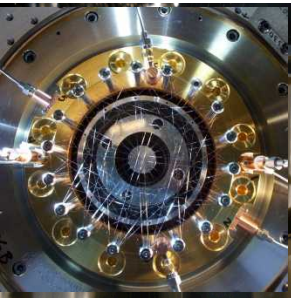
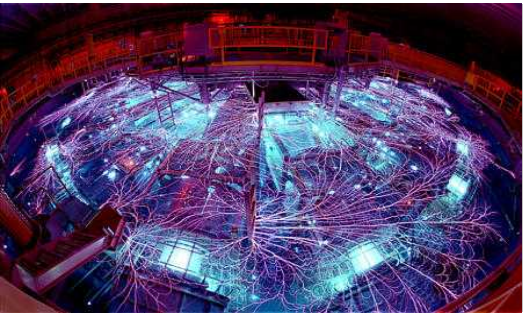
SAND2016-6471PE





Tion analysis for MagLIF experiments on Z

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Sandia National Laboratories

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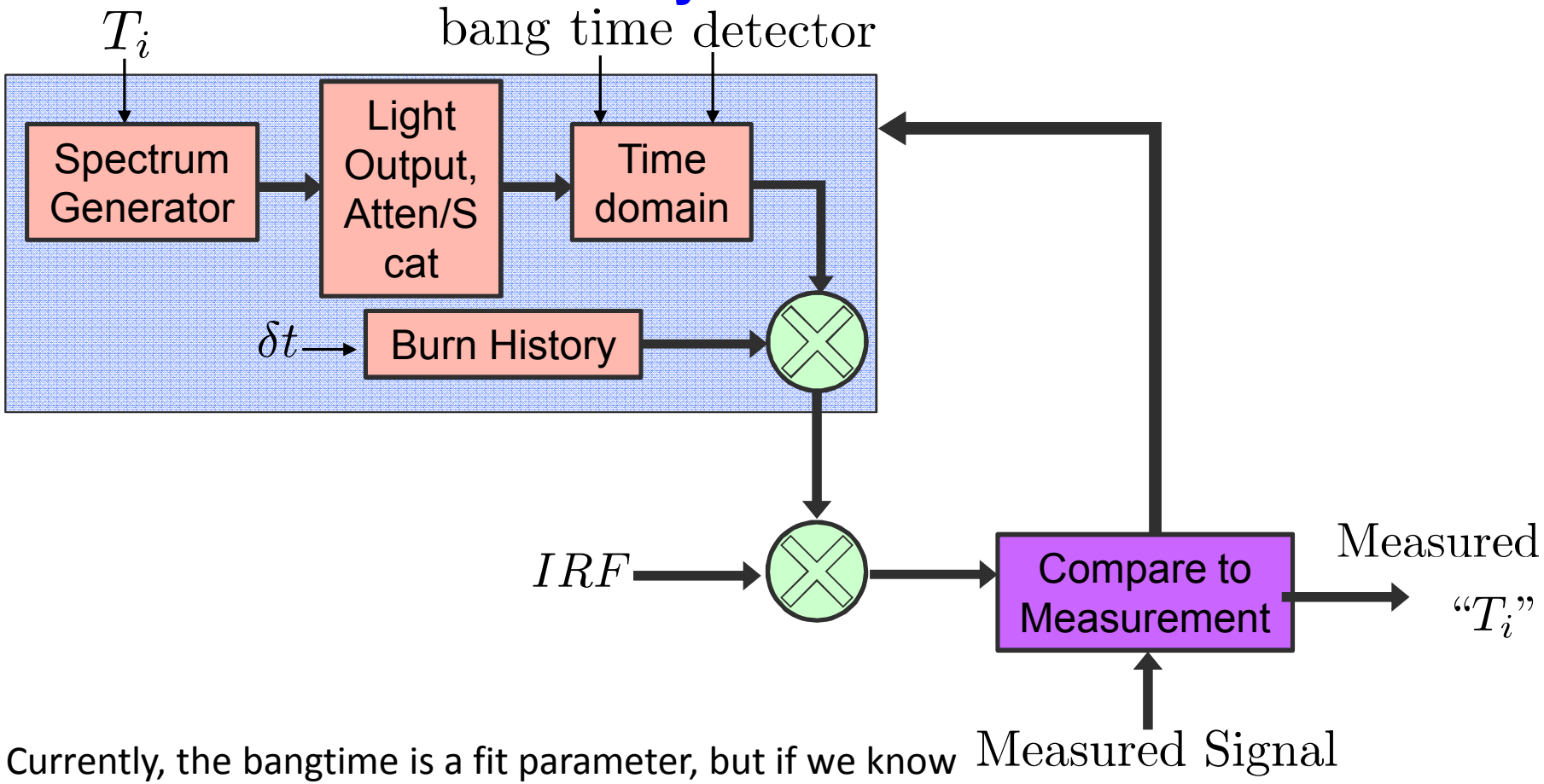
Outline

- “Forward” analysis to infer Tion
- Issues
- Goals for FY16

We are now developing a forward model approach to infer Tion.

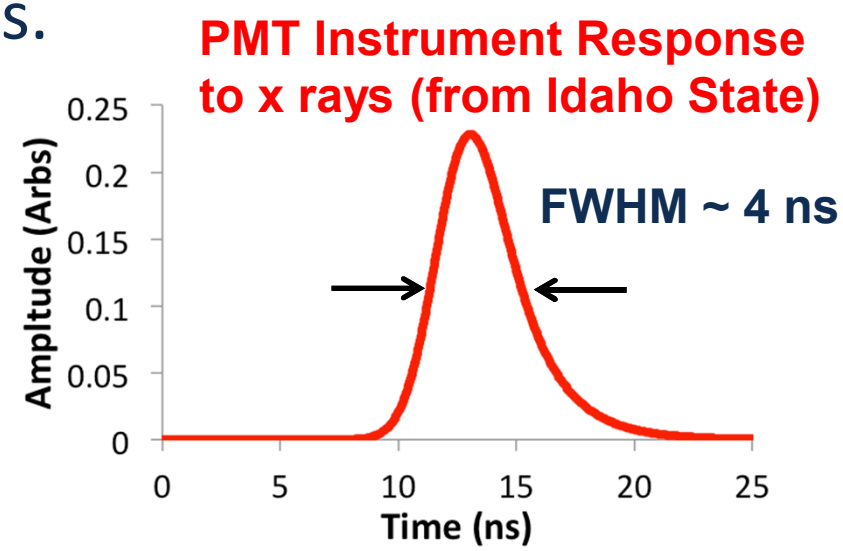
Initial nTOF forward analysis workflow

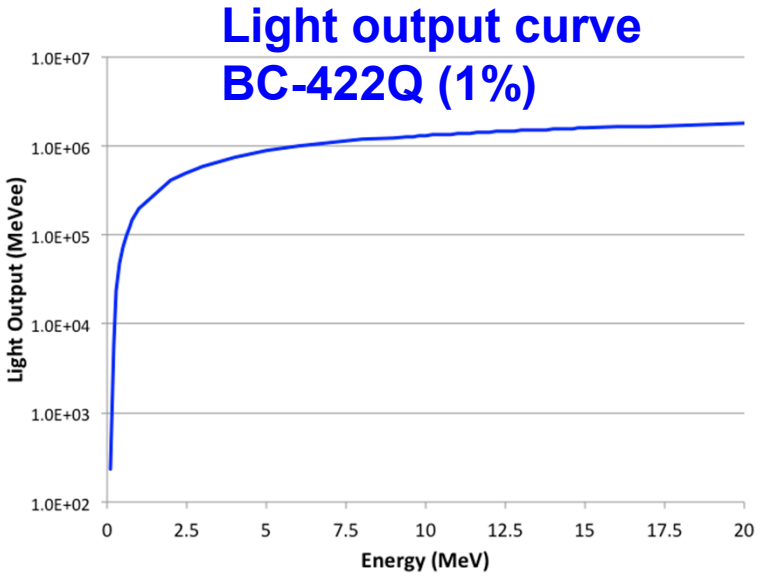


Currently, the bangtime is a fit parameter, but if we know all of the delays associated with the detectors, we can fix this parameter using the PCD signals.

The instrument response is constructed from measurements and calculations.

