LIDAR TS for ITER Core Plasma,

Part 3: Calibration and Higher Edge Resolution

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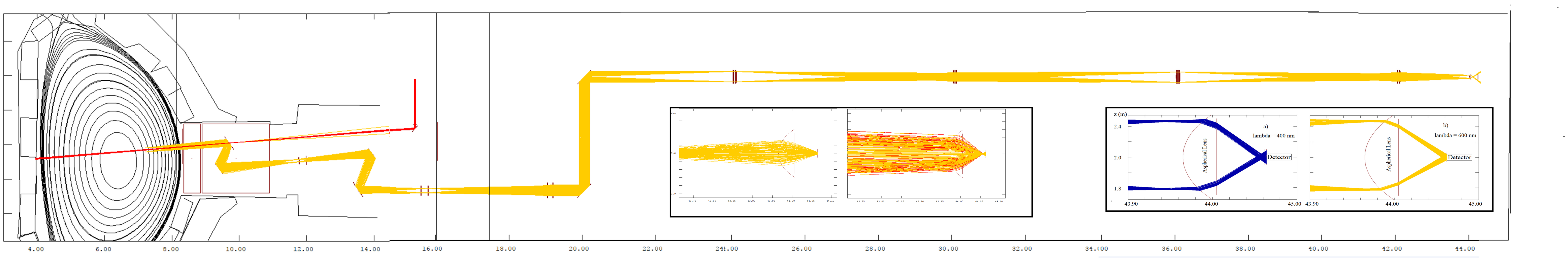


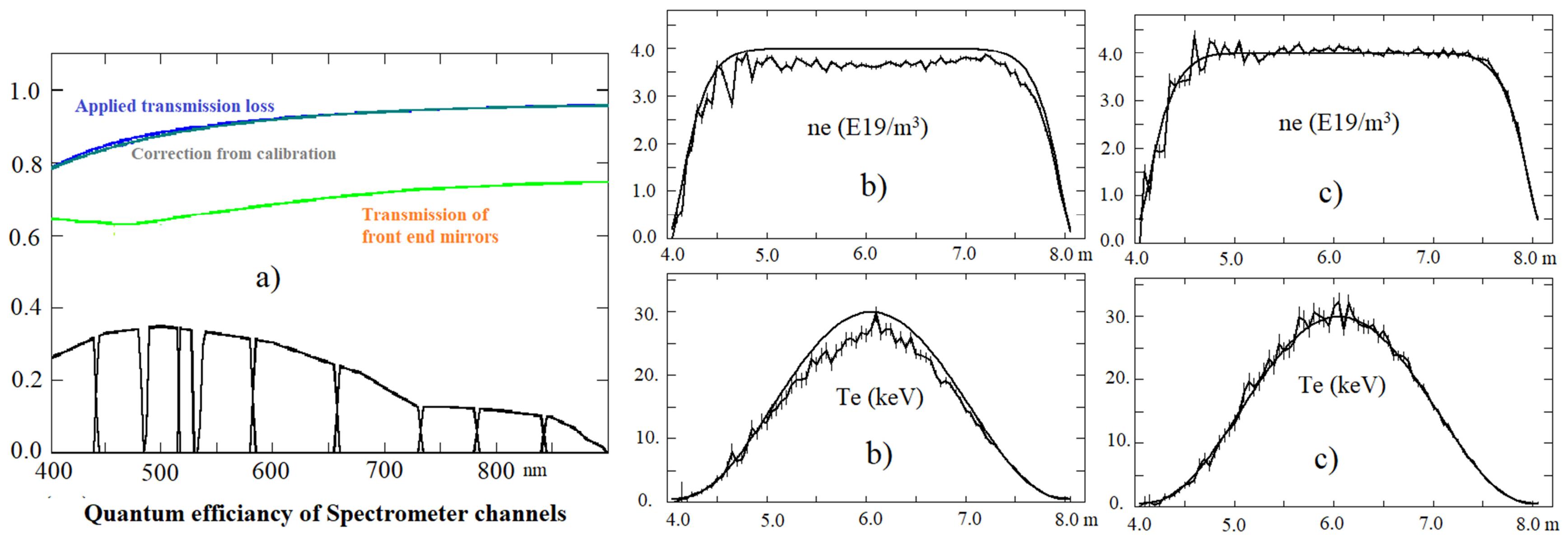
A layout of the full collection optics, illustrating also the laser beam path. Mirrors M1, M3, M5 and M6 are plane mirrors. Apart from M1 these mirrors are used for aligning the system. A number of plano convex lenses (L1-L5) are used inside the biological wall. To transport the signal to the spectrometer we use 4 relay lens pairs, R1-R4. The 8 lenses are 30 cm diameter achromates. The "Spectrometer" is simulated by using an aspheric lens. The inset shows the images of two random ray bundles. The origin of the two bundles are the extremes og the "Window Image" at R = 7.2 m. The aspheric lens approach demomstates that it is possible to maintain the D/F = 10 mm imaging without significant distortion. It also shows that the remaining chromatic effect can be handled by positioning the positioning of the detectors in the respective spectrometer channels.

