BRAINPET - A NEW PET-MR INSERT PROTOTYPE

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SCIENCE Scientific Challenges Applications and Methods Electronic ZEA-2 Systems

Georgian-German ScienceBRIDGE

CONNECTING PEOPLE AND KNOWLEDGE

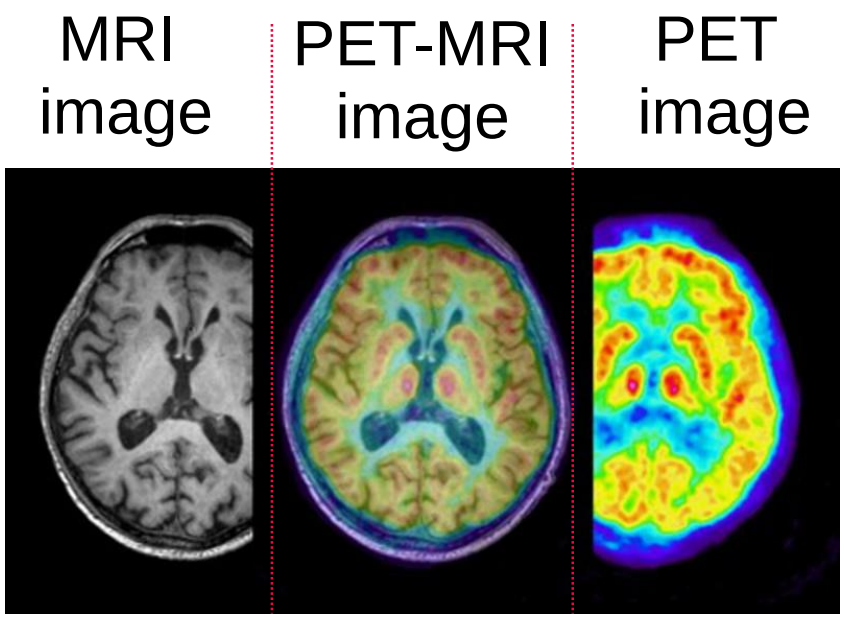
CONTENT

- INTRODUCTION
- PET REQUIREMENTS FOR MR
- CONCEPT OF THE PET INSERT
- SUMMARY & STATUS OF THE PROJECT

INTRODUCTION

MAIN IDEA

- The idea of the project is to mix two modalities, PET and MR inside a single device.
- Synergy of the two modalities brings simultaneous, non-invasive diagnostics to the next level as it combines morphological and functional imaging
- A completely new, high-resolution, and highly sensitive PET insert must be designed to operate in combination with UHF MR with the field up to 9.4T

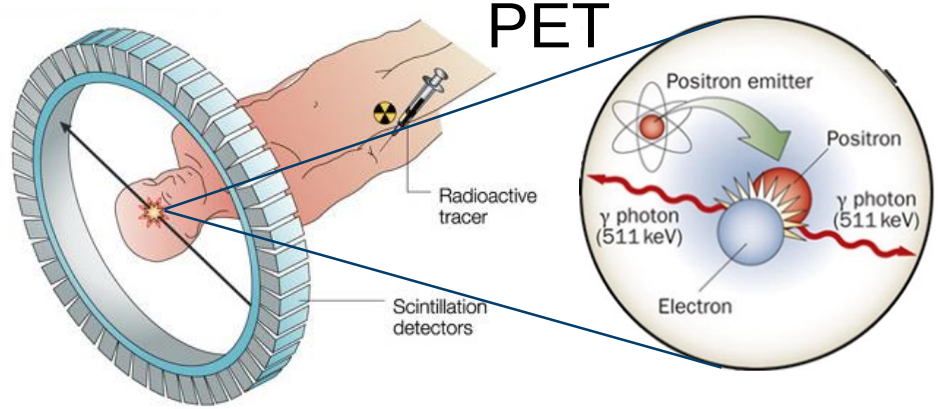


INTRODUCTION

WORKING PRINCIPLES OF TWO MODALITIES

MR

PET



- A body acts as a radio transmitter in a very high magnetic field if exposed to an EM wave.
- An image is obtained from the “radio transmission” of your body.
- Detection: mostly regions including fat and water

