O055, ID 42

New R&D platform with unique capabilities for electron FLASH and VHEE radiation therapy and radiation biology under preparation at PITZ (FLASHlab@PITZ)*

Frank Stephan for the PITZ team,

Head of the Photo Injector Test facility at DESY in Zeuthen (PITZ)

If you have interest in collaborating with us or doing experiments at PITZ ?

→ Please contact me: frank.stephan@desy.de

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

PITZ Photo Injector Test Facility Zeuthen

DESY.

* Former name „HP²eFLASH-RT@PITZ “ seemed too complicated.

Faculty Disclosure

FRPT FLASH RADIOTHERAPY & PARTICLE THERAPY 2021

I am only employed by DESY, a public research center in Germany, so there are

No Disclosures

DESY

Largest accelerator center in Germany, one lab - two locations: Hamburg + Zeuthen (near Berlin)

(ARES: single e^- bunches, 50Hz, **160 MeV)**

Facts and Figures

- publicly funded national research centre of the Helmholtz Association
- **Employees** at DESY
  - approximately **2700**, including 1180 scientists
- Interdisciplinary research, international cooperation
- Research at DESY in 4 areas:
  - **Accelerators**
  - Photon Science (focus in Hamburg)
  - Particle Physics
  - Astroparticle Physics (focus in Zeuthen)

Courtesy of Ulrike Behrens

PITZ

New activity: → FLASHlab@PITZ

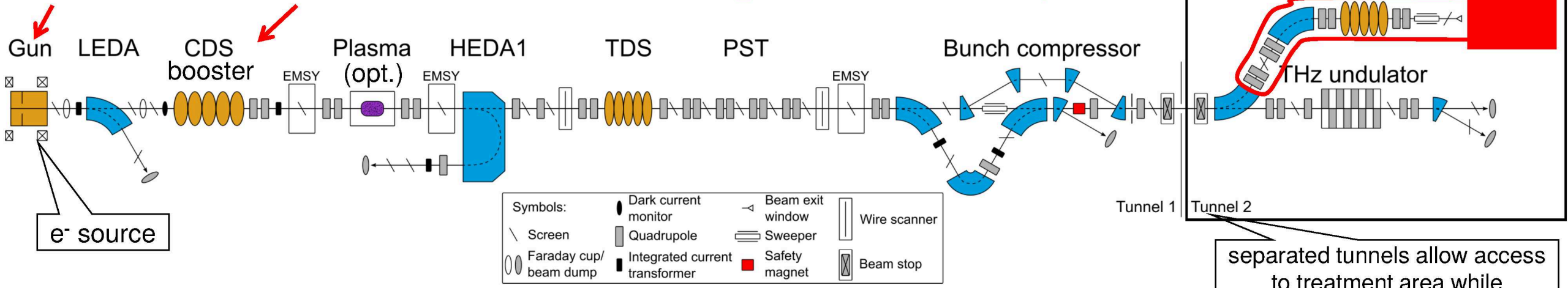
Where we come from and where we go ?

- The **P**hoto **I**njector **T**est facility at DESY in **Z**euthen (**PITZ**) was+is used to **test** and **optimize** high brightness **electron sources** for Free-Electron-Laser user facilities (**FELs**) like FLASH & European XFEL in Hamburg

- We also do general accelerator R&D + applications of high brightness beams
  → **R&D on electron FLASH radiation therapy (FLASHlab@PITZ)**

free space for FLASHlab@PITZ area:
> 6 x 2 x 3 m (l x w x h)

<7 MeV/c **<22 MeV/c** **lots of beam diagnostics and beam manipulation**



separated tunnels allow access to treatment area while accelerator is running

Use existing accelerator + expect add. resources (e.g. from **structure funds**)

