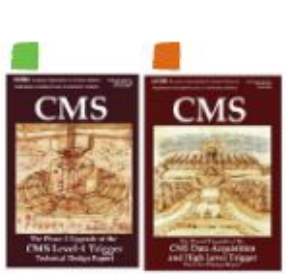
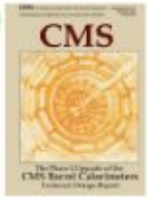
CMS PD hardware activities

riunione Gr1
14.12.2021

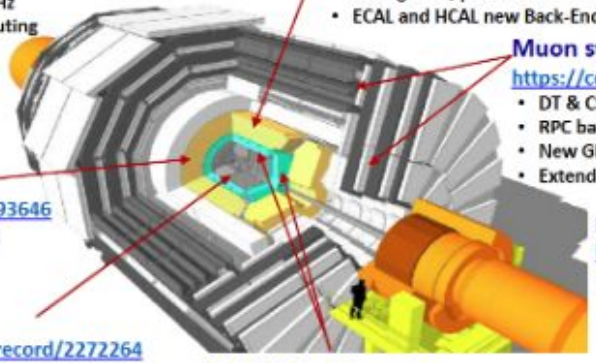
CMS Phase2



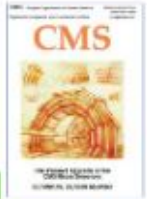
L1-Trigger HLT/DAQ
https://cds.cern.ch/record/2714892
https://cds.cern.ch/record/2759072
- Tracks in L1-Trigger at 40 MHz
- PFlow selection 750 kHz L1 output
- HLT output 7.5 kHz
- 40 MHz data scouting

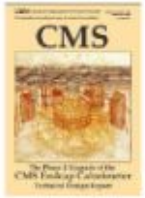


Barrel Calorimeters
https://cds.cern.ch/record/2283187
- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards



Muon systems
https://cds.cern.ch/record/2283189
- DT & CSC new FE/BE readout
- RPC back-end electronics
- New GEM/RPC 1.6 < η < 2.4
- Extended coverage to η ≃ 3



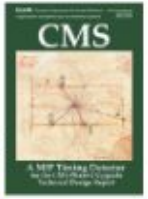


Calorimeter Endcap
https://cds.cern.ch/record/2293646
- 3D showers and precise timing
- Si, Scint+SiPM in Pb/W-SS

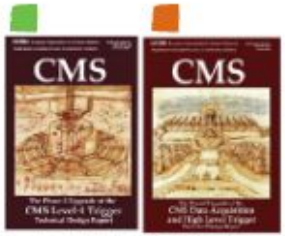
Beam Radiation Instr. and Luminosity
http://cds.cern.ch/record/2759074
- Bunch-by-bunch luminosity measurement: 1% offline, 2% online

Tracker https://cds.cern.ch/record/2272264
- Si-Strip and Pixels increased granularity
- Design for tracking in L1-Trigger
- Extended coverage to η ≃ 3.8

MIP Timing Detector
https://cds.cern.ch/record/2667167
Precision timing with:
- Barrel layer: Crystals + SiPMs
- Endcap layer: Low Gain Avalanche Diodes



CMS Phase2 : PADOVA



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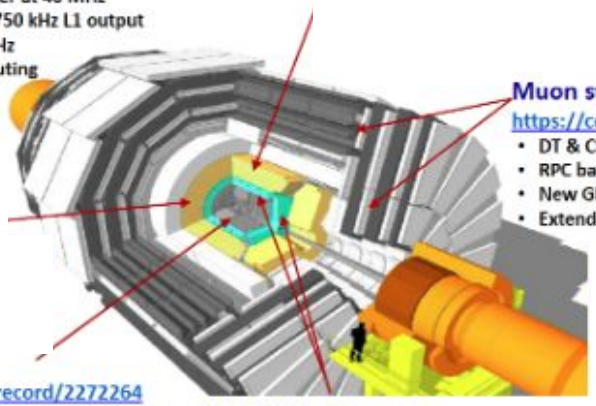

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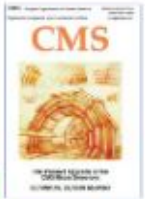

