2nd Workshop on
Level Density and Gamma Strength
Oslo, May 11 - 15, 2009

Concluding Remarks

(A very subjective, biased, and politically incorrect point of view of a non-expert.)

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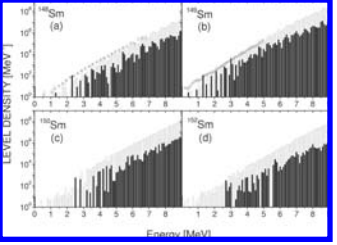
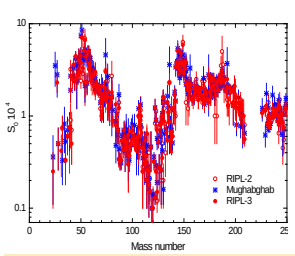
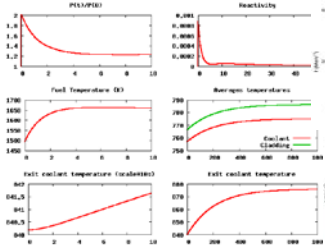
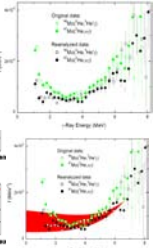
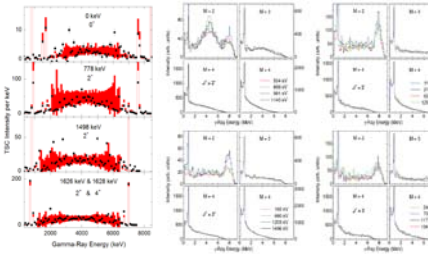
Universität zu Köln
www.zilges.de

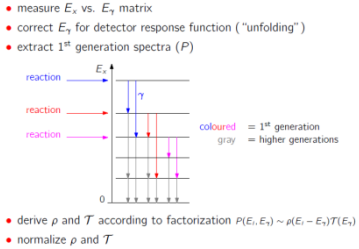

LEVEL DENSITY (MeV⁻¹)
Energy (MeV)

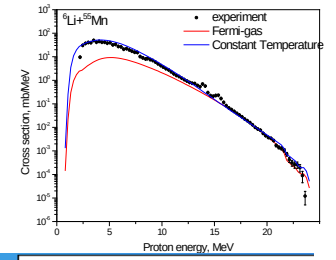

RIPL-2
Mughabghab
RIPL-3
Mass number

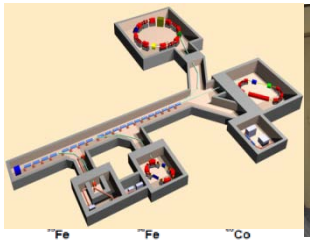


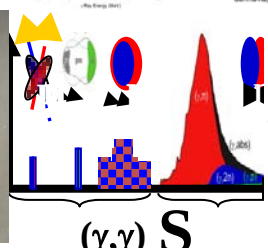


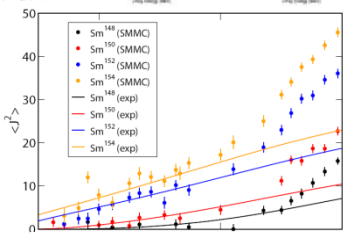

Gamma-Ray Energy (keV)

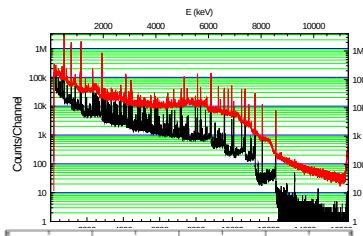

measure E_x vs. E_γ matrix
correct E_γ for detector response function ("unfolding")
extract 1st generation spectra (P)
reaction
reaction
reaction
coloured = 1st generation
gray = higher generations
derive ρ and $\mathcal{T}$ according to factorization $P(E_i, E_\gamma) \sim \rho(E_i - E_\gamma)\mathcal{T}(E_\gamma)$
normalize ρ and $\mathcal{T}$

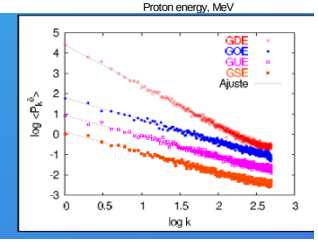

^{6}Li+^{55}Mn
experiment
Fermi-gas
Constant Temperature
Cross section, mb/MeV
Proton energy, MeV

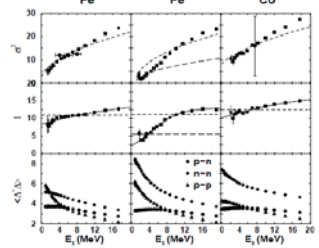


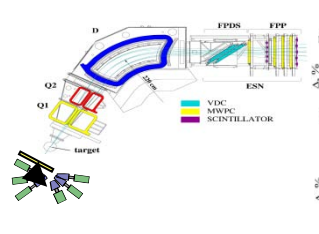

(γ,γ) S_n

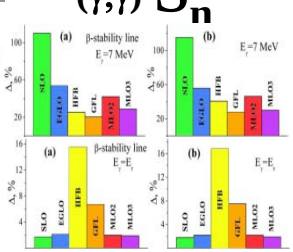

Sm (SMMC)
Sm (exp)
<J²>

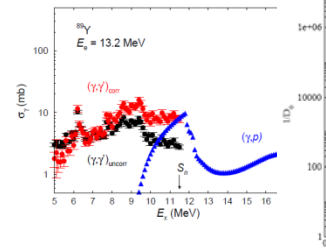

E (keV)
Counts/Channel

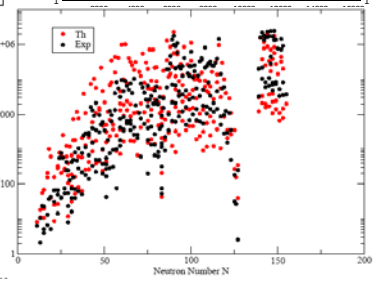

GDE
GOE
GLE
GSE
Ajuste
log k

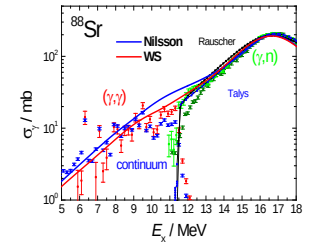

E_γ (MeV)

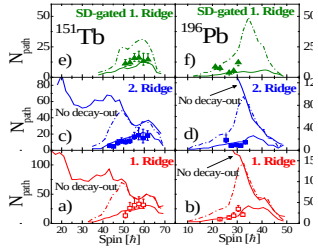

FPDS
FPP
ESN
VDC
MWPC
SCINTILLATOR
target

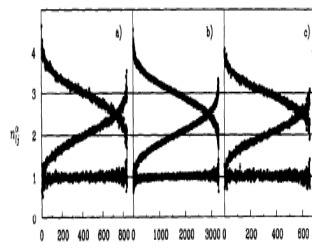

β-stability line
E_γ=7 MeV
E_γ=E_γ

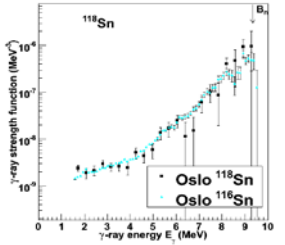

^{89}Y
E_n = 13.2 MeV
$(\gamma,\gamma')_{corr}$
$(\gamma,\gamma')_{uncorr}$
(γ,p)
S_n
E_x (MeV)

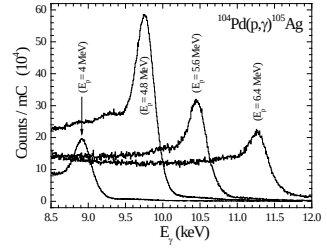

Th
Exp
Neutron Number N

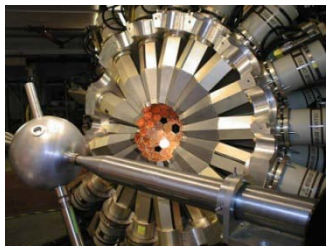

^{88}Sr
Nilsson
WS
Rauscher
Talys
(γ,γ)
(γ,n)
continuum
σγ / mb
E_x / MeV

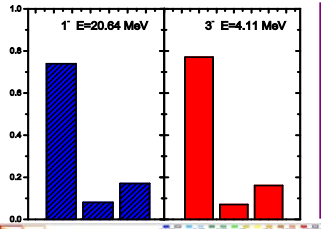

SD-gated 1. Ridge
^{151}Tb
^{196}Pb
2. Ridge
1. Ridge
No decay-out
Spin [ħ]

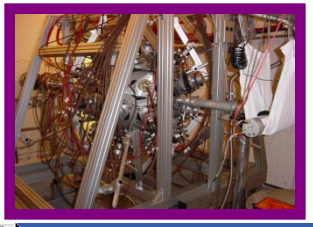

a)
b)
c)

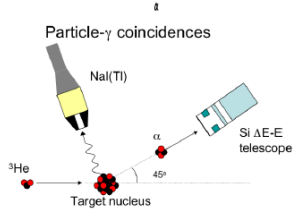

^{118}Sn
Oslo ^{118}Sn
Oslo ^{116}Sn
γ-ray energy E_γ (MeV)

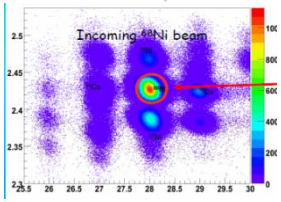

^{104}Pd(p,γ)^{105}Ag
Counts / mC
E_γ (keV)

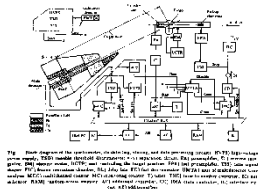


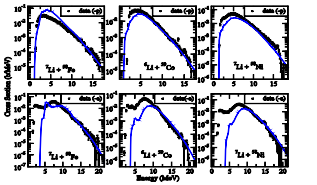

1⁻ E=20.64 MeV
3⁻ E=4.11 MeV

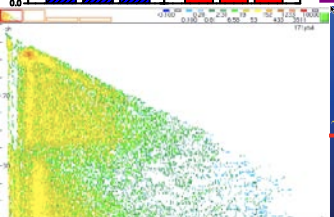


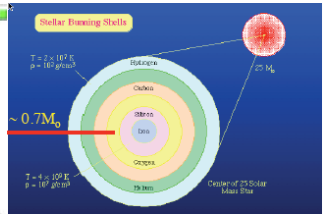

Particle-γ coincidences
NaI(Tl)
Si ΔE-E telescope
^{3}He
α
45°
Target nucleus

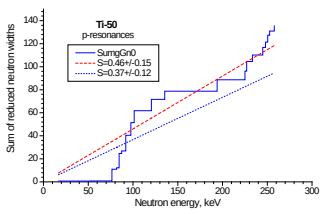

Incoming ^{68}Ni beam

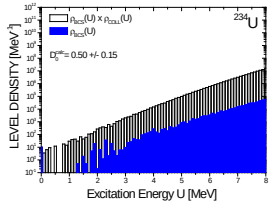


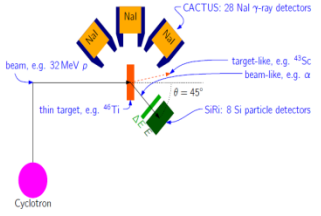





Stellar Burning Shells
Hydrogen
Carbon
Neon
Oxygen
Silicon
Iron
~ 0.7$M_\odot$
25 $M_\odot$
Center of 25 Solar Mass Star


Ti-50
p-resonances
SumgGn0
S=0.46+/-0.15
S=0.37+/-0.12
Sum of reduced neutron widths
Neutron energy, keV


^{234}U
D_0^{obs}= 0.50 +/- 0.15
LEVEL DENSITY (MeV⁻¹)
Excitation Energy U [MeV]


CACTUS: 28 NaI γ-ray detectors
NaI
beam, e.g. 32 MeV p
target-like, e.g. ^{45}Sc
beam-like, e.g. α
θ = 45°
thin target, e.g. ^{45}Ti
SiRi: 8 Si particle detectors
ΔE-E
Cyclotron

What do we want to achieve ?

