Chemistry of flerovium – current status

Lotte Lens[1,2] for the TASCA Flerovium Chemistry Collaboration

[1]Johannes Gutenberg University Mainz, Germany
[2]GSI Darmstadt, Germany

TASCA Workshop 16 – Darmstadt, Germany, August 26, 2016

L.Lens@gsi.de

The TASCA Flerovium Chemistry Collaboration

GSI Darmstadt (D)	A. Yakushev, M. Block, H. Brand, H.M. David, F.P. Heßberger, J. Hoffmann, A. Hübner, E. Jäger, B. Kindler, J. Krier, N. Kurz, B. Lommel, V. Pershina, J. Runke, M. Schädel, B. Schausten, J. Steiner
Univ. Mainz (D)	Ch.E. Düllmann, A. Di Nitto, K. Eberhardt, J.V. Kratz, L. Lens, C. Mokry, P. Thörle-Pospiech, N. Trautmann, N. Wiehl
HIM Mainz (D)	M. Götz, S. Götz, J. Khuyagbaatar, M. Laatiaoui, A. Mistry, P. Scharrer, V. Yakusheva
Univ. Liverpool (UK)	R.-D. Herzberg, L. Harkness-Brennan, D. Judson, A. Ward
Univ. Lund (S)	U. Forsberg, P. Golubev, D. Rudolph, L. Sarmiento
Univ. Jyväskylä (F)	J. Konki, P. Papadakis, J. Uusitalo
Univ. Oslo (N)	J.P. Omtvedt
RIKEN, Wako-shi (J)	H. Haba, Y. Komori
JAEA, Tokai (J)	M. Asai, Y. Nagame, T. Sato , K. Tsukada
IITR Uttarakhand, (IN)	M. Maiti
SINP Kolkata (IN)	S. Lahiri
LLNL Livermore, (USA)	J. Despotopulos, K. Moody, D. Shaughnessy
ANU Canberra, (AU)	D. Hinde, E. Williams
ITE Warsaw (PL)	M. Wegrzecki

JG|U

Acknowledgments

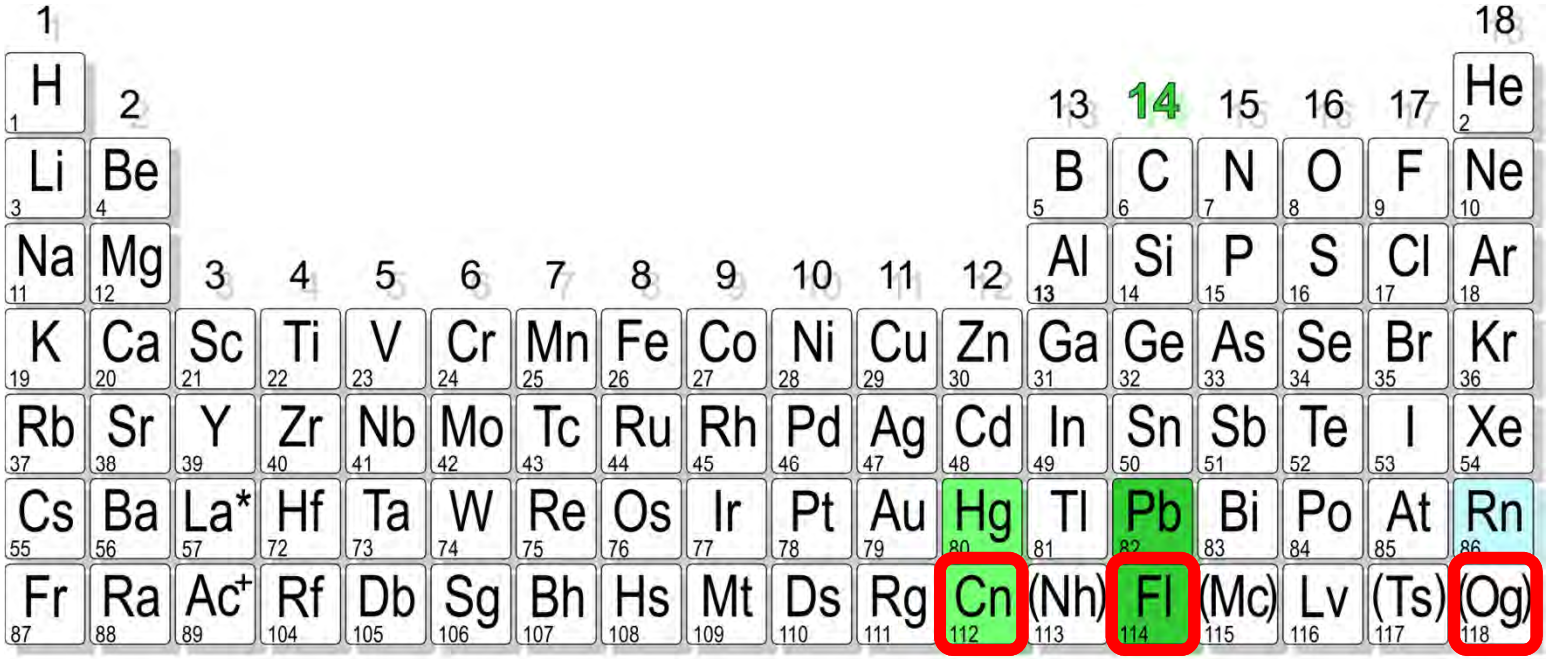
- GSI Ion source and accelerator operation staff
- Electrical / mechanical workshops
- Experimental electronic department GSI

- BMBF Verbundforschung

- JAEA ASRC's Reimei Program

- ENSAR Travel support Program

Introduction



Are elements 112, 114, and 118 relatively inert gases?

