Power Distribution in the Mu3e Experiment

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DPG Conference 2021, Dortmund

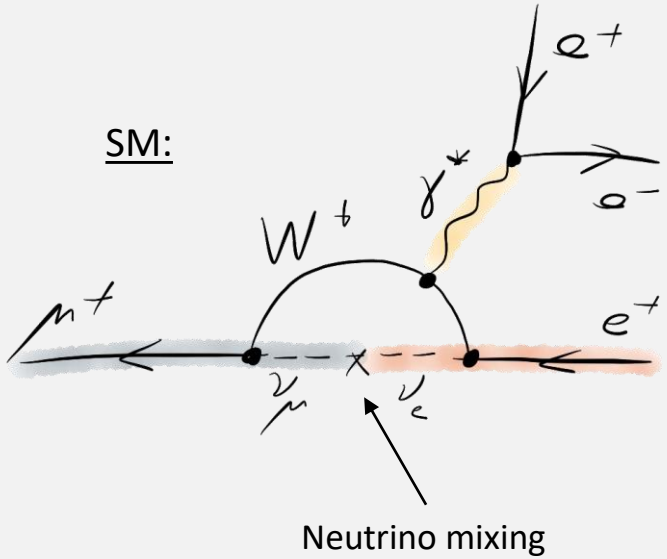
On behalf of the Mu3e Collaboration

The Mu3e Experiment

- Lepton-flavor-violating decay: $\mu^+ \rightarrow e^+e^-e^+$
- Standard Model: Br < 10^{-54}(essentially not observable)
- Any decay observed will be a hint toward new physics
- Aim for final sensitivity one in 10^{16} muon decays
- High intensity muon beam

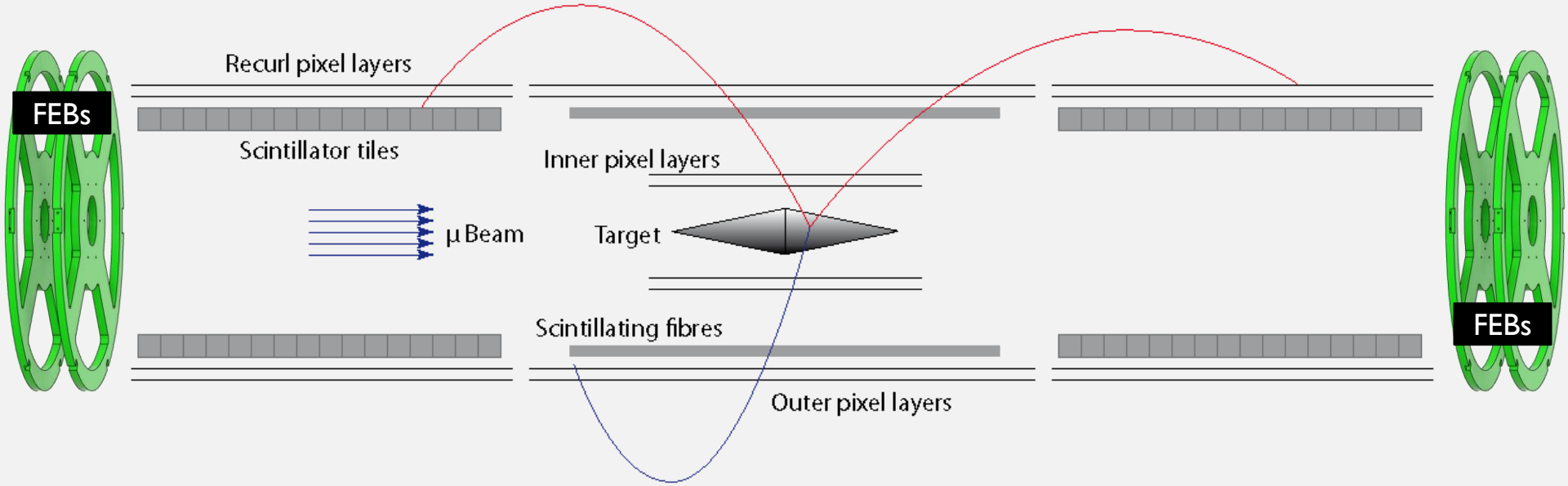
  → Paul Scherrer Institute, Switzerland

