Brief summary

CMS VL+ application review
20210927

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Charge from this morning

- **The intention is to provide an overview of the CMS VTRx+ and lpGBT use cases by CMS subsystems. The relatively short presentations should include e.g.**
  - **Detector unit format, e.g. "ECAL super module, one out of 36", and expected radiation level**
  - **Versatile link carrier PCB format**
  - **Power supplies, filtering, and lpGBT - VTRx+ interconnects**
  - **Cooling of the VTRx+ and the lpGBT**
  - **Reliability requirements and QC concerns**
  - **Requested delivery schedule update**

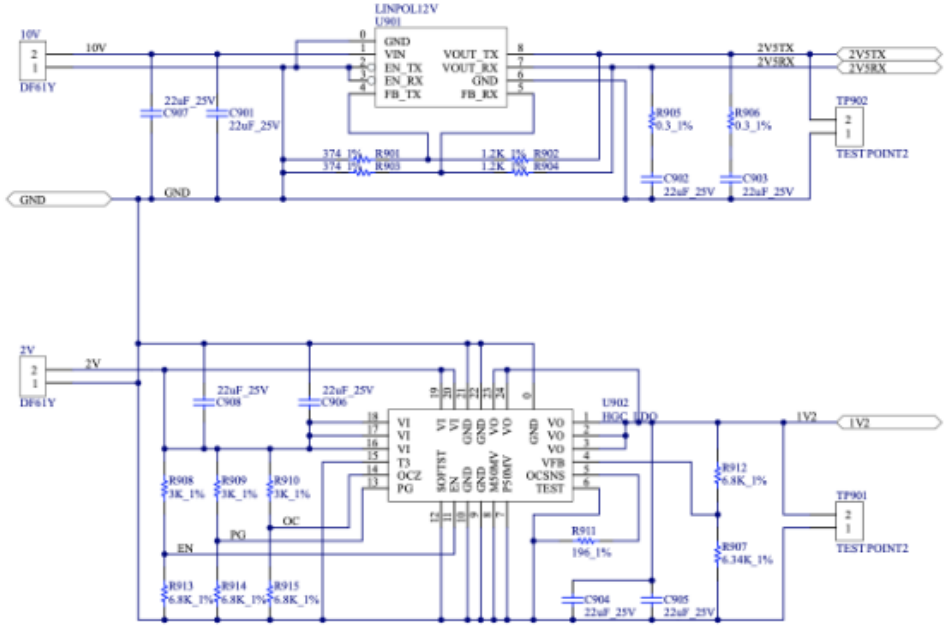
HGCal

- Large heterogeneous system
- Synch controls at 320MHz
  - HD & LD; Skewable or not, tbd.
- Slow control through lpGBT I2C
  - Master through Trigger lpGBTs acting as ~I2C fanouts
- One master (DAQ) lpGBT and two slave (TP) lpGBTs
- lpGBTs transmitting at 10GBPS with FEC5, not FEC12.
  - <40mm traces
- VTRx+ power (2V5) provided by LinPOL12V
- lpGBT power provided by HGCal LDO

Power

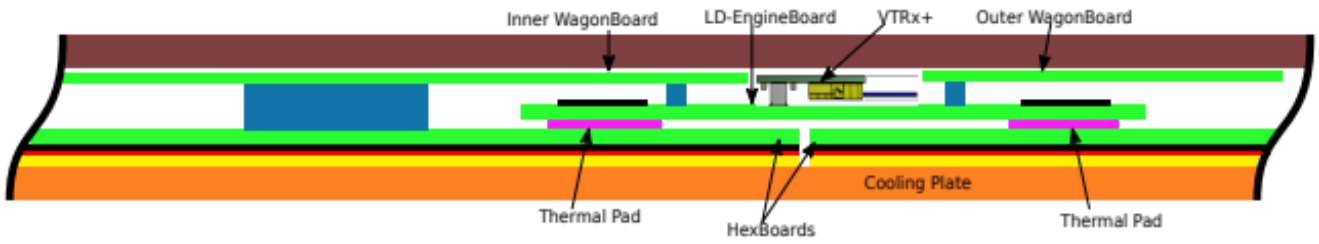
Power for the V3-LD-EngineBoard

- linPOL12V regulates 10V down to 2.5V for VTRX+
  - Using one channel of the linPOL for TX power and one for RX power
- HGCAL LDO to regulate ~1.5V output from (off board) bpol12V down to 1.2V



