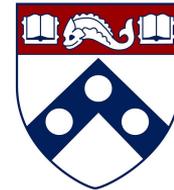
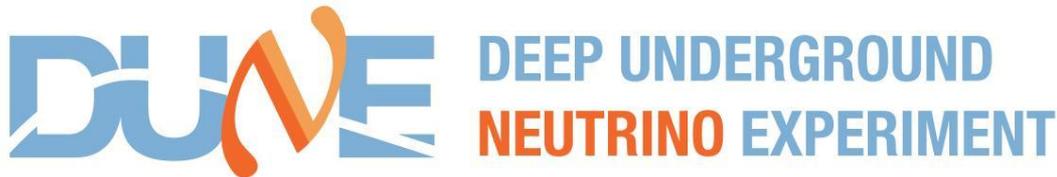
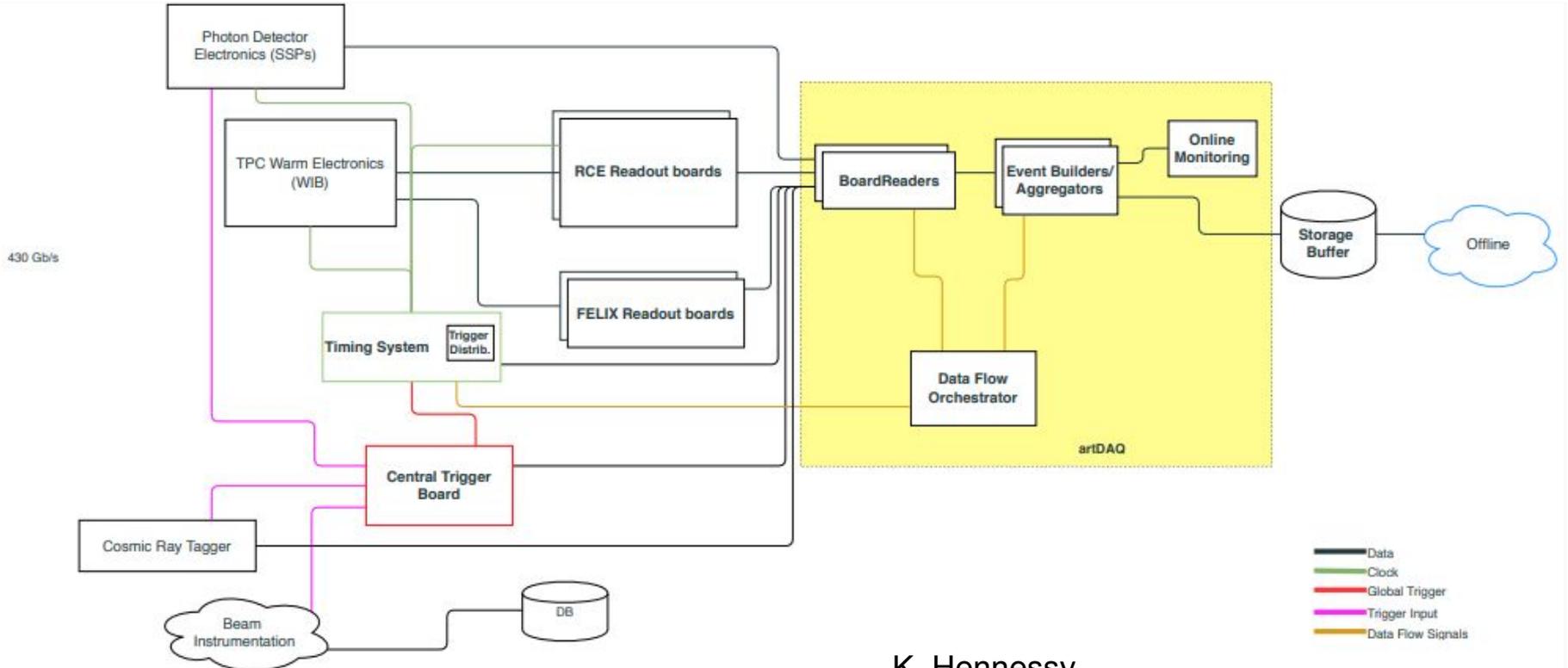


# Central Trigger Board

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**Penn**  
UNIVERSITY of PENNSYLVANIA



