Meeting ILD Electronics and Cooling

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LAL Orsay Feb. 2018

Purpose of meeting

- Coordination of integration of Ecal services (electronics and cooling) is pending since a while
- Progress on both sides
- Hardware development
  - Cooling loop and heat exchangers at LPSC
  - SL-Board at LAL

-> Morning 1: Understand how to bring these devices together
Which constraints and how to remedy them?

- Design
- Considerations on power and cabling needs for Ecal

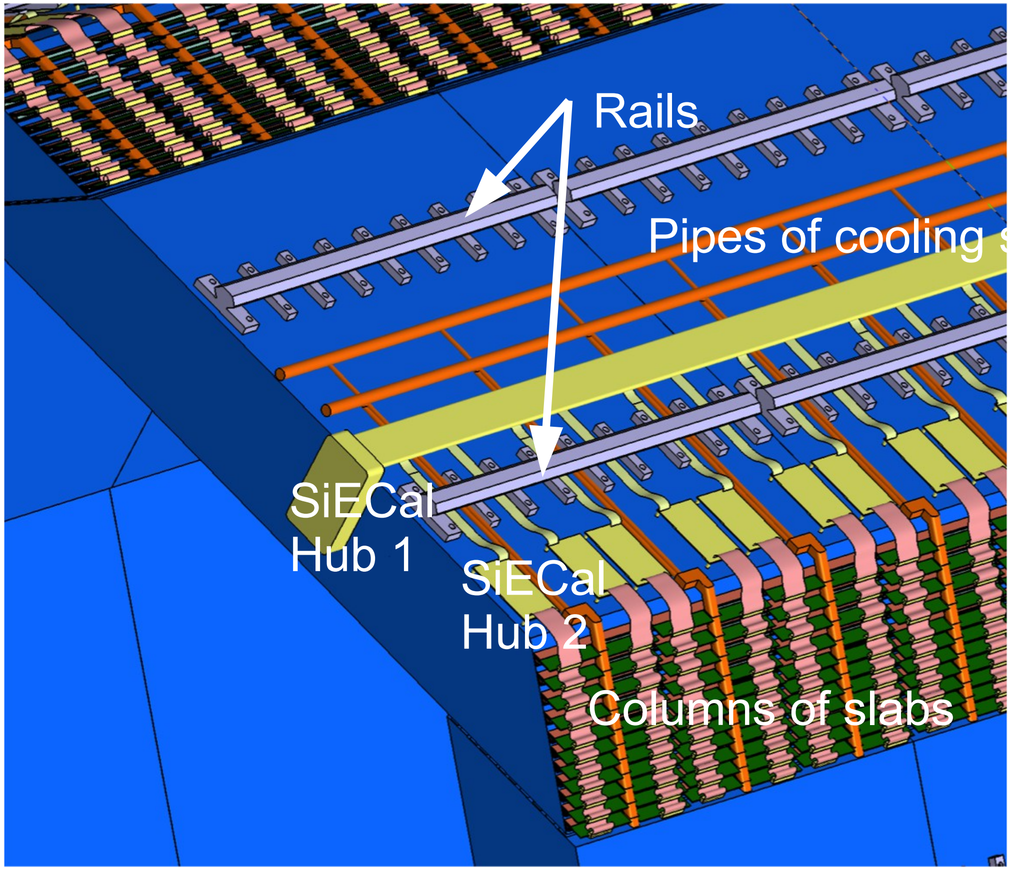
=> Morning 2: Occupation of space between Ecal and Hcal by Electronics Hubs and cooling circuitry

- Technical drawing for cooling system of barrel and endcaps

=> Afternoon 2: Does the cooling system comply with current constraints of ILD in general and the Ecal in particular

Remark: Today concentration (mainly) on Ecal barrel

Between Ecal and Hcal



Current "design"

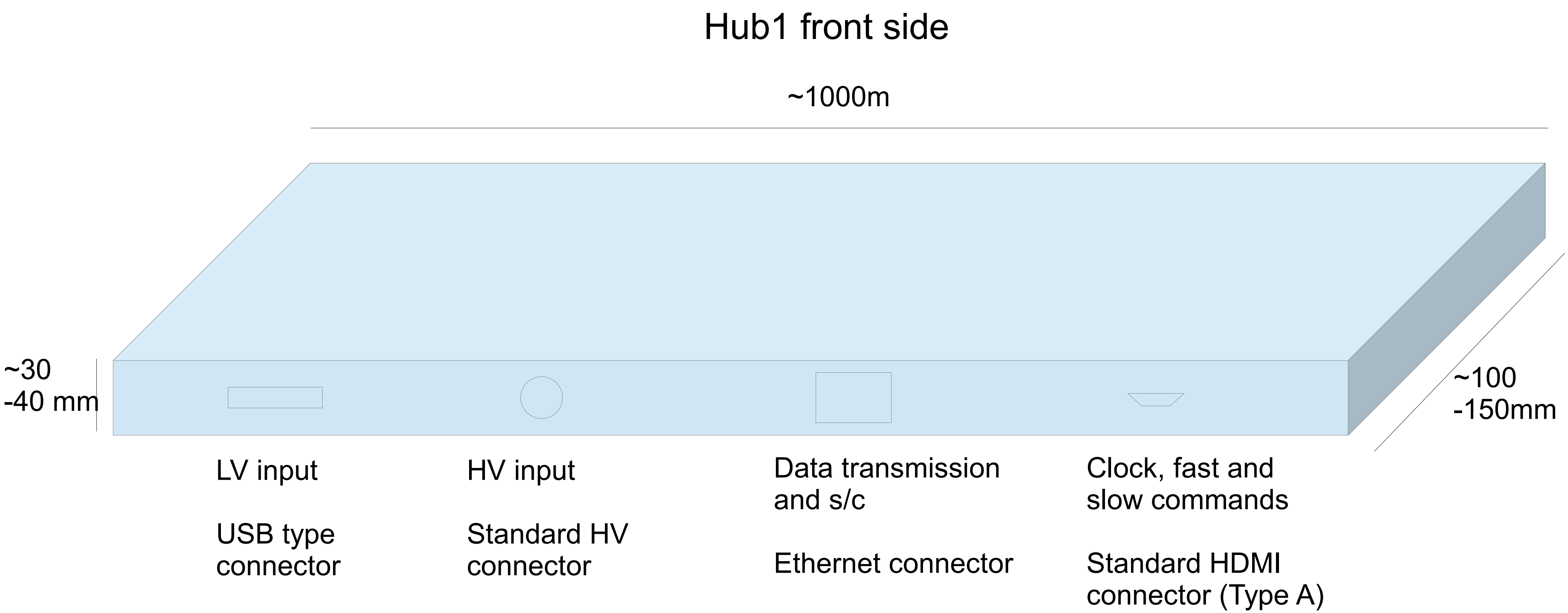
- SiEcal Hub 1
  (hub to external supplies and DAQ)

SiECal internal components

- SiEcal Hub2
  (internal hub to be checked whether heat source)

