The beginning of a success story

Атомная энергия

Том 21, Вып. 2. Август 1966

Химические свойства элемента 104

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Content

- Reaction $^{22}Ne + ^{242}Pu$ (0.7 mg/cm^2; energy 113-115 MeV; $\phi \approx 2x10^{12}\ s^{-1}$)
- 2 gas chemistry experiments performed
- 1st experiment: dose $4x10^{18}$ (600 h); chlorinating gas, 220-250°C; transit time along detectors 0.2 - 1.2 s. Observed: 4 SF events assigned to ^{260}Rf (estimated yield 10 %).
- 2nd experiment: dose $0.6x10^{18}$ (90 h); 300-350°C; observed 8 SF assigned to ^{260}Rf.

OUTLINE

- Pro’s and con’s of gaschemistry as separation method
- Major achievements of on-line gas chemistry: from Dubna TC via OLGA to IVO
- Breakthrough in gas chemistry studies with transactinides: coupling to (gas-filled) separators

Pro’s and Con’s

- Pro of gas chemical separation:

→ Easy coupling to accelerator and transport of reaction products to gas chemical device

→ Fast and continuous separation technique (down to ≈ 1 s separation time)

→ Easy coupling to on-line detection of α- and coincident SF events from separated products

Pro's and Con's

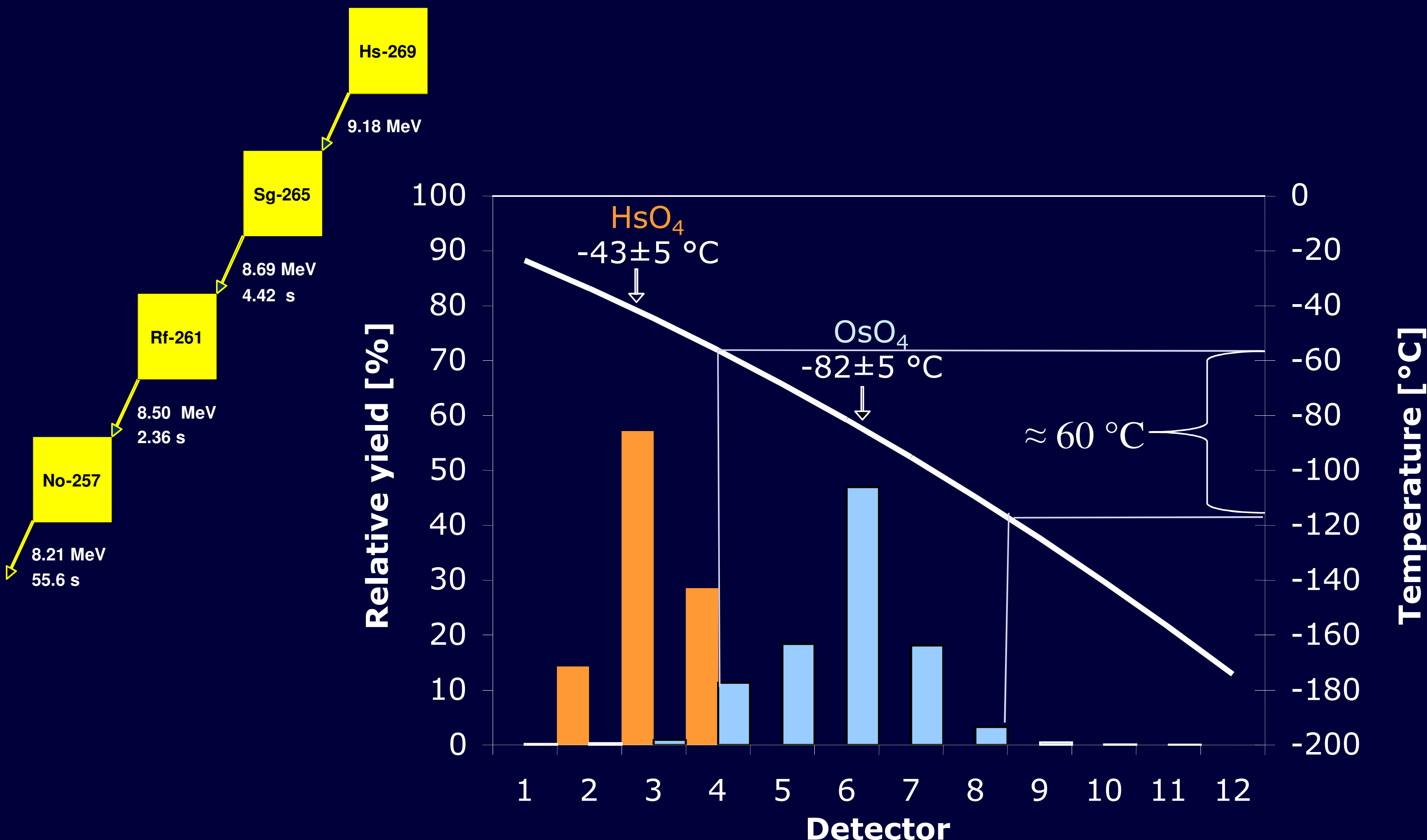
- Con of gas chemical separation:

→ Poor chemical separation factors (low number of theoretical plates)

→ Consequence: Contamination of separated species with products of similar volatility

→ In TC (mostly used in recent studies): background from products with higher volatility than the studied product (decay during transport in column; Example: Rn)

OsO_4 & HsO_4: poor resolution!



Slide from C.E. Düllmann

Application of gas chemistry restricted to

→ Products with favorable decay chains (mother with exceptional high α-decay energy & daughter with very short half-life). Example: ^{283}Cn (E_{α} = 9.4 MeV; $T_{1/2}$ = 3s) → ^{279}Ds (SF; 0.3 s). Example which failed: ^{289}Fl ($T_{1/2}$ = 2.7s) → ^{285}Cn ($T_{1/2}$ = 34s) → ^{281}Ds ($T_{1/2}$ = 9.6s)

→ *Breakthrough: Operate gas chemistry set-up behind a (gas-filled) separator (BGS, TASCA; GARIS; DGFS)*

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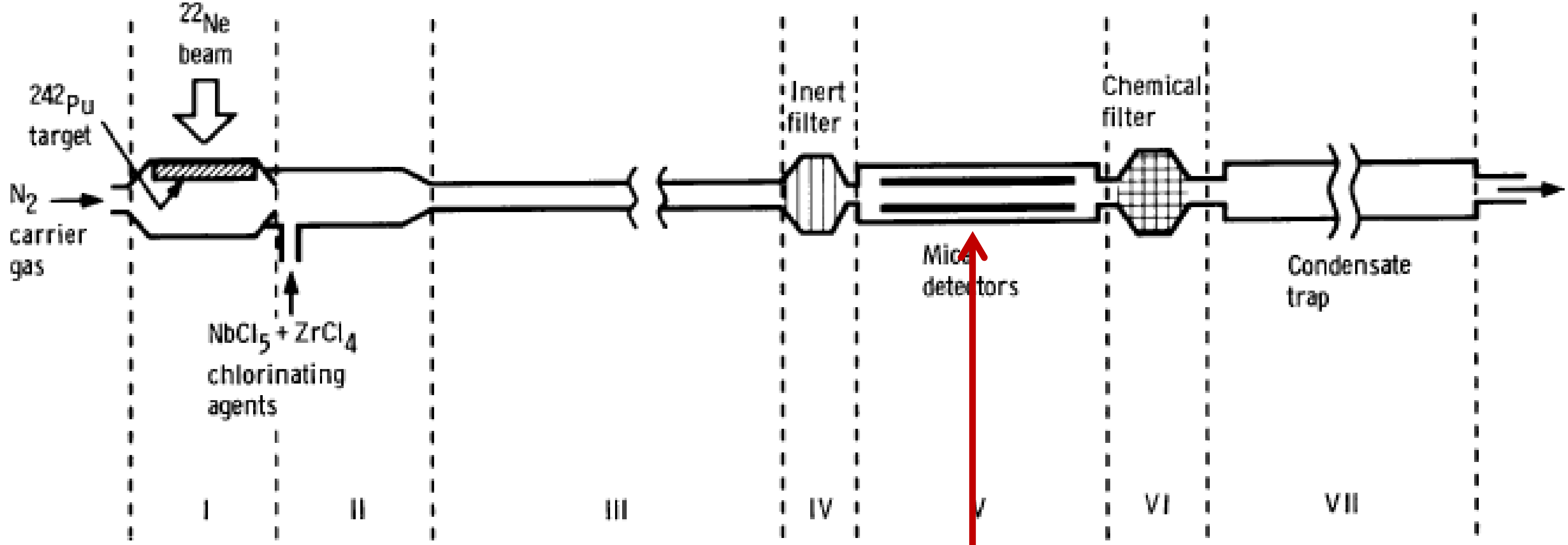
Device used for the first gas chemical study of Rf



