^{20}Ne and ^{22}Ne fragmentation on ^{12}C at 11.7 MeV per nucleon at TRIUMF

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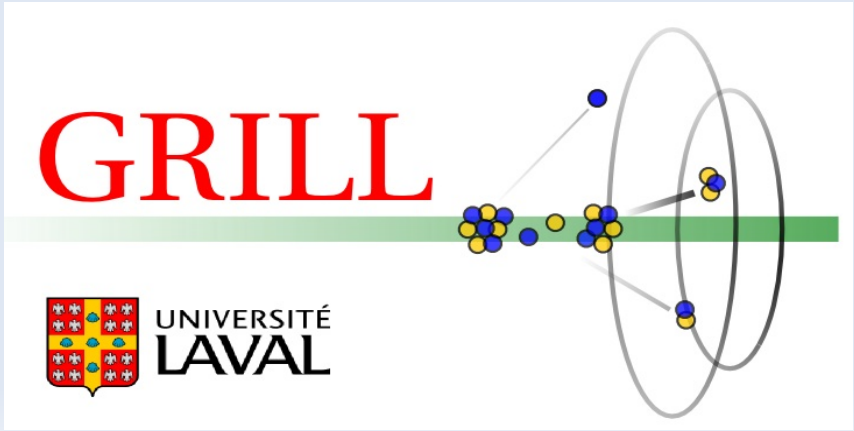


- Motivation and theory
- Experimental details and preliminary results
- Hybrid simulation code AMD+GEMINI
- Conclusion

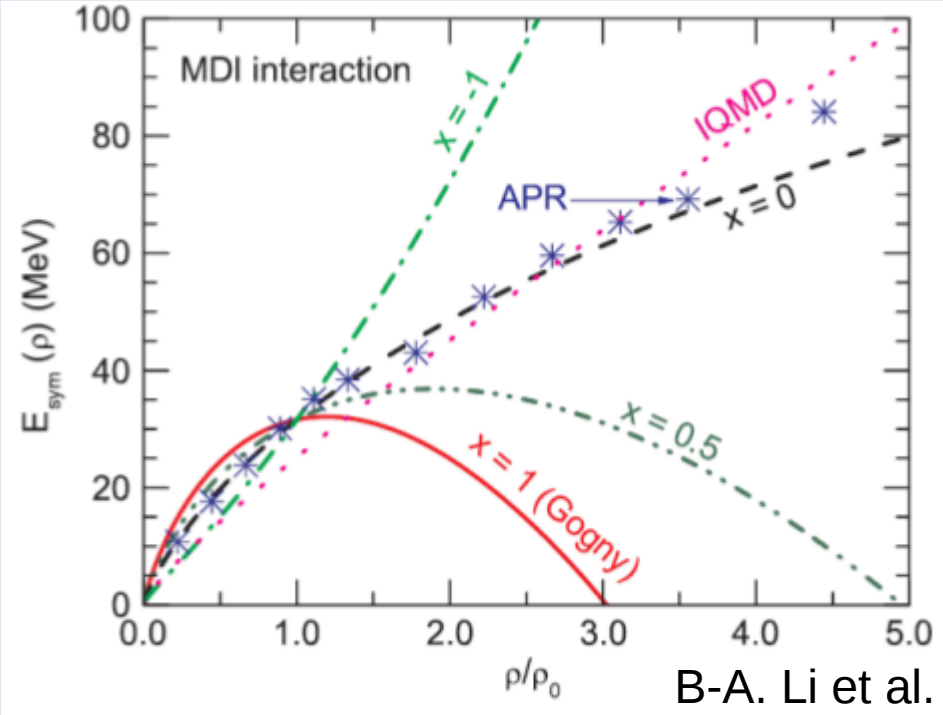
Motivation and theory

- Equation of state (EOS)
  - $E(\rho, \delta) = E(\rho, \delta=0) + E_{sym}(\rho) \cdot \delta^2 + \ldots$

    $\delta = (\rho_n - \rho_p)/\rho$

    ρ_n = neutron density

    ρ_p = proton density



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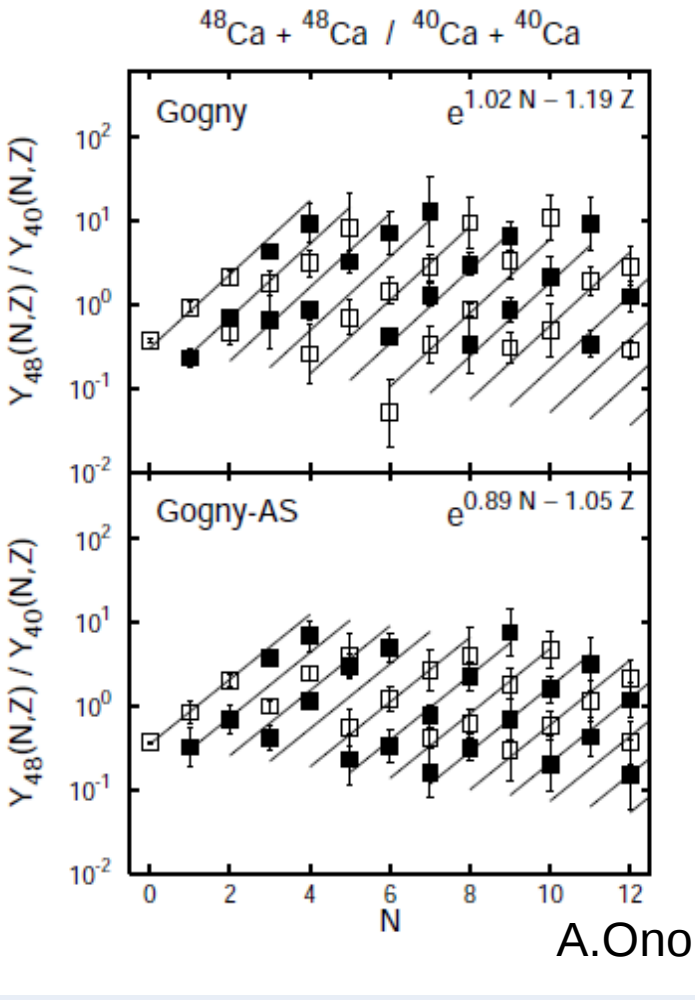
- Isoscaling

$$R_{21} = \frac{Y_2(N,Z)}{Y_1(N,Z)} = C\exp(N\alpha + Z\beta)$$

$$\alpha = \frac{4C_{sym}}{T}\Delta$$

$$E_{sym} = C_{sym} I^2$$



- Isoscaling values are lost after deexcitation
- Reconstruction of primary fragments using fragments detected in coincidence in a multidetector
  - All fragments need to be isotopically identified
  - Free neutrons are not detected
- Deexcitation models can help to estimate the number of missing neutrons and charged particules

- Excitation energy of primary fragments is around 3-5 MeV per nucleon
- Parameters used in deexcitation models come from extrapolation from low energy experiments
- Dependence with isospin

