涨落温度计的失真

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内容

- 引言：

  如何使用涨落温度计提取有限核系统的温度

- 涨落温度计的应用

- 涨落温度计失真的主要来源

  费米影响

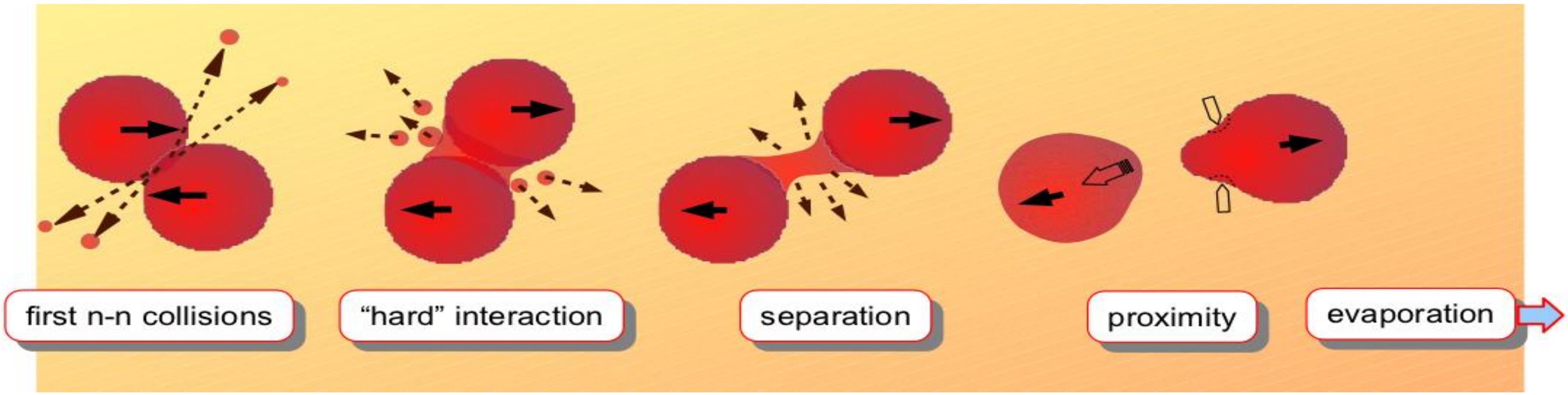
  库仑影响

  粒子发射时间影响

- 结论

  粒子发射时间的不同带来的测量失真

热源的选取



- 质量的选择 $48 \le A_{QP} \le 52$
- 碎块的选择 $$\mathrm{m}_- \le v_z / v_{z,PLF} \le \mathrm{m}_+$$
- 平衡热源的选择 $$-0.3 \le \log Q \le 0.3$$ $$Q = \frac{\sum p_{z,i}^2}{\frac{1}{2}\sum p_{T,i}^2}$$

