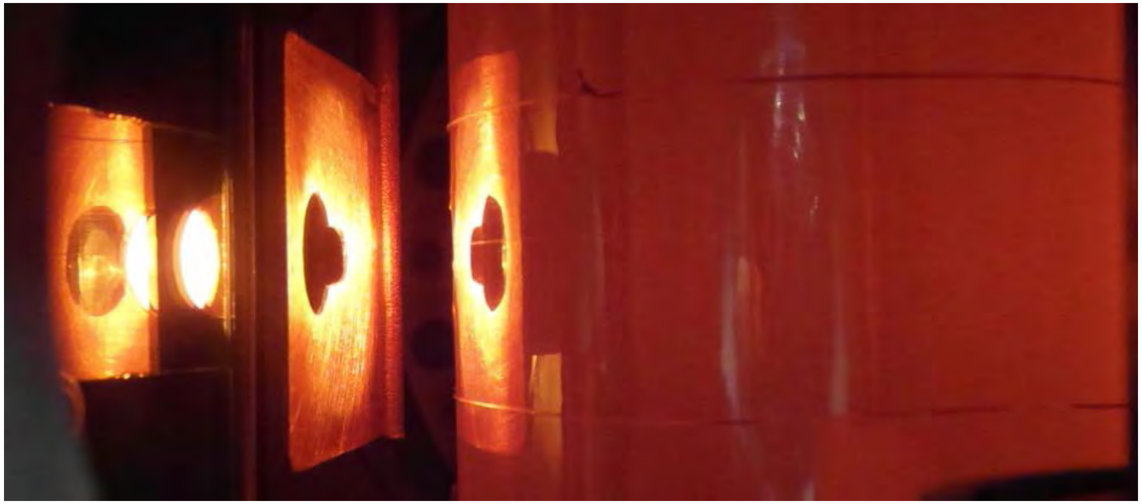
Patrick Steinegger :: Paul Scherrer Institut

Diamond detectors, Tl adsorption on quartz (and E113)

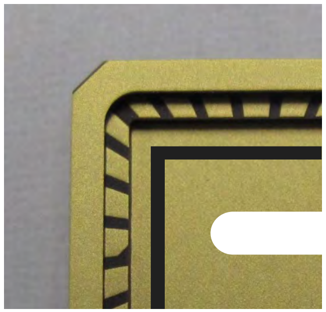
TASCA 15, 14th Workshop on Recoil Separator for Superheavy Element Chemistry @ GSI, Darmstadt – October 23, 2015

Outline

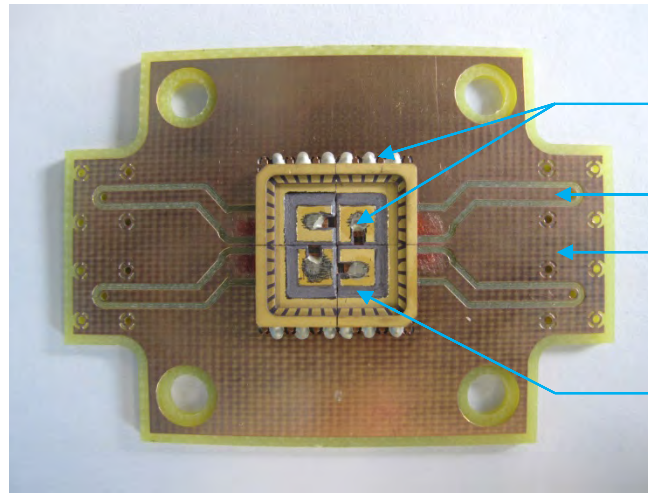
- 4-fold Diamond Detector – Fabrication, α-Spectroscopy and HT-Operation
- High Temperature α-Spectroscopy
- Adsorption of Thallium on Quartz



