Pauli-principle driven correlations in $4n$ nuclear decays

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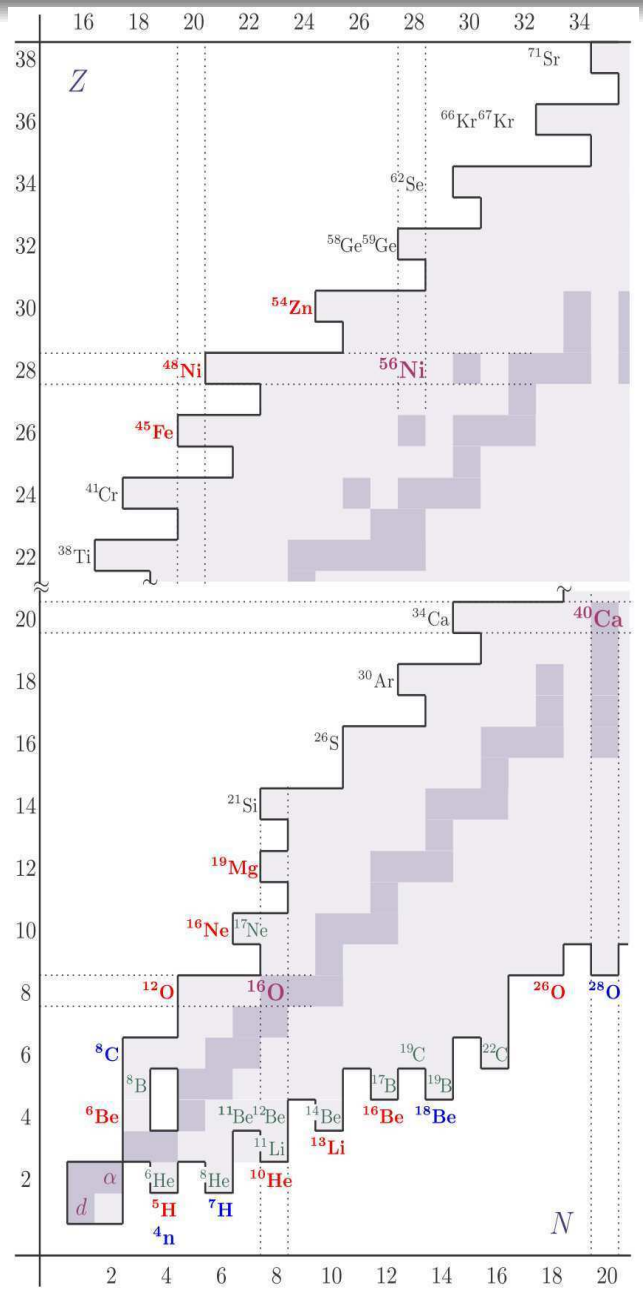
- $2p$- $2n$-decays are rather good studied.
- Next step is $4p$- $4n$-decays

In this report:

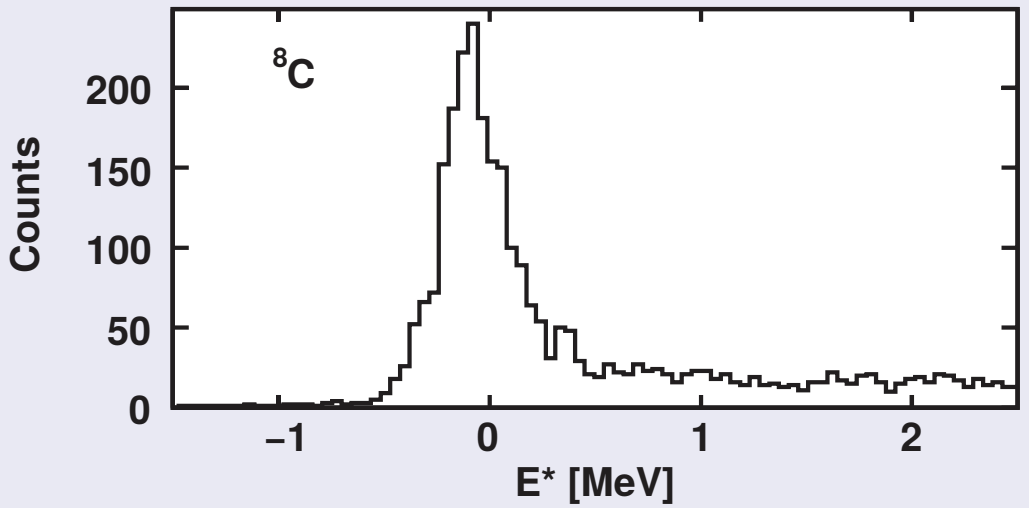
- We discuss model for $4n$-decay.
- Offer a way for correlation studies.
- Show correlations pictures for $4n$-decay.



