Ecloud Simulations Group: Summary

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Electron Cloud Group Charge
(M. Palmer)

The charge to the Electron Cloud working group is to review the status of electron cloud simulations, both for electron cloud growth and for electron cloud induced beam dynamics, the benchmarking of the major codes against each other, and benchmarking of the codes against experiment. The group should also review the status of electron cloud measurement and mitigation techniques. Finally, the group should look at the world-wide experimental program and inputs that are required for the ILC and CLIC damping ring designs, paying particular attention to identifying tests that are needed as part of the CesrTA program.

This charge is quite ambitious; we made headway, but continuing discussions and real work will be required to fulfill the charge

Talks in simulation session

- G. Dugan: “Simulations at Cornell for CesrTA”
- J. Calvey: “Simulations for RFA studies at CesrTA”
- J. Crittenden: “Simulations for witness bunch studies at CesrTA”
- T. Demma: “Build-up of electron cloud in DAΦNE in the presence of a solenoid field”
- C. Celata: “Electron cloud cyclotron resonances for short bunches in magnetic fields”
- K. Ohmi: “Study of electron cloud instabilities in CesrTA and KEKB”

All but the last talk are about “build-up ecloud physics”

Three build-up codes now in use at CesrTA: ECLOUD, CLOUDLAND, POSINST

I apologize for not reviewing the talks; all were very interesting, but I have no time to do it in this brief summary

What is to be done… (1)

- **Understand ecloud build-up, decay, and spatial/energy distribution**

- Benchmarking of build-up codes
  - bring the codes (ECLOUD, CLOUDLAND, POSINST) into agreement
  - "rediffused electrons" likely to be the source of the discrepancy
- Simulate a few beam fill patterns and
  - obtain electron flux J_e and dN/dE at RFAs
  - obtain transverse distribution of ecloud at dipoles
  - fit basic SEY parameters to the above so as to agree with data
  - then predict J_e, dN/dE, tune shift along train and transverse electron distribution for other fill patterns
  - iterate if necessary
- This subprogram will
  - characterize the ecloud distribution around the machine
  - increase the confidence in build-up codes

The 3 aspects of “benchmarking” (1)

- Do the code simulations agree with…
  1. Analytic results whenever they are available (algorithm validation)
  2. Each other (benchmarking)
  3. Measurements (code validation)
- Item 1: few opportunities; no strong tests, overall; however:
  - Kick from the beam on an individual electron agrees with Bassetti-Erskine formula (gaussian beams): POSINST, WARP, ECLOUD,…
  - POSINST: agreement for other tr. beam distributions
  - POSINST: $J_e/\rho_e = a/(2\Delta t)$ when a-->0 (a=radius of chamber or subset of electrons) (my thanks to R. Zwaska)
  - Gröbner multipacting condition leads to strongest effect when applicable

    QuickTime™ and a
    TIFF (Uncompressed) decompressor
    are needed to see this picture.
  - (a= chamber radius, N_b=bunch pop., s_b=bunch spacing, r_e=class. e^- rad.)
- Item 2: mandatory to use same physical model in 2;
  - POSINST, WARP/(static beam mode) and ECLOUD have been benchmarked with good agreement
  - WARP/(QSM mode), HEADTAIL and QUICKPIC have been benchmarked with good agreement

http://conf-ecloud02.web.cern.ch/confecloud02/CodeComparison/instres2008.html

The 3 aspects of “benchmarking” (2)

- Item 3: problem here is that many input parameters are not well known, so can usually fit (some) data; however, there’s a good history of understanding measurements (qualitative or semi-quantitative agreement):
  - Essential difference bet positive/negative beams at PF, DAΦNE, CESR (codes PEHTS, POSINST,…)
  - Influence of SEY, sometimes drastic
    - low-SEY coatings proven effective
  - Gröbner multipacting condition reproduced by simulations (POSINST, ECLOUD…)
  - Suppression of ecloud with solenoidal magnets (PEHTS, ECLOUD, POSINST,…)
  - Cyclotron resonances (C. Celata) were a genuine novel prediction, soon afterwards verified by expt. (M. Pivi) (POSINST, …)
  - Effects on the beam (HT instabil., incoherent emittance growth below HTI threshold,…)

What is to be done… (2)

- **Understand effects of the ecloud on the beam**

- Obviously, CesrTA ecloud R&D is driven by the necessity to preserve a very low beam emittance
- This will bring intense scrutiny of ecloud codes that compute effects on the beam
  - reliability/completeness of the physics model embodied in the codes
  - reliability of the numerical algorithms
- Available codes: HEADTAIL, WARP, PEHTS, CMAD,…
- To a large degree, this subprogram can proceed in parallel with the build-up subprogram
  - Just assume a value for the ecloud density near the beam and proceed
  - Look at single bunch (coherent and incoherent) effects
  - Multibunch coherent effects
- As the build-up subprogram provides more information on the ecloud around the ring, refine the understanding of the ecloud effects on the beam

Questions, odds and ends

- Why does $\Delta\nu$ keep increasing after the end of the train with e^- beams?
  - plausibility argument exists; check it with simulated movies of the ecloud
- Why is $\Delta\nu_x << \Delta\nu_y$?
  - I thought K. Ohmi provided the answer (ecloud distribution concentrated in the midplane, or 2 clumps of electrons on either side of the center)
  - This argument is operative if ecloud in the machine is dominated by dipoles
- Will the cyclotron resonances (C. Celata) be important in wigglers (3D field)?
  - question will be answered by 3D simulations and RFA measurements in wigglers
- Effect on e^- survival time due to ions (longer lifetime than otherwise expected)
  - suspicions at SPS and RHIC (?)
- Secondary ionization
  - ionization X-section of residual gas by ~100 eV electrons is >> than for a ~GeV beam
- Surface roughness of extruded Al surface has a preferential direction ==> SEY depends on (θ,ϕ), not simply θ
  - but please: do <u>not</u> attempt an even more complicated SEY model
  - instead, fit beam data with a few effective parameters

Conclusions

- This is a superb and ambitious ecloud R&D program
- Essential resources are in place
  - Hardware
  - Diagnostics and simulation tools
  - Operational expertise
  - Knowledge, flexibility and maturity of the machine
    - e^+ / e^-, almost arbitrary fill pattern,…
  - Knowledge of certain relevant ecloud parameters (eg SR distribution)
  - Dedicated beam time
- Close collaboration with outside experts is highly desirable to make rapid and sustained progress
- I have a suspicion that 2 years will not be enough to achieve all the desired goals
- Nevertheless, I am quite confident of a large degree of success, both for CesrTA in particular, and for the ecloud field in general

Thanks to M. Palmer, G. Dugan and all other participants for such an inspiring workshop!

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