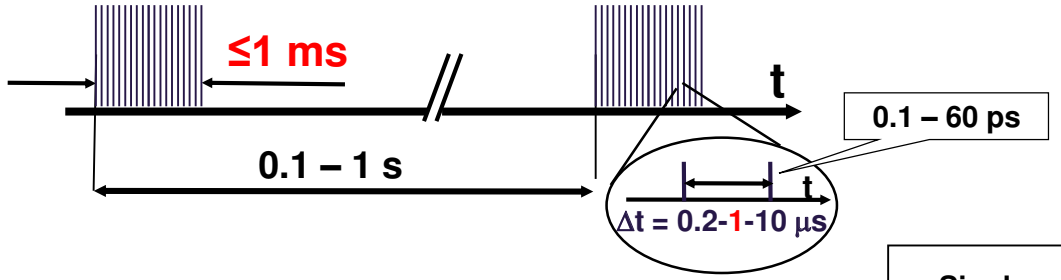
Unique beam properties at PITZ

allow extremely flexible treatment parameters and dose distribution (in space + time)

- Possibility of **bunch trains** with **up to 1 ms** length:
  - Bunch repetition rate within train 0.1 – 1 MHz (opt. 4.5 MHz)
  - Trains can be repeated with up to 10 Hz

  ➔ **1 – 1000 bunches in 1 ms (opt. up to 4500)**

  ➔ 1 – 10 000 bunches in 1 s (opt. up to 45 000)
  - Depending on **bunch charge (<fC – 5nC)** indiv. bunches have
    a) **length** of **~0.1 – 60 ps** (bunch compressor)
    b) **spot size** down to **~100µm**

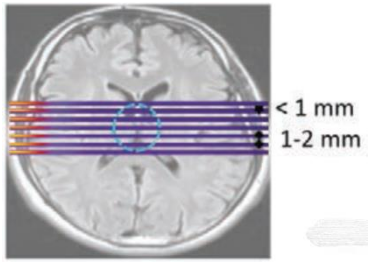


- **Kicker** can be used to distribute the bunches of the bunch train (1ms) over treatment area

  ➔ **"painting" tumor** with micro beams **within 1 ms**

  ➔ **~no organ motion**
  - Kicker system is already existing

  ➔ **possibility of micro beam radiation therapy (MBRT)**



Courtesy of Angeles Faus-Golfe

Two examples:

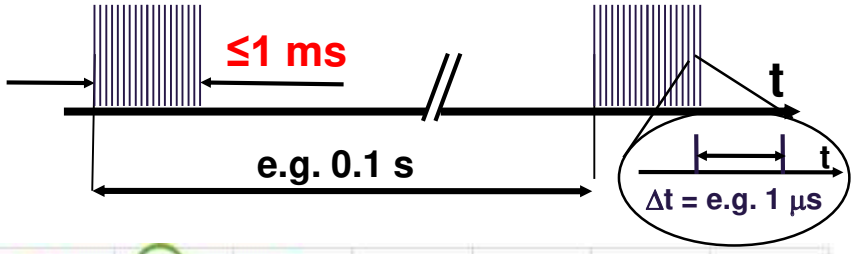
Single bunch: ~9 Gy/cm³

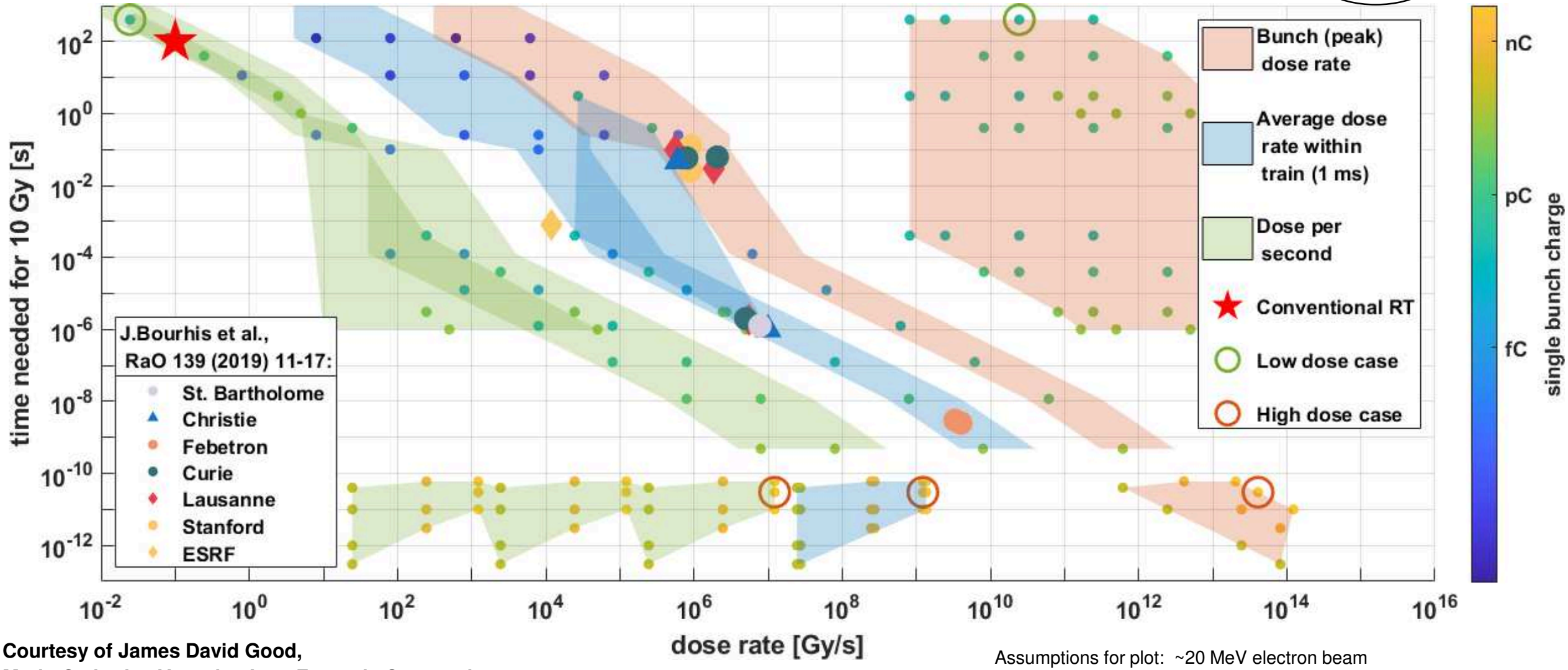
Options @PITZ:	low dose case	high dose case
Bunch charge [pC]	0.1	5 000
Single bunch OR train	single bunch	1ms train (1MHz)
RF pulse rep. rate	1Hz	10Hz
Bunch length [ps]	<1	~30
Dose | Dose rate **per bunch** [Gy | Gy/s]	0.02 | >2E+10	1000 | 4E+13
Dose | Dose rate **per train(ms)** [Gy | Gy/s]	0.02 | 20	1E+6 | 1E+9
Dose **per second** [Gy/s]	0.02	1E+7

Assumptions for table:
~20 MeV e-beam in water with **1mm³** irradiation volume.

Parameter space available at PITZ

In comparison with the state-of-the-art up to now



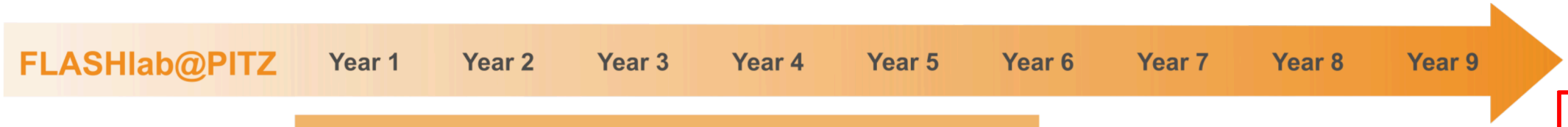


Courtesy of James David Good, Marie-Catherine Vozenin, Jean-Francois Germond

Assumptions for plot: ~20 MeV electron beam in water with **1mm³** irradiation volume.

