# Morphology of High-Multiplicity Events in Heavy Ion Collisions.

*Using methods from the analysis of the CMB to study single HI collisions events.*
*A first application to collective flow.*


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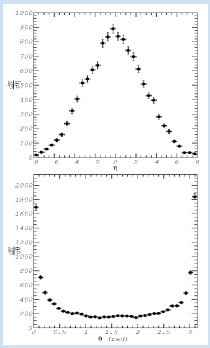
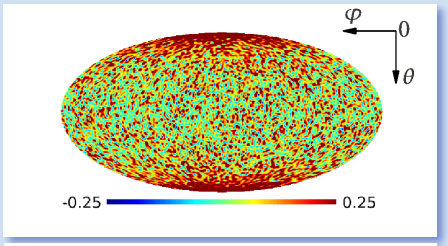
**Main idea:**

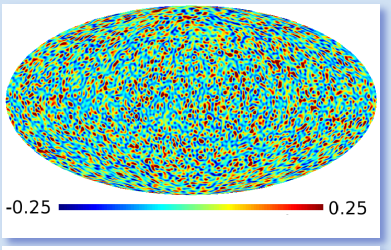
1) Analyze the distribution of particles from single Heavy Ion collisions in spherical coordinates.
2) Decompose the signal in spherical harmonics. $f(\theta,\phi)=\sum_{l=1}^{l=\infty}\sum_{m=-l}^{m=l} a_{l,m}Y_{l,m}(\theta,\phi)$
3) Analyze the image in terms of the amplitudes and phases of the weight coefficients. $a_{l,m}=|a_{l,m}|\exp(-im\Phi_{l,m})$



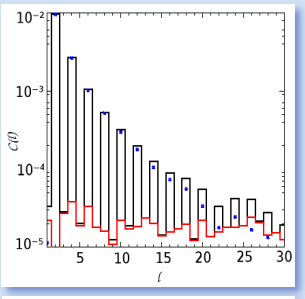
1 Event from HIJING




Molweide projection of 1 HI event.
Note the "polar caps " arizing from the kinematics of dN/dη translated into dN/dθ.
The figure shows the distribution of counts for 1 semi peripheral event around the average level. The representation is similar to that of the CMB fluct. map.




Main symmetry (m=0 mode) omitted.
NB: that this removes the dominant underlying (trivial) symmetry.

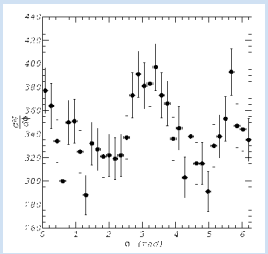



Power spectrum.
Black: total power spectrum
Blue: m=0 mode . Note its dominance.
Red: m>= 1 modes .

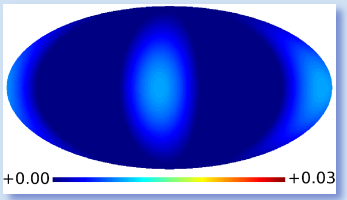
Flow in HI collisions => new stochastic map : $S(\theta,\phi)=f(\theta,\phi)\left[1+2\sum_n v_n cos[n(\phi-\Psi_n)]\right]$

$$b_{l,m}\simeq a_{l,m}+\sum_n v_n\left(c_{l,m+n}e^{-in\Psi_n}+c_{l,m-n}e^{in\Psi_n}\right)$$

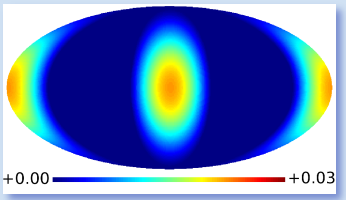
Exploiting the symmetries. Even n: $v_n\simeq\frac{|b_{n,n}|}{g(n)|b_{n,0}|},\quad n\Psi_n=\phi_{n,n}.$ Odd n: $v_n=\frac{|b_{n+1,n}|}{g(n+1)|b_{n+1,0}|},\quad n\Psi_n=\phi_{n+1,n}.$



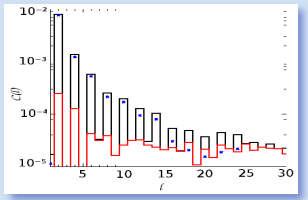
HIJING event with flow, $v_2$= 0.10



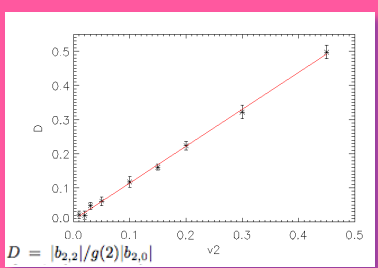

Morphology of the Molweide map ( $v_2$= 0.01)



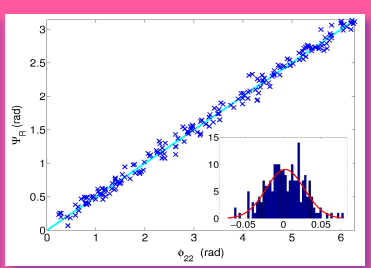

Molweide map for $v_2$= 0.10.
NB: a reaction plane angle different from 0 will be seen as a phase shift is a function of Φ.




Power spectrum for event with v2= 0.07.
Black: total power spectrum
Blue: m=0 mode . Red: m>= 1 modes .




**RESULT:**
**Can reconstruct flow and event plane for individual events with good precision.**
Higher order flow, detector effects and real data to follow.
Stay tuned!





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