Alice ITS Upgrade

Readout Electronic – WP10

Shaping time influence on data bandwidth

01 March 2016

Summary

Accordingly to simulations, for a sensor noise occupancy of 10^{-6} px^{-1}, and for shaping times up to at least 15 µs, the sensor occupancy scales almost linearly with the pulse duration, as there is no saturation effect in the pixel buffers and/or periphery. Therefore, the overall data bandwidth scales in an almost linear fashion as well.

Assuming one GBT optical link capacity as bandwidth limit (3.2 Gb/s per Readout Unit), for Pb-Pb @ 50 kHz, there is no concern for shaping time durations up to 15 µs in both triggered and continuous mode with a frame length equal or longer than 20 µs. For higher frame frequencies in continuous mode, the sensor will have no problem, but two GBT optical links are likely required to ship the data if the shaping time is longer than 5 µs.

For Pb-Pb @ 100 KHz it is unlikely the system could reliably operates with only one GBT optical link per Readout Unit independently from the shaping time. With two GBT links per Readout Unit, the system will be able to operate with the same performance of the 50 KHz interaction mode, therefore in Triggered and Continuous mode with frame lengths equal or longer than 20 µs. A shaping time of 5 µs or shorter could allow operating the ITS in continuous mode with 10 µs length frames and only two optical links, but the uncertainties in the simulations would require further investigation to confirm this projection.

For p-p collision up to 1 MHz the shaping time has no practical influence on the sensor and system behaviour.

As explained in the last section, as reference bandwidth for the Readout Electronic – CRU link the 5 µs figures should be considered.

