# Environmental monitoring using the Embedded Local Monitoring Board (ELMB)

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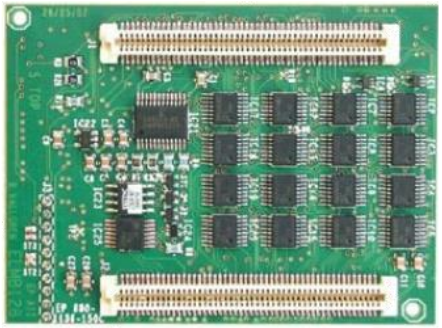
# ELMB

- A board that provides:
  - 64 channel multiplexed 16 bit ADC with multiple ranges (25, 55 mV, 1, 2.5, 5 V) and unipolar or bipolar operation.
  - Three 8 bit digital ports for input or output.
    - Some more communications options.
  - Easy integration of sensors via adaptors.
- Communicates via the CAN bus
  - LHCb uses USB-CAN controllers.
  - Power can be provided on the same cable (from D2).
- Integrated very well in WinCC via OPC server.
- https://twiki.cern.ch/twiki/bin/view/Atlas/DcsElmb

Top side

50x67mm

Bottom side



Optional ADC on the back side

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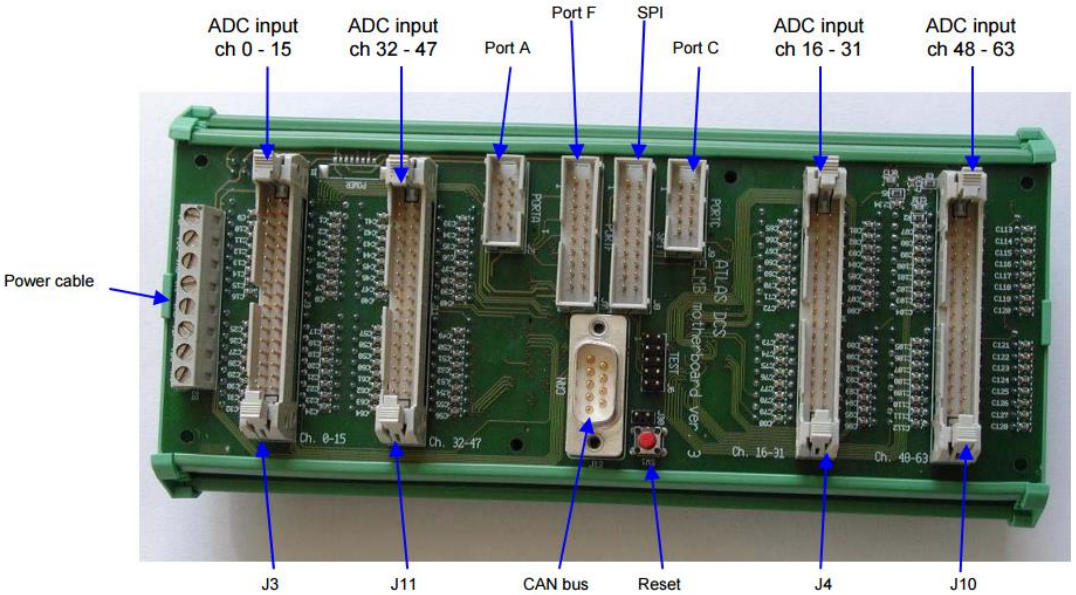
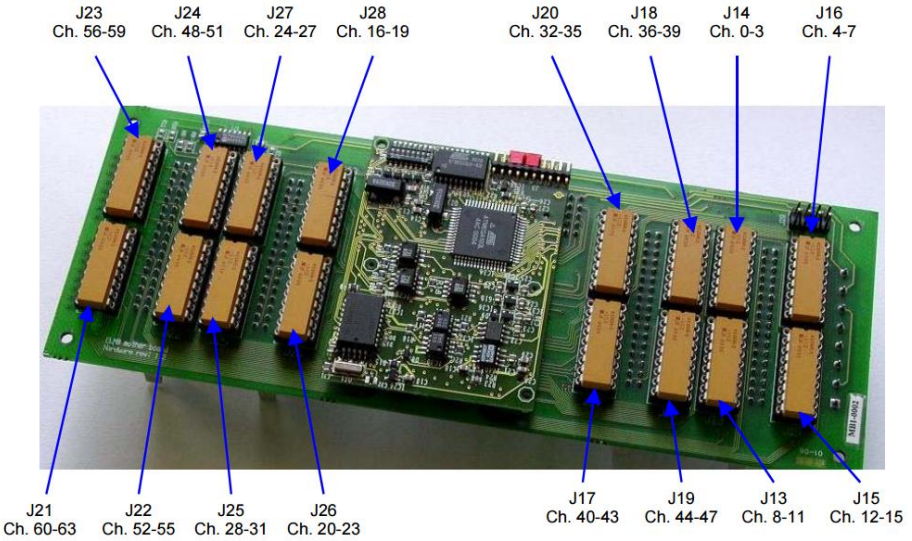
# ELMB motherboard




