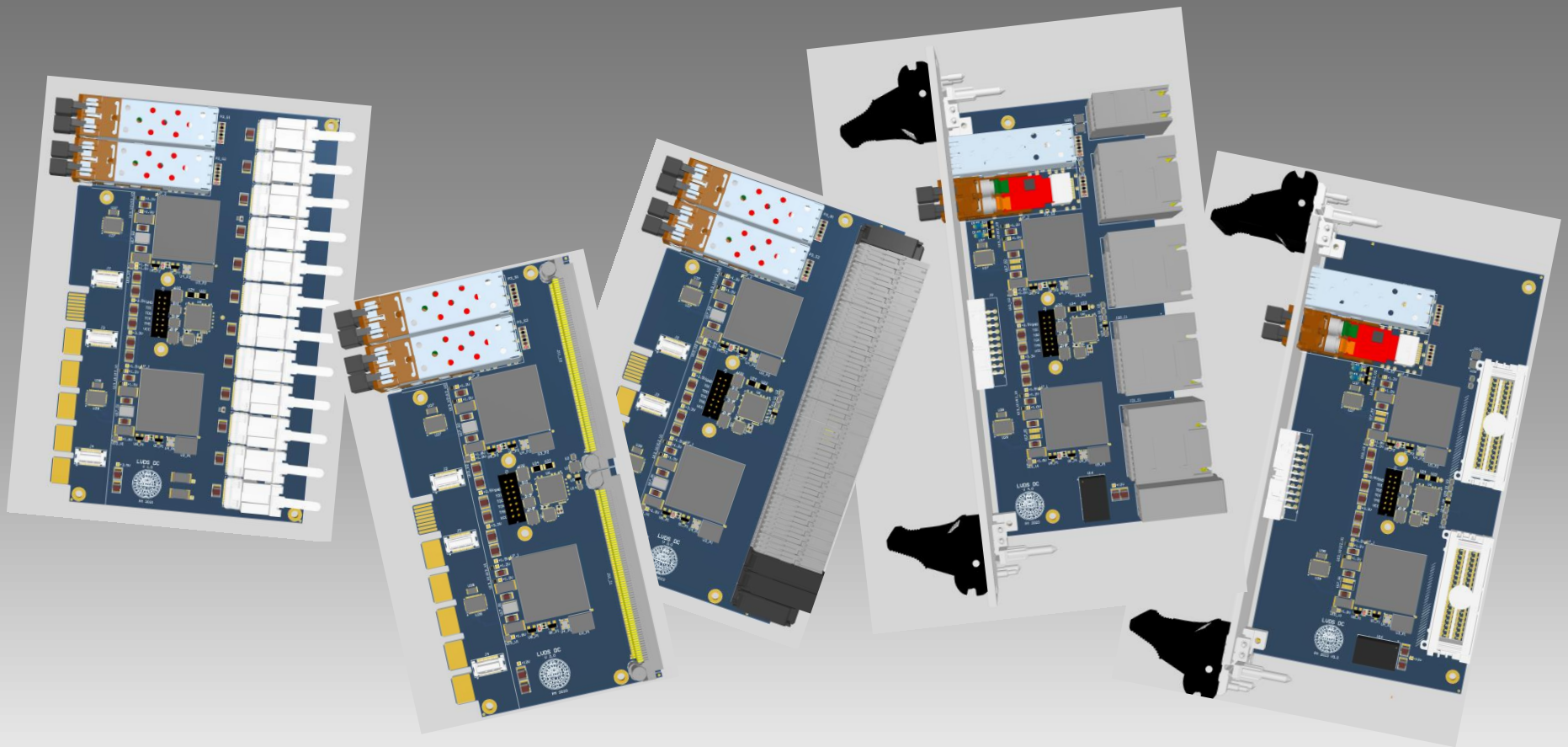
A development work on the LVDS Data Concentrator



Short presentation and application

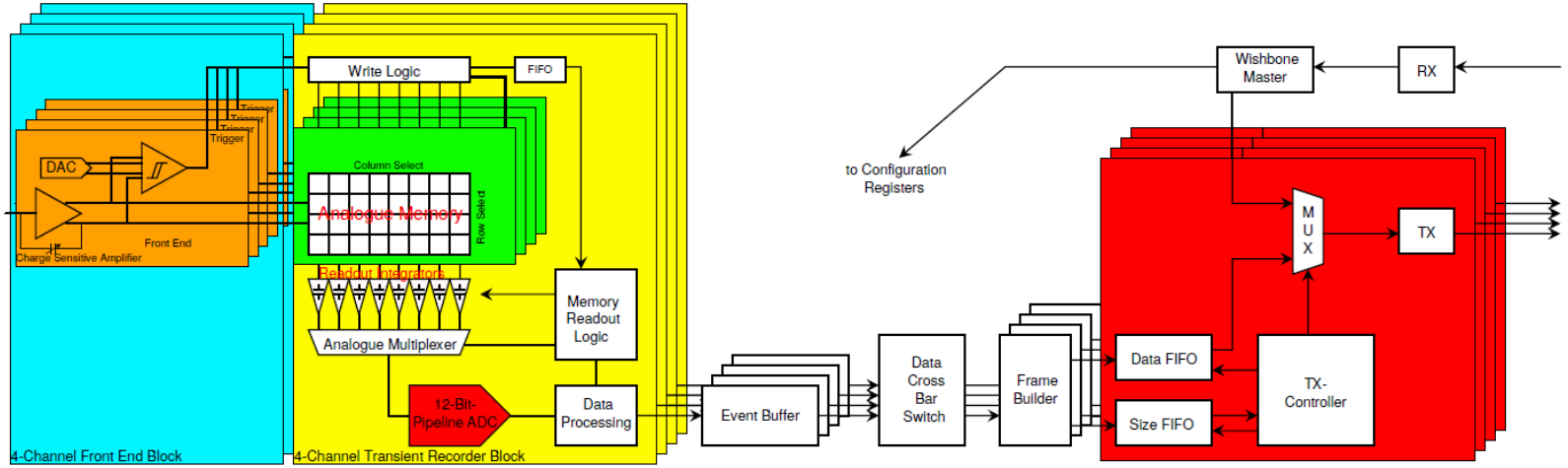
Readout interface using LVDS

- A broad interest arouse in utilizing LVDS lines for transporting data between front-end electronics and data collection systems
- LVDS are electrical signals and do not need any expensive and power consuming conversion to/from optical media
- The achievable data rate over LVDS is lower compared to optical, but is sufficient in many (majority) of applications

Application 1
EMC Barrel

- ~12000 crystals
- Each crystal is read-out by 2 APDs with 2 different gain channels each
- A CTR serving 4 crystals communicates over 4 LVDS lines
- -> a need for 12000 LVDS (digital) I/O for the readout.
- The signals are planned (?) to be transported via Samtech FireFly (ECUE-08)
- Data rate? Coding?

Below a schematic of a EMC Barrel readout ASIC (by Holger Flemming)



CTR16

Short presentation and application

Application 2
Luminosity Monitor

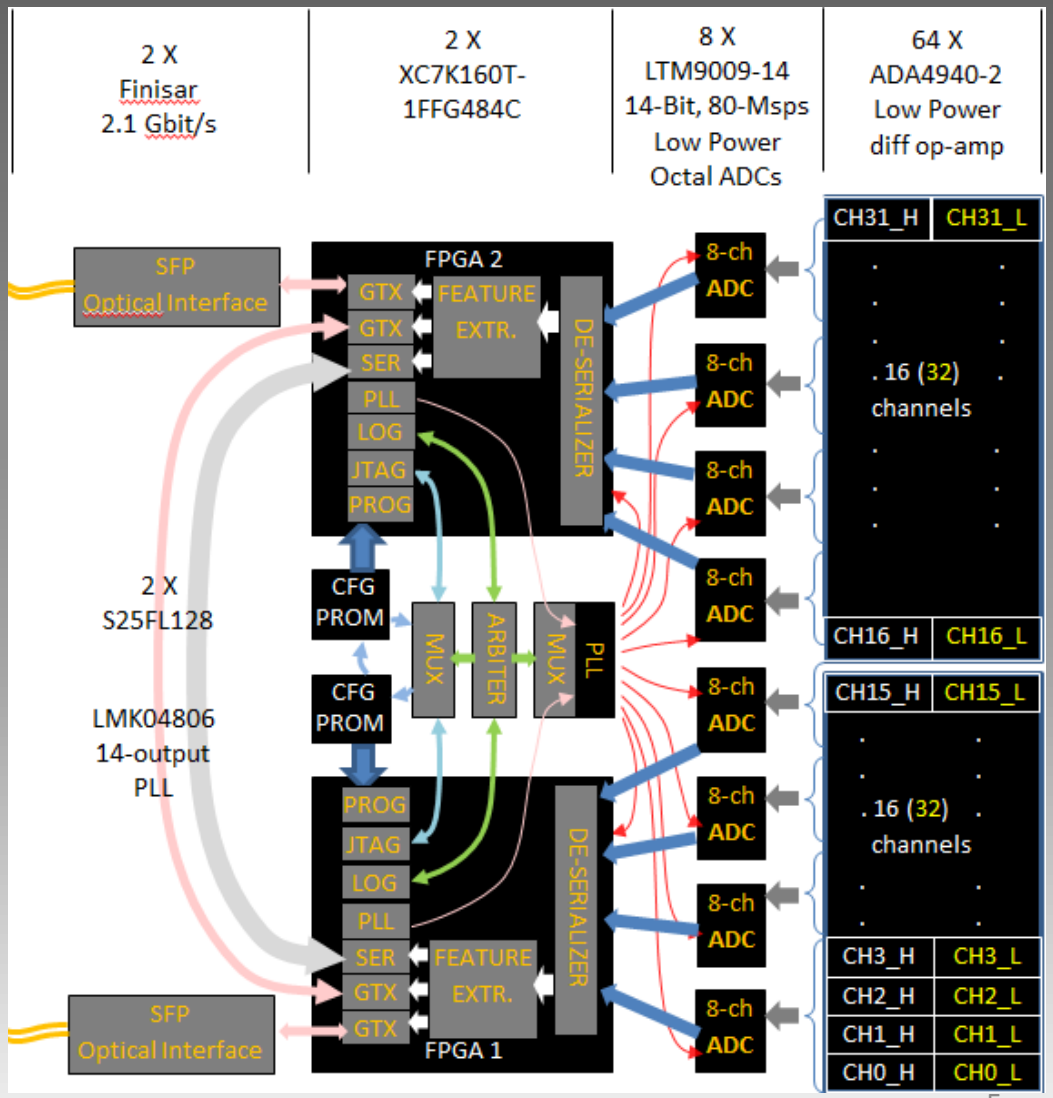
- ~2500 channels
- The signals are planned to be transported via some twisted pair cables (?)
- Data rate? (~800 Mbit/s)
- Coding? (8B/10B)
- Preliminary tests shown positive outcome (Florian Feldbauer)

Application 3
Crystal Barrel (?)

Application 4
Other systems (?)

PANDA SADC

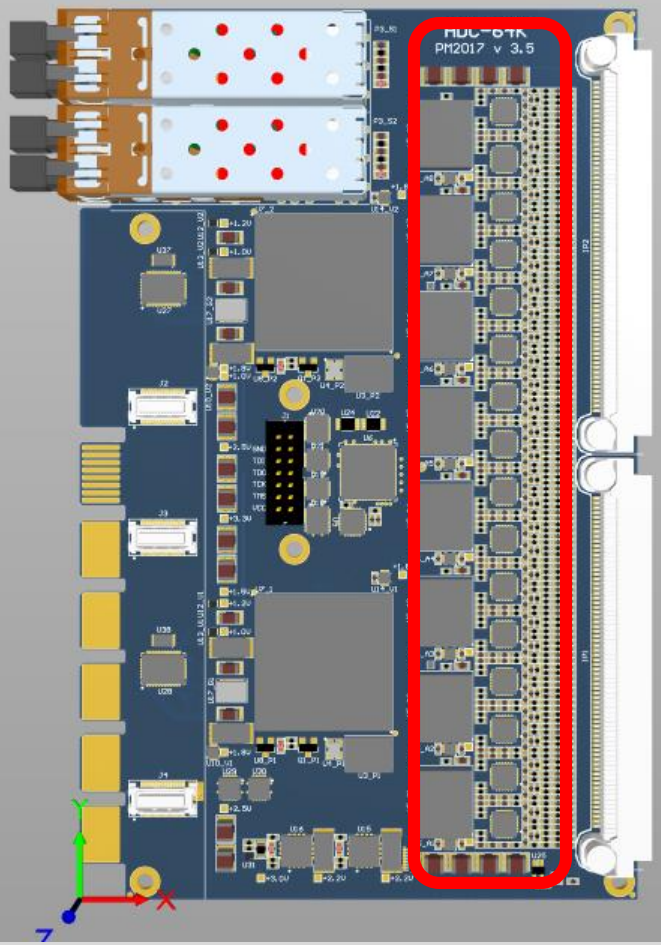
The development is based on the PANDA SADC



LVDS DC

PANDA SADC

The development is based on the PANDA SADC

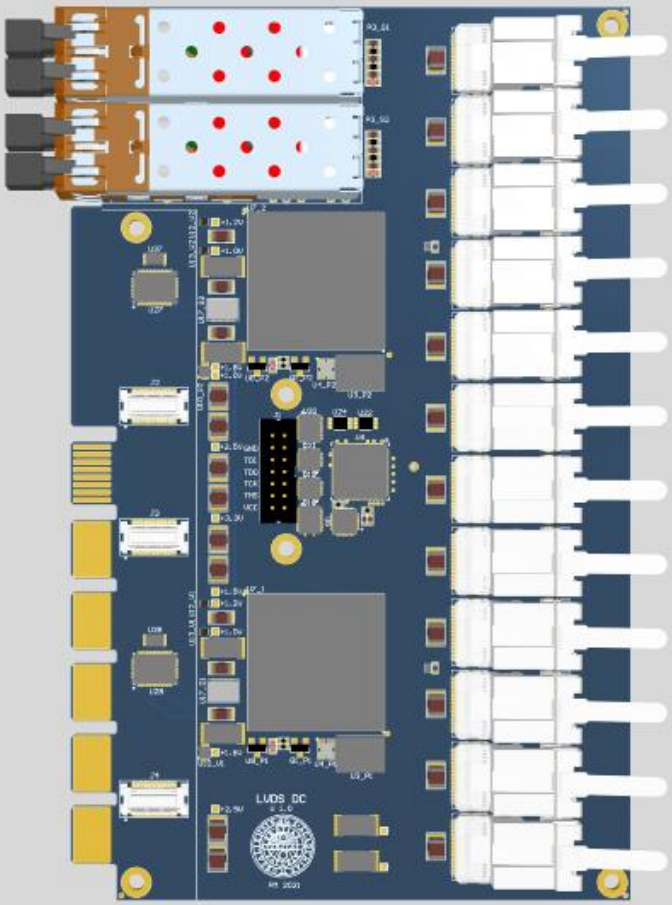


- The A/D converter part is removed.
- The LVDS data lines are used for direct coupling to incoming digital signals
- 144 LVDS lines

