FRIDA

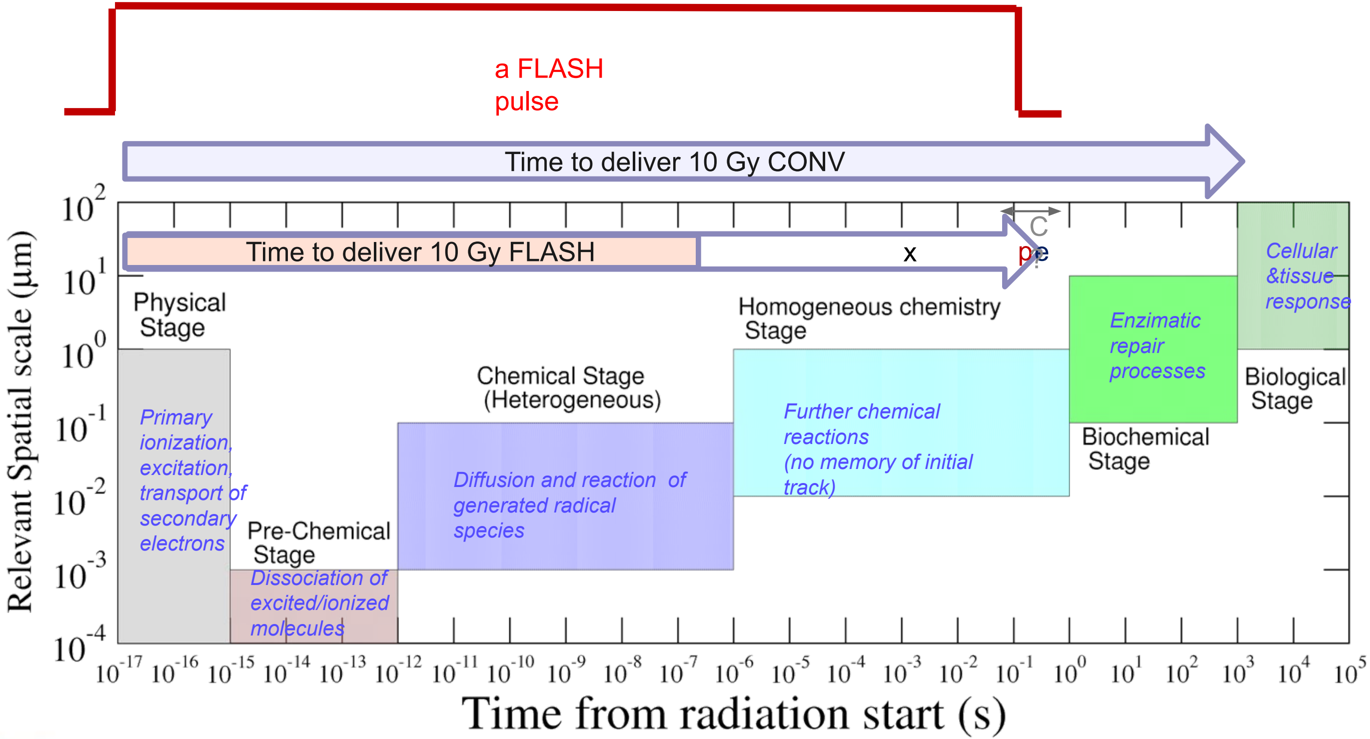
FLASH Radiotherapy with hIgh Dose-rate particle beAms

