STATUS AND PERSPECTIVES FOR MASS MEASUREMENTS OF HEAVY ELEMENTS AT SHIPTRAP

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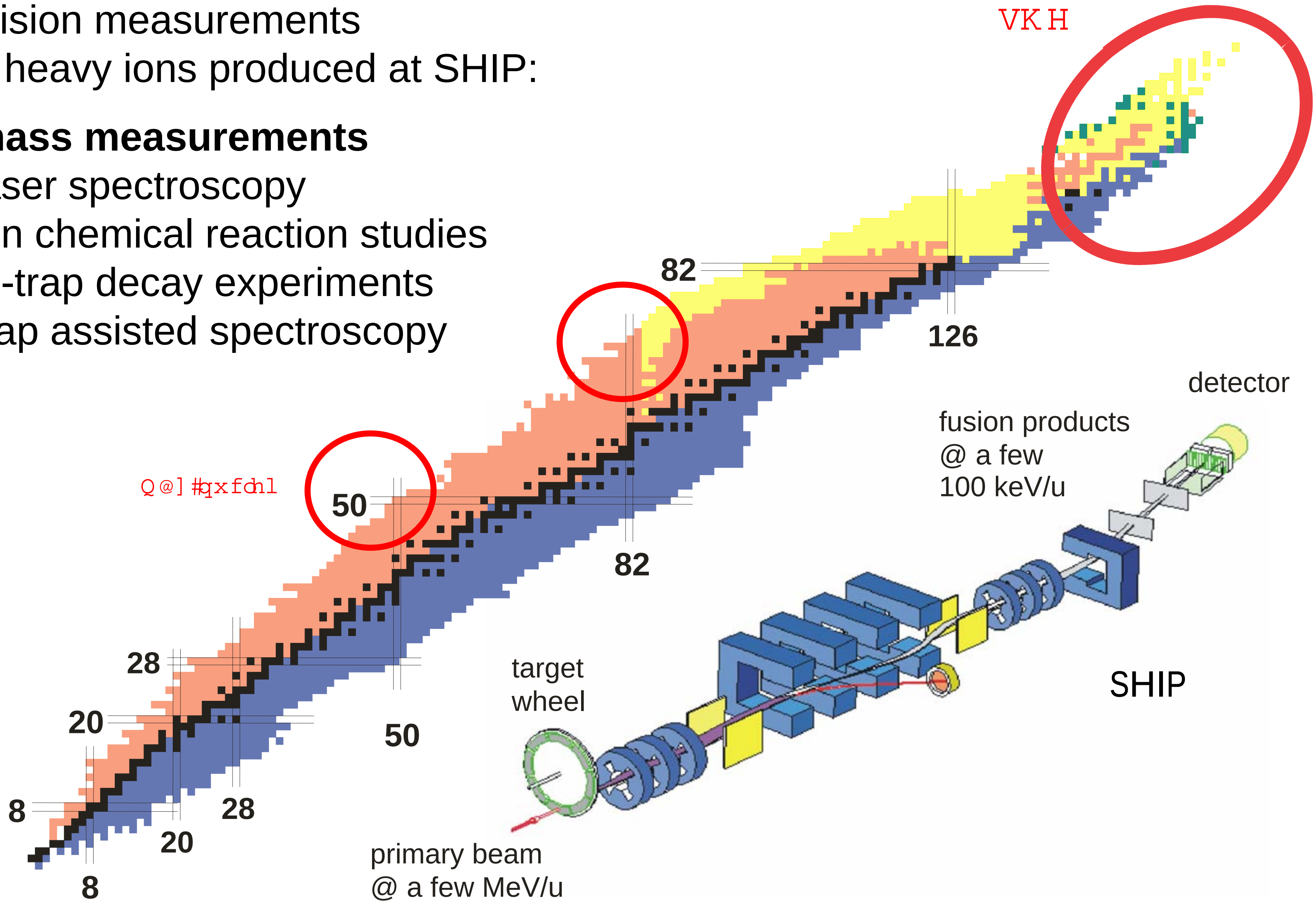
for the SHIPTRAP collaboration

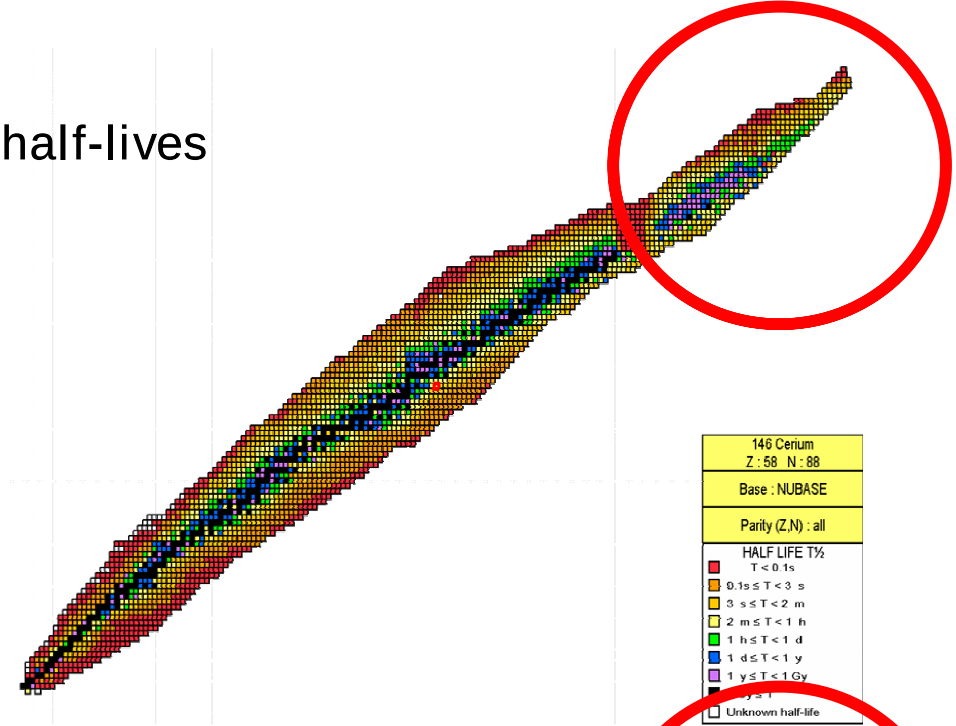
SHIPTRAP physics program:

precision measurements
with heavy ions produced at SHIP:

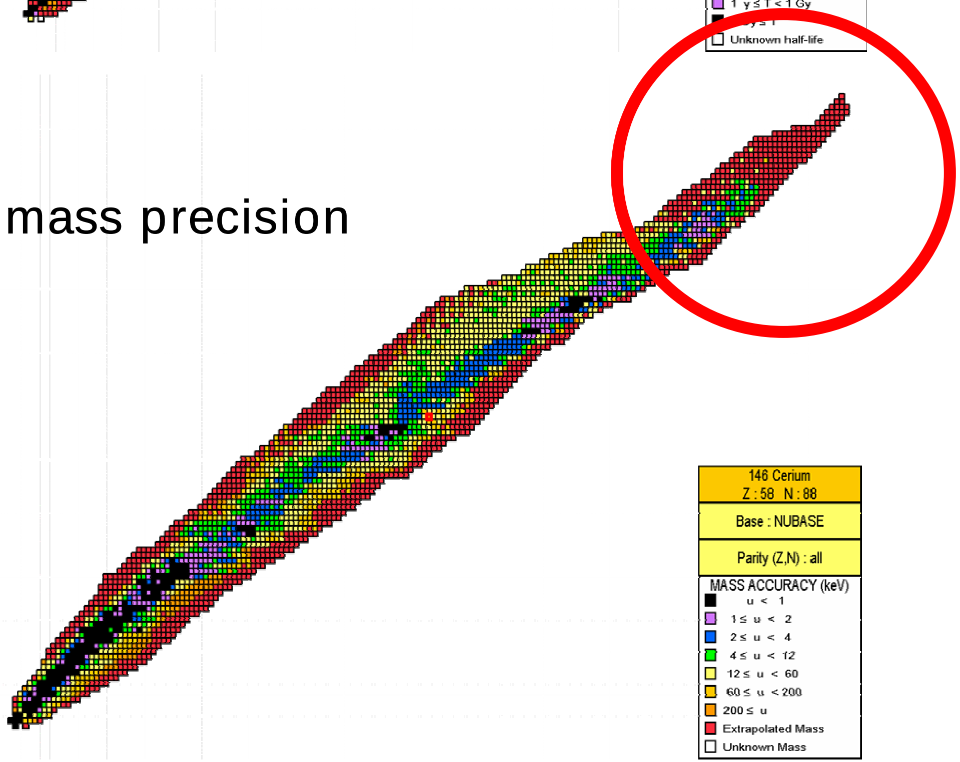
- **mass measurements**
- laser spectroscopy
- ion chemical reaction studies
- in-trap decay experiments
- trap assisted spectroscopy



half-lives



mass precision



SHE region:

