



# The Readout Speed Jadepix3 DAQ

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# The speed in the CDR

## Design specification:

- Rolling shutter speed
  - CEPC: 1~100 us
  - Research for now: 100 us
- Design applied
  - System clock: 12 ns
  - 192 ns/row
  - Frame Period:  $512 \times 192 \text{ ns} = 98.304 \mu\text{s}$
  - Chip Size =  $10.4 \times 6.1 \text{ mm}^2$

Operation mode	H (240)	W (160)	Z (91)
Bunching spacing (us)	0.68	0.21	0.025
Hit density (Hit·cm <sup>-2</sup> ·BX <sup>-1</sup> )	2.4	2.3	0.25
Data rate (Hit·cm <sup>-2</sup> ·us <sup>-1</sup> )	6.3	10.9	10

## Maximum hit number in each frame:

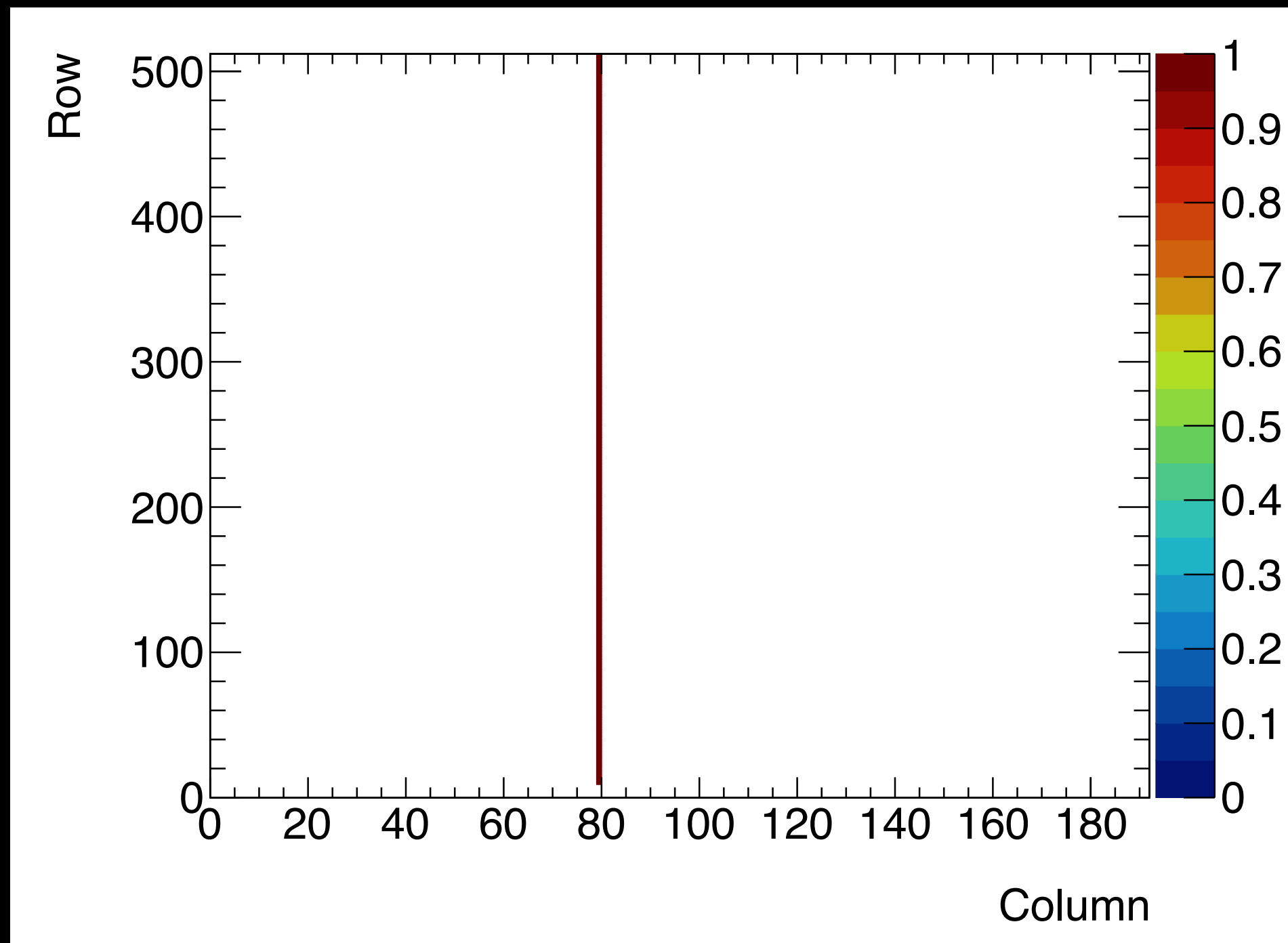
$$\text{Multiplicity} \approx 3$$

$$\text{DataRate} \times \text{ChipSize} \times \text{FramePeriod} = 10.9 \times \frac{10.4 \times 6.1}{100} \times 98.304 = 680$$

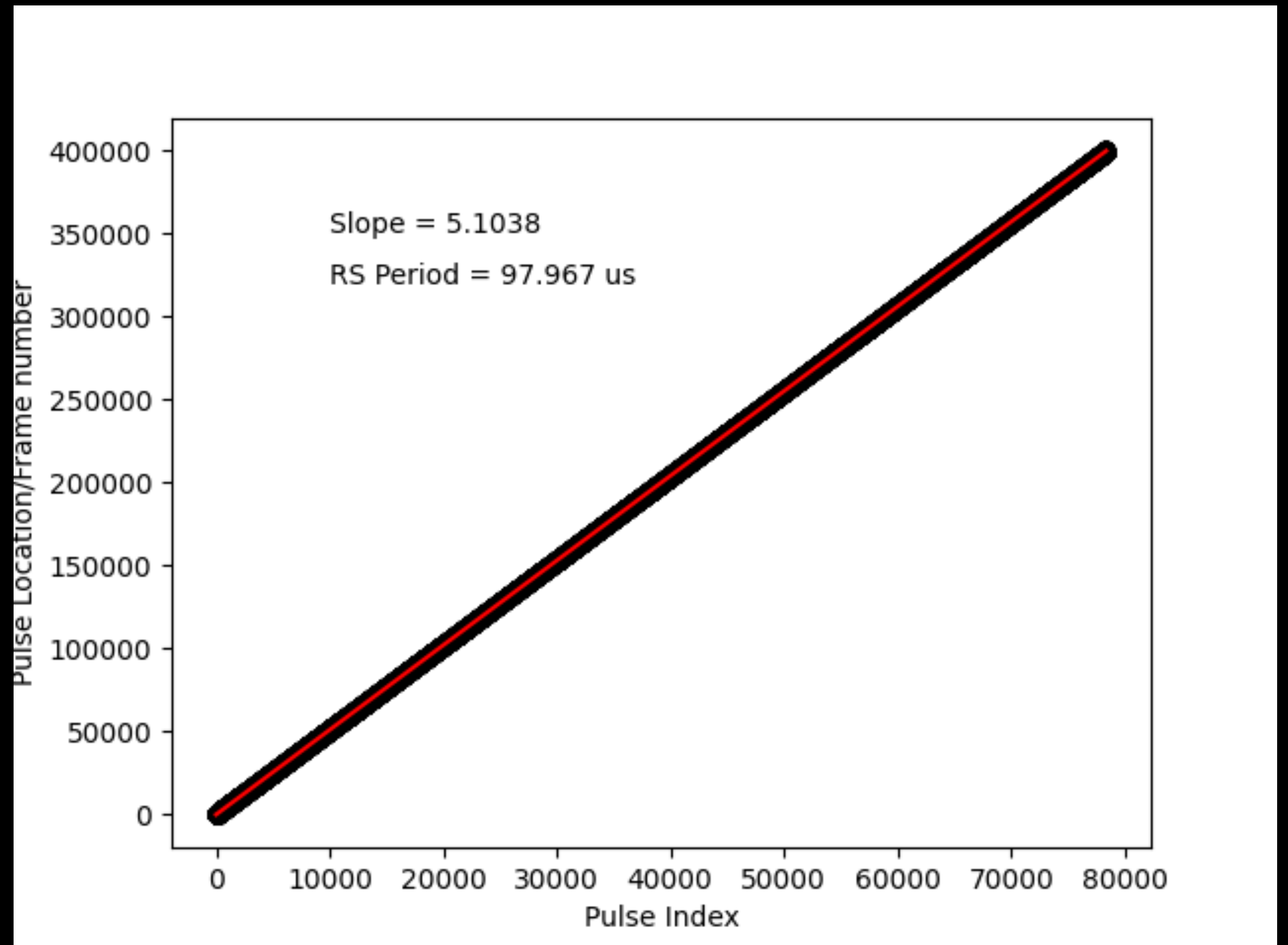
$$\text{DataRate}_{\text{raw}} = \frac{680 * 32}{98.304} \text{ Mbps} = 220 \text{ Mbps}$$

