

Working Group 3 (ECE) report

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Topics

- **Definition of electron cloud or electron cloud effect**
- **Clarification of points raised at the BNL workshop**
- **Status of our present understanding**
- **Unresolved issues**
- **Future plans and work that needs to be done**
 - ◆ **Needed experiments**
 - ◆ **Comparison of codes and comparison of simulations to experiments**
- **Recommendations for RHIC**

Definitions

- **Terms are used loosely and speakers/authors need to clarify what they mean especially for wider audiences**
- **Electron cloud or electron cloud effect**
 - ◆ **No clear consensus**
 - Is amplification required for electron cloud? Yes, for many machines but not for some machines with huge number of photo-electrons
 - ◆ **Collection of sufficient low energy electrons in the beam chamber to cause noticeable effect on beam or accelerator operation**
- **List of electron cloud effects**
 - ◆ **Gas desorption (pressure rise)**
 - ◆ **Beam instabilities**
 - ◆ **Emittance growth**
 - ◆ **Heat load on cryogenic walls**
 - ◆ **Interference with diagnostics**
- **Saturation/neutralization/equilibrium value of e-density**
 - ◆ **Multibunch machines- buildup along bunch train to a value where losses = generation (equilibrium value)**
 - ◆ **PSR maximum value of electron density surviving the gap is one type of saturation**
- **Beam scraping**

Clarification of points raised at this workshop

- **G. Bellodi reported on comparison of POSINST and E-CLOUD simulations of PSR and ISIS**
 - ◆ Problems putting the geometry of ISIS chamber
 - ◆ RF shields in ceramic chambers are tough to model
 - ◆ Needed ~4-5000 slices of PSR pulse to get agreement with POSINST
 - ◆ For more details, graphs etc check with Guilia Bellodi
- **G. Bellodi also discussed preliminary results of search for e-cloud at ISIS**
 - ◆ Used channel plate, no turn by turn resolution
 - ◆ Saw weak signal early in the ramp (0.1 nA/cm² ?)
 - ◆ at end of acceleration saw number consistent with residual gas ionization
- **In experiments (Jimenez), saturation density at SPS does not differ between Cu and SS but POSINST simulation showed factor of ~ 5-10**
 - ◆ May be due to conditioning in the experiment whereas simulations used SEY for unconditioned materials

Clarification cont'd

- Evidence for or against ECE in arcs at RHIC is important to LHC project (per Jimenez and Ruggiero)
 - ◆ Can't measure pressure rise in RHIC arcs (Trbojevic)
 - ◆ Upper bound from increase in heat load has large uncertainties
 - ◆ Electron detector in the arcs would be most helpful
- Did offline test of NEG at BNL show δ went from 1.5 to 2.0 in 22 days? This is at odds with experience at CERN. Need to clarify with SY Zhang.

Status of our present understanding of ECE

- **Important basic features are understood at varying levels of sophistication**
 - ◆ SEY curve in POSINST is quite detailed and validated against data
 - ◆ Strip position vs bunch spacing at SPS predicted then measured
 - ◆ Benchmarking of codes is far from complete
- **Some missing physics**
 - ◆ Electrons from stripper foil for PSR and SNS
 - ◆ Electrons born at the wall from residual gas ions driven to the wall not included
 - ◆ Extra residual gas ionization from electron cloud also not included in some codes
 - Was studied by F. Zimmermann and G. Rumulo and found negligible for SPS/LHC conditions
 - ◆ Clearing fields not included in most codes
 - ◆ Coupling of e-cloud with beam in a fully dynamical simulation is difficult and just beginning to be addressed
 - Very computer intensive
- **Simulations have numerous poorly determined parameters**
 - ◆ SEY for surfaces in particular machines can vary a lot depending on beam scrubbing history, venting etc. Overall scale can have big effect on multipactor gain
 - ◆ Sources of seed electrons from beam losses is very uncertain
- **Confidence in predictions for new machines is not high and needs to be improved**
 - ◆ More benchmarking and successful comparisons with experiments are needed

