Measurements of shape co-existence in $^{182,184}Hg$ using Coulomb excitation

Addendum to proposal IS452

CERN-ISOLDE (J. Cederkäll, P. Delahaye, D. Voulot, L.Fraile, F.Wenander, J. Van de Walle)

CCLRC Daresbury Laboratory (B. Gomez, J. Simpson)

University of Edinburgh (T. Davinson, P. Woods)

University of Göttingen (K.-P. Lieb)

University of Jyväskylä (P.T. Greenlees, P. Jones, R. Julin, S. Juutinen)

KU Leuven (**N. Bree**, A. Andreyev, B. Bastin, J. Diriken, N. Patronis, M Huyse, O. Ivanov and P. Van Duppen)

University of Liverpool (P.A. Butler, T. Grahn, R.-D. Herzberg, D.T. Joss, R.D. Page, E.S. Paul, J. Pakarinen, **A. Petts**, M. Scheck)

University of Lund (A. Ekstrom, C. Fahlander)

TU-München (T. Behrens, V. Bildstein, T. Fästermann, R. Gernhäuser, Th. Kröll, R. Krücken, M. Mahgoub, P. Maierbeck, K. Wimmer)

University of Oslo (M. Guttormsen, A.-C. Larsen, S. Siem, N. U. H. Syed)

CEA-Saclay (E. Clement, C. Dossat, A. Goergen, W. Korten, J. Ljungvall, Ch. Theisen, M. Zielinska)

University of Sofia (G. Rainovski)

HIL University of Warsaw (T. Czosnyka, J. Iwanicki, P. Napiorkowski, J. Srebrny, K. Wrzosek)

University of York (D.G. Jenkins, B.S Nara Singh, N.S. Pattabiraman, R. Wadsworth)

Argonne National Laboratory (R.V.F. Janssens, M. Carpenter, F. Kondev)

University of Maryland (I. Stefanescu)

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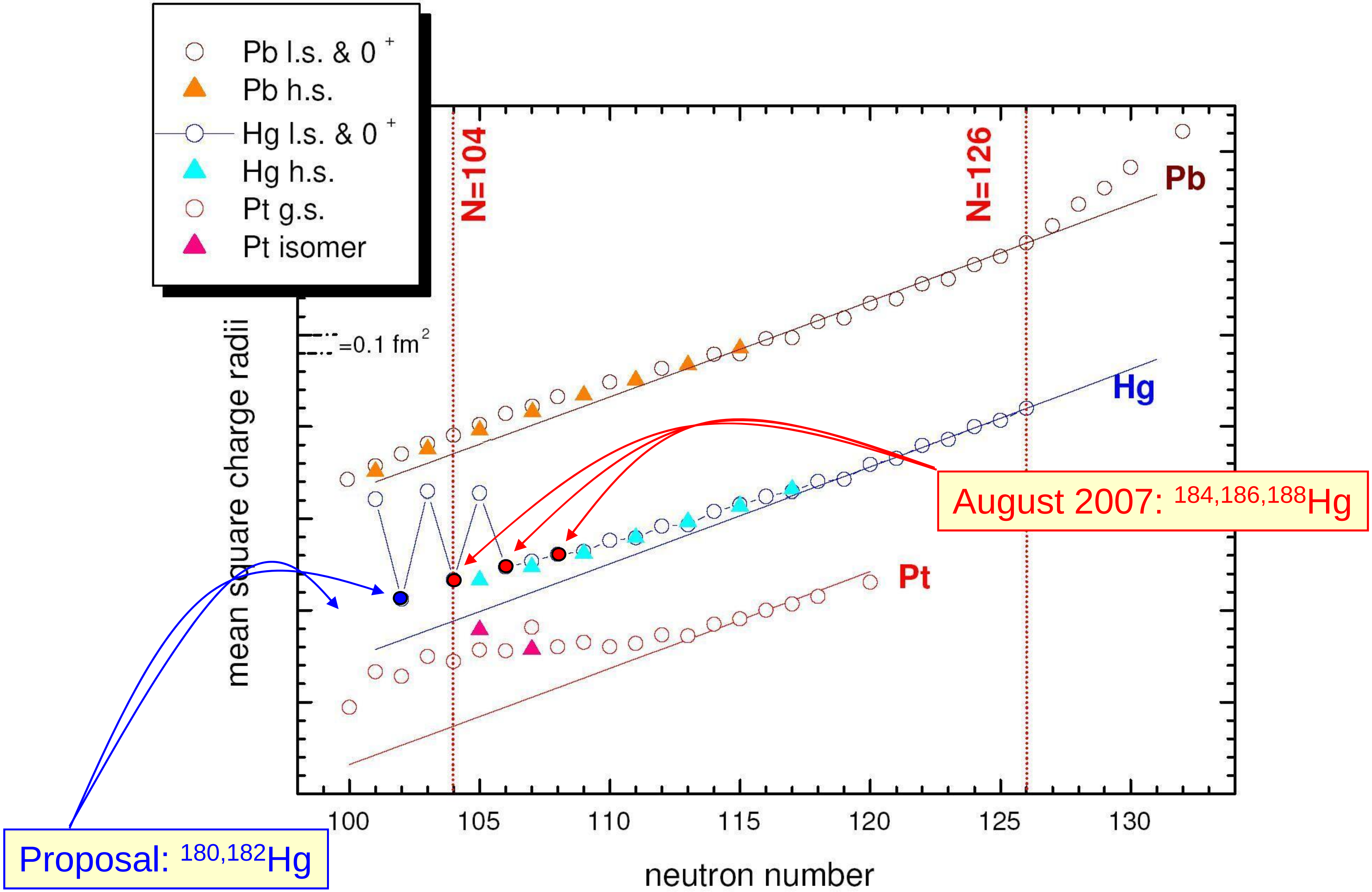
- Physics motivation (cfr. IS452 proposal)
- ^{180,182}Hg Coulomb excitation
- Preliminary results from the August 2007 experiment
- Beam time request

