Static type, windowless gas targets underground

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Windowless gas target systems

- For low-energy, low counting rate experiments, the ion beam induced background may be a problem.
- This is especially true for experiments with ^{1}H beam.

Typical backgrounds:

(a) Direct capture on nuclei with similar atomic charge

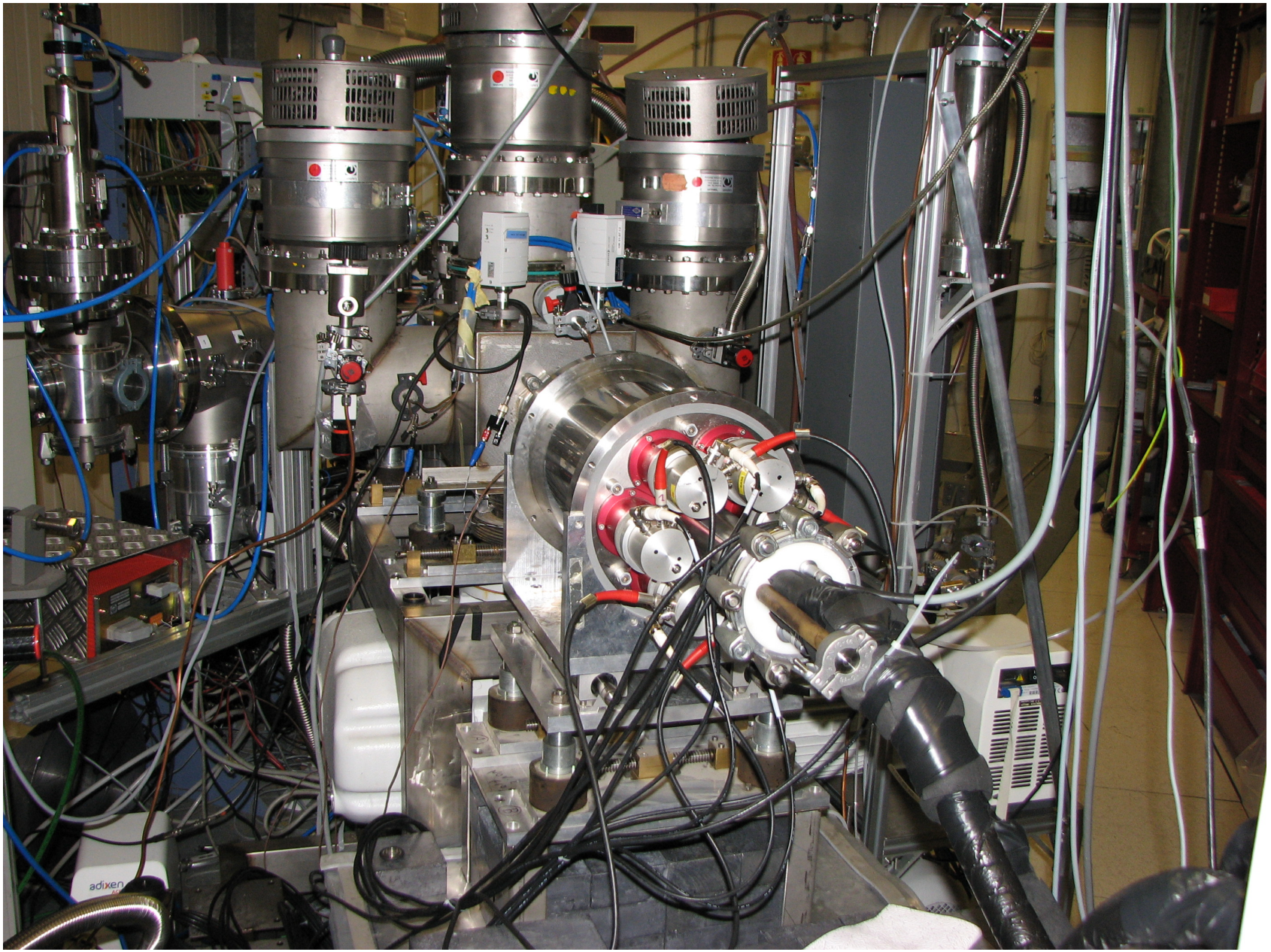
- $^{13}C(p,\gamma)$ background when $^{14}N(p,\gamma)$ is to be studied

