Research of Fast DAQ system in KSTAR Thomson scattering diagnostic

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I. Abstract

Thomson scattering diagnostic is most important diagnostic system in fusion plasma research. This diagnostic system gives reliable electron temperature and density profiles in magnetically confined plasma. In KSTAR tokamak, Q-switched Nd:YAG Thomson system was installed several years ago to measure the electron temperature and density profiles. For the KSTAR Thomson scattering system, a Charged-to-Digital Conversion (QDC) type data acquisition system was used to measured pulse type Thomson signal. However recently some error was found during the Te, ne calculation, because the QDC system had integrated the pulse Thomson signal that included a stray light-like signal. To overcome such errors, we introduce a fast data acquisition (F-DAQ) system. To test this system, a CAEN V1742 5 GS/s was used, which is Versa Module Eurocard Bus (VMEbus) type 12 bit Switched capacitor digitizer with 32 channels. In this experiment, the Te calculated results of Thomson scattering data measured simultaneously using QDC and F-DAQ were compared. For the F-DAQ system, the shape of the pulse was restored by fitting.

II. KSTAR Thomson system and Digitizer setup

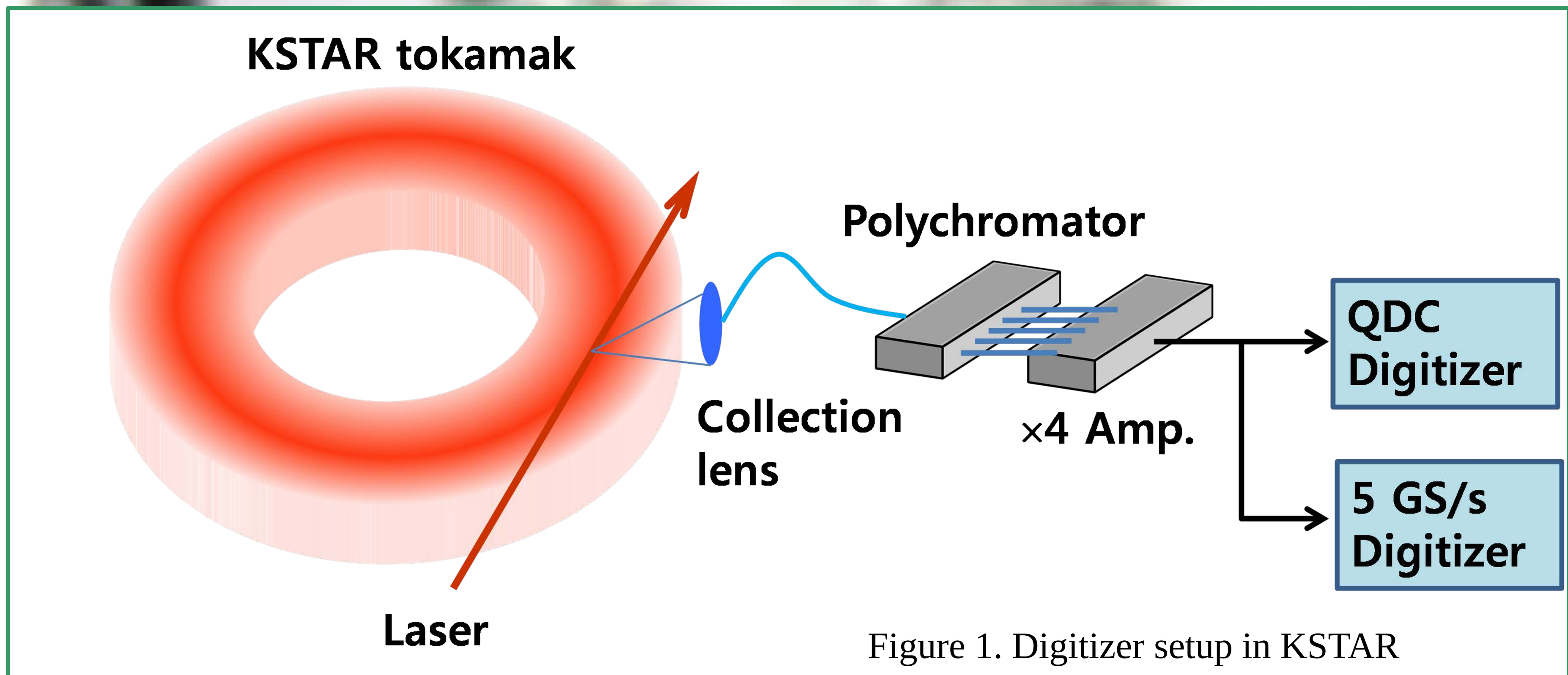
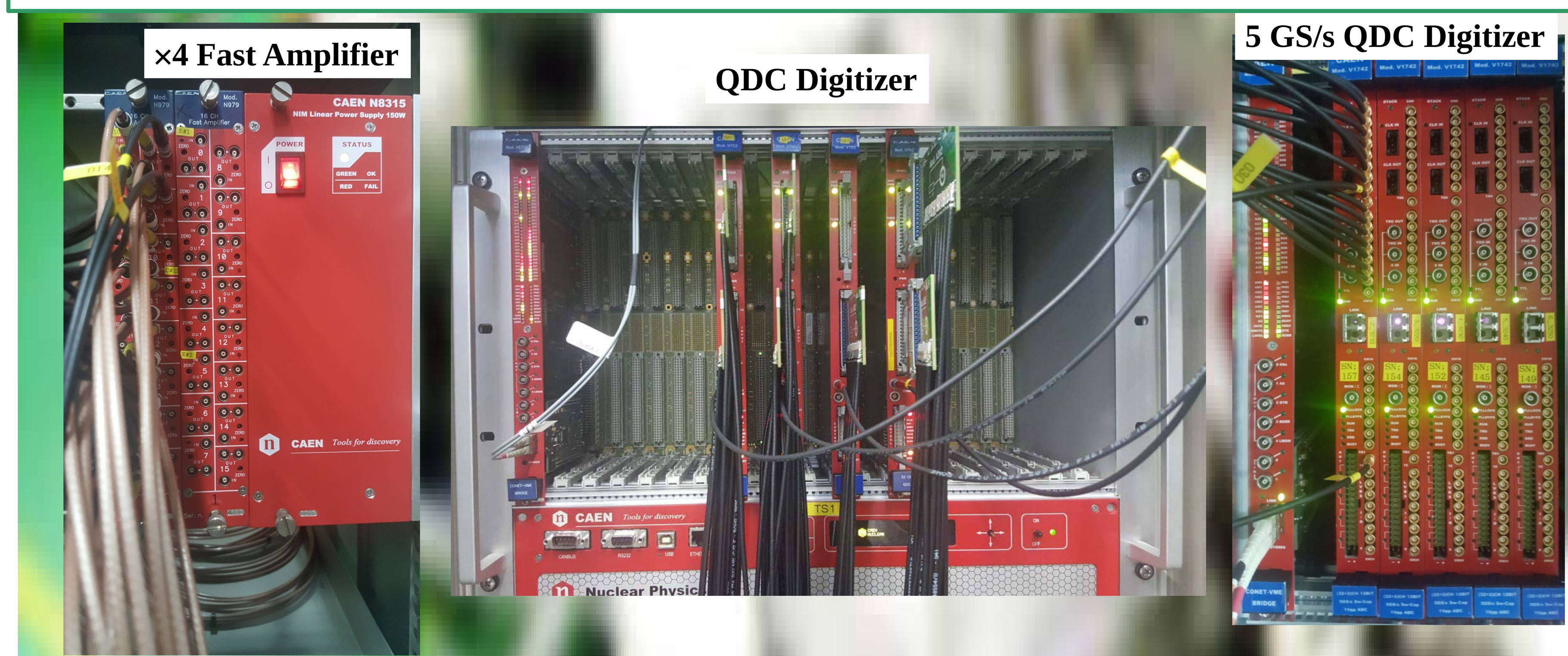


Figure 1. Digitizer setup in KSTAR



III. Test and Measurement

Prior to installing the fast digitizer in KSTAR, **the linearity** was checked using an oscilloscope and a function generator. The full-width-at-half-maximum (FWHM) of the pulse generated by the function generator was about 50 ns. The voltage was adjusted from 0.2 V to 1 V in 0.2 V increments, and this voltage was measured and compared with an oscilloscope and a fast digitizer.

