Effect of Detector Blurring on Apical Region in Myocardial Perfusion SPECT Imaging

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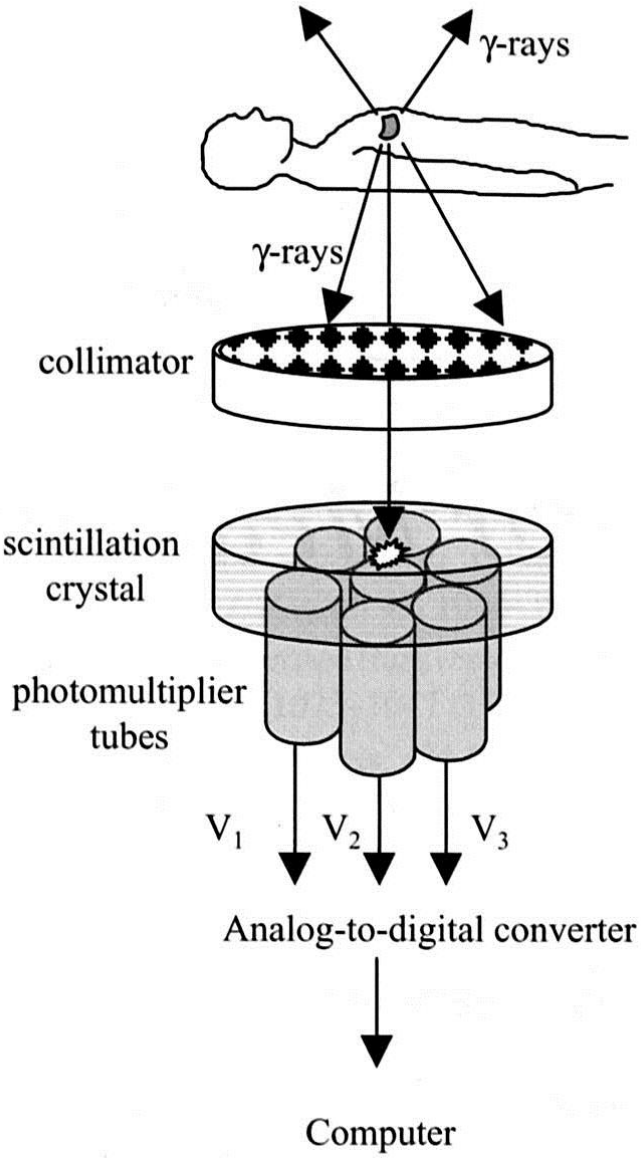
Single Photon Emission Computed Tomography (SPECT) Imaging



- Inject radiolabeled substance (tracer) into the patient
- The tracer emits γ-photons
- γ -photons passes through the collimator (lead) and it is absorbed by NaI crystal
- The PMTs detect the point of absorption
- After a while there is a projection image is created
- The process is repeated in different detector angles positions (rotating camera)

The Most Significant Imperfections in Parallel Based SPECT Imaging

- **Depth dependent resolution of the parallel projection**
    - Non-linear image distortion (i.e. image blur) due to the finite hole and septa size of the collimators
    - Gamma photon penetration between collimator holes
    - Manufacturing imperfections of the collimators - random misalignment of the holes -
- **The imaged object is surrounded by non-homogenous attenuation medium**
- **The imaged activity is not in the centre of the field of view**

The Applied Methods to Reduce Image Distortion Effects

- Improved MLEM algorithm has been created to correct the photon attenuation and compensate the **D**istance **D**ependent **S**patial **R**esolution (DDSR) effect:
  - CT based attenuation correction is applied into the forward projection
  - Special PSF (**P**oint **S**pread **F**unction) calibration based DDSR compensation is implemented into the forward projection
- Fast GPU implementation
- Verification:
  - NCAT simulation
  - AnyScan® phantom and patients' studies

Hypo-perfusion segment have been detected around the apical region on both mathematical phantoms, physical

NCAT Phantom Simulation Study

- OpenGATE simulation
- SPECT system with HR collimator
  - σintr = 4.2 mm
  - PSFa = 1.140517 mm
  - PSFb = 0,035809
  - RoR = 281 mm

