RIDOS: Real-Time **I**on **Do**se Planning and Delivery **S**ystem (2014-2015)

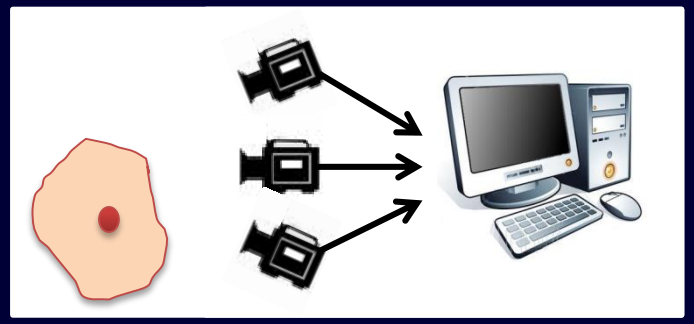
PI: Simona Giordanengo - INFN - Torino

INFN RESEARCH PROJECT (Grant for Young Researcher CSN5 call 2013)

Dose Delivery System

+

Target tracking system



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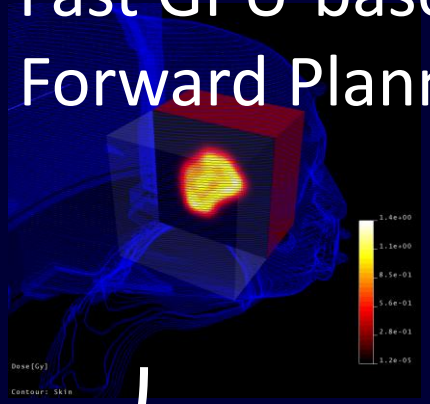
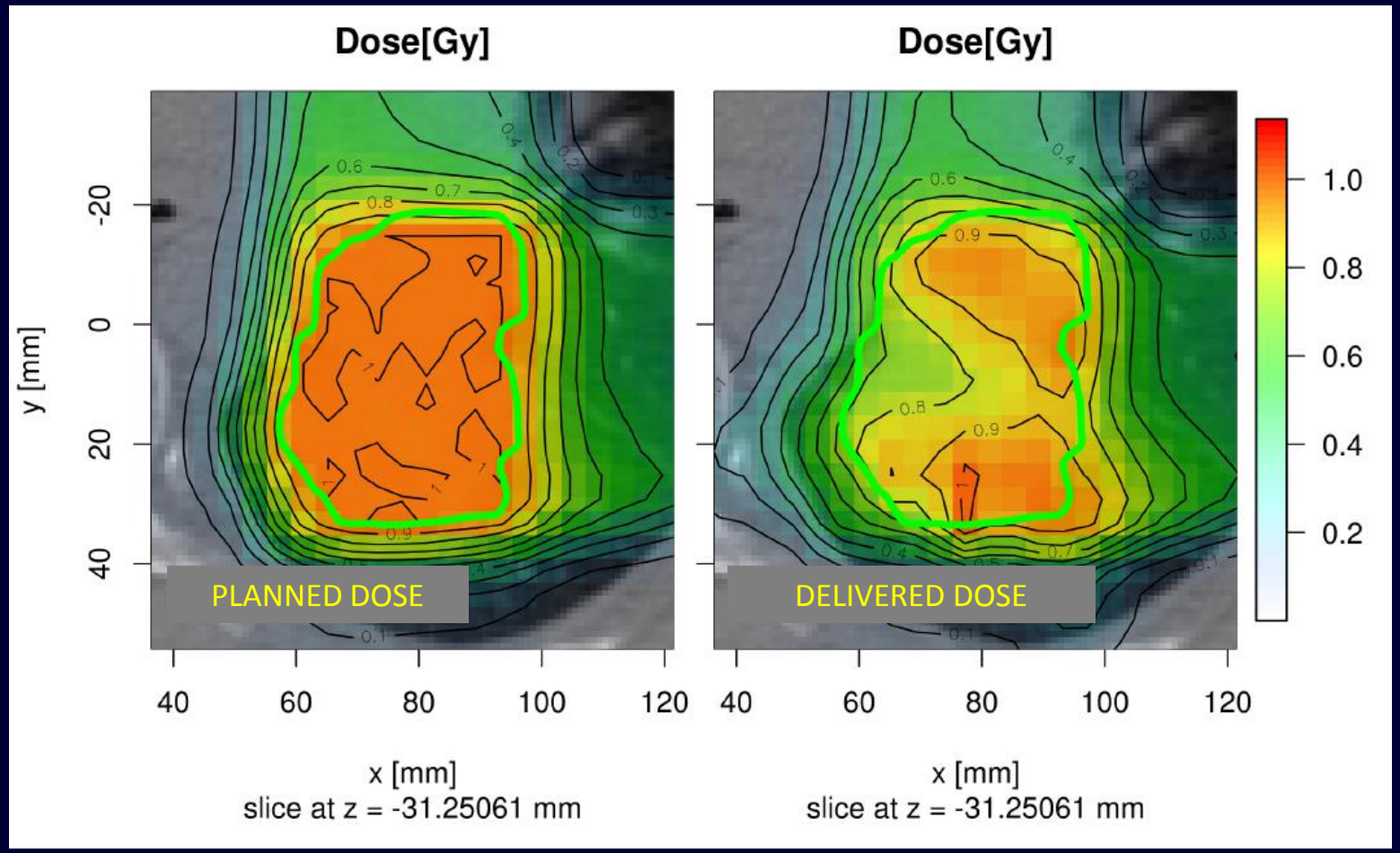
Fast GPU-based Forward Planning



- **RIDOS checks ON-LINE the uncertainties in the delivered DOSE DISTRIBUTIONS due to measured patient and beam deviations from planned conditions.**
- **RIDOS provides an integrated platform for adaptive therapy at CNAO**

RIDOS goal

Calculate online the dose distribution, using measured data of the beams and of the patient's movement.