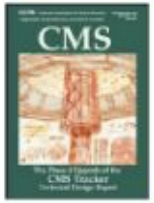

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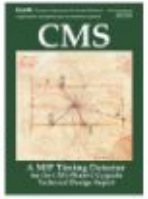
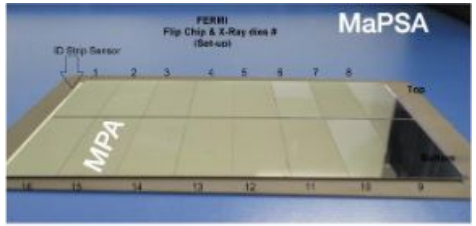
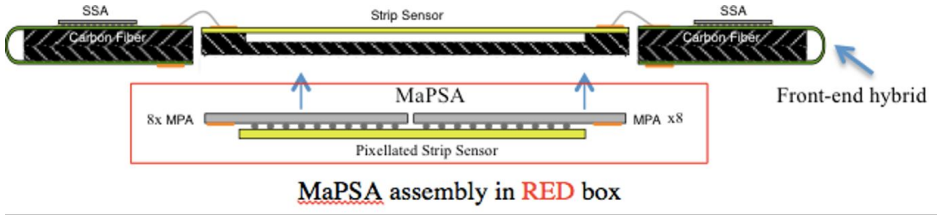


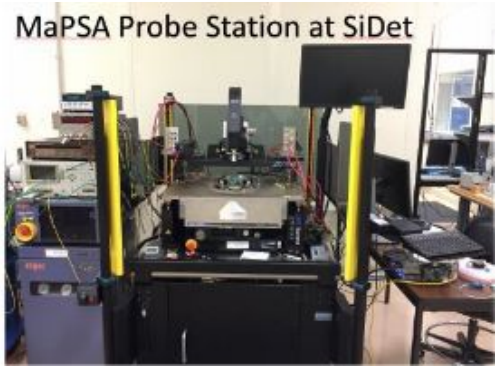
Tracker : MaPSA

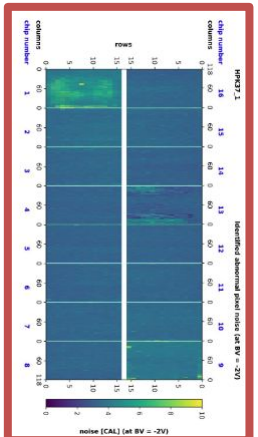
- the MaPSA is the bump bonded assembly
  of the pixelated PS-p sensor and 16 MPAs (Macro Pixel ASICs)

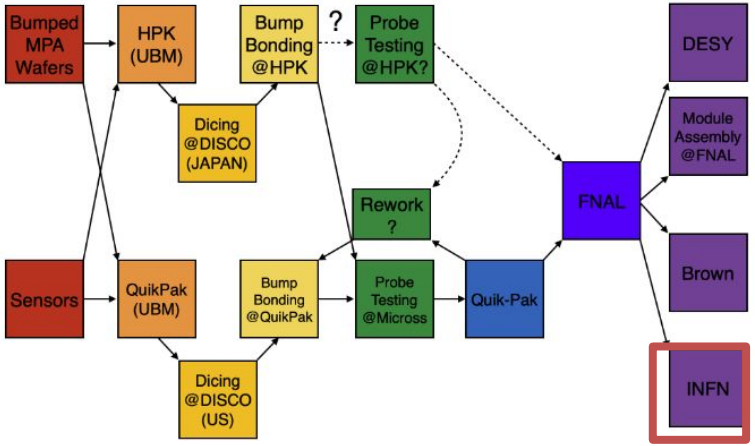




- MaPSA probe testing (N. Bacchetta + D. Pantano) in camera pulita @PD
  → assegno di ricerca 2 anni (INFN)







DT : OBDT

@CERN **DT slice test**

One sector split and readout by phase-1 and phase-2 in parallel during LS2 / Run-3

(13 OBDT v1)

UXC split setup @CERN

In July, splitters were installed to bring signals from 2 FE cables of a DT chamber (YB+2 S1 MB4) to the racks on the balconies

