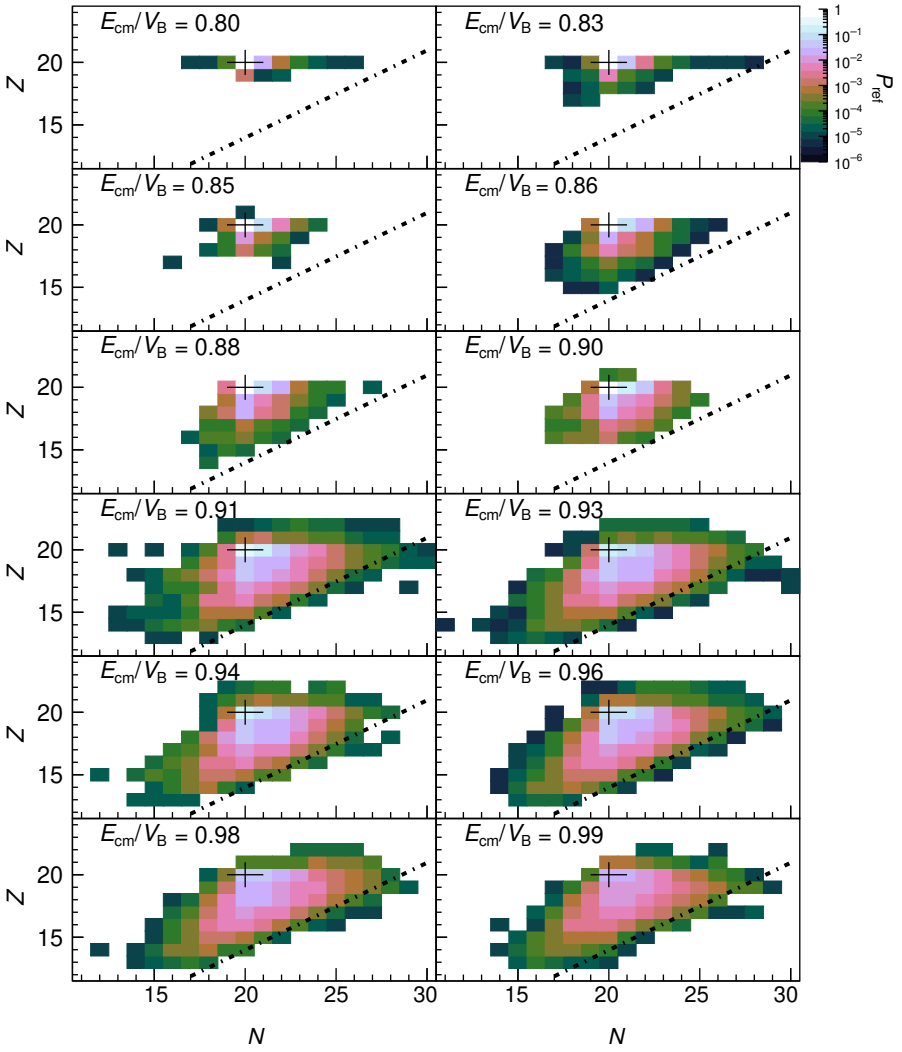
# Colliding heavy nuclei take multiple identities on the path to fusion

