

SciFi TELL40: Progress and Status

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SciFi General Meeting, Feb 27th 2023

<https://indico.cern.ch/event/1253790/>

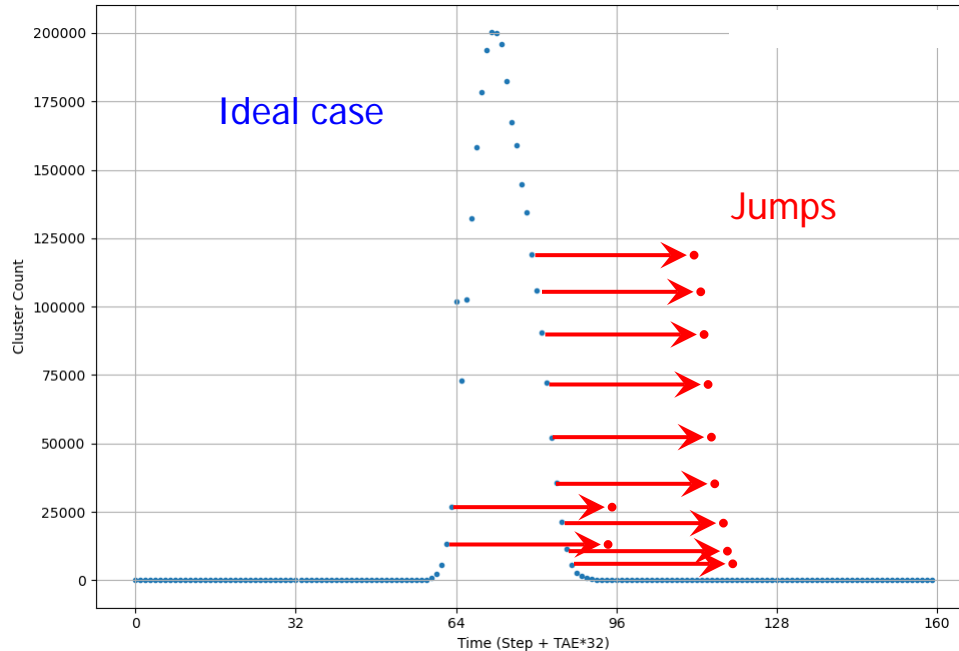


Progress on the « BXID jumps » problems in TELL40s

- Problem identified in July-August '22 when trying to fine tune the front-end PACIFIC sampling clock with respect to the beam (see [Ulisses' presentation in December](#))

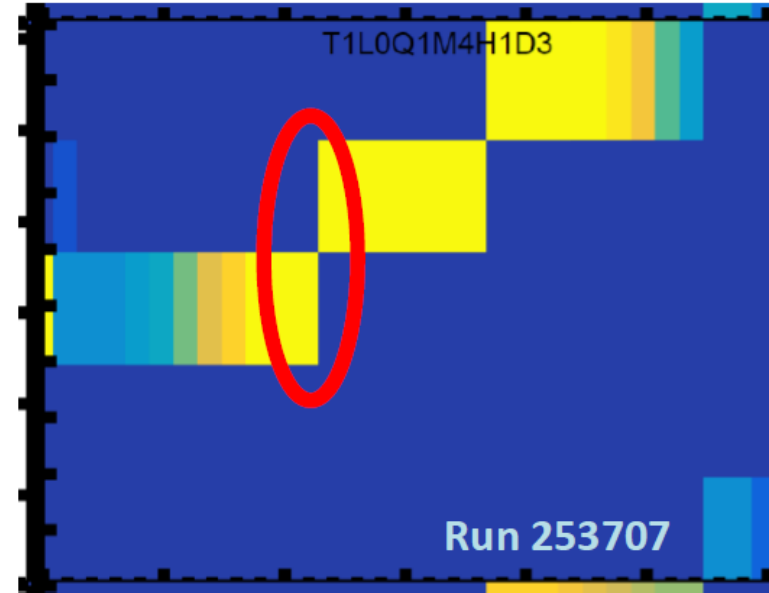
 - To calibrate the delays of the Master-GBT clocks distributed to the PACIFIC ASIC
 - Perform a “BEAM TIMING SCAN” Step run
 - ◆ TAE run, with central BXID set to an isolated bunch BXID (window of 5 events)
 - ◆ accumulate the number of clusters per link and per BXID for each step
 - ◆ at each step, apply an additional fine delay on the PACIFIC sampling clock (~32 steps for 25 ns)
- => Identify the step for which the maximum clusters are detected

