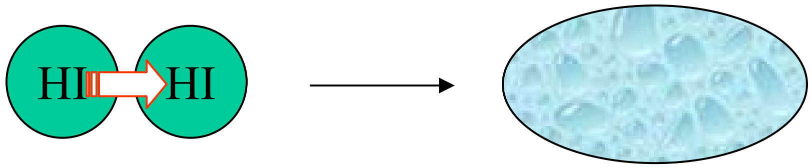
Statistical Multifragmentation of Non-Spherical Expanding Sources

A. Le Fèvre, M. Ploszajczak, C. Schwarz, V.D. Toneev, INDRA-ALADIN Collaboration

arXiv:nucl-ex/0309016



Motivations

- Central collisions: transparency or bounce-back
- Anisotropies in fragment emissions
- Statistical approach still valid ?
- Yes. MMMC-NS* can describe the observed anisotropies
- Additional evidence for elongation in coordinate space?

* : A. Le Fèvre et al., Phys. Rev. C **60** (1999) 051602

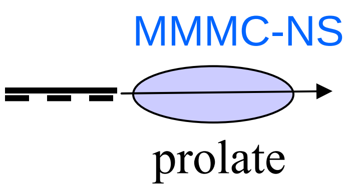
Motivation

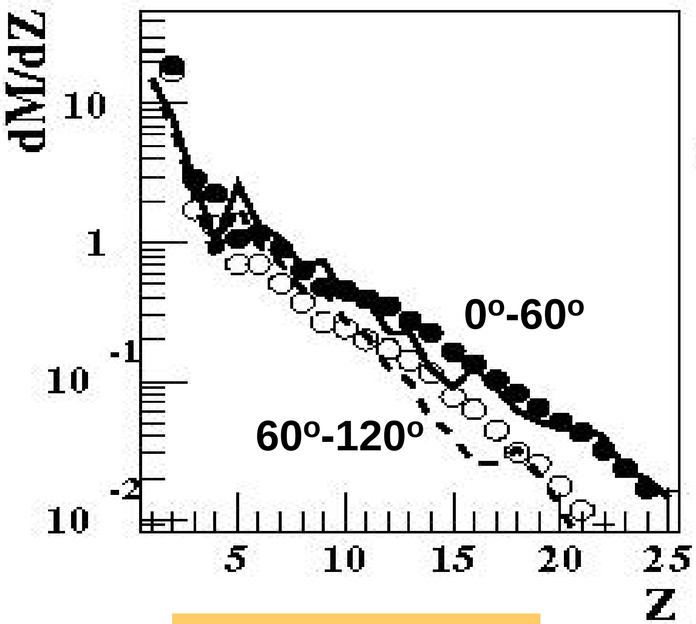
Ref. : A. Le Fèvre et al. – arXiv:nucl-ex/0309016

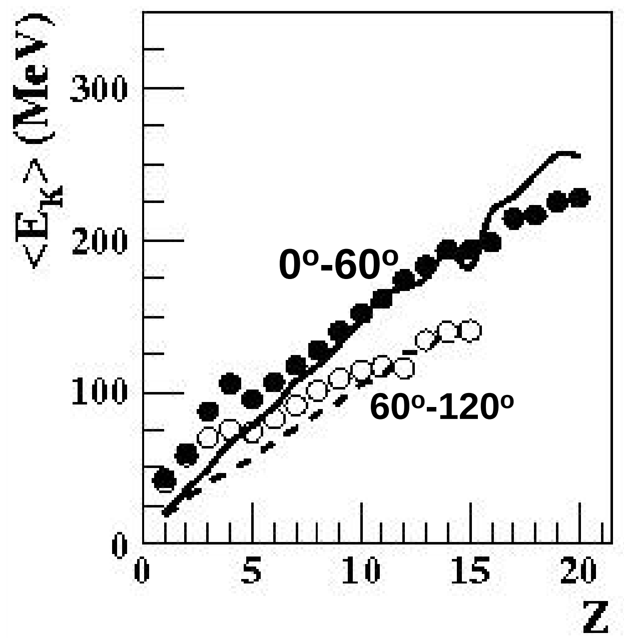
Fragment anisotropies in central collisions INDRA at GSI

Deformed source or anisotropic flow?

● ○ Data Au+Au at 60 A.MeV

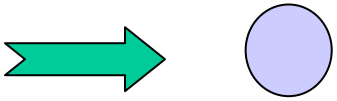






Anisotropies in fragment distributions

Anisotropies in fragment kinetic energies

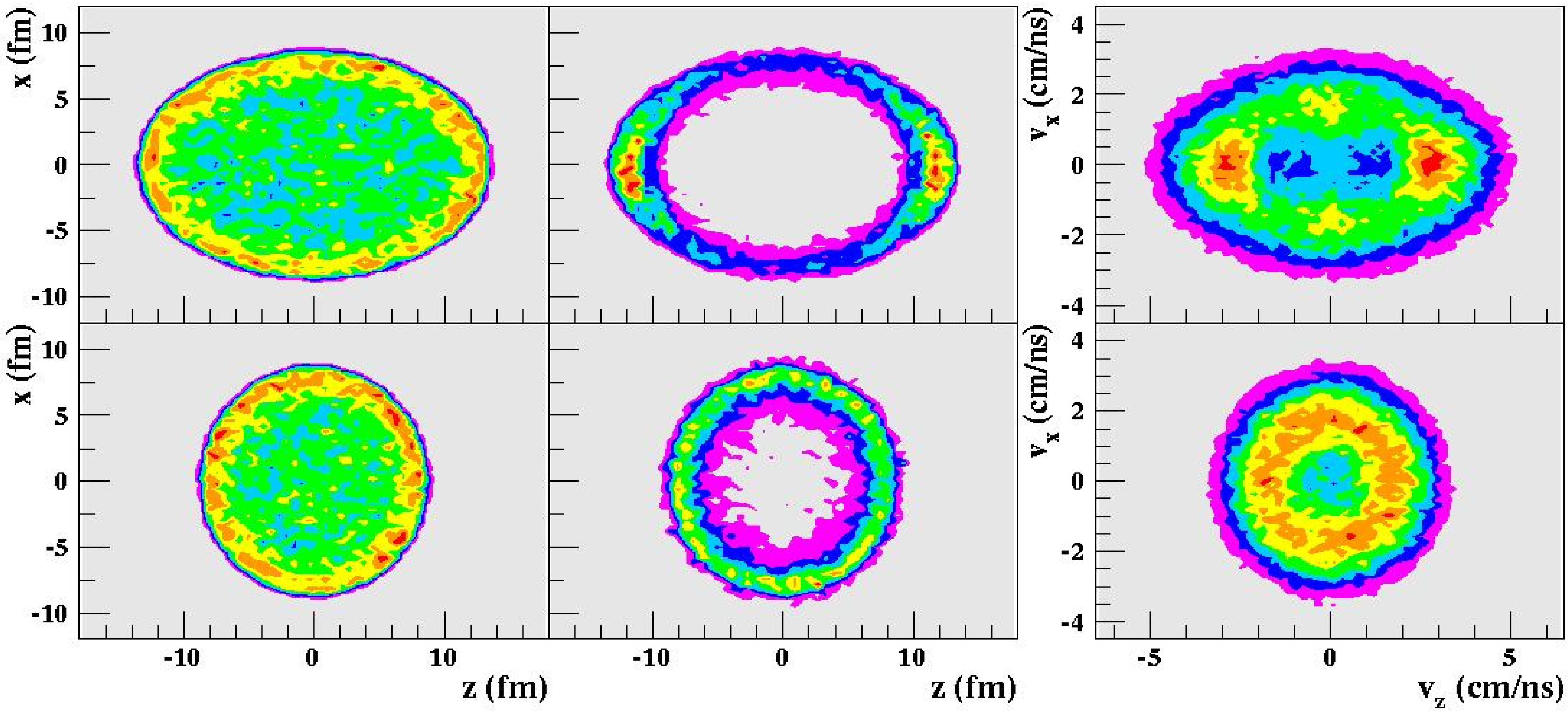


+ anisotropic flow : **excluded**

MMMC: central Xe+Sn, 50 A.MeV phase space (Z>4)

