Transition from order to chaos in rotational nuclei

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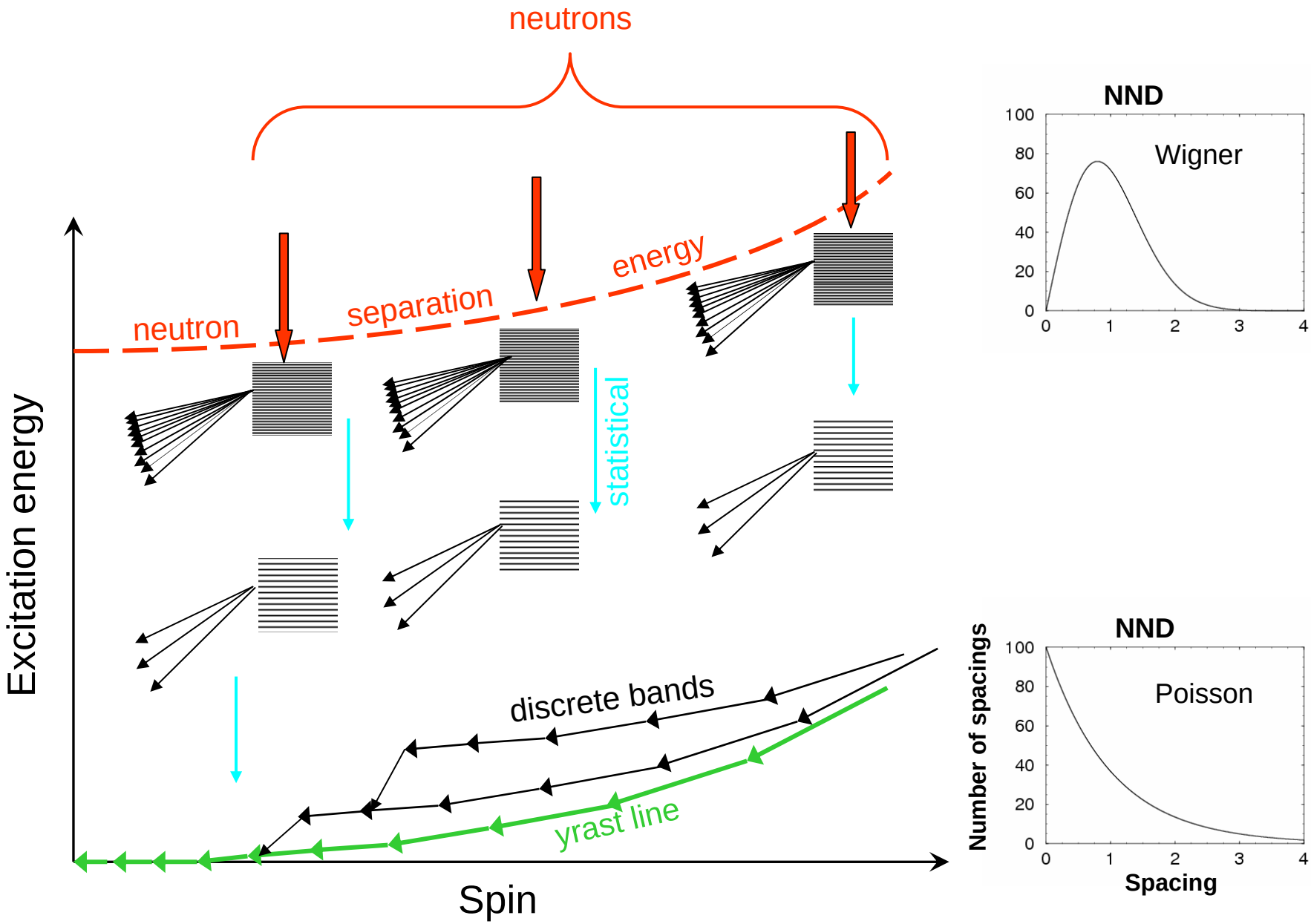
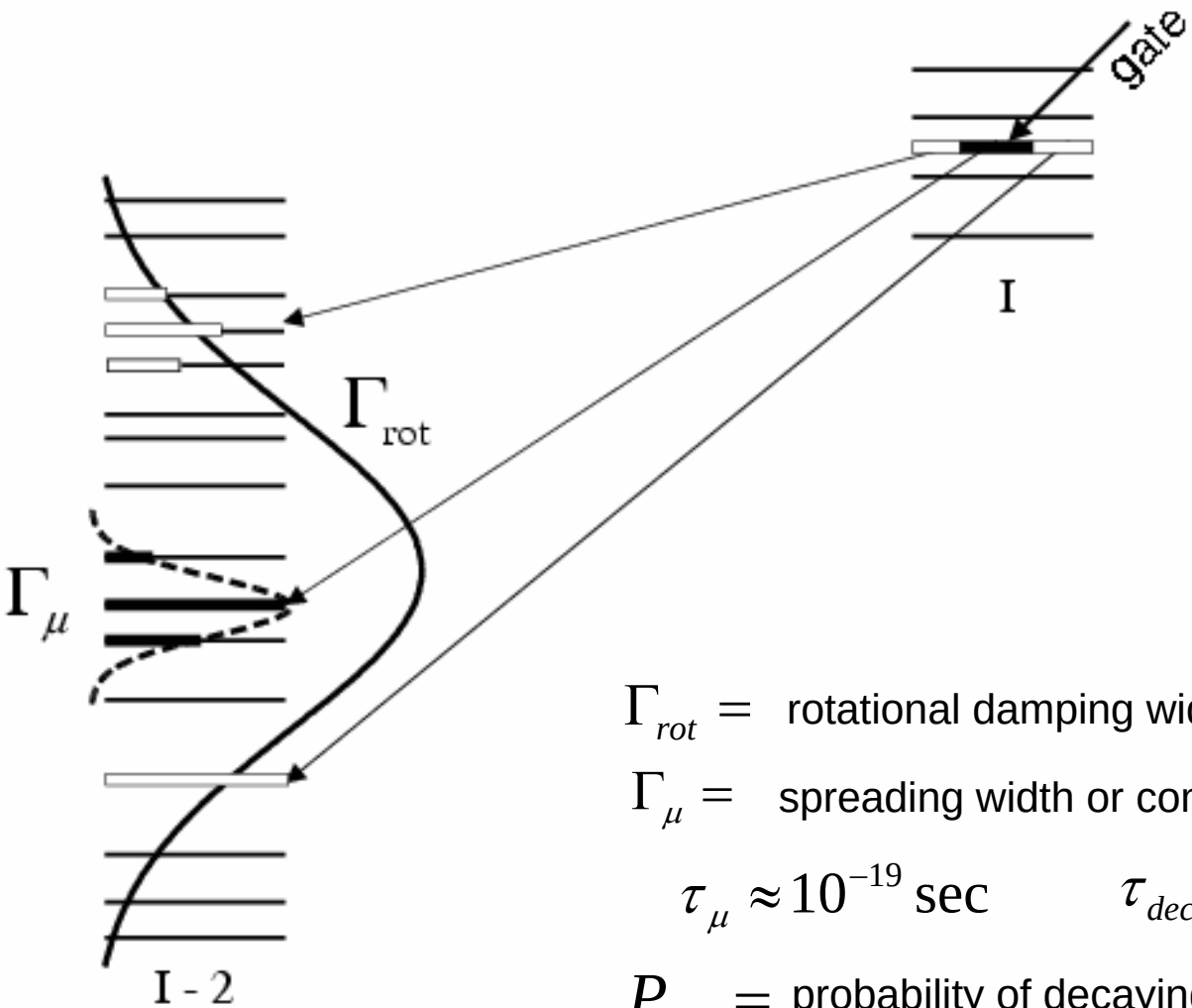