Beam Timing Scans: the BXID jumps



5 consecutive cluster counts, superimposed over the 32 steps (scan over 25 ns)

Also cf [Blake's presentation](#) in December'22



Distribution of cluster counts:

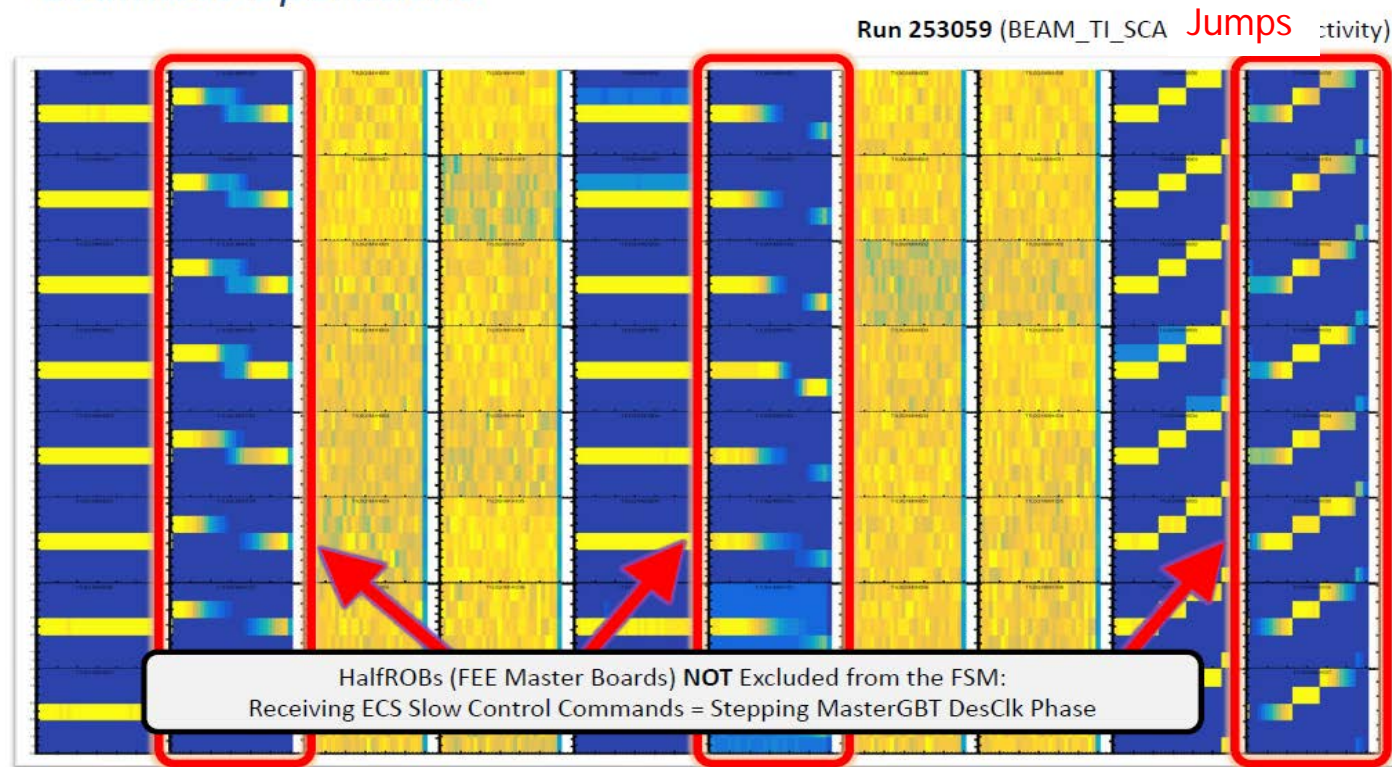
- X axis = step number (0 to 31)
- Y axis = from centralBxid-2 to +2