Shape coexistence in the neutron-deficient Hg isotopes



Ulm et al. Z. Phys. A 325(1986)247

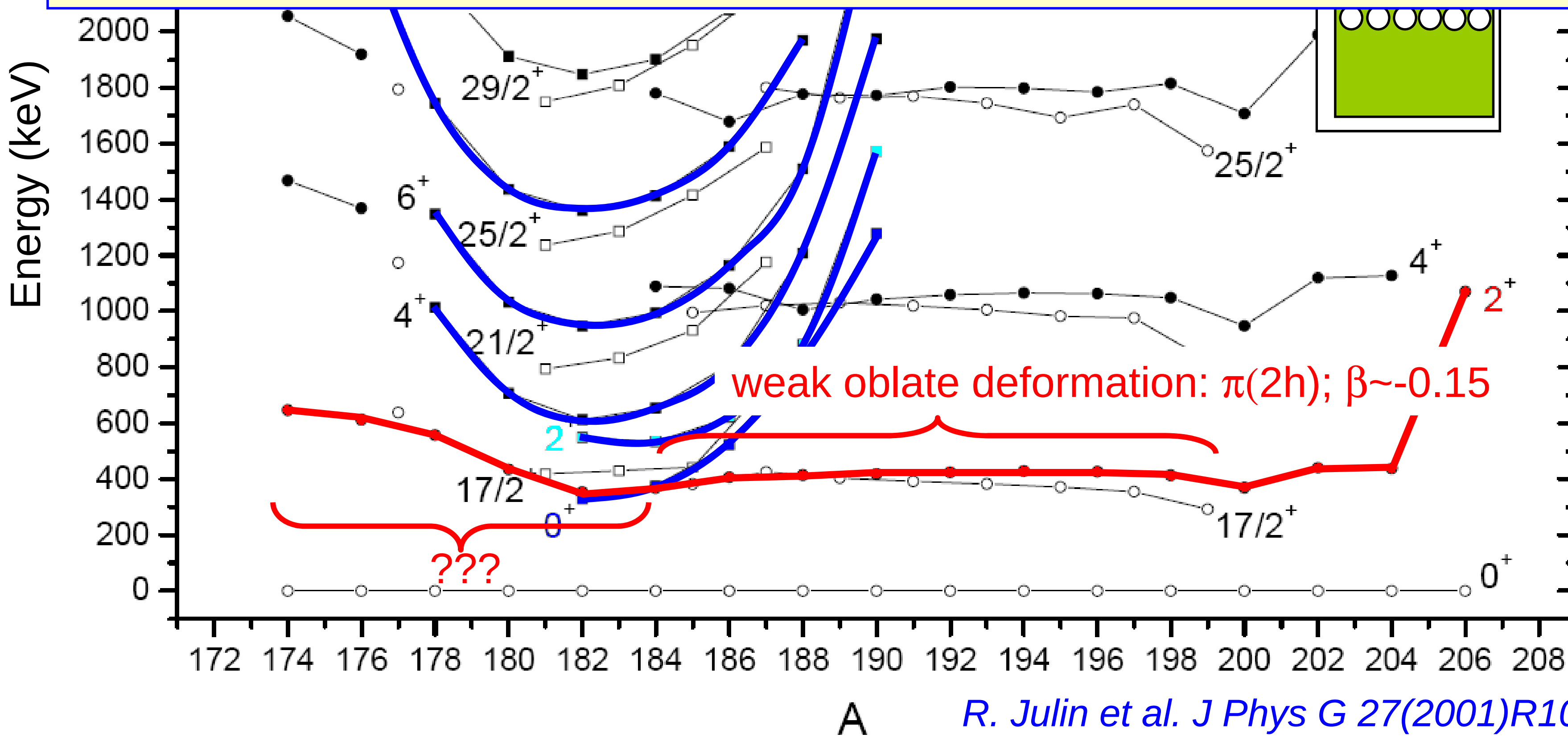
Energy systematics of the neutron-deficient Hg isotopes

<u>$^{180-184}$Hg: oblate – prolate shape coexistence / mixing</u>

- degree of mixing?

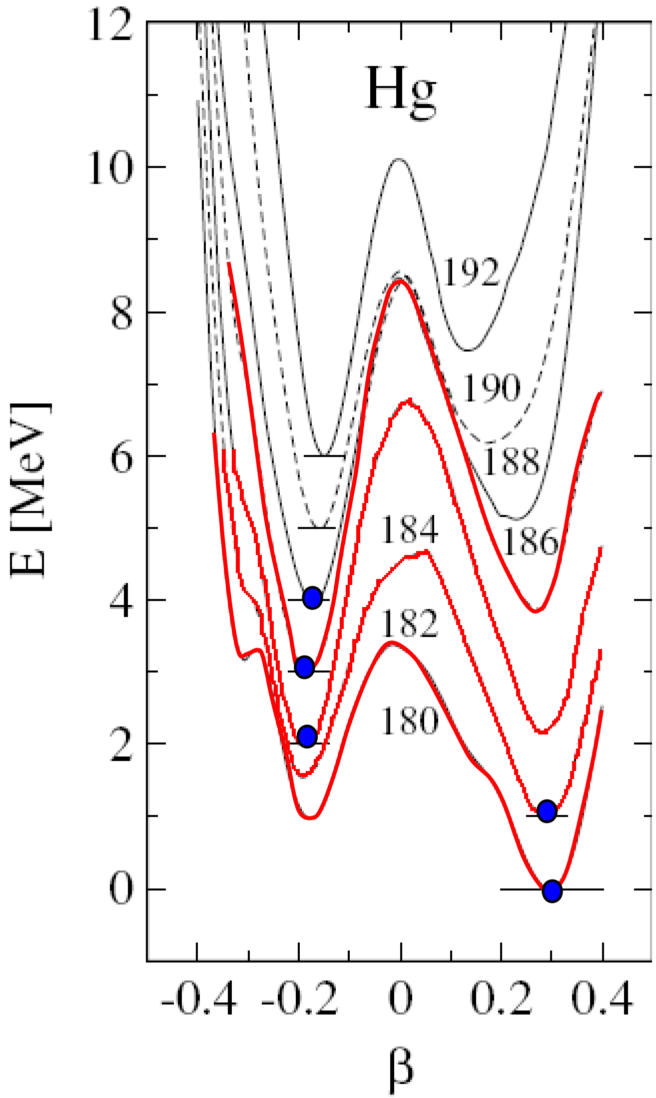
^{182}Hg: <4% band mixing calculations (Ma et al. PLB 139 (1984) 276)
16% from alpha decay data (Wauters et al. PRC50 (1994) 2768)