Coordinate space

Velocity space

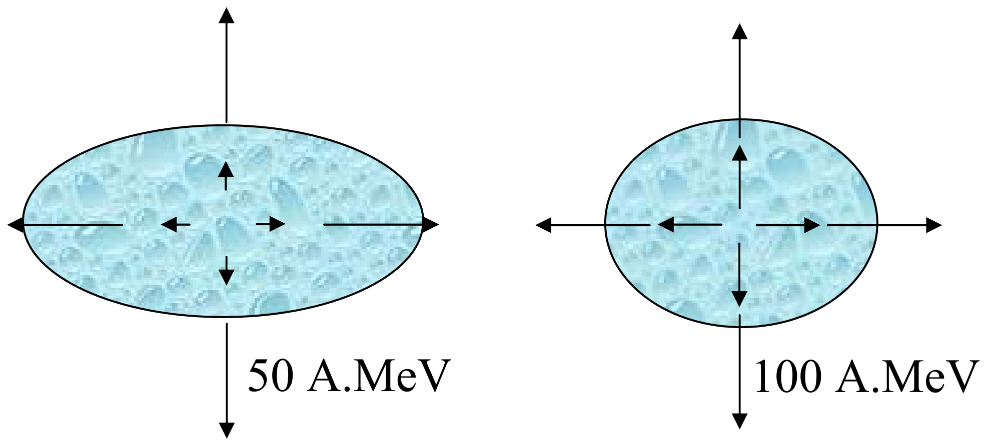


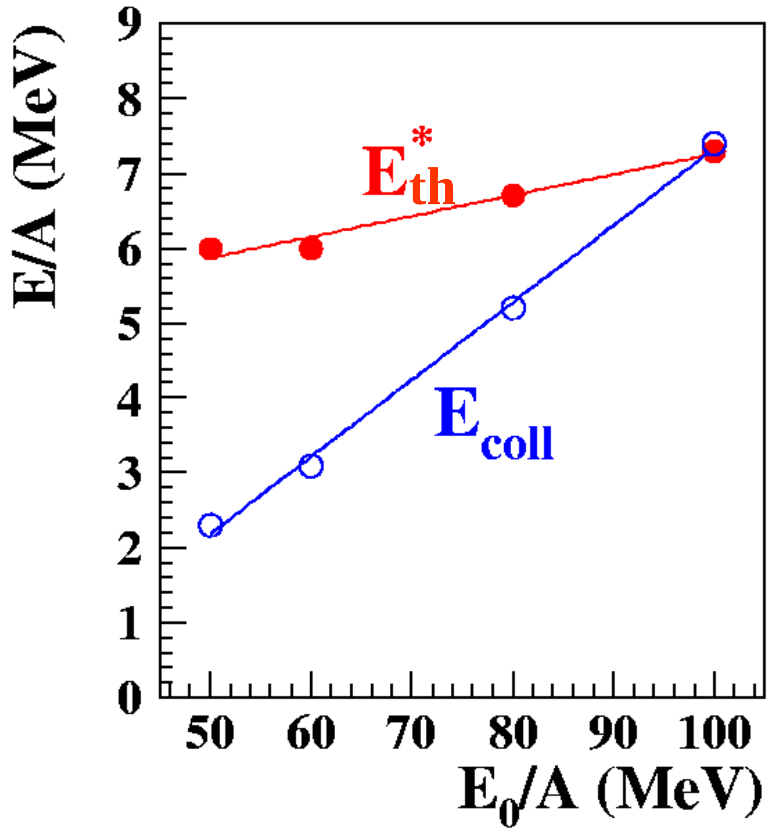
Without Coulomb

With Coulomb

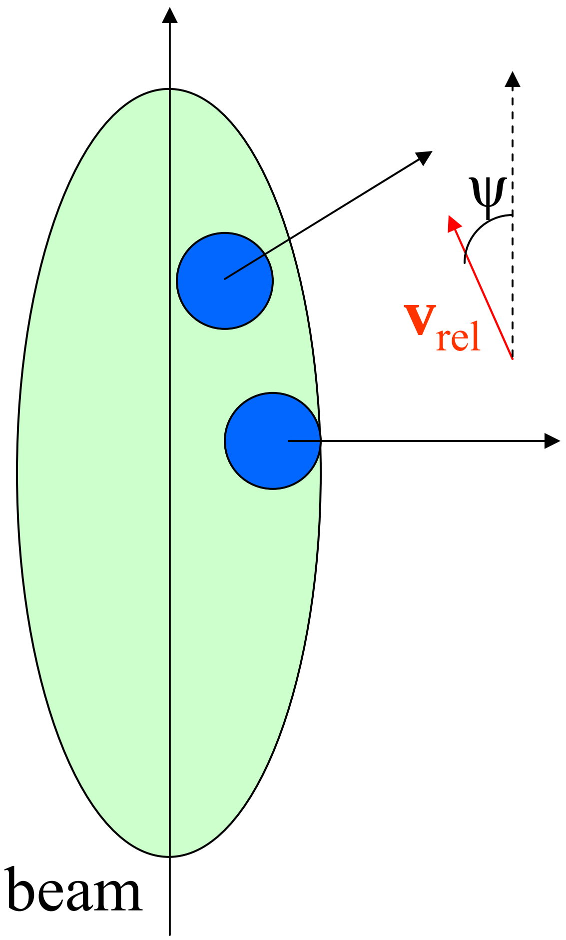
With Coulomb

Central Xe+Sn, Au+Au: Overview





Already existing method: directional cuts & weights.