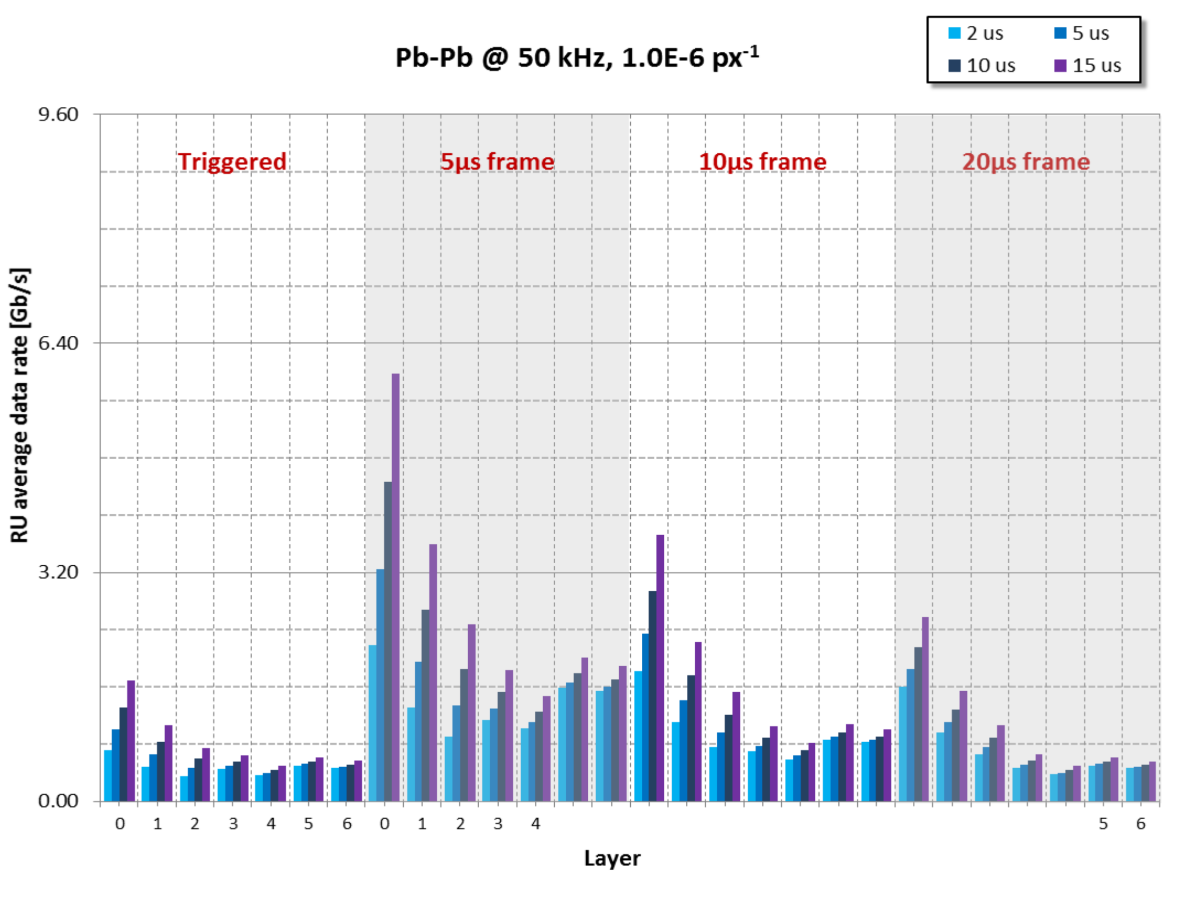

Figure 1 – Pb-Pb @ 50 kHz per RU bandwidth for different shaping times, noise of 10^{-6} px^{-1}.

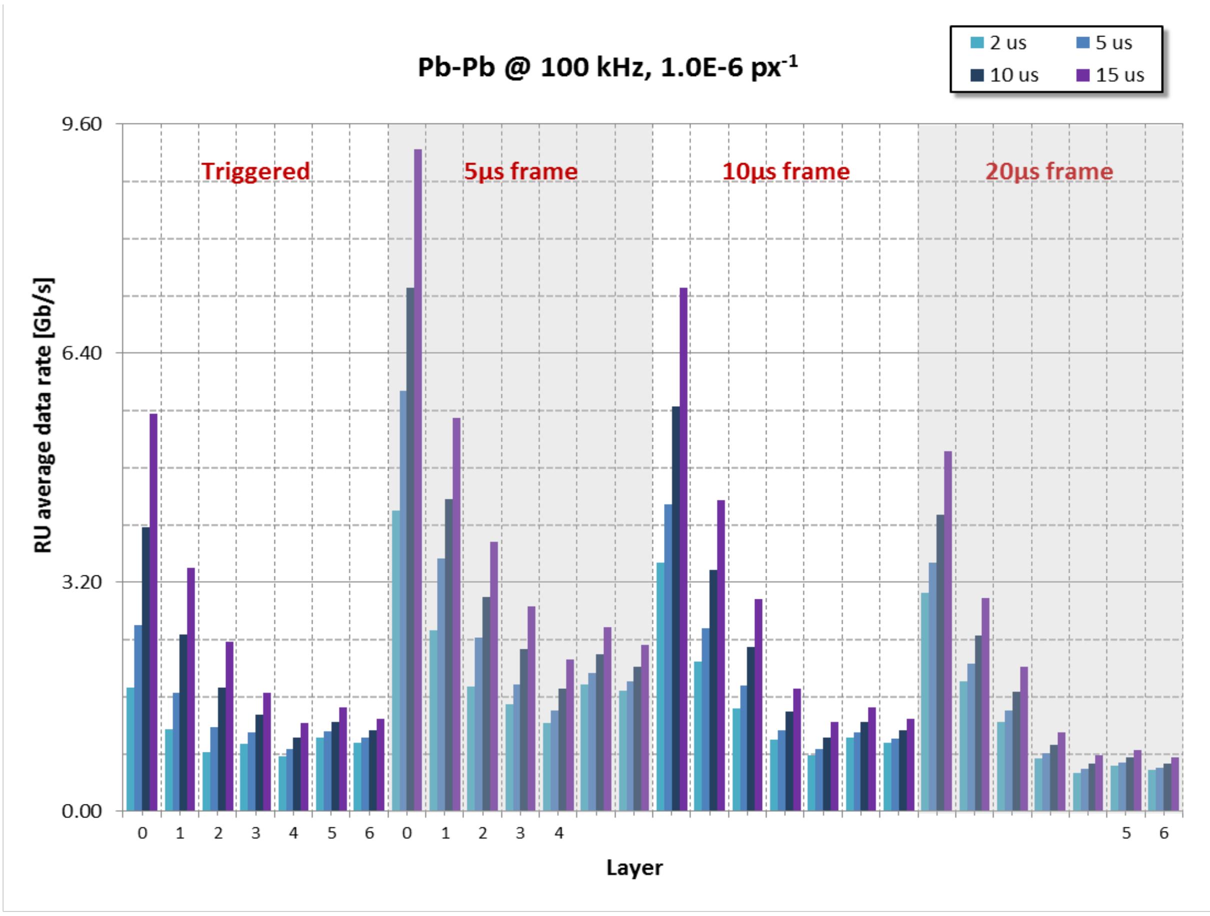

Figure 2 – Pb-Pb @ 100 kHz per RU bandwidth for different shaping times, noise of 10^{-6} px^{-1}.