- masses only known with low precision
- most masses extrapolated
- linked to only few α decay chains
- relatively long half-lives
- SHE so far exclusively available at SHIPTRAP

challenge

low production rates

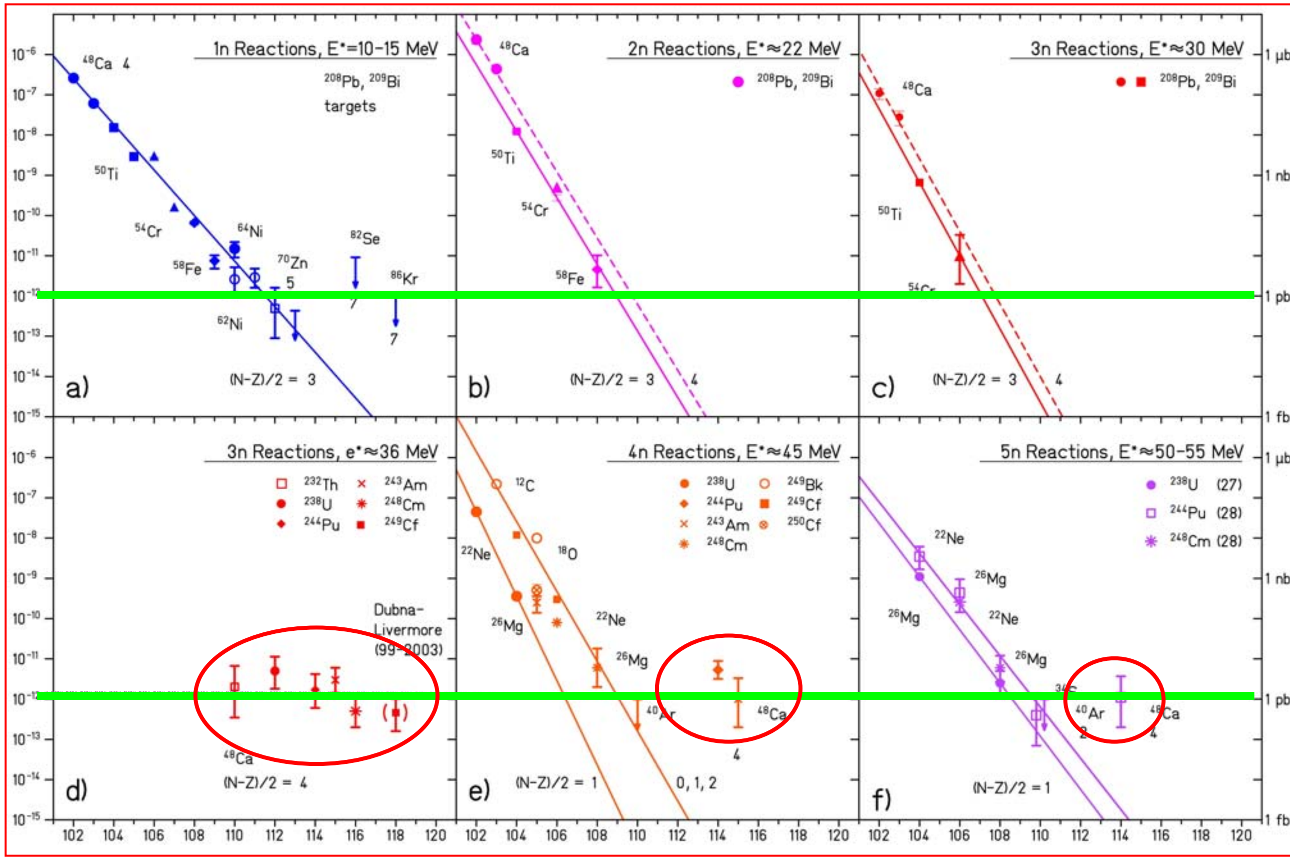
solution for long-lived nuclides

non destructive FT-ICR detection

Χροσσ Σεχτιον Σψστεματιχσ

Χολδ φυσιον (ΓΣΙ)
βασεδ ον
Πβ ανδ Βι ταργετσ

1 pb



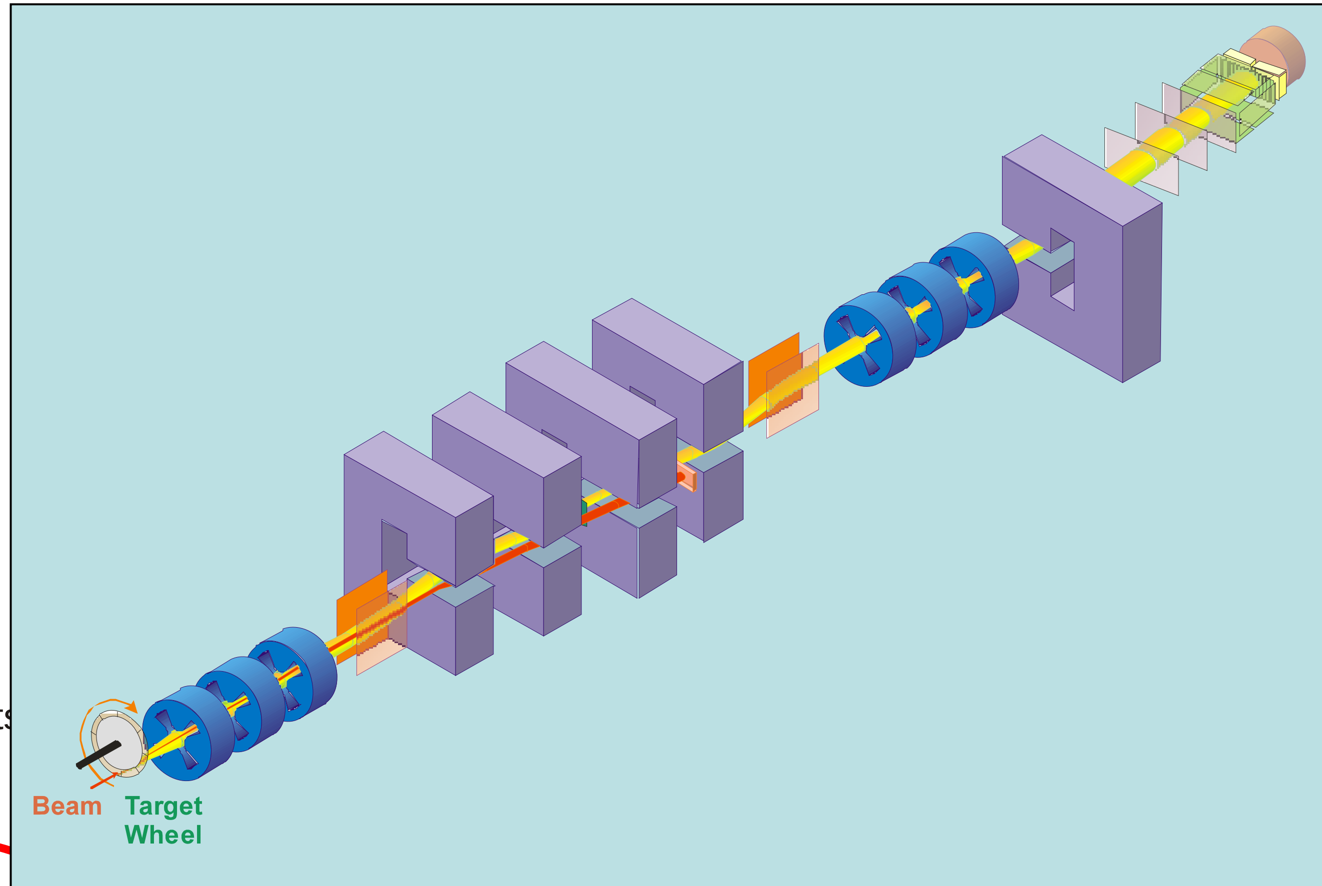
Ηοτ φυσιον (ϑINP)
βασεδ ον
αχτινιδε ταργετσ