- **<u>Problems for electronics</u>:**
  - Very high magnetic fields (up to 9.4T)
  - Very low signal

- If a trace amounts of short-lived radioactive labeled molecules are injected into bloodstream
- Radioactive decay can reveal dynamics of metabolic processes

- **<u>Problems for electronics</u>:**
  - Complex / fast readout electronics
  - Large amount of data to be processed

PET REQUIREMENTS FOR MR

REQUIREMENTS OF THE PET INSERT

Restrictions on the PET electronics:

- Works inside static B_0 magnetic fields up to a 9.4T
- … fast changing gradient field of several tens of militesla
- … accompanying RF environment

Avoid using ferrites, mechanical cooling FANs, vacuum tubes, etc.

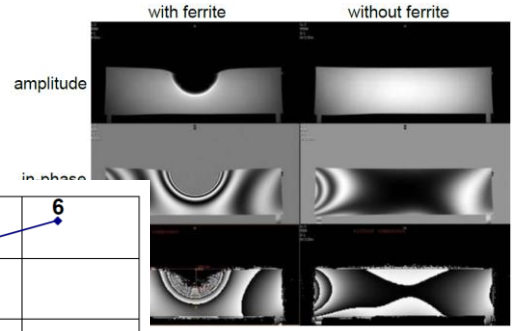
No real countermeasures are available. avoid large areas of conductive materials

Proper shielding, but should be transparent to gradient field

Requirements for PET Insert from the MR system:

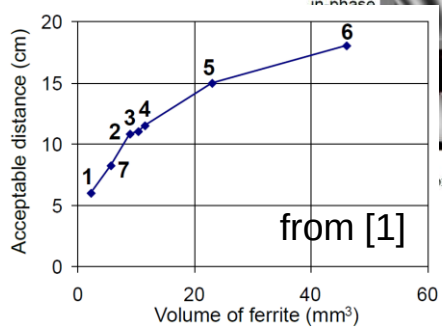
- should not emit certain frequencies and harmonics
- Parts close to the MR bore should contain as low amount of magnetic material as possible (at best, after 5 Gauss line)
- PET insert should be disinfectable, human safe (no leakage), total weight is limited, etc.

Applies certain restriction on a choice of data transmission



ırtion, in amplitude and phase, due to the ferrite.

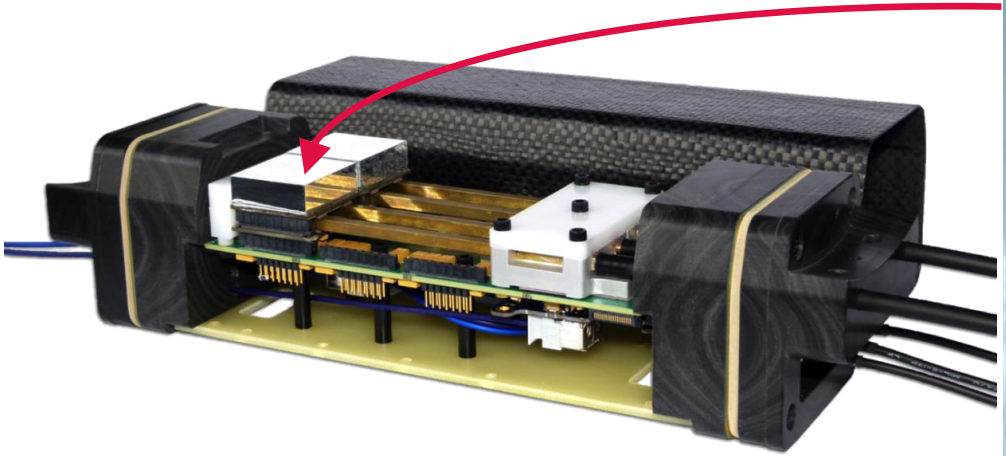
from [1]