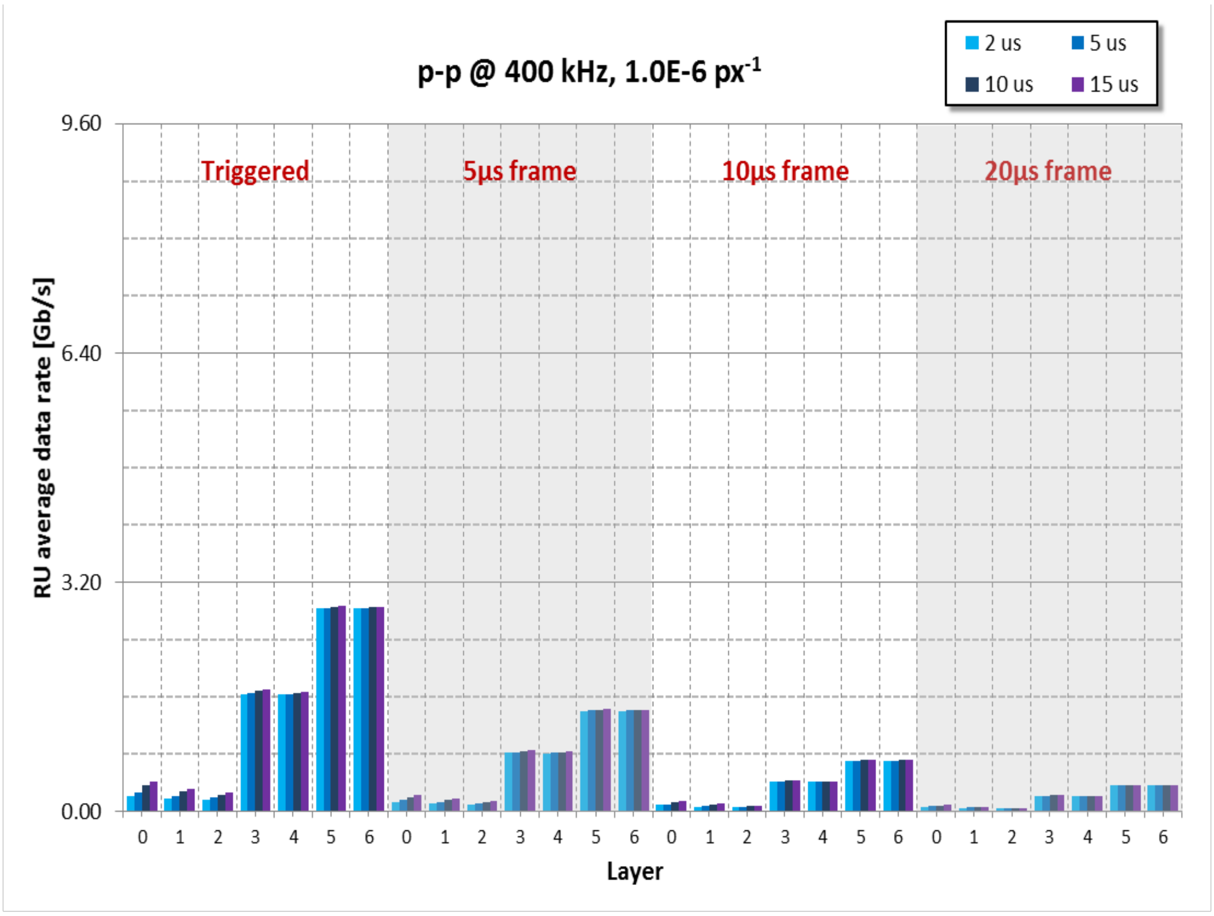

Figure 3 – p-p @ 400 kHz per RU bandwidth for different shaping times, noise of 10^{-6} px^{-1}.

