Vacuum

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- What is Vacuum?
- Why Vacuum at CERN?
- Our Experiment
- How outgassing is limited?
- General technology
- Experimental data
- Conclusion

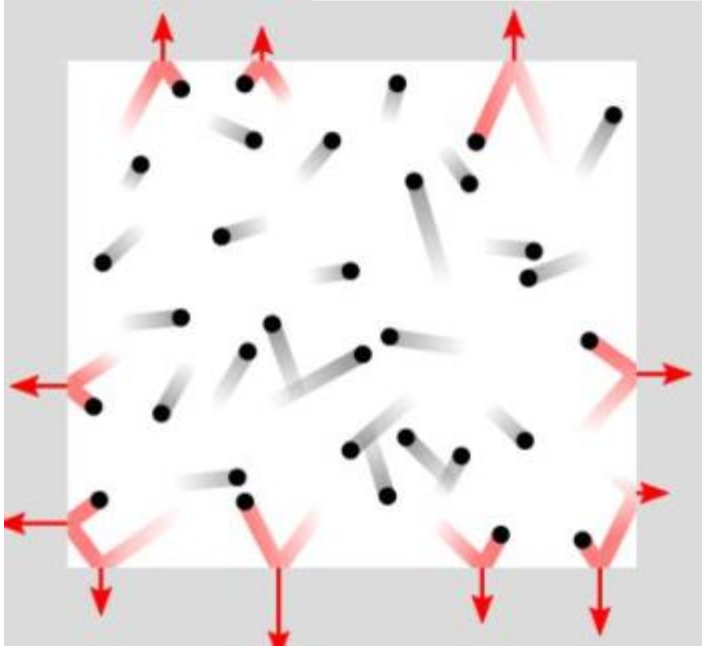
What is vacuum?

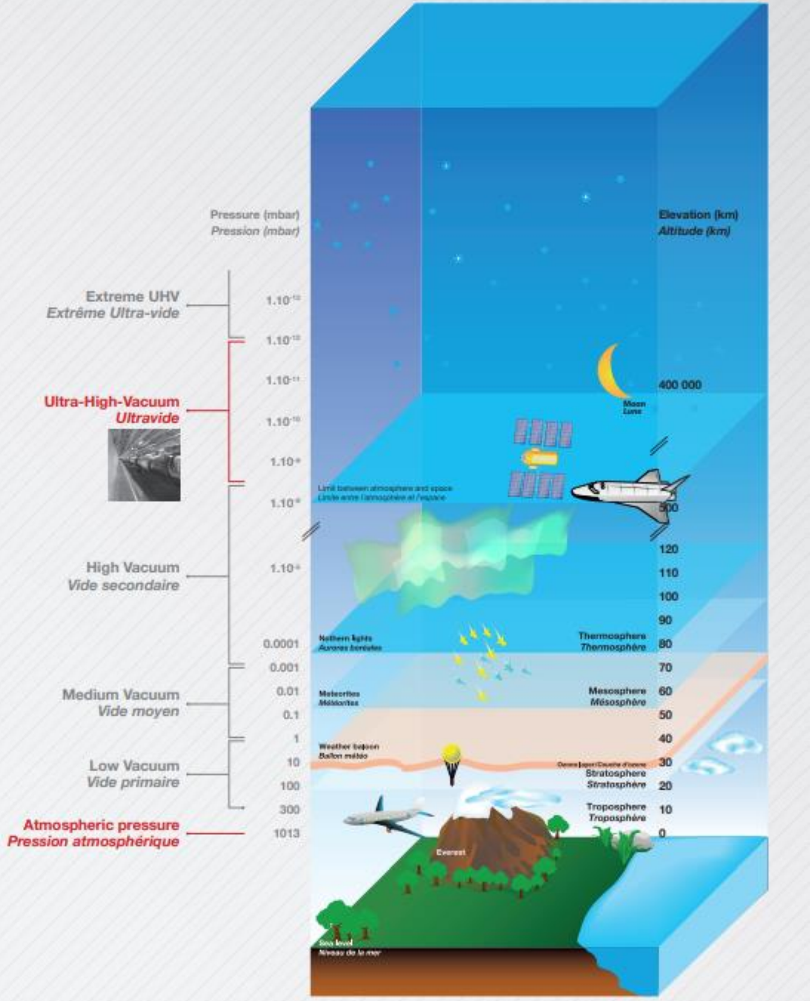
- Vacuum is empty space
- High vacuum=low pressure