- PMT response
  - From 100-ps, 5 MeV brems at Idaho State accelerator (> 6 years ago)
  - Testing cosmic/coincidence technique
- Light output
  - From modified Stanton code
- Neutron attenuation/scattering
  - From “simple” MCNP model of LOS materials (does not yet capture scatter from outside LOS)
  - Note, we have lots of Pb in LOS to shield from brems



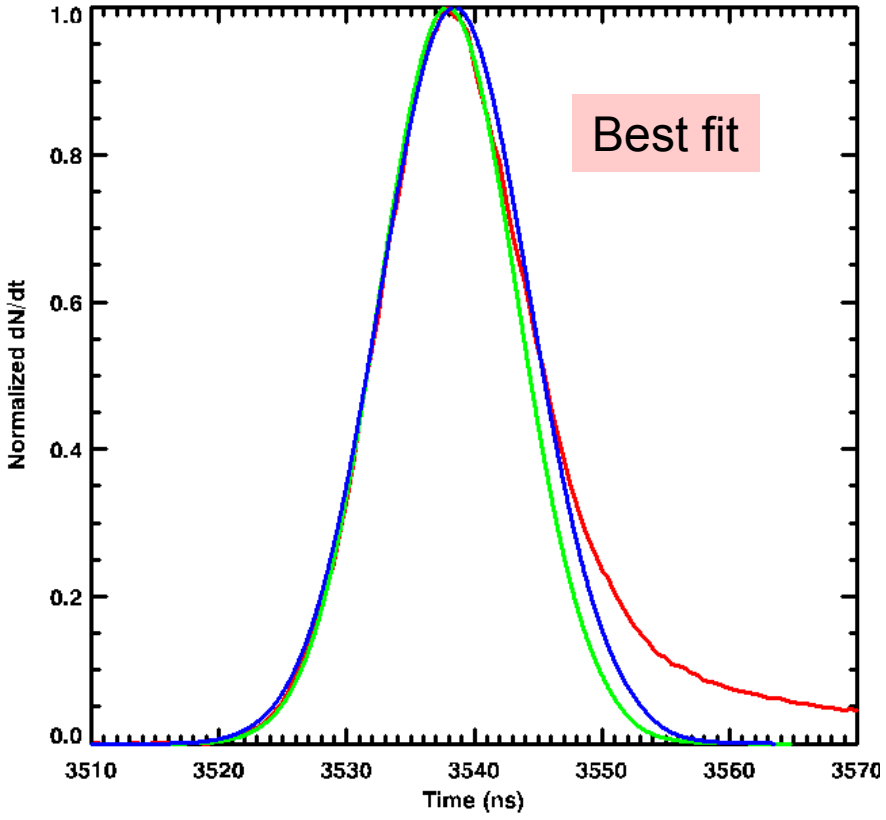


There are some issues…

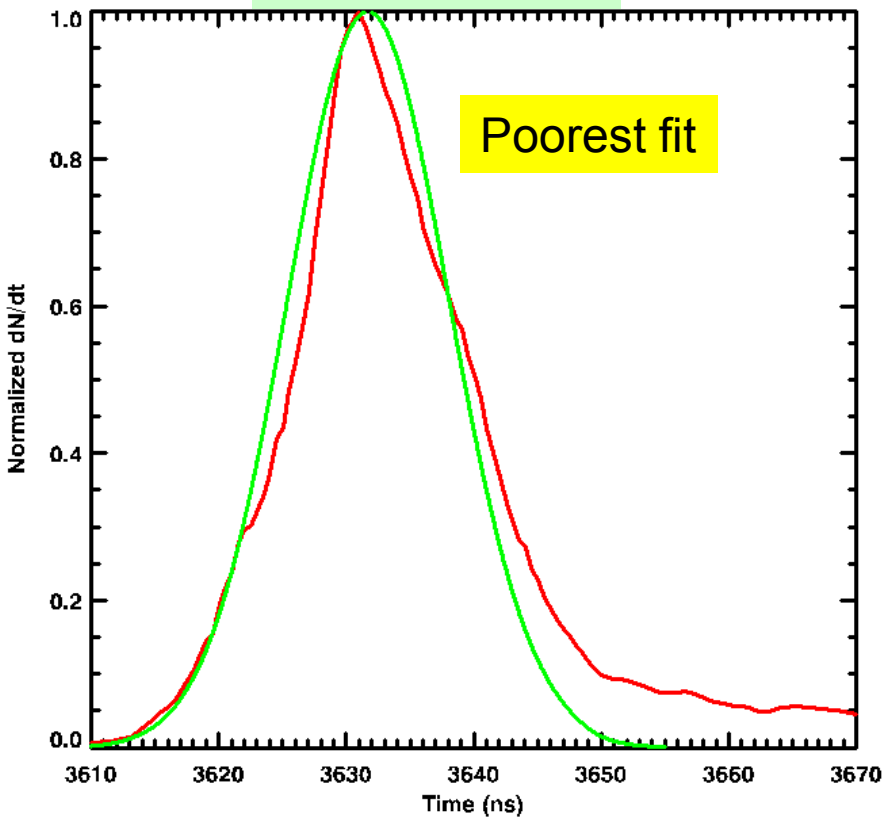
- Some signals appear more Gaussian for first 2/3rd's than others
  - The 2 farthest detectors (with very different collimation/shielding) appear "pointy" compared to closer-in signals…
  - We don't yet have a good enough understanding of the scattering on Z to argue skew/kurtosis/scoliosis and NIF-esque phenomenon
  - How should we decide what portion of signal to fit?
- If we infer Tion from all/most of our detectors, the stdev is typically ~ 30% which is what we quote for uncertainty.

Two detectors along same LOS have very different shapes. We suspect scatter issues and possibly PMT response issues...

Radial @ 9.5 m,
Low=2.6 keV High=3.1 keV



Radial @ 11.5 m,
~ 2.5 keV

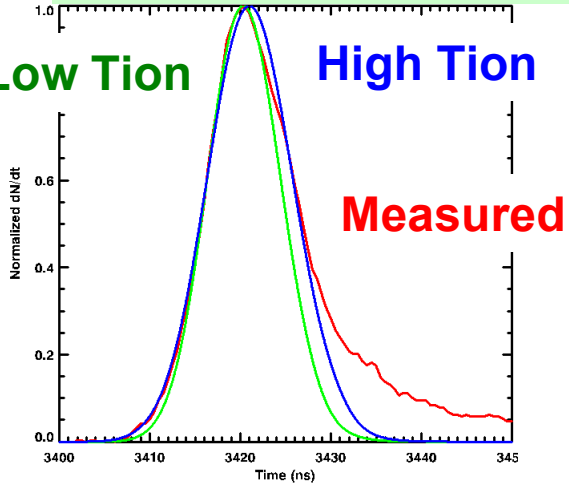


Fits are normalized here. Baseline, peak, and Tion are adjusted to optimize fit to first 2/3rd's of data.

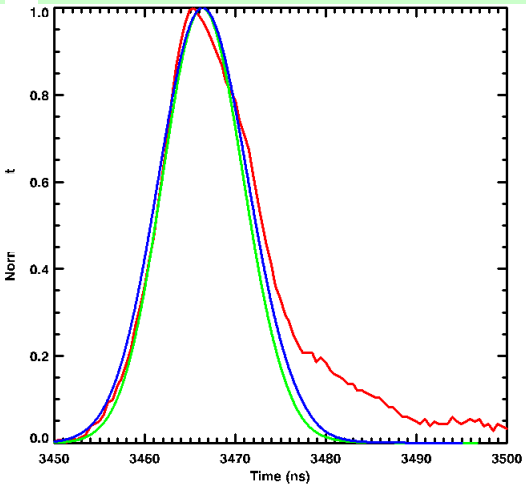
MagLIF shot 2850: 3e12 DD neutron yield,

Tion can range from 2.4 to 3.4 keV depending on portion of data used for fit

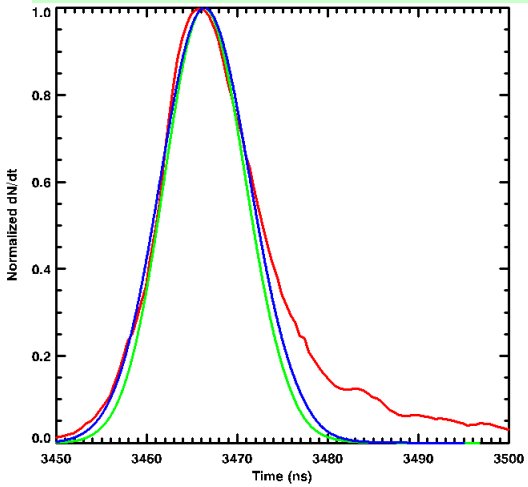
Axial @ 7 m,
Low=2.4 keV High=3.4 keV



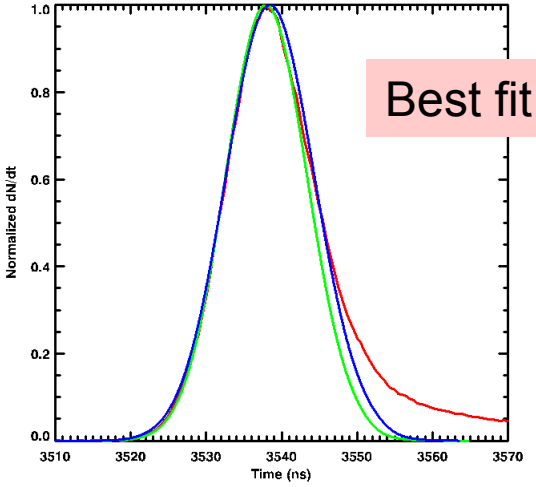
Axial @ 8 m,
Low=2.4 keV High=3.0 keV



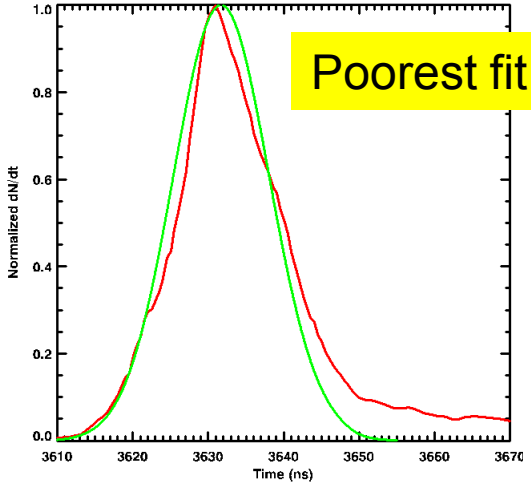
Axial @ 8 m (2nd PMT),
Low=2.4 keV High=3.0 keV