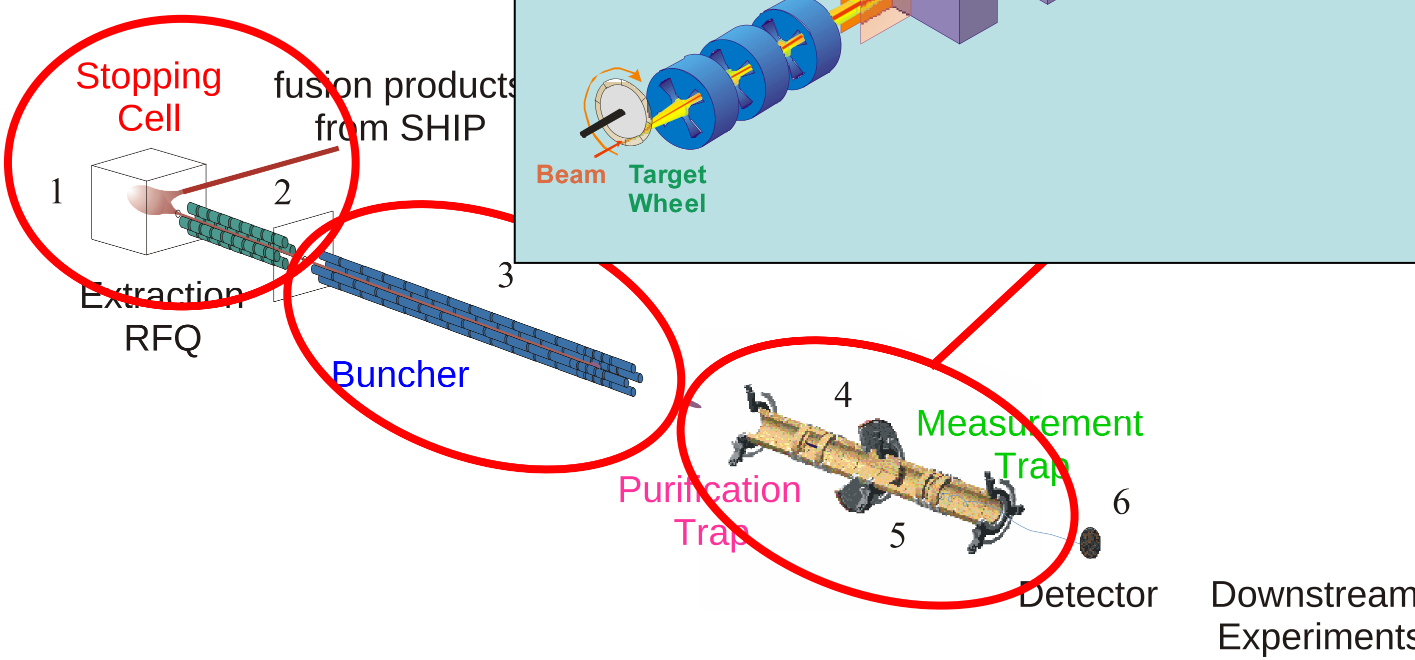
1 pb

Συρπρισινγ ηιγη χροσσ–σεχτιονσ (0.5 □ 5 πβ) φορ σψντηεσισ οφ σπηεριχαλ ΣΗΕ

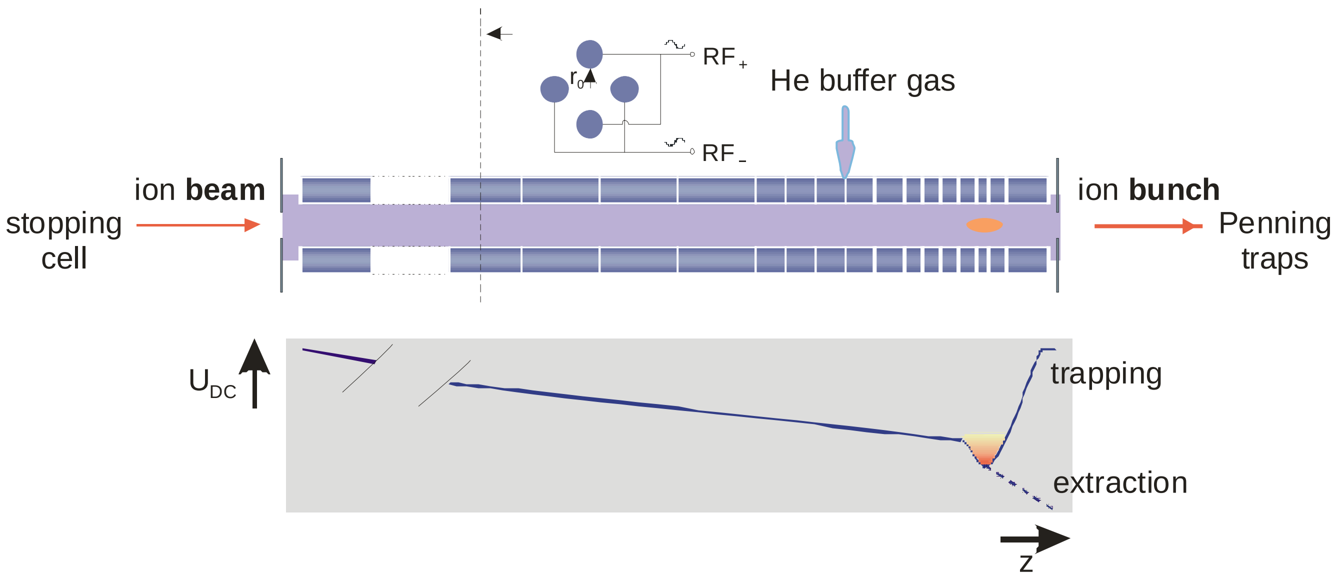
Wkh#VKLSWUDS#vhw0xs

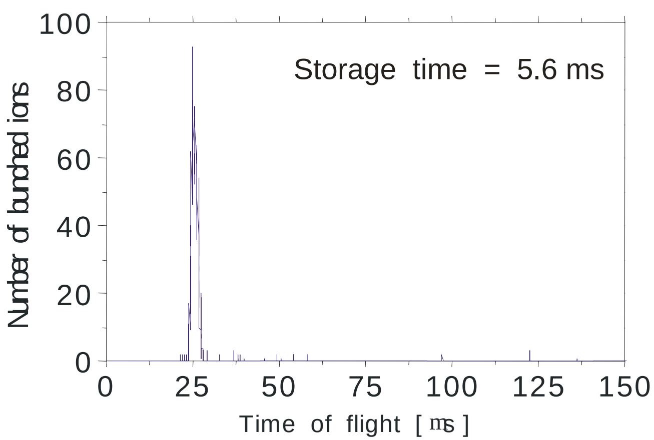
- Vwrsslqj
- Frrolqj
- Dffxp xodwlrq
- Sxulilfdwlrq#
- P hdvxuhp hqw





