Flair development for the MC TPS

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TPS Quality Assurance tool

REASON:

- According to IAEA[1] one of the major contribution factor to the accidents in the radiation therapy related to the Treatment Planning System (TPS) derives from the **lack of independent calculations for beam intensities**

USER:

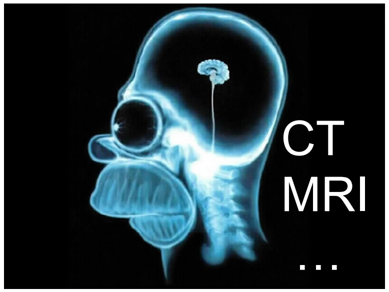
- Medical proton/ion therapy facilities:
  Tool for fully independent calculations based on DICOM RT files exported from TPS

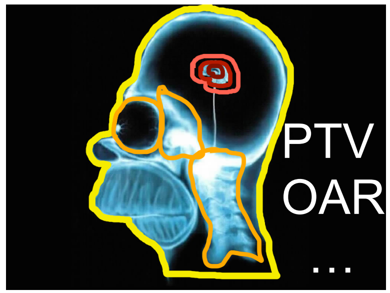
AIM:

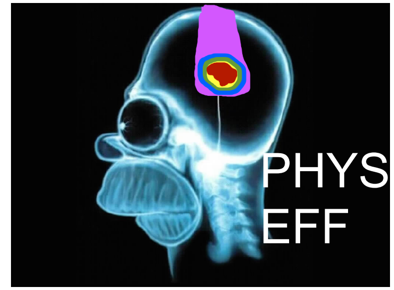
- Avoiding random errors
- Ensuring the input treatment data
- Contributing to more accurate dose deposition calculations for complex patients cases
- Providing more precise and easy-to-use tool for the ion therapy studies
- Serving with a tool for additional optimization of the treatment plan
- Contributing to increasing interest of LET-painting
  (LET-painting increases the Tumor Control Probability for hypoxic tumours[2])

[1] IAEA (2013) *Record and Verify Systems for Radiation Treatment of Cancer: Acceptance Testing, Commisioning and Quality Control; Number 7*
[2] Bassler N., et al. (2014) *LET-painting increases tumor control probablility in hypoxic tumours. Acta Oncologica, 53(1), 25-32*