- type of deformation? weakly oblate - spherical - prolate



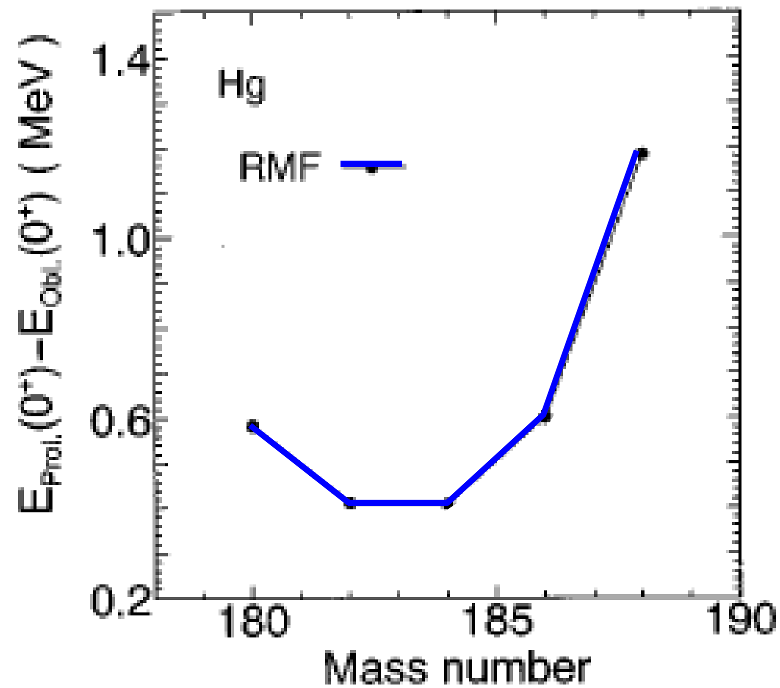
R. Julin et al. J Phys G 27(2001)R109

Self consistent mean field
Skyrme Hartree-Fock + pairing (BCS)



Moreno et al. PRC73 (2006) 054302

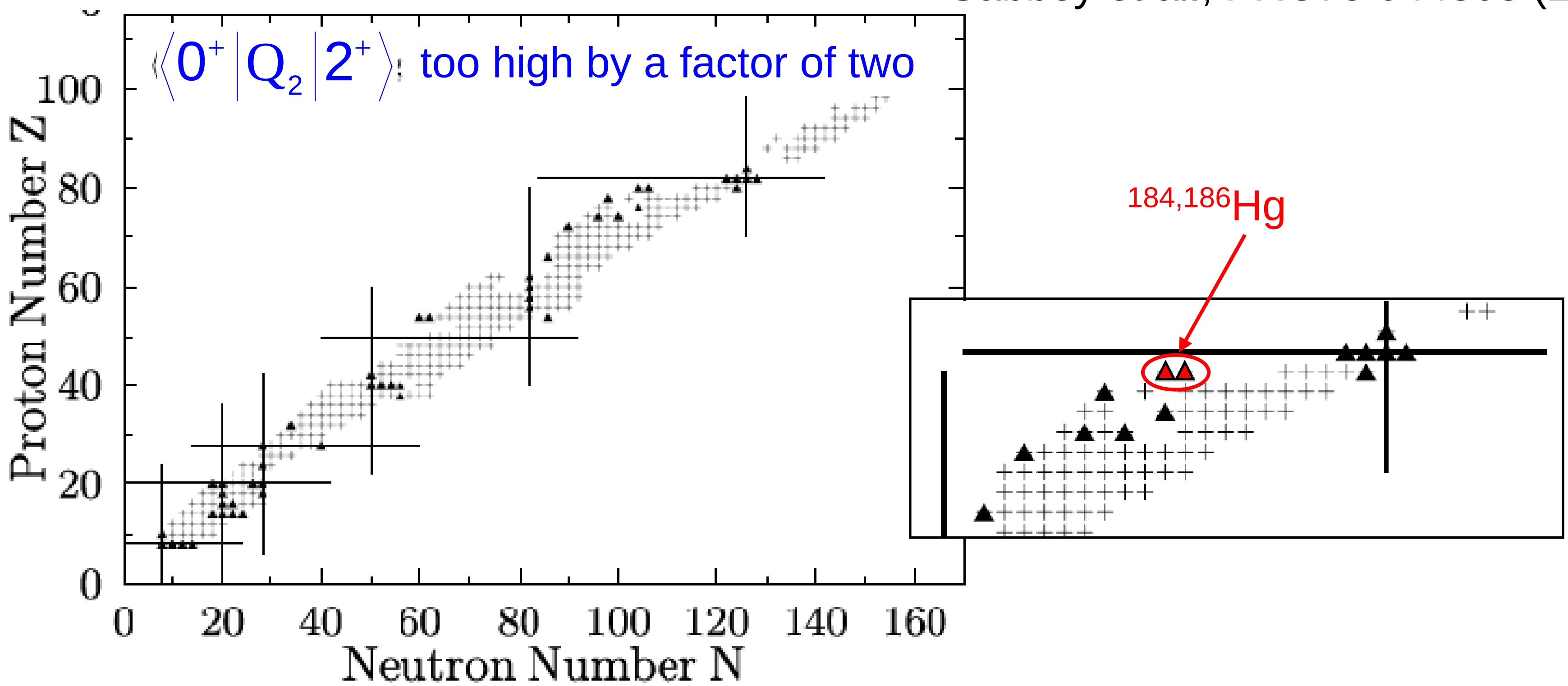
Relativistic mean field calculations + pairing (BCS)