  (currently $10^8 \mu/s$, planned $> 10^9\ \mu/s$)
- Commissioning in 2021-2022



PAUL SCHERRER INSTITUT
PSI

The Mu3e Detector



- Muon decays at rest
- 1 Tesla magnetic field

Pixel Layers

- HV-MAPS
- Thin & high granularity sensors
- Combined with onboard signal processing → MuPix chips
- Very good spatial resolution

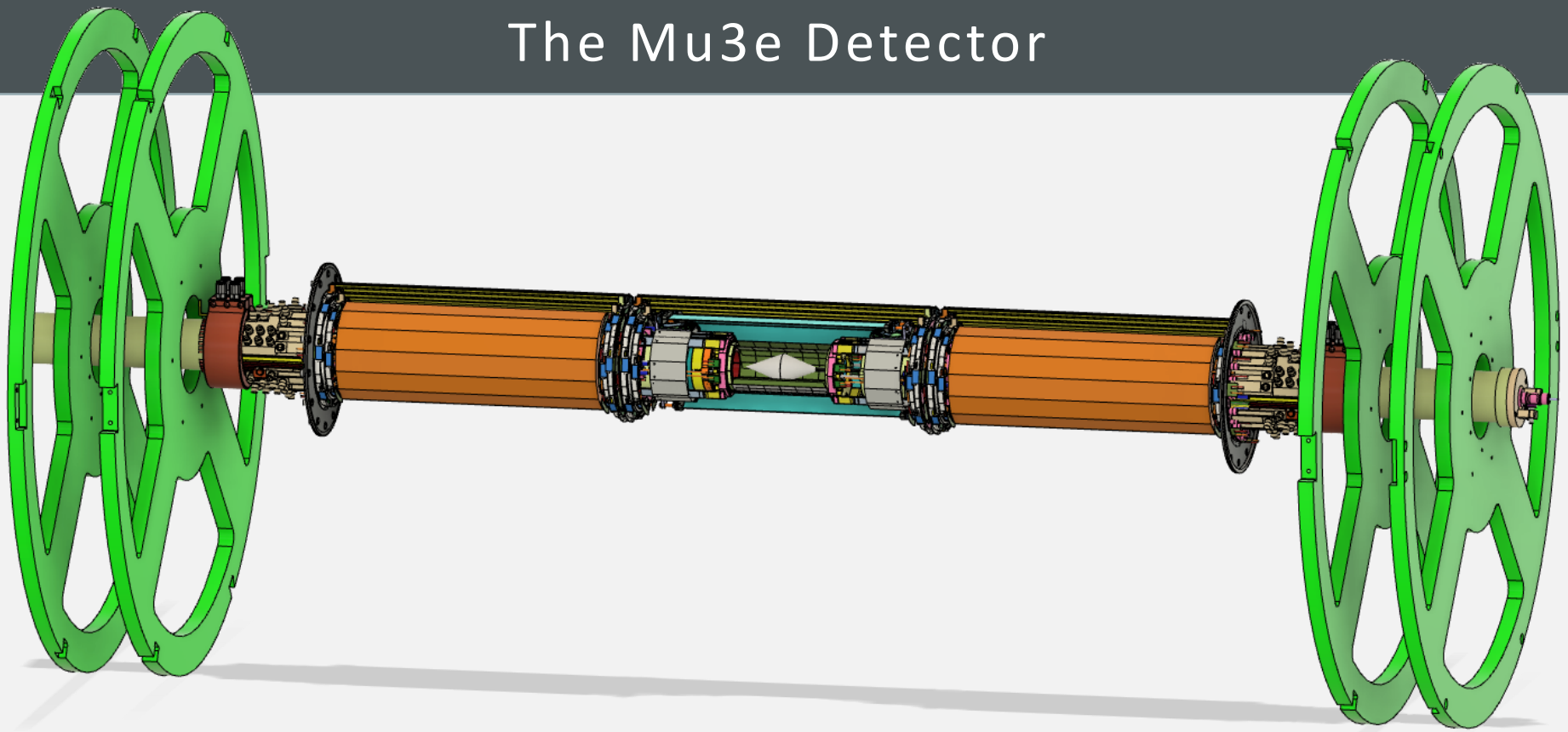
Scintillating Fibres/Tiles