RIDOS deliverables

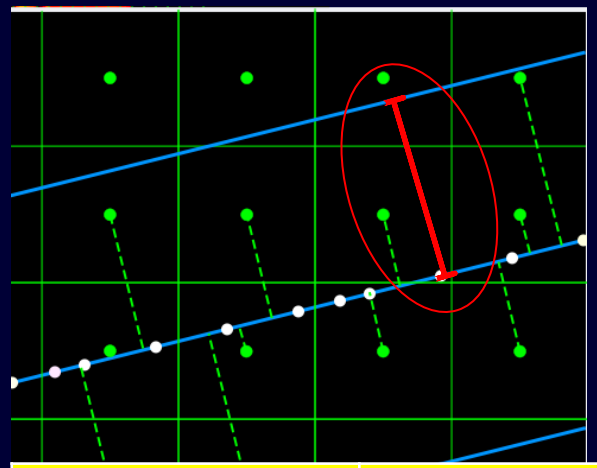
- D1: **Fast Forward Planning** implementation with CUDA porting of the PlanKIT TPS libraries

- D2: **HW Instrumentation to integrate** existing on-line data provided by the CNAO dose delivery and target tracking systems **with** the fast GPU-based dose computation **and to show** results in the CNAO local control room

D1: RIDOS-Fast Forward Planning versions

RIDOS-FP_Old :	- Only protons, not optimized
RIDOS-FP_1.0 :	- New RayTracing + Optimizations
RIDOS-FP_2.0:	*- Memory optimizations (worst time performance)*
RIDOS-FP_3.0:	- Voxel Pre-selection
RIDOS-FP_1.1:	- Biological Dose (also carbon ion dose) - 4D (Versatility to manage 4D-CT and provide several doses)

D1: RIDOS-Fast Forward Planning performances



Computing Grid = 170x170x125;
N of Rays = 1248; N of slice = 39;

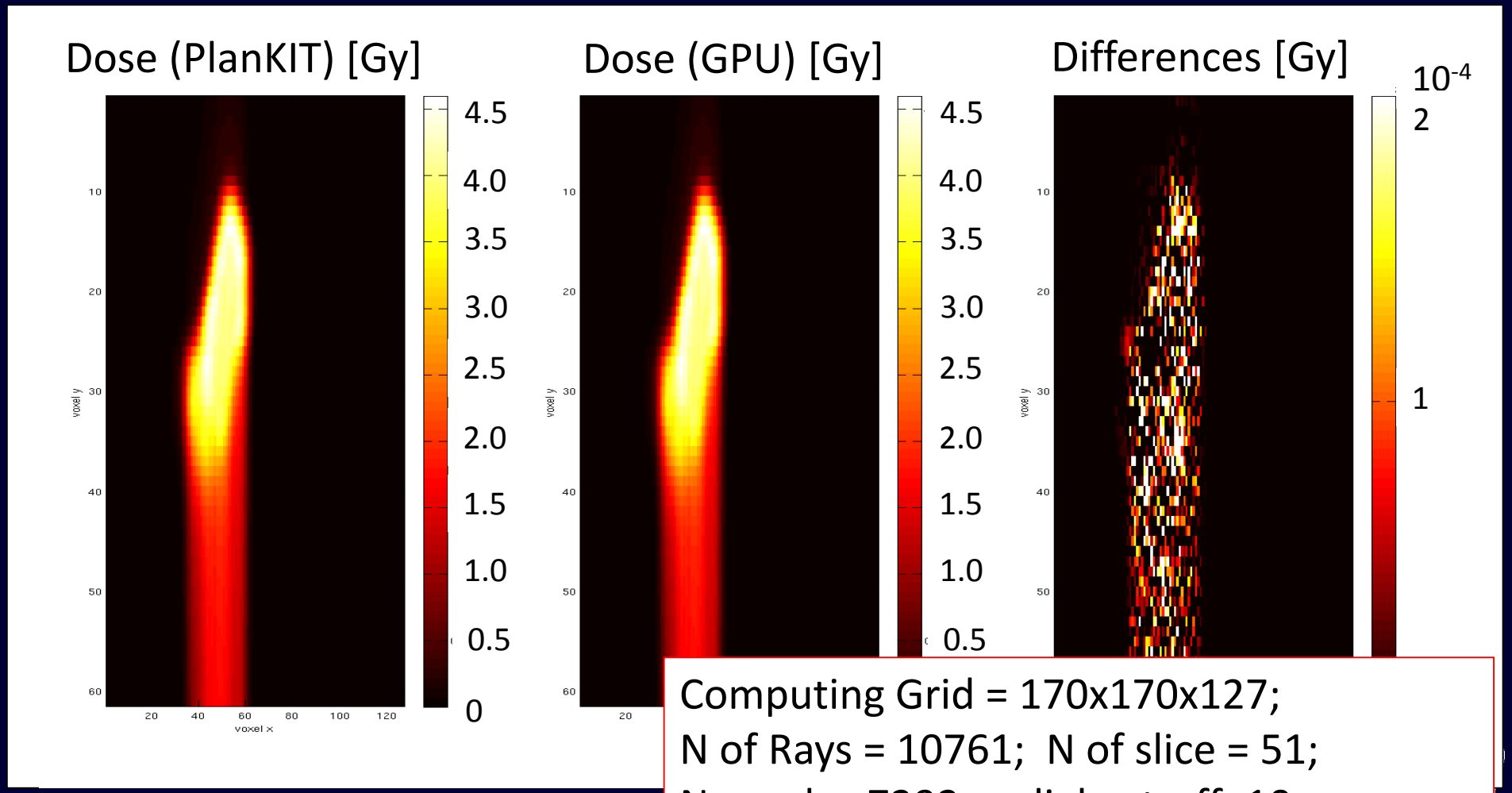
Entire treatment

Per spill

Radial cut-off (mm)	Number of voxels	RIDOS F-FP time (s)		PlanKIT FP time (s)	Gain
20	44678	1.35	**0.035**	150	110
40	178702	2.33	**0.059**	600	270
50	279243	2.76	**0.071**	1000	350
80	714861	4.68	**0.120**	2500	500

D1: RIDOS-Fast Forward Planning results

F-FP for a treatment with Carbon ions



Computing Grid = 170x170x127;
N of Rays = 10761; N of slice = 51;
N voxels= 7292; radial cut-off=10 mm.