Yoshida and Takigawa PRC55 (1997)1255

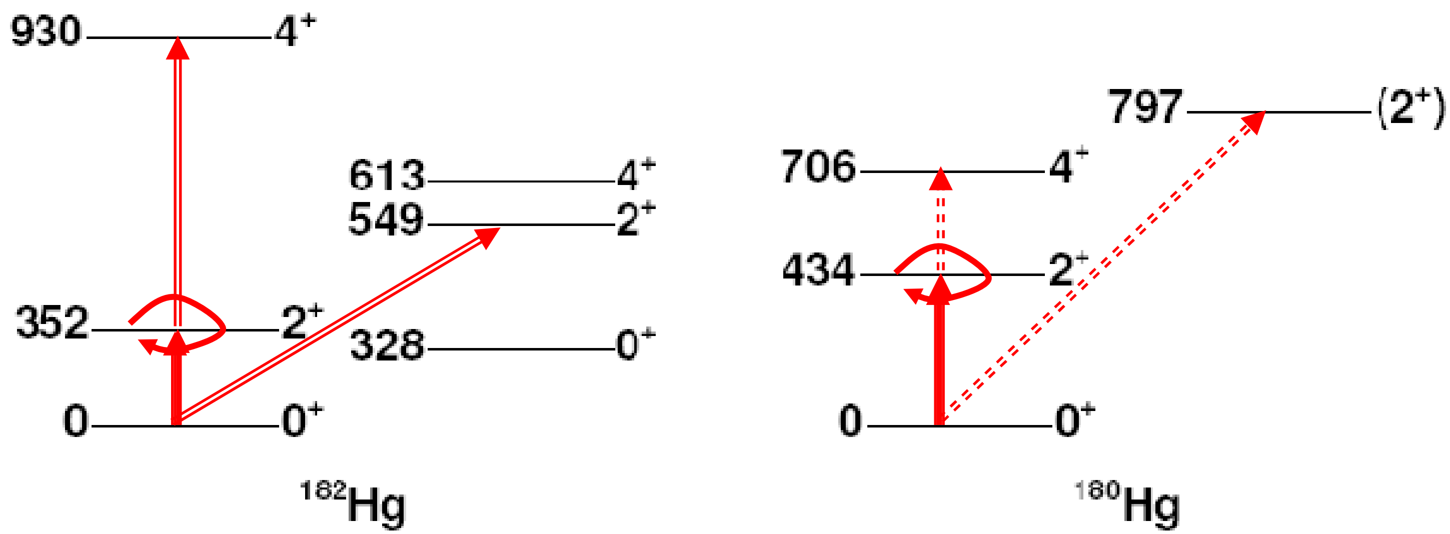
Self consistent beyond mean field – generator coordinator method
Skyrme + density dependent pairing

Sabbey et al., PRC75 044305 (2007)



• calculated energies and B(E2) values can be directly compared to calculations

Coulomb excitation as a probe for nuclear structure: a case for $^{180,182}Hg$



• Coulex will preferentially excite states **strongly coupled to the ground state** so the oblate or prolate excited states will be readily observed and identified

• Low energy Coulex will measure the **sign of the diagonal quadrupole matrix element** and hence distinguish between prolate and oblate excitation provided half-life data are available; $^{180,182}Hg$ $\tau(2^+)$ have been measured at JYFL
(Hurst et al, PRL98 072501 (2007))

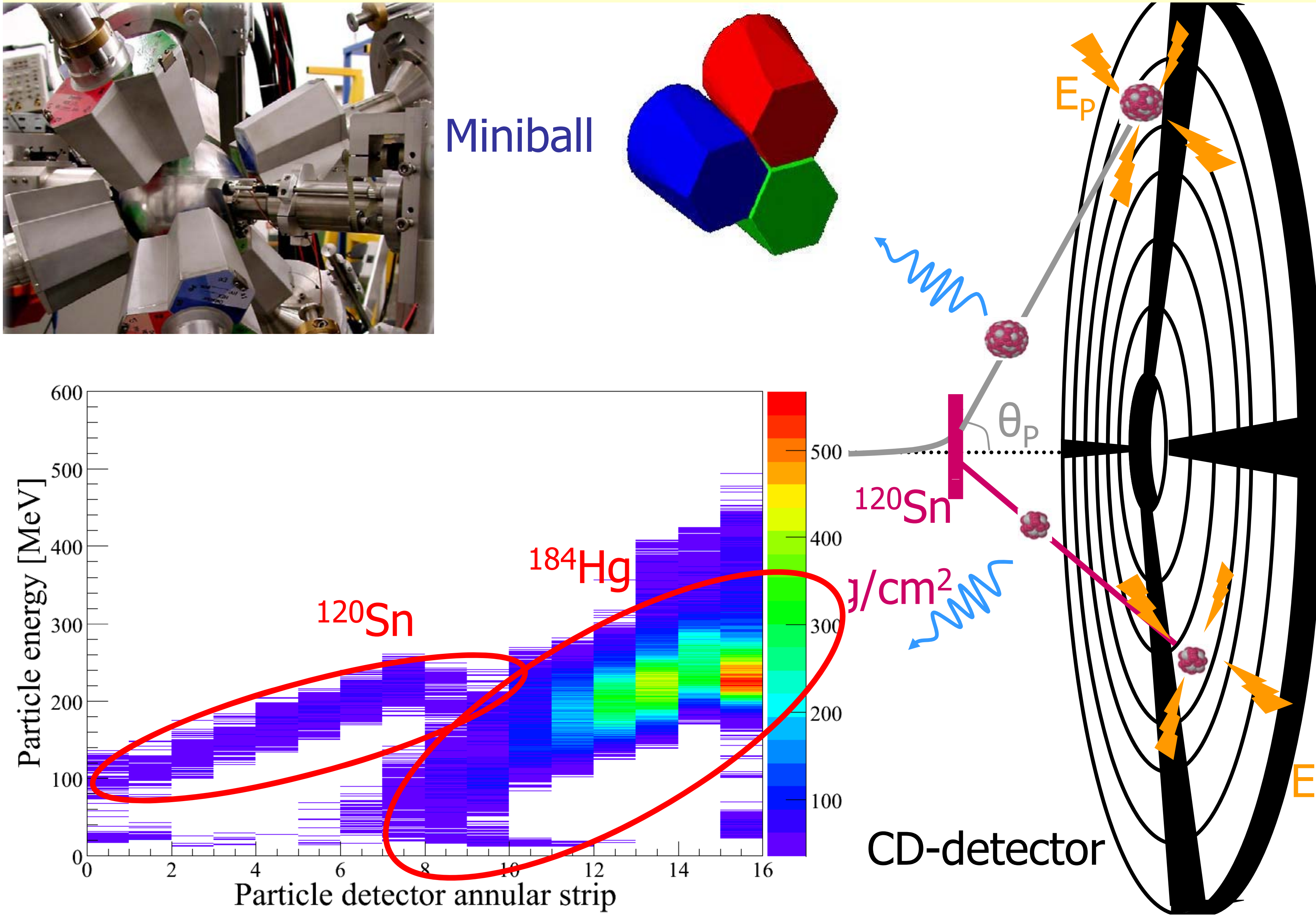
• The **degree of mixing** between the oblate and prolate structures is determined directly from the transition matrix elements.

