5th Workshop on Nuclear Level Density and Gamma Strength

Oslo, May 18 - 22, 2015

Pete Jones

iThemba LABS, South Africa

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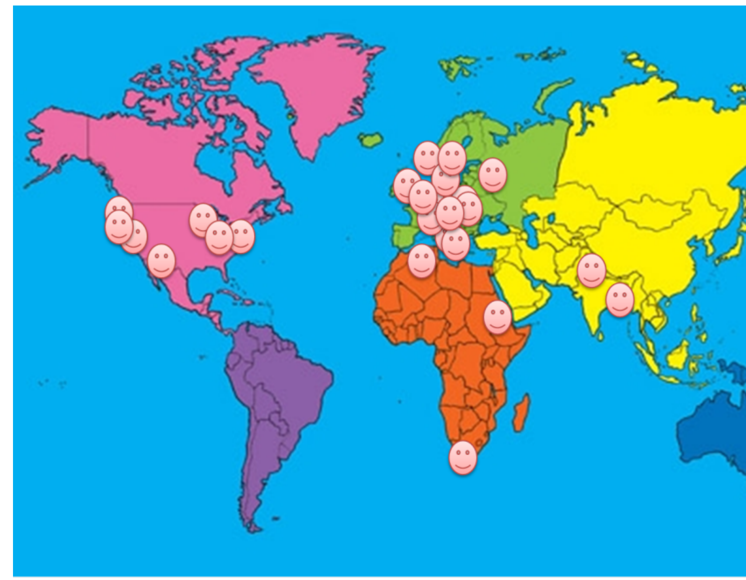
Abstract

- The 5th Workshop on Level Density and Gamma Strength was held at the University of Oslo, May 18-22 2015
- Attended by over 60 leading scientists in the field from ~30 institutes in ~15 countries



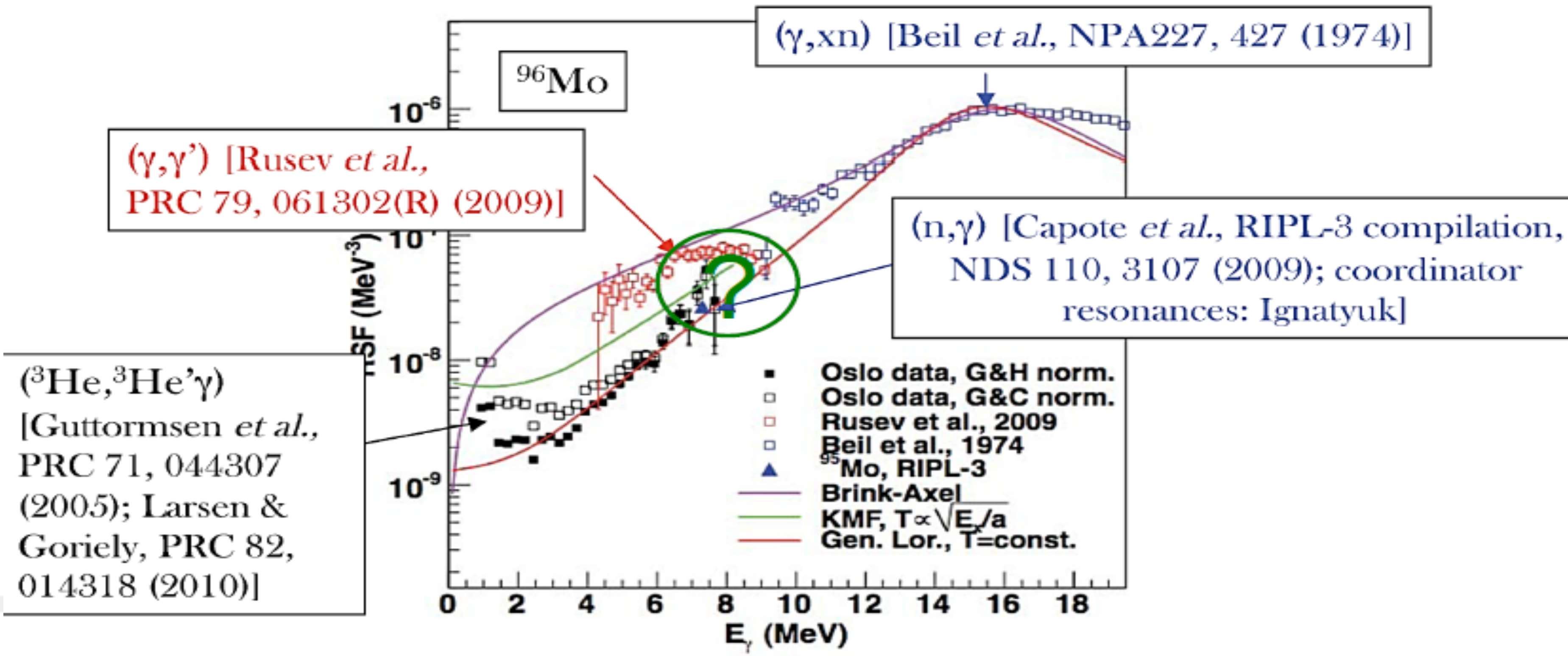
- The scientific program included talks, and poster presentations, covering the following topics:
  - Nuclear level density
  - Gamma-ray strength function
  - Phase transitions in mesoscopic systems
  - Applications in astrophysics and reactor physics
  - Other related topics
- As in previous Oslo Workshops (2007, 2009, 2011, 2013), the program allowed for ample time for discussions

Peter von Neumann-Cosel

Introduction

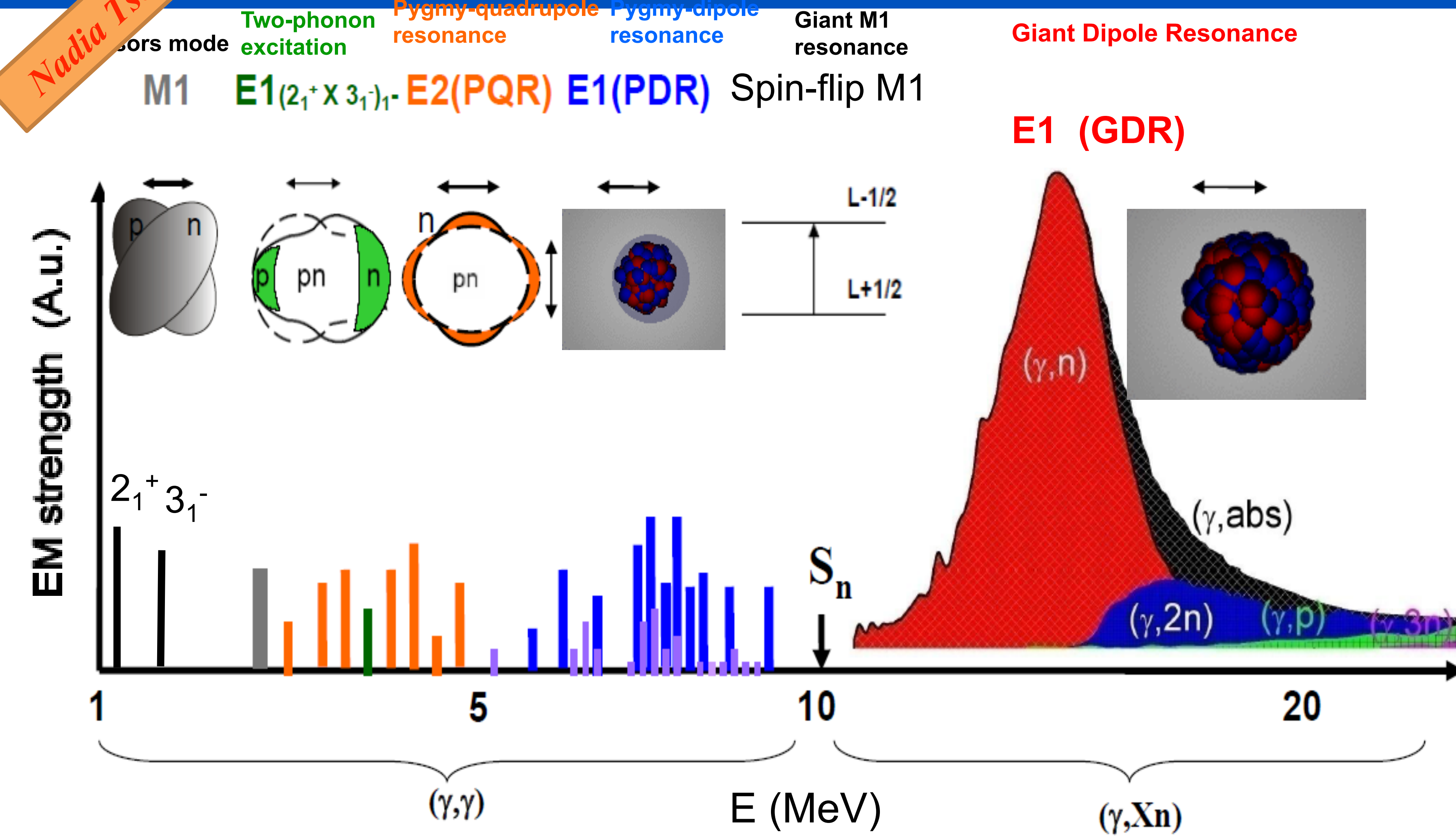
Experimental Discrepancies in GSF: ^{96}Mo

TECHNISCHE UNIVERSITÄT DARMSTADT



Ann-Cecilie Larsen, Workshop on Gamma Strength and Level Density, Dresden-Rossendorf, August 2010

Characteristic Response of an Atomic Nucleus to EM Radiation



Moderate and Heavy nuclei

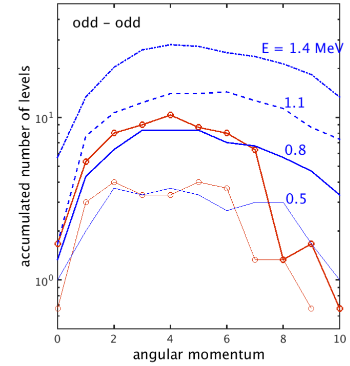
Theoretical prediction of Pygmy Quadrupole Resonance: N. Tsoneva, H. Lenske, Phys. Lett. B 695 (2011) 174.

Thomas Døssing

Theory

Odd-even staggering of level density as function of angular momentum

Summed rho(E,I) – three odd-odd



Comparison of combinatorial level density versus data on counted level densities:

- low excitation energy (up to 2 MeV):

  individual levels within +- 500 keV (typical for single particle potentials)

  fine agreement when averaging over 3 nuclei

  pairing influence well reproduced e-e versus o-o

  odd-even staggering in deformed nuclei well explained: r – symmetry of potential

- intermediate excitation energy (2-4 MeV) transfer resonance data

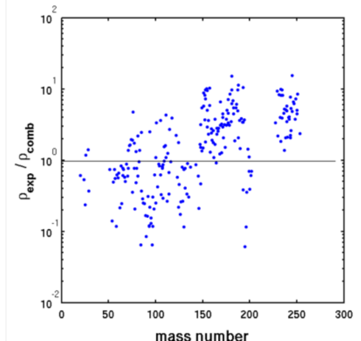
  start to fall behind data – factor 1.5 to 2

- at neutron separation energy (6-7 MeV)

  factor increases – factor of about 4

ρ (S)

For nuclei with |ε| >0.04



ρ

underestimates level density for heavy nuclei

Reconcile RBM and MM

- If

$$\sigma^2(RBM) \propto \sqrt{(U/\alpha)}A^{7/6}$$
$$\sigma^2(MM) \propto \sqrt{U\alpha}A^{1/2} < m^2 >$$

If $< m^2 > \propto A^{\frac{2}{3}}$ the A dependence agrees.

- If we assume $a = A/8$ $(\alpha = 1/8)$ then

$< m^2 >= 0.1985A^{\frac{2}{3}}$ makes MM equivalent to RBM

- p shell $< m^2 > /A^{2/3} = 0.144$
- sd shell $< m^2 > /A^{2/3} = 0.164$
- fp shell $< m^2 > /A^{2/3} = 0.175$
- sdg shell $< m^2 > /A^{2/3} = 0.182$
- This is close to the estimate ab

- Microscopic Model goes to the rigid body model if $< m^2 > \propto A^{\frac{2}{3}}$ a
  $a \propto A$
- Convergence $\sim$ 20 MeV to Rigid Body Model.
- Not yet converged at 6-8 MeV.

A	U (MeV)	σ^2	$\sigma^2/\sigma^2(RBM)$
20	2	1.2	0.6
	4	2.4	0.85
	6	5.9	1.7
	8	7.8	1.96
	10	8.1	1.81
	20	6.96	1.11
30	2	0.97	0.3
	4.0	2.6	0.58
	6	4.2	0.76
	8	5.43	0.85
	10	7.52	1.05
	20	11.0	1.1
40	2	1.36	0.31
	4	5.49	0.87
	6	11.29	1.46
	8	14.1	1.6
	10	16.1	1.7
	20	15.9	1.13
50	2	2.44	0.42
	4	8.04	0.98
	6	16.0	1.6
	8	16.1	1.38
	10	16.25	1.25
	20	17.4	0.95

A	U (MeV)	σ^2	$\sigma^2/\sigma^2(RBM)$
60	2	2.1	0.3
	4	7.43	0.7
	6	11.14	0.9
	8	12.86	0.9
	10	13.65	0.85
	20	23.02	1.02
70	2	2.96	0.33
	4	9.71	0.8
	6	19.32	1.3
	8	24.32	1.42
	10	25.41	0.32
	20	30.11	1.11
80	2	5.0	0.5
	4	12.47	0.88
	6	22.58	1.3
	8	30.55	1.52
	10	32.6	1.45
	20	36.3	1.14
90	2	4.04	0.35
	4	10.58	0.65
	6	18.9	0.94
	8	20.7	0.9
	10	24.43	0.95
	20	38.2	1.05

Conclusions

- Have compared Rigid Body and Microscopic Model predictions for σ^2
- Find A and U dependence similar if $a \propto A$ and $< m^2 > \propto A^{2/3}$
- Data base limited: low $U \rightarrow \sigma^2 \sim \frac{1}{2}\sigma^2(RBM)$
- Some evidence for shell modulations in calculations with microscopic model for $U \leq 10$ MeV.
- Goes to $\sigma^2(RBM)$ as $U \rightarrow 20$ MeV
- Two body model calcualtions agree with data and generally with Microscopic Model.
- Need reanalysis of level densities for deformed nuclei.

