# *A utility to read automatically DICOM format data for GAMOS/Geant4 simulation*

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Outline:

- Status in Geant4
- New DICOM reading tool
  - CT images ⇨ GEANT4 format
  - RT structures
  - RT plans
  - Dose calculations
  - PET images

# DICOM data reading status in Geant4

## GEANT4 examples/extended/medical/DICOM

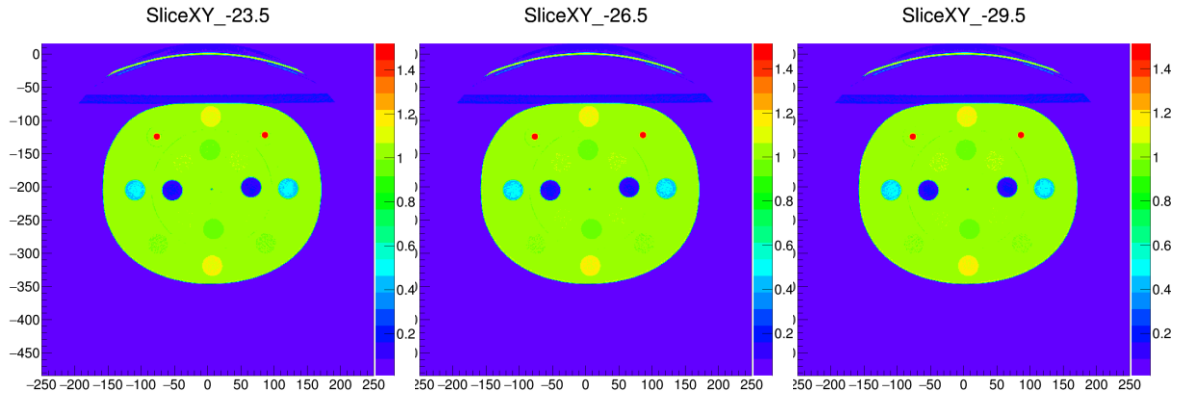
- Converts DICOM CT Hounsfield numbers (HN) => Geant4 materials
  - User selects table of conversion HN → material name
  - User selects table of conversion HN → material density
- Available since release 5.2 (June 2003)

- ❑ Home-made code
- ❑ Works with simple example provided

☹ Has many problems with other files (lots of complains in Geant4 forum)

☹ No treatment of other DICOM data:

- RT Structures
- RT Plans
- PET images



# New DICOM data tool

✓ **New DICOM data processing based on *DcmTk* software**

**Robust:**

- *DcmTk* is one of the most used DICOM processing software in C++
- Checked with several dozens of files from different origins

☺ Available in the same old Geant4 example

- Change an environmental variable

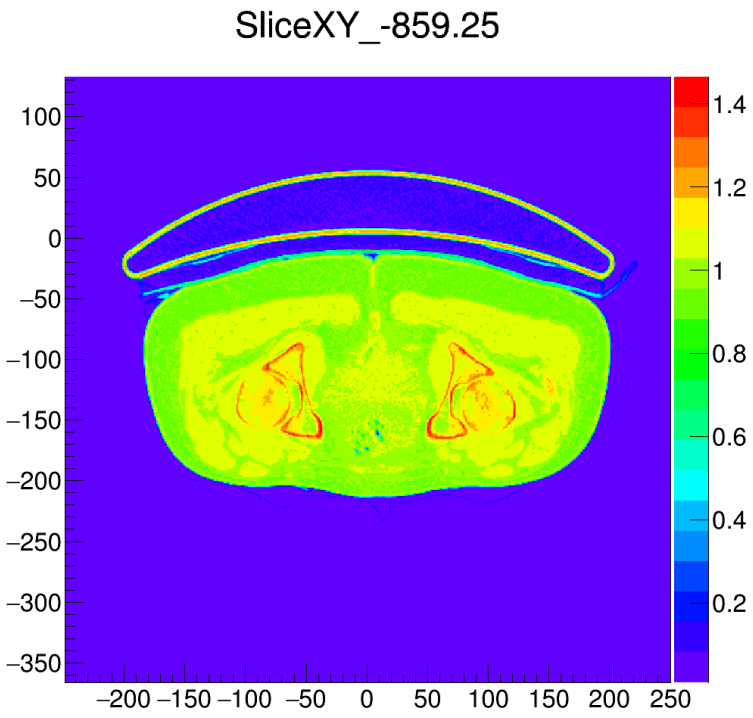
✓ Can process any DICOM CT image,
even in compressed format (**Openjpeg** package

