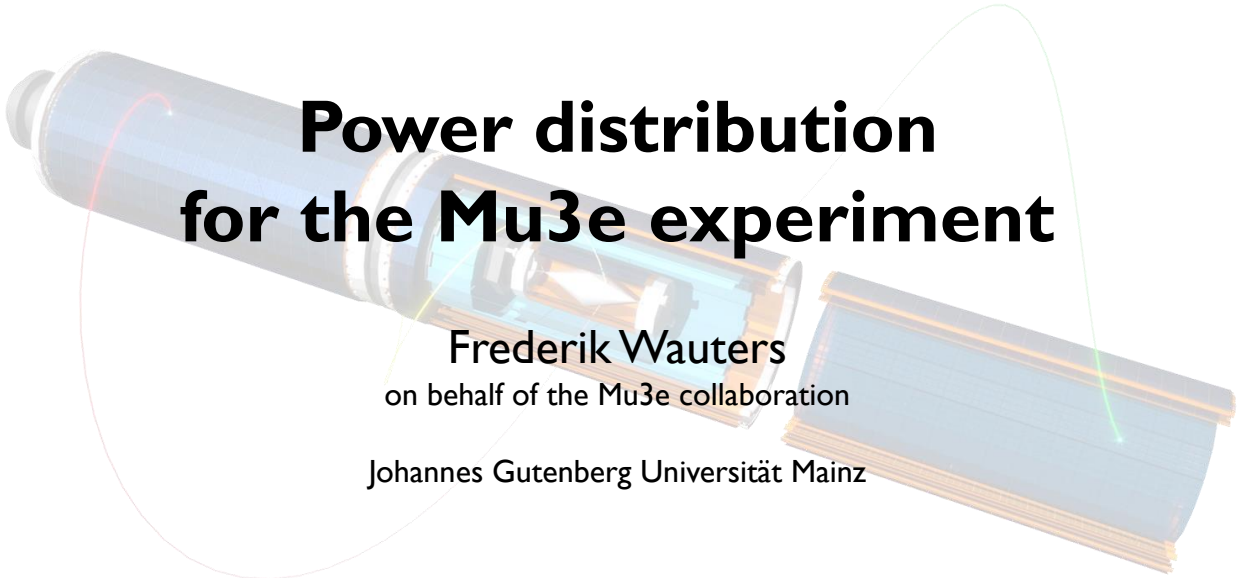


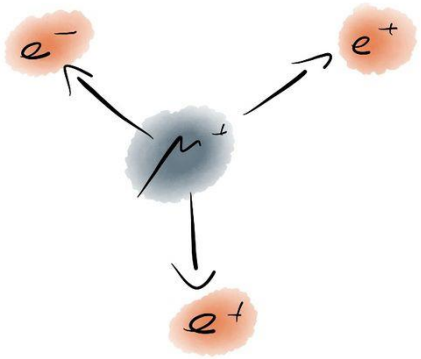
Power distribution for the Mu3e experiment

Frederik Wauters
on behalf of the Mu3e collaboration

Johannes Gutenberg Universität Mainz

The Mu3e experiment

SM background free
new physics search



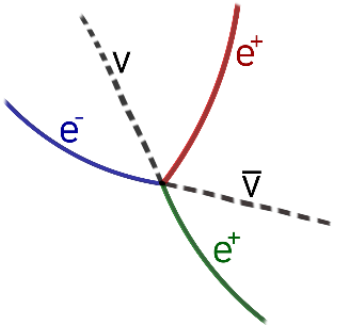
- Standard Model branching ratio $5 \cdot 10^{-55}$
- Mu3e aims for a single event sensitivity
  of $1 \cdot 10^{-16}$ (Phase II)
  of $2 \cdot 10^{-15}$ (Phase I = this talk)
  → Search for new physics
  → Previous limit $1 \cdot 10^{-12}$ (SINDRUM, 1988)

Signal:

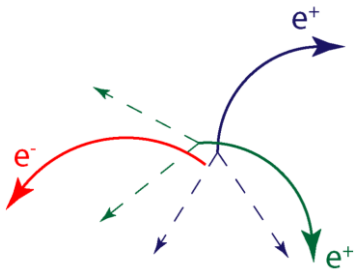
- $\sum E = m_\mu$
- $\sum \vec{p} = 0$

Background:

Internal conversion

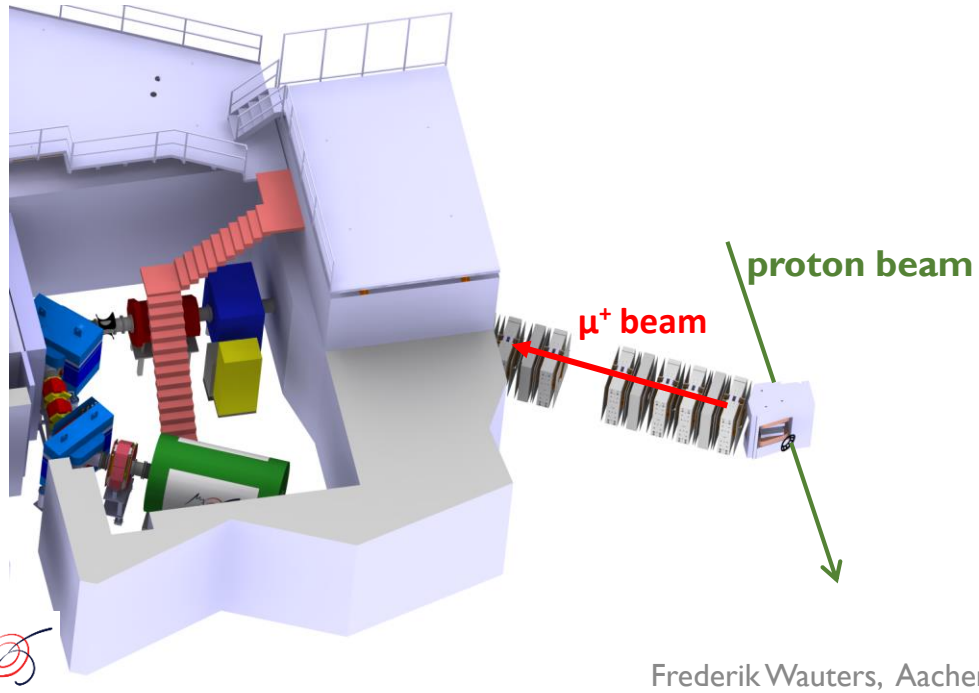


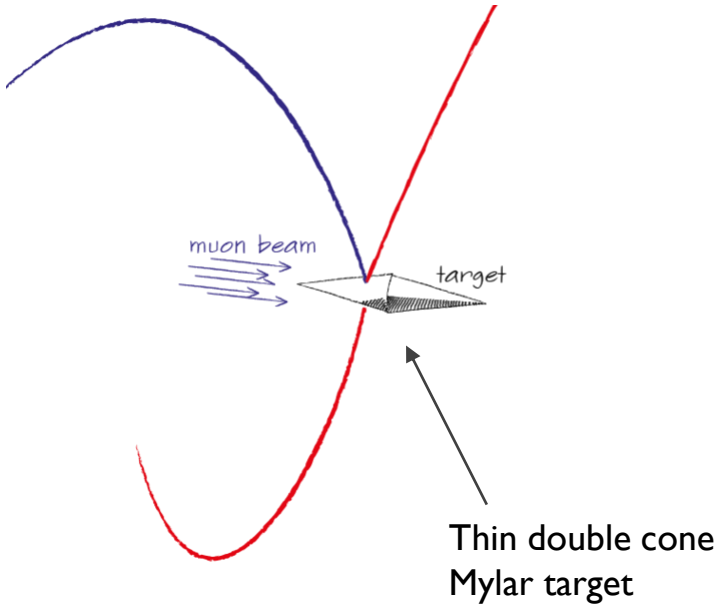
Combinatorial



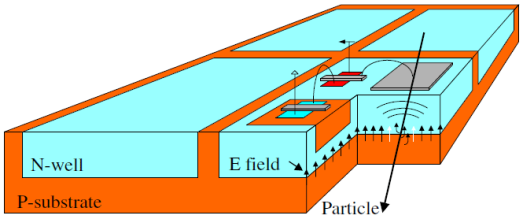
The Mu3e detector

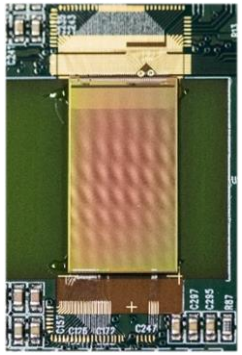
- Mu3e detector:
  - $1 \cdot 10^8$ μ^+ at the Paul Scherrer Institute
  - Stop muons inside a 1T magnet