## Supplementary Information

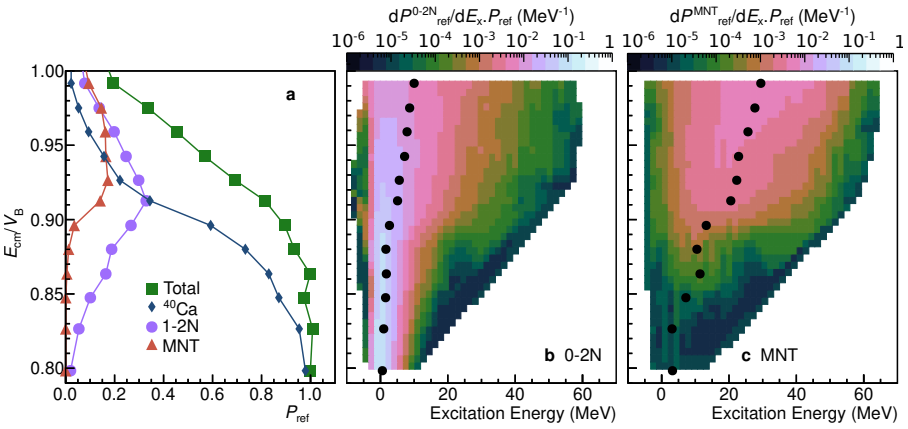
K.J. Cook[1,2*], D.C. Rafferty[1], D.J. Hinde[1], E.C. Simpson[1], M. Dasgupta[1], L. Corradi[3], M. Evers[1], E. Fioretto[3], D.Y. Jeung[1], N. Lobanov[1], D.H. Luong[1], T. Mijatović[4], G. Montagnoli[5], A.M. Stefanini[3] and S. Szilner[4]

[1]Department of Nuclear Physics and Accelerator Applications, Research School of Physics, The Australian National University, Canberra, 2601, ACT, Australia.
[2]Facility for Rare Isotope Beams, Michigan State University, East Lansing, 48824, Michigan, USA.
[3]Istituto Nazionale di Fisica Nucleare, Laboratori Nazionali di Legnaro, Legnaro, I-35020 Italy.
[4]Ruđer Bošković Institute, Zagreb, HR-10001, Croatia.
[5]Dipartimento di Fisica e Astronomia, Universita di Padova, via Marzolo 8, Padova, I-35131, Italy.

*Corresponding author. E-mail: kaitlin.cook@anu.edu.au;



