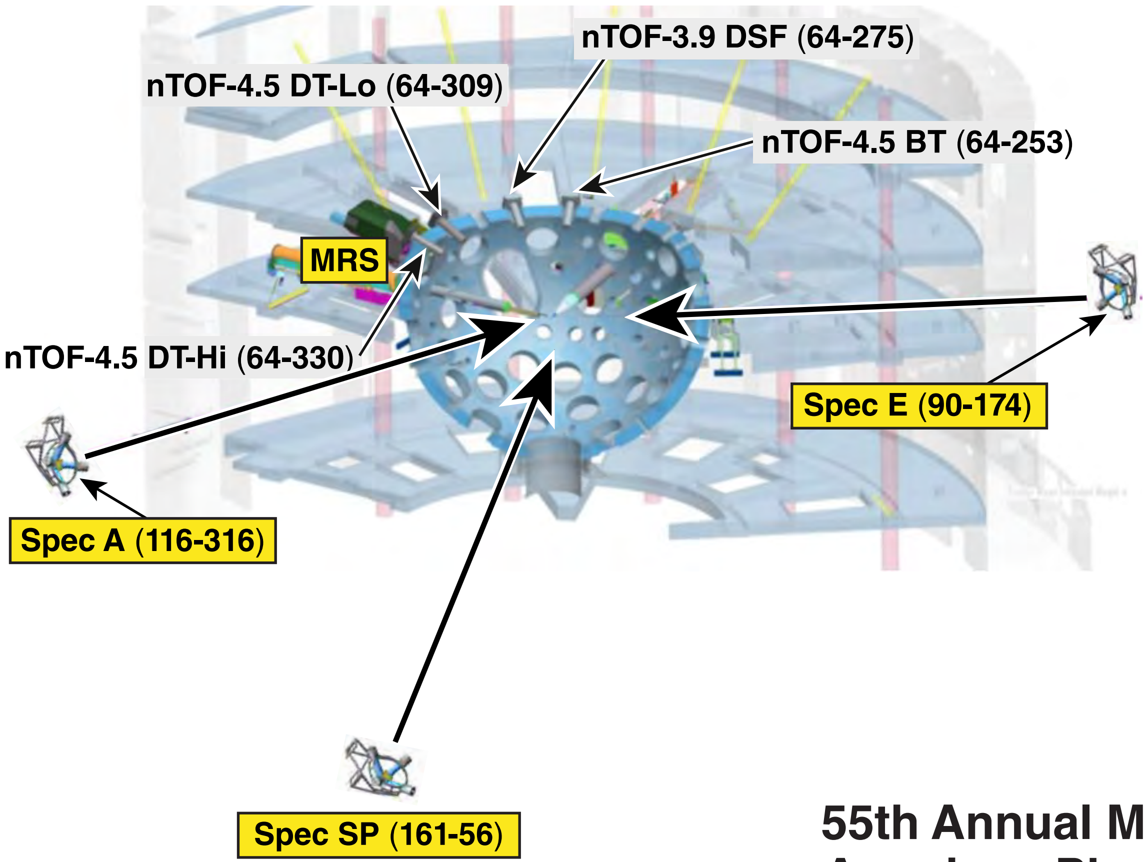
Bulk Fluid Velocity Construction from NIF Neutron Spectral Diagnostics



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Summary

The velocity of the neutron emission region is routinely measured by National Ignition Facility (NIF) neutron spectral diagnostics

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NIF

- A minimum χ^2 method is used to determine the best fit for the resultant velocity (V_x, V_y, V_z) from the measured detector velocity components*
- The velocity calculation is checked by a series of perturbed drive experiments**
- Gas-filled targets have lower neutron-emitting fluid velocities than layered targets
  - mass perturbation is seen in layered target experiments
  - large velocities are measured for implosions with drive and mass perturbations

*R. Hatarik *et al*., NO7.00010, this conference; M. Gatu Johnson *et al*., NO7.00014, this conference.
**B. K. Spears *et al*., NO7.00012, this conference.