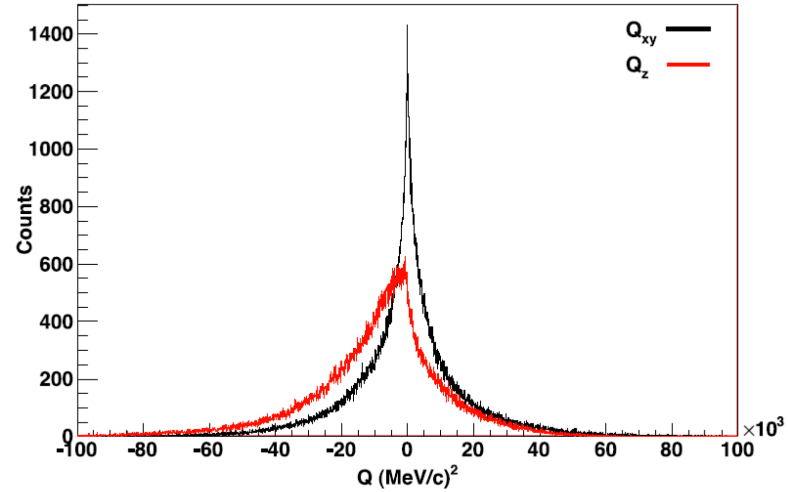
动量涨落提取温度

$$\sigma^2 = \langle Q_z^2 \rangle - \langle Q_z \rangle^2$$

$$\langle Q_z^2 \rangle = \int d^3p \left(2P_Z^2 - P_T^2\right)^2 f(p)$$

$$\sigma^2 = 12A^2 m_0^2 T^2$$

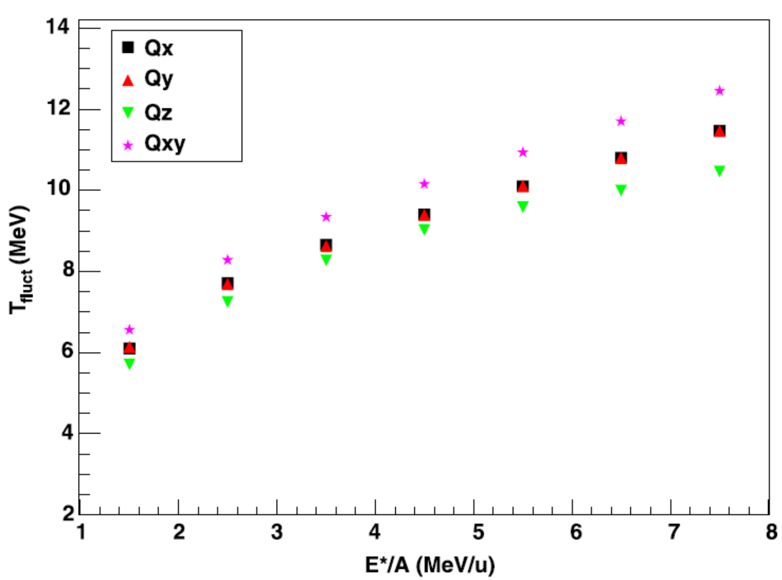
$$T_f = \sigma^2 / m_N$$



- 使用轻粒子动量四极矩的涨落来提取温度

- 该方法提取的温度同样大于热力学温度。因为费米动量和热动量同样不可区分。

S. Wuenschel et al., Nuclear Physics A 843 (2010) 1–13



动量涨落温度计的应用

- 研究原子核量热曲线的同位旋依赖。

A.B.McIntosh, et al., PLB 719, 337(2013)

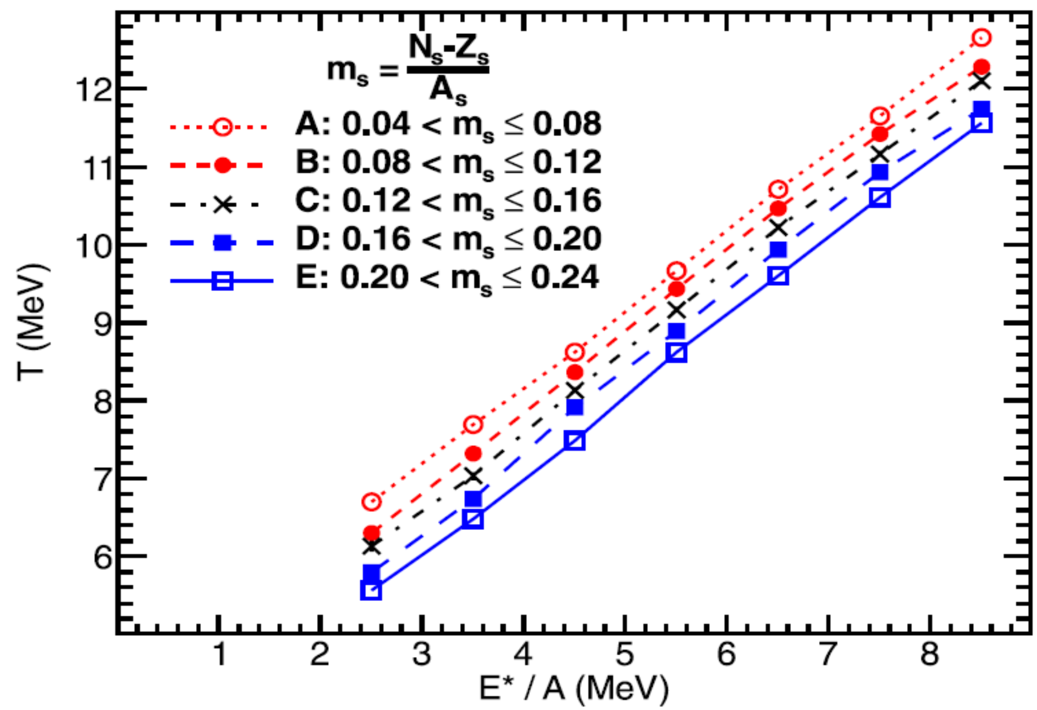


Fig. 1. (Color online.) Caloric curves for isotopically reconstructed sources with mass $48 \leqslant A \leqslant 52$, extracted with the momentum quadrupole fluctuation method. Each curve corresponds to a narrow range in source asymmetry, m_s.