DICOM RT mode in TP







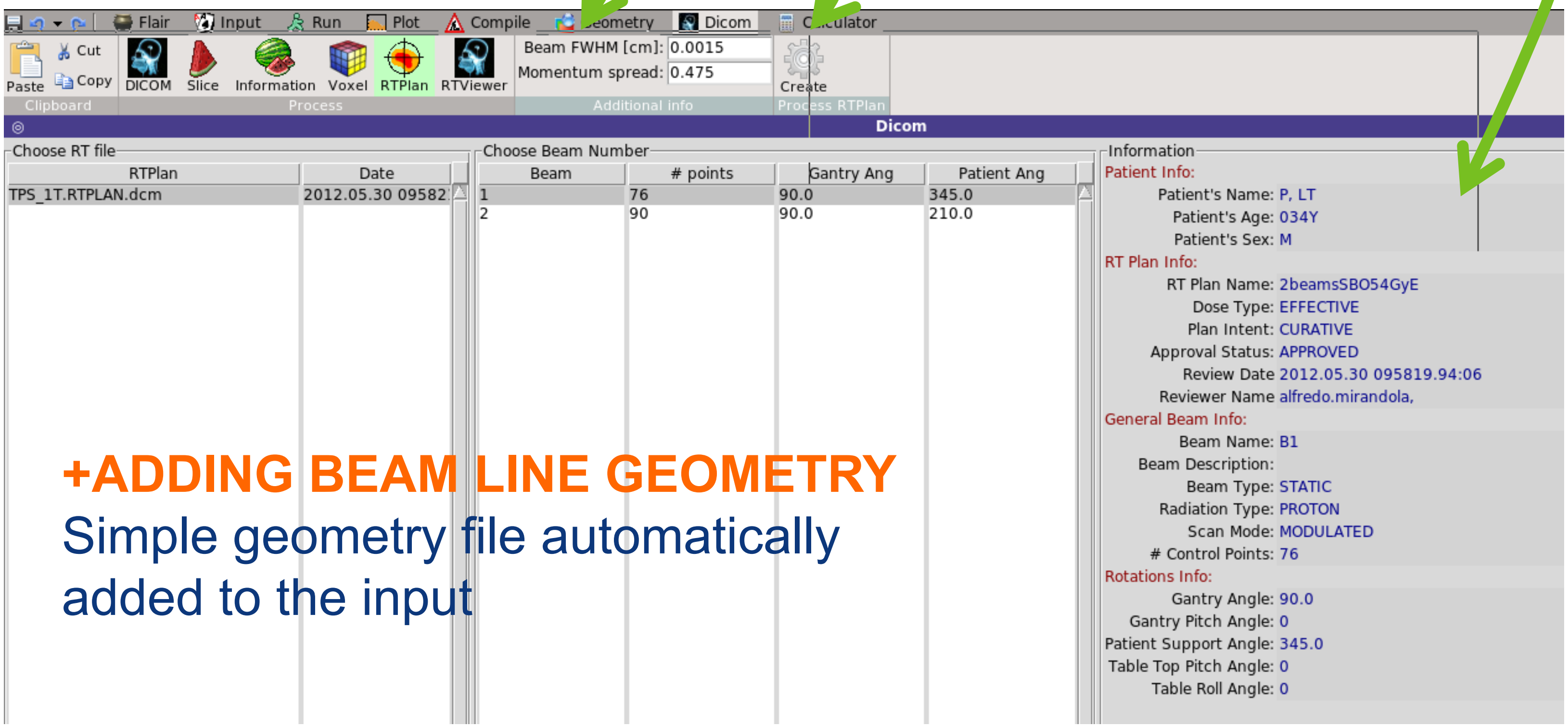
Flair for DICOM RT

- **RT IMAGE:** Creating patient voxel with FLUKA material files based on Schneider parameterization for CT scans;
  It is important to apply dE/dx correction dependent on CT calibration -> the same calibration curve as in TPS
- **RT STRUCT:** ROI structures are implemented inside the voxel file, easy to be used for further applications
- **RT DOSE:** Exporting of usrbin files from DICOM files;
  dose usrbin mapped and visualized together with CT scan
- **RT PLAN:** Pencil beam parameters exported and read by the source routine (updated version of A.Mairani), covering patient, gantry, table rotations.

PROVIDE A USER FRIENDLY, FLEXIBLE TOOL

RTPlan

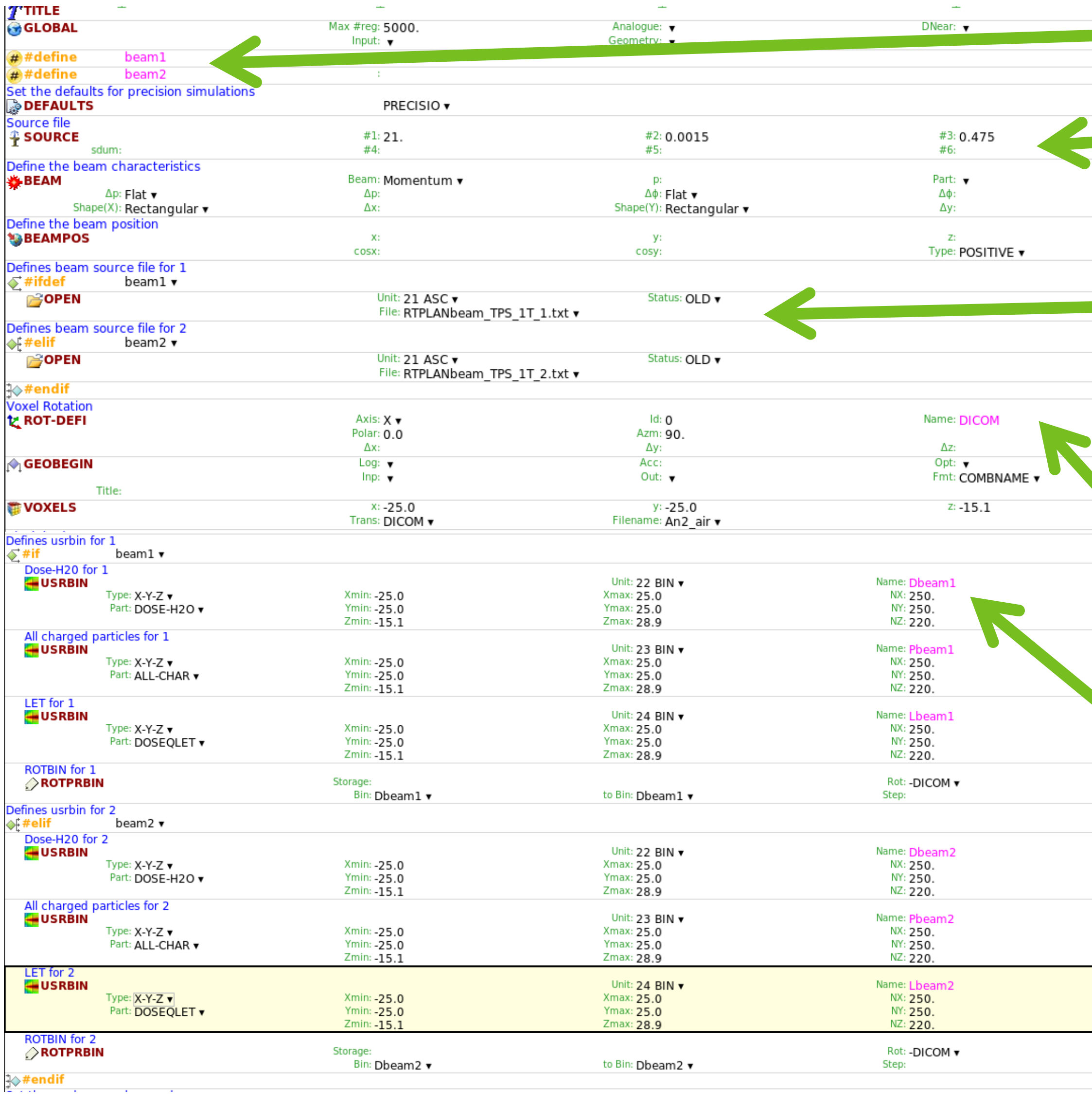
- Generates FLUKA input file and exports beam data files
- Provides basic information of DICOM RT PLAN
- Additional info based on the beam line parameters, filled by the user