Collaborators

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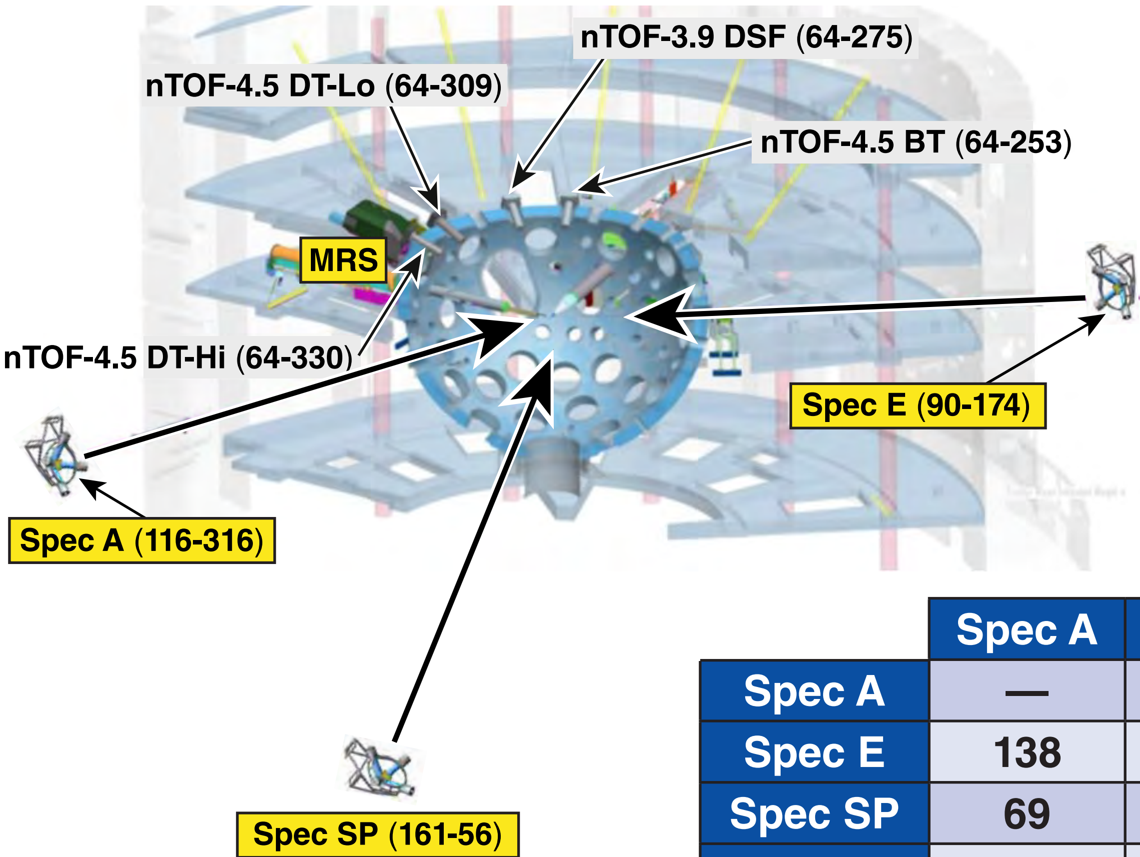
General Atomics

Neutron time-of-flight (nTOF) measurements are made on three nearly orthogonal lines of sight (LOS) and are complemented by the magnetic recoil spectrometer (MRS)



Relative angles

	Spec A	Spec E	Spec SP	MRS
Spec A	—	138	69	42
Spec E	138	—	99	146
Spec SP	69	99	—	107
MRS	42	146	107	—

Multiple LOS allow for the construction of a resultant velocity.

