Preliminary results on photon strength functions of ^{195}Pt from resonance neutron radiative capture measured by DANCE experiment

N. Bazhazhina[1], F. Bečvář[2], M. Krtička[2], S. Valenta[2], W. Furman[1], A. Couture[3], R.F. Casten[3]

[1]Joint Institute for Nuclear Research, RU-141980 Dubna, Russia

[2]Charles University in Prague, CZ-180 00 Prague 8, Czech Republic

[3]Los Alamos National Laboratory, P.O. Box 1663, Los Alamos, New Mexico 87545, USA

Outline

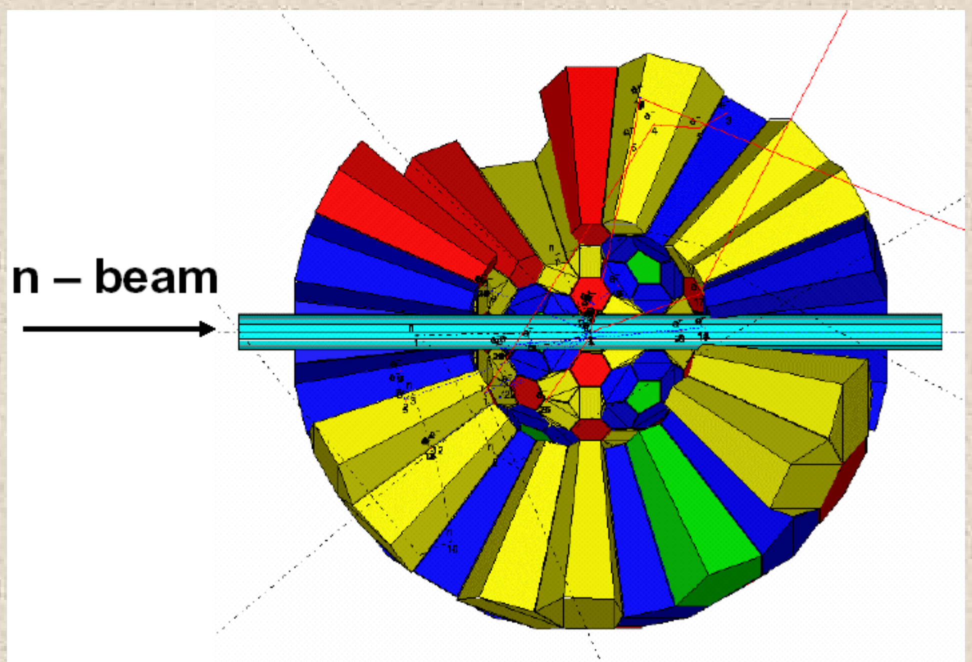
- Experiment
- Data processing

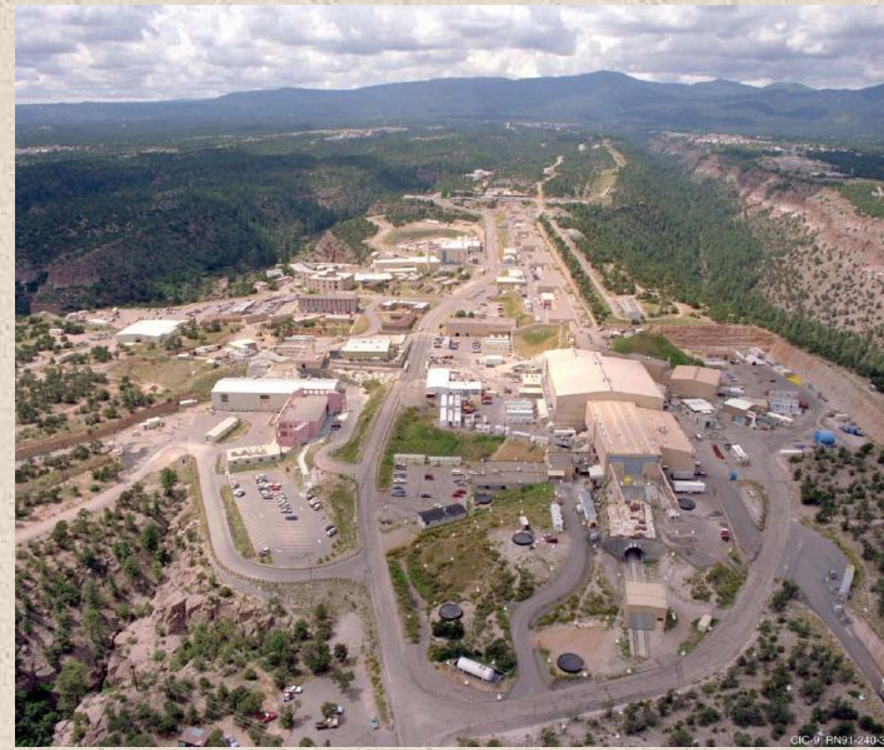
  comparison of experimental spectra with their predictions

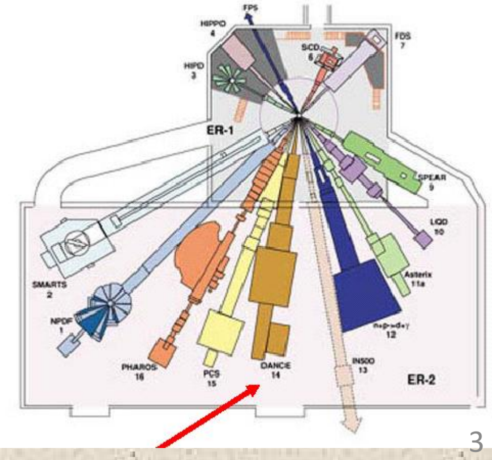
  obtained simulations within statistical model
- Results
- Conclusion

DANCE @ LANSCE

- Moderated W target gives “white” neutron spectrum, ~14 n’s/proton
- DANCE is on a 20 m flight path / ~1 cm @ beam after collimation
- repetition rate 20 Hz
- pulse width ≈ 125 ns
- DANCE consists of 160 BaF_2 crystals