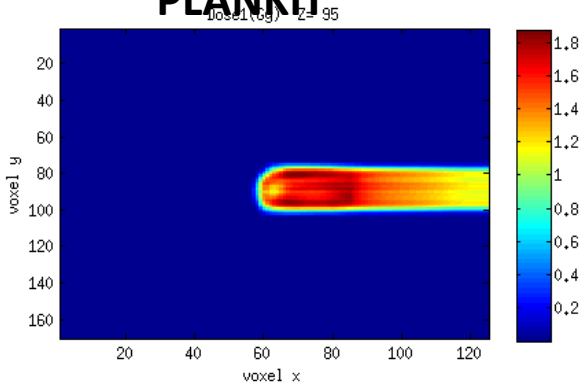
PLANKIT

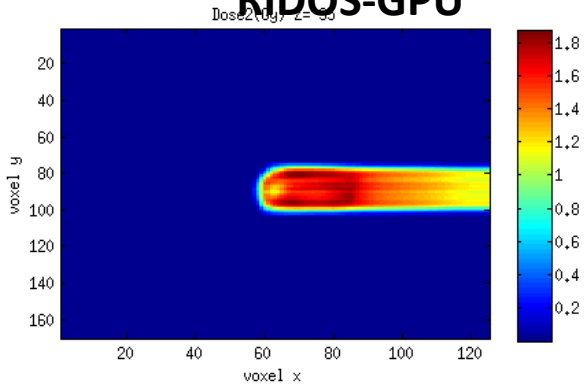
RIDOS-GPU

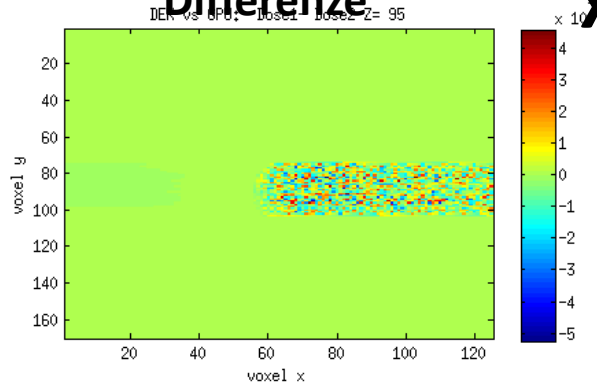
Differenze

x10^{-4}

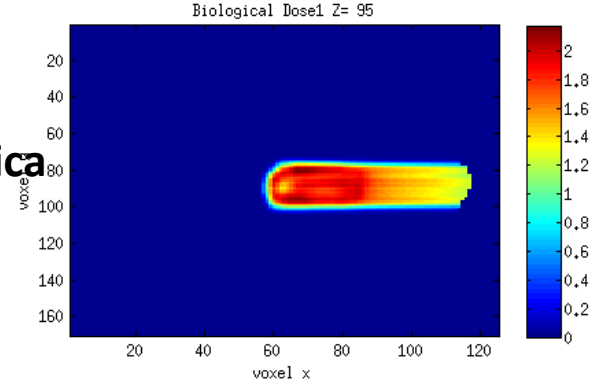
Dose Fisica

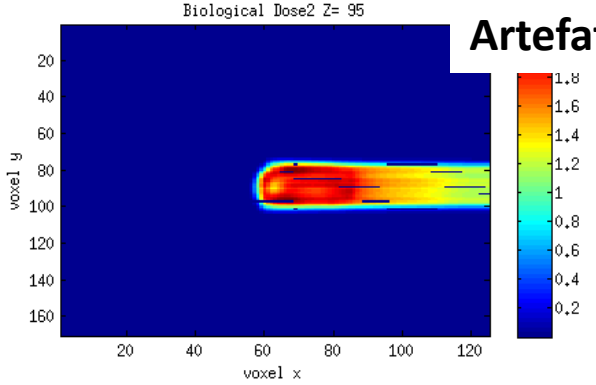






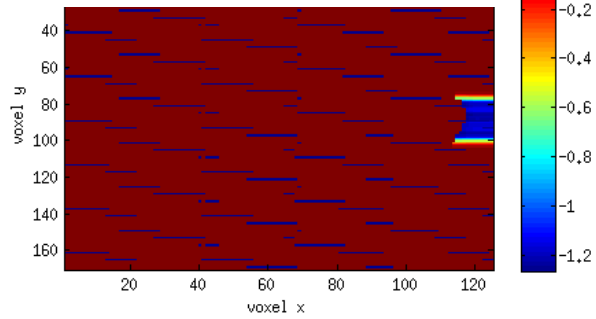
Dose Biologica



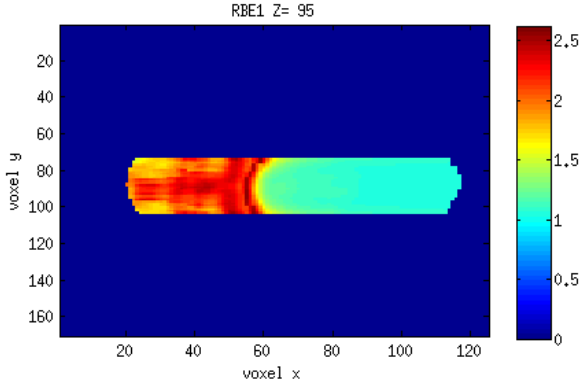


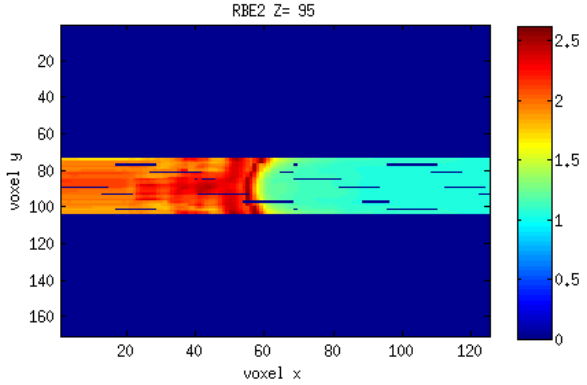
Artefatti della GPU in fase di debug

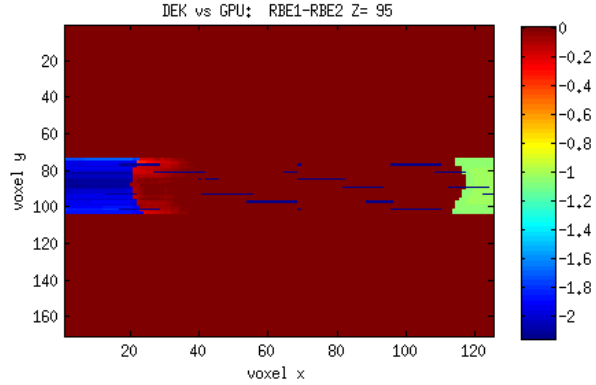
x10^{-4}



RBE

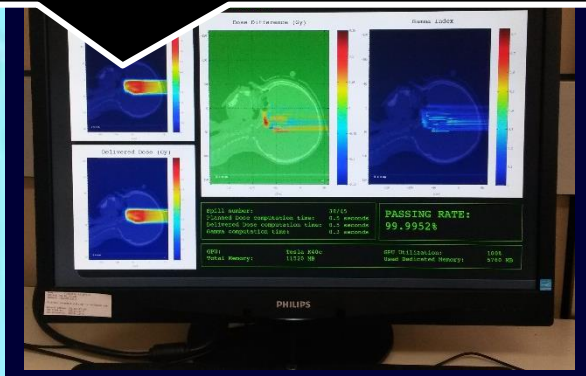






D2: RIDOS HW Interfaces

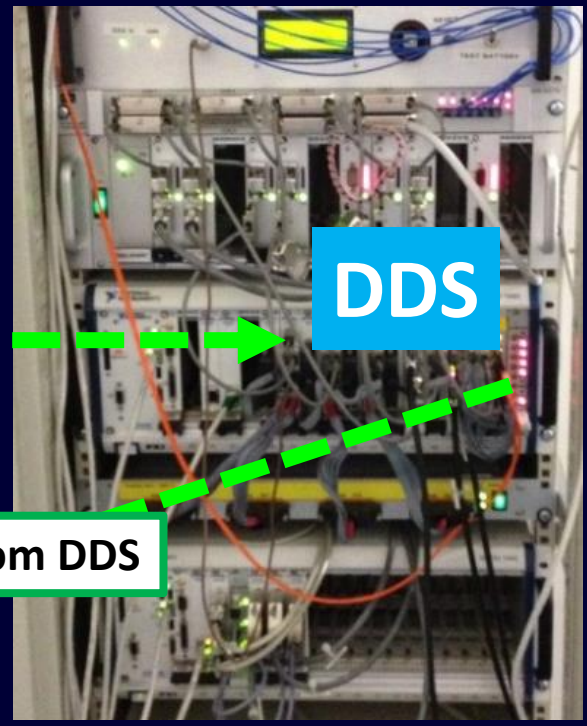
SPILL DELIVERED DOSE MONITOR (Matlab-based GUI)