Coulomb excitation of $^{184,186,188}Hg$ at REX-ISOLDE & MINIBALL
August 2007 experiment

- Technical problems:
  - Total REX-transmission efficiency: ~ 0.2 %
  (mainly due to incorrect scaling, not due to trapping/charge-breeding efficiency)
  - Primary production for ^{182}Hg: lower compared to yield book values
  (no data taken on ^{182}Hg)

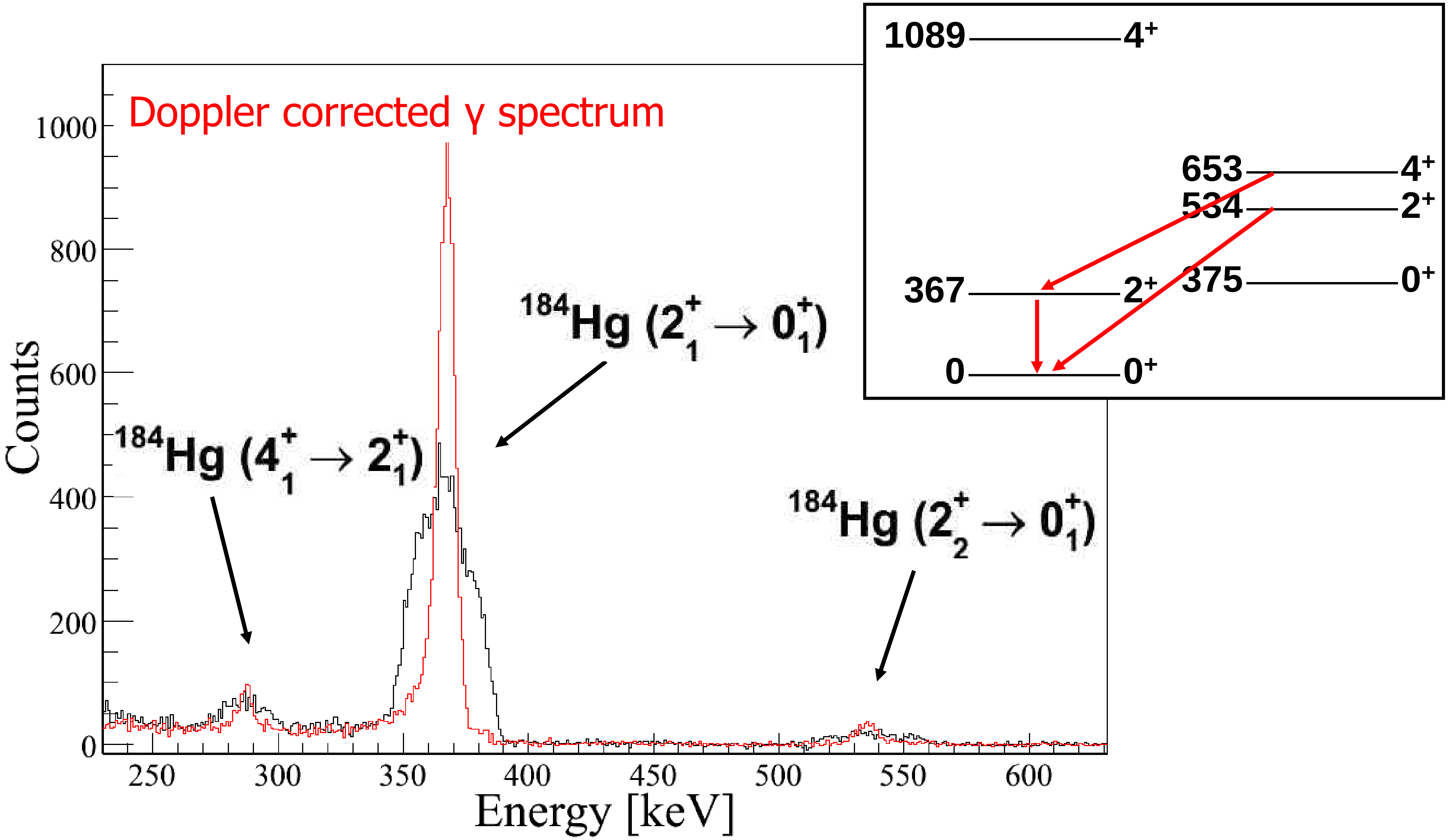
Isotope	Charge state	Intensity@Miniball 2.85 MeV/u	Data collection time
^{184}Hg	43+	3 x 10^3 pps	77h02m
^{186}Hg	43+	2 x 10^5 pps	5h34m
^{188}Hg	44+	2.5 x 10^5 pps	12h56m