动量涨落温度计的应用

- 推测热源的密度。

$$\frac{\rho}{\rho_0} = \left(\frac{a_0 T^2}{E^*} \right)^{3/2}.$$

S.Wuenschel, et al., NPA 843, 1(2010)

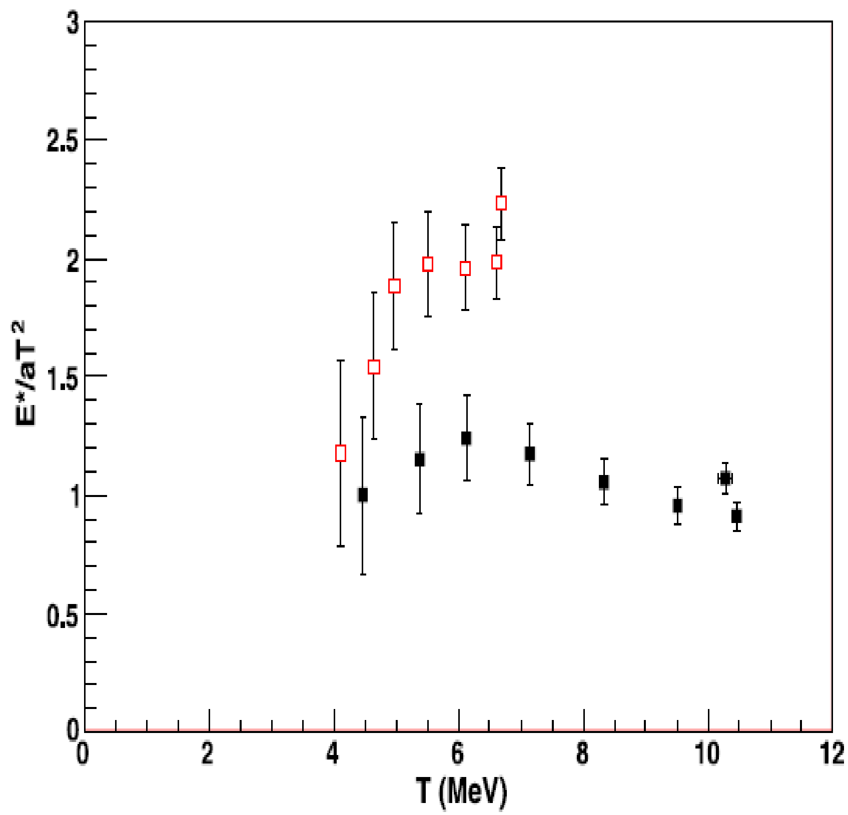


Fig. 6. E^*/aT^2 vs T derived from the transverse kinetic energy of the fragments (full squares) and the total kinetic energy (open squares) for the $^{86}Kr + ^{64}Ni$ system. (Color online.)

费米修正

- 热动能和费米动能在能谱中不可分。
- 原子核系统是一个费米系统。末态碎片的动能由两部分组成：费米动能和热动能。
- 需从动能谱中扣除费米动能，才能提取准确的热力学温度。

$$T_{\text{fluct}} = \sqrt{\frac{4E_F^2}{35} + \frac{2\pi^2}{15} T'^2_{\text{fluct}}}$$

