Joint QUASAR and THz Group Workshop on Accelerator Science and Technology

USR Beam Instrumentation

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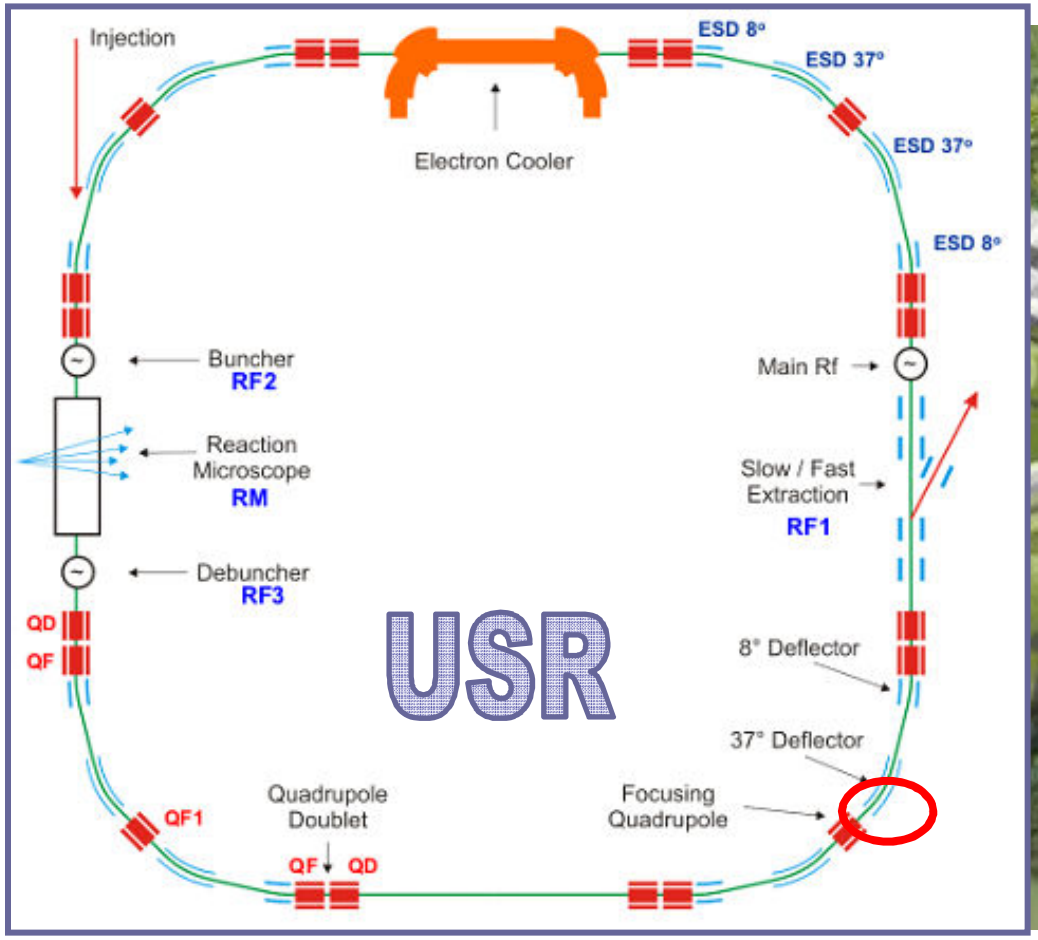
Ultra-low Energy Storage Ring