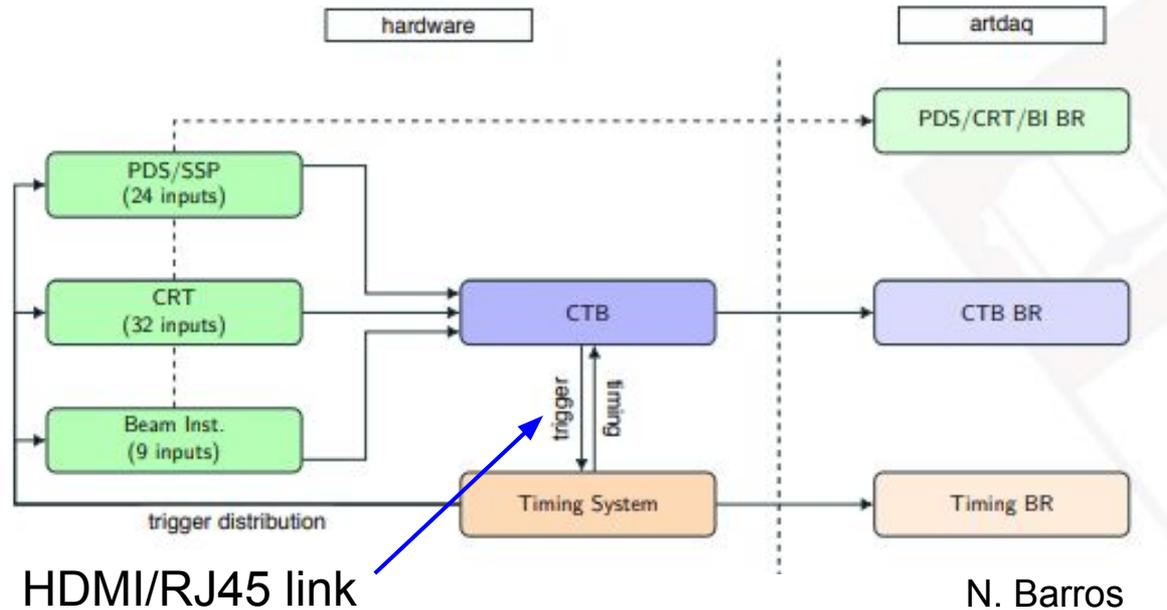


CTB in rack at CERN

- Inputs from 3 main sub-systems: Beam, CRT, PDS
- Link I/O to timing
- Spare I/O (not shown here)

