SIEMENS

PET/MRI: Technical Design Challenges and Innovations

Niraj K. Doshi, PhD, PMP, ExecJD – August 2013

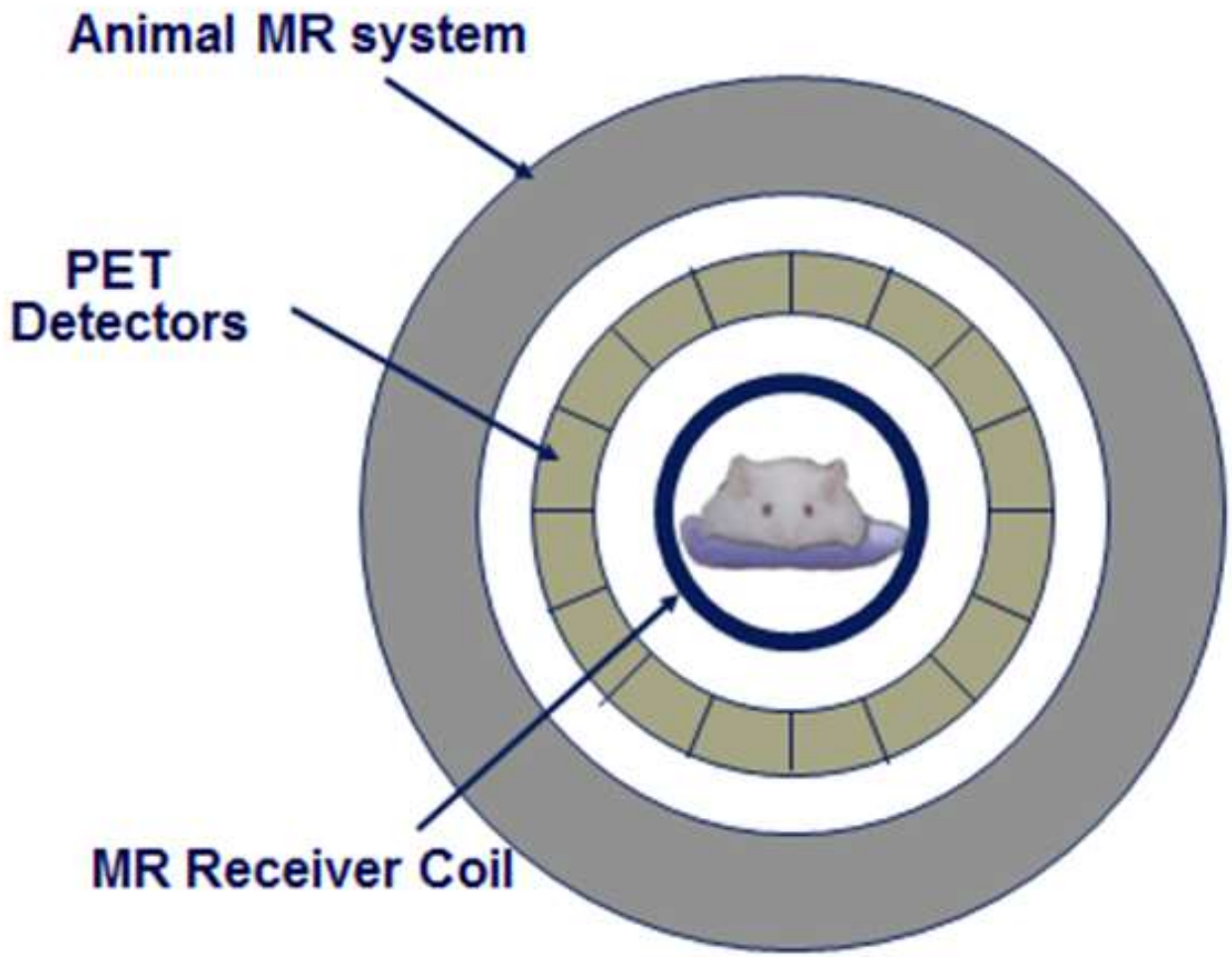
PET/MRI: Technical Design Challenges and Innovations Agenda

- Historical development of MR and PET technology
- Current hybrid technology
- Potential future outlook

Historical Development of MR and PET Technology

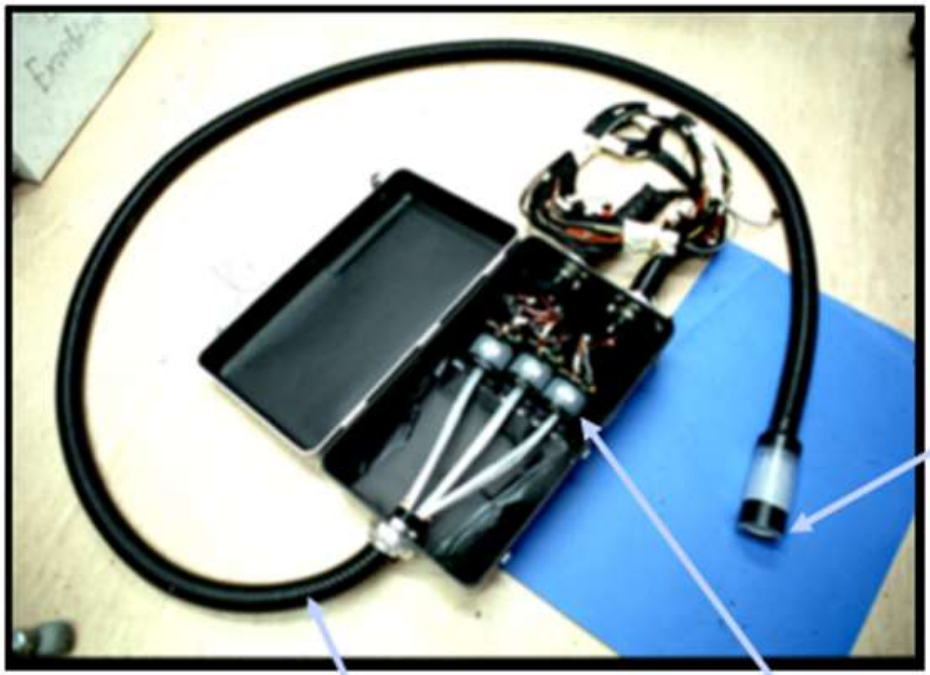
MR Compatible PET System (McPET)

Insert concept by Cherry, et al. – Circa 1997



Courtesy of Simon R. Cherry, PhD – UCLA School of Medicine. Crump Institute for Biological Imaging.

