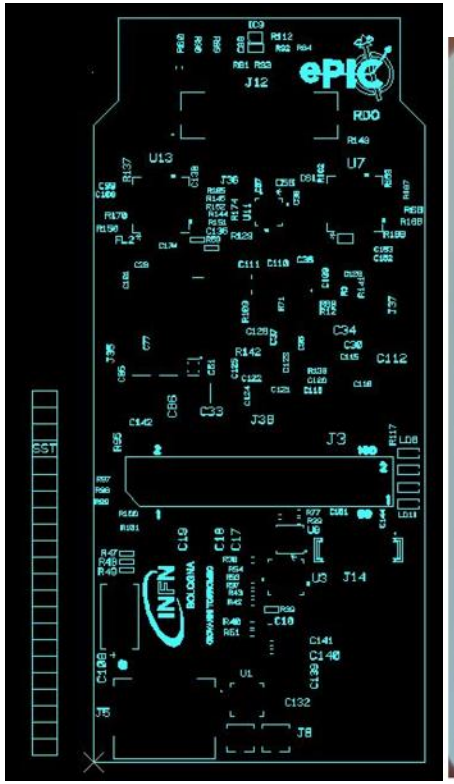
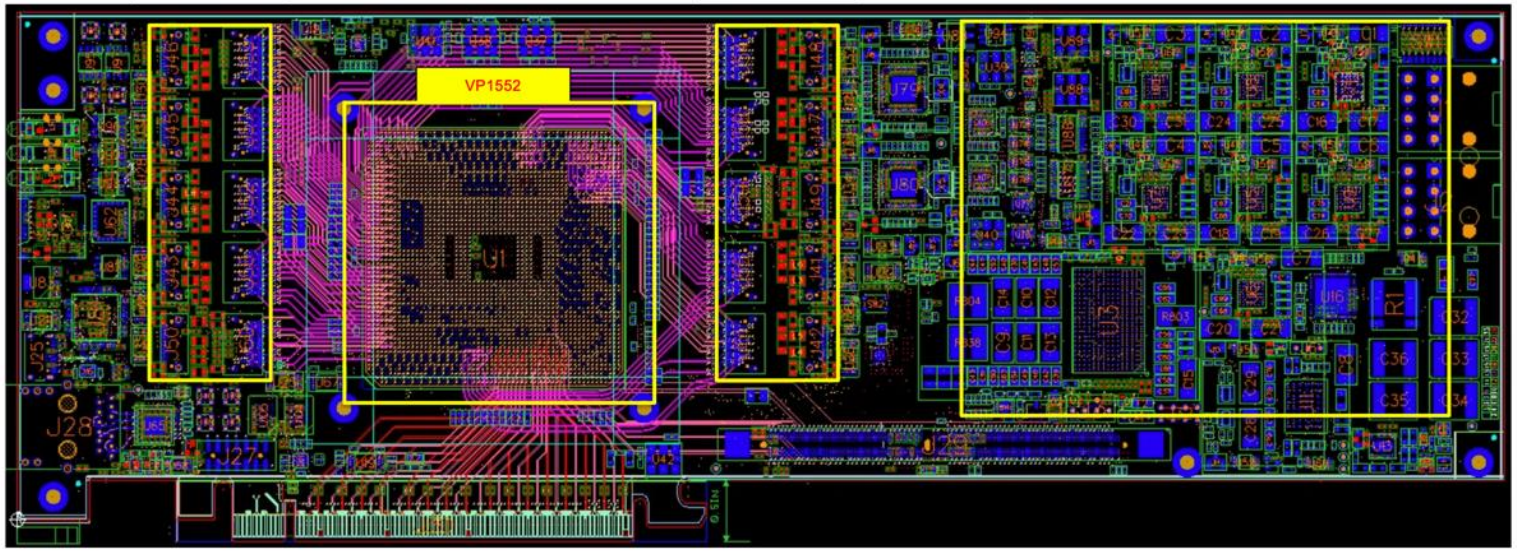
dRICH DAQ
(frontend and backend DAQ)



