CESRTA Instrumentation

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CESRTA Instrumentation

This is an overview of some of the instrumentation that is available at CESRTA

- Devices to excite the beam
- Instruments that measure the beam and/or the effect of the electron cloud on the beam
  - CESR Beam Position Monitors (CBPM)
  - X-ray Beam Size Monitor (xBSM)
  - Visible-light Beam Size Monitor (vBSM)
  - Gated Shaking/Detection, Spectrum Analyzers

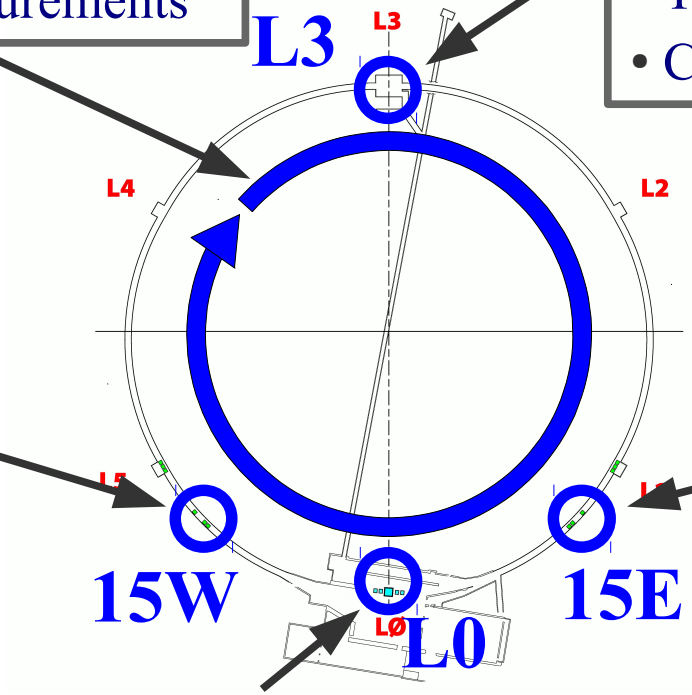
CESRTA Instrumentation

- Instruments designed to measure cloud electrons
  - Electron Cloud Flux into the Beam-pipe Wall
    - Retarding Field Analyzers (RFA)
      - Straight Sections, Dipoles, Wigglers, Quadrupoles
    - Shielded Pickups (SPU)
    - Time Resolved RFAs (TR_RFA)
  - Electron Cloud Density
    - TE Wave Measurements

CESRTA Instrumentation

- CBPM: Orbit, Phase, Coupling and Dispersion Measurements

- Visible-light Beam Size vBSM
- Time Resolved RFAs
- TE Wave Detectors
- Chicane Magnet



- Shielded Pickup
- RFAs

- Shielded Pickup
- RFAs
- TE Wave Detector

- RFAs in wigglers and straight section
- TE Wave Detectors
- X-ray Beam Size Monitor (xBSM)

Beam Excitation (H, V, L)

Feedback System:

- Input: two front ends can be used - 14 ns and 4 ns (Dimtel).
- 14 ns external modulation can drive individual 14 ns bunches.
- Output: striplines are used for H, V; a cavity is used for longitudinal.
- Feedback kickers are designed for 14 ns spacing (also used at 4 ns).

Tune Tracker:

- Excites the beam at betatron or synchrotron tunes
- Can drive individual bunches using the feedback system

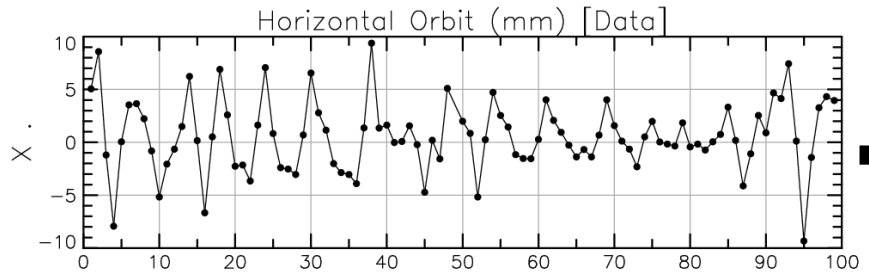
Pinger (H, V):

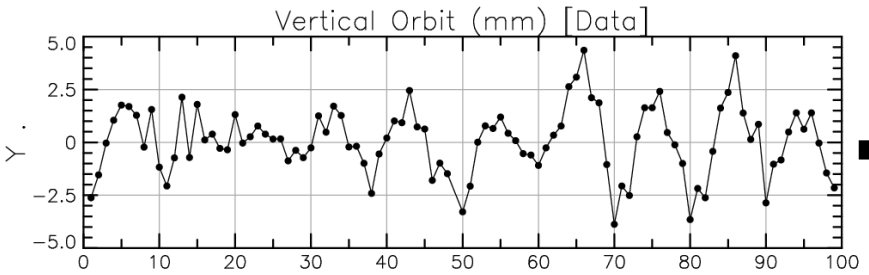
- A pulsed magnet that can give a large kick to all bunches during a single turn.

CESR Beam Position Monitors (CBPM)

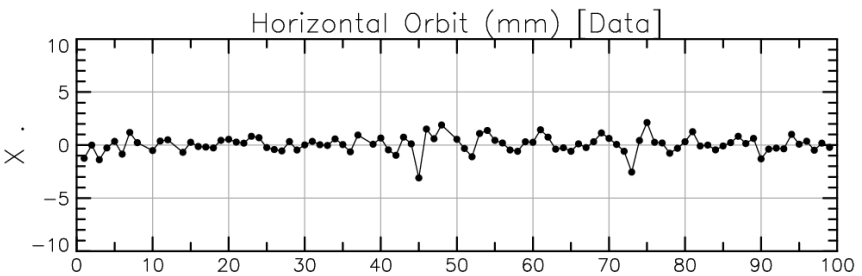
- Beam positions measured with difference error of 10 microns.
- Bunch-bunch sampling with 4 ns spacing
- 300 k total memory depth (bunches x turns) for each detector
- Corrections are made with the program CESRV (bmad)