+ADDING BEAM LINE GEOMETRY

Simple geometry file automatically added to the input

INPUT FILE



#define card for each field

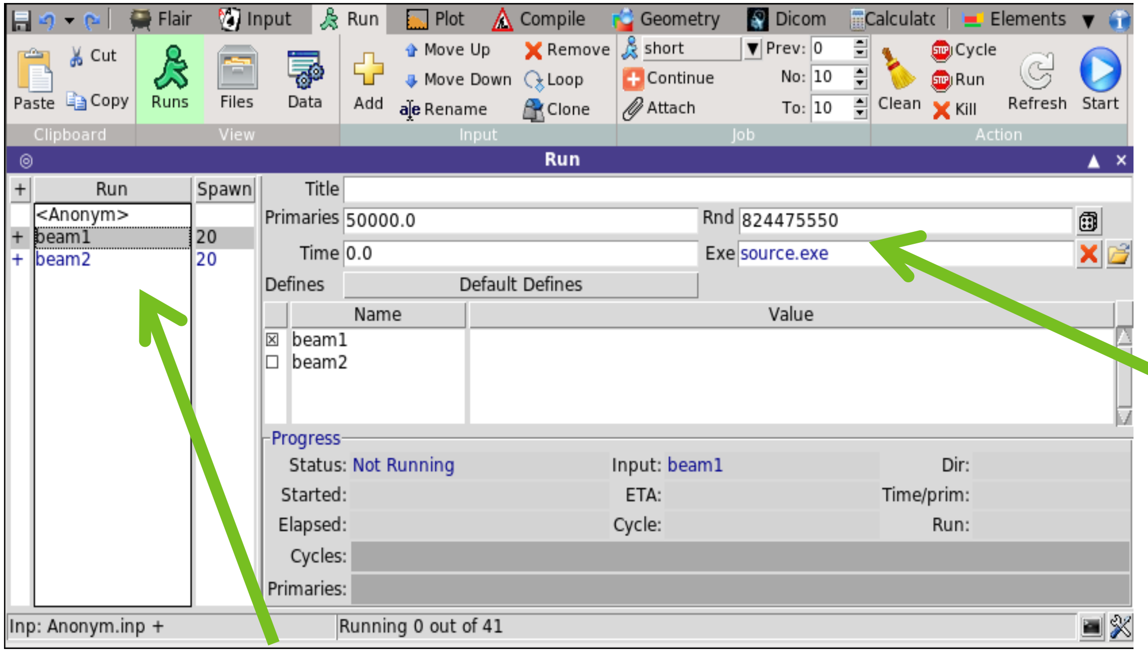
source routine variables

beam data files for source routine

ROT-DEFI card for conversion between DICOM to RT PLAN coordination system

USRBIN cards modified according to RT DOSE parameters

SIMULATION RUN



Source routine

+ FREEZING THE RT SOURCE ROUTINE CODE

Set a standardized version for RT calculations

Separate runs for each field

+ REQUIRES NORMALIZATION OF USRBIN FILES

According to field intensity from RT PLAN

Summing of the treatment plan fields

RT Viewer

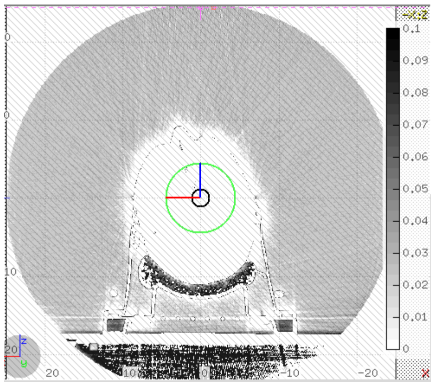
- Patient in 3 views (Axial, Coronal, Sagittal)
- Input: CT scans and bnn files from RT DOSE and FLUKA simulations
- Comparison between TPS and FLUKA dose distribution
- Based on PIL and NumPy Python libraries

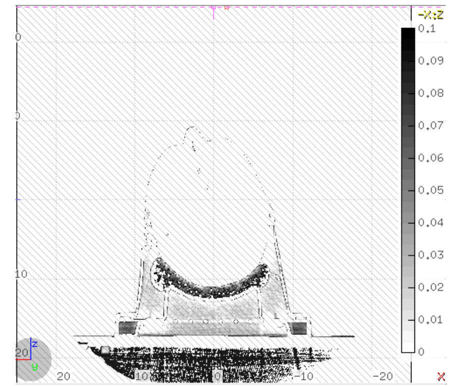
+ADDING RT STRUCT

With correct interpolation between slices

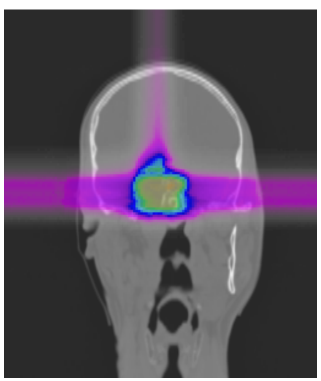
Additional functions by external scripts