THE THEORETICAL MODEL

Quasiparticle-Phonon Model: V. G. Soloviev: Theory of Atomic Nuclei: Quasiparticles and Phonons (Bristol, 1

N. Tsoneva, H. Lenske, Phys. Rev. C 77 (2008) 024321

$$H = H_{MF} + H_{res}$$

$$H_{MF} = H_{sp} + H_{pair} \qquad H_{res} = H_M^{ph} + H_{SM}^{ph} + H_M^{pp}$$

Nuclear Ground State

Single-Particle States

Phenomenological density functional approach based on a fully microscopic self-consistent Skyrme Hartree-Fock-Bogoljubov (HFB) theory

Pairing and Quasiparticle States

Excited states

deformations, vibrations, rotations

H_M^{ph} - multipole interaction in the particle-hole channel;

H_{SM}^{ph} - spin-multipole interaction in the particle-hole channel;

H_M^{pp} - multipole interaction in the particle-particle channel

$$V(|\vec{r} - \vec{r}'|) \approx \sum_{\lambda\mu\tau} (-)^{\mu} R_{\tau}^{\lambda}(r, r') Y_{\lambda\mu}(\theta, \varphi) Y_{\lambda -\mu}(\theta', \varphi')$$

$$R_{\tau}^{\lambda}(r, r') = \kappa_{\tau}^{\lambda} R_{\lambda}(r) R_{\lambda}(r')$$

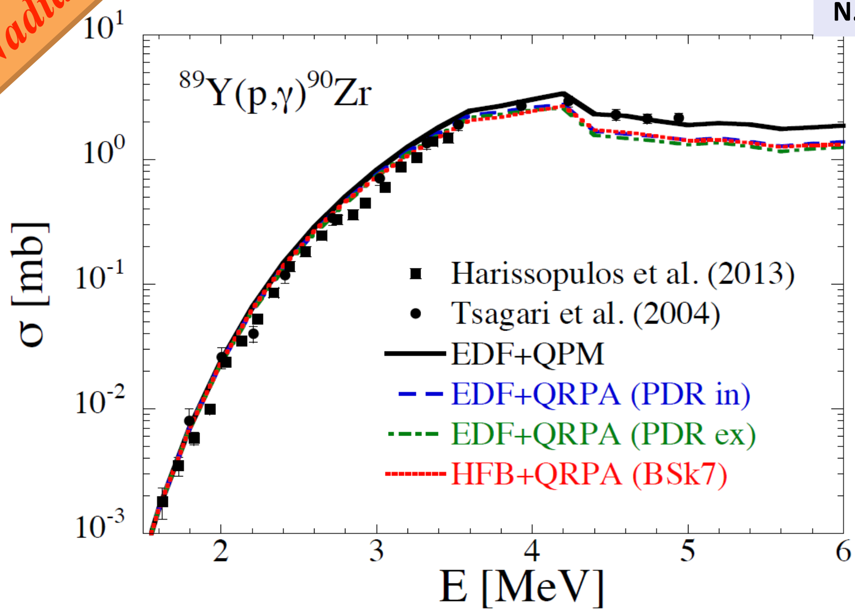
$\tau = 0$ isoscalar interaction

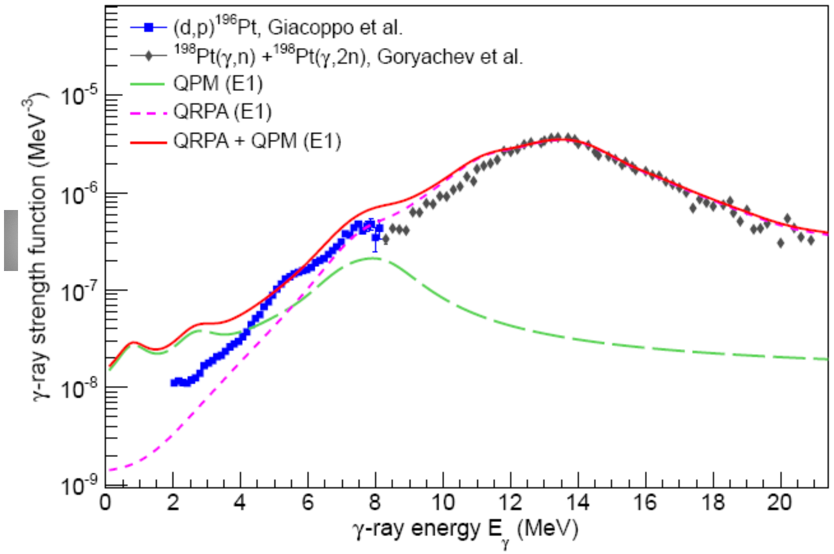
$\tau = 1$ isovector interaction

Proton capture cross section of the $^{89}Y(p,\gamma)^{90}Zr$ calculated with TALYS using EDF+QRPA, HFB+QRPA and three-phonon QPM strength functions.

Nadia Tsoneva

N. Tsoneva, S. Goriely, H. Lenske, R.Schwengner, PRC 91, 044318 (2015).



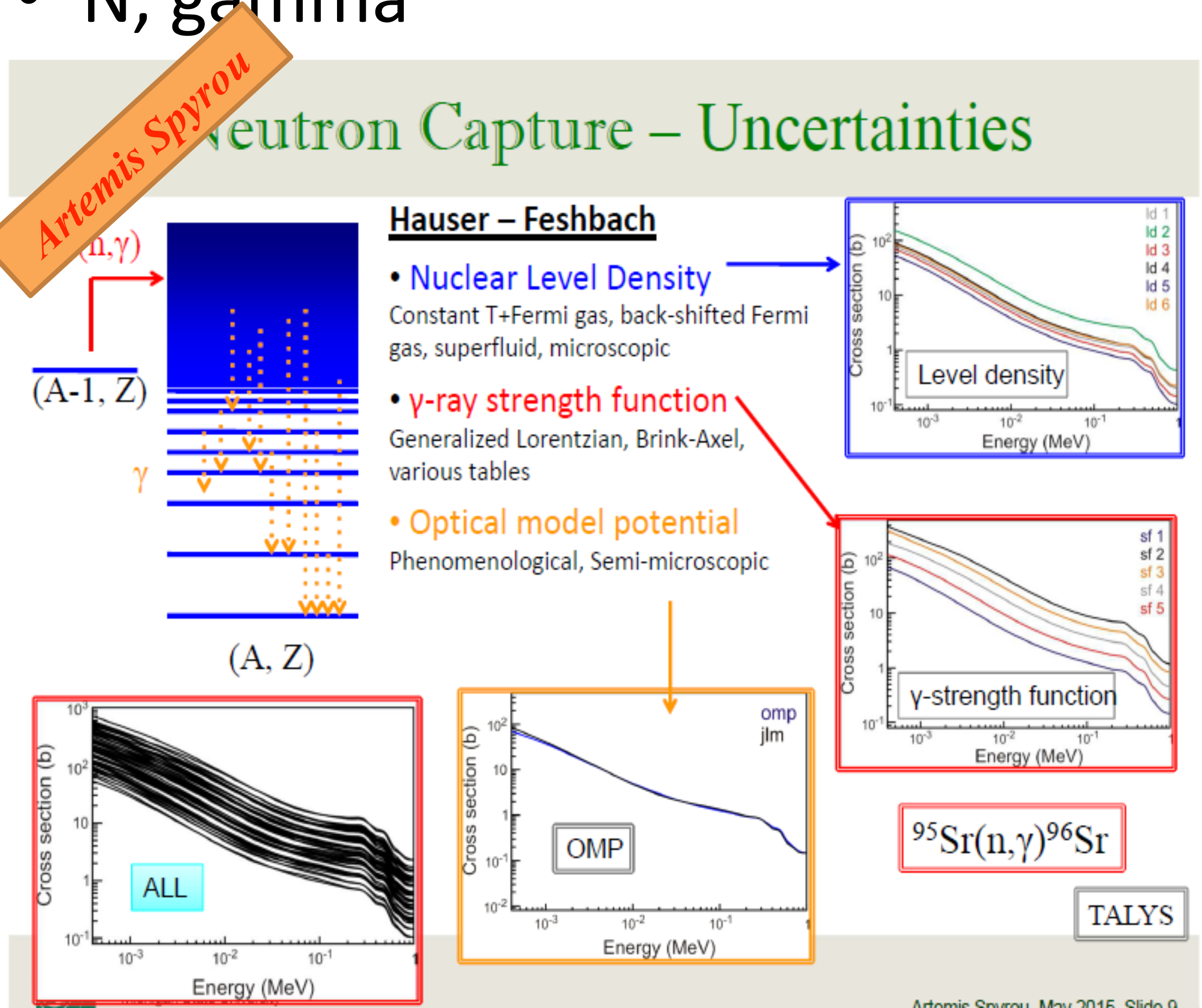


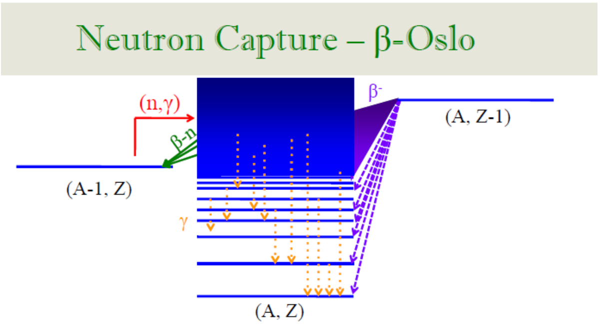
- **A new theoretical method based on Density Functional Theory and Quasiparticle-Phonon Model is developed.**

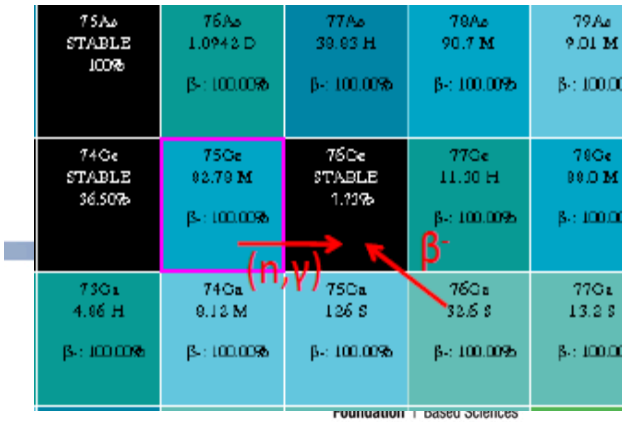
Presently, this is the only existing method allowing for sufficiently large configuration space such that a unified description of low-energy single-parti multiple-phonon states and the giant resonances is feasible.

Methods I (Reactions)

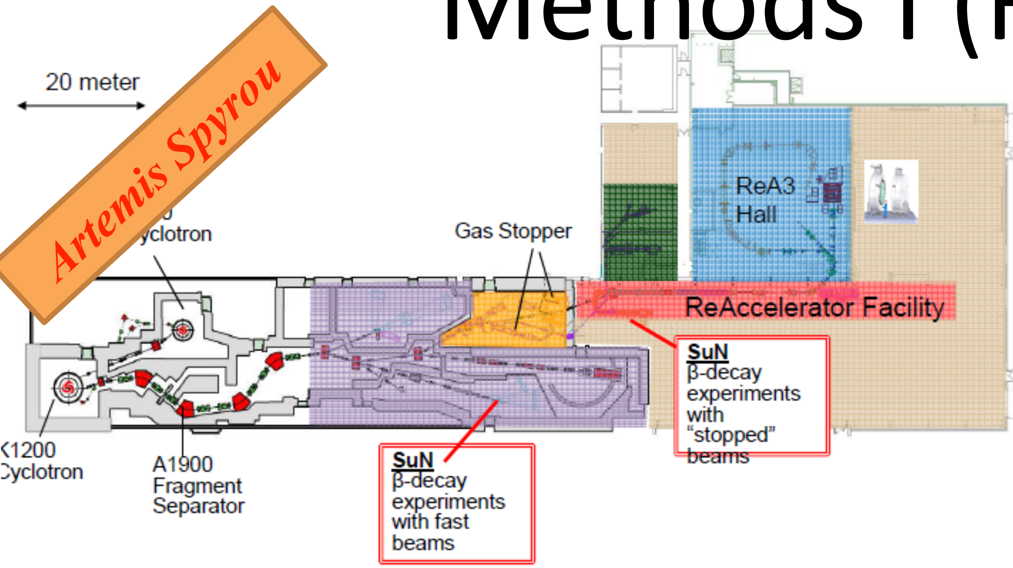
- N, gamma

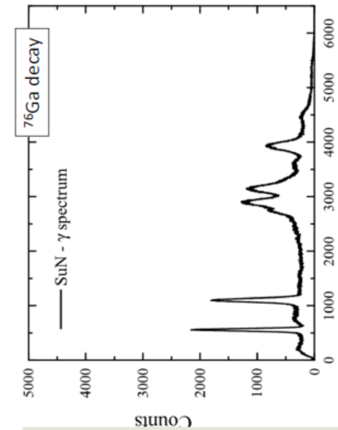


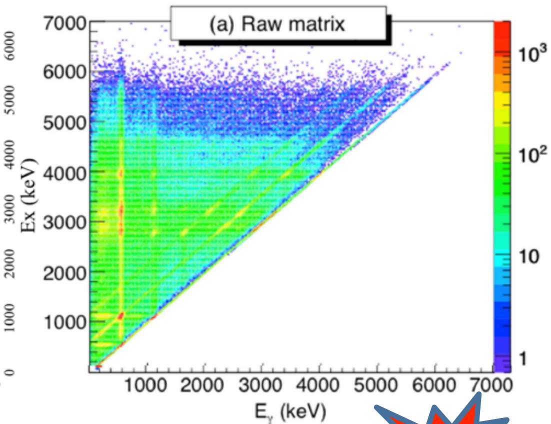




Methods I (Reactions)

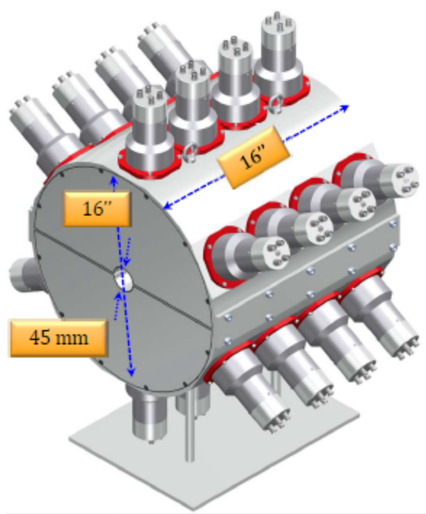




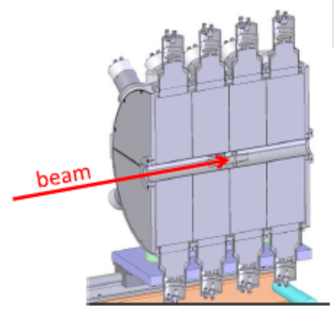


$^{75}Ge(n,\gamma)^{76}Ge$

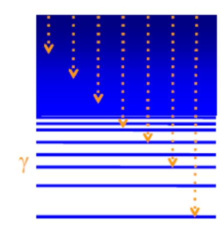
Beta-Oslo Method



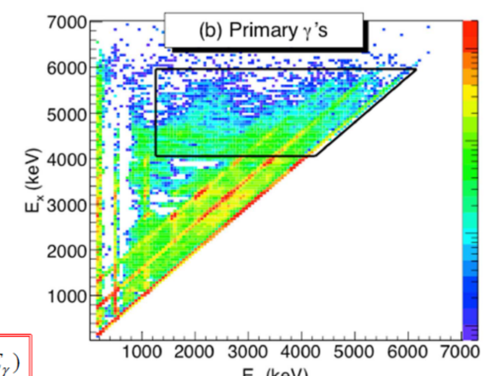
$$E_x = E_{\gamma 1} + E_{\gamma 2} + E_{\gamma 3} + E_{\gamma 4} + \ldots$$



- ✓16x16 inch
- ✓45 mm borehole
- ✓2 pieces
- ✓8 segments
- ✓24 PMTs
- ✓ Efficiency > 85% for 1 MeV



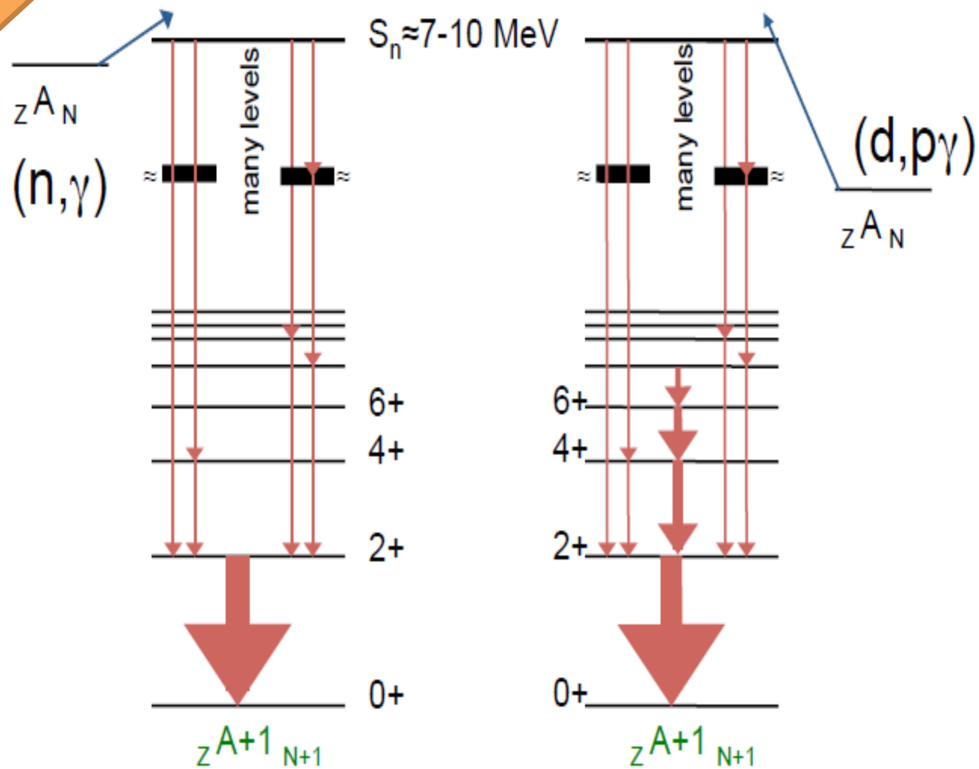
$$P(E_\gamma, E_x) = \rho(E_x - E_\gamma)\mathcal{T}(E_\gamma)$$