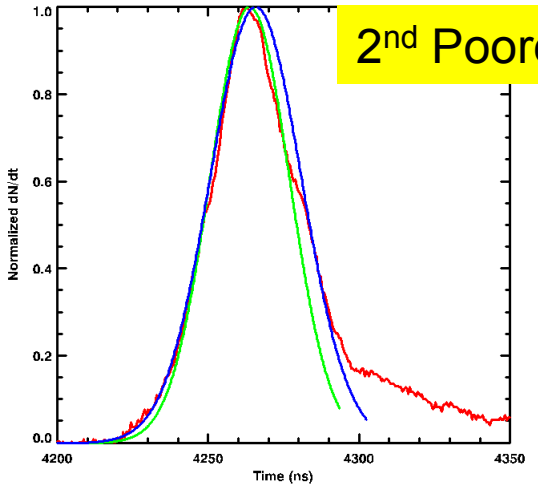
Radial @ 9.5 m,
Low=2.6 keV High=3.1 keV



Radial @ 11.5 m,
~ 2.5 keV

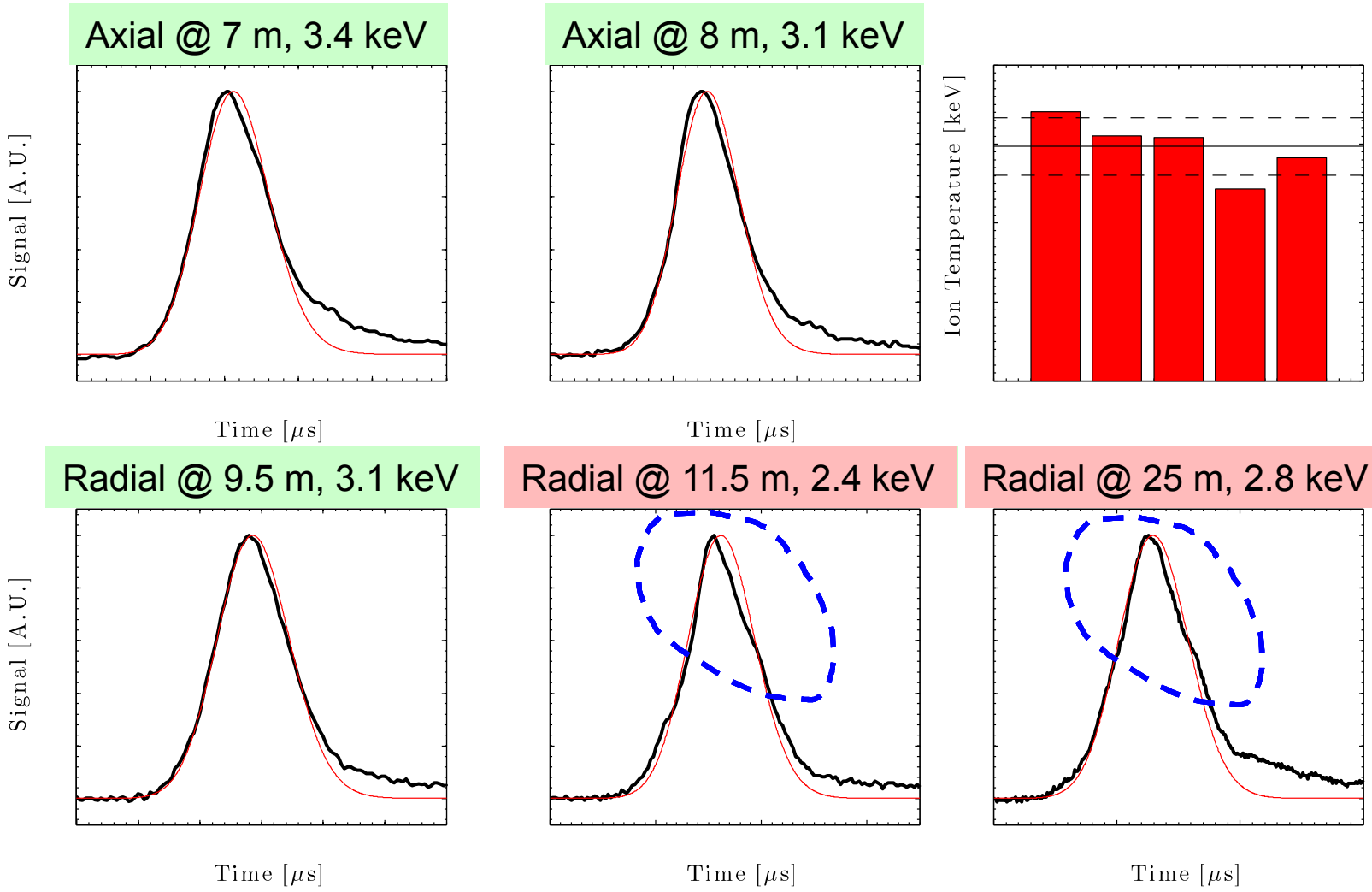


Radial @ 25 m,
Low=2.5 keV High=3.3 keV



Fits are normalized here. Baseline, peak, and Tion are adjusted to optimize fit to first 2/3rd's of data.

