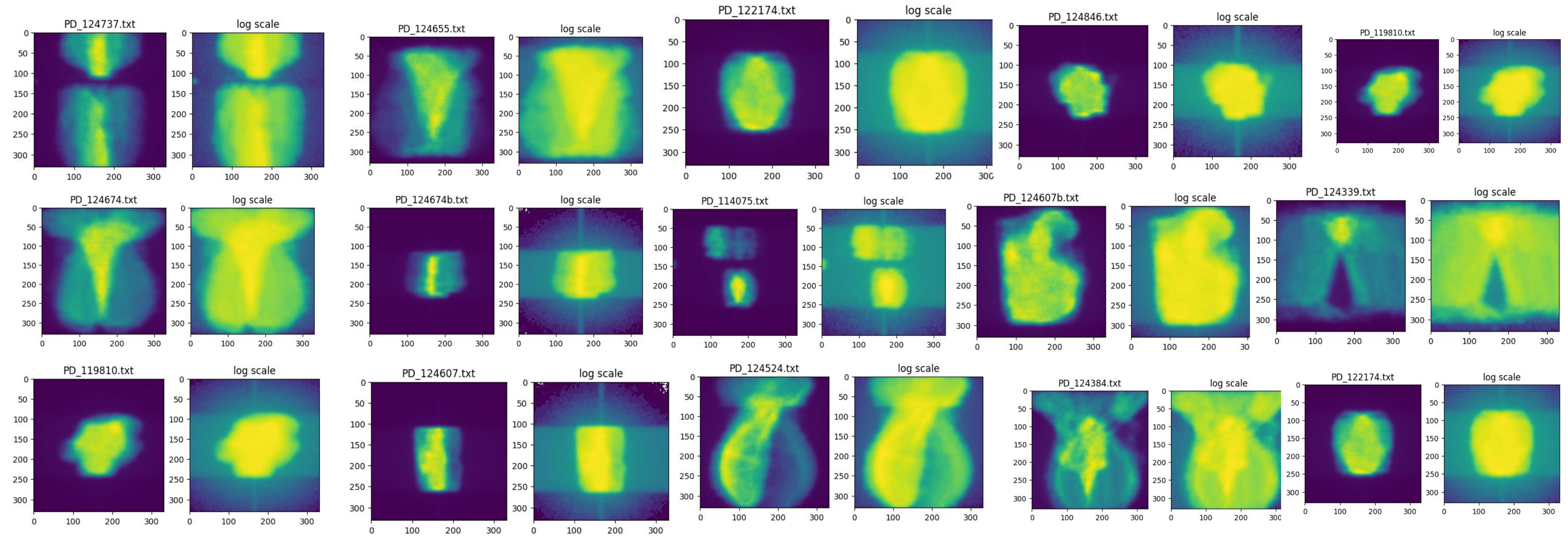
InTrEPID

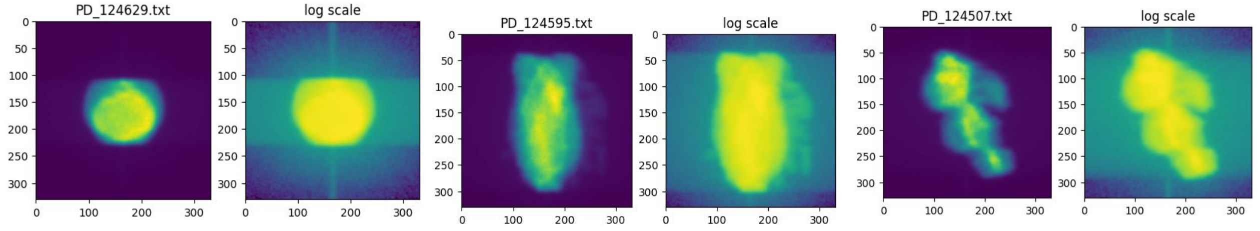
General meeting, Firenze, 07/10/2025

Update

lorenzo.marini@phd.unipi.it

2D: 18 nuovi casi (EPID-PD) per l’addestramento



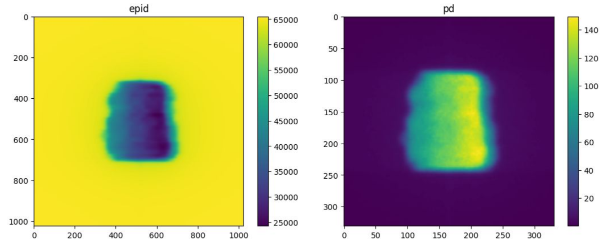


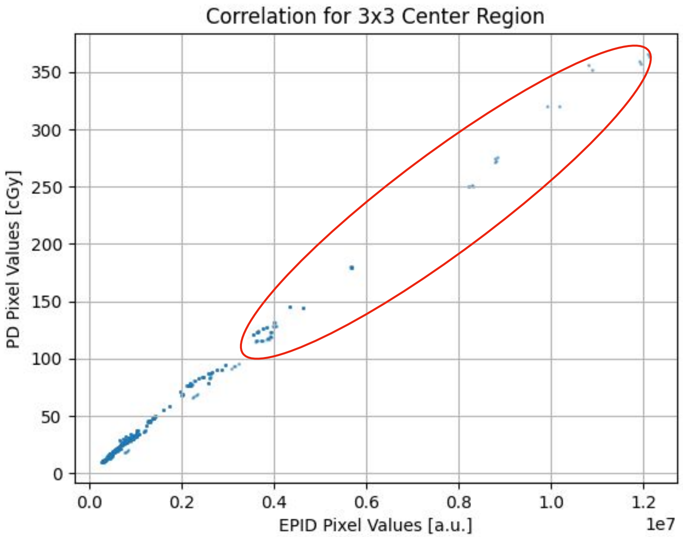

```
print(f"Numero di immagini EPID: {len(epid_images)}")
print(f"Numero di immagini PD: {len(pd_images)}")
#print(len(epid_filenames_list))
#print(len(pd_filenames_list))
```

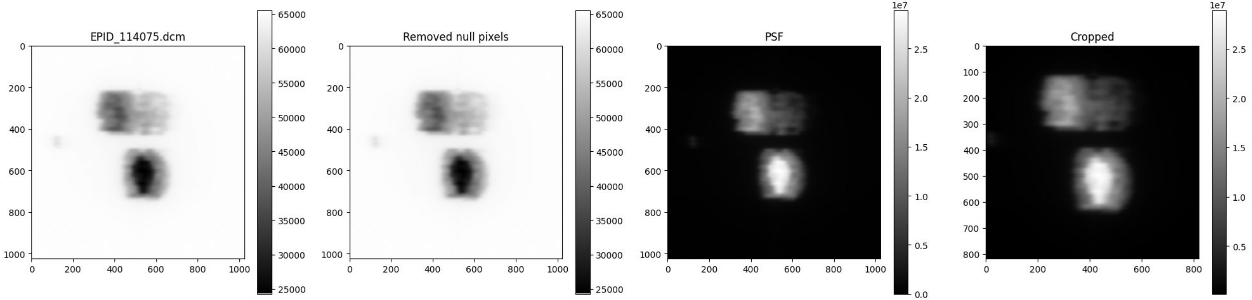
```
Numero di immagini EPID: 264
Numero di immagini PD: 264
```

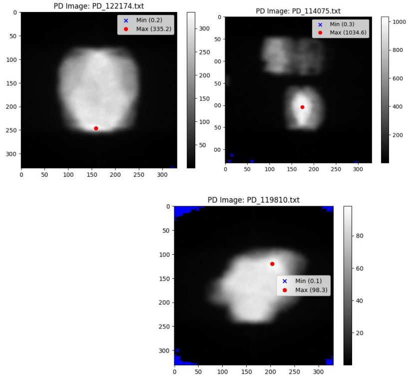
2D: 18 nuovi casi (EPID-PD) per l'addestramento

```
EPID min value: 0, file: EPID_6s10_100MU_1.dcm
EPID max value: 65535, file: EPID_114075.dcm
PSF min value: 0.00142706, file: EPID_114075.dcm
PSF max value: 0.15469, file: EPID_6s30b3_100MU_6.dcm
PD min value: 0.0, file: PD_124607.txt
PD max value: 1034.6, file: PD_114075.txt
```



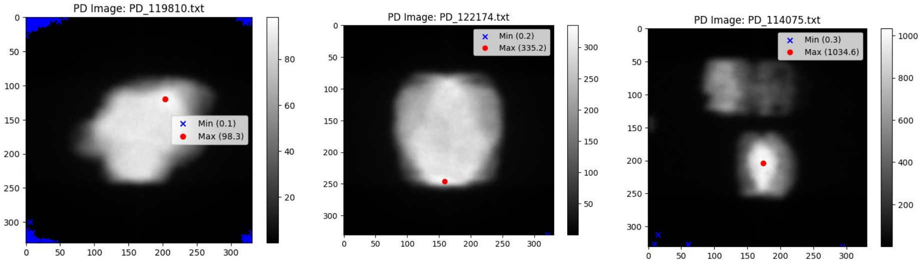


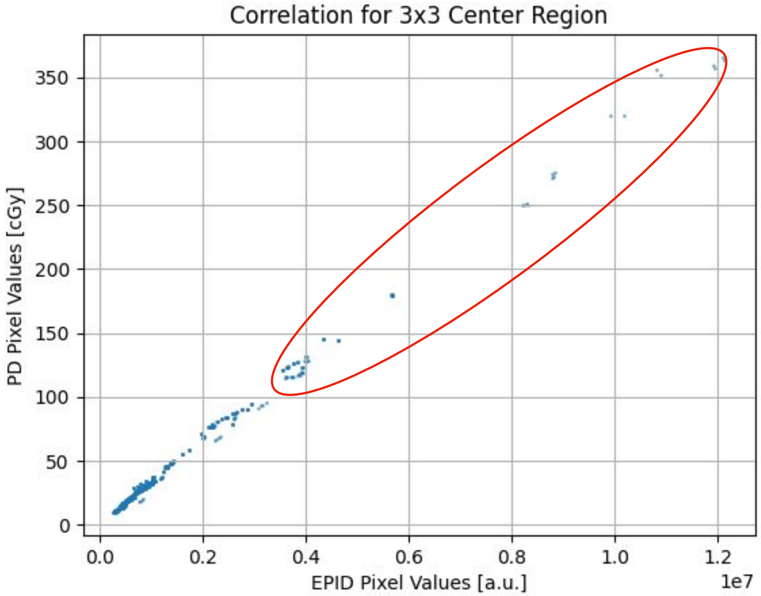


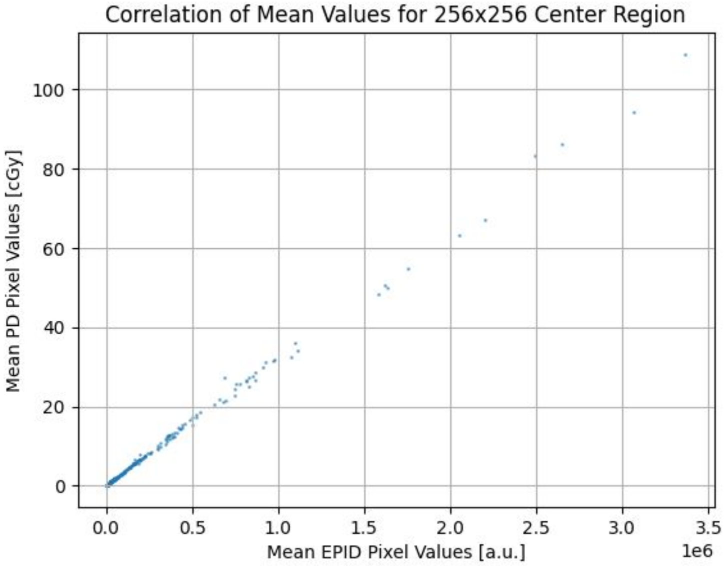


2D: 18 nuovi casi (EPID-PD) per l’addestramento

```
EPID min value: 0, file: EPID_6s10_100MU_1.dcm
EPID max value: 65535, file: EPID_114075.dcm
PSF min value: 0.00142706, file: EPID_114075.dcm
PSF max value: 0.15469, file: EPID_6s30b3_100MU_6.dcm
PD min value: 0.0, file: PD_124607.txt
PD max value: 1034.6, file: PD_114075.txt
```

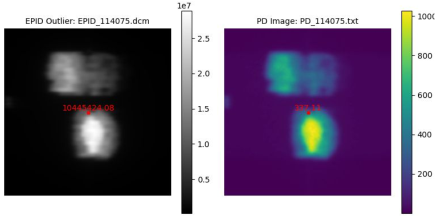


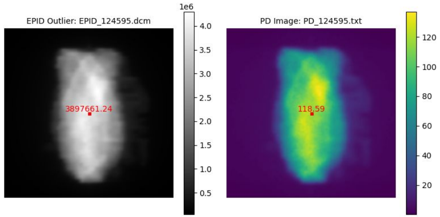


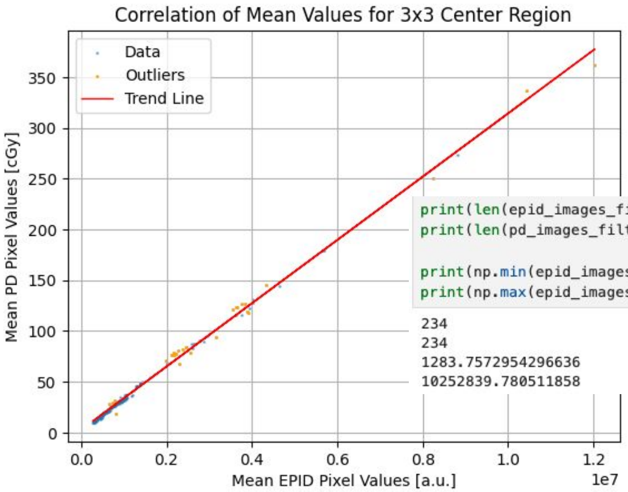


2D: 18 nuovi casi (EPID-PD) per l'addestramento

```
Analisi per dimensione della finestra: 3x3
Outliers:
EPID_114075.dcm
EPID_124339.dcm
EPID_124384.dcm
EPID_124507.dcm
EPID_124524.dcm
EPID_124595.dcm
EPID_124607b.dcm
EPID_124655.dcm
EPID_124737.dcm
EPID_6s10_300MU_1.dcm
EPID_6s10_300MU_2.dcm
EPID_6s10_300MU_5.dcm
EPID_6s10_300MU_6.dcm
EPID_6s10_500MU_3.dcm
EPID_Air5cm_100MU_1.dcm
EPID_Air5cm_100MU_2.dcm
EPID_Air5cm_100MU_3.dcm
EPID_Bone_ell_300MU_2C.dcm
EPID_Cirs_centroEll_0g_400MU_2C.dcm
EPID_Cirs_centroEll_270g_400MU_1C.dcm
EPID_Cirs_centroEll_90g_400MU_1C.dcm
EPID_Cirs_centroEll_90g_400MU_1E.dcm
EPID_Cirs_lesEll_0g_400MU_2C.dcm
EPID_Cirs_lesEll_0g_400MU_2E.dcm
EPID_Cirs_lesEll_180g_400MU_2C.dcm
EPID_Cirs_lesEll_270g_400MU_1C.dcm
EPID_Cirs_lesEll_270g_400MU_1E.dcm
EPID_Cirs_lesEll_90g_400MU_1E.dcm
EPID_Lung_ell_400MU_1C.dcm
EPID_Lung_ell_400MU_2E.dcm
```

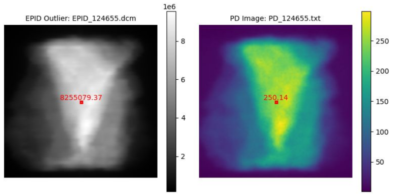


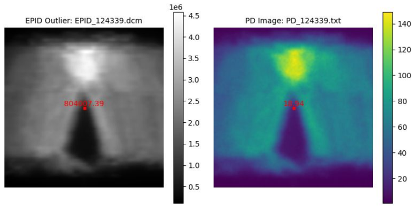


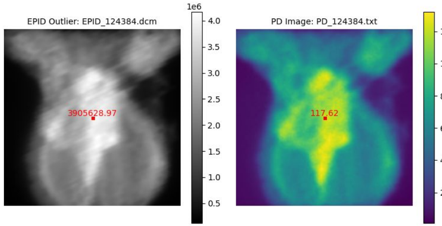



```
print(len(epid_images_filtered))
print(len(pd_images_filtered))

print(np.min(epid_images_filtered))
print(np.max(epid_images_filtered))
```

```
234
234
1283.7572954296636
10252839.780511858
```

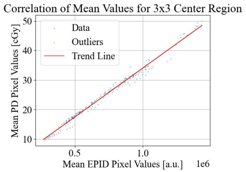






2D: 18 nuovi casi (EPID-PD) per l'addestramento

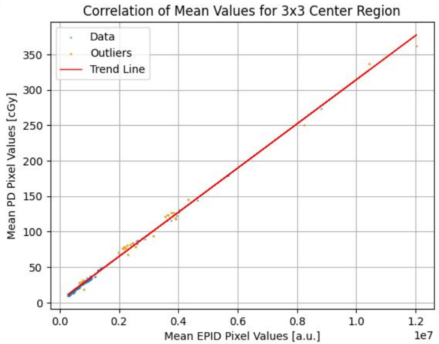
prima, quando applicavo un filtro sui casi > 300 MU



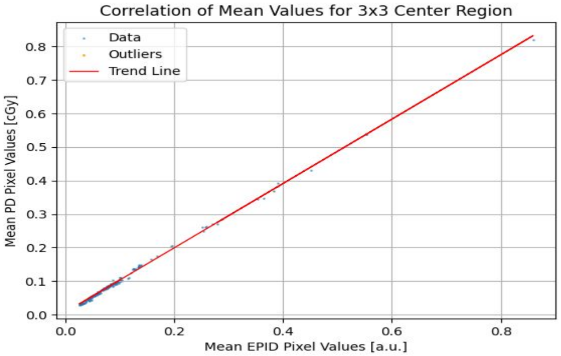

```
EPID min value: 0, file: EPID_6s10_100MU_1.dcm
EPID max value: 65535, file: EPID_114075.dcm
PSF min value: 0.00142706, file: EPID_114075.dcm
PSF max value: 0.15469, file: EPID_6s30b3_100MU_6.dcm
PD min value: 0.0, file: PD_124607.txt
PD max value: 1034.6, file: PD_114075.txt
```

prima, quando applicavo un filtro sui casi > 300 MU

```
EPID min value: 1283.7572954296636, file: EPID_6s30b3_100MU_1.dcm
EPID max value: 1584183.7185058743, file: EPID_Multiplug_PMMA_tondo_270g_1C.dcm
PD min value: 0.0, file: PD_6s10_100MU_1.txt
PD max value: 59.21971367954349, file: PD_Multiplug_PMMA_tondo_270g_1C.txt
```




```
EPID min value: 1283.7572954296636, file: EPID_6s30b3_100MU_1.dcm
EPID max value: 10252839.780511858, file: EPID_122174.dcm
PD min value: 0.0, file: PD_124607.txt
PD max value: 334.1020618697719, file: PD_122174.txt
```

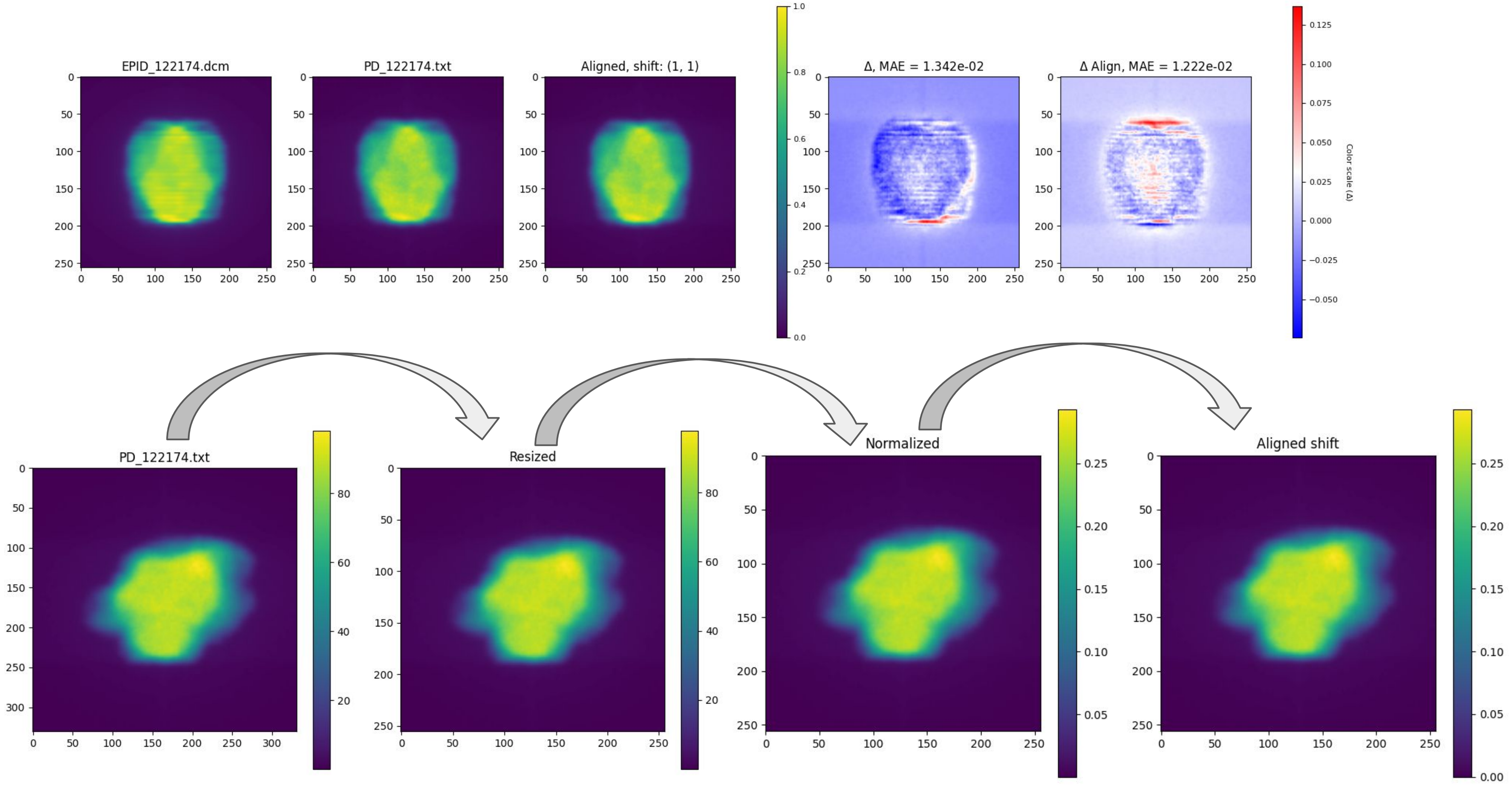


NORMALIZZO

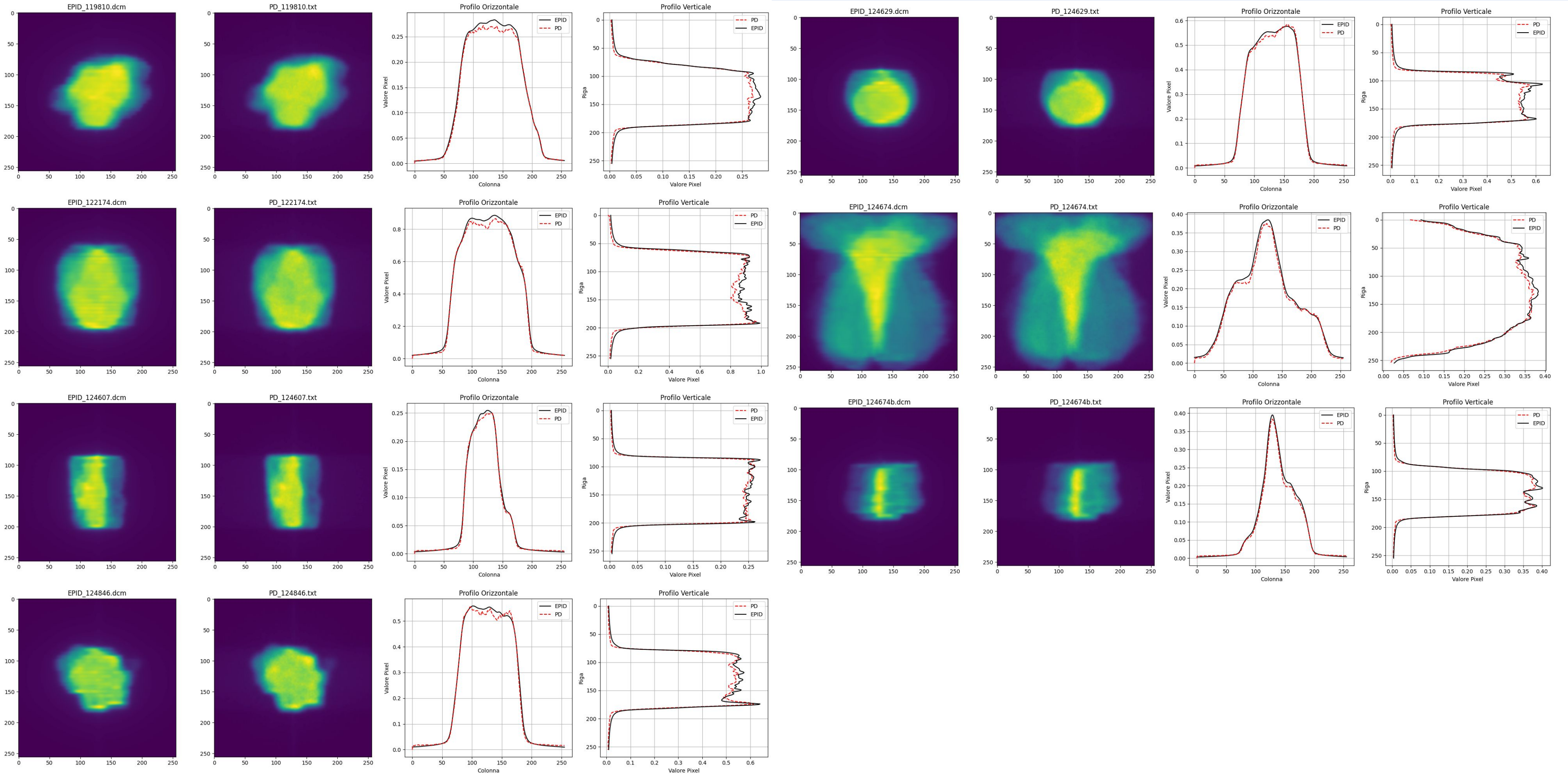
```
epid_images_normalized, pd_images_normalized = norm_sample(epid_images_filtered,
                                                           pd_images_filtered
                                                          )
```

```
max_epid_value: 10252839.780511858
min_epid_value: 1283.7572954296636
max_pd_value: 334.1020618697719
min_pd_value: 0.0
```

