

# Incorporation of a two metre long PET scanner in STIR

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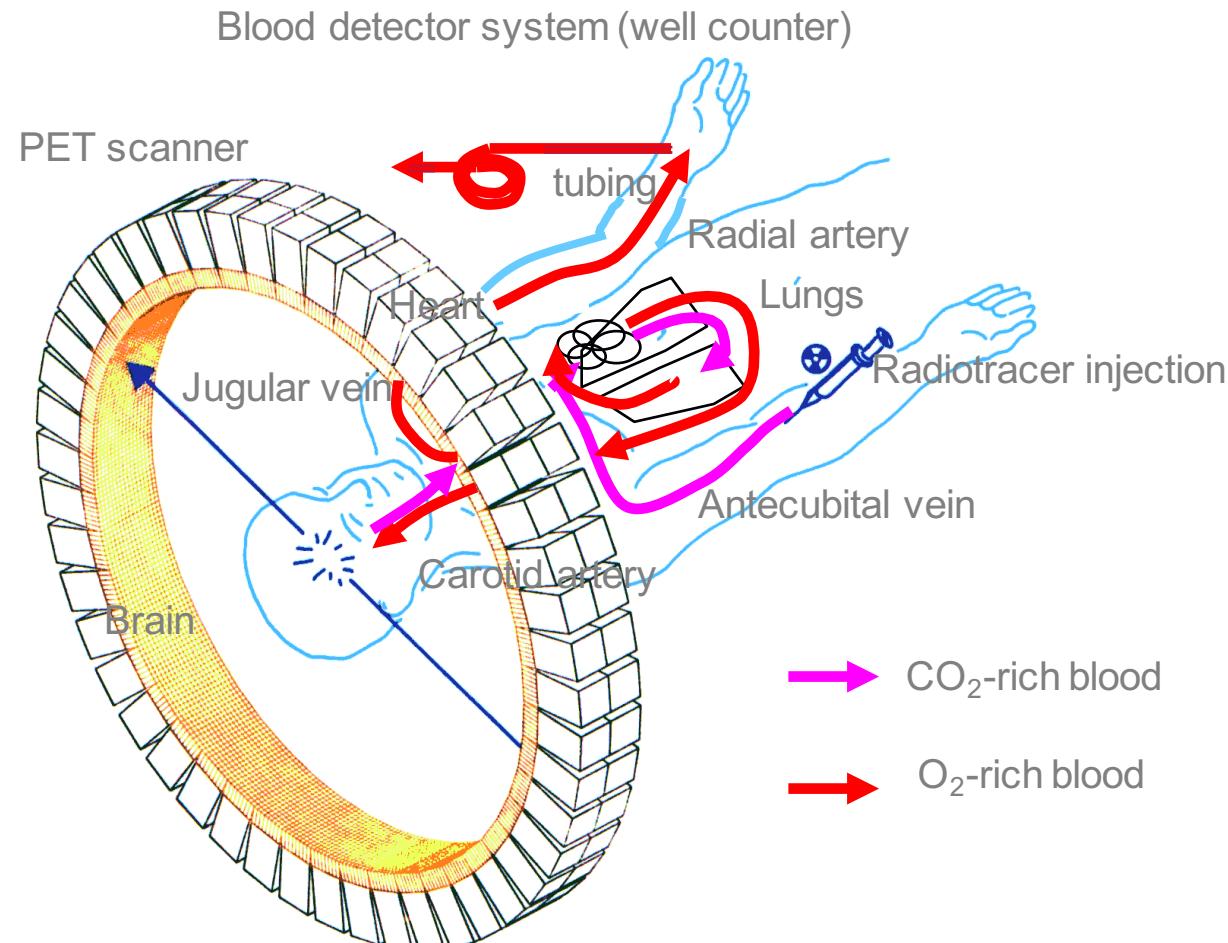
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## OVERVIEW