Kenneth S. Pitzer

Department of Chemistry and Inorganic Materials Research Division of the Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720

(Received 14 April 1975)

The Journal of Chemical Physics, Vol. 63, No. 2, 15 July 1975 1032

Predictions of adsorption Enthalphies for

Adsorption enthalphies $-\Delta H_{ads}$ (in kJ/mol) of Hg-Au_n , Pb-Au_n , Cn-Au_n and Fl-Au_n for Au(111) and of Hg-SiO_2, Pb-SiO_2, Cn-SiO_2, Fl-SiO_2 for SiO_2 hydroxylated α-quartz (001) surface

Hg

	$-\Delta H_{ads}$ Theory	$-\Delta H_{ads}$ Experiment	Ref.
SiO_2	54	42±2	4,2,3
Au	54	98±3	1,7

Pb

	$-\Delta H_{ads}$ Theory	$-\Delta H_{ads}$ Experiment	Ref.
SiO_2	152	165±4	4,2,3
Au	232	234	1,5,6

Cn

	$-\Delta H_{ads}$ Theory	$-\Delta H_{ads}$ Experiment	Ref.
SiO_2	-38	-	4
Au	45	52^{+4}_{-3}	1,5,6

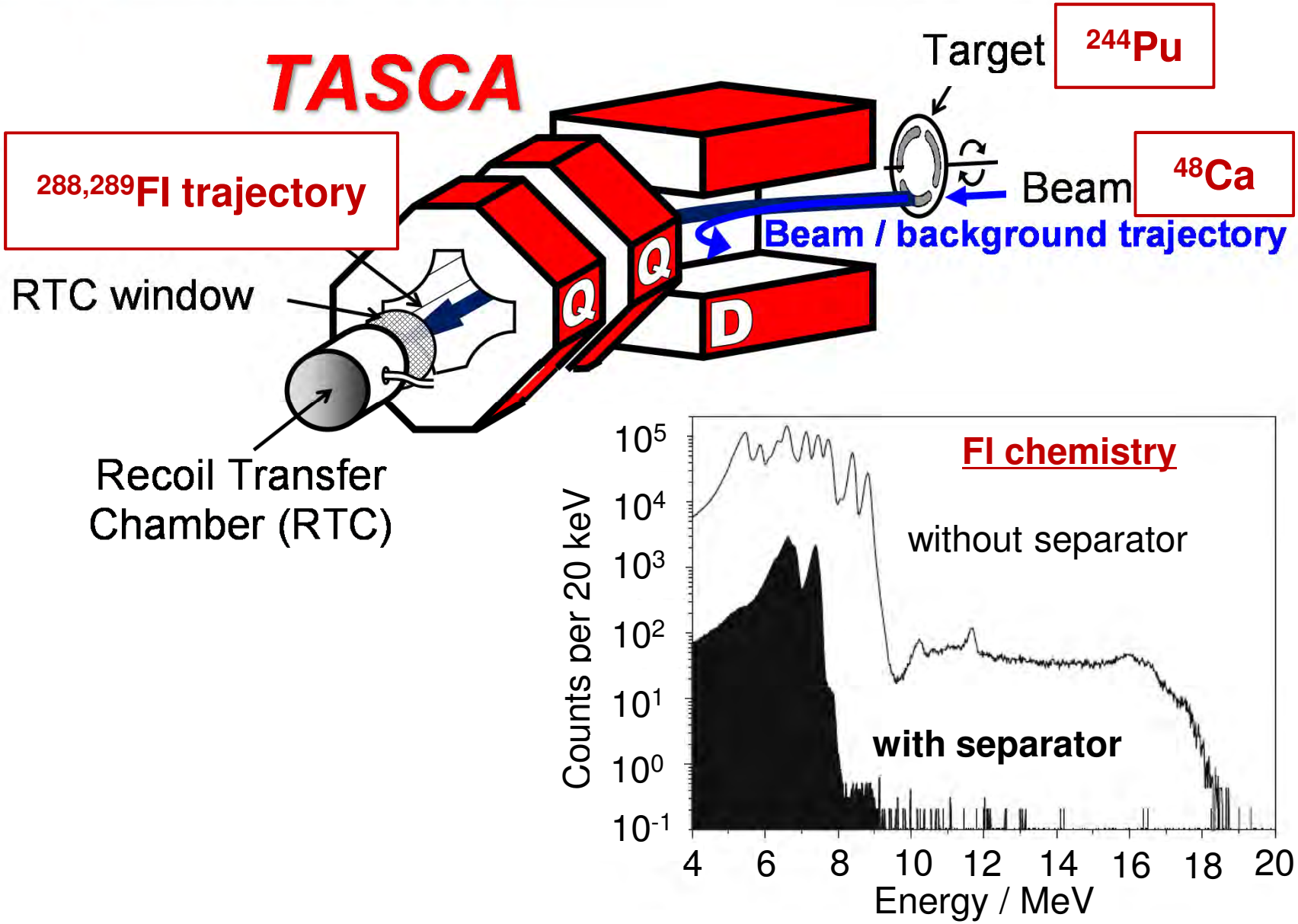
Fl

	$-\Delta H_{ads}$ Theory	$-\Delta H_{ads}$ Experiment	Ref.
SiO_2	-22	-	4
Au	68	Under discussion	1,5,6

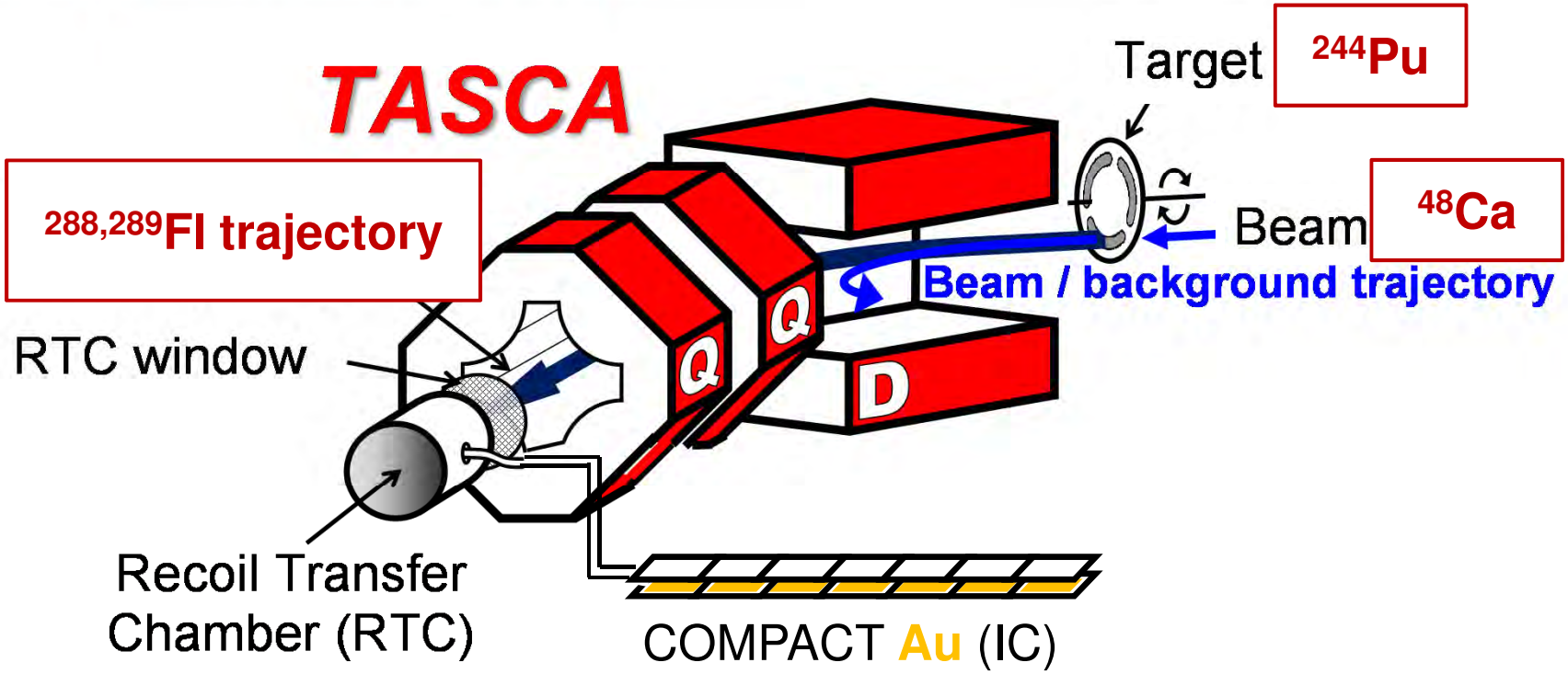
1. V. Pershina ***et al.***, J. Chem. Phys. 131, 084713 (2009)
2. S. Soverna, Doctoral Thesis, University Bern (2004)
3. R. Eichler, private communication, (2015) to be published
4. V. Pershina, Phys. Chem. Chem. Phys. 18, 17750-17756 (2016)
5. R. Eichler ***et al.,*** Nature 447, 72 (2007)
6. R. Eichler ***et al.,*** Radiochim. Acta 98, 133 (2010)
7. S. Soverna ***et al.***, RCA 93 (2005)