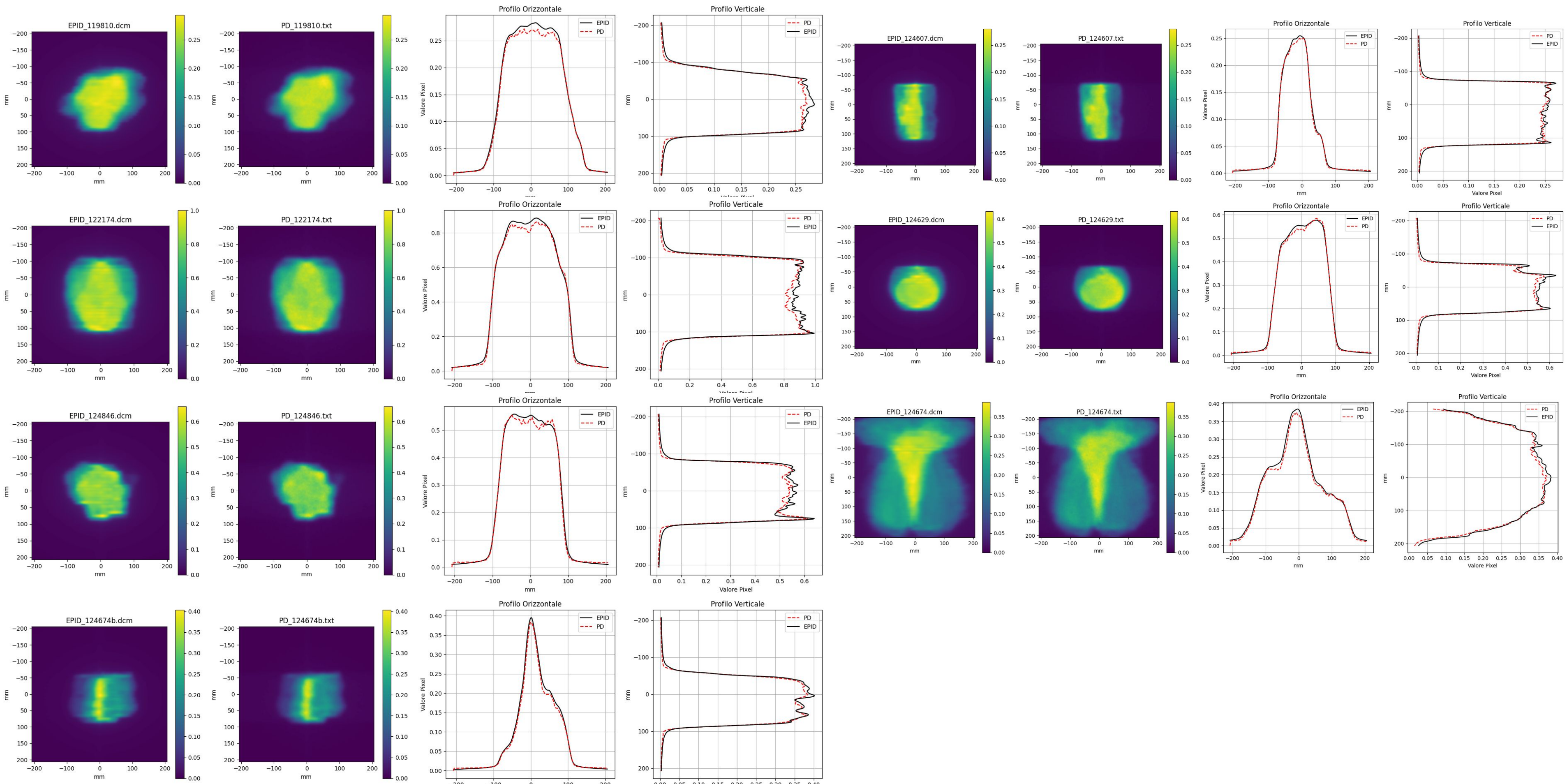
2D: 18 nuovi casi (EPID-PD) per l’addestramento



2D: 18 nuovi casi (EPID-PD) per l'addestramento



2D: 18 nuovi casi (EPID-PD) per l’addestramento



Problemi col centro di calcolo…

```
➜  ~ ssh lomarini@gridui.pi.infn.it

@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@    WARNING: REMOTE HOST IDENTIFICATION HAS CHANGED!     @
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
IT IS POSSIBLE THAT SOMEONE IS DOING SOMETHING NASTY!
Someone could be eavesdropping on you right now (man-in-the-middle attack)!
It is also possible that a host key has just been changed.
The fingerprint for the ECDSA key sent by the remote host is
SHA256:Qd/99p24N1MZUD3/6vmFWCAC11QNtWEok7+OdzM06lQ.
Please contact your system administrator.
Add correct host key in /Users/lorenzomarini/.ssh/known_hosts to get rid of this message.
Offending ECDSA key in /Users/lorenzomarini/.ssh/known_hosts:4
Host key for gridui.pi.infn.it has changed and you have requested strict checking.
Host key verification failed.
➜  ~ ssh lomarini@gridui.pi.infn.it
```

EM **Enrico Mazzoni** 26 settembre 2025, 10:21

Fermo calcolo scientifico lunedì 6/10 | Scientific computing suspended on Monday 6/10

A: all@lists.pi.infn.it, sc_all@lists.pi.infn.it

Sicurezza: Firmato (Enrico Mazzoni)

Cari Utenti

lunedì 6 ottobre sarà necessario fermare l'infrastruttura di storage per permettere la sostituzione del componente danneggiato a seguito del problema di condizionamento dello scorso giugno. Questo comporterà il fermo di tutta l'infrastruttura di calcolo scientifico secondo il seguente schema:

- sabato 4/10 alle 00:01 chiusura di tutte le code batch
- domenica 5/10 alle 00:01 chiusura delle code interattive
- domenica 5/10 alle 23:59 spengimento User Interface
- lunedì 6/10 dalle 06:00 fermo del filesystem

la riaccensione inizierà la mattina di martedì 7/10 salvo imprevisti.

Gli step

- PREPROCESSING
  - Rieseguito il preprocessing su tutte le nuove immagini. Dati di output (EPID e PD) in formato .npy → ricontrollato tutte le coppie
- SPLITTING DEL DATASET
  - DIvisione tra dati di training e dati di test (prese le stesse immagini di test, per confrontare direttamente le performance)
- TRAINING
  - Allenamento sul centro di calcolo
  - Stessi iperparametri ottenuti dalla precedente gridsearch
  - 150 epoche
- INFERENZA
- ANALISI GAMMA

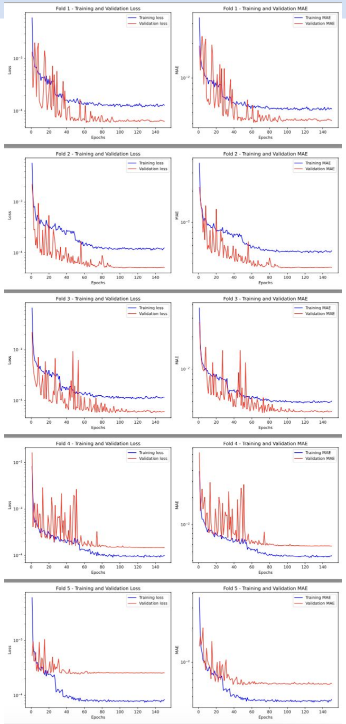


Table 1: Optimal configuration and average metrics obtained across all folds and repetitions.

Hyperparameters	Value
Initial number of filters	16
Learning rate	0.001
Batch size	8

```
TEST_2D
├── epid
│   ├── EPID_6s10b2_100MU_3.npy
│   ├── EPID_6s10b2_100MU_6.npy
│   ├── EPID_6s10b3_100MU_1.npy
│   ├── EPID_6s20_100MU_4.npy
│   ├── EPID_6s30b1_100MU_2.npy
│   ├── EPID_Air2cm_100MU_1.npy
│   ├── EPID_Air2cm_100MU_6.npy
│   ├── EPID_Bone2Slab_100MU_3.npy
│   ├── EPID_Bone2Slab_100MU_4.npy
│   ├── EPID_Bone2Slab_b2_100MU_2.npy
│   ├── EPID_Cirs_centro_0g_100MU_8.npy
│   ├── EPID_Cirs_centro_270g_100MU_6.npy
│   ├── EPID_Cirs_les_0g_100MU_1.npy
│   ├── EPID_Cirs_les_0g_100MU_3.npy
│   ├── EPID_Cirs_les_0g_100MU_9.npy
│   ├── EPID_Cirs_les_270g_100MU_2.npy
│   ├── EPID_Cirs_les_90g_100MU_7.npy
│   ├── EPID_Multiplug_180g_5cm_ARIA_2.npy
│   ├── EPID_Multiplug_PMMA_180g_6.npy
│   ├── EPID_Multiplug_PMMA_90g_3.npy
│   ├── EPID_Multiplug_Ti_90g_8.npy
│   └── EPID_Multiplug_Ti_tondo_0g_1E.npy
└── pd
    ├── PD_6s10b2_100MU_3.npy
    ├── PD_6s10b2_100MU_6.npy
    ├── PD_6s10b3_100MU_1.npy
    ├── PD_6s20_100MU_4.npy
    ├── PD_6s30b1_100MU_2.npy
    ├── PD_Air2cm_100MU_1.npy
    ├── PD_Air2cm_100MU_6.npy
    ├── PD_Bone2Slab_100MU_3.npy
    ├── PD_Bone2Slab_100MU_4.npy
    ├── PD_Bone2Slab_b2_100MU_2.npy
    ├── PD_Cirs_centro_0g_100MU_8.npy
    ├── PD_Cirs_centro_270g_100MU_6.npy
    ├── PD_Cirs_les_0g_100MU_1.npy
    ├── PD_Cirs_les_0g_100MU_3.npy
    ├── PD_Cirs_les_0g_100MU_9.npy
    ├── PD_Cirs_les_270g_100MU_2.npy
    ├── PD_Cirs_les_90g_100MU_7.npy
    ├── PD_Multiplug_180g_5cm_ARIA_2.npy
    ├── PD_Multiplug_PMMA_180g_6.npy
    ├── PD_Multiplug_PMMA_90g_3.npy
    ├── PD_Multiplug_Ti_90g_8.npy
    └── PD_Multiplug_Ti_tondo_0g_1E.npy
```

Old test set

```
├── epid
│   ├── EPID_6s10b2_3.npy.npy
│   ├── EPID_6s10b2_6.npy.npy
│   ├── EPID_6s10b3_1.npy.npy
│   ├── EPID_6s20_4.npy.npy
│   ├── EPID_6s30b1_2.npy.npy
│   ├── EPID_CIRS_0gradi_ISOcentro_8.npy.npy
│   ├── EPID_CIRS_0gradi_ISOlesione_1.npy.npy
│   ├── EPID_CIRS_0gradi_ISOlesione_3.npy.npy
│   ├── EPID_CIRS_0gradi_ISOlesione_9.npy.npy
│   ├── EPID_CIRS_270gradi_ISOcentro_6.npy.npy
│   ├── EPID_CIRS_270gradi_ISOlesione_2.npy.npy
│   ├── EPID_CIRS_90gradi_ISOlesione_7.npy.npy
│   ├── EPID_Multiplug_90g_5cm_ARIA_2.npy.npy
│   ├── EPID_Multiplug_PMMA_180g_6.npy.npy
│   ├── EPID_Multiplug_PMMA_90g_3.npy.npy
│   ├── EPID_Multiplug_Ti_90g_8.npy.npy
│   ├── EPID_Multiplug_Ti_tondo_1E0g.npy.npy
│   ├── EPID_SLABBone_3.npy.npy
│   ├── EPID_SLAB_Bone_2slab_4.npy.npy
│   ├── EPID_SLAB_Boneb2_2slab_2.npy.npy
│   ├── EPID_SLABinhomAir2_1.npy.npy
│   └── EPID_SLABinhomAir2_6.npy.npy
└── pd
    ├── PD_6s10b2_3.npy.npy
    ├── PD_6s10b2_6.npy.npy
    ├── PD_6s10b3_1.npy.npy
    ├── PD_6s20_4.npy.npy
    ├── PD_6s30b1_2.npy.npy
    ├── PD_CIRS_0gradi_ISOcentro_8.npy.npy
    ├── PD_CIRS_0gradi_ISOlesione_1.npy.npy
    ├── PD_CIRS_0gradi_ISOlesione_3.npy.npy
    ├── PD_CIRS_0gradi_ISOlesione_9.npy.npy
    ├── PD_CIRS_270gradi_ISOcentro_6.npy.npy
    ├── PD_CIRS_270gradi_ISOlesione_2.npy.npy
    ├── PD_CIRS_90gradi_ISOlesione_7.npy.npy
    ├── PD_Multiplug_90g_5cm_ARIA_2.npy.npy
    ├── PD_Multiplug_PMMA_180g_6.npy.npy
    ├── PD_Multiplug_PMMA_90g_3.npy.npy
    ├── PD_Multiplug_Ti_90g_8.npy.npy
    ├── PD_Multiplug_Ti_tondo_1E0g.npy.npy
    ├── PD_SLABBone_3.npy.npy
    ├── PD_SLAB_Bone_2slab_4.npy.npy
    ├── PD_SLAB_Boneb2_2slab_2.npy.npy
    ├── PD_SLABinhomAir2_1.npy.npy
    └── PD_SLABinhomAir2_6.npy.npy
```

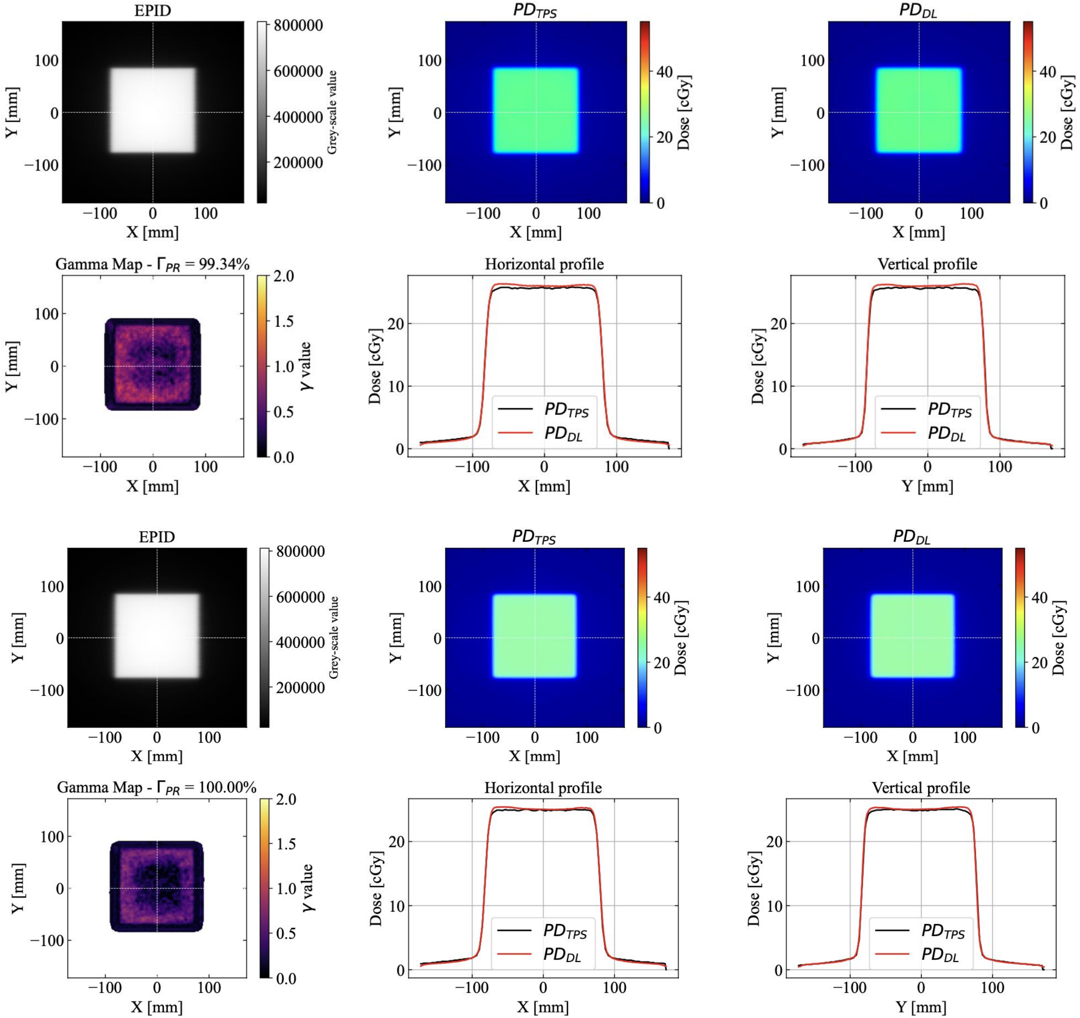
New test set

```
TEST_2D
├── epid
│   ├── EPID_6s10b2_100MU_3.npy
│   ├── EPID_6s10b2_100MU_6.npy
│   ├── EPID_6s10b3_100MU_1.npy
│   ├── EPID_6s20_100MU_4.npy
│   ├── EPID_6s30b1_100MU_2.npy
│   ├── EPID_Air2cm_100MU_1.npy
│   ├── EPID_Air2cm_100MU_6.npy
│   ├── EPID_Bone2Slab_100MU_3.npy
│   ├── EPID_Bone2Slab_100MU_4.npy
│   ├── EPID_Bone2Slab_b2_100MU_2.npy
│   ├── EPID_Cirs_centro_0g_100MU_8.npy
│   ├── EPID_Cirs_centro_270g_100MU_6.npy
│   ├── EPID_Cirs_les_0g_100MU_1.npy
│   ├── EPID_Cirs_les_0g_100MU_3.npy
│   ├── EPID_Cirs_les_0g_100MU_9.npy
│   ├── EPID_Cirs_les_270g_100MU_2.npy
│   ├── EPID_Cirs_les_90g_100MU_7.npy
│   ├── EPID_Multiplug_180g_5cm_ARIA_2.npy
│   ├── EPID_Multiplug_PMMA_180g_6.npy
│   ├── EPID_Multiplug_PMMA_90g_3.npy
│   ├── EPID_Multiplug_Ti_90g_8.npy
│   └── EPID_Multiplug_Ti_tondo_0g_1E.npy
└── pd
    ├── PD_6s10b2_100MU_3.npy
    ├── PD_6s10b2_100MU_6.npy
    ├── PD_6s10b3_100MU_1.npy
    ├── PD_6s20_100MU_4.npy
    ├── PD_6s30b1_100MU_2.npy
    ├── PD_Air2cm_100MU_1.npy
    ├── PD_Air2cm_100MU_6.npy
    ├── PD_Bone2Slab_100MU_3.npy
    ├── PD_Bone2Slab_100MU_4.npy
    ├── PD_Bone2Slab_b2_100MU_2.npy
    ├── PD_Cirs_centro_0g_100MU_8.npy
    ├── PD_Cirs_centro_270g_100MU_6.npy
    ├── PD_Cirs_les_0g_100MU_1.npy
    ├── PD_Cirs_les_0g_100MU_3.npy
    ├── PD_Cirs_les_0g_100MU_9.npy
    ├── PD_Cirs_les_270g_100MU_2.npy
    ├── PD_Cirs_les_90g_100MU_7.npy
    ├── PD_Multiplug_180g_5cm_ARIA_2.npy
    ├── PD_Multiplug_PMMA_180g_6.npy
    ├── PD_Multiplug_PMMA_90g_3.npy
    ├── PD_Multiplug_Ti_90g_8.npy
    └── PD_Multiplug_Ti_tondo_0g_1E.npy
```

I nuovi dati hanno nomi leggermente cambiati…

Mi sono fatto dire da Carlotta quali dati usare per il test

Average predictions



Prima

3%/3mm

	Mean	Median	Sigma
cv_1	95,02245	98,13686	9,16085
cv_10	94,50223	97,91041	9,44479
cv_2	95,04624	98,51857	9,49802
cv_3	95,59046	98,45063	8,04998
cv_4	94,6782	98,75133	10,43327
cv_5	94,89045	98,84238	9,48046
cv_6	93,95543	97,81283	10,10313
cv_7	93,99619	98,39791	10,21614
cv_8	94,72434	98,09562	8,98636
cv_9	95,00334	98,36919	9,14435

5%/5mm

	Mean	Median	Sigma
cv_1	99,65698	100	0,91608
cv_10	99,64691	100	0,90339
cv_2	99,70077	100	0,90606
cv_3	99,851	100	0,48034
cv_4	99,45582	100	1,9824
cv_5	99,52778	100	1,50605
cv_6	99,35725	100	2,08105
cv_7	99,24514	100	1,9276
cv_8	99,52623	100	1,0782
cv_9	99,61401	100	0,86279

Avg pred

Metric	GPR 3%/3mm	GPR 5%/5mm
Mean	94,52945	99,55365
Median	98,02795	100
Sigma	9,74269	1,15211

nuova tecnica acquisizione dati

nessun miglioramento significativo: media e mediana compatibili entro l'errore statistico

Dopo

3%/3mm

	Mean	Median	Sigma
cv_1	95,32429	99,00717	7,70595
cv_10	95,03767	99,31101	9,60835
cv_2	94,64929	97,80723	8,89038
cv_3	93,94913	96,58175	8,20462
cv_4	94,78057	98,65631	9,1478
cv_5	95,0322	98,3546	8,07085
cv_6	94,42928	97,01817	7,20954
cv_7	93,78198	98,35133	10,16285
cv_8	95,99193	99,35975	7,57454
cv_9	94,8803	97,82867	8,1523

5%/5mm

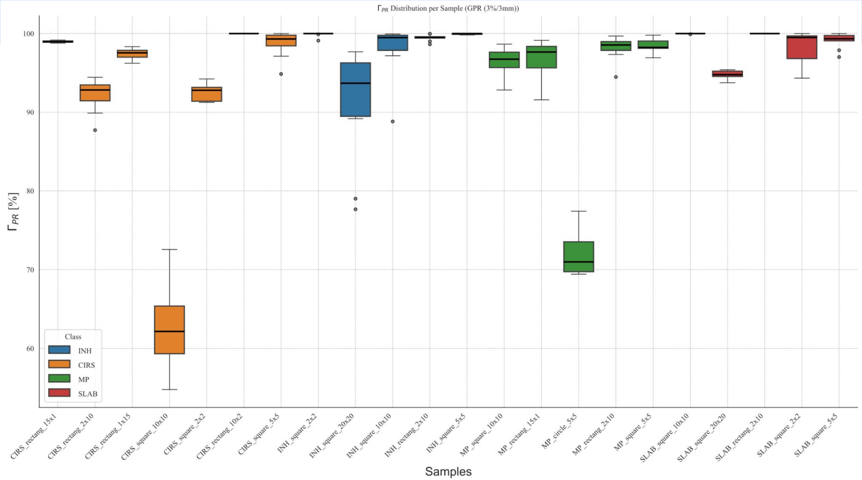
	Mean	Median	Sigma
cv_1	99,54652	100	1,03494
cv_10	99,24974	100	1,79492
cv_2	98,99852	100	2,3178
cv_3	99,40793	100	1,21565
cv_4	99,40682	100	1,1455
cv_5	99,48531	100	0,9482
cv_6	99,45989	100	1,16016
cv_7	98,99879	100	2,31911
cv_8	99,24095	100	1,82838
cv_9	99,36146	100	1,21255

