

2nd DRD3 week on Solid State Detectors R&D

Geneva, 3rd December 2024





DRD3

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

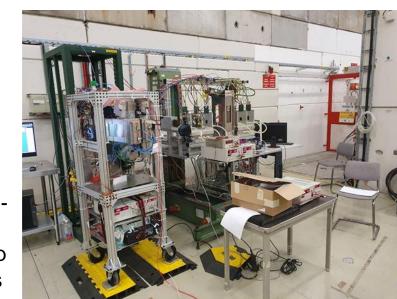
Introduction

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





 Permanently installed in SPS/H6B



- 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)

AZALEA

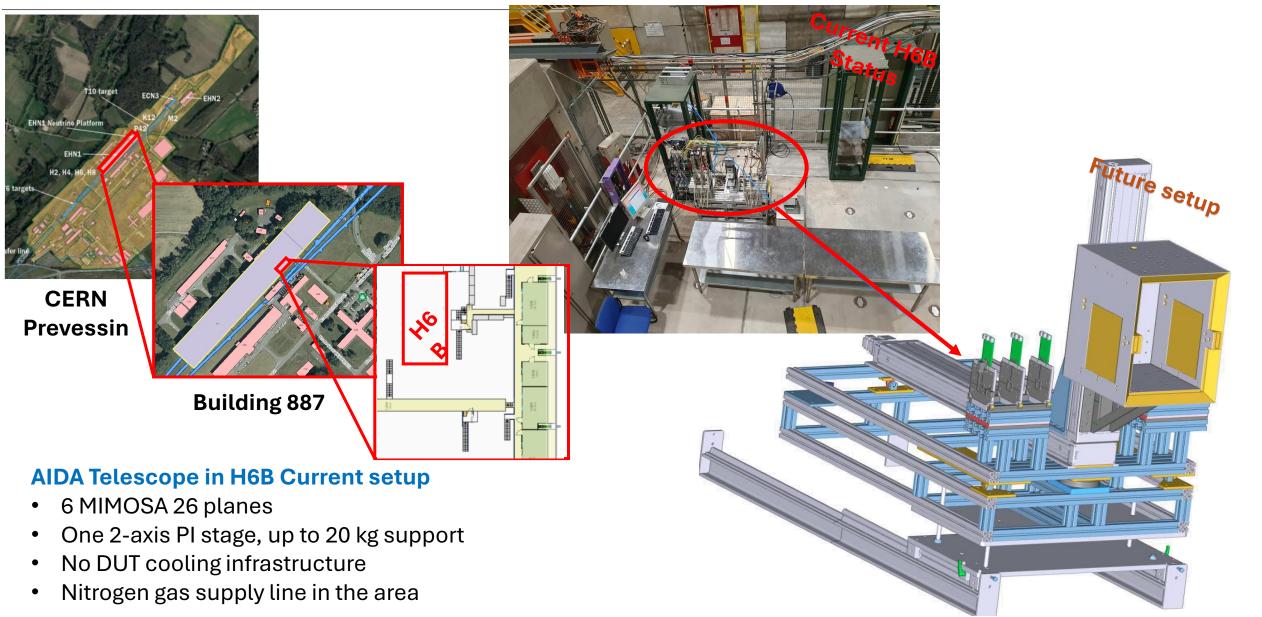
- ✓ Mobile telescope
- Primarily used at
 PS but also
 transported to SPS