Connector side

Adaptor side

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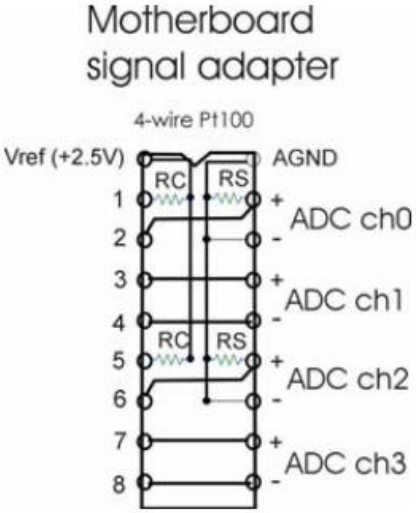
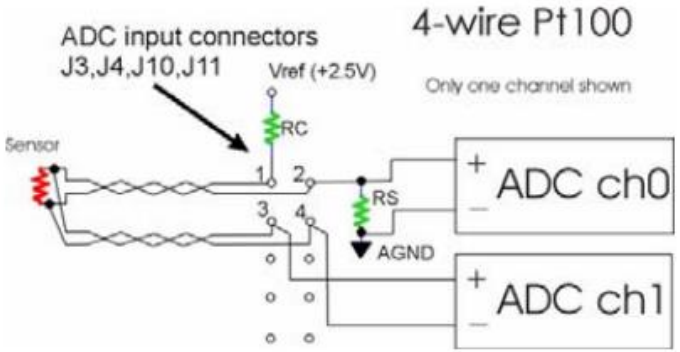
# pt100 4wire adaptor




Schematic diagram




Using two channels eliminates the voltage drop on the wires.
Calibration with an accurate resistor instead of the sensor possible.
RC should keep the current through the sensor low.

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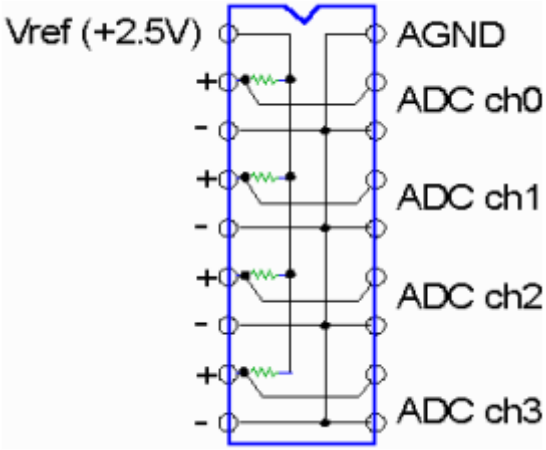
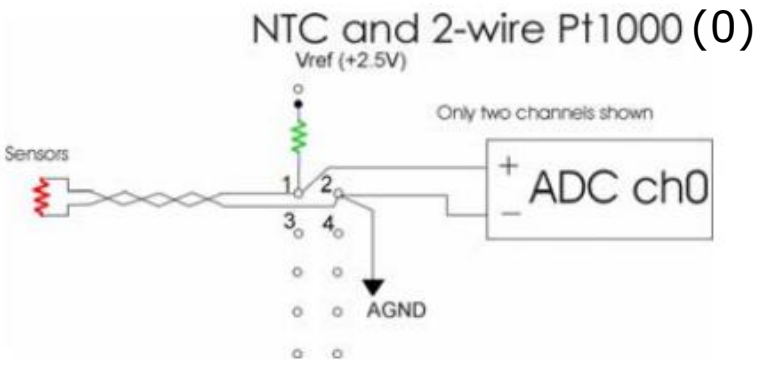
# NTC and pt10000, 2wire