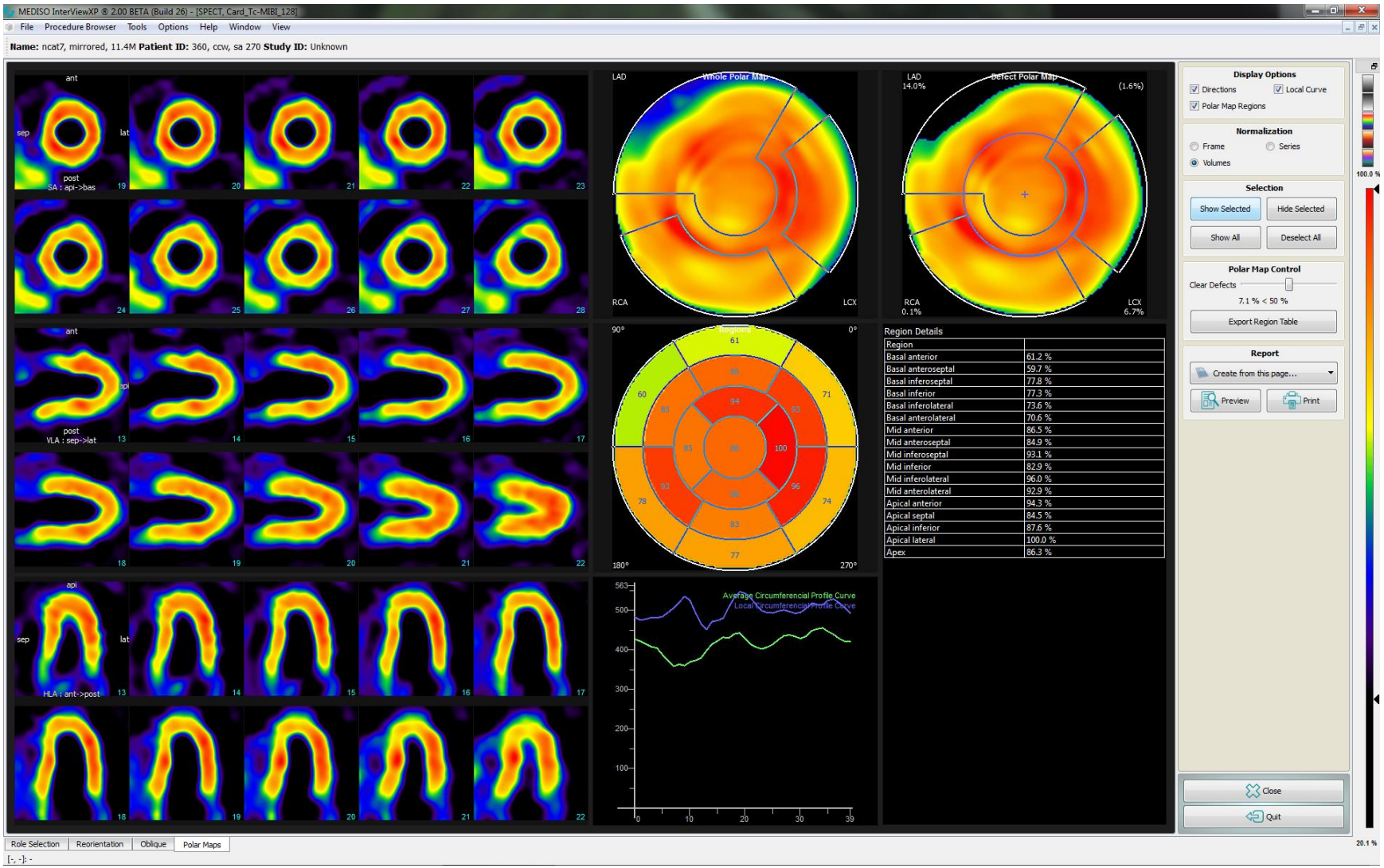
NCAT phantom

Data Acquistion:

- 128 x 128×128 projection images, pixel size=3mm
- 360º scanning angle
- ~80 000 sounts / image
- 11,4 million total counts

NCAT Phantom Simulation

Reconstruction:
3D-OSEM with attenuation correction and DDSR compensation
20 iteration, 8 subset, TV regularisation, Butterworth prefilter



AnyScan® Camera Study with Cardiac Torso Phantom

SPECT/CT multimodality imaging

- Dual head gamma camera
- with LEHR collimator
  - σintr = 4.2 mm
  - Psfa = 1.140517 mm
  - Psfb = 0,035809
  - RoR = 356 mm

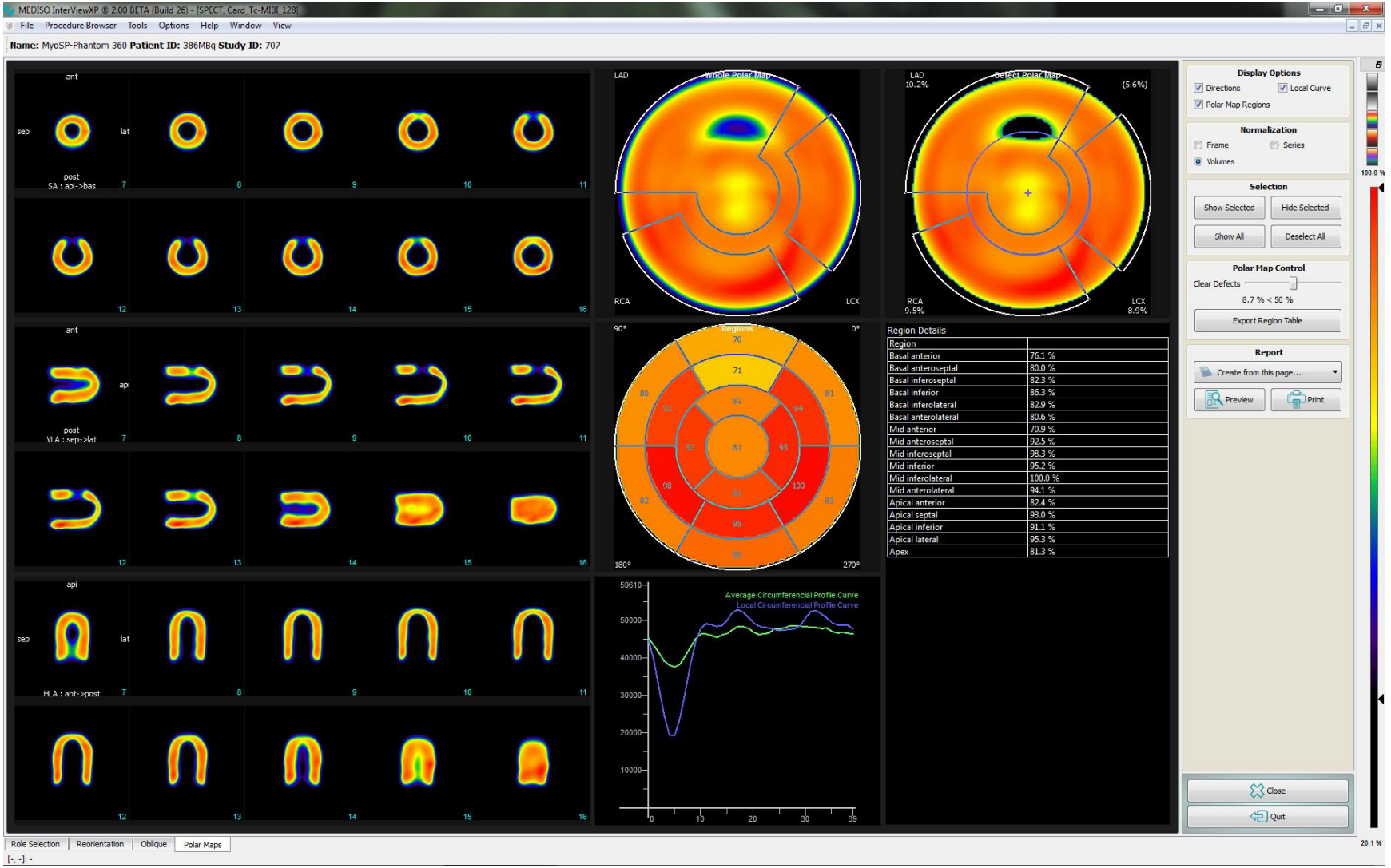
Biodex Lung-Spine SPECT phantom, with Tc99m