- Very good time resolution
- E.g. background suppression

Frontend Boards

- Readout electronics
- Preprocessing + sorting of hits
- Send data to GPU farm

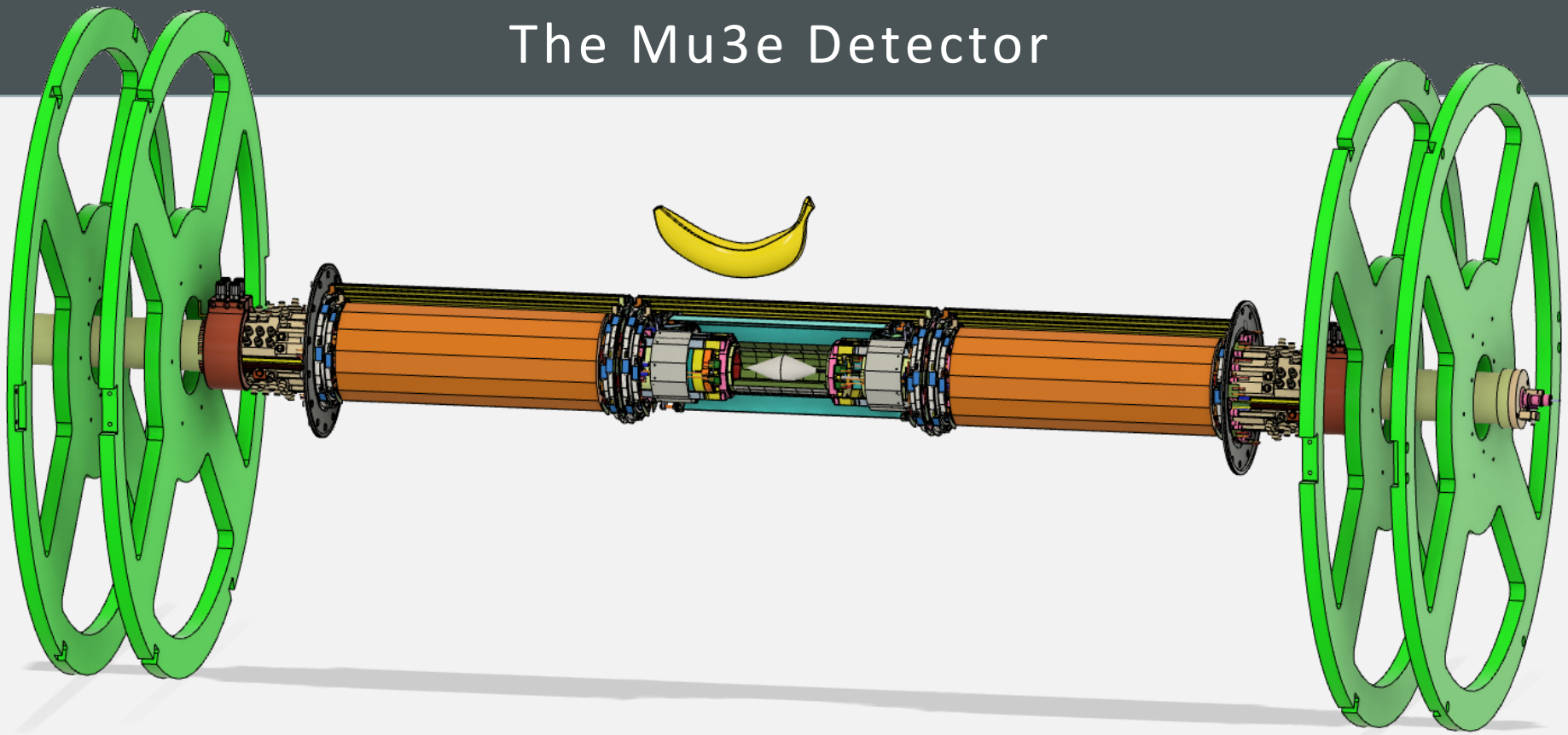
The Mu3e Detector



Component	Voltage [V]	# Partitions	Current per Partition [A]
MuPix (inner layers)	2.3	8	10
MuPix (outer layers)	2.3	78	21
Fibre	2.0	12	7
Tile	2.0/3.3	14	9/3
Front-end board	1.1/1.8/3.3	8	2/1.7/2.2