Introduction

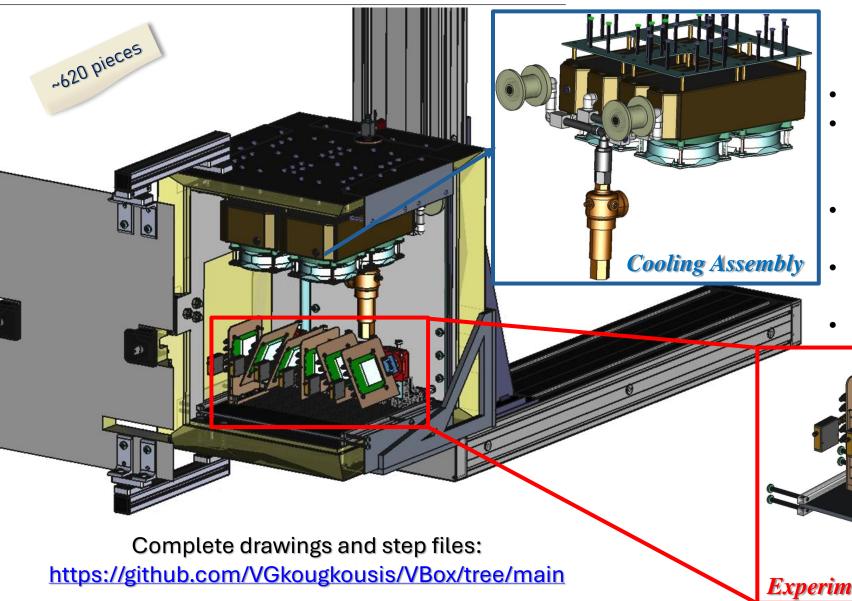
Problem: Low temperature environment needed for leakage current mitigation at high fluences $>10^{15}$ n_{eq}/cm^2 and charge carrier mobility for impact ionization-based technologies (LGADs) Create a common framework within AIDA INNOVA WP2 to implement necessary infrastructure **Deep Temperature Chiller Controllable multi-plane High-capacity precision** cold box stage, ILE Low material, permanent installation, 34.2 kN dynamic carrying load, 5 mm Hubert P815W with 3 Bar pump removable DUT assembly pitch, and 1 m travel range 1.2 kW, water-cooled, -60 °C

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•General Infrastructure: H6B

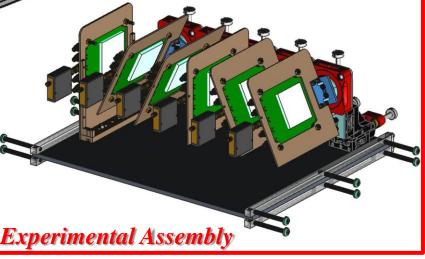


General Infrastructure: ColdBox (VBox)



