HSX Vacuum system and practices

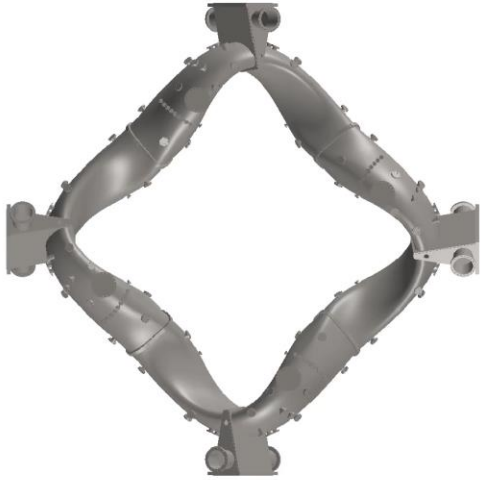
Presented by Thomas Gallenberger and the HSX team

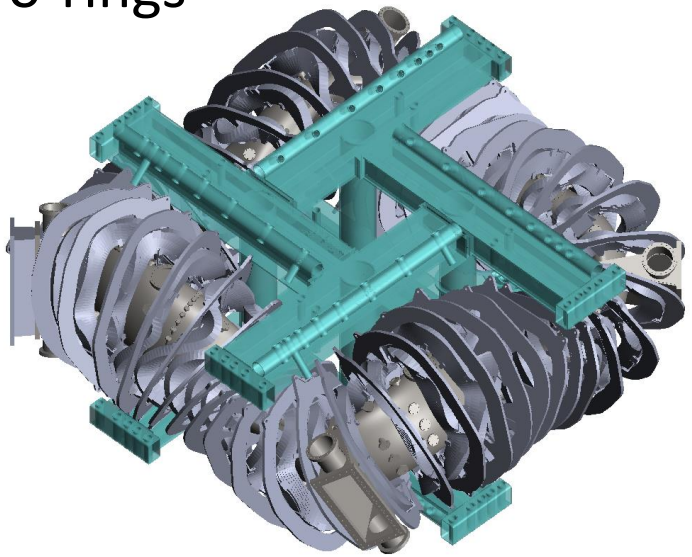
Personal introduction

- Graduated with BS in Engineering Physics in 2022 and MS in NEEP in 2024
- Started working with Prof. Geiger in 2019 on the design of a new tabletop stellarator
- Built spectrometers installed on DIII-D and W7-X
- Joined HSX as an instrumentation engineer in 2024 and recently became the interim lab manger

HSX machine introduction

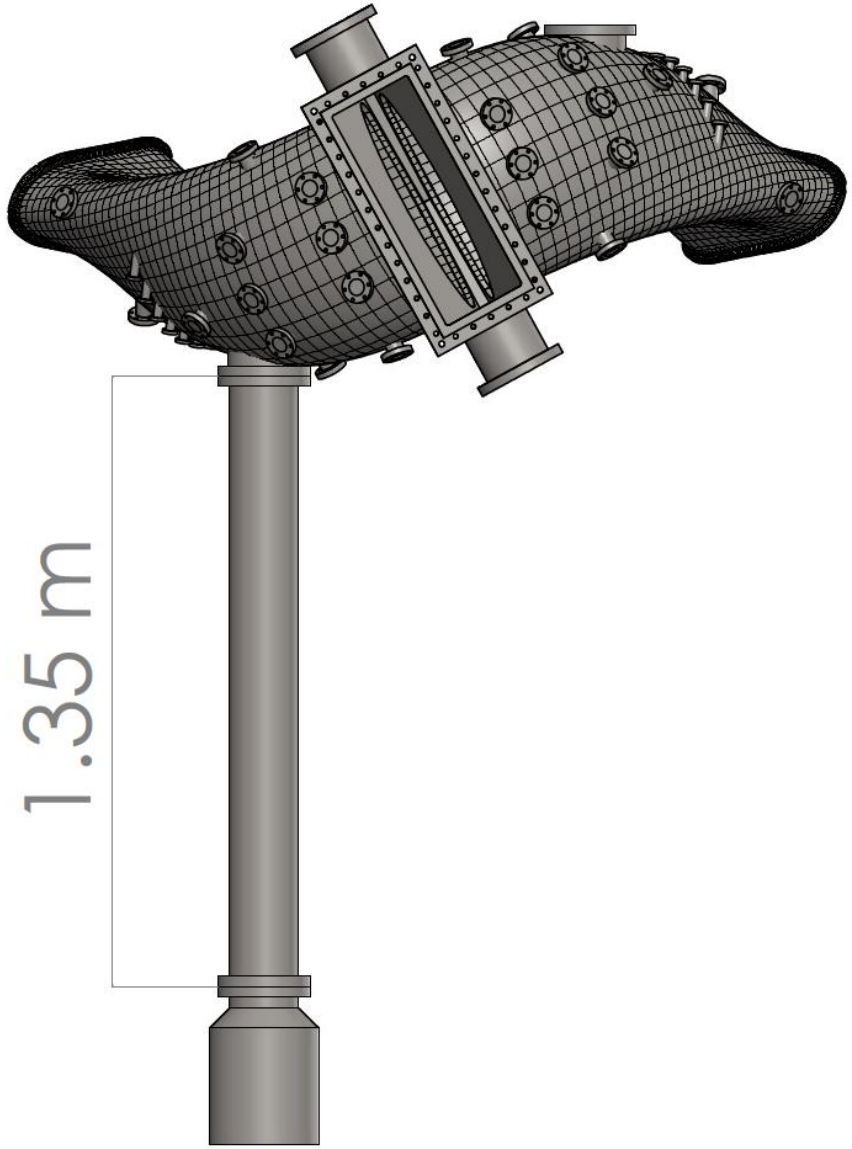
- Vessel is composed of 4 symmetric periods
  - Each period has 2 stellarator symmetric half periods
  - Half periods are welded to box ports
  - Full periods are joined by o-ring seals
- Approximately 930 cm of Viton seals
  - 4 o-rings between vessel segments and 3 box port o-rings