The Mu3e detector: power hungry ASICs



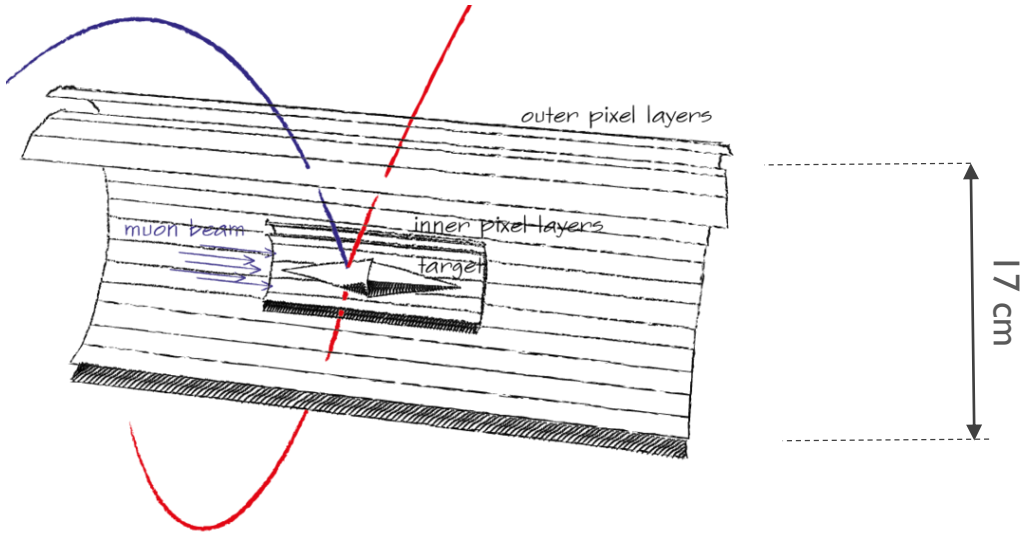


T 27.1, T 27.2, T 27.3, T 45.6, T 54.1

MuPix chip:

- High Voltage Monolithic Active Pixel Sensors
- < 0.1% of a radiation length/layer
- 2x2 cm, 50 um thick
- 1.25 Gb/s LVDS readout
- **1.8 VDC, <1.6W**, He gas cooled

- Mu3e detector:
  - $1 \cdot 10^8$ μ^+ at the Paul Scherrer Institute
  - Stop muons inside a 1T magnet
  - HV-MAPS Si pixel tracker



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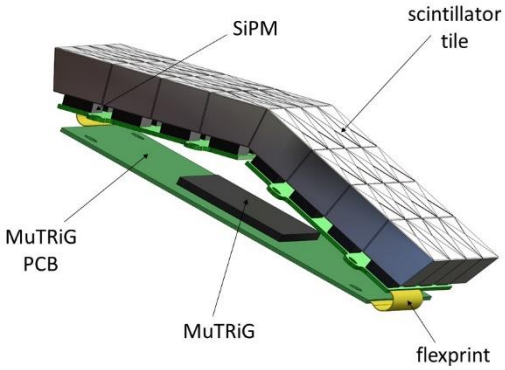
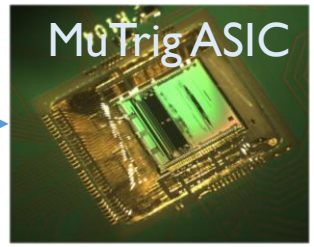