Calibrations

In principal **LIDAR TS does not require any calibrations** after initial installation. The simple alignment system makes certain that the variation of solid angle with scattering position does not change, The system is in any case insensitive to small misalignments in relation to the outer half of the plasma.

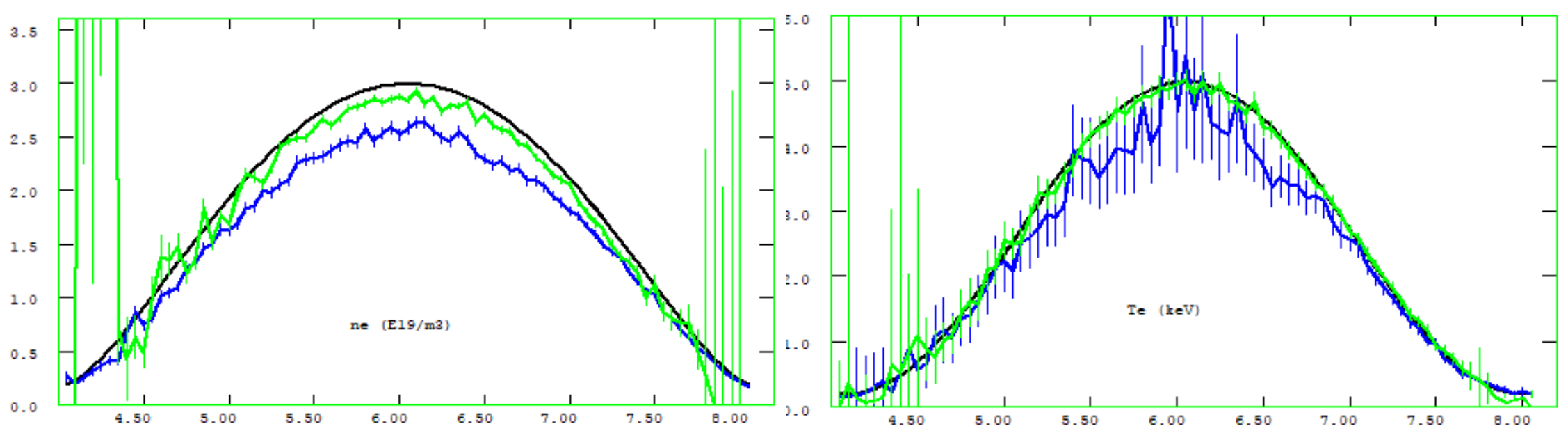
The only inaccessible elements that require calibration are the two front optics metal mirrors. The transmission of these mirrors is likely to change with time.

It is essential that changes in the optical transmission is monitored at all times and that corrections to the transmission can be corrected without acces to vessel.