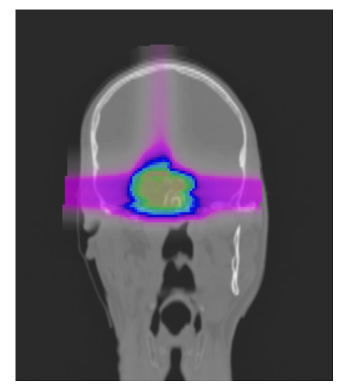
- **VOXEL:** Heterogeneous density of the area outside the patient; Assigning air to all regions outside the body; the additional voxel region is created consisting all voxels outside the ROI structures





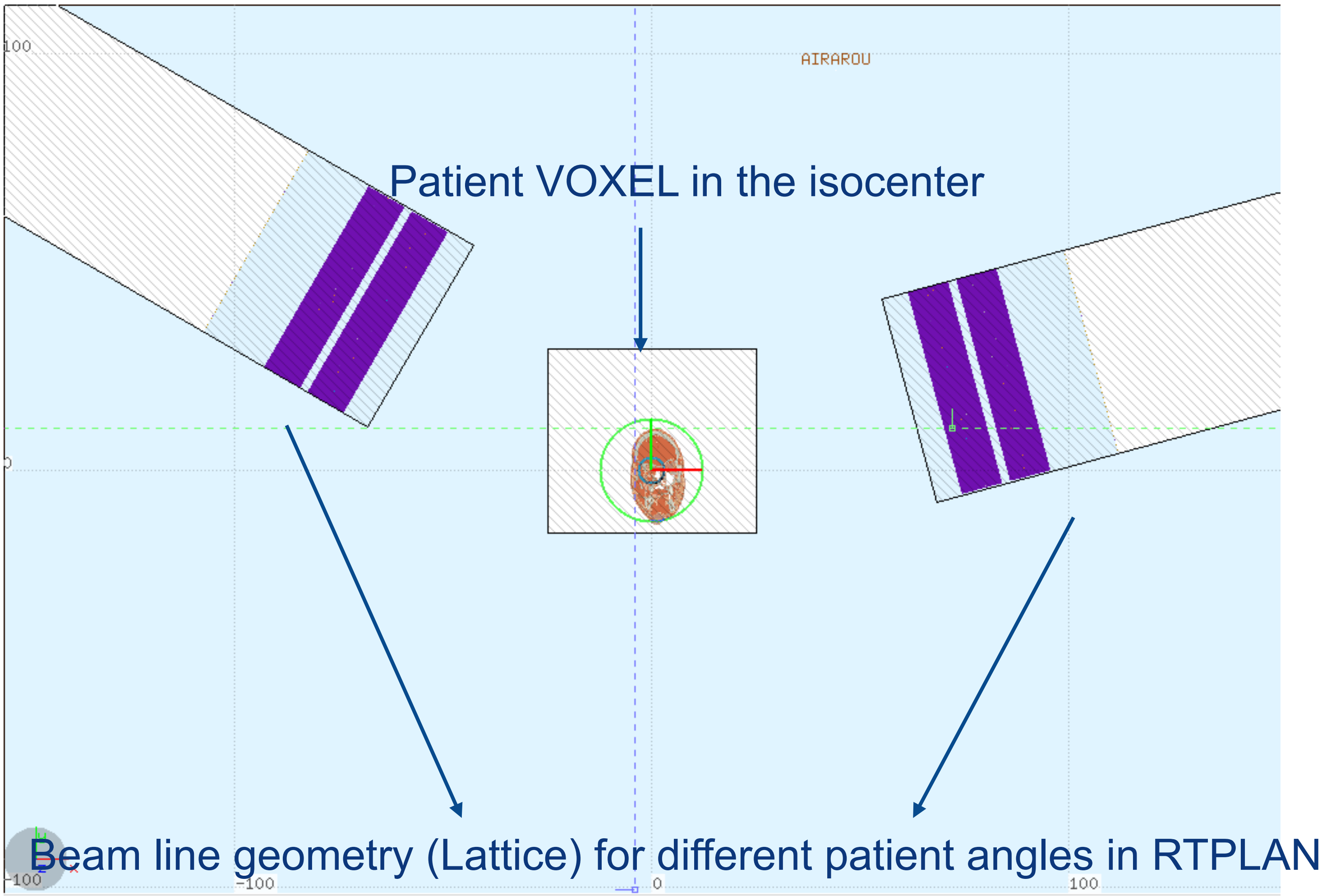
- **USRBIN:** Better comparison with TPS RT DOSE; all values in usrbin outside the ROI structures set to 0 value



