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Image reconstruction of J-PET *by* QETIR *and limitations*

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Frascati 26.09.2019

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Outline

- **24 Modular J-PET**
- **Geant4 Application for Tomographic Emission (GATE)**
- **Propose of 24 Modular J-PET simulation by GATE**
- **GATE Output J-PET Analyzer, GOJA**
- **Image reconstruction**
- **Quantitative Emission Tomography Iterative Reconstruction**
- **Configuration in QETIR**
- **List_Mode**
- **Sensitivity Map**

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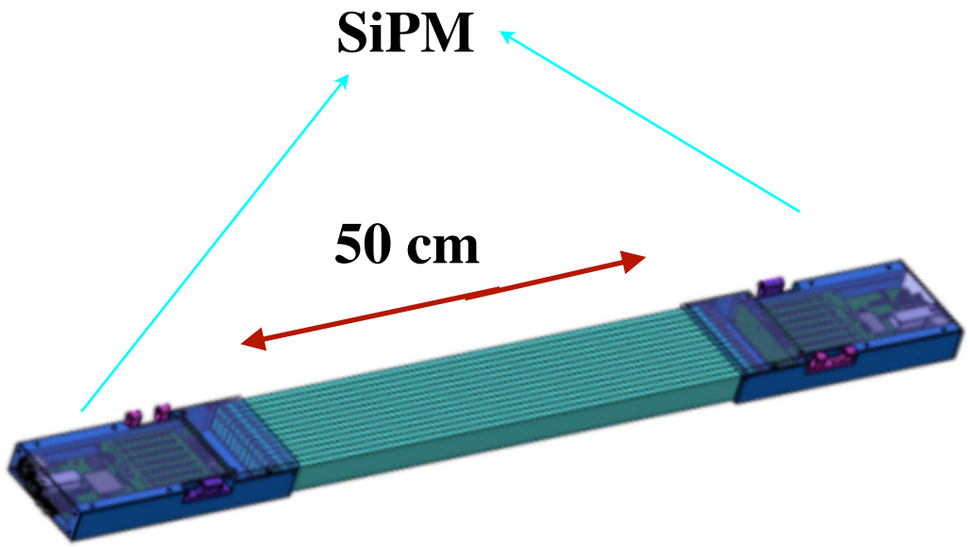
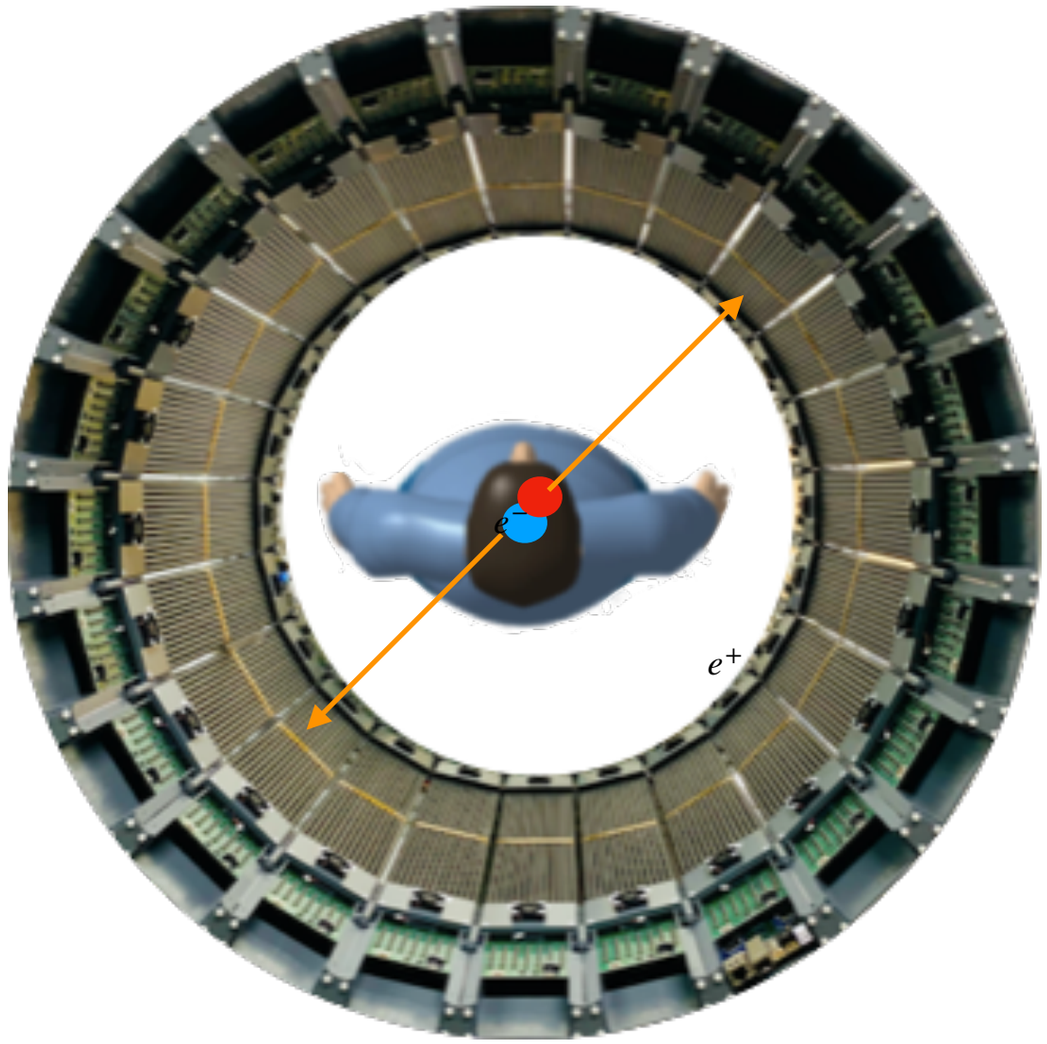
24 Modular J-PET

- **Material of the scintillator EJ230**
- **13 plastic scintillator strips in each modules**
- **24 modules in cylinder shape scanner**
- **Based on SiPM**



EJ230 Plastic strips



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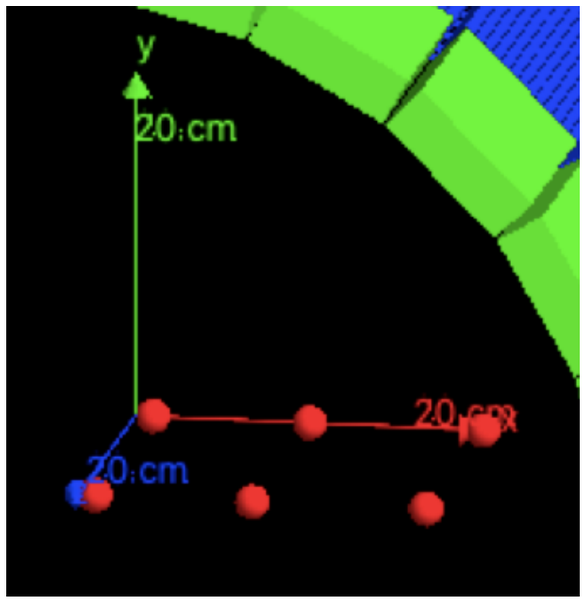
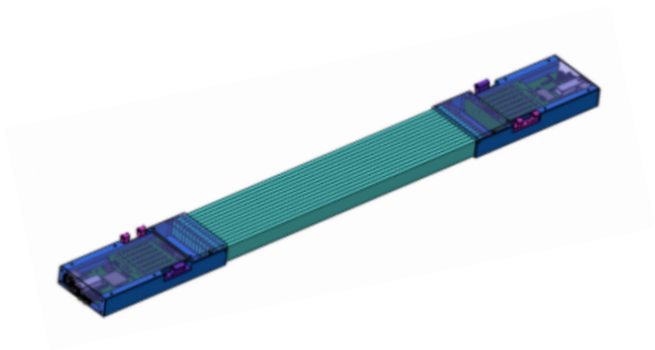
Geant4 Application for Tomographic Emission (GATE)