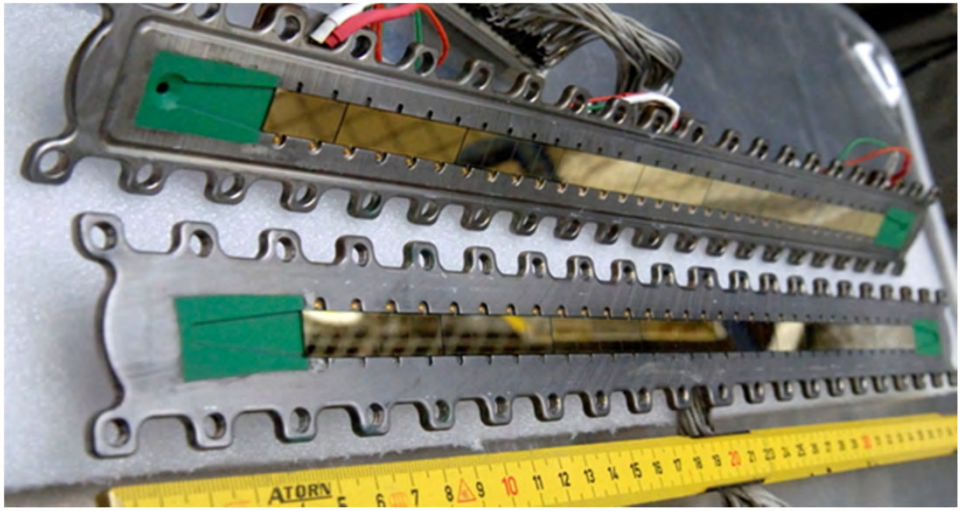
JG|U

Experimental setup

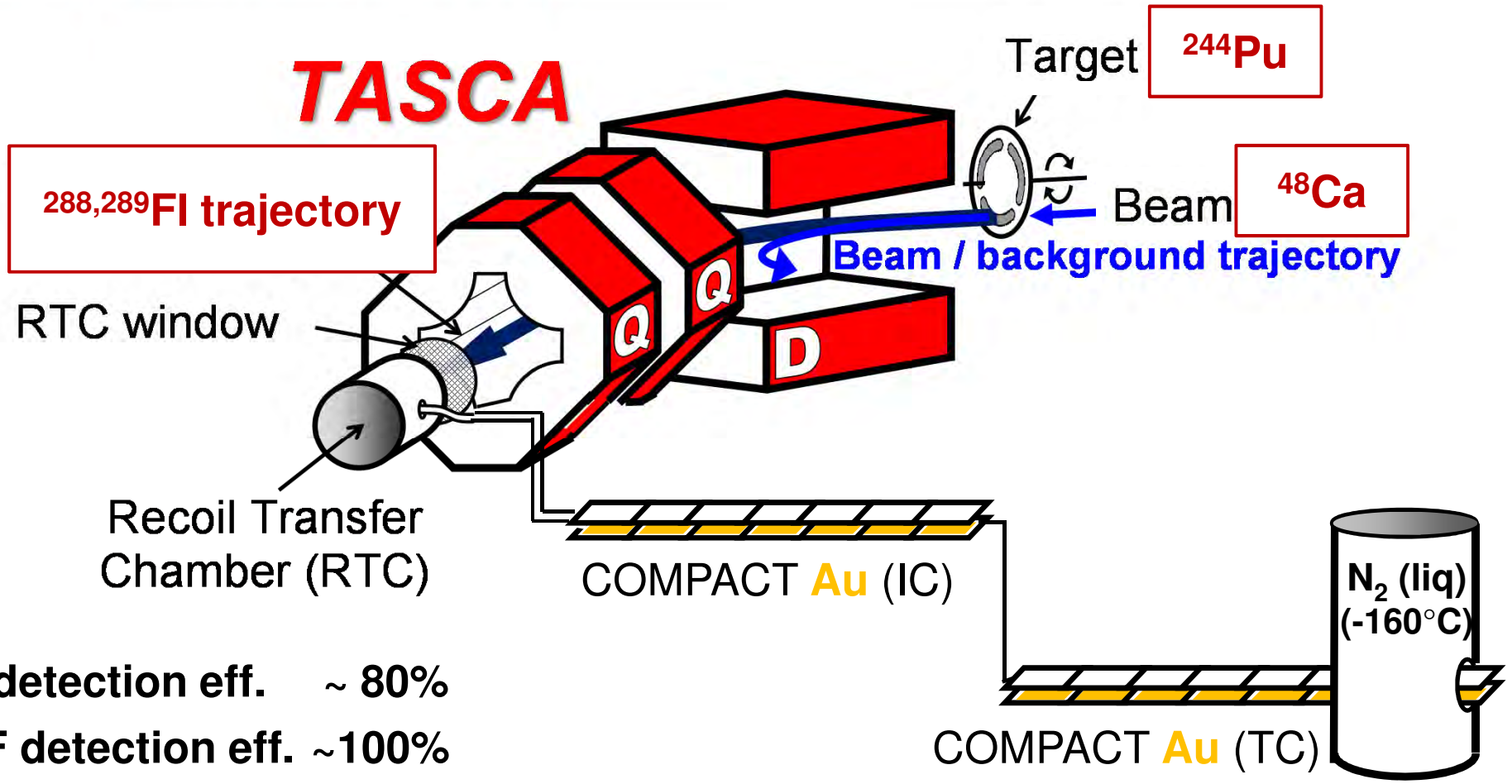


Experimental setup





Experimental setup

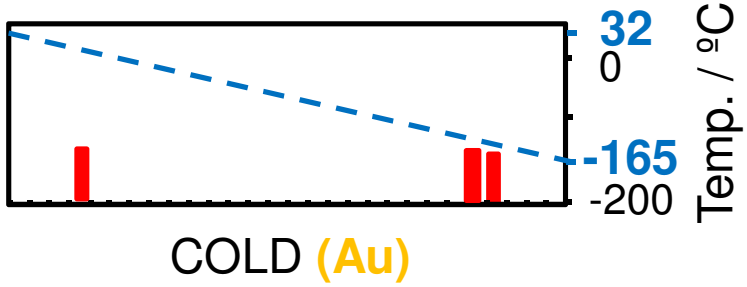


- **α detection eff. ~ 80%**
- **SF detection eff. ~100%**
- **Full digital electronics**

[N. Kurz ***et al***., GSI Scientific Report 252 (2012)]