WP4 Meeting 19-01-2022

Outline

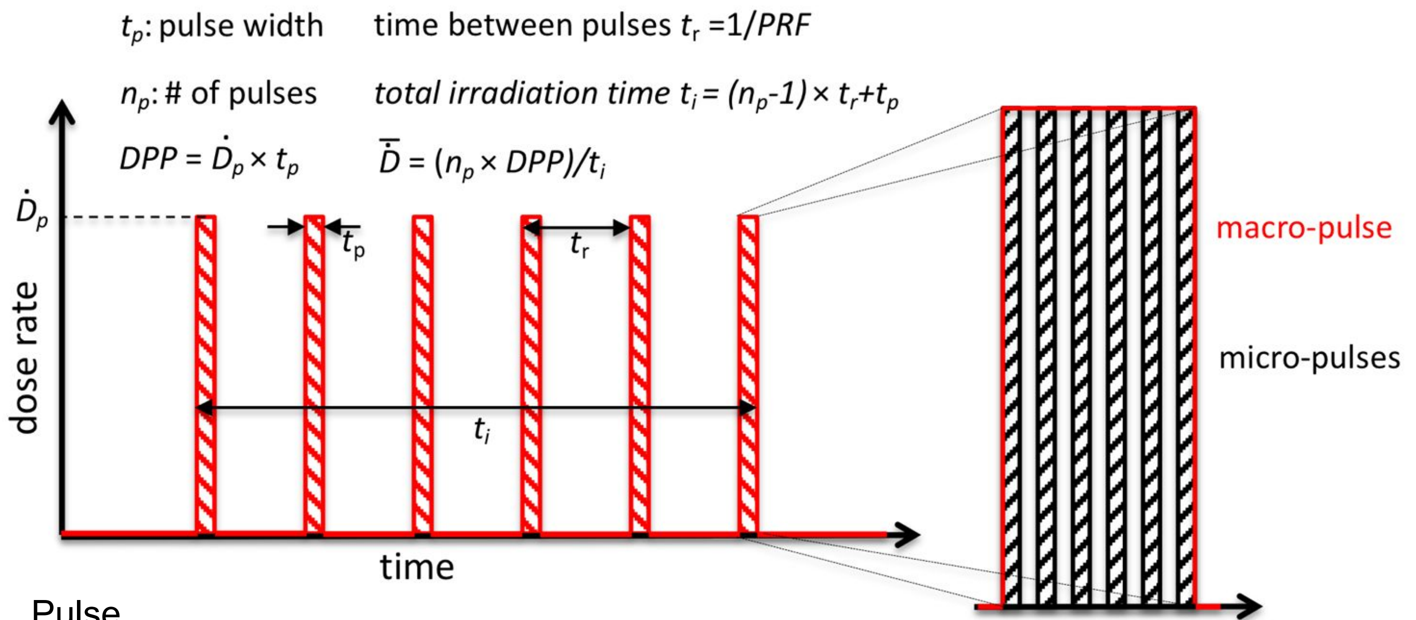
- recap of WP4 framework (from Alessio presentation)
- who we were / who we are in WP4
- WP4 tasks
- WP4 deliverables
- Kick-off meeting schedule

Time scale of FLASH effect



Weber, Scifoni, Durante Med Phys 2021 acc.

A crucial role is played by the dose delivery time structure..