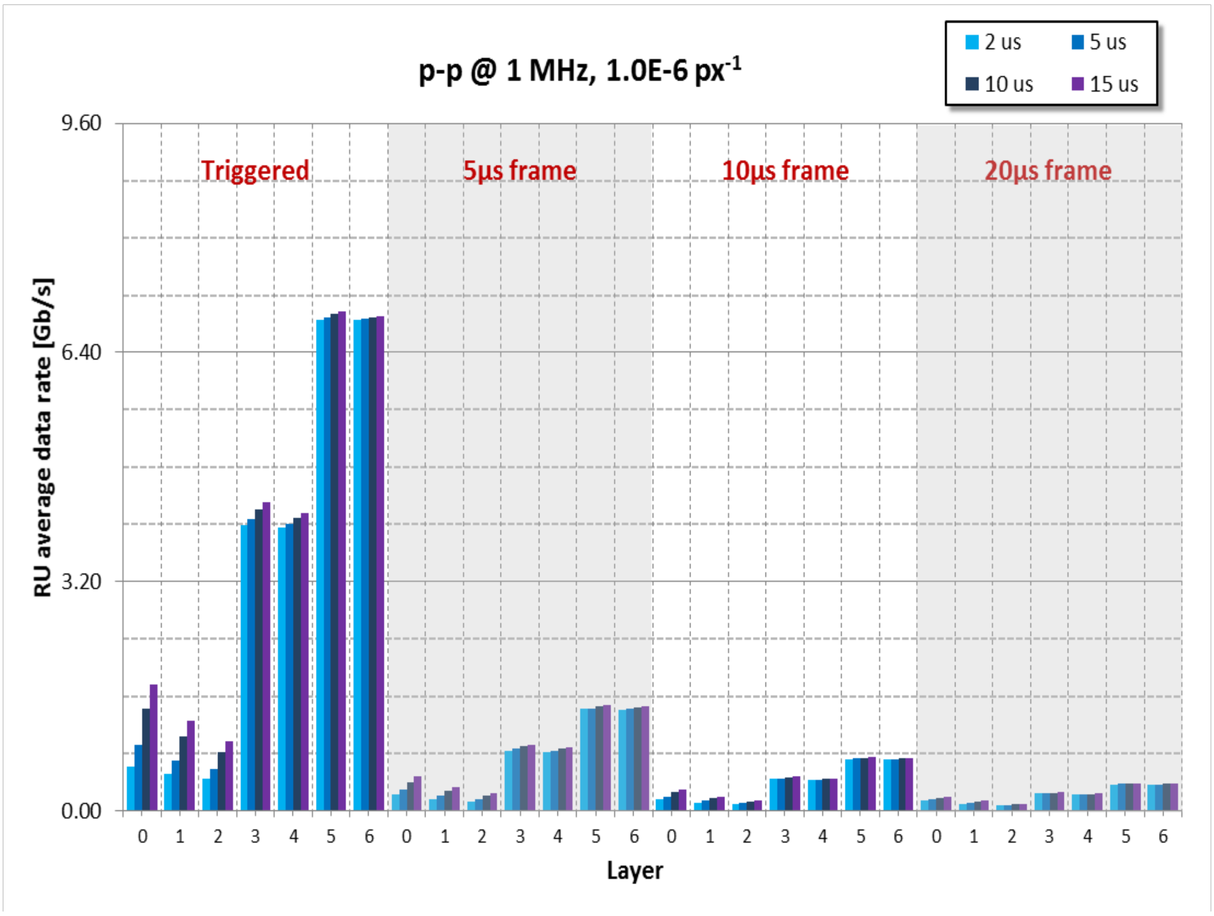

Figure 4 – p-p @ 1 MHz per RU bandwidth for different shaping times, noise of 10^{-6} px^{-1}.

Data breakdown and Readout Electronic sparsification

Data reported in previous plot are raw data from the sensors, but effective data reduction can be implemented into the Readout Electronic. Data reduction can act both on protocol overhead and on data redundancy. Figure 5 and Figure 6 show that for Pb-Pb collisions the most effective strategy depends from the layers: the protocol overhead is almost negligible in the inner layers, while plays a significant role in the middle and outer layers, whilst data redundancy (due to the shaping time) is clearly predominant in the innermost layers, and less important in the outer layers.