Experimental details and preliminary results

- TRIUMF ISAC-II

- July 2011 experiment

  $^{25}Na+^{12}C$ at 9.23 AMeV

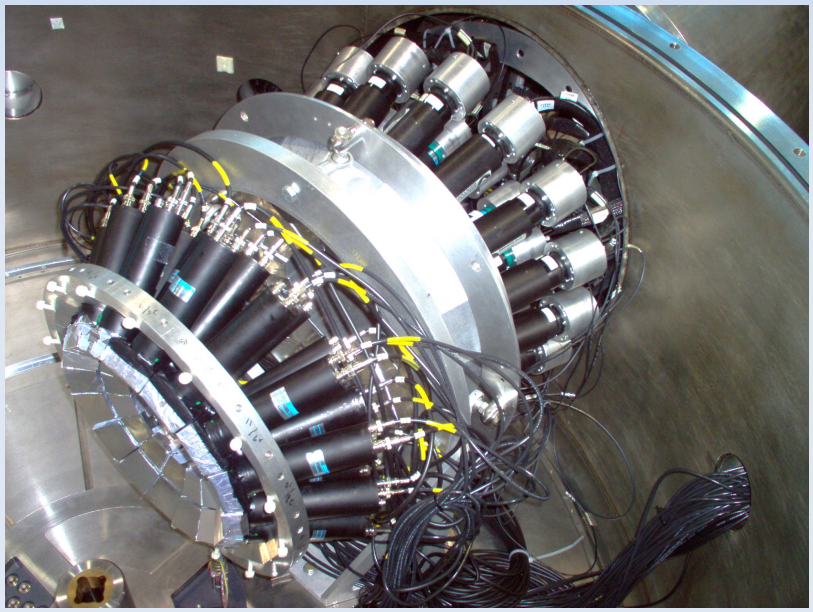
  $^{25}Mg+^{12}C$ at 9.23 AMeV

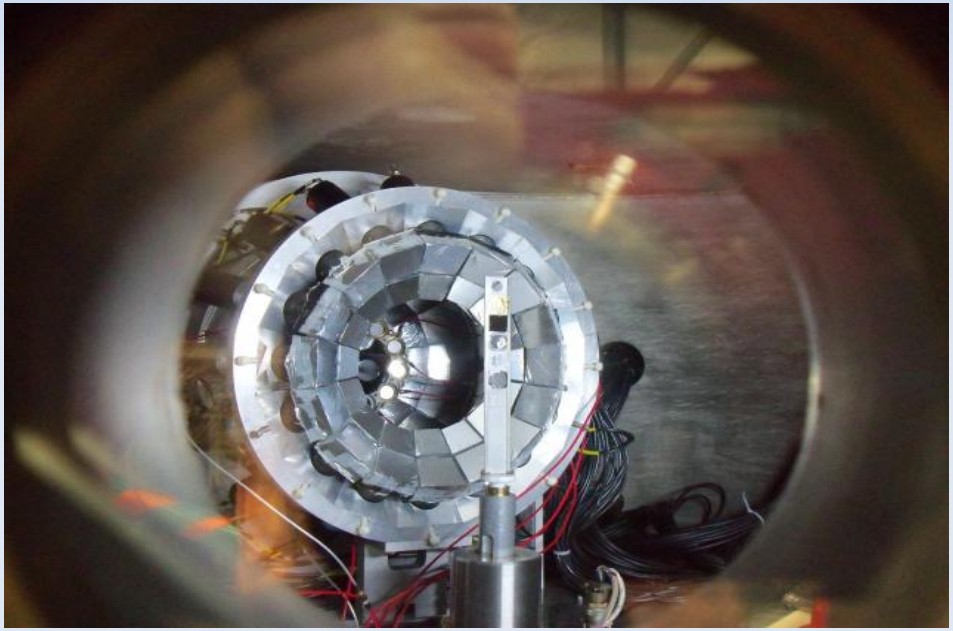
- July 2013 experiment

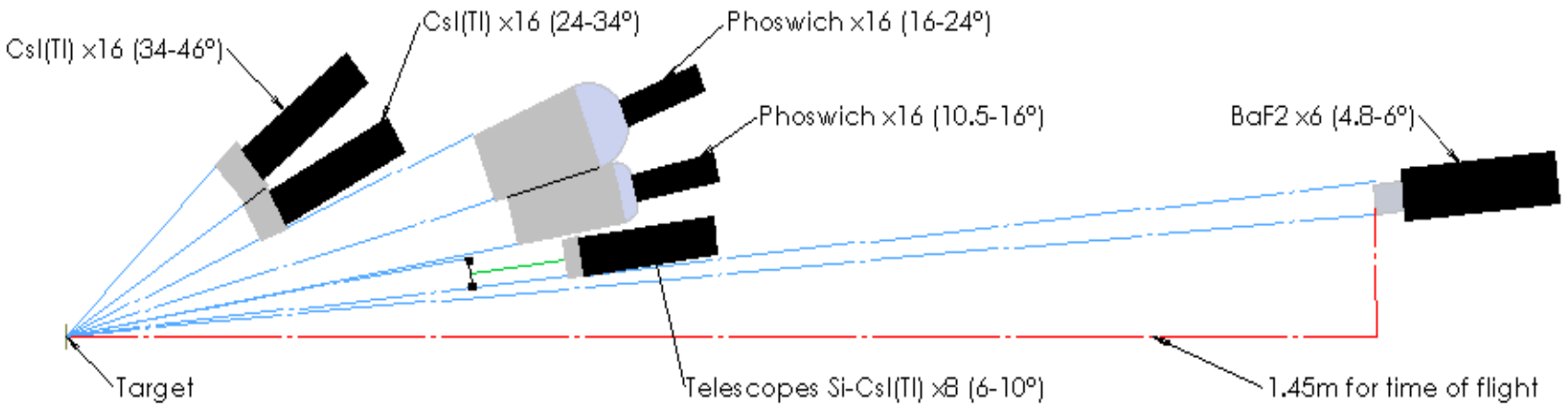
  $^{20}Ne+^{12}C$ at 11.7 AMeV

  $^{22}Ne+^{12}C$ at 11.7 AMeV

- HERACLES



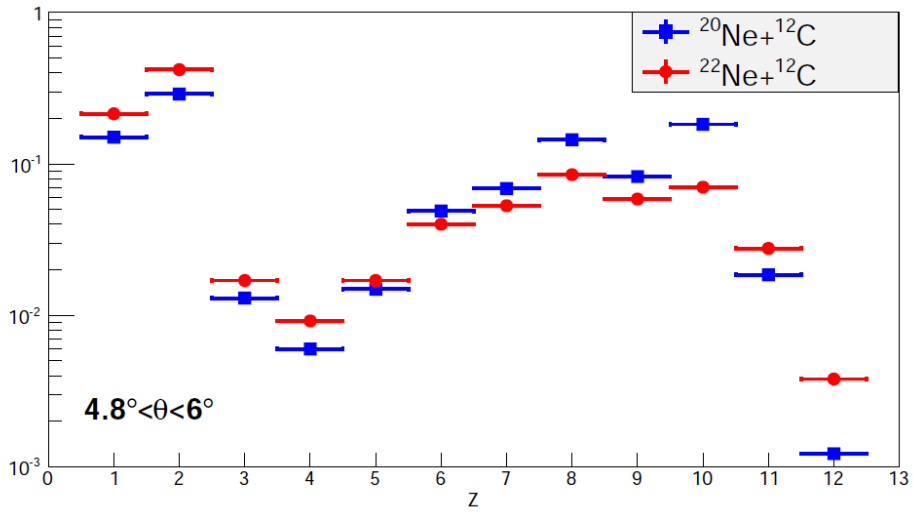


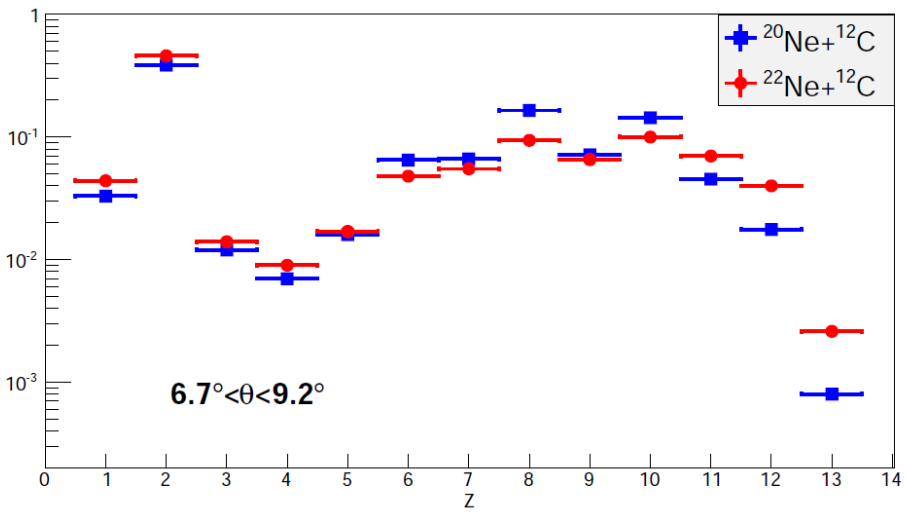


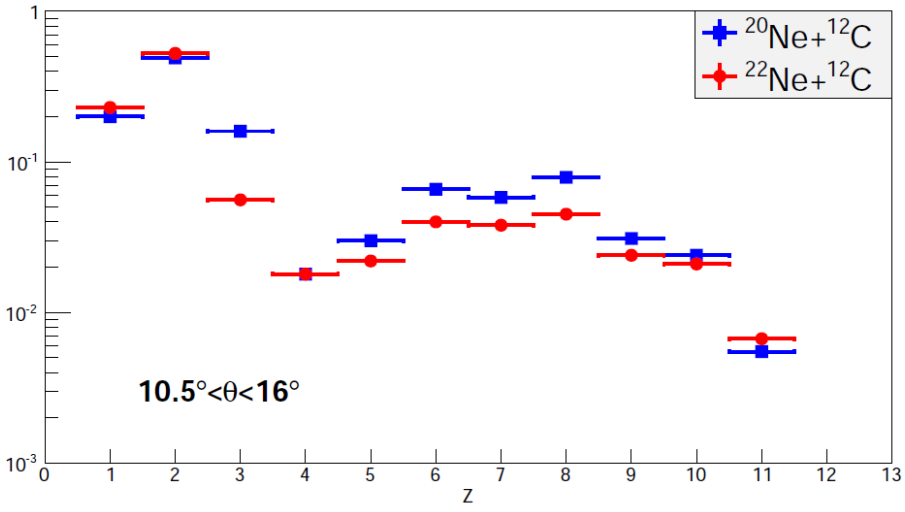
Ring No.	ΔE detector	E detector	θ_{min} (°)	θ_{max} (°)	N	$\Delta\phi$ (°)	ΔE thickness (μm)
0	BC408	BaF_2	4.8	6	6	15	100
1	Si	CsI(Tl)	6	10	8	18	50
2	BC408	BC444	10.5	16	16	22.5	100
3	BC408	BC444	16	24	16	22.5	100
4	-	CsI(Tl)	24	34	16	22.5	-
5	-	CsI(Tl)	34	46	16	22.5	-

- In summary:
  - Identification of the charge between 4.8° and 24°
  - Light charged particles are partially identified up to Z=2 using TOF between 4.8° and 6°
  - Light charged particles are identified up to Z=4 in silicon detectors between 6° and 10°
  - Light charged particles are identified up to Z=2 between 24° and 46°