Optical Fiber

NIM Logic

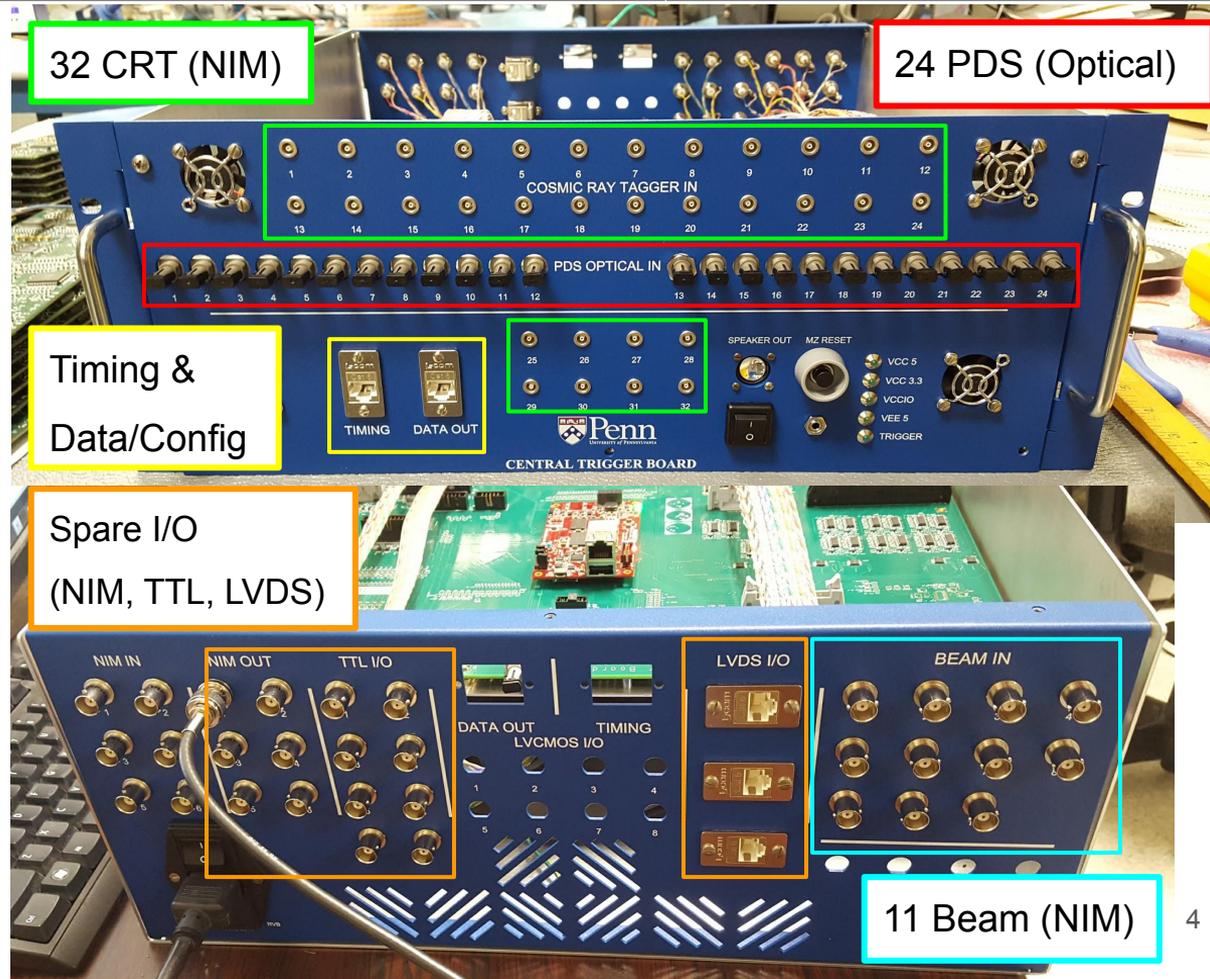


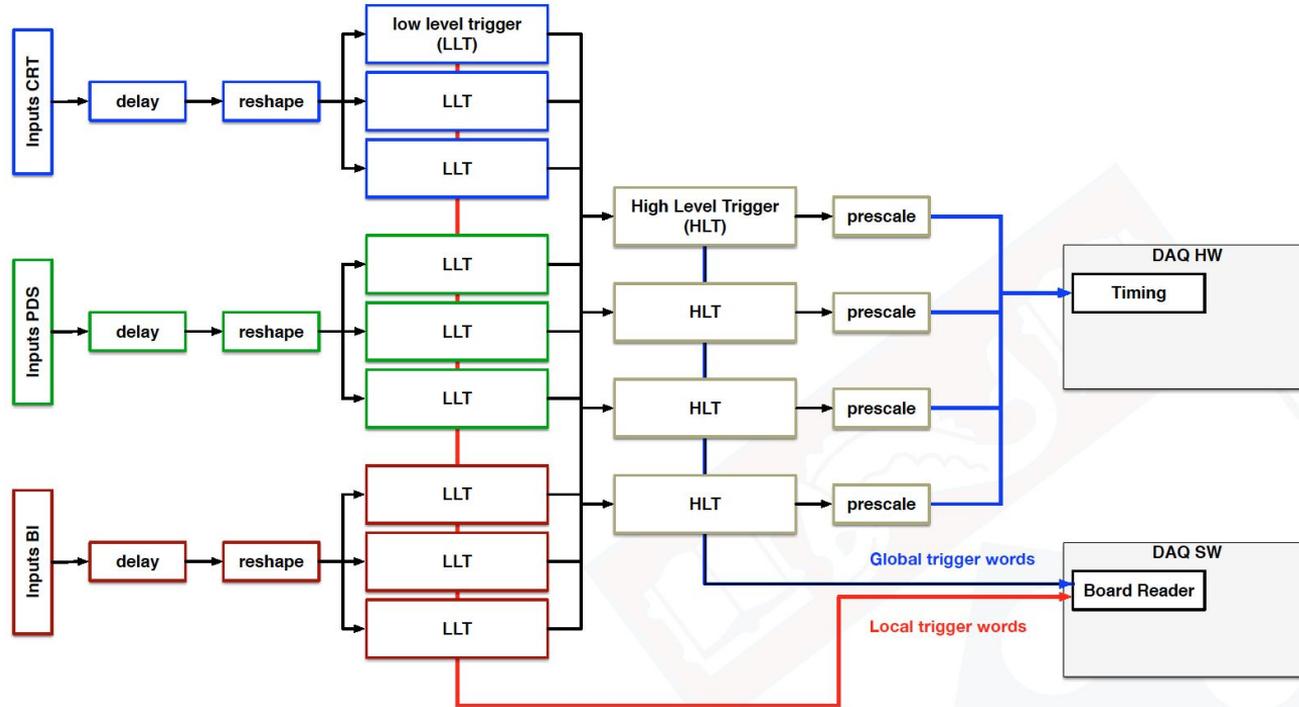
# Central Trigger Board: Inputs/Outputs

03/16/2021

Penn

| System     | # I/O  | Input Signals                  |
|------------|--------|--------------------------------|
| CRT IN     | 1 - 32 | CRT 1 - 32                     |
| PDS IN     | 1 - 24 | PDS 1 - 24                     |
| BEAM IN    | 1 - 8  | Beam Trig, Monitors, Cherenkov |
| 5V TTL I/O | 1      | HV current limit threshold     |
|            | 2      | Ground Planes Signals          |
|            | 3      | Beam Gate (not connected)      |
|            | 4      | Purity Monitor                 |
|            | 6      | Spare                          |
|            | 7      | Spare                          |
|            | 8      | Spare                          |
| LVDS I/O   | 8      | Spare                          |
| NIM OUT    | 6      | Spare                          |





- Raw trigger inputs are delayed and reshaped as necessary.
- **Low Level Triggers (LLTs)** form triggers within a subsystem.
