G.M. Tveten

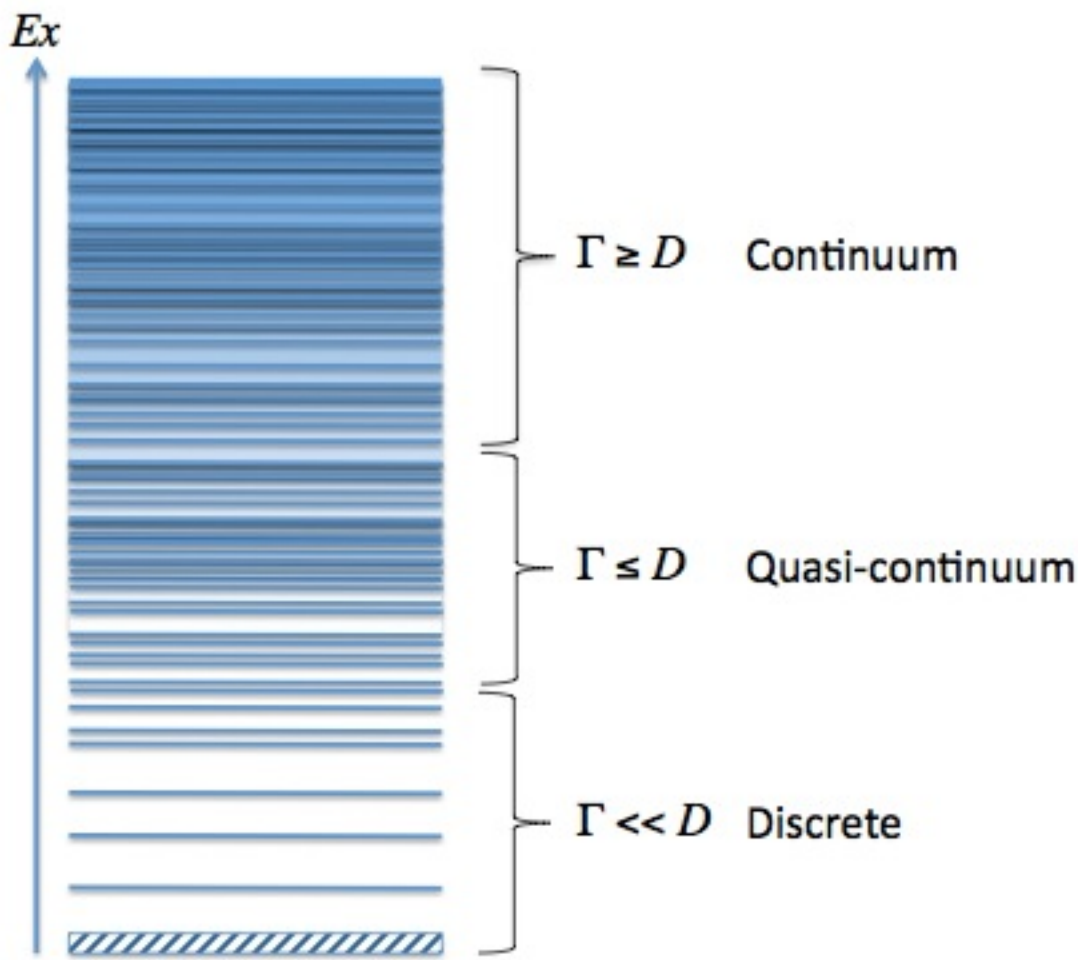
Post doc

Presented at the 5th Workshop on Nuclear Level Density and Gamma Strength Oslo, May 18 - 22, 2015

UiO : Department of Physics
University of Oslo

THE OSLO METHOD

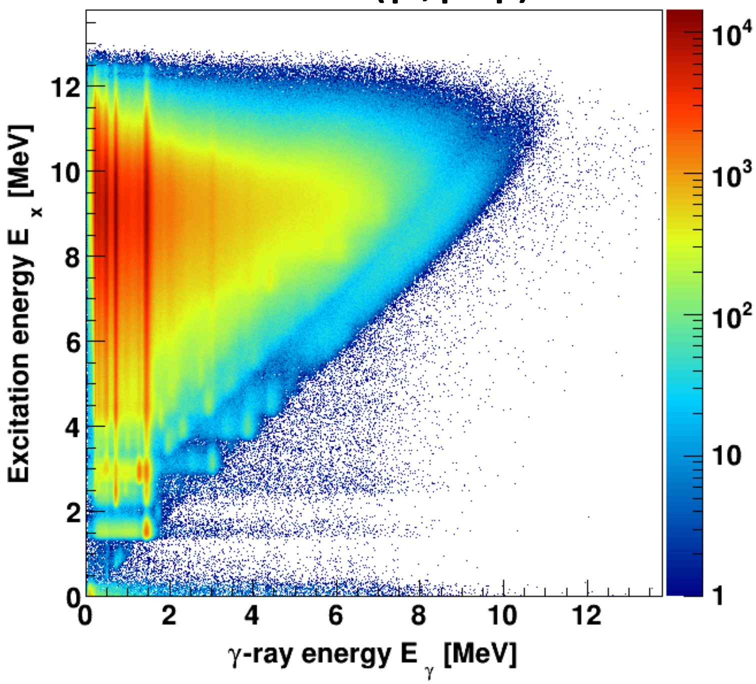
The quasi-continuum region



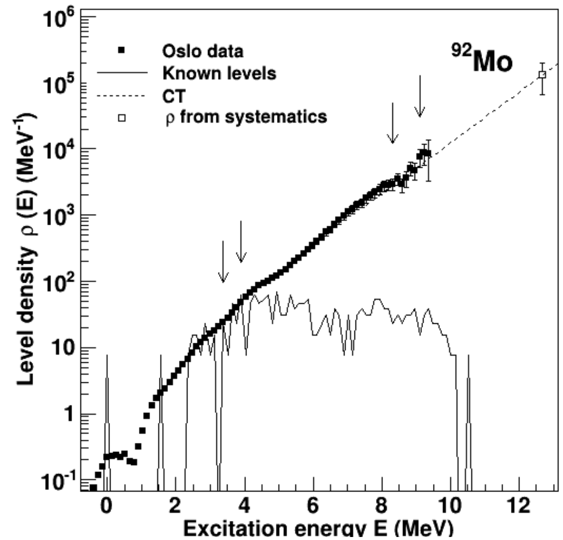
M. Guttormsen et al.: Experimental level densities of atomic nuclei

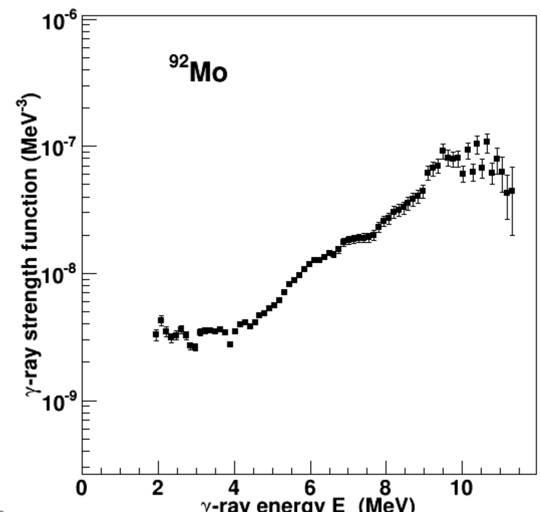
Simultaneous extraction of the functional form of the level density and γ strength function

Particle-γ coincidences from ^{92}Mo(p,p'γ)