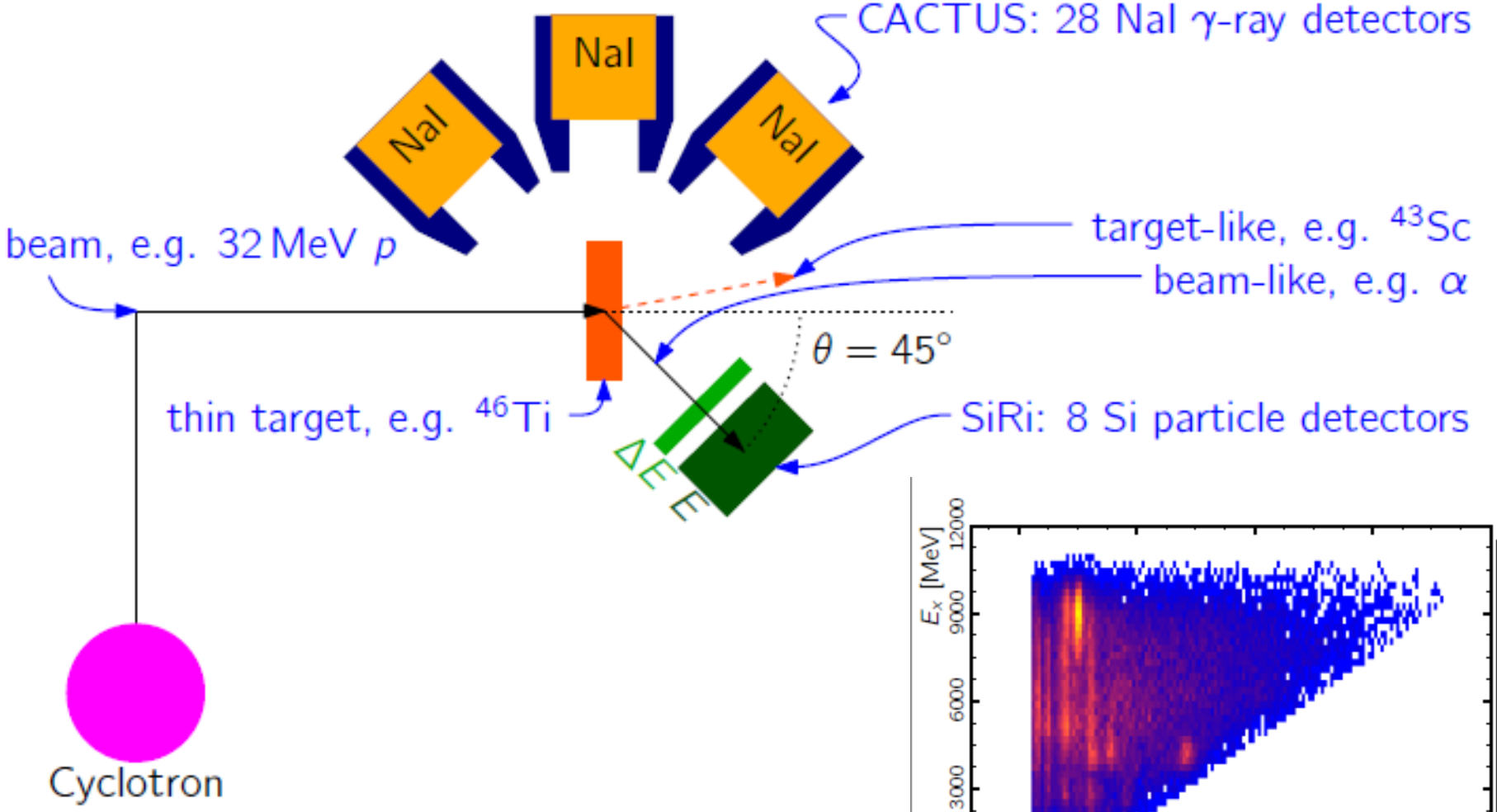
- **Derive a reliable and comprehensive data set on level densities and gamma ray strength functions;**
- **understand impact of spin, parity, deformation, damping, collective enhancement, low lying states, K-quantum number, and chaoticity;**
- **establish a well founded, global, and robust theoretical description;**
- **apply the knowledge in neighbouring fields.**

