Power Distribution
Existing Systems

- Power in the trackers
- Power in the calorimeters
- Need for changes

Introduction

- Similar power needs for the ATLAS & CMS trackers and for the ATLAS & CMS calorimeters

	CMS			ATLAS		
		Power	*Current*		*Power*	*Current*
Tracker	**Pixel**	3 kW	1.5 kA	**Pixel**	6 kW	3.7 kA
	Si Strips	31 kW	15 kA	**Si Strips**	18 kW	6 kA
				TRT	22 kW	6.5 kA
EM Calorimeters	**ECAL**	116 kW	46 kA	**Larg***	140 kW	27 kA
				** Including the hadronic end-cap*		

Power dissipated by the front-end electronics

- However different solutions have been implemented

- Useful to look at them and see whether they could be used for SLHC

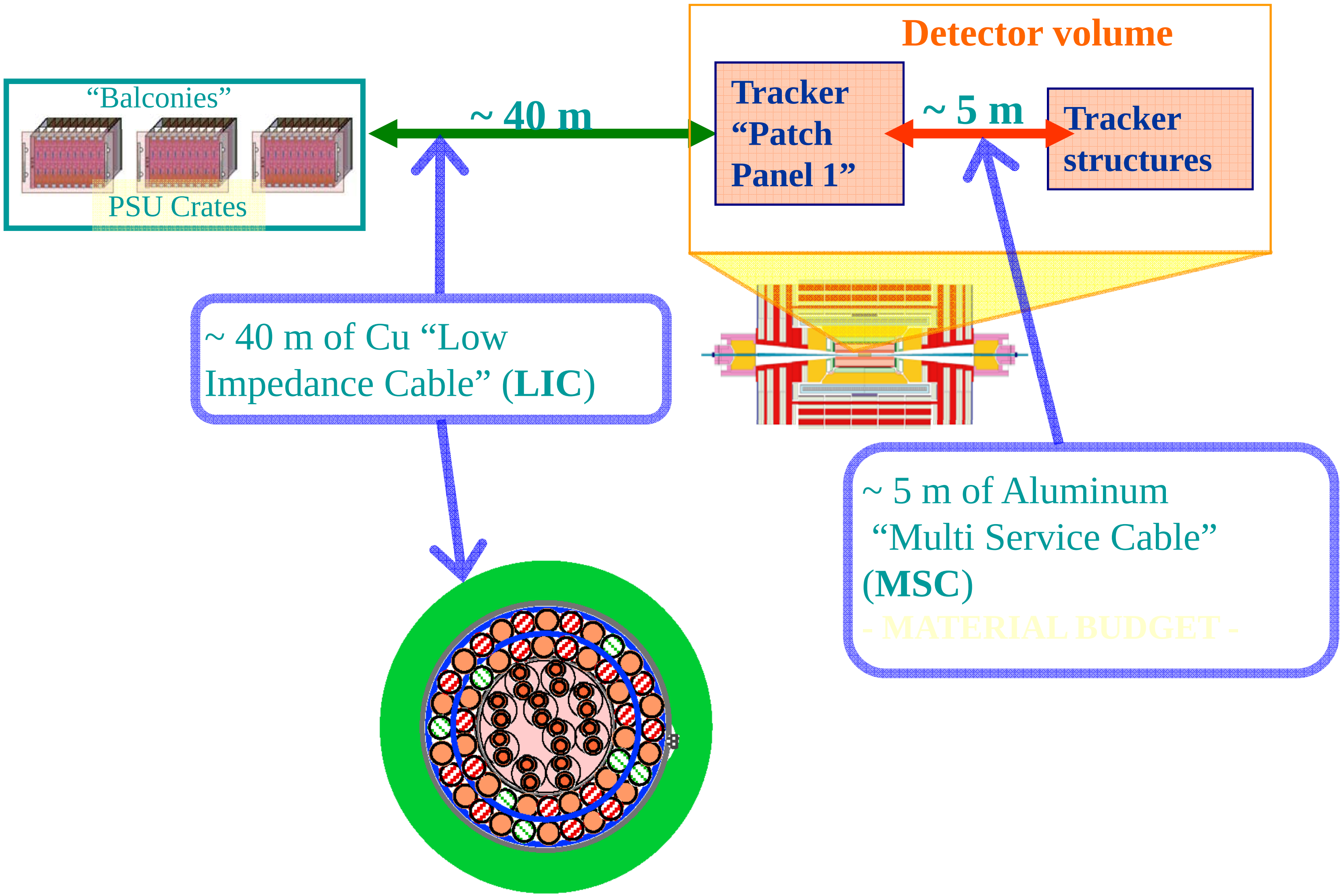
ATLAS & CMS Silicon Strips

- Same concept:
  - Regulated power supplies out of the detectors
    - One per detector module in ATLAS (4088 modules)
      - In the control rooms → > 100-m cables
      - 4 power lines (4 V, 3.5 V, opto devices)
    - One per group of modules in CMS (1944 groups)
      - In the experimental cavern → 45-m cables
      - 2 power lines (2.5 V and 1.25 V)

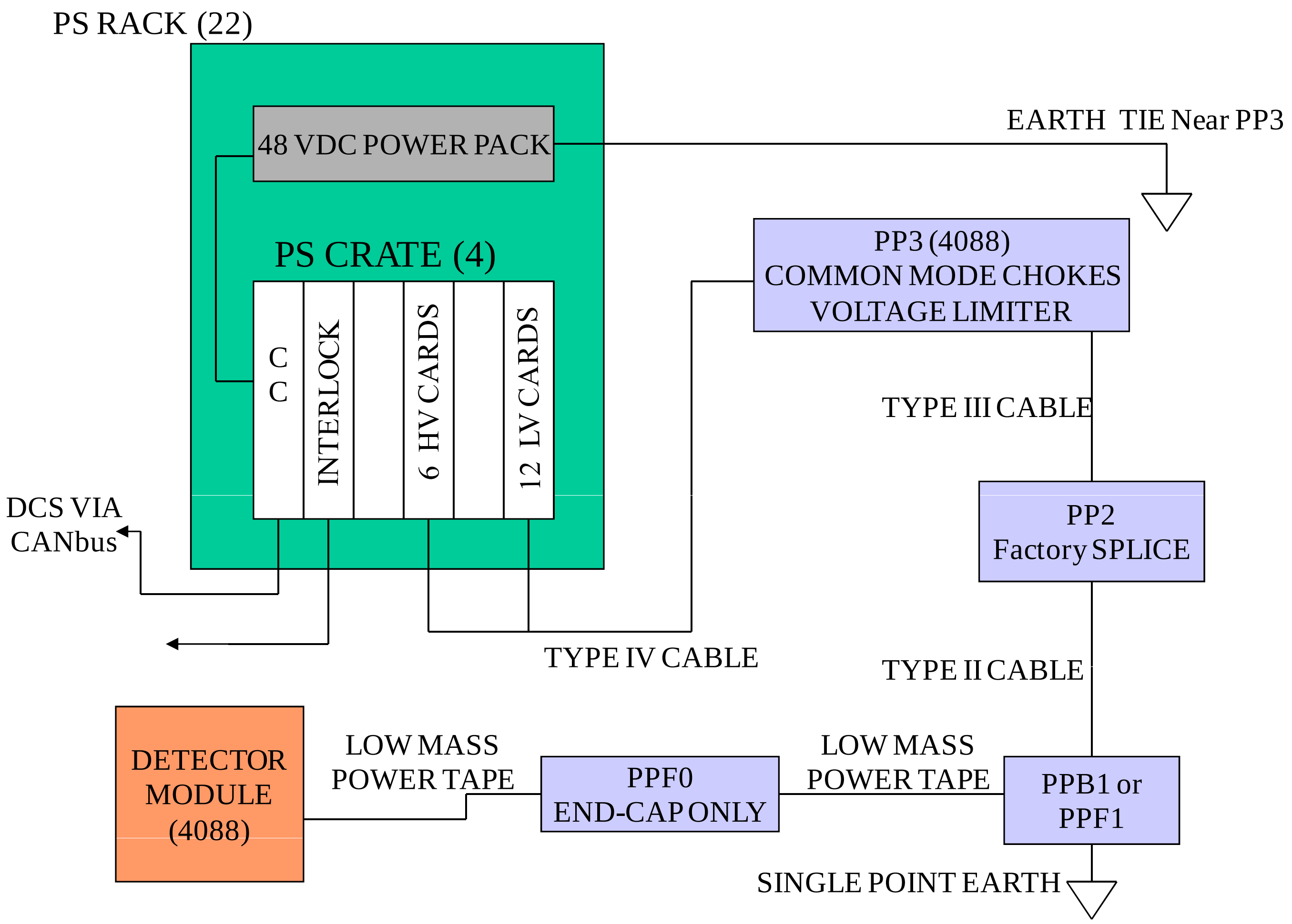
- Advantages:
  - No need for power devices inside the detector volume
    - No extra power in the detector volume
  - Very good control of the current returns