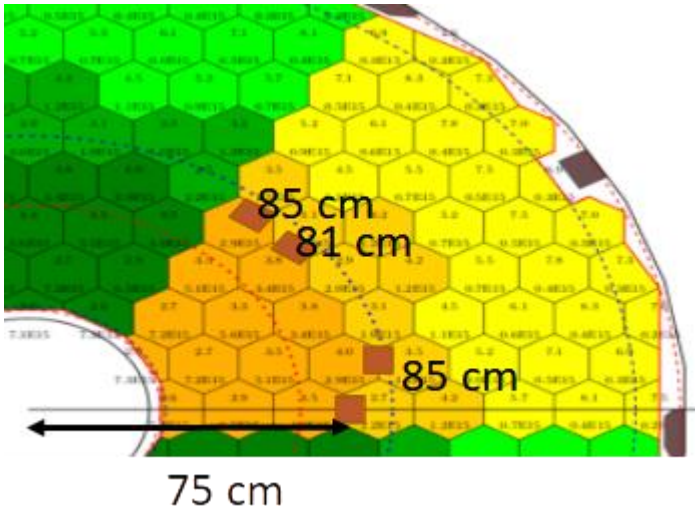
HGCal

- **Cooling**
  - **Temp below 40 degrees recommended for VCSEL longevity reasons. Should be no issue when cold.**
  - **Sandwich between absorber and PCBs / cooling layer**
  - **Suggest gap pad between VTRx+ and Lead**
    - ➔ **May not be easy to achieve. To be investigated.**



HGCal

- **Radiation**
  - **VTRx+ moved away from the center yielding an estimated factor 2 margin in radiation tolerance**



