BRAINPET - A NEW INSERT FOR PET-MR PROTOTYPE

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Scientific Challenges
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- CONCEPT OF THE PET INSERT
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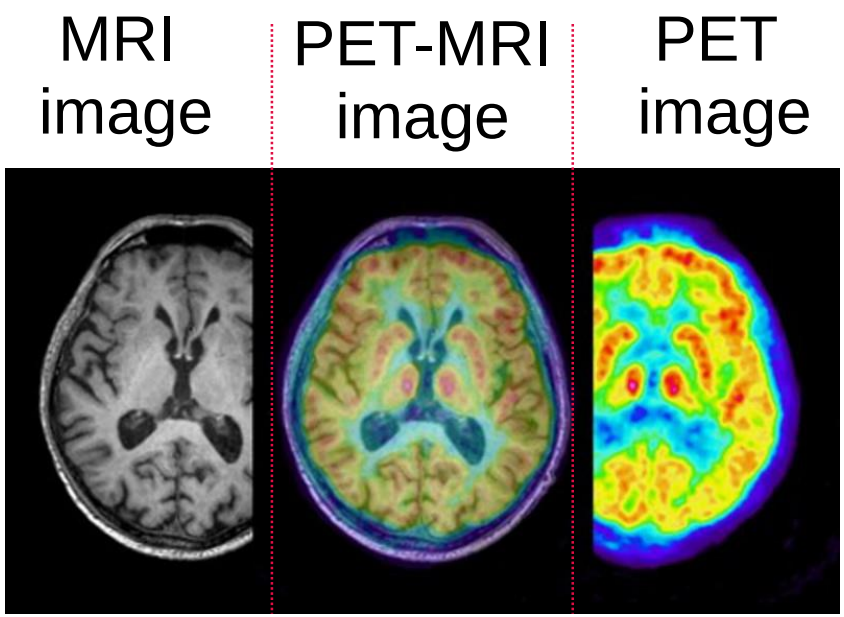
INTRODUCTION

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

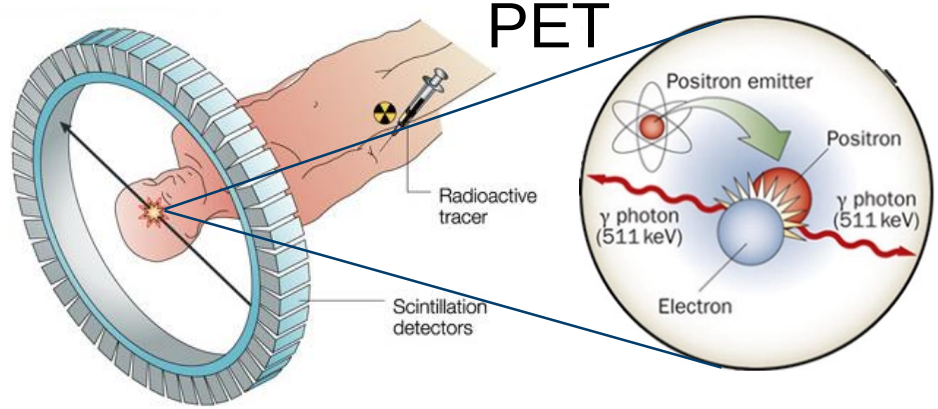


INTRODUCTION

WORKING PRINCIPLES OF TWO MODALITIES

MR

PET



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

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

- A trace amounts of short-lived radioactive labeled molecules are injected into bloodstream
- Radioactive decay can reveals 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

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

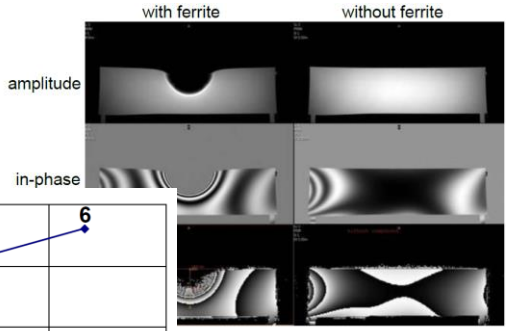
Applies certain restriction on a choice of data transmission

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

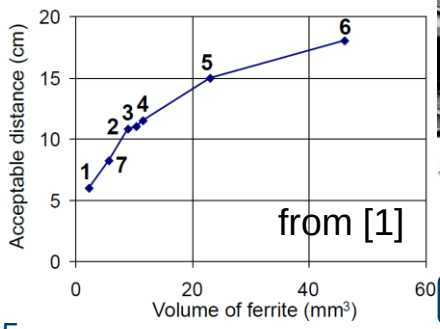
Requirements for PET Insert from the MR system:

- should not emit certain frequencies and harmonics thereof.
- 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 current leakage), total weight is limited, etc.