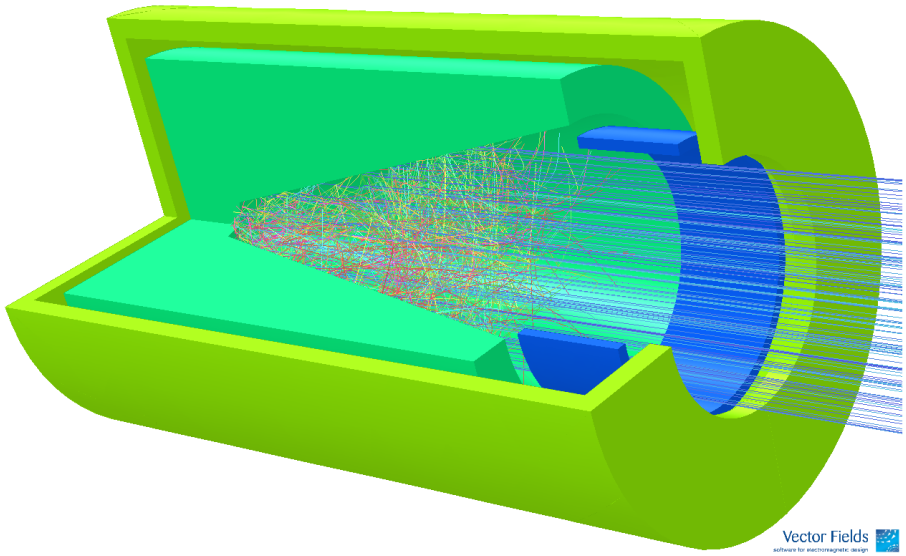


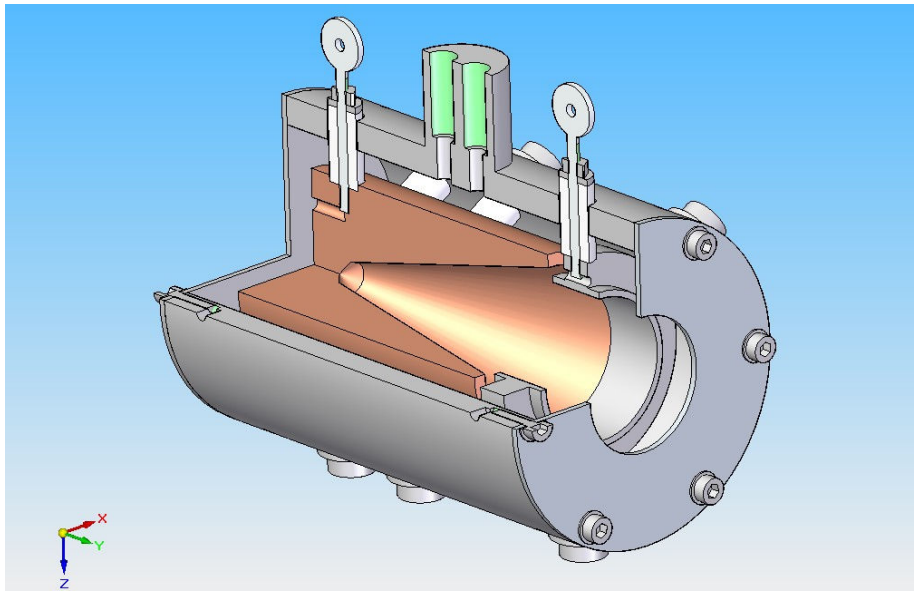
ANTIPROTONS

Energy	300 keV → 20 keV
Revolution frequency	178 kHz → 46 kHz
# of particles	~10^8 → ~10^7
Bunch length	1 ns – DC beam
Effective pbar rates for in-ring experiments	10^{10} pps – 10^{12} pps
Average rates of extracted pbars	$5x10^5$ pps – 10^6 pps
Beam diameter	5 mm – 20 mm