(b) Resonant capture at particular beam energies

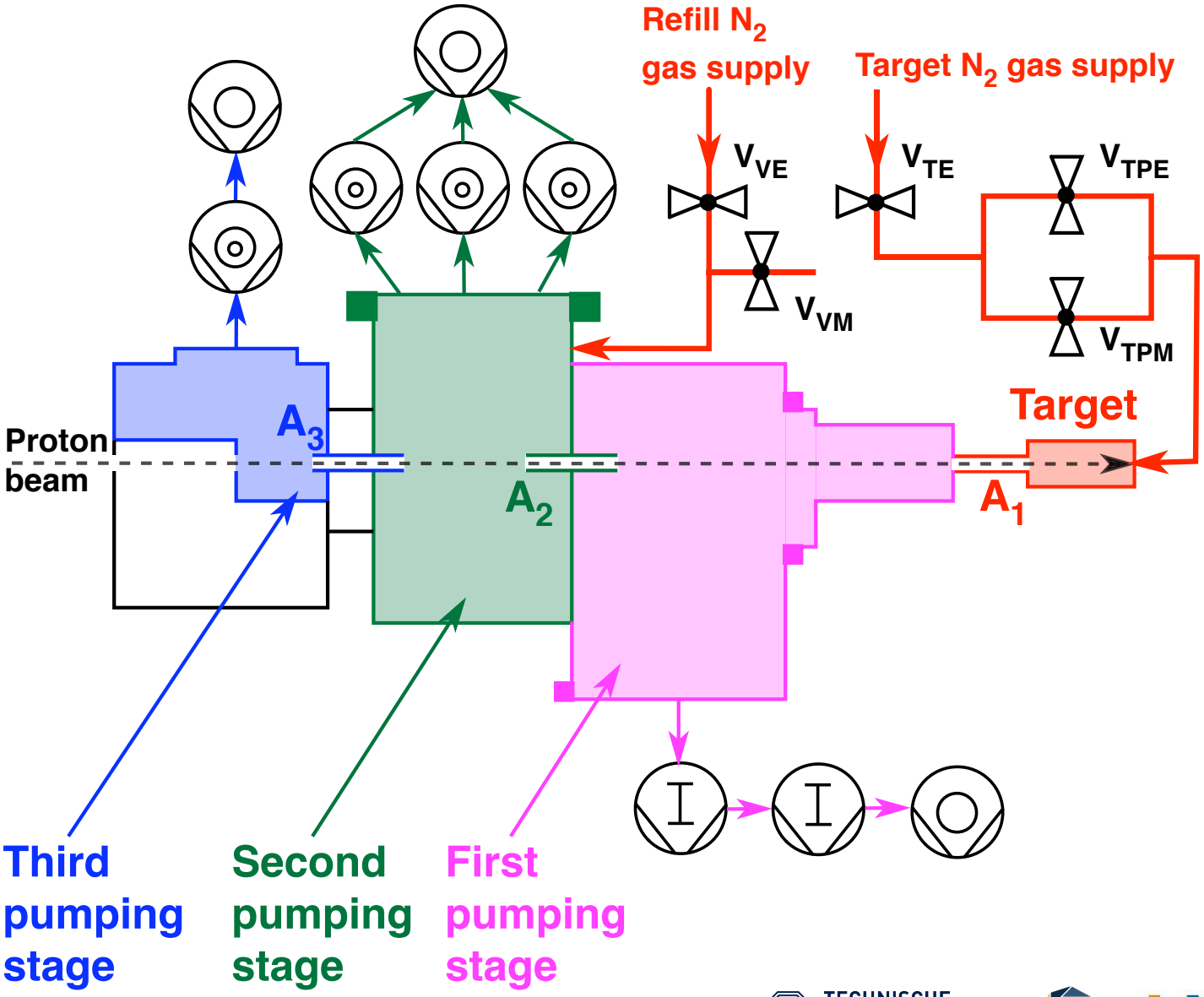
- $^{19}F(p,\alpha\gamma)$ at 224 keV, 340 keV, and at higher energies
- $^{11}B(p,\gamma)$ at 163 keV, 600 keV, and at higher energies
- $^{15}N(p,\alpha\gamma)$ at 430 keV and 897 keV, and at higher energies

Gas targets are one way to reduce this beam induced background!

