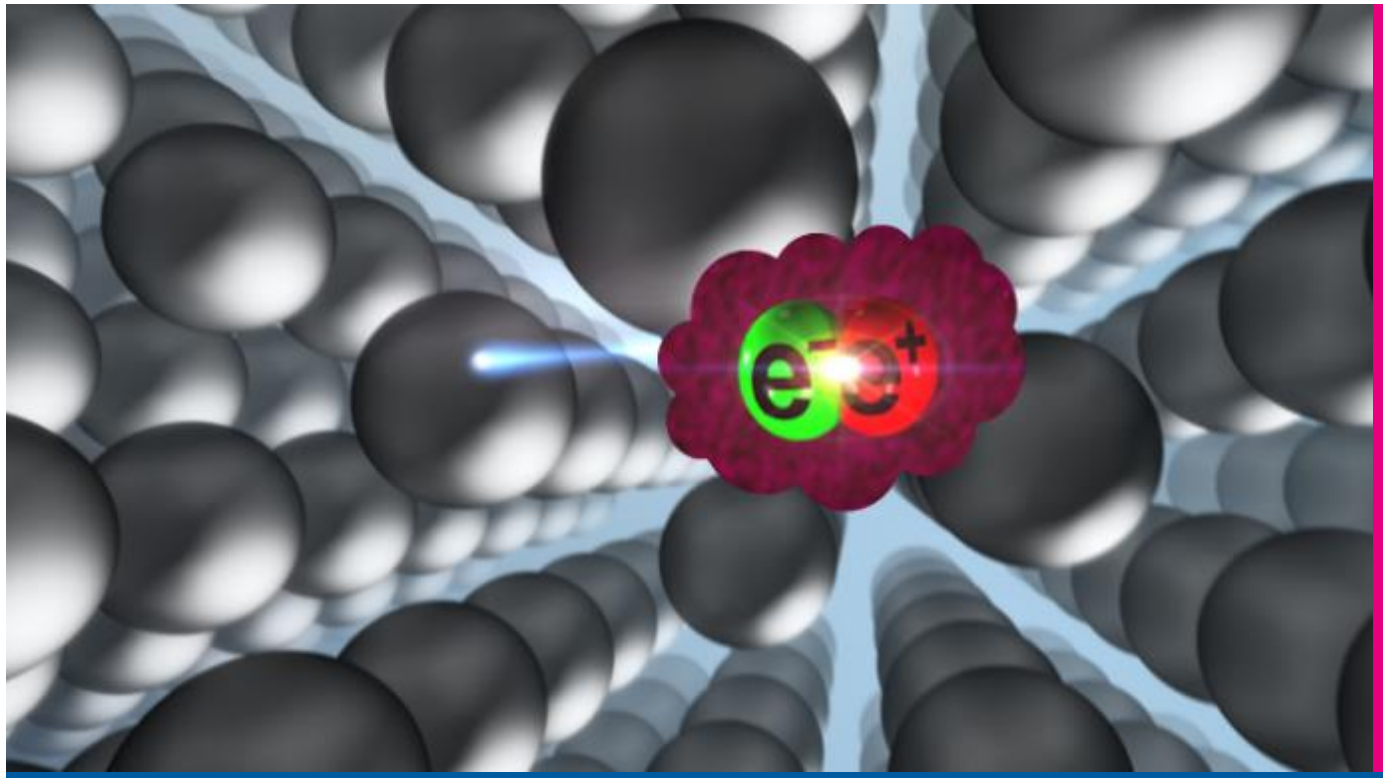
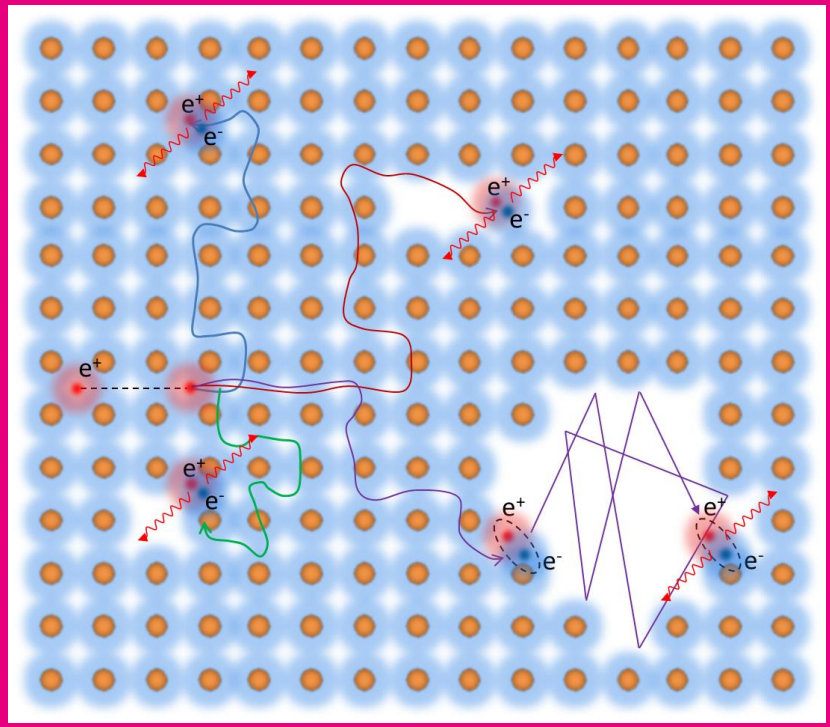
HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF





Positron annihilation spectroscopy (PAS) – NOVALIS 5th

Maciej Oskar Liedke

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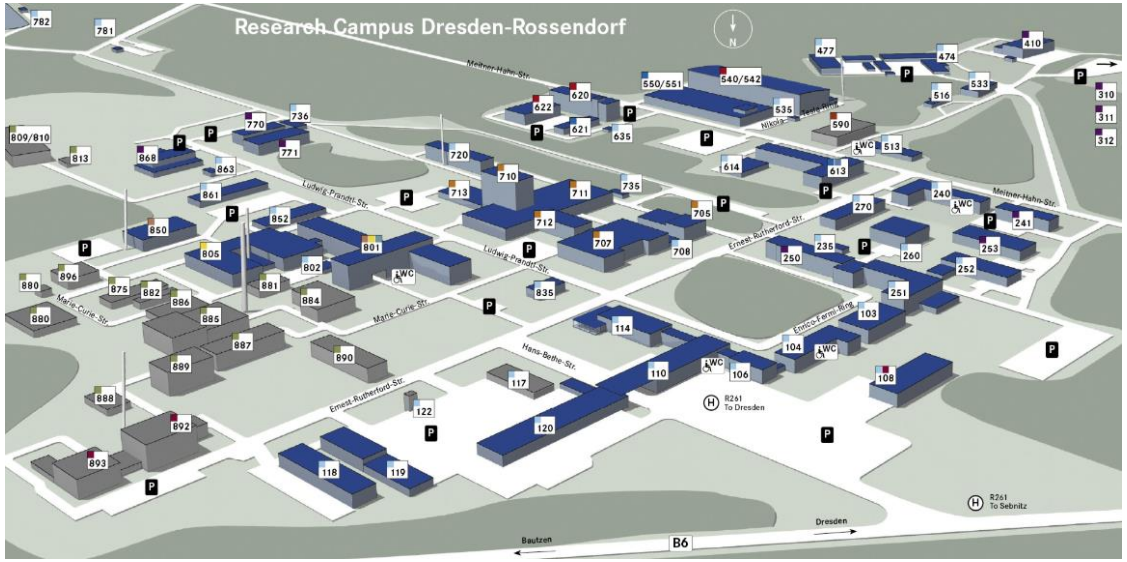
DRESDEN concept

Helmholtz-Zentrum Dresden-Rossendorf e.V.

