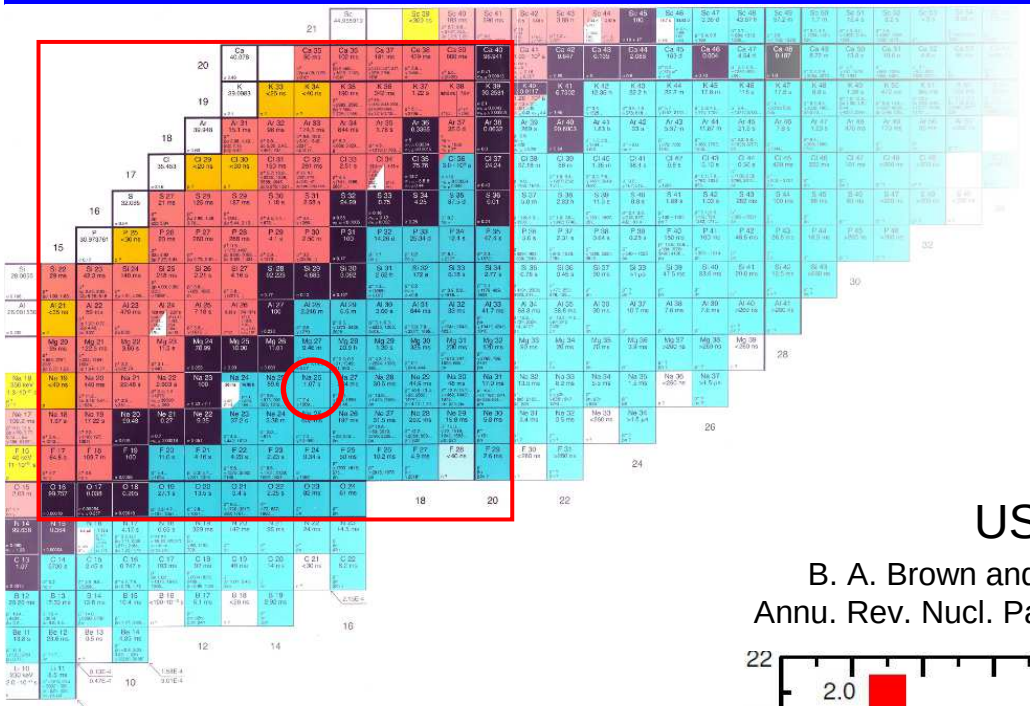
Coulomb excitation of ^{26}Na and ^{48}K with MINIBALL at REX-ISOLDE

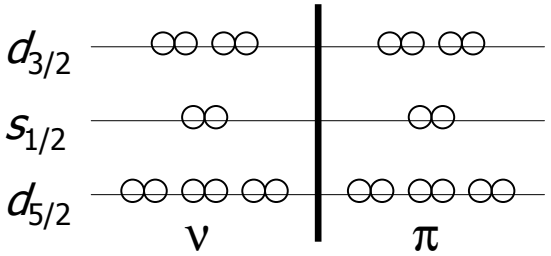
MINIBALL Workshop 2014

Orsay 09.10.2014

Burkhard Siebeck

Shell model



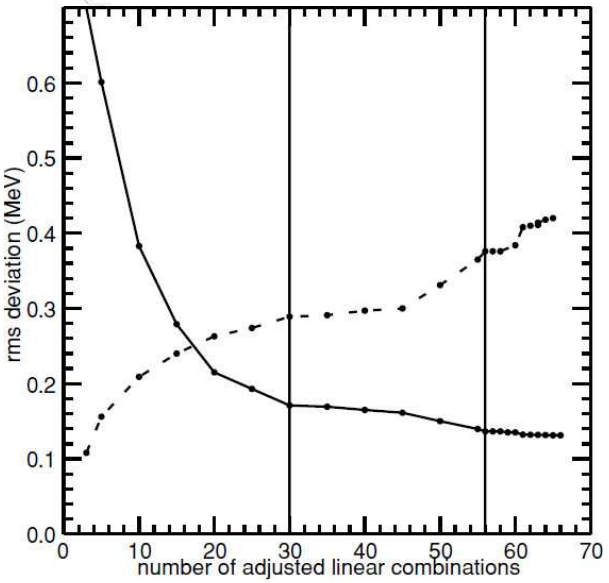


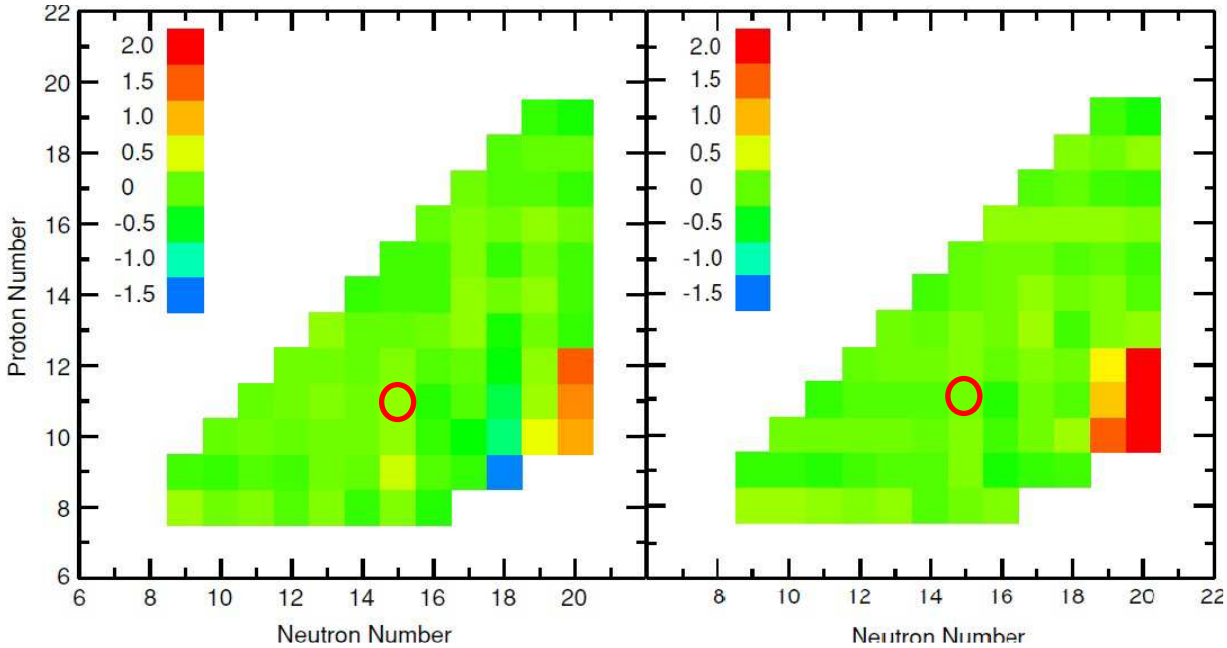
USD

B. A. Brown and B. H. Wildenthal
Annu. Rev. Nucl. Part. Sci. 38, 29 (1988)

USDA/B

B. A. Brown and W. A. Richter
Phys. Rev. C 74 034315 (2006)





^{26}Na

- USDA/B interactions reproduce experimental spin assingments
- USD four 1^+ states

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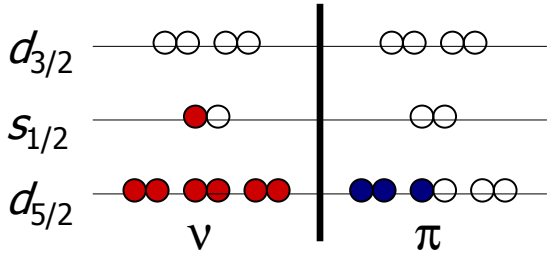
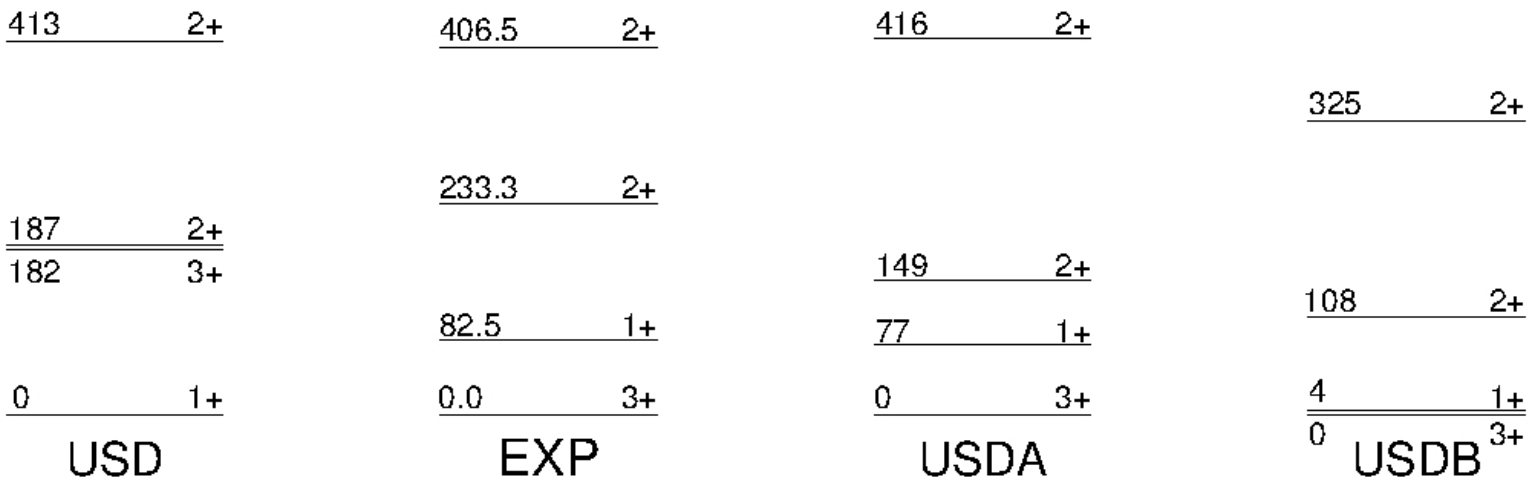
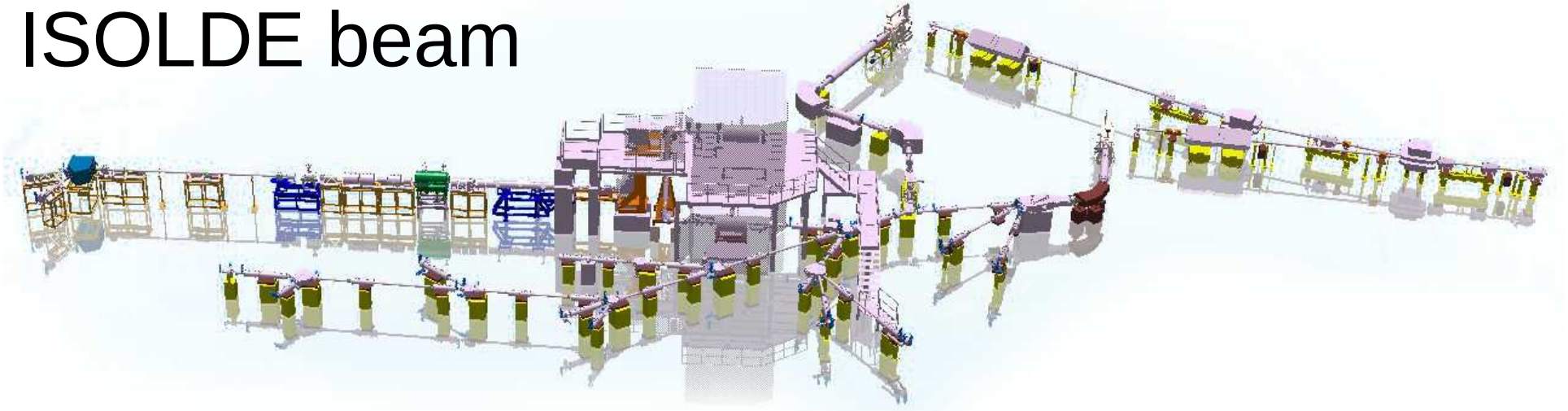
  } ^{26}Ne β-decay experiments: three 1^+ states

Additional experimental data needed





ISOLDE beam



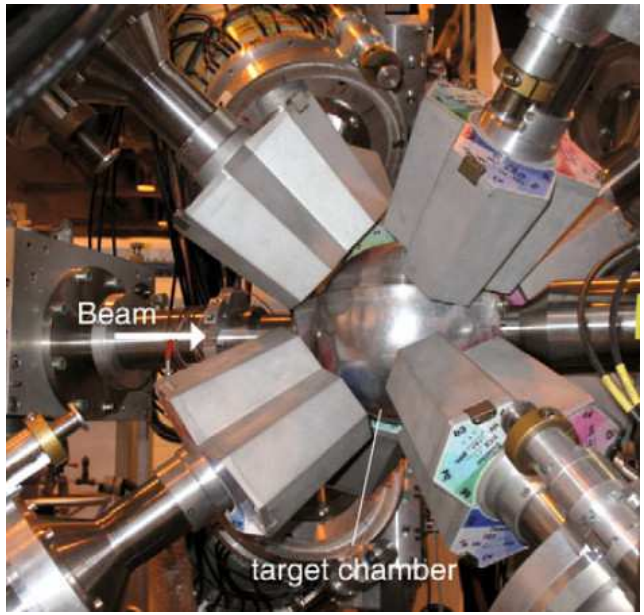
Production: 1.4 GeV protons → UC_x
Ionisation: surface ionisation (tungsten)
Mass separation: GPS
Beam cooling & charge breeding at REX-TRAP/EBIS

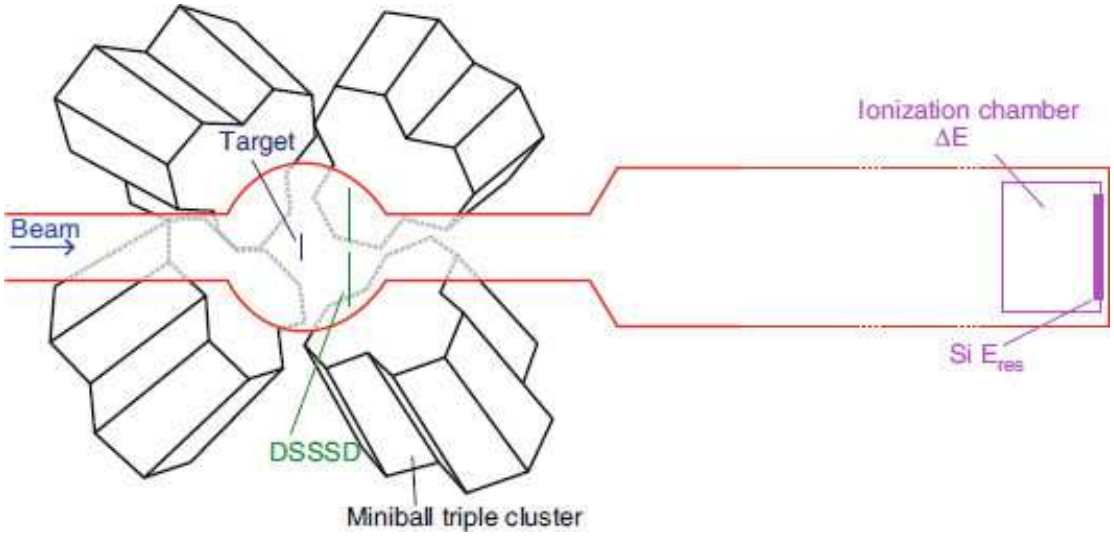
$t_{trapping}$ = 20 ms
$t_{breeding}$ ≈ 12 ms for $^{26}Na^{6+}$

A/q selection: 4.33
Final beam characteristics:

beam energy: 2.82 MeV/u
Intensity at MINIBALL: 6.4(5) x 10^4 ions/s
beam composition: ^{13}C, ^{26}Na