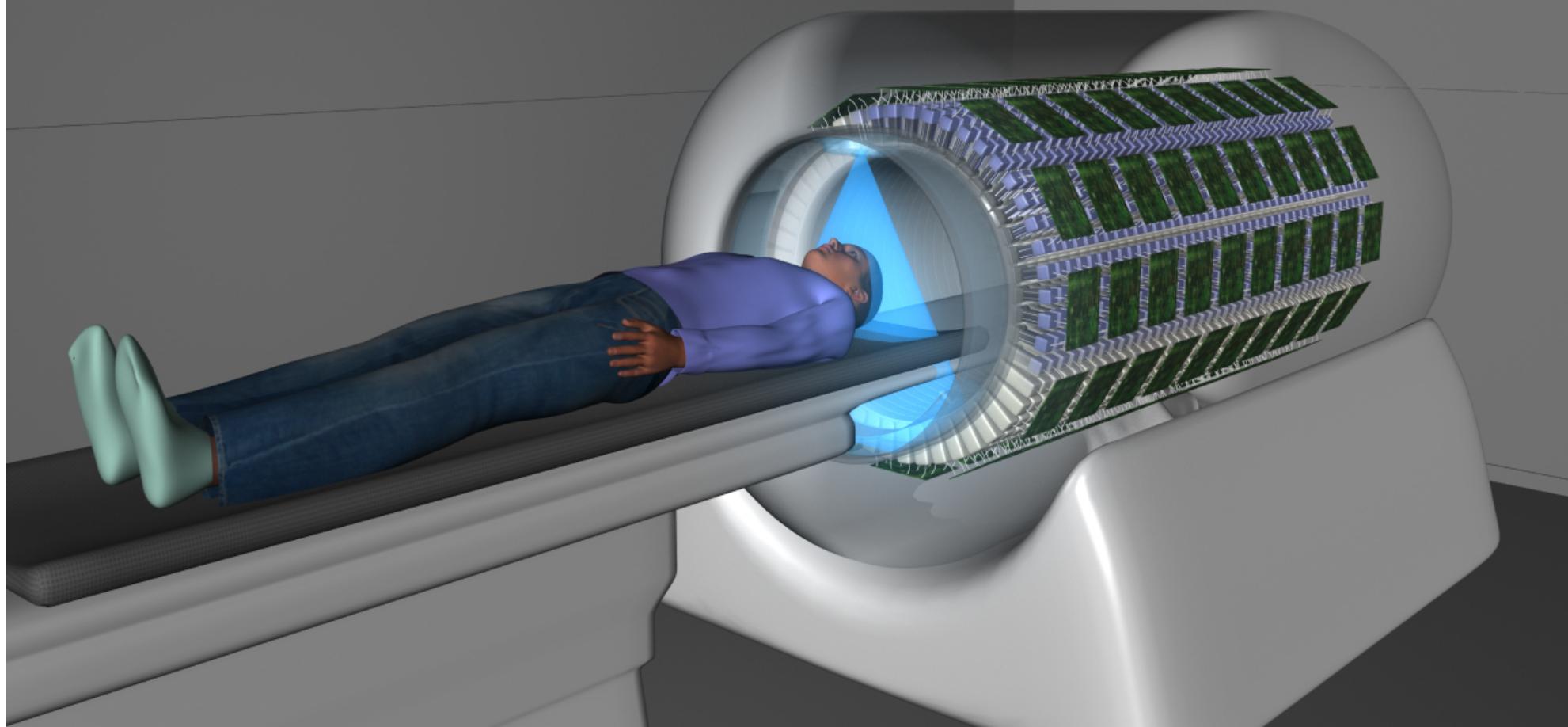
- Introduction to UltraPET
- Aim: UltraPET reconstruction & scatter simulation
- Methods & Materials: Phantoms, Software & HPC
- Results: Computational times & Scatter Profiles
- Future Directions: Speedup & List-mode reconstruction

# PET



PET assays the fate of natural molecules labelled with positron emitters (e.g.  $^{18}F$ ,  $^{11}C$ ,  $^{15}O$ ) by measuring the annihilation photons with a ring of detectors.

