

#### 2nd DRD3 week on Solid State Detectors R&D



#### Geneva, 3<sup>rd</sup> December 2024







# SPS test-beam infrastructure extension for low temperature, fast triggering applications

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- 1: University of Zurich
- 2: CERN
- 3: Université Paris-Saclay

### Introduction

#### 3 EUDET telescopes available

- Mimosa26 planes featuring 4µm resolution
- EUDAQ1/2 and TLU1/2 as options
- Can be booked as an option in PS/SPS beam request
- For information and help with usage contact André Rummler (telescope maintenance and support); particularly if anything special is needed

#### **ACONITE**

- Permanently installed in SPS/H6A
- Equipped with cold box allowing stable -60°C using two ethanol cooled deep temperature chillers



- FE-I4 timing and ROI
- Controlled PI stages
- Used by various groups
- 35 weeks across all telescopes
- 7 different user groups; including Operation inside H4 magnet
- Full set of Mimosa26 planes procured by ATLAS and CMS)

#### **AIDA**

✓ Permanently installed in SPS/H6B





#### **AZALEA**

- ✓ Mobile telescope
- Primarily used at PS but also transported to SPS

### Introduction

**Problem:** 

Low temperature environment needed for leakage current mitigation at high fluences  $> 10^{15}$   $n_{eq}/cm^2$  and charge carrier mobility for impact ionization-based technologies (LGADs)

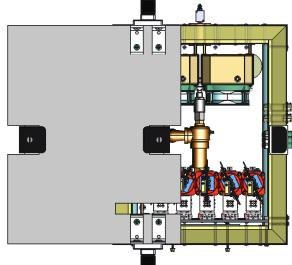
Create a common framework within AIDA INNOVA WP2 to implement necessary infrastructure

#### **Deep Temperature Chiller**



Hubert P815W with 3 Bar pump 1.2 kW, water-cooled, -60 °C

# Controllable multi-plane cold box



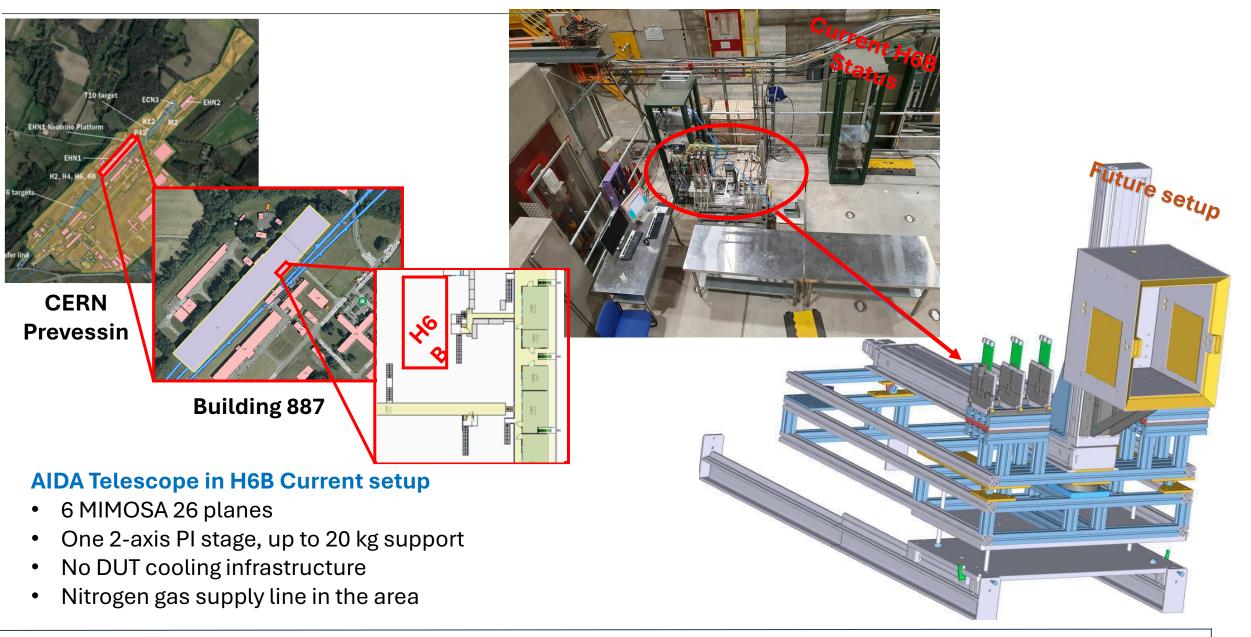
Low material, permanent installation, removable DUT assembly

