Simulating a Co–60 source of an irradiation facility

Afonso Cabrita

Supervisors
Lia Pereira
Pamela Teubig | Carina Coelho

Procedure

1. Familarizing with TOPAS using the Bragg peak
2. Simulating the PRECISA facility @ C2TN/IST
3. Benchmarking the plates used in the protocols

BRAGG PEAK

```
s:Ge/World/Material  = "Vacuum"
d:Ge/World/HLX       = 40.0 cm
d:Ge/World/HLY       = 40.0 cm
d:Ge/World/HLZ       = 40.0 cm
#b:Ge/World/Invisible = "True"

s:Ge/Phantom/Type      = "TsBox"
s:Ge/Phantom/Parent    = "World"
s:Ge/Phantom/Material = "G4_WATER"
d:Ge/Phantom/HLX       = 5.0 cm
d:Ge/Phantom/HLY       = 5.0 cm
d:Ge/Phantom/HLZ       = 20 cm
i:Ge/Phantom/ZBins = 1
#b:Ge/World/Invisible = "True"
d:Ge/Phantom/RotX = 180. deg
############################################################
s:So/Example/Type                      = "Beam"
s:So/Example/Component                 = "BeamPosition"
s:So/Example/BeamParticle              = "proton"
d:So/Example/BeamEnergy                = 190 MeV
u:So/Example/BeamEnergySpread          = 0.757504
s:So/Example/BeamPositionDistribution  = "Flat"
s:So/Example/BeamPositionCutoffShape   = "Rectangle"
d:So/Example/BeamPositionCutoffX       = 0.65 cm
d:So/Example/BeamPositionCutoffY       = 0.65 cm
d:So/Example/BeamPositionSpreadX       = 0.65 cm
d:So/Example/BeamPositionSpreadY       = 0.65 cm
s:So/Example/BeamAngularDistribution   = "None"
sv:So/Example/OnlyIncludeParticlesNamed = 1 "proton"
i:So/Example/NumberOfHistoriesInRun = 100
############################################################
```

Geometry

Beam source

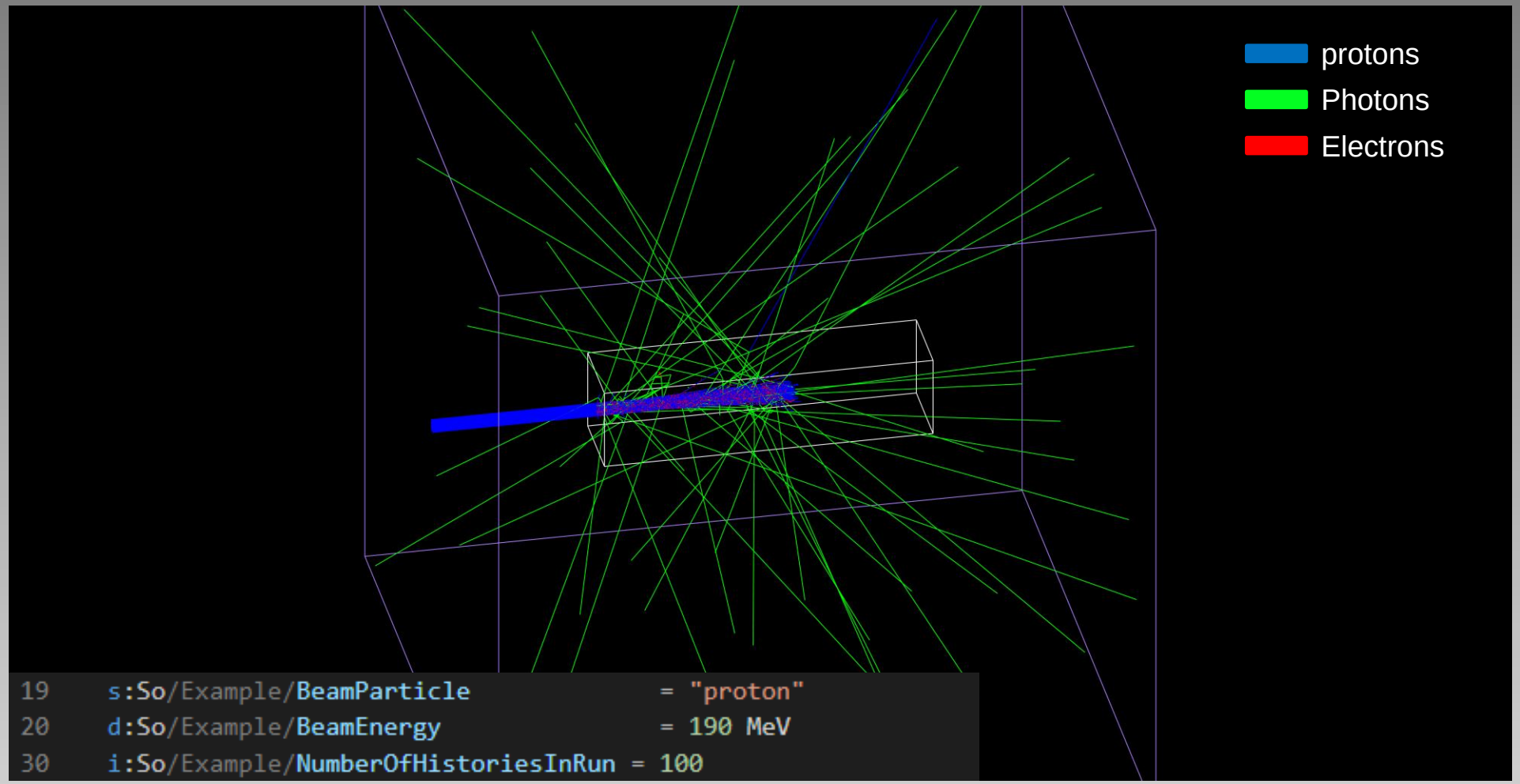


Fig. 01. TOPAS simulation of the bragg peak

Bragg Peak

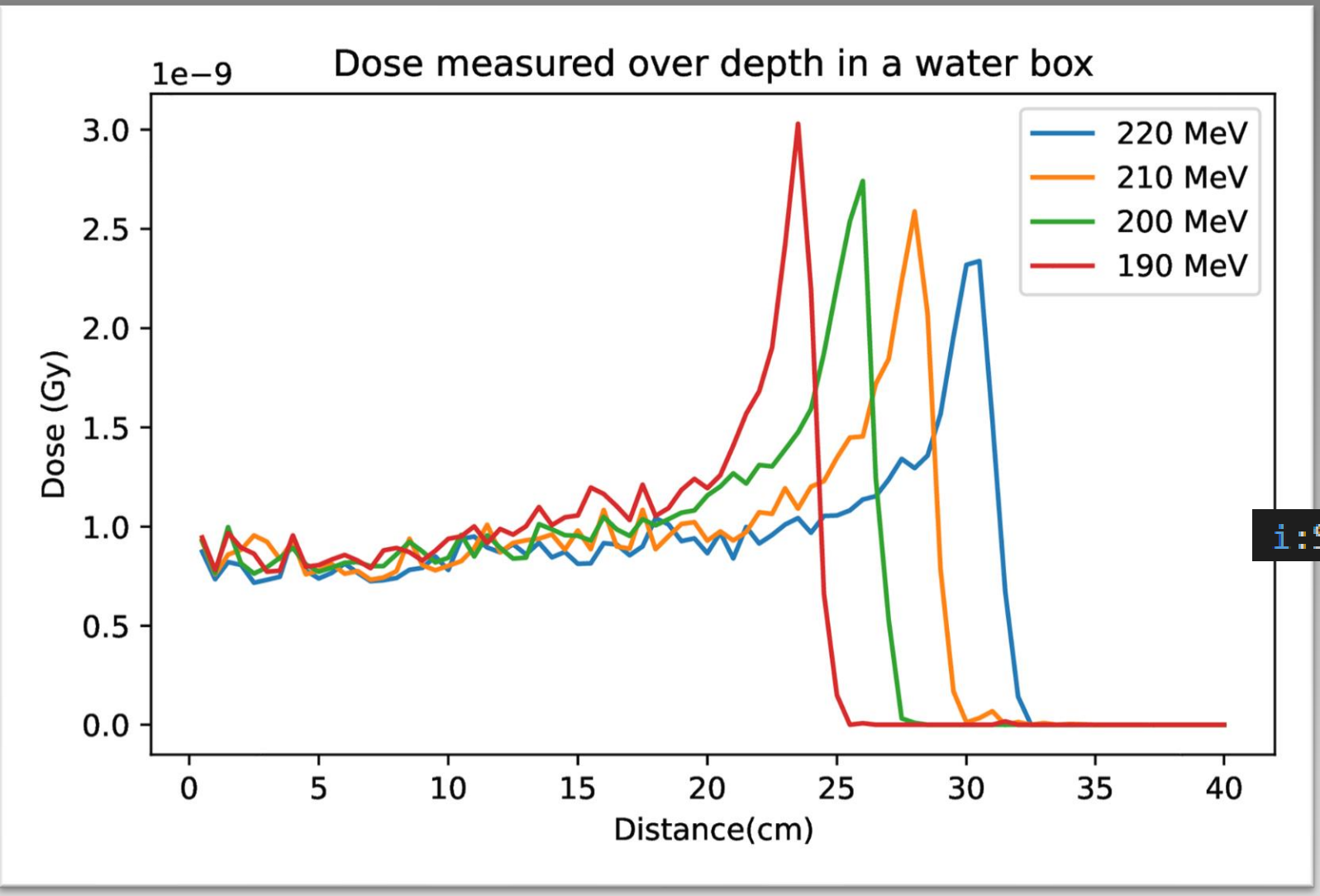


Fig. 02. TOPAS simulation results with different energies

```
i:So/Example/NumberOfHistoriesInRun = 100
```

The PRECISA facility

Fig. 03. a) Lead container where the the sources, plates are located and where the irradiation takes place

The PRECISA facility at C2TN/IST

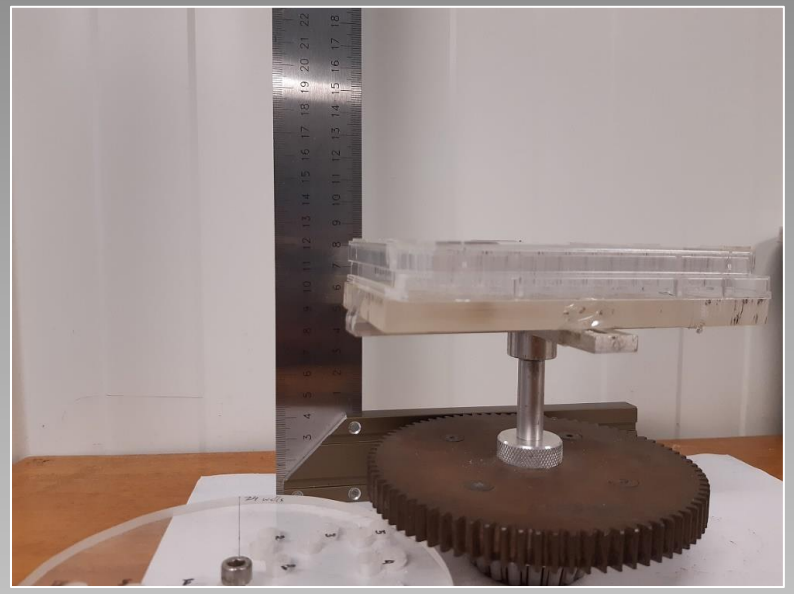
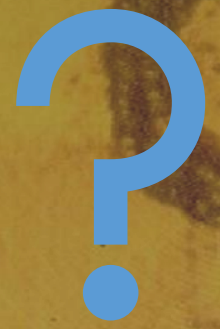


Fig. 03. b) Plate with a rotating disc

Cobalt–60



Why is it used?