P. Antonioli (INFN Bologna), A. Lonardo (INFN Roma1)



dRICH DAQ kick-off meeting
Zoom, 5 September 2025

dRICH: frontend and backend DAQ

INFN BOLOGNA Istituto Nazionale di Fisica Nucleare

dRICH RDO

INFN ROMA Istituto Nazionale di Fisica Nucleare

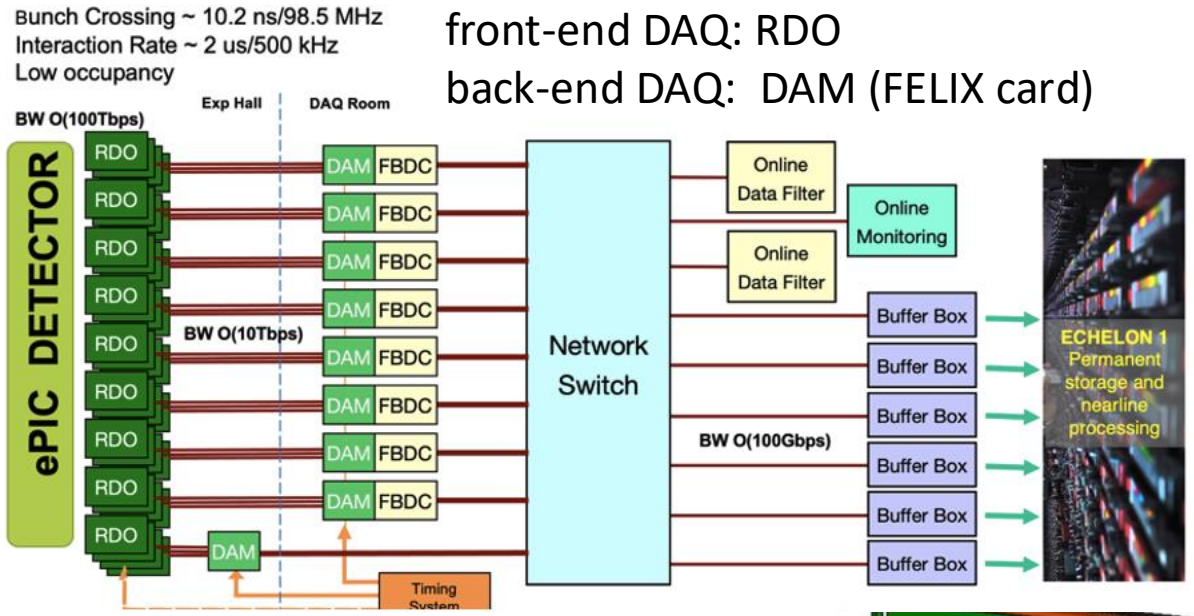
FELIX card and dRICH data reduction

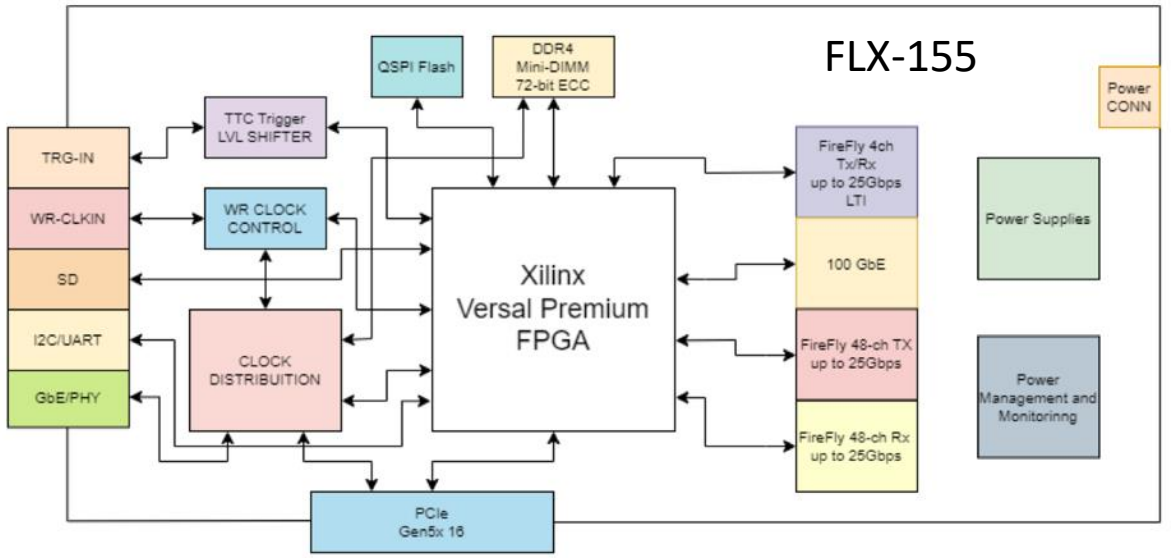
(+ Rome2: Roberto A)