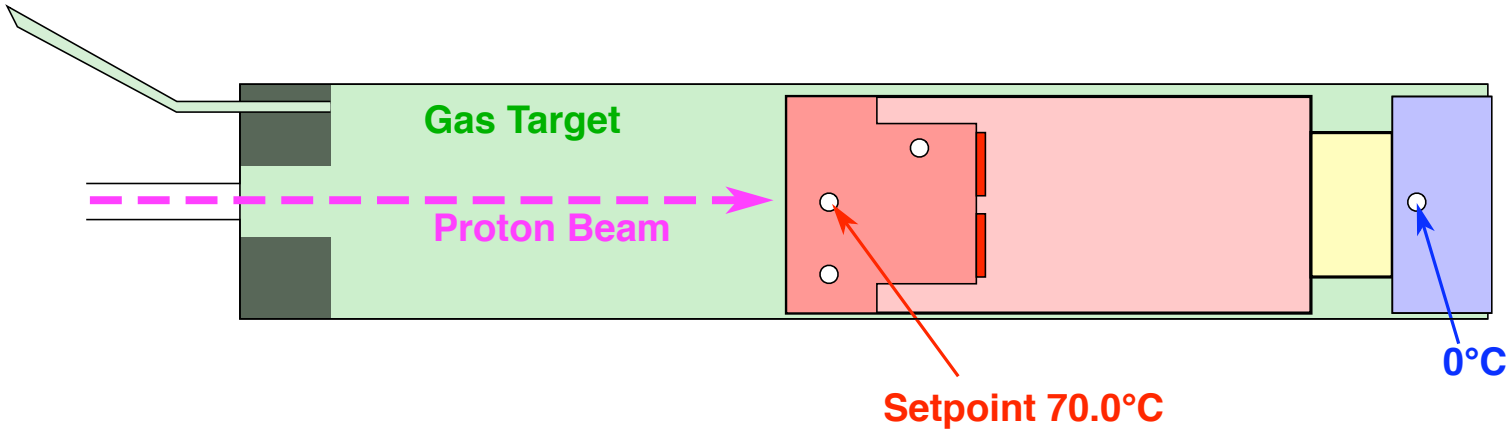
Windowless gas target system at LUNA

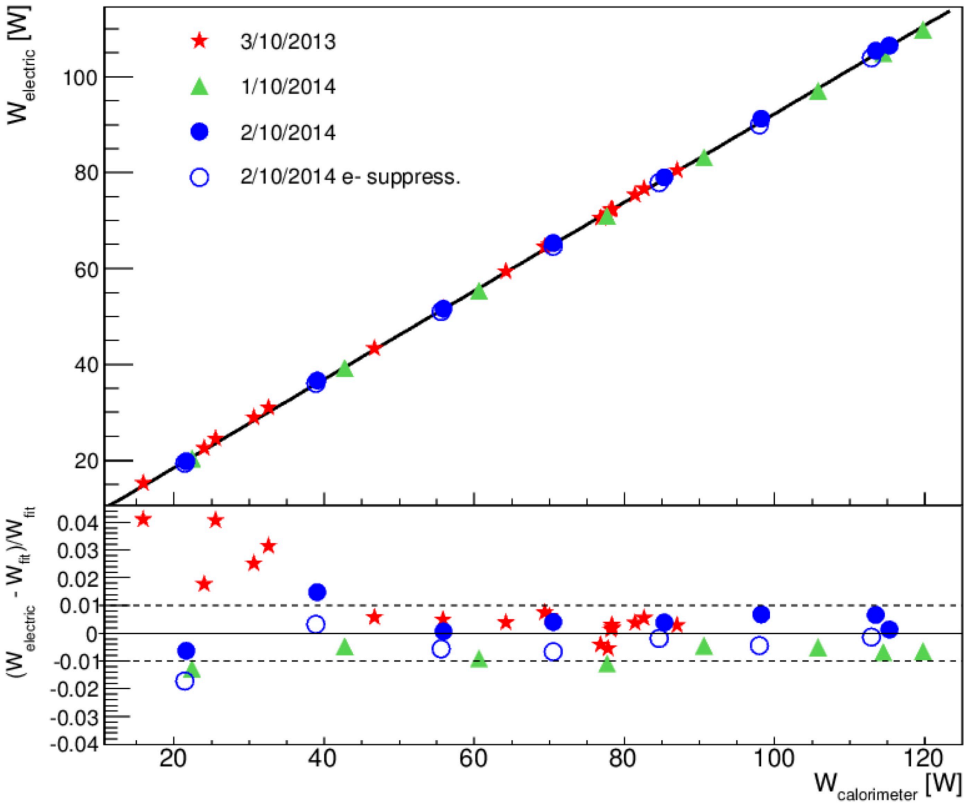


Pumping scheme

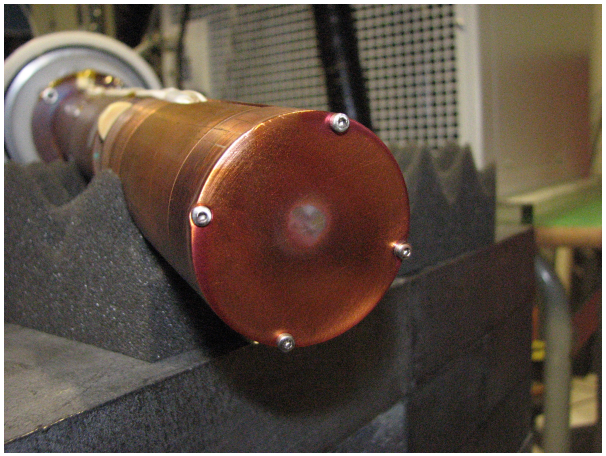


Beam intensity measurement: Calorimeter with constant temperature gradient