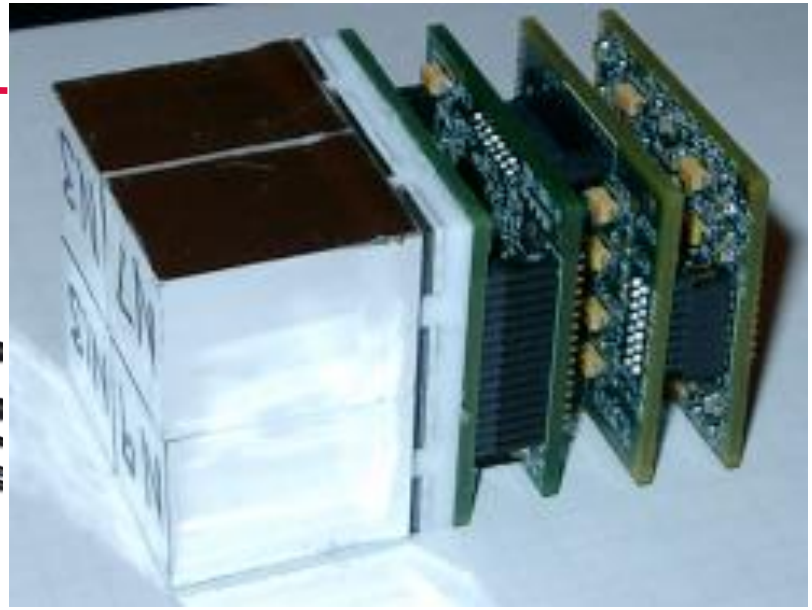


from [1]

CONCEPT OF THE PET INSERT

DETECTORS



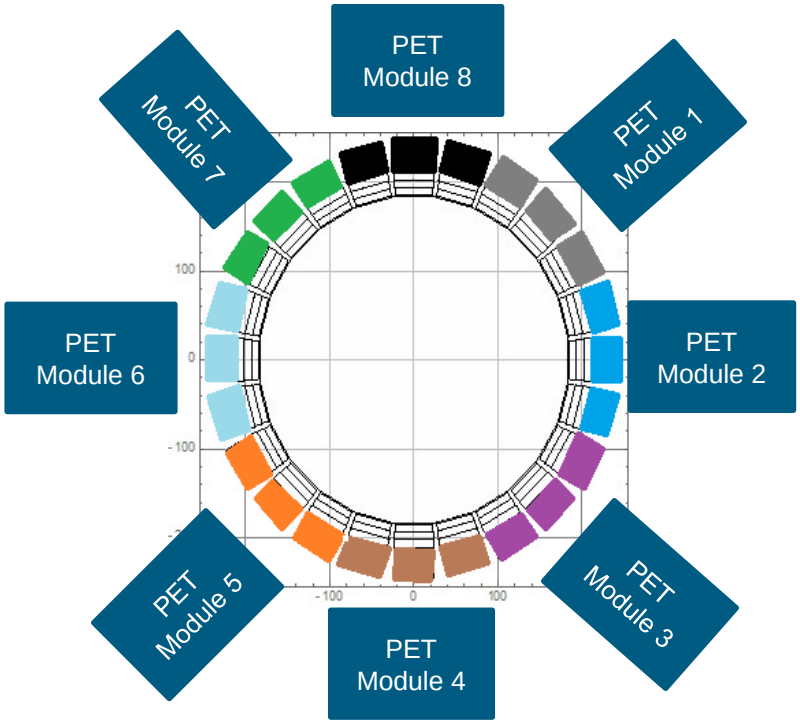


PET module is comprised of detector staks. Communication via optical link. Air cooled. Carbon shielded [2].