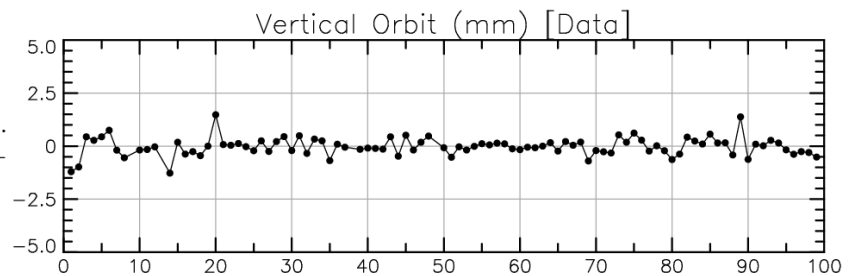
Data: pmbinj 4 GeV
4 GeV Optics





Data: after correction
4 GeV Optics

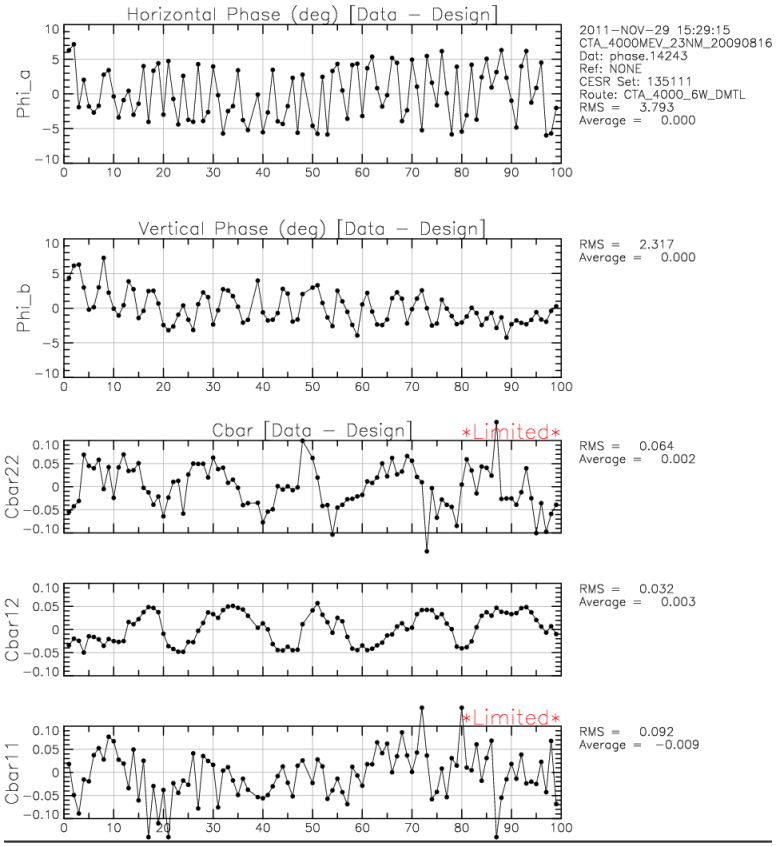




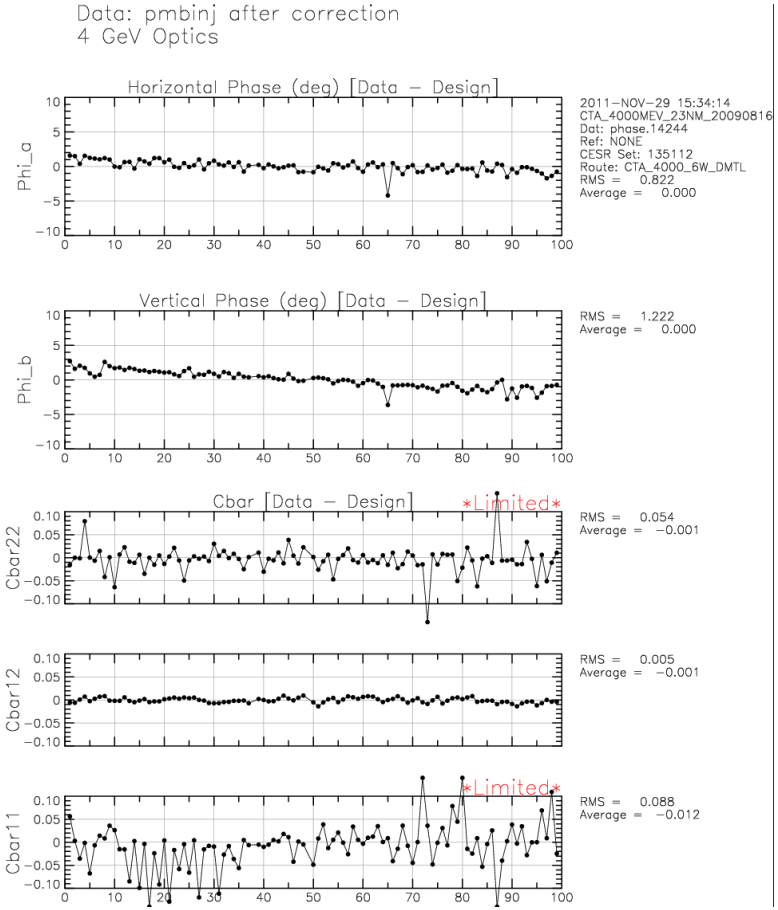
Optics Corrections

- The Tune Tracker is used for excitation at the H, V tunes.
- Betatron phase and coupling can be measured and corrected to a given lattice.

Data: pmbinj initial phase
4 GeV Optics

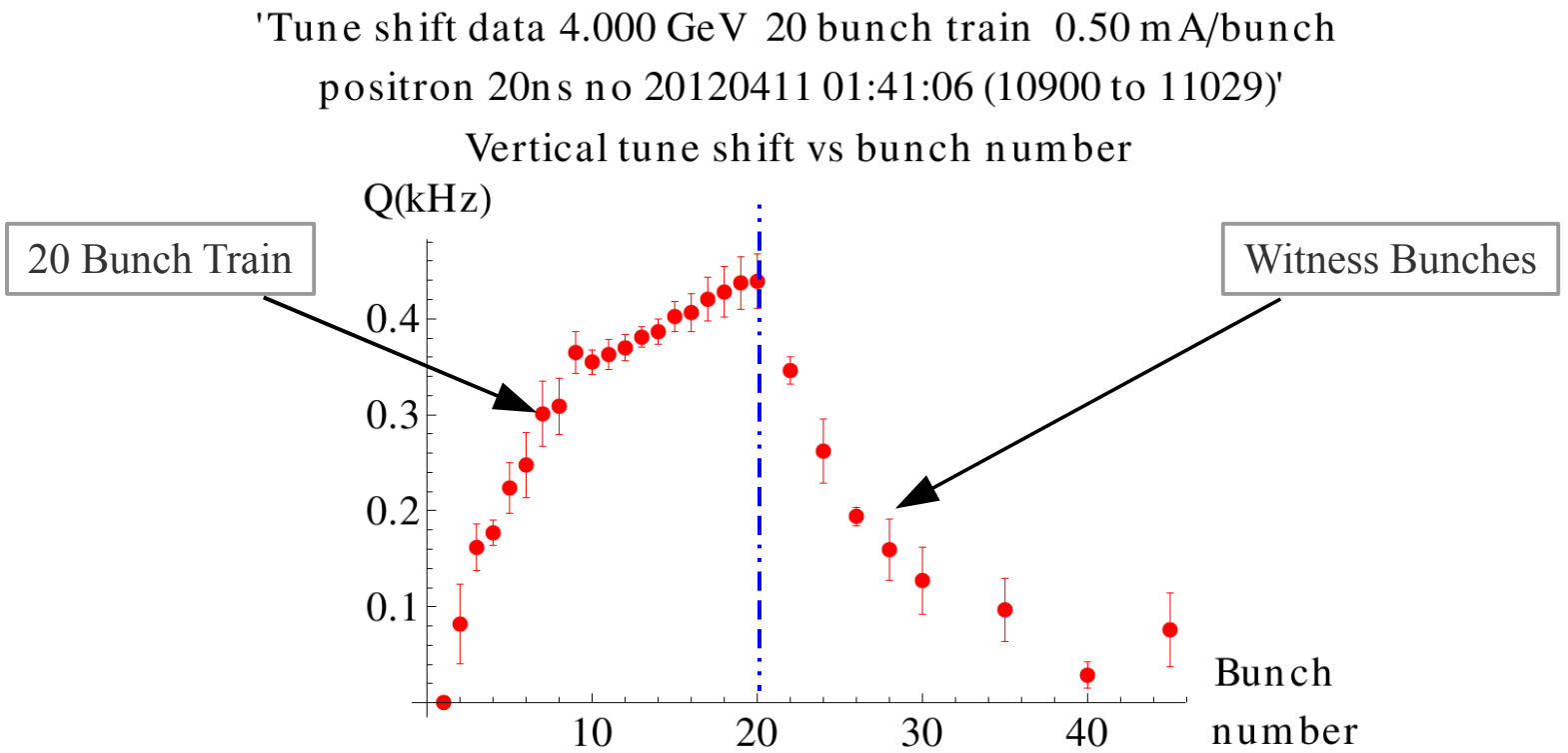


Data: pmbinj after correction
4 GeV Optics



Beam Position

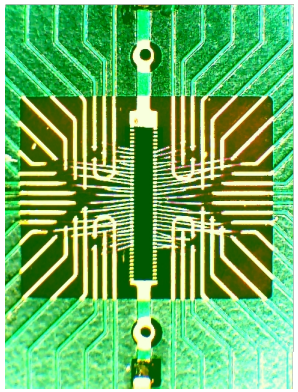
The beam can be excited and the response of each bunch downloaded from the CBPM system for analysis (multi-bunch, multi-turn data).



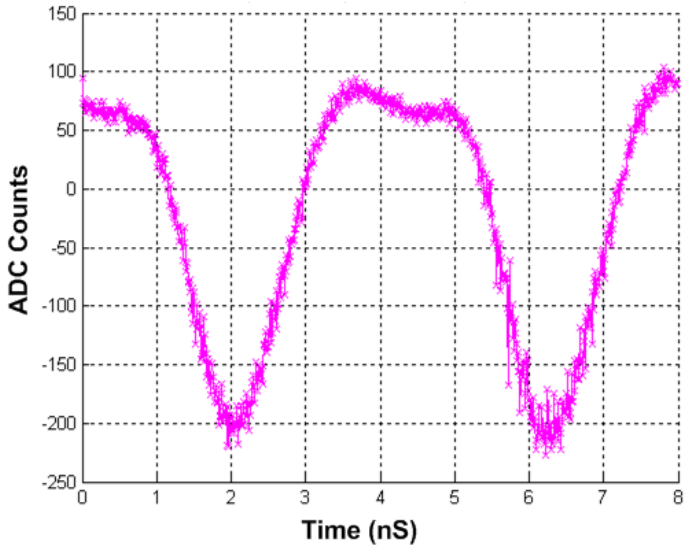
With a 20 bunch train in the storage ring, witness bunches were injected after the train. The response frequencies are then recorded and compared to the first bunch. The tune shift is a global measurement – the integrated effect of the electron cloud around the storage ring.

