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LLNL-CONF-677223

A Survey of the Effect of Convergence Ratio with Low-Mode Drive Asymmetry on ICF Implosions

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September 15, 2015

Inertial Fusion Science and Applications
Seattle, WA, United States
September 20, 2015 through September 25, 2015

Disclaimer

A Survey of the Effect of Convergence Ratio with Low-Mode Drive Asymmetry on ICF Implosions

IFSA, September 2015

John E. Field

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This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Collaborators

Co-authors:

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N120321 HYDRA simulation:

D. Clark, C. Weber

Discussion

At LLNL, we have been advancing in the direction of doing larger simulations and more of them to increase accuracy and to search through parameter space.

Three critical challenges stand out in addressing this :

- PARALLEL POST PROCESSING
- STANDARDIZED COMPARISON OF SIMULATIONS
- STATISTICAL SAMPLING OF SIMULATIONS

This is a large topic, and we are learning a lot from it. I promised to talk about convergence ratio and asymmetries, and so I will – very quickly. Then, I am going to move on to show some x-ray movies and neutron spectrum results that I think are much more exciting.

Three very important points :

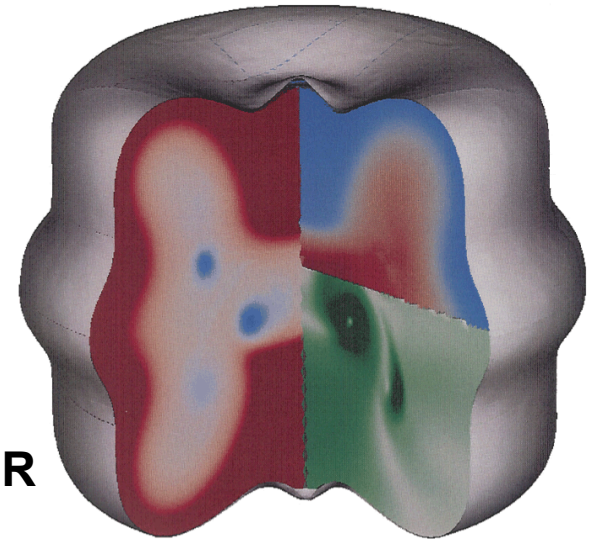
- The temperature is changing drastically during the burn
- Fluid velocity significantly changes neutron inferred temperatures
- Self-emission X-ray images can be very different above and below 15 KeV

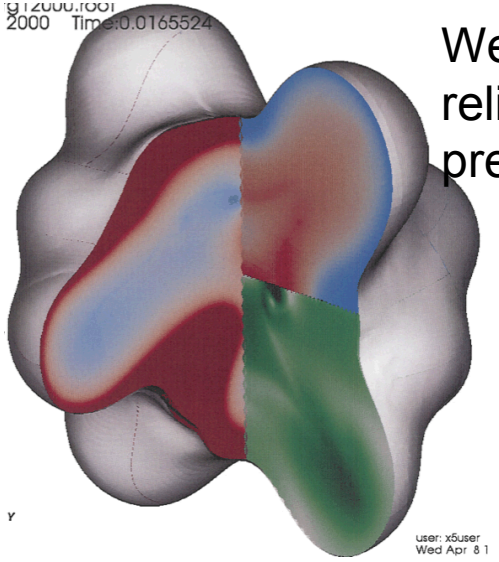
3D hot spots develop more serious weak spots and are less tolerant of convergence.

More realistic perturbations amplify weak spots

2D → 3D

CR ~ 30
Standard
capsule fill

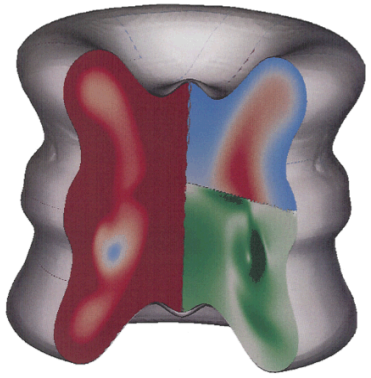


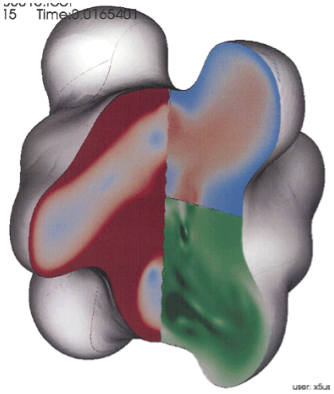


Weak spots
relieve
pressure

Increased CR worsens asymmetry

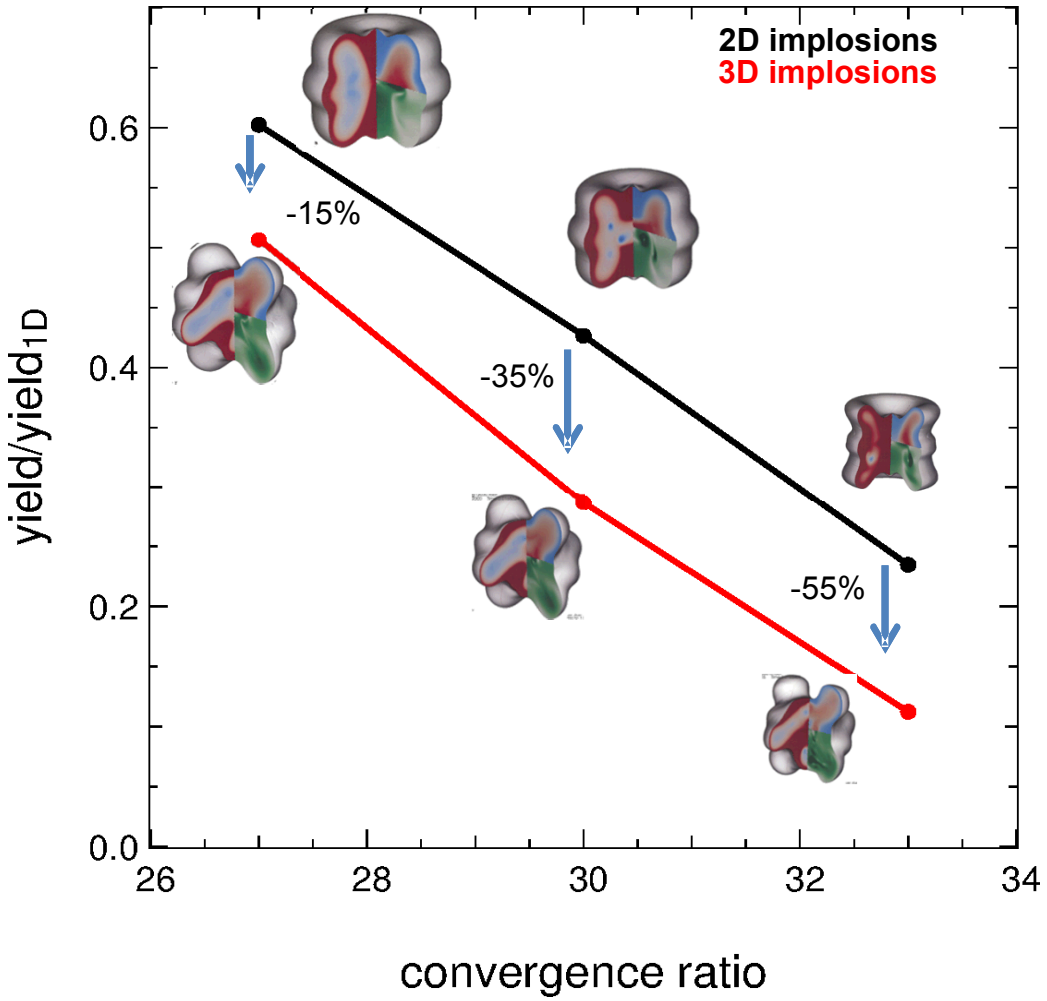
CR ~ 33
Reduced fill
0.33x





Weak spots are more exaggerated at high CR

3D perturbations are more damaging than 2D, and they become more so with increased convergence ratio

