Karlsruhe Institute of Technology

The Loop-System of the KATRIN-Experiment

Moritz Hackenjos
School for Astroparticle Physics
Obertrubach-Bärenfels

INSTITUTE FOR EXPERIMENTAL NUCLEAR PHYSICS (IEKP)

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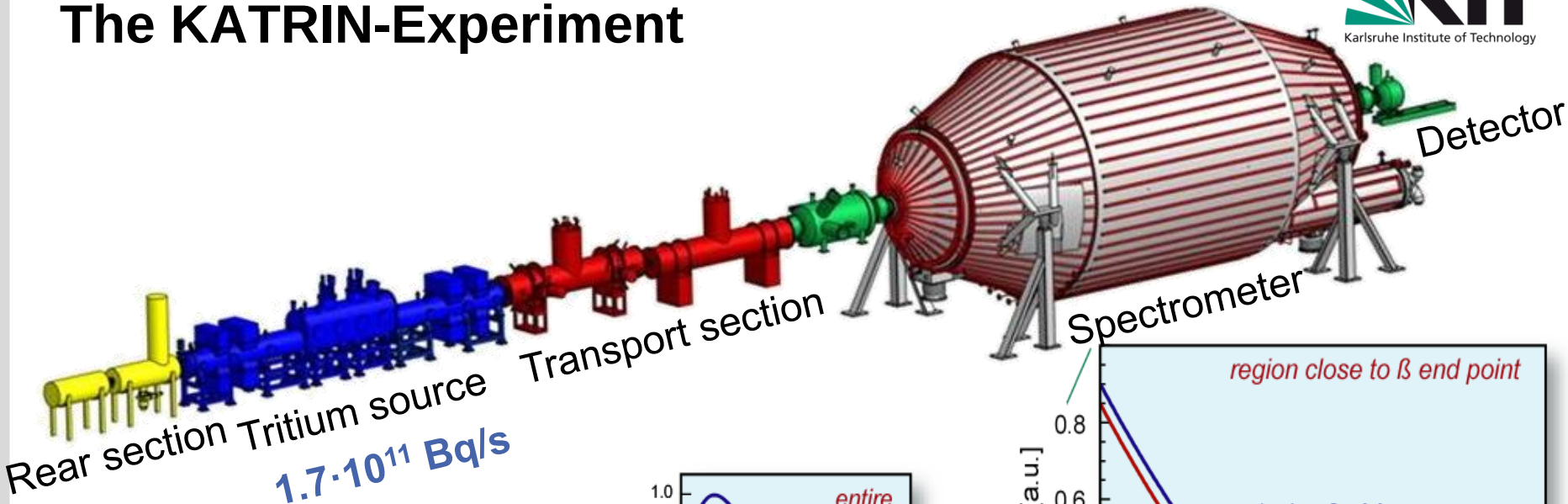
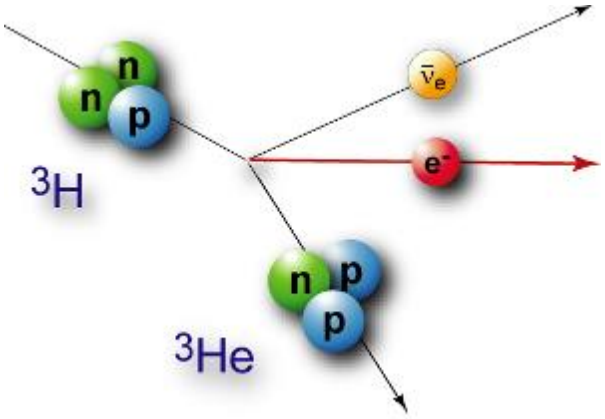
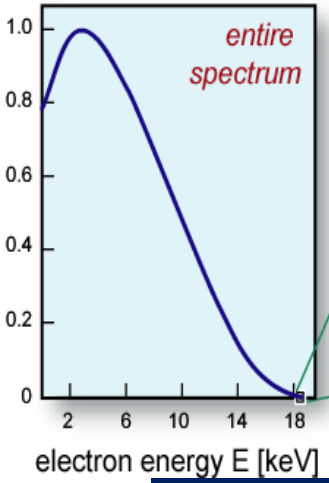
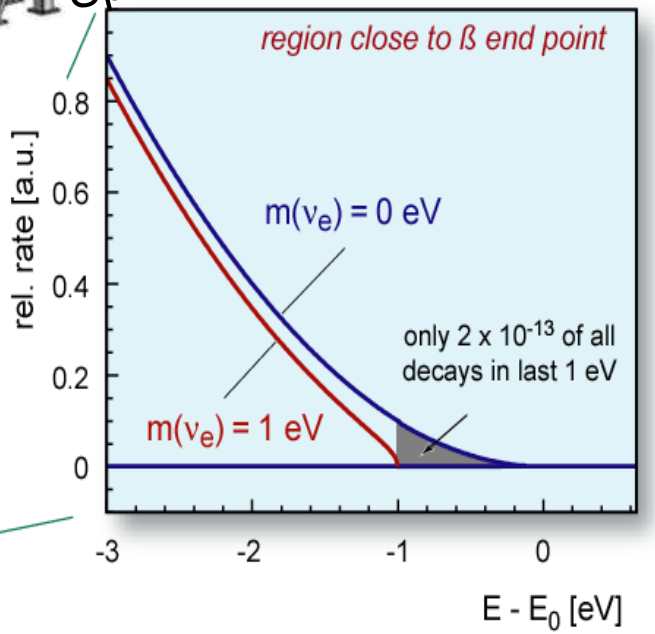
- Introduction
- Design of the KATRIN-Experiment
- Measurements and results
- Summary and Outlook