WS with GPU TESLA k40c

Tested at CNAO (July 2015)

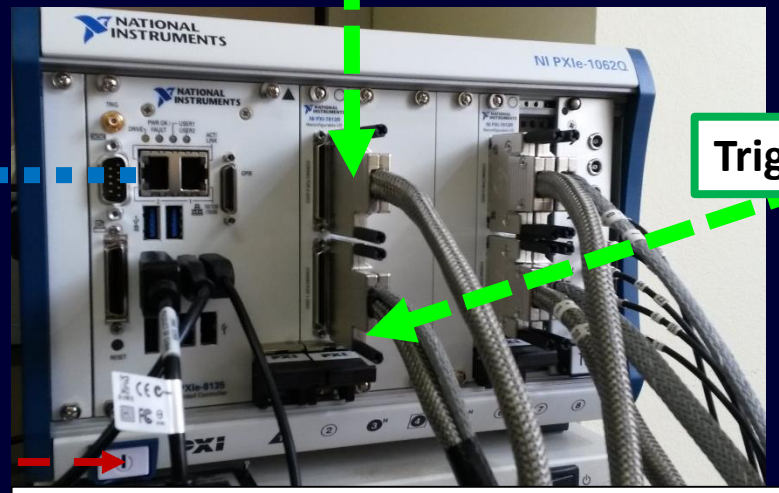
Beam monitors measurements from FPGAs of the DDS to the RIDOS FPGA



CNAO Dose Delivery cabinet

Trigger from DDS

Delivered spots with measured characteristics for dose computation (TCP-IP communic tested)

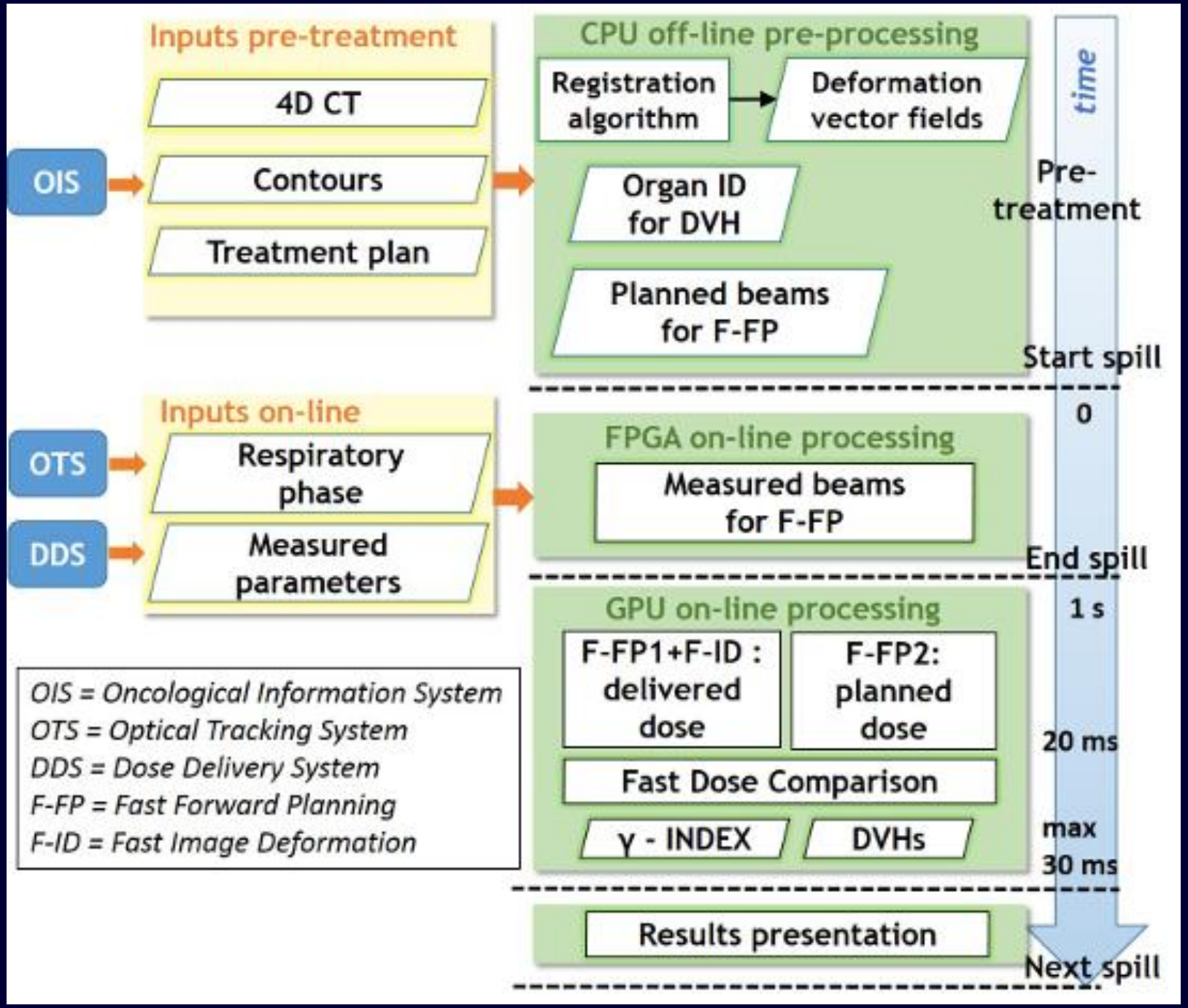


NI-PXIe chassis with CPU and FPGA modules to interface the DDS with the dose computation

