Foto: G. Otto, GSI 12.07.2010, GSI

Prof. Dr. Dr. h.c. mult. Peter Armbruster
(25.07.1931 – 26.06.2024)

Peter Armbruster –
A Devoted Universal Explorer's Passion for Separators and his Life Journey to Superheavy Elements

Matthias Schädel

His liking for (Gas-filled) Separators
His journey to Superheavy Elements (SHE)

Foto: G. Otto, GSI 12.07.2010, GSI

Peter Armbruster: A Great Personality

Outstanding multiple talents, skills, interests ...

Scientist / researcher / explorer

- Engineer ("TH-Klempner" (plumber))
- Atomic physics !
- Nuclear physics – FISSION, - **SHE**, ...

- Group and division leader, director
- Science advisor and administrator

- Winner of many high-ranking awards

Nature and peace loving staunch European

1 year old
Peter Armbruster
Courtesy Klaus Armbruster

Peter Armbruster

- 25. July 1931 in Dachau
  Beautiful, 1200 a old district city
  outskirts of München,
  ≈ 15 km from city center

Dark shadow: the terrible Dachau Concentration Camp (KZ) (1933-1945)

Peter Armbruster

1931 Dachau
1933 München
1935 Braunschweig
1937 Köln
1938 Düsseldorf

1940-48 Bad Wildbad

1948-51 Salem (Abitur)

1951 Bad Wildbad
Mechanics, Internship

1952 TH Stuttgart

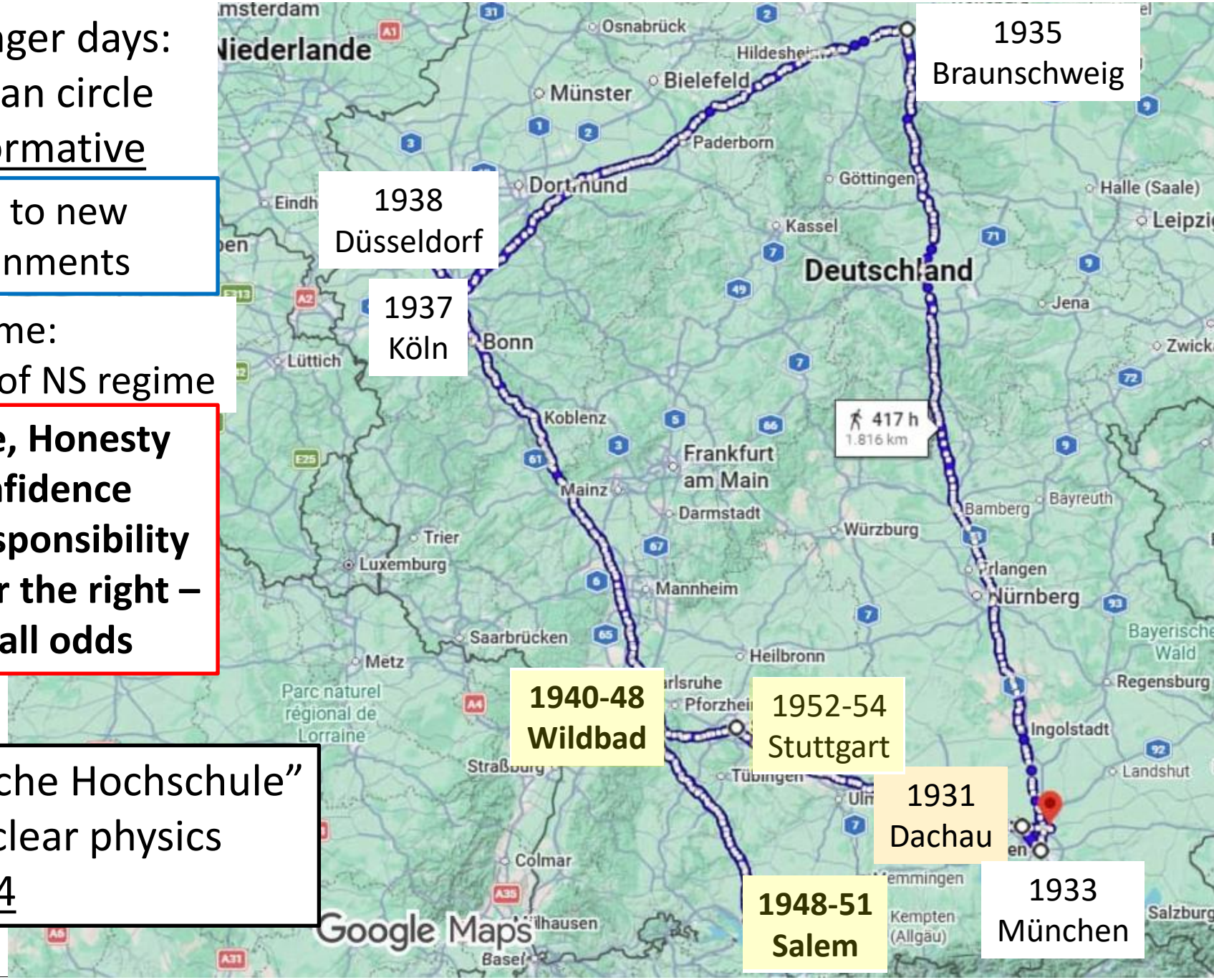
His younger days:
a German circle
Very formative

Adapt to new environments

Parental home:
Opponents of NS regime

Courage, Honesty
Self-confidence
Bear responsibility
Fight for the right – against all odds

To **study Physics** at the "Technische Hochschule" aiming for the still forbidden nuclear physics
First diploma ("Vordiplom") 1954



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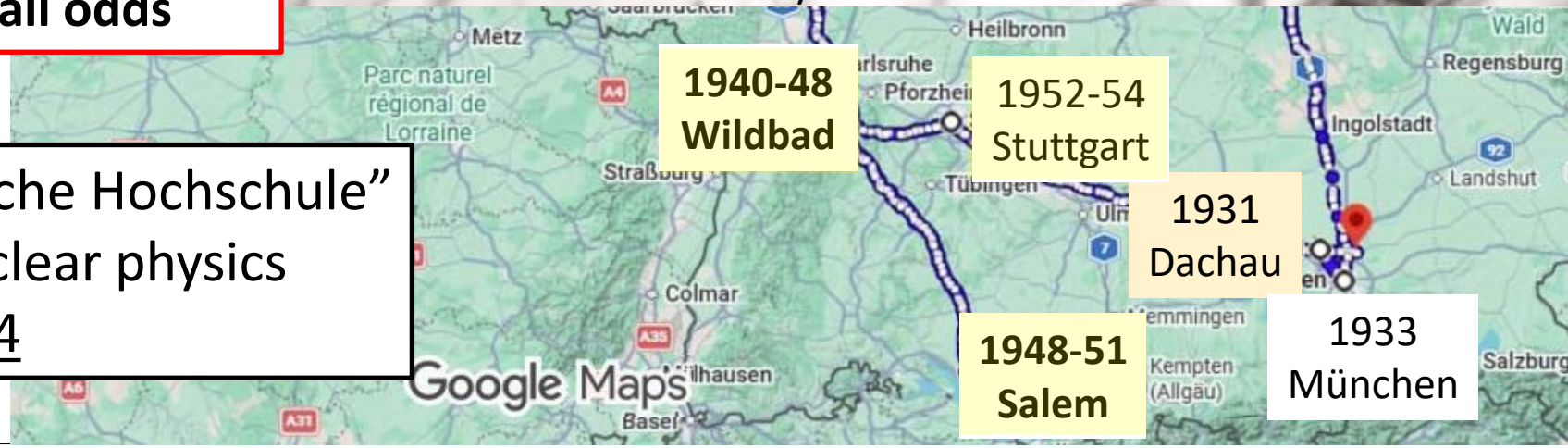
Abiturient Peter Armbruster
Photo Courtesy Klaus Armbruster



To **study Physics** at the "Technische Hochschule" aiming for the still forbidden nuclear physics
First diploma ("Vordiplom") 1954

1954 TH München "In München war das Leben lockerer ... Die Berge waren näher... Jahr 1954/55 sah mich oft in Schnee und Eis ... Bernina-Gruppe Ostschweiz"

1957 Diploma Atomic Physics, methodological development

1958 Laboratorium für Technische Physik, FRM (Garching)

His teacher and mentor *Prof. H. Maier-Leibnitz* asked:

"Herr A.: Was machen die 92 Elektronen bei der Spaltung des Urankerns?"

"From this question and the related problems my work has evolved"#

(Gas-filled) Separator + Detector(s)

Atomic electrons ➔ Atomic physics

Nuclear fission fragments ➔ Nuclear physics

Interaction with matter ➔ Material science

Superheavy Elements (1955)
speculation by J.A. Wheeler

Photo from Wikipedia

P. Armbruster in "*Forschung in der Bundesrepublik Deutschland",* Verlag Chemie, Weinheim, 1983, pp. 523-529

1961
Doctoral Thesis
TH München

"Bau eines Massenseparators für Spaltprodukte und Nachweis einer Anregung innerer Elektronenschalen bei der Abbremsung von Spaltprodukten"

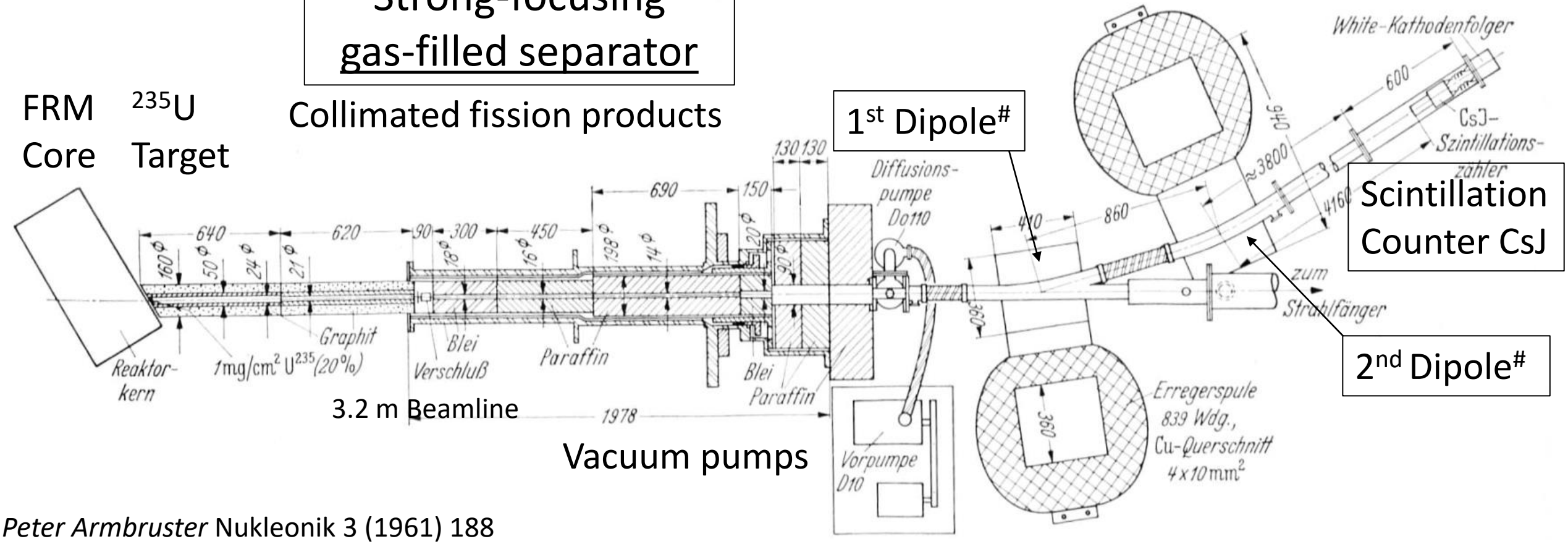
(Aus der Studiengruppe der AEG-Entwicklungsleitung;
Gast im Laboratorium für Technische Physik der Technischen Hochschule München)

Strong-focusing gas-filled separator

FRM Core

^{235}U Target

Collimated fission products



3.2 m Beamline

Vacuum pumps

Peter Armbruster Nukleonik 3 (1961) 188

following *B.L. Cohen, C.B. Fulmer*, Nucl. Phys. 6 (1958) 547, *C.B. Fulmer, B.L. Cohen*, Phys. Rev. 109 (1958) 94 at ORNL

1961
Doctoral Thesis
TH München

Massenseparator für die Massentrennung von Spaltprodukten

Von Peter Armbruster

(Aus der Studiengruppe der AEG-Entwicklungsleitung;
Gast im Laboratorium für Technische Physik der Technischen Hochschule München)

Strong-focusing gas-filled separator

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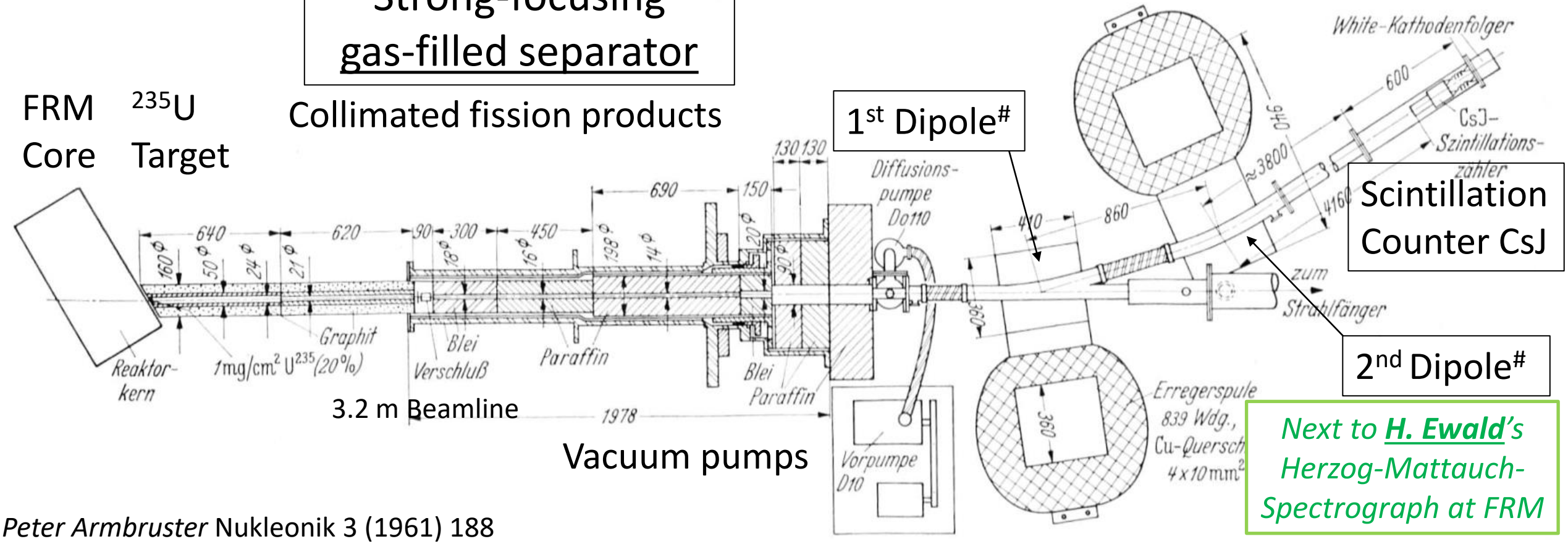


3.2 m Beamline

Vacuum pumps

*Next to **H. Ewald**'s Herzog-Mattauch-Spectrograph at FRM*

Peter Armbruster Nukleonik 3 (1961) 188

following *B.L. Cohen, C.B. Fulmer*, Nucl. Phys. 6 (1958) 547, *C.B. Fulmer, B.L. Cohen*, Phys. Rev. 109 (1958) 94 at ORNL

Peter Armbrusters 1st student *Hans J. Specht*

1960-62 at FRM 60 a of "*deep scientific respect*
2021 at GSI: *and personal warmth*" (HJS)