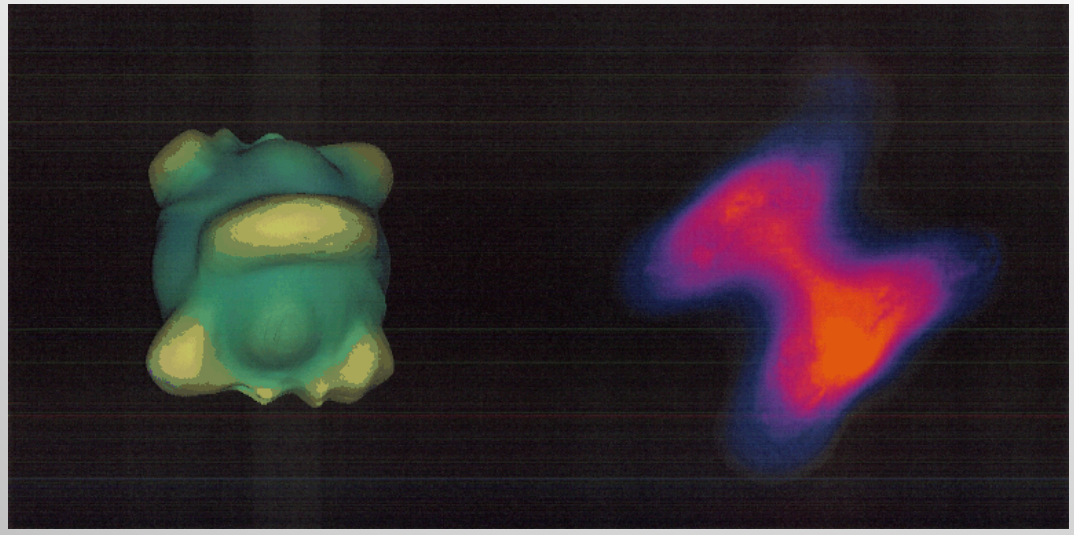


1D CR	1D yield
27	8.3e15
30	1.4e16
33	2.0e16

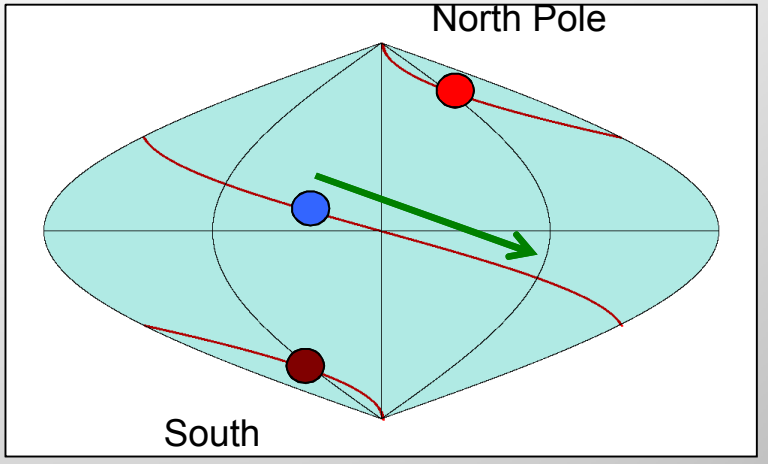
Though convergence increases 1D yield, it poses risks in 2D and 3D

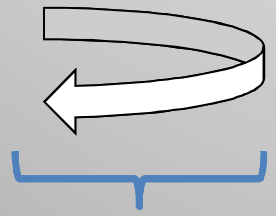
The movies show a rotating view of the ablation front and the x-ray image at 10 KeV from the same view.