Experimental Approaches

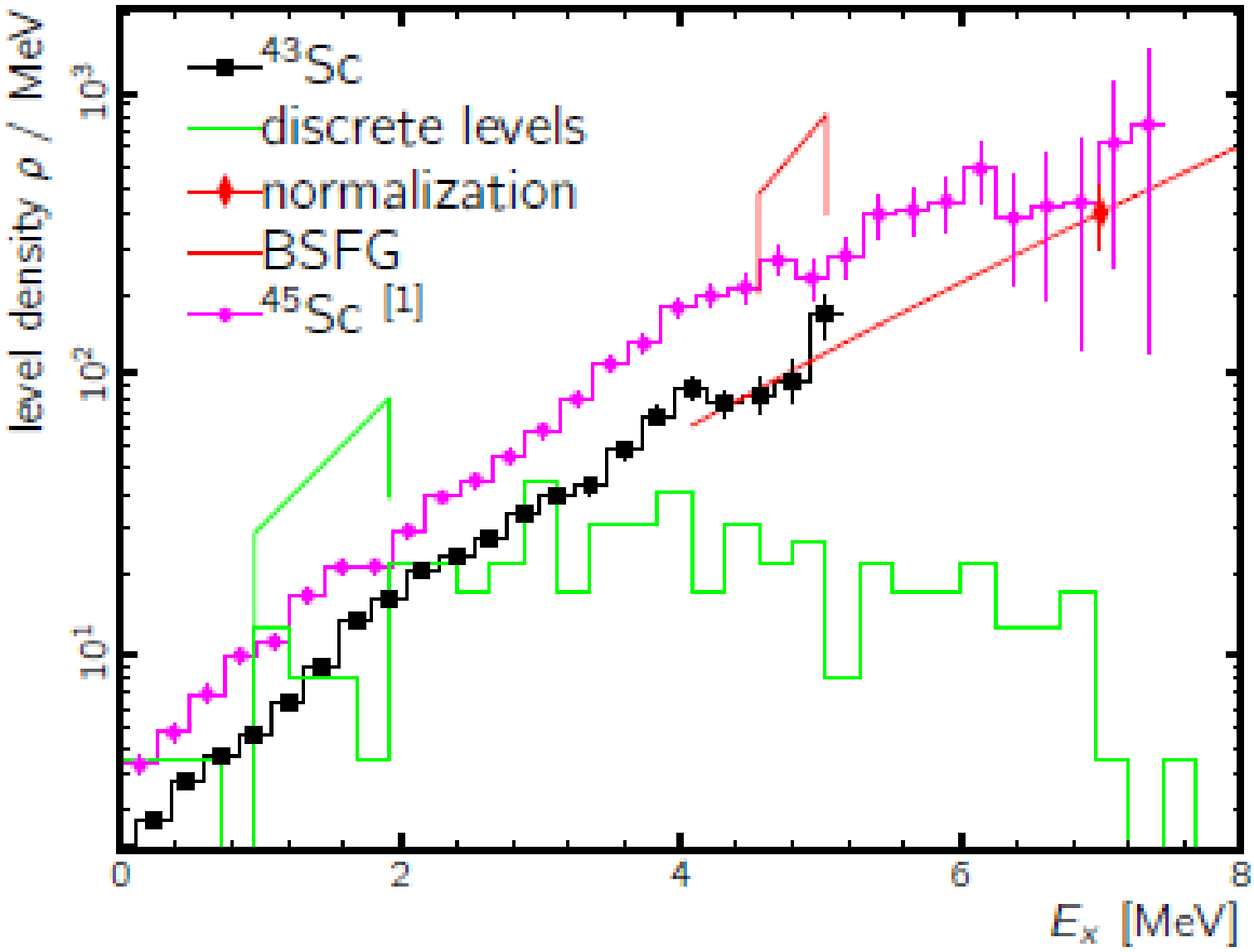
The Oslo Method

Alexander Bürger
Hilde T. Nyhus
Heide K. Toft

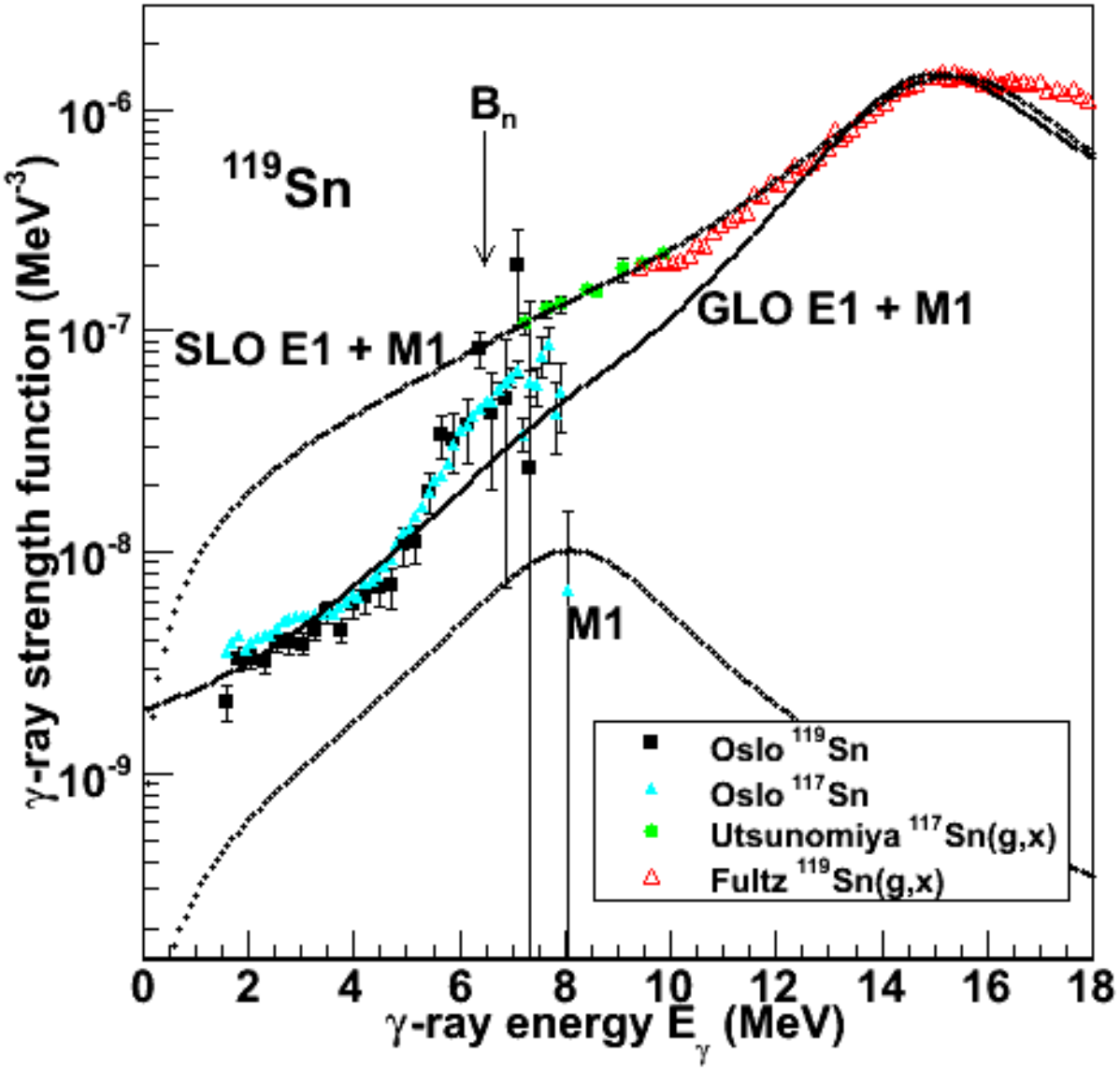
The Oslo Method



The Oslo Method



The Oslo Method



Experimental Approaches

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Heide K. Toft

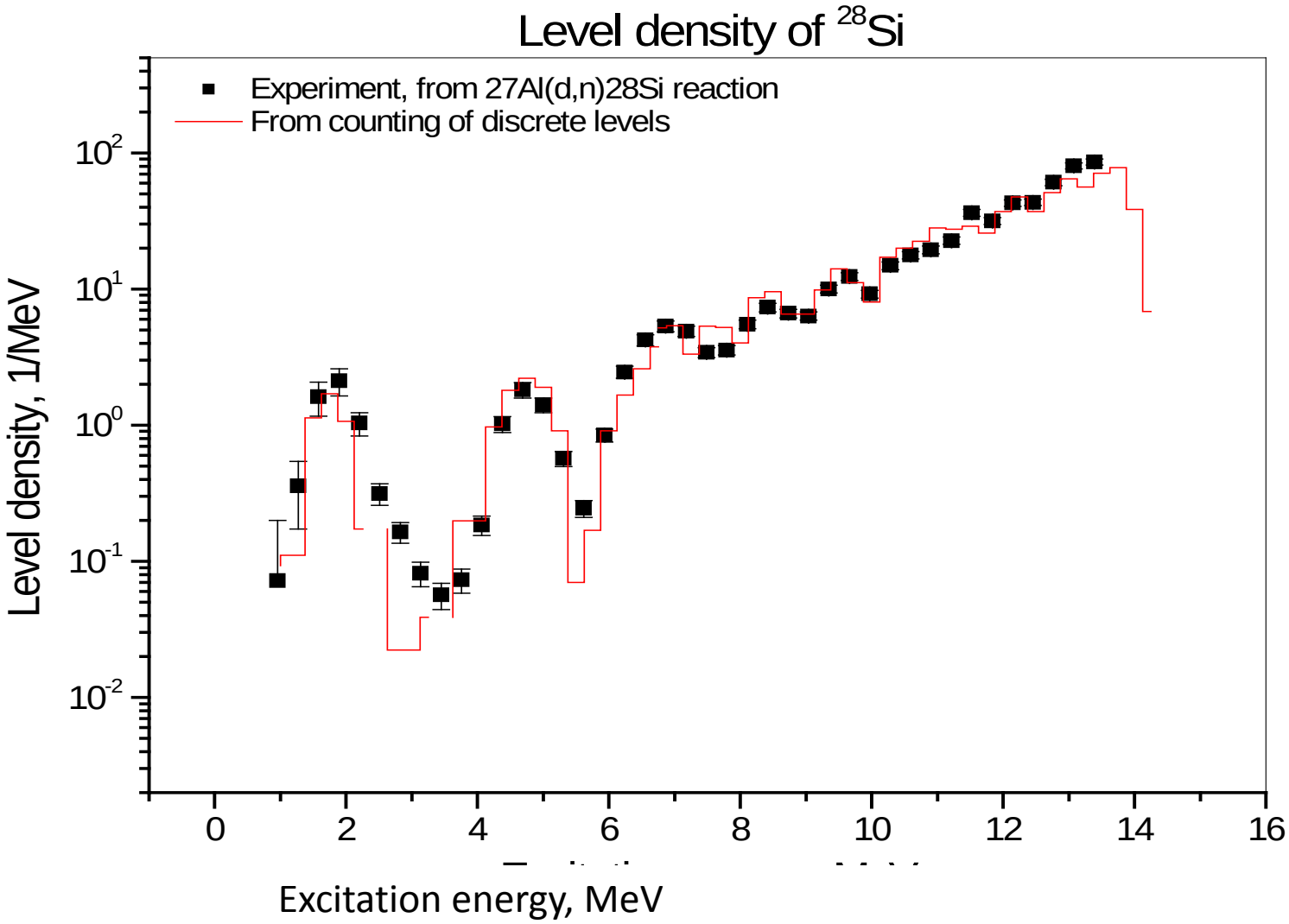
The Ohio Method

(p,2γ) and (d,n), exotic nuclei

Alexander Voinov
Steve Grimes

The Ohio Method

Testing the technique with $^{27}Al(d,n)^{28}Si$



Experimental Approaches

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The Ohio Method
(p,2γ) and (d,n), exotic nuclei

Alexander Voinov
Steve Grimes

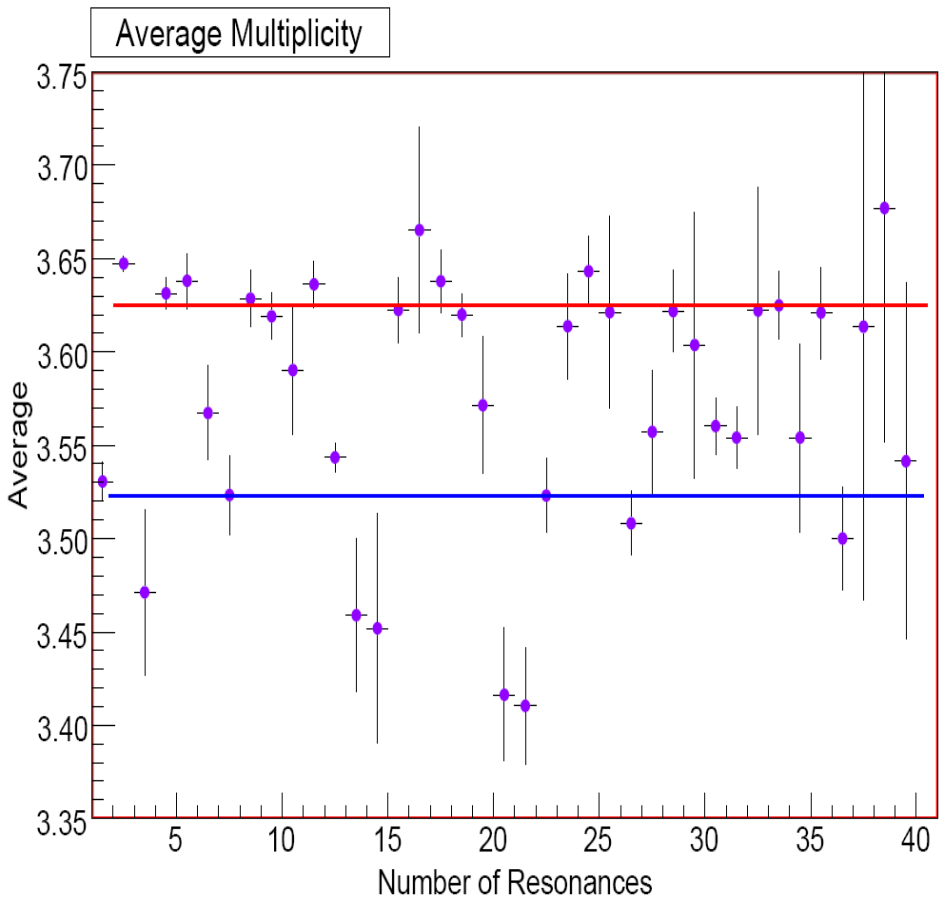
Two step cascade method
(n capture + dicebox)