Timeline of joint project proposal by DESY + TH Wildau

Bridge to Lausitz: CTK, medical faculty @BTU Cottbus, training center, medical technologies



Major responsibilities:
DESY (Z): accelerator, 64%
DESY (HH): module/cryo., 16%
TH Wildau: biology, 20%

PITZ Photo Injector Test Facility Zeuthen

DESY.

Technische Hochschule Wildau *Technical University of Applied Sciences*

WILDAU

22 MeV beam:

beam dynamics, dosimetry and adaptation, *in silico* (computer-based) simulation

prep | *in vitro* studies (cell-based) | prep | *in vitro* studies (cell-based)

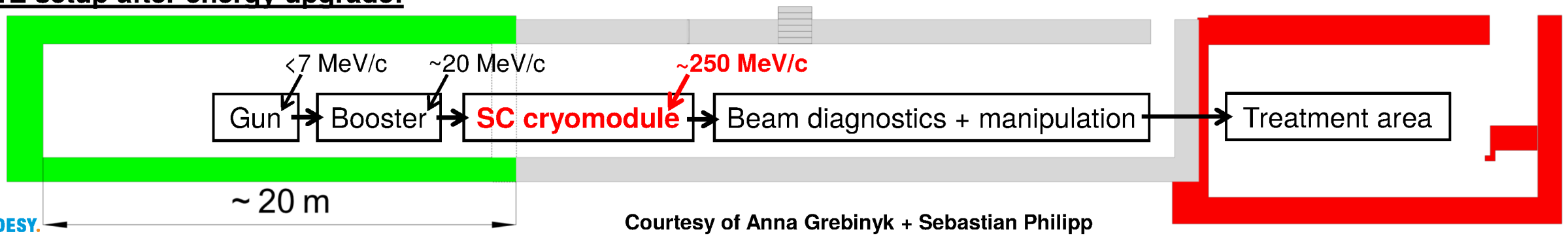
prep | *in vivo* studies (organism-based) | prep | *in vivo* studies (organism-based)

energy upgrade to 250 MeV beam:

prep | shutdown | beam dynamics, dosimetry

Define optimum **clinical beam parameters** for curing different **types of tumor** in human body

PITZ setup after energy upgrade:



DESY.

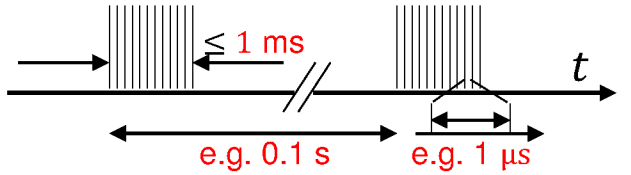
Courtesy of Anna Grebinyk + Sebastian Philipp

