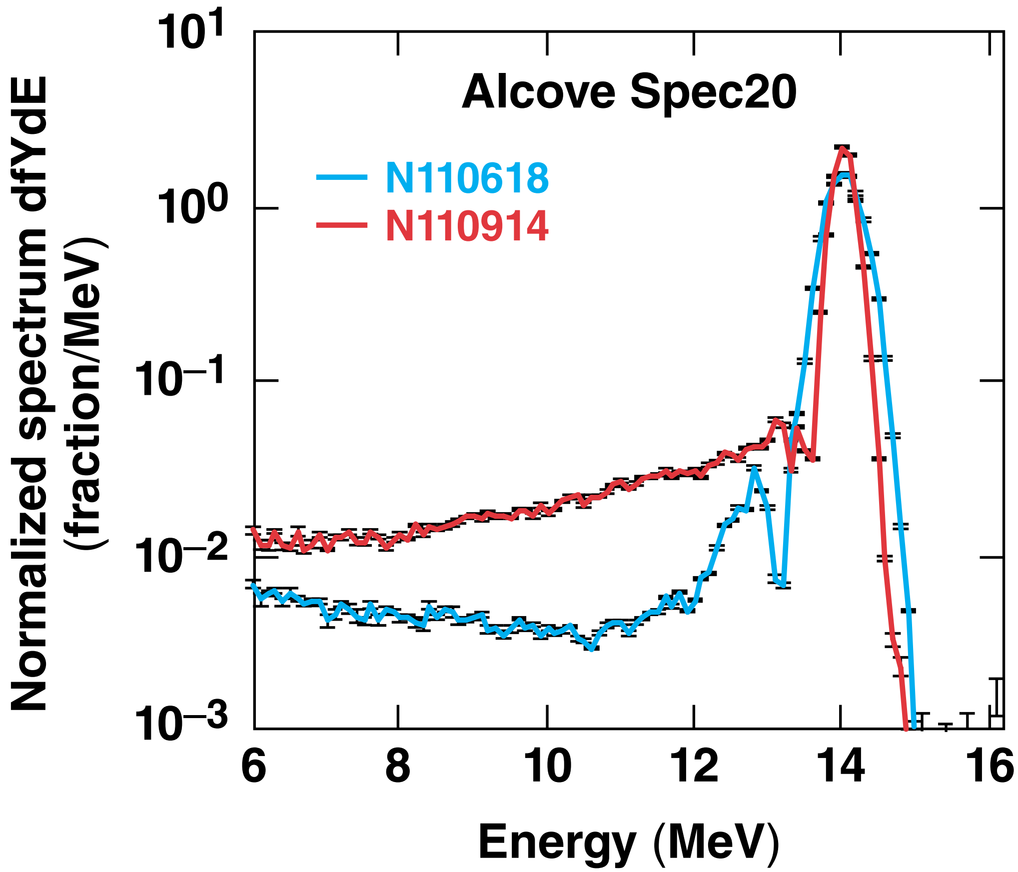
Neutron Spectra Measured with Time-of-Flight Detectors on the National Ignition Facility



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Summary

High-quality data from NIF Spec20 detectors make it possible for neutron spectra to be calculated from a deconvolution

- Instrument response function (IRF) determined from *in-situ* measurements
- Spec20 detectors probe NIF implosions from two different lines-of-sight
- Neutron spectra are calculated with an error analysis built into the deconvolution