→ 4.6 kW

The Mu3e Detector



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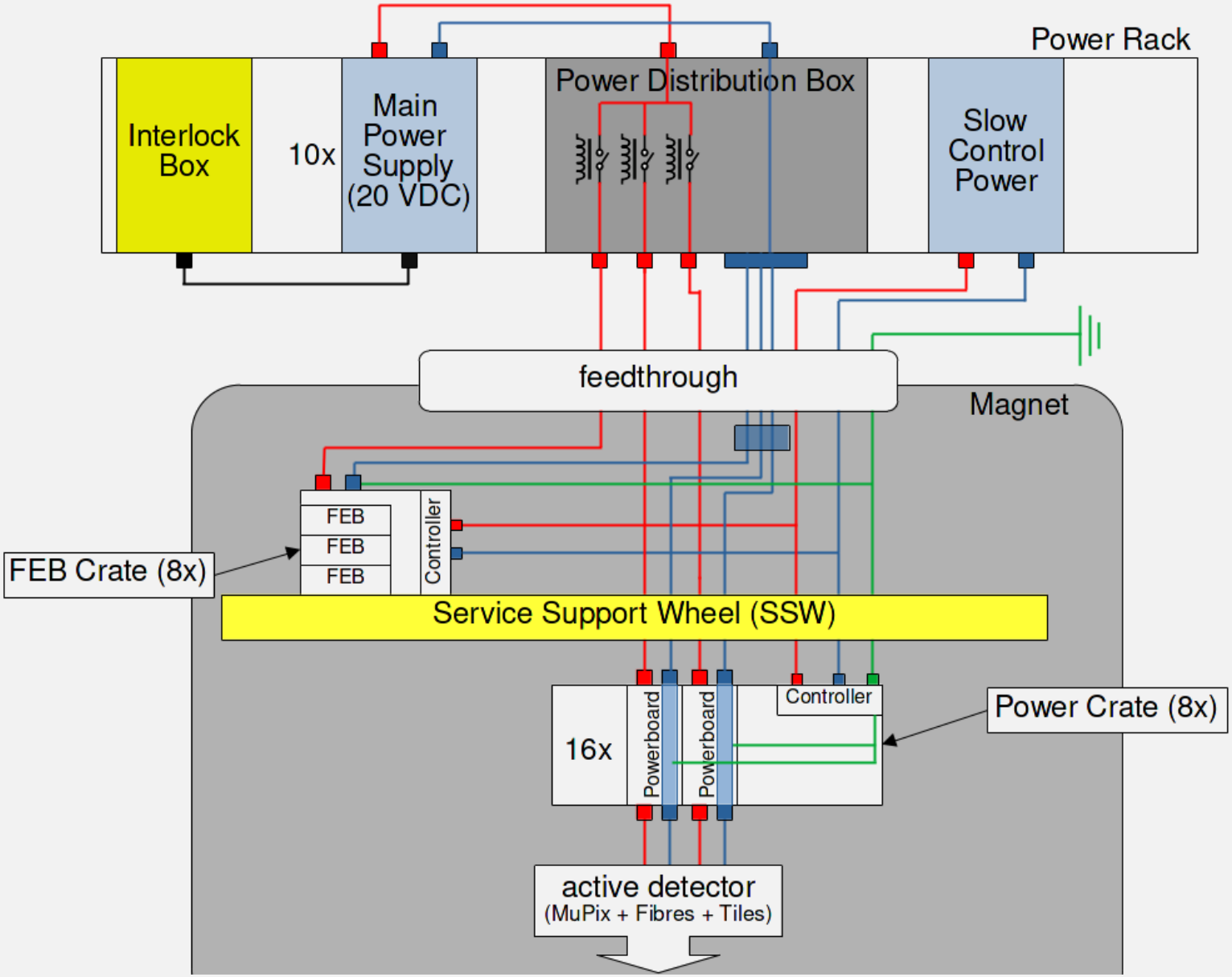
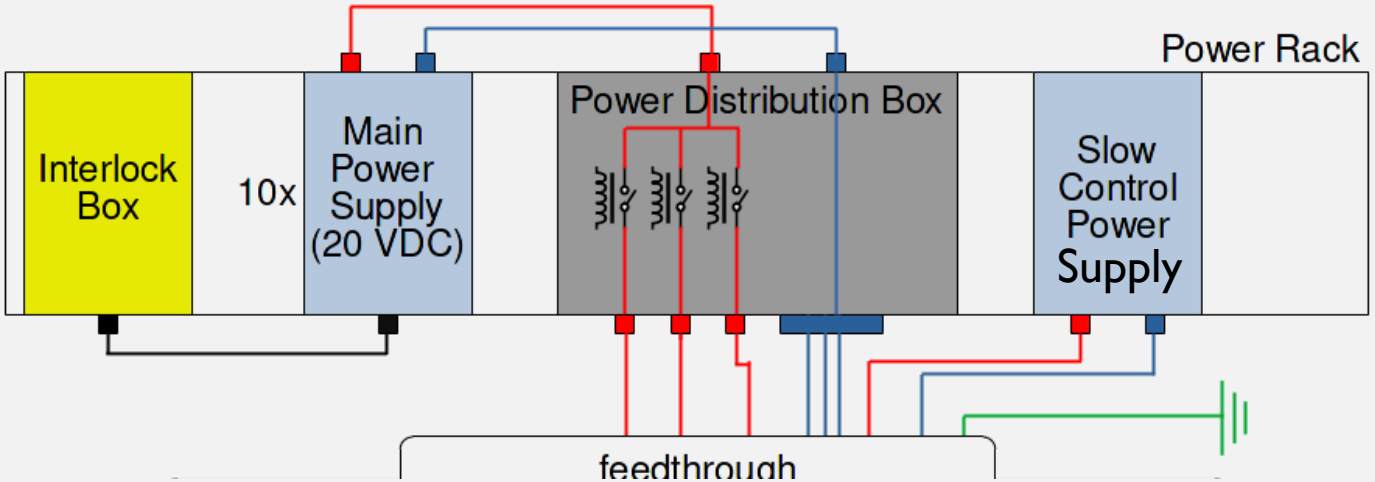
Overview Power Distribution