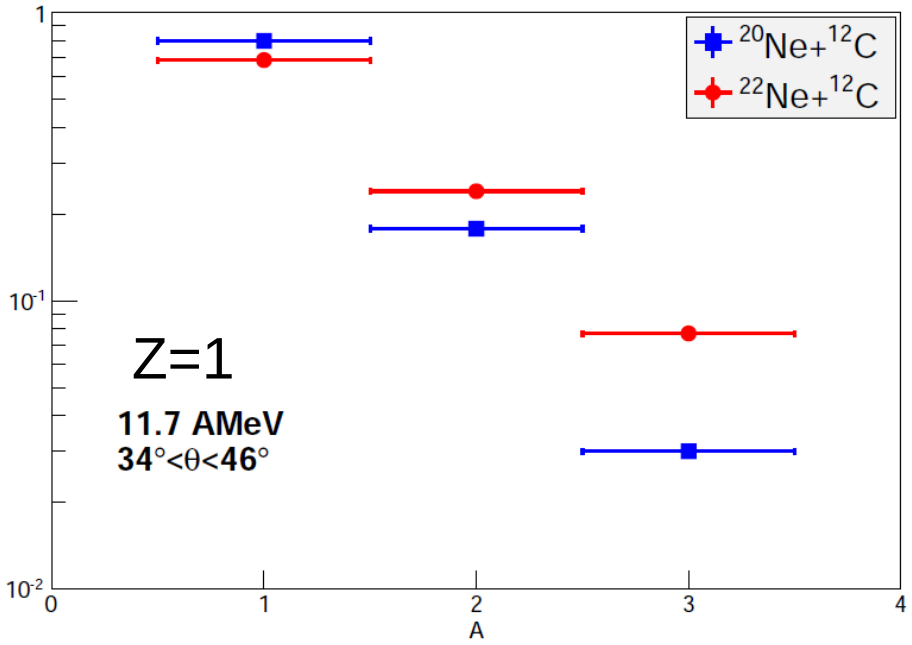
Preliminary results

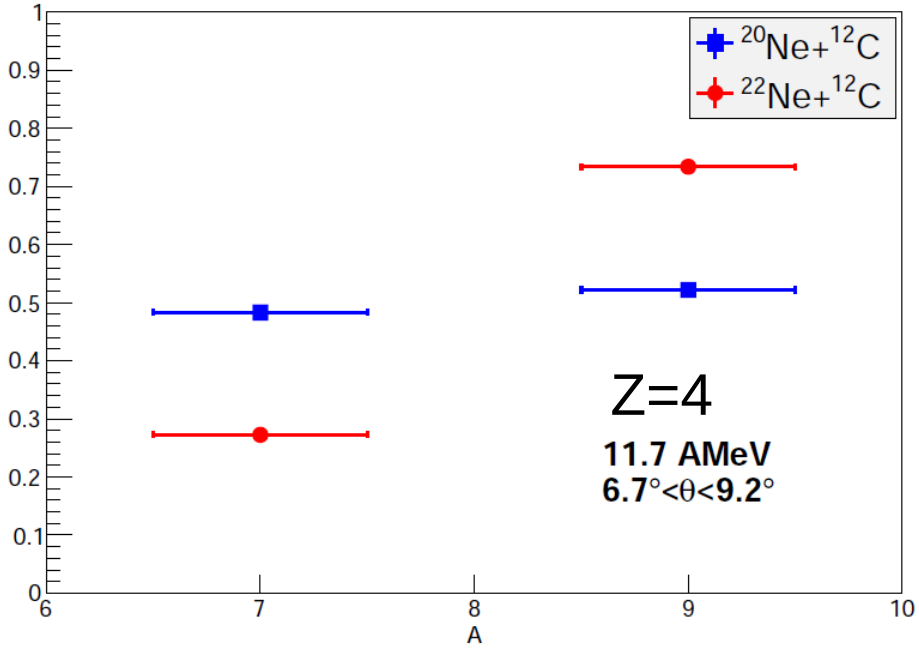






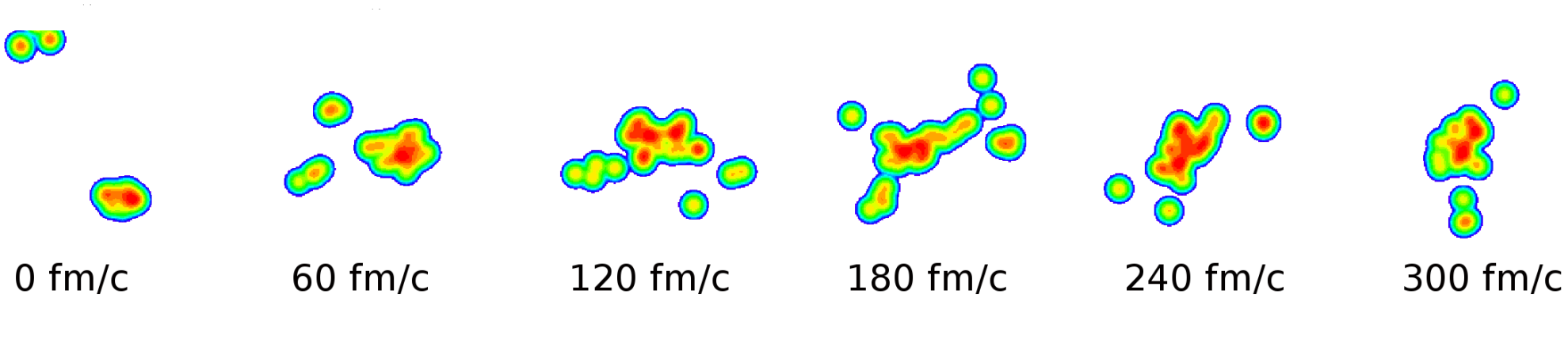
Preliminary results





Hybrid simulation code

- Antisymmetrized Molecular Dynamics
  - Dynamical calculations up to t= 300 fm/c

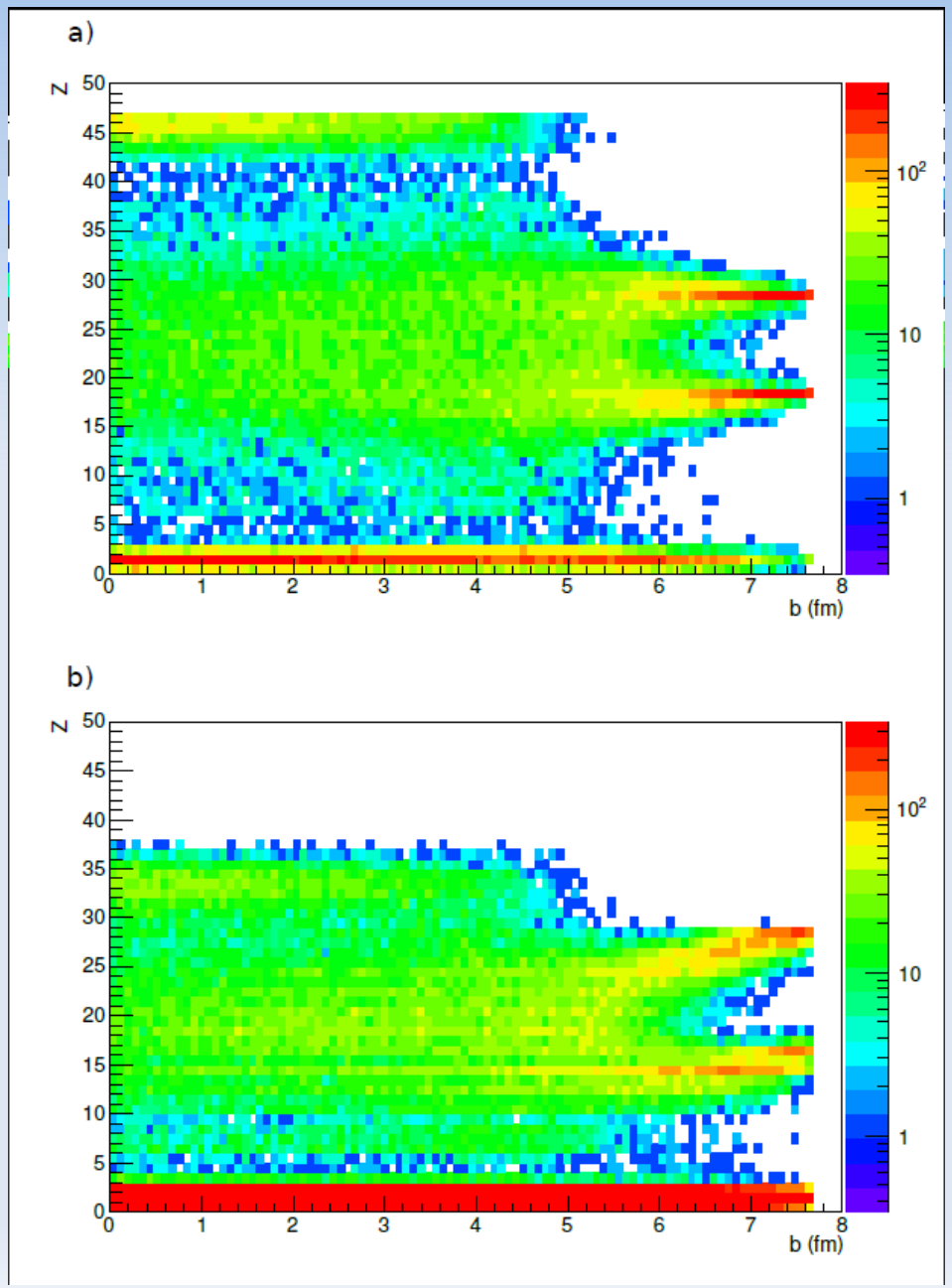


- Fragment identification using a coalescence algorithm in phase-space (momentum, spin, excitation energy)
- Statistical decay of fragments using GEMINI