- **High Level Triggers (HLTs)** composed of LLTs.
- All LLTs and HLTs are recorded and passed to the board reader.
- Assertion of HLT results in a command being passed to the timing system specifying the *type* of trigger, e.g., beam or cosmic.

- Trigger firmware runs on the 50 MHz timing system clock domain.
- 5 clock cycles (100 ns) from signal latched to clock until HLT trigger output.
- Trigger firmware built in a generic way.
- Triggers defined by configuration at run start (json configuration).
- All inputs are masked so easily include/exclude channels.
- Example config snippets below

```
"HLT":{  
  "command_mask" : {  
    "C" : "0x6",  
    "D" : "0x0",  
    "E" : "0x1",  
    "F" : "0x0"  
  },  
  "trigger": [  
    { "id":"HLT_1",  
      "description": "Reconstructable track beam trigger, no PDS selection, no CRT selection",  
      "enable":true,  
      "minc" : "0x2",  
      "mexc" : "0x0",  
      "prescale" : "0x1"  
    },
```

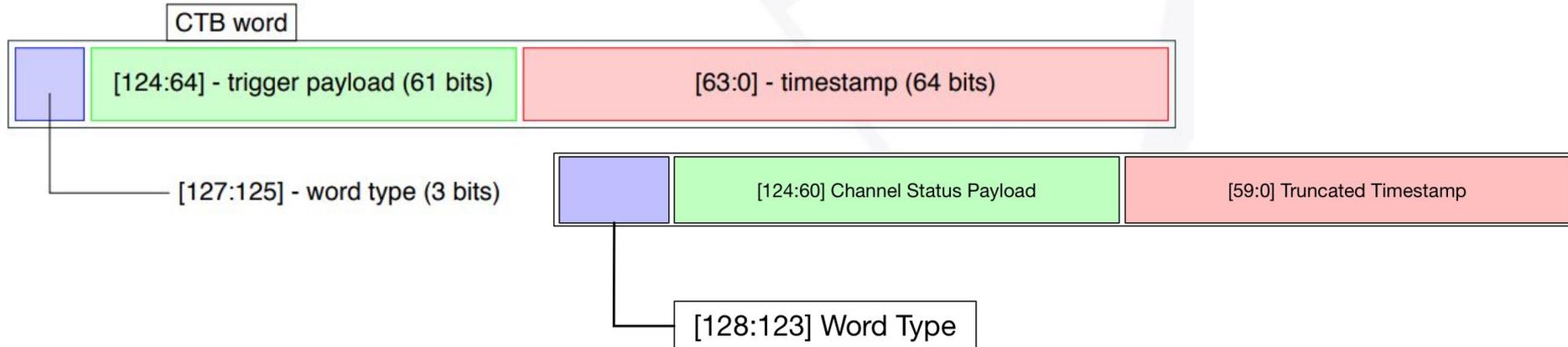
Assigning an HLT to a trigger command.