Adaptor




Schematic diagram




Use correct bias resistor depending on sensor
Default option 1 MΩ
For pt1000 there was a batch of 250 adaptors with R=200 kΩ

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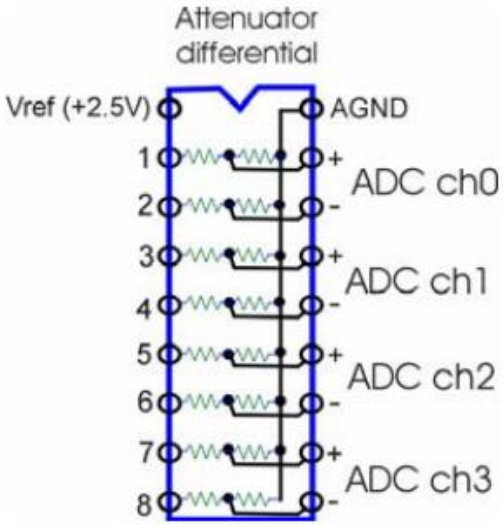
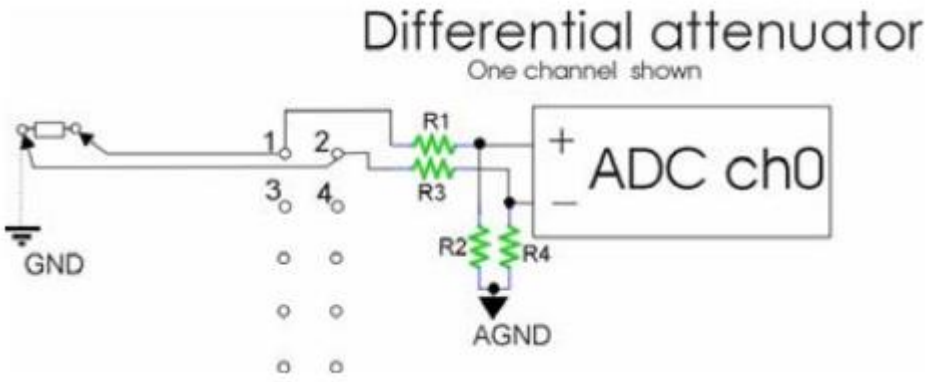
# Differential attenuator

Adaptor




Schematic diagram




For increased voltage range

# Other sensors

- Pressure, humidity etc.
- If output is voltage, straight forward
  - Consider range.
  - Common mode can be limited.
- If output is current one possibility is to use an inline resistor
  - 4..20 mA with 1Ω resistor → 4..20 mV.
  - (Our current sensors more noisy that voltage sensors)
- Conversion in OPC server or WinCC (better).
- Can be used to monitor voltages on detector.
  - The RICH monitors the HV on detector.