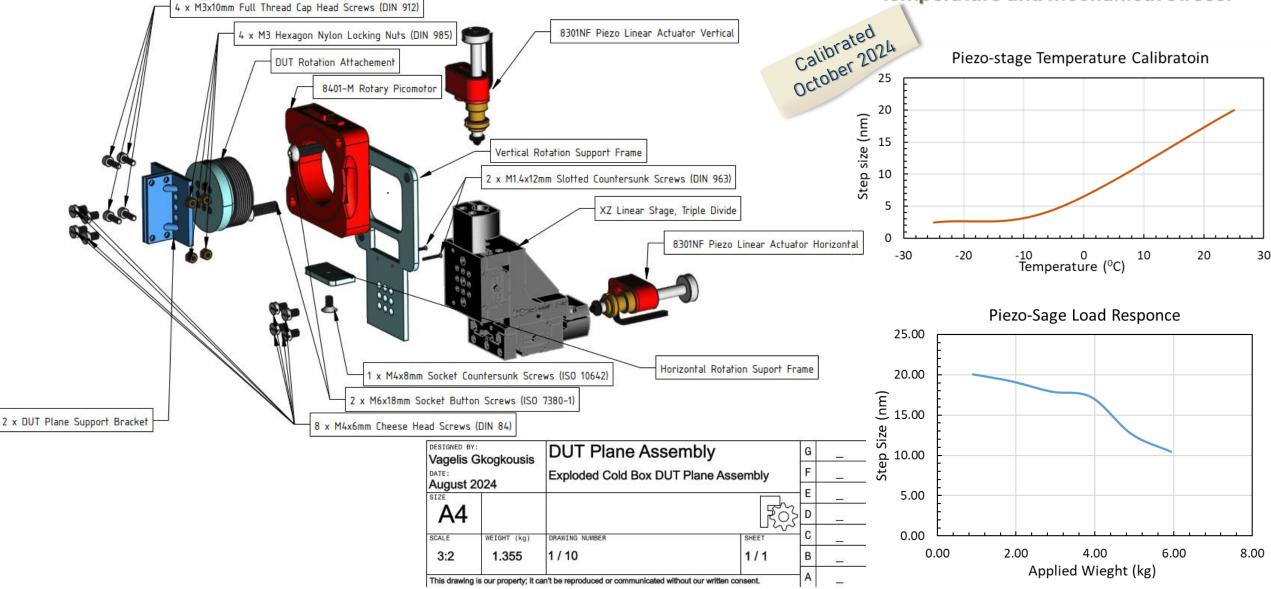


- - 60 °C with ethanol cooling
- 20 % ⁰X for pions using aluminum clad XPS fly-ash reinforced-core wall, 8 % in the beam region (2 x 5 cm XPS foam)
- Carbon-fiber impregnated hydraulic pass though
- 5 plane X-Y independent DUT translation
- Independent DUT rotation up to 35°



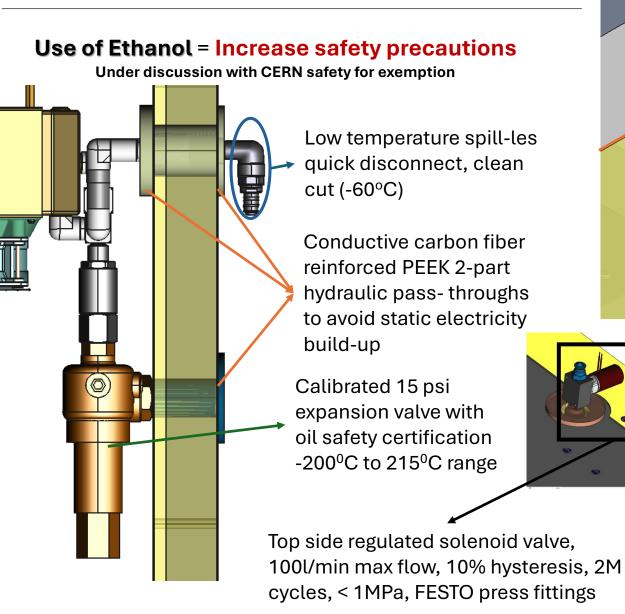
Individual Stage Assembly

Performance and precision depends on temperature and mechanical stress:



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•Important Design Elements

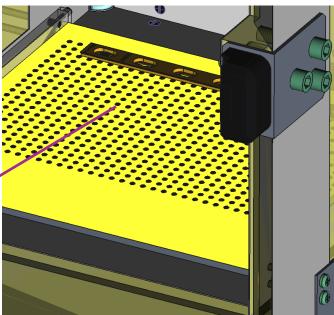


M5 X 10 Grid with optical rail for independent DUT placement on removable drawer

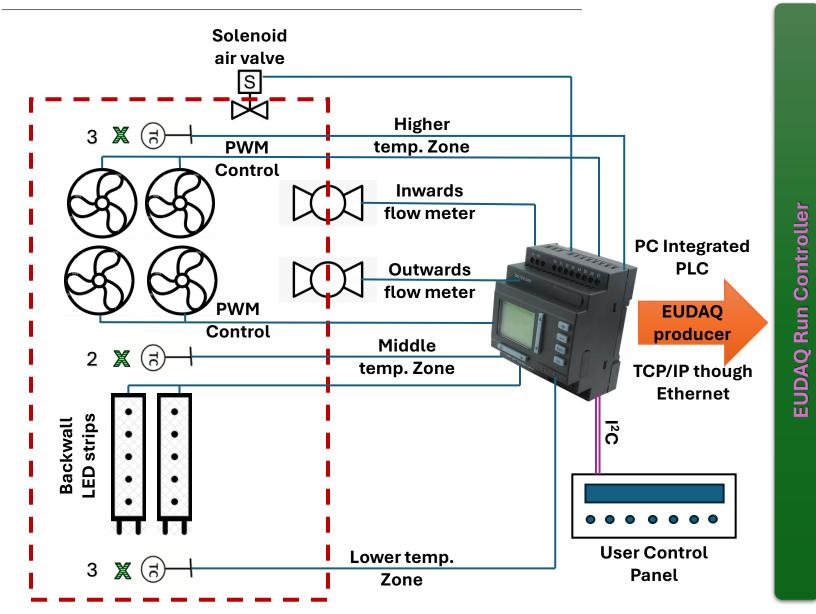
2 x 16 contact bayonet gold coated circular pass-through per side

