Concluding remarks & suggestions

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3rd Workshop on Level Density and Gamma Strength

Characteristics of meeting

- Focused
- Wide-open, stimulating and lively discussions.
- Civil discussion between those who disagree.
- Even the opposition invited.
- Very interesting workshop.
- On important physics.
- Delightful social organization.
- Thanks to organizers

Local organizing committee:

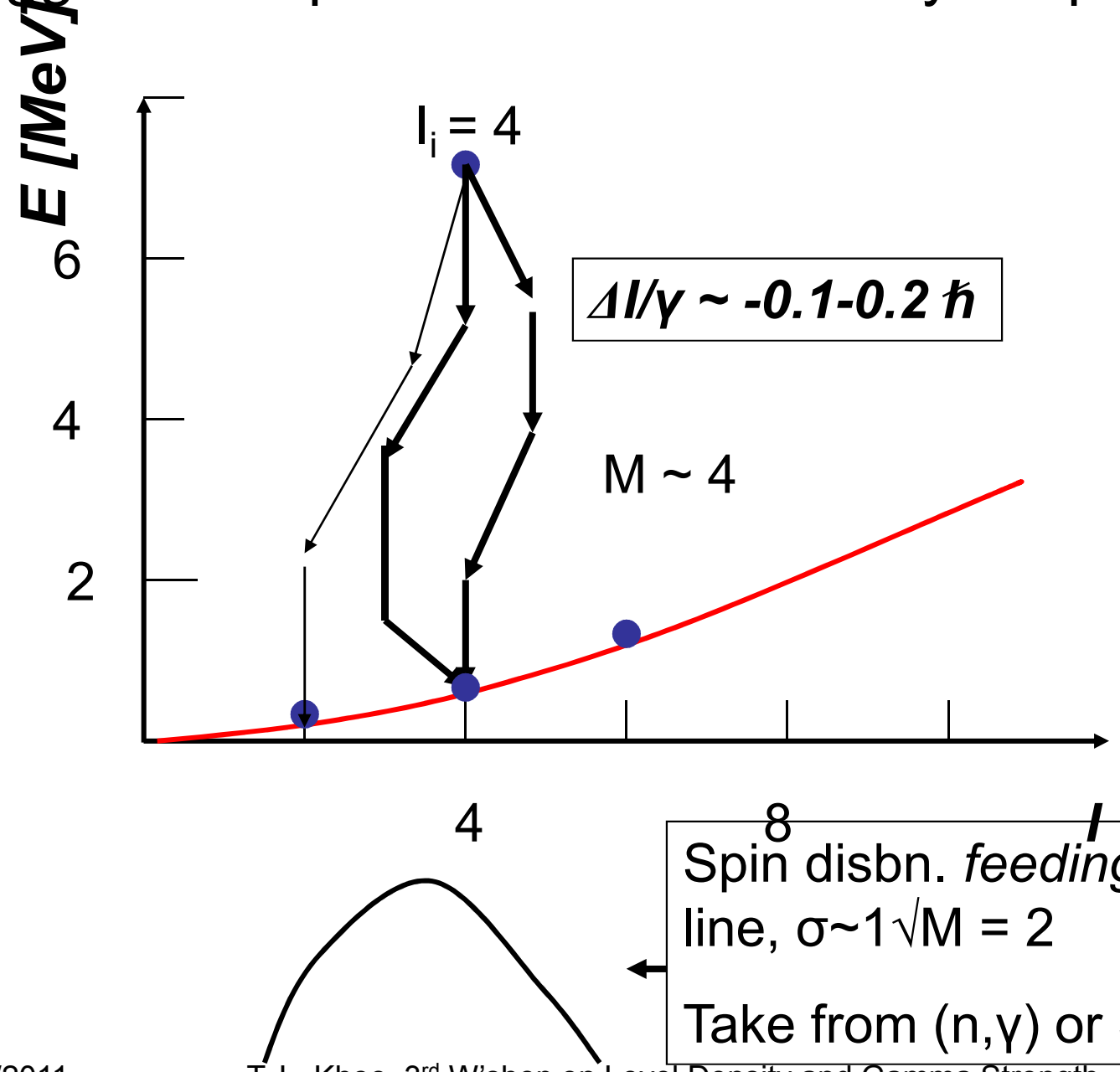
- Sunniva Siem (chairman)
- Alexander Bürger
- Tomas K. Eriksen
- Andreas Görgen
- Magne Guttormsen
- Trine W. Hagen
- Ann-Cecilie Larsen
- Hilde Therese Nyhus
- John Rekstad
- Therese Renstrøm
- Sunniva J. Rose
- Heidi K. Toft

