JÜLICH
FORSCHUNGSZENTRUM

STIR User‘s Meeting

Reconstruction of PET data acquired with the BrainPET using STIR

31. October 2013 | Liliana Caldeira

Mitglied der Helmholtz-Gemeinschaft

Outline

- 3T MR-BrainPET System
- Reading BrainPET data into STIR
- FBP reconstruction
- OSEM/OSMAPOSL reconstruction

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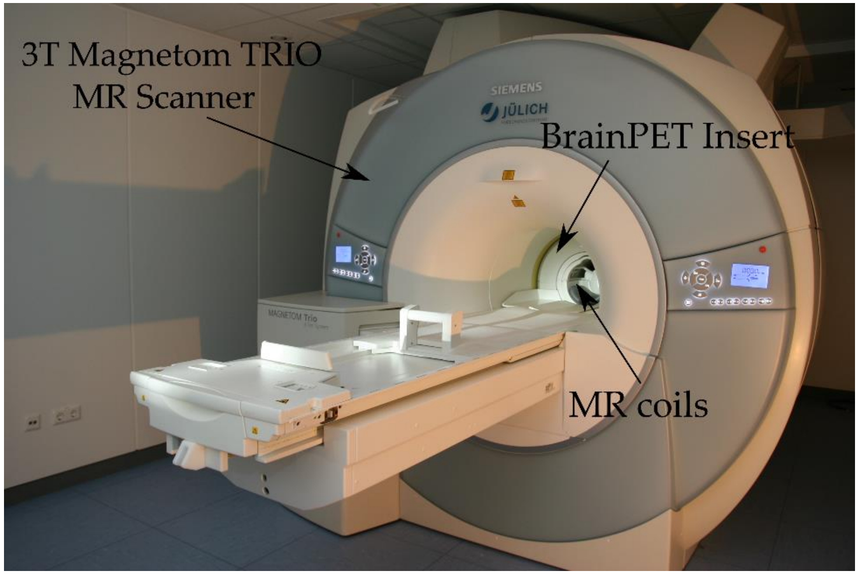
3T MR-BrainPET System

3T Magnetom TRIO + BrainPET Insert



Complete System

BrainPET Insert

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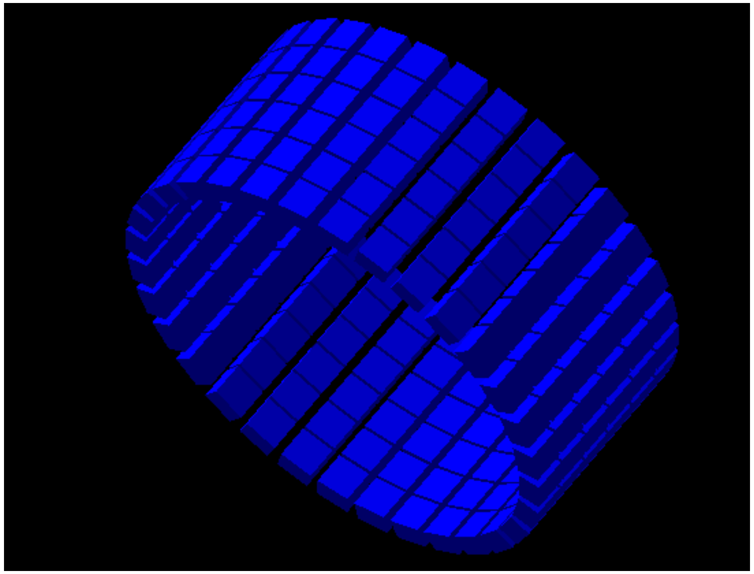
3T MR-BrainPET System