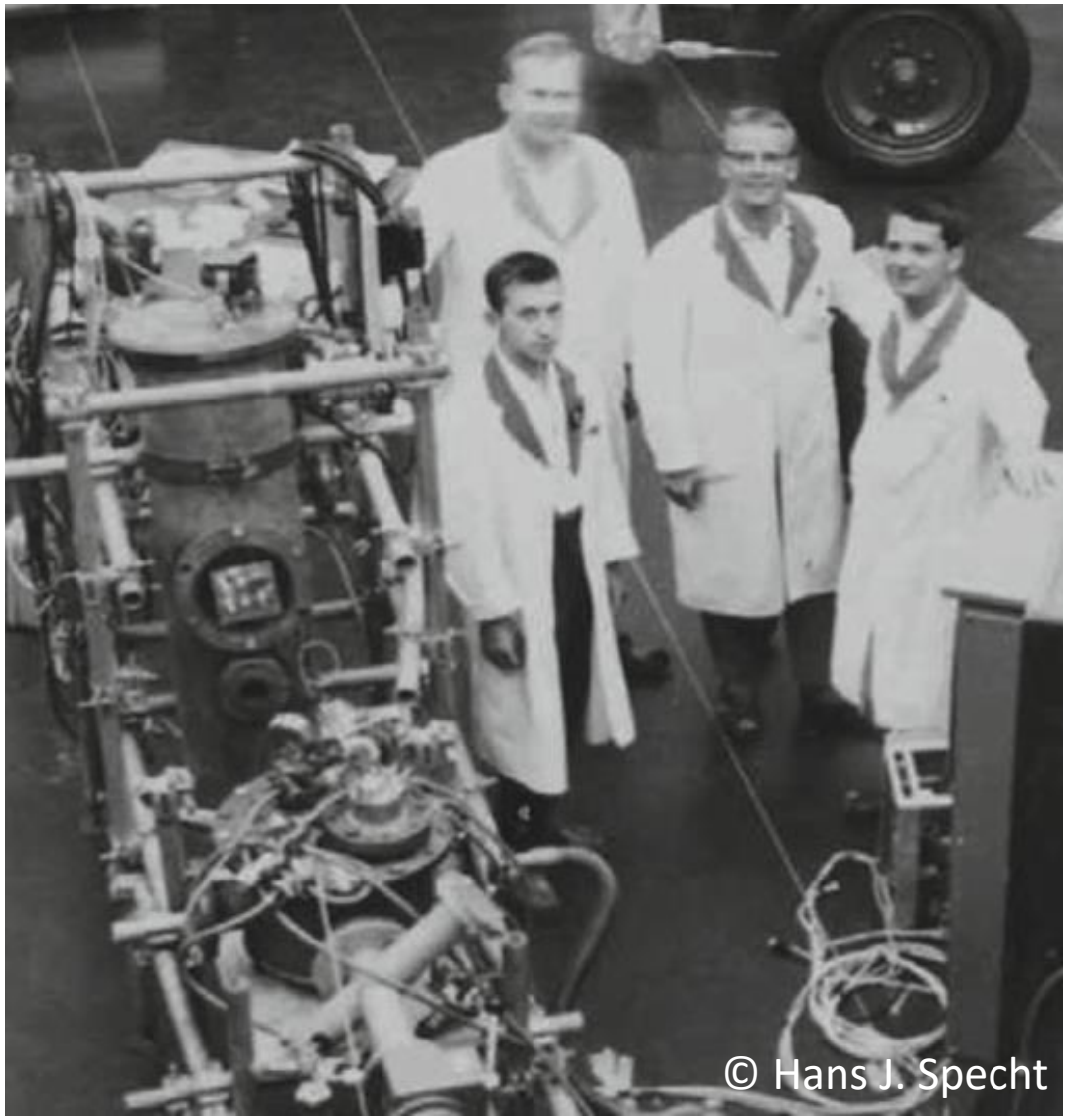


Foto: G. Otto, GSI

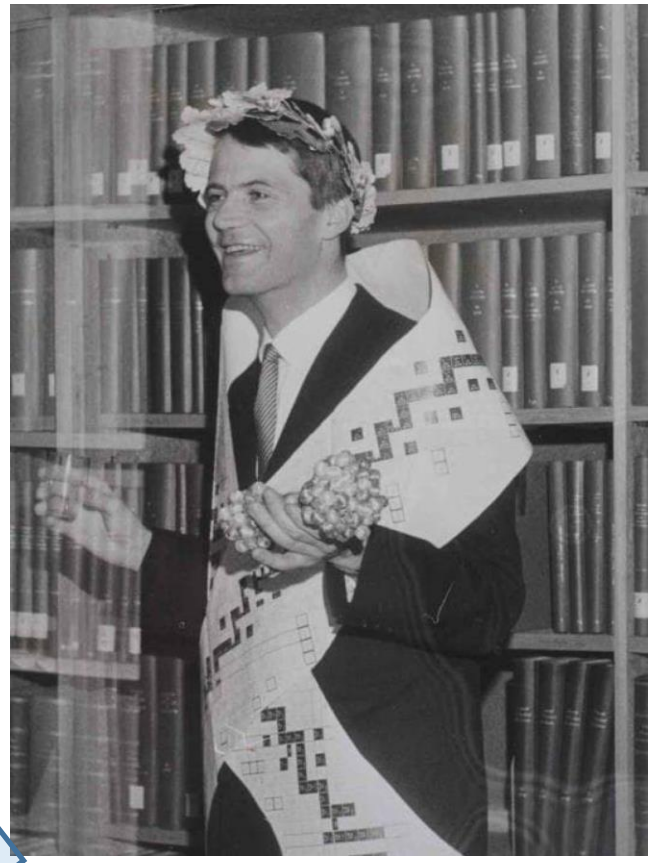
From Fig. 3.4 In: Specht, H.J. (2025). Hans Joachim Specht (in His Own Words) Sixty Years of Physics—The Fascination of Diversity. In: Damjanovic et al. (eds) Hans Joachim Specht. Springer Biographies. Springer, https://doi.org/10.1007/978-3-031-92353-1_3

1963 UNILAC study group established at HD
Ch. Schmelzer, D. Böhne, K. Blasche et al.

1966 SHE Island of Stability Z=114, N=184
Lysekil Symposium "Why and how should we investigate Nuclides far off the stability line?"
Theory: *H. Meldner; A. Sobiczewski, ...;*
W.D. Myers, W.J. Swiatecki; V. Strutinsky
T. Sikkeland: **σ (126) ≈ 100 mb**

1966-68 UNILAC Lay-out fixed, work on details
Enthusiasm about science case
Ch. Schmelzer, D. Böhne Report

The research highlight: **Superheavy Elements**
Rate expected at UNILAC: **10^6 SHE/s**



1964 Habilitation
TH München

Untersuchungen zum β-Zerfall der U^{235}-Spaltprodukte

P. Armbruster
with his separator moved from FRM München to FRJ-2 Jülich

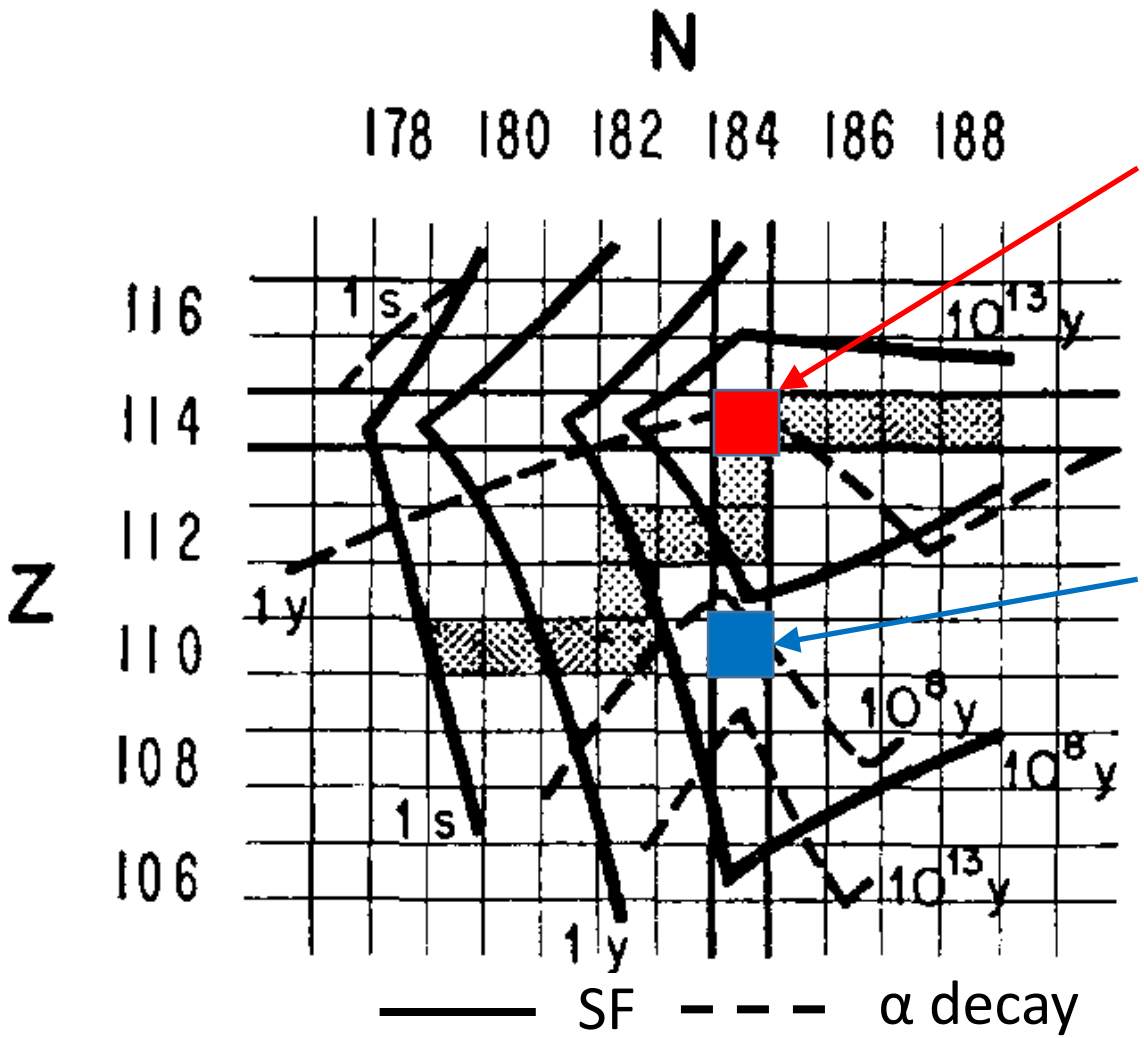
1966
Peter Armbruster (Jülich) and *Heinz Ewald* (Gießen)
- ➔ Lysekil symposium; spark of SHE research
- ➔ first acquaintance with SHE science
- ➔ start thinking about separators for SHE

Foto: *Hans J. Specht*, Vortrag, *60 Jahre Physik Faszination der Vielfalt,* Uni. HD, 2016

Peter Armbruster
his wife Elisabeth, son Klaus
and daughter Susanne
entering the boat at the
Lysekil Symposium outing

Photo and Newspaper Copy
Courtesy Klaus Armbruster

1969 SHE Island of Stability - Half-lives



$^{298}114_{184}$ maximum stability

$^{294}110_{184}$ longest $T_{1/2}$

(SF) = 10^{13} a

(β) = stable

(α) = 10^8 a

... shell effects are so dominant,
... large half-lives against fission,
... **α-decay** ... critical decay-channel.
... lifetimes ... at least one day,...

⇔ **8 h to 10^3 a**

U. Mosel, W. Greiner Z. Phys. 222 (1969) 261

S.G. Nilsson, S.G. Thompson, CF. Tsang Phys. Lett 28B (1969) 458

S.G.Nilsson, C.F. Tsang, A. Sobiczewski, Z. Szymanski, S. Wycech, C. Gustafson, L.-L. Lamm, P. Möller, B. Nilsson

Univ. Lund, 1970

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S.G.Nilsson, C.F. Tsang, A. Sobiczewski, Z. Szymanski, S. Wycech, C. Gustafson, L.-L. Lamm, P Möller, B. Nilsson

1965-70 **GSI** Strong and painful birth pangs – Very turbulent times

1968-70 **Fierce disputes** between leading protagonists from KA, HD, DA, F, MR, MZ,...about
- location, - organization, - accelerator, - separators, - financing, ...

Apr 1969 **Research center** to be built at **Darmstadt** (*G. Stoltenberg*, Minister of Research)

17.12.69 **GSI founded,** (DESY like) **GmbH**; Staff: **1** person - Admininistr. Director: *H.O. Schuff*
Exceptional situation
One of the main research goals: **Superheavy Elements**

24.07.1970 *... **final decision** was made .... The conservative concept of **UNILAC** was selected and the plans to build a helix accelerator were abandoned.*[#]
P. Armbruster, Lecture Notes in Physics, Vol. 23, Proc. Minreva Symp. on Physics, Rehovot, 1973, p. 236-253

01.07.1971 *Christoph Schmelzer "father of the UNILAC"*
Scientific Director, completing the board of founding directors

Cordial thanks to Katrin Große, GSI, for making part of her in-depth document about the GSI founding history available to me

1965-70 Peter Armbruster – A very busy young (age 34-39) scientist and advisor

* Research program at FRJ-2, KFA Jülich (FZJ)

* ILL (HFR), Grenoble:
  - Founded (Jan 1967), French-German science, *"peace and reconciliation project"*
  - Scientific Council (1965-72); together with *Karl-Heinz Beckurts* (KFZ Karlsruhe)
  - Recoil spectrometer proposed (*Thompson* type parabula spectrograph)
  - Strongly involved in LOHENGRIN; in-optics by *Heinz Ewald* (Gießen)

* Jan 1968 Director Institut für Festkörperforschung und Neutronenphysik, KFA Jülich
* Aug 1968 Honorary Professorship, Univ. Köln

* 1967-68: Proposal **KFZ Karlsruhe** (*K.-H. Beckurt's* Initiative); Contact with heavy-ion physics
  "Studiengruppe" proposed → - **UNILAC** from HD (out of five accelerator options)
  - at KFZ Karlsruhe (existing infrastructure, ..)

* **July 1970 GSI offer accepted - Leading Scientist (Accelerator Division !)**
  Jan 1971 Start at GSI - Member Boards of Directors

01.07.71 **GSI** Founding Directors: *Hans Otto Schuff* Administrative director (since 1969)
Christoph Schmelzer Scientific-technical director
Rudolf Bock Nuclear Physics
Günter Herrmann Nuclear Chemistry
Peter Armbruster **Buildings and Accelerators (UNILAC)**

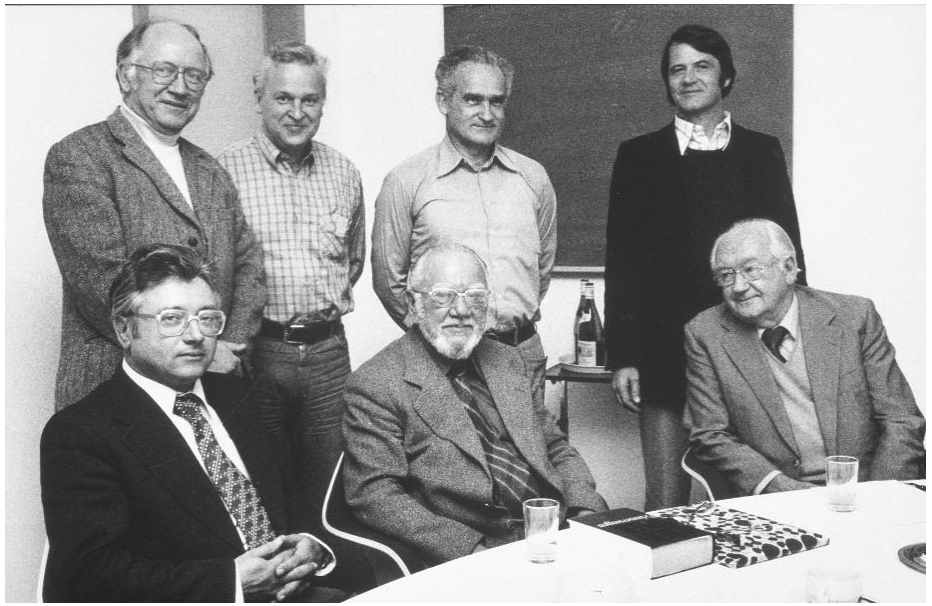
Thrilling atmosphere
Great Expectations

Fall of 71 START Civil Construction
1974 Buildings, Offices and Labs READY

P. Armbruster, "Status of the GSI Project"
Proc. Minerva Symposium, Rehovot

Photos: A. Zschau, GSI

G. Herrmann (*D. Böhne*) ***R. Bock P. Armbruster***



H.O. Schuff (Baudirektor *Flöter*) ***Ch. Schmelzer***
(Oberfinanzdirektion)

1972-75 UNILAC *Peter Armbruster* (Director responsible), *Dieter Böhne* (Project manager)
N. Angert, K. Blasche, B. Franzke, H. Gaiser, W. Jacoby, E. Malwitz, R. Schwedhelm, P. Strehl, ...