MINIBALL coulex setup





- beam time: ~ 73 h
- 3.6 mg/cm^2 ^{104}Pd-target
- identification of scattered particles with DSSSD @ θ_{lab}= 16-53°
- coincident with MINIBALL γ-ray spectrometer
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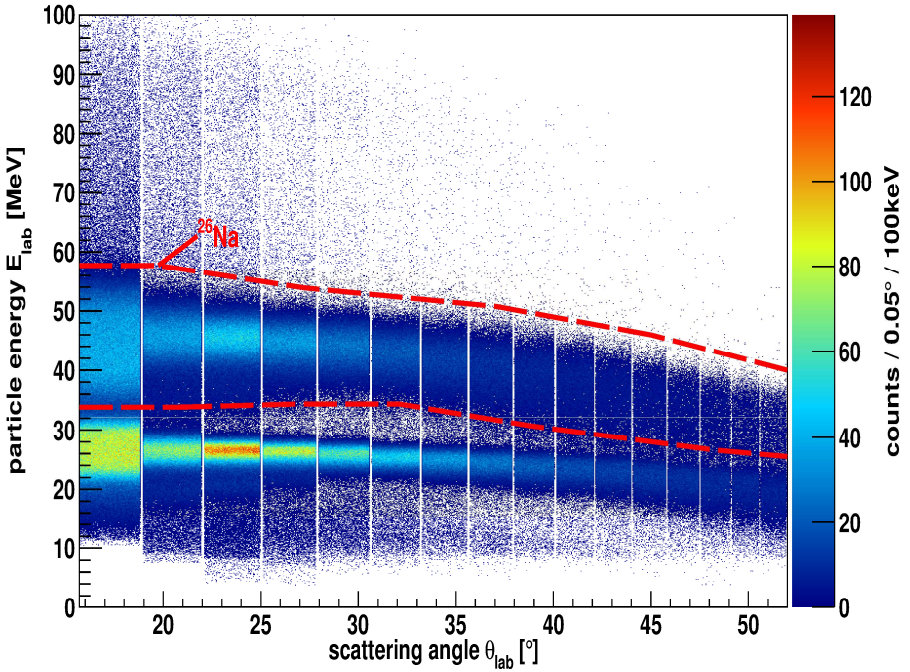
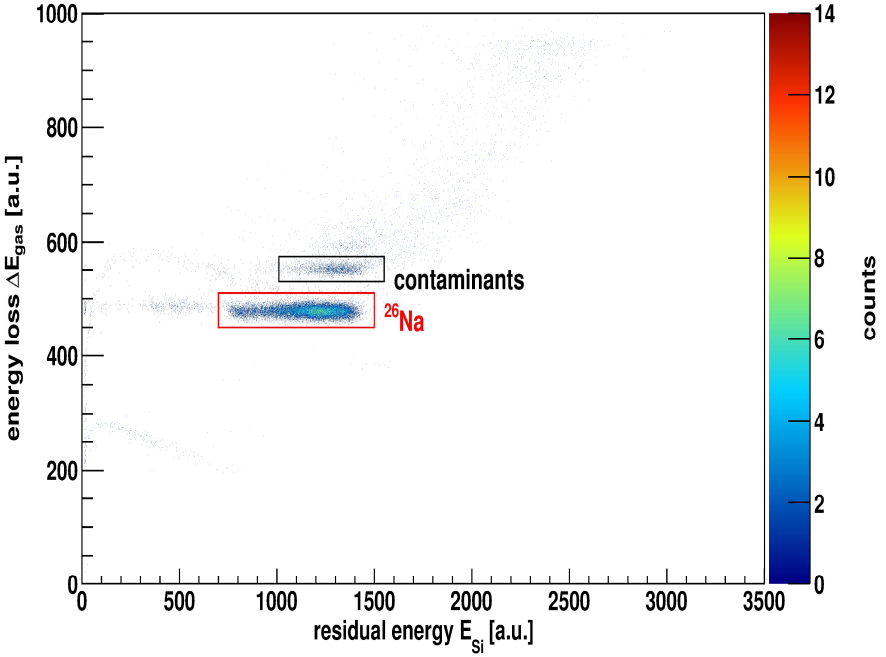
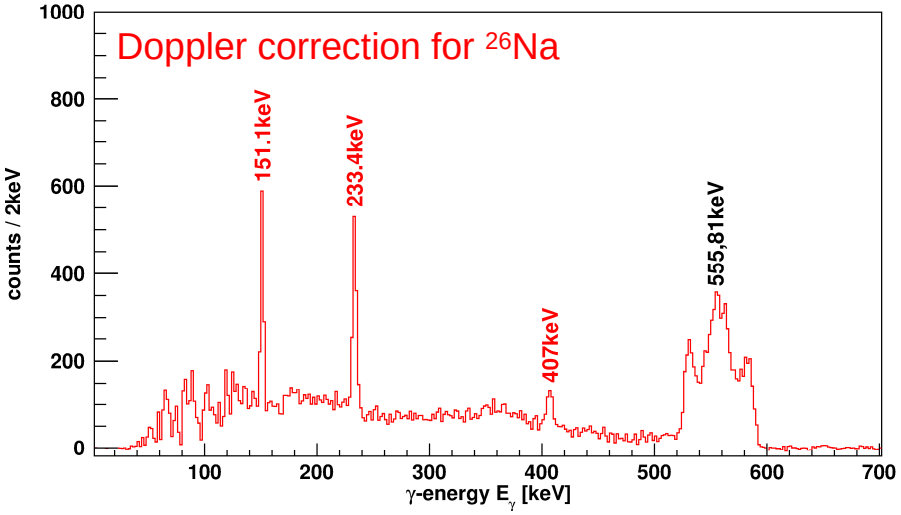
particle spectrum

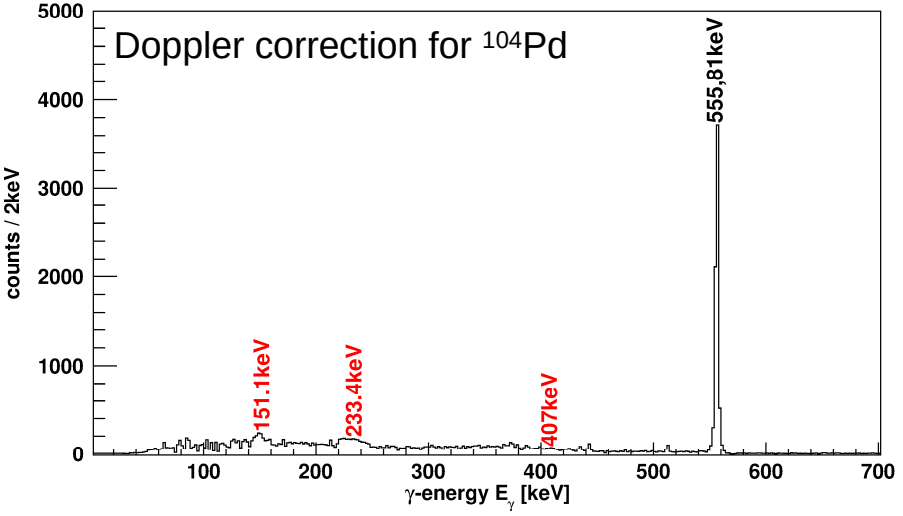




- ratio of A=13 to A=26 isotopes: 54% ^{13}C to 46% (^{26}Na + ^{26}X)
- cut on A≈26 leads to effective beam composition:
  92% ^{26}Na
  8% contaminants

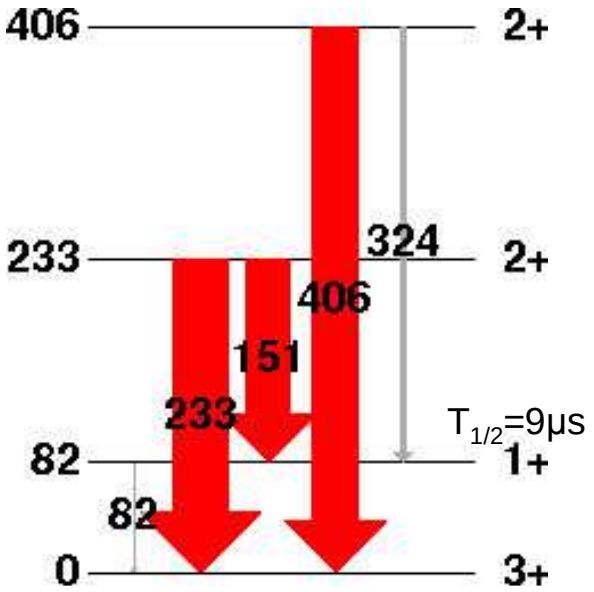
final γ-ray spectrum





- efficiency correction
- correction of target excitation by contaminant

Isotope	transition	E_γ lit.	E_γ	N_γ	N_γ corr.
		[keV]	[keV]	[counts]	[counts]
	$2^+_1 \rightarrow 1^+_1$	151.1(5)	151.1(1)	894(35)	3351(133)
26Na	$2^+_1 \rightarrow 3^+_1$	233.6(2)	233.4(1)	981(38)	4236(165)
	$2^+_2 \rightarrow 3^+_1$	420(15)	407.0(10)	262(25)	1505(144)
104Pd	$2^+_1 \rightarrow 0^+_1$	555.796(23)	555.81(5)	6957(83)	44654(624)



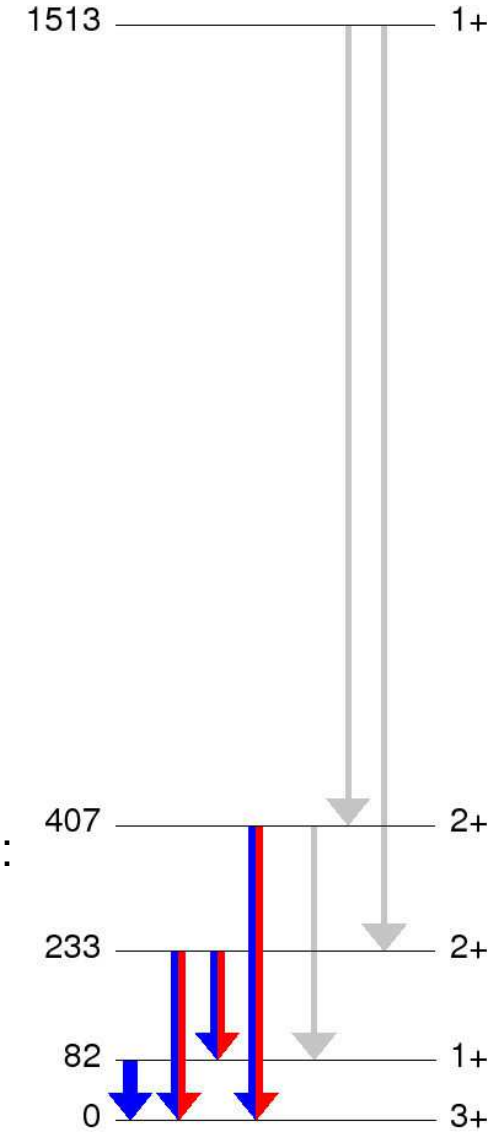
GOSIA2 input for ^{26}Na

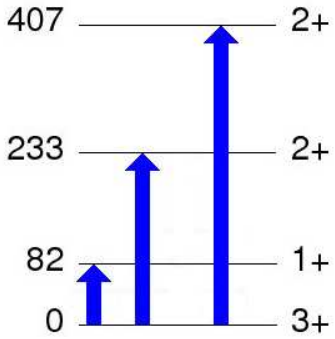
N(233keV)	4236(165)
N(151keV)	3351(133)
N(407keV)	1505(144)
b(233keV/151keV)	1.22(12)
b(407keV/324keV)	5.44(54)
$\delta(2^+_1 \rightarrow 3^+_1)$	-0.32(14)
$\delta(2^+_1 \rightarrow 1^+_1)$	0.16(7)
$\delta(2^+_2 \rightarrow 3^+_1)$	-0.25(12)
$T_{1/2}(1^+_1)$	9(2) μs

yields
this experiment

branching ratios b
multipole mixing ratios δ
Lee et. al.
Phys. Rev. C 73 057306 (2006)

