Effects of nuclear structure in residual-nuclei production

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OUTLOOK

1) Experiment: $^{238}U \rightarrow Ti$ at 1 A·GeV at the FRS (GSI)

2) Results: production cross section of residual nuclides

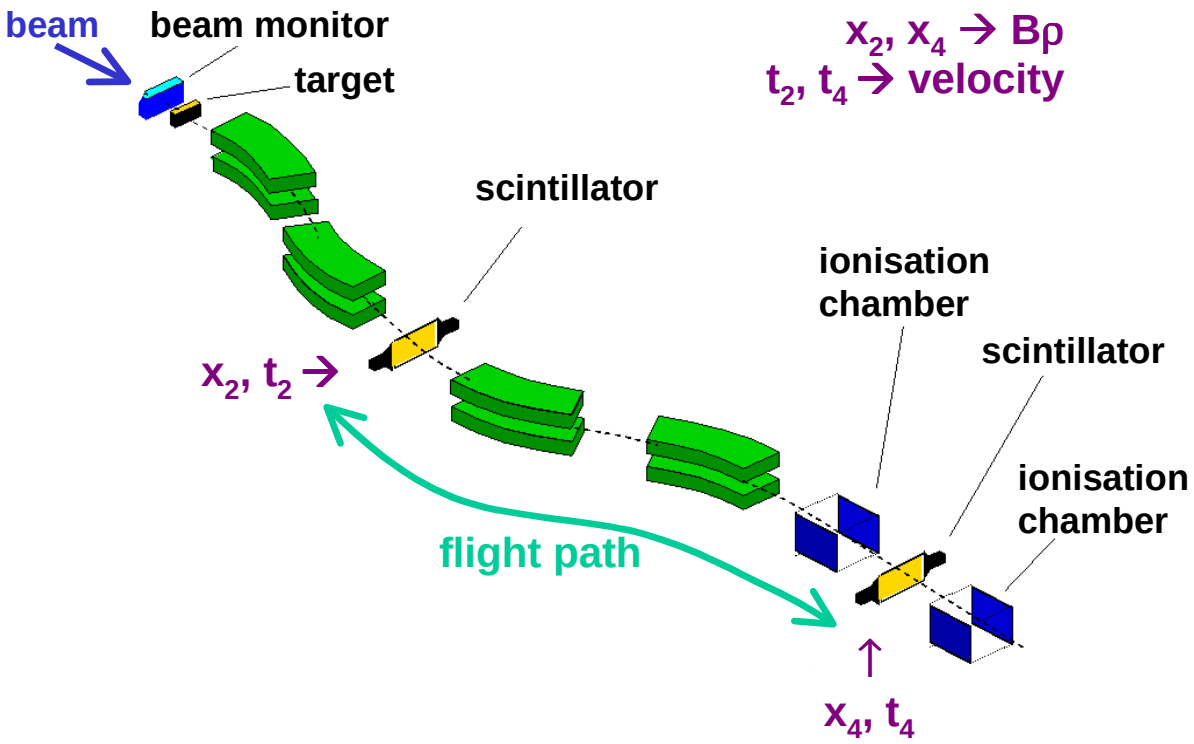
3) Data reveal complex structural effects

