

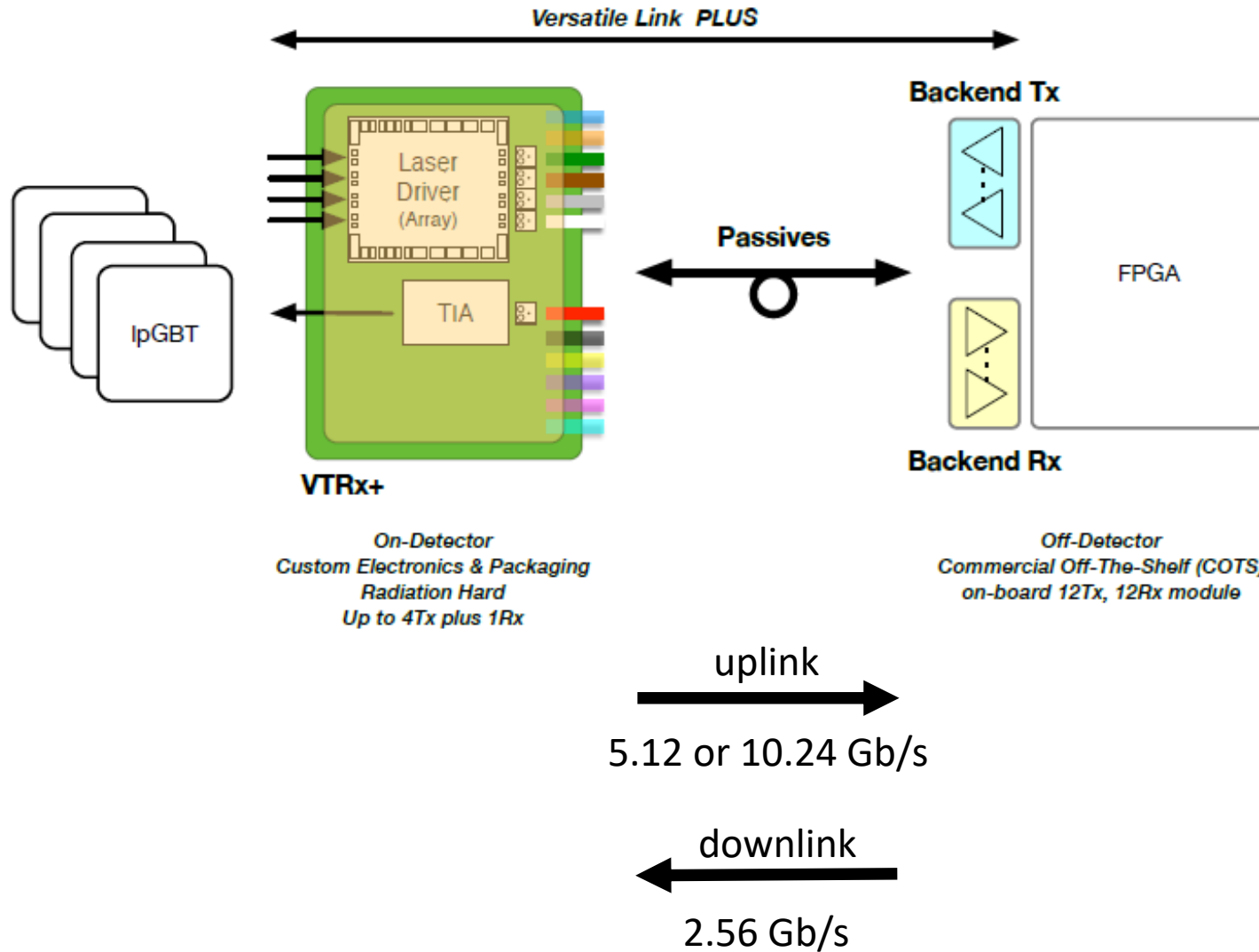
# CERN Rad Hard Data Transmission Components for TDIS

2<sup>nd</sup> generation components

IpGBT, VTRx+ (HL LHC)

Estimate number needed and cost to instrument TDIS mTPC

# Versatile Link+ (IpGBT)



## IpGBT uplink modes

- 5.12 FEC5 – 4.48 Gb/s user data
- 5.12 FEC12 – 3.84 Gb/s user data
- 10.24 FEC5 – 8.96 Gb/s user data
- 10.24 FEC12 – 7.68 Gb/s user data