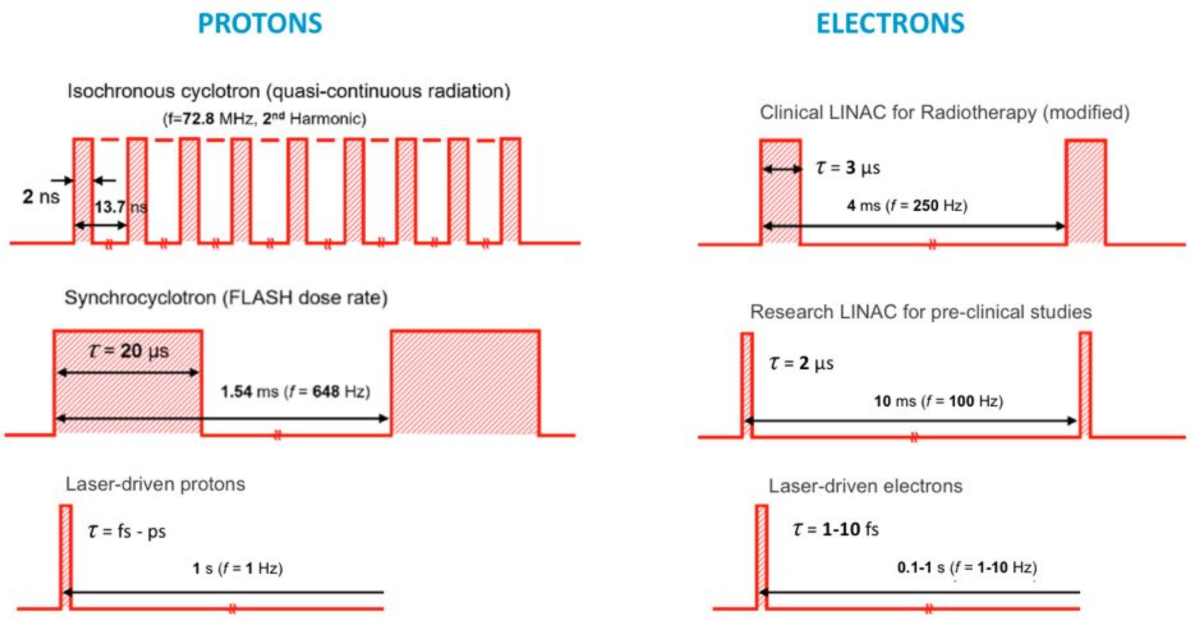


Esplen et al. PMB 2020

Pulse frequency

$$\dot{n} = \frac{n_p}{t_i}$$

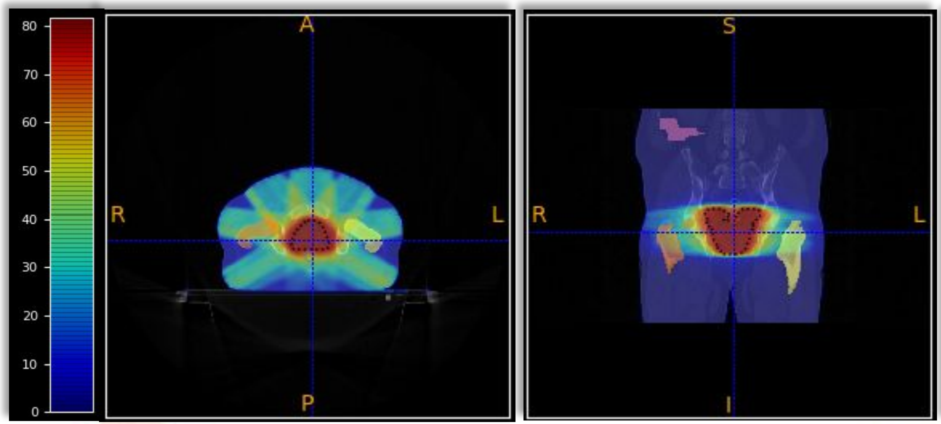
A crucial role is played by the dose delivery time structure..



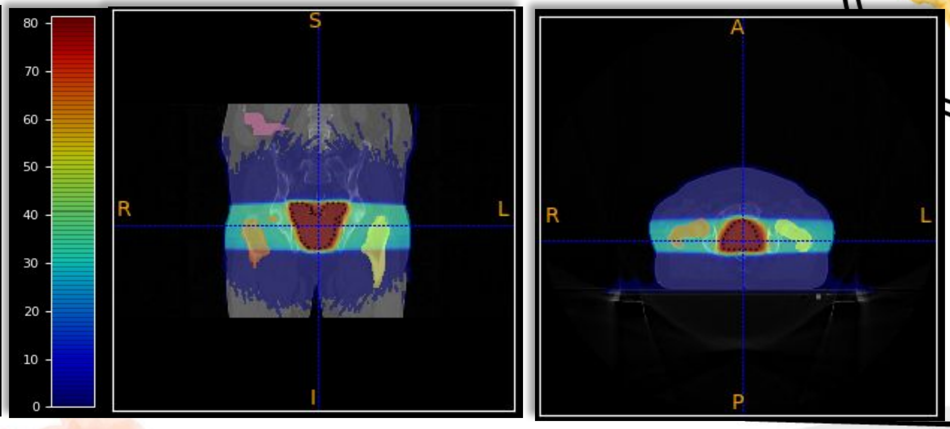
F. Romano et al., Medical Physics (Supplemental issue “FLASH radiotherapy: Current Status and Future Developments”, edited by K. Parodi, J. Farr and D. J. Carlson.), under review

WP4 challenge: TPS & FLASH potential

- Assuming that the FLASH effect and some kind of NT sparing are confirmed.
  - How can we evaluate the **impact and real potential of such effect in a real clinical environment/scenario**?
- There are some reasonable constraints that have to be considered.. And the final word comes only after **comparing with standard, state of art, RT and PT**..