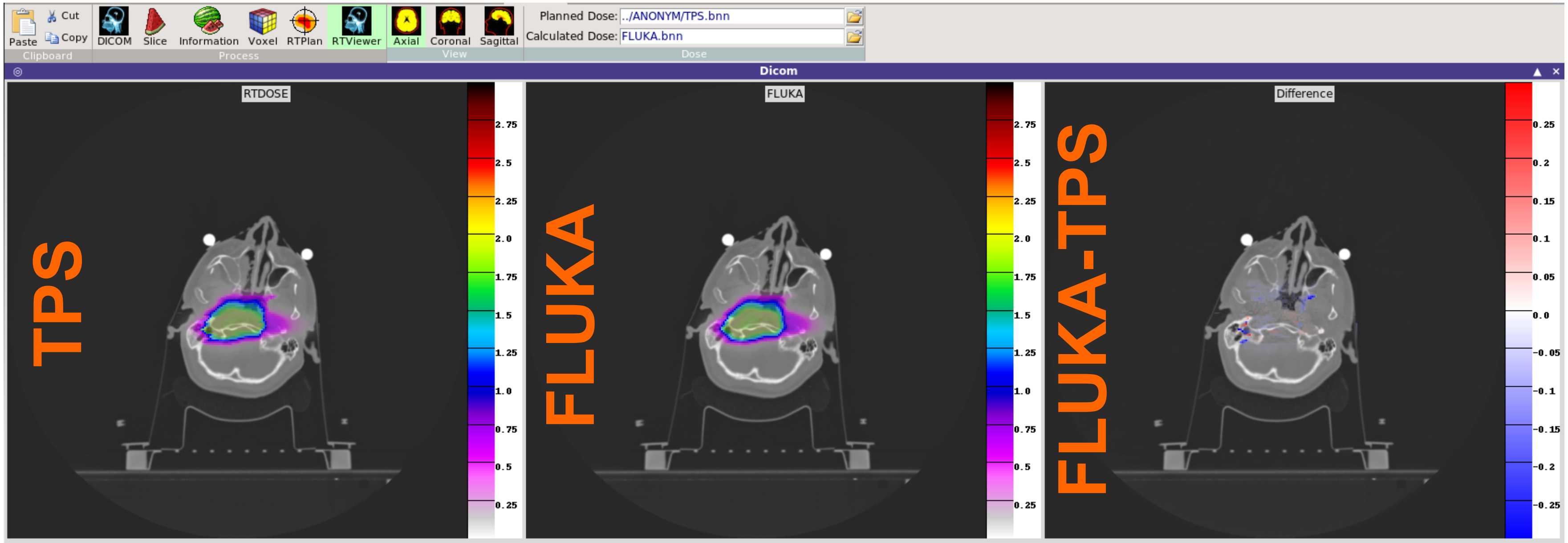


+EMBEDD SCRIPTS INTO Flair or FLUKA?

FLUKA recalculation –
2 field chordoma CNAO case



RESULTS – DOSE-H2O



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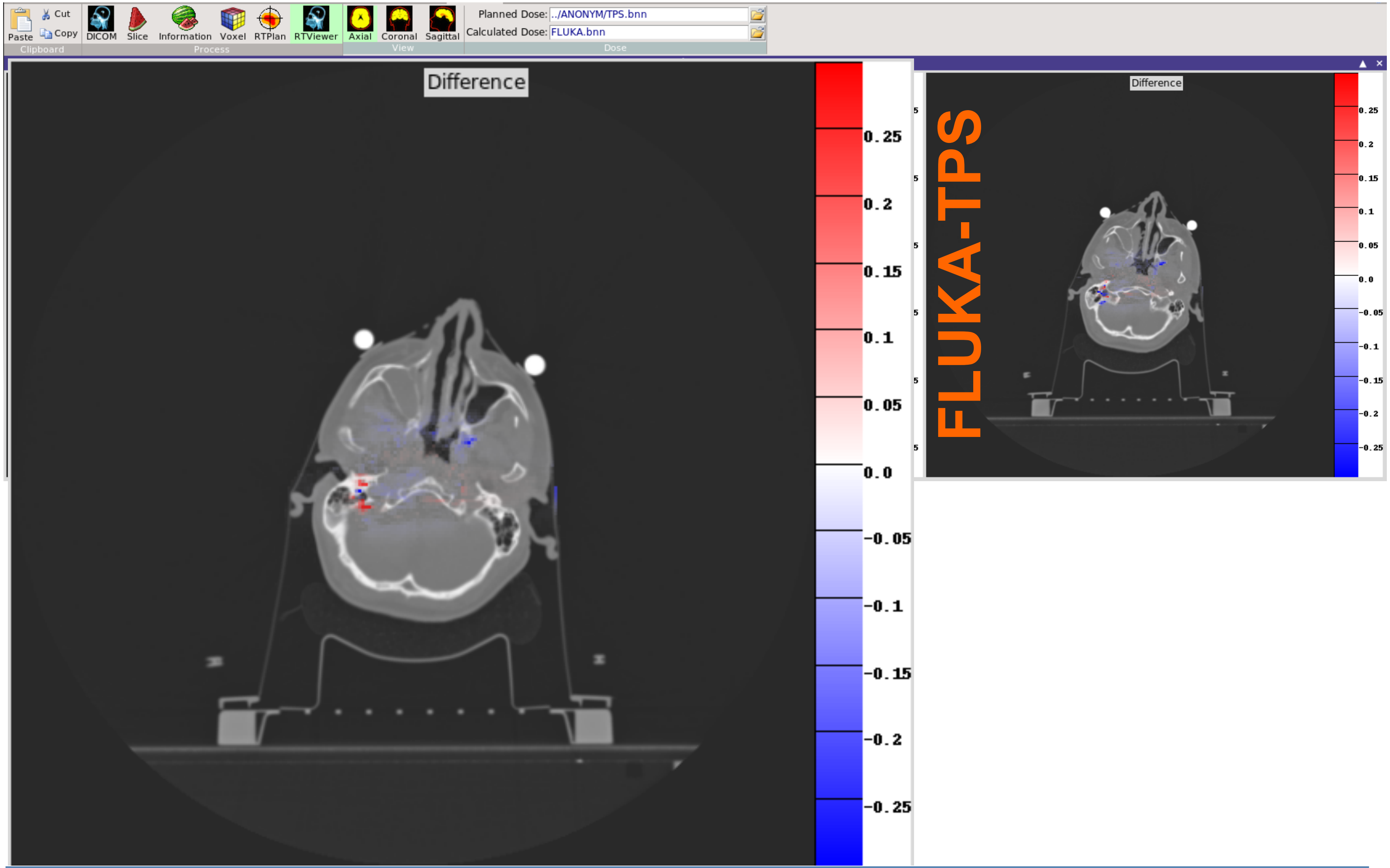