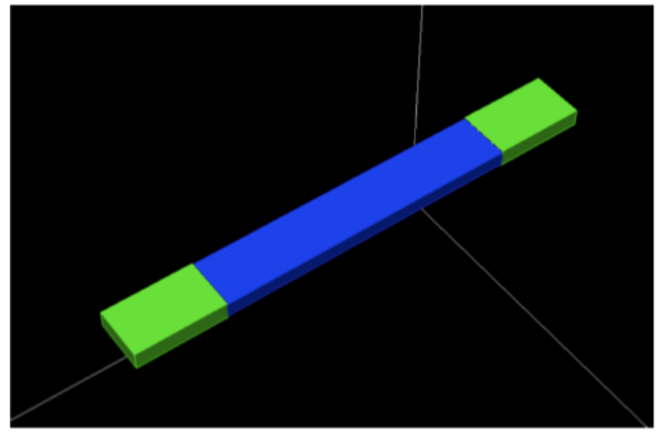
6 point sources in simulations



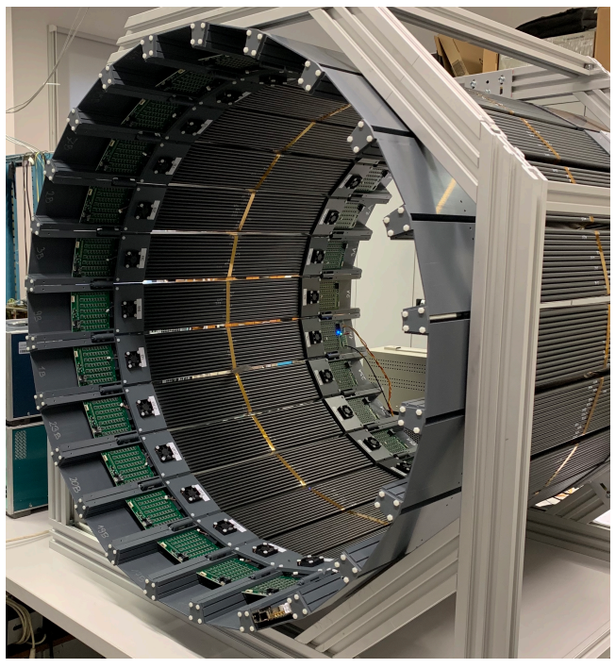
Source Number	Position (cm)
Source N1	(1,0,0)
Source N2	(1,0,18.75)
Source N3	(10,0,18.75)
Source N4	(10,0,0)
Source N5	(20,0,0)
Source N6	(20,0,18.75)



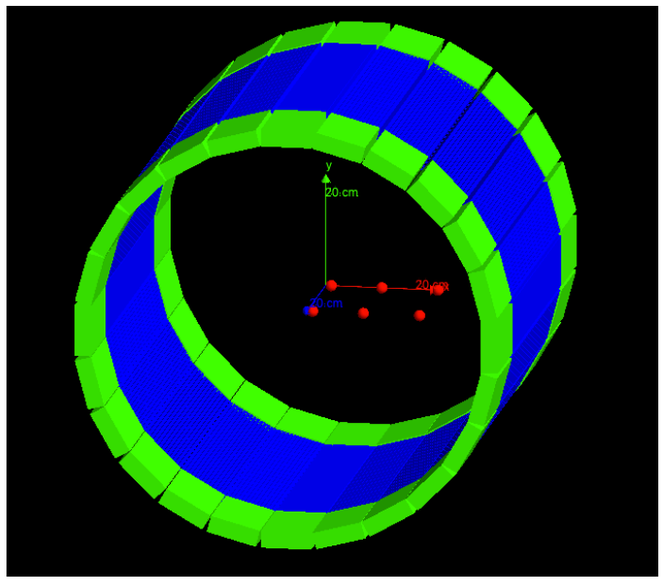
Schematic view of a Module



GATE simulation visualization of a Module



24 Modular J-PET



24 Modular J-PET include 6 sources by GATE visualization

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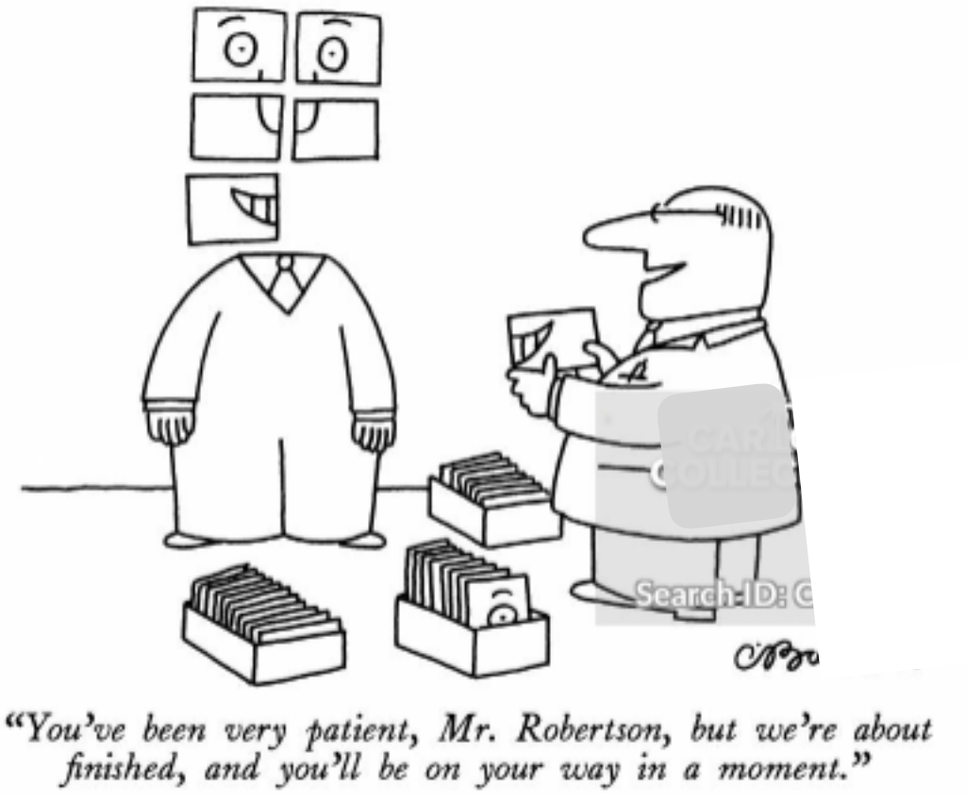
Propose of 24 Modular J-PET simulation by GATE



"You've been very patient, Mr. Robertson, but we're about finished, and you'll be on your way in a moment."

GATE simulation Root output files

?

List_Mode

Image reconstruction software

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GATE Output J-PET Analyzer, GOJA

By Pawel Kowalski

- **GATE root files are input for that**
- **Able to categorize each events and their type: true or scatter**
- **Can generate a List_Mode which is essential in image reconstruction**

★ **GOJA List_Mode will describe**

Versions of GOJA:

I Version
- **Generate List_Mode**
- **Categorize events**

II Version
- **Generate List_Mode**
- **Categorize events**
- **Generate sensitivity map ..**

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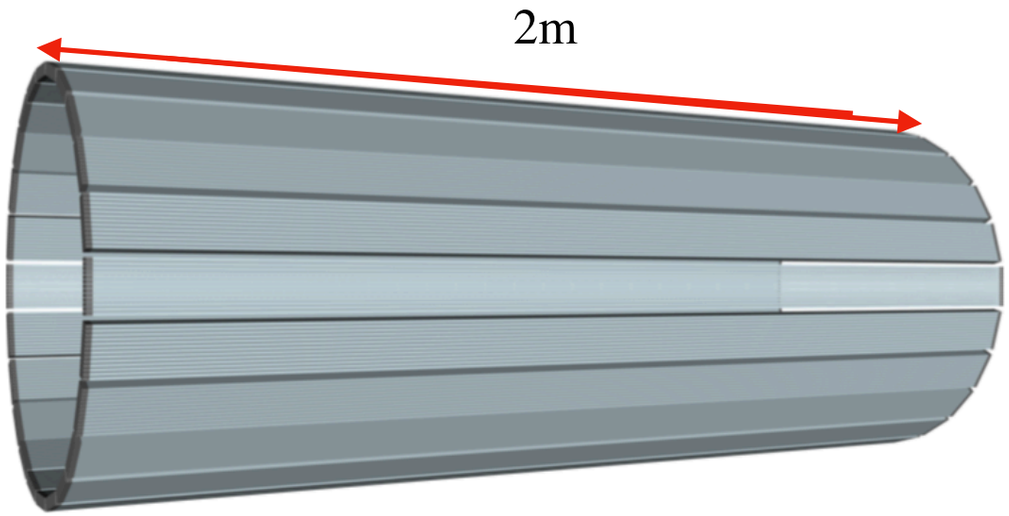
Image reconstruction

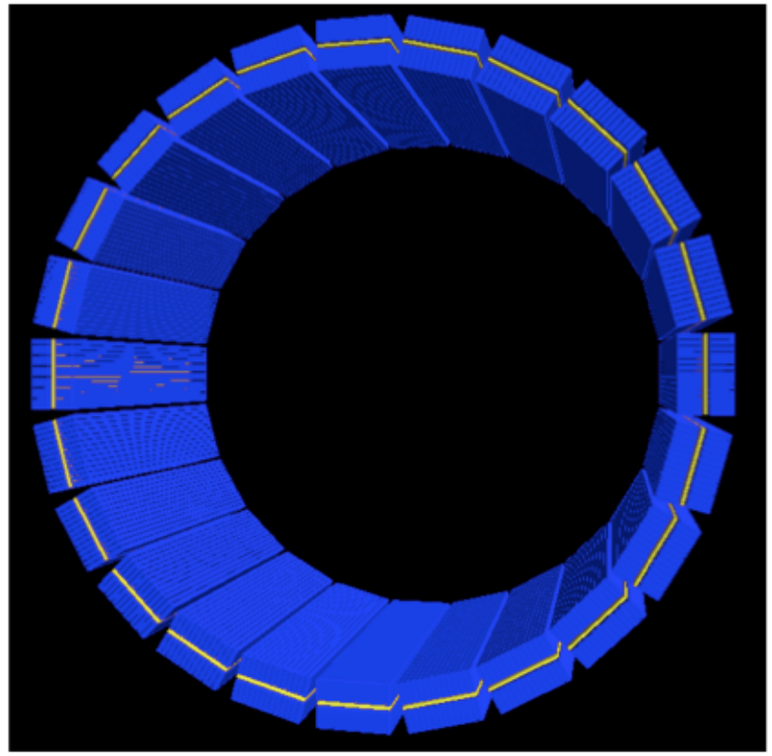
In Image reconstruction we have two goals:

- **Reconstructing image for Long AFOV**
- **Reconstructing image for Multilayer geometries**

Layer	1	1	2	2
Length (cm)	50	200	50	200



2m with 2 Layers



0.5m with 2 Layers

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Image reconstruction softwares:

STIR

CASToR

```
QETIR_PUB-master — -bash — 94×27

++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                +
+                WELCOME TO QETIR                +
+                                                +
+   Emission Tomography Iterative Reconstructor  +
++++++++++++++++++++++++++++++++++++++++++++++++++

Usage:

QETIR <function> <configuration file>
          |
          |--> sensmap   : generate geometrical PET sensitivity map by
          |                backprojection of each LOR into image space.
          |
          |--> MLP       : Most Likely Position based on TOF;
          |                place each event in most likely voxel.
          |
          |--> FBP       : Filtered BackProjection
          |
          |--> recon     : Iterative MLEM/OSEM PET image reconstruction
          |
          |--> attrecon  : Iterative MLTR/MLAA/MLAA+ PET attenuation reconstruction
```

QETIR

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Quantitative Emission Tomography Iterative Reconstruction (QETIR)

Is an image reconstruction software which developed in Medisip and is adapting

For J-PET Group for reconstruction propose.

Challenges of using of QETIR

- **List_Mode** → Binary List_Mode $(x_1, y_1, z_1), (x_2, y_2, z_2)dt$
- **J-PET Geometries** → 2 Layered geometry implemented
- **Sensitivity Map** → For Image reconstruction
- **Configuration File** → Designing of geometrical parameters
- **Function File** → Defining algorithms of the function

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Quantitative Emission Tomography Iterative Reconstruction (QETIR)

These two function implemented For Modular J-PET

QETIR_PUB-master — -bash — 94×27

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++
+                                                     +
+                  WELCOME TO QETIR                   +
+                                                     +
+   Emission Tomography Iterative Reconstructor       +
+++++++++++++++++++++++++++++++++++++++++++++++++++++++