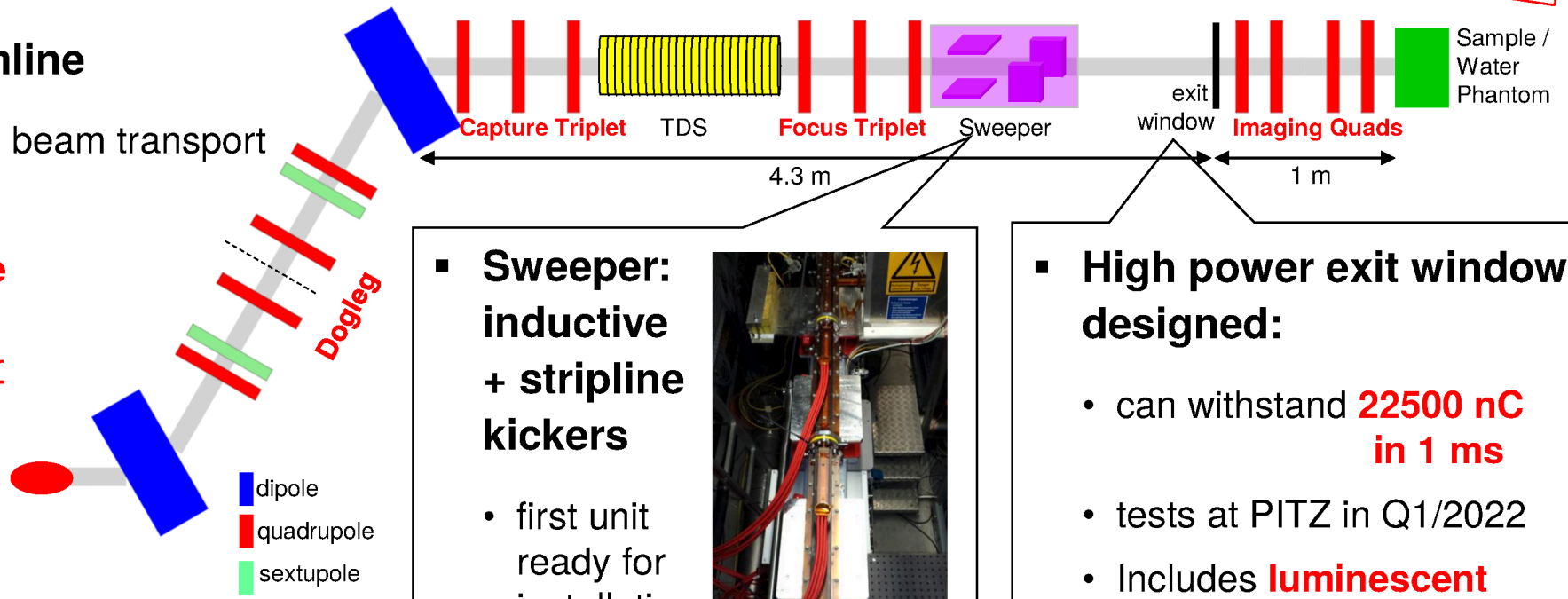
Preparations for FLASHlab@PITZ are ongoing

Beamline design will allow very flexible treatment parameters

Unpublished material, when following these ideas please refer to this presentation

- **Design of FLASH-RT beamline**
  - **fully controlled high charge** beam transport
  - **sweep** bunch train in **1 ms**
  - **image** exit window **to sample**



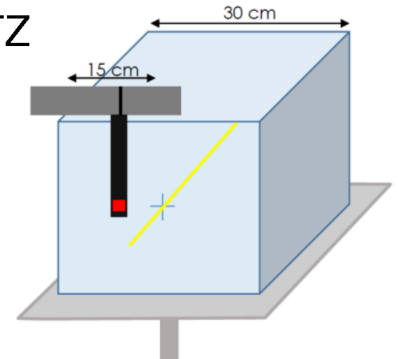


- **Sweeper: inductive + stripline kickers**
  - first unit ready for installation **1/2022**

- **High power exit window designed:**
  - can withstand **22500 nC in 1 ms**
  - tests at PITZ in Q1/2022
  - Includes **luminescent layer** on air side → **online** monitoring of **transverse beam distribution**
  - Imaged on sample ➔ **online** monitoring of **transverse dose distribution**