✓ Can also process RT structure files

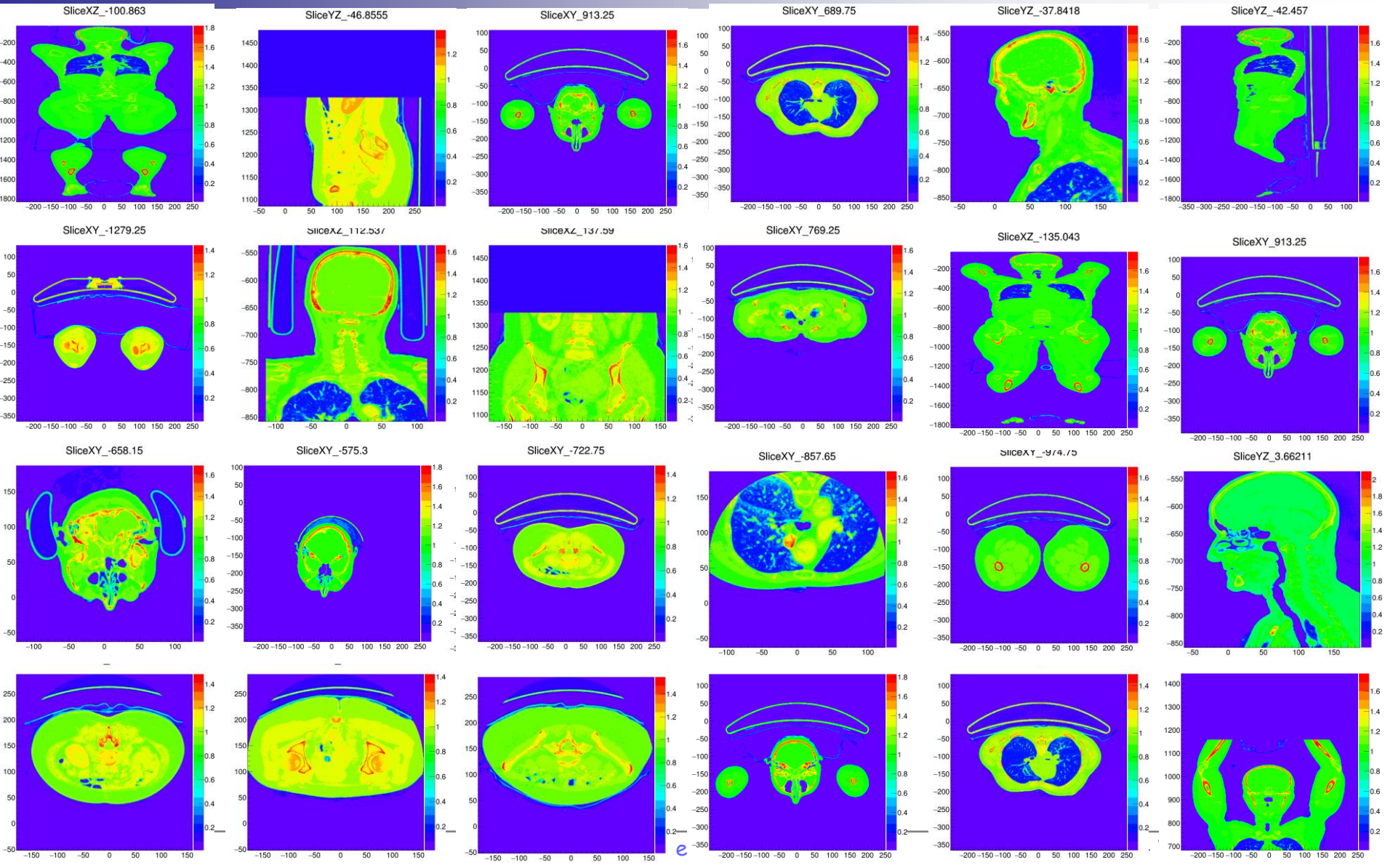
✓ Can also process PET files

✓ Can also process Planification files

✓ Others could be processed at user request



# DICOM data reading in GAMOS: CT images



# DICOM data reading in GAMOS: CT images to Geant4 format

User defines a meta file defining:

```
:COMPRESSION 1
:MATE G4_AIR 0.207
:MATE G4_LUNG_ICRP 0.919
:MATE G4_ADIPOSE_TISSUE_ICRP 0.979
:MATE G4_WATER 1.01