Facts and Data

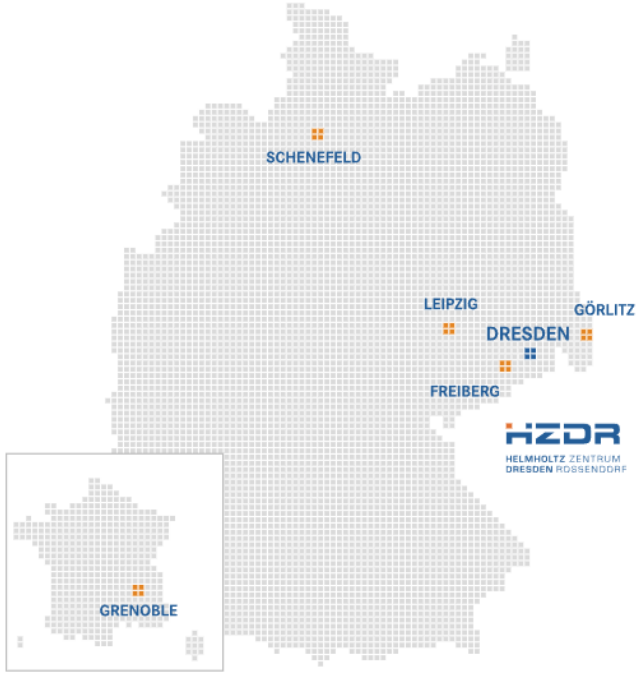
Foundation	01.01.1992
Member of the Helmholtz Association	01.01.2011
Scientific Director & Speaker:	Prof. Dr. Sebastian M. Schmidt
Administrative Director	Dr. Diana Stiller
Employees	~ 1500 (~ 680 scientists)
Budget	~ 180 M€ (2023)

6 research sites: Dresden, Leipzig, Freiberg, Görlitz, Schenefeld (near Hamburg) and Grenoble (France)