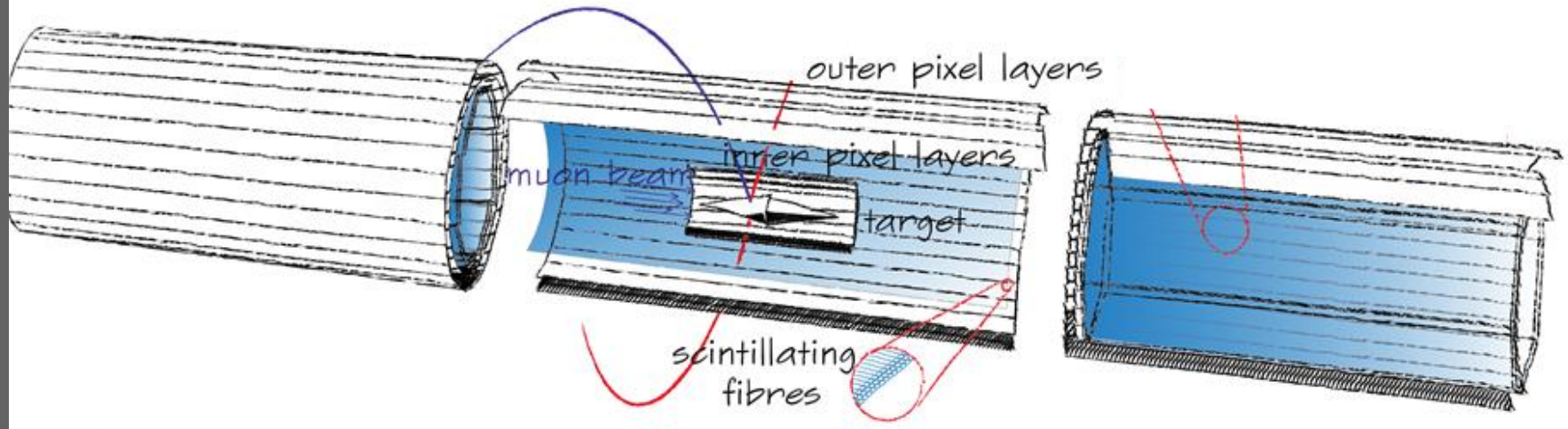
Scintillator → SiPM → MuTrig ASIC



MuTrig chip:
- SiPM readout
- 1.25 Gb/s LVDS
- **1.8 VDC, < 1W**

T 94.4

- Mu3e detector:
  - ➢ $1 \cdot 10^8$ μ^+ at the Paul Scherrer Institute
  - ➢ Stop muons inside a 1T magnet
  - ➢ HV-MAPS Si pixel tracker
  - ➢ Outer tracker and timing detectors

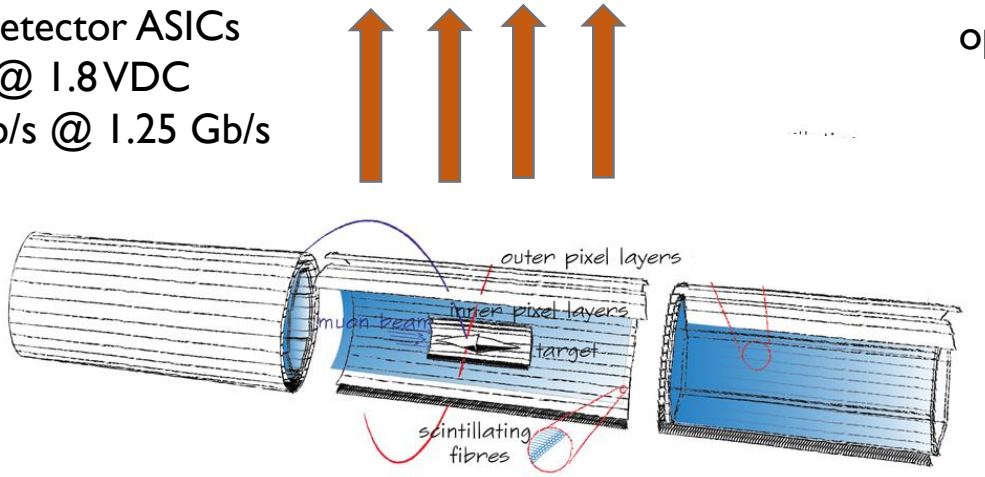


The Mu3e experiment

- Mu3e detector:
  - $1 \cdot 10^8$ μ^+ at the Paul Scherrer Institute
  - Stop muons inside a 1T magnet
  - HV-MAPS Si pixel tracker
  - Outer tracker and timing detectors
  - Frontend board with FPGA to merge data and send data out via optical links

112 x Frontend board:
- ArriaV FPGA
- LVDS in, optical out
- **1.1→3.3 VDC @ ≈15 W**