Coulomb excitation of $^{184,186,188}Hg$ at REX-ISOLDE & MINIBALL

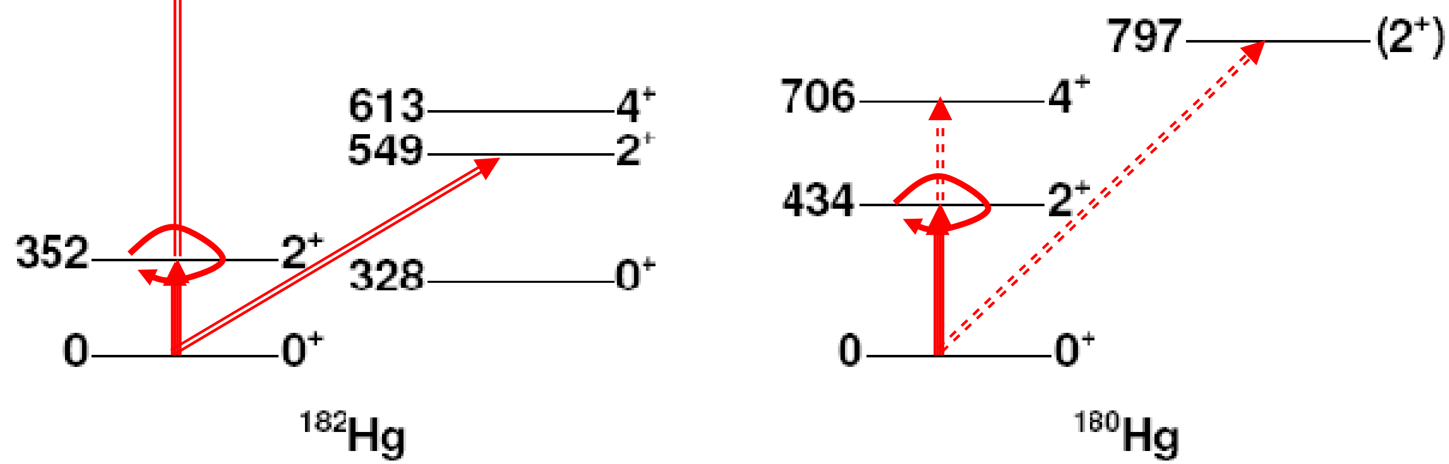


Coulomb excitation of $^{184,186,188}Hg$ at REX-ISOLDE & MINIBALL

- Part of the data obtained on ^{184}Hg
- Data obtained for $^{186,188}Hg$ as well
- Coulomb excitation at REX-ISOLDE & MINIBALL for heavy mass isotopes is feasible



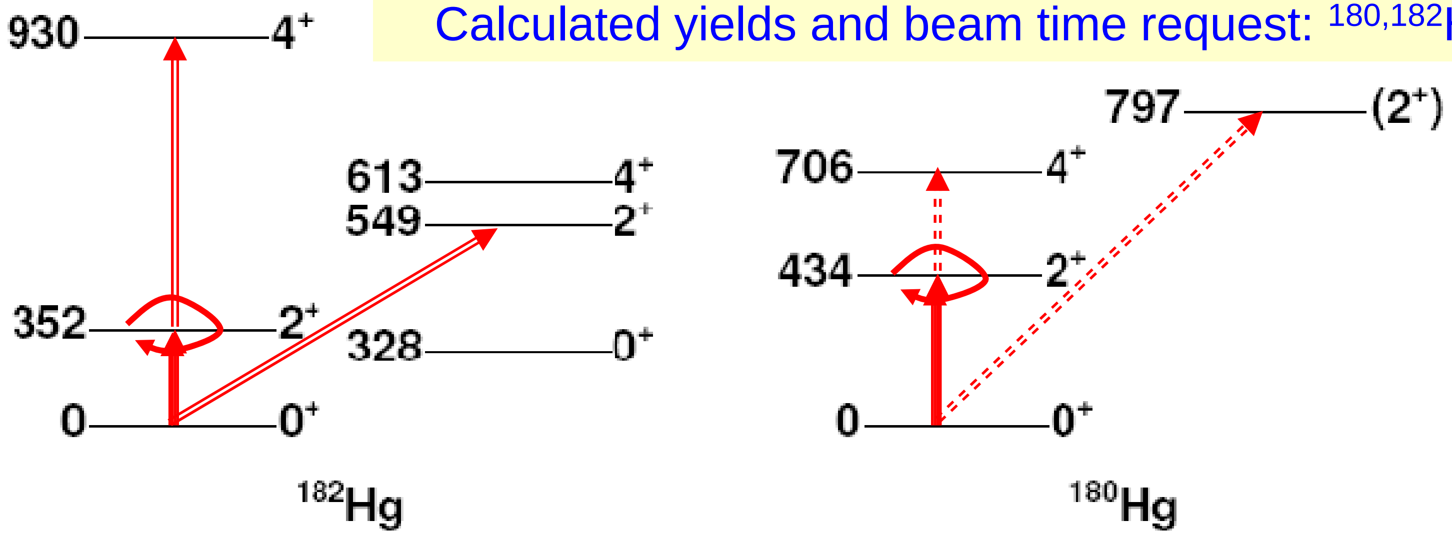
Calculated yields and beam-time request: $^{180,182}Hg$



transition	transition energy (keV)	matrix element trans./diag. (eb)	γ-ray yields
2^+_1-0^+_1 oblate	352	-1.32/1.57	**57800**
2^+_1-0^+_1 prolate	352	1.32/-1.57	**45800**
4^+_2-2^+_1 oblate	578	-2.13/2.02	**1360**
2^+_2-0^+_1 prolate	549	0.13/-1.57	**200**

