TITAN Penning Trap Mass Spectrometer: Status Report

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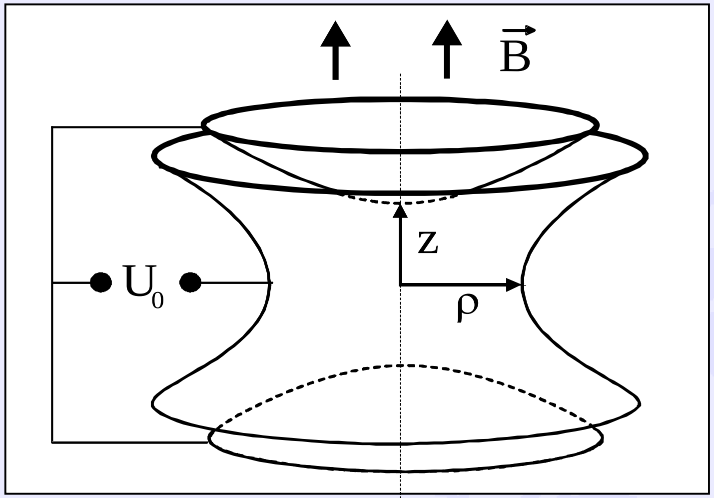
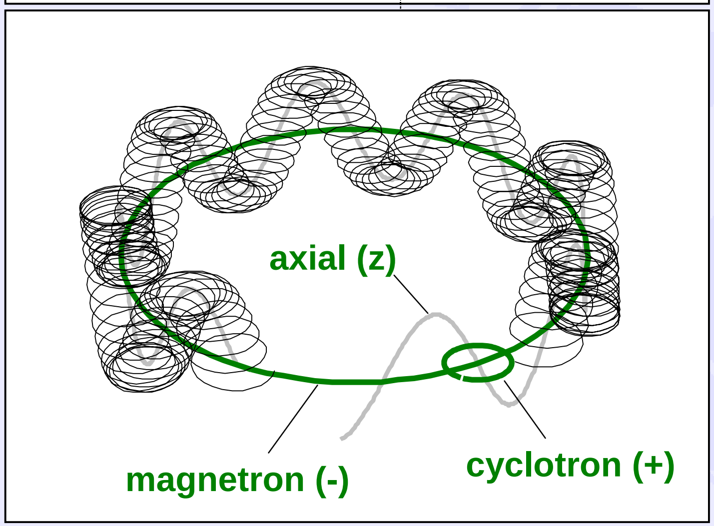
- Mass measurements and Penning trap
- HCIs: design decisions for battling the vacuum and energy spread
- TITAN setup
- Summary