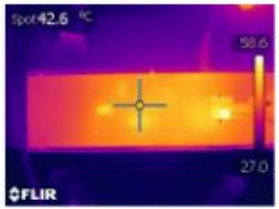
Plan to use them to connect and test lpGBT OBDT (v2) prototypes before EYETS access

@SPE-PD

OBDT v2: 8 boards (pre production batch) tested in Padova

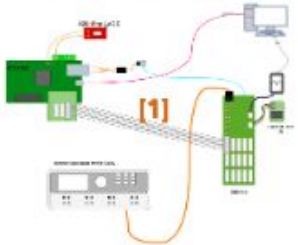
1. GBTx → lpGBT both for timing/slow control (lpGBT chip) and readout (lpGBT FPGA)
2. Safety subsystem is on-board **[TO]**
3. Clock distribution to logic different w.r.t. v1
4. SFP+/QSFP → VTRX+ (dual)

Thermal management (filler gap tests)



Liquid gap that turns solid after application and can be removed.

lpGBT clock & fast/slow controls



Basic functionalities:

1. lpGBT Tx/Rx (10gFEC5) link for lpGBT chip
2. lpGBT Rx (10gFEC5) for readout (test purpose)
3. Fast reset forwarded by the lpGBT - Elink0
4. "Emulated" F.E. pulses (16 channels) **[1]**

Irradiation @ TIFPA

Setup for OBDT v2 qualification prepared

TIFPA (TN) facility schedule still unstable, as of now beam time reserved in October

L1/DAQ : 40 MHz scouting

repliche a footprint ridotto (~ 0.5 m^2) delle DT @LAE in LNL

→ readout compatibile con Phase2 upgrade di CMS

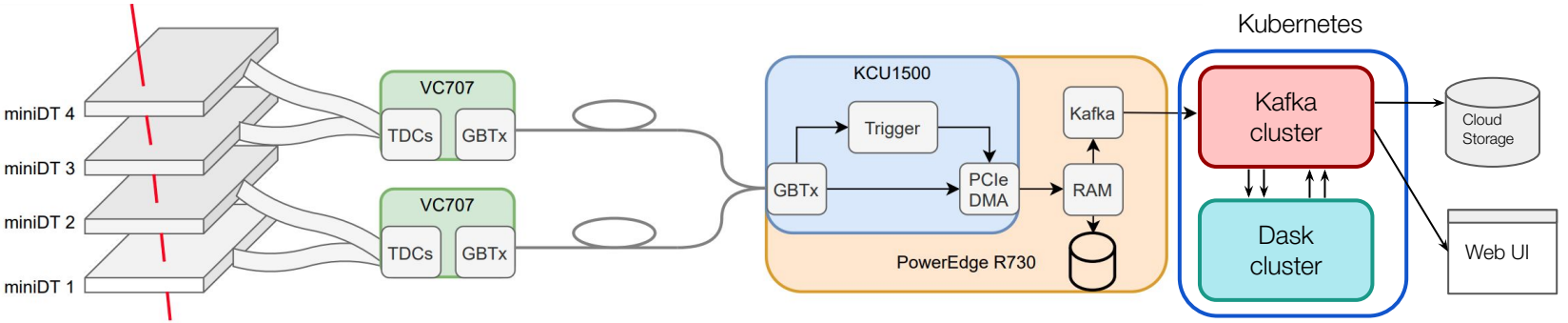
⇒ testbed per elettronica di Phase2 di CMS-DT (OBDT)

→ sviluppo sistema DAQ "trigger-less" ed online processing

- readout di tutti gli hit prodotti dalle camere
- processing online usando risorse
  - *in-situ* : strumenti di calcolo distribuito (Apache Kafka, Apache Spark/Dask)
  - *off-site* : cloud (INFN Cloud e/o Cloud Veneto)
- sviluppo di architetture per il processing **scalabili** e facilmente **portabili** a molteplici use-cases [Kubernetes]

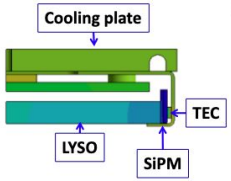
→ sviluppo di algoritmi di trigger basati su NN su FPGA