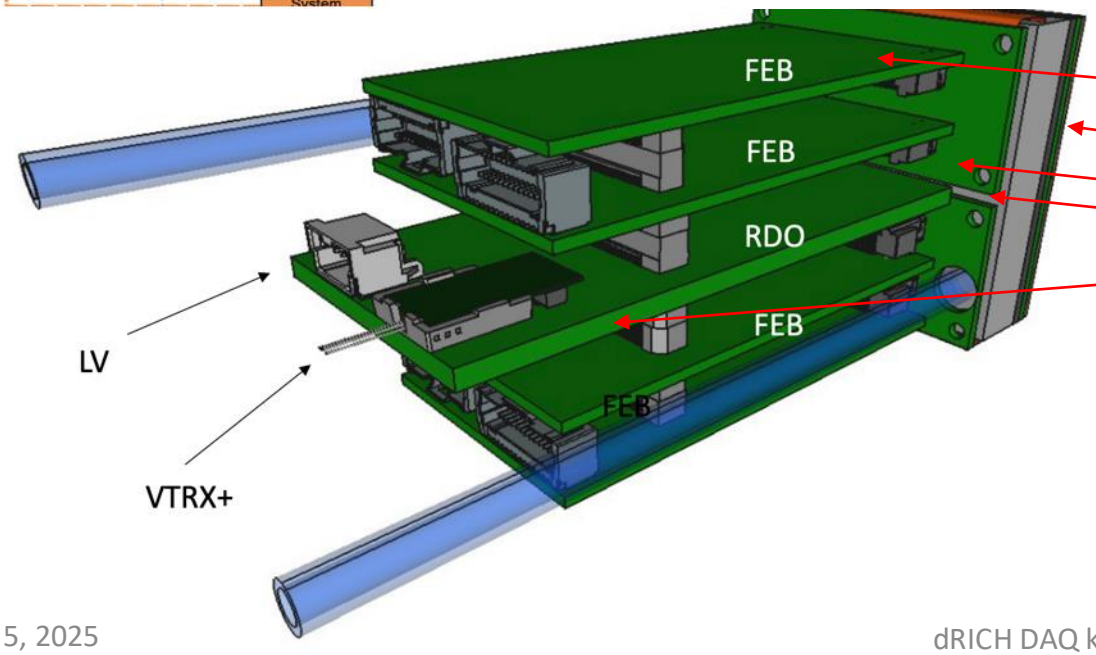
6/7 September

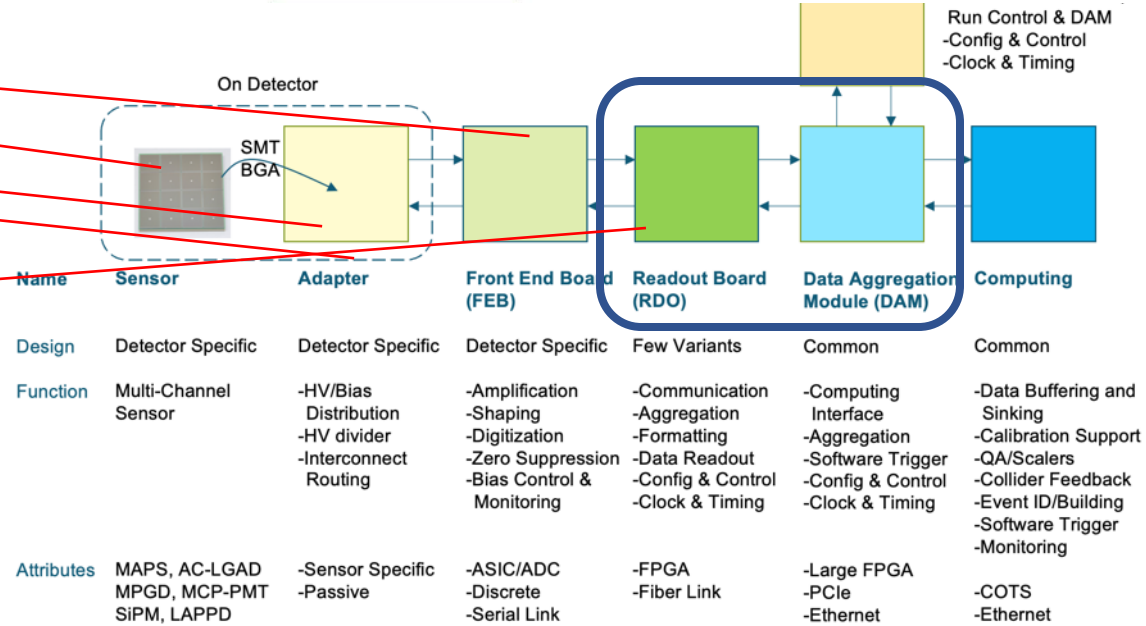
RDO/DAM role in ePIC and dRICH PDU

front-end DAQ: RDO
back-end DAQ: DAM (FELIX card)





