Statistical properties of warm nuclei: Investigating the low-energy enhancement in the gamma strength function of neutron-rich nuclei

S.Siem[1], M. Wiedeking[2], F.L.Bello Garrote[1], L. Bernstein[3], D. Bleuel[3], P.A.Butler[4], T.Eriksen[1], F.Giacoppo[1], A.Görgen[1], M.S.Guttormsen[1], T.W.Hagen[1], P.Hoff[1], B.V.Kheswa[2], M.Klintfjord[1], A.C. Larsen[1], D. Negi[2], H.T. Nyhus[1], J.Rekstad[1], T.Renstøm[1], S. Rose[1], E. Sahin[1], G.M.Tveten[1], A.Voinov[5], J. Wilson[6]

[1] Department of Physics, University of Oslo, Norway
2 iThemba LABS, South Africa
3 Lawrence Livermore National Laboratory, USA
4 Oliver Lodge Laboratory, University of Liverpool, United Kingdom
5 Department of Physics and Astronomy, Ohio University, USA
6 IPN Orsay, CNRS-IN2P3, Orsay, France

Spokesperson(s): S.Siem (sunniva.siem@fys.uio.no), M.Wiedeking (wiedeking@tlabs.ac.za)

Local contact: E.Rapisarda(elisa.rapisarda@cern.ch)

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2 Approved HIE-ISOLDE experiments including UiO spokesperson:

IS 558: Shapes transitions and coexistence in neutron-deficient rare earth isotopes

U Oslo (N), U Liverpool (UK), Lund U (S), GANIL (F), CEA Bruyères-le-Châtel (F), U York (UK), U Köln (D), CEA Saclay (F), CSNSM Orsay (F)

Spokesperson: A. Görgen (Oslo)

Status: preparation

IS 559: Statistical properties of warm nuclei: Investigating the low-energy enhancement in the gamma strength function of neutron-rich nuclei

U Oslo (N), iThemba (ZA), Lawrence Livermore (US), U Liverpool (UK), Ohio U (US), IPN Orsay (F)

Spokesperson: S.Siem (Oslo), M. Wiedeking (iThemba)

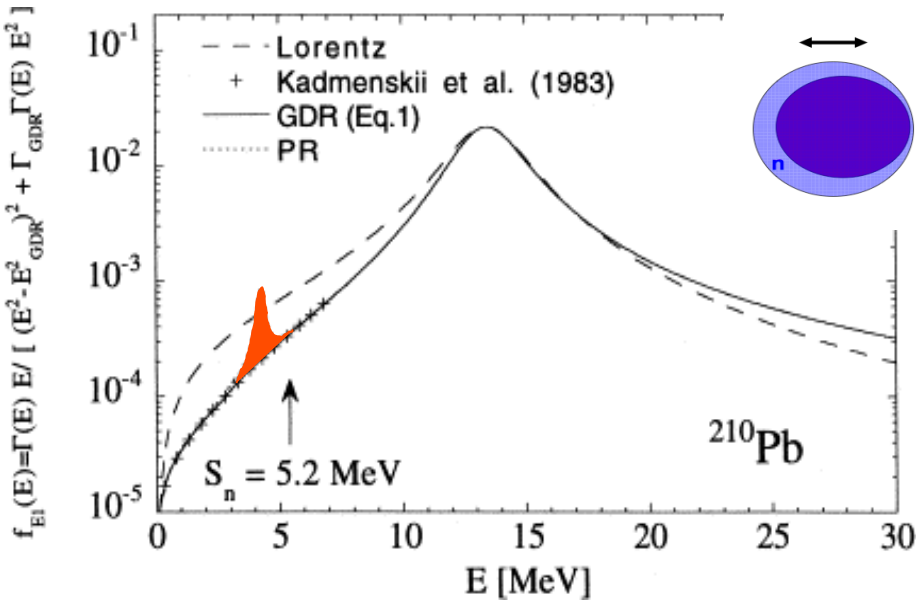
Status: preparation

Our priority is to run IS559 in 2016

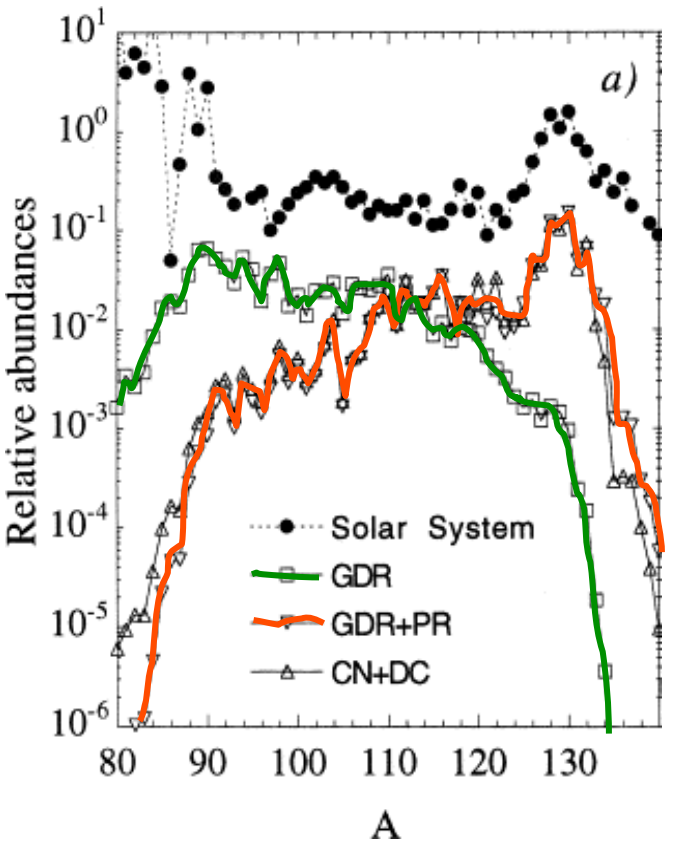
IS558 can wait until 2017

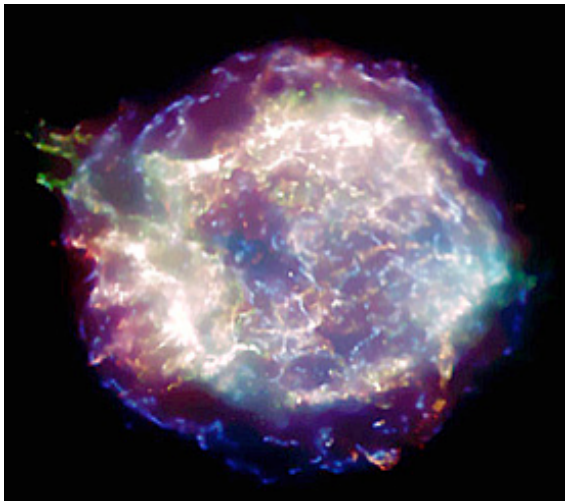
Why we give IS559 priority for beam in 2016

- New type of experiment made possible by HIE-ISOLDE upgrade
- Proof of principle for Oslo method in inverse kinematics tested with stable Kr beam at iThemba
- LaBr3 detectors will be available in fall 2016
- Ni beam better suited as a early beam than the heavier Sm beam.
- PhD student at UiO waiting for data (oslo method analysis)
- Postdoc starting at iThemba in May to analyze using Ratio method.



