# An Improved Vacuum System for Storing Highly Charged Ions in a Penning Trap

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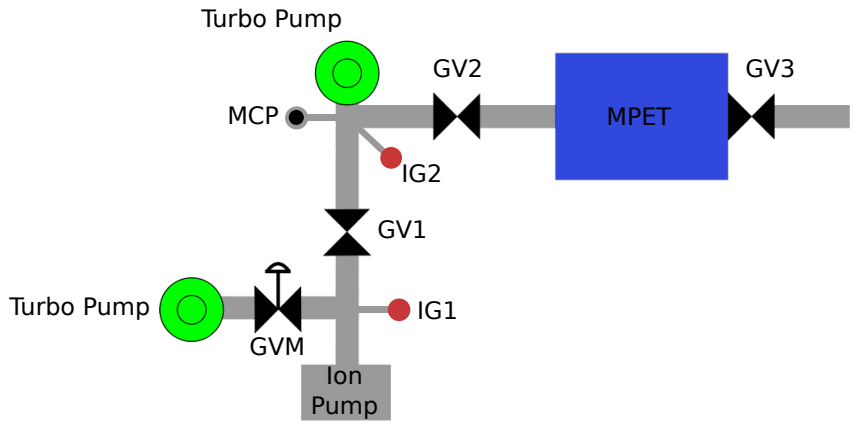
# Agenda

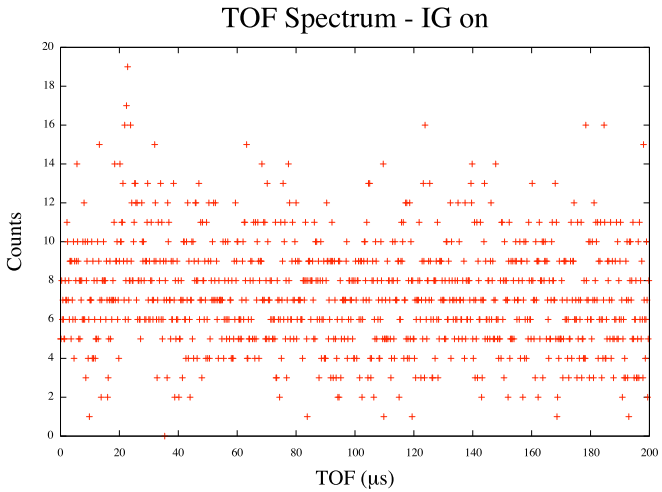
- Introduction
- Ion Pump Baking and Testing
- EIGB Design and Testing
- Conclusions

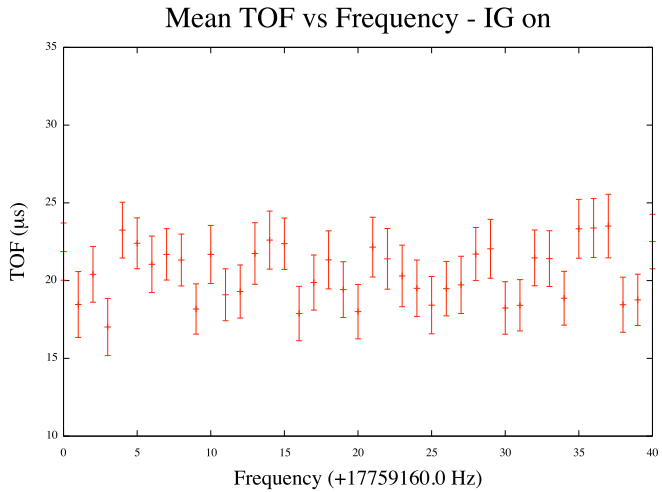
# Motivation

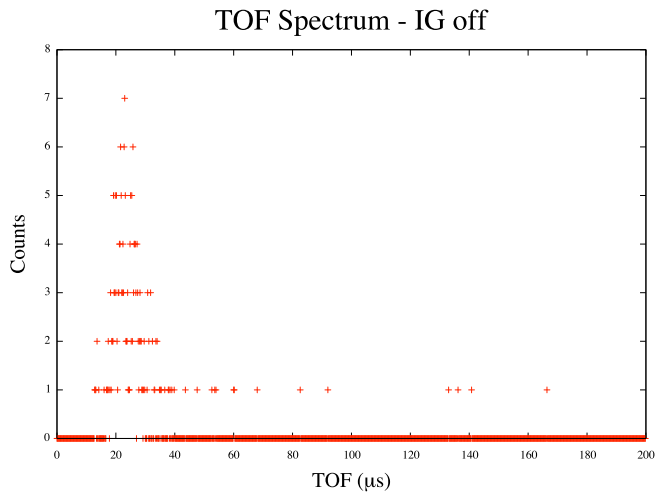
- Gave valves provide safety in event of vacuum failure.
- Interlocks - gave valves close, high voltage power shut off.
- Compartments rely on ionization and convection gauges.
- Convection gauge operates in mtorr range.
- Ion gauge interferes with MCP.