Data Acquisition:

-128×128×128 projection images
- pixel size = 4.14 mm
- 360º scanning angle
- ~140 000 counts / image
- ~17,7 million total counts
- Frame duration: 20 sec

AnyScan® Camera Study with Cardiac Torso Phantom

Reconstruction:
3D-OSEM with attenuation correction and DDSR compensation
20 iteration, 16 subset, TV regularisation, Butterworth prefilter



AnyScan® camera: Patient Study

SPECT/CT multimodality system

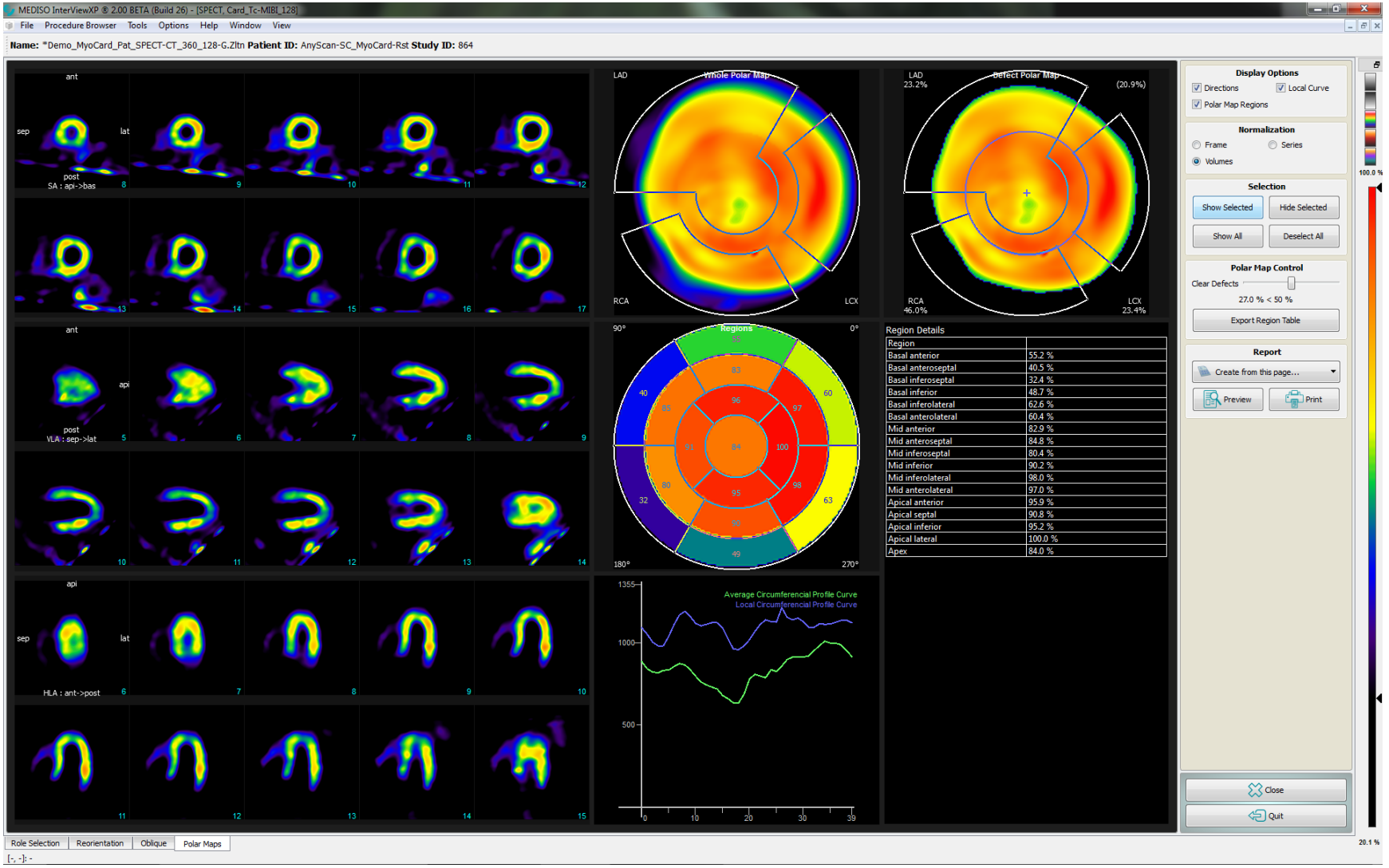
- Dual head gamma camera
- with LEHR collimator
  - σintr = 4.2 mm
  - Psfa = 1.140517 mm
  - Psfb = 0,035809
  - RoR = 356 mm

Data Acquisition

- 128×128×128 projection images,
- Pixel size = 4.73 mm
- 360º scanning angle
- ~51 000 counts / image
- ~6,5 total counts
- Frame duration: 20 sec.

