



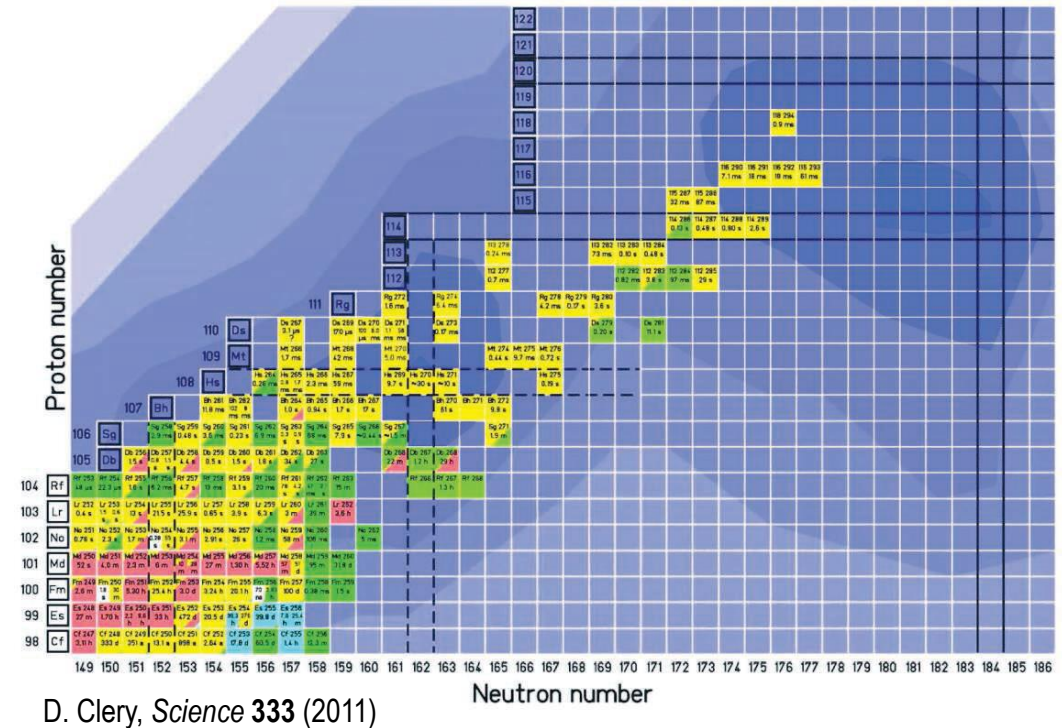
Wir schaffen Wissen – heute für morgen

Paul Scherrer Institute & University of Bern

Patrick Steinegger

Diamond Detector Design for Measuring α -Decay Chains

- Introduction to Superheavy Element Chemistry
- Test Beam Time @ JAEA, Japan (2014 / 2015)
- Diamond Detectors for Measuring α -Decay Chains
- The pureCOLD System



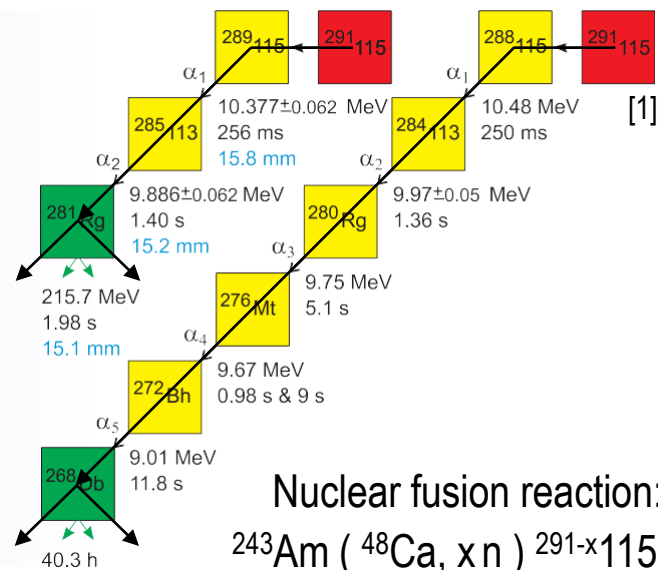
Introduction to SHE Chemistry

We are interested in **the chemical properties of transactinide elements** ($Z > 103$) with a special focus on the volatile superheavy element metals.