Hard cuts:

• longitudinal : $\psi < 30^o$

• transversal : $60^o < \psi < 120^o$

S.E. Koonin, Phys. Lett. **B** 70 (1977) 43

OR

Weighted:

• longitudinal: $\cos^2(\psi)$

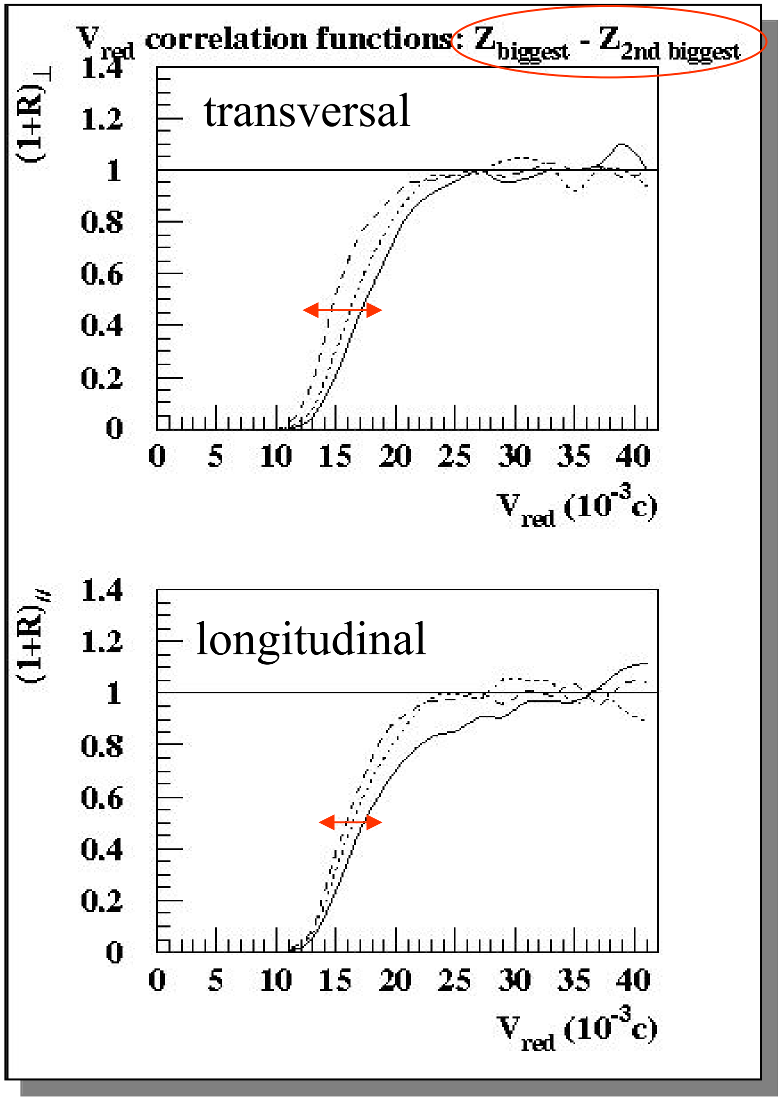
• transversal: $\sin^2(\psi)$

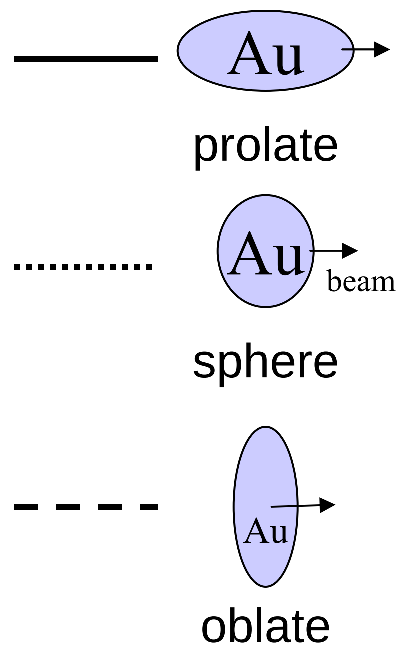
C. Schwarz et al., Nucl. Phys. A **681** (2001) 279

Directional weights

MMMC-NS calculations

(INDRA filtered)



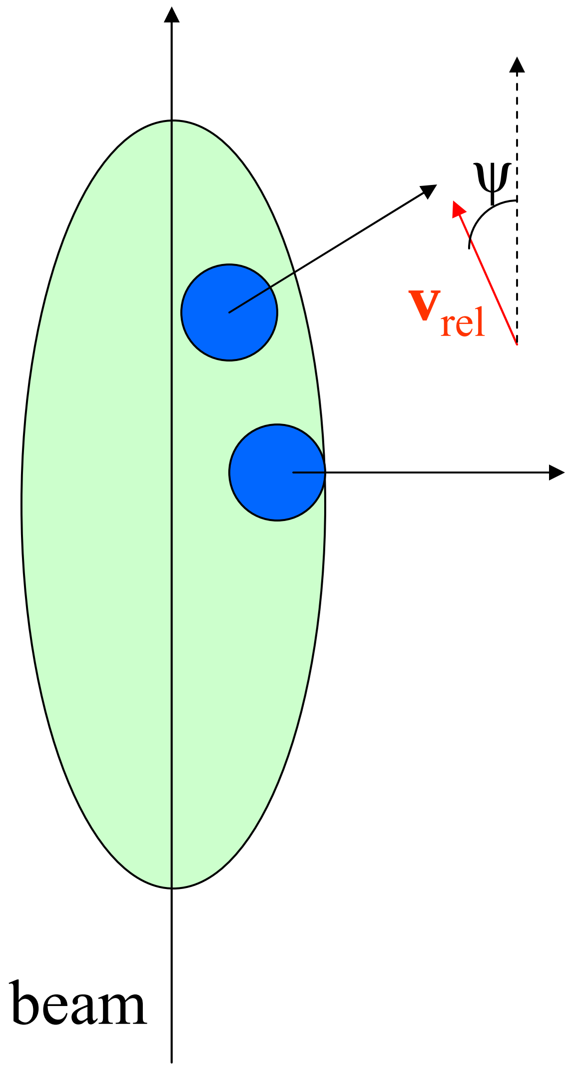


$\rho = \rho_0 / 6$

E*= 6 A.MeV

Ecoll = 2.3 A.MeV

Second method (new) : directional projections.



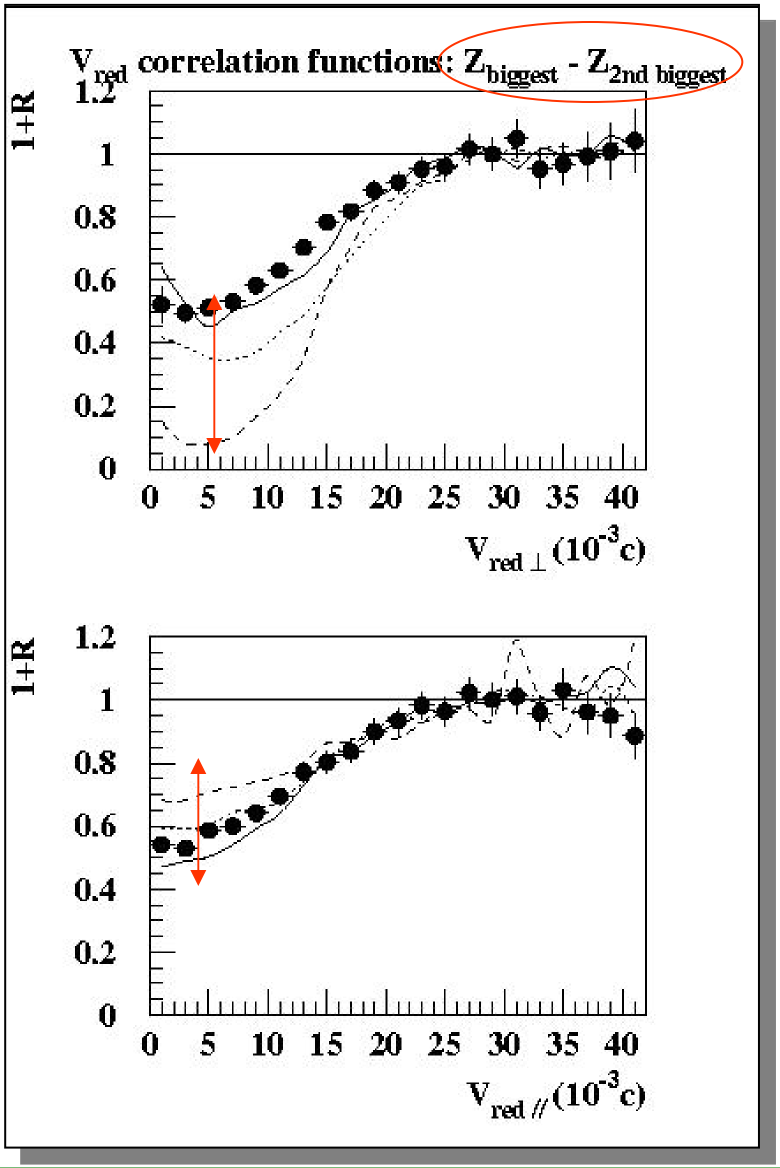
Longitudinal projections:

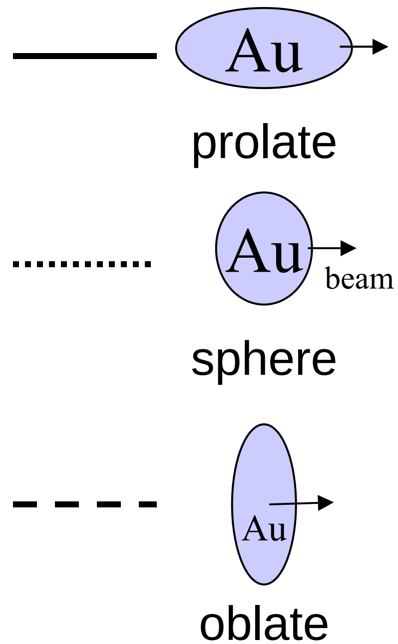
$v_{rel}*\cos(\psi)$

Transversal projections:

$v_{rel}*\sin(\psi)$

Directional projections





MMMC calculations :

$\rho = \rho_0 / 6$

E*= 6 A.MeV

Ecoll = 2.3 A.MeV

Prolate elongation :

(1:0.70)

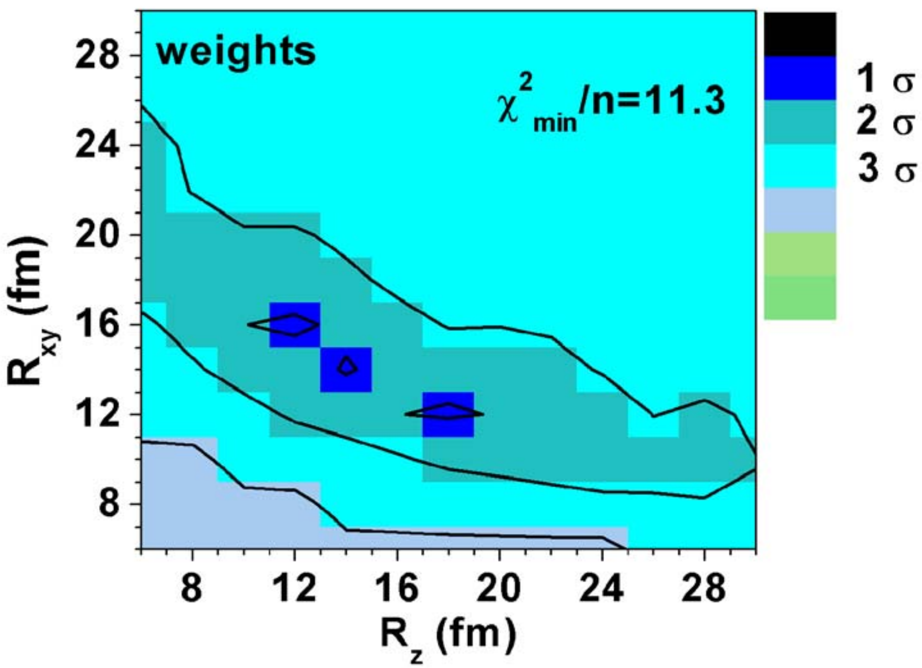
● Data central Xe+Sn at 50 A.MeV

Directional weights vs projections

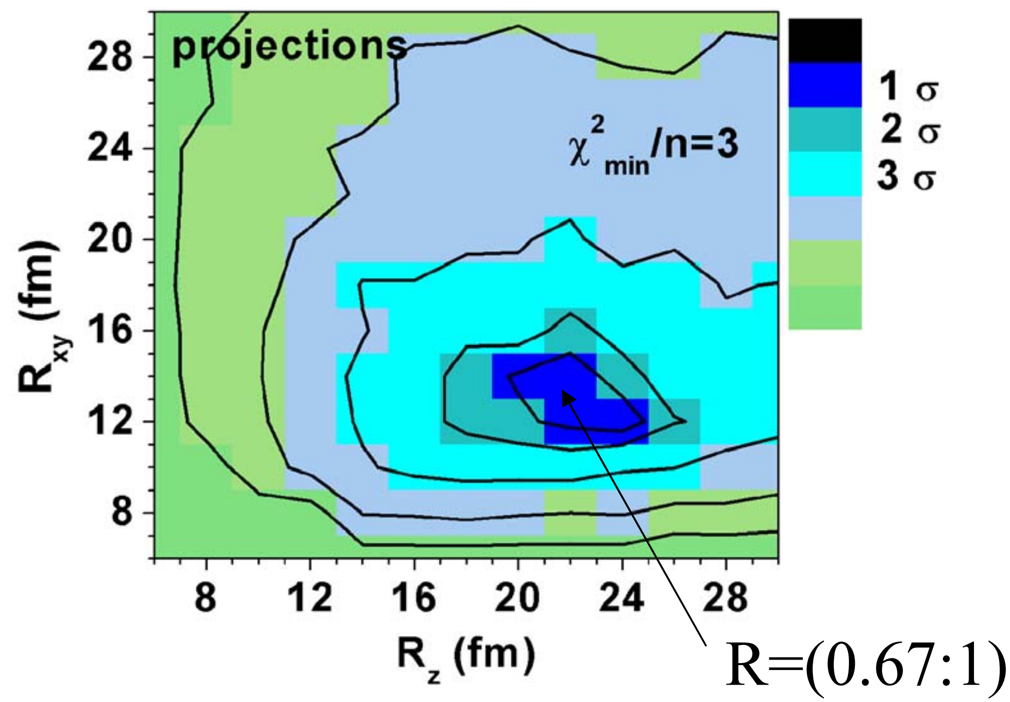
N-body Coulomb trajectory

Data : central Xe+Sn 50 A.MeV (INDRA@GSI)

Directional weights



Projections



Good sensitivity on density
Broad minimum for shape

Good sensitivity on shape and density.