Outside the Magnet



Power supplies: TDK Lambda Genesys

- providing 20 VDC (rated 90 A @ 30 V)
- Floating outputs, referenced ground inside magnet
- Connected to interlock box
  → safety, e.g. no power without cooling of detector

Slow Control Power

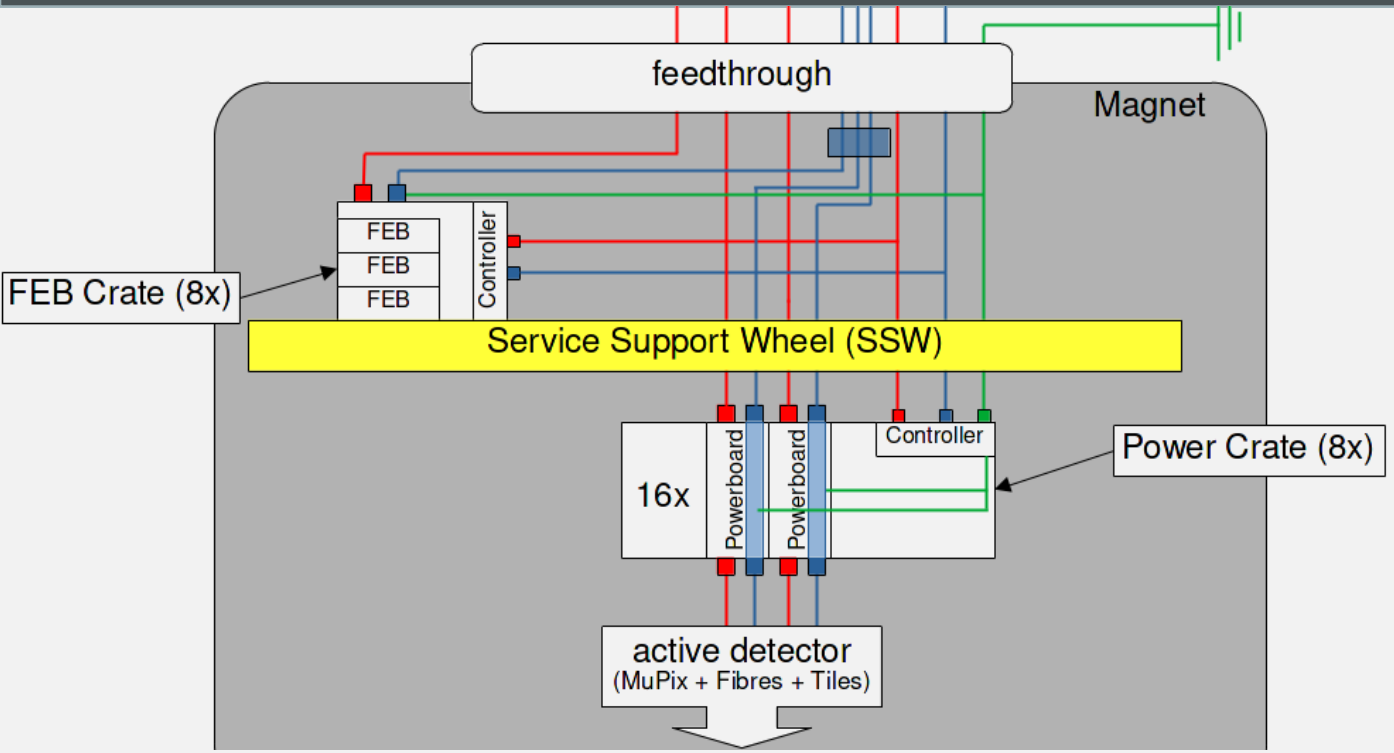
- E.g. environment sensors, crate controllers, alignment system
- Operate independent from main power