I	II	IIIa	IVa	Va	VIa	VIIa	—VIIIa—					Ia	IIa	III	IV	V	VI	VII	VIII
H																			He
Li	Be													B	C	N	O	F	Ne
Na	Mg													Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr		
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe		
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn		
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	113	Fl	115	Lv	117	118		
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr			

Identification of single SHE atoms (e.g. E113):

- Known decay chains from nuclear physics experiments
- Measurement Technique: **α - and SF-Spectroscopy**
- Time correlated emission of a α -particle or SF-decay



Faced limitations in SHE chemistry:

- Very short-lived products ([s] to [ms])
- One-atom-at-a-time experiments
- Rather volatile SHE metals (homologues)

The investigation method: **adsorption chromatography**

Adsorption interaction with various surfaces

Relativistic effects

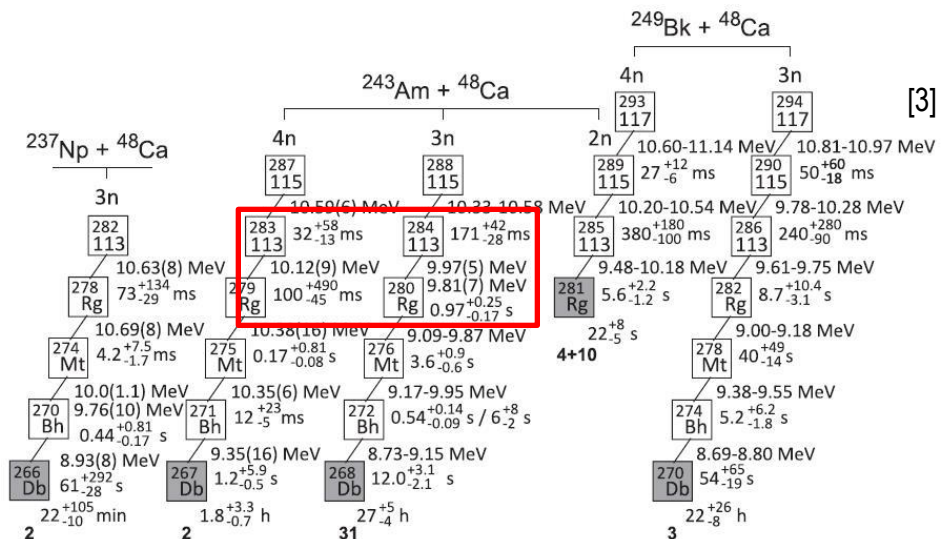
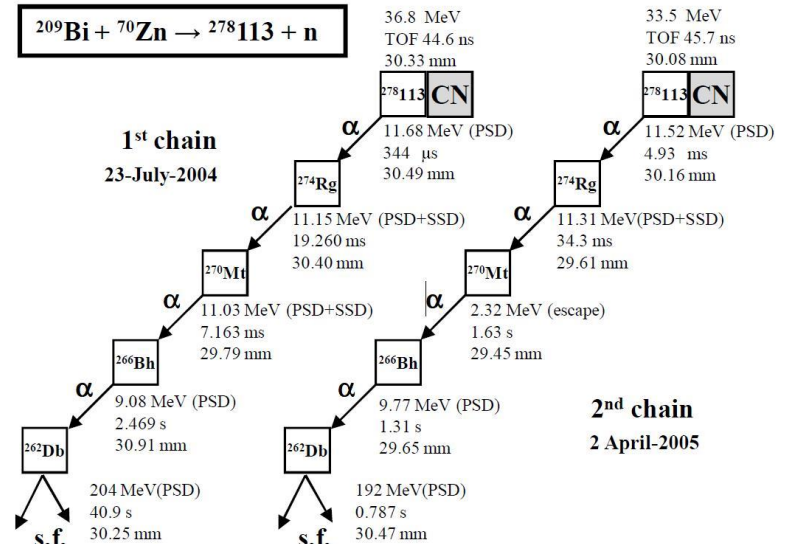
[1] Oganessian, Yu. T. et al., *Physical Review Letters* **108**(2) (2012)

Motivation: Chemistry with E113

E113 has been produced by several heavy ion induced reactions (cold and hot fusion reactions):