:MATE "ICRU46_Muscle (skeletal) Adult" 1.05
:MATE G4_B-100_BONE 1.496
:CT2D    -5000     0.0
:CT2D    -1000     0.01
:CT2D    -400        0.602
:CT2D    -150        0.924
:CT2D    100 1.075
:CT2D    300 1.145
:CT2D    2000      1.856
:FILE  IM-0001-0001.dcm
:FILE  IM-0001-0002.dcm
...
```

**Compression in X &Y**

**Hounsfield number to material name assignment**

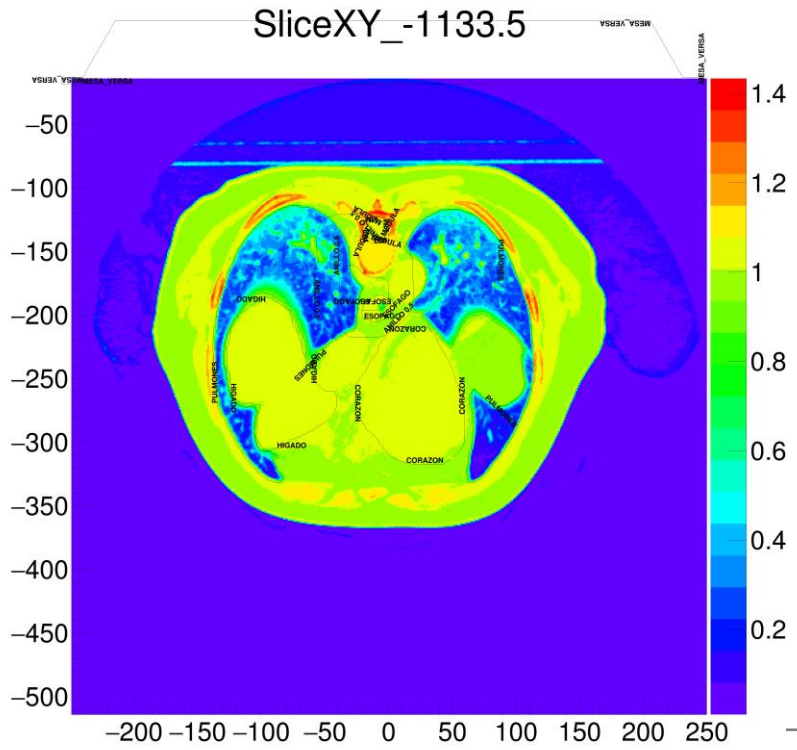
**Hounsfield number to density conversion (linear interpolation)**