Limits of the nuclear structure

What happens $4N$ away from dripline?

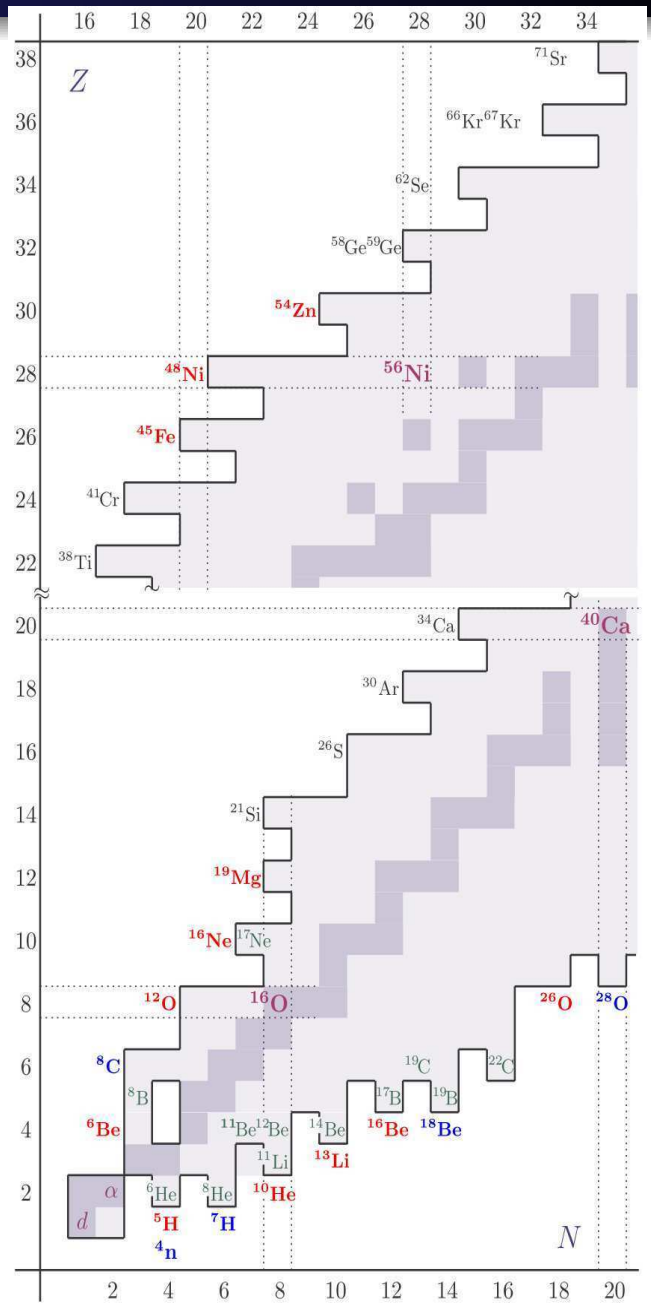
$4p$-emitter



$4n$-emitters

^{7}H, ^{18}Be, ^{28}O