[J. Hoffmann ***et al***., GSI Scientific Report 253 (2012)]
[J. Khuyagbaatar ***et al***., GSI Scientific Report 212 (2012)]

Experimental status

2007 (PSI / FLNR) (without seperator, 5 weeks, beam dose: $6*10^{18}$)

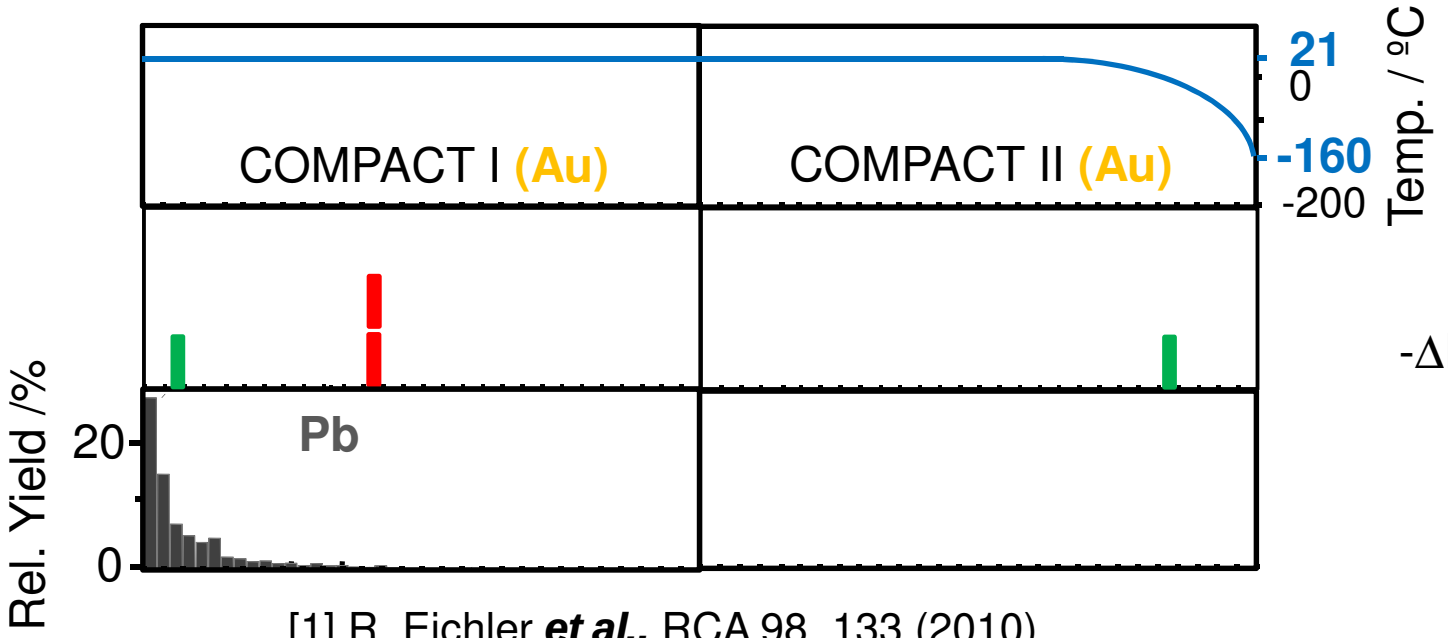


$-\Delta H_{ads}^{Au}(Fl) = 34^{+54}_{-11}$ kJ/mol[1]

➢Weak physisorption bond Fl(Au)