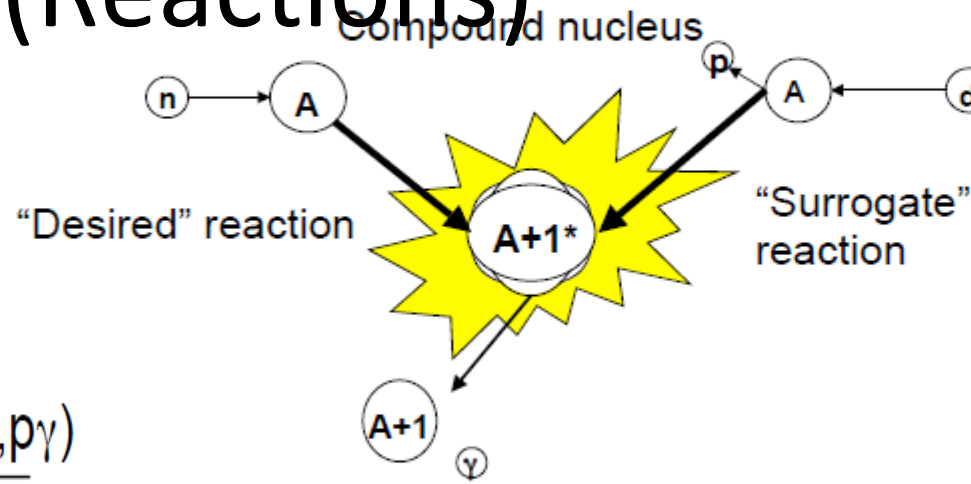
Methods I (Reactions)

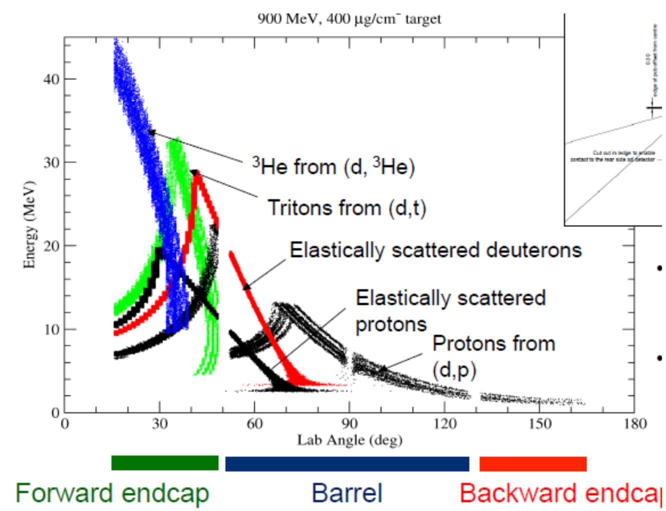
Jolie Cizewski

N, g surrogate -> d,p



Collecting transition(s) OR
Sidefeeding, e.g., subtract I($4^+ \Rightarrow 2^+$) from I($2^+ \Rightarrow 0^+$)





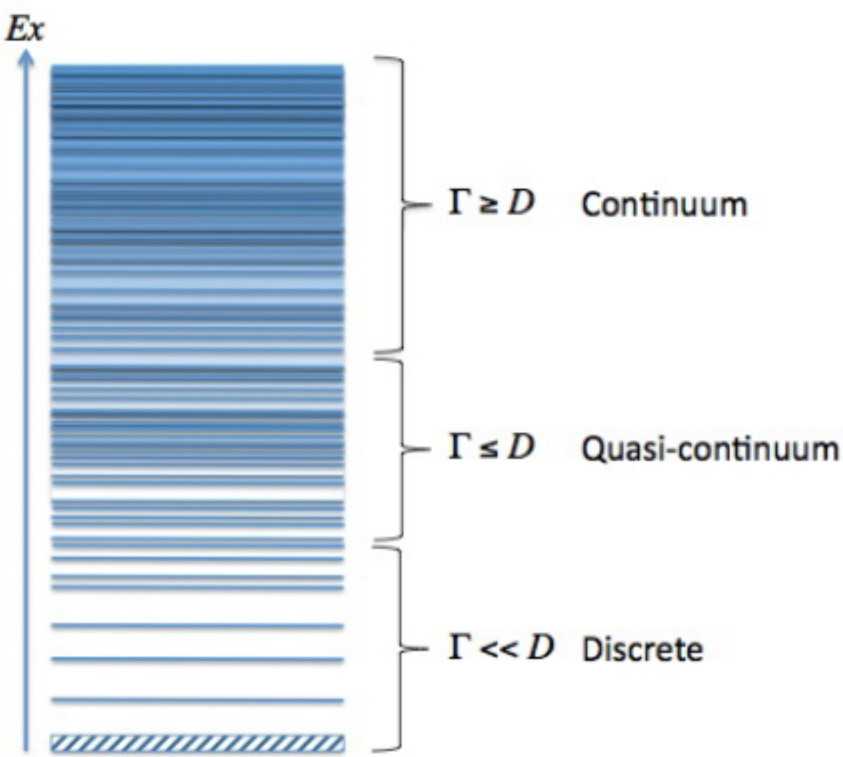
Future with ^{95}Mo beam and GODDESS
(Gammasphere ORRUBA: Dual Detectors for Experimental Structure Studies)

Methods II (Data Analysis)

Gry Tveten

Oslo Method

The quasi-continuum region

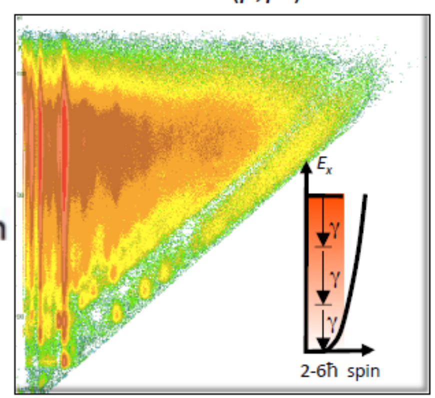


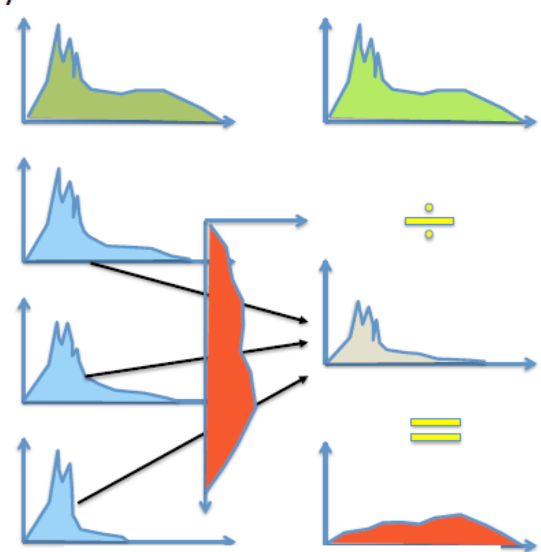
The Oslo method step-by-step

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

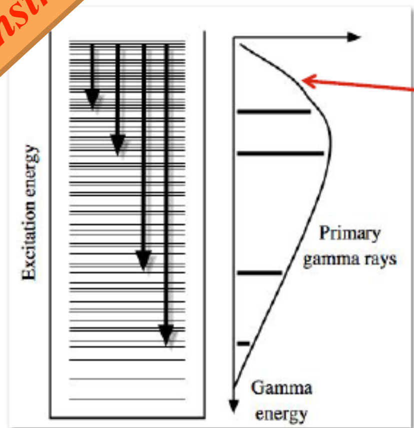
^{92}Mo(p,p')





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

Therese Renstrøm



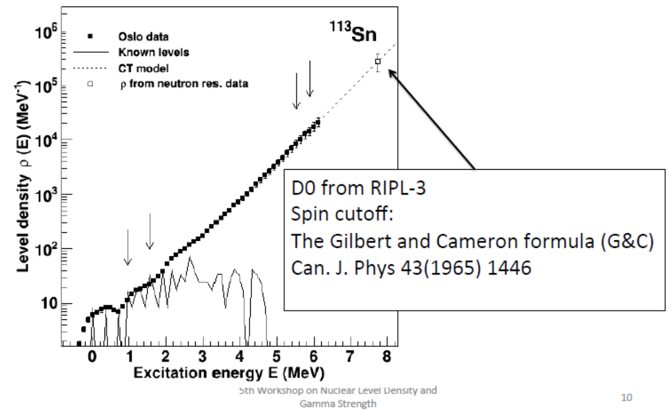
$$\lambda = \frac{2\pi}{\hbar}\left|M_{if}\right|^2 \cdot \rho(E_f)$$

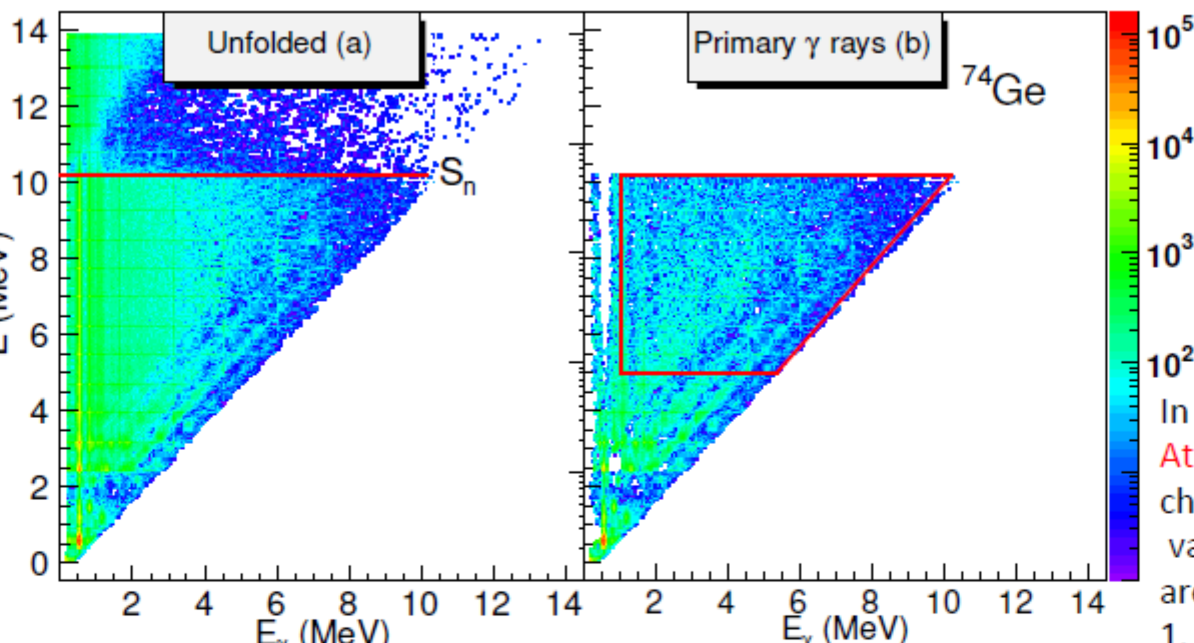
Fermi's golden rule

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

Brink hypothesis

Example: ^{113}Sn



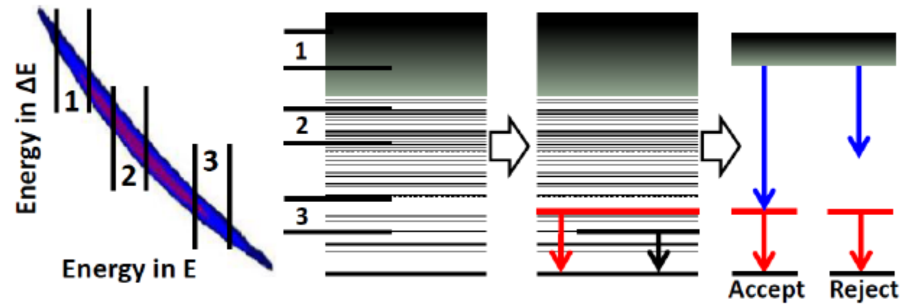


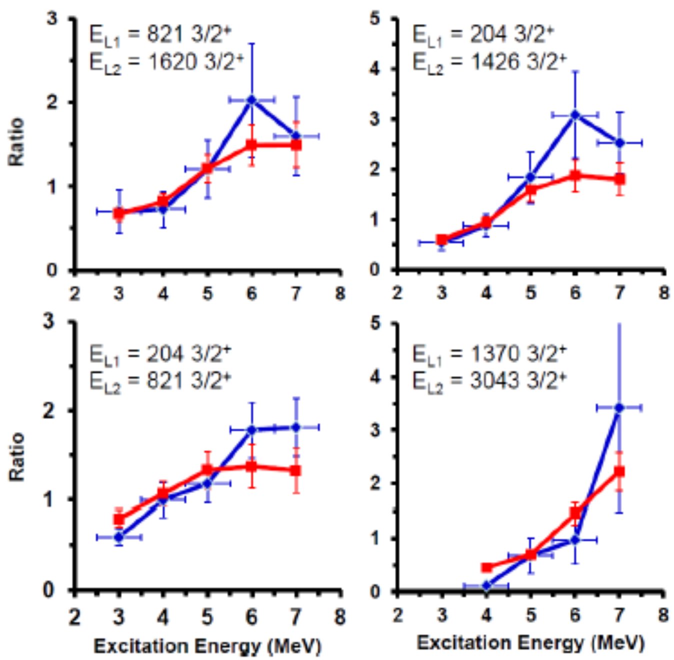
In the case of ^{73,74} Ge, s-wave spacings, **D**0 , are gi
Atlas of N. Res. by S.F. Mughabghab and RIPL. Afte
chosen to use an average value of the two propos
values and uncertainties. The two main reasons f
are:

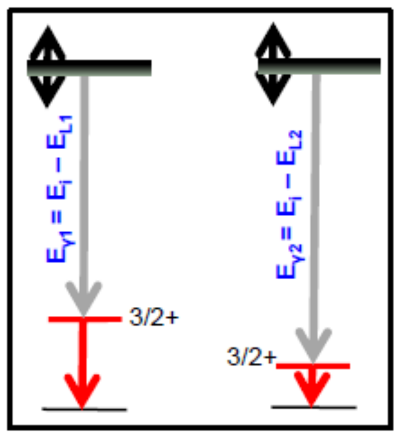
1. For 73,74 Ge the **D**0 values from Atlas of N. Re
and 60%, respectively, than the values given in RIP

Mathis Wiedeking

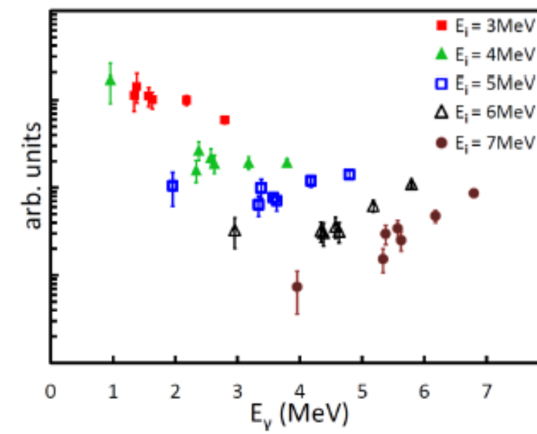
Ratio Method

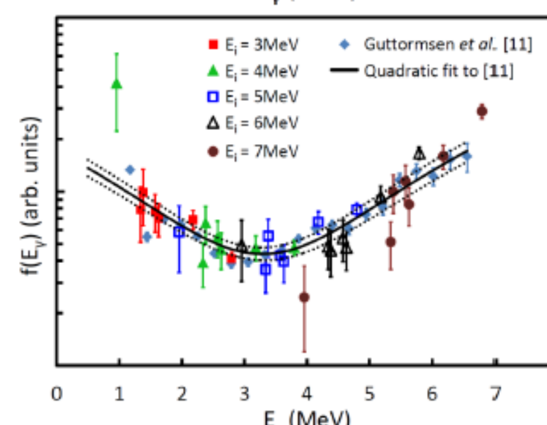






Ratio Method





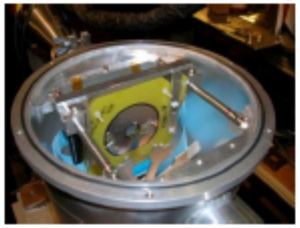
χ^2 method

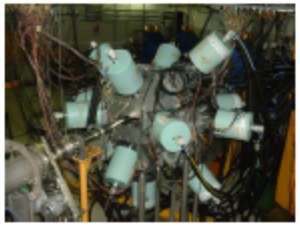
Red: Guttormsen at al., Phys. Rev. C 71, 044307 (2005).