Hub 1 – Closer look I

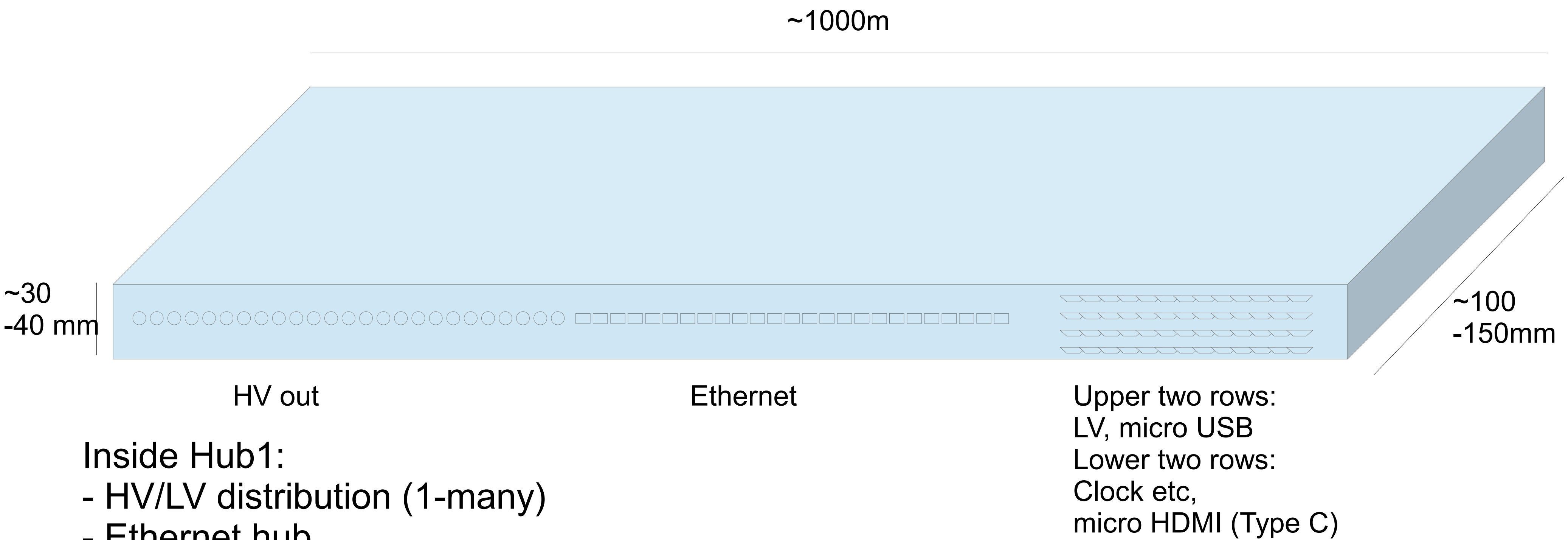
"Old and obsolote drawing by R.P. but hopefully instructive for discussion



Hub 1 – Closer look I

“Old and obsolete drawing by R.P. but hopefully still instructive for discussion

Hub1back side



Inside Hub1:
- HV/LV distribution (1-many)
- Ethernet hub
- Clock fan out, fast signal distribution

- In this design Hub1 supplies all 25 columns of a stave
=> Huge number of cables

- May be doable if enough space available but ... Fixation of TPC needs to be taken into account

Constraint - TPC Fixation

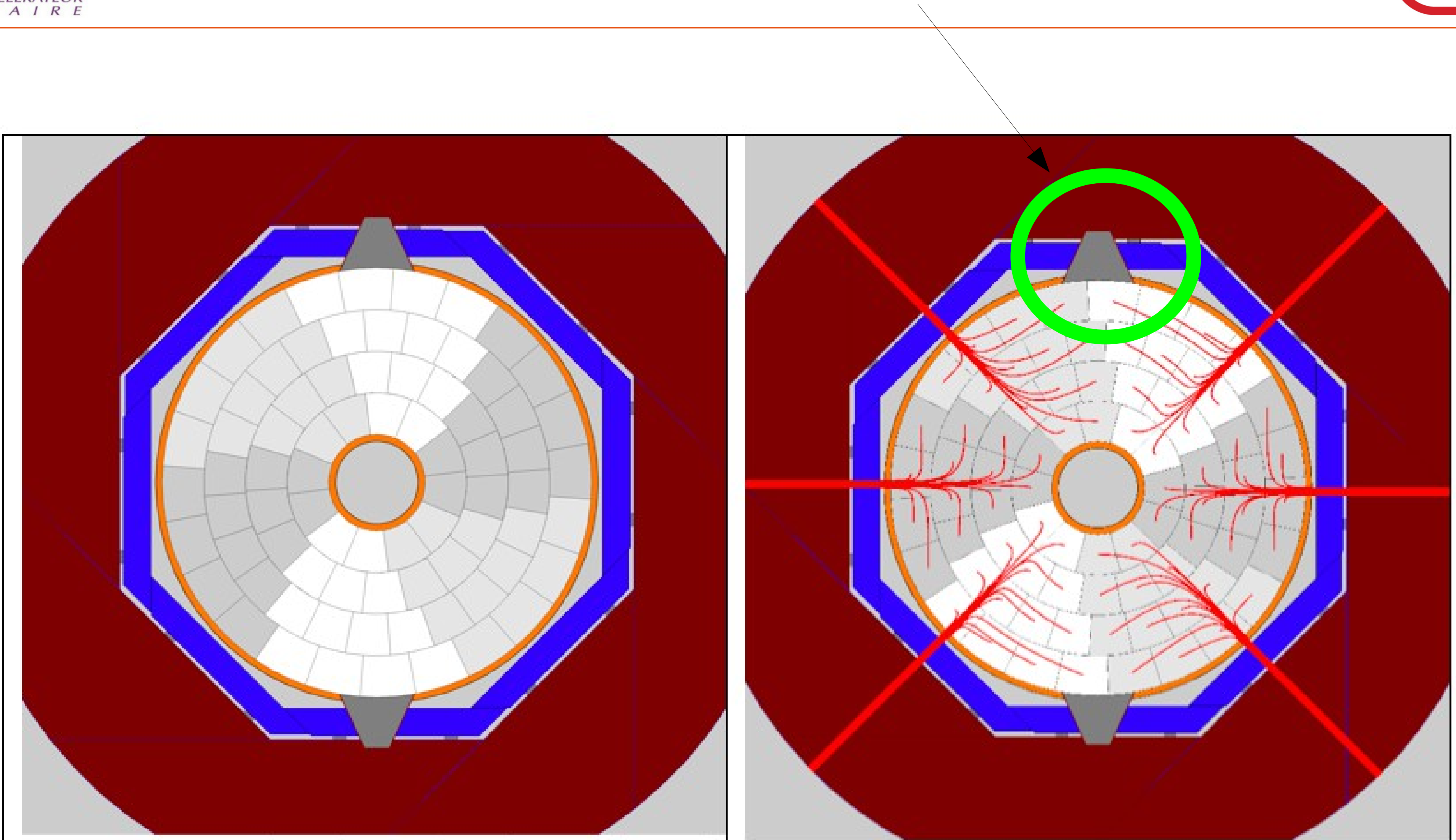


Figure 3. The TPC is shown hanging from the HCal. The ECal barrel is also represented with its rails.

Figure 4. Getting the services out of the TPC. An example.

Hub1 Constraints and consequences

Summary of constraints:

1) TPC Fixation will most likely limit space available for Ecal Hub1

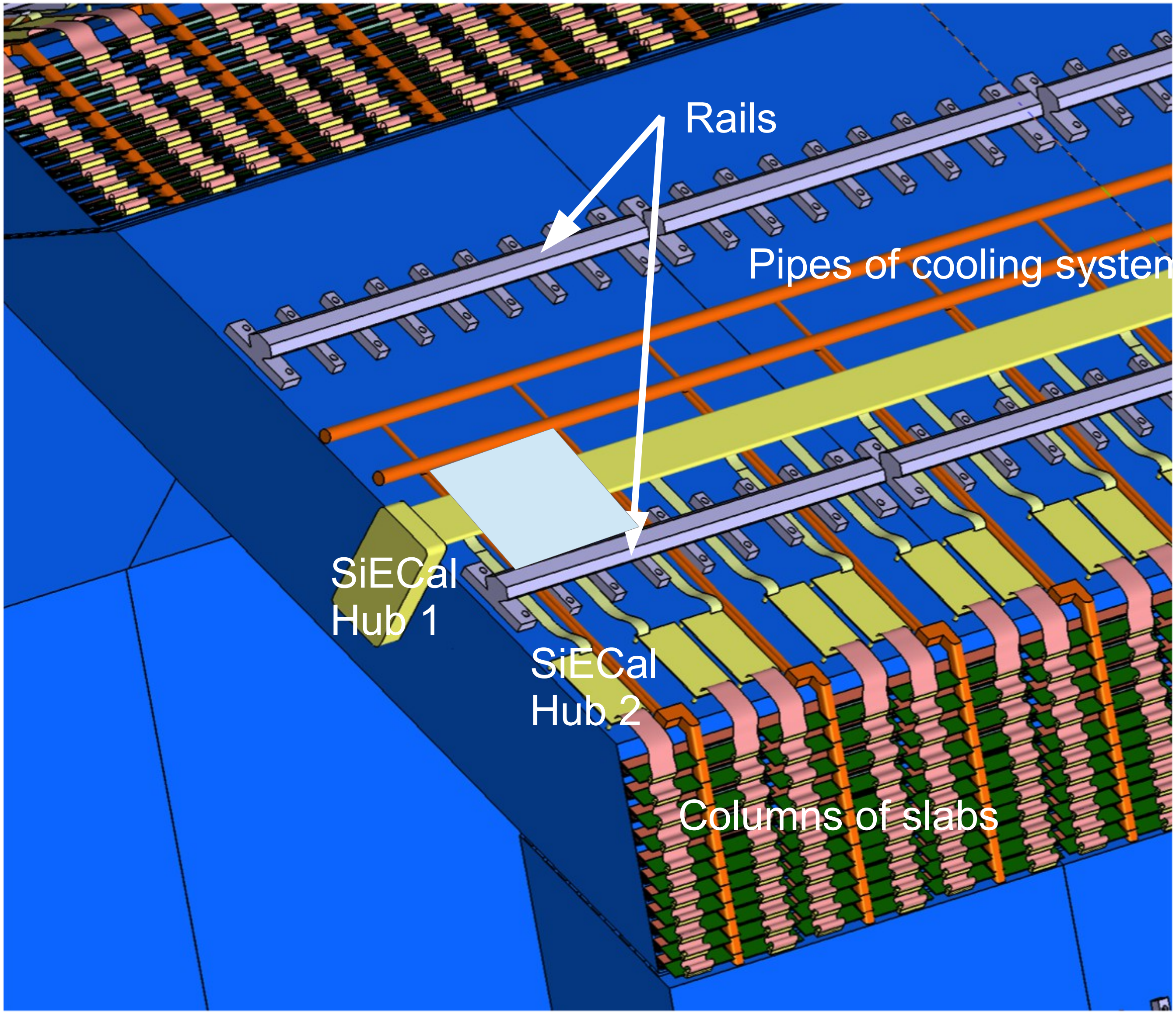
2) Huge number of outgoing and incoming cables renders design very difficult

Consequences:

1) Reduce what is now Hub1 to simple patch panel that receive and fan out limited number of service cables (LV, HV, data transfer)

2) Integrate a very much "slimmed" Hub1 in space between Ecal and Hcal
   that serves Hub2
   Hub1
   In: 48 V LV, 150 V HV, optical fibres for clock and data transfer
   Out: 12 V LV (after DCDC Conversion), 150 V HV, optical fibres for clock and data transfer

New architecture?



New hub sitting beween pipes of cooling system

Cooling system in ILD

Latest (?) drawings from AIDA2020 delivery report:

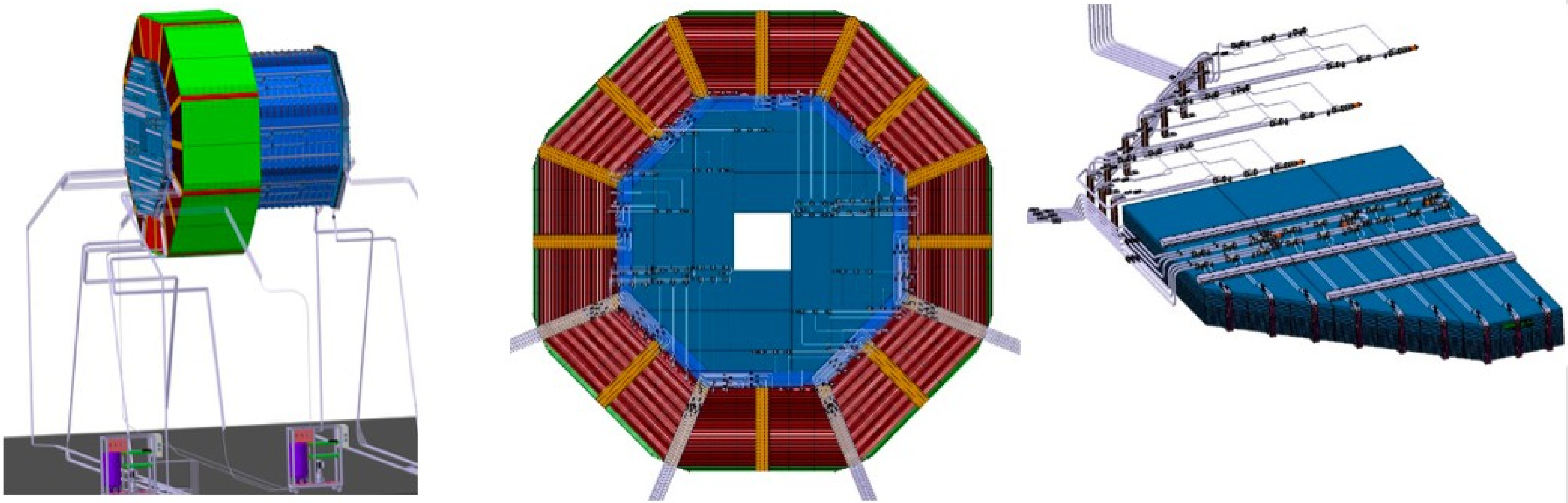
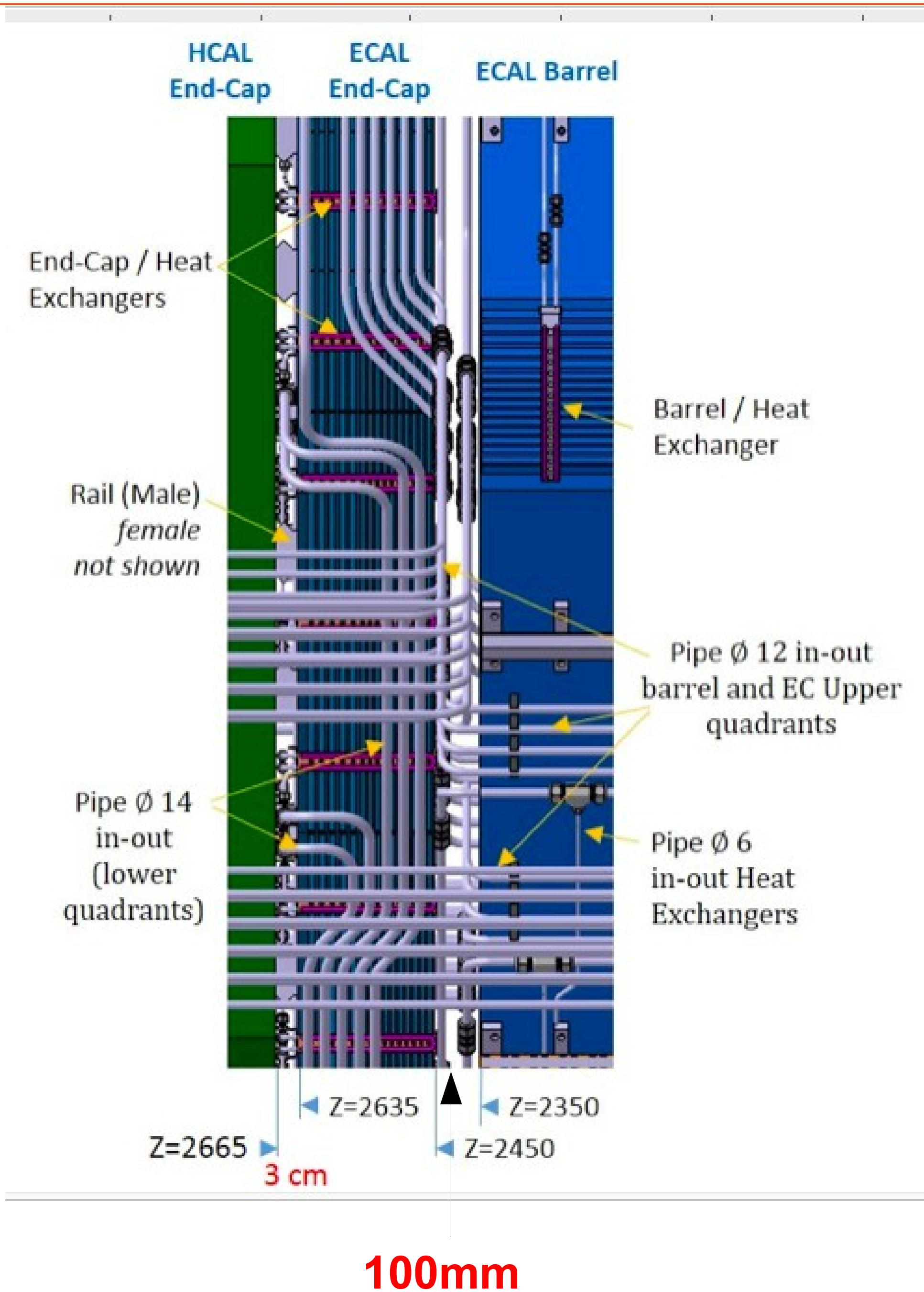
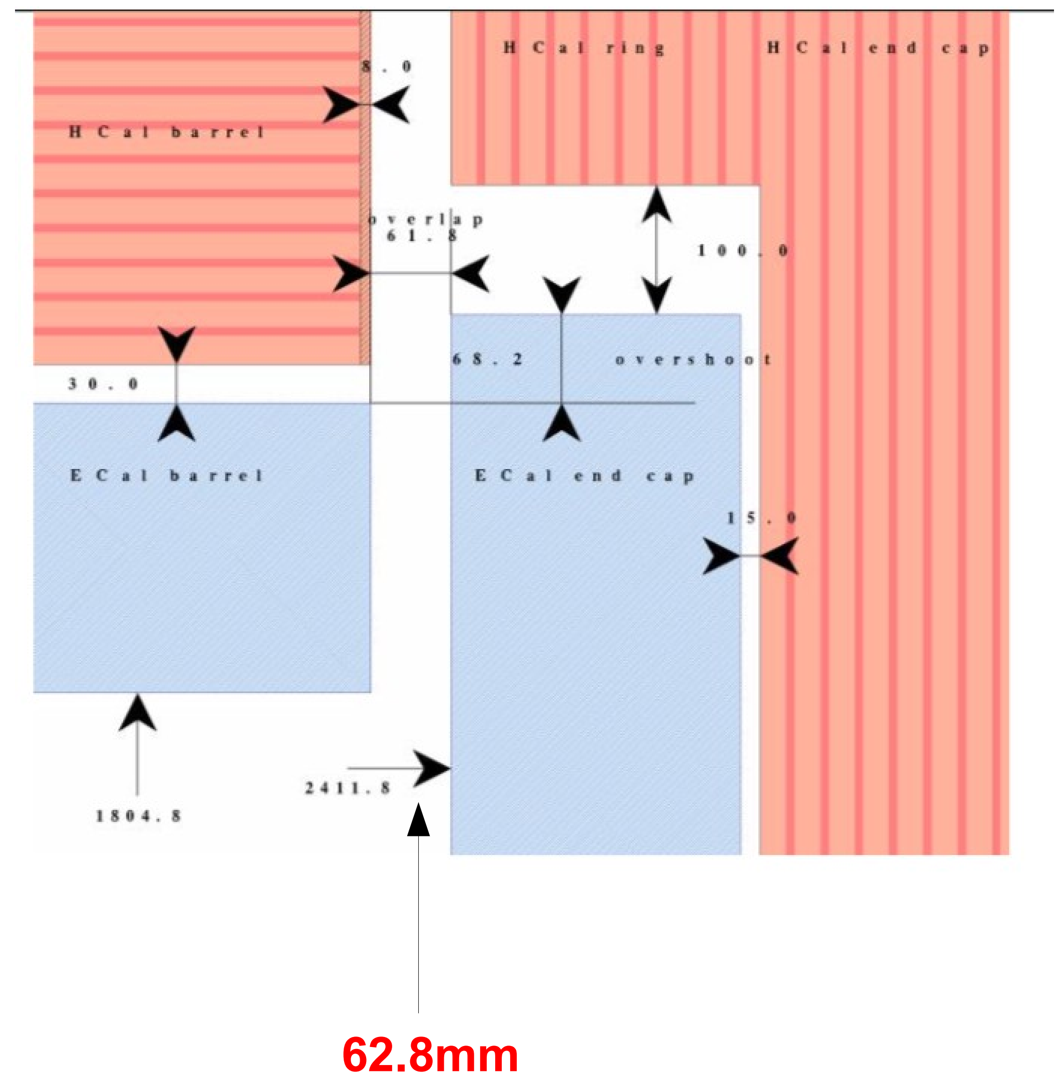


Figure 4: – (Left) Schematics of a general cooling distribution network of SiECAL for 1 Barrel and 2 EndCaps (Middle) Four main cooling lines arriving at the bottom, trough AHCAL, due to sub atmospheric configuration specific distribution network for leak-less cooling (Right) local cooling network on 2 EndCap Quadrants.

Question: Do cooling pipes for barrel enter only on one side of the barrel

Cooling system in ILD





Cooling system in ILD

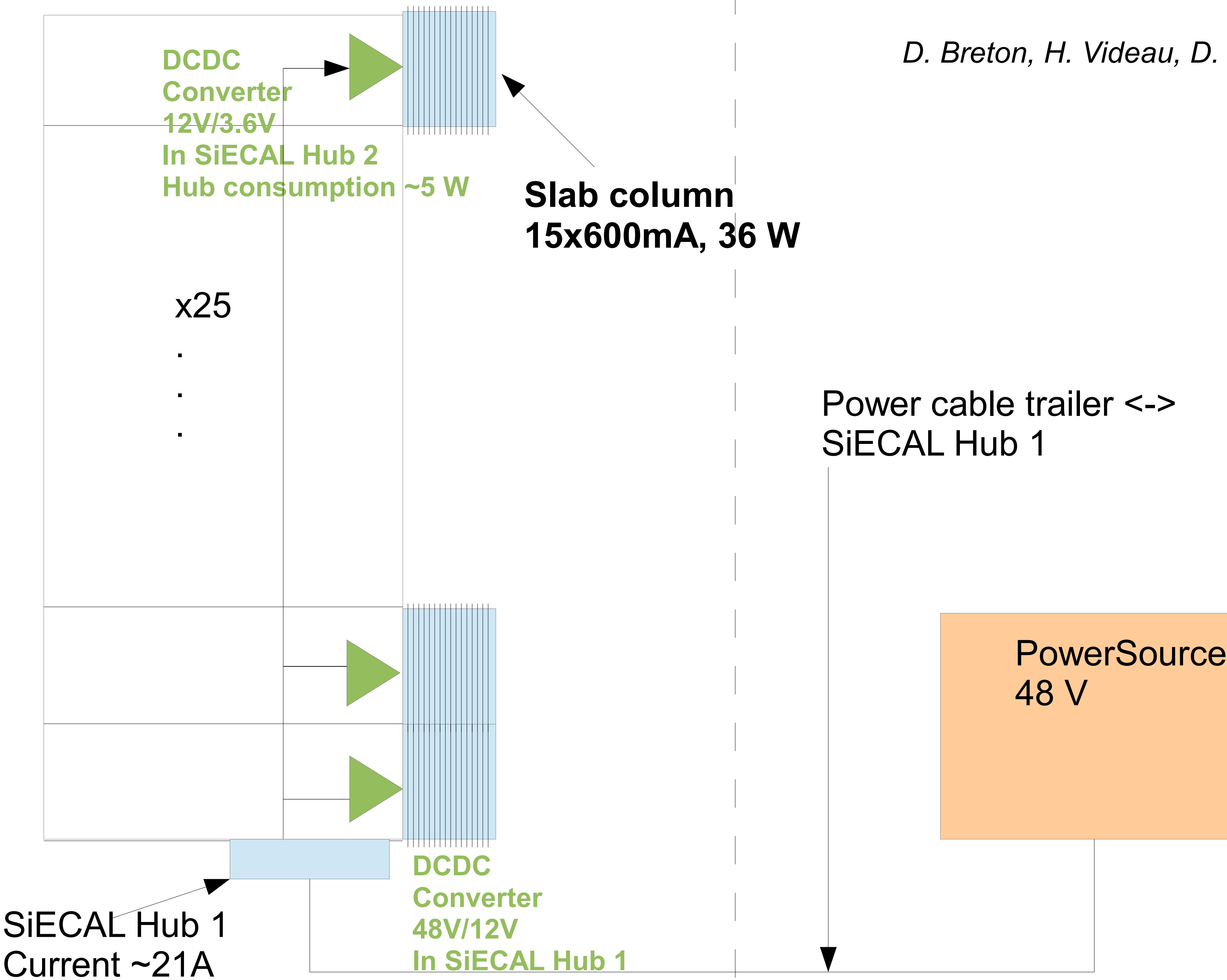
- Comment: Drawing with cooling pipes found in early version of AIDA2020 Report (maybe obsolete)