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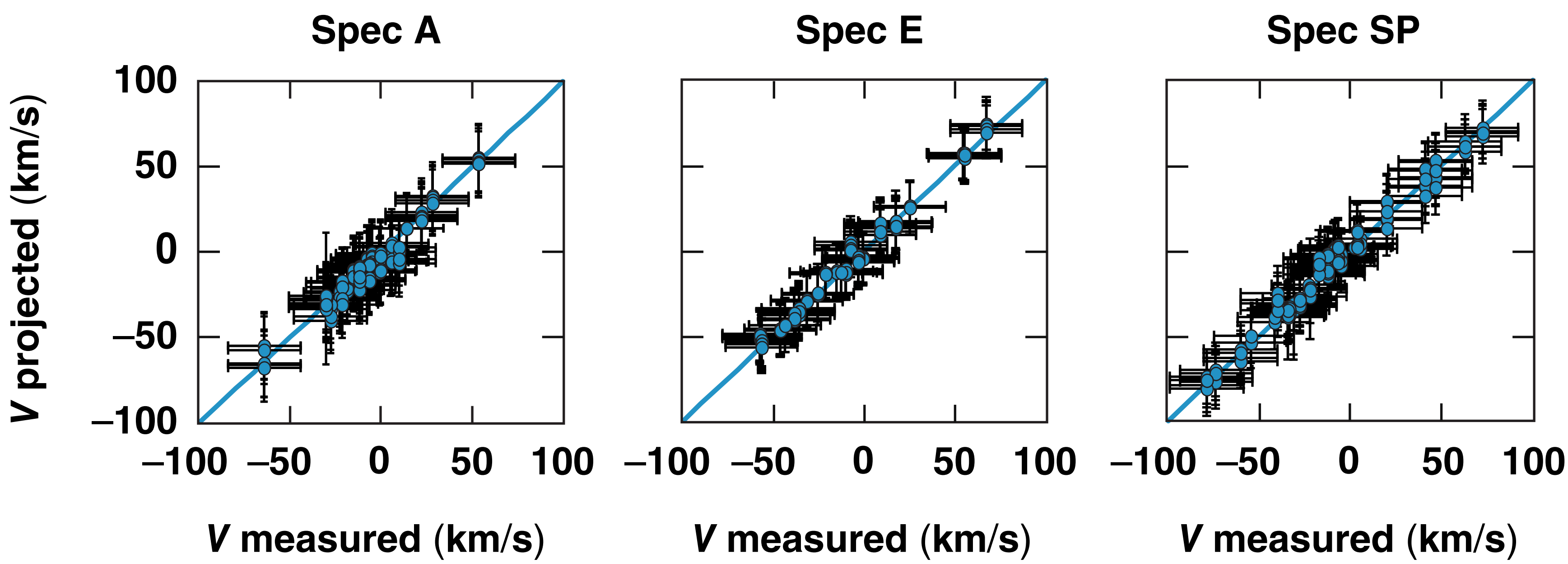
Neutron-emitting fluid velocity (V_x,V_y,V_z) is determined by fitting to the measured detector velocity projections