2009 GSI Darmstadt (with separator, 4 weeks, beam dose: $4*10^{18}$)

Fl decay SF



$-\Delta H_{ads}^{Au}(Fl) > 48$ kJ/mol[2]

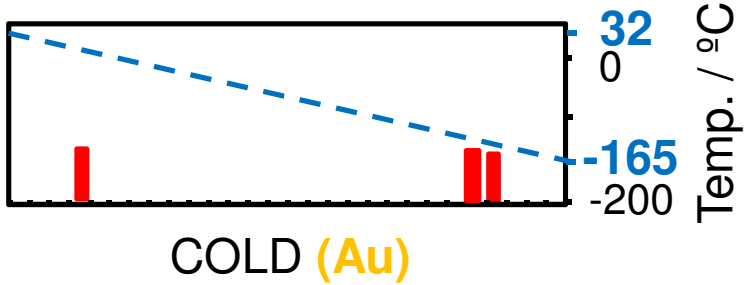
➢ Metallic character

[1] R. Eichler ***et al.,*** RCA 98, 133 (2010),

[2] A. Yakushev ***et al.,*** Inorg. Chem. 53, 1624 (2014)

Experimental status

2007 (PSI / FLNR) (without seperator, 5 weeks, beam dose: $6*10^{18}$)

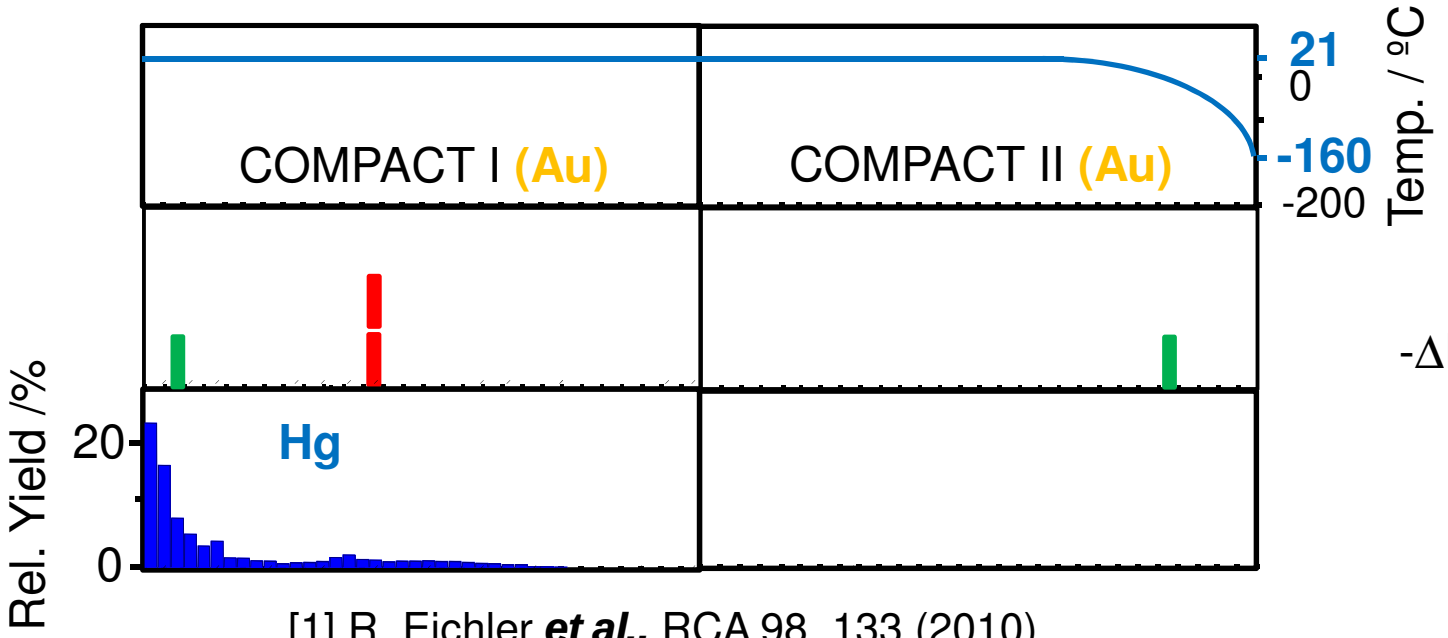


$-\Delta H_{ads}^{Au}(Fl) = 34^{+54}_{-11}$ kJ/mol[1]

➢Weak physisorption bond Fl(Au)

2009 GSI Darmstadt (with separator, 4 weeks, beam dose: $4*10^{18}$)

Fl decay SF



$-\Delta H_{ads}^{Au}(Fl) > 48$ kJ/mol[2]