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      |--> recon      : Iterative MLEM/OSEM PET image reconstruction
      |
      |--> attrecon   : Iterative MLTR/MLAA/MLAA+ PET attenuation reconstruction
```

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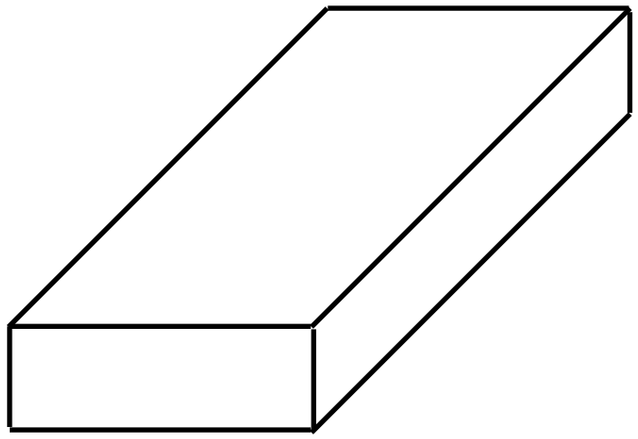
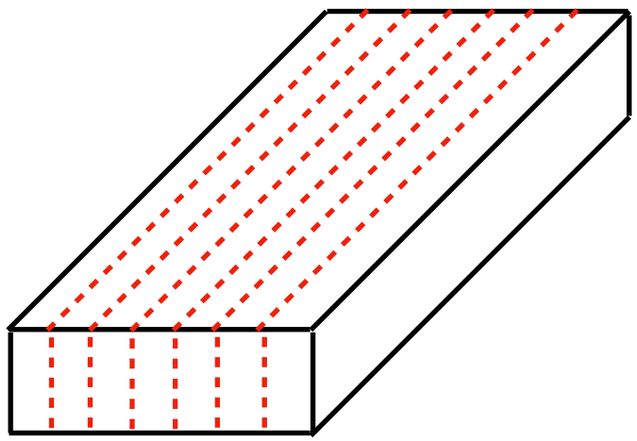
Configuration in QETIR

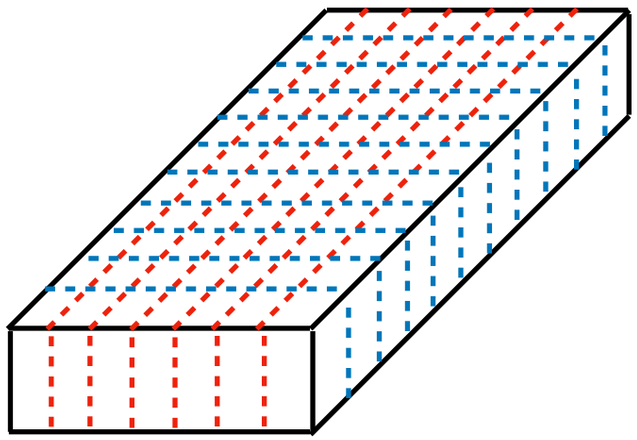
Defined Geometries in QETIR: 1, 2, 3, 4 & a Blank geometries as CUSTOM



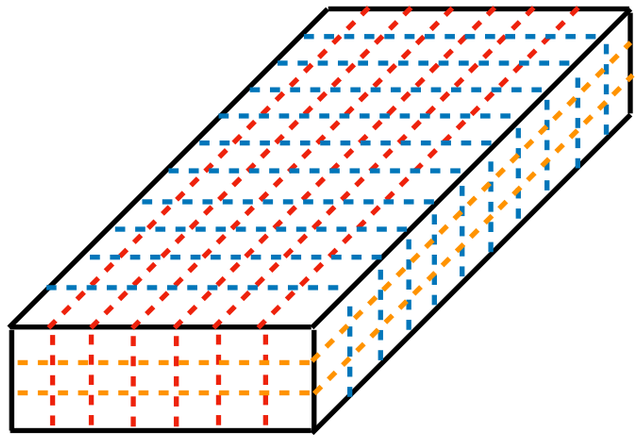
1 Layered



2 Layered



3 Layered



4 Layered

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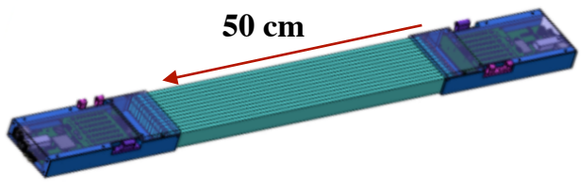
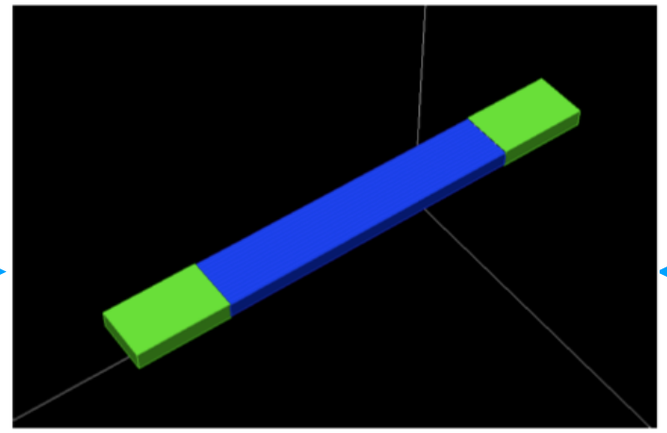
Configuration in QETIR

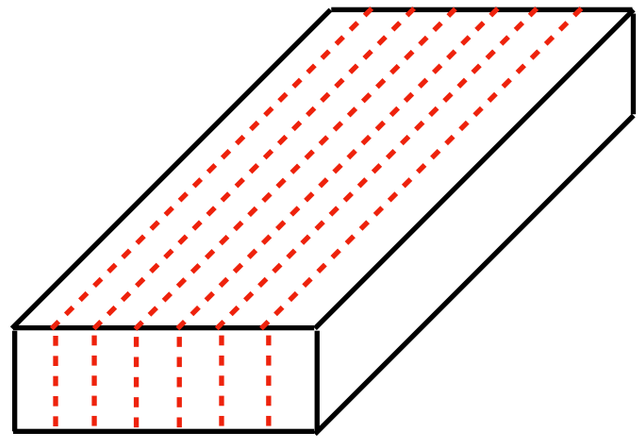
Geometry for the 24 Module J-PET

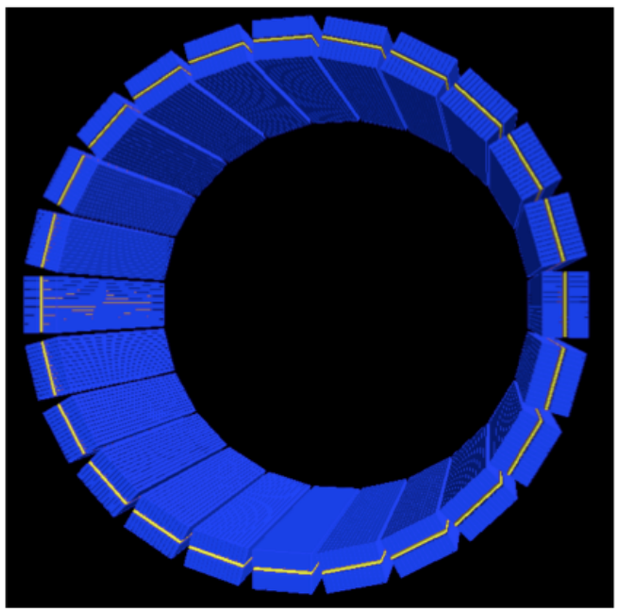


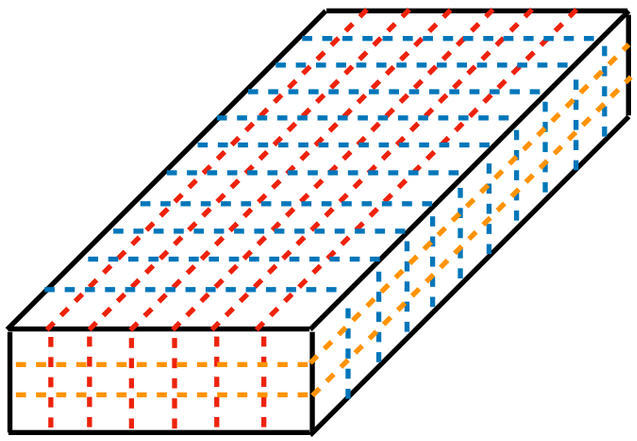
EJ230 Plastic strips



GATE simulation visualization of a Module







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List_Mode