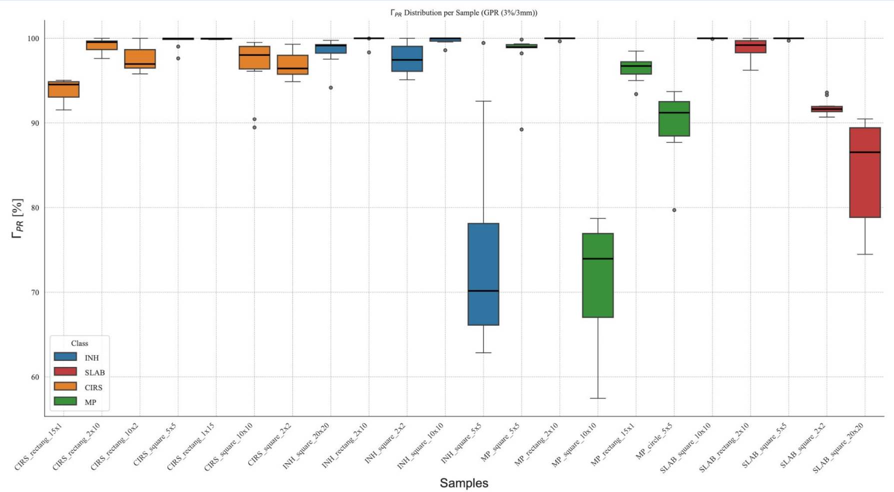
Avg pred

Metric	GPR 3%/3mm	GPR 5%/5mm
Mean	94,10076	99,1141
Median	98,92598	100
Sigma	9,72128	1,83146

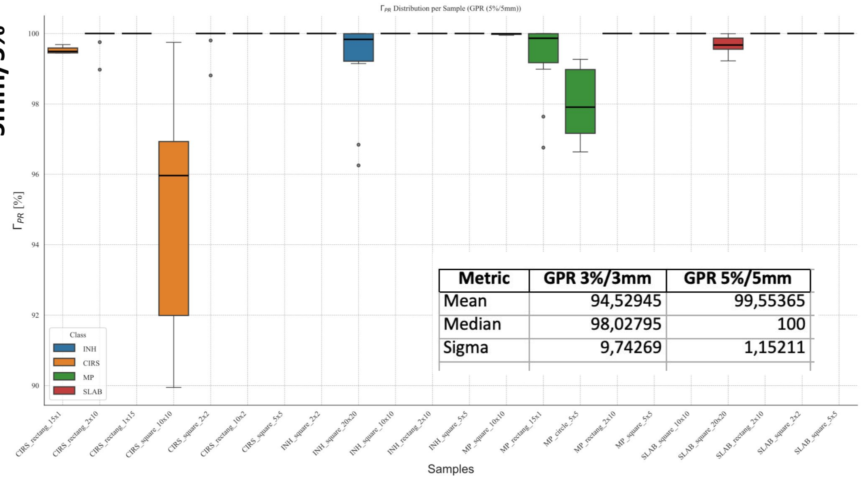
Prima | **Dopo**

3mm/3%

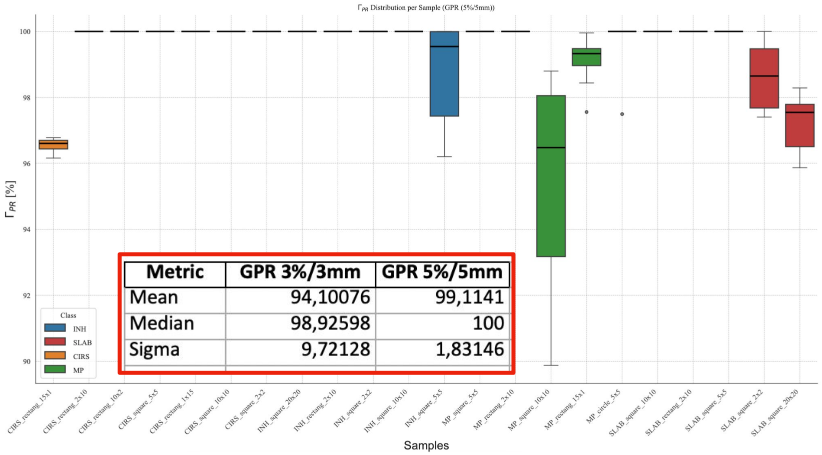




5mm/5%

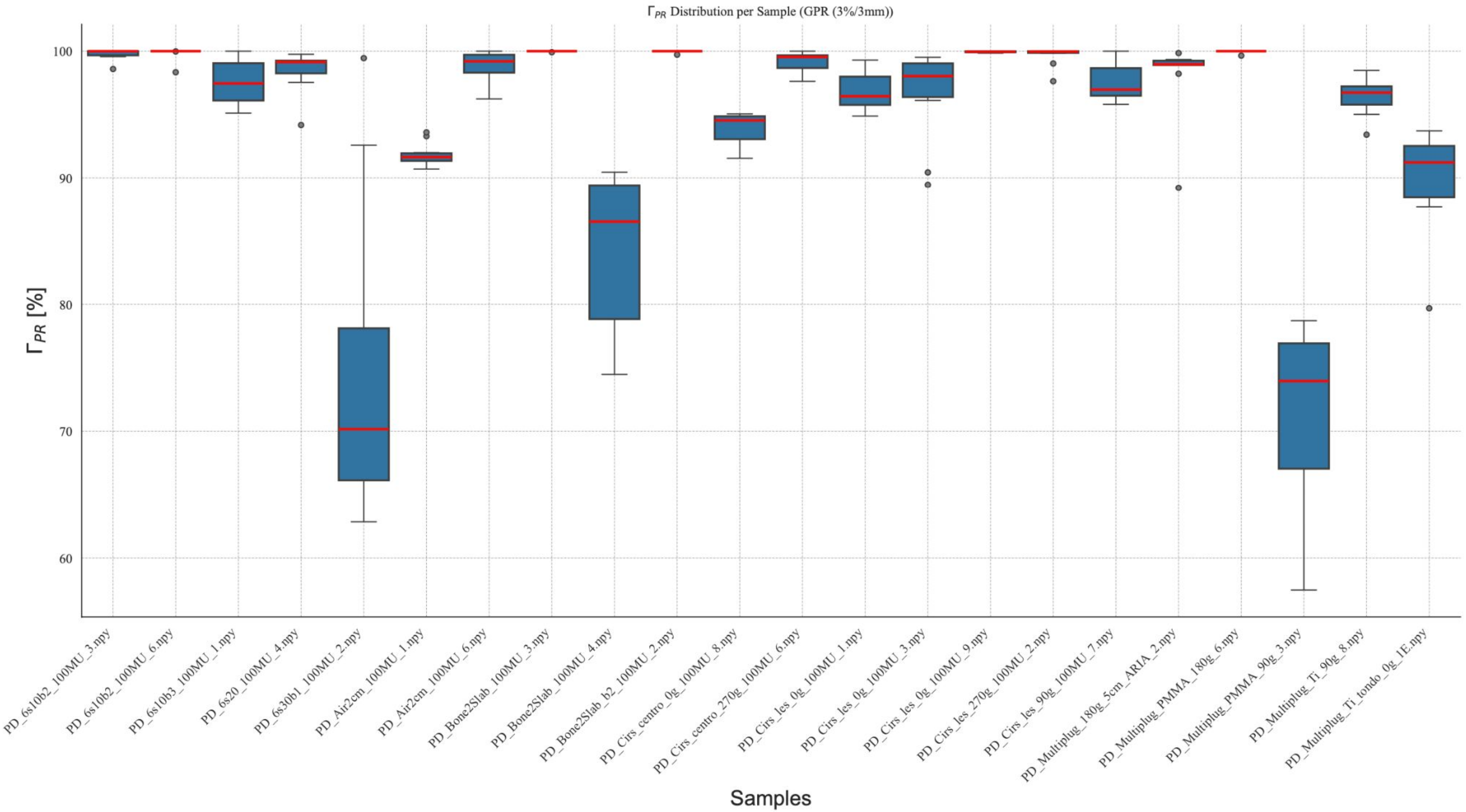


Metric	GPR 3%/3mm	GPR 5%/5mm
Mean	94,52945	99,55365
Median	98,02795	100
Sigma	9,74269	1,15211

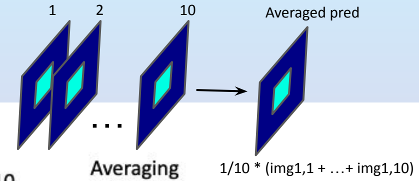


Metric	GPR 3%/3mm	GPR 5%/5mm
Mean	94,10076	99,1141
Median	98,92598	100
Sigma	9,72128	1,83146

Plot coi nomi originali dei file (3%/3mm)



3%/3mm

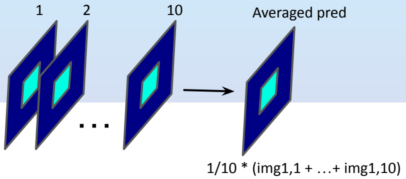


FIle name		CV 1	CV 2	CV 3	CV 4	CV 5	CV 6	CV 7	CV 8	CV 9	CV 10	Averaging predictions
		Cross Validations										
PD_6s10b2_100MU_3	INH_square_10x10	100	99,99	99,57	100	99,99	98,59	100	100	99,57	100	100
PD_6s10b2_100MU_6	INH_rectang_2x10	100	100	100	100	100	100	98,34	100	100	99,98	100
PD_6s10b3_100MU_1	INH_square_2x2	98	96,71	95,81	97,9	95,11	95,91	100	99,5	97	99,4	96,61
PD_6s20_100MU_4	INH_square_20x20	99,1	98,08	97,54	99,19	99,76	98,75	94,17	99,27	99,5	99,22	99,13
PD_6s30b1_100MU_2	INH_square_5x5	74,88	62,85	72,89	65,05	67,32	79,19	92,58	99,45	65,72	67,43	63,3
PD_Air2cm_100MU_1	SLAB_square_2x2	92	91,8	91,3	91,3	91,6	90,7	93,6	91,7	91,5	93,3	91,2
PD_Air2cm_100MU_6	SLAB_rectang_2x10	99,58	99,29	96,23	98,14	99,11	97,22	99,98	99,76	98,8	100	98,8
PD_Bone2Slab_100MU_3	SLAB_square_10x10	99,92	100	100	100	100	100	100	100	100	100	100
PD_Bone2Slab_100MU_4	SLAB_square_20x20	90,43	85,73	74,47	86,23	88,48	76,18	76,55	89,72	86,82	90,45	84,48
PD_Bone2Slab_b2_100MU_2	SLAB_square_5x5	100	100	100	100	100	100	99,72	100	100	100	100
PD_Cirs_centro_0g_100MU_8	CIRS_rectang_15x1	92,49	94,7	92,96	94,95	94,93	94,58	91,55	93,37	95,05	94,51	93,89
PD_Cirs_centro_270g_100MU_6	CIRS_rectang_2x10	99,68	98,64	98,78	99,66	97,62	99,43	100	99,75	98,03	99,66	99,39
PD_Cirs_les_0g_100MU_1	CIRS_square_2x2	97,39	96,69	95,49	95,69	96,189	94,88	99,3	98,19	95,99	98,6	95,99
PD_Cirs_les_0g_100MU_3	CIRS_square_10x10	99,51	97,18	90,44	97,69	99,09	89,45	98,36	99,26	96,12	98,89	98
PD_Cirs_les_0g_100MU_9	CIRS_rectang_1x15	99,94	99,91	99,94	99,88	99,97	99,85	99,97	100	100	100	99,97
PD_Cirs_les_270g_100MU_2	CIRS_square_5x5	99,98	99,03	99,96	100	99,92	100	99,85	100	97,63	100	100
PD_Cirs_les_90g_100MU_7	CIRS_rectang_10x2	98,82	95,8	96,93	99,66	96,93	96,34	98,18	96,17	97,01	100	97,77
PD_Multiplug_180g_5cm_ARIA_2	MP_square_5x5	98,92	98,9	99,23	99,17	99,85	98,98	89,21	98,94	99,34	98,22	98,66
PD_Multiplug_PMMA_180g_6	MP_rectang_2x10	100	100	100	100	100	100	99,65	100	100	100	100
PD_Multiplug_PMMA_90g_3	MP_square_10x10	72,17	75,74	76,64	71,27	77,02	78,72	57,47	65,63	78,19	65,16	70,94
PD_Multiplug_Ti_90g_8	MP_rectang_15x1	96,19	97,53	95,65	97,23	97,23	96,82	95,02	93,41	98,48	96,64	95,71
PD_Multiplug_Ti_tondo_0g_1E	MP_circle_5x5	88,14	93,71	93,03	92,17	90,6	91,85	79,7	87,69	92,65	89,38	89,19

GPR>95%
90%<GPR<95%
GPR<90%

https://docs.google.com/spreadsheets/d/1PfSidpiRLkXysVgFdrYhreBmwheSBT81/edit?gid=1273724532#gid=1273724532

3%/3mm & 5%/5mm



3%/3mm

Phantom	GPR	Specified field size [cm^2]								
	Average	15x1	2x10	2x2	10x10	1x15	5x5	10x2	20x20	Circle
CIRS	97,86	93,89	99,39	95,99	98	99,97	100	97,77		
INH	91,81		100	96,61	100		63,3		99,13	
Multiplug	90,9	95,71	100		70,94		98,66			89,19
SLAB	94,9		98,8	91,2	100		100		84,48	

5%/5mm

Phantom	GPR	Specified field size [cm^2]								
	Average	15x1	2x10	2x2	10x10	1x15	5x5	10x2	20x20	Circle
CIRS	100	100	100	100	100	100	100	100		
INH	99,85		100	100	100		99,23		100	
Multiplug	98,69	98,74	100		94,7		100			100
SLAB	98,95		100	97,5	100		100		97,26	

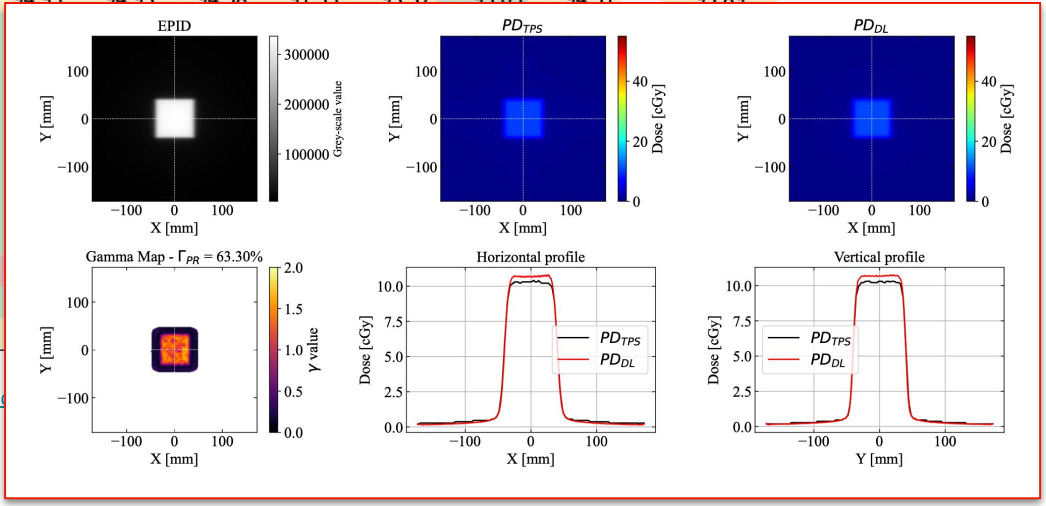
https://docs.google.com/spreadsheets/d/1PfSidpiRLkXysVgFdrYhreBmwheSBT81/edit?gid=1273724532#gid=1273724532

3%/3mm

File name		CV 1	CV 2	CV 3	CV 4	CV 5	CV 6	CV 7	CV 8	CV 9	CV 10	Averaging predictions
		Cross Validations										
PD_6s10b2_100MU_3	INH_square_10x10	100	99,99	99,57	100	99,99	98,59	100	100	99,57	100	100
PD_6s10b2_100MU_6	INH_rectang_2x10	100	100	100	100	100	100	98,34	100	100	99,98	100
PD_6s10b3_100MU_1	INH_square_2x2	98	96,71	95,81	97,9	95,11	95,91	100	99,5	97	99,4	96,61
PD_6s20_100MU_4	INH_square_20x20	99,1	98,08	97,54	99,19	99,76	98,75	94,17	99,27	99,5	99,22	99,13
PD_6s30b1_100MU_2	INH_square_5x5	74,88	62,85	72,89	65,05	67,32	79,19	92,58	99,45	65,72	67,43	63,3
PD_Air2cm_100MU_1	SLAB_square_2x2	92	91,8	91,3	91,3	91,6	90,7	93,6	91,7	91,5	93,3	91,2
PD_Air2cm_100MU_6	SLAB_rectang_2x10	99,58	99,29	96,23	98,14	99,11	97,22	99,98	99,76	98,8	100	98,8
PD_Bone2Slab_100MU_3	SLAB_square_10x10	99,92	100	100	100	100	100	100	100	100	100	100
PD_Bone2Slab_100MU_4	SLAB_square_20x20	90,43	85,73	74,47	86,23	88,48	76,18	76,55	89,72	86,82	90,45	84,48
PD_Bone2Slab_b2_100MU_2	SLAB_square_5x5	100	100	100	100	100	100	99,72	100	100	100	100
PD_Cirs_centro_0g_100MU_8	CIRS_rectang_15x1	92,49	94,7	92,96	94,95	94,93	94,58	91,55	93,37	95,05	94,51	93,89
PD_Cirs_centro_270g_100MU_6	CIRS_rectang_2x10	99,68	98,64	98,78								
PD_Cirs_les_0g_100MU_1	CIRS_square_2x2	97,39	96,69	95,49								
PD_Cirs_les_0g_100MU_3	CIRS_square_10x10	99,51	97,18	90,44								
PD_Cirs_les_0g_100MU_9	CIRS_rectang_1x15	99,94	99,91	99,94								
PD_Cirs_les_270g_100MU_2	CIRS_square_5x5	99,98	99,03	99,96								
PD_Cirs_les_90g_100MU_7	CIRS_rectang_10x2	98,82	95,8	96,93								
PD_Multiplug_180g_5cm_ARIA_2	MP_square_5x5	98,92	98,9	99,23								
PD_Multiplug_PMMA_180g_6	MP_rectang_2x10	100	100	100								
PD_Multiplug_PMMA_90g_3	MP_square_10x10	72,17	75,74	76,64								
PD_Multiplug_Ti_90g_8	MP_rectang_15x1	96,19	97,53	95,65								
PD_Multiplug_Ti_tondo_0g_1E	MP_circle_5x5	88,14	93,71	93,03								

GPR>95%
90%<GPR<95%
GPR<90%

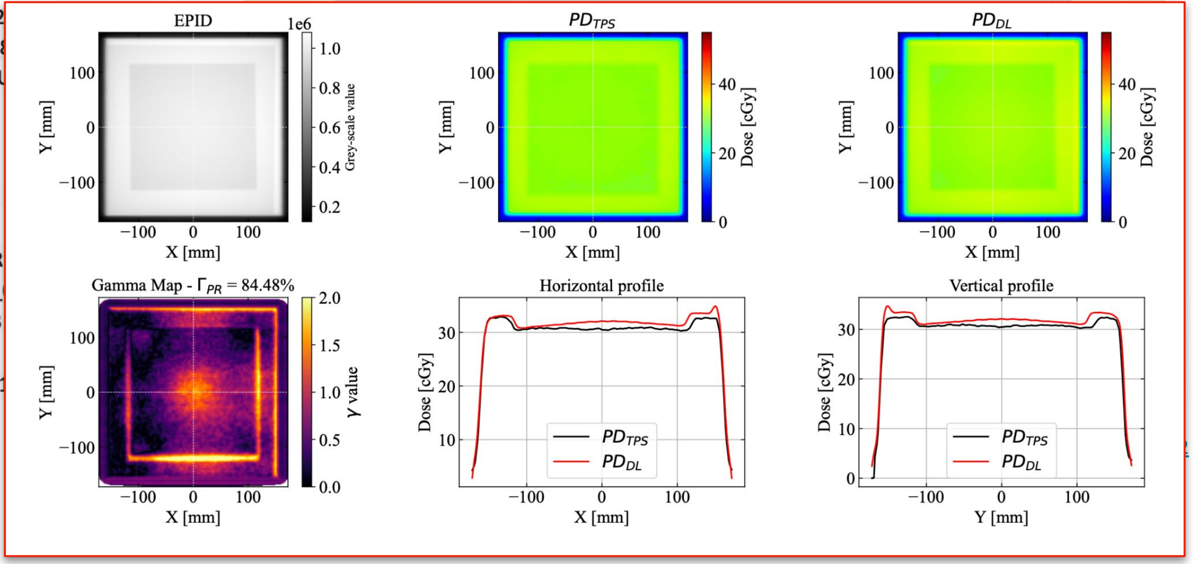
https://docs.google.com/spreadsheets/d/1PfSi



Cross Validations

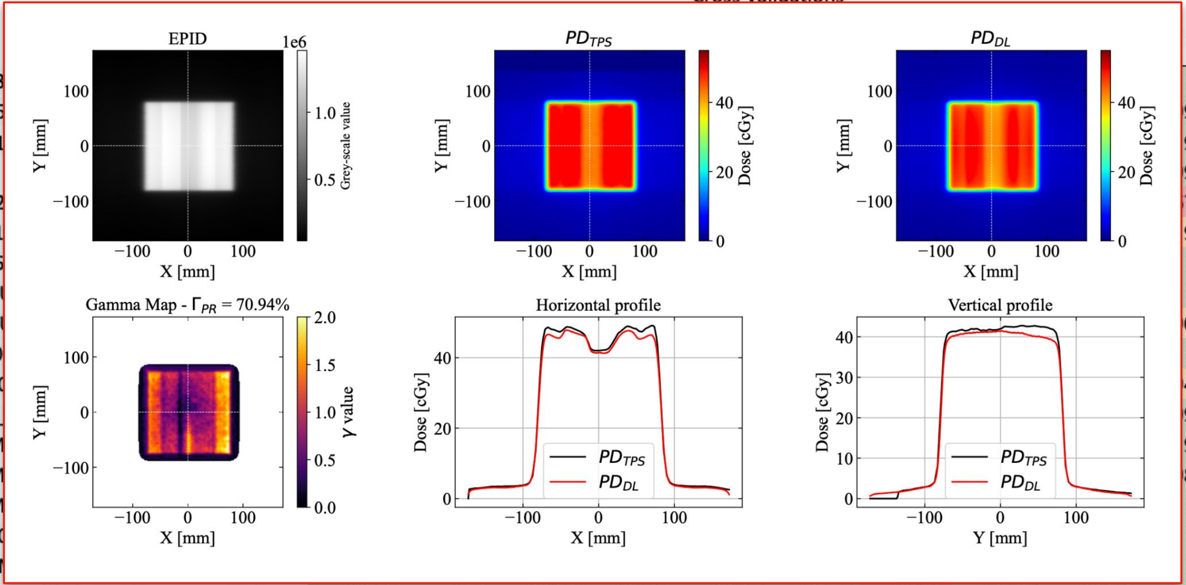
File name		CV 1	CV 2	CV 3	CV 4	CV 5	CV 6	CV 7	CV 8	CV 9	CV 10	Averaging predictions
PD_6s10b2_100MU_3	INH_square_10x10	100	99,99	99,57	100	99,99	98,59	100	100	99,57	100	100
PD_6s10b2_100MU_6	INH_rectang_2x10	100	100	100	100	100	100	98,34	100	100	99,98	100
PD_6s10b3_100MU_1	INH_square_2x2	98	96,71	95,81	97,9	95,11	95,91	100	99,5	97	99,4	96,61
PD_6s20_100MU_4	INH_square_20x20	99,1	98,08	97,54	99,19	99,76	98,75	94,17	99,27	99,5	99,22	99,13
PD_6s30b1_100MU_2	INH_square_5x5	74,88	62,85	72,89	65,05	67,32	79,19	92,58	99,45	65,72	67,43	63,3
PD_Air2cm_100MU_1	SLAB_square_2x2	92	91,8	91,3	91,3	91,6	90,7	93,6	91,7	91,5	93,3	91,2
PD_Air2cm_100MU_6	SLAB_rectang_2x10	99,58	99,29	96,23	98,14	99,11	97,22	99,98	99,76	98,8	100	98,8
PD_Bone2Slab_100MU_3	SLAB_square_10x10	99,92	100	100	100	100	100	100	100	100	100	100
PD_Bone2Slab_100MU_4	SLAB_square_20x20	90,43	85,73	74,47	86,23	88,48	76,18	76,55	89,72	86,82	90,45	84,48
PD_Bone2Slab_b2_100MU_2												100
PD_Cirs_centro_0g_100MU_												93,89
PD_Cirs_centro_270g_100MU												99,39
PD_Cirs_les_0g_100MU_1												95,99
PD_Cirs_les_0g_100MU_3												98
PD_Cirs_les_0g_100MU_9												99,97
PD_Cirs_les_270g_100MU_2												100
PD_Cirs_les_90g_100MU_7												97,77
PD_Multiplug_180g_5cm_AR												98,66
PD_Multiplug_PMMA_180g_												100
PD_Multiplug_PMMA_90g_3												70,94
PD_Multiplug_Ti_90g_8												95,71
PD_Multiplug_Ti_tondo_0g_												89,19