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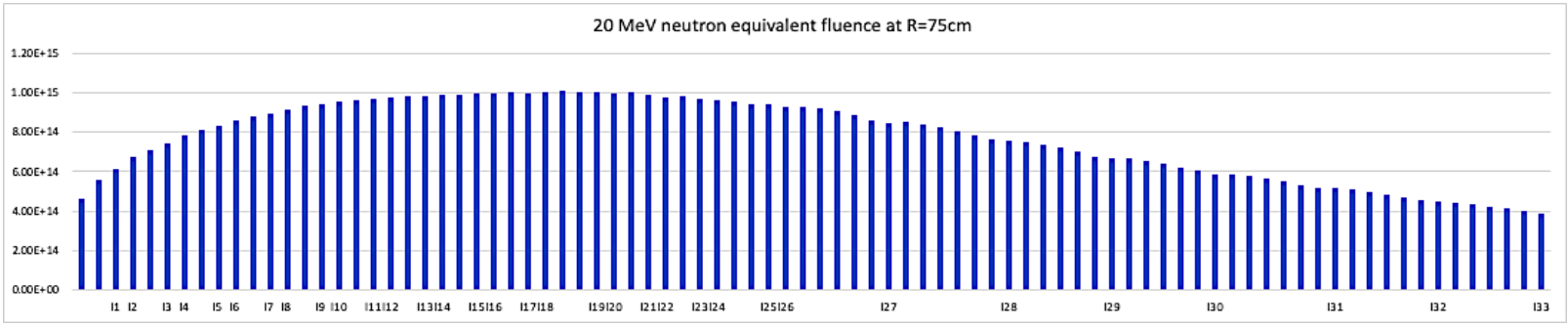
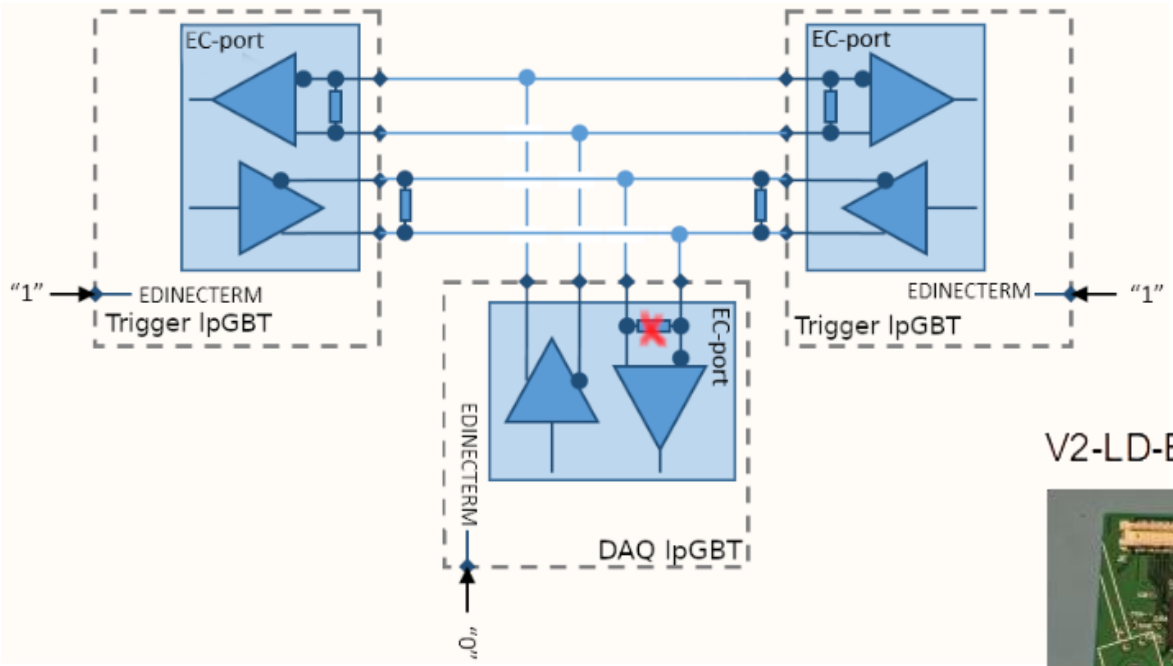


HGCal Experiment Control bus configuration

EC bus configuration

- Propose to use double-ended multidrop configuration
  - Configuration based on lpGBTV1 documentation, but not exactly the same topology as the example in the documentation
  - Requires external termination resistor on EC transmitters for both trigger lpGBTs
  - Minimal stub length to DAQ lpGBT (vias from internal layer as bus passes from one end to the other)



V2-LD-EngineBoard

Outer tracker

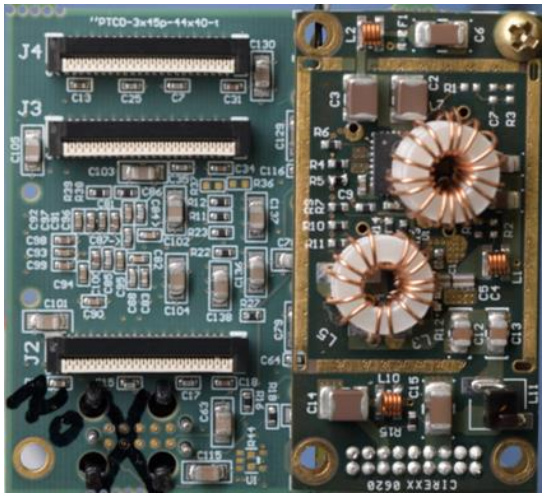
- **PS**
  - **Power from local DCDC; 2V5 from BPOL12V, 1.25 from BPOL2V5**
  - **5GBPS**
- **2S**
  - **Power from remote DCDC; 2V5 from BPOL12V, 1.25 from BPOL2V5**
  - **5GBPS or 10GBPS**
    - ➔ **Set with resistor**