Shuirup dqfh#ri#wkh UIT #Exqfkhu

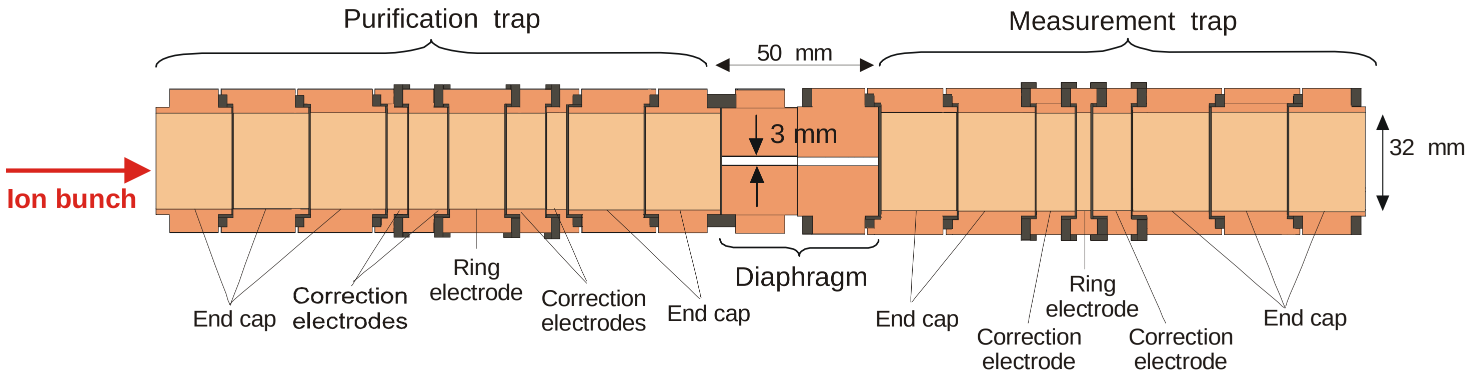




SkG wkhvlv#G1#Urgu,jxh}
P 1#P xnkhumhh

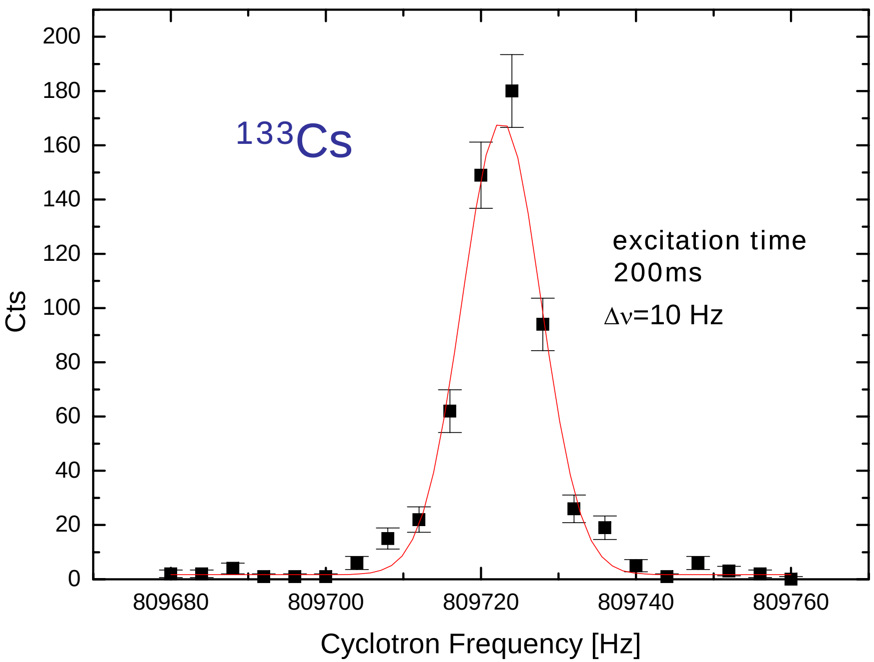
- **efficiency**:
  - in transmission mode: 95 %
  - in bunched mode: 40 %
- **cooling time**: ~3 ms
- **emittance** (2.5 keV):
  - longitudinal: 5 eV µs
  - transversal: 20 p mm mrad

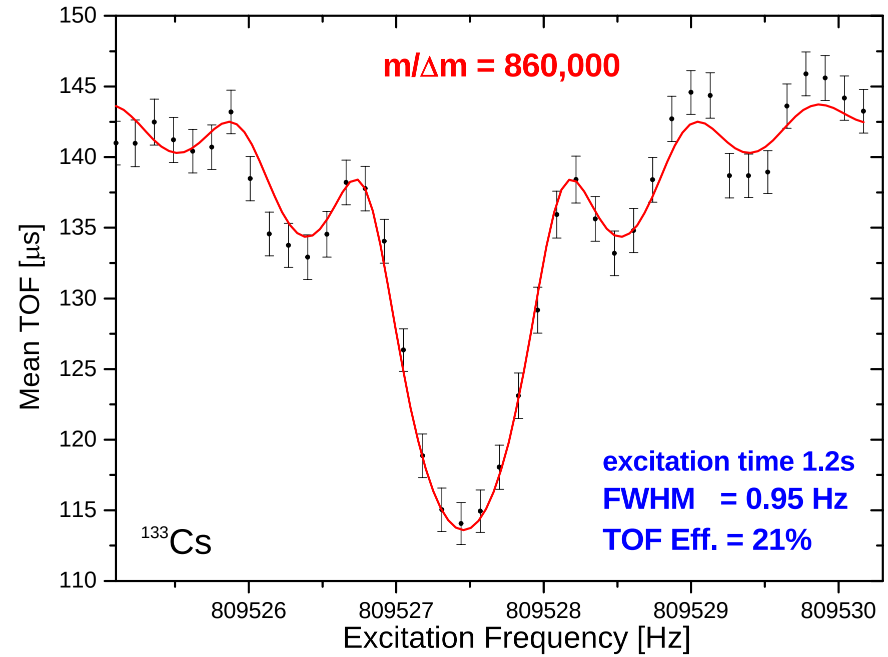
Penning trap performance



sxulilfdwlrq wuds

p hdvxuhp hqw wuds



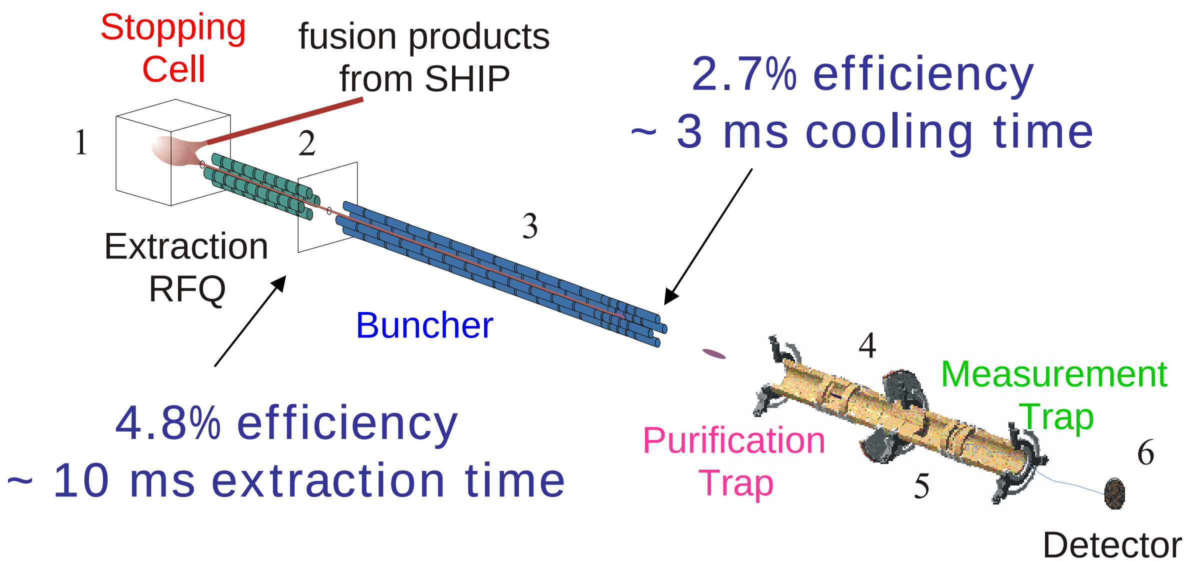


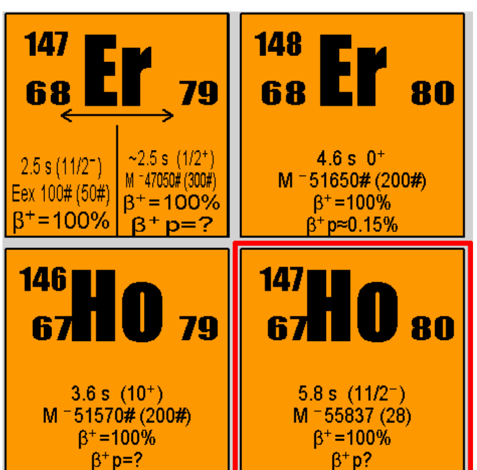
m/Dm > 80,000 for ^{133}Cs (400ms cycle)