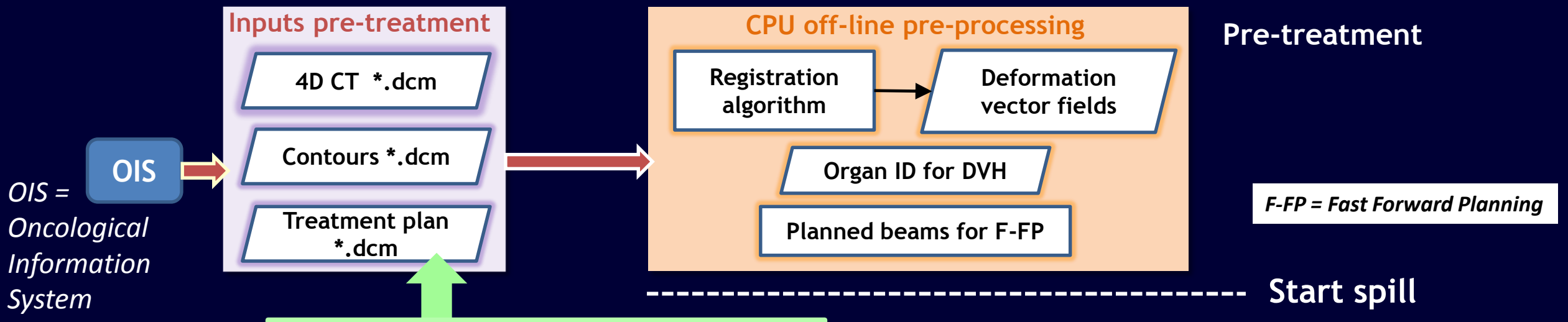
Respiratory Phase and Surrogate target motions measurements

Under development

D2:
SW tools
SW interfaces
DATA management



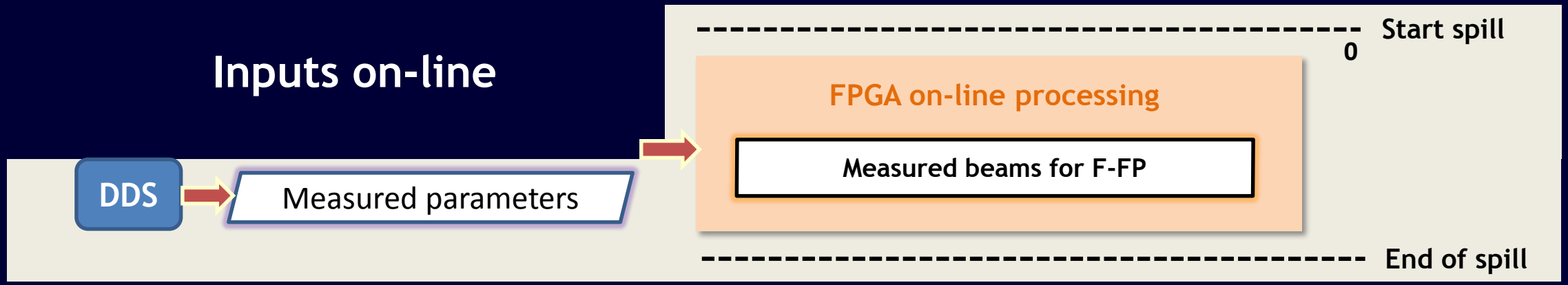
INPUT data Pre-treatment and Pre-Processing



MatLAB scripts to manage DICOM files :

- *LoadCT.m*
- *LoadContours.m*
- *CreateVois.m*
- *LoadValues.m*
- *CreateDVH.m*
- *ComputeGammaIndex.m*

On-line input data and FPGA processing



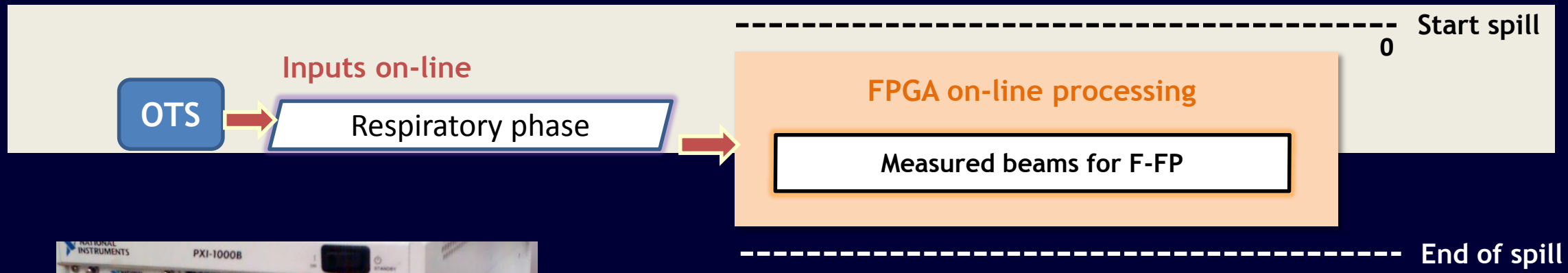
DDS-RIDOS FPGA firmware + interface with WS

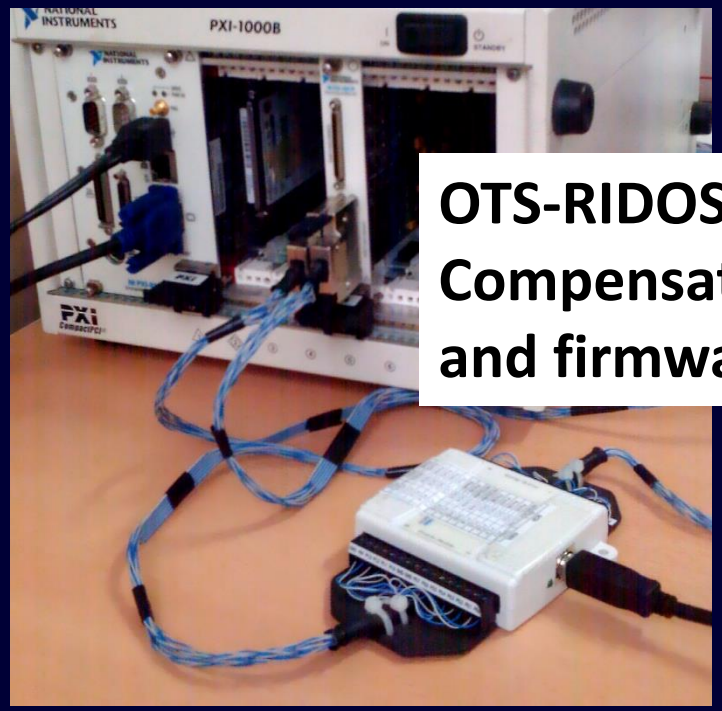
DONE: cables and protocols to receive on-line DD data from FPGA-CNAO (Integral chambers measurements) to FPGA-RIDOS; data transfer to RIDOS controller via FIFO-DMA; file .beam creation.