- 3304 detector ASICs
- 5 kW @ 1.8 VDC
- 100 Gb/s @ 1.25 Gb/s



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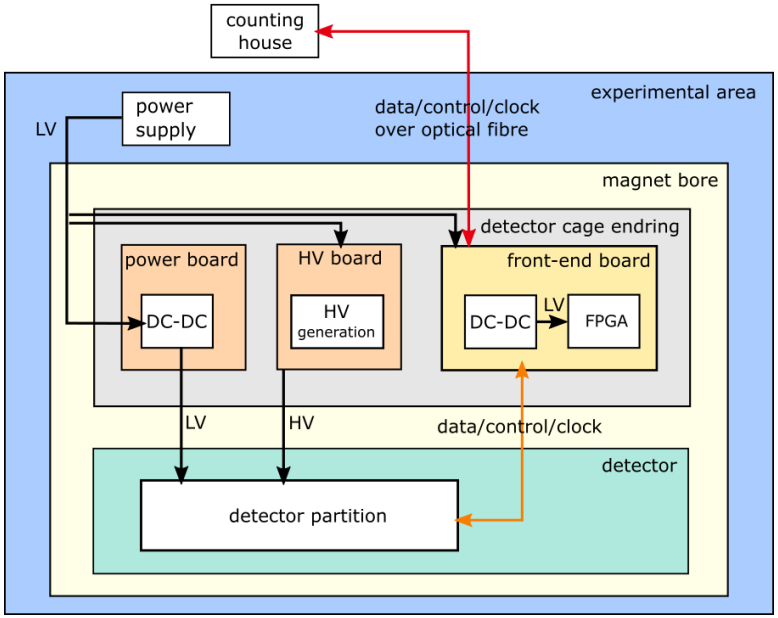

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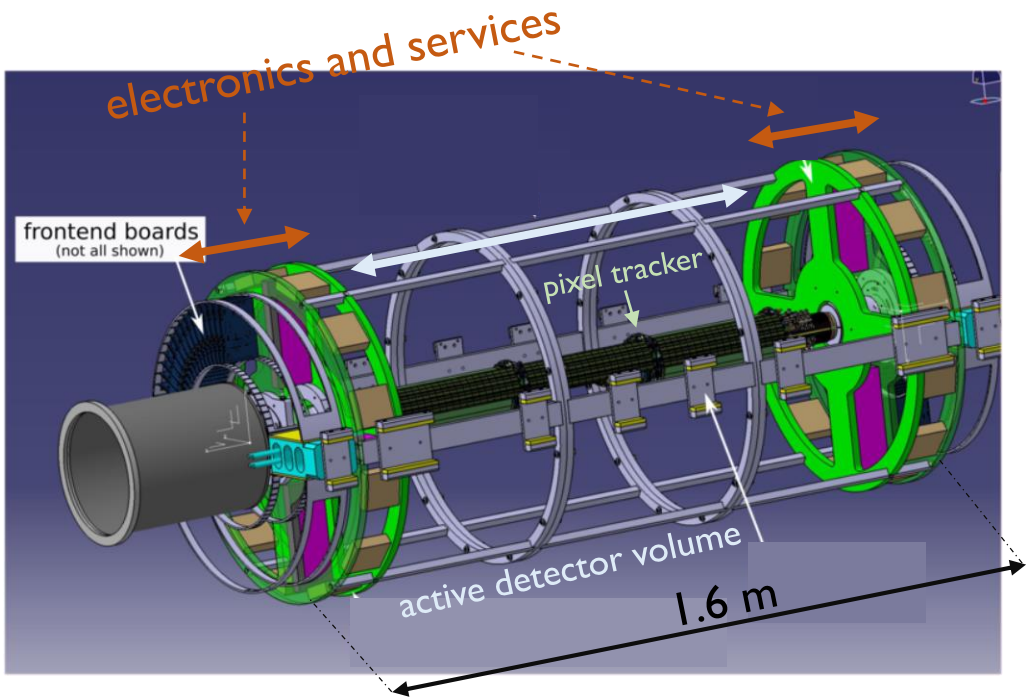
  - Frontend board with FPGA to merge data and send data out via optical links
  - Power distribution & DC-DC conversion

The Mu3e experiment



- Mu3e detector:
  - $1 \cdot 10^8$ μ^+ at the Paul Scherrer Institute
  - Stop muons inside a 1T magnet
  - HV-MAPS Si pixel tracker
  - Outer tracker and timing detectors
  - Frontend board with FPGA to merge data and send data out via optical links
  - Power distribution & DC-DC conversion
  - Very limited space for electronics