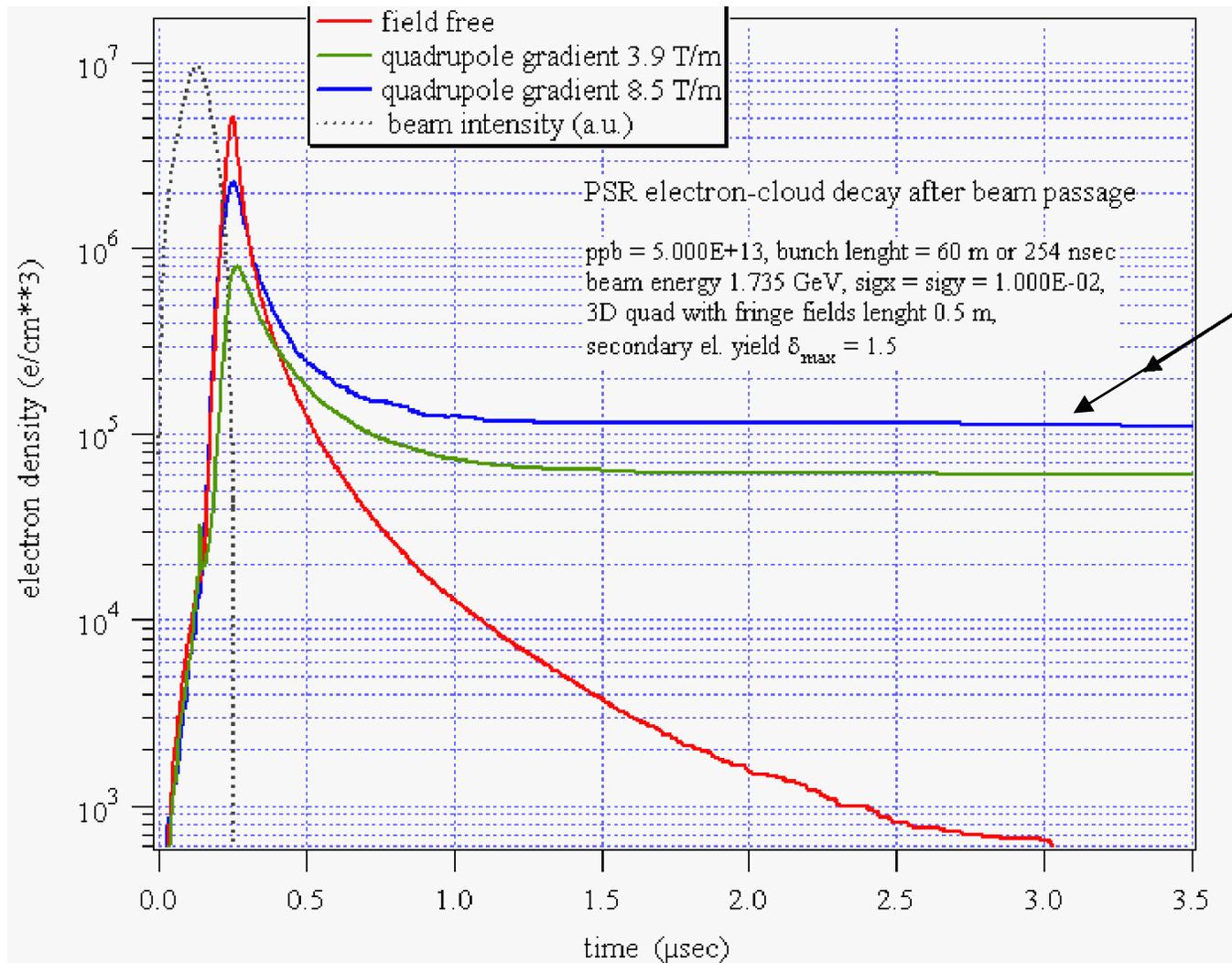
Some unresolved issues

- **Estimates of seed electrons from losses at PSR, SNS and ISIS is very poorly determined and is almost impossible to measure**
 - ◆ **Use experimental data on electron signals and varying input until simulations agree with experiment to fix the source term**
 - ◆ **Then vary other beam parameters (e.g. beam intensity) for other tests of the simulations**
 - ◆ **Could do detailed simulations of losses (tracking code such as ORBIT) and scattered beam (LAHET, MCNPX) to see where scattered beam goes**
- **Microwave transmission measurements at CERN are not well understood but could be compatible with effect of dust particles stirred by the beam**
 - ◆ **New test will be performed at the SPS in a few months by mechanically shaking the beam pipe**
- **Discrepancies between experiments and simulations regarding flux and spectrum of electrons hitting the wall for SPS**
- **3rd stripe at SPS vs Nb, strips with no dipole**
- **Electron bursts at PSR are not understood**
- **Ditto for the 1st pulse instability at PSR**