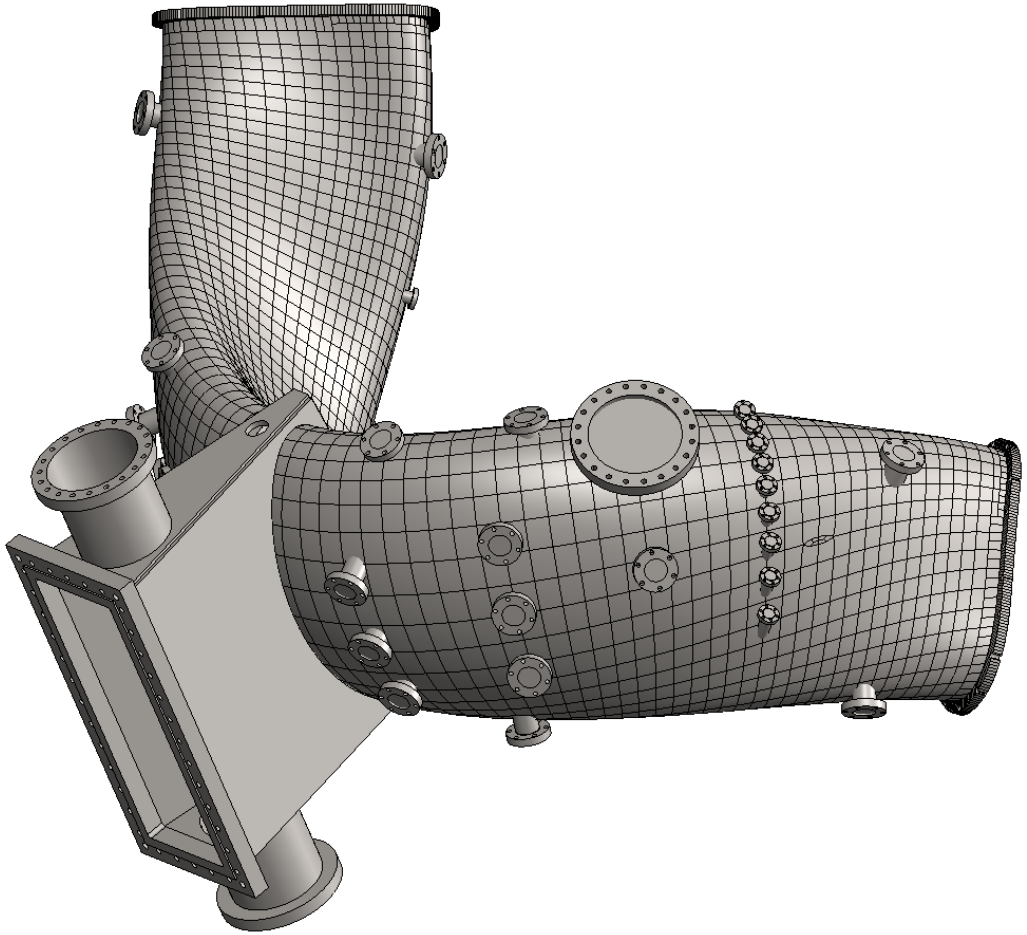
HSX Vacuum introduction

- Typical base pressure 5 x 10^{-8} torr
- “Pumping through a straw”
  - 2 turbopumps 1000 L/s
  - Total effective pumping speed is only 500 L/s
- 12 m² surface area
- Currently no Cryopump



