



# An extremely high stability cooling system for planet hunter.

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The detection of exoplanets is done by measuring very tiny periodical variations of the radial velocity of the parent star. Extremely stable spectrographs are required in order to enhance the wavelength variations of the spectral lines due to Doppler effect. CARMENES is the new high-resolution, high-stability spectrograph built for the 3.5m telescope at the Calar Alto Observatory (CAHA, Almería, Spain) by a consortium formed by German and Spanish institutions. This instrument is composed by two separated spectrographs: VIS channel (550-1050 nm) and NIR channel (950-1700 nm). The NIR-channel spectrograph's has been built under the responsibility of the Instituto de Astrofísica de Andalucía (IAA-CSIC). It has been manufactured, assembled, integrated and verified in the last two years, delivered in fall 2015 and commissioned in December 2015.

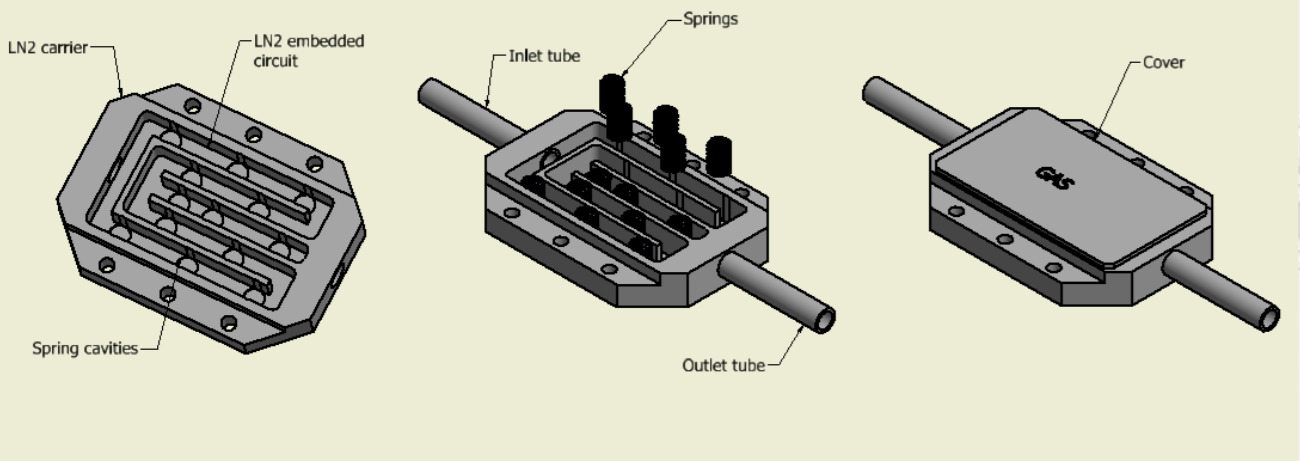
Beside the various opto-mechanics challenges, the cooling system was one of the most demanding sub-system of the NIR channel. Due to the highly demanding requirements applicable in terms of stability, this system arises as one of the core systems to provide outstanding stability to the channel at an operating temperature finally fixed at 140K. Really at the edge of the state-of-the-art, the Cooling System is able to provide to the cold mass (~1 Ton) better thermal stability than few hundredths of degree within 24 hours (goal: 0.01K/day).

|  |  |
|--|--|
| Working temperature                      | ~140 K   |
| Temperature stability                    | ±0.07 K (±0.01 K goal) in the timescale of 1 day |
| Pre-cooling time                         | 48h (goal)                                       |
| Cooldown and warm-up rate for the optics | <10 K/h  |
| Liquid nitrogen consumption              | <90l/day   |
| Environment temperature                  | 285±0.5 K  |
| Vacuum level                             | ~10-6mbar  |