, in amplitude and phase, due to the ferrite.

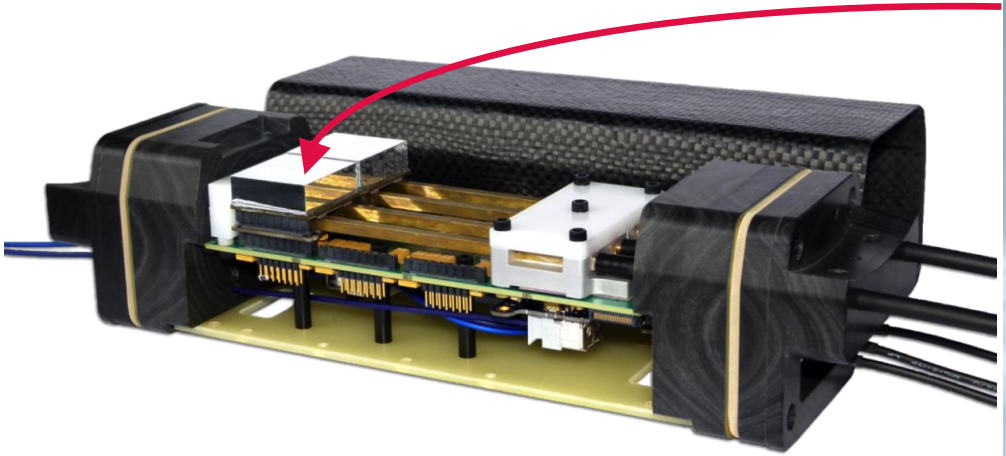
from [1]

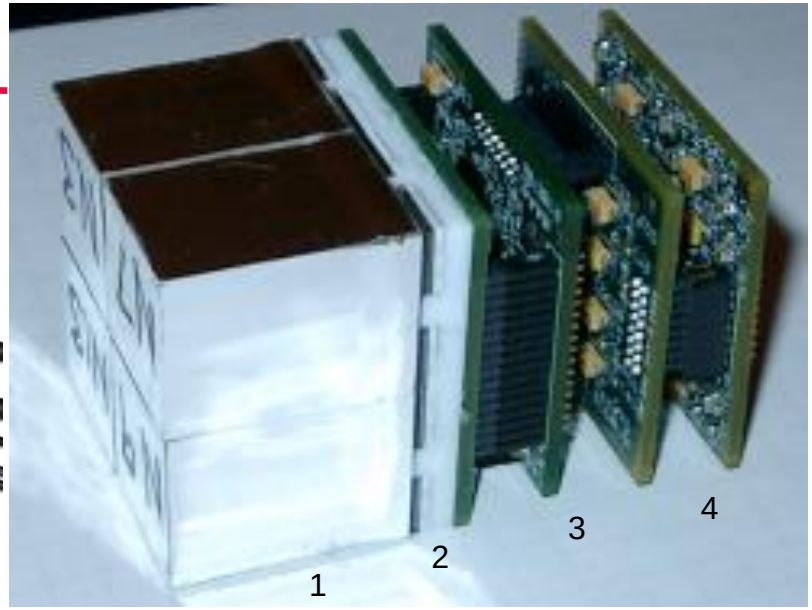


from [1]