Average Ref. [28] 31 chains	Average this work 22 chains	Chain 1 242.1 MeV Pixel 465	Chain 16 245.0 MeV Pixel 203	Chain 20 245.0 MeV Pixel 842	Chain 23 245.0 MeV Pixel 903
$^{288}_{115}$	$^{288}_{115}$	$^{288}_{115}$	$^{288}_{115}$	$^{288}_{115}$	$^{287}_{115}$
10.33–10.58 0.171(42)	10.29–10.56 0.150(43)	10.29(1) 0.366	10.43(1) 0.159	10.30(1) 0.0614	10.63(5) 0.0676
$^{284}_{113}$	$^{284}_{113}$	$^{284}_{113}$	$^{284}_{113}$	$^{284}_{113}$	$^{283}_{113}$
9.97(5), 9.81(7) 0.97(25)	9.10–10.11 0.81(23)	9.24(1) 0.935	9.10(1) 0.179	9.97(1) 1.12	10.23(1) 0.0684
$^{280}_{\text{Rg}}$	$^{280}_{\text{Rg}}$	$^{280}_{\text{Rg}}$	$^{280}_{\text{Rg}}$	$^{280}_{\text{Rg}}$	$^{279}_{\text{Rg}}$
9.09–9.87 3.6(9)	9.25–9.92 6.4(13)	9.77(1) 11.1	9.77(1) 11.6	9.77(1) 3.21	escape 0.0161
$^{276}_{\text{Mt}}$	$^{276}_{\text{Mt}}$	$^{276}_{\text{Mt}}$	$^{276}_{\text{Mt}}$	$^{276}_{\text{Mt}}$	$^{275}_{\text{Mt}}$
9.17–9.95 0.54(14)/6(8)	9.43–9.89 0.75(25)	escape 0.515	9.60(1) 0.607	9.53(1) 0.702	10.33(1) 0.0513
$^{272}_{\text{Bh}}$	$^{272}_{\text{Bh}}$	$^{272}_{\text{Bh}}$	$^{272}_{\text{Bh}}$	$^{272}_{\text{Bh}}$	$^{271}_{\text{Bh}}$
8.73–9.15 12.0(31)	8.55–9.09 9.2(31)	9.06(1) 15.3	9.07(1) 3.35	8.86(5) 11.8	9.27(7) 2.60
$^{268}_{\text{Db}}$	$^{268}_{\text{Db}}$	$^{268}_{\text{Db}}$	$^{268}_{\text{Db}}$	$^{268}_{\text{Db}}$	$^{267}_{\text{Db}}$
27(5) h	26(7) h	197 MeV 17.4 h	210 MeV 64.1 h	275 MeV 15.1 h	191 MeV 30.6 min

[1]

