Introduction to Data Acquisition System

Part I

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Outline

What is the goal of this talk?

Detectors & Readout Electronics

How:
- Our detectors
- The digitizers and A/D converters
- Everything else: Voltage supplies, gas, …

Trigger Logic?

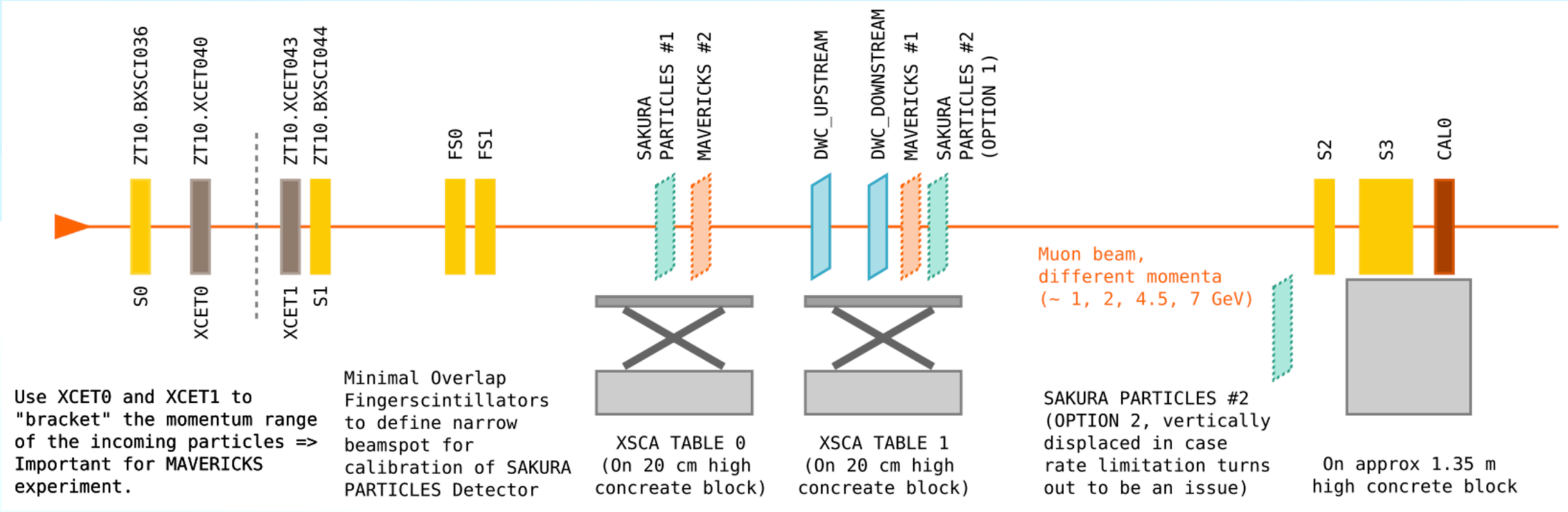
What is happening at T10?

Organization
- The logbook, good run list, mattermost,
- Where to find the data

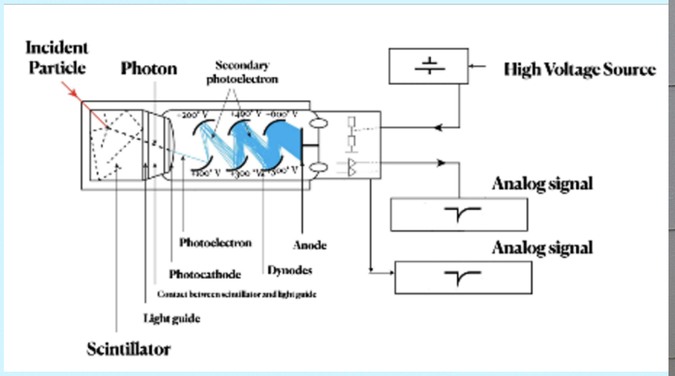
Some Abbreviations

DETECTOR TYPE	NAMES
S0, S1	Scintillator Before and After Cherenkov Detector
XCET0, XCET1	High Pressure and Low Pressure Cherenkov Detector
FSO, FS1	Finger Scintillators
DWC_UP, DWC_DOWN	Delay Wire Chambers
S2, S3	Scintillators (end of the zone)
CAL	Lead Glass Calorimeter

Our Setup


ZT10.BXSCI036
ZT10.XCET040
ZT10.XCET043
ZT10.BXSCI044
FS0
FS1
SAKURA PARTICLES #1
MAVERICKS #2
DWC_UPSTREAM
DWC_DOWNSTREAM
MAVERICKS #1
SAKURA PARTICLES #2 (OPTION 1)
S2
S3
CAL0
S0
XCET0
XCET1
S1
Muon beam, different momenta (~ 1, 2, 4.5, 7 GeV)
Use XCET0 and XCET1 to "bracket" the momentum range of the incoming particles => Important for MAVERICKS experiment.
Minimal Overlap Fingerscintillators to define narrow beamspot for calibration of SAKURA PARTICLES Detector
XSCA TABLE 0 (On 20 cm high concreate block)
XSCA TABLE 1 (On 20 cm high concreate block)
SAKURA PARTICLES #2 (OPTION 2, vertically displaced in case rate limitation turns out to be an issue)
On approx 1.35 m high concrete block

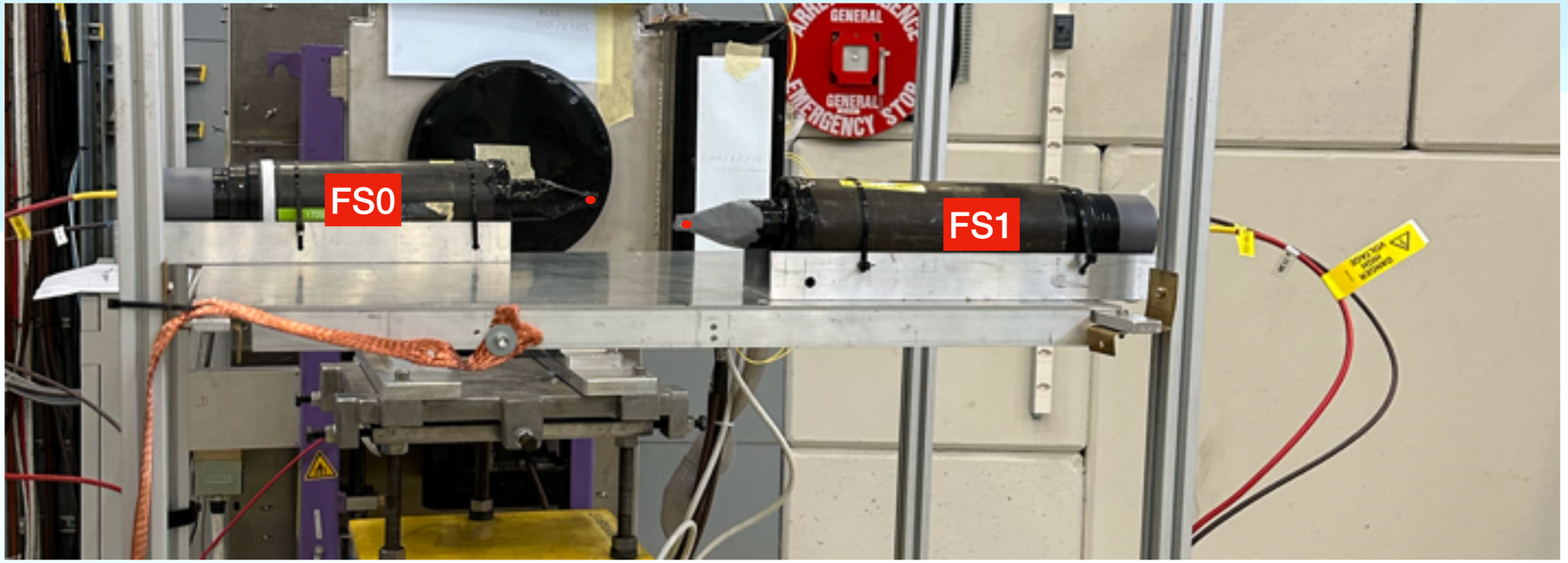
Scintillators



3 main steps:

- The scintillator converts the energy from incoming particles into light.
- The PMT captures this light, converts it into electrons, and amplifies the signal.
- The resulting electrical signal is sent to the DAQ system, where it can be recorded and analyzed.