AnyScan® camera: Patient Study

Reconstruction:
3D-OSEM with attenuation correction and DDSR compensation
10 iteration, 8 subset, TV regularisation, Butterworth prefilter



Investigating Apical Lesion

- We have investigated the reason of the decreased activity in the apical region in myocardial perfusion SPECT studies:
  - Using different mathematical phantoms
  - Using different spatial resolution (2mm, 4mm)
  - Using different deteltor blurring extent (0, half, full)

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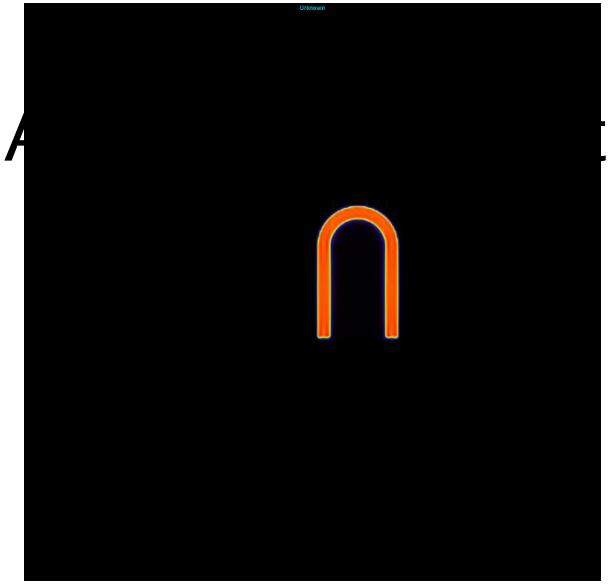
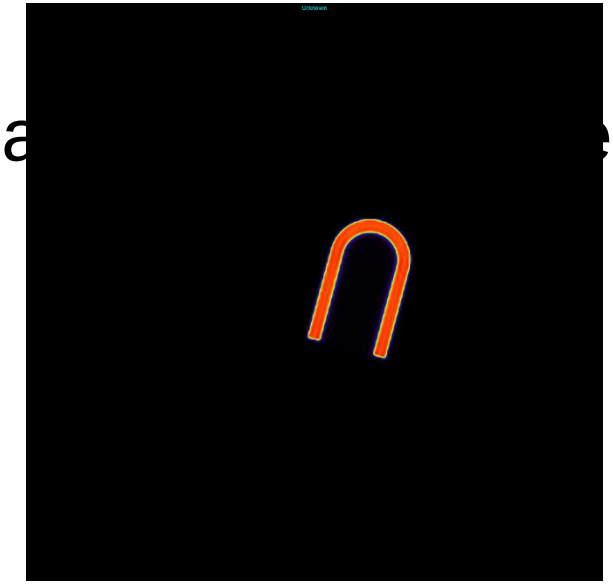
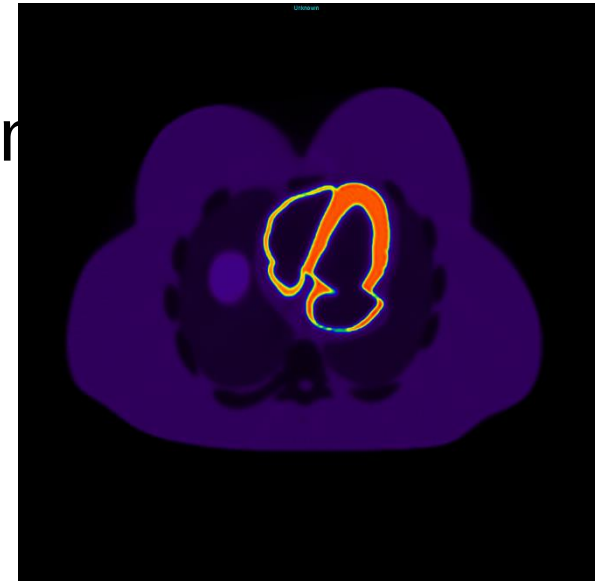