The KATRIN-Experiment





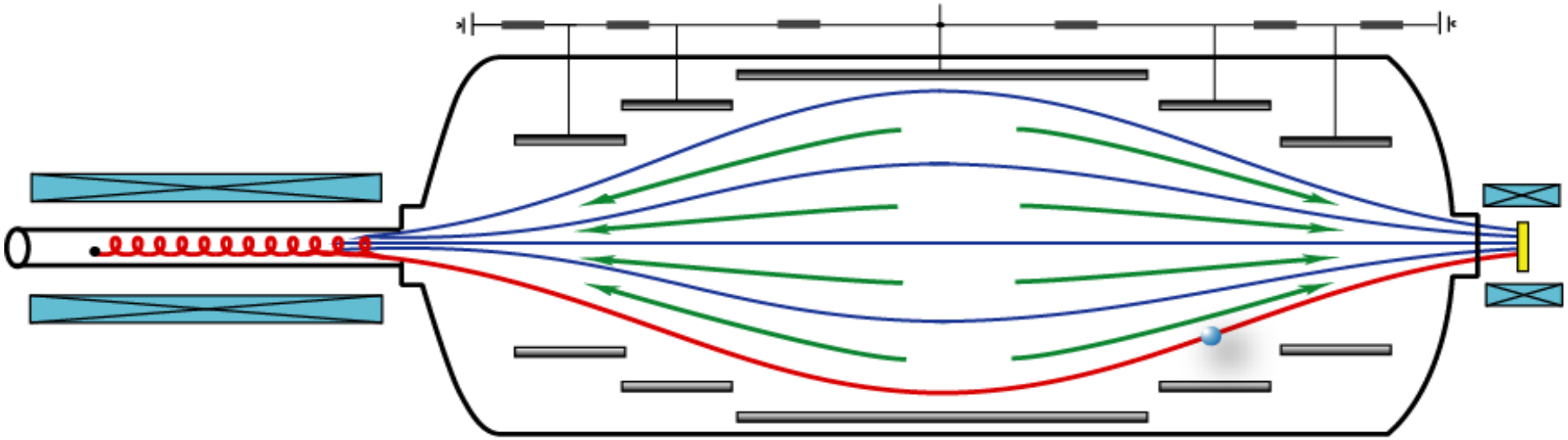


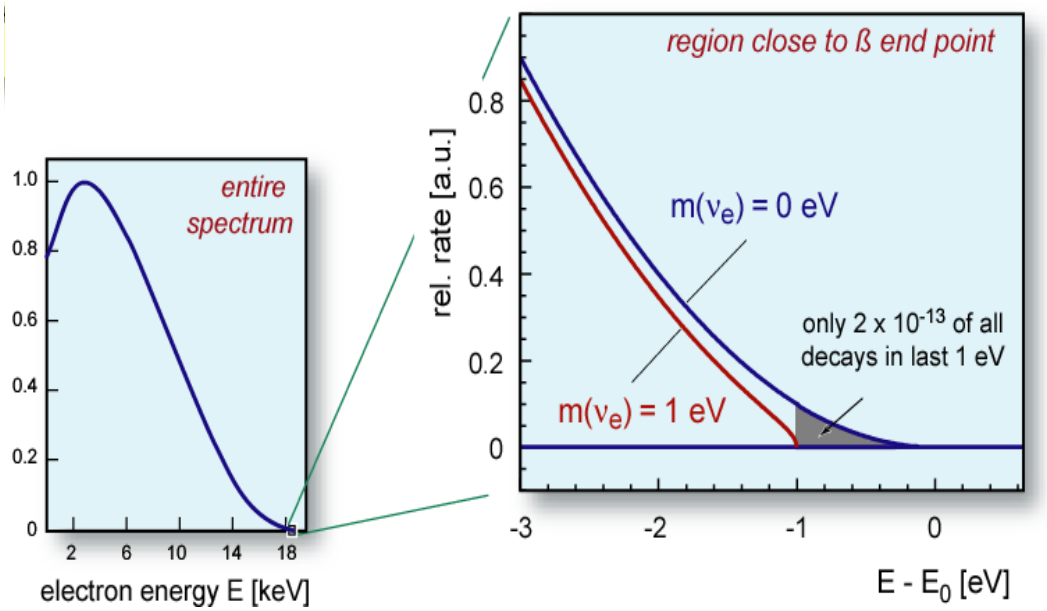


Determination of electron anti-neutrino mass with 0.2 eV sensitivity (90 % C.L.)

Institute for Technical Physics
Tritium Laboratory Karlsruhe

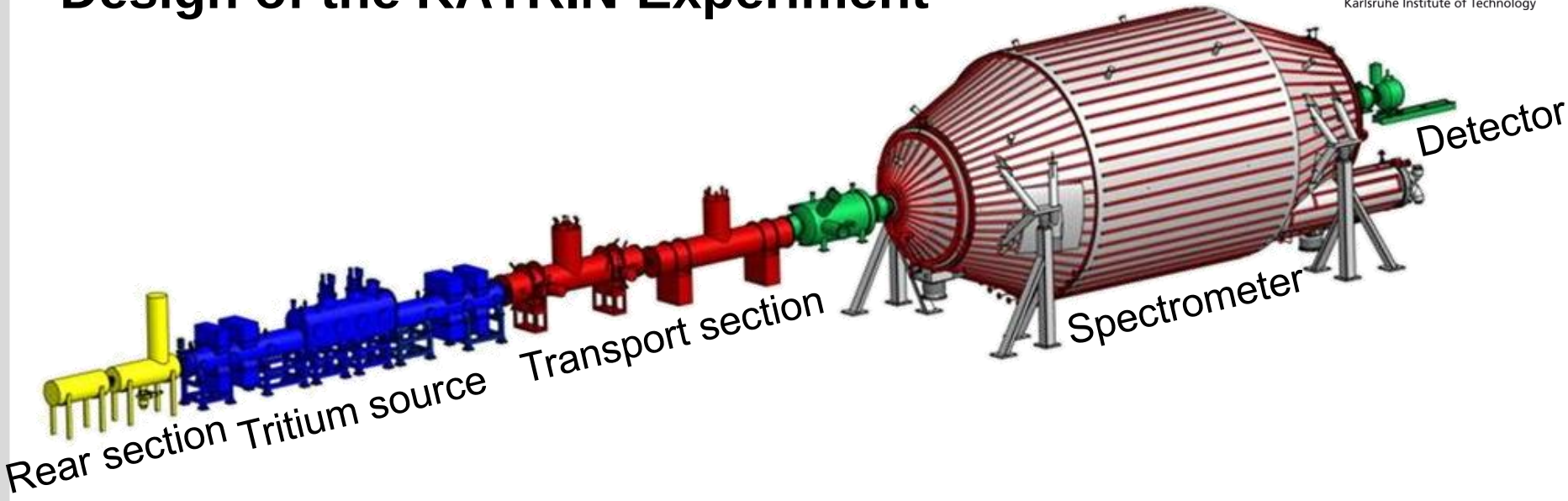
The KATRIN-Experiment





The Main-Spectrometer

Design of the KATRIN-Experiment



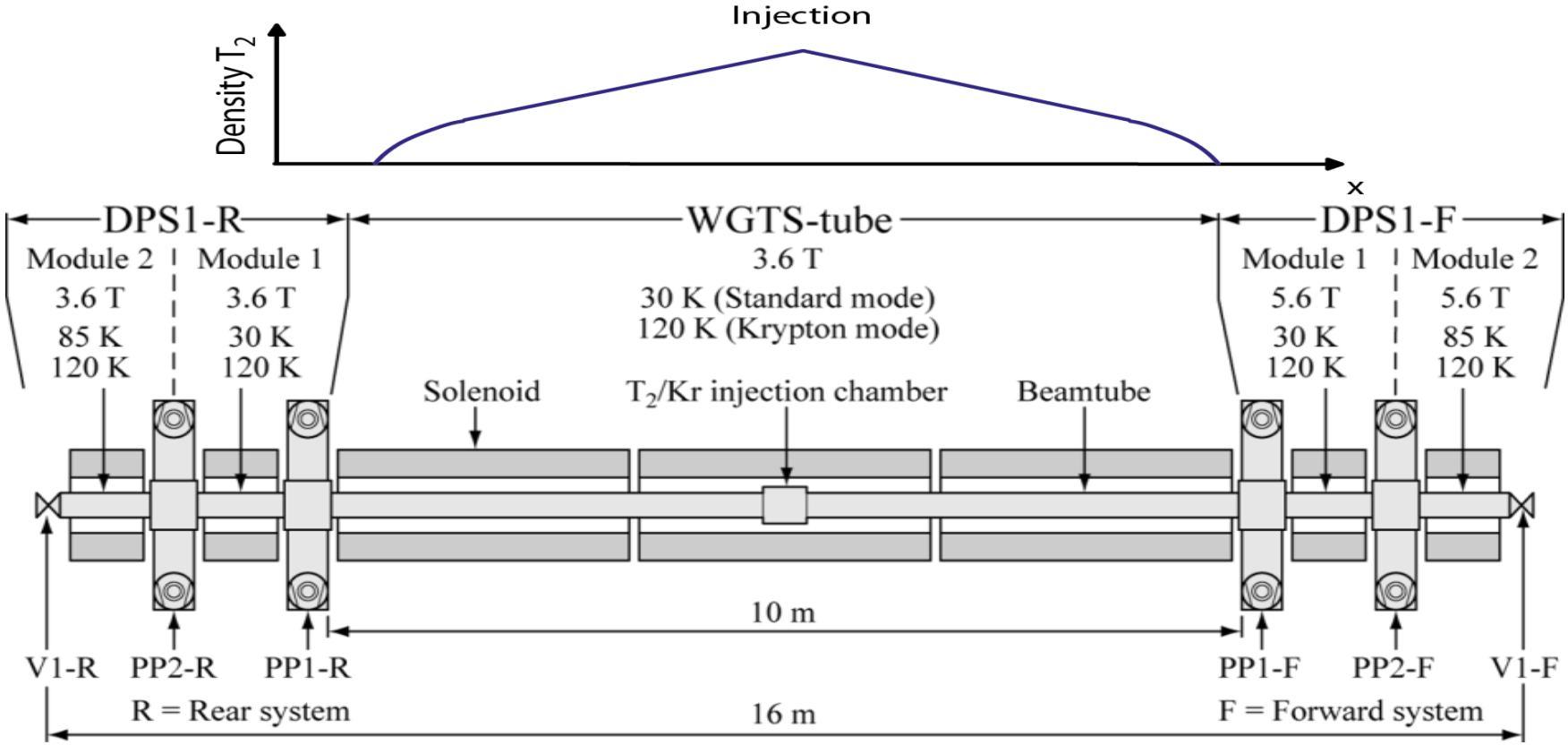
Goals:

- High and stable source activity
- Guide the electrons adiabatically
- Reduce the molecular tritium flux by 14 orders of magnitude

Windowless Gaseous Tritium Source (WGTS)

Responsibilities:

- Providing high and constant rate of signal electrons
- Magnetic guiding of electrons



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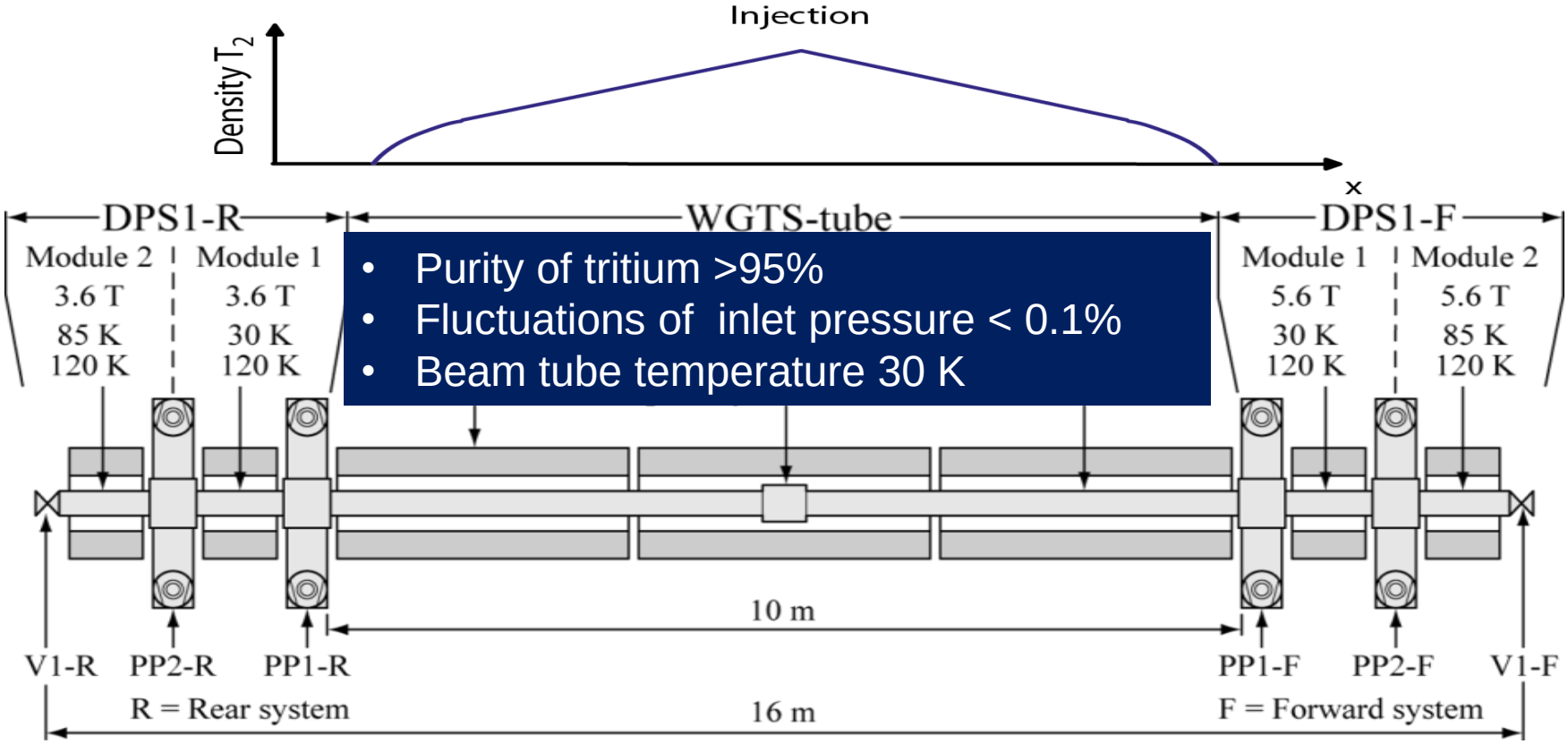
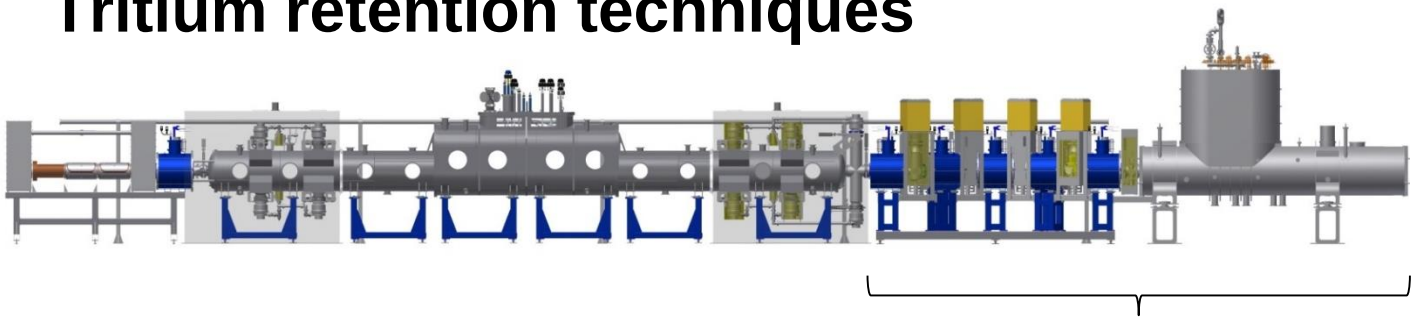