TO DO: select useful data, send to WS and test overall time

DDS = Dose Delivery System
F-FP = Fast Forward Planning

On-line input data and FPGA processing





OTS-RIDOS-FPGA: the old Organ Motion Compensator should be used as OTS, hw and firmware ready

OTS = Optical Tracking System
DDS = Dose Delivery System
F-FP = Fast Forward Planning

GPU on-line processing

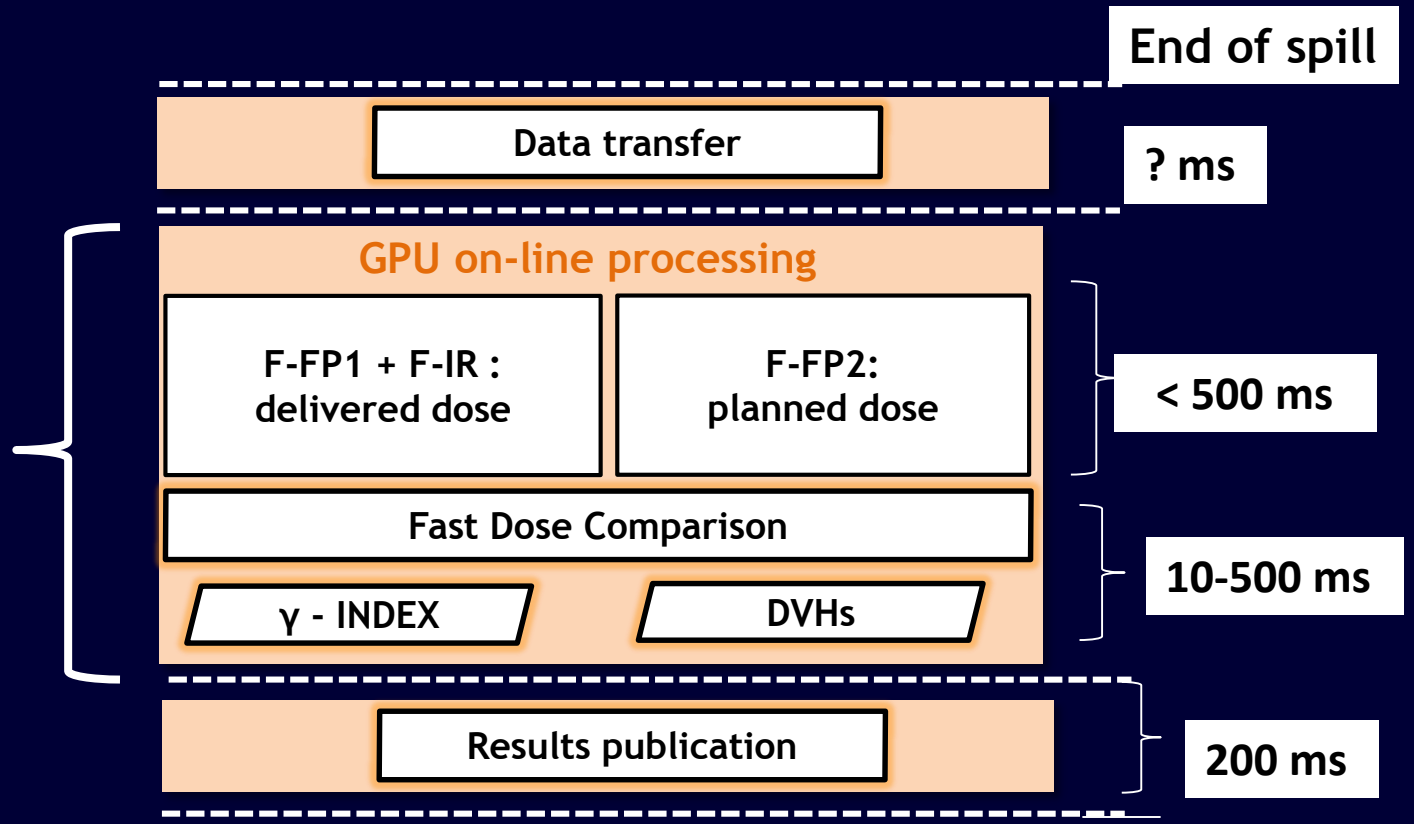
Main tools on GPU:

1 Forward Planning (DONE)

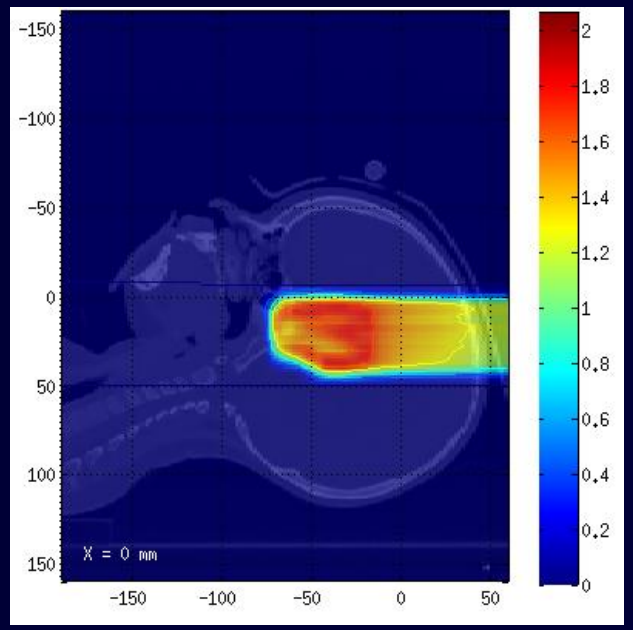
γ - INDEX (DONE)

DVHs (TO DO)