How does it decay?

Why use Co−60?

Used as a radiation source in various gamma irradiation cases

Easy and reliable industry backing production

Co–60 Decay

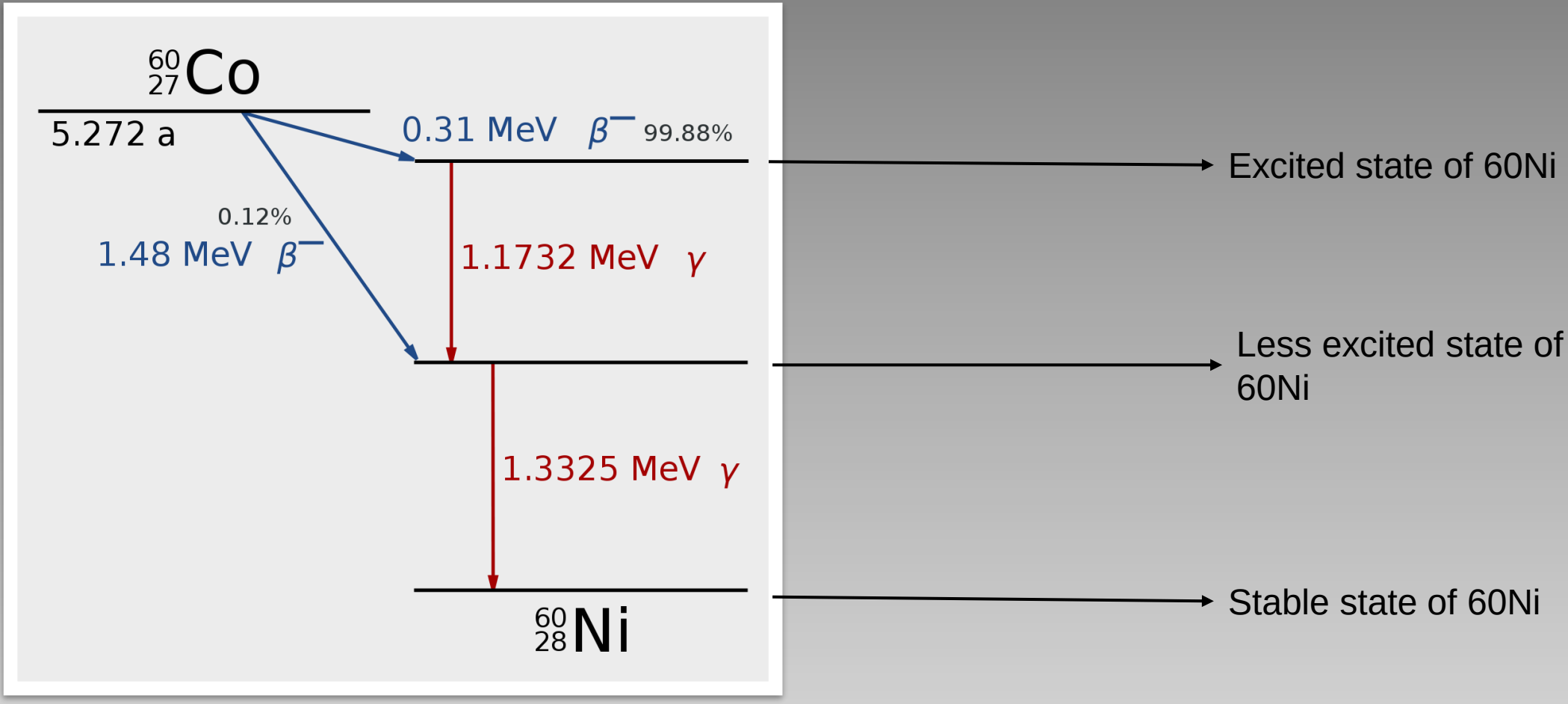


Fig. 04. β- Decay of Co-60

Plate geometry

Plate geometry

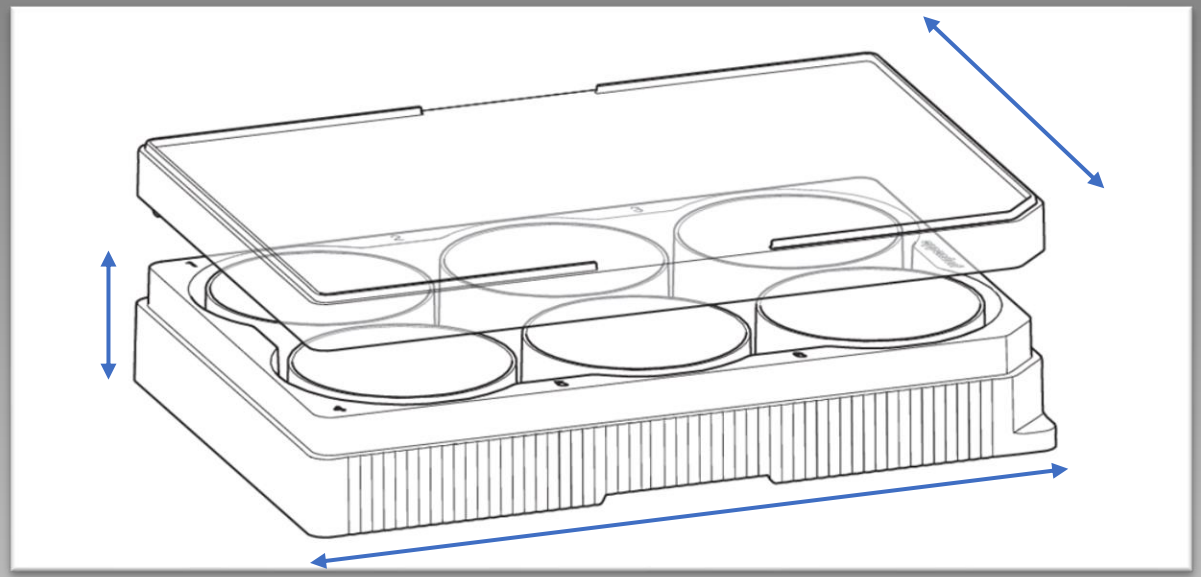


Fig. 05. Eppendorf cell culture plate, consisting of 6 wells

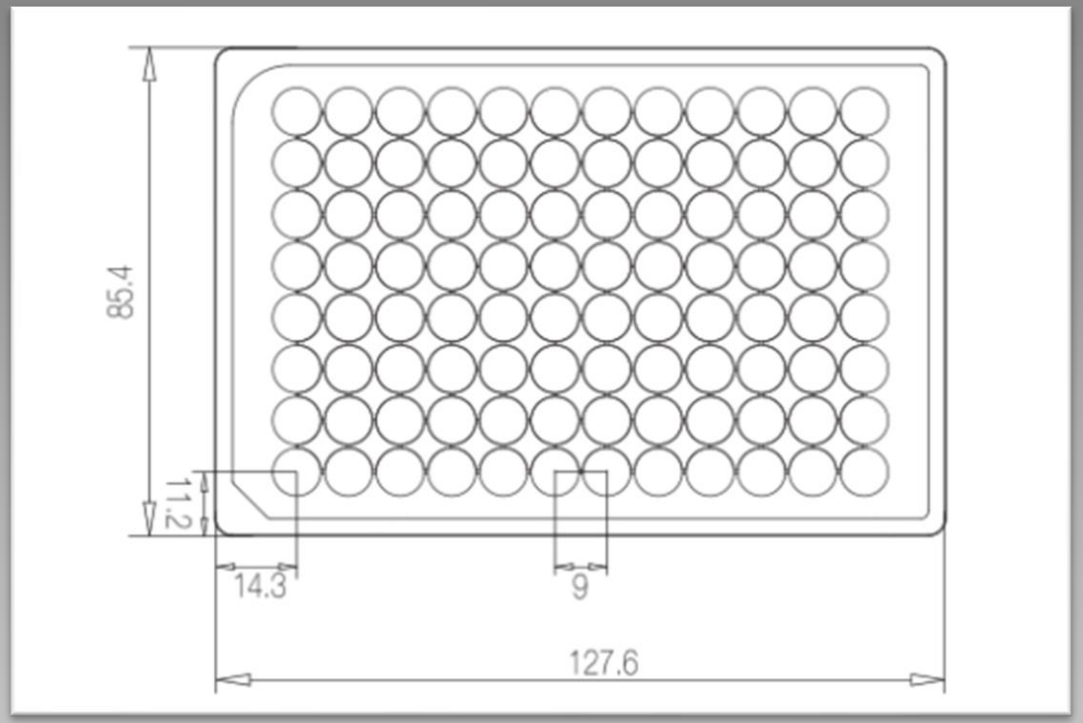


Fig. 07. Cell Culture Plate, 96 wells and their geometry contained in the plate

Ionization chambers

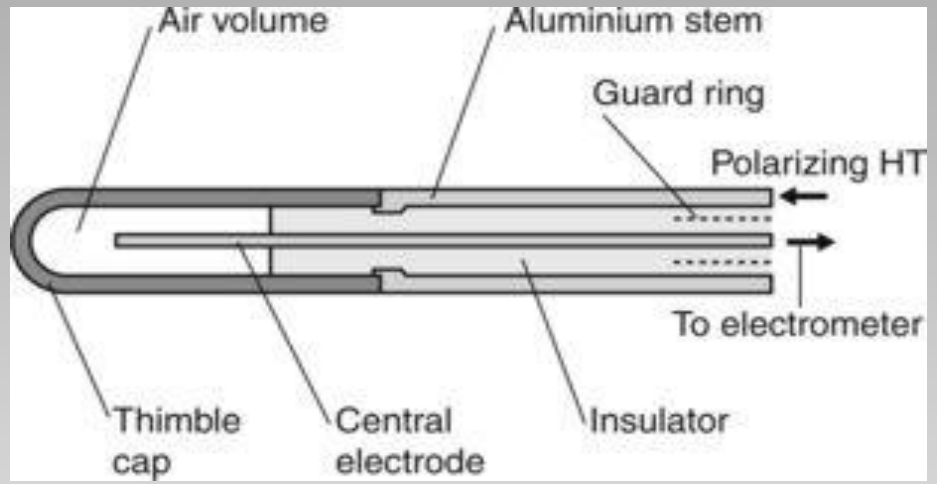
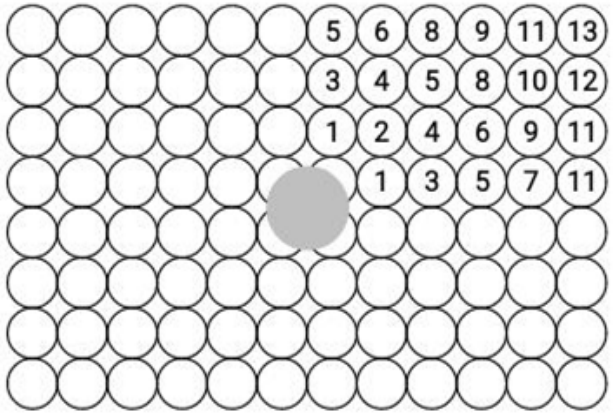