Tritium retention techniques

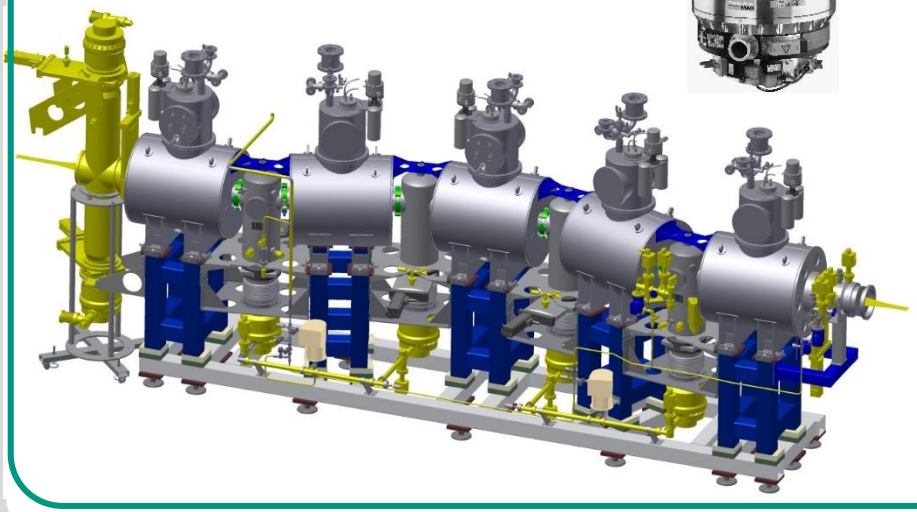


tritium free

DPS & CPS: overall retention **factor > 10^{14}**

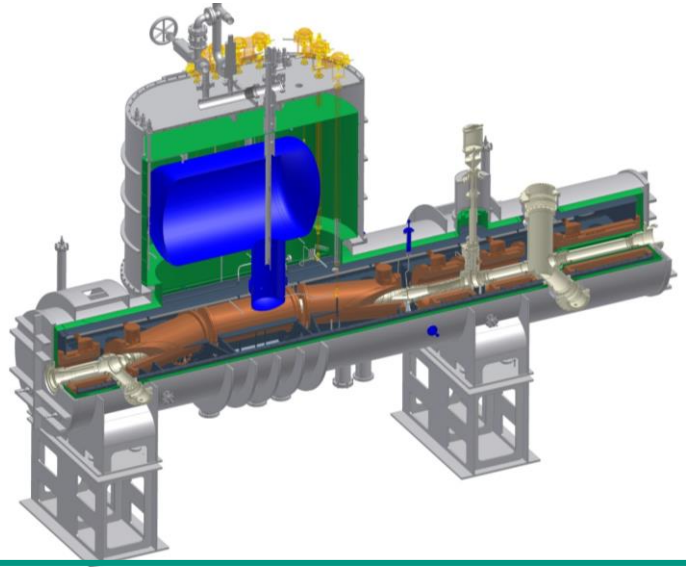
differential pumping section DPS:

- active pumping by turbo molecular pumps

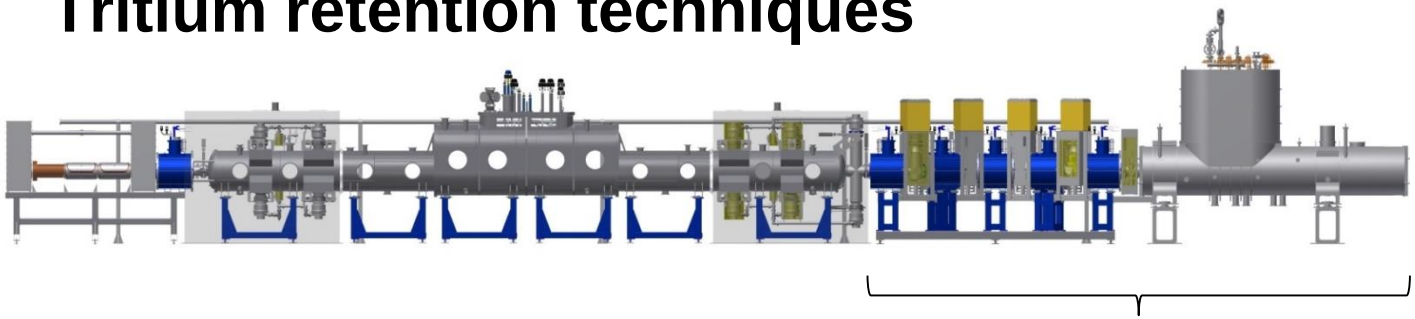


cryogenic pumping section CPS

- cryosorption on Argon frost



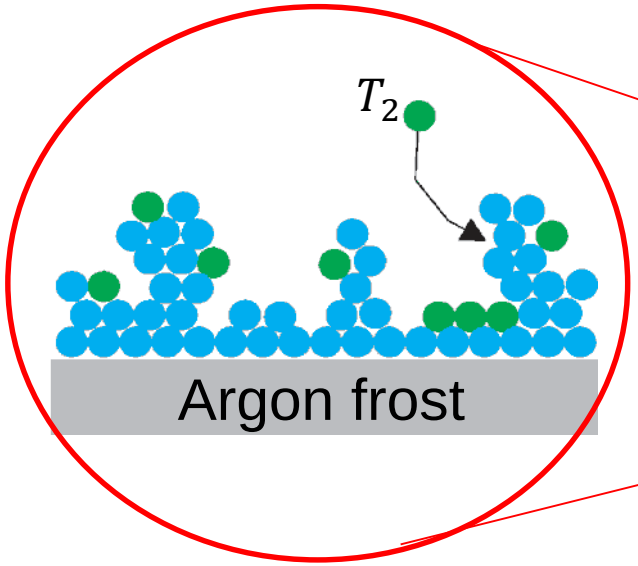
Tritium retention techniques



tritium free

DPS & CPS: overall retention **factor > 10^{14}**

Kryo-sorption



cryogenic pumping section CPS

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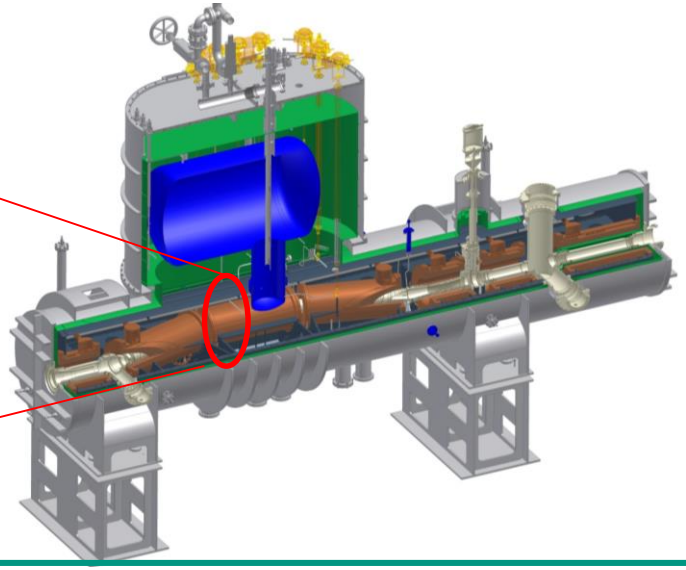
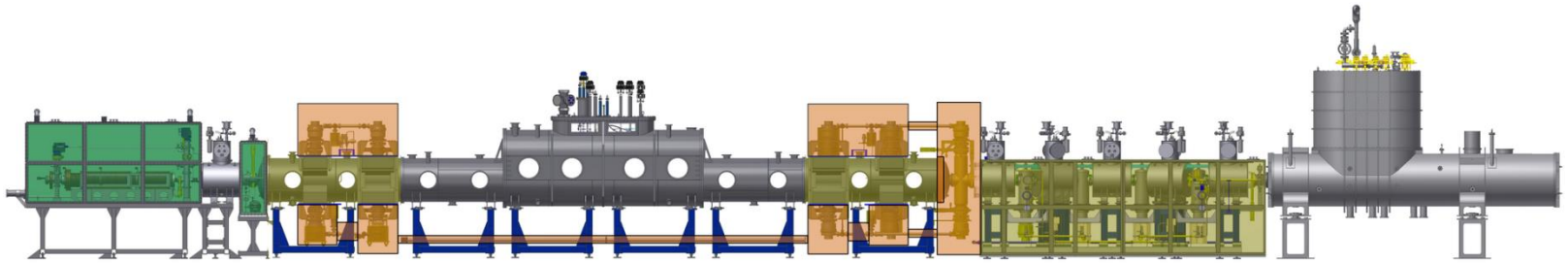
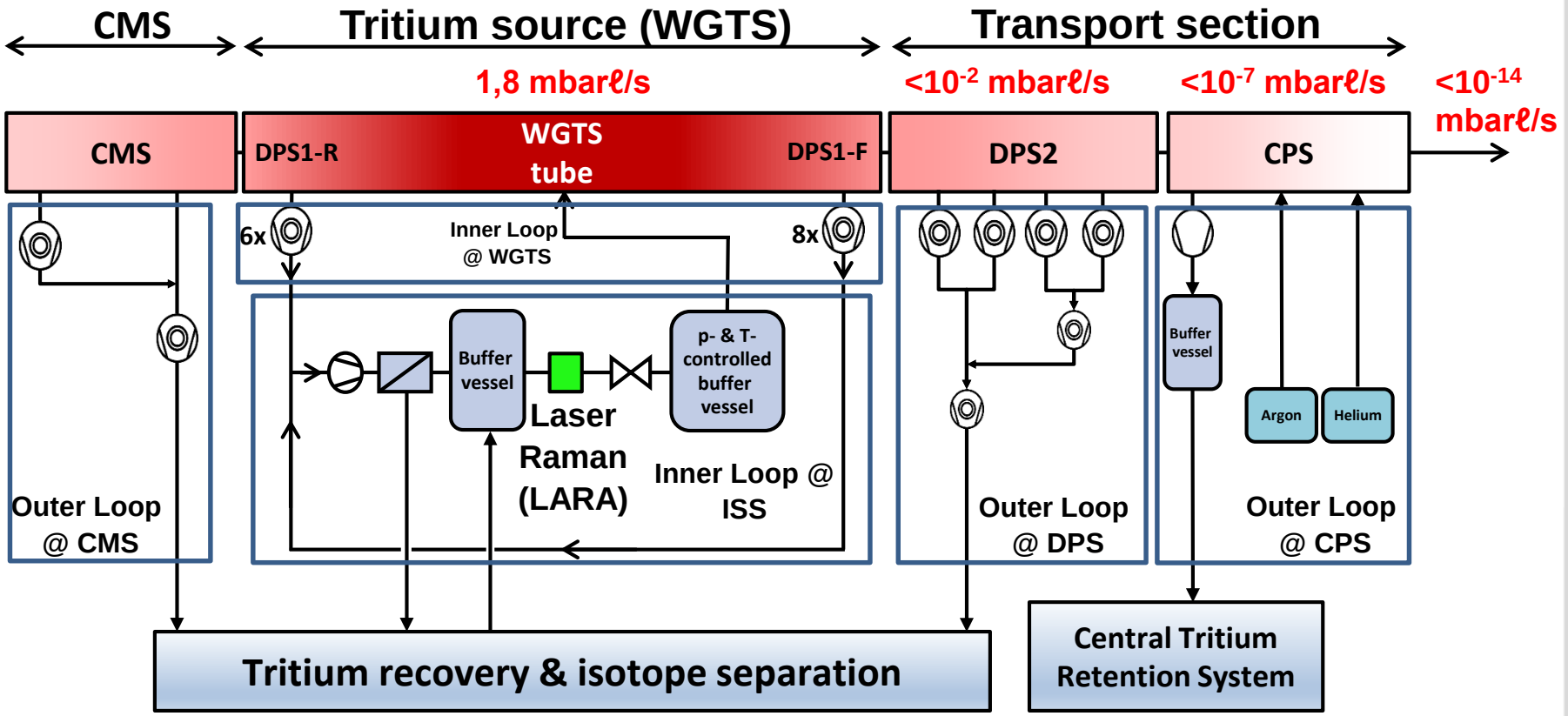
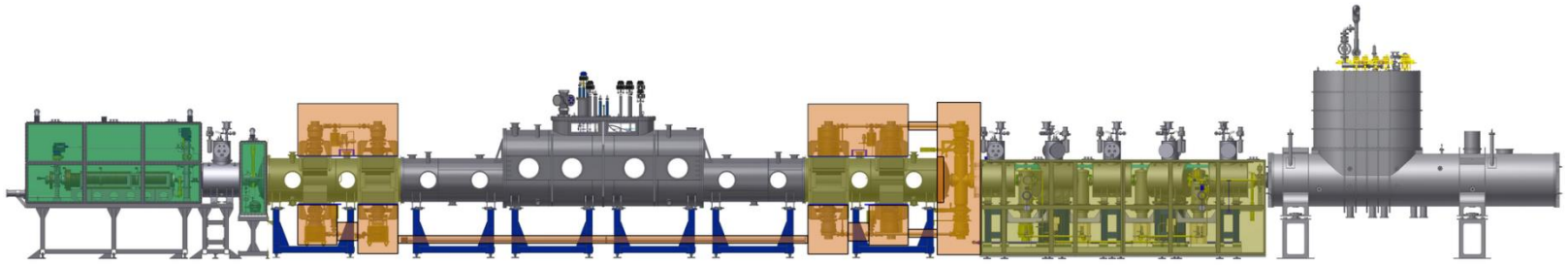


Loop System




CMS
Tritium source (WGTS)
Transport section
1,8 mbarℓ/s
<10-2 mbarℓ/s
<10-7 mbarℓ/s
<10-14 mbarℓ/s
CMS
DPS1-R
WGTS tube
DPS1-F
DPS2
CPS
6x
Inner Loop @ WGTS
8x
Buffer vessel
p- & T-controlled buffer vessel
Laser Raman (LARA)
Inner Loop @ ISS
Buffer vessel
Argon
Helium
Outer Loop @ CMS
Outer Loop @ DPS
Outer Loop @ CPS
Tritium recovery & isotope separation
Central Tritium Retention System