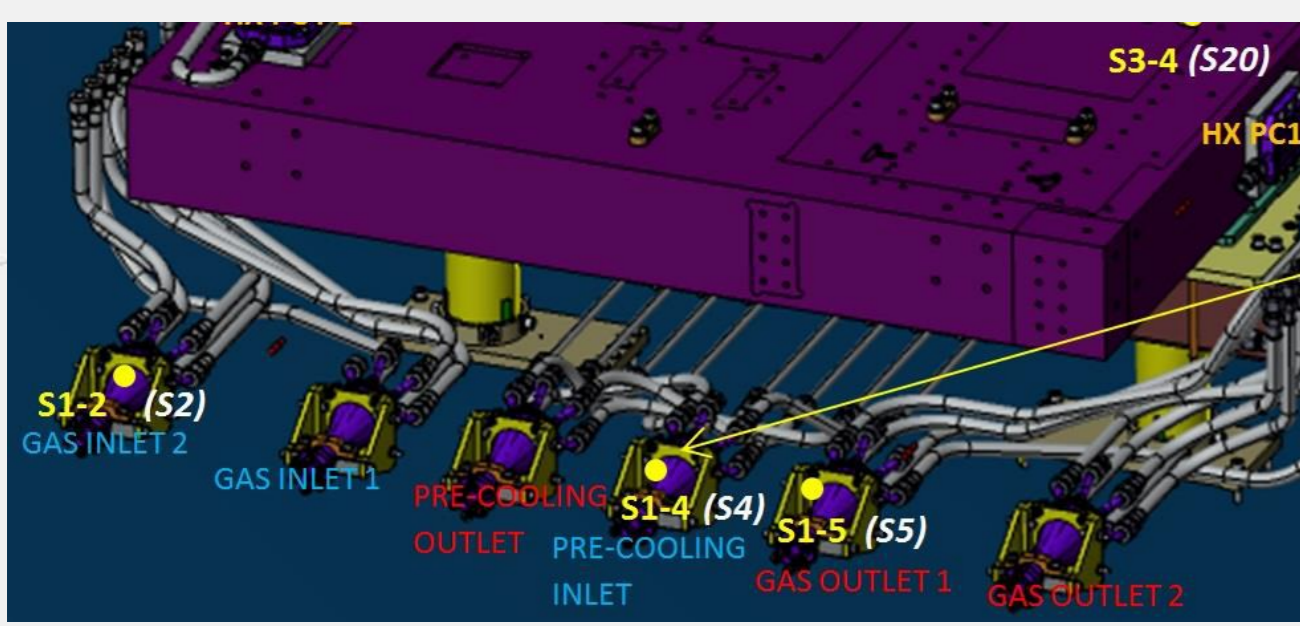
| Available technologies           | Pro  | Contra   |
|----------------------------------|--|--|
| Thermally refrigerated enclosure | Easy to implement<br>Commercial solutions                    | Poor efficiency, very long setting time. Problem with vacuum tightness |
| LN2 bath cryostat                | Fully passive  | Safety, temperature variation according to atmospheric pressure change |
| N2 continuous circulation        | Very flexible<br>Operating temperature can be changed easily | Need expertise and experience  |
| Mechanical cooler                | Easy implementation, easy operation                          | Vibrations, temperature fluctuations                                   |