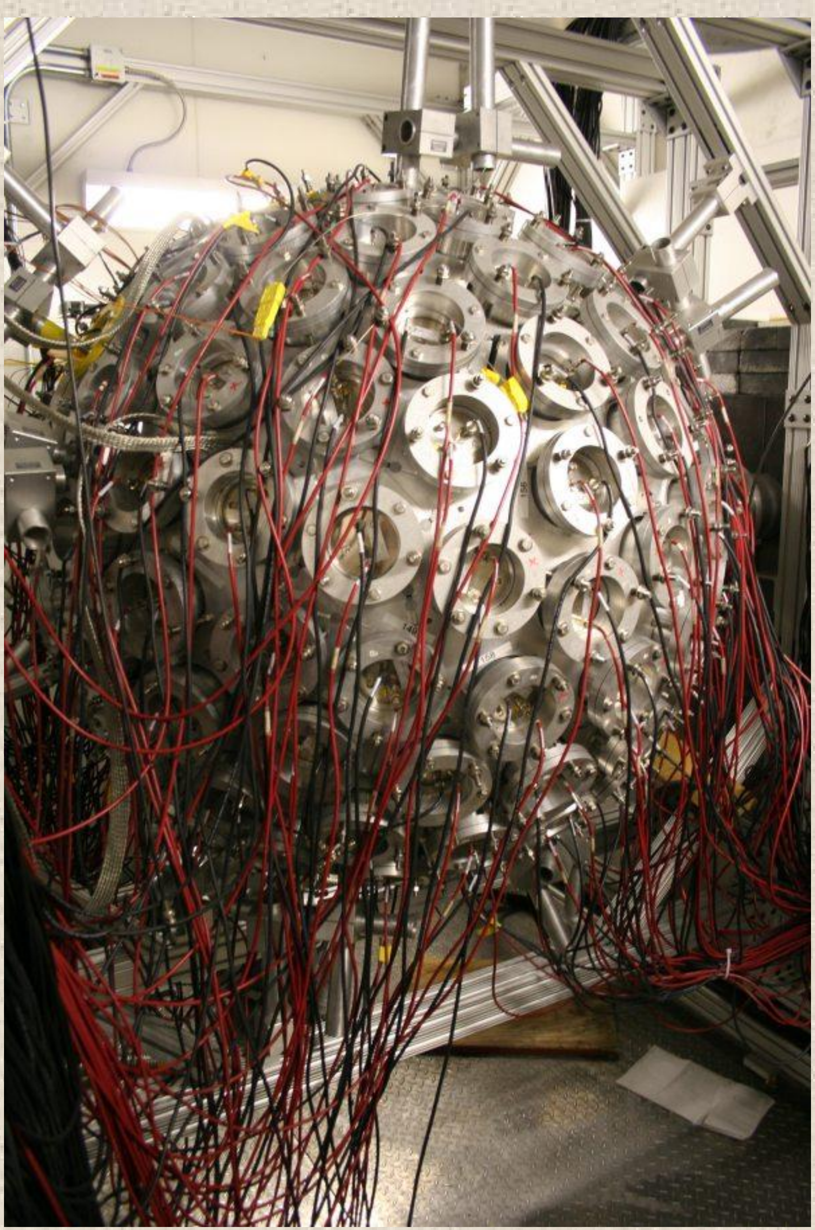




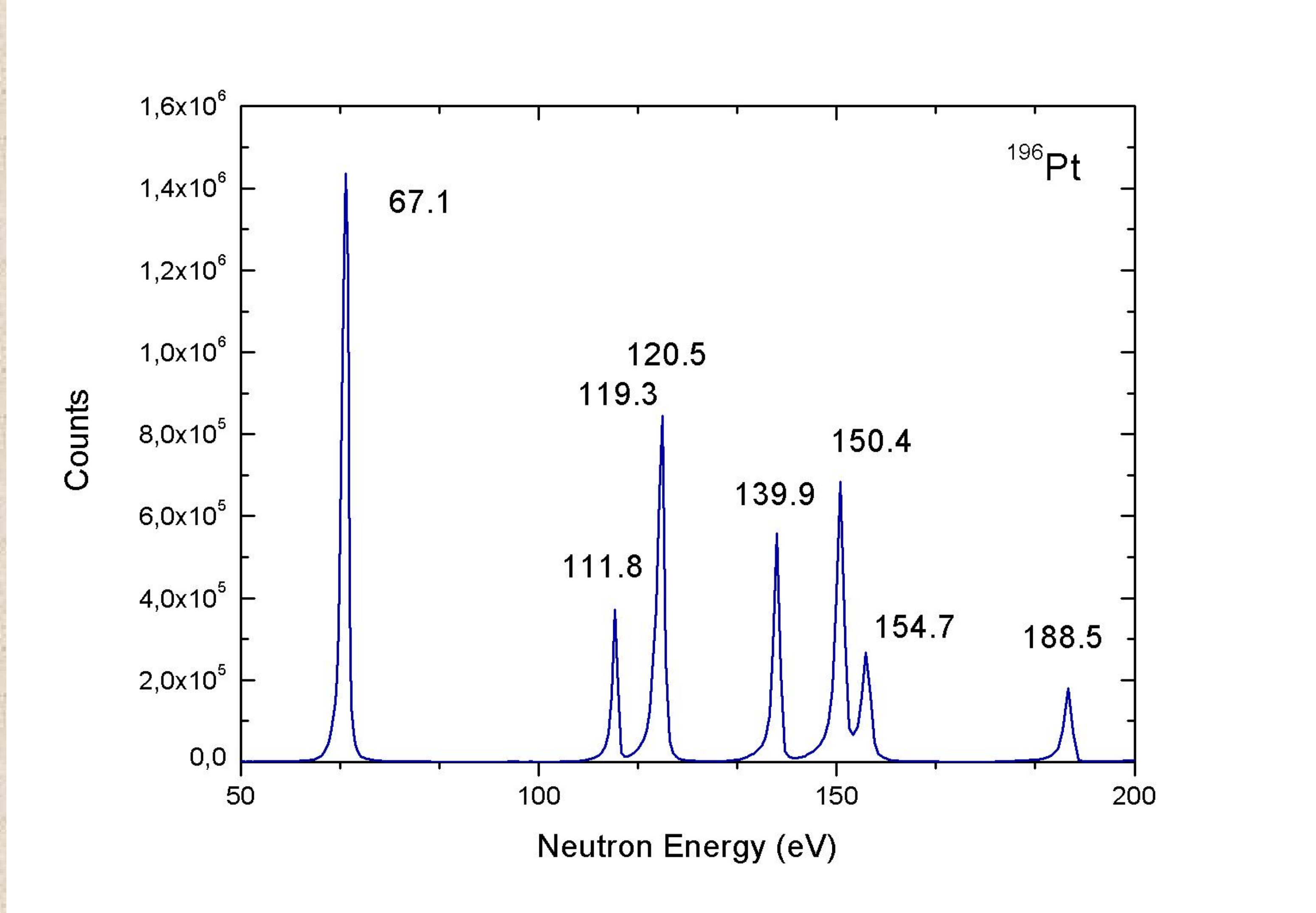


DANCE detector

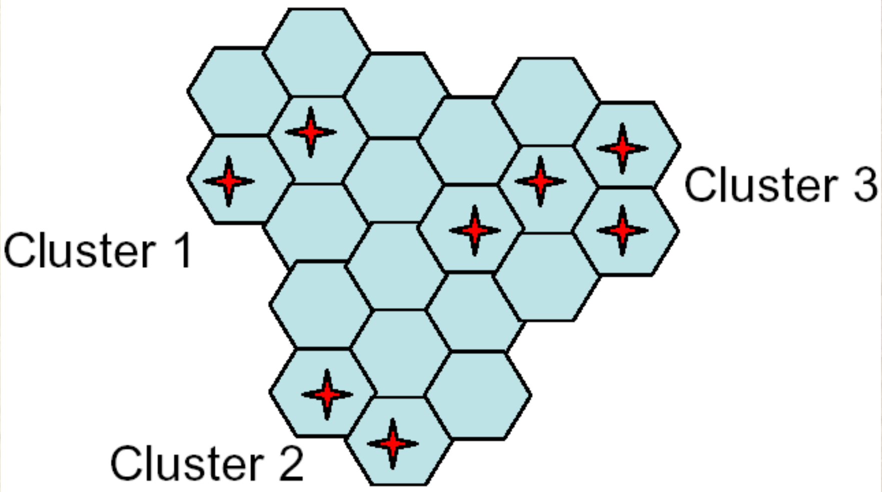
- Measurement of cross sections of small amounts of (radioactive) samples (advanced fuel cycle, astrophysics)
- Determination of properties of resonances (spins and parities)
- Study of γ-decay of distinct neutron resonances and γ-ray strength functions