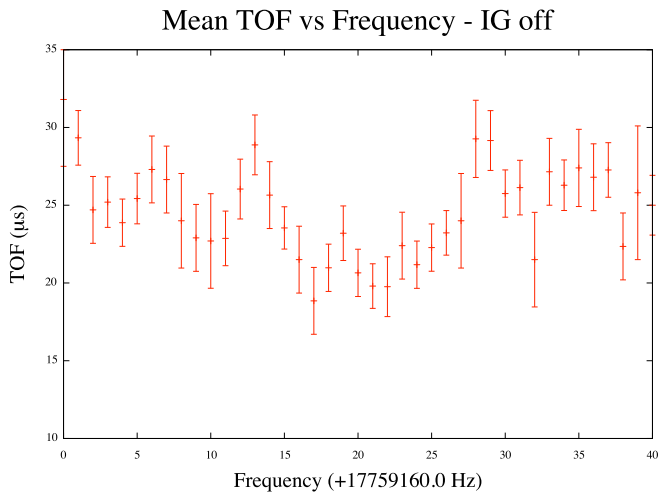


# Ion Gauge Interference



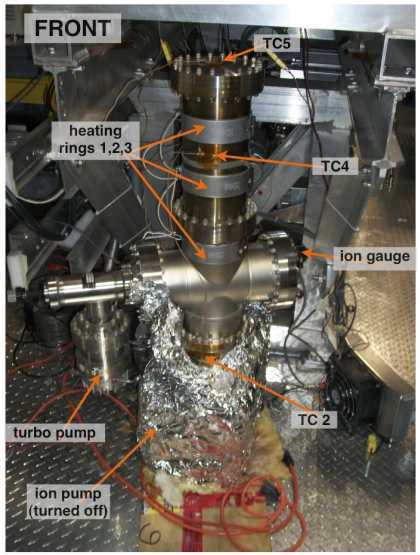



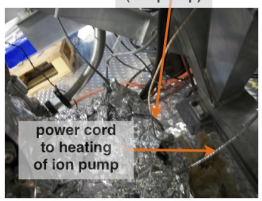



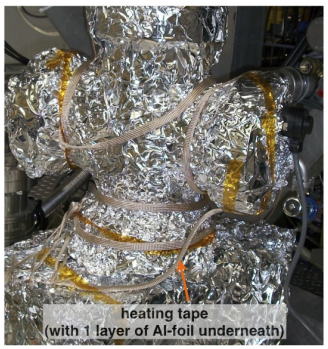
# Charge Exchange

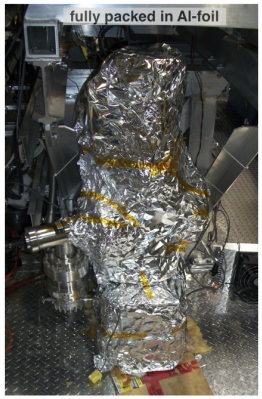
- Higher pressure translates into greater likelihood that ions may interact with stray molecules.
- Changing the charge state of ions is problematic especially for HCI.
- Low vacuum and ion gauges can contribute to charge exchange by making the vacuum worse.
- Critical that UHV is achieved for mass measurement, MPET.