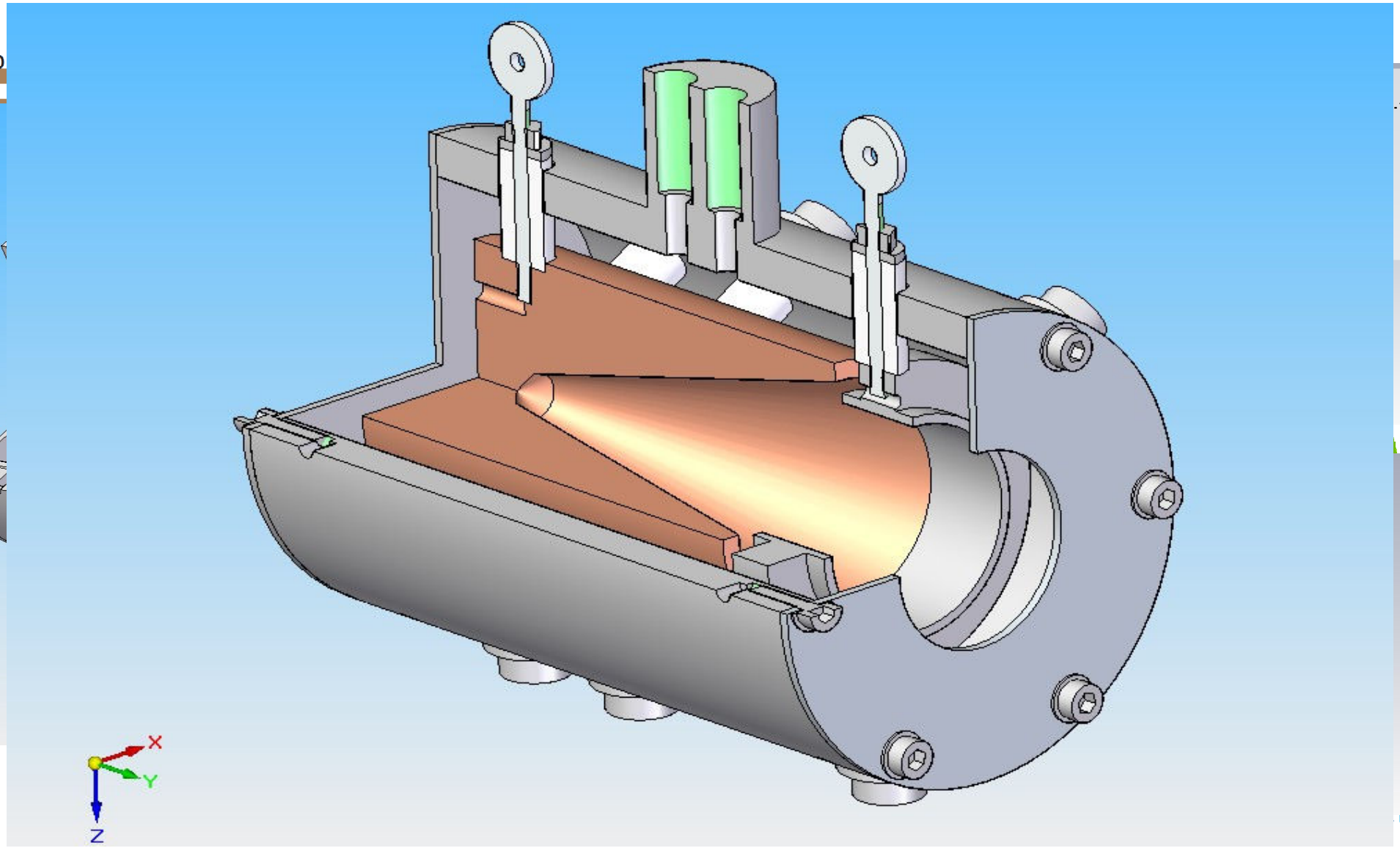
Faraday cup

- Destructive beam current measurements
- Collection of secondary particles (total charge)
  - Secondary electrons
  - Annihilation products: MeV-scale charged pions and recoil ions
- Expected beam intensities
  - AC mode: ~100 nA_{p-p}
  - Quasi-DC mode: ~100 fA