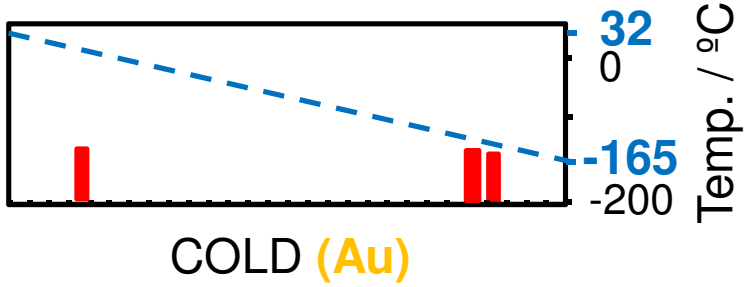
➢ Metallic character

[1] R. Eichler ***et al.,*** RCA 98, 133 (2010),

[2] A. Yakushev ***et al.,*** Inorg. Chem. 53, 1624 (2014)

Experimental status

2007 (PSI / FLNR) (without seperator, 5 weeks, beam dose: $6*10^{18}$)

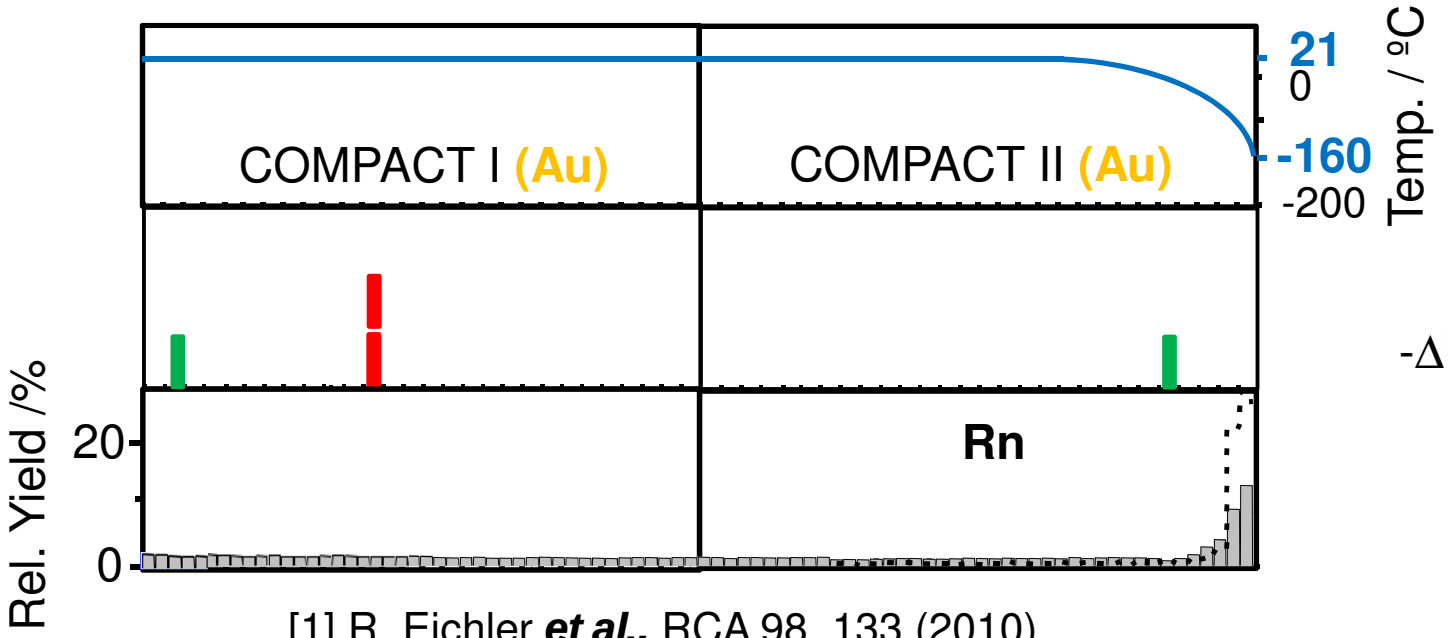


$-\Delta H_{ads}^{Au}(Fl) = 34^{+54}_{-11}$ kJ/mol[1]

➢Weak physisorption bond Fl(Au)

2009 GSI Darmstadt (with separator, 4 weeks, beam dose: $4*10^{18}$)

Fl decay SF



$-\Delta H_{ads}^{Au}(Fl) > 48$ kJ/mol[2]

➢ Metallic character

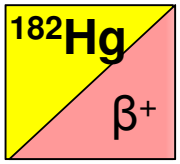
[1] R. Eichler ***et al.,*** RCA 98, 133 (2010),

[2] A. Yakushev ***et al.,*** Inorg. Chem. 53, 1624 (2014)

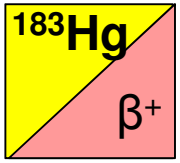
Results of preparatory experiments with Pb and Hg

Reaction

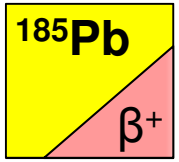
- $^{50}Ti + {}^{140}Ce \xrightarrow{5n\text{-}8n} {}^{182\text{-}185}Hg$
- $^{50}Ti + {}^{142}Nd \xrightarrow{6n,7n} {}^{185,186}Pb$



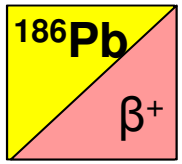
$T_{1/2}$: 10.8 s, **E_α**: 5.9 MeV
b_α: 15.2%