07.10.1973

23.01.1974

28.05.1974

August 1975 ^{40}Ar ... ^{136}Xe

01. 04. 1976: ^{238}U, 6.7 MeV/u - **1st worldwide, UNIQUE**

All Photos: A. Zschau, GSI

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All Photos: A. Zschau, GSI

 # Norbert Angert The Story of the GSI Accelerators
GSI-FAIR Colloquium, 15.05.2018

14.09.1976 Visit *H. Matthöfer,* BMFT

Hans Matthöfer, BMFT
Ch. Schmelzer *H.O. Schuff*
G. Herrmann P. Armbruster *R. Bock*
with GSI Directors at UNILAC

Photo: A. Zschau, GSI

Sept 1973 Decision for **SHIP** (***S***eparator for ***H***eavy ***I***on reaction ***P***roducts)

large acceptance two-stage velocity filter

strongly focusing quadrupole magnets (*G. Münzenberg, H. Wollnik*)

Reason: Efficiency, Selectivity AND Budget and Time

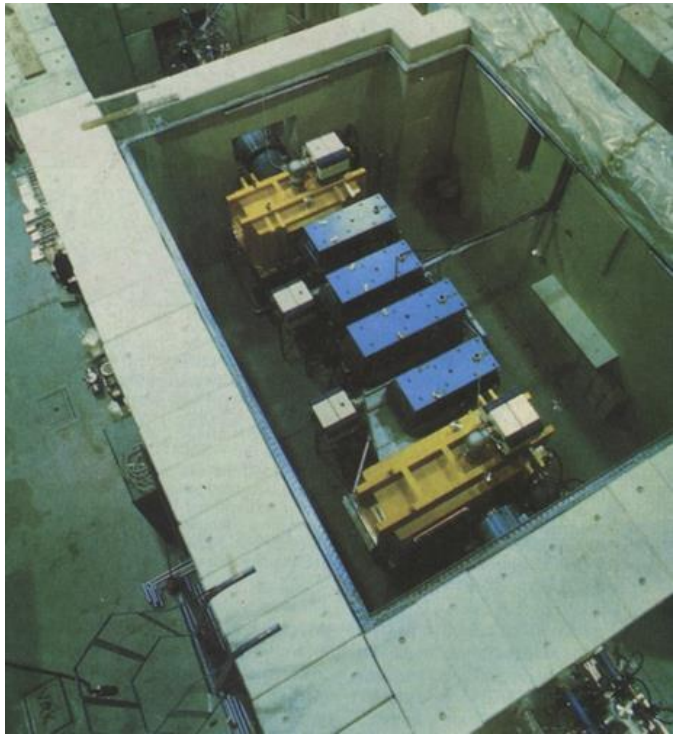
Collaboration contract: GSI (***Peter Armbruster***) –
II. Physikalisches Institut, JLU Gießen (***Heinz Ewald***)

All Photos: A. Zschau, GSI

12.05.1975 Building SHIP

Peter Armbruster, GSI
(Admin. Project Leader)

Gottfried Münzenberg, JLU GI
(Project Manager)
K. Güttner, P. Hinkel, W. Faust, H.-J. Schött, H.G. Burkhard ...
and GSI and JLU infrastructure



Dec 1975 First beam in SHIP (^{40}Ar)

Mar 1976 Fully operational

SHIP The Preparation Phase

1973 Concern: Primary beam separation efficiency **?**

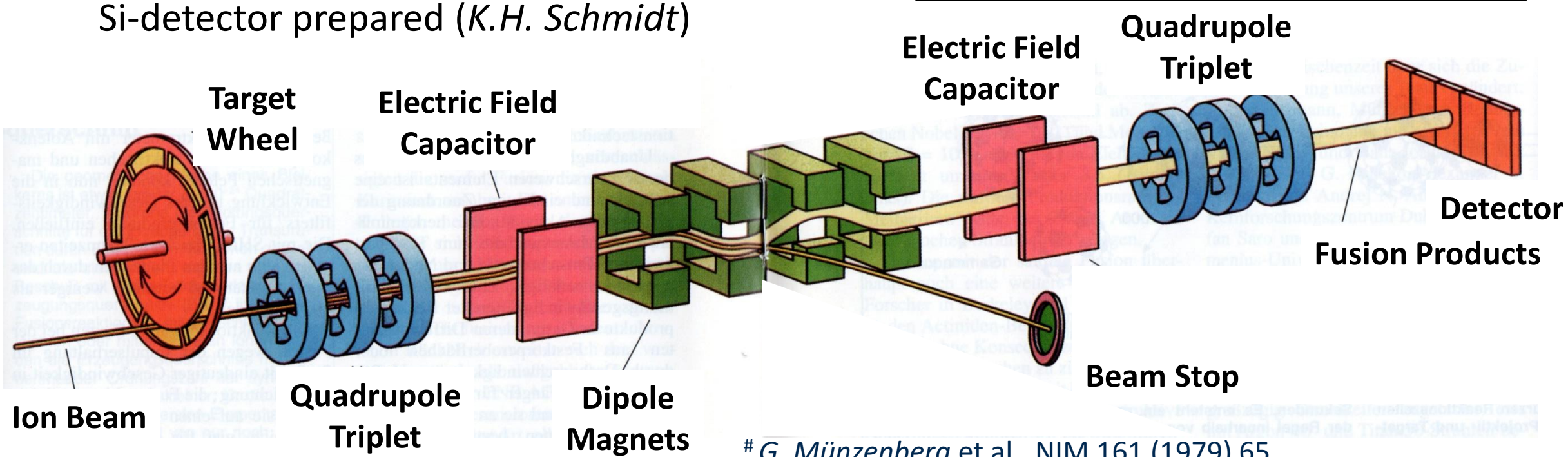
P. Armbruster, **Head of SHIP**, assigned tasks:

< 10^6: He-Jet + Tape system prepared (*S. Hofmann, K. Valli*)

> 10^6: E-TOF det. prepared (*W. Schneider*)
Si-detector prepared (*K.H. Schmidt*)

1975 Primary beam reduction
>> 10^6 Obtained[#] ***GREAT !!!***
10^{12} Ar+Sm ...10^8 Xe+ Fe
➔ Si-Detectors + E-TOF

1976 SHIP Ready for Experiments



Graphic: *P. Armbruster*, Spektrum der Wissenschaften 12/1996

[#] *G. Münzenberg* et al., NIM 161 (1979) 65
H. Ewald et al., Jahresbericht 1976 GSI-Bericht J1-77 (1977), p. 152

SHIP Developments and Progress 1975-79

Peter Armbruster, Division Leader
KC II + AP

G. Münzenberg,
W. Faust et al. finetuned SHIP

H. Folger et al. advanced target technology

K.-H. Schmidt established **mother-daughter α-α-time-correlation !**
➔ **element (Z) and mass (A) identification**
K.H. Schmidt et al., Nucl. Phys. A 318 (1979) 253

S. Hofmann introduced **subdivided, position sensitive implantation detectors**
➔ **strong background reduction**

W. Reisdorf,
K.H. Schmidt et al. made basic nuclear reaction studies

F.P. Heßberger joint the SHIP group (1979)

My cordial thanks to Fritz Heßberger for many interesting and enlightening discussions and deep insights into the history of SHIP

1976-78 Search for SHE Approaches Fusion ⇔ Transfer $^{238}U + ^{238}U$

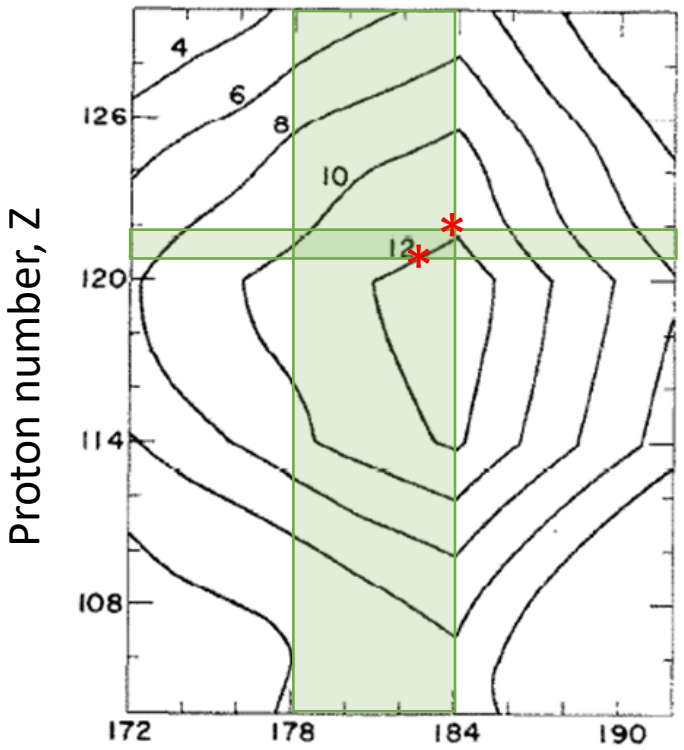
SHIP $^{136}Xe + ^{170}Er \rightarrow ^{306}122^{*}$ and $^{65}Cu + ^{238}U \rightarrow ^{303}121^{*}$

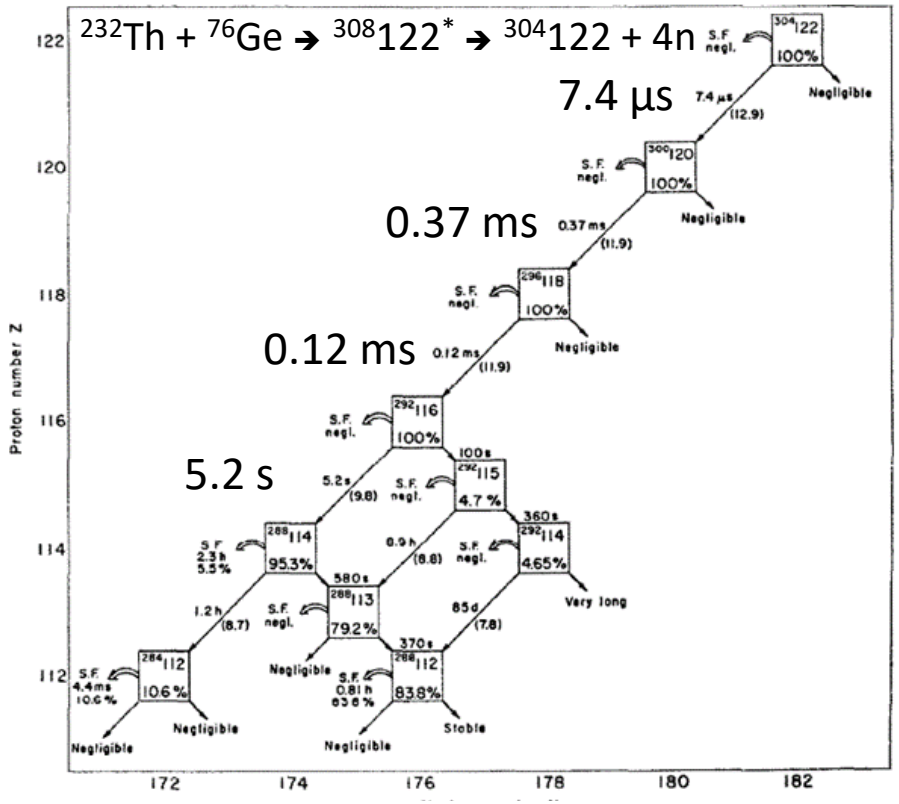
No SHE σ(lim) = 1.5 nb and 0.4 nb (>> 10 mb ! expected)

P. Armbruster et al., Jahresbericht 1976 GSI Bericht J1-77 (1977) p. 74

G. Münzenberg et al., Jahresbericht 1977 GSI Bericht J1-78 (1978) p. 75

Strong shell at Z = 120





$B_f \leq 12$ MeV *E.O. Fiset, J.R. Nix* Nucl. Phys. A193 (1972) 647

Physics

No SHE σ(lim) = 20 nb

Z, E, ∠ Product distribution measured

Massive particle diffusion observed

K.D. Hildenbrand et al.

PRL 39 (1977) 1056

Chemistry

No SHE σ(lim) = 1 nb .. 10 pb

$t_{1/2}$ = 1 ms .. 100 a

Transfer + Fission measured

Actinide synthesis revealed

M. Schädel et al. PRL 41 (1978) 469

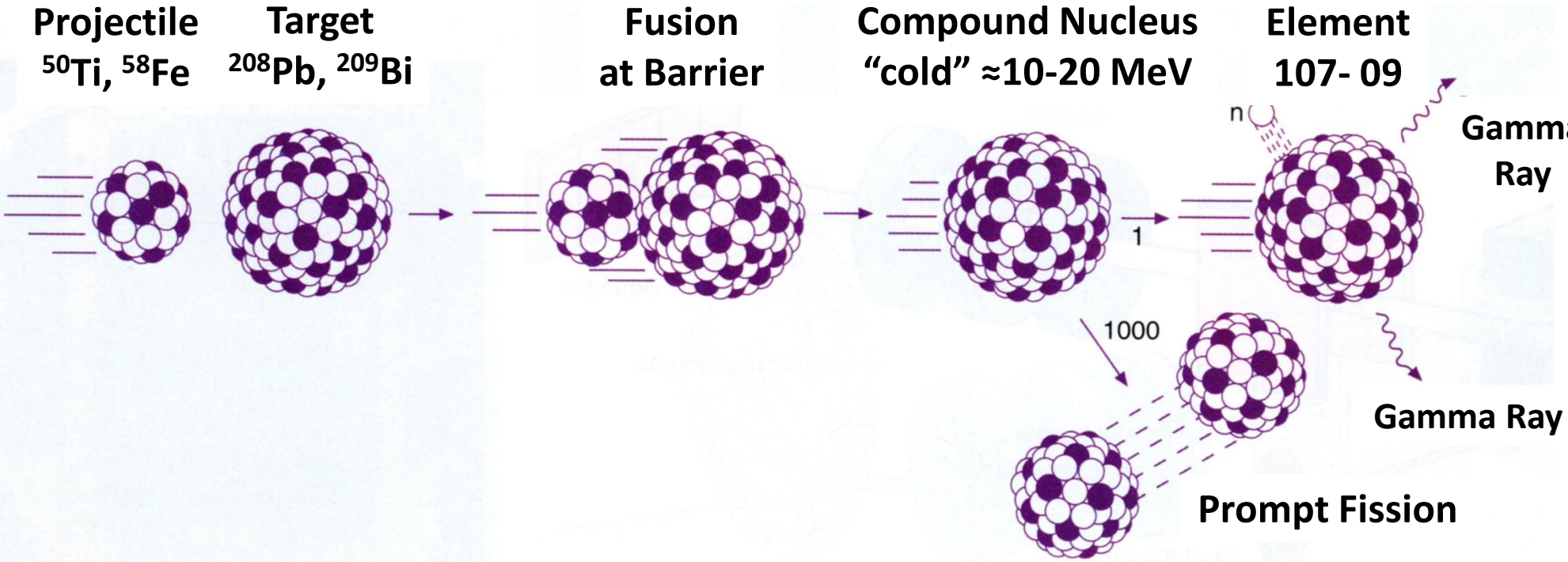
H. Gäggeler et al. PRL 45 (1980) 1824

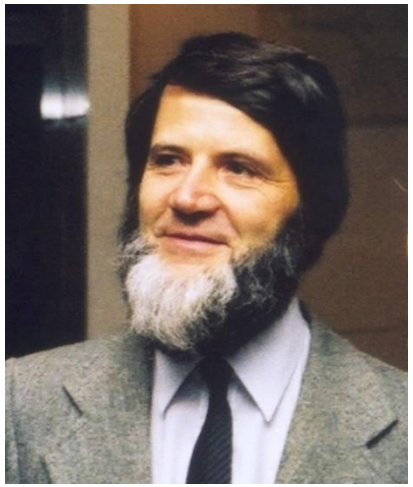
1979 - ... An Exciting Period at SHIP – From Fm to Element 107, 108 and 109

P. Armbruster: Stepwise Upwards into SHE – including nuclear reaction / decay studies

"Cold-Fusion" - Pb/Bi targets – suggested by *Yu. Ts. Oganessian*[#]

Compound nuclei with low excitation energy ➔ high survivability





17.12.1979
Photo: A. Zschau, GSI

[#] *Yu. Ts. Oganessian* Lecture Notes in Physics 33 (1975) 221 and Nucl. Phys. A 239 (1975) 157

Graphic*: P. Armbruster* Die Synthese überschwerer Elemente, Spektrum der Wissenschaften, Dezember 1996; mod. MS 2026