What we Have From GATE → **Root file**

What we Have From GOJA → **List_Mode in textfile** ! **What we Need For QETIR** → Binary List_Mode $(x_1, y_1, z_1), (x_2, y_2, z_2)dt$

(x_1, y_1, z_1) of First Hit , cm | Time of First Hit (ns) | (x_2, y_2, z_2) of Second Hit , cm | Time of second Hit (ns)

16.80	-32.90	18.75	32401356.2	-13.25	33.90	-19.32	32401397.5	15	2	328.60	315.66	1	2.00	0.00	0.00	2.00	0.00	0.00
-18.57	30.65	19.74	202301238.6	13.41	-32.69	-20.49	202301557.0	3	14	339.39	222.42	2	0.00	0.00	10.00	0.00	0.00	10.00
36.31	8.21	1.92	210701179.6	-36.16	-8.73	-17.26	210701426.9	20	8	215.43	329.15	2	2.00	0.00	0.00	2.00	0.00	0.00
25.49	24.42	-6.35	245901183.7	-26.09	-24.99	-13.73	245901211.5	22	10	267.71	304.17	1	0.00	0.00	-10.00	0.00	0.00	-10.00
-31.95	14.67	-15.34	382701224.5	36.00	8.78	8.11	382701342.1	5	20	234.05	216.31	2	-2.00	0.00	0.00	-2.00	0.00	0.00
-22.10	-29.74	-22.70	421001412.5	23.37	28.67	23.55	421001507.1	11	22	201.86	257.26	3	0.00	-2.00	0.00	0.00	-2.00	0.00