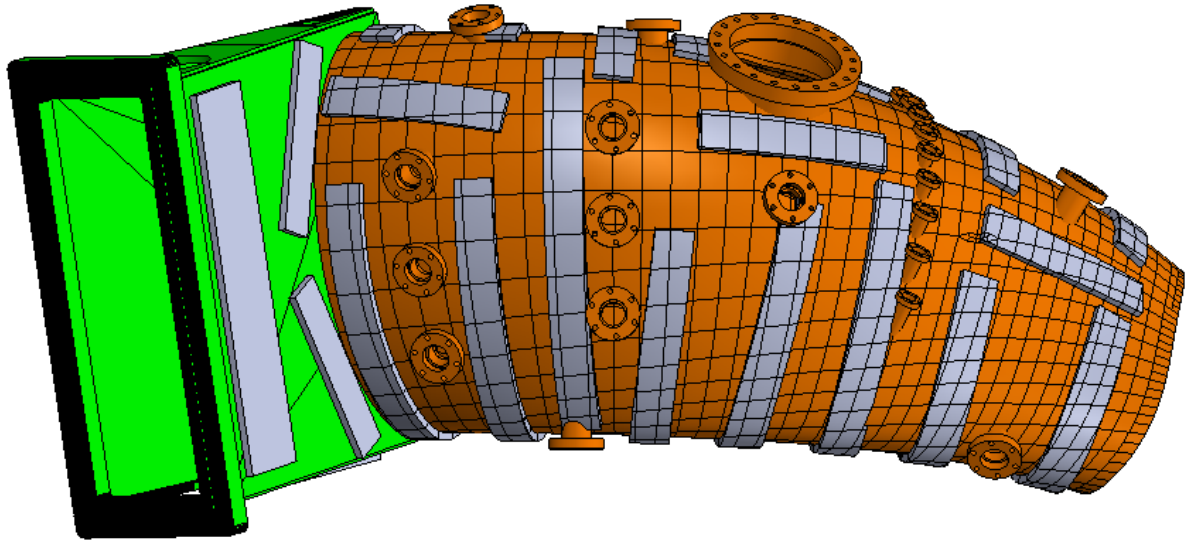
HSX Vacuum introduction

- 43 ports per period
  - 1 x box port
    - Custom ports, windows
  - 2 x 8” conflat on box port
    - ECRH wave guides, reflectometry
  - 2 x 2.75” conflat flanges on box port
    - Thomson, interferometry
  - 2 x 8” conflat on main vessel
    - Vacuum pumps, bolometers and CHERS
  - 24 x 2.75” conflat flanges on main vessel
    - Boronization ovens, probes, gauges
  - 9 x 1.33” conflat flanges on main vessel
    - H-alpha optics



