



The 4th International Conference on the Chemistry and Physics of the Transactinide Elements

Physics experiments on superheavy elements at the GSI SHIP

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Status of SHE experiments



Agreement with theory



Gsi

Important results and perspectives



Outstanding properties of ²⁴⁸Cm targets



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Experiments with ²⁴⁸Cm targets



Velocity separator SHIP









Eight targets of 0.46 mg/cm² 248 Cm₂O₃, total 10.7 mg, size 36 mm × 8 mm, on 1.05 mg/cm² Ti backing, prepared at Institute for Nuclear Chemistry, Mainz



Target control, α 's at focal plane of SHIP





On-line measurement of target thickness by scattering of 30 keV electrons. Here, after irradiation with 1.2×10¹⁸ ⁵⁴Cr ions



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Conditioning of the Cm targets (12 hours)



a), b), c): α 's from target

d): sputtered α's from
charge equilibration foil
(after experiment)

Short half-lives with digital signal processing





Fine structure in proton emission from $^{145gs}Tm$ T_{1/2} = 3.1 µs

80 channels DGF 4C modules 25 ns sampling rate



M. Karny et al., PRL 90, 012502, 2003 (HRIBF, Oak Ridge)



Experiment SHIP, June 24 – July 26, 2010



The total number of fission-like events was eight

Experiment SHIP, June 24 – July 26, 2010



Energy distributions



Time distributions



Events from

${}^{48}Ca + {}^{248}Cm \rightarrow {}^{292}116 + 4n$

and

 $^{48}Ca + {}^{244}Pu \rightarrow {}^{288}114 + 4n$

Experiment SHIP, June 24 – July 26, 2010

chain 1: assignment tentative



 $^{48}Ca + ^{248}Cm = 293116 + 3n$

Energy distributions



Events from ⁴⁸Ca + ²⁴⁸Cm \rightarrow ²⁹³116 + 3n and ⁴⁸Ca + ²⁴⁴Pu \rightarrow ²⁸⁹114 + 3n



Time distributions

 $^{48}Ca + ^{248}Cm \rightarrow ^{293}116 + 3n$ $^{48}Ca + ^{244}Pu \rightarrow ^{289}114 + 3n$

Calculated quasiparticle energies



⁴⁸Ca + ²⁴⁸Cm => ²⁹⁶116*, cross-sections



Theory: V. Zagrebaev and W. Greiner, 2008 Experiments: Yu.Ts. Oganessian et al., 2000, 2001, 2004 GSI-SHIP, 2010



4 chains	1 chains
3.4 pb	0.9 pb
E* = 41.0 MeV	GSI-SHIP
6 chaine	2 chains

6 chains	2 chains
3.3 pb	1.2 pb
E* = 39.0 MeV	FLNR

Q_{α} values: experiment and theory



Shell correction energies, theory und "experiment"



Expected decay chains from ⁵⁴Cr + ²⁴⁸Cm => ³⁰²120*



Cross-section systematics and extrapolation



Calculated cross-sections for element 120



V. Zagrebaev and W. Greiner, 2011, using P. Möller's fission barriers

Results from first part of ⁵⁴Cr + ²⁴⁸Cm => ³⁰²120*

	1st wheel	1st wheel, but 2nd wheel available	2nd wheel	
Period:	24.04 13.05.	13.05. – 24.05.	26.05. – 01.06.	
Calendar days:	19 days	11 days	6 days	
Beam on target:	17 days	10 days	6 days	
Beam dose:	3.4×10^{18}	2.4 × 10 ¹⁸	1.2 × 10 ¹⁸	
Maximum current:	450 pnA	650 pnA	450 pnA	
Mean current:	370 pnA	450 pnA	390 pnA	
Target, ²⁴⁸ Cm ₂ O ₃ :	505 μg/cm ²	505 μg/cm ²	411 μg/cm ²	
Total efficiency:	22 %	22 %	27 %	
Cross-section limit:	1.20 pb	1.69 pb	3.40 pb	
σ-lim total:	0.56 pb in 36 days at restricted beam current			

Expected:

 σ -lim = 90 fb in 85 days more at 750 pnA mean current

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Perspectives



Transfer at low beam energy



V. Zagrebaev and W. Greiner, 2007 and 2008

Other experiments

Tranfer-reactions: S. Heinz, V. Comas et al.





Ion-trap mass measurements: M. Block, E.M. Ramirez et al., (this conference)

Proton radioactivity, beta-delayed fission, shape co-existence: A. Andreyev et al.



Potential Energy Surface for ¹⁸⁶Pb



Subbarrier fusion: K. Nishio et al. (this conf.)



W. Greiner, 1965-70: Prediction of "Magic Numbers"





Sufficient beam time and intensive beams are needed for further exploration of the physics of the heaviest nuclei



SHIP element 120 collaboration

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