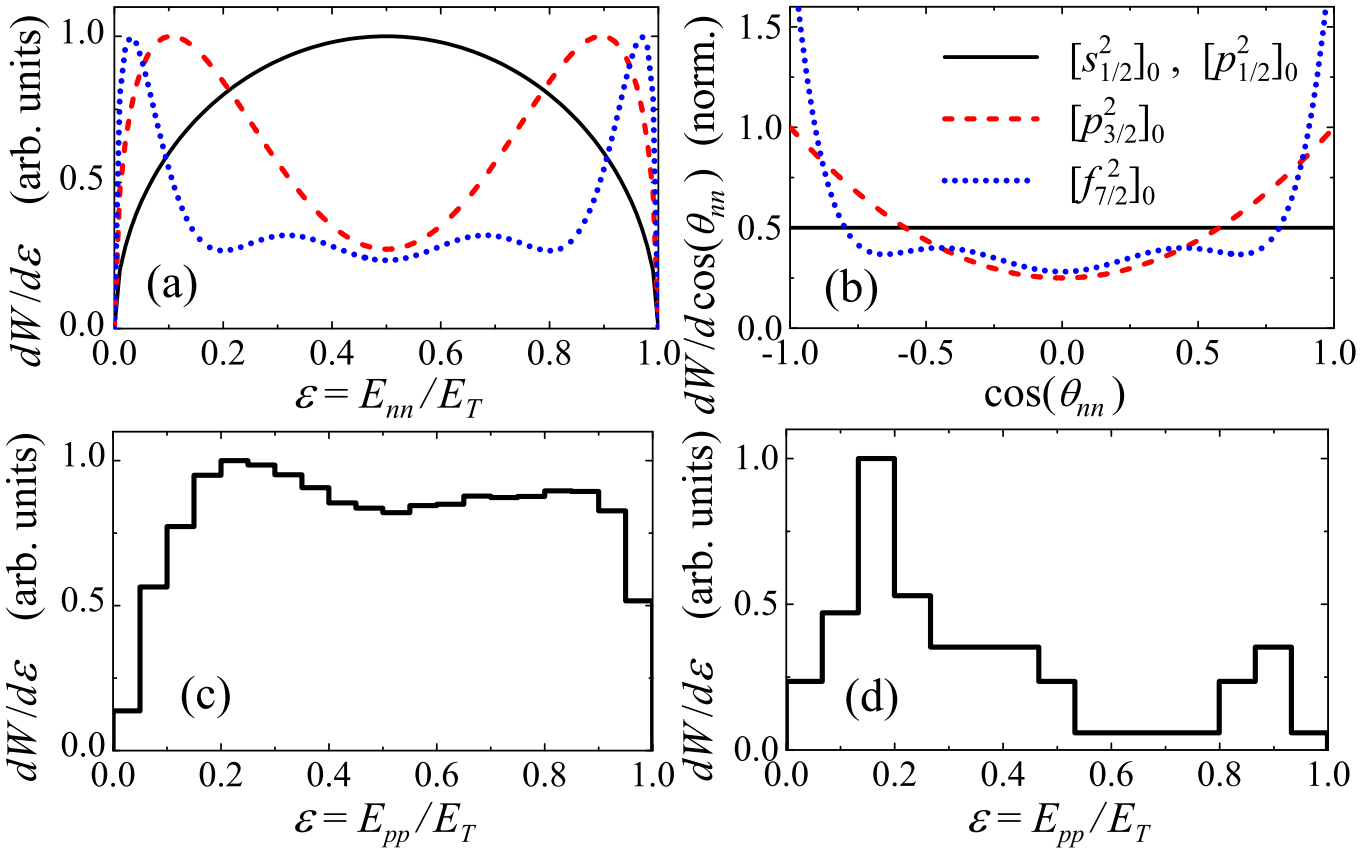
- Full kinematic experiment is rather complicated for $4n$-emitter.
- Correlations can provide data about structure in incomplete kinematic experiment.



