FriDAQ DataFlow

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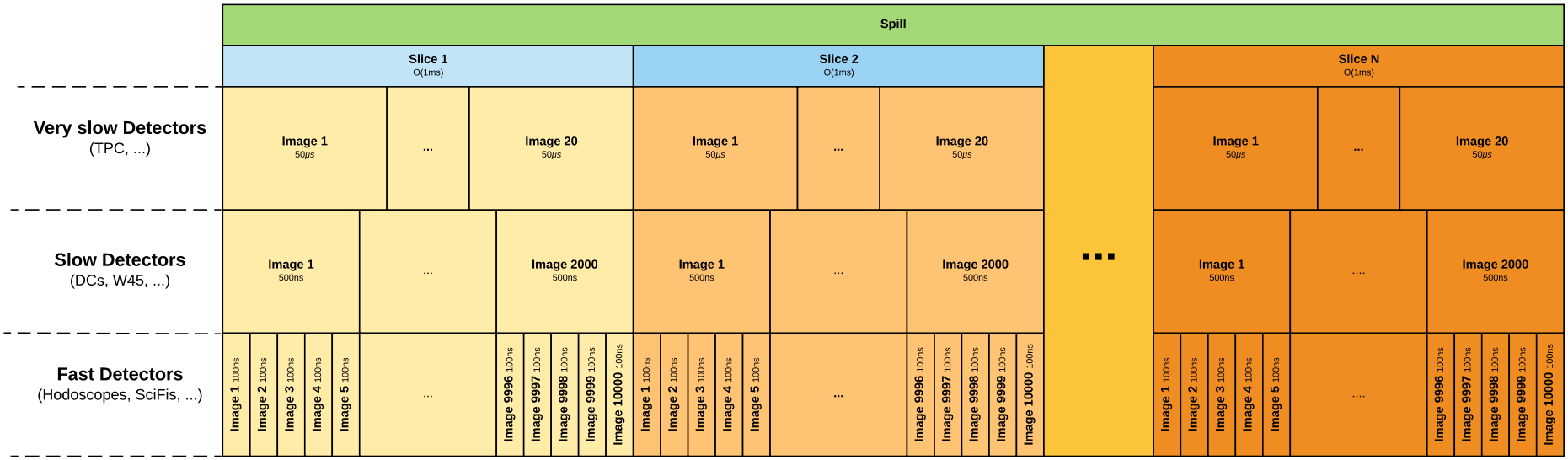
and Research