$^{34}Ar+^{58}Ni$ at 13.5 AMeV

Primary fragments

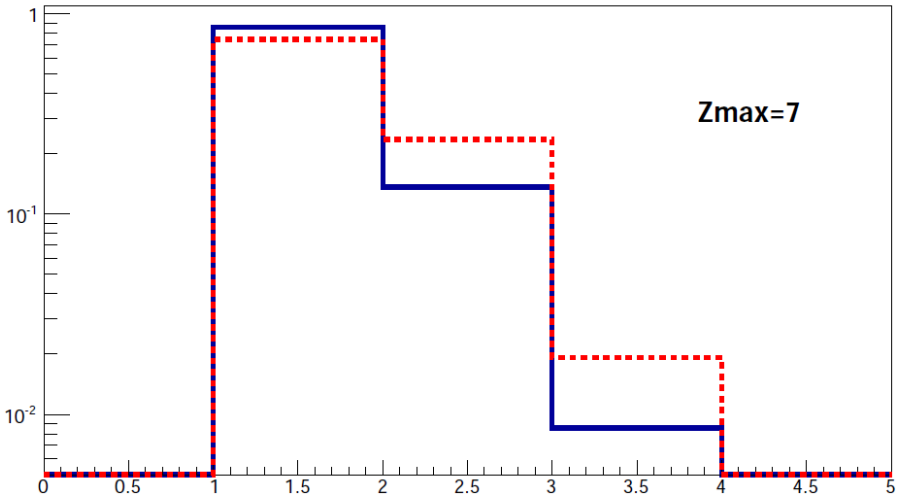
After deexcitation

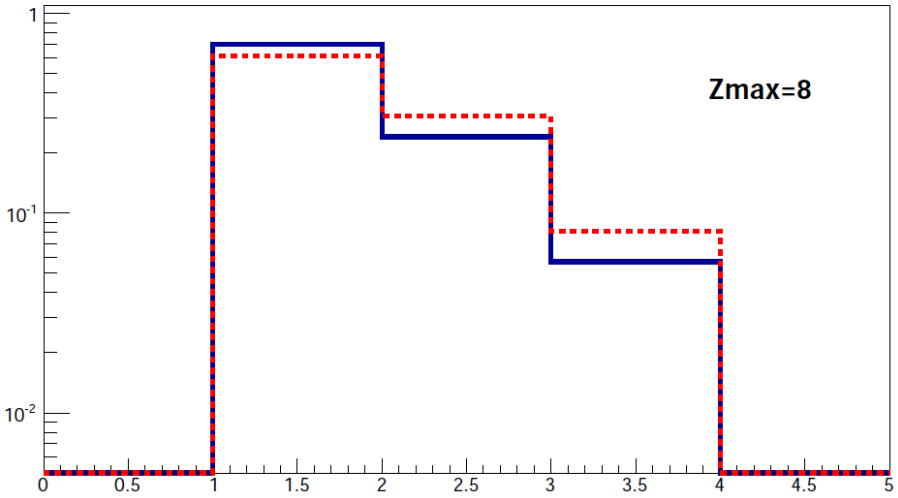


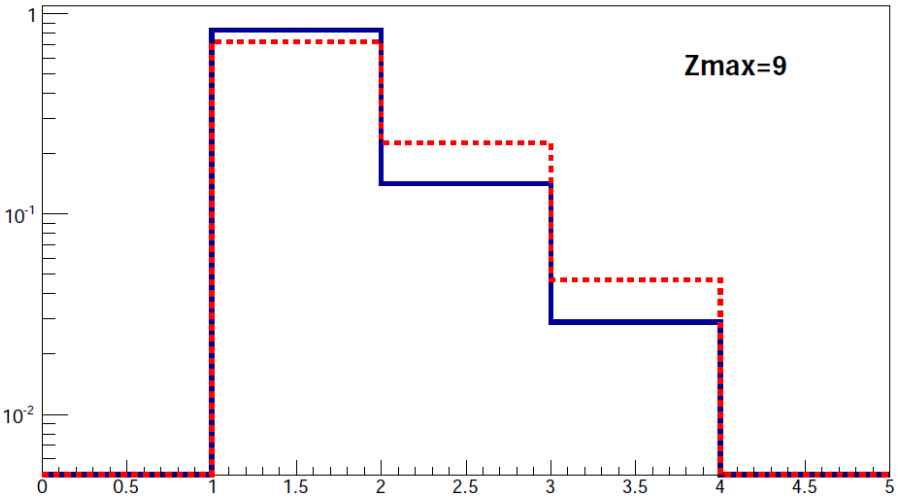
AMD+GEMINI
$^{20}Ne+^{12}C$ at 11.7 AMeV

Hydrogen isotopes detected between 24° and 46° in coincidence with a charge Zmax detected between 4.8° and 24°.