- Disadvantages:
  - Large amount of cables and power supplies modules
  - Trade-off power loss – material budget
  - Regulation loop of the PS includes long cables

Power Cables: CMS Strips

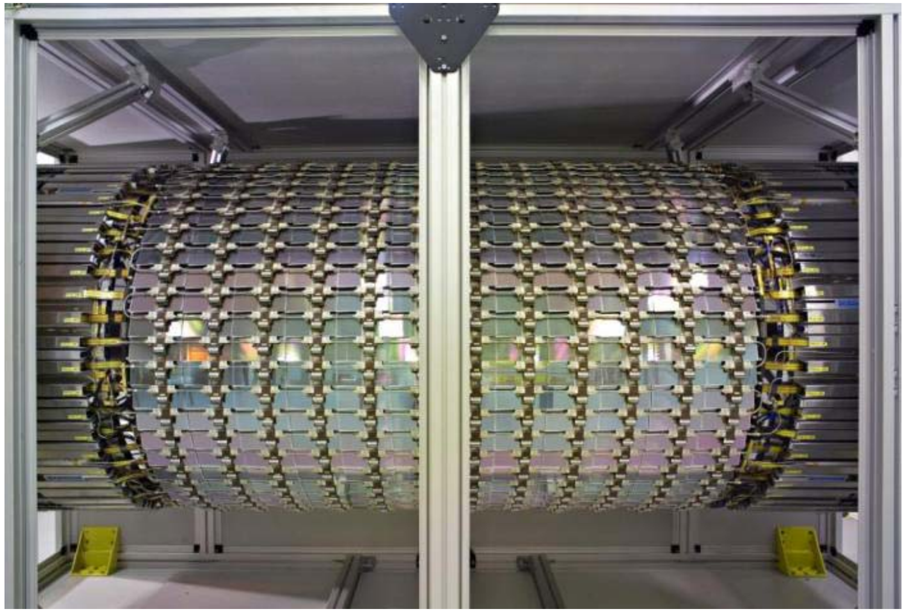


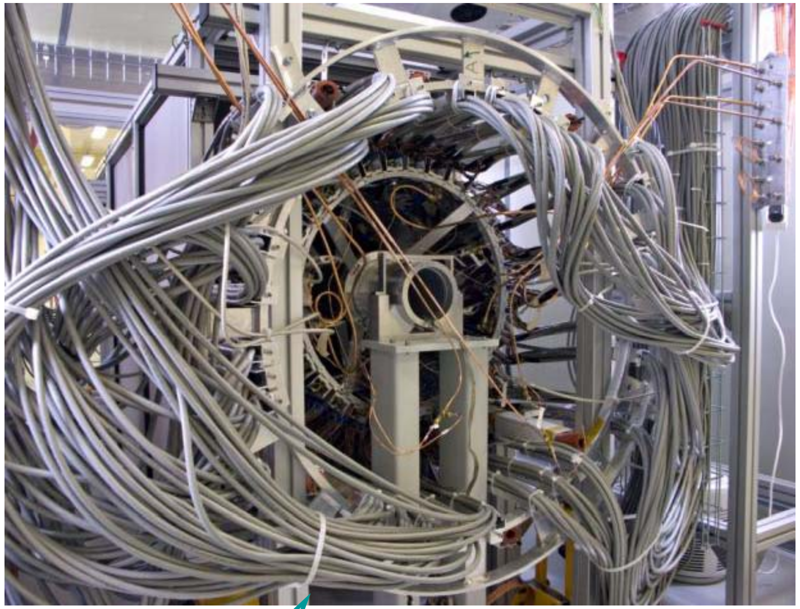
Power Cables: ATLAS Strips



- 3 Types of cables outside the tracker volume
- Low mass tapes in the tracker volume