S. Goriely Phys. Lett. B 436 (1998)

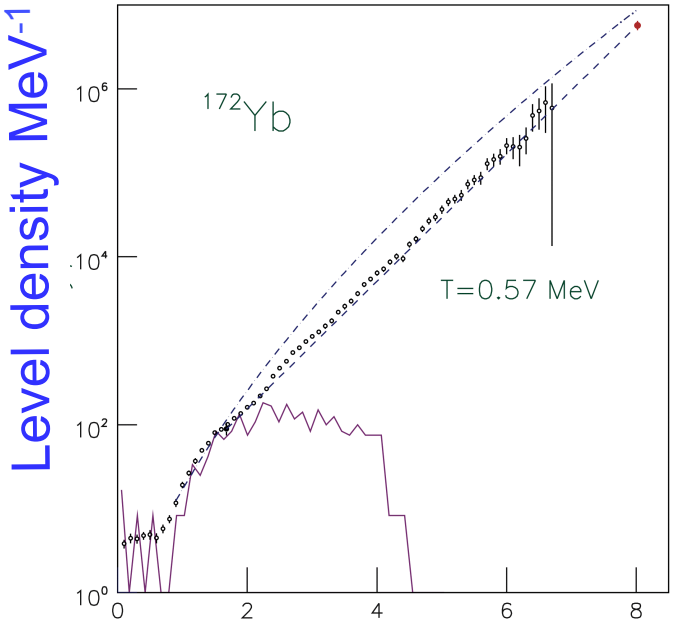


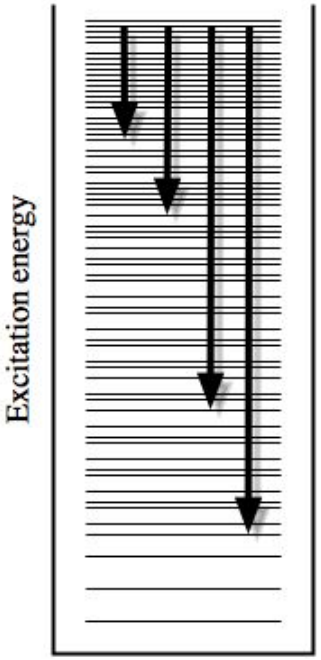


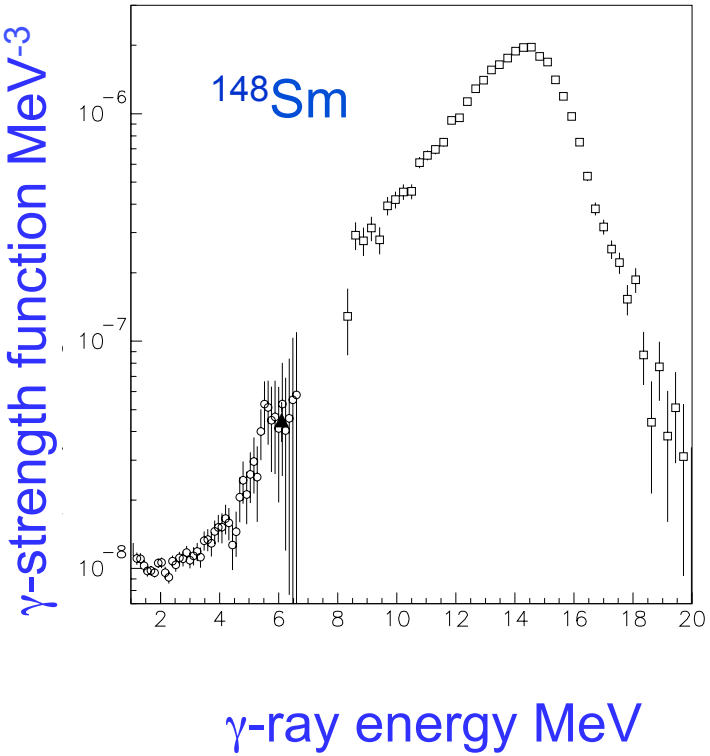
- Gamma strength functions important input in cross section calculations
- Small resonances in the strength function can effect the results of abundance calculations.
- We need more/better data on gamma strength functions, especially for exotic nuclei

Method A (The Oslo method)