Pauli focusing

$[j_1 \otimes j_2]_J$

^{6}Be, ^{45}Fe



$[[j_1 \otimes j_2]_{j_{12}} \otimes [j_3 \otimes j_4]_{j_{34}}]_j$?

Model

Ansatz

- Permutation symmetry
- Reasonable core + n interaction
- Monte-Carlo method for the decay probability calculation

$$dW \sim |T|^2 \, dV_4 \, \prod_{i=1..4} d\Omega_i \, .$$

$$T = \mathcal{A} \left[\prod_{i=1..4} A_{cn_i}(l_i, j_i, \mathbf{p}_{cn_i}) \right]_J \, ,$$

$$A_{cn_i}(l_i j_i, \mathbf{p}_{cn_i}) = \frac{1}{2} \frac{a_{l_i j_i} \sqrt{\Gamma_{cn_i}(E_{cn_i})}}{E_{r,cn_i} - E_{cn_i} - i\Gamma_{cn_i}(E_{cn_i})/2} \, ,$$

Kinematical variables for the $4n$-decay

3-body kinematical variables

are based on the Jacobi momenta

$$\varepsilon = \frac{E_x}{E_T}$$

$$\cos\theta_k = \frac{(\mathbf{k}_x, \mathbf{k}_y)}{k_x k_y}$$

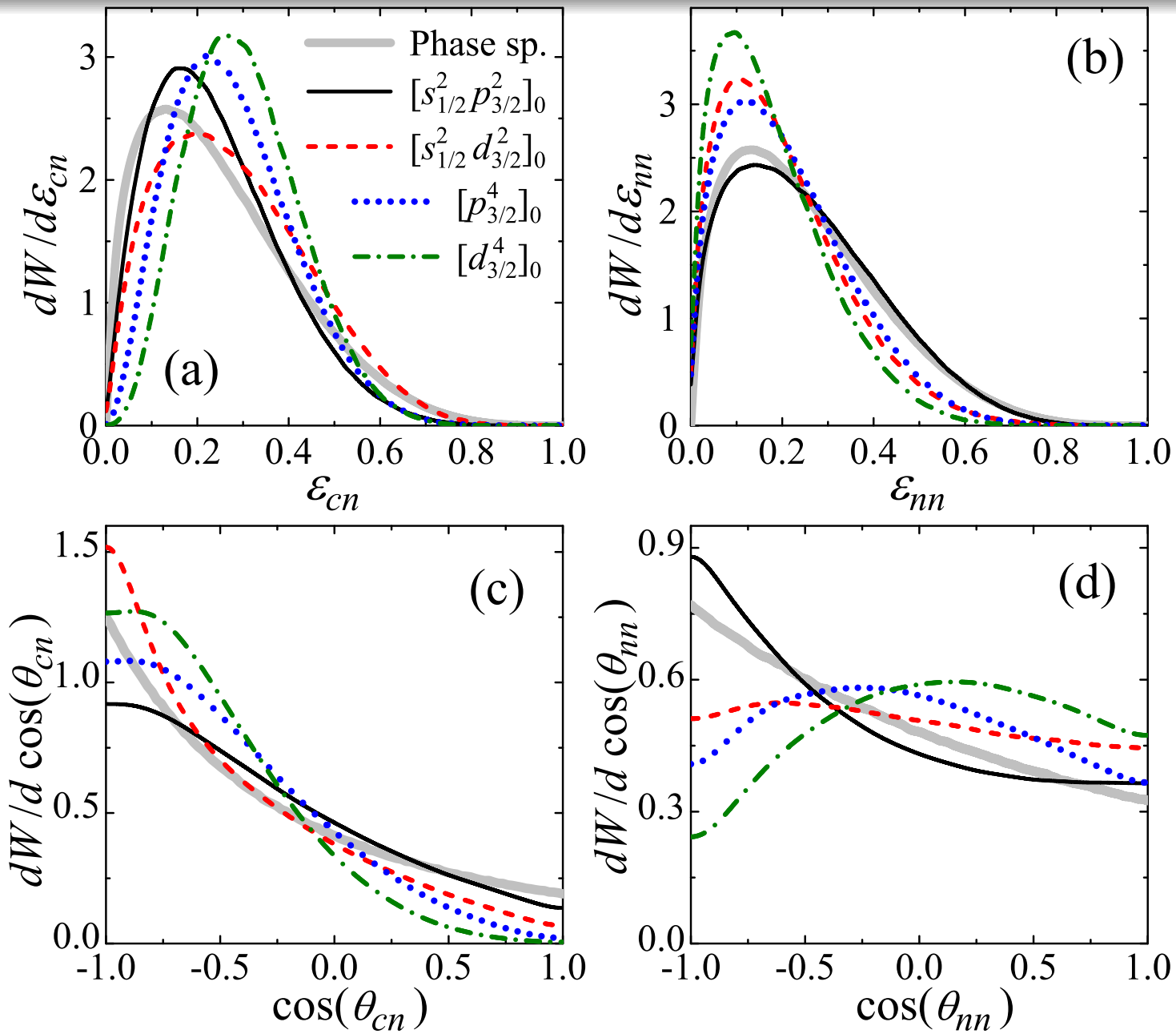
5-body kinematical variables

are based on the momenta of particles

$$\varepsilon_{ij} = \frac{E_{ij}}{E_T}$$

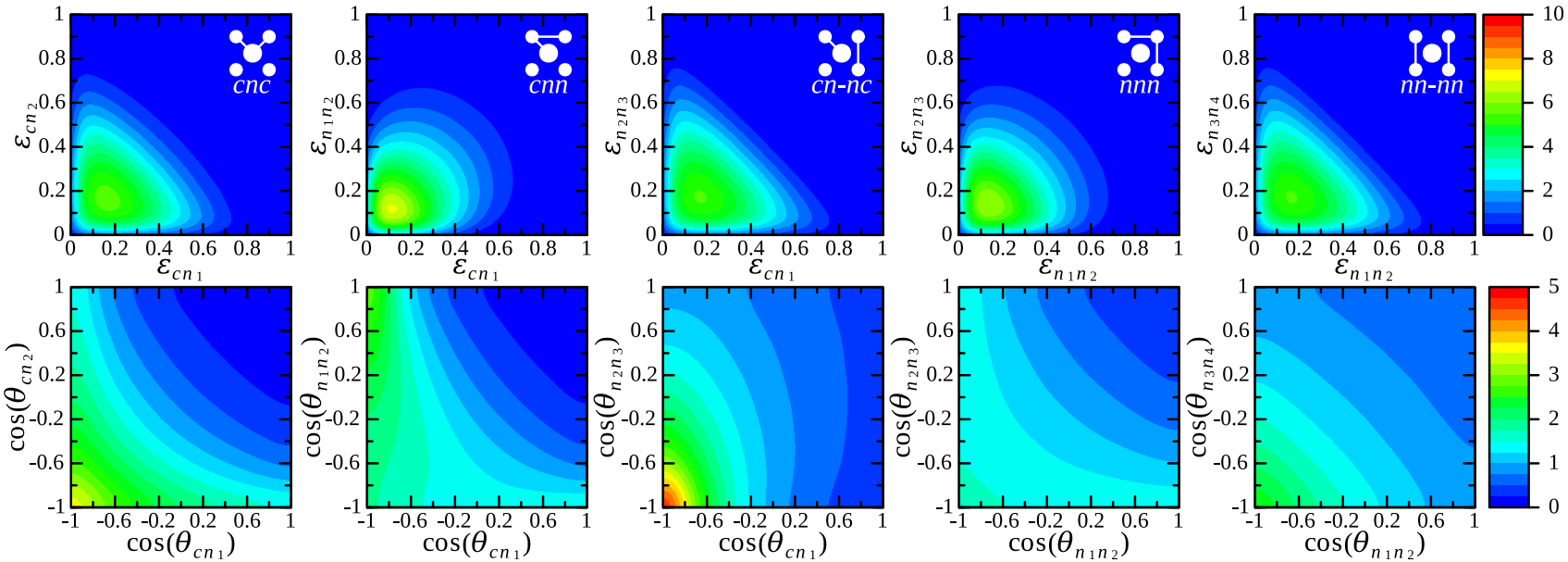
$$\cos\theta_{ij} = \frac{(\mathbf{p}_i, \mathbf{p}_j)}{p_i p_j}$$