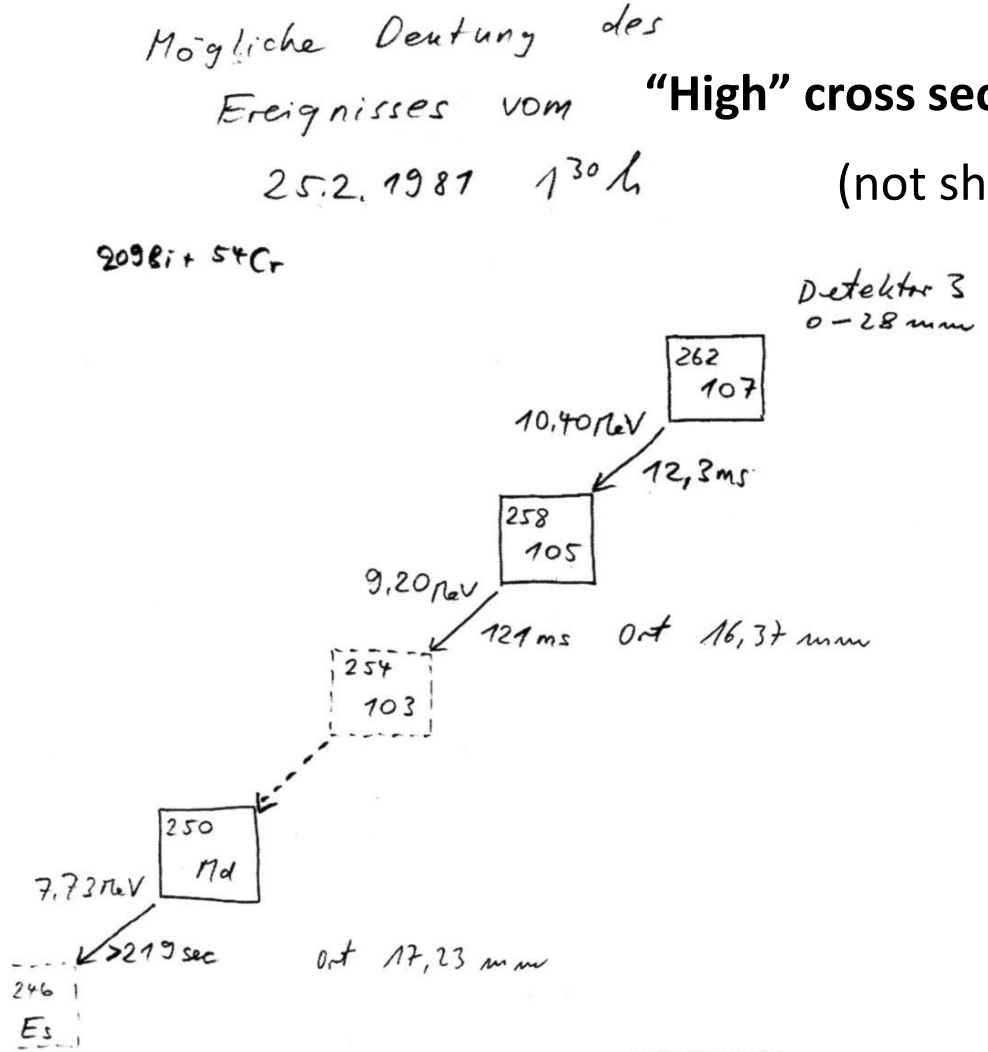
Element 107 *Discovery*

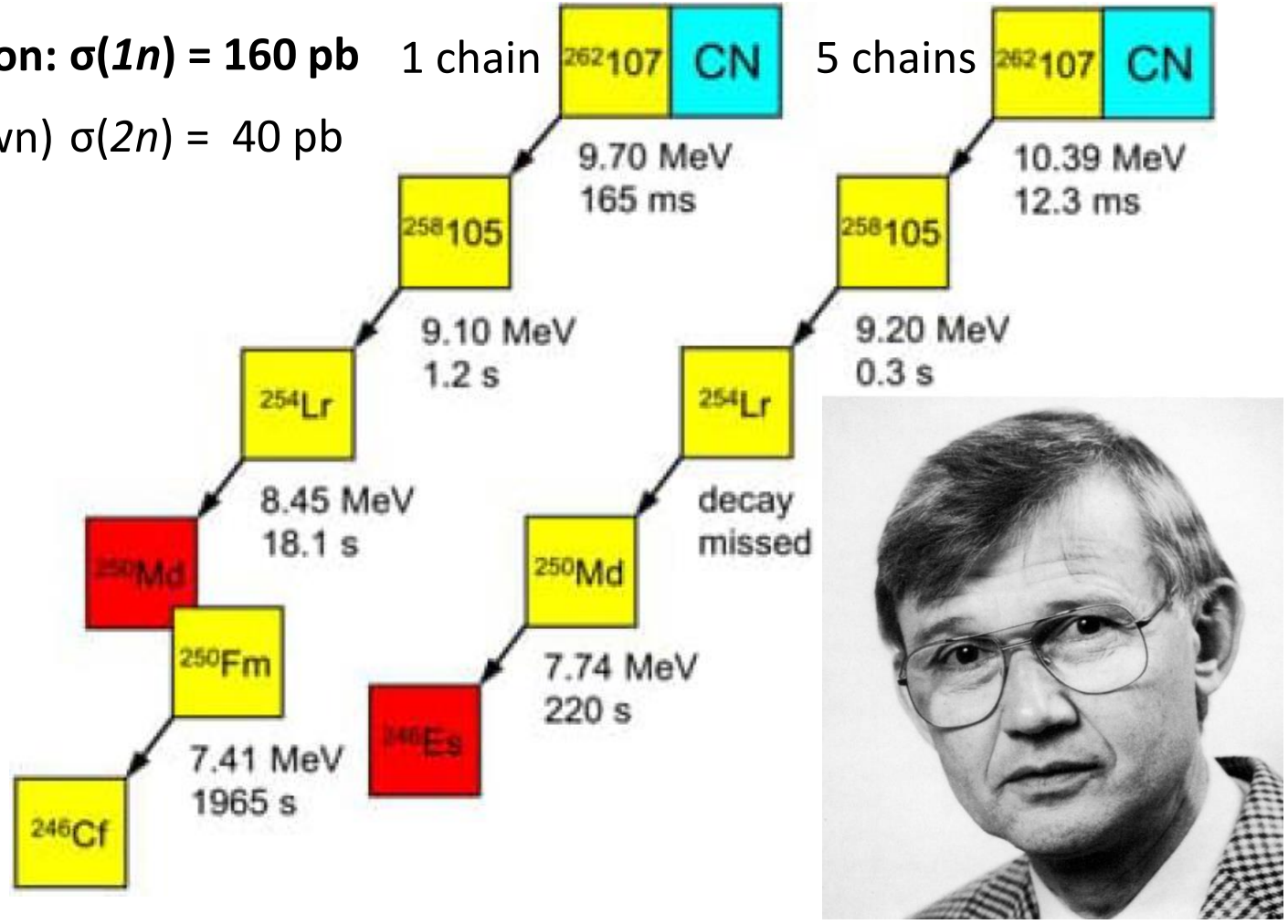
Six *1n*-events observed in 1981

Feb. 1981 $^{54}Cr + ^{209}Bi \rightarrow ^{263}107^{*} \rightarrow ^{262}107 + \underline{1n}$

"High" cross section: σ(*1n*) = 160 pb

(not shown) σ(*2n*) = 40 pb





G. Münzenberg et al., Z. Phys. A 300 (1981) 107

G. Münzenberg, M. Schädel Moderne Alchemie, Vieweg (1996)

G. Münzenberg et al., Z. Phys. A 333 (1989) 163

S. Hofmann, EPJ 131 (2026) 06001 (Graphic)

Element 109 *"Evidence for Element 109"*

August 1982 $^{58}Fe + {}^{209}Bi \rightarrow {}^{267}109^{*} \rightarrow {}^{266}109 + \underline{1n}$

Photo: A. Zschau, GSI

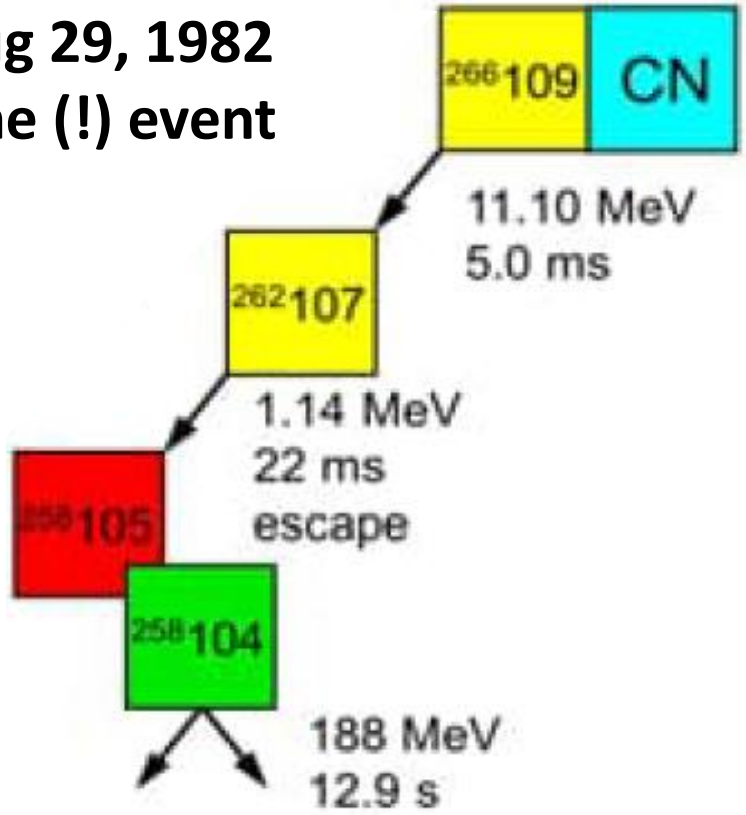
Pride, Happiness and Satisfaction

Zero events after 5 d of irradiation ➔
Heated debate about beam energy

Stay? Go up? Go down?

Unknown, narrow excitation fct.!
From 4.95 up to 5.15 Me/u

Aug 29, 1982
One (!) event



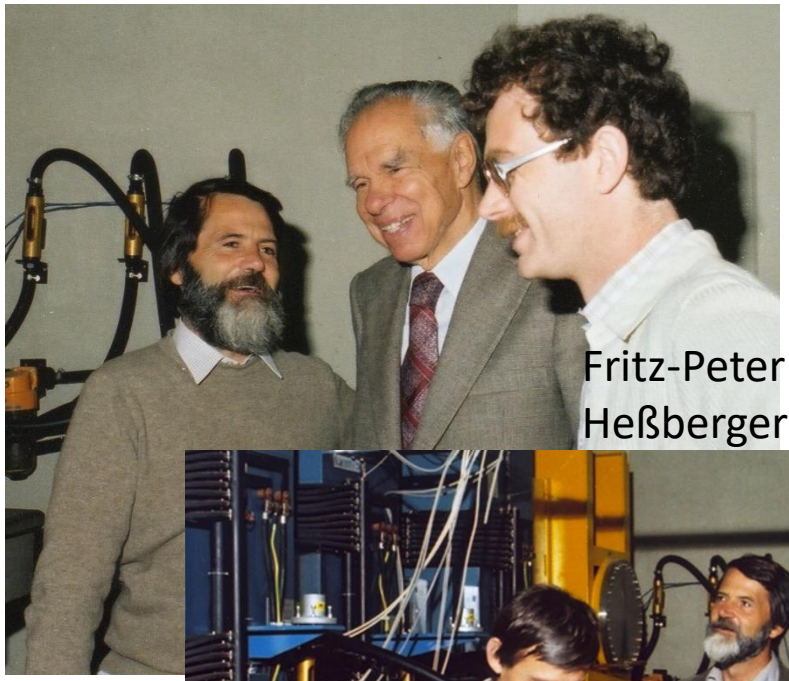
G. Münzenberg et al., Z. Phys. A 309 (1982) 89
S. Hofmann, EPJ 131 (2026) 06001 (Graphic)

Sept 1982-1983 $^{48}Ca + {}^{248}Cm \rightarrow {}^{296}116^{*}$ Challenge, "World" Collaboration

22.09.1982 G.T. Seaborg at GSI: Kudos to *SHIPPERS* for the new elements

Start the $^{48}Ca + {}^{248}Cm$ collaboration → "A Great Depression"

With Günter Herrmann
for the "chemists" –
long-term collaboration
with Glenn T. Seaborg
LBL and LASL, LLNL, ORNL



Fritz-Peter
Heßberger

P. Armbruster, G. Münzenberg
S. Hofmann showing the event
of the element 109 discovery

Gottfried Münzenberg
at SHIP

Fotos: A. Zschau, GSI

Sept 1982-1983 $^{48}Ca + ^{248}Cm \rightarrow ^{296}116^{*}$ Challenge

Darmstadt-Berkeley-Mainz-Los Alamos-Bern-Göttingen Collaboration

Joint Experiments – including exchange of personnel -

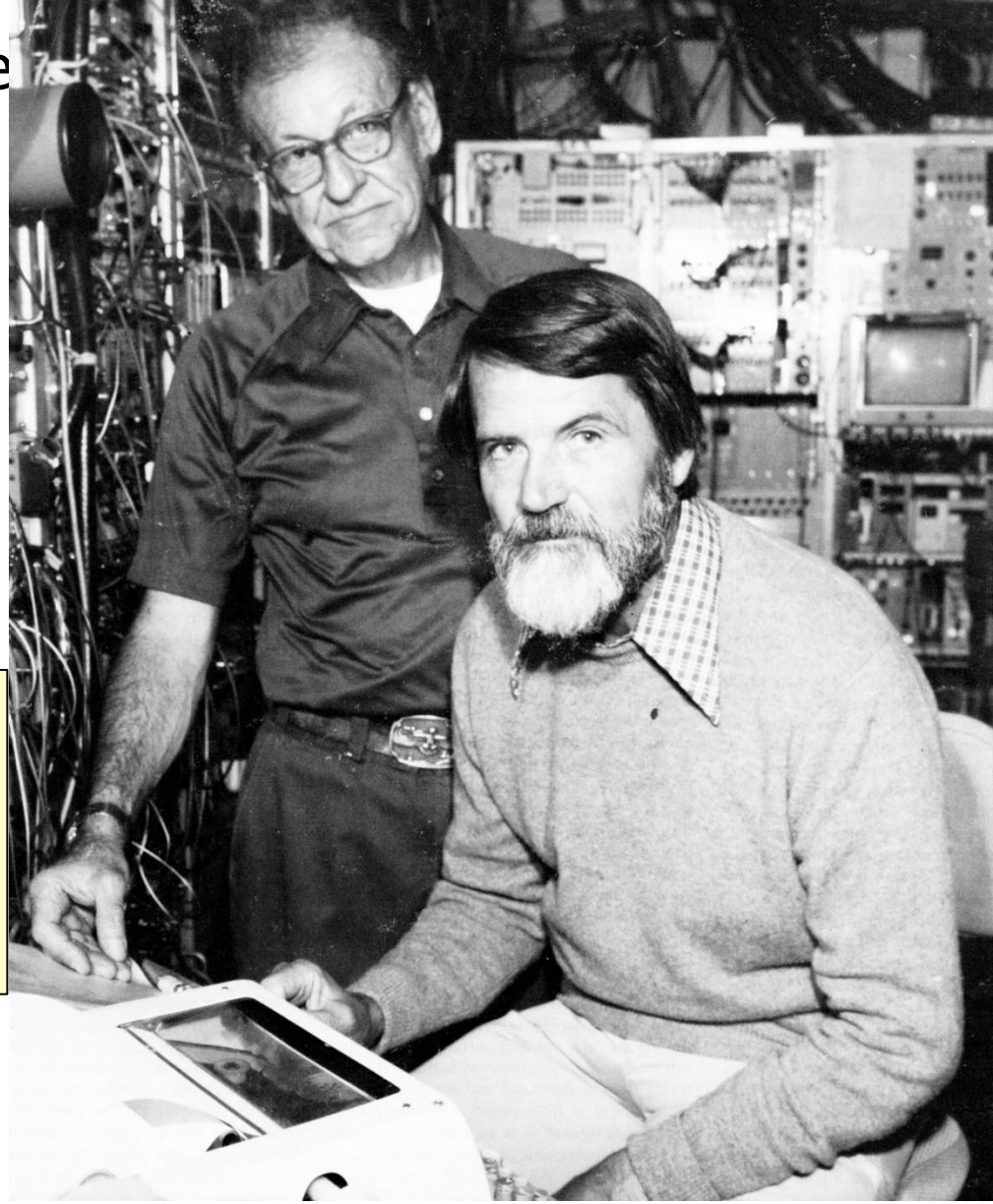
* LBL's SuperHILAC: SASSY, Chemistry ("slow", manual)

* GSI's UNILAC: SHIP, Chemistry ("fast", automated)

Working at and jointly optimizing *"Al" Ghiorso's* gas-filled separator **SASSY** (**S**mall **A**ngle **S**eparator **SY**stem)[#] at the SuperHILAC - together with postdoc *Matti E. Leino* - *Peter Armbruster*, as THE expert, was "in his element"

[#] *A. Ghiorso*, ... *M.E. Leino*... *P. Armbruster* et al., NIM A269 (1988) 192

Enormously engaged in the experiment preparation, Peter Armbruster also found time to enjoy the beauty of California's nature from seashores to the mountains



"Al" Ghiorso, *Peter Armbruster* at SASSY shack
Foto: LBL News Magazine 7 (3-4) Fall/Winter 1982/83

Sept 1982-1983 $^{48}Ca + ^{248}Cm$, Great Expectations ➔ Great Disappointment

VOLUME 54, NUMBER 5 PHYSICAL REVIEW LETTERS 4 FEBRUARY 1985

Attempts to Produce Superheavy Elements by Fusion of ^{48}Ca with ^{248}Cm in the Bombarding Energy Range of 4.5–5.2 MeV/u

P. Armbruster

P. Armbruster, Y. K. Agarwal, W. Brüchle, M. Brügger, J. P. Dufour, H. Gäggeler, F. P. Hessberger, S. Hofmann, P. Lemmertz, G. Münzenberg, K. Poppensieker, W. Reisdorf, M. Schädel, K.-H. Schmidt, J. H. R. Schneider, W. F. W. Schneider, K. Sümmerer, D. Vermeulen, and G. Wirth

Darmstadt *Gesellschaft für Schwerionenforschung, Darmstadt, Federal Republic of Germany*

and

A. Ghiorso, K. E. Gregorich, D. Lee, M. Leino, K. J. Moody, G. T. Seaborg, R. B. Welch, P. Wilmarth, and S. Yashita

Berkeley *Lawrence Berkeley Laboratory, University of California, Berkeley, California 94720*

and

C. Frink, N. Greulich, G. Herrmann, U. Hickmann, N. Hildebrand, J. V. Kratz, and N. Trautmann

Mainz *Universität Mainz, Mainz, Federal Republic of Germany*

and

Los Alamos M. M. Fowler, D. C. Hoffman, and W. R. Daniels
Isotope and Nuclear Chemistry Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87544

and

H. R. von Gunten

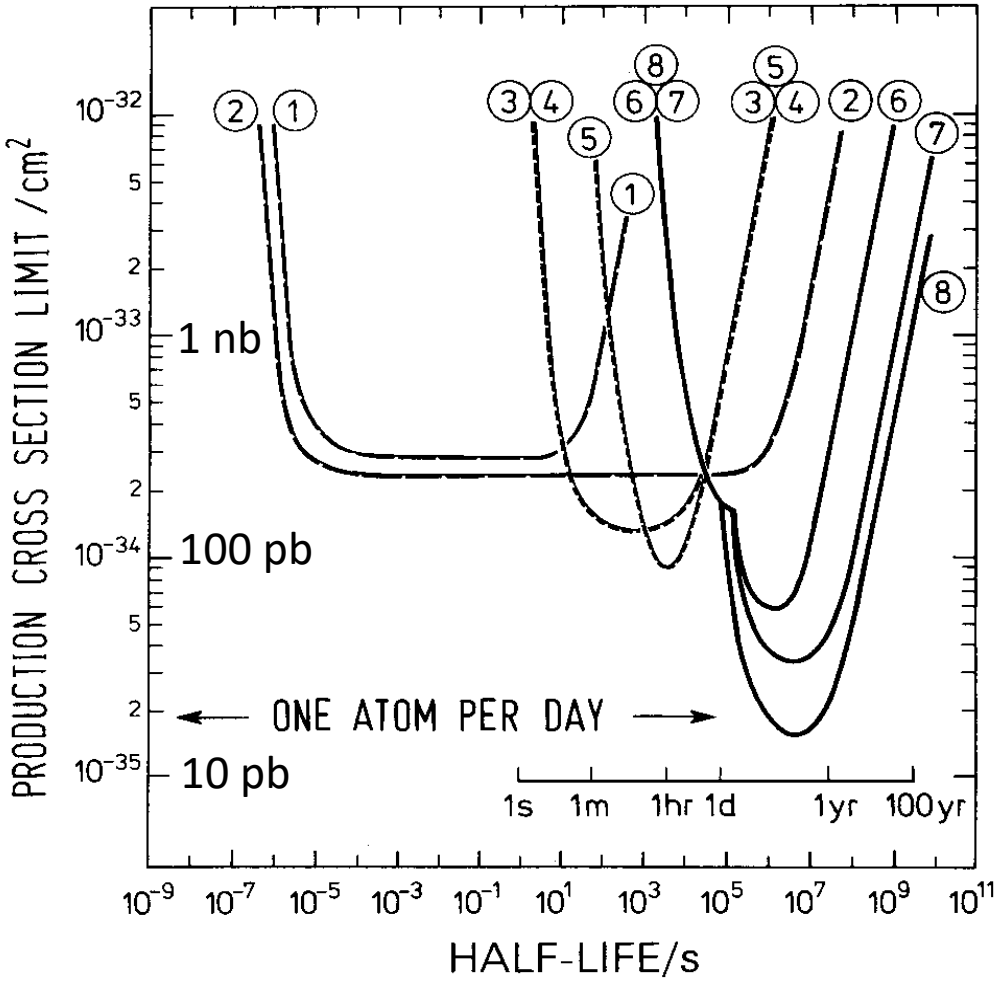
Bern *Universität Bern, Bern, Switzerland, and Eidgenössische Institut für Reaktorforschung, Würenlinger, Switzerland*

and

H. Dornhöfer

Göttingen *Universität Göttingen, Göttingen, Federal Republic of Germany*

(Received 2 November 1984)