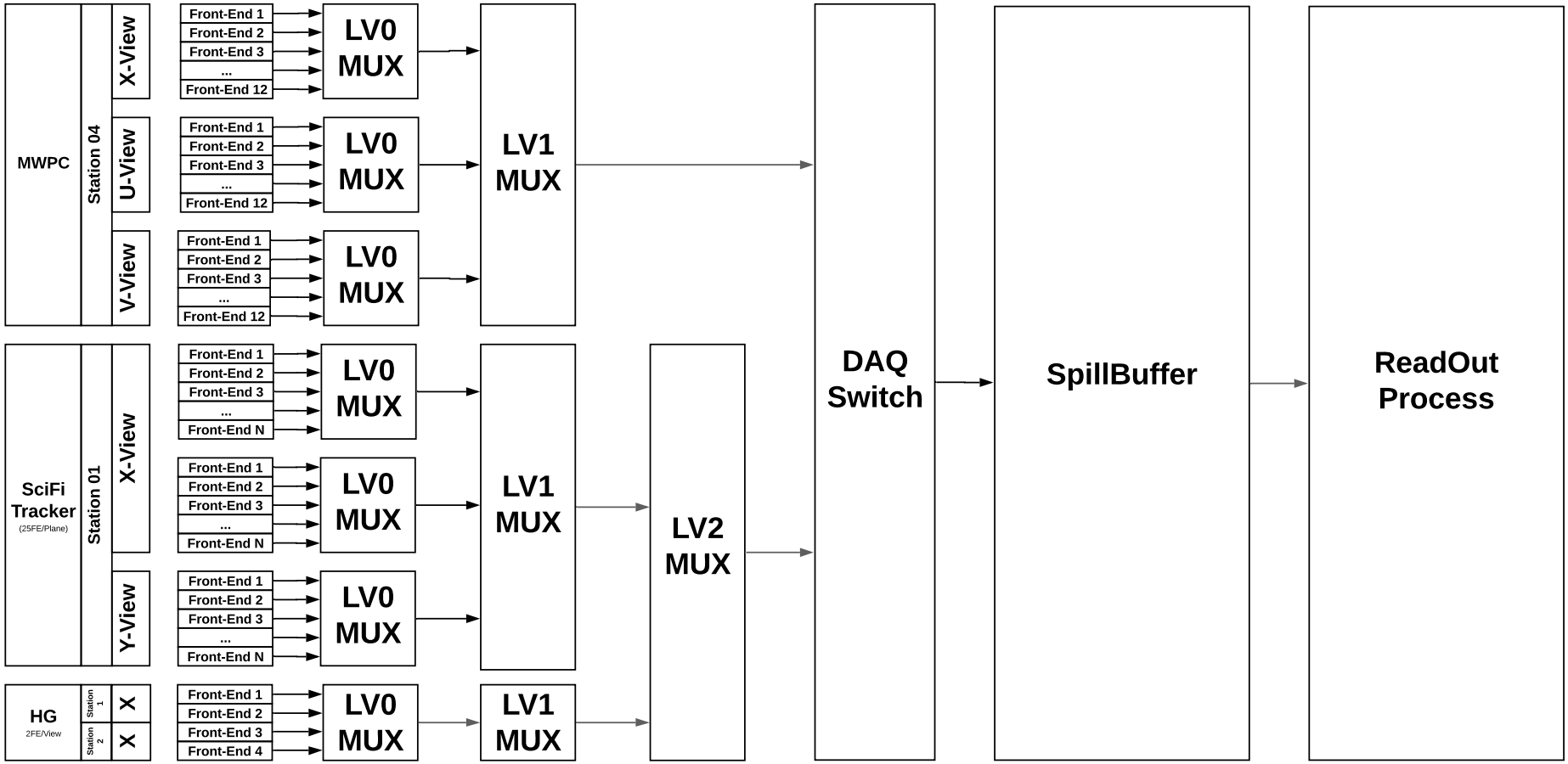
Time Slices vs Images

Time Slices are generated by a synchronous signal which is distributed to all front-ends.

Additional partition in **images** according to detector resolution and rates.



DAQ Structure



Protocol Considerations

The communication of DAQ equipment is organized in **frames**.

Every equipment always sent a **Begin of Slice Frame** (BOS) and **End of Slice** (EOS) frame encapsulating the payload data frame(s) in between.
$\rightarrow$ Even LV0 MUX can be directly connected to spill buffer for test setups.

The Time Slice length is in the order of 1 ms (see Dmytro talk).

The data is partitioned in 32 bit data words.

Naming Convention:

- A **Spill** is made out of **Time Slices**.
- A **Time Slices** are made out of **Images**.
- A **Image** contains **Hit Payload**

Common Frame Information I

The first three data words and the two last are the same for all different frames:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Magic Word (8b)								Frame Type (4b)				SliceID (18b)																		NU (1b)	EOSB (1b)
Spill# (12b)												NU (4b)				SrcID (16b)															
Time of Slice (32b)																															
Frame Payload (N x 32b)																															
0	Slice Size (31b)																														
0	CRC (31b)																														

- **Magic Word (8b):**
  A 8bit magic word starts every frame (0b01010101 = 0x55).
- **Frame Type (4b):**
  Used to indicate the format of the frame (16 different frame types).
- **SliceID (18b):**
  Counter which continuous increment and reset with the start of a new spill.
- **End of Slice Bit (1b):**
  Bit which indicates that this frame is the last one for the current Time Slice.

Common Frame Information II

The first three data words and the two last are the same for all different frames:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Magic Word (8b)								Frame Type (4b)				SliceID (18b)																		NU (1b)	EOSB (1b)
Spill# (12b)												NU (4b)				SrcID (16b)															
Time of Slice (32b)																															
Frame Payload (N x 32b)																															
0	Slice Size (31b)																														
0	CRC (31b)																														

- **Spill Number (12b):**
  Number of Spill in the current run (Maximum 4096 Spills).
- **SrcID (16b):**
  16bit as SrcID.
- **Time of Slice (32b):**
  The start time of Slice since the start of the spill as 32 bit counter which indicates the global time of the slice in TCSticks (26 ns steps). The maximum value is $2^{32} \cdot 26\,\text{ns} = 111.66\,\text{s}$ (Maximum duration of Spill). With 2^{18} SliceIDs the minimum Slice length is 426 μs.

