„Minutes“ from last Thursday‘s informal meeting on e-cloud induced incoherent emittance growth

- People who attended the meeting:

  E. Benedetto, W. Bruns, G. Rumolo, D. Schulte, F. Zimmermann
- Frank‘s presentation to summarize motivations and issues for the meeting
- Try to draw a full picture of what the existing codes can do (what they can model and what their limits are) and how they could be improved.
- Different proposals for future studies.

HEADTAIL (CERN)

- It correctly models the interaction bunch-ecloud, a limit is given by the numerical noise introduced by the finite grid size in the transverse directions (but the beam is always spread over at least 10 x 10 cells).

  D. Schulte pointed out that there are many ways to minimize the numerical noise coming from the discretization (like symmetrizing the electron distribution)
- The interaction bunch-ecloud can happen once per turn to speed up the computation (but the lumped nonlinear kick would excite all resonances), or it can be smeared over many interaction points per turn, with the possibility of choosing different beta functions (and -planned- phase advances) between them.
- It can be run with turn-by-turn (or IP-to-IP) field calculation (but time consuming!) or in a frozen fashion, storing the field distribution and using it for many turns (no different beta functions in this case!)
- It can use as initial electron distribution the one coming from the build up code ECLOUD

MICROMAP (GSI)

- It is an optics program and therefore contains a refined model of the lattice (only the correct resonance lines are excited)
- A rough model of the interaction bunch-ecloud is implemented:
  - The value of the central density as the bunch goes through the e-cloud is taken from a HEADTAIL simulation
  - A Gaussian approximation of the e-cloud is then constructed starting from this value and the analytical field expression is used (noiseless!)
  - The size of the Gaussian changes as the bunch passes, because the density increases (but also exhibits some peaks corresponding to the „focusing“ times of the pinch) and the charge is conserved
- Results from the correct HEADTAIL pinch passed to the MICROMAP are not available so far.
  - How many pinches (3D) have to be passed? In principle as many as the number of different beam cross sections at the interaction points...
- Uses frozen field approximation
  - For how many turns does it deliver correct results? Bunch shortens, its size grows, its intensity decreases...

FAKTOR2 (CERN)

- It is so far an electron/ion build up code
  - Electron/ion generation, electron secondary emission
  - Electron/ion tracking in the beam and their own space charge field.
- Interesting because:
  - It can deal with 2D arbitrary boundary conditions (beam pipe shape)
  - Fine meshing for the calculation of space charge field
  - Grooved surfaces, clearing electrodes
- Benchmarked with ECLOUD, it delivers now the same growth time for the build up and same saturation density value.
- It is presently being extended to a 3D code, but the computation time is still too large (certainly more than 2 days for a build up over an SPS bunch train!)
- It potentially contains the information to be extended to a self-consistent build-up + instability code (i.e. the e-cloud space charge field), but **the action of the electron cloud back on the bunch is so far not included in the model**
  - How would the macroparticle model for the beam/bunch be?
  - How would the bunch propagation along the accelerator be modeled?

Proposals

- F. Zimmermann → Get MICROMAP to CERN, develop it to remove its limits in the cloud-bunch interaction and learn how to run it so as to deliver a reliable number for the expected LHC emittance growth
- D. Schulte → The cloud-bunch interaction should not be treated with a rough analytical model. HEADTAIL could be improved by removing the1-kick approximation in a clever way: many kicks are needed over a betatron wavelength, but they should not be applied IP by IP, instead they should be stored in an array and finally applied at the end of the wavelength
- E. Benedetto → Why depend on MICROMAP? It is just an optics code and needs anyway a significant improvement in the bunch-cloud interaction.
  - Undertake an upgrade of HEADTAIL, followingthe track of what she had started during her PhD thesis (implementation of the FODO cell)
  - Include an ecloud module in MAD-X, which is developed at CERN, locally supported, widely used and benchmarked.
- What is actually our goal?
  - Emittance growth is very hard to predict quantitively even in those cases where the source is perfectly known both in intensity and location....
  - Maybe more reasonable to aim at parameter studies which can explain observations and tell what can be done to improve the performance (working point, chromaticity, e-cloud mitigation...)