McPET
System design



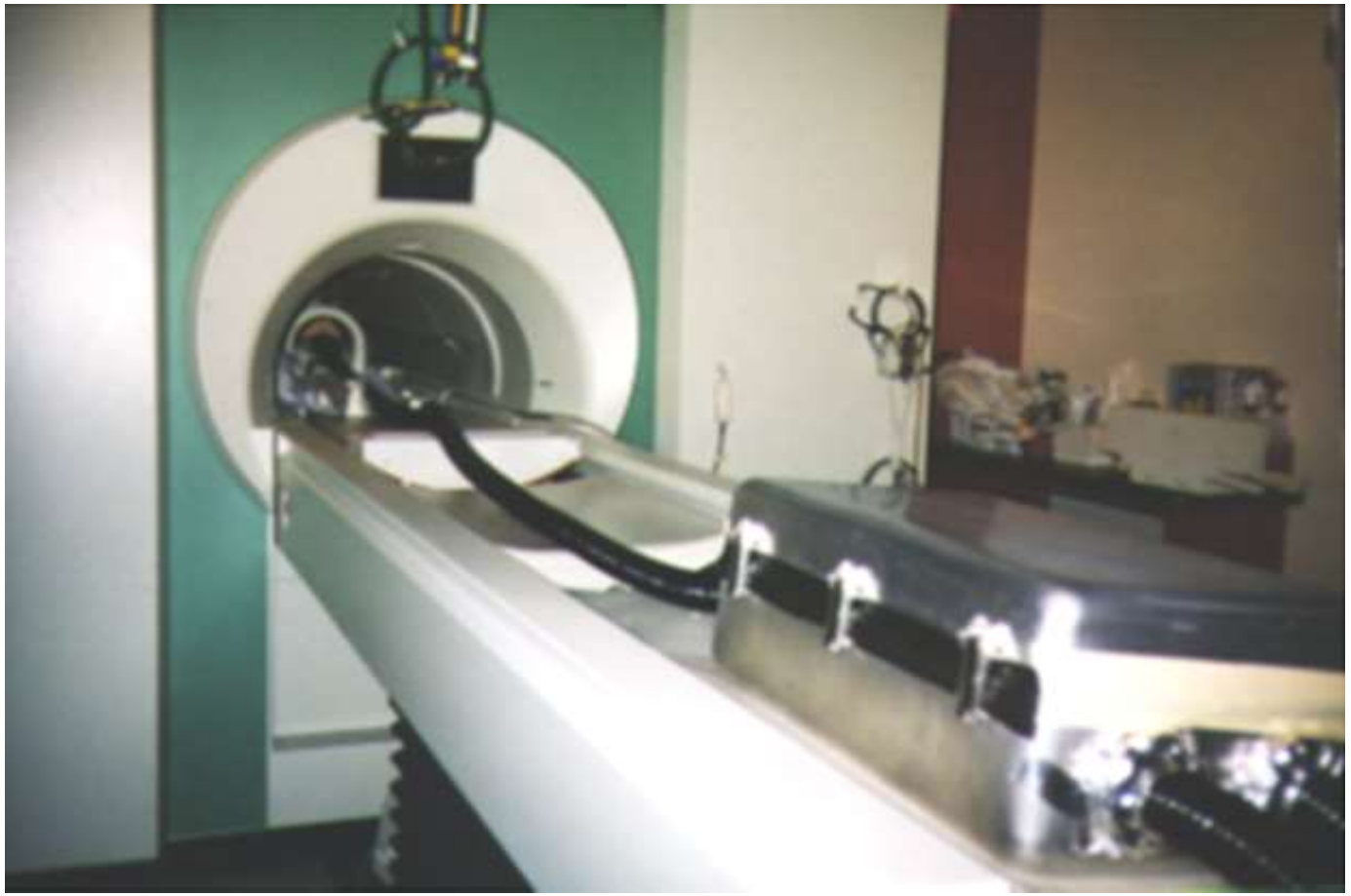
56 mm ring diameter
72 2x2x25 mm LSO scintillators

optical fibers

PMT's

Courtesy of Simon R. Cherry, PhD – UCLA School of Medicine. Crump Institute for Biological Imaging.

McPET
Experiment



- Prototype MR compatible PET scanner inside 1.5T clinical MR

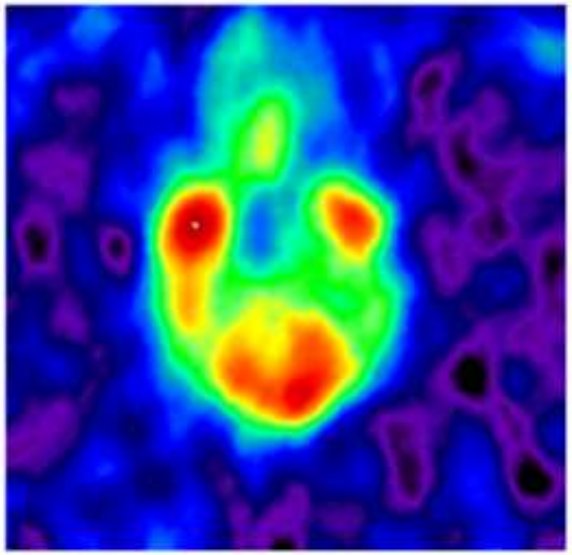
Courtesy of Simon R. Cherry, PhD – UCLA School of Medicine. Crump Institute for Biological Imaging.