X-ray Beam Size Monitor (xBSM)

for both electrons and positrons

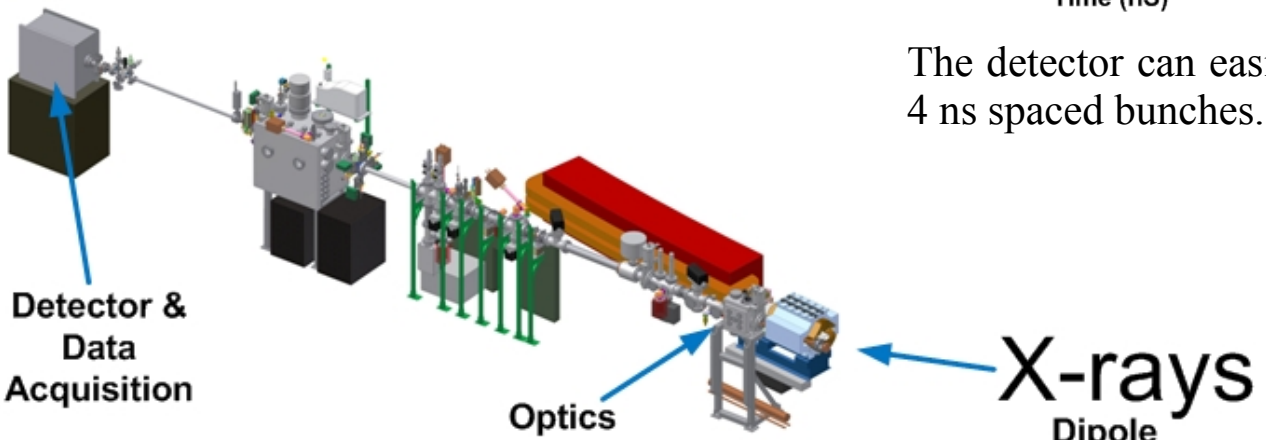


Optic element before the detector can include: slits, Fresnel zone plate or a coded aperture.



The detector is a vertical array of 32 InGaAs diodes with pitch 50μm and horizontal width 400μm.

The detector can easily resolve 4 ns spaced bunches.

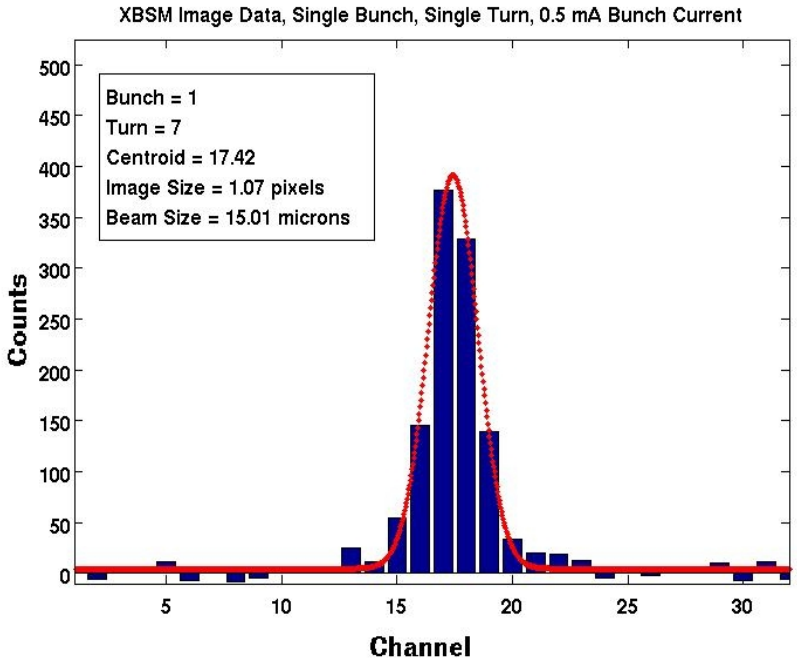


Geometric Magnification ~2.5

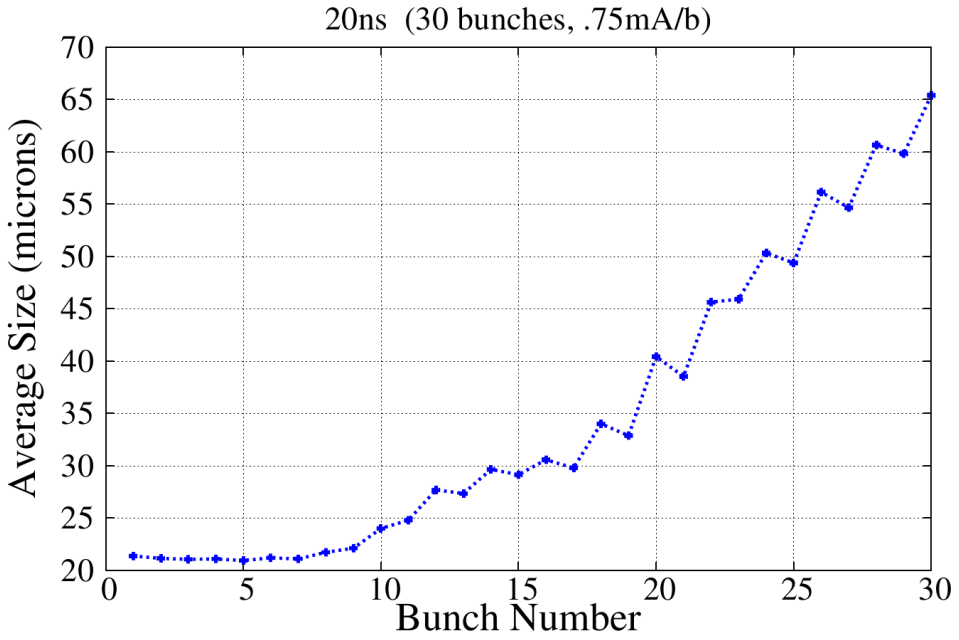
E_c = 0.6 keV at 2 GeV

X-ray Beam Size Monitor (xBSM)

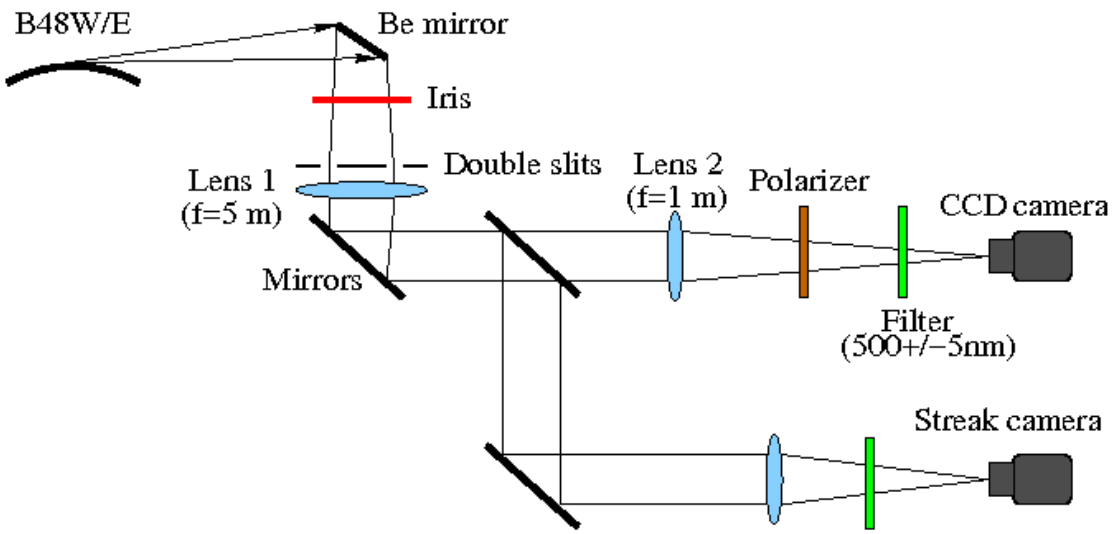
Example of single shot data with vertical slits at 2.1 GeV with a 0.5 mA electron bunch



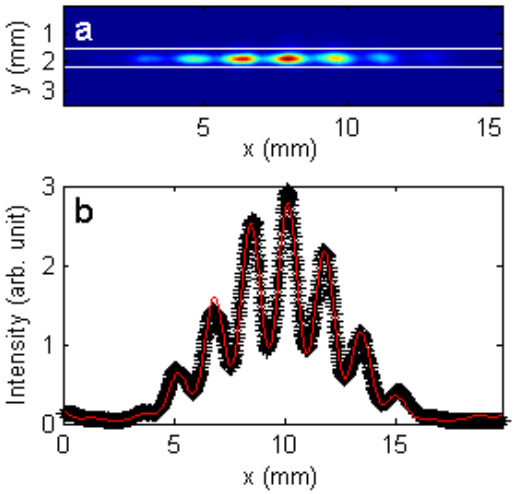
This example of averaged data from a train of 30 bunches shows an increase of beam-size along the train. The averages are of single shot data, so that the beam-size and centroid motion can be separated.