- ρ & S_γ are fundamental nuclear properties.
- Why are they not better defined after so many years of nuclear physics?
- What would it take to properly define them?
- Role of theory. Impressive progress on ρ, less so on S_γ.
- Keeps you all gainfully employed.

Exclusive measurements

- Exclusive measurements are necessary to ensure that particles/gammas are indeed from the putative source, with no contributions from, e.g., hydrocarbons which inevitably build up on target.
- Requirement/check on E_{Σ} or E_{max} effective. Sufficient? Nevertheless it's a minimum requirement when it is possible to impose.

Suggestion: spin distribution – a very simple method



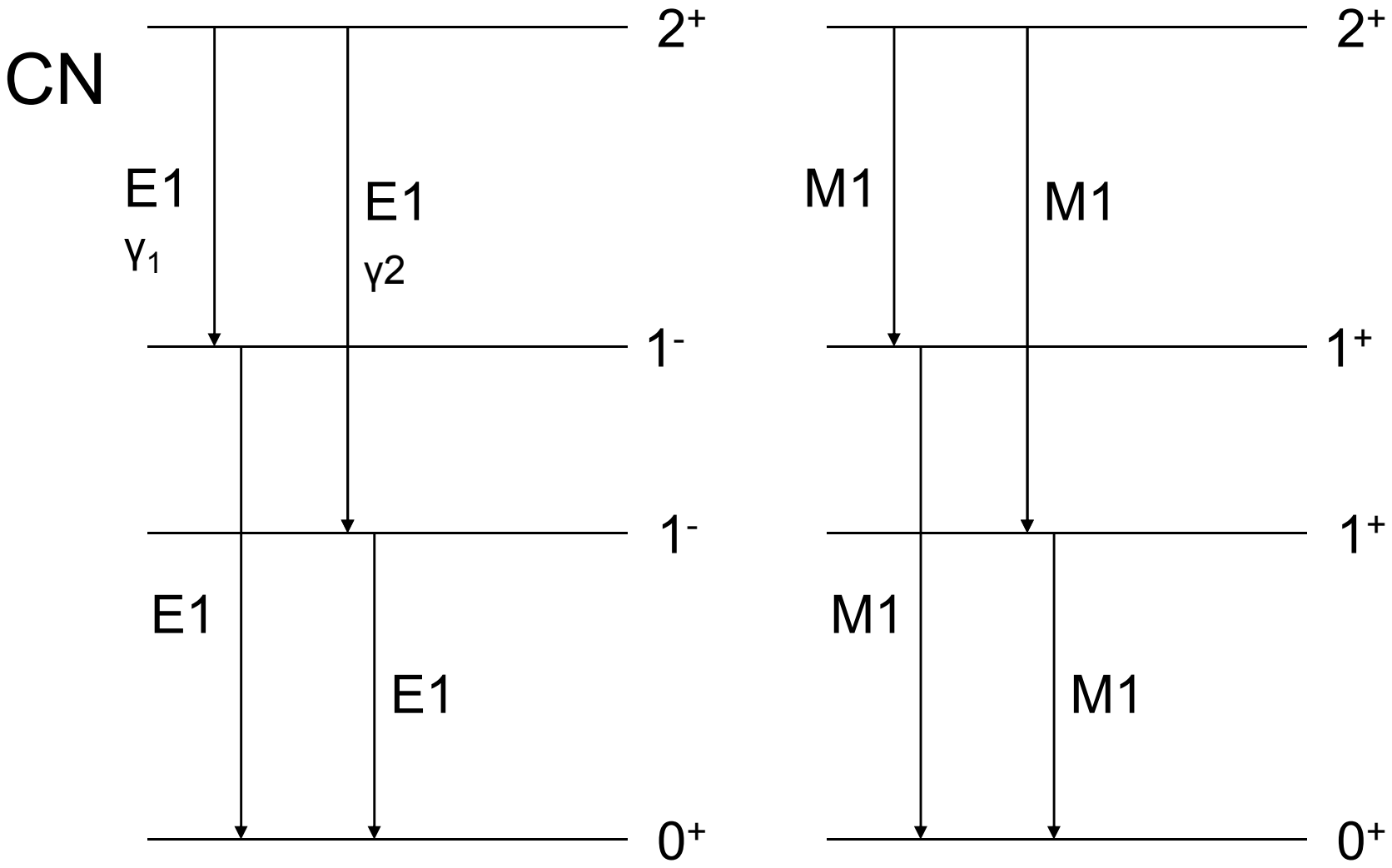
Spin disbn. *feeding into* yrast line, σ~1√M = 2