-31.30	-19.41	11.98	466101238.7	29.96	21.17	-13.06	466101351.0	9	21	236.59	333.89	1	-2.00	0.00	0.00	-2.00	0.00	0.00
-32.50	15.56	-4.76	742301214.5	32.81	-15.71	-15.29	742301226.1	5	17	291.87	288.97	1	0.00	0.00	-10.00	0.00	0.00	-10.00
17.44	31.31	-19.14	847101233.7	-17.90	-32.14	-0.62	847101266.4	23	11	203.99	301.67	1	0.00	0.00	-10.00	0.00	0.00	-10.00
31.21	-16.31	1.91	1110001147.0	-33.81	13.50	-2.07	1110001242.7	17	6	233.24	225.99	1	0.00	-2.00	0.00	0.00	-2.00	0.00

GOJA List_Mode

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List_Mode

To solve this problem :

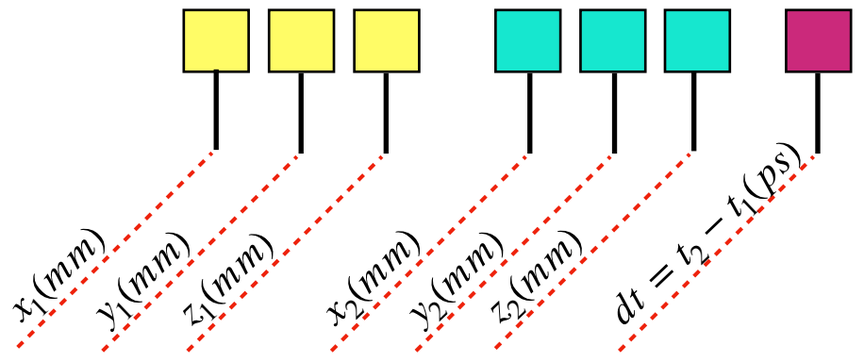
Step 1: Number of the columns in GOJA List_Mode from 19 to 7 $(x_1, y_1, z_1), (x_2, y_2, z_2)dt$

Step 2: changing Value from *cm* to *mm* and *ns* to *ps*

Step 3: converting these datas to root to be as a new input for QETIR List_Mode Generator

(not adaptable because of the digitizer issue)

QETIR List_Mode:



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Sensitivity Map