half-life
ENSDF

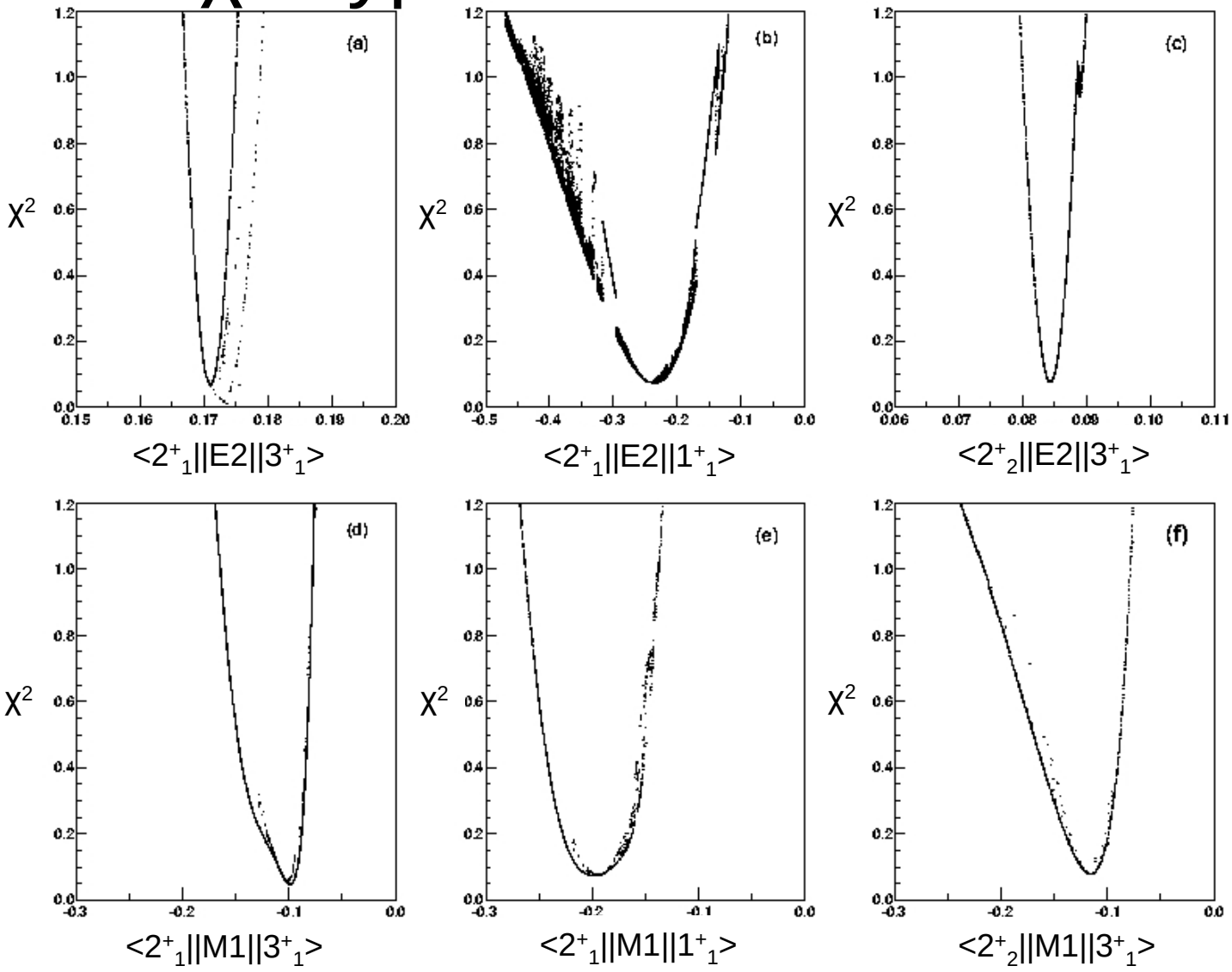




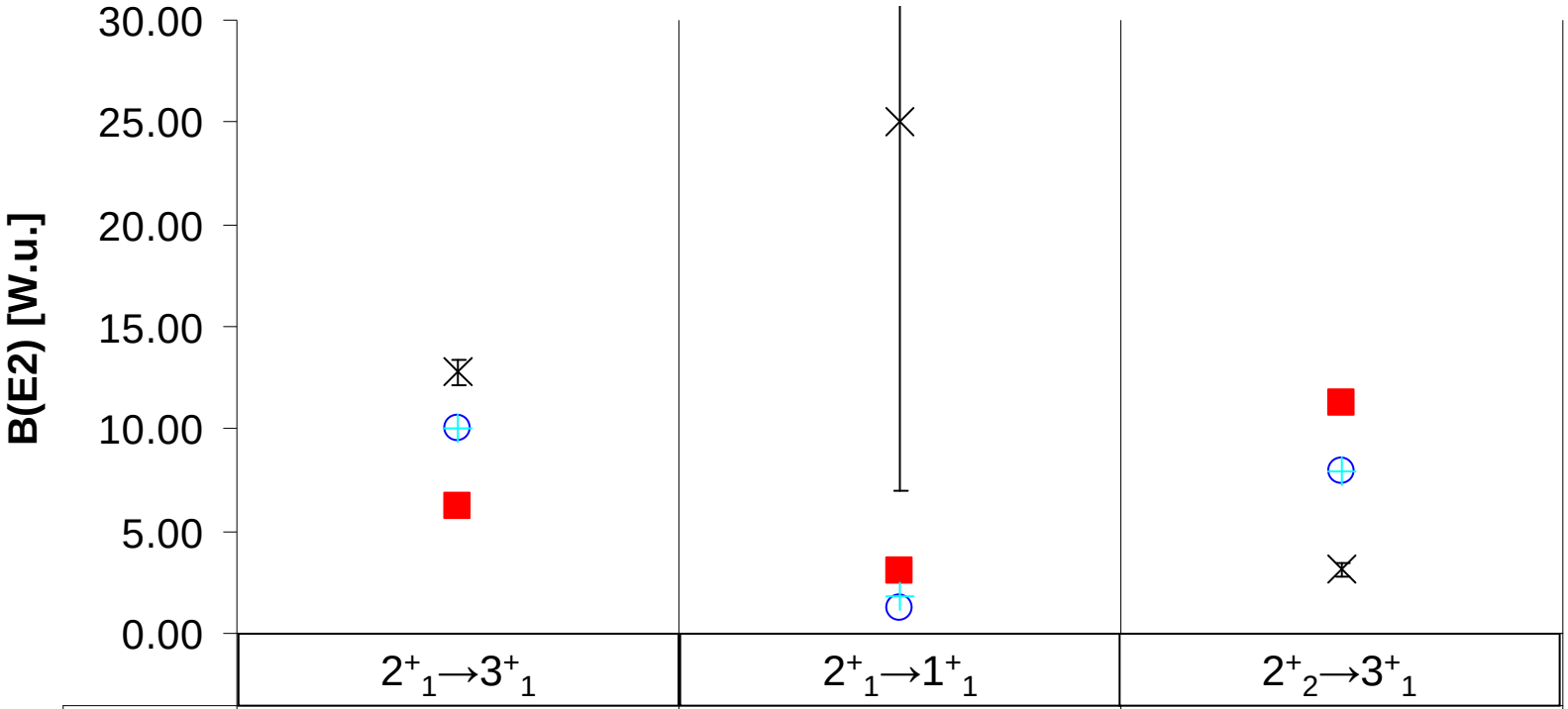
excitation:
mainly E2

de-excitation:
M1 / E2

χ^2-hypersurface scans

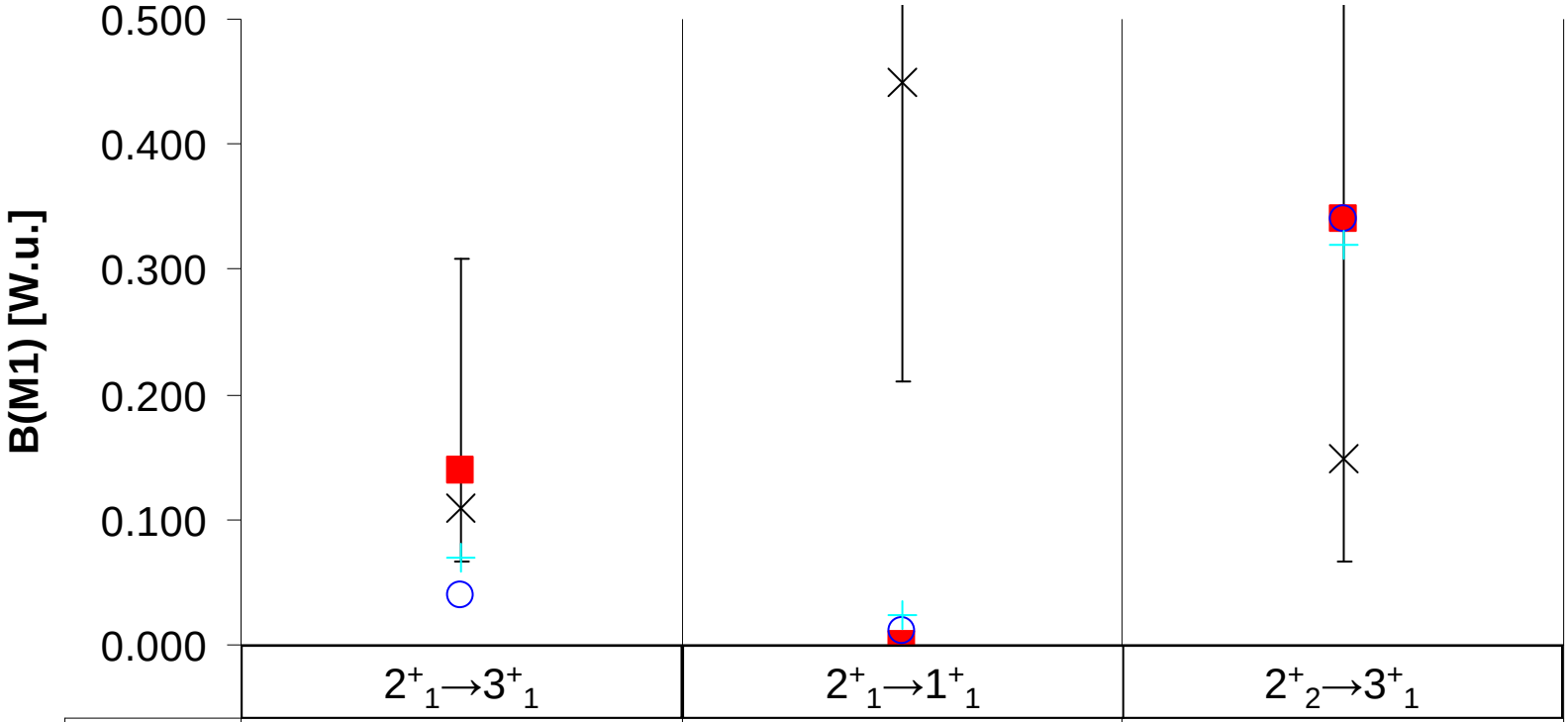


results – B(E2)



	$2^+_1 \rightarrow 3^+_1$	$2^+_1 \rightarrow 1^+_1$	$2^+_2 \rightarrow 3^+_1$
EXP	12.78^{+62}_{-60}	25^{+64}_{-18}	3.11^{+33}_{-33}
USD	6.25	3.09	11.27
USDA	10.06	1.23	7.91
USDB	10.04	1.84	7.89

results – B(M1)



	$2^+_1 \rightarrow 3^+_1$	$2^+_1 \rightarrow 1^+_1$	$2^+_2 \rightarrow 3^+_1$
× EXP	$0.109\ ^{+199}_{-\ 42}$	$0.45\ ^{+33}_{-24}$	$0.148\ ^{+422}_{-\ 82}$
■ USD	0.140	0.00016	0.340
○ USDA	0.040	0.011	0.340
+ USDB	0.070	0.023	0.320

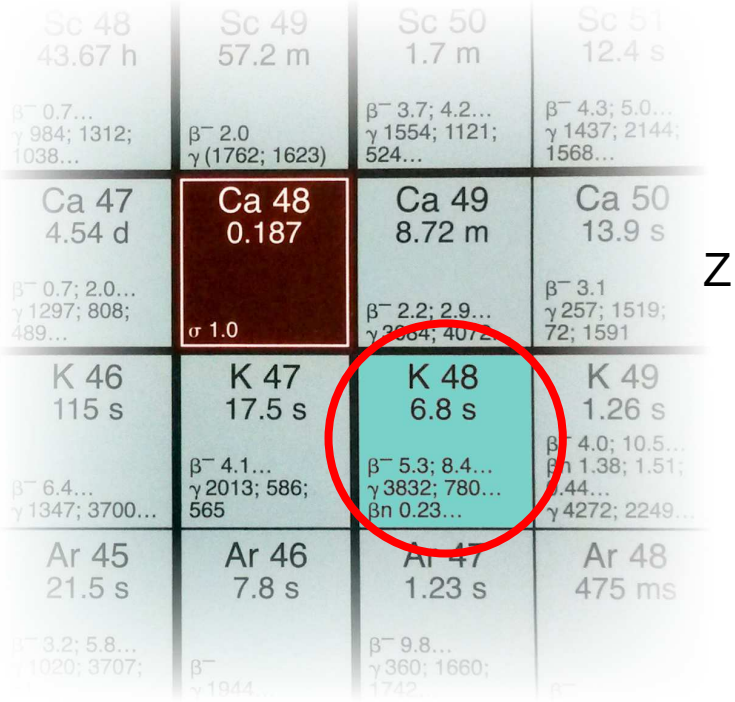
results

- reduced transition propabillities in ^{26}Na measured with Coulomb excitation

- comparison with theoretical predictions from calculations shows improvemts of USDA/B interaction:
  1. spin order
  2. number of ^{26}Ne(0^+) $\rightarrow$ ^{26}Na(1^+)
  3. B(E2; $2^+_1 \rightarrow 3^+_1$) > B(E2; $2^+_2 \rightarrow 3^+_1$)

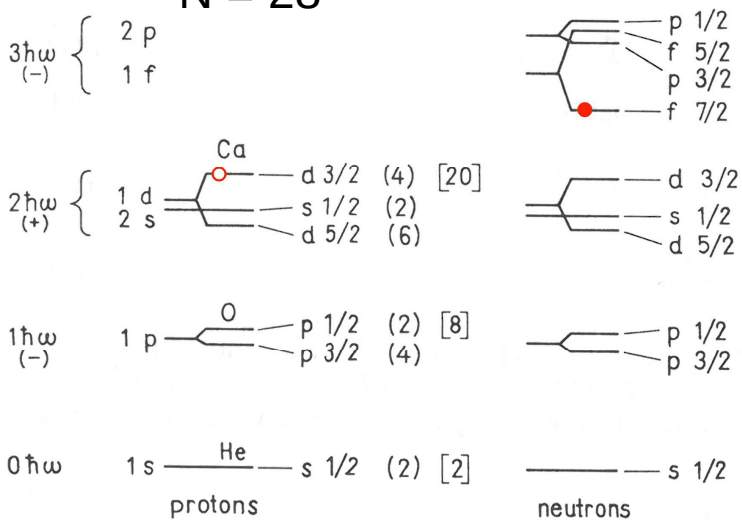
✓ USDA/B in better agreement with experiment than USD
no significant difference between USDA and USDB