Take from (n,γ) or SD decay

Enhanced S_γ at low E_γ – all E1? Is there an M1 contribution?

- *Suggestion*

- Variation of Wiedeking ratio method with $\pi_{initial}$ specified, e.g. in (n,γ) with s-wave capture $\pi_i = +$.
- 2-step γ cascade to ground state.
- $\pi_{intermediate} = -$ E1/E1; $\pi_{intermediate} = +$ M1/M1.
- $R = I(E\gamma_1)/I(E\gamma_2) = S(E\gamma_1)/ S(E\gamma_2)$.
- N.B. R gives direct information on $S(E\gamma)$; P does not enter.



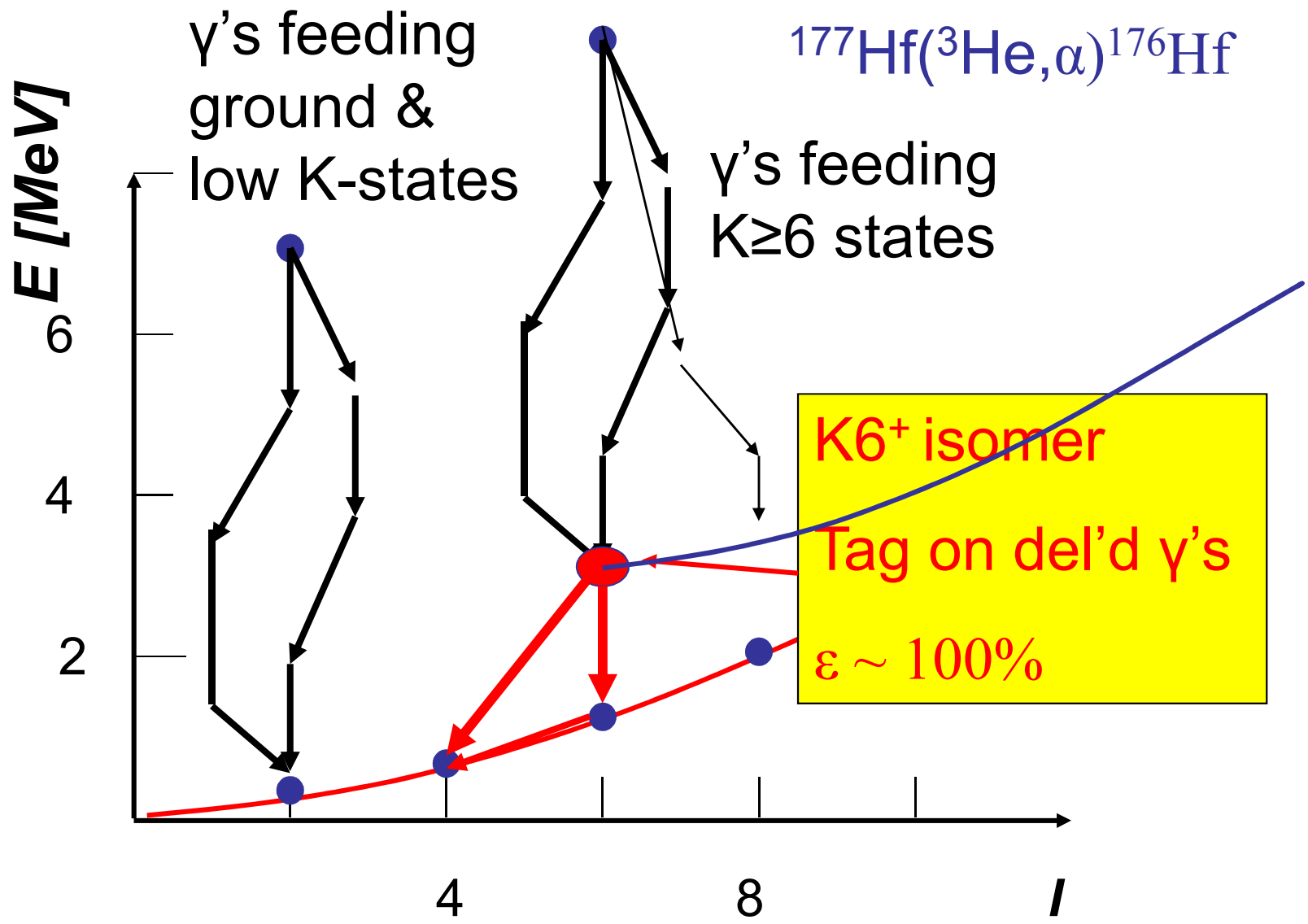
$R = I(E_{\gamma 1})/I(E_{\gamma 2}) = S(E_{\gamma 1})/S(E_{\gamma 2})$.

Extension: gate final state & E_Σ → total 2-step feeding γ's.

ρ, S_γ & γ spectra feeding ground & high-K states

- Are the above different?
- ρ probably smaller due to limited configurations that can contribute.
- Any theoretical grounds for expecting S_γ to be different? Not if Brink hypothesis holds.
- Test of Brink hypothesis.
- Tail of GDR built on high-K states.
- If γ spectra different → K conservation above yrast line.
- How does the K quantum number damp with U?
- Order to chaos transition.

Example


γ's feeding ground & low K-states
γ's feeding K≥6 states
$^{177}Hf(^{3}He,\alpha)^{176}Hf$
E [MeV]
6
4
2
4
8
I
K6+ isomer
Tag on del'd γ's
ε ~ 100%

Suggestion: 3 ways for measuring ρ, S_γ in one expt. Cross check & test of methods. Measure protons & γ with Gammasphere → high resolution, straightforward unfolding, calorimetry.