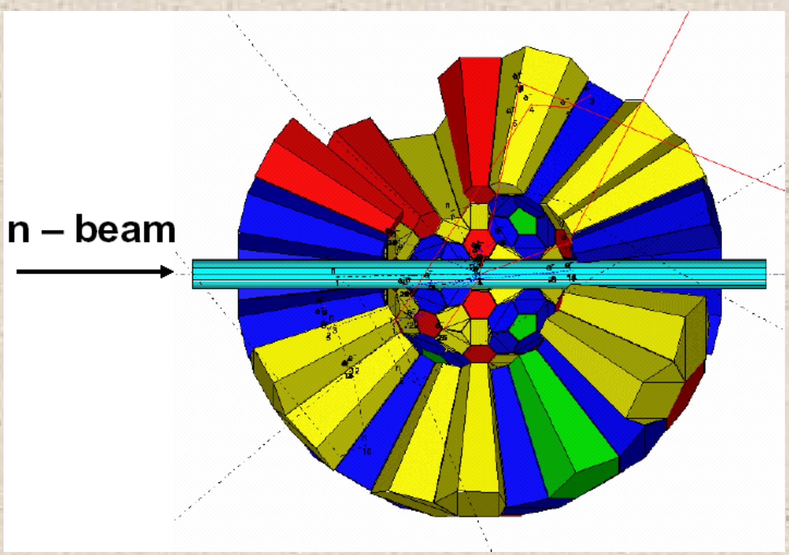
"TOF" spectrum for ^{195}Pt

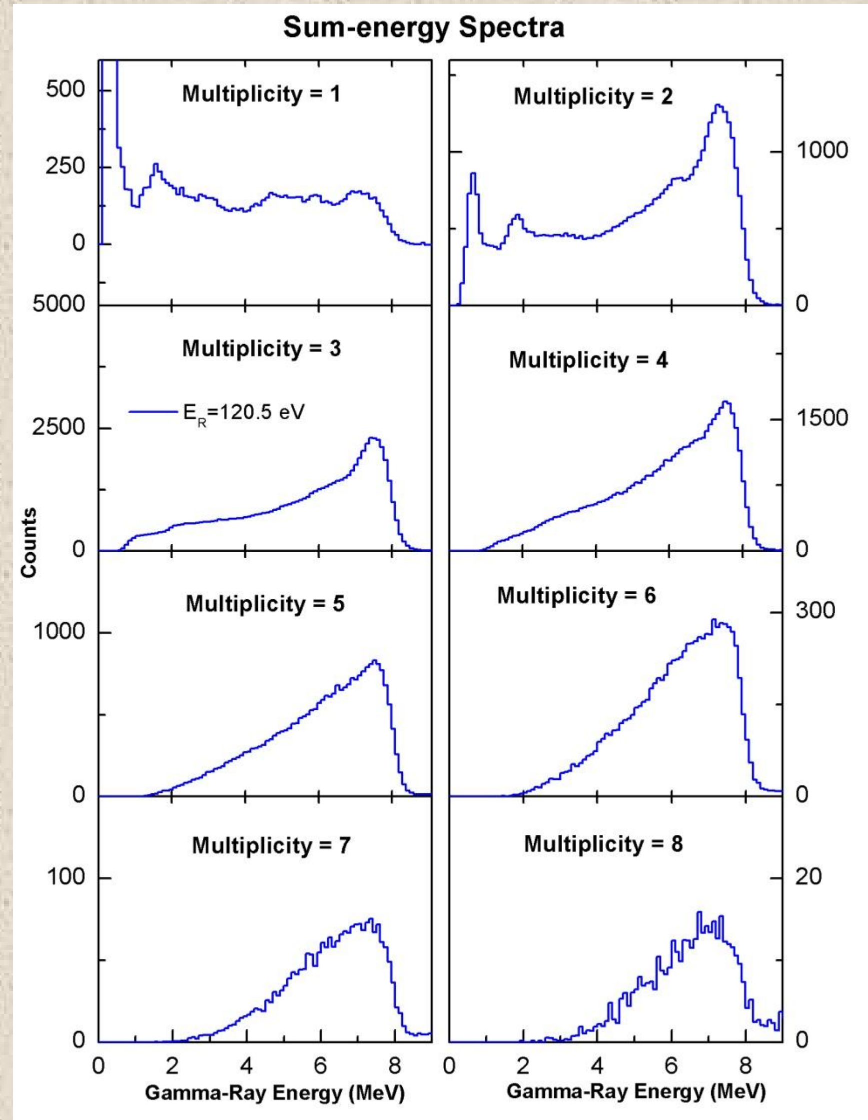


What can be compared? – Multiplicity method

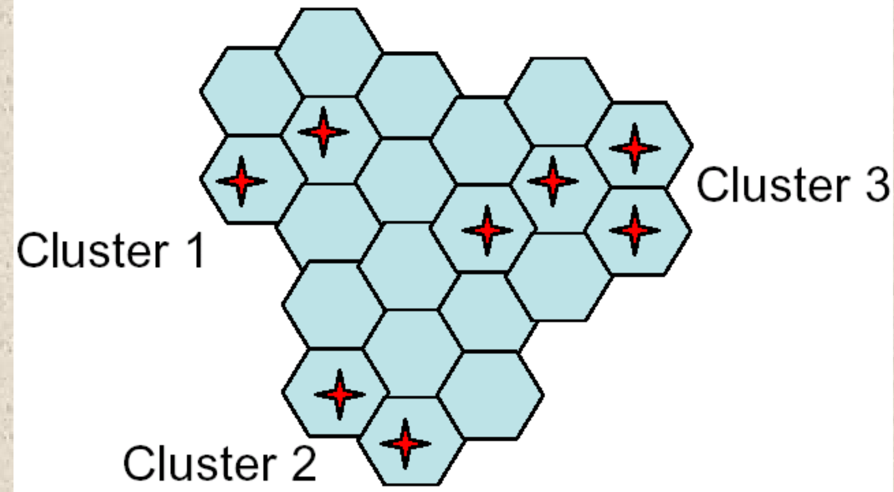


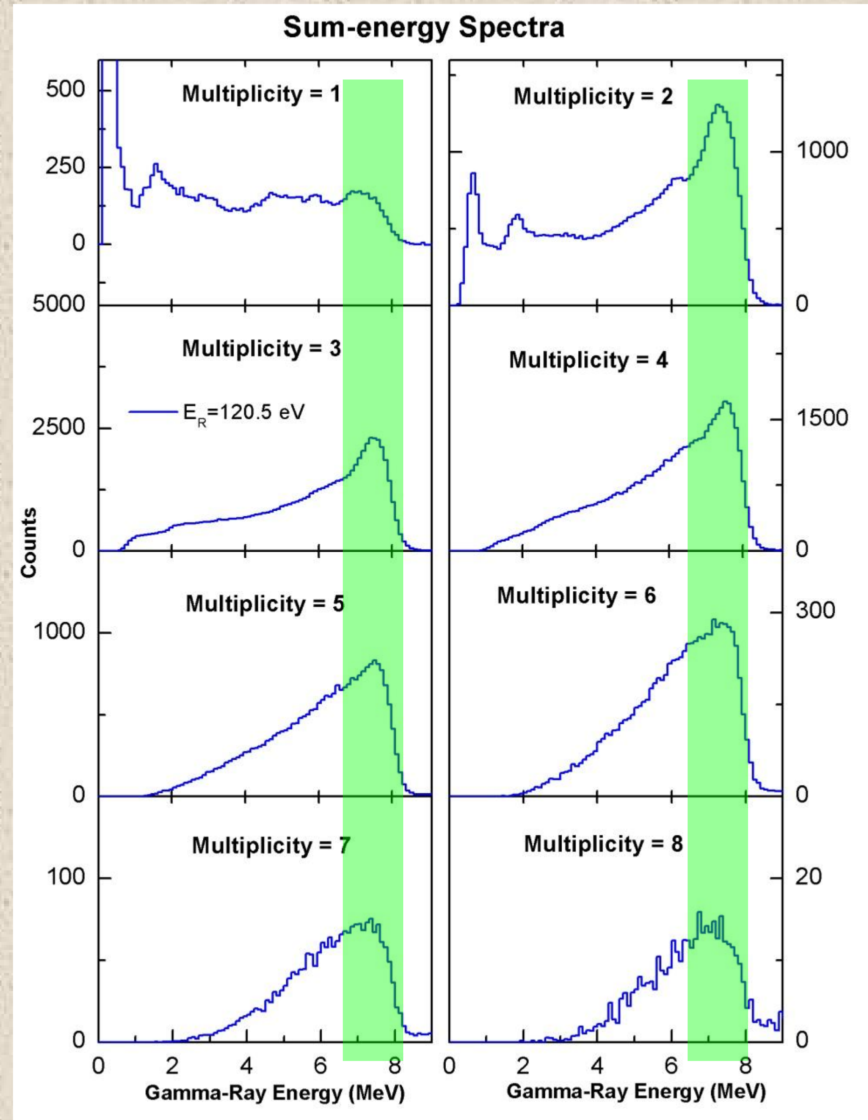
Signals in adjacent Ba $F_{2\ crystals}$ are grouped in clusters – cluster multiplicity *m*





What can be compared?