Trying to identify the source of the problem

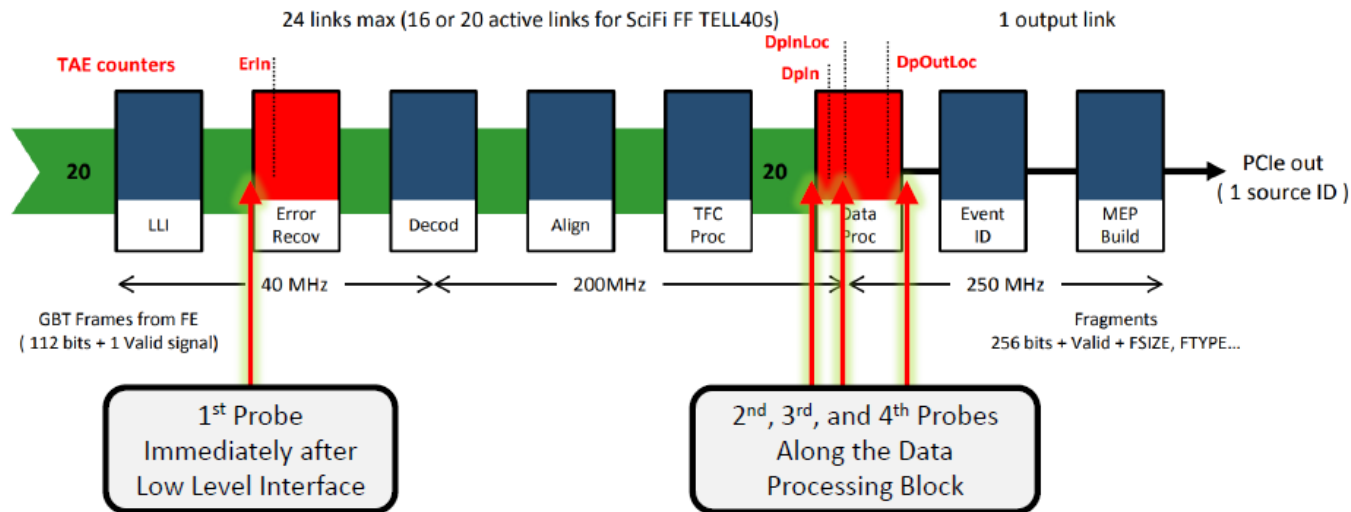
- We could quickly find that those jumps occur only when a TFC FE reset & BE reset is issued at each step (actually disabling the FE reset and BE reset vetos in the ODIN settings)
- For successful scan runs, FE reset and BE reset are needed between steps (because shifting PACIFIC clocks between steps has the side-effect that, during a transient period, the decoders in the TELL40s enter in error at the start of the following step)
- We continued the investigations without beam, using the light injection system on the FE electronics
 - See Ulisses' presentation in December
https://indico.cern.ch/event/1222331/contributions/5166004/attachments/2560386/4413312/SciFi%20General%2005-12-2022%20_%20Operations%20v3.pdf
 - Insertion of probes in the SciFi specific parts of the TELL40 firmware, storing the cluster counts at several places in the flow. Development of addition WinCC tools to read, at each step of the run, the contents of those counters and other diagnostics information and write them in a "Run Summary" file (1 yaml format file per half-TELL40)