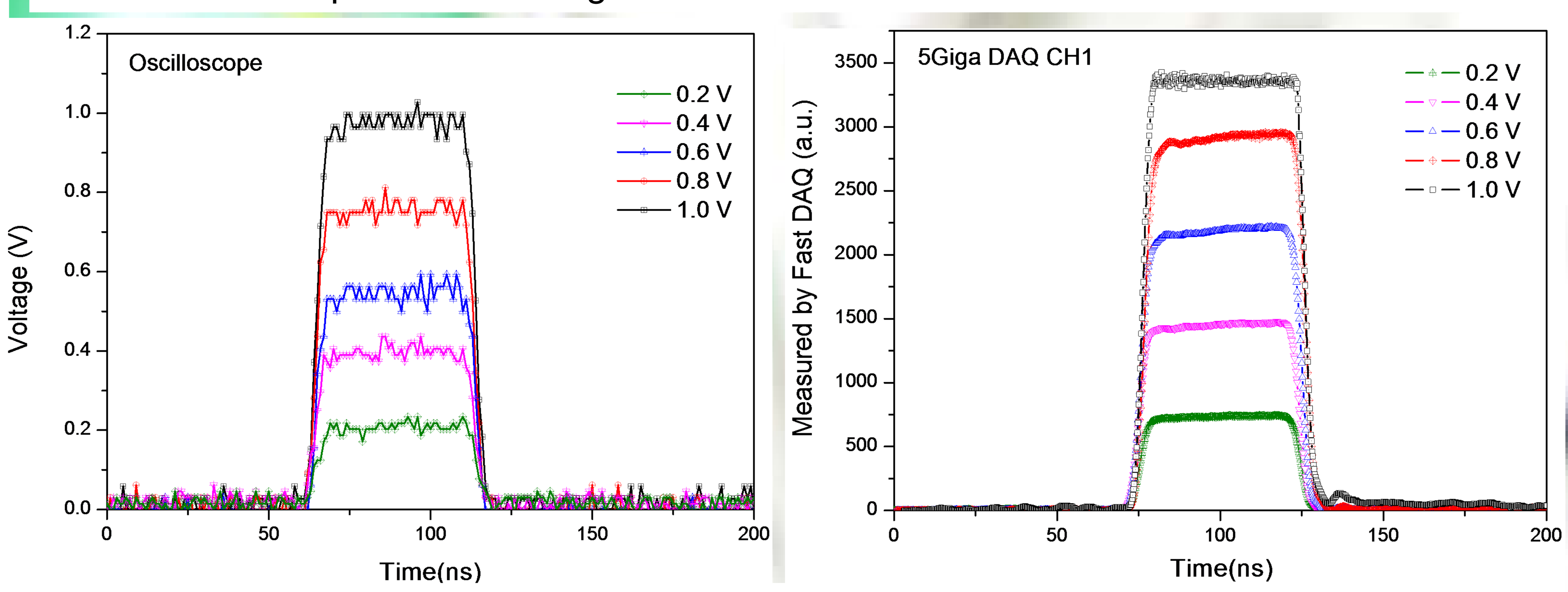


Figure 2. Applied voltage is measured by (a) Ocsilloscope (Agilent DSO7104B, bandwidth 1GHz, Max. 4 GSa/s), (b) Fast digitizer (CAEN 1724B, 5Gs/s)