McPET
Initial images ~1997-98

SIEMENS

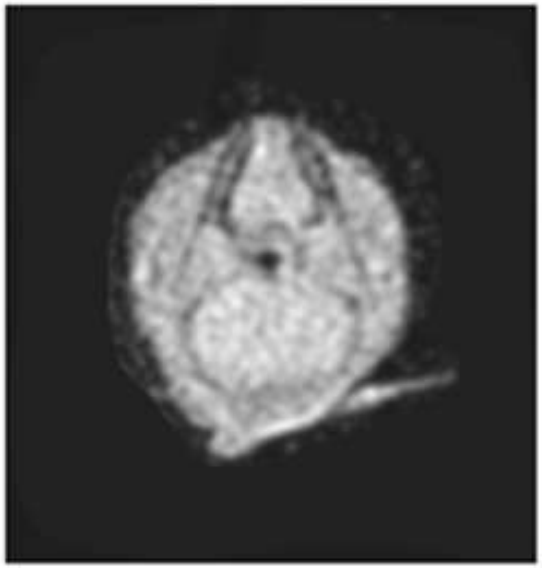
Simultaneous *In Vivo* Imaging

PET Brain



- 200 g rat injected with 1.3 mCi ^{18}F FDG
- Imaging time = 30 mins
- Slice thickness ~ 2 mm

MR Brain



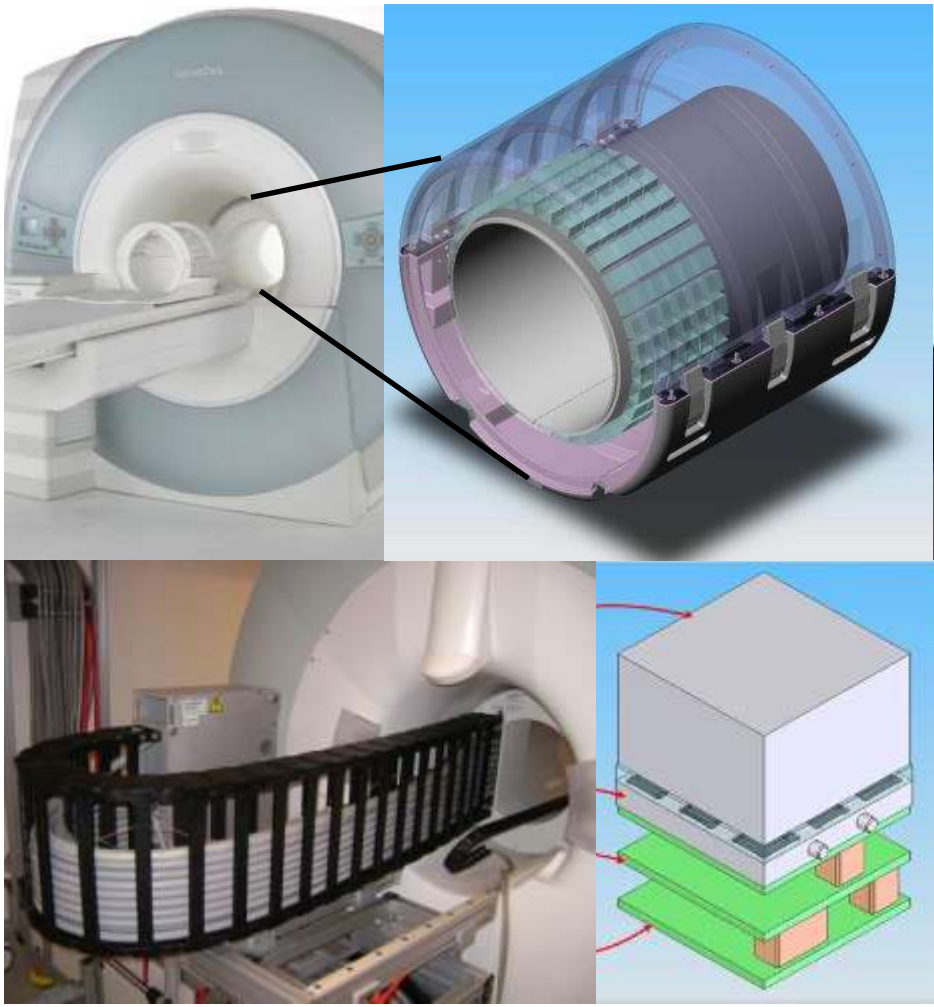
- TE = 12 msec, TR = 280 msec
- Continuous 75 sec acquisition during PET study
- Slice thickness = 4 mm

Courtesy of Simon R. Cherry, PhD – UCLA School of Medicine. Crump Institute for Biological Imaging.

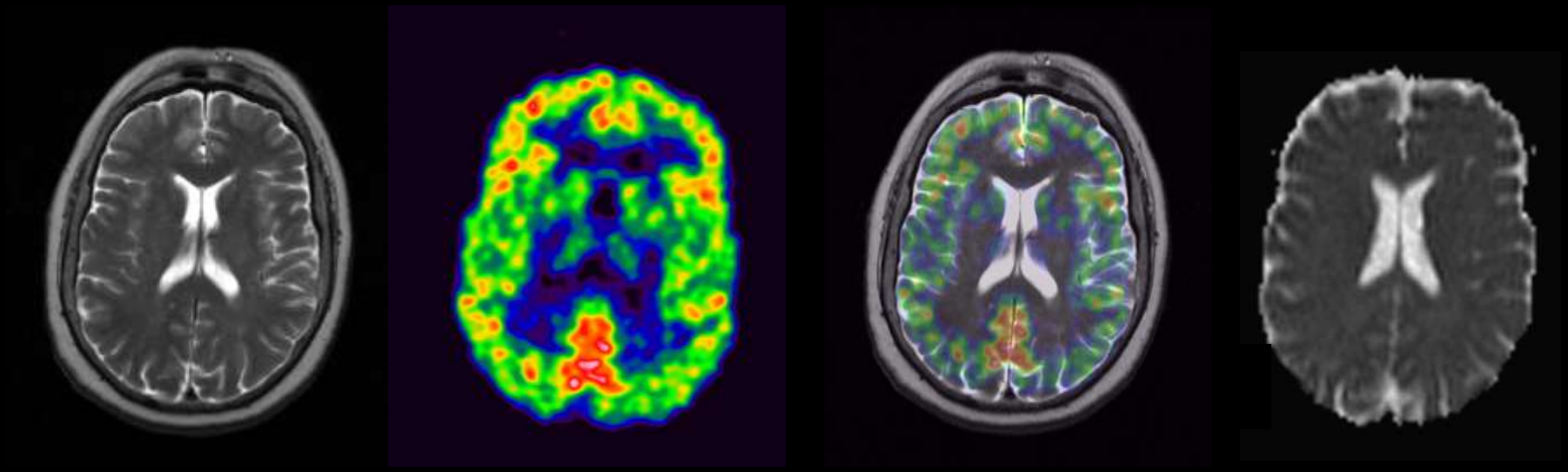
BrainPET
Siemens' 1st Clinical PET/MRI – Head Insert – Circa 2006

Technical Hurdles:

- Physical size constraints
- Cooling requirements
- RF interference
- Perturbation of MR image quality
- Perturbation of PET image quality
- Serviceability



BrainPET
Clinical results ~2006



T2 TSE | PET | MR-PET | ADC

- Diffusion EPI sequence applied during PET acquisition.