LVDS DC

A FireFly variant

A single module with on-board FireFly transceivers



- In the first version we use Samtec FireFly modules.
- It could be:
  optical (ECUO) or
  electrical (ECUE)
- The design is **complete**, manufactured and positively tested.
  (Florian)

A FireFly variant

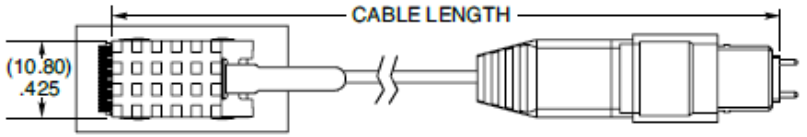
FIREFLY™

28 Gbps

OPTICAL MICRO FLYOVER SYSTEM™

ECUO	-	WIDTH	-	DATA RATE	-	CABLE LENGTH	-	0	-	HEAT SINK	-	1	-	FIBER TYPE	-	END 2 OPTIONS
		–B04 = 4 Tx + 4 Rx **–T12** = 12 Tx **–R12** = 12 Rx **–Y12** = 12 Tx + 12 Rx **–U12** = 12 Channel AOC (Unidirectional)		**–14** = 14 Gbps per lane **–16** = 16.1 Gbps per lane (N/A –B04) **–25** = 25.7 Gbps per lane **–28** = 28.1 Gbps per lane (–B04 only)		**–"XXX"** = Overall Length in Centimeters				**–1** = Flat **–2** = Pin-fin (–14 & –16 only) **–3** = Flat with groove **–4** = PCIe® Pin-fin (–14 & –16 only) **–5** = 1.75 cm tall Pin-fin (–B04 only)				**–4** = Aqua loose tube with boot **–5** = Jacketed ribbon with boot **–6** = Jacketed ribbon **–7** = Black loose tube with boot **–8** = Black loose tube		(Leave blank for -U12) -Y12 requires -2X end option **12 Fibers** –01 = MTP® Male –02 = MTP® Female –07 = MXC® Internal Plug* –0E = MPO Plus®, Male, bayonet **24 Fibers** –21 = MTP® Male –22 = MTP® Female –27 = MXC® Internal Plug* –2E = MPO Plus®, Male, bayonet

ECUO
Mates with:
UEC5, UCC8, OPA



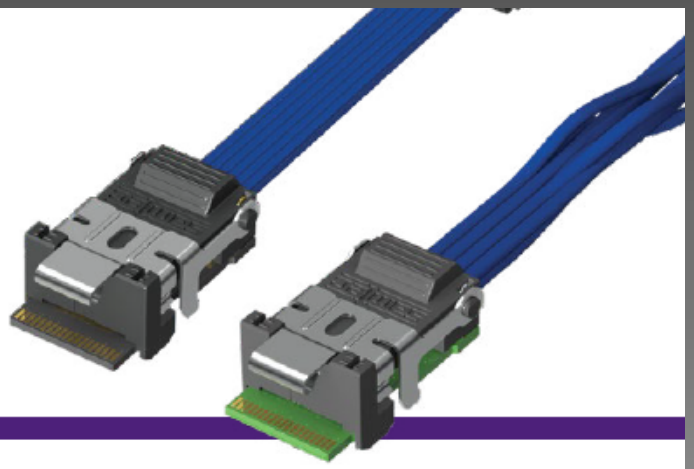
A FireFly variant

FIREFLY™

COPPER MICRO FLYOVER SYSTEM™

28 Gbps

ECUE/PCUE SERIES

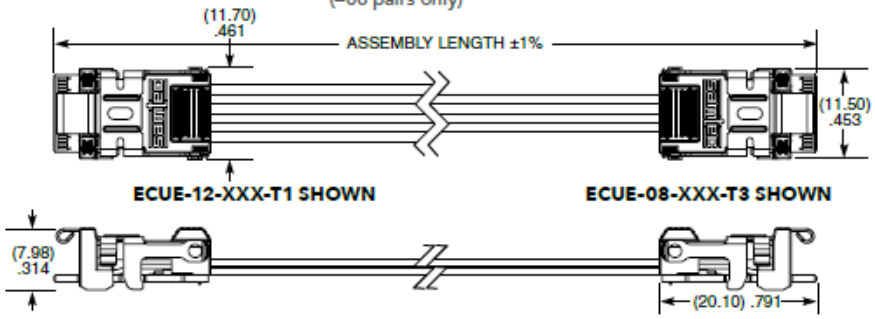


ECUE
Mates:
UEC5, UCC8

SPECIFICATIONS

Cable:
36 AWG twinax cable
34 AWG twinax cable
34 AWG ultra low skew twinax cable
Signal Routing:
100 Ω Differential
Bend Radius:
(3.18 mm) .125"

SERIES	NO OF PAIRS	ASSEMBLY LENGTH	CABLE TYPE	END 2 OPTION	WIRING OPTION	DATA RATE	OPTION
ECUE = Rugged FireFly™ Cable Assembly	**–08** = Eight Pair (– T2 & –T3 cable only) **–12** = Twelve Pair (–T1 cable only)	**–"XXX"** = Assembly Length in Centimeters (007 cm to 999 cm)	**–T1** = 36 AWG twinax (–12 pairs only) **–T2** = 34 AWG twinax (–08 pairs only) **–T3** = 34 AWG ultra low skew twinax (–08 pairs only)	**–FF** = FireFly™ (Mates with UEC5/UCC8)	**–01** = Pin A1 to Pin A19 **–02** = Pin A1 to Pin B1 **–B4** = Pin A1 to Pin B19 (–08 pair only)	**–1** = 14 Gbps (–T1 or –T2 only) **–2** = 28 Gbps (–T3 only)	Leave blank for standard FireFly™ **–D1** = Decoupling Capacitors (only available with –02 & –B4 wire options)



Notes:
All FireFly™ designs, specifications and components are subject to change without notice.

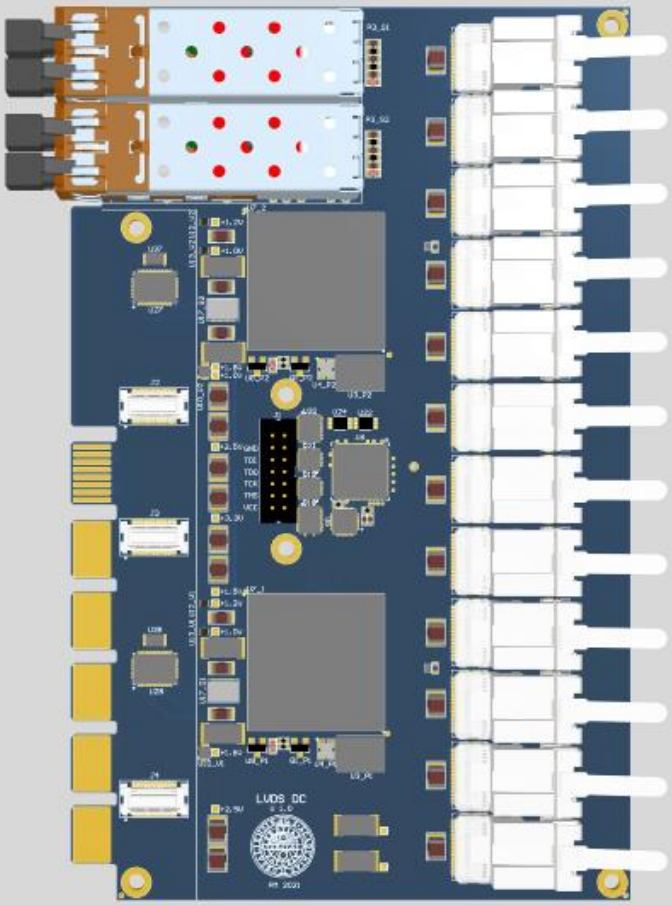
Cable lengths longer than 150 cm (59.06") are not supported with S.I. test data.

View complete specifications at: samtec.com?ECUE

LVDS DC

A FireFly variant

A single module with on-board FireFly transceivers

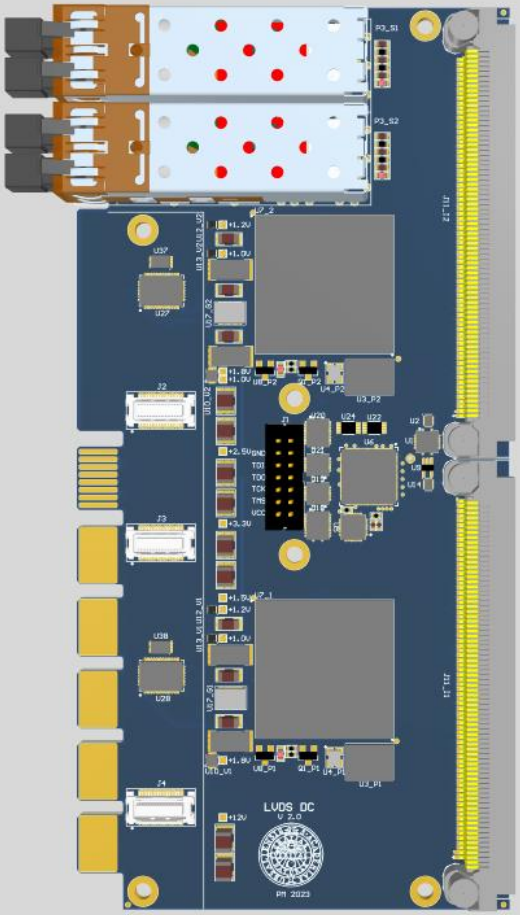


- FireFly modules are extremely fiddly to insert or remove. One can easily damage a module mechanically.
- The front becomes back – the module is inserted with the edge connector toward the back plane of a crate.
- Hardly service-able system

LVDS DC

An EdgeRate variant

A module prepared for back-to-back FireFly interfacing over a back-plane



- The idea is to split the design into a processing module inserted from the front of a crate and signals to be inserted from the back of the crate.
- The signals should connect to the processing module over a backplane's feed-through.
- The module uses EdgeRate connectors, the same type as on SADC, but slightly more pins (140 -> 150).

An EdgeRate variant

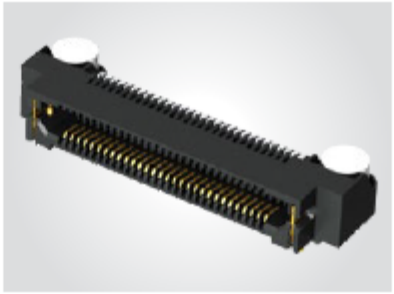
EDGE RATE SYSTEM

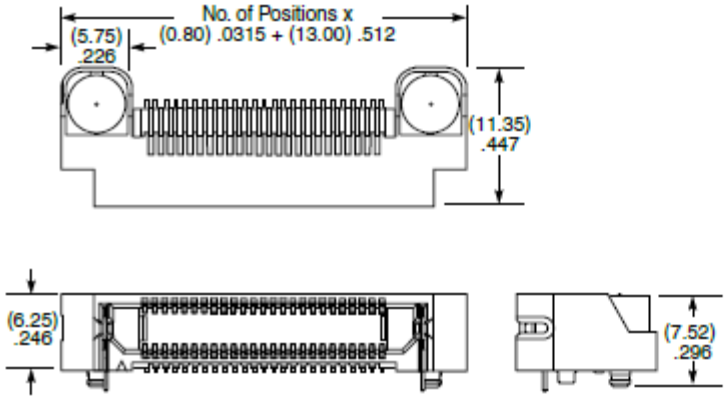
NRZ 28 Gbps

(0.80 mm) .0315" PITCH • RIGHT-ANGLE & EDGE MOUNT HIGH-SPEED SOCKETS

ERF8	-	POSITIONS PER ROW	-	01	-	PLATING OPTION	-	D	-	RA	-	OPTIONS	-	"X"R
Right-Angle Socket		–010, –013, –020, –025, –030, –040, –049, –050, –060, –070, –075				–L = 10 µ" (0.25 µm) Gold on contact area, Matte Tin on tail						–L = Latching (N/A with -EGP Option) –EGP = Extended Guide Post (N/A with –L Option)		–TR = Tape & Reel –FR = Full Reel Tape & Reel (must order maximum quantity per reel; contact Samtec for quantity breaks)