HLT parameters

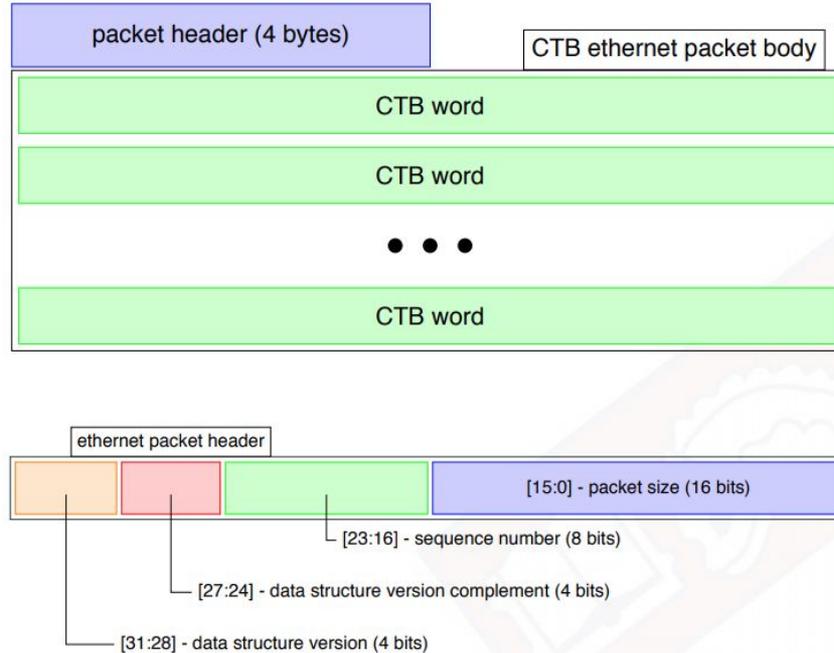
```
{ "id":"LLT_2",  
  "description": "Mask in High Pressure Cherenkov (C713)",  
  "enable":true,  
  "mask" : "0x8"  
},
```

LLT parameters

- Data created in firmware as 5 different word types:
  - Channel Status, Error, HLT, LLT, Timestamp
- All words 128b with:
  - 3b header specifying word type
  - 61b payload (channel status 65b)
  - 64b full timestamp (channel status 60b)
- Channel status truncated 60b TS to fit all channels in payload, 64b TS reconstructed in SW.

