ePIC Electronics & DAQ WG meeting 11/9/23

- News / Schedule
  - 11/14-16 CD-3A review
  - 11/16 E&DAQ WG – expect to hold meeting (timing update?)
  - 11/30 Thanksgiving (No E&DAQ WG)
  - 11/27-12/2 APS / Streaming Workshop XI (No E&DAQ WG)
  - 12/7-12/8 Resource Review Board (Computing: starts 12/7 afternoon)
  - 12/7 joint E&DAQ WG / Streaming Readout WG (Time frame specs and contents)
  - Timing group needs shared resources
    - Sharepoint for sharing Xilinx Projects & such
    - Git Repo
- VTRX+ specifications & how to make progress
- H2GCROC3A
  - Norbert comments on the testing and operations
  - I'll comments regarding the implications on the requirements for the RDO and the operation of DAQ

VTRX+ specifications

- I think there is consensus that we need VTRX+ for the MAPS, and that it is beneficial for the dRICH.
- I don't think there is a demonstrated need for other detectors.

- But how do we make progress?

- If this becomes a CD-3b request it will need to be accompanied by 90% designs
  - Timing is an issue even with a CD-3b request as the CD-3b review would be Oct 24. So the scheme would need to be a juggling detector development funds and then restoring the using a hoped for 3b
  - The scope of the 90% design might be limited to the fiber connections themselves, but the descriptions/requirements of the electronics on either side of the fiber will need to be rather firm
  - The numbers need to be firm

- dRich numbers are firm: 1242 VTRX+. These to be configured with 2 fibers used 1TX/1RX leaving 3TX unpowered. 258 extra need for contingency, language to be recommended by project

- MAPS numbers are not firm: Best guess about ~1000 VTRX+, configured with 5 fibers (4TX/1RX). Also another ~1500 VTRX+ for SC & Clock connections? Also potentially lpGBT, which is also murky.

We do have numbers for the MAPS trackers, but I don't know *exactly* how they translate to VTRX+ or if they are official or complete or optimized for ePIC:

SVT by the Numbers

Jo Shambach (9/28/23)

	width (mm)	length (mm)		# pixels per reticle								
RSU size	19.564	21.666		894,240								
Pixel size	0.0200	0.0225										
Barrel					Sensor							
Layer Index	**radius (mm)**	**z (mm)**		**Area (mm^2)**	**RSUs in width**	**RSUs in length**	**# of sensors in r-phi**	**# of sensors in z**	**# pixels**	**# sensors**	**Notes**	**# Readout Links**
0	36	270		61,073	3	12	4	1	128,770,560	4	bent ITS3	72
1	48	270		81,430	4	12	4	1	171,694,080	4	bent ITS3	96
2	120	270		203,575	5	12	8	1	429,235,200	8	bent ITS3	240
3	270	540		916,088	1	5	87	5	1,944,972,000	435	1x5 LAS	435
4	420	840		2,216,706	1	5	135	8	4,828,896,000	1080	1x5 LAS	1080
e-endcap												
Disk index	**z (mm)**	**inner r (mm)**	**outer r (mm)**									
1	-250	36.76	240	176,710	1	5			375,580,800	84	1x5 LAS	84
2	-450	36.76	415	536,815	1	5			1,135,684,800	254	1x5 LAS	254
3	-650	36.76	421.4	553,632	1	5			1,171,454,400	262	1x5 LAS	262
4	-900	40.0614	421.4	552,835	1	5			1,166,983,200	261	1x5 LAS	261
5	-1150	46.3529	421.4	551,127	1	5			1,166,983,200	261	1x5 LAS	261
h-endcap												
Disk index												
1	250	36.76	240	176,710	1	5			375,580,800	84	1x5 LAS	84
2	450	36.76	415	536,815	1	5			1,135,684,800	254	1x5 LAS	254
3	700	38.52	421.4	553,216	1	5			1,171,454,400	262	1x5 LAS	262
4	1000	53.43	421.4	548,909	1	5			1,158,040,800	259	1x5 LAS	259
5	1350	70.14	421.4	542,422	1	5			1,144,627,200	256	1x5 LAS	256
TOTAL				**8,208,062**					**17,505,642,240**	**3768**		**4160**

VTRX+ Specifications (2)

- The VTRX+ specifications are fully detailed:
  https://edms.cern.ch/ui/#!master/navigator/project?P:1767090345:1767090345:subDocs
- Several documents: Versatile Link Transceiver, application notes, passive optical components etc…

Table 1 – Versatile Link Plus general specifications (TBC).