Matter

Health Energy

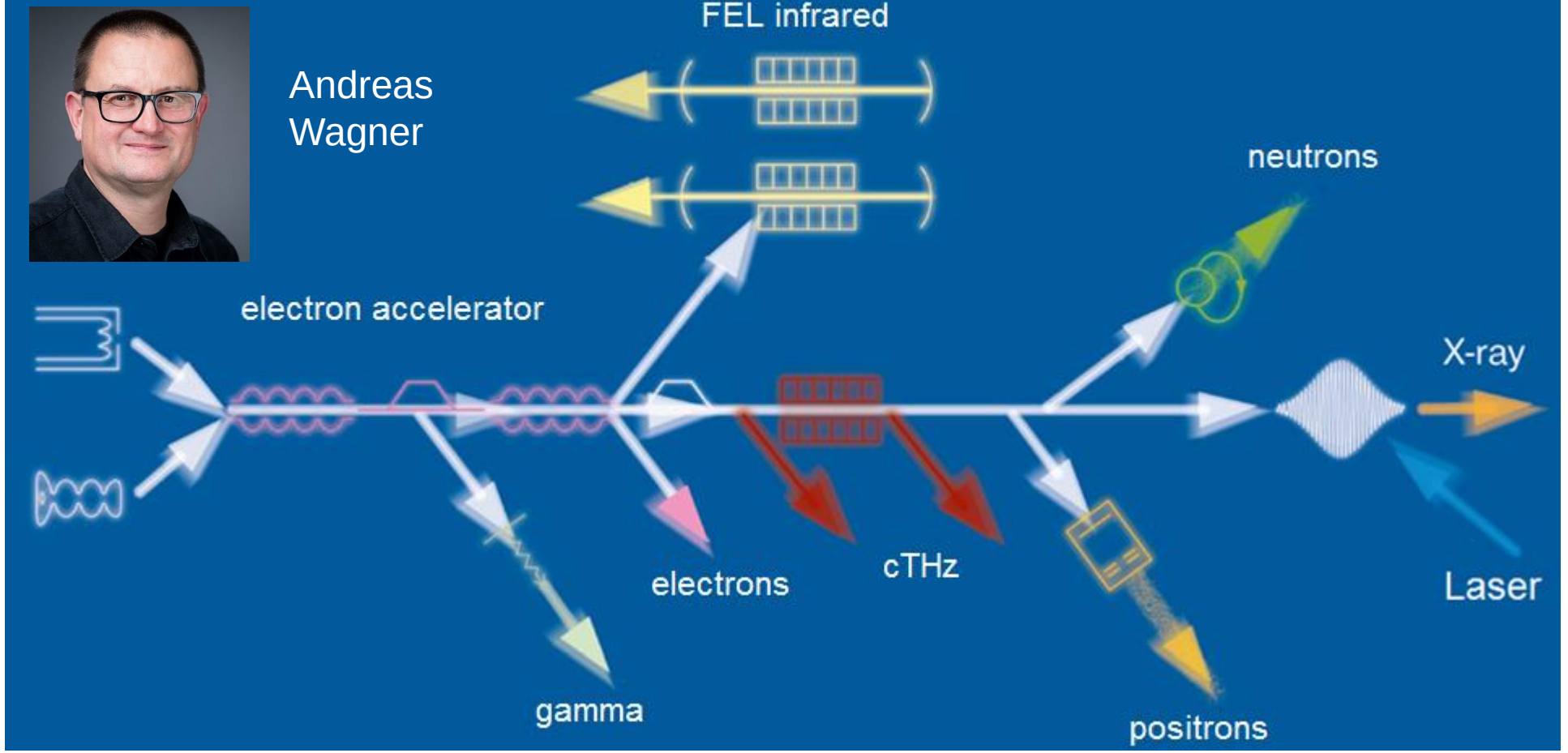


DRESDEN concept SCIENCE AND INNOVATION CAMPUS

HZDR

ELBE Center for High-Power radiation Sources

(Electron Linear accelerator with high Brilliance and low Emittance)



Eric Hirschmann

Ahmed G.A. Elsherif

Sebastian Klug

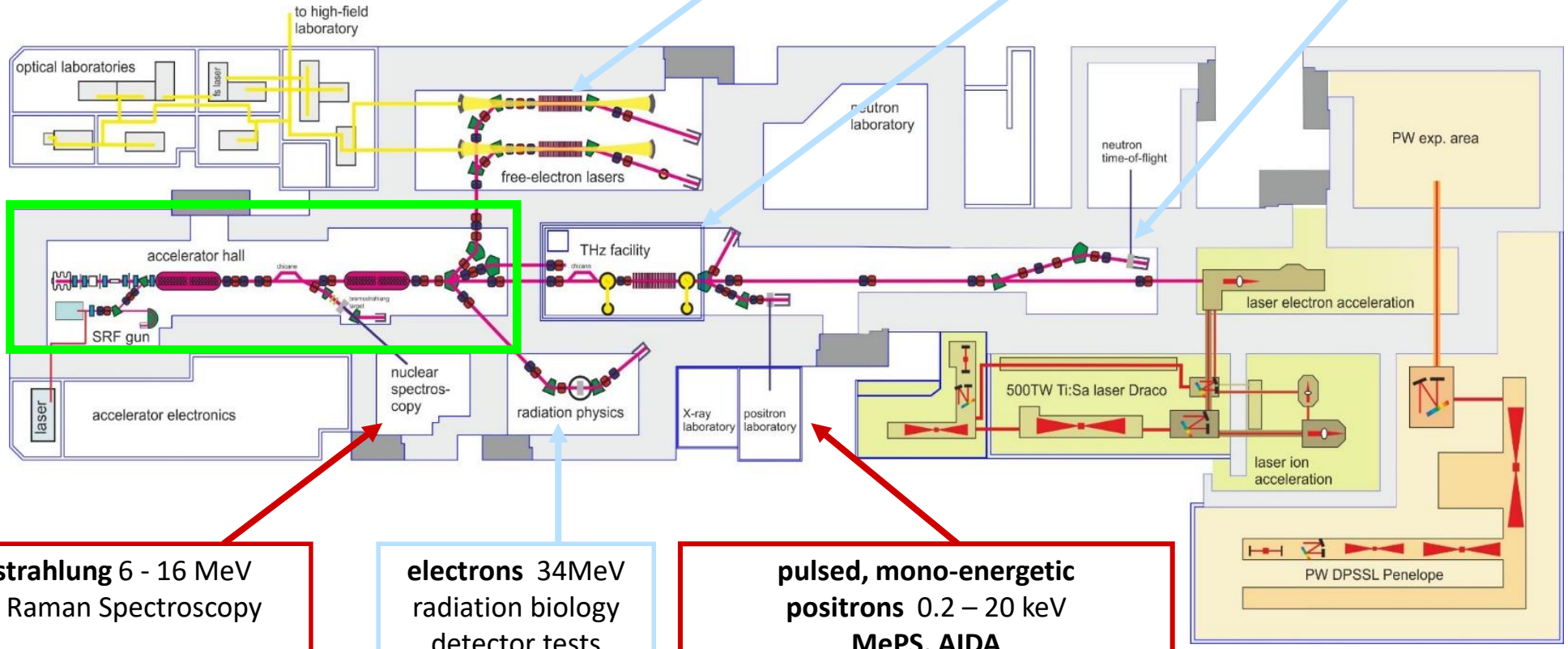
ELBE Center for High-Power radiation Sources