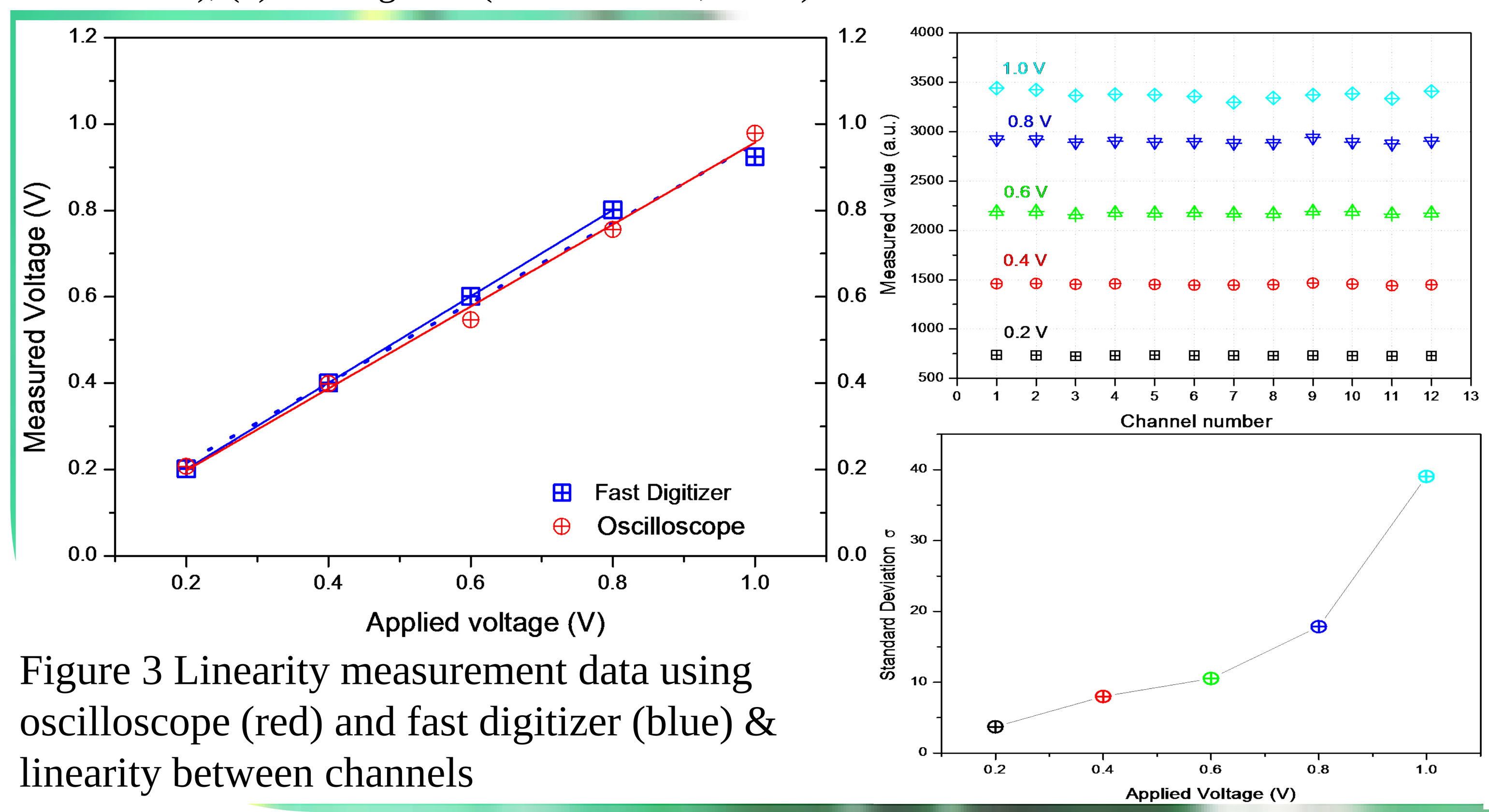