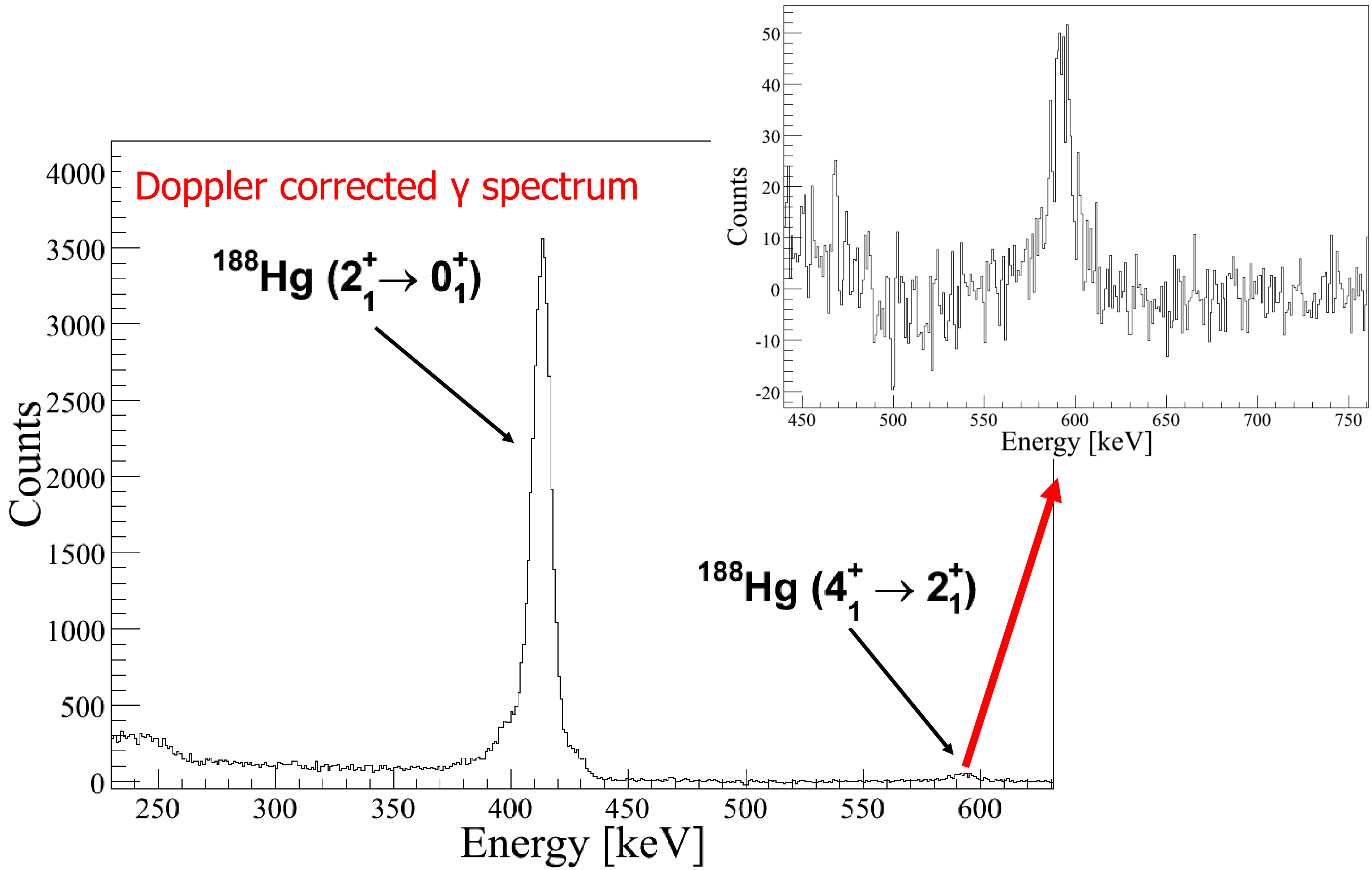
100 hours of 5 x 10^4 ions/s at 2.75 MeV/u on a 1 mg/cm^2 ^{120}Sn target

