On evolution of the ePIC MPGD readout architecture

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A report to MPGD-DSC
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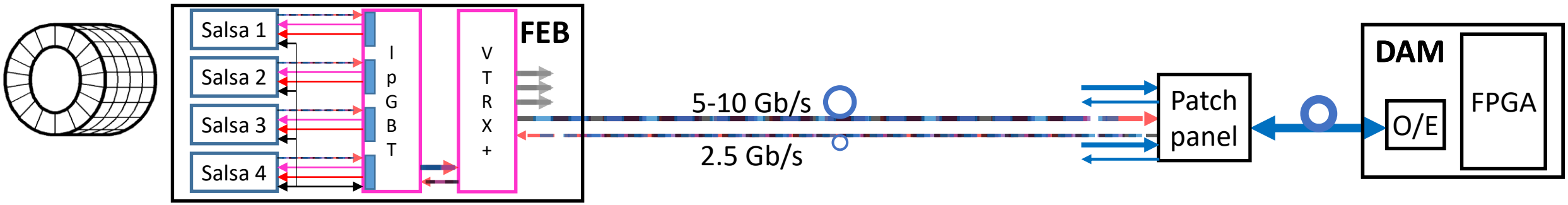
MPGD readout architecture considered as the baseline

On-detector

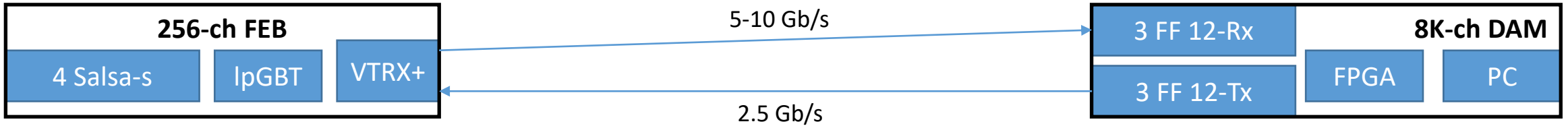
Low restriction area



- Direct FEB-DAM connection avoiding intermediate RDO stage
  - → Downstream : clock, synchronous run-control commands, async slow control and monitoring requests
  - → Upstream : physics and calibration data, slow control and monitoring responses

- Reminder
  - → Merits briefly introduced during eDAQ weekly on 17 October 2024
    https://indico.bnl.gov/event/25106/contributions/97861/attachments/57983/99568/241017_IM_lpGbt2Salsa.pdf
  - → Presented as baseline at collaboration meeting in Frascati, January 2025
    https://agenda.infn.it/event/43344/contributions/253075/attachments/130667/194487/250124_IM_MpgdRo_Update.pdf
  - → Presented again during eDAQ weekly on 18 September 2025
    https://indico.bnl.gov/event/29858/contributions/113751/attachments/64847/111404/250918_IM_MpgdRo.pdf

176K-ch MPGD readout component count



- Operational quantities

	CyMBaL	µRWell-BOT	µRWell-ECT	Total
Channels	36K	96K	32K	**176K**
Salsa	576	1 536	512	**2 624**
FEB	144	384	128	**656**
DAM	4	12	4	**20**

- Production quantities
  - Including prototyping, test-bench and quality assurance needs

→ 4 000 Salsa-s

→ 725 FEBs
  - 725 VTRX+
  - 725 lpGBT

} A common pool of spare components expected

→ 25 DAMs
  - 75 12-Rx and 12-Tx FireFly modules

Excerpt from September 18, 2025 presentation

Excerpt from September 18, 2025 presentation : Summary

- Reminder : RDO subsystem is complex and has non negligible size
  - → O(100) RDO boards to be housed, powered, cooled, controlled and monitored
  - → Effort to develop, validate, produce, install and commission
    - Hardware, firmware, software
  - → A group to be identified responsible for RDO subsystem

- Pros and cons of presented *(FEB-DAM)* architecture
  - → Pros : Avoids RDO complexity and related effort
    - Inline with several other subsystems – developments can be shared
  - → Cons : increases number of DAMs
    - Basically doubles
      - 1.5 increase with higher channel count DAMs : Fully populated with FireFly components
    - GTU has to accommodate the extra DAMs

- Are there strong arguments for not to adopting this *(FEB-DAM)* architecture for MPGDs ?