Summary and outlook

- In central collisions at intermediate energies, non-spherical expanding sources are formed.
- However, the statistical approach can still describe them, and allow to deduce their elongation in space.
- Projected correlation functions can confirm these predictions
- They yield information on volume (density) AND elongation.
- The correlations between the 2 largest fragments seem to be the most sensitive to the spatial extensions.
- Outlook…

Experimental results

Reaction	INDRA@GSI		Derived source elongation	
			MMMC-NS	Corr. funct.
central	Xe+Sn	50 A.MeV	0.70 : 1	0.67 : 1
—	Au+Au	60 A.MeV	0.70 : 1	
—	—	80 A.MeV	0.70 : 1	
—	—	100 A.MeV	0.76 : 1	

Ref. : A. Le Fèvre et al. – arXiv:nucl-ex/0309016

Motivation

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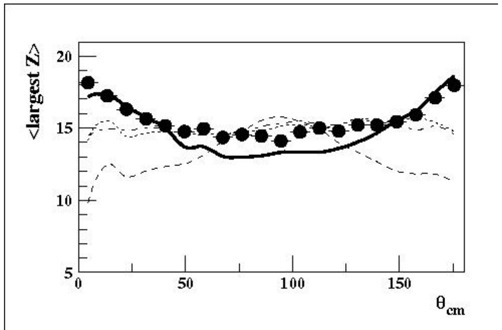
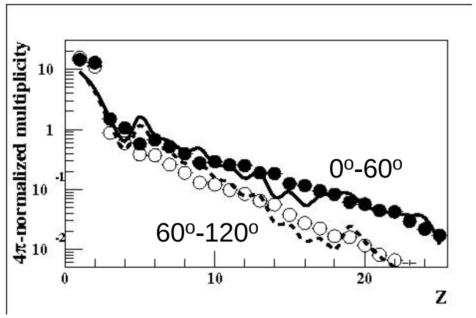
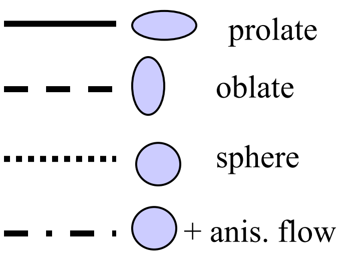
Fragment anisotropies in central collisions INDRA at GSI