- If not obsolete: No compliance with current ILD Design

Backup

SiECal – Power supply scheme

D. Breton, H. Videau, D. Zerwas, R.P.



SiECal Power – Some numbers

1) The total power consumption of a stave 41 W (=25 columns) is about
25 x 41W =1000 W

2) These 1000W have to be provided by the main power supply of 48 W
=>current drawn from the power supply is
1000W/48V = 21 A (Note that these are average currents, peak current scale with DCDC conversion)

These 21 A arrive at the SiECAL Hub 1

3) 21 A require a cable with a cross section of about 1.5 mm^2 maybe 2.5 mm^2 .

Voltage drop:
ΔU = (0.0171/1.5)Ohm x 21A = 0.24 Volt => ~5 Volt after 20m in case of 1.5 mm^2
with a thermal dissipation of 0.24Vx21A ~ 5W/m
ΔU = (0.0171/2.5)Ohm x 21A = 0.14 Volt => ~3 Volt after 20m in case of 2.5 mm^2
with a thermal dissipation of 0.14Vx21A ~ **3W/m**
ΔU = (0.0171/4)Ohm x 21A = 0.09 Volt => ~1.8 Volt after 20m in case of 4 mm^2
with a thermal dissipation of 0.09Vx21A ~ 2W/m

Cable thickness subject to compromise between material budget and thermal dissipation

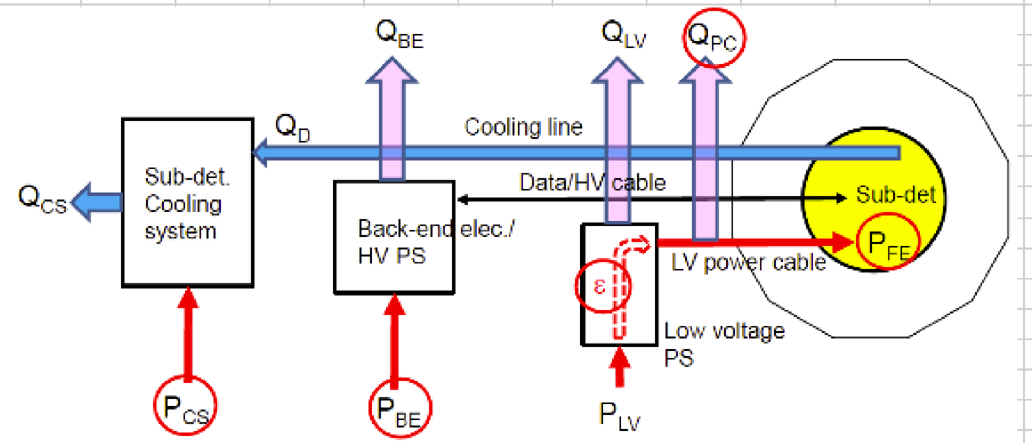
=> Propose to choose 2.5 mm^2 (requires coordination with other detector components)
Remark: Numbers agree with the ones provided by C. Clerc and R. Cornat for DBD

Utility survey

Distributed by Yasuhiro beginning of September

Example SiEcal Power

05/09/18			
	Sub-detector name	ECAL	
P_FE	Power consumption of Front-end Electronics	17	kW
Q_PC	Heat loss in Power Cables	1	kW
e	Efficiency of low voltage power supply	90%	
P_BE	AC Power input to Back-end Electronics		kW
P_CS	Electric power to drive Cooling System	8	kW
	Type of cooling water for cooling system	Chilled water	
P_LV	AC Power input to Low Voltage power supply	20	kW
Q_LV	Heat loss in Low Voltage power supply	2	kW
Q_BE	Heat loss in Back-end Electronics	0	kW
Q_CS	Heat to be extracted from cooling system	25	kW

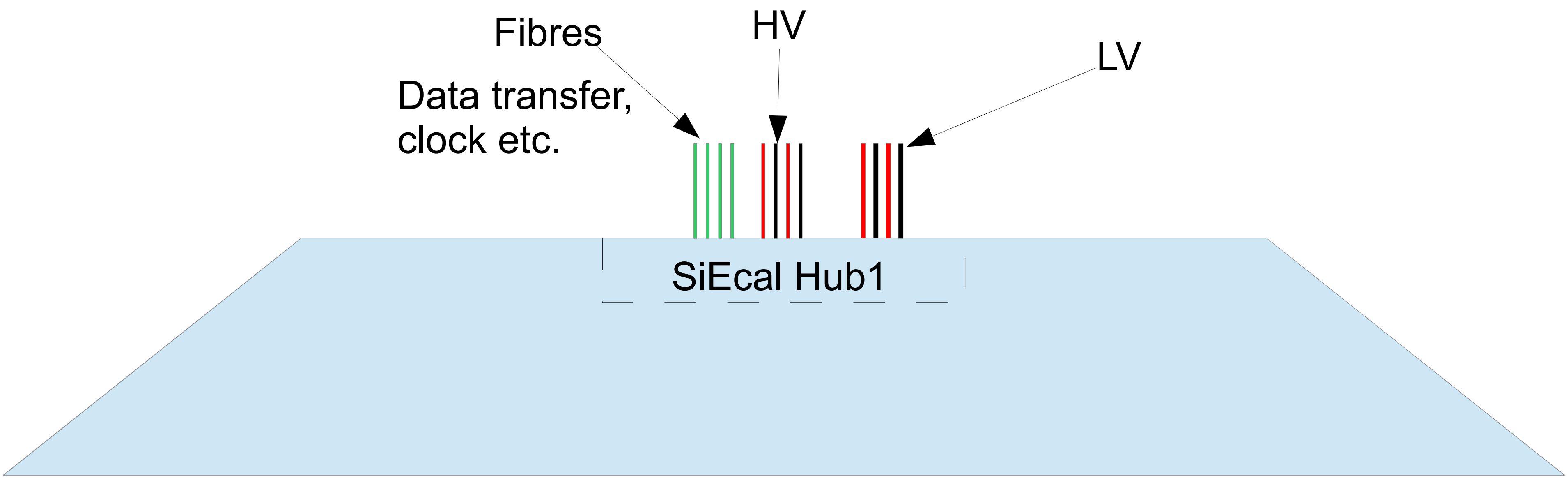


- P_{FE} : Power consumption of sub-detector Front-end Electronics
- Q_D : Heat loss in sub-det. (= P_{FE})
- Q_{PC} : Heat loss in power cables
- P_{LV} : AC power input to LV PS
- ε : Efficiency of LV PS ($P_{LV}*\varepsilon= P_{FE}+Q_{PC}$)
- Q_{LV} : Heat loss in the LV PS (=$(1-\varepsilon)*P_{LV}$)
- P_{BE} : AC power input to back-end elec./HV power supply
- Q_{BE} : Heat loss in the BE/HV PS (=P_{BE})
- P_{CS} : Electric power to drive the cooling system
- Q_{CS} : Heat to be extracted from cooling system (= Q_D+P_{CS})