Electrical calibration



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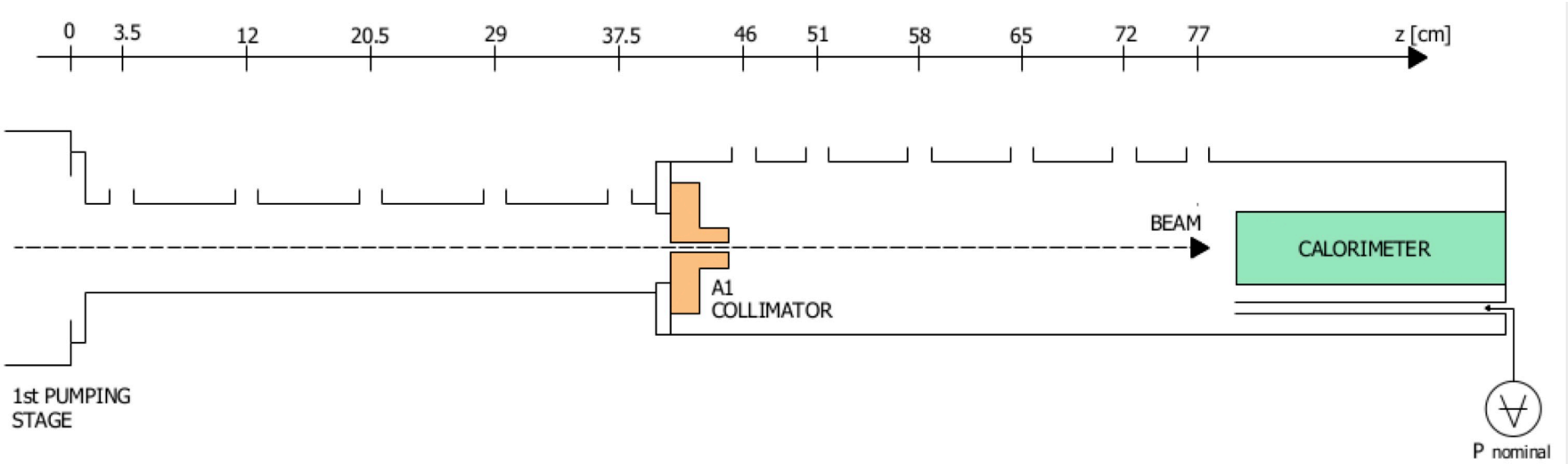
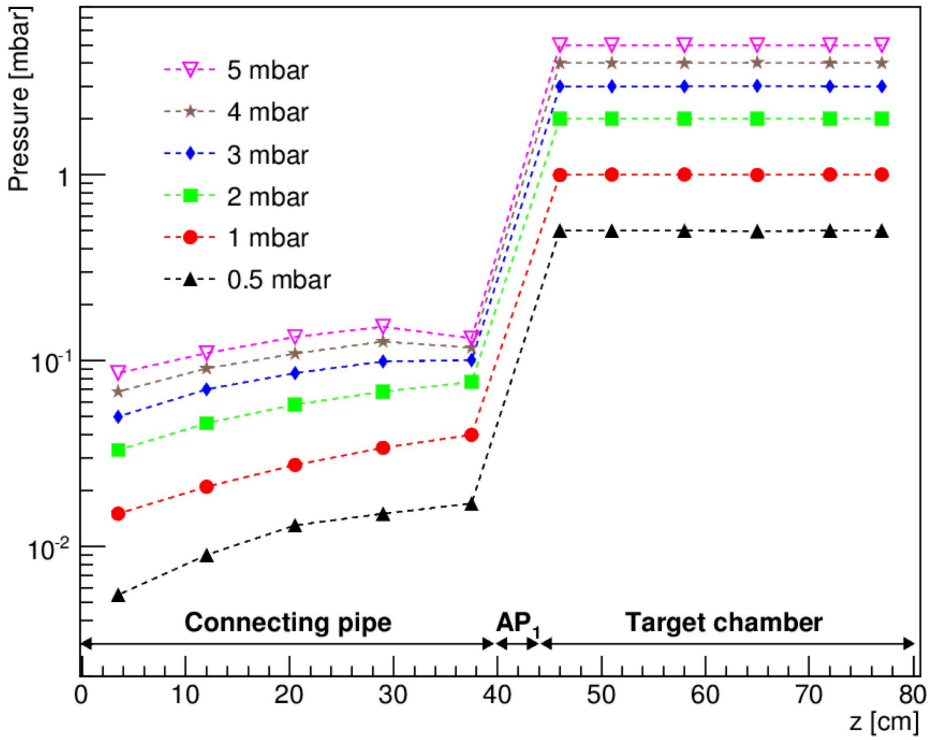
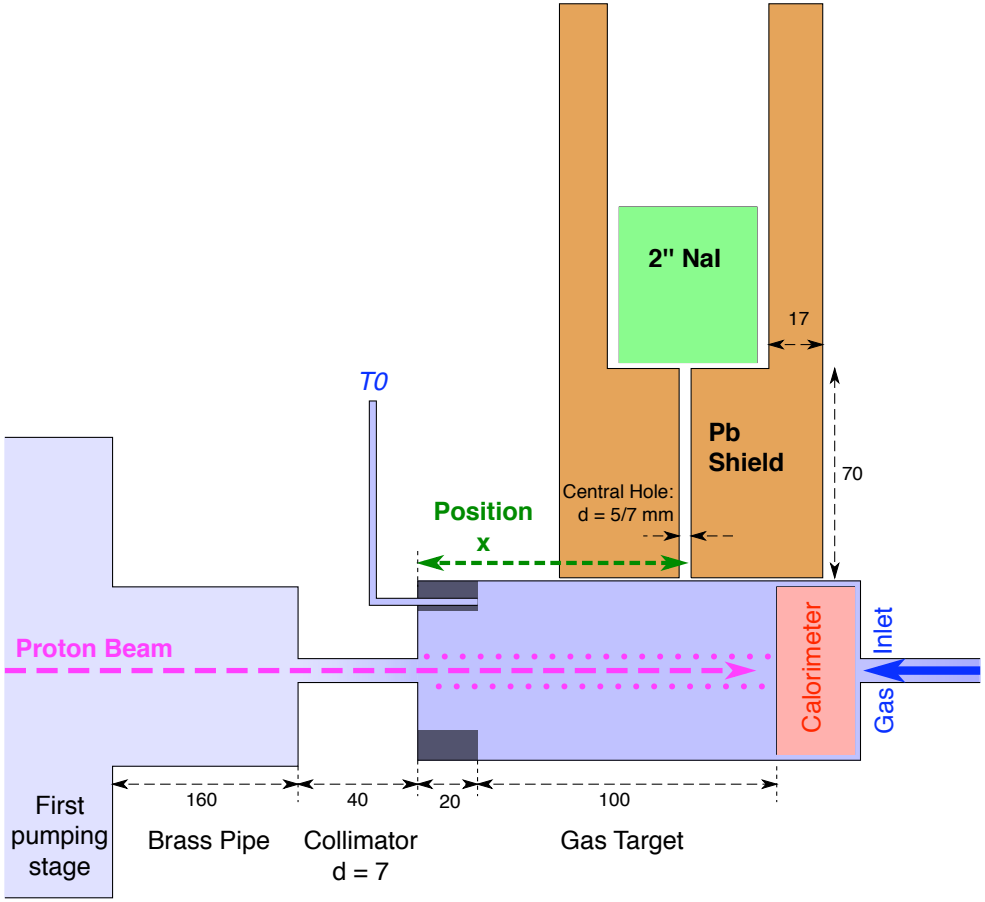
Target density: Pressure measurement