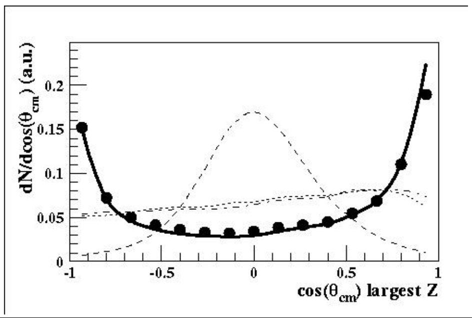
- Xe+Sn at 50 A.MeV





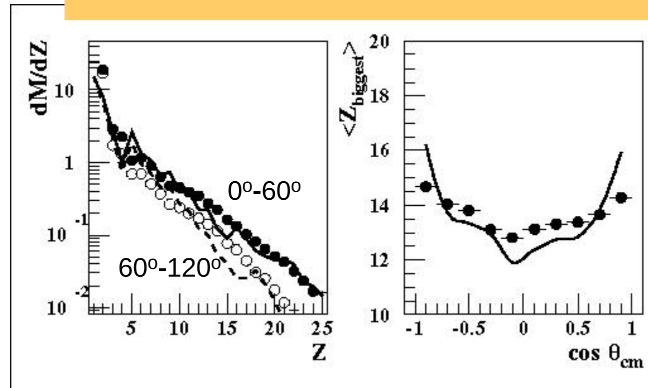
MMMC-NS



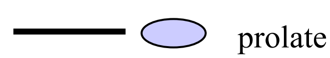


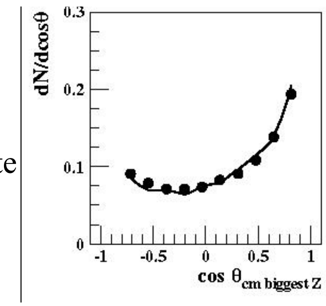
Anisotropies in fragment distributions

- Au+Au at 60 A.MeV

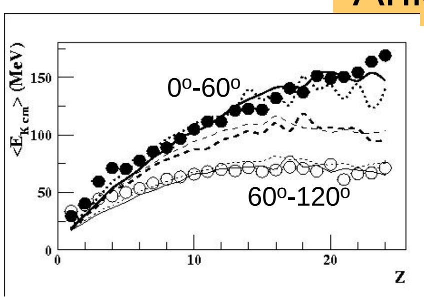


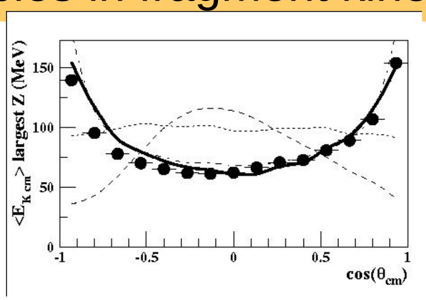
MMMC-NS

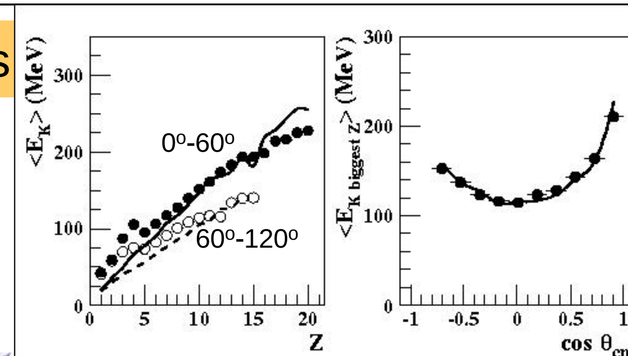




Anisotropies in fragment kinetic energies







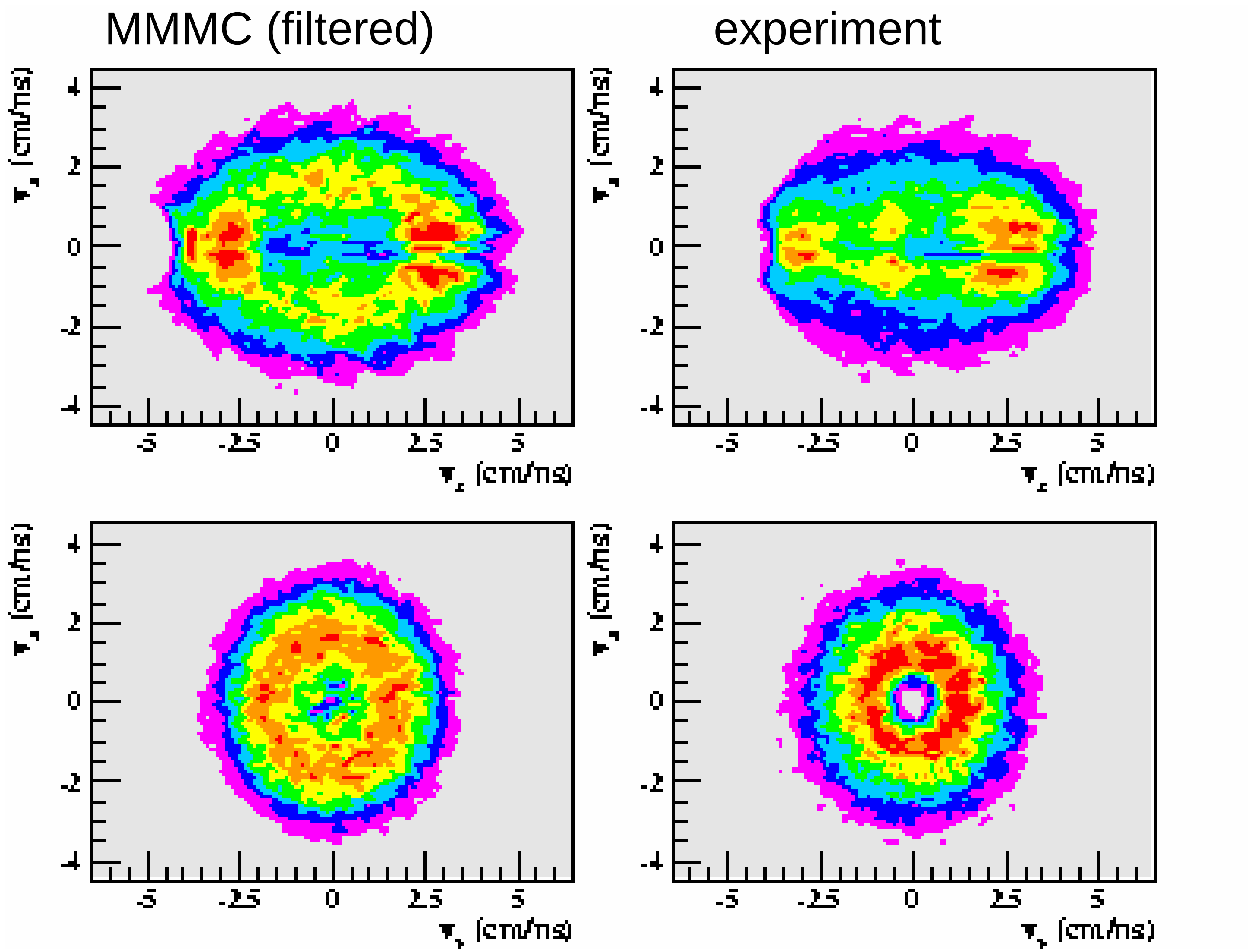
Motivation

Fragment anisotropies in central collisions studied with MMMC-NS indicate an incomplete relaxation in

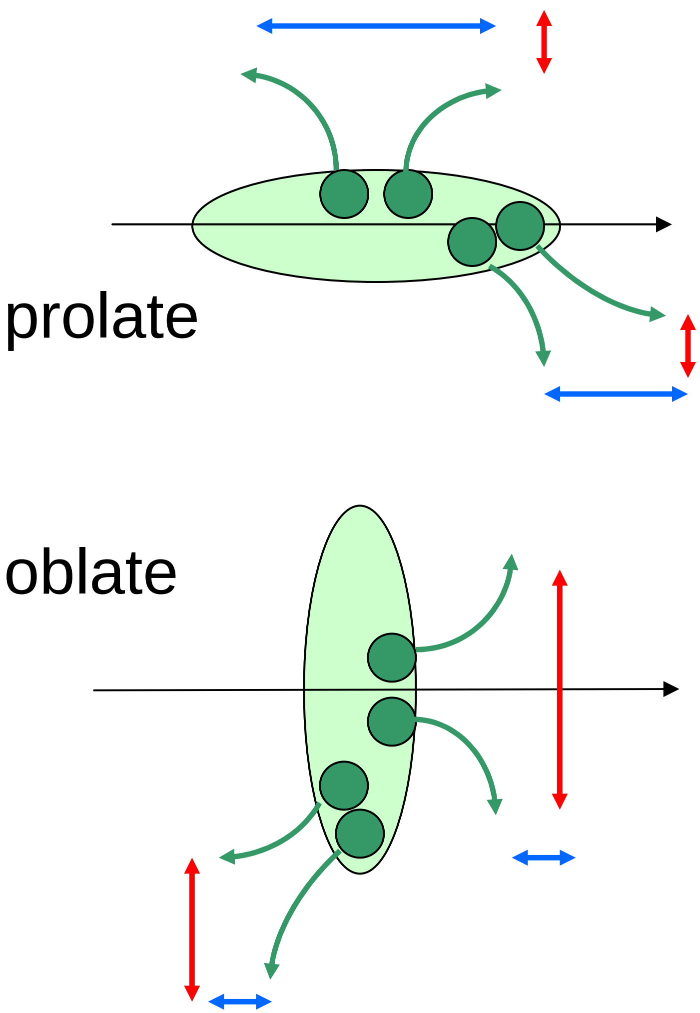
Reaction INDRA at GSI	$^{129}Xe +^{nat} Sn$	$^{197}Au +^{197} Au$		
E_0/A (A.MeV)	50	60	80	100
E_{cm} (A.MeV)	12.5	15	20	25
Z_S	79 (76%)	125 (79%)	110 (70%)	95 (60%)
A_S	197	312	275	238
$\mathcal{R}$	(0.70:1)	(0.70:1)	(0.70:1)	(0.76:1)
E^* (A.MeV)	6.0	6.0	6.7	7.3
$< E_{coll} > (A.MeV)$	2.3	3.1	5.2	7.4
α_{coll}	2.0	1.5	1.3	1.2

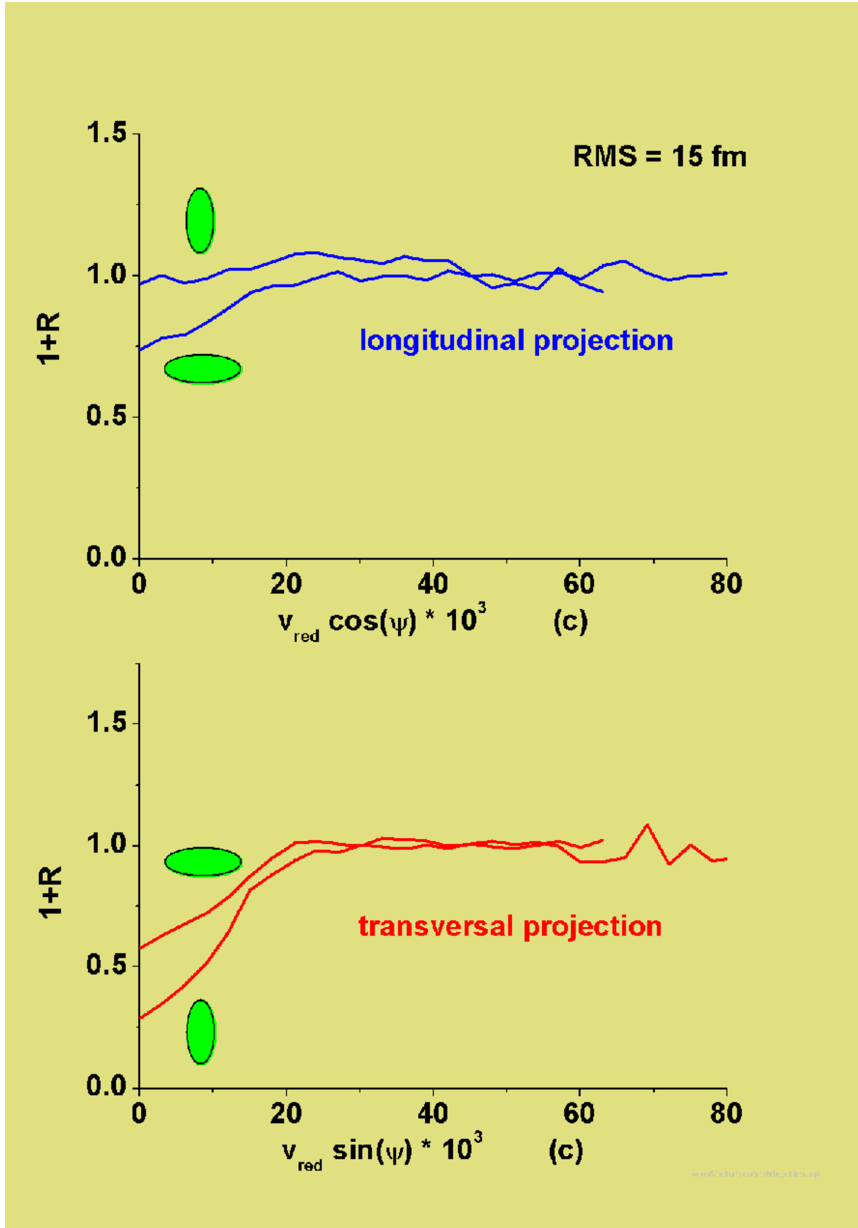
Ref. : A. Le Fèvre et al. – arXiv:nucl-ex/0309016