4-fold Diamond Detector: Fabrication



x 4

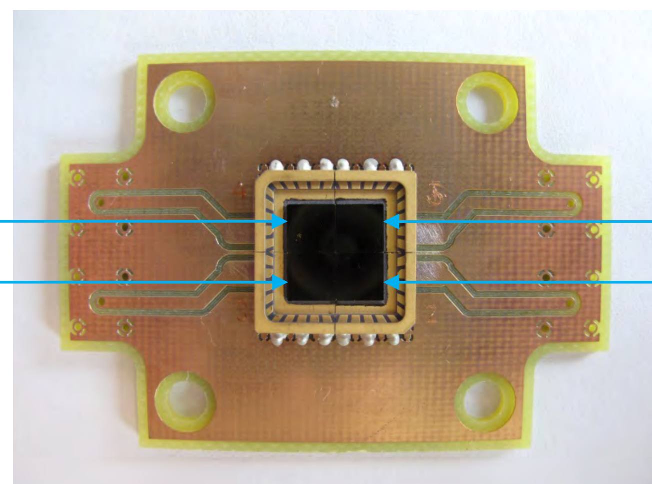


Conduc. glue

PCB signal pad

PCB GND

Grinded insul. groove



EG Diamonds

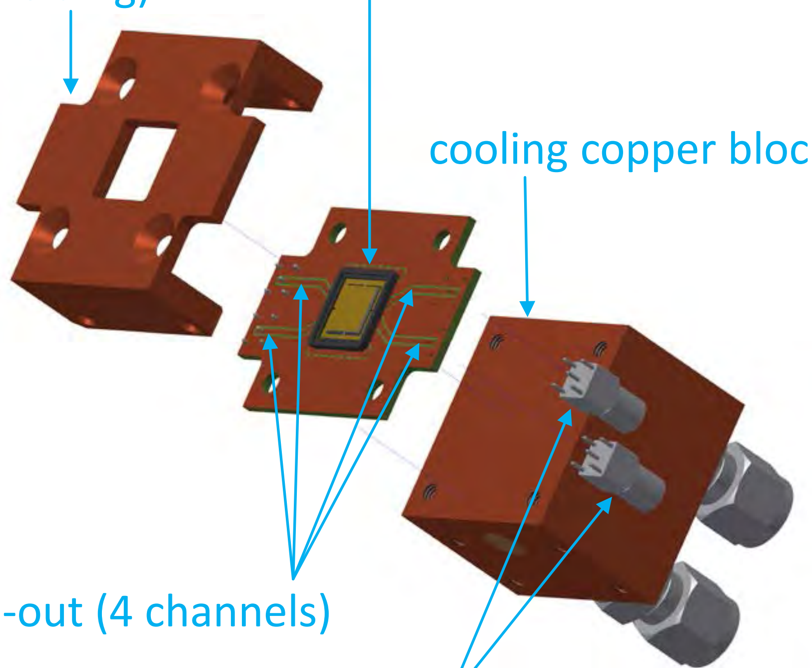
EG Diamonds

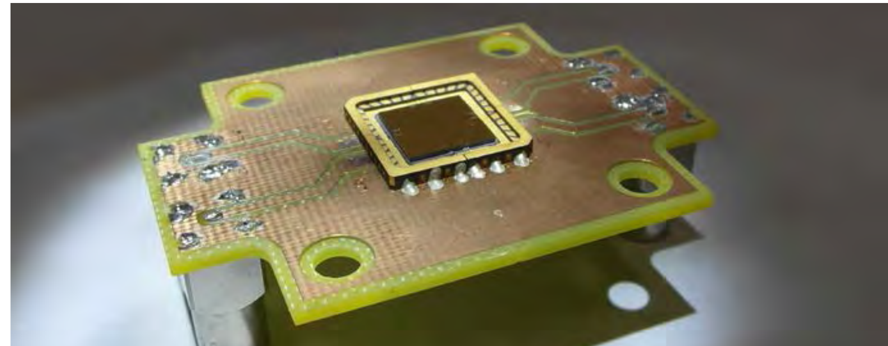
EG Diamonds

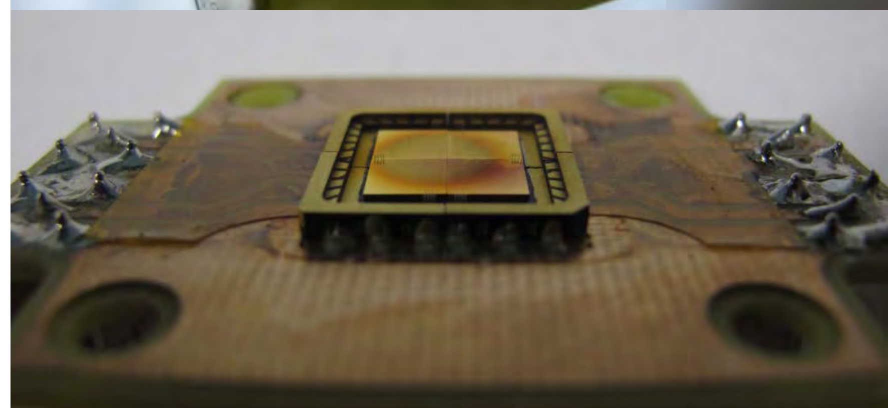
EG Diamonds

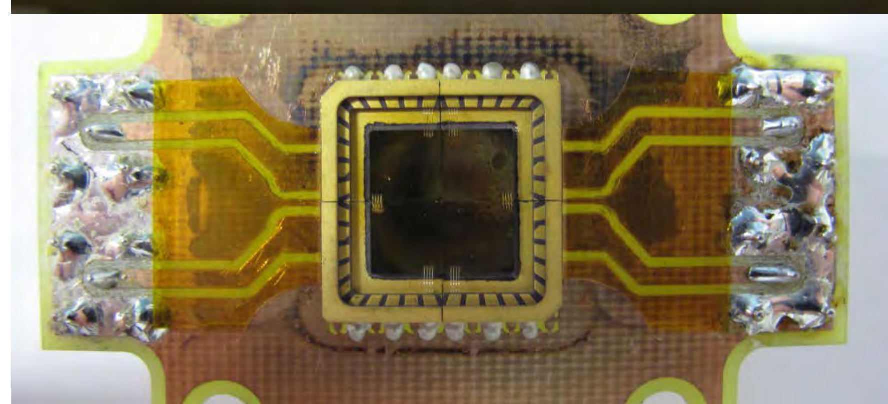
4-fold Diamond Detector: Fabrication

Exploded view of the detector mount









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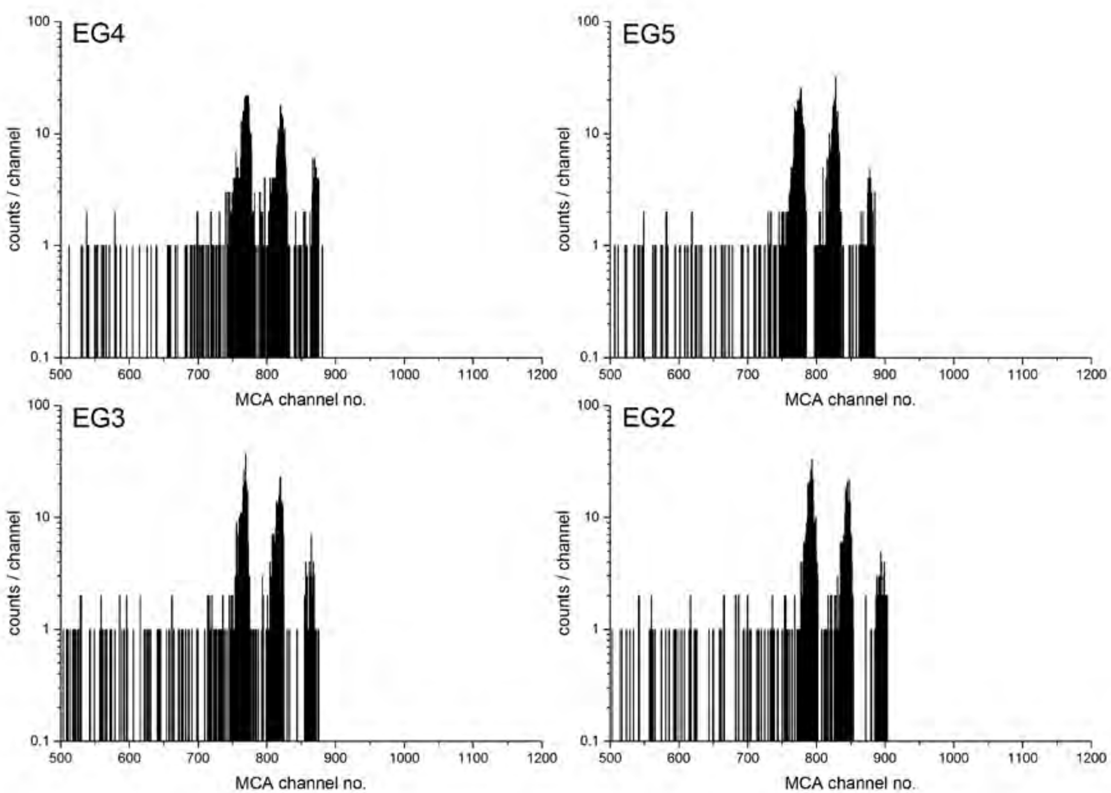
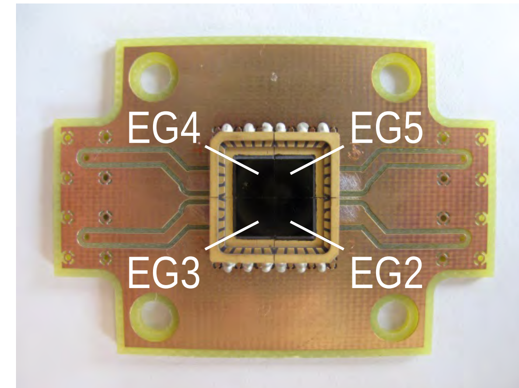
4-fold Diamond Detector: α-Spectroscopy