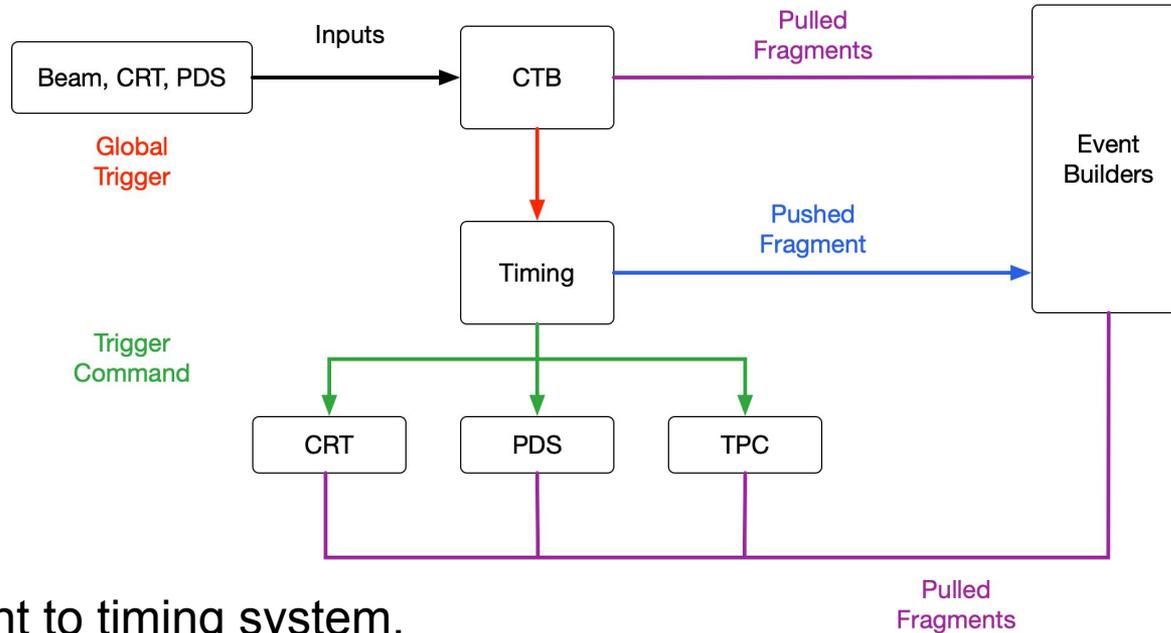


- **Channel Status Word** sent whenever a HLT trigger word is sent. A snapshot of all inputs at the time of HLT generation. (1 channel is 1b in payload & full TS added in SW)
- **LLT & HLT Words** sent when the state of an LLT or HLT, respectively, changes. (1 LLT, HLT is 1b in respective payload)
- **Timestamp Word** sent periodically with empty payload, acts as “heartbeat monitor”. Not passed to event builder.
- **Error Word** contains the error code in payload. Passed downstream to take action.

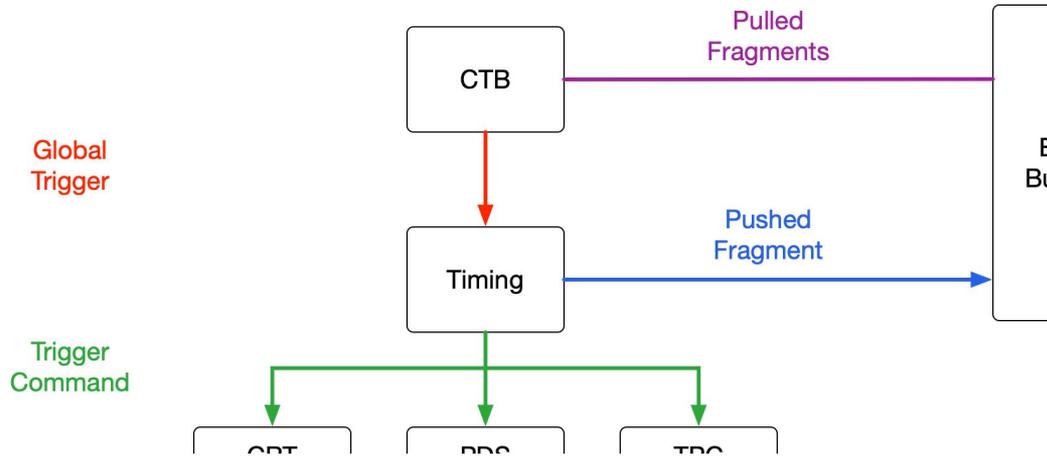


N. Barros

- Server reads data from DMA and packages into ethernet packets.
- Data aggregated for  $n \mu\text{s}$  and sent as a bundle. ( $n$  configurable)
- Packets buffered, unpacked and fragments created in boardreader.

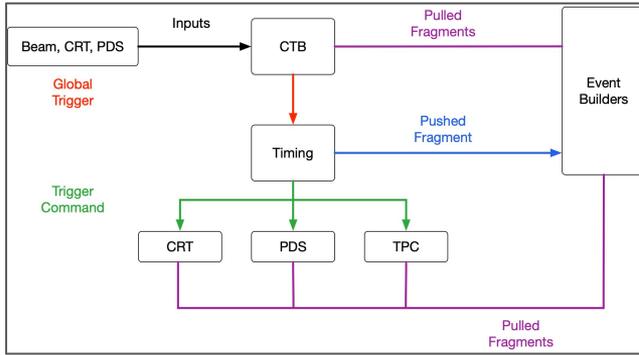


1. **Trigger** sent to timing system.
2. Timing **sends** trigger command to subsystems.
3. Timing **pushes** fragment to event builder, initiates event building.
4. Event builder **requests/collects** fragments from all subsystems (board readers).