MMMC vs experiment: velocity (Z>4)



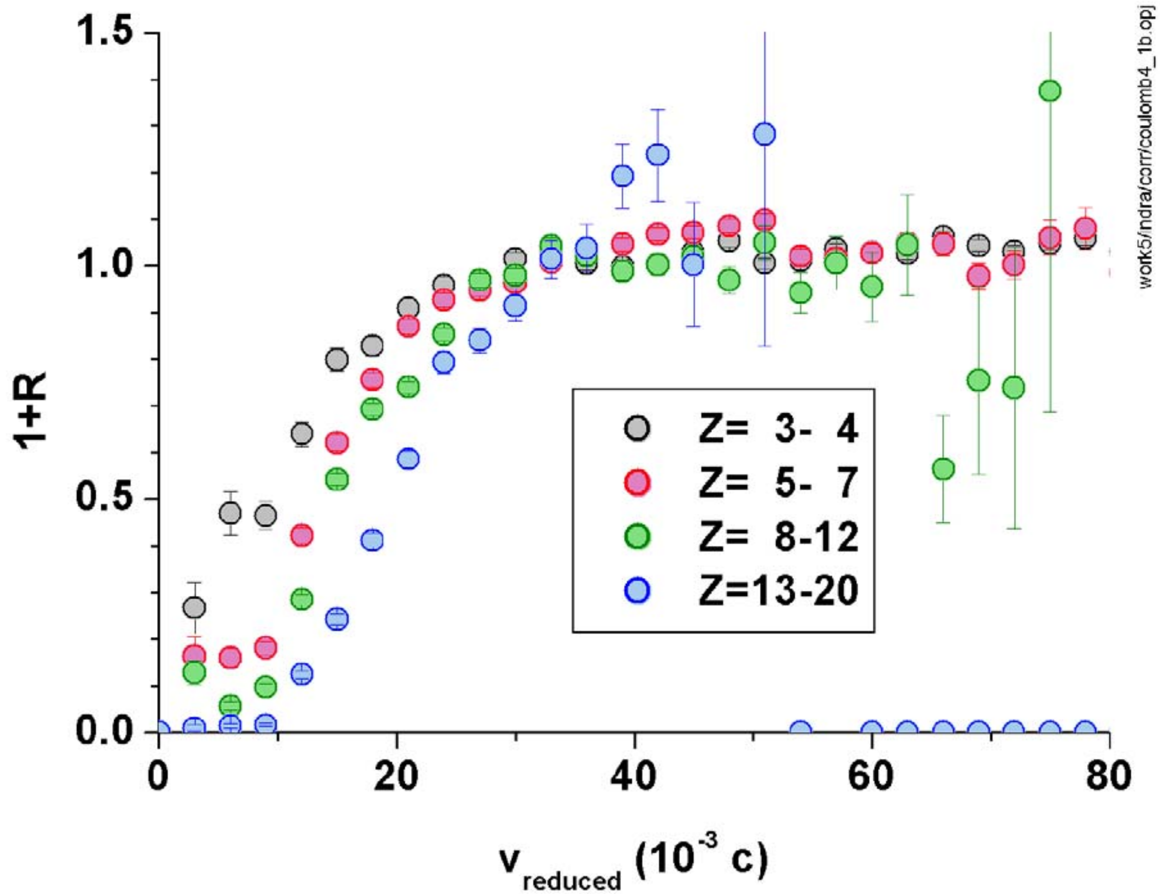
Projected corr. func.





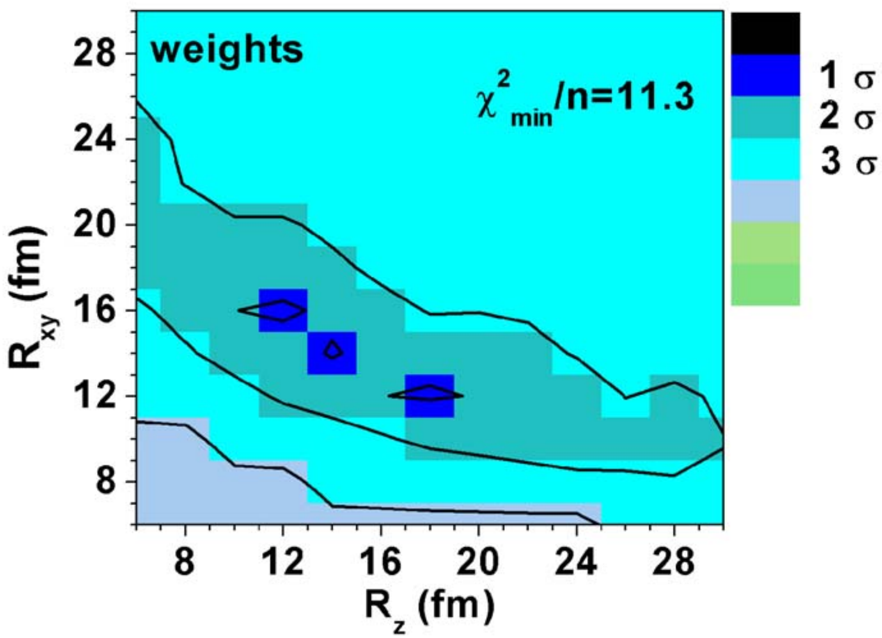
Coulomb correlation functions for Xe+Sn @ 50 AMeV