CONCEPT OF THE PET INSERT

DETECTORS





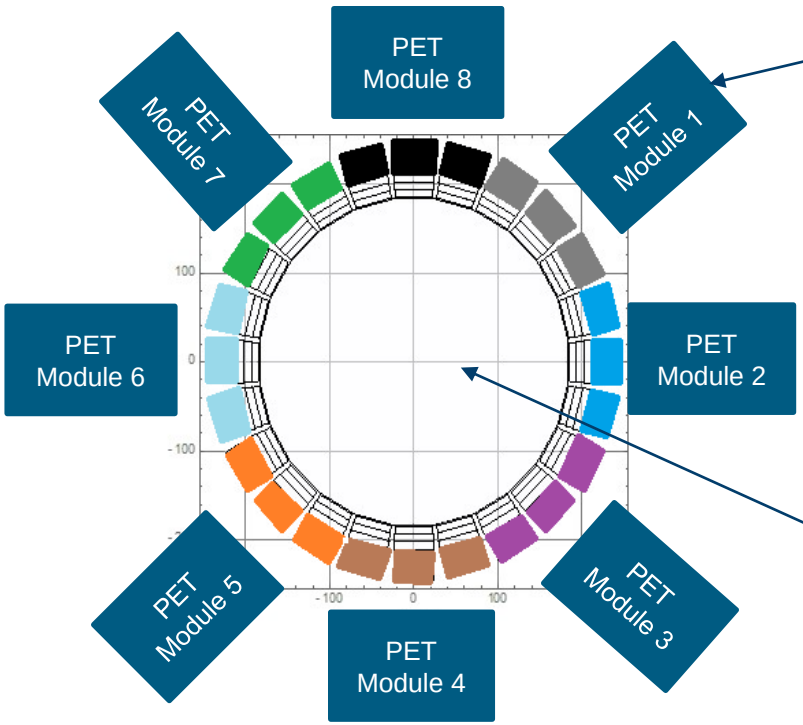
- PET module comprised of detector stacks
- Communication via optical link
- Air cooled
- Carbon shielded [2]

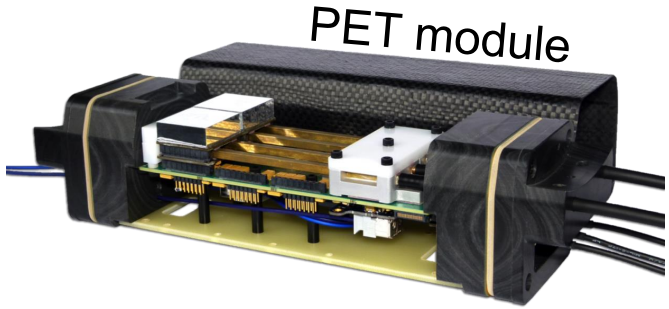
The detector stack based on dSiPM [2].