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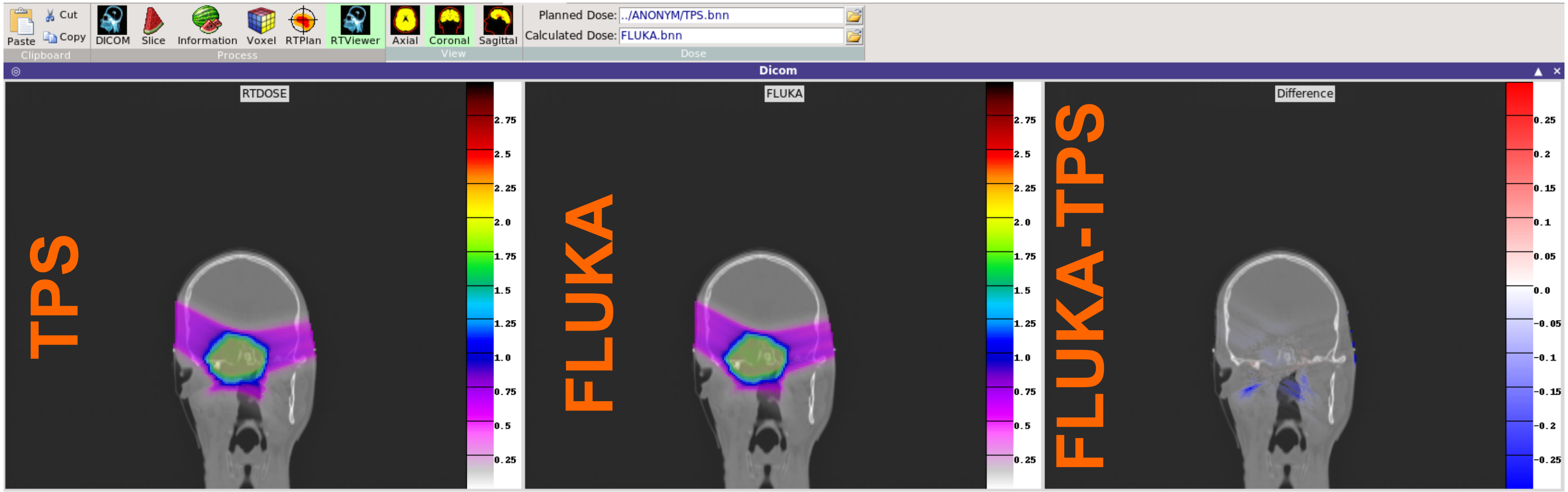