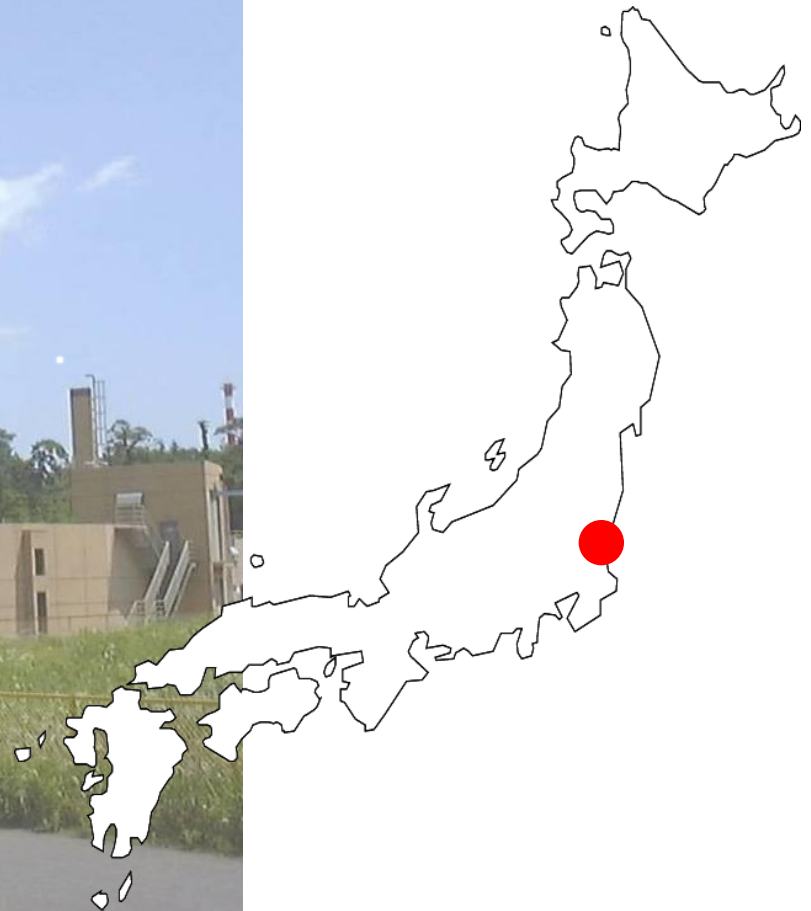


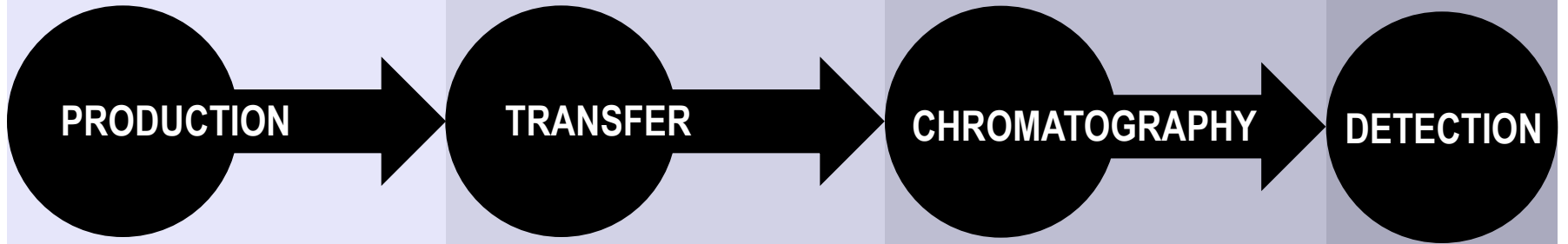
[1] D. Rudolph et al., *Physical Review Letters* **111** (2013) 11

[2] K. Morita, *Modern Physics Letters A* **25** (2010) 21-23

[3] Yu. Ts. Oganessian et al., *Physical Review C* **87** (2013) 1

The IVAC Test Beam Time at JAEA (2014 / 2015)





Isothermal Vacuum Chromatography (IVAC)

Nuclear fusion
reaction and
JAEA -ISOL



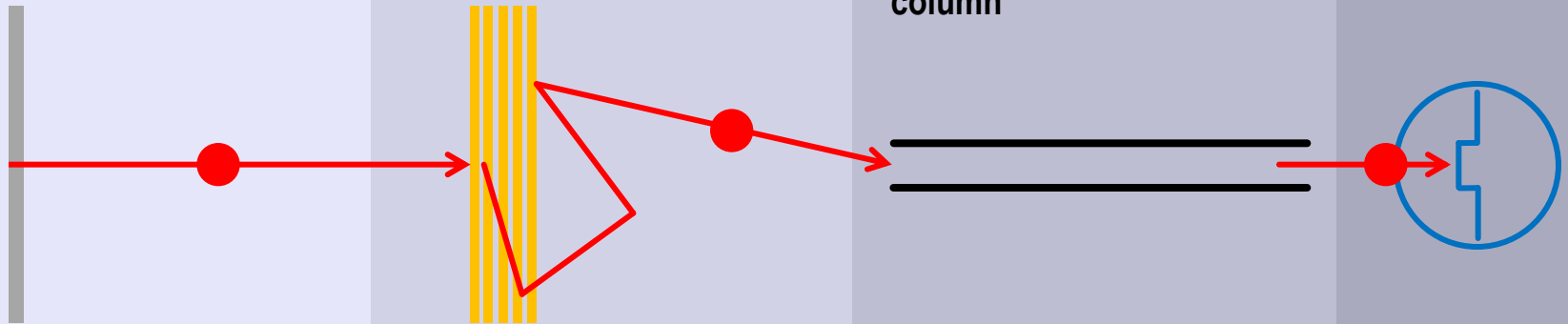
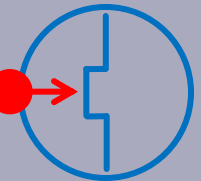
Hot catcher:
implantation &
thermal release