GPR>95%
90%<GPR<95%
GPR<90%



3%/3mm

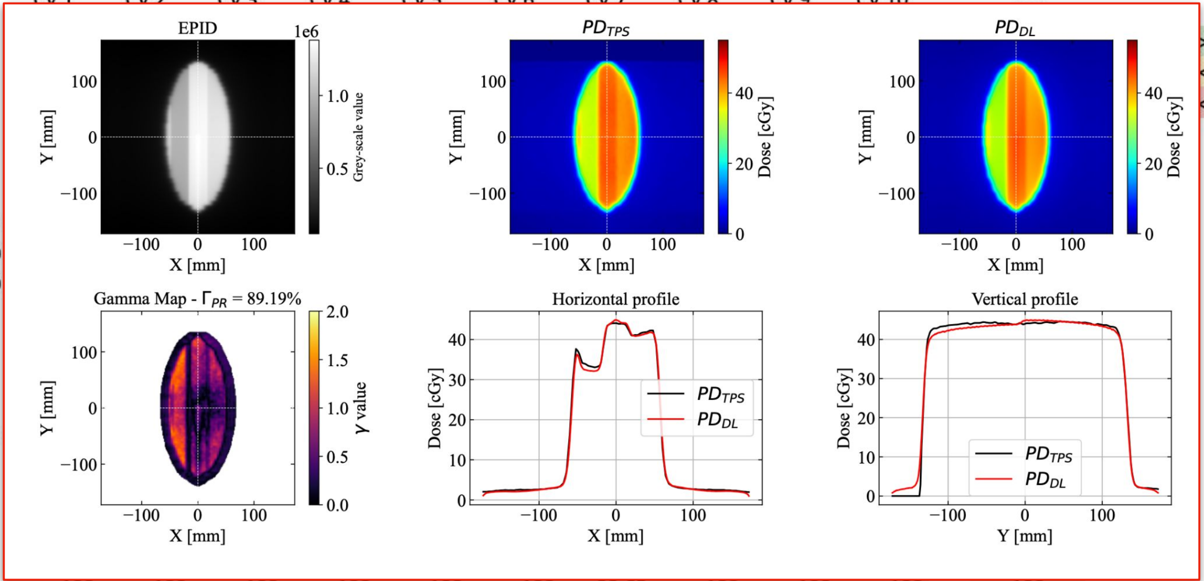
File name		Cross Validations									10	Averaging predictions
PD_6s10b2_100MU_3											100	100
PD_6s10b2_100MU_6											9,98	100
PD_6s10b3_100MU_1											99,4	96,61
PD_6s20_100MU_4											9,22	99,13
PD_6s30b1_100MU_2											7,43	63,3
PD_Air2cm_100MU_1											93,3	91,2
PD_Air2cm_100MU_6											100	98,8
PD_Bone2Slab_100M											100	100
PD_Bone2Slab_100M											0,45	84,48
PD_Bone2Slab_b2_10											100	100
PD_Cirs_centro_0g_10											4,51	93,89
PD_Cirs_centro_270g_											9,66	99,39
PD_Cirs_les_0g_100M											98,6	95,99
PD_Cirs_les_0g_100M											8,89	98
PD_Cirs_les_0g_100M											100	99,97
PD_Cirs_les_270g_100											100	100
PD_Cirs_les_90g_100											100	97,77
PD_Multiplug_180g_5cm_ARIA_2	MP_square_5x5	98,92	98,9	99,23	99,17	99,85	98,98	89,21	98,94	99,34	98,22	98,66
PD_Multiplug_PMMA_180g_6	MP_rectang_2x10	100	100	100	100	100	100	99,65	100	100	100	100
PD_Multiplug_PMMA_90g_3	MP_square_10x10	72,17	75,74	76,64	71,27	77,02	78,72	57,47	65,63	78,19	65,16	70,94
PD_Multiplug_Ti_90g_8	MP_rectang_15x1	96,19	97,53	95,65	97,23	97,23	96,82	95,02	93,41	98,48	96,64	95,71
PD_Multiplug_Ti_tondo_0g_1E	MP_circle_5x5	88,14	93,71	93,03	92,17	90,6	91,85	79,7	87,69	92,65	89,38	89,19



GPR>95%
90%<GPR<95%
GPR<90%

https://docs.google.com/spreadsheets/d/1PfSidpiRLkXysVgFdrYhreBmwheSBT81/edit?gid=1273724532#gid=1273724532

3%/3mm



Cross Validations

FIle name		CV 1	CV 2	CV 3	CV 4	CV 5	CV 6	CV 7	CV 8	CV 9	CV 10	Averaging
PD_6s10b2_100MU_3	INH_square_10x10											
PD_6s10b2_100MU_6	INH_rectang_2x10											
PD_6s10b3_100MU_1	INH_square_2x2											
PD_6s20_100MU_4	INH_square_20x20											
PD_6s30b1_100MU_2	INH_square_5x5											
PD_Air2cm_100MU_1	SLAB_square_2x2											
PD_Air2cm_100MU_6	SLAB_rectang_2x10											
PD_Bone2Slab_100MU_3	SLAB_square_10x10											
PD_Bone2Slab_100MU_4	SLAB_square_20x20											
PD_Bone2Slab_b2_100MU_2	SLAB_square_5x5											
PD_Cirs_centro_0g_100MU_8	CIRS_rectang_15x1											
PD_Cirs_centro_270g_100MU_6	CIRS_rectang_2x10											
PD_Cirs_les_0g_100MU_1	CIRS_square_2x2											
PD_Cirs_les_0g_100MU_3	CIRS_square_10x10											
PD_Cirs_les_0g_100MU_9	CIRS_rectang_1x15											
PD_Cirs_les_270g_100MU_2	CIRS_square_5x5											
PD_Cirs_les_90g_100MU_7	CIRS_rectang_10x2											
PD_Multiplug_180g_5cm_ARIA_2	MP_square_5x5											
PD_Multiplug_PMMA_180g_6	MP_rectang_2x10	100	100	100	100	100	100	99,65	100	100	100	100
PD_Multiplug_PMMA_90g_3	MP_square_10x10	72,17	75,74	76,64	71,27	77,02	78,72	57,47	65,63	78,19	65,16	70,94
PD_Multiplug_Ti_90g_8	MP_rectang_15x1	96,19	97,53	95,65	97,23	97,23	96,82	95,02	93,41	98,48	96,64	95,71
PD_Multiplug_Ti_tondo_0g_1E	MP_circle_5x5	88,14	93,71	93,03	92,17	90,6	91,85	79,7	87,69	92,65	89,38	$\boxed{89,19}$

>95%
<GPR<95%
<90%

https://docs.google.com/spreadsheets/d/1PfSidpiRLkXysVgFdrYhreBmwheSBT81/edit?gid=1273724532#gid=1273724532

5%/5mm

File name		Cross Validations										Averaging predictions
		CV 1	CV 2	CV 3	CV 4	CV 5	CV 6	CV 7	CV 8	CV 9	CV 10	
PD_6s10b2_100MU_3	INH_square_10x10	100	100	100	100	100	100	100	100	100	100	100
PD_6s10b2_100MU_6	INH_rectang_2x10	100	100	100	100	100	100	100	100	100	100	100
PD_6s10b3_100MU_1	INH_square_2x2	100	100	100	100	100	100	100	100	100	100	100
PD_6s20_100MU_4	INH_square_20x20	100	100	100	100	100	100	100	100	100	100	100
PD_6s30b1_100MU_2	INH_square_5x5	99,88	89,84	99,98	99,21	97,89	100	100	100	96,2	97,28	99,23
PD_Air2cm_100MU_1	SLAB_square_2x2	99,5	98,6	97,4	97,5	98,7	97,6	99,8	99,4	97,9	100	97,5
PD_Air2cm_100MU_6	SLAB_rectang_2x10	100	100	100	100	100	100	100	100	100	100	100
PD_Bone2Slab_100MU_3	SLAB_square_10x10	100	100	100	100	100	100	100	100	100	100	100
PD_Bone2Slab_100MU_4	SLAB_square_20x20	98,29	97,39	95,88	97,72	97,69	95,87	96,21	97,82	97,39	98,11	97,26
PD_Bone2Slab_b2_100MU_2	SLAB_square_5x5	100	100	100	100	100	100	100	100	100	100	100
PD_Cirs_centro_0g_100MU_8	CIRS_rectang_15x1	96,4	96,67	96,45	96,7	96,77	96,67	96,16	96,43	96,72	96,53	96,5
PD_Cirs_centro_270g_100MU_6	CIRS_rectang_2x10	100	100	100	100	100	100	100	100	100	100	100
PD_Cirs_les_0g_100MU_1	CIRS_square_2x2	100	100	100	100	100	100	100	100	100	100	100
PD_Cirs_les_0g_100MU_3	CIRS_square_10x10	100	100	100	100	100	100	100	100	100	100	100
PD_Cirs_les_0g_100MU_9	CIRS_rectang_1x15	100	100	100	100	100	100	100	100	100	100	100
PD_Cirs_les_270g_100MU_2	CIRS_square_5x5	100	100	100	100	100	100	100	100	100	100	100
PD_Cirs_les_90g_100MU_7	CIRS_rectang_10x2	100	100	100	100	100	100	100	100	100	100	100
PD_Multiplug_180g_5cm_ARIA_2	MP_square_5x5	100	100	100	100	100	100	100	100	100	100	100
PD_Multiplug_PMMA_180g_6	MP_rectang_2x10	100	100	100	100	100	100	100	100	100	100	100
PD_Multiplug_PMMA_90g_3	MP_square_10x10	96,6	95,87	98,37	96,34	98,15	98,8	89,88	92,1	97,78	92,27	94,7
PD_Multiplug_Ti_90g_8	MP_rectang_15x1	99,35	99,59	98,9	99,48	99,48	99,18	98,44	97,55	99,96	99,31	98,74
PD_Multiplug_Ti_tondo_0g_1E	MP_circle_5x5	100	100	100	100	100	100	97,49	100	100	100	100

GPR>95%

90%<GPR<95%

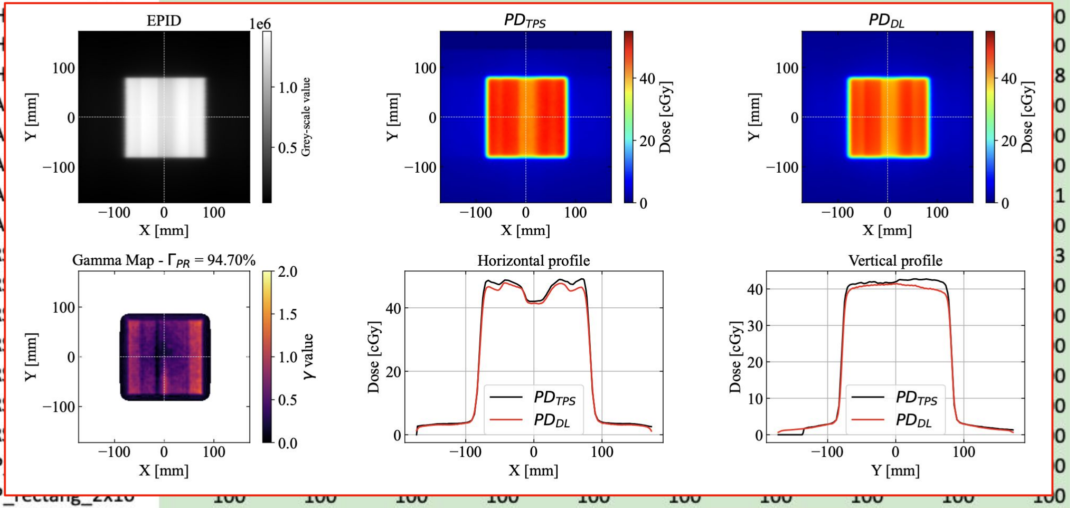
GPR<90%

https://docs.google.com/spreadsheets/d/1PfSidpiRLkXysVgFdrYhreBmwheSBT81/edit?gid=805514763#gid=805514763

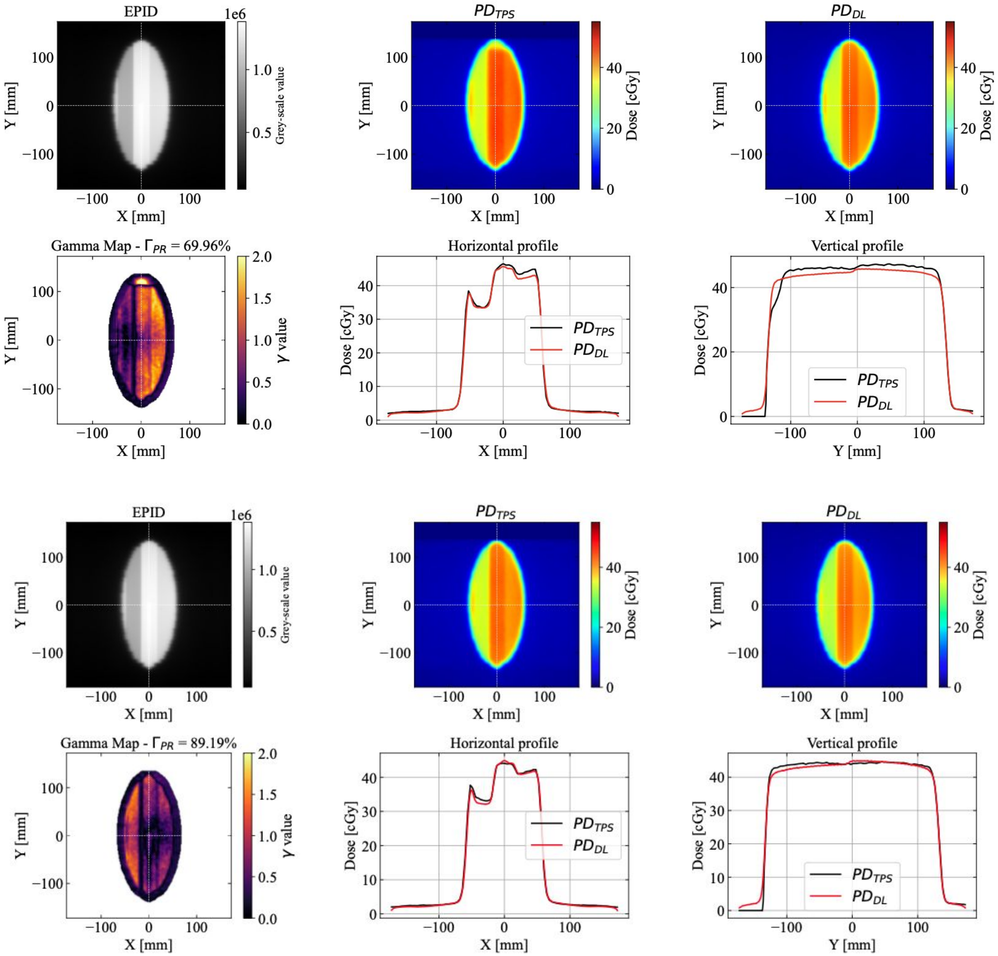
5%/5mm

File name		Cross Validations CV 1	CV 2	CV 3	CV 4	CV 5	CV 6	CV 7	CV 8	CV 9	CV 10	Averaging predictions
PD_6s10b2_100MU_3	INH_square_10x10	100	100	100	100	100	100	100	100	100	100	100
PD_6s10b2_100MU_6	INH_rectang_2x10	100	100	100	100	100	100	100	100	100	100	100
PD_6s10b3_100MU_1	INH										0	100
PD_6s20_100MU_4	INH										0	100
PD_6s30b1_100MU_2	INH										8	99,23
PD_Air2cm_100MU_1	SLA										0	97,5
PD_Air2cm_100MU_6	SLA										0	100
PD_Bone2Slab_100MU_3	SLA										0	100
PD_Bone2Slab_100MU_4	SLA										1	97,26
PD_Bone2Slab_b2_100MU_2	SLA										0	100
PD_Cirs_centro_0g_100MU_8	CIR										3	96,5
PD_Cirs_centro_270g_100MU_6	CIR										0	100
PD_Cirs_les_0g_100MU_1	CIR										0	100
PD_Cirs_les_0g_100MU_3	CIR										0	100
PD_Cirs_les_0g_100MU_9	CIR										0	100
PD_Cirs_les_270g_100MU_2	CIR										0	100
PD_Cirs_les_90g_100MU_7	CIR										0	100
PD_Multiplug_180g_5cm_ARIA_2	MP										0	100
PD_Multiplug_PMMA_180g_6	MP_rectang_2x10	100	100	100	100	100	100	100	100	100	100	100
PD_Multiplug_PMMA_90g_3	MP_square_10x10	96,6	95,87	98,37	96,34	98,15	98,8	89,88	92,1	97,78	92,27	94,7
PD_Multiplug_Ti_90g_8	MP_rectang_15x1	99,35	99,59	98,9	99,48	99,48	99,18	98,44	97,55	99,96	99,31	98,74
PD_Multiplug_Ti_tondo_0g_1E	MP_circle_5x5	100	100	100	100	100	100	97,49	100	100	100	100

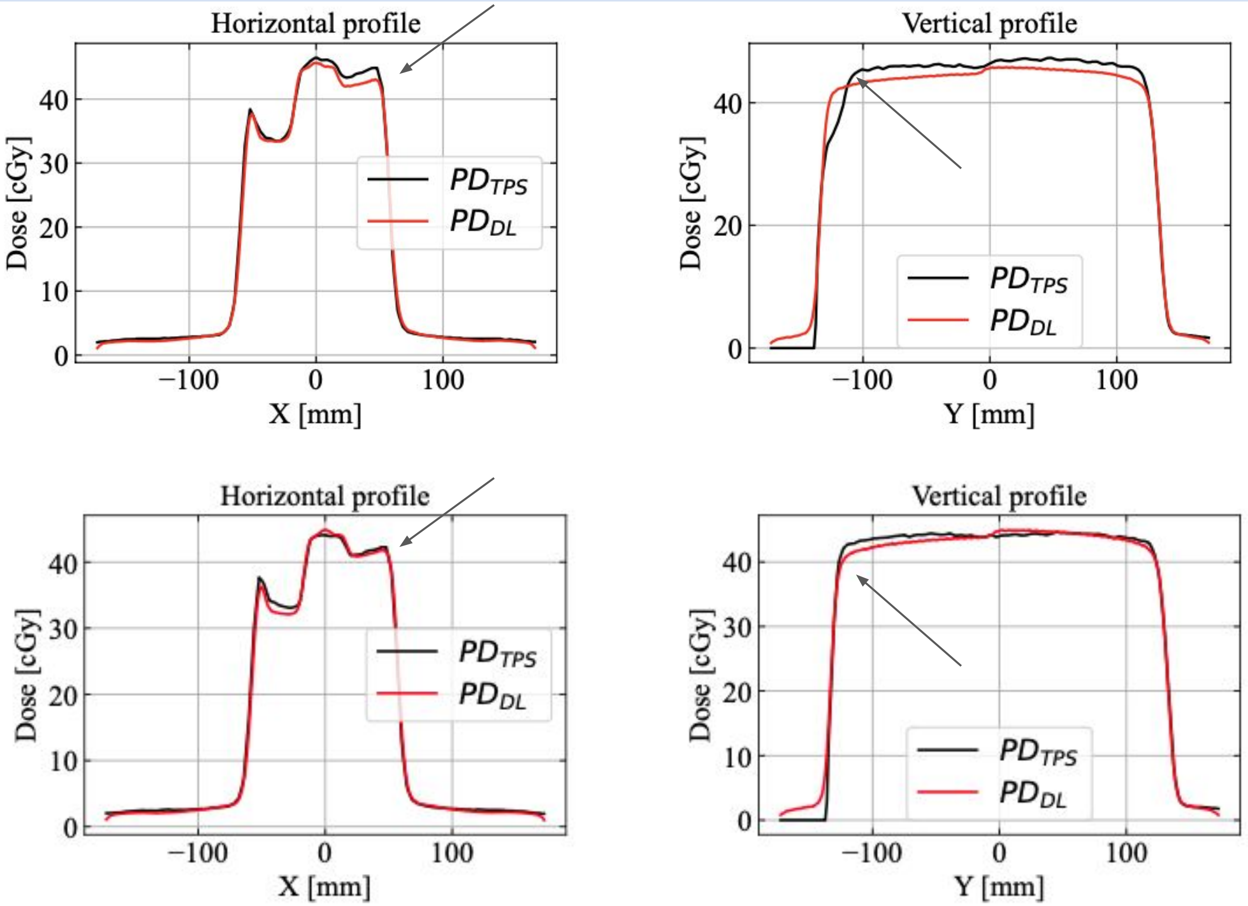
GPR>95%
90%<GPR<95%
GPR<90%



https://docs.google.com/spreadsheets/d/1PfSidpiRLkXysVgFdrYhreBmwheSBT81/edit?gid=805514763#gid=805514763



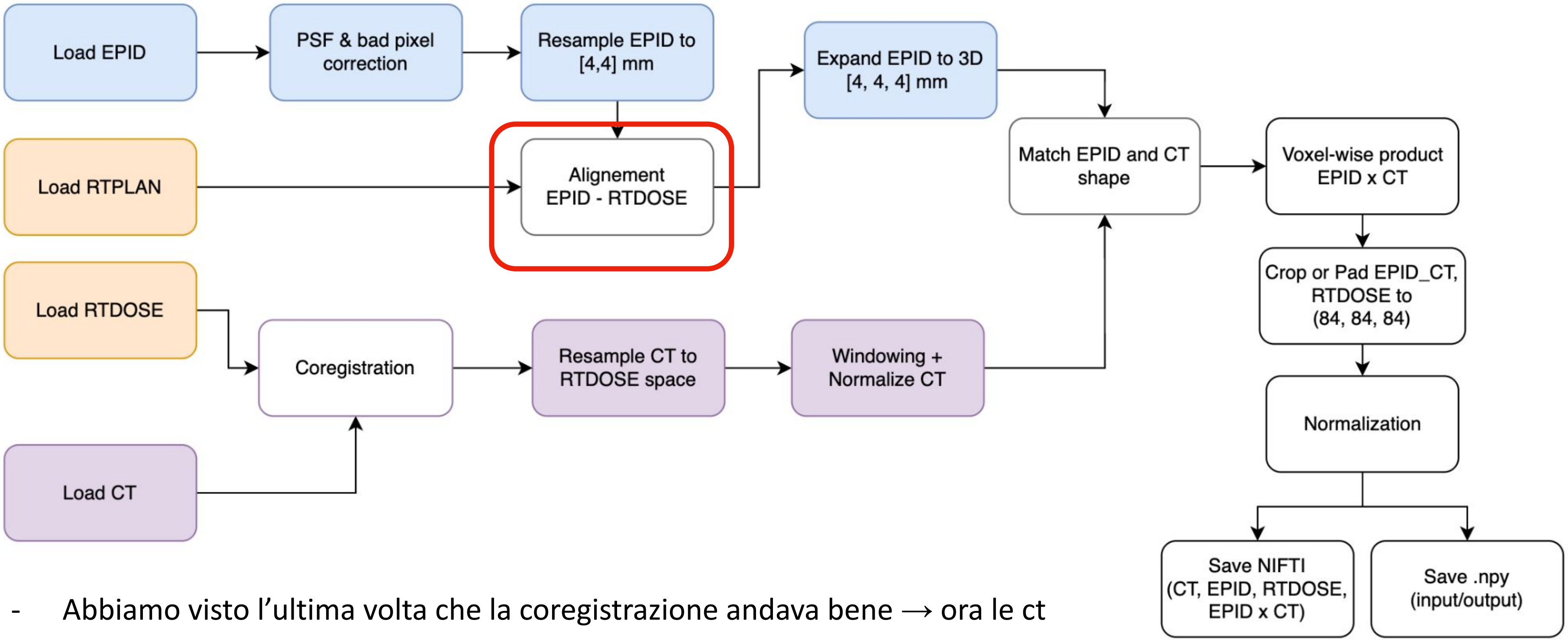
il caso peggiore di prima passa da 70% a 90%.