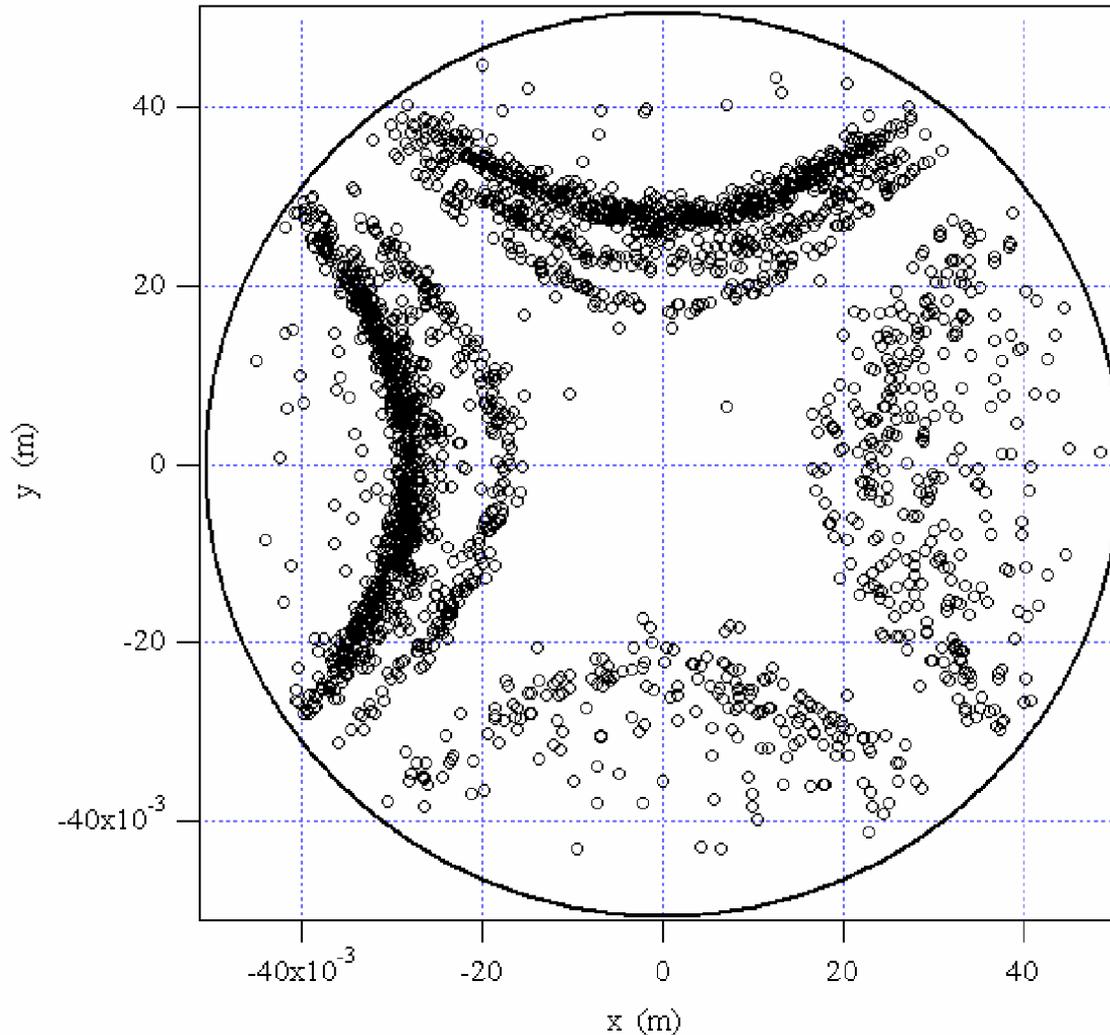
Work needed or planned for the future

- **Look for e-cloud and electron trapping in quadrupoles**
 - ◆ See proposal for PSR
 - ◆ Strip detector in quad planned at CERN
- **More detailed benchmarking of codes is urgently needed**
 - ◆ Code to code comparison
 - ◆ More comparison with experiments exploring various parameter variations
 - There is a lot of experimental data that has not been compared with simulations
- **LHC/SPS needs (F. Ruggiero)**
 - ◆ Further simulate heat load and compare with warm/cold measurements
 - ◆ Explore dependence of energy spectrum on bunch dimensions
 - ◆ Simulate spectrum of multi-bunch instabilities including conventional impedance
 - ◆ Calculate growth rate and scaling of single bunch instability and emittance growth with damper and $Q' \neq 0$
 - ◆ Simulate LHC scrubbing scenarios, heat load, collimator regions, emittance preservation
 - ◆ Compare simulations for field free region, dipoles and quadrupoles at $\delta_{\max} = 1.5$ and $N_b \cong 1.2 \cdot 10^{11}$, where multipacting stops in drift space