Power Distribution Box

- Power supply outputs multiplied via relay bank
  → each power partition can be switched separately
- 112 power partitions for active detector (MuPix, Fibre, Tile) (each 6 A @ 20 V)
- 8 power partitions for FEBs (20 A @ 20 V)

→ 120 cables @ 20V going in magnet + return lines

Inside the Magnet – Converters



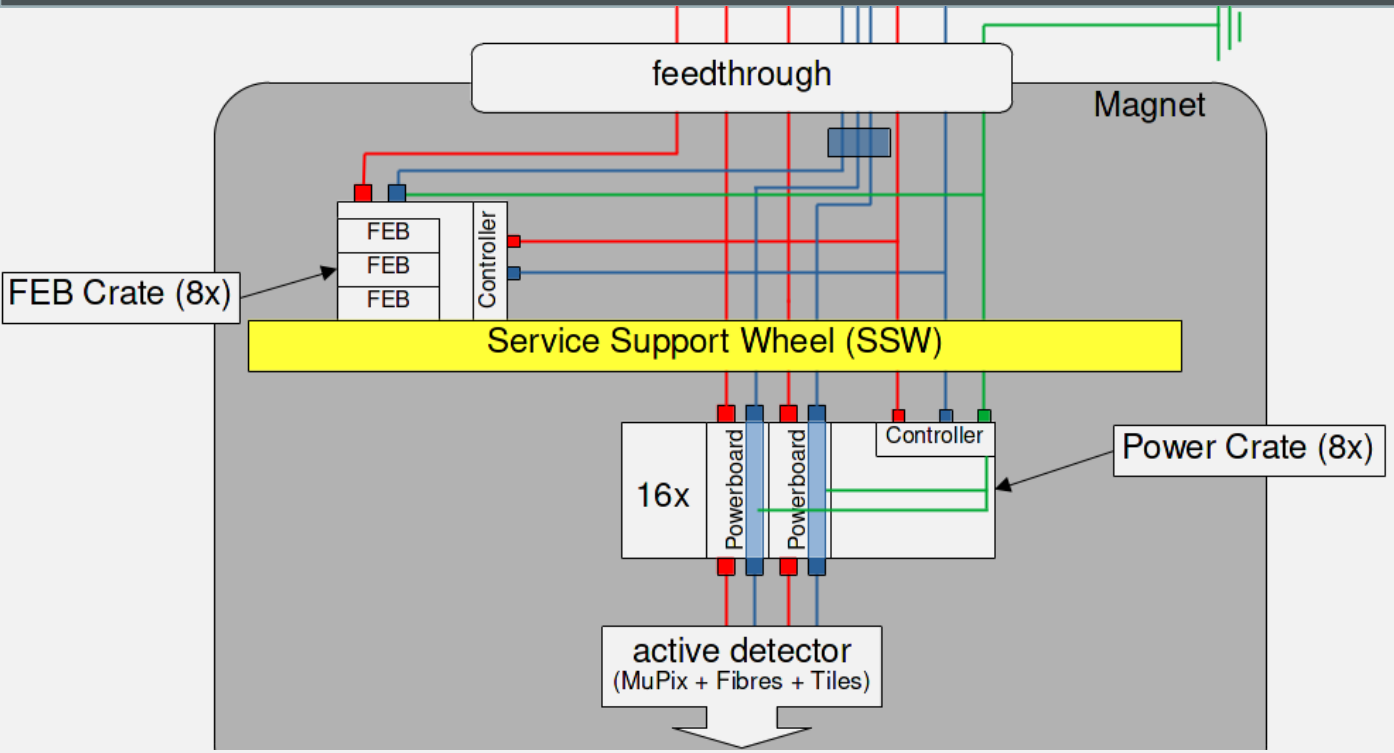
General Design Choices

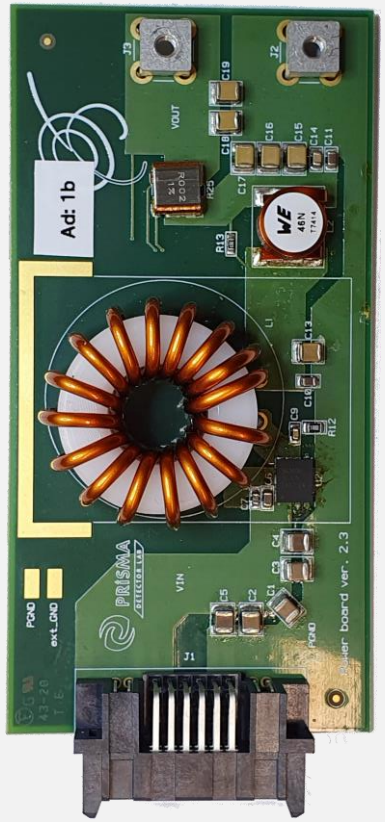
- Buck converters for high-power application and large voltage steps
- LDOs for low-power applications or small volage steps
- can't use ferrite core inductors in magnet → use custom air coils

Frontend Boards

- Located in FEB-crates with crate controller
- Each crate has its own power partition → 8 partitions needed
- Embedded buck converters 20 V to 1.1 V, 2.5 V, 3.3 V