#	Specification	Min.	Typ.	Max.	Unit.
2.1	Bit Rate (uplink)	5.12		10.24	Gbps
2.2	Bit Rate (downlink)		2.56		Gbps
2.3	Link length		50	150	m
2.4	Wavelength		850		nm
2.5	Fibre attenuation (150 m)			0.375	dB
2.6	Insertion loss			1.750	dB
2.7	Fibre radiation penalty				
	- Standard grade			0.500	dB
	- Extended grade			1.500	

Asymmetrical Rate seems to be feature of the VTRX+, not just the lpGBT

Links are independent and can be left unattached as can FELIX. 24 port FELIX has 48 fibers, but can be configured with arbitrary numbers of TX/RX within that constraint

Most experiments have asymmetric bandwidth needs in the up- and downstream directions. This typically results in applications requiring many more front-end transmitters than receivers. To cover this need, the VTRx+ uses four up-stream channels at 10.24 Gb/s and one down-stream channel at 2.56 Gb/s, Figure 2. The VTRx+ module can be used in different configurations, depending on user requirements. In case of smaller up-stream bandwidth requirement unused transmitting channels can be disabled by programming the laser driver via I2C and the transceiver then operates in a single Tx/Rx mode. If there is no need for a down-stream connection, the receiver side of the VTRx+ need not be powered and in this case the module operates as a quad-transmitter.

VTRX+ Specifications (3)

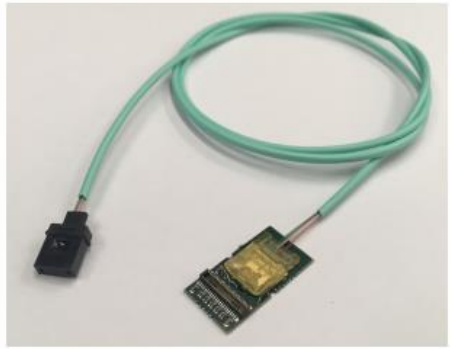


Figure 2: Photograph of a VTRx+ module showing pigtail and MT connector

Need to define pigtail lengths when ordering

The VTRx+ module has an optical fibre pigtail as shown in Figure 2. The five individual fibres shown are bundled into a single sheath with outer diameter 1.5 to 2.0 mm (TBD). The minimum bend radius for the pigtail is 10 mm for a single quarter turn (i.e. one 90° bend) and 25 mm for three complete turns. The pigtail length can be chosen from a pre-determined range (TBD) of values when ordering. Each pigtail is terminated with a female MT connector. The female MT does not have guide pins because for an MT-MT connection the guide pins must be added before making the connection since they are retained only by the MT spring clip that unites the two MT connectors. For test systems it is recommended to use an MT-MPO adapter with a male MPO connector for connection to the test system.

To what extent is this true? Are we constrained to FireFLY CERN-B modules on the other end of the fiber? (These are the links used by the FELIX 182) Do these modules have a similar end-of-life availability issues as the VTRX+

Samtec Inc. is the exclusive supplier of Back-end components compatible with the VTRx+ modules, the FireFly™ CERN-B. Three different assembly types are available: 12- or 24-channel transmitter module with pigtail (T12/T24); 12- or 24-channel receiver module with pigtail (R12/R24); and an assembly where the pigtails of one T12 and one R12 module terminate in a single multi-fibre connector (Y12). Furthermore, each assembly type is available in standard (-1) or extended (-2) grade. The part numbers to be used are given in Table 6. Further information regarding the FireFly™ CERN-B module can be found in the product brief[3] and in the datasheet available under NDA by contacting firefly@samtec.com. For information regarding purchasing please contact the Electronics Coordinator of your HL-LHC experiment.