I. Zvara et al., Atomn. Energ., **21**, 83 (1966)

Detection of SF products via fission-track counting

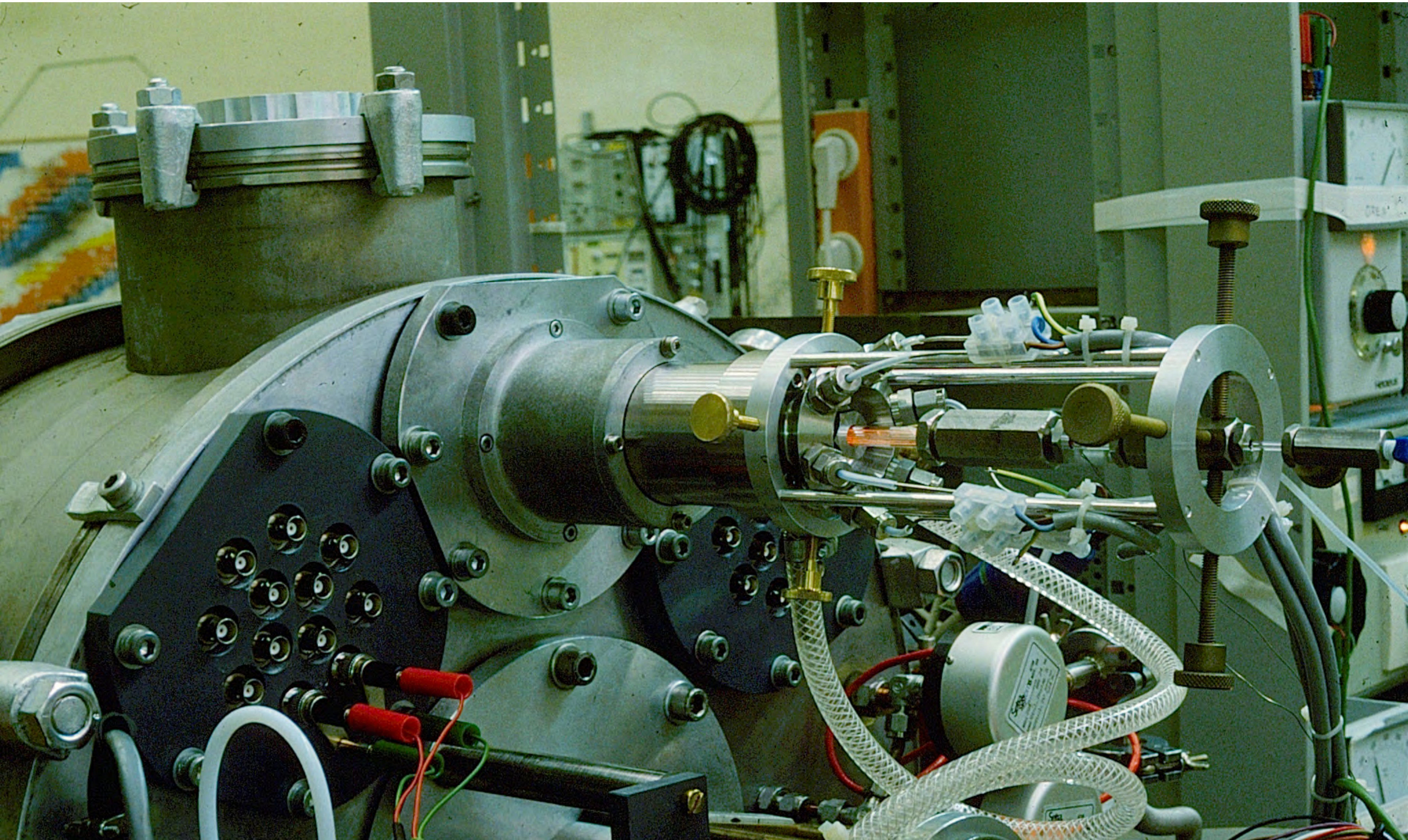
Drawback: No identification of nuclide possible

OLGA I (*O*n-*L*ine *G*aschemistry *A*pparatus)

First on-line gas chemistry separation device coupled to an on-line detection (α & SF)

Search for volatile SHE in:

$^{48}Ca+^{248}Cm$, P. Armbruster et al., PRL, **54**, 406 (1985))



OLGA II (H. Gäggeler et al. NIM, **A309**, 201 (1991)

Study of Db bromide (H. Gäggeler et al., RCA, 57, 93 (1992))

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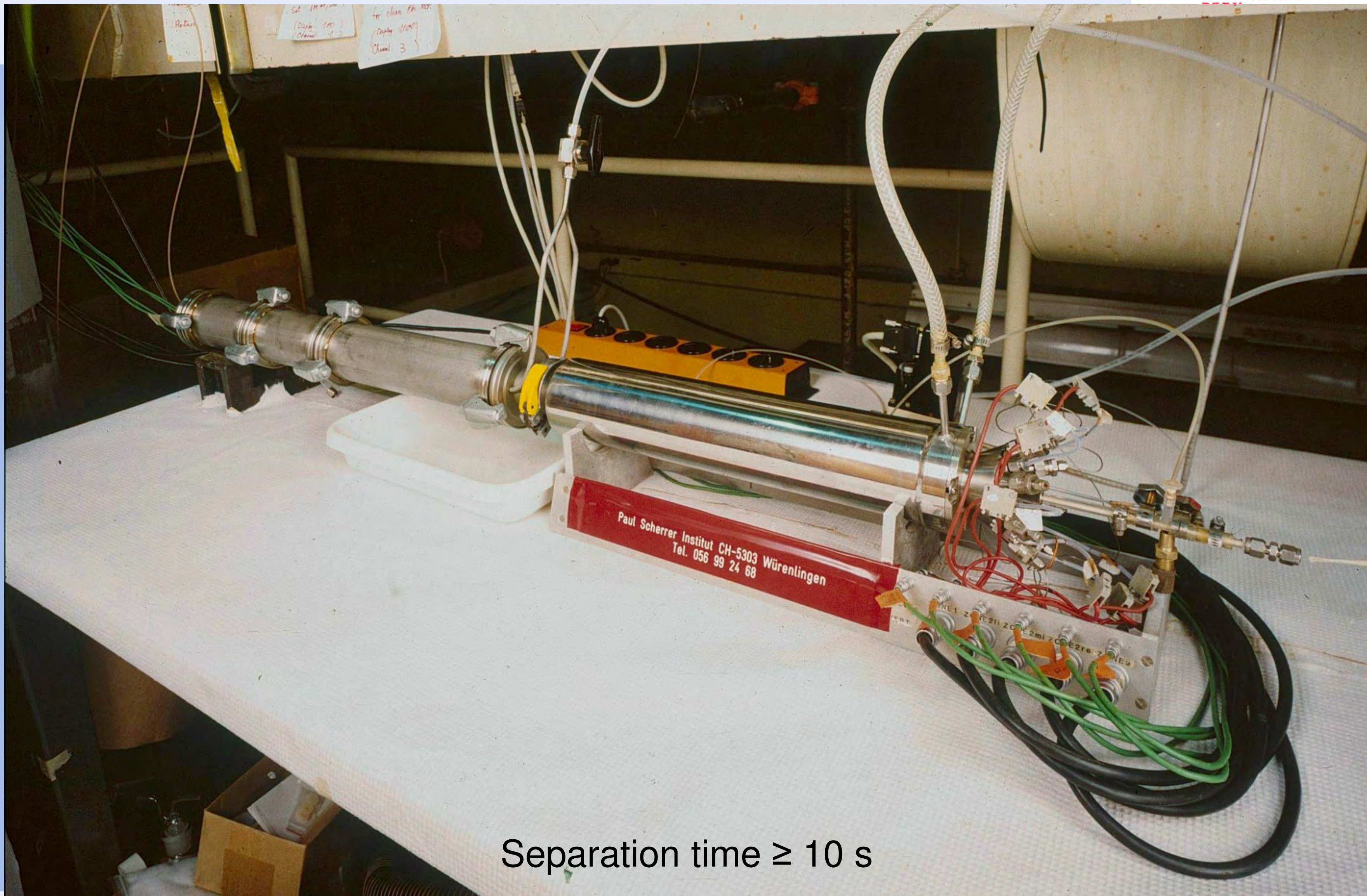
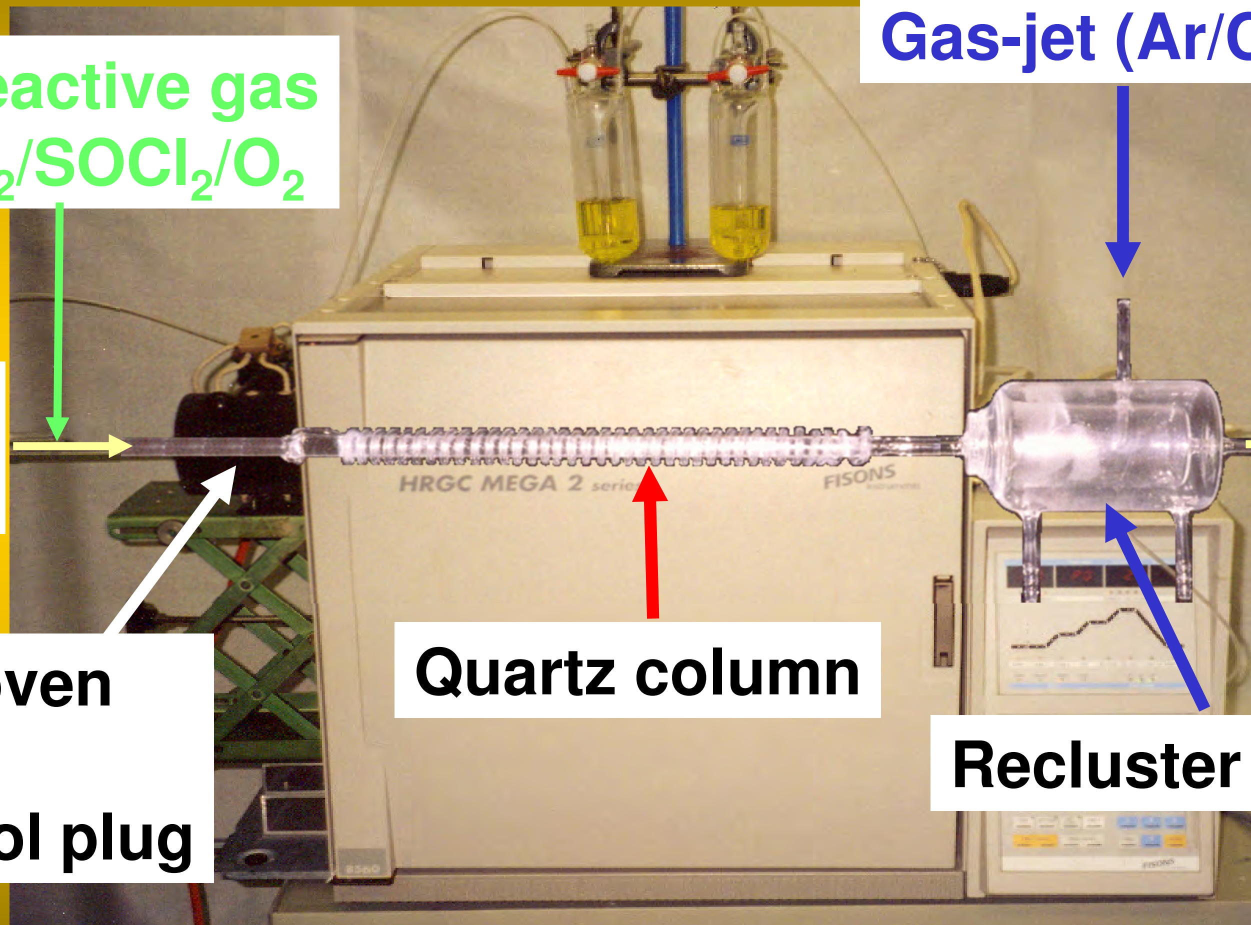