FEC = Forward error correction  
(FEC12 more robust than FEC5)

- IpGBT – includes some of GBT-SCA functionality (I2C, GPIO)
  - **35 CHF** (~\$35)
  - Pre-series parts available in small quantities
  - Production quantities for users at beginning of **2023**
  
- VTRx+
  - **200 CHF** (~\$200)
  - Pre-series parts available in small quantities
  - Production in monthly batches starting 2022
  - Batches reserved for LHC experiments through 2024
  - Other users after end **2024**

# 1 – SAMPA in Triggered Mode

- Modest experiment trigger rate (~6 KHz)
- High channel hit rate (~1 MHz)
- Small mTPC drift time (1.5  $\mu$ s)
- More efficient to operate the SAMPA chips in triggered mode than in continuous mode
  
- Set channel thresholds below pedestal – all channels report samples for each trigger
- 2  $\mu$ s capture window, 20 MHz ADC sampling (40 samples/window, 10 bits each = 400 bits/ch/trig)
- 50 bit header + 20 aux bits for each channel => 470 bits/ch/trig => 15,040 bits/chip/trig
  
- 25 KHz triggers => 376 Mb/s/SAMPA
- Use 3 e-links @ 160 Mb/s from SAMPA to IpGBT
- IpGBT: 5.12 Gb/s FEC12 supports 24 e-links @160 Mb/s each
- **1 IpGBT supports 8 SAMPAs**

# 1 – SAMPA in Triggered Mode

- **32K** channels => **1000** SAMPA
- IpGBT cost:  $\$35 \times 125 = \$4,375$
- VTRx+ cost:  $\$200 \times 125 = \$25,000$
- **Total: \$29,375**

- (Suggest 20% more for spares)

## Notes:

- Front-end card with 8 SAMPA + 1 IpGBT + 1 VTRx+ may not be the optimal solution for the geometry of the mTPC.
- 1 IpGBT can support 12 SAMPAs when operated at 10.24 Gb/s FEC12. Negatives: Front end card becomes more complex with additional SAMPAs; receiving end of 10.24 Gb/s link is more expensive.

## 2 – SAMPA in Streaming Mode (DAS)

- **ALICE card:** 2.5 SAMPAs → 1 GBT (SAMPA V4 – 160 ns shaping time)
- Can stream **ALL ADC samples** at **5 MHz** ADC sampling rate (DAS mode)
- Also can stream at **20 MHz** ADC sampling with zero suppression applied (DSP mode)
  
- For **SAMPA V5**, DAS mode must be at **10 MHz** ADC sampling to be equivalent (**80 ns** shaping time)
- Can do: **2 SAMPA → 1 IpGBT** at **10 MHz** ADC sampling (DAS mode)
- IpGBT 10.24 Gb/s FEC12
  
- Cost: **4x** triggered solution
  
- IpGBT cost:  $\$35 \times 500 = \$17,500$
- VTRx+ cost:  $\$200 \times 500 = \$100,000$
- **Total: \$117,500**

### 3 – SAMPA in Streaming Mode (DSP- zero suppression)

- **1 MHz** average hit rate per channel, **20 MHz** ADC sampling
- Frame = 1000 samples = 50  $\mu$ s => 50 hits/frame/ch
- Zero suppression: 1 hit ~ 9 samples (3 pre, 3 above threshold, 3 post) (**80 ns** shaping time)
- 1 hit = 100 bits (ADC = 90, TDC = 10)
- Bits/frame/ch = 5060 (100 bits/hit x 50 hits/frame + 50 (header) + 10 (counter))
- SAMPA bits/frame = 161,920 (5060 bits/frame/ch x 32 ch)
- **SAMPA bit rate = 3.24Gb/s** (161,920 / 50  $\mu$ s)
- Use 11 e-links @ 320 Mb/s each
  
- **2 SAMPA → 1 lpGBT** can handle **1 MHz** average hit rate per channel with **20 MHz** ADC sampling (zero suppression applied)
- lpGBT 10.24 Gb/s FEC12
- **(\$117,500)**

# Observations

- **IpGBT** are relatively cheap – buy 500 (no equivalent chip available)
- **VTRx+** are expensive – buy enough for TDIS and for prototyping other projects (e.g. SoLID).  
Alternative fiber optic transceivers may become available (SMU)