## Cooling using continuous circulation of thermalized Nitrogen gas

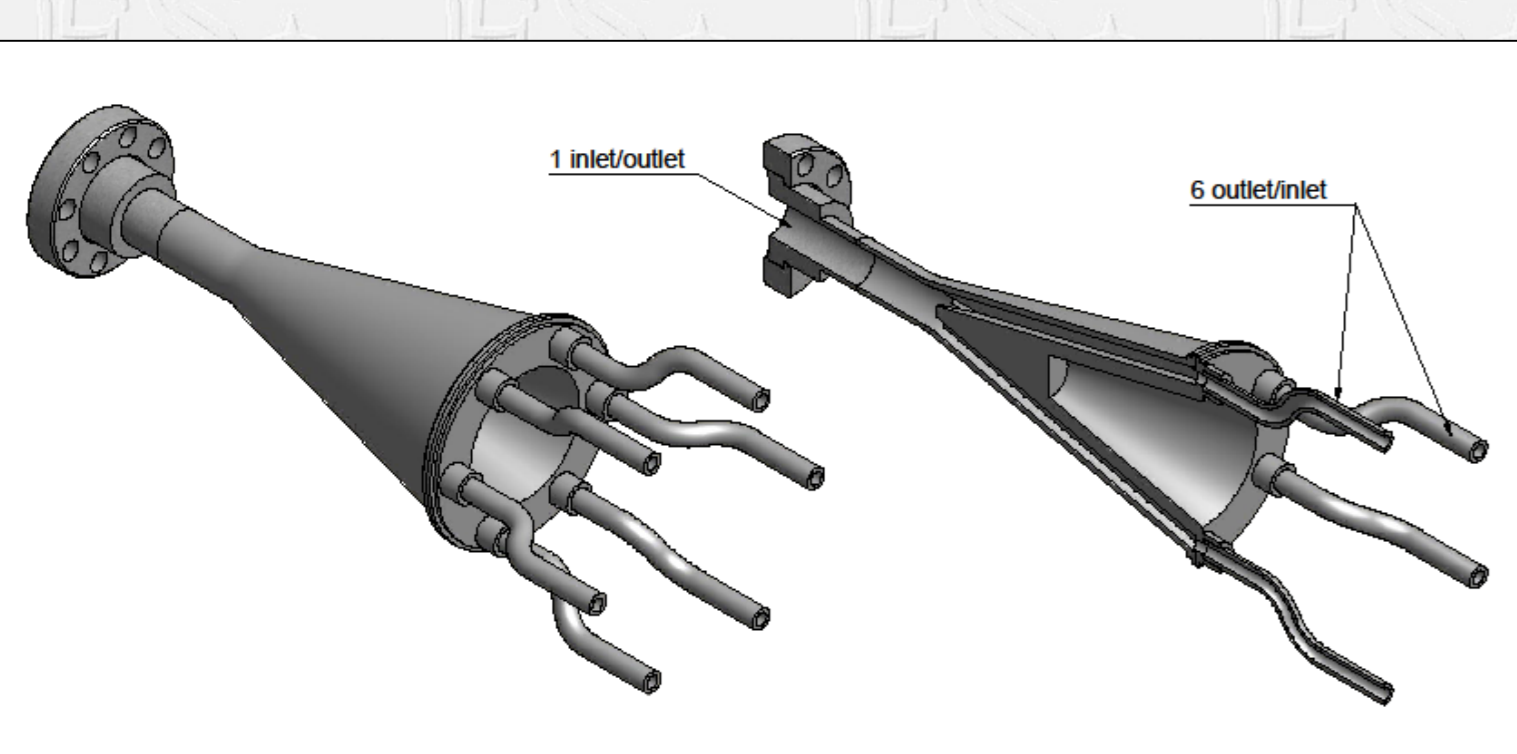