As I mentioned already these are the geometries which are interested for us

Layer	1	1	2	2
AFOV (cm)	50	200	50	200

For each one of these geometries we need:

- List_Mode
- Configuration file of the geometries and values
- Function file
- Sensitivity map

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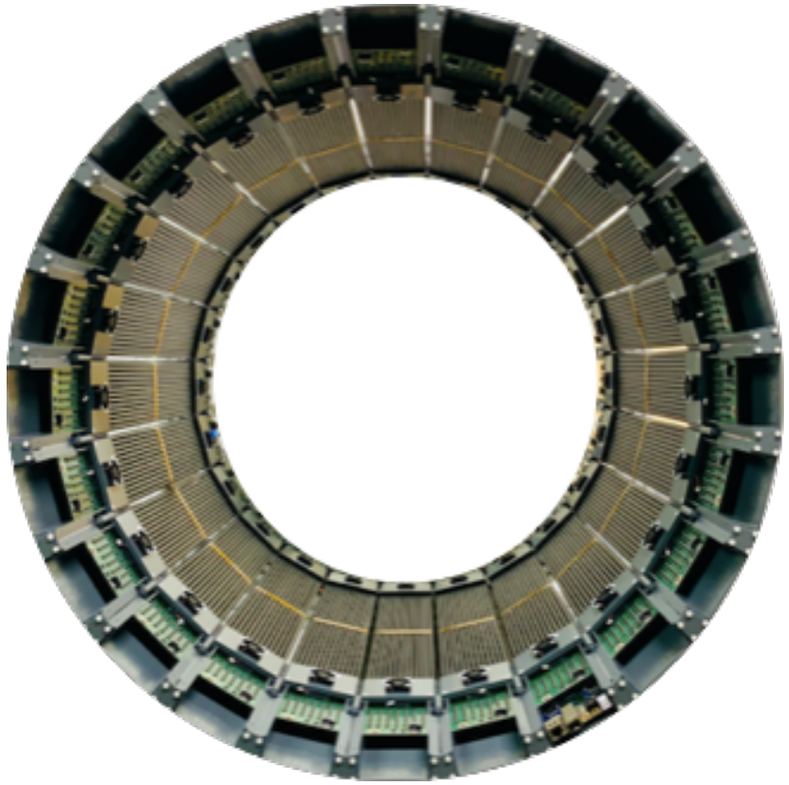
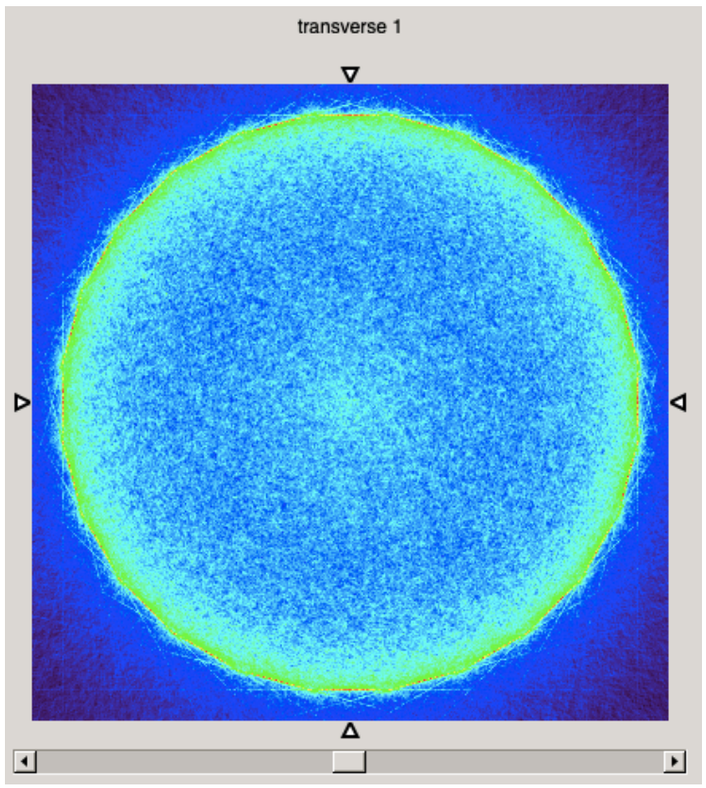
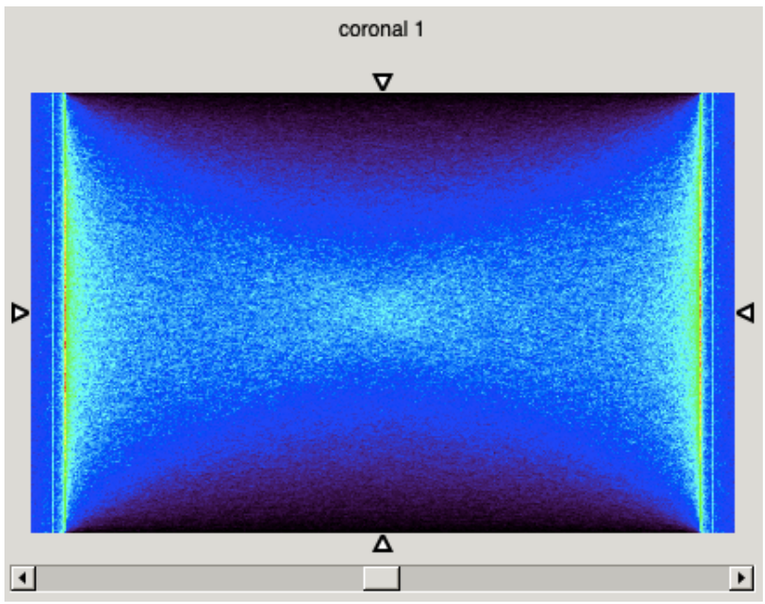
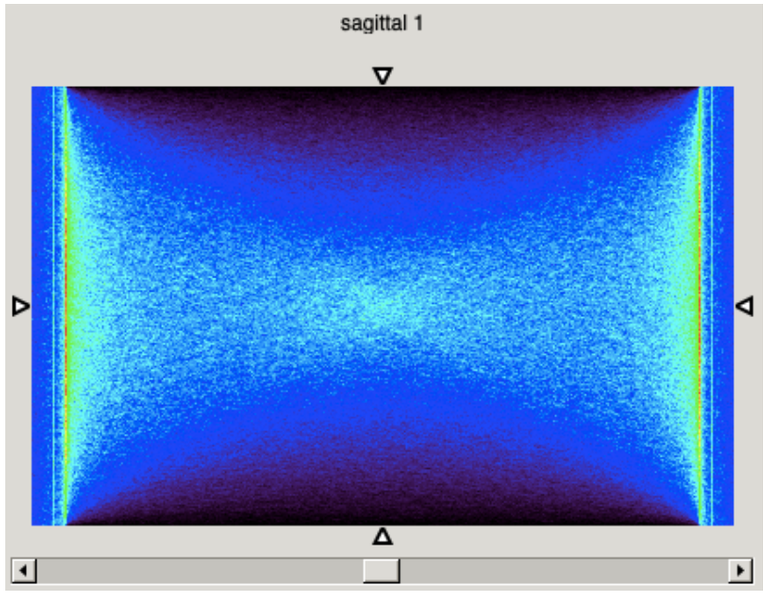
Sensitivity Map

1 Layer 24 Modular J-PET with 50 cm AFOV









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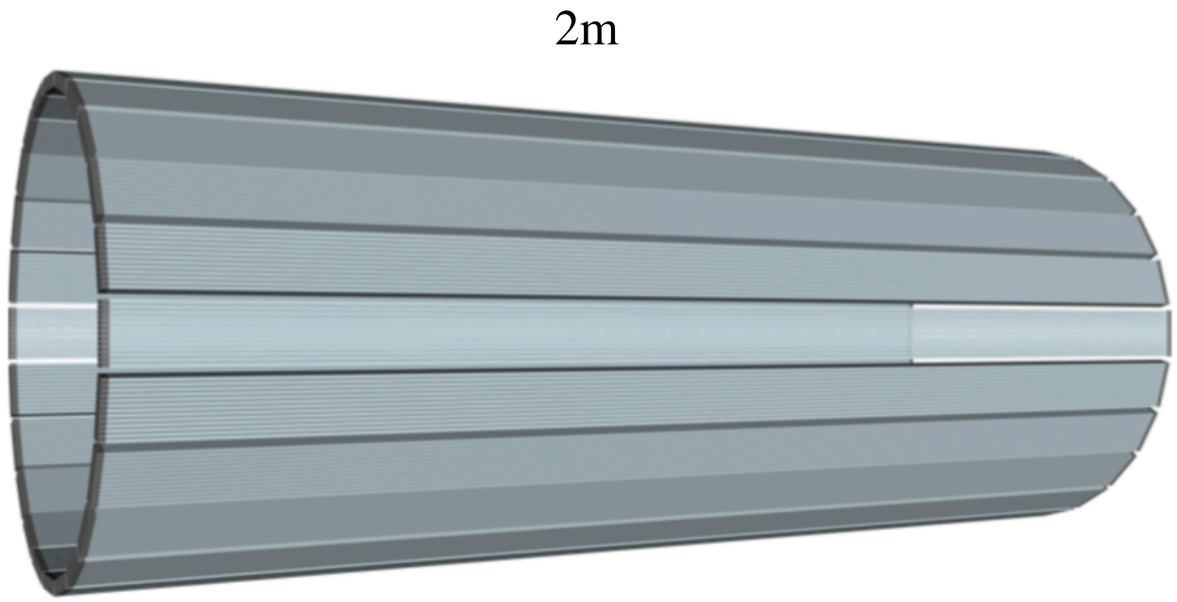
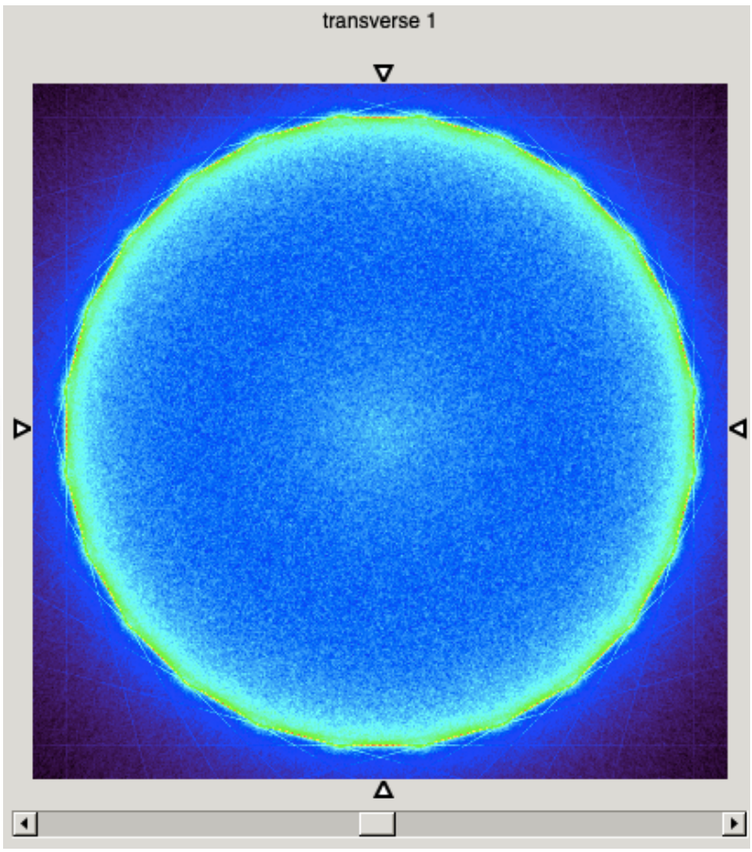
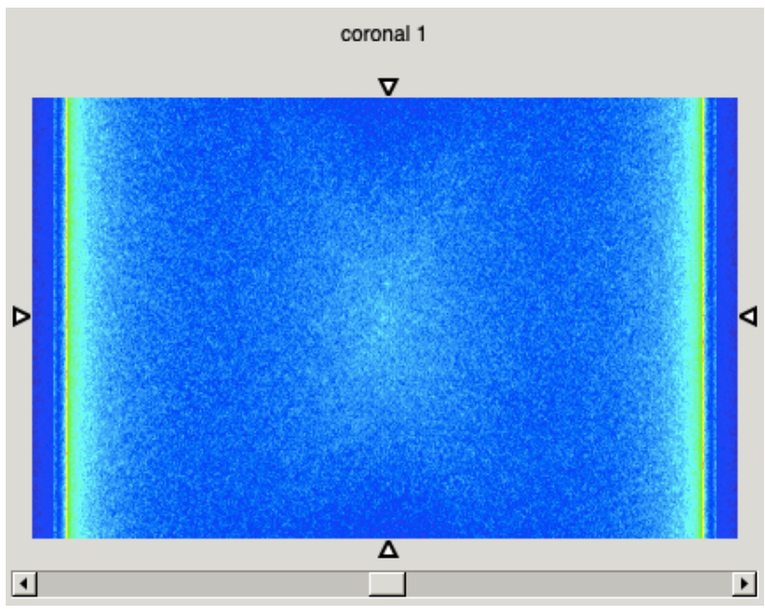
Sensitivity Map

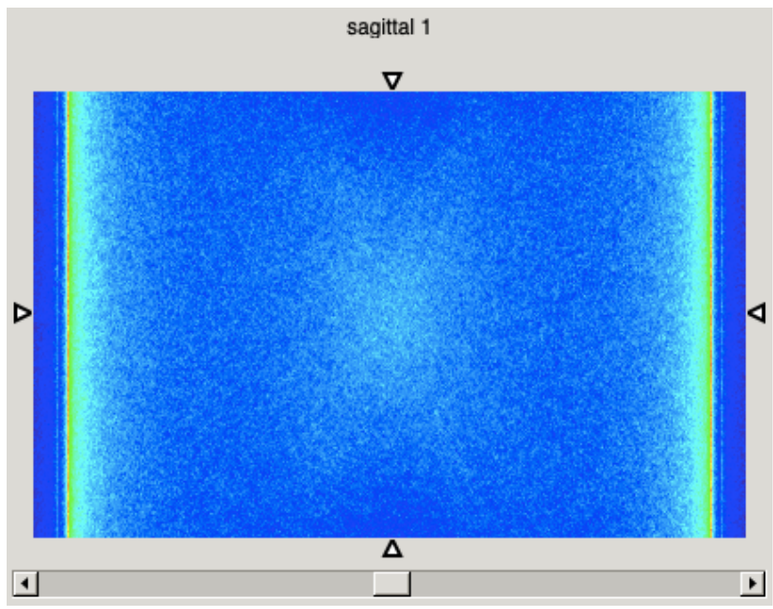
1 Layer 24 Modular J-PET with 200 cm AFO



2m AFOV with 1 Layers







Preliminary

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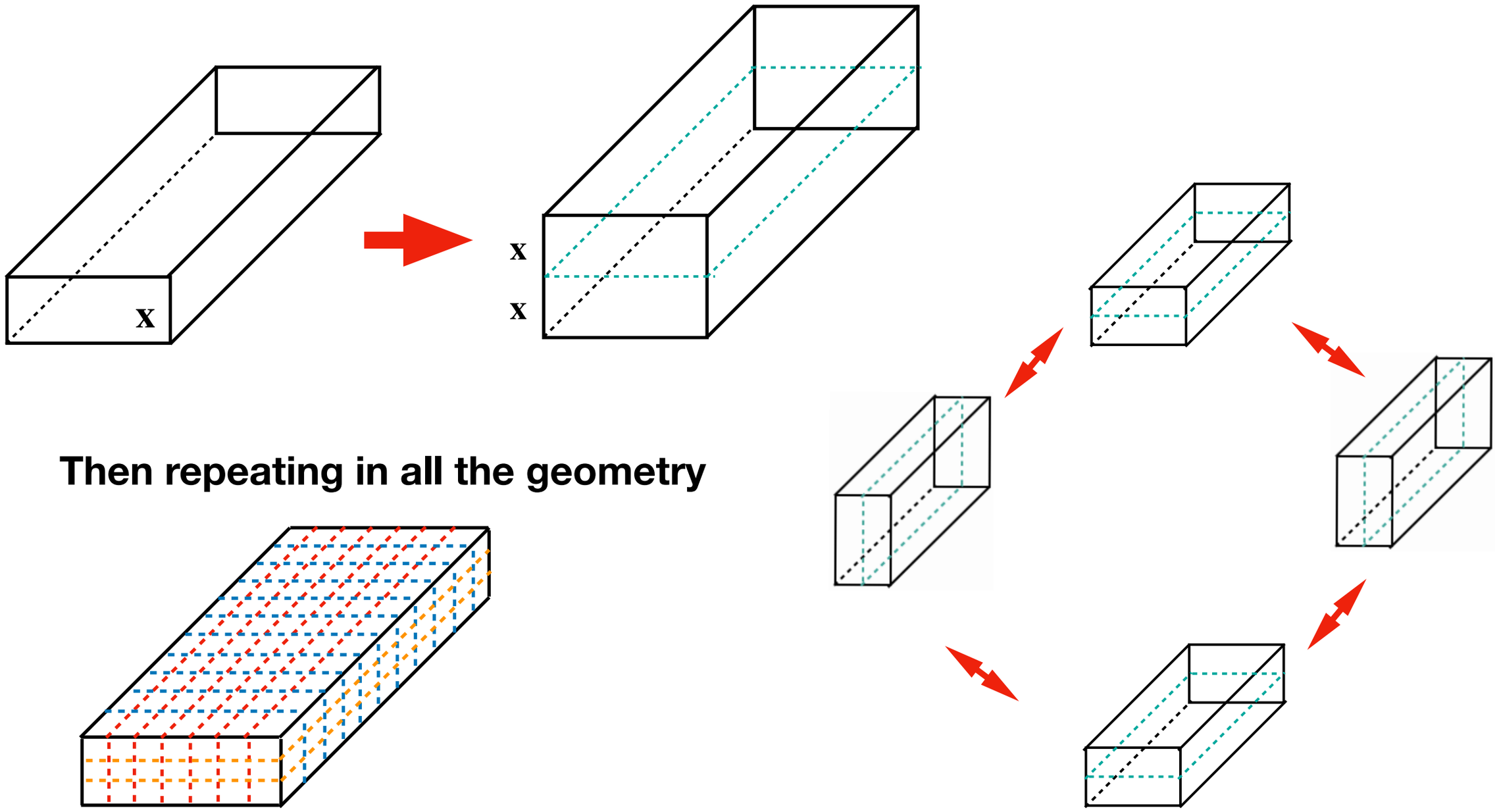
Sensitivity Map

2 Layer 24 Modular J-PET with 50 cm AFOV