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



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

Sensors						
ß	Flow (In / Out)	2				
Cooling loop	Pressure (In/out)	2				
Ö	Temperature (In/out)	2				
doc	Flow (In / Out)	2				
Water Loop	Pressure (In/out)	2				
Wat	Temperature (In/out)	2				
Box terior	Temperature	3 x 3 zones				
Box Interior	Humidity with in. heater	3				

Tables - dimensions

• Three available design variations:

- ✓ $\pi^{0,\pm}$ & other high energy particle beams 5 DUT + 1 REF
- \checkmark e⁻ beams \longrightarrow 2 DUT
- 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 weig	ght ex. Coolant	Estimated Coolant	Max. No. of			
Design variant	Box Mass 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				
Met	Austenitic stainless steel	8000	N/A	16				
	CoraPan Al 85	85	100 (XPS part)	0.035				
es 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				
ŏ	Polyamide	1150	50 (PA66)	0.23				
	Polyethylene Plastic	940	-110	0.40				

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

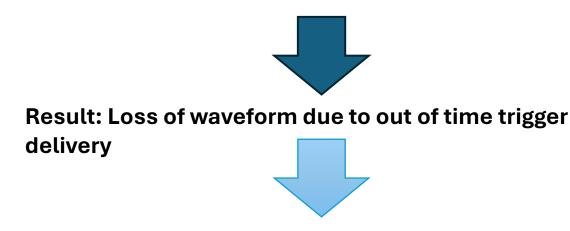
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Fast Trigger Generator

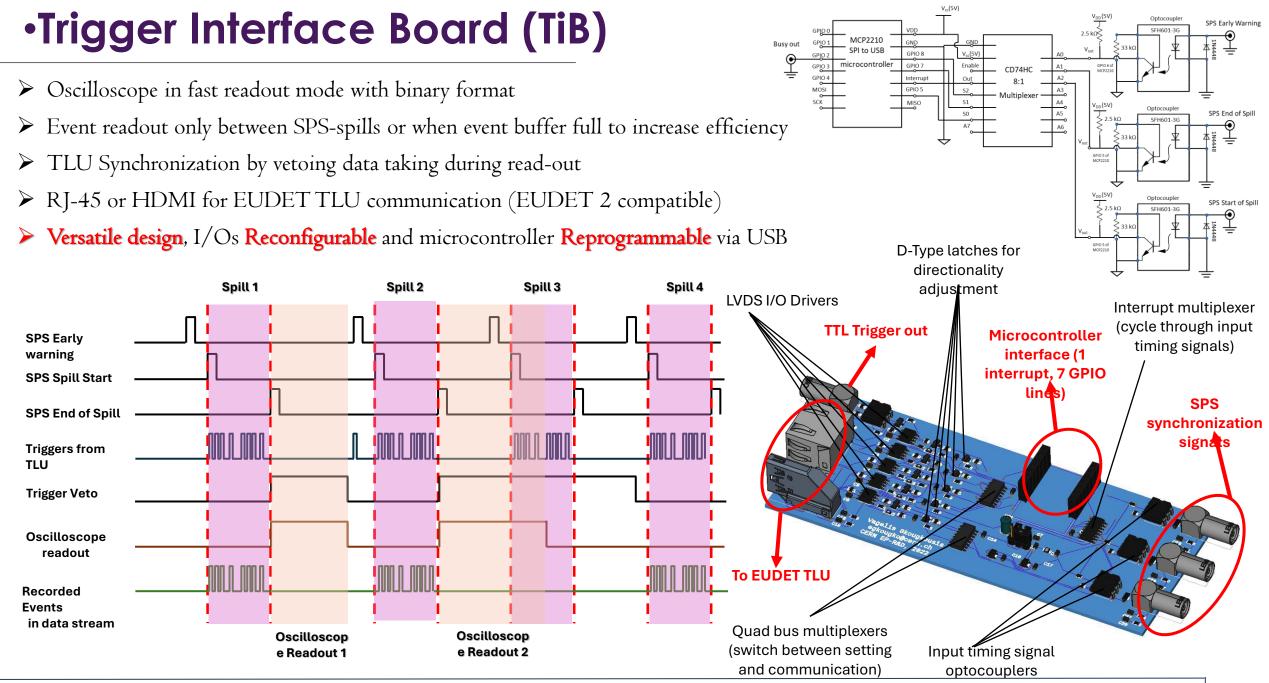
The issue

- 1. Current AIDA TLU requires ~ 120 ns 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 kSmp./event @ 5GHz