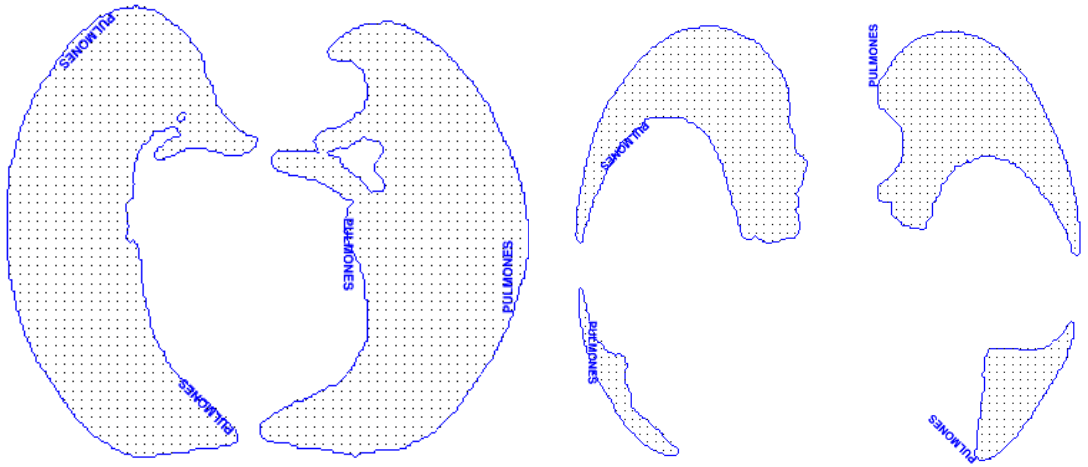
**List of files**

# DICOM data reading in GAMOS: RT structures

➢ Just include the CT structure file in the DICOM2G4 meta file
*:FILE DICOMExample/Patient_structures.dcm*

✓ Robust algorithm to assign voxels to structures:

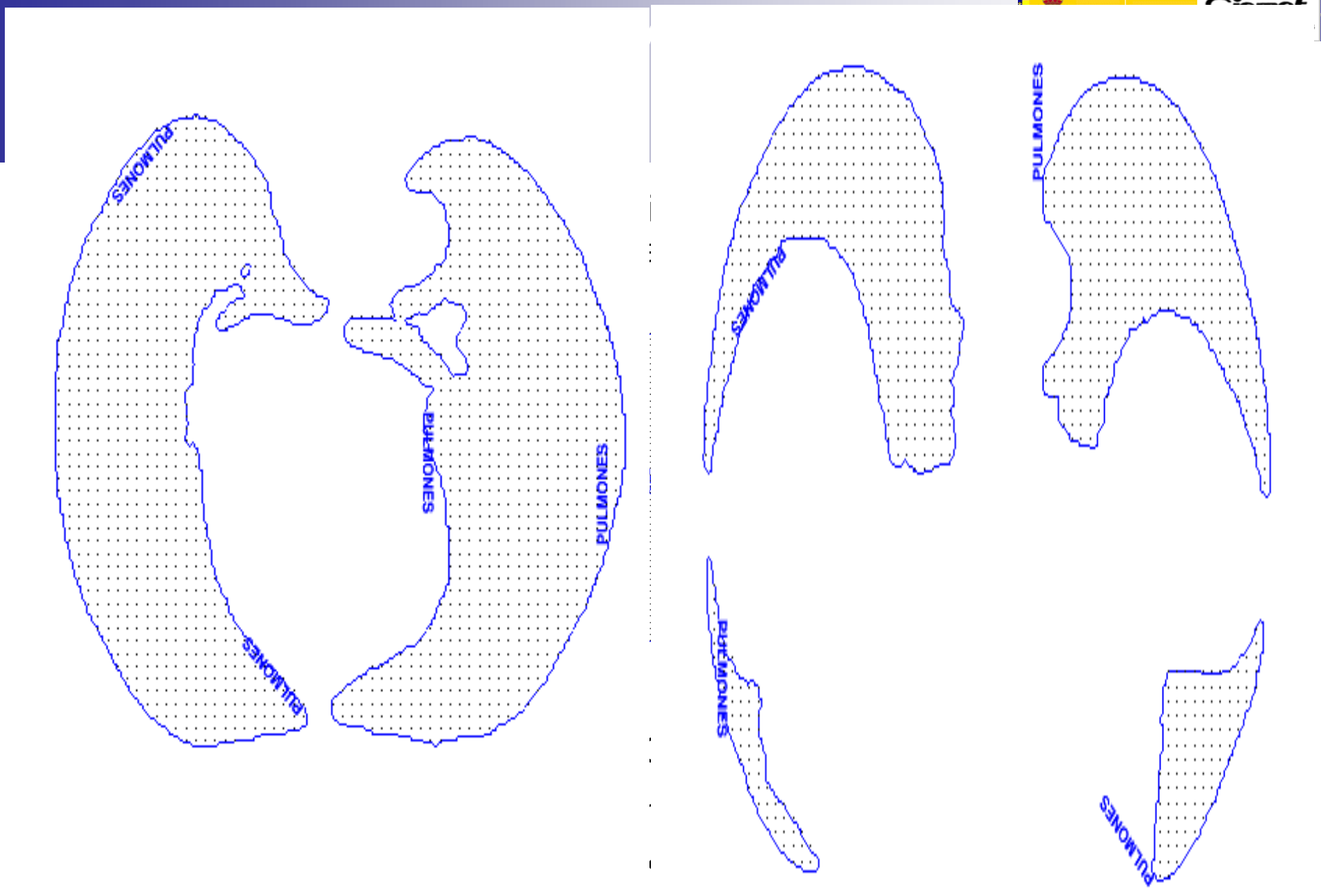



✓ Command to visualise structures superimposed on CT images (ROOT):

*drawG4dcmSt –fDCM test.g4dcm*

*–fSt structure.dcm*




*–fSt structure.dcm*

# DICOM data reading in GAMOS: RT plans

- Just include the CT structure file in the DICOM2G4 meta file

*:FILE DICOMExample/Patient_plan.dcm*

- ✓ Convert DICOM data to text files, readable by Geant4 ASCII format
  - ⇨ Geometry data is automatically included
  - ⇨ Beam data can be included in a GAMOS input file with a simple script

***RTPlan_1***

*:P BeamMeterset 234*
*:P ASYMX_Z 401.77*
*:P ASYMY_Z 509*
*:P MLCX_Z 500*

***RTPlanControlPoint_1_11***

*:P NominalBeamEnergy 10*
*:P IsocenterPositionX 0*
*:P IsocenterPositionY -155.136*
*:P IsocenterPositionZ -1175.69*
*:P SourceToSurfaceDistance 862.012*
*:P GantryAngle 229*
*:P BeamLimitingDeviceAngle 20*
*:P SourceToSurfaceDistance 862.012*
*:P ASYMX_1_POS -28.3*
*:P ASYMX_2_POS 49.3*
*:P ASYMY_1_POS -45*