- HLT creates a global trigger.
- Trigger tagged and passed to timing system via bi-directional link.
- 4 available tags, e.g. beam, cosmic, misc (purity monitor, hv trip, ground plane)

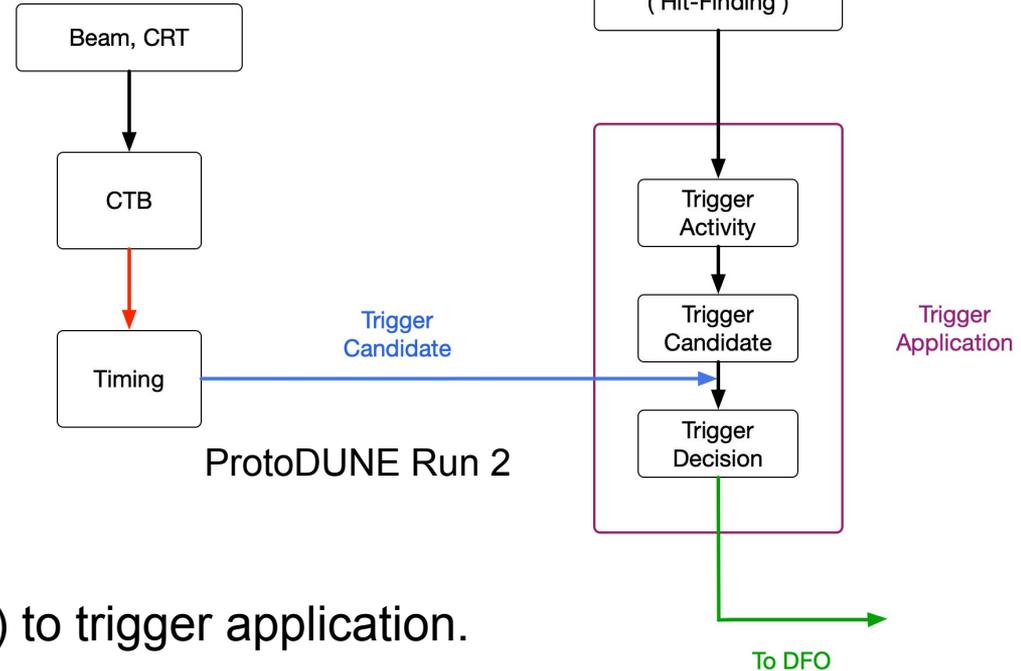
# ProtoDUNE 2 Proposal



ProtoDUNE Run 1

Inputs

Global Trigger



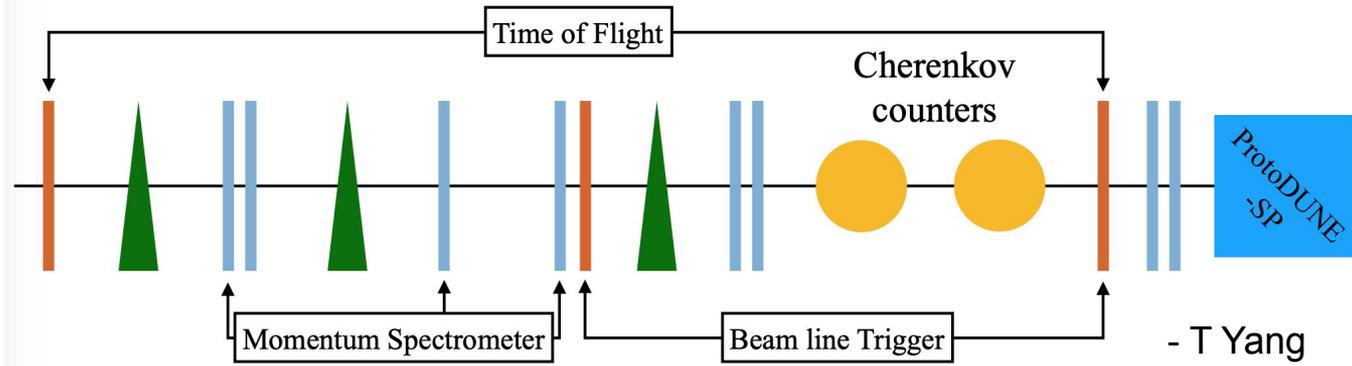
ProtoDUNE Run 2

1. **Trigger** sent to timing system.
2. Timing **sends** trigger candidate (TC) to trigger application.
3. Trigger decision (TD) made, e.g. for beam run: 1 beam TC = 1 TD
4. All data collected from queues.