Example of beamless fine time scans

Beamless Operations



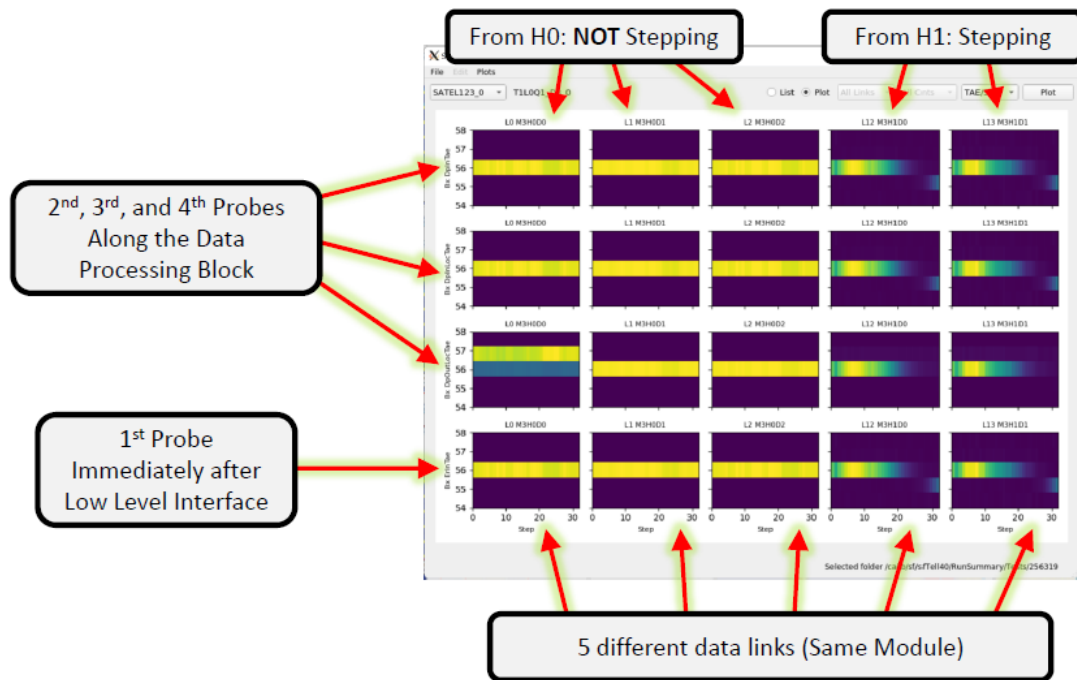
Debug TELL40 firmware on a few data links



- Covers 5 data links per Tell40 Half-Board, on 5 BxIDs: From TAE -2 to TAE +2
- Counters readable through slow control registers;
- FSM Handler, if enabled, read all counters and write values to a file after each Step or on STOP_RUN.

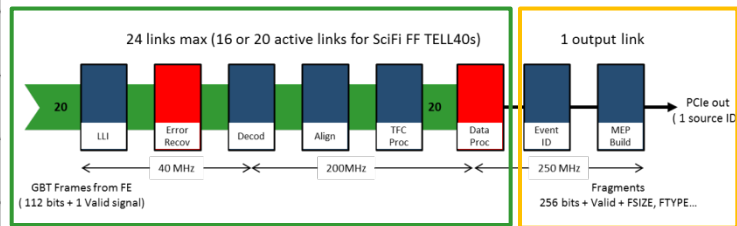
Probes analysis with beamless Fine Timing Scans

- Python tool to parse yml files and make plots:



Outcome:

No BXID jumps observed from the TELL40 flow input to the Data Processing block output



Could it come from the downstream TELL40 modules (EventID, MEP builder) or from the EB, software ?

Errors in the TELL40 Event ID block

- In Dec'22, thanks to new monitoring tools developed by the online team (Grafana web interface), a correlation was found between the BXID jumps and the generation of error fragments generated by the Event ID block (Event ID jump errors)
- Beginning of 2023:
 - Using a version of the TELL40 FW modified by Guillaume (including “SignalTap” internal probes), we could determine that those Event ID jump errors were **fake** errors (due to the generation of BE resets between steps)
 - Eventually, production of a modified version of the TELL40 FW, strengthening the reset tree in the Event ID block. This FW was deployed on the whole SciFi detector TELL40s and some Beam Timing scans were performed
=> **No BXID jumps errors was observed anymore**
- **Conclusion:**
 - **The latest version of TELL40 firmware seems to have solved the problem (crossing fingers), even if the reason why the generation of error fragments in the Event ID block induced those jumps is not really understood**
 - A lot of efforts was needed over several months to understand and fix the problem. However, we learned a lot about the full processing chain. New monitoring tools were developed, which can be used, in the future, for a better understanding of unexpected behaviors.