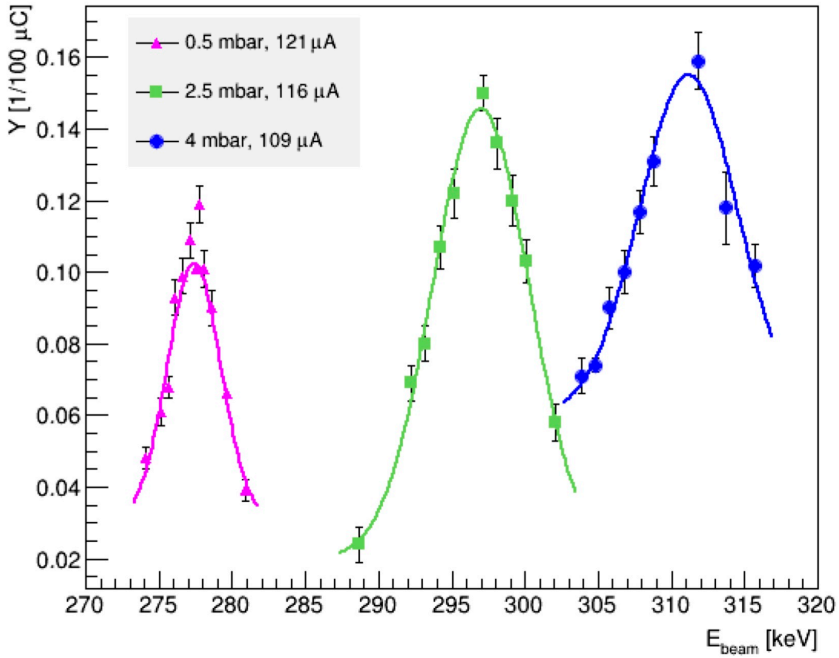


Target density: Effective target density (resonance scan technique)

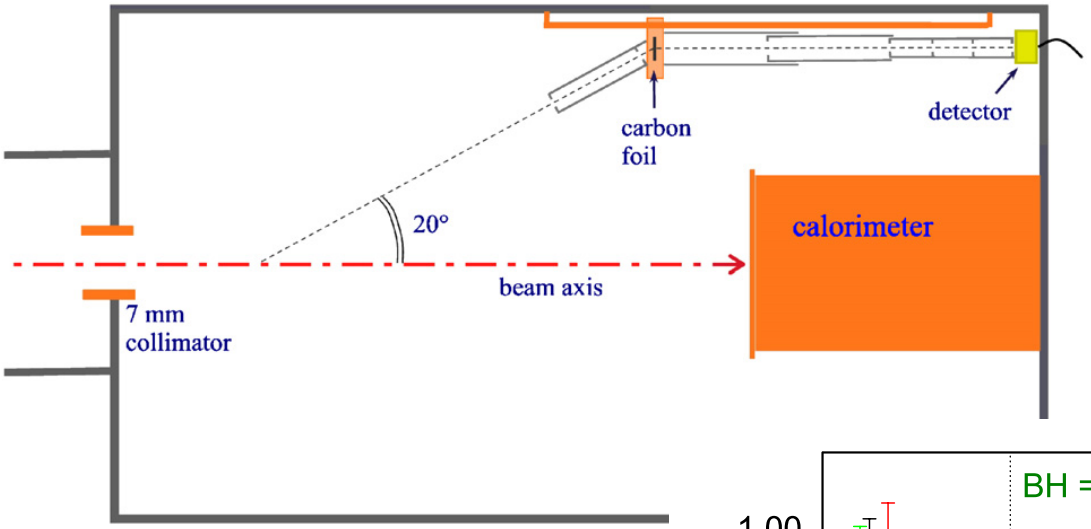


Thinning of the target by local (!) heating of the gas by the ion beam

Need narrow resonances:
$^{14}N(p,\gamma)^{15}O$ at 278 keV
$^{21}Ne(p,\gamma)^{22}Na$ at 271 keV