Data courtesy of Townsend and Nahmias University of Tennessee, USA and Schlemmer, Pichler, Claussen University of Tuebingen, Germany

Current Hybrid Technology

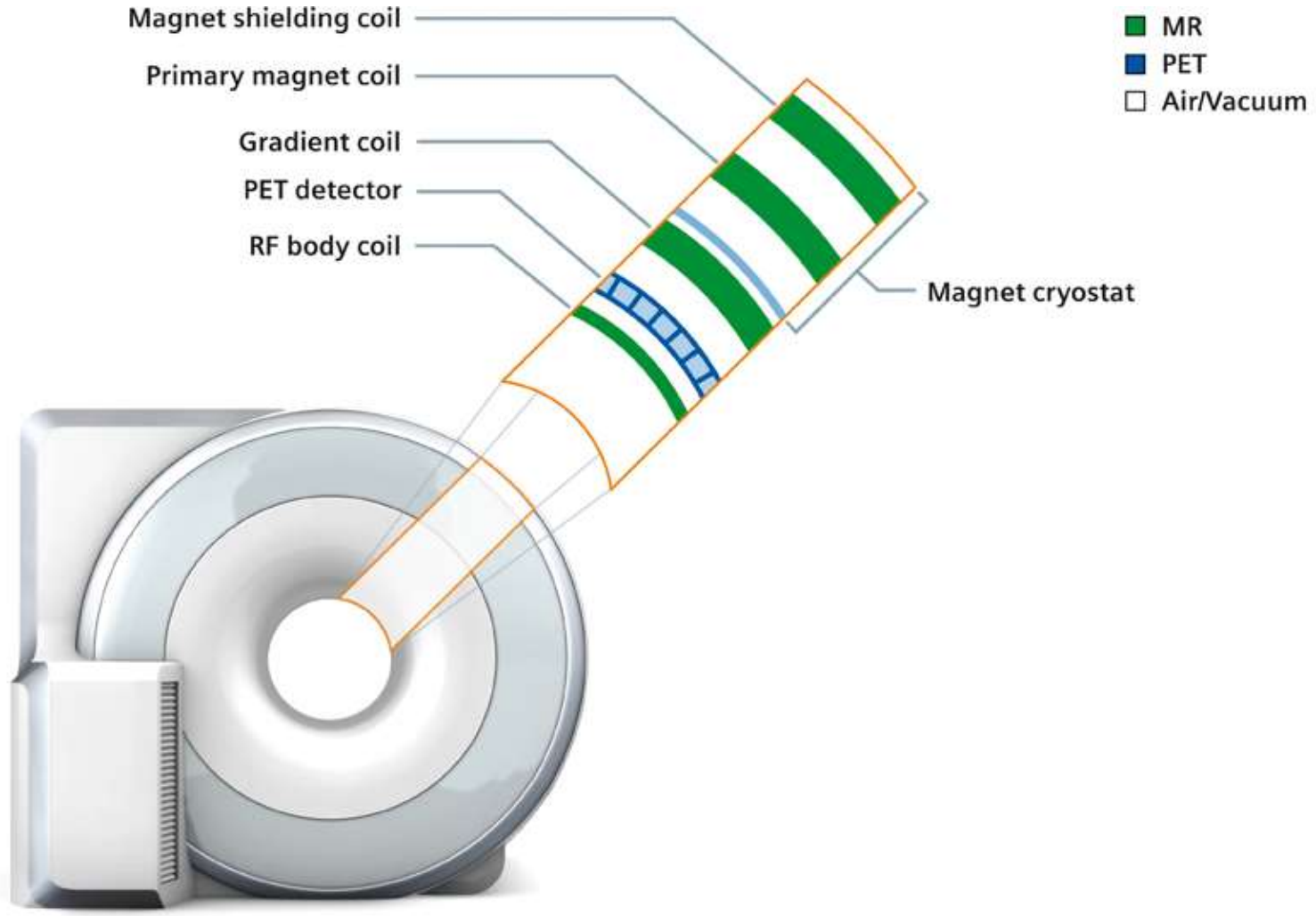
Biograph mMR
First to chart a path

SIEMENS

Goals:

- First fully integrated MR and PET system in the world
- Simultaneous imaging of MR and PET
- Ability to image the whole-body
- No compromises on image quality for MR or PET systems
- Workflow integration and efficiency