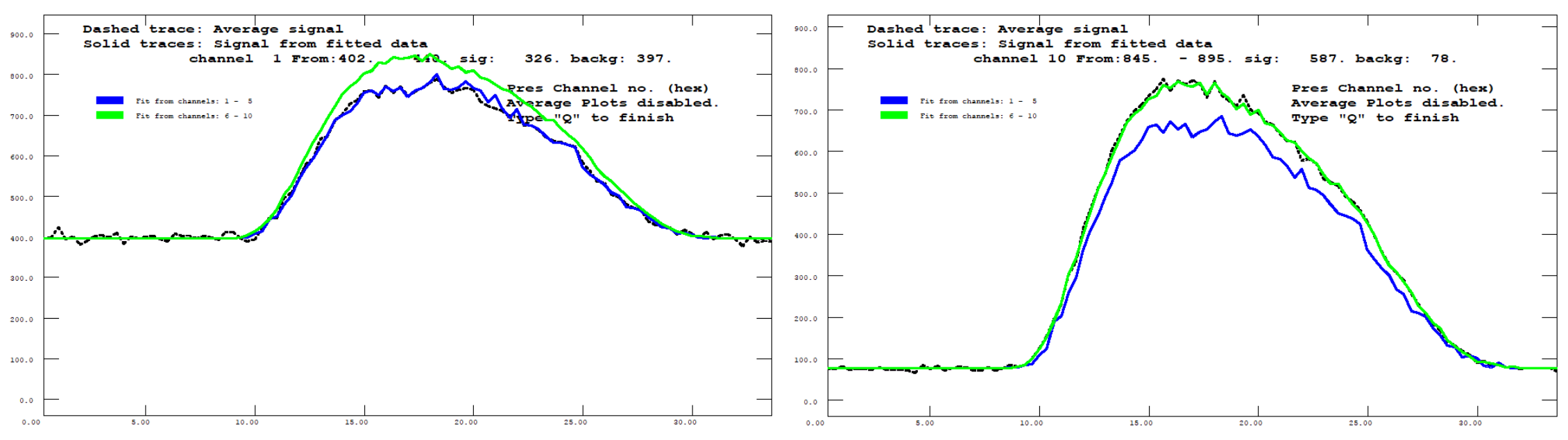


In the simulations we introduce an artificial change of the transmission. The change is illustrated in (**a**) "Applied transmission loss". Fitting these new data with the "old" transmission yields the results shown in (**b**), showing the fit relative to the input data.

How would we learn that this wrong, apart from a small increase in the chi-square value?



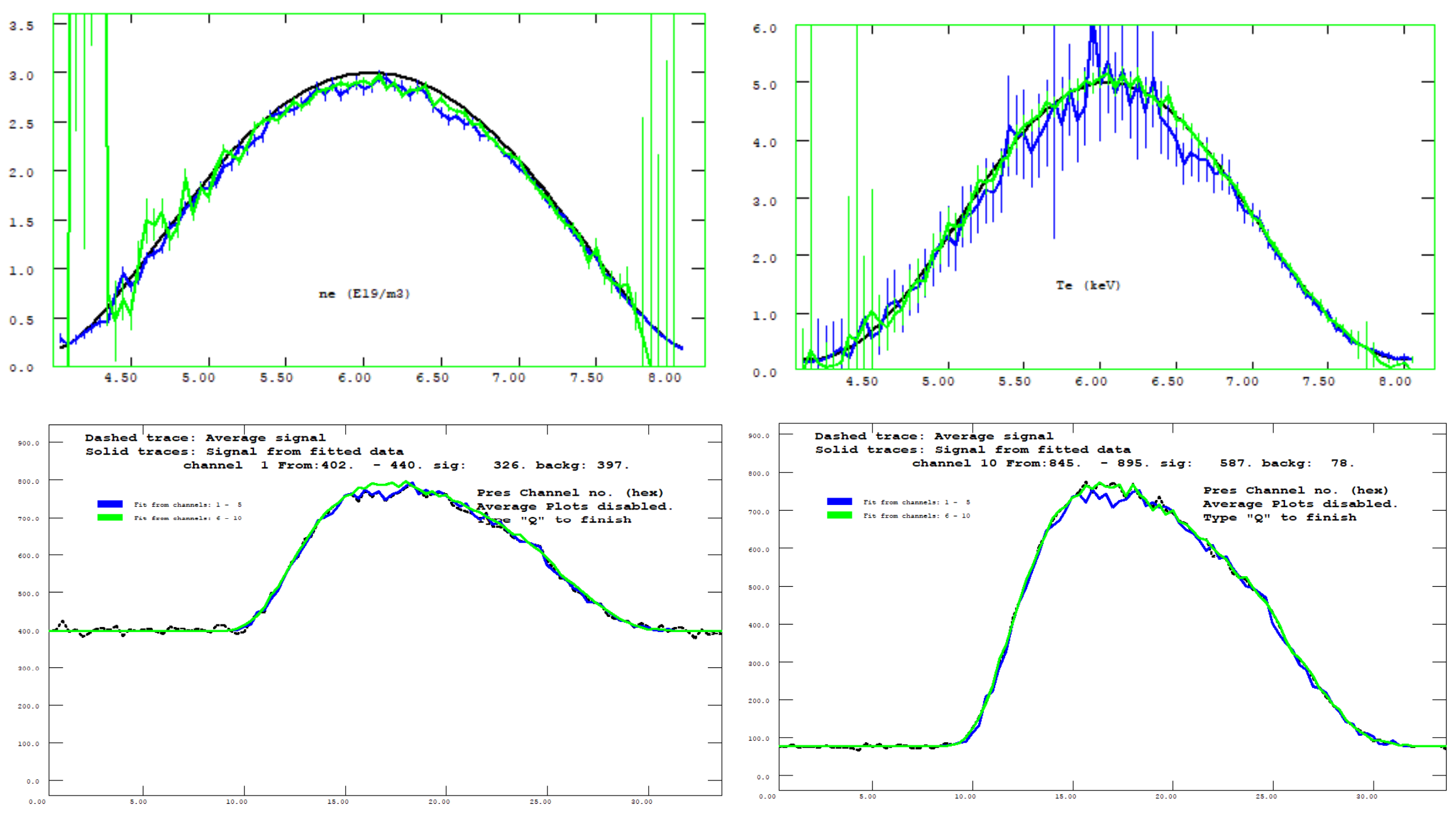
At low temperature (<6-7 keV) the spectra from each of the two wavelengths barely overlap. This allows us to make two independent fits to the data. The fit shown is based on an average of 10 measurements.