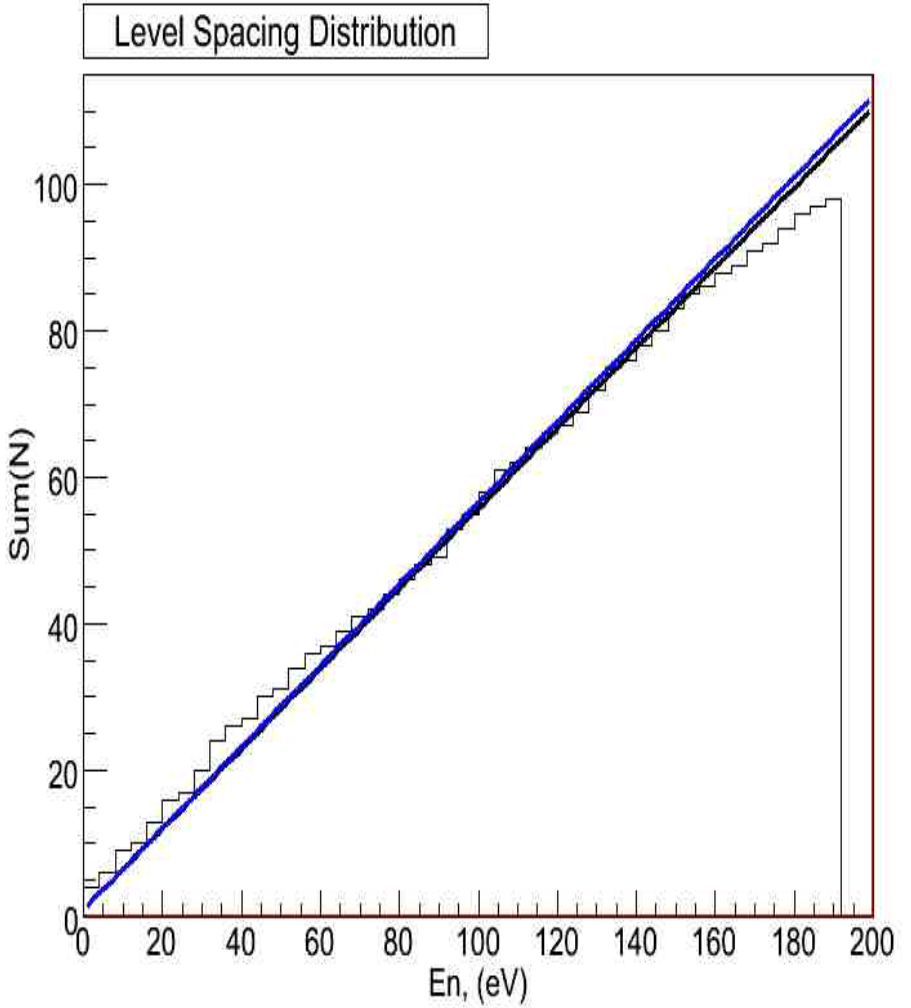
Milan Krticka

Neutron capture
@DANCE and n_TOF

Gary Mitchell
Stefano Marrone

Neutron capture data





G. Mitchell

Experimental Approaches

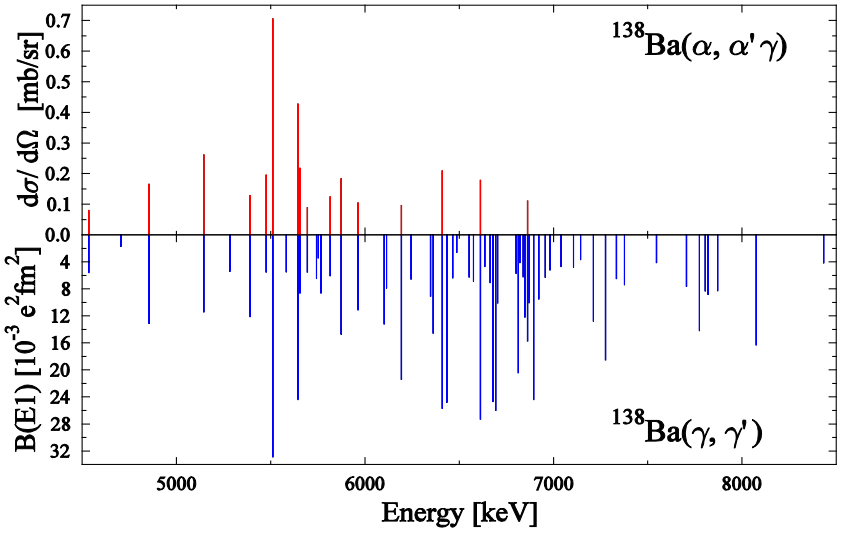
Photon induced reactions
(monoenergetic photons)
Hiroaki Utsunomiya
Anton Tonchev

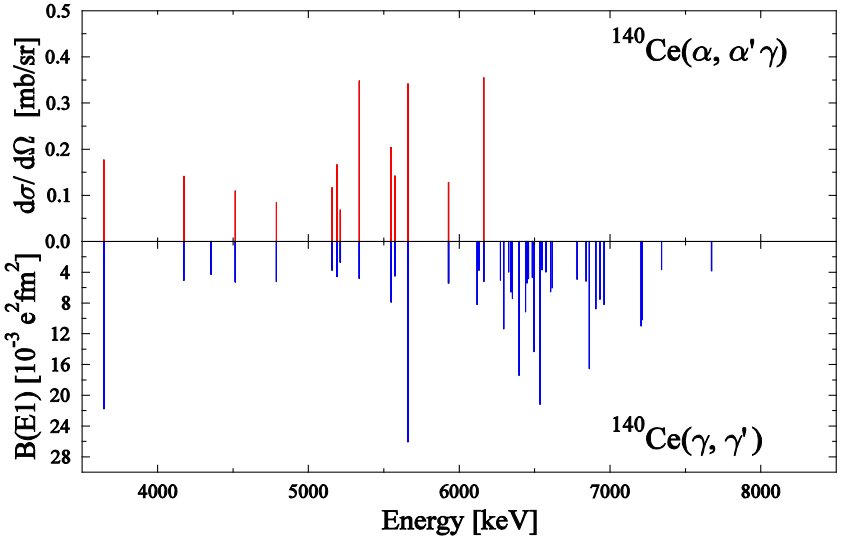
Photon induced reactions
(bremsstrahlung photons)
Ronald Schwengner

PDR in Coulex excitation
(virtual photons, inverse kinematics)
Oliver Wieland

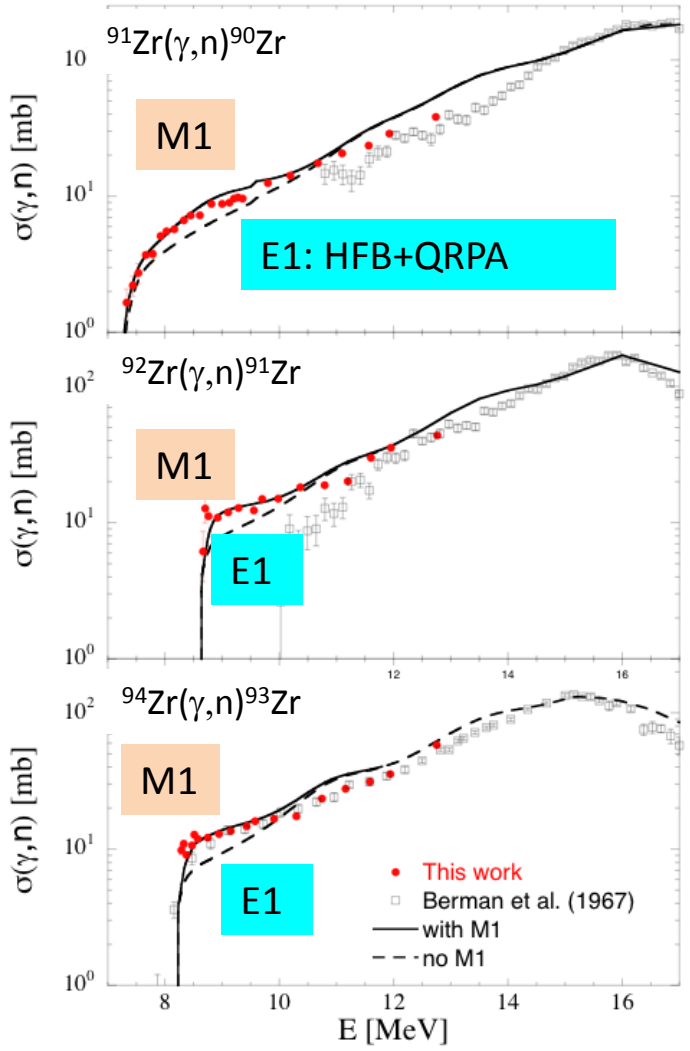
Alpha scattering
$(\alpha,\alpha'\gamma)$
Janis Endres