TRIUMF

ISAC

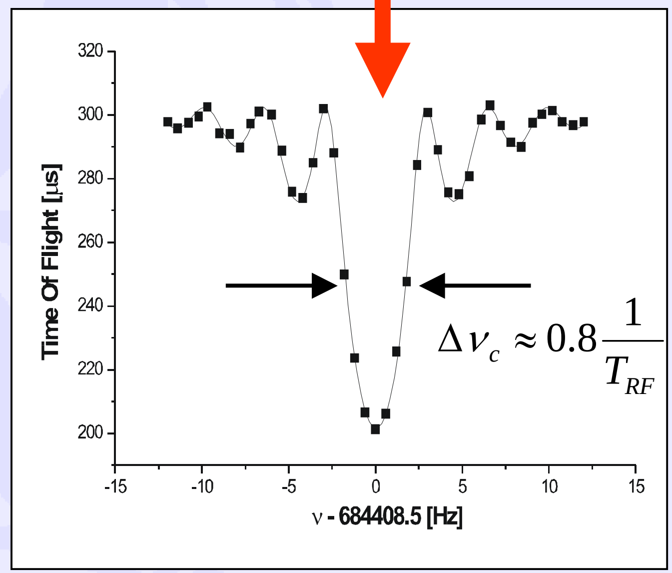
Penning trap mass spectrometry





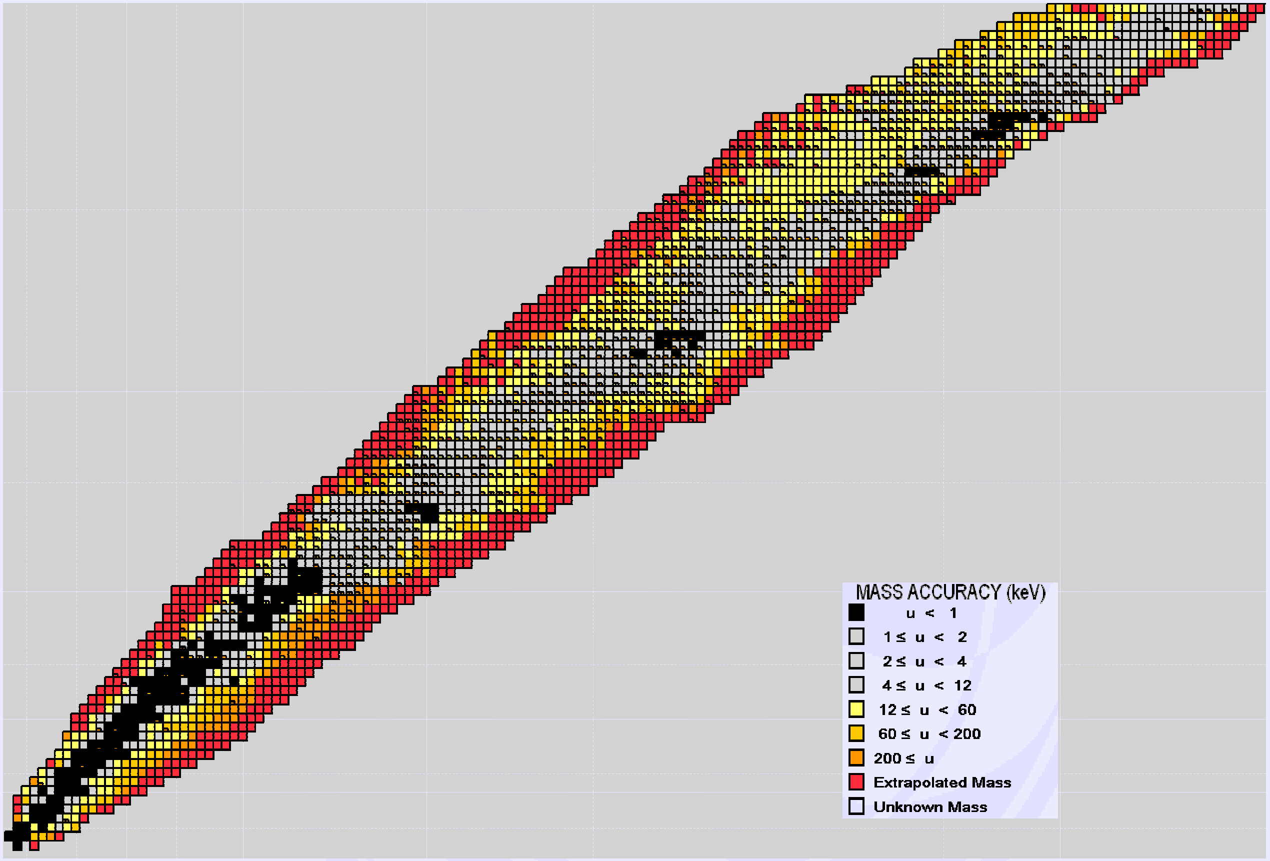
Quadrupole excitation

$$\nu_c = \nu_+ + \nu_- = \frac{1}{2\pi} \cdot \frac{q}{m} B$$



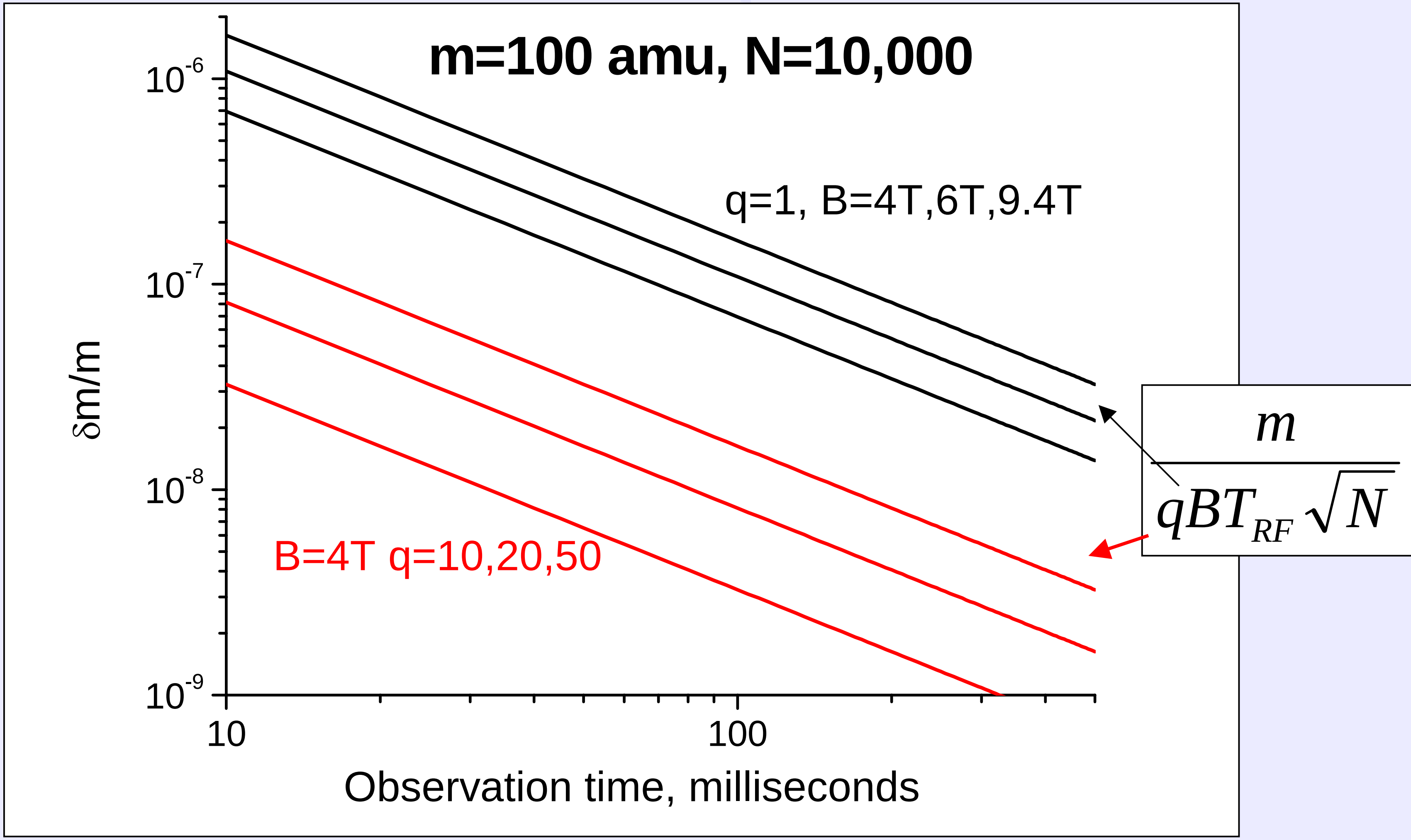
$$\frac{\delta m}{m} = \frac{\Delta \nu_c}{\nu_c} \cdot \frac{1}{\sqrt{N}} \approx \frac{1}{\nu_c T_{RF}} \cdot \frac{1}{\sqrt{N}}$$

What is (un)known



TITAN Penning trap will rely on the ISAC yields and charge breeding from EBIT to produce unique results for short-lived isotopes

Short-lived isotopes



Potential to improve the accuracy for the short-lived isotopes by more than order of magnitude. What's the catch?

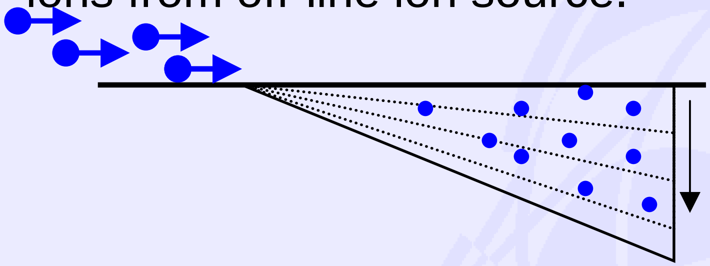
Highly-charged ions (HCIs)

- Electron capture from background gas. Transfer beam lines under UHV conditions ($<10^{-8}$ mbar). Penning trap under XHV conditions ($<10^{-11}$ mbar).
- HCIs from EBIT are significantly “hotter” than from RFQ. Emittance of 50(0?)π mm mrad and energy spread of 50(0?)eV/q is possible. Need to cool them.

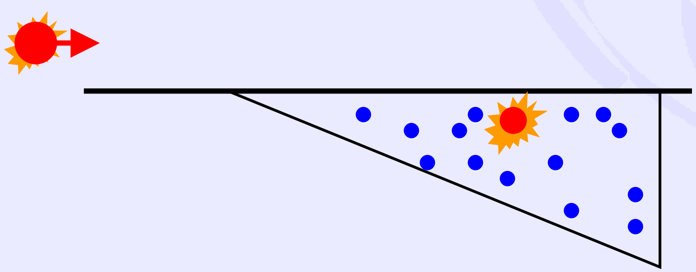
Cooling the HCIs with protons

Buffer gas cooling doesn't work (recombination). Only possibility – charged particle cooling (electrons, positrons … protons?).