Fig. 09 FC65-P
Ionization Chambers

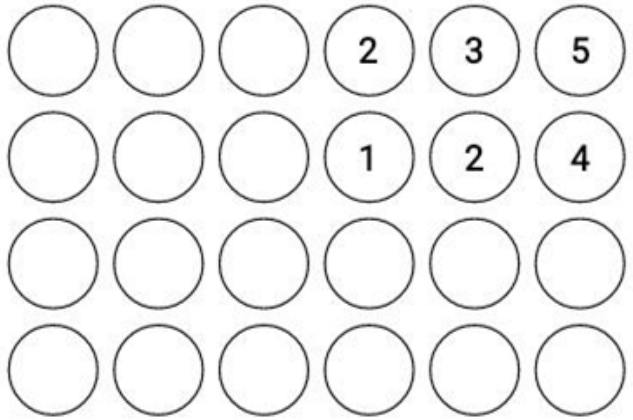
Experimental Data



Dosimetria 11 de Março 2020

Placa	#	DD (Gy/min)
96	1	1,055 ± 0,007
	2	1,033 ± 0,005
	3	1,029 ± 0,004
	4	1,020 ± 0,006
	5	1,008 ± 0,003
	6	0,996 ± 0,009
	7	0,979 ± 0,001
	8	0,990 ± 0,003
	9	0,977 ± 0,008
	10	0,972 ± 0,003
	11	0,968 ± 0,002
	12	0,961 ± 0,007
	13	0,9575 ± 0,0005

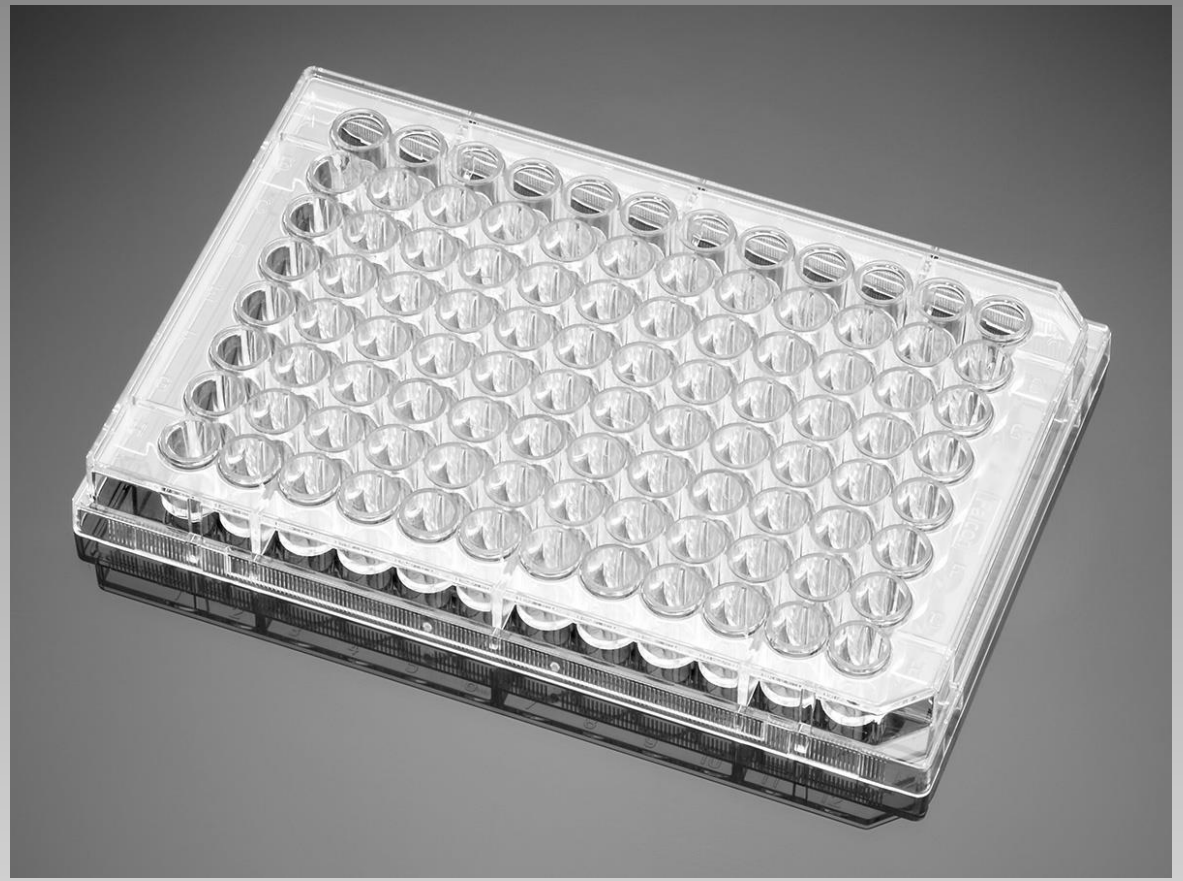
Placa	#	DD (Gy/min)
24	1	1,050 ± 0,002
	2	1,016 ± 0,005
	3	0,988 ± 0,007
	4	0,980 ± 0,003
	5	0,964 ± 0,003