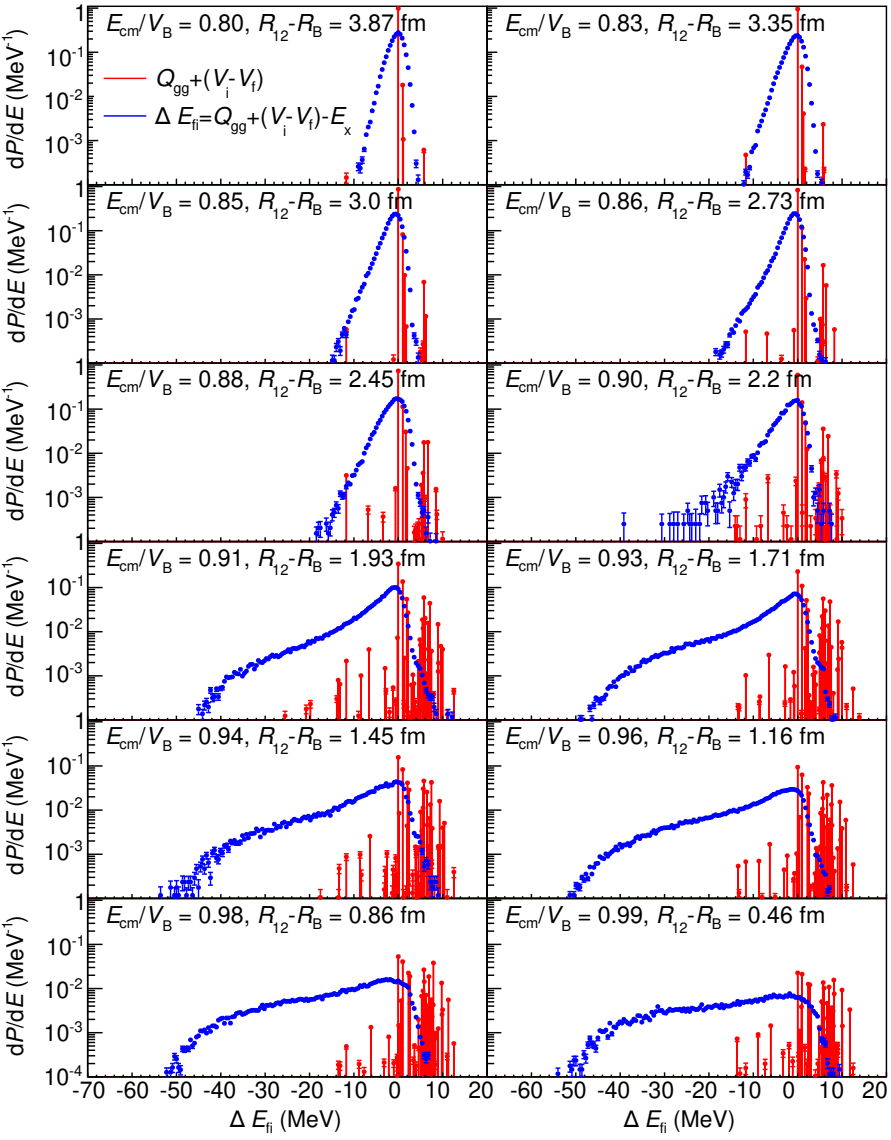

**Supplementary Fig. 1** $Z$ and $N$ distribution of reflected nuclei produced in reactions of $^{40}$Ca+$^{208}$Pb at $\theta_{lab} = 115°$ at measured energies from $E_{cm}/V_B = 0.81$ to 0.99. The common colour scale indicates the probability of forming each nucleus. The location of $^{40}$Ca is indicated with the cross. Diagonal lines indicate the isospin asymmetry equal to that of the compound nucleus $^{248}$No (N/Z = 1.43)