Using each of the two fits we can calculate the expected signals and compare to the measured signals. This can in principle be used to work out the transmission loss!

At low temperatures we find that the deviation of the fit is not too different from the input data. Assuming the fitted profiles, using all channels, to be correct, we can simply calculate the correction factor to the spectral channels required to match the measured data. We then make a second order fit to the correction values:

$$Corr(\lambda) = c1 + c2 *(1/\lambda) + c3 *(1/\lambda)2$$



Using this correction and testing again with the two independent fits we see that the calculated signal agrees with the measured signal.

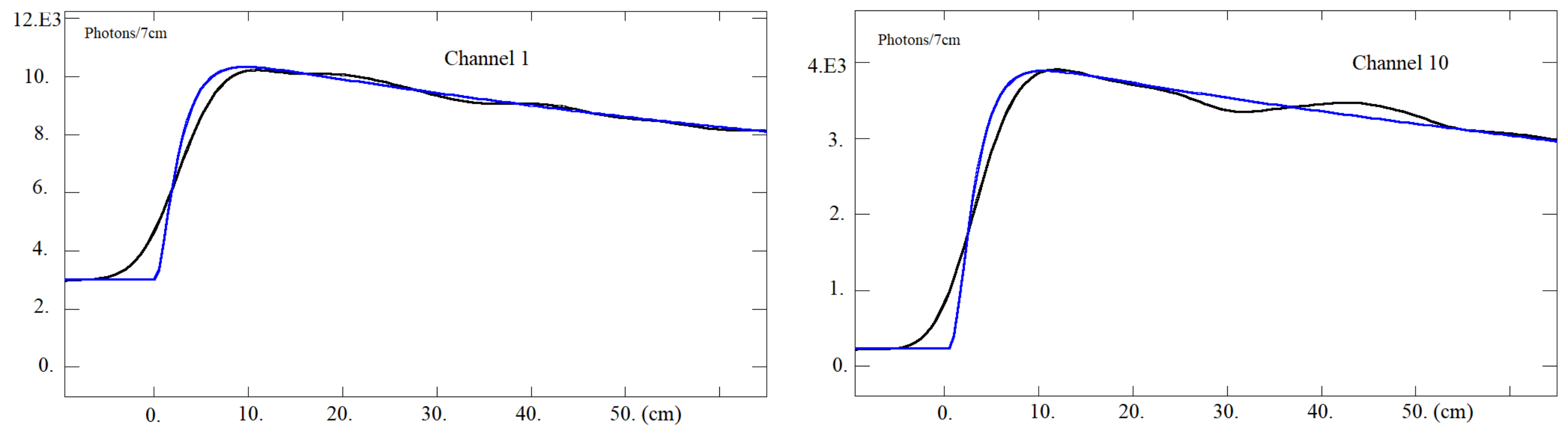
Using finally the line integral comparison we determine the coefficient c1.