ERF8-RA
Board Mates:
ERM8
Cable Mates:
ERCD, ERDP

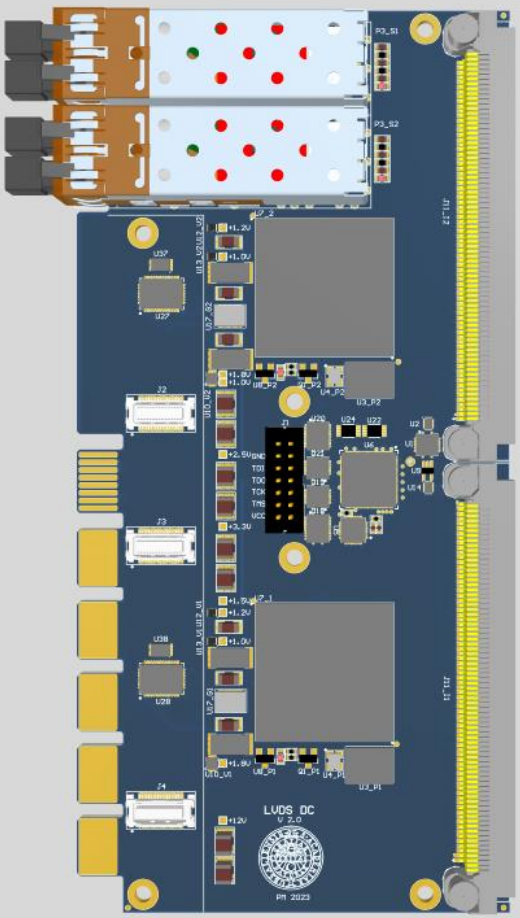




LVDS DC

An EdgeRate variant

A module prepared for back-to-back FireFly interfacing over a back-plane

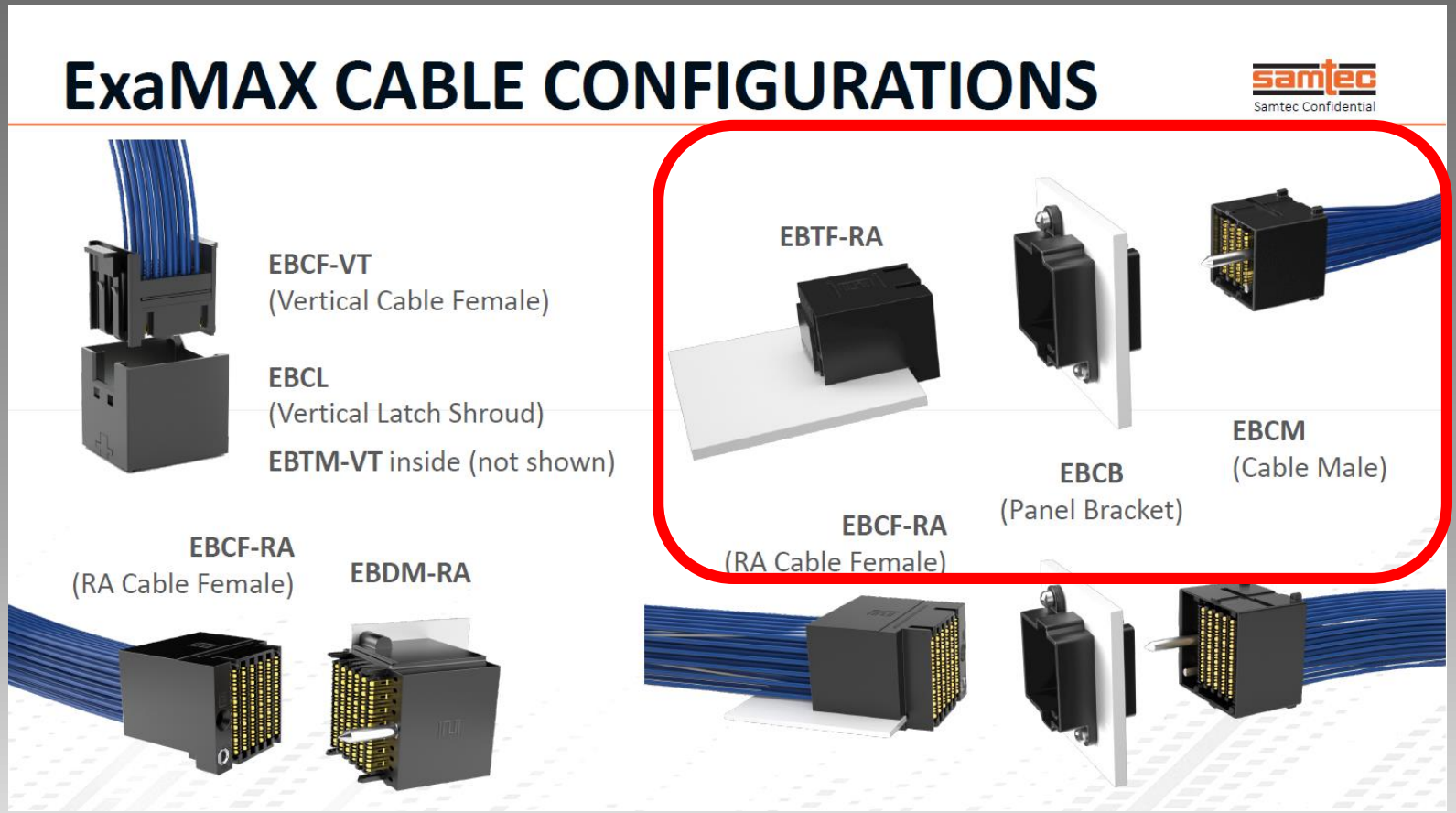


- EdgeRate 0.8 mm pitch connectors offer 300 pins. **288** are used for data.
  There is only **12** pins left for power and control. Too little...
- No guard separation between signals may lead to cross-talk – reducing data rate.
- The design is ready, however it's currently powered either from the front connector or by a dedicated mezzanine PS module. This could be subsitituted with a miniature **uModule** PS from TI and only use +12V as input.

An ExaMAX variant

ExaMAX connector system

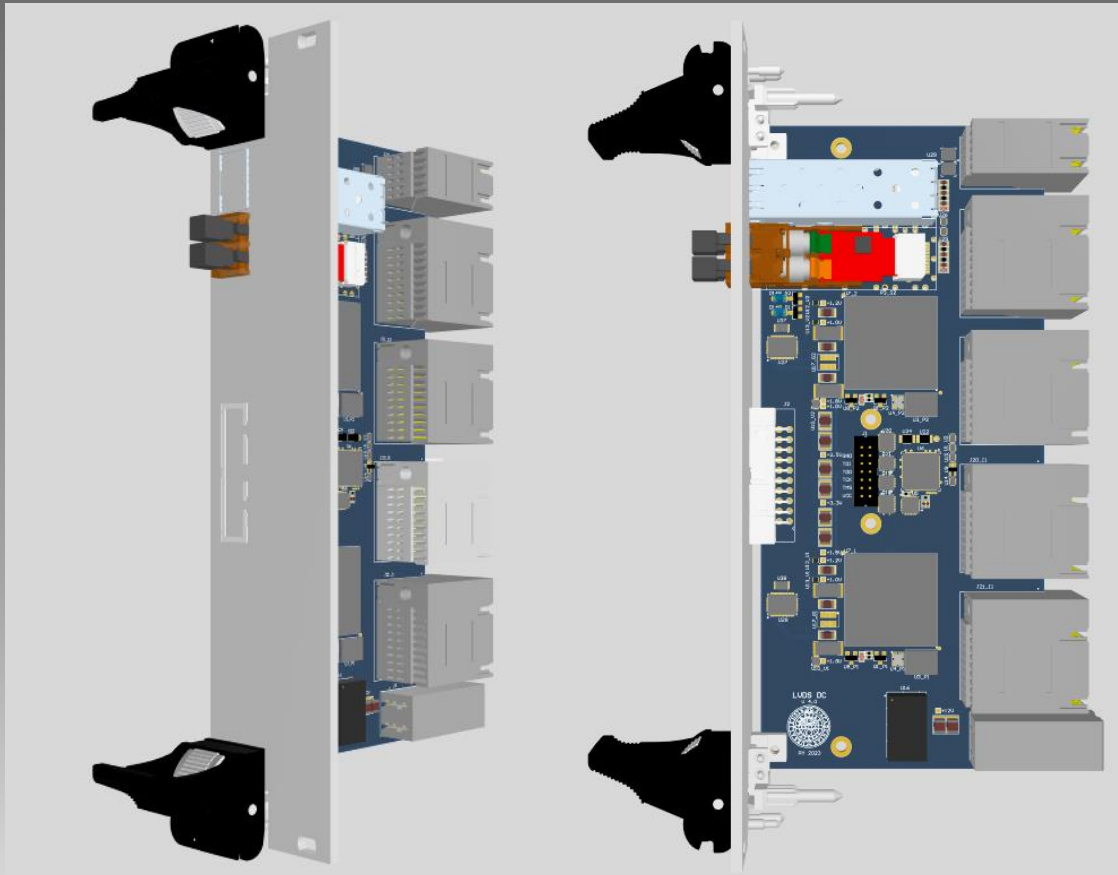
- ExaMAX connectors offer a direct cable connection without a feed-through



LVDS DC

An ExaMAX variant

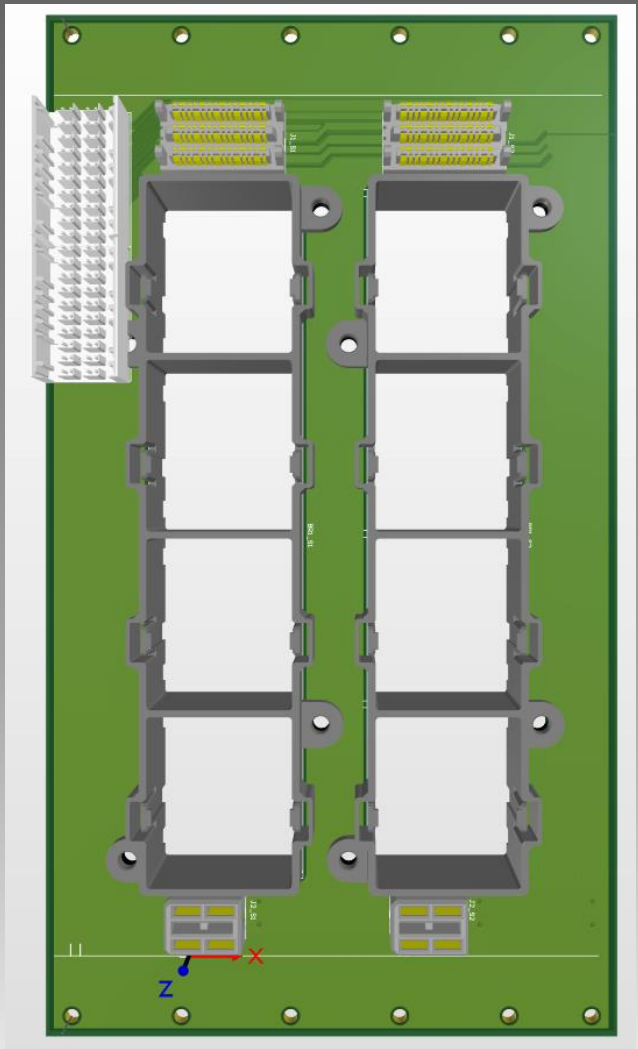
A module prepared for direct LVDS cable mating through a back-plane opening



- The module is **fully designed** and is powered by a uModule from +12V delivered from the back-plane.
- A monitoring system with +3.3V reference is distributed over the back-plane
- A number of control signals, JTAG programming and utility pins is available on a connector to be mated to the back-plane
- **Signal inputs are ESD protected**
- The module will fit in a customized Schroff mechanics
- The module is **8HP** (double width)

An ExaMAX variant

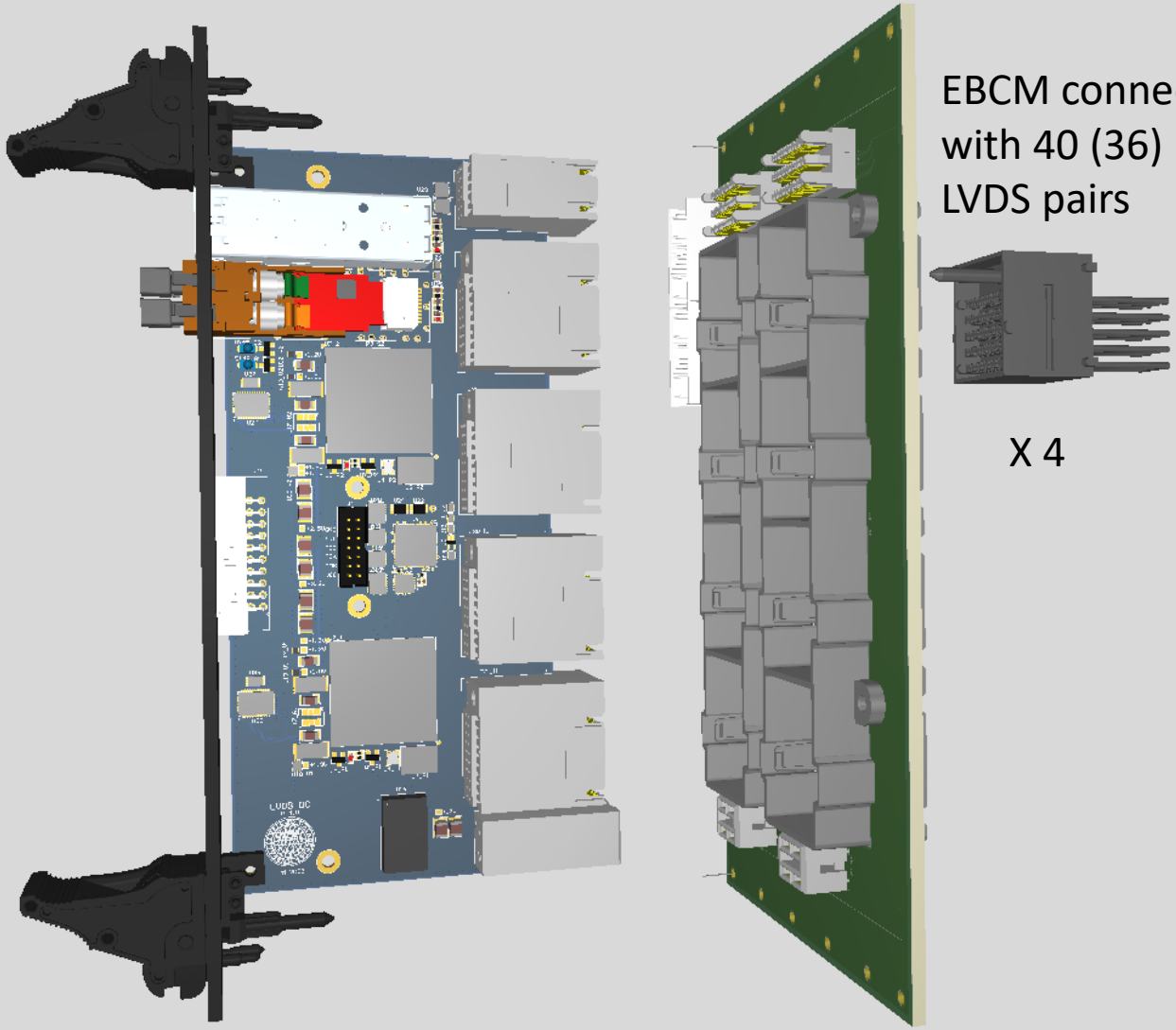
A two-slot back-plane



- A **10-slot** Back-Plane is **fully designed.** It will be presented later
- Here is a **2-slot** back-plane model for checking mechanical conditions.
- LVDS-DC slots are equiped with brackets. These hold cable connectors in place.
- On the left-hand side there is a slot for a Crate Controller. It will provide a possibility for configuration and control of the LVDS-DC modules in the crate. The Crate Controller will be **4HP** (standard width)