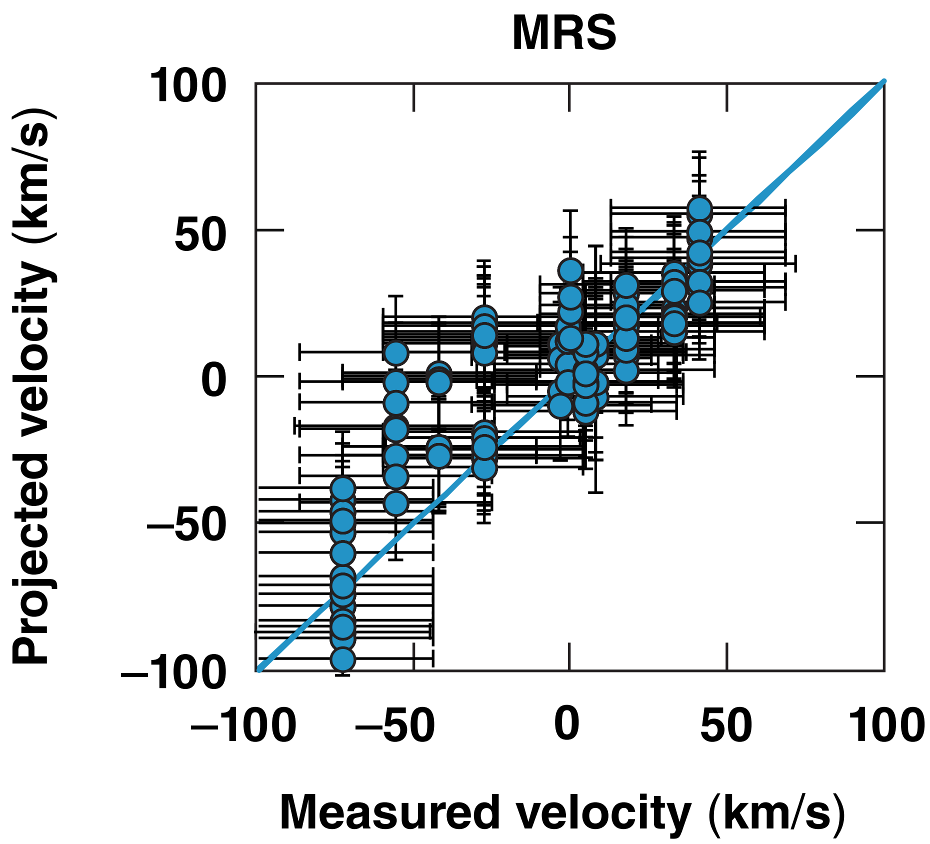
- Velocities projected along the instrumental LOS are calculated with V_x, V_y, and V_z
  - $V_{\text{det}}^{\text{proj}} = V_x * \hat{x}_{\text{det}} + V_y * \hat{y}_{\text{det}} + V_z * \hat{z}_{\text{det}}$
  - $\chi^2 = \Sigma_{\text{det}} \dfrac{\left[V_{\text{det}}^{\text{meas}} - V_{\text{det}}^{\text{proj}}\left(V_x, V_y, V_z\right)\right]^2}{dV_{\text{det}}^{\text{meas}\,2}}$
- V_x, V_y, and V_z are calculated by minimizing χ^2
  - δV_x, δV_y, and δV_z are calculated from the error matrix
- The polar velocity vector and its associated errors are calculated from Cartesian components

The projected velocities of nTOF spectral detectors agree with measured velocities