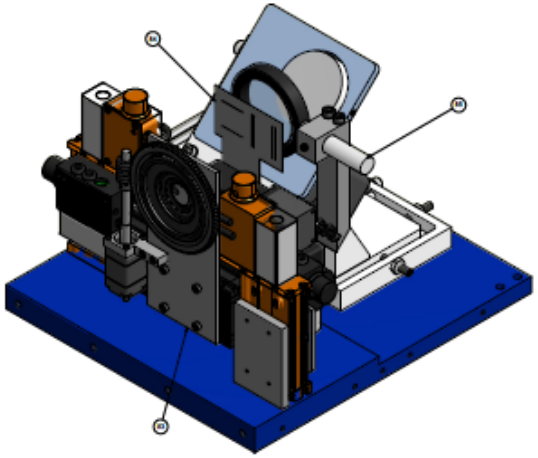
Visible-light Beam Size Monitor (vBSM)



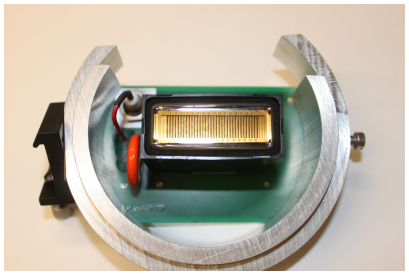
Horizontal beam size using double slit interferometer



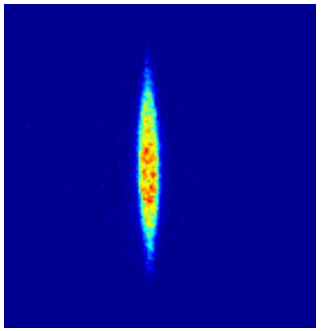
Optics box



Photomultiplier Array for Bunch-Bunch Beam Size

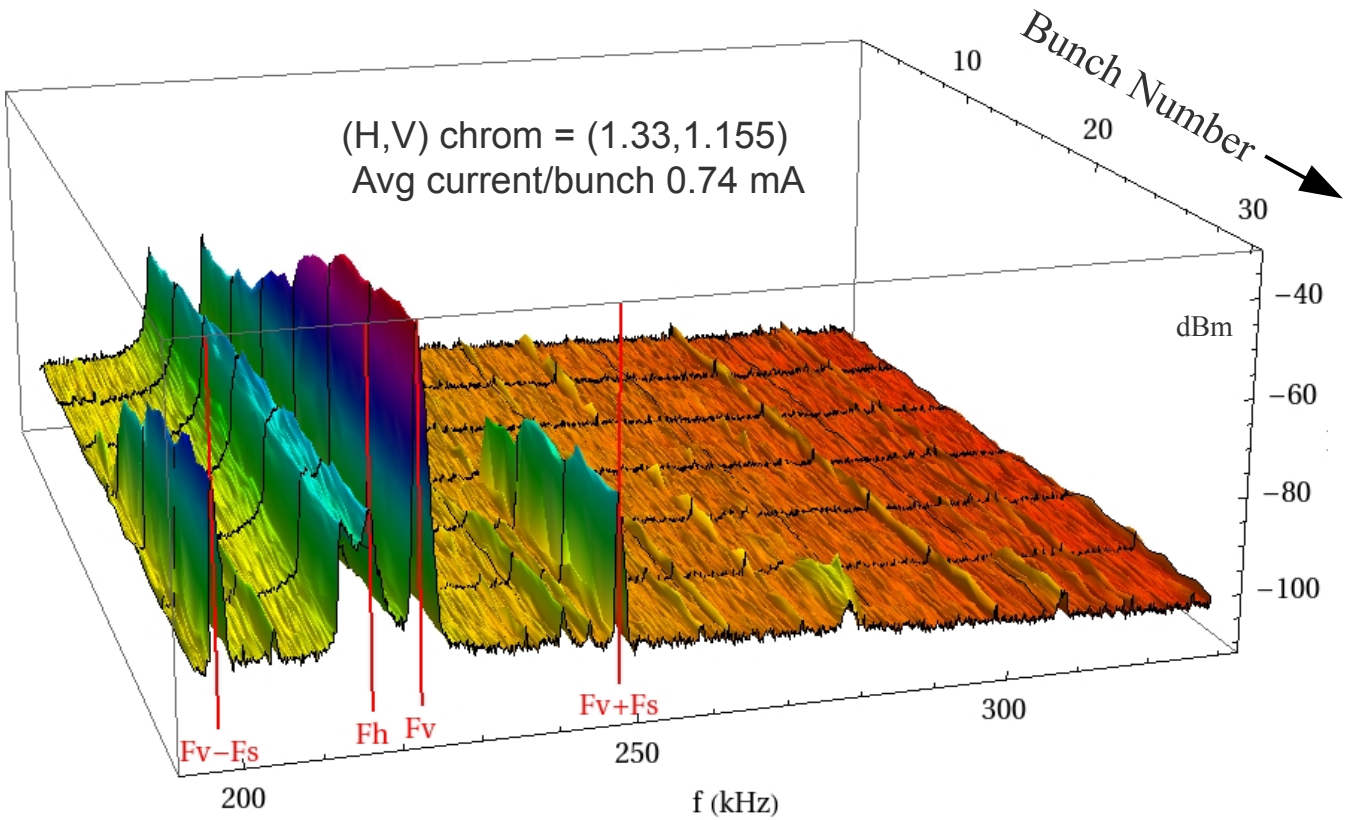


Streak Camera Image for Bunch Length Measurement



Spectrum Analyzers

- Gated receiving can be used to measure bunch tunes.
- Gated shaking/receiving can be used to measure bunch damping times.



Gated Receiving: Self excitation of bunches within a train

Retarding Field Analyzers (RFA)

Time Averaged Electron Cloud Flux into the Beam-pipe Wall

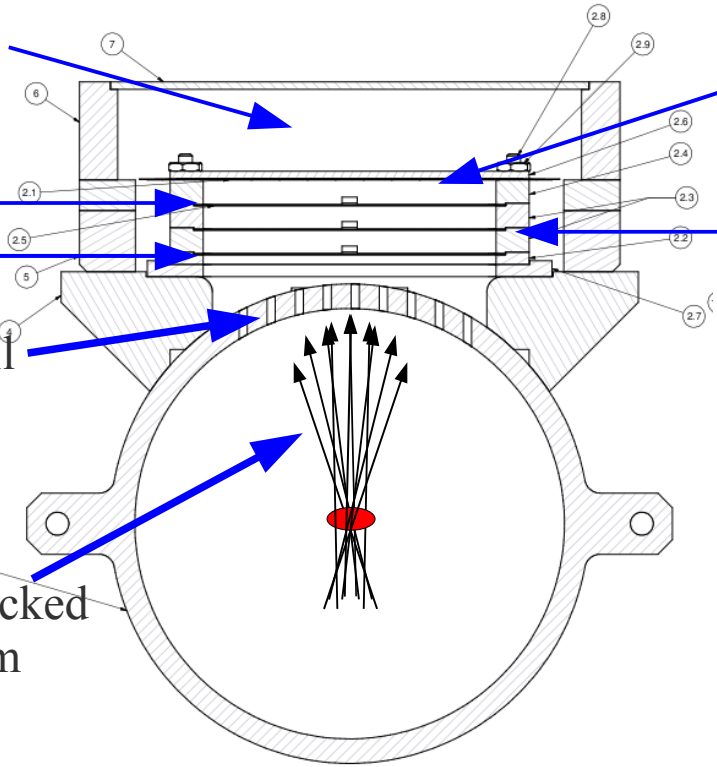
vacuum

Collector Array (from 5 to 17 segments)

Grounded Grids

Biased Grid

If the Biased Grid is at -V, electrons below that energy will not enter the detector.

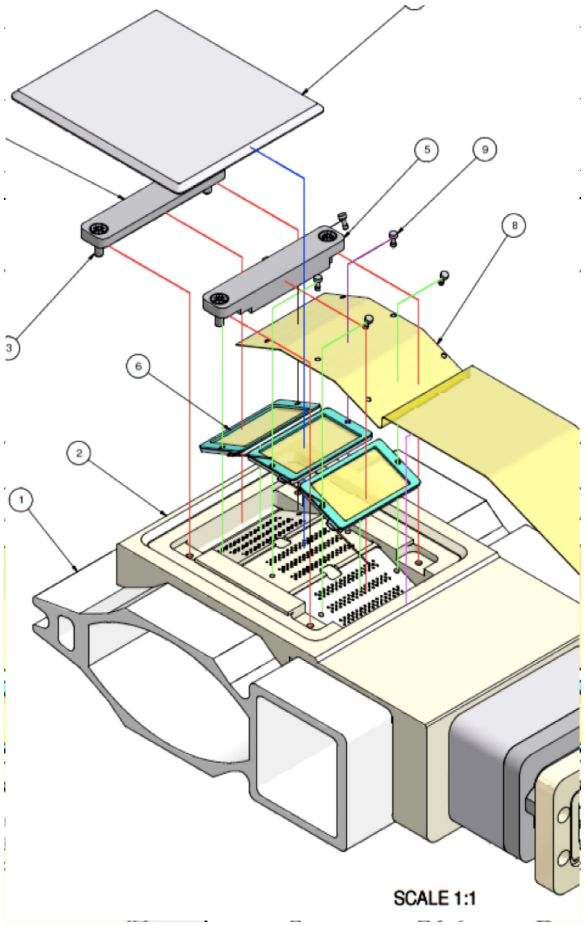


Holes in the beam-pipe wall allow electrons to enter the detector.