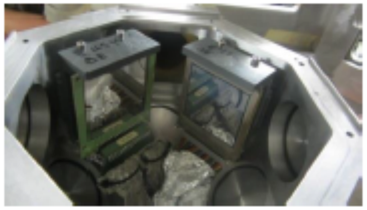
Blue: ^{94}Mo(d,p) data

- (d,p) reactions to populate ^{95}Mo.
- 24 ratios in total.
- Independent of level density.
- Independent of (d,p) cross-sectio
- No systematic uncertainties.

^{74}Ge experiments

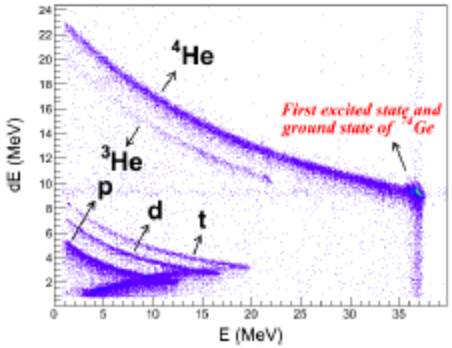


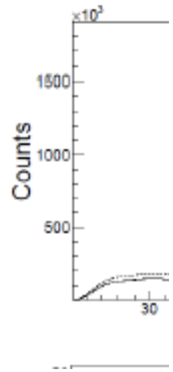


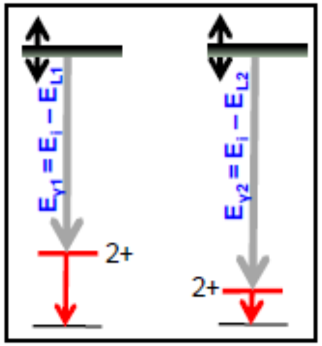


Stars-LIBERACE at LBNL, (p,p') at 18 MeV

Extracted quasi-continuum feeding to 7 states (red). Other good candidates are shown in black.



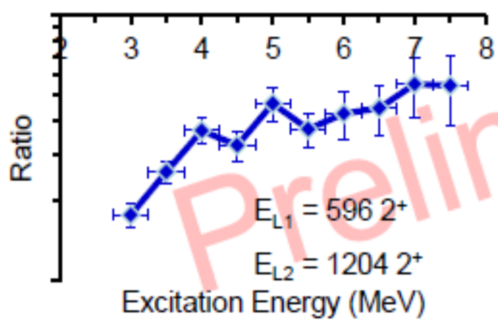


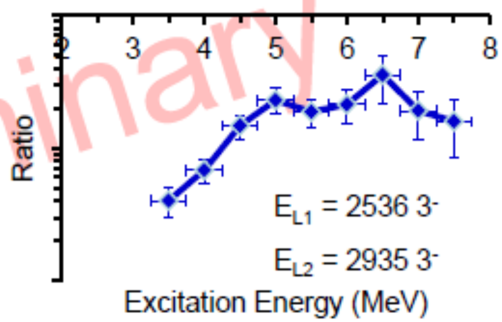


$$N_{L_j}(E_i) \propto \sum_{J^\pi} \sigma_{J^\pi}(E_i)\overline{\Gamma}_{J^\pi}(E_i, E_i - E_{L_j})\rho_{J^\pi}(E_i)$$
$$= f_{J^\pi}(E_i - E_{L_j})E_\gamma^3 \sum_{J^\pi}\sigma_{J^\pi}(E_i)$$

$$R = \frac{f(E_i - E_{L1})}{f(E_i - E_{L2})} = \frac{N_{L1}(E_i)(E_i - E_{L2})^3}{N_{L2}(E_i)(E_i - E_{L1})^3}$$

Thanks to B.V. Kheswa



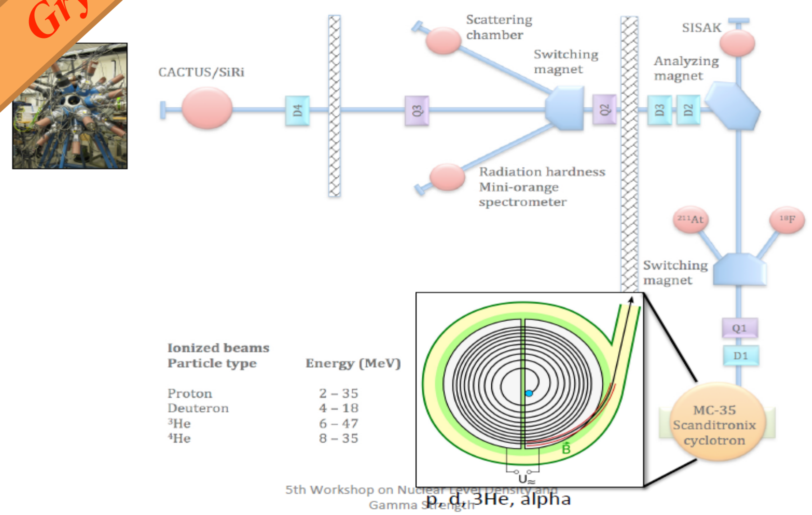


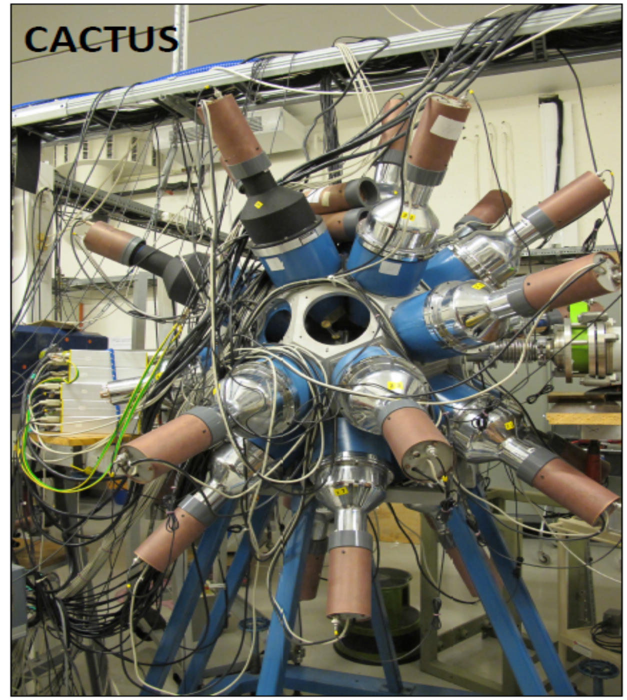
We do observe the low-energy enhancement!

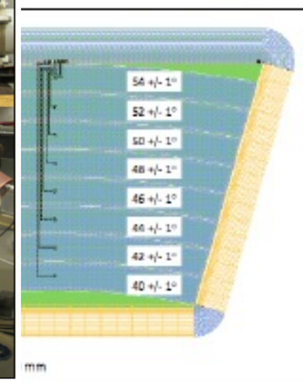
Apparatus

Gry Tveten

The ucture at the Oslo Cyclotron Laboratory

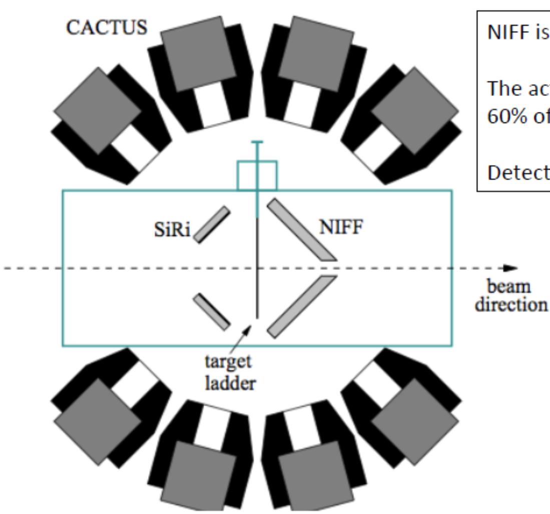






M. Guttormsen et al., NIM **A648** (2011)168

Newest addition: Fission-fragment detector (NIFF)

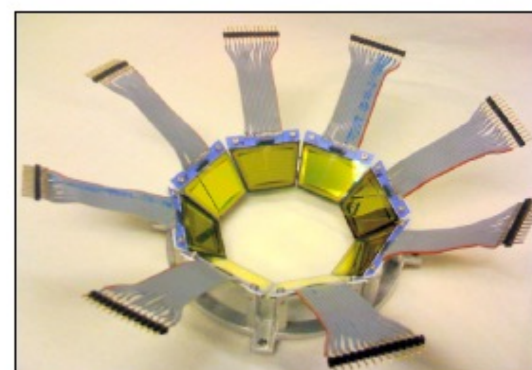


T.G. Tornyi et al. / Nuclear Instruments and Methods in Physics Research A 738 (2014) 6–12

NIFF is a PPAC detector.

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

Detection efficiency higher than 90 %.

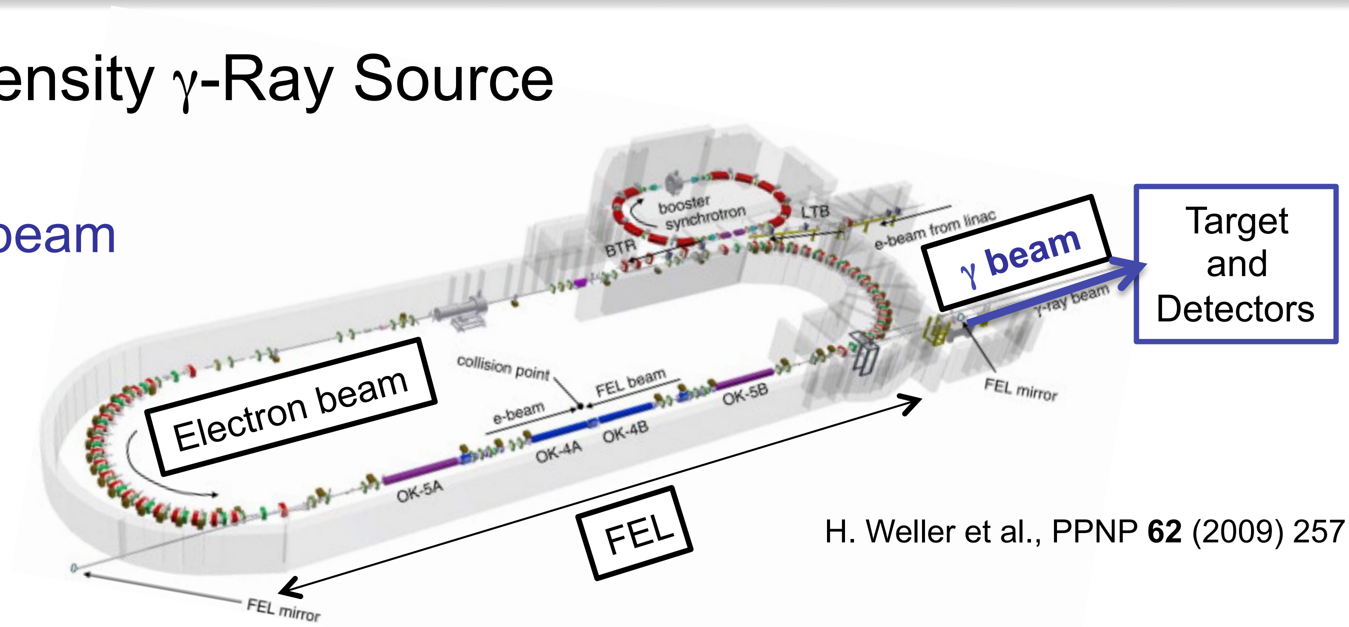


NRF measurements at HIγS

Vera Derya

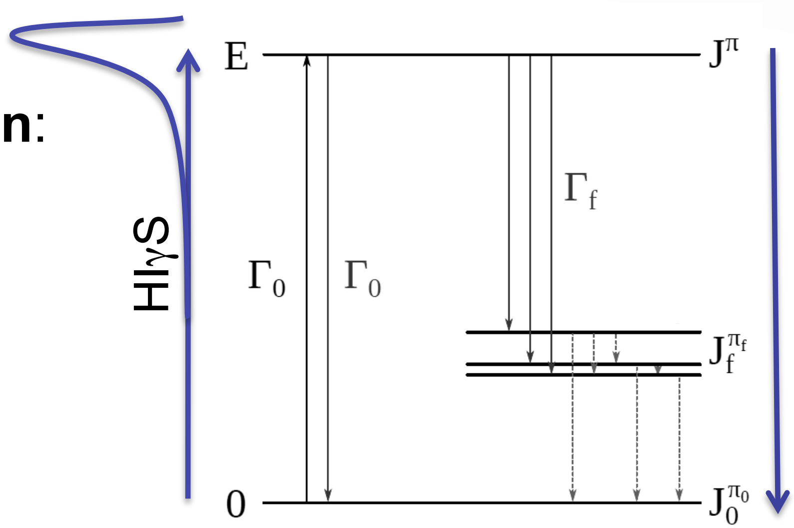
HIγS = High Intensity γ-Ray Source

linearly polarized,
mono-energetic γ beam



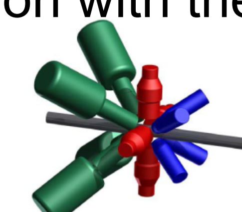
H. Weller et al., PPNP **62** (2009) 257

Selective **excitation**:
- Spin J=1
- Energy E_x



Decays to:
- Ground state
- Excited states

γ-ray detection with the γ^3 **setup**



Experimental setup

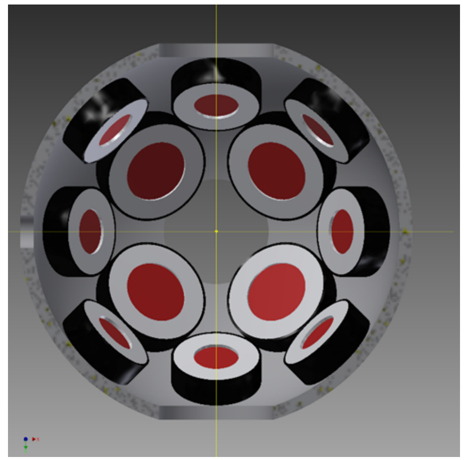
Simon Pickstone

SONIC

- Up to 8 detector positions
  - ΔE-E or single PIPS
- 4 angles relative to beam
  - 60°, 90°, 120°, 130°
- Solid angle coverage:

  Up to 4%
- Typical energy resolution

  ~70 keV in-beam



HORUS

- 14 HPGe detectors
  - Up to 6 BGO shields

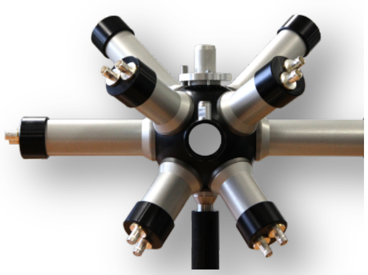
5 angles relative to beam

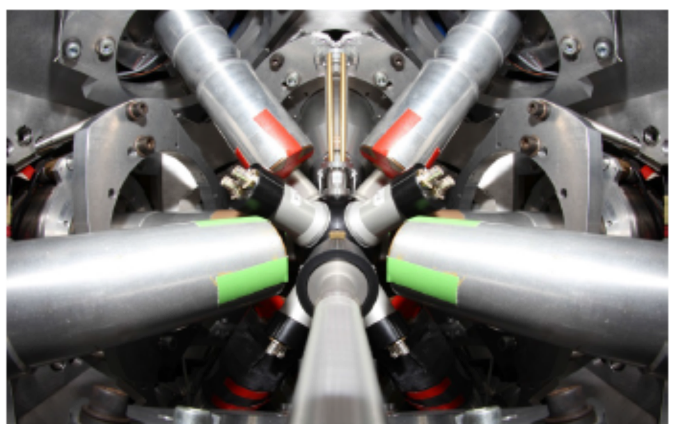
Photopeak efficiency:

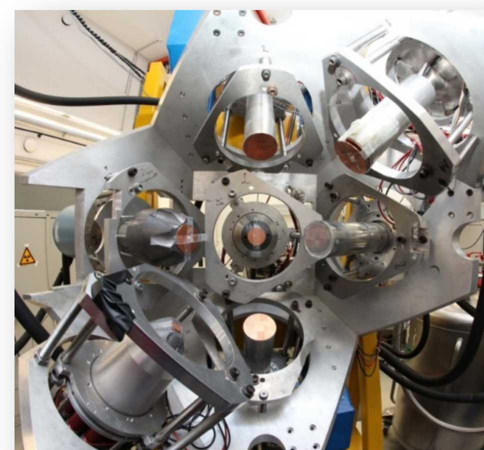
~2% @1332 keV

Energy resolution:

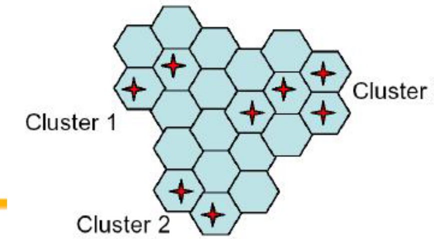
~2 keV@1332 keV



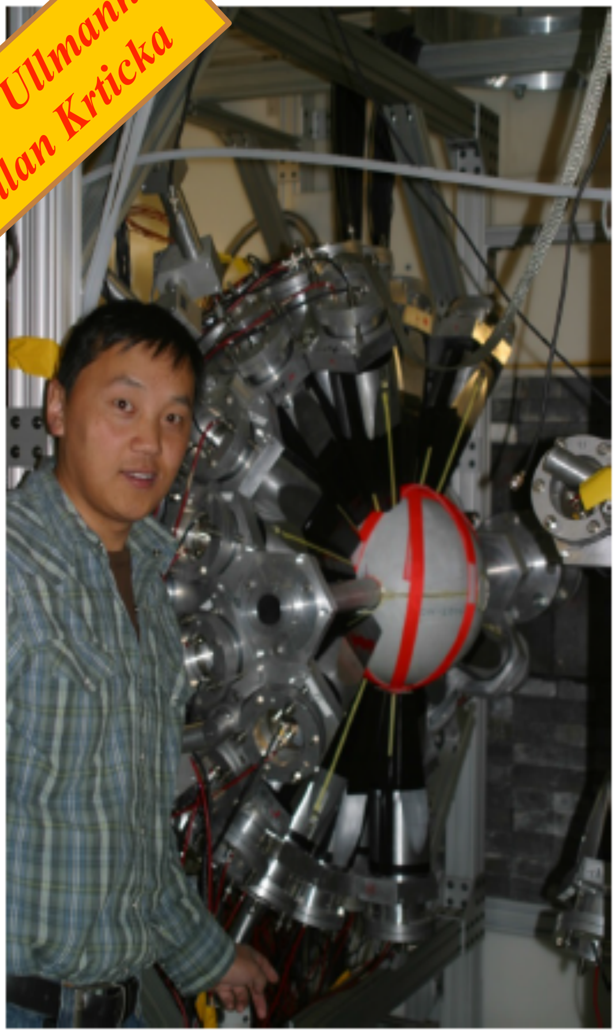




The DANCE array



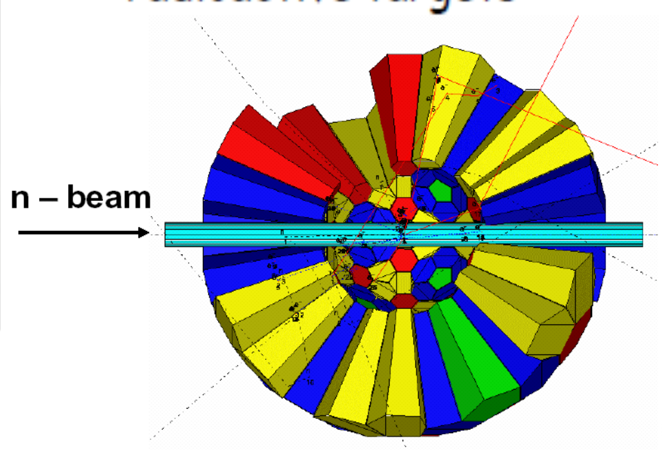
John Ullmann
Milan Krticka

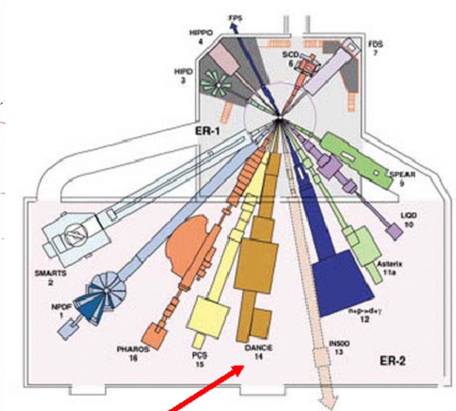


Half of DANCE array with ^{6}LiH ball

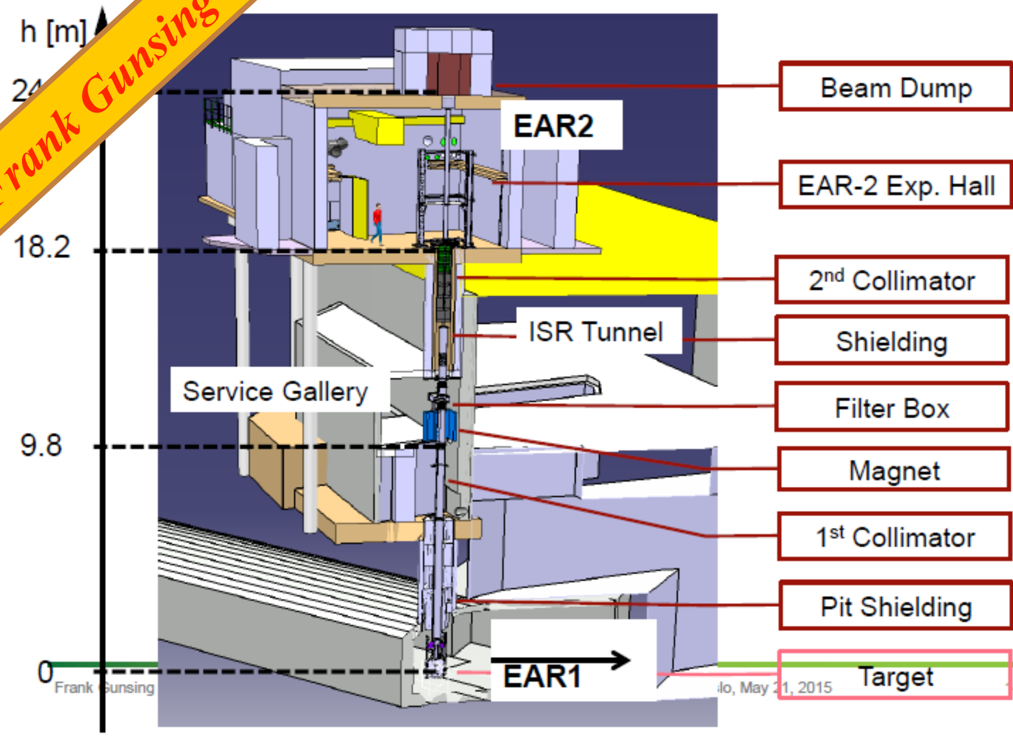
Detector for Advanced Neutron Capture Experiments

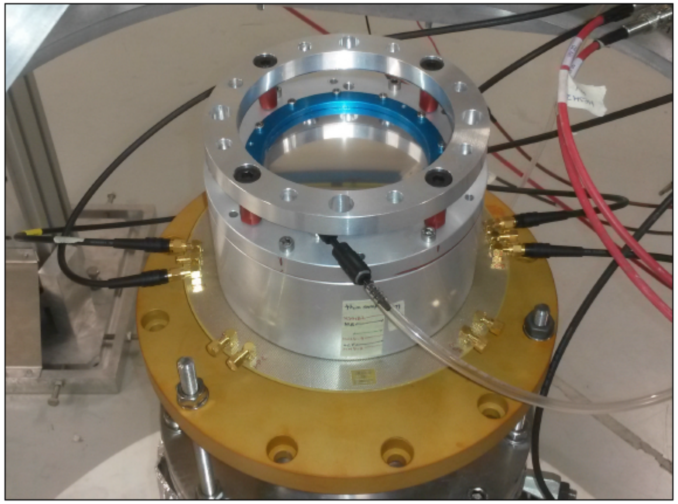
- 162 segments with 4 different shape crystals (160 segments with crystals)
- Calorimetric detector (nearly 4π) - detects full energy of decay cascade
- High efficiency and high neutron flux allows measurements on milligram samples
- Highly segmented to allow detection of radioactive targets

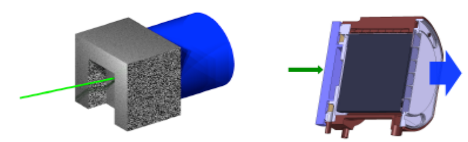


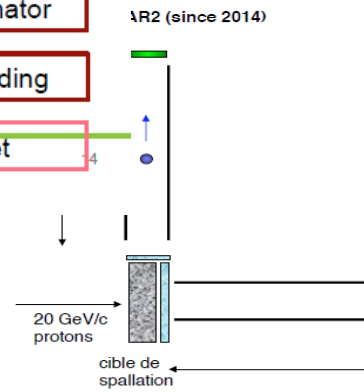


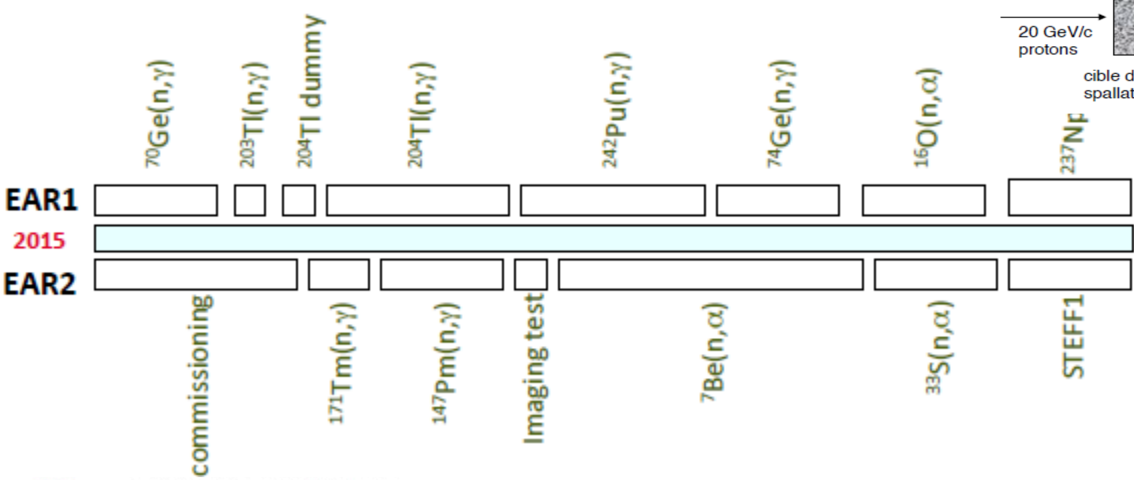
Frank Gunsing





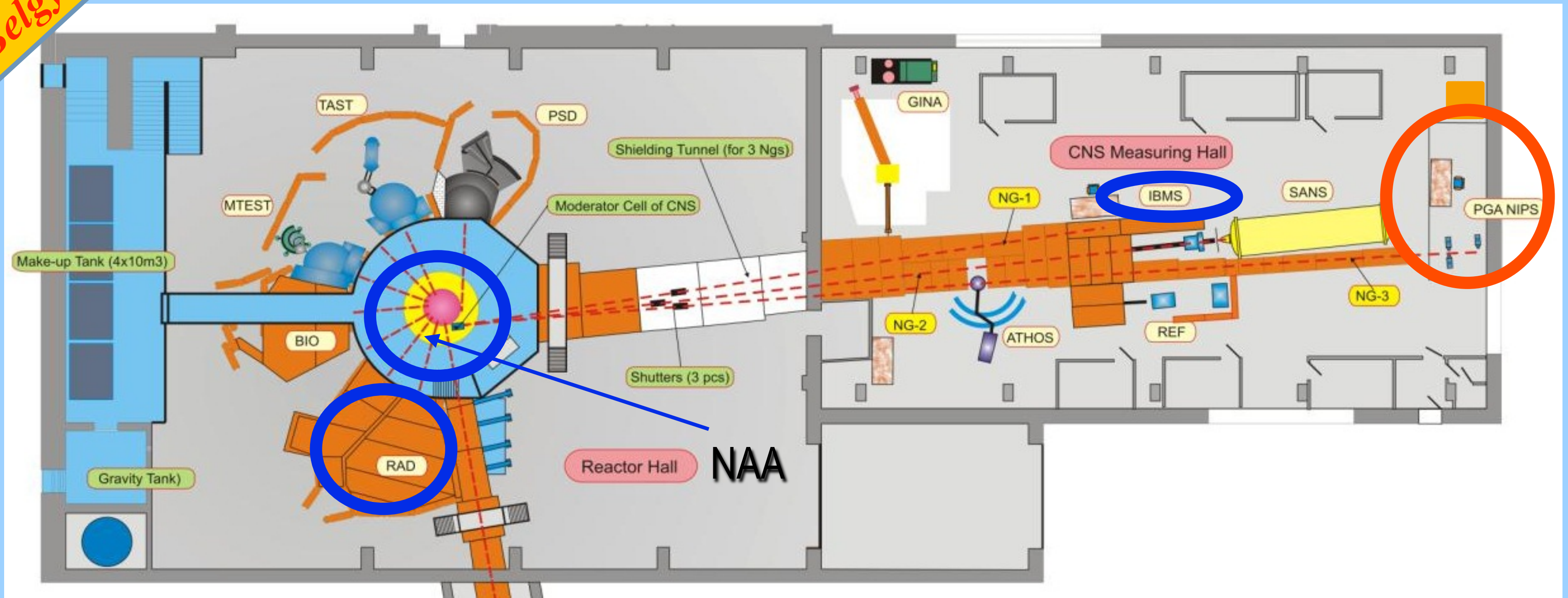






The research infrastructure of BNC

Budapest Neutron Centre (1993)



- **Nuclear analytical and imaging tools of MTA EK**
  - Prompt-gamma Activation Analysis (PGAA) (mm)
  - PGAI-NORMA elemental and structural imaging (2 mm, 200 μm)
  - Neutron-, gamma- and X-ray radiography (RAD) (100 μm)
  - Neutron Activation Analysis (NAA)
  - Mössbauer spectroscopy (chemical environment)

Macroscopic structure, composition

- **Material microstructure tools of Wigner FK (not all listed)**
  - Neutron powder diffractometer (PSD, MTES) (~ 0.1 nm, 1Å)
  - Small angle scattering (SANS, FSANS) (1-150 nm)
  - Reflectometer (REF and GINA) (nm surface structure)
  - TOF diffractometer (TOF) (nm lattice distance)
  - Triple Axis Spectrometer (Athos, TAST) (inelastic scattering)

Microscopic structure

Tamas Belgya

Dan Mihai Filipescu

ELI-NP – Laser and Gamma Beam systems

Laser beam system:

- 2 HPLS up to 10 PW – 6 output lines

2 x 0.1 PW

2 x 1 PW

2 x 10 PW

Gamma beam system

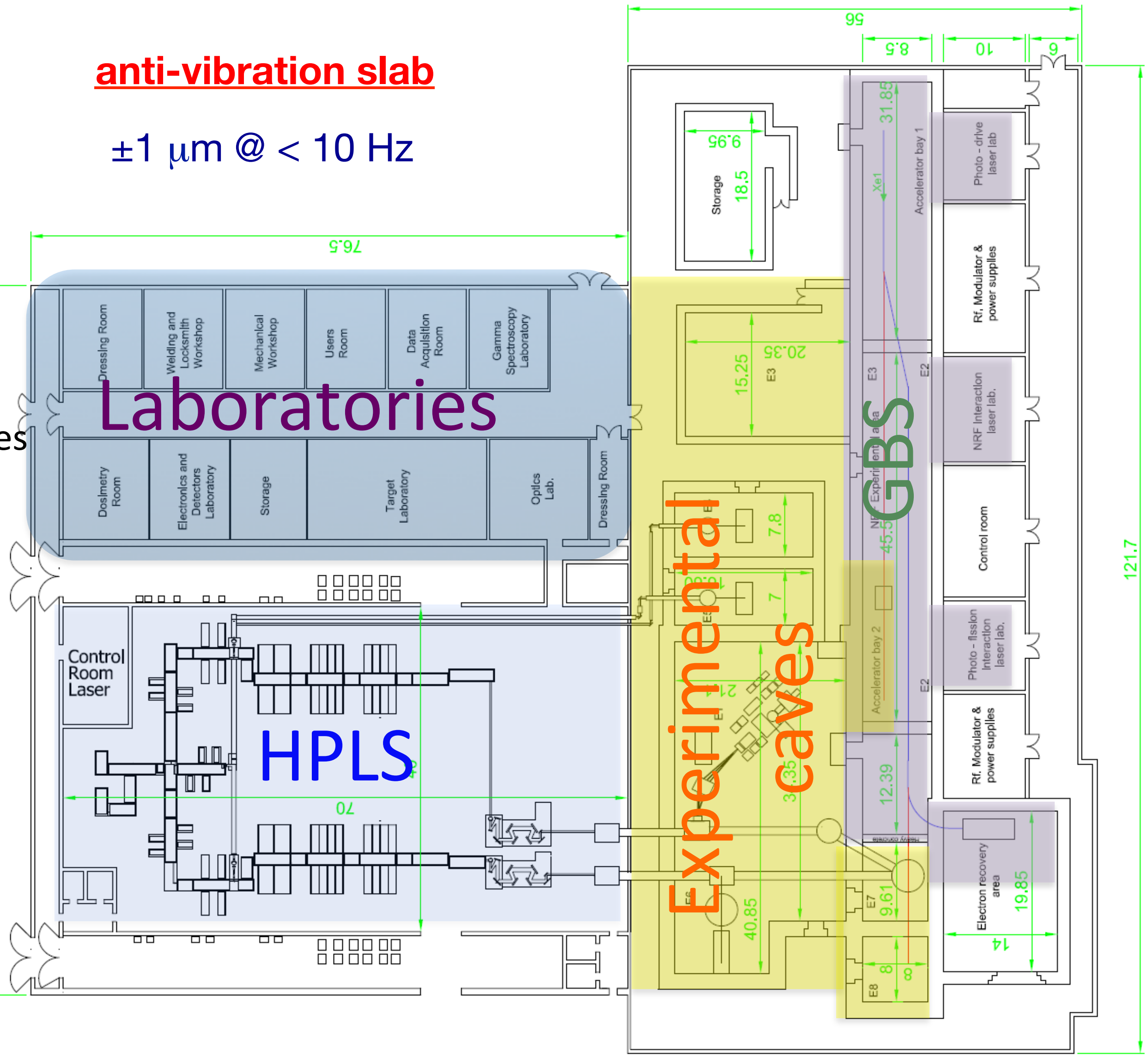
- High intensity
- High energy resolution