neutrons
neutron
separation
energy
statistical
Excitation energy
discrete bands
yrast line
Spin
NND
Wigner
100
80
60
40
20
0
0
1
2
3
4
NND
Poisson
Number of spacings
Spacing

Decay of a mixed rotational state



$\Gamma_{rot} =$ rotational damping width

$\Gamma_{\mu} =$ spreading width or compound damping width

$$\tau_{\mu} \approx 10^{-19}\ \text{sec} \qquad \tau_{decay} \approx 10^{-15}\ \text{sec}$$

$P_{nar} =$ probability of decaying via the entry component

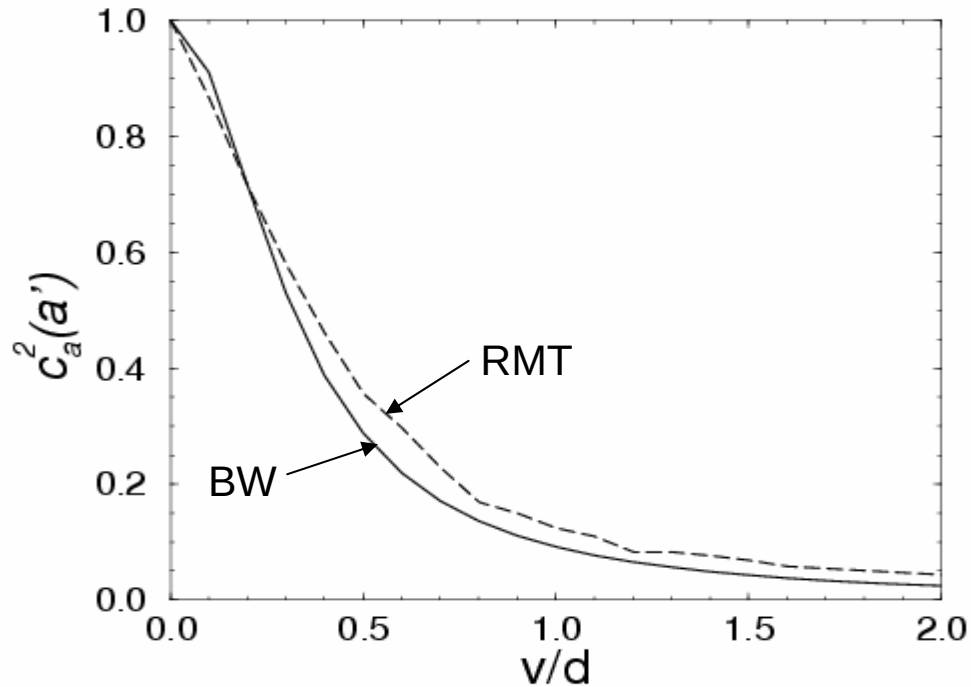
$$P_{nar} = c_a^2(a')$$

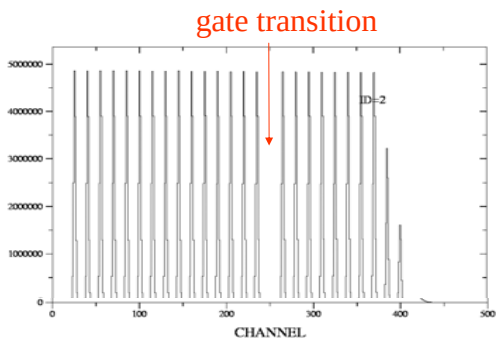
Key parameter: v/d

- A la Breit-Wigner
  - constant level spacing = d
  - constant ME = v

$$P_{nar} = c_a^2(a') = \frac{1}{1+\pi^2(v/d)^2}$$

- Random matrix:
  - <random initial spacing> = d
  - rs ME from Gaussian: (center: 0; rms = v)
  - v/d ~ 0 ➡ Ordered (Poisson)
  - v/d ~ 1 ➡ Chaotic (Wigner)