Il modello si comportava bene anche prima, solo la PD di riferimento era simulata nel modo sbagliato

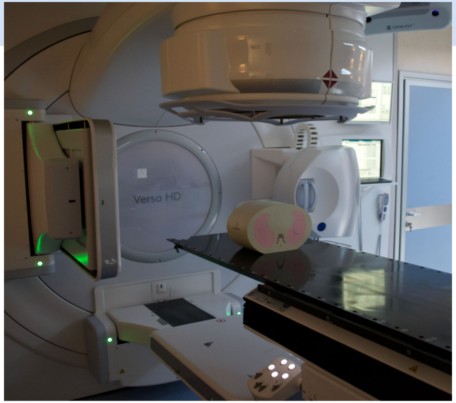
InTrEPID 3D

Cosa fa il preprocessing 3D



- Abbiamo visto l’ultima volta che la coregistrazione andava bene → ora le ct sono coregistrate agli rtdose
- problema aperto: allineare il segnale dell’immagine EPID a quello dell’RTDOSE tramite il valore di isocentro riportato nel tag dicom rtdose

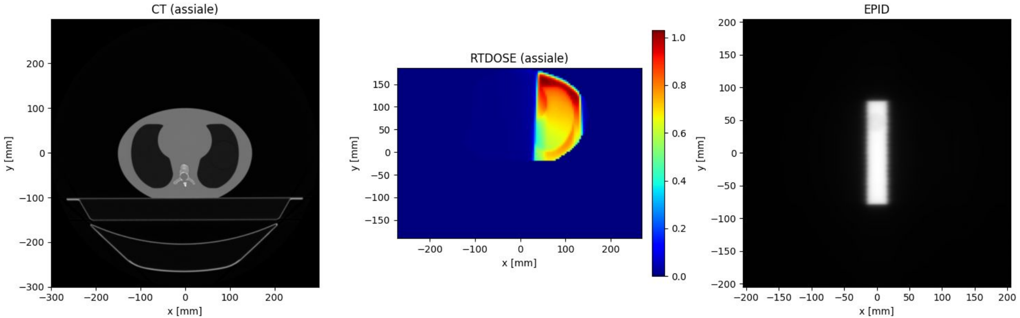
Notebook preprocessing_3D



ESEMPIO SUL CASO CIRS_lesione_0gradi_6

[64]:
```python
ct_dir = '/Volumes/lm/STUDY/3D/CT/CT_CIRS_lesione_0gradi_6/'
dose_path = '/Volumes/lm/STUDY/3D/RTDOSE/RTDOSE_CIRS_lesione_0gradi_6.dcm'
epid_path = '/Volumes/lm/STUDY/3D/EPID/EPID_CIRS_lesione_0gradi_6.dcm'
plan_path =  '/Volumes/lm/STUDY/3D/RTPLAN/RTPLAN_CIRS_lesione_0gradi_6.dcm'

ct_array, ct_spacing, ct_origin = load_ct_images(ct_dir)
dose_array, dose_spacing, dose_origin = load_rtdose(dose_path)
epid_array, epid_spacing = load_epid(epid_path)
iso, sep = load_rtplan(plan_path)
```

```
CT
shape = (214, 512, 512)
ct_spacing = [1.171875, 1.171875, 2.0] mm
ct_origin = [-300. -207. -220.] mm

RTDOSE
shape = (107, 95, 136)
rtdose_spacing = [4.0, 4.0, 4.0] mm
rtdose_origin = [-270.3  -11.6 -220. ] mm

EPID
shape = (1024, 1024)
epid_spacing = [0.4, 0.4] mm

RTPLAN
Isocenter = [85.7, 92.4, 0.0] mm
Surface Entry Point = [85.7, 11.0, 0.0] mm
```



Affinché la U-Net 3D si alleni su questi dati, devono avere **stessa shape**, **pixel spacing** e stesso **origine** (coregistrazione)

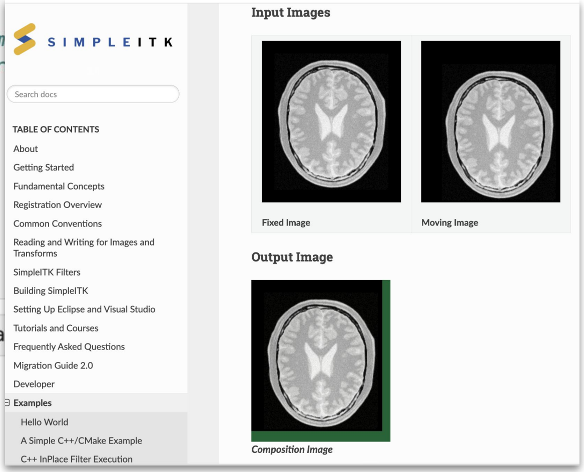
Ricampionamento CT in RTDOSE

import SimpleITK as sitk

```
def resample_ct(ct_array, ct_spacing, ct_origin, target_spacing, target_shape, target_origin):
    """Ricampiona le CT nello spazio dell'RTDOSE."""
    image = sitk.GetImageFromArray(ct_array) # Converte ct_array in un oggetto SimpleITK.Image
    image.SetSpacing(ct_spacing) # Imposta il pixel spacing originale della CT (in mm) nell'immagine [z, y, x].
    image.SetOrigin(ct_origin) # Imposta l’origine dell'immagine CT nello spazio del paziente.
    resampler = sitk.ResampleImageFilter() # Crea un oggetto ResampleImageFilter per interpolare il volume su una nuova griglia spaziale.
    resampler.SetOutputSpacing(target_spacing) # Specifica lo spacing desiderato (target),
    resampler.SetSize(target_shape[::-1]) # Imposta la dimensione (size) dell’output; inverte l’ordine da (z, y, x) a (x, y, z).
    resampler.SetOutputOrigin(target_origin) # Specifica il punto di origine (corner) per il volume target.
    resampler.SetInterpolator(sitk.sitkLinear) # Imposta il metodo di interpolazione.
    resampled = resampler.Execute(image) # Esegue la ricampionatura vera e propria.
    ct_resampled = sitk.GetArrayFromImage(resampled) # Converte l’immagine interpolata da SimpleITK.Im
    ct_resampled_spacing = target_spacing # Il nuovo pixel spacing coincinde a quello target per costr
    # PRINT
    print('Coregistrazione CT in RTDOSE: ')
    print(f'Vecchia shape: {ct_array.shape}')
    print(f'Vecchio pixel spacing: {ct_spacing} mm')
    print(f'Nuova shape: {ct_resampled.shape}')
    print(f'Nuovo pixel spacing: {ct_resampled_spacing} mm')

    return ct_resampled, ct_resampled_spacing
```

```
ct_resampled, ct_resampled_spacing = resample_ct(ct_array, ct_spacing, ct_origin, dose_spacing, dose_a
```

```
Coregistrazione CT in RTDOSE:
Vecchia shape: (214, 512, 512)
Vecchio pixel spacing: [1.171875, 1.171875, 2.0] mm
Nuova shape: (107, 95, 136)
Nuovo pixel spacing: [4.0, 4.0, 4.0] mm
```



https://simpleitk.readthedocs.io/en/master/link_ImageRegistrationMethod1_docs.html

SimpleITK documentation

SIMPLEITK

Search docs

TABLE OF CONTENTS

Registration Overview

The goal of registration is to estimate the transformation which maps points from one image to the corresponding points in another image. The transformation estimated via registration is said to map points from the **fixed image** coordinate system to the **moving image** coordinate system.

SimpleITK provides a configurable multi-resolution registration framework, implemented in the ImageRegistrationMethod class. In addition, a number of variations of the Demons registration algorithm are implemented independently from this class as they do not fit into the framework.

Actual Code

Code illustrating various aspects of the registration framework can be found in the set of examples which are part of the SimpleITK distribution and in the SimpleITK Jupyter notebook repository.

Initialization and Center of Rotation

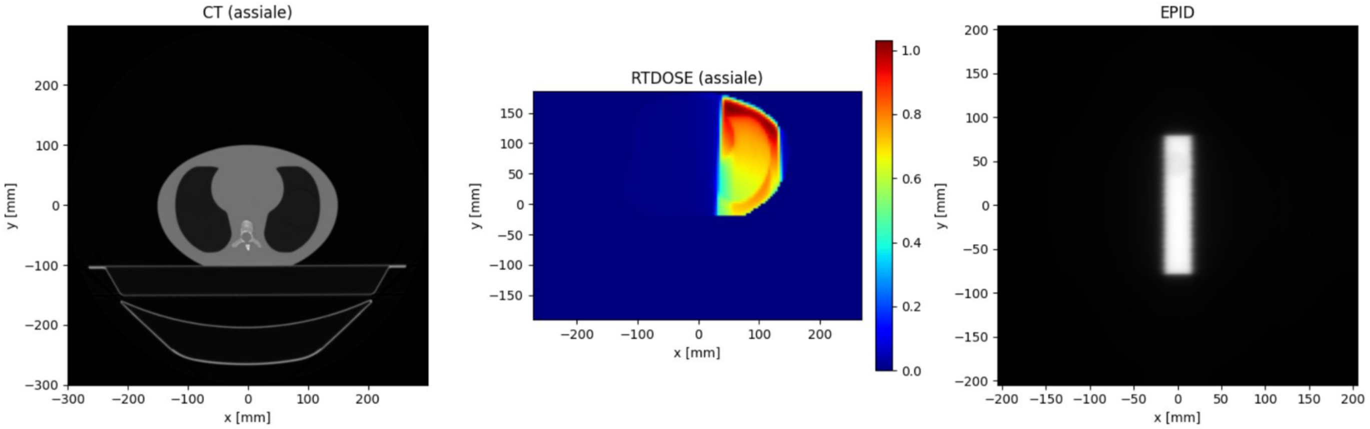
The task of registration is formulated using non-linear optimization which requires an initial estimate. The two most common initialization approaches are (1) Use the identity transform (a.k.a. forgot to initialize). (2) Align the physical centers of the two images (see CenteredTransformInitializerFilter). If after initialization there is no overlap between the images, registration will fail. The closer the initialization transformation is to the actual transformation, the higher the probability of convergence to the correct solution.

If your registration involves the use of a global domain transform (described here), you should also set an appropriate center of rotation. In many cases you want the center of rotation to be the physical center of the fixed image (the CenteredTransformCenteredTransformInitializerFilter ensures this). This is of significant importance for registration convergence due to the non-linear nature of rotation. When the center of rotation is far from our physical region of interest (ROI), a small rotational angle results in a large displacement. Think of moving the pivot/fulcrum point of a lever. For the same rotation angle, the farther you are from the fulcrum the larger the displacement. For numerical stability we do not want our computations to be sensitive to very small variations

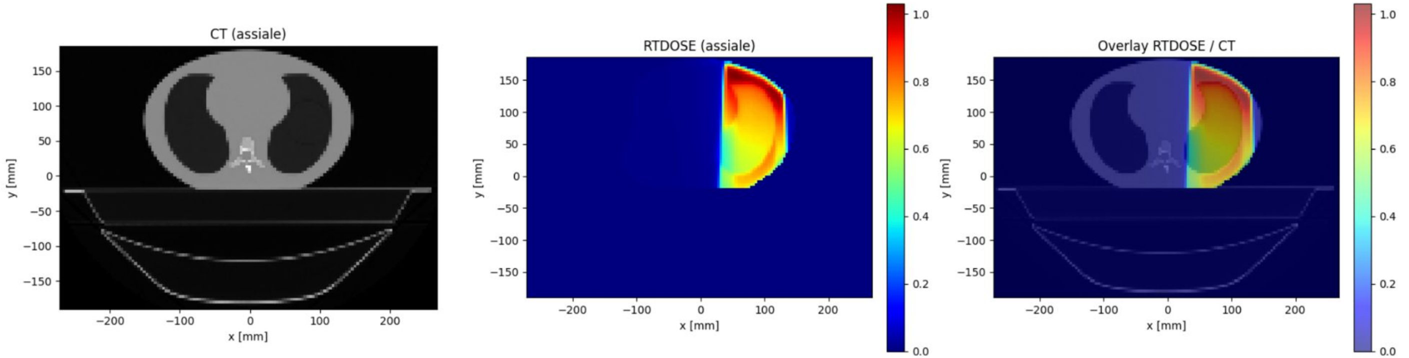
https://simpleitk.readthedocs.io/en/master/registrationOverview.html#lbl-registration-overview

Ricampionamento CT in RTDOSE

```
[66]: plot_ct_dose_epid(ct_array, dose_array, epid_array, ct_spacing, dose_spacing, epid_spacing)
```

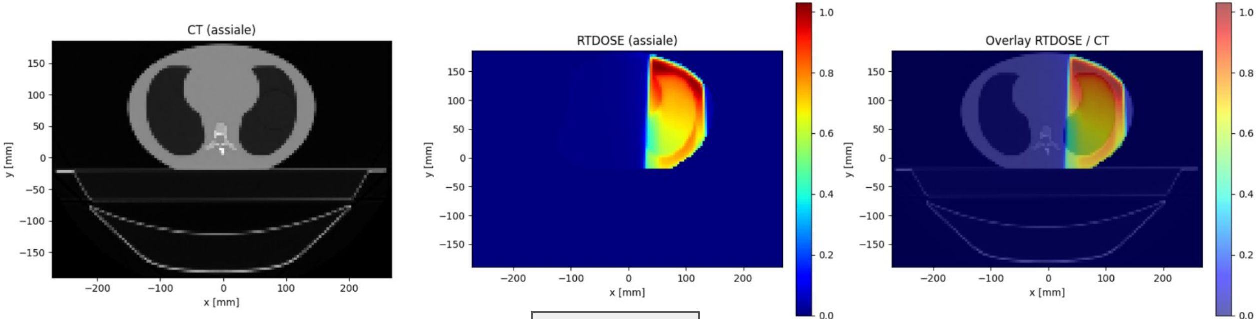



```
[85]: plot_ct_dose_overlay(ct_resampled, dose_array, ct_resampled_spacing, dose_spacing)
```

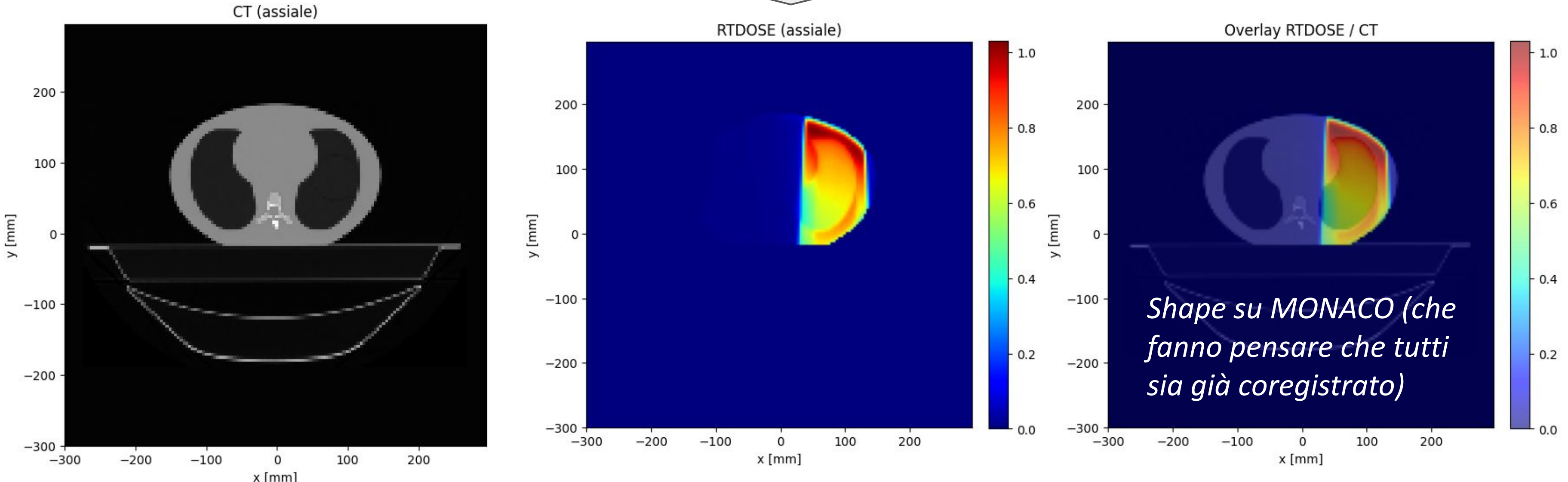


In realtà, MONACO inganna: padda i volumi per motivi estetici

Le vere shape dopo il ricampionamento …



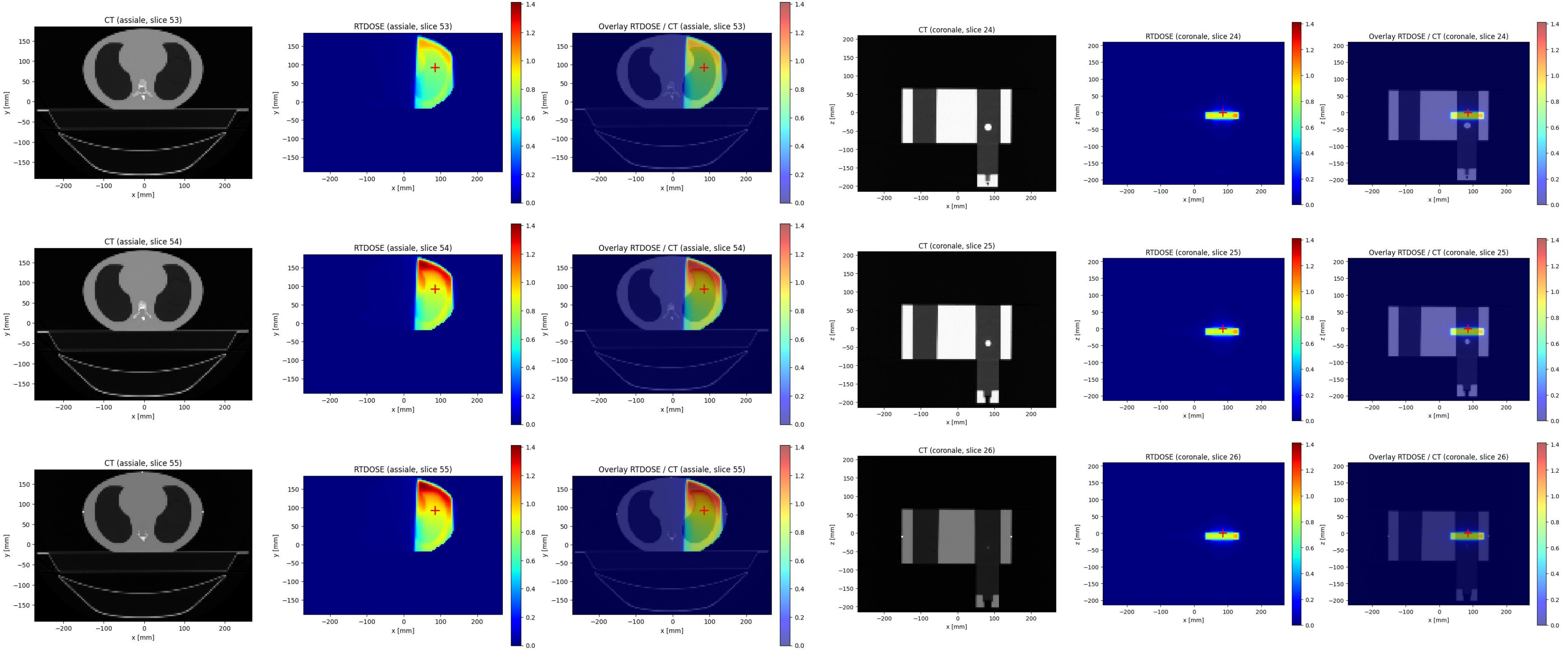
padding



Shape su MONACO (che fanno pensare che tutti sia già coregistrato)

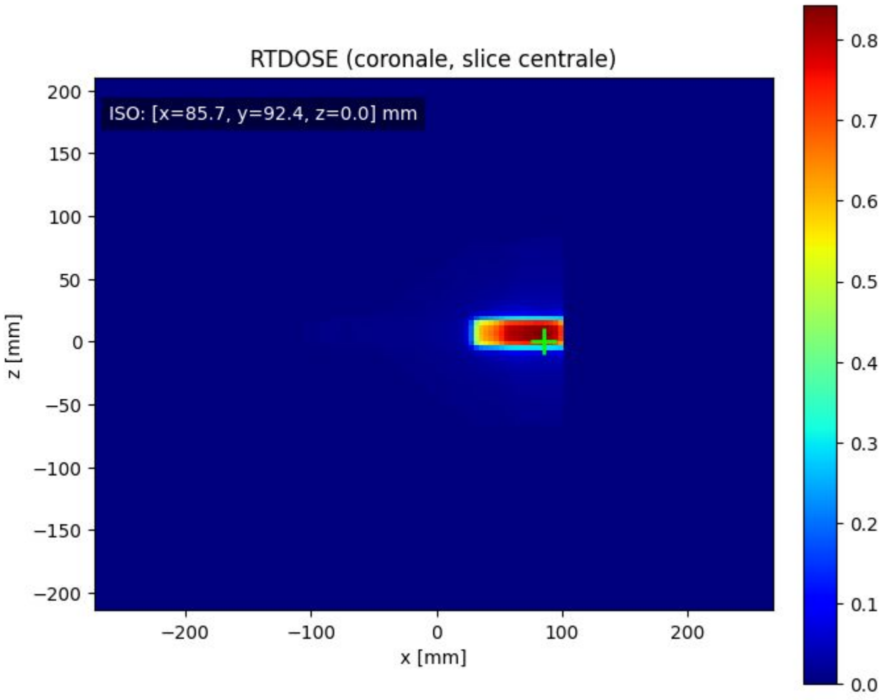
Isocentro (+) e RTDOSE

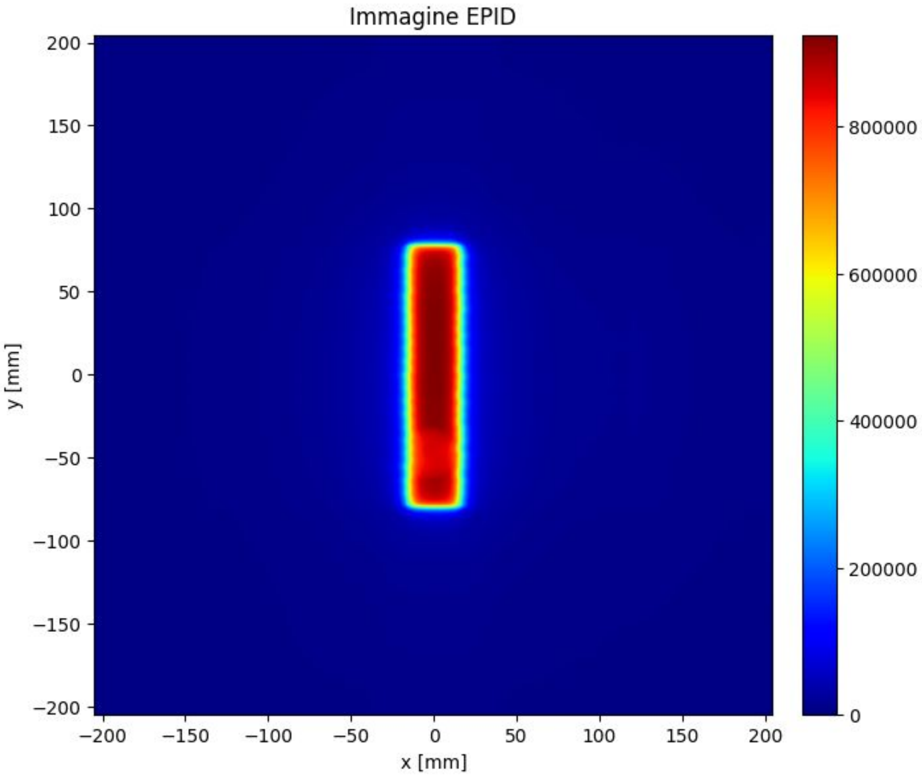
```
RTPLAN
Isocenter = [85.7, 92.4, 0.0] mm
Surface Entry Point = [85.7, 11.0, 0.0] mm
```



sembrerebbe che l'iso rappresenti veramente l'isocentro della distribuzione di dose

Perché allineare EPID - RTDOSE?





Allineamento EPID - RTDOSE

1. Rotazione della EPID

- Se la vedo “girata” rispetto alla dose ⇒ una rotazione di 90° (np.rot90). Da confermare se clockwise o counterclockwise.

2. Ricampionamento al pixel spacing della dose

- RTDOSE è a 4 × 4 × 4 mm.
- EPID ha pixel spacing diverso (es. ~0.405 × 0.405 mm).
- Resample della EPID → 4 × 4 mm ⇒ coordinate comparabili.