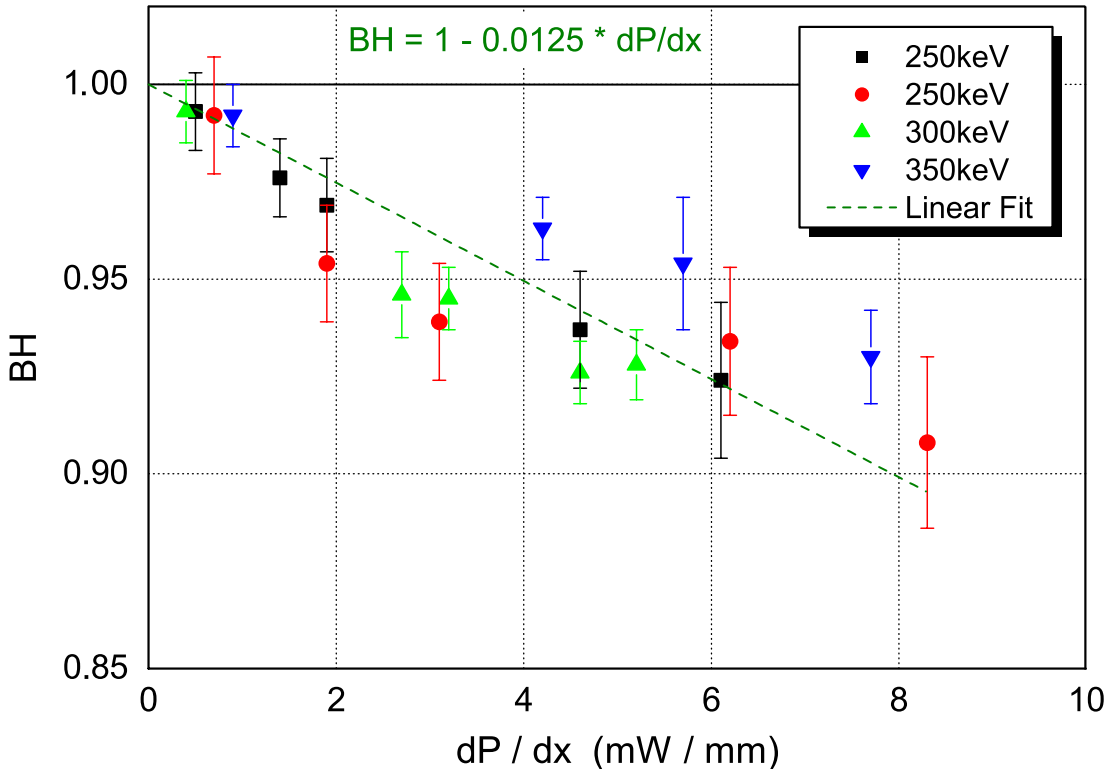


Target density: Effective target density (elastic scattering)