Cables…



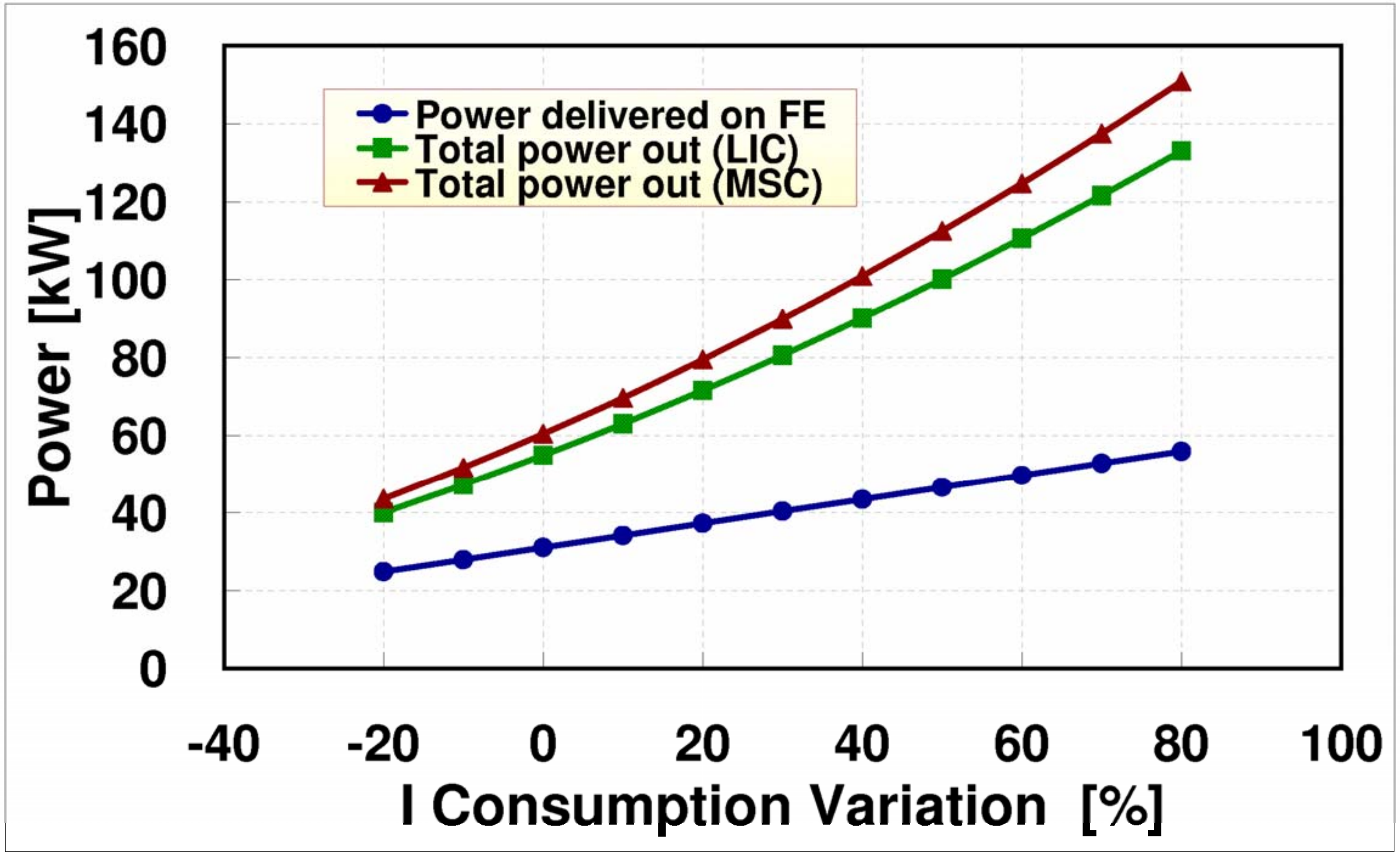


The beauty

The beast

- ATLAS Barrel SCT *(from Allan Clark)*

Voltage Drop & Power Loss



CMS Tracker

- Similar for both detectors:
  - As much power dissipated in the cable as in the electronics for nominal conditions

Can it be used for SLHC?

- Number of channels and modules x10
  - No way to have one PS channel per module