Experiments with:

- High power laser beams
- **Gamma ray beams**
- Laser + gamma ray beams

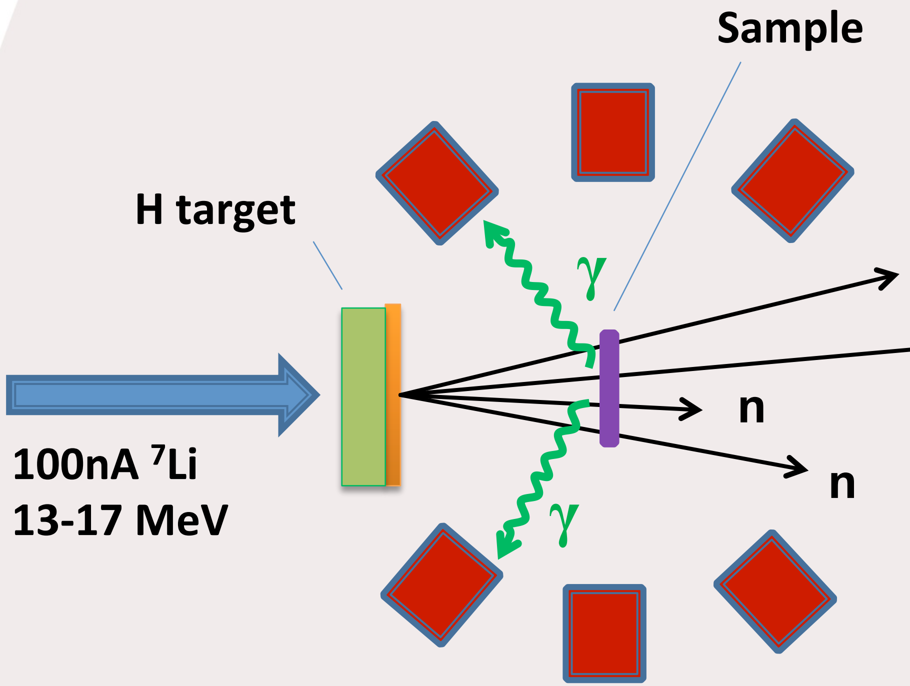
anti-vibration slab

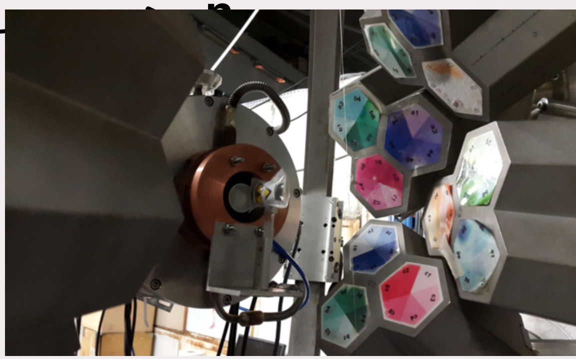
±1 μm @ < 10 Hz



LICORNE

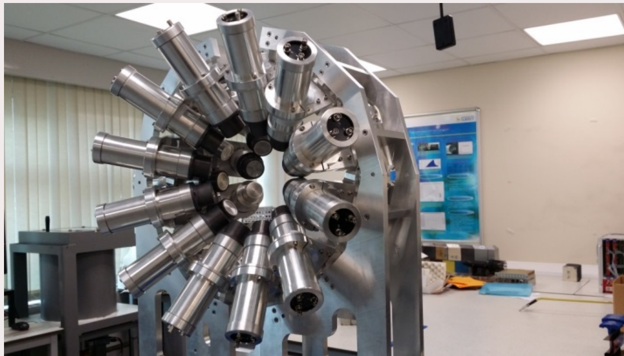
NEUTRON PRODUCTION IN INVERSE KINEMATICS





Lithium Inverse Cinematiques ORsay NEutron source

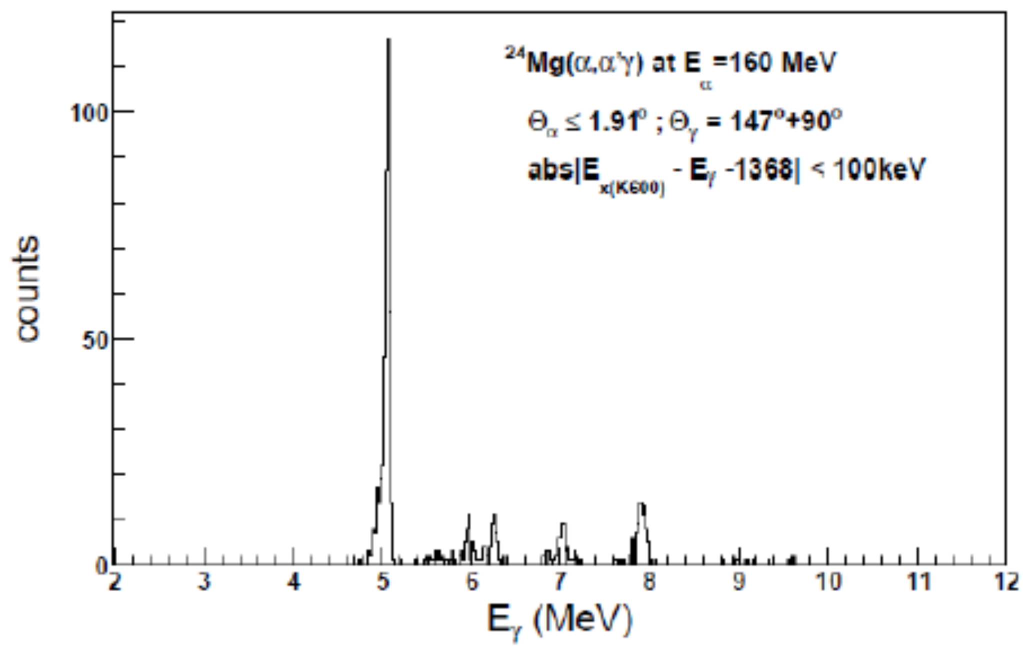
- p(^{7}Li,^{7}Be)n reaction in inverse kinematics
- Focused source of fast neutrons between 0.5 and 4 MeV



Isospin structure of the PDR in stable nuclei: The K600 collaboration @ iThemba LABS

Andreas Zilges

(α,α‘γ) @ E_{α}= 120 MeV combining K600 with eight Ge(HP) from AFRODITE array

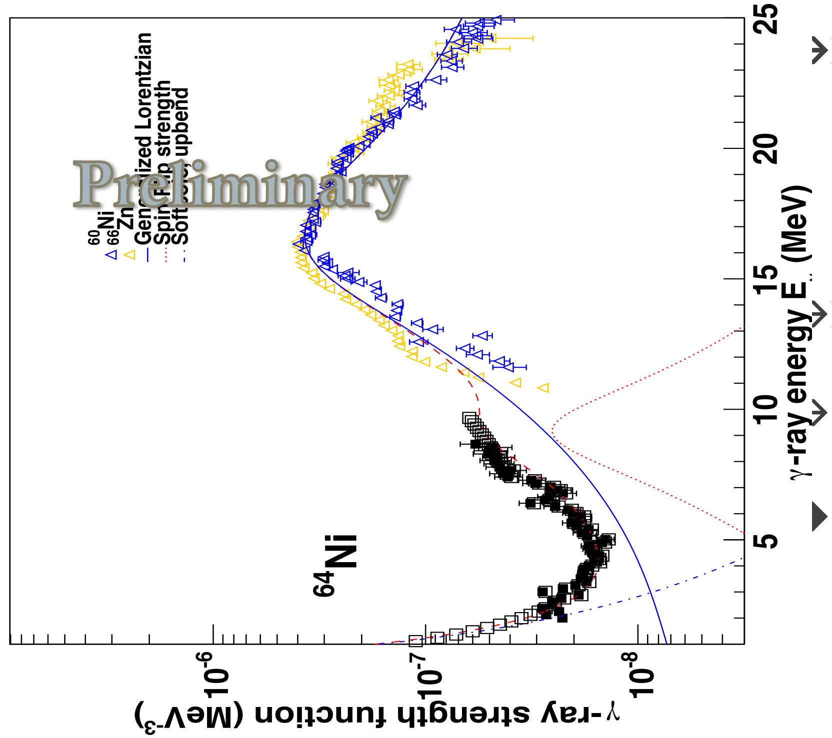


Collaboration: Cape Town – Cologne - Darmstadt – Milano – Osaka – Notre Dame

Results

Lucia Crespo-Campo

GAMMA STRENGTH FUNCTION OF ^{64}Ni



- **At 9.3 MeV :**

➤ If it is of E1 character, it could be a **pygmy** mode:

- Often described as a neutron skin oscillation vs N≅ Z core.
- Seen in ^{68}Ni at 9.5 MeV.

➤ If it is of M1 character: possible spin-flip resonance.

➤ **Fitted to a Standard Lorentian (SLO).**

- **Below 3 MeV:** Data suggest a **low-energy enhancement or upbend!** (seen in ^{60}Ni, suggested by the ^{59}Ni data).

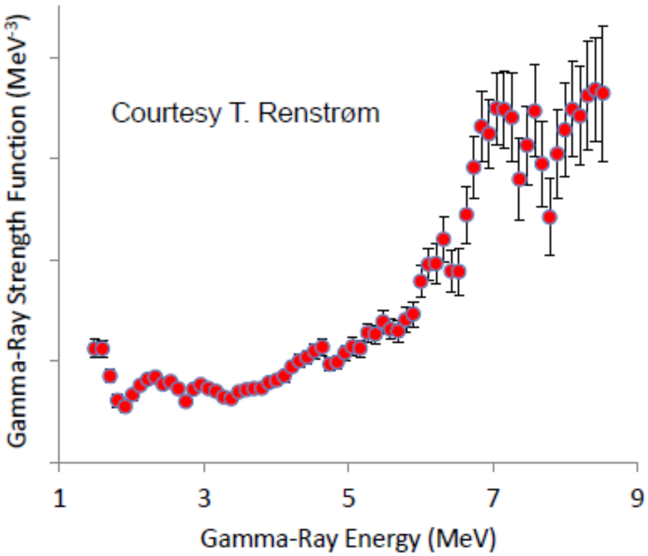
$$f^{upb} = \theta A e^{-bE_\gamma}$$

Mathis Wiedeking

- ad experimental effort on ^{74}Ge.

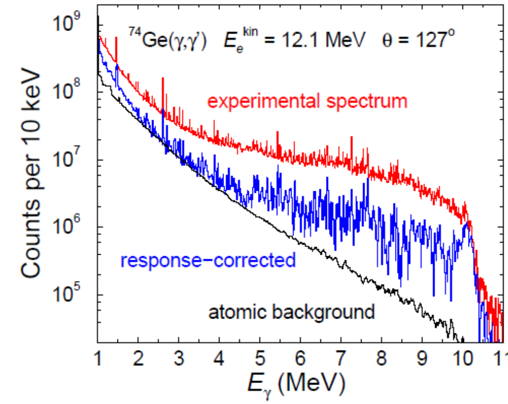
  Method to characterize feeding from the quasi-continuum to discrete states.

- ^{74}Ge(p,p') and ^{74}Ge(α,α') data.



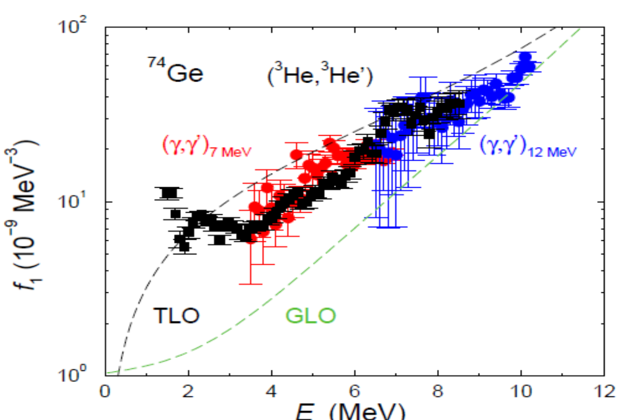
- Up-bend is real.
- Pygmy resonance at ~7 MeV.
- What about (γ,γ')? Next Talk!

Measurement at γELBE



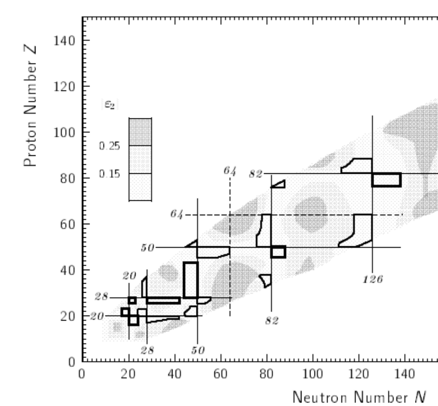
Ronald Schwenger

Dipole strength functions in ^{74}Ge



(^{3}He,^{3}He') data:
T. Renstrøm et al.