EXAMPLE MOVIE SCENE

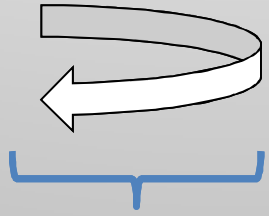


VIEW PATH

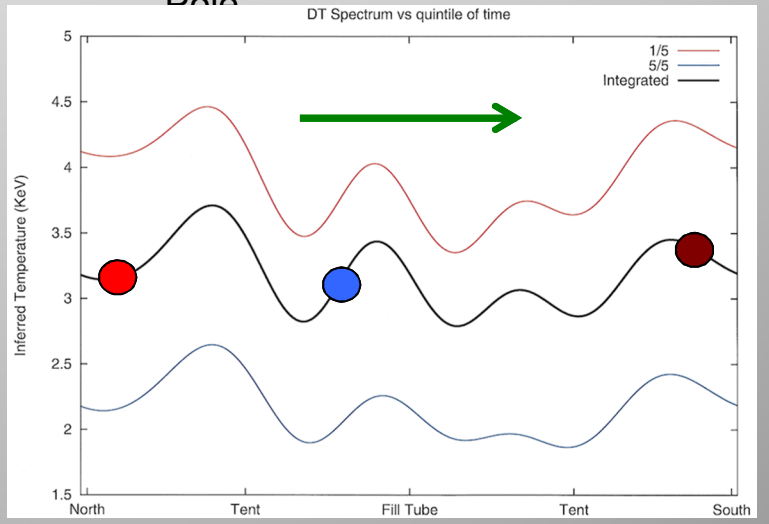




Ablation Front

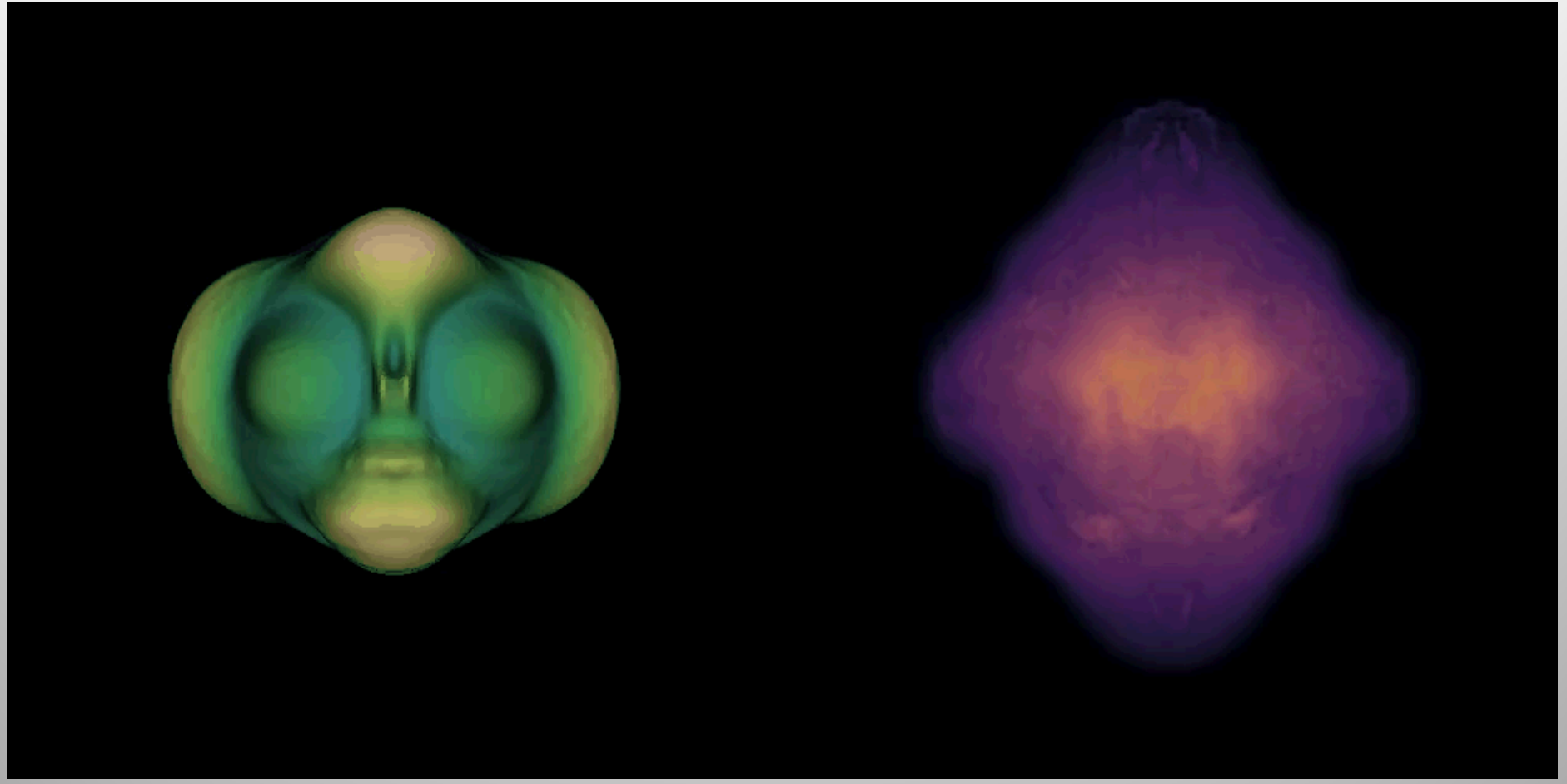


X-Ray View



Time in the movie corresponds to view direction and the x-axis in neutron plots

3D simulation with “typical” drive perturbations at 10 KeV

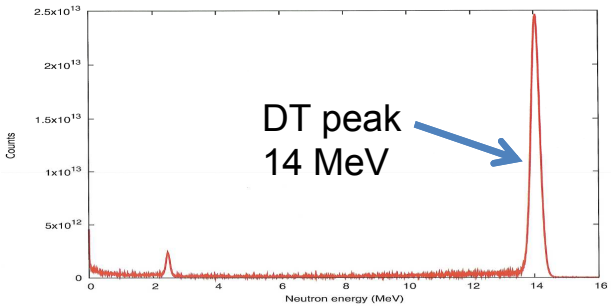


(different scales)

This is a 3D simulation with typical drive asymmetries magnitudes but adjusted to eliminate axisymmetric preference (7M zones)

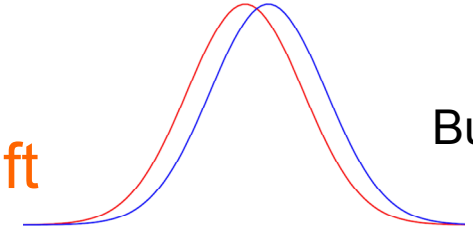
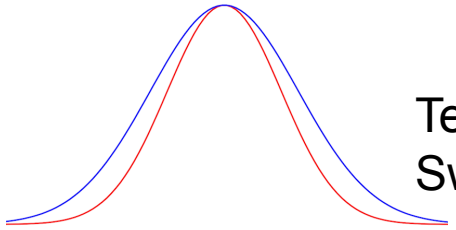
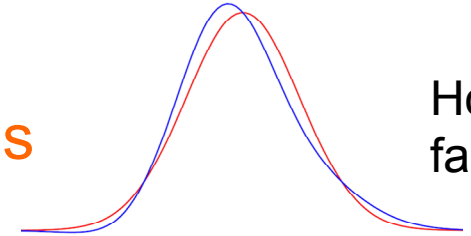
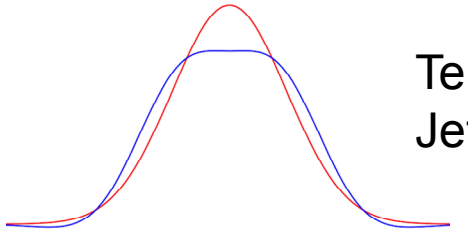
The neutron spectrum moments have an important physical interpretation.