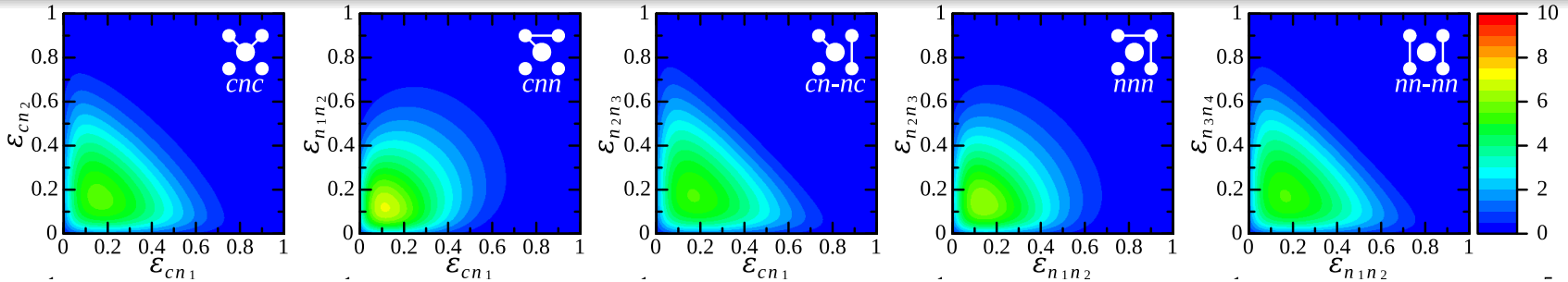
1D correlation



2D correlations

- Five types of coordinates selection
- Phase space for $\varepsilon_{ij} - \varepsilon_{i'j'}$ and $\cos\theta_{ij} - \cos\theta_{i'j'}$.