MagLIF shot 2850: 3e12 DD neutron yield, Tion ~ 3 keV



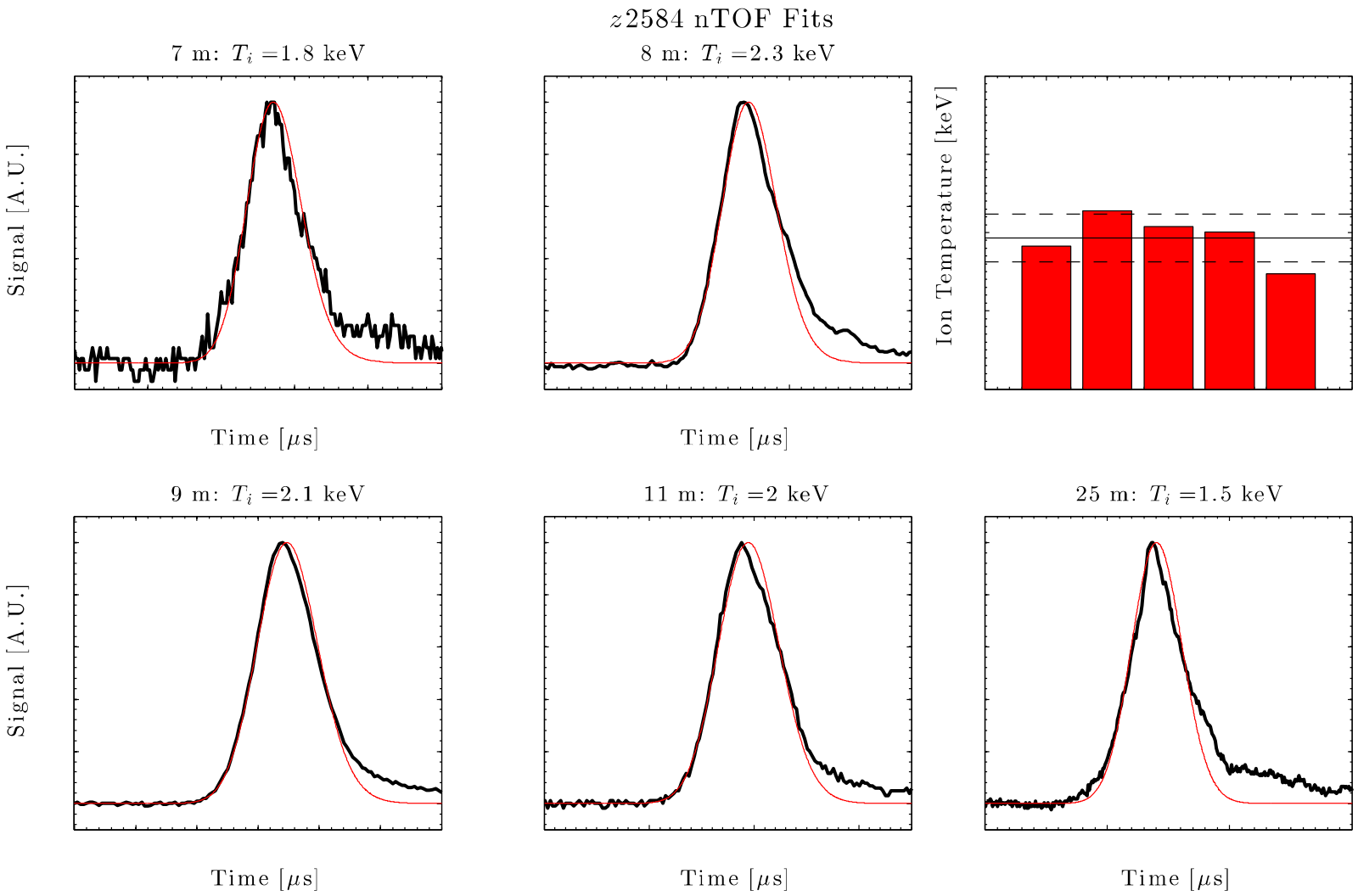
Goals for FY16

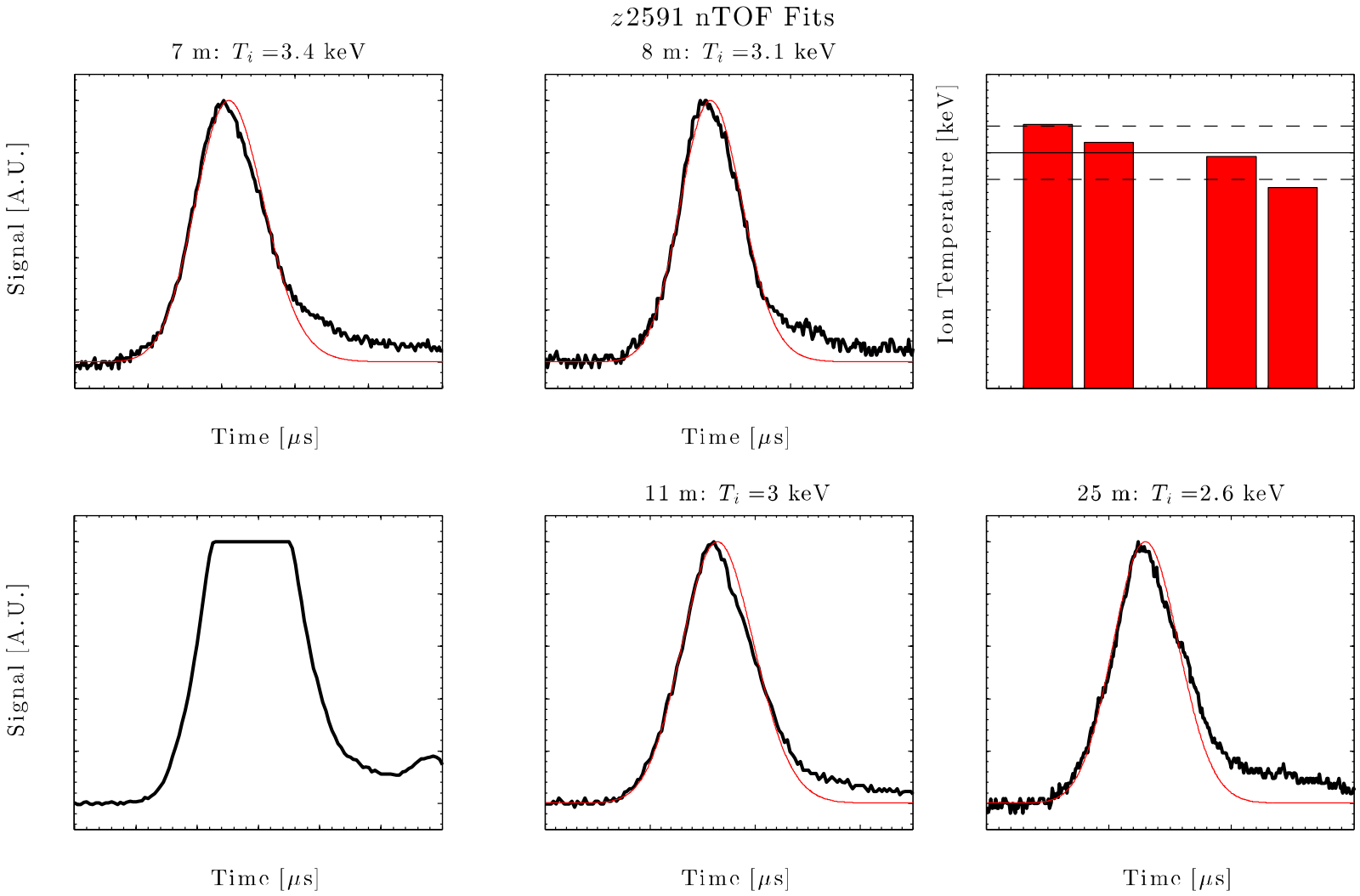
- Improve forward model for Tion with improved signal analysis features (baselining, statistical analysis, etc.).
  - Also for Tbang, Epeak, secondary DT….
- Develop more accurate MCNP models for most of the nTOF LOS's to better assess scattering effects.
  - Includes scattering studies/benchmarking
  - Propose improved designs (to be implemented in FY17?)
  - Also important for liner ρR (n-Be down-scatter) inferences
- Develop enough understanding for at least 1 radial and 1 axial detector to infer Tion with 10-15% uncertainties.