Inside the Magnet – Powerboards



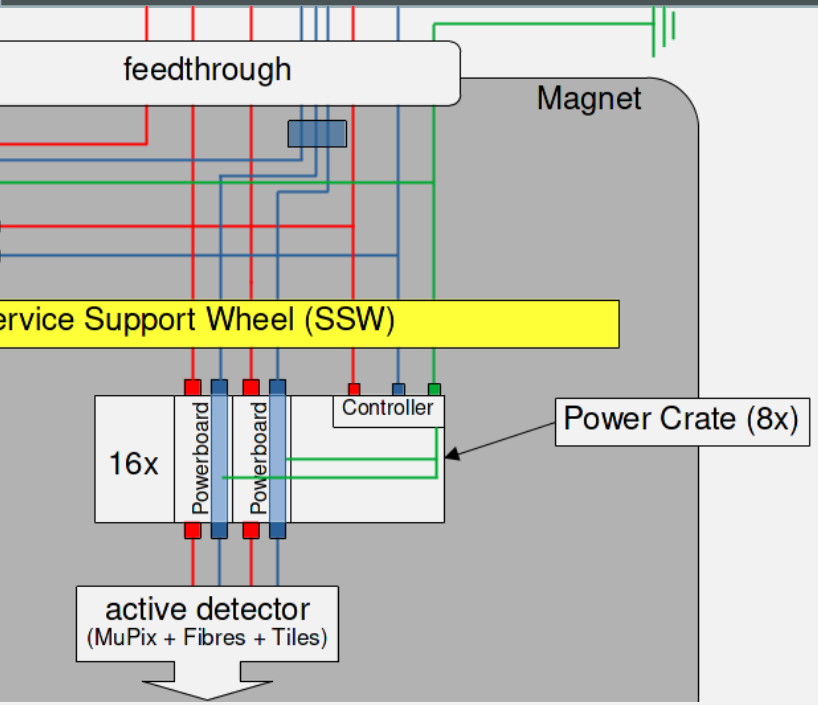


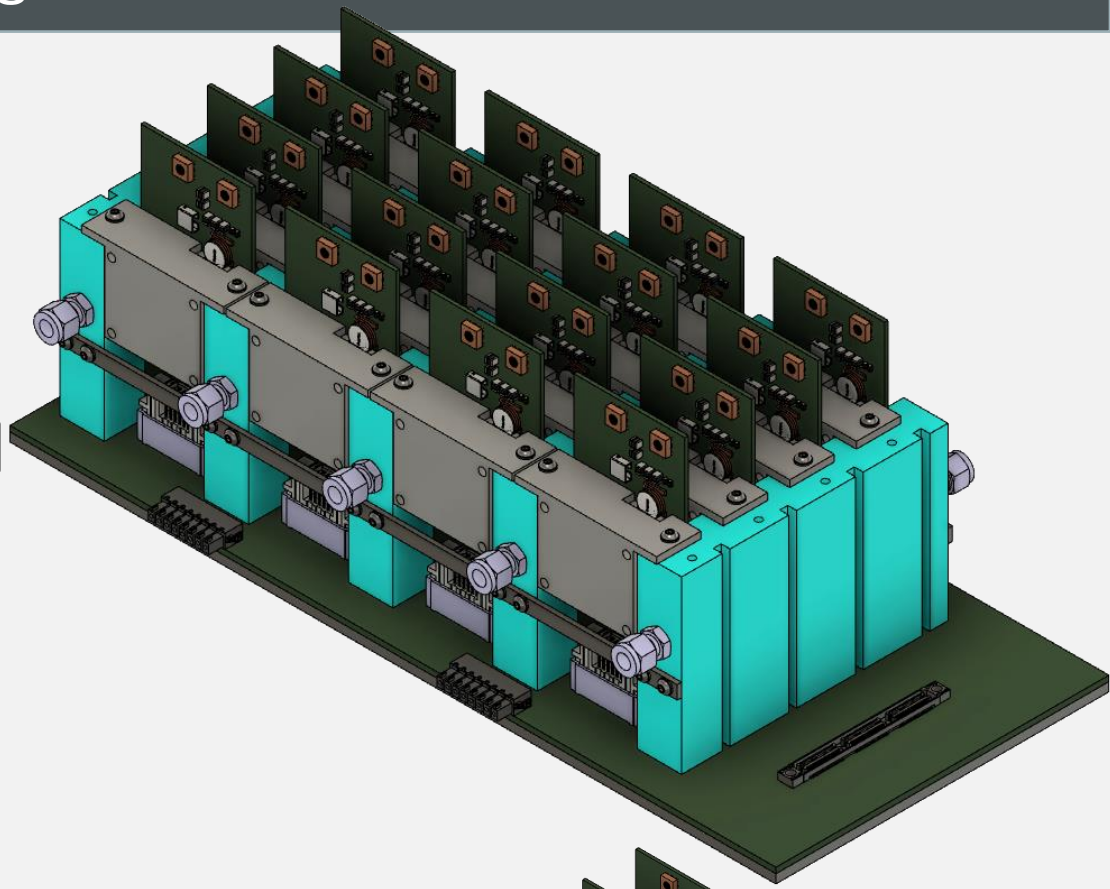
Powerboards

- Custom designed buck converters
  (using Texas Instruments controller + switching ICs)
- Provide power to active detector
- Rated for 30 A on output, nominal 20 A (2.0 - 3.3 V)
- Output ripple < 10 mV Peak-Peak
- Each powerboard is one power partition
  (112 partitions)

- Lots of interesting features implemented (sense wires, temperature interlock, etc.)
  → Talk by Sophie Gagneur (T 41.7)

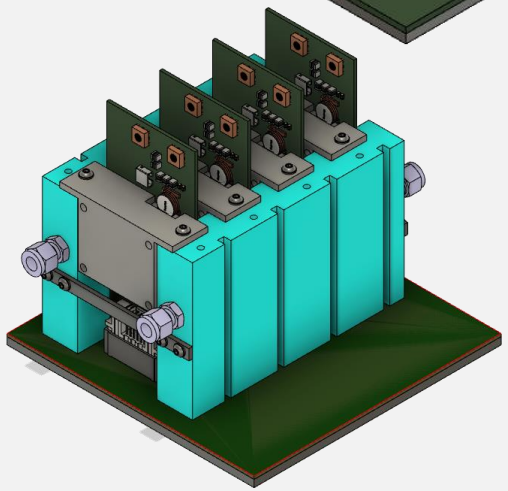
Inside Magnet – Power Crate





Power Crates

- Max. 16 powerboards mounted in one crate
- Water-cooled with custom heatsinks
- 32 pin connector (16x 6 A @ 20 V inputs + 16x return lines)
- Crate controller connected to slow control + interlock system
  - Controls powerboards through PMBus + analog enable signal



Thanks for the attention!