Many cloud electrons are kicked into the detector by the beam

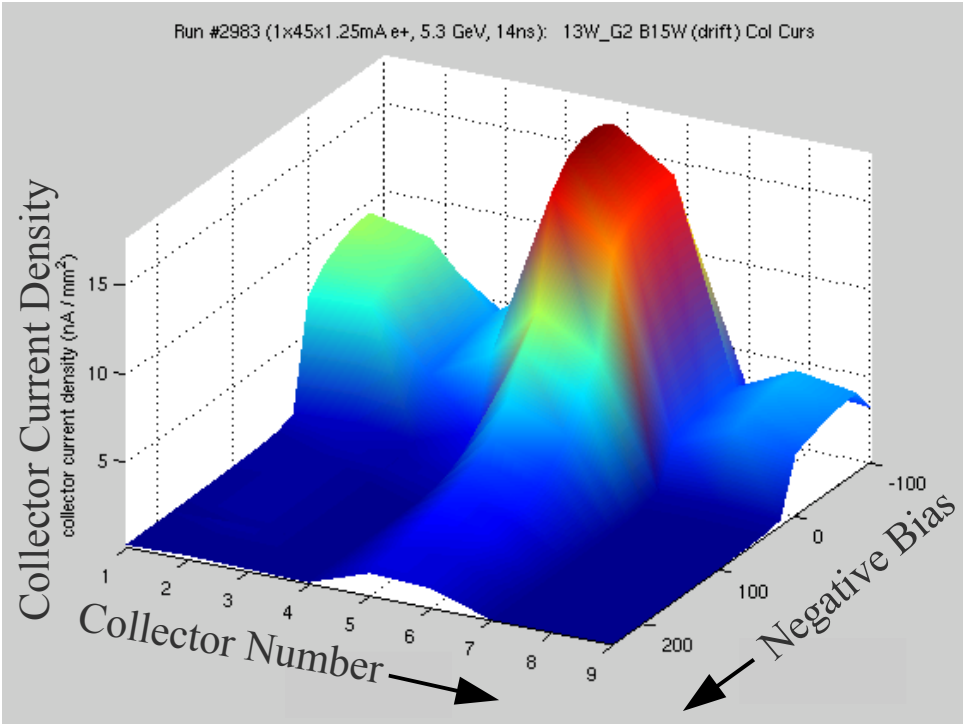
Electron Cloud Measurements

Retarding Field Analyzers (RFA)



RFA construction details vary with location. This example is for a dipole.

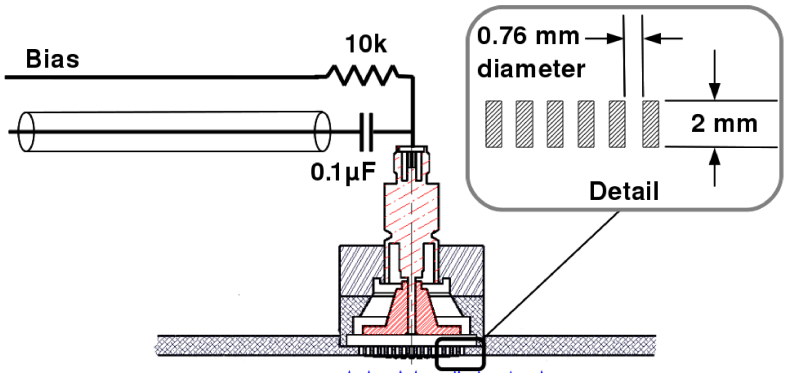
RFA Collector Data in a Drift



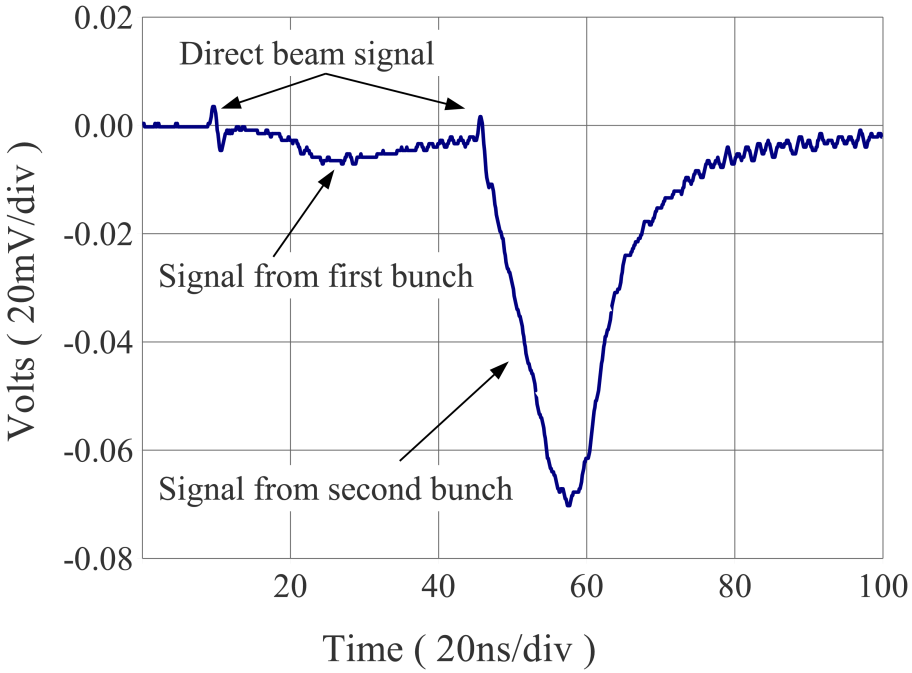
Electron Cloud Measurements

Shielded Pickups (SPU)

Measuring Electron Cloud Wall Currents vs. Time



Data two positron bunches with 36 ns spacing

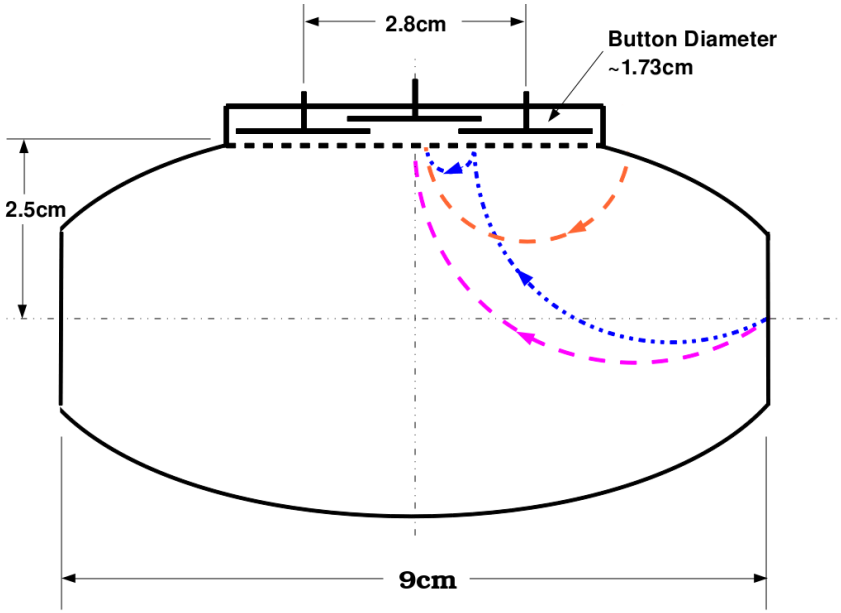


The electrode is the same as used by the CBPM system
Except that it is isolated from the direct beam signal.

Shielded Pickups (SPU) with Helmholtz Coils

The SPU at 15W is show below with a pair of coils.

With a longitudinal field, cloud electrons will follow circular trajectories.