a=A/8
a=A/11



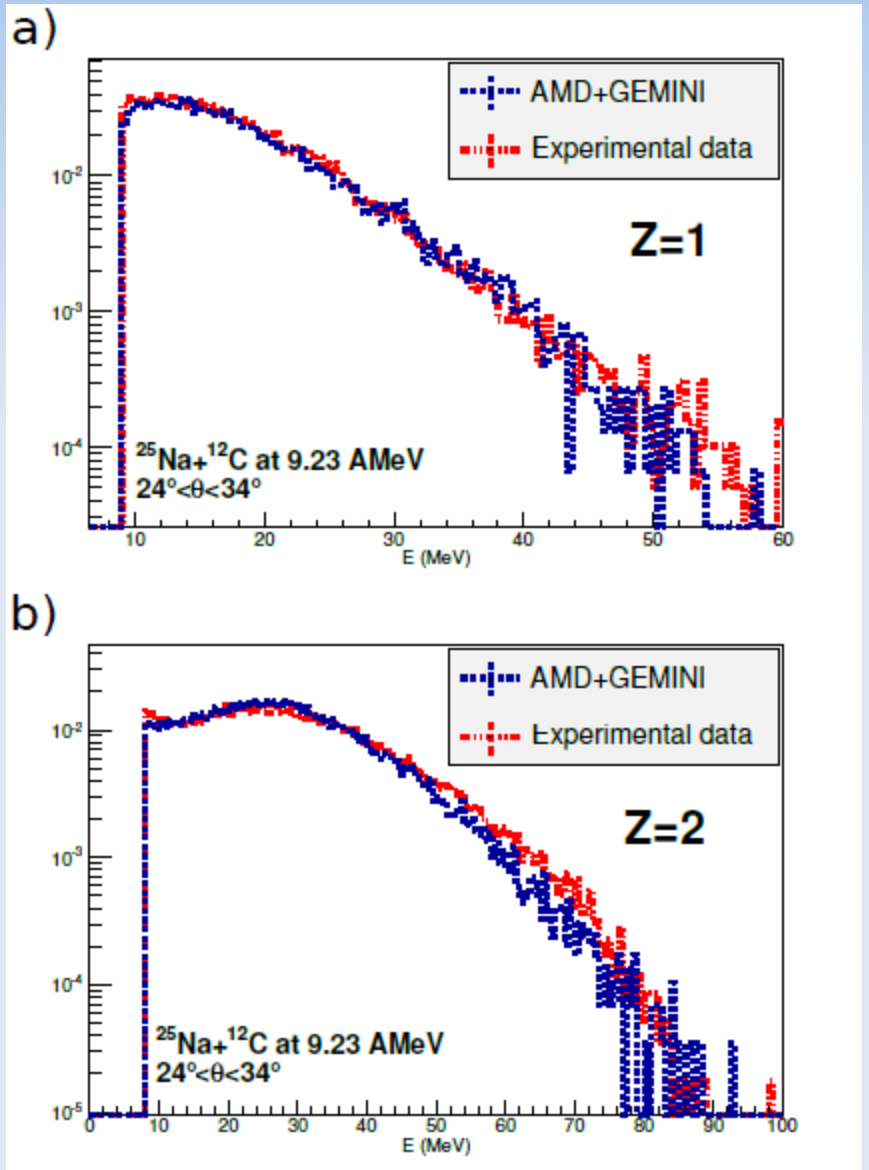


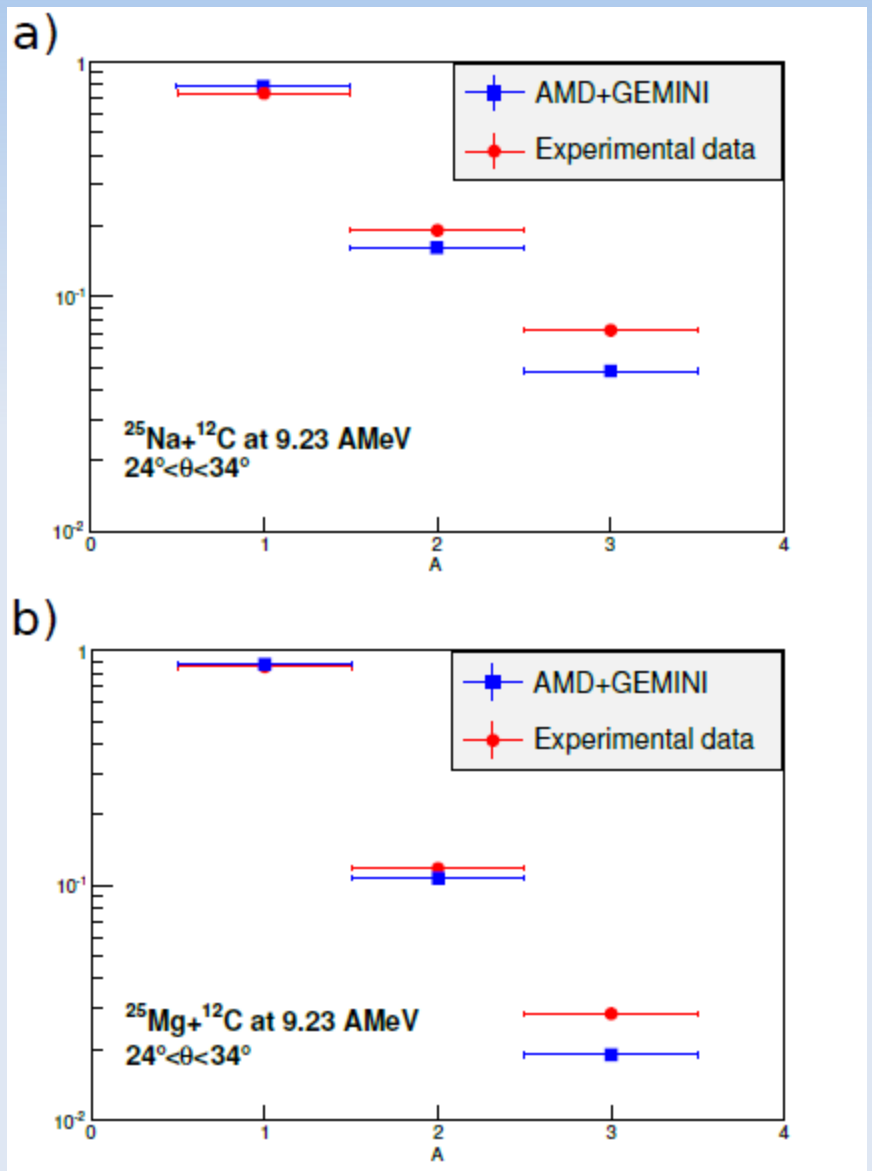


Conclusion

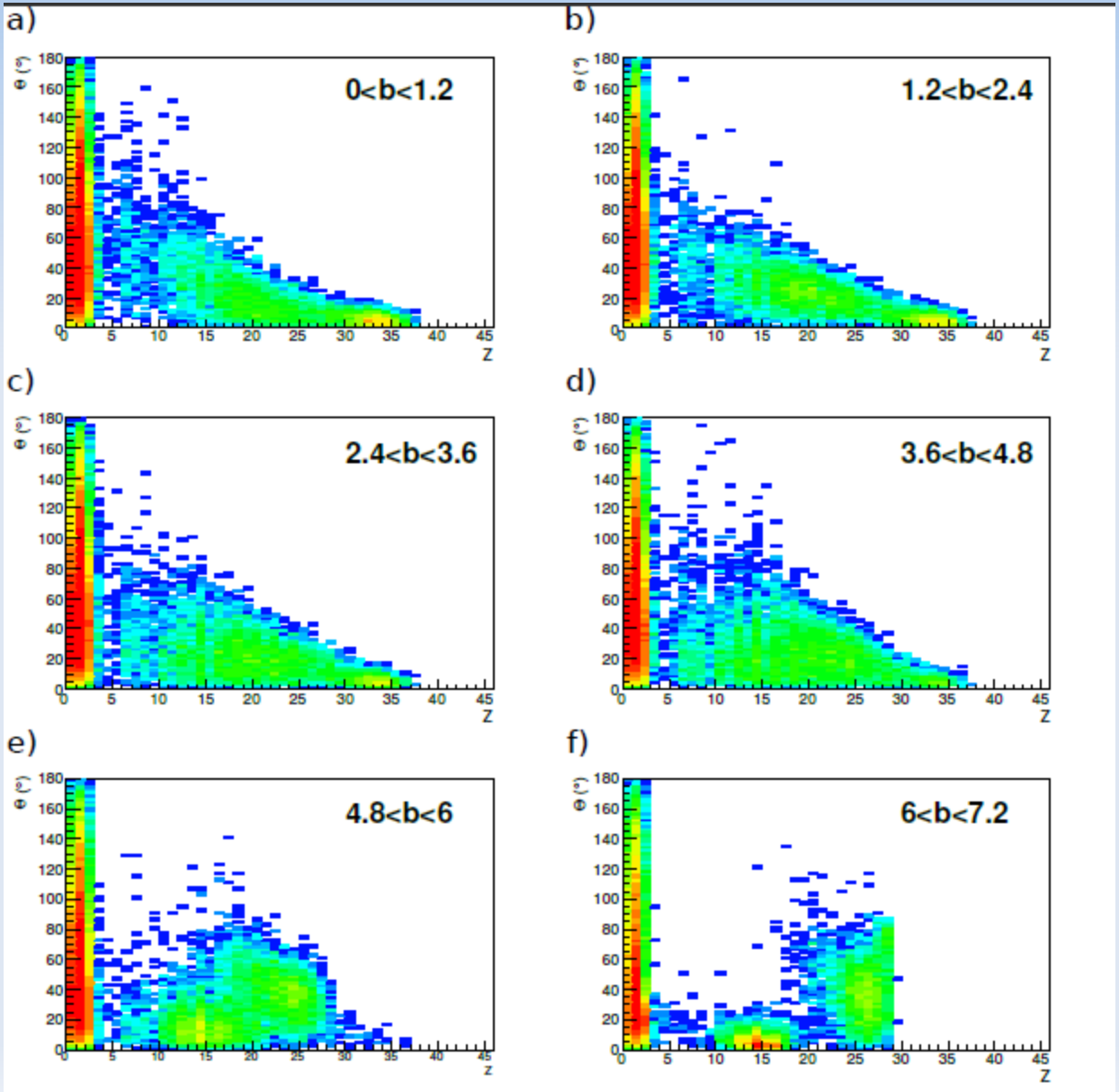
- HERACLES experiment at TRIUMF is completed
- Still a lot of data analysis to do
  - Identification and calibration for all detectors
  - Comparaison with AMD-GEMINI

- Backup


a)
AMD+GEMINI
Experimental data
Z=1
^{25}Na+^{12}C at 9.23 AMeV
24°<θ<34°
E (MeV)
b)
AMD+GEMINI
Experimental data
Z=2
^{25}Na+^{12}C at 9.23 AMeV
24°<θ<34°
E (MeV)


a)
AMD+GEMINI
Experimental data
^{25}Na+^{12}C at 9.23 AMeV
24°<θ<34°
A
b)
AMD+GEMINI
Experimental data
^{25}Mg+^{12}C at 9.23 AMeV
24°<θ<34°
A