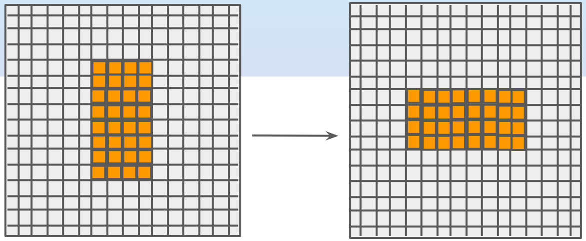
3. Padding per match dimensionale

- La EPID sarà più piccola rispetto al campo della dose.
- Va centrata e “bordata” con valori di background
- Obiettivo: avere la stessa shape in pixel della fetta della dose.

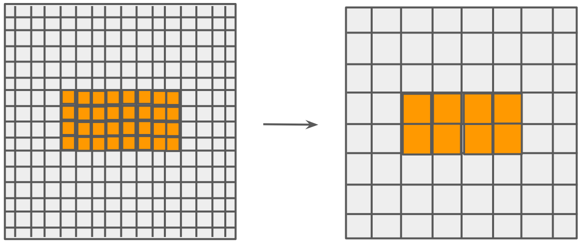
4. Shift dell’ISO in pixel

- Lo shift va calcolato in mm, poi convertito in pixel con lo spacing della dose (4 mm)
- Es: se devo spostare di +8 mm → corrisponderà a +2 pixel.
- Lo shift si applica con scipy.ndimage.shift o con slicing.

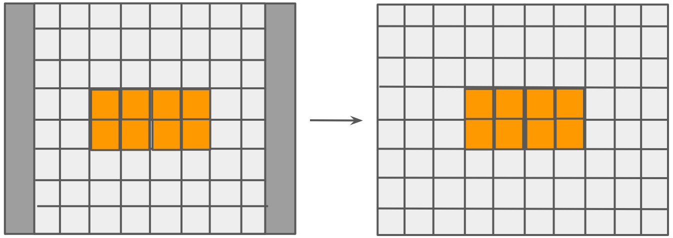
(1) Rot 90°



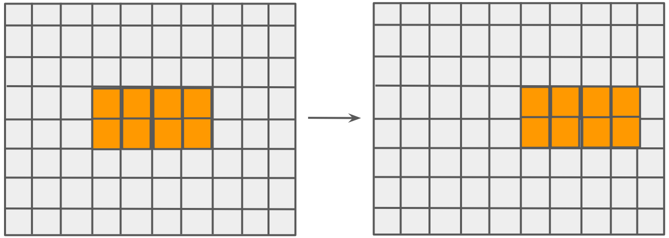
(2) Res 4mm



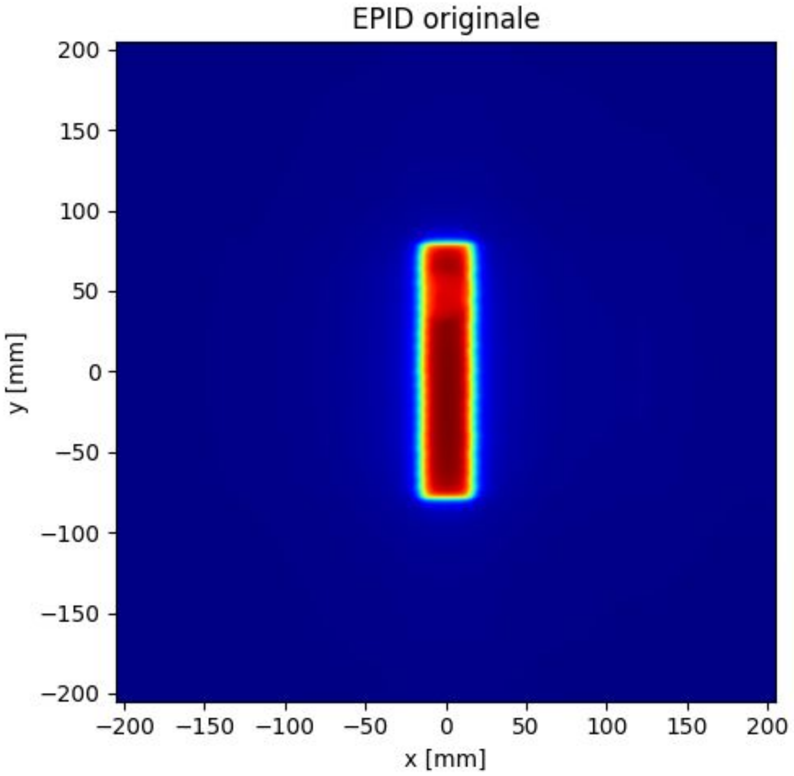
(3) Pad

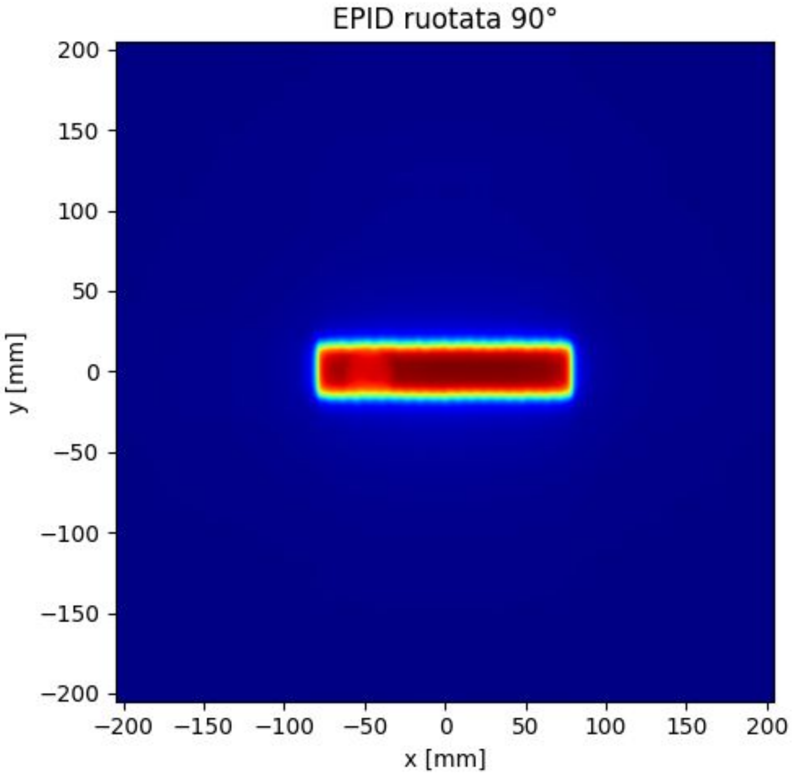


(4) Shift



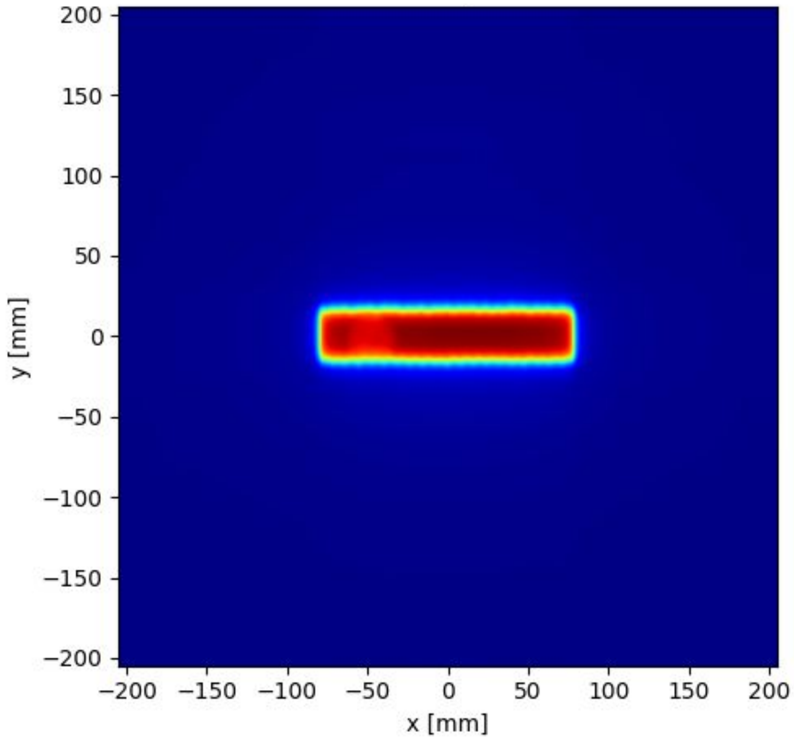
1) Rotazione 90°



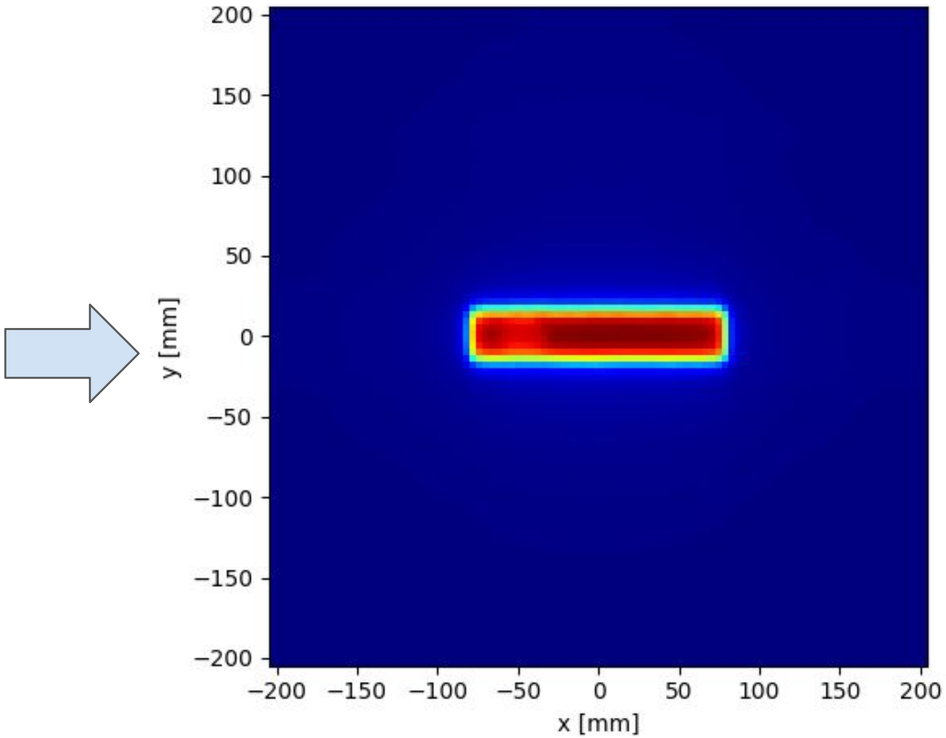


2) Ricampionamento EPID: da a ps 0.405 a 4 mm

[0.405, 0.405] mm

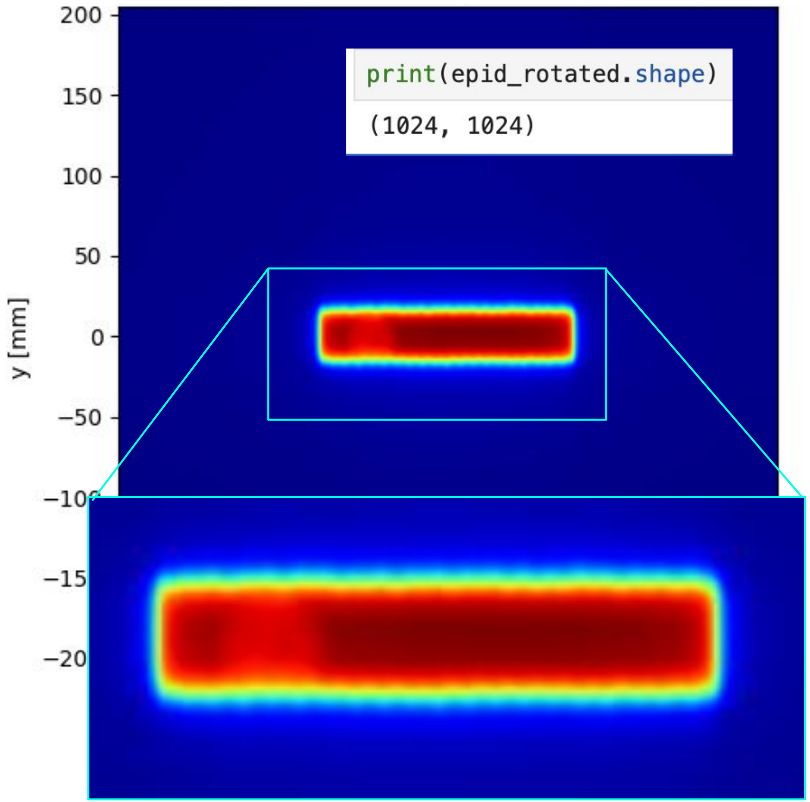


[4.0, 4.0] mm

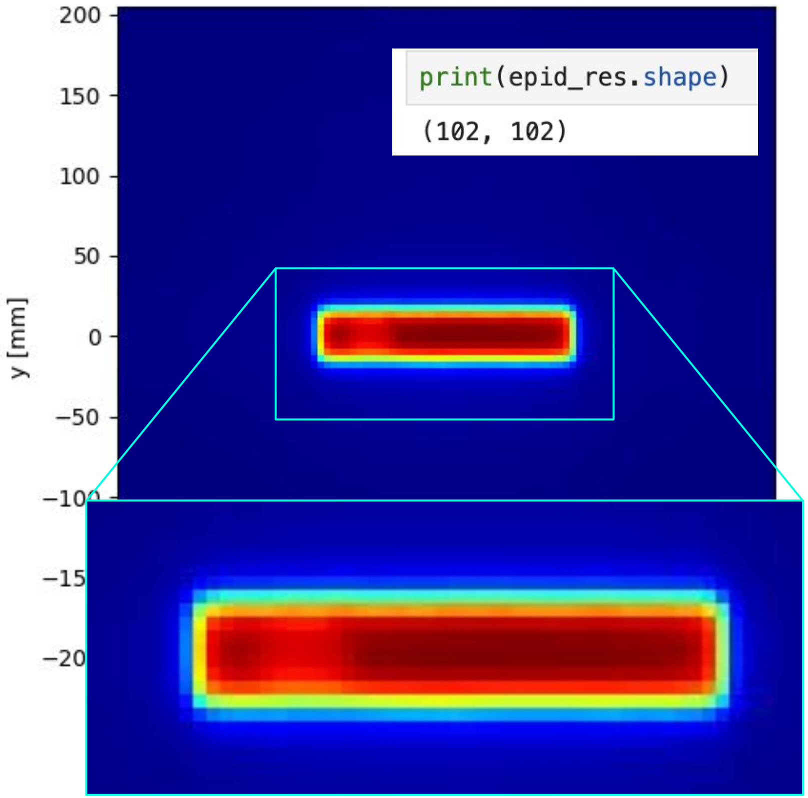


2) Ricampionamento EPID: da a ps 0.405 a 4 mm

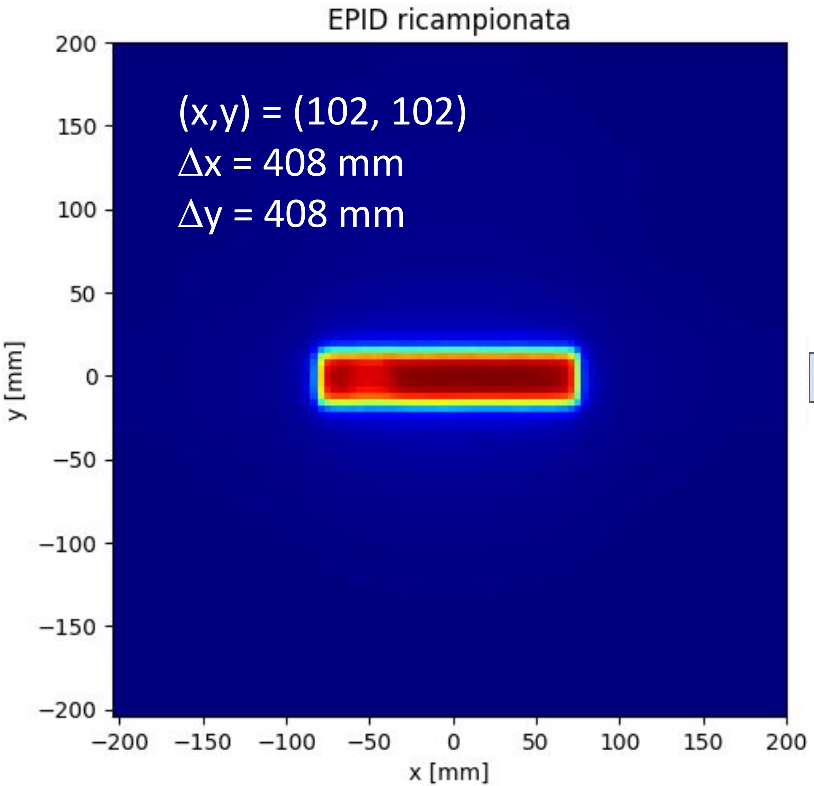
[0.405, 0.405] mm

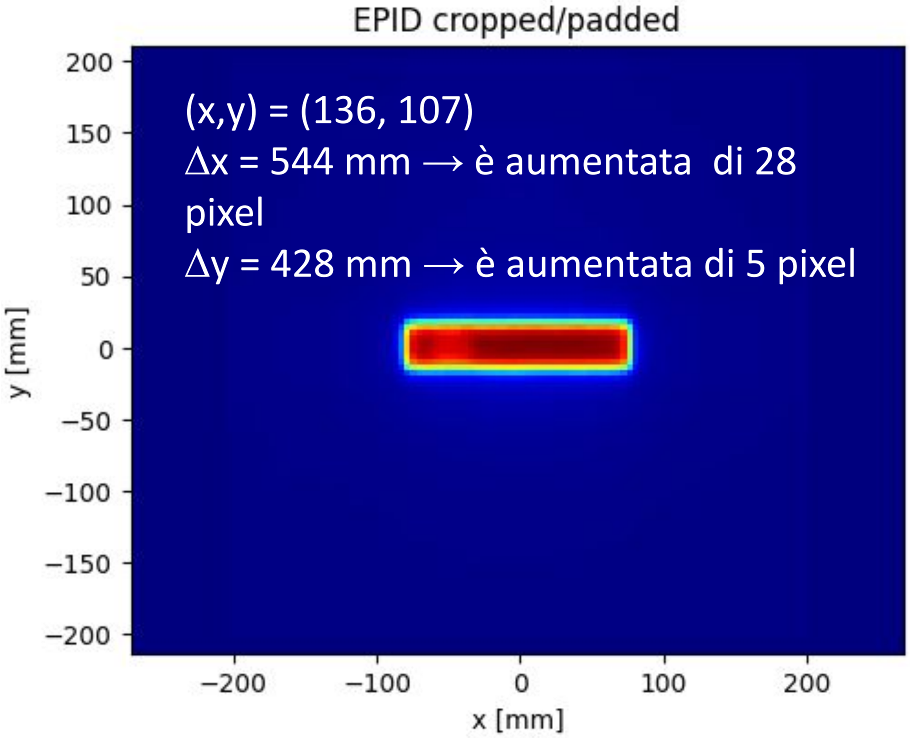


[4.0, 4.0] mm



3) Padding di EPID per match con RTDOSE (in coronale)

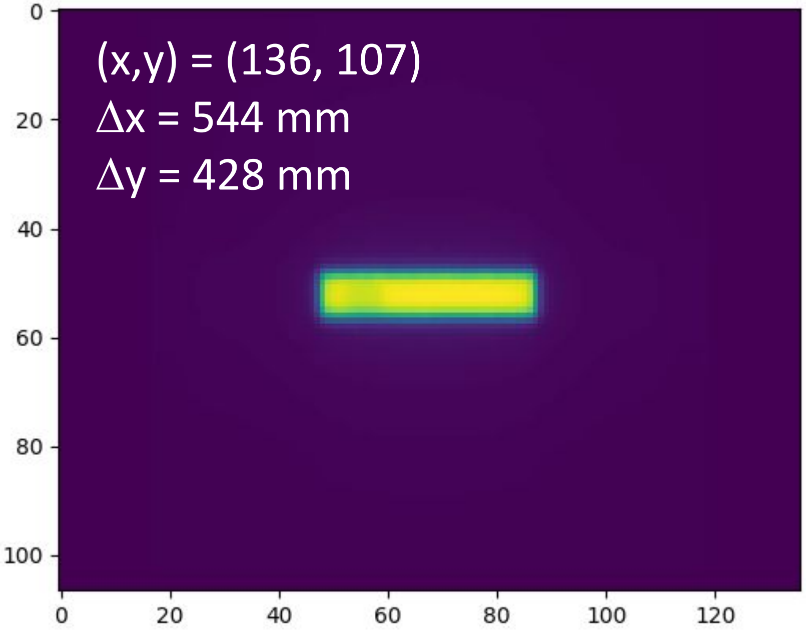




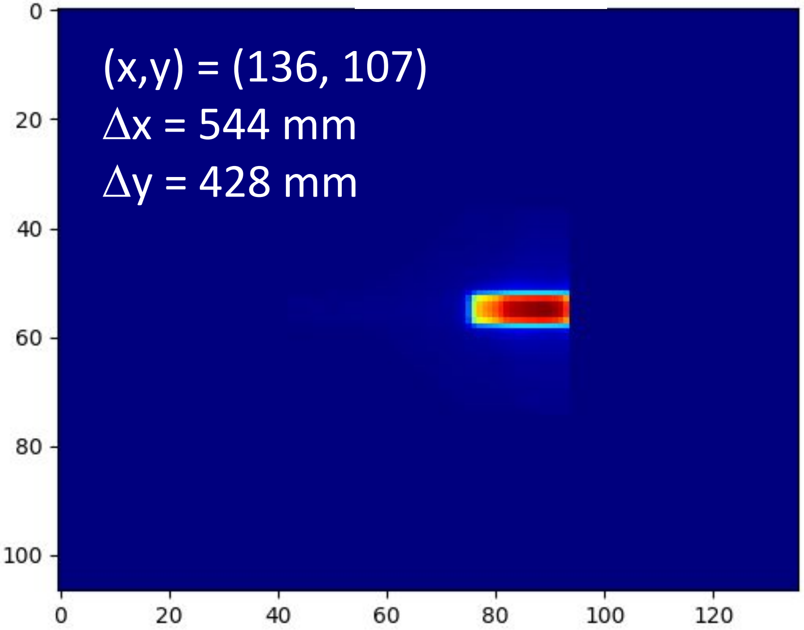
e se non conosco la shape di rtdose?