Oslo method



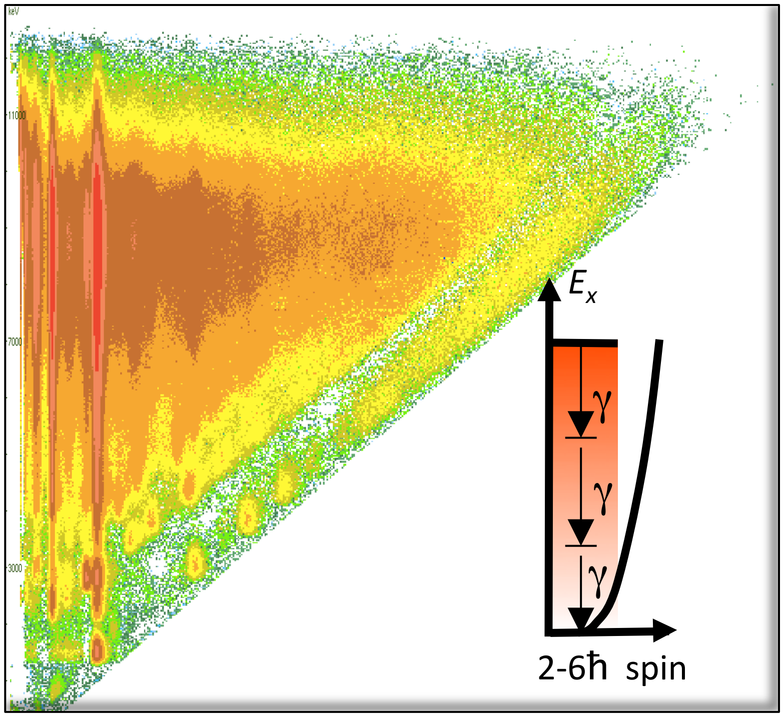


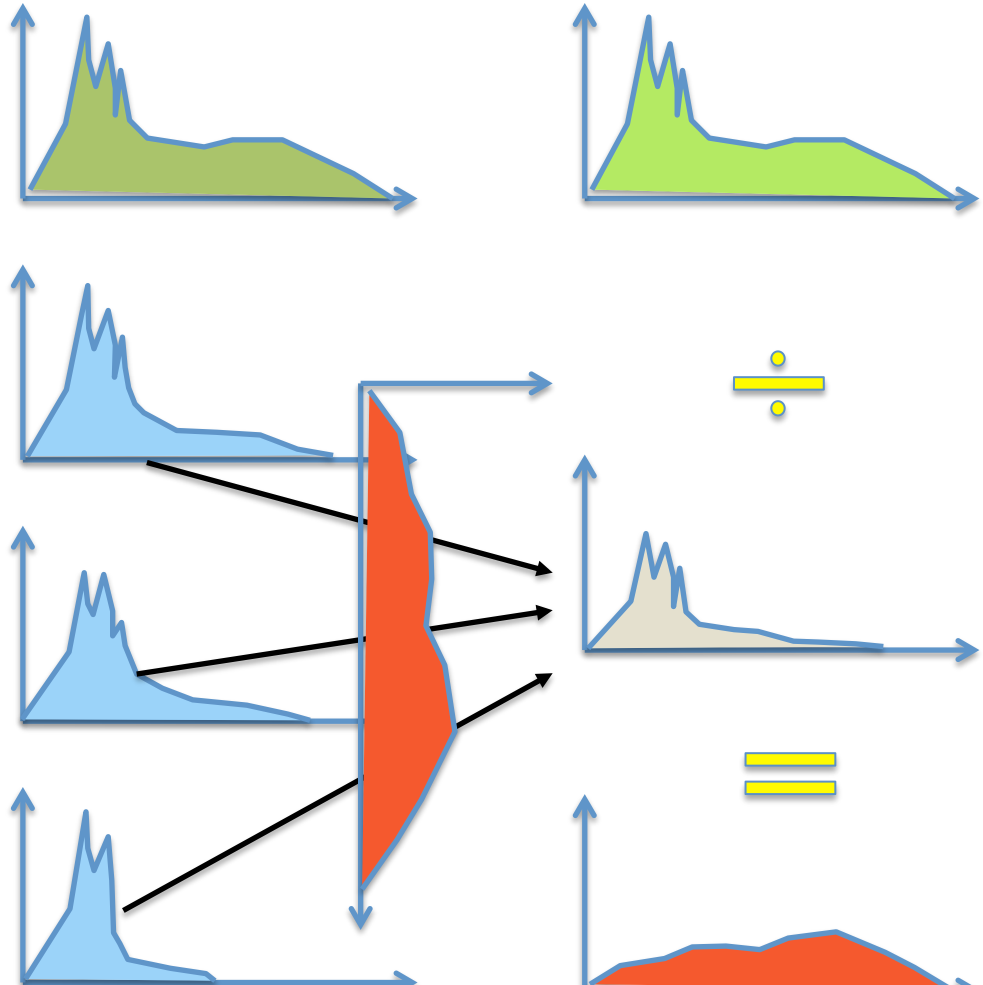
The Oslo method step-by-step

1. Run experiment and obtain particle-γ coincidences
2. Unfold spectra with detector respons
3. Extract first-generation matrix
4. Extract level density and gamma strength functional forms from first-generation matrix
5. Normalize results to other data

From total to primary γ-ray matrix

^{92}Mo(p,p')



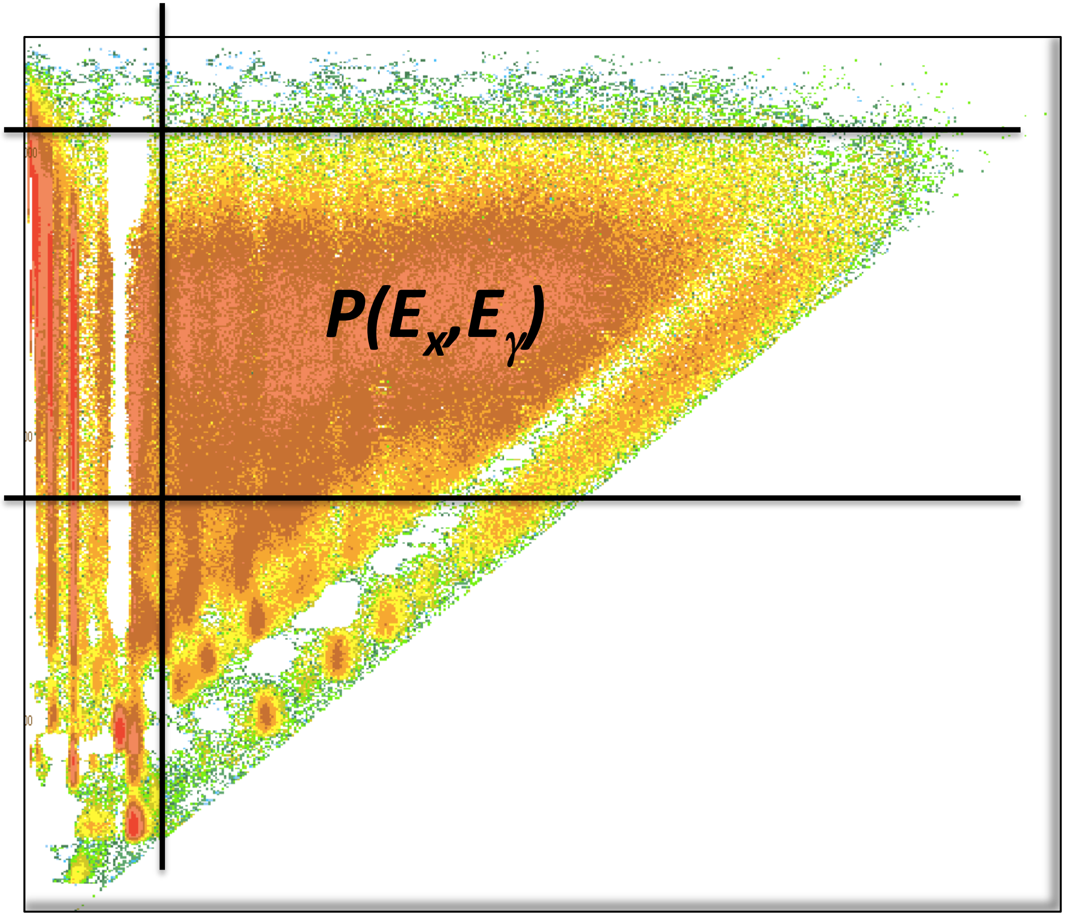


$$F^E(E_\gamma) = U^E(E_\gamma) - \sum_{E'<E} w_{E'} U^{E'}(E_\gamma)$$

M. Guttormsen et al, Phys. Scr. T32, 54 (1990)

Illustration courtesy of: M. Guttormsen

Primary γ-ray matrix

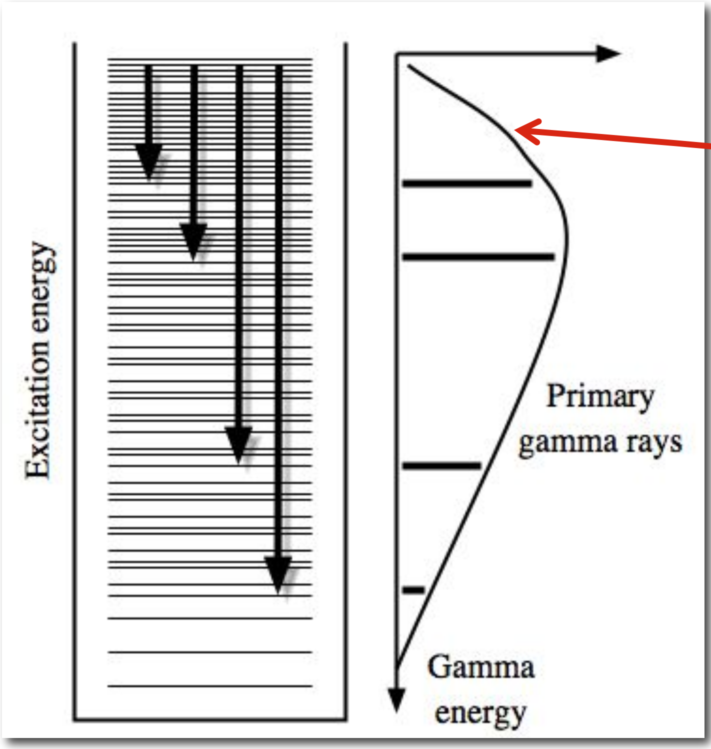


$P(E_x,E_\gamma)$

Level density $\rho(E_f)$

Trans. coeff. $T(E_\gamma)$

Multiplicative factors



$$\lambda = \frac{2\pi}{\hbar}\left|M_{if}\right|^2 \cdot \rho(E_f)$$

Fermi's golden rule

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

Brink hypothesis

Slides: M. Guttormsen

Normalization:

We have infinitely many functions that reproduce the first generation matrix[1]:

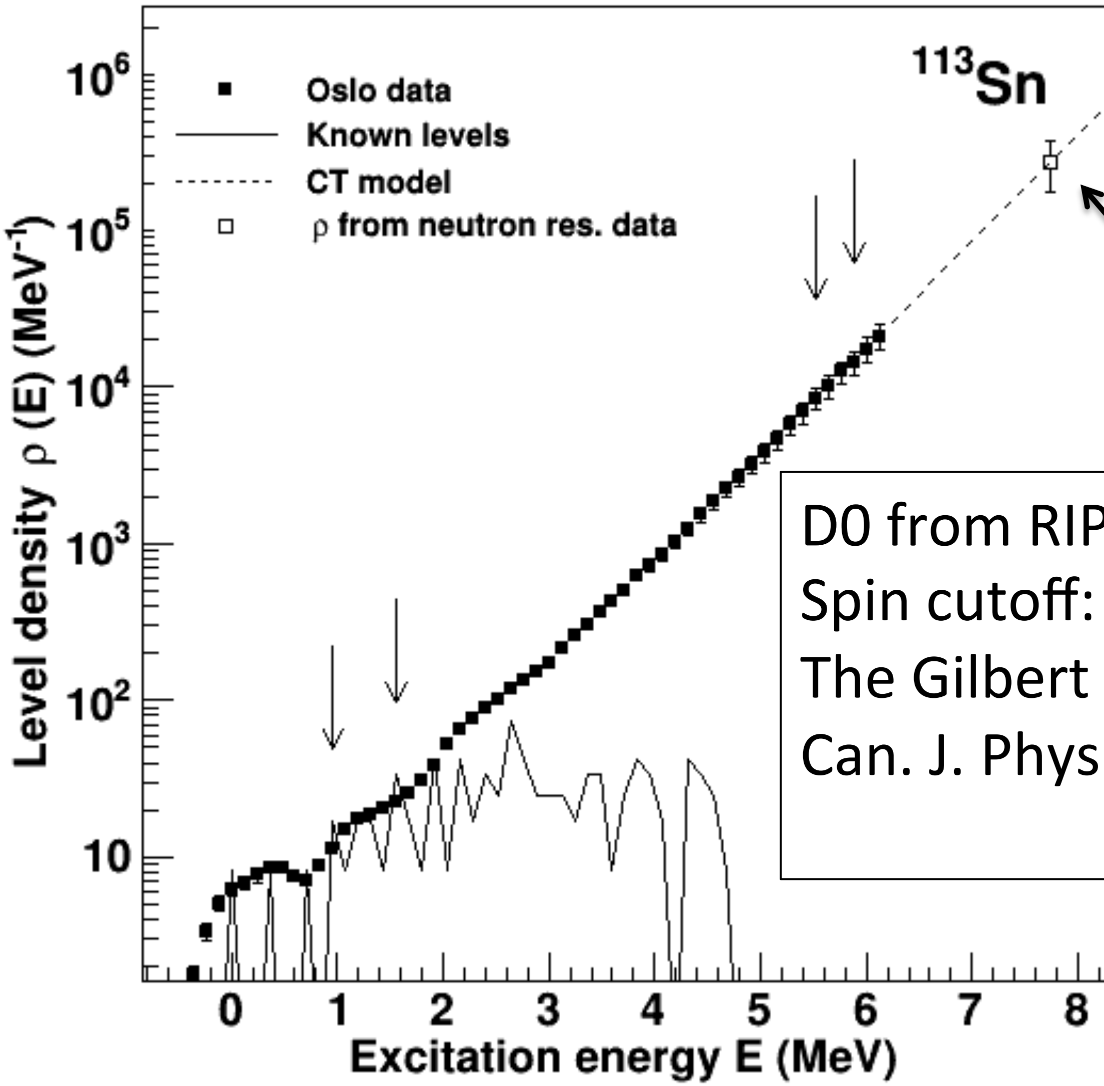
$$\begin{aligned}\tilde{\rho}(E_i - E_\gamma) &= A\exp[\alpha(E_i - E_\gamma)]\,\rho(E_i - E_\gamma),\\ \tilde{\mathscr{T}}(E_\gamma) &= B\exp(\alpha E_\gamma)\,\mathscr{T}(E_\gamma).\end{aligned}$$

When available, we find the constants A and α by reproducing the level density at the neutron separation energy. We assume the following spin distribution[2]:

$$g(E,I) \simeq \frac{2I+1}{2\sigma^2}\exp\left[-(I+1/2)^2/2\sigma^2\right]$$

1) A. Schiller et al, NIM A 447, 498 (2000).
2) T. Ericson, Nucl. Phys. A 11, 481 (1959).

Example: ^{113}Sn



D0 from RIPL-3
Spin cutoff:
The Gilbert and Cameron formula (G&C)
Can. J. Phys 43(1965) 1446

Normalization cont.

$$\langle \Gamma_\gamma(S_n, I_t \pm 1/2, \pi_t) \rangle = \frac{B}{4\pi\, \rho(S_n, I_t \pm 1/2, \pi_t)} \int_0^{S_n} dE_\gamma\, \mathcal{T}(E_\gamma)\, \rho(S_n - E_\gamma) \times \sum_{J=-1}^{1} g(S_n - E_\gamma, I_t \pm 1/2 + J).$$

Normalization cont.

$$\langle \Gamma_\gamma(S_n, I_t \pm 1/2, \pi_t) \rangle = \frac{B}{4\pi \, \rho(S_n, I_t \pm 1/2, \pi_t)} \int_0^{S_n} dE_\gamma \, \mathcal{T}(E_\gamma) \, \rho(S_n - E_\gamma) \times \sum_{J=-1}^{1} g(S_n - E_\gamma, I_t \pm 1/2 + J).$$

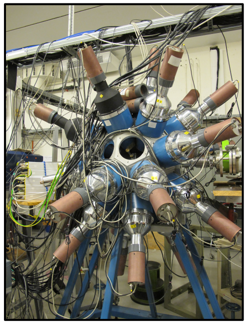
$$g(E,I) \simeq \frac{2I+1}{2\sigma^2} \exp\left[-(I+1/2)^2/2\sigma^2\right]$$

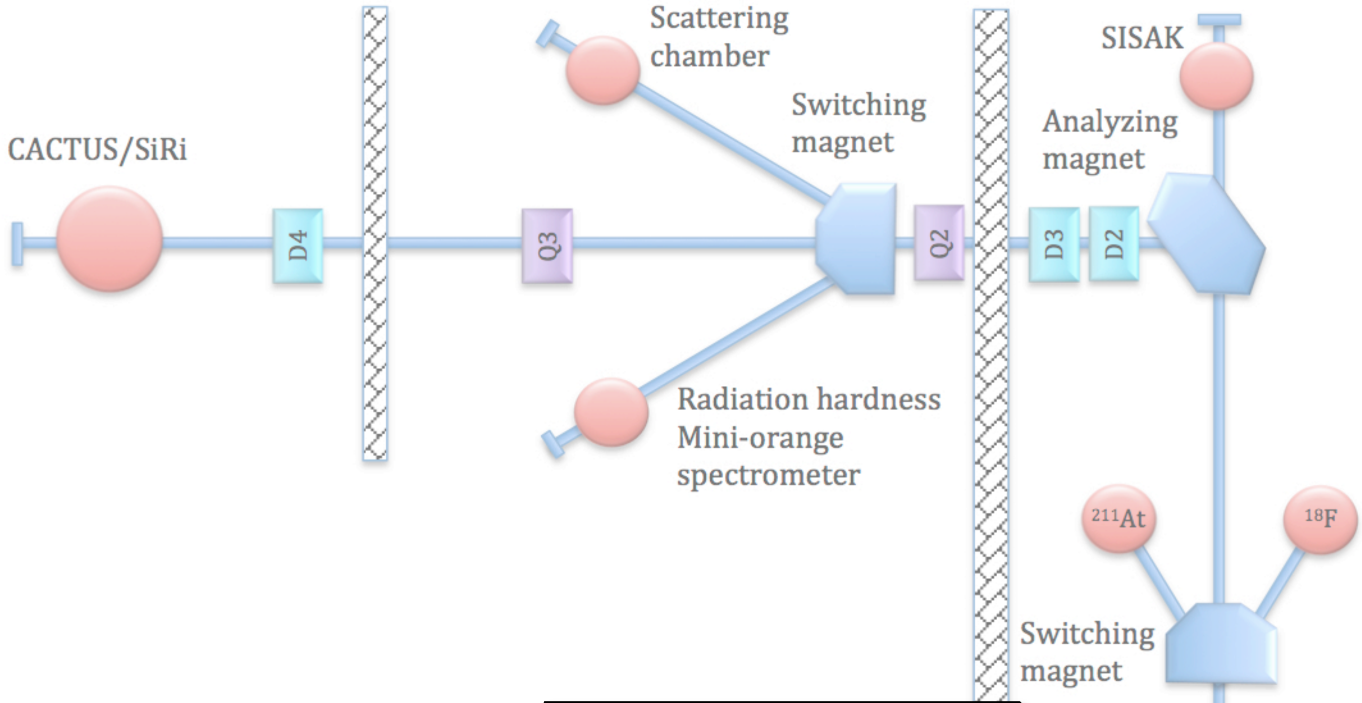
Finally, we assume dipole transitions to dominate:

$$f(E_\gamma) = \mathcal{T}(E_\gamma)/2\pi E_\gamma^3$$

EXPERIMENTAL SETUP AT OSLO CYCLOTRON LABORATORY

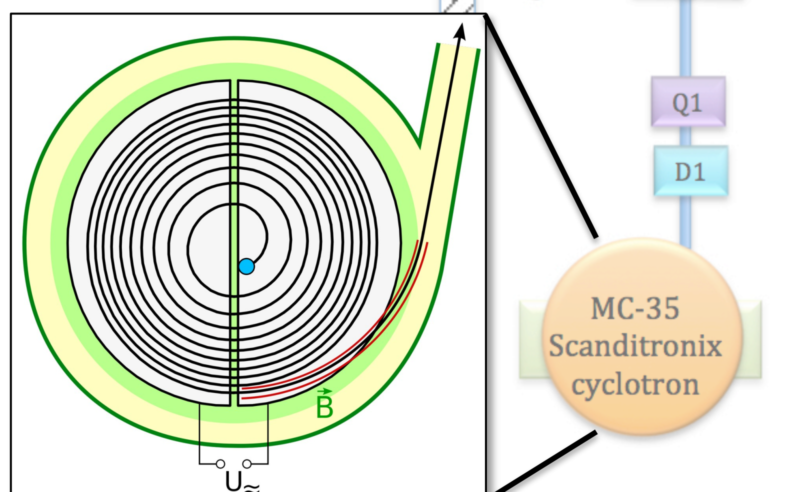
The infrastructure at the Oslo Cyclotron Laboratory