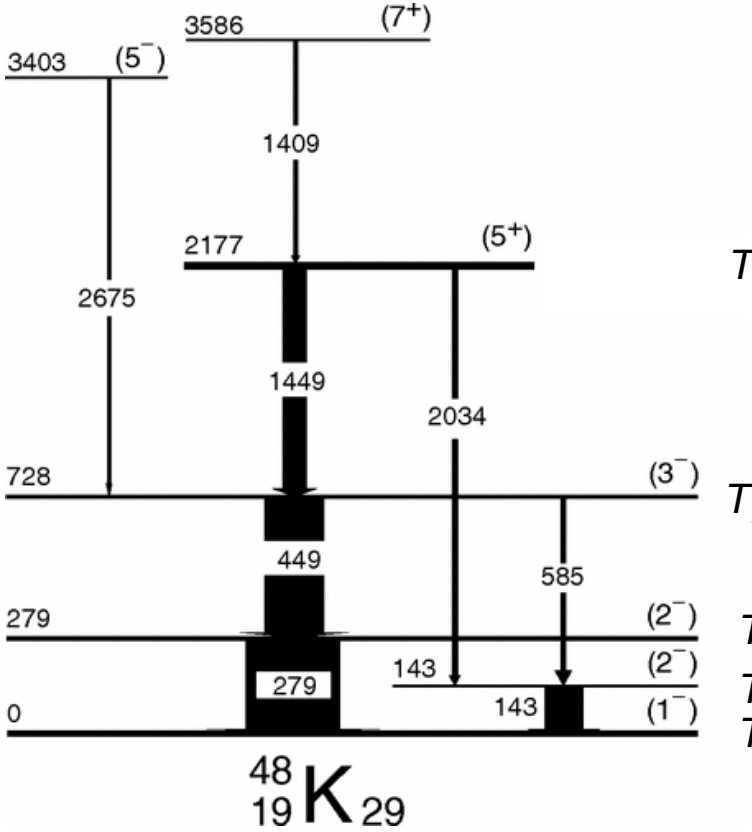
^{48}K



Z = 20

N = 28





$T_{1/2}$=7.1ns

$T_{1/2}$=3.6ps

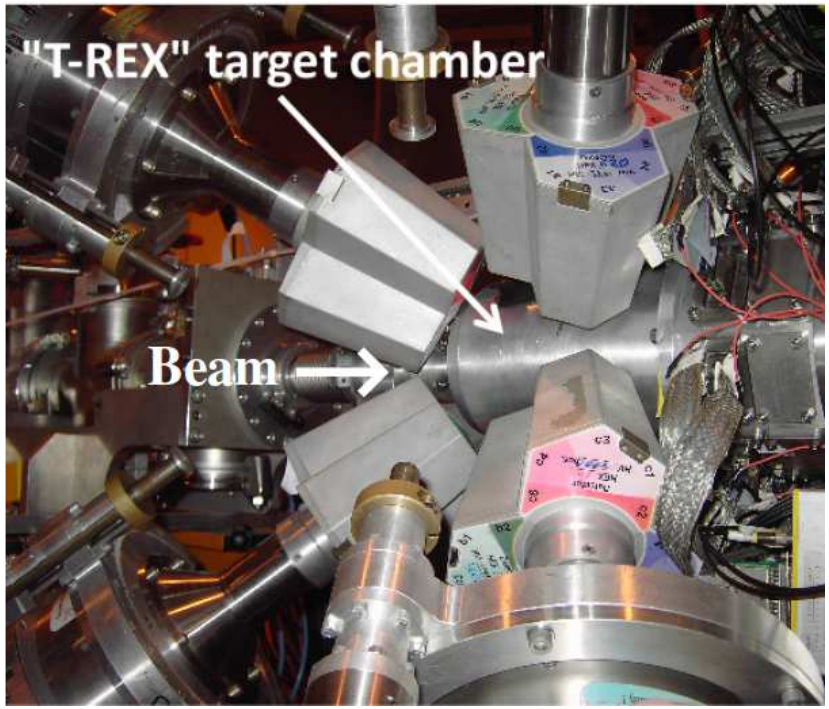
$T_{1/2}$=5.3ps

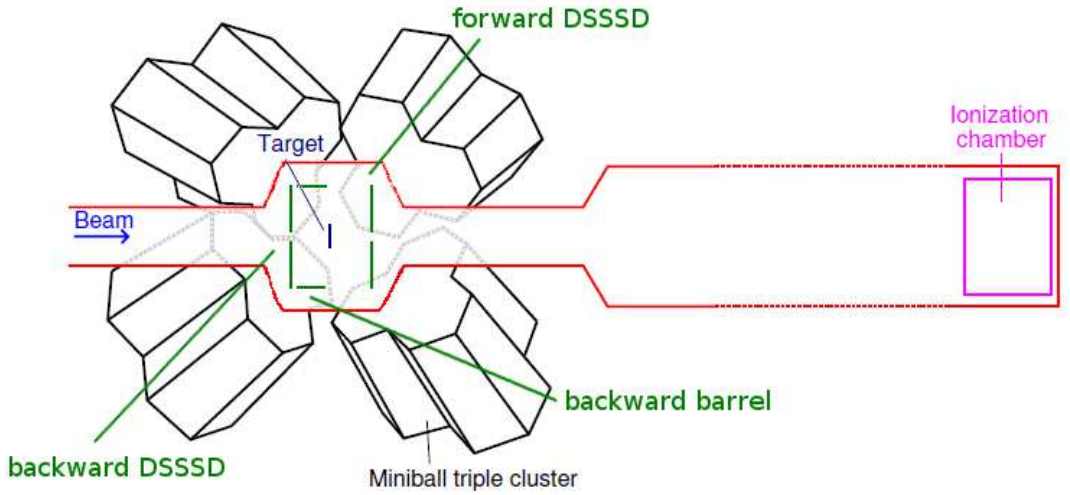
$T_{1/2}$=21ps

$T_{1/2}$=6.8s

W. Królas et. al.
Phys. Rev. C 84 064301 (2011)

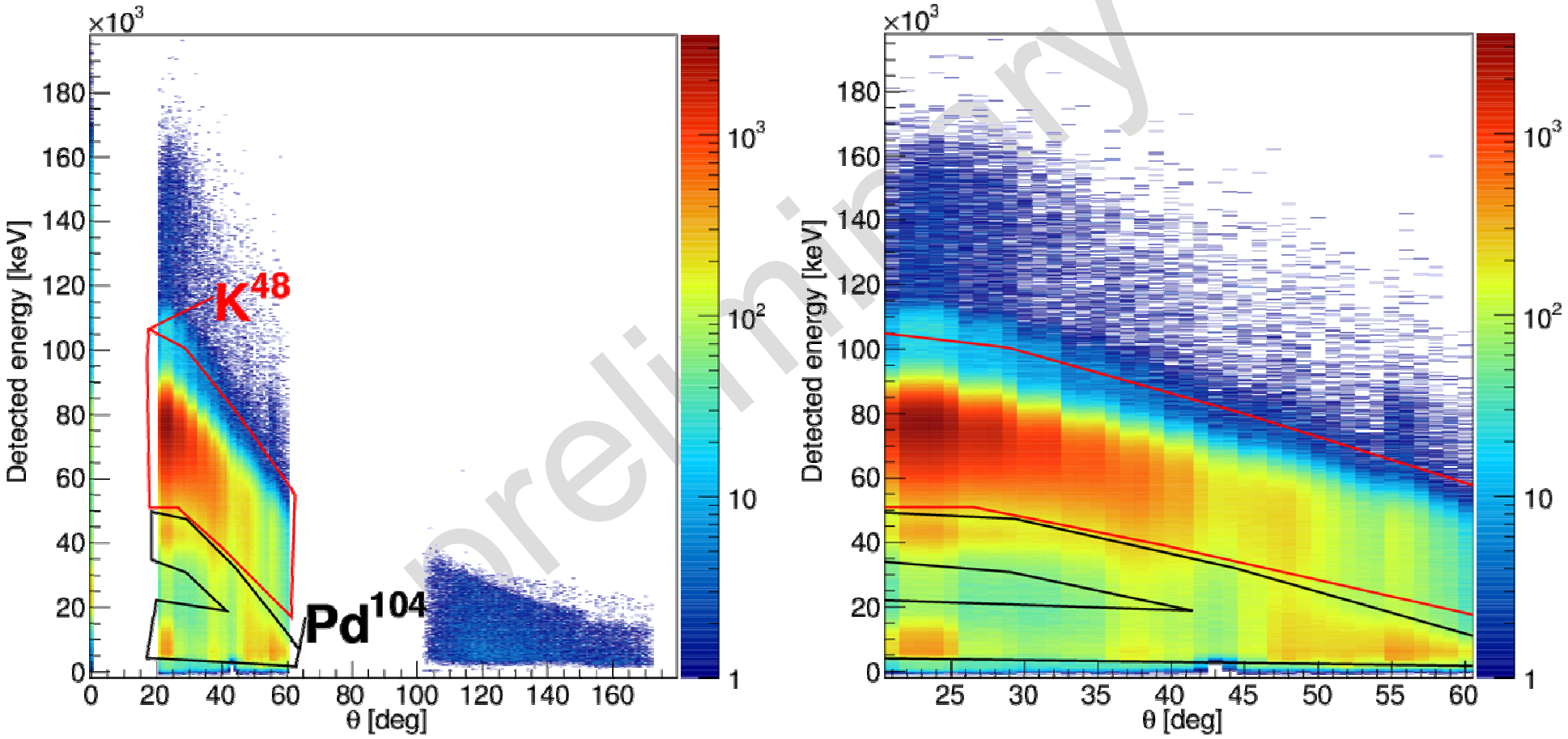
MINIBALL CREX setup





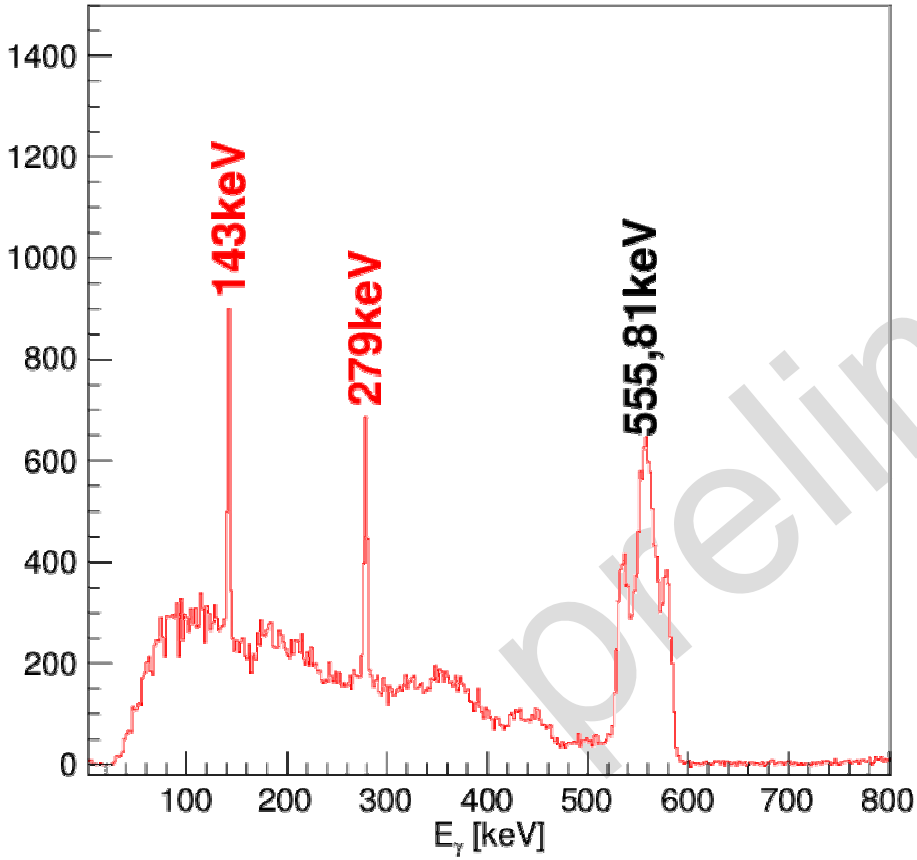
- beam time: ~ 66h
- 4 mg/cm^2 ^{104}Pd-target
- identification of scattered particles
  - forward DSSSD @ θ_{lab}= 21-60° (variable distance)
  - backward barrel @ θ_{lab}= 102-150°
  - backward DSSSD @ θ_{lab}= 150-172°
- coincident with MINIBALL γ-ray spectrometer
- beam monitoring with ionisation chamber

preliminary results – particle spectrum



preliminary results – gamma spectrum

Doppler corrected for ^{48}K



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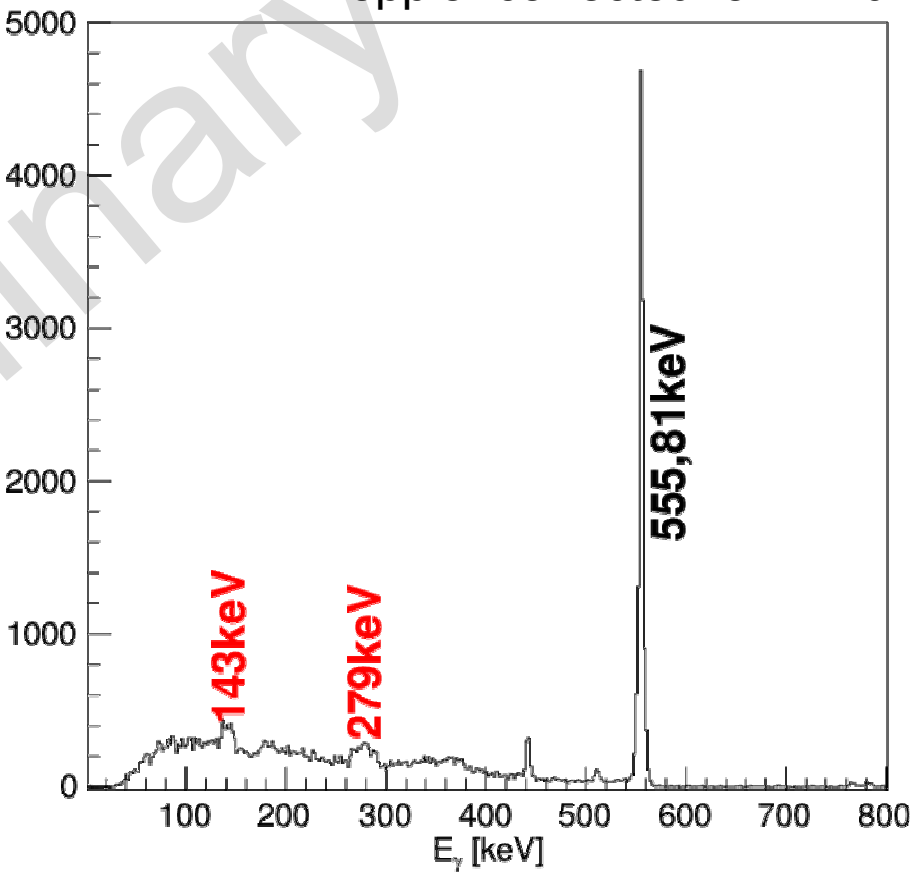

summary & outlook

26Na

- reduced transition propabillities in 26Na measured with Coulomb excitation
- Comparison with theoretical calculations show improved interactions USDA/USDB
- prepared for submission to PRC

48K:

- Analysis ongoing

Thanks for your attention!

B. Siebeck[1], R. Altenkirch[1], C. Bauer[2], A. Blazhev[1], P. Butler[3], J. Cederkäll[4], T. Davinson[5], H. De Witte[6], P. Delahaye[4], R. Gernhäuser[7], H. Hess[1], M. Huyse[6], S. Klupp[7], T. Kröll[2], R. Lutter[7], D. Mücher[7], J. Pakarinen[4], F. Radeck[1], S. Reichertz[7], P. Reiter[1], M. Seidlitz[1], M. Scheck[2], D. Schneiders[1], C. Sotty[8], T. Steinbach[1], P. Van Duppen[6], D. Voulot[4], N. Warr[1], F. Wenander[4], P.J. Woods[5], for the MINIBALL and REX-ISOLDE collaboration

[1] Institut für Kernphysik, Universität zu Köln, Germany
[2] Institut für Kernphysik, TU Darmstadt, Germany
[3] Department of Physics, University of Liverpool, United Kingdom
[4] Physics Department / ISOLDE, CERN, Genf, Switzerland
[5] Nuclear Physics Group, University of Edinburgh, United Kingdom
[6] Instituut voor Kern- en Strahlingsfysica, K. U. Leuven, Belgium
[7] Physik-Department E12, TU München, Germany
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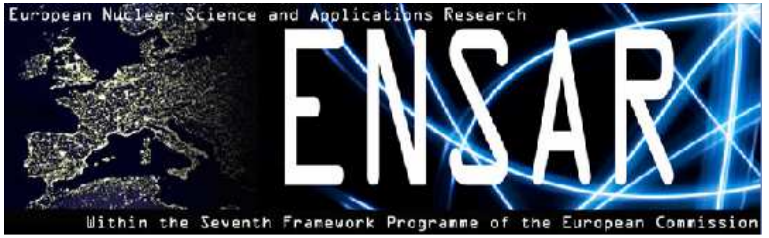
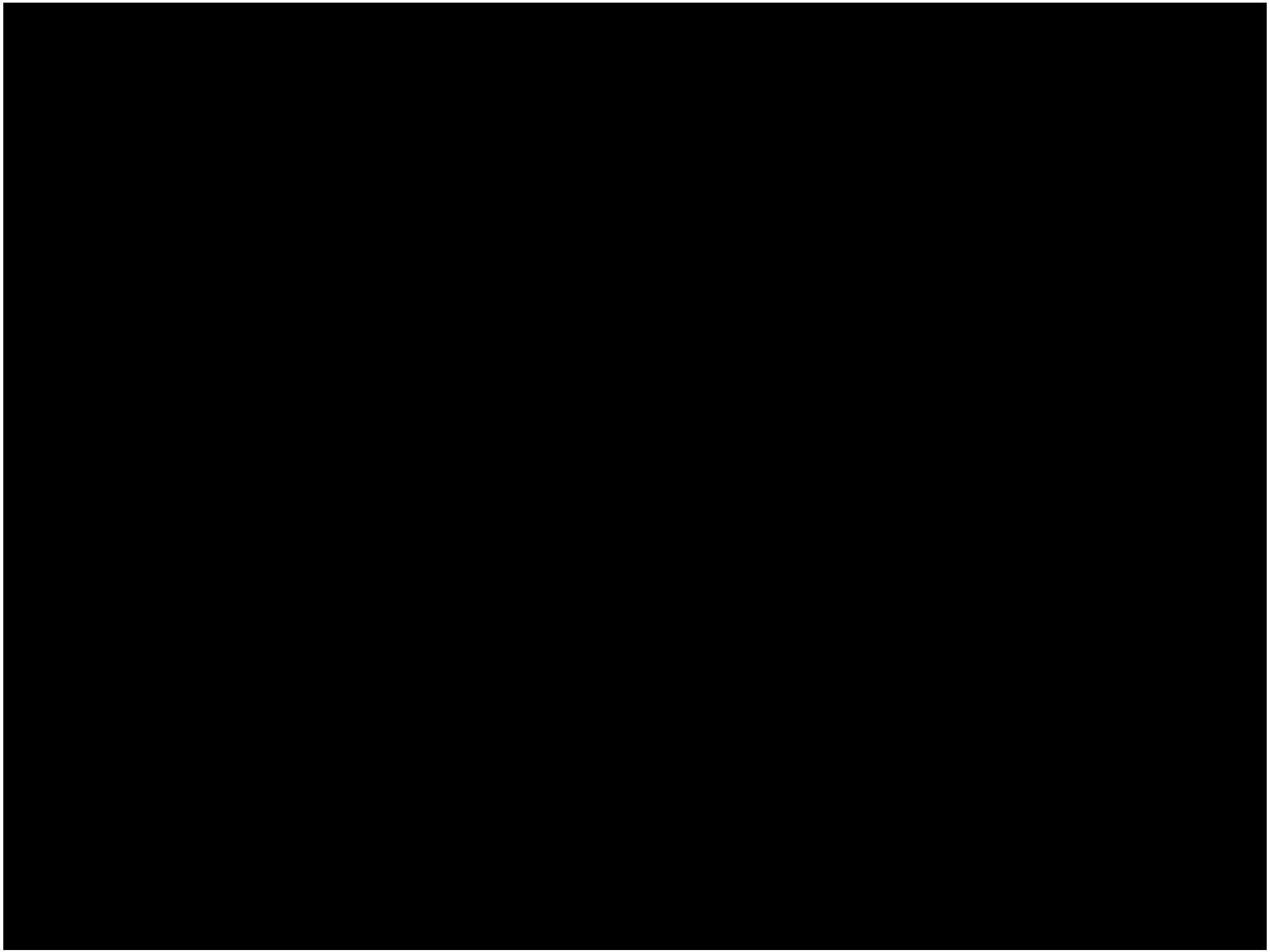


GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung



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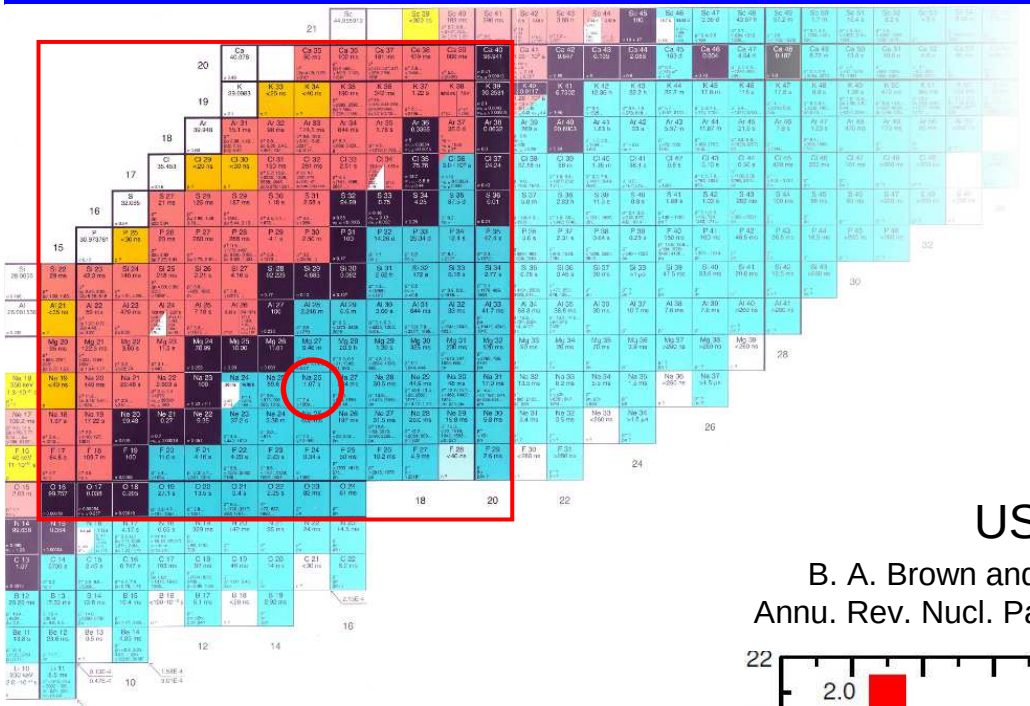

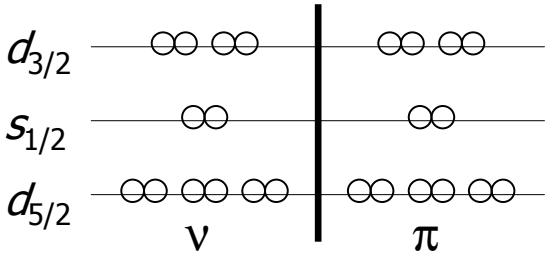

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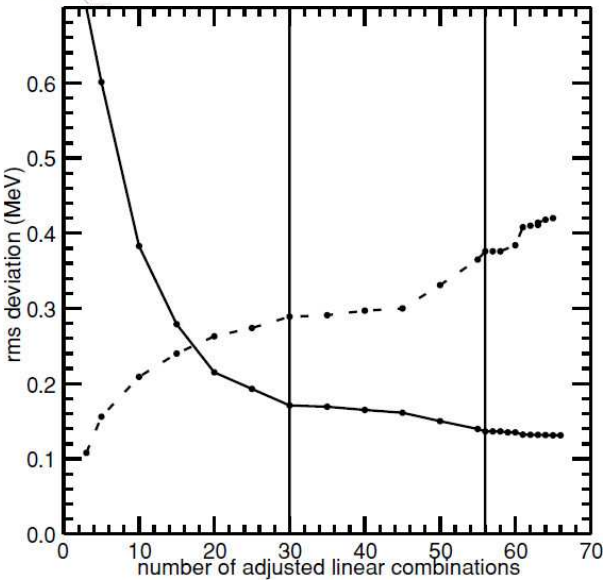

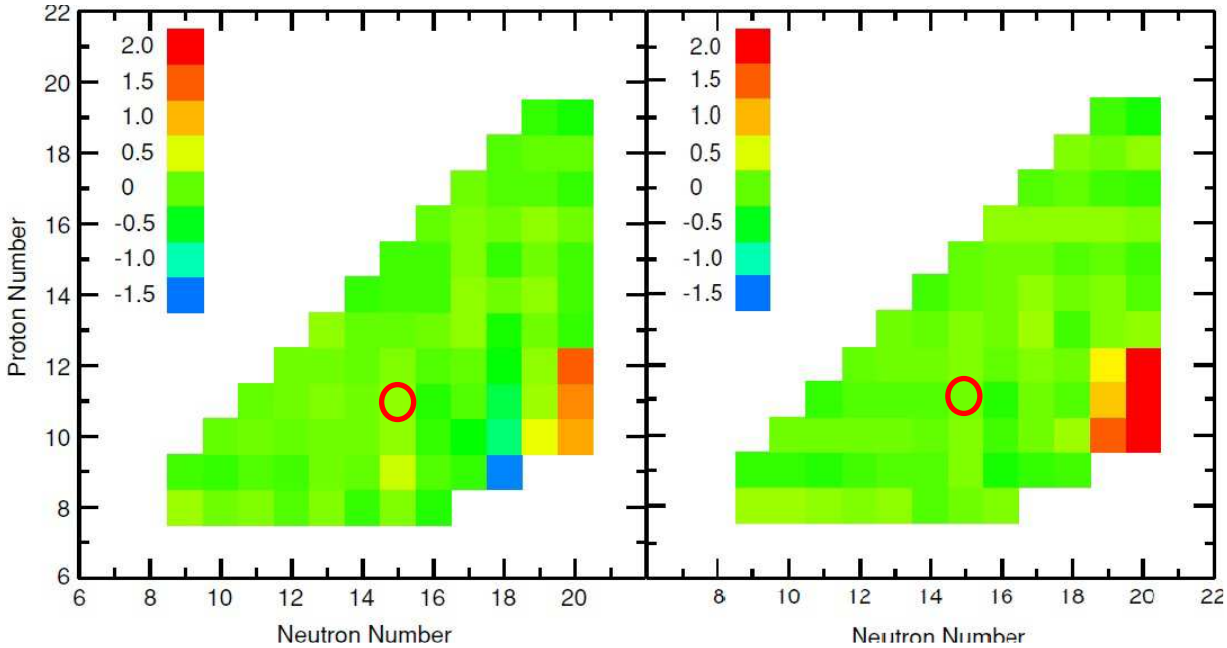

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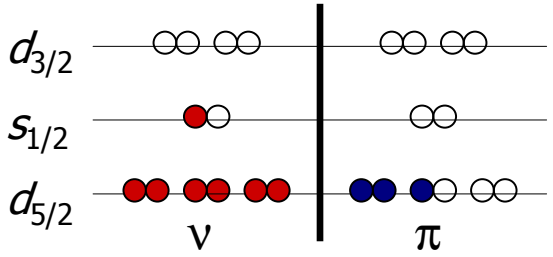

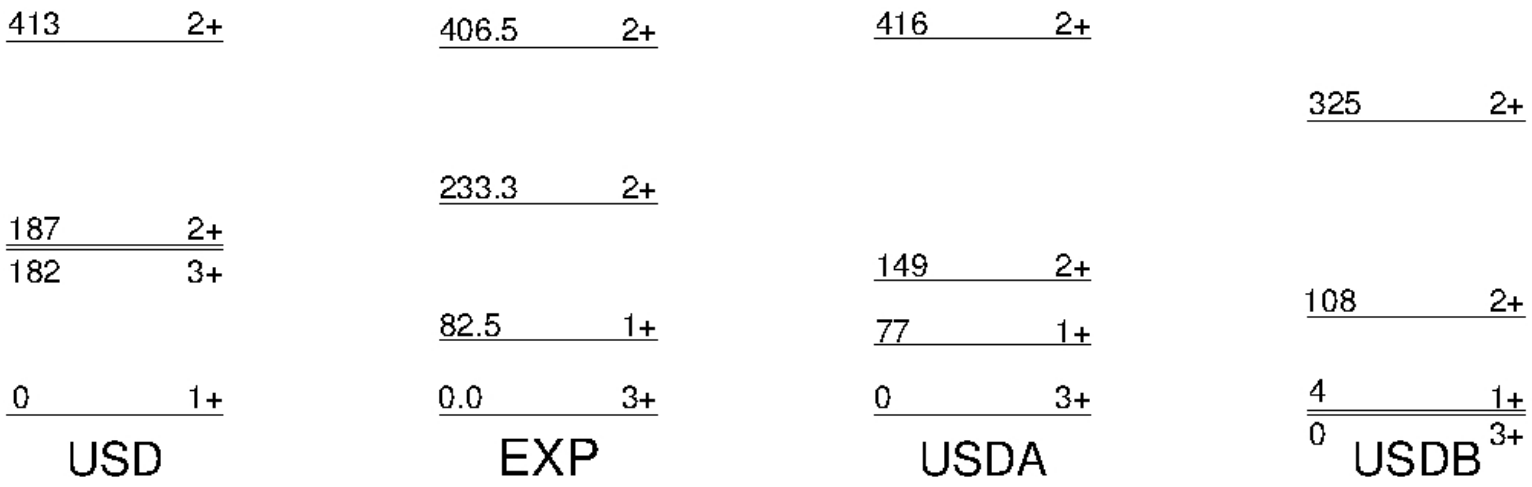

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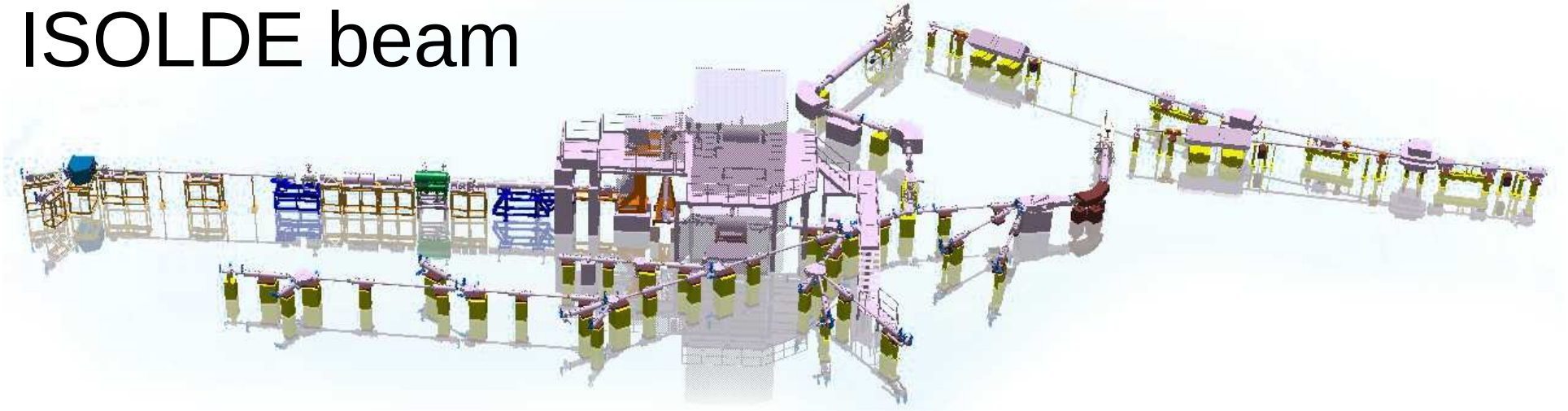

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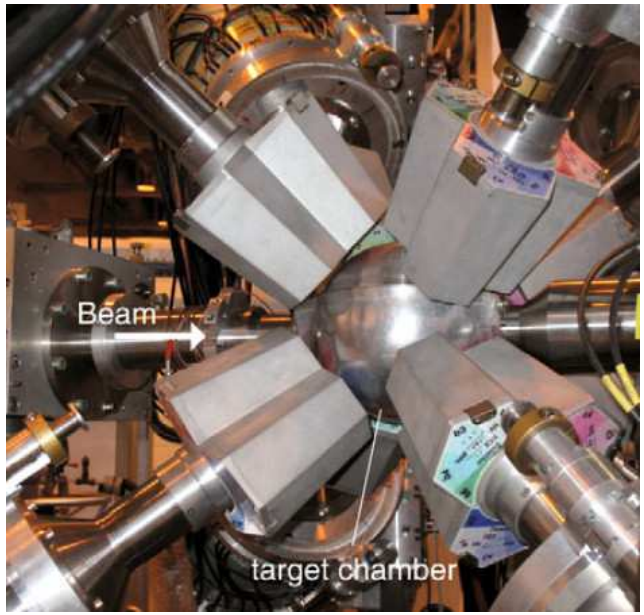

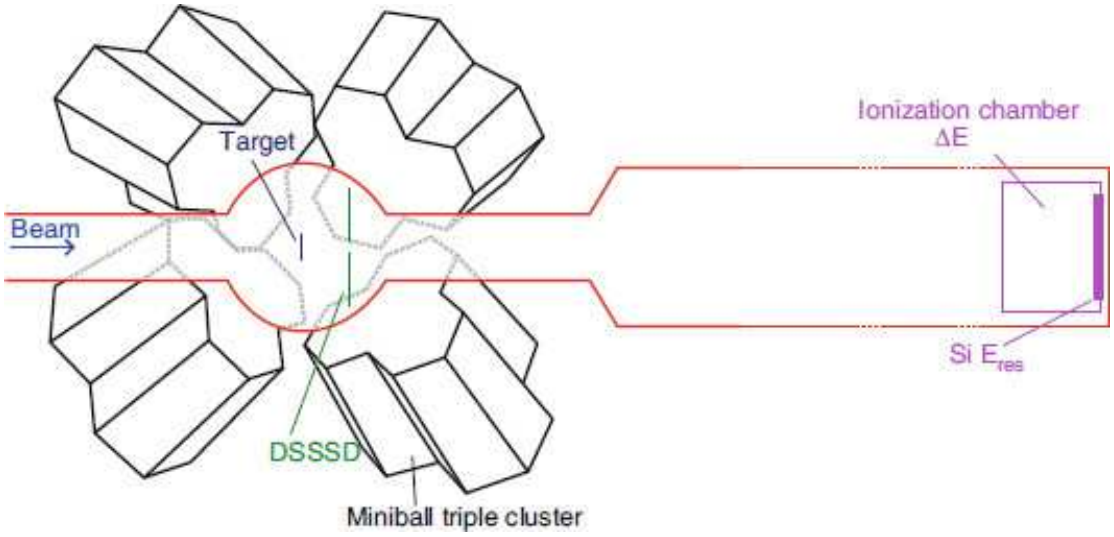

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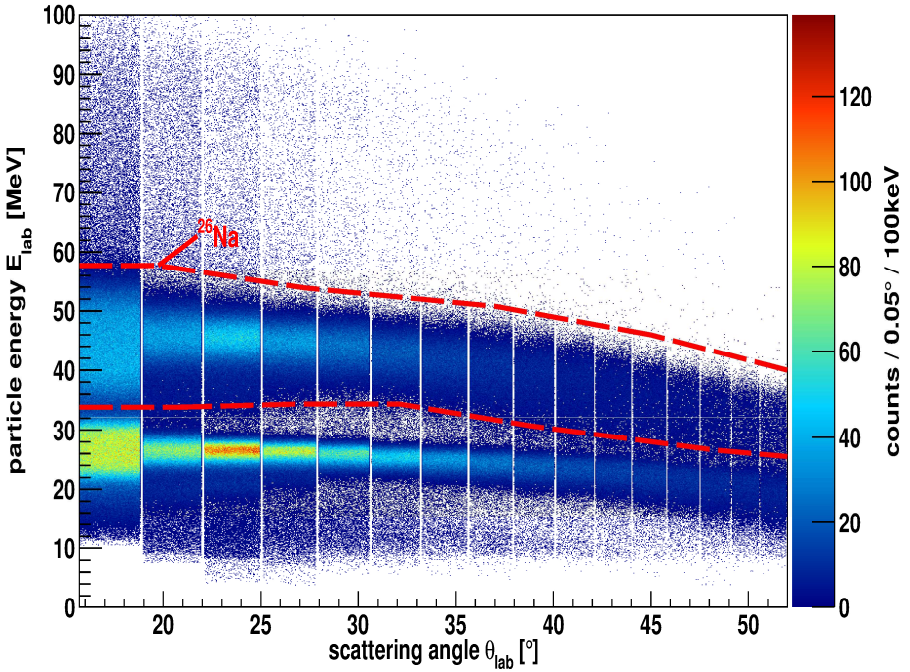