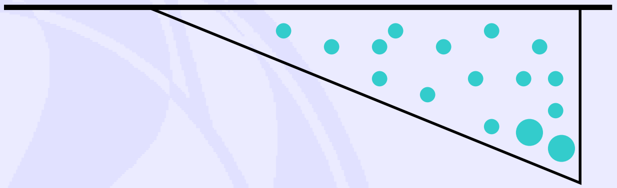
1. Load the cooling trap with "cold" ions from off-line ion source.



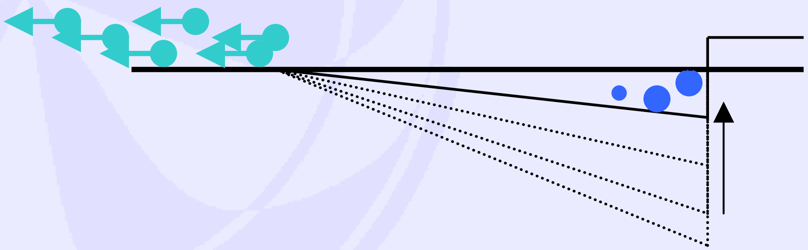
2. Inject the "hot" ions from the EBIT



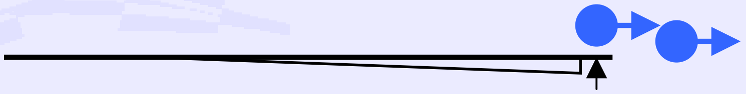
3. Thermalization



4. Light ion separation/evap. cooling

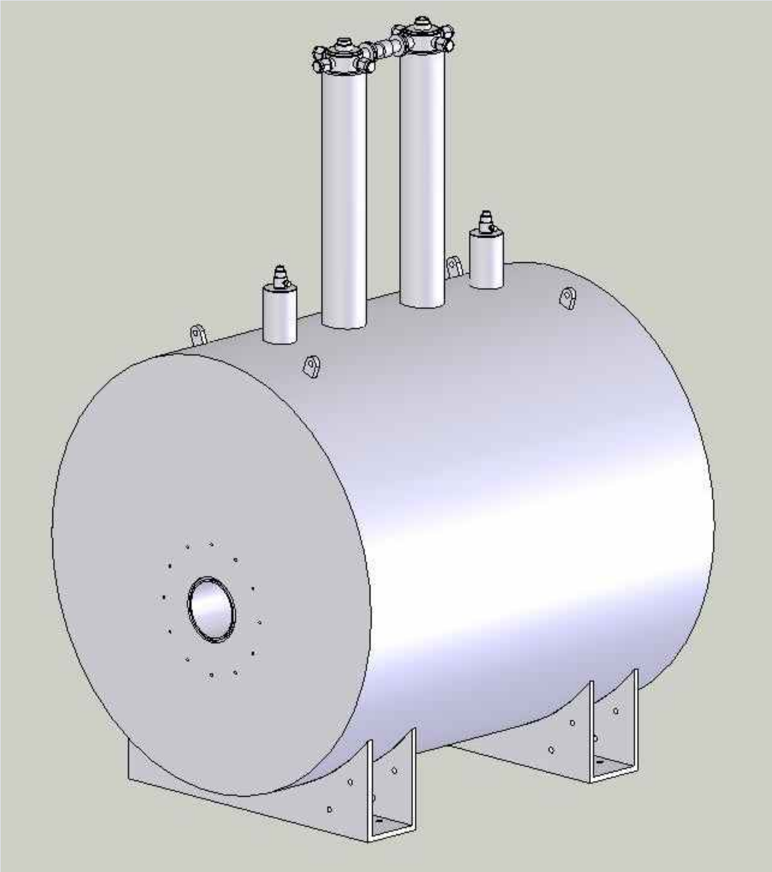


5. Send HCI into the measurement trap



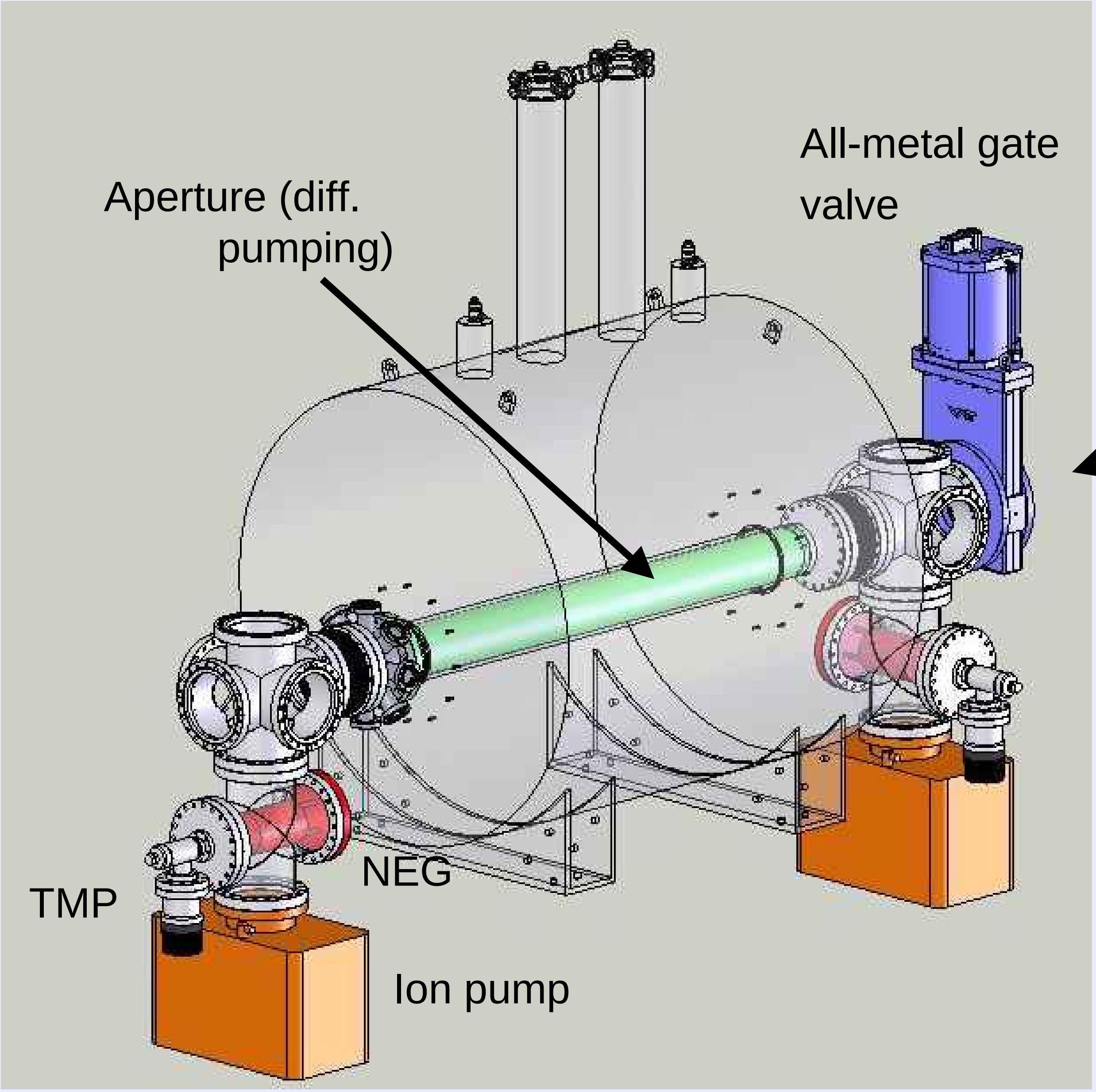
For the rest – remember G. Gwinner's presentation