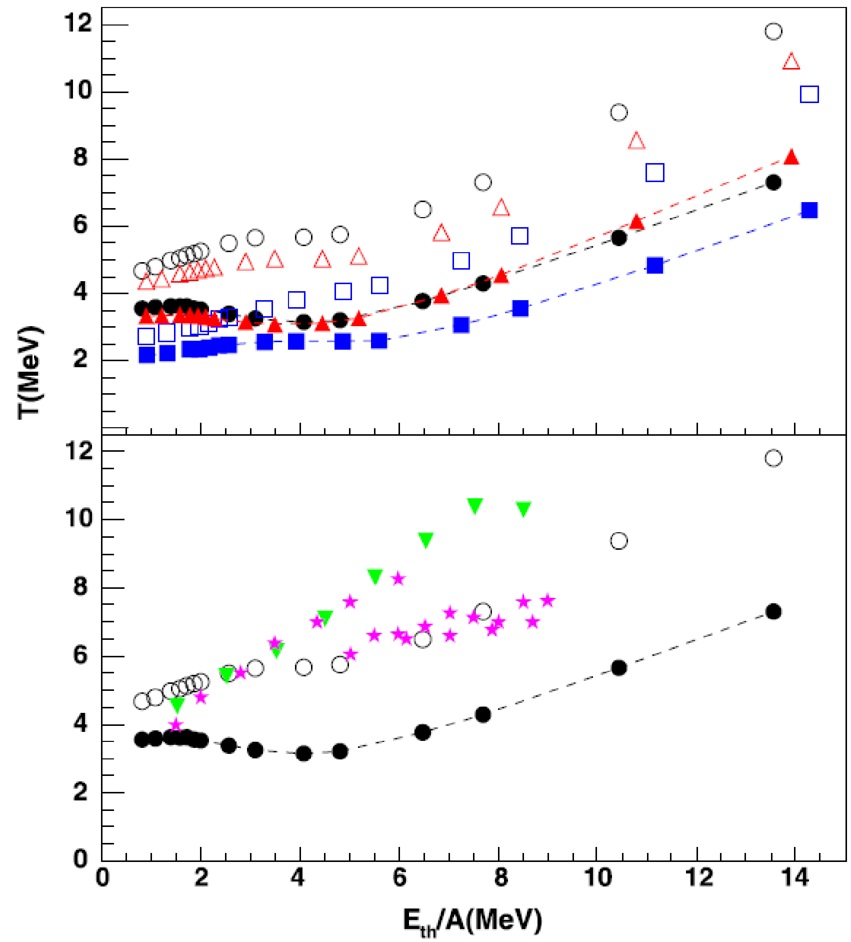


Fig. 1. Temperature versus thermal energy per particle derived from quantum fluctuations (full symbols joined by dashed lines) compared to the classical case (open symbols). (Top) Circles refer to protons, squares to neutrons and triangles to protons and neutrons. (Bottom) Same as above for protons. Data: down triangles from classical quadrupole fluctuations [10], star symbols from particle ratios [9].