### Heat Exchangers



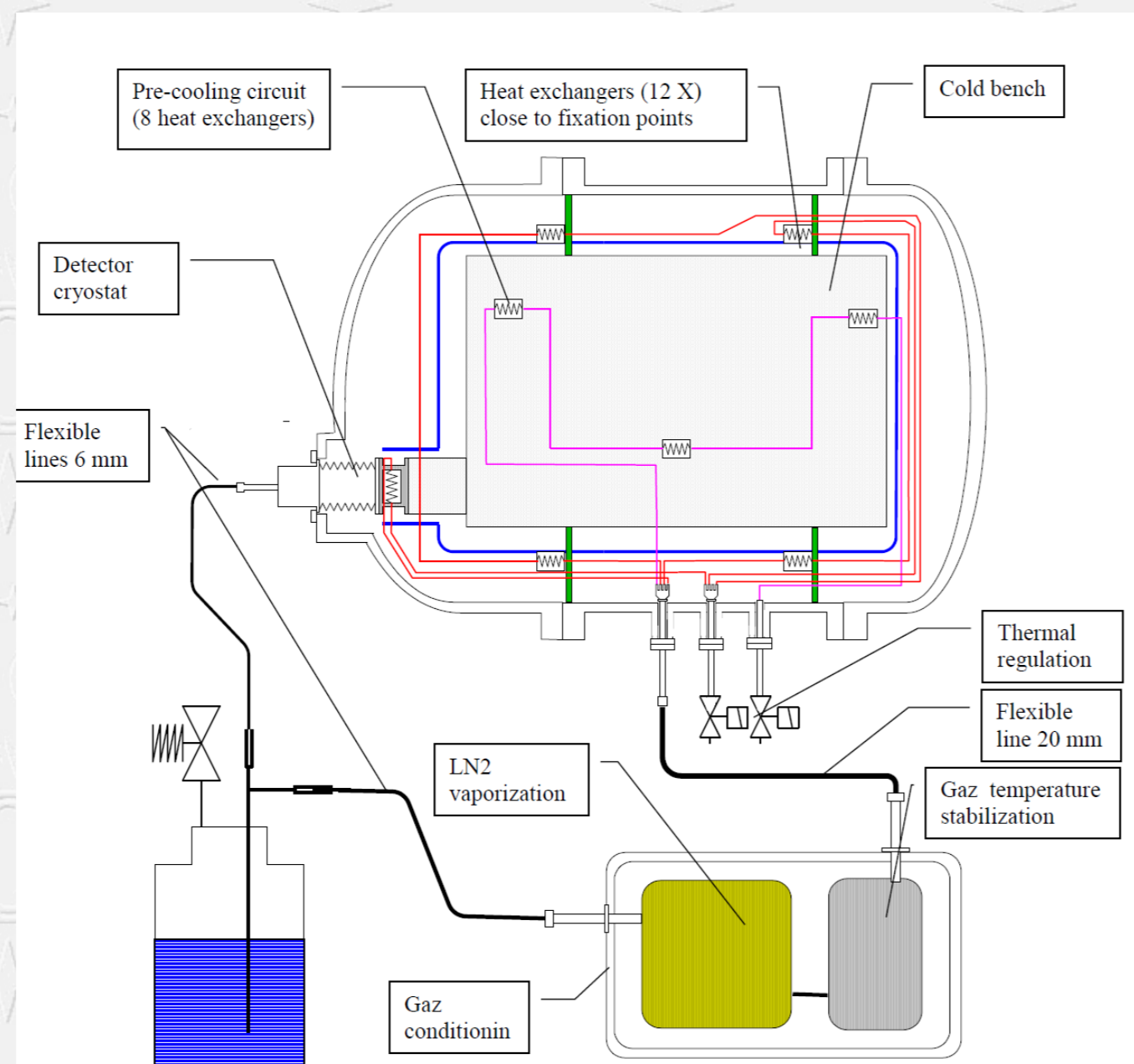
### Distribution