1. Scintillator
2. Philips dSiPM sensor module
3. FPGA based readout module
4. Powering

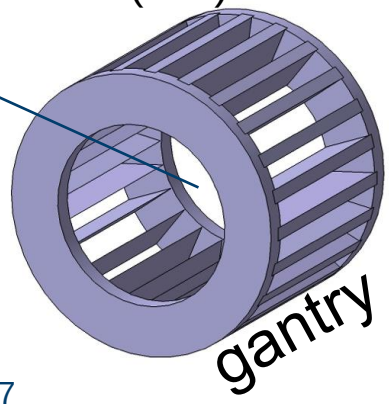
CONCEPT OF THE PET INSERT

DETECTOR RING AND THE GANTRY



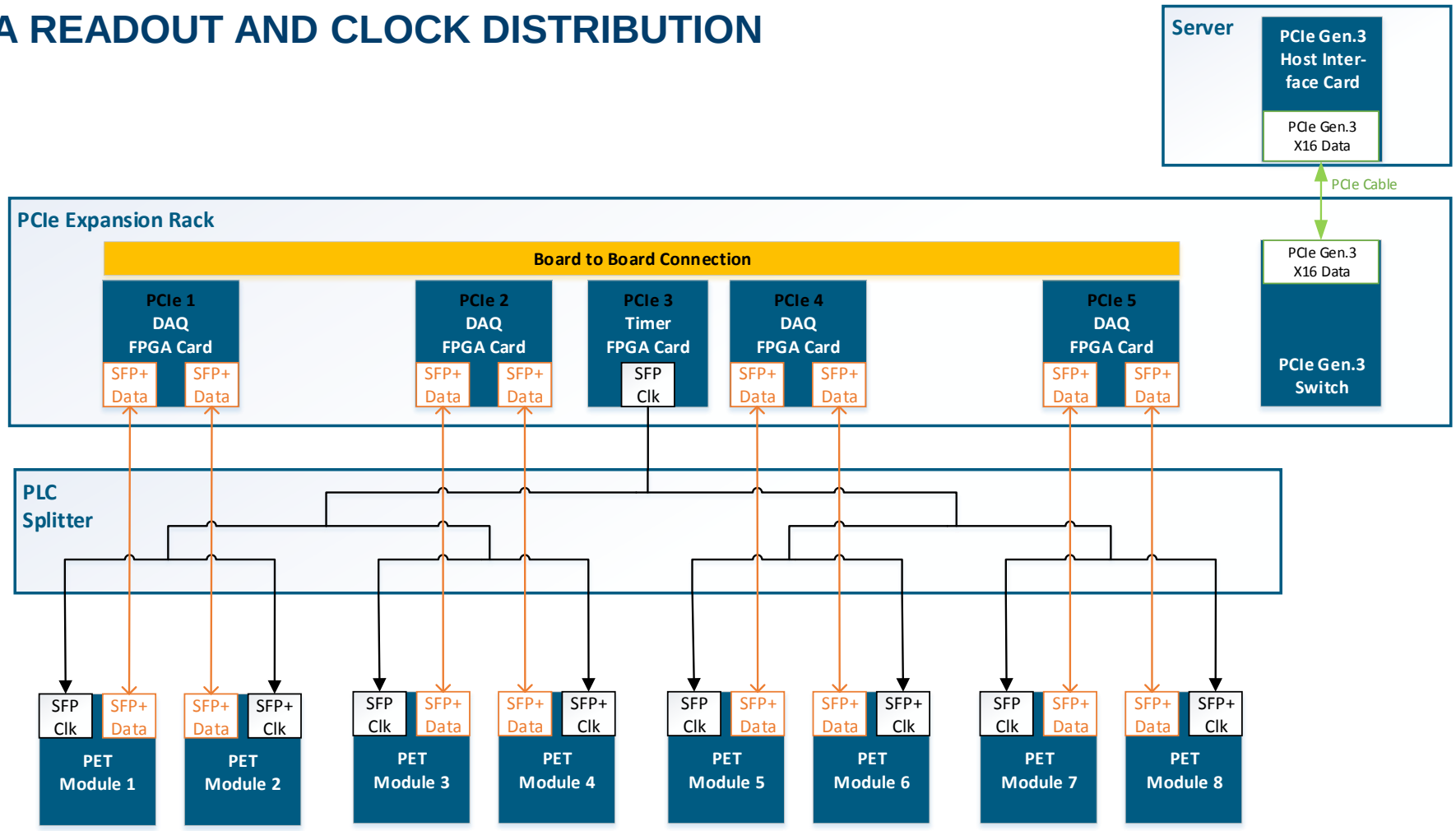


- Total amount of PET modules - 8
- Total amount of detector stacks - 120
- Total amount of isolated voltages (avoid loops in the magnetic field) - 96
- Total amount of optical links - 16
- Total current (with safety margin) [A] ~ 400
- The field-of-view of the insert (cm) - 23/26
- PET resolution (mm) ~ 1.5