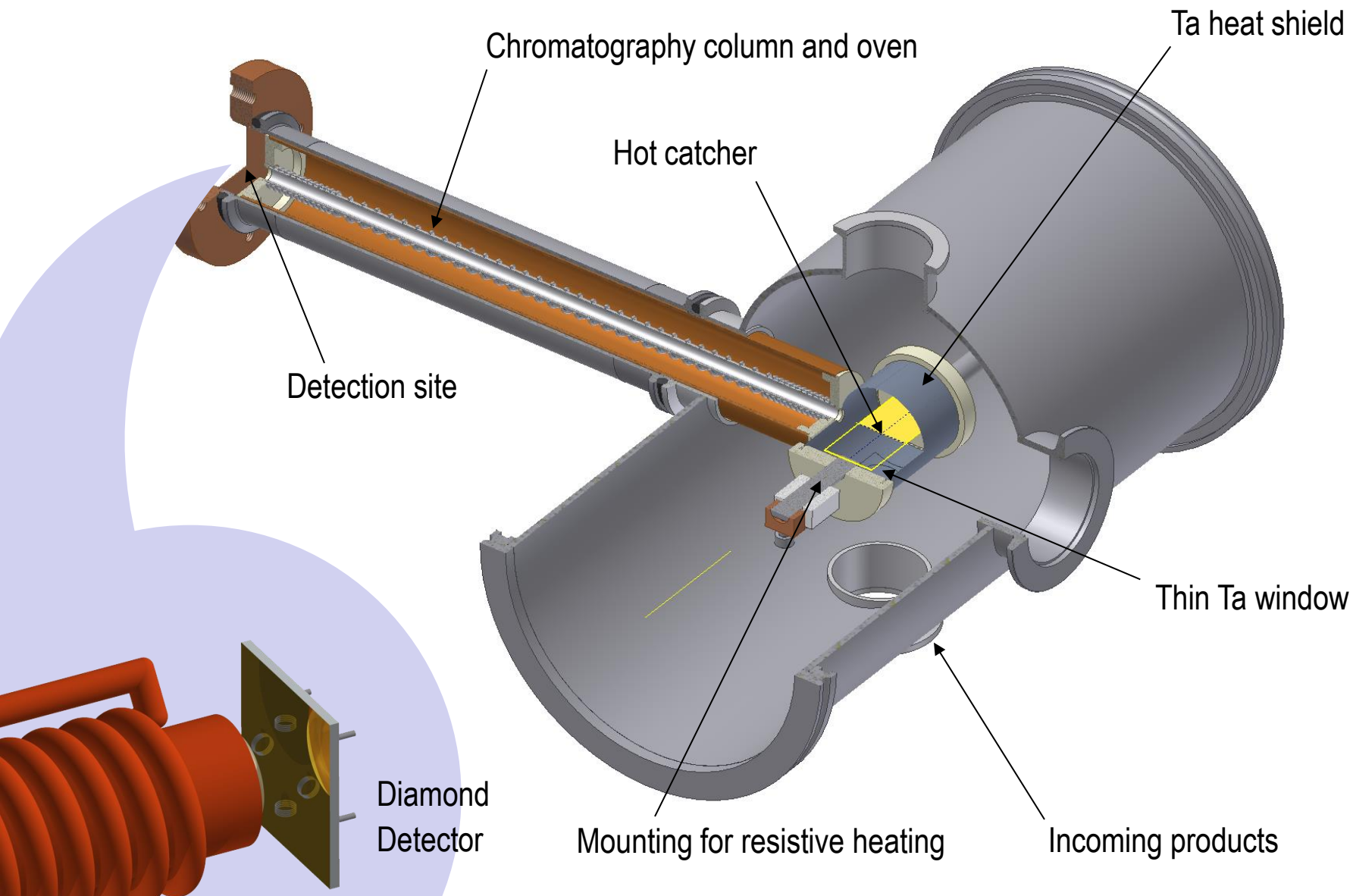


Isothermal
vacuum
chromatography
column

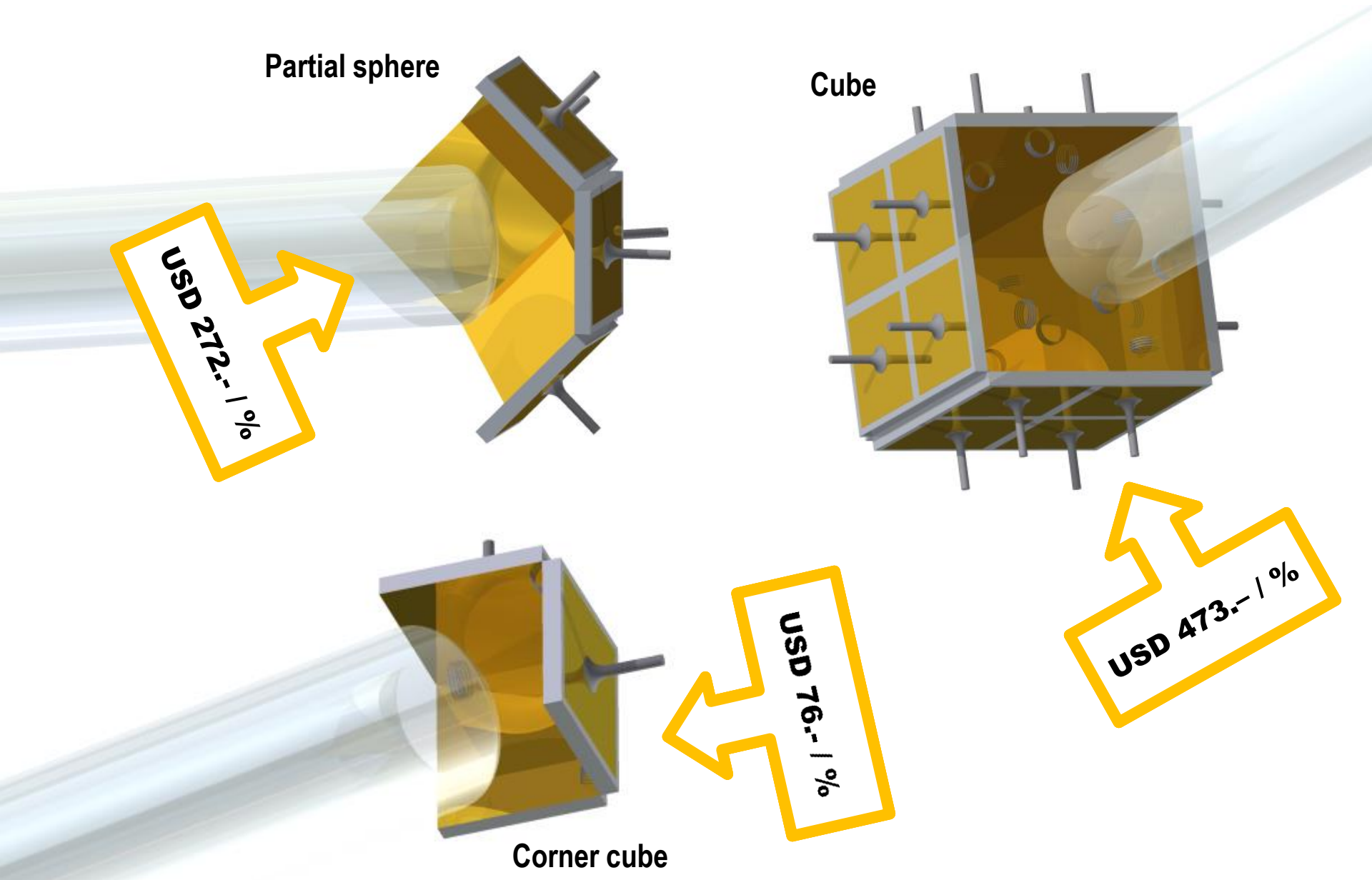