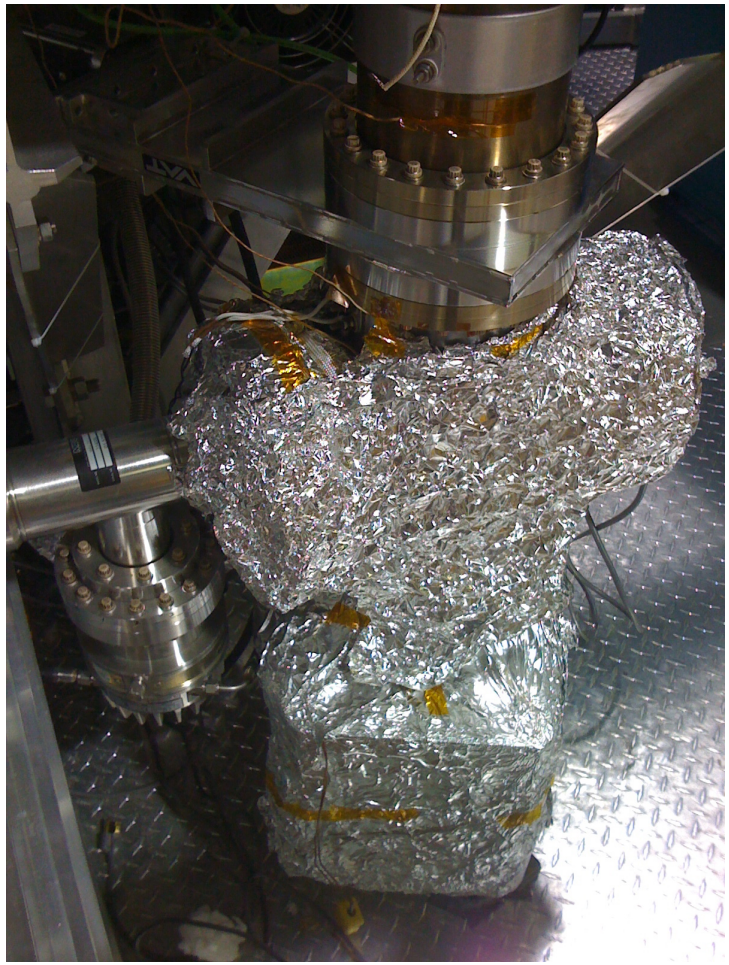
# Ion Pump Baking Preparation



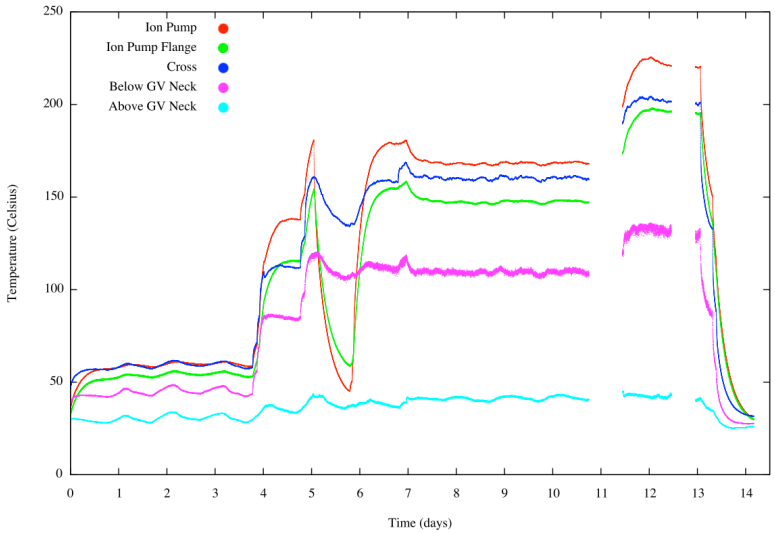


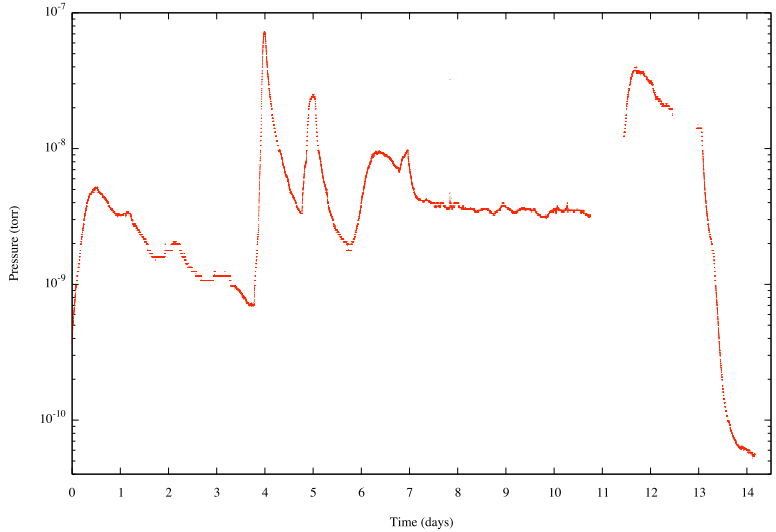



# Ion Pump Baking

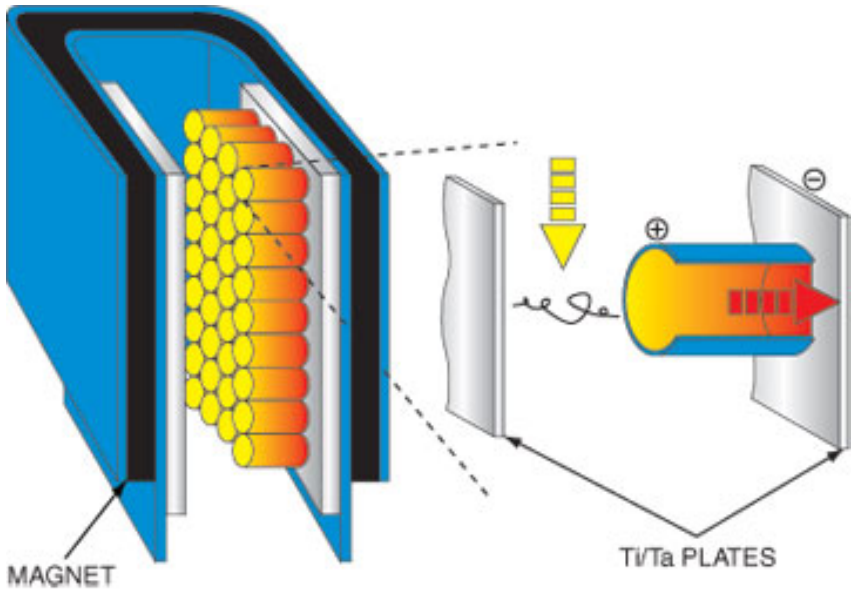



- Start pressure $1.78 \times 10^{-10}$ torr, end pressure $5.43 \times 10^{-11}$ torr.

# Ion Pump Operation

- Large permanent magnets, HV cathode plates.
- Honeycombed cylinders maintain plasma that ionizes air molecules.
- Ions are accelerated towards cathode plates, are buried or sputter.
- Ion pump has three HV settings, 3 kV, 5 kV and 7 kV.



# Testing Procedure

- Ion Pump had not been activated for two years.