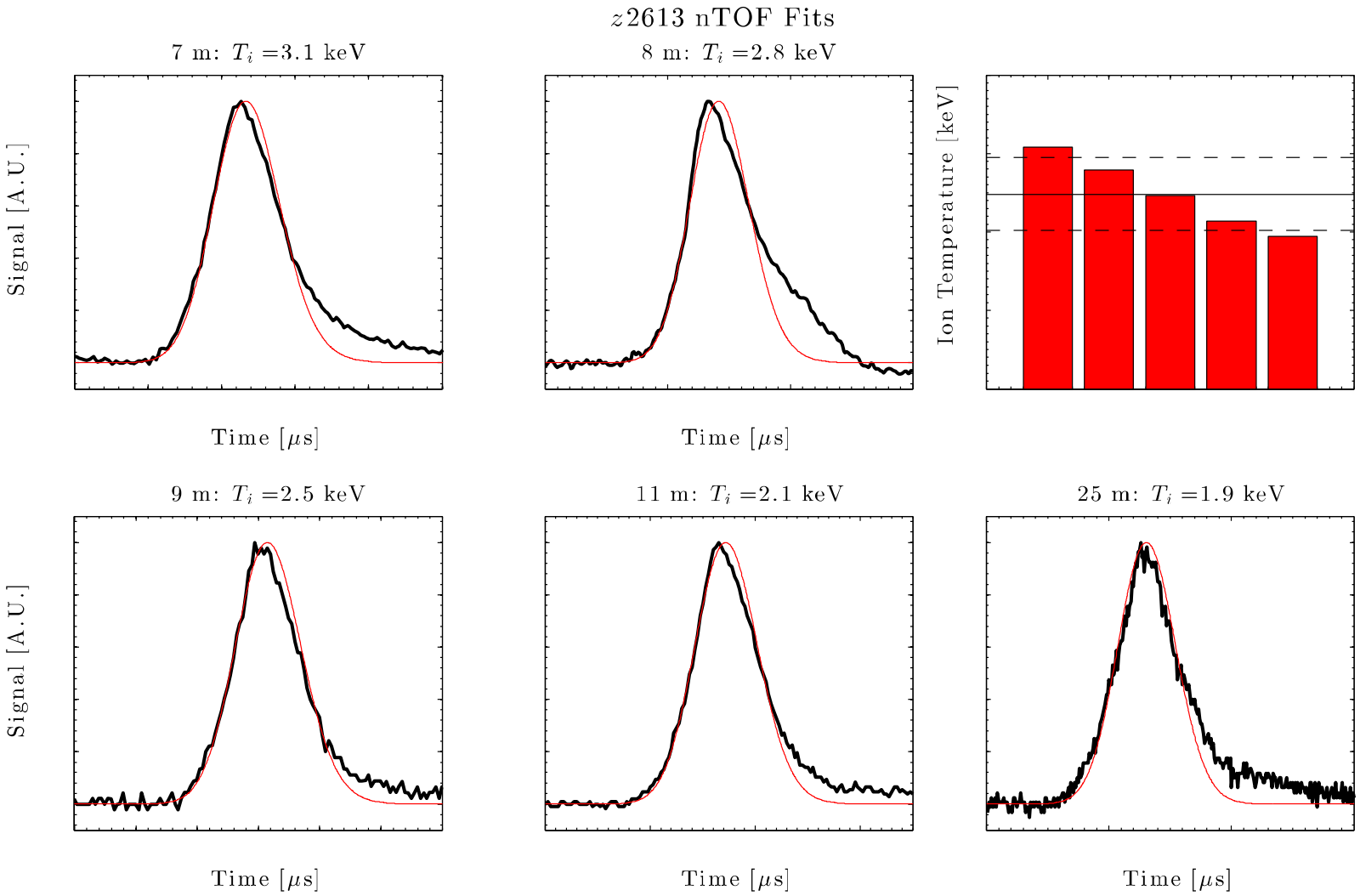
Kelly reminder questions

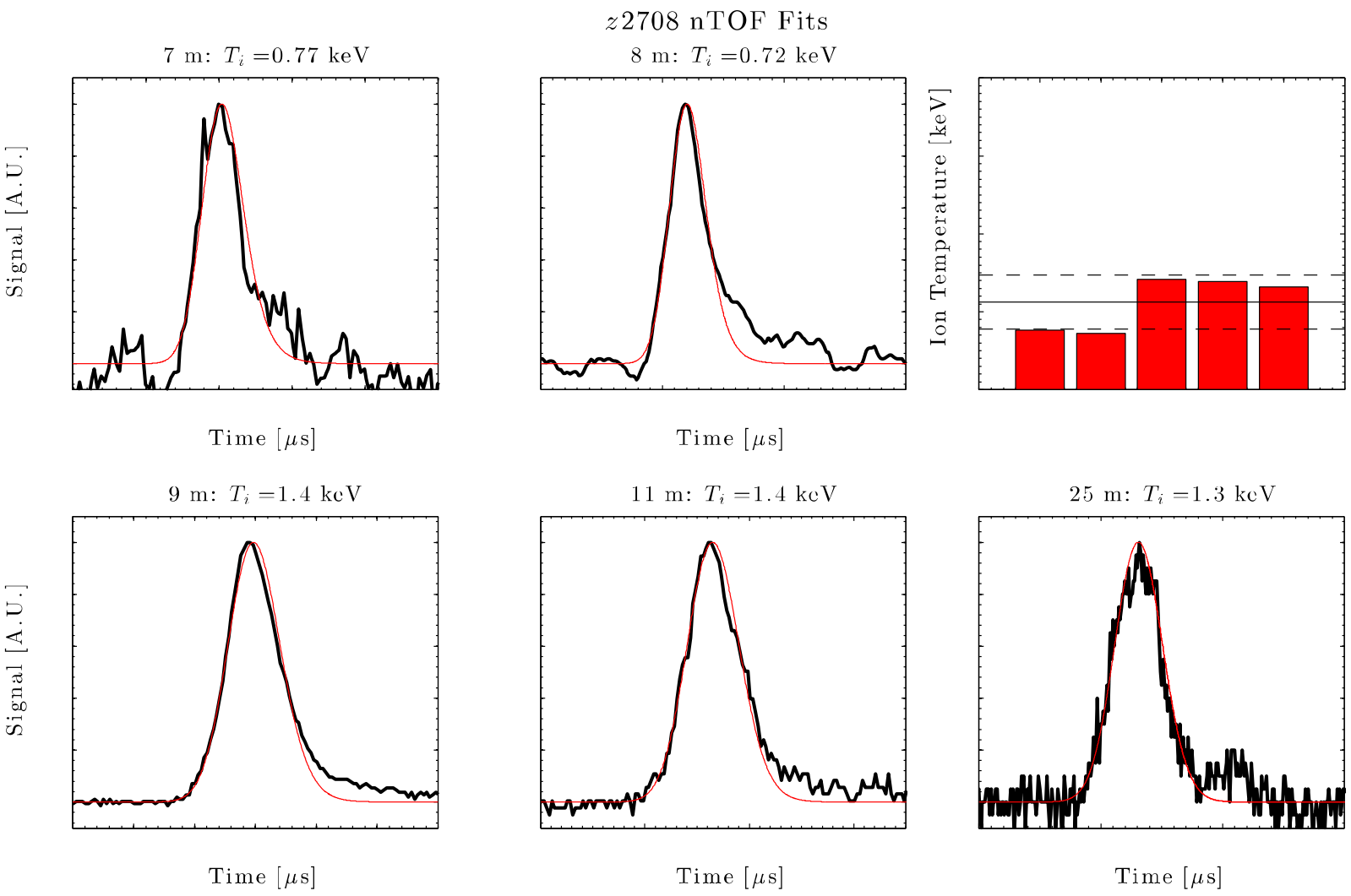
- Corrections for Pb seem to vary as func of energy in “DD” range…. Should be smoothed out? Perhaps I need to convolve with instrum response to see this effect?
- Resolution: Hamamatsu mesh-type (mod 4) PMT ~ 4 ns (photons) vs 0.5 ns digitizer time step (~ 5 keV)