Common Frame Information III

The first three data words and the two last are the same for all different frames:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Magic Word (8b)								Frame Type (4b)				SliceID (18b)																		NU (1b)	EOSB (1b)
Spill# (12b)												NU (4b)				SrcID (16b)															
Time of Slice (32b)																															
Frame Payload (N x 32b)																															
0	Slice Size (31b)																														
0	CRC (31b)																														

- **Slice Size (31b):**
  The size of the frame in number of data words (max: 8129 Mbyte/slice).
- **CRC (31b):**
  31 bit checksum of the frame.

Begin of Slice Frame

The BOS frame is sent by every type of equipment:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Magic Word (8b)								Frame Type (4b)				SliceID (18b)																		NU (1b)	EOSB (1b)
Spill# (12b)												NU (4b)				SrcID (16b)															
Time of Slice (32b)																															
Port Mask (32b)																															
0	Slice Size (31b)																														
0	CRC (31b)																														

- **Port Mask (32b):**
  The Port Mask is a bit mask which indicated which ports on this equipment are enabled. Also determines how many Port Error Words are transmitted in the EOS Frame.

End of Slice Frame

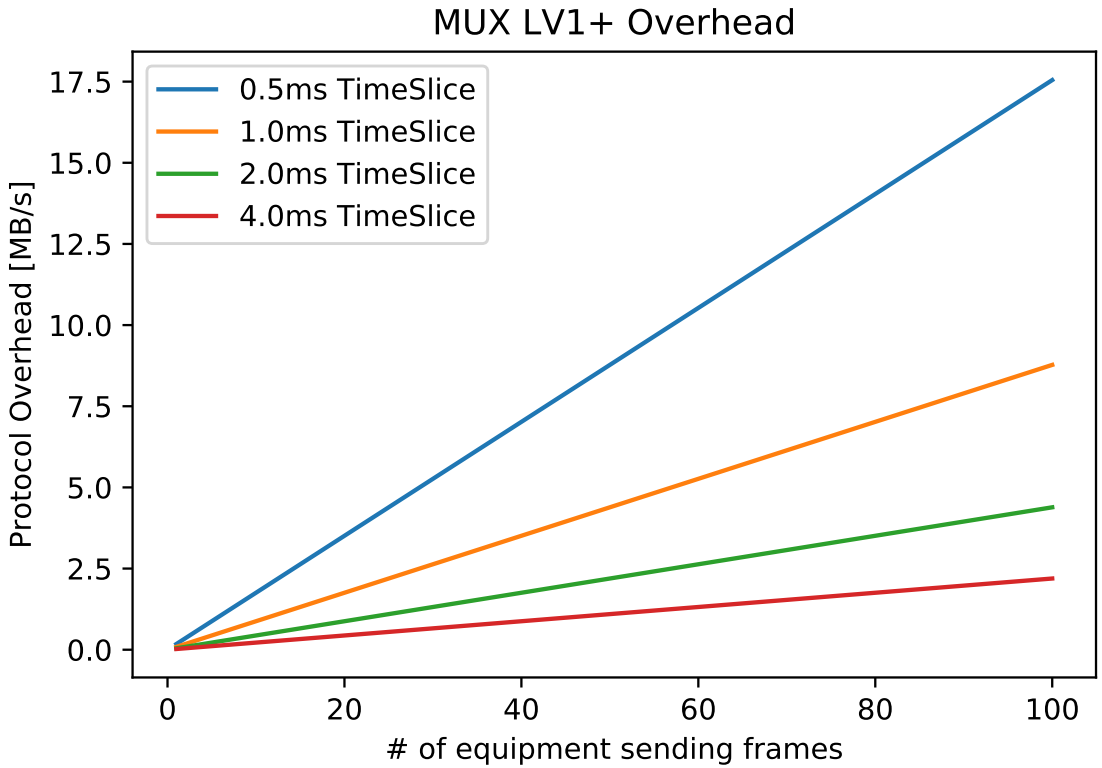
The EOS frame is sent by every type of equipment:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Magic Word (8b)								Frame Type (4b)				SliceID (18b)																		NU (1b)	EOSB (1b)
Spill# (12b)												NU (4b)				SrcID (16b)															
Time of Slice (32b)																															
Port0 Error Word (32b)																															
Port1 Error Word (32b)																															
...																															
Port32 Error Word (32b)																															
0	Slice Size (31b)																														
0	CRC (31b)																														

- **Nx Port Error Words (32b):**
  Depending on the number of enabled Ports in the Port Mask a number of error words for each enabled port is transmitted.