system



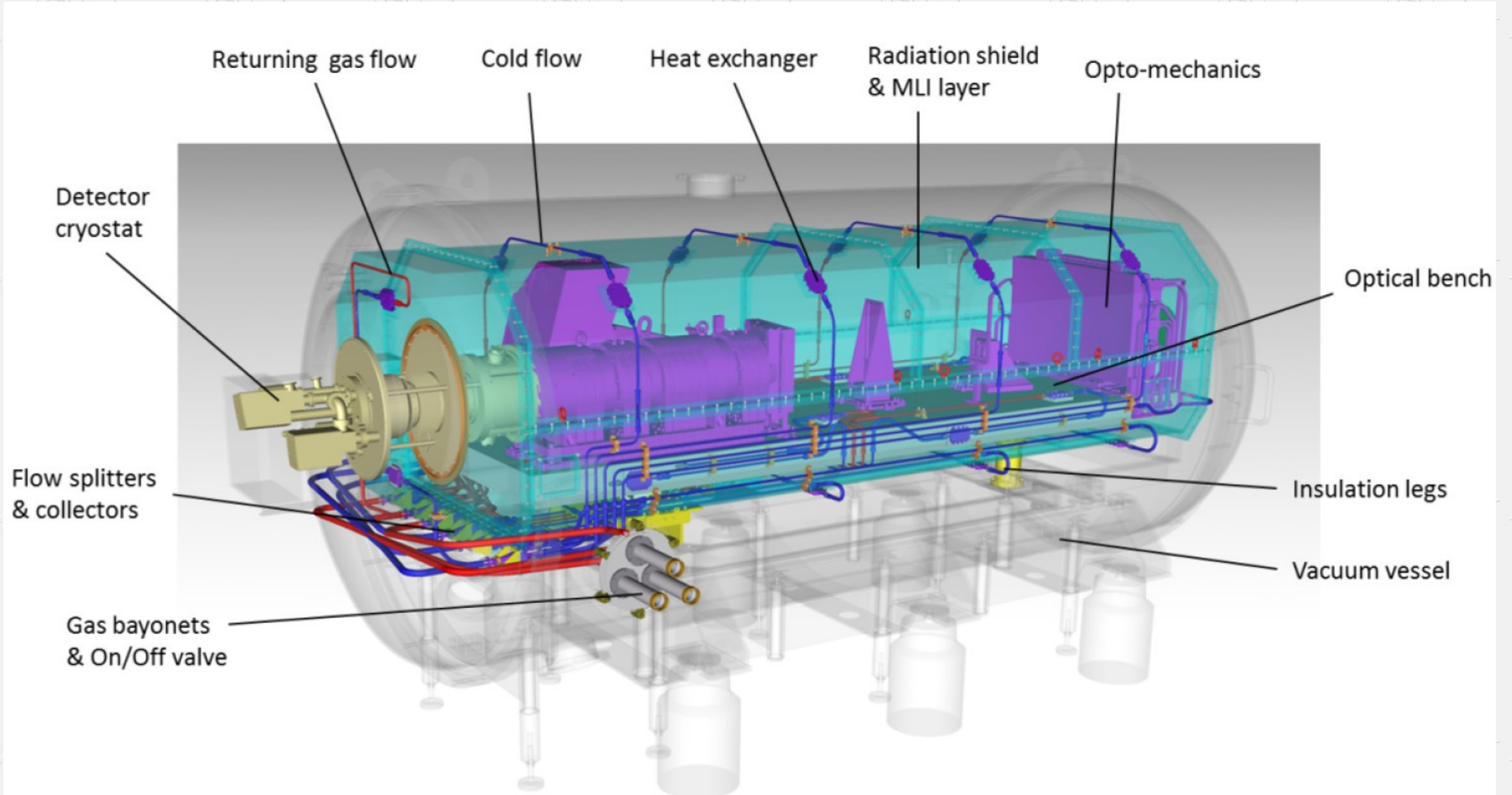
### Distribution head (flow splitters)