Outer tracker

- **Radiation**
  - **The VTRx+ has been specified for the ATLAS and CMS trackers, thus radiation and tolerance match with some margin.**
- **Issues with light leakage VTRx+ into sensor; ABS cover developed but not working. Black tape (50micron polyamide) is the only currently working solution. To be followed up.**
- **Issues with operation cold for a fraction of modules; Prototypes, pre-series, both? More information later today.**
- **Will need production grade VTRx+ units early 2022.**

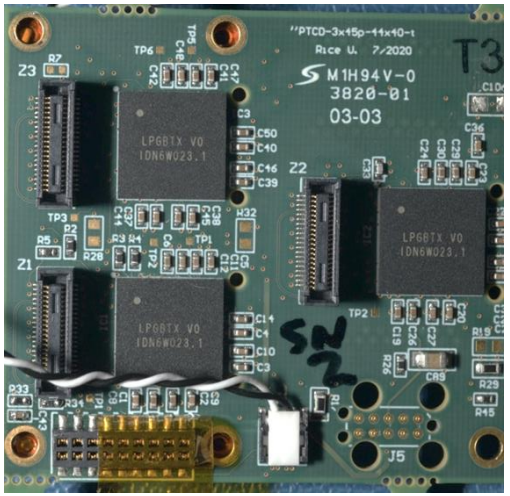
Inner tracker

- **Power from DCDCs on mezzanine; 2V5 from BPOL12V, 1.25 from BPOL2V5**
- **One lpGBT for one VTRx+**
  - **VTRx+ sitting right on top of the lpGBT. Cooling issues, if any, not presented this morning**
- **Radiation tolerance marginal – complete replacement in LS5**



3 lpGBT Port Card - Front
3 45-pin connectors (J2,J3,J4)
6 data, 5 command links
SMDs 0402, 0603, 0805
DC-DC mezzanine mounts over SMDs RHS
5 mounting holes

3 lpGBT Port Card – Back
3 lpGBT, 3 VTRx+ (Z1,Z2,Z3), mounting brackets
J1 Power in
Z4 DC-DC mezzanine connector footprint
J5 Test connector
High speed serial data pairs routed this layer



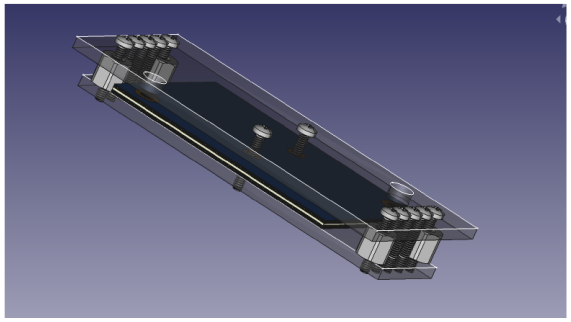
GEM ME0 layer (GE 1/1 and 2/1 use VTRx)