1.6 mA, 40 MeV (64 kW)
CW electron accelerator

coherent IR-radiation
3 – 230 µm

coh. THz radiation
100 µm – 3 mm

neutron time of flight
E_n 0 – 10 MeV



Bremsstrahlung 6 - 16 MeV
Nuclear Raman Spectroscopy

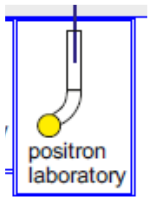
Gamma-induced Positron Source
GiPS

electrons 34MeV
radiation biology
detector tests

pulsed, mono-energetic
positrons 0.2 – 20 keV
MePS, AIDA

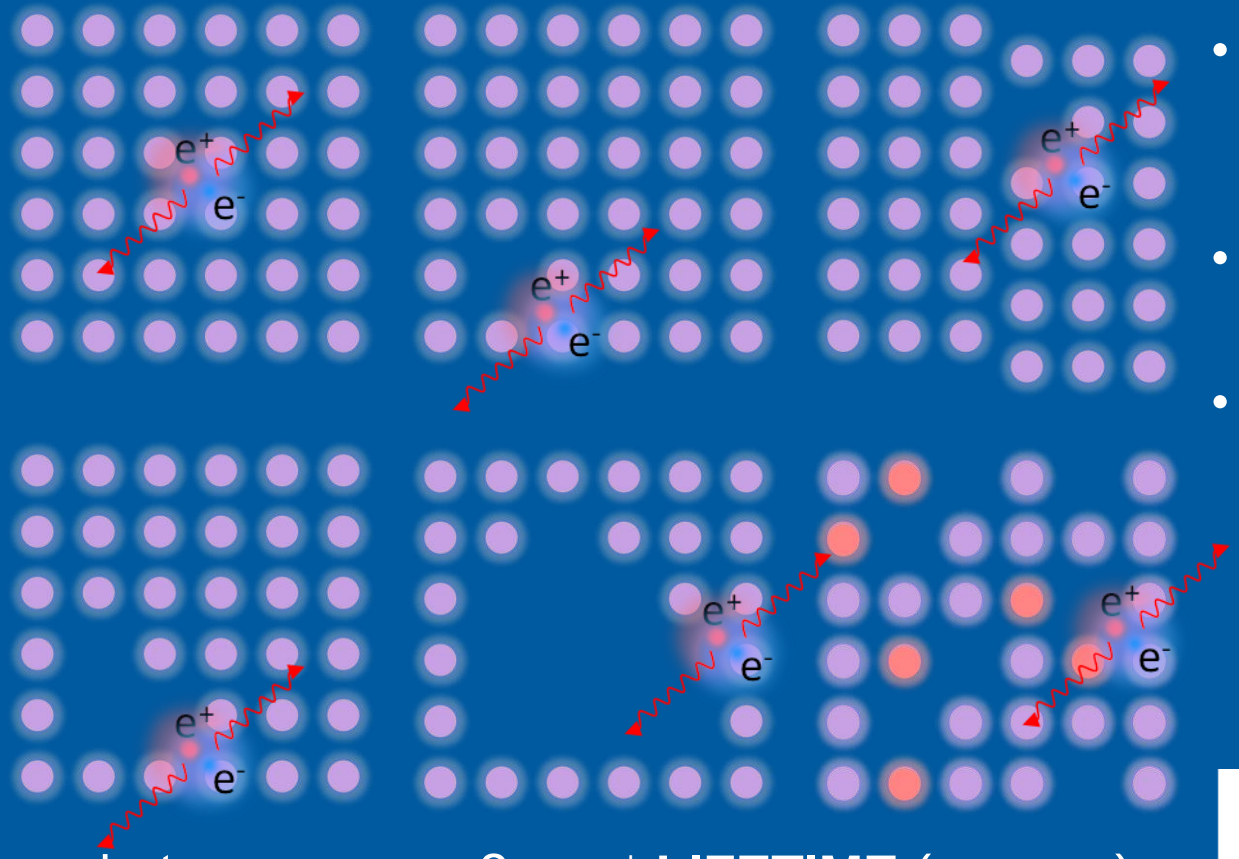
PW-class laser systems
Laser plasma acceleration
High-density plasma physics