Scintillators:



Threshold Cherenkov Detectors (XCET)

- Principle:

$$\theta_c \sim \frac{1}{\beta \cdot n(p)}$$

- $\beta = \frac{v}{c}, n \ldots refractive\ index,$

$p \ldots pressure$

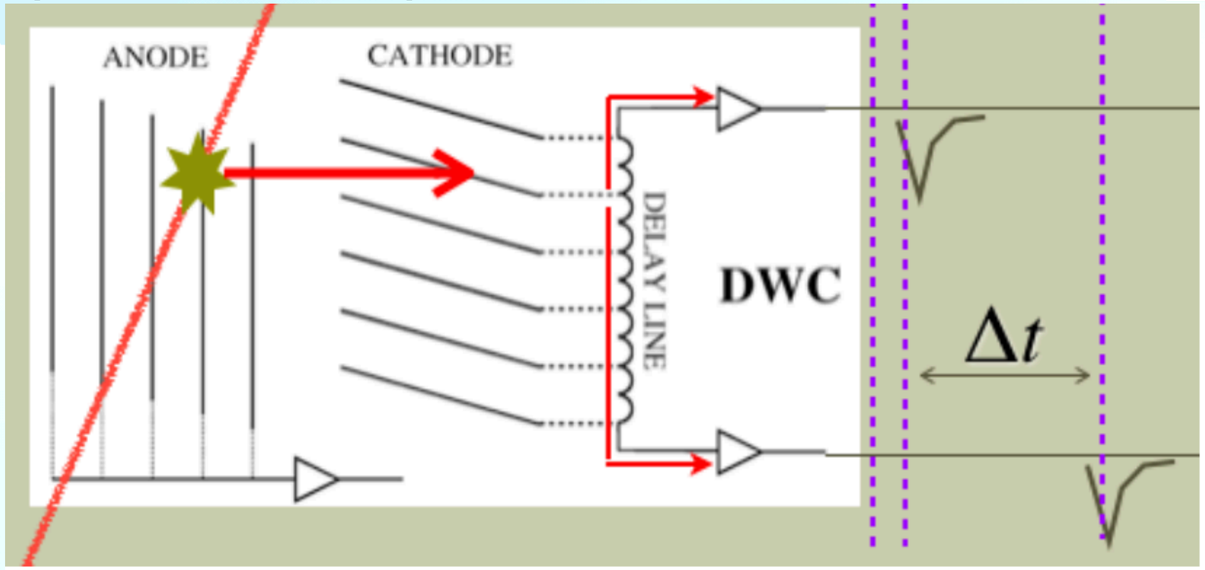
- If θ_c is above a threshold, then particles emit light as they pass through the gas enclosed in the detector

- One High – Pressure Threshold Cherenkov Detector (up to approx 15 Bar)
- One Low – Pressure Threshold Cherenkov Detector (up to approx 4.3 Bar)

DWC

Delay Wire Chamber

- A **delay wire chamber (DWC)** is a type of particle detector used primarily in high-energy physics to track charged particles. It operates based on the
-

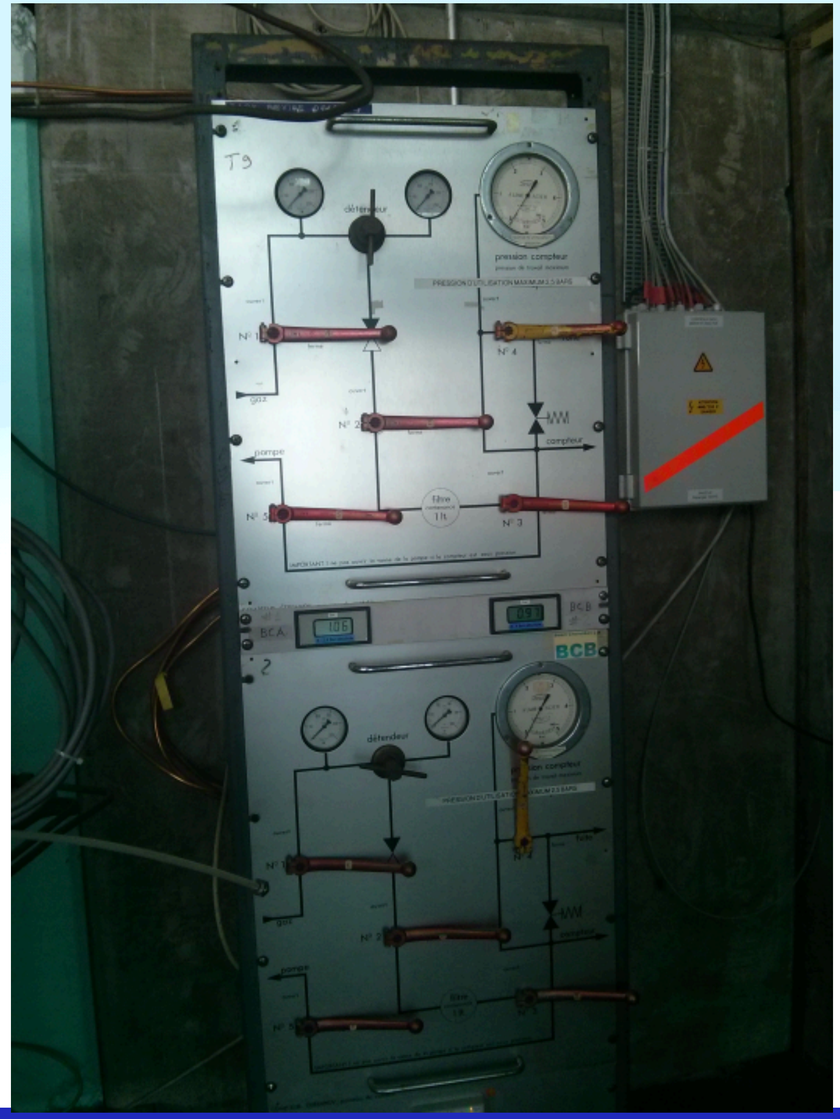


Calorimeter

- Absorb electromagnetic particles!
- Energy converted to light PMT converts light into electrical pulse
- Integrate pulse to recover the particle energy
- For us: The idea is to give the particles more chance to release photons which might give us a better resolution for the tiny differences in deposited energy compared to what we expect with a 1 cm wide "normal" scintillator.

Gas Supply

- Ar + C02 mixing gas is needed for DWC
- A supply of Argon and Carbon Dioxide (Ar + CO2) is provided from a distribution panel behind the beam control room



Power Supply

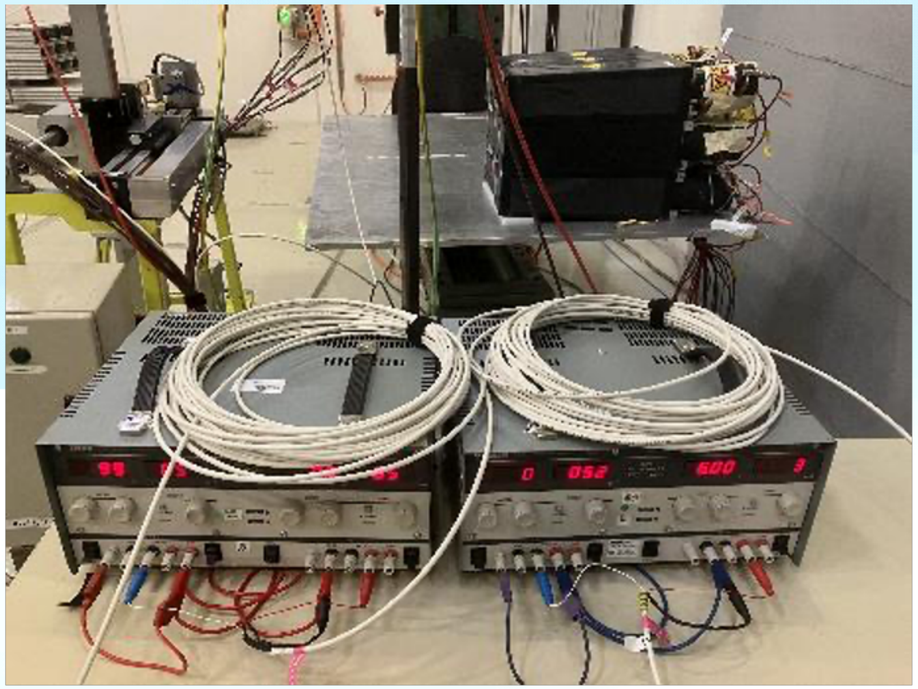
High Voltage Power Supply

- GECO - Software for remotely control HVs:
- For Scintillators: 1500-2500 V negative voltage
- For DWC: 2800-3000 V positive voltage

