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 **P**hoto **I**njector **T**est facility at DESY in **Z**euthen (**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

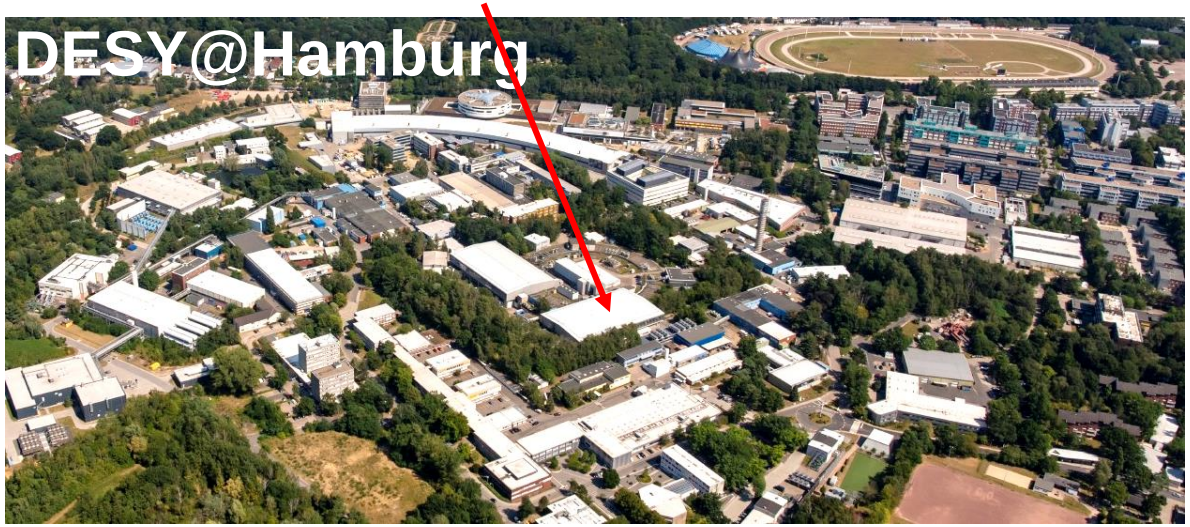
DESY

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)



PITZ

Courtesy of Ulrike Behrens

New activity: → FLASHlab@PITZ

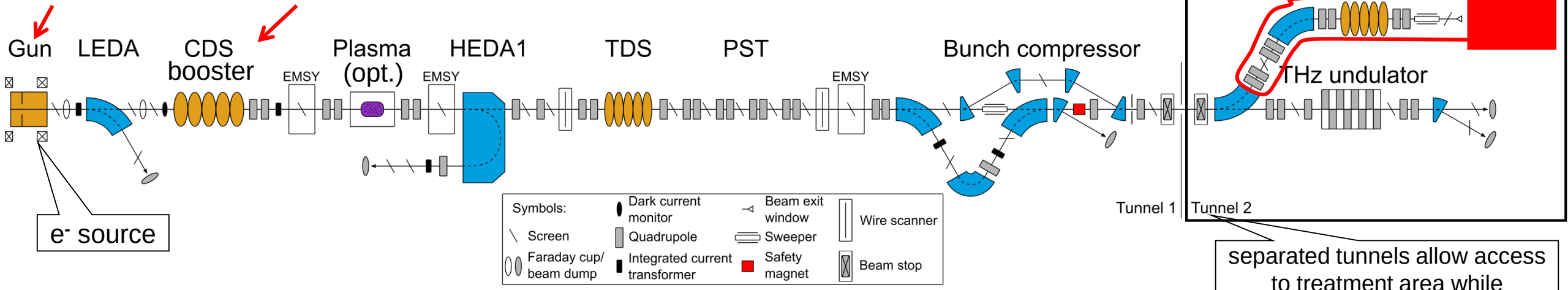
Where we come from and where we go ?

