# *MRC-SPECT: A Sub-500 um Resolution MR-Compatible SPECT System for Simultaneous Dual-Modality Study of Small Lab Animals*

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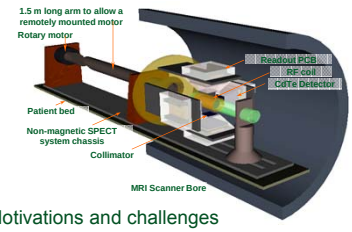
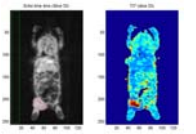
## Microscopic SPECT Imaging inside MR Scanners ?




The Siemens Allegra 3 T MRI scanner at BIC that will be used in the combined SPECT/MRI System.



Left: A 3-D whole-body image of a rat acquired with the 3 T Allegra scanner. Right: T2* relaxation of the tissues. The images were obtained with a multiecho fast low angle shot (FLASH) sequence written by Professor Brad Sutton of UIUC. It resulted in 0.5 mm isotropic resolution from an 8 minutes whole body scan.

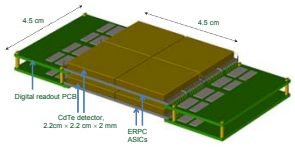
Motivations and challenges

- How to allow simultaneous SPECT and MR imaging without sacrificing the strength of both modalities?
- SPECT and MR images at matching spatial resolutions (~500/250 um)?

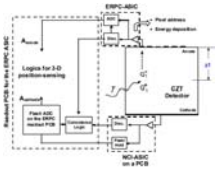
## Development of an Energy-Resolved Photon Counting CdTe/CZT Detectors

A generic and flexible detector architecture

- Very high spatial resolutions: First-gen (2007-2011): Sub-350 μm in all 3 dimensions, Second-gen (developed in 2012): sub-100um resolution in 3D.
- Excellent energy resolution (3-4 keV @ 140 keV) and adequate sensitivity.
- Operation in strong magnetic fields (3T, 9.4T or higher).
- Adequate timing and DOI resolutions and count-rate capabilities for PET applications.

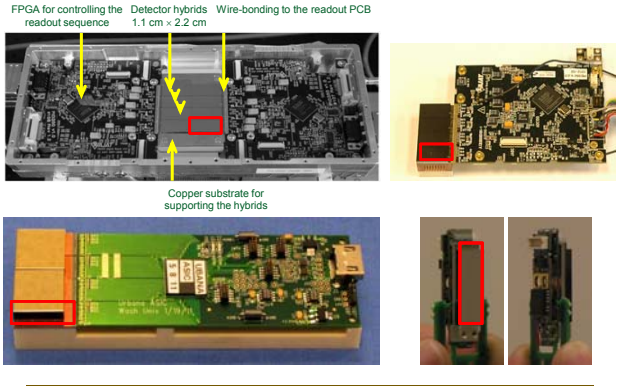



The proposed MRI-compatible ERPC CdTe detector

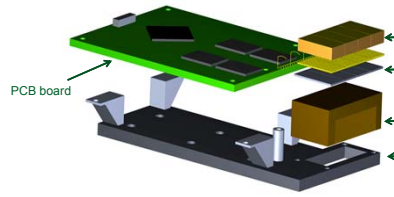


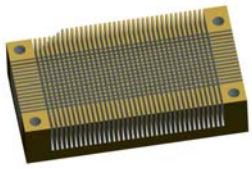
Meng et al., NIM, 2009
Meng et al., IEE NSS/MIC 2011.
Z. He et al, NIM A380 (1996) 228, NIM A388 (1997) 180.

