

High Rate / Triggerless Considerations for KLM

Belle II TRG DAQ Workshop
LS2 & Beyond Session
December 2, 2022



Event Size & Throughput Estimation

Triggered version:

- Quick KLM digit estimate using DQM:

- Exp. 26, Run 1707

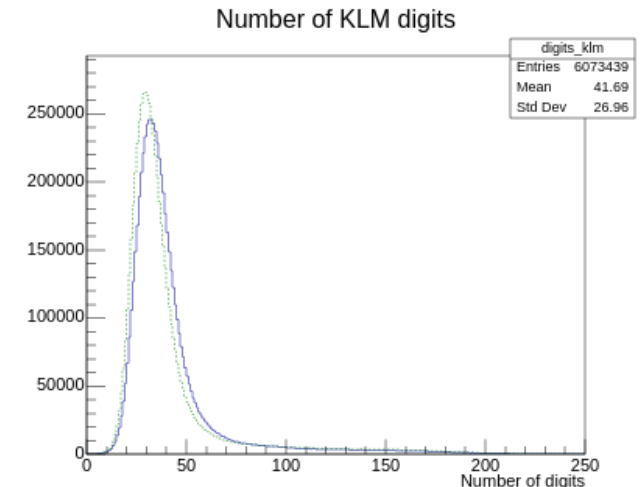
$$\text{Throughput} = (\text{Bytes / hit}) (\text{hits / event}) (\text{events / s})$$

$$\text{Most probable: } 8 * 33 * 100e3 = 26.4 \text{ MB/s}$$

$$\text{Mean: } 8 * 41.7 * 100e3 = 33.4 \text{ MB/s}$$

$$\text{Mean}+3\text{Sigma: } 8 * (41.7 + 3*27.0) * 100e3 = 98.1 \text{ MB/s}$$

N.B. This is throughput over all 32 KLM Belle2Links combined.



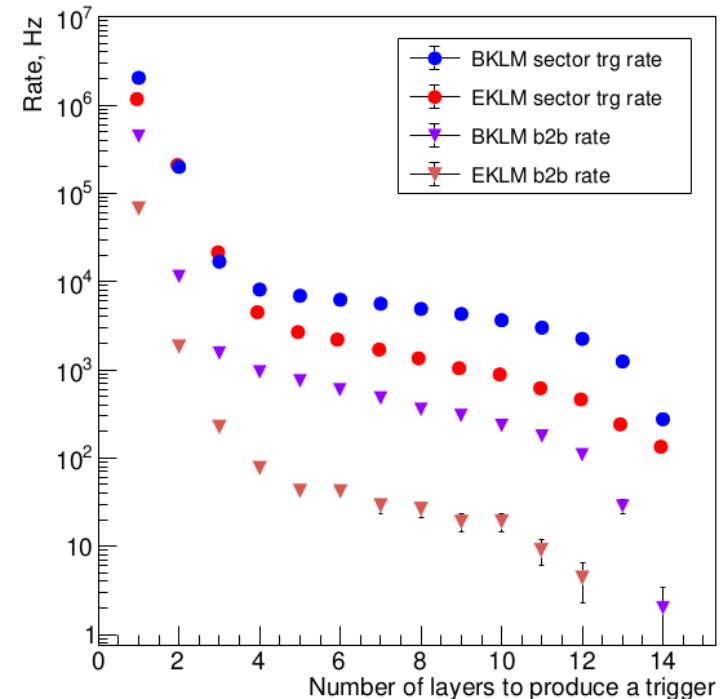
No extrapolation for increased backgrounds, just using existing hit estimates at 100 kHz.

Triggerless / Waveform Readout:

Another estimation using KLM-TRG hitrate:

In triggerless mode, all hits would appear in DAQ stream (i.e., every hit that currently shows up in TRG stream).

Figure on the right has inherent coincidence of 4-5 TTD clocks for sector trigger. To avoid issues with hot channels in triggerless mode, a 2-d coincidence requirement could be implemented in the FEE FPGAs.



Cumulative 2D-hit rates:

BKLM = 2 MHz, EKLM = 1 MHz

$T_{BKLM} = 8[\text{bytes}] * 2e6[1/\text{s}] / 16[\text{links}] = 1 \text{ MB/s}$

$T_{EKLM} = 0.5 \text{ MB/s}$

Limitation of Current FEE

- Limitation of the current FEE or possible future improvements
 - Buffer size on FEE is not enough to store such a large amount of data
 - Current FPGA transceiver is not capable of sending at such high-rate data etc.
- Digitization and waveform sample shifting from the TARGETX to the FPGA is the bottleneck for scintillator waveform readout.
- TARGETX *does not digitize continuously*, it holds samples for later digitization.
- Digitization itself takes ~ 24 us/event and right now happens only upon receipt of L1 trigger.
- A high trigger rate is currently only possible if occupancy is very low (wherein most events don't require digitization).
- **Most likely a “triggerless” mode on would use trigger bits only (no waveform) or would require new FEE.**

Other Comments

- With existing readout electronics, *waveform readout over Belle2Link may be possible, but most likely without a triggerless setup.*
 - Even so, it would require considerable changes to the firmware of the KLM Data Concentrator and moderate changes to the firmware of the KLM SCROD.
- Data Concentrator bottlenecks also need to be considered.
 - For example, in KLM TRG path, with 6 byte hits, bandwidth from Data Concentrator to UT3 tops out around 25 MHz / sector.
- We can do some further feasibility study to minimize number of samples required and the digitization rate, but this is probably out of scope of current available manpower.