Bullet phantom

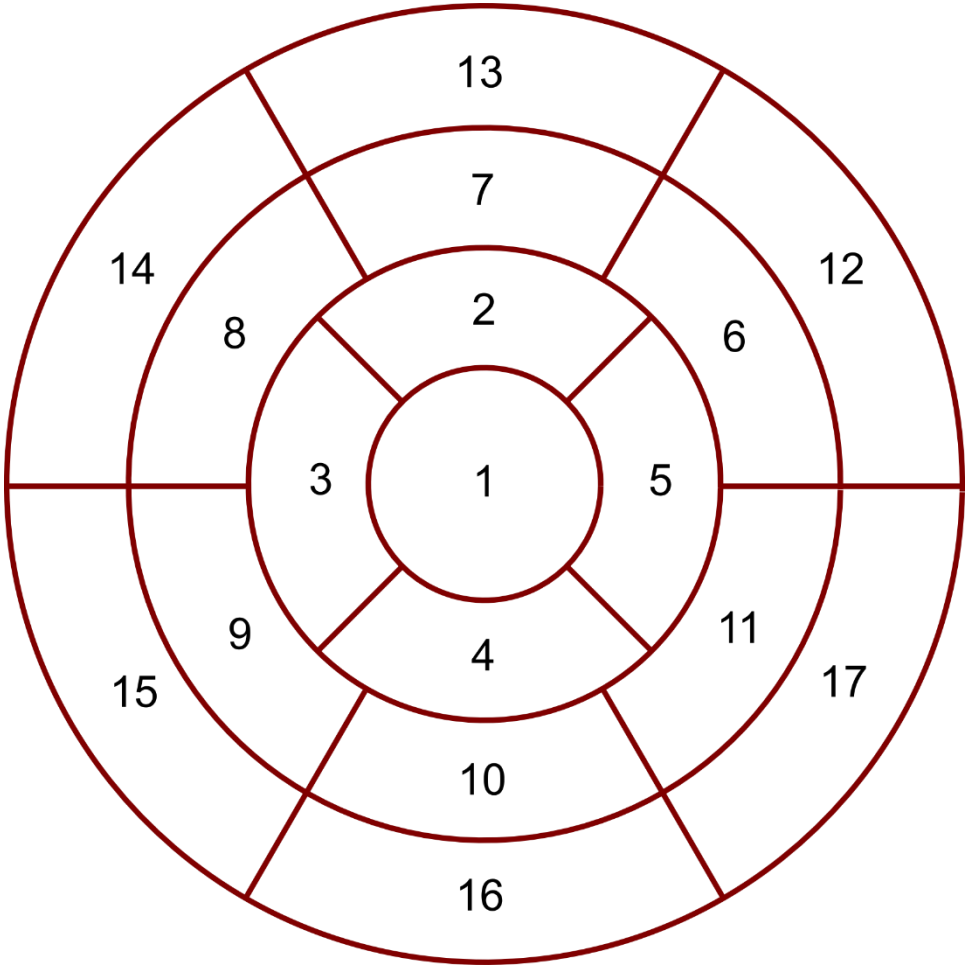


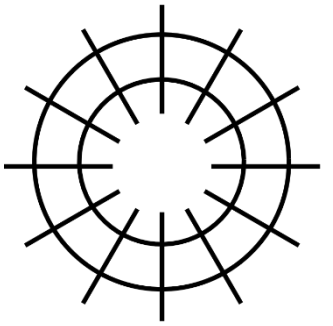
Slant bullet phantom

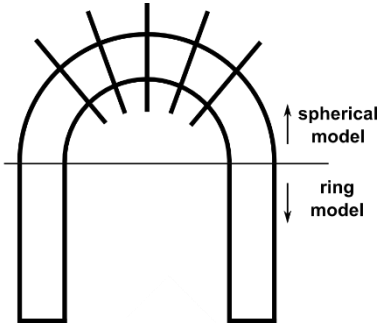


NCAT phantom

Creating Bullseye



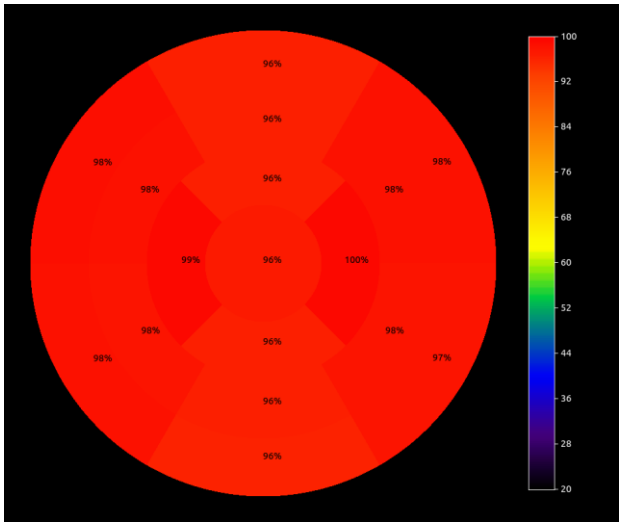




Bullet phantom: effect of different detector blurring extent

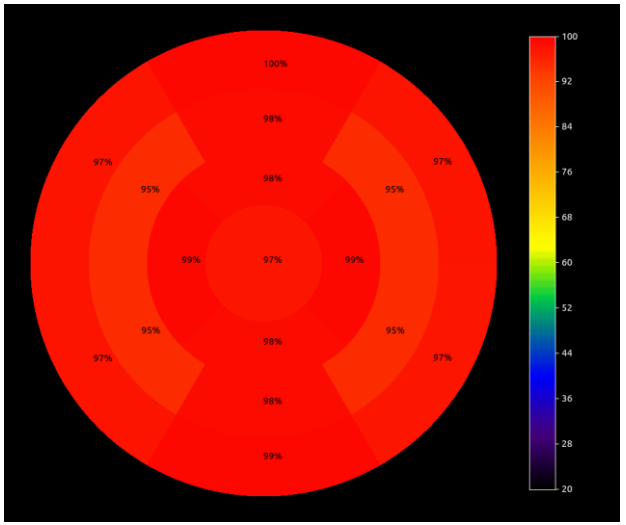
128x128x128 volume, pixel size = 4mm

σ_{intr} = 0 mm
psfa = 0 mm
psfb = 0



Apex region: 96%

σ_{intr} = 4 mm
psfa = 1 mm
psfb = 0.0175



Apex region: 97%

σ_{intr} = 4 mm
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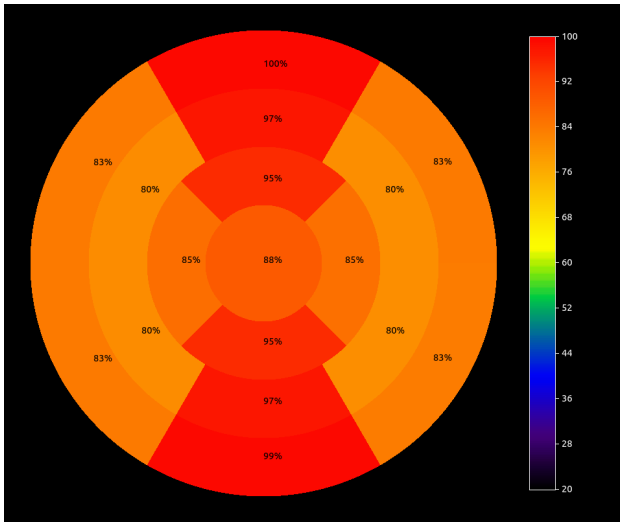
psfb = 0.035