An ExaMAX variant

A module prepared for direct LVDS cable mating through a back-plane opening

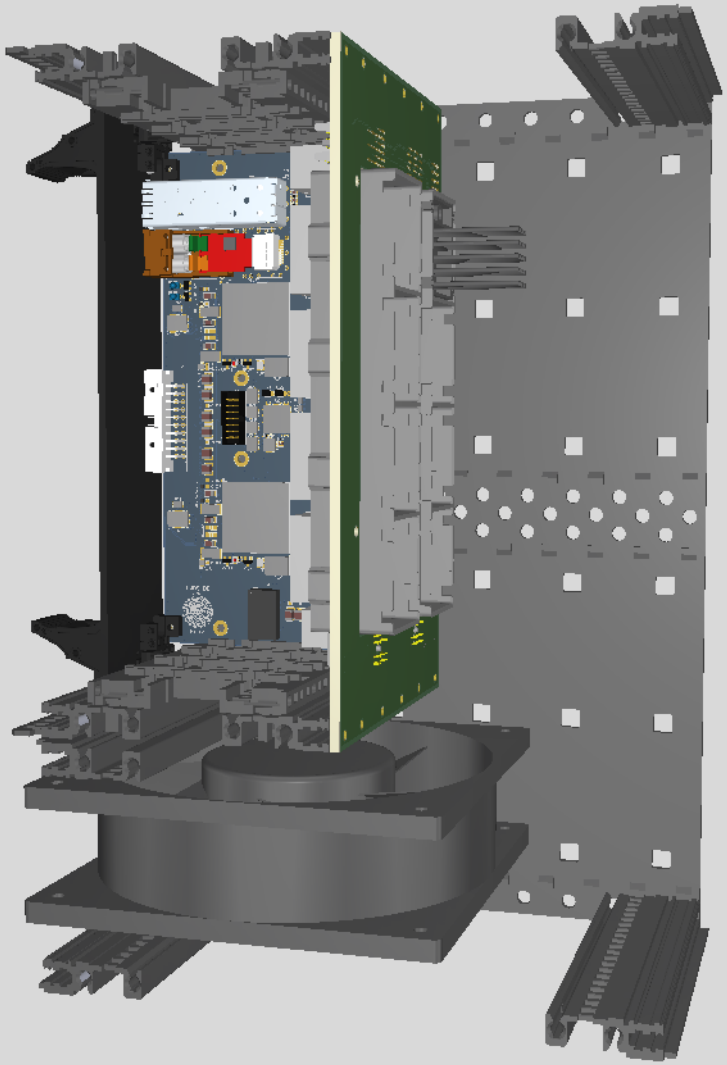


- A 4-row 10 column EBCM connector can provide up to 40 LVDS pairs. Since our system is somewhat ECUE-12 oriented, we skip one column and only use 36 LVDS pais per connector.

LVDS DC

An ExaMAX variant

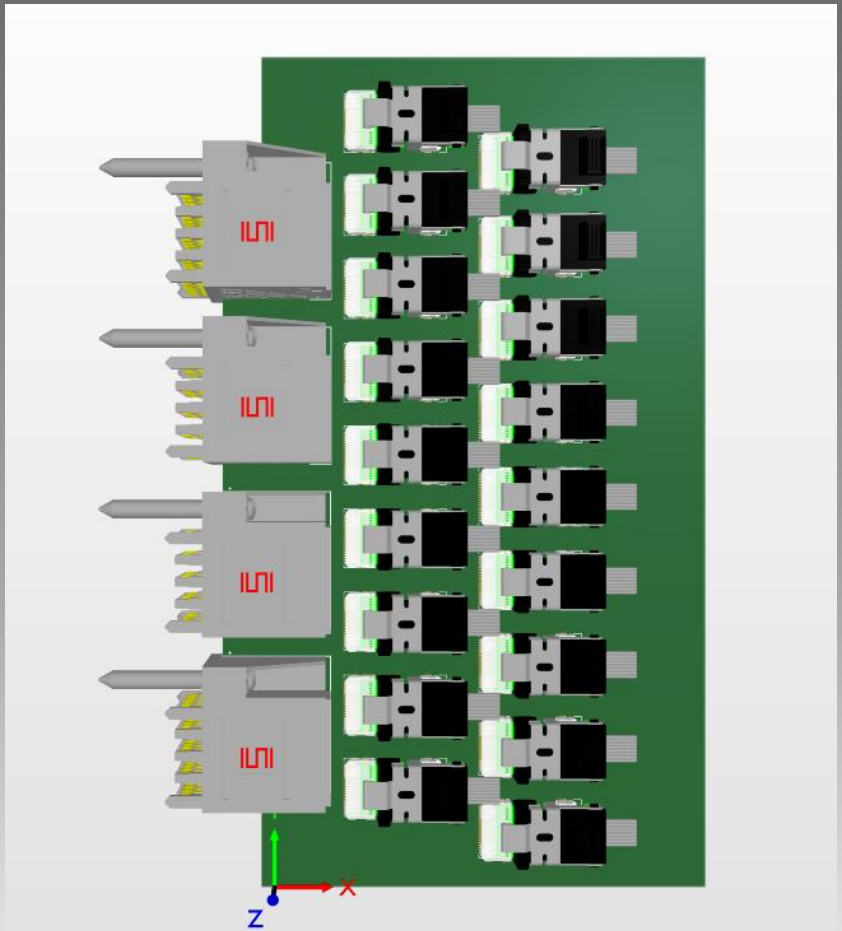
Crate assembly for direct signal cable mating



- The mechanics of the crate mostly uses standard of the shelf components. The overall height is 6U.
- The module is 160 mm high, which is not standard
- The sides of the crate need drilling of a few extra holes to fit horizontal bars.
- Module front panels will need cutting from standard 6U and drilling/milling of one of the edges to fit handles/module extractors

An ExaMAX variant

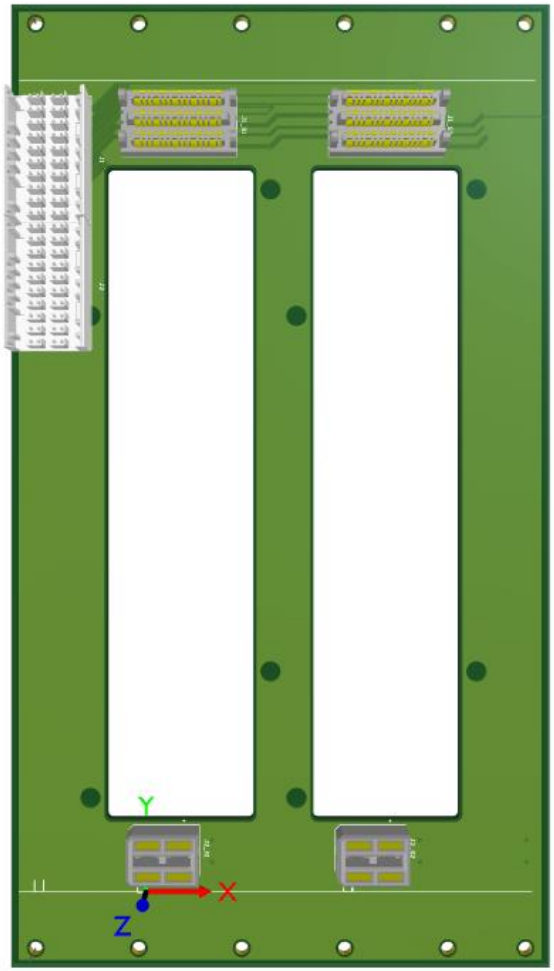
A FireFly option for the ExaMAX system

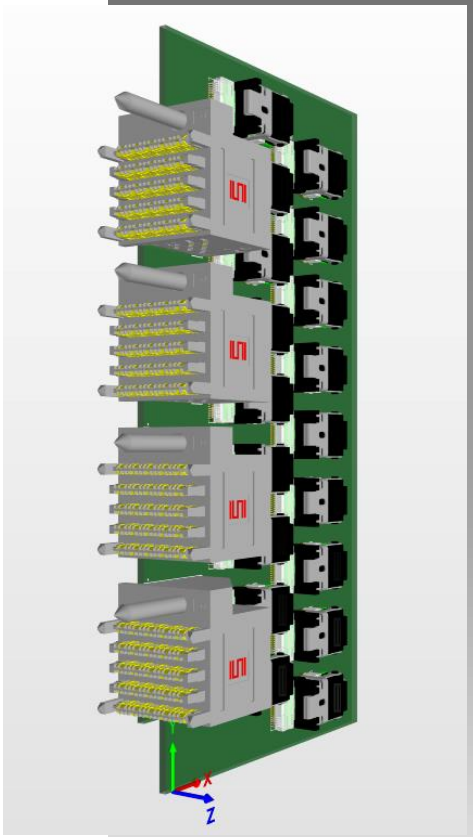


- A FireFly ECUE-08 carrier board for the rear side of a crate. This is only a **mockup** with well-positioned connectors. A real design is **pending.** It's though a relatively simple design with passive interconnections.
- Using ECUE-12 would be more space saving. Most probably one can order cable sets with 3 ECUE-08 on one end and 2 ECUE-12 on the other. The carrier will only have one column with 12 ECUE-12.
- Samtec seems to be very flexible. They offer making custom cables with ECUE on one side and ExaMAX on the other.

An ExaMAX variant

A FireFly option for the ExaMAX system



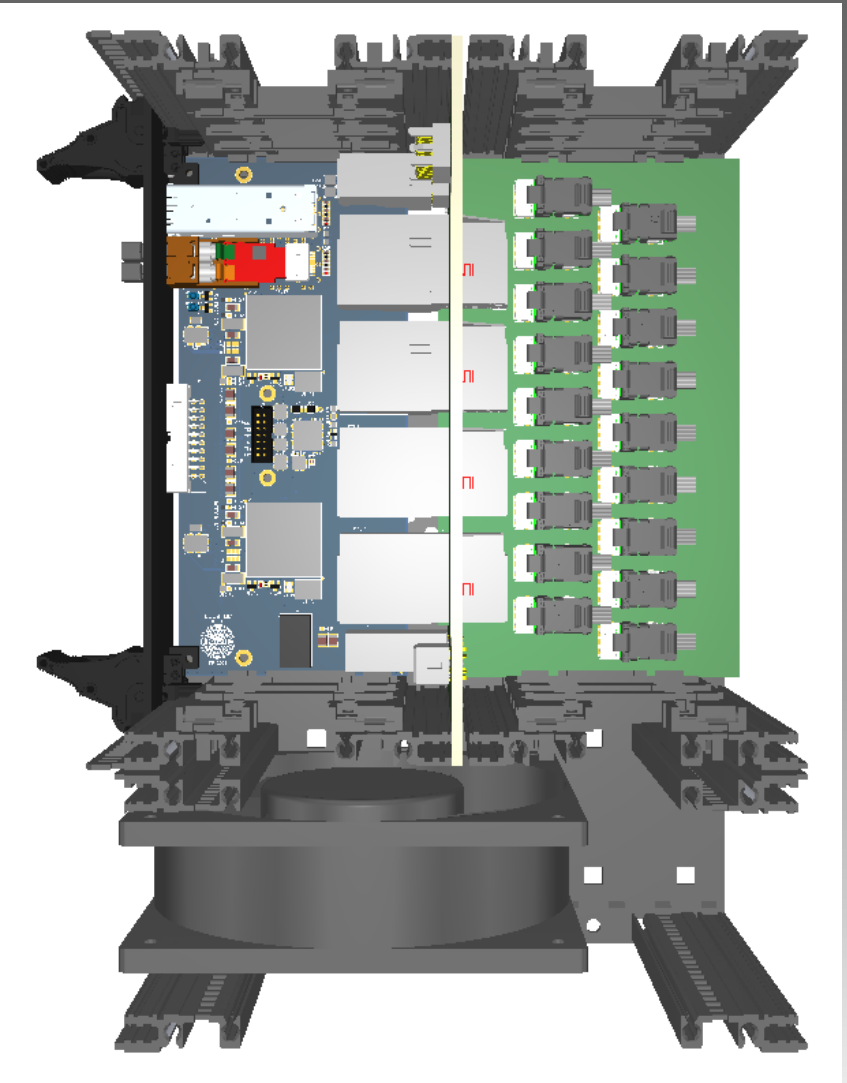


- A Back-Plane for ECUE doesn't need brackets.
- ECUE carrier board needs a back plate for fixing it when mated by the LVDS-DC module

LVDS DC

An ExaMAX variant

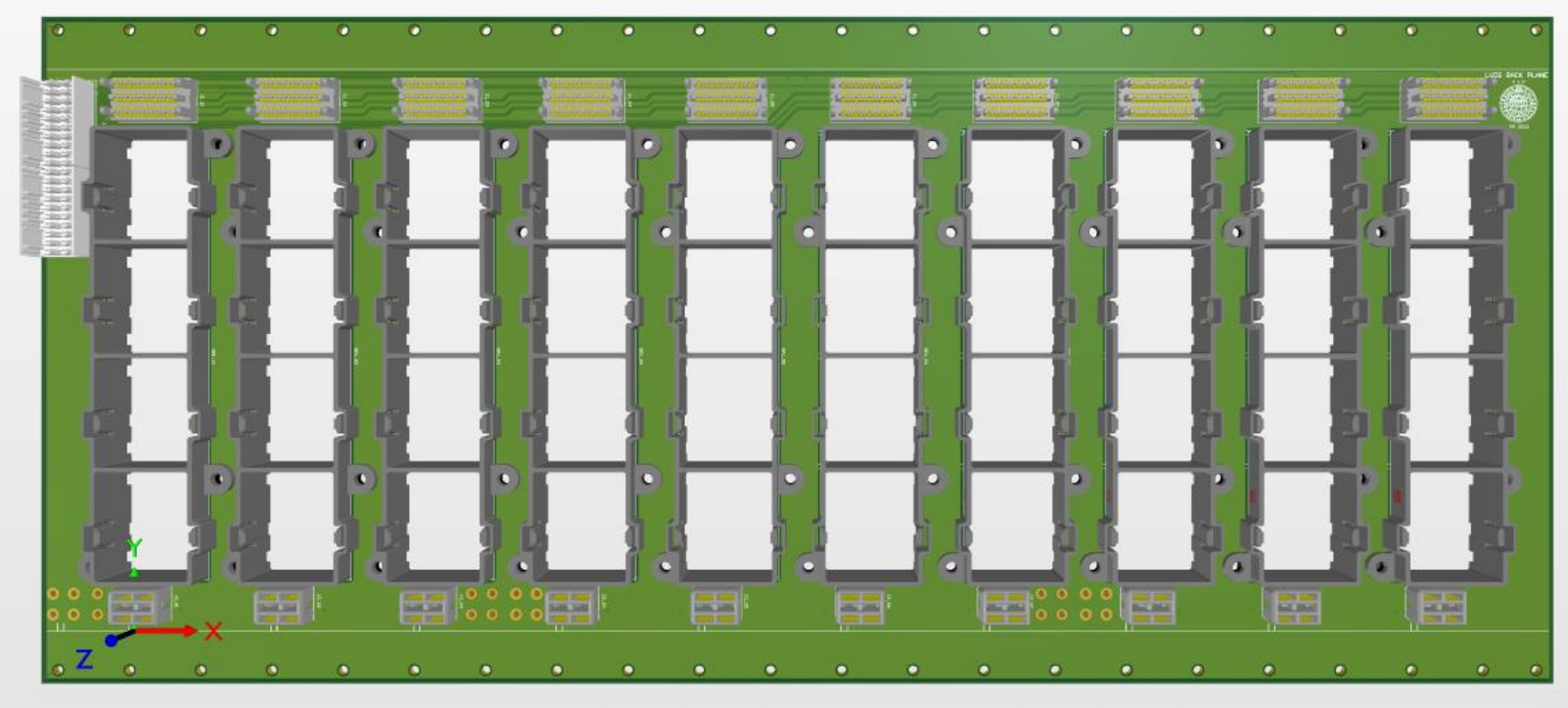
A FireFly option for the ExaMAX system



- The crate's rear compartment has rails for stable insertion of the FireFly carrier boards.
- The fan is 90 mm. The smaller fans, the more noisy.
- It seems that the rear compartment of the crate will need to be increased to fit power supplies below.
- The air-flow opening from below electronics is somewhat narrow...