Numbers were pre-filled but seem about to be correct

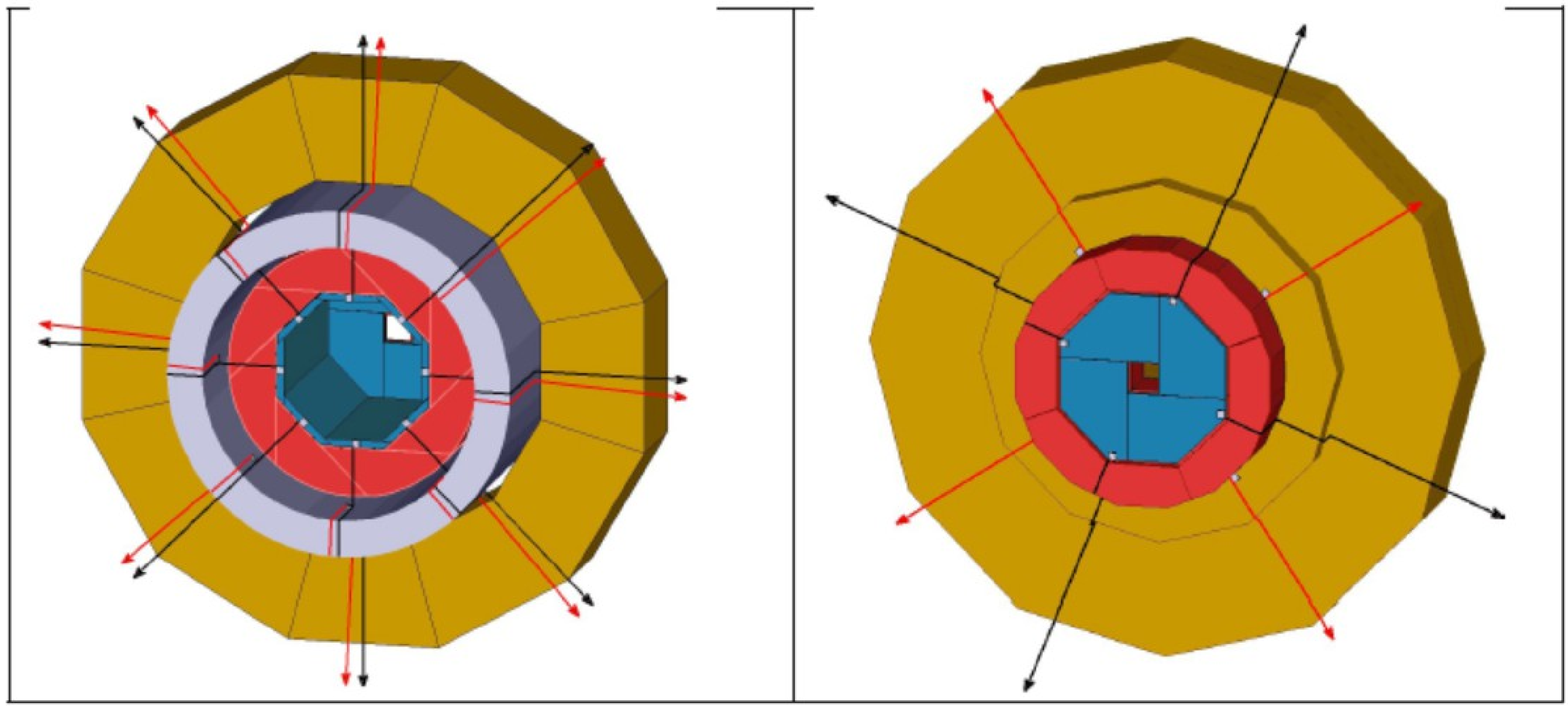
Note that this survey contains all subdetectors

SiECal Power – Cables/Fibres arriving at Hub1



- Not to scale!!!
- Number of cables include redundancy
  - LV cables will constitute a block of about 10x2.0 mm^2
  - HV cables can be even thinner since they don't carry current O(10 mA)
  - Space consumption by optical fibres is also negligible
- Professional CAD drawing will be provided by A. Gonnin at the beginning of November
- SiEcal Hub1 has to be designed