TELL40 FV format firmware

- Fall '22 : FV format TELL40 tested in the pit setup
 - Correct decoding at the 'START' WinCC phase
 - Decoding errors as soon as a WinCC 'GO' command is applied
At 'GO', a set of SYNC commands are sent by the TFC, while the decoder is already running.
This case was not supported by the FV decoders
- Feb '23 : New FV TELL40 version, where the decoder supports SYNC frames while running
 - Tested on the whole SciFi-A partition (24 FV, 48 FF TELL40)
No WinCC related problem
 - Stable run for most boards
 - But some boards went in error, when 1 or 2 links of have a high cluster occupancy (e.g. hot SiPMs)
⇒ **Need more investigation to understand the problem, using: Emulated data (produced by TELL40 embedded emulators or the Cluster FPGA) and dedicated VHDL simulations**

GBT frames read in TELL40, with light injection

Fragment Monitoring									
Counter Plot		NZS Plot		Counters		Front-End Emulators		Front-End Frames	
Link 7	Pattern	0100 0050000 0050000 0050000 0050000	Acquire	Available	✓ Show GBT	Frames	35		
Setup...	Mask	0100 FFFE000 FFFE000 FFFE000 FFFE000	✓ Auto Read	Read	✓ Parse	FV	from 0	Q2	
Set link to 7 Set Options: 0x00000020 PATTERN = 0100 0050000 0050000 0050000 0050000 MASK = 0100 FFFE000 FFFE000 FFFE000 FFFE000									
931008C 4001012 0050145 0E88C4E	0060183C5845262018200	00701C3282354627184CD 0001002	0081183C584C402318400	0090A583C2896CD09804E3099A0101003	00A0243C58342293100C24003003	00B1144C4C744E3080000	00C1A43C583422931009B6133800	00D01C508A524627184CE000000	00E1243C5845261FD189B5930800
00F11C5048523A27184CE000000	0101243C583422931009C6139000	011024081C140E99868454E30800	0121203C58452620136C24001003	013118503C21A21718400	0140243C583422931009C6136400	01501C506A4C291D138C2000000	01601C358442620184E44002003	01711050989C610000000	0181203C584C3F6A0084E44006003
0191144C509C613900000	01A01C3C584C3F6B099CE44002003	01B01450A49C593080000	01C1A03C5834261FD38C27200000	01D02450A4C21A1D11A996133400	01E03C61E18160C06845261D10040013830410111	01F01C384C524627184C0000000	02001C3C584C40260084E44001003	02101850589C613350000	0220283C5834261FD18C28002003
02311450989C613900000	0241A83C584526201809B61331C8	02501C5058744E2A584C0000000	0261283C583022931009B4001003	02701850000000000000000					
BXID=005 OK NORM STD PAR OK FLAG=0 LEN= 5	BXID=006 OK NORM STD PAR OK FLAG=0 LEN= 6	BXID=007 OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=008 OK NORM STD PAR OK FLAG=0 LEN= 6	BXID=009 OK NORM STD PAR OK FLAG=1 LEN=11	BXID=00A OK NORM STD PAR OK FLAG=0 LEN= 6	BXID=00B OK NORM STD PAR OK FLAG=0 LEN= 5	BXID=00C OK NORM STD PAR OK FLAG=1 LEN= 9	BXID=00D OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=00E OK NORM STD PAR OK FLAG=0 LEN= 9
BXID=00F OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=010 OK NORM STD PAR OK FLAG=0 LEN= 9	BXID=011 OK NORM STD PAR OK FLAG=0 LEN= 9	BXID=012 OK NORM STD PAR OK FLAG=0 LEN= 8	BXID=013 OK NORM STD PAR OK FLAG=0 LEN= 6	BXID=014 OK NORM STD PAR OK FLAG=0 LEN= 9	BXID=015 OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=016 OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=017 OK NORM STD PAR OK FLAG=0 LEN= 4	BXID=018 OK NORM STD PAR OK FLAG=0 LEN= 8
BXID=019 OK NORM STD PAR OK FLAG=0 LEN= 5	BXID=01A OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=01B OK NORM STD PAR OK FLAG=0 LEN= 5	BXID=01C OK NORM STD PAR OK FLAG=1 LEN= 8	BXID=01D OK NORM STD PAR OK FLAG=0 LEN= 9	BXID=01E OK NORM STD PAR OK FLAG=0 LEN= 15	BXID=01F OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=020 OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=021 OK NORM STD PAR OK FLAG=0 LEN= 6	BXID=022 OK NORM STD PAR OK FLAG=0 LEN= 10
BXID=023 OK NORM STD PAR OK FLAG=0 LEN= 5	BXID=024 OK NORM STD PAR OK FLAG=1 LEN= 10	BXID=025 OK NORM STD PAR OK FLAG=0 LEN= 7	BXID=026 OK NORM STD PAR OK FLAG=0 LEN= 10	BXID=027 OK NORM STD PAR OK FLAG=0 LEN= 6					