Measure gamma-particle coincidences
isolate the primary gamma spectra

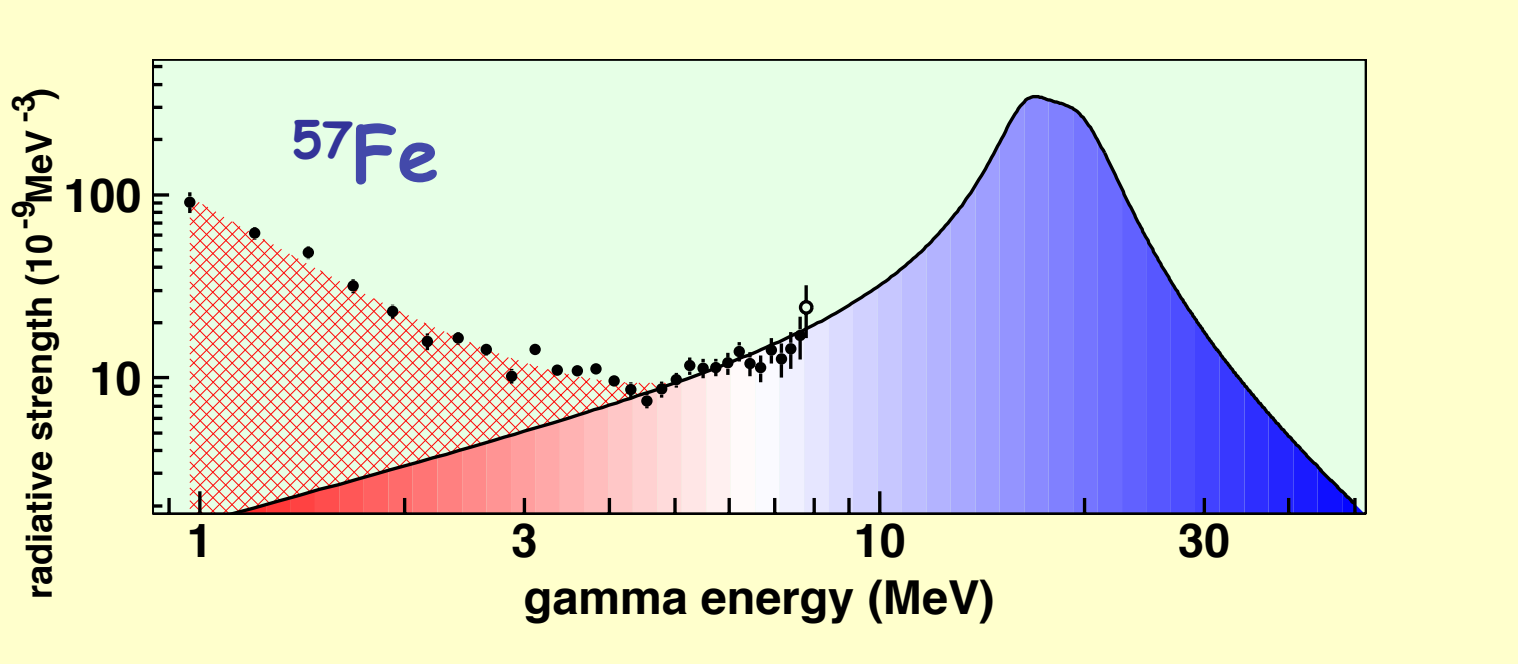






$$P(E_i, E_\gamma) \propto \rho(E_f) \cdot T(E_\gamma)$$

Low energy enhancement of the strength function



A.Voinov et al. Phys.Rev.Lett. 93, 142504 (2004)

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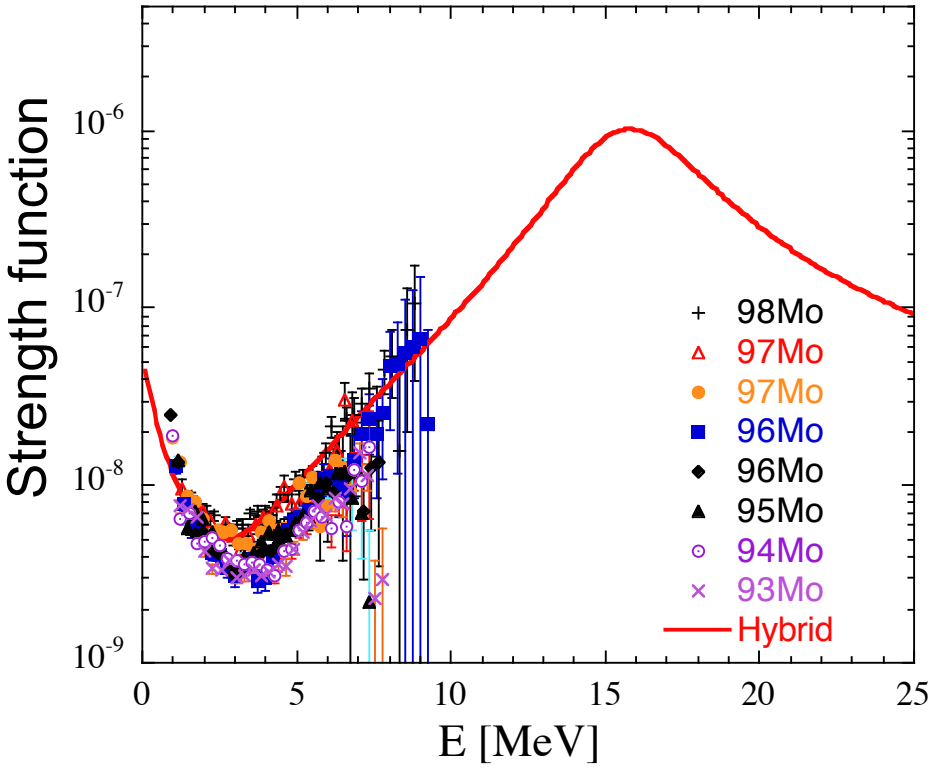
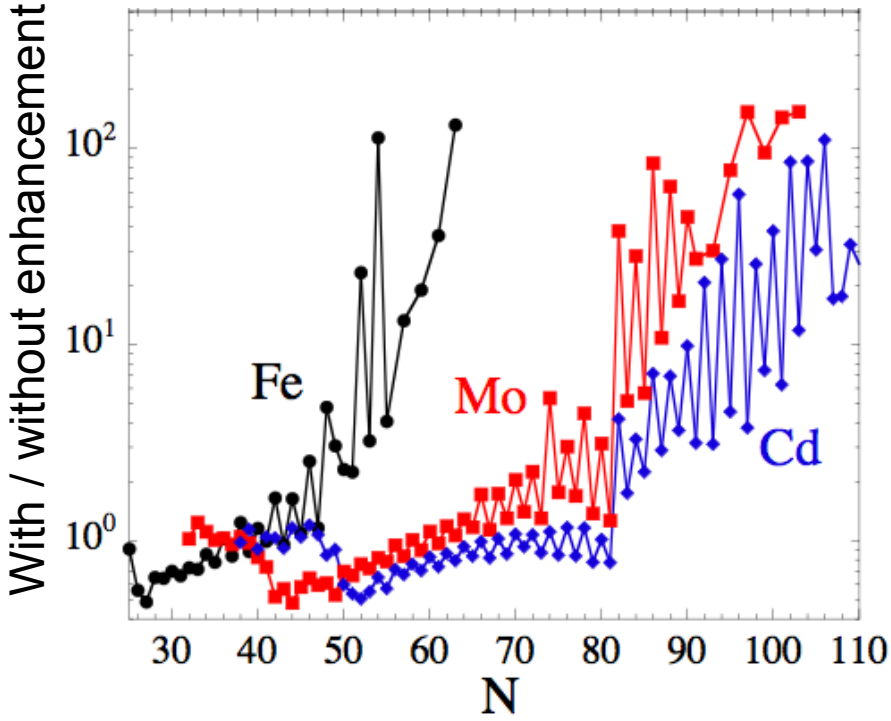
Later the enhancement has been observed in several nuclei including preliminary results for ^{60}Ni

How does the low energy enhancement effect neutron capture cross sections?