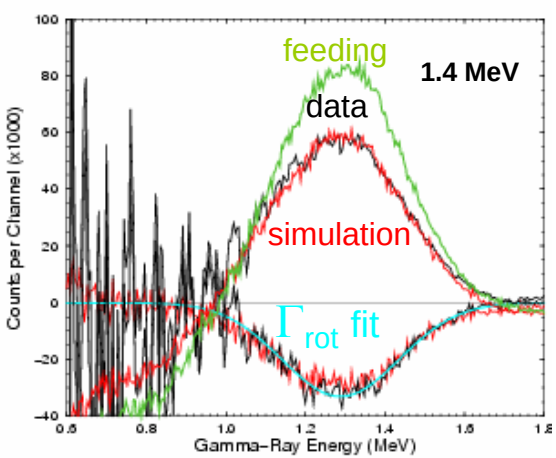




Missing gate transition

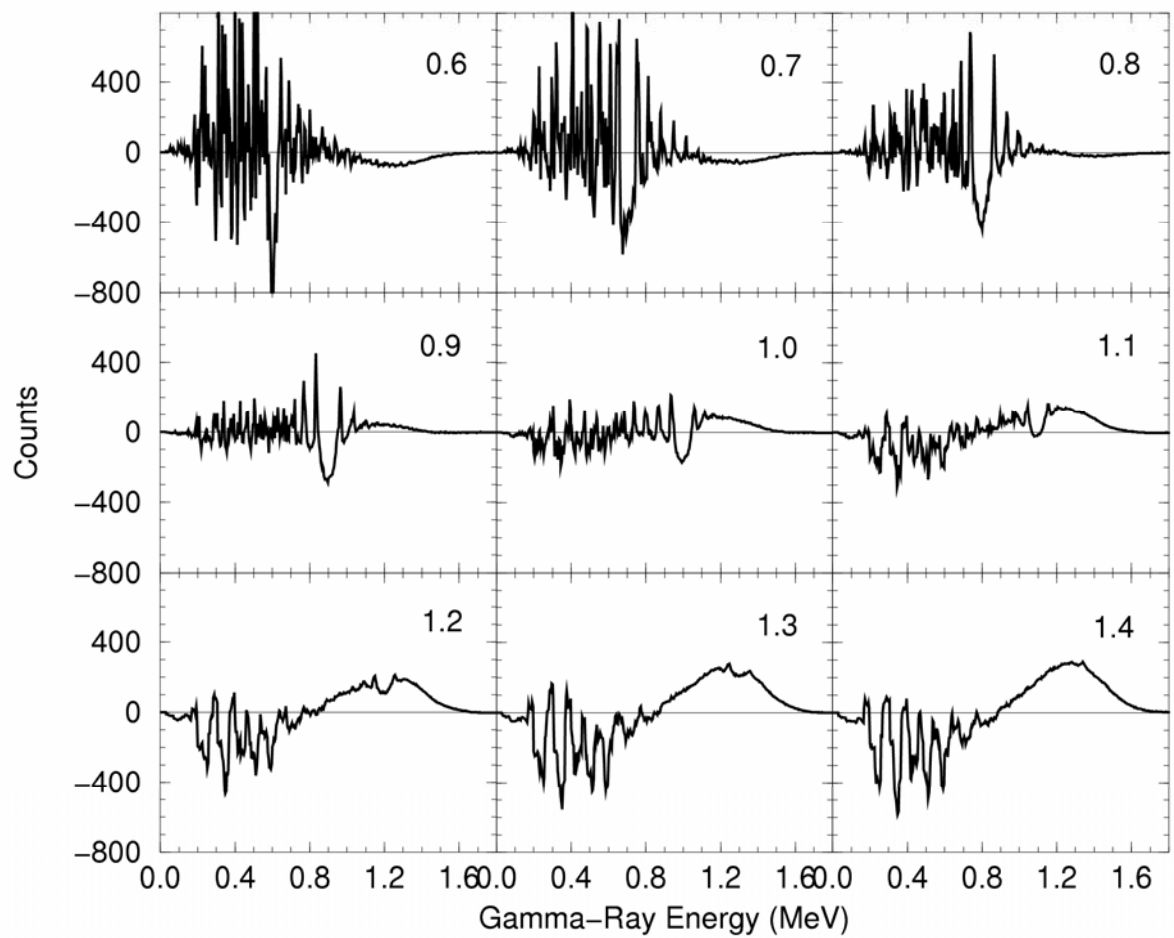
Valley-ridge structure

Determination of Γ_{rot}



Gates (S&A): 60 keV (15 x 4 keV)

124Sn+48Ca –> Yb*, Gated Spectra, COR, S&A



Gates: 60 keV (15 x 4 keV)