- Correct starting procedure was observed.
- All three settings were tried while manual gate valve was both open and closed.
- Pressure allowed to stabilize after setting changed and recorded.
- Ran through twice to ensure reproducibility.

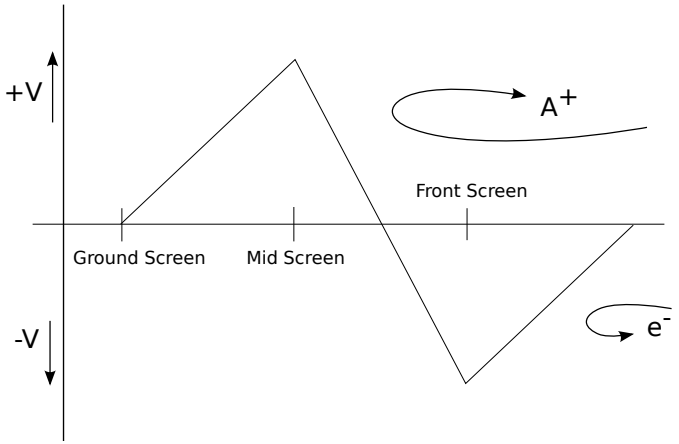
# Testing Results

| | Gate valve open (torr) | Gate valve closed (torr) |
|---|---|---|
| 7 kV | $1.0 \pm 0.1 \times 10^{-10}$ | $1.1 \pm 0.1 \times 10^{-10}$ |
| 5 kV | $5.4 \pm 0.2 \times 10^{-11}$ | $9.2 \pm 0.3 \times 10^{-11}$ |
| 3 kV | $3.8 \pm 0.1 \times 10^{-11}$ | $7.2 \pm 0.2 \times 10^{-11}$ |