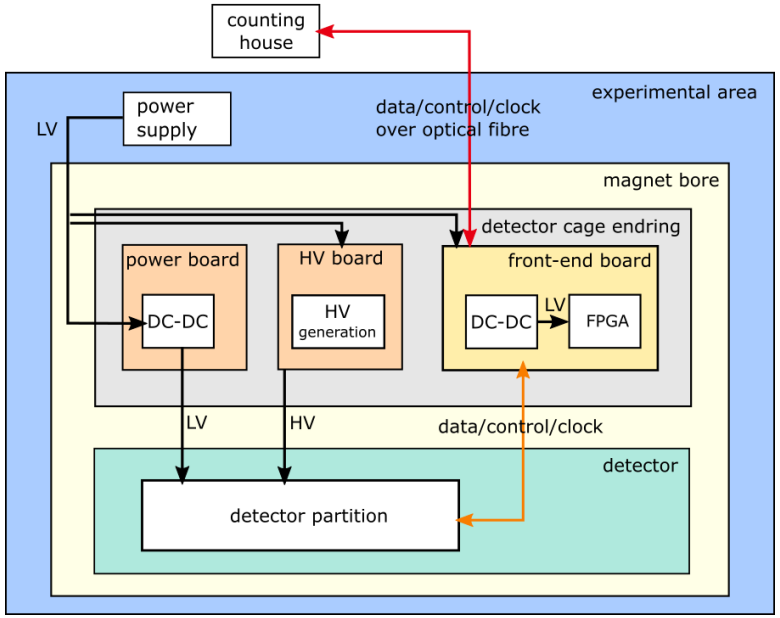
Power distribution

12 x 12 20VDC

high density feedthrough
~ 10 kW

Outside

He volume



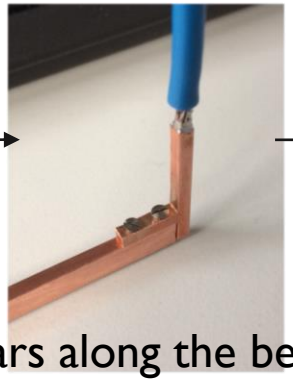
- 2x18 cm flex with tap bonded 2x2 cm chips
- ! 2 x 14 µm Al for signal and power !

'no space' region

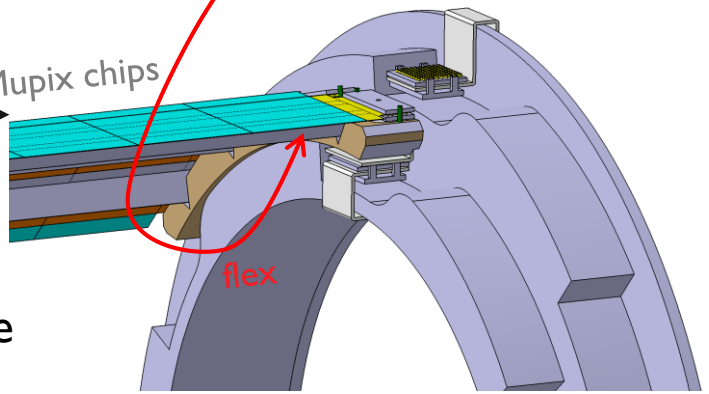
Frontend boards

power crate

DC-DC converters in magnetic field



Cu bars along the beamline



DC-DC converters

- Requirements DC-DC converters
  - Vin = 20 VDC
  - Efficiency > 75%
  - Ripple of Vout < few mV
  - Compact

Number	Device	Vout (V)	Current (A)
112	Frontend board	1.1	2
112	Frontend board	1.8	2
112	Frontend board	3.3	2.5
112	Detector ASIC	2.2	10-27

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- Design concept
  - Buck convertor topology
  - Commercial controller / switch +
  - Custom aircoil because **B Field**