Confronto rtdose fetta centrale coronale vs epid padded

final epid



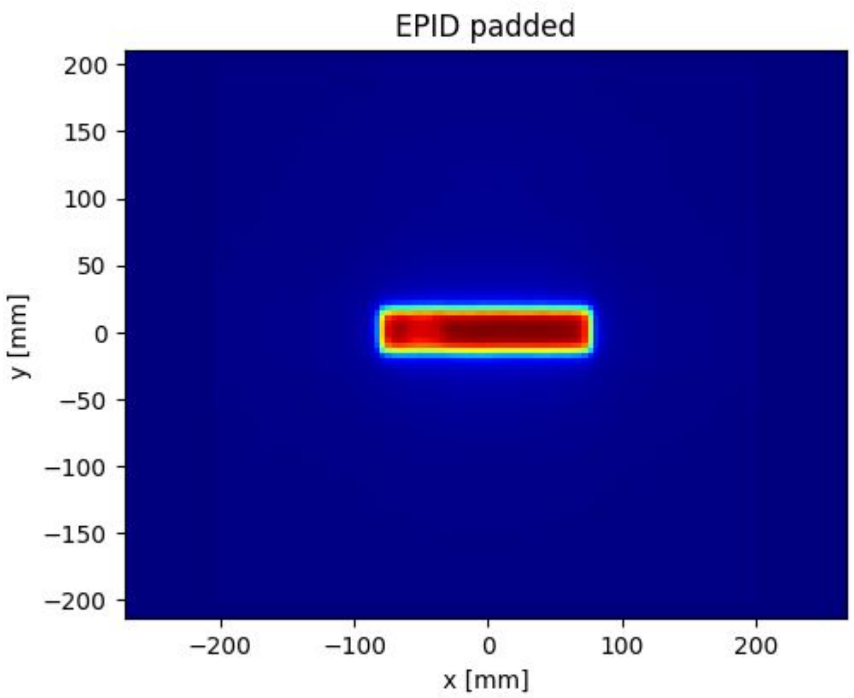
dose array

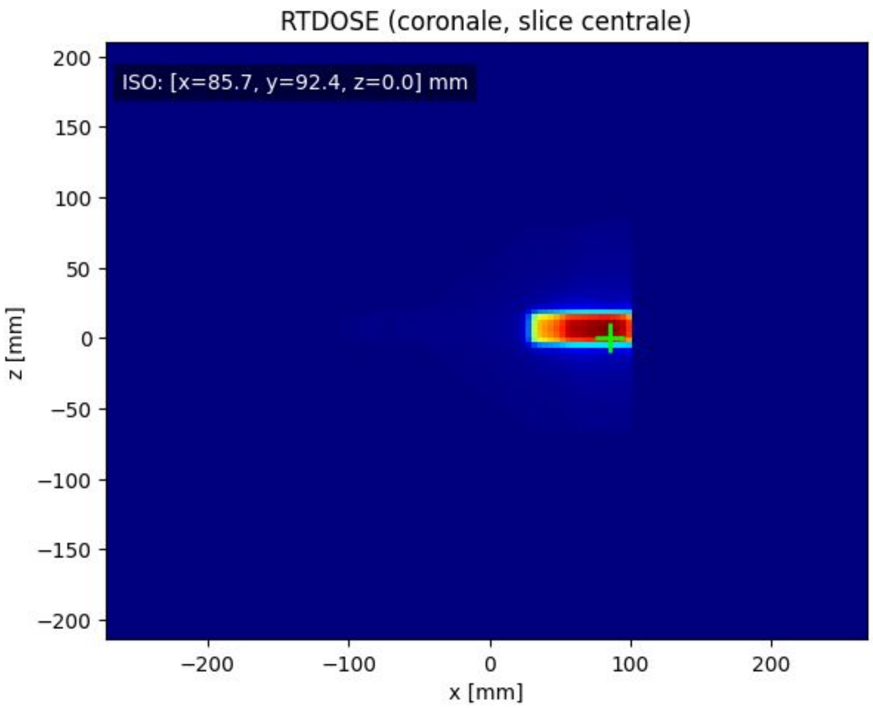



```
epid_final = match_shape(epid_res, (dose_array.shape[0], dose_array.shape[2]), pad_value=0.0)

print(epid_final.shape)
print(dose_array.shape[0:])
```

```
(107, 136)
(107, 95, 136)
```

4) Shift isocentro

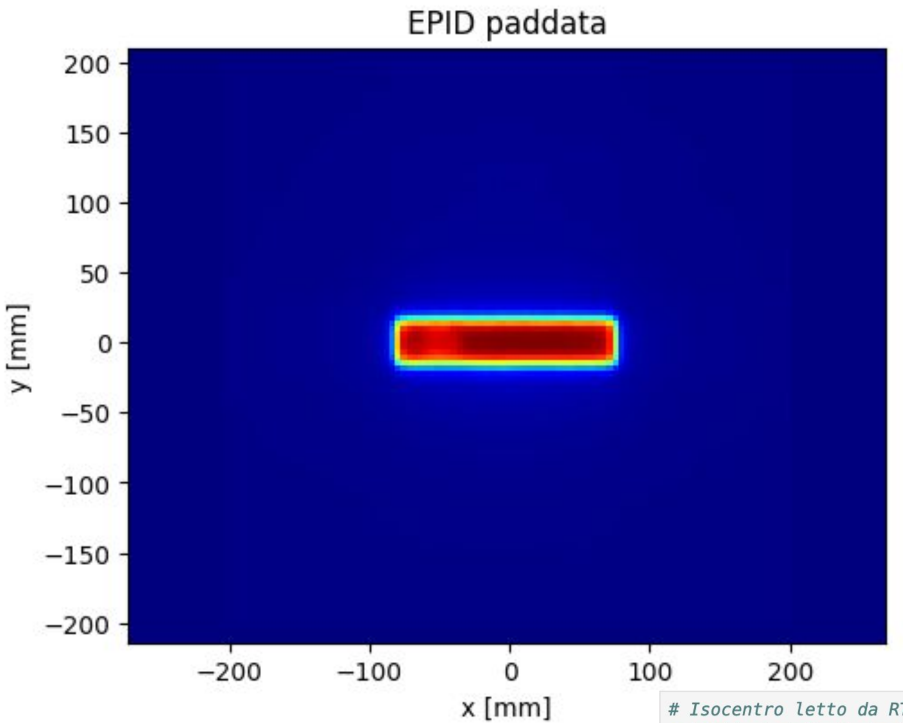


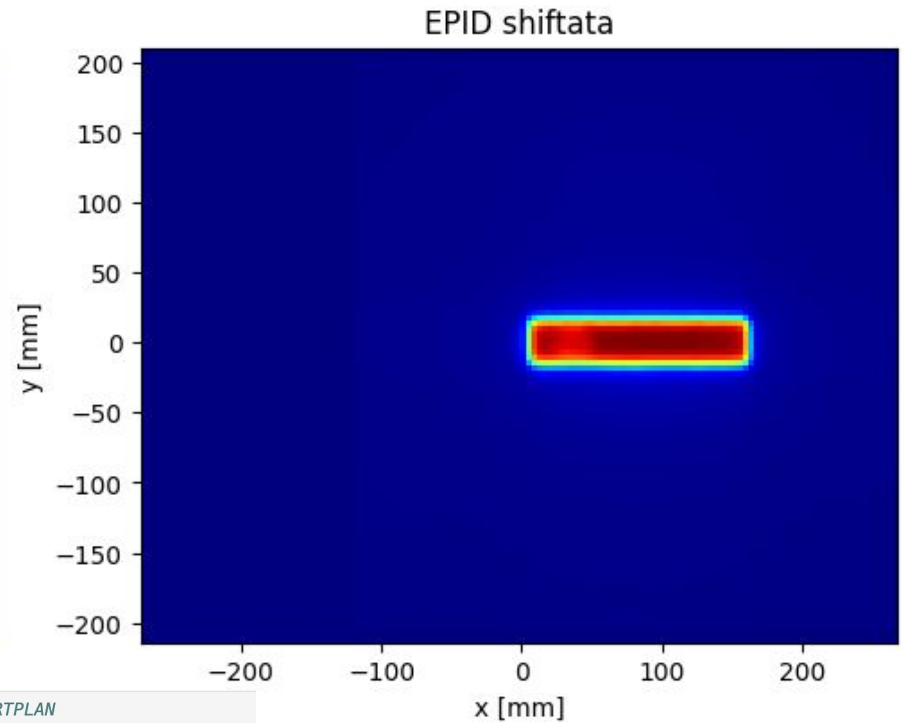


EPID e RTDOSE (coronale) hanno finalmente stessa shape e pixel spacing. Adesso siamo pronti a shiftare la distribuzione del segnale EPID di una quantità uguale all’isocentro letto dallRTPLAN.

Ci sono dei fattori geometrici che non sto considerando? Magnificazione etc?

4) Shift isocentro





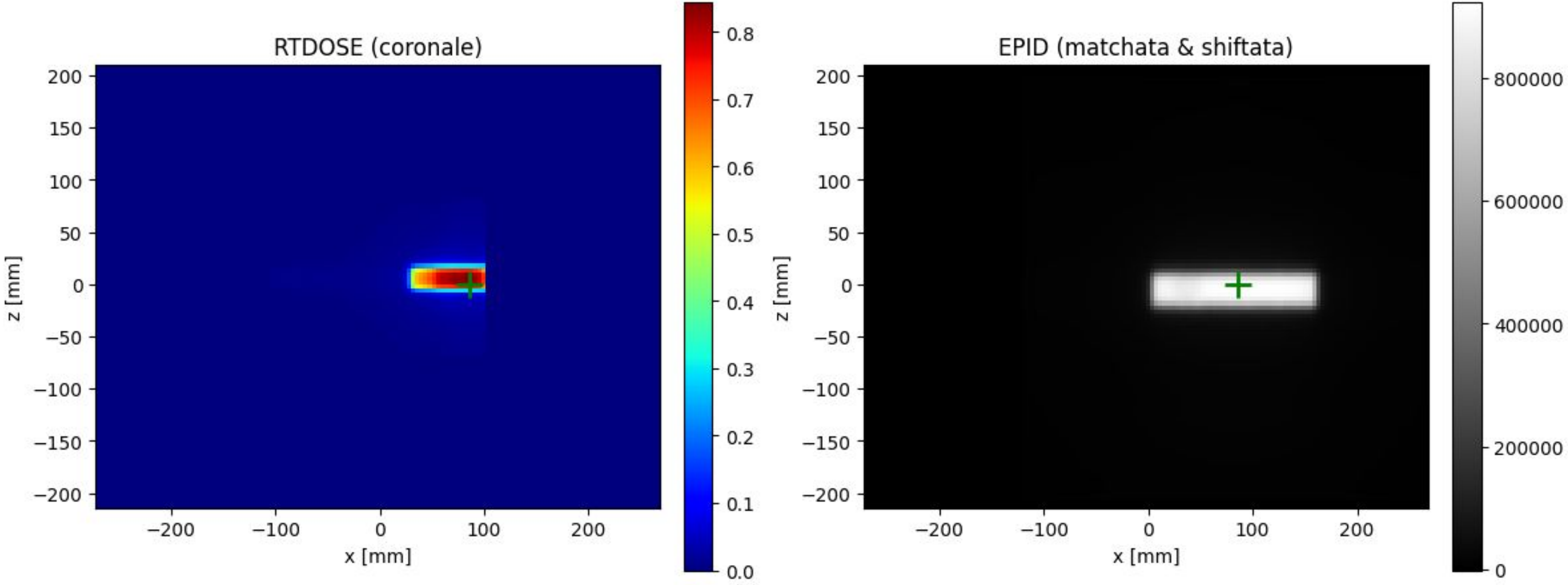

```
# Isocentro letto da RTPLAN
print(iso) # X, Y, Z (io voglio solo x e y)
```

```
[85.7, 92.4, 0.0]
```

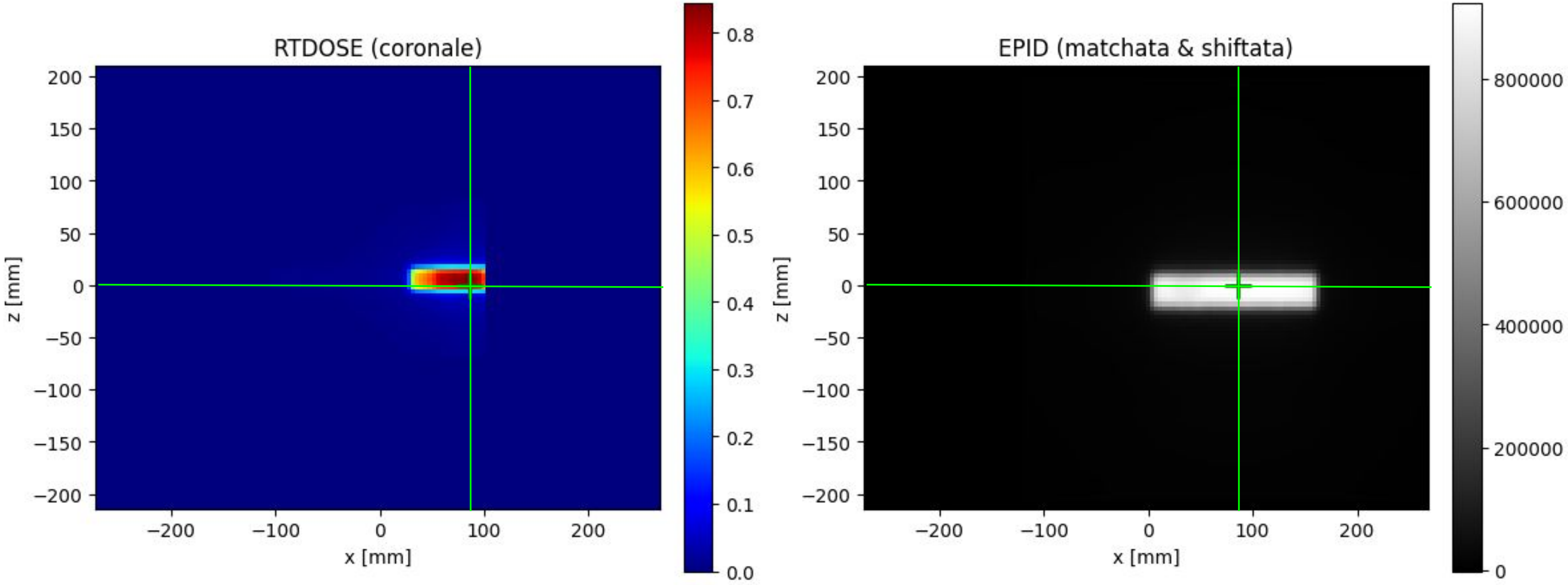
```
iso_coronal = [iso[0], iso[2]]

print(f'iso_coronal = {iso_coronal}mm')
```

```
iso_coronal = [85.7, 0.0]mm
```

EPID vs RTDOSE

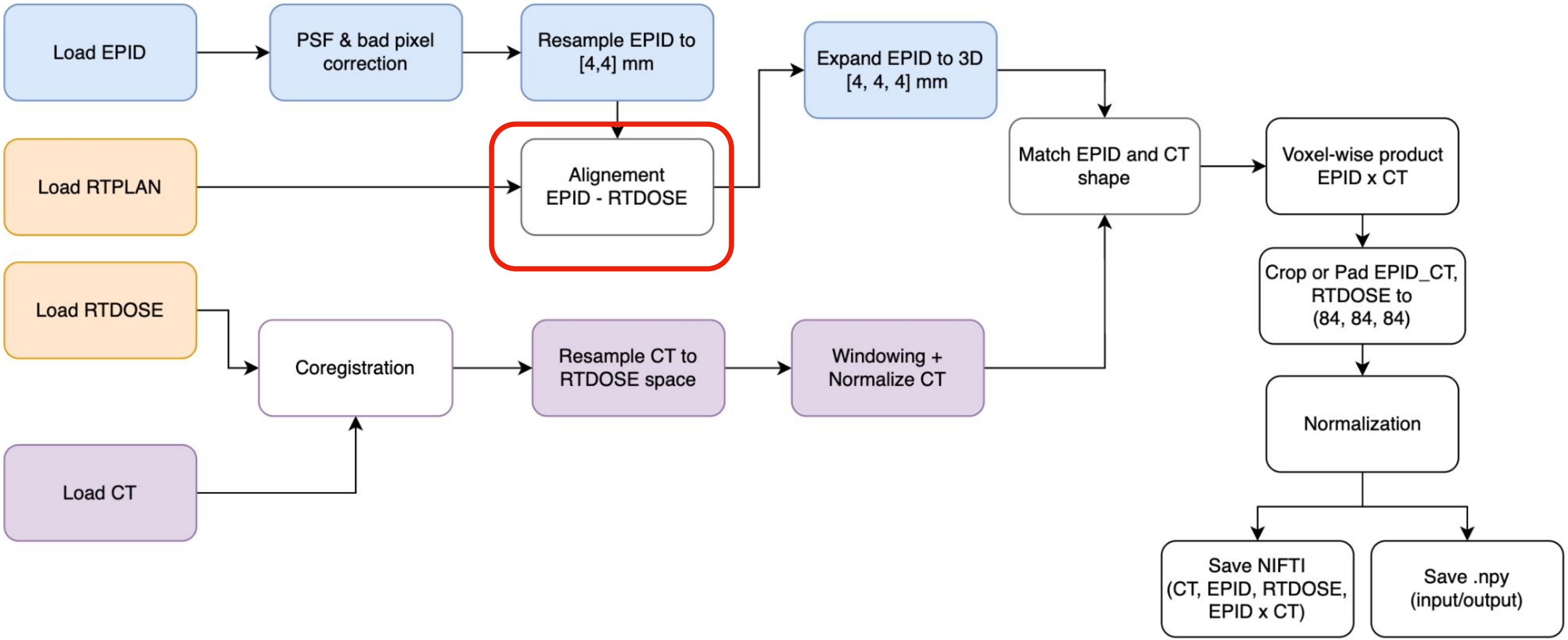


EPID vs RTDOSE



L’isocentro sull’rtdose non sembra proprio centratissimo rispetto alla distribuzione di dose, ma questo penso sia dovuto al TPS… da indagare

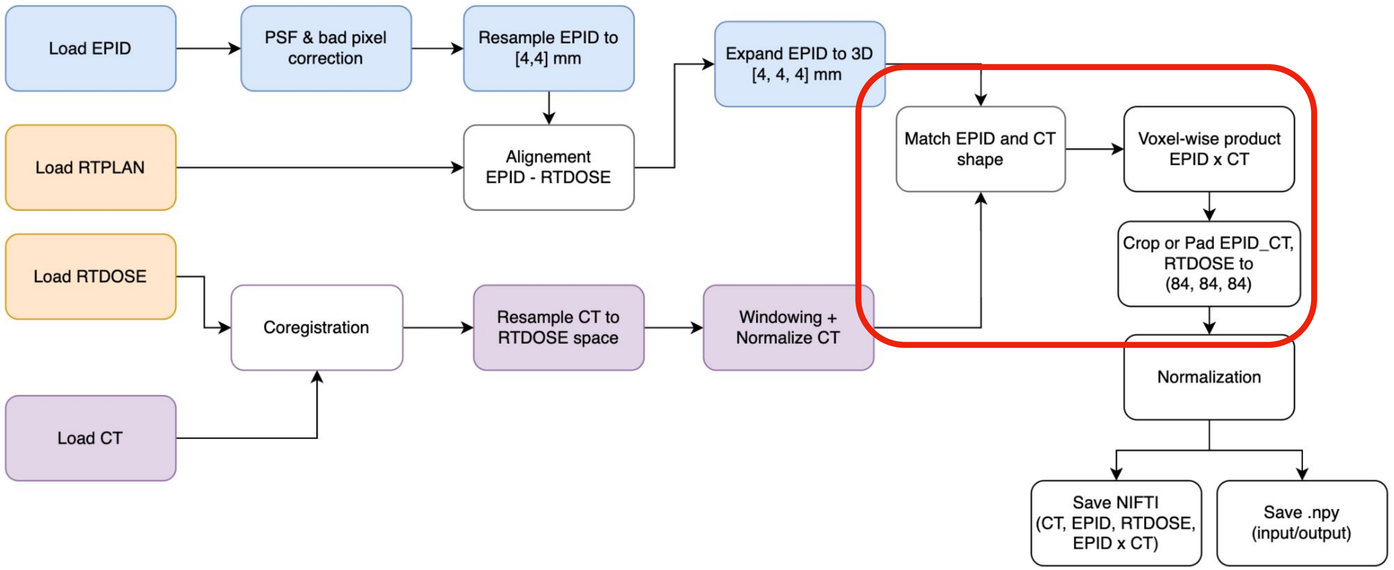
Cosa fa il preprocessing 3D



Matching EPID con CT

Al posto della retroproiezione facciamo una moltiplicazione EPID x CT (voxel wise)

Per fare questo, la EPID deve essere estesa al 3D in modo da matchare la sua shape (il numero dei voxel deve essere lo stesso lungo x,y,z)



Espansione EPID allineata da 2D a 3D

```python
# EPID (allineata)
print(epid_shifted.shape) # (Z, X)

# CT (ricampionata)
print(ct_resampled.shape)
print(ct_resampled_spacing)

# RTDOSE
print(dose_array.shape) # (Z, Y, X)
```

```
(107, 136)
(107, 95, 136)
[4.0, 4.0, 4.0]
(107, 95, 136)
```

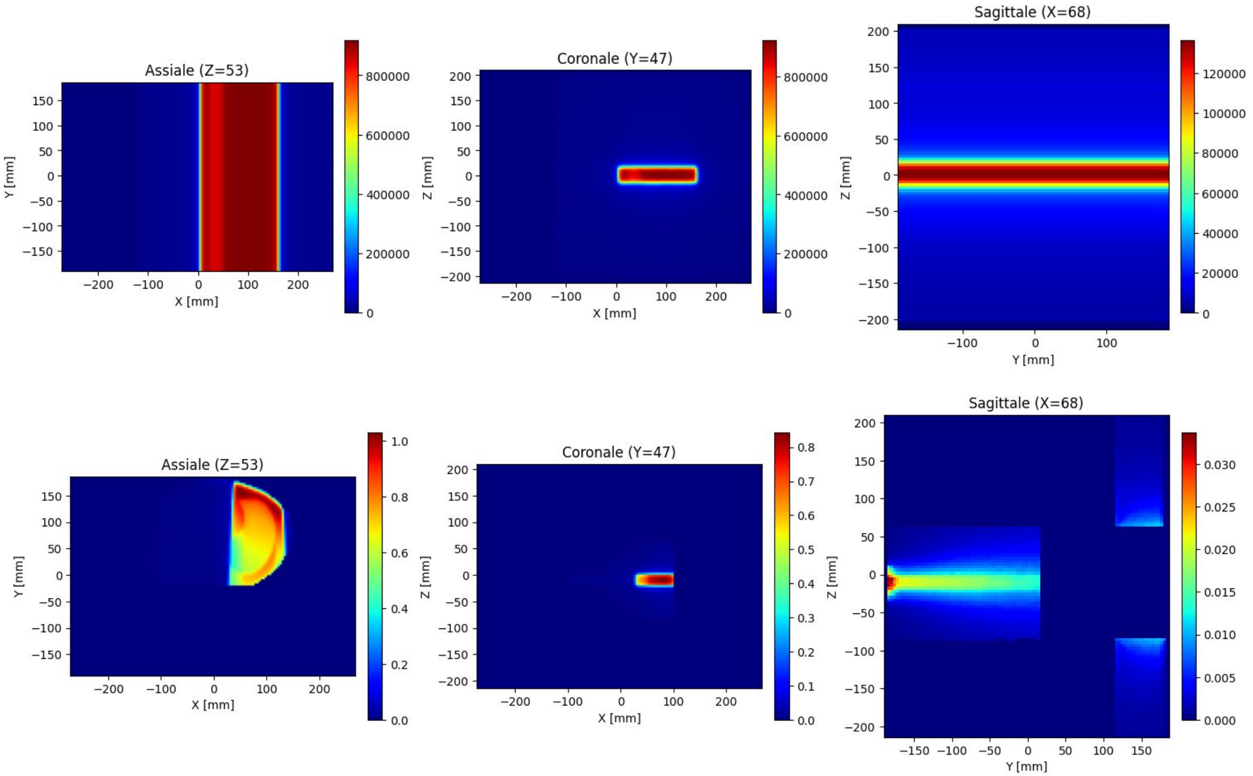
Quindi basta replicare la EPID lungo Y = 95 e moltiplicare.