Loop System



CMS | Tritium source (WGTS) | Transport section

1,8 mbarℓ/s | $<10^{-2}$ mbarℓ/s | $<10^{-7}$ mbarℓ/s | $<10^{-14}$ mbarℓ/s

CMS | DPS1-R | WGTS tube | DPS1-F | DPS2 | CPS

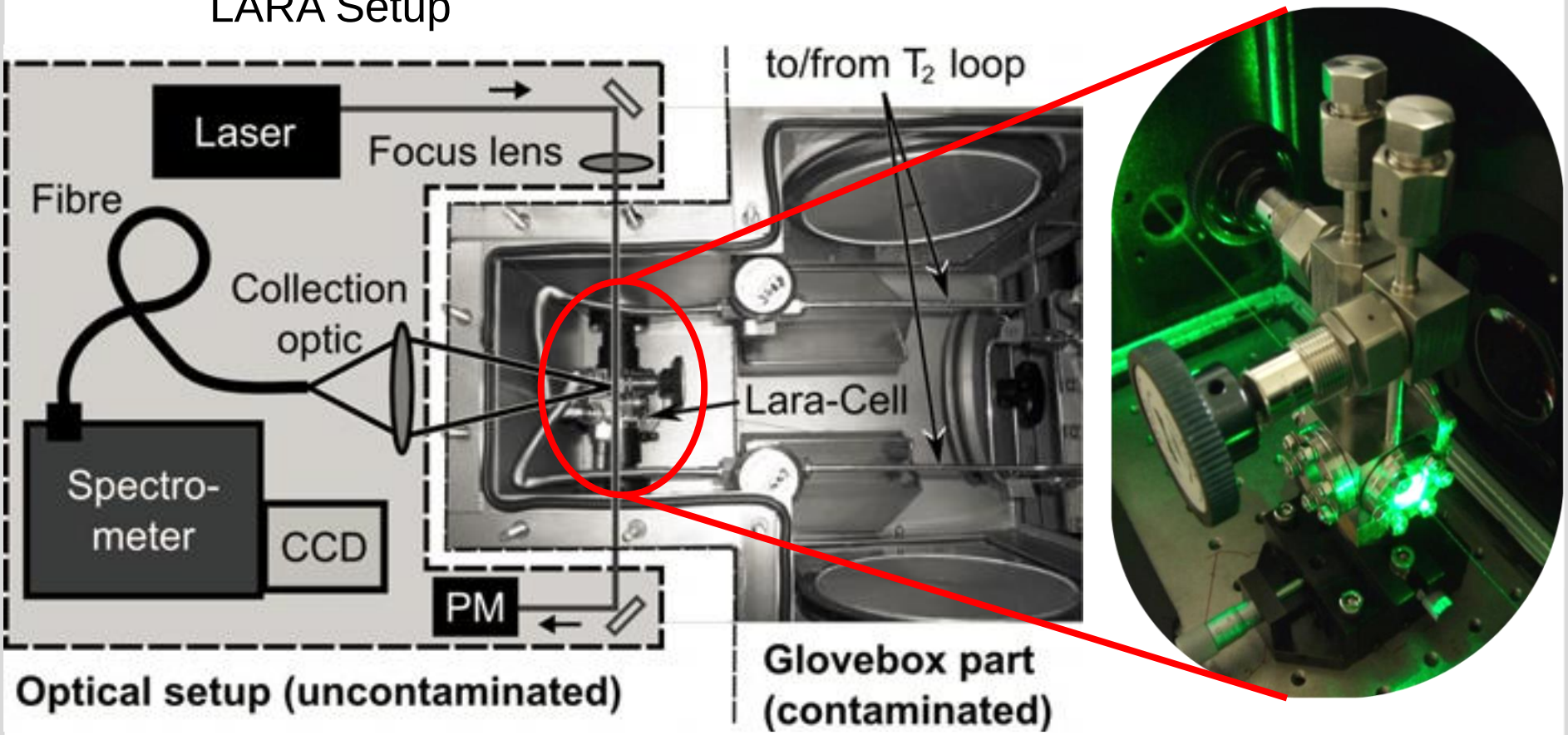
- Purity of tritium >95%
- Fluctuations of inlet pressure < 0.1%
- Beam tube temperature stability ΔT ≤ 30 mK

Outer Loop @ CMS | (LARA) | ISS | Outer Loop @ DPS | Outer Loop @ CPS

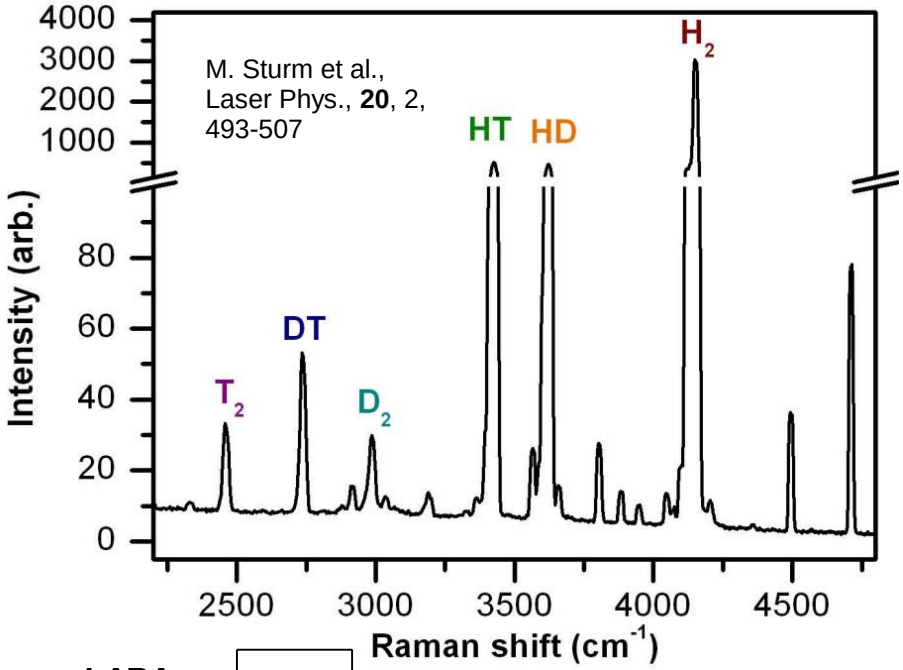
Tritium recovery & isotope separation | Central Tritium Retention System