- Material budget cannot be increased
  - → no extra material for cables
  - → very likely more current per Cu mm^2
    - Power / channel reduced but Vdd as well
  - → more power loss and more cooling needs
- Not very attractive

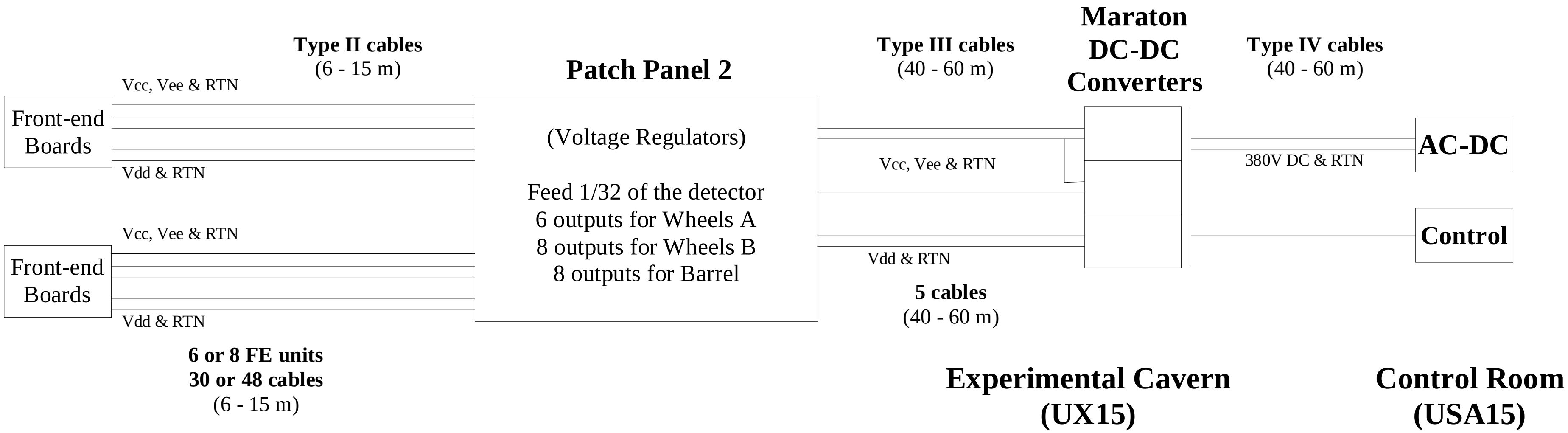
Use of Voltage Regulators

- CMS Pixel (regulators in Read-Out Chip),
  CMS ECAL, ATLAS Pixel and TRT (STm voltage regulators)