# High-capacity precision stage, ILE

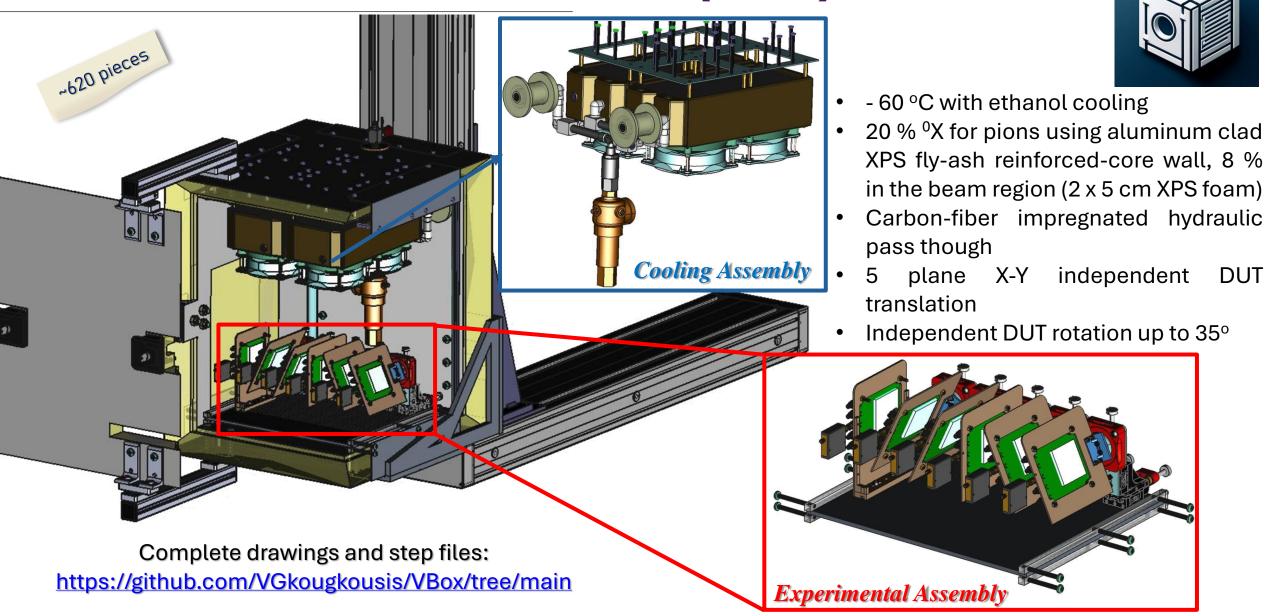


34.2 kN dynamic carrying load, 5 mm pitch, and 1 m travel range

# •General Infrastructure: H6B

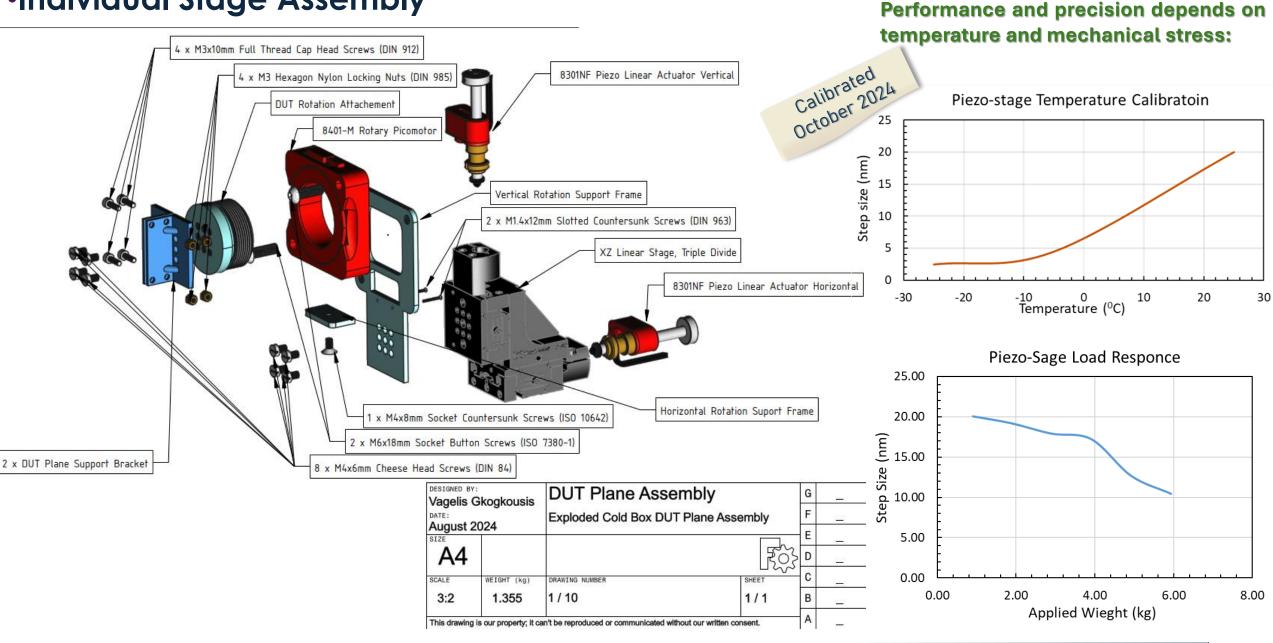


# General Infrastructure: ColdBox (VBox)



DUT

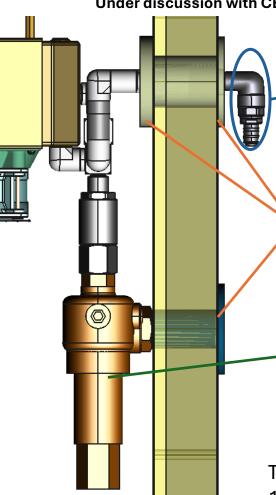
### Individual Stage Assembly



### Important Design Elements

#### **Use of Ethanol = Increase safety precautions**

Under discussion with CERN safety for exemption



Low temperature spill-les quick disconnect, clean cut (-60°C)

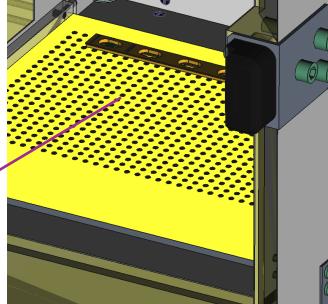
Conductive carbon fiber reinforced PEEK 2-part hydraulic pass- throughs to avoid static electricity build-up

Calibrated 15 psi expansion valve with oil safety certification -200°C to 215°C range

Top side regulated solenoid valve, 100l/min max flow, 10% hysteresis, 2M cycles, < 1MPa, FESTO press fittings 2 x 16 contact bayonet gold coated circular pass-through per side