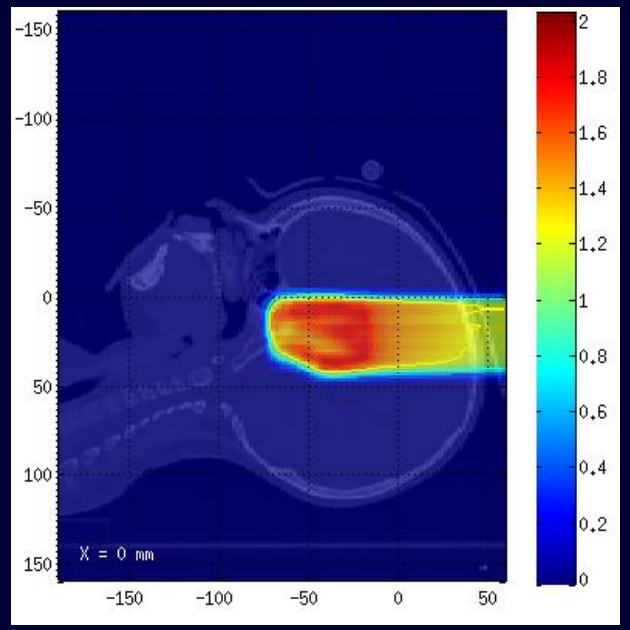
Useful for WP-11



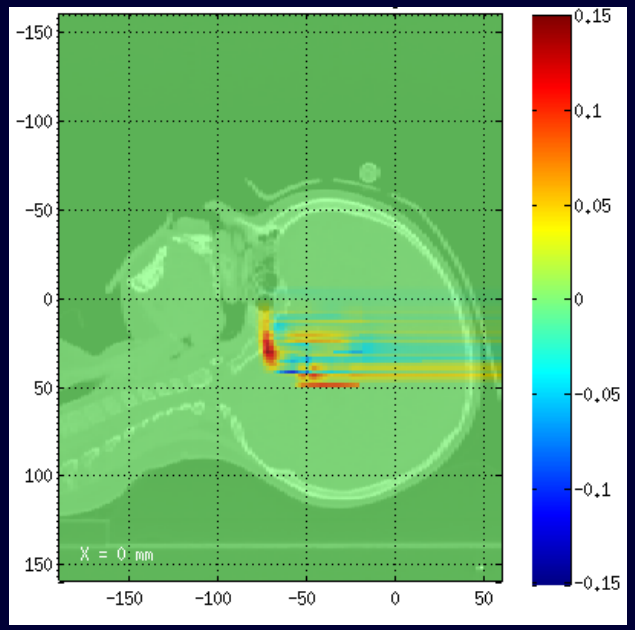
Example of Dose comparison



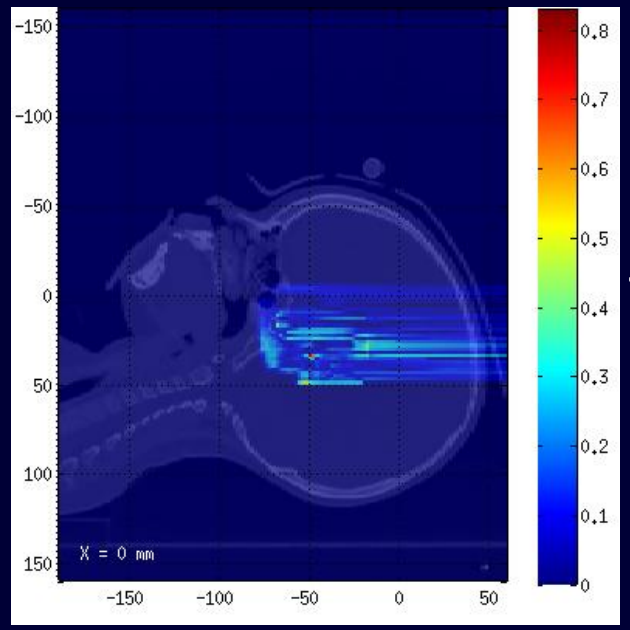
Planned Dose (Gy)



Delivered Dose (Gy)

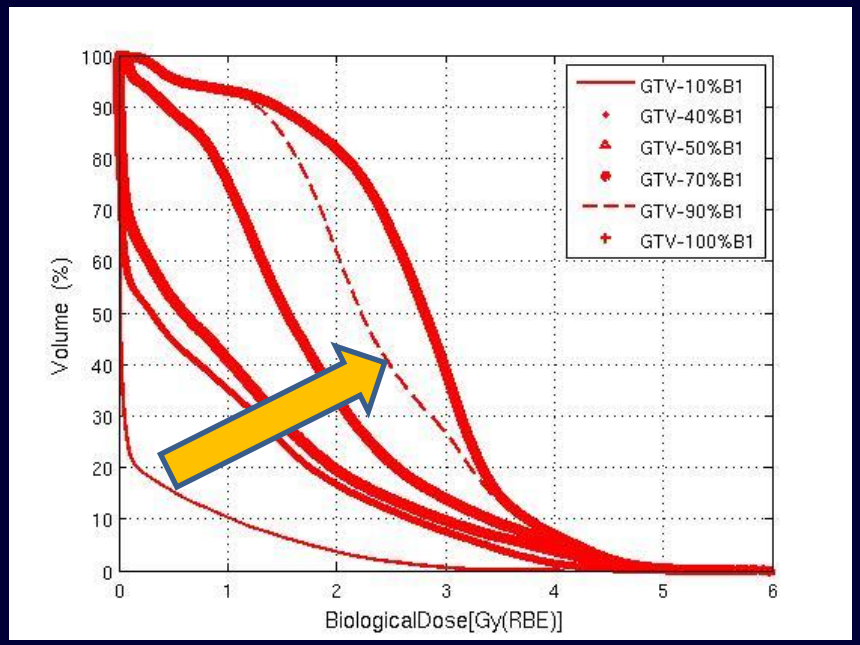


Dose Difference (Gy)