NIF nTOF development has been done by a large team of collaborators

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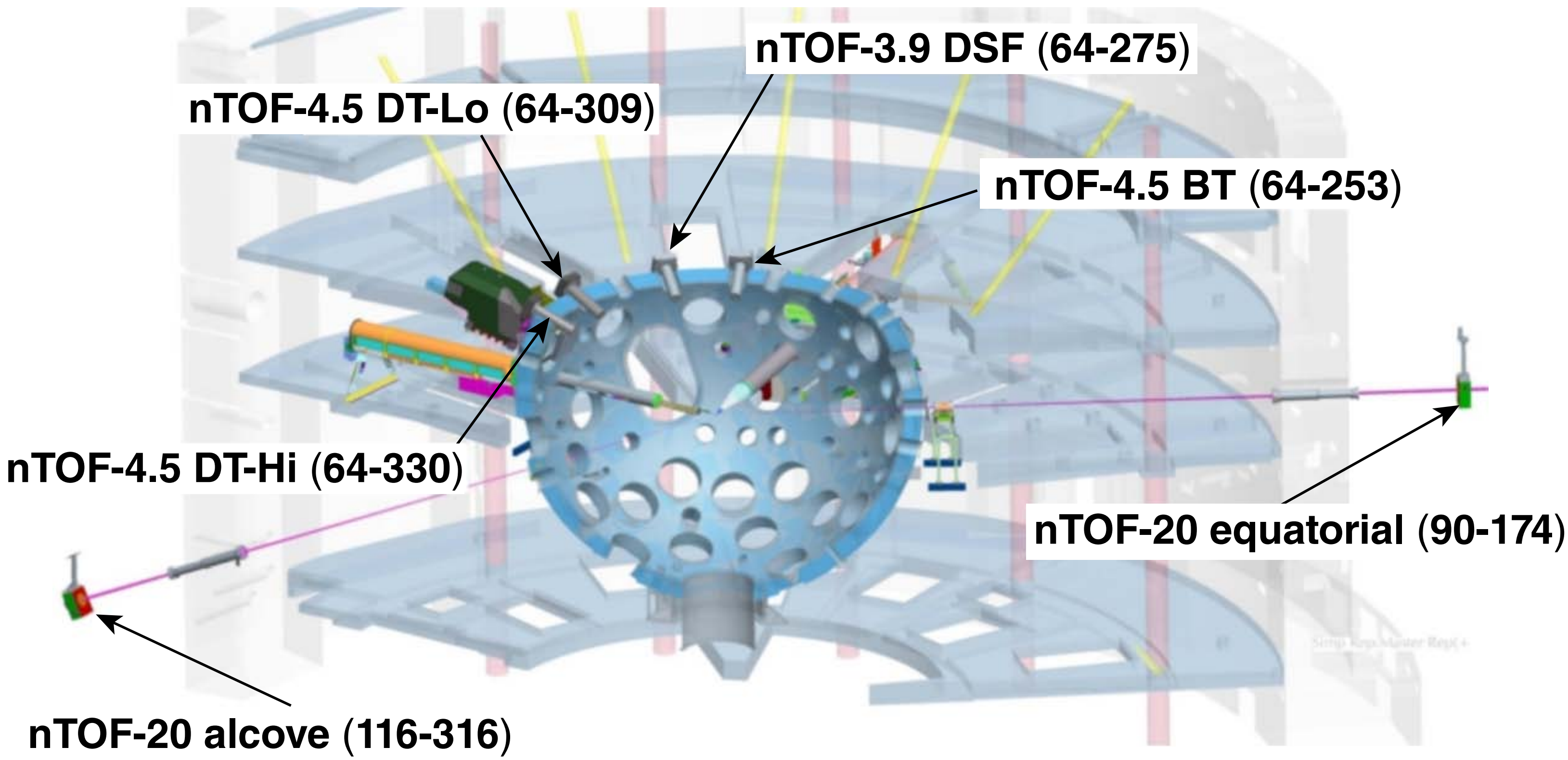
Several nTOF detectors are distributed around the NIF target chamber



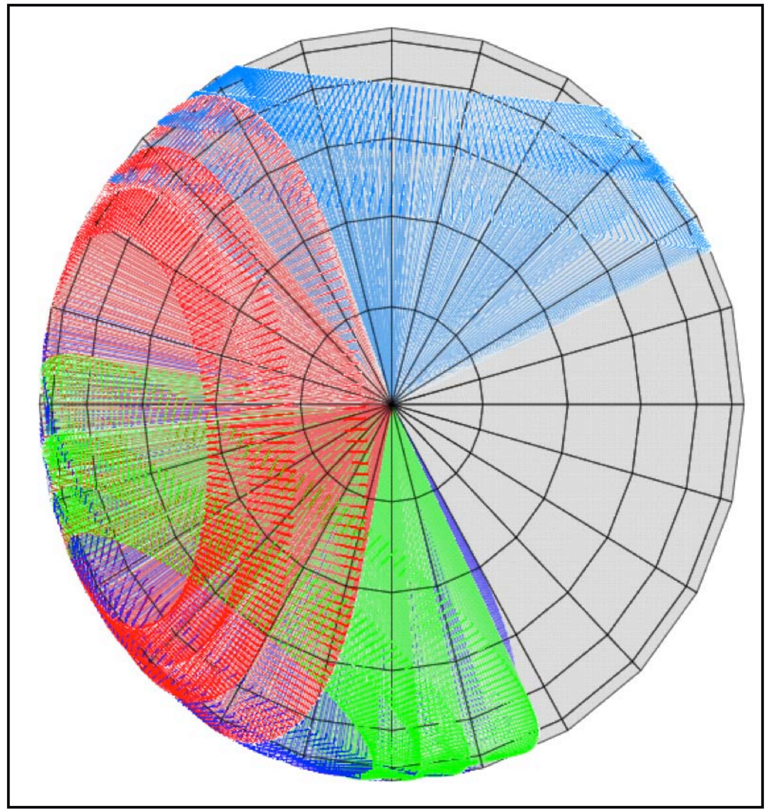
Neutron down scatter is measured along four lines-of-sight.

E20356

DSR measurements sample ρR of large-opening angle cones about the diagnostic direction