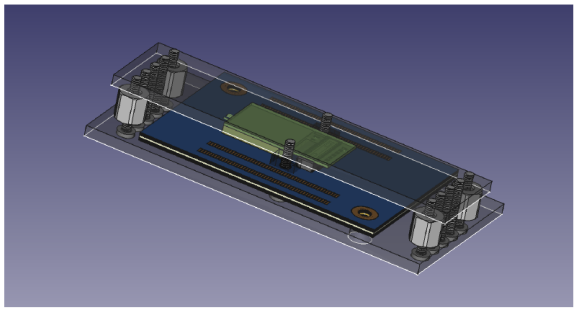
- Detector unit format, e.g. "ECAL super module, one out of 36", and expected radiation levels
  - 1 VTRx+ per OH, 4 OH per ME0 module, 6 ME0 modules per stack, 18 stacks per endcap = 864 total
- Versatile link carrier PCB format
  - 45mm x 30mm rectangular PCB
- Power supplies, filtering, and lpGBT - VTRx+ interconnects
  - DF40C(2.0)-40DS-0.4V(51) on carrier board to match VTRx+ connector
  - VTRx+ power supply comes from FEASTs on GEB, through the carrier board, to the VTRx+
  - Filtering capacitors near each connector (FEAST, carrier board, VTRx+)
- Cooling of the VTRx+ and the lpGBT
  - See next slide for preliminary design
- Reliability requirements and QC concerns
  - Need reliable I2C of VTRx+ to enable necessary TX channels
- Requested delivery schedule update
  - Ordering 1100 VTRx+ for full production (864 on detector + spares)
  - Lengths (of fiber only) for production order:
    - 275 - 29.5 cm
    - 275 - 46.0 cm
    - 275 - 62.0 cm
    - 275 - 81.0 cm

<250 krad tid

ME0 OH preproduction version

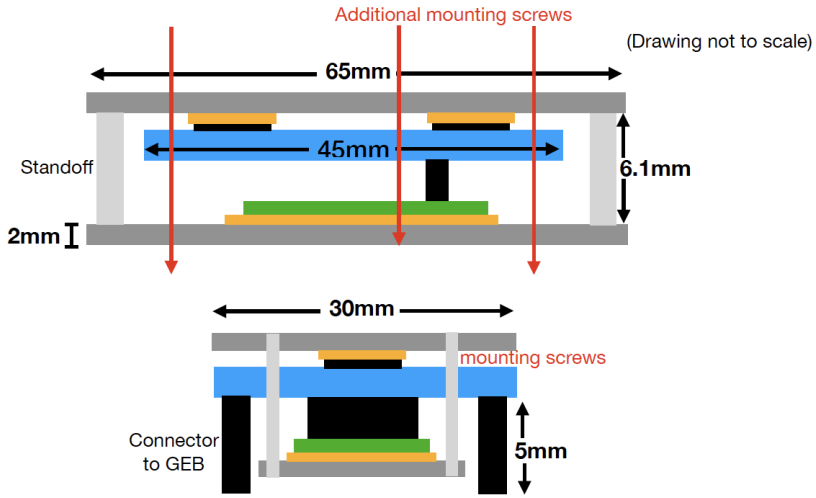
ASIAGO & VTRx+ cooling standalone unit
(optional connection to ME0 cooling through copper braid attached to top plate screws)





Standoff height (plate to plate):

-thermal pad thickness	0.5 mm
-lpGBT height	1.0 mm
-ASIAGO board thickness	1.6 mm
-VTRx+ connector stackup	2.0 mm
-VTRx+ board thickness	0.5 mm
-thermal pad thickness	0.5 mm
-TOTAL	6.1 mm



Drift Tubes

Detector unit format, e.g. "ECAL super module, one out of 36", and expected radiation levels
DT chamber on detector readout board, 3 to 5 boards per chamber, 1lpGBT + 1 SCA + 2 VTRx+ per board, <100krad td
Total foreseen pieces including preprod, yield and spares : 1200 lpGBT, 1200 SCA, 2400 VTRx+

Versatile link carrier PCB format
Custom, 215 x 90 mm

Power supplies, filtering, and lpGBT - VTRx+ interconnects+3.2V, +6V external power, LpGBT and VTRX+ powers derived via linear regulators and L-C filtered,
LpGBT - VTRX+ interconnects are high speed tracks ending on Hirose connector.