Detector Geometry



Detector Cassette

GATE model of BrainPET insert

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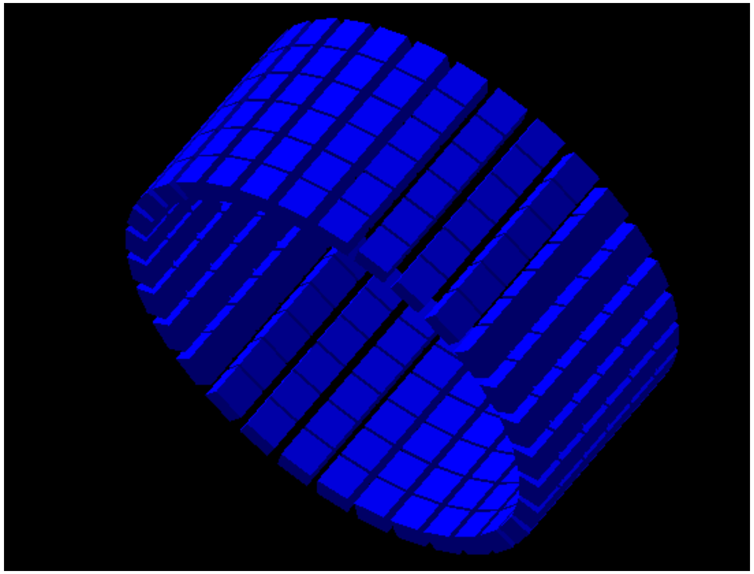
3T MR-BrainPET System

BrainPET properties

Ring Diameter	376 mm
Axial FOV	192.5 mm
Crystal	2.5x2.5x20 mm^3
Crystal Block	12x12
# of Crystal Rings	12x6=72
# of Crystals/Ring	12x32=384



GATE model of BrainPET insert

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3T MR-BrainPET System

BrainPET properties **including GAPS**

Ring Diameter	376 mm
Axial FOV	192.5 mm
Crystal	2.5x2.5x20 mm^3
Crystal Block	12x12
# of Crystal Rings	12x6=72
# of Crystals/Ring	12x32=384

Axial Gaps	**5**
Size Axial Gap	**2.5 mm**
Transaxial Gaps	**32**
Size Transaxial Gap	**7.5 mm =3x2.5 mm**
# of Crystal Rings	12x6=72 **+5 =77**
# of Crystals/Ring	12x32=384 **+32x3 =480**

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Reading BrainPET data into STIR

Understanding Sinogram Structure

Ring Diameter	376 mm
Axial FOV	192.5 mm
Crystal	2.5x2.5x20 mm^3
Crystal Block	12x12
# of Crystal Rings	12x6=72 **+5 =77**
# of Crystals/Ring	12x32=384 **+32x3 =480**

- Sinogram Order
- Use simple data
- Use manip_projdata

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Reading BrainPET data into STIR

Header File sinogram.hs (1/4)

```
!INTERFILE  :=
name of data file := sinogram.s
originating system := Userdefined
!GENERAL DATA :=
!GENERAL IMAGE DATA :=
!type of data := PET
imagedata byte order := LITTLEENDIAN
!PET STUDY (General) :=
!PET data type := Emission
applied corrections := {arc correction}
!number format := float
!number of bytes per pixel := 4
```

User Defined Scanner

Data Format

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Reading BrainPET data into STIR

Header File sinogram.hs (2/4)

Sinogram Organisation:

Span 9 (5+4)

```
number of dimensions := 4
matrix axis label [4] := segment
!matrix size [4] := 15
matrix axis label [3] := view
!matrix size [3] := 192
matrix axis label [2] := axial coordinate
!matrix size [2] := {35,53,71,89,107,125,143,153,143,125,107,89,71,53,35}
matrix axis label [1] := tangential coordinate
!matrix size [1] := 256
minimum ring difference per segment :={-67,-58,-49,-40,-31,-22,-13,-4,5,
14,23,32,41,50,59}
maximum ring difference per segment :={-59,-50,-41,-32,-23,-14,-5,4,13,
22,31,40,49,58,67}
```

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Reading BrainPET data into STIR

Header File sinogram.hs (3/4)

```
Scanner parameters:=
Scanner type := Userdefined
Number of rings                     := 77
Number of detectors per ring        := 480
Inner ring diameter (cm)            := 376
Average depth of interaction (cm)  := 0.7
Distance between rings (cm)         := 0.25
Default bin size (cm)               := 0.125
View offset (degrees)                       := 0
Maximum number of non-arc-corrected bins := 256
Default number of arc-corrected bins     := 256
```

Scanner Information

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Reading BrainPET data into STIR