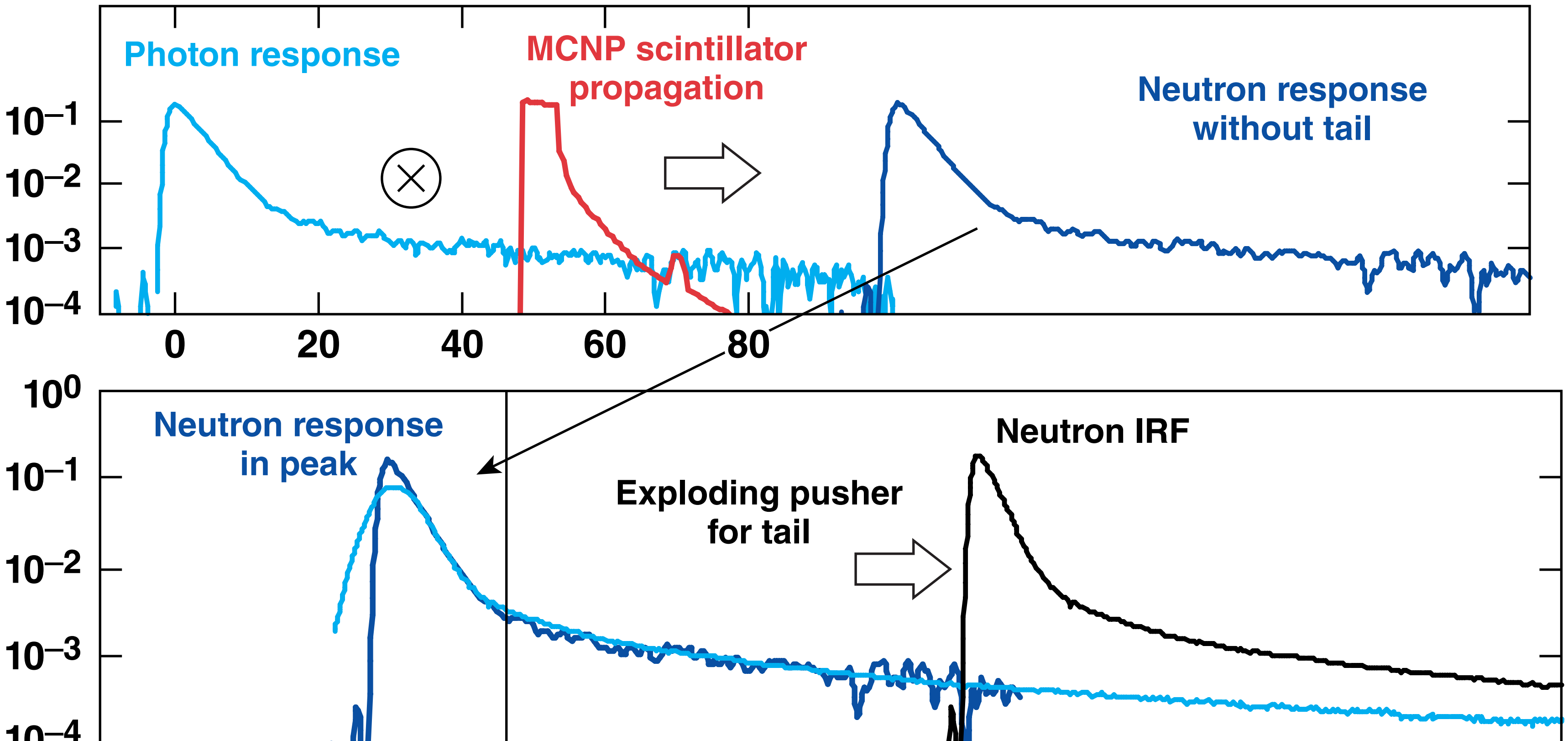
Neutrons scattered from tritium and deuterium

Instrument – (θ, ϕ)
3.9 m DSF – (64, 275)
MRS – (77, 324)
Alcove Spec20 – (116, 316)
Equator Spec20 – (90, 174)



The average of all DSR measurements represents the average target ρR.

Instrument response functions (IRF's) are constructed with a dynamic range of 10^3



Instrument IRF is calculated from x-ray data, neutron propagation in scintillator calculated from MCNP, and exploding-pusher data.

E20358

Spec20 deconvolution uses a Wiener-filtered FFT technique

- Use signal-to-noise to determine number of points for FFT analysis (typically 4096)
- Use same number of points in data for leading and trailing noise windows
- FFT data, noise, and IRF
- Construct Wiener filter from power spectrum from IRF and noise using a Lagrangian multiplier
- Calculate deconvolved signal from inverse FFT of (WF*[FFT(data)/FFT(IRF)]
- Optimize Lagrangian multiplier by minimizing under- and overshoots in signal (subjective)
- Convert data to energy domain
- Calculate scalars DSF, T_{ion}, yield
- Calculate energy spectrum with 50-keV resolution

Errors propagated throughout deconvolution analysis

- δ FFT from noise
- δ signal from δ FFT
- δ spectrum from δ signal
- σ scalars

Exploding-pusher neutron spectra agree but may show a difference between 1.5- and 2.1-mm shells