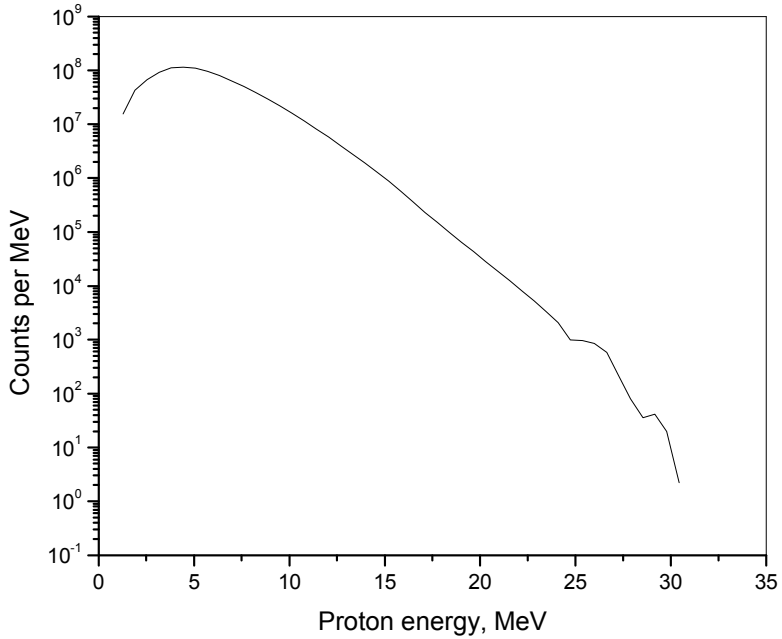
(a) protons from reaction, e.g. $^{12}C(^{45}Sc,p)^{56}Fe$ or $^{12}C(^{51}V,p)^{62}Ni$ (Voinov) → ρ.

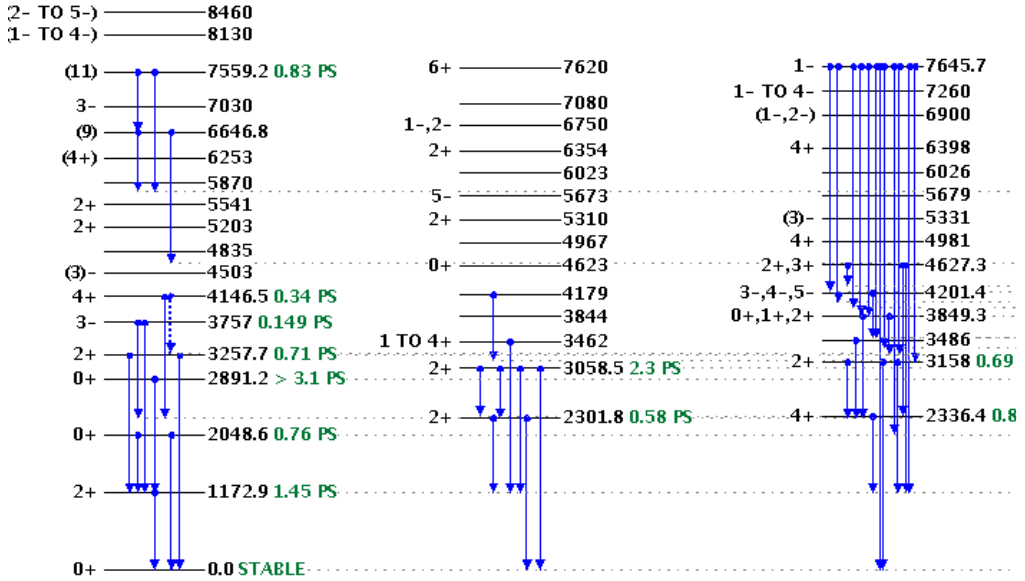
(b) γ's with the Oslo method after specifying E* with E_p → ρ & S(Eγ). Possible reactions

- $^{12}C(^{51}V,p)^{62}Ni$ Q = 7.26 MeV
- $^{12}C(^{45}Sc,p)^{56}Fe$ Q = 12.25 MeV

(c) Spin distribution.