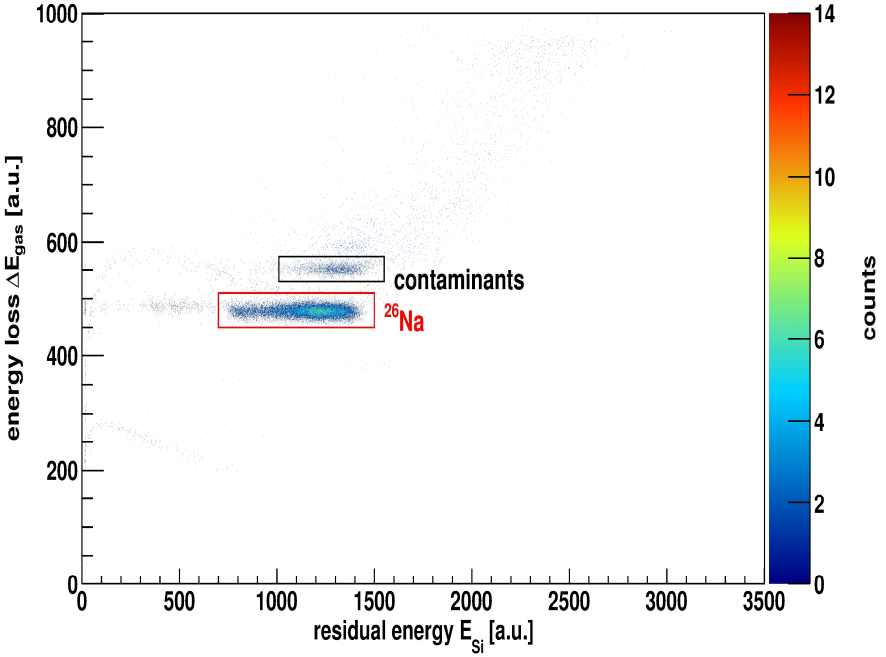

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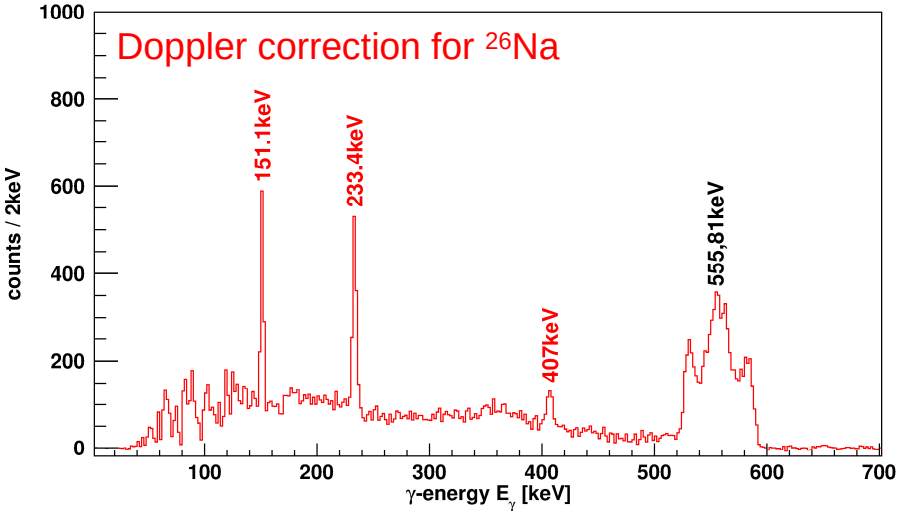

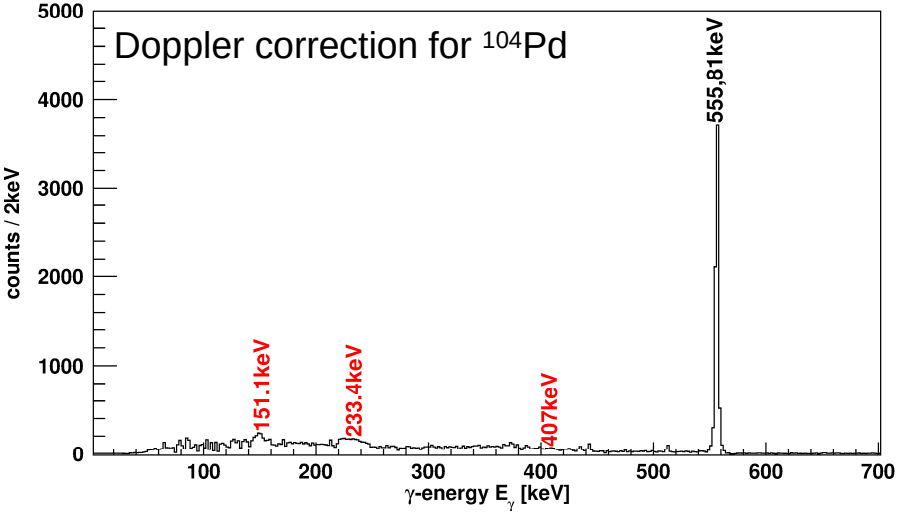

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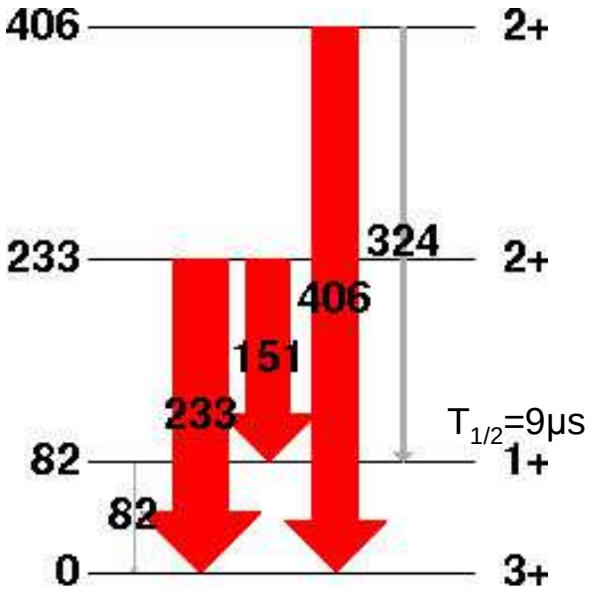
26Na	$2^+_1 \rightarrow 3^+_1$	233.6(2)	233.4(1)	981(38)	4236(165)
	$2^+_2 \rightarrow 3^+_1$	420(15)	407.0(10)	262(25)	1505(144)
104Pd	$2^+_1 \rightarrow 0^+_1$	555.796(23)	555.81(5)	6957(83)	44654(624)



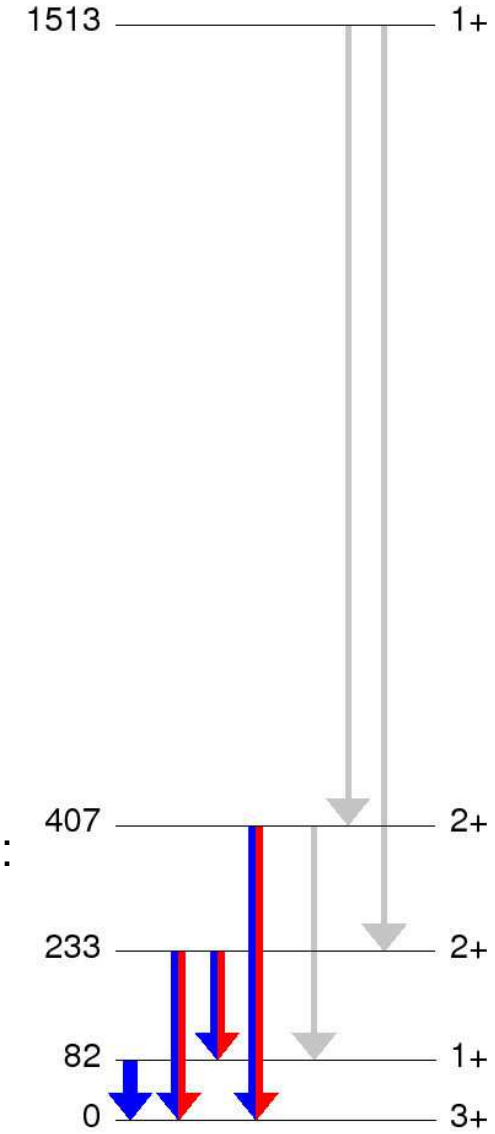
GOSIA2 input for ^{26}Na

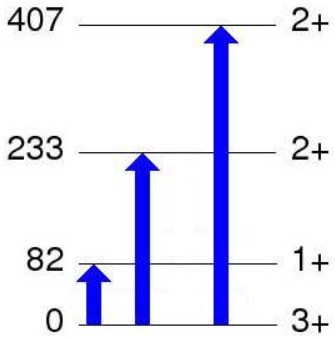
N(233keV)	4236(165)
N(151keV)	3351(133)
N(407keV)	1505(144)
b(233keV/151keV)	1.22(12)
b(407keV/324keV)	5.44(54)
$\delta(2^+_1 \rightarrow 3^+_1)$	-0.32(14)
$\delta(2^+_1 \rightarrow 1^+_1)$	0.16(7)
$\delta(2^+_2 \rightarrow 3^+_1)$	-0.25(12)
$T_{1/2}(1^+_1)$	9(2) μs

yields
this experiment

branching ratios b
multipole mixing ratios δ
Lee et. al.
Phys. Rev. C 73 057306 (2006)