Cooling of the VTRx+ and the lpGBT
Water cooled 3D moulded thermal pad, aimed working temperature below 40 C

Reliability requirements and QC concerns
FIT < 6 for VTRX+
FIT < 6 for LpGBT
Test board designed for QC

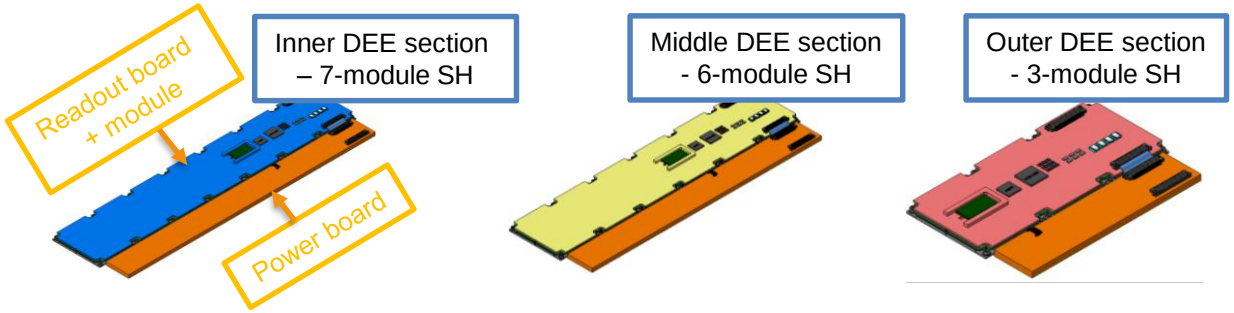
Requested delivery schedule update Start of electronics production planned on Q2 2022 (will be adjusted in case of an updated LS3 schedule)