Pygmy Dipole Resonance



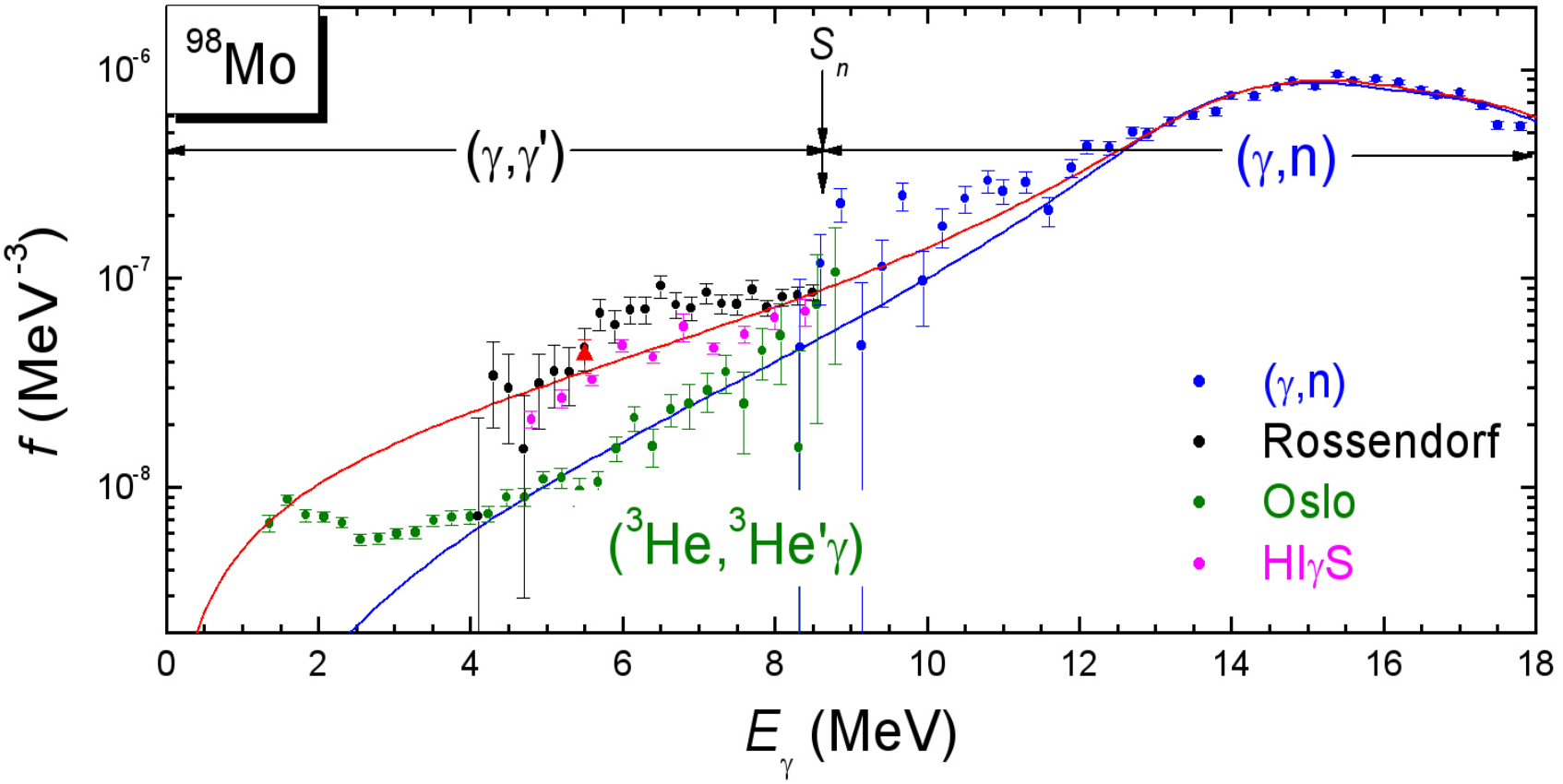


J. Endres



H. Utsunomiya

Pygmy Dipole Resonance



Experimental Approaches

Neutron spectra
(p,n)@IPPE

Boris Zhuravlev

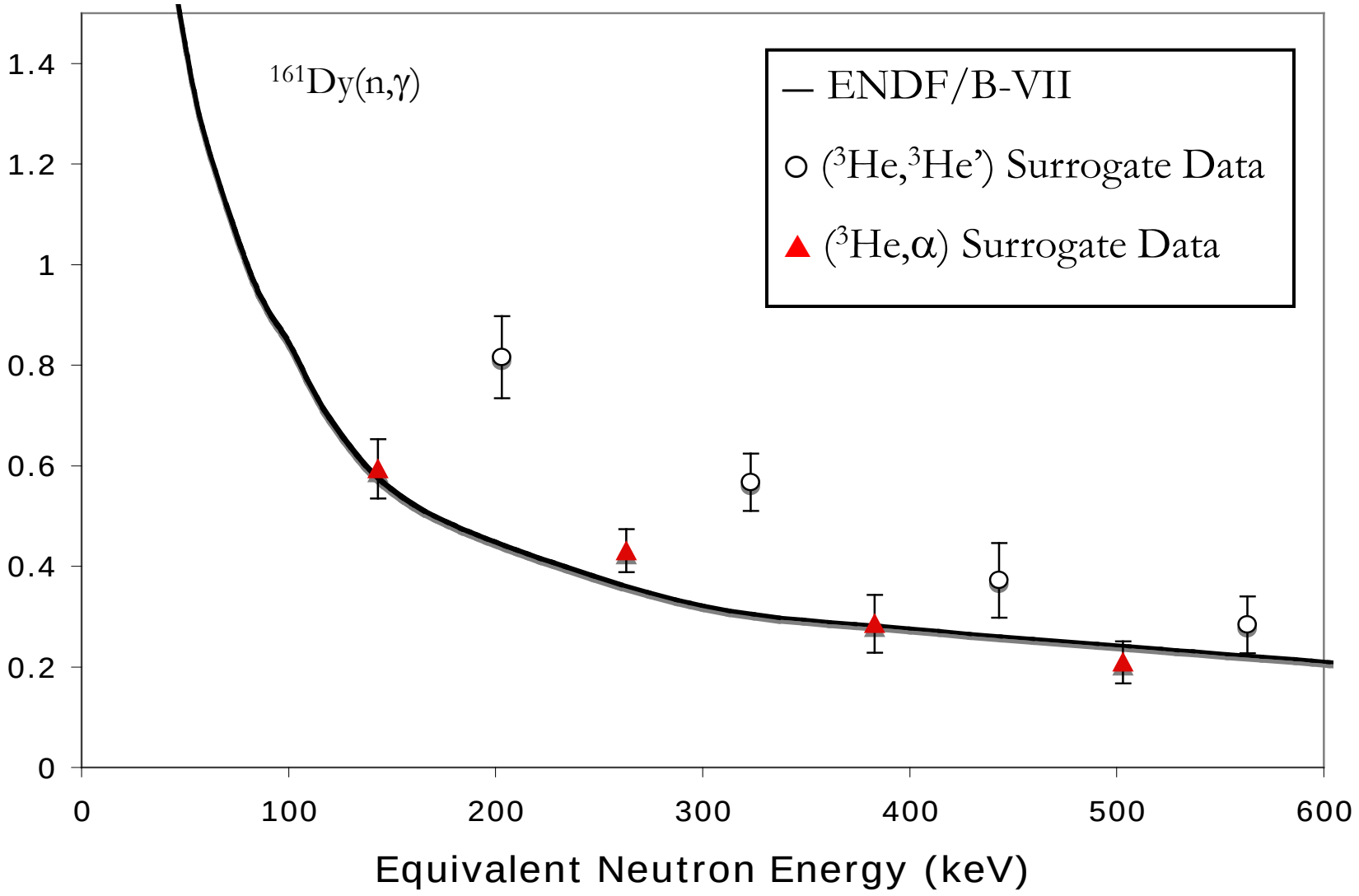
Lifetimes
(near particle separation)

Mathis Wiedeking

Surrogate reactions

Jutta Escher
Bethany Lyles Goldblum

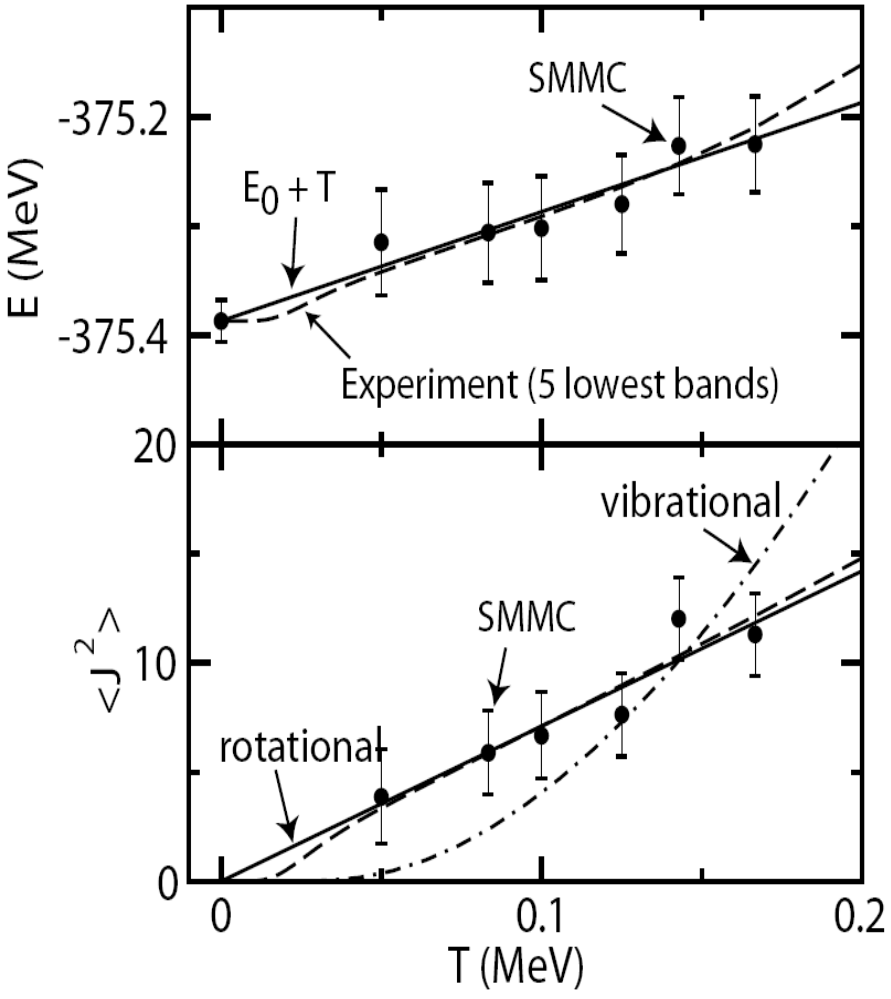
Surrogate reactions – cross section

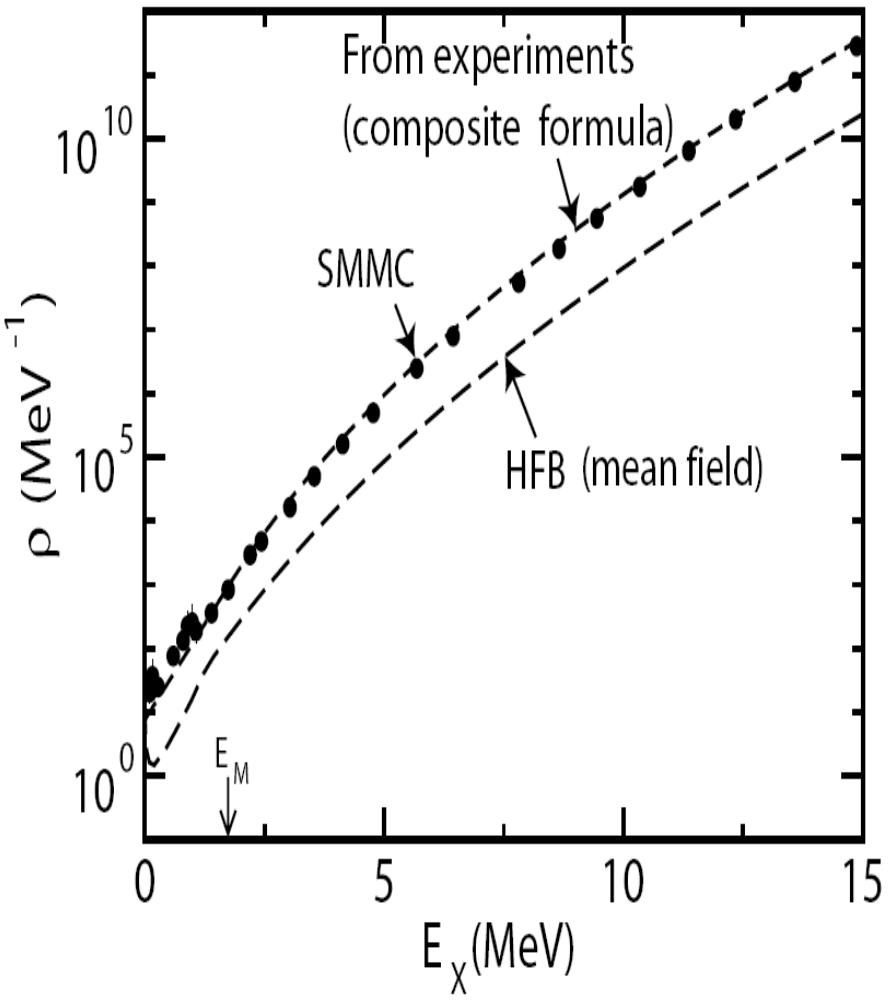


Theoretical Approaches

The Brink hypothesis	David Brink
IBA folded with intrinsic level densities	Roberto Capote
Monte Carlo	Yoram Alhassid Hitoshi Nakada