Protocol overhead on MUX LV1+

For a MUX with 12ports enabled we have an overhead of 92 byte per time slice.



The protocol overhead of the LV1+ MUX is negligible with the foreseen Time Slice lengths.

Time Slice Data Frame

Time Slice Data Frames are sent by the LV0 multiplexer and contains the information of the attached front-ends:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Magic Word (8b)								Frame Type (4b)				SliceID (18b)																		NU (1b)	EOSB (1b)
Spill# (12b)												NU (4b)				SrcID (16b)															
Time of Slice (32b)																															
Port Mask (32b)																															
Slice Length (18b)																						Image Length (14b)									
N x Payload Datawords (32b)																															
1	Slice Size (31b)																														
1	CRC (31b)																														

- **Port Mask (32b):**
  bit mask to indicated which ports on this equipment are enable.
- **Slice Length (18b):**
  Slice duration in tcs ticks of 26 ns (max $2^{18} * 26\,\text{ns} = 6.815\,\text{ms}$).
- **Image Length (14b):**
  Image duration in tcs ticks of 26 ns (max $2^{14} * 26\,\text{ns} = 0.426\,\text{ms}$).
- **Payload Data words (Nx 32b):**
  The hit information transferred from the front-ends divided into images.

TSD Payload - The Images

The LSB is used as a control bit to indicate if it is a header/trailer (1) or data (0):

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Description
1	ImageID (16bit)																LIOPS (1b)	StationID (4b)				ViewID (4b)				DataType (6b)						BOI 1
0	Nx Image Data Payload (31b)																															DATA
1	ICRC (31b)																															EOI 1
	.....																															
1	ImageID (16bit)																LIOPS (1b)	StationID (4b)				ViewID (4b)				DataType (6b)						BOI N
0	Nx Image Data Payload (31b)																															DATA
1	ICRC (31b)																															EOI N

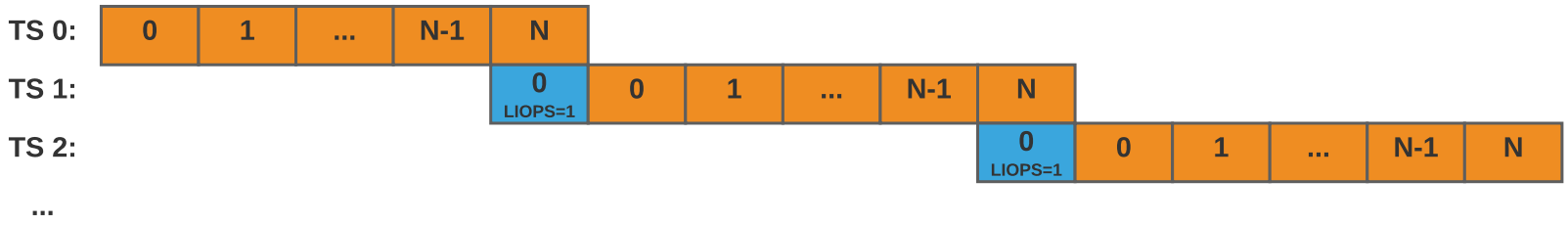
- **ImageID (16b):**
  16bit $\rightarrow$ 65536 $\frac{images}{TimeSlice}$. For the maximum slice length of 6.815 ms, this allows a minimum image length of $2^{18} * 26\,\text{ns}/2^{16} = 104\,\text{ns}$
- **DataType (6b):**
  The data format of the image data payload. 6 bits $\rightarrow$ 64 different data formats.
- **Nx image data payload (Nx 31b):**
  The hit information which belongs to that image
- **imageCRC (31b):**
  A 31bit checksum of the image.

Empty images are not transmitted!

TSD Payload - Last Image of Previous Slice

Data is distributed in Time Slice to the HLT for filtering. Duplicating the last image of previous Time Slice allows to identify also trigger conditions between two consecutive Time Slices.