half-life
ENSDF

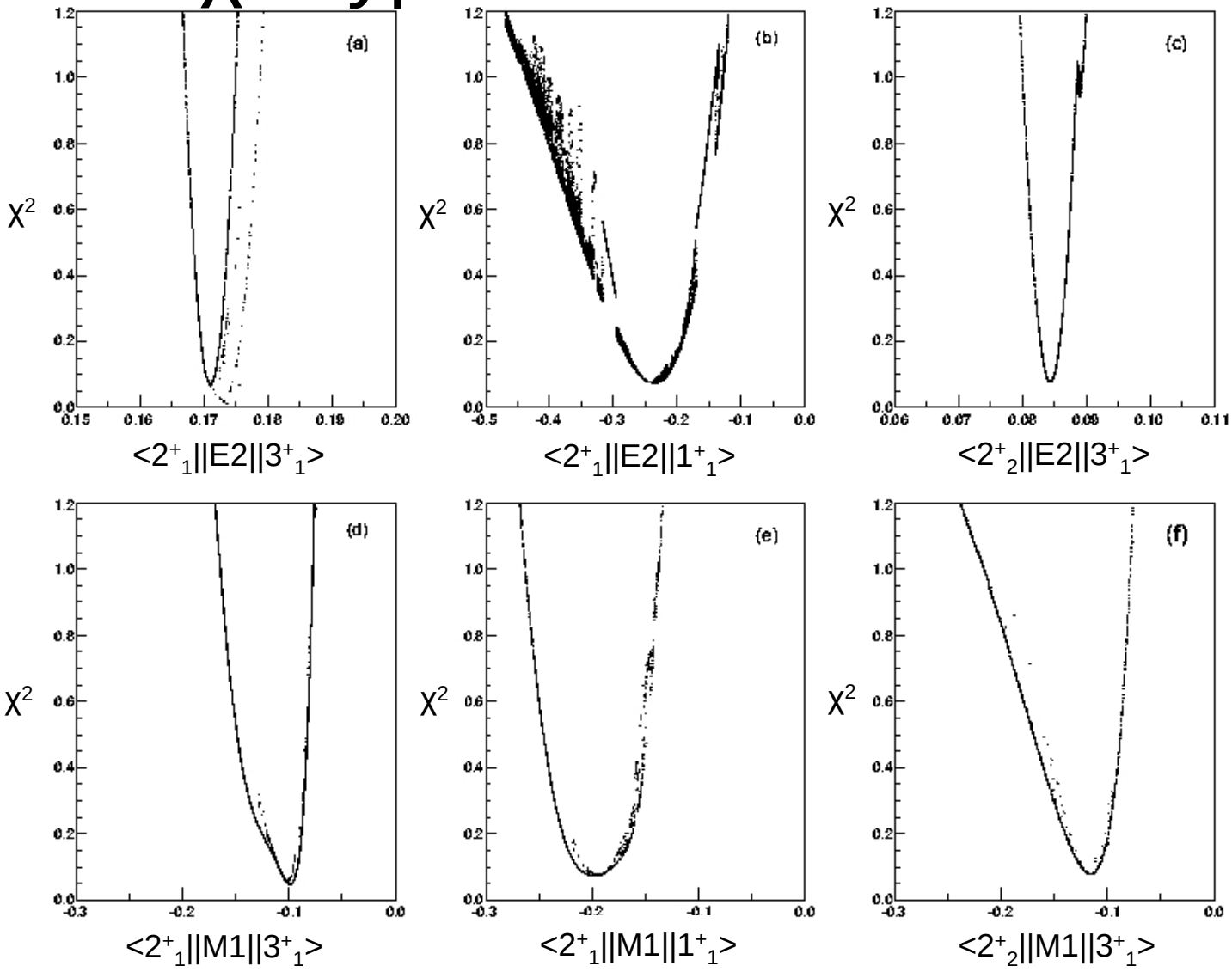




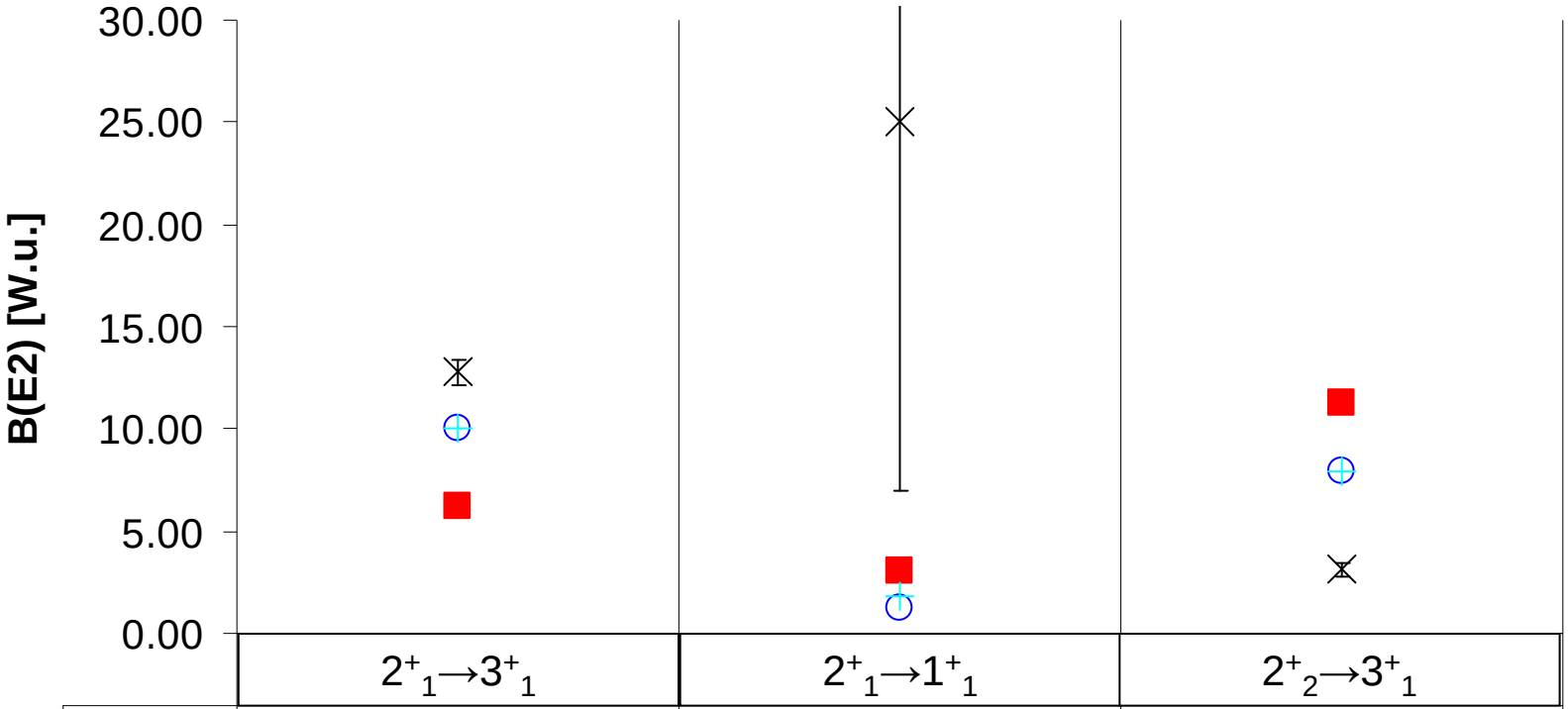
excitation:
mainly E2

de-excitation:
M1 / E2

χ^2-hypersurface scans

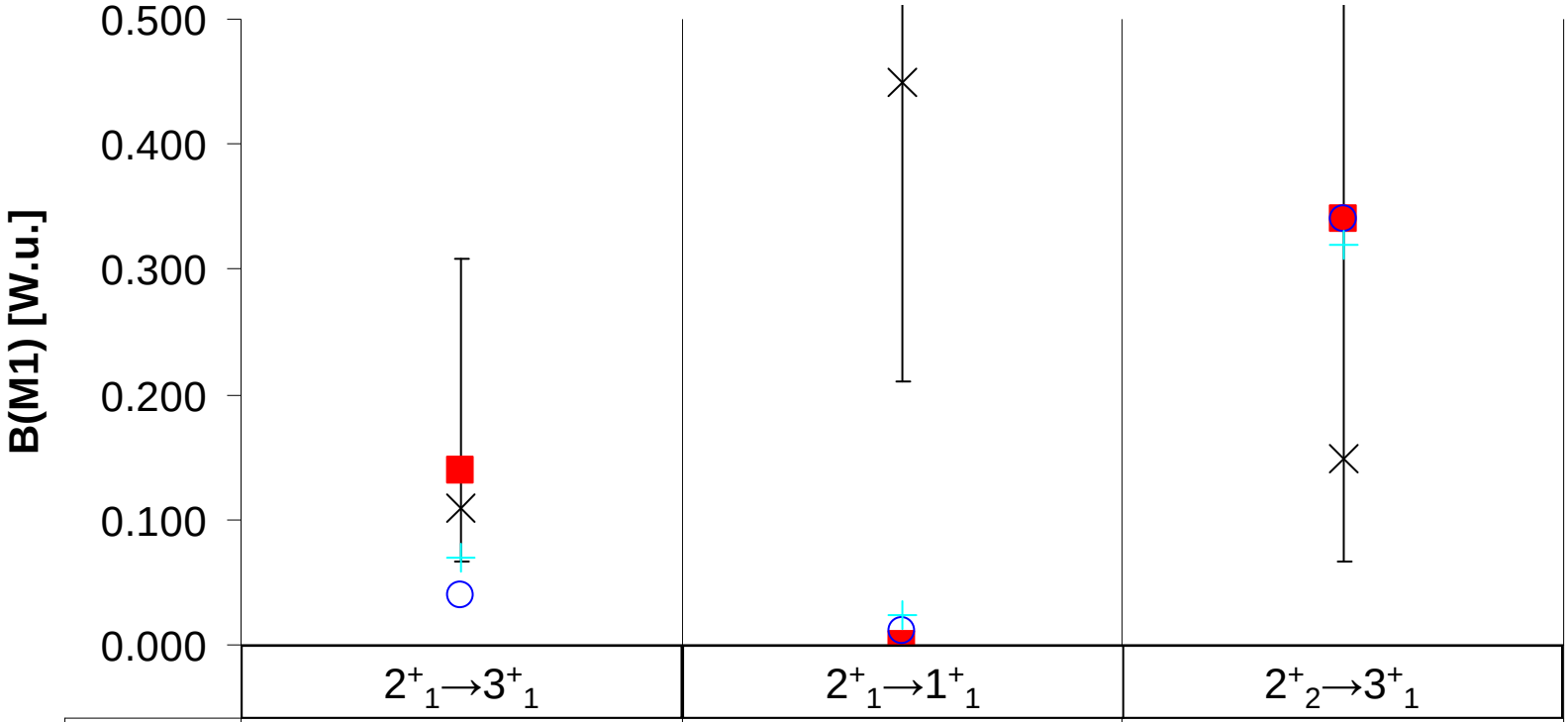


results – B(E2)



	$2^+_1 \rightarrow 3^+_1$	$2^+_1 \rightarrow 1^+_1$	$2^+_2 \rightarrow 3^+_1$
EXP	12.78^{+62}_{-60}	25^{+64}_{-18}	3.11^{+33}_{-33}
USD	6.25	3.09	11.27
USDA	10.06	1.23	7.91
USDB	10.04	1.84	7.89

results – B(M1)



	$2^+_1 \rightarrow 3^+_1$	$2^+_1 \rightarrow 1^+_1$	$2^+_2 \rightarrow 3^+_1$
× EXP	$0.109\ ^{+199}_{-\ 42}$	$0.45\ ^{+33}_{-24}$	$0.148\ ^{+422}_{-\ 82}$
■ USD	0.140	0.00016	0.340
○ USDA	0.040	0.011	0.340
+ USDB	0.070	0.023	0.320

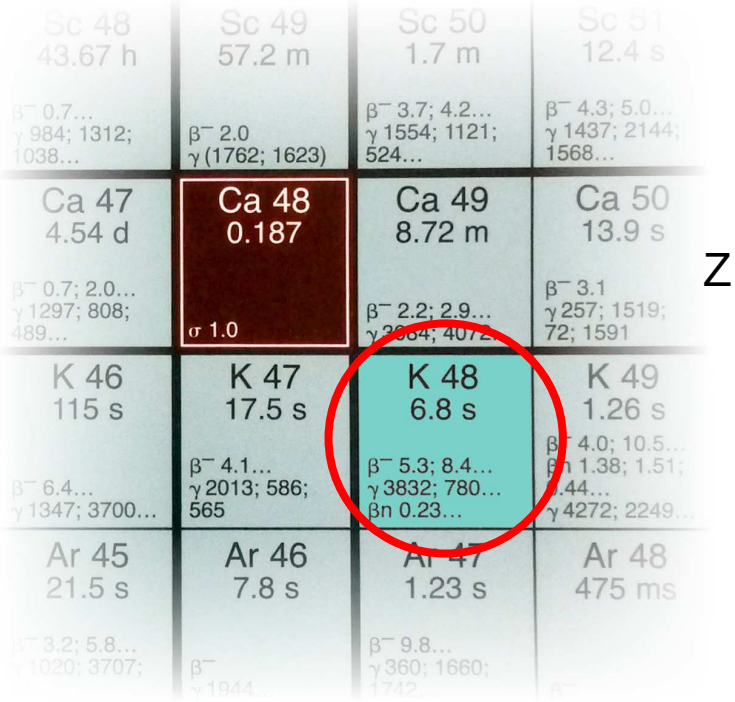
results

- reduced transition propabillities in ^{26}Na measured with Coulomb excitation

- comparison with theoretical predictions from calculations shows improvemts of USDA/B interaction:
  1. spin order
  2. number of ^{26}Ne(0^+) $\rightarrow$ ^{26}Na(1^+)
  3. B(E2; $2^+_1 \rightarrow 3^+_1$) > B(E2; $2^+_2 \rightarrow 3^+_1$)

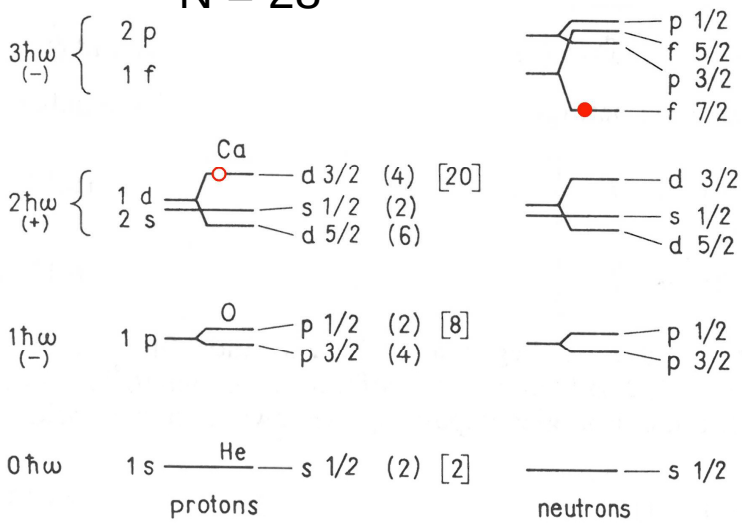
✓ USDA/B in better agreement with experiment than USD
no significant difference between USDA and USDB