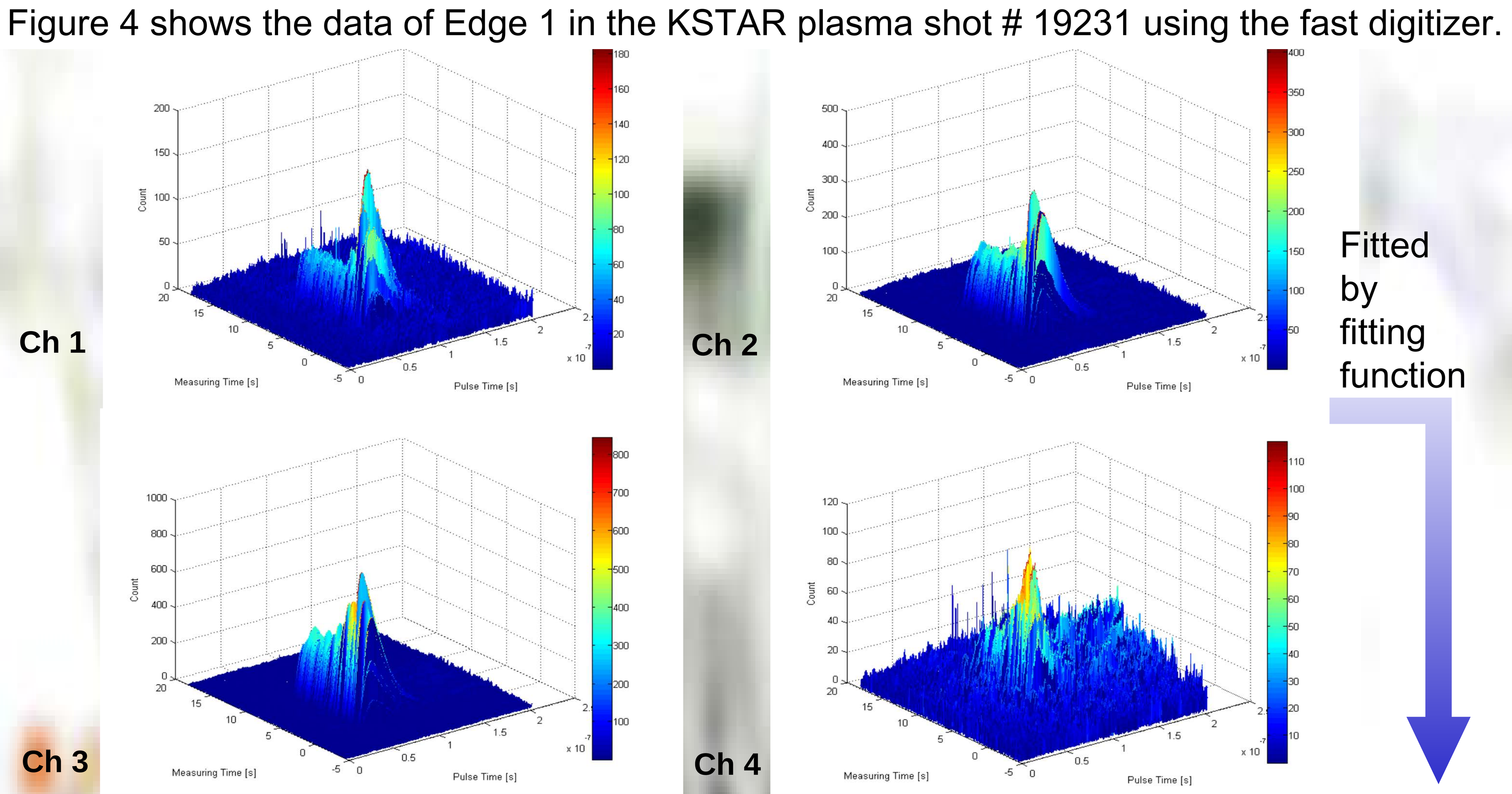


