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GOALS FOR THE WORKSHOP*

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Abstract

I present a list of issues that I consider important for the ECLOUD'04 Workshop to address. This list is necessarily incomplete, and reflects my points of view.

LONG-BUNCH MACHINES

Although the electron-cloud effect (ECE) for lepton beams was first reported in 1995 [1], the ECE was apparently first discovered 30 years earlier at the Budker Institute (Novosibisrk) as a form of a two-stream instability for coasting proton bunches [2] and later, in resonant form, at the CERN ISR in the mid 70's [3] (a recent historical overview has been presented by F. Zimmermann [4]). The first workshop dedicated to the spallation neutron sources PSR (LANL) and SNS (ORNL) was apparently held in 1997 [5]. Since then, details of the measurements, theory and simulations have been reported at all ECE workshops [6–13], PAC and EPAC conference proceedings [14], the ICFA Beam Dynamics Newsletter [15], and regional meetings [16]. Various repositories maintain publications in this and related topics [17–20].

Since the ECLOUD'02 workshop [10] interest has intensified in simulations of the ECE for PSR, SNS, ISIS, JPARC, heavy-ion fusion drivers and superbunches [21–27]. For these machines, it would be interesting to address the following issues:

- Understand qualitative differences with short-bunch machines.
- How to suppress the effect:
  - would solenoids work as well as they do for PEP-II and KEKB?
  - are clearing electrodes practical?

LEPTON RINGS

The two B factories, KEKB and PEP-II, are operating well beyond their design specifications, after controlling the electron-cloud effect by means of weak solenoidal fields. At present, ambitious upgrade plans are contemplated for both machines. The design for BEPCII machine, well under way, contemplates similar electron-cloud suppression mechanisms as the B factories [12]. Some questions that arise are:

- PEP-II had its aluminum arc chambers coated with TiN at the outset, but this was not enough to suppress the effect; why?
- Characterize ECE as a function of bunch fill pattern.
- Understand single-bunch instability differences in PEP-II vs. KEKB (V or H?).

SIMULATIONS

There has been recent progress towards 3D and/or self-consistent simulations (bunch and cloud are both dynamical). Some issues that arise are:

- When is the 3rd dimension important? (this is a basic physics question, not a simulation issue).
  - the tentative answer seems to be: not very for short-bunch machines, somewhat for spallation sources, very for HIF drivers. Spell out the detailed criteria as a function of bunch length, chamber size, bunch intensity, etc.
- Produce list of code features, contact persons, availability, etc.
- Reinvigorate code benchmarking effort (started after ECLOUD'02).

SURFACE MATERIAL PROPERTIES AND GAS SOURCES

In most cases of practical interest, the chamber surface is the primary source of electrons via the mechanisms of the photoelectric effect, secondary electron emission, and electron generation from stray beam particles striking the walls. In addition, desorbed gas from the chamber surface can be ionized by the beam or by electrons in the volume of the chamber, leading to additional electrons (and ions). It seems desirable to:

- Quantify secondary emission yield (SEY) and its dependence on various parameters.
  - how well do we know them (e.g., SEY below 10 eV)?
  - do we have reliable, standardized, reproducible measurements? (is this too much to ask for? probably)
  - are new, more precise, measurement apparatuses called for?

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- how fast does the surface condition? What is the detailed mechanism for warm and cold surfaces?

- When does the primary electron source dominate over secondary electron source?
- Quantify gas desorption (plus residual gas ionization).
- Quantify electron generation from stray beam particles striking the walls.

ECE SUPPRESSION TECHNIQUES

Electron suppression techniques are routinely used at present. Passive techniques include: antechamber (to remove radiation); transverse grooves to suppress photoelectrons [29]; longitudinal grooves to suppress secondary electrons (not yet operational, but the concept shows promise) [30]; and low-SEY coatings, particularly TiN and TiZrV [31]. Active techniques include clearing electrodes, weak solenoidal magnetic fields, and tailoring the bunch train pattern [32]. It seems desirable to address these issues:

- TiN and TiZrV coatings are considered "good."
  - how good? How do the coatings hold up after several years' worth of running?
  - how significant a drawback is the required activation of TiZrV e.g., in the LHC warm regions?
- TiN coating samples at PSR show mixed results. There is a significant dependence on azimuthal location. Energetic electrons are effectively suppressed, but not slow electrons. Conditioning is clearly observed for fast, but not for slow, electrons. Nevertheless, results are, on average, favorable (certainly not detrimental) [33]. Items to consider:
  - SNS chamber is being coated with TiN.
  - RHIC warm chambers are being coated with TiZrV (claim is that these "work better than solenoids")
  - what to do if SNS shows a higher-than-expected ECE?
  - what to do if LHC shows a higher-than-expected ECE?
- PEP-II arcs (Al chamber) were TiN-coated at the outset; however:
  - why were solenoids required in the PEP-II arcs in addition to the straight sections?
  - how big an improvement can be attributed to the arc solenoids?
  - what would the performance have been without TiN coatings? Reality check: it is desirable to measure the SEY of a current sample of a piece of TiN-coated PEP-II chamber.
- Given details of the chamber geometry and SEY, specify optimal bunch fill pattern.
- What could be done when solenoids are not practical? Specify the effective limit of the applicability of the solenoid suppression technique.

PRACTICAL ECE ISSUES

We are doing more and more detailed simulations (3D, self-consistent, more detailed lattice fields, etc.). Valuable and necessary as these calculations are, they will probably not evolve into practical design tools. We should also step back from detailed accuracy in favor of an approximate picture, and distill from them a global, approximate, description based on a few parameters and (hopefully) simple criteria. Perhaps the primary example of such criteria is the condition for beam-induced multipacting [3]. Questions to consider:

- Do we already know enough from experience and simulations to construct a "parameter phase space" for the ECE?
  - identify a few important parameters, analogous to temperature, applied magnetic field and magnetization for a ferromagnet
  - for ECE: possible variables are: electron line density vs. bunch spacing, bunch intensity, and effective SEY (?)
  - is this possible in general? Probably not, but should be possible within a narrower context

IT GOES WITHOUT SAYING THAT...

- We should encourage ongoing collaborations and foster new ones.
  - in simulations, theory, experiments
- We ought to understand differences in calculations and measurements.
  - identify the source of the differences, iron them out, or decide which calculations are more reliable
  - please contribute to the code-benchmarking effort [34], started after ECLOUD'02!
- I am sure there are other important questions.
- I do not expect clear answers to all of them, but at least we should keep them in mind in our future work.

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