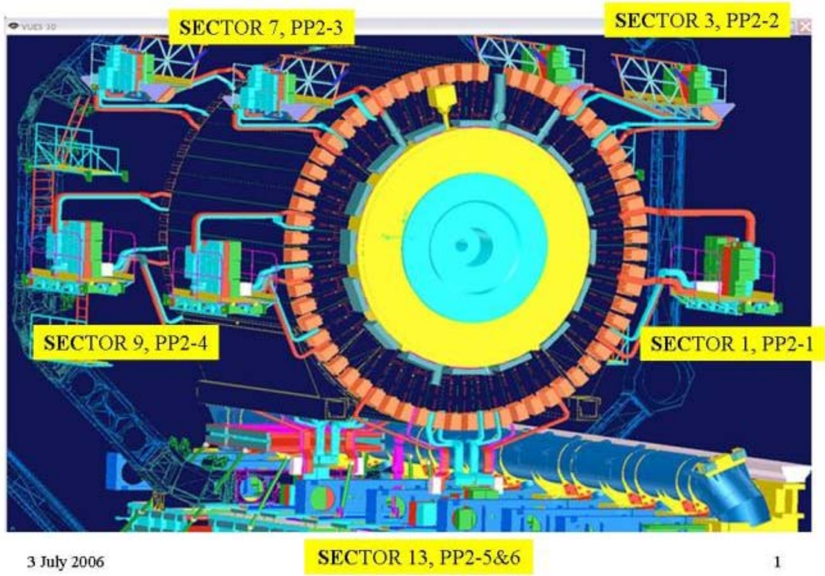
- Advantages
  - No need for remote voltage regulation
  - Possibility of using high current “bulk” supplies
    - Less cables and cheaper

- Disadvantages
  - Additional drop (lower efficiency & extra cooling)
  - Less control of the return currents

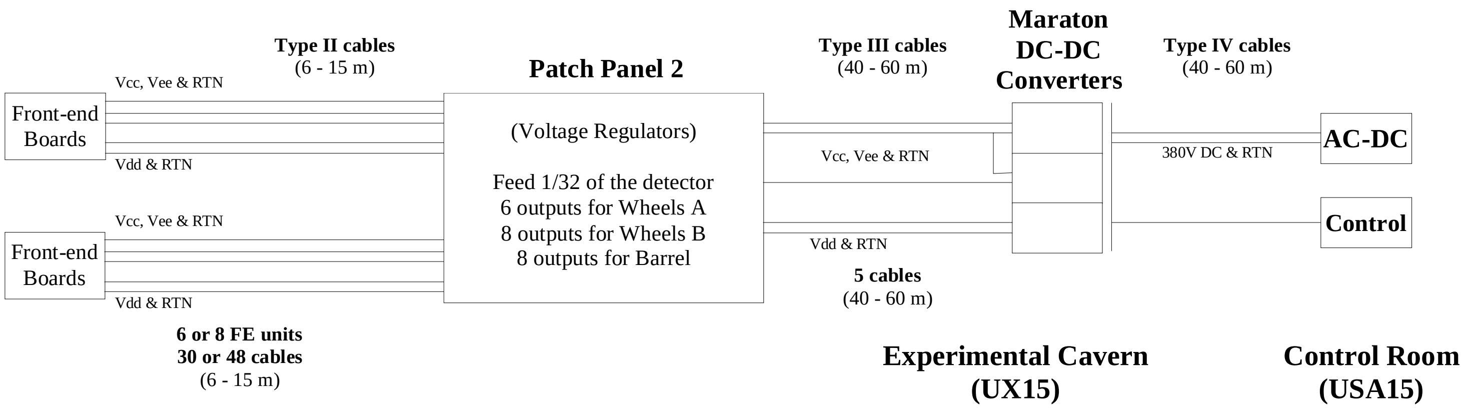
- A few details on ATLAS TRT and CMS ECAL



- Very similar to ATLAS Pixel
- Few PS units
- Digital and Analog return currents separated