Assuming the strength functions of Mo isotopes all have the same energy trend



A.C.Larsen et al. PRC (2010)

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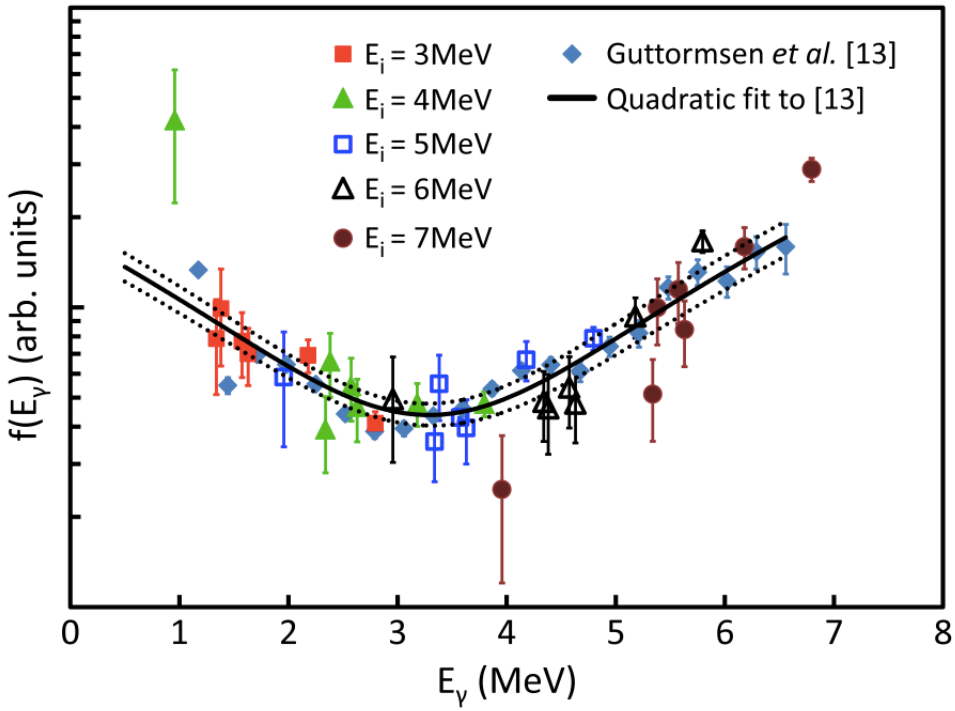
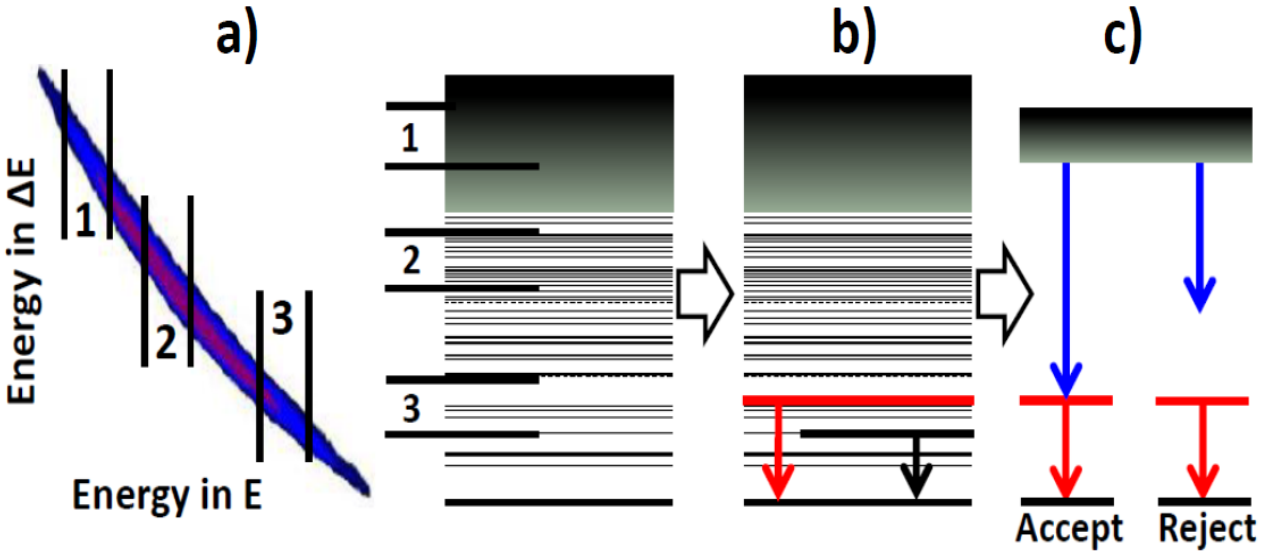
The low energy enhancement was recently confirmed in ^{95}Mo

M. Wiedeking, L. A. Bernstein *et al.,* PRL 108, 162503 (2012)

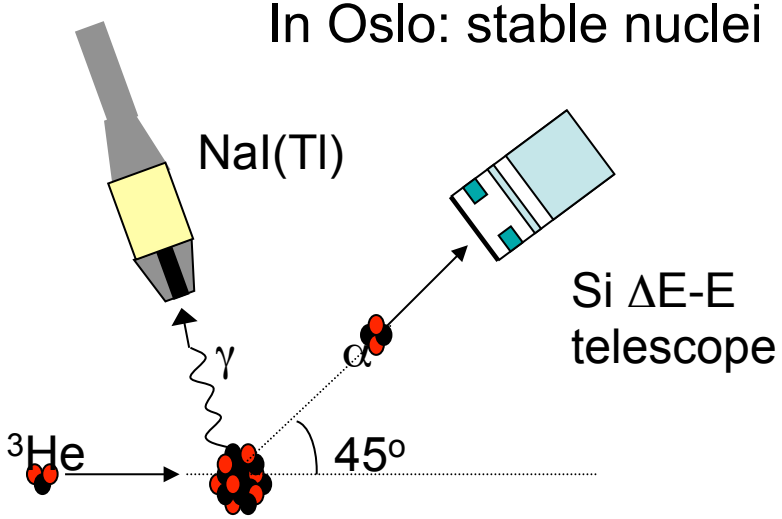


Proton-γ-γ correlations from the ^{94}Mo(d,p)^{95}Mo reaction (experiment at Berkeley National Lab).
Ge detectors. **Completely model-independent!**

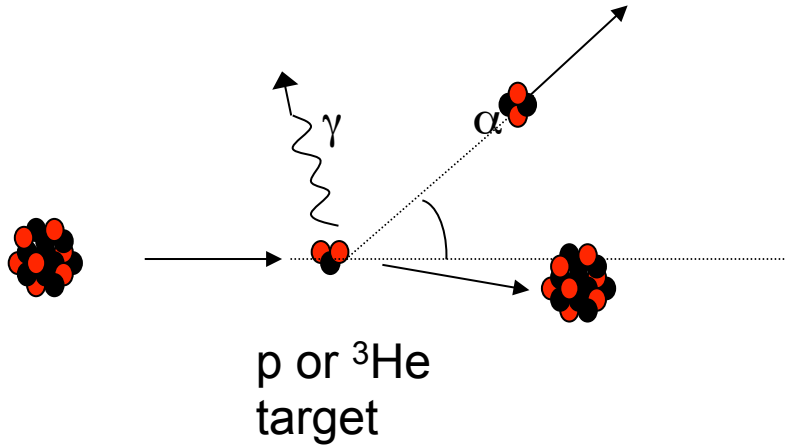
Method B (Ratio Method)