An ExaMAX variant

10-slot backplane for a 84HP (19”) crate

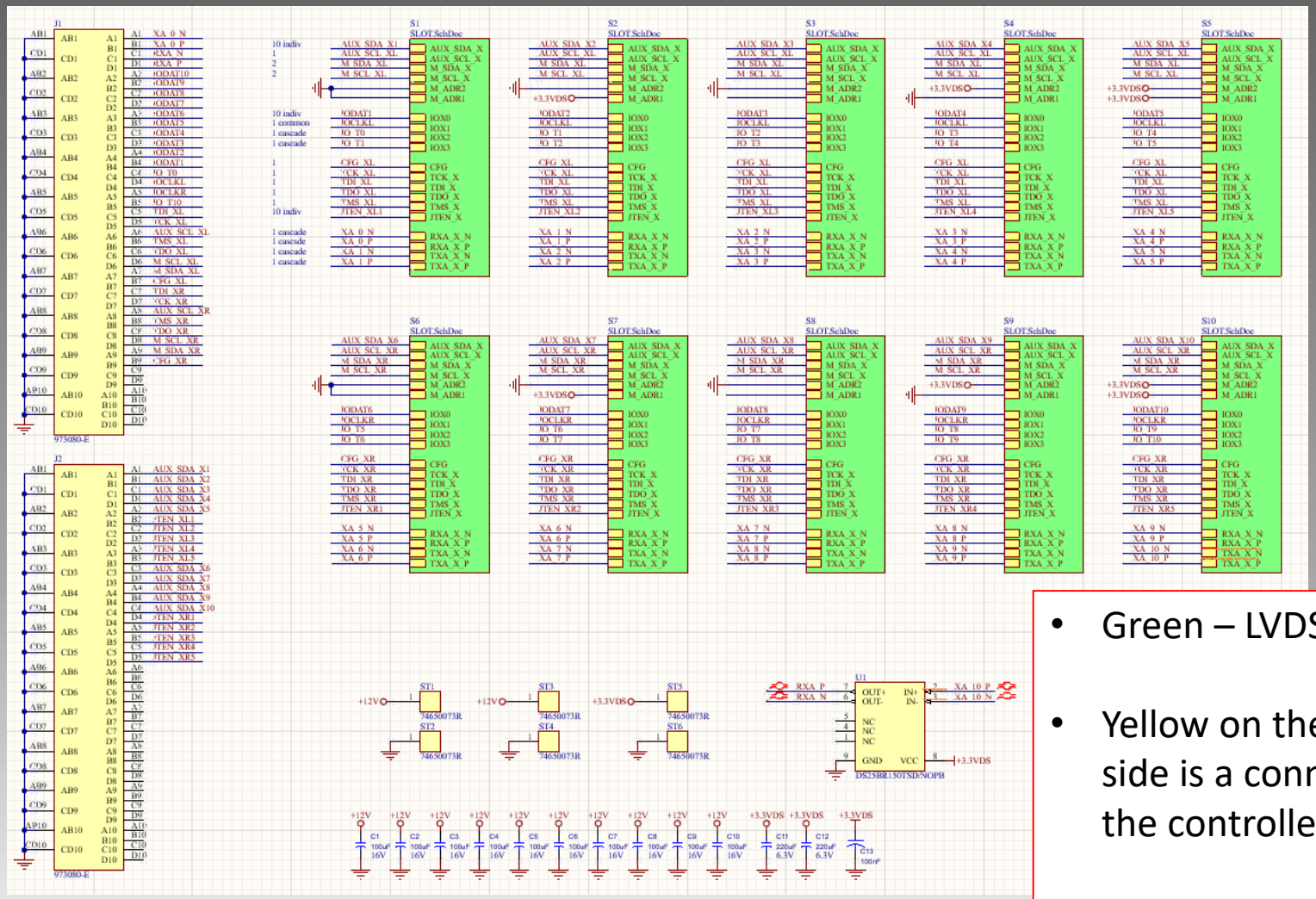


- The **Back-Plane** design is fully routed and **completed**
- It can suite both direct cable connection as well as FireFly carriers
- The **Crate Controller** design is **pending**

LVDS DC

An ExaMAX variant

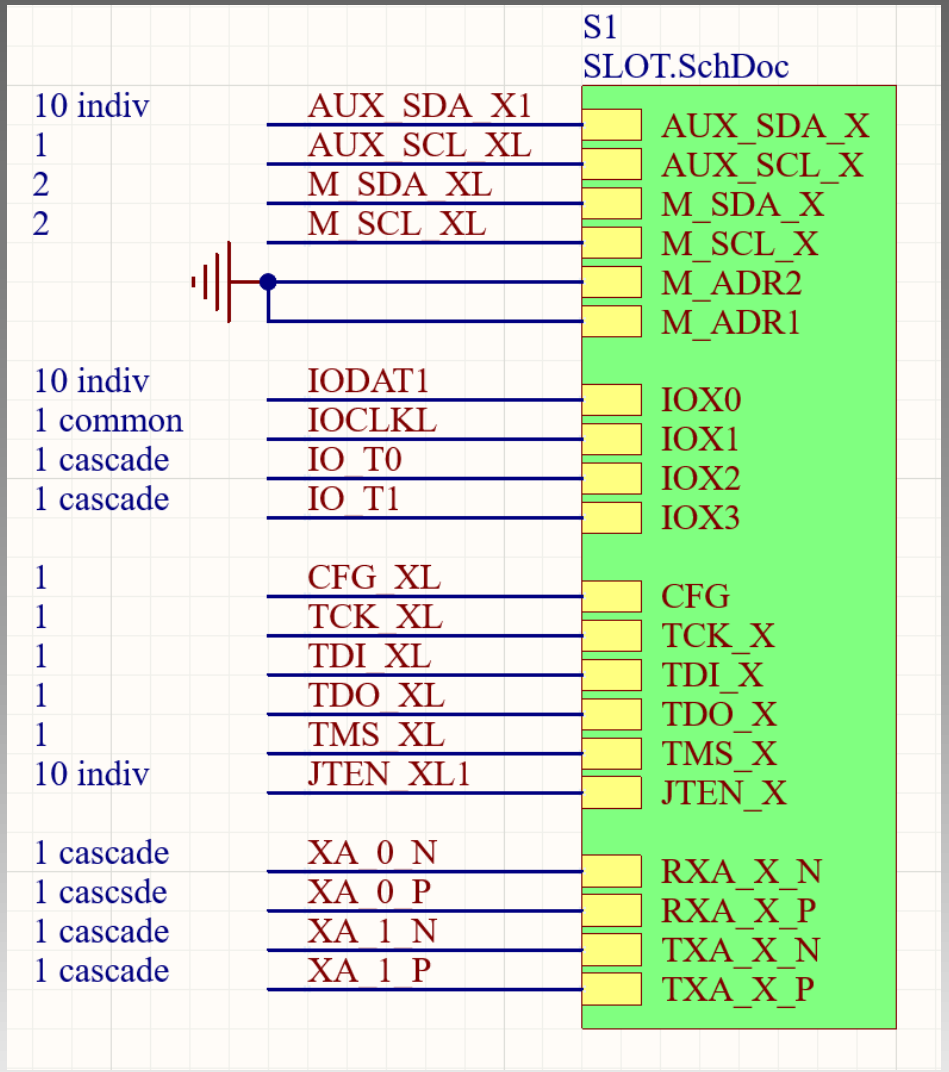
10-slot backplane for a 84HP (19”) crate



- Green – LVDS-DC slots
- Yellow on the left-hand side is a connector for the controller

An ExaMAX variant

10-slot backplane for a 84HP (19”) crate



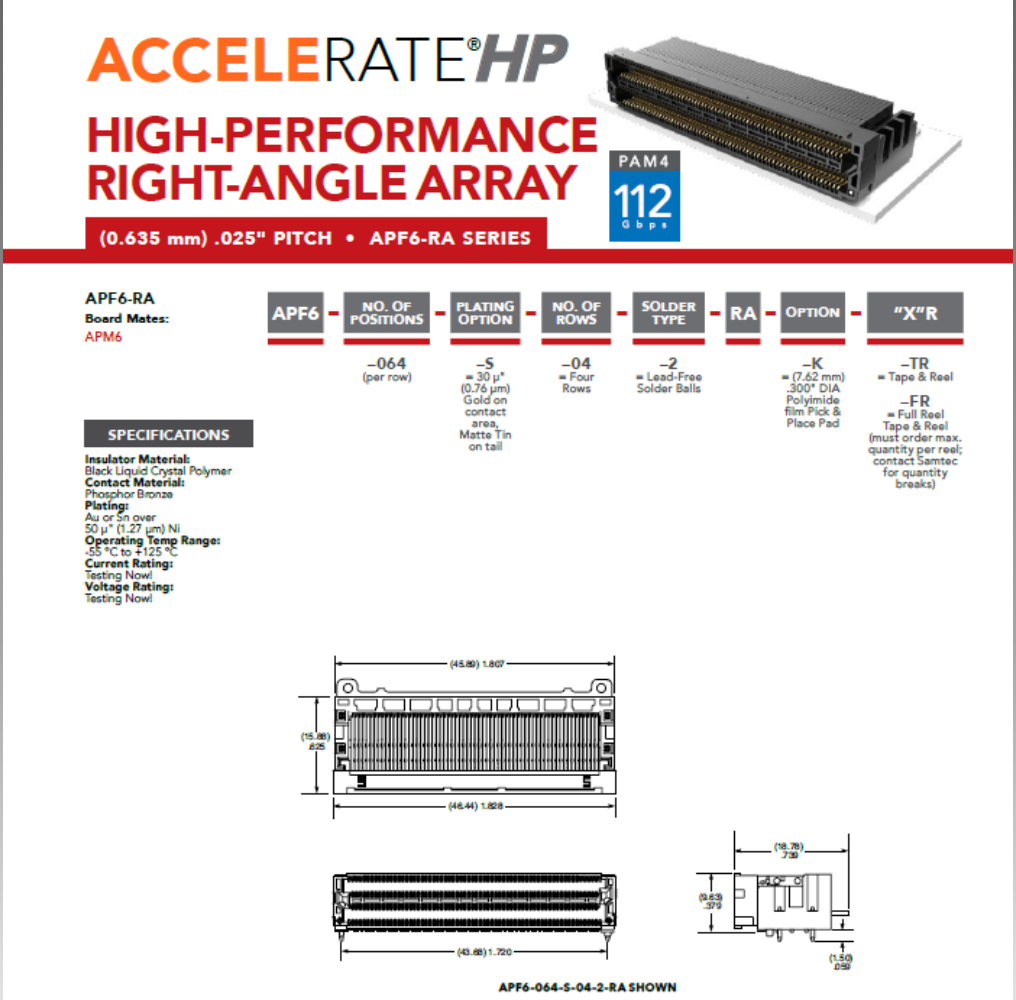
Control signals for each LVDS-DC module.