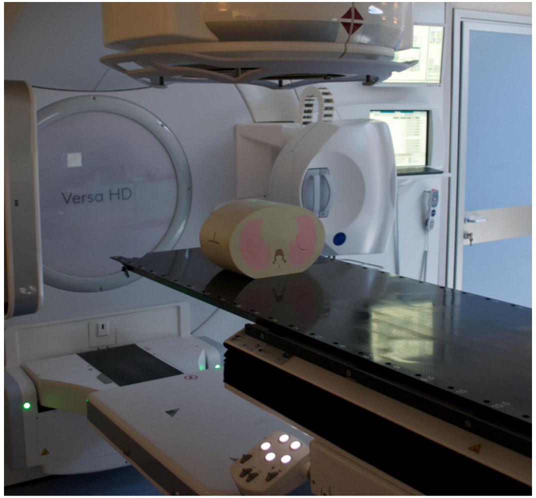
```python
def expand_epid_to_3d(epid_2d: np.ndarray, target_y: int) -> np.ndarray:
    """
    Espande un'immagine EPID 2D (Z, X) replicandola lungo l'asse Y per ottenere shape (Z, Y, X).
    """

    # broadcast_to crea una "vista" leggera, .copy() materializza l'array
    epid_3d = np.broadcast_to(
        epid_2d[:, np.newaxis, :],
        (epid_2d.shape[0], target_y, epid_2d.shape[1])
    ).copy()

    # non crea davvero un nuovo array pieno di dati duplicati: crea una vista che “finge” di avere shape (Z, Y, X),
    # ma ogni “striscia” lungo l’asse Y punta sempre alla stessa memoria originale di epid_2d.
    return epid_3d
```

```python
# Espandi la EPID allineata
epid_3d = expand_epid_to_3d(epid_shifted, target_y=dose_array.shape[1])
print("EPID 3D shape:", epid_3d.shape)    # (107, 95, 136)
```

```
EPID 3D shape: (107, 95, 136)
```

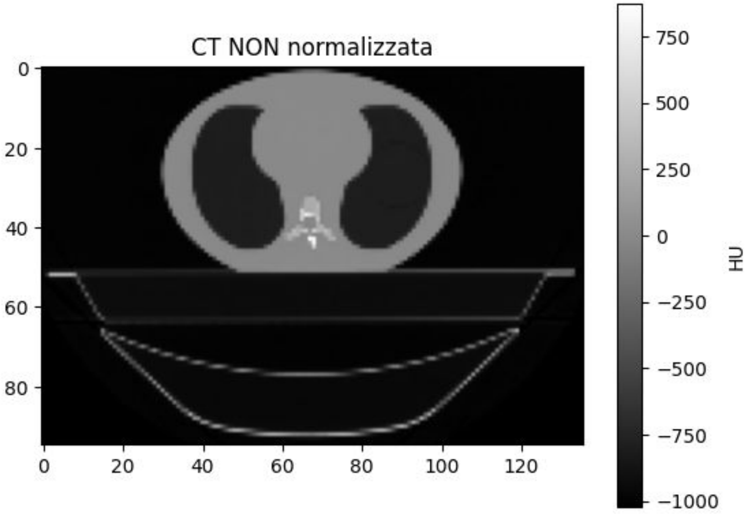
EPID 3D vs RTDOSE (slice centrali delle 3 viste)

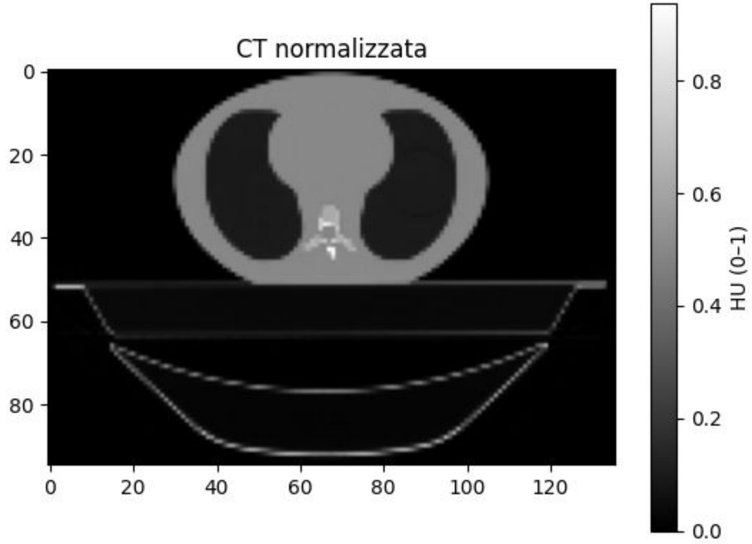




CT: windowing e normalizzazione

```
def normalize_ct_with_windowing(volume, window_min=-1000, window_max=1000):
    """Applica windowing alla CT e normalizza tra 0 e 1."""
    clipped = np.clip(volume, window_min, window_max)
    normalized_ct = (clipped - window_min) / (window_max - window_min)

    return normalized_ct
```





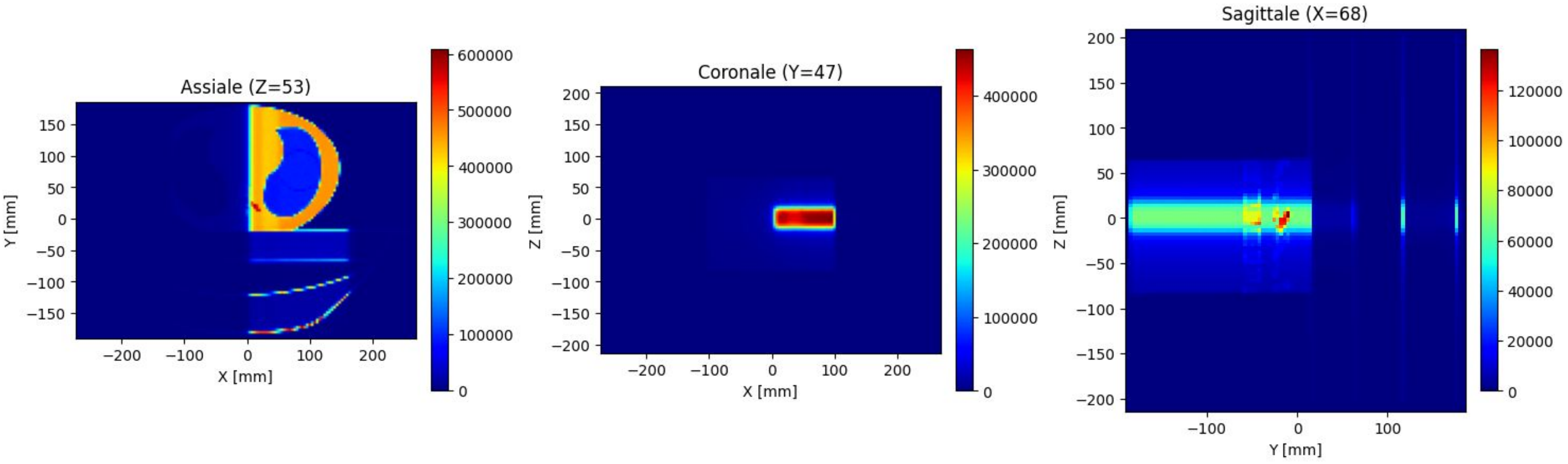
EPID 3D allineata a rtdose * CT ricampionata e normalizzata

```
# Prodotto voxel-wise tra EPID 3D e CT
epid_ct = ct_norm * epid_3d
```

```
epid_ct.shape
```

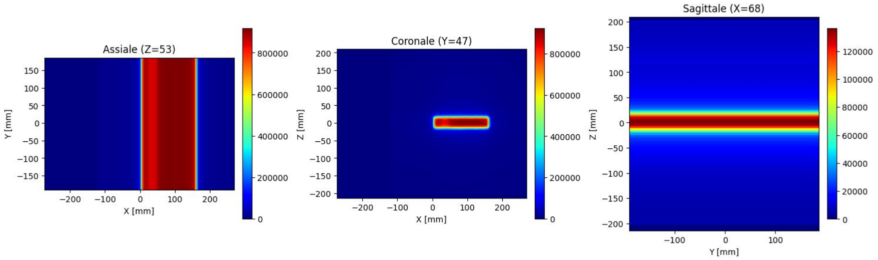
```
(107, 95, 136)
```

```
plot_central_slices(epid_ct, spacing=(4.0, 4.0, 4.0), cmap="jet")
```



EPID 3D

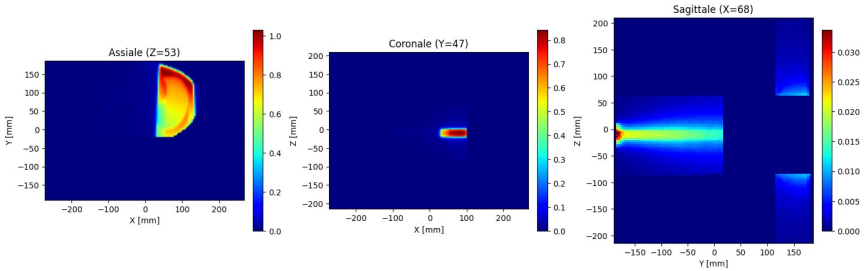
ricampionata all’rtdose e allineata all’RTDOSE

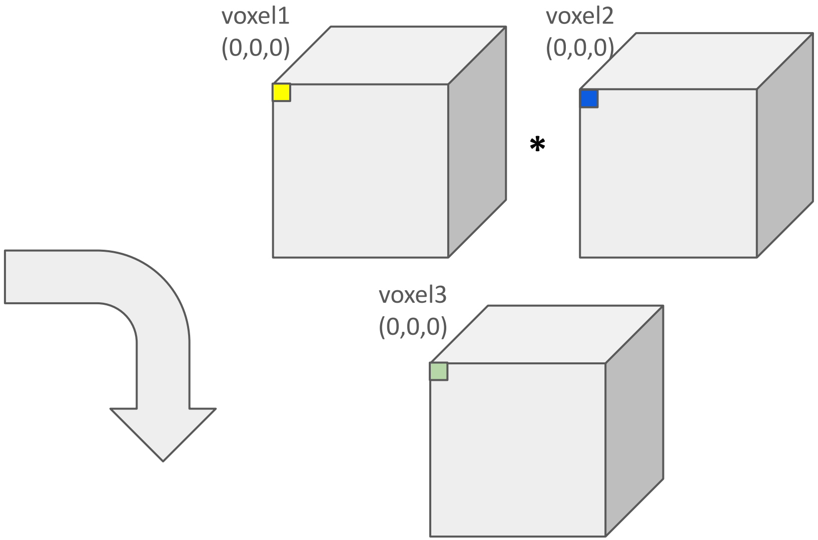


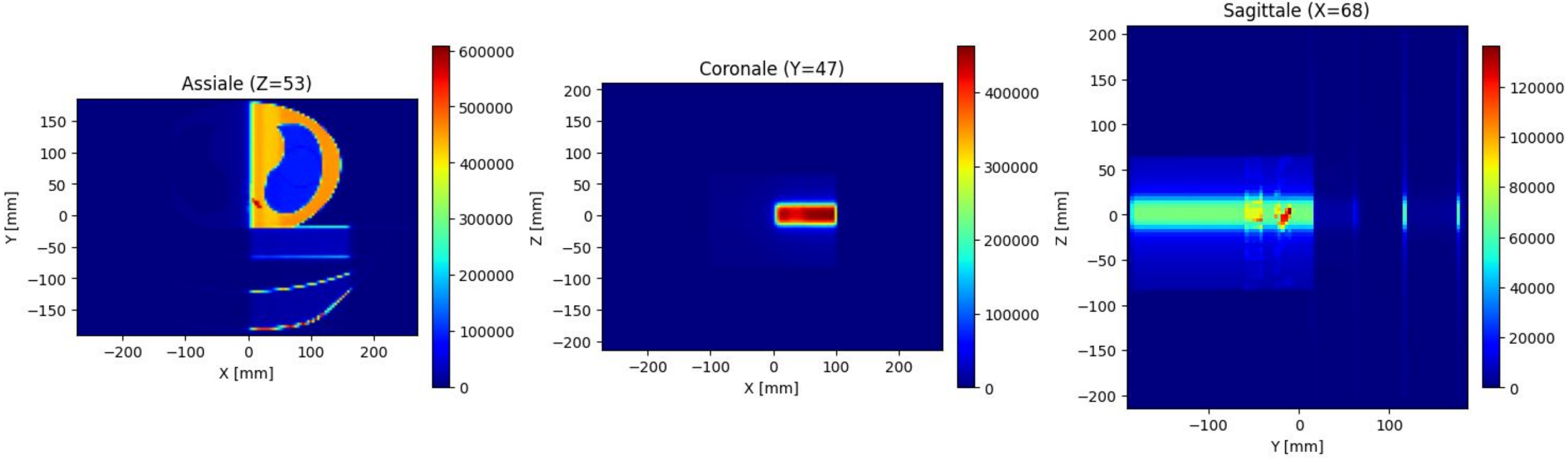
*

CT

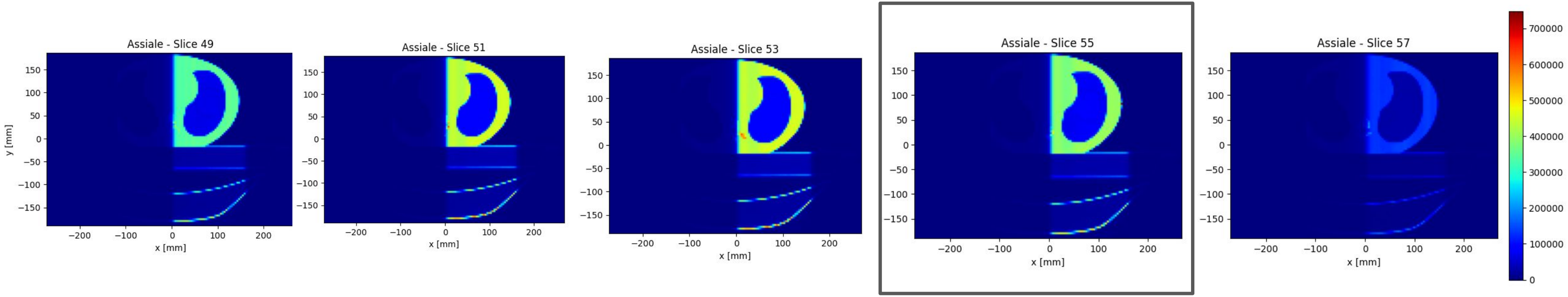
ricampionata all’RTDOSE e normalizzata

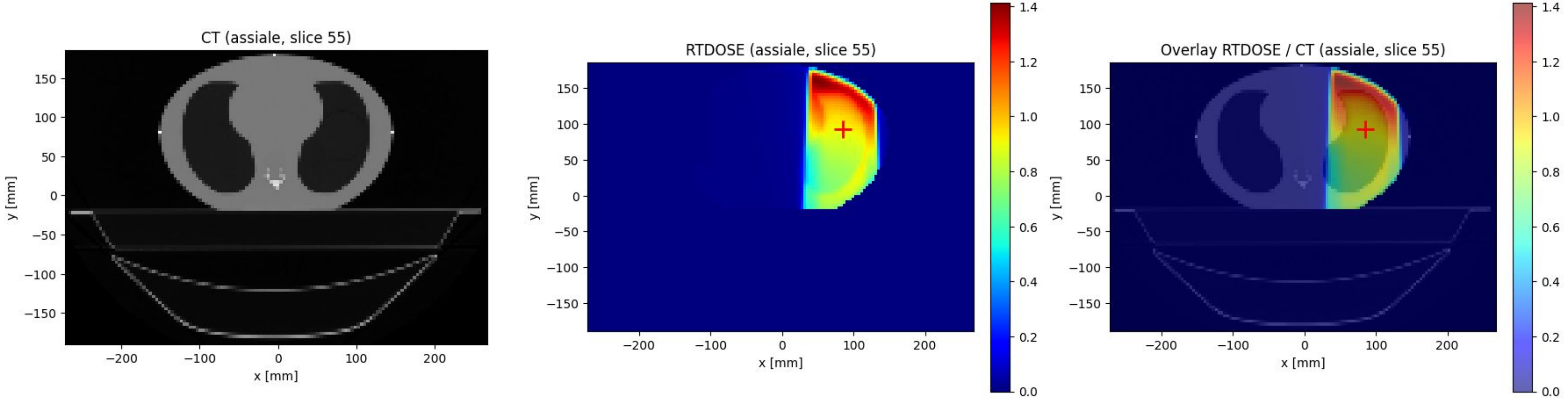




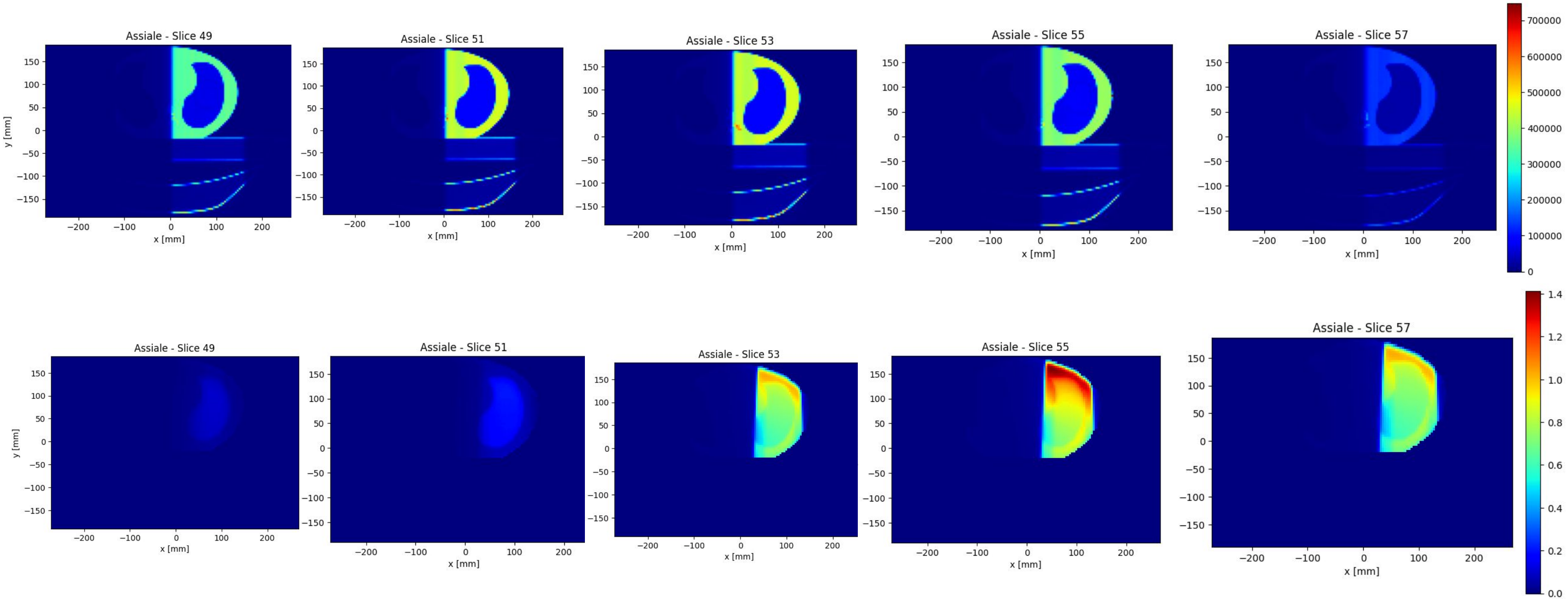


EPID-CT vs RTDOSE

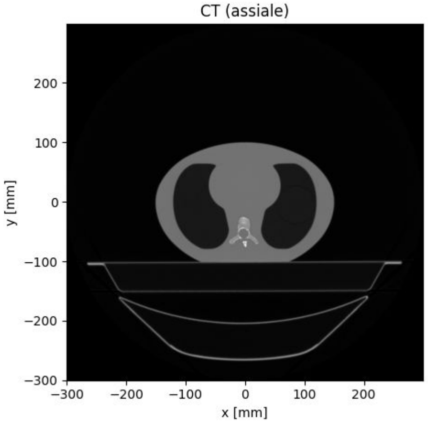


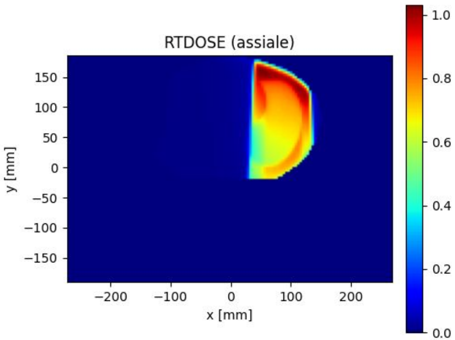


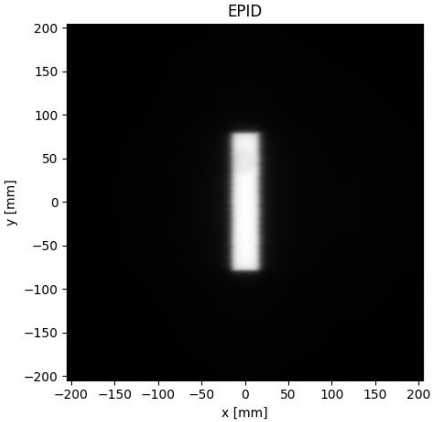
EPID-CT vs RTDOSE



Siamo partiti così…



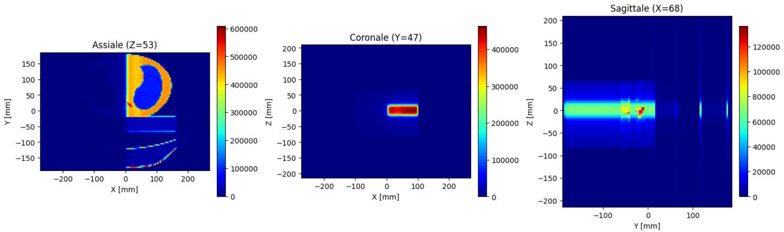


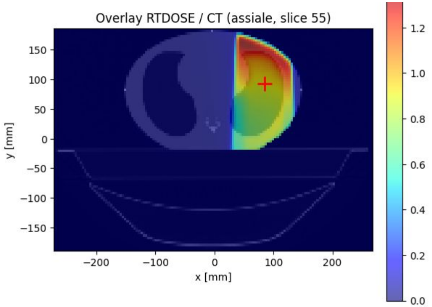



```
CT
shape = (214, 512, 512)
ct_spacing = [1.171875, 1.171875, 2.0] mm
ct_origin = [-300. -207. -220.] mm

RTDOSE
shape = (107, 95, 136)
rtdose_spacing = [4.0, 4.0, 4.0] mm
rtdose_origin = [-270.3  -11.6 -220. ] mm

EPID
shape = (1024, 1024)
epid_spacing = [0.4, 0.4] mm
```

INPUT
EPID-CT

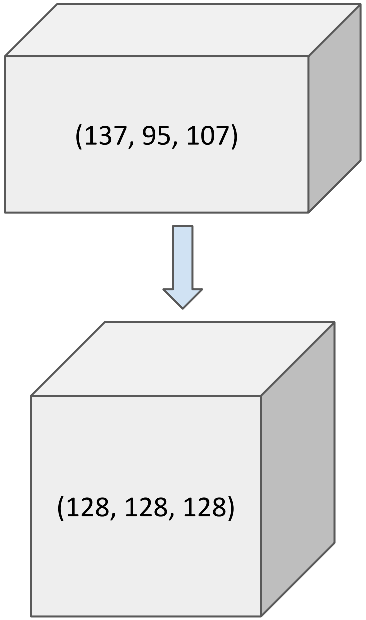
OUTPUT
RTDOSE

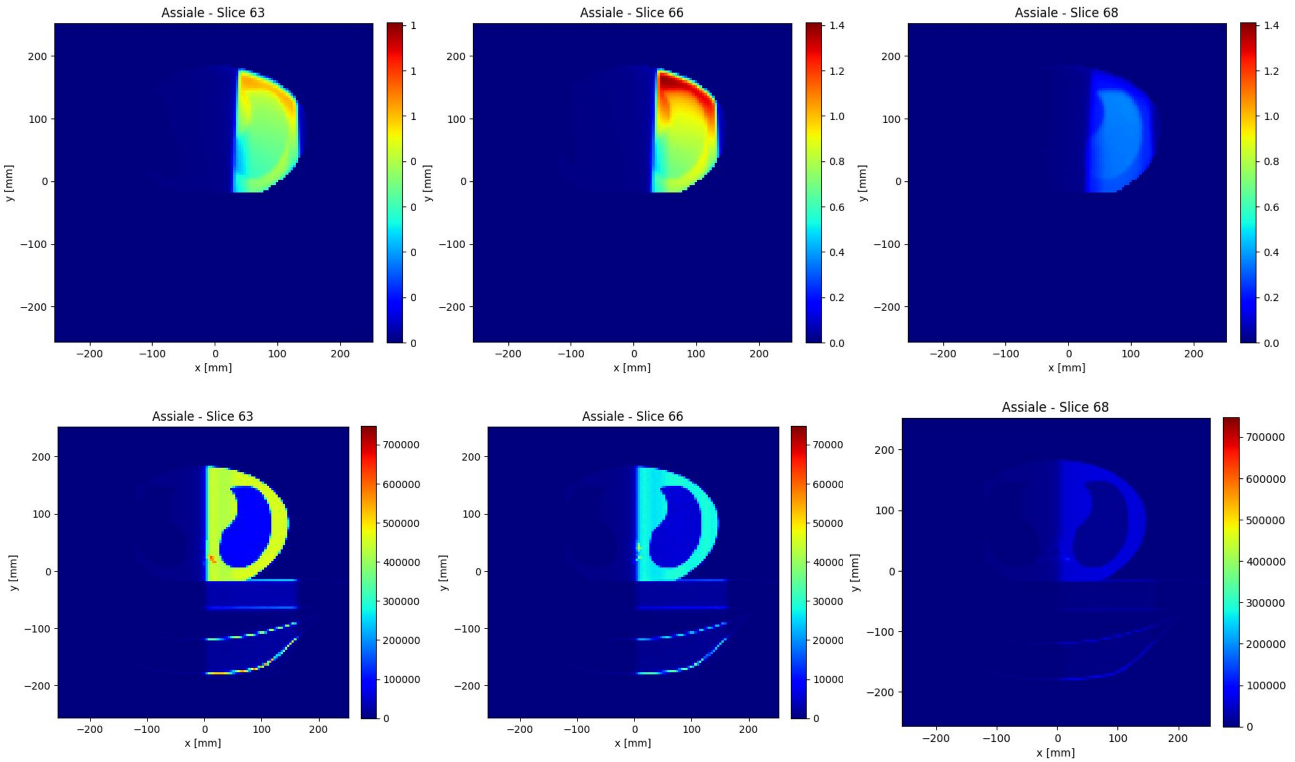




E arrivati qui

Padding simmetrico dei volumi per shape cubica → (128, 128, 128)?






```
epid_ct_128 = pad_to_shape_centered(epid_ct, target_shape=(128,128,128), pad_value=0.0)
rtdose_128  = pad_to_shape_centered(dose_array, target_shape=(128,128,128), pad_value=0.0)

print("EPID×CT:", epid_ct_128.shape)
print("RTDOSE:", rtdose_128.shape)
```

```
EPID×CT: (128, 128, 128)
RTDOSE: (128, 128, 128)
```

Padding simmetrico dei volumi per shape cubica → (128, 128, 128)?