4) Analysis of the results with the statistical model

5) Conclusions

THE EXPERIMENT AT THE FRAGMENT SEPARATOR

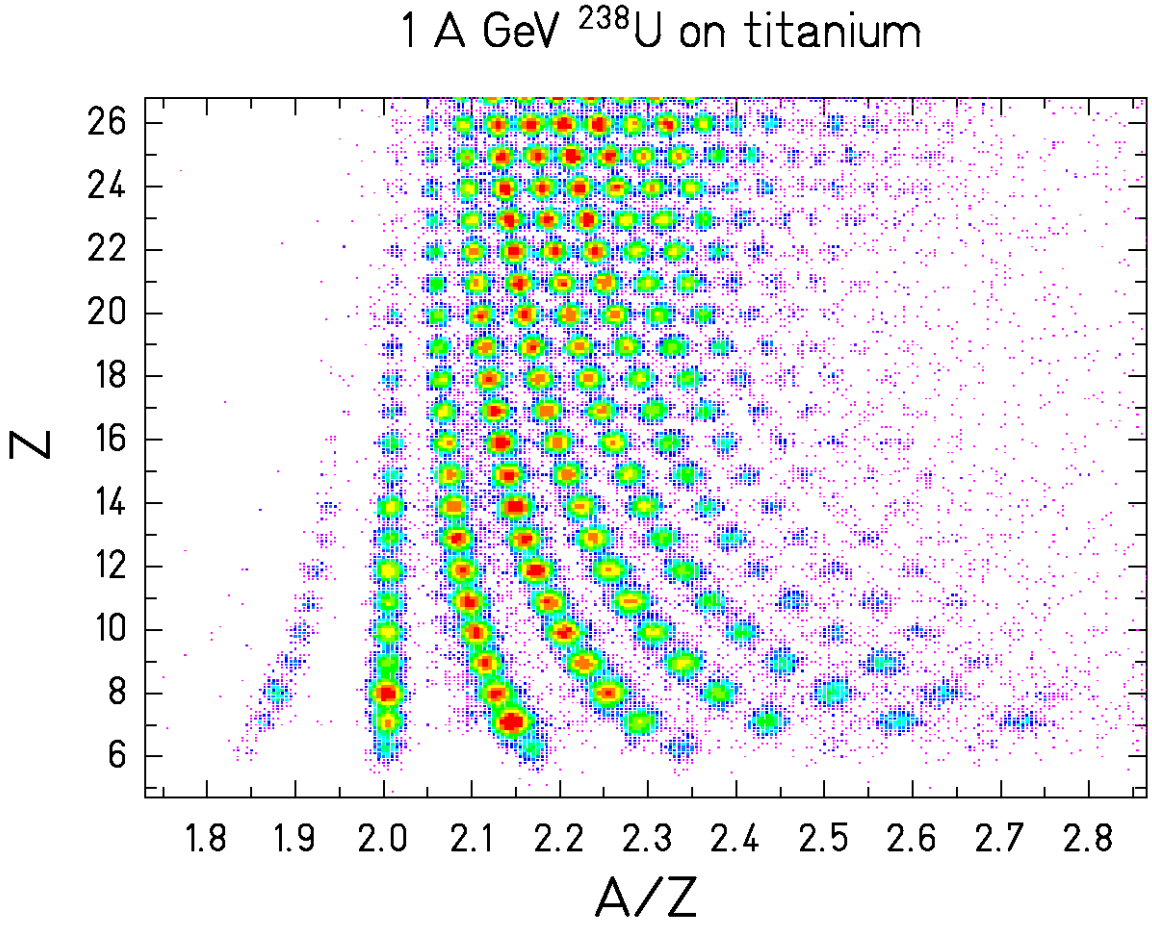
1 A GeV ^{238}U beam into a thin Ti target