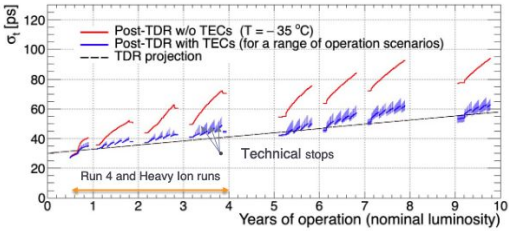
- ricostruzione veloce in FW di segmenti per il trigger locale delle DT ["alto" combinatorio]
  - tempi di inferenza della rete di O(2) clock (→ ~50 ns)
  - latenza fissa indipendentemente dalla complessità degli input
  - elasticità e portabilità potenzialmente vantaggiose anche per lo sviluppo di processing online per esperimenti locali e test beams



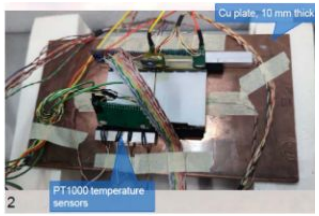
MTD : thermal tests timeline

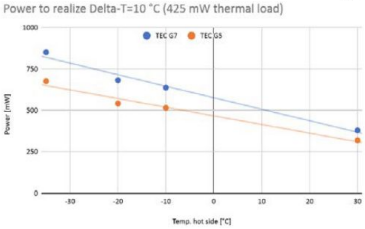
Thermoelectric Coolers (TECs) integrated on SiPM array
to further reduce the SiPM operating temperature [from -35°C to -45°C]





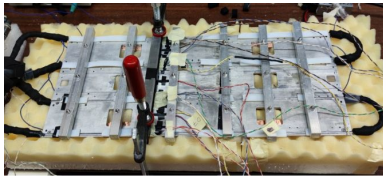
- test of the interface between TECS and copper housing
  → probably the most critical part of the interface
  - in progress in our Gr1 lab w/ different thermal coupling materials
  - need to converge in the first half of 2022

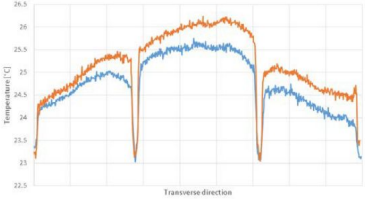




both designed by PD

- test of the interface between CO2 cooling pipes and cold plates
  - test in our Gr1 lab w/ a cold plate and water cooling
    → detailed test of different grooves dimensions and thermal interfaces being performed in the heat transfer lab of the department of engineering in Vicenza





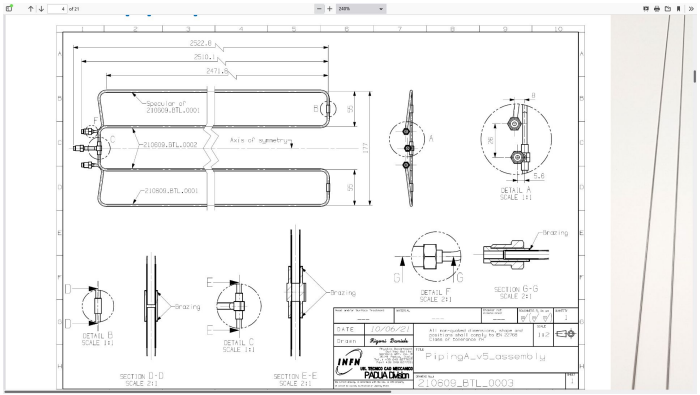
- test of a fully equipped readout unit (a cold plate w/ 12 readout modules) w/ glicole cooling at -35C in our specially equipped fridge in our Gr1 lab
  → system overhauled, expected in the first months of 2022

- other test planned in 2022
  - verify mechanical and thermal stability of thermal interfaces w/ radiation
  - verify mechanical stability of all interface w/ thermal cycles between -40C and +40C
    → plan to use the climate chamber in the electronics lab