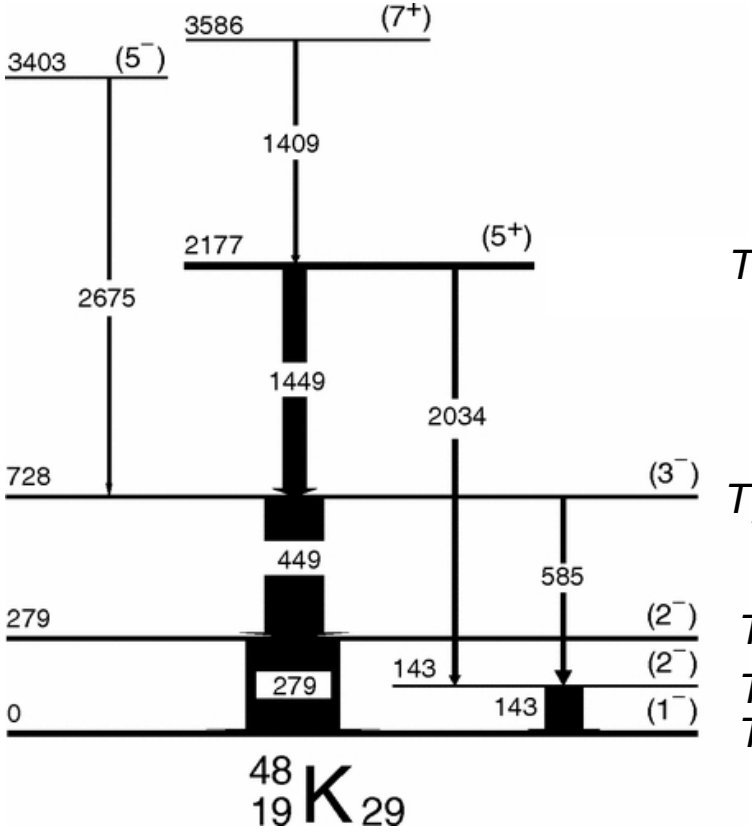
^{48}K



Z = 20

N = 28





$T_{1/2}$=7.1ns

$T_{1/2}$=3.6ps

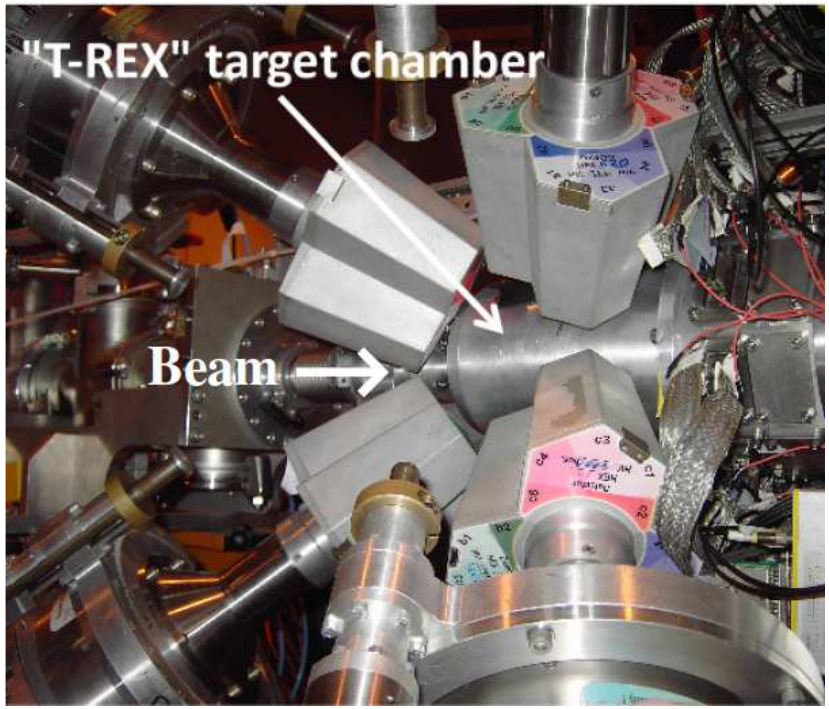
$T_{1/2}$=5.3ps

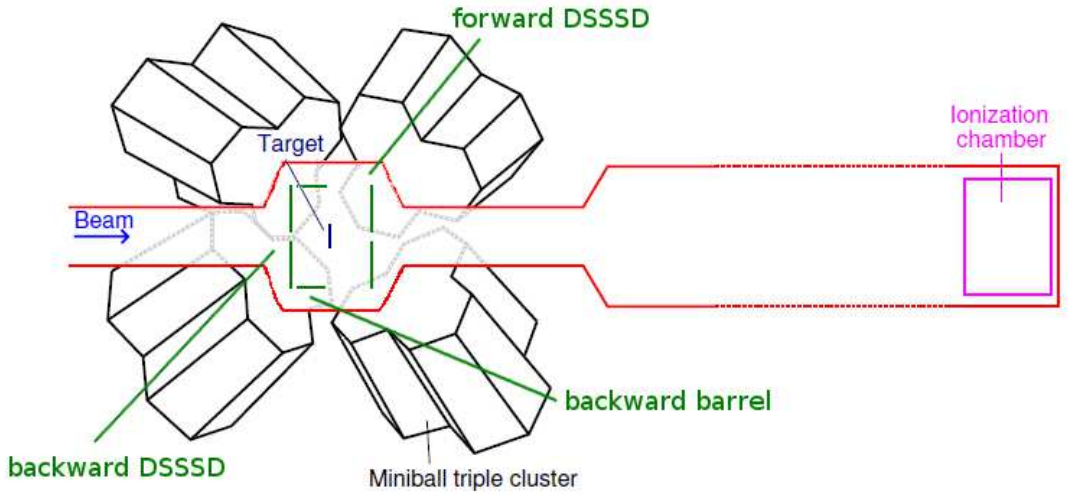
$T_{1/2}$=21ps

$T_{1/2}$=6.8s

W. Królas et. al.
Phys. Rev. C 84 064301 (2011)

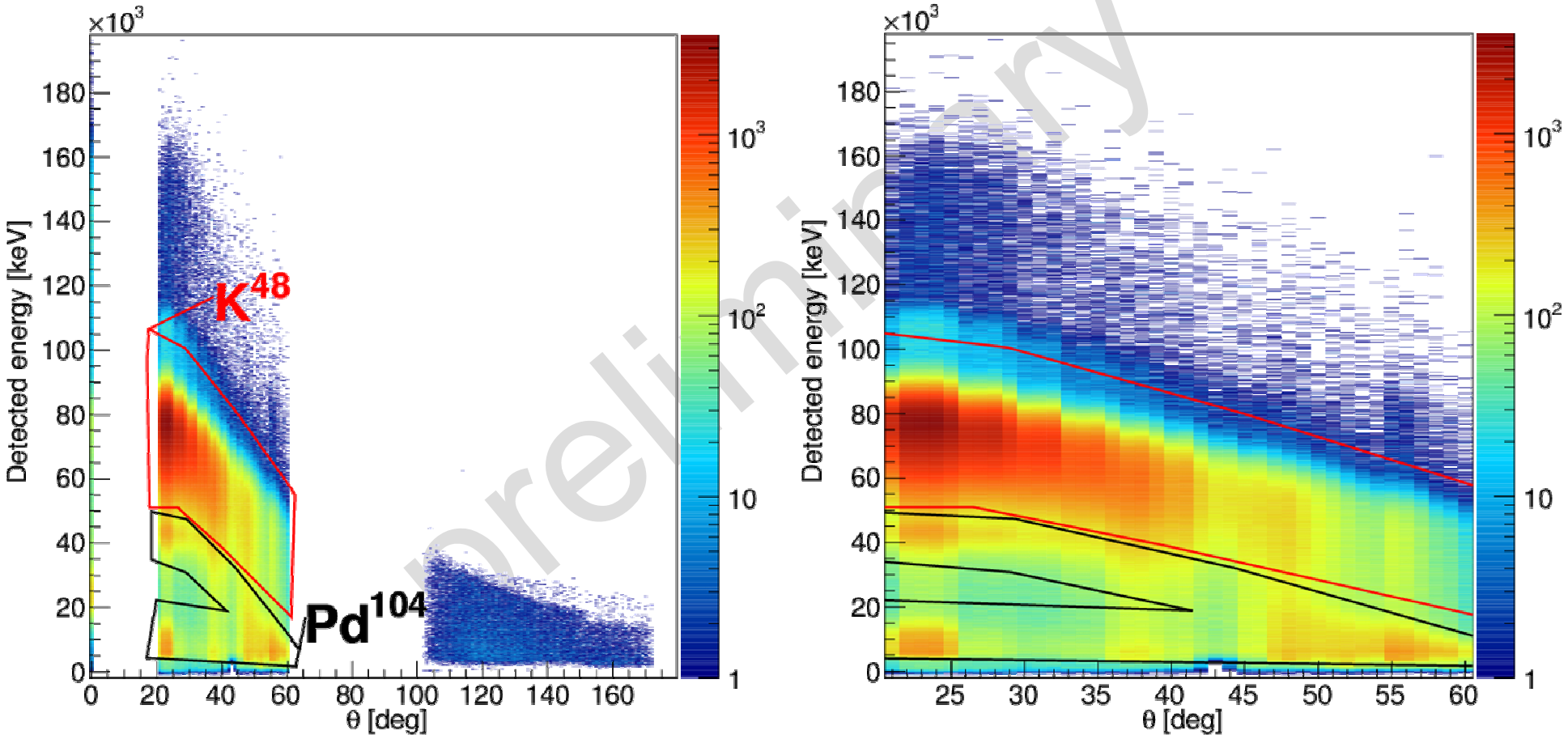
MINIBALL CREX setup





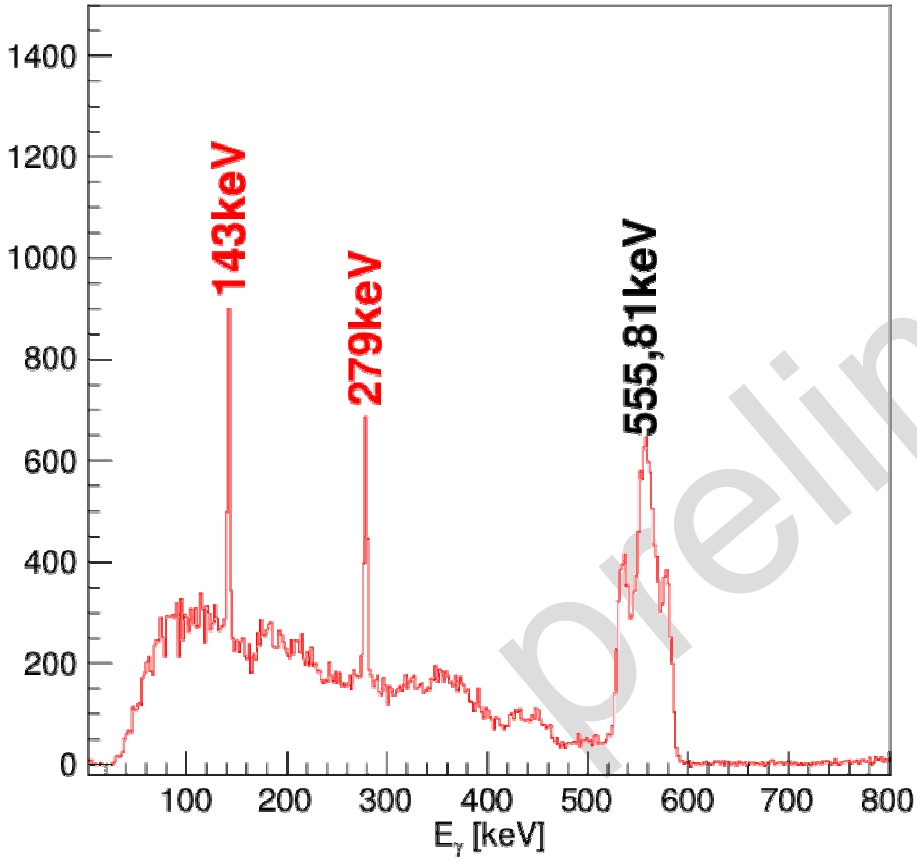
- beam time: ~ 66h
- 4 mg/cm^2 ^{104}Pd-target
- identification of scattered particles
  - forward DSSSD @ θ_{lab}= 21-60° (variable distance)
  - backward barrel @ θ_{lab}= 102-150°
  - backward DSSSD @ θ_{lab}= 150-172°
- coincident with MINIBALL γ-ray spectrometer
- beam monitoring with ionisation chamber

preliminary results – particle spectrum

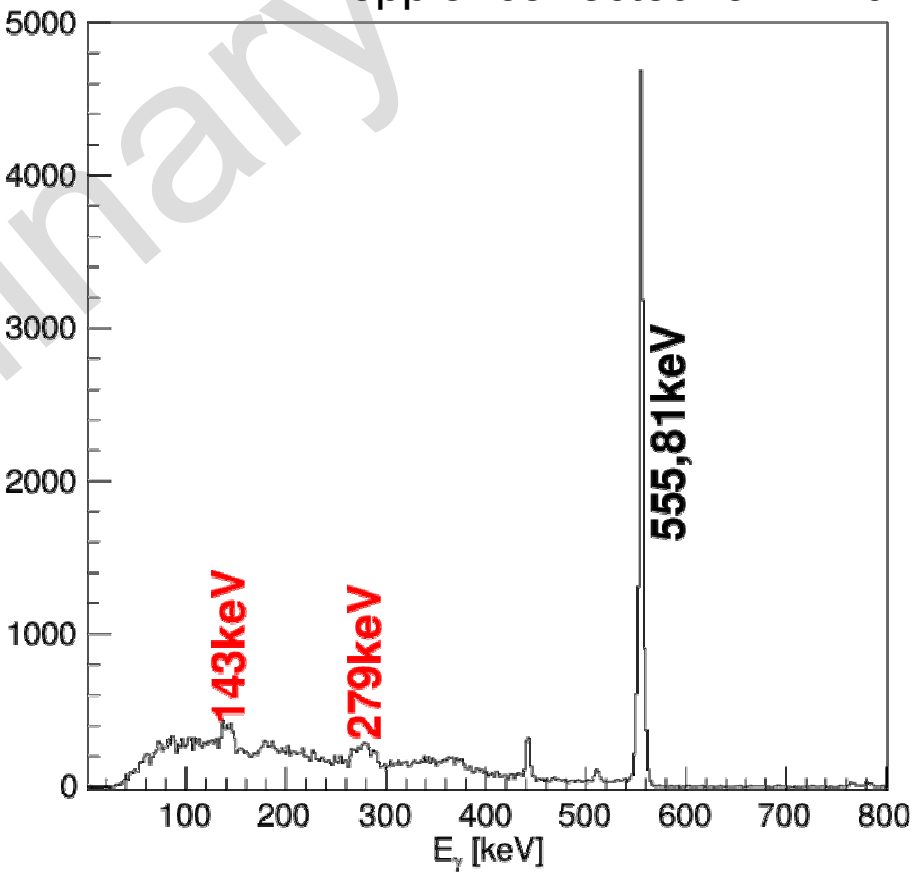


preliminary results – gamma spectrum

Doppler corrected for ^{48}K



Doppler corrected for ^{104}Pd



summary & outlook

26Na

- reduced transition propabillities in 26Na measured with Coulomb excitation
- Comparison with theoretical calculations show improved interactions USDA/USDB
- prepared for submission to PRC

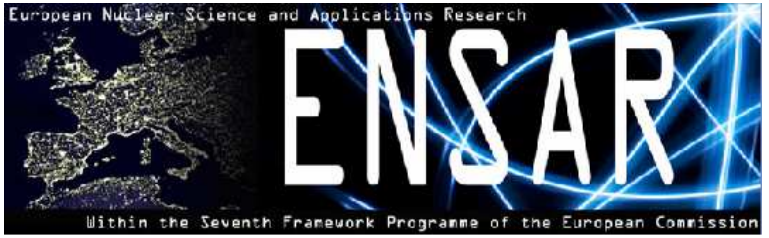
48K:

- Analysis ongoing

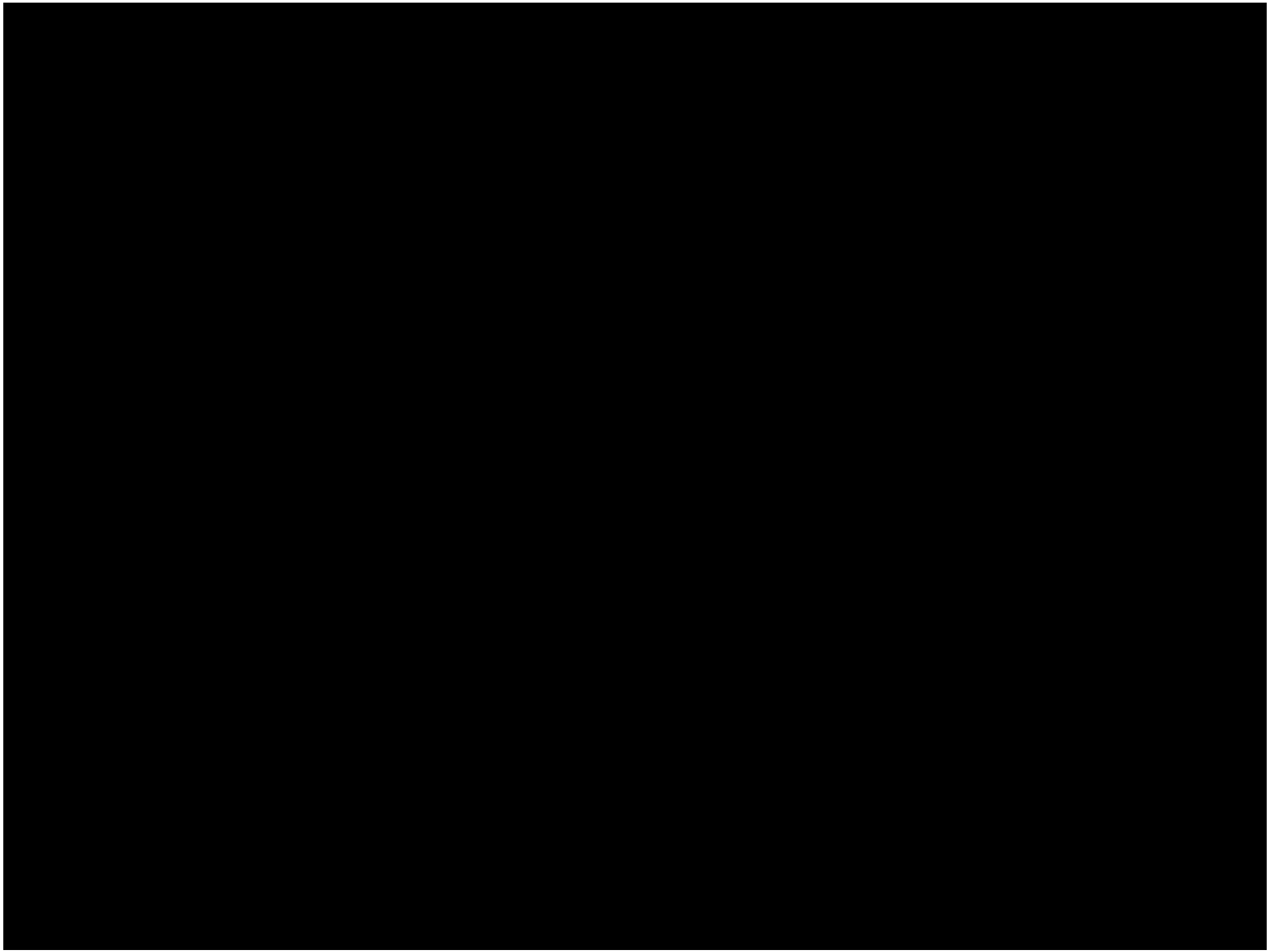
Thanks for your attention!

B. Siebeck[1], R. Altenkirch[1], C. Bauer[2], A. Blazhev[1], P. Butler[3], J. Cederkäll[4], T. Davinson[5], H. De Witte[6], P. Delahaye[4], R. Gernhäuser[7], H. Hess[1], M. Huyse[6], S. Klupp[7], T. Kröll[2], R. Lutter[7], D. Mücher[7], J. Pakarinen[4], F. Radeck[1], S. Reichertz[7], P. Reiter[1], M. Seidlitz[1], M. Scheck[2], D. Schneiders[1], C. Sotty[8], T. Steinbach[1], P. Van Duppen[6], D. Voulot[4], N. Warr[1], F. Wenander[4], P.J. Woods[5], for the MINIBALL and REX-ISOLDE collaboration

[1] Institut für Kernphysik, Universität zu Köln, Germany
[2] Institut für Kernphysik, TU Darmstadt, Germany
[3] Department of Physics, University of Liverpool, United Kingdom
[4] Physics Department / ISOLDE, CERN, Genf, Switzerland
[5] Nuclear Physics Group, University of Edinburgh, United Kingdom
[6] Instituut voor Kern- en Strahlingsfysica, K. U. Leuven, Belgium
[7] Physik-Department E12, TU München, Germany
[8] CSNSM, Orsay, France



GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung



Angular distriubution