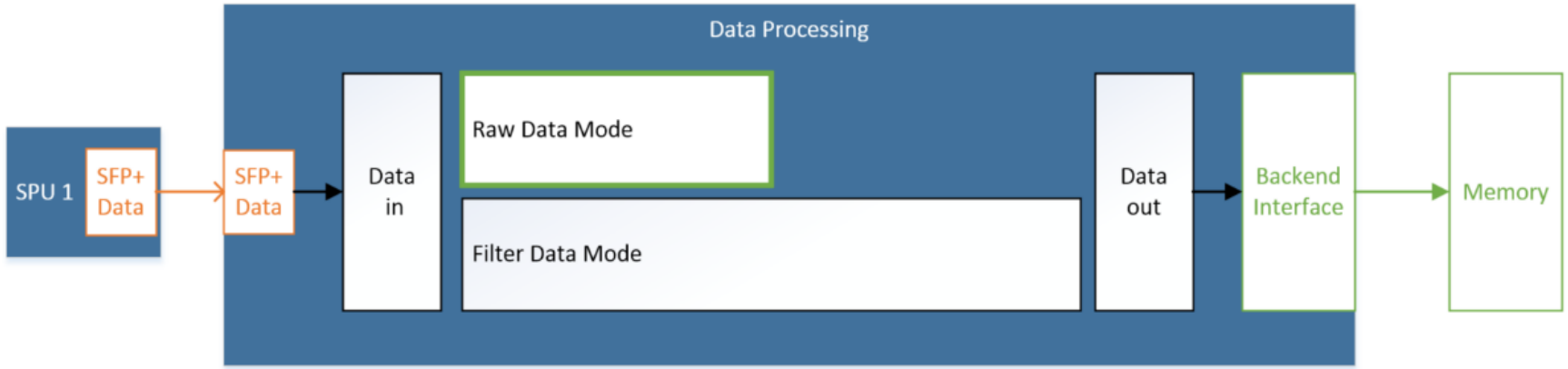
CONCEPT OF THE PET INSERT

DATA READOUT AND CLOCK DISTRIBUTION



CONCEPT OF THE PET INSERT

DATA PROCESSING: MODE I

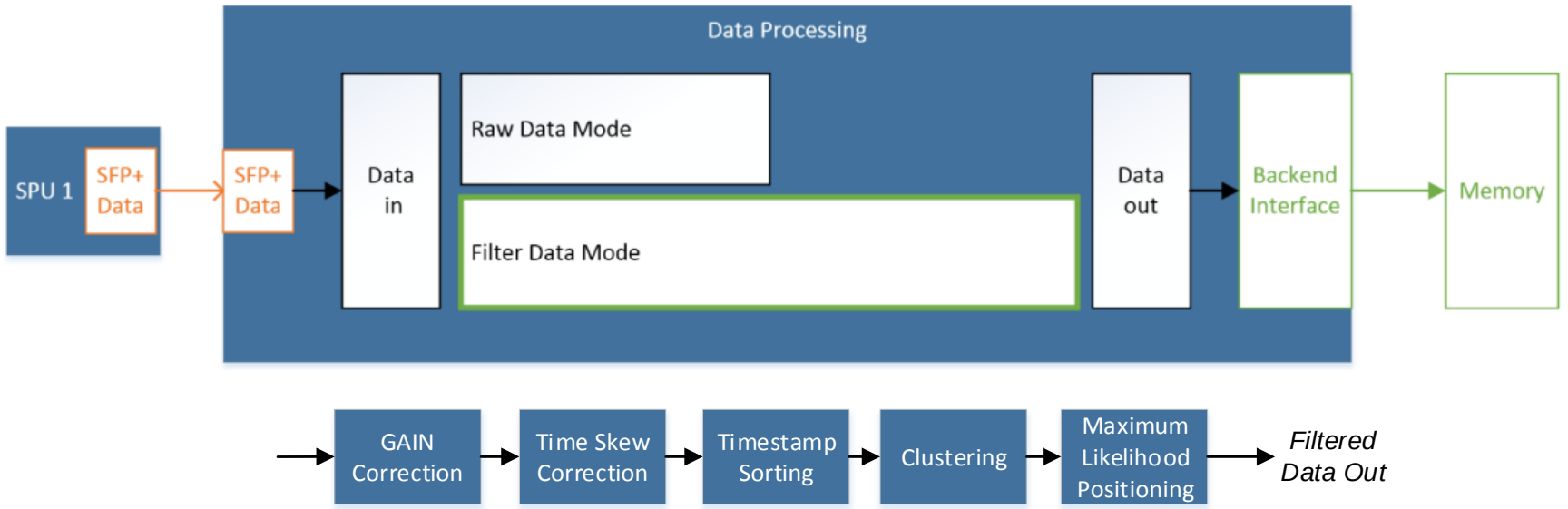


All the data is transmitted over the backend Interface and stored into an external memory (a. k. a. **debugging mode)**