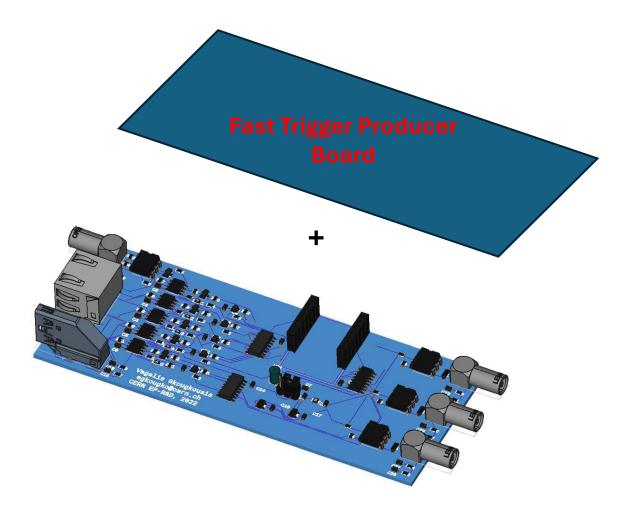
Proposed solution:

- ✓ 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

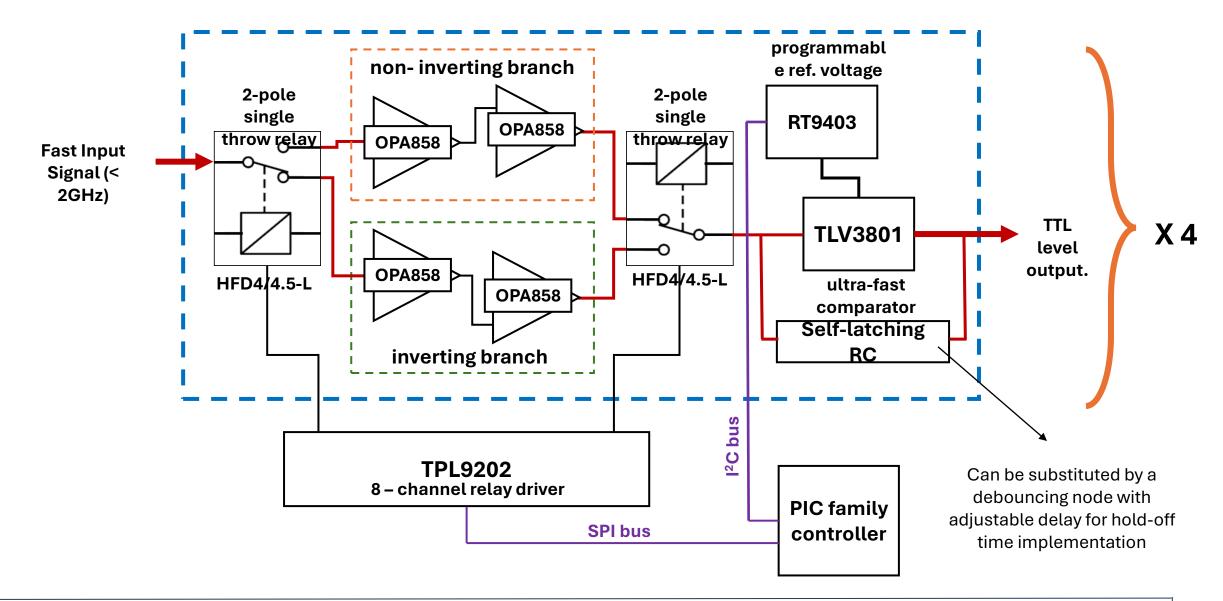


E. L. Gkougkousis

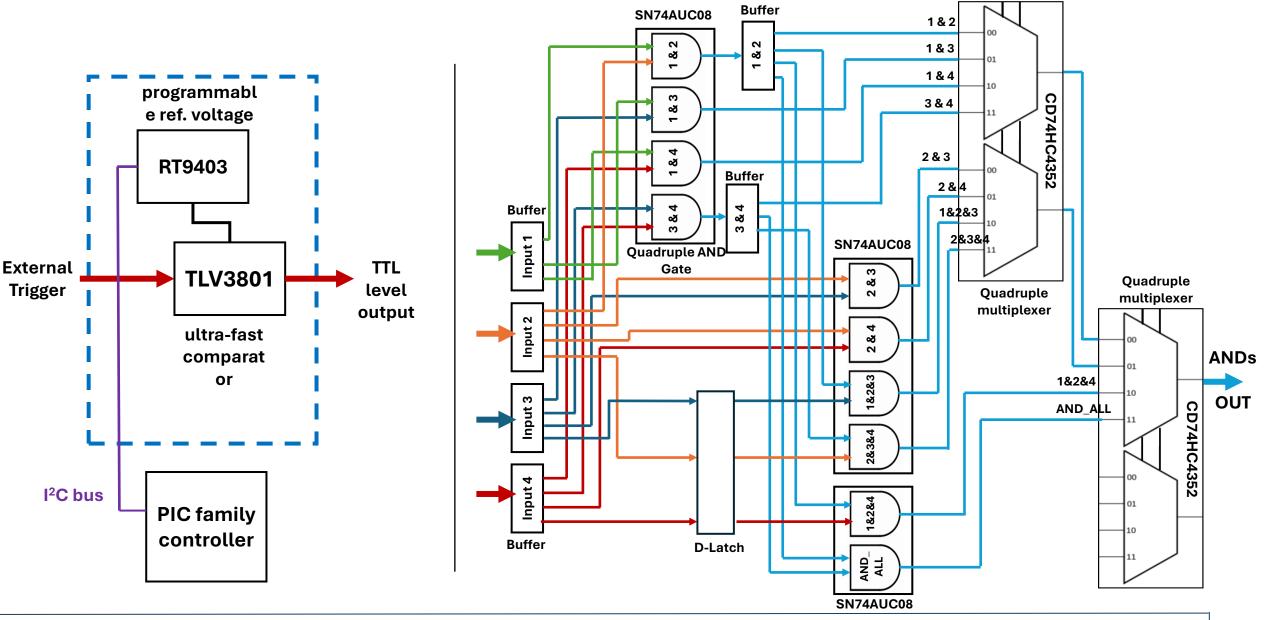
•Fast Trigger Producer



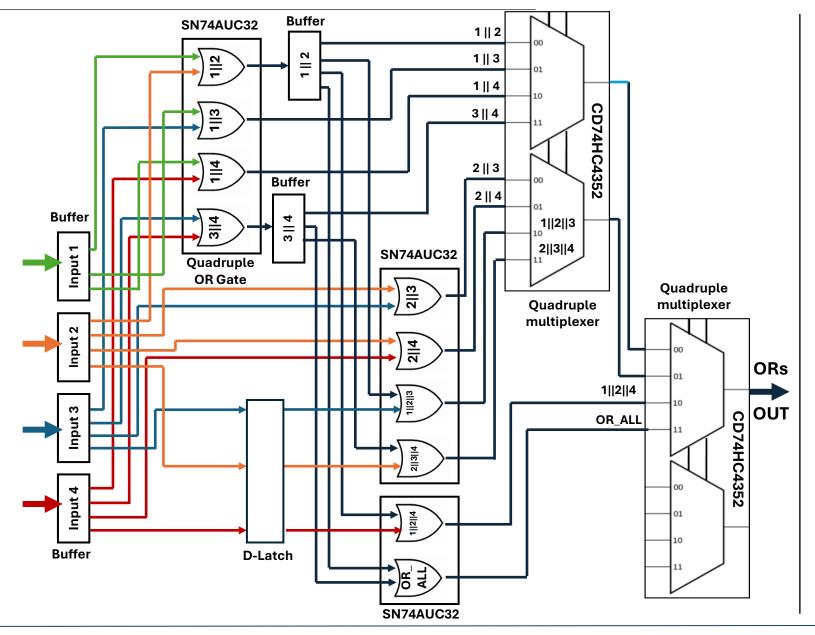
Trigger input channel



External input & AND decision matrix



•OR decision matrix

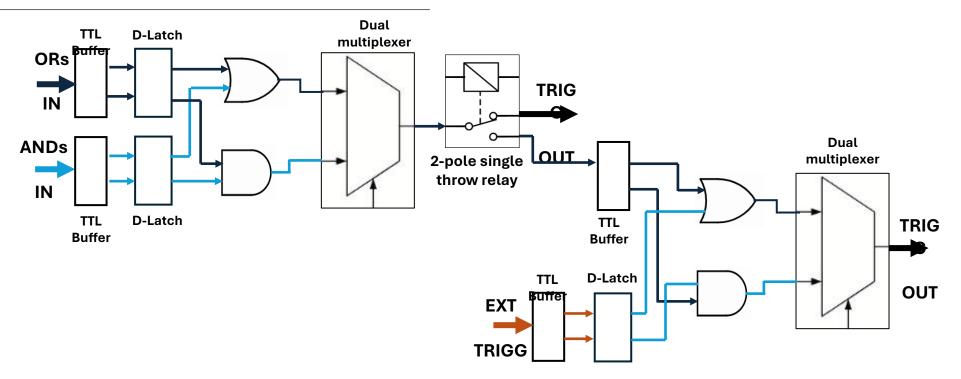


Open issues

- 1. Select quad and dual TTL buffers