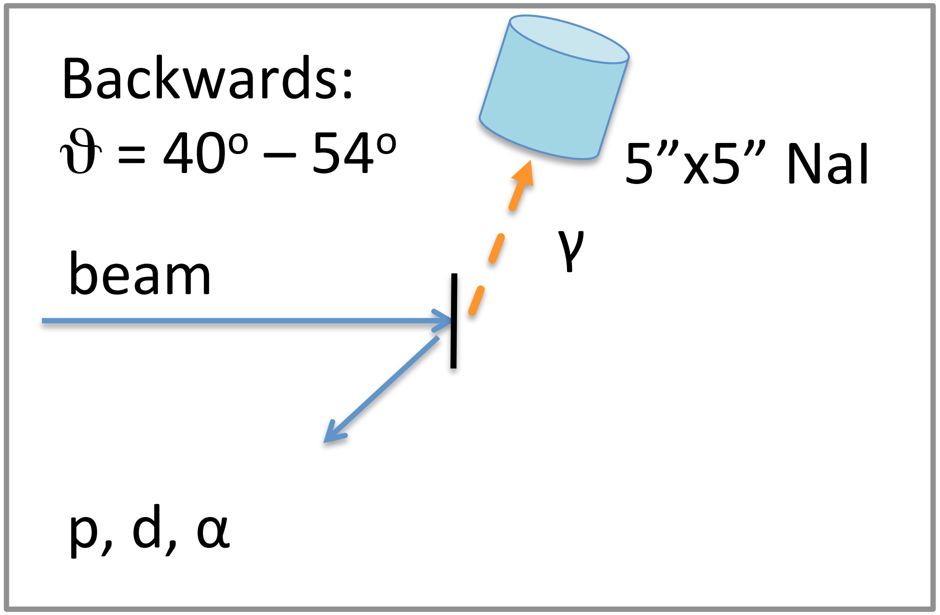


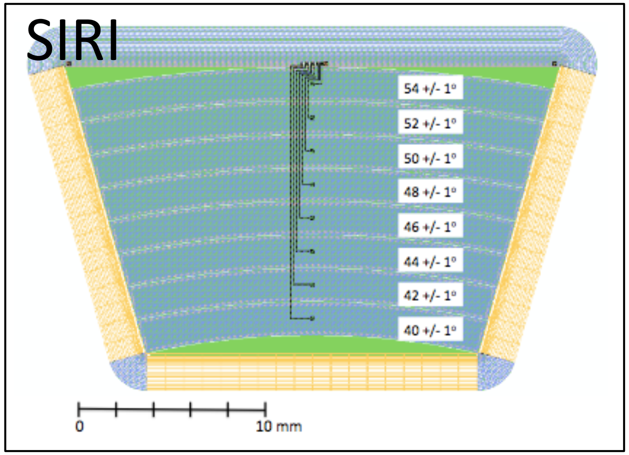
Ionized beams

Particle type	Energy (MeV)
Proton	2 – 35
Deuteron	4 – 18
^{3}He	6 – 47
^{4}He	8 – 35

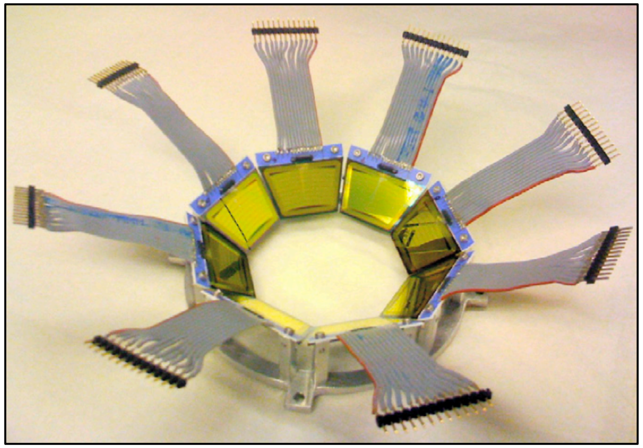


p, d, 3He, alpha





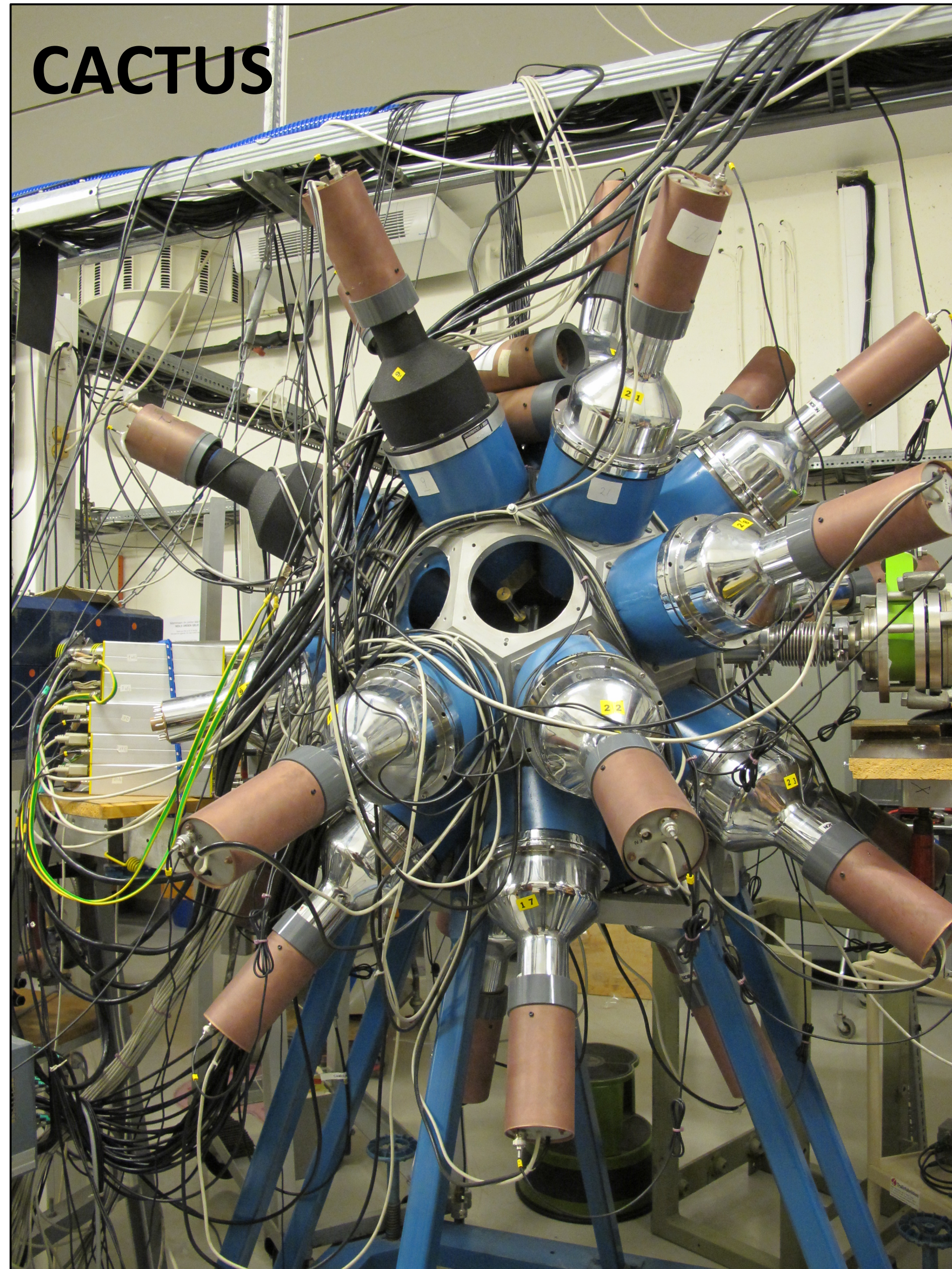
M. Guttormsen et al., NIM **A648** (2011)168



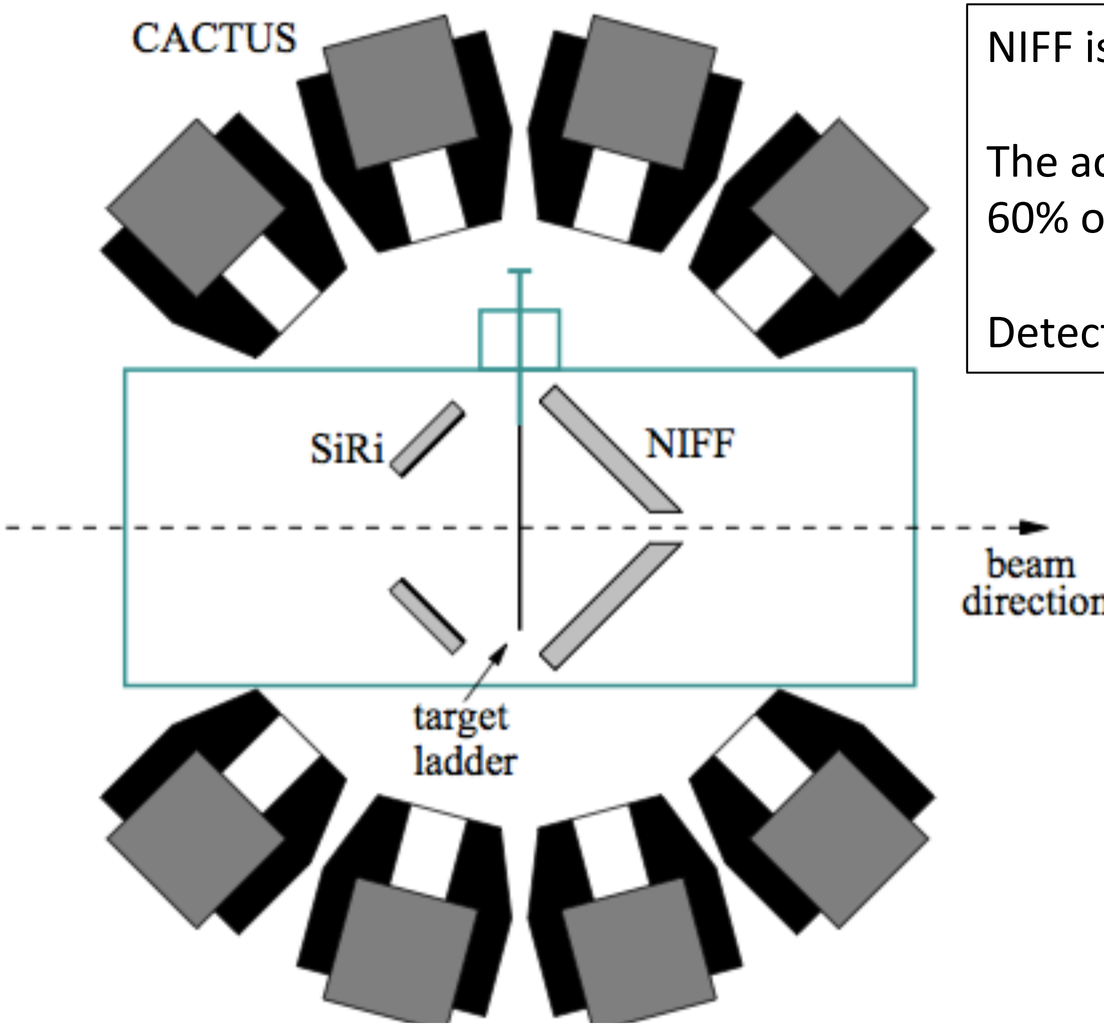
Facts:

25 NaI(Tl) scintillators
full-energy peak efficiency of 15% at 1.3 MeV

(2 $LaBr_3$ scintillators)



Newest addition: Fission-fragment detector (NIFF)



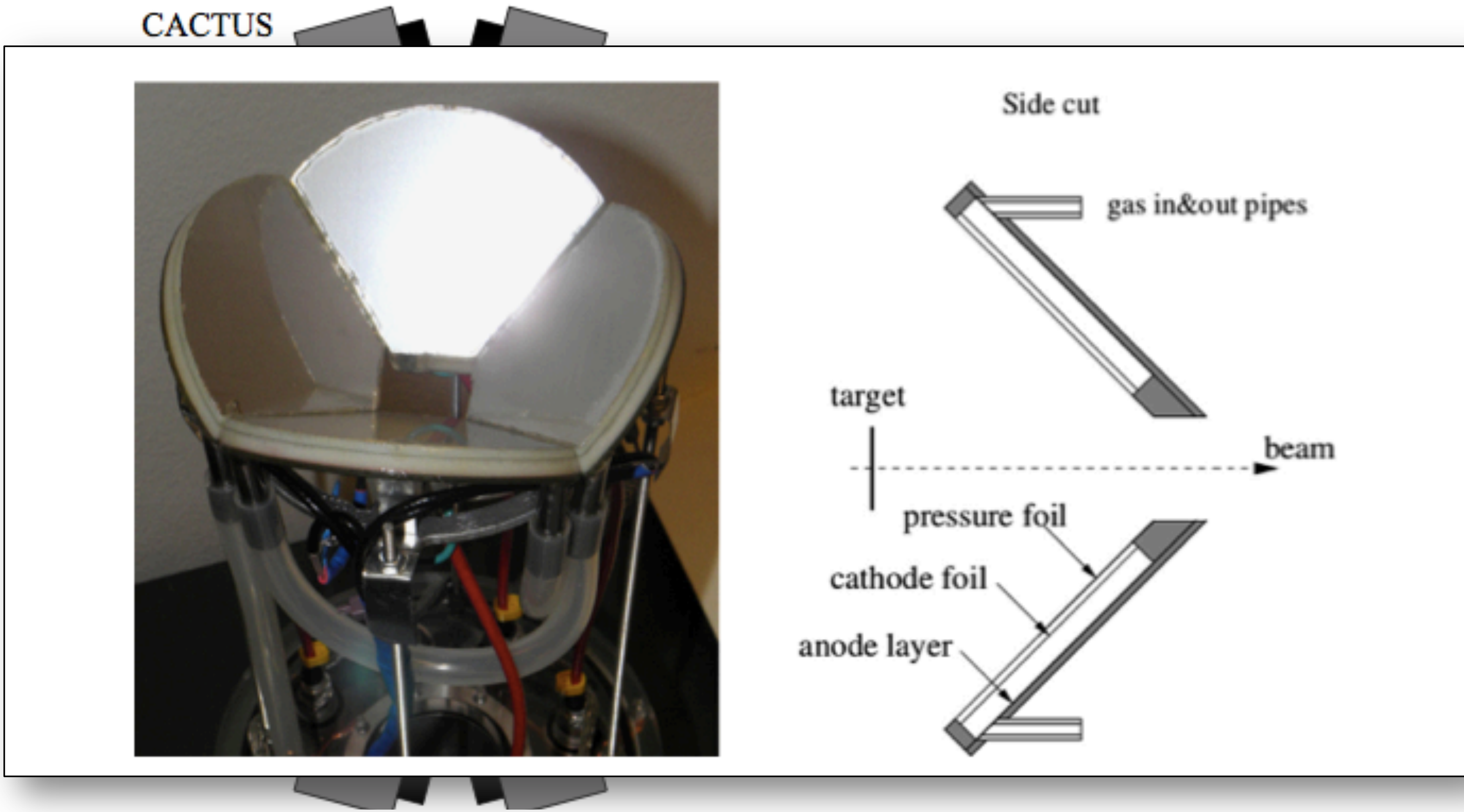
T.G. Tornyi et al. / Nuclear Instruments and Methods in Physics Research A 738 (2014) 6–12

NIFF is a PPAC detector.

The active area of NIFF covers about 60% of the forward hemisphere.

Detection efficiency higher than 90 %.

Newest addition: Fission-fragment detector



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SOME RECENT RESULTS FROM OCL

Session		**Monday**		**Tuesday**		**Wednesday**		**Thursday**		**Friday**
	08:30	Registration	08:30	Coffee	08:30	Coffee	08:30	Coffee	08:30	Coffee
1st		Chair: S. Siem		Chair: A. Görgen		Chair: A.C. Larsen		Chair:		Chair:
	09:15	Opening	09:00	L. Moretto	09:00	T. Renstrøm	09:00	F. Gunsing	09:00	R. Firestone
	09:30	P. von Neumann-Cosel	09:30	T. Døssing	09:30	M. Wiedeking	09:30	Q. Ducasse	09:30	A. Voinov
	10:00	J. Cizewski	10:00	Y. Alhassid	10:00	R. Schwengner	10:00	J. Ullmann	10:00	F. Crespi
	10:30	A. Zilges	10:30	L.A. Bernstein	10:30	A. Tonchev	10:30	M. Lebois	10:30	P. Stevenson
	11:00	Coffee	11:			ee	11:00	Coffee	11:00	Coffee
2nd		Chair: M. Guttormsen		Cha		etto		Chair: D.L. Bleuel		Chair: M. Wiedeking
	11:30	A. Spyrou	11:30	G. Bertsch	11:30	E. Litvinova	11:30	T. Laplace	11:30	D.L. Bleuel
	12:00	G.M. Tveten	12:00	V. Zelevinsky	12:00	N. Tsoneva	11:50	F. Zeiser	12:00	Z. Podolyak
	12:30	B.V. Kheswa	12:30	V. Derya	12:30	O. Achakovskiy	12:10	S. Rose	12:30	P. Jones
							12:30	S. Åberg	13:00	End of Conference
							13:00	J. Vujic		
	13:00	Lunch	13:00	Lunch	13:00	Lunch, photo	13:30	Lunch	13:00	Lunch
3rd		Chair: E. Sahin		Chair: L.A. Bernstein		Chair: A. Zilges	15:00 17:00	Excursion, Oscarshall		
	14:00	S. Valenta	14:00	N. Cieplicka	14:00	M. Krtička				
	14:30	D. Filipescu	14:30	S. Grimes	14:30	V. Plujko				
	15:00	M. Spieker	15:00	L. Crespo-Campo	15:00	T. Belgya				
	15:20	S. Pickstone	15:20	L. Ne		geanu				
	15:40	Y. Byun	15:40	M. Av						
	16:00	Coffee	16:00	Coffee	16:00	Coffee				
4th		Chair: L.A. Bernstein		Chair: L. Moretto		Chair: R. Firestone				
	16:30 18:00	Discussions, IAEA data	16:30 18:00	Discussions on level density	16:30 18:00	Discussions on gamma strength				
	18:00 21:00	Poster Session, tapas and wine					17:45 23:00	Conference Dinner		

Upbend in Ge?