The detector stack based on SiPM [2]. FLTR: scintillator, Philips dSiPM sensor module, FPGA based readout module, powering

CONCEPT OF THE PET INSERT

DETECTOR RING AND THE GANTRY



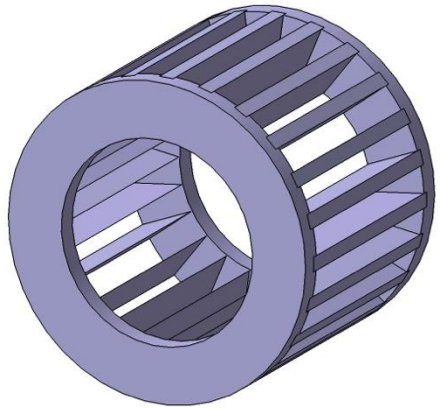
- In total 8 PET modules will be used in the insert
- Total amount of detector stacks 120
- The field-of-view of the insert is 23-26 cm
- Resolution ~ 1.5mm
- In total 96 variable voltages are required (to avoid ground loops)
- Total amount of optical links - 16
- Total current ~ 400A

Projekt 229
BrainPet Insert

Prinzipskizze zur
24er Gantry

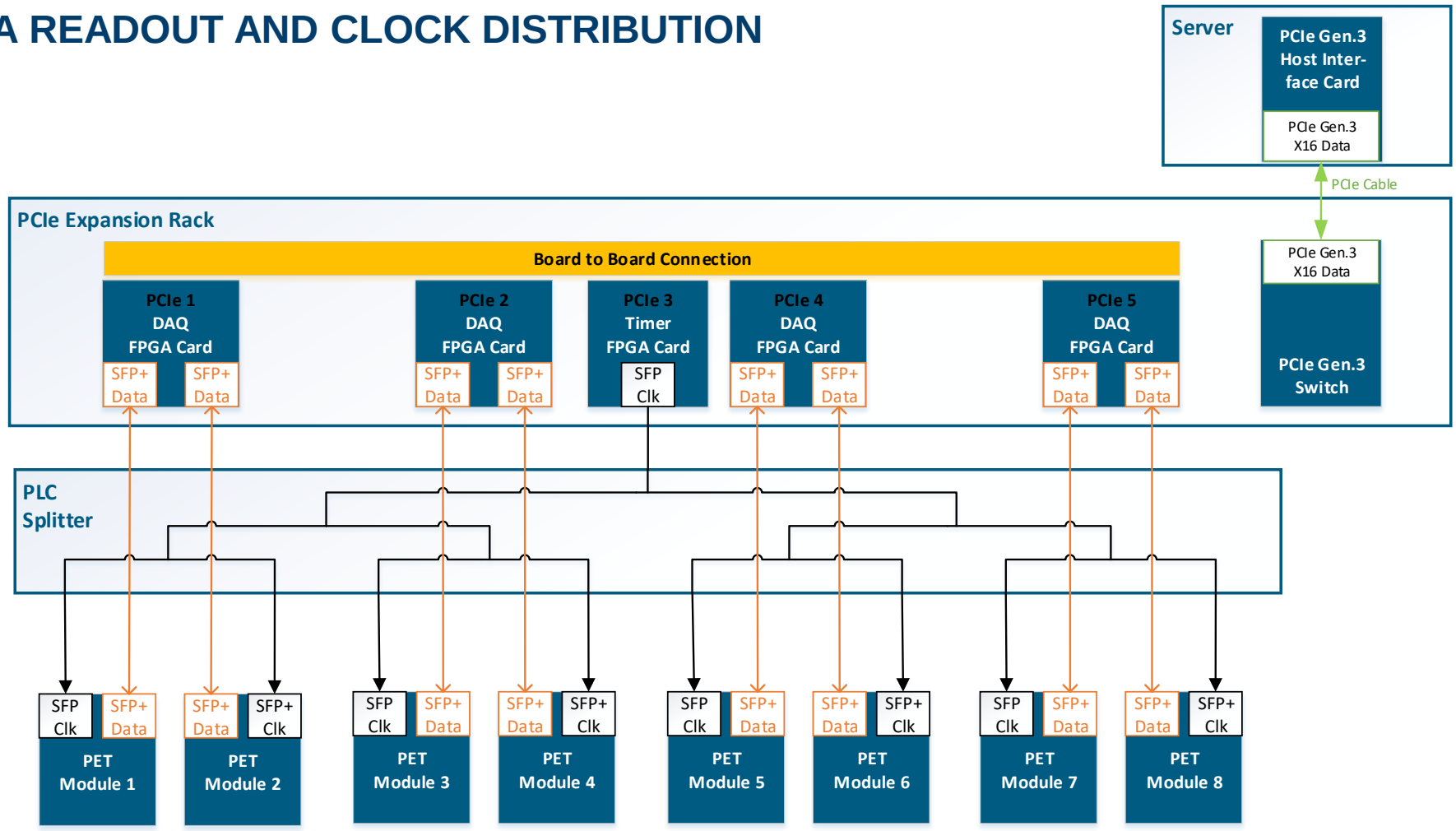
Nur zur Information

ZEA-1, J.Collienne
01.12.2016