Table 6: Samtec FireFly™ CERN-B Module part numbers for use in VL+ back-end

Assembly type	Standard Grade	Extended Grade
12-channel Tx module	CERN-B-T12-XXX-H-1-F-C	CERN-B-T12-XXX-H-2-F-C
12-channel Rx module	CERN-B-R12-XXX-H-1-F-C	CERN-B-R12-XXX-H-2-F-C
12-channel TRx module	CERN-B-Y12-XXX-H-1-F-C	CERN-B-Y12-XXX-H-2-F-C
24-channel Tx module	CERN-B-T24-XXX-H-1-F-C	CERN-B-T24-XXX-H-2-F-C
24-channel Rx module	CERN-B-R24-XXX-H-1-F-C	CERN-B-R24-XXX-H-2-F-C

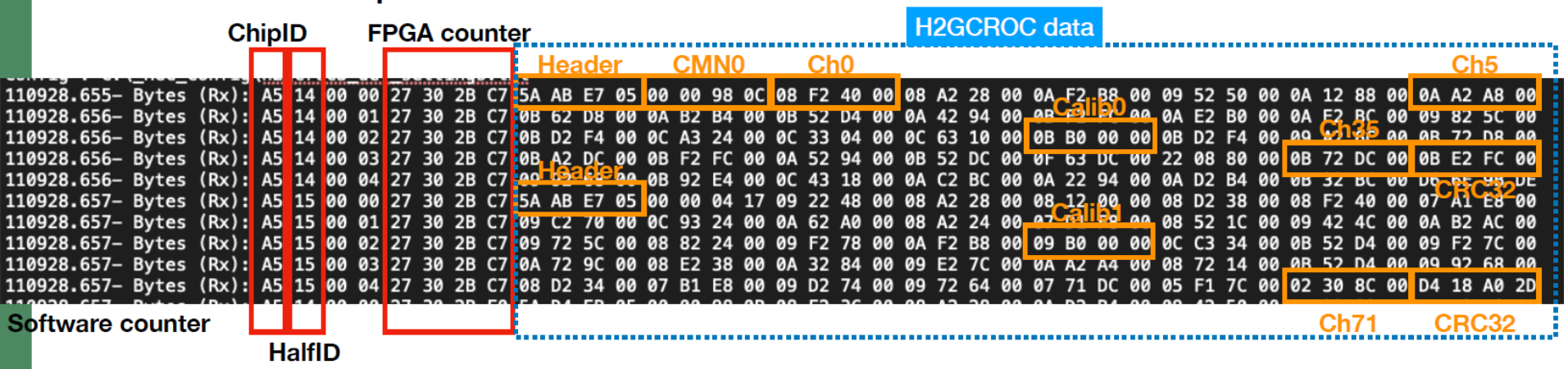
VTRX+ Specifications (4)

Questions:

1. For VTRX+
   - What are the firm numbers for VTRX+ for each detector with pigtail lengths specified?
   - Are there other obsolescence issues (CERN-B firefly?)
2. For lpGBT in MAPS
   - What is the commitment schedules for these?
   - Is there still a path under which these are built into the Sensors or are they definitely separate units?
   - Will there be separate boards, or VTRX+/lpGBT mounted on staves/sensor ends
   - Are they only in the RX path, or are they also in the TX path?
   - What are the firm numbers for these? If 300, How does 300 cover the full detector when 1000 VTRX+ are required?
   - Is the 39.4Mhz vs 40MHz an issue for the PLLs?
3. General
   - The lpGBT/VTRX+ are part of the CERN ecosystem. Any parts we are missing that are needed?