Neutron Energy Spectrum

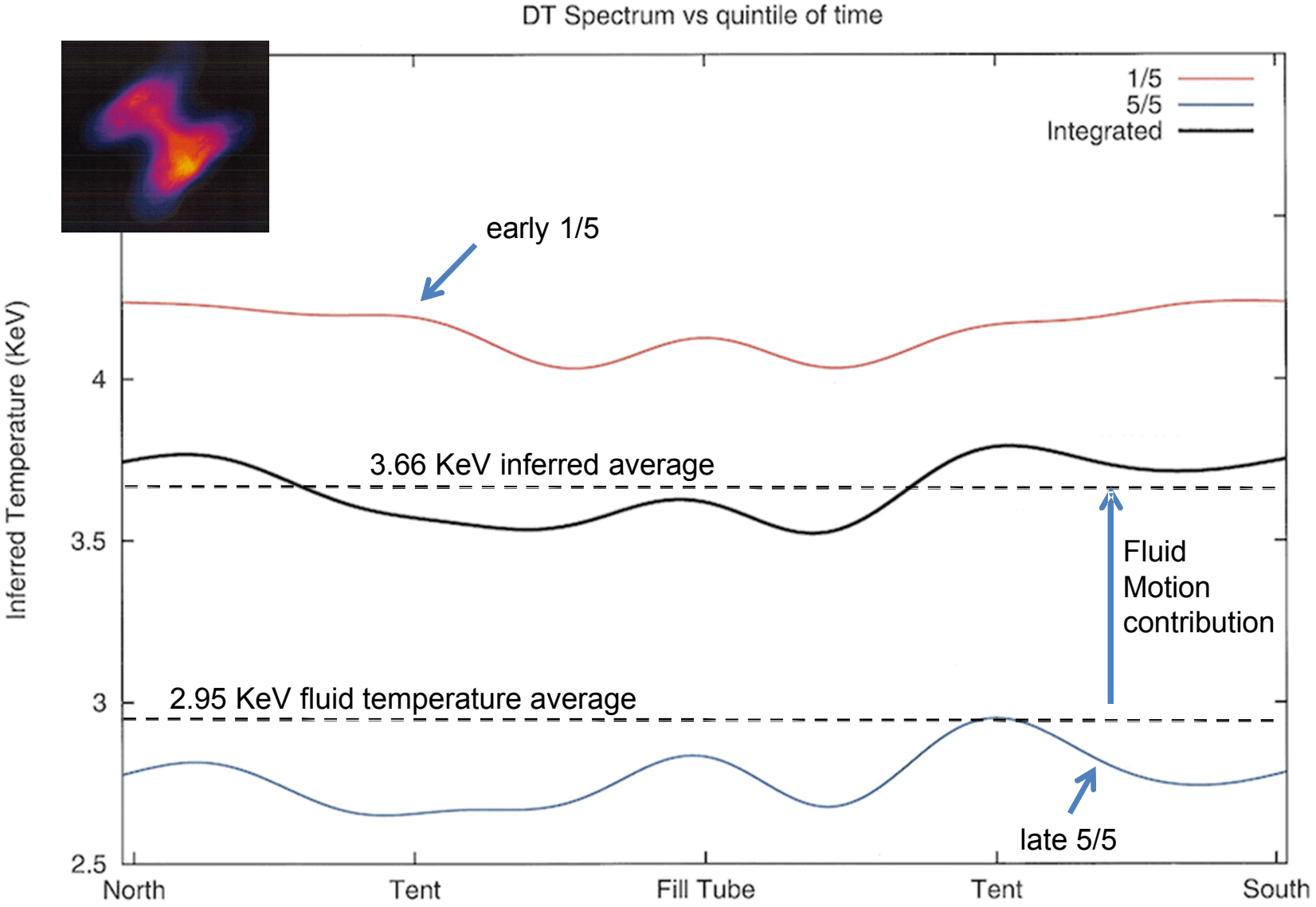


Scalar effects have no directional dependence, but tensor effects will vary with line of sight.

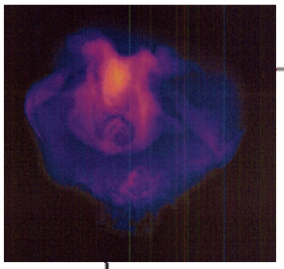
is diagnostic of

Mean shift		Bulk motion + Ballabio shift
Width		Temperature Swirling or stirring
Skewness		Hot fluid is moving faster or vice versa
Kurtosis		Temperature variation Jetting

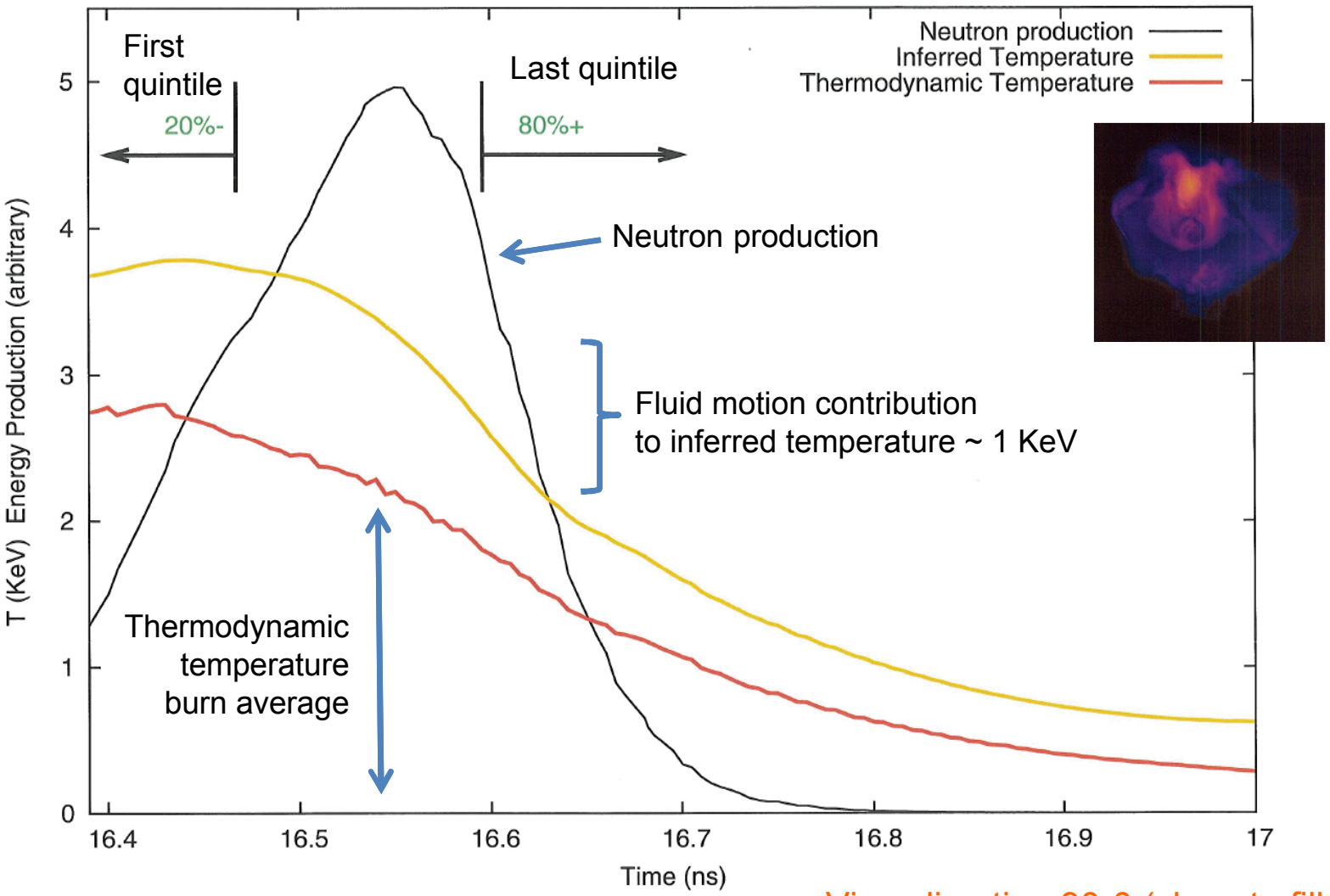
Fluid velocity causes the inferred temperature to vary with line of sight, but the variation in time is far greater.



The variation of inferred temperature is much greater still for perturbed simulations

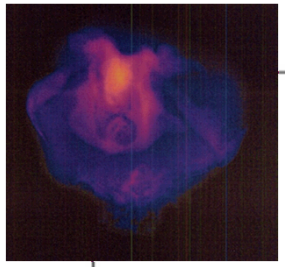


The temperature is plummeting during the burn period.

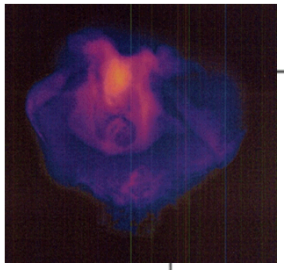


View direction 90-0 (close to fill tube)

Meanwhile, then the velocity variation is entirely dominated by the motion of the burning region.

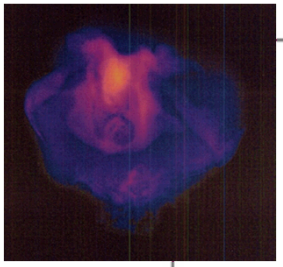


The kurtosis varies wildly with line of sight and is increasing during the burn.