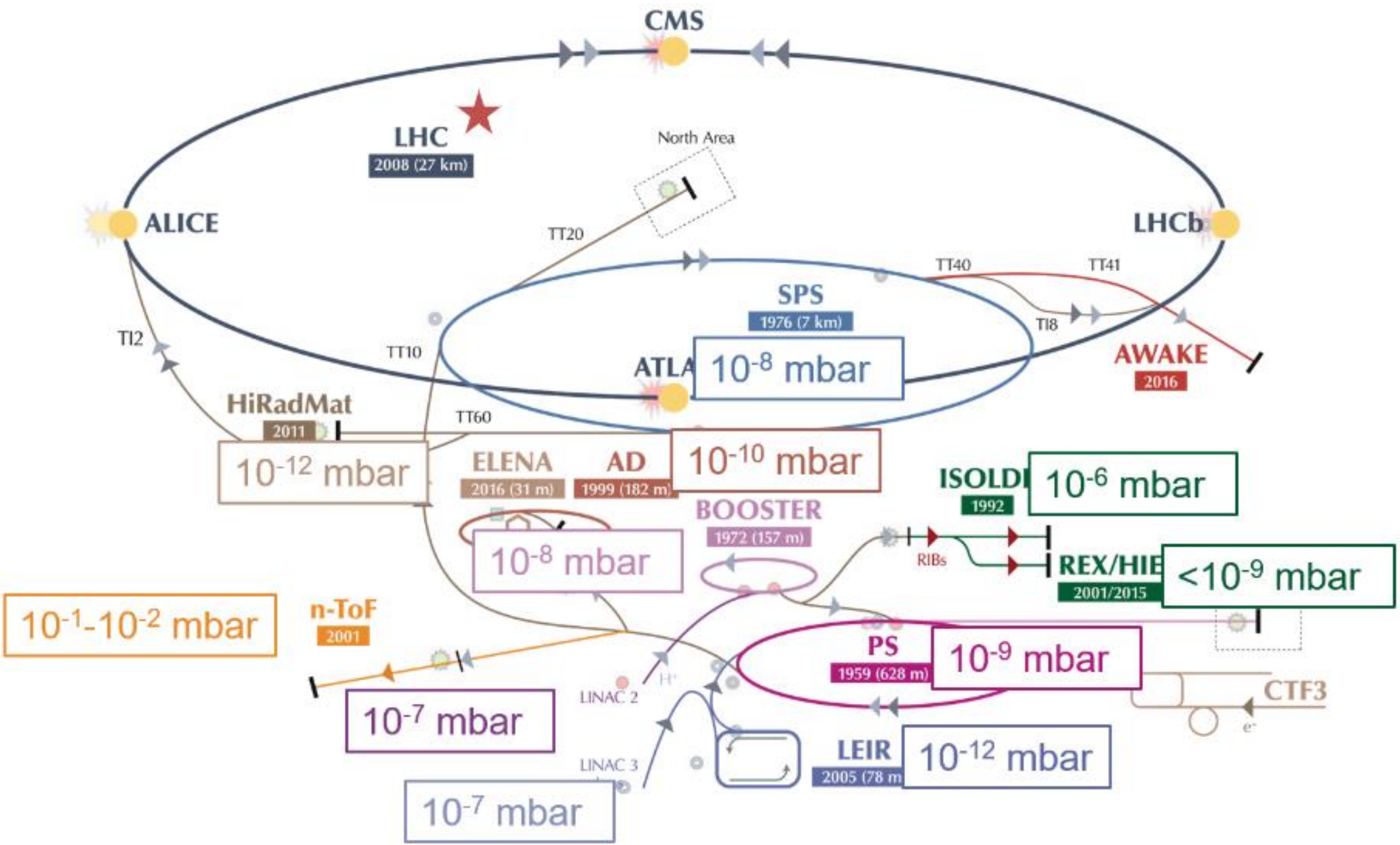
$$p = \frac{F}{A}$$

Mean free path

Number density



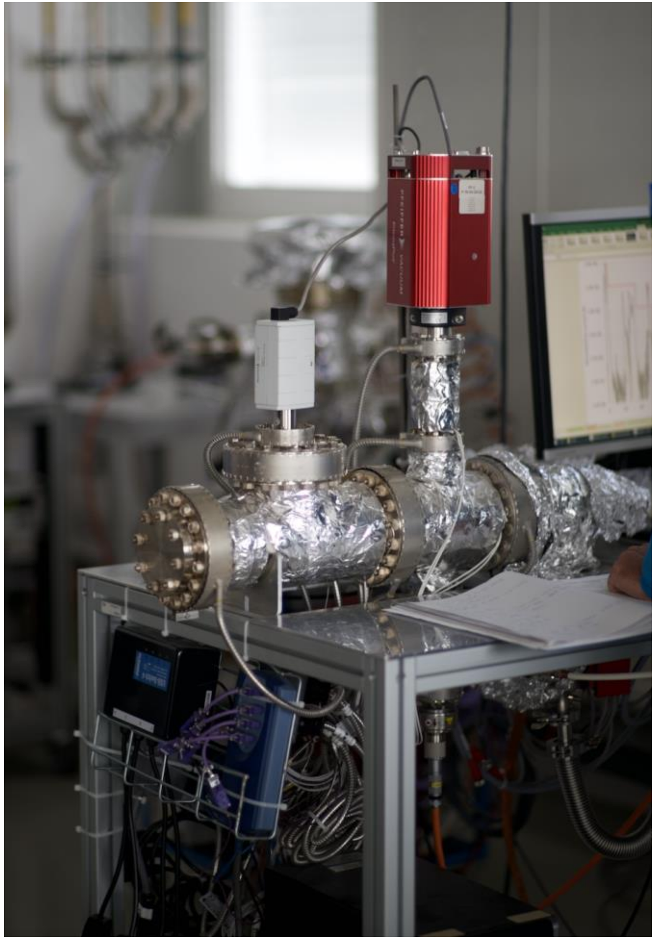




CMS
LHC
2008 (27 km)
North Area
ALICE
LHCb
TT20
TT40
TT41
SPS
1976 (7 km)
TI8
TI2
TT10
ATLA
10^{-8} mbar
AWAKE
2016
HiRadMat
2011
TT60
10^{-12} mbar
ELENA
2016 (31 m)
AD
1999 (182 m)
10^{-10} mbar
ISOLD
1992
10^{-6} mbar
BOOSTER
1972 (157 m)
10^{-8} mbar
RIBs
REX/HIE
2001/2015
$<10^{-9}$ mbar
10^{-1}-10^{-2} mbar
n-ToF
2001
PS
1959 (628 m)
10^{-9} mbar
CTF3
LINAC 2
10^{-7} mbar
LEIR
2005 (78 m
10^{-12} mbar
LINAC 3
10^{-7} mbar