1,2 Separators SASSY and SHIP
3,4,5 Online chemistry
6,7,8 Offline chemistry

1984-86 Element 108 Discovery – Big surprise: α-decay, NOT fission

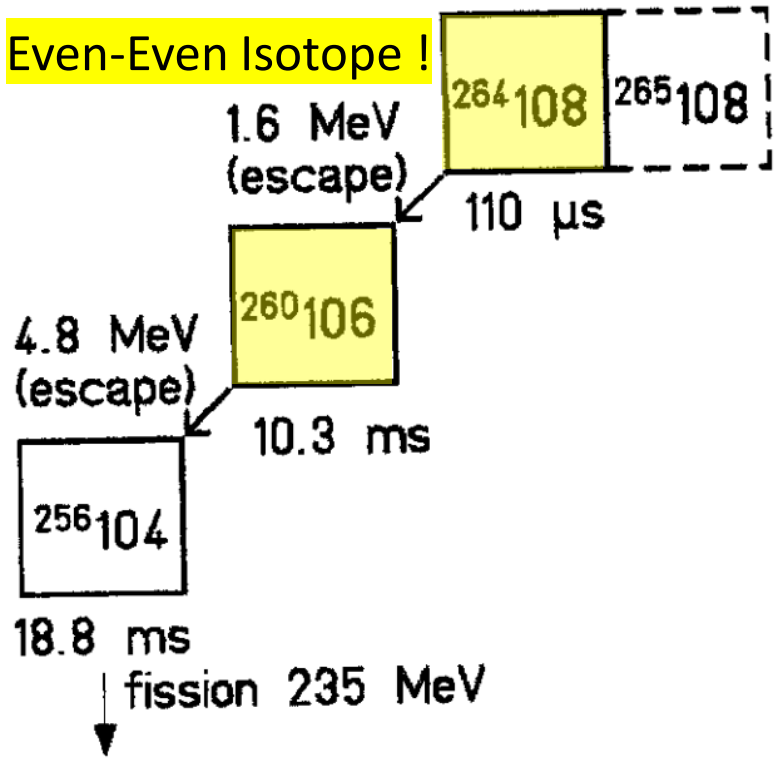
1984 1. $^{54}Cr + {}^{207,208}Pb \rightarrow {}^{261,262}106^{*} \rightarrow {}^{259,\mathbf{260,261}}\mathbf{106}$ ***isotopes discovered, α-decay !***

Intense (!) discussions about the beam energy

2 . $^{58}Fe + {}^{208}Pb \rightarrow {}^{266}108^{*} \rightarrow {}^{\mathbf{265}}\mathbf{108} + \underline{\textit{1n}}$ ***α-decay !***

1986 3 . $^{58}Fe + {}^{208}Pb \rightarrow {}^{266}108^{*} \rightarrow {}^{\mathbf{264}}\mathbf{108} + \underline{\textit{2n}}$ ***α-decay !!!***

Even-Even Isotope !

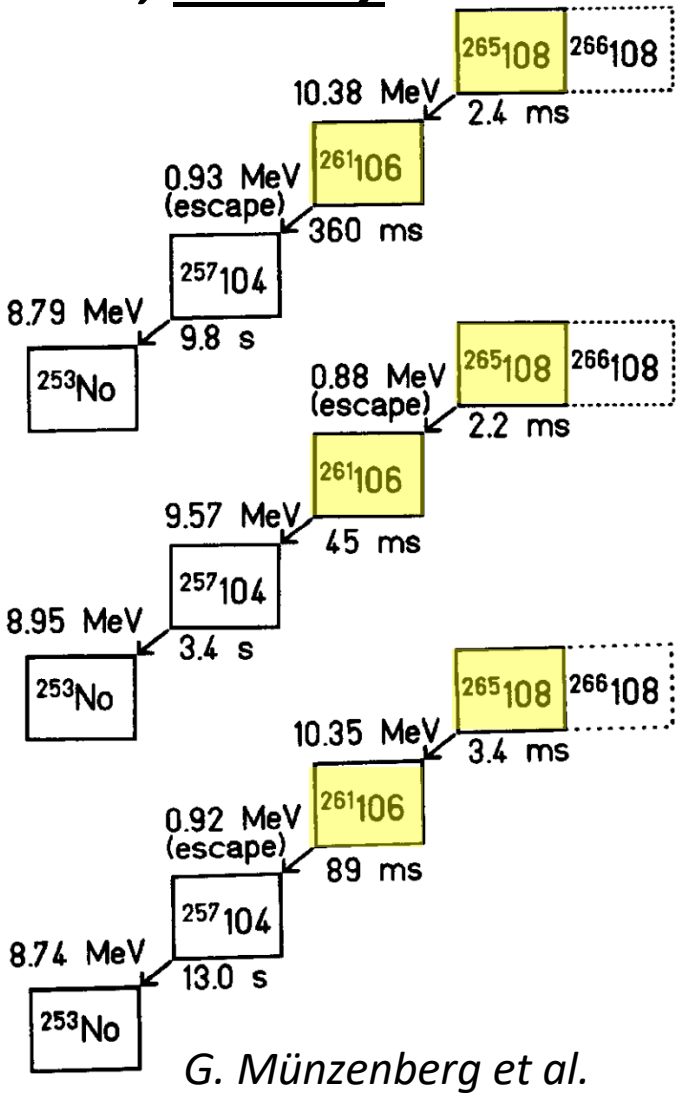


G. Münzenberg et al.
Z. Phys. A 324 (1986) 489; 328 (1987) 49

"... a sensation..."

P. Armbruster, G. Münzenberg
Eur. Phys. J. H 37 (2012) 237

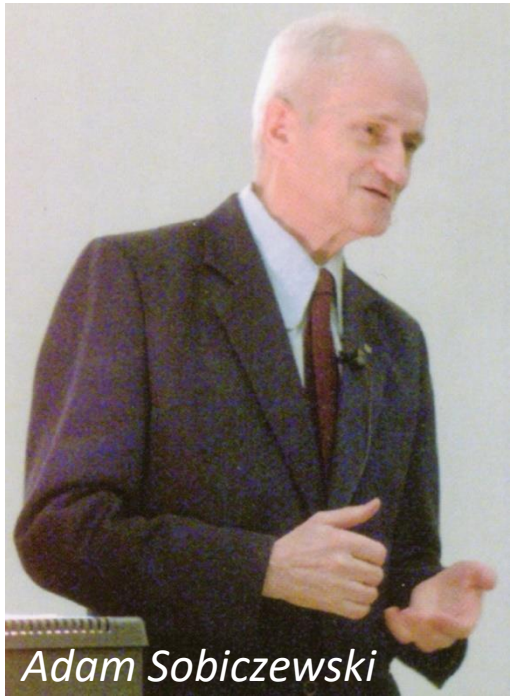
Experimental observation of enhanced shell stabilization around Z=108



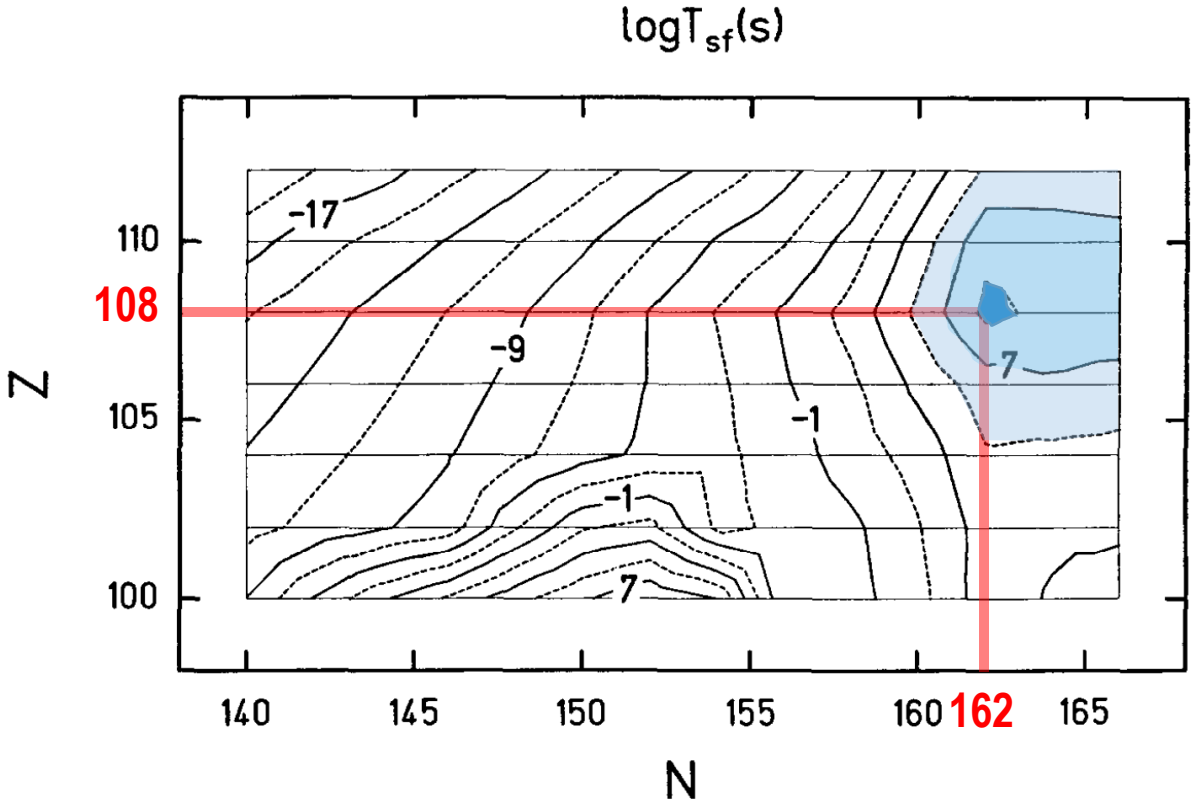
G. Münzenberg et al.
Z. Phys. A 317 (1984) 235

01.02.1985 Peter Armbruster
Professor für Physik, TU Darmstadt

Element 108 – Game Changer and Door Opener – Discovery of Deformed SHE



J.M. Nitschke Memorial
LBNL 1999; *D.C. Hoffman*
Acta Phys. Pol. B 34 (2003) 1639



Contour plot, calculated sf half-lives

Z. Patyk, J. Skalski, A. Sobiczewski, S. Cwiok,
Nucl. Phys. A502 (1989) 591c
See also:
Z. Patyk, A. Sobiczewski, P. Armbruster, K.-H. Schmidt
Nucl. Phys. A491 (1989) 267

Region of <u>deformed</u> SHE nuclei
along <u>N=162 shell</u>

Maximum sf half-lives at Z=108

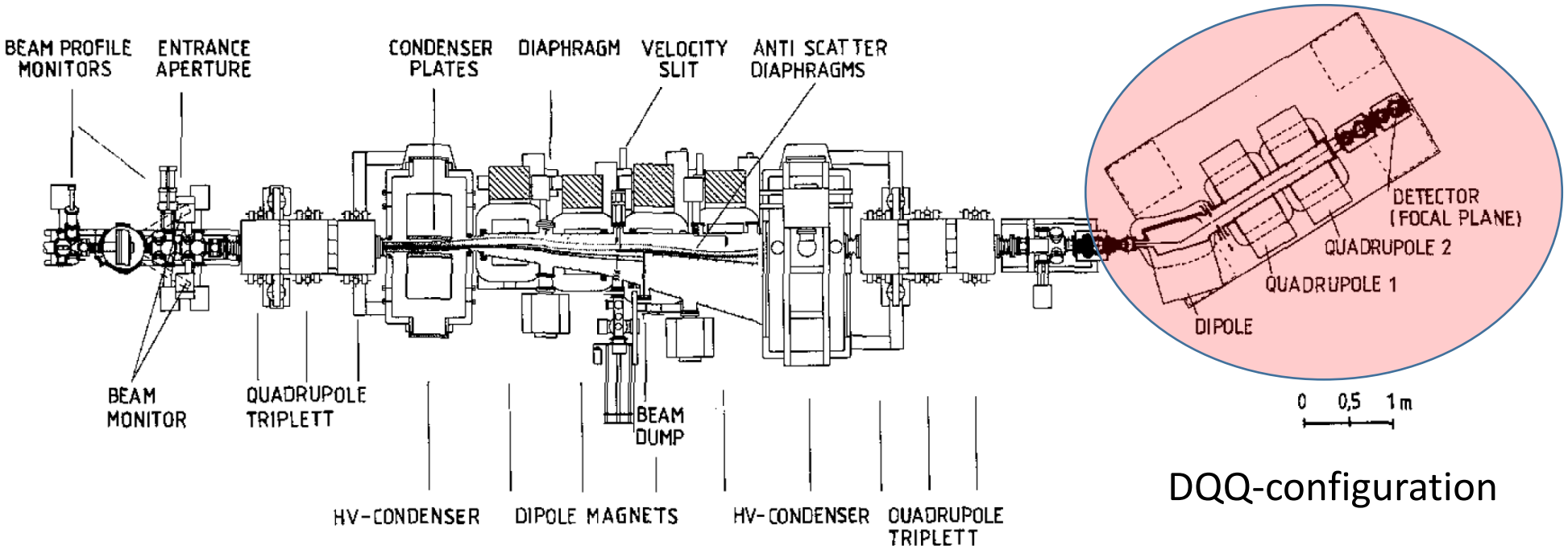
Macroscopic-microscopic theory
applying multi-dimensional spaces

1987-94 Intermission – Improvements at SHIP (Efficiency, Sensitivity... ➔ *SHIP94*)
– Improvements at UNILAC (new ECR-HLI injector, ...)
– Great shift in personnel, leadership, responsibilities

1987 Gas-filled separator behind SHIP: "NASE" in operation with SHIP, "HECK" as stand-alone

(**Na**ch**se**parator, Post-separator) (**HECK**, stern of SHIP)

Peter Armbrusters favorite



DQQ-configuration

Design, construction
B. Thuma, G. Bertes, G. Münzenberg, ...

Optim., Experiments
F.P. Heßberger et al., Lecture Notes in Phys. 317 (1988) 289
V. Ninov, P. Armbruster et al., Nucl. Instr. Meth. A357 (1995) 486

1987-94 Intermission – Improvements at SHIP (Efficiency, Sensitivity... ➔ *SHIP94*)
– Improvements at UNILAC (ECR-source, ...)