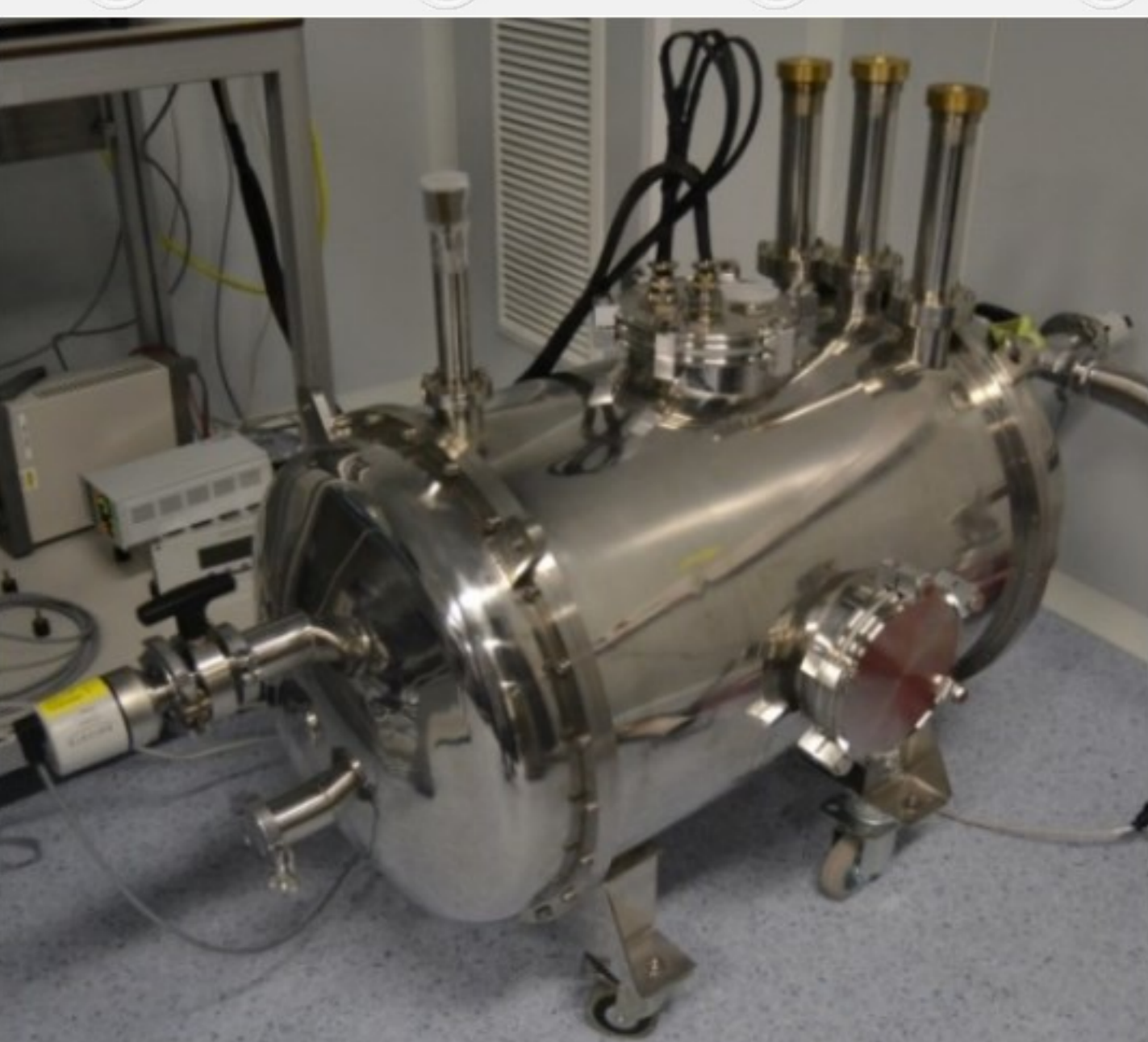
### Flexible connections



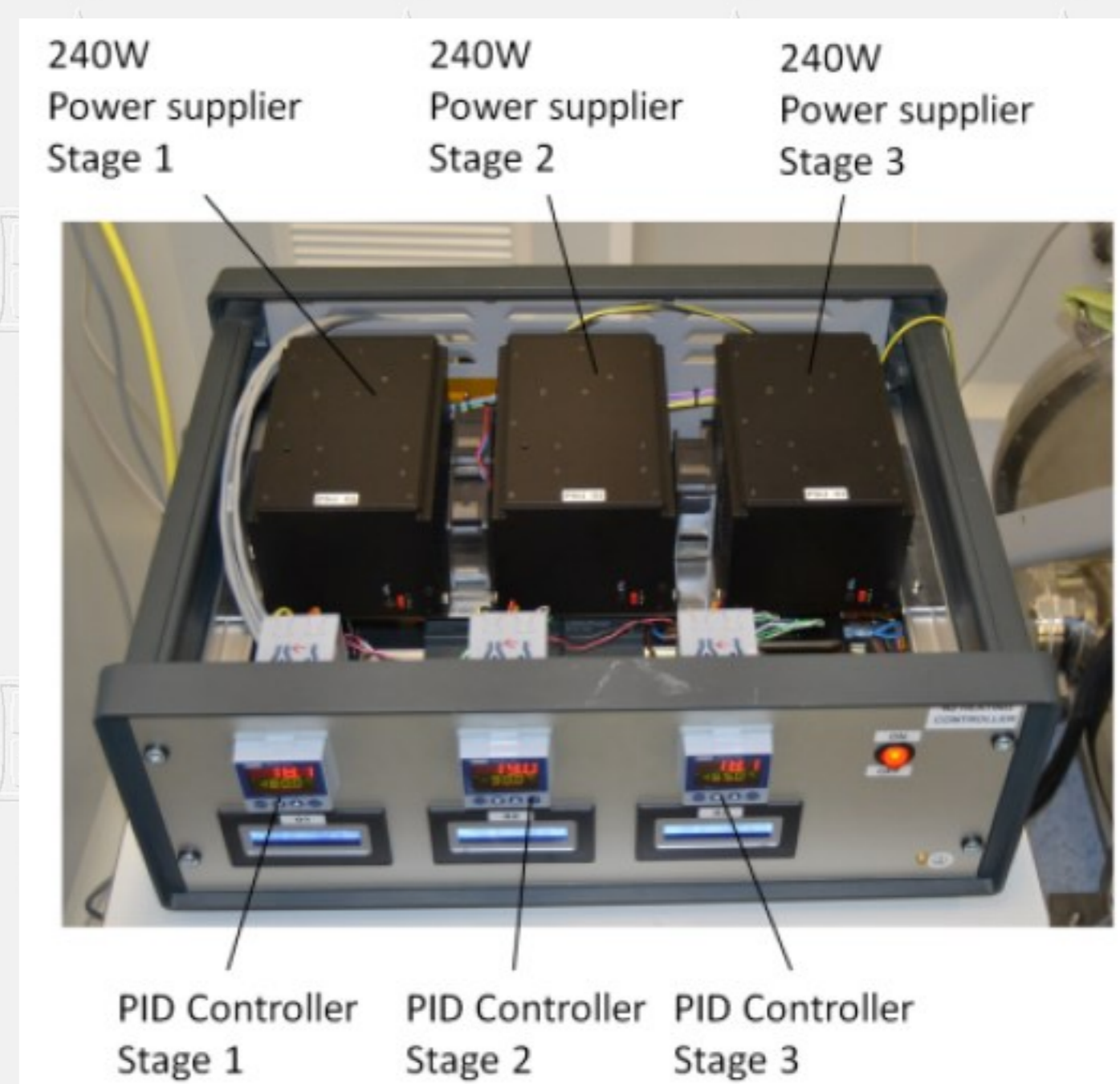
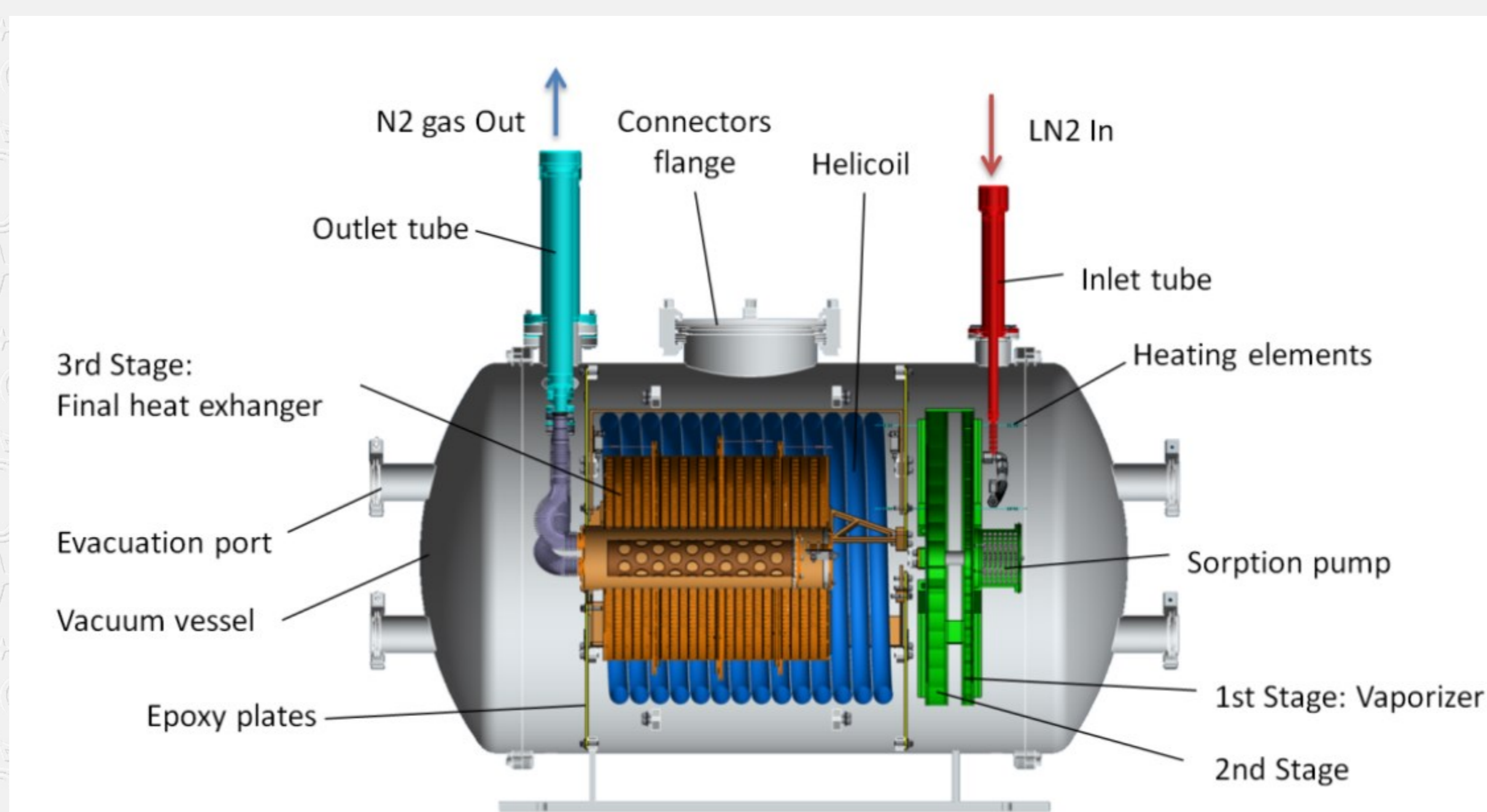
### Cooling schematic: Pre-cooling of the bench, final cooling through the radiation shield



## Gas Preparation Unit



Gas preparation unit



Gas preparation unit controller

### Radiation shield fitted with heat exchangers



### Provide thermal stabilized N2 Gas

- Vaporize LN2
- Store enough gas for one opening of the on/off regulation valve