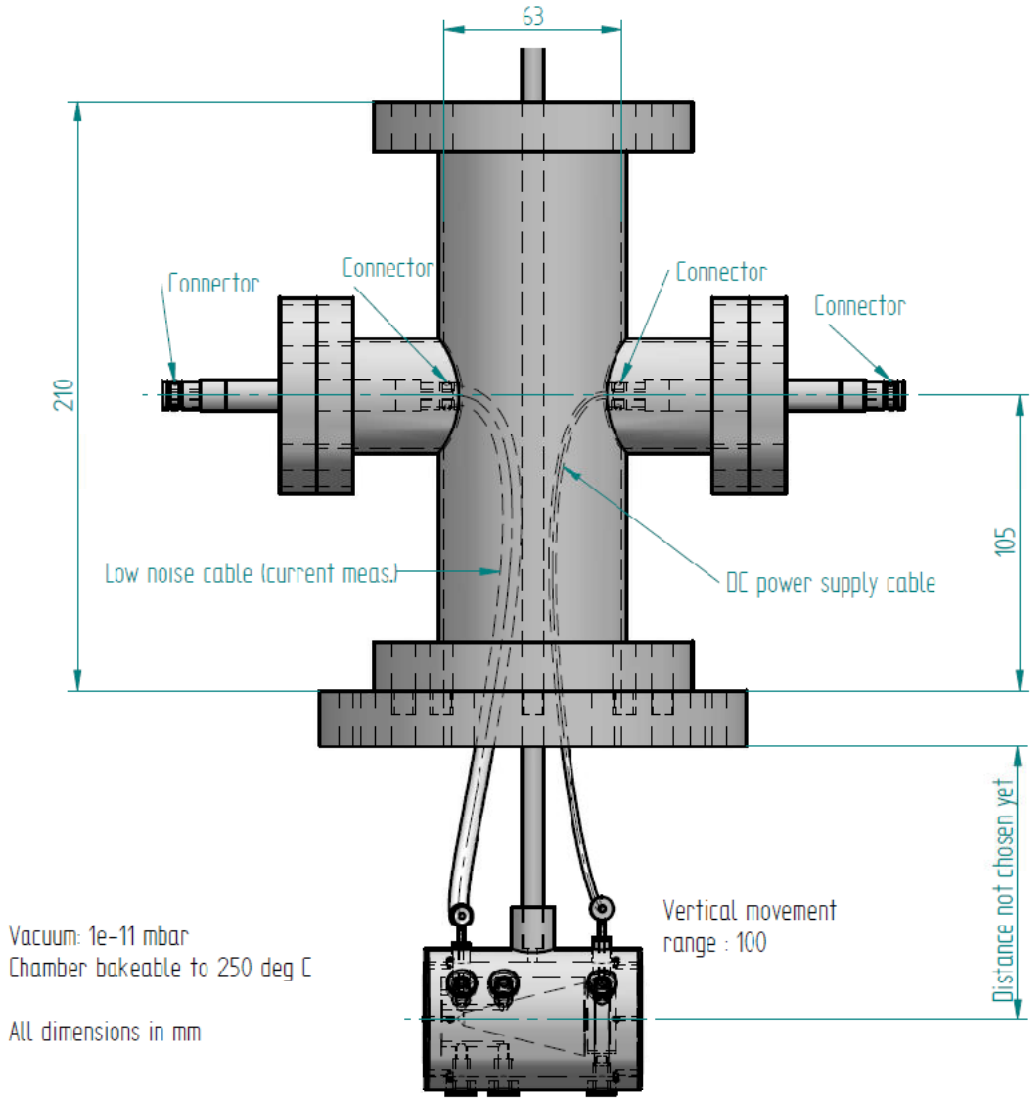


Faraday cup



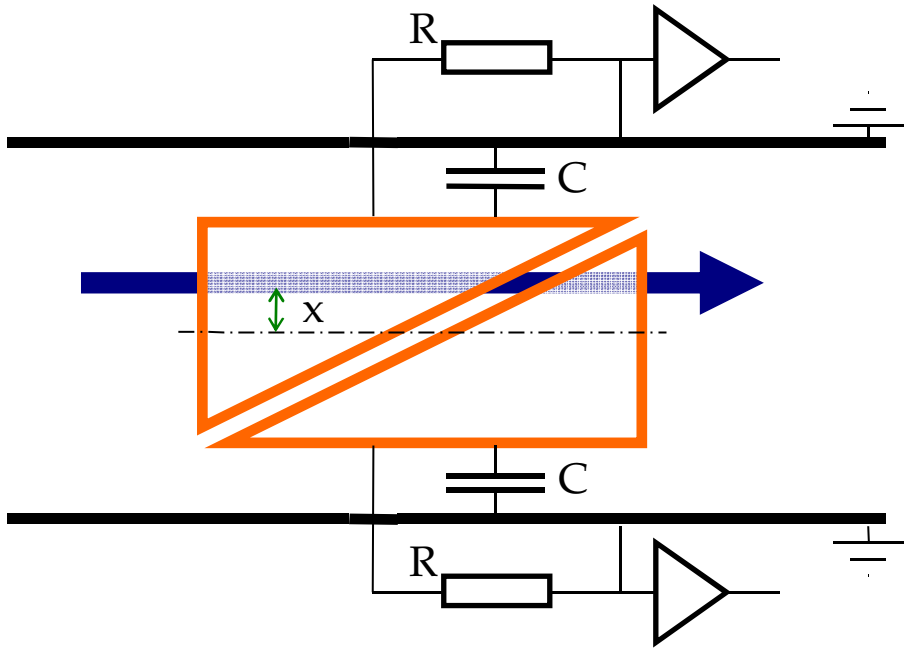
Faraday cup

- DC and AC mode
- Current down to ~100 fA
- Low noise cables and connectors
- Movable device
- UHV system (10^{-11} mbar and ~250 ˚C baking)