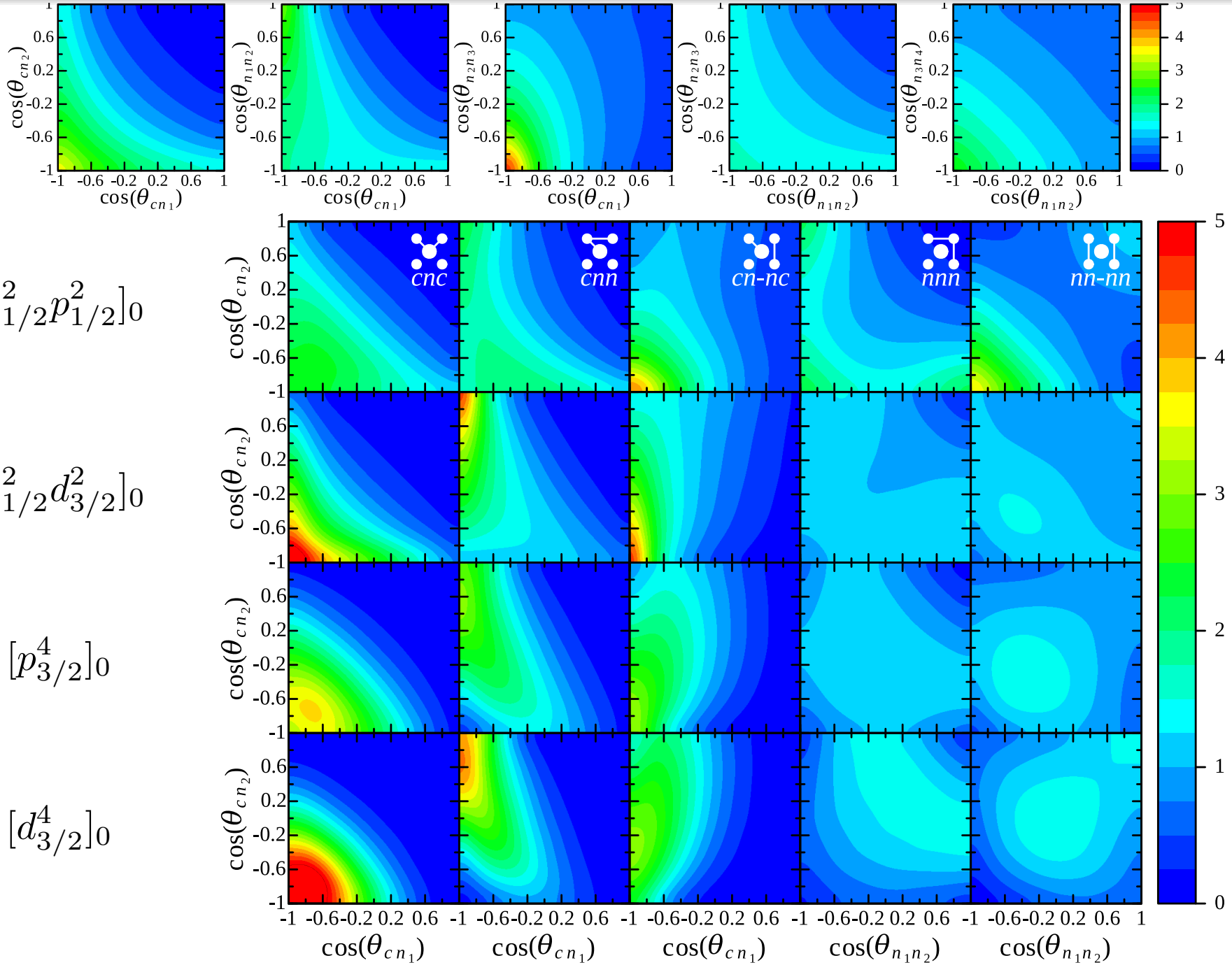


$[s^2_{1/2}p^2_{1/2}]_0$

$[s^2_{1/2}d^2_{3/2}]_0$

$[p^4_{3/2}]_0$

$[d^4_{3/2}]_0$


$[s^2_{1/2}p^2_{1/2}]_0$
$[s^2_{1/2}d^2_{3/2}]_0$
$[p^4_{3/2}]_0$
$[d^4_{3/2}]_0$
cnc
cnn
cn-nc
nnn
nn-nn
$\cos(\theta_{cn_1})$
$\cos(\theta_{cn_2})$
$\cos(\theta_{n_1n_2})$
$\cos(\theta_{n_2n_3})$
$\cos(\theta_{n_3n_4})$