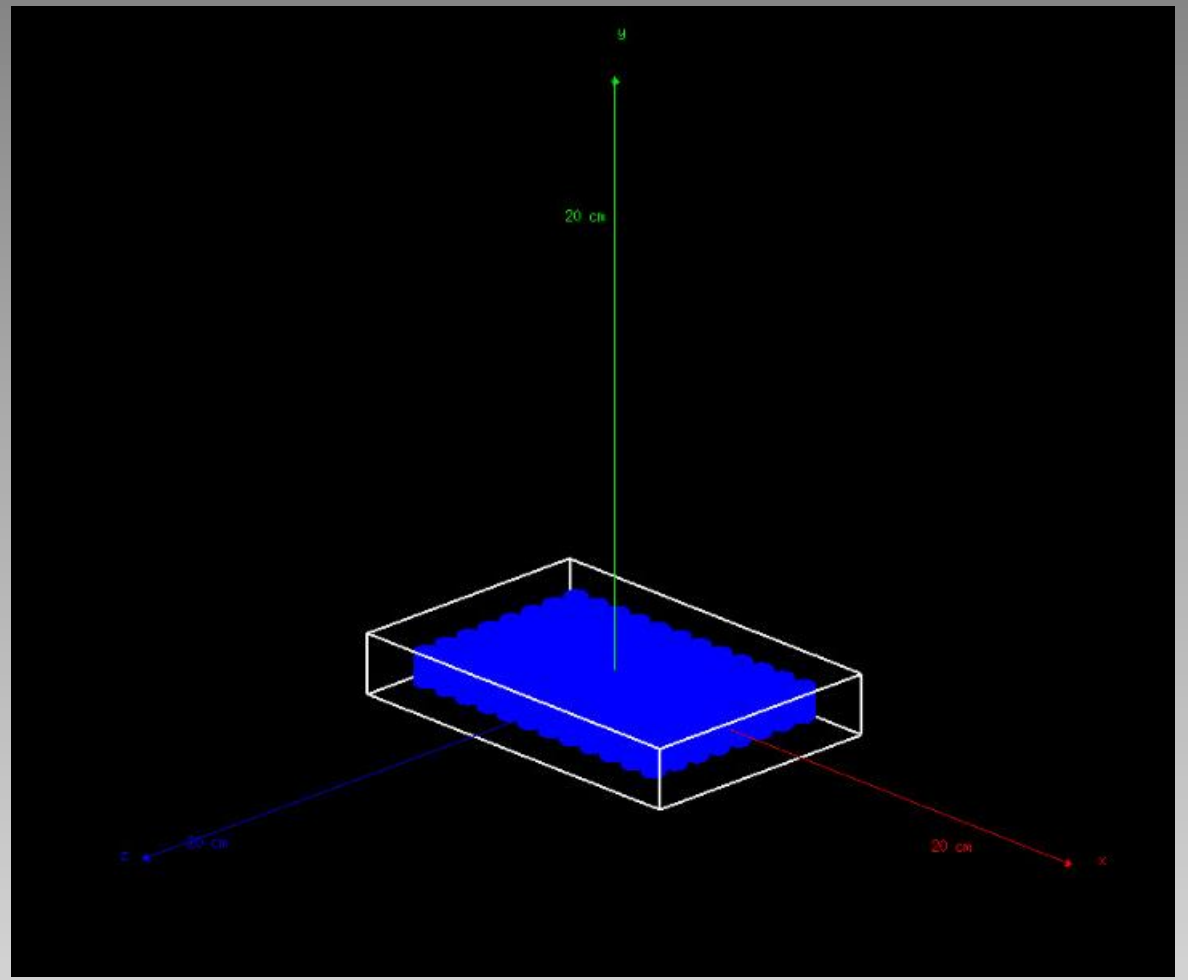


PhD. Pedro Santos

The simulation

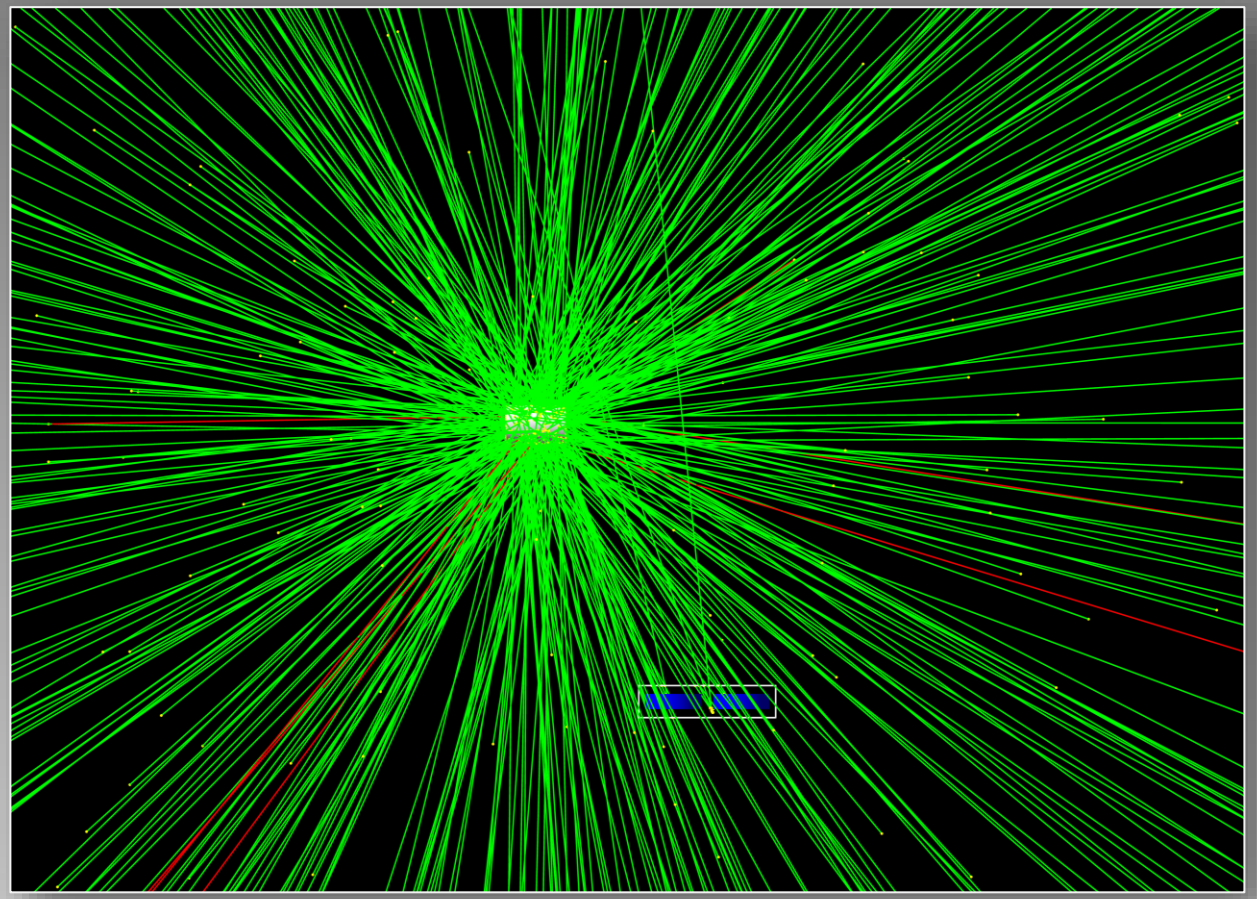
Simulating the container





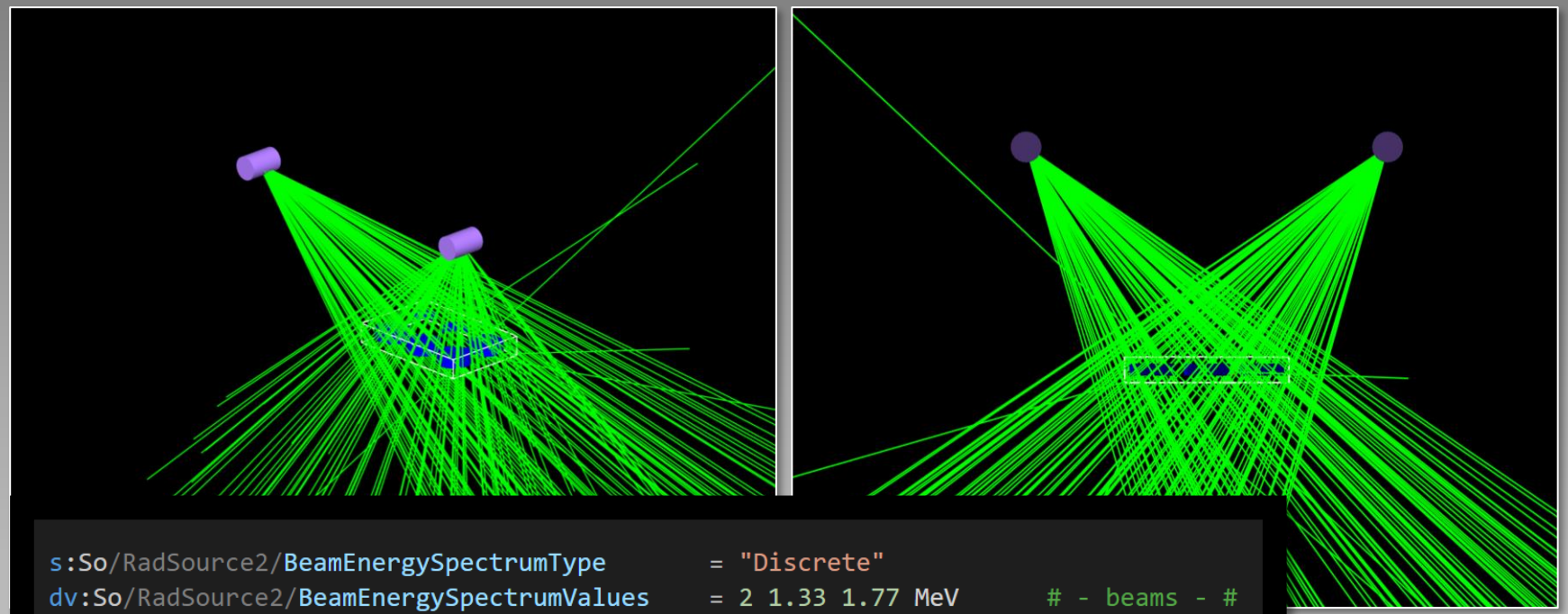
Simulating the sources

Volumetric sources



- Needless computational processing

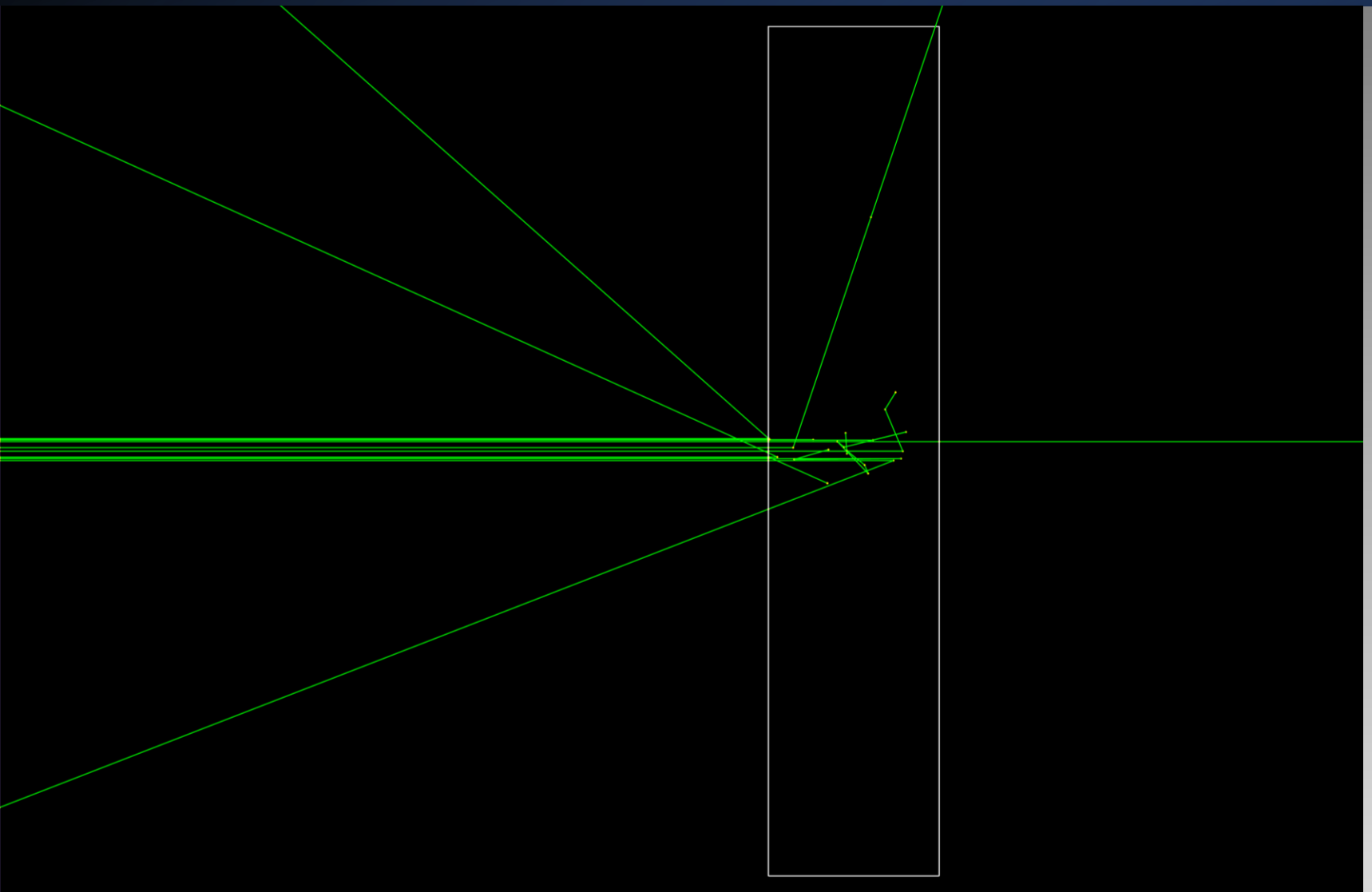
Restricting the angle



```
s:So/RadSource2/BeamEnergySpectrumType       = "Discrete"
dv:So/RadSource2/BeamEnergySpectrumValues    = 2 1.33 1.77 MeV      # - beams - #
uv:So/RadSource2/BeamEnergySpectrumWeights   = 2 0.5 0.5
s:So/RadSource2/Type = "Beam"
s:So/RadSource2/Component = "BeamPosition"
s:So/RadSource2/BeamParticle = "gamma"
s:So/RadSource2/BeamPositionDistribution = "None"
s:So/RadSource2/BeamAngularDistribution = "Flat"
d:So/RadSource2/BeamAngularCutoffX = 20. deg
d:So/RadSource2/BeamAngularCutoffY = 20. deg
i:So/RadSource2/NumberOfHistoriesInRun = 100000000
```