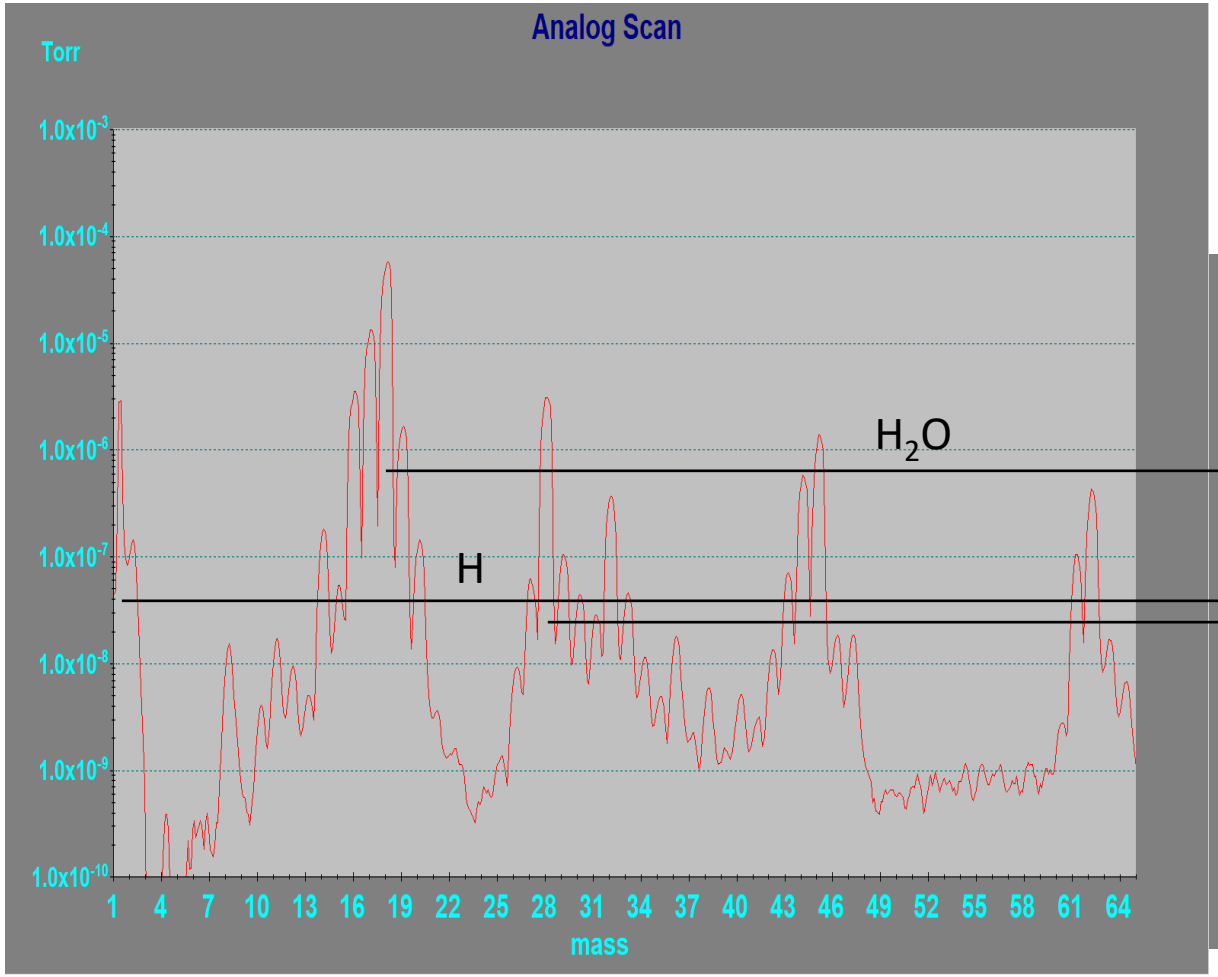
Baking system

- Heating tape with Teflon insulating blanket
- Designed to go to 150^{o}C
  - Restricted by Viton seals between half periods
- Operating temp is 60^{o}C
- Typical baking times range from 2-14 days