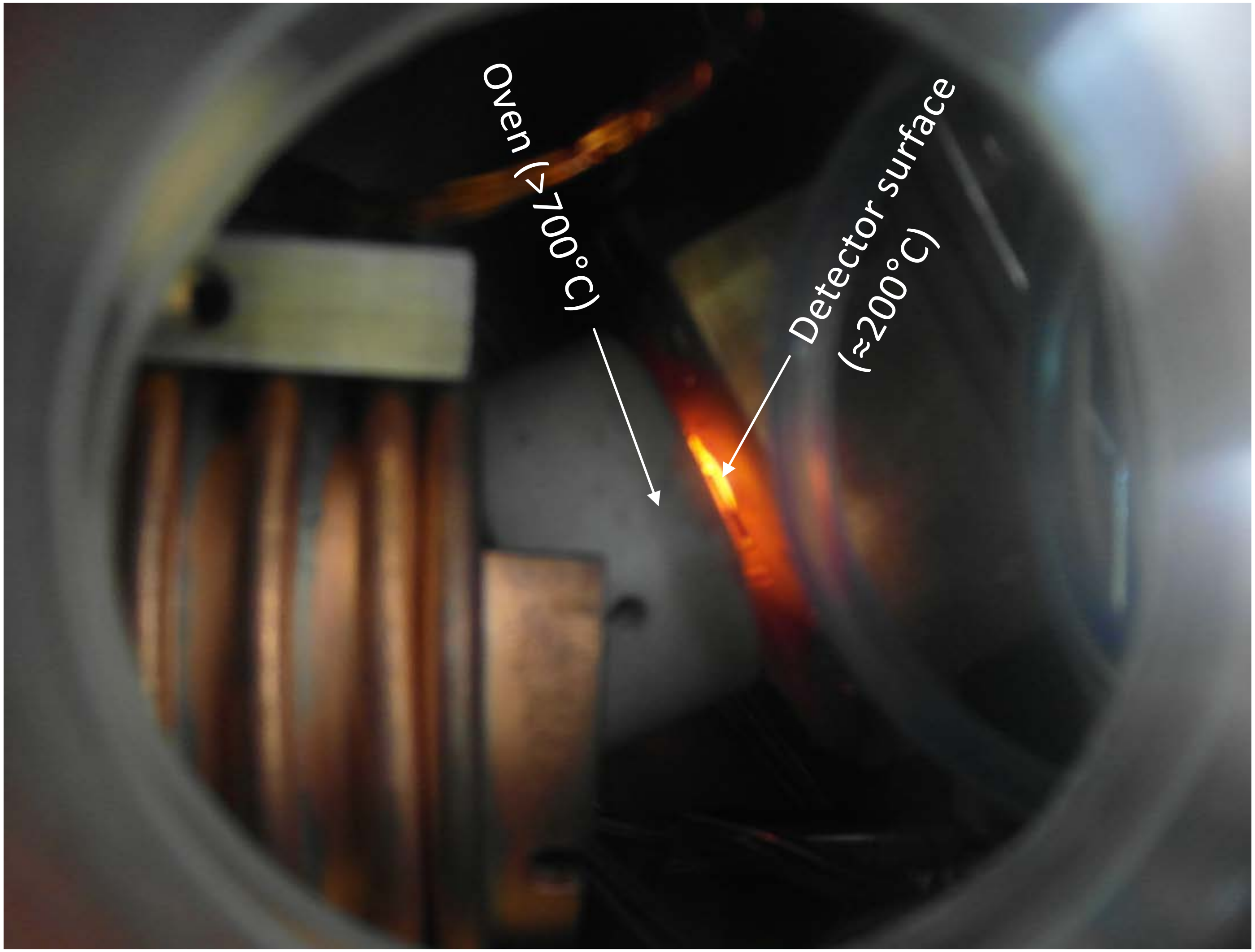
α-Spectroscopic behavior of each channel (3-line source, ^{239}Pu, ^{241}Am and ^{244}Cm).