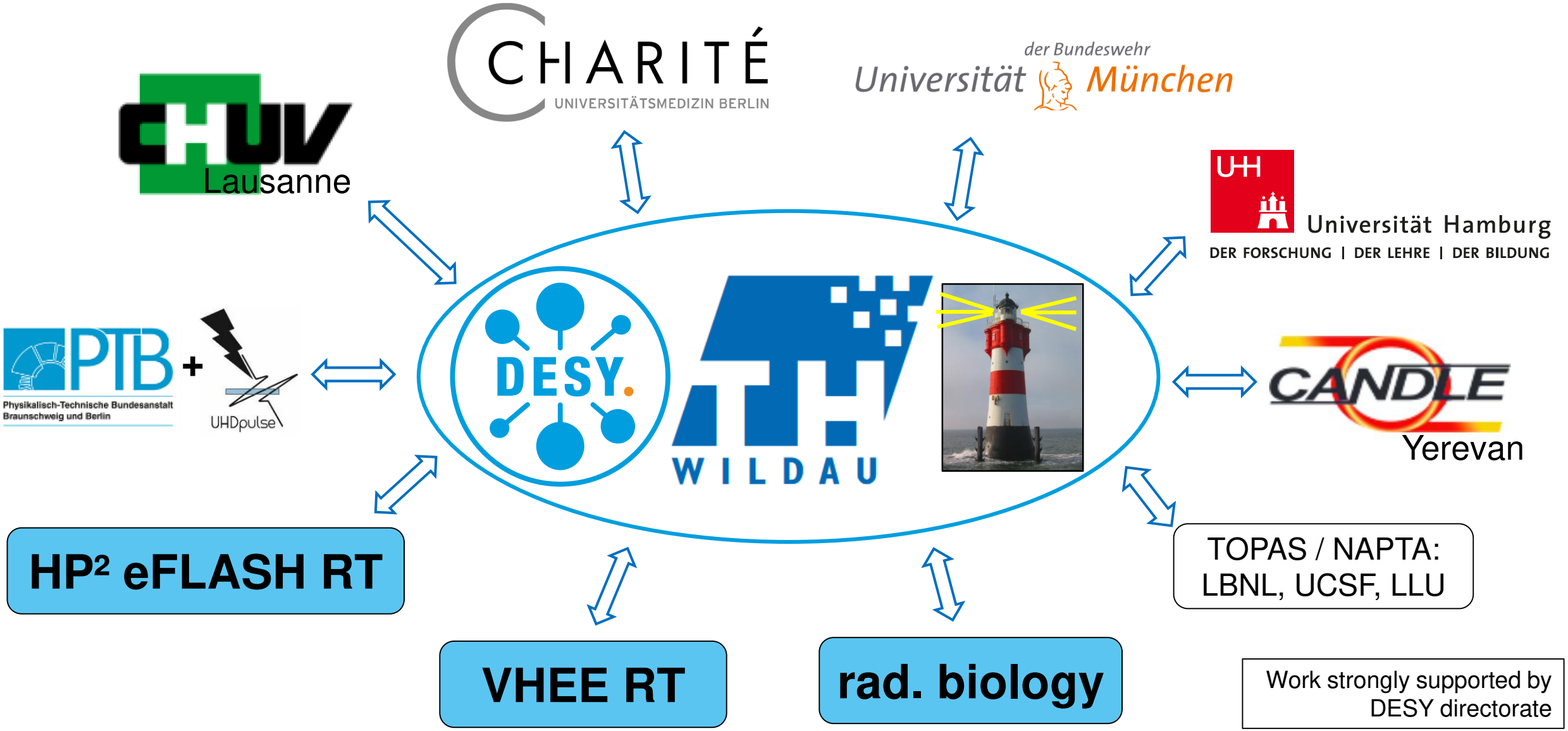
- **First dosimetry tests in Q1/2022**
  - Advacam interested to test **TimePIX3** at PITZ

More info on TimePIX3 → see poster of Cristina Oancea



Courtesy of Xiangkun Li, Gregor Loisch, Michael Schmitz, Cristina Oancea

The project FLASHlab@PITZ schematically:



Work strongly supported by DESY directorate

Summary

- **DESY is Germanys largest accelerator laboratory with a high international reputation.**
- **PITZ (Zeuthen) will offer a uniquely wide beam parameter range for R&D in FLASH radiation therapy.**
- **ARES (Hamburg) will offer single bunches at 160 MeV.**

➔ If you are interested in cooperation or performing experiments @DESY (PITZ / ARES), please contact me frank.stephan@desy.de

See also E-Posters by

- **Marcus Frohme, EPV007 (ID 97)**
- **Houjun Qian, EPV015 (ID 286)**
- **Zakaria Aboulbanine (ID 510)**

Picture PITZ Tunnel 2, 20.9.2021. Meanwhile more components were installed.