Other topics

- Threshold scan activities for FE SiPM channels calibration
 - Operational
 - But the scan procedure is slow (~2 hours)
 - ◆ Bottleneck = change the threshold values between scans on all the FE boards
 - ◆ Some efforts currently made on the FE WinCC system optimisation (esp. partitioning the project into several sub-projects could speed-up the FE accesses (parallelized))
 - Since a recent WinCC modification of the TELL40 generic parts, some difficulties in configuring correctly all the TELL40s for threshold scan. Workaround used until the problem is fixed by the online team
- Problems of long term stability of the coarse time alignment
 - SOL40 firmware related. Online team working on it (fixed latency firmware)

Conclusion

- Problem of BXID jumps during step runs seems solved (although the reason why is not very clear)
- TELL40 FV firmware:
 - Operational for nominal operation. Tested over a full partition
 - Still some problems in high occupancy cases
=> Next steps: stress tests with emulated data (in TELL40 or in the cluster FPGA) and with dedicated FW simulations

Thank you!

TELL40 modularity

- T1 and T2: 5 modules of 16 SiPMs per quadrant
- T3: 6 modules per quadrant
- 4 quadrants => 1 C-Frame

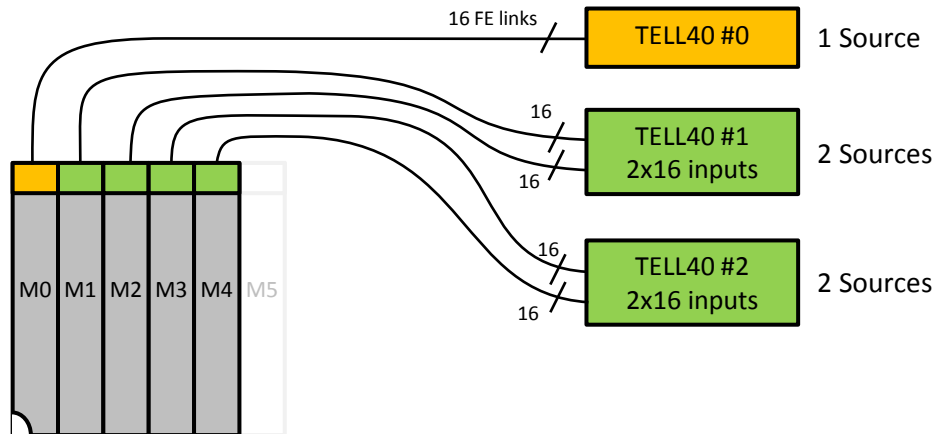
- **2 different TELL40 firmwares:**

- M0: **TELL40 #0**
16 links TELL40 **FV** format

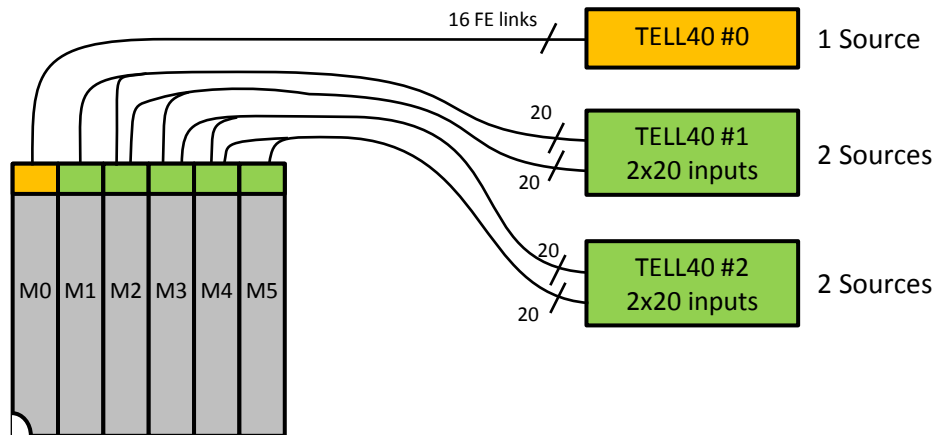
- M1-M5: **TELL40 2x20 inputs**
2x20 links TELL40 **FF** format