IMRT with 7 fields [actual treatment]

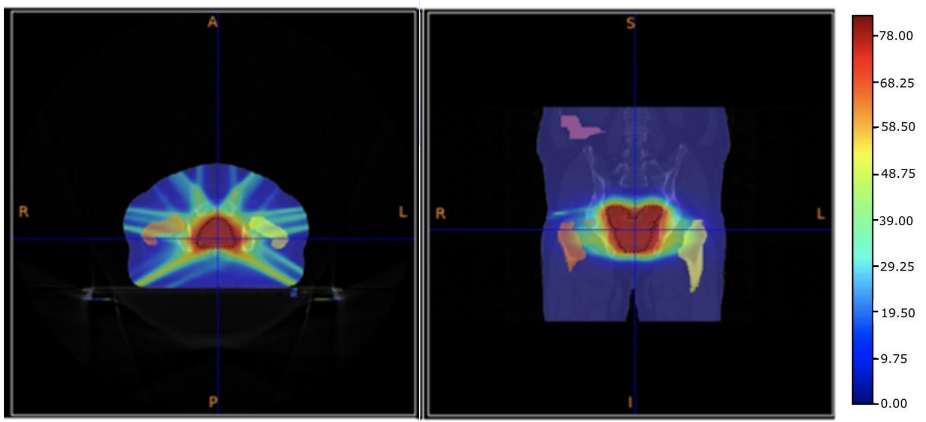


Protons [simulation]

WP4: the VHEE example

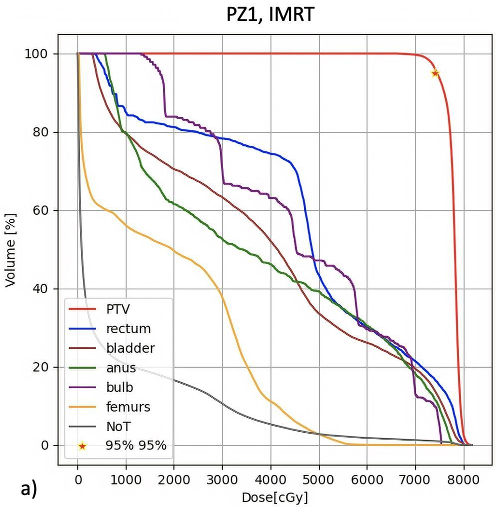
- The high energy electrons potential:
  - **Suitable for FLASH implementation**
  - **IORT is already there**

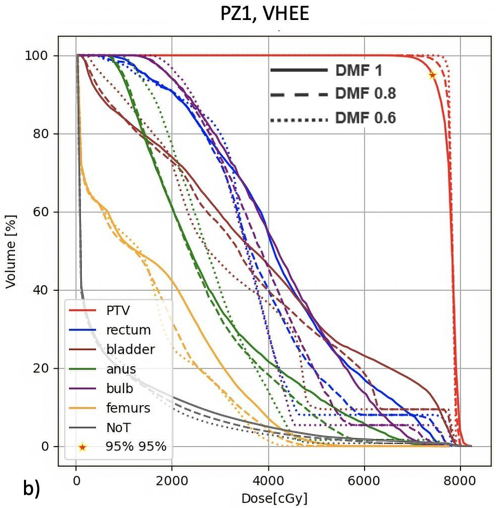
The FLASH potential has been studied [1] comparing the DVH for different techniques assuming different sparing levels

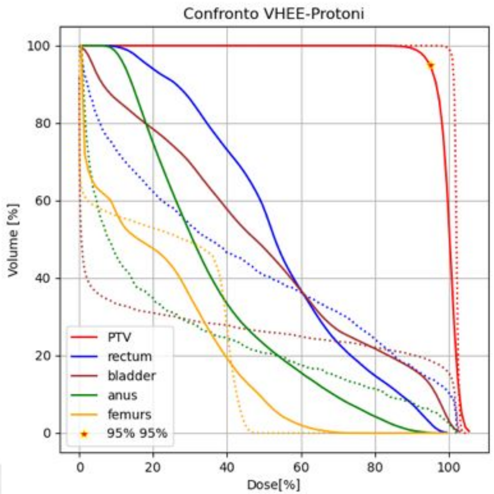


Biological Dose after optimisation (no FLASH effect)