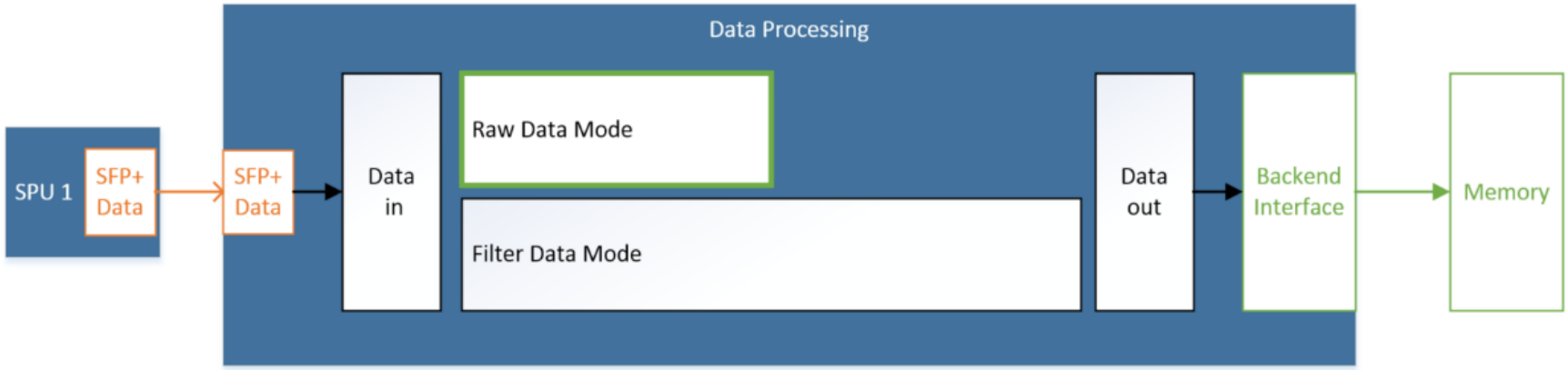
CONCEPT OF THE PET INSERT

DATA READOUT AND CLOCK DISTRIBUTION



CONCEPT OF THE PET INSERT

DATA PROCESSING: RAW DATA MODE

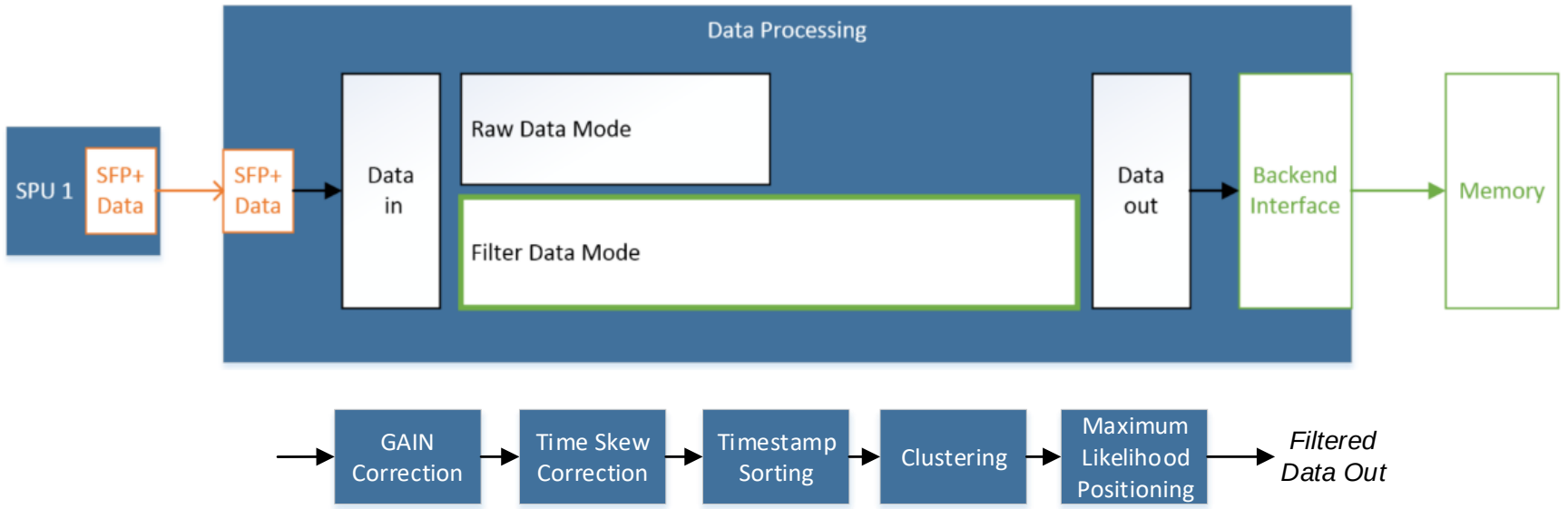


All the Data is transmitted over the Backend Interface and stored into an external Memory. a. k. a. **debugging mode**