SiECAL – Service lines



- Service lines leaving from barrel
- Service lines leaving from endcap

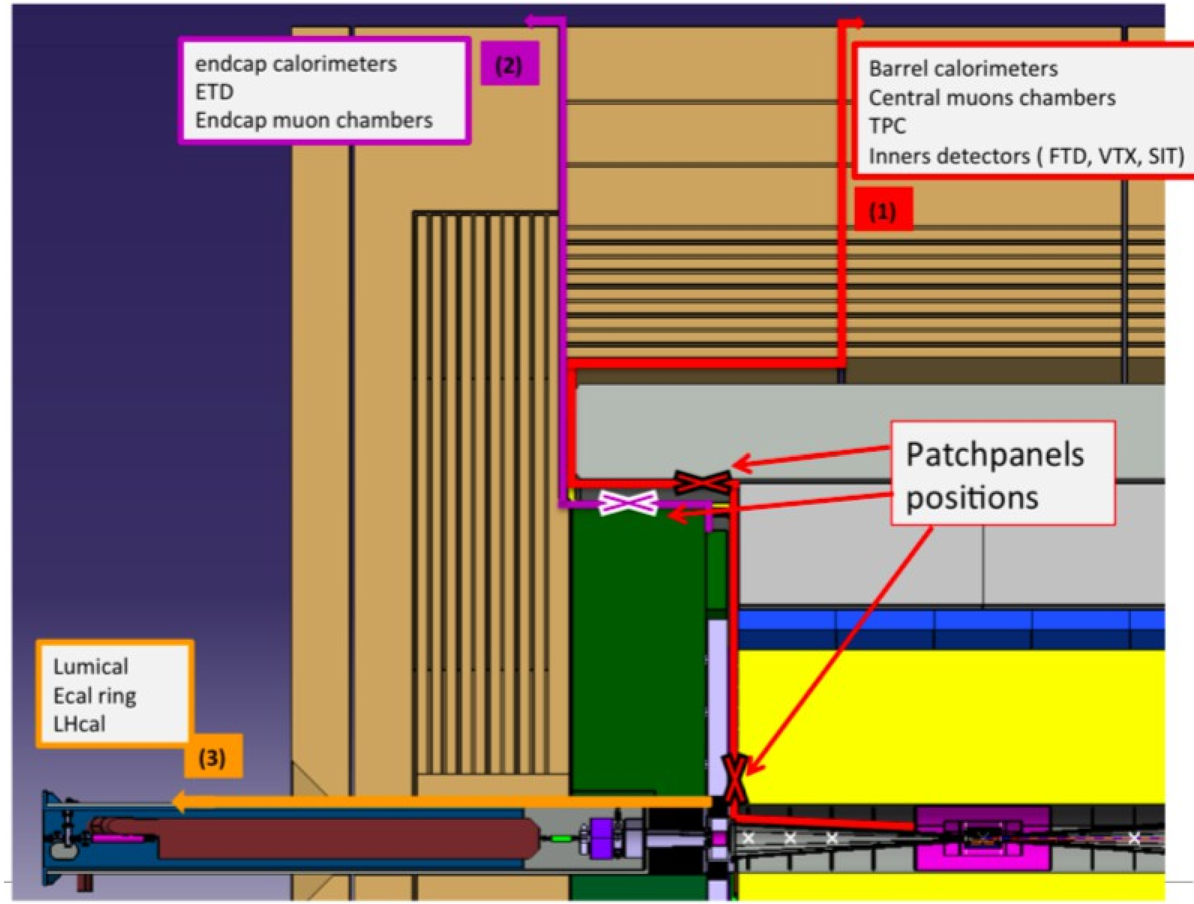
Drawing by Henri

ILD Cabling

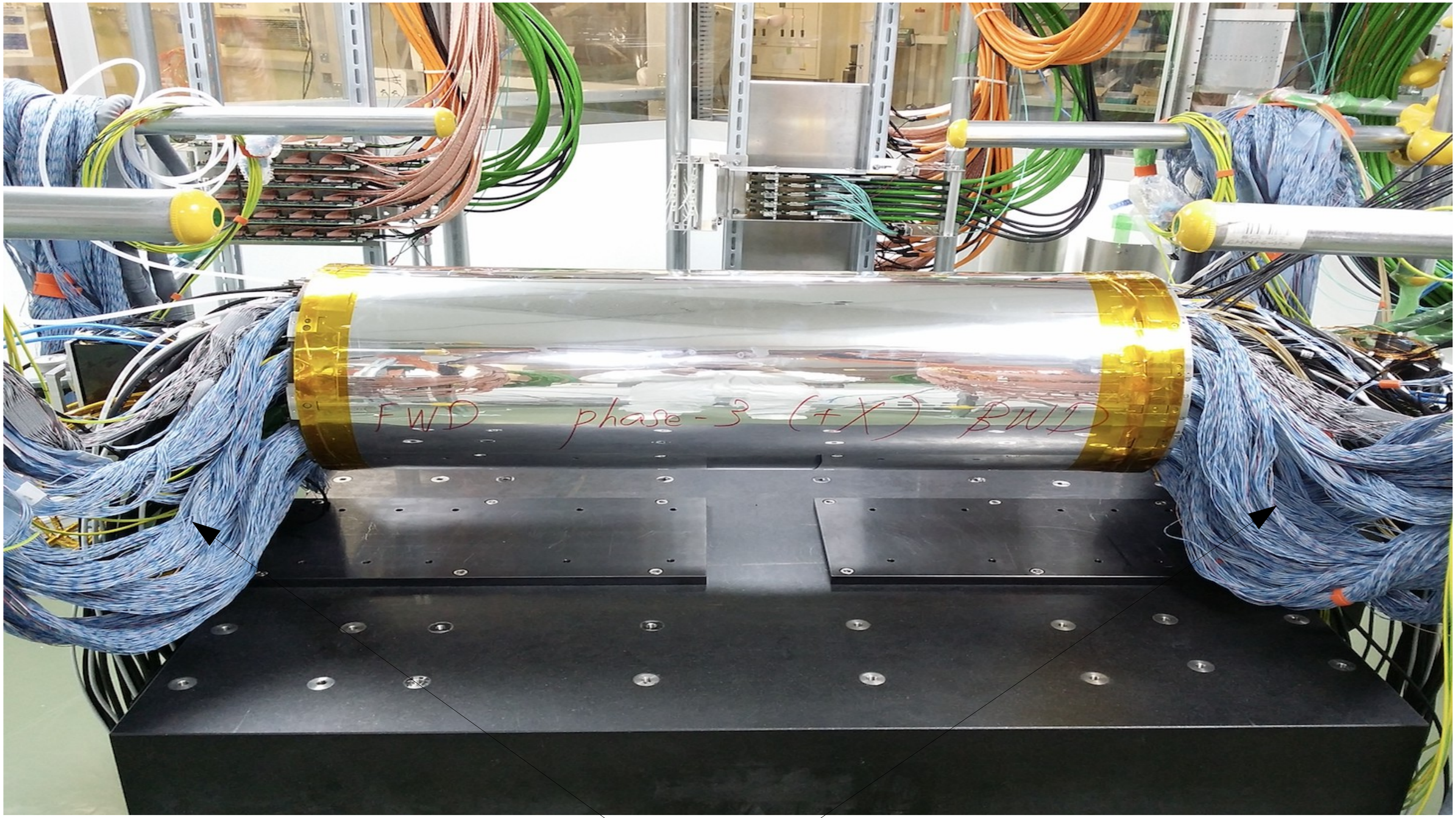
- Drawing as shown by Karsten in Fukuoka

- Coordination of review of Cable and services by R.P.
- Prefered to do “my” homework before annoying others

- Take this talk as the first call to send me “your” updated cabling schemes



The reality !? Belle II Vertex Detector



Cables!!!!

Thin but many

To do list - Electrical interfaces

- Have to assume my charge and coordinate cable and service revision

- Started with understanding system requirements for Ecal and to request updated technical drawings for SiEcal
  - First step: From trailer to first hub
  - Power consumption agreed very well with pre-filled number in survey by Yasuhiro
    - Numbers on cable thicknesses agree with those from DBD (not a miracle but good to know)
    - Numbers don't look critical

- SiEcal power scheme (most likely) requires DCDC Converters
  - Basis of current considerations but subject of technical decision
  - (Not today) survey on possible products by D. Breton over summer
  - DCDC converter is pulsed device that operates in magnetic field
  - Some negative experience in CMS

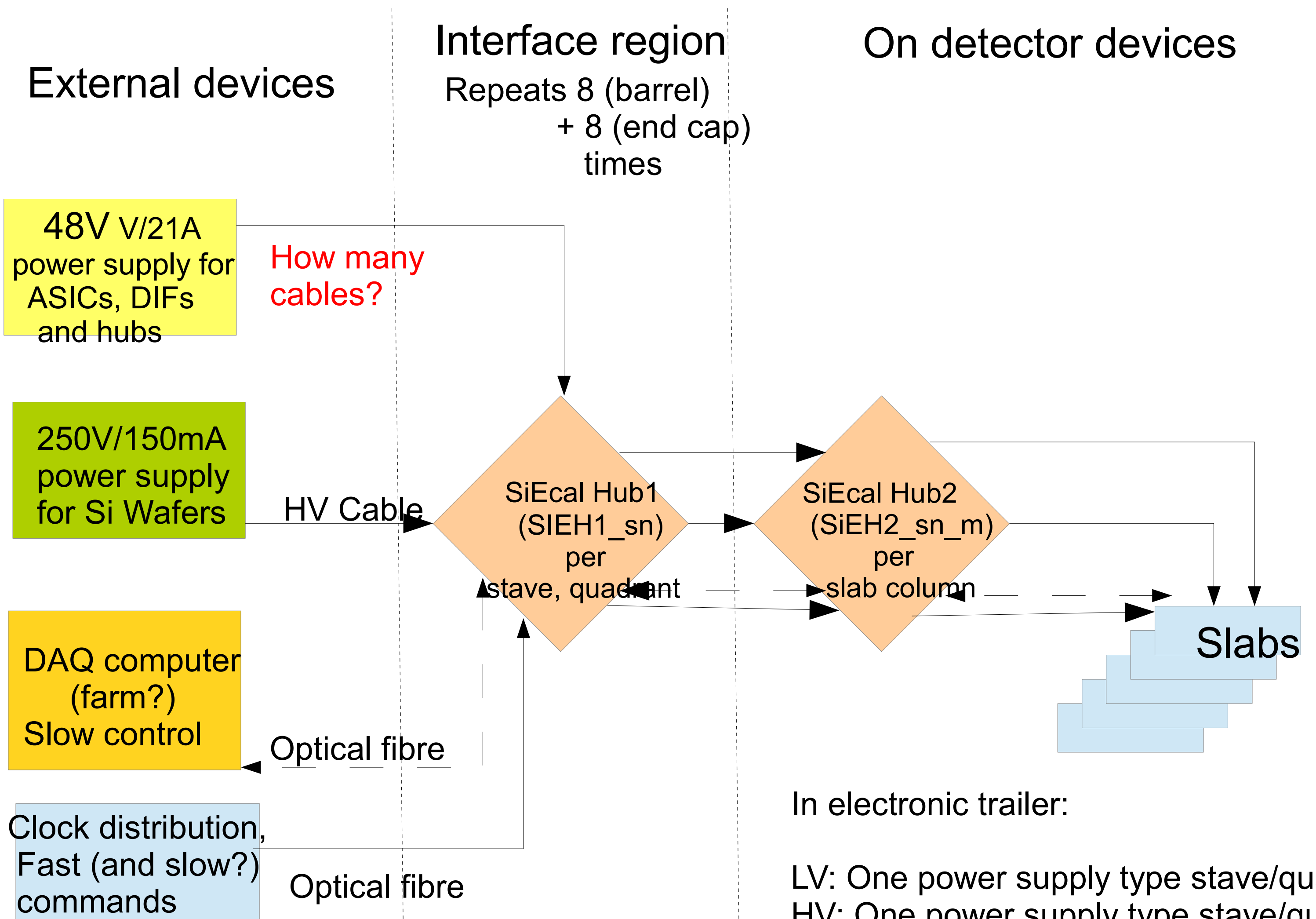
- Considerations for other detectors not using DCDC Converters exist