m/Dm > 850,000 for ^{133}Cs

SkG wkhvlv#V1#Udkdp dq/J1#Vlndu

First on-line mass measurement at SHIPTRAP





fusion reaction at SHIP

$^{92}Mo(^{58}Ni,xpyn)^{147}Ho$

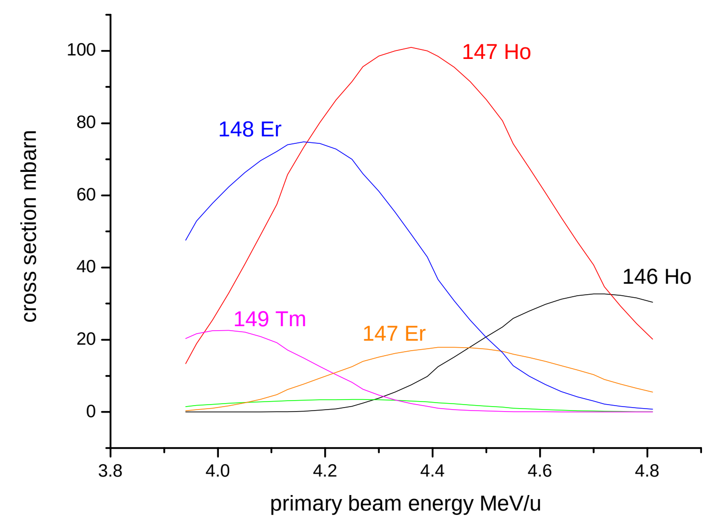
primary beam energy

4.36 MeV/u

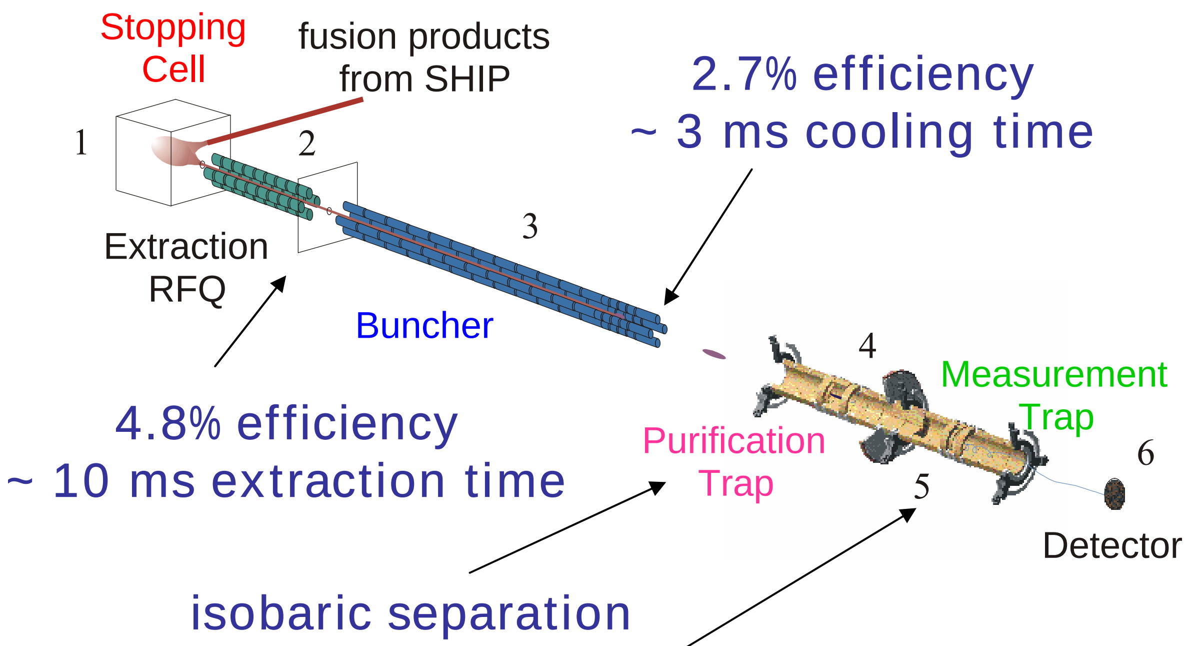
target thickness

500mg/cm^2

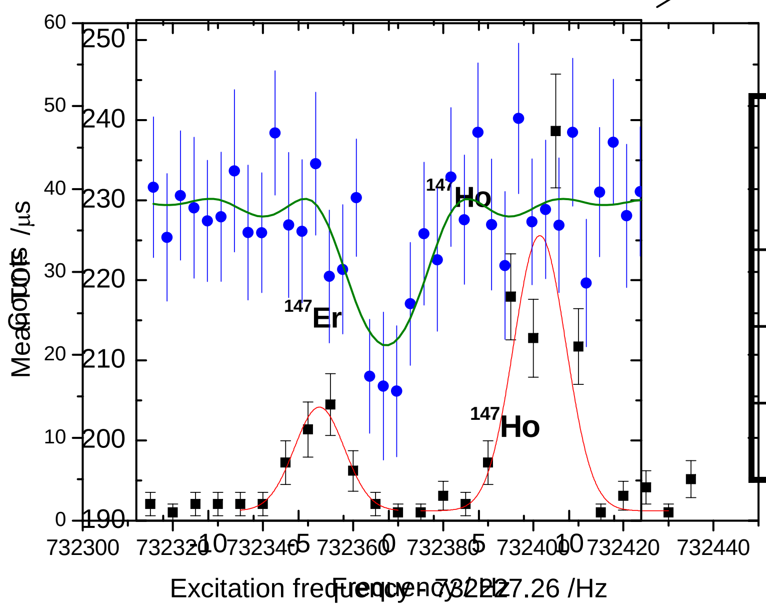
HIVAP calculation



First on-line mass measurement at SHIPTRAP



beam time July 2004:



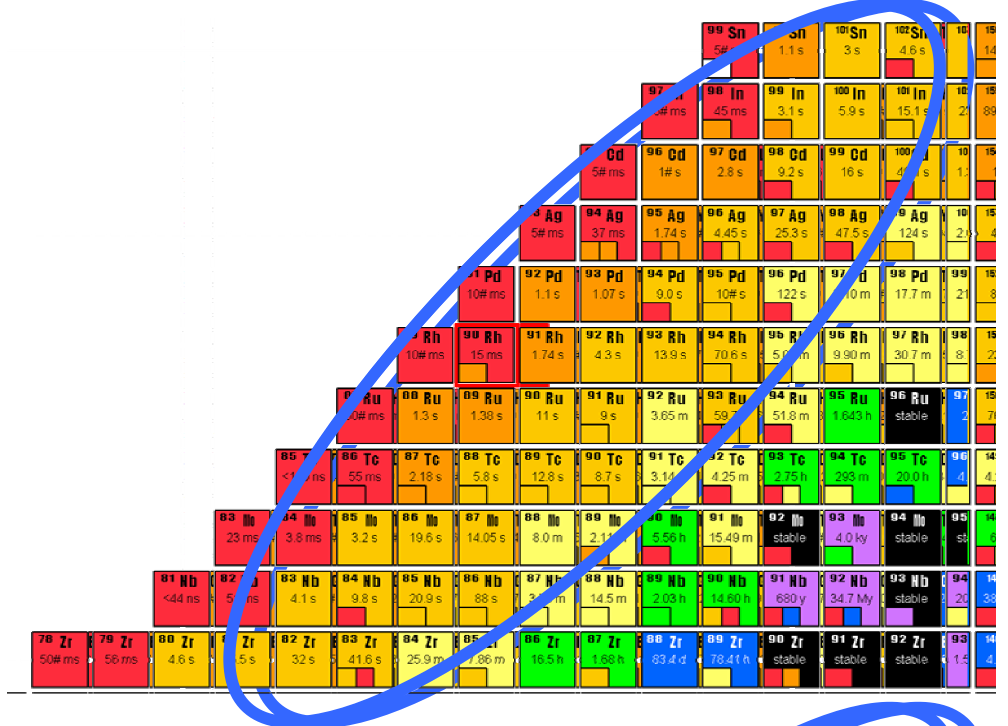
nuclide	ME / keV	
	SHIPTRAP	AME 2003
^{147}Ho	-55651(173)	-55837(28)
^{147}Er	-46465(169)	-47050#(300#)
^{148}Er	-51360(190)	-51650#(200#)

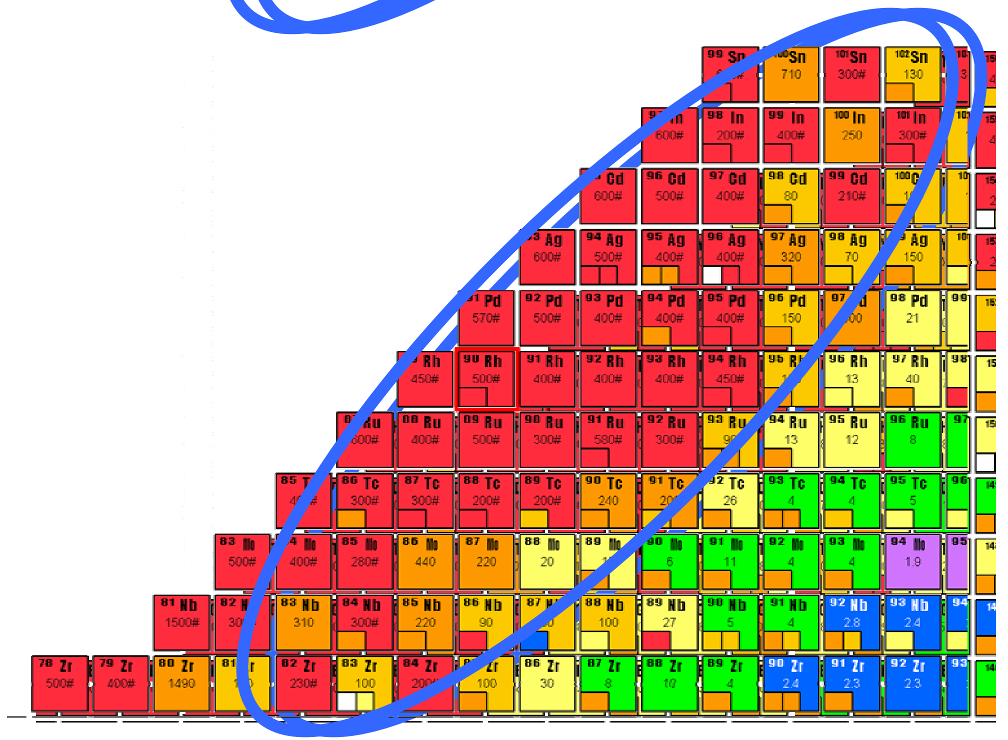
Jhqhudolvvxhv#iru#p dvv#p hdvxuhp hqw#dw#VKLSWUDS=