[1] A. Sarti et al, "Deep seated tumour treatments with electrons of high energy delivered at FLASH rates: the example of prostate cancer" Frontiers Oncology



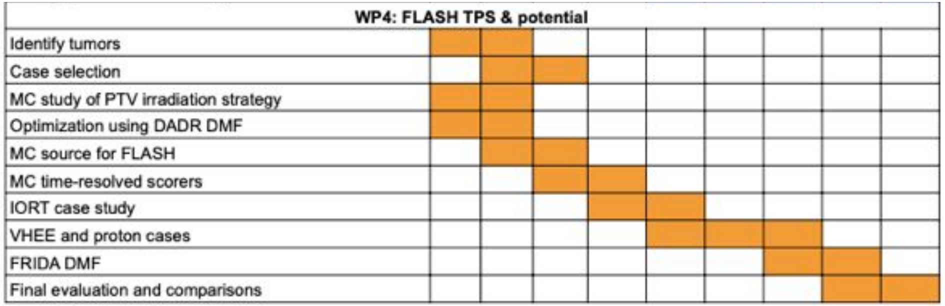




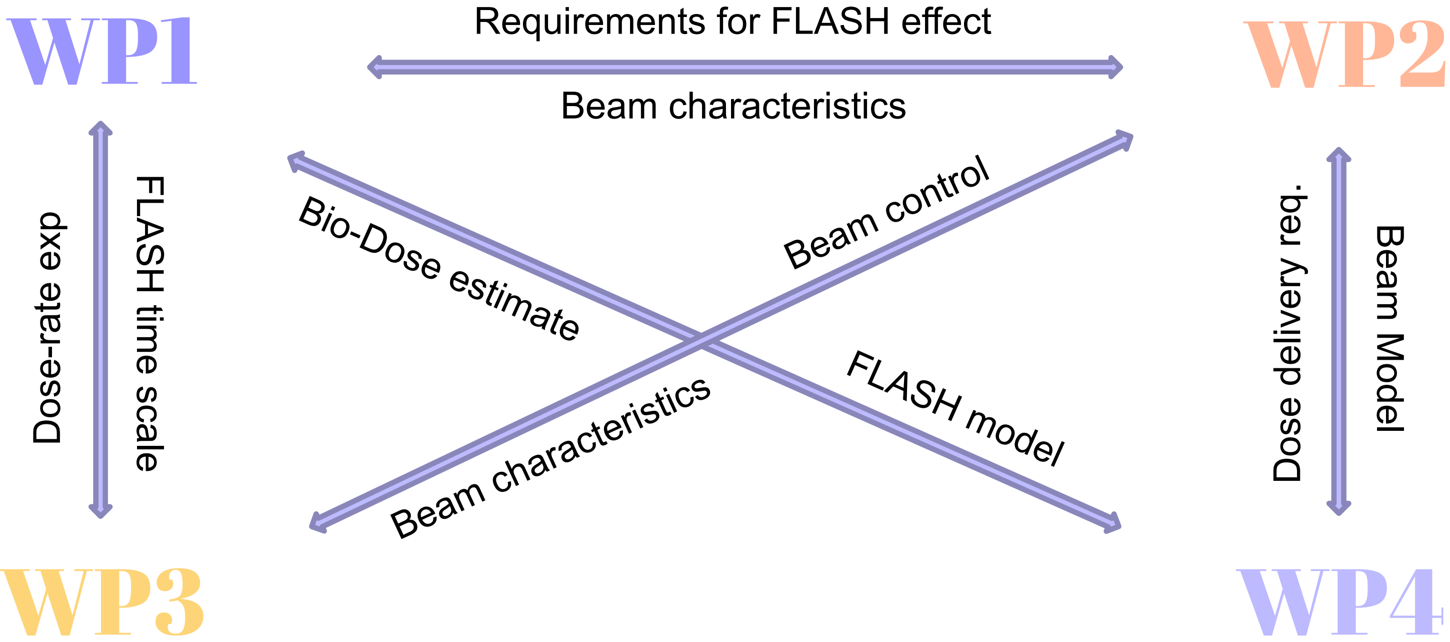
WP4: deliverables & schedule

With a budget of 62 k€ (6% of the total), WP4 aims to

- Compute [MC] the biological dose that enters the treatment optimisation procedure and implement the time scale of interest for FLASH studies (a real computational challenge!)
- Develop the algorithms for a **fast and reliable optimisation for a FLASH treatment [here, going GPU is mandatory].**
- Explore the most promising scenarios where we already know the standard/common RT/PT are known to fail (be suboptimal)..
    - **Keywords are: Hypofractionation, radio resistance.**
    - **We're going to start from: primary tumors and multiple brain metastases, pancreatic cancer and lung cancer**



Networking in FRIDA is crucial!