Meeting on “details of the ePIC RDOs“ held on April 23, 2026

- “including the ASIC choices, costs, and aggregation estimates, and locations”
- Called by eDAQ WG conveners as a replacement to an ordinary weekly meeting

- A SharePoint Excel file « RDO sources » has been made available
  → MPGD related information

System	Detector	Channels	Generic RDO based on Kintex UltraScale+ FPGA device	Location
MPGD Tracking	Electron Endcap	16384	6	S. Platform
	Hadron Endcap	16384	6	S. Platform
	Inner Barrel	36864	12	S. Platform
	Outer Barrel (Cymbal)	98304	32	S. Platform

- According to the meeting conveners, as a response to my question, the MPGD readout architecture with direct FEB – DAM connections has not been retained !

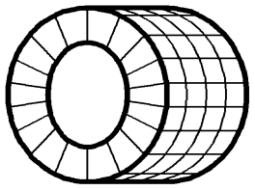
- With the suggested FEB-RDO-DAM architecture the MPGD groups require
  → 52 RDOs each capable of aggregating data from 12 FEBs
  → ~5 DAMs with aggregation capability of 48K MPGD channels per DAM

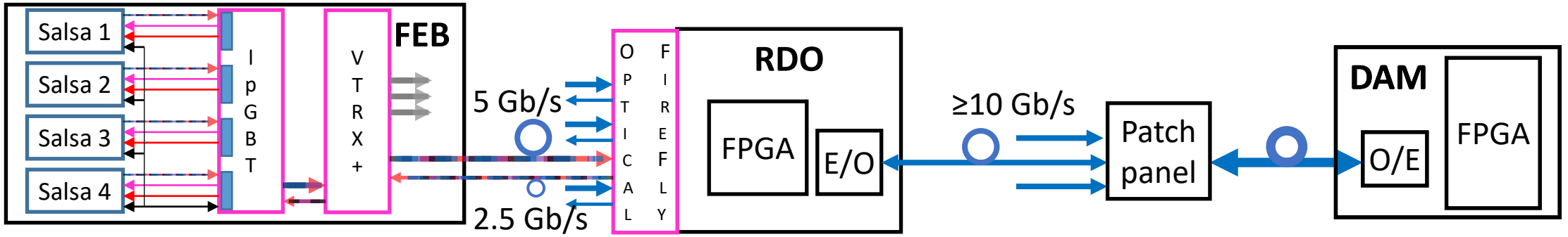
MPGD readout architecture with intermediate RDO stage

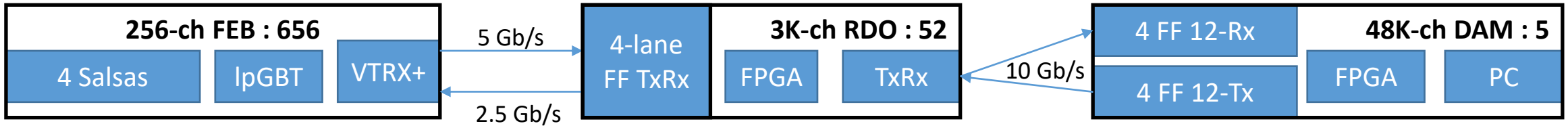
Low restriction area

Low restriction area

On-detector







Intermediate RDOs system to design, debug, produce install, commission and maintain