Superconducting magnet

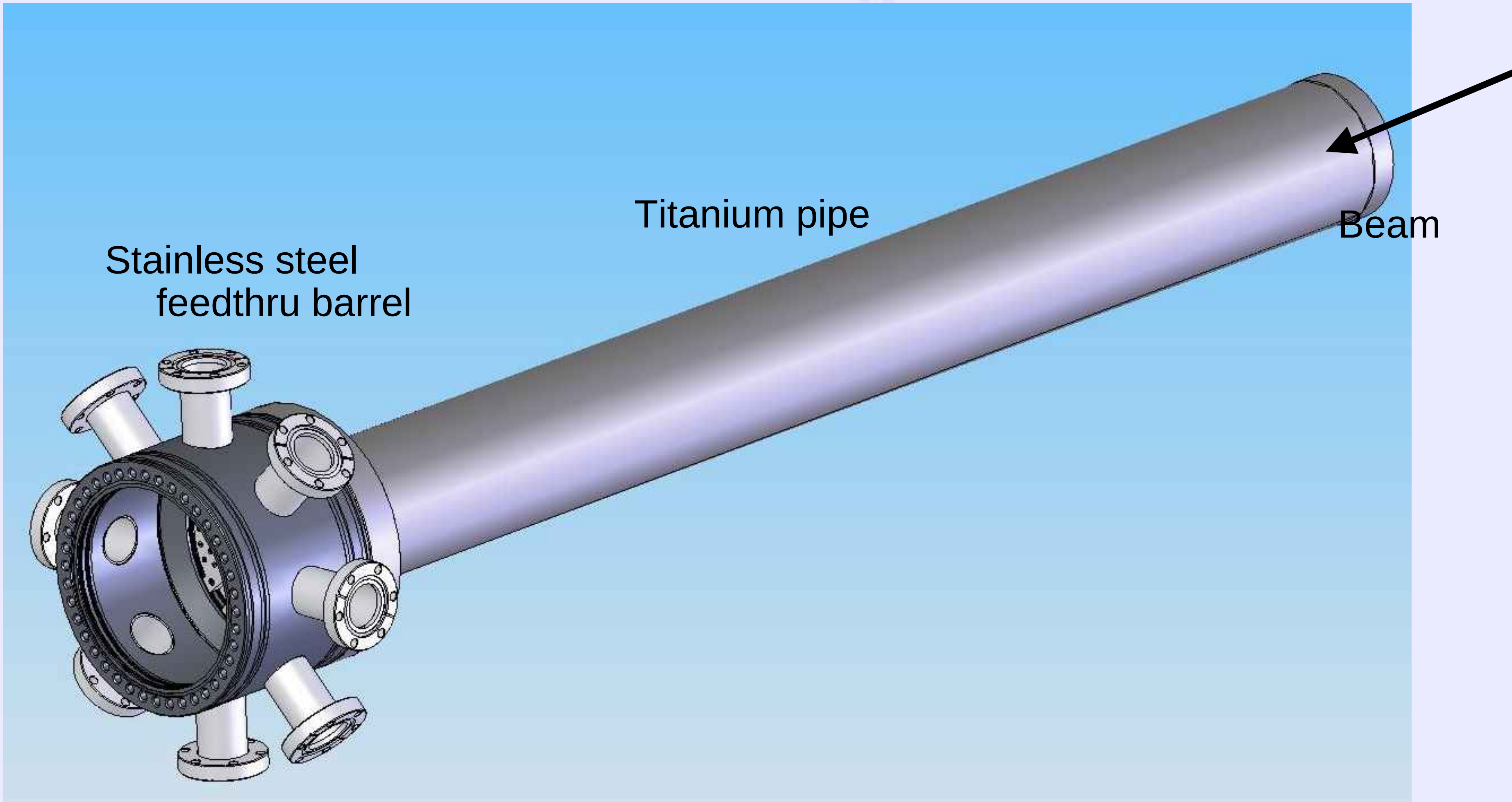


- 4T
- To be delivered: July 2005 (oops, I meant December 2005)
- Room temperature bore of 130mm diameter
- Calculated field inhomogeneity: 0.2ppm over 1x2cm cylinder
- LN hold time 4 weeks, LHe hold time 4 months.