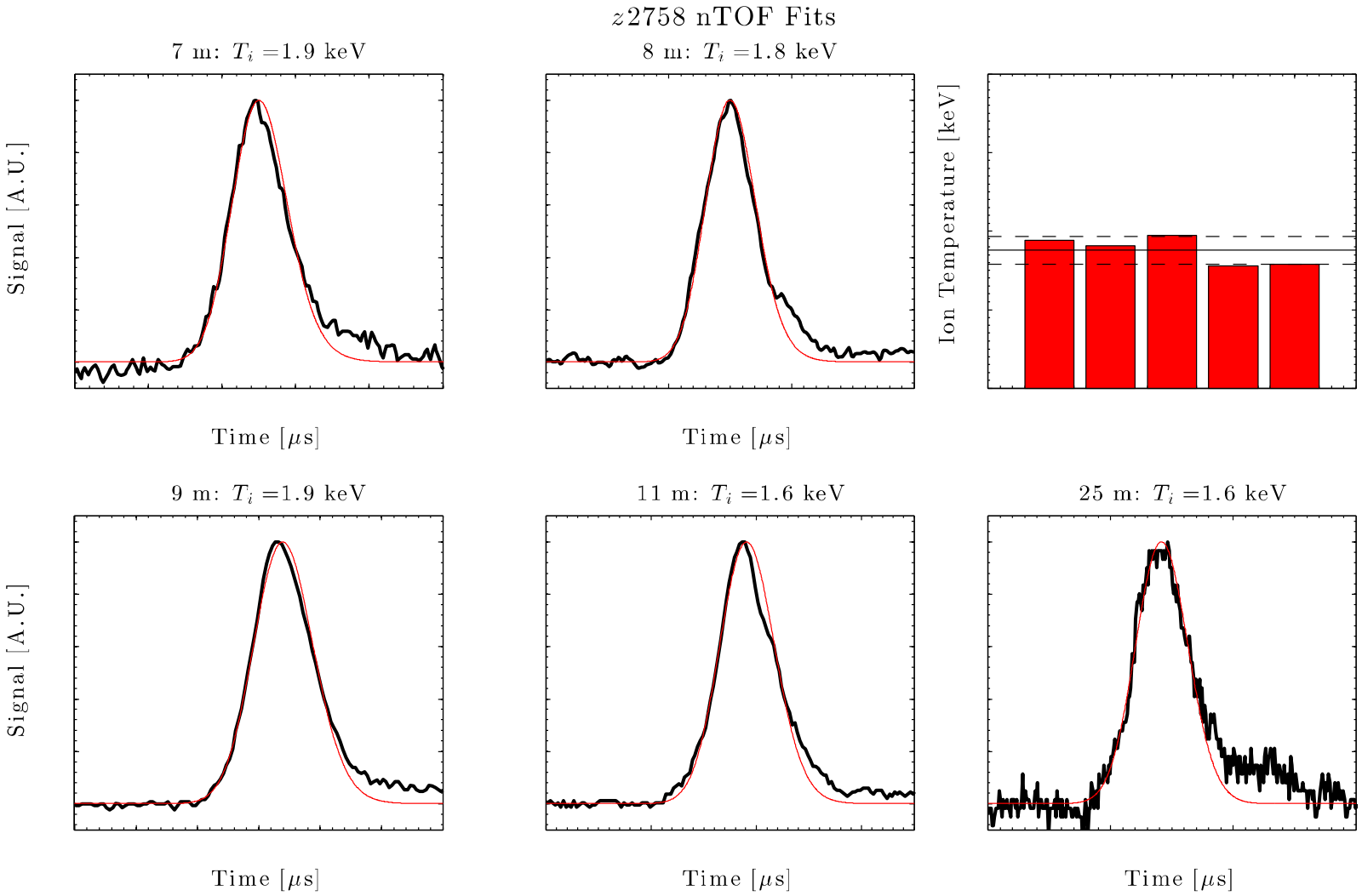
BACKUPS

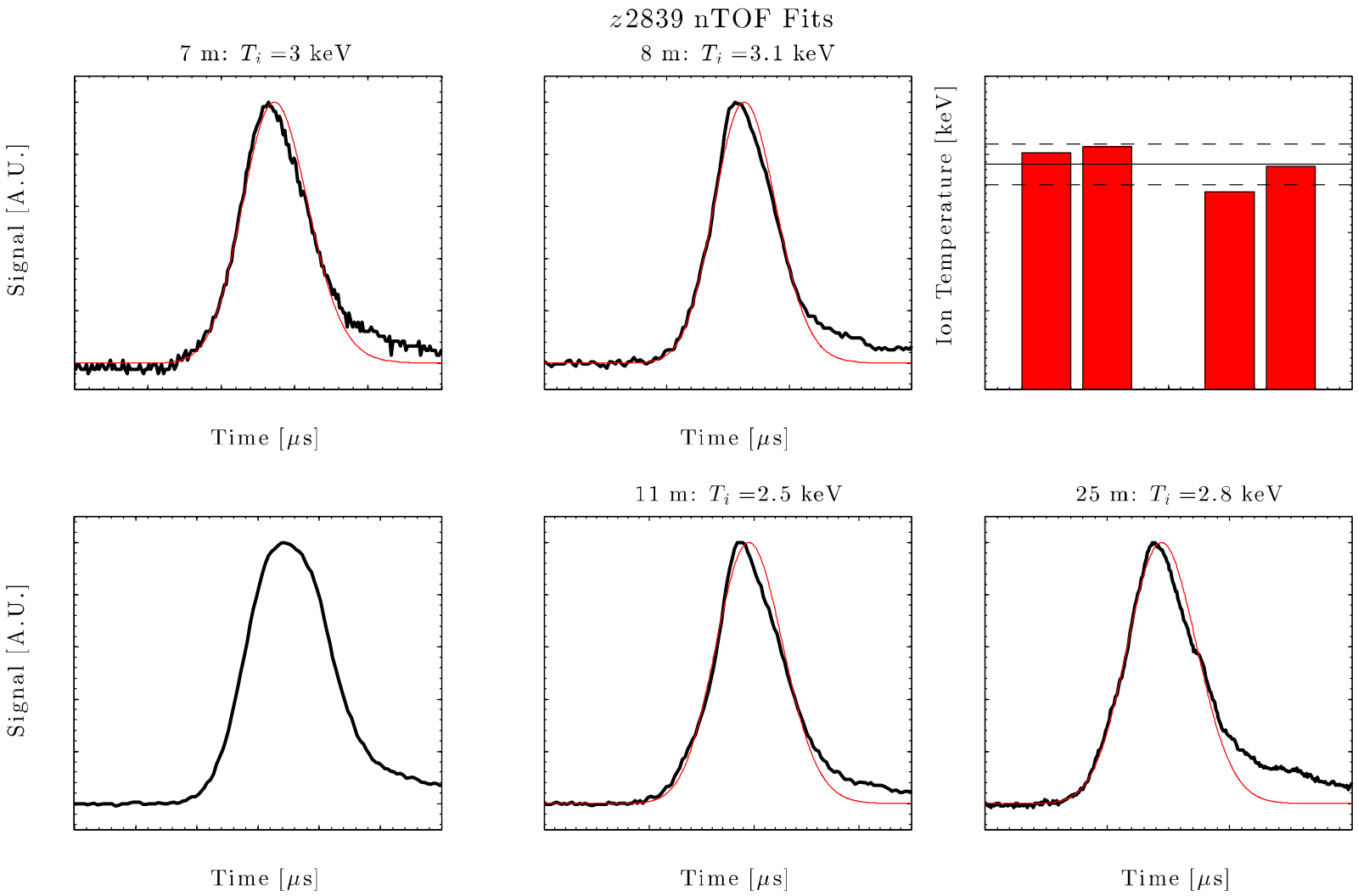

z2584 nTOF Fits
7 m: T_i =1.8 keV
8 m: T_i =2.3 keV
Signal [A.U.]
Time [μs]
Time [μs]
Ion Temperature [keV]
9 m: T_i =2.1 keV
11 m: T_i =2 keV
25 m: T_i =1.5 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]

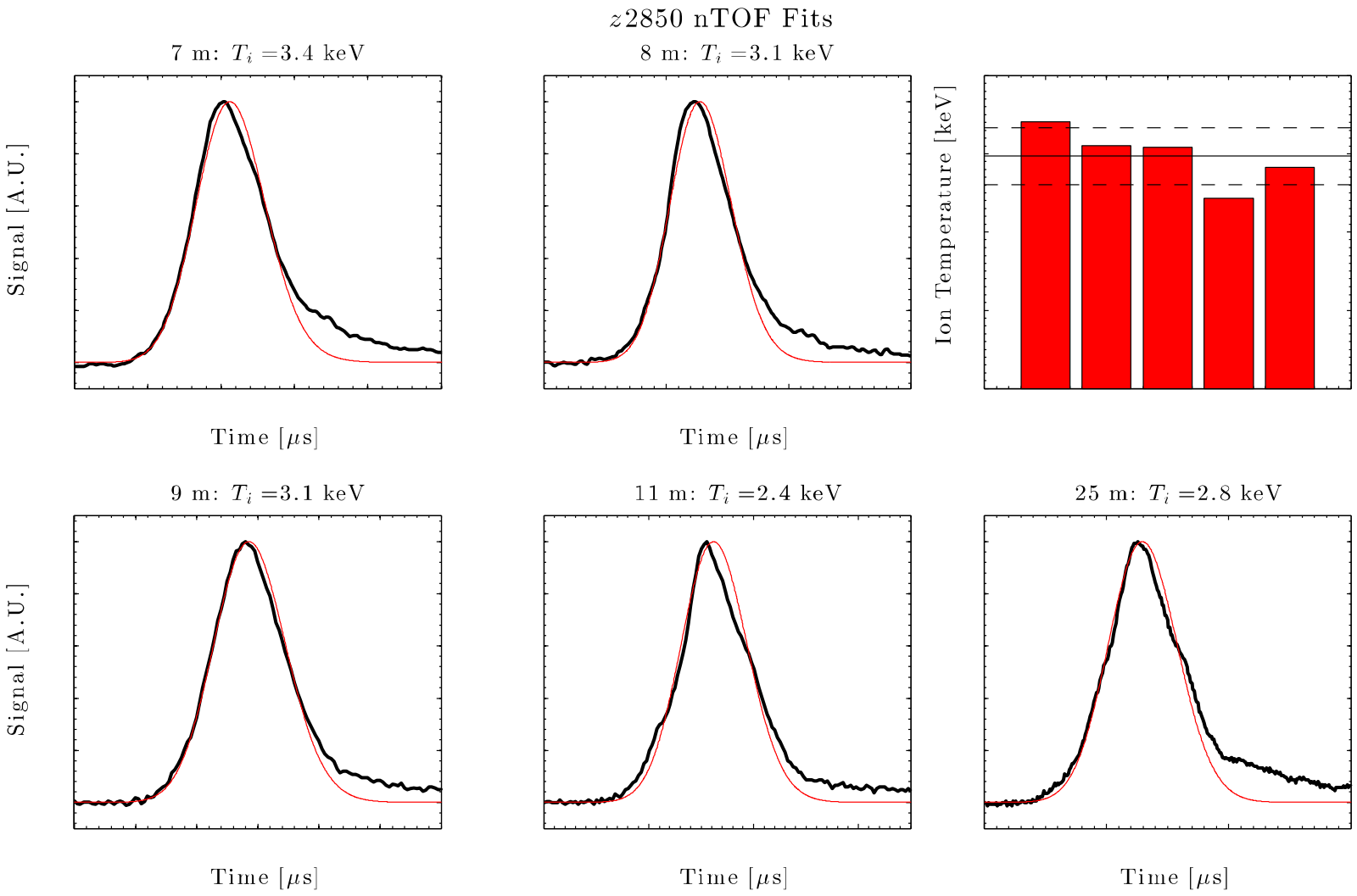

z2591 nTOF Fits
7 m: T_i =3.4 keV
8 m: T_i =3.1 keV
Signal [A.U.]
Time [μs]
Time [μs]
Ion Temperature [keV]
11 m: T_i =3 keV
25 m: T_i =2.6 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]

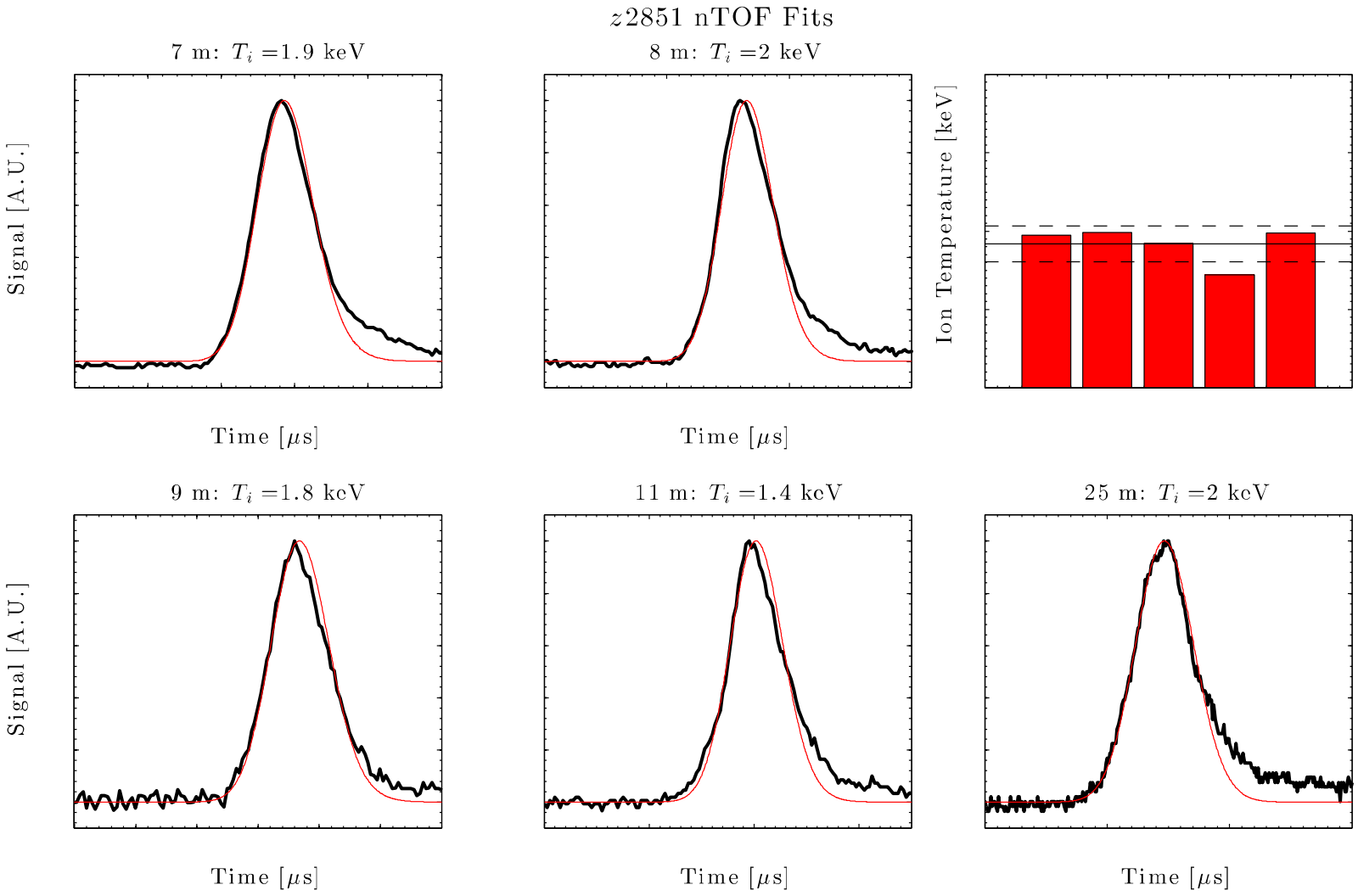

z2613 nTOF Fits
7 m: T_i =3.1 keV
8 m: T_i =2.8 keV
Signal [A.U.]
Ion Temperature [keV]
Time [μs]
Time [μs]
9 m: T_i =2.5 keV
11 m: T_i =2.1 keV
25 m: T_i =1.9 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]