# Ultra Sensitive PET Scanner (UltraPET)





## AIM

Integrate UltraPET in a common open access library  
(Software for Tomographic Image Reconstruction - STIR)

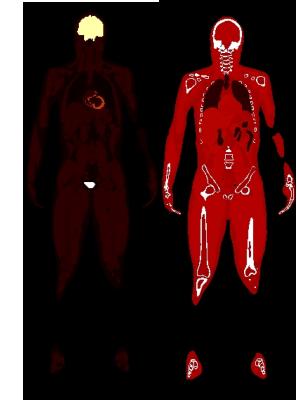
Perform a “crash test” e.g. memory & computational requirements for reconstruction

Assess the extent of validity of using the current scatter simulation algorithm, which assumes that scatter between oblique rings is similar to scatter within the same ring

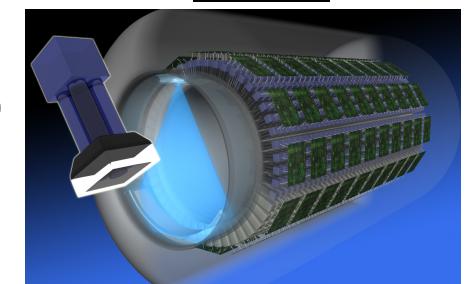


## MATERIALS & METHODS

Phantom: **XCAT 2.0** total-body anthropomorphic phantom,  
**195×195×1150 voxels** with sizes **3.42×3.42×1.71 mm<sup>3</sup>**



Scanner: **70x196 cm<sup>2</sup>** field of view (**575 rings**) – max ring diff: **336**



Simulation: Projectors – emission & attenuation (**span 11 & mash 2**)

Software: **STIR library** (release 3.0)



Algorithms: **FBP-3DRP & OSEM & MPI OSEM** (15 subsets & cores)

Scatter simulation: Fully 3D for compressed scanner (23 block rings)

Computational Resources: 3040-core high performance computer

ARC2: 8-core Intel E5-2670 **2.6 GHz, 32 GB** memory





## Part of the Scanner Information Configuration:

```
case UltraPET: set_params(UltraPET,  
    string_list("UltraPET","UPET"), 575, 244, /* (15*36) +35 */  
    229,15*48, 400.F, 8.F, 3.42F, 3.42F, ...);
```