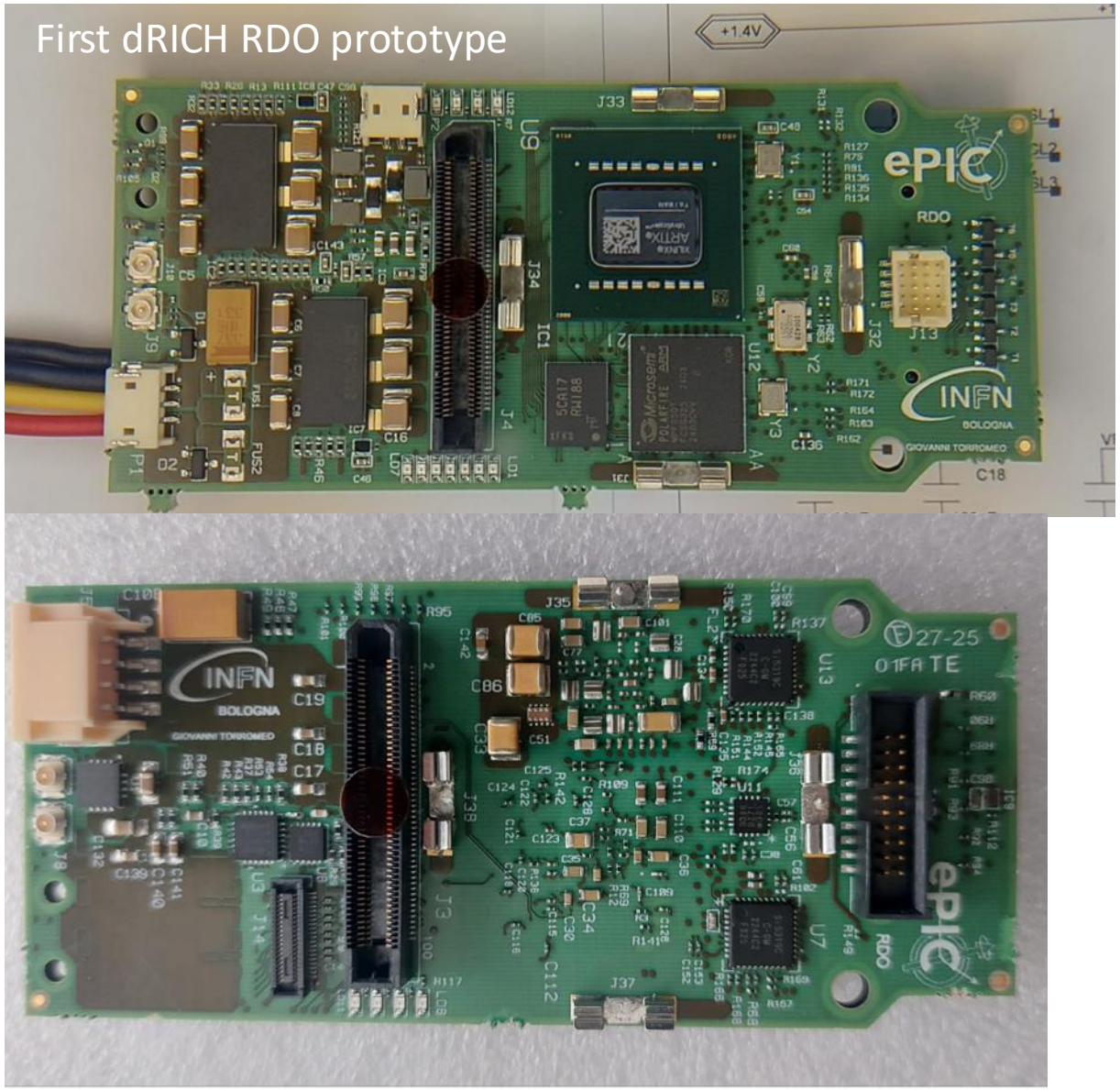




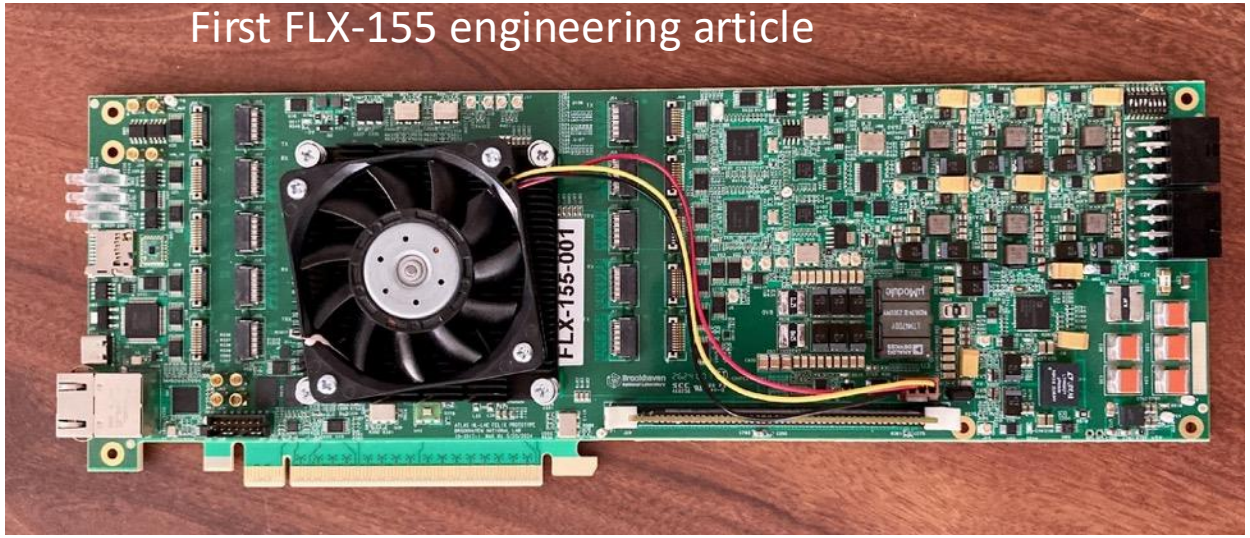
	Name	Sensor	Adapter	Front End Board (FEB)	Readout Board (RDO)	Data Aggregation Module (DAM)	Computing
Design		Detector Specific	Detector Specific	Detector Specific	Few Variants	Common	Common
Function		Multi-Channel Sensor	-HV/Bias Distribution -HV divider -Interconnect Routing	-Amplification -Shaping -Digitization -Zero Suppression -Bias Control & Monitoring	-Communication -Aggregation -Formatting -Data Readout -Config & Control -Clock & Timing	-Computing Interface -Aggregation -Software Trigger -Config & Control -Clock & Timing	-Data Buffering and Sinking -Calibration Support -QA/Scalers -Collider Feedback -Event ID/Building -Software Trigger -Monitoring
Attributes		MAPS, AC-LGAD MPGD, MCP-PMT SiPM, LAPPD	-Sensor Specific -Passive	-ASIC/ADC -Discrete -Serial Link	-FPGA -Fiber Link	-Large FPGA -PCIe -Ethernet	-COTS -Ethernet

RDOs and DAMs are getting real!

First dRICH RDO prototype



First FLX-155 engineering article



*Take home message

We finally understood that in US for mysterious reasons prototypes are called first engineering articles.