- production method not chemically selective
- no mass separator but velocity filter
- currently only stable beams available and (almost) no radioactive targets
- restricted to neutron deficient nuclides
- limited 'energy acceptance' of the gas cell (min. window thickness)
- SHIP transmission efficiency depends on reaction
- lack of beam time and flexibility e.g. long SHIP runs, TASCA, cancer therapy

other mass regions

- N=Z nuclei
- rp process
- superallowed b emitter
- nuclei close to the p dripline
- region of p emitter
- comparably high production rates

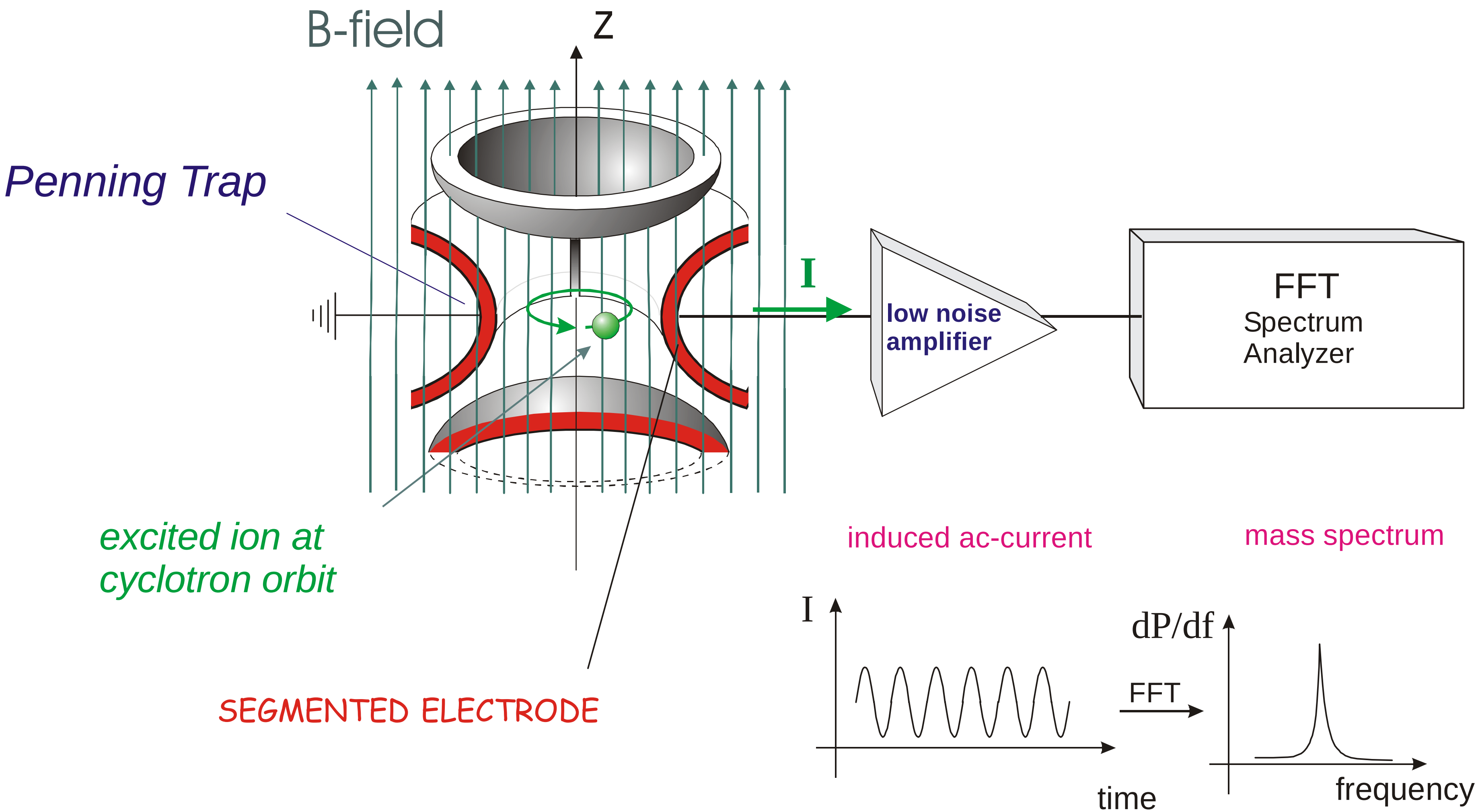




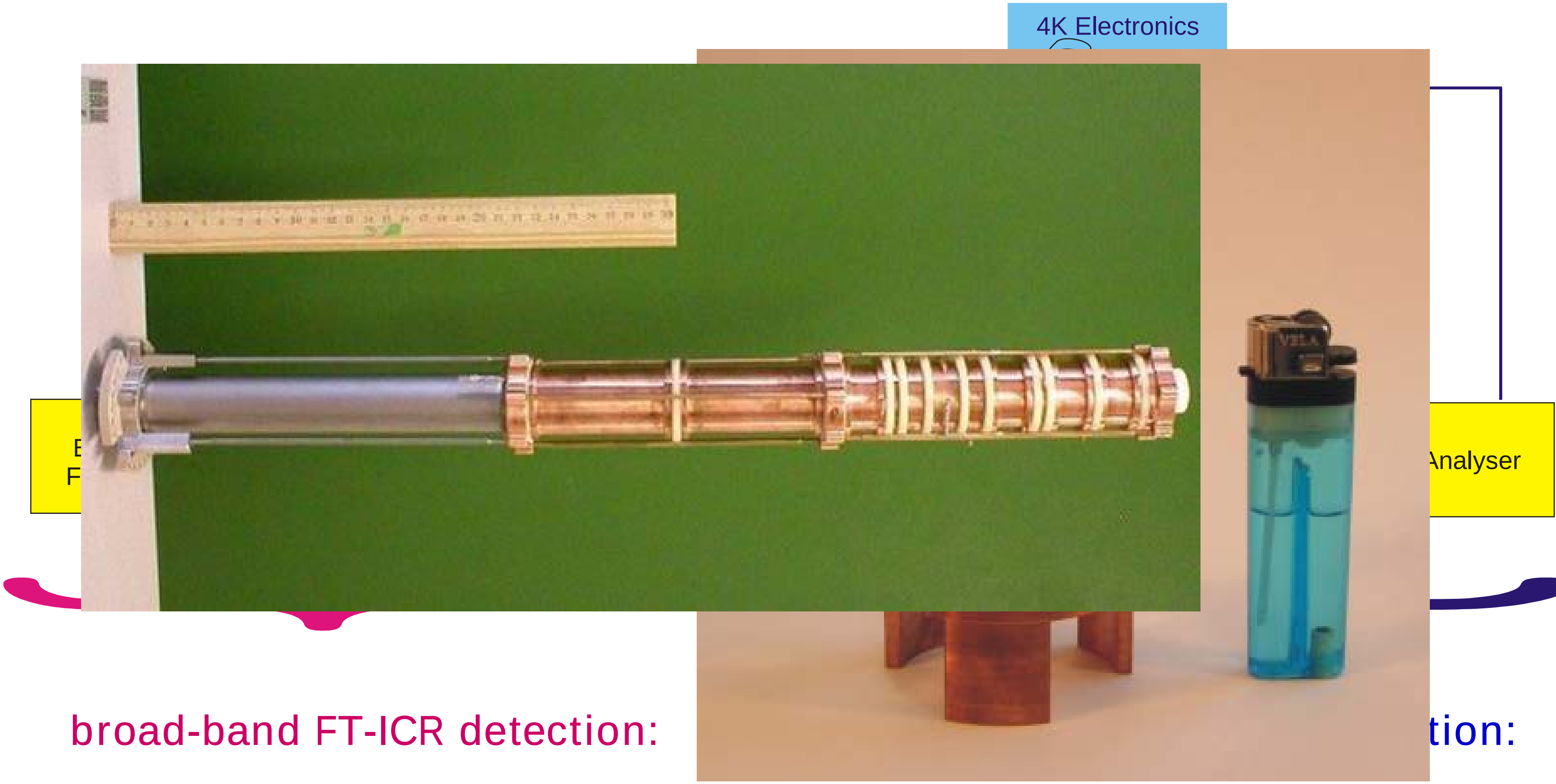
Vrp h#h{dp sdhv

Projectile	Target	Nuclide	$T_{1/2}$	Dm / keV AME 03	cross section (PACE/HIVAP) mb
^{58}Ni	^{92}Mo	^{146}Ho	3.6 s	200 #	14
		^{147}Ho	5.8 s	28	100
^{32}S	^{122}Te	^{148}Ho	2.2 s	130	93
^{58}Ni	^{92}Mo	^{146}Er	4.1 s	300 #	10
		^{147}Er	2.5 s	300 #	18
^{32}S	^{122}Te	^{148}Er	4.6 s	200 #	74
		^{147}Tm	0.58 s	300 #	10
^{58}Ni	^{92}Mo	^{148}Tm	0.7 s	400 #	1
		^{149}Tm	0.9 s	300 #	22
^{58}Ni	^{96}Ru	^{151}Lu	0.08 s	400 #	
		^{152}Lu	0.65 s	200 #	
		^{153}Lu	0.9 s	210	