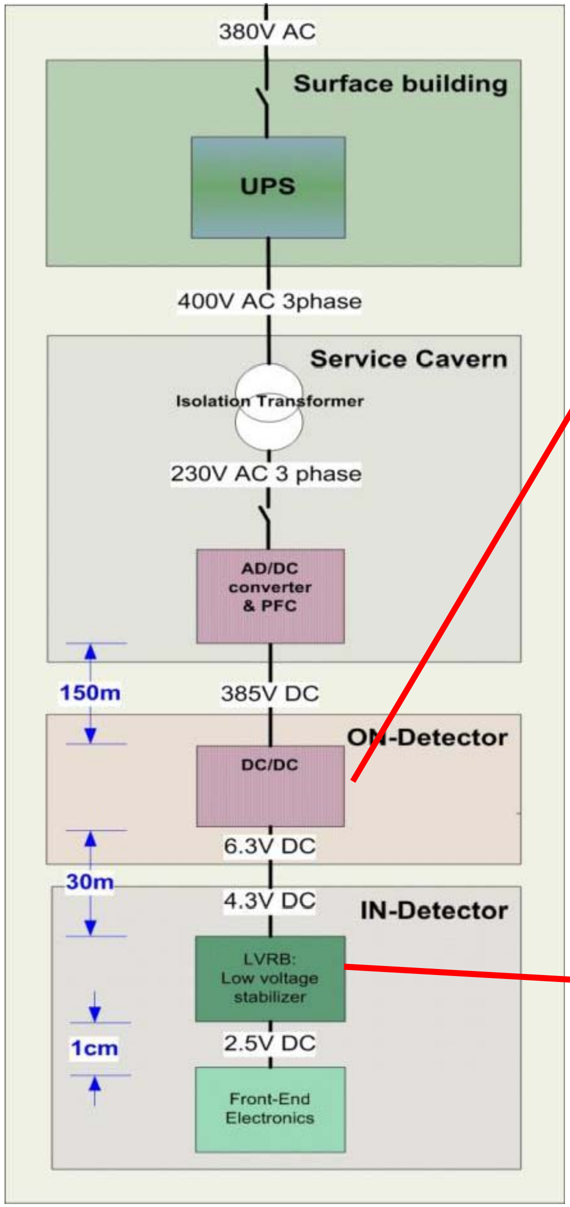
ATLAS TRT: Voltage Drops



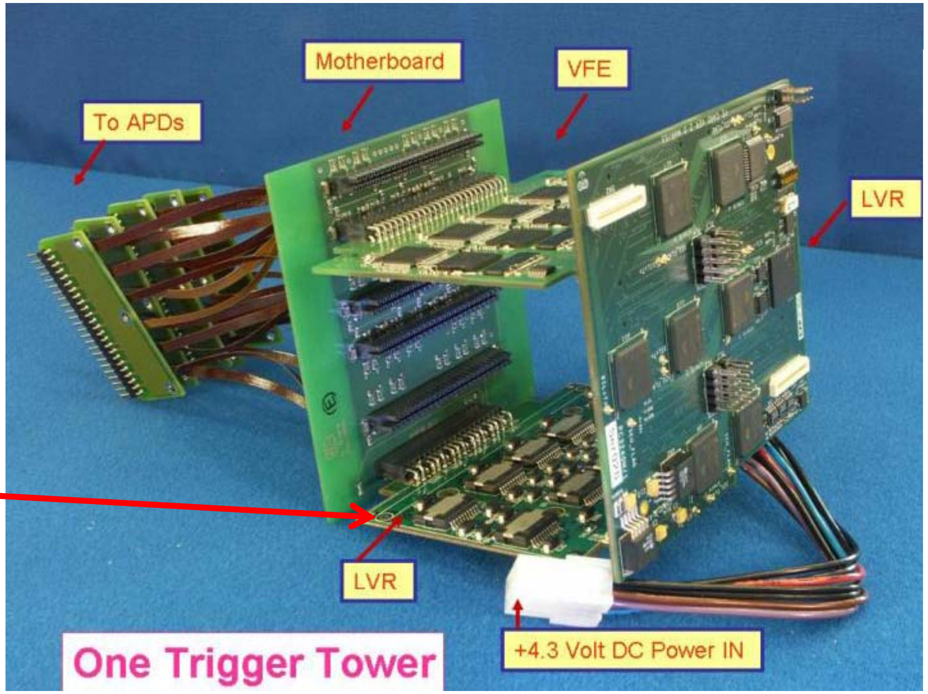
Element	Drop
Type III cables	0.5 – 1 V
Voltage Regulators	0.8 – 1.5 V
Type II cables	0.5 – 1.3 V
Maximum drop	***3.8 V***

- 6.3 V at the source for getting 2.5 V on the front-end
- 40 % efficiency (30% if AC/DC and type IV cables included)

CMS ECAL



- 812 DC-DC converters
- Drop in the regulators: 1.8 V
  - Power loss: ~80 kW (46 kA * 1.8 V)
  - ~60% efficiency in-detector
- Overall efficiency ~30%