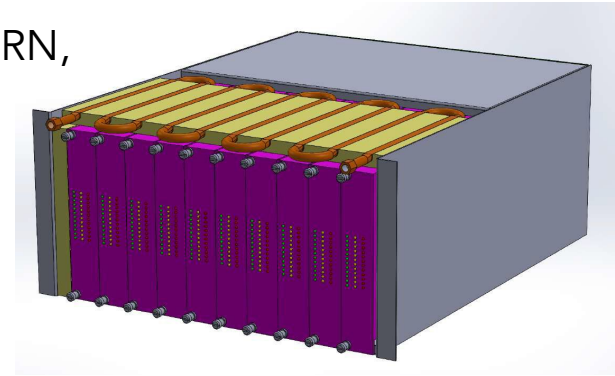
needed for the SiPM annealing

MTD : test of mechanics

- a full size “tray” designed by PD has been produced by a company in Italy and assembled at CERN
- cooling pipes manifold for the tray, also designed by PD, were electron-beam brazed at CERN and need to be tested at 150 bar for compliance with CO2 cooling
- full assembly will then be tested at CERN CMS TIF facility with dummy thermal loads
  - in the first months of 2022
  - to complement the test made in Padova of a fully equipped (not dummy) readout unit tested w/ liquid cooling



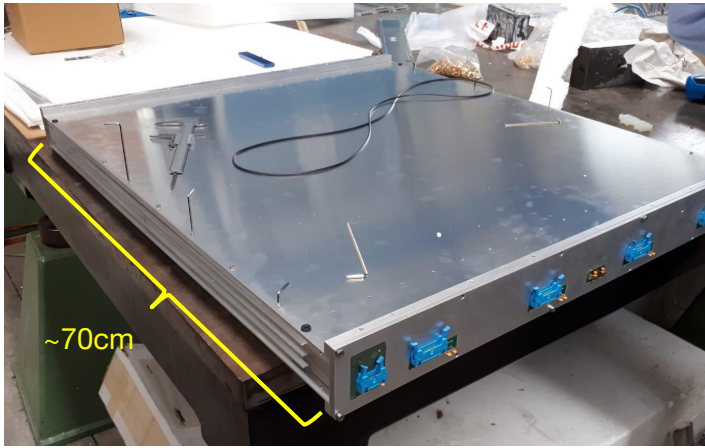
MTD : test TECs power supplies



- CMS is making a **global tender** for **power supplies** through CERN,
  for several sub-detectors upgrades
  - hostile environment (magnetic field, radiation)
- main version will be for MTD endcap (ETL) and barrel (BTL) LV,
  and for the endcap calorimeter (HGCAL)
- MTD will have two more versions,
  for the bias voltages and for the TECs
- Padova is expected to test the prototypes of the power supply for the TECs,
  coherently w/ the involvement on the TECs cooling interface
  - it is special as it needs to be able to invert the voltage,
    to use TECs as heater for the annealing
  - goal is to verify the compliance of the prototype w/ specs,
    not the functionality of the full production that will be tested by the company
  - expected to happen in the second part of 2022 in our Gr1 lab


BACKUP

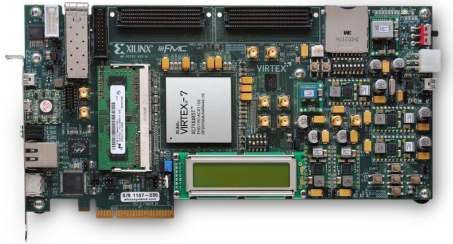
Camere a deriva (mini-DT)



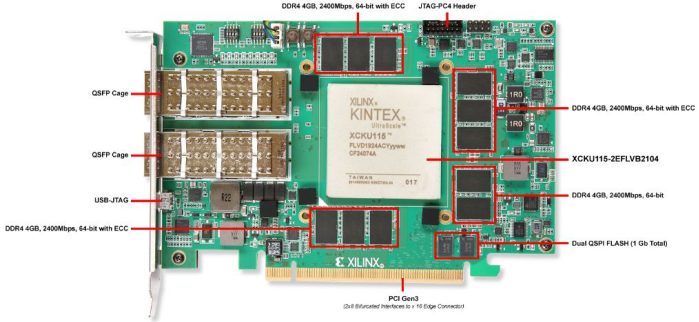
- Costruzione e operazione di camere a deriva presso il LAE di LNL
  - Repliche a footprint ridotto (~ 0.5 m^2) delle DT di CMS
  - Readout compatibile con Phase2 upgrade di CMS
- Utilizzate in diverse applicazioni:
  - Sviluppo sistema DAQ triggerless e online processing
  - Sviluppo di algoritmi di trigger basati su Reti Neurali su FPGA
  - Testbed per elettronica di Phase2 di CMS-DT (OBDT, in sviluppo a PD)
  - Muon-spectrometer per testbeam collaborazione LEMMA
  - Previsto il deployment nel corso della presa dati di MUTOMCA (muon tomography)
- 8 camere costruite
  - 4 (+1 spare) correntemente usate in uso in configurazione “telescopio” presso il LAE
  - 1 al CERN per test di integrazione dell’elettronica di readout e trigger di CMS on-site
  - 2 assemblate assieme a colleghi di INFN-BO, interessati a replicare un setup simile a BO