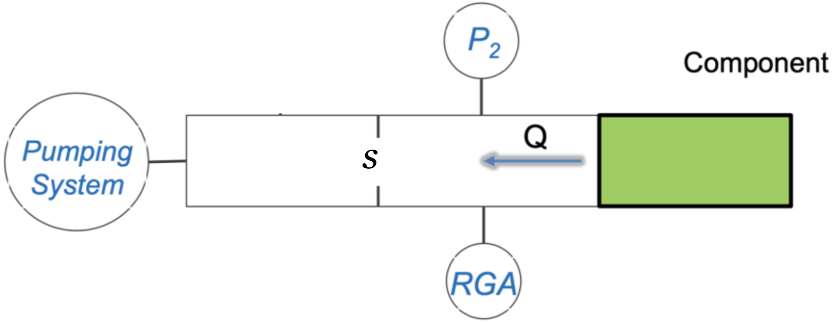
Why Vacuum at CERN?

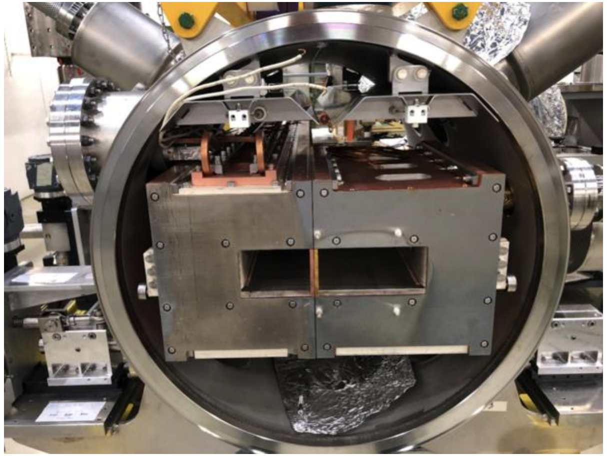
- Minimize disturbance of the beam
- Used for many purposes
  - Acts as insulator on LHC
    - Cryomagnets
    - Helium Distribution Line



Our Experiment

Whether a new type of insulator P25 is compatible with the PS. To be used as insulator on a high voltage feedthrough. In a septum magnet.





The PS, septum magnet

What is outgassing, and how is it limited?

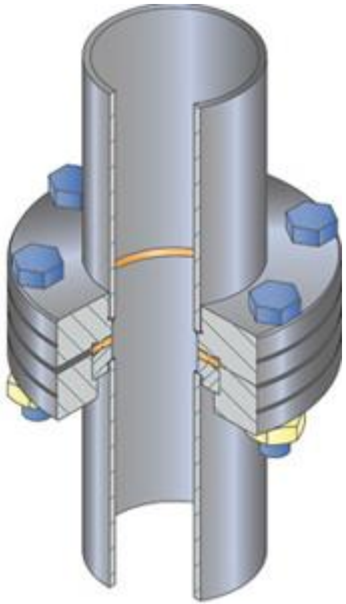
- All materials outgas
  - molekyles from the surface evaporating
- Minimize components with high outgassing rate
  - polymers
- Bakeout
  - baking a system to reduce water
- Vacuum firing
  - By baking a system at 600° hydrogen from the steel can be reduced.
- Increase number of pumps

General technology

- Seals
- Pumps
- Gauges

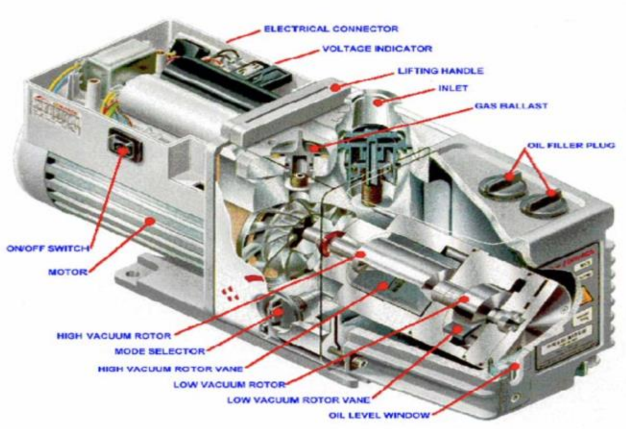
Seals

- **All valves and seals are stainless steel to minimize degassing**
- **Conflat flange** (most used flange, in baked systemt)
- **Copper gaskets** (the part between two flanges)
    - low degassing
    - is pressed into shape by knife edge
    - Better seal than O-rings (rubber)