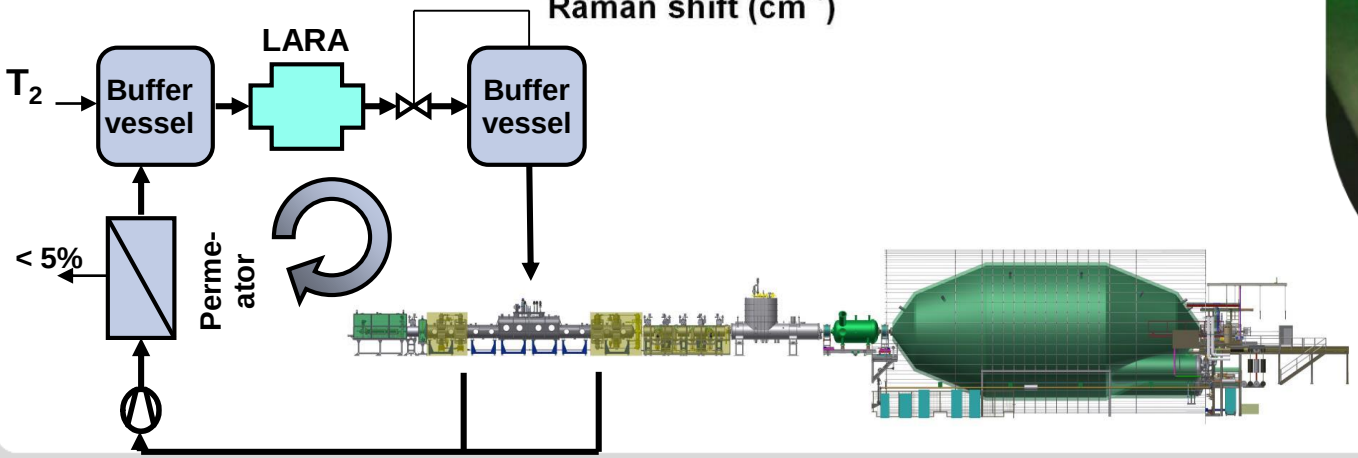
Measurements and Results

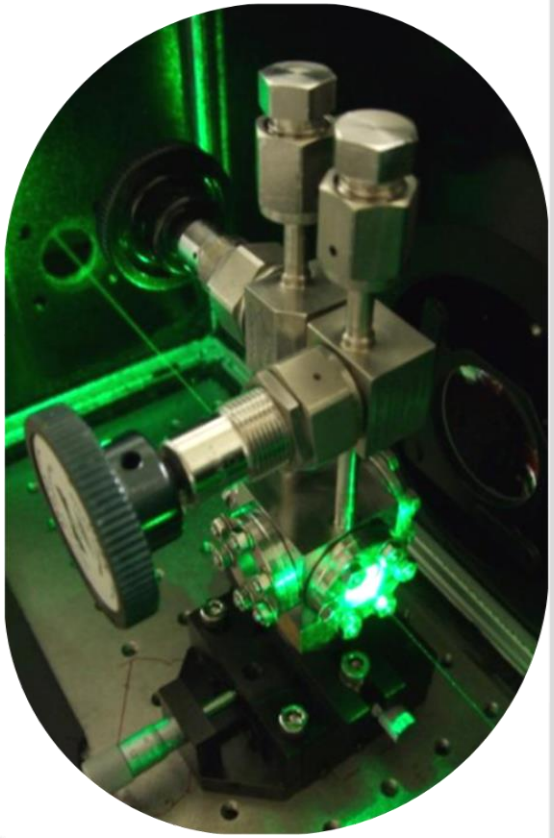
LARA Setup



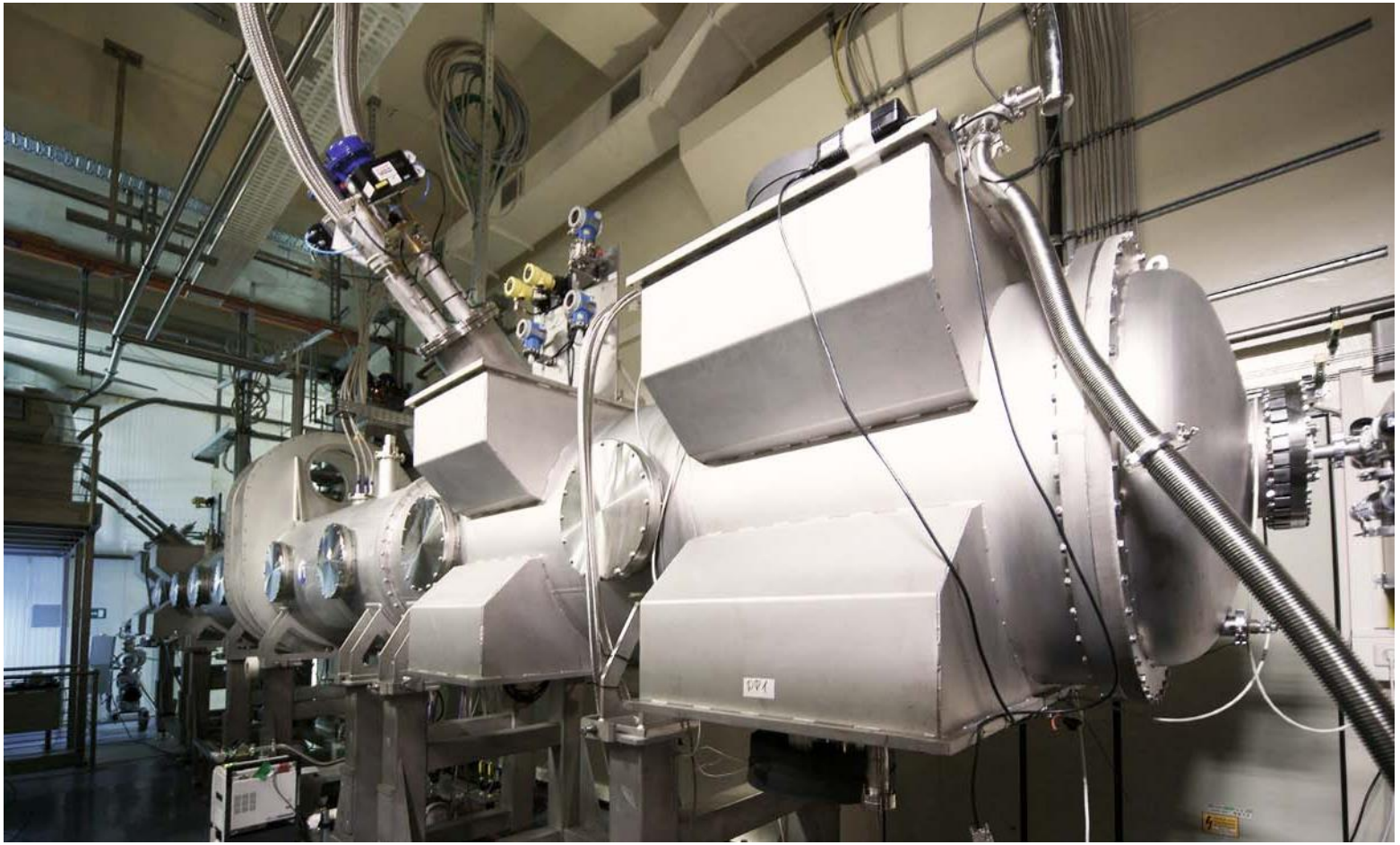
Simultaneous monitoring of all 6 hydrogen isotopologues