This correction is sufficient to bring the diagnostic within specifications.

NOTE: The accuracy without correction was apparently also within specifications, demonstrating the need for constant monitoring.

H-mode edge gradient

A "weakness" of LIDAR-TS, it is claimed, is the limited spatial resolution. It is not clear to us why you need better spatial resolution inside |r/a| < 0.85. The region where you do need better resolution is near the edge to determine the edge gradient of H-mode plasmas. Therefore, what is the resolution required and can LIDAR-TS fill the gap of the 0.85 < r/a < 1? The specification of the Edge TS system is a resolution of 0.5 cm [5], the actual barrier region being several cm wide.



When the barrier region is shorter than our resolution the laser beam sees a kind of step function. The measured signals will all, to some extent display the leading part of our detection response function. The figure shows the scattered signals in two channels compared to the non convoluted input data.

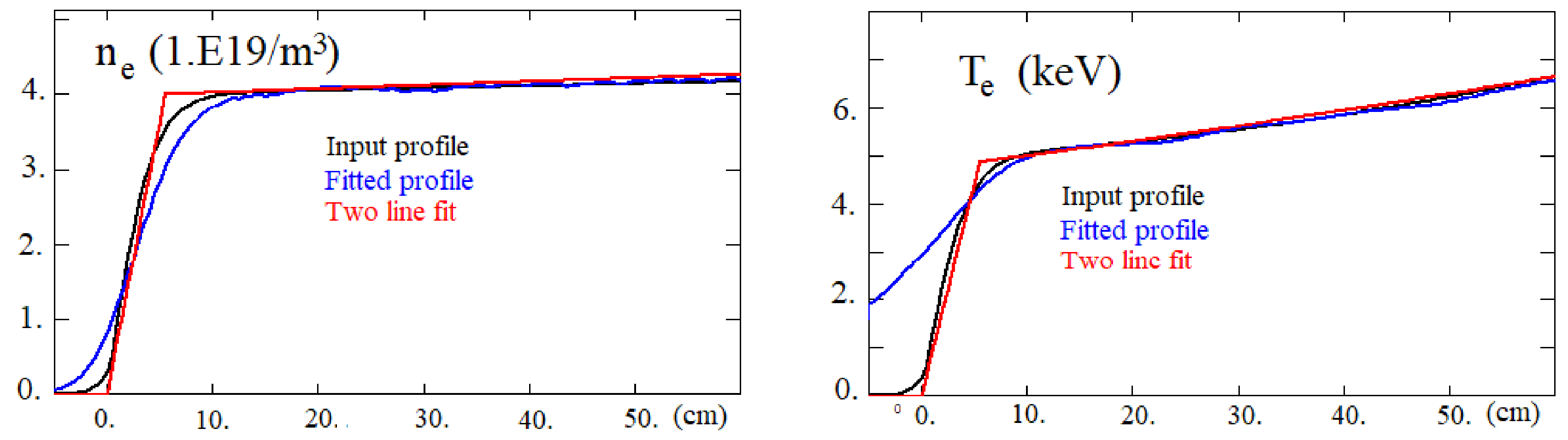
Deconvolution of individual channel signals?