In Oslo: stable nuclei



HIE-ISOLDE: Exotic beams,
using inverse kinematics



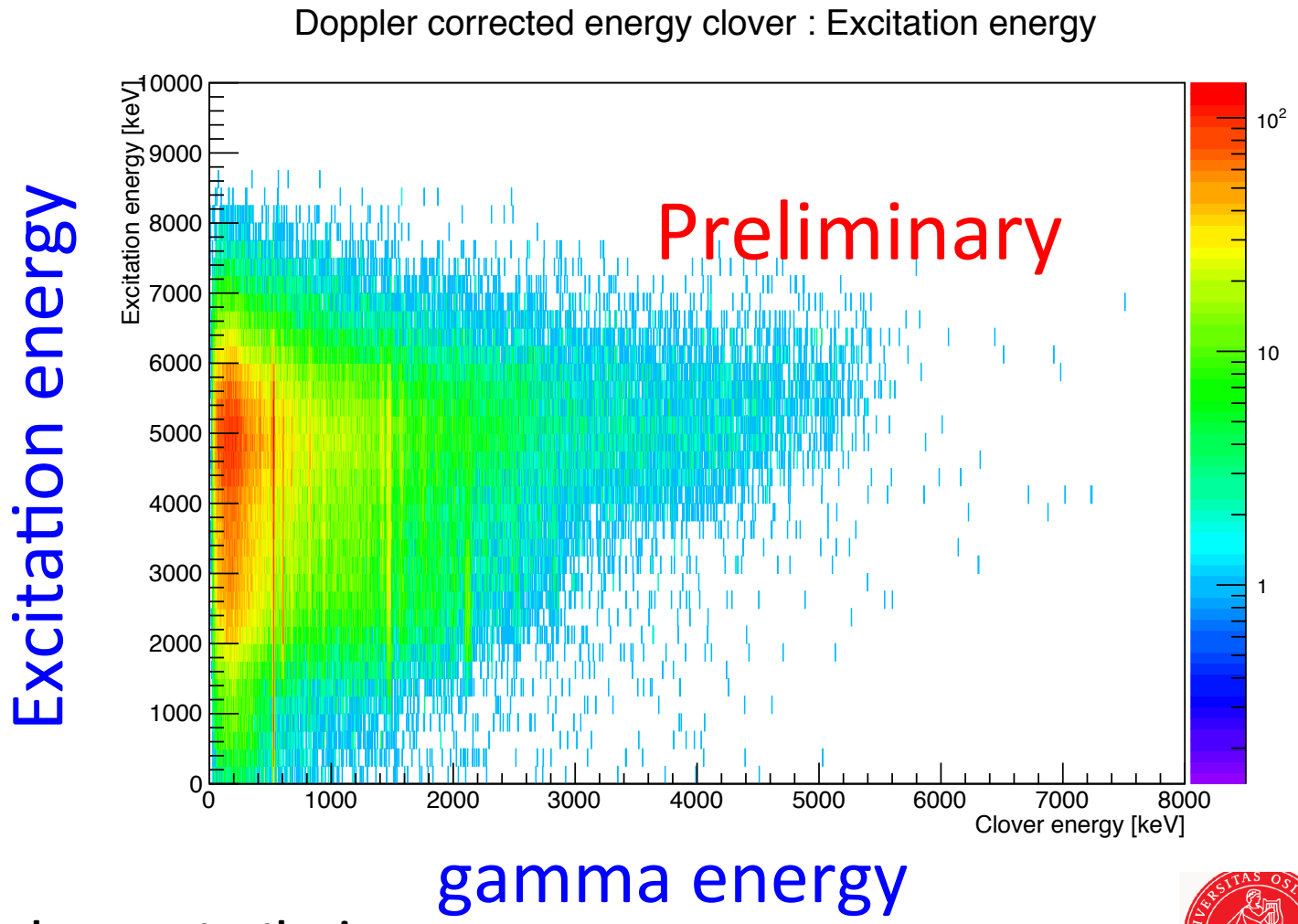
Conclusion:

want to measure the gamma strength function with two independent methods:

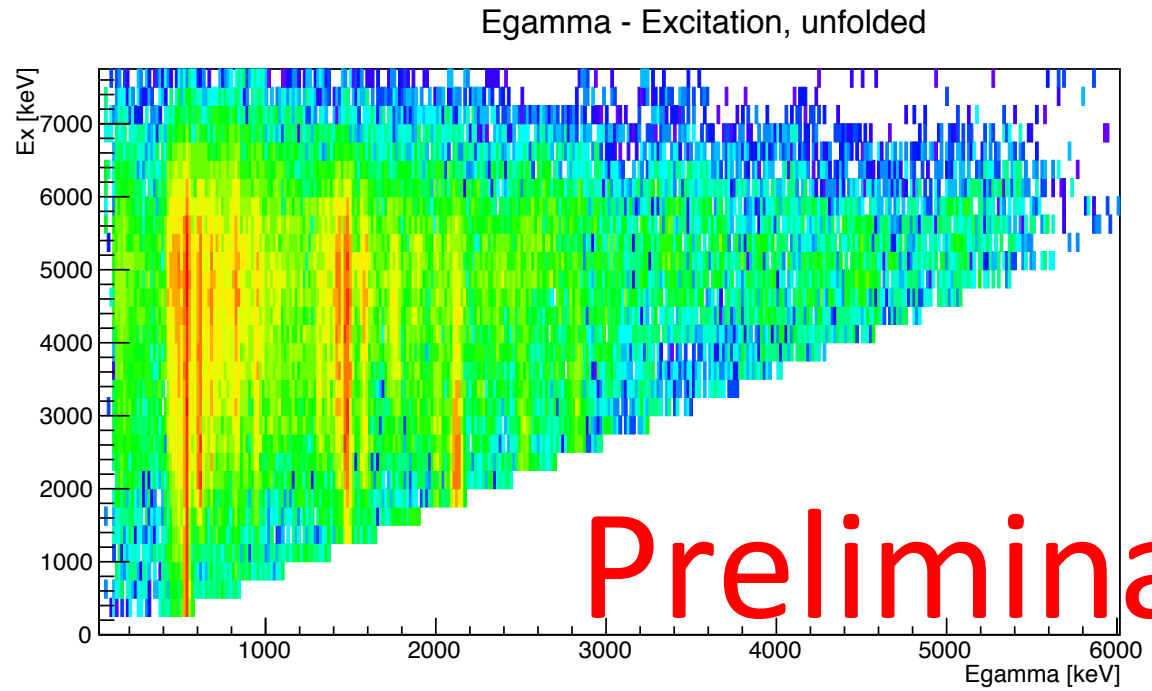
Method A (Oslo method)
Method B (Ratio Method)

Well established for normal kinematics, performed a proof of principle experiment in inverse kinematics at iThemba last year -> it works!