*:P ASYMY_2_POS 35*
*:P MLCX_1_POS -2.5*
*:P MLCX_2_POS -2.5*
*:P MLCX_3_POS -2.5*
*:P MLCX_4_POS -2.5*
*…*

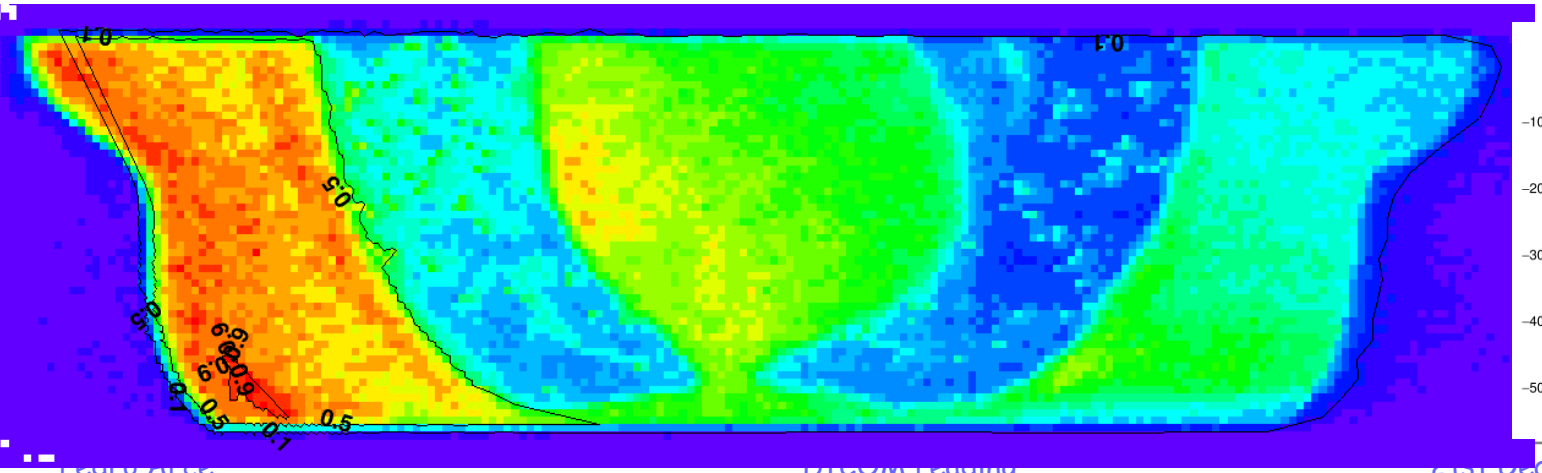
# DICOM data reading in GAMOS: Dose calculations

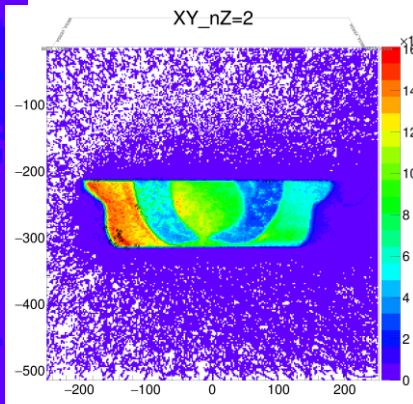
- Phantom in Geant4 format can be easily used in a Geant4 or GAMOS job
  */gamos/geometry GmReadPhantomG4withPSGeometry*

- ✓ Dose in phantoms histograms:
  - ✓ PDD
  - ✓ Cross profiles
  - ✓ Dose-volume
  - ✓ Also a subset of voxels can be selected for profiles

| TYPE | NAME | XVOXEL_MIN | XVOXEL_MAX | YVOXEL_MIN | YVOXEL_MAX | ZVOXEL_MIN | ZVOXEL_MAX |
|---|---|---|---|---|---|---|---|
| 1Y | ProfX_Z=30cm | 0 | 0 | 0 | 162 | 119 | 119 |
| 1Z | PDD | 81 | 81 | 0 | 0 | 0 | 119 |

- Command to draw isodose lines superimposed on dose (ROOT)