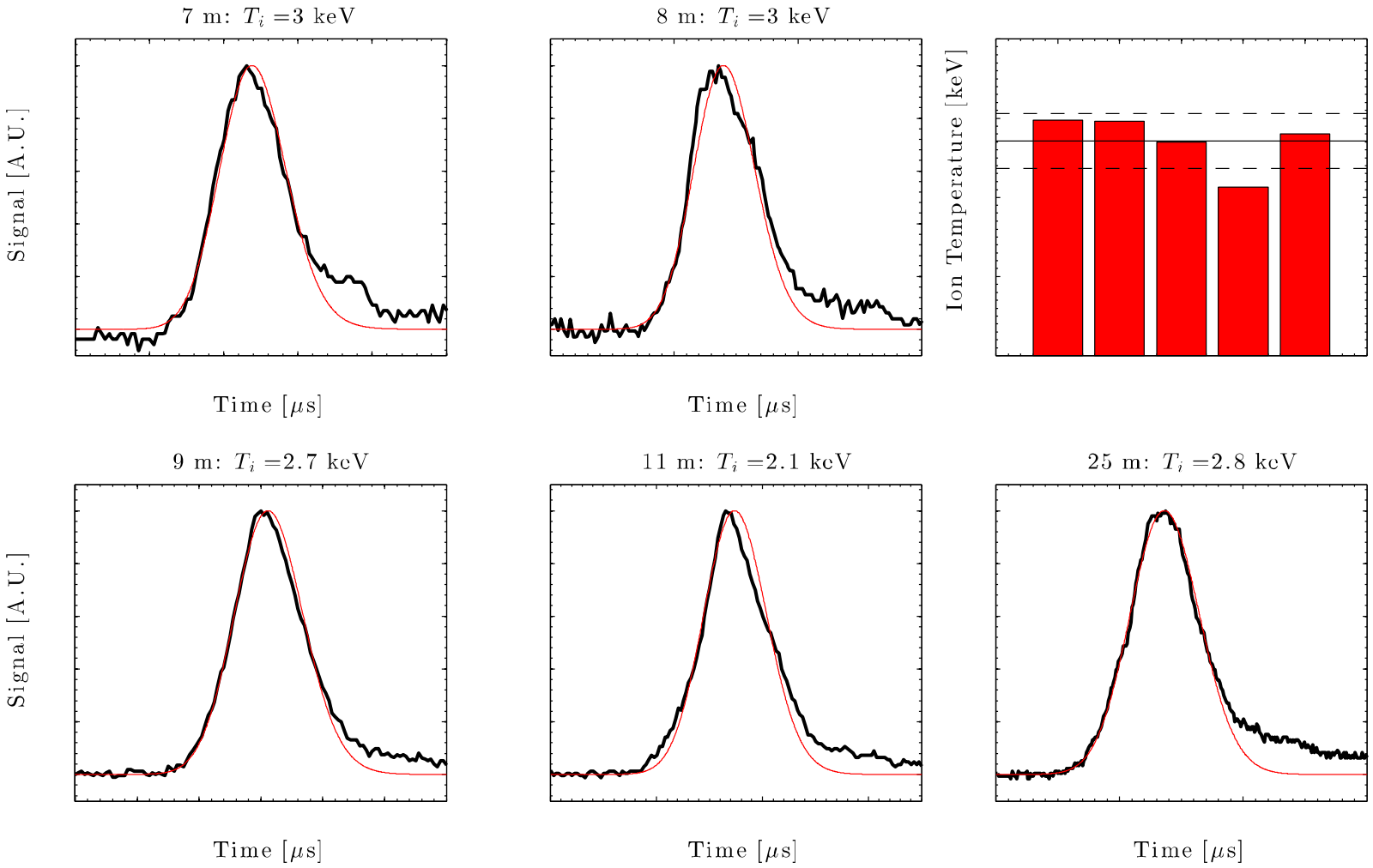

z2708 nTOF Fits
7 m: T_i =0.77 keV
8 m: T_i =0.72 keV
Signal [A.U.]
Time [μs]
Time [μs]
Ion Temperature [keV]
9 m: T_i =1.4 keV
11 m: T_i =1.4 keV
25 m: T_i =1.3 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]

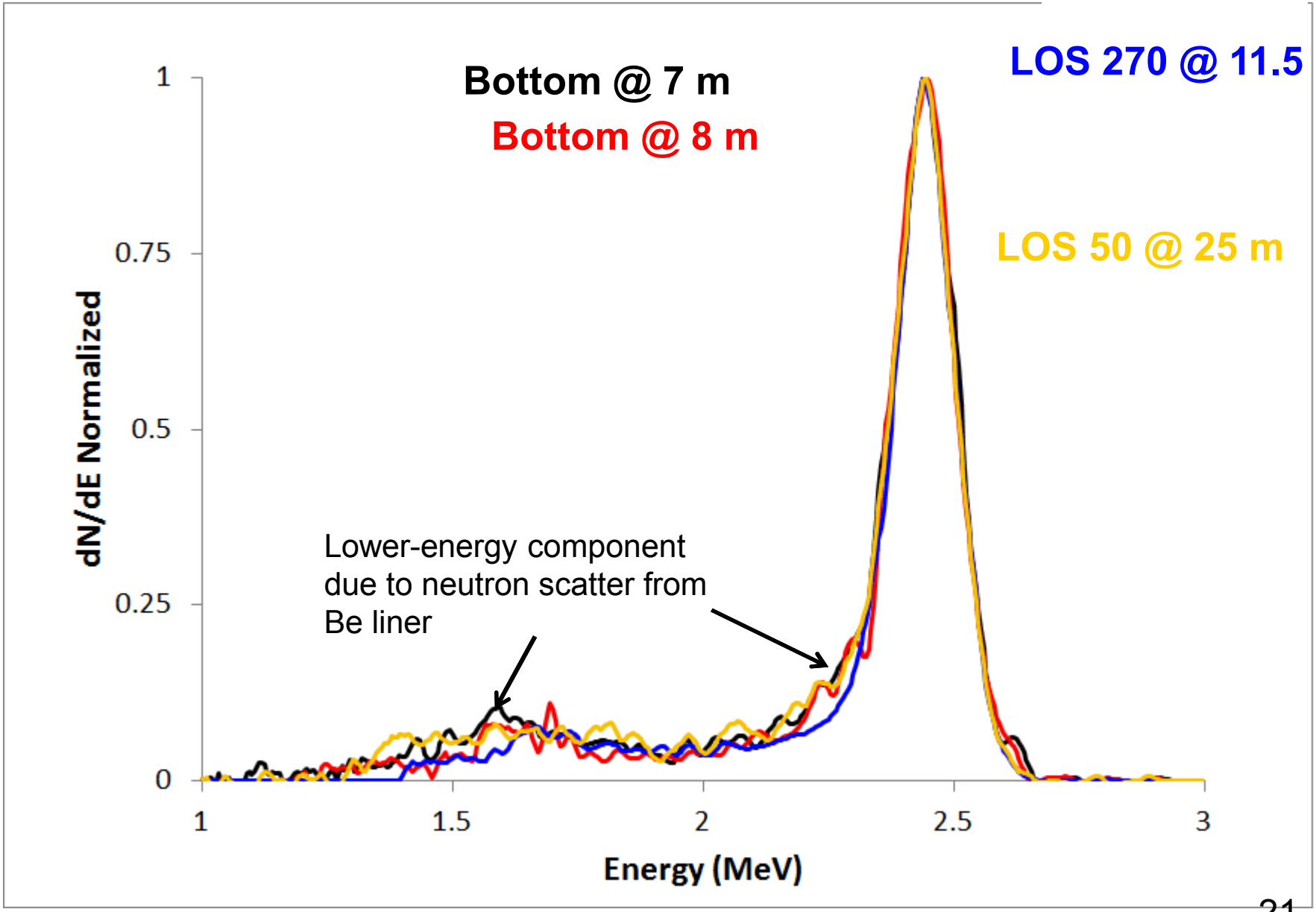

z2758 nTOF Fits
7 m: T_i =1.9 keV
8 m: T_i =1.8 keV
Signal [A.U.]
Ion Temperature [keV]
Time [μs]
Time [μs]
9 m: T_i =1.9 keV
11 m: T_i =1.6 keV
25 m: T_i =1.6 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]


z2839 nTOF Fits
7 m: T_i =3 keV
8 m: T_i =3.1 keV
Signal [A.U.]
Time [μs]
Time [μs]
Ion Temperature [keV]
11 m: T_i =2.5 keV
25 m: T_i =2.8 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]