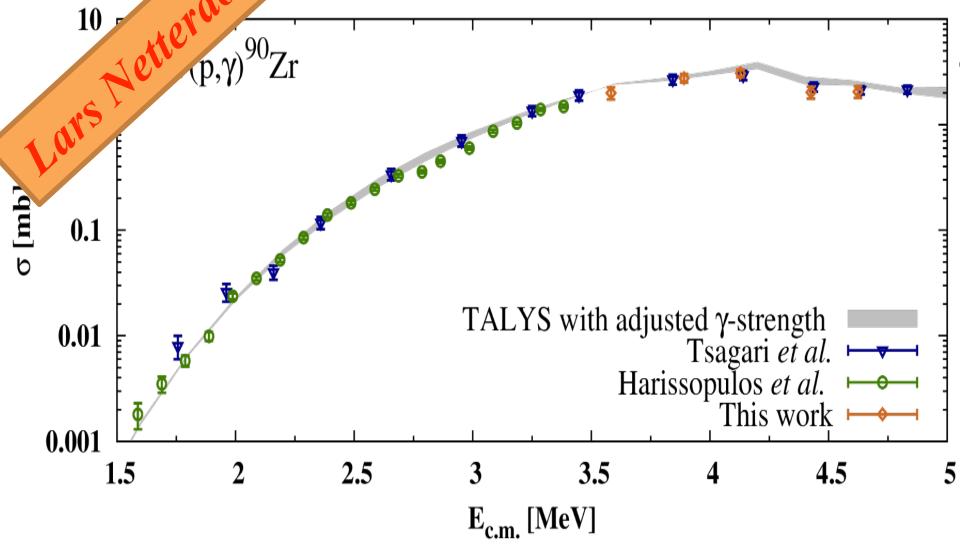
Predicted Appearance of magnetic rotation

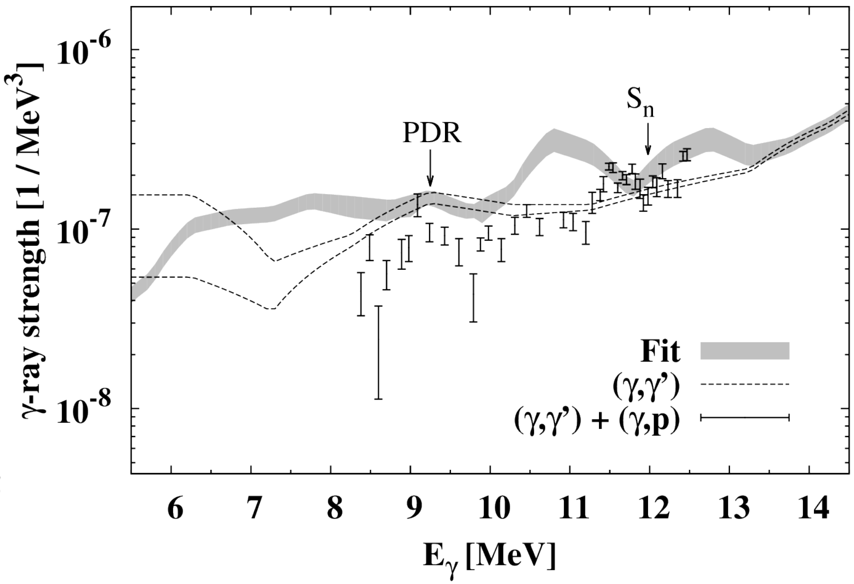


$^{89}Y(p,\gamma)$ – Total cross-section

^{90}Zr – γ-ray strength

Lars Netterdon





- excellent agreement of experimental data with previous measurements
- using adjusted γ-strength also reproduces total cross section

R. Schwengner *et al.*, Phys. Rev. C **78** (2008) 064314
P. Axel *et al.*, Phys. Rev. C **2** (1970) 689
L. Netterdon *et al.*, Phys. Lett. B **744** (2015) 358

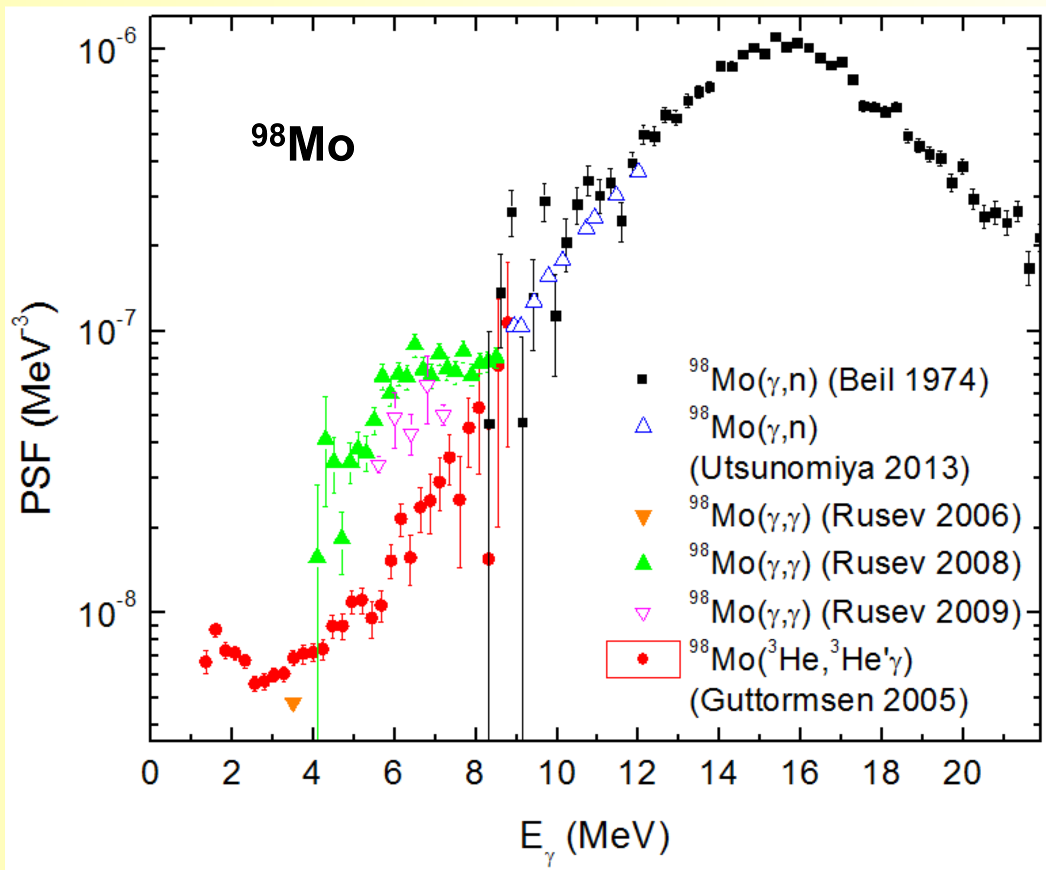
- location and strength of PDR is consistent
- where do deviations come from?

  → γ-branching ratios, dependence on nuclear temperature?

Milan Krticka

Why are "PSFs" different?

- Experimental data are incorrect
- Concept of photon strength function and/or Brink hypothesis is not valid



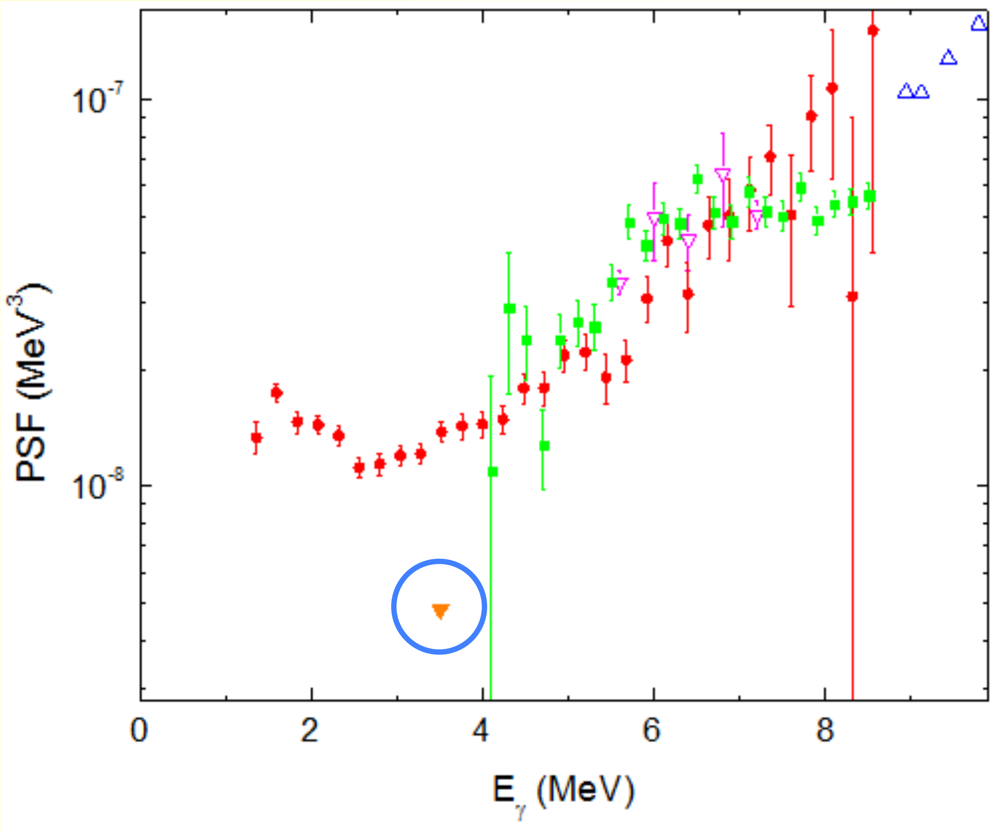
Consistency of data?

Milan Krticka

- These "corrections" - renormalization of Oslo data and correction of ELBE shape at high energies - would give a reasonable agreement of all data for E_γ > 4 MeV ...

But problems remain

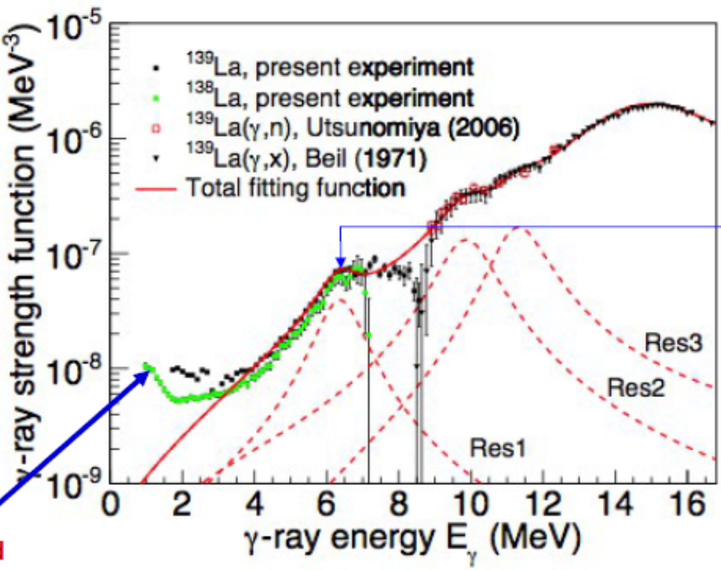
1. Total radiation width reproducing "HIγS normalization"
2. NRF point at 3.5 MeV – temperature dependence of PSF?
3. Problem with reproduction of feeding low-lying excited levels in NRF



Vincent Kheswa

^{138,139}La Results

Interesting Features

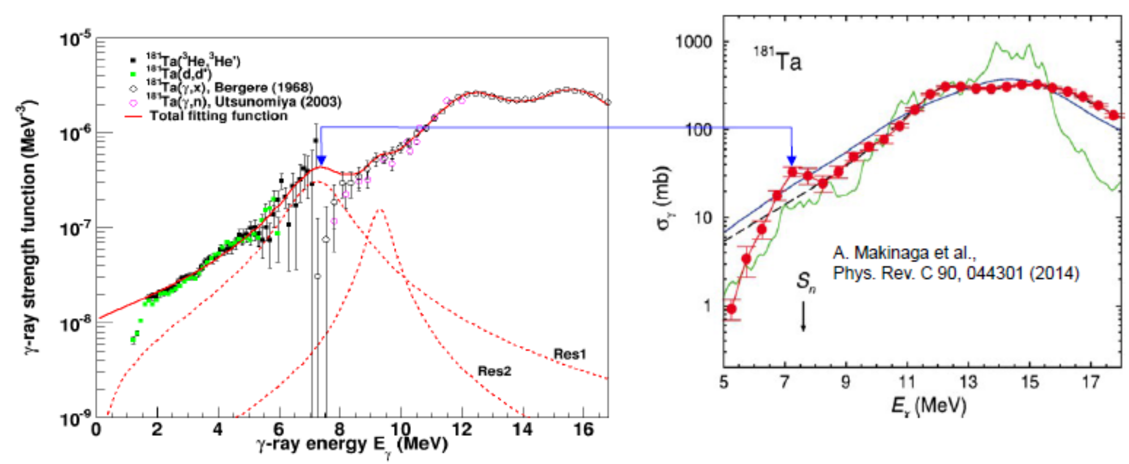


Pygmy Resonance

Pronounced up-bend
for the first time at A > 106 !!!!!

Preliminary Results on ^{180,181}Ta

γSF of ^{180,181}Ta

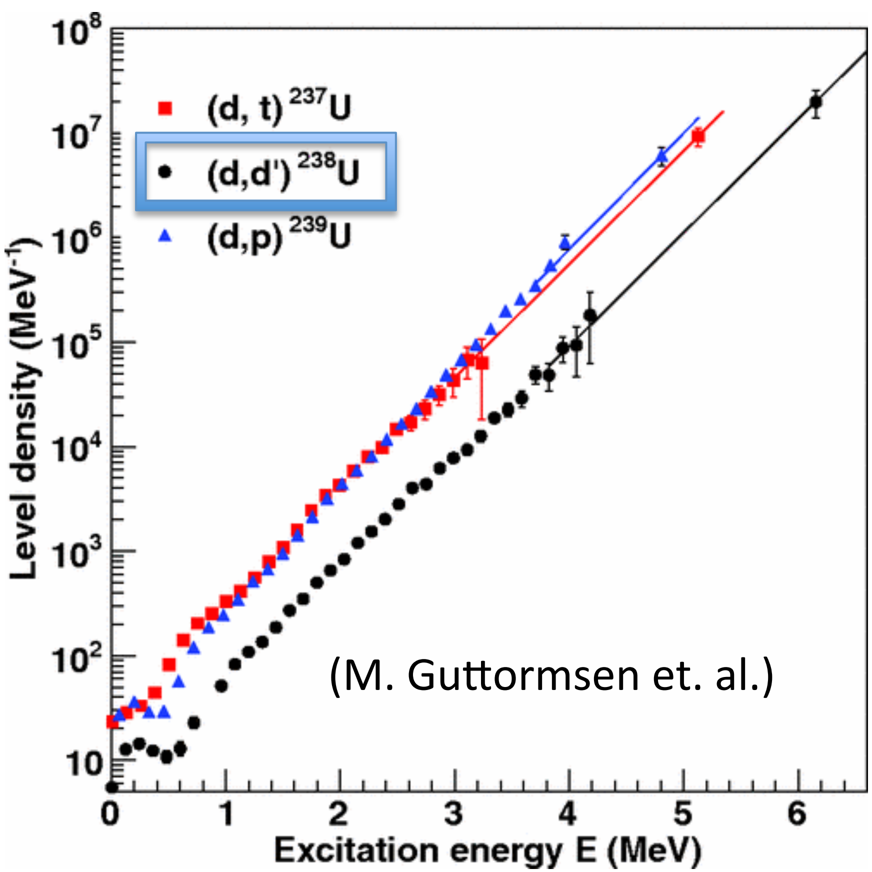


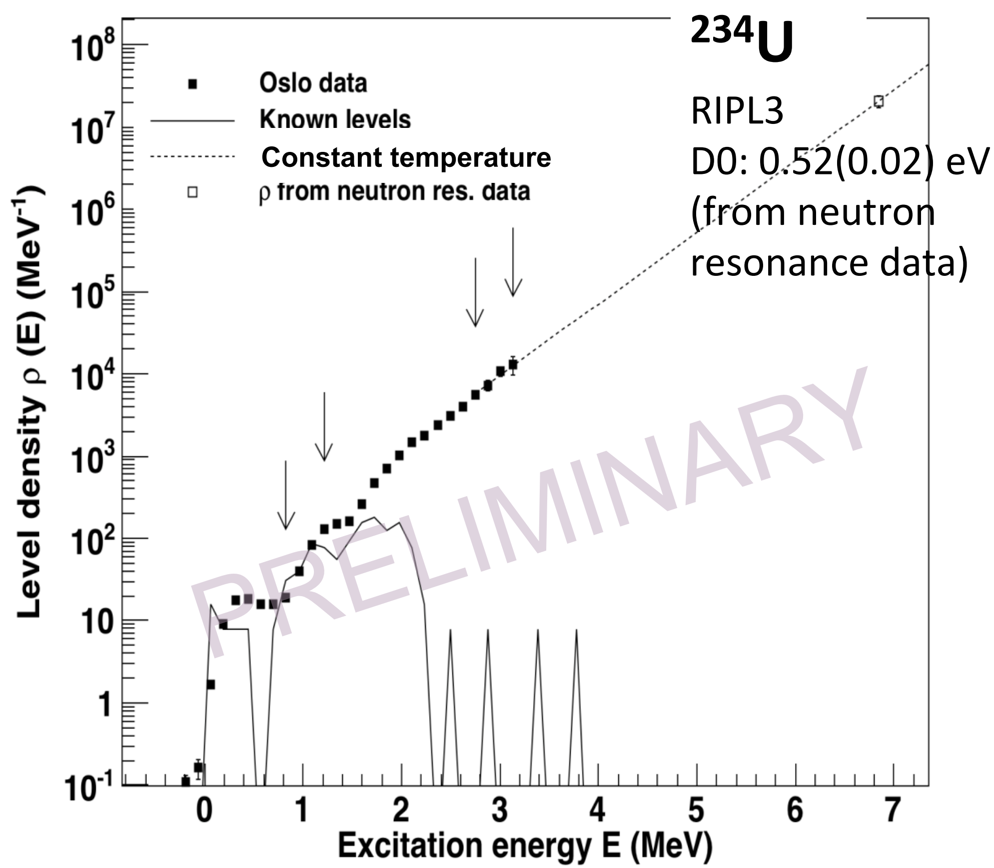
Level density of ^{234}U, found by the "Oslo method"

Sunniva Rose

Constant temperature – consistent with other U and actinide nuclei

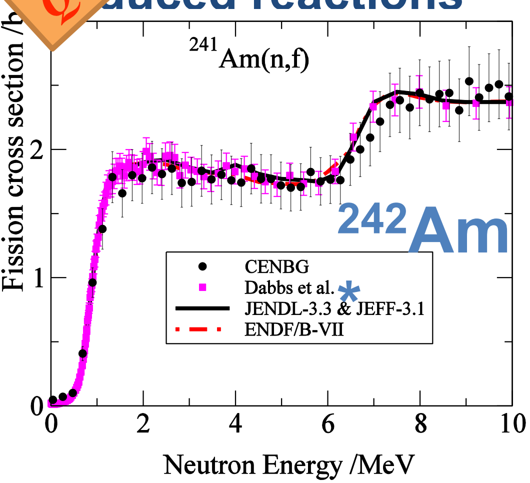
Hope to get to S_n – work in progress to subtract fission gammas





Surrogate Experiment : Recent work

Comparison surrogate/neutron induced reactions



G. Kessedjian, et al., Phys. Lett B 692 (2010) 297

Examples of surrogate reactions performed since 2004

Fission

OK !

