Cornell University
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Status and Plans for

Time-Resolved Measurements of Electron Cloud Buildup

What have we learned?

What questions remain?

What is the plan to address these questions?
-- Instrumentation -- Measurements -- Analysis

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What have we learned from time-resolved measurements of cloud buildup?

Shielded Button Detectors

- **Witness-bunch studies with positrons provide sensitivity to the individual physical parameters governing cloud buildup**
  - **Photoelectron yield and energy distributions can be analyzed by varying bunch current**
  - **Differentiate between secondary emission processes. Sensitivity to cloud kinetic energy.**
  - **Cloud lifetimes for various mitigation techniques. Al, TiN, aC (2), DLC.**
  - **Dependence of photoelectron production and secondary emission on beam conditioning**
  - **Measurements with solenoidal magnetic field are very sensitive to the azimuthal dependence of photoelectron production rate and energy distribution.**

Time-resolved Retarding Field Analyzers

- **Ten-bunch positron trains with 8 mA/bunch provide comparisons of secondary emission properties**
  - **Grounding/noise problems solved**
  - **Effective time resolution of 25 ns**
  - **Comparison of cloud buildup with uncoated Al, TiN-coated Al, with and without grooves.**
  - **Measurement of the SEY mitigation provided by grooves in storage ring operation**

Shielded Stripline Detectors in Q48W

- **Comparison of signals from ten- and twenty-bunch trains provide good sensitivity to cloud trapping**
  - **First measurement of cloud trapping in a positron storage ring**
  - **Intermediate trains and bunches provide a clearing effect**
  - **Signals are dominated by secondary emission properties of stainless steel**

What questions remain?

Shielded Button Detectors

- Need to understand measurements with an electron beam.
  - Model predicts a large prompt signal which is not observed
  - Essential for present and future light sources
- Need improved modeling for buildup in solenoid field, PEY, 2.1 GeV, 4 GeV
- More detailed cross calibration with other measurement techniques, such as TE-wave and RFAs

Time-resolved Retarding Field Analyzers

- Measure PEY properties of the Al, TiN and grooved surfaces at lower bunch current
- Use two-bunch studies to differentiate SEY properties such as cloud lifetime
- How does the dipole magnetic field influence the cloud buildup and mitigation?
- Measure resonant effects by varying bunch spacing and scanning B field in small steps
- Characterize cloud kinetic energy using the retarding field

Shielded Stripline Detectors in Q48W

- Measure dependence of cloud trapping on train length and bunch spacing (April 2014)
- Use bunch current dependence to further constrain SEY properties
- Characterize cloud in fringe field
- Is there trapping with an electron beam?
- Use validated model to estimate trapping effects in the ILC positron damping ring (PRL)

Phase III Proposal

- **Move the chicane assembly to a region of the CESR ring with higher photon rates**
  - **The chicane is 2.54 m long. Between BPMs 13W and 14W, 5.1m are occupied by 4 RFAs. Between BPMs 14E and 13E, 5.9m are occupied by 4 RFAs and doglegs.**
  - **In L3, the photon rate [$E_{critical}$] for e+(e-) is 0.07-0.12 (0.034-0.044) γ/m/e [2.3 (2.3) keV]**
  - **At 15E, the photon rate [$E_{critical}$] for e+(e-) is 0.45 (1.0) γ/m/e [3.7 (5.6) keV]**
  - **At 15W, the photon rate [$E_{critical}$] for e+(e-)is 0.8 (0.6) γ/m/e [5.6 (3.7) keV]**
  - **By increasing the photon rate by a factor of 10 to 30, witness bunch studies at lower bunch current would be made possible, giving differential sensitivity to PEY and the SEY processes**
  - **Other v.c. materials could also be tested in these variable dipole fields**
    - **Stainless steel for comparison and systematic check of cloud trapping model**
    - **Amorphous carbon (different!). Cu (common). Any newly proposed mitigation techniques**
- **Design and install a shielded stripline in an arc quadrupole. Vary field strength. e- beam.**
- **Second-generation designs for time-resolved RFAs and shielded striplines**
  - **This may take the form of developing filtering techniques (hardware/software)**

Additional Ideas

- **Intentional design of TE-wave resonators and detectors in chicane region for cross-calibration with the time-resolved RFAs, as opposed to serendipity/opportunism**
- **Install shielded button detectors in round flanges at 45 and 180 degrees**
- **If dedicated, tunable X-ray beam: shielded pickups and solenoids for PEY, slotted antechamber with floating stripline. Is E-line available?**

What is the plan to address these questions?
-- Analysis --

Two Examples of Many ...

- The measurements of shielded button signals with solenoidal magnetic field have been understood to depend on the detailed 2D distribution of photoelectron production energy and azimuth (Jared G.)
  - The present model is crude and inflexible: energy distributions can be defined only for direct and reflected photons separately.
  - The necessary flexibility is easy to code.
  - The optimal 2D distribution can be obtained from a *single ECLOUD run* by using weights which match the modeled to the measured signal in each time bin.
  - The potential payoff is enormous.
    - Quantitative validation of Synrad3D models
    - Information more detailed than XPS (1981 Nobel for Kai Siegbahn's work in the 1960's)
- Make use of two recent major advances in the analysis of the TR_RFA measurements
  - Quantitative understanding of the shielding hole transmission for an axial magnetic field
  - Corrected L3 vacuum chamber model with major change in Synrad3D result
  - Only presentation of results at present is IPAC13. Restricted to SEY of uncoated grooves.

**Phase II served to demonstrate many novel methodological concepts.
They have yet to be exploited.**