Figure 3 Linearity measurement data using oscilloscope (red) and fast digitizer (blue) & linearity between channels

(a) Measured values of the fast digitizer value using the 12 channels

(b) Standard deviation between each channel

Figure 4 shows the data of Edge 1 in the KSTAR plasma shot # 19231 using the fast digitizer.



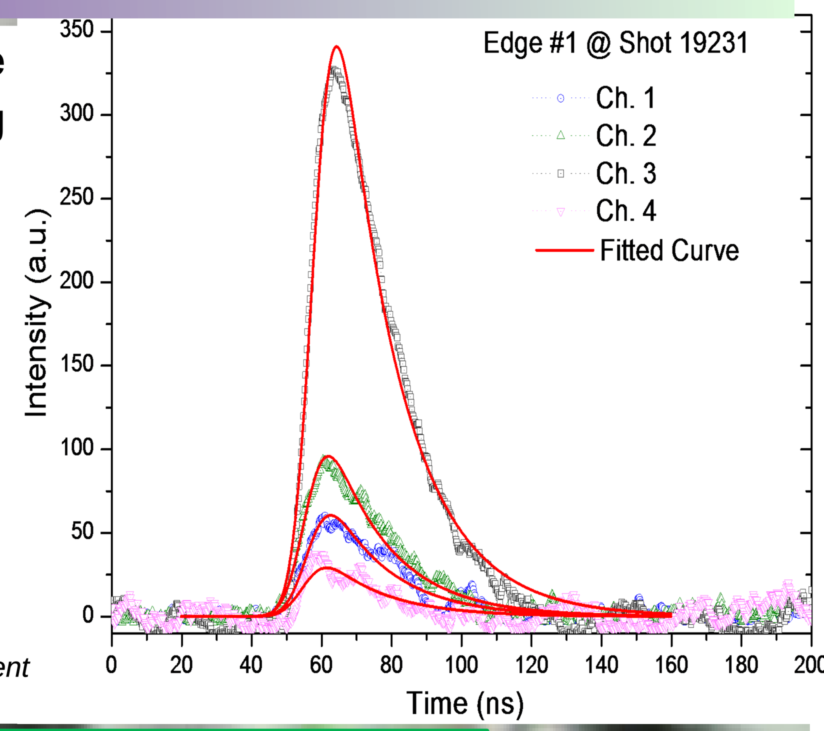
IV. Calculation of measured Data

The measured data was fitted to each pulse using a fitting function such as the following equation.

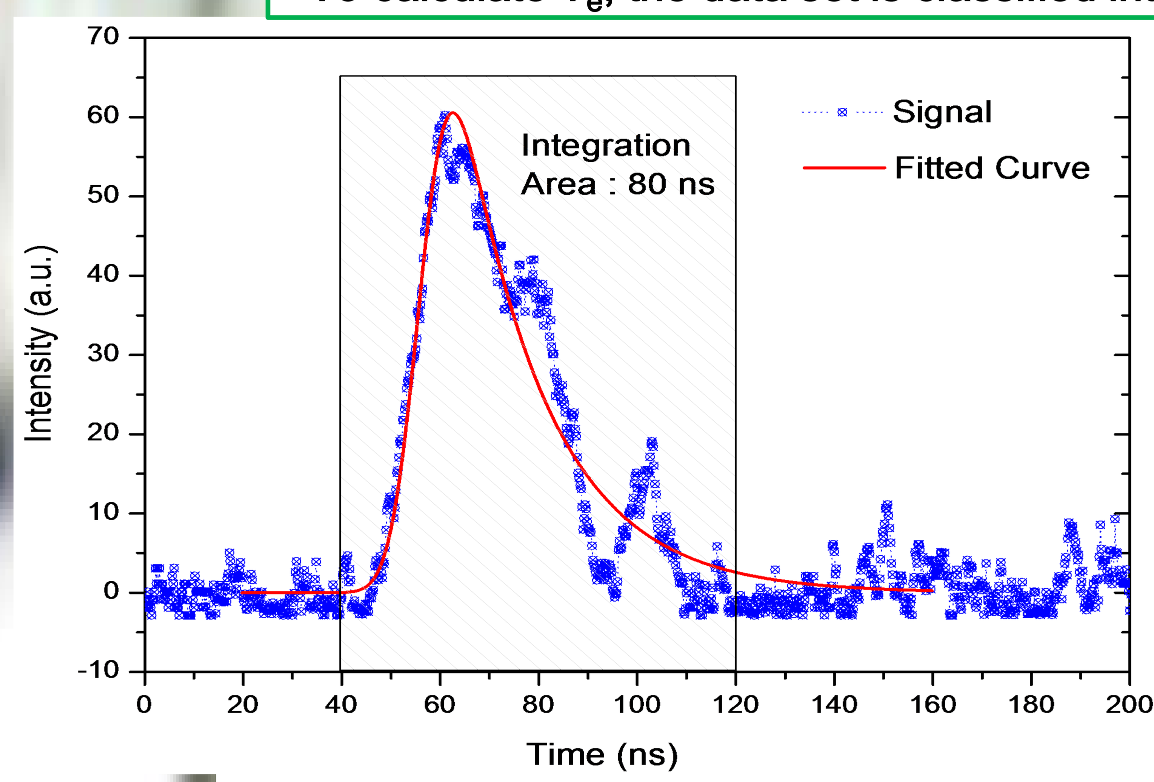
$$P(t) = P_L \int_0^t \exp\left[-\frac{(t'-t_L)^2}{\tau_L^2}\right] \exp\left(-\frac{t-t'}{\tau_{amp}}\right) dt'$$

$P(t)$: *expected pulse shape*
P_L: *signal amplitude*
t_L: *Laser pulse amplitude attains a maximum time*
τ_L: *time duration of the laser pulse*
τ_{amp}: *characteristic time of amplifier system*

B.Kurzan et al., *Signal processing of Thomson scattering data in a noisy environment in ASDEX Upgrade*, Plasma Phys., Control. Fusion **46** (2004) 229



* To calculate T_e, the data set is classified into three data sets.