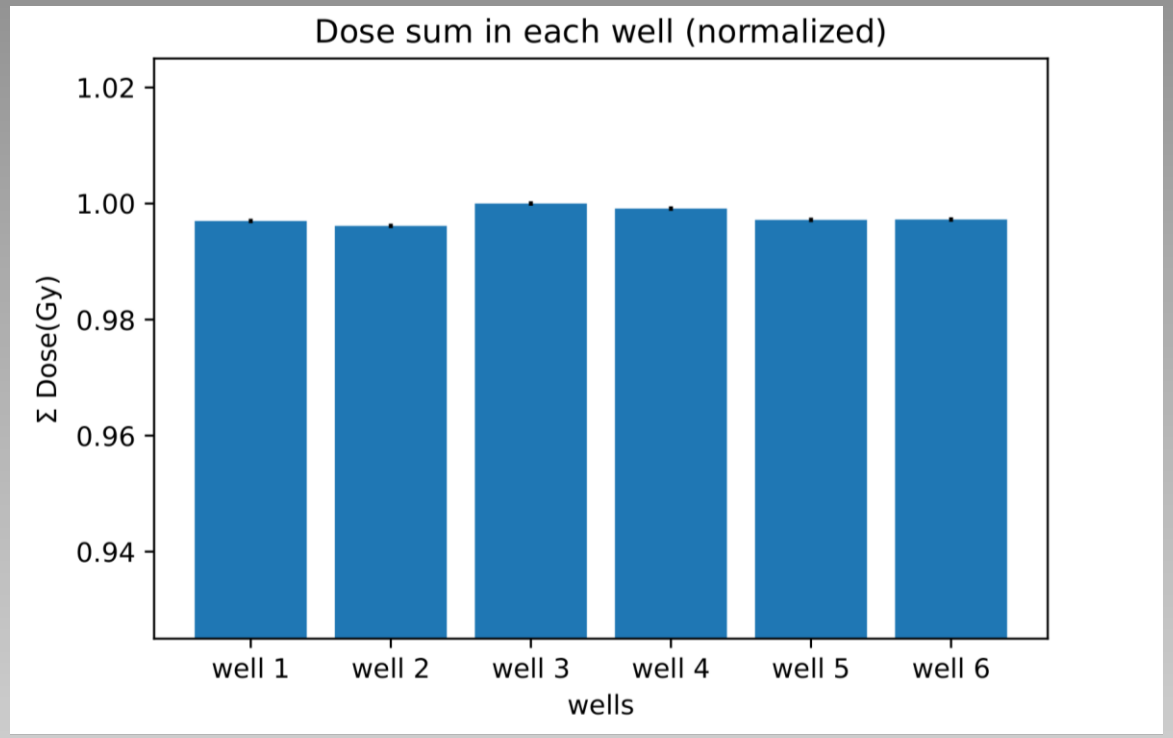
- Saving time by angle restriction

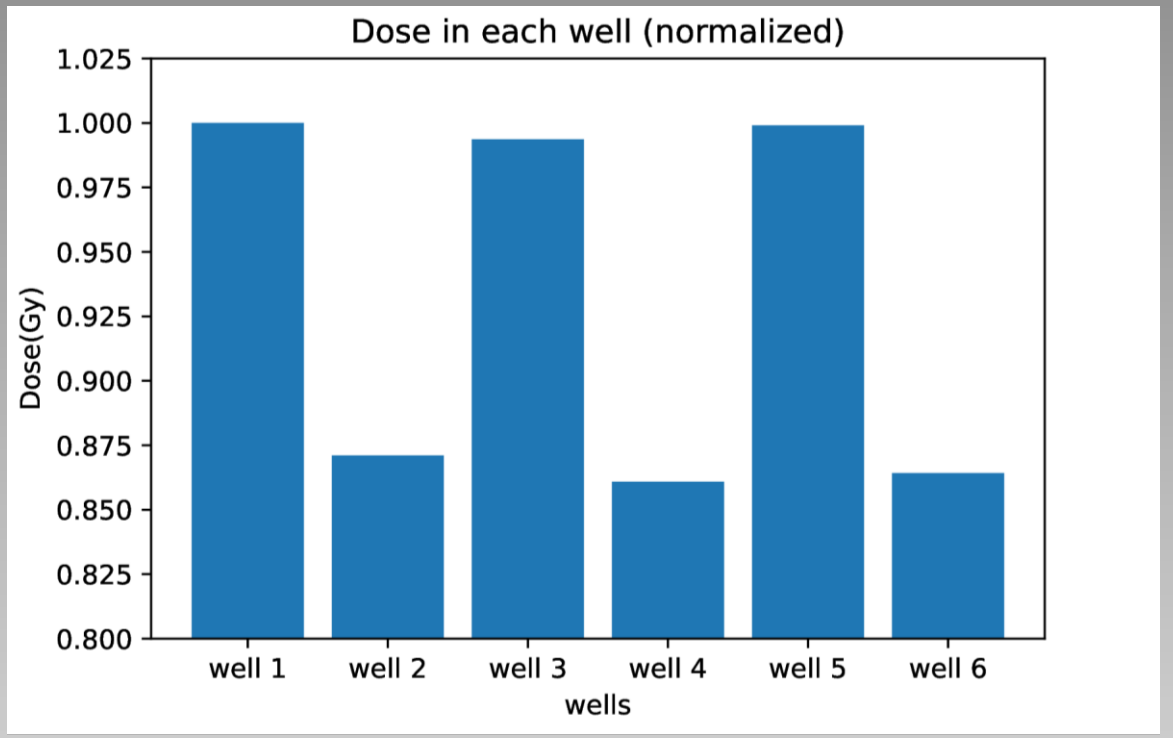
Simulation results



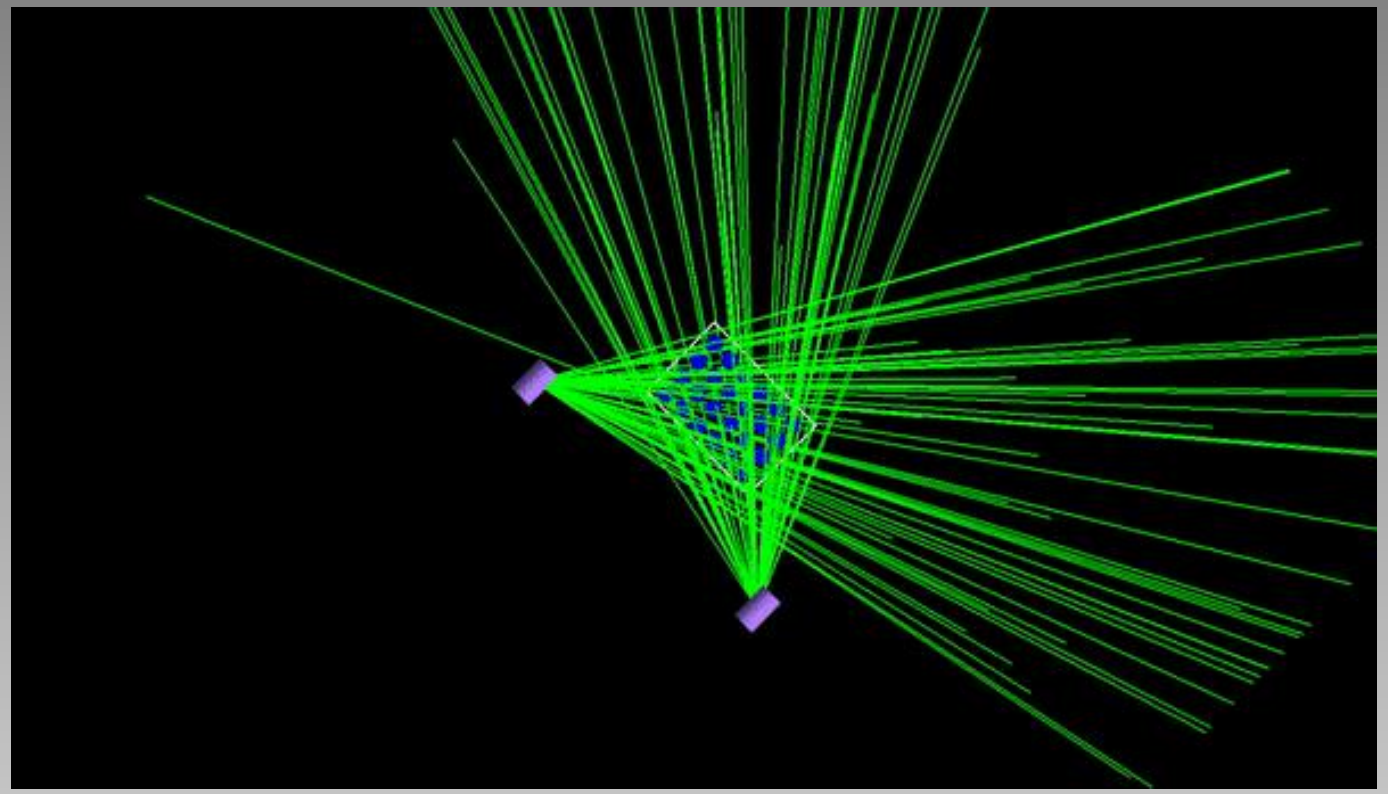
```
s:Sc/DoseAtPhantomProf/Quantity = "DoseToMedium"
s:Sc/DoseAtPhantomProf/Component = "Phantom"
s:Sc/DoseAtPhantomProf/IfOutputFileAlreadyExists = "Increment"
```