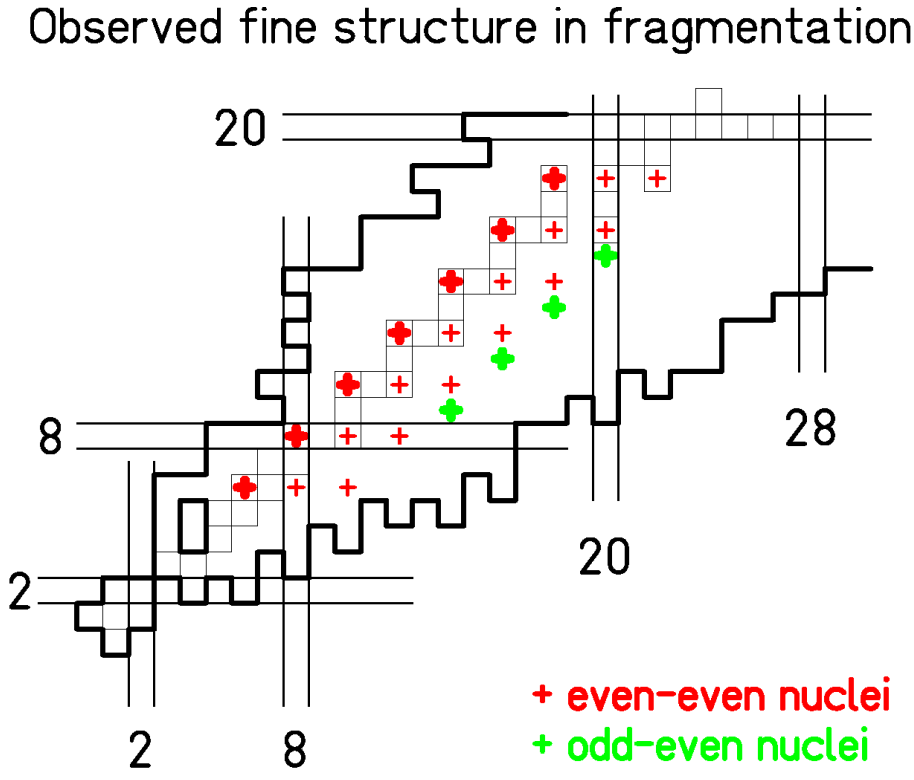


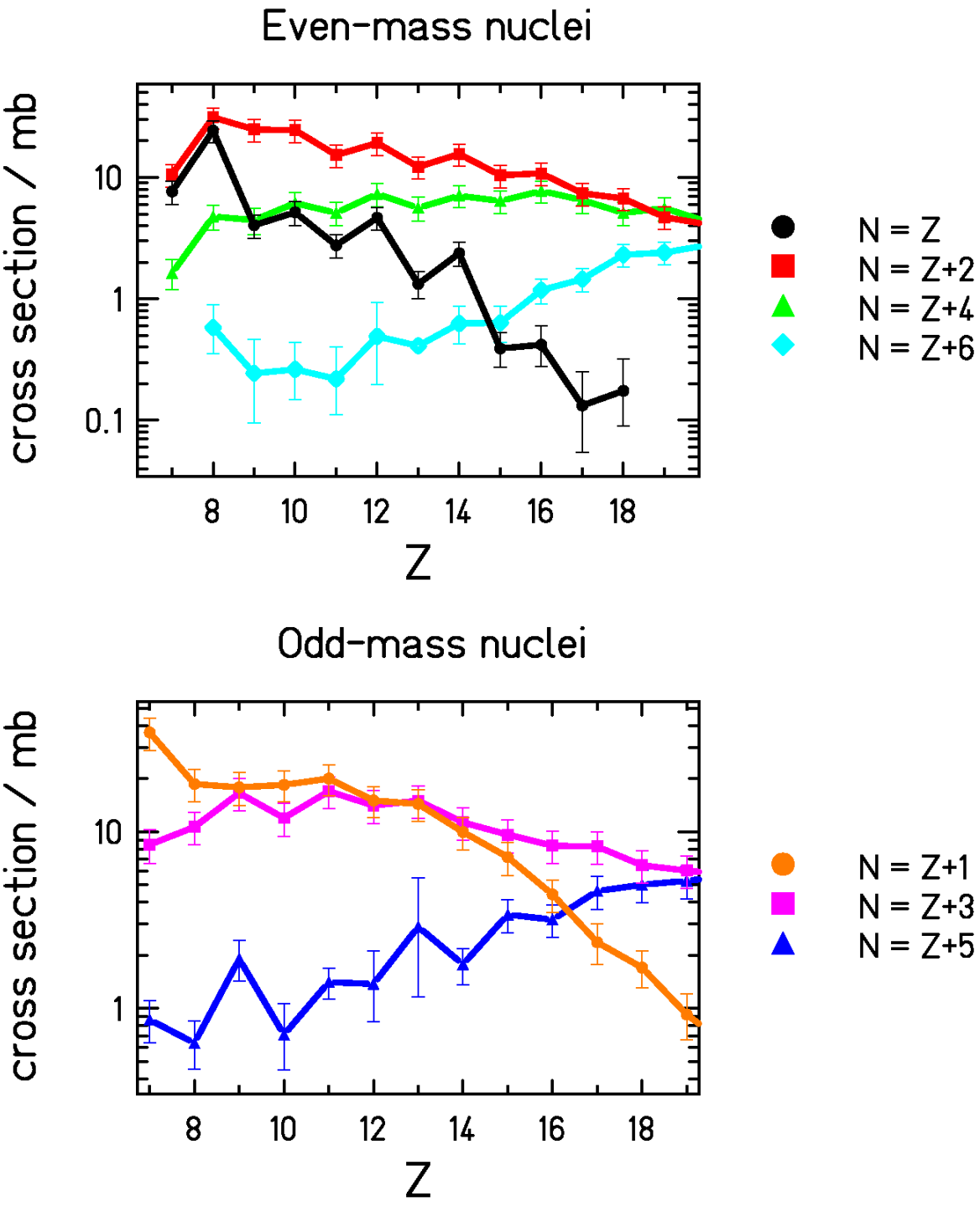
identification of Z from IC: $\Delta E \propto Z^2$