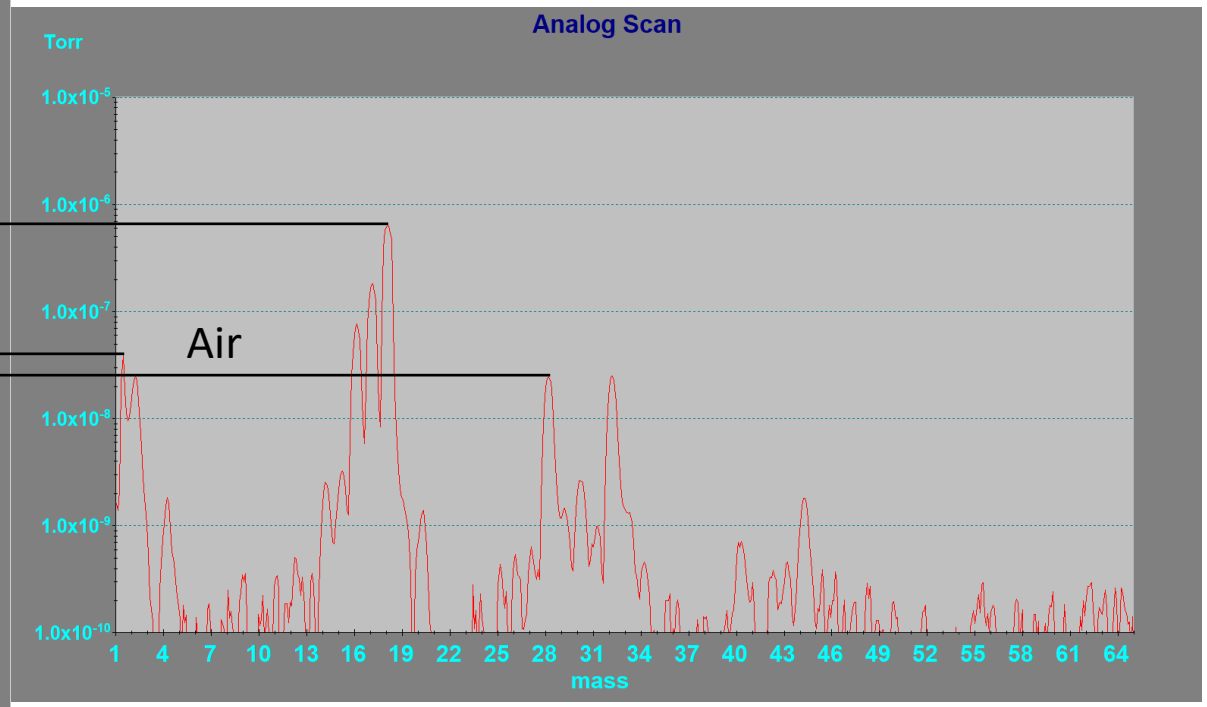


Pre and Post Bake RGA scans – 11/09/2023

RGA scan after an extended up to air



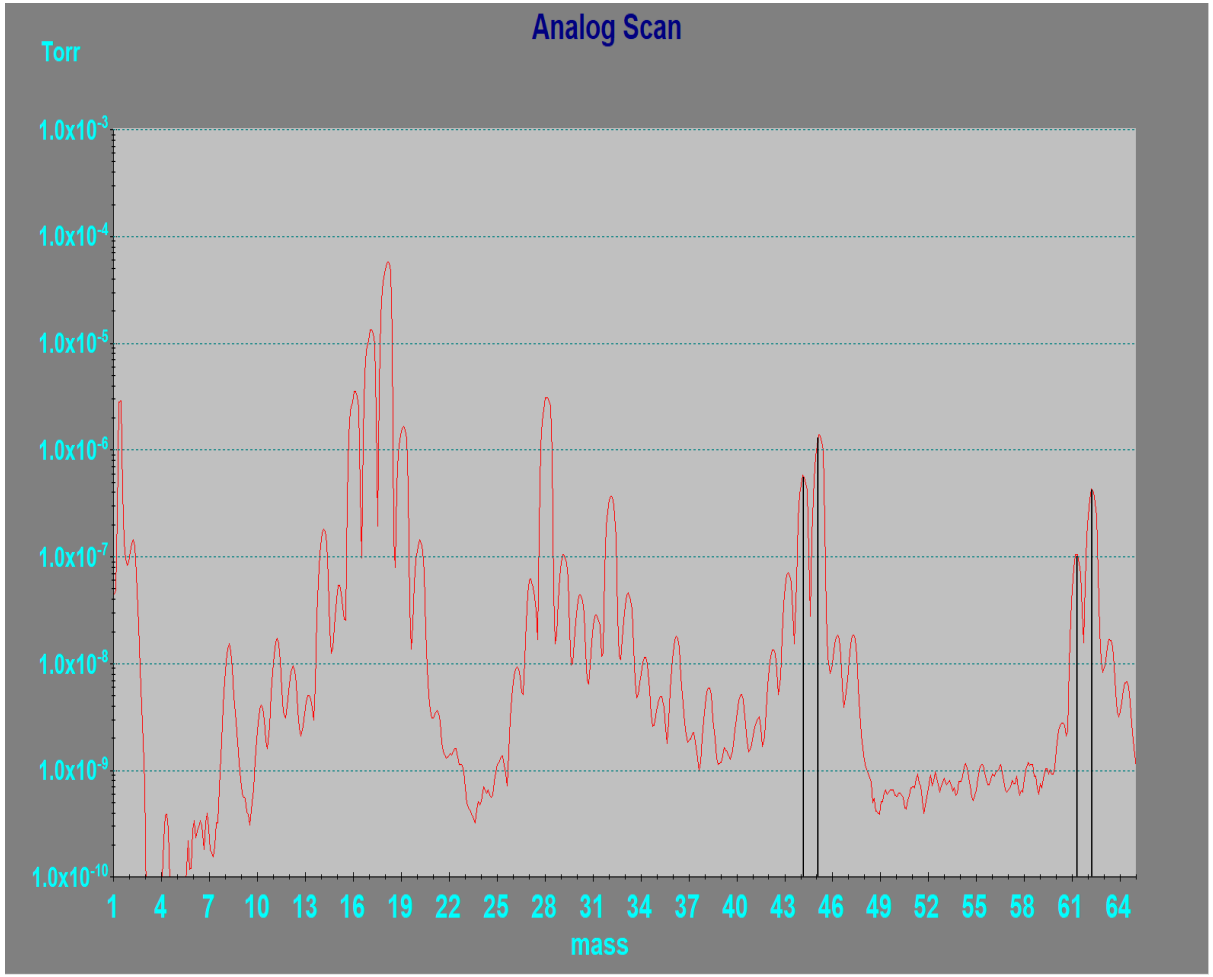
RGA scan after baking over the weekend

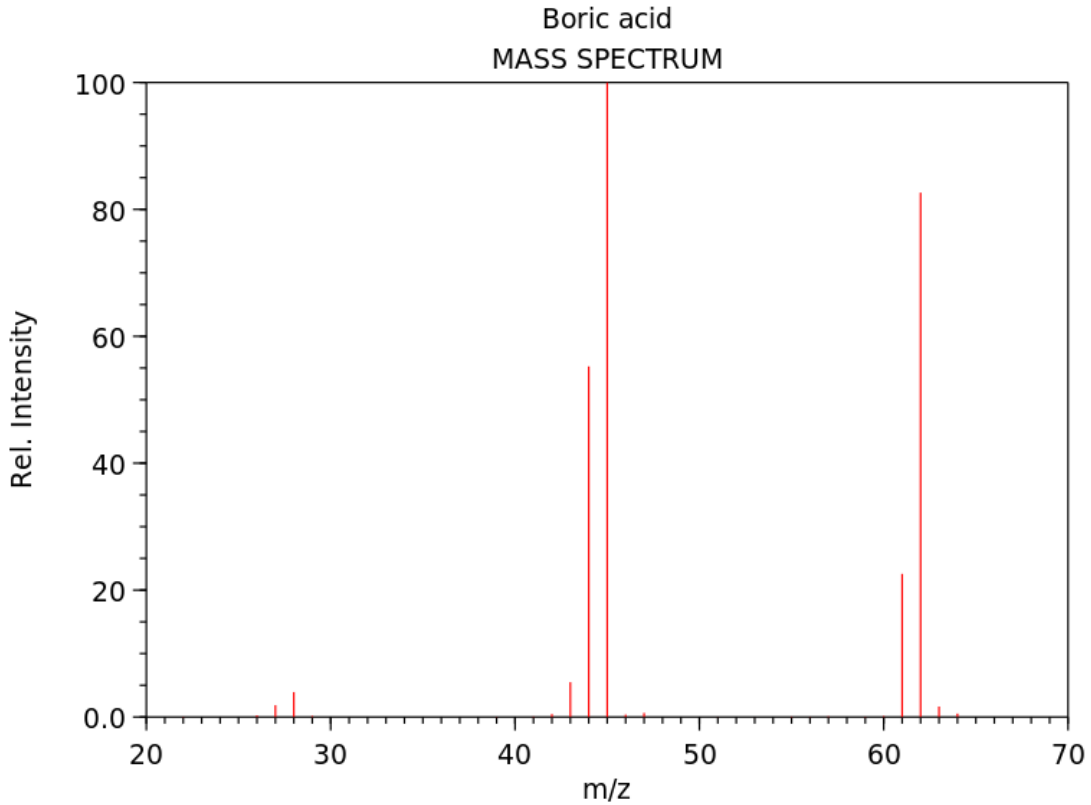