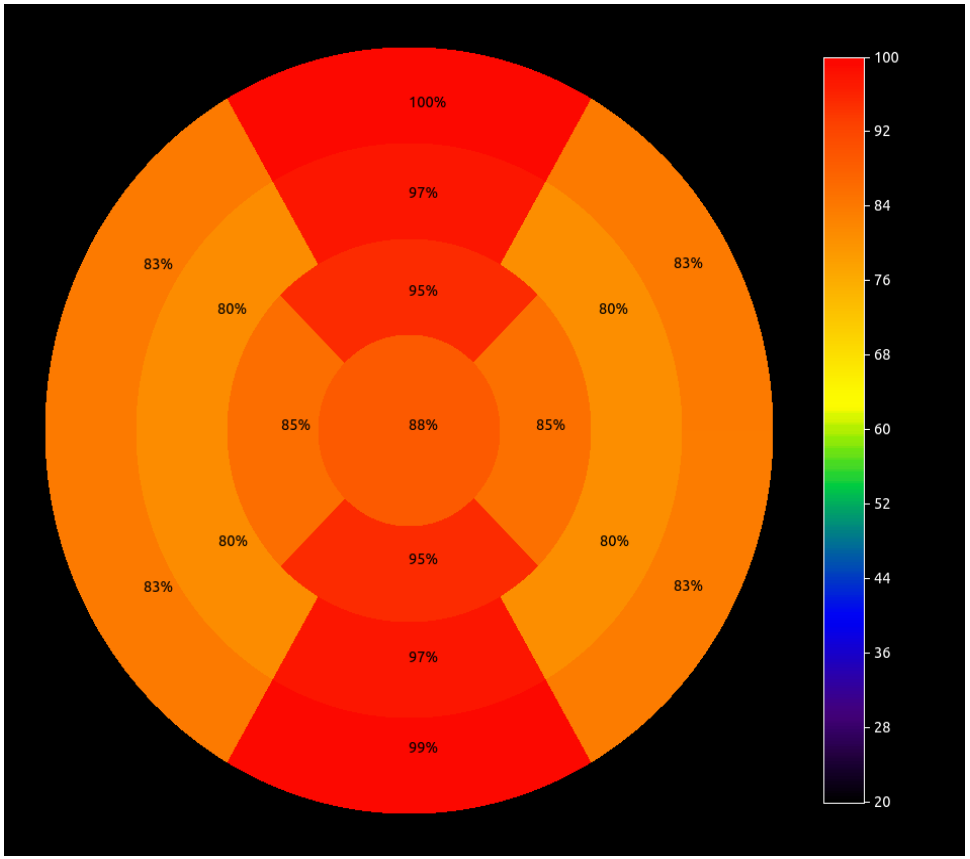
Apex region: 88%

Bullet vs Slant bullet

128x128x128 volume, pixel size = 4mm

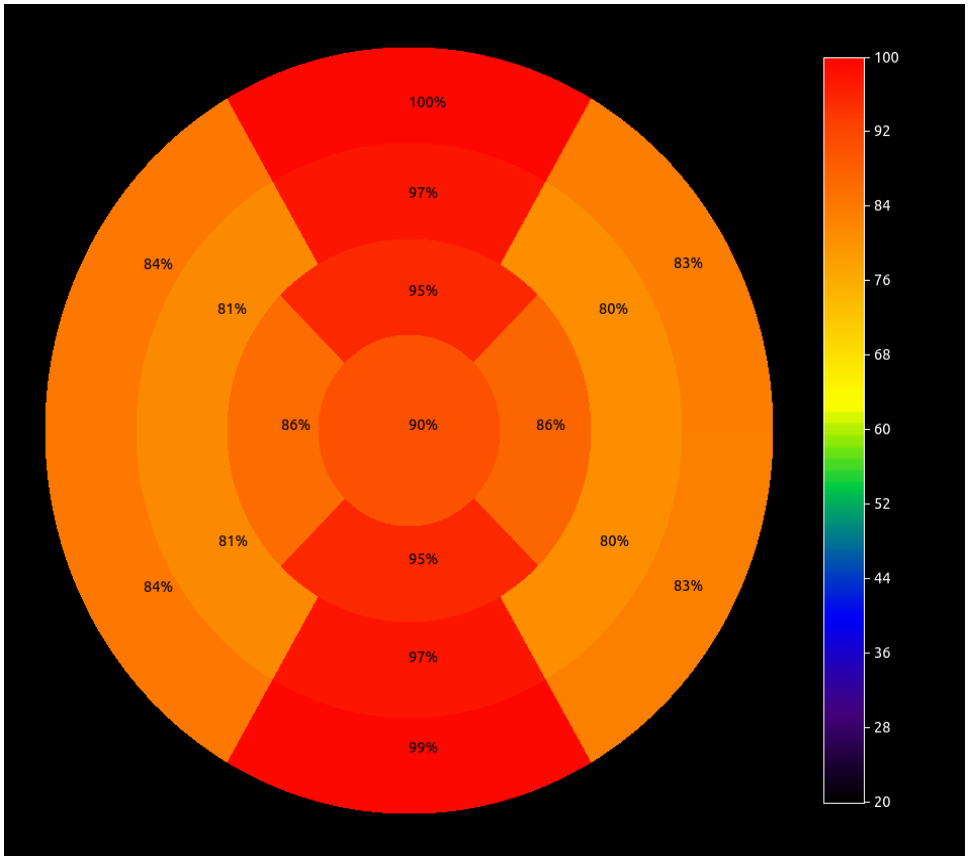
σ_{intr} = 4 mm, psfa = 1 mm, psfb = 0.035