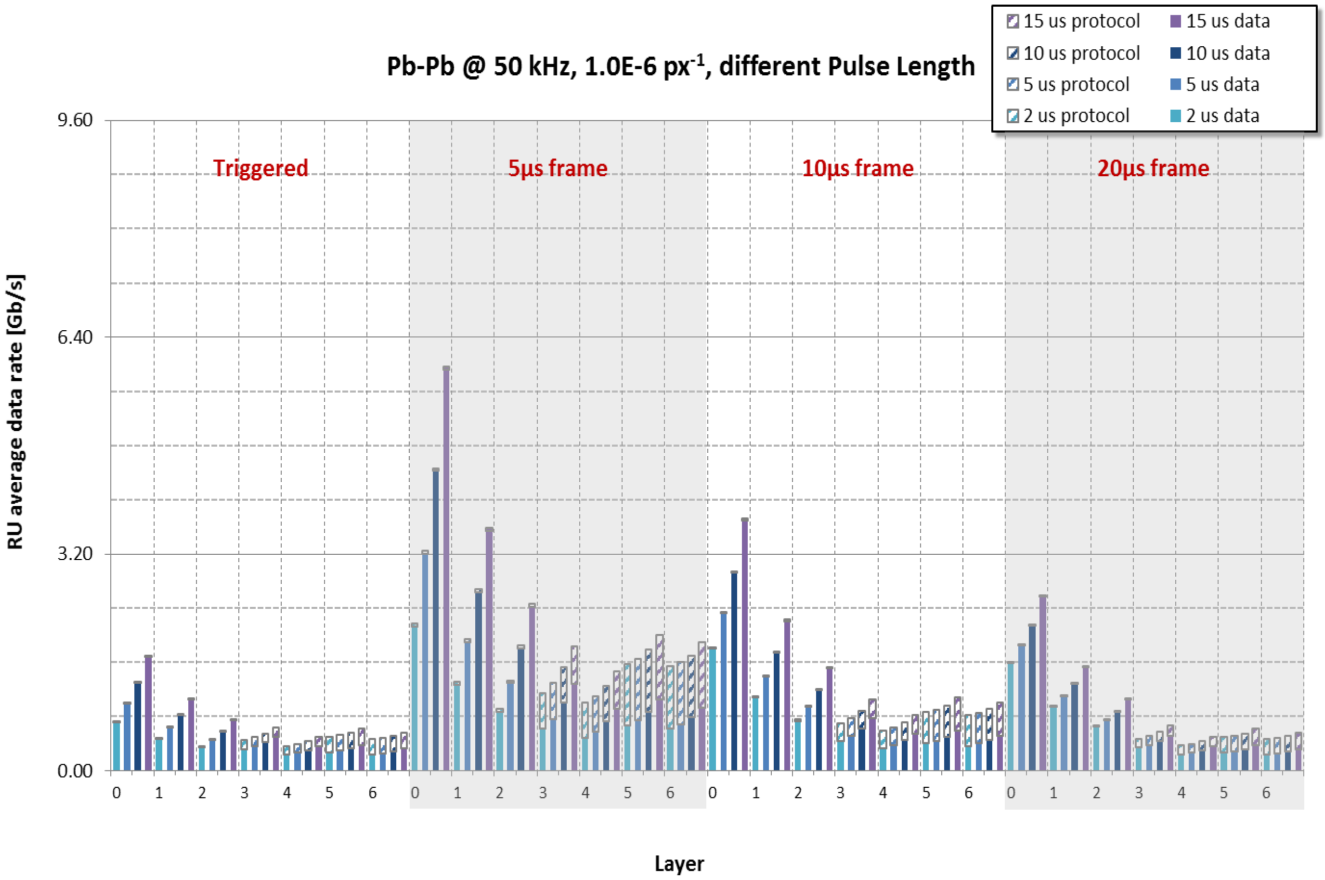

Figure 5 – Pb-Pb @ 50 kHz, noise 10^{-6} px^{-1}, different shaping times, data and protocol breakdown.

The relevant information from the plots is therefore the expected amount of actual data, as this set buffer size necessary to perform data suppression at the Readout Unit level. By looking at the triggered mode 2 µs bar for layer 0 in Figure 5 and Figure 6 it is possible to see how a single minimum bias event takes on average about 16 kbit of data. In triggered mode, a buffer of at least eight-times this size (4 times the depth plus double buffering) is likely necessary to allow implementing an effective data redundancy suppression in-FPGA. This figure is well within what offered by modern devices (a Kintex XC7K325 has more than 25 Mb of block-RAM).

In continuous mode, for the limit case of a 5 µs frame length (200,000 frames/s), again looking at the 2 µs bar, it is apparent how the actual data flux for layer 0 is about 4 Gb/s per readout unit, which is roughly equivalent to 20 kbit per frame, a figure close to that one of the triggered mode.