- Shared genera I2C
- Common I2C for voltage monitoring
- Individual, common and cascaded communication
- Common JTAG with individual slot enable
- Cascaded multi-gigabit link

LVDS DC

An AcceleRATE variant

AcceleRATE connector system

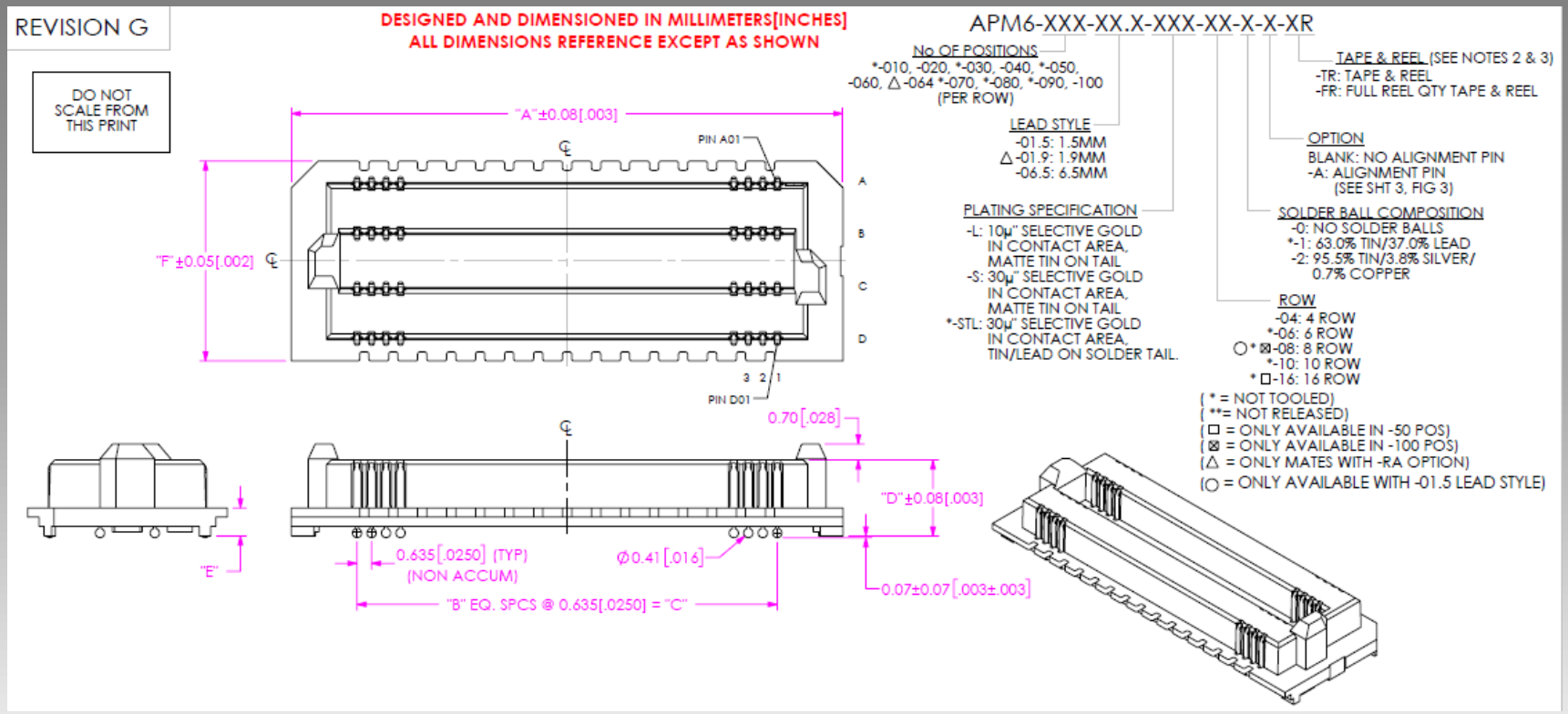


- ExaMAX connectors are bulky and do not offer a high-density module placement.
- For EMC Barrel ExaMAX system would necessitate ca 30 crates (6 racks with 5 crates each) (?)
- AcceleRATE right-angle connector is a quad-row surface mounted, allowing for high pin count feed-through interconnection over the backplane

An AcceleRATE variant

AcceleRATE connector system

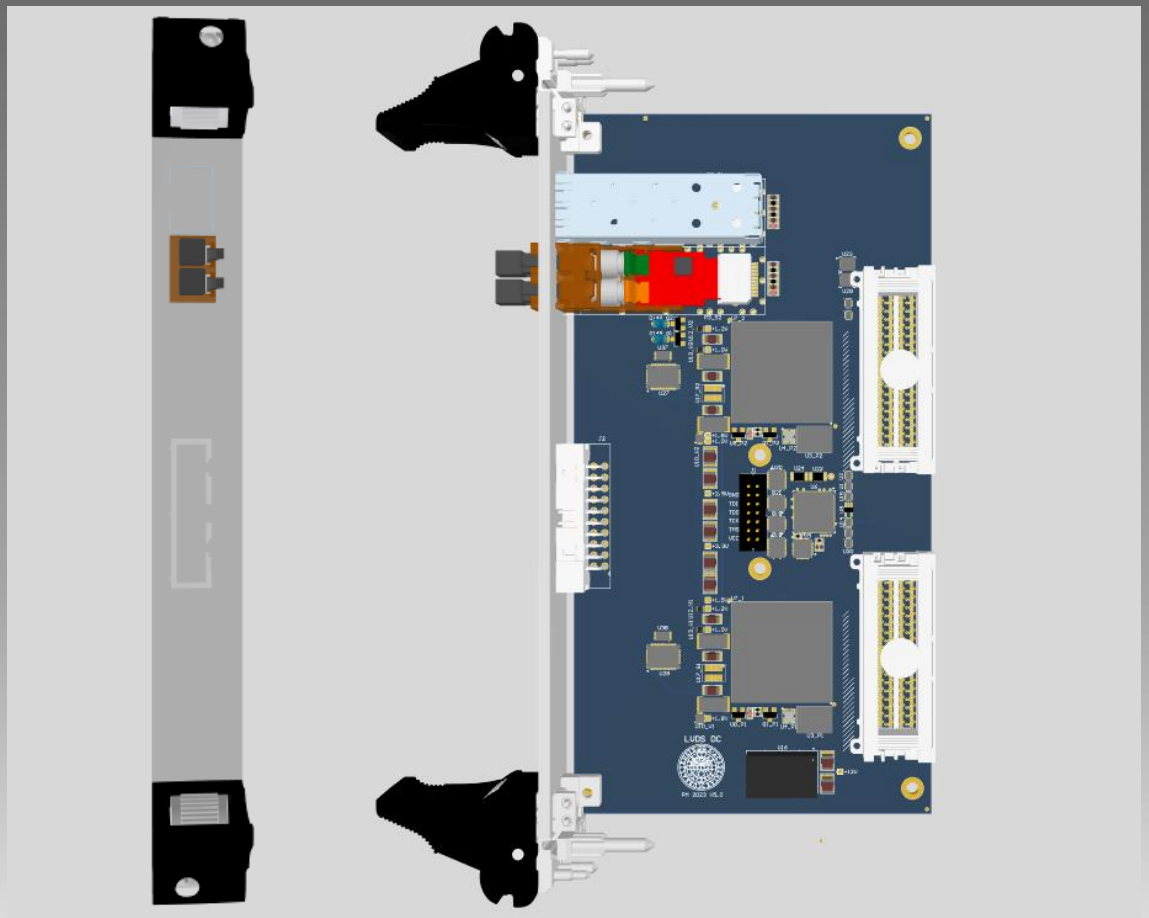
- A back-plane connector is also flat, 4-row surface mounted
- AcceleRATE connector system **doubles** the module density for FireFly and possibly also if flat cable connectors are used. Samtec has a broad offer.



LVDS DC

An AcceleRATE variant

A high pin-density module for mating via a back-plane feed-through

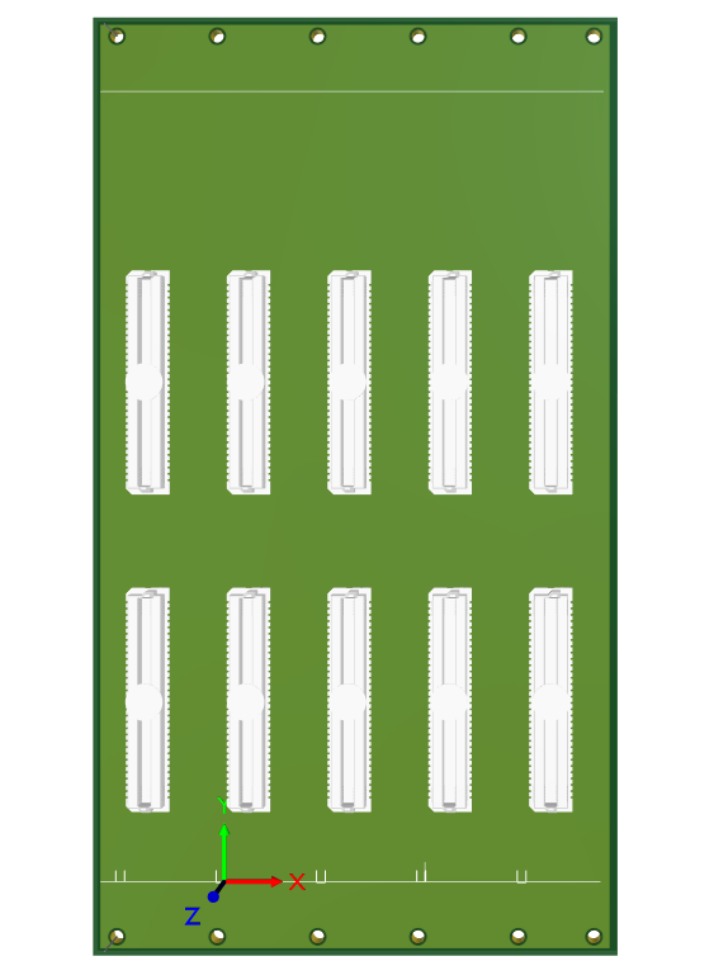


- The module is **fully designed** and is powered by a uModule from +12V delivered from the back-plane.
- A monitoring system with +3.3V reference is distributed over the back-plane
- A number of control signals, JTAG programming and utility pins is available on a connector to be mated to the back-plane
- The module will fit in a customized Schroff mechanics
- The module is **4HP** (single width)

LVDS DC

An AcceleRATE variant

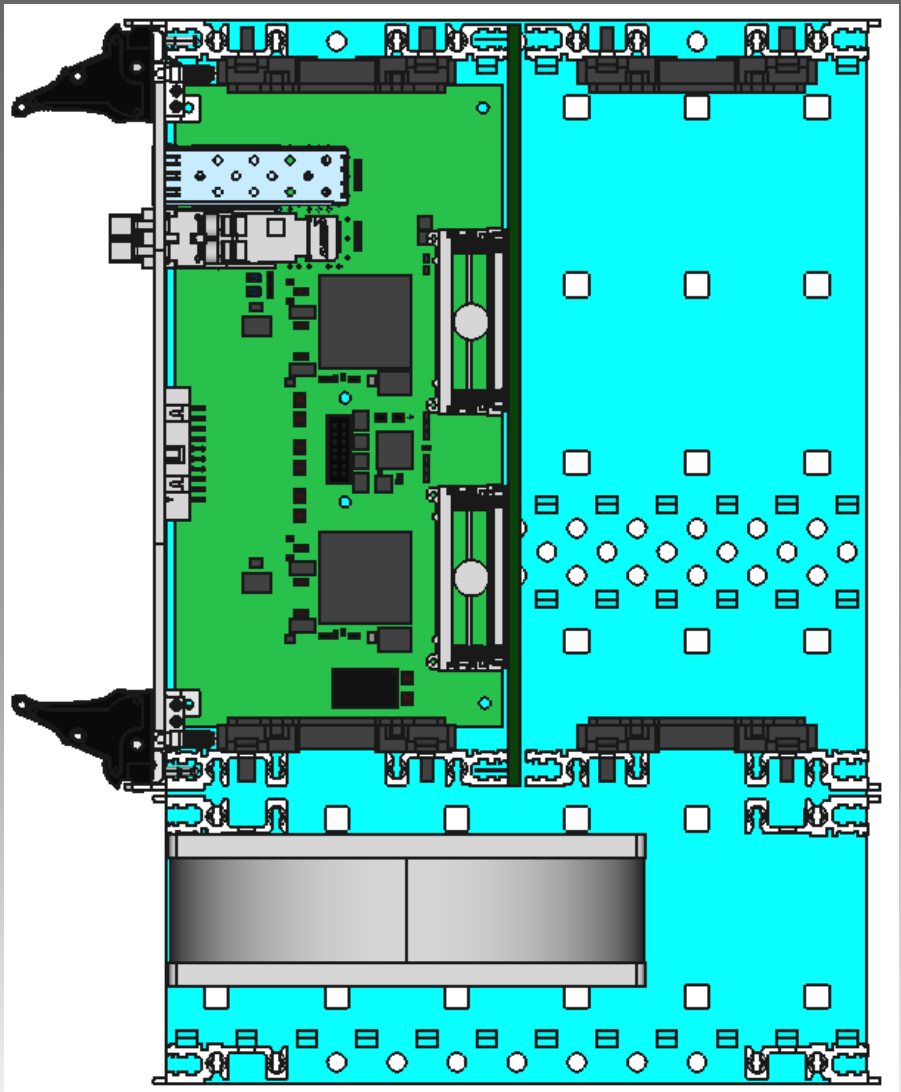
A four-slot back-plane



- Here is a **4+1 slot** back-plane model. The left-most is a controller slot.
- It is an empty design for checking mechanical conditions and adjust connector placement. No connections yet. The full design for 20+1 slot (84HP, 19”) **is pending**
- A Crate Controller design **is pending**

An AcceleRATE Crate mechanics

Crate construction



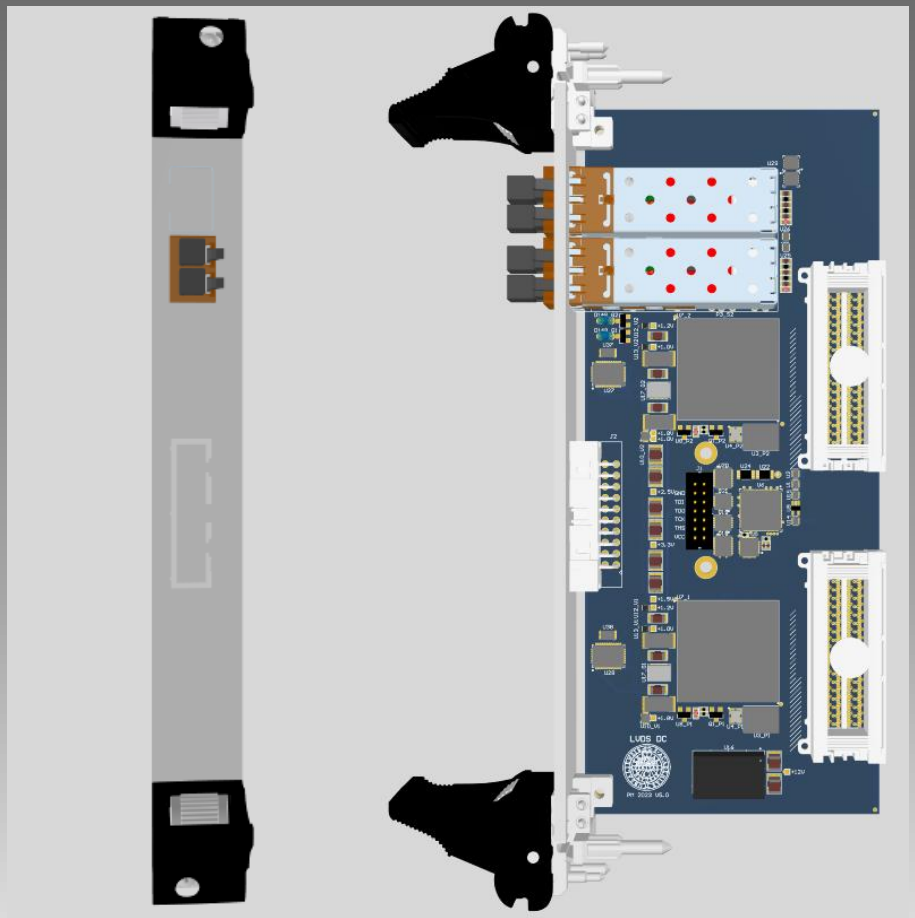
- The crate mechanical dimensions were elaborated in FreeCAD using STEP files provided by Schroff.
- The design and front panel models are available in STEP format.