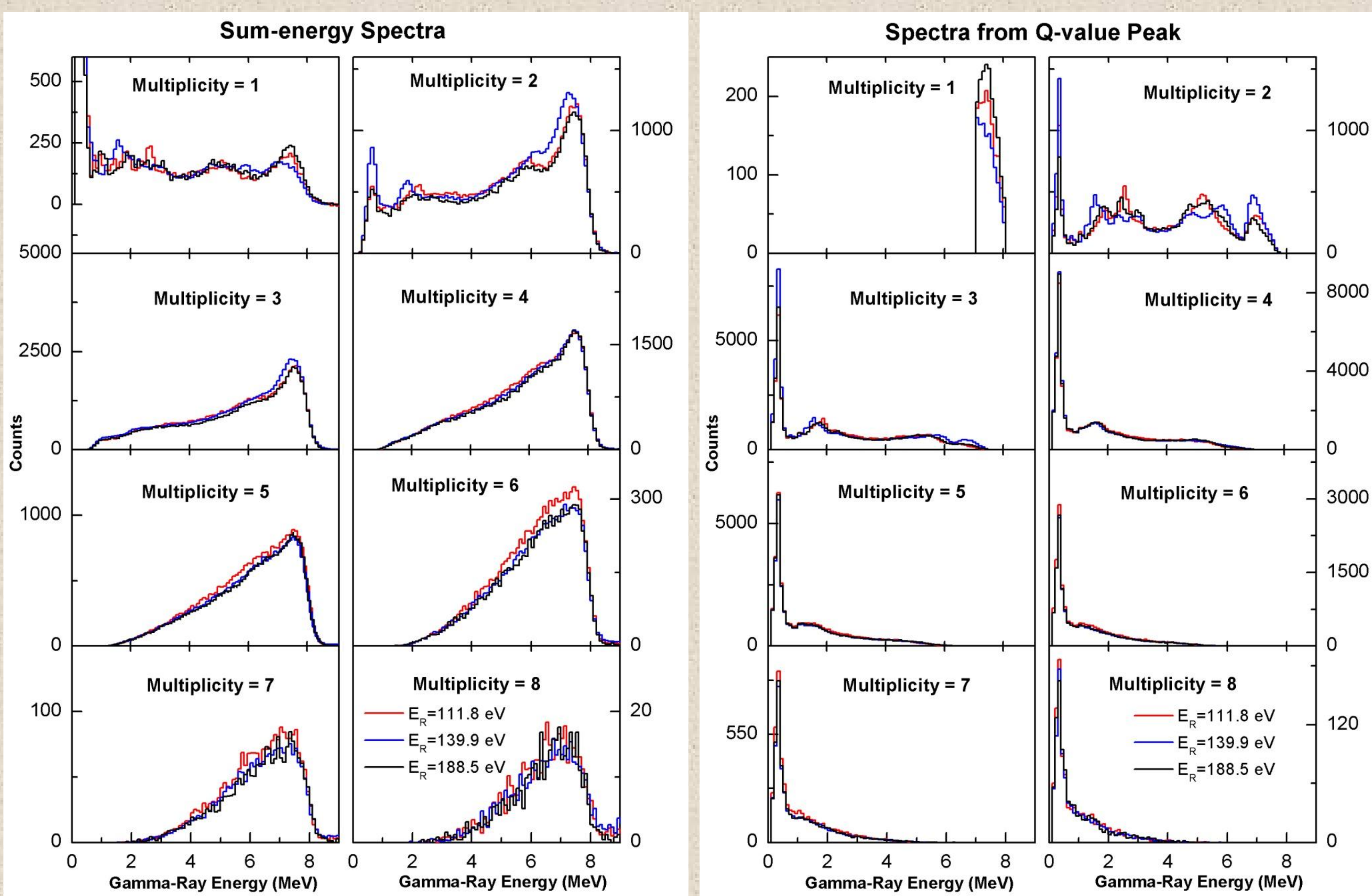




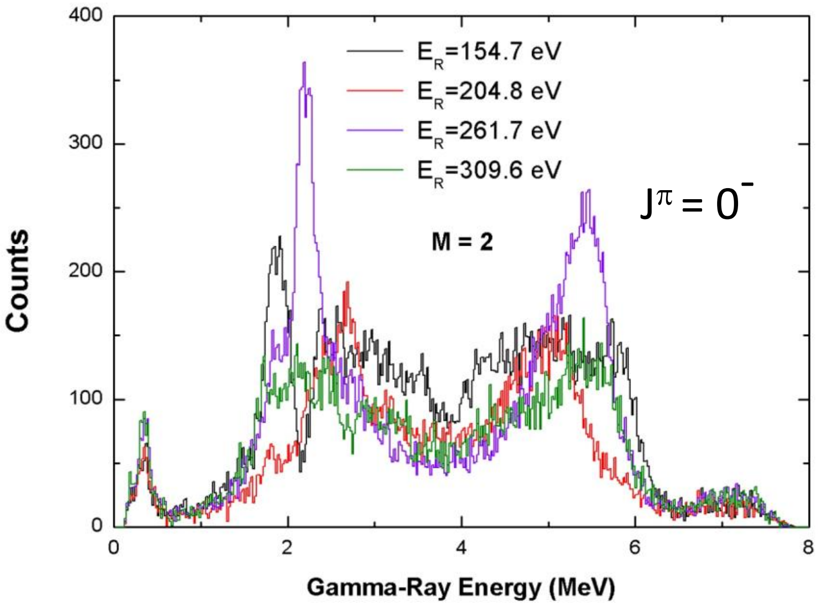
Each spectrum consists of a full-energy peak which is located near the neutron separation energy Sn and a low-energy tail that corresponds to cascades for which part of the emitted γ energy escaped the detection.

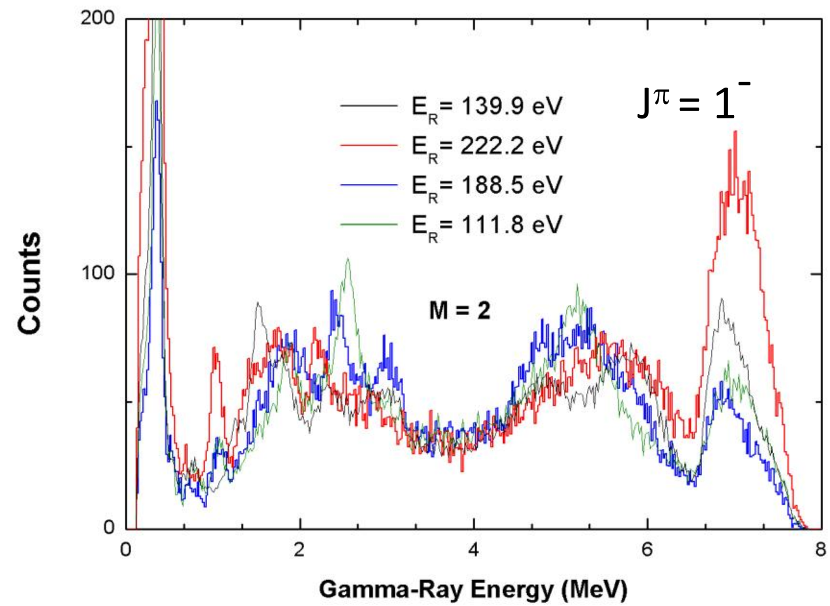
Only events for which the detected E is close to the full-energy peak were included in our analysis.

Experimental multi-step γ cascades (MSC) spectra of ^{196}Pt



Experimental spectra from different resonances M=2





Different levels at excitation energy of 1.5 - 3 MeV are populated from different resonances $\Rightarrow$ the "bumps in the spectra" at E_γ = 1.5 - 3 MeV are very likely not due to any "structure" effects but due to the γSF

DICEBOX
code for statistical model simulations of γ decay

Simulation of γ cascades - DICEBOX algorithm

Main assumptions:

- For nuclear levels below certain "critical energy" spin, parity and decay properties are known from experiments
- Energies, spins and parities of the remaining levels are assumed to be a random discretization of an *a priori* known level-density formula
- A partial radiation width $\Gamma_{i\gamma f}^{(XL)}$, characterizing a decay of a level *i* to a level *f*, is a random realization of a chi-square-distributed quantity the expectation value of which is equal to

  $$f^{(XL)}(E_\gamma)\, E_\gamma^{2L+1}/\rho(E_i),$$

  where $f^{(XL)}$ and ρ are also *a priori* known
- Selection rules governing the γ decay are fully observed
- Any pair of partial radiation widths $\Gamma_{i\gamma f}^{(XL)}$ is statistically uncorrelated

Main feature of DICEBOX

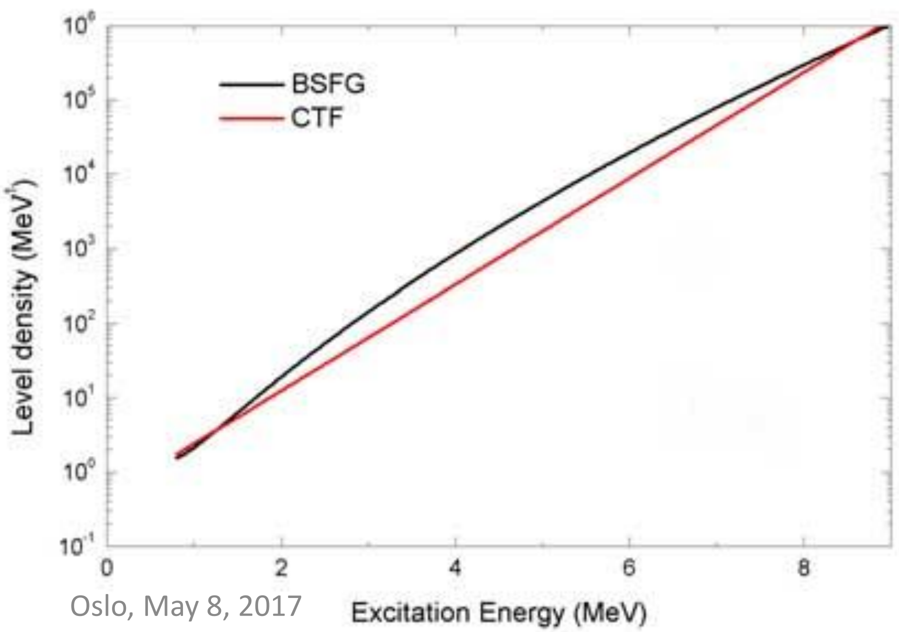
- There exists infinite number of artificial nuclei (nuclear realizations), obtained with the same set of level density and PSFs models, that differ in exact number of levels and intensities of transitions between each pair of them
  $\Rightarrow$ leads to different predictions from different nuclear realizations
- DICEBOX allows us to treat predictions from different nuclear realizations
- The size of fluctuations from different nuclear realizations depends on the (observable) quantity and nucleus
- Electron conversion is taken into account correctly

DICEBOX can produce any quantity related to γ decay

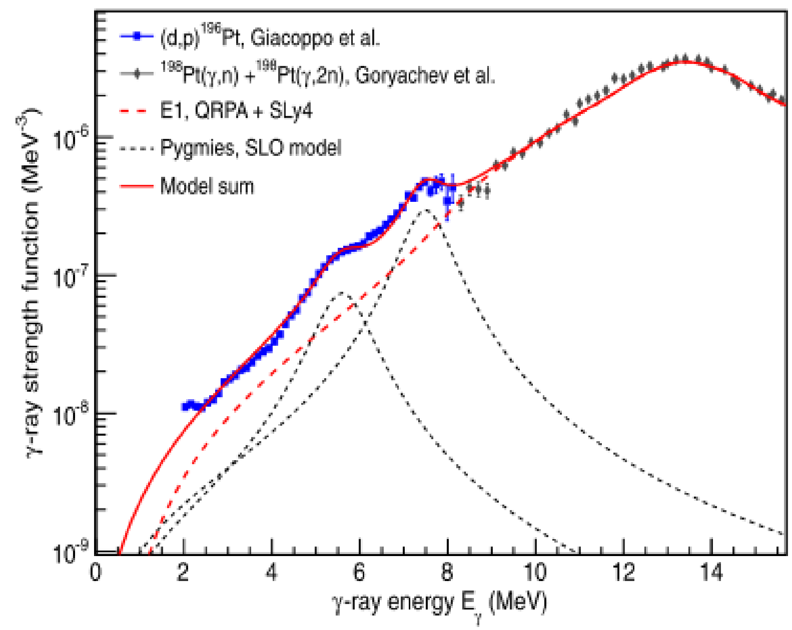
The response of the DANCE detector to the generated cascades for each nuclear realization was subsequently obtained with the help of a code based on the GEANT4 package