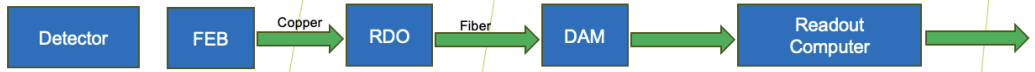
dRICH throughput is huge due to SiPM DCR

Summary of Channel Counts and Data Flow

Charge 1

Detector Group	Channels					Det Fiber Down	Det Fiber Up	RDO	Fiber Pair (DAQ)	DAM	Data Volume (RDO) (Gb/s)	Data Volume (To Tape) (Gb/s)
	MAPS	AC-LGAD	SiPM/PMT	MPGD	HRPPD/ MCP-PMT							
Tracking (MAPS)	16B					187	4976	323	323	7	15	15
Tracking (MPGD)				164k		640	2560	160	160	5	27	5
Calorimeters	500M		100k					522	522	17	70	17
PID (TOF)		6.1M				500	1364		1364	30	50	12
PID Cherenkov			318k		143k	1334	1334	1242	1334	33	1275	32
Far Forward		1.5M	10k					80	80	6	36	12
Far Backward	66M		3.4k					25	289	11	37	8
Lumi		128k	5.1k					41	41	4	264	8
Polarimetry	Independent Electronics, DAQ, & Controls from central detector but expected to build on same technologies											
TOTAL	**16.6B**	**7.7M**	**432k**	**164k**	**143k**	**2,661**	**10,234**	**2,393**	**4,113**	**113**	**1,774**	**109**

Summary of Data Flow



Aggregate	2.0 Tb/sec
Noise	1.6 Tb /sec
Signal from Physics + Background	400 Gb / sec

Aggregate	2.0 Tb/sec
Per RDO (Avg)	0.7 Gb/sec

Aggregate	115 Gb/sec
Collision Signal	62 Gb/sec
Synchrotron Rad	6 Gb/sec*
Electron Beam	4.5 Gb/sec
Hadron Beam	1.0 Gb/sec
Noise	41 Gb/sec

Scale of the system:

- **Electronics**
  - ~ 25 detector subsystems
  - ~ 5 Readout Technologies
  - ~ 2500 RDOs (on detector/in racks)
  - ~ 110 DAM boards (DAQ room)
  - GTU (with interface boards)
- **Maximum Data Volume**
  - ~ 2 Tb/sec digitized
  - ~ 115 Gb/sec recorded
- **Online Computing (Echelon 0)**
  - ~200 nodes (DAQ Room/SDCC)

* Synchrotron radiation caveats:

1. Rates are based upon hit rate for all ePIC detectors. In fact, data volumes depend upon specific detector hit (64 bits/hit assumed)
2. Highest Synchrotron radiation / electron beam gas will correspond to lower values for collision signal
3. Plan to analyze by component soon

how to approach dRICH throughput?

cool down the sensors → -40 C heal the damage → annealing optimize overvoltage and choice of the sensors	sensors
electronics gated: ALCOR shutter	electronics, clock distribution, RDO INFN-TO/INFN-BO
understand if the event is noise or signal → ML techniques on DAM	DAM INFN-RM
understand if the event is noise or signal with a dRICH interaction tagger → give a trigger to DAM	INFN-GE
get an external trigger from another sub-detector (Forw. HCAL?) → give a trigger to DAM	ePIC

Updated dRICH data trhoughput modeling (v2)

https://docs.google.com/spreadsheets/d/15elDcbKlyVyNN7K2lp0K7B3QMZzEk61vn69HfGunIyU/edit?usp=sharing

dRICH DAQ parameters	
RDO boards	1248
ALCOR64 x RDO	4
dRICH channels (total)	319488
Number of DAM	30
Input link in DAM	42
Output links from DAM to TP	1
Number of DAM Trigger Processor	1
Input link to DAM Trigger Processor	30
RDO-DAM Link Bandwidth (VTRX+) [Gb/s]	10
DAM to Echelon-0 Switch Bandwidth [Gb/s]	100
dRICH Interaction tagger reduction factor	5
Interaction tagger latency [s]	1,00E-04
EIC parameters	
EIC Clock [MHz]	98,522
Orbit efficiency (takes into account gap)	0,92