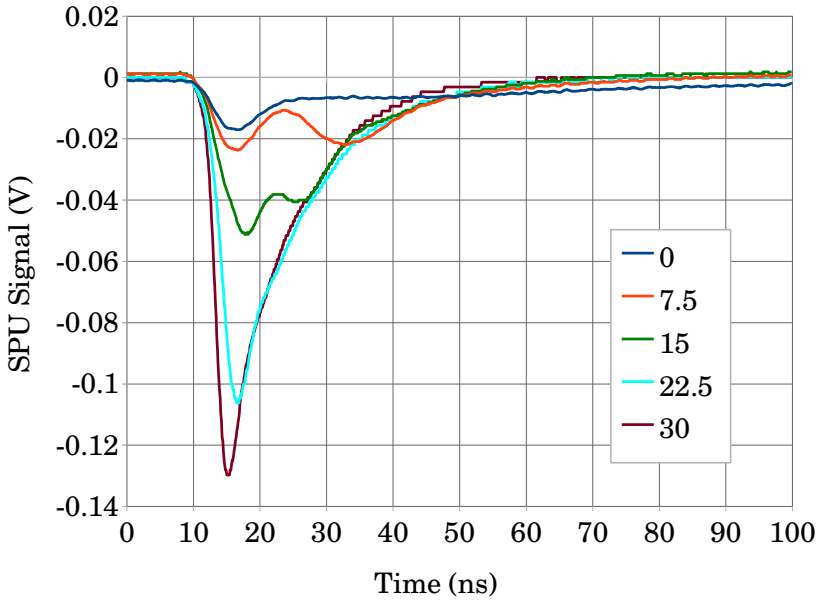


Shielded Pickups (SPU) with Helmholtz Coils

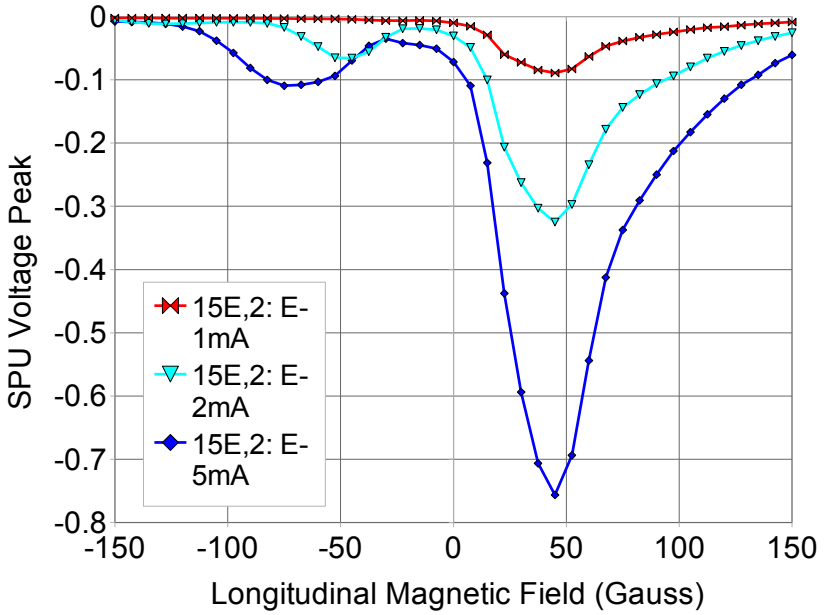
Data with Single Bunch of 5.3 GeV Electrons

SPU Signal at Low Fields

E- at 2 mA

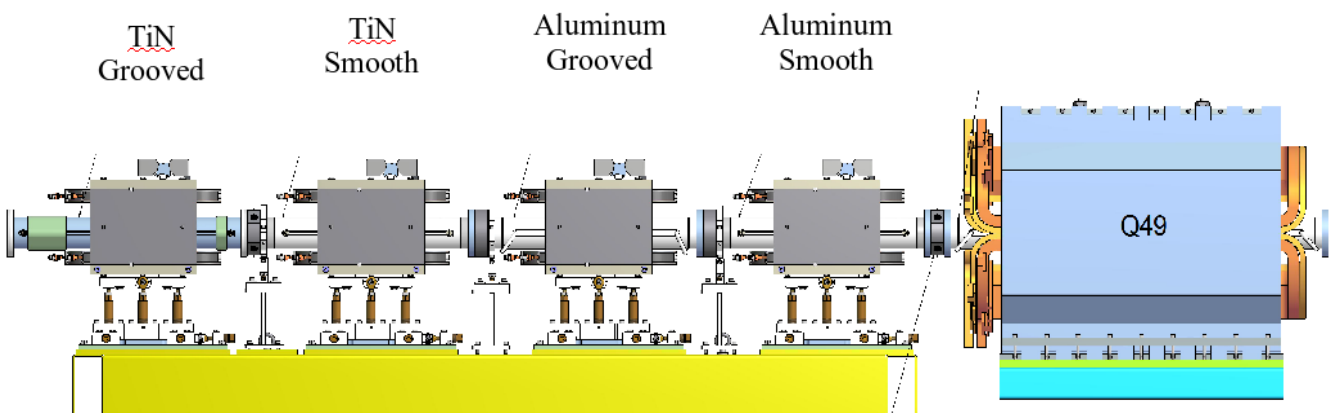


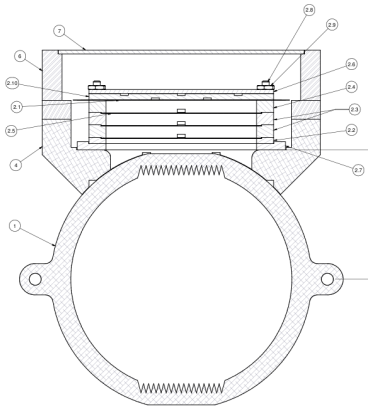
SPU Peak Voltage vs. Magnetic Field



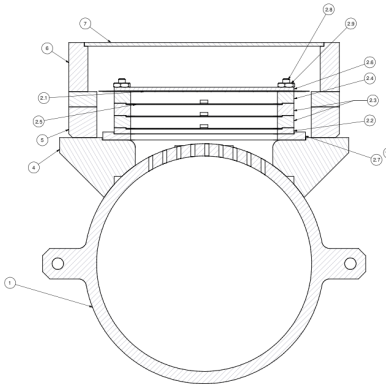
Time Resolved RFA in a Dipole Field (Chicane)

Smooth and Grooved Chambers with Bare Aluminum and TiN Coatings





Grooved Chamber



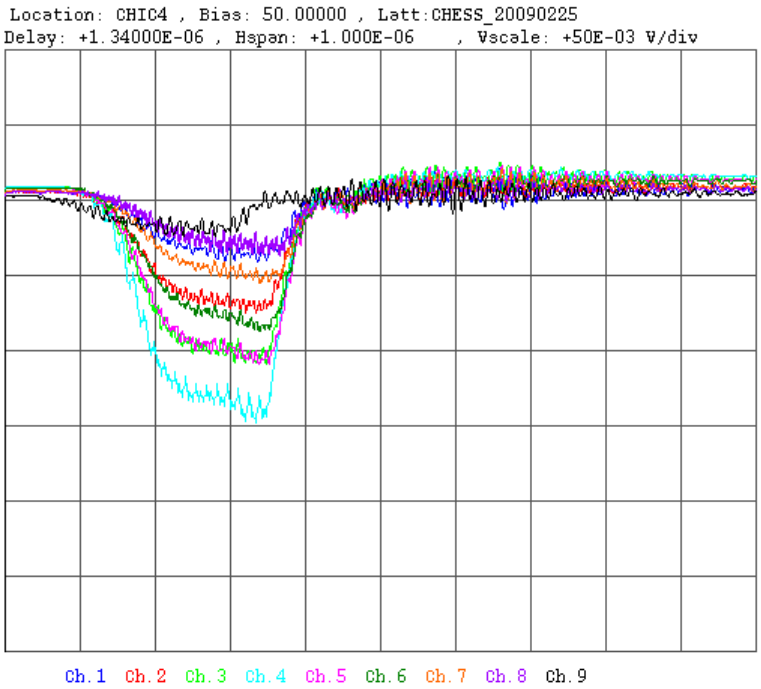
Smooth Chamber

Time Resolved RFA in a Dipole Field (Chicane)

Aluminum chamber with a train of 20 bunches of positrons at 145mA total (witness bunch 84ns after the train)