- Power dissipation and influence on other detectors to be understood
  - e.g. Ecal -> Hcal <= 5 W/m, can this be cooled away by Hcal cooling?
  - Subject to discussion

- The list is for sure much longer and sorry for being late ...

Backup ....

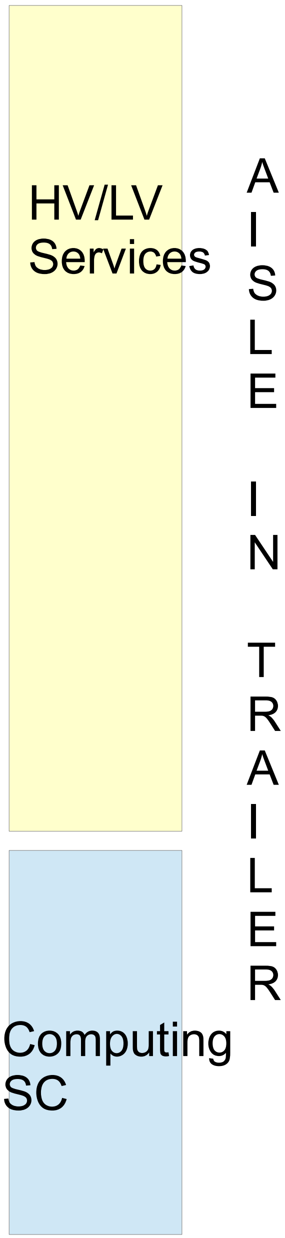
Supplies – Naive block scheme



In electronic trailer:

LV: One power supply type stave/quadrant
HV: One power supply type stave/quadrant
DAQ farm: 1 computer stave/quadrant for acquisition
Slow control: One slow control computer
One clock source

Ecal in trailer



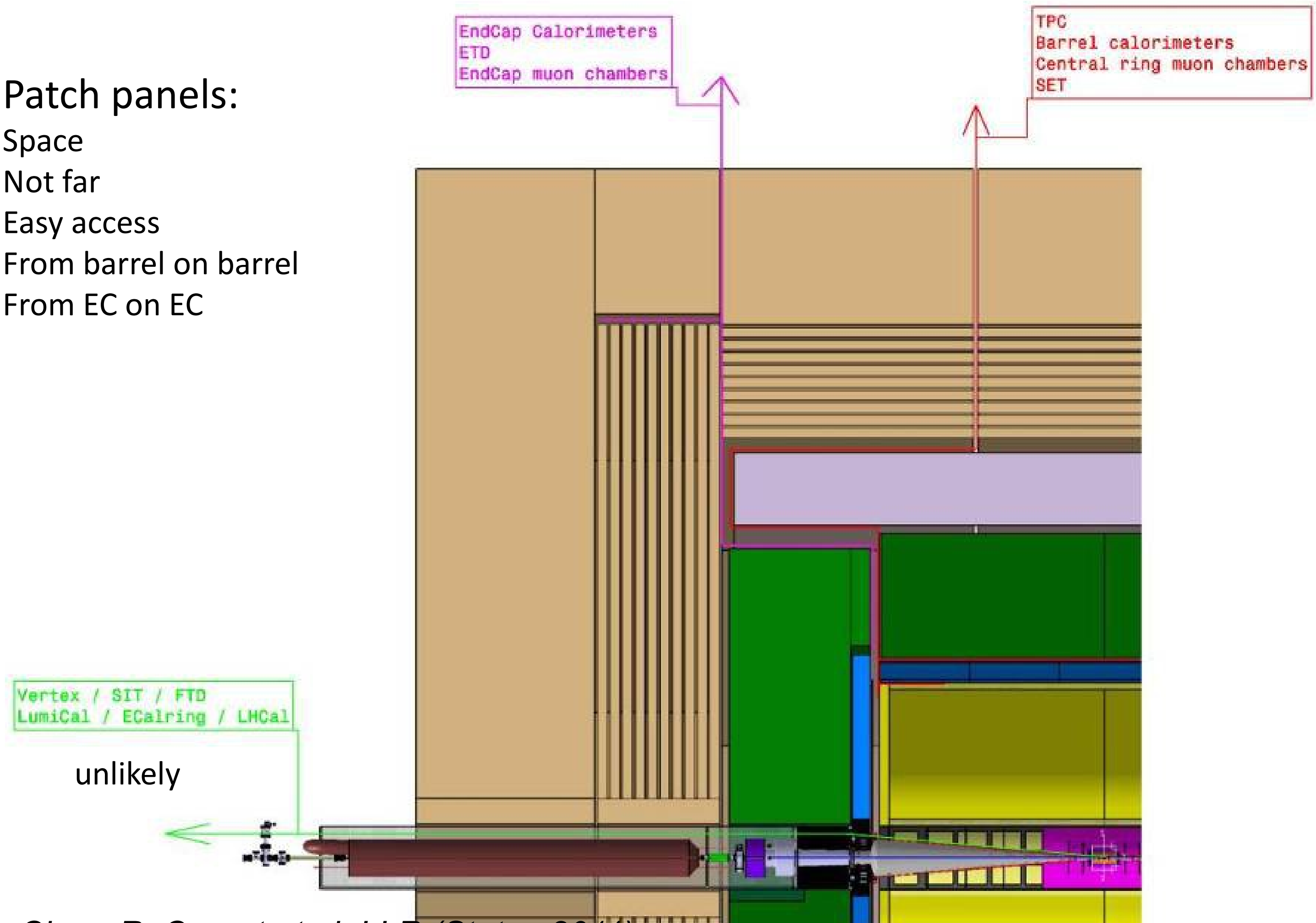
One aisle should be enough
Add a second as safety margin

Cabling and power

A reminder

Patch panels:

Space
Not far
Easy access
From barrel on barrel
From EC on EC



C. Clerc, R. Cornat et al. LLR (Status 2011)

Study for DBD needs regular update!!!!
Use ICD

On DCDC Converters

... a poor man's point of view

- The advantage of a DCDC converter is that is realises the step down of the voltage **without** ohmic losses (in contrast to a “simple” linear regulator)

- From a “crash course” on DCDC converters I have learned that energy is stored in an inductor during time t_{on} and released during a time t_{off}
  The output of a (Buck) DCDC Converter is $V_{out} = V_{in} \times t_{on}/(t_{on} + t_{off})$
  The duty cycle V_{out}/V_{in} determines the average current that is drawn from the power source V_{in}

- Ay each layer the voltage 4V is available from a 12V/4V DCDC Converter.
  The total current of a layer is 200mA (regard SL-Boards only for simplicity)

- Therefore the average current drawn from the power source is in this case (4/12)x200mA = 66mA