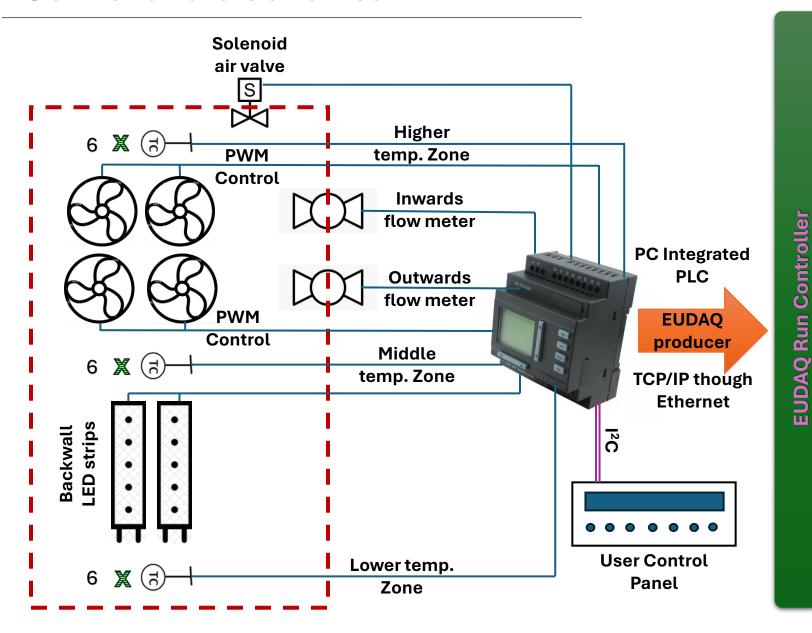
250 x 300 mm beam window aligned with DUT center, removed Al cladding (1 mm)

3 x 50 mm diameter steel pipe clamps for cooling circuit hose retention per side



M5 X 10 Grid with optical rail for independent DUT placement on removable drawer

#### Control and electronics



- ✓ Industrial PID (Proportional Integral Derivate) control system with PC capabilities
- ✓ Integrated control with an independent front panel and Local/Remote mode
- ✓ EUDAQ integration in a producer style concept to be initialized by Run Controller
- ✓ Combined "Infrastructure" producer integrating chiller, stages and pico-motor control
- Plans for future LV an HV integration with multi-instrument support

Seniors						
Flow (In / Out)	2					
Temperature	6 x 3 zones					
Controlled Parameters						
Fan Speed	4					
Internal Lightning	2					
Rotation	5					
X-Y displacement	5					

#### Tables - dimensions

#### • Three available design variations:

- $\checkmark$   $\pi^{0,\pm}$  & other high energy particle beams
- ✓ e<sup>-</sup> beams
- ✓ Climate Chamber variant for lab environment



→ 2 DUT + 1 REF → Extended Height

(foreseen to fir CMS end cap TEPIX disk)

Mass, Coolant & DUT Planes						
Design Variant	Total wei	ght ex. Coolant	(kg)	Estimated Coolant	Max. No. of	
Design variant	<b>Box Mass</b>	Sages Mass	Total	Volume (l)	DUT Planes	
CERN	37.51	3.71	50.64	1.65	5	
DESY	22.5	1.5	31.2	0.85	2	
Climate Chamber	38.91	3.71	42.62	1.65	5	

#### **Material Properties table**

	Material	Density (kg/m³)	Glass Transition Temperature (°C)	Thermal Conductivity (W/m·K)
Metals	Aluminum	2600	N/A	205
Μe	Austenitic stainless steel	8000	N/A	16
	CoraPan Al 85	85	100 (XPS part)	0.035
S	Carbon Fiber Reinforced PEEK (CFK)	1500	140 – 150	0.5 (transversal)
osit	White Acrylic	1100	105	0.25
Composites	TECAPEEK ELS	1450	150	0.46
ပိ	Polyamide	1150	50 (PA66)	0.23
	Polyethylene Plastic	940	-110	0.40