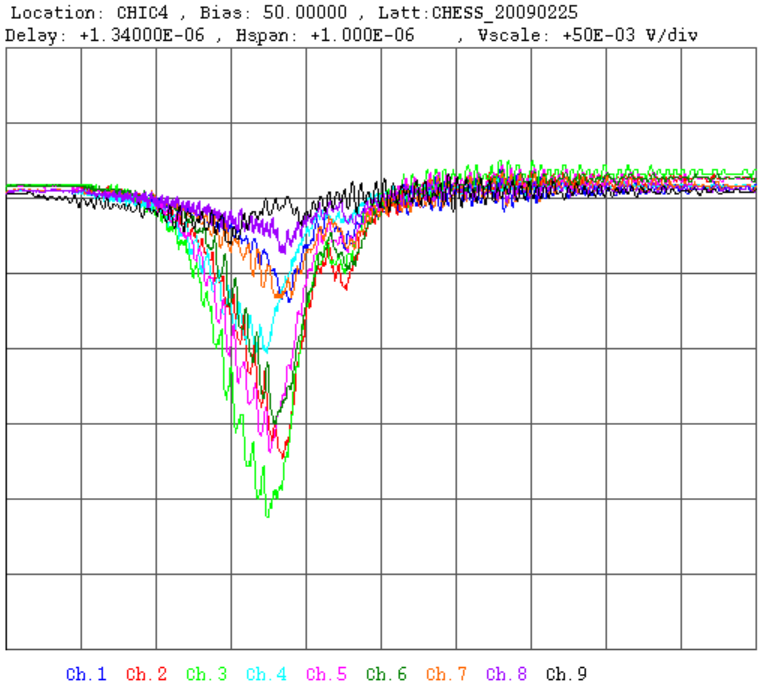
Chicane Dipole OFF

100 ns/div



Chicane Dipole ~800 Gauss

100 ns/div



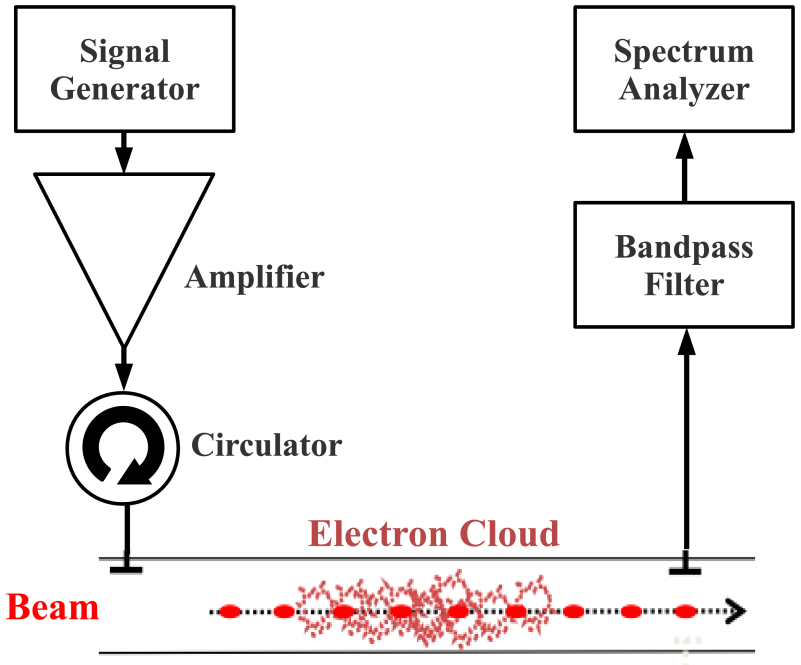
Retarding Grid +50 V

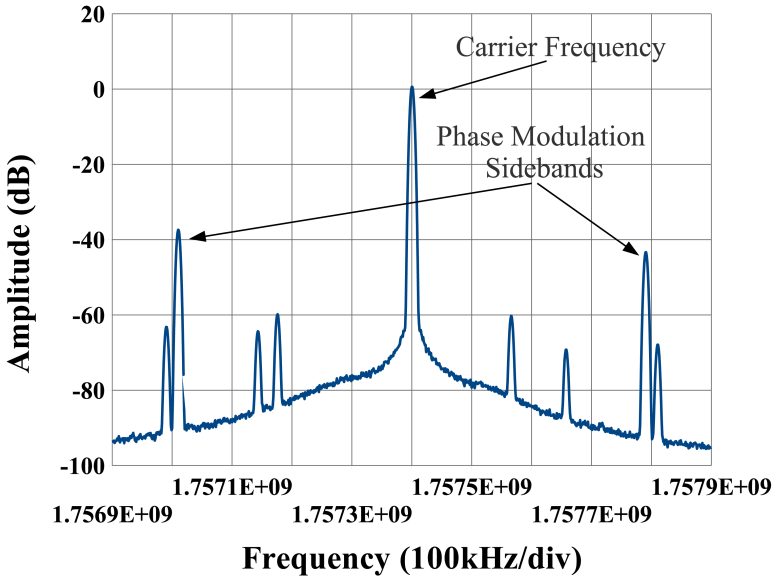
Data: April 4, 2012

TE Wave Resonances

BPM buttons are used to couple to microwave resonances in the beam-pipe.

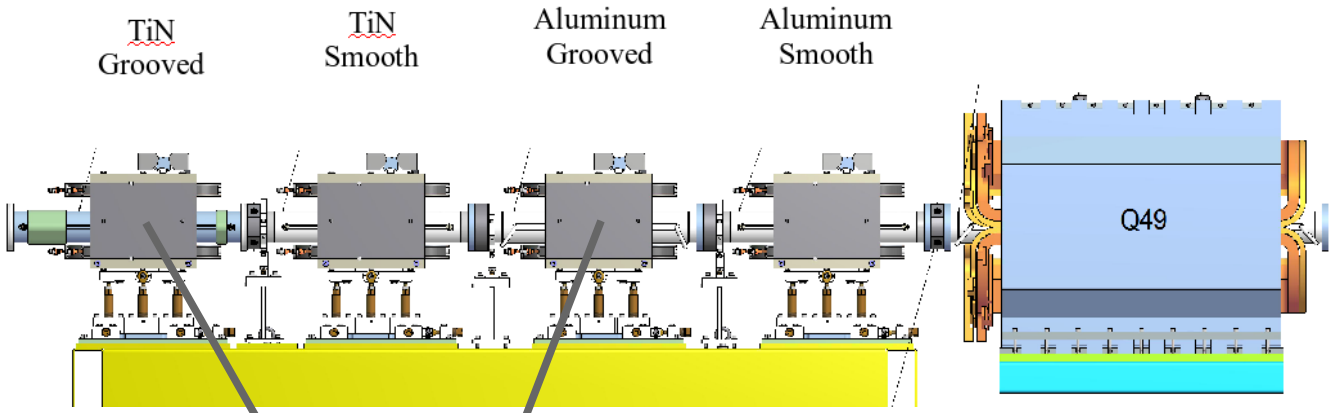
Driving with a fixed frequency near resonance, the electron cloud from a short bunch train will change the resonant frequency and produce modulation sidebands.

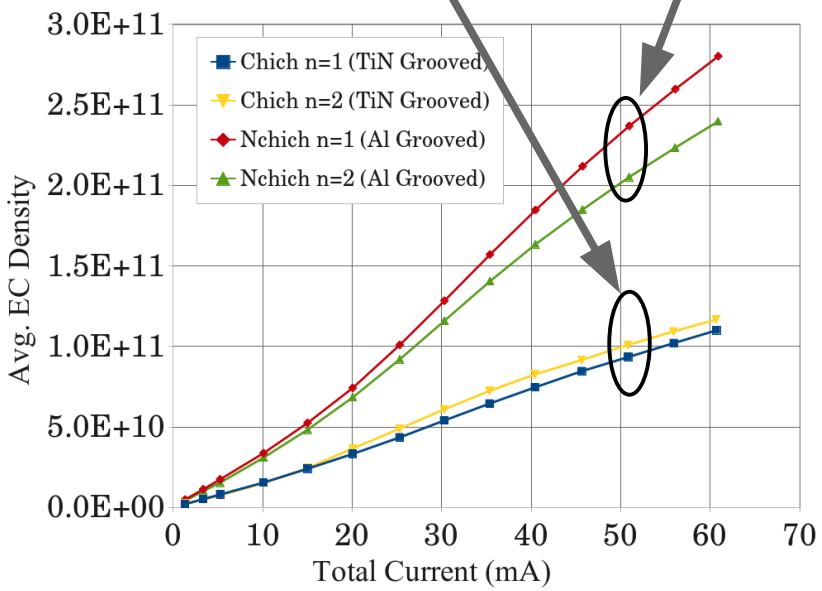




Electron Cloud Measurements

TE Wave Resonances in the L3 Chicane





Resonances can be very localized, as in the grooved chambers in L3.

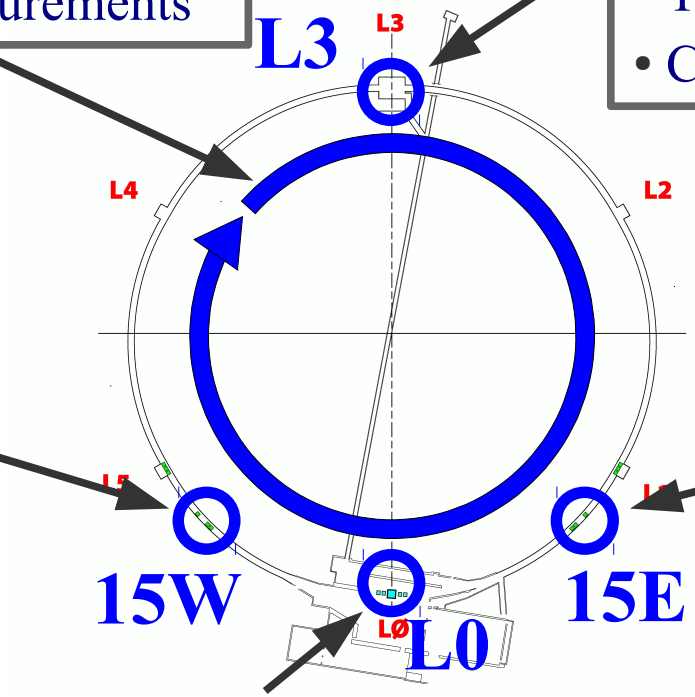
These will give localized measurement of the EC density in each chamber.

The measurement at left was made with a 10 bunch train of positrons at 5.3 GeV. The Chicane magnets were OFF.