Example

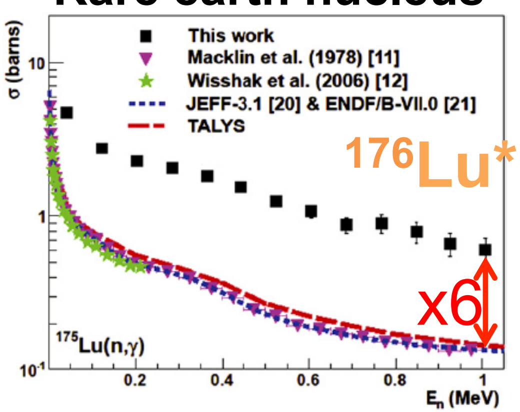
Desired reaction	E_n range (MeV)	Surrogate reaction	Type	Reference
		(n, f) cross sections		
^{230}Th(n, f)	0.5–10	^{232}Th(^{3}He, α))	absolute	Petit *et al.* (2004)
^{230}Th(n, f)	0.22–25	^{232}Th(^{3}He, α))	ratio	Goldblum *et al.* (2009)
^{231}Th(n, f)	0.36–25	^{232}Th(^{3}He, ^{3}He′)	ratio	Goldblum *et al.* (2009)
^{231}Pa(n, f)	0.5–10	^{232}Th(^{3}He, t)	absolute	Petit *et al.* (2004)
^{233}Pa(n, f)	0.5–10	^{232}Th(^{3}He, p)	absolute	Petit *et al.* (2004)
^{233}Pa(n, f)	11.5–16.5	^{232}Th(^{6}Li, α)	ratio	Nayak *et al.* (2008)
^{233}U(n, f)	0.4–18	^{234}U(α, α′)	ratio	Lesher *et al.* (2009)
^{236}U(n, f)	0–20	^{238}U(^{3}He, α)	absolute, ratio	Lyles *et al.* (2007a)
^{237}U(n, f)	0–13	^{238}U(d, d′)	ratio	Plettner *et al.* (2005)
^{237}U(n, f)	0–20	^{238}U(α, α′)	ratio	Burke *et al.* (2006)
^{239}U(n, f)	0–20	^{238}U(^{18}O, ^{16}O)	ratio	Burke *et al.* (2011)
^{237}Np(n, f)	10–20	^{238}U(^{3}He, t)	absolute, ratio	Basunia *et al.* (2009)
^{238}Pu(n, f)	0–20	^{239}Pu(α, α′)	ratio	Ressler *et al.* (2011)
^{241}Am(n, f)	0–10	^{243}Am(^{3}He, α)	absolute	Kessedjian *et al.* (2010)
^{242}Cm(n, f)	0–10	^{243}Am(^{3}He, t)	absolute	Kessedjian *et al.* (2010)
^{243}Cm(n, f)	0–3	^{243}Am(^{3}He, d)	absolute	Kessedjian *et al.* (2010)
		(n, γ) cross sections		
^{155}Gd(n, γ)	0.05–3.0	^{156}Gd(p, p′)	absolute, ratio	Scielzo *et al.* (2010)
^{157}Gd(n, γ)	0.05–3.0	^{158}Gd(p, p′)	absolute, ratio	Scielzo *et al.* (2010)
^{161}Dy(n, γ)	0.13–0.56	^{162}Dy(^{3}He, ^{3}He′)	ratio	Goldblum *et al.* (2010)
^{170}Yb(n, γ)	0.165–0.405	^{171}Yb(^{3}He, ^{3}He′)	ratio	Goldblum *et al.* (2008)
^{170}Yb(n, γ)	0.225–0.465	^{172}Yb(^{3}He, α)	ratio	Goldblum *et al.* (2008)
^{171}Yb(n, γ)	0.12–0.24	^{171}Yb(d, p)	ratio	Hatarik *et al.* (2010)
^{233}Pa(n, γ)	0–1	^{232}Th(^{3}He, p)	absolute	Boyer *et al.* (2006)
^{235}U(n, γ)	0.9–3.3	^{235}U(d, p)	ratio	Allmond *et al.* (2009)
^{237}U(n, γ)	0.2–1.0	^{238}U(α, α′)	absolute, ratio	Bernstein *et al.* (2006);
^{232}Th(n,γ)	0-1.2	^{232}Th(d,p)	absolute	J. Wilson et al. (2012)
^{175}Lu(n,γ)	0-1	^{174}Yb(^{3}He,p)	absolute	G. Boutoux et al. (2012)
^{172}Yb(n ,γ)	0-1	^{174}Yb(^{3}He,α)	absolute	G. Boutoux et al. (2012)

Capture

NOT OK !

Example

Rare earth nucleus



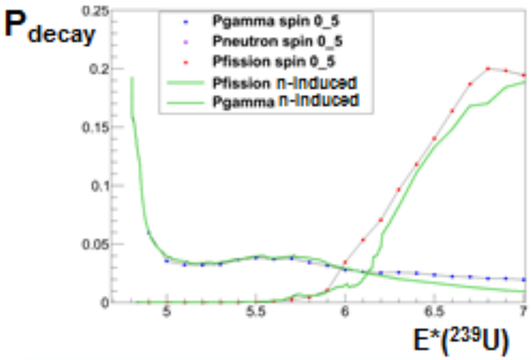
G. Boutoux, et al., Phys. Lett B 712 (2012) 319

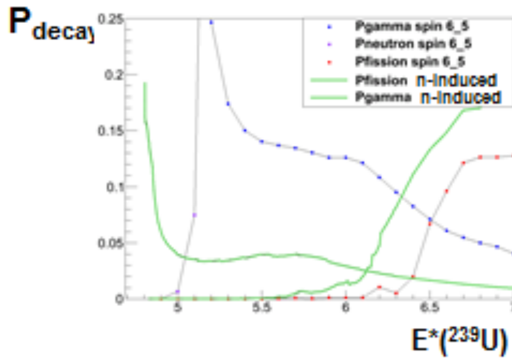
Jutta Escher, et al., Rev. Mod. Phys. 84 (2012) 353

Oslo measurements: Comparison with statistical models 2/2

STEP 1 : Fix the parameters of the model that reproduce the neutron data (LD, γSF…)

(neutron-induced) $^{238}U + n \rightarrow {}^{239}U^* \leftarrow {}^{238}U + d$ (surrogate)





Observations :

- P_γ and P_f are both very sensitive to the Jπ

➡ In contradiction with what we observe → can not reproduce surrogate data ?

➡ Surrogate data represent an important test to statistical models

Conclusion

The surrogate method

- The surrogate method is the only way to obtain information of very radioactive nuclei ($T_{1/2}$ < few days)

Results

- Fission : Cross section measurements are comparable to neutron data
- Gamma emission : Cross section measurements are NOT comparable to neutron data → use it for fixing statistical model parameters

Observations

- Fission much less sensitive to the spin distribution than gamma emission

Statistical model calculations

- Seem not to be able to reproduce experimental surrogate data

Discussion(s)

Lee Bernstein

• IAEA Data

- Evaluation Methodology – differences in data – Panel?

1. Data Sources
2. Data Format
3. Evaluation Methodology
4. New Measurements
5. Understanding Sources of Discrepancy

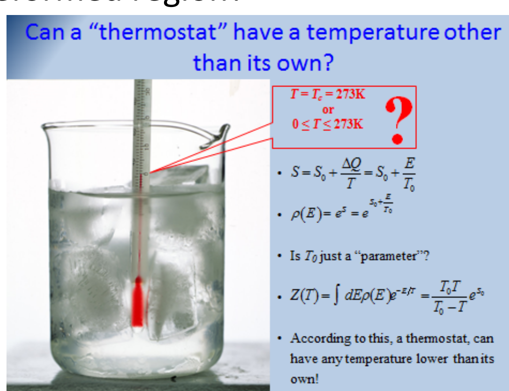
2016 New 5 year Project

Luciano Moretto

• Level Density

1. Collective Enhancements (and demise with excitation energy)
2. Can we go from an experimental level density to the partition function ?

Discussion on change of deformations, staggering in bands due to coriolis force. How to measure these, systematic survey across region deformed region?



Richard Firestone

Gamma Strength

- Collective Strength
  - Brink-Axel –E1's
  - Rotation – E2's
  - Scissor Mode – M1
- Single Particle Strength
- Level Spin Dependence
- Level Energy Dependence
- Statistical Model for Analysis (PT?)
- Separation of Photon Strength from Level Densities

Discussion on problem with large errors, consistency. Population mechanism, dependent on K? Dependent on reaction mechanism (p, p'), (n, g'), (^3He,^4He)? Any evidence to invalidate our assumptions?

Conclusion

- **Need for database of measurements**

- **Need for systematic experiments**

- **Need for better consistency**

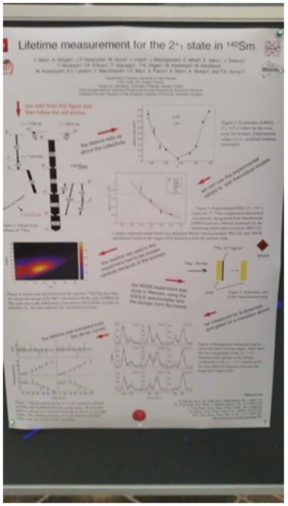
References

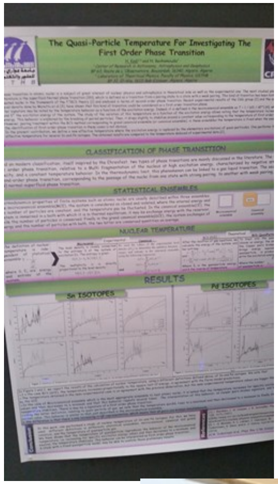
- **(Oslo)** http://www.mn.uio.no/fysikk/english/research/about/infrastructure/OCL/nuclear-physics-research/compilation
- **(Dubna)** A.M. Sukhovoj et al.(2005-08)

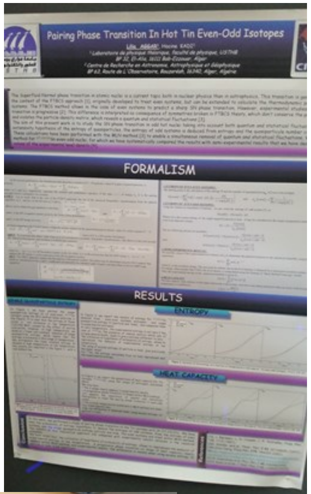
Vladimir Plujko

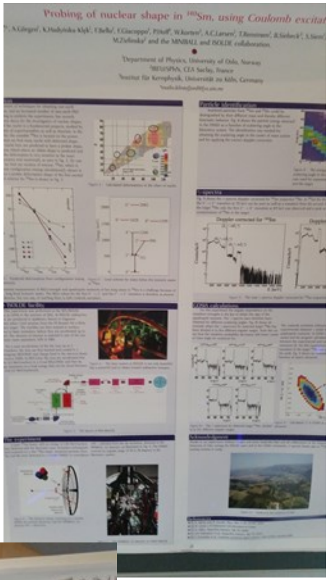
- **Compile "high priority" nuclides in the atlas into ENSDF format**
- **Model the partial γ-ray production cross sections using EMPIRE and TALYS**

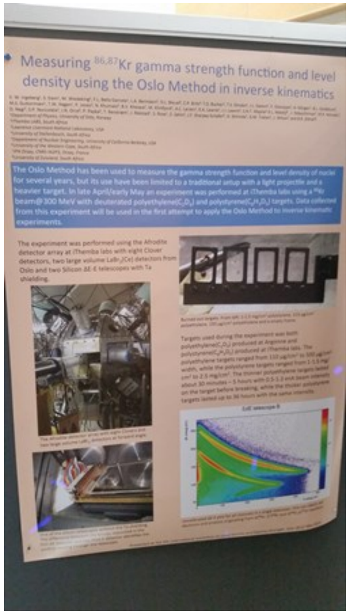
Lee Bernstein

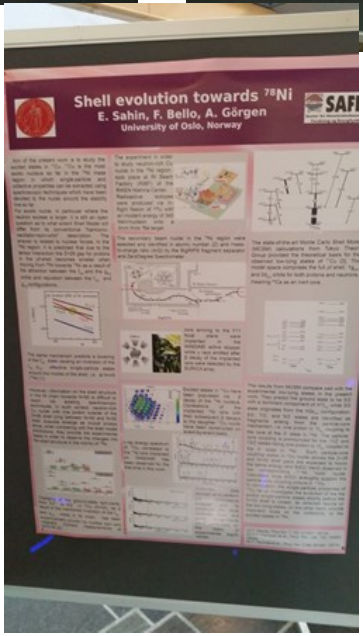


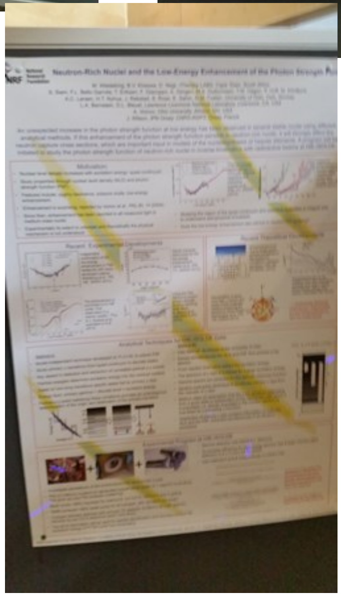


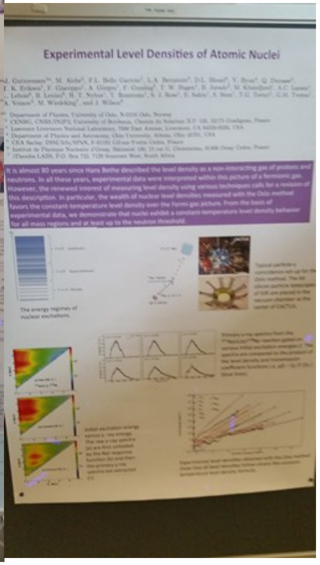












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NRF National Research Foundation
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Ackowledgements

Achakovskiy, Oleg
Aggar, Lilia
Alhassid, Yoram
Asres, Yihunie Hibstie
Avrigeanu, Marilena
Avrigeanu, Vlad
Badola, Amit
Balaram, Dey
Belgya, Tamás
Bello Garrote, Frank Leonel
Bernstein, Lee
Bertsch, George
Bleuel, Darren
Byun, Youngshin
Campo, Lucia Crespo
Cieplicka-Orynczak, Natalia
Cizewski, Jolie
Derya, Vera
Ducasse, Quentin
Døssing, Thomas
Filipescu, Dan Mihai
Firestone, Richard
Görgen, Andreas
Grimes, Steven
Gunsing, Frank
Guttormsen, Magne
Hadynska-Klek, Katarzyna
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Ingeberg, Vetle W.
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Kheswa, Bonginkosi Vincent
Klintefjord, Malin
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Larsen, Ann-Cecilie
Lebois, Matthieu
Litvinova, Elena
Modamio, Victor
Moretto, Luciano
Netterdon, Lars
Pickstone, Simon
Plujko, Vladimir
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Popa, Gabriela
Rekstad, John
Renstrøm, Therese
Rose, Sunniva J.
Sahin, Eda
Schwengner, Ronald
Spyrou, Artemis
Siem, Sunniva
Spieker, Mark
Stevenson, Paul
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Valenta, Stanislav
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Voinov, Alexander
Wiedeking, Mathis
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Zelevinsky, Vladimir
Zilges, Andreas
Zhuravlev, Boris
Åberg, Sven