		^{154}Lu	1 s #	200 #	

Rxworrn#0IW0LFU#ghwhfwlrq



IWOLFU#DW#VKLSWUDS



broad-band FT-ICR detection:

- identification of the trap's contents
- study of ion chemical reaction kinetics

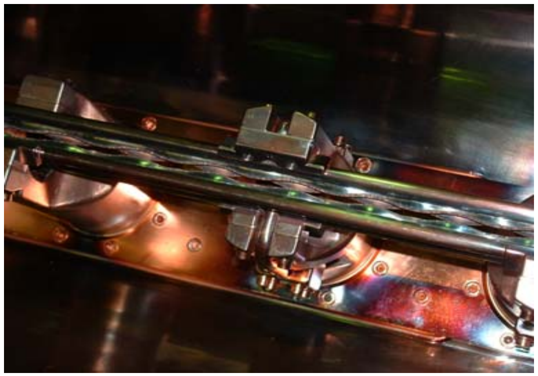
tion:

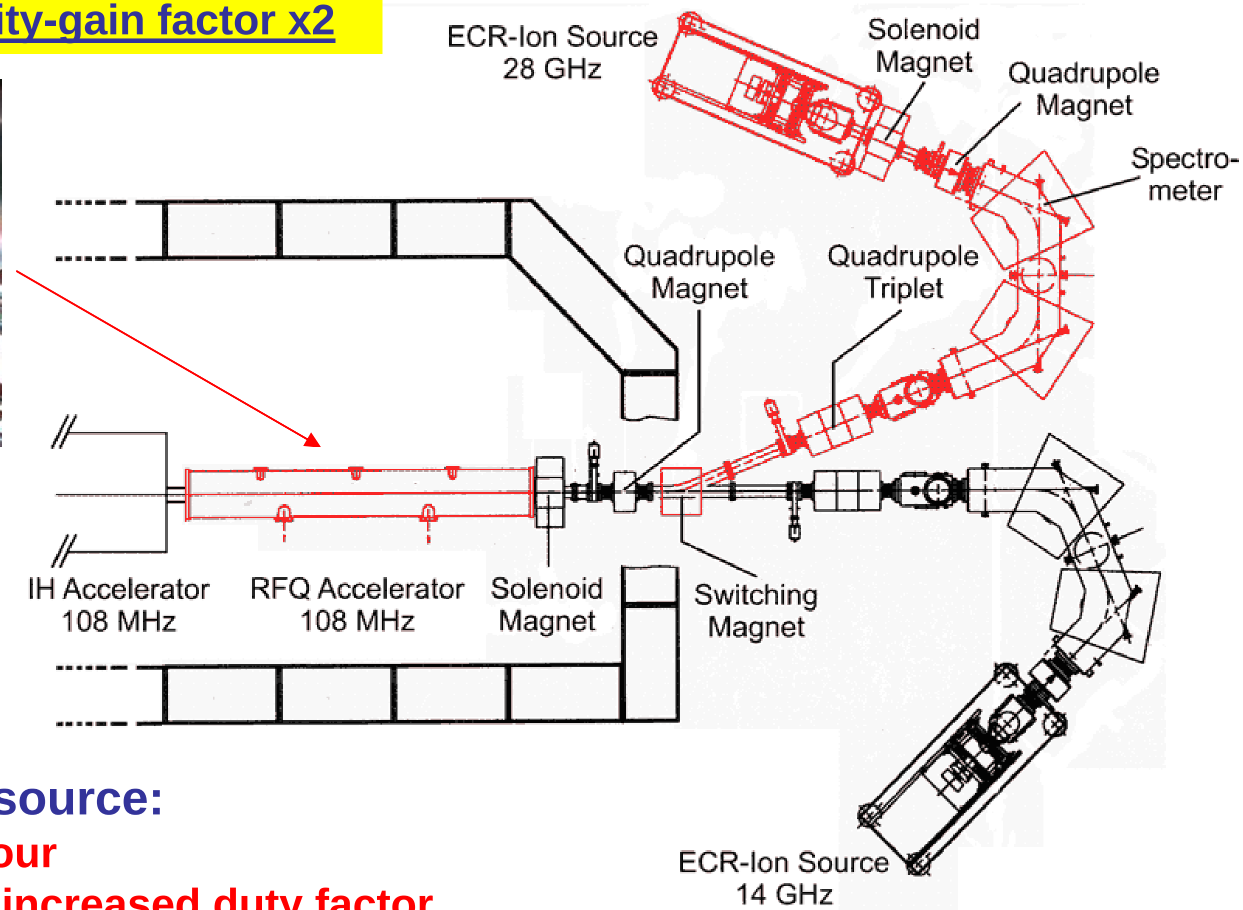
- highly sensitive mass spectrometry on rare nuclei

ri0olqh whvw lq#frodeudwlrq zlwk N1#Eodxp /#F1#Z hehu/#V1#Vwdko

Qhz#Iurqwhqg#iru#wkh#Kljk#Fkdujh#Vwdwh#Lqmhfwru

50% duty factor **intensity-gain factor x2**





New RFQ-structure:

- gain of the duty factor
- higher injection energy
- increased acceptance

Additional 28 GHz-ion-source:

- **intensity gain of factor four**
- **higher charge states for increased duty factor**

28 GHz ECRIS **intensity-gain factor x4**

LEBT – Laminated magnets:

- redundancy for ion sources
- preparation for future pulse to pulse operation with different ion-species

VKLSWUDS#frooderudwruv

JVL#2#VKLSWUDS

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Pxqlfk

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S. Heinz
V. Kolhinen
J. Neumayr
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Jlhvvhq