Level density and Photon Strength Functions

- There exist different models of LD and γSFs
- For LD we usually used Constant-Temperature model
- For γSF we started with γSF from "Oslo method" (F.Giacoppo et al.,2015) indicating a presence of strong γSF above about 5 MeV.
- Similar γSF shapes indicated also from other data (A.G. Bartholomew, Adv. Nucl. Phys. 7, 1973)



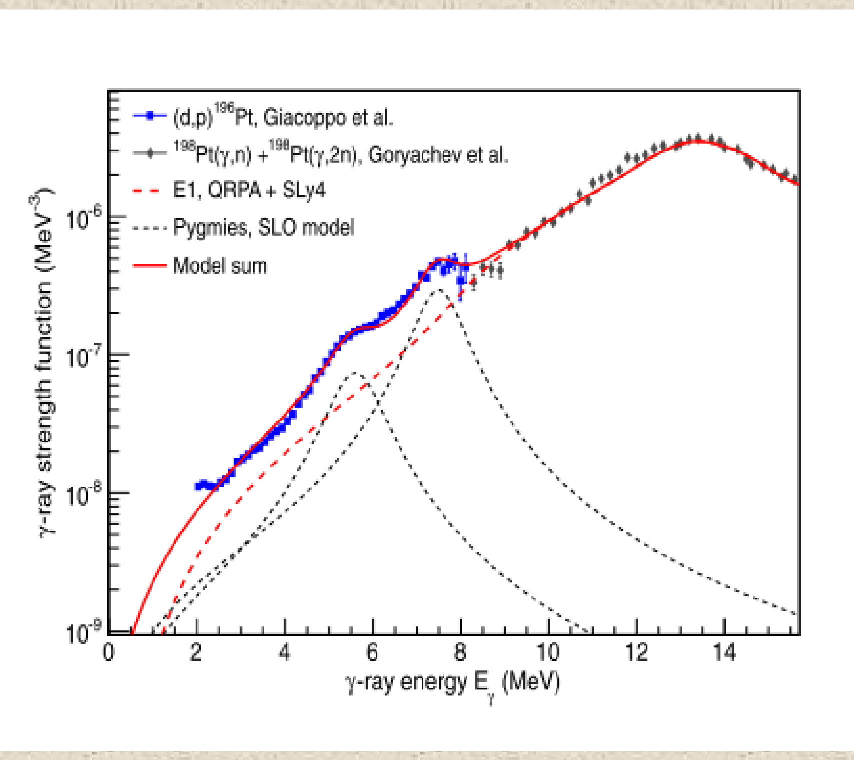
F. Giacoppo et al., EPJ WoC 93, 01039 (2015)



Results
(comparison of experimental and simulated spectra)

Results with the "Oslo model"

(extrapolation of γSF down to low E_γ according to F. Giacoppo et al.)



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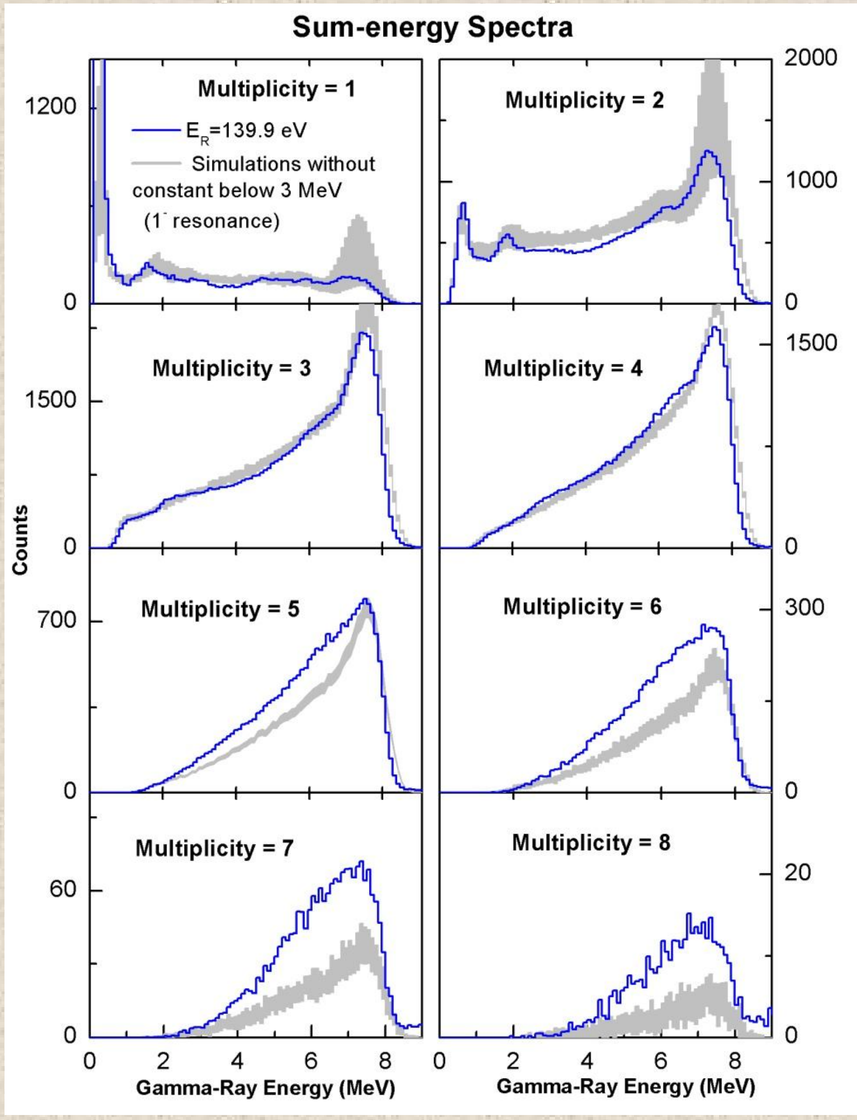