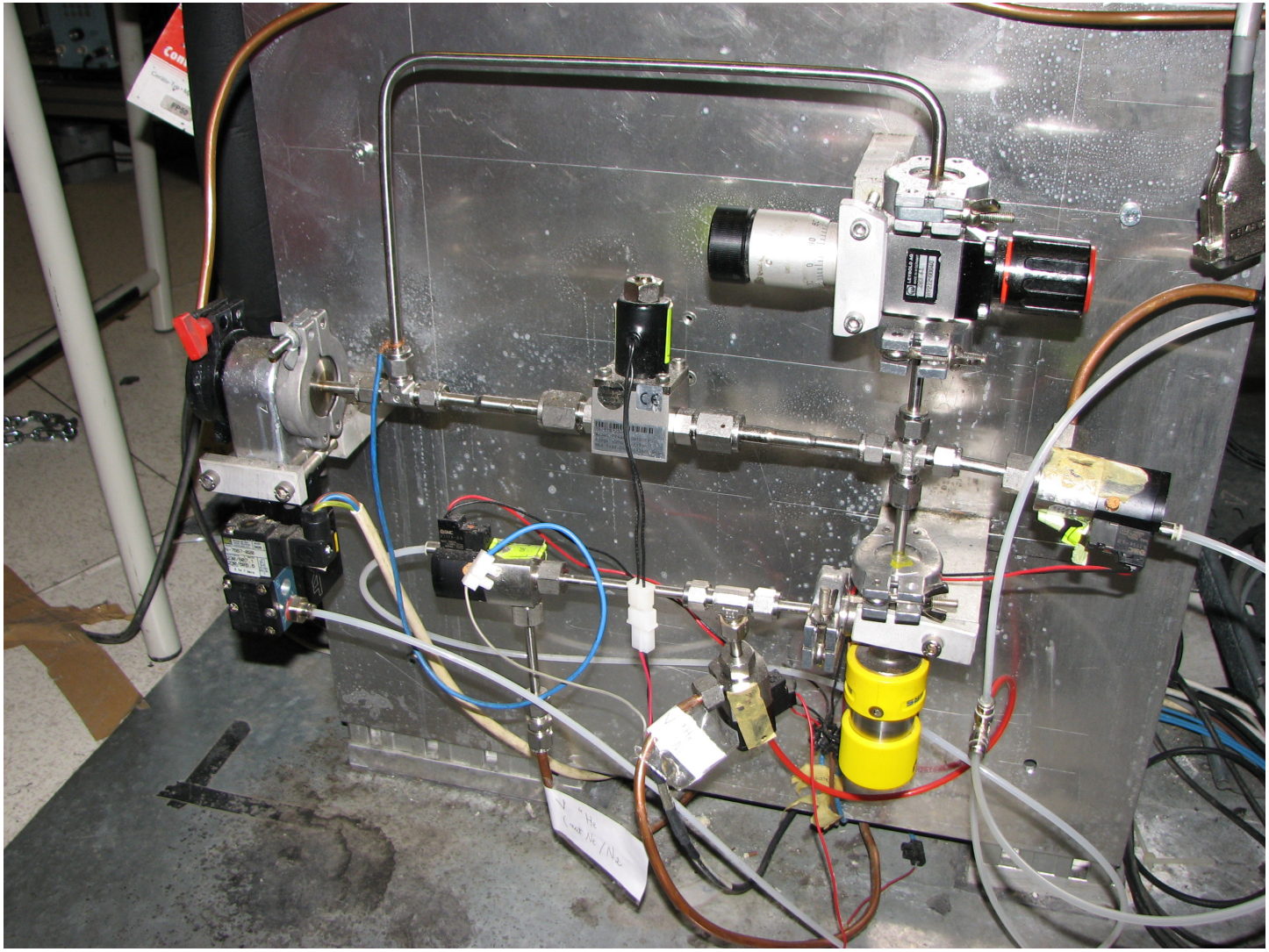


$^3He(\alpha,\gamma)^7Be$

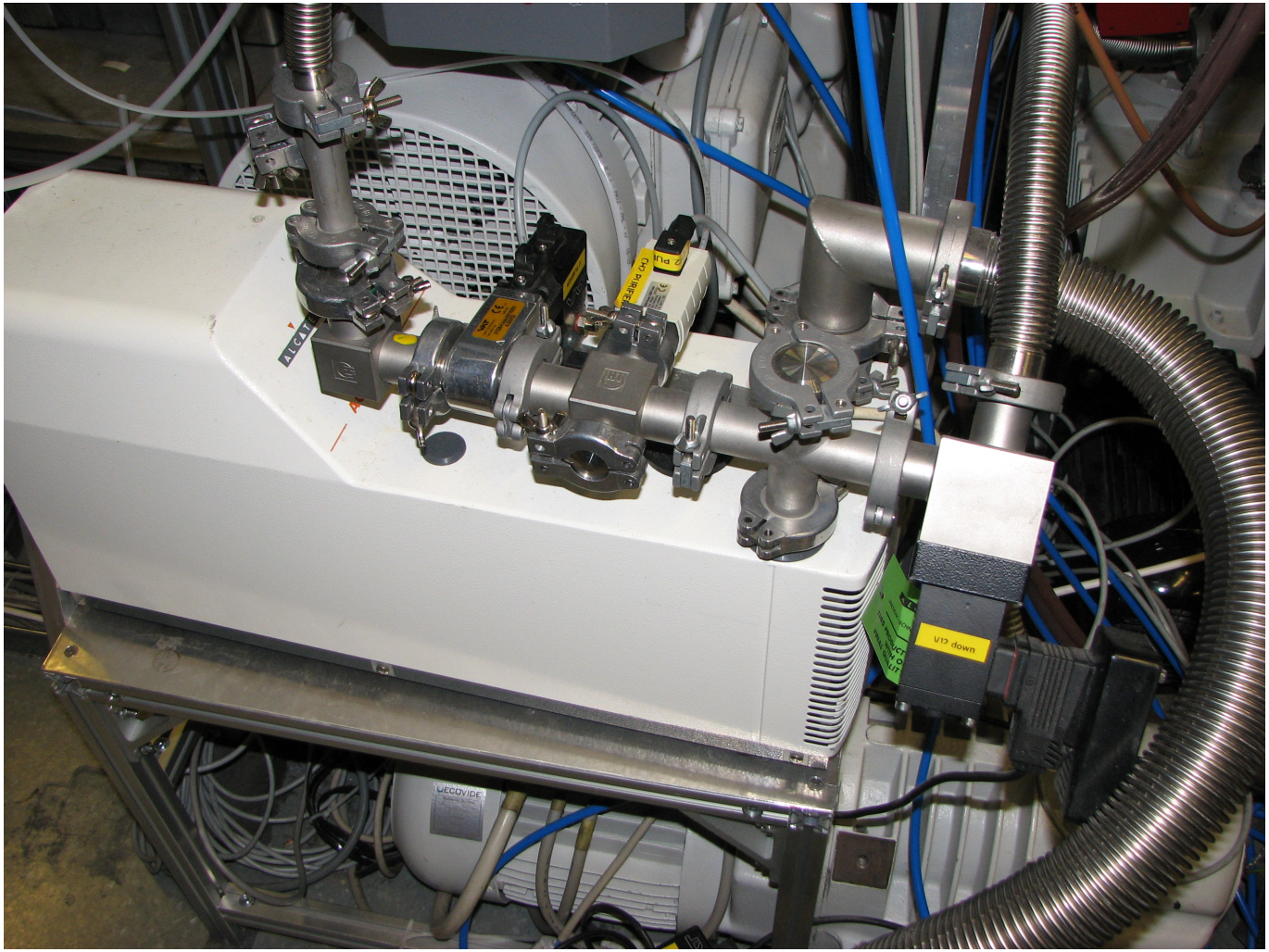
$$\frac{dW}{dx} = n_0 \cdot \frac{dE}{d\tilde{x}} \cdot I_{\text{target}}$$