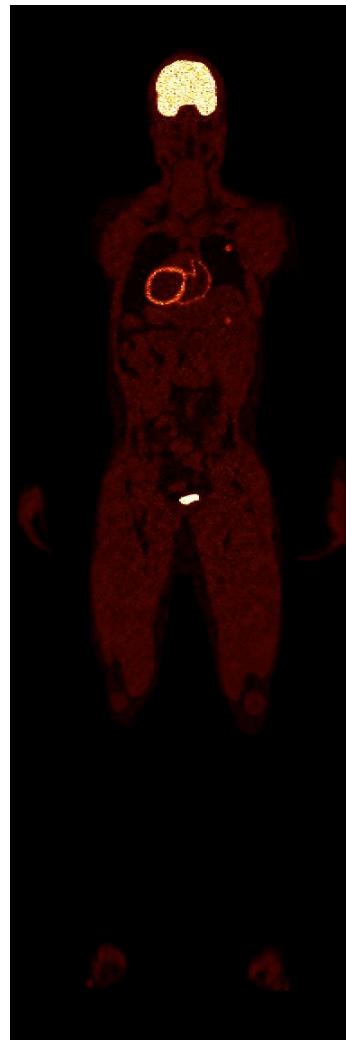


$2.5 \times 10^9$  counts

FBP-3DRP

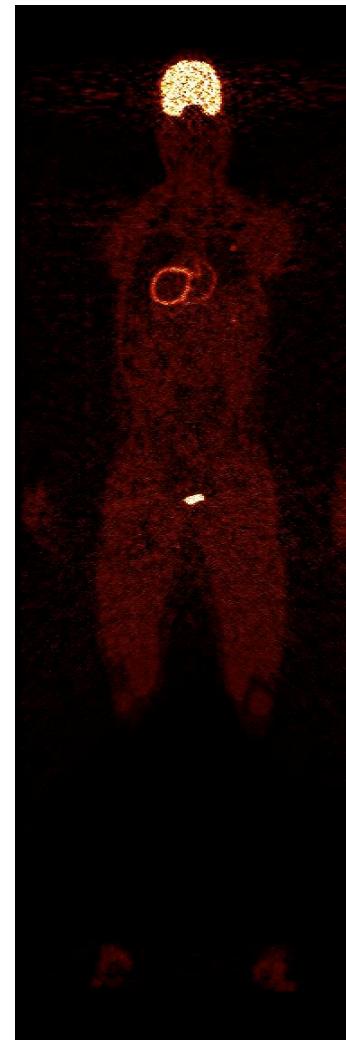


OSEM

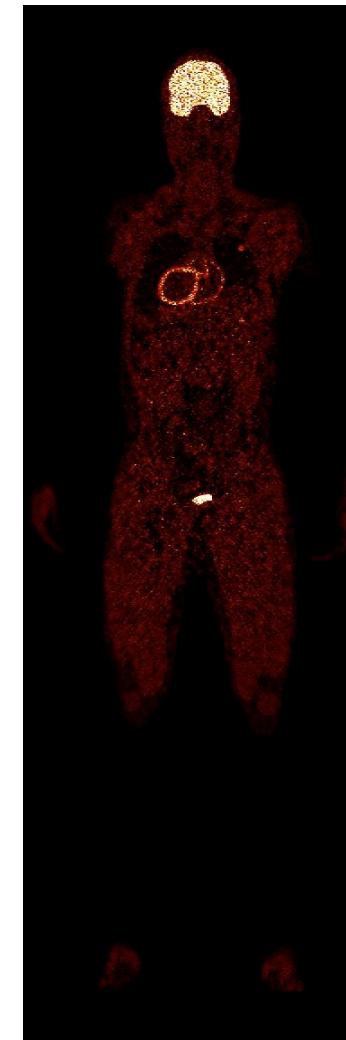


$5 \times 10^8$  counts

FBP-3DRP



OSEM



Requirements:

### Time

FBP-3DRP: 4hrs

OSEM: 9hrs

MPI OSEM: 2hrs/it.

### Memory

FBP-3DRP: 500MB

OSEM: 5GM

MPI OSEM: 15GB



## Part of the Scatter Template Interfile Information:

Segments: 27; Views: 36;

Axial coordinate range: From 10 to 23;

Tangential coordinate: **61**;

Min & Max ring difference per segment: From **-13**, to **13**;

Number of rings: **23**;

