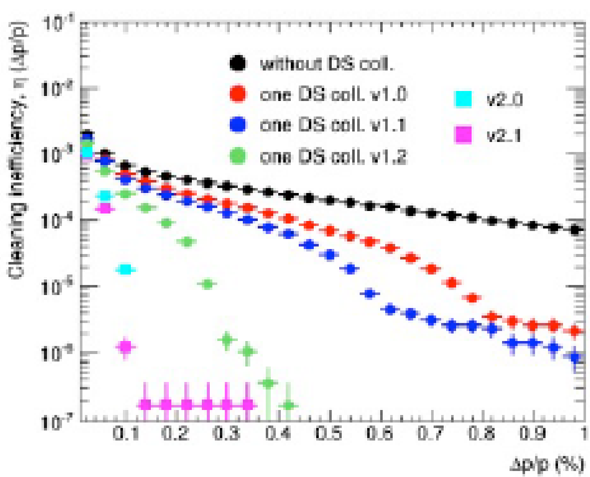
- Dedicated insertion for off-momentum cleaning (yet to be implemented)

DS collimators in FCC



- **Main cleaning limitation** of current system: critical losses in the DS after the betatron cleaning
- Present system: make space for two room temperature collimators close to first dipole where dispersion starts growing (one15m long dipole replaced with two 5.5m long 11T dipoles)
- We run simulations with one or two DS collimators in FCC layout in cells 8(9), 10(11)
- Two DS collimators provide good cleaning of off-momentum particles





TASK 2.6: DEVELOP OPTICS CONCEPT FOR COLLIMATION SYSTEMS

- Development of an aperture model and define baseline collimator settings - Oct. 2015 (CERN)
- Define specifications for momentum cleaning - soon (July 2015 ?)
- Decision on lattice layout - Sept. 2015
- Optics for momentum cleaning - Sept. 2015 (IPNO)
- Design of dispersion suppressor regions including TCLD collimators - Sept. 2015 (CERN)
- Integration of colliation optics lattice - Oct. 2015 (CEA)
- Performance evaluation with first collimation inefficiciency tracking- end of 2015 (LAL)
- ➡input for impedance evaluation and HW design
- **EuroCirCol WP2 contribution:** optics design for collimation

HIRING POSITIONS

- CEA post-doctoral position for task 2.2 and task 2.3
  3 candidates under review next week
  beam dynamics
  multi-turn tracking
  (MAD-X expertise will be very appreciated)

- CNRS post-doctoral position for task 2.6:

INSPIRE link: https://inspirehep.net/record/1374276
Experiment: Future Circular Collider - EurCirCol Design Study
Deadline: 2015-07-20
Position: Post-doctoral position in Accelerator Physics
Topic: Performance Evaluation of the Future Circular Collider hadron beam collimation system