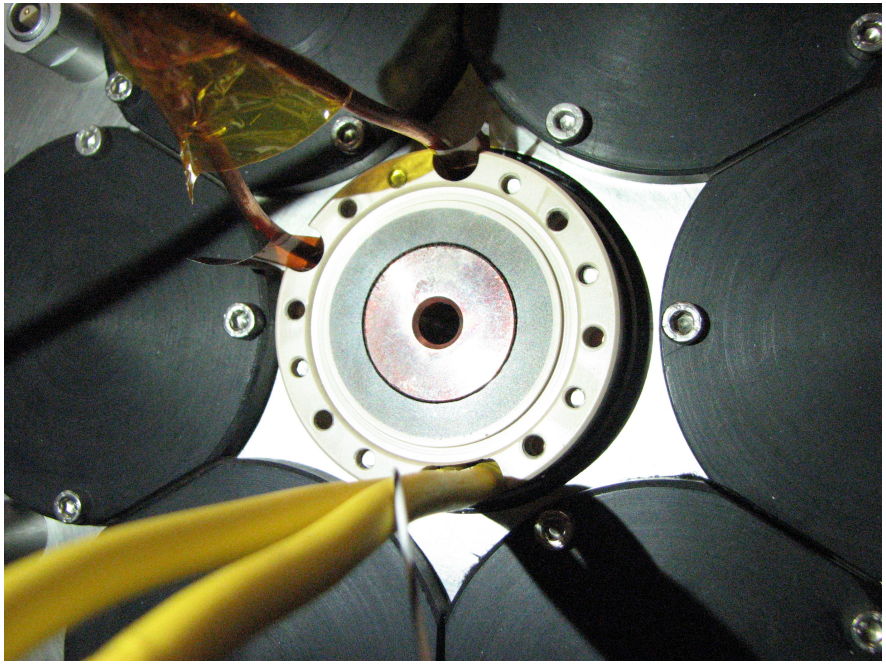
Gas inlet regulation with manual offset and active feedback



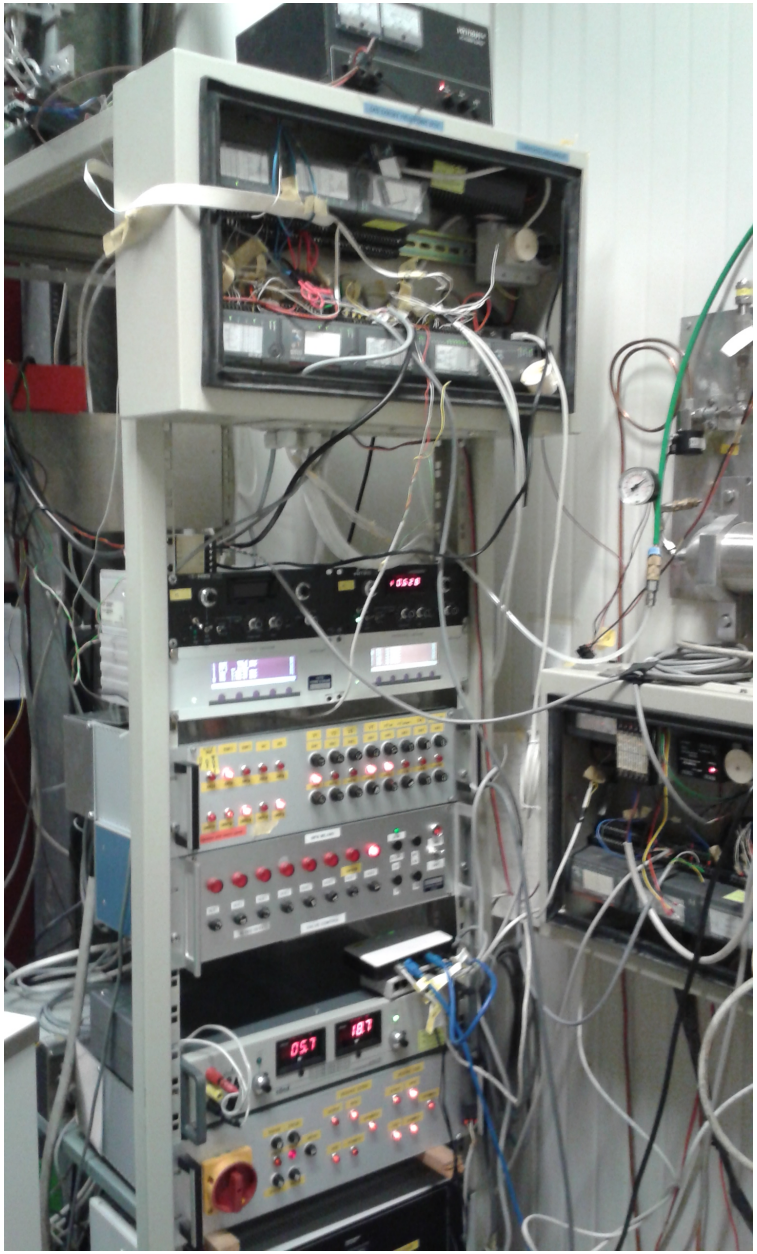
“Oil-free” forepump



Watercooled input detector



Rack with slow control



Windowless gas target systems, summary and lessons learned

Gas targets were instrumental in several highly successful LUNA measurement campaigns:

- ^{nat}N for $^{14}N(p,\gamma)^{15}O$ and $^{15}N(p,\gamma)^{16}O$
- ^{3}He for $^{3}He(\alpha,\gamma)^{7}Be$ and $^{3}He(^{3}He,2p)^{4}He$
- ^{2}H for $^{2}H(\alpha,\gamma)^{6}Li$ (Davide Trezzi's talk yesterday)
- ^{22}Ne for $^{22}Ne(p,\gamma)^{23}Na$ (Federico Ferraro's talk yesterday)

Lessons

- Try to keep your setup free from water (deuterium), oil (^{12}C, ^{13}C), teflon (^{19}F)
- New problem boron, not yet clear where it is coming from

You need many pumps!

- Sensitive: high pumping speed turbomolecular pumps
- New turbopumps can handle 10^{-2} mbar pressure over longer periods

You need a recirculation system for expensive gases

- Chemical getters work fine
- Monitor either by nuclear reactions, or by mass spectrometer