Table 1. CEPC的束流时间结构与顶点探测器的击中率  
(Ref: Jdepix3 设计文档)

# Speed verification



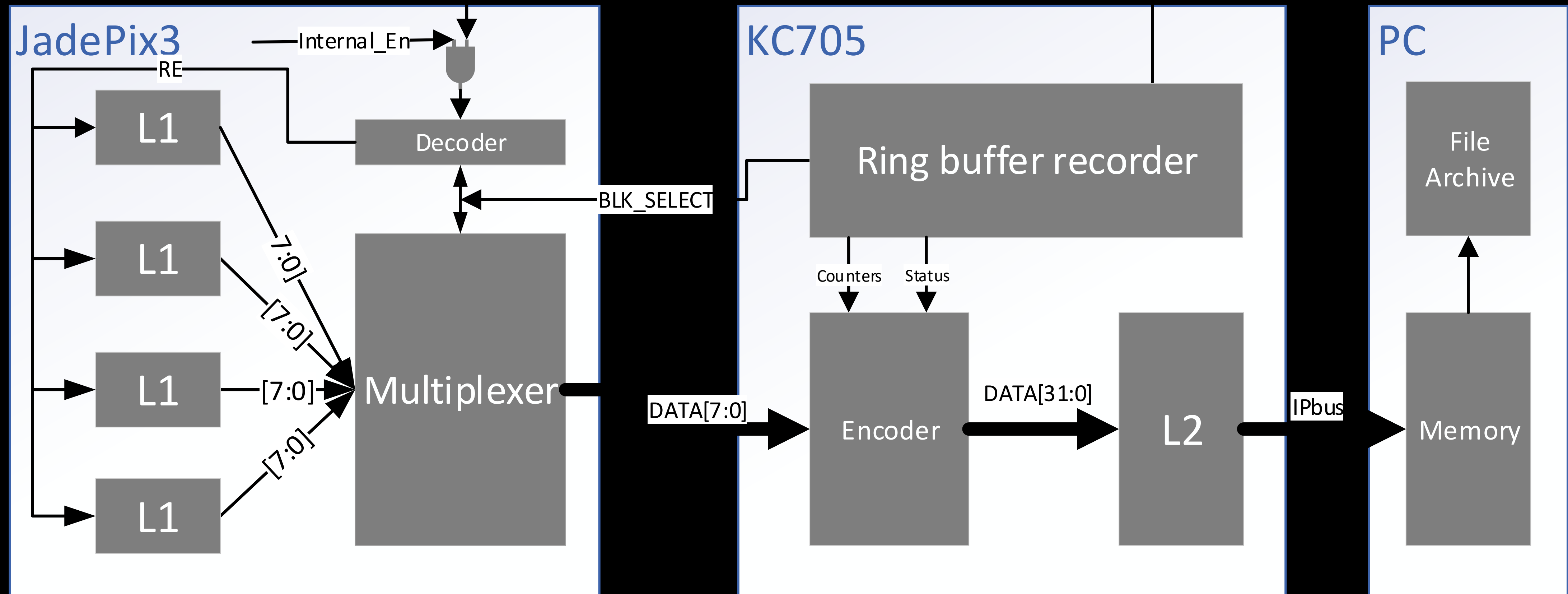
Test Pattern (One column).



The pulse index and the location of its frame number.

- Pulse high: 1.7 Volt, Pulse low: 1.2 Volt
- Pulse input period: 500 us
- Rolling shutter frame number: 400000
- Rolling shutter period: *97.967us*

# The limitation



## Where's the limitation?

1. Data caches (Depth, Read Speed)
2. Ethernet Speed (1Gbps, JumboFrame, **750Mbps**)

- L1: FIFO (46 × 16) in Jadepix3
- Ring buffer: 8192 × 92
- L2: IPbus Data FIFO (131072 × 32)

# Testing

Method: Fire the specified pixels and inject negative pulse.