124Sn+48Ca –> Yb*, Gated Spectra, COR, S&A

Monte Carlo Simulation

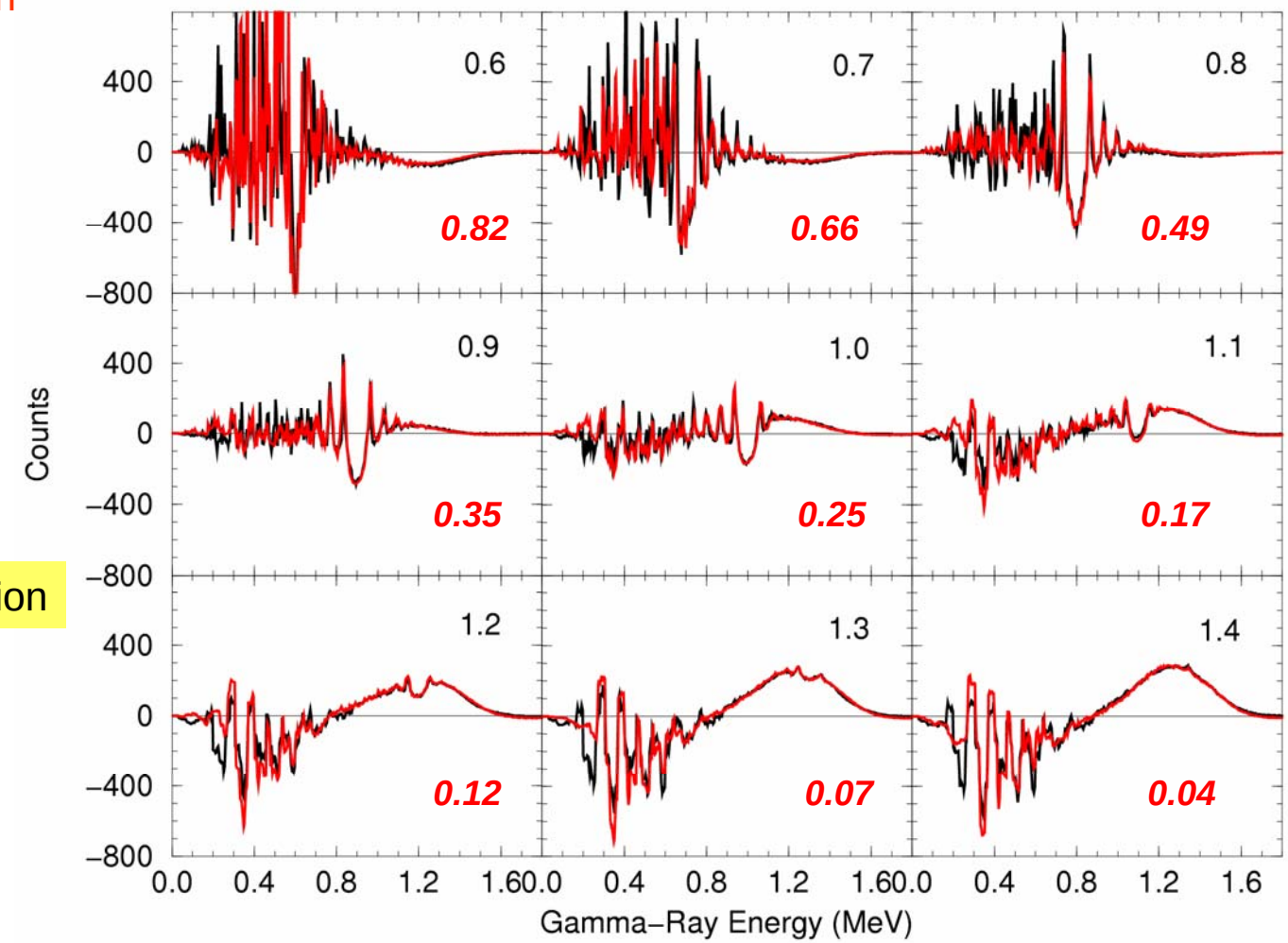
Select entry E*, Spin

Calculate E_γs from competitive E1, E2 cascade, include E2 strength function

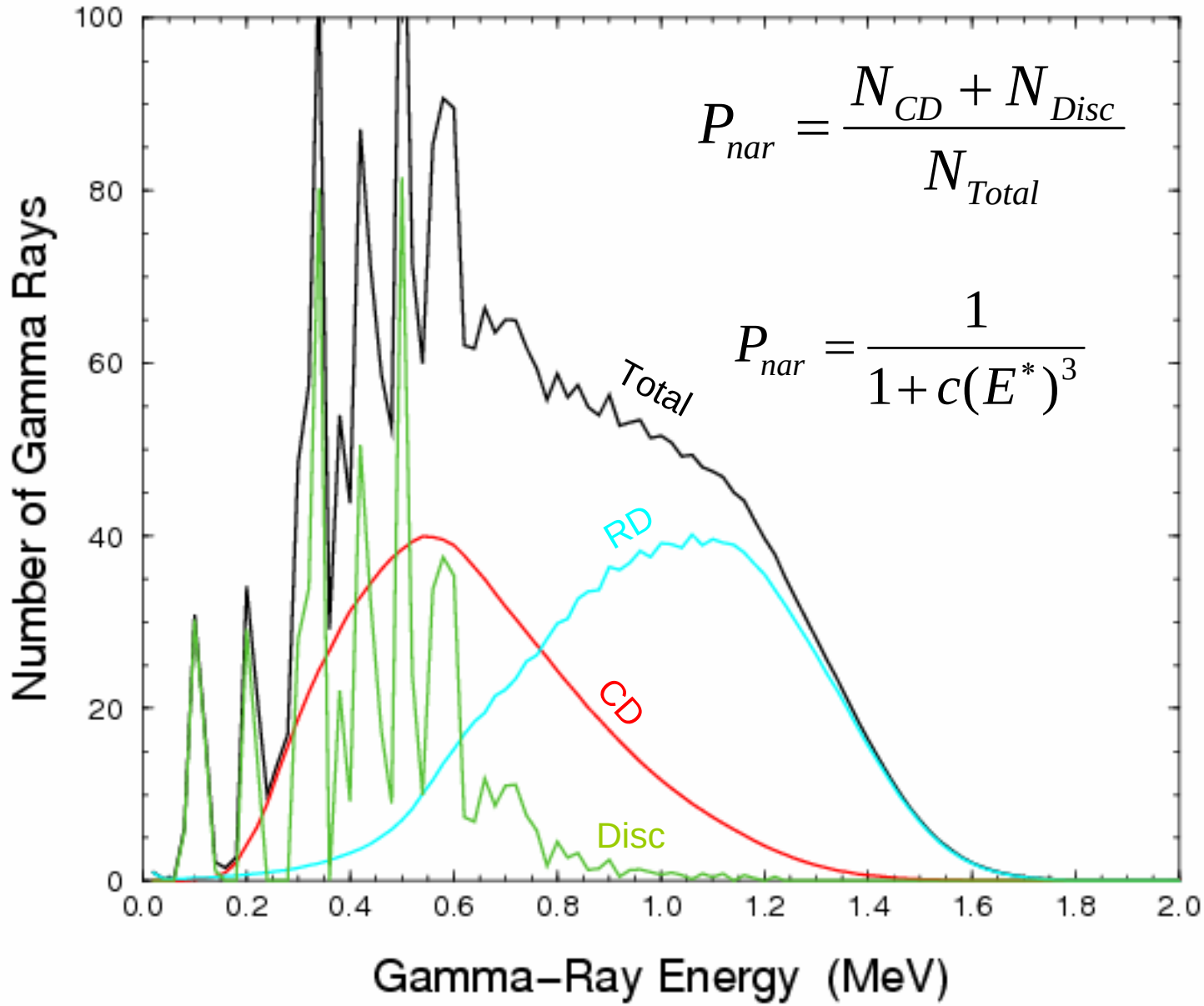
Fold in response function

Create γ-γ matrix

Treat like data



Distribution of Gamma Rays