CESRTA Instrumentation

- CBPM: Orbit, Phase, Coupling and Dispersion Measurements

- Visible-light Beamsize vBSM
- Time Resolved RFAs
- TE Wave Detectors
- Chicane Magnet



- Shielded Pickup
- RFAs

- Shielded Pickup
- RFAs
- TE Wave Detector

- RFAs in wigglers and straight section
- TE Wave Detectors
- X-ray Beam Size Monitor (xBSM)

Summary

CESRTA instrumentation can be used to:

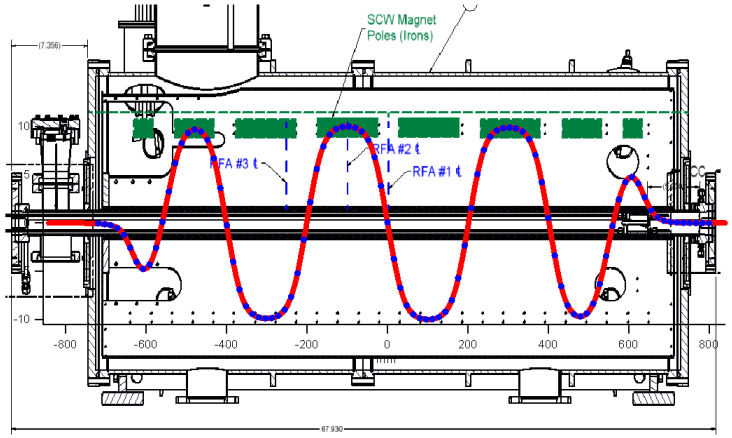
- Excite individual bunches, as needed by the experiment
- Measure and correct the orbit and optics of a given lattice
- Measure individual bunch motion, turn by turn
- Measure individual bunch size, turn by turn
- Measure electron cloud flux into the beam-pipe wall, both time-averaged and time-resolved
- Measure electron cloud densities in a localized region.

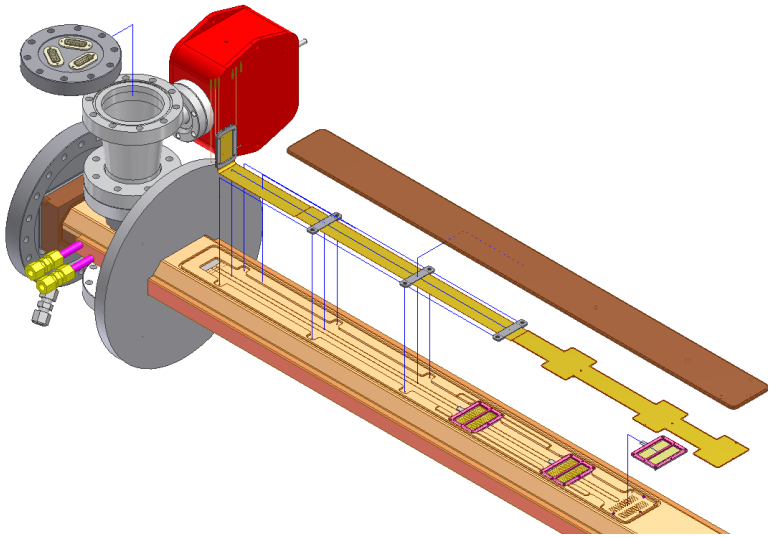
Extra Slides Follow

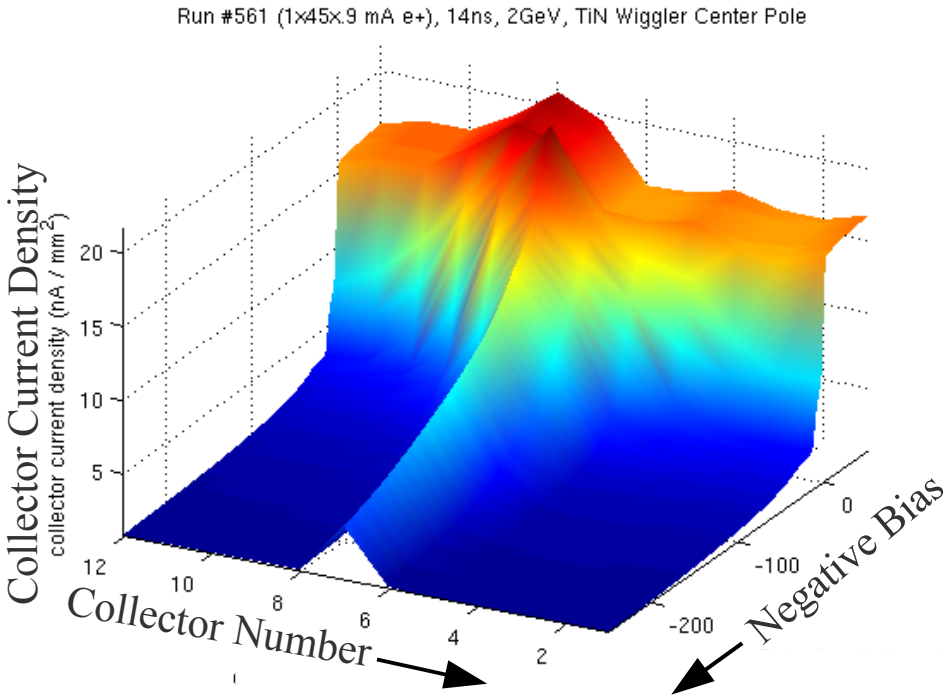
Electron Cloud Measurements

Retarding Field Analyzers (RFA)

Wigglers: with collectors in High, Low and Intermediate field regions.

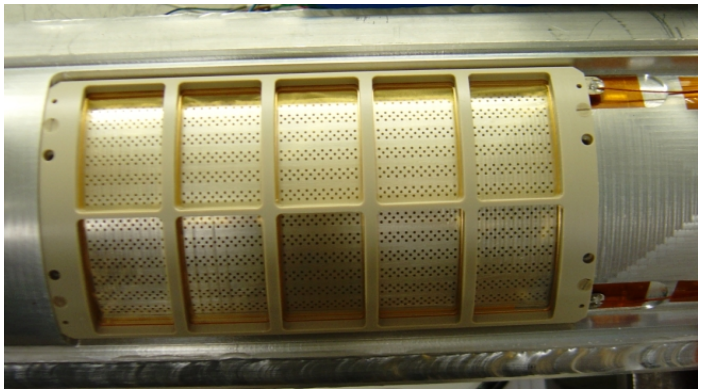


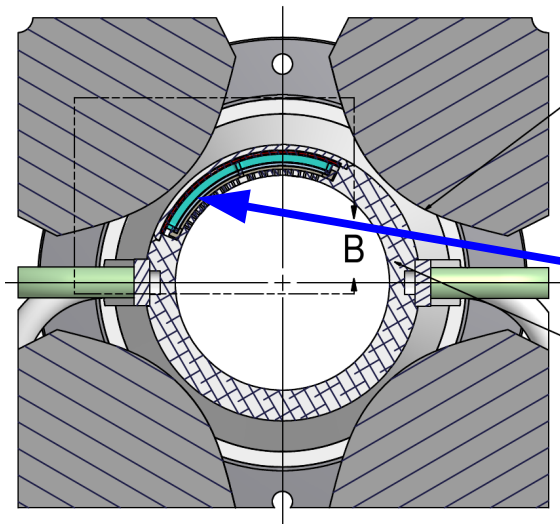


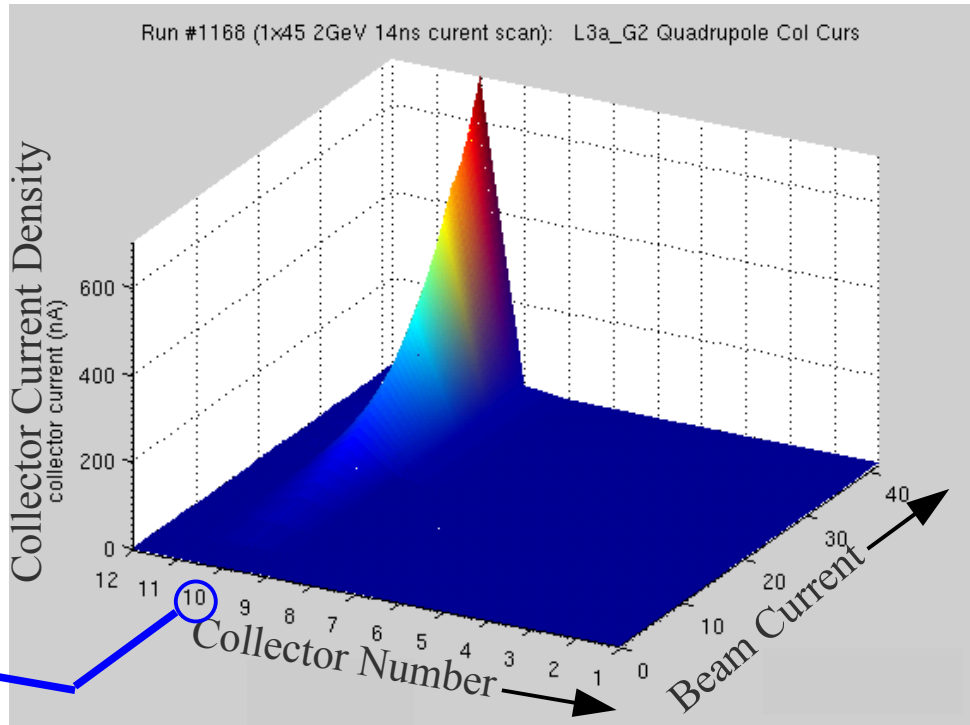


Electron Cloud Measurements

Retarding Field Analyzer (RFA)
in a Quadrupole







TE Wave: Bead Pull of L3 Beam-pipe

This example shows two resonances localized to the TiN grooved chamber.