Biograph mMR
System design concept



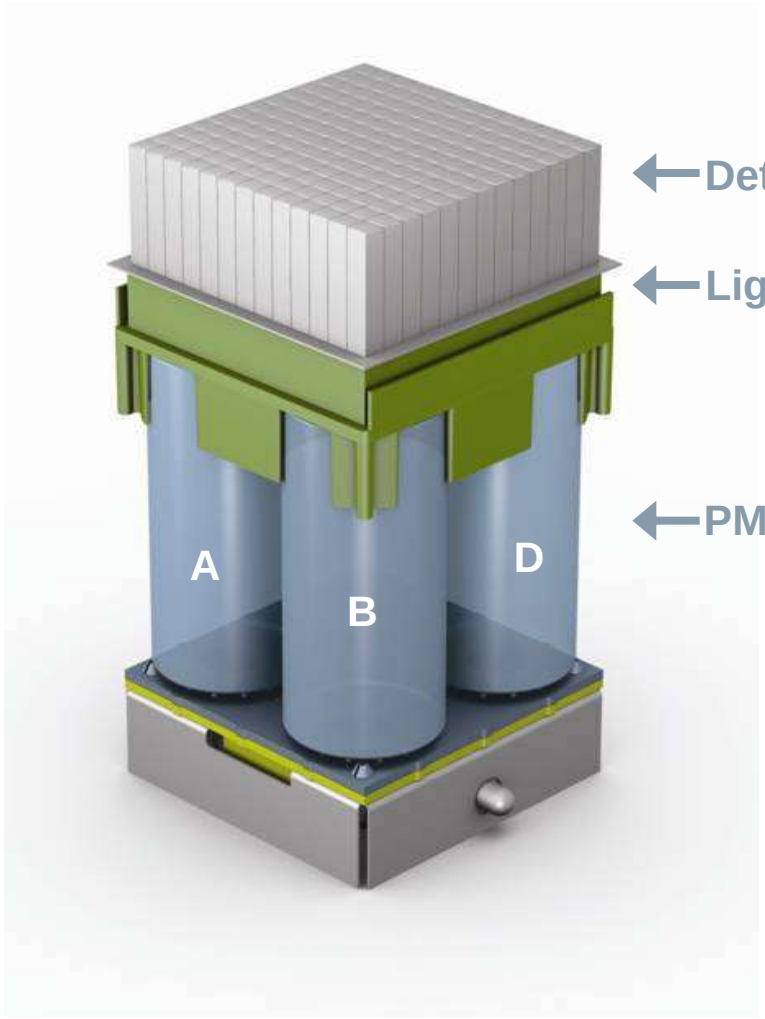
Biograph mMR
System architecture

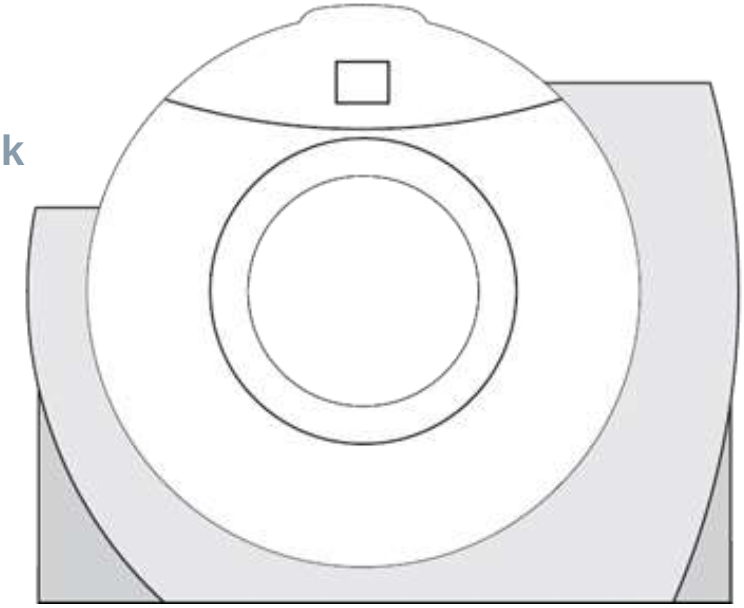
SIEMENS

Technical Innovations:

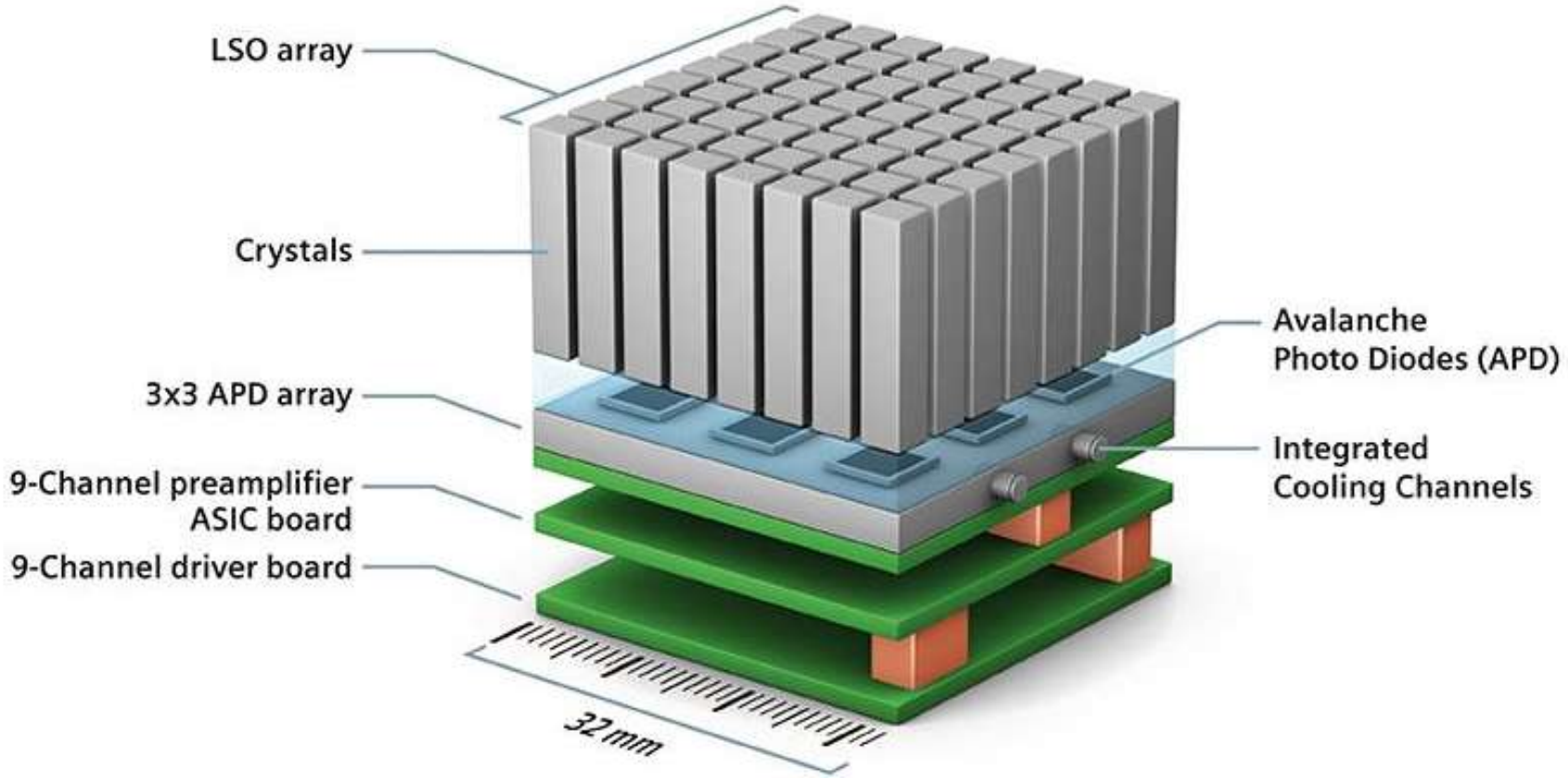
- Solid state detector design
- Common cooling and feedback system
- Component redesign for PET optimization (reduce attenuation)
- RF interference optimization using filtering
- Heat dissipation through design and component selection
- Baseline correction to avoid gradient amplifier noise effects