Shell Model Monte Carlo





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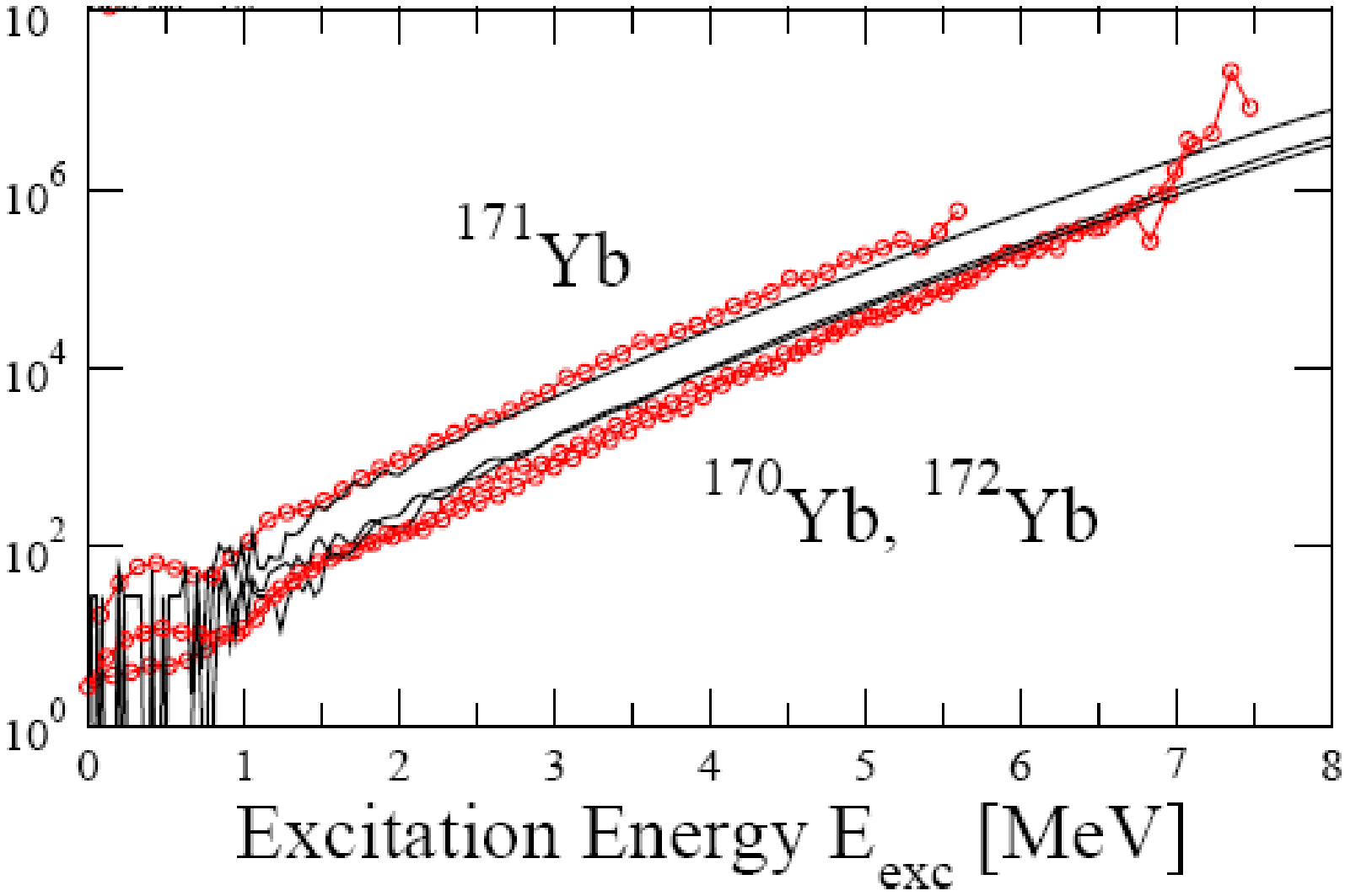
IBA folded with intrinsic level densities	Roberto Capote
Monte Carlo	Yoram Alhassid Hitoshi Nakada
Microcanonical model	Sven Aberg

Combinatorial level density – comparison to Oslo data



S. Aberg

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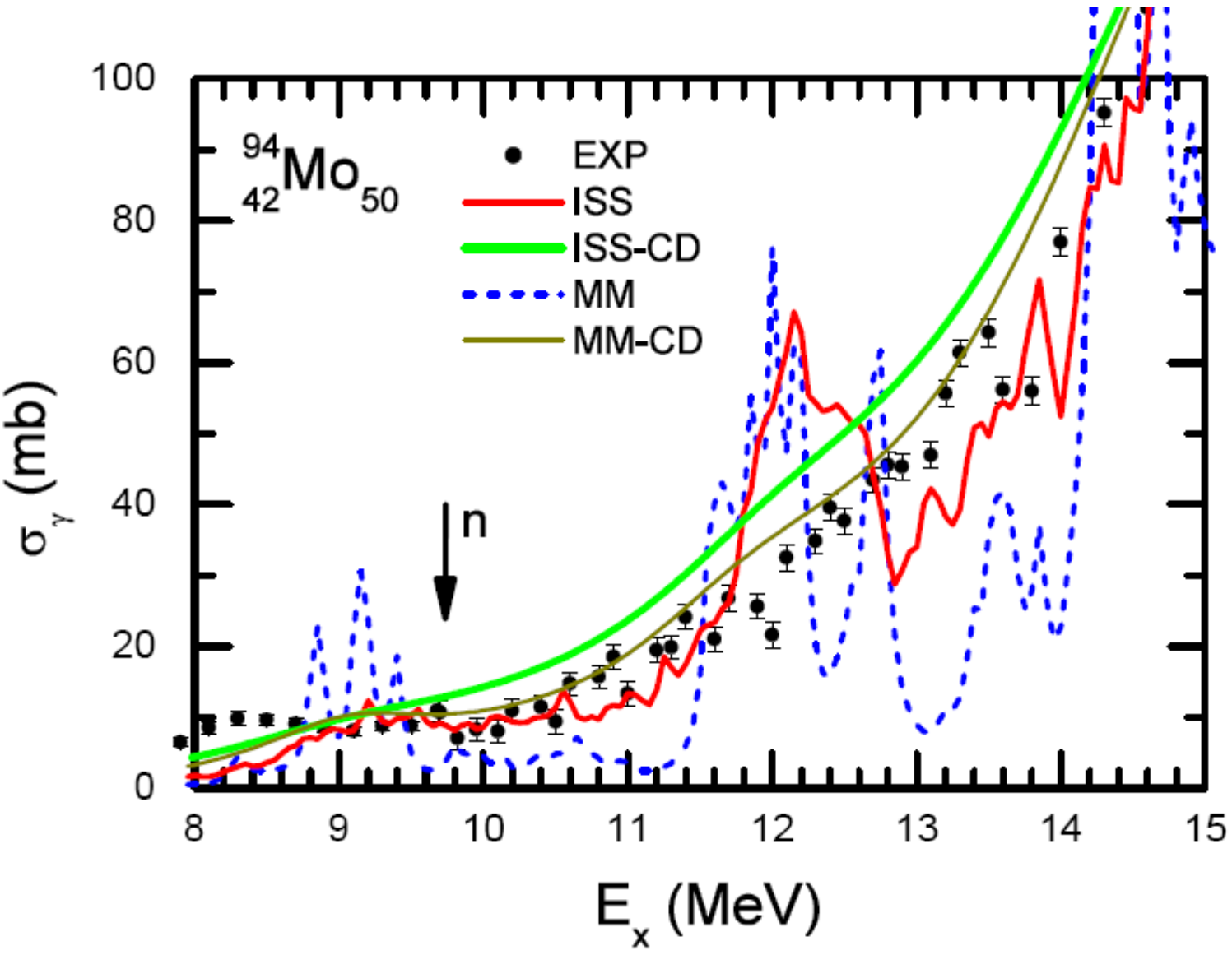
Microcanonical model	Sven Aberg
Instantaneous-shape sampling	Stefan Frauendorf

Instantaneous-Shape Sampling



S. Frauendorf

Theoretical Approaches

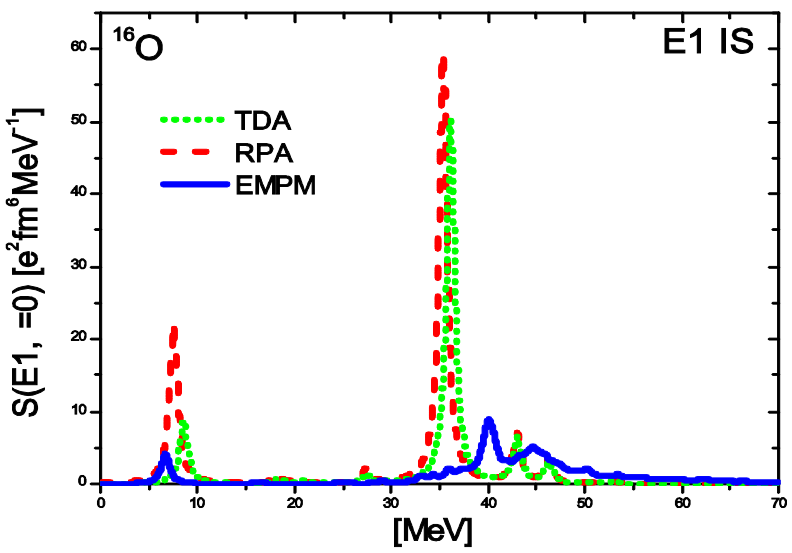
Microscopic combinatorial model Stephane Hilaire
(spin and parity dependence)

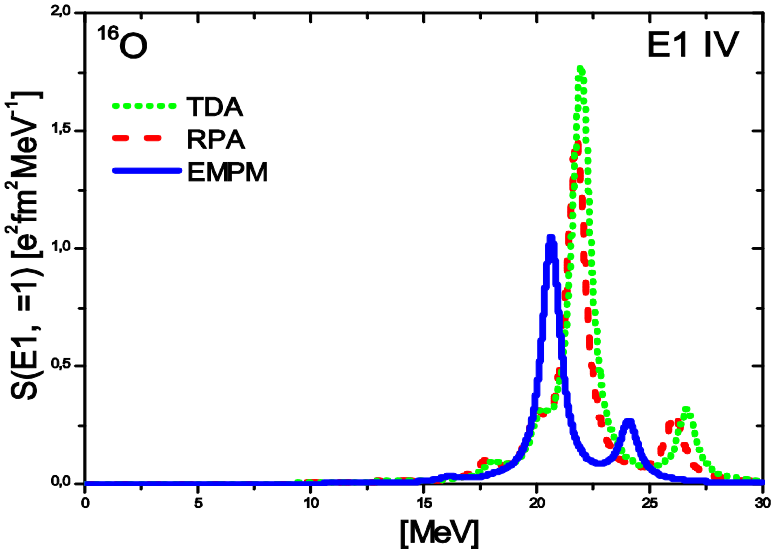
Modified Lorentzian approach Vladimir A. Plujko
(comparison of different models)