Energy resolution: ≈ 1.1 %
Breakdown: no

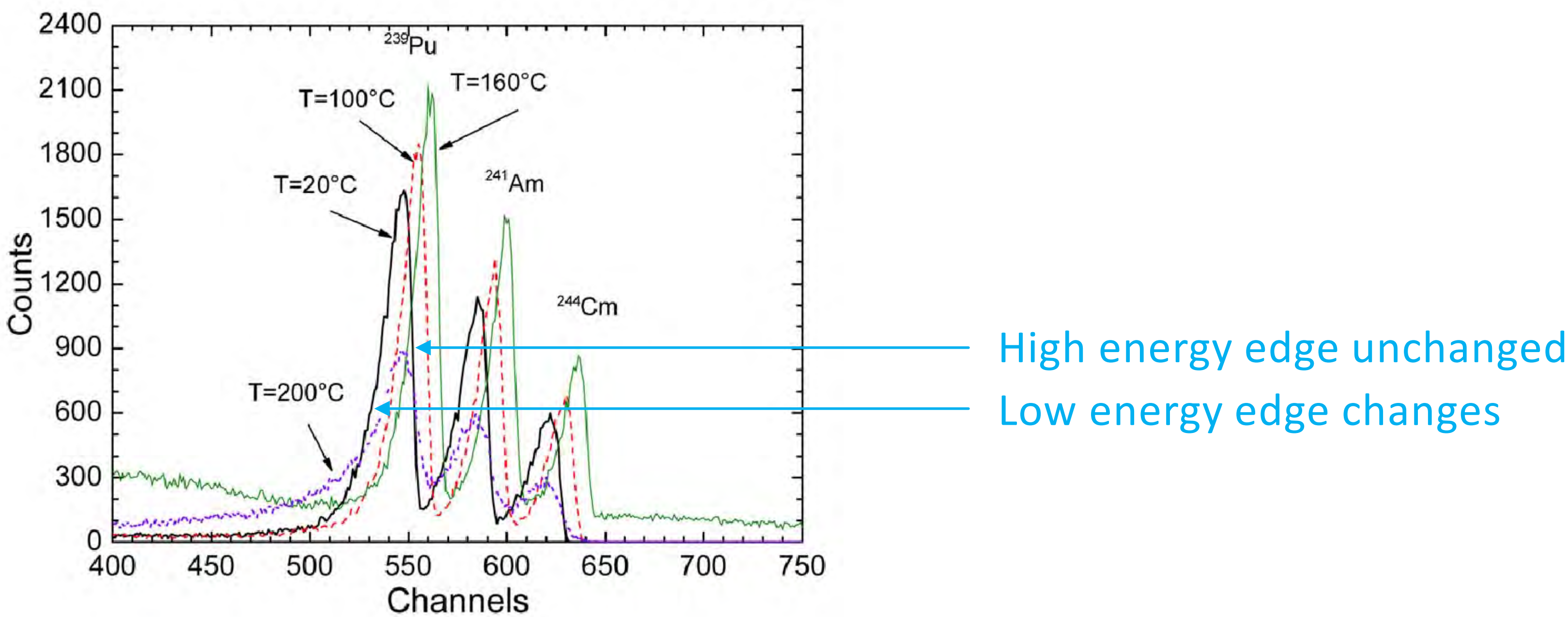
4-fold Diamond Detector: HT Operation



High Temperature α-Spectroscopy

Diamond is a wide band gap material (5.47 eV @ RT) and is therefore well suited for high temperature operation and can accept high IR/VIS/UV-loads. The energy resolution reaches the same level as Si-based solid state detectors [1].

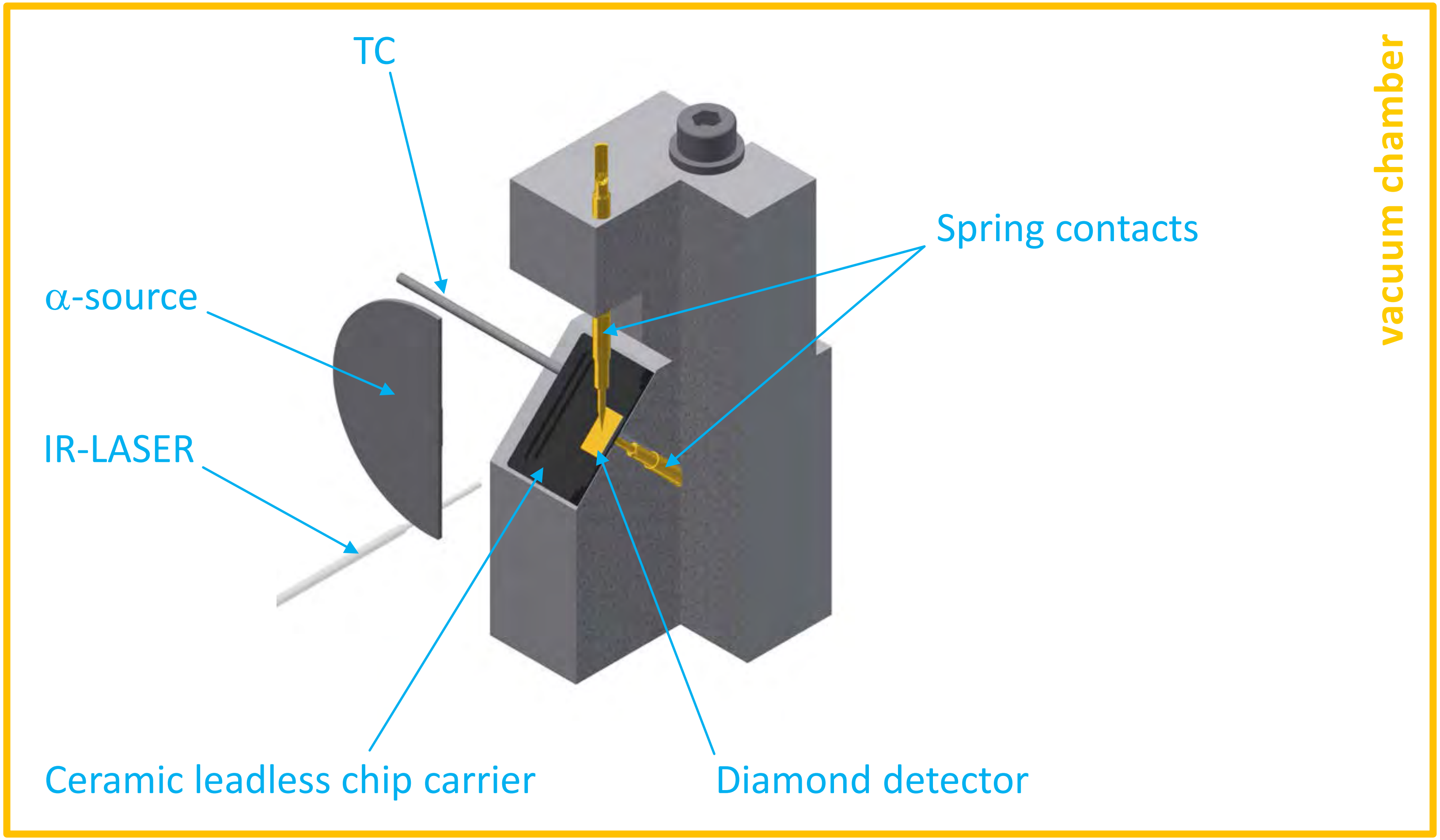
α-spectroscopic measurements reached 200°C [2]:



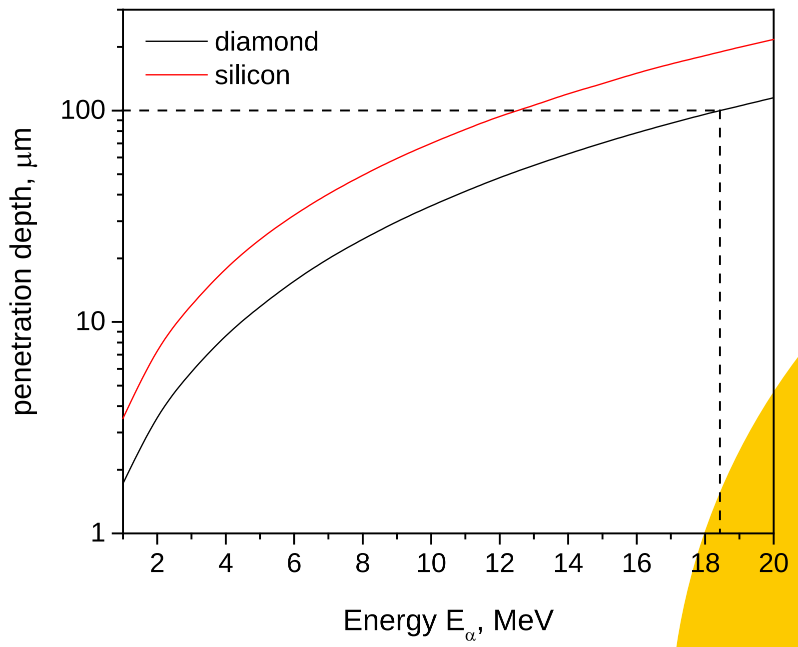
[1] M. Pomorski et al., *Physica Status Solidi (a)* **203** (2006), pp. 3152-3160
[2] M. Angelone et al., *IEEE Transactions on Nuclear Science* **59** (2012) pp. 2416-2423

High Temperature α-Spectroscopy

Laser heated diamond detector for high temperature α-spectroscopic measurements.