Custom	Name	I0Set	V0Set	IMon	VMon	Pw	Status	RUp	RDWn	Trip	V1Set	I1Set	SVMax
00.000	FS0	400.0 uA	1625.0 V	**292.0 uA**	**1625.0 V**	On		250 Vps	250 Vps	10.0 sec	0.0 V	300.0 uA	1800 V
00.001	FS1	400.0 uA	1575.0 V	**284.5 uA**	**1575.5 V**	On		250 Vps	250 Vps	10.0 sec	0.0 V	300.0 uA	1800 V
00.002	S2	2000.0 uA	2400.0 V	**1519.0 uA**	**2401.0 V**	On		250 Vps	250 Vps	10.0 sec	0.0 V	300.0 uA	2500 V
00.003	S3	2000.0 uA	1900.0 V	**1136.5 uA**	**1900.0 V**	On		250 Vps	250 Vps	10.0 sec	0.0 V	300.0 uA	2500 V
00.004	CAL17	700.0 uA	1200.0 V	**368.5 uA**	**1200.5 V**	On		250 Vps	250 Vps	10.0 sec	0.0 V	300.0 uA	1250 V
04.000	DWC_DUT	100.00 uA	2600.00 V	**0.598 uA**	**2599.85 V**	On		250 Vps	250 Vps	10.0 sec	0.00 V	1.00 uA	3000 V
04.001	DWC_UP	100.00 uA	2700.00 V	**0.108 uA**	**2699.73 V**	On		250 Vps	250 Vps	10.0 sec	0.00 V	1.00 uA	3000 V
04.002	DWC_DOWN	100.00 uA	2600.00 V	**0.096 uA**	**2599.86 V**	On		250 Vps	250 Vps	10.0 sec	0.00 V	1.00 uA	3000 V

Power Supply

Low Voltage Power Supply



- Required for the DWCs
- Four units, symmetrically +/- 6V with approx. 50 – 60 mA
- Have to be carefully monitored to detect issues with the DWC before they take damage

Readout Electronics

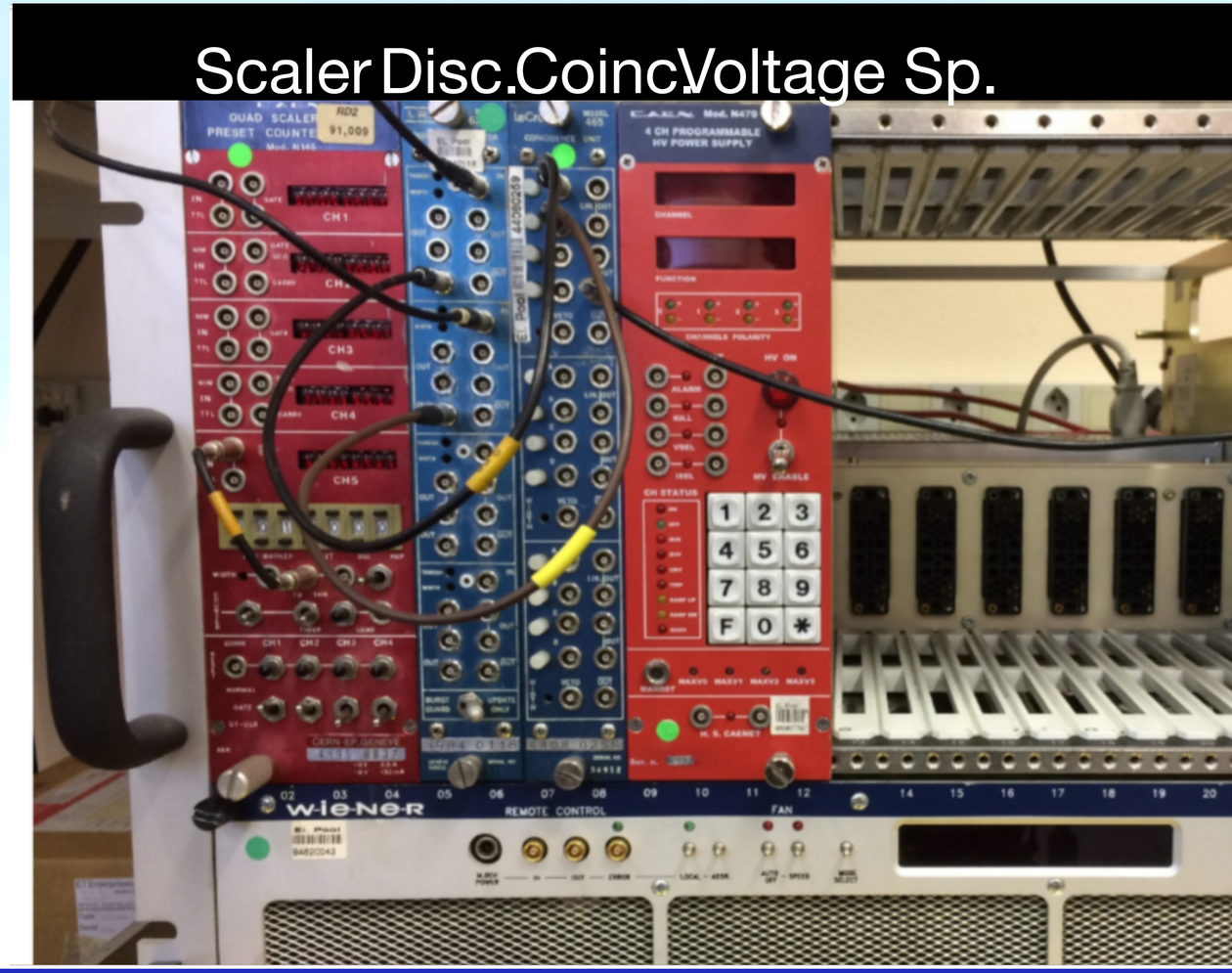
NIM Module

Nuclear Instrumentation Module (NIM)

Modular standard for analog electronic components Rack mount ’bin’ holds modules and provides power

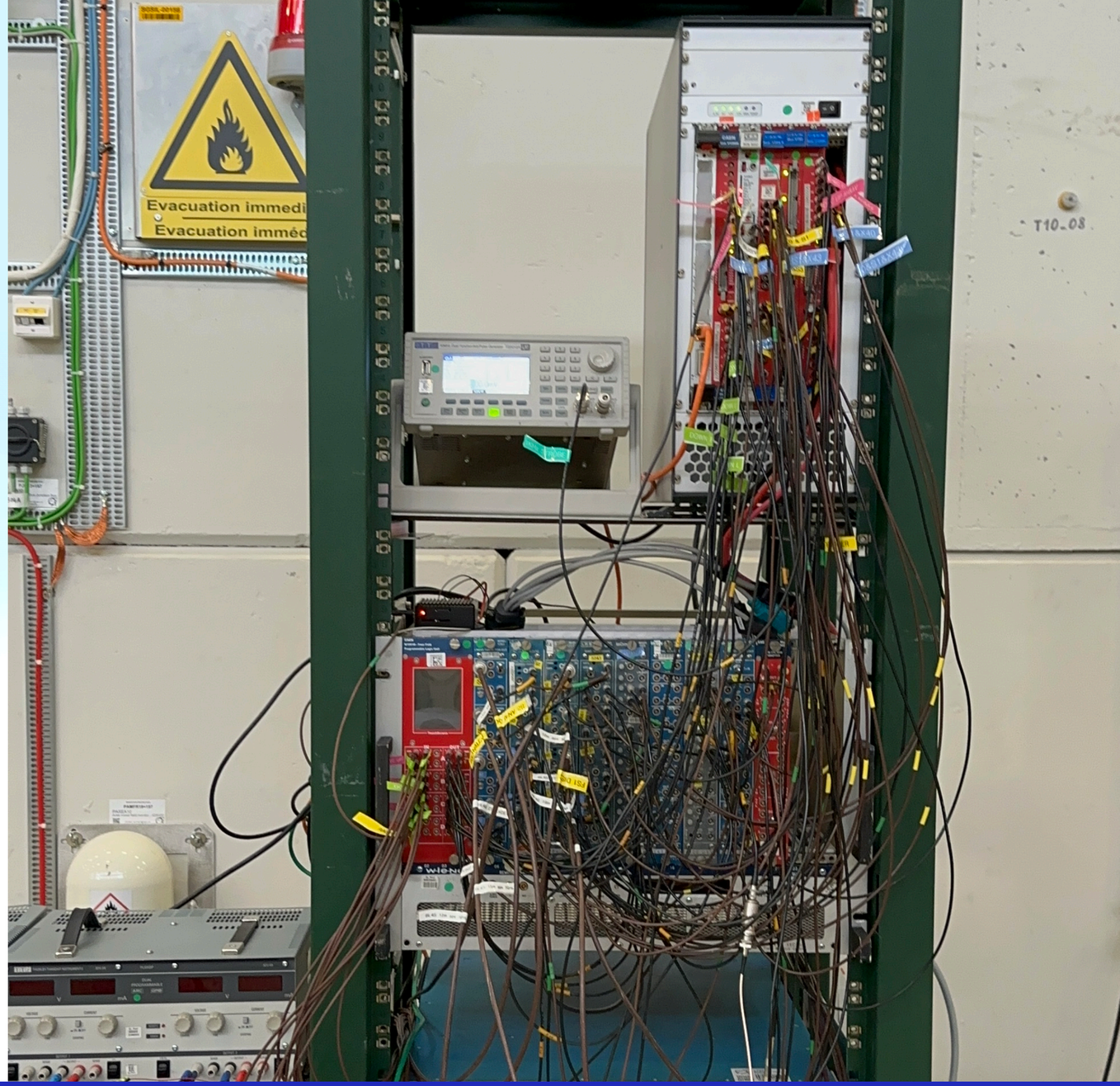
Modules:

- Logical and Linear Fan-In/Out
- Discriminator
- Coincidence (logical AND)
- Timer Counter (TDC)



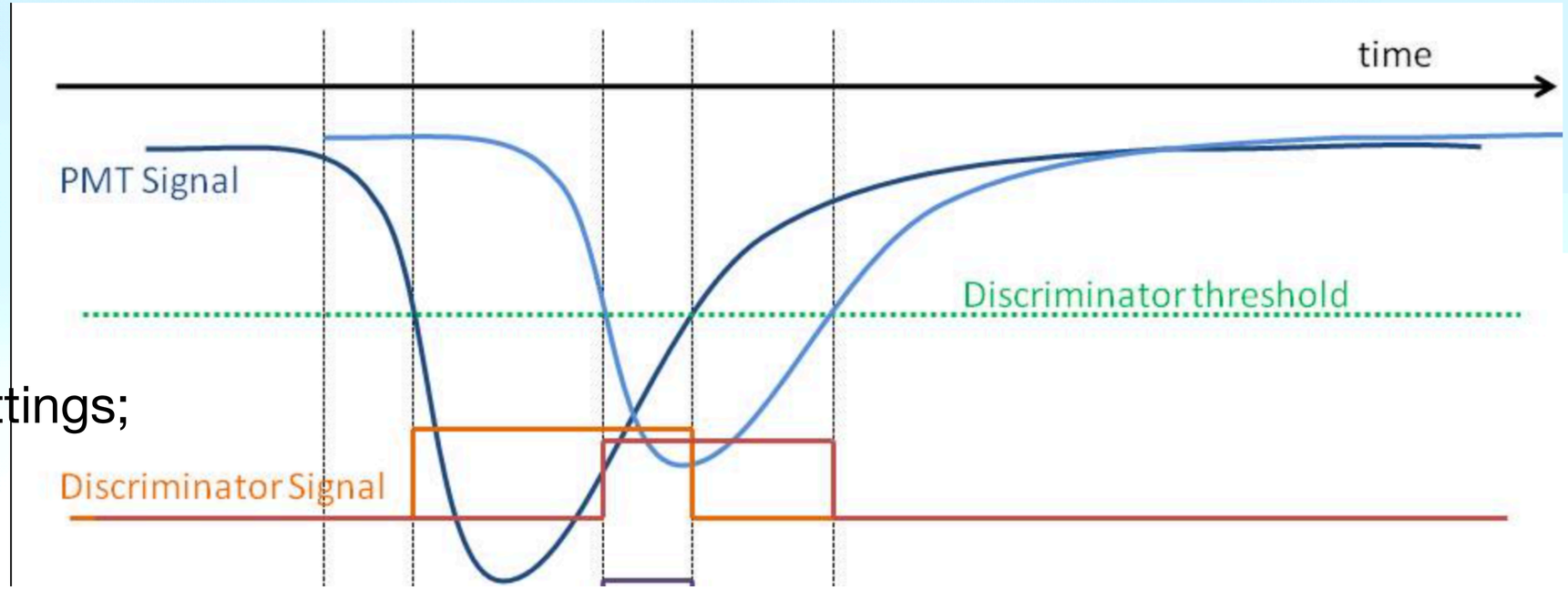
That might look like slightly complicated system

- Slightly…



NIM Modules:

Discriminator



- A discriminator has two settings;
- a ’Threshold’ and a ’Width’
- Noise with a voltage below the Threshold is ignored
- If the input signal crosses the Threshold, a pulse is generated with the desired Width

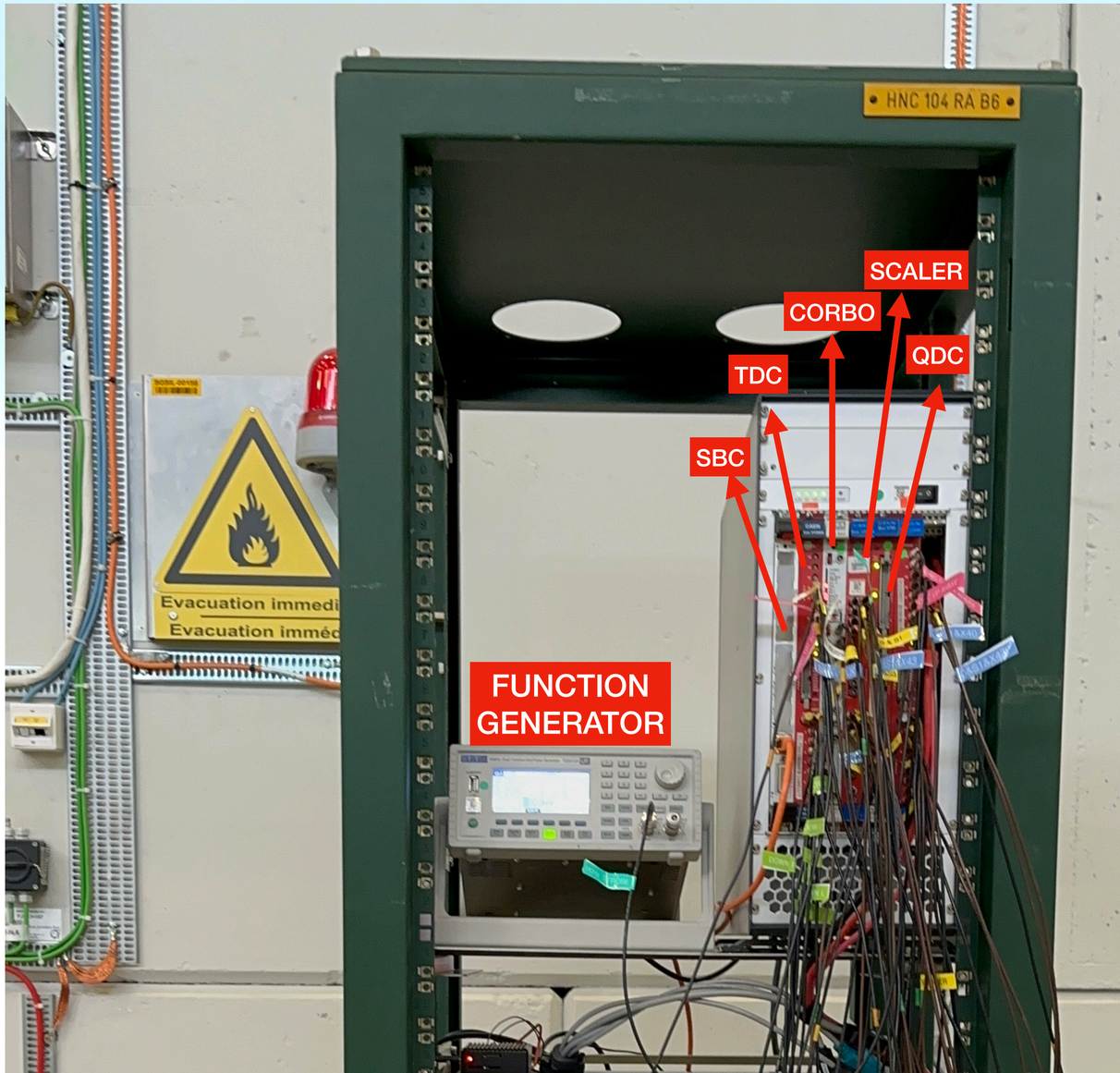
NIM Modules

Coincidence

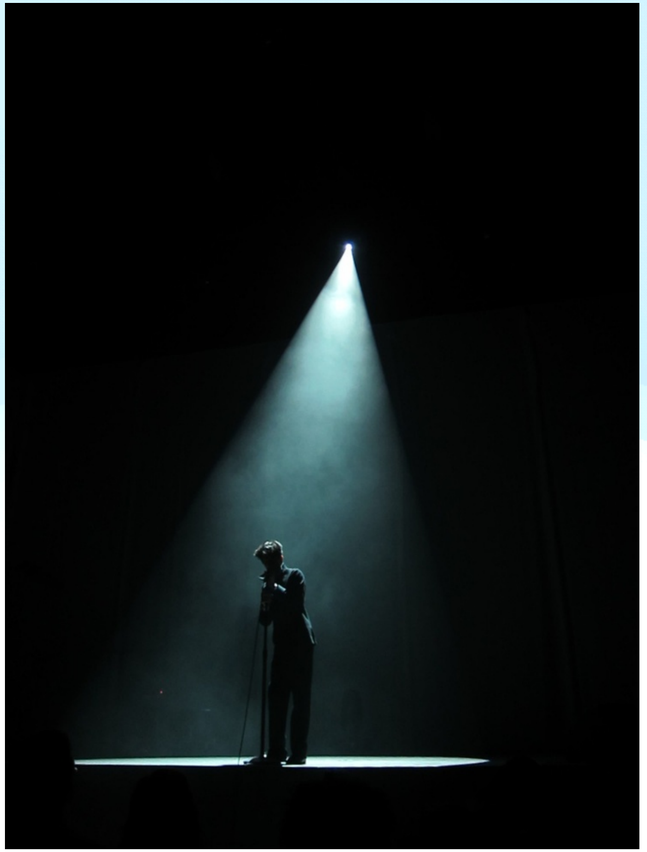
- Many pulses are not interesting but if two detectors see a signal at the same time, there may be something interesting
- A coincidence is the logical AND of some signals