H. Geissel
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Pdlq}

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Juhlivzdog

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G. Marx
L. Schweikhard

Irup hu#SkG vwxghqwv dqg#jxhvww=

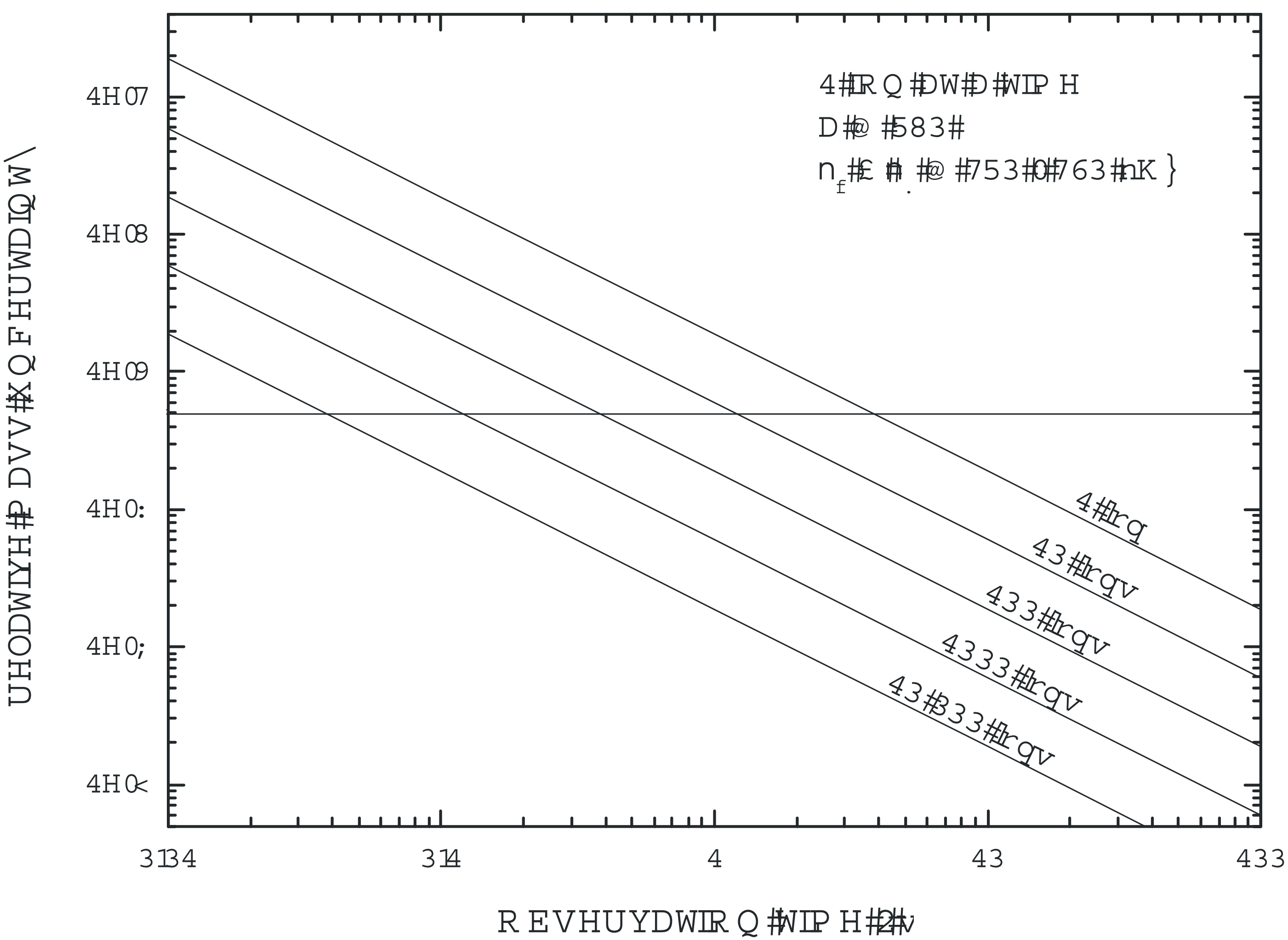
J. Dilling, G. Sikler, D. Rodríguez, M. Suhonen, A.Doemer

Wkdqn |rx iru |rxu dwwhqwlrq$

Vrp h#h{dp sdhv

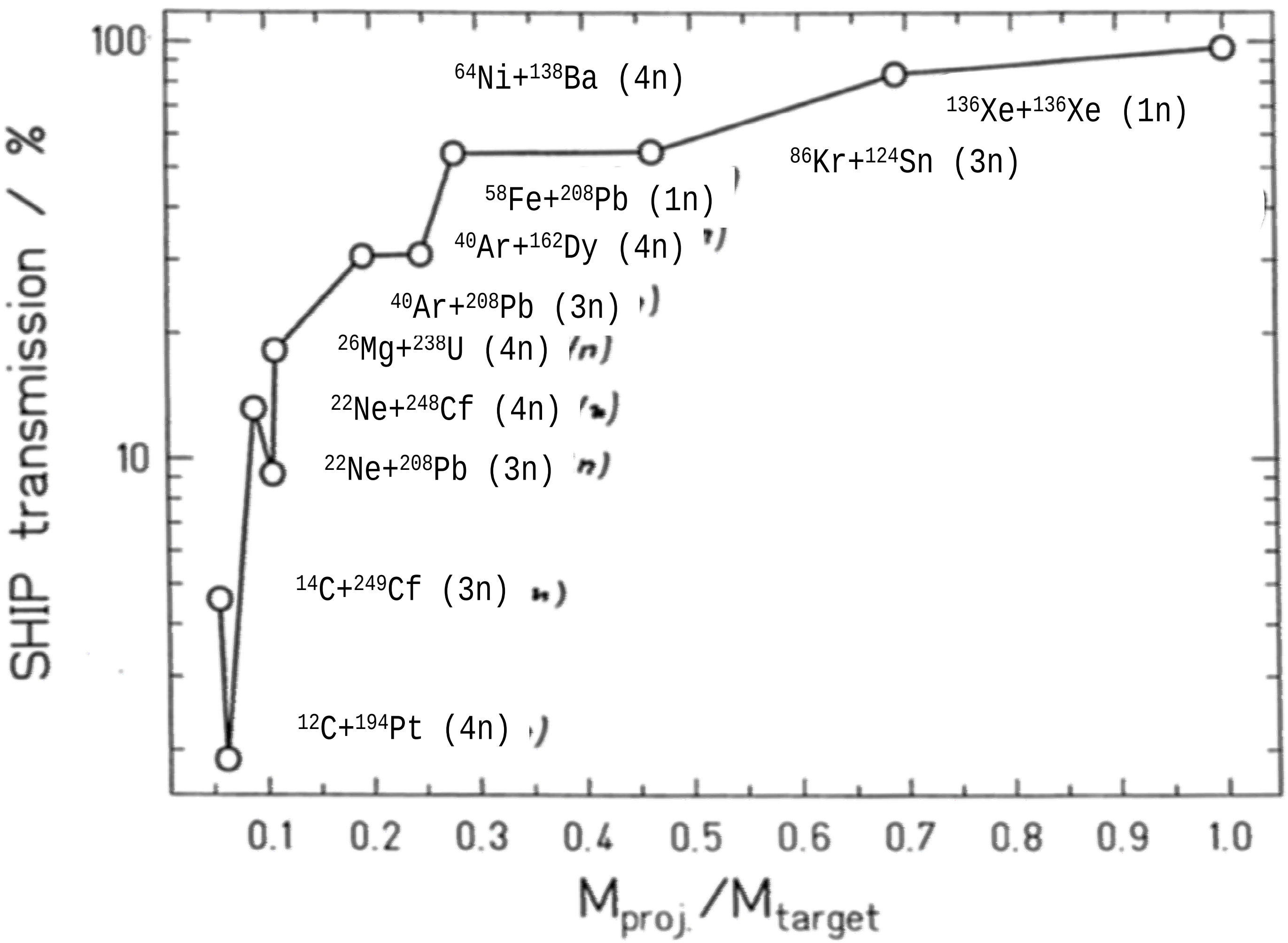
Projectile	**Target**	**Nuclide**	**$T_{1/2}$**	**Dm / keV AME 03**	**cross section (PACE/HIVAP) mb**
^{32}S	^{54}Fe	**^{80}Zr**	4.6 s	1490	3
	^{54}Fe	**^{81}Zr**	5.5 s	170	10
^{32}S	^{54}Fe	**^{82}Zr**	3.2 s	230 #	30
^{32}S	^{54}Fe	**^{83}Nb**	4.1 s	310	10
^{36}Ar	^{54}Fe	**^{85}Mo**	3.2 s	280 #	5
^{32}S	^{58}Ni	**^{86}Mo**	19.6 s	440	25
		^{87}Mo	14.1 s	220	24
^{32}S	^{58}Ni	**^{88}Tc**	5.8 s	200 #	21
^{32}S	^{64}Zn	**^{90}Ru**	11 s	300 #	5.5
^{40}Ca	^{54}Fe	**^{91}Ru**	9 s	580 #	17
		^{92}Ru	1.38 s	300 #	149 ?
^{32}S	^{64}Zn	**^{92}Rh**	4.3 s	400 #	1, 2
		^{93}Rh	13.9 s	400 #	3,14 ?

vwdwlvwlfdo#uhodwlyh#p dvv#xqfhuwdlqw|



$$\left(\frac{\delta m}{m}\right)_{stat} \propto \frac{1}{R \cdot \sqrt{N}}$$

VKLS#wudqvp lvvlrq#hiilflhqf|



courtesy of D. Ackermann