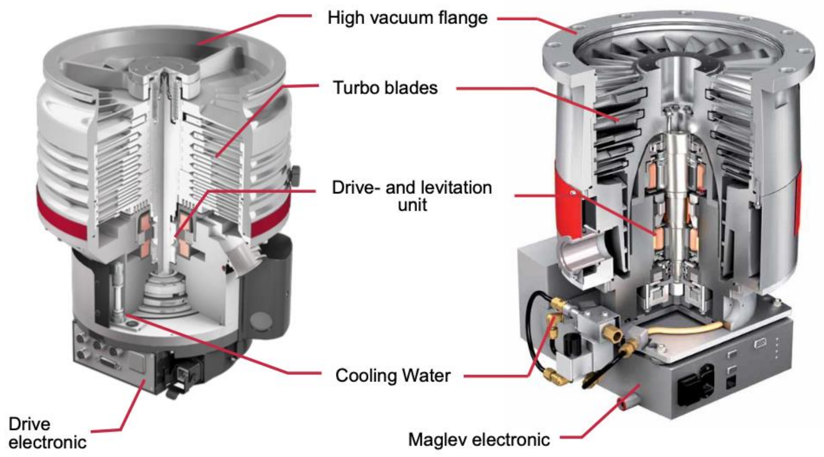


Pumps in our experiment

- **Primary pump**
  - atm -> 10-3 mbar

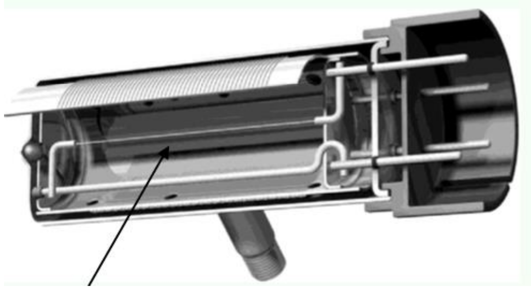


- **Turbo molecular pump**
  - 10-3 mbar -> 10-10 mbar
  - Turbine blades, spinning faster than the molecules move, to “kick” them out.
  - “Momentum transfer”



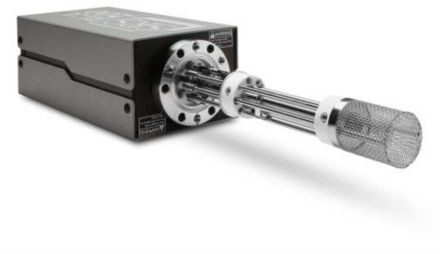
Gauges

- **Pirani gauge**
  - atm to 10-3 mBar

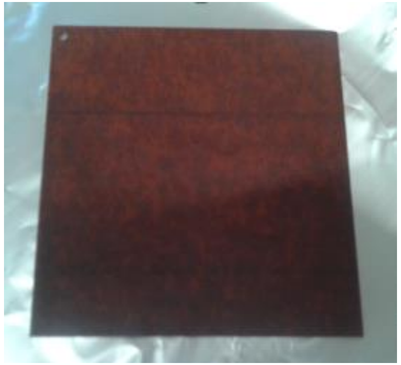


- **Penning gauge**
  - 10-3 mBar to 10-10 mBar

- **RGA, residual gas analyser**
  - measures the composition of the gas inside the chamber