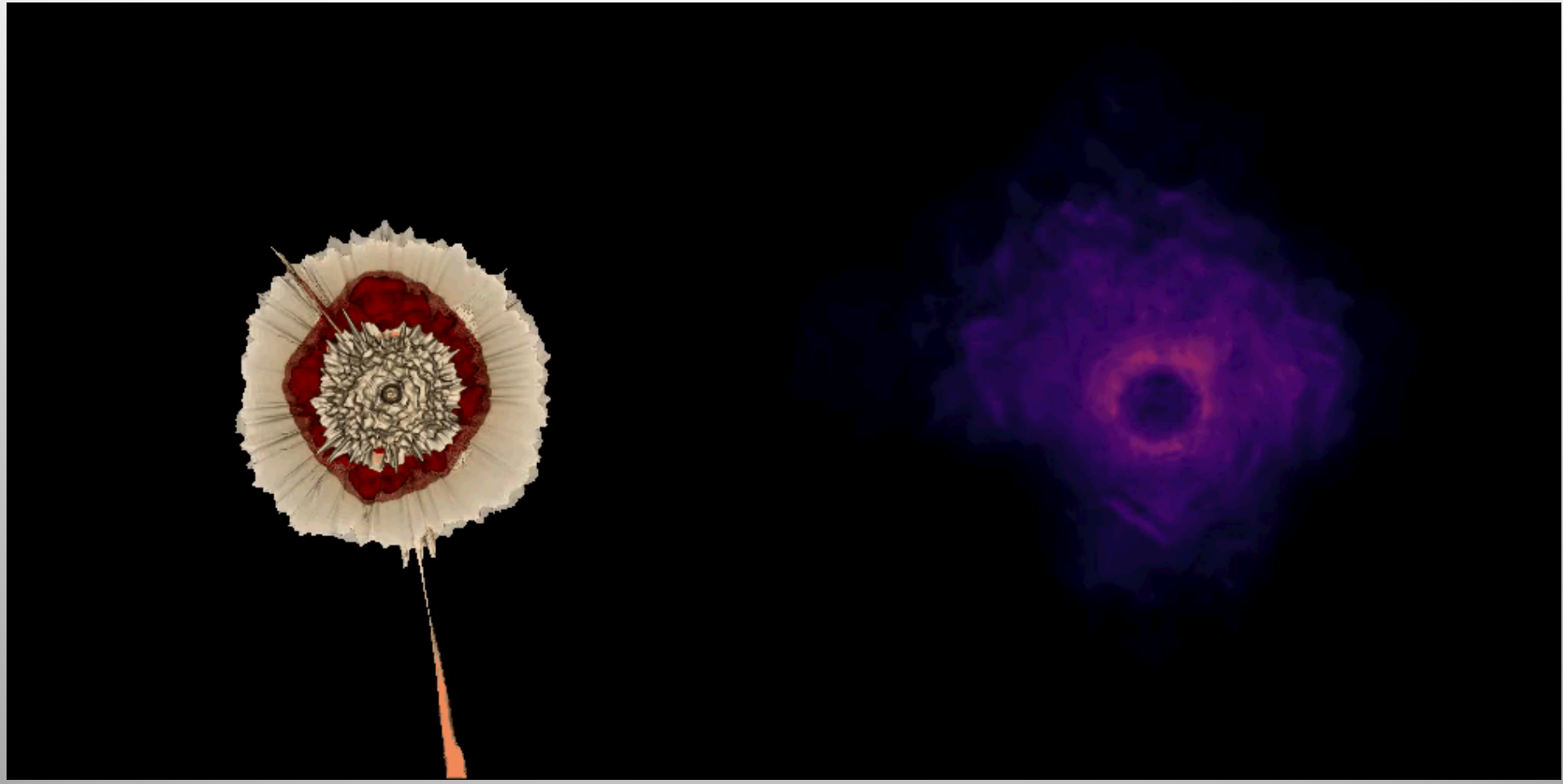


Positive kurtosis suggests temperature variation in the burn, while negative kurtosis implies velocity variation.

The skew has a large and complex variation with line of sight also.



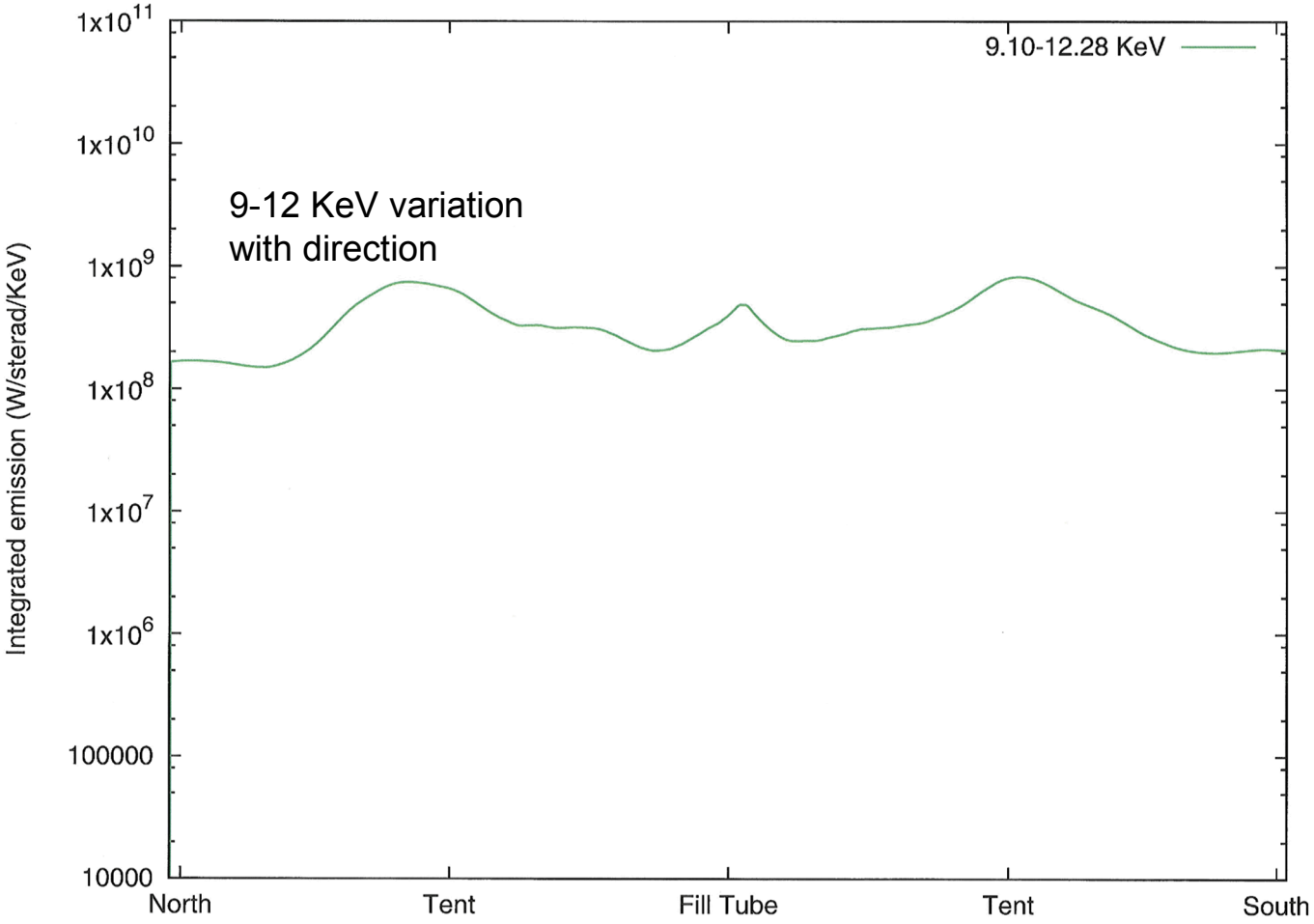
High convergence NIC capsule view at 10 KeV