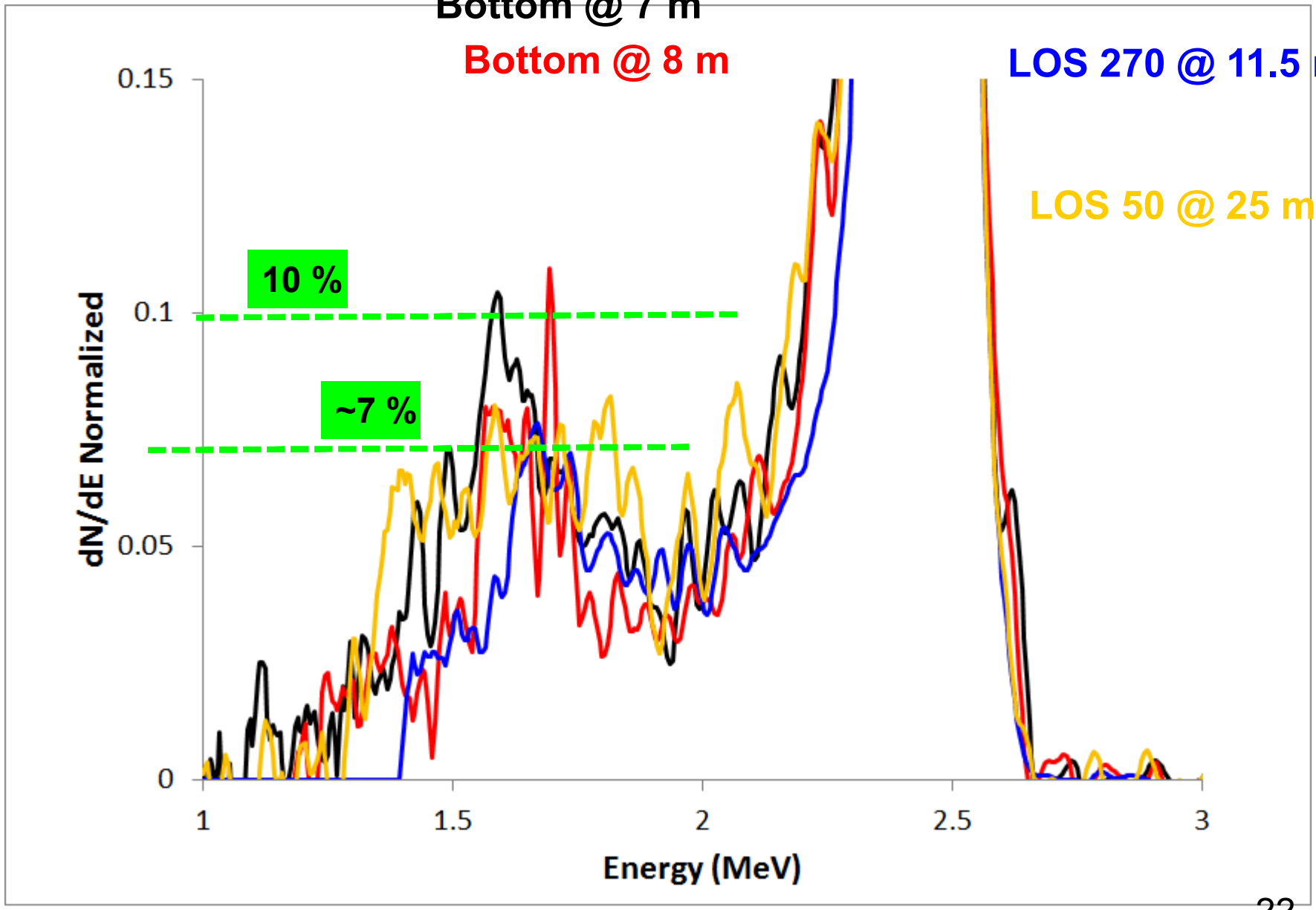

z2850 nTOF Fits
7 m: T_i =3.4 keV
8 m: T_i =3.1 keV
Signal [A.U.]
Time [μs]
Time [μs]
Ion Temperature [keV]
9 m: T_i =3.1 keV
11 m: T_i =2.4 keV
25 m: T_i =2.8 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]


z2851 nTOF Fits
7 m: T_i =1.9 keV
8 m: T_i =2 keV
Signal [A.U.]
Time [μs]
Time [μs]
Ion Temperature [keV]
9 m: T_i =1.8 kcV
11 m: T_i =1.4 kcV
25 m: T_i =2 kcV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]


z2852 nTOF Fits
7 m: T_i =3 keV
8 m: T_i =3 keV
Signal [A.U.]
Ion Temperature [keV]
Time [μs]
Time [μs]
9 m: T_i =2.7 keV
11 m: T_i =2.1 keV
25 m: T_i =2.8 keV
Signal [A.U.]
Time [μs]
Time [μs]
Time [μs]



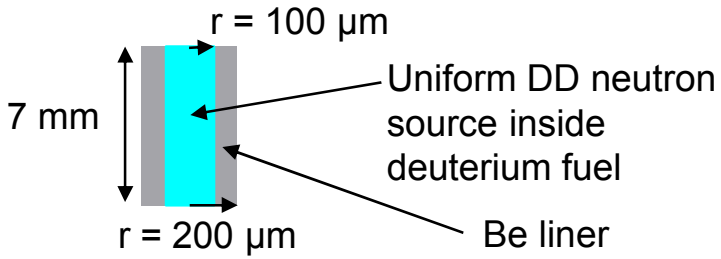
All waveforms have been corrected for instrument response, LO, and atten/scat.
All waveforms were boxcar smoothed.



All waveforms have been corrected for instrument response, LO, and atten/scat.
All waveforms were boxcar smoothed.

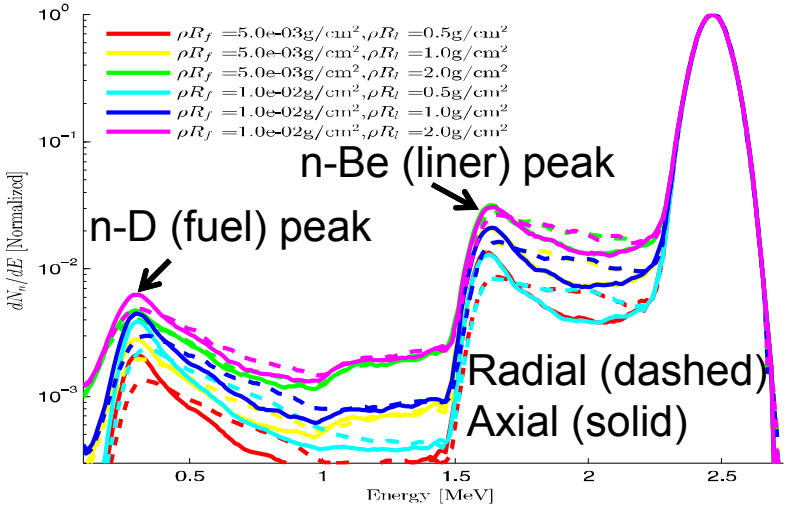
Down-scattered neutrons from Be liner reveal information about *liner* areal density.

- **Neutron down-scattering simulations (MCNP, MonteBurns) show how fuel and liner areal densities affect neutron spectra.**

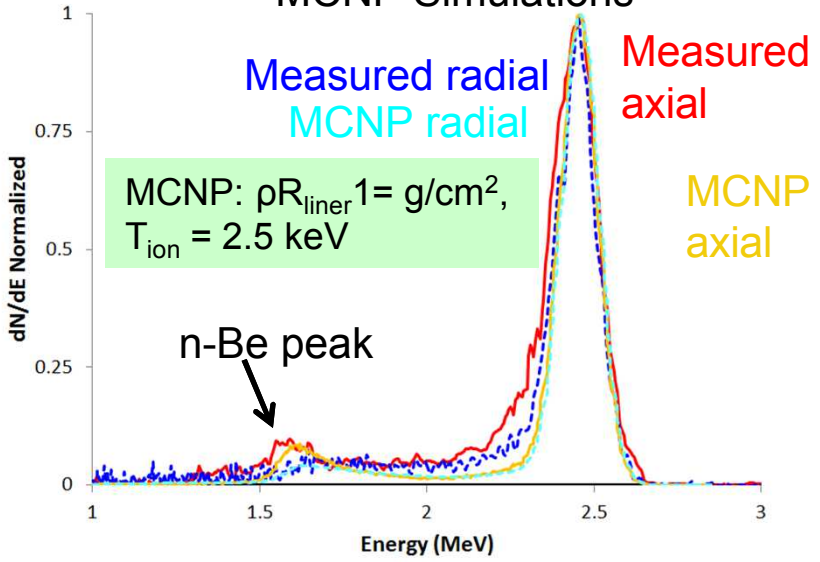


- **Measured ~1.6 MeV peaks associated with n-Be down-scatter from liner suggest ρR_{liner} ~ 1 g/cm^2.**
  - Differences between measured and simulated scattering tails are likely due to additional scattering in surrounding hardware.
  - Agrees with x-ray spectroscopy measurements[17] and simulations.

MonteBurns Simulations



Measured Spectra Compared to MCNP Simulations



MCNP:
$\rho R_{liner}1$= g/cm^2, T_{ion} = 2.5 keV