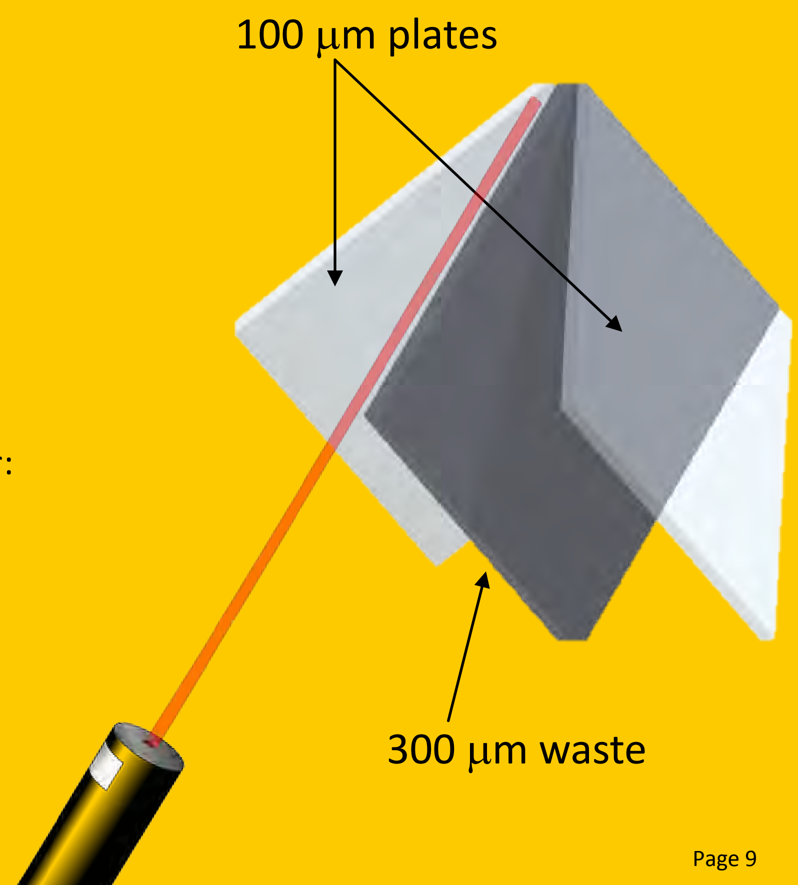
Economical Considerations



Shopping list for a 81 mm^2 active area diamond detector:

2x	escCVD plate (4.5 x 4.5 x 0.5 mm)	EUR 3600.00
2x	LASER-cutting	EUR 200. 00
4x	Polishing to 100 µm	EUR 1000.00
		<u>EUR 4800.00</u>

4x escCVD plate (4.5 x 4.5 x 0.5 mm) **<u>EUR 7200.00</u>**



High Temperature α-Spectroscopy

Preliminary outcome

- High temperature operation up to 250°C succeeded.
- A resolution of roughly 1% could be maintained.
- A few direct heating runs showed a similar behavior as observed by [2].
- A constant count rate was obtained (charge loss, but no event loss).
- Stable operation over long periods (>24 h).
- Successfully tested the slicing option.

How to proceed

- Further tests above 250°C.
- Testing high temperature contact possibilities.
- Al/Au wire-bond stability in high temperature environment.

[2] M. Angelone et al., *IEEE Transactions on Nuclear Science* **59** (2012) pp. 2416-2423

Adsorption of Thallium on Quartz

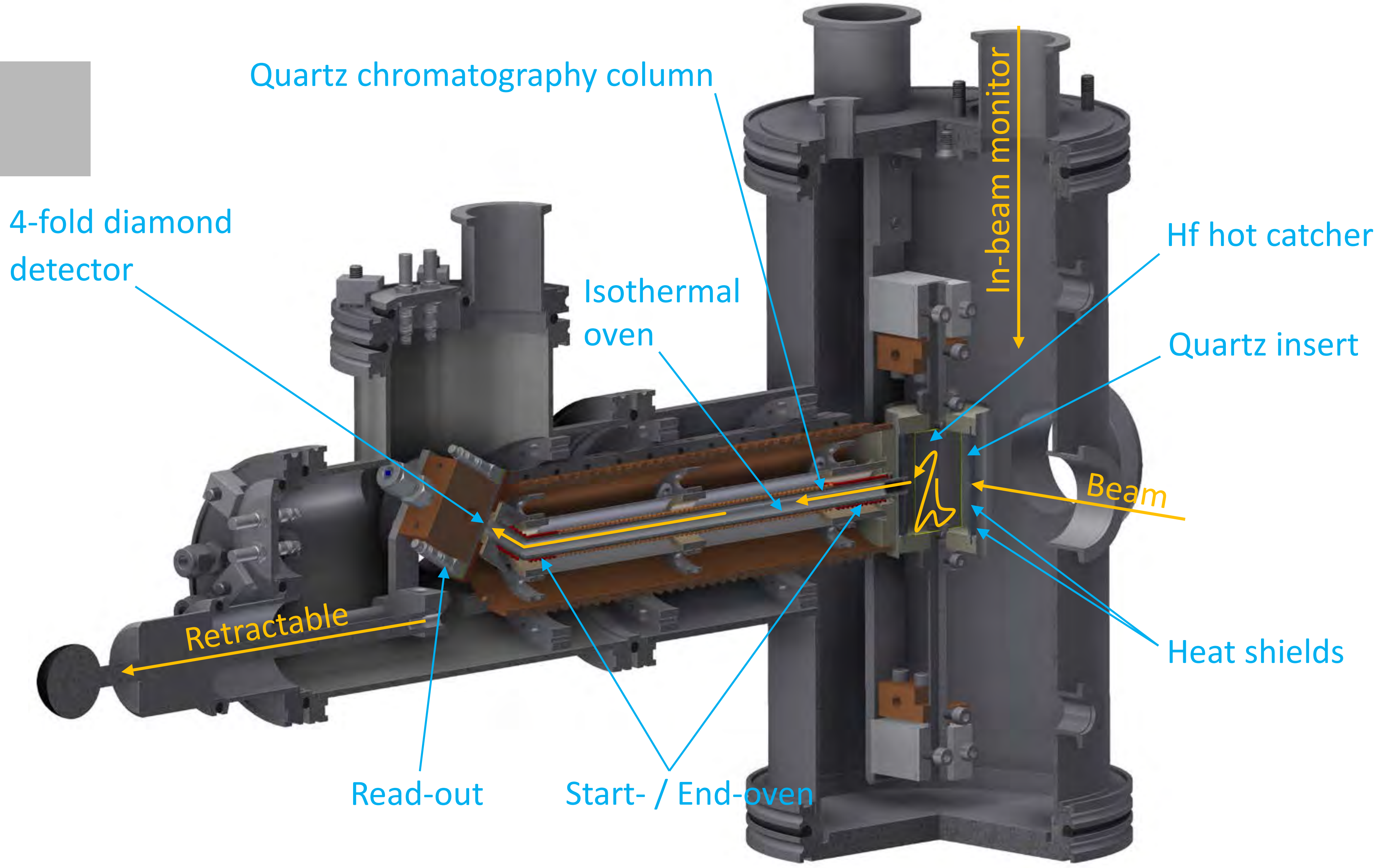
P. Steinegger[1,2], M. Asai[3], R. Dressler[1], R. Eichler[1,2], Y. Kaneya[3], A. Mitsukai[3], Y. Nagame[3], D. Piguet[1], T. K. Sato[3], M. Schädel[3], S. Takeda[3], A. Toyoshima[3], K. Tsukada[3], A. Türler[1,2], A. Vascon[3]