Dataset 1 : A data measured with a QDC digitizer, which is the same method that was used in KSTAR.
Dataset 2 : A software-integrated data (Hatched Area) measured by a fast digitizer (Blue data points)
Dataset 3 : a dataset fitting the measured data (Red line) with the fast digitizer to fit equation and integrating the 80 ns area.(Hatched Area)

Table 1. T_e at each location calculated by three datasets (Unit : eV)

	Data set 1	*Data set 2*	*Data set 3*
Edge 1	237	234	254
Edge 2	217	220	252
Edge 3	294	273	264

V. Analysis

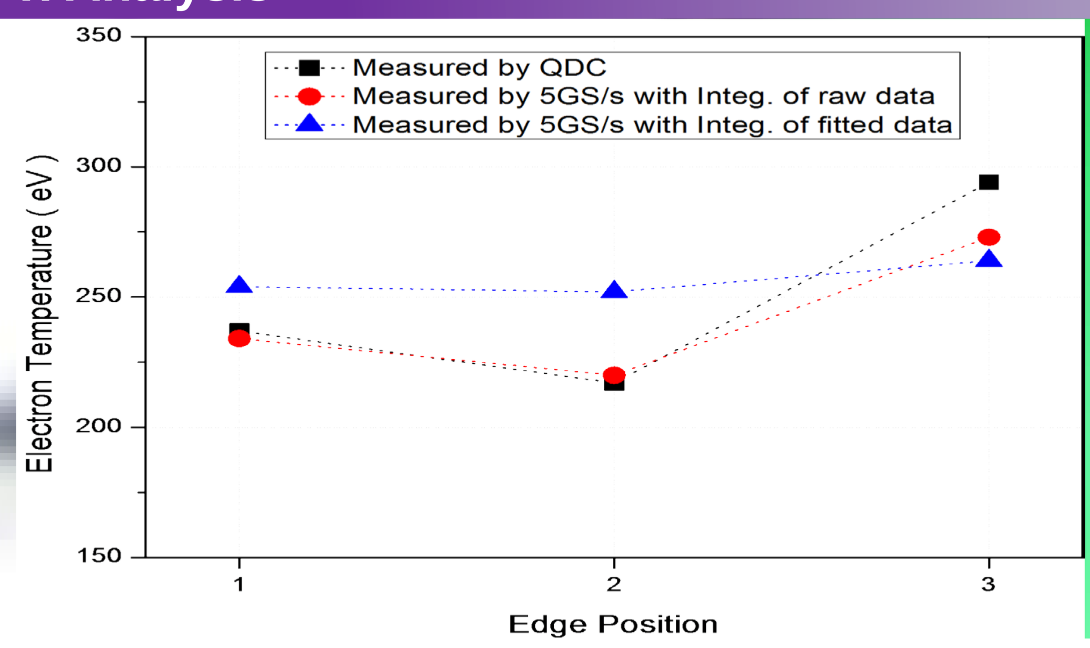


Table 2. Divide the integrated measurement signal by the integrated fit signal

Polychromator channel	*Edge 1*	*Edge 2*	*Edge 3*
Ch 1	0.997	1.088	1.093
Ch 2	0.999	1.085	0.968
Ch 3	0.983	0.989	1.011
Ch 4	0.736	0.714	1.13

To verify the signal noise effect, by **dividing the integrated measurement signal by the integrated fit signal, the value of 1 in the ideal case** is obtained. The calculation results are shown in Table 2. In Table 2, the divided values from channel 1 to channel 3 with a high signal-to-noise ratio are close to 1. However, channel 4 with a small signal-to-noise ratio exhibits a very different value from 1. Therefore, it can be seen that **the calculated value of T_e in Table 1 is over or underestimated due to noise among the integrated Thomson signals.**

VI. Discussion & Future Work

In the case of the existing QDC system, it is difficult to evaluate this error because the integration is made inside the digitizer circuit where noise cannot be confirmed. However, when calculating the T_e using the fast digitizer and its fitted curve, the signal noise can be removed, and more accurate T_e can be obtained and the error of the T_e value can be calculated clearly. In order to calculate the more accurate T_e and n_e with the Thomson scattering system, the next KSTAR campaign will simultaneously measure and evaluate the entire Thomson scattering signal using QDC and Fast digitizer.