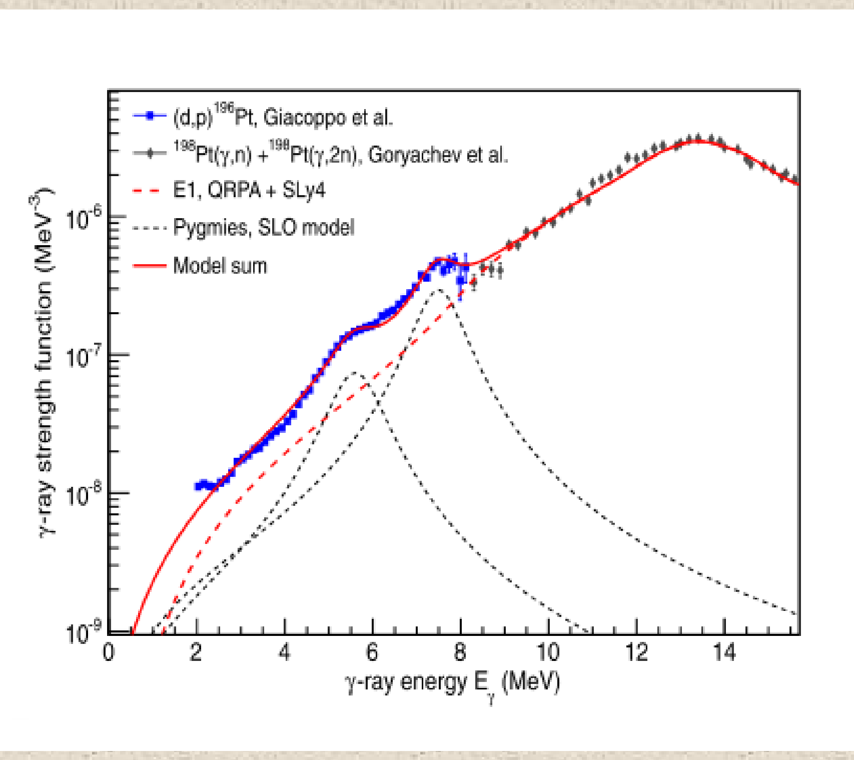

Predicted multiplicity distribution shifted to lower values

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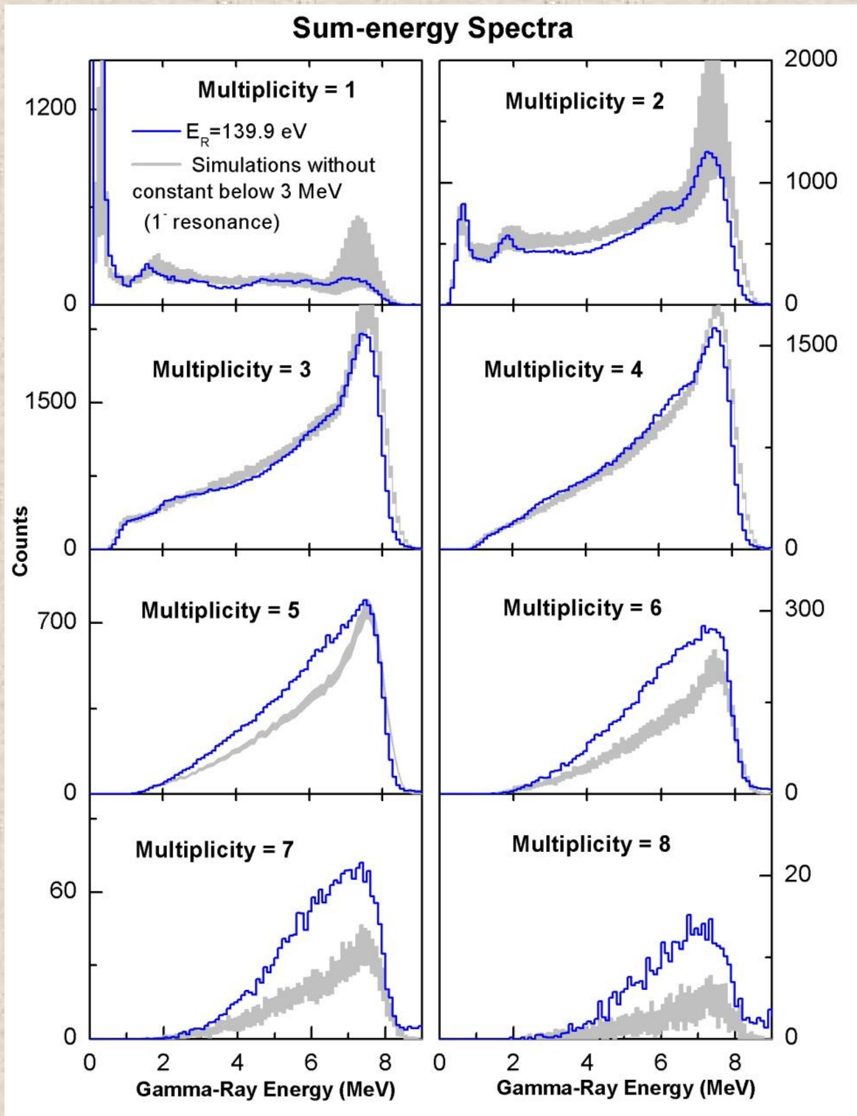
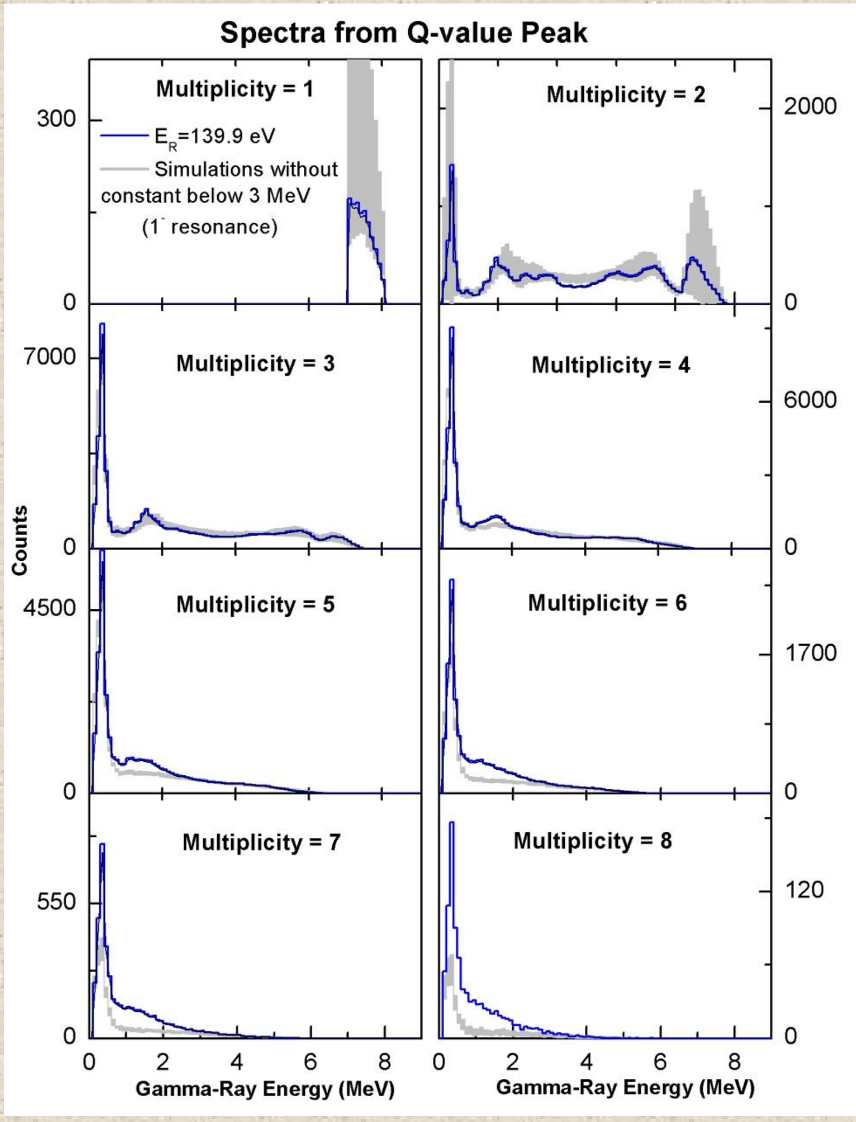
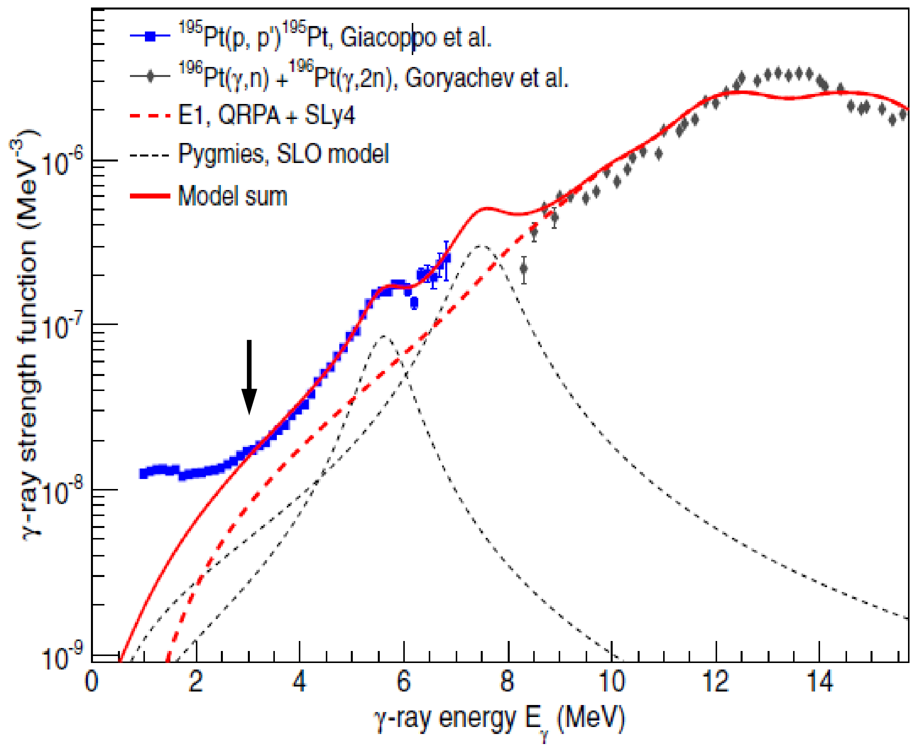