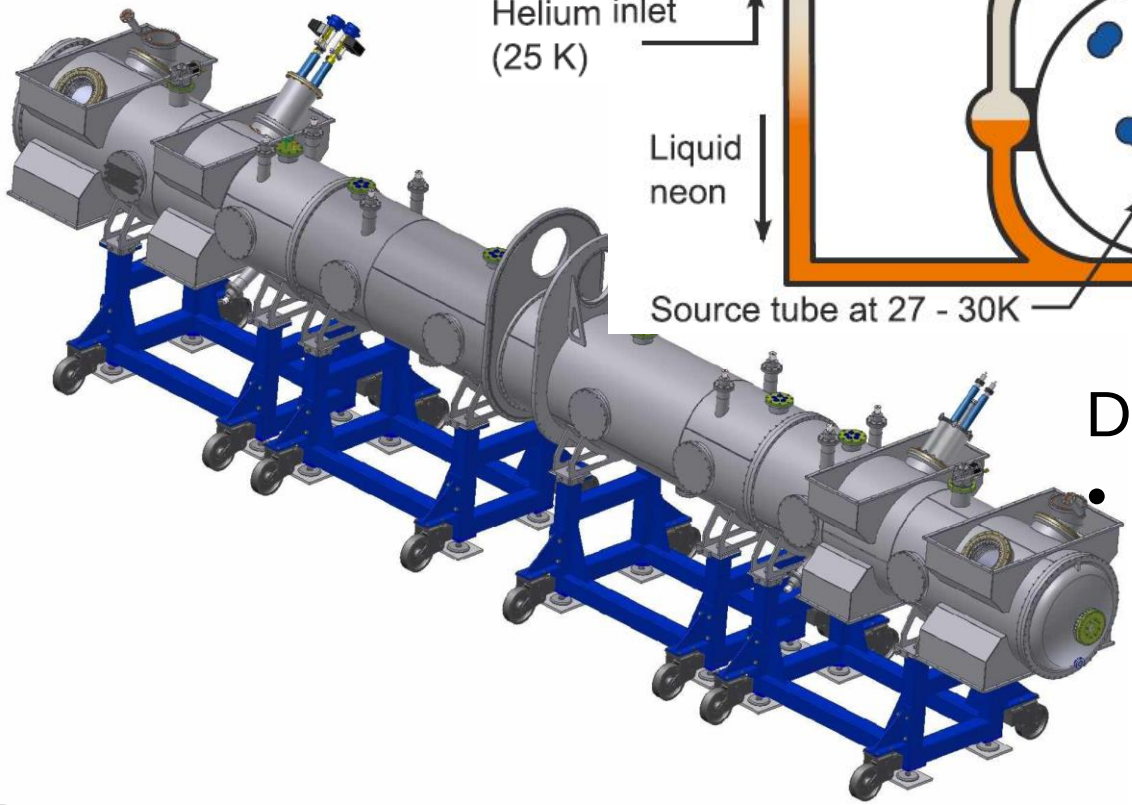


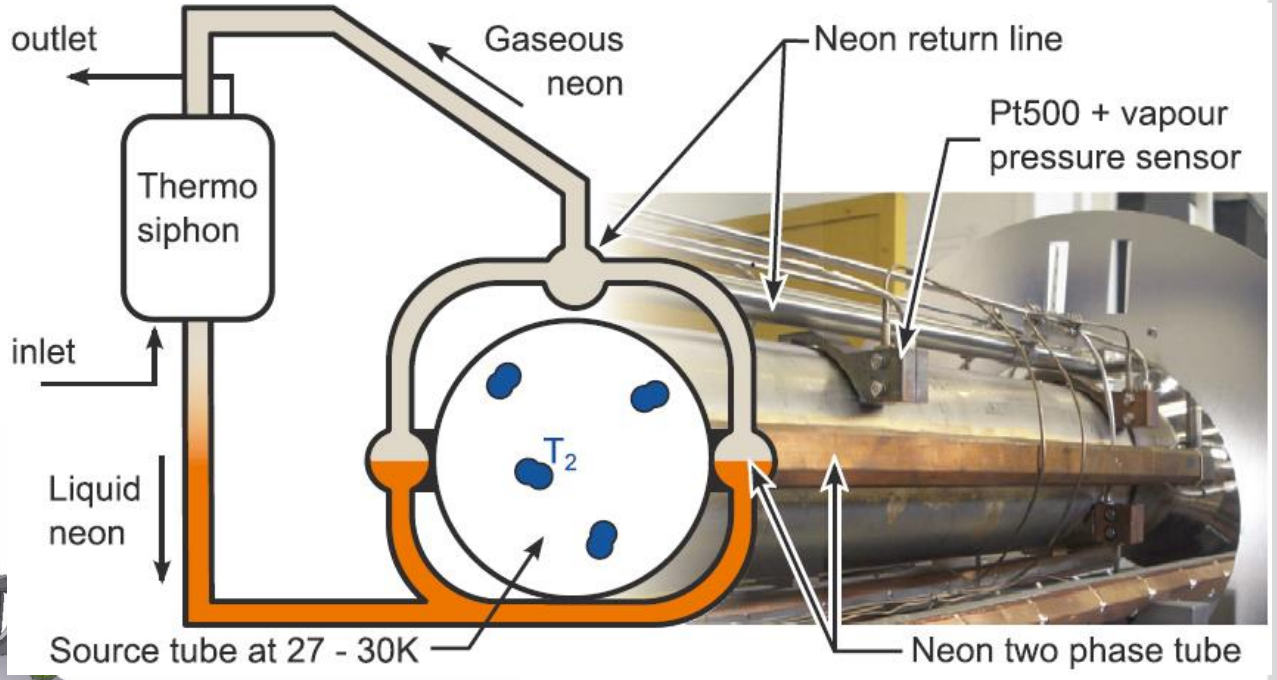
The Demonstrator



- Original components of cooling system (beam tube, pumping chambers..)
- No tritium, no magnets

The Demonstrator



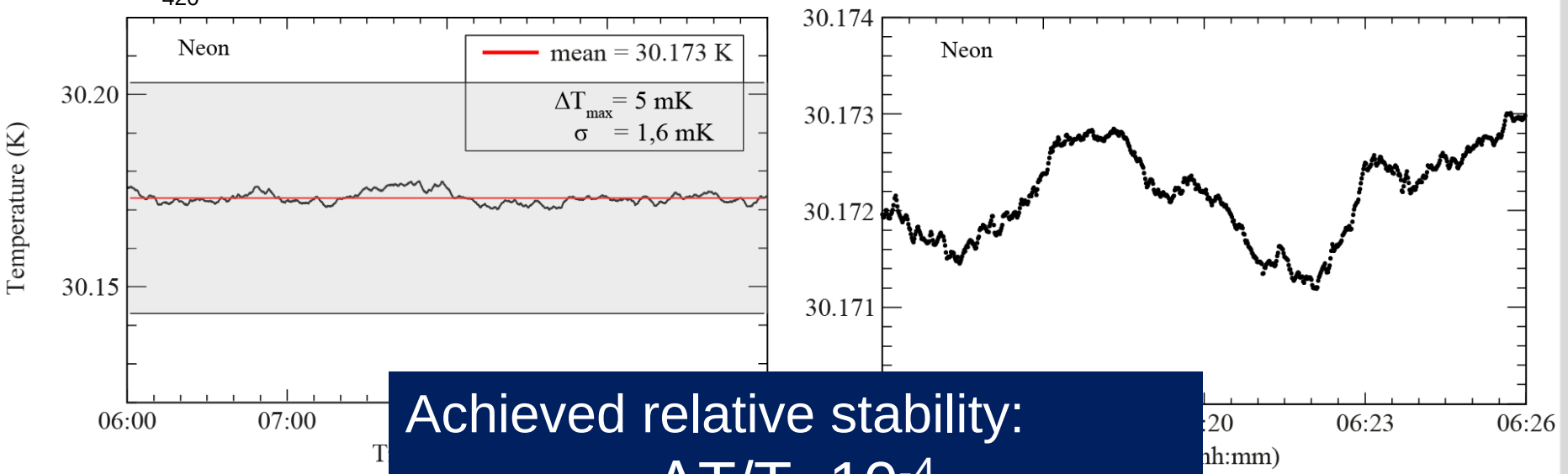


Demonstrator:

- proof-of-principle of 2-phase beam tube cooling principle

Results of temperature stability

S. Grohmann
Cryogenics 49 413–420



Achieved relative stability:

$\Delta T/T=10^{-4}$

one order of magnitude better than required

Summary and Outlook

- Stable and homogenous beam tube temperature requires two-phase cooling system
- Demonstrator showed a stability $\Delta T/T = 10^{-4}$
- Monitoring of hydrogen isotopologues mixture
- In the following year we have to check:
  - Temperature properties of the WGTS
  - Column density stability
  - Purity of the tritium gas

Thank you for your attention!