Same FW for the 3 stations for simplicity

For T1 and T2, connect only 2x16 FE links out of the 2x20 available inputs

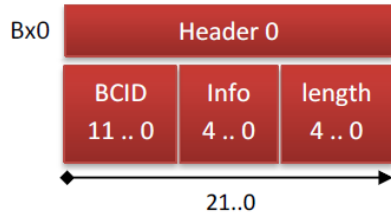


1 quadrant = 80 SiPMs (T1 and T2)



1 quadrant = 96 SiPMs (T3)

SciFi FF Front-End Data Format



Position in Info[4:0]	Position in Header[9:5]	Description
4:3	9:8	Frame-info bits
2	7	NZS data
1	6	Parity bit. Parity of the other 21 bits of the header
0	5	Error Flag (reserved for future use)

Frame Type	Frame Info		Frame Data
	Hdr[9]	Hdr[8]	
Normal (SFV)	0	0	Normal SFV data frame (Sect. 4.1)
Normal (FF)	0	0	Normal FF data frame (Sect. 4.2)
FE Buffer Full (SFV)	0	1	Only header sent by FE to recover FE-Buffer (Sect. 4.1.2), frame size 28b
Hdr-only (SFV)	1	0	Only header (requested by TFC), frame size 28b
Hdr-only (FF)	1	0	Only header (requested by TFC), frame size 112b
Hdr-only after NZS (FF)	1	1	Only header to recover FE-Buffer after NZS (Figure 7), frame size 28b (part of four-frames sequence)

SciFi FF Front-End Data Format

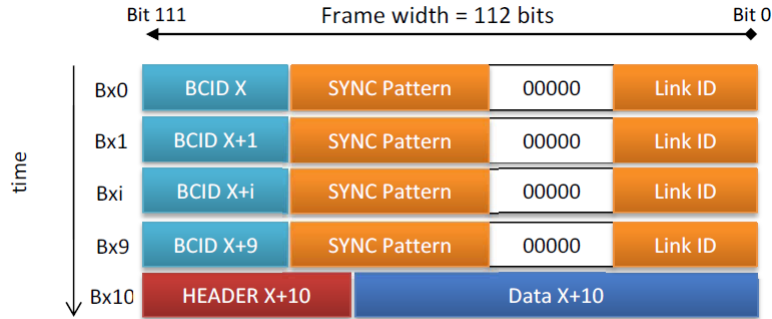
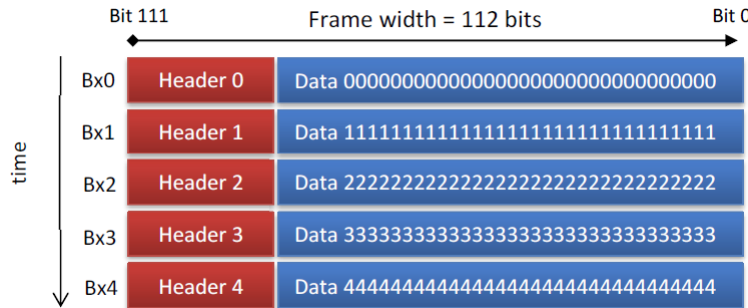


Figure 9: SYNC frames (BX0-BX9), followed (BX10) by a standard data frame.