Who in WP4?

WP4 - FLASH treatment planning. Resp: A. Schiavi and M. Schwarz

Nome	Unit	FTE	Nome	Unit	FTE	Nome	Unit	FTE
Schwarz M.	TIFPA	0.2	Kraan A.	PI	0.1	Sarti A.	RM1	0.5
Muraro S.	MI	0.2	Paiar F.	PI	0.1	Schiavi A.	RM1	0.3
Mattei I.	MI	0.2	Rosso V.	PI	0.1	Patera V.	RM1	0.1
Dong Y.	MI	0.2	Ursino S.	PI	0.1			

Tasks

Task 4.1 Identification of clinical cases

Identification of tumors (kind, location, and dosimetry/planning protocols) where the FLASH effect could offer the highest differential benefit with respect to conventional irradiations (PI and TIFPA). Selection of actual clinical cases and comparison using MC tools and optimization techniques (PI).

Tasks

Task 4.2 Enabling Monte Carlo simulations

Setup a complete start-to-end workflow for MC simulations. The code FLUKA will be used to perform detailed simulations of patient irradiation plans. Definition of beamline models for p and e beams. Input patient geometry and morphology from imaging diagnostic data (e.g. CT or NMR). Setup MC time-resolved scorers to provide dose-rate and radiation quality information on the timescale indicated by WP1 studies. (Roma1, MI and TIFPA)

Tasks

Task 4.3 Treatment plan optimisation using DADR DMF

Implementation of an optimization tool running on GPU hardware to enable fast exploration of optimization strategies (Roma1). The first attempt will use the most favourable Dose Modifying Factor (DMF) assuming a Dose-Averaged Dose-Rate (DADR). The selected plans will be simulated and optimized (Roma1 and MI), and the outcome will be compared with current state-of-the-art irradiation techniques (PI and TIFPA).

Tasks

Task 4.4 Inverse planning using “FRIDA DMF”

A new model for DMF will be investigated in close collaboration with the other FRIDA WPs. The so-called “FRIDA DMF” will be implemented in the optimization tool (Roma1), splitting the local dose deposition into two main contributions: a FLASH dose and a time-diluted dose.

Deliverables

Deliver.	Short name	Description	When (M)
D4.1	Identify tumors	Identification of tumors where the FLASH effect could offer the highest differential benefit	6
D4.2	Case selection	Selection of actual clinical cases for the identified tumors.	12
D4.3	MC irradiation workflow	Complete start-to-end workflow for MC simulation of an irradiation plan using electrons or proton beams.	6
D4.4	Optimization using DADR DMF	Optimization of treatment plan using the dose influence matrix produced by MC simulations. Use DADR DMF.	6
D4.5	MC source for FLASH	Implementation of a pencil beam source for MC simulations taking into account pulse time-structure for RF accelerator and laser-plasma acceleration.	12
D4.6	MC time-resolved scorers	Implementation of scorers capable of recording dose deposition and radiation quality on the relevant timescales.	16
D4.7	IORT case study	Complete evaluation of a low-energy electron treatment for IORT using static DMF.	20
D4.8	VHEE and proton cases	Evaluation and optimization of selected cases using VHEE electron and proton beams.	28
D4.9	FRIDA DMF	Implementation of DMF depending on considered tissue and irradiation time-structure	32
D4.10	Final evaluation and comparison	Report on comparison of treatment plans with standard and FLASH dose-rates. Report on preclinical static DMF and FRIDA dynamic DMF.	36

Table n.6 *WP4 deliverables*

Proposed KO meeting schedule

- “State of the art” by M. Schwartz
- “Tasks, tools and workflow organisation” by A. Schiavi
- Unit presentation (who/what/mats and methods)
  - PI
  - MI
  - TIFPA
  - Roma1
- Discussion