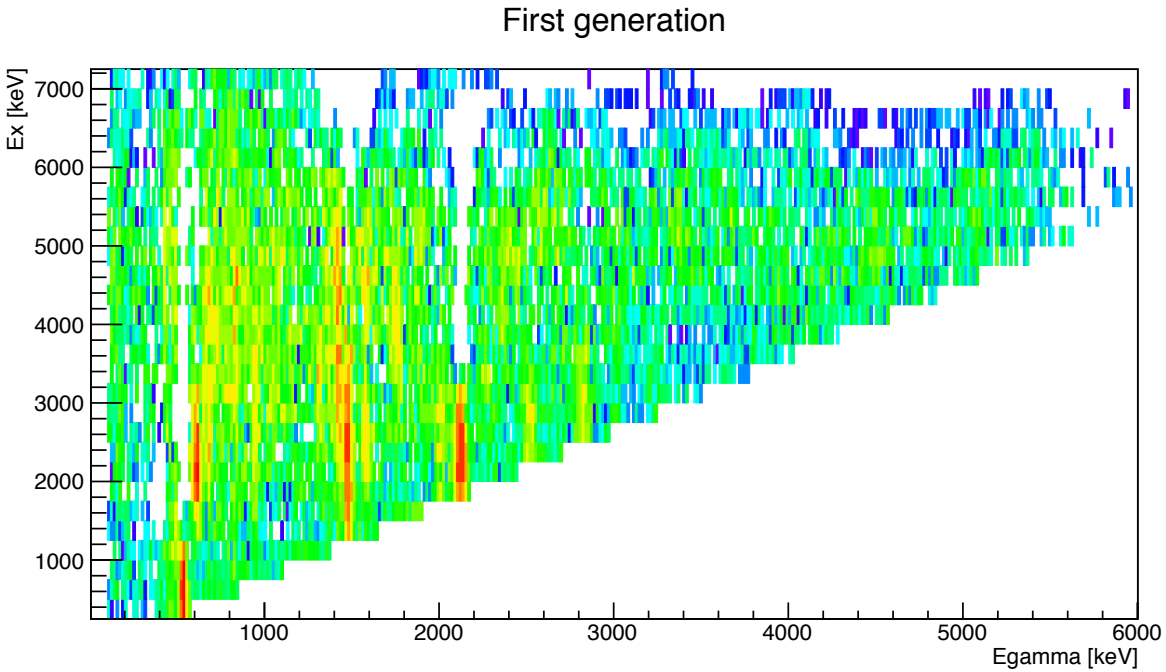
INVESTIGATING THE LOW ENERGY ENHANCEMENT IN THE GAMMA STRENGTH FUNCTION OF 87Kr IN INVERSE KINEMATICS



V. W. Ingeberg master thesis



Preliminary!



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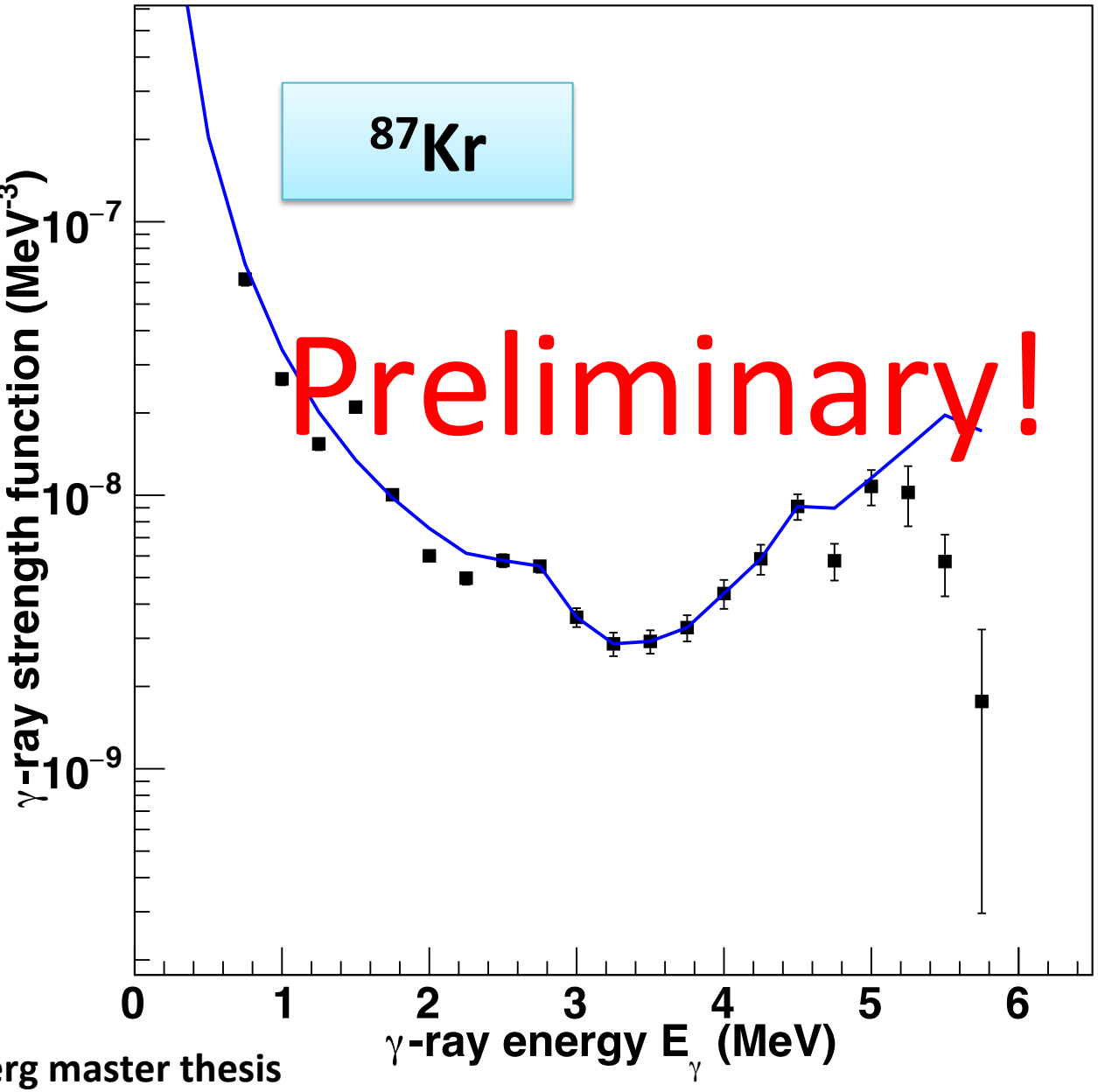