$T_{1/2}$: 8.8 s, **E_α**: 5.9 MeV
b_α: 11.7%



$T_{1/2}$: 4.3 s, **E_α**: 6.4 MeV
$T_{1/2}$: 6.3 s, **E_α**: 6.3 MeV, 6.5 MeV
b_α: 50%, 34%

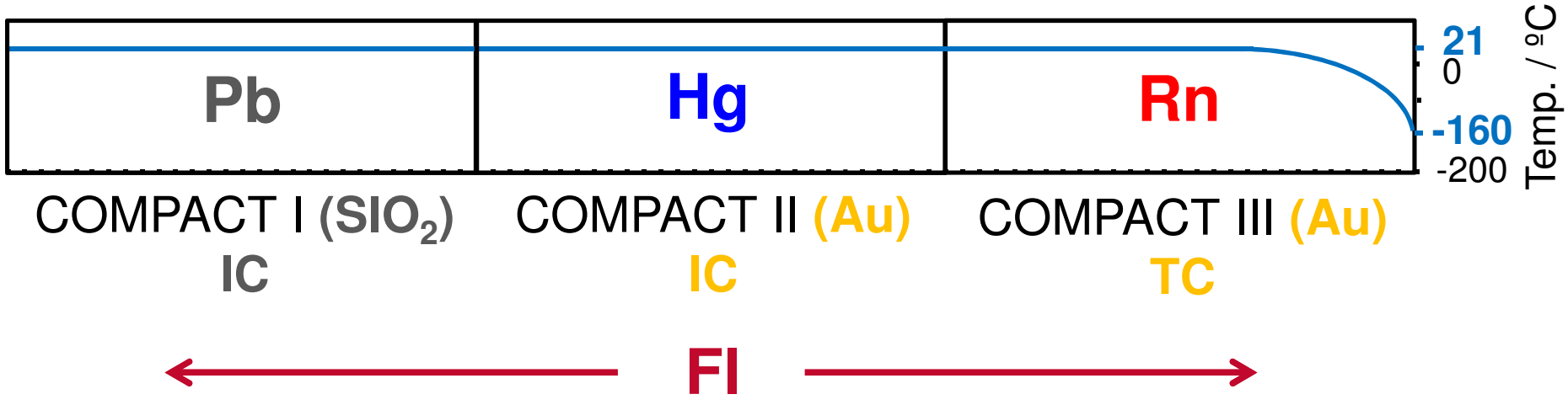


$T_{1/2}$: 4.8 s, **E_α**: 6.3 MeV
b_α: 54%

Fl experiment at TASCA 2014

Scope:

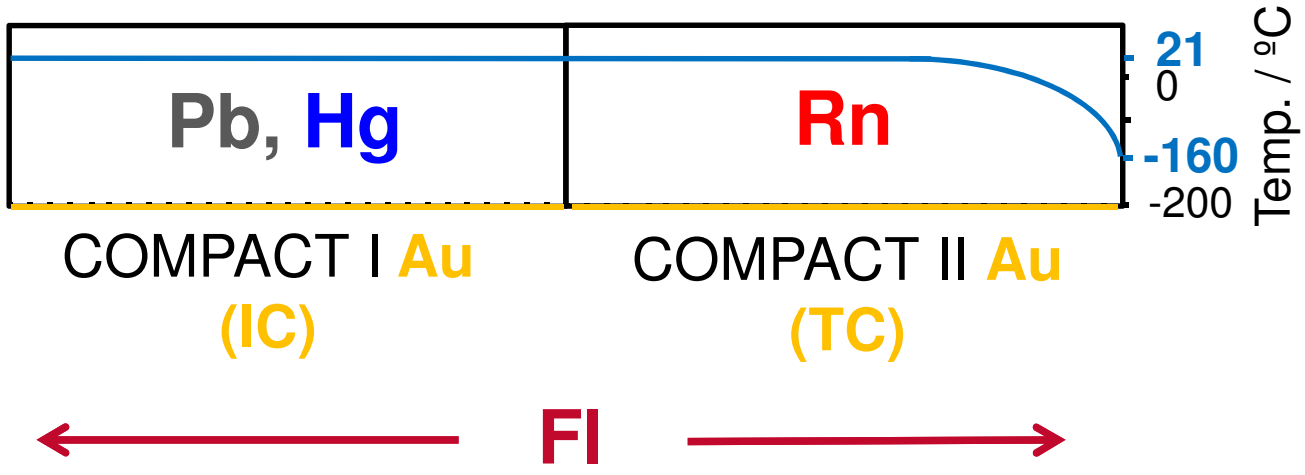
- Experimental investigations on the chemical properties of ^{288,289}Fl in comparison to Pb, Hg, Rn and Cn



The Flerovium Experiment 2015

Scope:

- Optimization of the transport time with Hg
- Experimental investigations on the chemical properties of ^{288,289}Fl in comparison to Pb, Hg, Rn and Cn



Flerovium experiments 2014 + 2015

Data are currently being analyzed