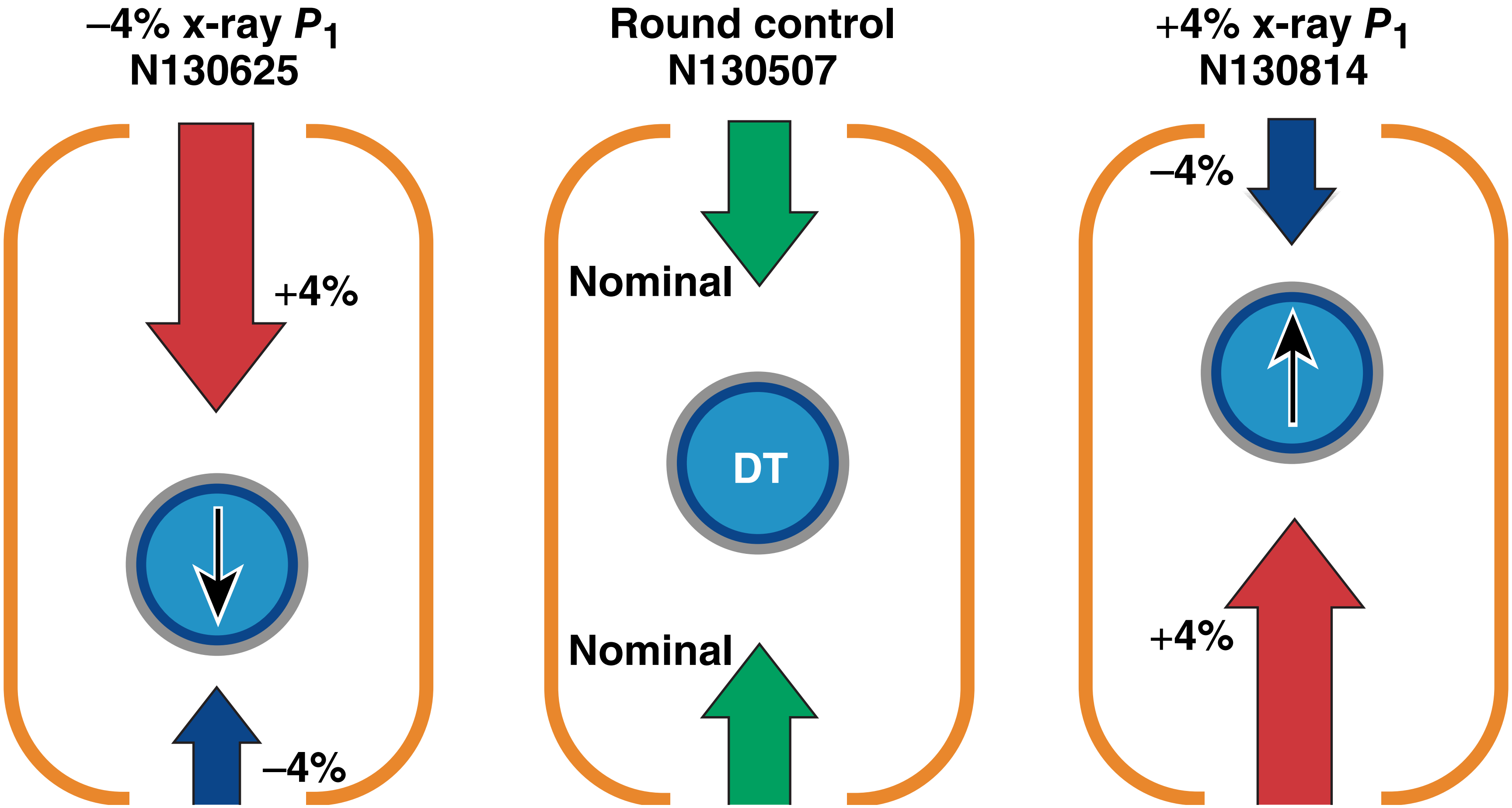
Spec E determines the velocity *x* component;
Spec SP determines the velocity *z* component.

MRS-projected velocities show larger variations with respect to measured velocities



Resultant velocity is weighted toward nTOF velocities.

A three-shot series of controlled P_1 symcap experiments were performed to test nTOF bulk-velocity measurements