Zheng H, et al., PLB 696, 178

波色子的库仑修正

- 对于不同的带电粒子，库仑排斥会对涨落温度计的测量带来影响。

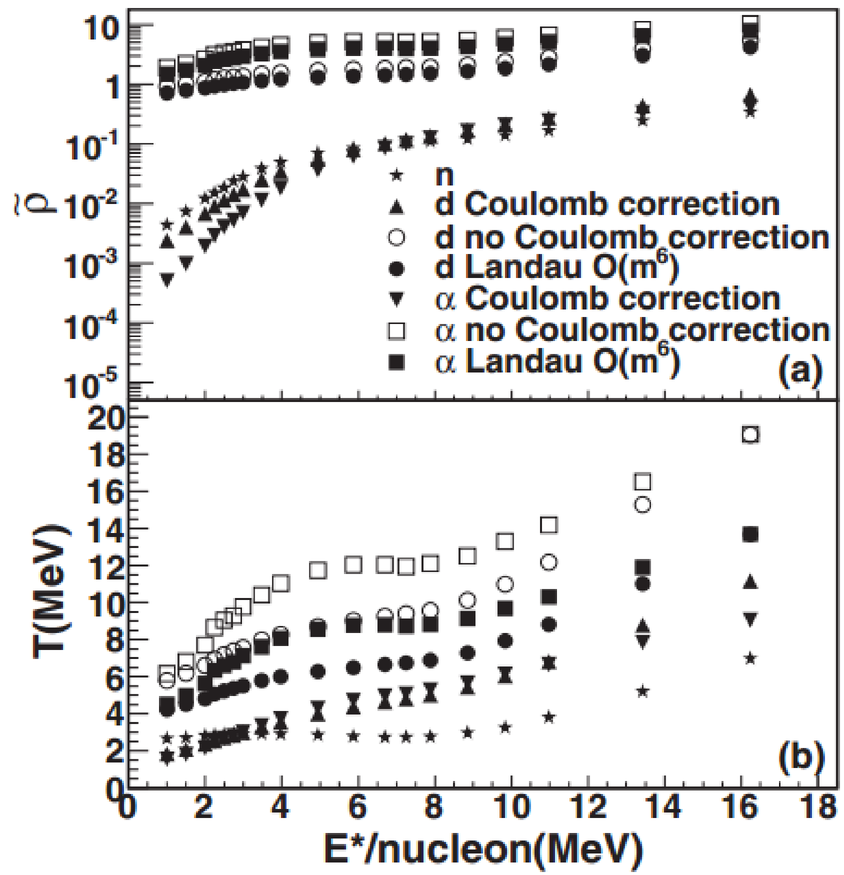


FIG. 4. The reduced density (a) and temperature T (b) versus E*/nucleon of d and α from CoMD simulations. Three methods, with Coulomb correction, without Coulomb correction, and Landau's $O(m^6)$ theory, are used to calculate the density and temperature. The corresponding results for neutrons are also included as a reference.

Zheng H, et al., PRC 88, 024607(2013)

费米子的库仑修正

Zheng H, et al.,
J.Phys.G.Nucl.Part.Phys
41, 055109(2014)

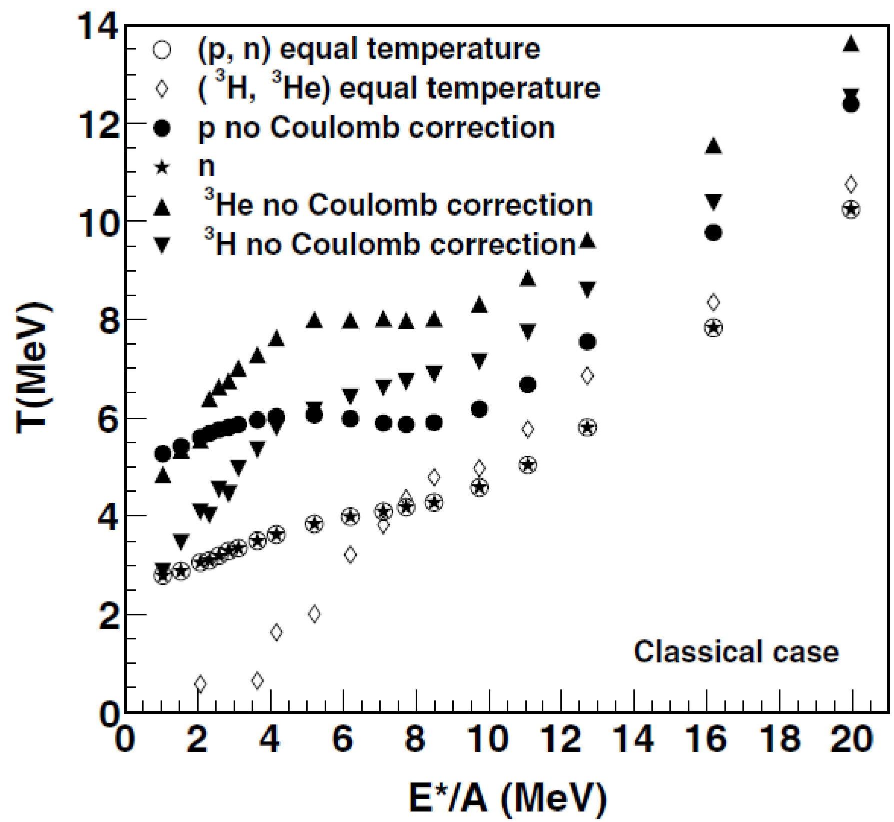
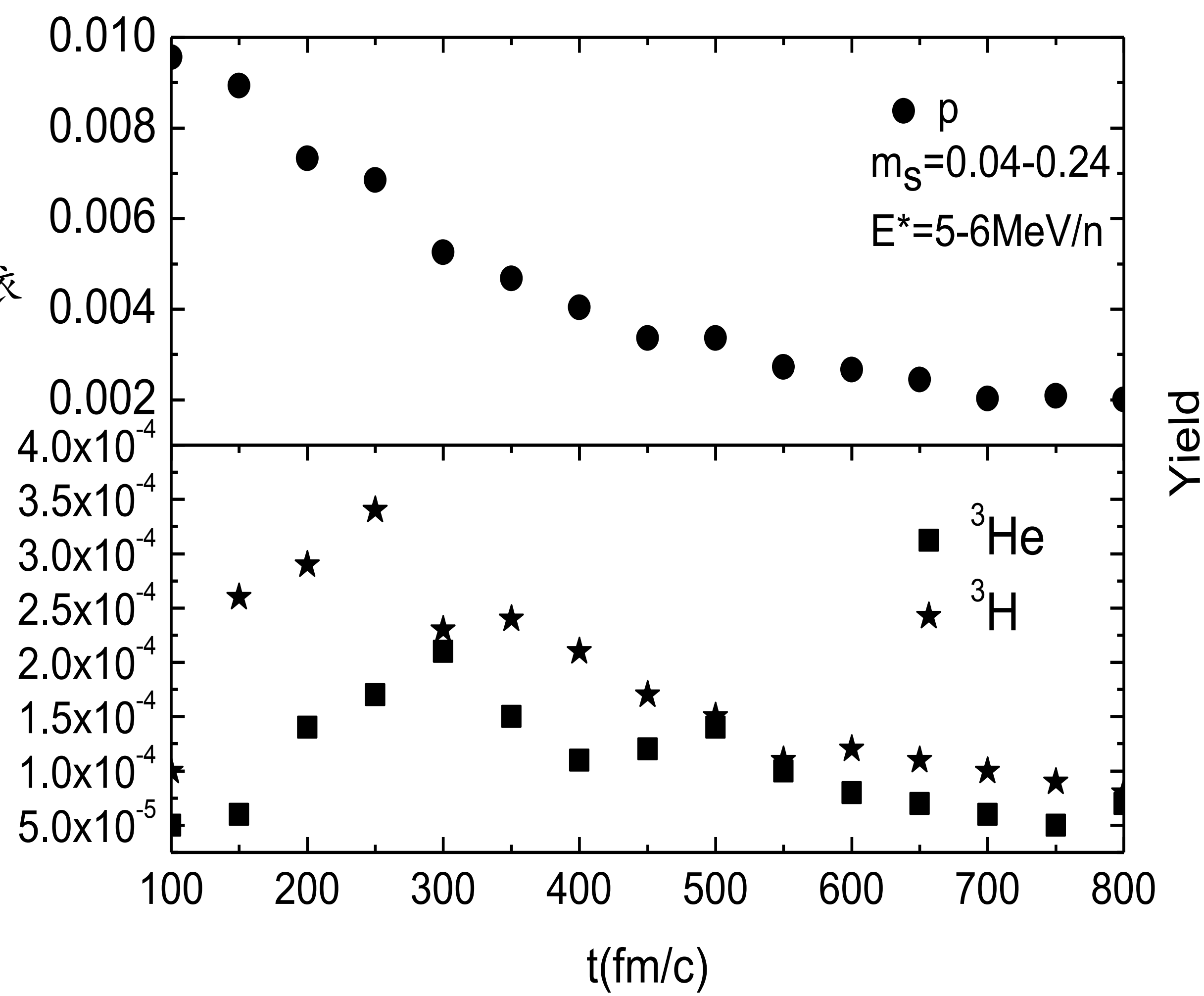