Gamma Index
DD=3% DTA=3mm

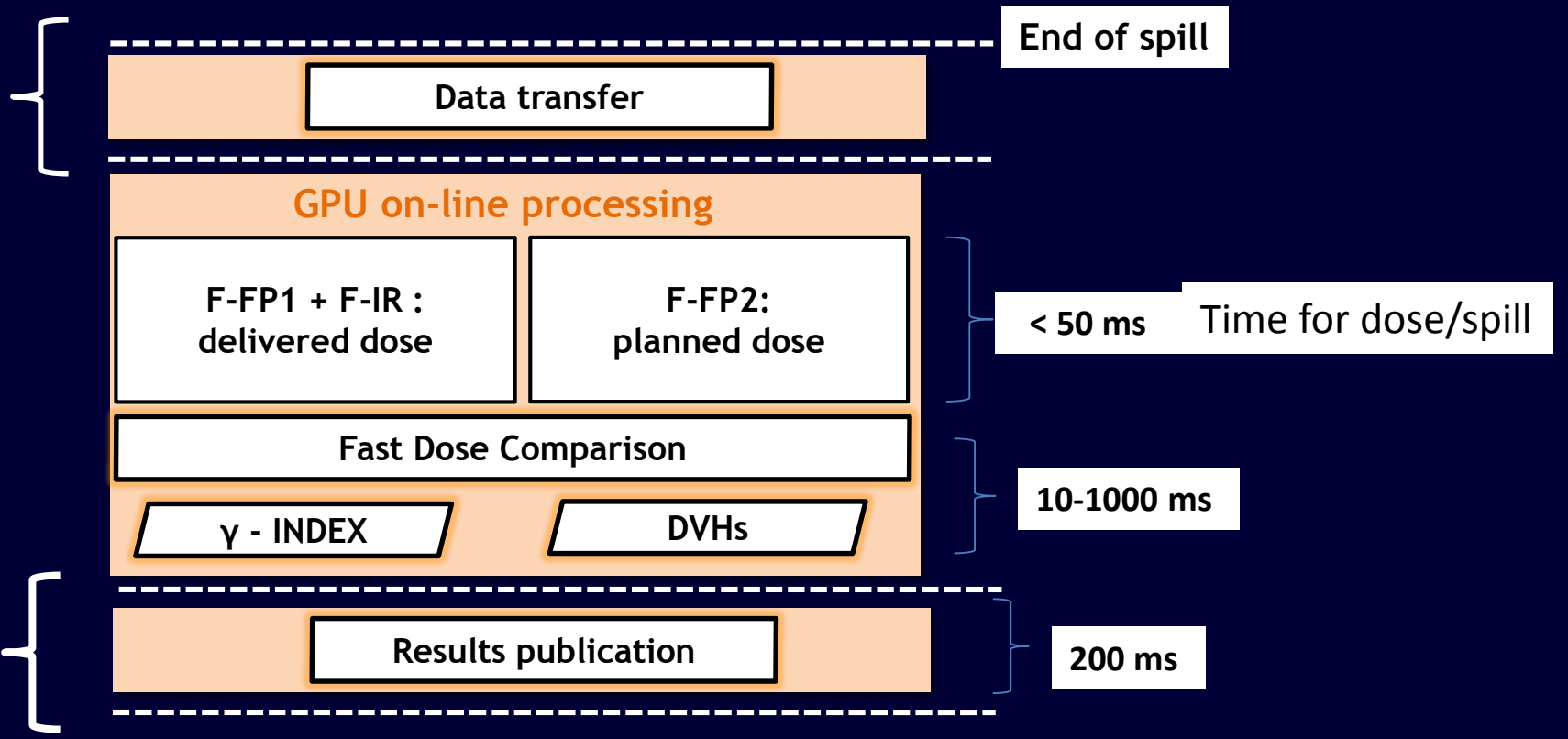
Dose Volume Histogram



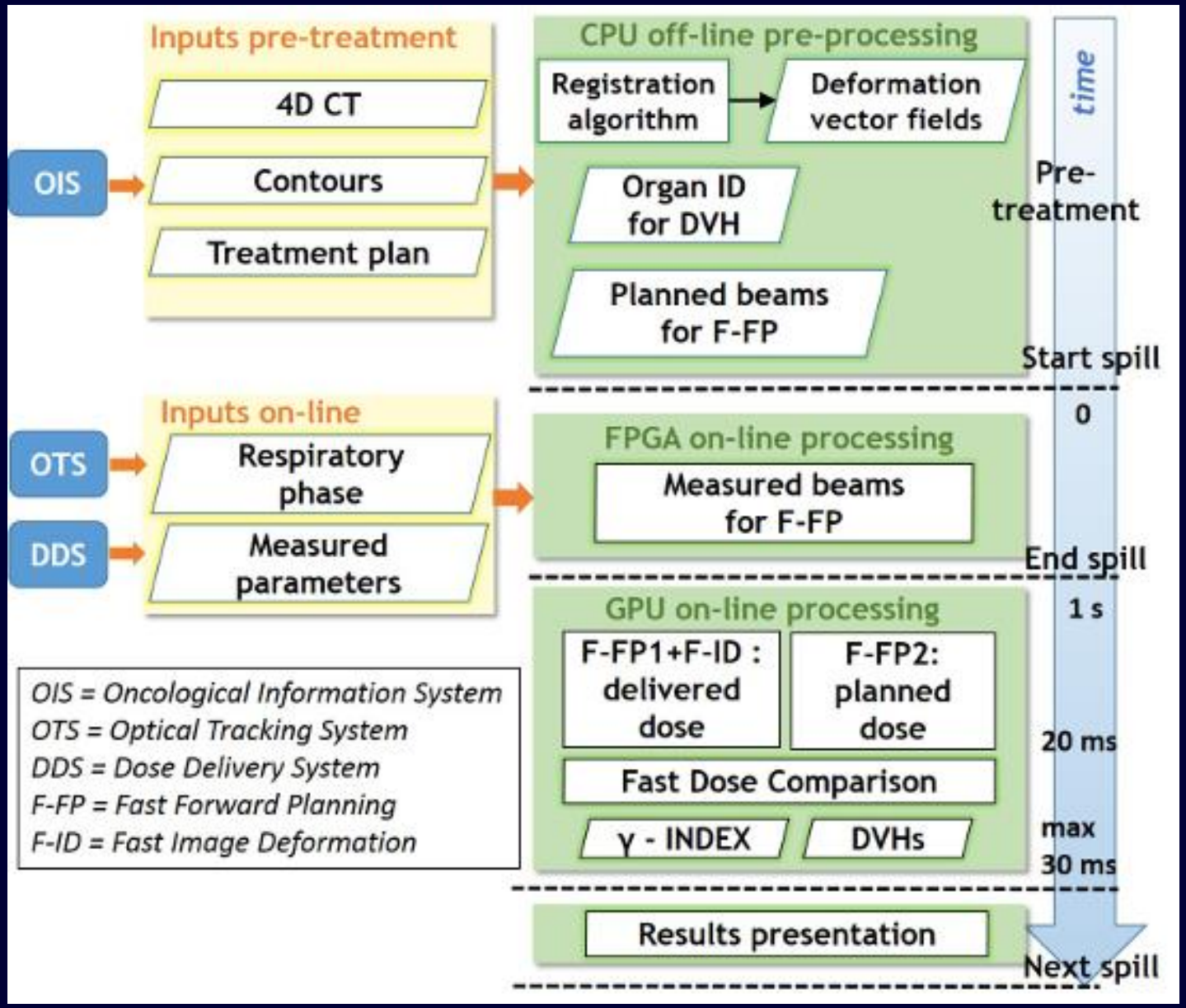
DVH all'aumentare degli spill

CPU-GPU data sharing: RIDOS-GUI

MatLAB-based GUI underdevelopment



RIDOS 2016: commissioning at CNAO



RIDOS 2016 → RDH - WP11 Milestone

- **WP11: Commissioning of an integrated platform for real-time and fast-MC dose calculation at CNAO**

M1: Testare e validare con 10 pazienti reali del CNAO (5 protoni e 5 carbonio) l'accuratezza di nuovi metodi-algoritmi per il calcolo veloce della dose per adroterapia utilizzando il sistema RIDOS, sviluppato in un progetto di CSN5 (Grant Giovani 2013).

RIDOS status

L’integrazione finale di tutti i processi e strumenti e’ in ritardo di 2/3 mesi e cosi’ anche il primo test a CNAO

L’interfaccia con l’OTS è ferma per mancanza di persone lato OTS

La maggior parte delle *milestones* sono state raggiunte e con l’approvazione del WP11 per il 2016 il sistema verrà testato e messo a disposizione dei fisici medici del CNAO

RIDOS 2017 - ?

→ Parliamone partendo per esempio da:

- [?] RIDOS per ciclotrone
- [?] Integrazione di nuovi algoritmi (come Fred) per il calcolo della dose
- [?] Integrazione di nuovi input al calcolo della dose
- [?] Implementazione della parte di ottimizzazione del TPS su GPU
- [?] Disegno di un nuovo progetto per l'implementazione clinica dell'adaptive therapy partendo dall'esperienza e competenze di RIDOS e di tutta la comunità di RDH-IRPT