PET Detector Technology
Photomultiplier tube (PMT) based

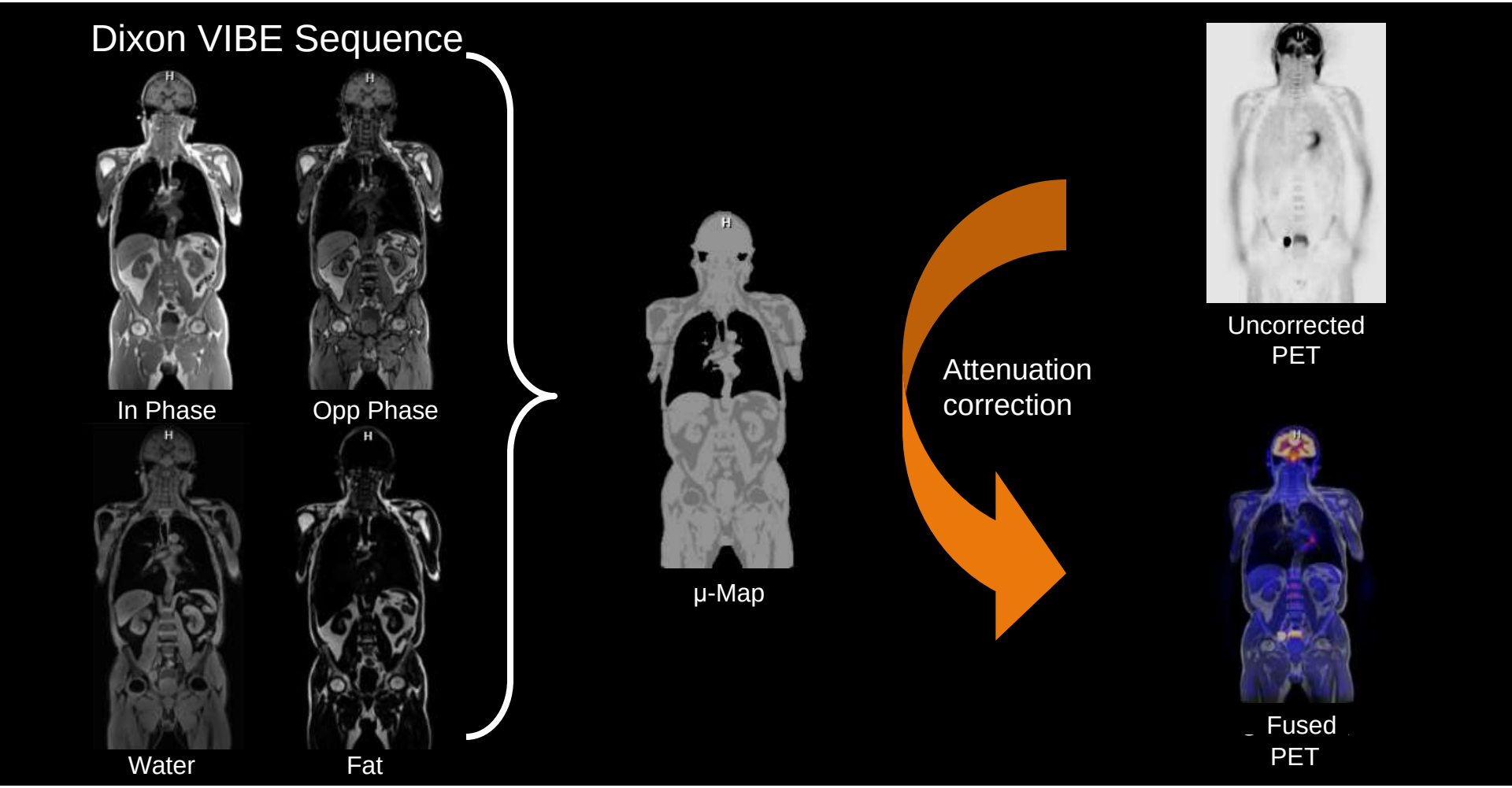




Biograph mMR
Solid state detector design concept



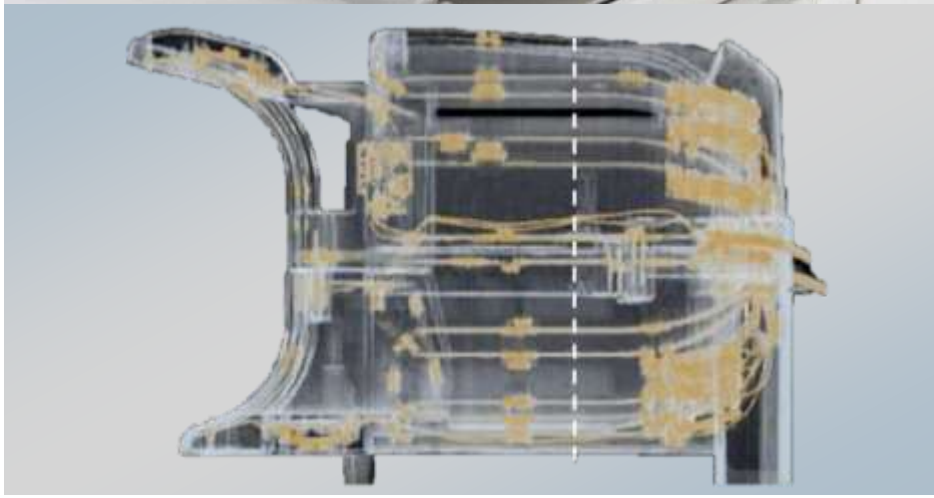
Attenuation Correction (AC)
MRI-based AC of a patient body