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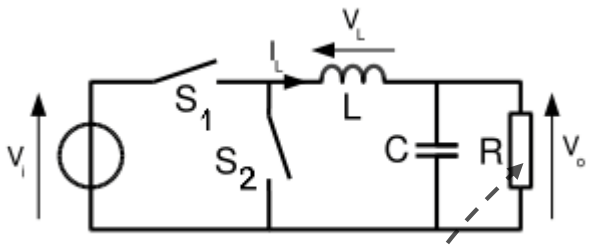
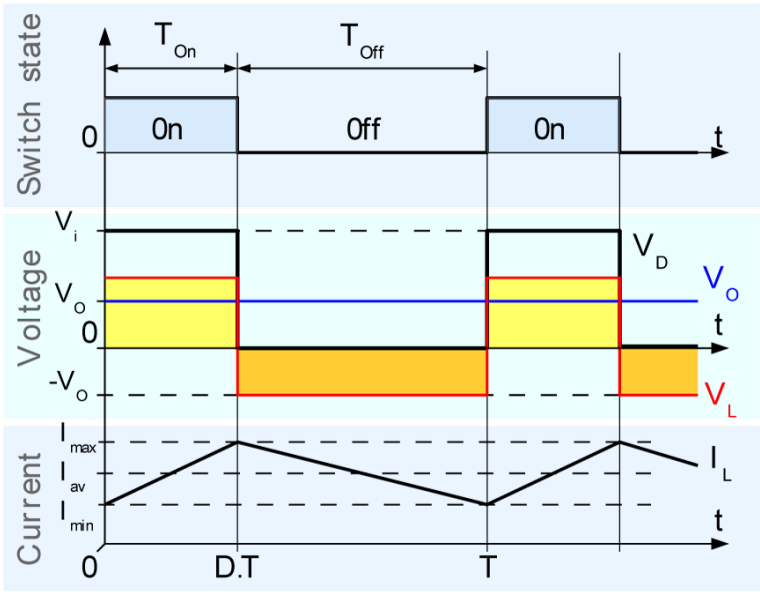
V_{out} = Duty cycle x V_{in}



$\Delta V = \Delta Q / C$ (in theory)



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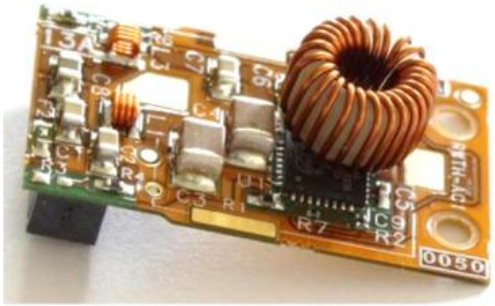
\+ We don`t have to invent the wheel
(e.g. FEAST modules of Atlas & CMS)

\- Specs of existing CERN boards
≠ Mu3e requirements



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  - Prototype for each type
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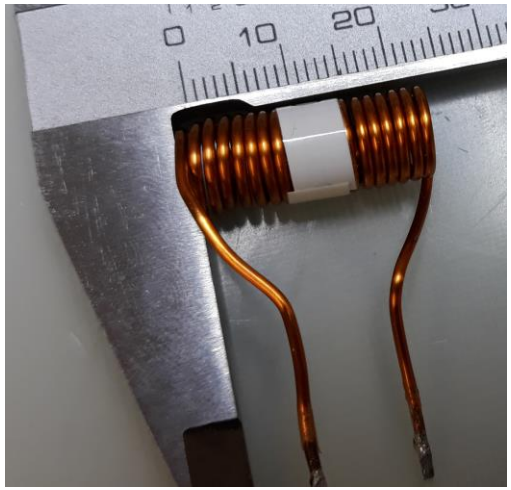

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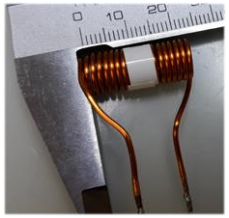

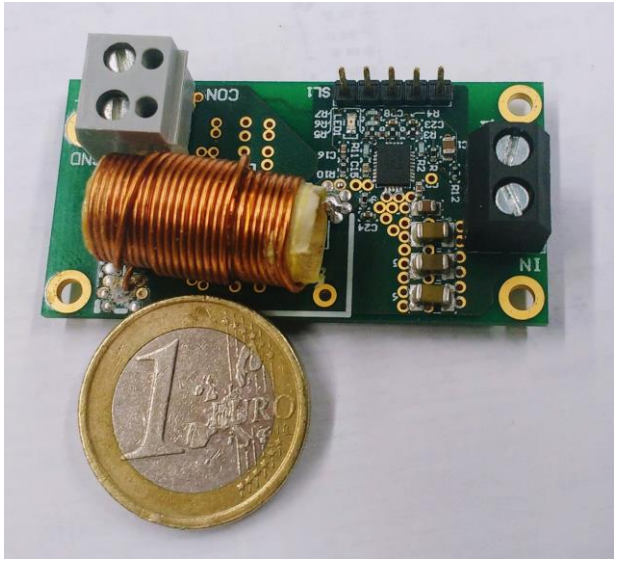

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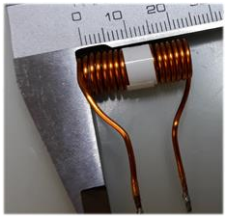