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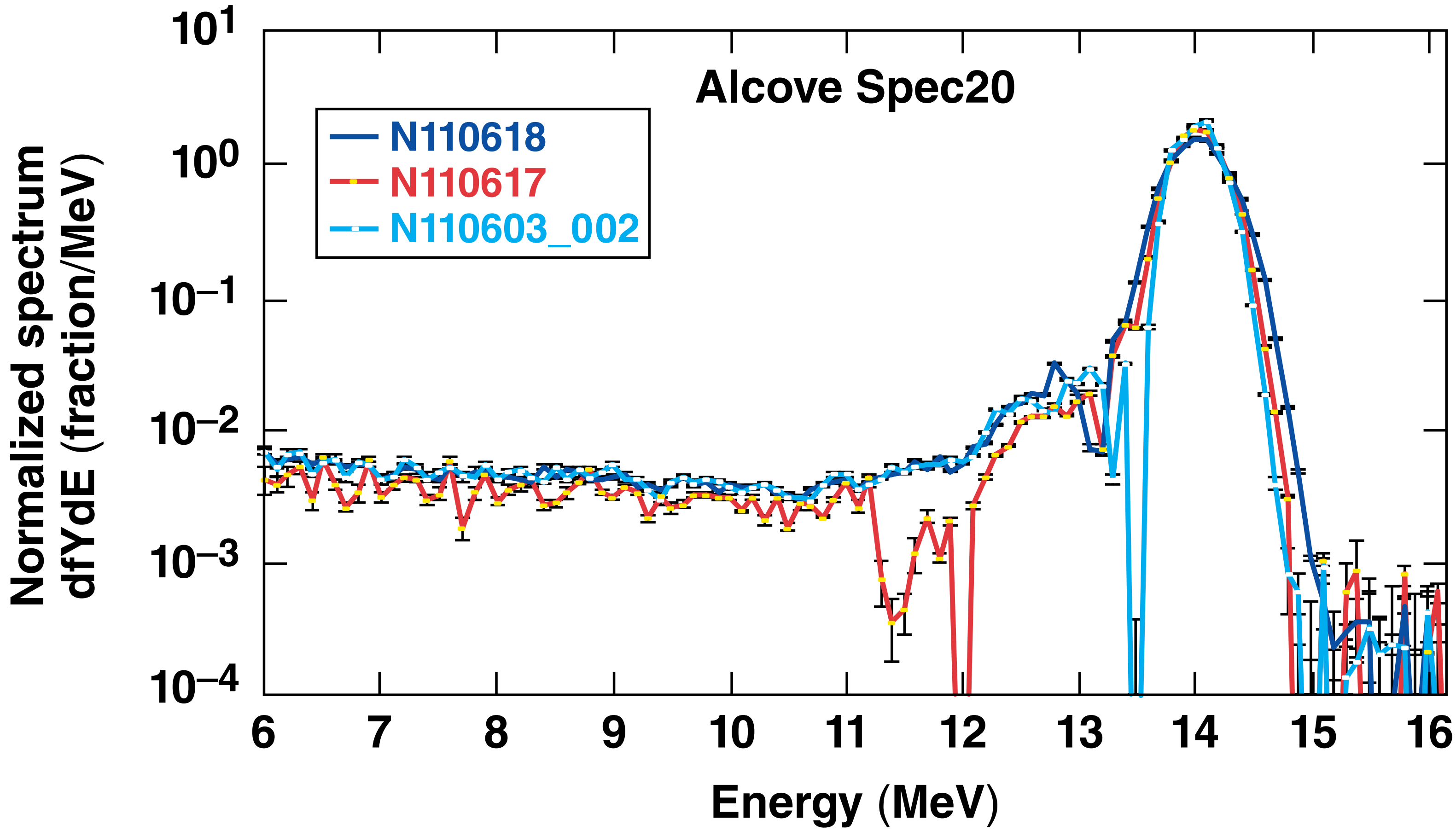
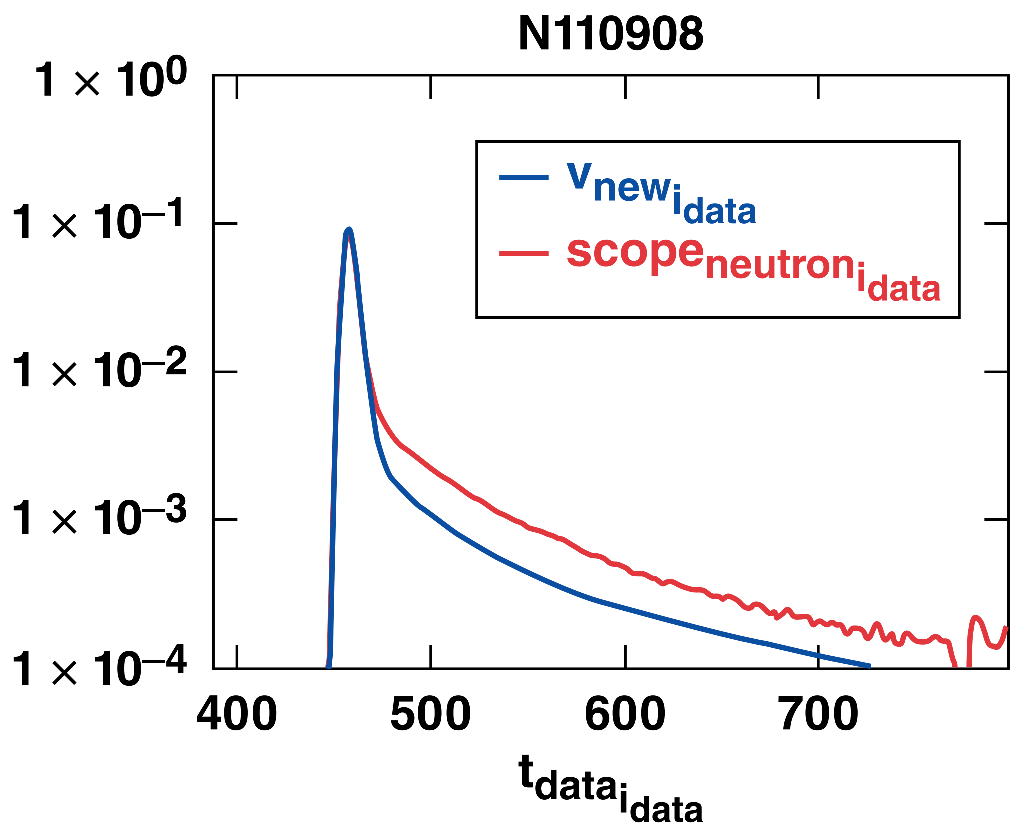