Why the need of rotation



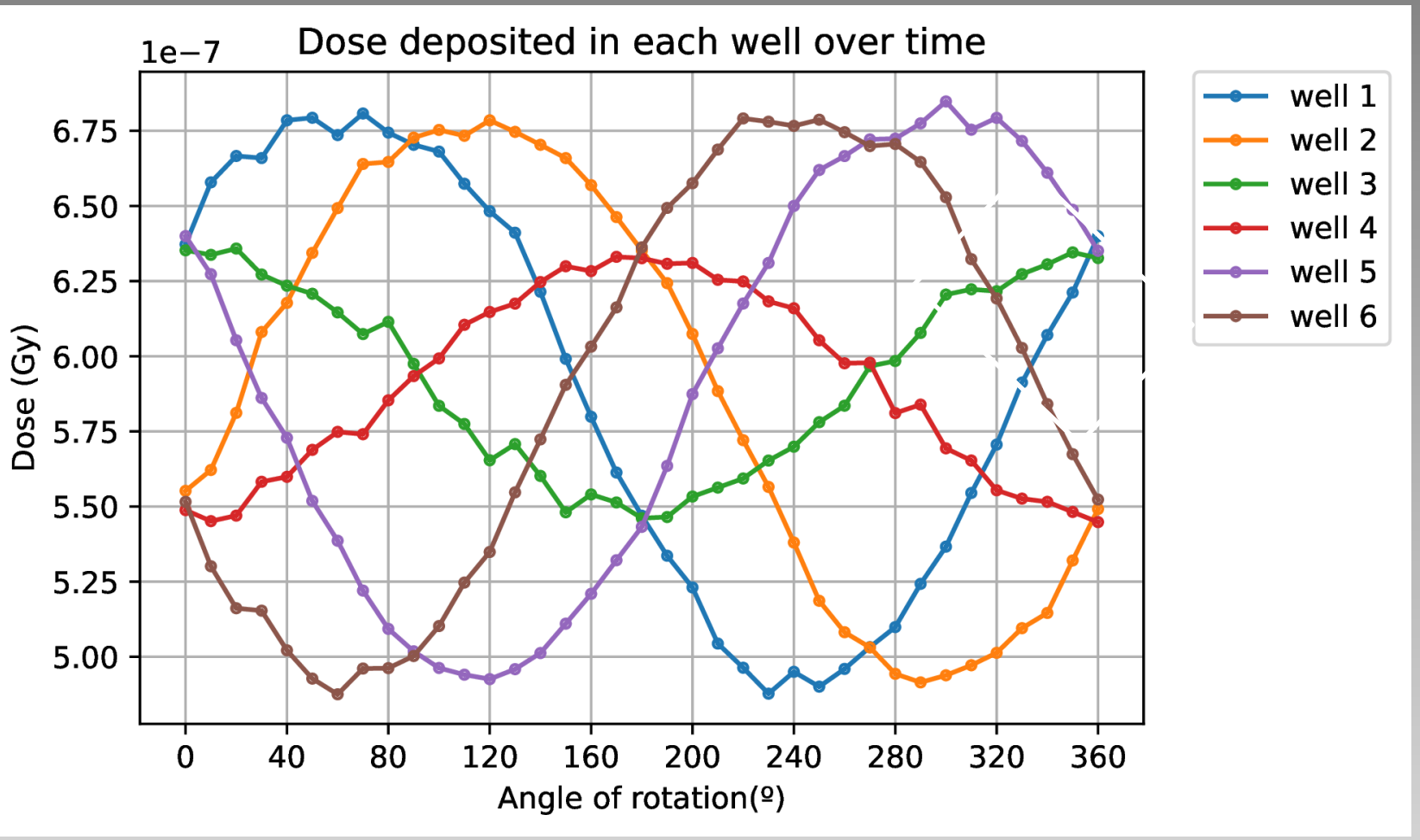


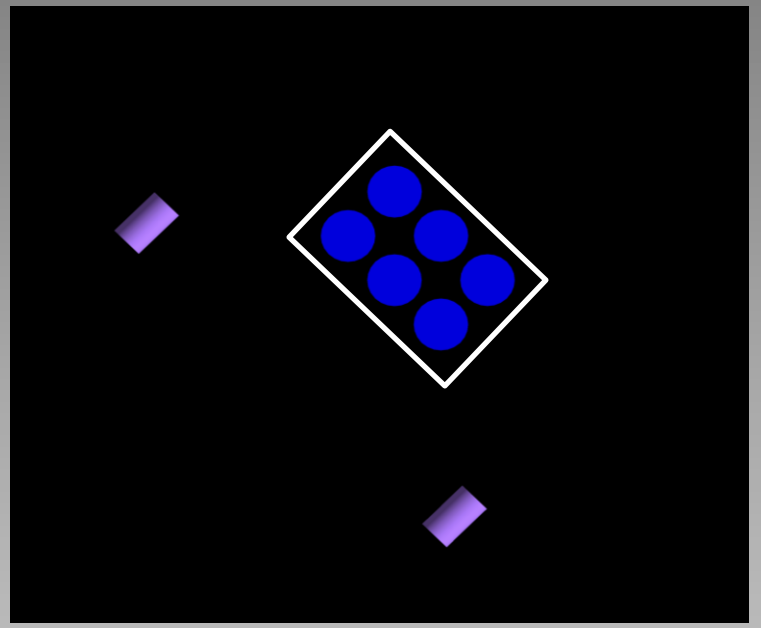
Actual situation at PRECISA

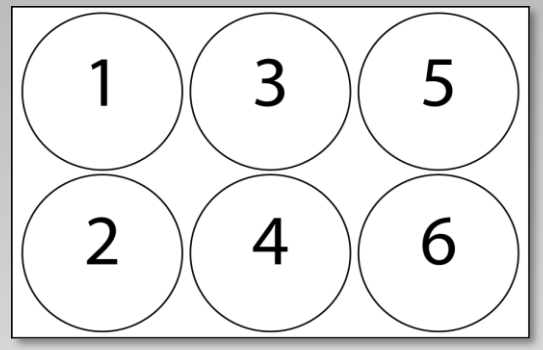


TOPAS simulation with a rotating plate

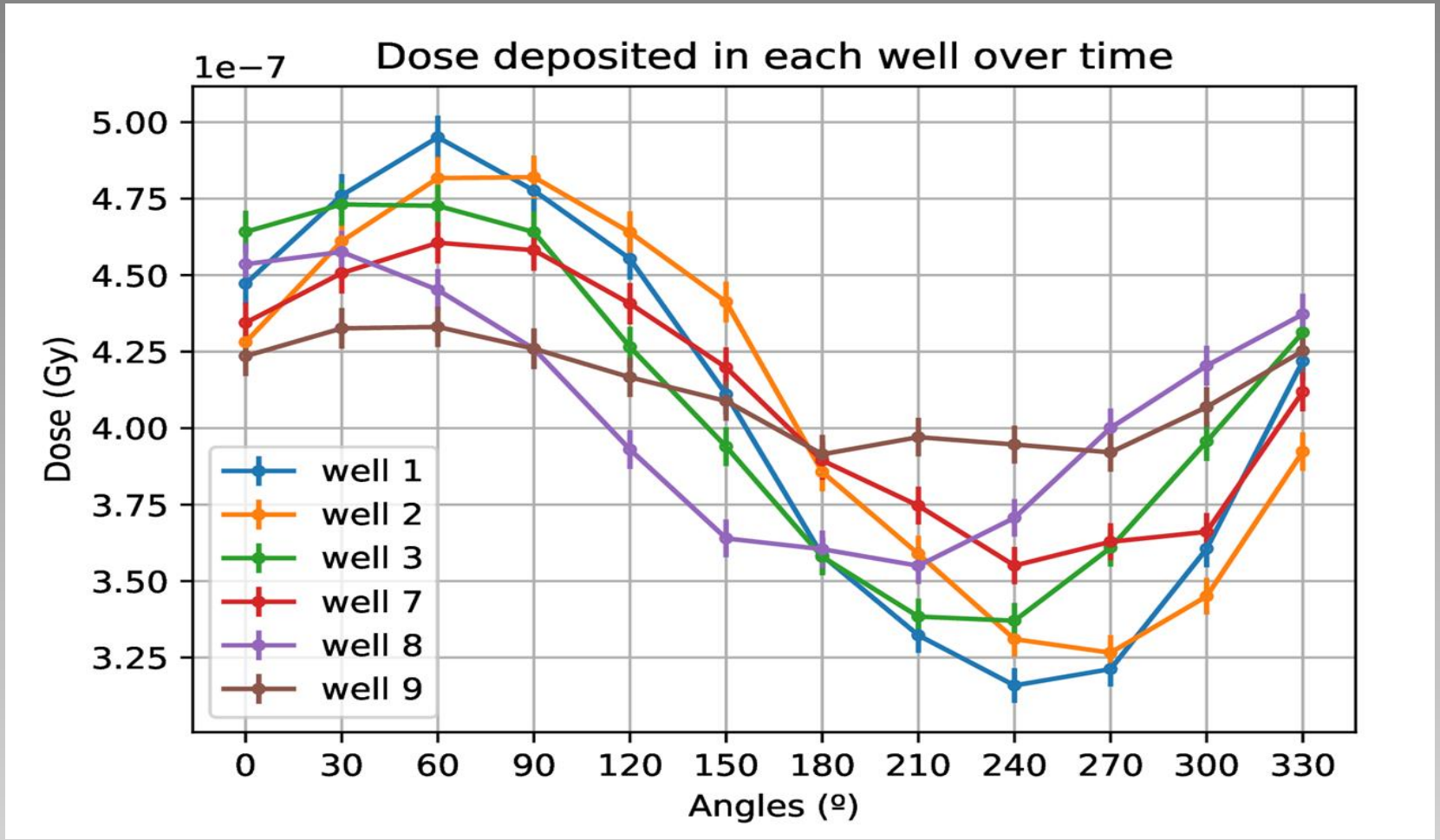
6 well plate

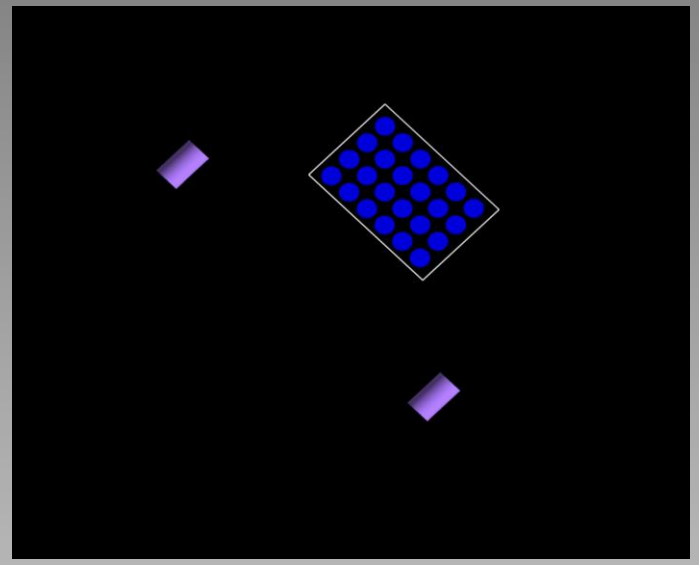

Dose deposited in each well over time
1e−7
6.75
6.50
6.25
6.00
5.75
5.50
5.25
5.00
Dose (Gy)
0
40
80
120
160
200
240
280
320
360
Angle of rotation(º)
well 1
well 2
well 3
well 4
well 5
well 6