Design Variant Dimensions						
D	imensions	CERN DESY		Climate Chamber		
_	Height (mm)	600	600	930		
Outer	Width (mm)	475	285	475		
0	Length (mm)	520	520	520		
	Height (mm)	500	500	830		
Inner	Width (mm)	375	185	475		
_=	Length (mm)	420	420	520		
e	Height (mm)	314	314	644		
Isable	Width (mm)	375	185	475		
Š	Length (mm)	320	320	520		

### Bill of Materials & Assembly

Part Count						
No. of Machined designs	32					
No. of 3D printed designs	1					
Total Machined Parts	51					
Total 3D Printed Parts	10					
Total Part Count	619					

5

**Custom machined** 





Assembly within the week @ UZH



	Californ	Descriplis.	Calegory/Halorial	Assrabla	Quantity	Camana Wright [hq]	Hanfalorr	Original Parl He.	Production	Saplin
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# Fast Trigger Generator

#### The issue

- 1. Current AIDA TLU requires ~ 120 nsec for trigger generation (TLU 2) and 71 ns (TLU 1)
- 2. CAEN Digitizer (WDT5742BXAAA) and other multi-channel digitization devoices have limited waveform buffer memory at high sampling rates (~ 200 ns) -> 1 kSamp./event @ 5GHz



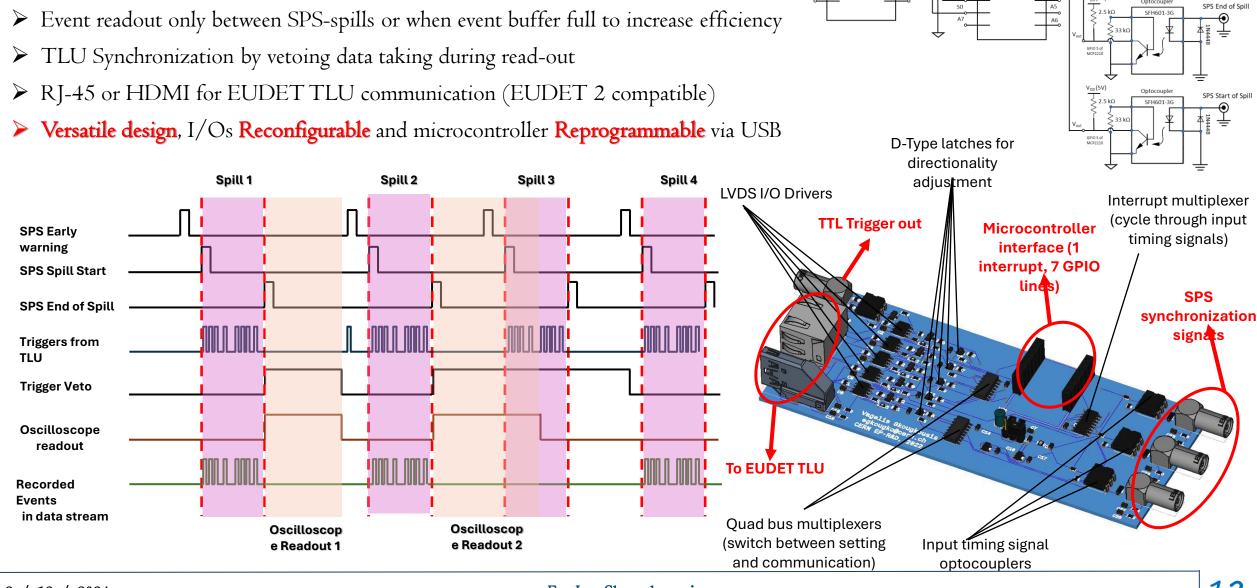
Result: Loss of waveform due to out of time trigger delivery



- ✓ Custom Trigger logic board delivering Trigger within 20 ns
- ✓ Function in tandem with AIDA TLU with a EUDAQ style producer.
- ✓ Capable of managing fast (>1GHz) omni-polarity (positive/negative) inputs
- ✓ Work in sync with SPS clock for efficient data readout within spills.
- Fully customizable logic matrix with external trigger input and adjustable thresholds