Digitization: VME (Versa Module Europa)

- Rack mount ’crate’ holds modules, provides power and hosts a data bus (CORBO)
- Single Board Computer (SBC)
- Modules:
  - Scaler/Counter
  - Charge to Digital converter (QDC)
  - Time to Digital converter (TDC)



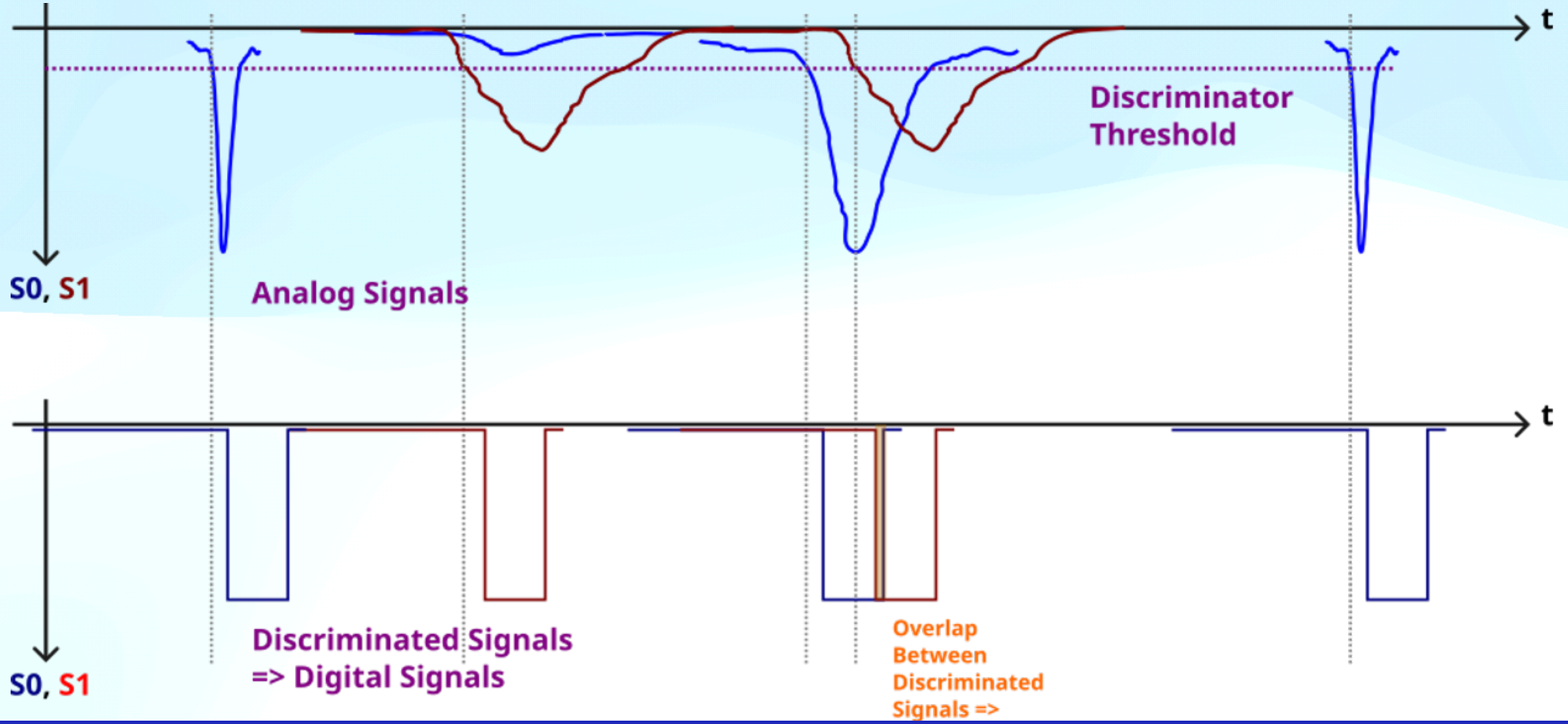
Trigger Logic



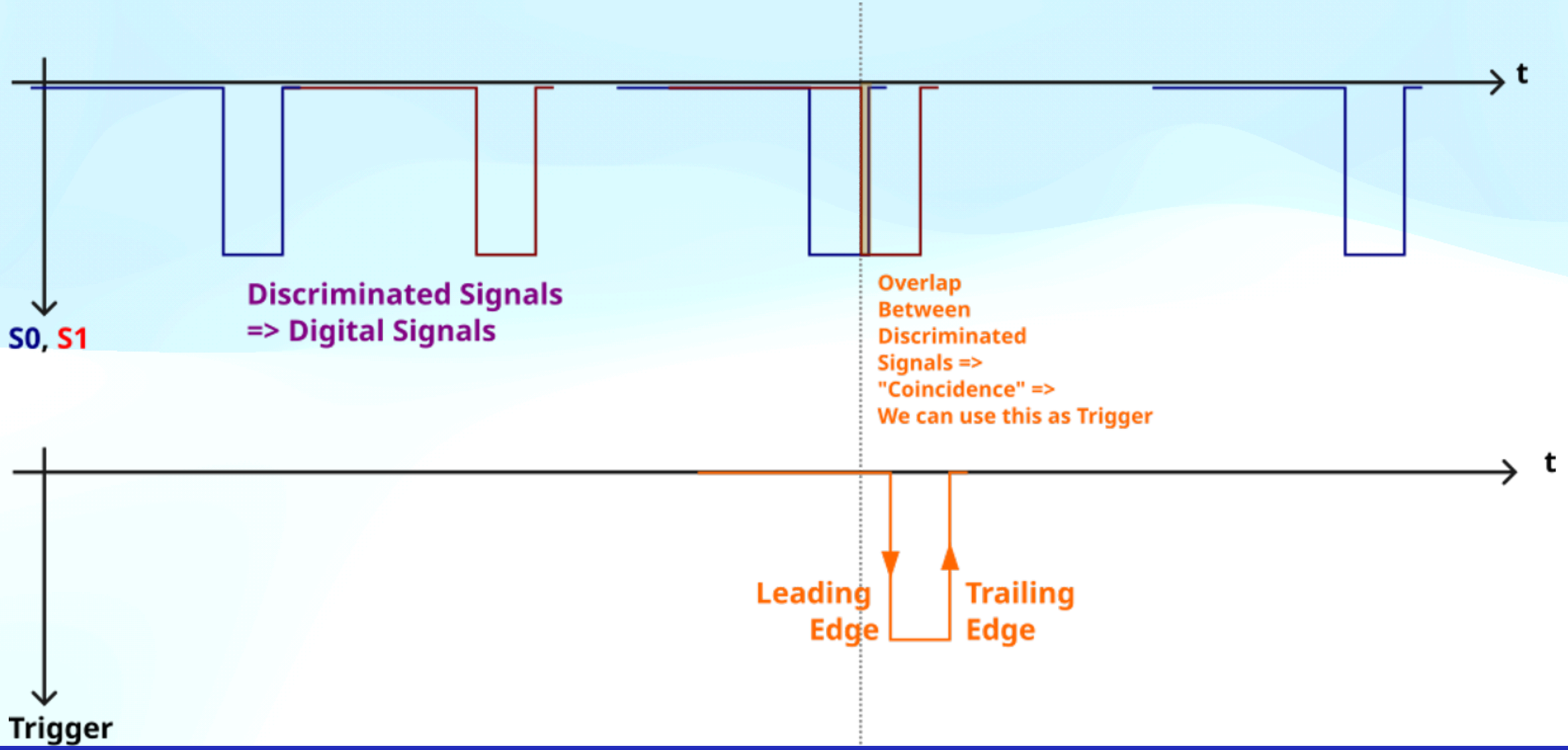
- Trigger system detects these important moments and sends a signal to the DAQ system, saying, “start recording now! ” -just like how the stage lights turn on at the perfect time.