(different scales)

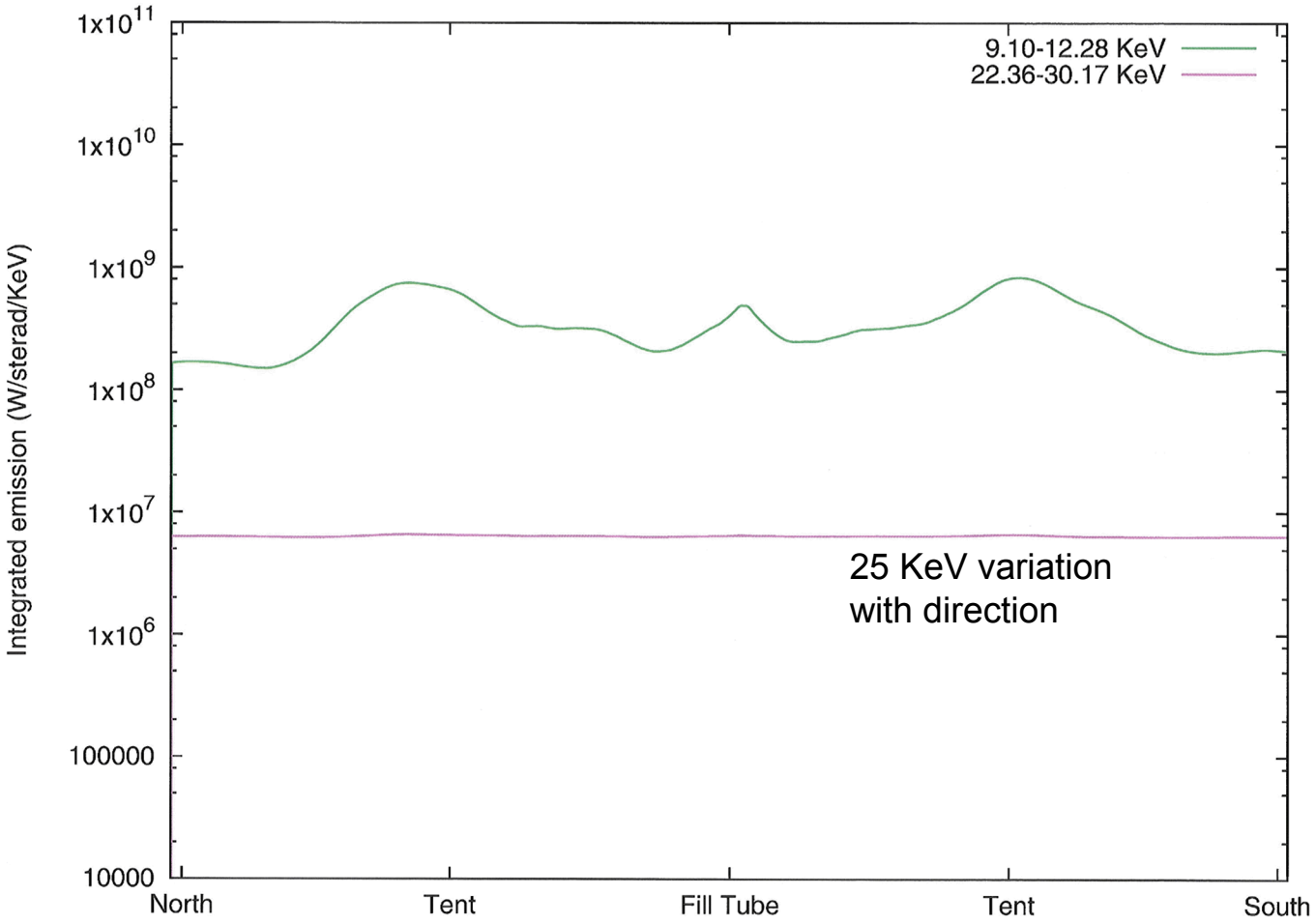
N120321 HYDRA hi-resolution simulation with 470M zones
by D. Clark and C. Weber

The variation of the x-ray emission varies drastically with direction at low x-ray energies.



Frame progression through the movie →

The variation of the x-ray emission varies drastically with direction at low x-ray energies.



Frame progression through the movie →

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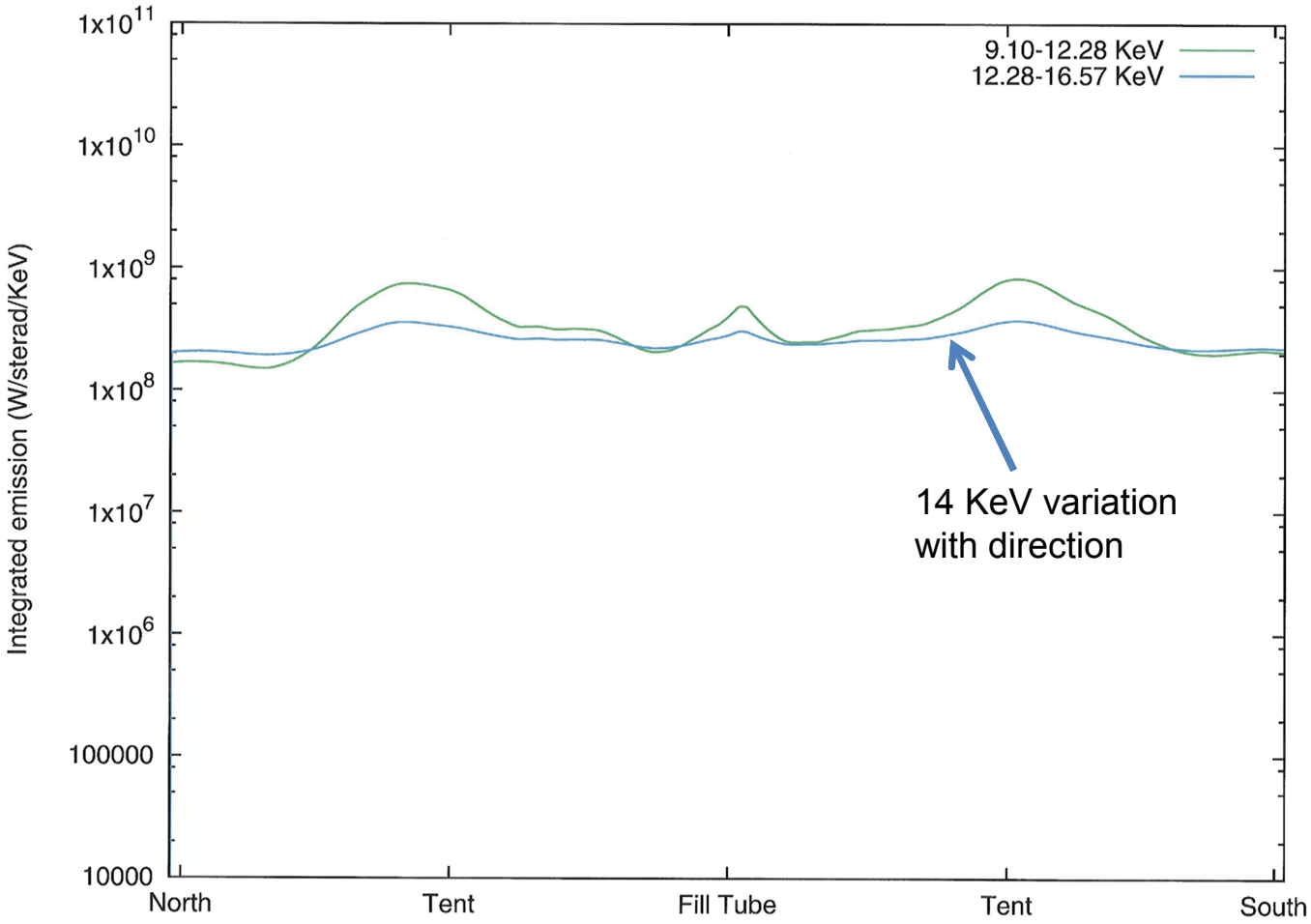