$$P_{nar} = \frac{N_{CD} + N_{Disc}}{N_{Total}}$$

$$P_{nar} = \frac{1}{1 + c(E^*)^3}$$

$$P_{nar} = \frac{1}{1+\pi^2 (v/d)^2}$$

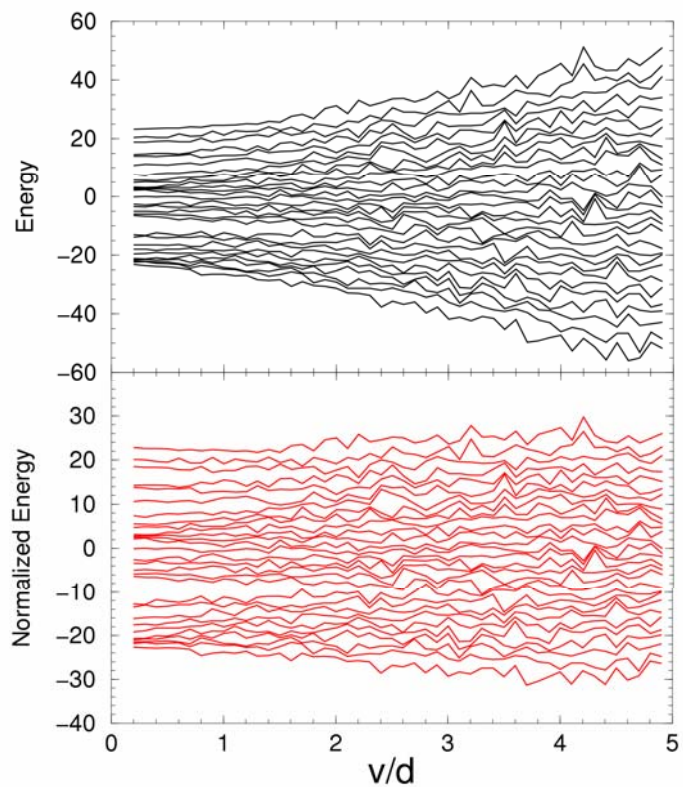
Random Matrix Theory

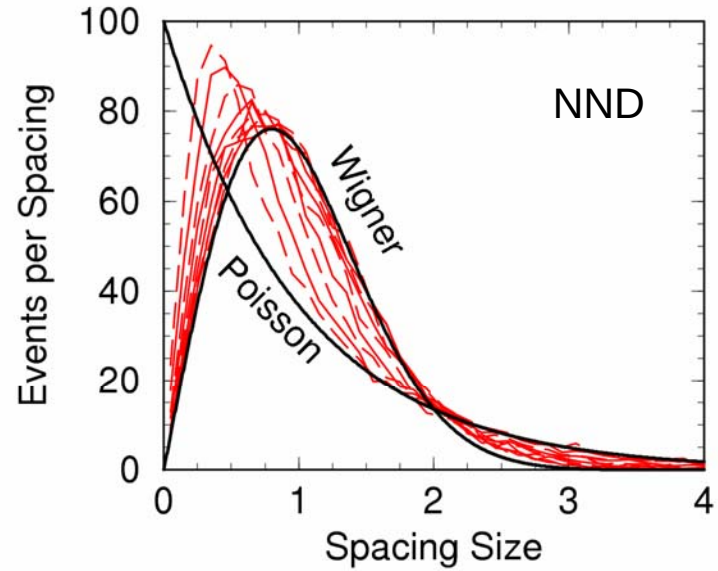
Level Energy: random number, -25<E<25

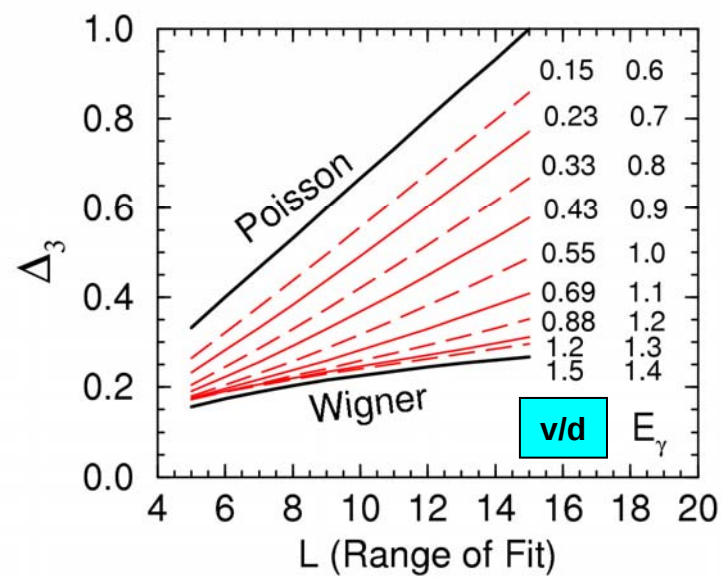
Separation, d; exponential; Poisson

Interaction: random selection from Gaussian

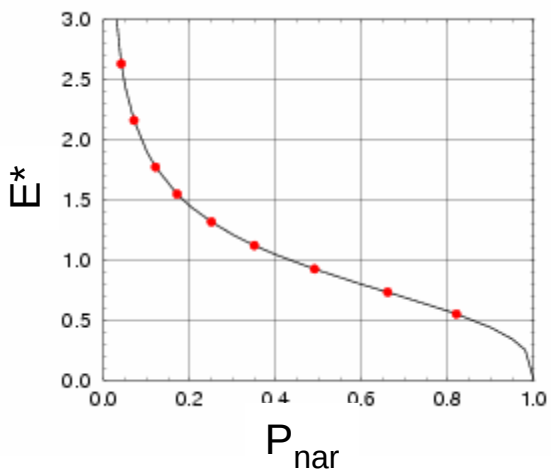
Center 0; σ=v







Conclusions

- A new method to study chaotic behavior
  - use wave function
  - key parameter: v/d
  - P_{nar} robust quantity

- Future
  - study other nuclei
  - restrict the pathways →
  - improve simulations
  - other applications