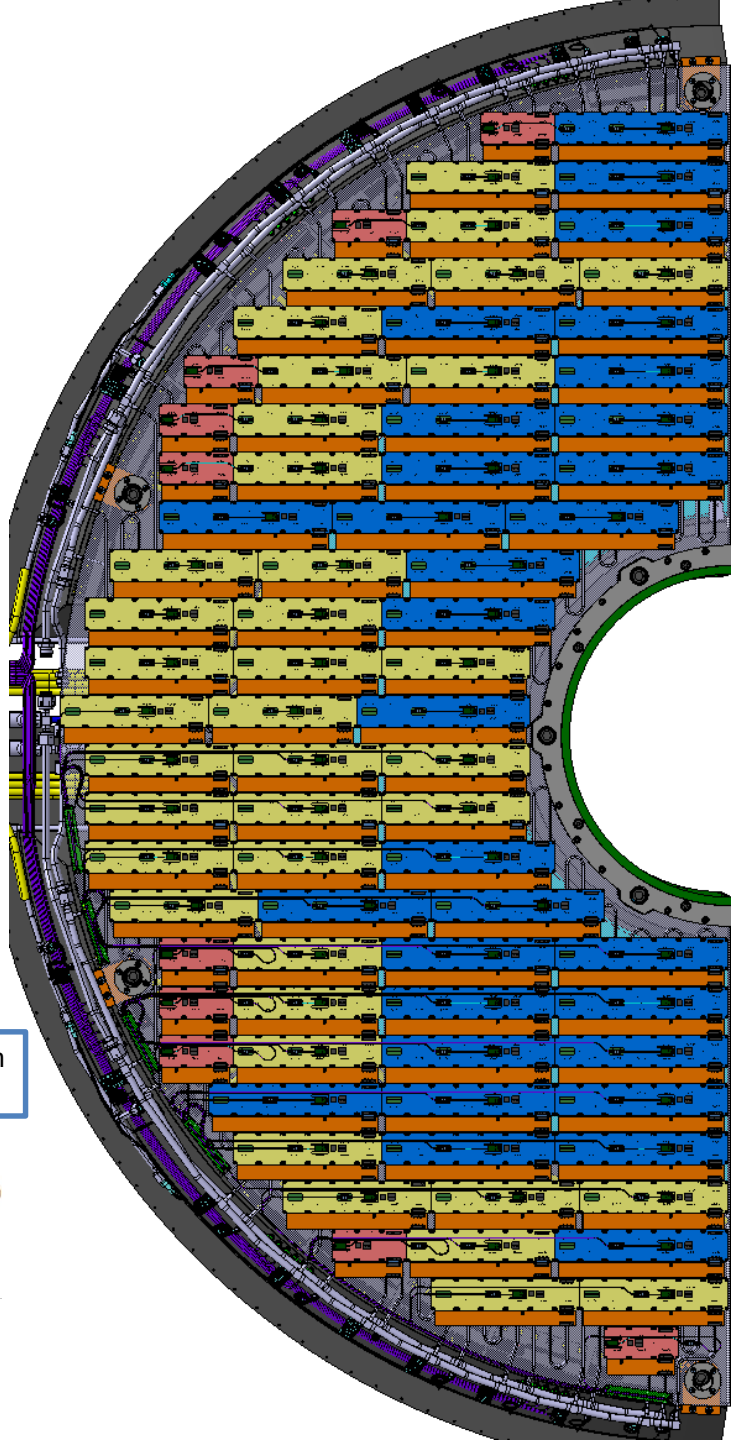
RPC

- A family of GBTx/SCA/ VTRx are used in the iRPC FEB-V2 electronics. In total, 180 set of each components have been ordered, 144 sets of each GBTx/SCA/VTRx will be used and the remain 36 sets will be spared.
- Based on our plan, on the last version of iRPC FEB (FEB-V3), the same family of rad-hard components will be used. But, to foreseen any requirement to exchange the GBTX/SCA/VTRx with LpGBT/VTRx+ we also booked 180 set of each brand new components.
- Nevertheless, in current version of FEB-V2, RSSI signal of the VTRx is checking by FPGA. Moreover, all necessary consideration have been taken into account to keep temperature of VTRx module around 30 'C to postpone outgassing effect.
- Total TID of that FEB will received during the 10 LH-LHC is below than 30 kRad which is well beyond of these rad-hard components limits.
- The bandwidth of the up and down link of system is 4.8 Gbps and recently fully validated by the RPC Backend electronics.