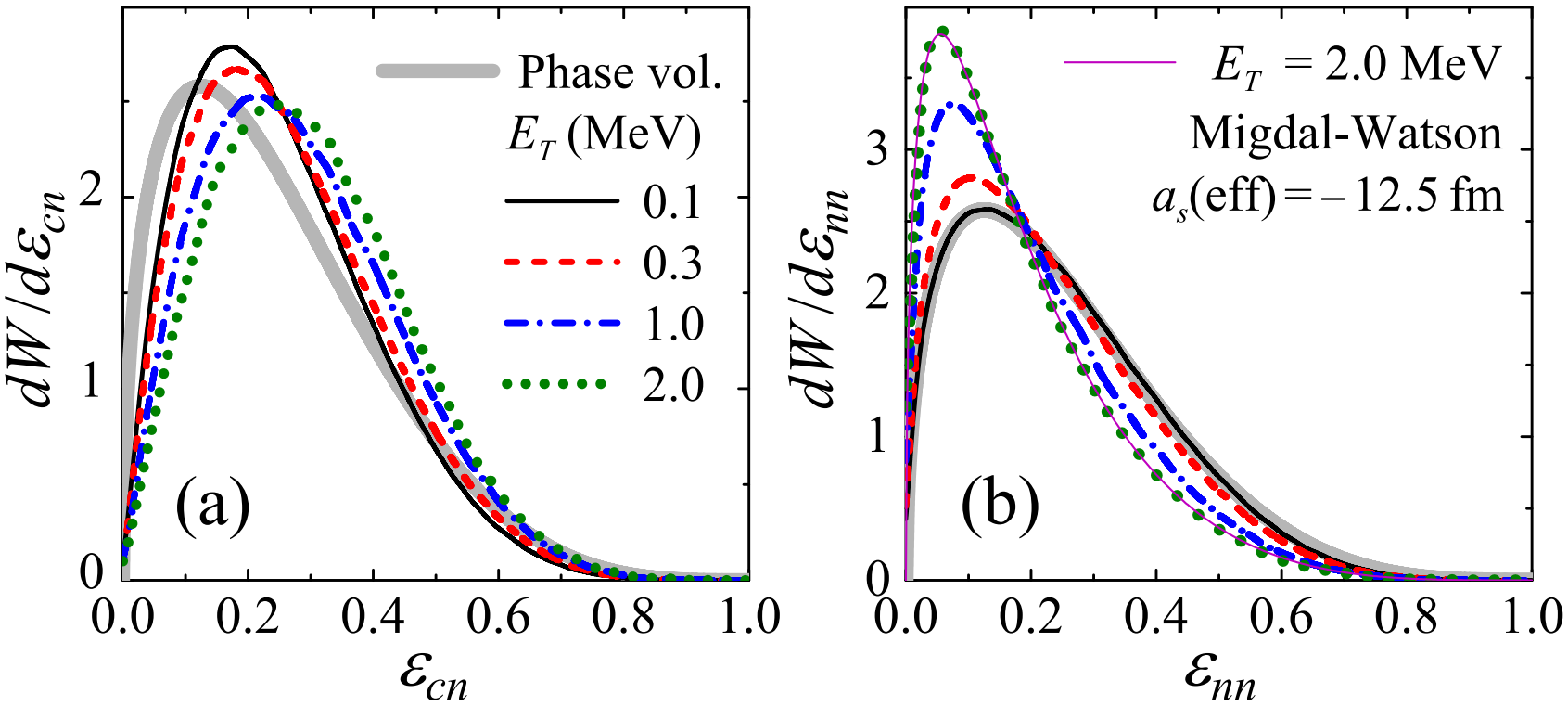
Summary

- We propose a simple model for four-neutron emission.
- Our calculations show that correlations patterns of the decay products significantly change with change of system configuration.
- Correlation measurements are prospective for four-neutron emission studies.

$n - n$ FSI

It is hard to estimate $n - n$ FSI, but it is easy to overestimate one

$$T = \mathcal{A}\left[\prod_{i=1..4} A_{cn_i}(\mathbf{p}_{cn_i}) \prod_{i>k} A_{n_i n_k}(\mathbf{p}_{n_i n_k})\right]; \quad A_{n_i n_k} = \frac{a_s}{1 - i\, p_{n_i n_k}\, a_s}.$$



Core correlations in ^{7}H

Recent JINR experiment

$^2\mathrm{H}(^8\mathrm{He}, ^3\mathrm{He}^3\mathrm{H})4n$ reaction, five events — candidates for ground state.