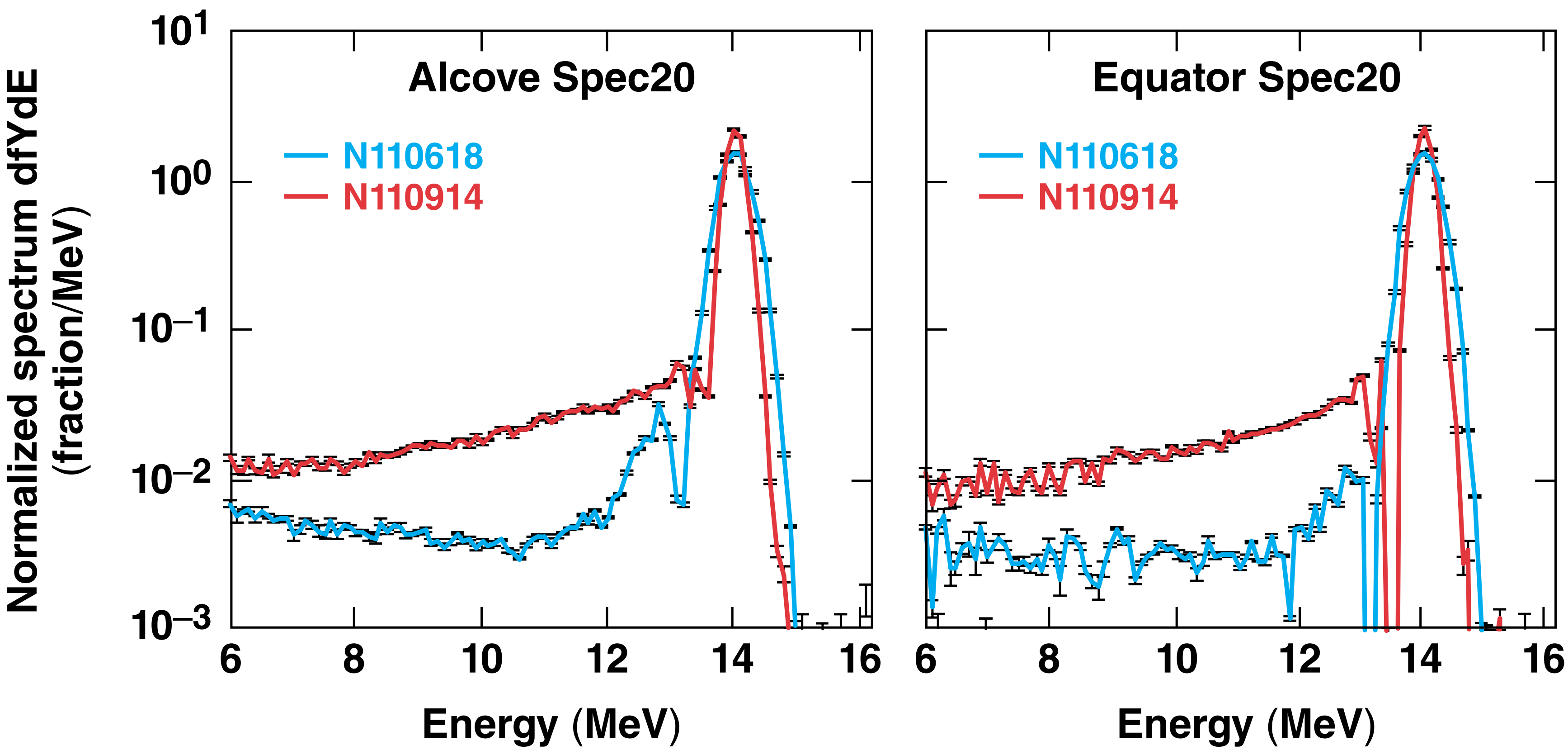
E20361

Convolution of DT peak with IRF shows scattered neutrons



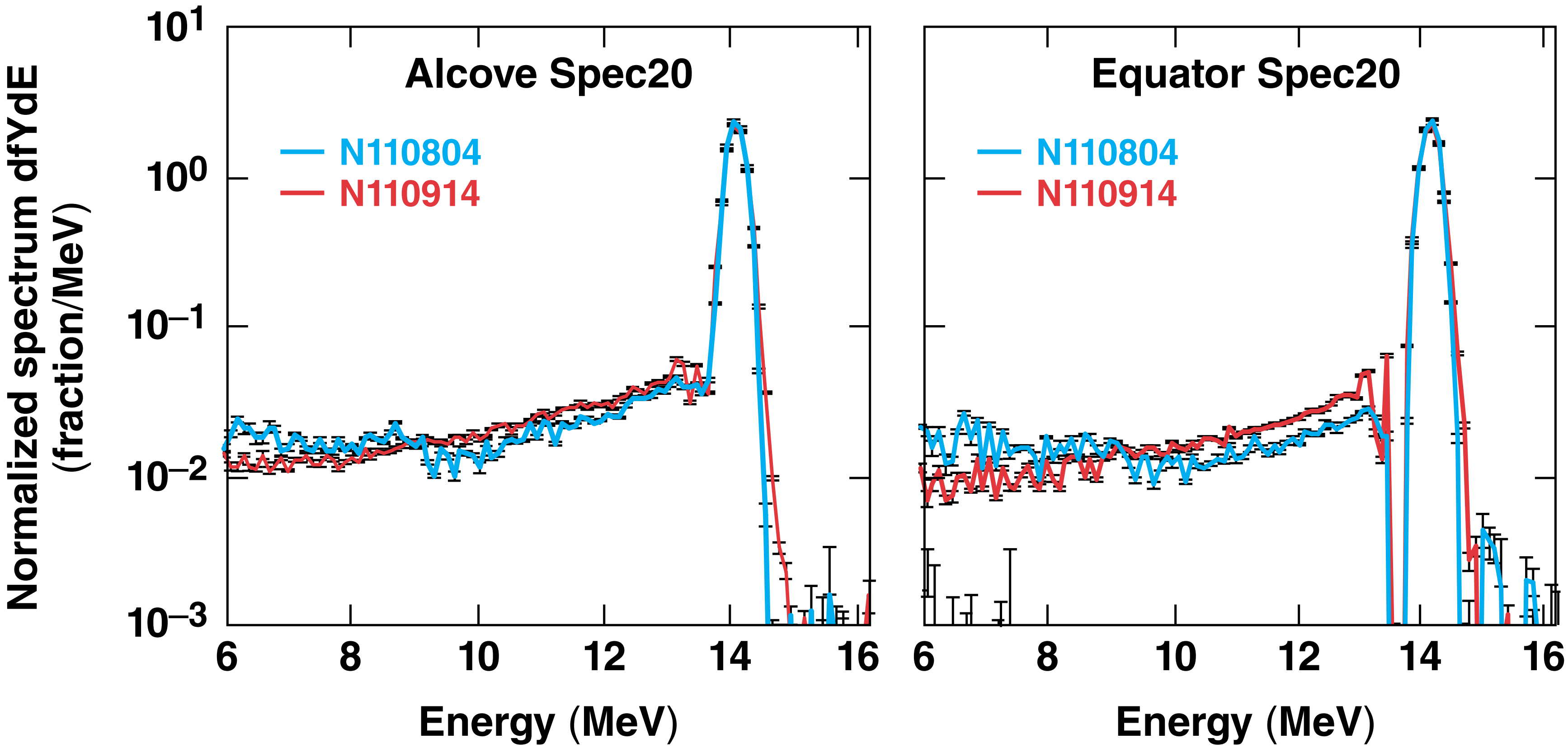
E20362

Down-scattered neutrons are clearly seen in deconvolved spectra



E20363

THD spectra show the TT neutrons in both alcove and equator Spec20's