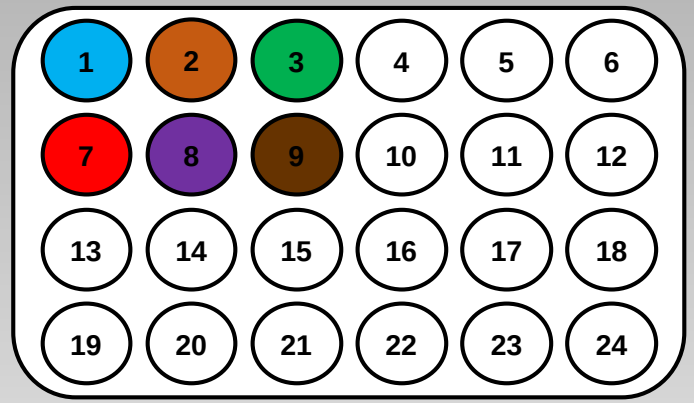



1
3
5
2
4
6

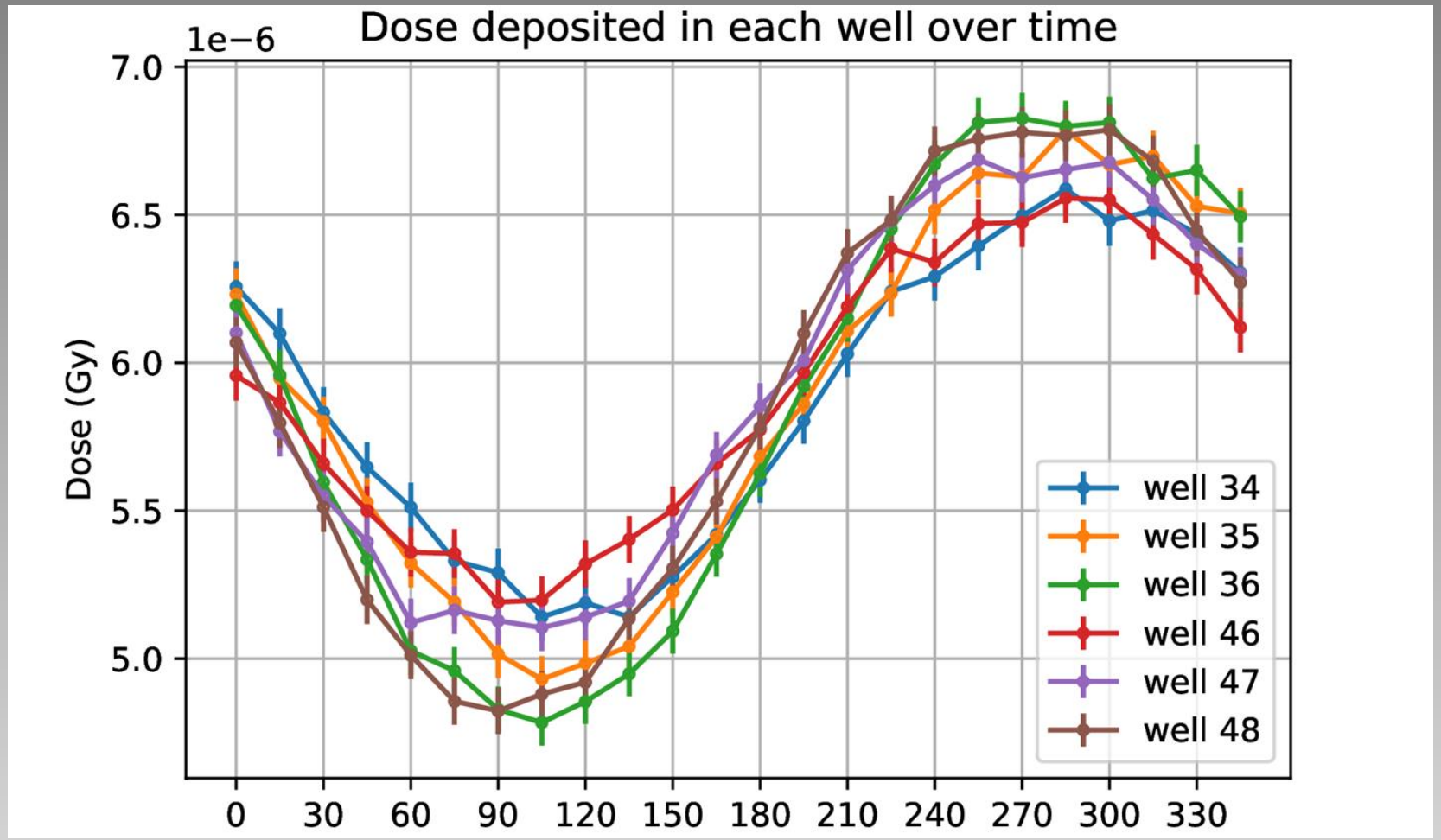
24 well plate

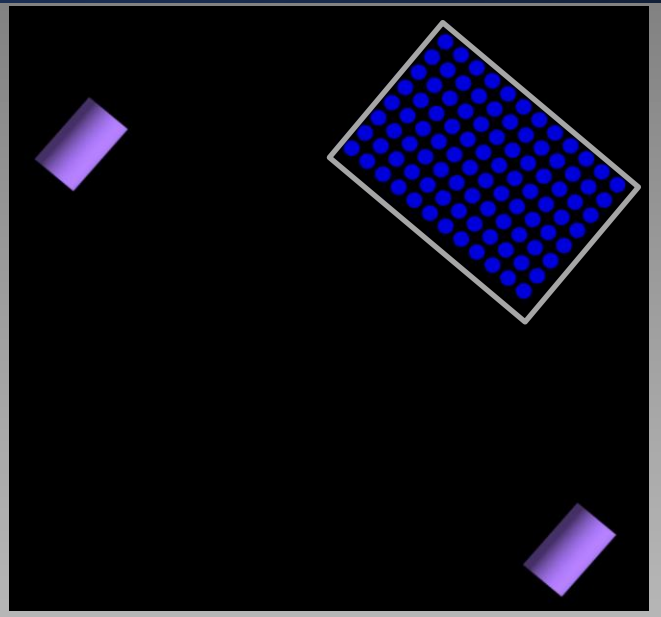


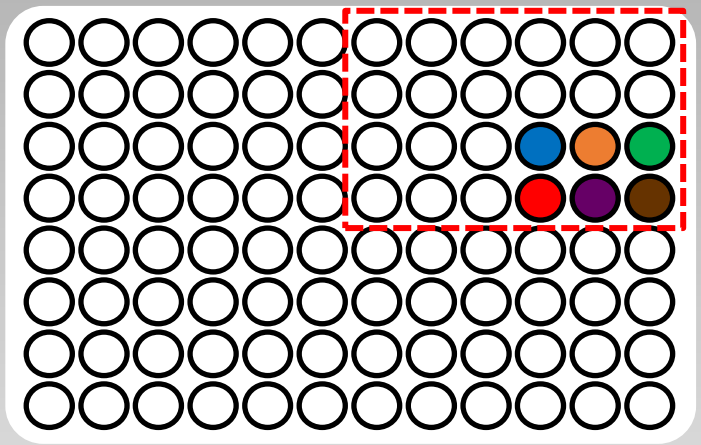




96 well plate

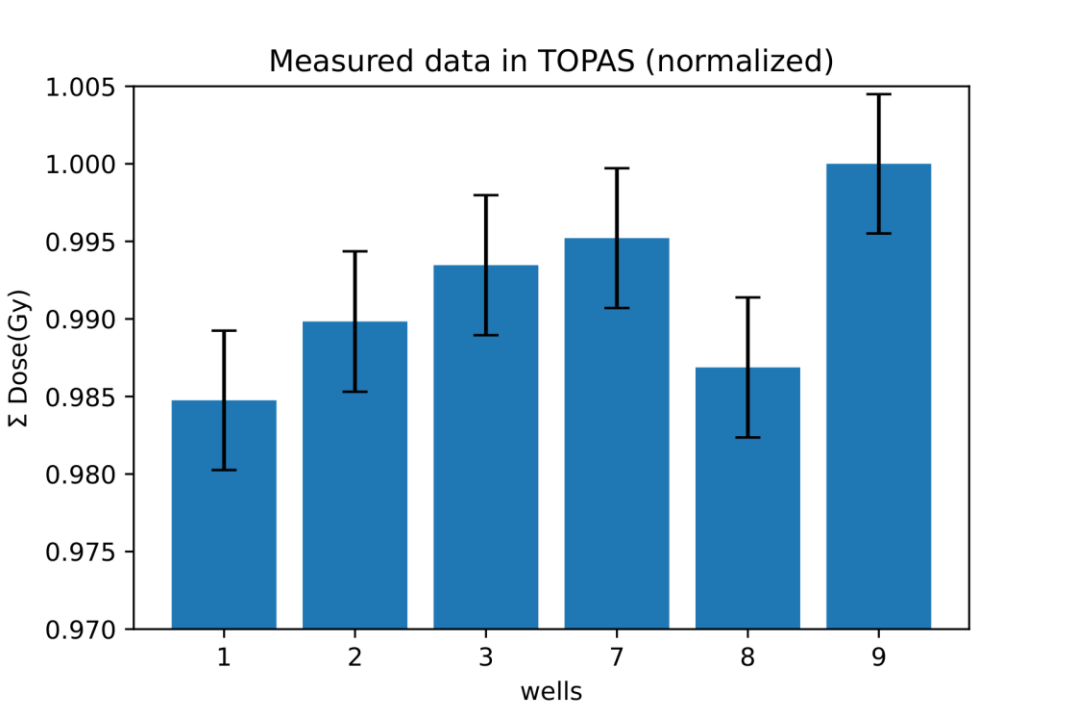


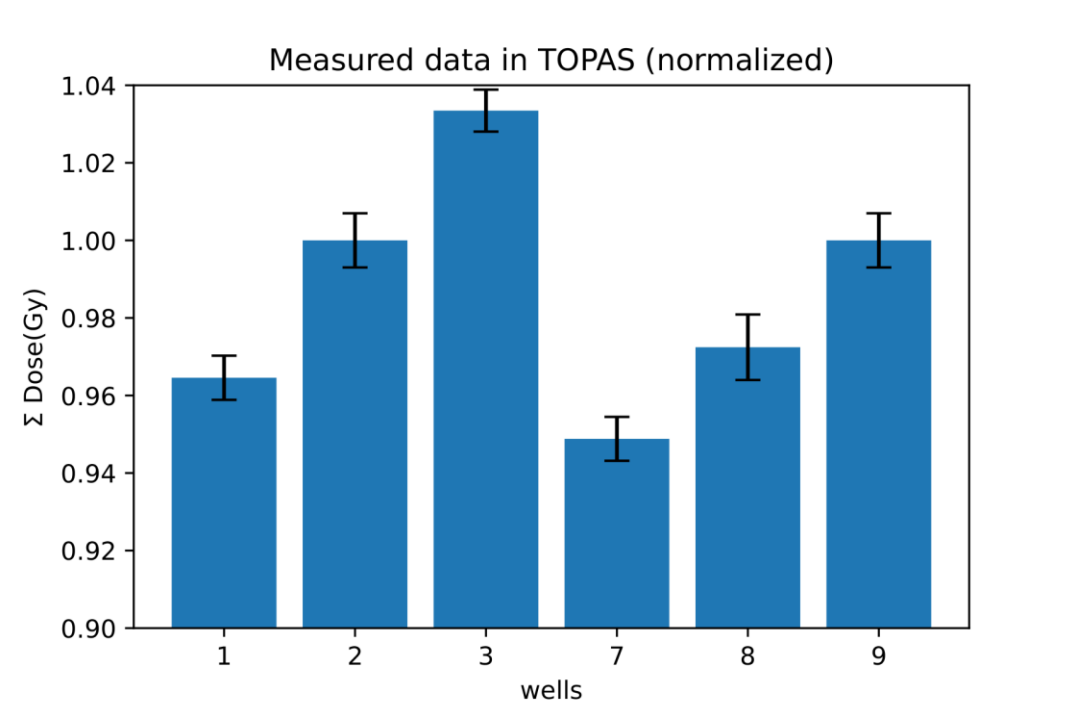




Dose sum in wells