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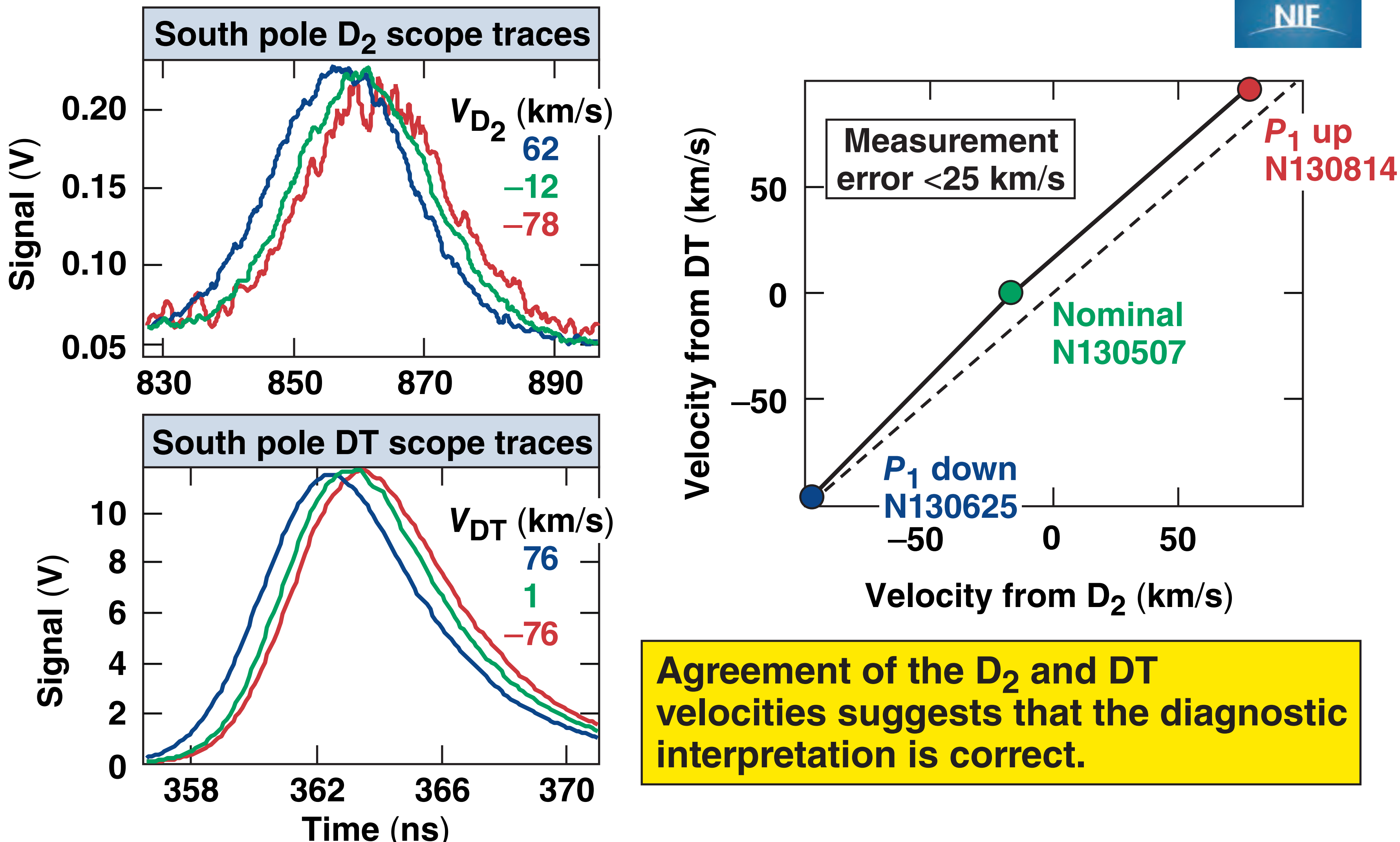
Velocity components are measured using both D_2 and DT neutron arrival times agreeing on all three shots



Agreement of the D_2 and DT velocities suggests that the diagnostic interpretation is correct.