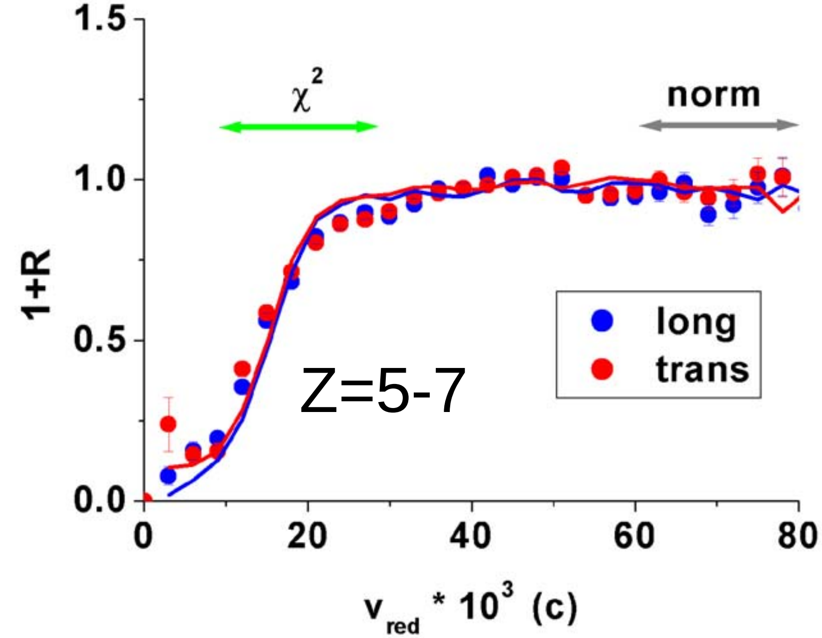
$$v_{red} = \frac{v_{12}}{\sqrt{z_1 + z_2}}$$

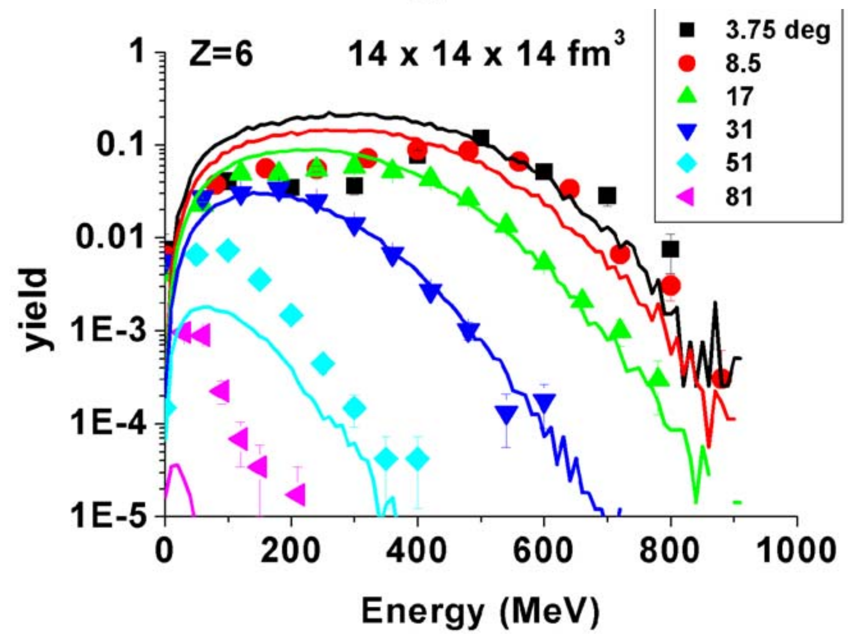


Weighted corr. func.

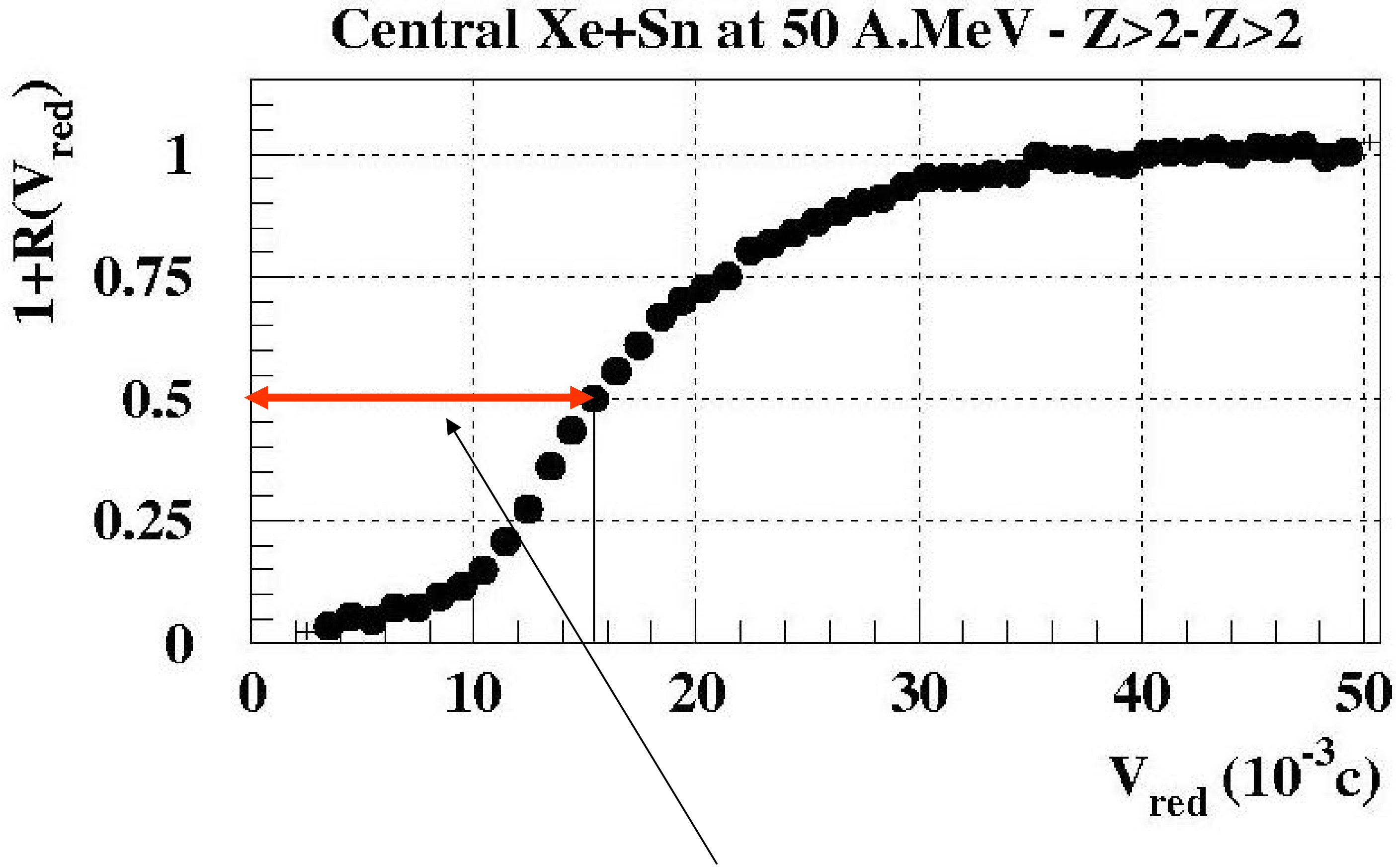
N-body Coulomb traj.







Short fragment emission times



$\tau < 20\text{-}50$ fm/c

Cf. L. Beaulieu et al., PRL 84(2000)5971