1989 – Great shift in personnel, leadership, responsibilities

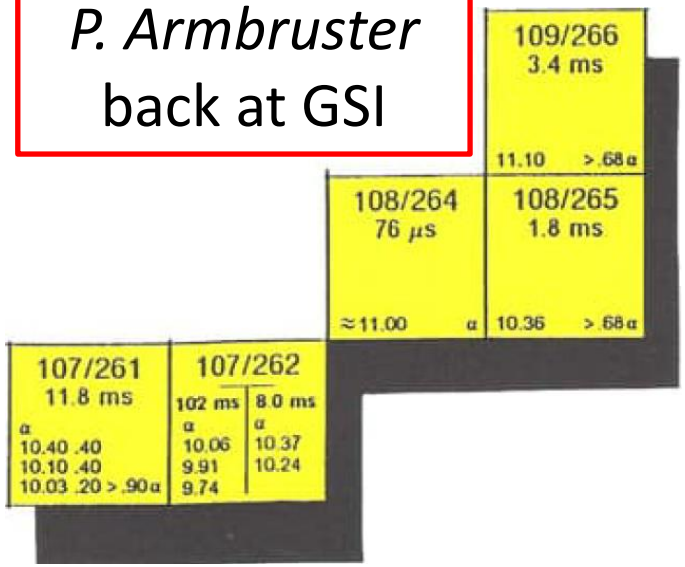
---

Peter Armbruster left GSI/SHIP ➔ Research Director, ILL, Grenoble **until 1992**
Remained involved in heated, international quarrels about **naming of elements** and their **discovery** (ongoing since > 20 a)

Gottfried Münzenberg	Acting Head of KCII and Head of the Fragment Separator (FRS) at SIS
Sigurd Hofmann	Head of the SHIP group
Karl-Heinz Schmidt	Joins the FRS group
Willibrod Reisdorf	Changed field to study relativistic heavy-ion collisions at SIS
Fritz Peter Heßberger	Responsible for the SHIP cave and safe operation
Victor Ninov	Continued until 1996/97
Dieter Ackermann	Contributes to SHIP improvements; diploma thesis TH DA 1989 Joins SHIP from JGU Mainz (1999-2005); GSI senior scientist (≥ 2006)

07.09.1992 “Naming Ceremony” at GSI - Discovery of Elements 107, 108 and 109

P. Armbruster
back at GSI



P. Kienle (GSI Director)
E. Mayer (Minister Hessen)
H. Riesenhuber (BMFT)
H. Folger, F.P. Heßberger,
S. Hofmann, W. Reisdorf,
M. Leino, K.-H. Schmidt,
K. Poppensieger
H.-G. Burkhard

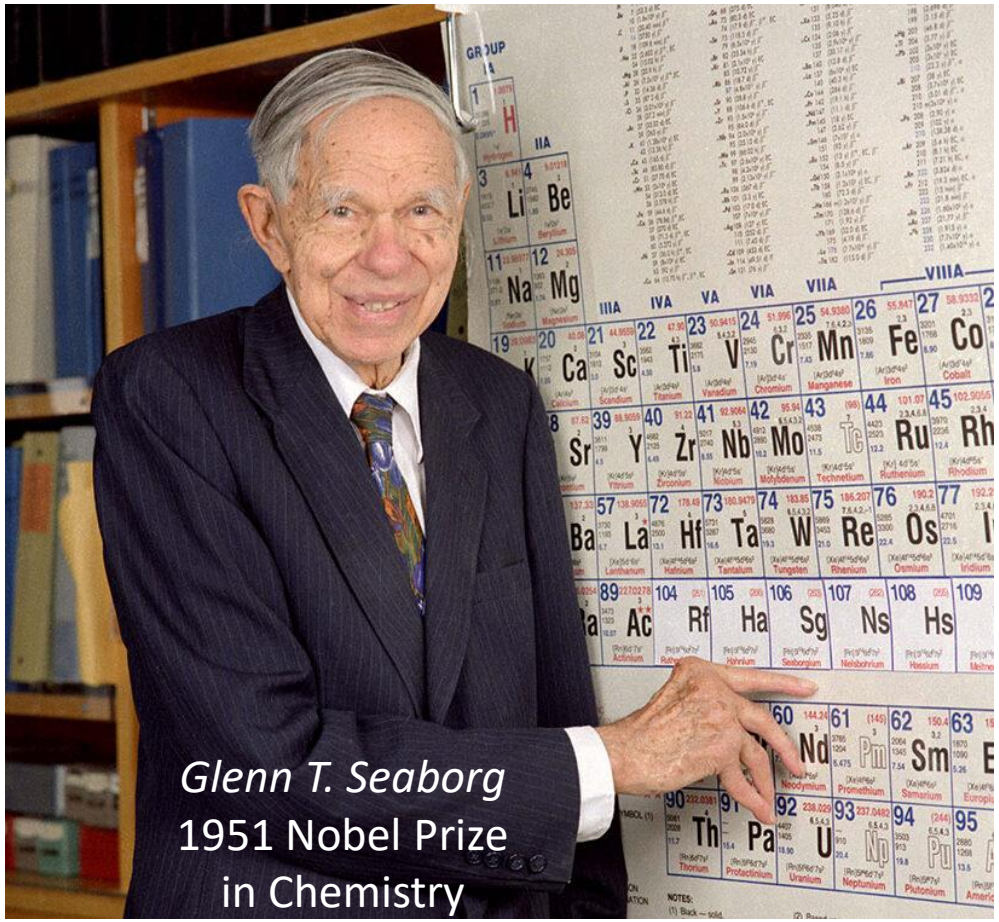
Name **proposed** for 107

P. Armbruster *G. Münzenberg*
H.-J. Schött

For *Peter Armbruster*
it was of utmost importance to honor *Lise Meitner*

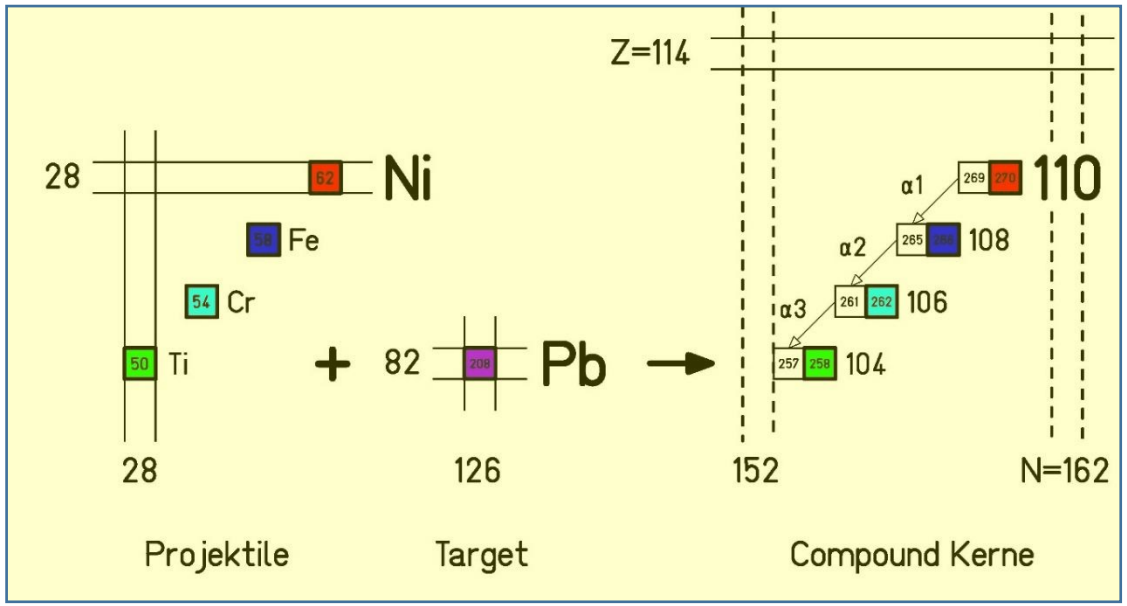
Element Names – Final IUPAC 1997

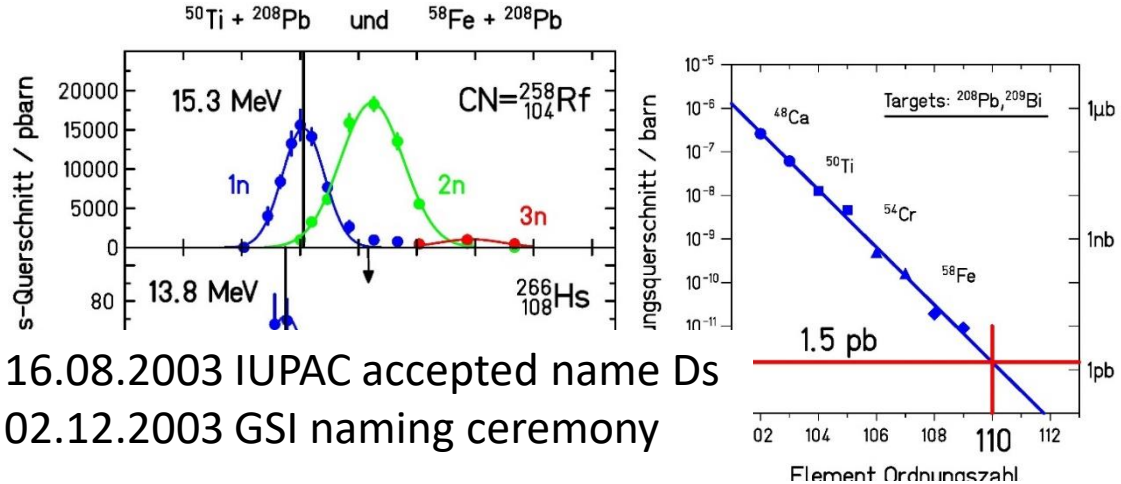
Name Seaborgium, Sg, proposed March 13, 1994
"This is the greatest honor ever bestowed to me – even better, I think, than winning the Nobel Prize"



Element	**Name**
104	Rutherfordium, Rf
105	Dubnium, Db
106	Seaborgium, Sg
107	Bohrium, Bh
108	Hassium, Hs
109	Meitnerium, Mt

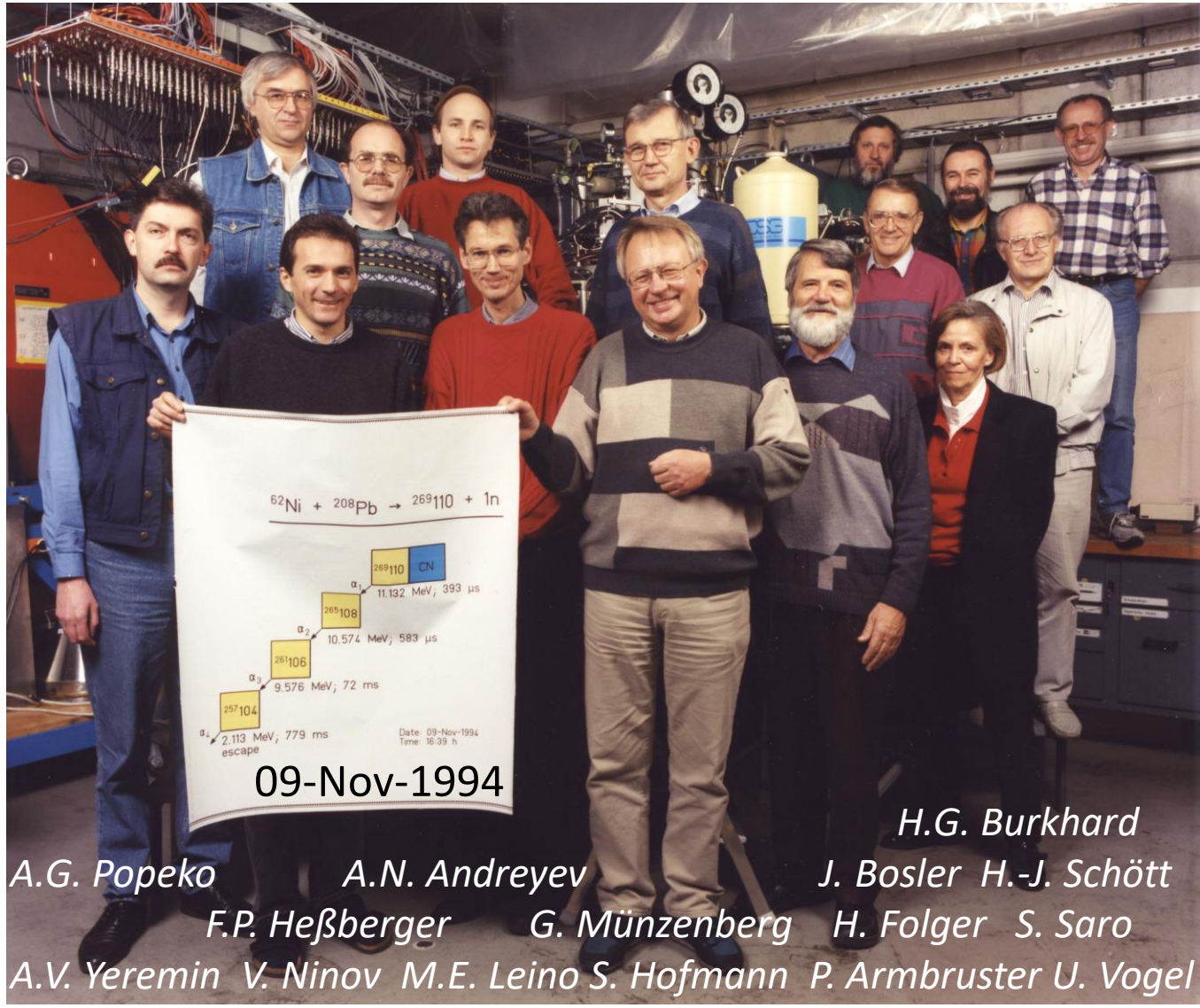
1994 Elements 110 Discovery - 2nd Round - SHE Discoveries at SHIP





16.08.2003 IUPAC accepted name Ds

02.12.2003 GSI naming ceremony



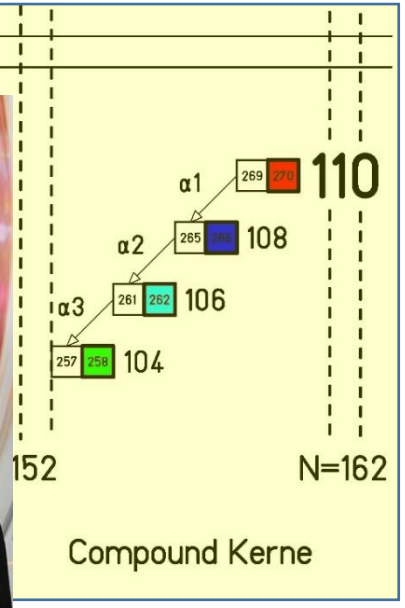
S. Hofmann[1], V. Ninov[1], F.P. Heßberger[1], P. Armbruster[1]
H. Folger[1], G. Münzenberg[1], H.J. Schött[1], A.G. Popeko[2]
A.V. Yeremin[2], A.N. Andreyev[2], S. Saro[3], R. Janik[3], M. Leino[4]

Production and decay of $^{269}110$ Z. Phys. A 350, 277–280 (1995)

End of beamtime: 20. November

Received: 14 November 1994

1994 Elements 110 Discovery - 2nd Round - SHE Discoveries at SHIP



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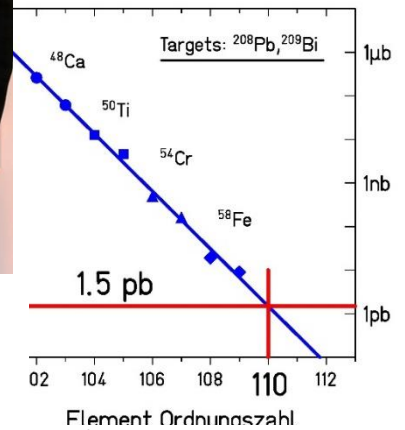
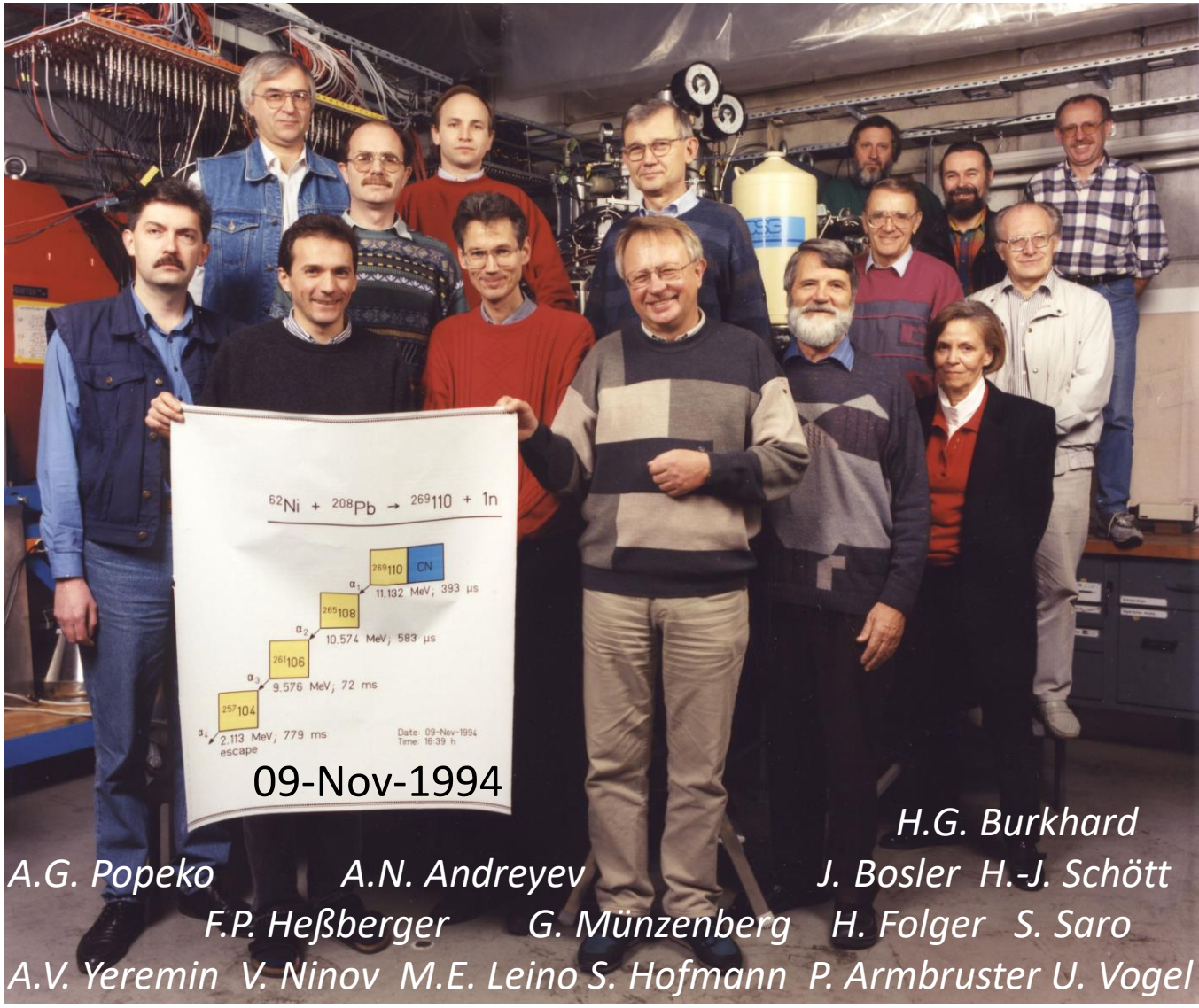
02.12.2003 GSI naming ceremony