ALCOR parameters		Notes
Front end limit [kHz]	4000	
ALCOR Clock [MHz]	394,08	It will be 394.08 MHz or 295.55 MHz
Channels/serializer	8	
Bits per hit	64	2 32-bit words per hit (also TOT)
Bits per hit encoding 8/10	80	
Serializer band limit [Mb/s]	788,16	
Theoretical Serializer limit/ channel [kHz]	1231,5	this would be with 0 control words
Serializer limit single ch [kHz]	800	this is expected to improve with ALCOR v3
Number of serializer per chip	8	
Channel/chip	64	
Shutter width (ns)	10	(if you put 10 ns == no shutter)

dRICH data stream analysis		Limit	Comments
Sensor rate per channel [kHz]	300,00	4.000,00	
Rate post-shutter [kHz]	276,00	800,00	
Throughput to serializer [Mb/s]	172,50	788,16	
Throughput from ALCOR64 [Mb/s]	1.380,00		limit FPGA dependent: - check with RDO
Throughput from RDO [Gb/s]	5,39	10,00	based on VTRX+
Input at each DAM [Gbps]	226,41	420,00	
Buffering capacity at DAM [Mb]	23,18		to be checked but seems manageable
Output from each DAM [Gbps]	45,28	100,00	

Aggregated dRICH data throughput		Comments
Total input at DAM [Gb/s]	6.792,19	This is only "inside" DAM, not to be transferred on PCI
Total output from DAM [Gb/s] to Echelon	1.358,44	Reduction from interaction tagger (FPGA or det. based)

- need to refine it (data headers + CRC absent here..)
- payload of the protocol absent here… (GBT: every 64 bits data, we have 112 bits..)
- ”viewer” mode but you can make a copy and play….

Why a kick-off meeting?

- things are finally getting real
- within dRICH so far we worked (Bologna/Rome) almost in “isolation” with respect to frontend/backend DAQ
- need to know each other / build networking
- we had the willingness to do something together since some time but … without hardware and a protocol choice between RDO and DAM from ePIC DAQ was even difficult to plan something!

Aim of the meeting

- know each other a little bit better
- share status of the respective projects
- plan joint activities
- plan a minimum of organization

Note:

new mailing list:
epic-italia-drich-daq@lists.infn.it

subscribe here

Note:

ePIC relevant mailing lists (BNL): WG Thursday at 3:00 PM
https://lists.bnl.gov/mailman/admin/eic-projdet-daq-l

General info about ePIC DAQ

Description Join ZoomGov Meeting
https://bnl.zoomgov.com/j/1618397692?pwd=Rm9zMmJxa1NNakpiMmN3K012ZndJUT09

Meeting ID: 161 839 7692
Passcode: 462040
One tap mobile
+16692545252,,1618397692#,,,,*462040# US (San Jose)
+16468287666,,1618397692#,,,,*462040# US (New York)

Dial by your location
+1 669 254 5252 US (San Jose)
+1 646 828 7666 US (New York)
+1 551 285 1373 US
+1 669 216 1590 US (San Jose)
Meeting ID: 161 839 7692
Passcode: 462040
Find your local number: https://bnl.zoomgov.com/u/alHADfMo1

Join by SIP
1618397692@sip.zoomgov.com

Join by H.323
161.199.138.10 (US West)
161.199.136.10 (US East)
Meeting ID: 161 839 7692
Passcode: 462040

Wiki :

DAQ - EIC Project Detector Collaboration (bnl.gov)

Mailing list :

https://lists.bnl.gov/mailman/listinfo/eic-projdet-daq-l

https://lists.bnl.gov/mailman/admin/eic-projdet-daq-l

eic-projdet-daq-l@lists.bnl.gov

Mattermost : join det1-daq channel

https://eic.cloud.mattermost.com/signup_user_complete/?id=i8gnmob4stdrpjfrezhegxs3ew

Digitization table link

https://docs.google.com/spreadsheets/d/1s8oXj36Sqlh7TJeHFH89gQ_ayU1_SVEpWQNkx6sETKs/edit?usp=sharing

Project information link

https://wiki.bnl.gov/EPIC/index.php?title=Project_Information

Cables and service spreadsheets subdetectors

in the Indico pages of Electronics & DAQ WG meetings there are several useful links

Go for example here to then access these links:
https://indico.bnl.gov/event/27013/