- 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 m³ (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**)

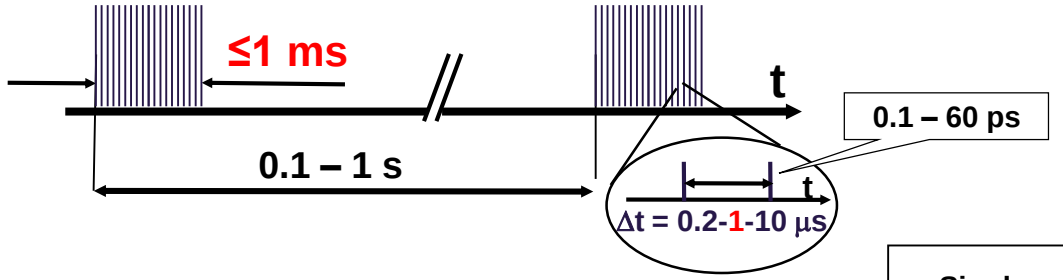
Unique beam properties at PITZ

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**

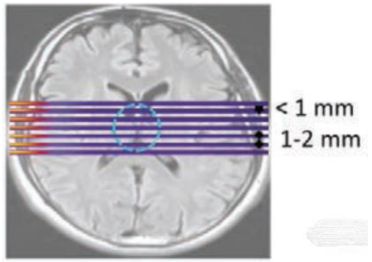


- **Kicker** can be used to distribute the bunches of the bunch train (1ms) over treatment area

  ➔ **"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

Single bunch: ~9 Gy/cm³

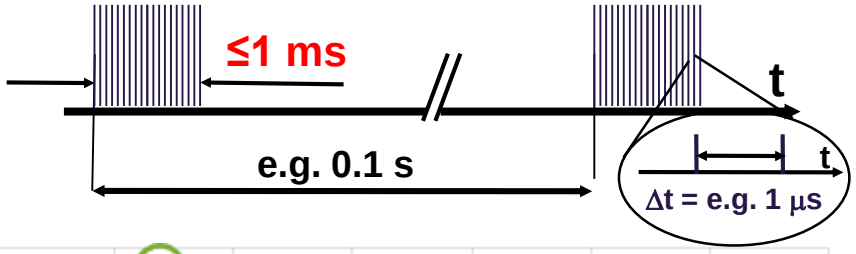
Two examples:

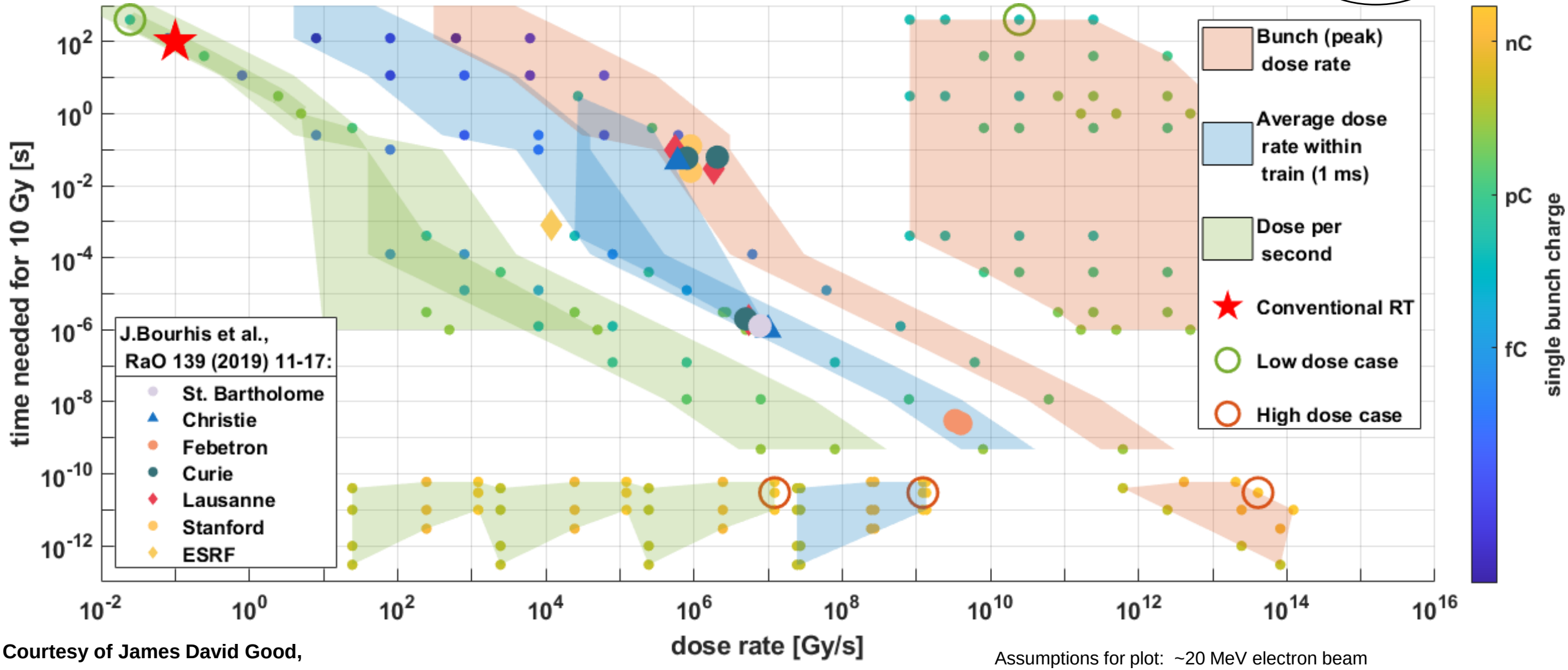
Options @PITZ:	low dose case	high dose case
Bunch charge [pC]	0.1	5 000
Single bunch OR train	single bunch	1ms train (1MHz)
RF pulse rep. rate	1Hz	10Hz
Bunch length [ps]	<1	~30
Dose | Dose rate **per bunch** [Gy | Gy/s]	0.02 | >2E+10	1000 | 4E+13
Dose | Dose rate **per train(ms)** [Gy | Gy/s]	0.02 |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