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Production and decay of $^{269}110$ Z. Phys. A 350, 277–280 (1995)

End of beamtime: 20. November

Received: 14 November 1994

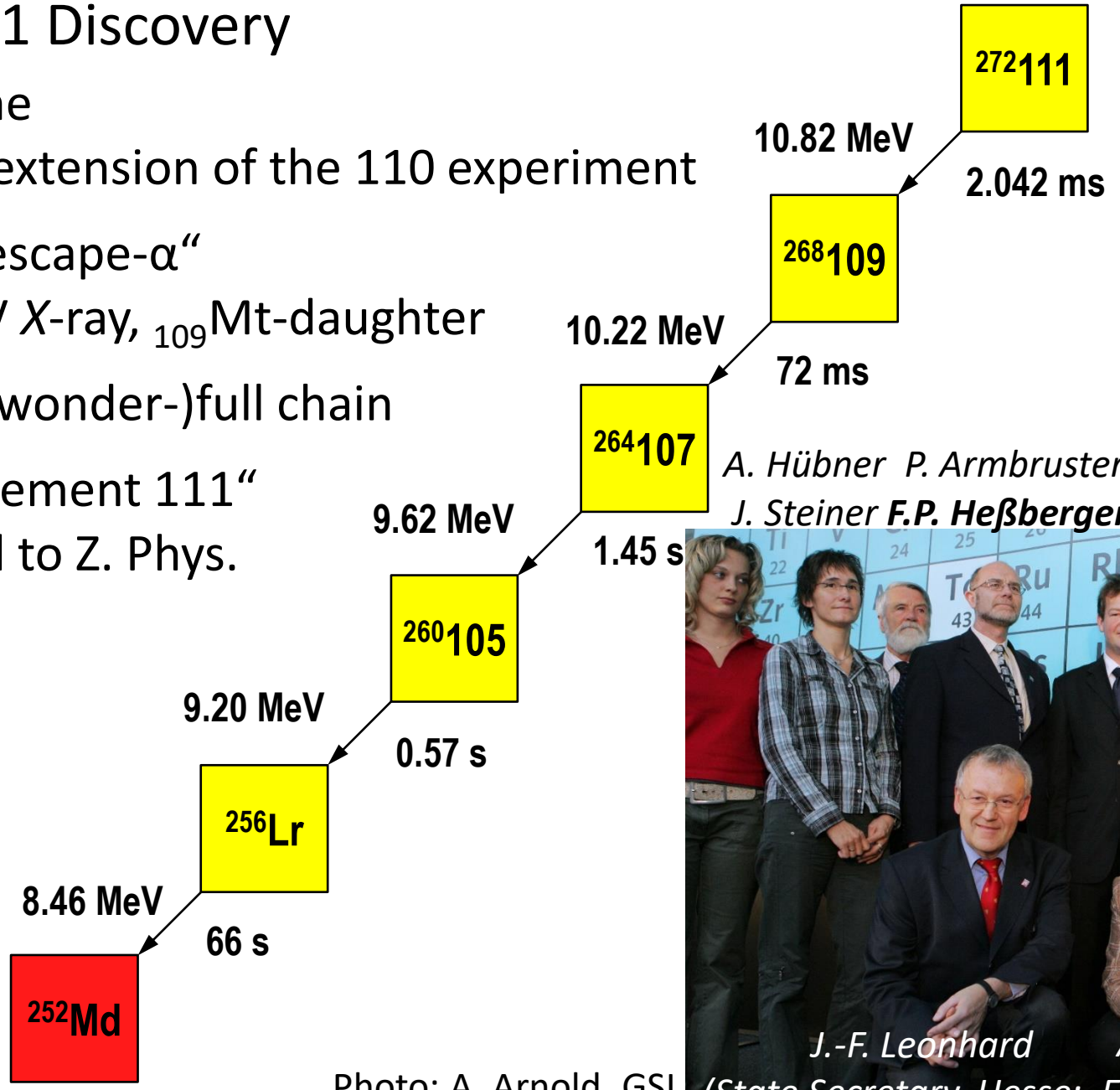
1994 Elements 111 Discovery

Dec 01-18: Beam time
- just an extension of the 110 experiment

Dec 08: 1st event "escape-α"
- but 155 eV *X*-ray, $_{109}$Mt-daughter

Dec 12: 3rd event (wonder-)full chain

Dec 21: „The New Element 111"
- submitted to Z. Phys.



Dec 17, 06:03 h

Naming Element 111
Roentgenium, Rg

Ceremony
GSI 17.11.2006

A. Hübner P. Armbruster *H. Folger, B. Lommel*
J. Steiner ***F.P. Heßberger*** *D. Ackermann*

σ = 2.9 pb (today)
$T_{1/2}$ = 1.7 ms, Isomer?

S. Hofmann et al.
Z. Phys. A. 350 (1995) 281
Eur. Phys. J. A 14 (2002) 147

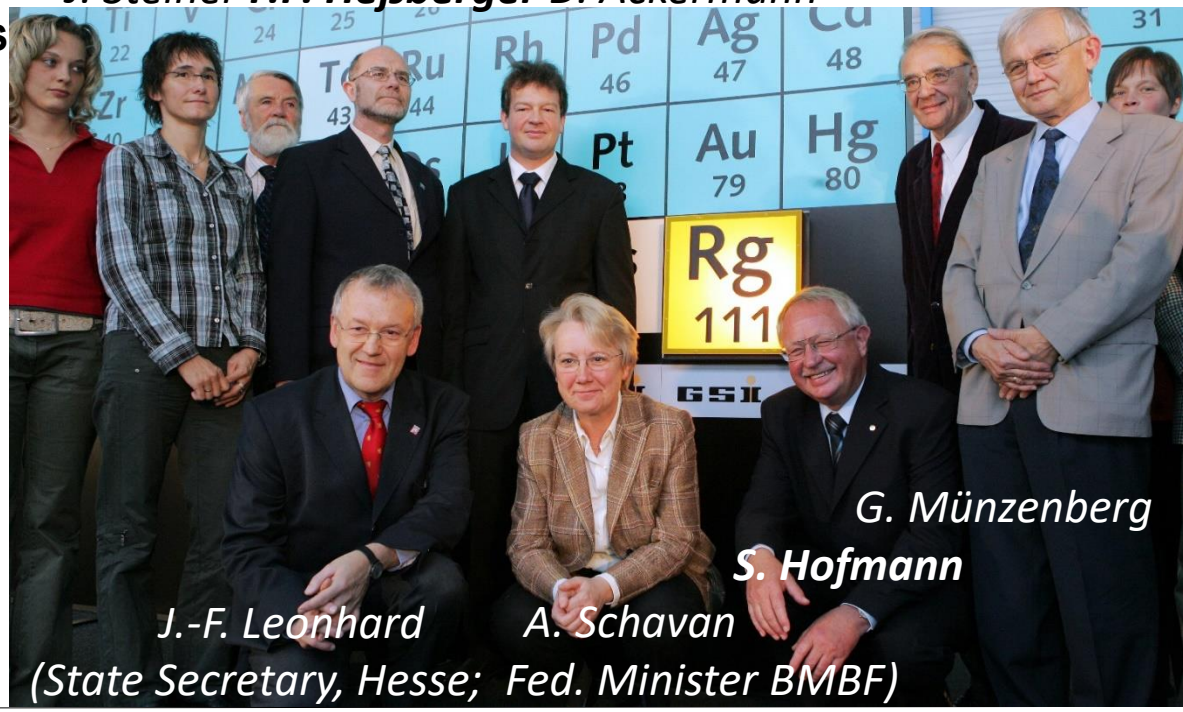
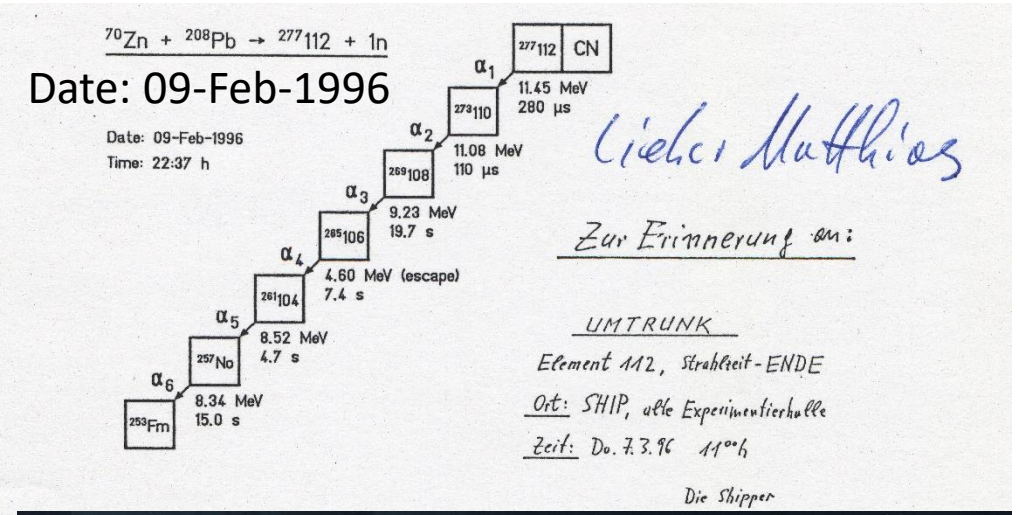
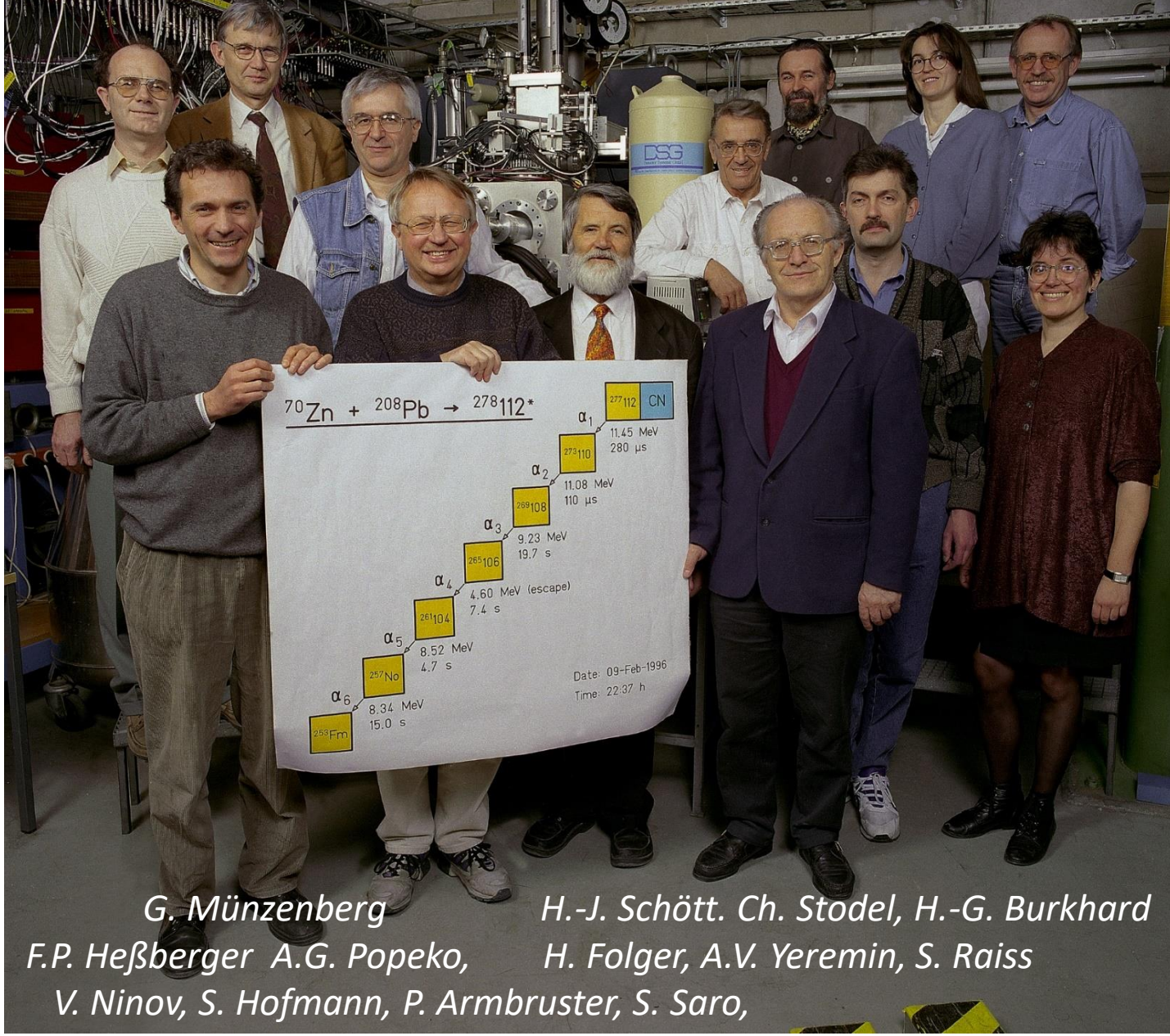


Photo: A. Arnold, GSI

1996 Element 112 Discoverv

End-of-beamtime celebration





G. Münzenberg *H.-J. Schött. Ch. Stodel, H.-G. Burkhard*
F.P. Heßberger A.G. Popeko, H. Folger, A.V. Yeremin, S. Raiss
V. Ninov, S. Hofmann, P. Armbruster, S. Saro,

S. Hofmann et al., Z. Phys. A 345 (1996) 229 and
S. Hofmann et al., Eur. Phys. J. A 14 (2002) 147

Photo: A. Zschau, GSI

1981-96 Discovery of the Island of *DEFORMED* Superheavy Elements

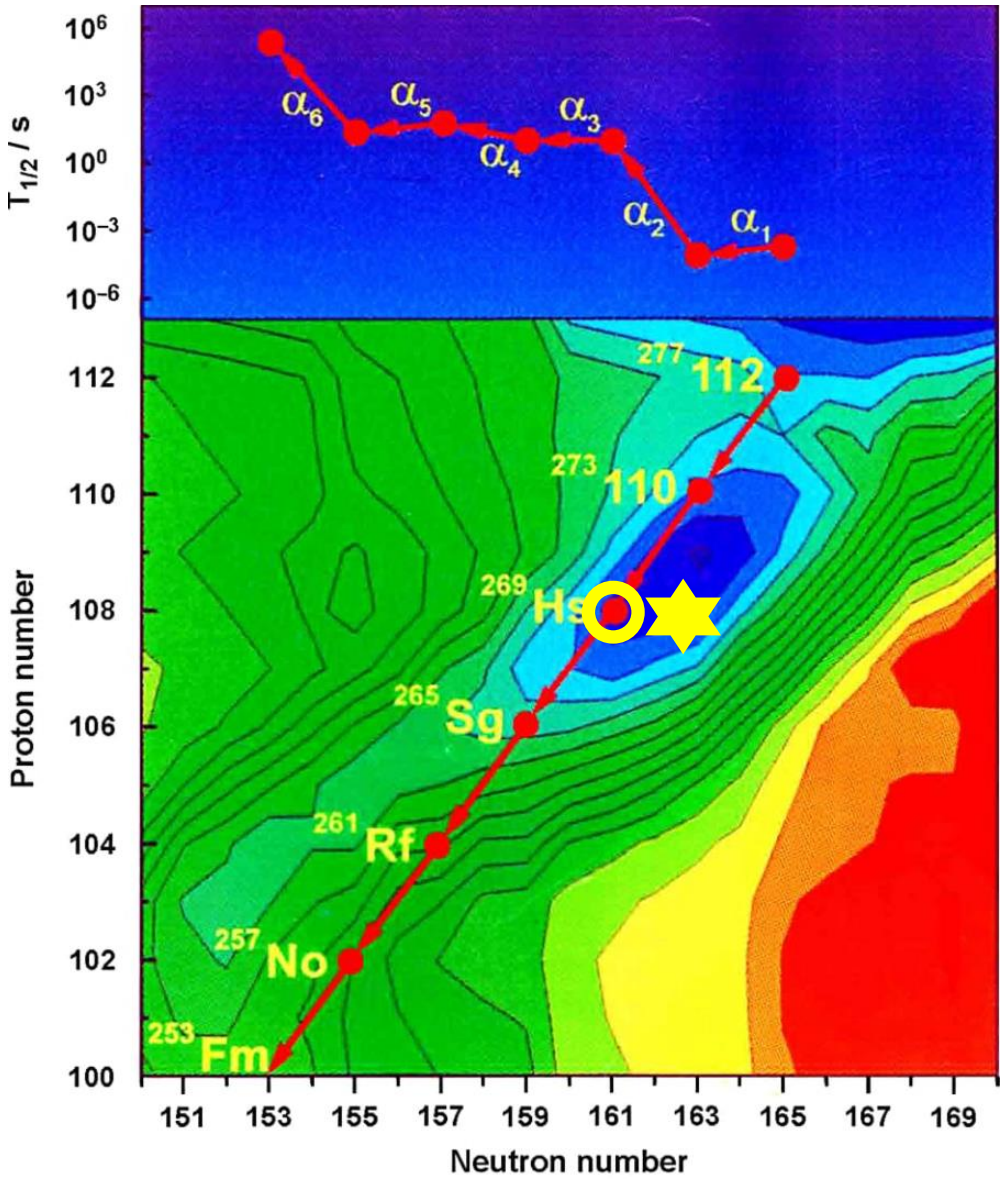


Fig. from: *G. Münzenberg* Nucl. Phys. A 944 (2015) 5

Exploring nuclear stability at N=162 and Z=108-110

Decay chain of the first atom of element 112 passing the shell region of deformed SHE