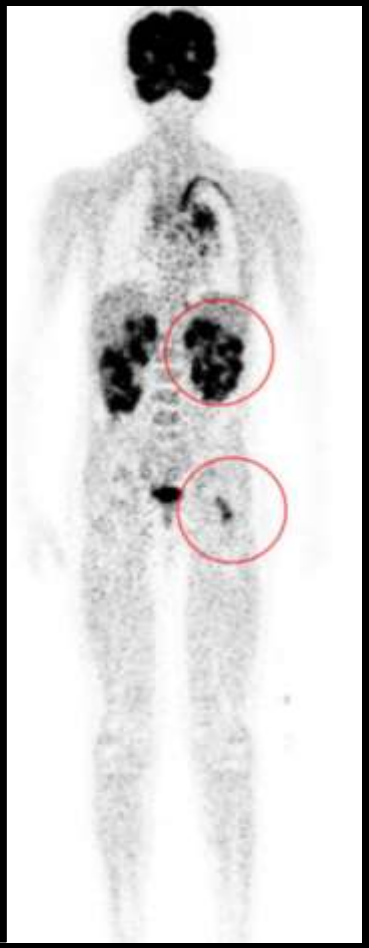
Data courtesy of the Institute of Medical Physics and University of Erlangen, Erlangen, Germany

Attenuation Correction
Rigid stationary hardware

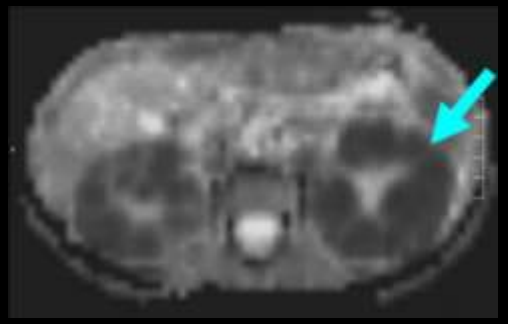
- CT-based AC for table, head/neck and spine coils
- µ-map is part of PET reconstruction process
- Relevant part of µ-map is automatically selected for each table position

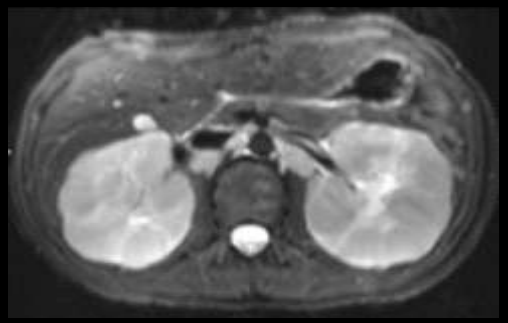


Biograph mMR
Pediatric images



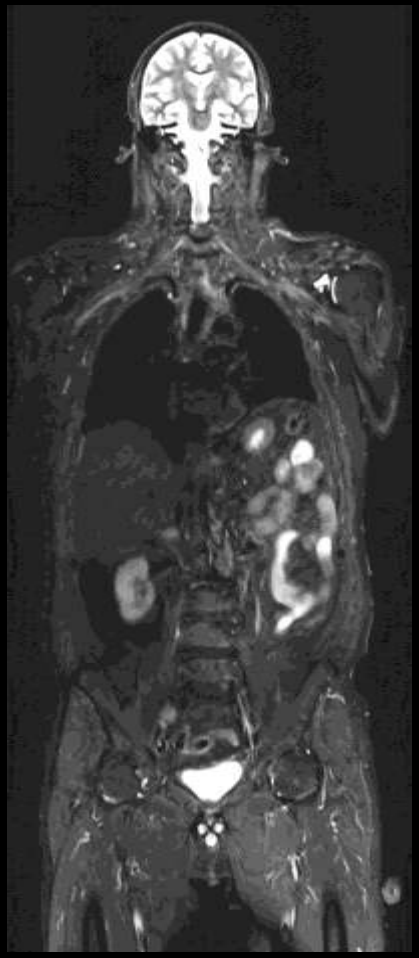
11-year-old, male with T-cell lymphoma; DWI and PET provide the full picture

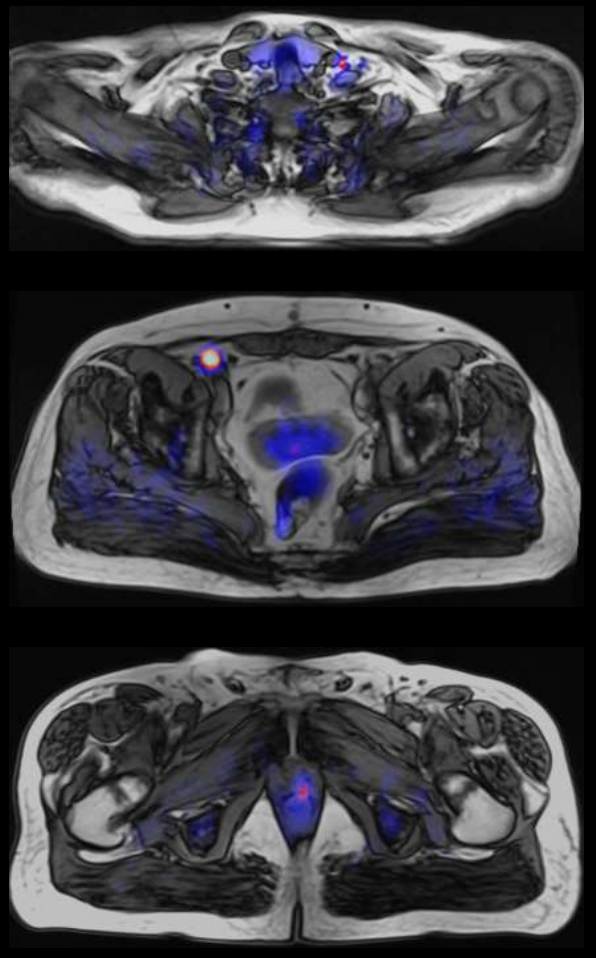




Data courtesy of Hirsch et al.: PET/MR in children. Initial clinical experience in pediatric oncology using an integrated PET/MR scanner. Pediatr Radiol (2013)