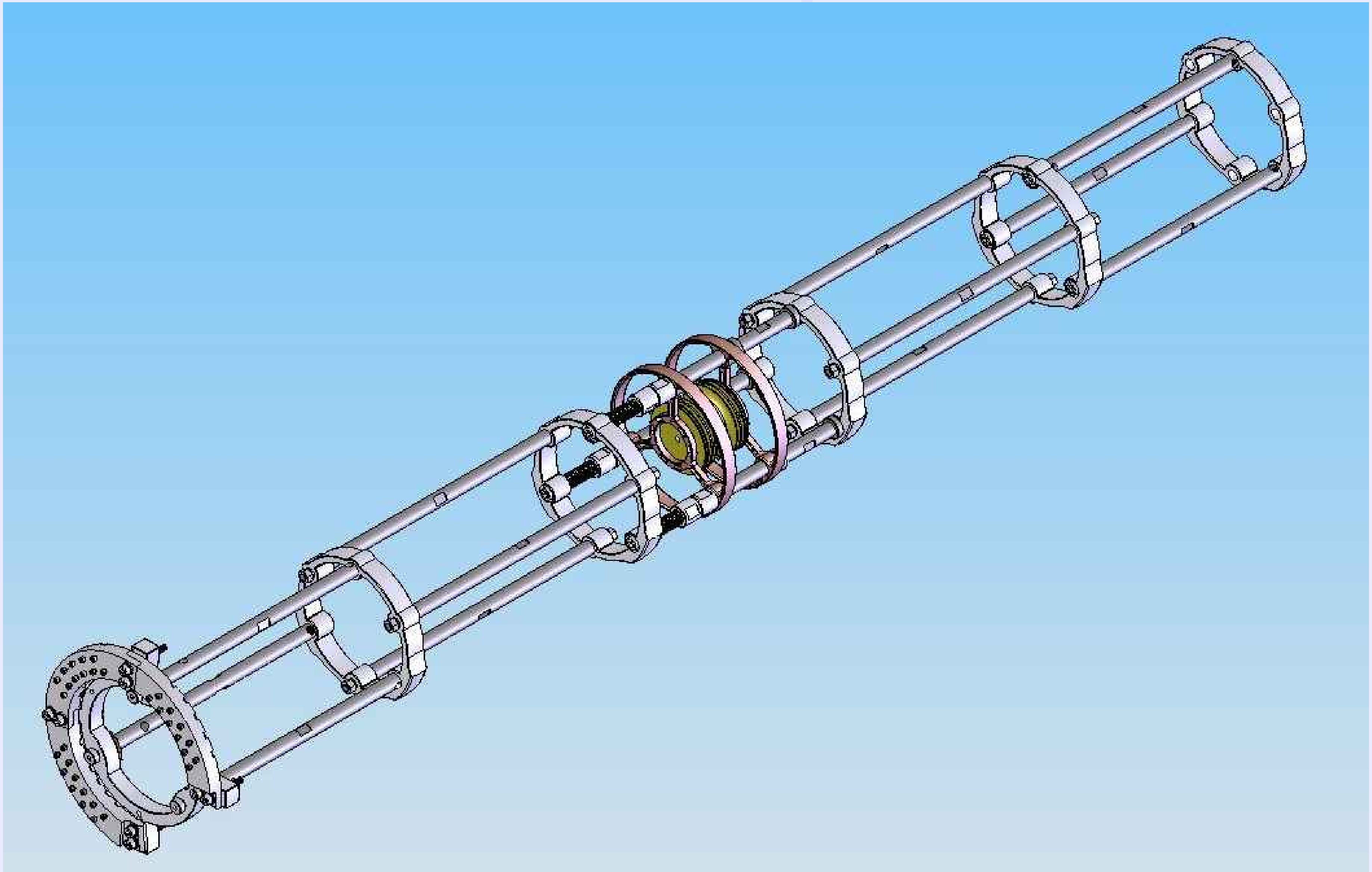
Vacuum system



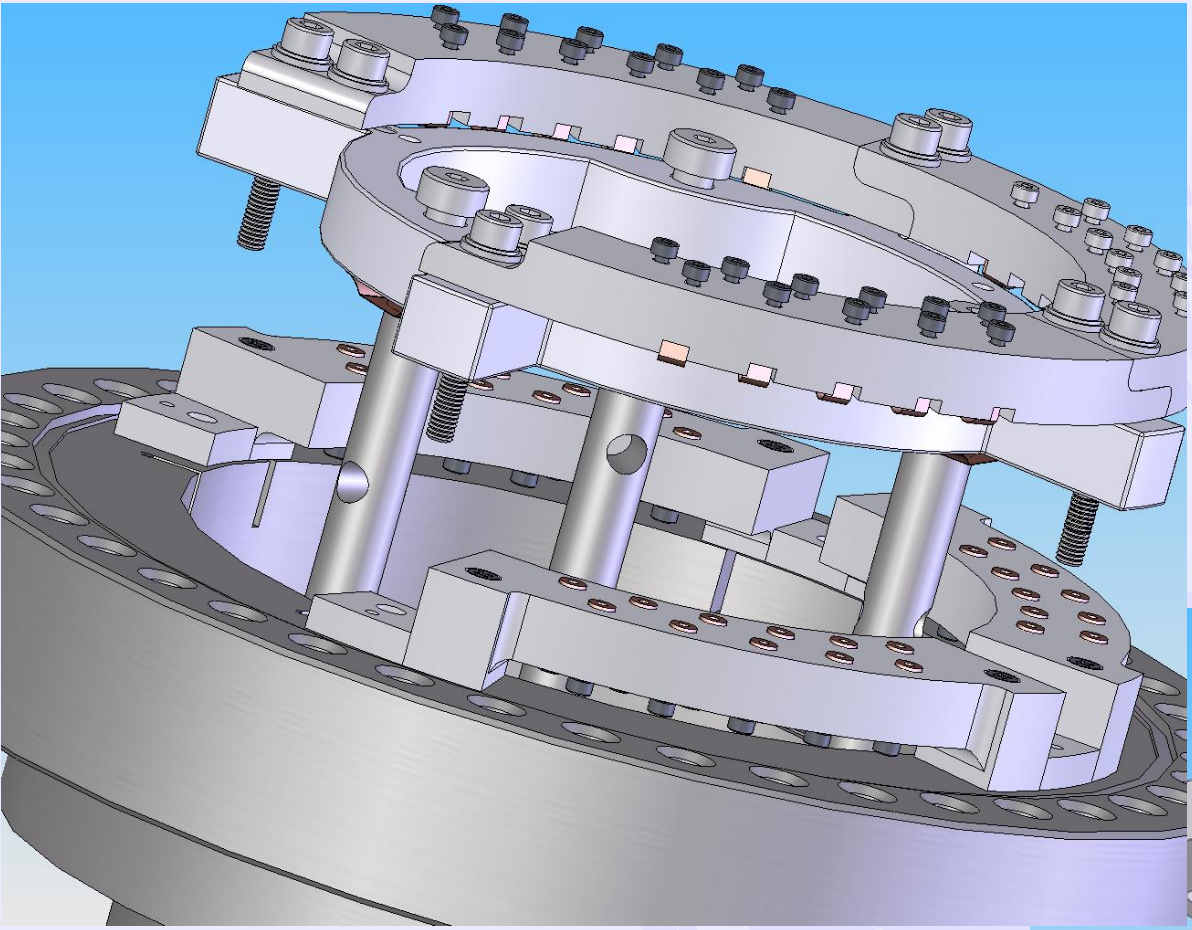
Vacuum chamber

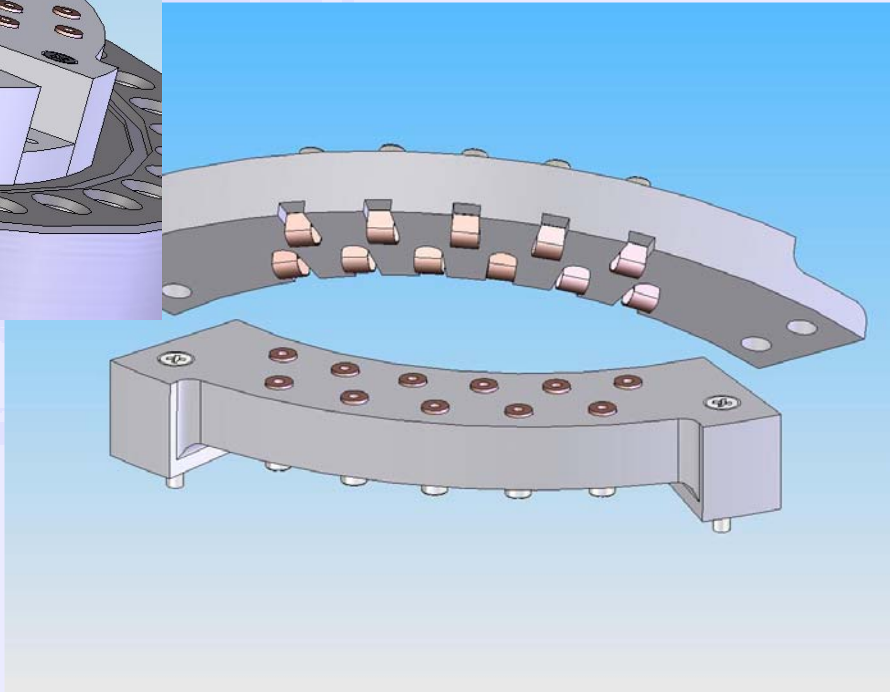


Support structure

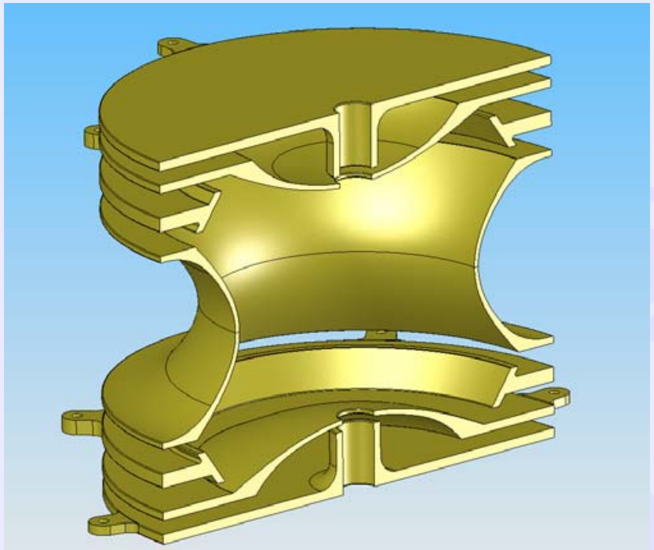


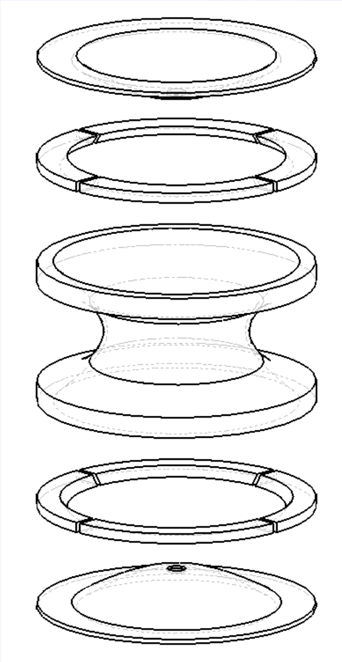