Header File sinogram.hs (4/4)

```
Number of blocks per bucket in transaxial direction    := 1
Number of blocks per bucket in axial direction         := 1
Number of crystals per block in axial direction        := 1
Number of crystals per block in transaxial direction   := 1
Number of detector layers                              := 1
Number of crystals per singles unit in axial direction := 1
Number of crystals per singles unit in transaxial direction := 1
end scanner parameters:=
effective central bin size (cm) := 0.125
image scaling factor[1] := 1
data offset in bytes[1] := 0
number of time frames := 1
!END OF INTERFILE :=
```

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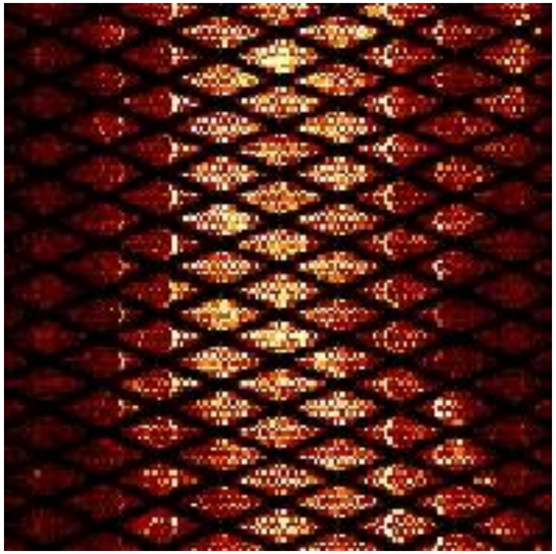
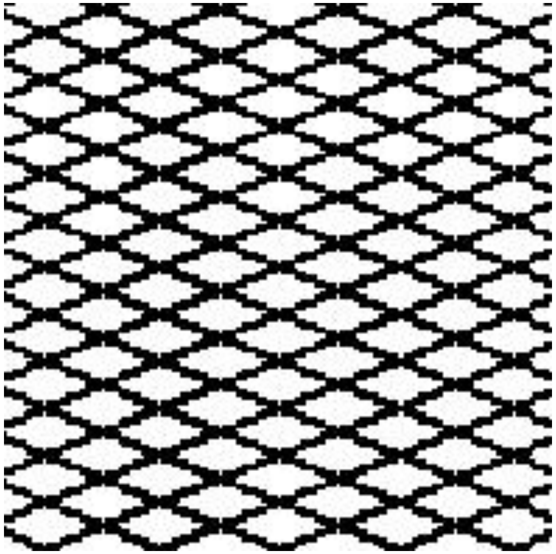
Reading BrainPET data into STIR

Projection Data



BrainPET data (using manip_projdata)



Gap Structure in Sinogram

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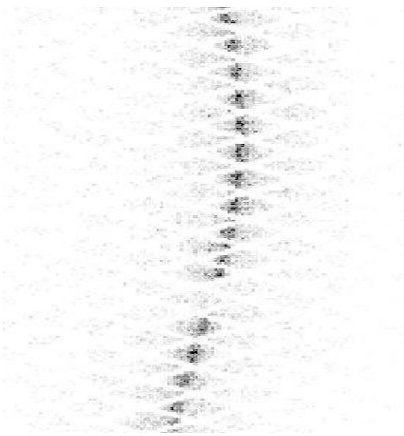
FBP reconstruction

Point Sources – Projection data



Example Figure from [3] H. Herzog et al. "Influence from high and ultra-high magnetic field on positron range measured with a 9.4T MR-BrainPET". IEEE NSS/MIC 2010.