Data courtesy of W. Goodman

Strong indication of Boric acid

RGA scan after an extended up to air





NIST Chemistry WebBook (https://webbook.nist.gov/chemistry)

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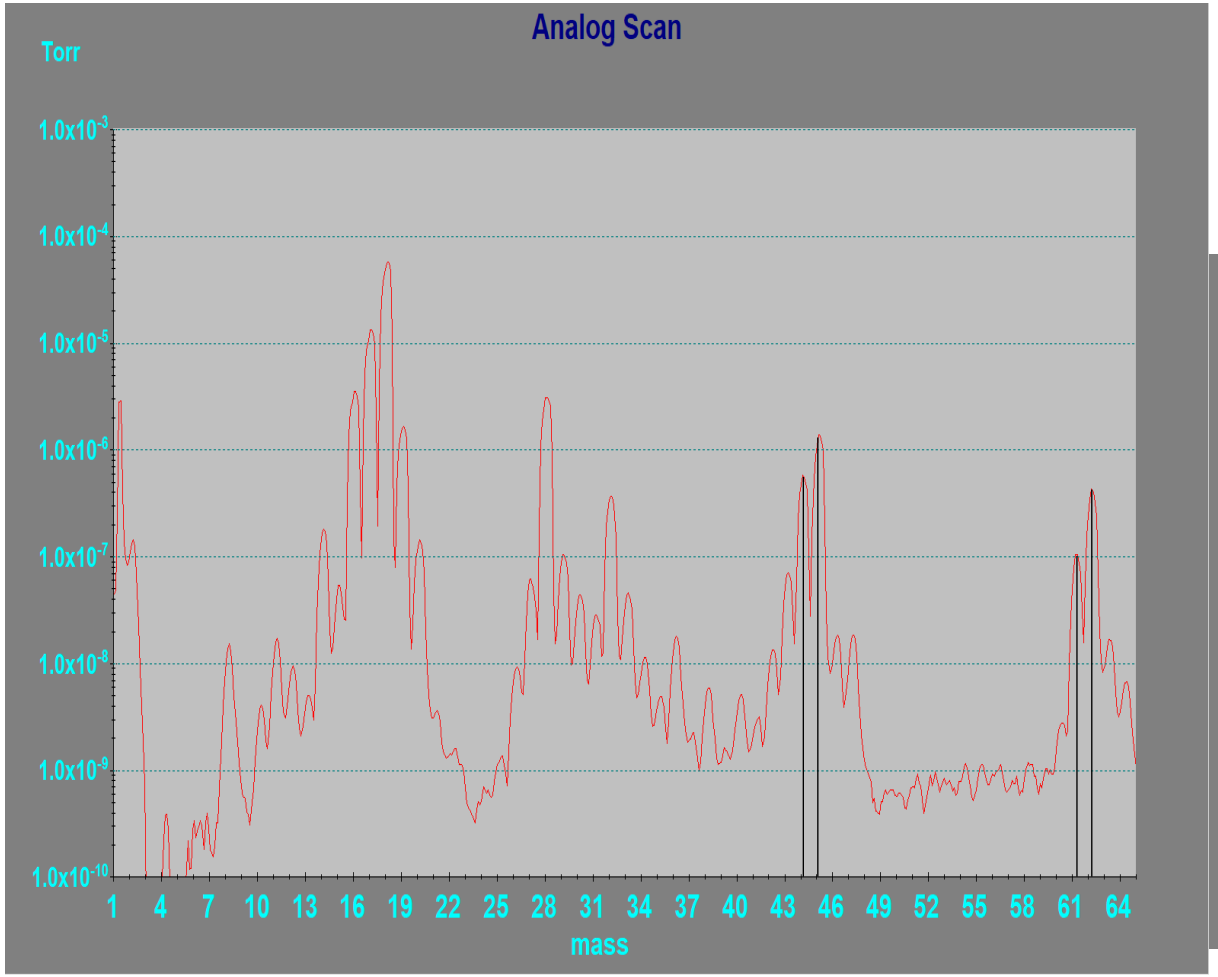