Electrical connections





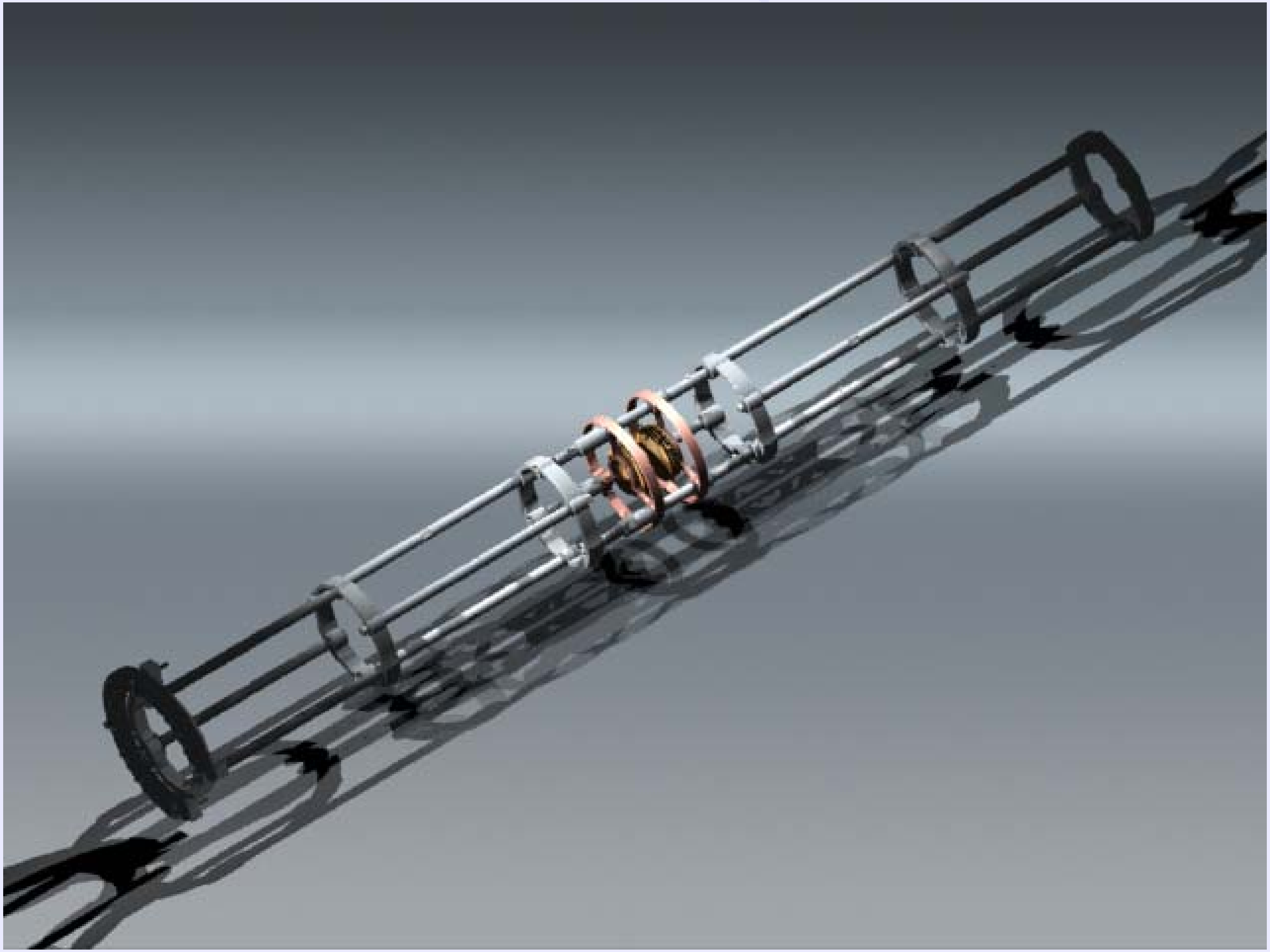
Penning trap





- Open structure with electrodes spaced by precision sapphire ball insulators.
- Trap size r0=15mm.
- The ring electrode is not split. Instead, the guard electrodes are split into 4 segments each.