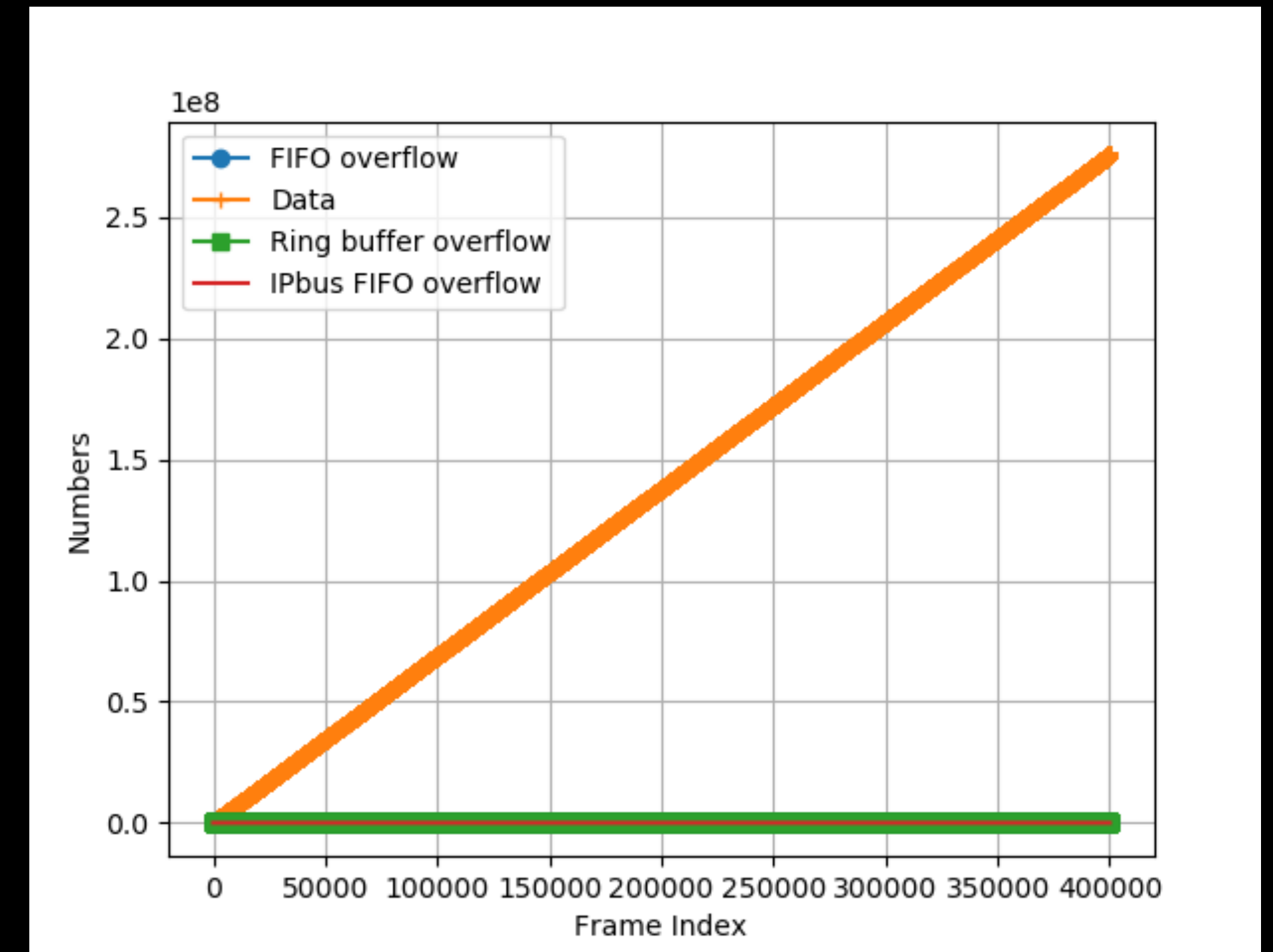
- Pulse high: 1.7 Volt, Pulse low: 1.2 Volt
- Period: 10ms, 5ms, 1ms, 500us, 300us, 110us, 100 us
- Hit number per frame:  $512 \times 4 = 2048$

While  $T_{frame} \leq T_{pulse}$ ,  $DataRate = \frac{Hit_{row} \times ROW}{T_{pulse}} \times 32$