H2GCROC3A data --- implications for downstream DAQ

Data format explained



Ch0 `08 F2 40 00`

0 0 0010001111 0010010000 0000000000

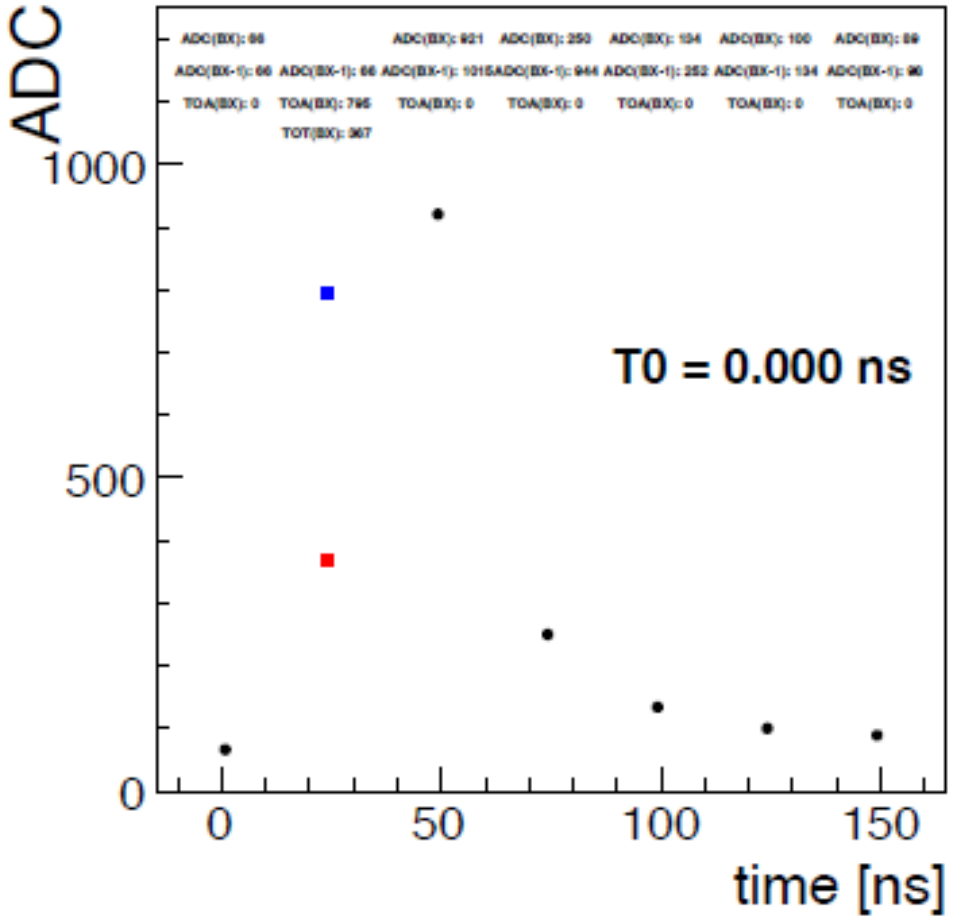
Tc Tp ADC(BX-1) ADC(BX) TOA(BX)

Different data format with different charge inputs:

Tc	Tp	10-bit	10-bit	10-bit	Explanation
0	0	ADC(BX-1)	ADC(BX)	TOA(BX)	TOA and TOT threshold is not reached
0	1	ADC(BX-1)	ADC(BX)	TOA(BX)	TOA threshold reached, TOT not
1	0	ADC(BX-1)	TOT(BX)	TOA(BX)	TOT threshold reached
1	1	ADC(BX)	TOT(BX)	TOA(BX)	Characterization

- Granularity of readout is half chip (36 channels).
- Data is 3x10 bit words per sample, but the meaning of the three words depends on the Tc, Tp flags
- Data is NOT pedestal subtracted, rather the pedestals are gain matched to the same value
- Can configure # time samples read out
- Can configure to disable certain Tc/Tp Combinations
- Details may be different in final ASIC, take as start