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Experimental details:

Beam purity: >95% important for the Oslo method.
Should be no problem (IS469 had >99% purity)

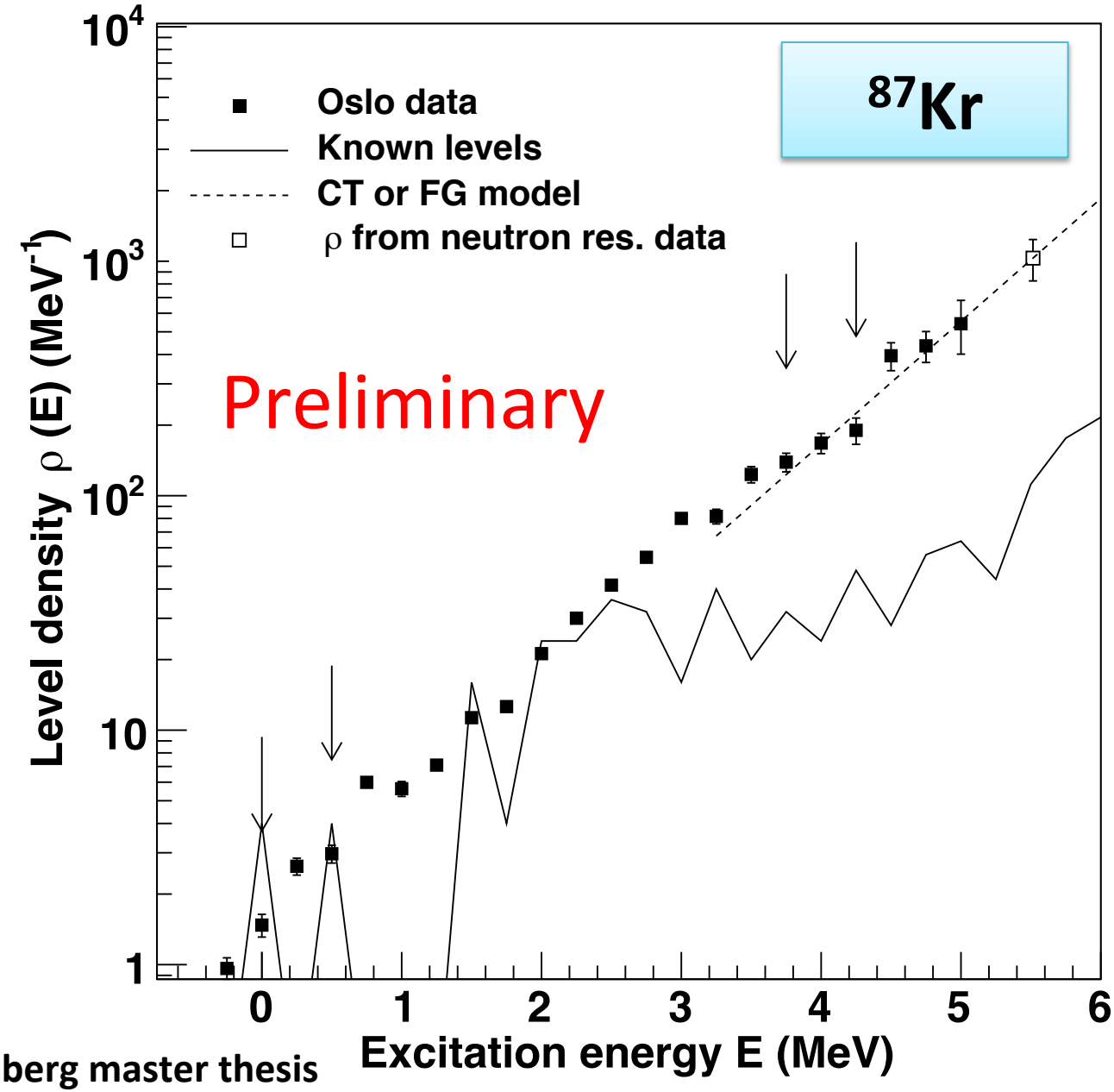
Beam: ^{66}Ni beam of 5,5 MeV/u
Intensity ca 1x107 pps at MINIBALL

Target: 0.3-0.5 mg/cm2 deuterated polyethylene, thin to minimize uncertainty in excitation energy from straggling/energy loss in target.
Will be produced at iThemba LABS.

gamma detection: MINIBALL + Replace/add large volume $LaBr_3$(Ce) detectors (3,5 x 8") to have higher efficiency for high energy gamma rays. 6- 8 LaBr3 detectors will be available in the fall 2016 (from Oslo).

Charge particle detectors: C-REX setup with Annular strip CD detectors: need Delta E + E detectors for particle identification.

Shifts approved: 24 total (21 shifts of 66Ni and 3 shifts for setup and calibrations)