$^{34}Ar+^{58}Ni$ at 13.5 AMeV

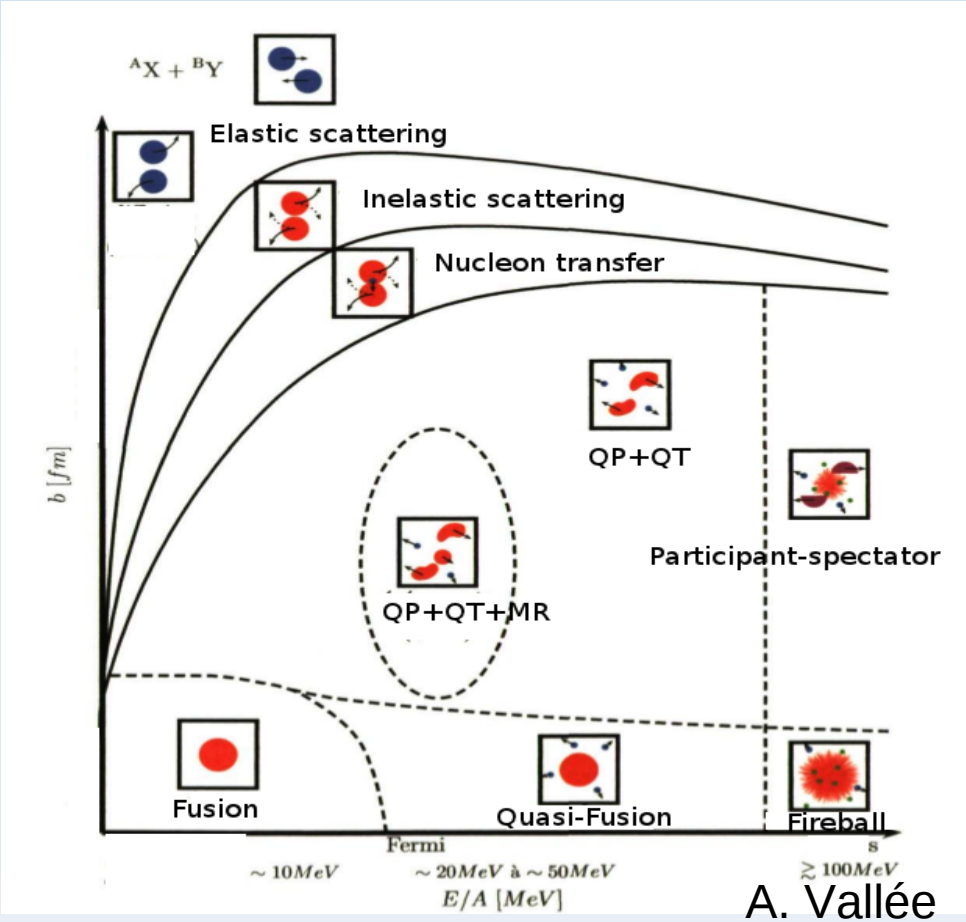


- Dynamic of heavy-ion collisions at intermediate energies

QP=Quasi-Projectile

QT=Quasi-Target

MR=Mid-Rapidity

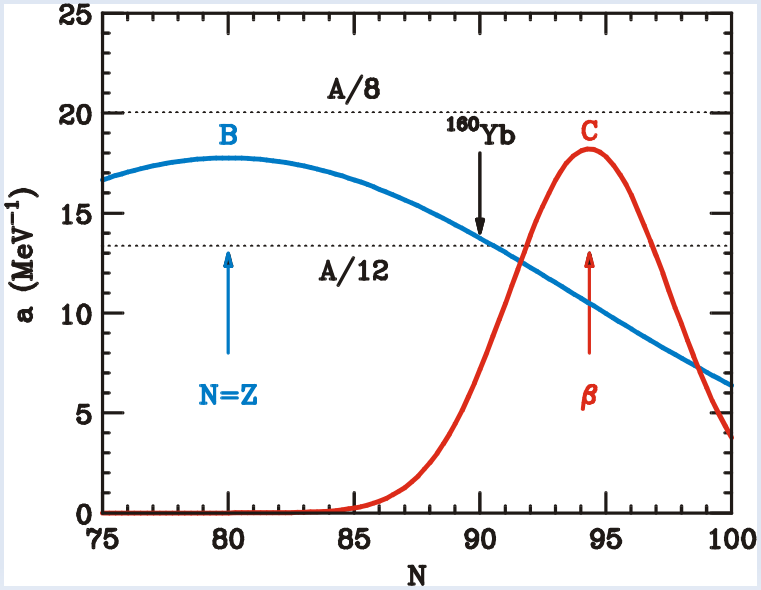


A. Vallée

$$a = \frac{A}{9.009 MeV} \exp\left[6.41\times10^{-4}\left(N-Z\right)^2\right] \quad \text{Case B}$$

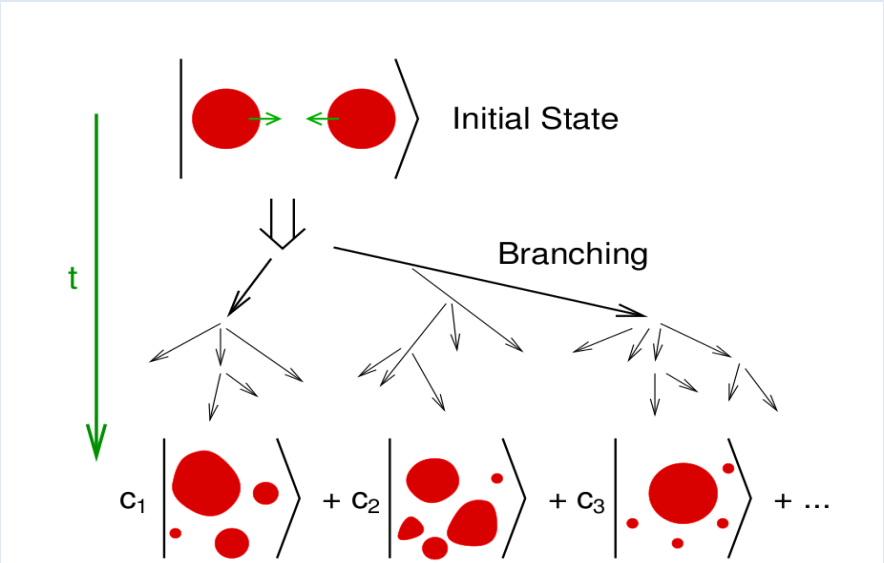
$$a = \frac{A}{8.787 MeV} \exp\left\{4.93\times10^{-2}\left[Z - Z_\beta\left(A\right)\right]^2\right\} \quad \text{Case C}$$

$$a = \frac{\pi^2}{6}\left(g_n + g_p\right) \propto A^{2/3}\left(N^{1/3}m_n + Z^{1/3}m_p\right) \approx mA\left[1 - \frac{1}{9}\left(\frac{N-Z}{A}\right)^2\right]$$



R. Charity

- AMD details
  - Nucleons are represented by wave packet with a fixed width
  - Antisymmetrization of wave functions
  - A stochastic BUU-type NN collision algorithm is used
  - Quantum Branching