LVDS DC

A customized AcceleRATE variant

A right approach for the EMC Barrel?

No!



- During our meeting we came to the following conclusions:
- LVDS transceivers for EMC Barrel will be placed **inside** of the detector (in the backward region)
- One can expect **radiation** and a strong **magnetic field**
- The size matters
- No small on-board DC/DC
- Optical transceivers need to be **Versatile Link+** from CERN
- Custom crate mechanics providing space for **air-core** DC/DC modules

Summary and Conclusions

Summary (1)

In search for a perfect solution, 5 different versions of the LVDS-DC were designed.

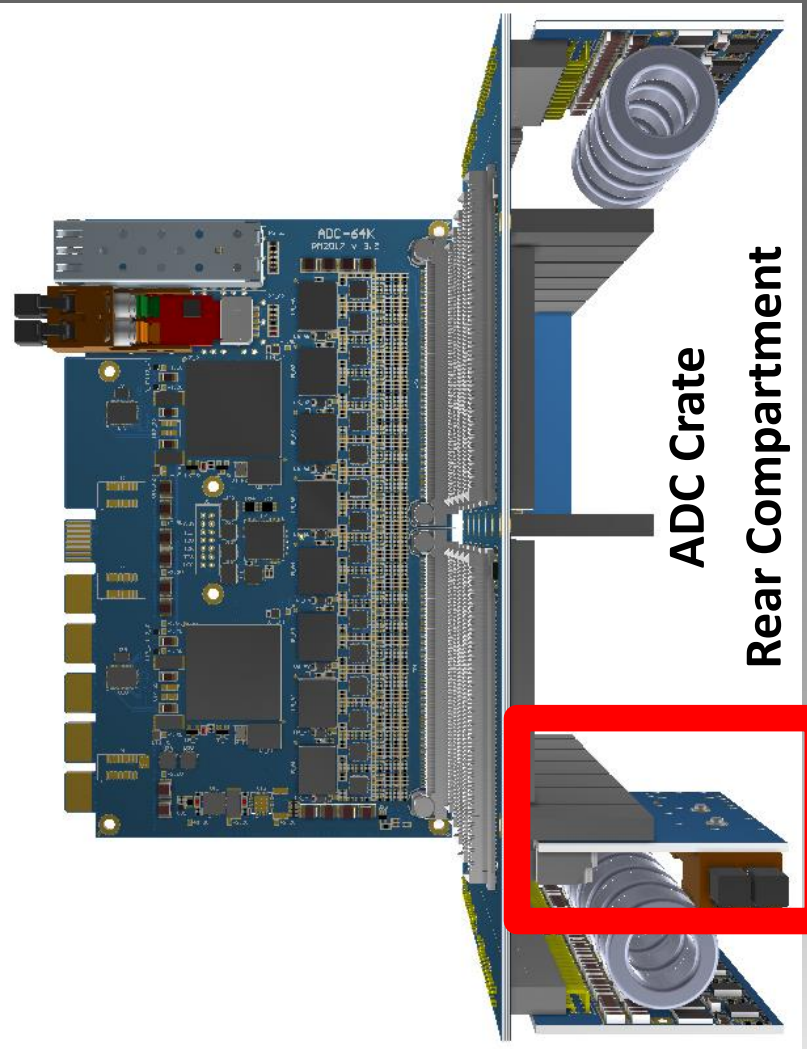
- The on-board **FireFly** version is considered fiddly and not easily serviceable
- The **EdgeRATE** version is the simplest, but because of the pin shortage it should rather be considered as a mezzanine or as a part of a more robust module.
- The **ExaMAX** is a perfect solution for systems, where signals are distributed over individual cables, which then get aggregated at the input connector. Signals do not propagate over multiple connectors contributing to signal distorsions. Inputs are ESD protected. Due to bulky connectors the system does not offer the highest spatial channel density.
- The **AcceleRATE** version offers a double spatial channel density compared to ExaMAX. This solution would probably be the most appropriate for a system, where signals are distributed with FireFly (EMC Barrel).

Summary and Conclusions

Summary (2)

- The **ExaMAX** is a perfect solution for the **Luminosity** detector. One needs **20 modules** including spares.
- The **ExaMAX** will be used for the **EMC Barrel**, but it needs some more work in adapting it to the hostile environment. One needs **100-150 modules** including spares
- There is a consensus to use only one system (for service, documentation, spare parts etc), hence the risk is that the **Luminosity** detector may adopt the solution for the Barrel, despite if it's not optimal.

A development work on the Crate Contoller



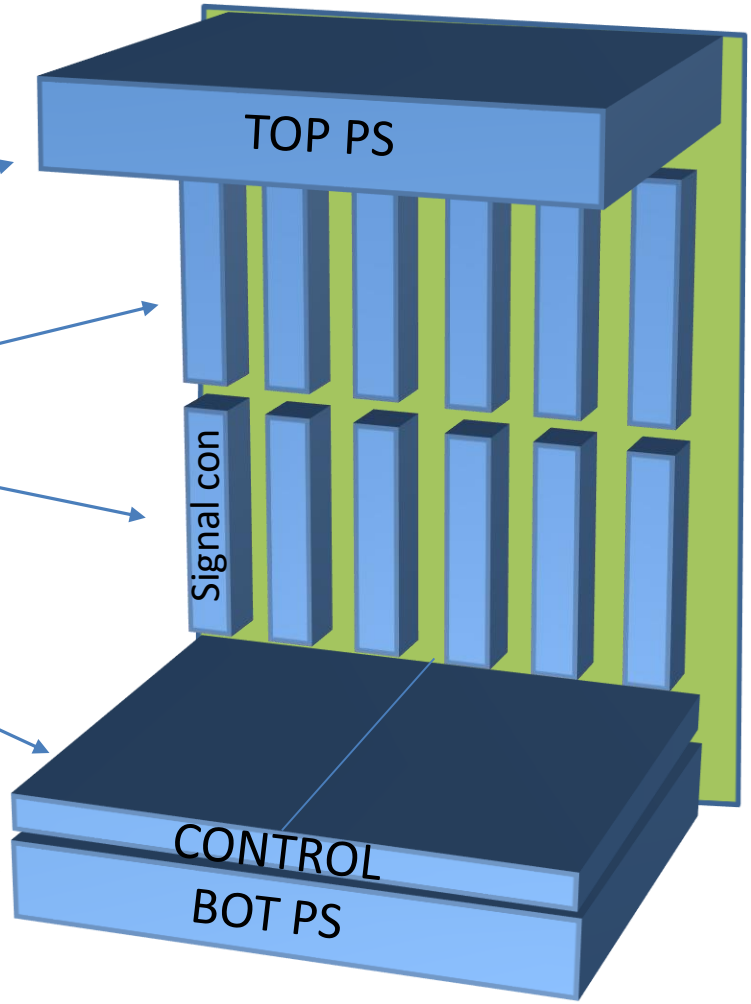
Crate Controllers

- Power/temperature control
- Remote programming of SADC
- SEU management
- Auxiliary data readout
- Additional I/O for trigger and cascading of JTAG

- Crate backplane preparation

Backward crate compartment

- **TOP Power Supply (Digital 1.0V, 1.5V, 2.5V, 3.3V)**
- **Signal connectors**
- **Crate Control**
- **Bottom Power Supply (Analog 2.5V)**

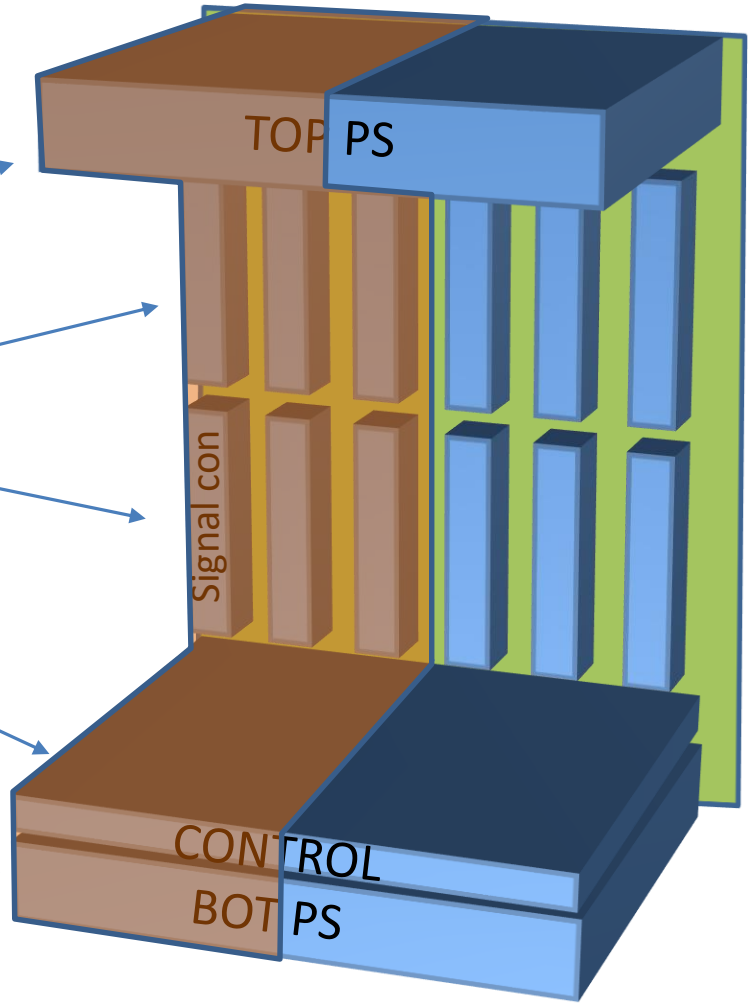


- Crate backplane preparation

Backward crate compartment

- **TOP Power Supply (Digital 1.0V, 1.5V, 2.5V, 3.3V)**
- **Signal connectors**
- **Crate Control**
- **Bottom Power Supply (Analog 2.5V)**

Tripple slot module division



ADC for EMC-Endcap

- Crate backplane preparation

TRIPLE SLOT MODULE

TX/RX - GTX Triple module loop (HF buffered)

Can be used for re-routing of faulty main transceivers or for multiplexing of the readout

I²C AUX – provides differential I2C control for the detector ASICS (requested by Barrel).

Can be used for indicating FPGA configuration status (DONE) to the control system

I²C PWR – For monitoring of the ADC voltages and currents

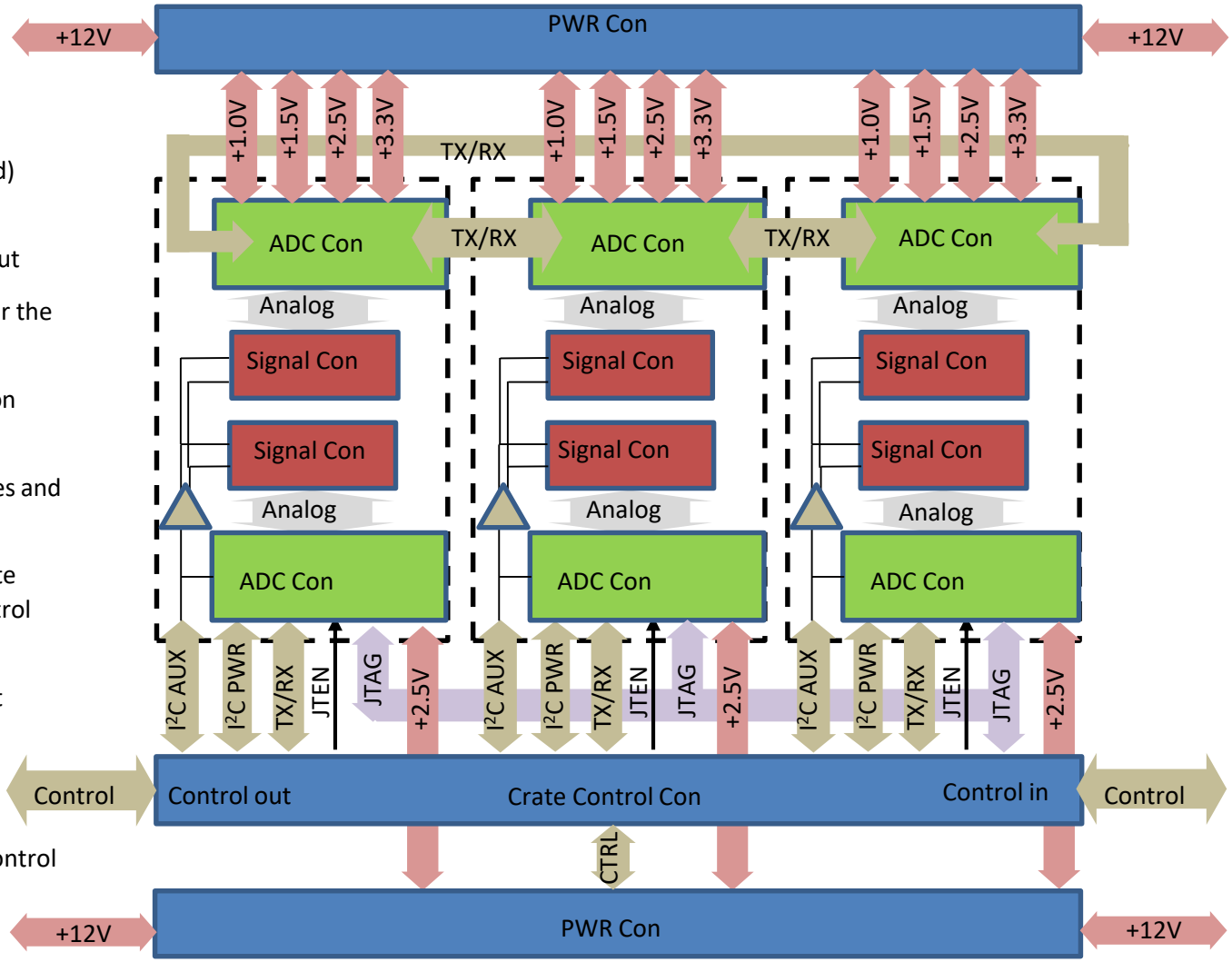
TX/RX – can be freely used inside of the Crate Control board. Either looped or fed to a control FPGA