Upper part: measured single-atom lifetimes

S. Hofmann et al., Z. Phys. A 354 (1996) 229

Lower part: shell correction energy surface and path of the ^{277}112 α-decay chain

P. Möller, J.R. Nix, W.D. Myers, W.J. Swiatecki
At. Data Nucl. Data Tables 59 (1995) 185

Confirmation: Hs chemistry experiment at GSI

○ ^{269}Hs member of the ^{277}112 decay chain

★ $^{270}Hs_{162}$ discovery, α-decay

Ch. E. Düllmann et al., Nature 418 (2002) 859
J. Dvorak et al. Phys. Rev. Lett. 97 (2006) 242501

1996 July 31 - Peter Armbruster retired (age 65)

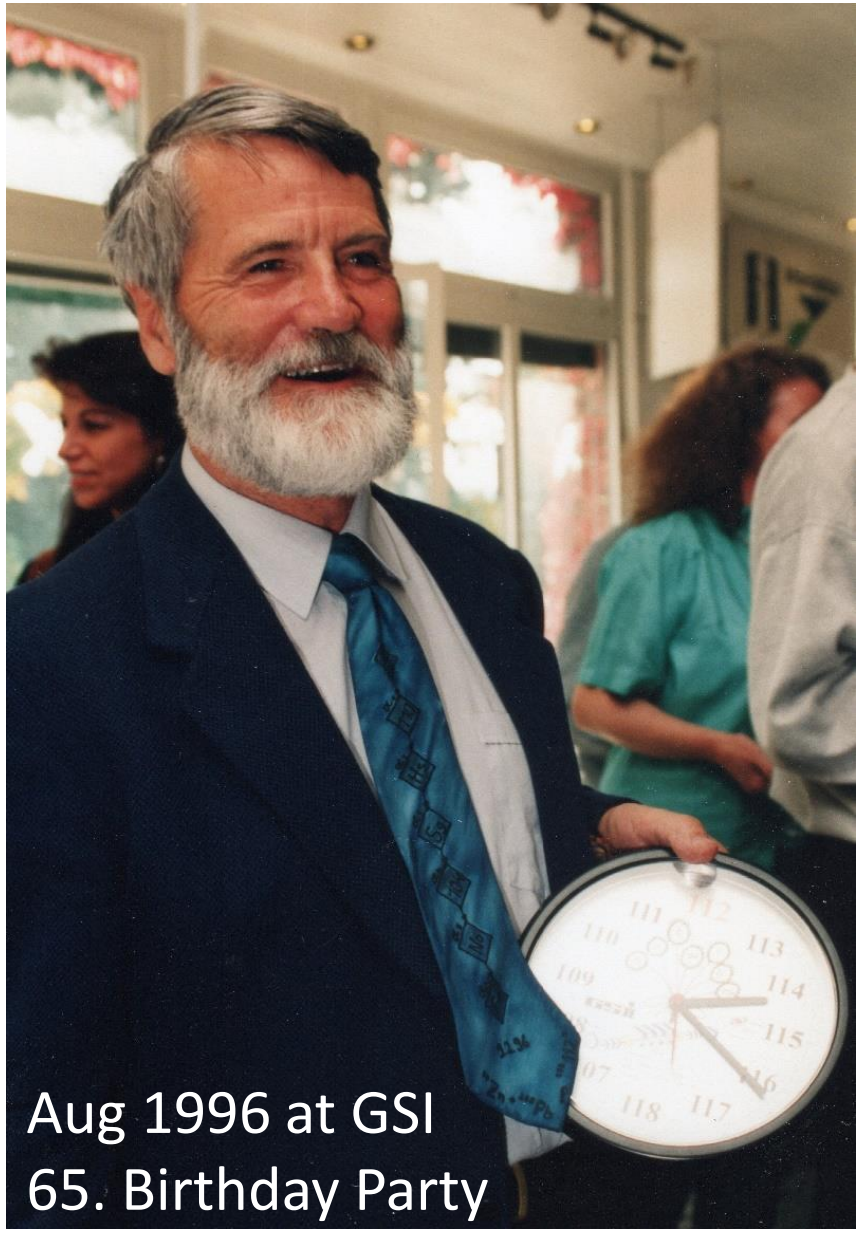


Photo: G. Otto, GSI

The 3 “Patriarchs” – Discovery of all 25 Chemical Elements above $_{93}$Np

A unique occasion at GSI
12. November 1996
“Festkolloquium zu Ehren von Peter Armbruster”

	(Age)
Peter Armbruster	(65)
Glenn T. Seaborg	(88)
Yuri Ts. Oganessian	(63)

2010 Naming Element 112

Copernicium, Cn

Crowning a glorious success story

Happy People

12.07.2010
at GSI

Monique Bernas

Gottfried Münzenberg

Fritz Peter Heßberger

S. Hofmann

E. Kühne-Hörmann
Science Minister, Hesse

R. Koch
Prime

Photos (Persons): G. Otto, GSI

Photo: *Arnold*, GSI

TASCA - *T*rans*A*ctinides *S*eparator and *C*hemistry *A*pparatus

2005-present:

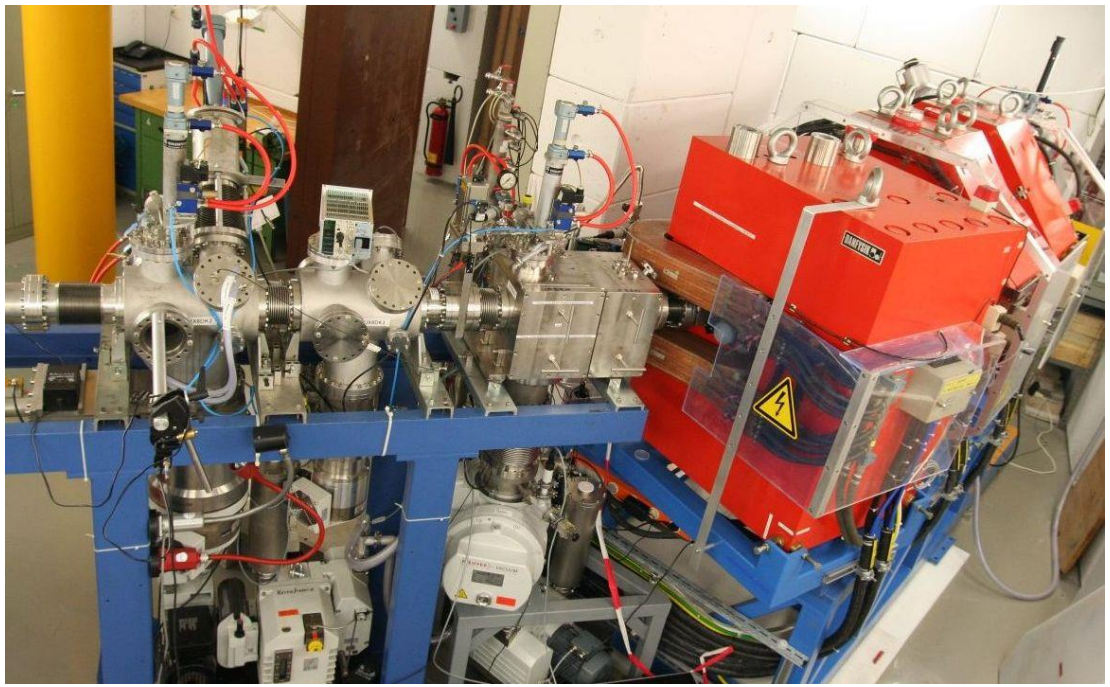
Most successful gas-filled separator – nuclear and chemical studies of SHE

THE workhorse for nuclear chemistry

Ch.E. Düllmann, A. Yakushev, J. Khuyagbaatar et al.

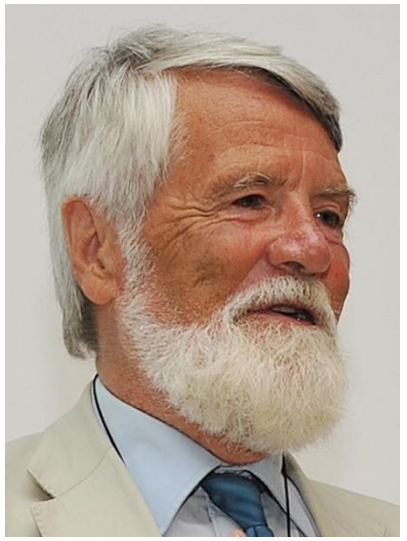
Chemistry: $Sg(CO)_6$ ... $_{112}Cn$, $_{113}Nh$, $_{114}Fl$, $_{115}Mc$

Physics: $_{112}Cn$, $_{113}Nh$, $_{114}Fl$, $_{115}Mc$, $_{117}Ts$



Photos: G. Otto, GSI

May 2006 – Ready for commissioning and experiments



Peter Armbruster

1. Driving force to built NASE/Heck
2. Continuously encouraging me to built a separator for the chemistry of SHE

"Herr Schädel, ein gas-gefüllter Separator ist so einfach, den können selbst Chemiker bedienen!"

From Lysekil (1966) to Bäckaskog - Peter Armbruster's 60 years with Superheavy Elements

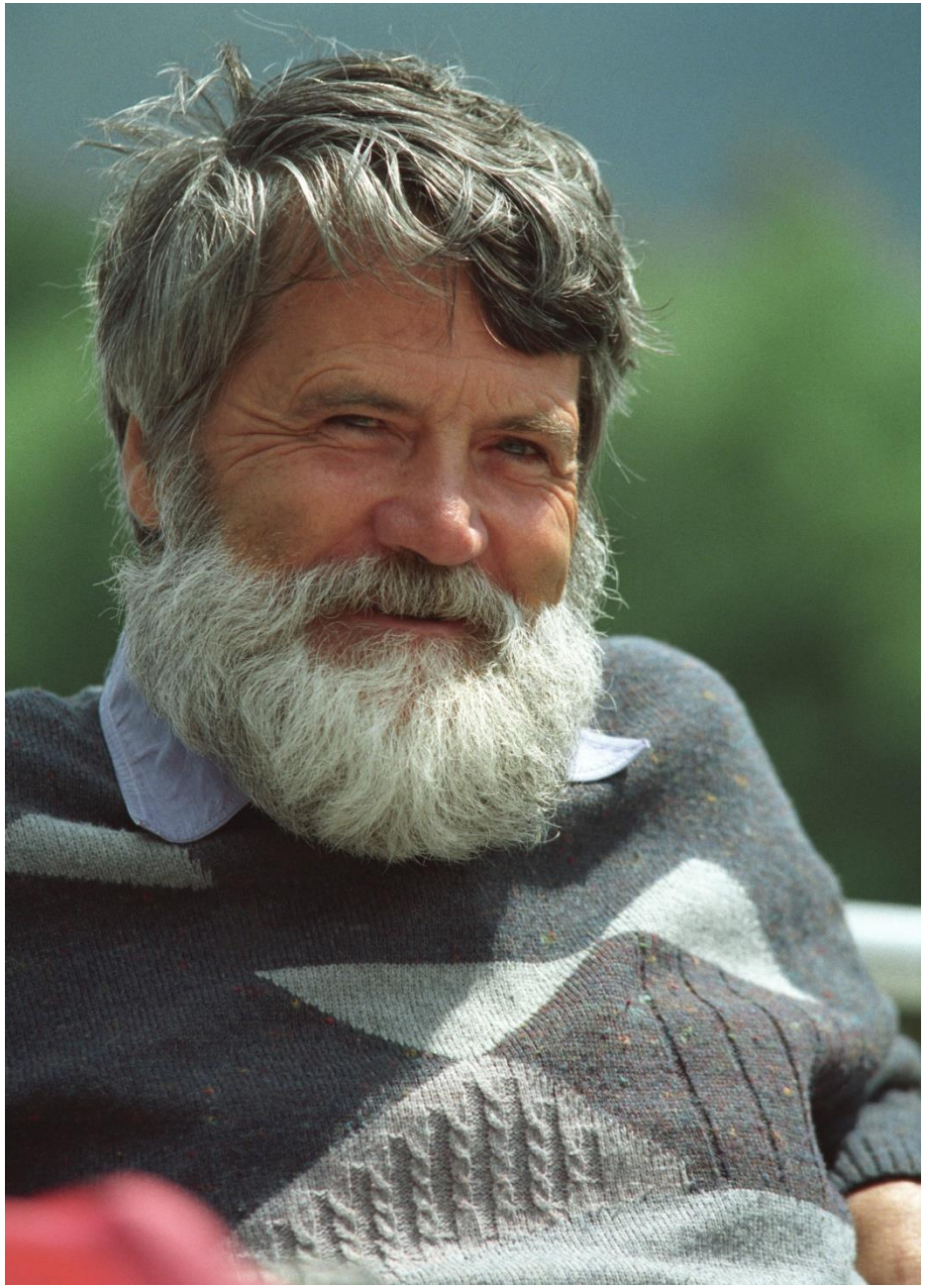
Nobel Symposium *Chemistry and Physics of Heavy and Superheavy Elements*, Bäckaskog, 2016

Photo: Courtesy Dirk Rudolph, Lund

From Lysekil (1966) to Bäckaskog - Peter Armbruster's 60 years with Superheavy Elements

Nobel Symposium *Chemistry and Physics of Heavy and Superheavy Elements*, Bäckaskog, 2016

Photo: Courtesy Dirk Rudolph, Lund



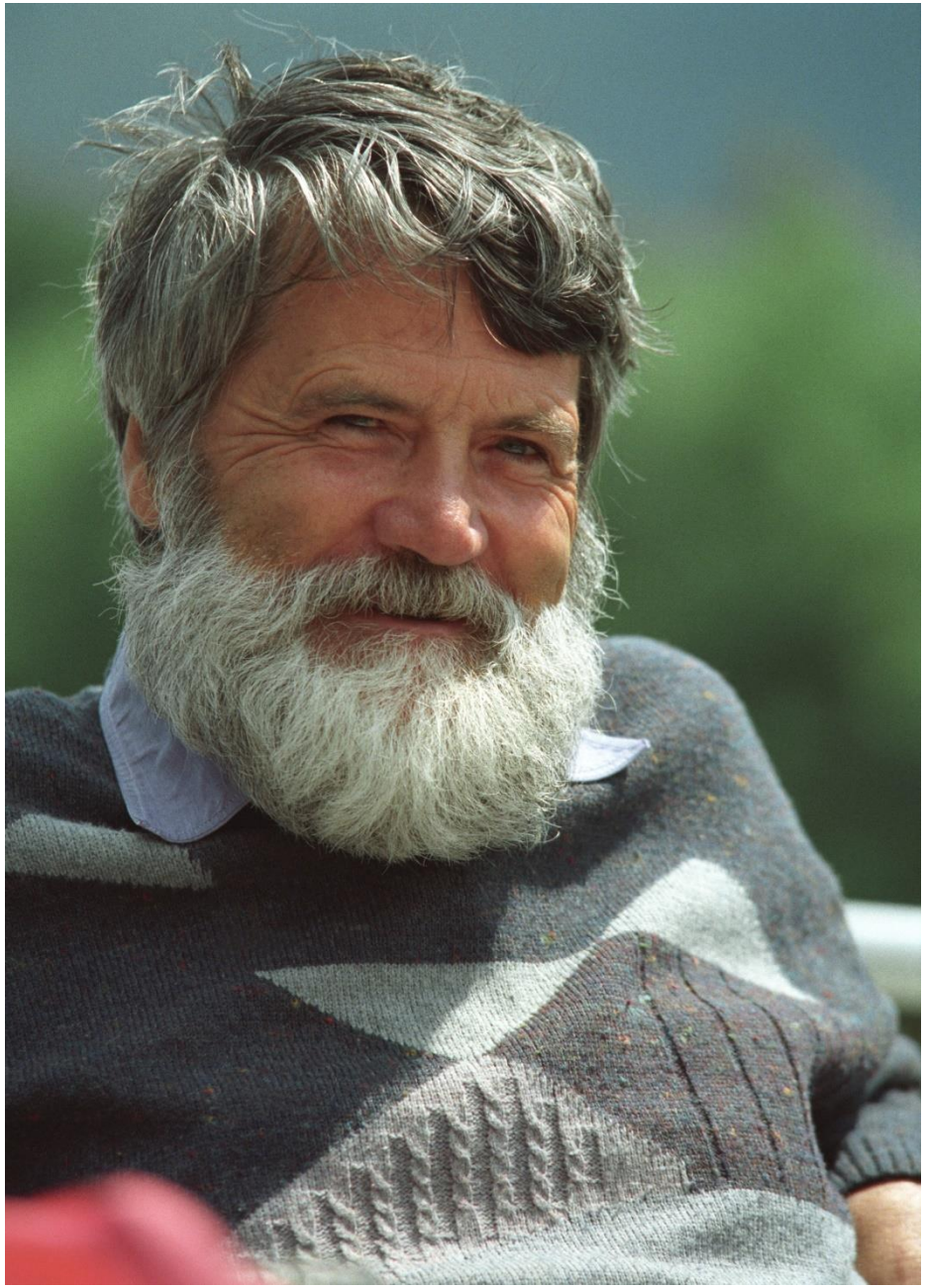
Peter Armbruster,

often, at the end of our inspiring discussions:

"Wenn Du es eilig hast,
must Du besonders langsam machen"

English: "Slow down to Speed up"

Based on the Chinese and Japanese wisdom:
"Wenn Du es eilig hast, gehe langsam.
Wenn Du es noch eiliger hast, mache einen Umweg"



Peter Armbruster

* 25.07.1931 †26.06.2024

It was a joy and privilege knowing you,
a wonderful person, dear colleague,
passionate scientist, good advisor,
inspiring discussion partner, and
friend and supporter of nuclear chemistry

You pushed a door wide open to explore
the limits of nature

Your legacy lives on in many fields of physics

We are missing you

Thank you and Farewell!