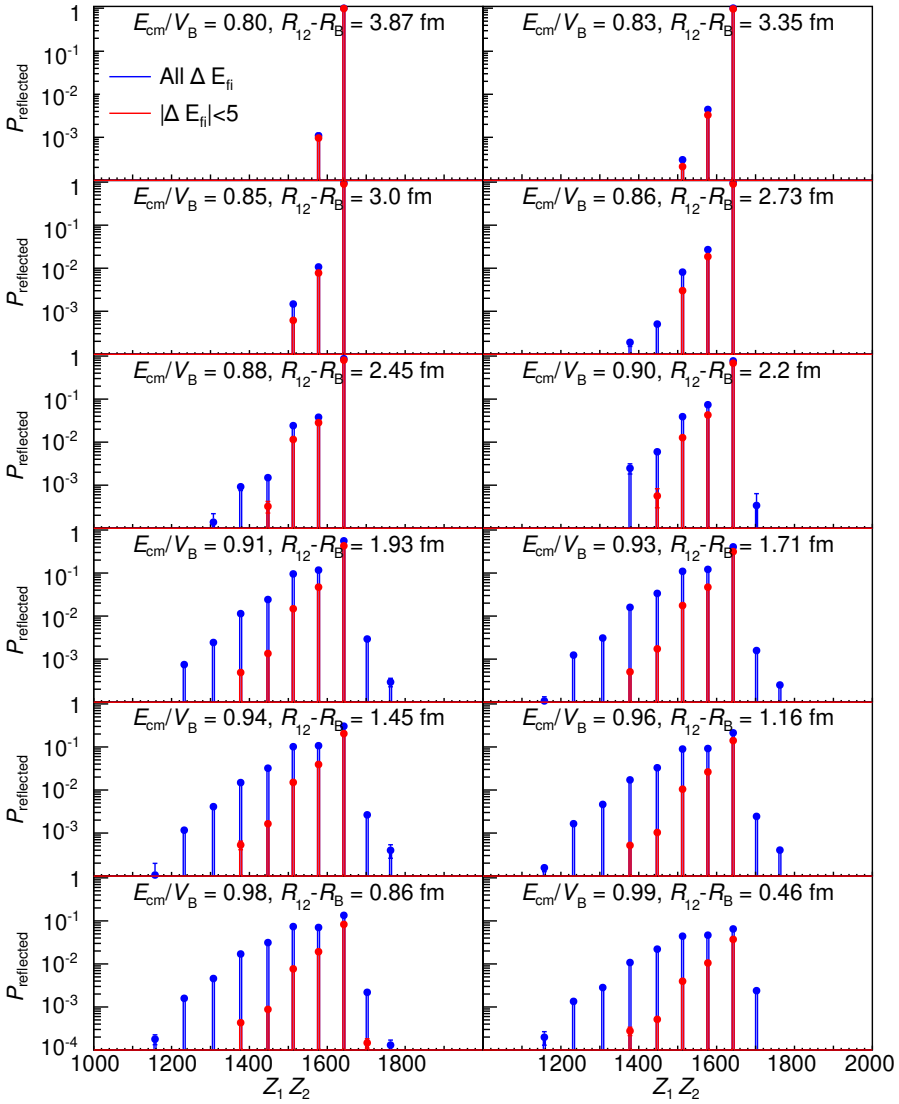

**Supplementary Fig. 2** (a) Absolute probability of reflected flux for all reflected flux (green squares), (in)elastic scattering ($^{40}$Ca, blue diamonds), 1-2N transfer (purple circles), and multi-nucleon transfer (MNT, orange triangles) as a function of $E/V_B$. Statistical errors are smaller than the points. (b) Evolution of excitation energy with increasing $E/V_B$ (decreasing separation) for the sum of in(elastic) scattering and 1-2N transfer, denoted "0-2N" and (c) for MNT. The points show the mean excitation energy at each measured energy. The colour axis indicates $P^{0-2\mathrm{N}}_{\mathrm{reflected}}/P_{\mathrm{reflected}}$ and $P^{\mathrm{MNT}}_{\mathrm{reflected}}/P_{\mathrm{reflected}}$, for panels (b) and (c) respectively. The data has been interpolated between measurement energies using Delaunay triangulation [1].

**Supplementary Table 1** Centre-of-mass energies, barrier height $V_B$ (incorporating the centrifugal potential for the $\ell$ value at 115°, distance of closest approach relative to the barrier and energy with respect to the barrier.

| Energy (MeV) | $V_B$ ($\theta_{lab}$ = 115°) (MeV) | $R_{min} - R_B$ | $E_{cm}/V_B$ |
|---|---|---|---|
| 156.7 | 196.3 | 3.87 | 0.80 |
| 161.8 | 195.8 | 3.35 | 0.83 |
| 165.6 | 195.4 | 3.00 | 0.85 |
| 168.5 | 195.1 | 2.73 | 0.86 |
| 171.5 | 194.9 | 2.45 | 0.88 |
| 174.4 | 194.6 | 2.20 | 0.90 |
| 177.4 | 194.4 | 1.93 | 0.91 |
| 179.9 | 194.0 | 1.71 | 0.93 |
| 182.8 | 193.7 | 1.45 | 0.94 |
| 185.8 | 193.5 | 1.16 | 0.96 |
| 188.7 | 193.3 | 0.86 | 0.98 |
| 191.7 | 193.1 | 0.46 | 0.99 |




**Supplementary Fig. 3** Distribution of kinetic energies with respect to the new potential following transfer at all measured energies. The blue curve shows the distribution including the measured excitation energy (i.e. $Q_{gg} + (V_i - V_f) - E_x$), where the red lines show the positions of ground-state to ground-state transfers (i.e. $Q_{gg} + (V_i - V_f)$). Error bars are statistical.




**Supplementary Fig. 4** Distribution of reflected flux probabilities in exit channel $Z_1 Z_2$ at all measured energies. The red curve shows the distribution including only those nuclides with energies with respect to the barrier similar to the entrance channel, i.e. $|\Delta E_{fi} < 5|$ , where the blue lines show the distribution of $Z_1 Z_2$ of the entire reflected flux. Error bars are statistical and mostly smaller than the size of each point.

## Supplementary References

[1] Delaunay, B. Sur la sphère vide. a la mémoire de georges voronoï. *Bulletin de l'Académie des Sciences de l'URSS. Classe des sciences mathématiques et na* 793–800 (1934) .