Frame progression through the movie →

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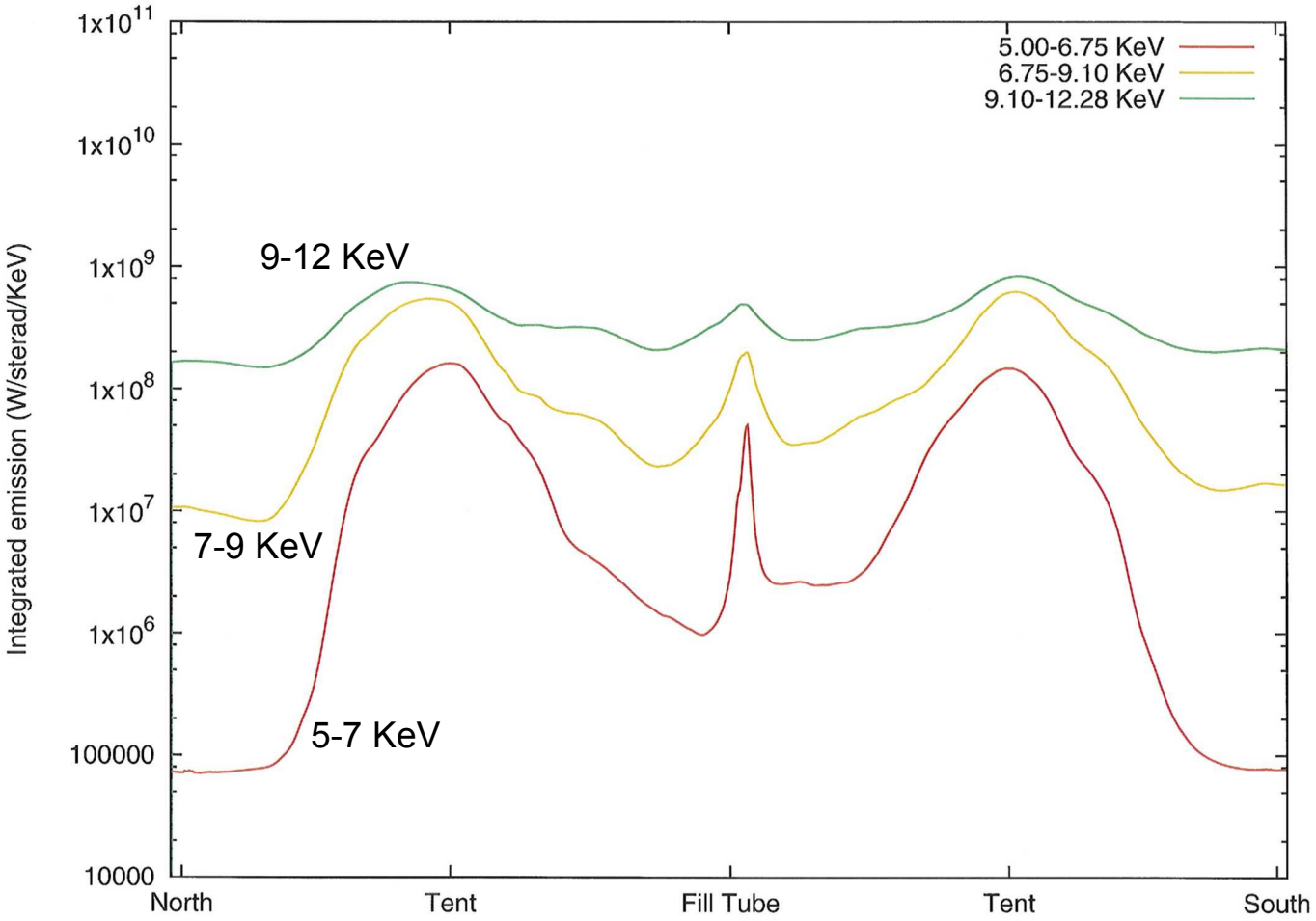


Frame progression through the movie →

Conclusions

- lots of exciting new capabilities
- extracting tons of useful information from the simulations
- steered sampling of simulations should yield much more soon