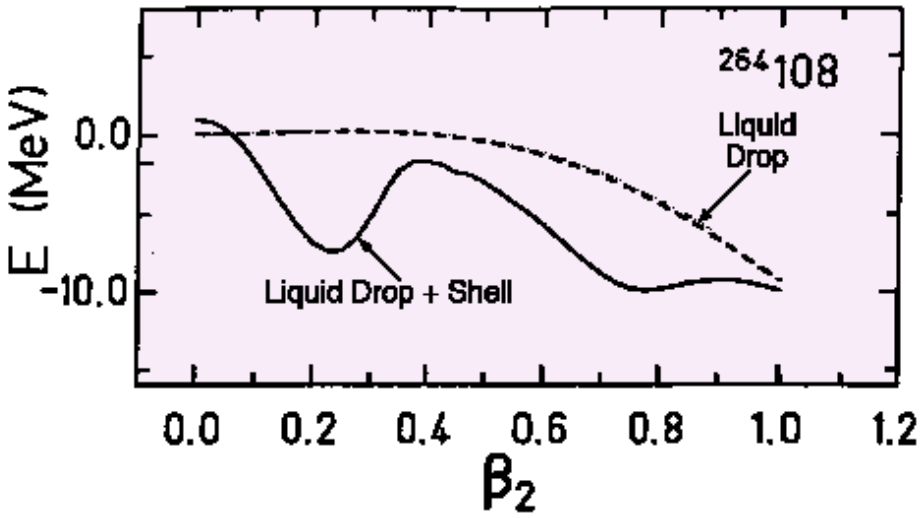
(d) 2- step γ's for $R = I(E_{\gamma 1})/I(E_{\gamma 2}) = S(E_{\gamma 1})/S(E_{\gamma 2})$.





Proton evaporation spectrum from 45Sc(12C,p)56Fe reaction at E(12C)=25 MeV calculated with Hauser-Feshbach model. Courtesy A. Voinov.

S_p = 10.2 MeV, S_n =11.2 MeV.



E=E(LD) + E(shell) + E(pair)

$T_{sf}(exp)/T_{sf}(LD)>10^{13}$

Superheavy nuclei are
at the limits of Coulomb stability;
would fission instantaneously, but

shell-correction energy lowers the ground state, thereby creating a ***barrier against fission.***

How does the shell-energy of superheavy nuclei damp with U?

- ρ in trans-actinides, e.g. with ^{244}Pu, ^{246}Cm, ^{249}Cf targets.
- Damping of shell-correction at high E^* → change of ρ.
- Test Ignatyuk damping parameter γ.

$a = a_0\{1 + \delta E^*[1 - \exp(-\gamma E)]/E\}$

- Is γ the same for all nuclei?

Common assumption is yes, but probably incorrect. Recent calculations based on density functional theory says "no".

- Needs data to test.

(n,γ) in n-rich nuclei, e.g. ^{132,133}Sn, via surrogate reactions with RIBs

- S_n low, <~4 MeV, few bound states.
- Is decay statistical? Yes for initial state above S_n, but to finite number states.
- P?
- S_γ?
- No data
- Important for r-process.

Speculation on why hot nuclei become spherical after pair damping

- Heretic view: pairing helps drive nucleus towards deformation.
- Pair gap clearly evident in deformed nuclei, indicating pair condensate.
- In spherical nuclei, no pair gap; shell energy from single-particle gaps more important.
- Check $E_{\text{pair correlation}}$.
- Hence, loss of pairing → loss of deformation.

Quasicontinuous strength in Pygmy Dipole Resonance

- Large; what fraction of sum rule?
- Not described by theory?

- Summary of trends in Workshop
- A few topics, then pose a set of **questions** of different topics & invite responses.
- ρ & S_γ are fundamental nuclear properties. Why are they not better defined after so many years of nuclear physics? What would it take to properly define them?
- B_f ^{254}No
- Examples of some experiments from CARIBU.
- N capture surrogate reaction in n-rich nuclei via surrogate reactions, e.g. (d,p)
- S_n ~4 MeV; different S_γ, ρ? Resonances, direct reactions more prevalent?
- 2-photon sum: S_γ, ρ spectrscopy
- EXILL Exogam@ILL opportunities