# Trigger Interface Board (TiB)

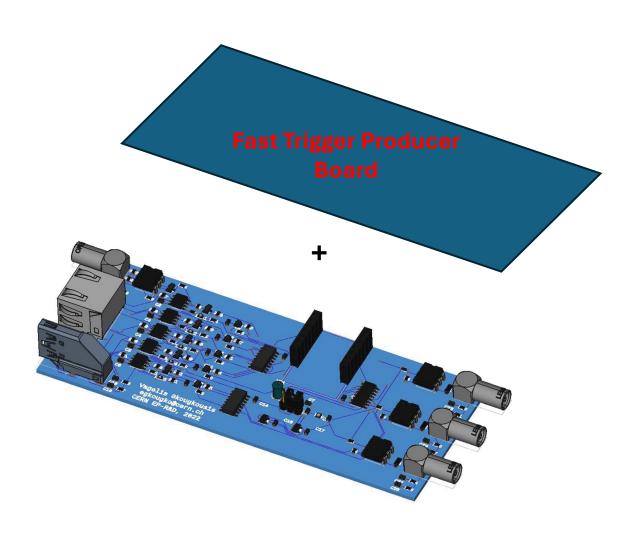
> Oscilloscope in fast readout mode with binary format



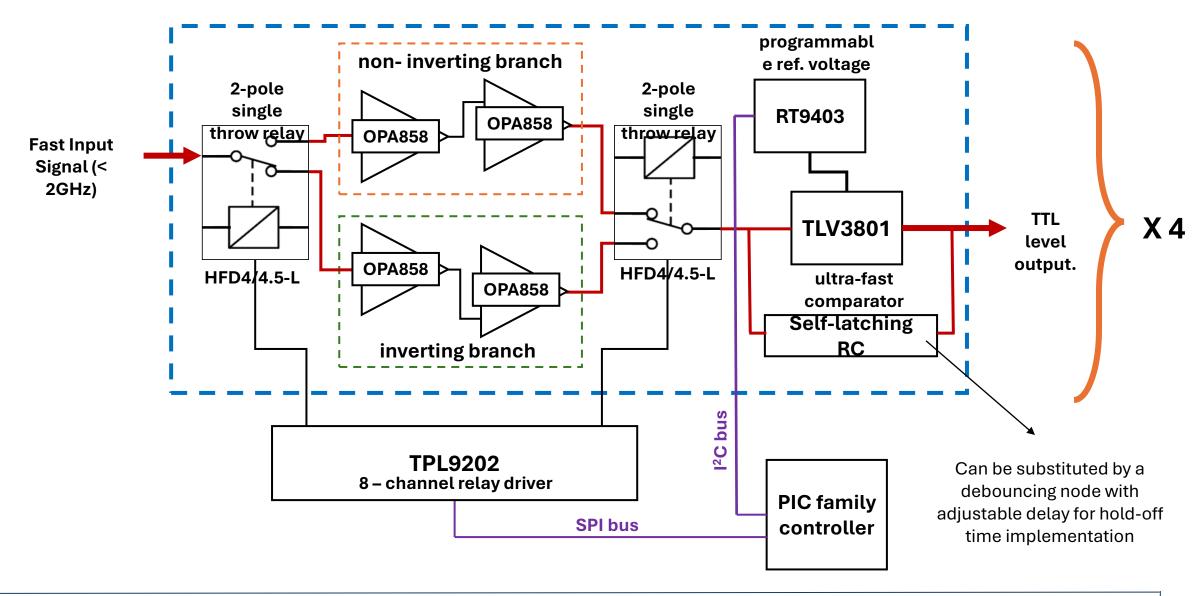
SPI to USB

GPIO 8

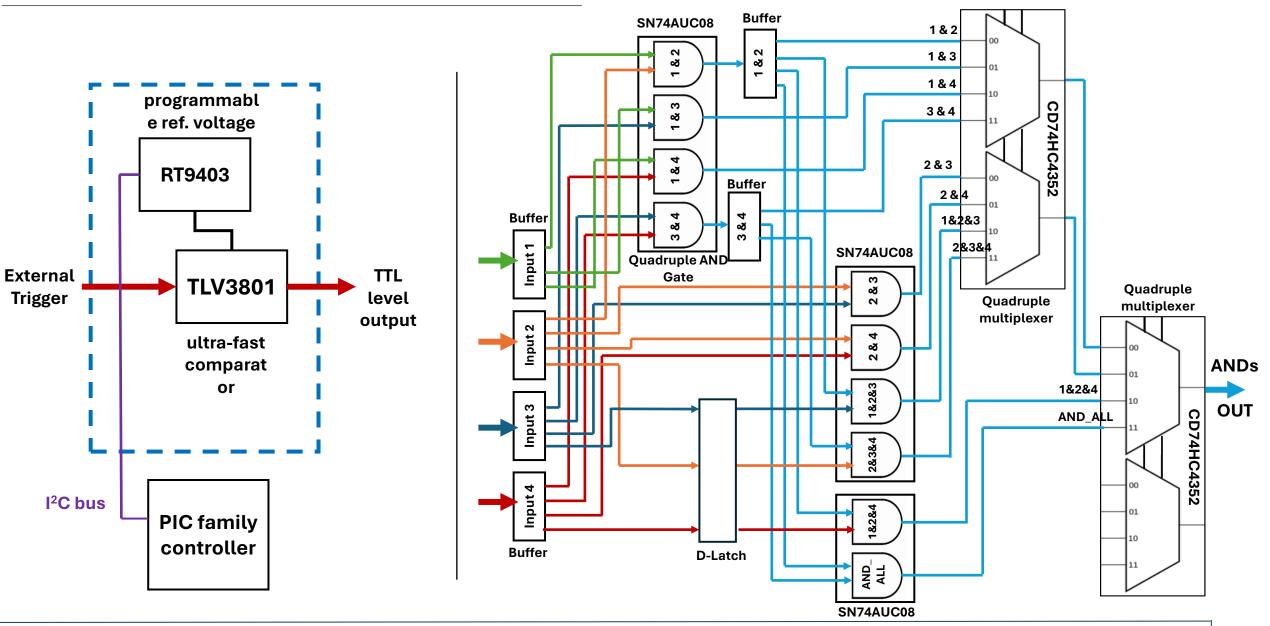
# Fast Trigger Producer



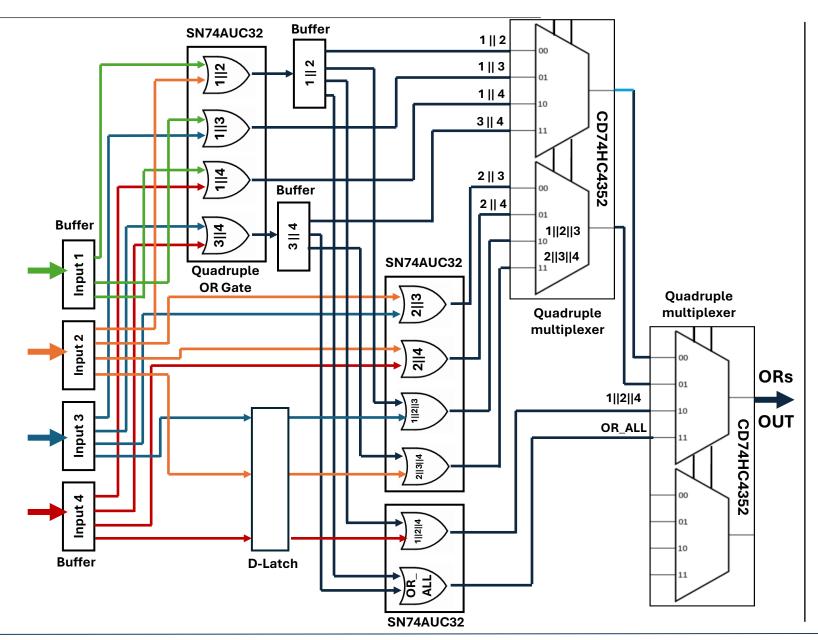
# Trigger input channel



# External input & AND decision matrix



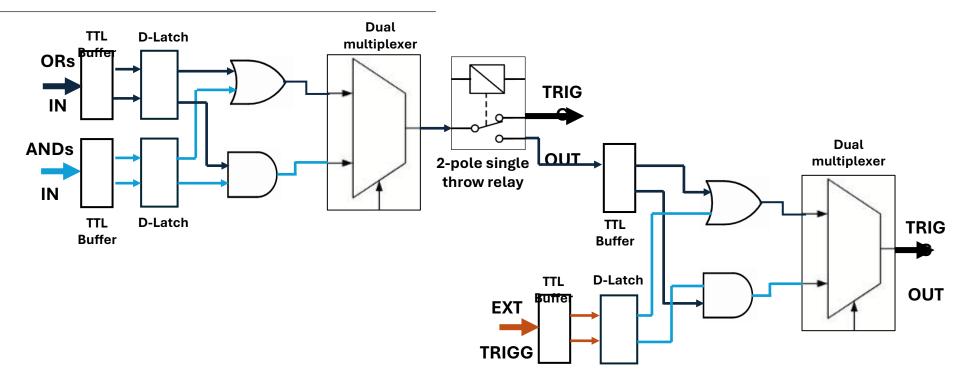
### OR decision matrix



#### **Open issues**

- Select quad and dual TTL buffers
- 2. Select input relays
- 3. Select Latches for all stages
- Configure the de-bouncing/ auto-latching circuit for comparator
- 5. Clocking and clock distribution
- 6. Microcontroller selection and I<sup>2</sup>C/SPI bus configuration
- 7. Proper full simulation for timing and clocking