- **Last Image of Previous Slice (1b):**
  1 bit to indicate the image which belongs to the previous slice



Allows calculation of absolute start time of image in spill:

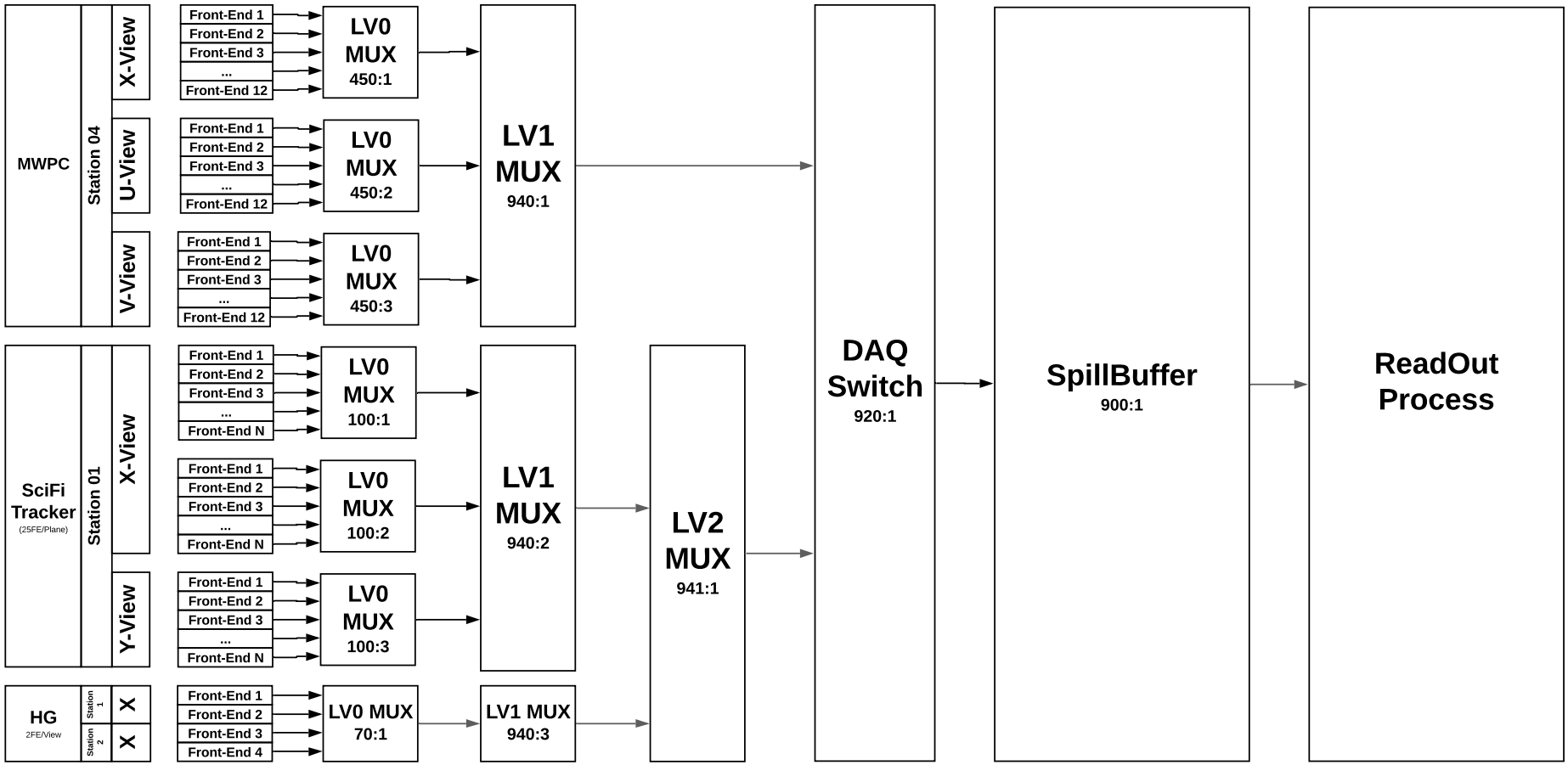
$$ImageStartTime_{absolut} = (TimeOfSlice + (ImageID - LIOPS) * ImageLength) * 26\ ns$$

TSD Payload - The naming scheme

TBName:	**HG**	**01**	**Y1**
	Detector Type	**Station Number**	**View**
	SrcID [9:0]	**StationID** [3:0]	**ViewID** [3:0]
#Values:	**1024**	**16**	**16**

- **SrcID (16b) from frame header:**
  Divided in EquipmentID (10 b→1024) and Sub-equipmentID (6 b→64).
- **StationID (4b)** → max: 16 Stations
- **ViewID (4b)** → max: 16 Views

SRCid Mapping to equipment



Splitting SRCid in EquipmentID and Sub-equipmentID allows easy filtering according to detector type or zones.