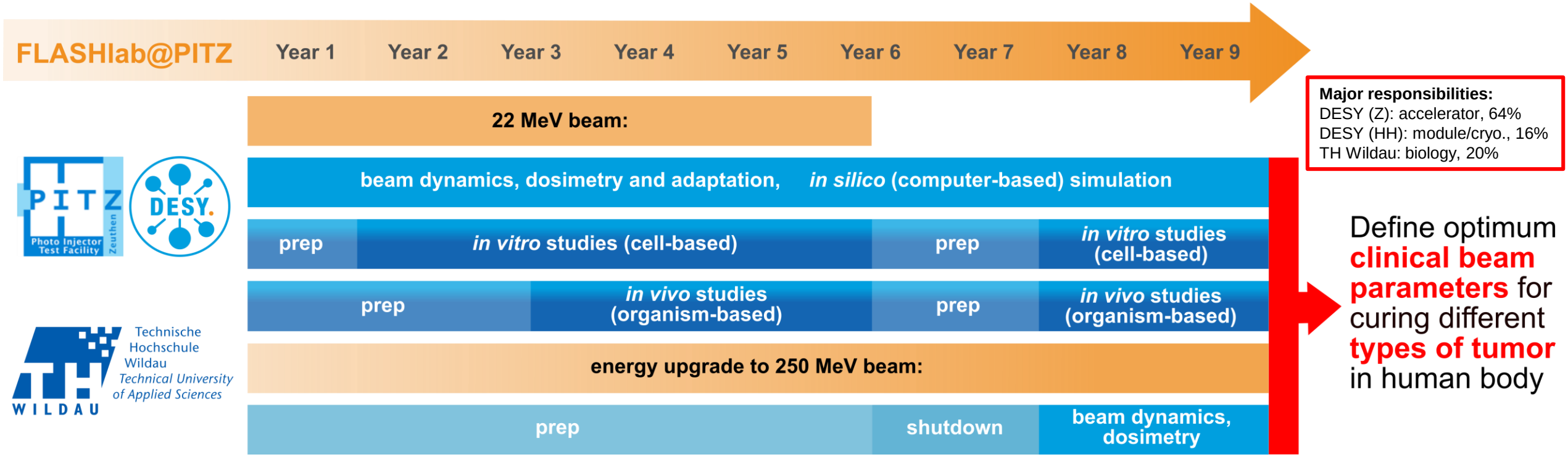


Courtesy of James David Good, Marie-Catherine Vozenin, Jean-Francois Germond

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

Timeline of joint project proposal by DESY + TH Wildau

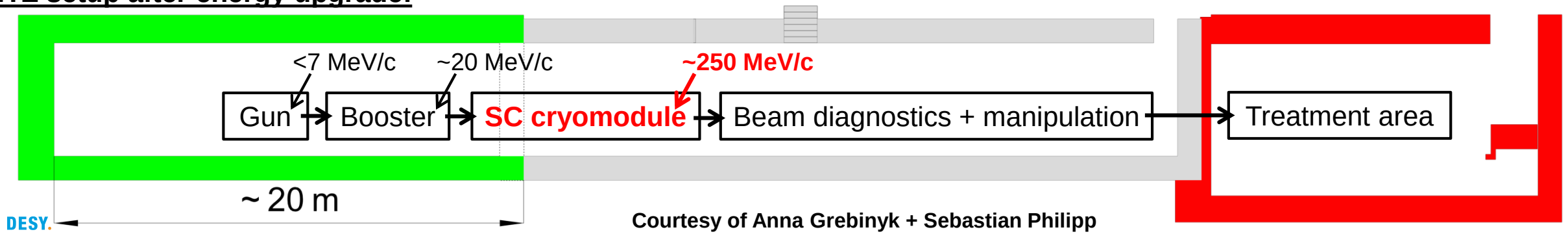
Bridge to Lausitz: CTK, medical faculty @BTU Cottbus, training center, medical technologies



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

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

PITZ setup after energy upgrade:



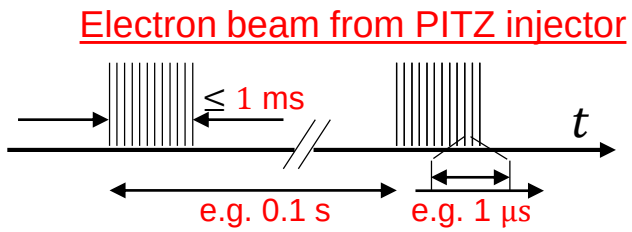
Courtesy of Anna Grebinyk + Sebastian Philipp