TT neutrons seen for energies <9.3 MeV

E20364

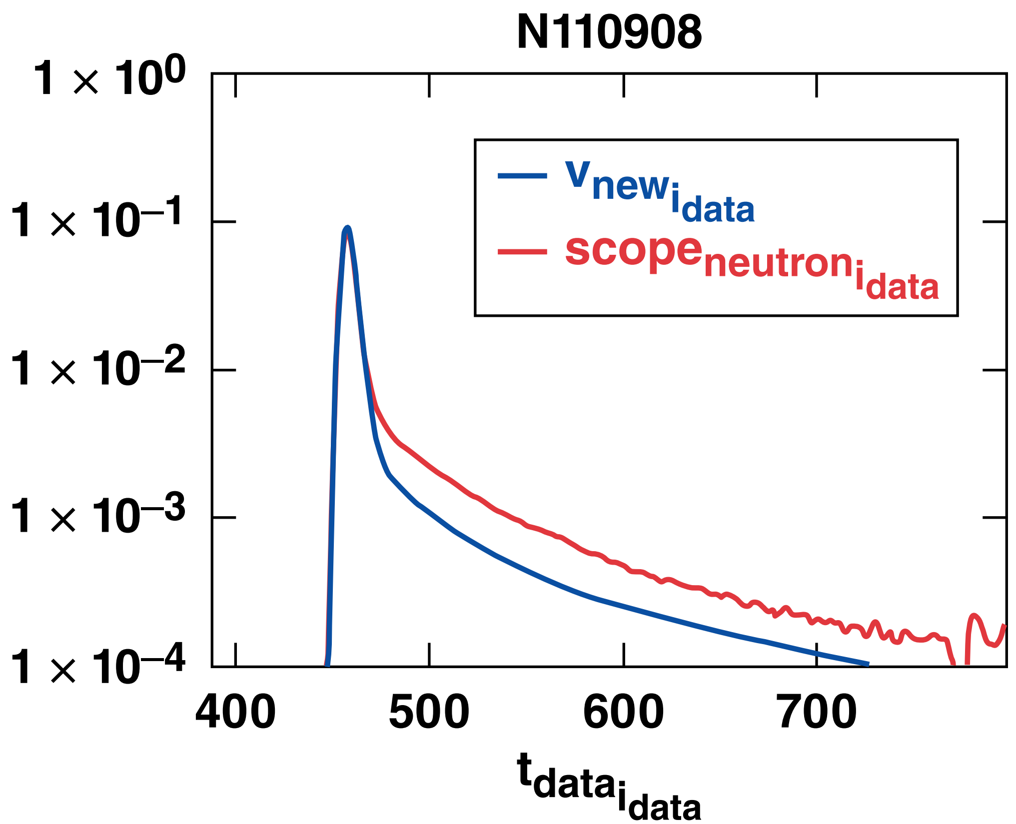
Summary/Conclusions

High-quality data from NIF Spec20 detectors make it possible for neutron spectra to be calculated from a deconvolution

- Instrument response function (IRF) determined from *in-situ* measurements