[1] Paul Scherrer Institute (PSI)

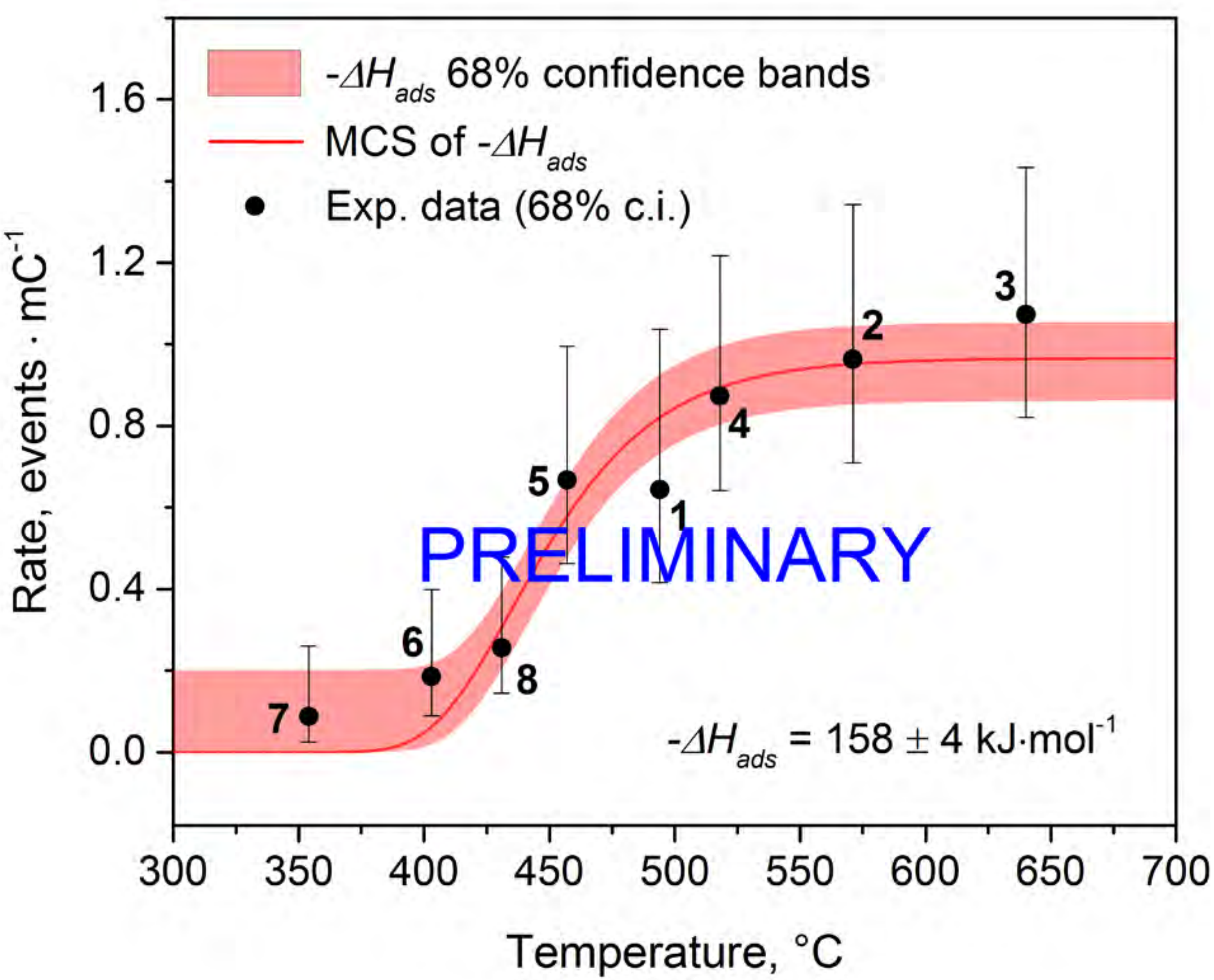
[2] University of Bern

[3] Japan Atomic Energy Agency (JAEA)