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FBP reconstruction

Point Sources – Parameter File (1/2)

FBP3DRP file.par

```
fbp3drpparameters :=
input file := noisy_testsino.hs
output filename prefix := output_noisy

;;;;;;; output image parameters
zoom := 1
; defaults to cover whole FOV
;xy output image size (in pixels) := 180
maximum absolute segment number to process := 7
;;;;;;; parameters for initial image
num segments to combine with ssrb := -1
```

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FBP reconstruction

Point Sources – Parameter File (2/2)

```
;filter parameters, default to pure ramp
alpha parameter for ramp filter := 1
cut-off for ramp filter (in cycles) := 0.5
;;;;;;;; parameters for Colsher filter
alpha parameter for colsher filter in axial direction := 1
cut-off for colsher filter in axial direction (in cycles) := 0.5
alpha parameter for colsher filter in planar direction := 1
cut-off for colsher filter in planar direction (in cycles) := 0.5
; define colsher on finer grid.
stretch factor for colsher filter definition in axial direction := 2
stretch factor for colsher filter definition in planar direction := 2
; allow less padding. DO NOT USE
transaxial extension for fft := 1
axial extension for fft := 1
;;;;;;;;; other parameters
save intermediate images := 0
display level := 0
end :=
```


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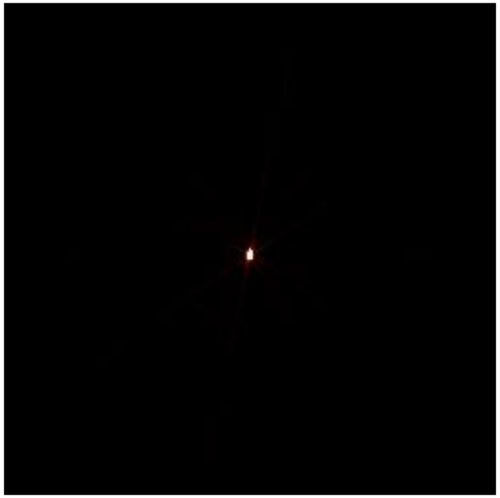
FBP reconstruction

Point Sources – Reconstructed Images



Transverse Image

Coronal Image

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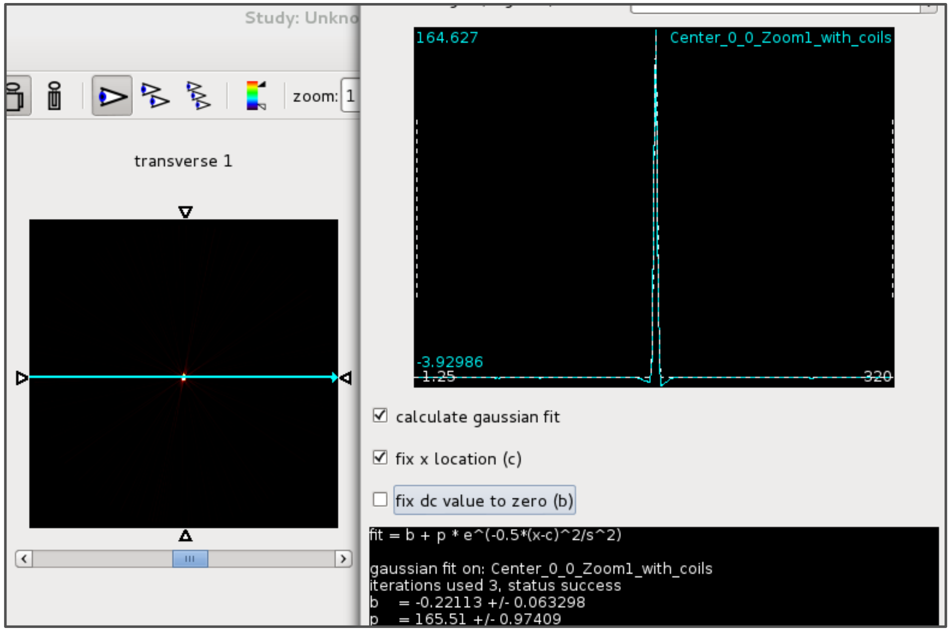
FBP reconstruction