Experiment process

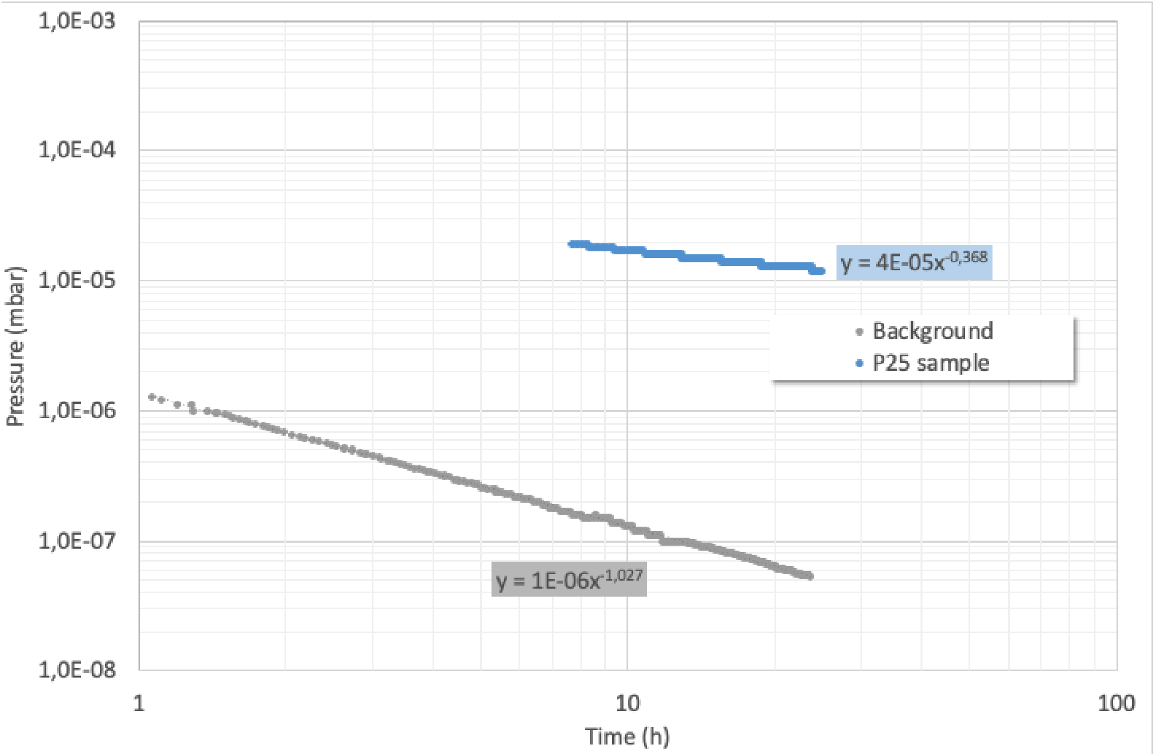


P25 sample

- **Background of the chamber**
  - Leak detection
  - 24 h pump down
  - Measuring contamination with RGA (Residual Gas Analyzer)
  - Determining degassing of champer
- **Pump Down with Sample**
  - Same process at before
  - Measuring contamination and degassing of sample.
- **Baking the chamber with sample**
  - Baked at 200° C for 24 h
  - RGA