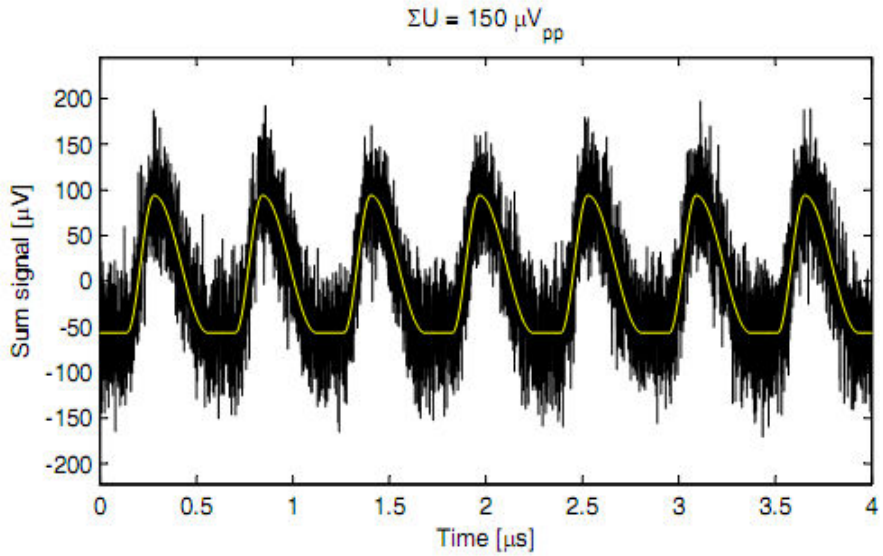


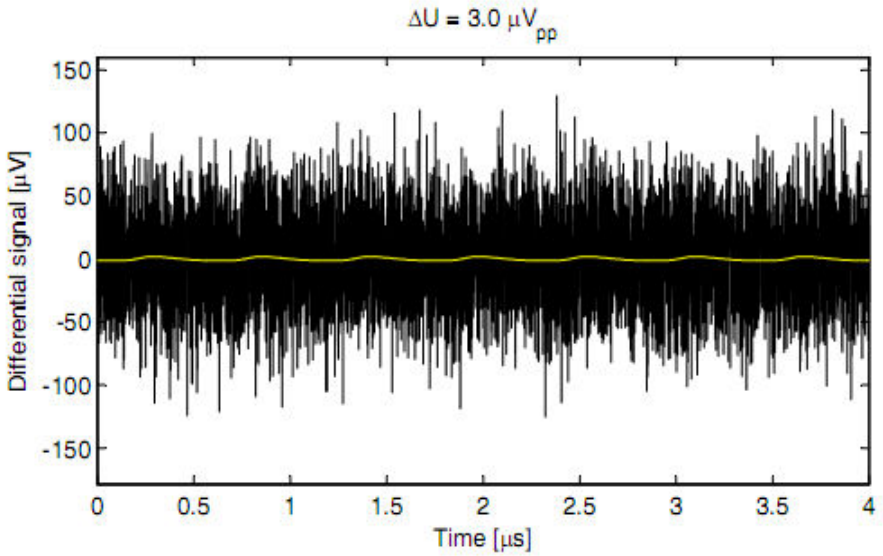
Capacitive pick-up

- Non-destructive beam position measurements
- RC circuit
- Expected signal
  - ΣU: ~150 μV_{p-p}
  - ΔU (1 mm): **~3 μV_{p-p}**