## Development of ERPC Detectors



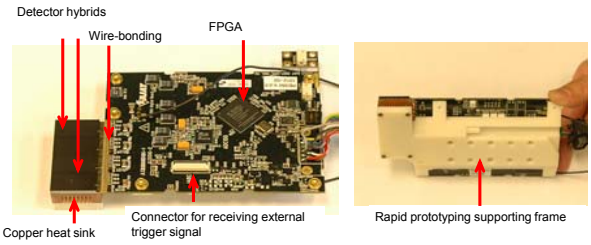

## Current Detector for the SPECT-MRI System



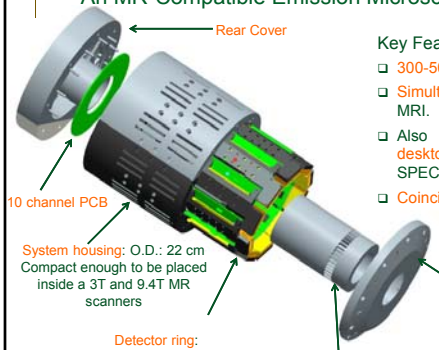
- 2.3 cm x 4.5 cm x 2 mm thickness
- Relatively compact packaging
- Customer designed copper heat sink

## Current Detector for the SPECT-MRI System




- High spatial (350um) and energy (ER: 3~4kev at 140kev) resolution
- Good MR compatibility
- Nylon-based rapid prototyping supporting frame with air cooling channel

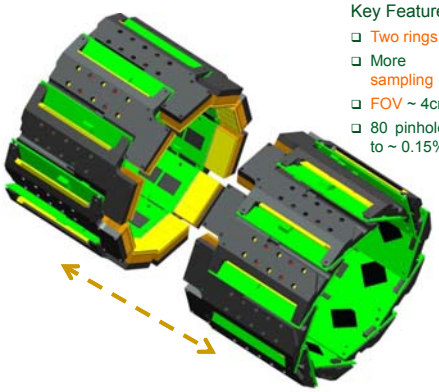
## An MR-Compatible Emission Microscope System




Key Features:

- 300-500um spatial resolution.
- Simultaneous SPECT and MRI.
- Also work as "low-cost" desktop ultrahigh resolution SPECT system.
- Coincidence measurements…

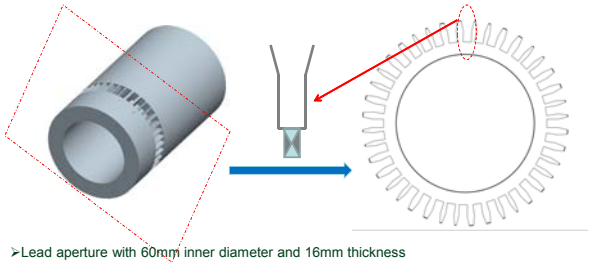
## An MR-Compatible Emission Microscope System



Key Features:

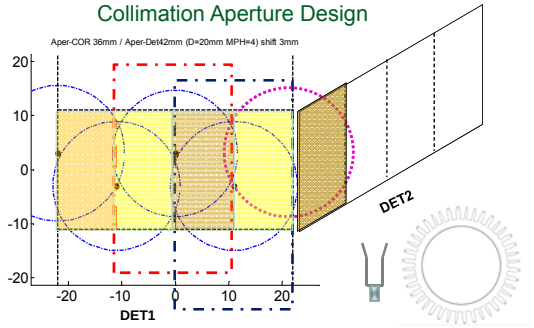
- Two rings can be put together
- More sufficient angular sampling
- FOV ~ 4cm × 4cm
- 80 pinholes with sensitivity up to ~ 0.15%

## Collimation Aperture Design



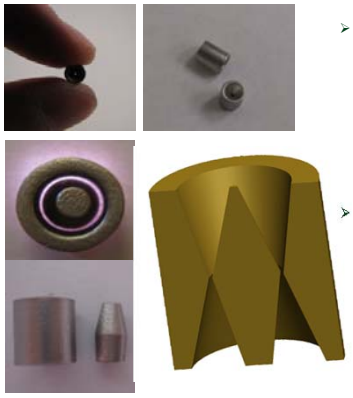
- Lead aperture with 60mm inner diameter and 16mm thickness
- 40 platinum (90%) die-cast pinhole inserts with 300/500μm diameter
- Apertures of different inner diameter (40/60mm) are designed for different imaging applications