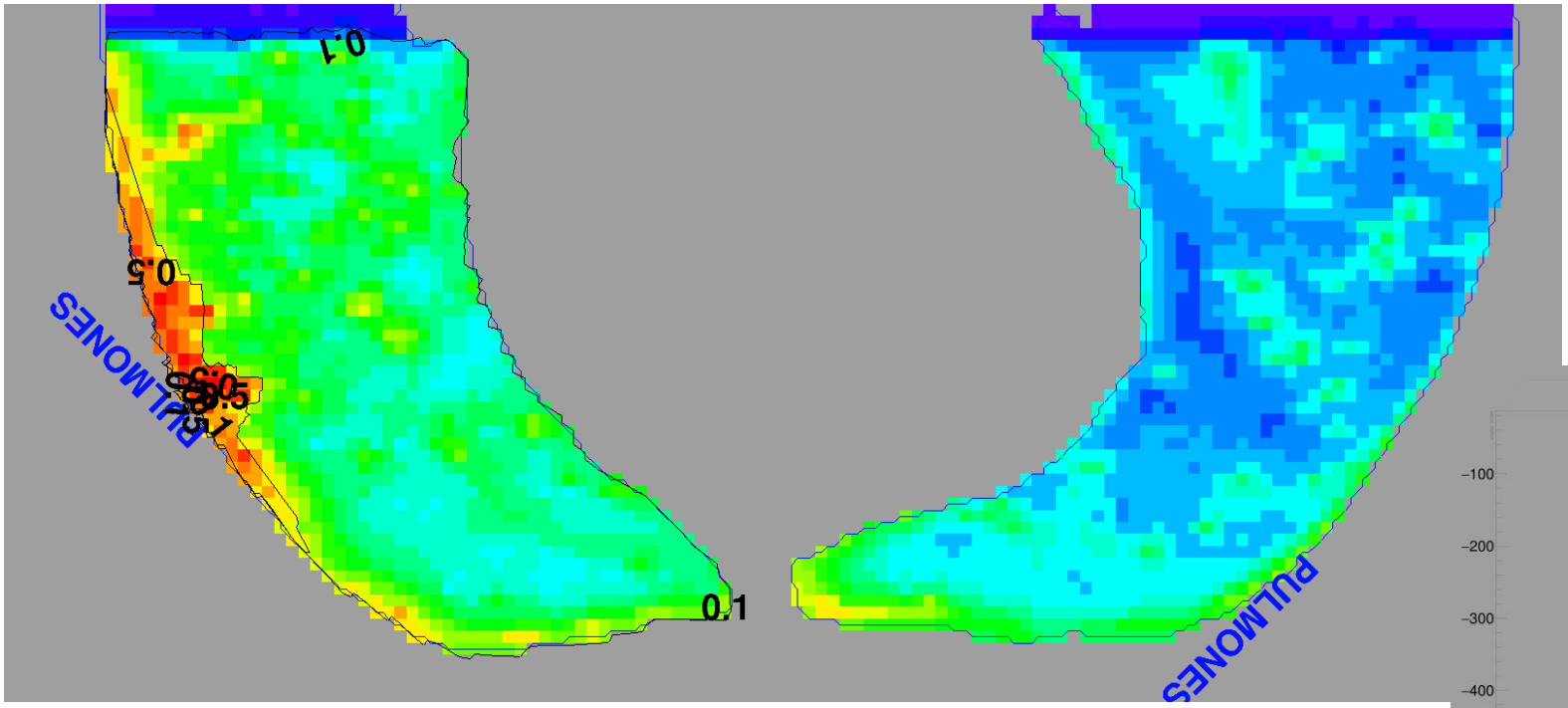


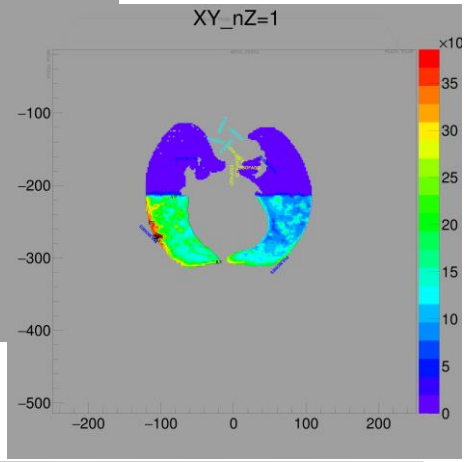
# DICOM data reading in GAMOS: Dose in RT structures