$T_{pulse} = 110 \text{ us}$ ,  $DateRate = 595.8Mbps$

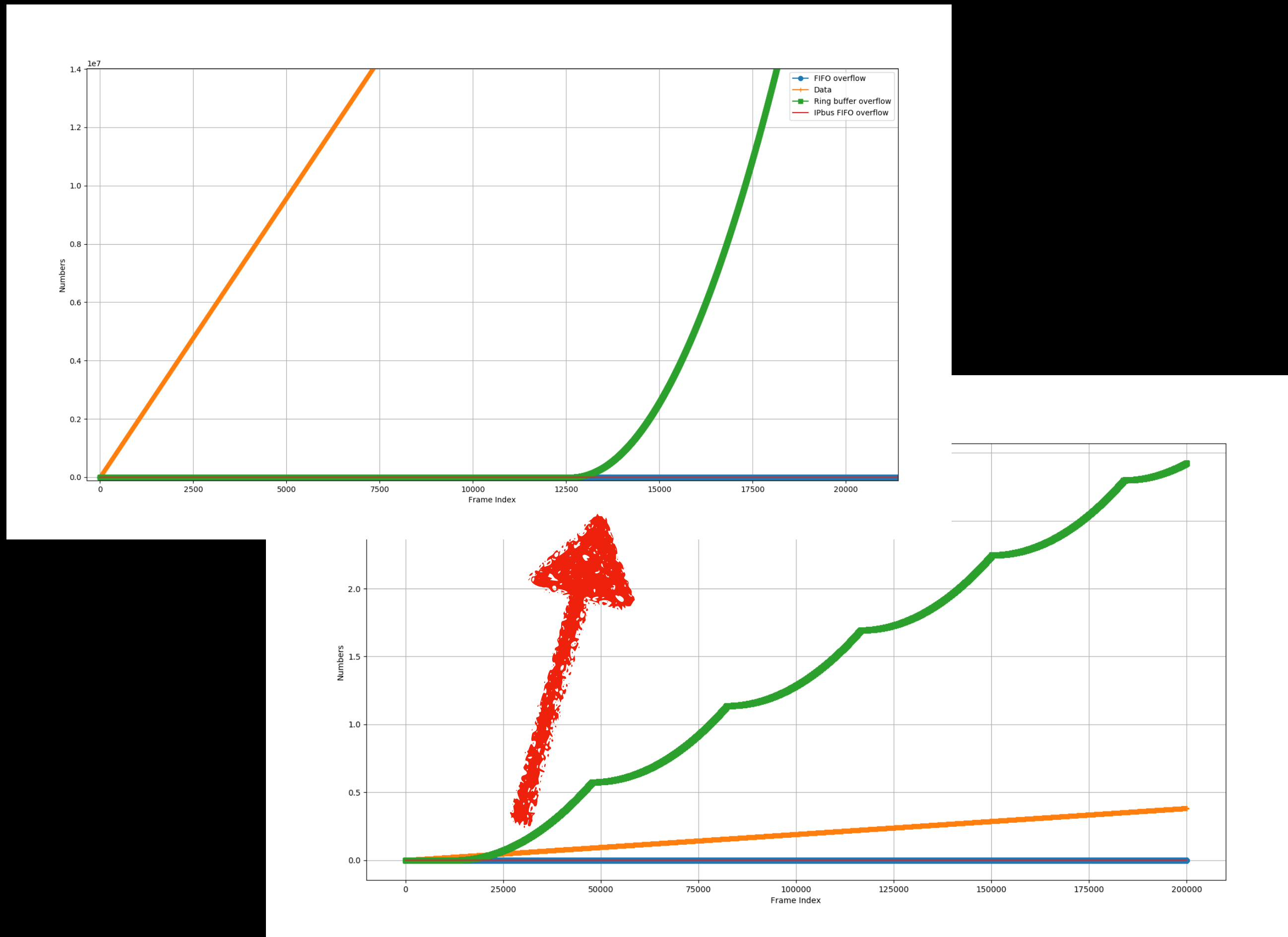
The reason the speed is lower than 750Mbps:

1. Small payload size decreased the efficiency.
2. Ring buffer limited

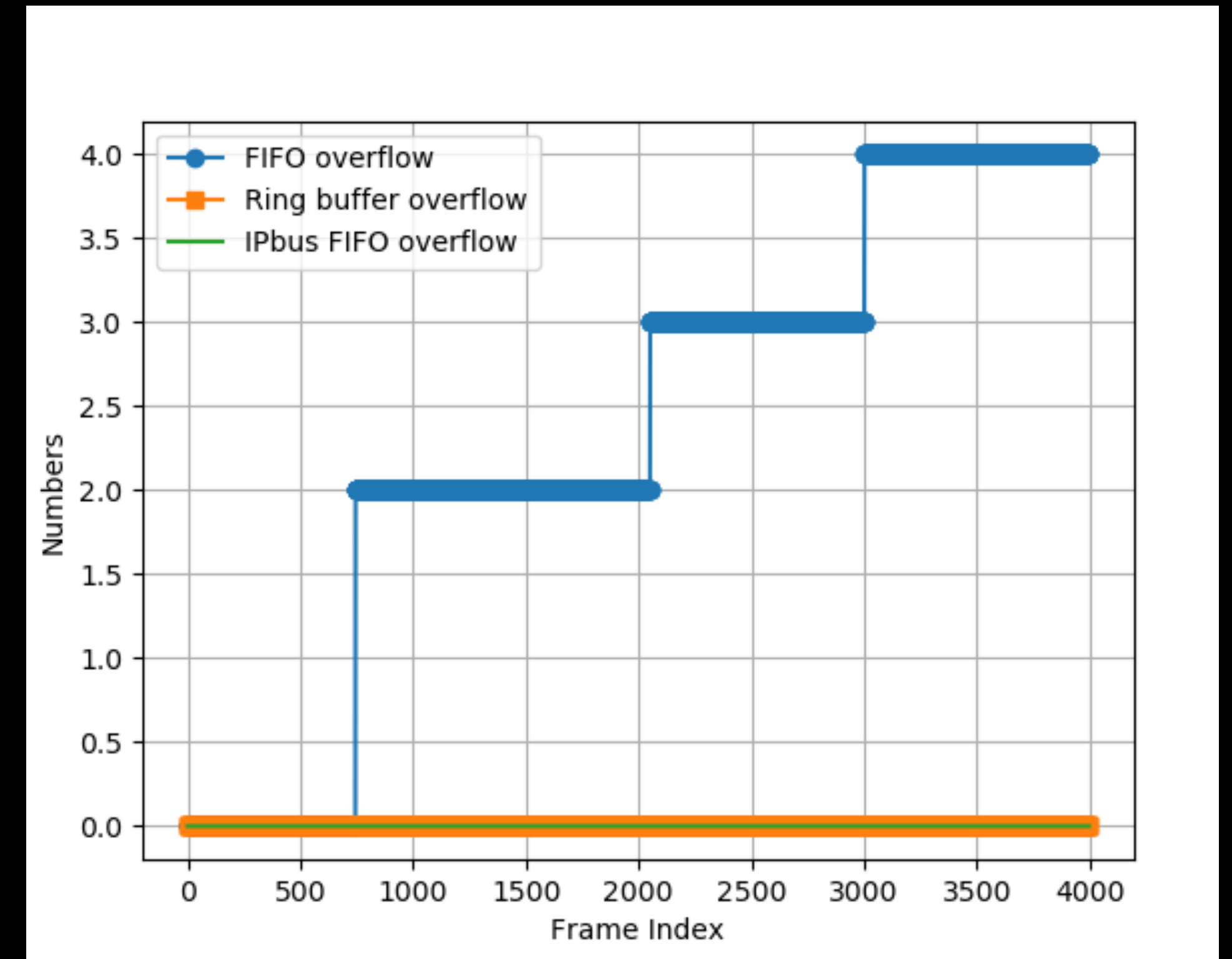


Pulse period: 110 us  
Frame number: 400000

# Testing



Pulse period: 108 us  
Frame number: 200000  
RBOF Overflow @ 12500



Pulse period: 200 us  
Frame number: 4000  
Chip FIFO Overflow @ row1, row2, row3 fired

# Conclusion

The DAQ of Jadepix3 can now handle the hit rate at

- 2048/Frame.
- 595.8 MHz effective data flow.

The limitations of the DAQ:

- Chip FiFO readout mode, one sector by one sector.
- Ring buffer depth.
- 1G ethernet.

??? Jadepix3 design specification fulfilled ???