Actinides

Ni-isotopes

Level densities are well described by the constant temperature model

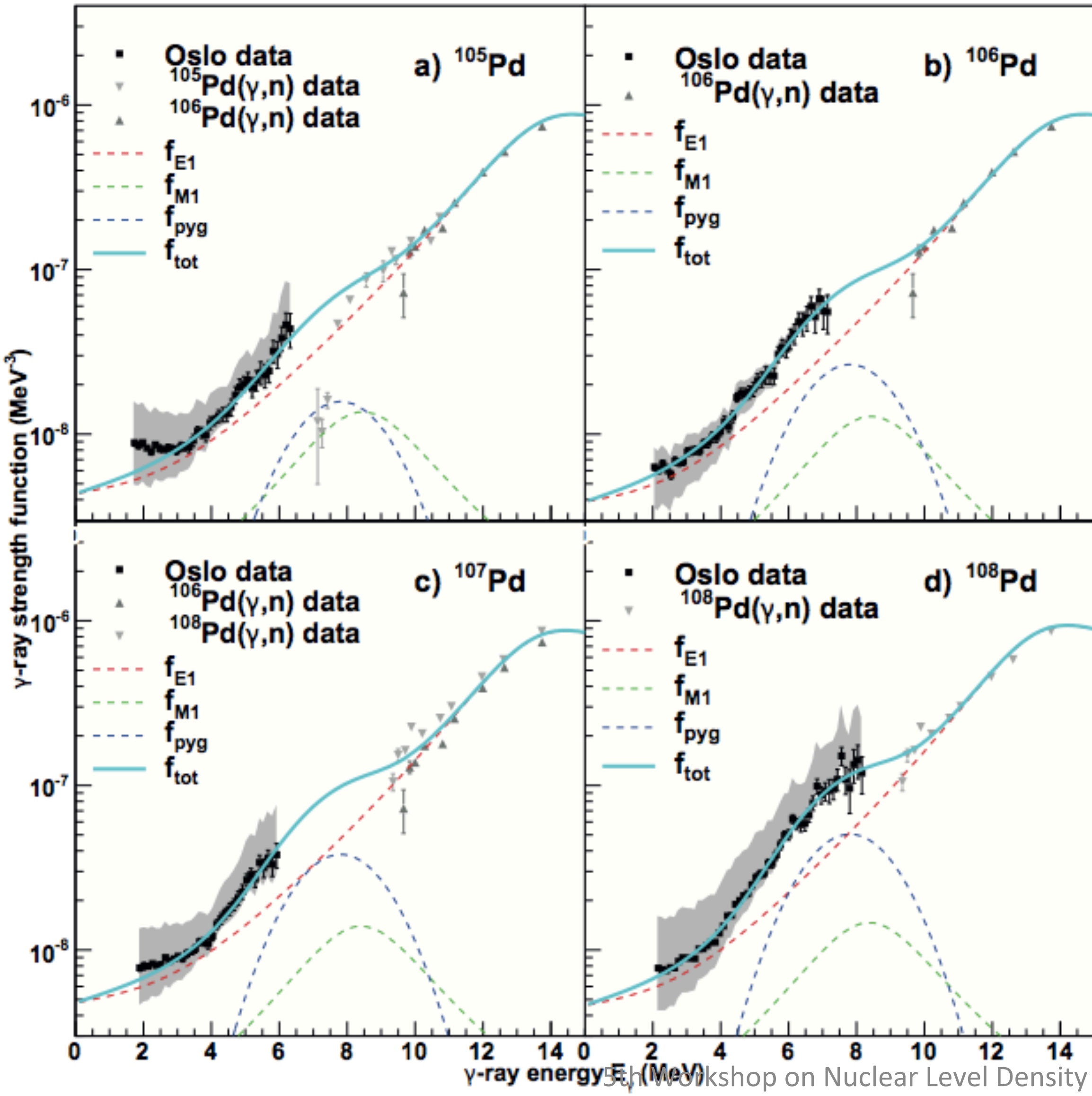
Table 1. Parameters to describe the level density.

Reaction	S_n (MeV)	T_{CT} (MeV)	E_0 (MeV)	$\rho(S_n)$ (10^6MeV^{-1})
$(p,p')^{45}$Ti	9.530	1.55	-2.33	0.0014(7)
$(d,p)^{46}$Ti	13.189	1.70	-2.07	0.0047(10)
$(p,p')^{89}$Y	11.478	1.00	0.48	0.060(20)
$(d,p)^{90}$Y	6.857	1.00	-1.38	0.0038(8)
$(^3$He,$\alpha)^{116}$Sn	9.563	0.76	-0.03	0.40(20)
$(^3$He,^{3}He$')^{117}$Sn	6.944	0.67	-0.40	0.091(27)
$(^3$He,$\alpha)^{163}$Dy	6.271	0.59	-1.55	0.96(12)
$(^3$He,^{3}He$')^{164}$Dy	7.658	0.60	-0.66	1.74(21)
$(d,p)^{238}$Np	5.488	0.41	-1.35	43.0(78)

$$\rho(E) = \frac{1}{T}\exp\left(\frac{E - E_0}{T}\right)$$

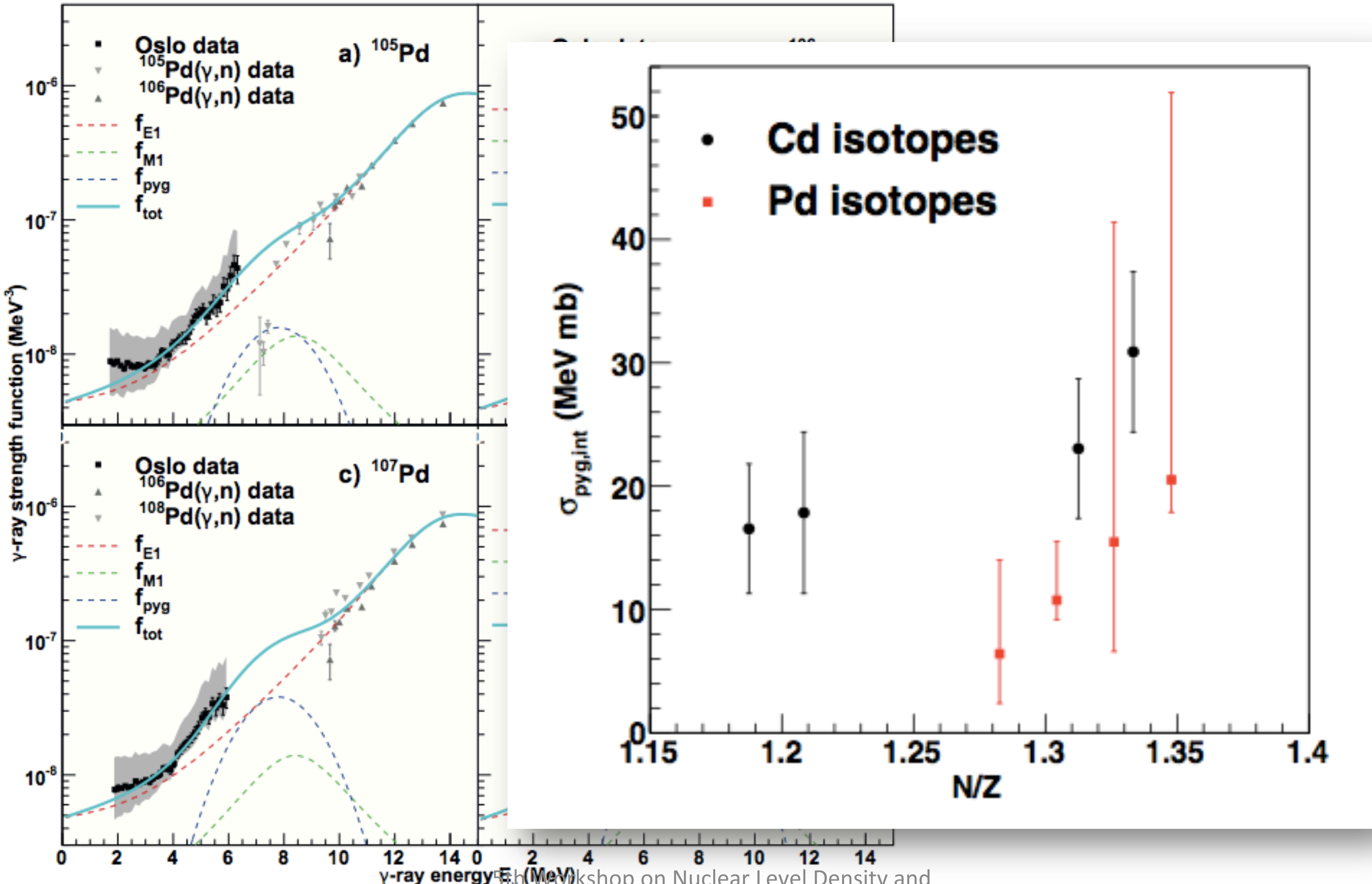
M. Guttormsen et al.: Experimental level densities of atomic nuclei

Pygmy resonance and low-energy enhancement in the γ -ray strength functions of Pd isotopes



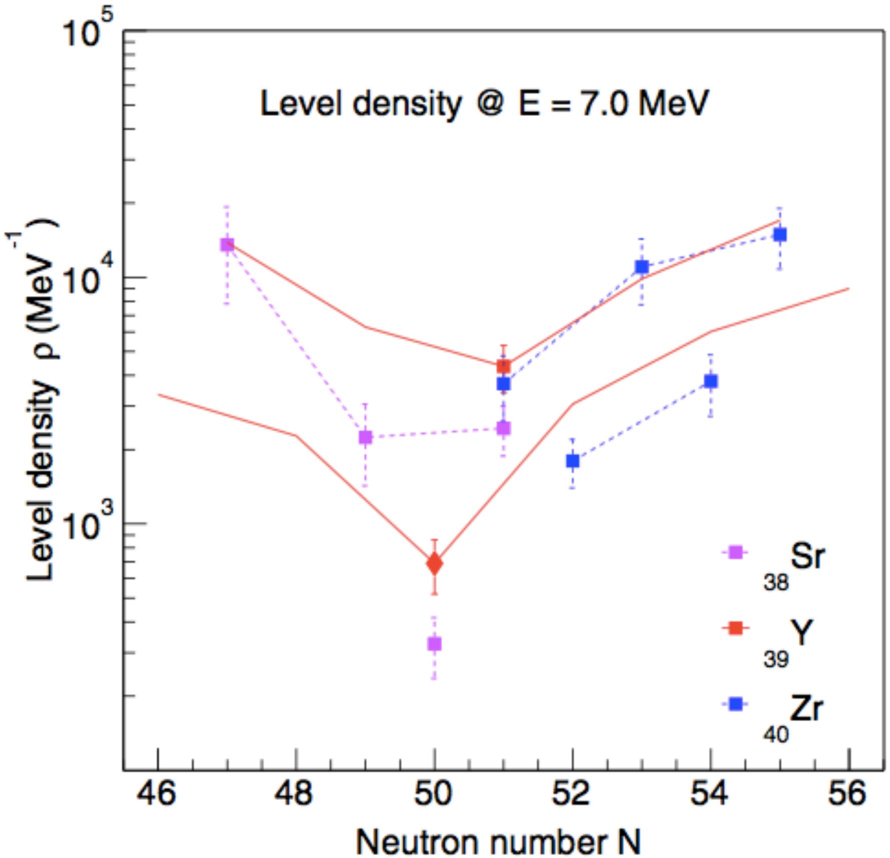
T. Eriksen et al.,PRC 90, 044311 (2014)