Total memory bandwidth: ~ 6GB/s

CONCEPT OF THE PET INSERT

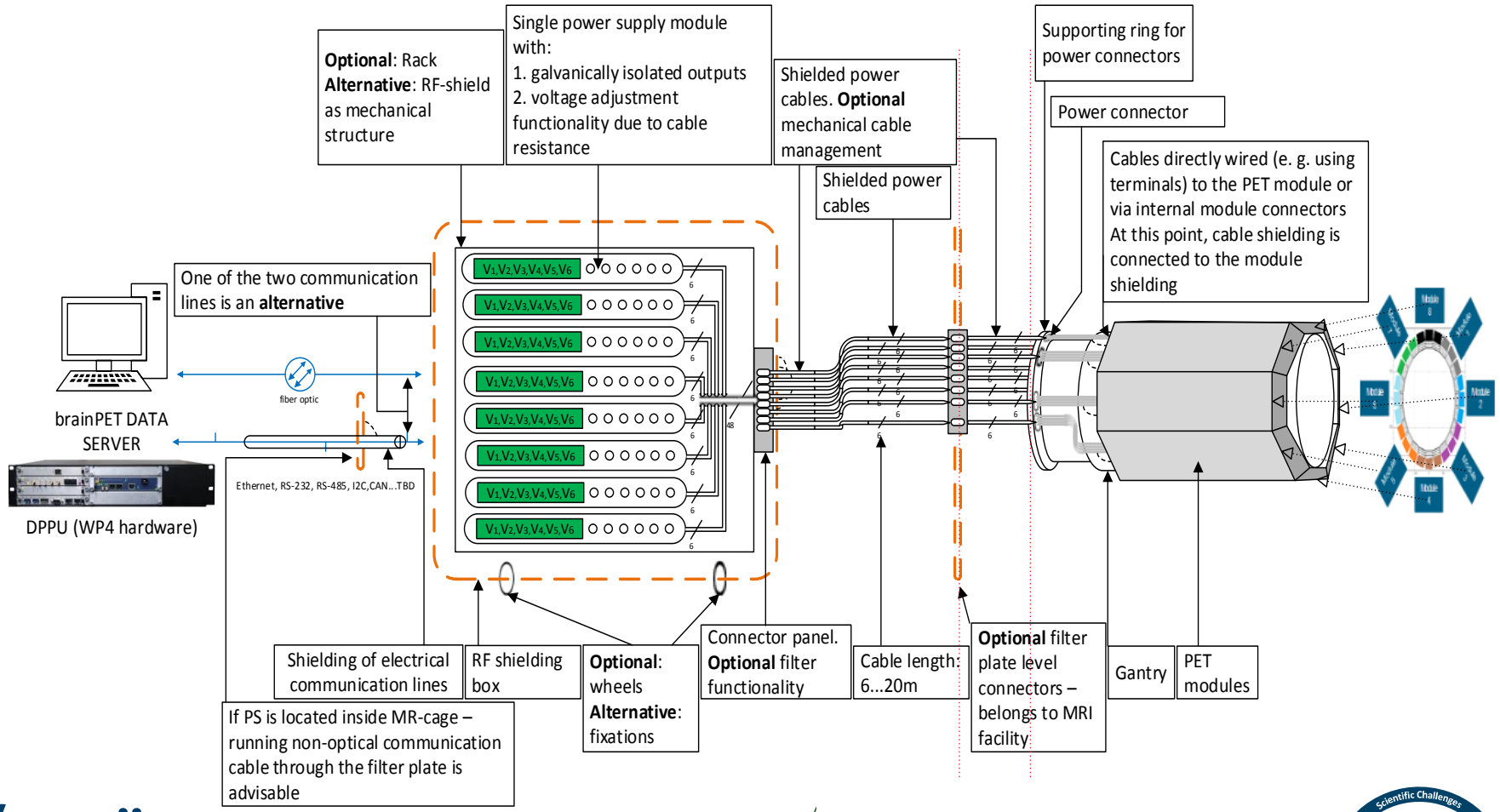
DATA PROCESSING: MODE II



Different filters and algorithms reduce the data, and only part required for further analysis and image reconstruction gets transmitted over the backend Interface and stored in the external memory (server).

CONCEPT OF THE PET INSERT

POWER SUPPLY



SUMMARY AND STATUS

- Development of the electronics for high magnetic fields requires a lot of care, since conventional designs might not be applicable. The literature is scarse, not much experienced people either.

- Our current concept went through several redesigns and we will have a final version soon.

- In order to eliminate other risks and better focus on project complexity we will try to base most of the hardware on already existing products on the market.

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.