## Collimation Aperture Design



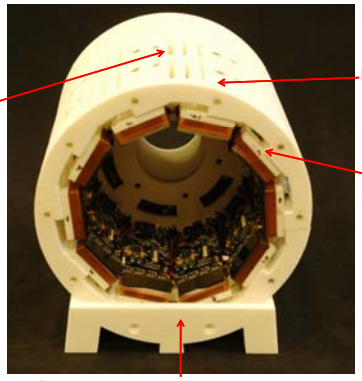

- Maximize the use of detection area, FOV~ axial 2.5cm x transversal 2.2cm
- Specific aperture structure designed to prevent severe projections overlap, projection through each pinhole locates on two adjacent detector hybrids

## Aperture Pinhole Fabrication

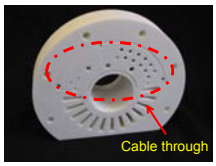


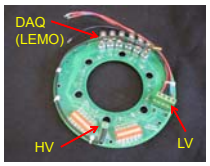
- platinum (90%) die-cast pinhole inserts with 300/500μm diameter, pinholes with 50 degree open angle and 6mm height
- Novel micro-ring aperture with 50-100μm gap will be experimentally investigated

## A Stationary MR-Compatible SPECT System




## MR-Compatible SPECT Components

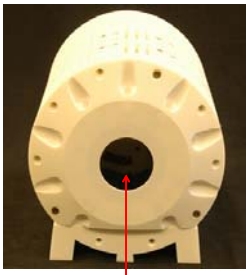


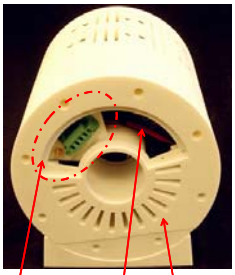




Rear cover with hollow buried in center to provide compressed air cooling

Up to 12 channel LV/HV/DAQ board

## MR-Compatible SPECT Front/Back View





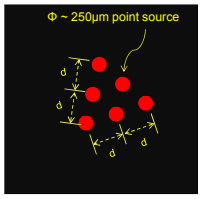
D~6cm for animal/phantom bed

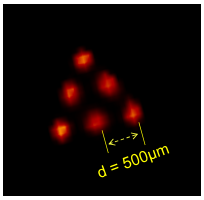
HV/LV power supply

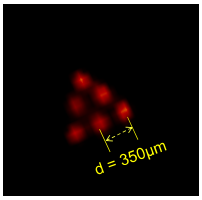
Slots for heat disperse

10 4-pin LEMO connector for communication

## SPECT Phantom Images Outside the MR Scanner



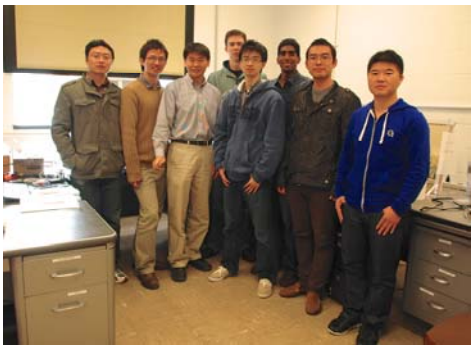

- regular-triangular shape Co-57 point source phantom generated by precise motor control, 16 angles
- point source of 250μm diameter active area, 500μm and 350μm between neighboring point source locations (d)
- Pinhole aperture: cast platinum-iridium inserts, 300 um diam.
- 350μm spatial resolution can be achieved , room to be improved

## MRC SPECT System Conclusion

*MRC-SPECT Inside 3T Siemens MR scanner*

*System Highlights:*

- Fully customized for operation in MR scanners
- 20 CdTe detectors in 2 rings, each detector is 2.2 cm x 4.5 cm in size.
- Detector ring diameter: 15.6 cm, and aperture diameter: 4 cm and 6 cm
- Up to a total of 80 pinholes, pinhole sizes: 300 and 500 um
- Imaging resolution: sub-500 um



***Thanks and any questions?***