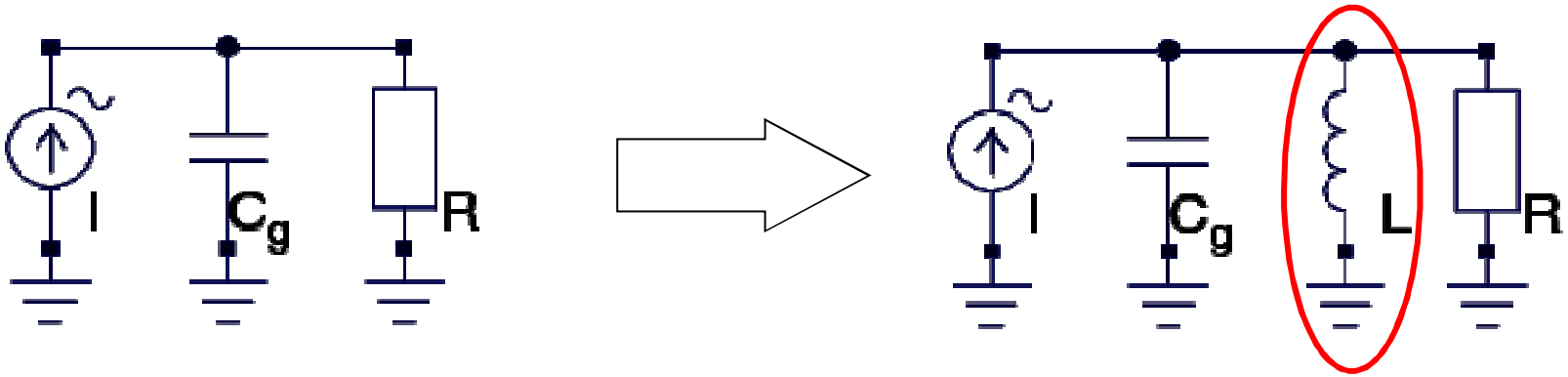


Expected signal

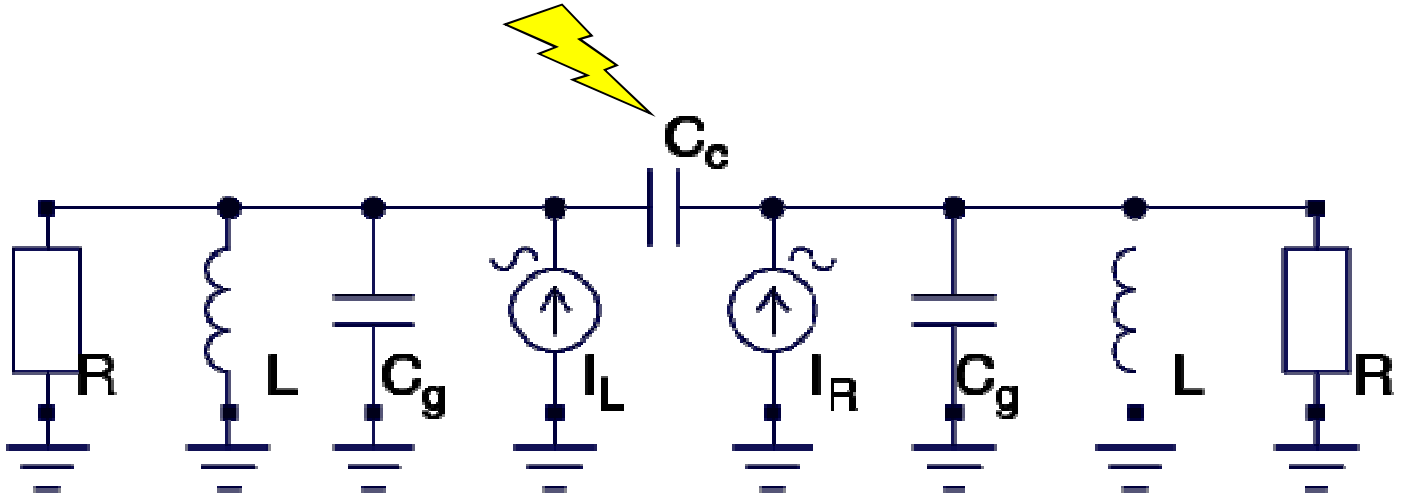




Resonant capacitive PU

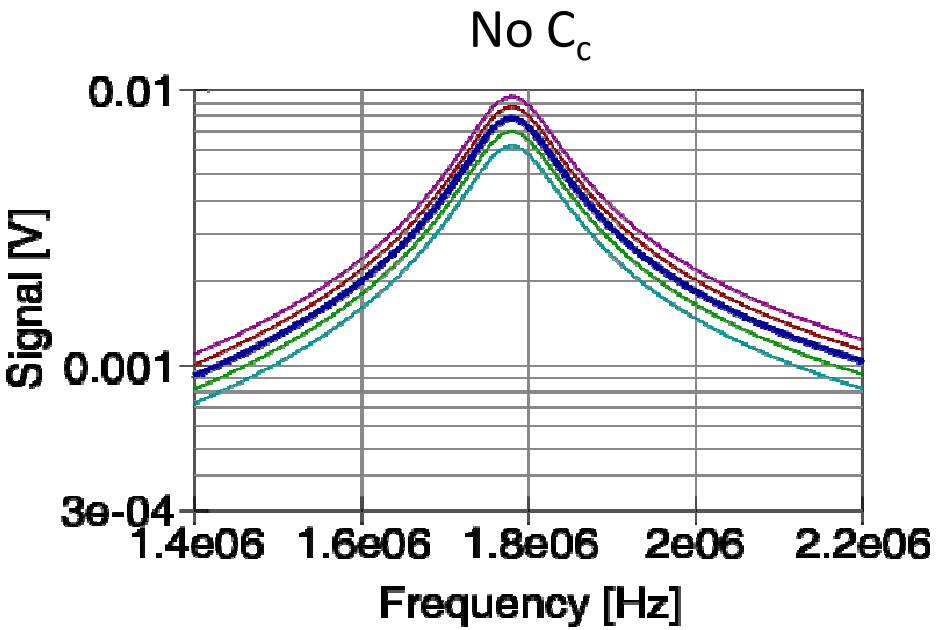


But…



Coupling capacitance

I_p = 500 nA, R = 1 MΩ, C_g = 100 pF, L = 80 µH, R_L = 50 Ω

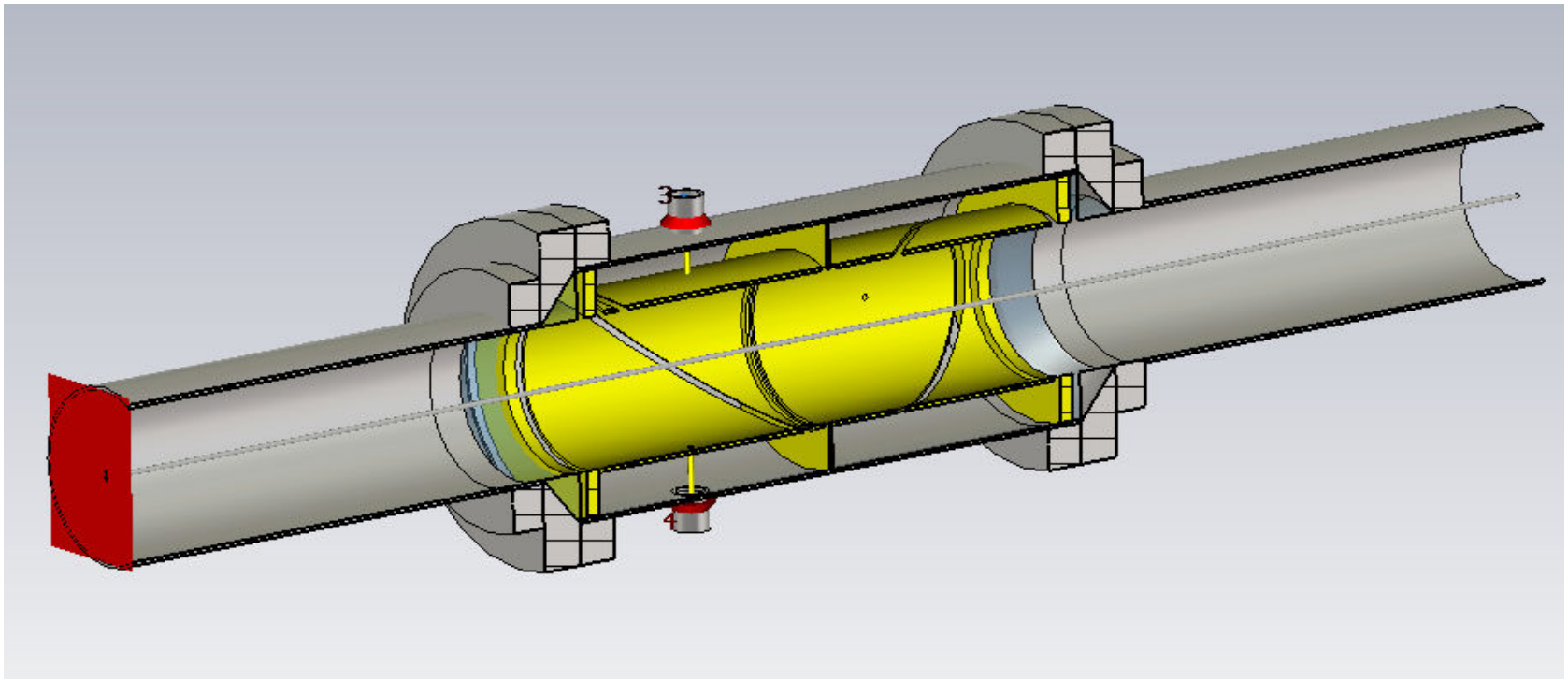


ΔU(0.1 mm, 1.78 MHz) = 16 µV

Increases with the increasing Q-factor

Capacitive PU

- Narrowband signal processing + averaging (closed orbit)
- Additional coil to improve S/N ratio?
  - Plates decoupling
  - High Q-factor



Beam profile monitor

- Destructive beam profile measurements
- Detector type:
  - Scintillating screen?
  - Secondary electron emission monitor?
  - Silicon detector?
- Expected intensities
  - Fast mode: ~10^7 particles in ~20 µs (~100 nA_{p-p})
  - Slow mode: **~5 x 10^5 pps** (~100 fA_{DC})

- Preliminary tests with a thin scintillator
  - 180 keV protons
    - Ø 1 mm
    - 25 frames/s
    - ~1 pA
  - 20 keV protons
    - several cm^2
    - ~100 pA

Summary

- **Faraday cup**
  - Low current (100 fA) measurements under UHV
- **Capacitive pick-up**
  - Low differential signal (~1 µV)
- **Scintillating screen**
  - Low number of particles (~5 x 10^5 pps)
  - Large beam spread (Ø 20 mm)
  - Low energy (20 keV)