Memory bandwidth: ~ 6GB/s

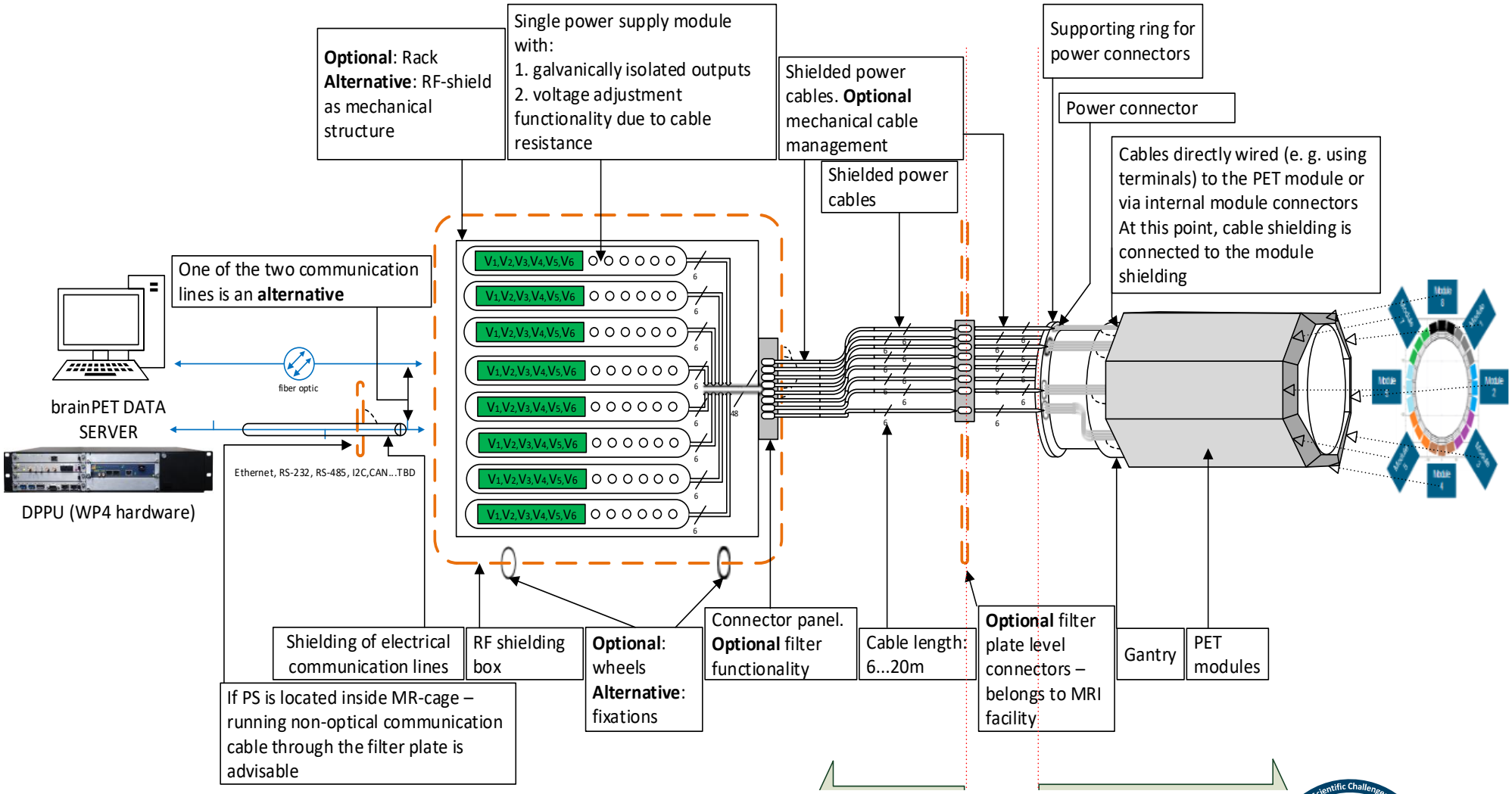
CONCEPT OF THE PET INSERT

DATA PROCESSING: FILTERED DATA MODE



Different Filters and Algorithms reduce the Data and only the useable data for Imaging Reconstruction get transmitted over the Backend Interface and stored into an external Memory.

CONCEPT OF THE PET INSERT PSU



SUMMARY AND STATUS OF THE PROJECT

- Development of the electronics for high magnetic fields requires a lot of care, since conventional designs might not be applicable. The literature is scarse, people with expertise even less.

- In order to eliminate some risks hardware will be based on existing products if possible. The rest – custom made ← requires lots of tests and discussions

- Our current concept went through several redesigns and we will have a final version soon (mid / end 2020)

Thanks You!

REFERENCES

[1] D. W. Harberts and M. van Helvoort, "MRI image distortion due to magnetic materials in medical i mplants," *2015 IEEE International Symposium on Electromagnetic Compatibility (EMC)*, Dresden, 2015, pp. 1463-1466.

[2] Weissler, Björn, et al. "Design concept of world's first preclinical PET/MR insert with fully digital silicon photomultiplier technology." Nuclear Science Symposium and Medical Imaging Conference (NSS/MIC), 2012 IEEE. IEEE, 2012.