Bullet



Apex region: 88%

Slant bullet

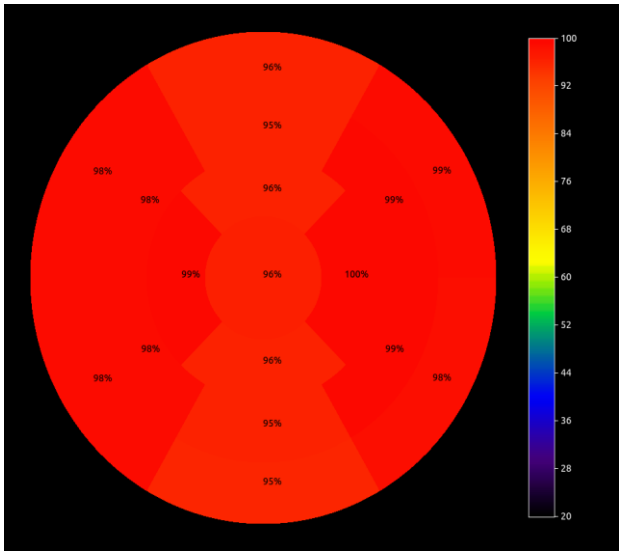


Apex region: 90%

Slant bullet phantom: effect of different detector blurring extent

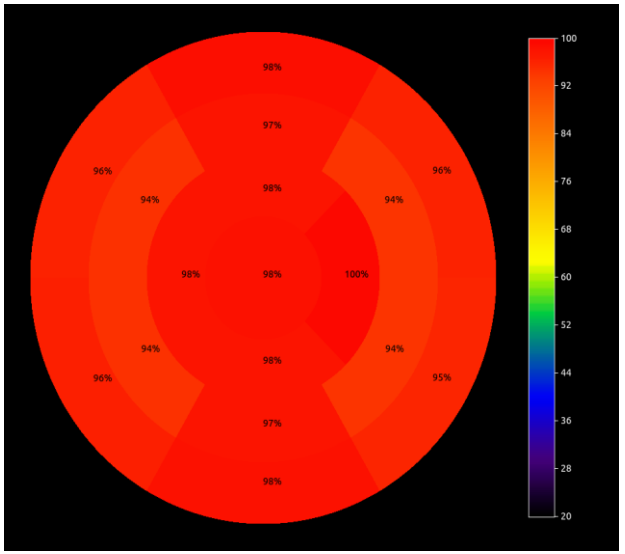
128x128x128 volume, pixel size = 4mm

σ_{intr} = 0 mm
psfa = 0 mm
psfb = 0



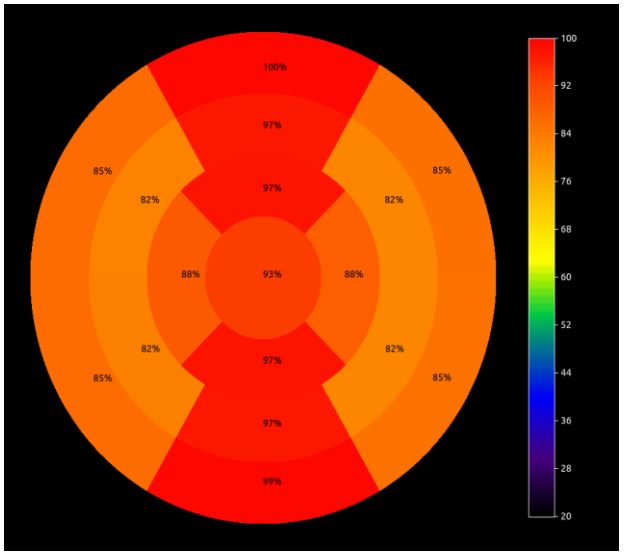
Apex region: 96%

σ_{intr} = 4 mm
psfa = 1 mm
psfb = 0.0175



Apex region:98%

σ_{intr} = 4 mm
psfa = 1 mm
psfb = 0.035

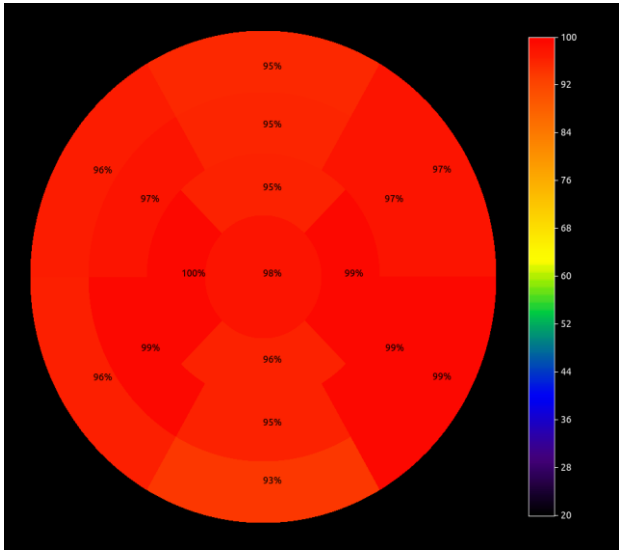


Apex region: 93%

NCAT phantom: effect of detector blurring extent

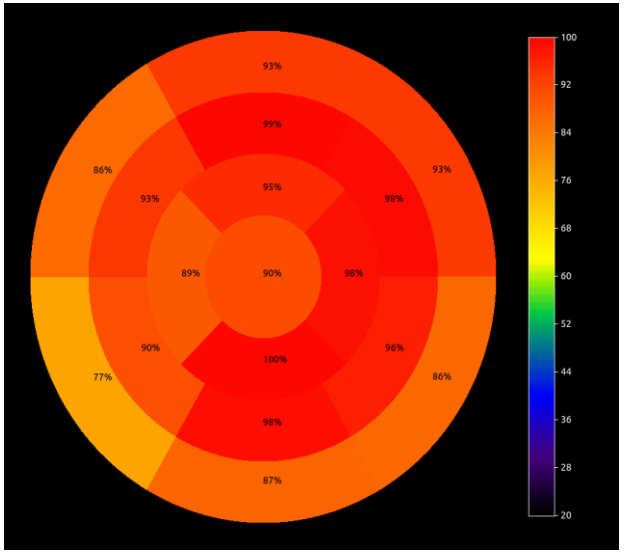
128x128x128 volume, pixel size = 4mm

σ_{intr} = 0 mm
psfa = 0 mm
psfb = 0



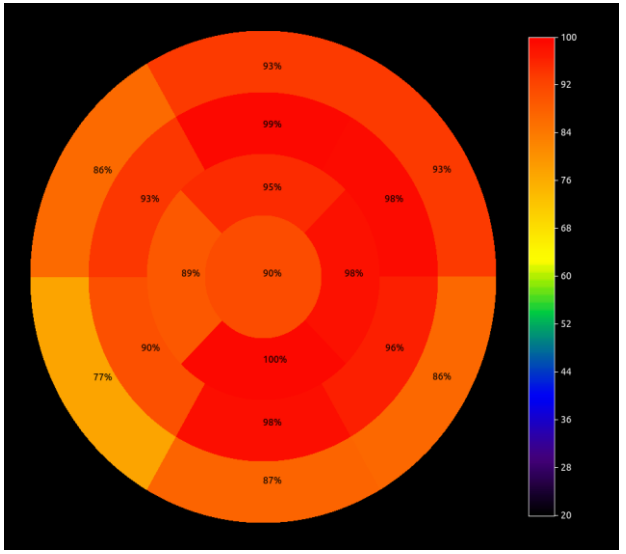
Apex region: 98%

σ_{intr} = 4 mm
psfa = 1 mm
psfb = 0.0175



Apex region: 90%

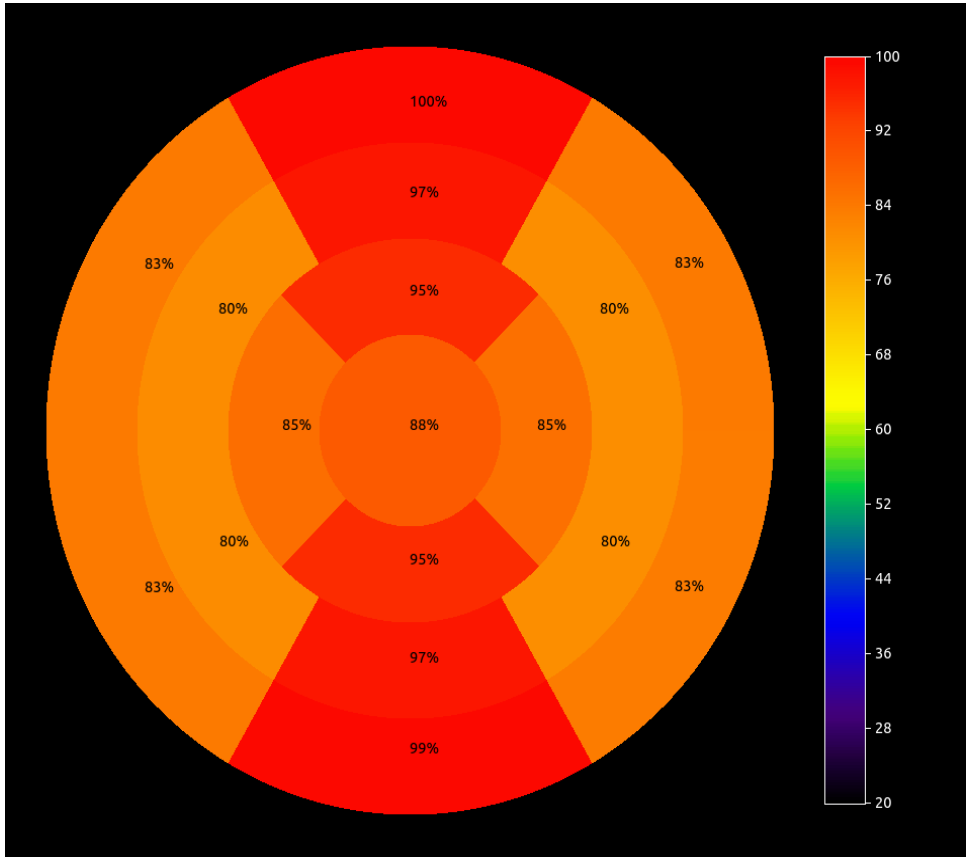
σ_{intr} = 4 mm
psfa = 1 mm
psfb = 0.035



Apex region: 90%

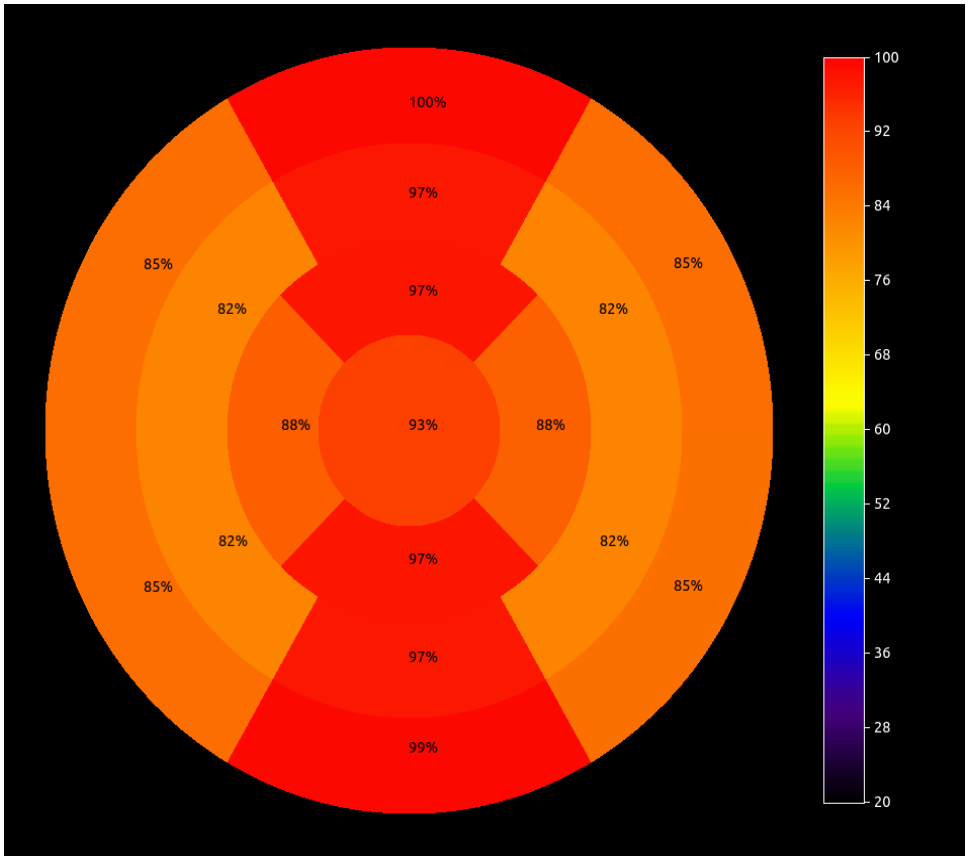
Partial Volume Effect

Bullet phantom
128x128x128 volume, pixel size = 4mm
σ_{intr} = 4 mm, psfa = 1 mm, psfb = 0.035



Apex region: 88%

Bullet phantom
256x256x256 volume, pixel size = 2mm
σ_{intr} = 4 mm, psfa = 1 mm, psfb = 0.035



Apex region: 93%

Conclusion and Future Works

1. We have investigated the apical lesion effect in myocardial perfusion SPECT imaging
2. Slant mathematical bullet phantom resulted in increased apical lesion (this setup will be further investigated)
3. One reason is the Partial Volume Effect (PVE): higher resolution volumes caused reduced PVE and consequently less apical lesion
4. Apical lesion depends on detector blurring extent: lesser extent resulted in less apical lesion

Further investigations are planned:

- *Applying different reconstruction setups,*
- *Investigating the effect of gamma photon*

Thank You for Your Attention

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