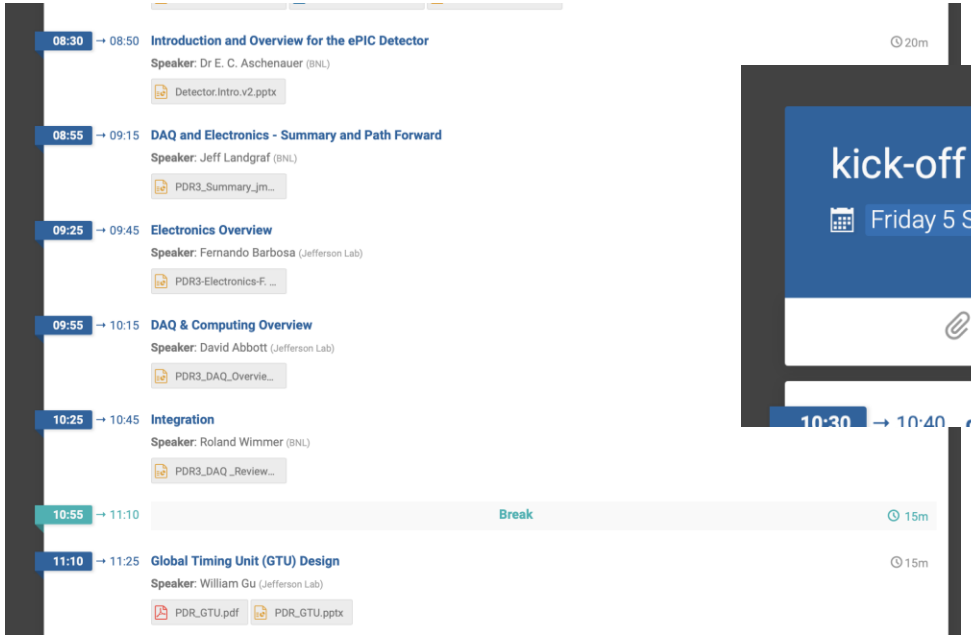
Background info

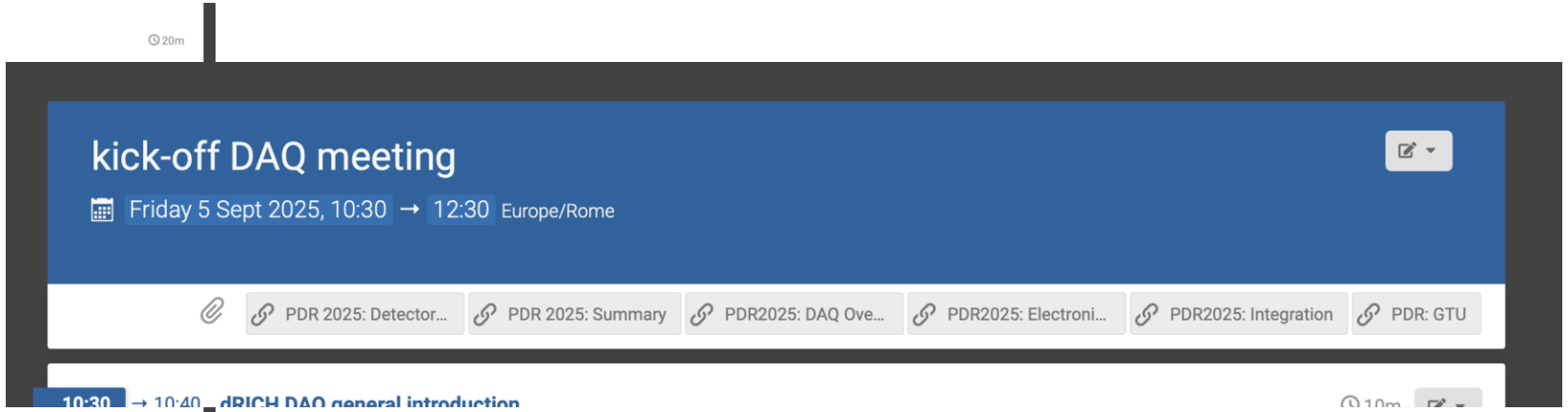
- P. Antonioli, Electronics and DAQ PDR, 3-4 September 2025
- P. Antonioli/A. Lonardo, meeting with INFN referees, July 2025
- A. Lonardo, talk at ePIC Itala meeting June 2025
- P. Antonioli, talk at ePIC Italia meeting June 2025
- A. Lonardo, talk at ePIC Collaboration meeting, January 2025
- L. Pontisso, talk at ePIC Collaboration meeting, July 2024
- D. Falchieri, talk at ePIC Collaboration meeting, July 2024
- dRICH Interaction tagger workfest + summary, ePIC Collaboration meeting July 2024

only “somehow overview” talks here about dRICH DAQ
ePIC Italia Indico:
ePIC Collaboration Indico:

I will add all the links!

Inside the general material of this meeting we posted several general talks given 3-4 September at Electronics & DAQ PDR





Today's agenda