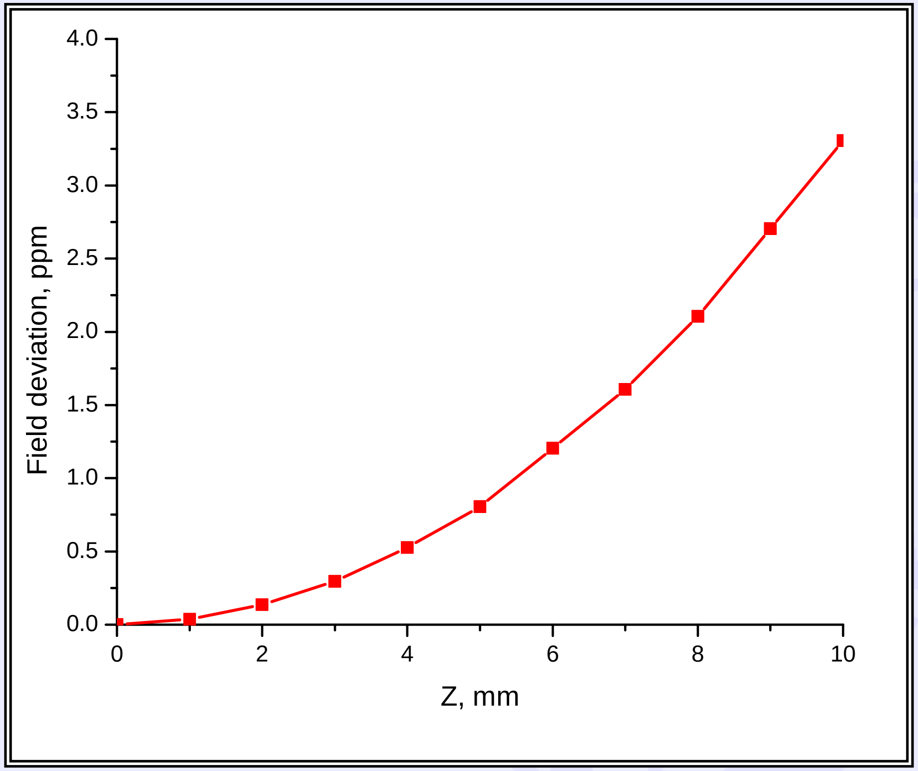
How will it look



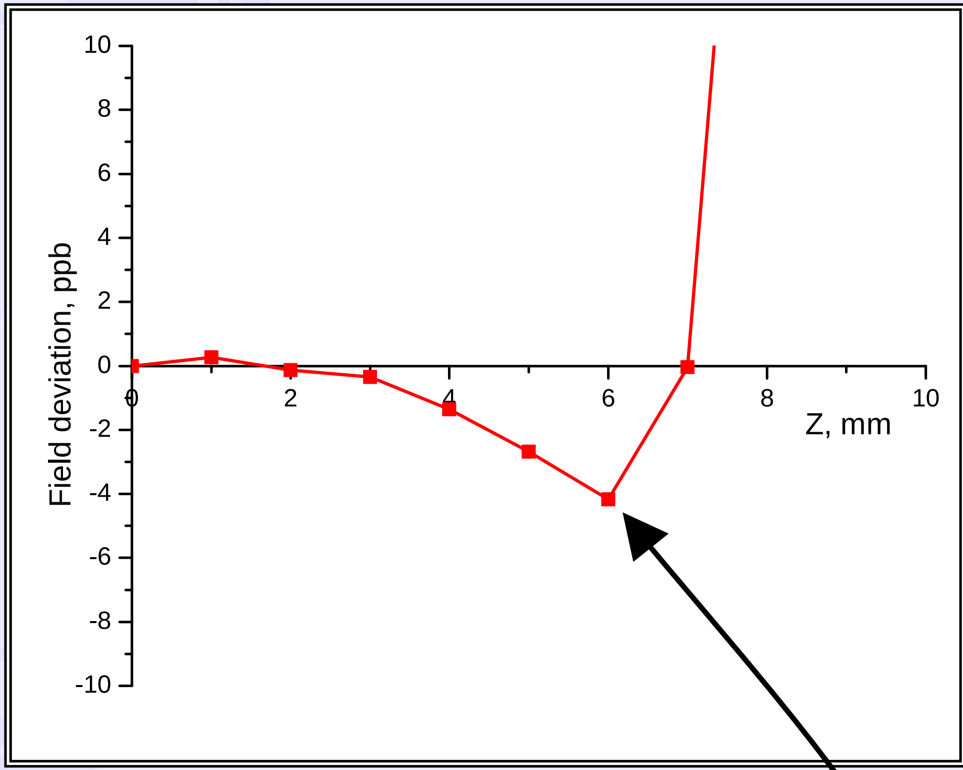
Handling the HCIs with a high energy spread

- Need higher trapping voltage on the electrodes.
- Larger orbit size means bigger field inhomogeneity.
- Field inhomogeneity and alignment will mix the ion motions and shift the frequencies. Larger ω_z creates a larger shift in $\omega_+ + \omega_-$ ($= \omega_c$?)