In conclusion, it seems likely that the actual bandwidth from the Readout Electronic toward the CRU could be limited to that described by a 5 µs shaping time (to consider a non-perfect efficiency in data suppression). By optimizing the transmission protocol within the Readout Unit it is possible to further reduce the bandwidth requirement, especially in continuous mode with high frame rate for the outer and middle layer.

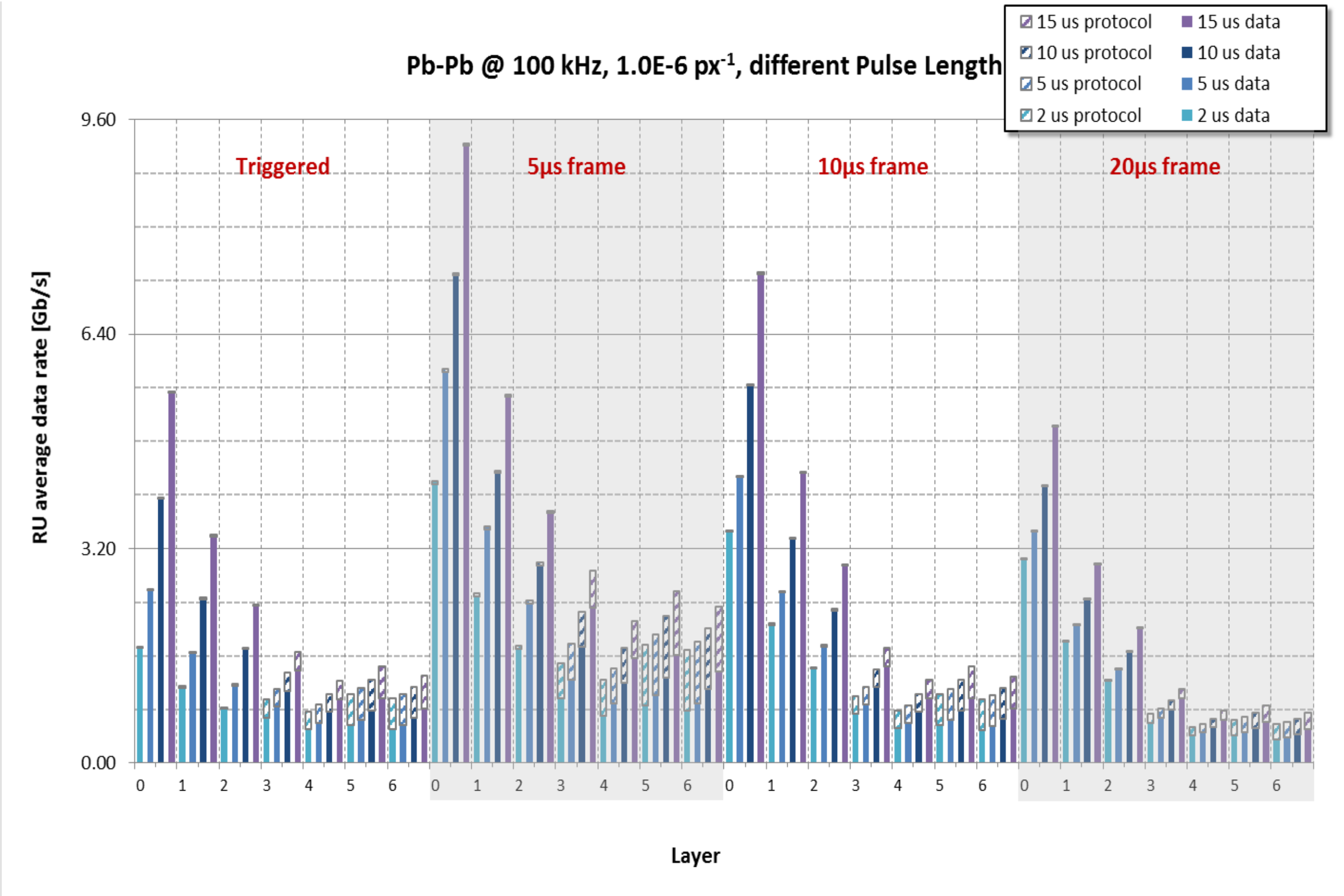

Figure 6 – Pb-Pb @ 100 kHz, noise 10^{-6} px^{-1}, different shaping times, data and protocol breakdown.