Trigger Logic

More Scientific Aspect



Trigger Logic



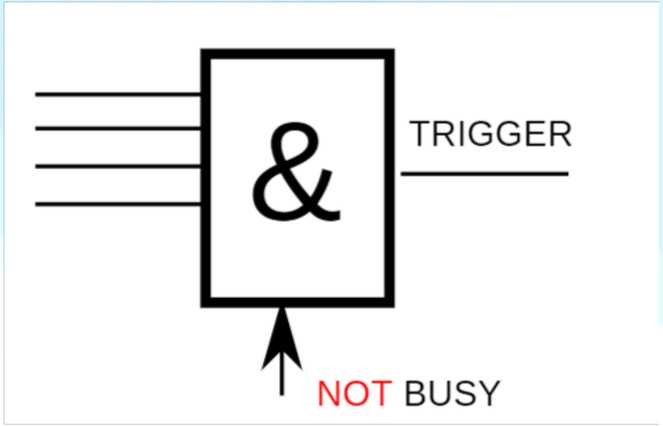
What is DAQ?

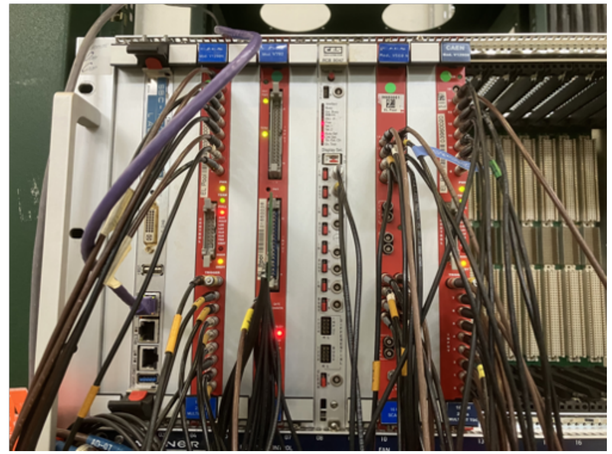
- **D**ata **A**c**Q**uisition is;
- the process of sampling signals –
- that measure real world physical conditions –
- and converting the resulting samples into digital numeric values that can be manipulated by a PC

NIM -> VME -> TDAQ Software

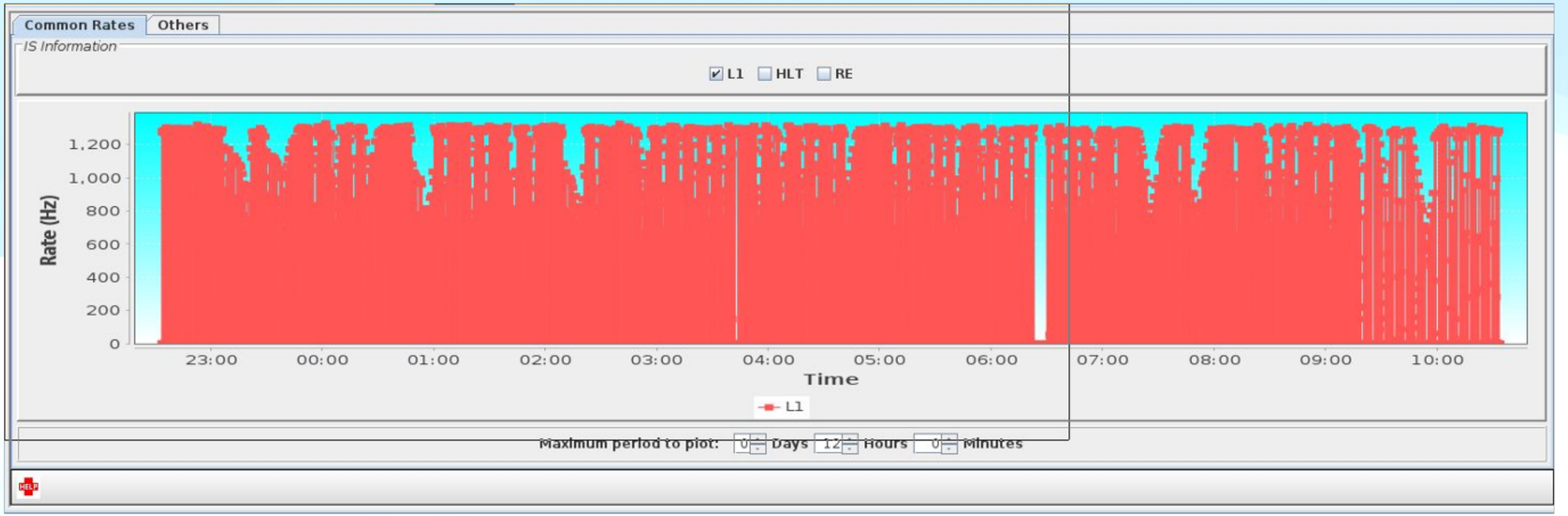
Busy Logic

- We have to ensure that our active measurements
- are not interrupted by incoming events that arrive a bit later => Block trigger until we are no longer **busy**
- Issuing and clearing the BUSY signal is handled via the CORBO card.
- **We can not record every particle that arrives and that would trigger our detector (at least not in T10)**
- That‘s why having a scaler is so important, it gives us a less detailed picture about some quantities for(almost) all particles while we take more detailed data (i.e., TDC, QDC) for as many particles as we can



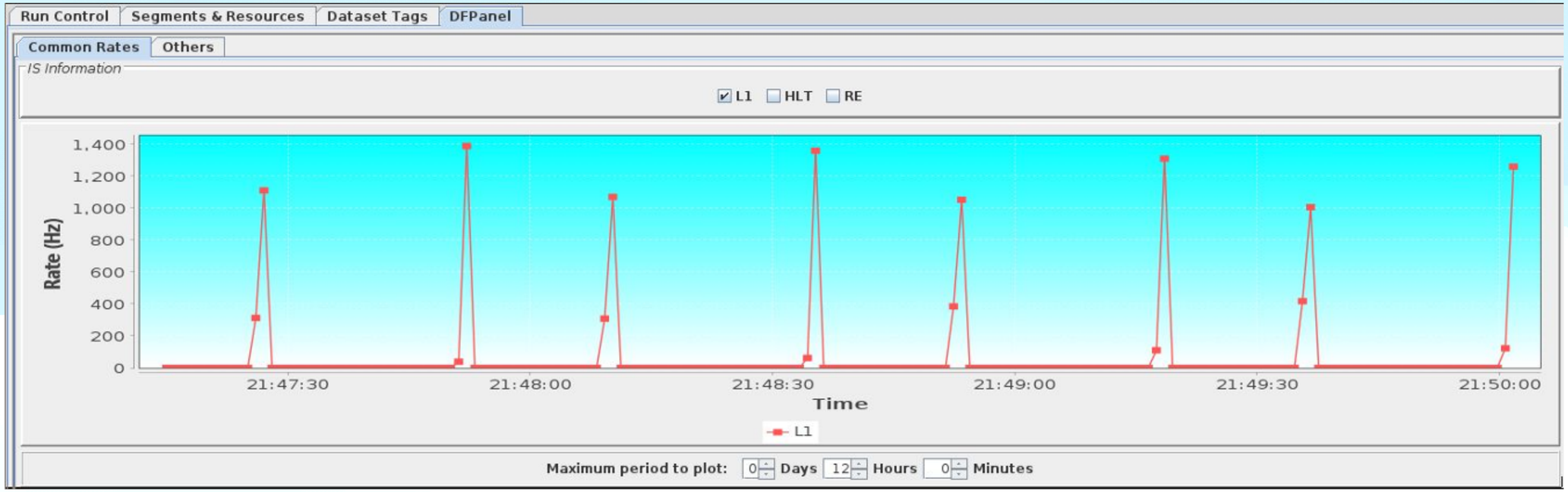


What is happening at T10?