Pygmy resonance and low-energy enhancement in the γ -ray strength functions of Pd isotopes



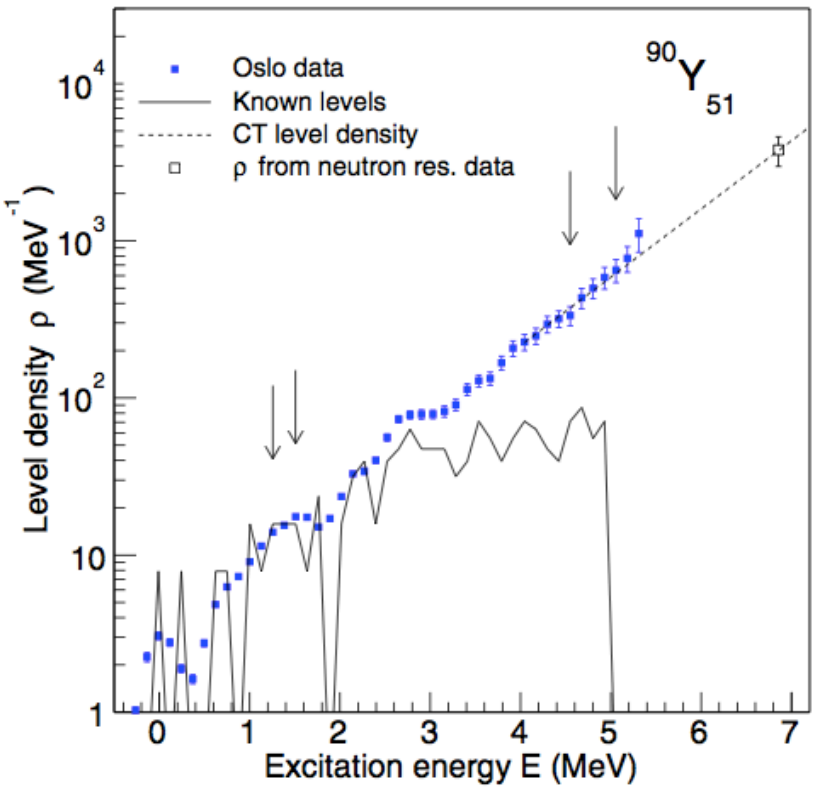
T. Eriksen et al.,PRC 90, 044311 (2014)

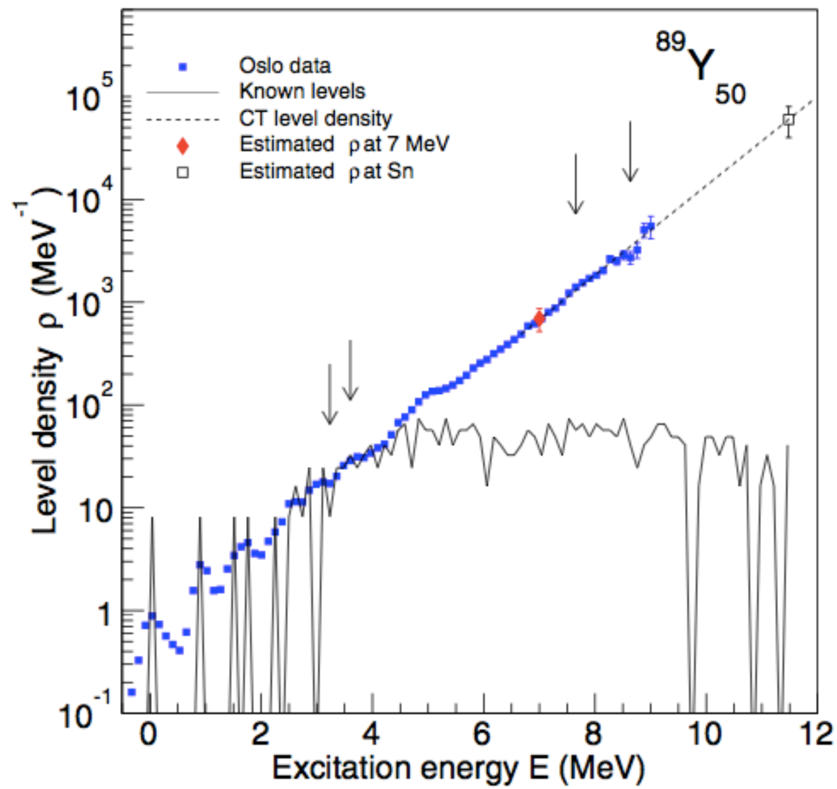
Shell-gap-reduced level densities in ^{89,90}Y



M. GUTTORMSEN *et al.* PHYSICAL REVIEW C **90**, 044309 (2014)

Shell-gap-reduced level densities in $^{89,90}Y$





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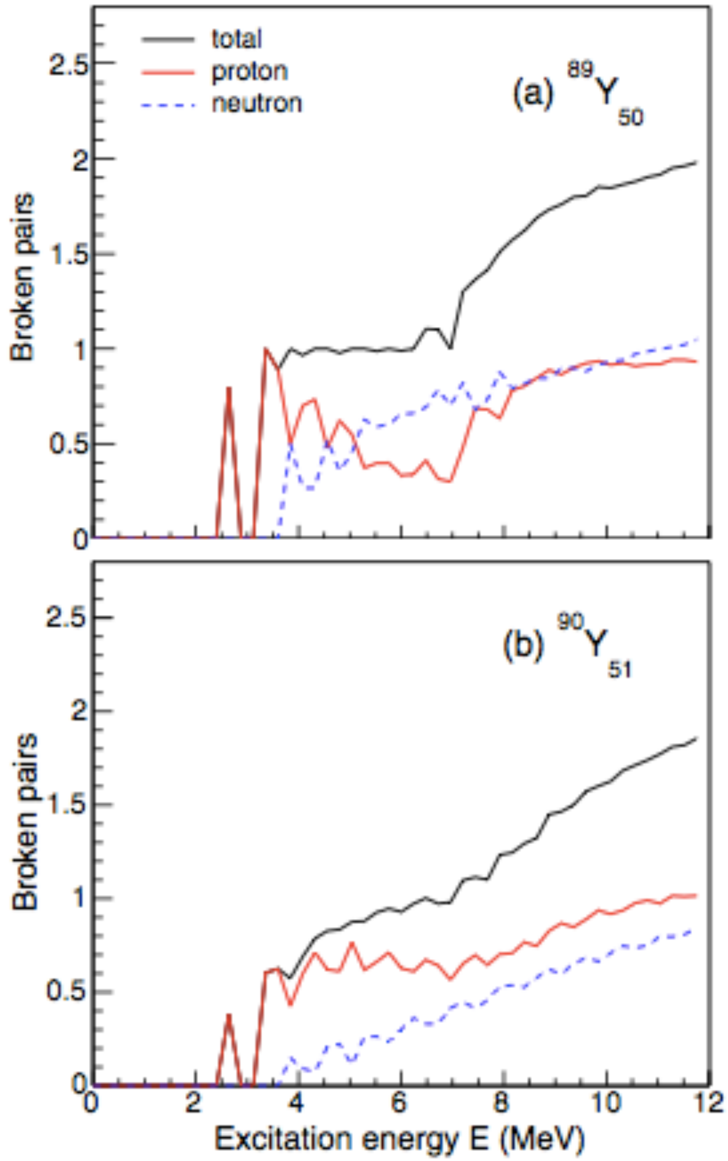
Pairing



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^{92}Mo

^{92}Mo: Motivation

- N = 50 shell closure effects
- Astrophysical production and destruction of ^{92}Mo