- 2. Select input relays
- 3. Select Latches for all stages
- 4. Configure the de-bouncing/ auto-latching circuit for comparator
- 5. Clocking and clock distribution
- 6. Microcontroller selection and I²C/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_{1st. stage})
- 2. ANDs/ORs combination branches at post-trigger logic f_{2nd.}

stage)

3. Ingestion of external Trigger (f_{ext} = 40 – 50 MHz)

Frequency calculation							
f _{ext.}	40 – 50 MHz						
$f_{2nd. Stage} = 2*f_{ext.}$	80 – 100 MHz						
f _{1st. Stage} = 2*f _{2nd. Stage}	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

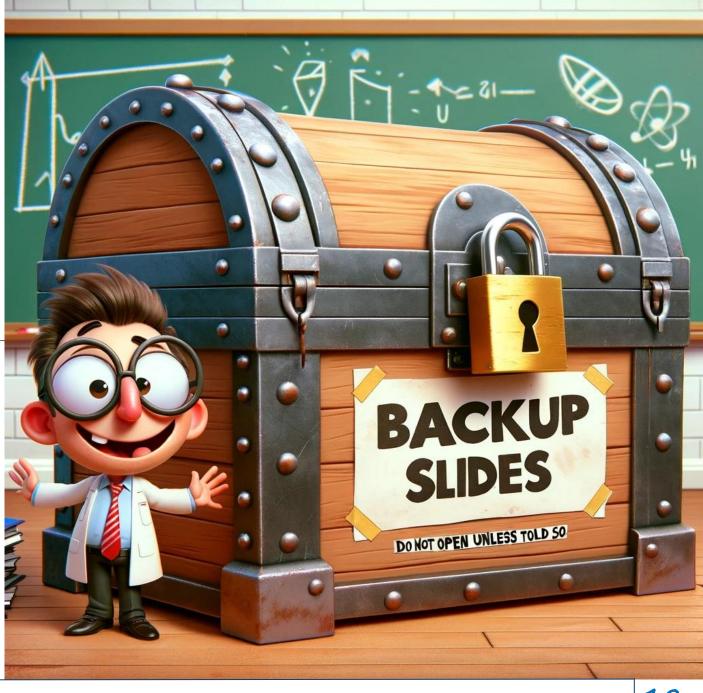
Cold Box Infrastructure

- 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
- Synchronous operation, if necessary, with external clock input
- Fast high bandwidth input amplifiers, low TOT for channel activation
- First tests March/April 2025

Backup



Fan Cabling Diagram