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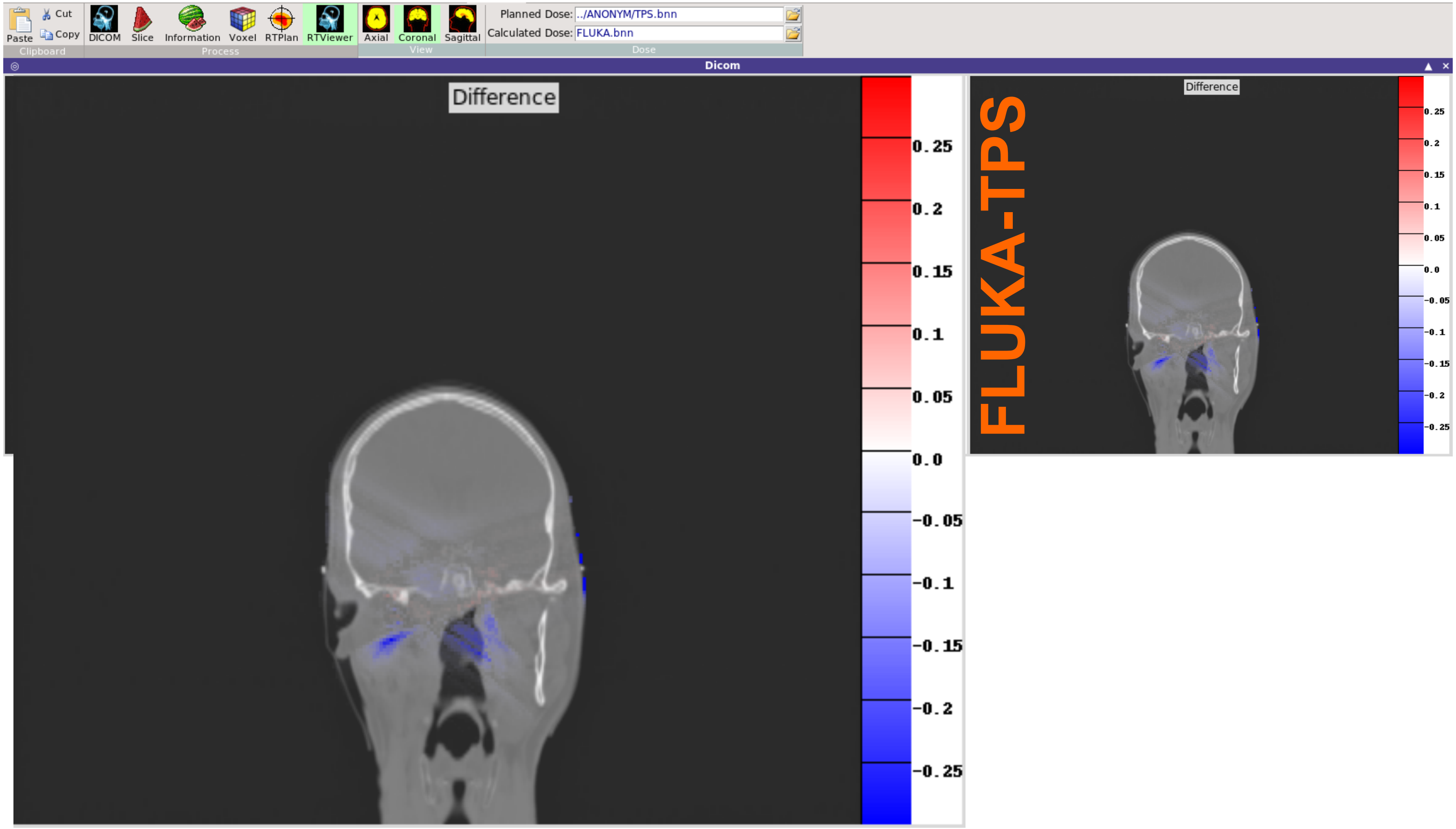
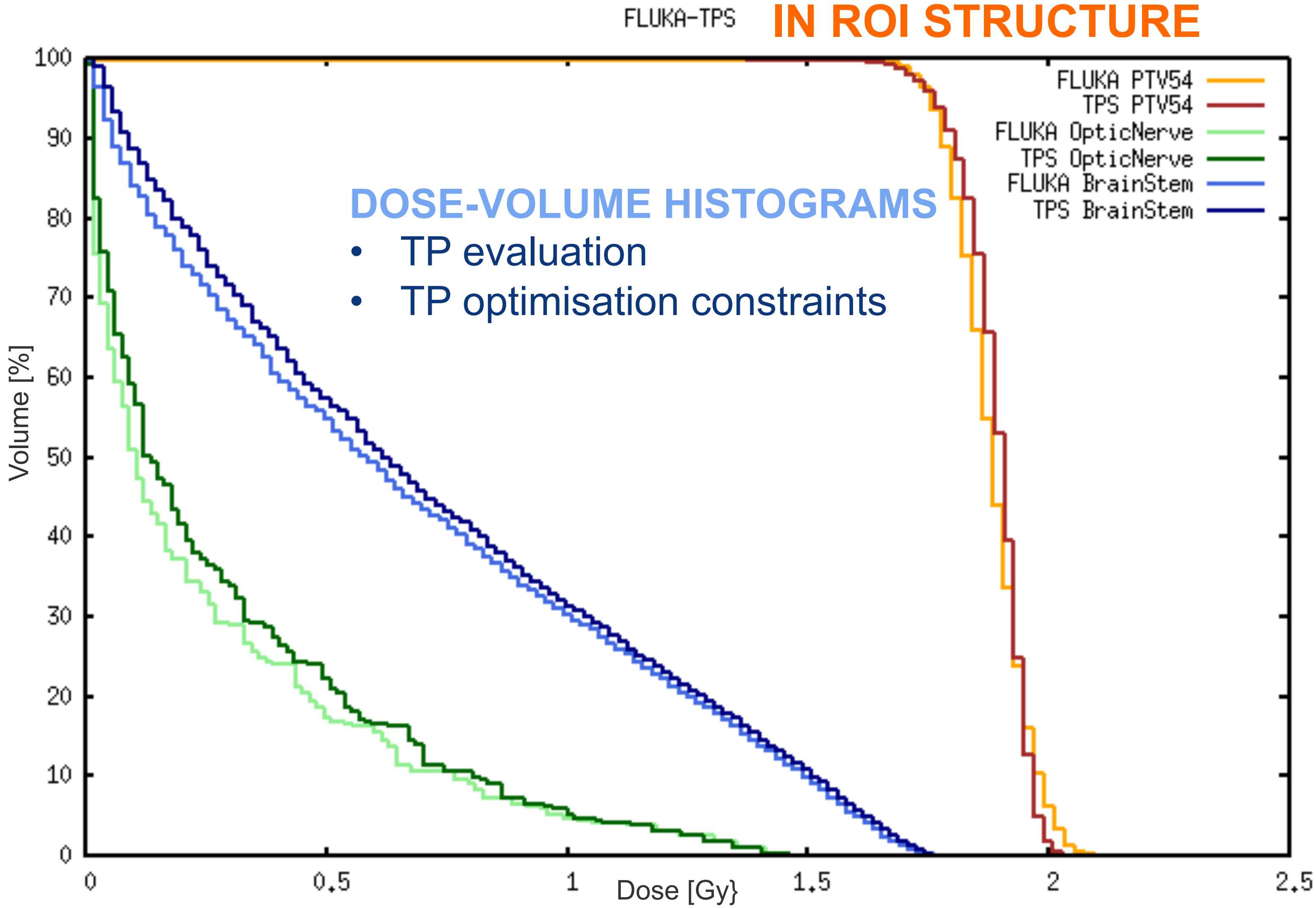