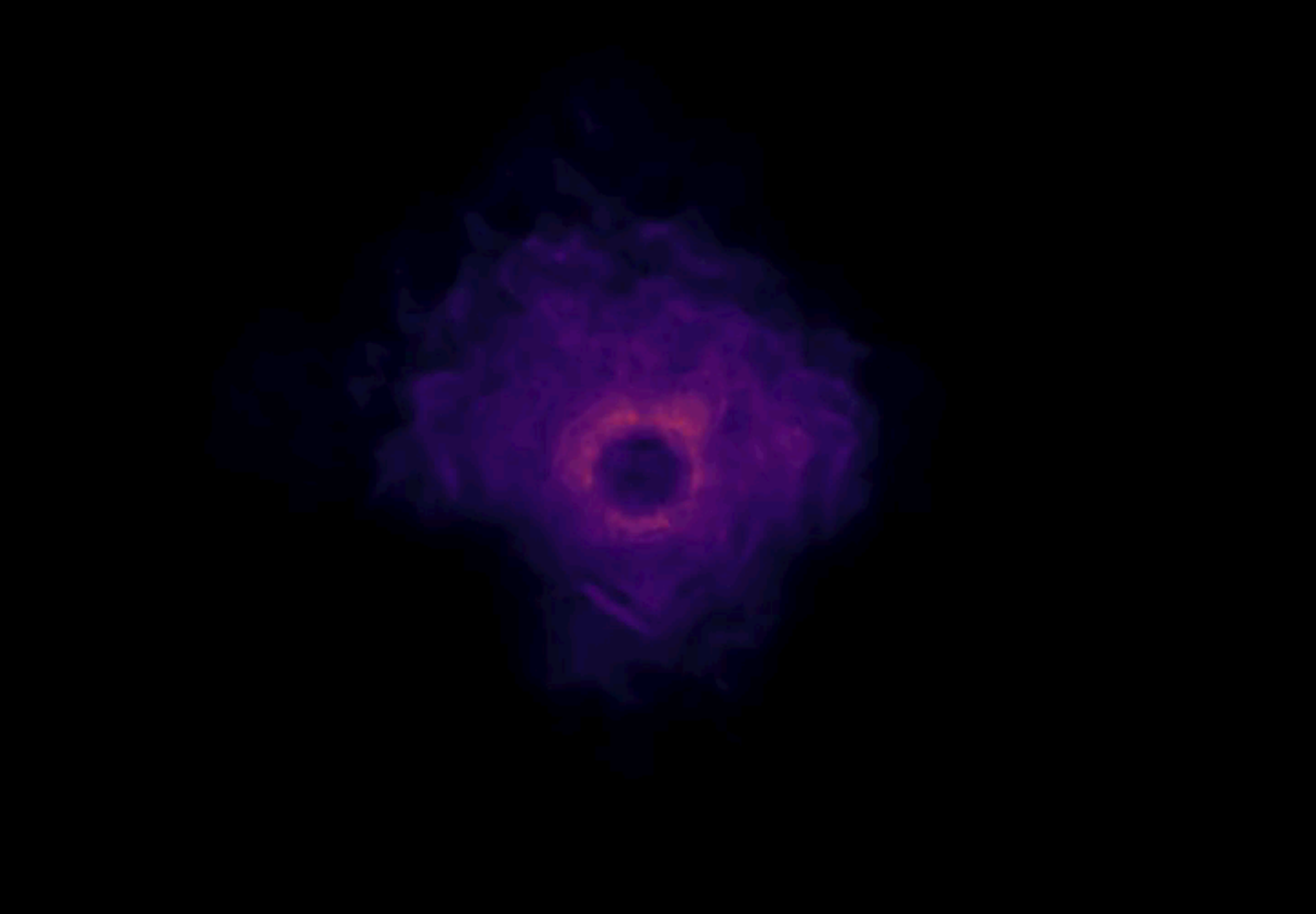
(see Andrea Kritcher's [ref] and Jim Gaffney's poster *Mo.Po.5*, and Luc Peterson and Ryan Nora's talks at APS DPP)

Important Take-Away Messages

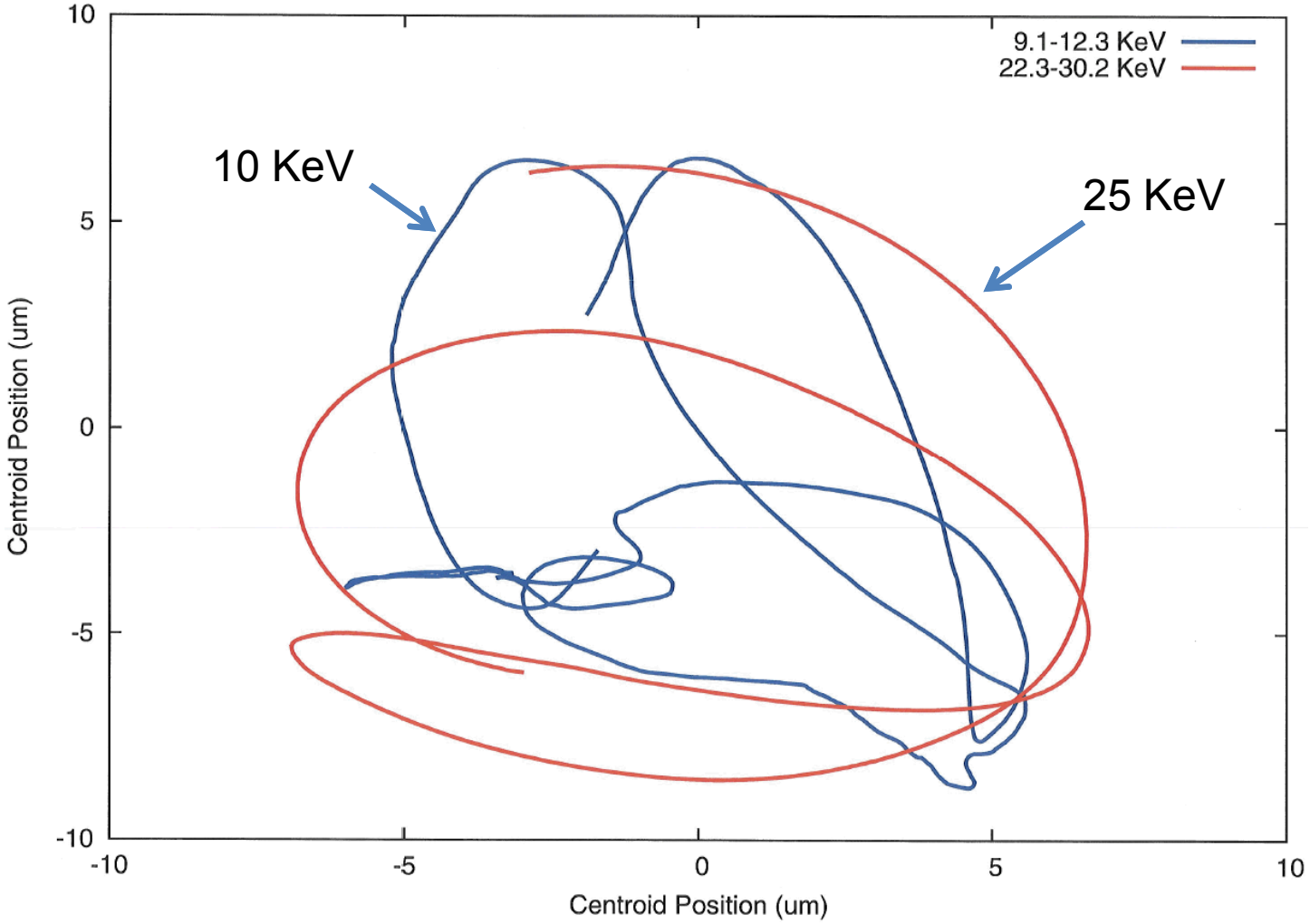
- X-ray images are very different above and below 15 KeV
- Small perturbations likely puncture the capsule
- Fluid velocity significantly changes neutron inferred temperatures
- The thermodynamic temperature is changing drastically during the burn

Our simulations are predicting effects large enough to potentially reconcile many apparent mysteries in the neutron and X-ray diagnostics.

BACKUP SLIDES

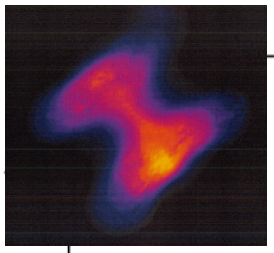


Because of the opacity, low energy x-ray images do not give the correct emission centroid.



The 25 KeV profile is close to the "true" emission centroid, but at 10 KeV, the deviations are several microns, and more than five microns in the tent region.

The centroid shift indicates a burning region accelerating toward the south pole from zero to a modest 30 km/sec



The variation of the x-ray emission varies drastically with direction at low x-ray energies.