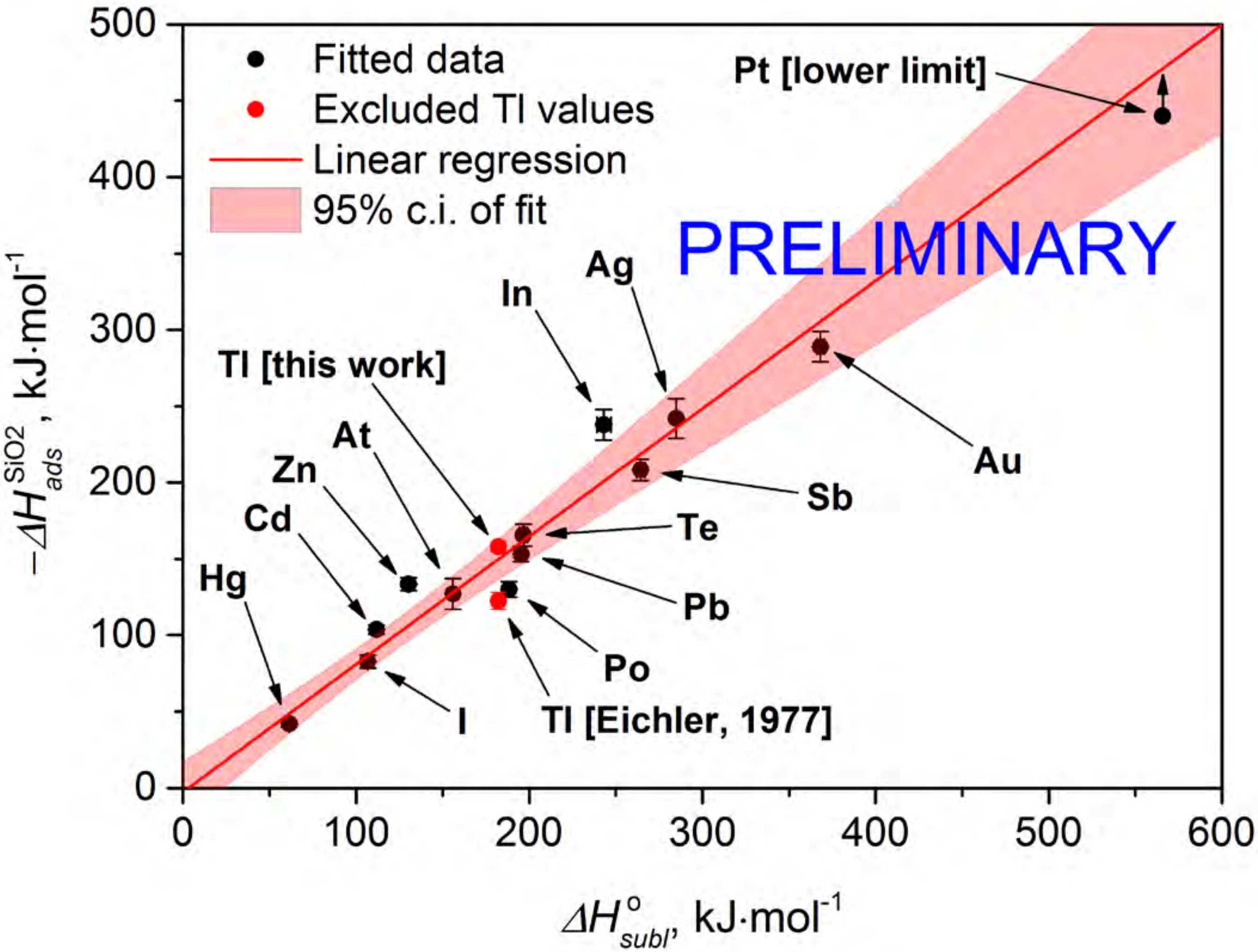
Adsorption of Thallium on Quartz



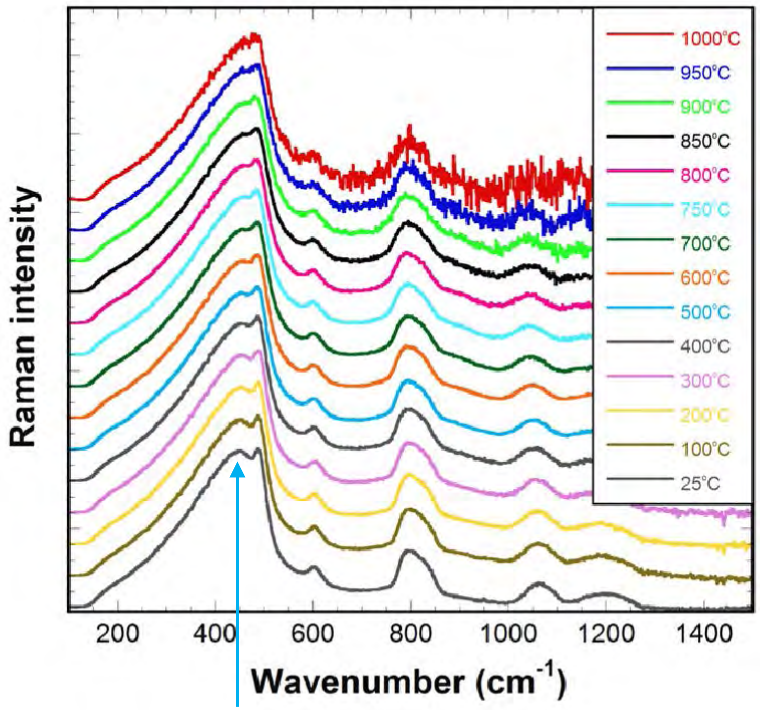
Adsorption of Thallium on Quartz

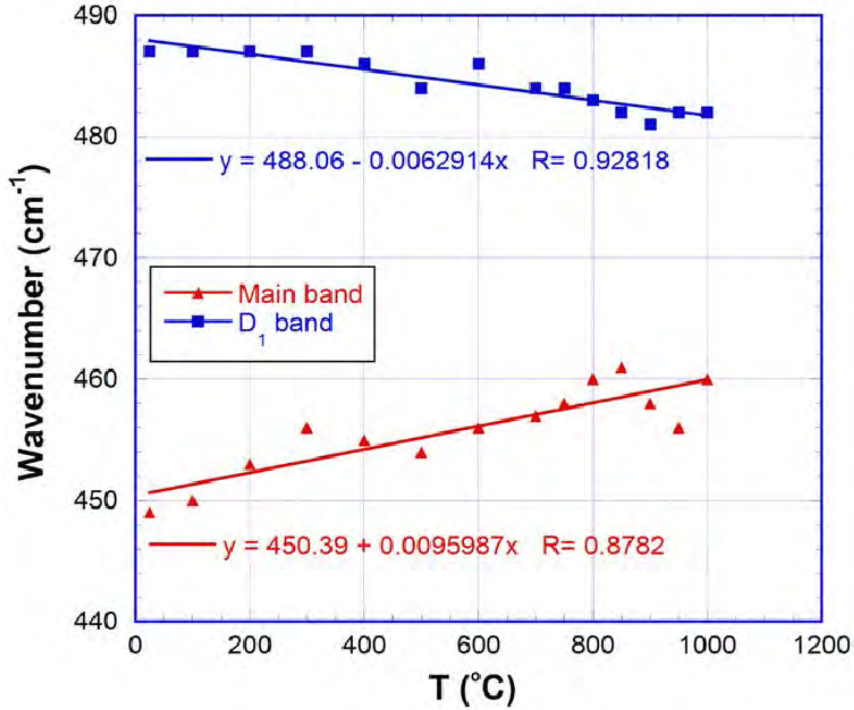


Adsorption of Thallium on Quartz



Remark: Phonon Frequency of Quartz





Main band

Lindemann:	5.46 THz [4]
Guerette:	**13.51 THz [3]**
Zvara:	10.26 THz [5]
Zvara (correct prefac.)	**13.65 THz**