- Code to use *RT structure information in GAMOS calculation*

*/gamos/filter InLungFilter GmInPhantomStructureFilter Pulmones*

*/gamos/scoring/addFilter2Scorer doseScorer inLungFilter*



# DICOM data reading in GAMOS: PET images

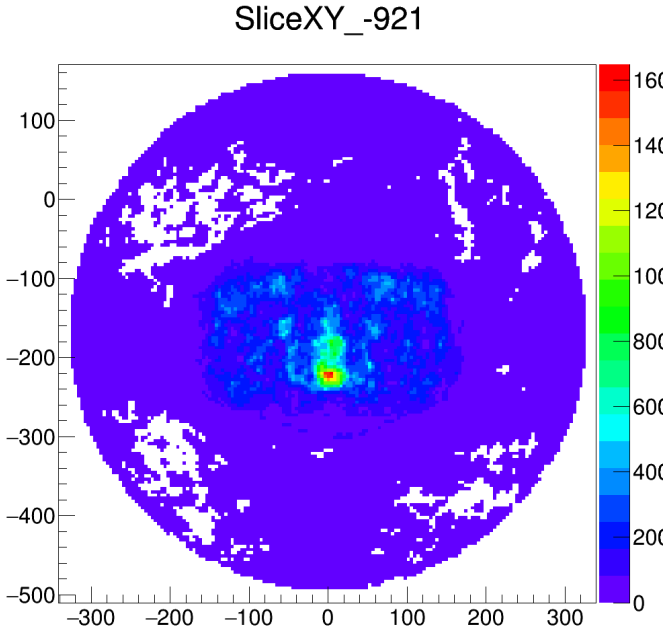
- Just include the PET structure files in the DICOM2G4 meta file

*:FILE DICOMExample/PET_001.dcm*

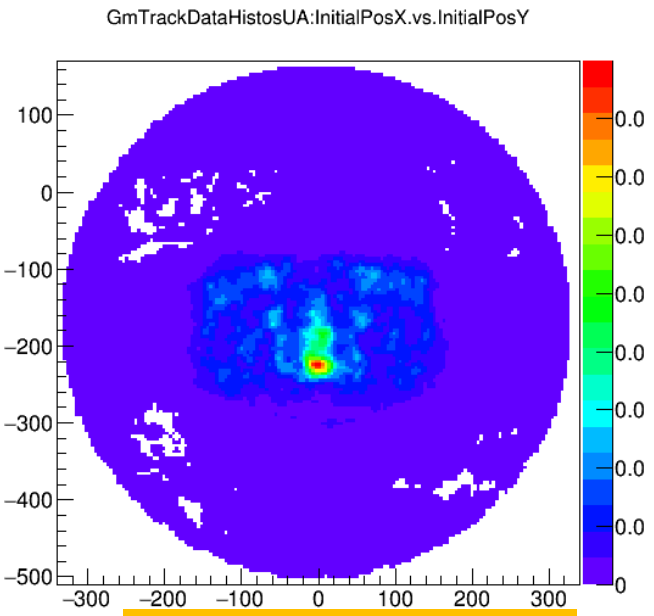
  - ✓ Automatic conversion of PET DICOM data into a simple text file containing activity per voxel

- Utility to use back PET data file to create a source spatially distributed according to PET activity

*/gamos/generator/positionDist mySource GmGenerDistPositionPETImage pet.g4dcm*




DICOM PET image




Initial position of F18 source particles

# SUMMARY

- ✓ **A new code to convert DICOM data for Geant4 use, with utilities to use DICOM data and visualize results**

- ➢ Robust (checked with several dozens of images)
- ➢ Not only uncompressed CT images as previous code
  - ✓ CT images
    - Uncompressed and compressed images
  - ✓ RT structures (robust assignment of voxels inside structures)
  - ✓ RT plans
  - ✓ PET images

**Utilities to visualize data:**

- ➢ Command to visualize CT images, with RT structures superimposed
- ➢ Command to visualize dose images, with isodose lines superimposed

**Use of data for simulation:**

- ➢ Can use DICOM CT images for dose calculations (+ RT structures)
- ➢ Can use DICOM Plan data to send GAMOS jobs
- ➢ Can use DICOM PET images as source activity

**NEXT: port it to Geant4 DICOM example (all? / several examples?)**