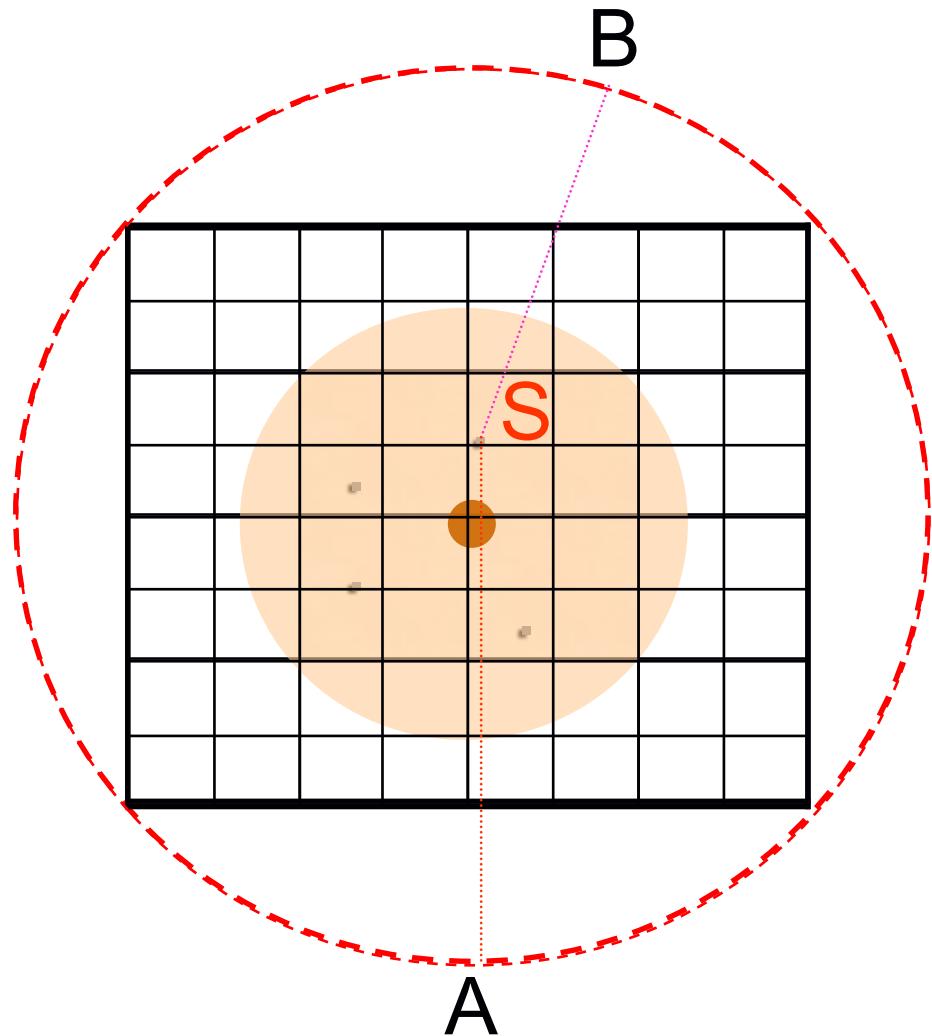
Number of detectors per ring: **72**; Inner ring diameter: 80; Distance between rings (cm): 8.55;

Default bin size (cm): 1.368;

Maximum number of non-arc-corrected bins: 61;

Default number of arc-corrected bins: 57; effective central bin size (cm): 0.712

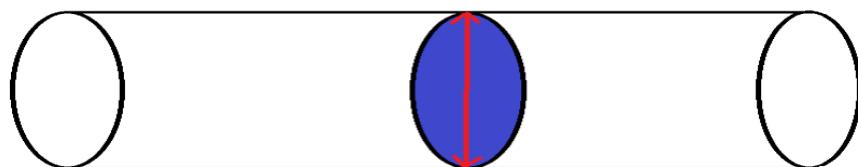
## SINGLE SCATTER SIMULATION (SSS)



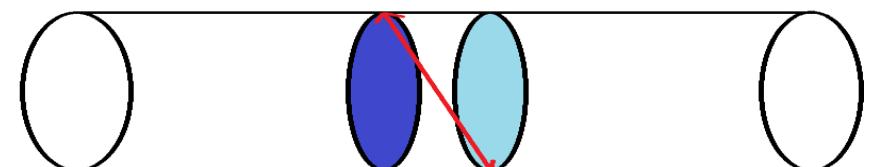
- Sub-sample scanner (A, B)
- Sub-sample attenuation map
- Select scatter points (S)
- Calculate Single Scatter giving as input the emission and the attenuation map
- Up-sample sinogram to find scatter distribution for all detector bins