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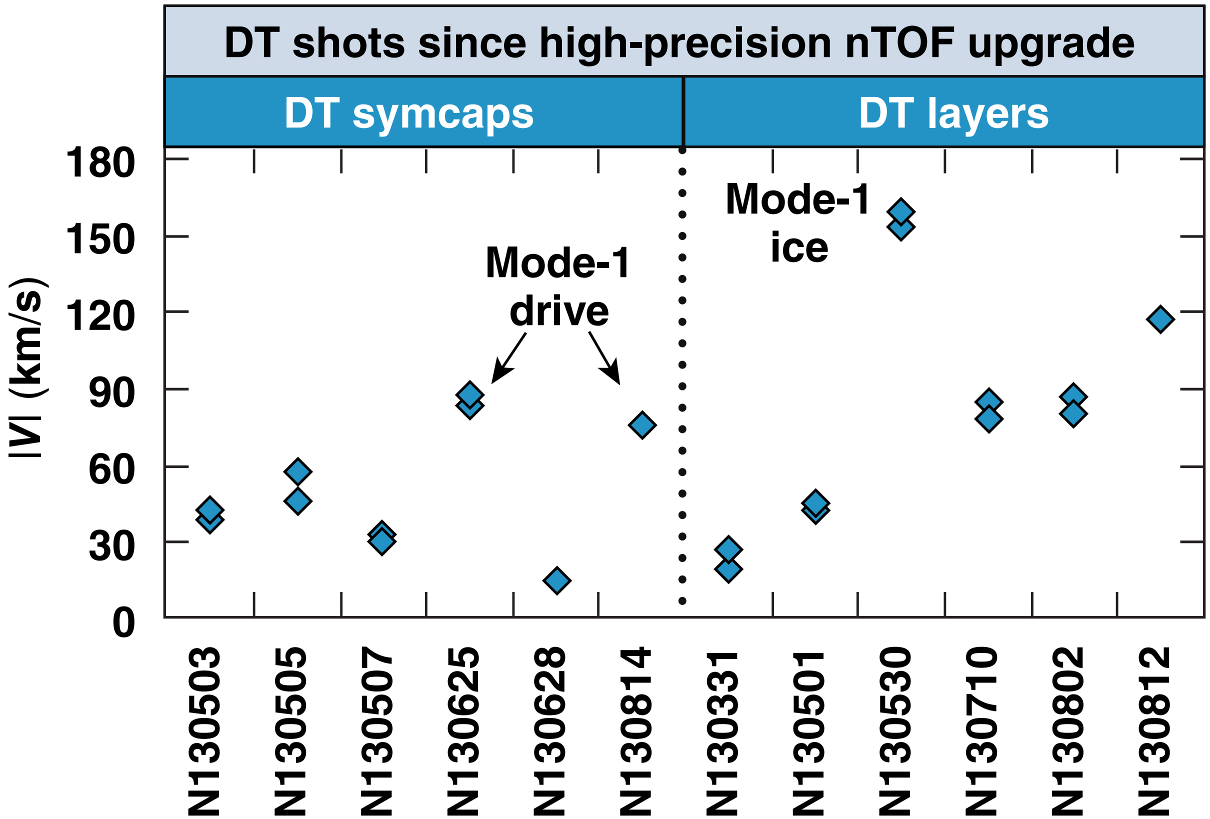
Velocity measurements from the new nTOF's show the presence of sizeable Mode-1 perturbations



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Summary/Conclusions

The velocity of the neutron emission region is routinely measured by National Ignition Facility (NIF) neutron spectral diagnostics

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The polar velocity vector and its associated errors are calculated from Cartesian components

- Given Cartesian velocity components $\begin{pmatrix} V_x \\ V_y \\ V_z \end{pmatrix}$ and their errors $\begin{pmatrix} \delta V_x \\ \delta V_y \\ \delta V_z \end{pmatrix}$

  V, θ, and ϕ as well as δV, θV, and $\theta\phi$ can be determined

$$V = \sqrt{V_x^2 + V_y^2 + V_z^2}$$

$$\delta V = \frac{1}{V} * \sqrt{\delta V_x^2 * V_x^2 + \delta V_y^2 * V_y^2 + \delta V_z^2 * V_z^2}$$

$$\vartheta = \cos^{-1} \frac{V_z}{V}$$

$$\delta\vartheta = \frac{1}{V} * \sqrt{\frac{\delta V_z^2 * V^2 + \delta V^2 * V_z^2}{V^2 - V_z^2}}$$

$$\varphi = \tan^{-1} \frac{V_x}{V_y}$$

$$\delta\varphi = \frac{1}{V_x^2 + V_y^2} * \sqrt{\delta V_x^2 * V_y^2 + \delta V_y^2 * V_x^2}$$