Separation time ≥ 10 s

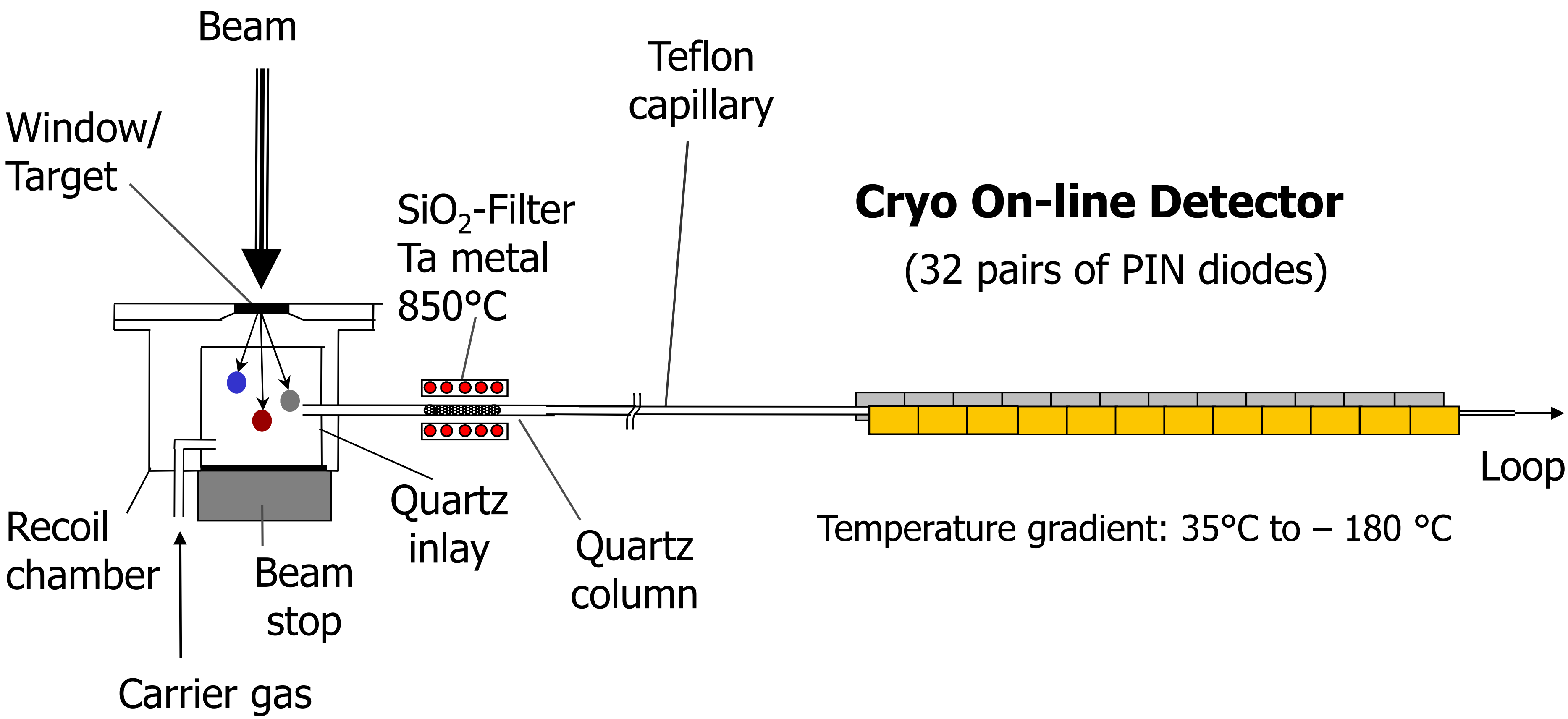
Gas Chromatography: OLGA III



Separation time: few seconds

First chemical study of
Sg (M. Schädel et al., Nature, **388,** 55 (1997)) and of Bh (R. Eichler et al., Nature, **407**, 63 (2000))

IVO (*In*-situ *V*olatilization and *O*n-line detection) technique



First chemical studies of Hs (in form of HsO_4) (C.E. Düllmann et al., Nature, **418**, 859 (2002)
Cn (in elemental form) (R. Eichler et al., Nature, **447**,72 (2007)) & Fl (in elemental form)
(R. Eichler et al., RCA, 98, 133 (2010))

Pre-cleaning via gas filled separator

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- Discussed during workshop@ LBL (May 1997): Chemistry behind BGS (E.K. Gregorich: organizer)
- Proposal by PSI heavy element chemistry group (A. Türler): gas chemistry experiment with group-8 element 108 (Hs) in form of its tetroxide
- Now world leading in chemistry behind a pre-separator: TASCA@GSI

Conclusion

> On-line gas chemical separations unique in chemical studies of heaviest elements with short half-lives

> No coupling to separator only possible if favorable decay chains

> Coupling to separator enables chemical studies irrespective of nuclear decay properties

> Actually worldwide efforts to study Nh (E113) and Sg carbonyls

> Future efforts to speed-up separation via gas stopping cell technology

> Yields vacuum chromatography cleaner surfaces?