Camere a deriva (mini-DT)

2x Xilinx VC707 ev. Boards
- TDCs in FW
- GBTx-FPGA protocol to 10Gbps SFP+ transceivers

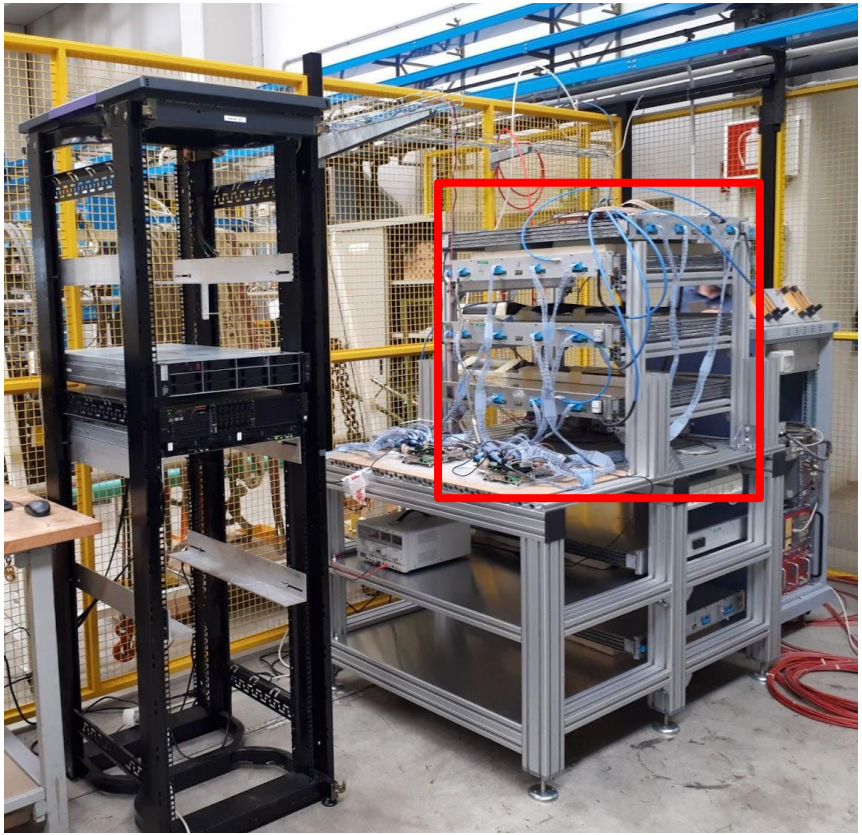


Xilinx KCU1500 ev. Boards
- Concentrator of up to 8 GBT links
- DMA data transfer over PCIe



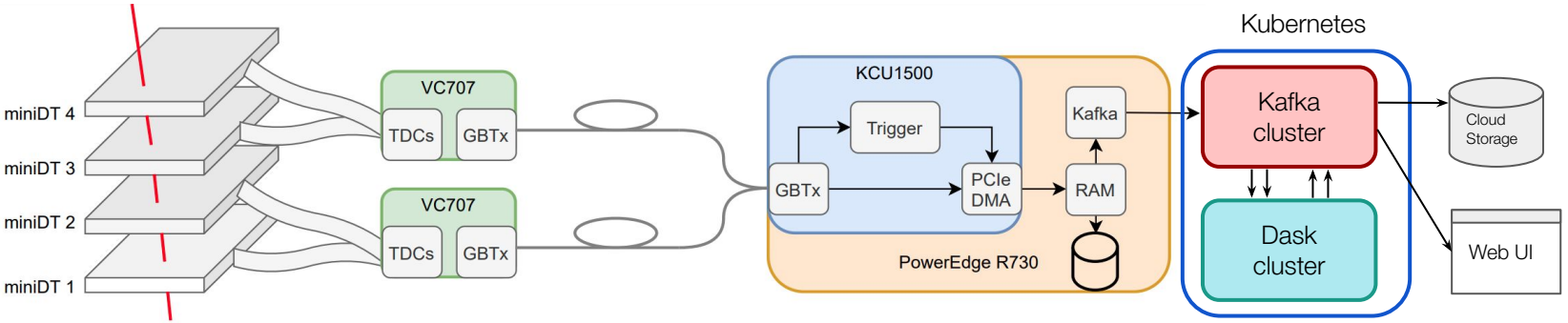
Rack slow-control e computing "on-site"