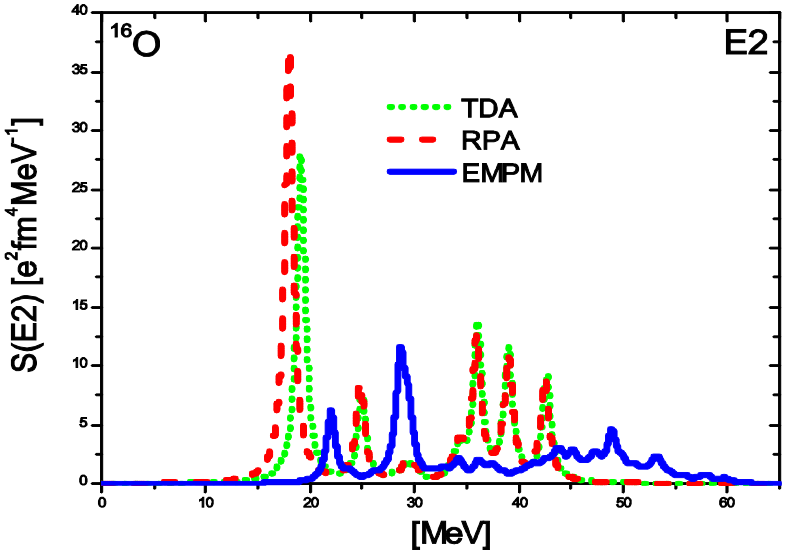
Deformed systems Katarzyna Mazurek
(Tetrahedal/octrahedal shapes)

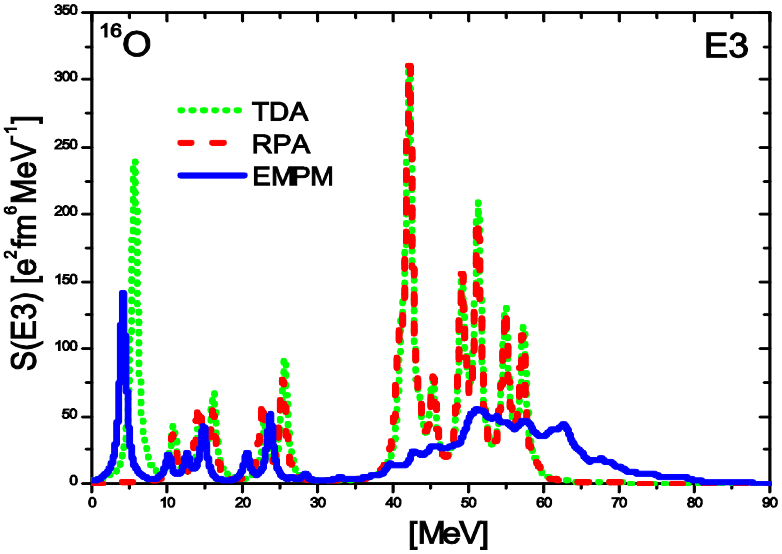
Quasiparticle-phonon model Nicola Lo Iudice
(influence of phonons on nuclear response)

Influence of phonons









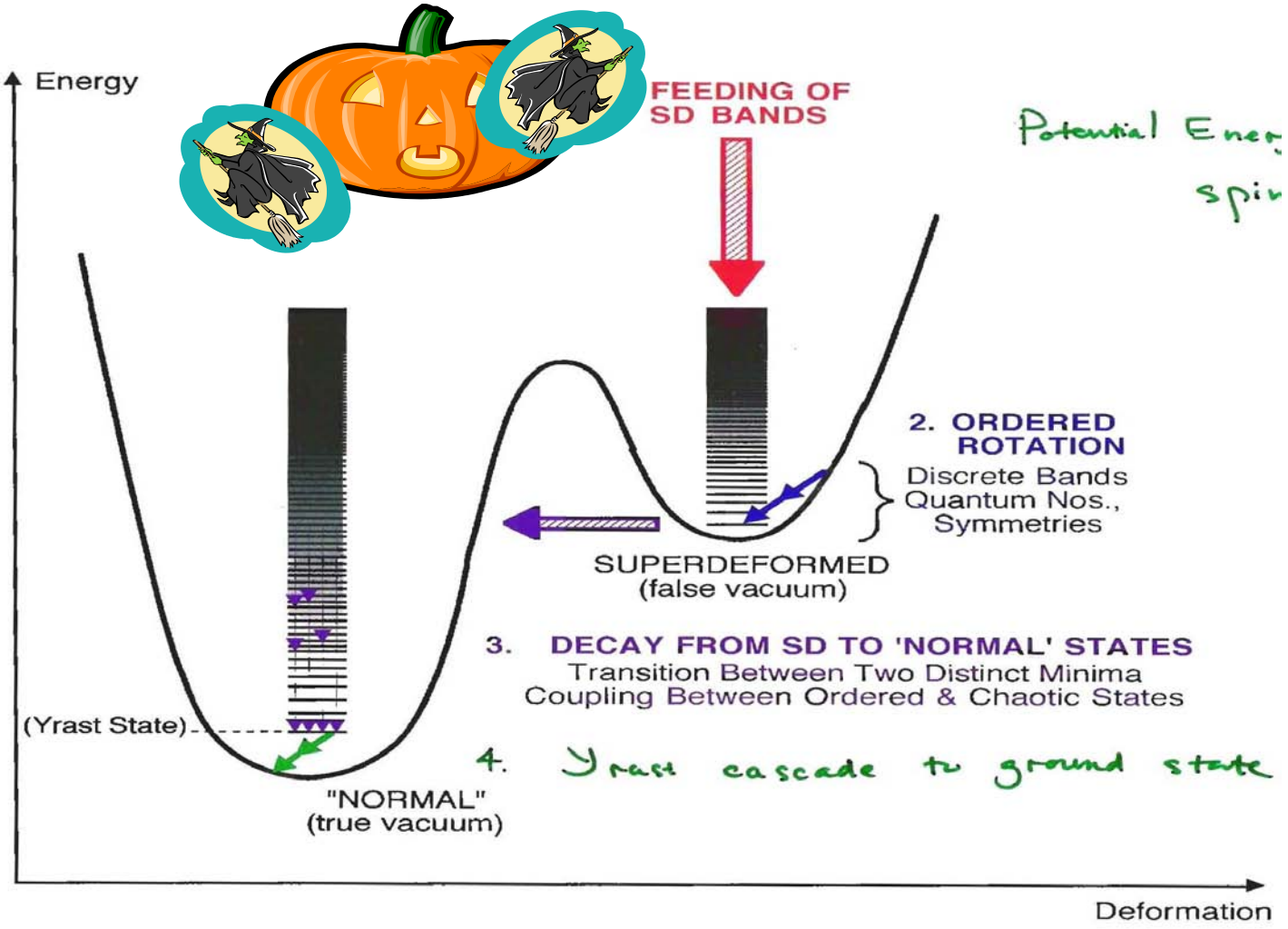
N. Lo Iudice

Hot nuclei and quantum chaos

Warm superdeformed nuclei Silvia Leoni

Superthings Teng Lek Khoo
(superdeformed and superheavy)

Superdeformed bands

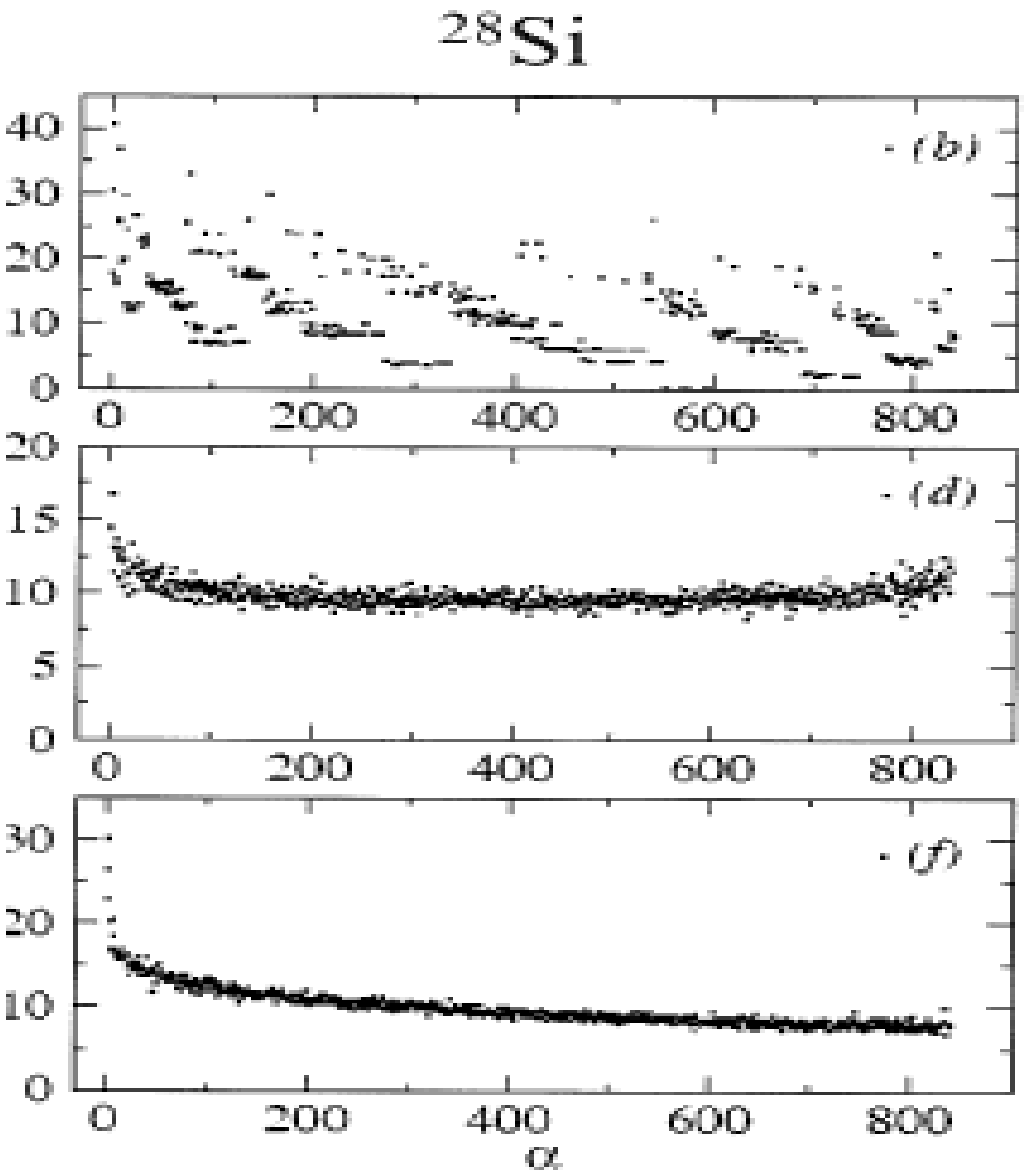


Teng Lek Khoo

Hot nuclei and quantum chaos

Warm superdeformed nuclei	Silvia Leoni
Superthings (superdeformed and superheavy)	Teng Lek Khoo
Nuclear Chaoticity	Jose M. Gomez
Thermodynamics and quantum chaos	Vladimir Zelevinsky