H2GCROC3A hit



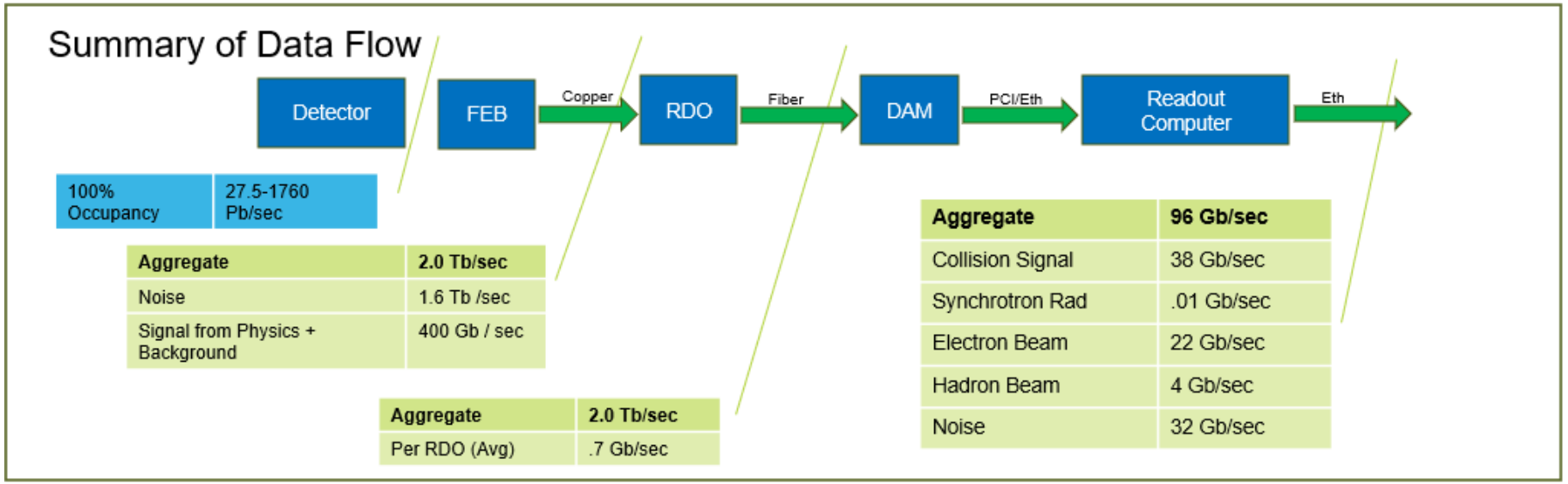
Time	Tc	Tp	Word 1	Word 2	Word 3
0	0	0	ADC[0]	ADC[-1]	0
1	1	0	ACD[0]	TOA	TOT
2	0	0	ADC[2]	ADC[1]	0
3	0	0	ADC[3]	ADC[2]	0
4	0	0	ADC[4]	ADC[3]	0
5	0	0	ADC[5]	ADC[4]	0
6	0	0	ADC[6]	ADC[5]	0
7	0	0	ADC[7]	ADC[6]	0
8	0	0	ADC[8]	ADC[7]	0

Readout 36 channels of this, most have no Tc=1 though

- Bits readout per hit: ~36 x 6 x 32 = 6912

- Tasks for RDO &/or Readout computer
  - Zero suppress channels (remove all with no Tc bit) [RDO]
  - Define Banks [Readout computer]
    - TOA bank: 5 header + (chID, TOA, TOT) x nHit
    - SAMPLE bank: 5 header + (chID, ADC[1]… ADC[7]) x nHit
    - RAW bank: Exact ASIC data
  - Remove wasteful banks from *most* time frames [Readout computer]
  - Translate 25ns time bins + TOA into ePIC 10ns BX.

H2GCROC3A hit



Will affect data volumes here:

- Have assume ~64 bits per hit, so final output not changed
- FEB->RDO traffic increased by a rather large amount 1 hit = 7 Kbits. I assumed 6 samples x 9 hits for calorimeters so a factor of 4 more to the RDO
- Will need to do some of this data reduction in the RDO! Assuming only the channel suppression is done in the RDO, then might have a x4 higher rate for the RDO->DAM for a sample value of 6

H2GCROC3A hit

Example Final Data file:

TimeFrame 1: TOABank, RAWbank, SAMPLEbank
TimeFrame 2: TOABank
…
TimeFrame 100: TOABank, RAWbank, SAMPLEbank
TimeFrame 101: TOABank
…

TOA bank is always present and the basis for “normal” reconstruction and analysis, but studies can use typically ignored RAW/SAMPLE banks…