TFC NZS=0

- **TFC Header Only = 0** => FrameInfo = "00"
- **TFC Header Only = 1** => FrameInfo = "10", Data=00000

TFC NZS=1
=> FrameInfo = "00"

TFC NZS=0
=> FrameInfo = "11"

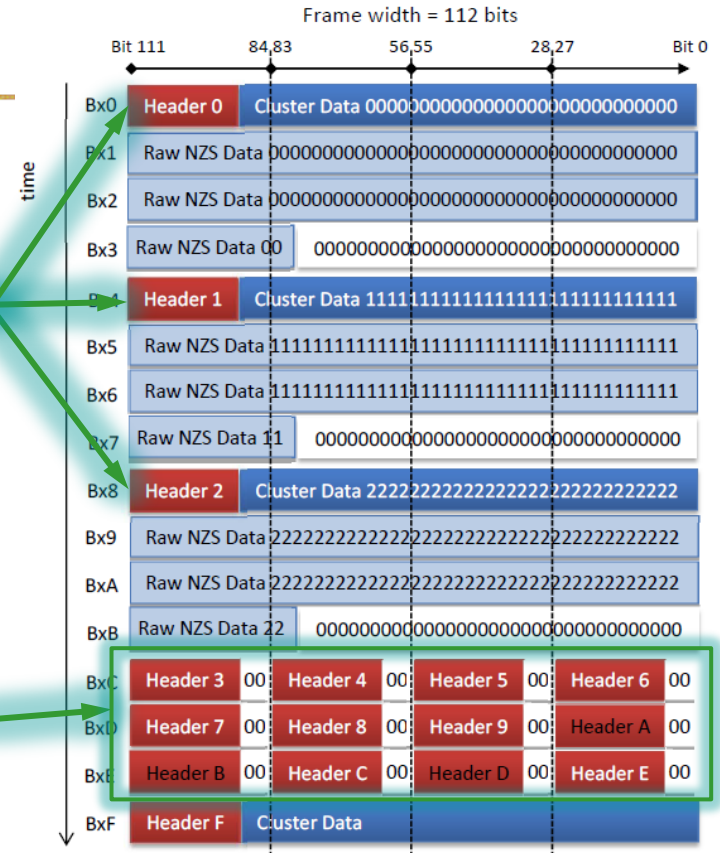


Figure 7: Data generated by three consecutive NZS commands in FF mode.

SciFi FV Front-End Data Format

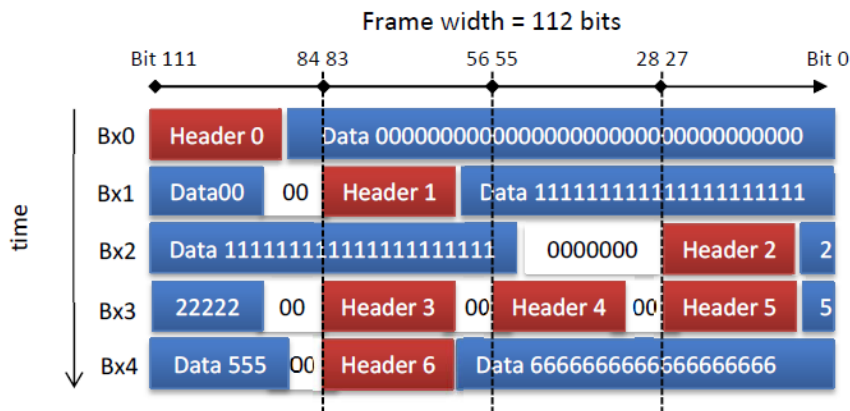


Figure 4: SciFi specific data format with a fixed header and variable data (SFV).

Frame Type	Frame Info		Frame Data
	Hdr[9]	Hdr[8]	
Normal (SFV)	0	0	Normal SFV data frame (Sect. 4.1)
Normal (FF)	0	0	Normal FF data frame (Sect. 4.2)
FE Buffer Full (SFV)	0	1	Only header sent by FE to recover FE-Buffer (Sect. 4.1.2), frame size 28b
Hdr-only (SFV)	1	0	Only header (requested by TFC), frame size 28b
Hdr-only (FF)	1	0	Only header (requested by TFC), frame size 112b
Hdr-only after NZS (FF)	1	1	Only header to recover FE-Buffer after NZS (Figure 7), frame size 28b (part of four-frames sequence)