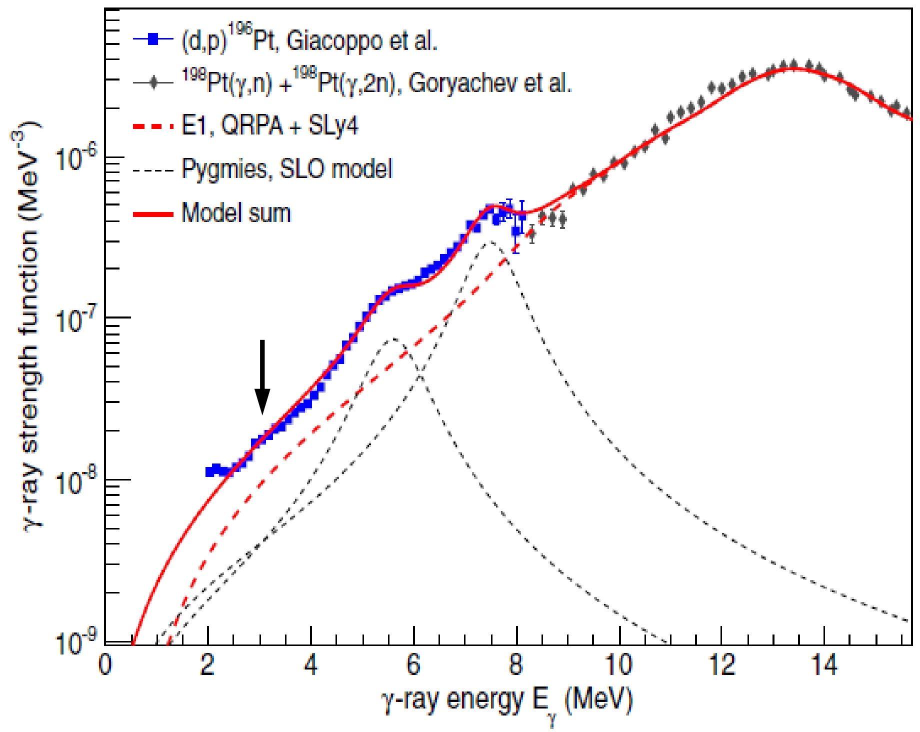


Predicted multiplicity distribution shifted to lower values

Search for a better model

How to shift the multiplicity distribution? … Enhance transitions with low E_γ





F. Giacoppo et al., EPJ WoC 93, 01039 (2015)

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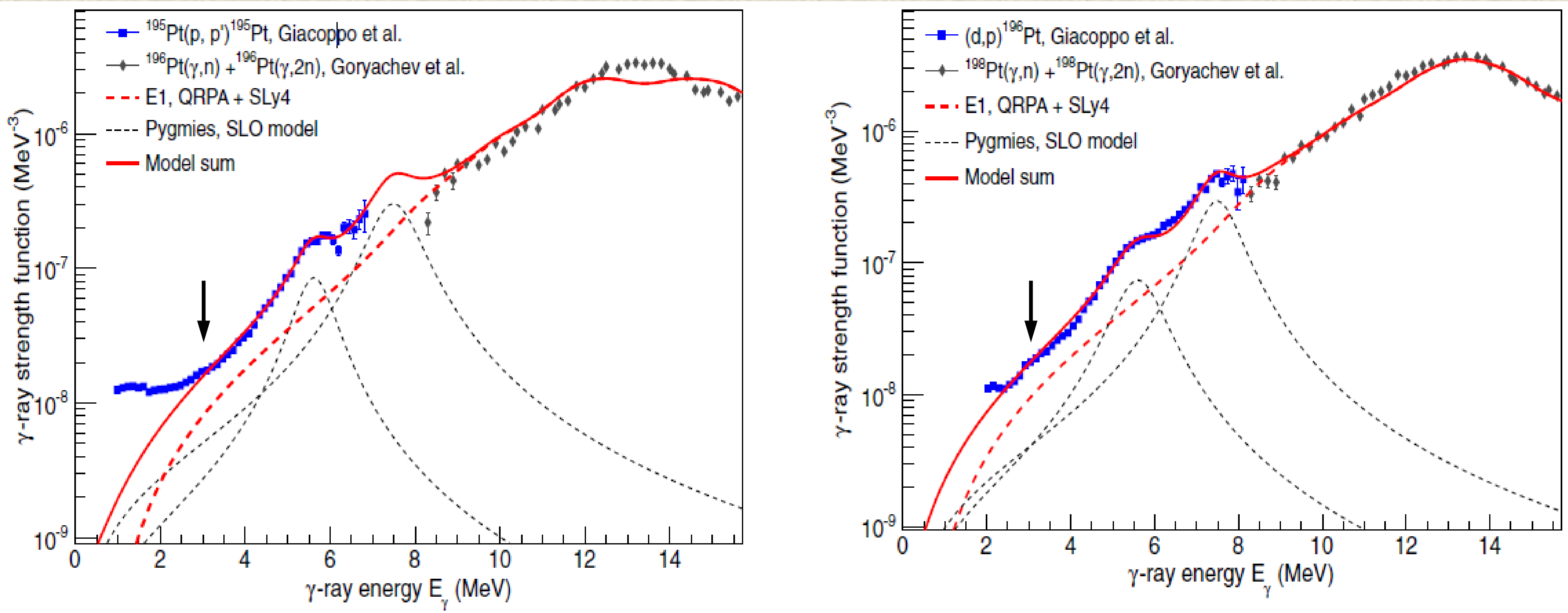

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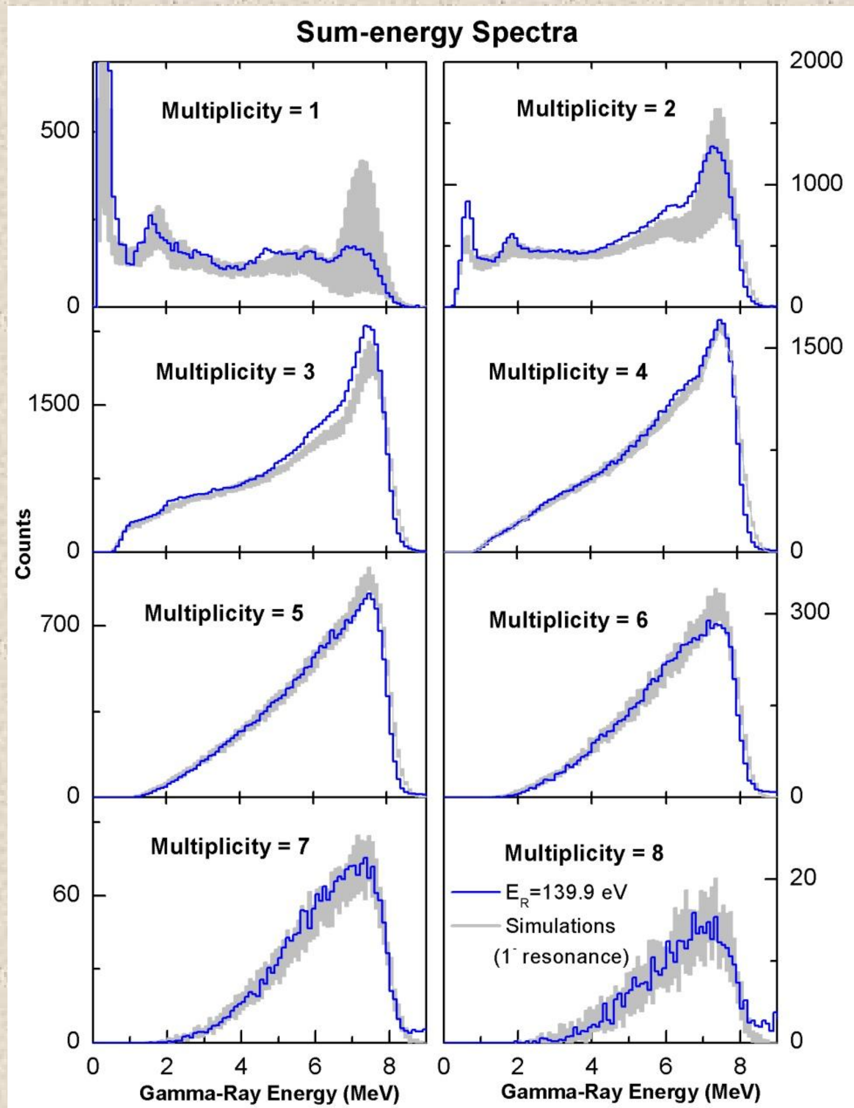
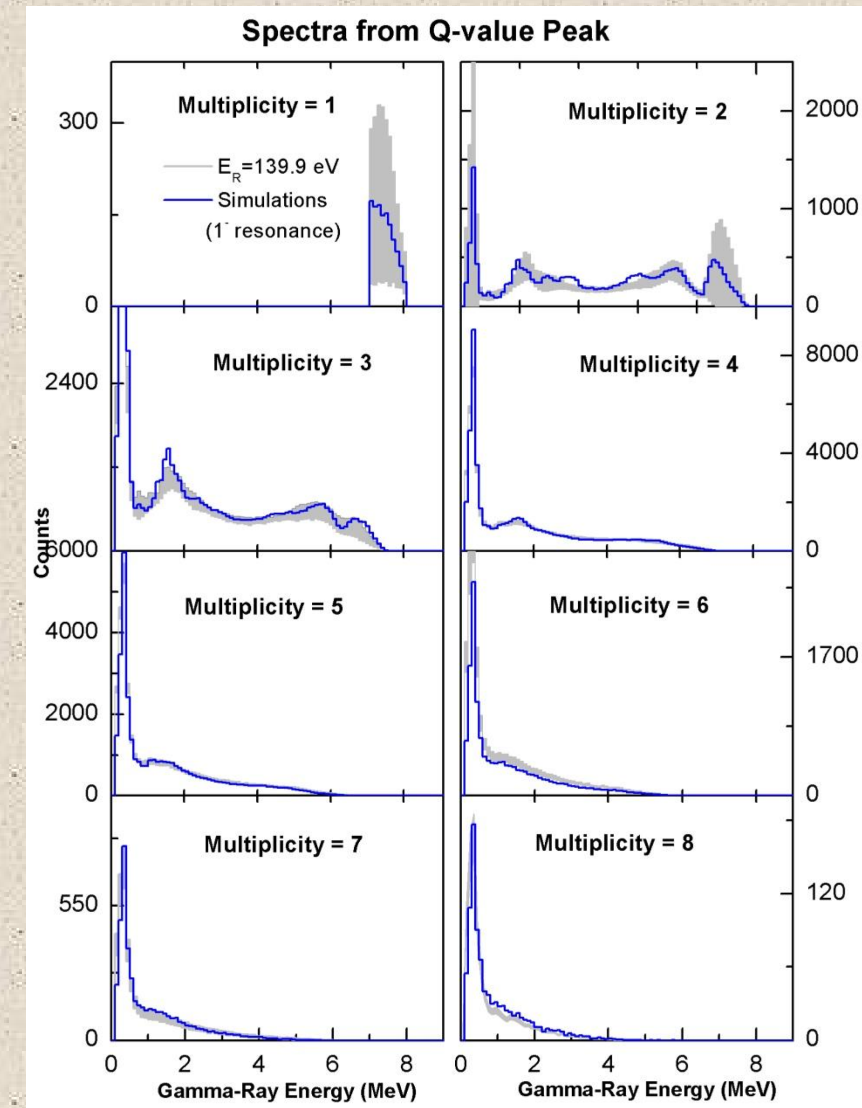
We tried to use a constant E1 γSF at low energies – indicated by "Oslo" data from two Pt isotopes. To reproduce out spectra we needed a constant γSF for E_γ < 3 MeV.