Magnetic field inhomogeneity



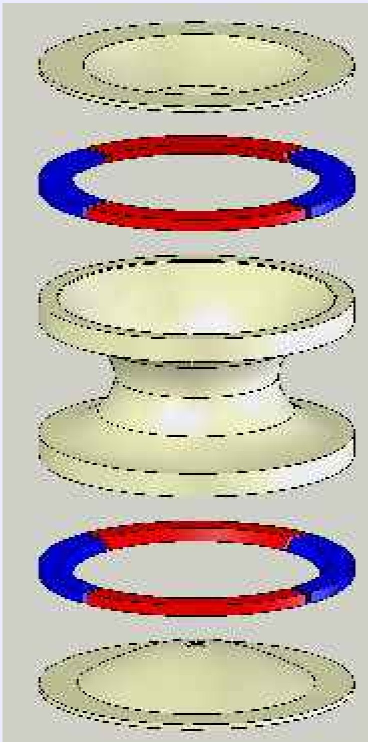
And after…

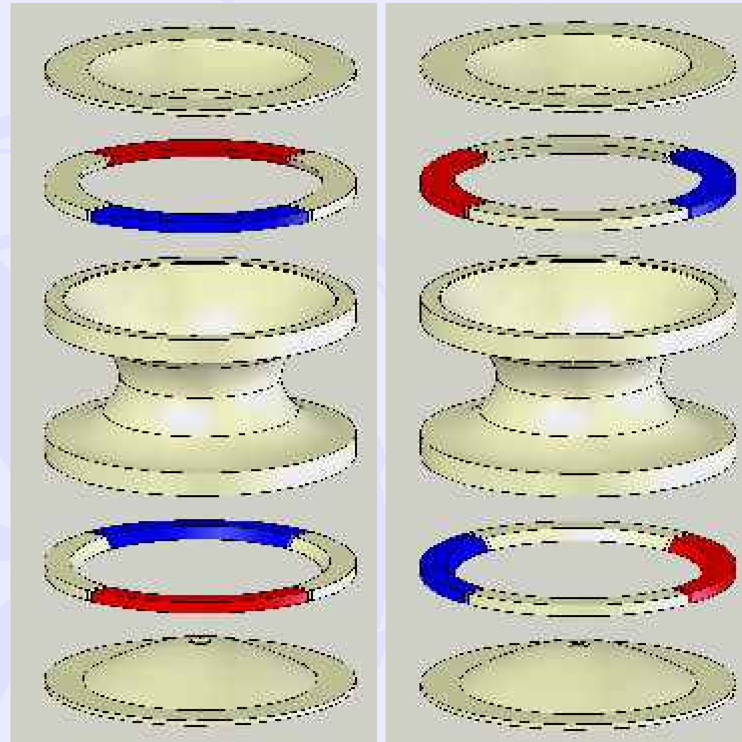


Before B2 tuning with a shim coil

Tune B2 out with a magnet shimming coil. Do fine tuning of B2 with a room temperature shim (also, B4 as well!)

Split guard ring possibilities

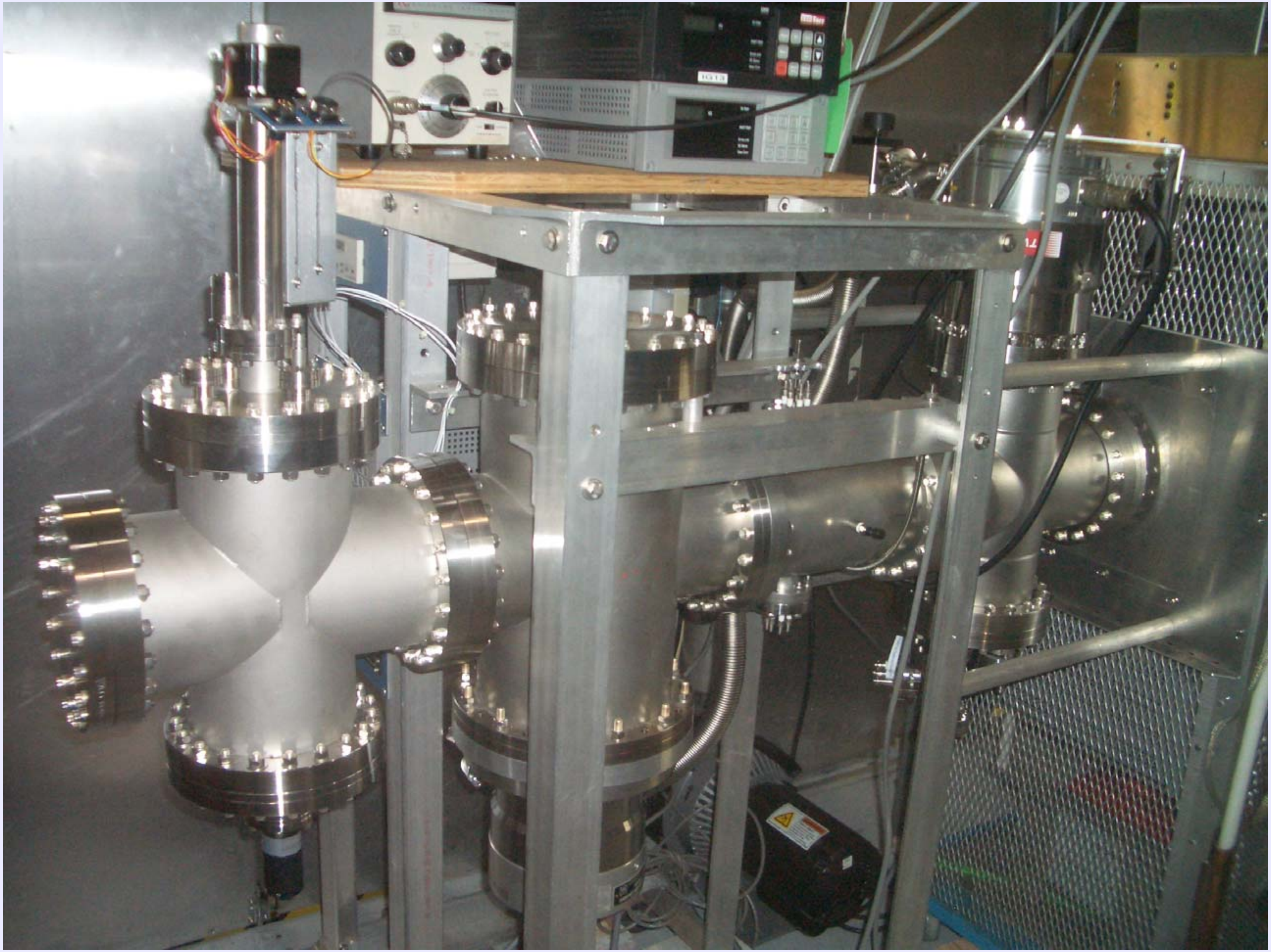




- x^2-y^2
- AC: Convert cyclotron and magnetron motions
- DC: Compensate for the electrode distortion (HIGHLY UNLIKELY)

- xz or yz
- DC: Rotate the electric field relative to z axis. <u>**Allows for precise alignment of B and E fields.**</u>
- AC: Convert axial and cyclotron/magnetron motions.

Some real metal



Summary

- TITAN Penning trap will take advantage of the ISAC yields to study short-lived isotopes.
- Coupled with EBIT it will be capable of very high precision on short-lived isotopes.
- In order to achieve high efficiency of the Penning trap+EBIT combination, we need a way to cool the ions coming out of the EBIT.
- Penning trap is designed to be robust to the incoming ion distribution.

People

- Jens Dilling
- Maxime Brodeur
- Daniel Lindner
- Zunjian Ke

TITAN Collaboration

TRIUMF: Jens Dilling, Pierre Bricault, Joseph Vaz, Guenther Sikler, Vladimir Ryjkov

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McGill: Bob Moore, John Crawford, Fritz Buchinger, Jonathan Lee, *L. Blomeley*

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U. of Calgary: Rob Thompson

U. of Windsor: Gordon Drake

York U.: William Van Wijngaarden, *G. Noble*

GSI Darmstadt: Juergen Kluge

MPI-K Heidelberg: Jose Crespo, Joachim Ullrich

U. of Mainz: Guenther Werth, Klaus Blaum

MSU: Georg Bollen

Texas A&M: Hans Schuessler

TRIUMF support: Controls group, Kicker group, Design office, Workshop, Vacuum, etc…