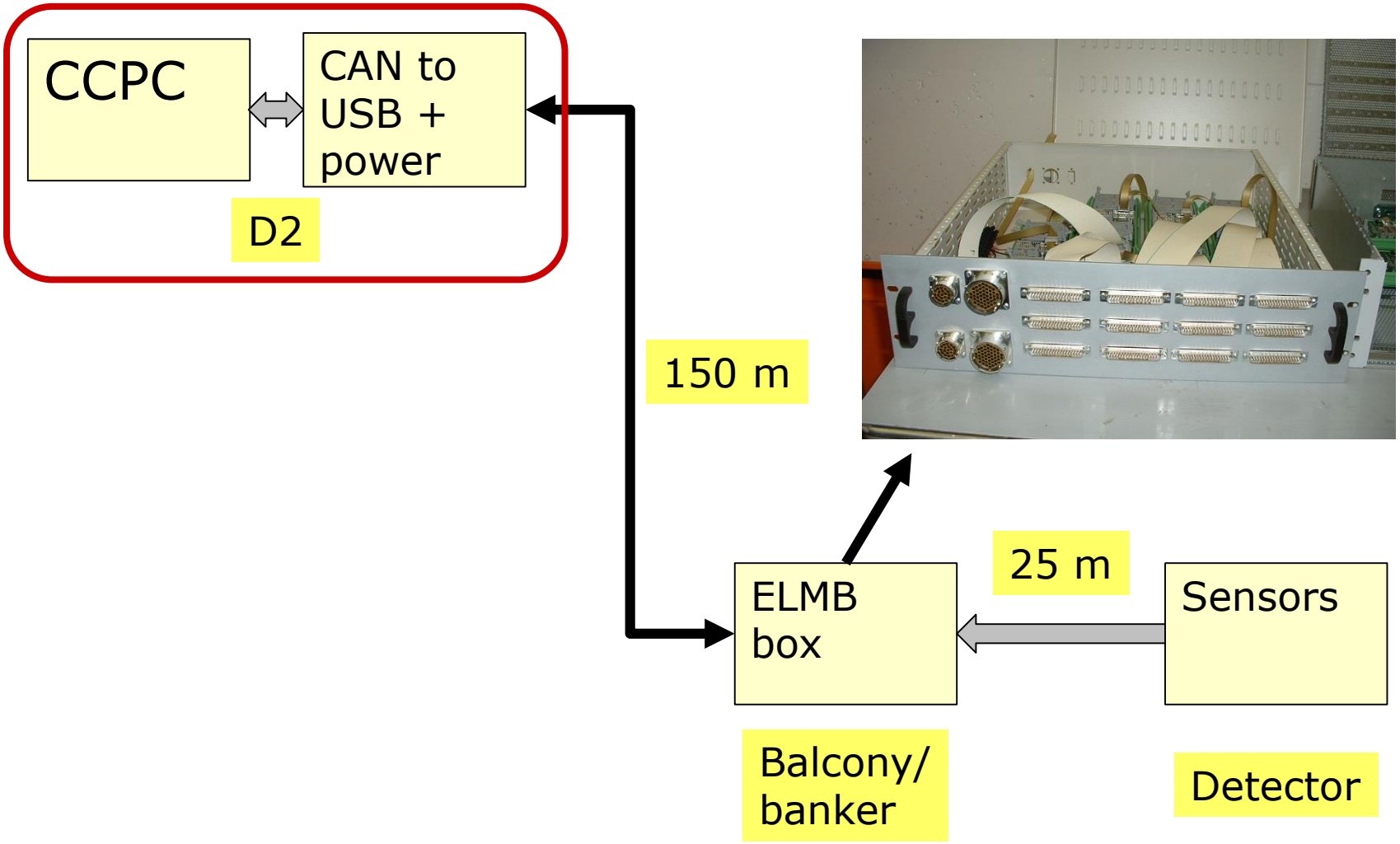
# Monitoring in no time

- Prepare your ELMB with the right adaptors.
- Describe the ELMB in WinCC (very quick).
- Generate OPC configuration file (automatic).
- Start OPC server.
- See values coming in.
- Default pt100 adaptors without calibration accurate to 0.1°C
- With the RICH adaptors pt1000 sensors better than 1°C

# Things to consider

- 64 channels are a lot, but:
  - All have the same range
  - Common mode limited at low ranges
    - -0.15–0.95 V on the three lowest voltage ranges.
    - -2.0–5.0 V in other two.
- Up to 63 ELMBs on a bus.
- Takes 7 s to transmit data from 7 ELMBs on the RICH CAN bus
  - SYNC sent every 10 s.
- High input impedance
  - Disconnecting a connector does not take the voltage to zero.

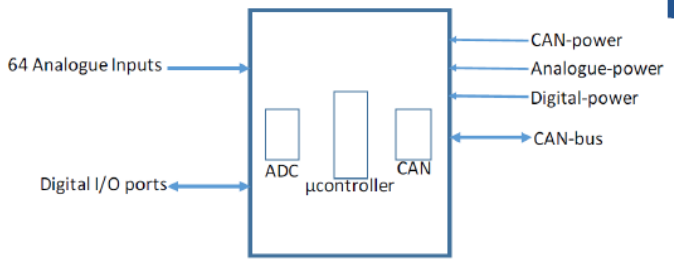
# ELMBs for the RICH



# New developments

## (Recent JCOP workshop)

### a) ELMB




- Galvanic isolation maintained with optocouplers
  - Very sensitive to displacement damage
- Note Analogue and Digital powers common on the CAN-PSU
- 5 digital I/O ports but some protocols not directly supported
  - 1 CAN cycle needed per clock transition
- No DAC outputs