Biograph mMR
Clinical images



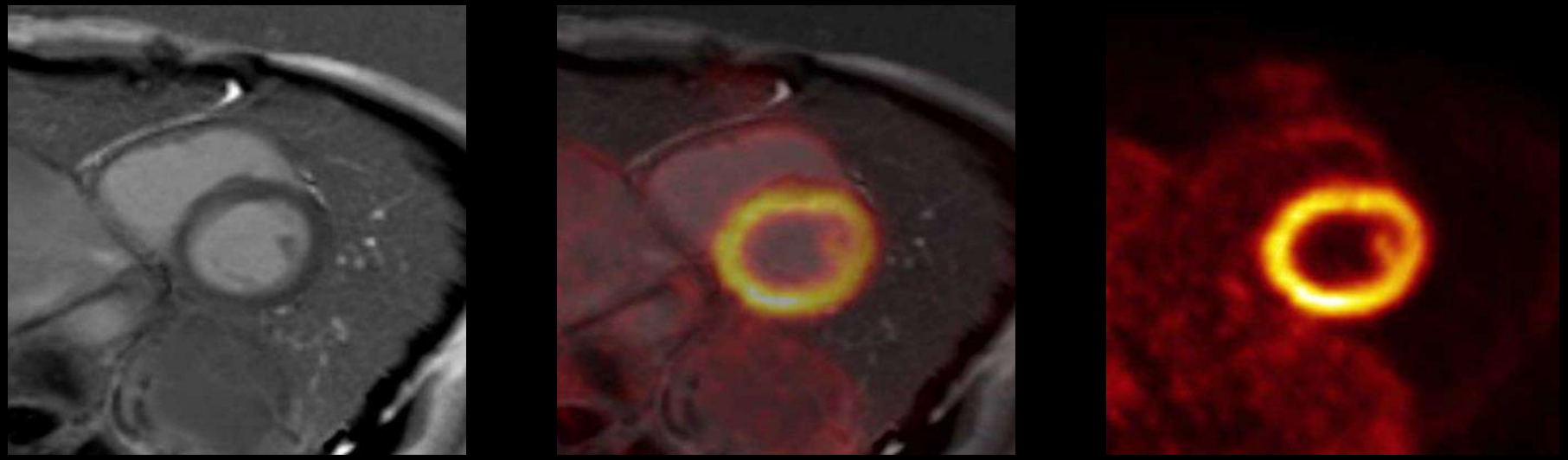


Data courtesy of Center for Modern Diagnostics (CEMODI), Bremen, Germany

Biograph mMR
Temporal co-registration

SIEMENS

Cardiac molecular MR



Simultaneously gated PET and cardiac MR images

- PET data acquired in list mode and binned retrospectively
- MRI acquired in diastole, fused with diastolic PET data

Data courtesy of Mallinckrodt Institute of Radiology, Washington University, St. Louis, USA

Future Outlook

Biograph mMR
Road forward

Facts:

- Biograph mMR is a clinical reality
- Numerous sites are performing clinical and research studies

Future Path:

- Incorporate further customer feedback
- Focus on clinical outcomes

Let the clinicians lead the way!

Biograph mMR
Clinical perspective

"**Dose reduction** is a major concern of ours -- and this can be quite **considerable**.

This is particularly **critical** in the examination of **children and young adults**, especially in cases of **frequent follow-up examinations** in therapy monitoring."

Markus Lentschig, MD
Radiologist and partner at the CEMODI practice
Bremen, Germany
First purely private Biograph mMR user

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" setting and many variables exist there can be no guarantee that other customers will achieve the same results.

Biograph mMR
Clinical perspective

SIEMENS

"From our own experience in cervical cancer patients, we see that **simultaneous** MR and PET is the ideal imaging tool covering the whole range of clinical care from diagnosis, therapy planning, monitoring and follow-up.

The **benefits** over other modalities are improved spatial registration, the high soft tissue contrast and functional capabilities of MRI, and minimizing the patient's scan time or dose burden."

Perry W. Grigsby, MD
Professor, Radiation Oncology
Director, Brachytherapy Center
Washington University, St. Louis, MO, USA

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" setting and many variables exist there can be no guarantee that other customers will achieve the same results.

Biograph mMR
Early adopters > 35

North America

- MGH, Boston, USA
- NIH, Bethesda, USA
- Washington Univ., St. Louis, USA
- Univ. of N. Carolina, Chapel Hill, USA
- Mt. Sinai Medical Center, New York, USA
- Indiana University, Indianapolis, USA
- Lawson Health Research Institute, London, Canada
- UPMC, Pittsburgh, USA
- NYU, New York, USA
- Cleveland Clinic Foundation, Cleveland, USA
- Stony Brook University, Stony Brook, USA
- Weill Cornell Imaging, New York Presbyterian, NY, USA (2x)
- Cedar-Sinai Medical Center, Los Angeles, USA
- UHN Toronto, Canada

Europe

- IMP Erlangen, Germany
- Klinikum r. d. Isar, Munich, Germany
- Univ. Hospital Tübingen, Germany
- Univ. Hospital Leipzig, Germany
- CEMODI Bremen, Germany
- Univ. Hospital Essen, Germany
- Univ. College London Hospitals, UK
- SDN, Naples, Italy
- DKFZ, Heidelberg, Germany
- Rigshospitalet, Copenhagen, Denmark
- St. Olav Hospital, Trondheim, Norway
- DLRZ, Bonn, Germany
- University of Padua, Italy
- CERMEP/Univ. of Lyon, France
- AKH/MUW, Vienna, Austria
- OAO RZD, Moscow, Russia
- King‘s College London, UK
- Centr. Onkologii, Bydgoszcz, Poland

Asia

- PLA 301 Hospital, Beijing, China
- Parkway Mt. Elizabeth Novena Hospital, Singapore
- CIRC/NUS/A*Star, Singapore
- Yeungnam Univ. Hospital, Daegu, Korea
- SNUH, Seoul, Korea
- Apollo Hospitals, Delhi, India
- Fukushima Medical Univ, Fukushima, Japan
- TNUH, Taipei, Taiwan
- NIMHANS, Bangalore, India
- HKSH, Hong Kong, China

Future innovations*...

- Workflow improvements
- Extended MR FoV
- Motion correction
- Whole-body bone segmentation

*These features are not commercially available in all countries. Due to regulatory reasons their future availability cannot be guaranteed. Please contact your local Siemens organization for further details.

Thank you!

Global Business Unit
Siemens Medical Solutions USA, Inc.
Molecular Imaging

810 Innovation Drive
Knoxville, TN
USA

www.siemens.com/mi

Answers for life.