RESULTS - DVH

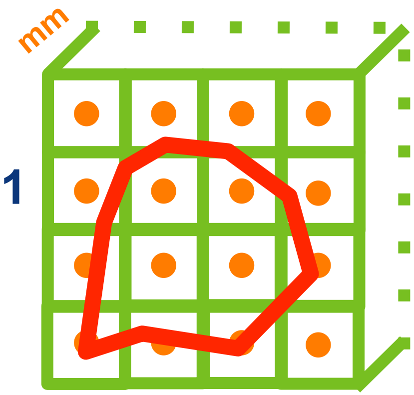
+SOLVING PROBLEM WITH PARTIAL VOXEL IN ROI STRUCTURE



DOSE-VOLUME HISTOGRAMS

- TP evaluation
- TP optimisation constraints

ROI - VOXEL PROBLEMS



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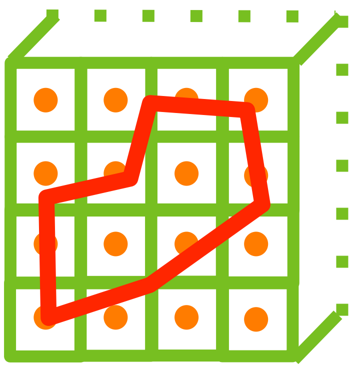

2

Id	Name	Dicom Volume (cm3)	Voxel Volume (cm3)
1	check	18.9672	22.8367
2	Brain Stem	22.8728	25.8694
3	Optic Nerve(R)	0.5705	1.0052
4	Optic Nerve(L)	0.5814	1.1044
5	Eye(R)	9.2542	10.5953
6	Eye(L)	8.4247	9.6817
7	Optic Chiasm	0.1383	0.4101
8	GTV 70	10.7121	12.3711
9	Parotid(R)	18.7912	21.1258
10	Parotid(L)	20.5473	22.5906
11	Ear(R)	0.032	0.103
12	Ear(L)	0.0378	0.1087
13	Pituitary Gland	0.2985	0.639
14	Temporal Lobe(R)	86.8269	92.1268
15	Temporal Lobe(L)	73.8533	78.2146
16	Middle Ear R	0.5841	1.0033
17	Middle Ear(L)	0.2581	0.6084
18	ATM R	1.8245	2.3594
19	ATM L	1.5506	2.1305
20	CTV 70	19.2875	21.4901
21	carotidi	1.8907	2.9774
22	Skin	14439.3692	14806.5777
23	PRVBrain Stem	38.5052	41.666
26	brain	1409.9538	1441.5913
27	CTV 54	42.5651	45.7764
28	PTV 54	55.4297	59.4254
29	PTV 70	32.4968	35.1353
30	CTV 54 - CTV 70	24.0074	64.127

+75-90% !

OVERVIEW AND PLAN

OVERVIEW:

- Focus of the software development is on **Quality Assurance** tool rather than the full Treatment Planning System
- RTPlan and RTViewer DICOM Tab available in the newest Flair svn version **(comments very appreciated !!!)**
- Physical dose calculations for proton therapies already compared with CNAO TPS. We are able to cope with multiple field plans.

OVERVIEW AND PLAN

NEXT STEPS:

- Simple attaching the beam line geometry into the input file
- Standardizing the RT_source routine
- Which external script shall be run directly from Flair?
  - USRBIN: normalisation based on RT PLAN
  - USRBIN: removing values from area outside of the patient
  - VOXEL: uniforming the material for area outside of the patient
- Solving the problem with partial voxel in the ROI structure
- Additional tests for different RT PLANS from different TPS
- Documentation and manual
- Biological dose calculations
- Ion RT PLANS recalculations
- Exporting the usrbin data to the DICOM RT DOSE format
- Embedding the MC TPS optimizer of A. Mairani and T. Böhlen into the Flair and providing a solution for exporting the RTPLAN

THANK YOU!