Shift of ≈10 kJ·mol^{-1} in vacuum chromatography

[3] M. Guerette, L. Huang, *Journal of Physics D: Applied Physics* **45** (2012) pp. 1-7
[4] B. Eichler, J. Kratz, Radiochimica Acta 88 (2000), pp. 475-482
[5] I. Zvara, *The Inorganic Radiochemistry of Heavy Elements*, Springer Science+Business Media, 1st edition (2008)

Remark: Phonon Frequency of Quartz

F. A. Lindemann [1]

I. Zvara [3]:

Temperature in [K]

Molar mass [g/mol]

$$\nu_0 = 2.8 \cdot 10^{12} \sqrt{\frac{T_{m.p.}}{\left(\frac{M}{\kappa_M}\right) \cdot \left(\frac{M}{\kappa_M \cdot \rho}\right)^{2/3}}}$$

Density in [g/cm^3]

Correct pre-factor

Number of atoms

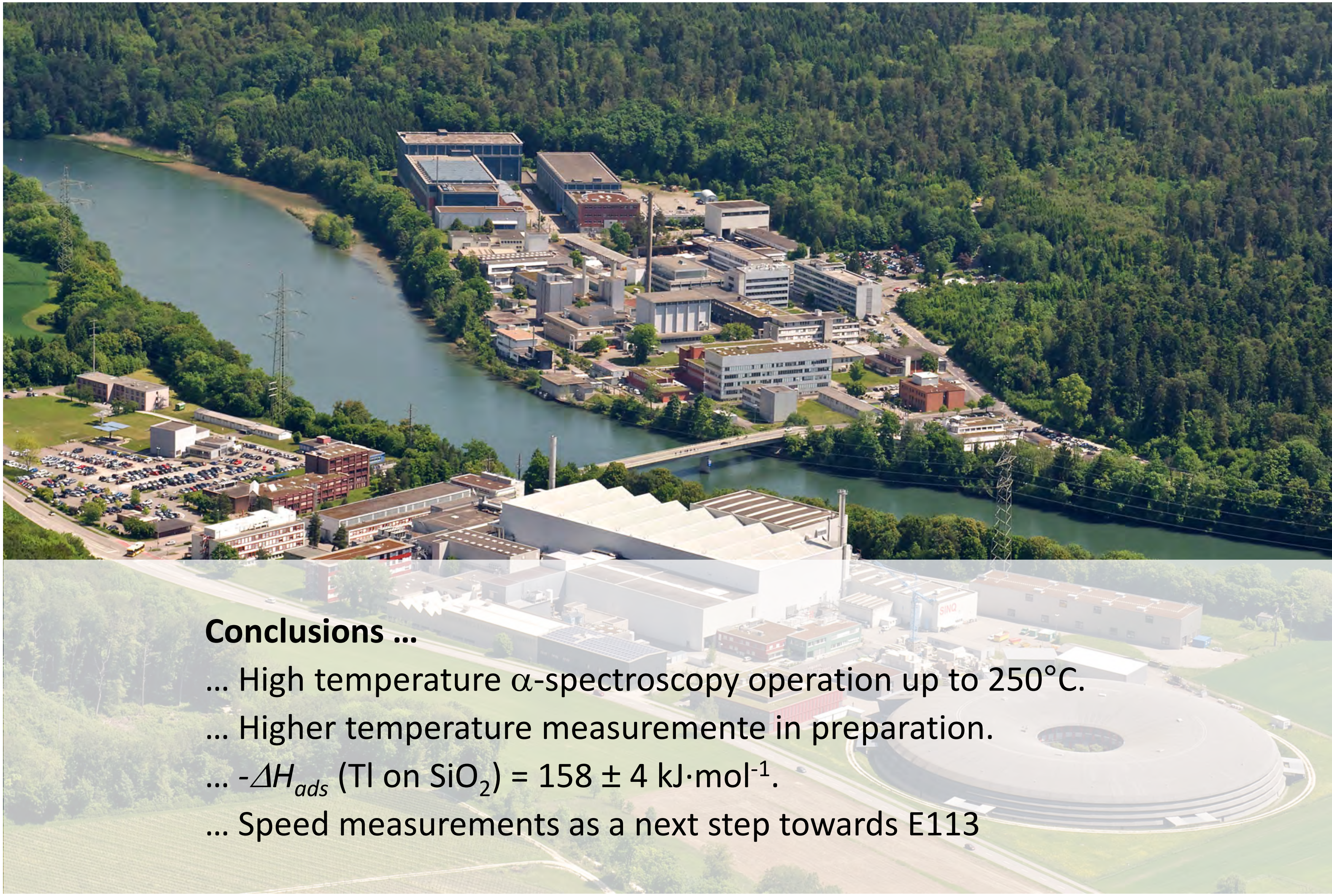
$$\nu_0 = 2.8 \cdot 10^{12} \sqrt{\frac{T_{m.p.}}{A \cdot V^{2/3}}}$$

Avg. “atomic” molar mass

Avg. atomic volume

[5] I. Zvara, *The Inorganic Radiochemistry of Heavy Elements*, Springer Science+Business Media, 1st edition (2008)

[6] F. A. Lindemann, *Physikalische Zeitschrift* **11** (1910), pp. 609-612



Conclusions …

… High temperature α-spectroscopy operation up to 250°C.

… Higher temperature measuremente in preparation.

… $-\Delta H_{ads}$ (Tl on SiO_2) = 158 ± 4 $kJ \cdot mol^{-1}$.

… Speed measurements as a next step towards E113

Involved People, Institutions & Company

/// Akina Mitsukai, Alessio Vascon, Alex ///
/// Vögele, Andreas Türler, Atsushi Toyoshima, ///
/// Christina Weiss, Dave Piguet, Erich Gries- ///
/// mayer, Ilya Usoltsev, Kazuaki Tsukada, ///
/// Masato Asai, Matthias Schädel, Nadine M. ///
/// Chiera, Robert Eichler, Rugard Dressler, ///
/// Shinsaku Takeda, Silvan Streuli, Tetsuya ///
/// K. Sato, Yuichiro Nagame, Yusuke Kaneya ///

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b UNIVERSITÄT BERN

FNSNF
FONDS NATIONAL SUISSE
SCHWEIZERISCHER NATIONALFONDS
FONDO NAZIONALE SVIZZERO
SWISS NATIONAL SCIENCE FOUNDATION

JAEA

cividec Instrumentation

Thank you for your kind attention!