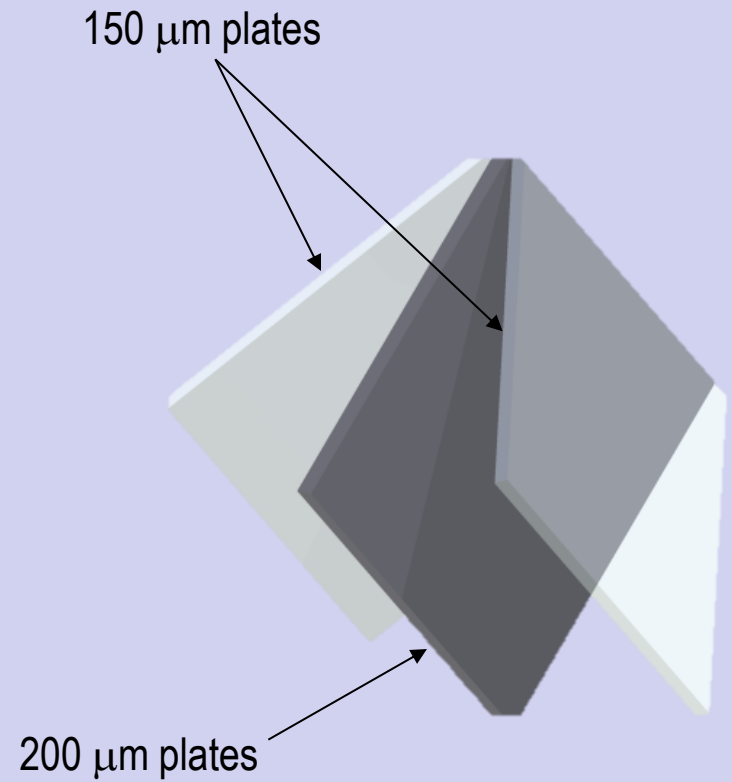
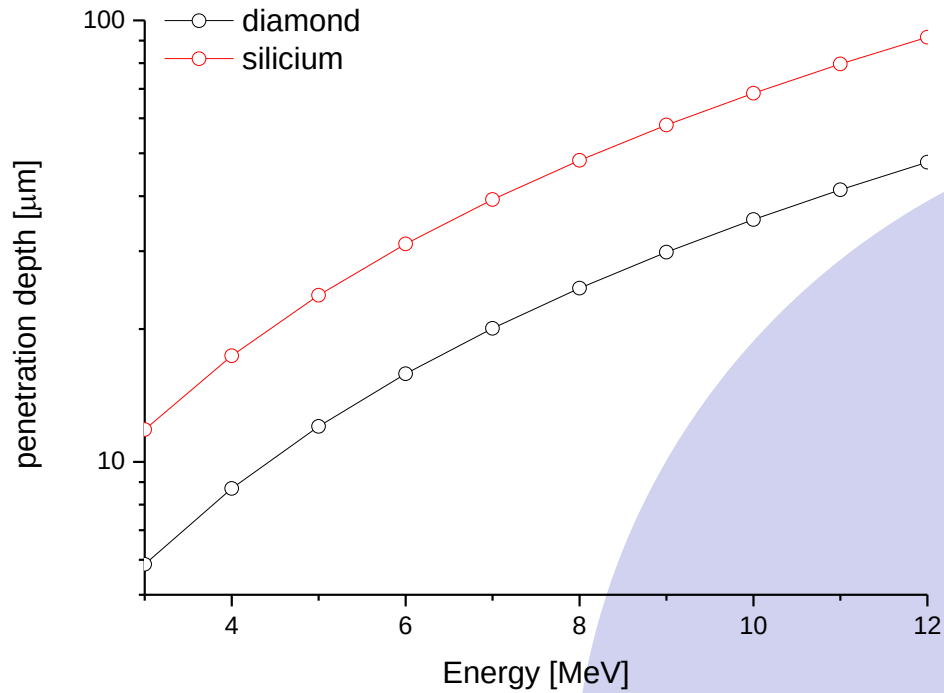
Diamond
detector