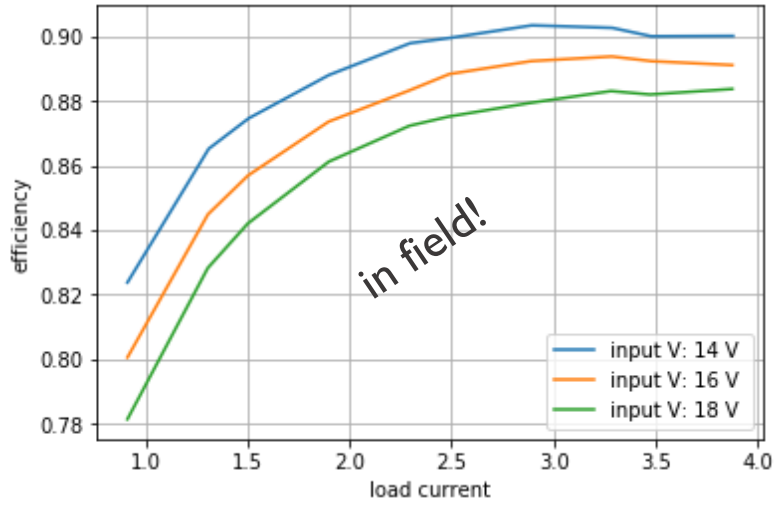

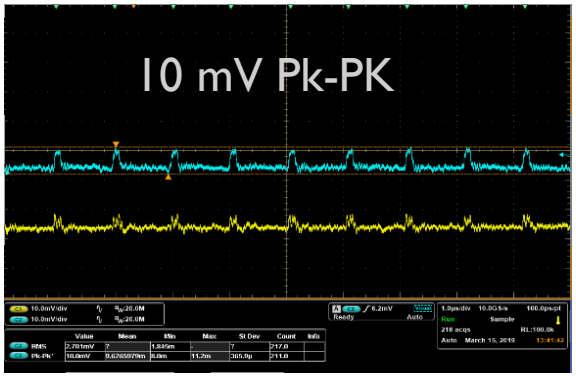

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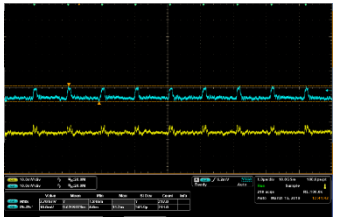
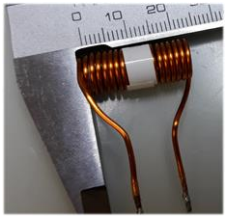
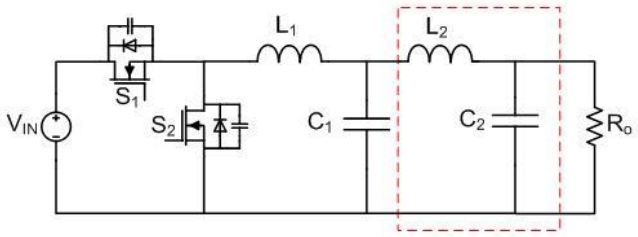
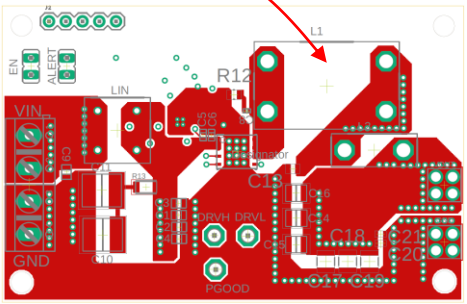
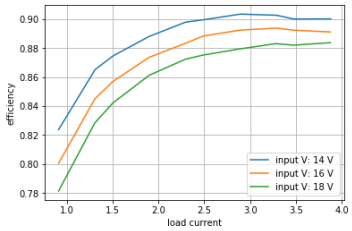




- Testing program:
  - Noise study: second filter? + shielding
  - Mechanical/durability testing
  - Feedback stability → load transients







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  - Ripple of Vout < few mV
  - Compact
- Status:
  - Aircoil design ready:
  - Prototype for each t
  - Currently: testing / n
- Testing program:
  - Noise study: second
  - Mechanical/durabilit
  - Feedback stability →

Number	Device	Vout (V)	Current (A)
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Conclusion

- Mu3e under construction (2021)
- Powering scheme
- DC-DC converter prototypes
  - High I
  - B field
  - Compact