Point Sources – Reconstructed Images



AMIDE

FBP reconstruction

Point Sources – Results in publications

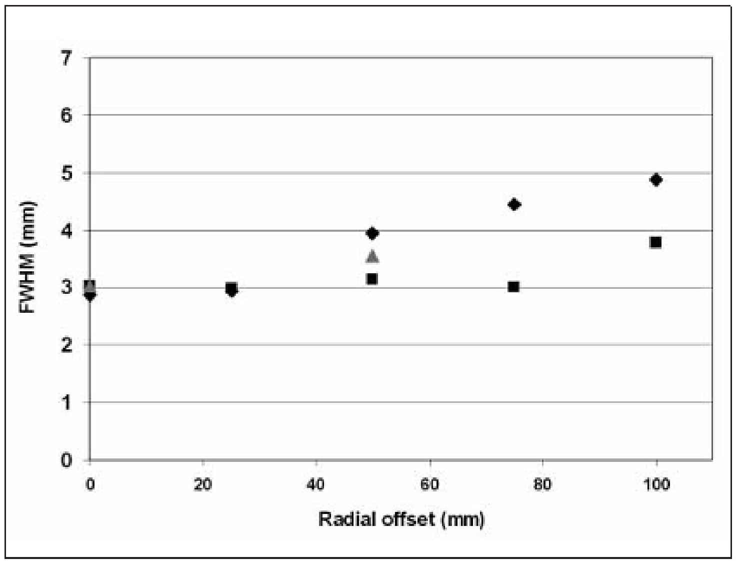


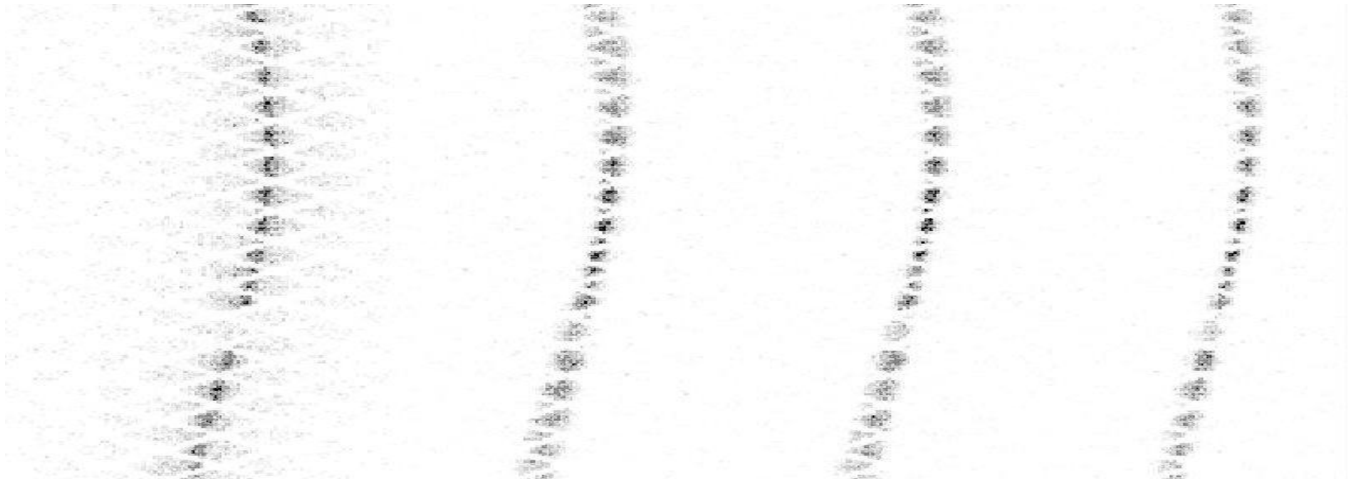
Fig. 2
Plots of tangential (■), radial (◆) and axial (Δ) image resolution expressed as full width at half maximum (FWHM) measured with line and point sources in air at different radial offsets.

Nuklearmedizin 2/2011

Figure from [1] H. Herzog et al. "High Resolution BrainPET combined with Simultaneous MRI". NuklearMedizin. 2011.

FBP reconstruction

Point Sources – Results in publications



Sinograms of the 120I point source measured at 0 T (left), 3T, 7T and 9.4 T (right): Figure from [3] H. Herzog et al. “Influence from high and ultra-high magnetic field on positron range measured with a 9.4T MR-BrainPET”. IEEE NSS/MIC 2010.