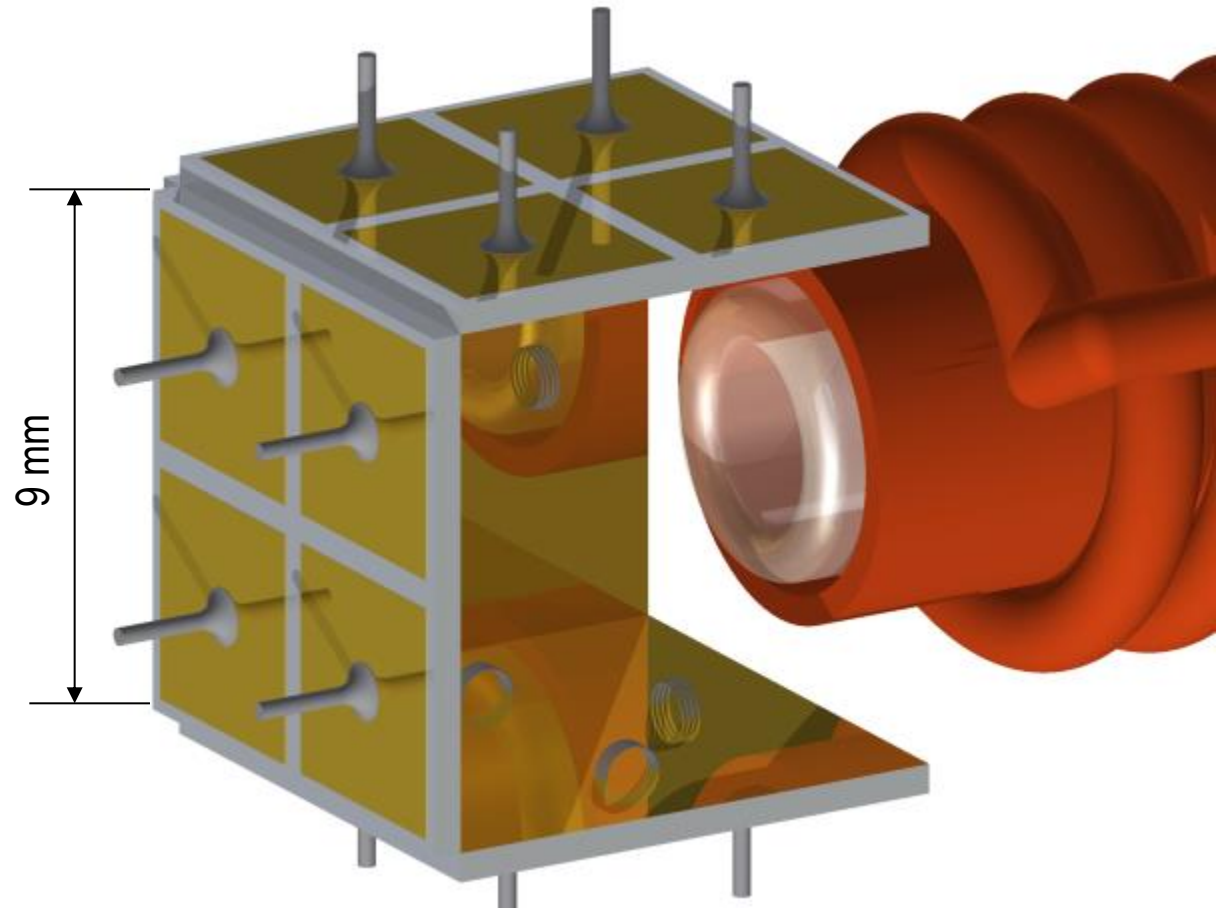


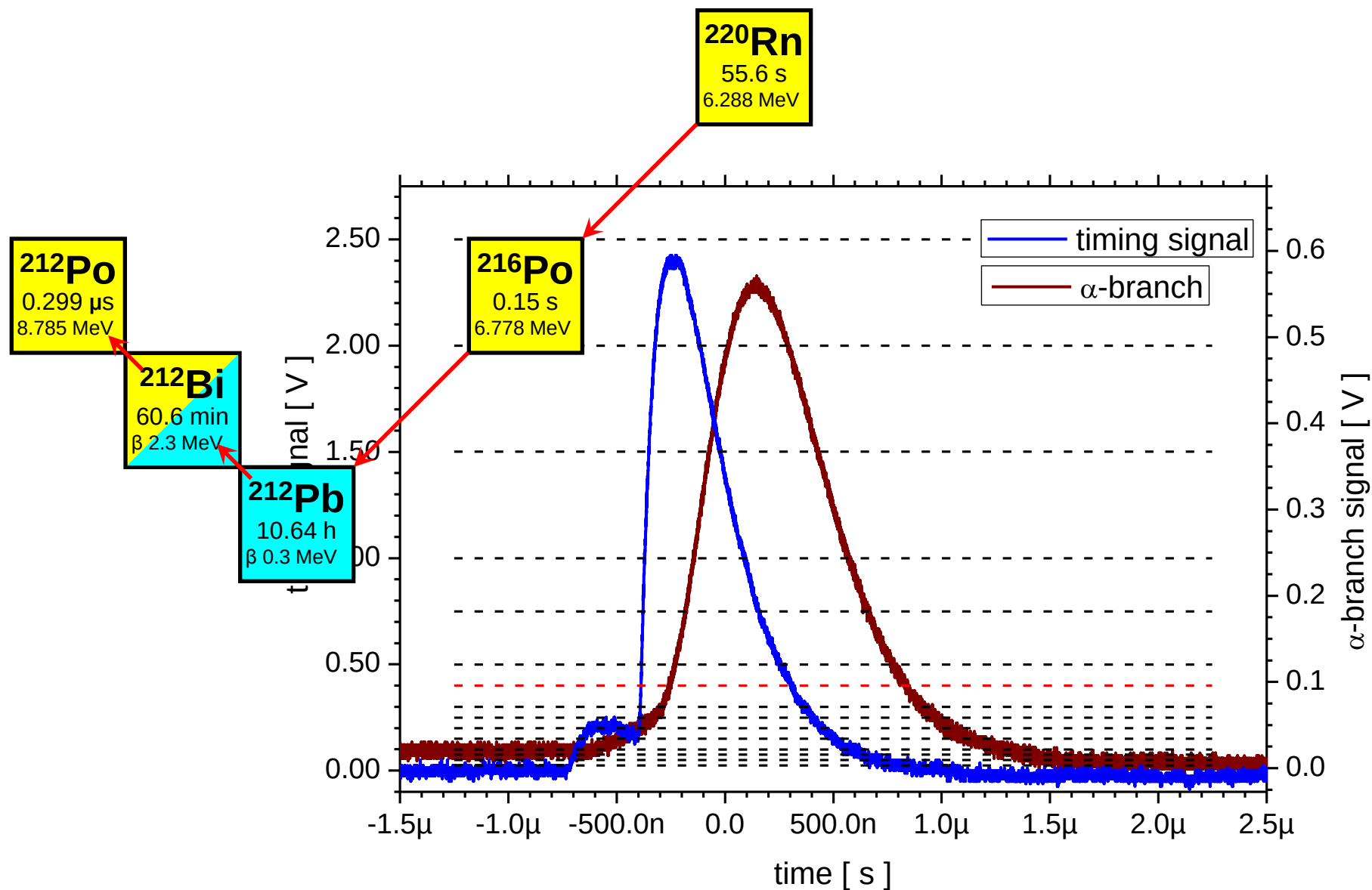
Diamond Detector Assembly





Diamond detector assembly



pureCOLD: β - α Pile-up Rejection


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////////////////////////
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///                      ///
///    Alex Vögele      ///
///    Andreas Türler   ///
///    Arnold Lücke     ///
///    Christina Weiss  ///
///    Dave Piguet      ///
///    Erich Griesmayer ///
///    Ilya Usoltsev    ///
///    Robert Eichler   ///
///    Rugard Dressler  ///
///    Silvan Streuli   ///
///                      ///
////////////////////////
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^b
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Thank you for your kind attention!