Experimental stand equipaggiato con 4 mini-DTs



Sviluppo di metodi di acquisizione e online-processing di stream di dati

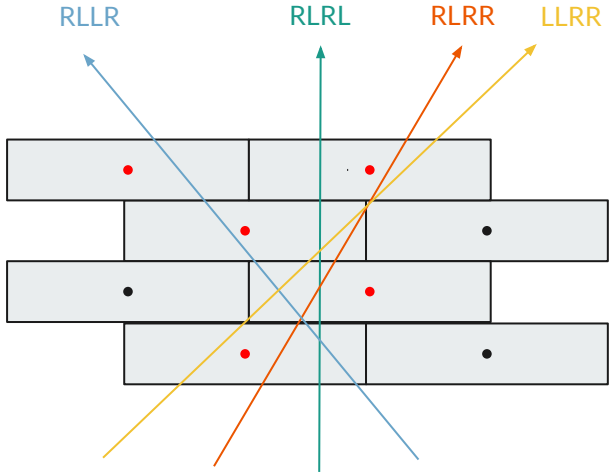
- Mini-DT usate come testbed per lo studio e implementazioni di sistemi di acquisizione **Triggerless** e **Processing Online**
  - Acquisizione in trigger-less mode di tutte le hits prodotte dalle camere
  - Processing online del 100% delle hits prodotte usando strumenti di calcolo distribuito (Apache Kafka, Apache Spark/Dask)
  - Processing online svolto “off-site” su risorse cloud (INFN Cloud e/o Cloud Veneto)
  - Sviluppo di architetture per il processing **scalabili** e facilmente **portabili** a molteplici use-cases
    - Deployment cointainerizzato basato su Kubernetes
    - Elasticità e portabilità potenzialmente vantaggiose anche per lo sviluppo di processing online per esperimenti locali e test beams
  - Discussioni attualmente in corso per l’integrazione di questi sistemi con DAQ e DT di CMS

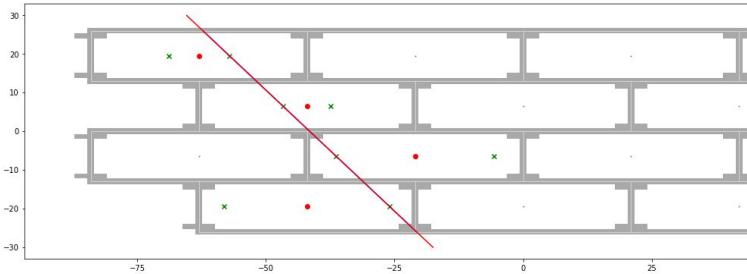


https://arxiv.org/abs/2111.05155

Sviluppo di trigger basati su reti neurali

- Sviluppo di algoritmi basati su reti neurali per la ricostruzione veloce in FW di segmenti per il trigger locale delle DT di CMS
  - Problema “semplice” ma caratterizzato da alto combinatorio (specialmente ad alto PU)
  - Reti neurali permettono di eliminare il combinatorio
  - Tempi di inferenza della rete di O(2) clock (→ ~50 ns)
  - Latenza fissa indipendentemente dalla complessità degli input
  - Tuning importante per contenere l’utilizzo delle risorse:
    - Scelta architettura NN
    - Quantizzazione pesi
    - Pruning modello





https://arxiv.org/abs/2105.04428