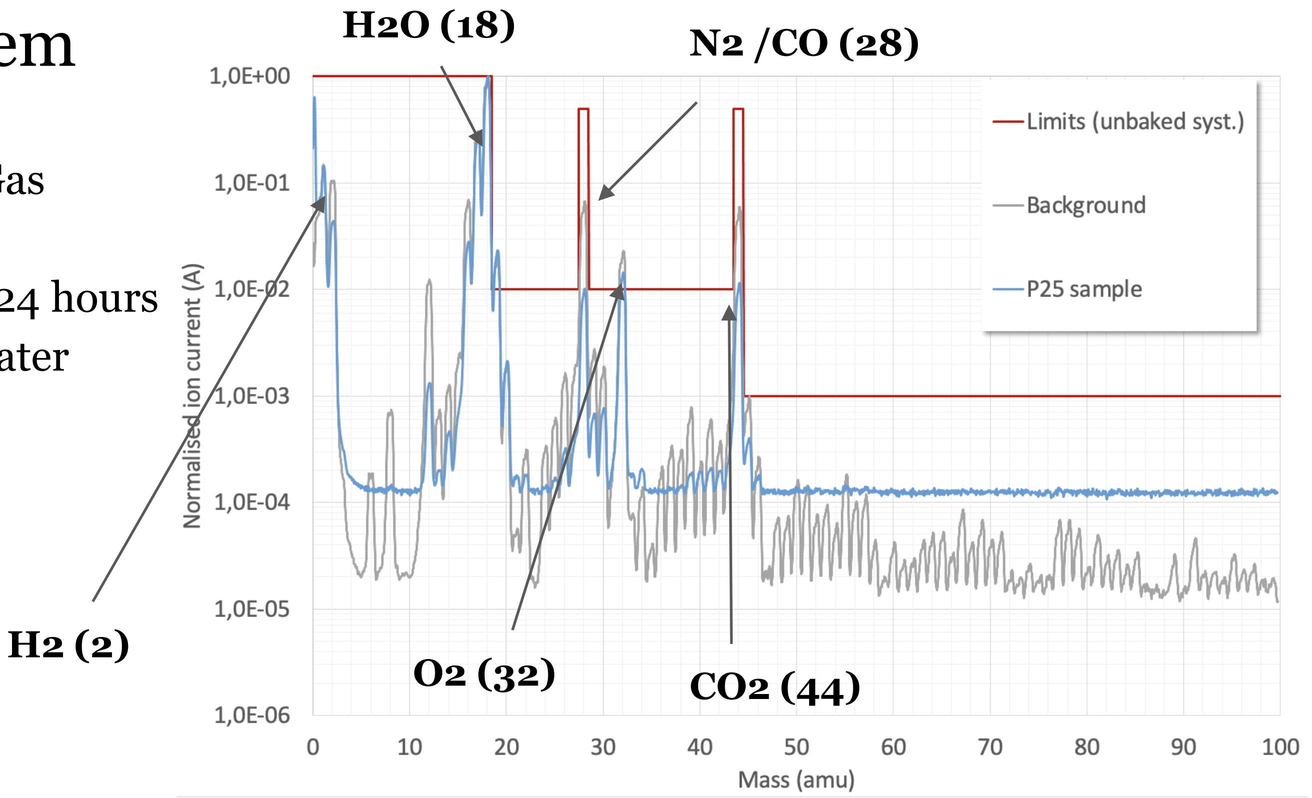
Unbaked system Data

Pump Down chart over 24h



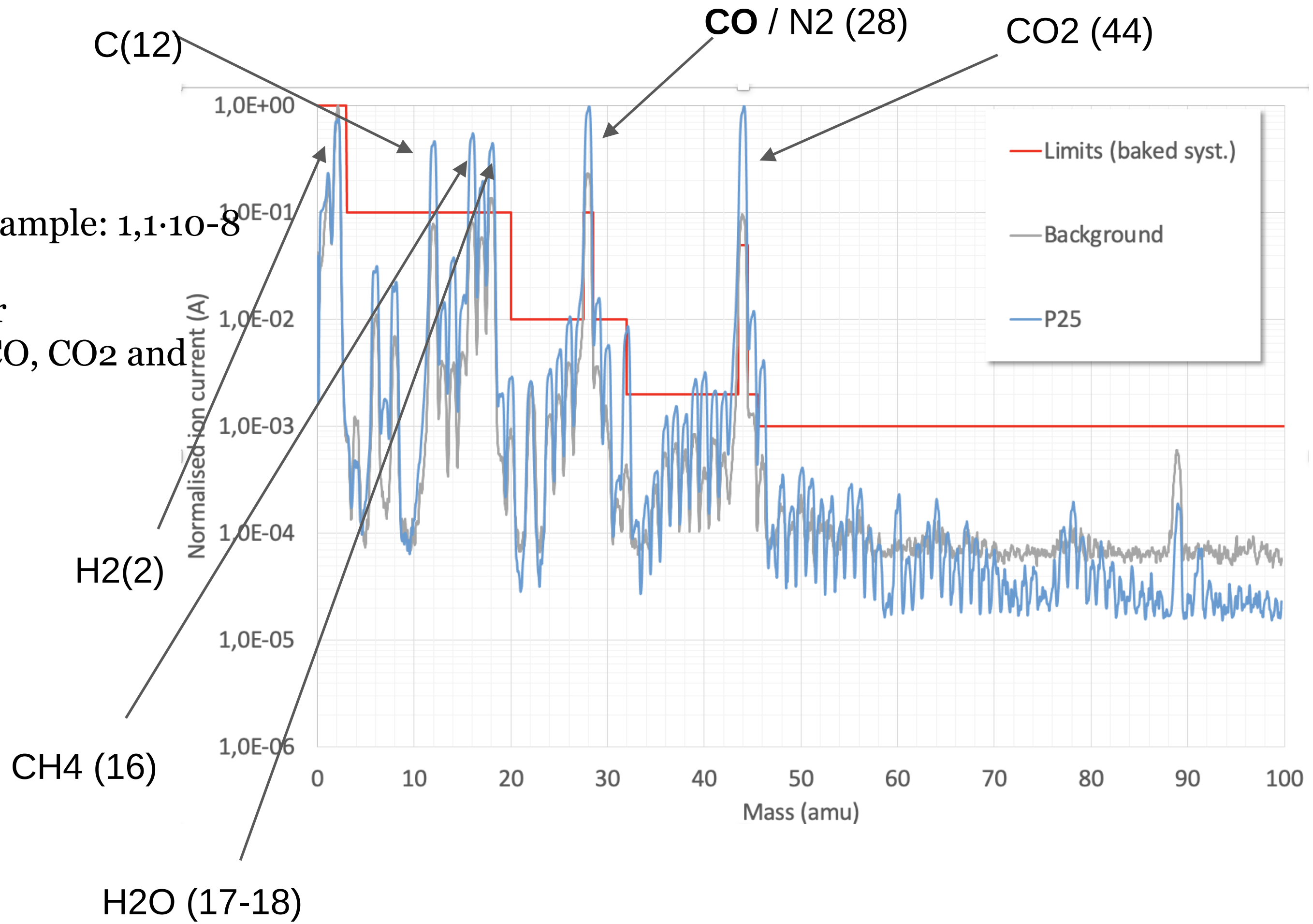
Unbaked system

- RGA - residual Gas Analyzer
- RGA chart after 24 hours
- Dominated by water



Baked system

- final pressure with the sample: 1,1·10-8
- Changes after bakeout
  - reduktion in water
  - dominated in by CO, CO_2 and hydrogen



Calculating degassing of the sample

Before bakeout, after 24 h of pump down:

$1{,}73 \cdot 10^{-6} mBar \cdot L \cdot s^{-1} \cdot cm^{-2}$

After bakeout:

$1{,}10 \cdot 10^{-9}\, mBar \cdot L \cdot s^{-1} \cdot cm^{-2}$

After the bakeout the total outgassing has dropped 1000 times

Outgassing is calculated by:

$$Q = \frac{\left(P_{sample} - P_{background}\right) \cdot s}{A_{sample}}$$

Conclusion, is the sample compatible with the PS?

- Outgassing limit for PS 1,5·10-6 mbar liter pr sekund
- **Before bakeout**
  - Sample is not compatible in terms of outgassing rate.
  - ok, in terms of cleanliness (RGA)
- **After bakeout**
  - Sample is now compatible, in terms of outgassing rate.
  - not compatible in terms of cleanliness (RGA)