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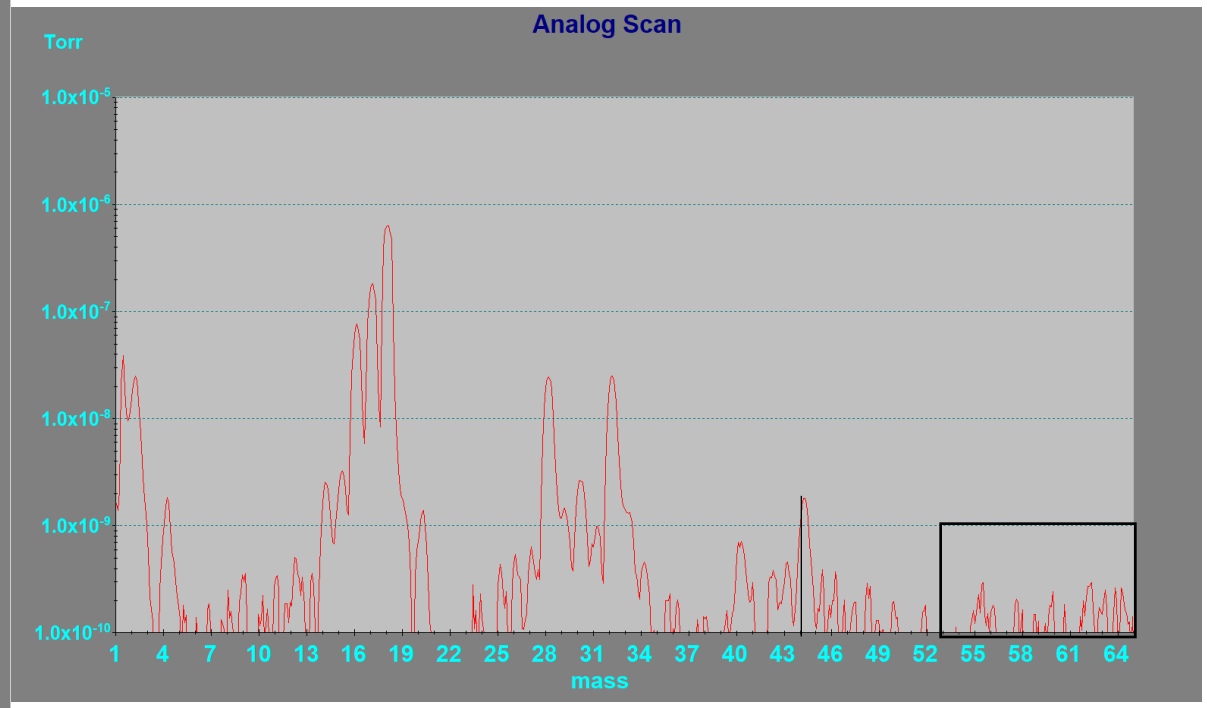


Ion gauge repair

- After extended periods up to air, filament-based gauges tend to fail
- Granville Phillips micro-ion gauges:
  - Trace white contaminants visible inside gauge
  - Gauges have been successfully repaired via DI soaks and bake
- Wide range magnetron gauges have also been successfully cleaned

Cleaning vacuum parts

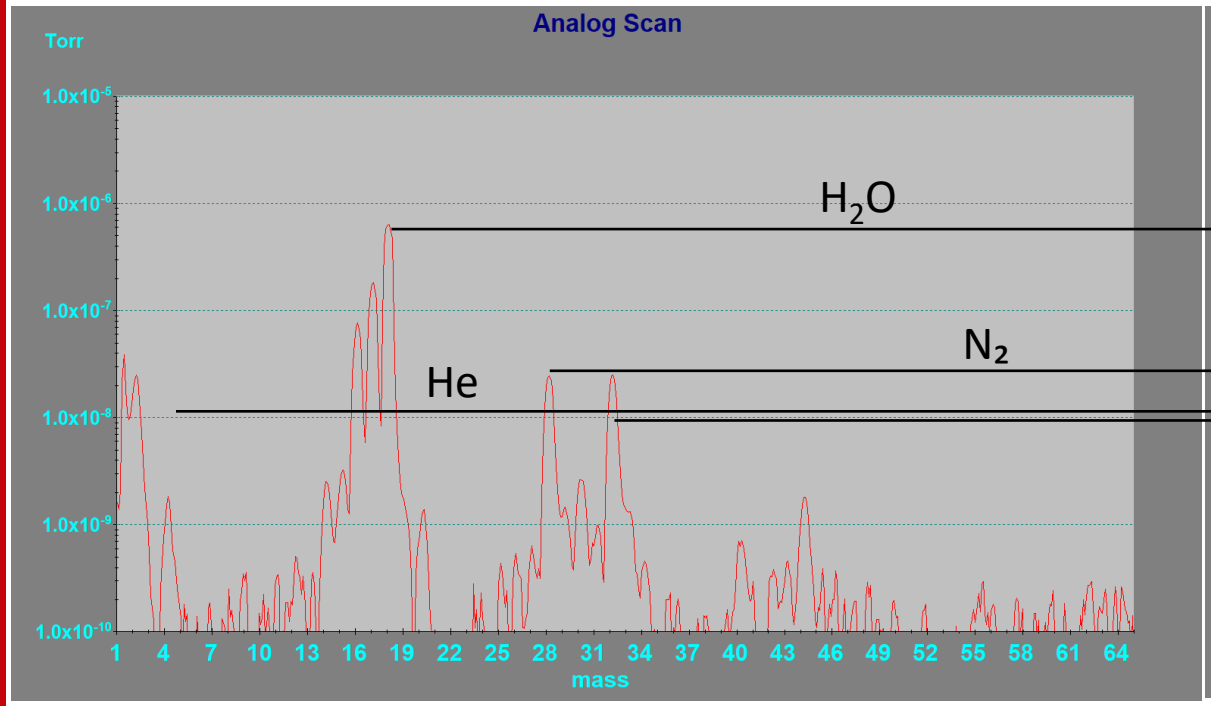
- Dawn dish soap for bulk degrease
- Oakite 33 for removing oxides and sputtered material
- Alconox for removing oils and organic contaminants
- DI water for removing detergents
- Acetone for removing trace oils and water
- Ethanol/methanol for removing the acetone and trace contaminants
- Vacuum drying removes solvents and trace water
  - Drying in vacuum oven or atmospheric oven and bake in situ
- Aluminum foil is used to wrap clean parts
  - Minimize time between cleaning and assembly
- Ultrasonic baths “scrub” parts