VTRx+ for ETL

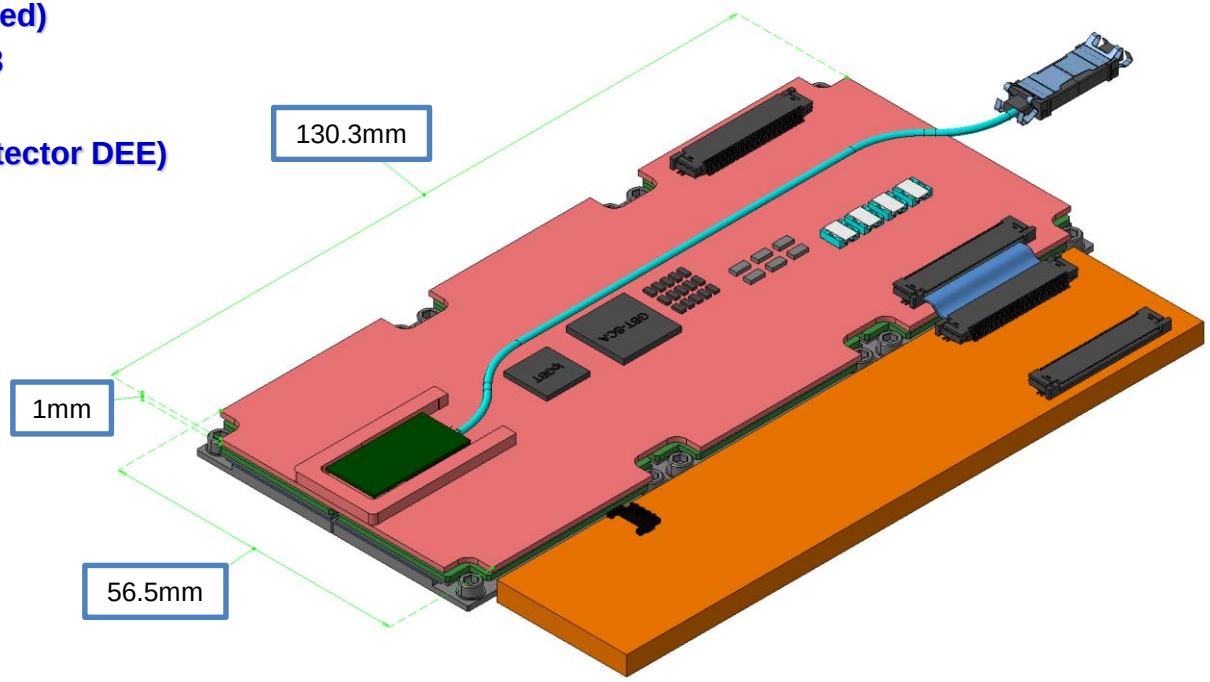
- **ETL will have 3 different detector units:**
  - Large service hybrids with 7 modules with one VTRx+ and one LpGBT
  - Medium service hybrids with 6 modules with one VTRx+ and one LpGBT
  - Short service hybrids with 3 modules with one VTRx+ and one LpGBT
  - All VTRx+ use 1 Rx and 2 Txs
  - 2.5V power is supplied with 2 x LINPOL12 ASICs. TX / RX each have their own LINPOL12. The two outputs of the LINPOL12 can be optionally connected together through small ballast resistors to increase current output.
  - 1.2V power is from a BPOL12 and shared with the LPGBT.
  - The possibility of adding an additional LpGBT for certain service hybrids is still being investigated.
- **The highest radiation dose is expected to be 1.7e15n/cm^2 and TID 69Mrad. The option of placing large service hybrids at the innermost section to keep VTRx+ out of the highest fluence detector sections is still being studied. This would reduce the fluence in the VTRx+ closer to 6.6e14n/cm^2 and TID closer to 26Mrad.**





VTRx+ for ETL

- VTRx+ will be placed on the 1mm thick rectangular PCB. All components will be mounted on the top side of the board, except its connectors with modules.
  - 1mm gap above VTRx+
  - 0.7mm gap below readout board
- All the service hybrids are places on the aluminium cooling plates, which have embedded pipes with two-phase CO_2 at -35°C. Detector will be flushed with dry gas in order to prevent humidity and ensure sufficient convection for components mounted on the readout board.
- Total amount of VTRX+ - 1932
- Pigtail length - 20cm (still being studied)
- Expected start of delivery - April 2023
- Delivery completed – June 2024
- Delivery rate – 100-200/month (1/2 detector DEE)



Current spec table status

System	Part count	Pigtail length	Latest start of delivery	Rate of delivery	Earliest start of delivery	Delivery completed
HGCal	9940	TBD	asap; 100 now		now	End 2024
ECAL	2871	35 cm			Soon	Mid 2024
Outer Tracker	7602	12 cm	February 22	550	October 21	June 2024
	4872	15 cm				
	327	20 cm				
	133	25cm				
	626	30 cm				
	300	Other				
Inner Tracker	1960	5.5 cm	April 23	120	January 23	June 2024
	960	7.5 cm				
	1200	20 cm				
MTD BTL	940	21 cm				September 2022
MTD ETL	1932	20 cm	April 2023	100-200 per month	April 2023	June 2024
Muon DT	1000	50 cm				
	500	100 cm				
	500	200 cm				
Muon GEM ME0	275	32.5 cm	2-3% asap			
	275	49 cm	2-3% asap			
	275	65 cm	2-3% asap			
	275	84 cm	2-3% asap			
Muon RPC	180	10 cm				
BRIL	132	10 cm, tbc Oct 21.	Early 2023, 1/3 of total	Insignificant	Late	2024, 2/3 of total.