JTEN – JTAG enable for operation on the slot

JTAG – Common lines (buffered)

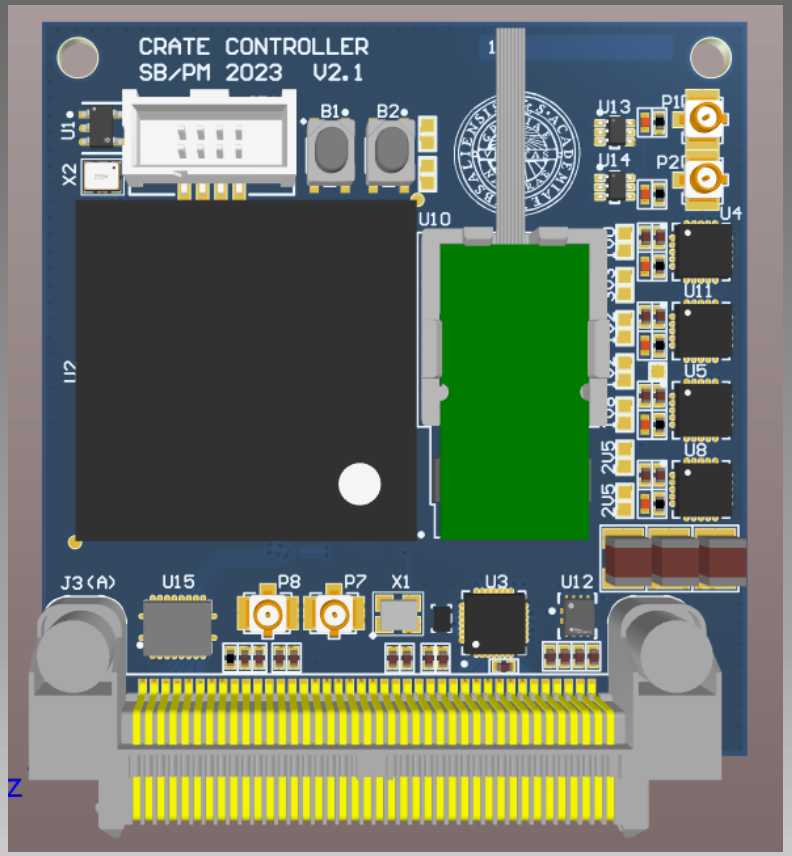
CTRL – PS control

Control – A daisy-chain interface for crate control (optical interface out?)



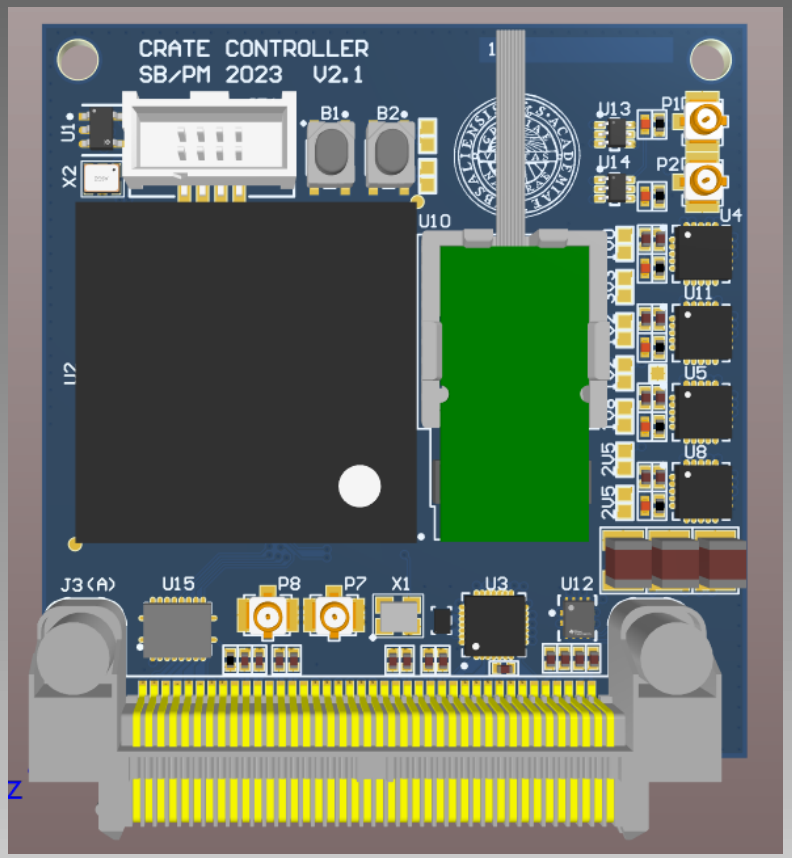
Crate Controller

- The controller utilizes a Actel/Microsemi/Microchip PolarFire – a flash based radiation tolerant FPGA with 12.5 Gbit/links
- For communication over optical fibers we will use Versatile Link + with 2 Tx and 1 Rx channels



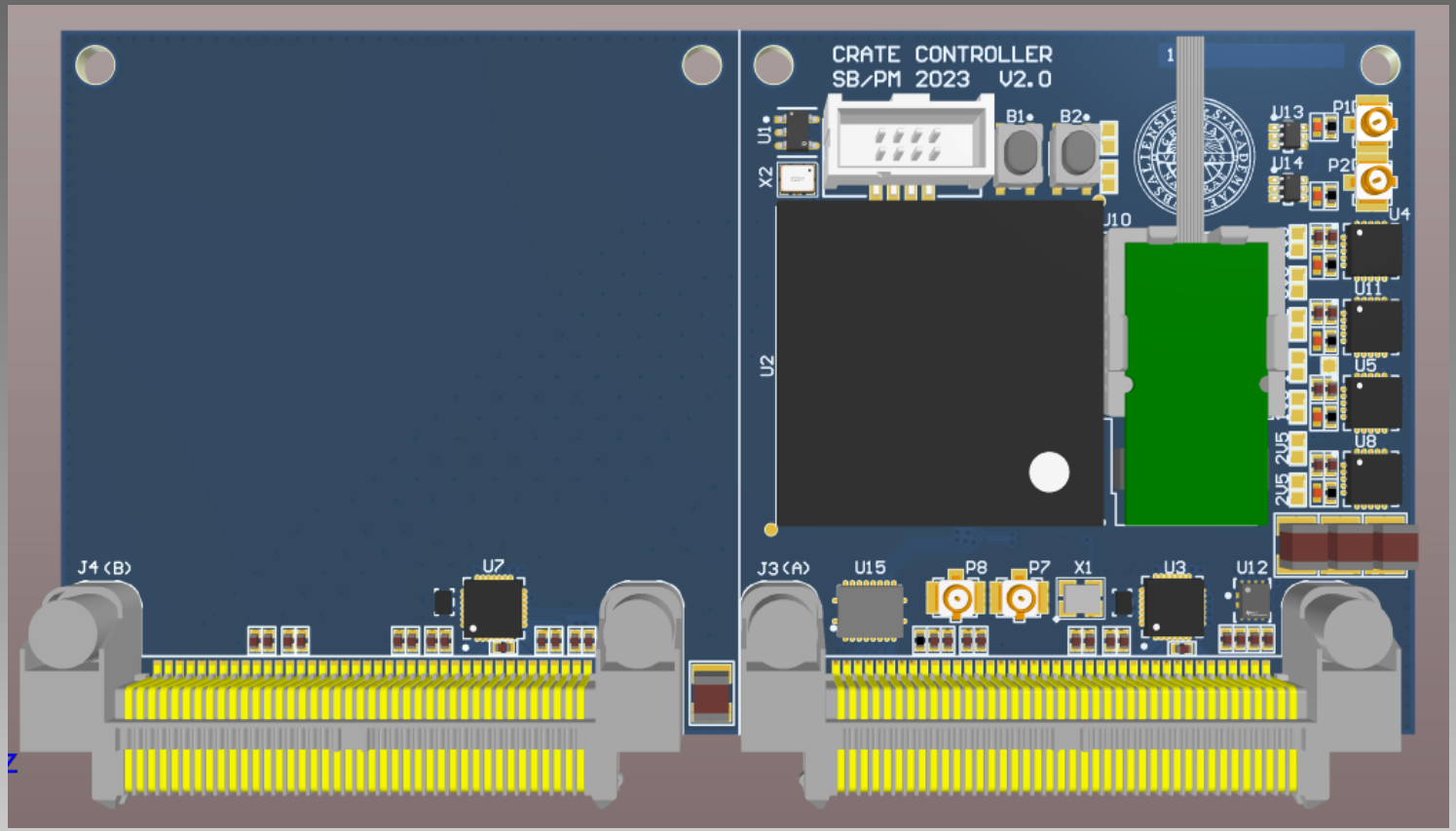
Crate Controller

3-slot version



Crate Controller

6-slot version



Crate Controller

Production Status

We are planning to have

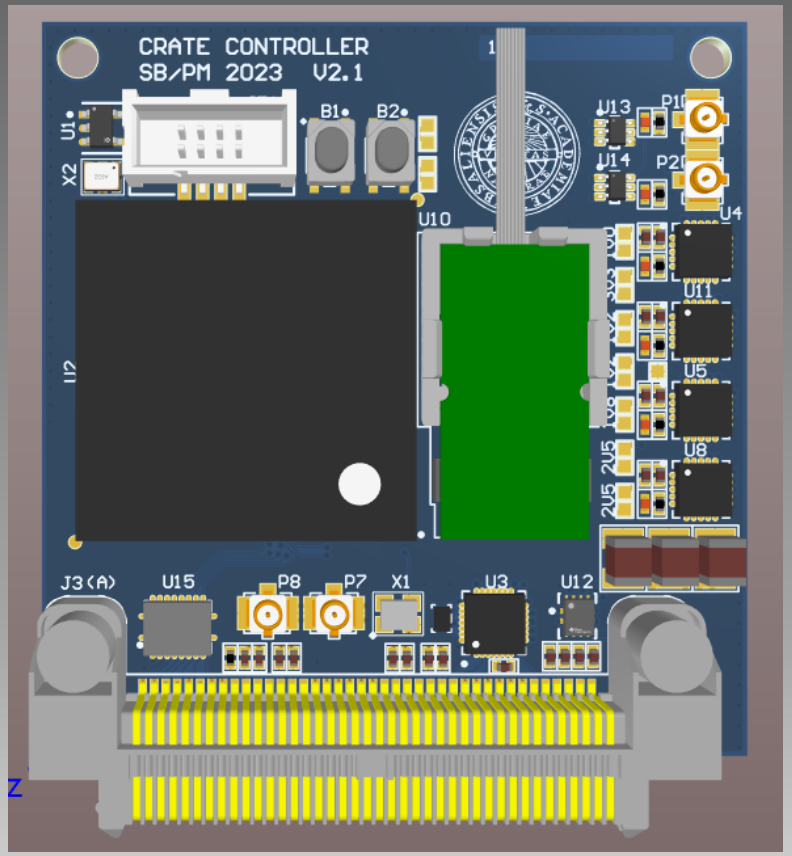
- **10 6-slot crates**

  We need 12 3-slot controllers
  (25 in production)

- **12 15-slot crates**

  We need 34 of 6-slot Controllers
  (45 in production)

- **All components apart from VL+ are in place. Non-disclosure agreement witrh CERN signed**
- **Production of Controllers started**

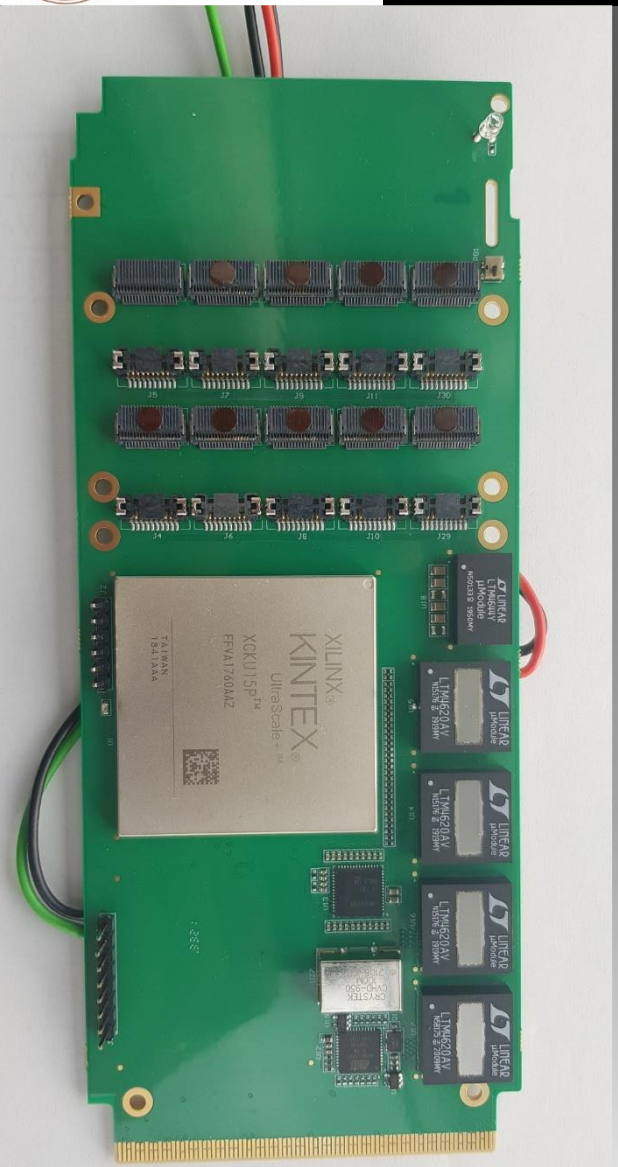


Summary and Conclusions

Summary

- The **Crate Controller** design is ready
- All components were procured and are available for production
- All PCBs are manufactured
- A prototype assembly is expected by the end of February.
- If the tests are positive, the volume production will start.

PANDA_DC status



- **Technical problems with manufacturing PCB (14-layer, HDI, High frequency substrate, impedance control) has delayed the project**
- The first 2 attempts were only partially successful.
- **1 prototype would be nicely working but some clock inputs were probably destroyed by ESD while debugging.**
- A batch of 10 PCB was ordered from HLT company recommended by Michele Caselle. **Unfortunately only 4 passed tests**. Negotiations about the rest are pending.
- 1 PCB was assembled and is under evaluation.
- **The tests shown positive results**
- 2 other PCBs are in assembly. Expected in 2 weeks.