Data Format example: General TDC data

In the image data payload N words of 31bit can be used.

Example TDC format:

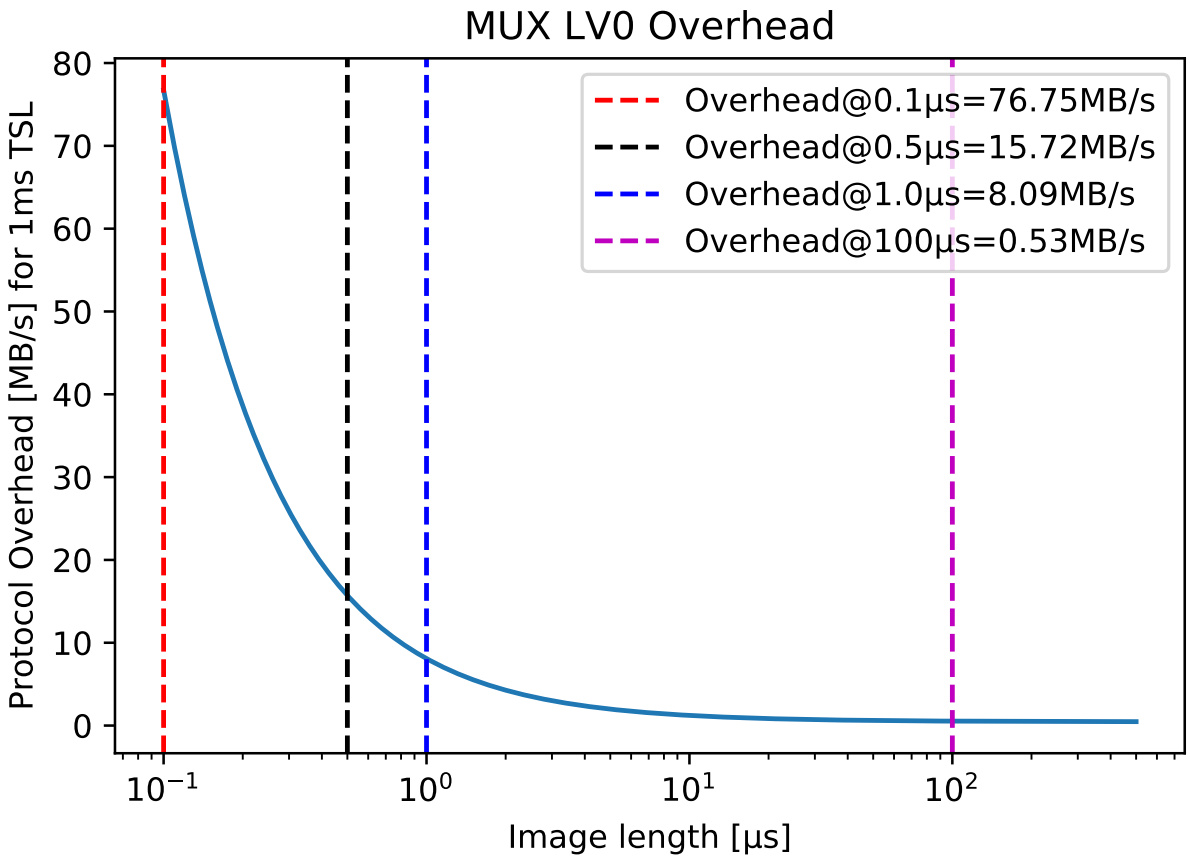
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	PortID (5b)					ChannelID (7b)							HitTime (19b)																		

- **PortID (5b):**
  Up to 64 ports
- **ChannelID (7b):**
  Up to 127 channels
- **HitTime (19b):**
  Minimum bin size for maximum image length: $2^{14} * 26\,\text{ns}/2^{19} = 0.8125\,\text{ns}$

Hits are sorted in time inside of a image.