Then repeating in all the geometry

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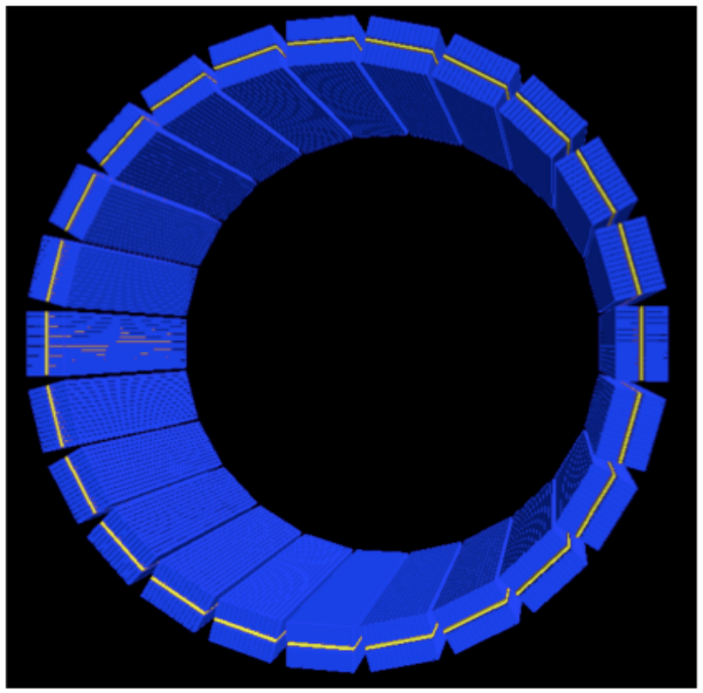
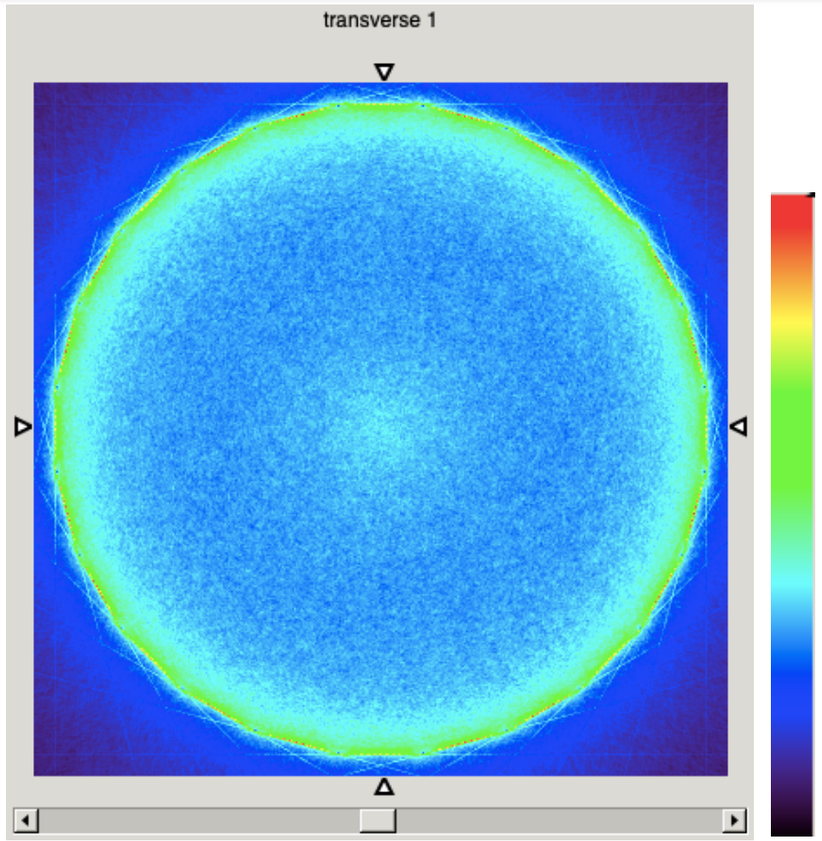
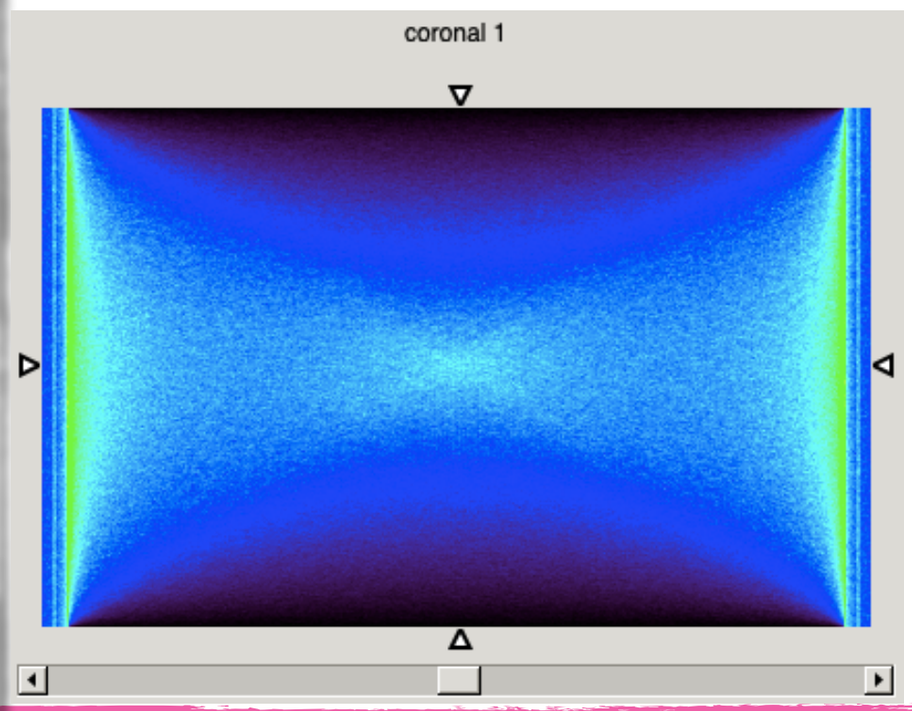
Sensitivity Map

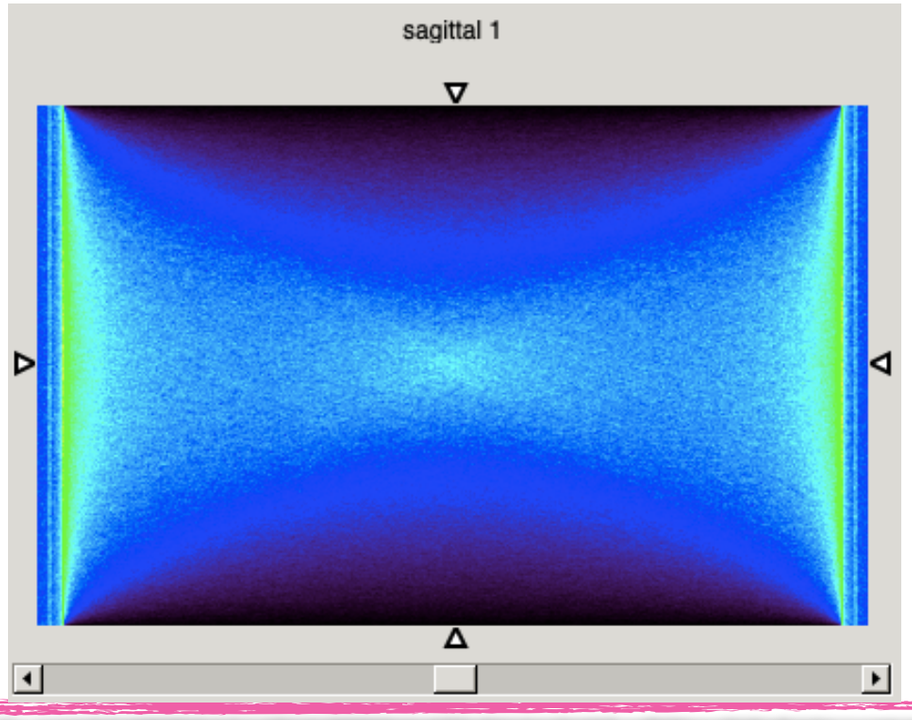
2 Layer 24 Modular J-PET with 50 cm AFOV





Preliminary





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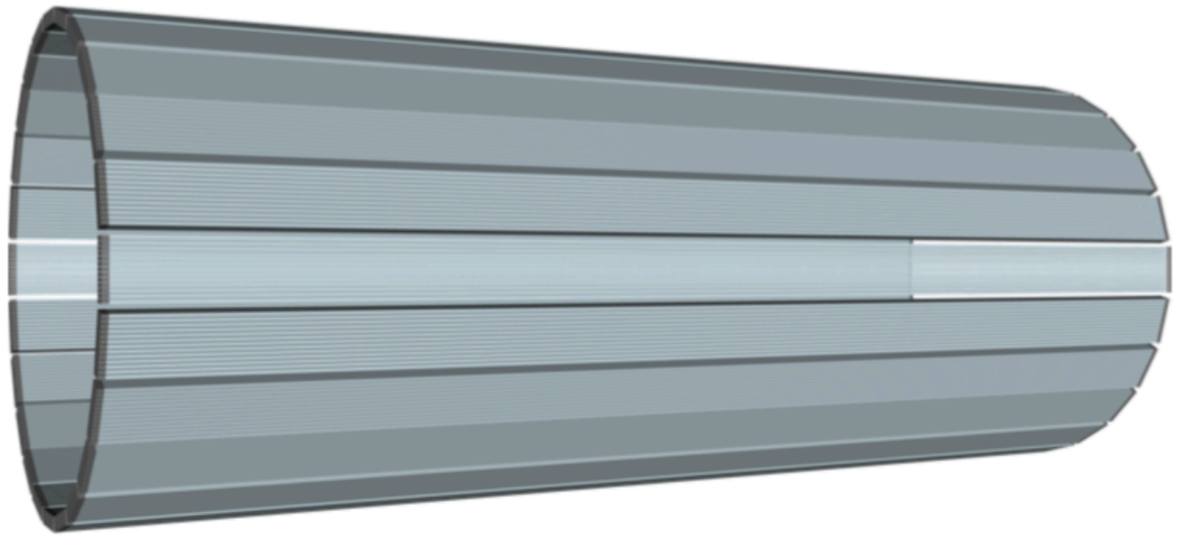
Sensitivity Map

2 Layer 24 Modular J-PET with 200 cm AFO

2m



2m AFOV with 1 Layers

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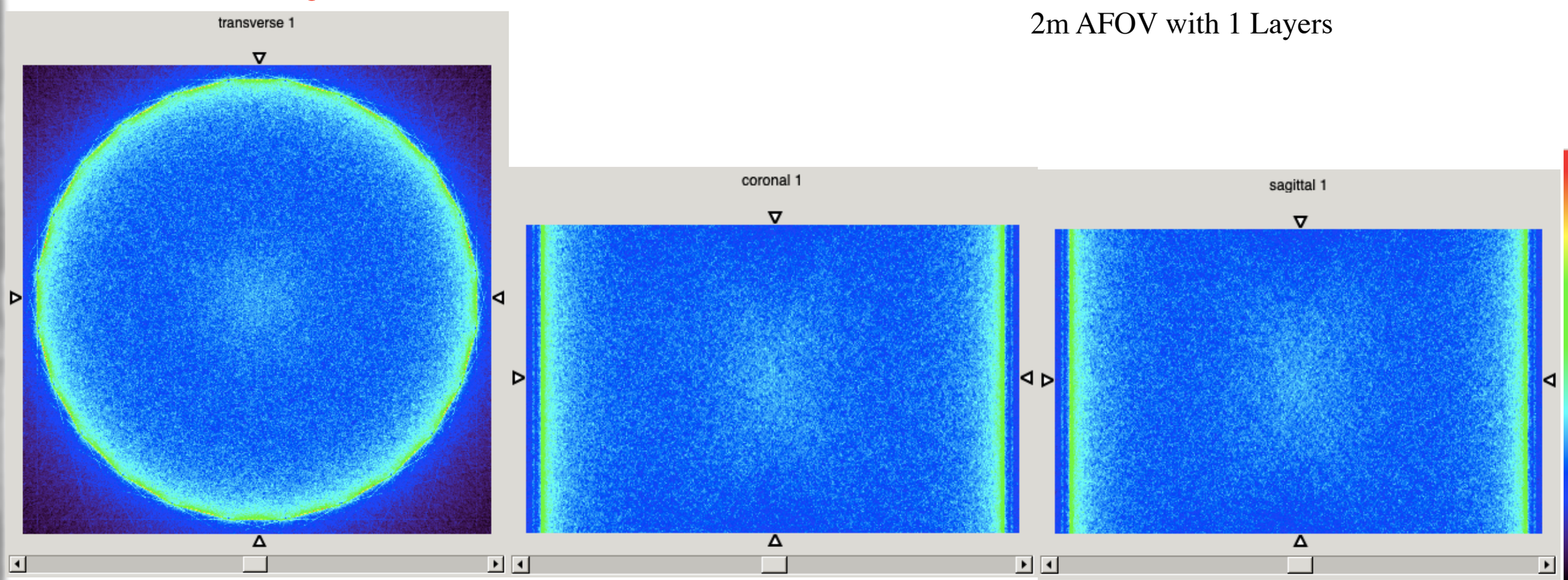

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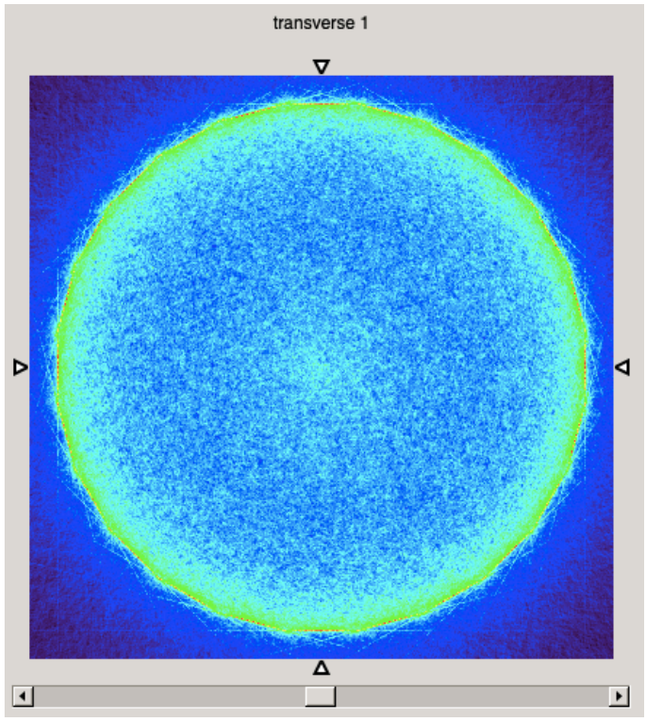
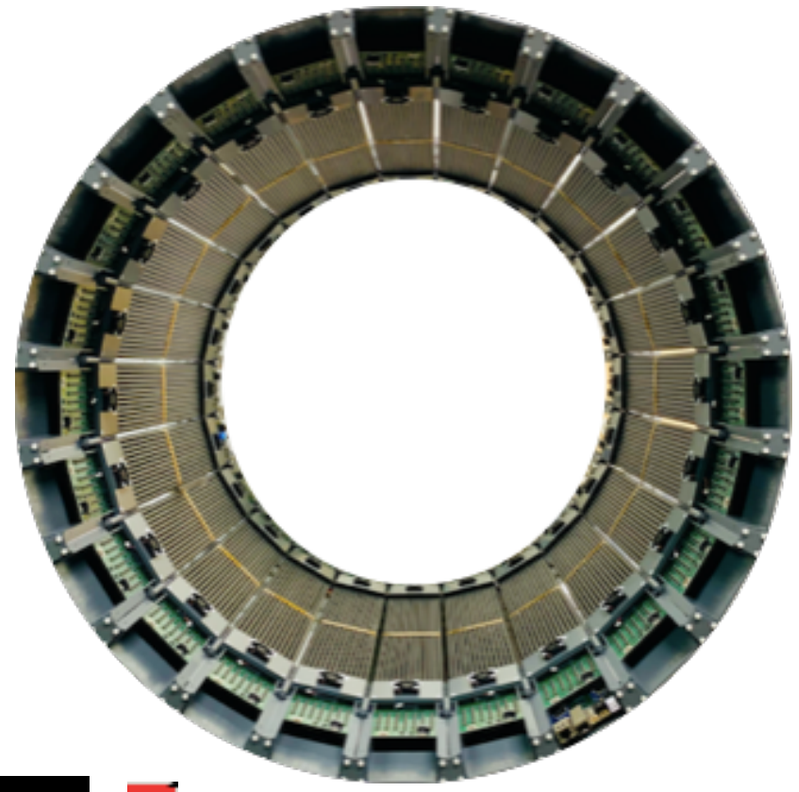
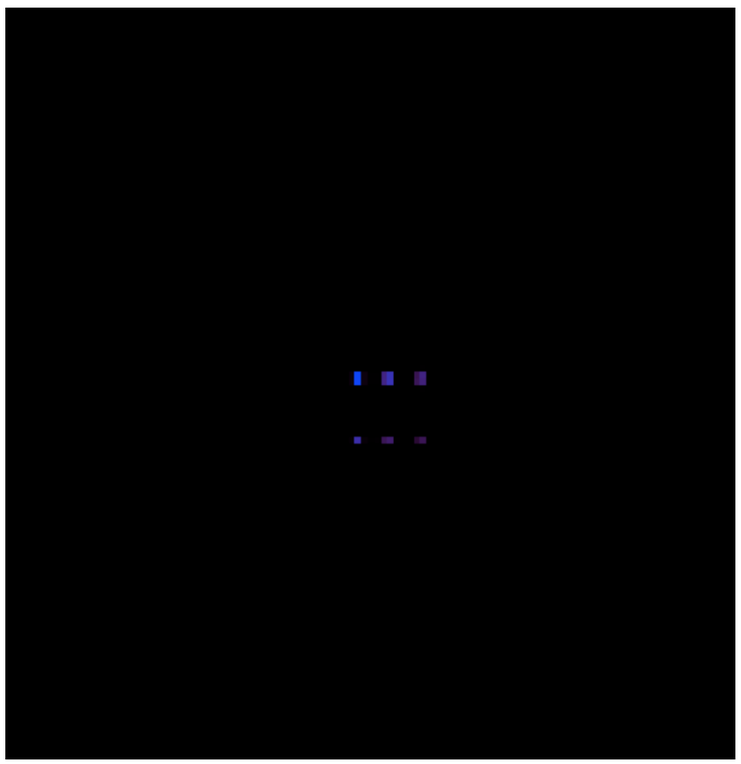
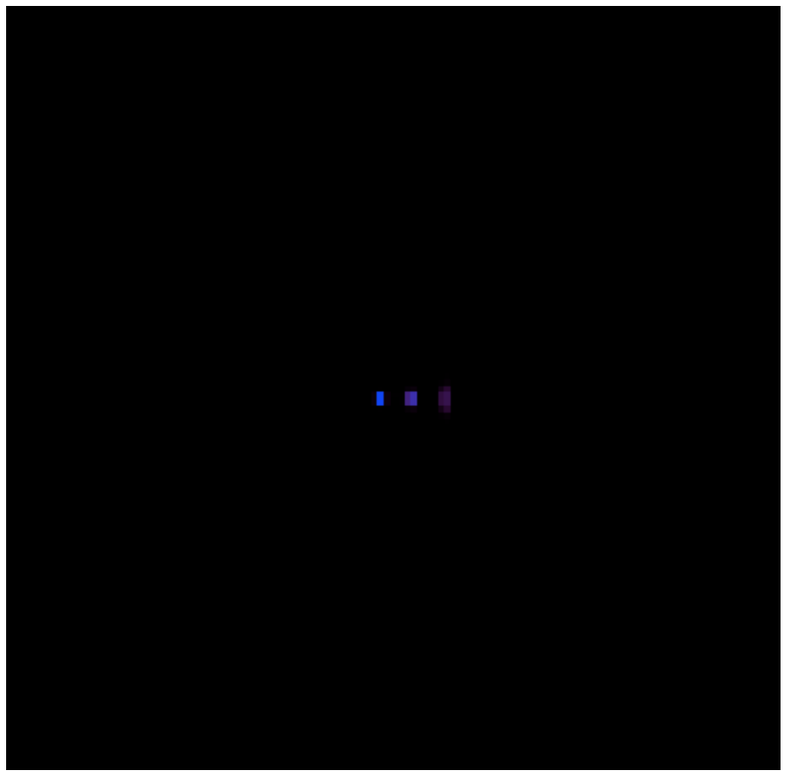
1 Layer 24 Modular J-PET with 50 cm AFOV







Coronal view



Transvers

Preliminary

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Thank you for your attention