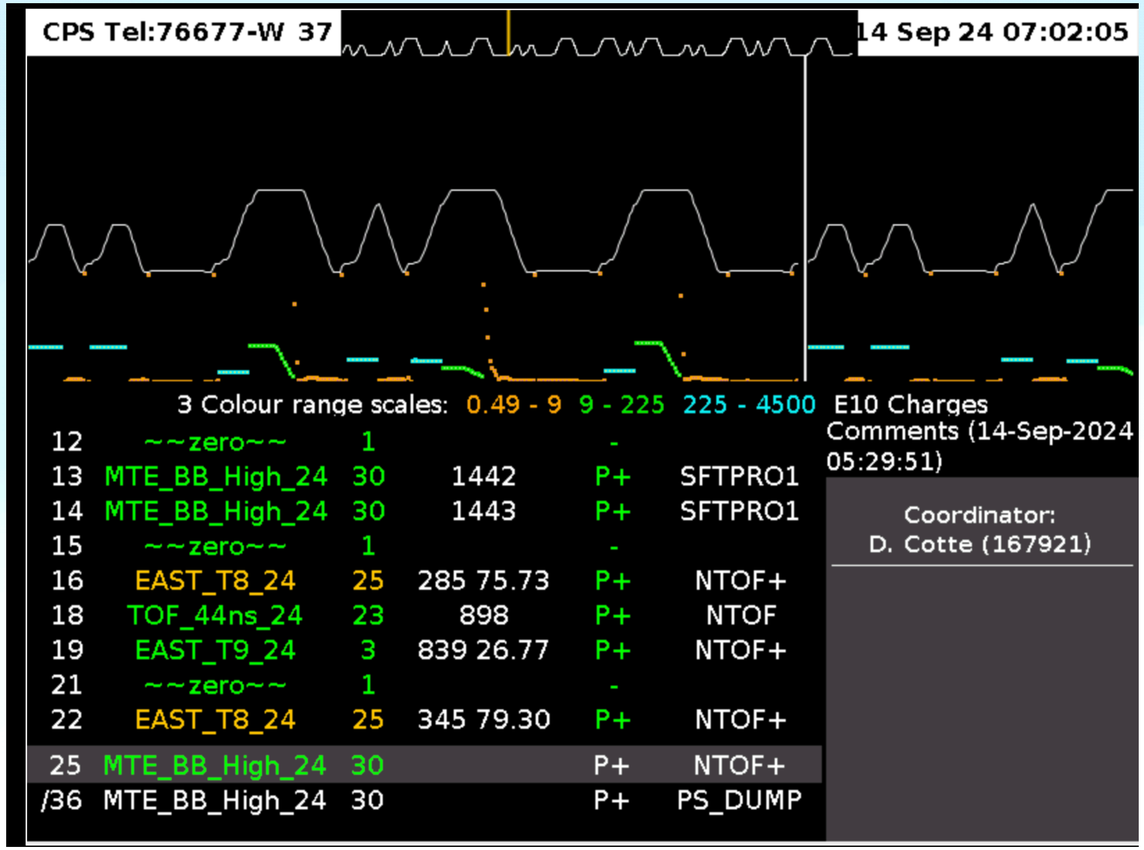
- Every red line corresponds to a „spill“ of particles received and data being recorded
- There is a structure in there – let‘s zoom in a bit!

What is happening at T10



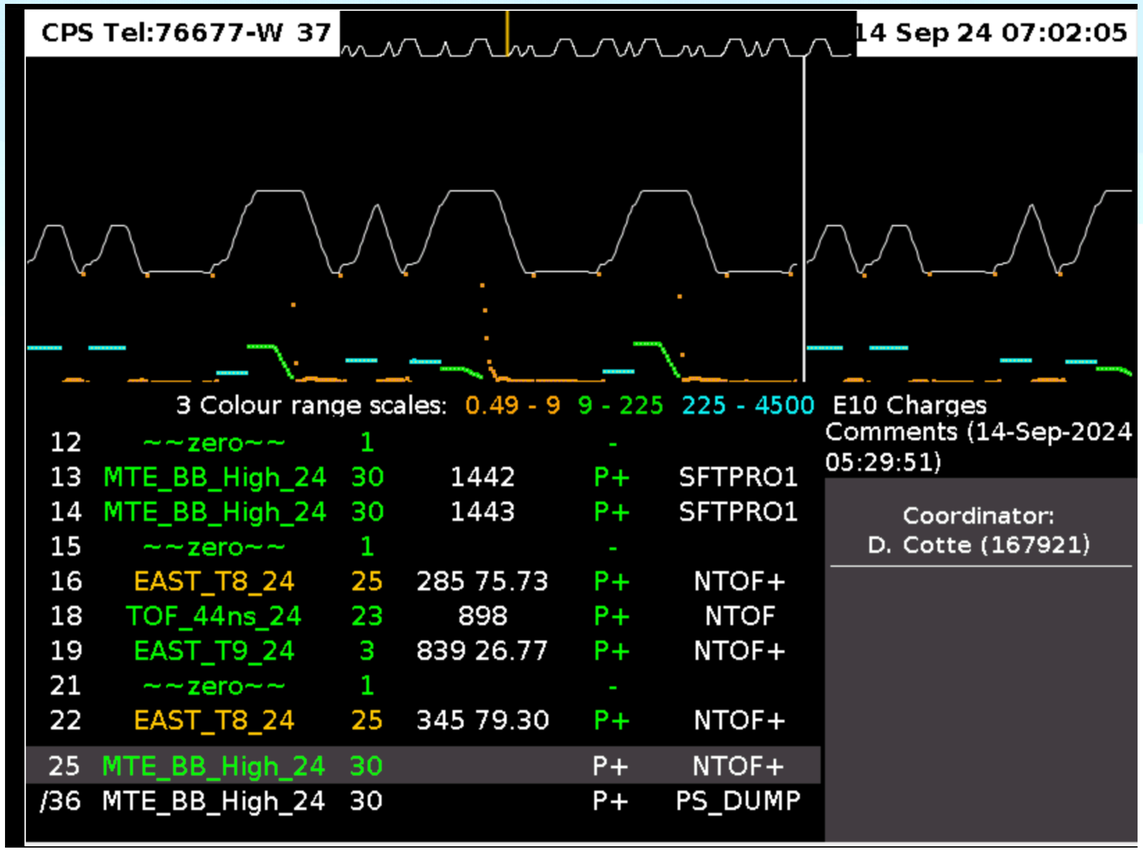
- The spills occur at fairly regular intervals (approx ~ 40 sec)
- According to the built-in detectors at T10, we receive ~ 42k events per spill
- According to our DAQ system, we record ~ 1200-2700 events per spill

What is happening at T10?



- The regular structure of the spills occurs because multiple users and facilities share the particles accelerated by the PS accelerator
- You can have a real-time view onto this cycle and see when it is your turn to get a spill
- => https://op-webtools.web.cern.ch/vistar/vistars.php?usr=CPS

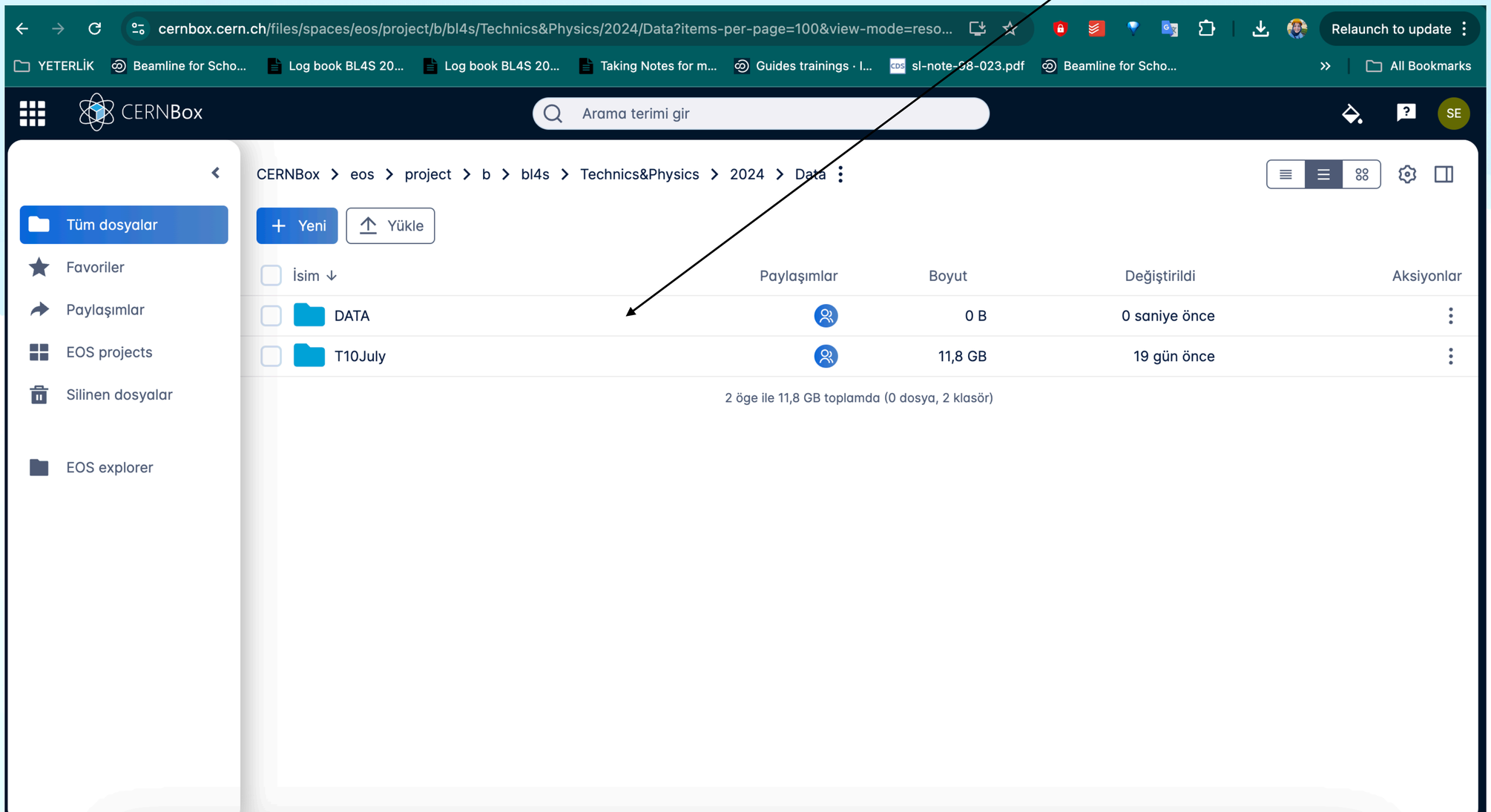
- Example: 2024/09/14 07:02:05
- The cycle contains 36 „slots“
- Each „slot“ is about 1.2 seconds long
- => The cycle repeats every ~ 40 seconds
- You can find the slots for T10 under the name „EAST_N24“
- The length of the cycle and our position(s) in the cycle can and will change over time