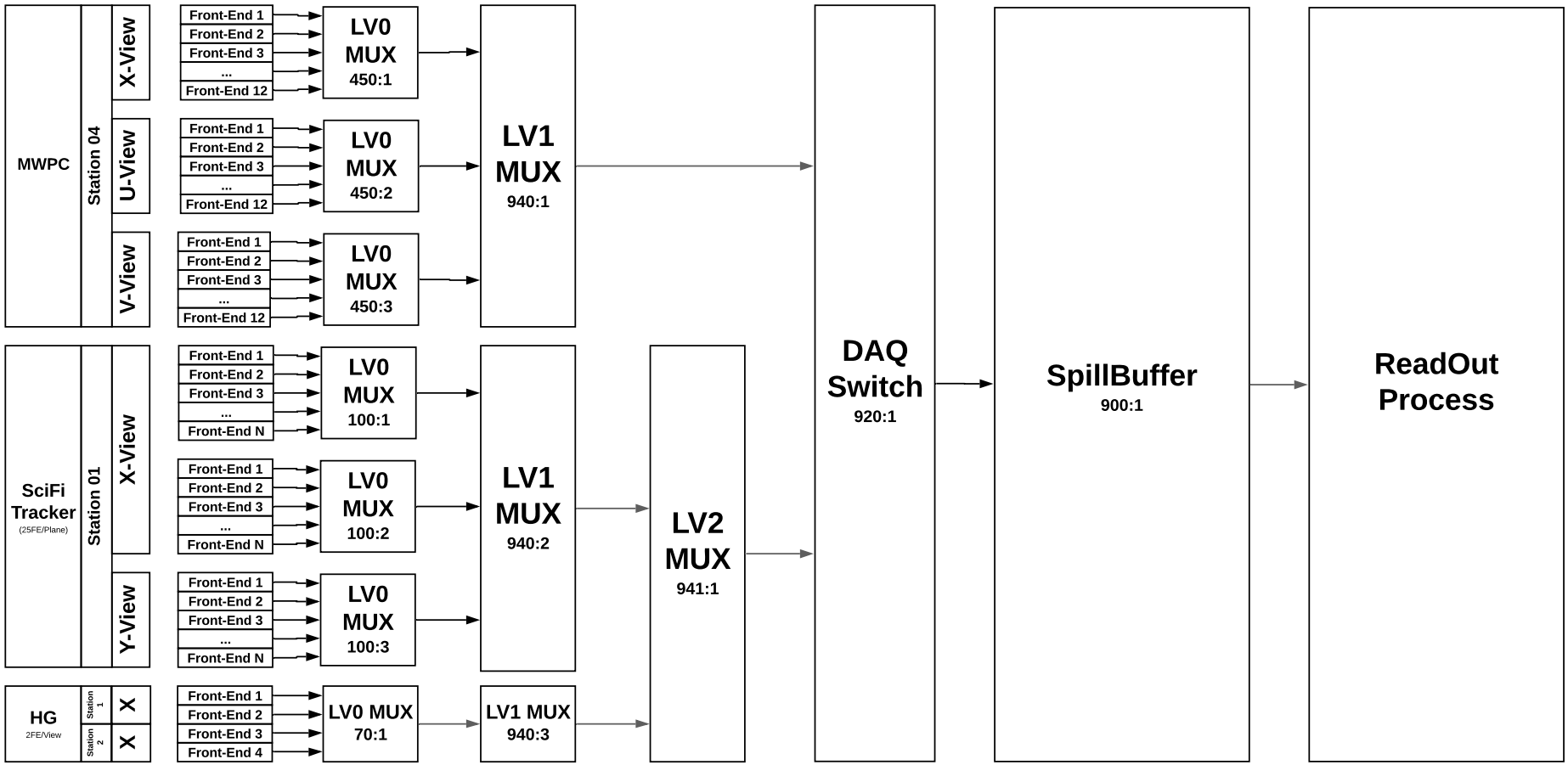
Protocol overhead on MUX LV0

The protocol overhead for one image is 8 byte:



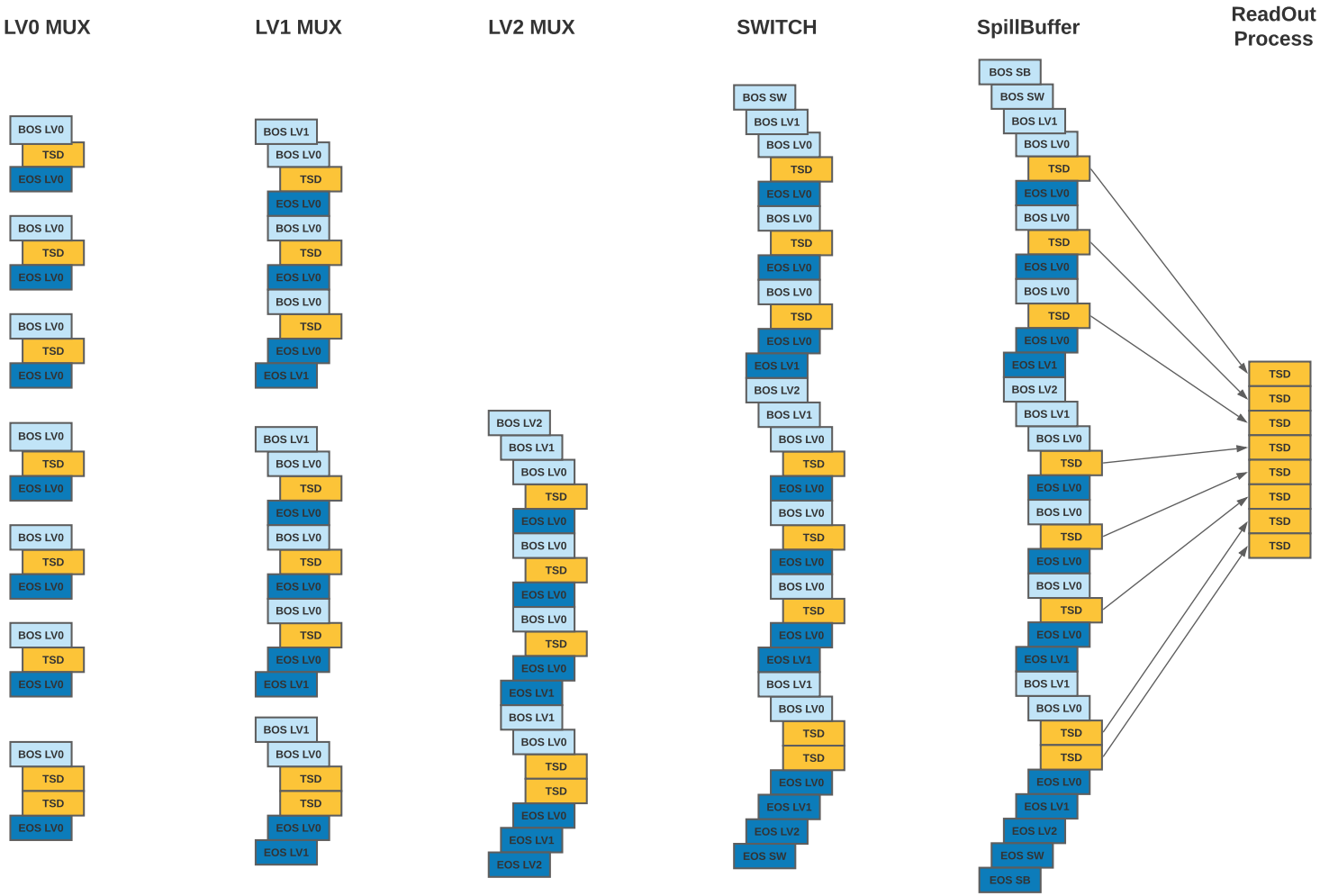
The protocol overhead on an LV0 MUX highly depends on the image length!

MUX Chain



How does this setup map to the protocol ?

MUX chain representation in protocol



The read-out process removes all multiplexer frames except of the TSD Frames.

Conclusion

The FriDAQ protocol is now in the 8th iteration and it is converging ...

Main Features:

- Unified Frame structure across all DAQ equipment.
- Maximum spill length of 111.6 s.
- Time Slice lengths from 426 μs to 6.815 ms.
- Image lengths from 26 ns to 426 μs.
- Maximum time-slice data size of 8192 MB.
- Nx 31 bit of image payload.
- Equipment naming is represented in the protocol down to the view.

The protocol is documented in the AMBER wiki:

`https://twiki.cern.ch/twiki/bin/view/AMBER/Protocol`