- Spec20 detectors probe NIF implosions from two different lines-of-sight
- Neutron spectra are calculated with an error analysis built into the deconvolution

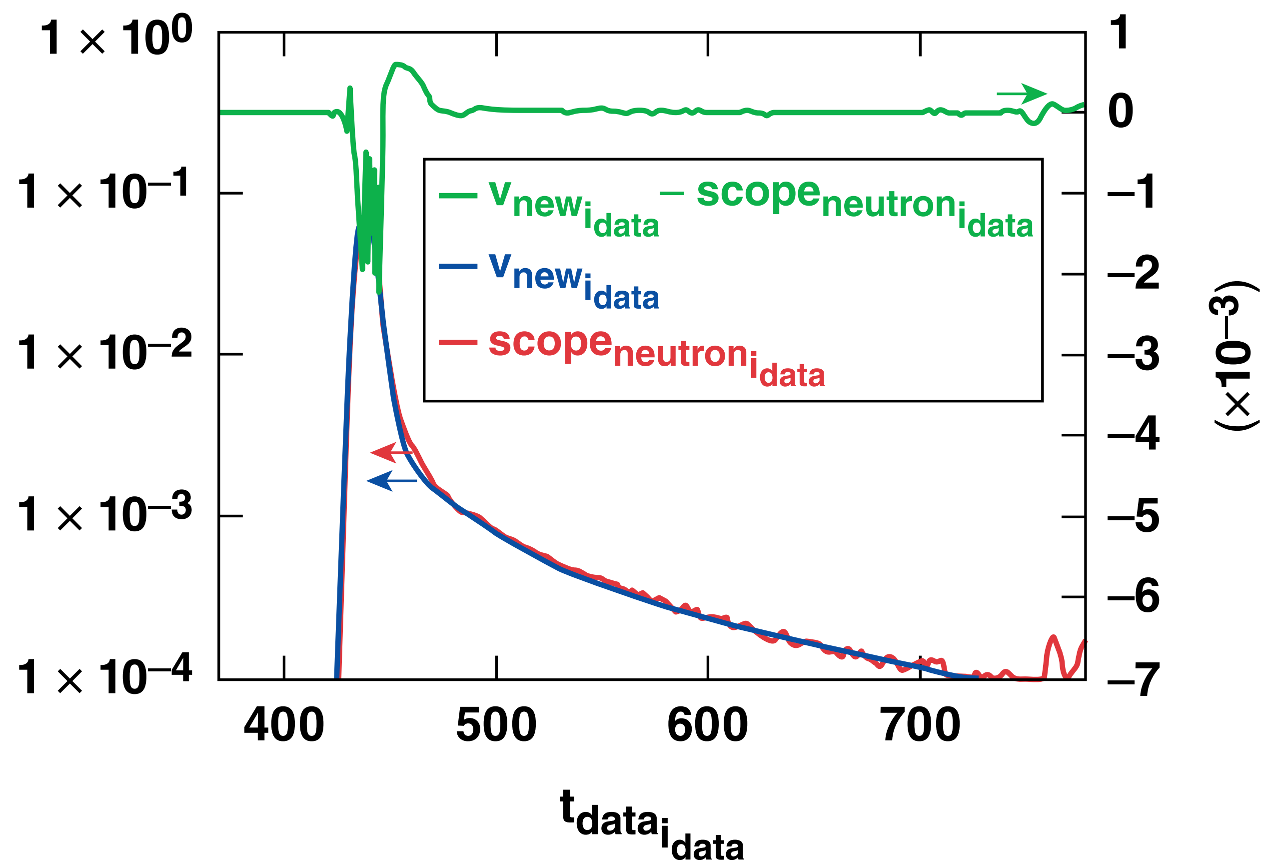
Deconvolution of neutron spectra allow for a generalized DSR to be calculated.