identification of A/Z from time and position:

$$\frac{A}{Z} = \frac{e}{m_0}\frac{B\rho}{c\beta\gamma} \qquad \beta = \frac{v}{c} \quad with \quad v = \frac{s}{ToF}$$


1 A GeV 238U on titanium
Z
A/Z
26
24
22
20
18
16
14
12
10
8
6
1.8
1.9
2.0
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8

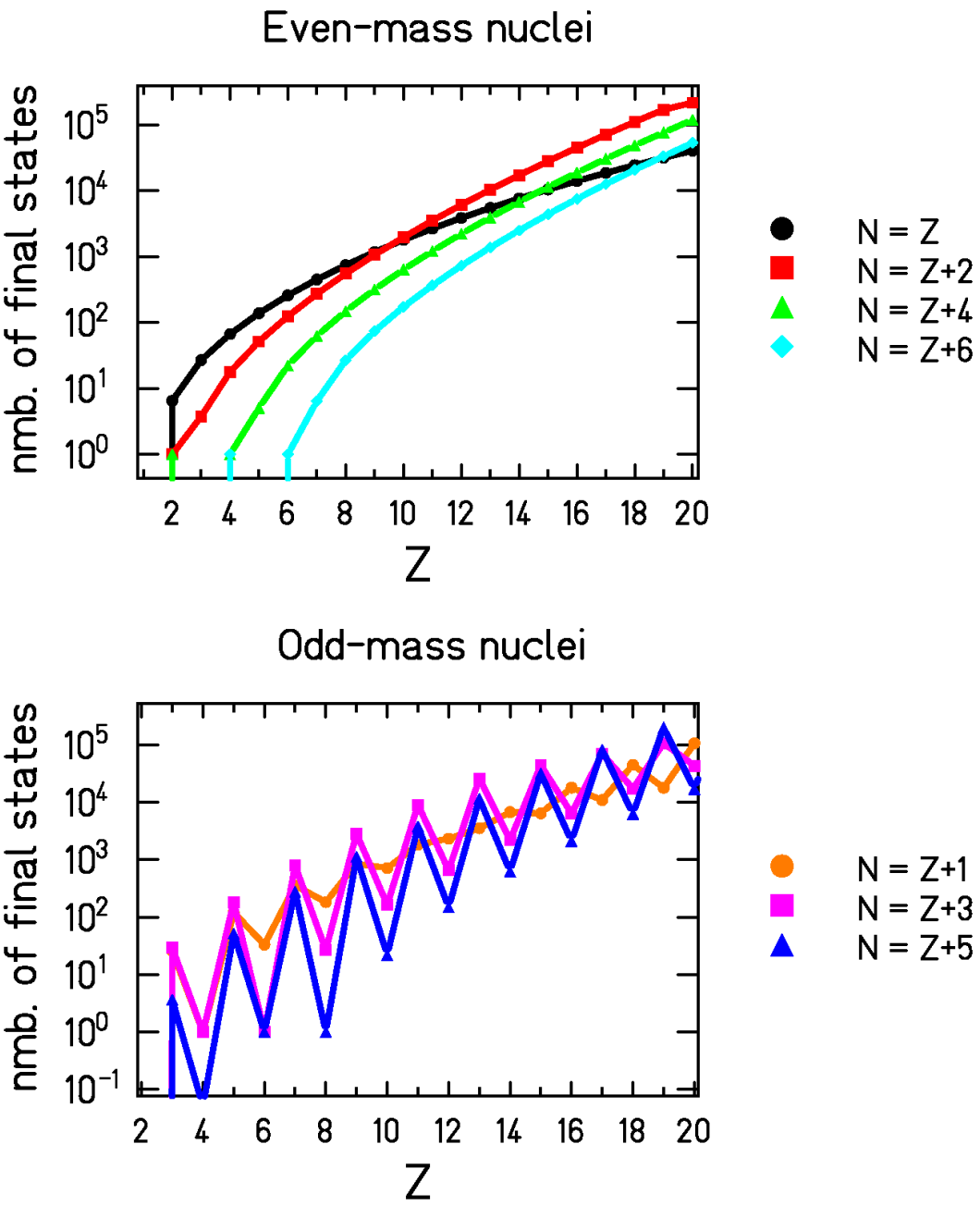

Observed fine structure in fragmentation
20
8
2
28
20
2
8
+ even-even nuclei
+ odd-even nuclei


Even-mass nuclei
cross section / mb
10
1
0.1
8
10
12
14
16
18
Z
N = Z
N = Z+2
N = Z+4
N = Z+6
Odd-mass nuclei
cross section / mb
10
1
8
10
12
14
16
18
Z
N = Z+1
N = Z+3
N = Z+5

NUMBER OF FINAL STATES

STATISTICAL MODEL with the simplest description of pairing:

- **in the masses:** $M = M_{LD} - \delta$ $\qquad \delta_{oo} = 0,\ \delta_{oe} = \Delta,\ \delta_{ee} = 2\Delta$
- **in level density:** $\rho \propto \exp\left(2\sqrt{a(E-\delta)}\right)$