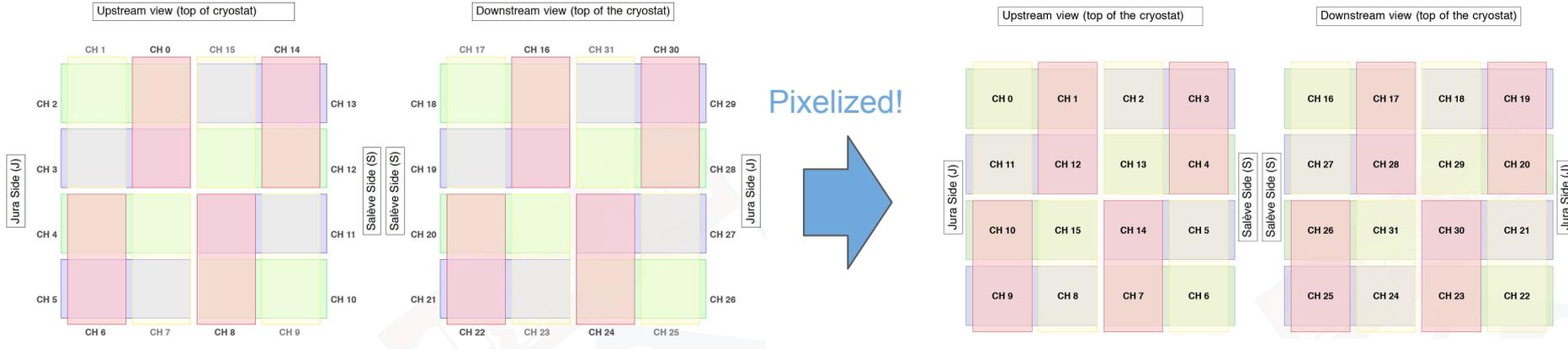
- Additional (straightforward) tasks,
  - Port current CTB artDAQ boardreader to Appfwk
  - Interface to CCM
- Message passing timing to trigger application already proposed: Stoyan Trilov [slides](#), Lukas Arnold [slides](#).

- Proposal how to handle non-DUNE-like triggering, e.g. beamline, CRT triggering.
  - Already implemented and proven in CTB firmware.
- Straightforward porting of current boardreader to Appfwk and CCM.
- Proposed interface timing app to trigger app.
- Additional inputs available for external signals.

# Backup Slides



| Signal               | CTB Input | Fw Ch | Enable input | Delay | Signal Composition and logic                               |
|----------------------|-----------|-------|--------------|-------|--|
| BI Beam Line Trigger | 1         | 0     | TRUE         | 1     | XS & TS (at 701 and 716 respectively)                      |
| Beam On              | 2 (TTL 2) | 1     | TRUE         | 1     | Gate made by WE and EE (connected to backplate TTL spares) |
| Sk = upstream signal | 3         | 2     | TRUE         | 1     | TS at 687 (very high rate!) - <b>not provided</b>          |
| C1 - cherenkov       | 4         | 3     | TRUE         | 0     | C713 (high pressure)                                       |
| C2 - cherenkov       | 5         | 4     | TRUE         | 0     | C716   |
| beam profiles 1      | 6         | 5     | TRUE         | 1     | XBPF1 (X & Y)  |
| beam profiles 2      | 7         | 6     | TRUE         | 1     | (XBPF1->X) & (XBPF2->X) & (XBPF3->X)                       |
| beam profiles 3      | 8         | 7     | TRUE         | 1     | XBPF4 (X & Y)  |
| beam profiles 4      | 9         | 8     | TRUE         | 1     | XBPF5 (X & Y)  |



## N Barros

- NIM signals sent from CRT to CTB.
- CRT inputs channels are mapped into pixels for more natural trigger formation.
- Example: through-going muon