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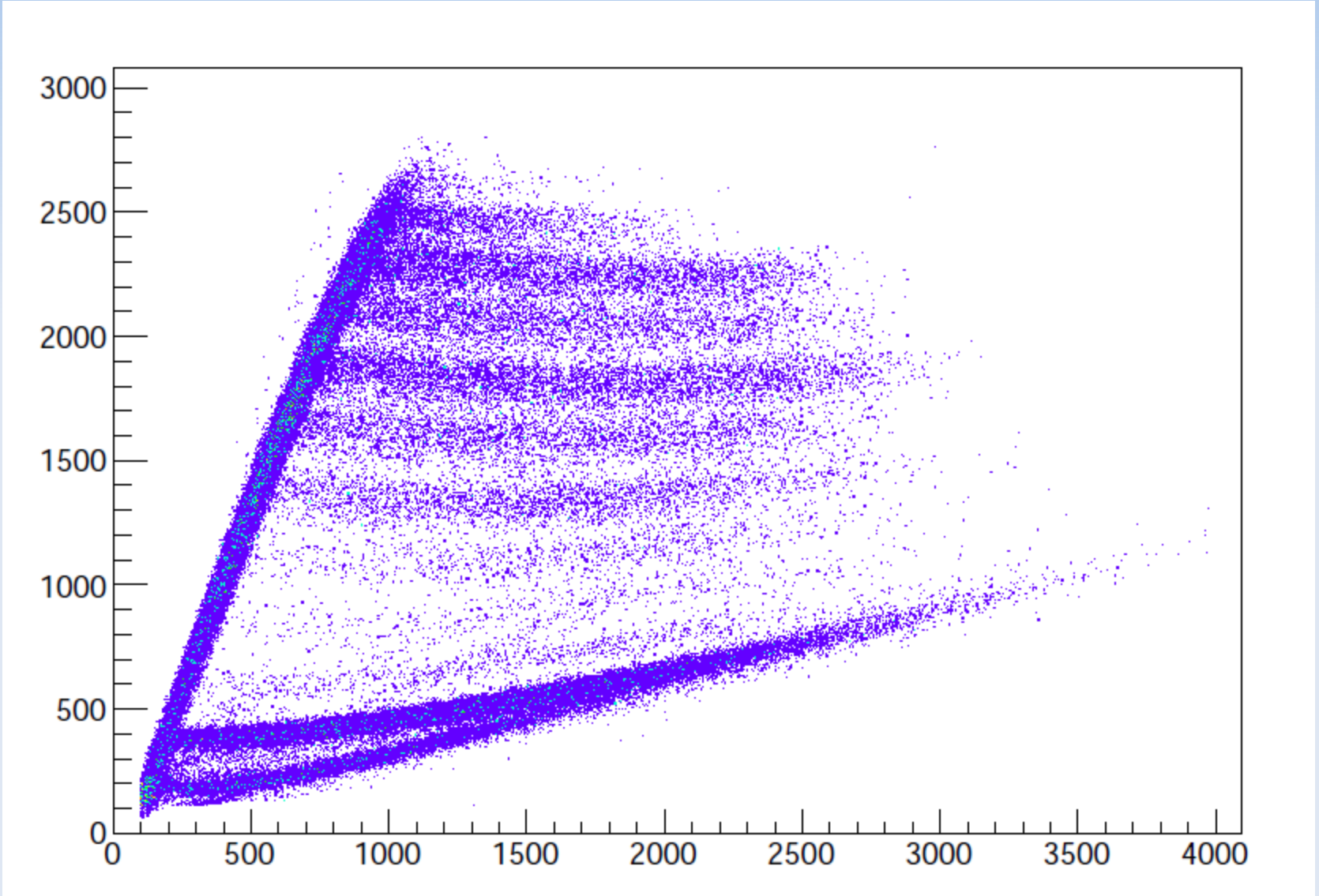
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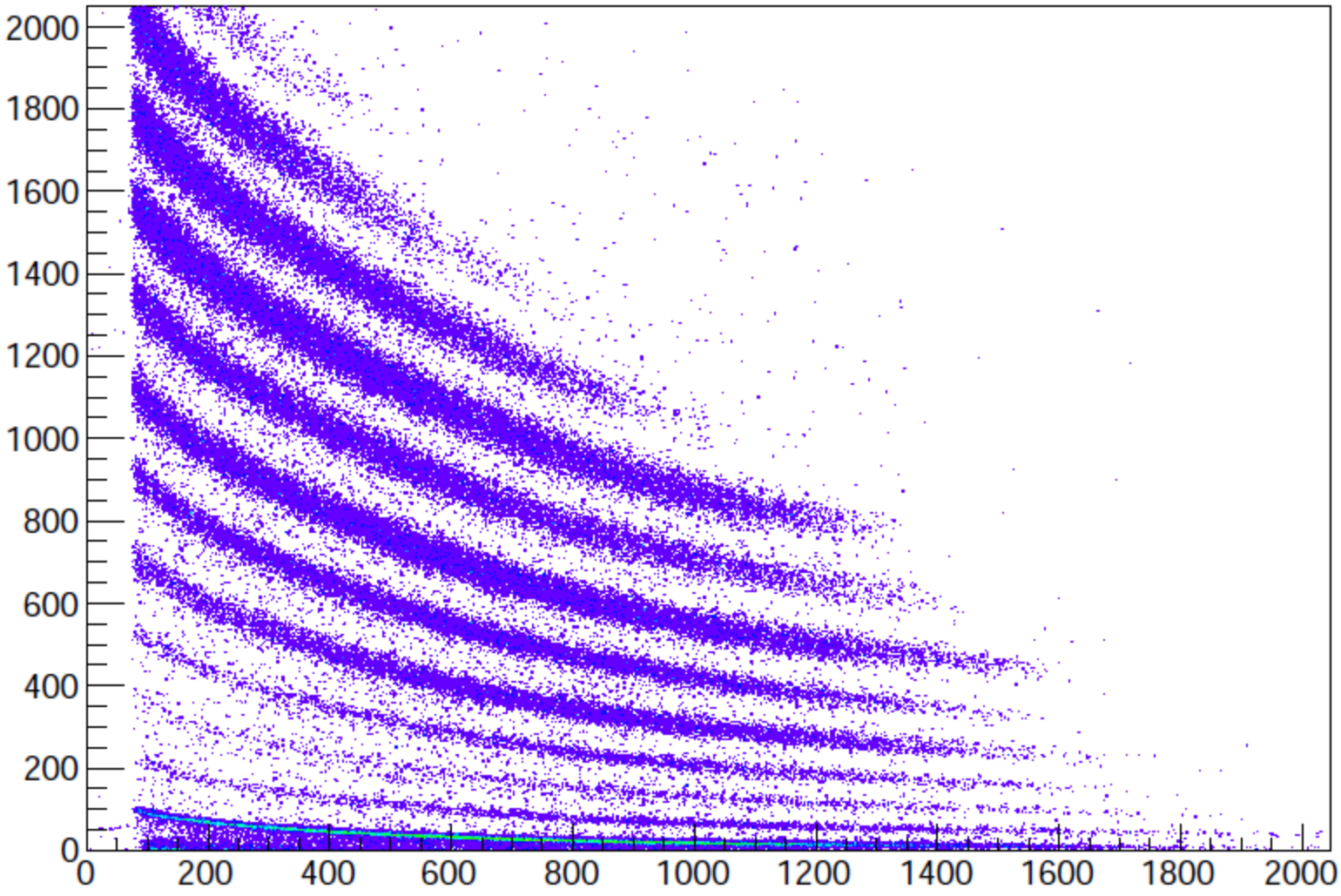
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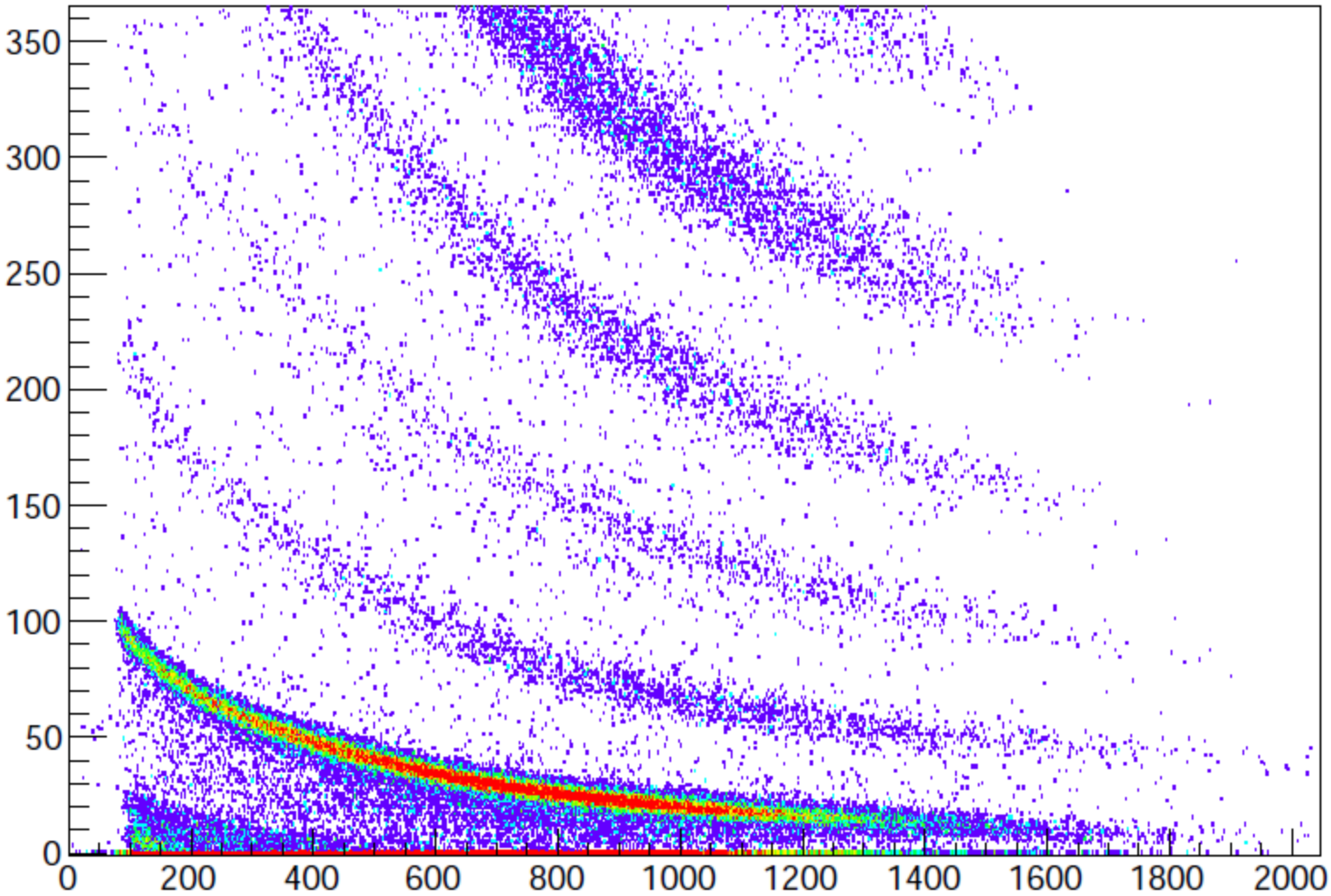