Convolution of DT peak with IRF does not match layer shot data



E20365

Convolution of DT peak with IRF matches data from 1.6-mm exploding-pusher shell

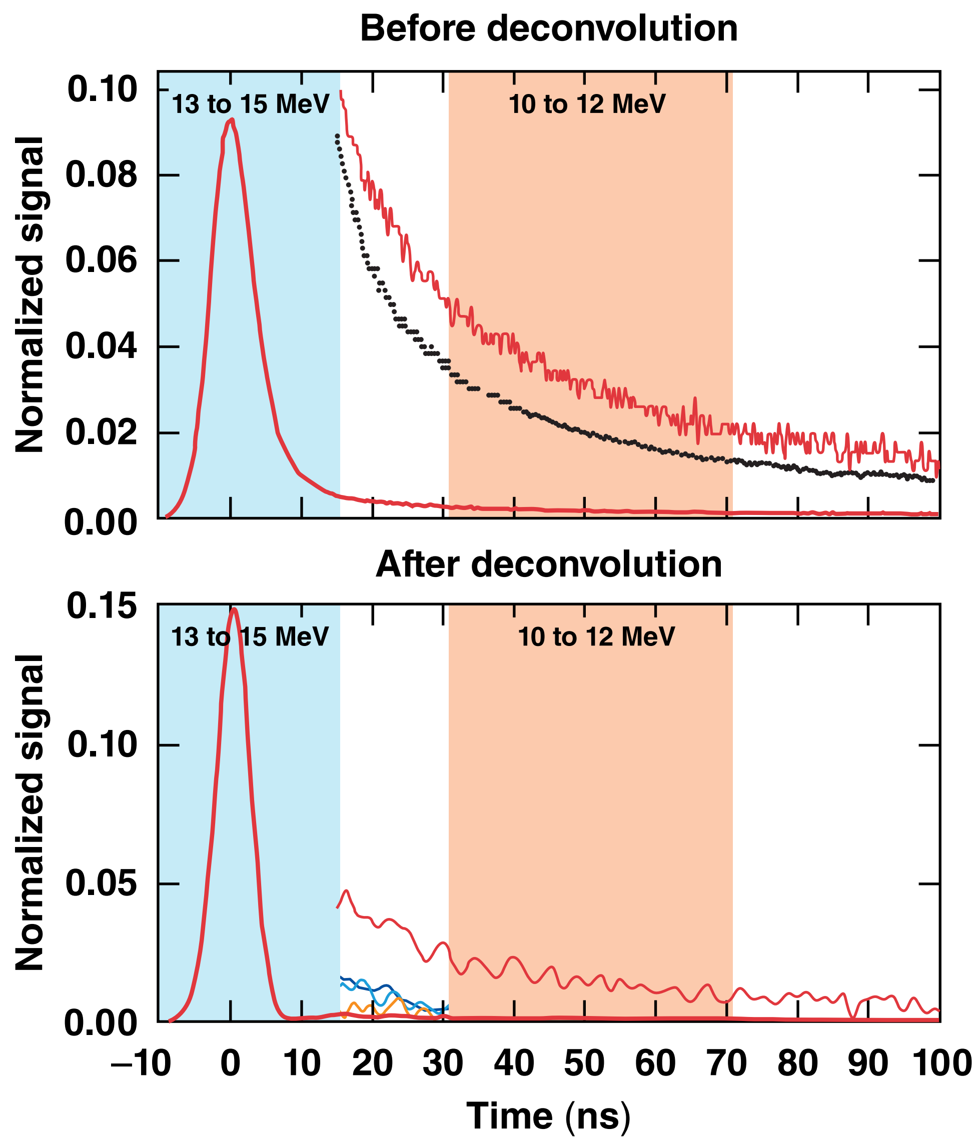


Forward convolution of deconvolved model agrees with measured data.

E20366

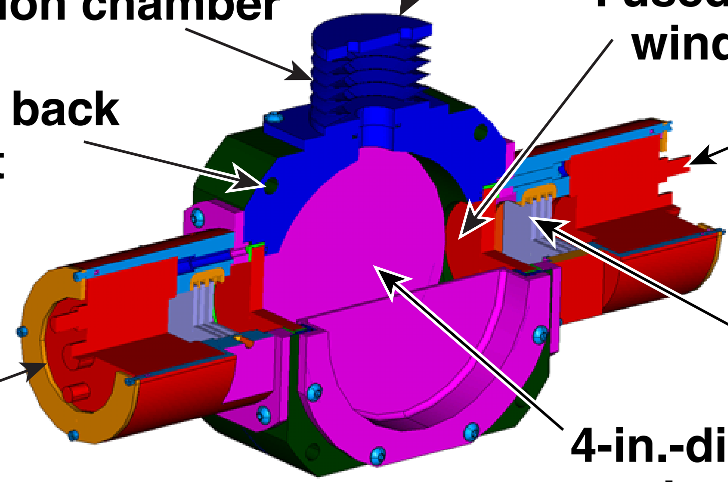
Deconvolution of IRF enhances the signal to background in the DSR region

- Layered shot data shown as red line
- Exploding-pusher shot data shown as points; time > 14.9-ns data multiplied by 20 to show signal background
- DSR $\equiv Y_{10\text{ to }12}/Y_{13\text{ to }15}$



E20100a

Two nTOF Spec20 detectors are installed on the NIF target chamber



Equator installation 20 m from tcc
Alcove installation 22 m from tcc

nTOF Spec20 has been calibrated with DT and D_2 implosions on both OMEGA and the NIF.