Why Study Electron Clouds?

The rate of particle events in a collider depends upon the product of two quantities:

* the interaction cross section of the reaction under study
* the luminosity (interacting beam particle flux)

Diluting the beam leads to reduction in luminosity. Electron clouds dilute positively charged beams.

Besides colliders, other applications such as spallation neutron sources and neutrino sources which use proton beams are also affected by electron clouds.

The electrons are liberated from the surface through a variety of mechanisms:

They are attracted toward a positively charged beam, which then interfere with the motion of the beam particles throwing them off course.

They are expected to pose a serious challenge to several future projects requiring high current beams.

Examples are: Upgrade of the Large Hadron Collider, The ILC and CLIC damping rings, the high-intensity neutrino (HINS) project at Fermilab, and the future B-factories KEK-B, Super-B.

Methods and Tools to Study Electron Clouds

Mitigation Techniques

Wide variety of custom vacuum chamber designs

Titanium-nitride, α-carbon, NICC coatings

Ultrasmooth stainless steel surfaces as control group

Additional electron cloud detector ports such as those shown here for retarding field analyzers and shielded pickups

Measurements

Worldwide effort: CERN (Switzerland), SLAC & LBNL (California), KEK (Japan), FNAL (Chicago), many more!

Modeling

Modeling witness bunch cloud density for reducing cloud electron densities

Some Facilities Potentially Affected by Electron Clouds

The spallation neutron source, located at Oak Ridge, Tennessee is a facility for neutron scattering experiments, which help understand and improve the properties of materials that are part of our everyday lives. (left)

Fermilab, in Batavia, Illinois is home to two experiments using neutrinos. These particles are highly elusive. Proton beams are used to produce neutrinos. Future upgrades and new experiments will require more intense beams, leading to increased electron cloud production (right).

A picture of the beam pipe of the LHC at CERN in Geneva. It collides proton beams to investigate fundamental processes in hitherto unexplored kinematic domains. (left)

The Large Hadron Collider

A Discovery Machine

The first publications are just now appearing!

The International Linear Collider

A PRECISION Machine

Such high-energy electron-positron collisions are feasible only in a linear collider because the radiation in a ring would be too intense. Therefore, the beams must be made small BEFORE acceleration.

The performance of the necessary damping rings will be limited by electron cloud buildup unless sufficient mitigation techniques are developed.