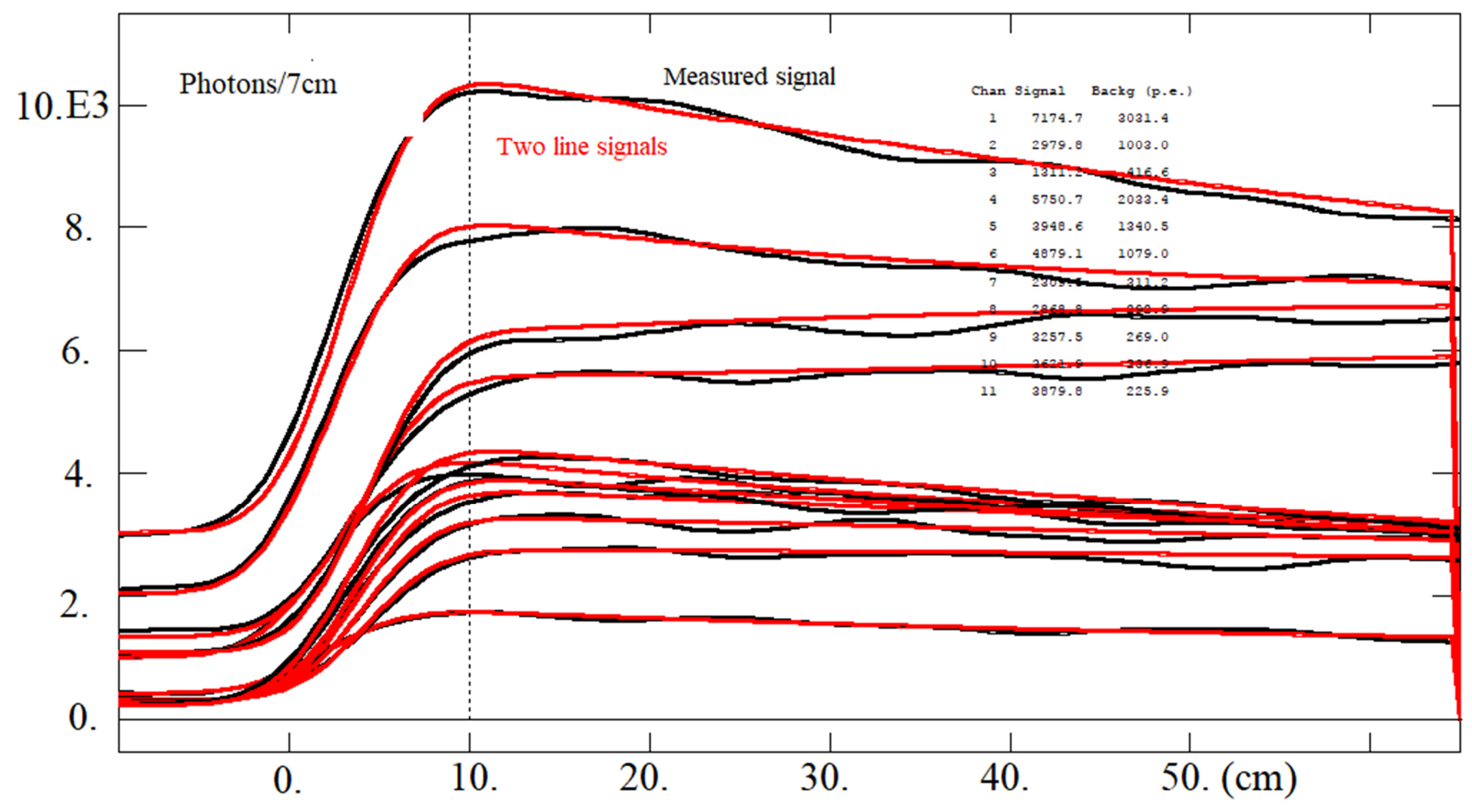
In principle deconvolution may be possible particularly as the signal at the boundary have the highest solid angle of collection and therefore the best signal to noise ratio (S/N).

This approach is beyond the scope of this presentation. Here we only want to demonstrate that it is feasible to determine the edge gradient using LIDAR TS.

We apply a model consisting of two straight lines for both temperature and density . The top line is determined by a linear fit to the standard fitted data from 20 – 50 cm from the edge.

From the simple model, we can calculate the expected signals in all the spectrometer channels and compare them to the measured signals. Simply stepping through different values of the crossing position, we determine the total minimum deviation of all the traces added together. The result shows that we can indeed determine the edge gradient down to a few cm.





Comparison of measured signals with signals calculated from two-line fit.