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FBP reconstruction

Point Sources – Results in publications

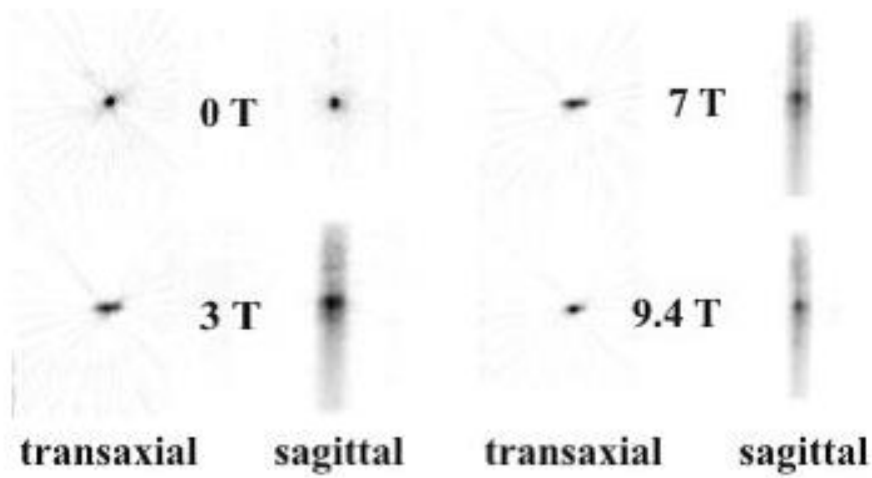

Fig. 7. Images of the point source filled with ^{120}I at different magnetic field strengths.

Figure from [3] H. Herzog et al. "Influence from high and ultra-high magnetic field on positron range measured with a 9.4T MR-BrainPET". IEEE NSS/MIC 2010.

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OSEM reconstruction

Patient data – Parameter File (1/2)

```
OSMAPOSLParameters :=
objective function type:=
PoissonLogLikelihoodWithLinearModelForMeanAndProjData

PoissonLogLikelihoodWithLinearModelForMeanAndProjData Parameters:=
input file := verynoisy_testsino.hs
additive sinogram := 0

projector pair type := Separate Projectors
  Projector Pair Using Separate Projectors Parameters:=
  Forward projector type := Ray Tracing
    Forward Projector Using Ray Tracing Parameters:=
    End Forward Projector Using Ray Tracing Parameters:=
  Back projector type := Interpolation
    Back Projector Using Interpolation Parameters:=
    End Back Projector Using Interpolation Parameters:=
  End Projector Pair Using Separate Projectors Parameters:=
```

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OSEM reconstruction

Patient data – Parameter File (2/2)

```
recompute sensitivity := 1
sensitivity filename:=sensOSMAPOSLpair.hv
end PoissonLogLikelihoodWithLinearModelForMeanAndProjData Parameters:=

output filename prefix := veryoutputnoisyOSMAPOSLpair

number of subsets:= 1
number of subiterations:= 24
Save estimates at subiteration intervals:= 3

END :=
```

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OSEM reconstruction

Patient data – Normalisation File

```
...
 End Projector Pair Using Separate Projectors Parameters:=
```

```
Bin Normalisation type := From ProjData
Bin Normalisation From ProjData :=
normalisation projdata filename:= NORMaddnozeros.hs
End Bin Normalisation From ProjData:=
```

```
recompute sensitivity := 1
...
```

Efficiencies Sinogram was available, but calculations were necessary for STIR:

1) STIR uses multiplicative factors (1/efficiency)
2) Zero efficiency -> Very high multiplicative factor