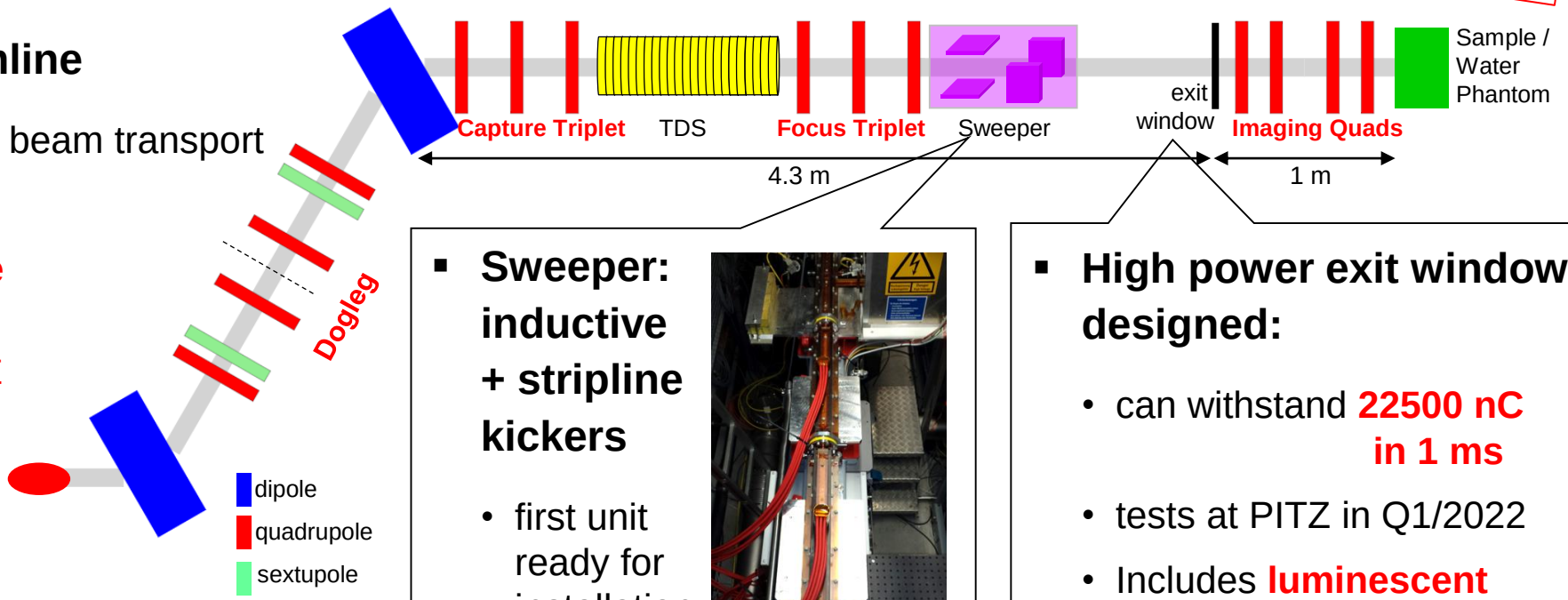
Preparations for FLASHlab@PITZ are ongoing

Beamline design will allow very flexible treatment parameters

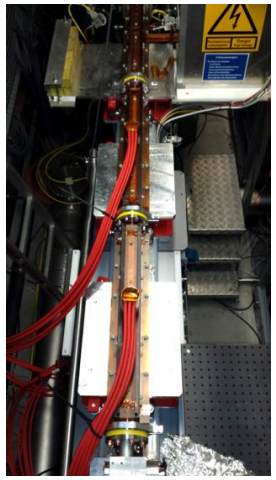
Unpublished material, when following these ideas please refer to this presentation

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





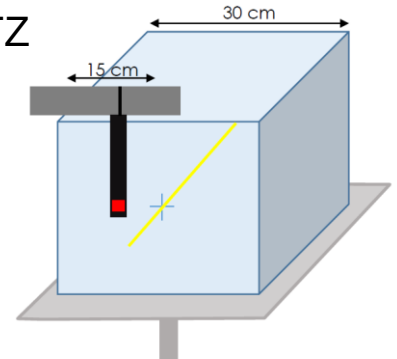
- **Sweeper: inductive + stripline kickers**
  - first unit ready for installation **1/2022**



- **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:

CHARITÉ UNIVERSITÄTSMEDIZIN BERLIN

der Bundeswehr Universität München

CHUV Lausanne

UHH Universität Hamburg DER FORSCHUNG | DER LEHRE | DER BILDUNG

PTB Physikalisch-Technische Bundesanstalt Braunschweig und Berlin + UHDpulse

DESY.

WILDAU

CANDLE Yerevan

HP² eFLASH RT

VHEE RT

rad. biology

TOPAS / NAPTA: LBNL, UCSF, LLU

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.