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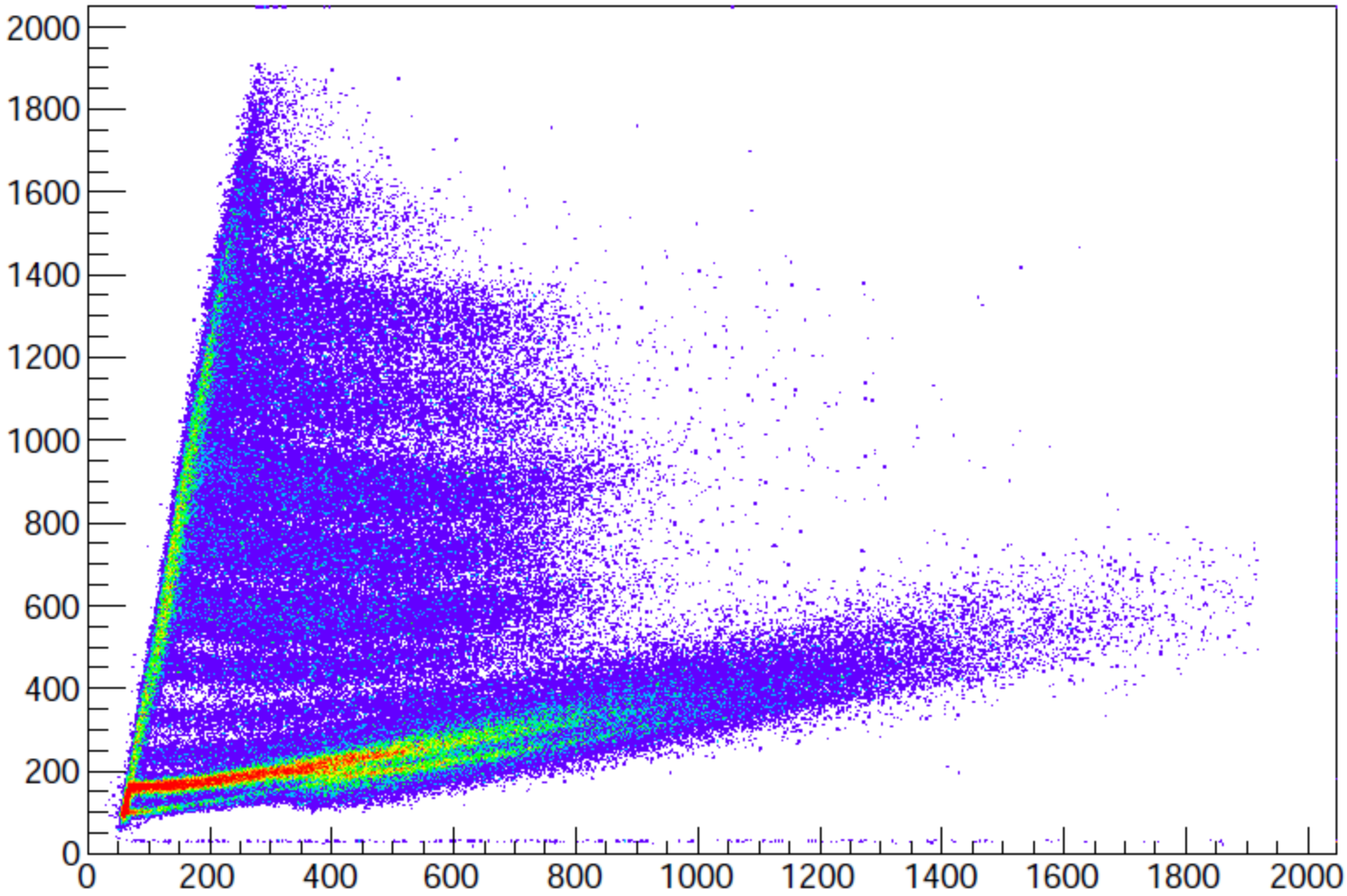
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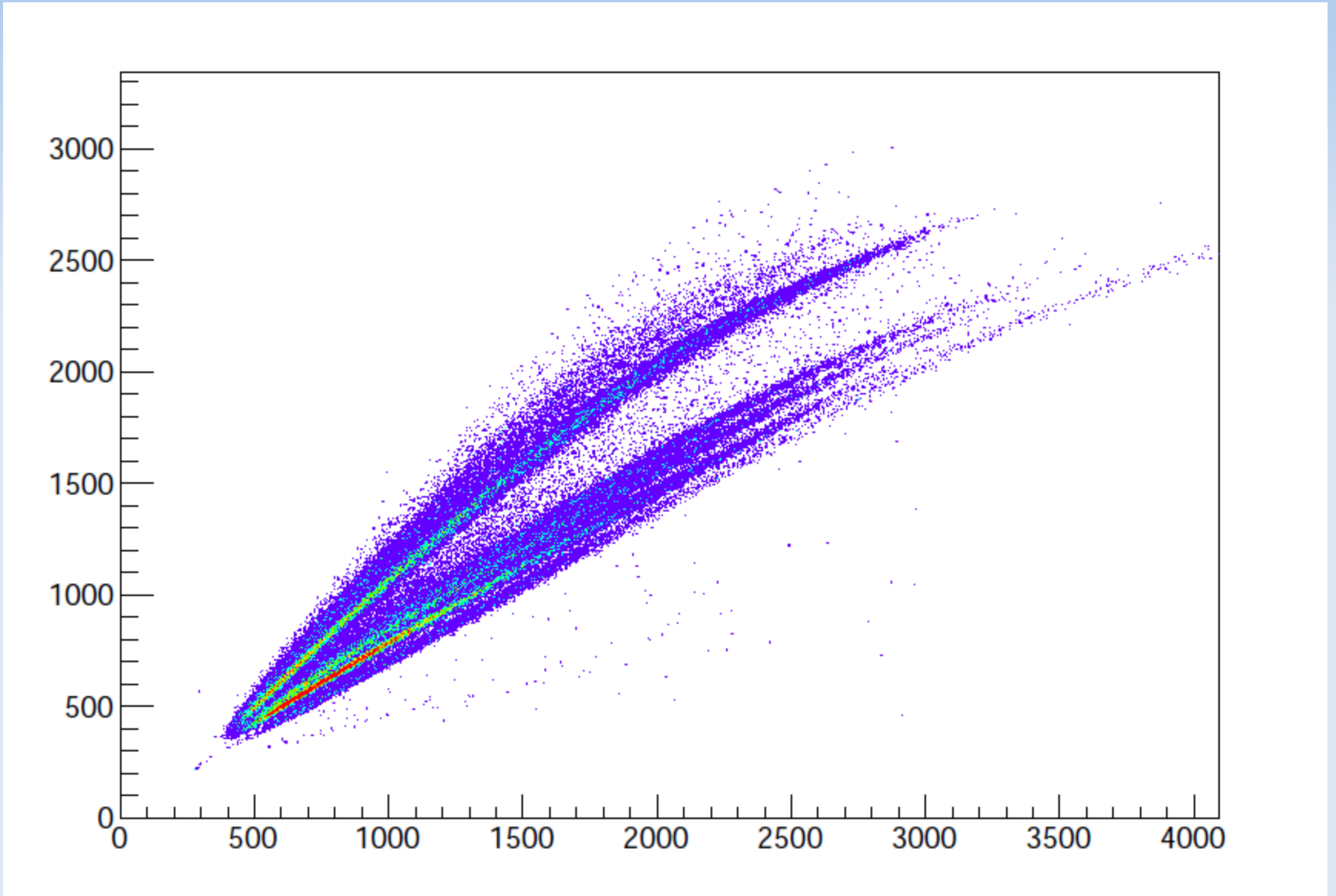
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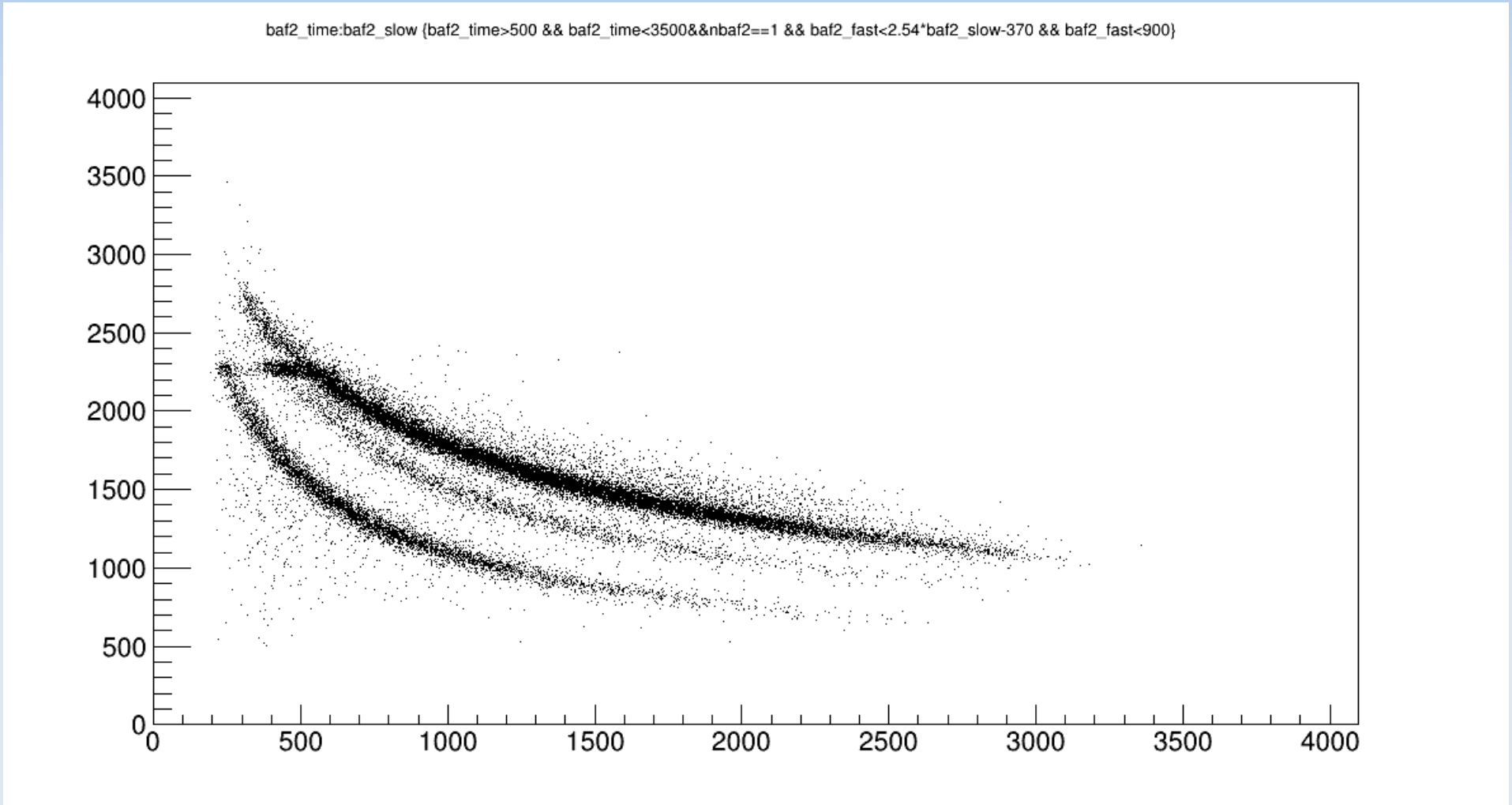
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