Organization

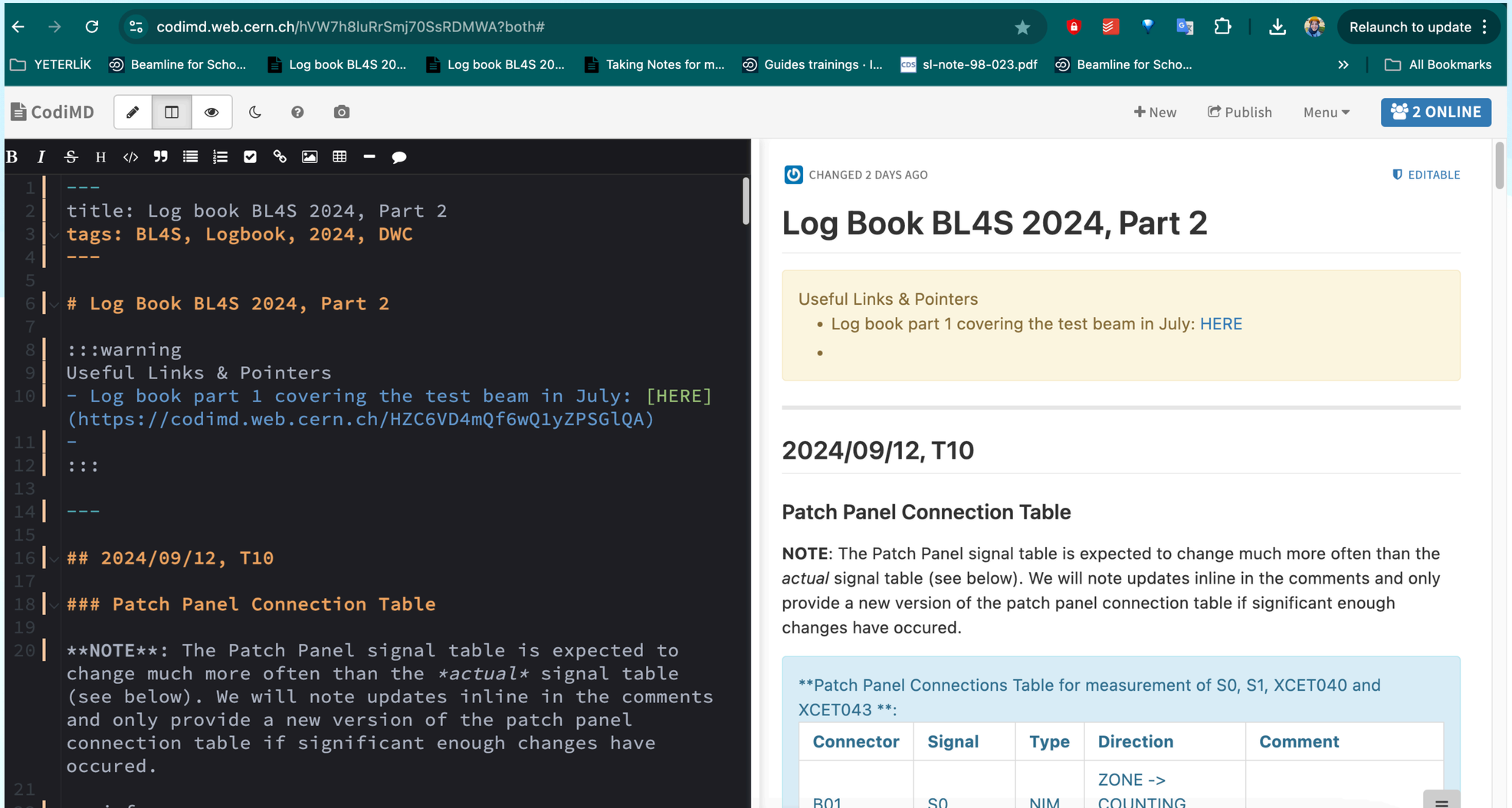
Where you can find the data?

In this directory



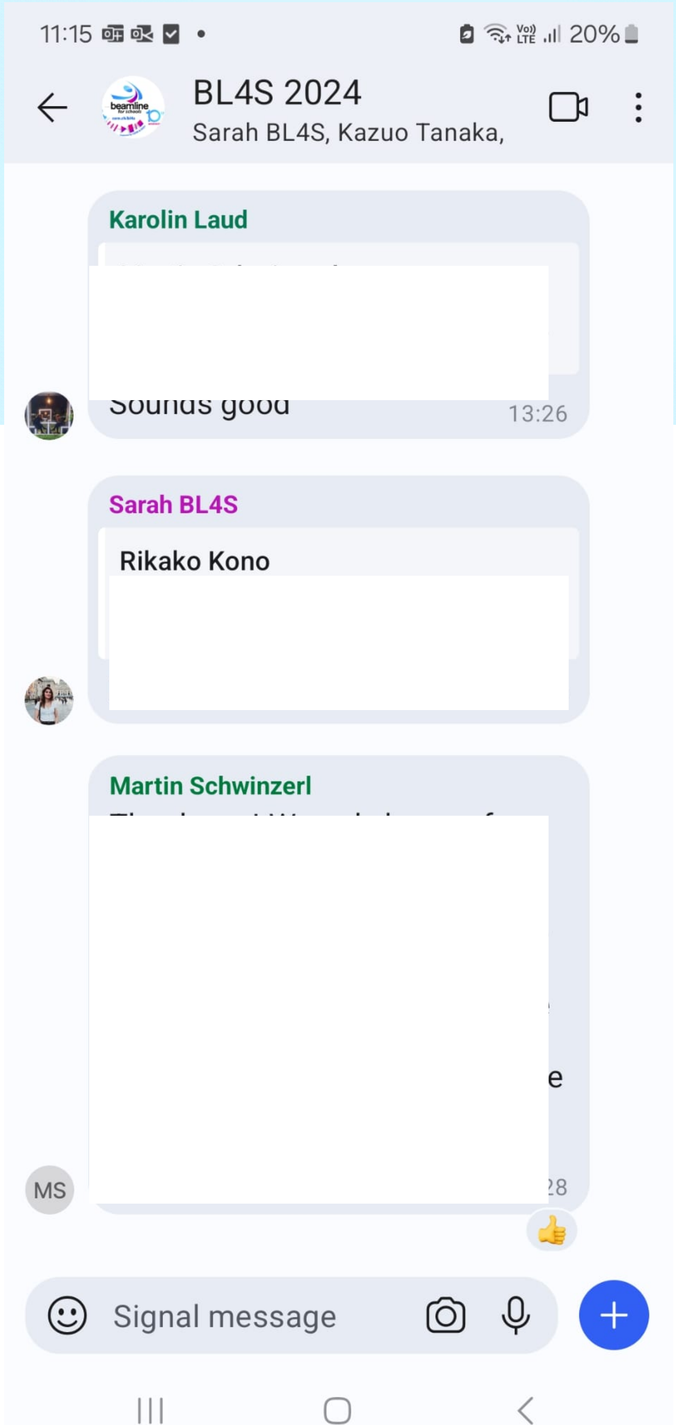
Organization

Log Book - 2024 PART II !! : https://codimd.web.cern.ch/hVW7h8luRrSmj70SsRDMWA?both#



Organization

Signal



Thank you.
Questions?