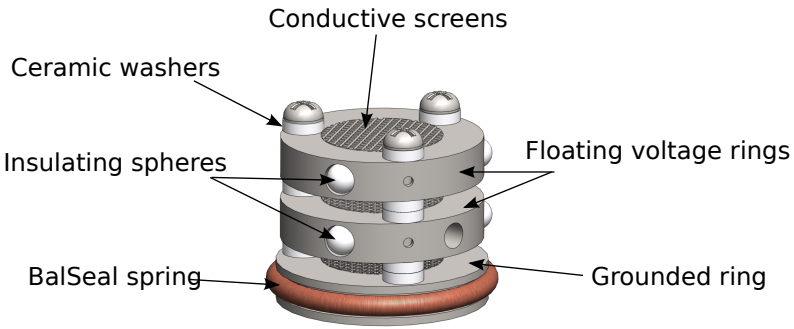
- All trials showed ion pump performed better with manual gate valve open.
- Based on present test, optimum setting is: Manual gate valve open, HV set to 3 kV.
- Optimum setting was used and allowed to pump a further two days, pressure went off scale, $< 1.0 \times 10^{-11}$ torr.

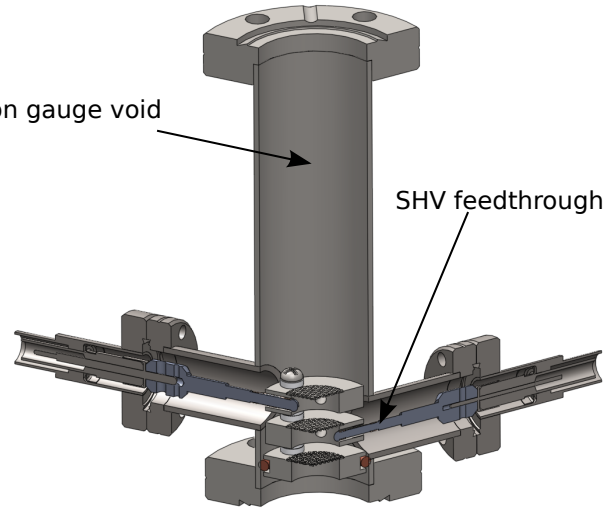
# Theory

- Ion gauge produces charged particles
- Through the use of electrostatic barrier, charged particles can be contained.



# Design




- SolidWorks design (EIGB) Electrostatic Ion Gauge Barrier.
- Conductive screens act as electrostatic barrier.
- Insulating spheres, BalSeal spring maintain electrical continuity.

# Design

# Test Setup and Procedure

- Intended to test in baking station in ISAC 1 Hall.
- Test setup would involve multiple scenarios involving ion gauge placement and an MCP.
- The EIGB and ion gauge would be within line of sight of each other, and multiple scenarios in which they would not be within line of sight of each other.
- Aim would determine if EIGB is necessary to create barrier for ions or if simply placing the ion gauge around a simple bend, thus eliminating line of sight, would tame the unwanted background noise on the MCP.
- Time did not allow such tests.