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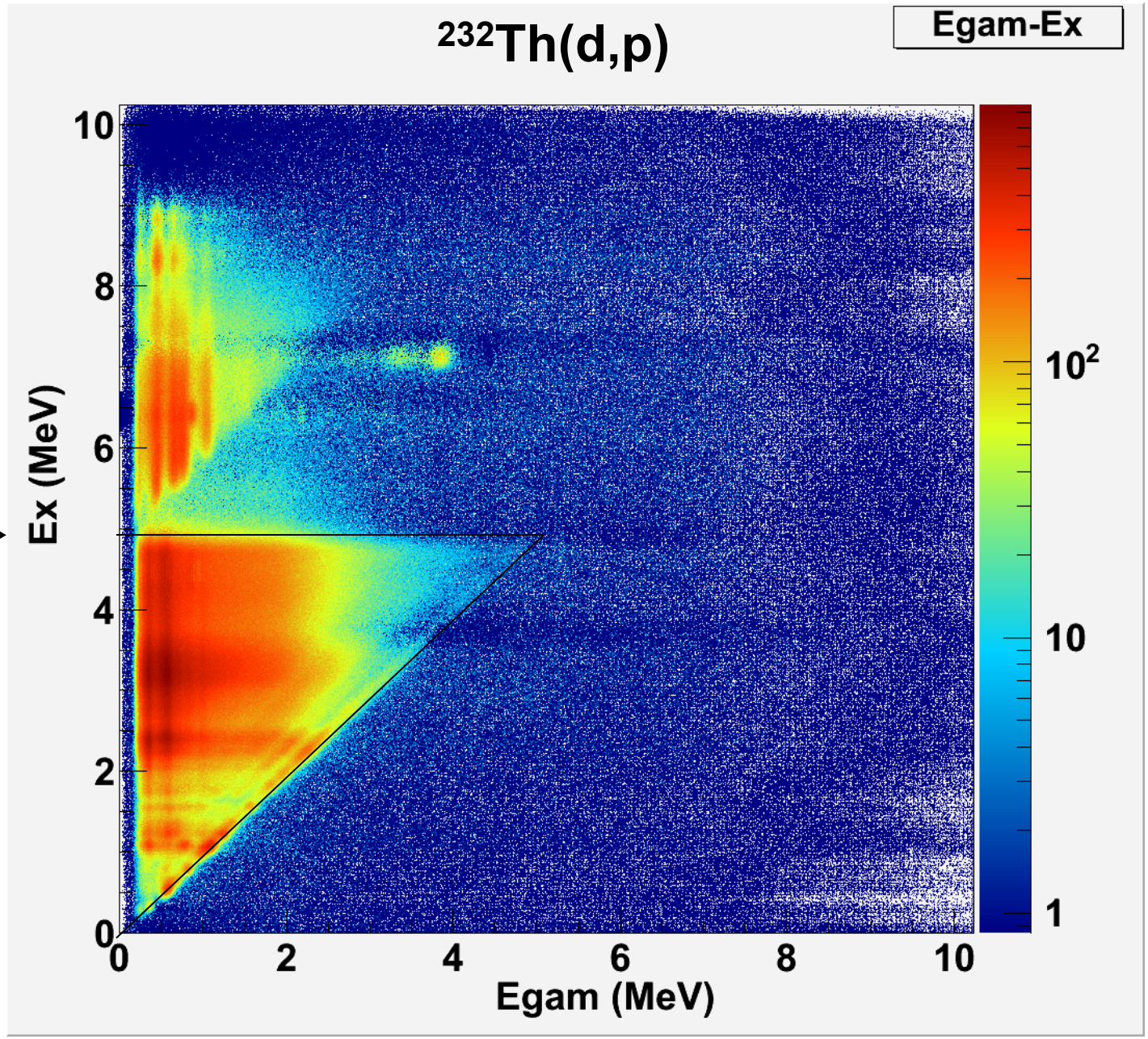
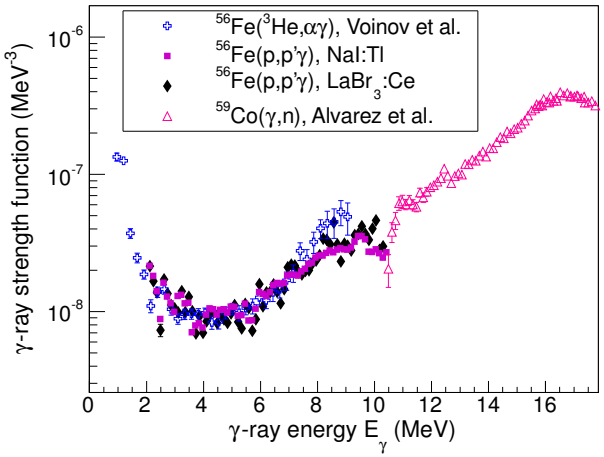
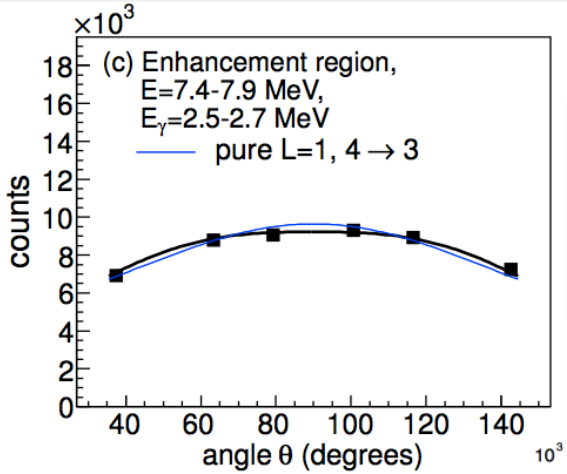
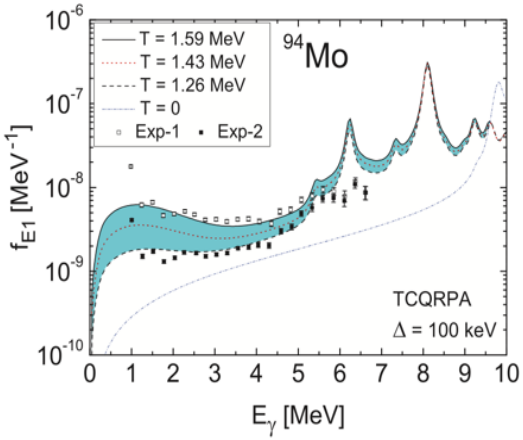

^{232}Th(d,p)
Egam-Ex
Ex (MeV)
Egam (MeV)
S_n
0
2
4
6
8
10
10^2
10
1

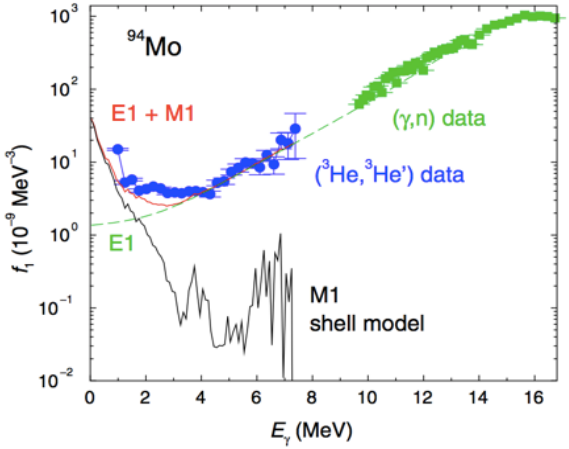
Recent experimental and theoretical efforts





Experimentally shown to be dominantly dipole radiation (A.C. Larsen *et al.*, PRL **111**, 242504 (2013)





E1 nature? E. Litvinova and N. Belov, PRC **88**, 031302(R) (2013). QRPA calculations.

M1 nature? R. Schwengner, S. Frauendorf, and A. C. Larsen, PRL **111**, 232504 (2013). Shell model calc.