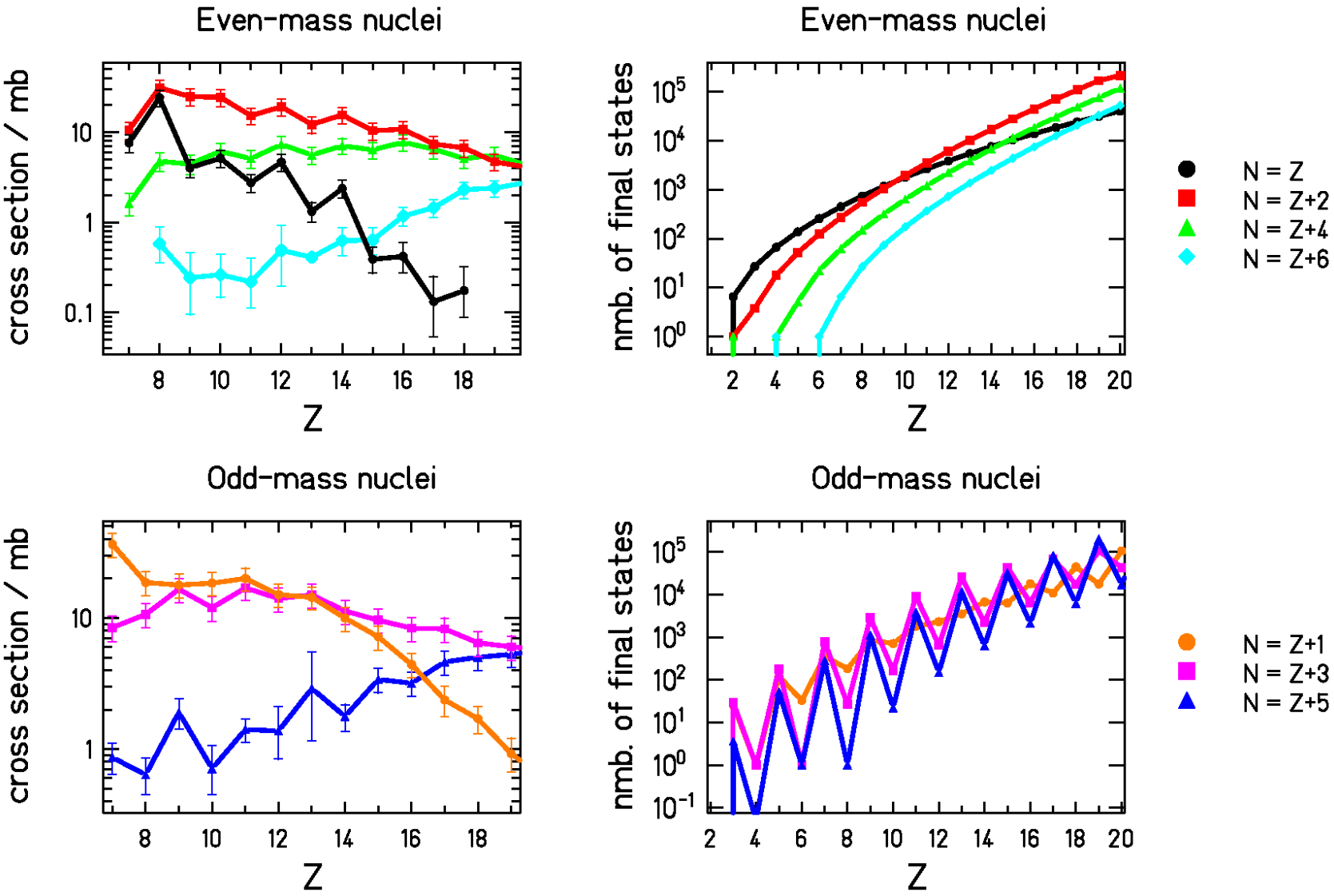
Conclusions

Experiment: light nuclides of 1A·GeV ^{238}U+Ti
FRS allows full (A, Z) identification
→ formation cross section for every isotope

Results:
complex structure of nuclei produced in rather violent collisions

Explanation:
1) the statistical model explains the structure of odd-mass nuclei as the most prominent manifestation of pairing
→ independence of the reaction mechanisms

2) even-odd structure of even-mass nuclei could be related to higher-order structural effects in the level density
→ yields from highly excited nuclei are a rich source of information on nuclear structure.


Even-mass nuclei
cross section / mb
10
1
0.1
8
10
12
14
16
18
Z
Even-mass nuclei
nmb. of final states
10^5
10^4
10^3
10^2
10^1
10^0
2
4
6
8
10
12
14
16
18
20
Z
N = Z
N = Z+2
N = Z+4
N = Z+6
Odd-mass nuclei
cross section / mb
10
1
8
10
12
14
16
18
Z
Odd-mass nuclei
nmb. of final states
10^5
10^4
10^3
10^2
10^1
10^0
10^{-1}
2
4
6
8
10
12
14
16
18
20
Z
N = Z+1
N = Z+3
N = Z+5