ELMB is obsolete (stock available, rad-soft)
No more CAN-PSU production planed
(repairs still possible)

### b) ELMB+ : Radiation constraints (ATLAS use case)

- Assuming the ATLAS LAr has the largest radiation levels
  - LAr temperature control
  - Local DC-DC high power converters
- HL-LHC constraints
  - ~100 krad
  - ~1.5 $10^{13}$ 1MeV.n.equivallent/cm2
  - ~2 $10^{12}$ >20MeV.hadrons/cm2
- Current "radiation tolerant" ELMB
  - 14 krad
  - 1.2 $10^{12}$ 1MeV.n.equivallent/cm2



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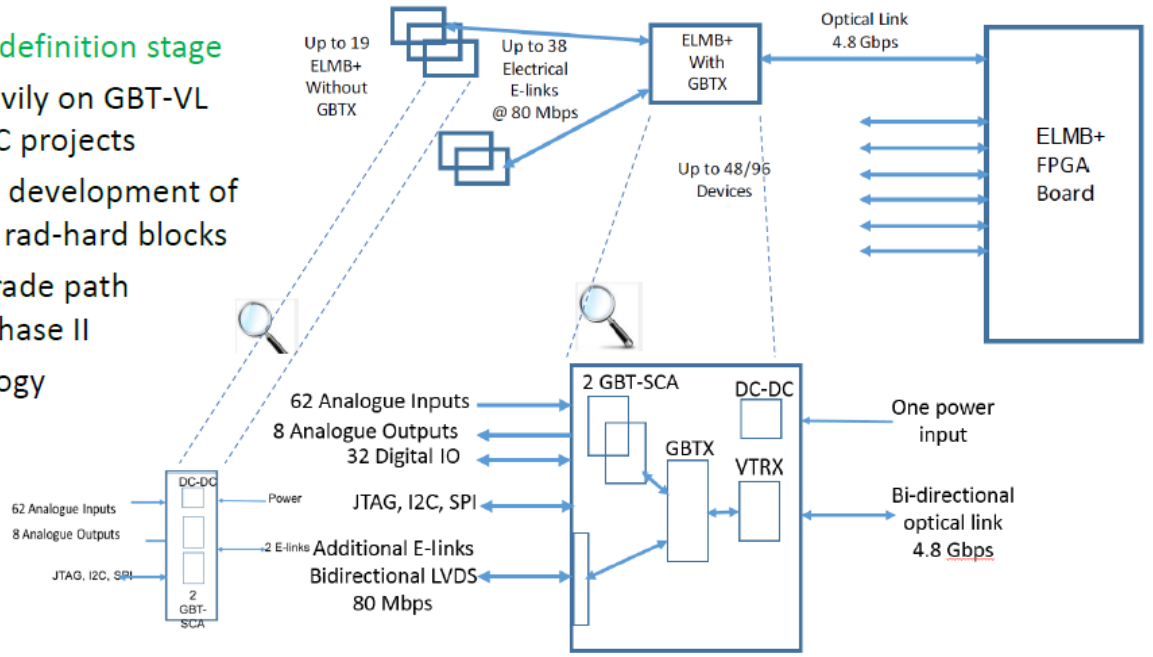
# New ELMB

## c) ELMB+ proposal under discussion

- Project in definition stage
- Based heavily on GBT-VL and DC/DC projects
- Minimizes development of dedicated rad-hard blocks
- Clear upgrade path towards phase II
- Star topology




- ADC in the SCA: 12-bit, 3.5 ksamples/s
  - ~100 measurements of each input per second
- All components exist and are radiation hard qualified
- Can be used as a hub for simpler boards with only the GBT-SCA's and electrical connection to this one
  - @ 80 Mbps. Transmission distance to be characterized
  - Up to 38 additional SCA possible
- A demo board with all these components already exists and can be used for validating the idea