Glow System

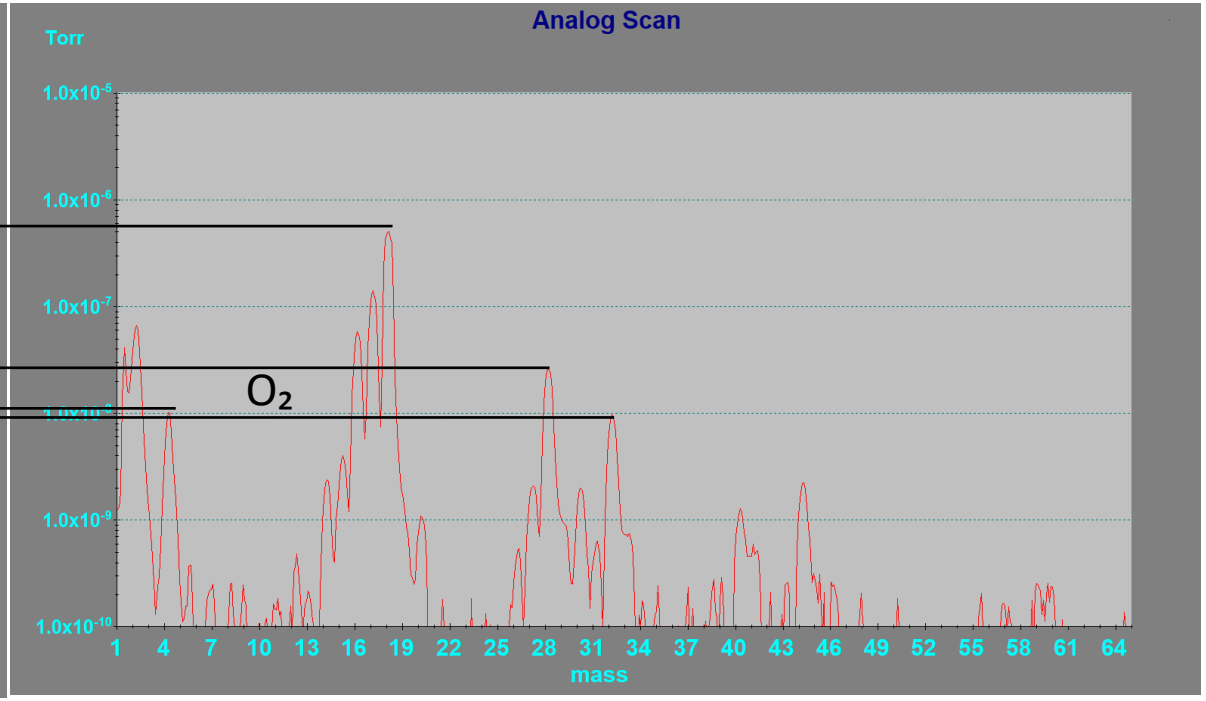
- He glows are usually 1-4 hr
- 1 anode per period (4 total) in parallel
- Vessel pressure is 1-10 mtorr
- Anode voltage is 300-500 V
- Max available current: 1.6 A
- Power is not necessarily divided evenly between periods
- Ionization sources have included:
  - Spark gap
  - Tungsten filaments
  - UV lights

Pre and Post He glow RGA scans – 11/09/2023

RGA scan after baking over the weekend



RGA scan after a 2 hr He glow



Questions?

If not, we'll move on to Dr. Geiger

References

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- Y. Tito Sasaki; A survey of vacuum material cleaning procedures: A subcommittee report of the American Vacuum Society Recommended Practices Committee. *J. Vac. Sci. Technol. A* 1 May 1991;
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