Search for a better model

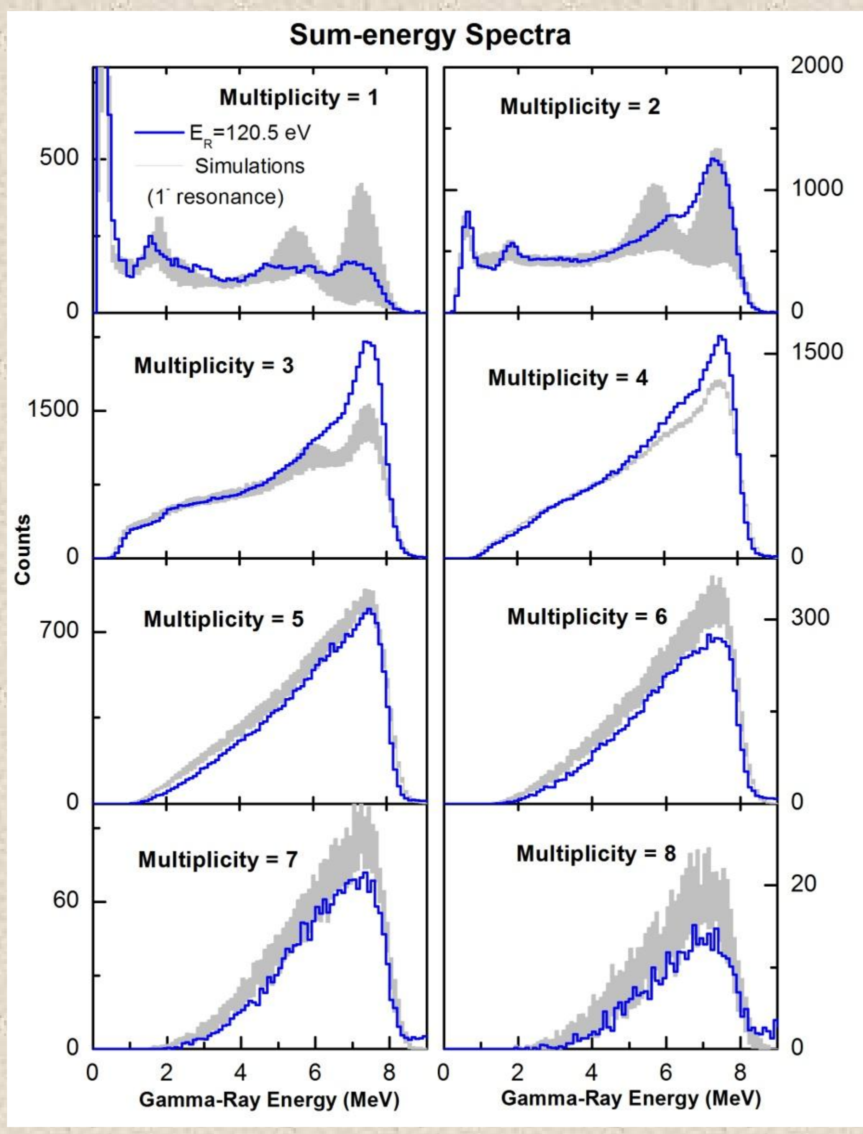
How to shift the multiplicity distribution? … Enhance transitions with low E_γ

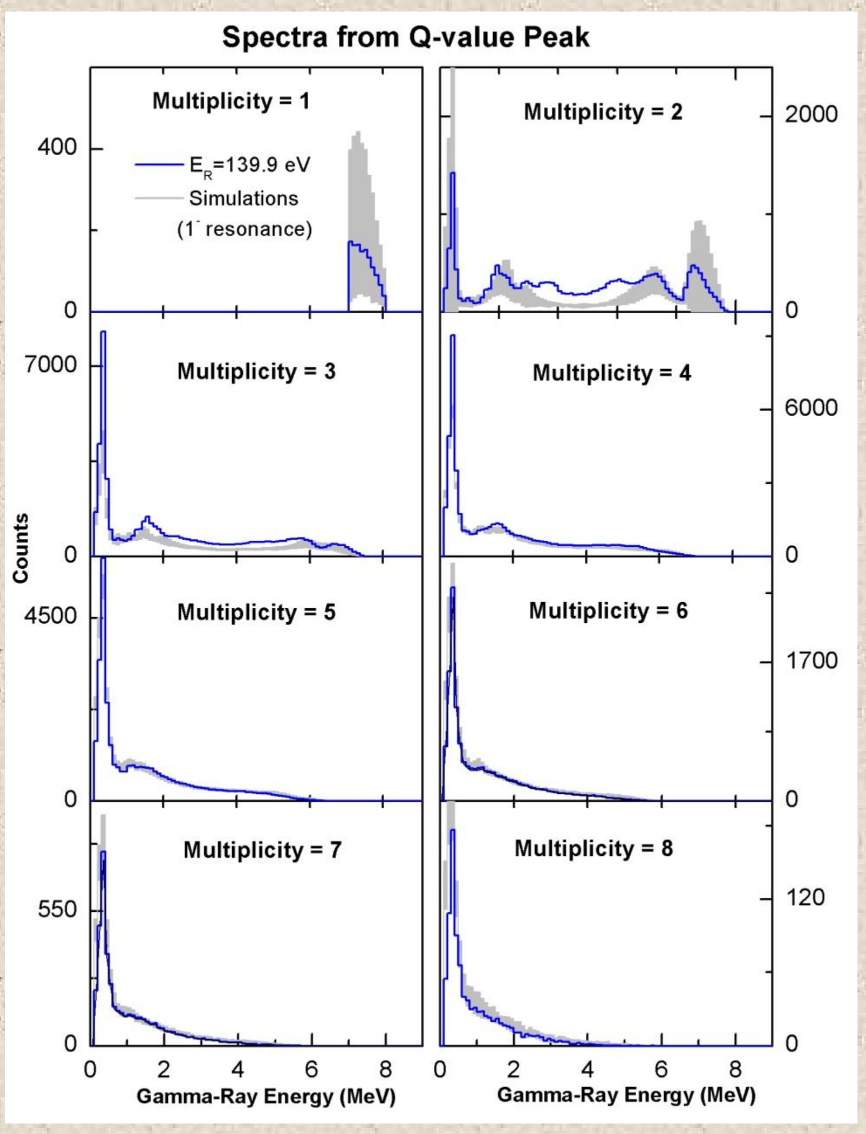




γSF consistent with Oslo data for E_γ > 3 MeV and constant E1 γSF at lower E_γ

Comparison of experimental data with simulation where PSF doesn't include 7.5 MeV Pygmy Dipole Resonance





Conclusions

- Experimental coincident spectra from $^{195}Pt(n, \gamma)$ reaction measured with DANCE were compared to predictions from statistical model simulations
- We reached a satisfactory description of the experiment data with at least one γSF + LD model combination - the model well reproduces "Oslo" results from $^{195}Pt(p,p')^{195}Pt$ (F.Giacoppo et al., EPJ WoC 93, 01039, 2015)
- This result can indicate that a temperature dependence of E1 γSF initially introduced in KMF model has universal meaning for low energy primary gamma-transitions
- Further investigations of other variants of γSF and LD will be continued.

Thanks for your attention