Figure 3. The temperatures extracted from CoMD simulated data versus excitation energy per nucleon E*/A for different particles with and without Coulomb corrections. Solid circles, solid stars, solid up triangles and solid down triangles refer to T of p, n, ^{3}He and ^{3}H without Coulomb corrections respectively; open circles refer to T of mirror nuclei (p, n) with Coulomb corrections, open diamonds refer to T of mirror nuclei (^{3}H, ^{3}He) with Coulomb corrections. d and α are assumed to have the same T as the neutrons and are not included in the figure for clarity.

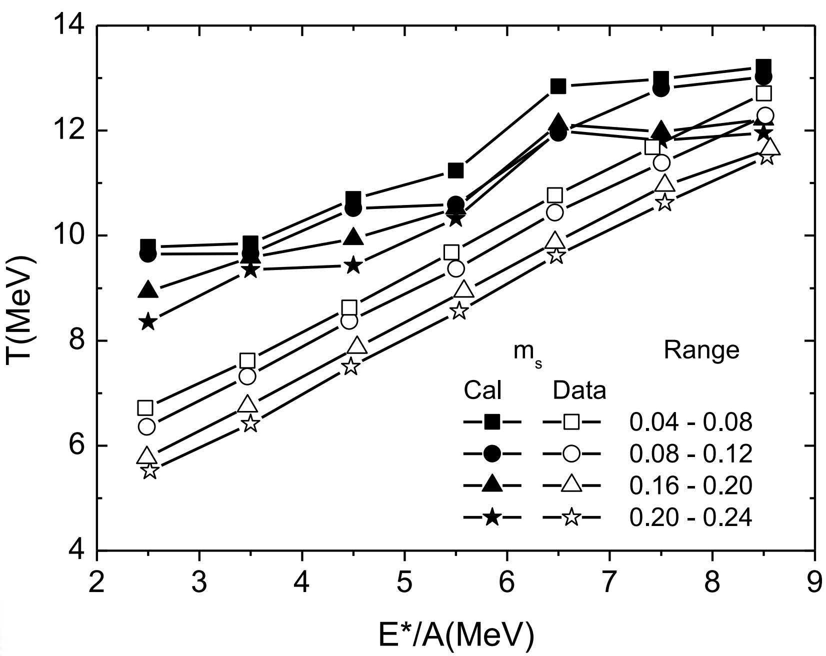
粒子发射时间的影响

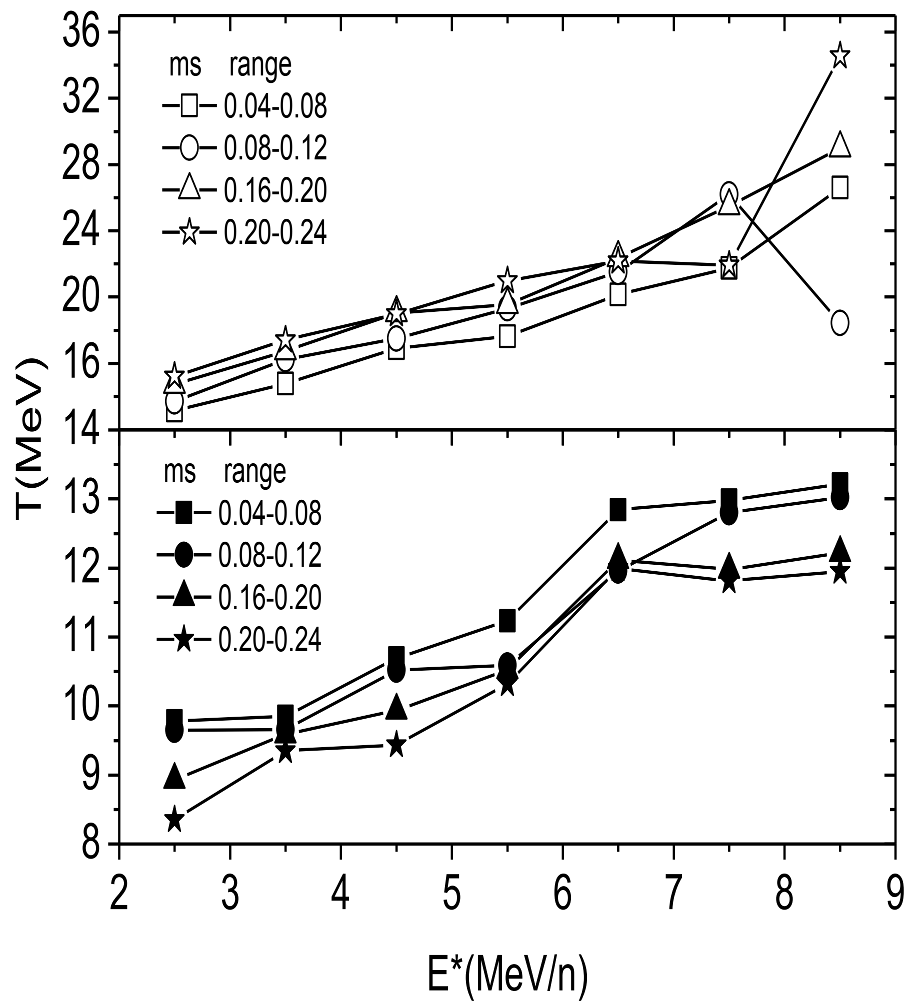
- 不同粒子产生的时间依赖。



粒子发射时间的影响

- 粒子发射时间对量热曲线的同位旋依赖的影响。

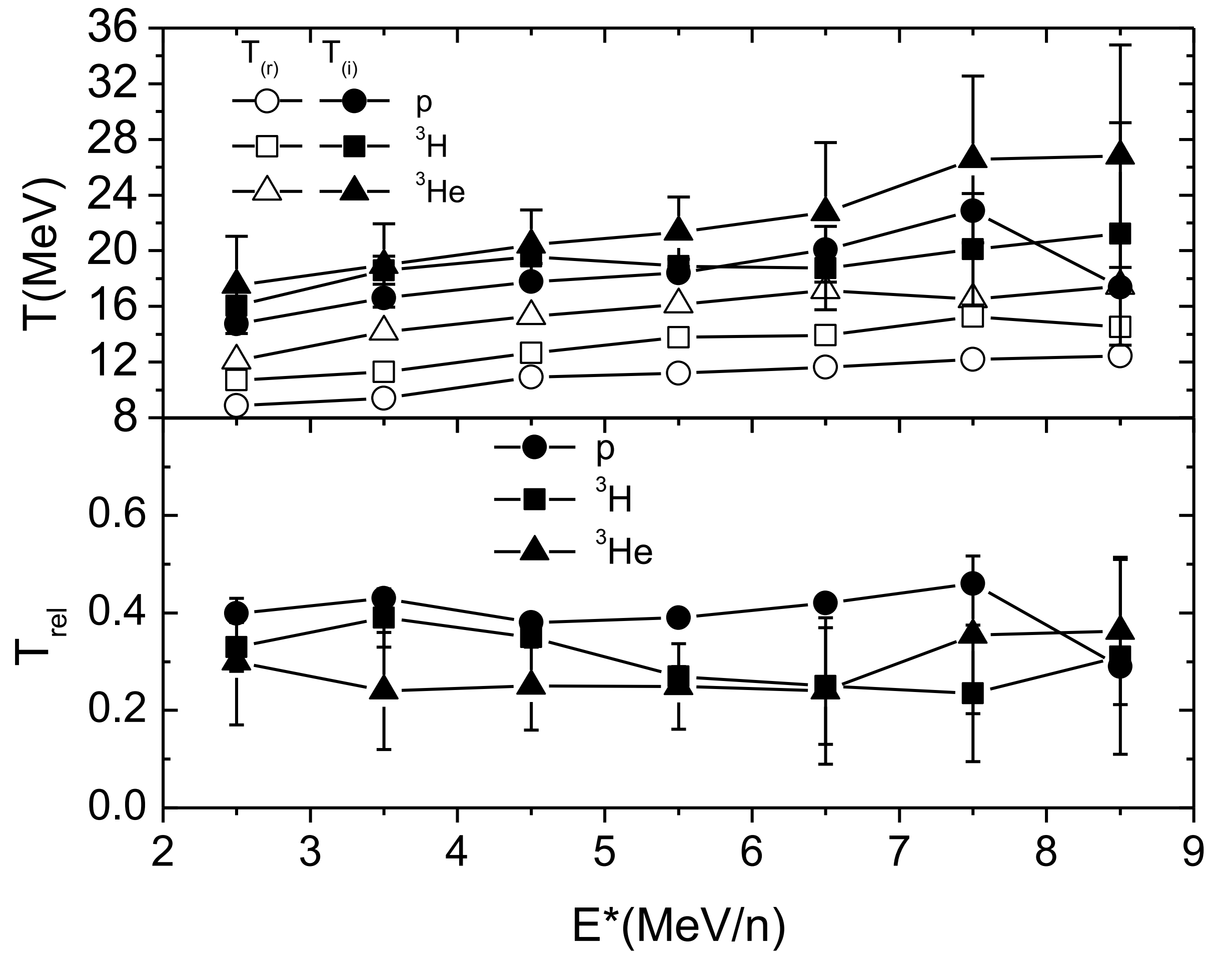




粒子发射时间的影响

- 粒子不同的发射时间对涨落温度的影响。
- Ti是早期发射的粒子的涨落温度
- Tr是反应结束后发射粒子的涨落温度

$$T_{rel} = (T_i - T_r)/T_i.$$



结论

1. 粒子的不同发射时间对涨落温度有明显的影响，最后的测量温度低估了准弹的实际温度。

2. 实验测量的涨落温度不能正确的反应原子核温度的同位旋依赖。

谢谢！