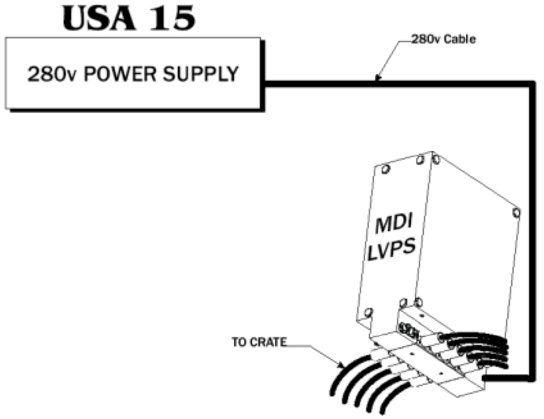


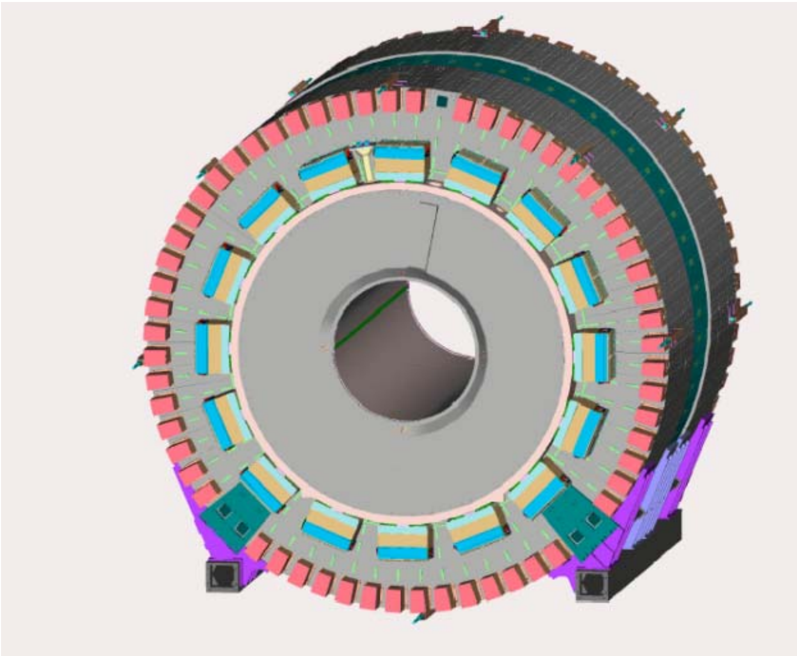
Can it be used for SLHC?

- Voltage regulators remotely located
  - Amount of cables entering the detector volume is not easily reduced
  - Large current → high power loss

- Voltage regulators on the load
  - Better power yield
  - Preferable very low drop VR, low current
  - Drawback: additional power dissipation in the detector volume
    - If Vdd is 1 – 1.3 V even low drop VR will add at least 10-20% of power

ATLAS LARG Calorimeter





- Use of DC-DC converters
- 58 PS units delivering up to 4 kW
  - 27 DC-DC in one unit
  - 7 Voltages
  - Redundant scheme

DC-DC Converters

- ATLAS Tile calorimeter also using this scheme

- Advantages
  - High efficiency (>80%)
  - Small cable volume to deliver high power
    - 280V DC → 4 – 11 V DC ; ratio 25 – 70

- Disadvantages
  - Very long development time to get a radiation (and low magnetic field) tolerant design
  - Complex devices not easy to produce

Can it be used for SLHC?

- Very attractive to reduce the volume of services
- Same drawback as the VR concerning additional power dissipation in the detector volume
  - Need for high efficiency
- Complex devices when radiation hardness is needed
  - Better to start development early on not too many variants

Conclusion

- Several schemes used for the current detectors
  - Individual PS remotely located
  - VR close to the load or a bit remote
  - DC-DC converters
- Only very low drop VR and DC-DC converters could be used for SLHC
  - At the cost of more power in the detector volume
- Because of our environment such devices will require a lot of development