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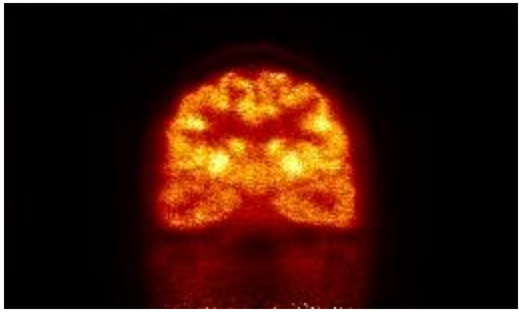
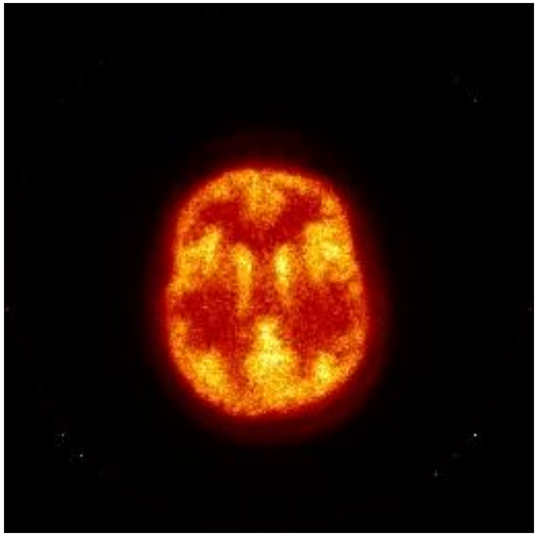
OSEM reconstruction

Patient data – Reconstructed Images



Coronal Image



Transverse Image

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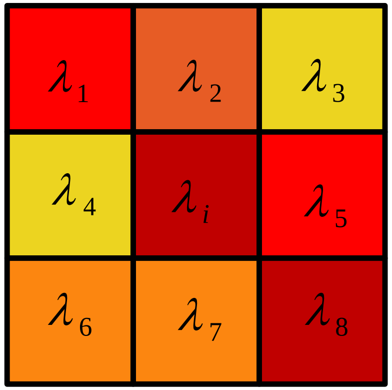
OSEM reconstruction

Patient data – Parameter File using Median Root Prior

```
prior type := FilterRootPrior
FilterRootPrior Parameters :=
  penalisation factor := 1
  Filter type := Median
    Median Filter Parameters :=
    mask radius x := 1
    mask radius y := 1
    mask radius z := 1
    End Median Filter Parameters:=
END FilterRootPrior Parameters :=

MAP model := multiplicative
```



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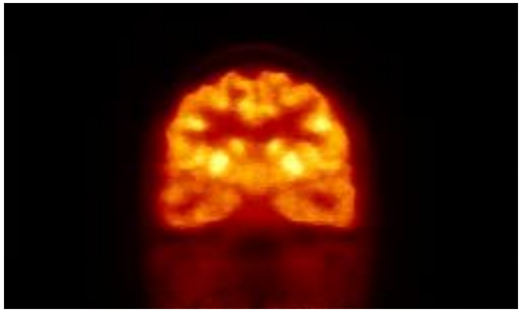
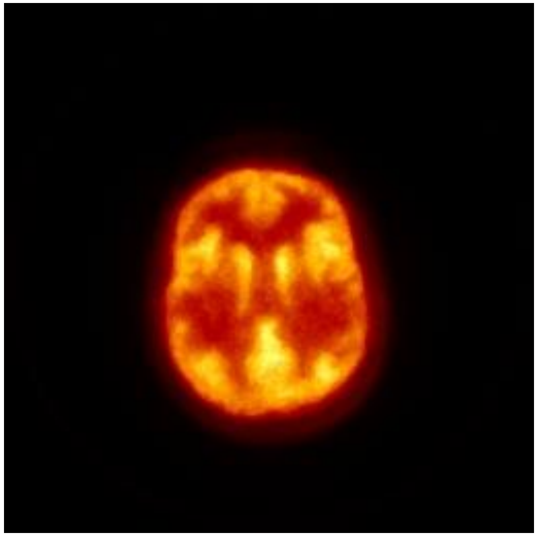
OSEM reconstruction

Patient data – Reconstructed Images with Median Root Prior



Coronal Image



Transverse Image

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Conclusion

- BrainPET data was read successfully into STIR
- FBP reconstruction for Point Source measurements
- OSEM/OSMAPOSL reconstruction for Patient data

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References

[1] H. Herzog et al. “High Resolution BrainPET combined with Simultaneous MRI”. NuklearMedizin. 2011.

[2] L. Caldeira et al. “Reconstruction of PET Data Acquired with the BrainPET using STIR”. IEEE NSS/MIC 2012.

[3] H. Herzog et al. “Influence from high and ultra-high magnetic field on positron range measured with a 9.4T MR-BrainPET”. IEEE NSS/MIC 2010.

Acknowledgements

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