- Expectation to reuse “Generic RDO” design

Generic RDO

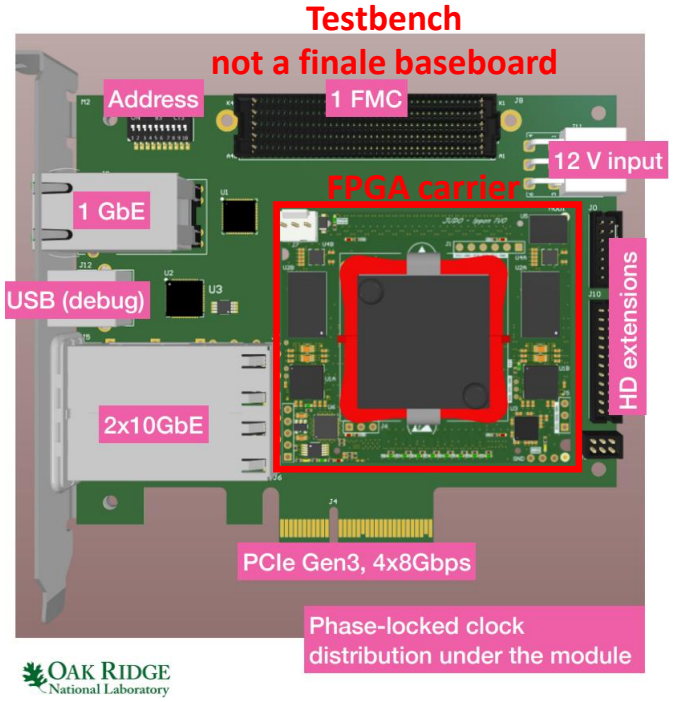
- Under development for calorimeters
- To be used by SVT
- Based on an FPGA-carrier mezzanine board and a baseboard

  https://indico.bnl.gov/event/30635/contributions/116848/attachments/66355/113872/20251120PED_Request.pdf

  https://indico.bnl.gov/event/25107/contributions/97959/attachments/58098/99790/003%20-%20Concept.pd

- FPGA-carrier board : same design may welcome 2 types of pin-compatible FPGA devices
  - → Artix UltraScale+ : expected data aggregation ability of 4
  - → Kintex UltraScale+ : expected data aggregation ability of 12
    - Assumed for MPGDs
  - → In-house development

- Baseboard
  - → Probably needs some per subsystem adaption
  - → In-house development



Arguments in favor of RDO-based architecture

- Home-made FPGA carrier is advantageous compared to readily available commercial boards
  - → For improved long term maintenance and maybe required functionality
    - My opinion : I doubt we can be better than industry in general purpose developments including maintainability
- RDO baseboard can be common for several sub-detectors
  - → Including MPGDs
    - My opinion : probably yes, but some adaptation effort may be needed
- RDO firmware development adds low overhead compared to the efforts needed for development of corresponding parts in the DAM firmware
  - → Almost the same functionality to control FEBs and aggregate their data whether by RDO or by DAM
    - My opinion : I doubt the same MPGD HR can work on FEB-RDO and RDO-DAM connectivity simultaneously
    - Caution : There is not only firmware but also software, slow control, power, cooling, extra cabling
- Adding RDO stage can be financially advantageous
  - → Because this decreases number of DAMs
    - My opinion : I doubt that addition of extra DAMs will outweigh the design, debugging, producing, installation, commissioning and maintenance of a 52-board RDO sub-system
    - Caution 1 : if ratio of 12 FEBs per RDO won't be possible, the number of RDOs may go up to 208
    - Caution 2 : if aggregation of 48K channels per DAM cannot be possible, the number of DAMs has to be increased

Summary

- To be fair, the MPGD groups need to estimate the impact of the background radiation
  - → This is important for FEB design
    - Number of active Salsa TX links and required lpGBT devices to be verified
  - → This is important to determine the number of RDO and/or DAM units

- It seems that RDO-based readout is imposed on the MPGD
- Excerpt from to my mail to eDAQ conveners on September 17, 2025 :
  - → “If this *(RDO)* approach has to be pursued, we need to identify a group responsible for this *(RDO)* subsystem – it requires a considerable effort.”
  - → “We will also need to ponder the financial weight of it – the hardware cost and the support of human resources.”
  - → “Currently at Saclay we do not have the personnel to dedicate for this task.”
  - → “Can we understand if there is a strong argument against the architecture with the direct FEB-DAM connections?”

- The lack of support for the direct FEB-DAM communications for MPGD readout might have been more effectively addressed through prior discussions with the MPGD community
  - → Rather than being discovered unexpectedly during a replacement session of the weekly eDAQ meeting
  - → Going forward, it would be great to keep closer coordination on such points

Given the current conditions

- Make sure that the MPGD needs in lpGBT components are indeed taken into account
  → The eDAQ WG conveners are not 100% sure on this point

- A group responsible for MPGD RDO sub-system needs to be identified

- A new MPGD DAQ representative needs to be appointed
  → Meanwhile I will remain available in an interim capacity