# Testing EIGB in MPET

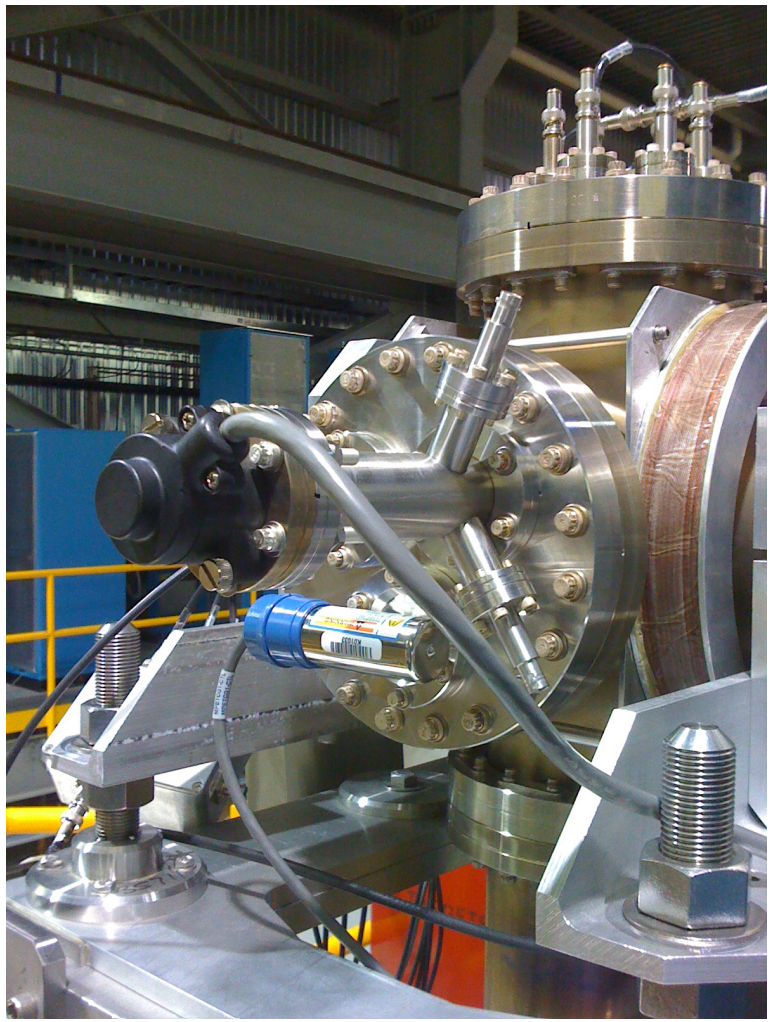
- MCP biased to $\approx$ 1950 V.
- Various scenarios using barrier voltage from $0 - 3000$ V.

| | MCP count rate (Hz) |
|---|---|
| Ion gauge in original position | $\approx$15000 |
| Ion gauge in EIGB, barrier potentials off | $\approx$ 450 |
| Ion gauge in EIGB, barrier potentials on | $\approx$ 300 |

- Barriers set to $\pm$500 V.
- EIGB's best performance; middle screen biased to 200 V or higher, front screen biased to $-150$ V or lower.
- Strange phenomena at 150 V.

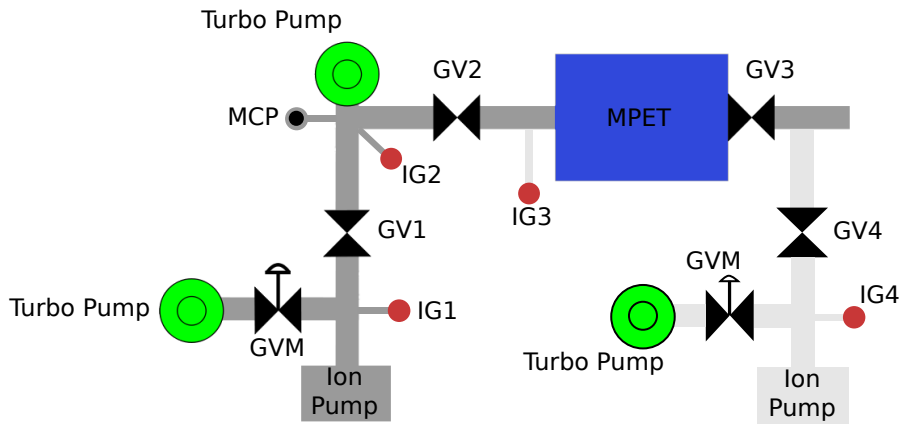
# Results of EIGB in MPET

- Performance of EIGB was not as expected but new phenomena discovered.
- Testing found that ion pump/IG1 can contribute to MCP interference as well.
- This interference was thought to be unavoidable background noise.
- Raises new questions about filtering interference.
- Proper test setup should identify new problems.



# Ion Pump Implementation

- Given the success of the ion pump, second pump should be added, shown in light grey.
- May provide the lowest pressure for the MPET.
- Ion gauge, IG3, added to monitor pressure in MPET, outside of mag field.



# Limitations

- Removing ion gauge from line of sight showed improvement by a factor of $\approx$33.
- Activating EIGB showed improvement by a factor of $\approx$1.3.
- May be other effects of charged particle creation from ion gauge EIGB is missing.
- Possible that EIGB is missing charged particles due to convex conductive screens.
- Further study needed to improve design of EIGB to activate IG2.

# Closing

- A challenging, time consuming project.
- Very interesting, found myself trying to work out new approaches to problems.
- Thank you to Stephan Ettenauer, Usman Chowdhury and Mel Good for their help and the rest of the TITAN team for allowing me to "try" stuff out on MPET.