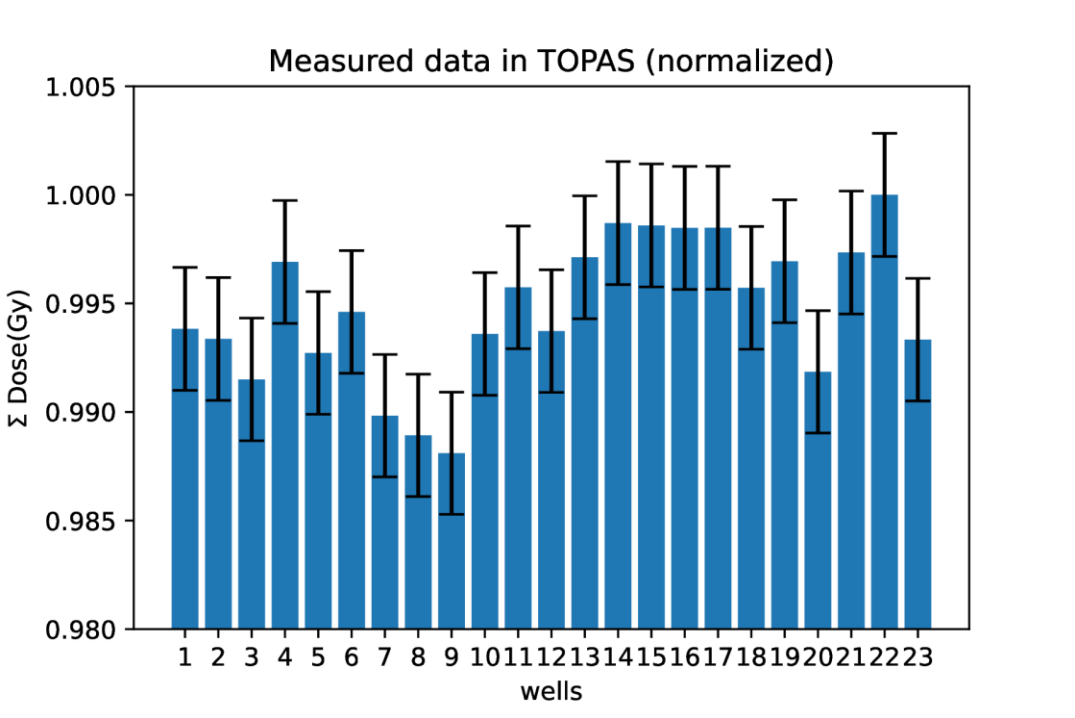
24 wells

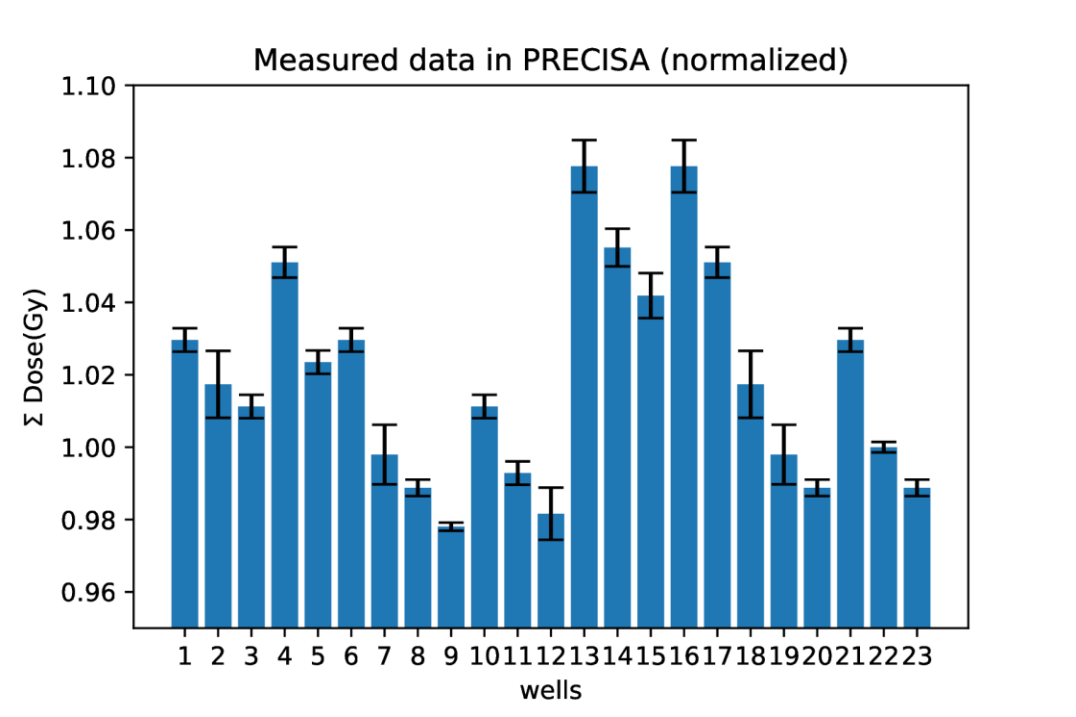




Dose sum in wells

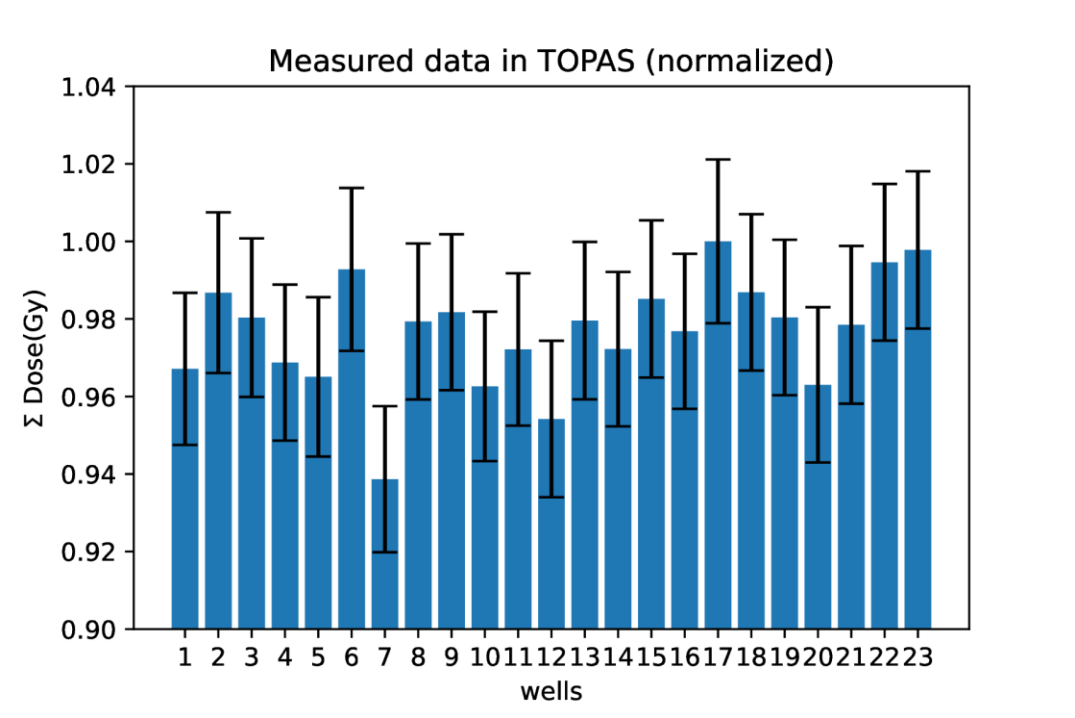
96 wells

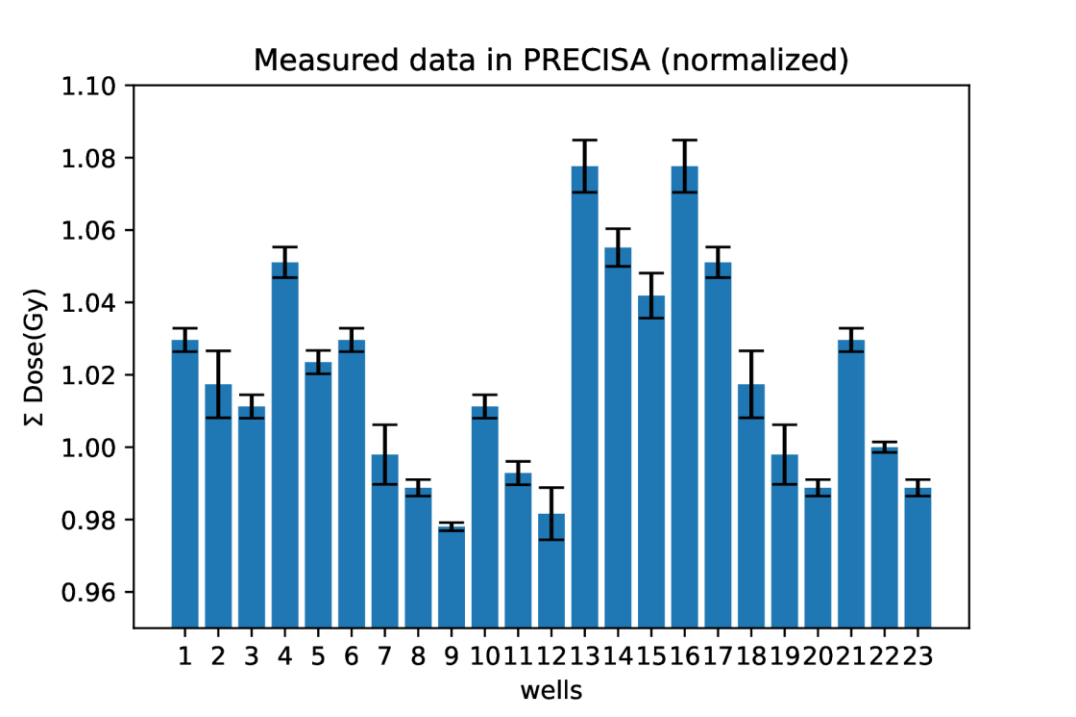




Dose sum in wells

96 (Air) wells





Conclusions

Recency of TOPAS?

Incomplete geometry?

Beam`s characteristics

Reliable