Pair correlator

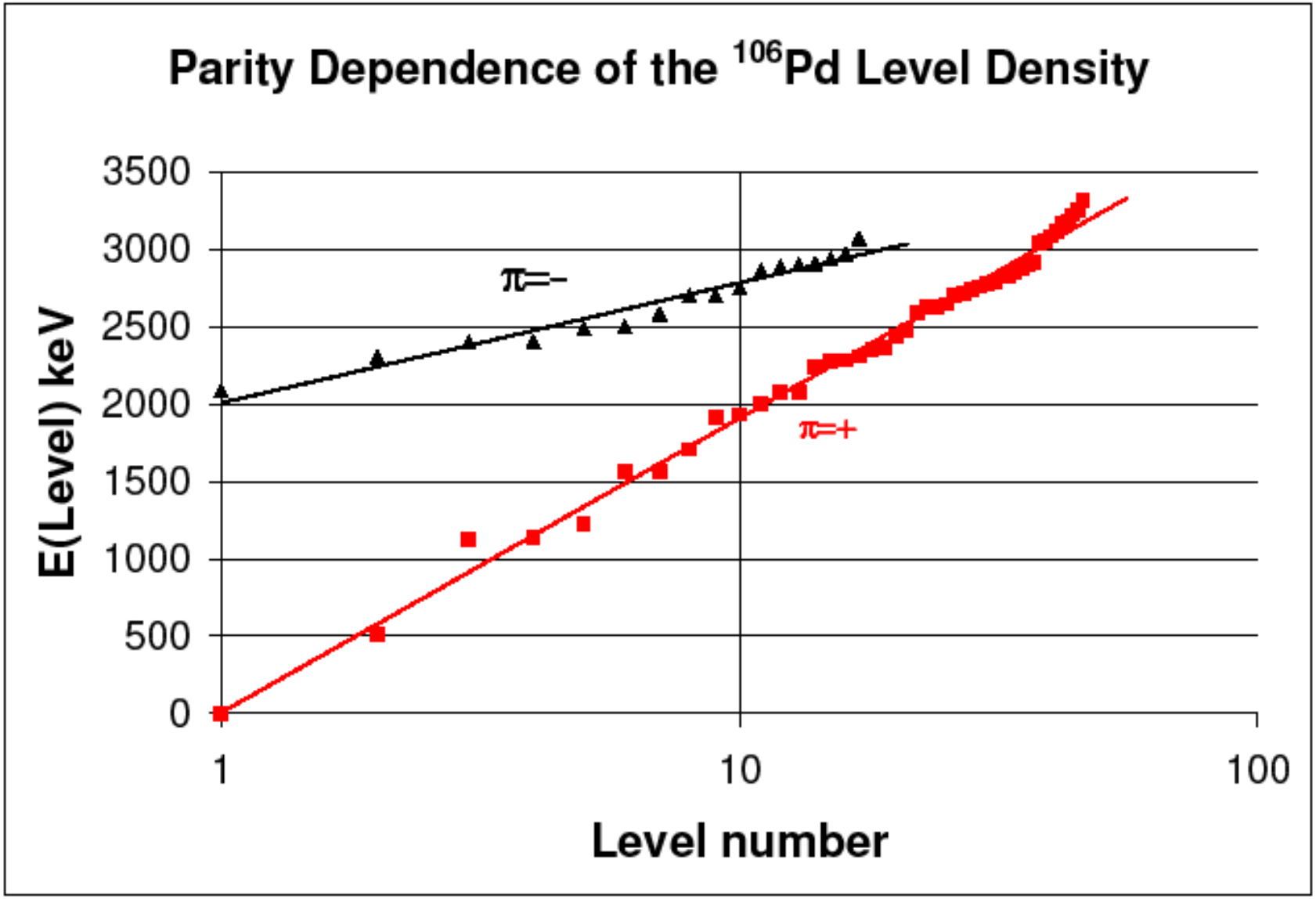


V. Zelevinsky

Nuclear Data

RIPL-3 (neutron resonances density)	Anatoly Ignatyuk
Level densities from nuclear data libraries	Frank Gunsing
Nuclear Structure and Statistical Decay Properties	Richard B. Firestone

Parity dependence



R.B. Firestone

Applications

Reactor physics
(nuclear data importance for generation IV reactors)

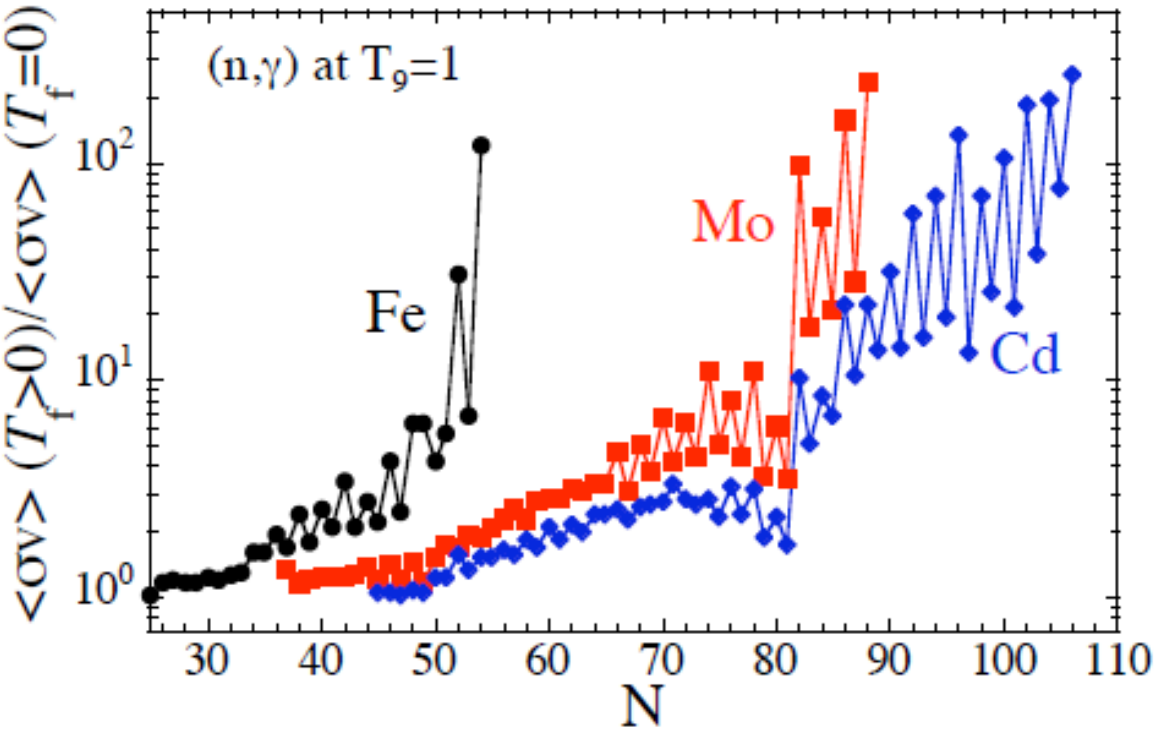
Jonathan Wilson

Nucleosynthesis

Stephane Goriely
Sotirios Harissopulos
Lee Bernstein

Nucleosynthesis

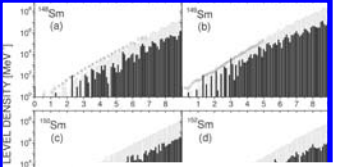
Impact of the upbend pattern on the radiative n-capture rate

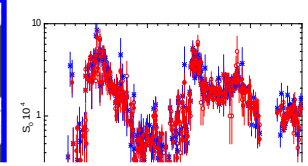


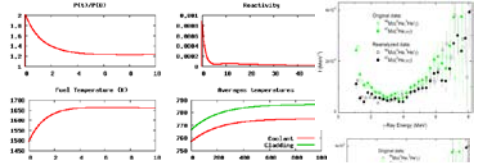
Small impact on the stable nuclei (~ factor of 2 at most)

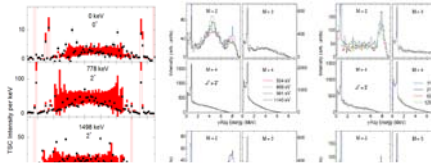
Large impact on exotic n-rich nuclei ($N>N_{mag}$: up to a factor ~100)

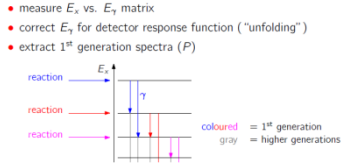
--> The upbend structure, but if true, its impact is far from being negligible



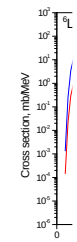


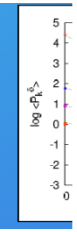


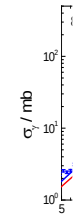


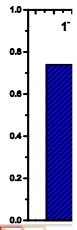


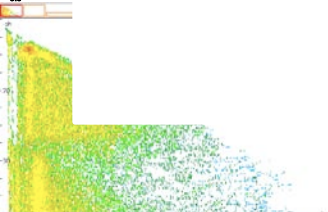
ARSF = Anatoly's Remarks Strength Function

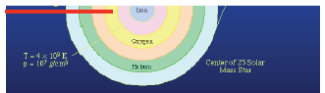


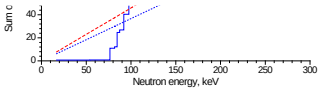


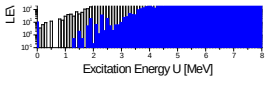


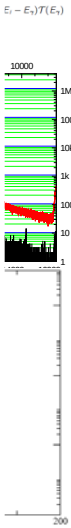












UNIFIED THEORY OF NUCLEAR MODELS AND FORCES

by

G. E. BROWN

Professor of Physics
Princeton University

and optical. The courage to try this came in the Norwegian mountains, at the joint Nordic-Dutch meeting on nuclear reactions, when I felt that by giving really 'basic' lectures, I would necessarily come first on the program, at 8.30 a.m., and would then have the rest of the day free to ski on slopes unencumbered by physicists, all inside absorbing the necessarily less basic material which must follow. And what was, at this time, the basic of basics, the modest excuse for existence of theoretical nuclear physicists, but nuclear models, which I disposed of one by one each morning. Whether the exhilaration associated with this rapid disposal came primarily from success in this or from the Norwegian mountains, I cannot say, but I approached the task outlined in this short book in the same light-headed manner. In any case, if the reader receives half the enjoyment out of reading this book that I did out of skiing in Golå, I shall consider my task successfully completed.

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Princeton University

Preface to Second Edition

Many readers regarded the preface to the first edition as light hearted, but I found it exceedingly useful, and as a result of it, have had several invitations from Universities to lecture during the skiing season near mountainous regions.

THANK YOU !!!

Sunniva Siem, Alexander Bürger, Magne Guttormsen
Andreas Görgen, Trine W. Hagen, Ann-Cecilie Larsen
Hilde Therese Nyhus, John Rekstad, Therese Renstrom
Sunniva J. Rose, Naeem Syed, Heidi Toft, Kristine Wikan