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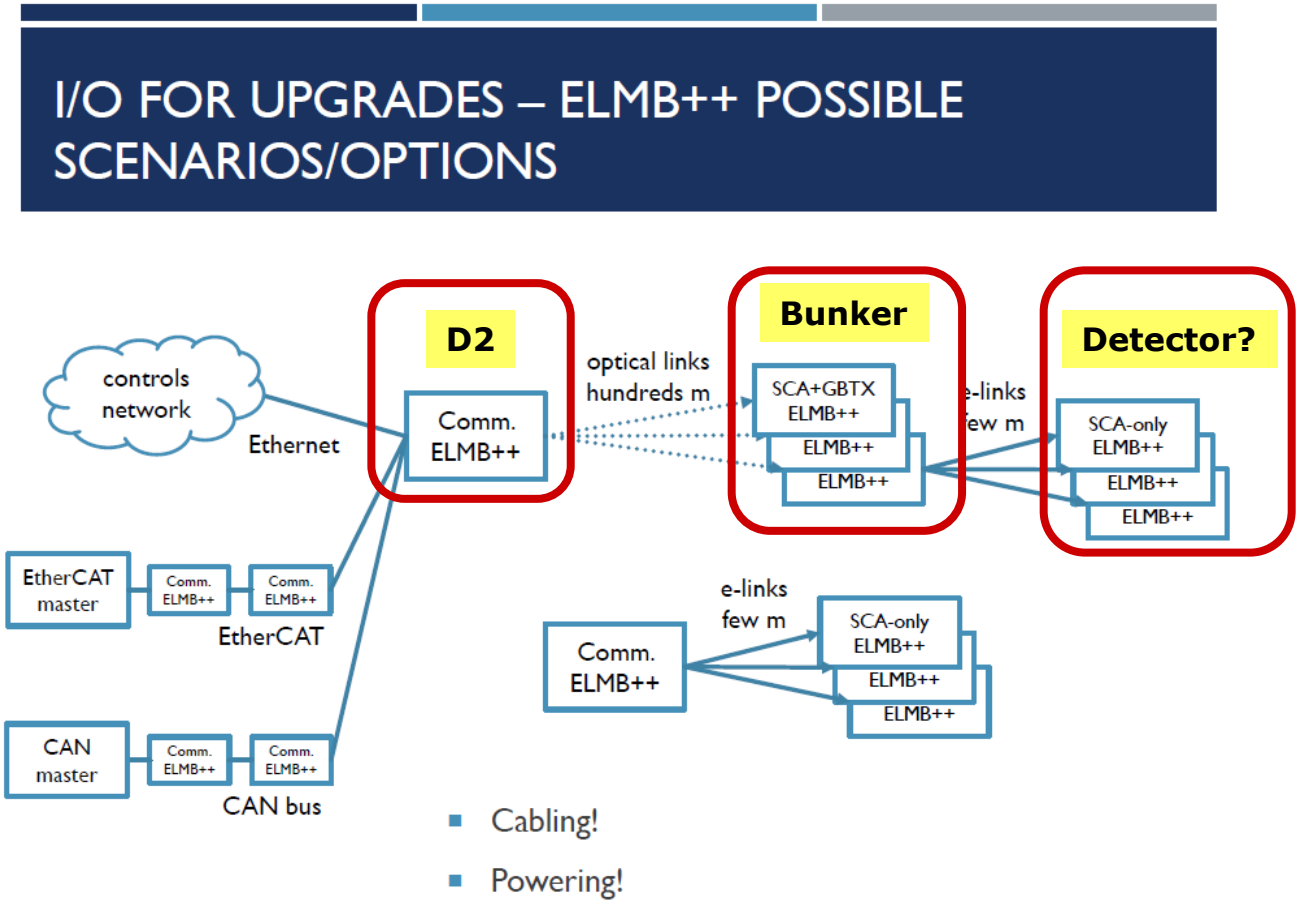
# Possible implementations



# Summary

- Current ELMB offers attractive solution for environmental monitoring
  - Already implemented.
  - Will survive radiation in the bunker/balcony.
  - Need to last another 10+ years.
  - Plenty of spares from MUON upgrade.
- New ELMB++ based on GBT-SCA
  - Solution with existing components
  - Better radiation tolerance
  - Complex
  - Power? (Is it possible use DC-DC and power from D2?)
  - Expensive? (small test systems in the lab?)
  - If starting from scratch…
  - Will need firmware development (similar to SOL40?)