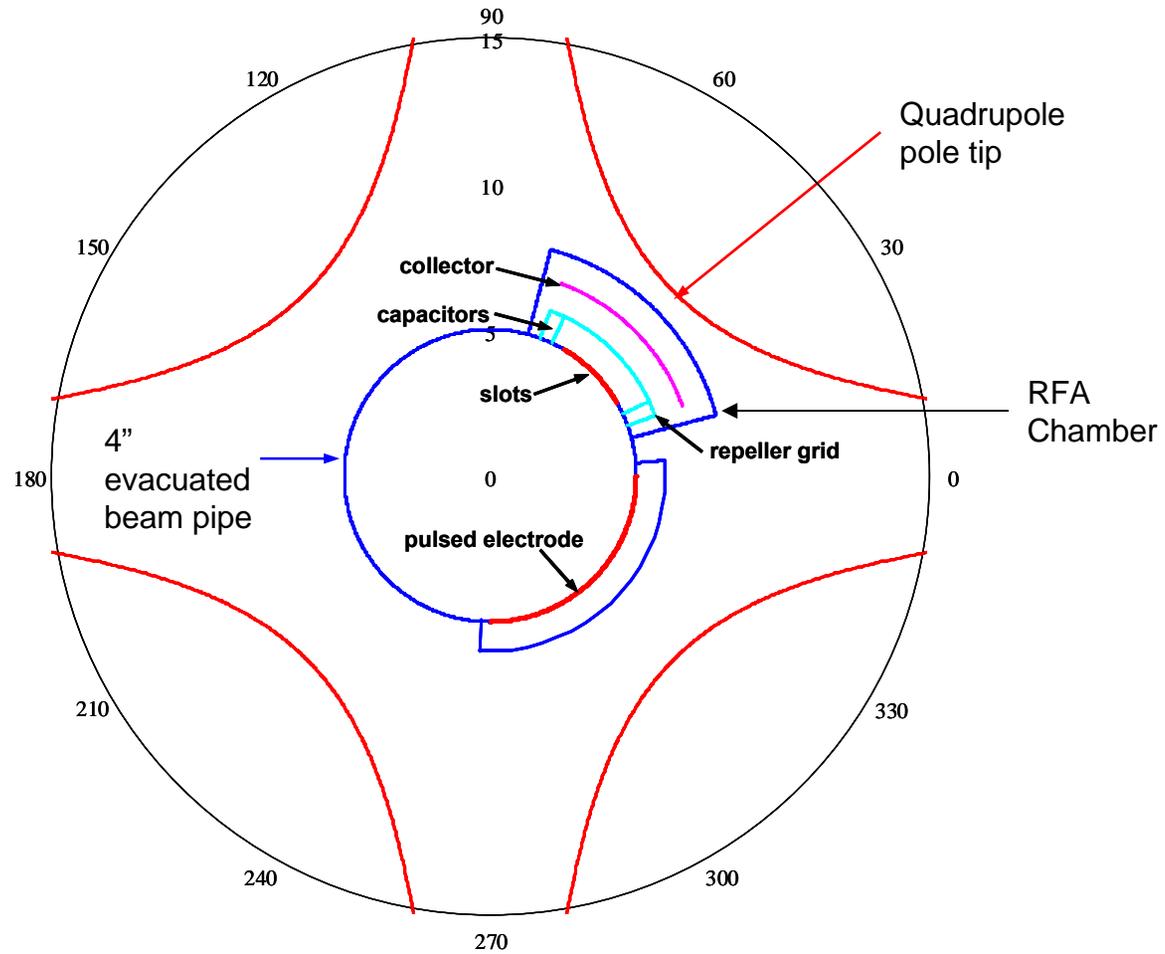
Simulation of electrons in PSR quad (courtesy M. Pivi)



Snap shot of trapped electrons in PSR quad 5 μ s after passage of beam pulse (courtesy M. Pivi)



Proposed Electron Sweeping Detector for Quad



Recommendations

- **Add some means to detect EC in RHIC arcs**
- **E-CLOUD'04 ICFA workshop Ap 19-23, 2004 at Napa, CA**