## Scatter simulation:

Direct sinogram



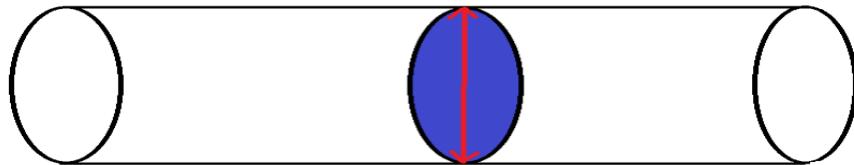
Oblique sinogram



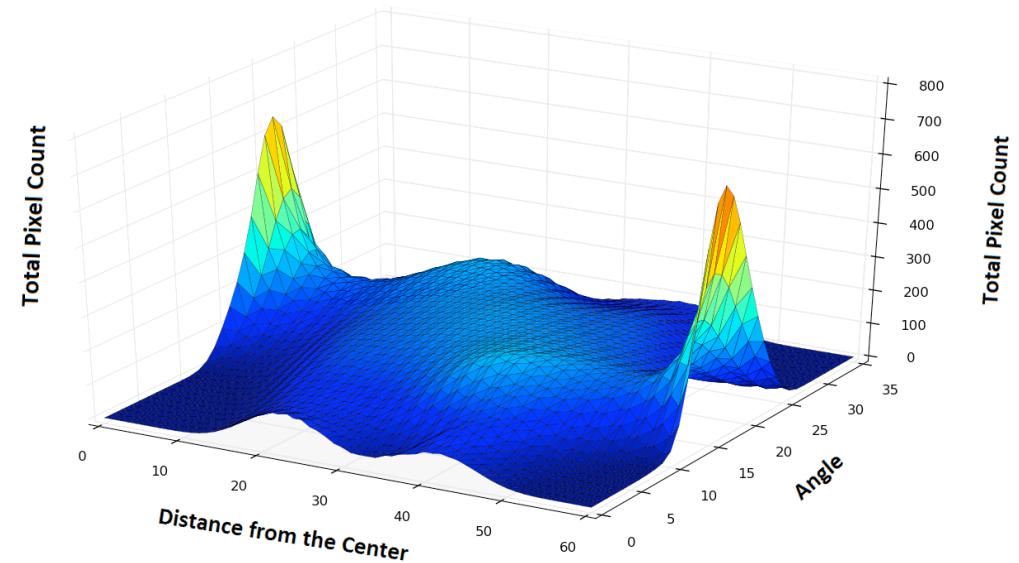
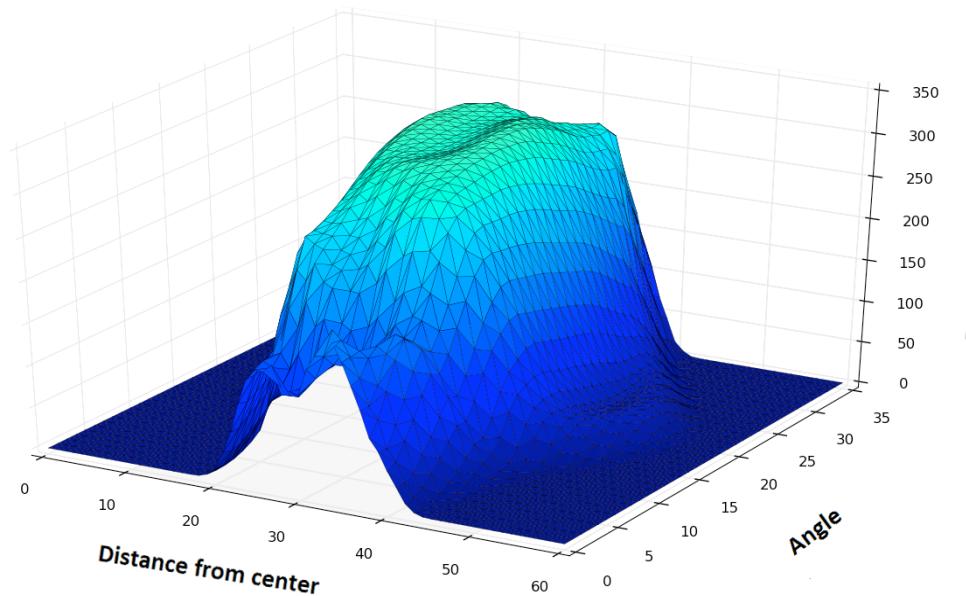
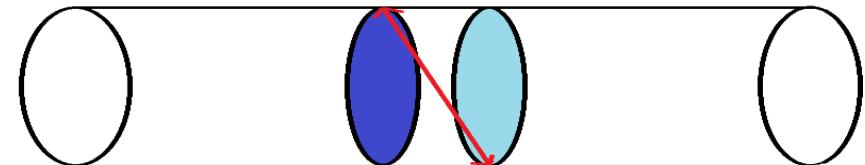