### Post decision Matrix



#### **Clocking considerations**

Three stage configuration:

- 1. AND/OR matrices decision tree (f<sub>1st. stage</sub>)
- 2. ANDs/ORs combination branches at post-trigger logic  $f_{2nd.}$   $s_{tage}$ )
- 3. Ingestion of external Trigger ( $f_{ext.} = 40 50 \text{ MHz}$ )

Frequency calculation					
f <sub>ext.</sub>	40 – 50 MHz				
f <sub>2nd. Stage</sub> = 2*f <sub>ext.</sub>	80 – 100 MHz				
f <sub>1st. Stage</sub> = 2*f <sub>2nd. Stage</sub>	160 – 200 MHz				

For a 200 MHz first stage frequency, the combined propagation time of the AND/OR logic and the TTL buffer at the first stage should be < 5 nsec

## Conclusions & Outlook

#### Cold Box Infrastructure

- Stage and Chiller already procured and delivered at CERN
- Three cold box designs available, DESY / SPS / Climate Chamber
- SPS Cold box fabricated, assembly at the end of the week in Zurich
- Working on basic infrastructure services at CERN (power, water delivery, ect)
- Installation to start at the YETS (next week?) plan for operation early next year
- Future common fund required to equip other AIDA telescopes (2 @CERN and 2@DESY)
- Electronics to be implemented

### Fast Triggering implementation

- Preliminary 4-channel board design with discreet logic
- Interacts as producer with standard TLU and EUDAQ
- < 20ns propagation / decision time</li>
- Synchronous operation, if necessary, with external clock input
- Fast high bandwidth input amplifiers, low TOT for channel activation
- First tests March/April 2025