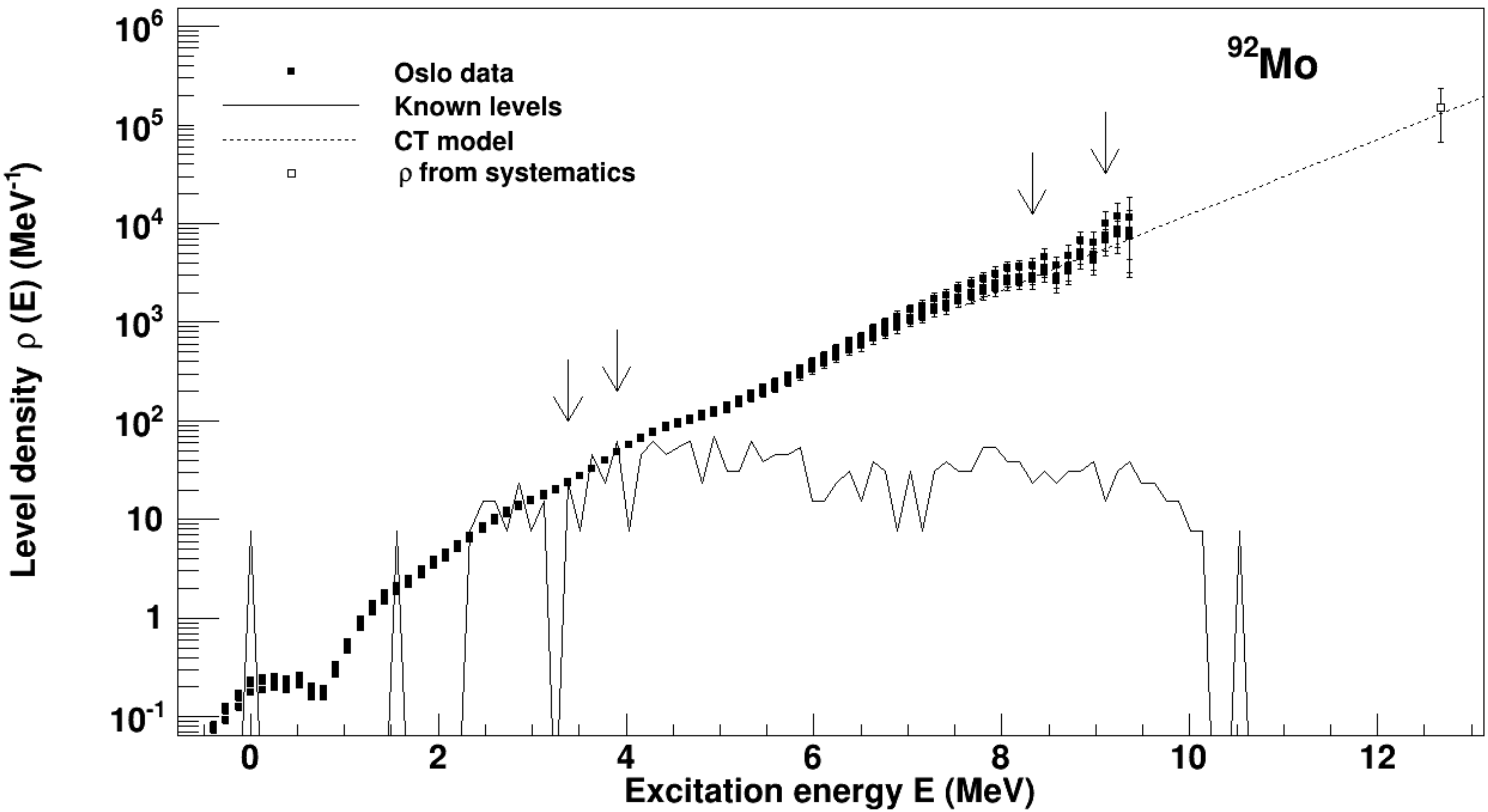
^{92}Mo: Motivation

- N = 50 shell closure effects
- **Astrophysical production and destruction of ^{92}Mo**

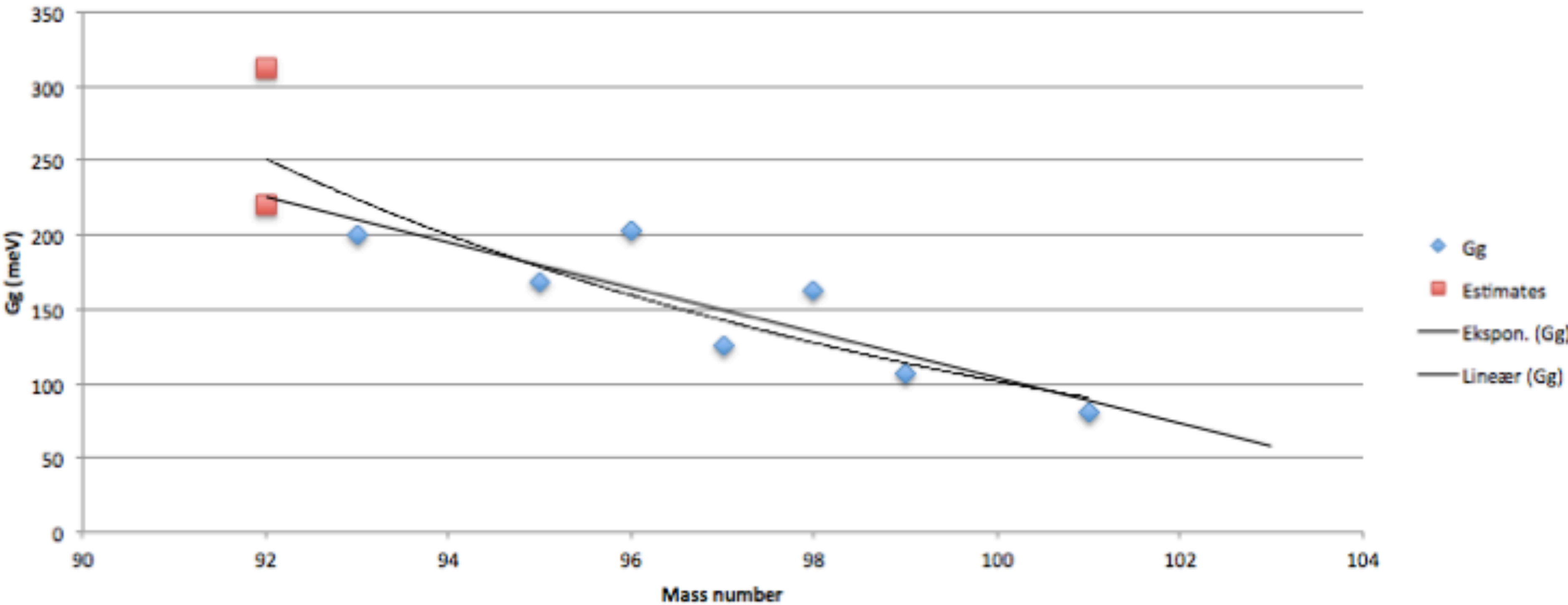
Input used to normalize the NLD

- Systematics for the Mo-isotopes
- Systematics for N=50 isotopes
- Microscopic calculations from GHK 08

Preliminary results: NLD for ^{92}Mo

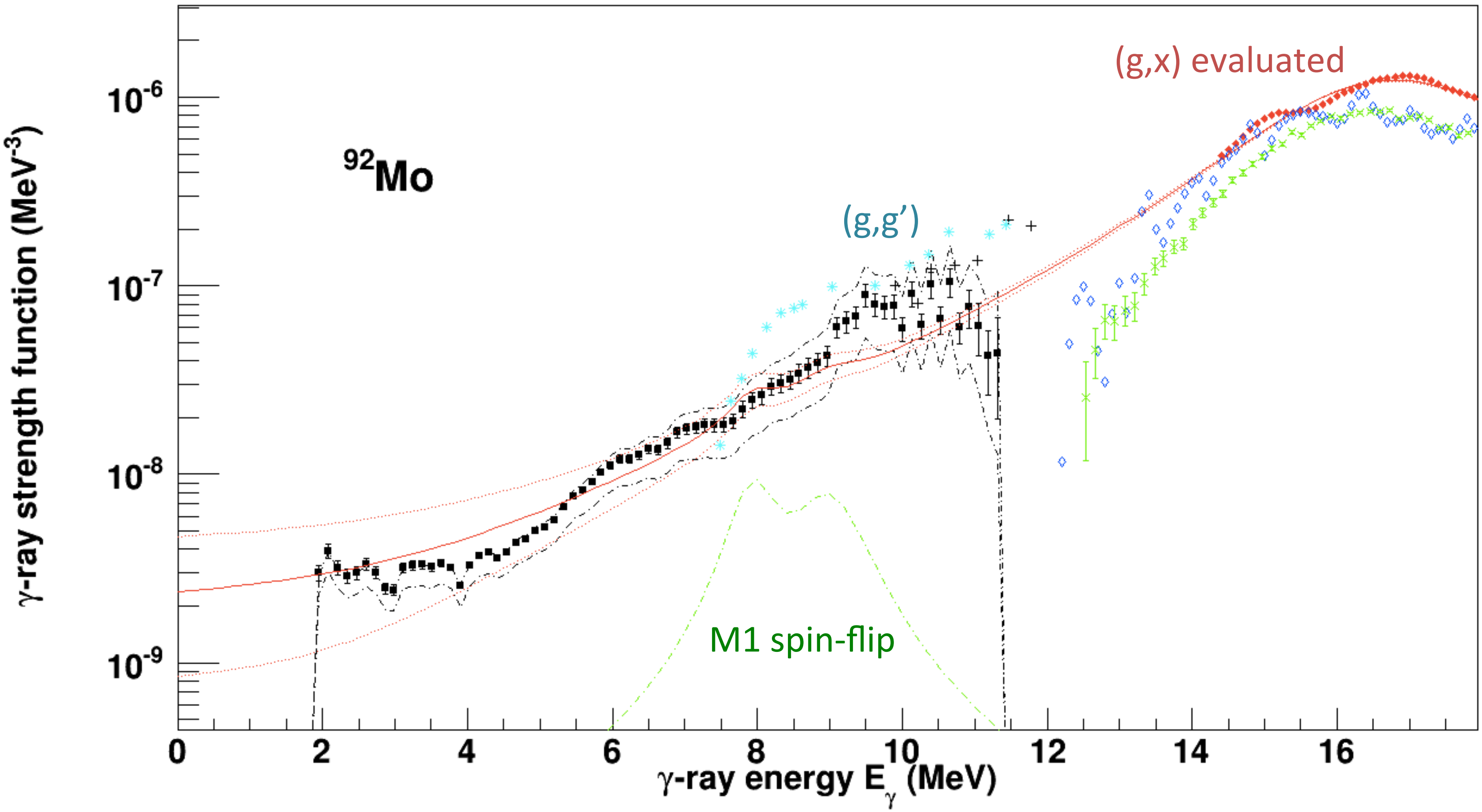


Estimating G0 from systematics



Spin distribution from microscopic calculations of GHK08

Preliminary results: GSF for ^{92}Mo



QUESTIONS?
THANKS FOR YOUR ATTENTION.