## Scatter simulation:

Direct sinogram

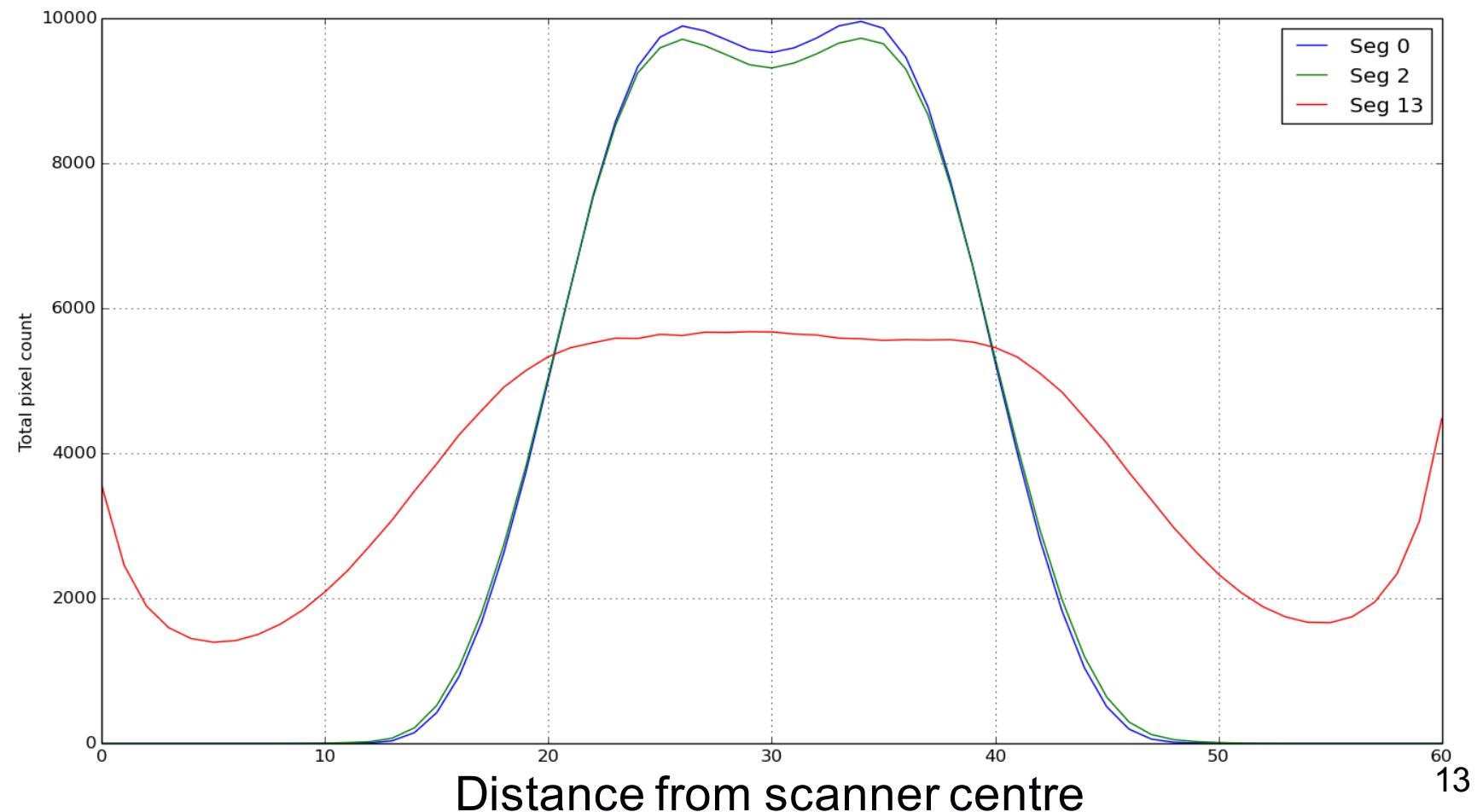


Oblique sinogram



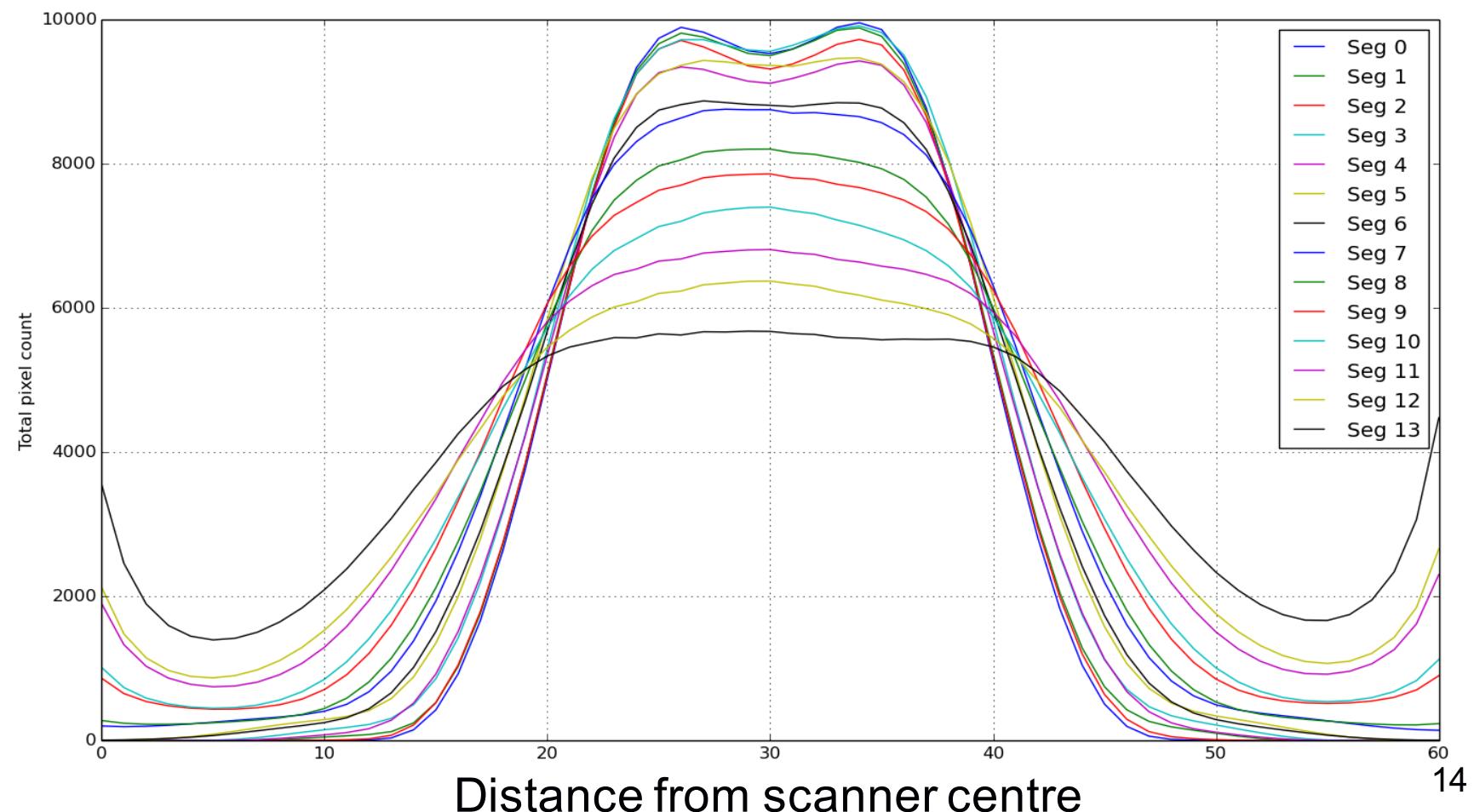


## Line profiles for scatter between oblique sinograms





## Line profiles for scatter between oblique sinograms





## CONCLUSIONS

Reconstruction: (not in high resolution)

FBP-3DRP: 4 hours

MPI 3D OSEM: 2 hours per iteration

Future work:

Scatter simulation & interpolation for oblique rings

List-mode reconstruction

Time of flight

Depth of interaction

Point spread function



## ACKNOWLEDGMENTS

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