Calculated yields and beam time request: $^{180,182}Hg$

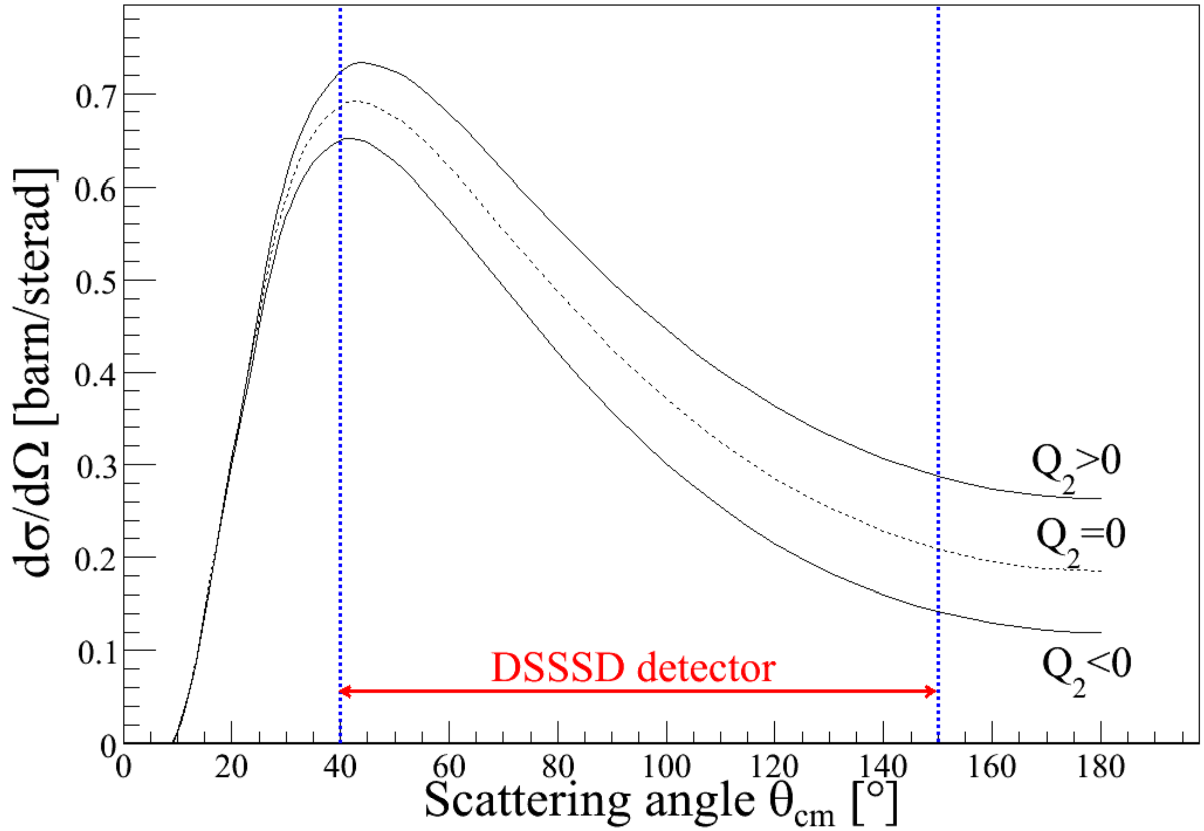


	^{182}Hg	^{180}Hg
ISOLDE production rate (molten Pb target / plasma ion source)	7.9 10^6 pps	5.3 10^4 pps
Beam intensity @ MINIBALL (total REX eff. = 2%) Maximum available energy (3 MeV/u)	> 10^5 pps	> 10^3 pps
Beam time request (data taking)	12 shifts	9 shifts
Beam time request (setting up REX)	3 shifts	
Total beam time request	24 shifts =**13 (new)** + 11 (remaining)	

Coulomb excitation of ^{184,186,188}Hg at REX-ISOLDE & MINIBALL



Coulomb excitation and the sign of the diagonal quadrupole matrix element



$$B(E2: 0^+ \rightarrow 2^+) \propto \left(\frac{d\sigma_{CE}}{d\Omega} \right)$$

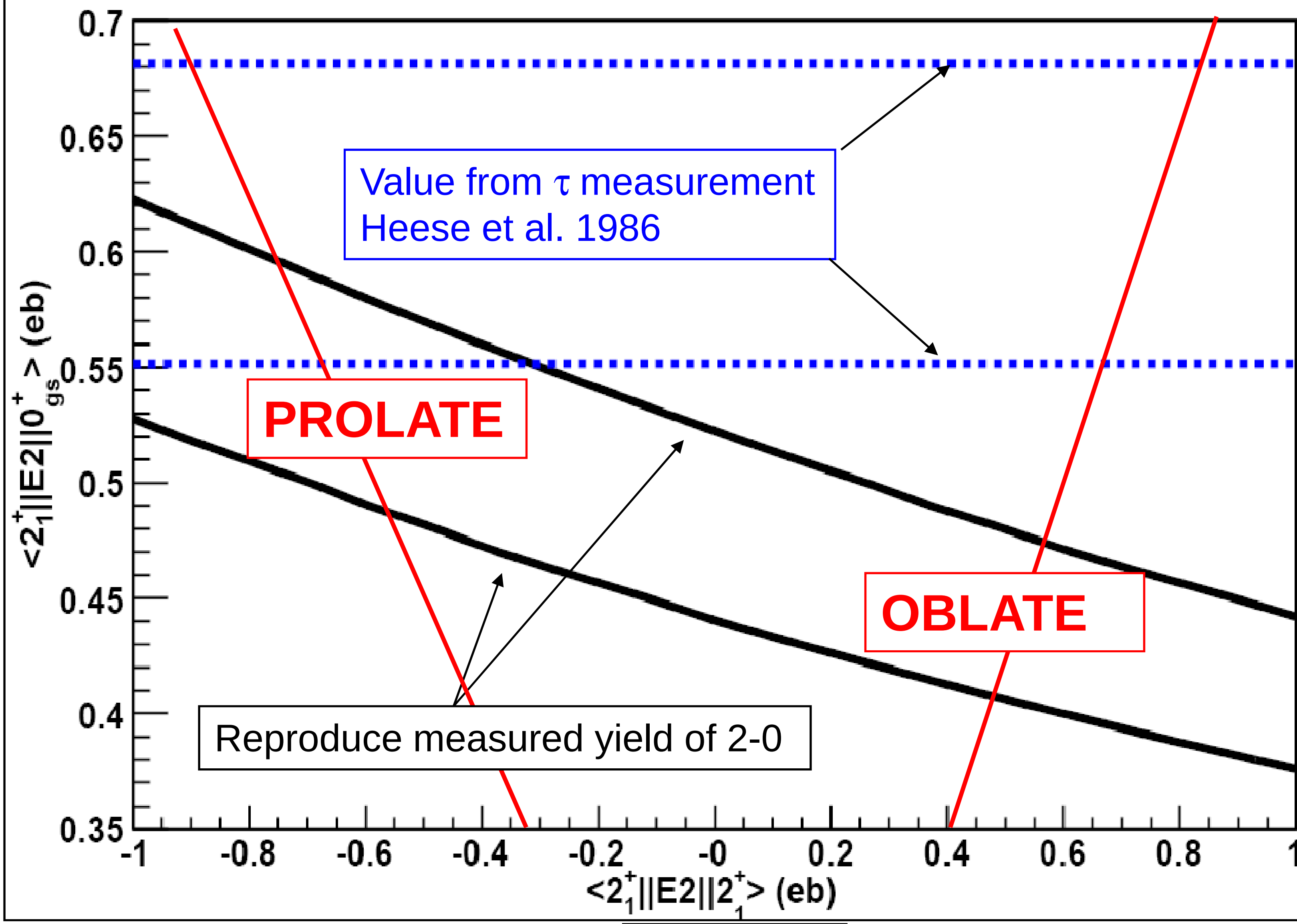
The cross section for exciting ^{184}Hg to its 2^+ state does not only depend on its reduced transition probability B(E2: 0^+ -> 2^+), but also on the diagonal matrix element <2^+||M(E2)||2^+>.

Reorientation effect

$$P_{2+} \propto \langle 0||E2||2^+\rangle^2 \cdot [1 - \langle 2^+||E2'||2^+\rangle \; f(\xi)]$$

where $\xi \sim \Delta E/(E_{beam})^{3/2}$

Results: ^{70}Se



$\beta_2 \sim 0.3$