mono-energetic positrons
0.05 – 35 keV from ^{22}Na
SPONSOR



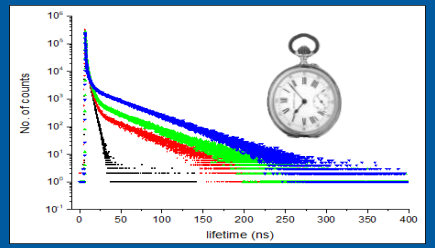
DRESDEN concept SCIENCE AND INNOVATION CAMPUS
HZDR

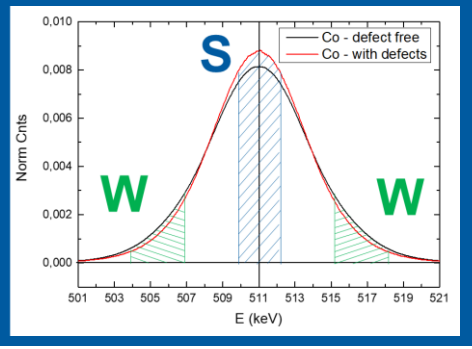
- positrons (e^+) annihilate with electrons (e^-) → gamma (511 keV) radiation
- where?

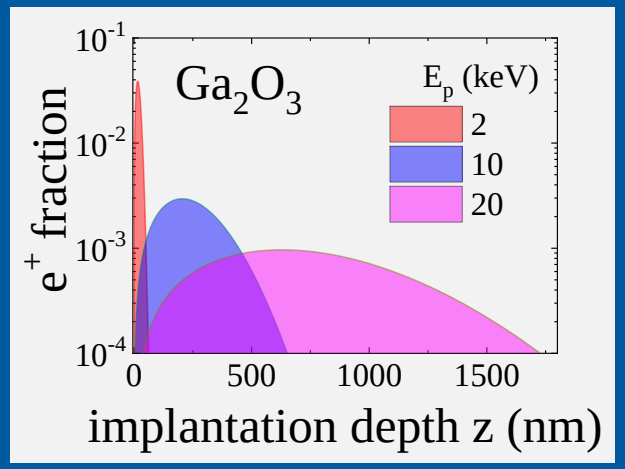


- what we measure? → e^+ **LIFETIME** (**ps – ns**)
- local chemistry → **decoration of defects**

- Defect SIZE and TYPE:
  single vacancy → dislocations → vacancy agglomeration → pores (<100 nm)
- Defect DENSITY:
  → **~10^{-7} – 10^{-3} atom^{-1}** (~10^{16} – 10^{20} cm^{-3})
- Implantation of positrons → depth profiling
  → **~20 nm to several µm**

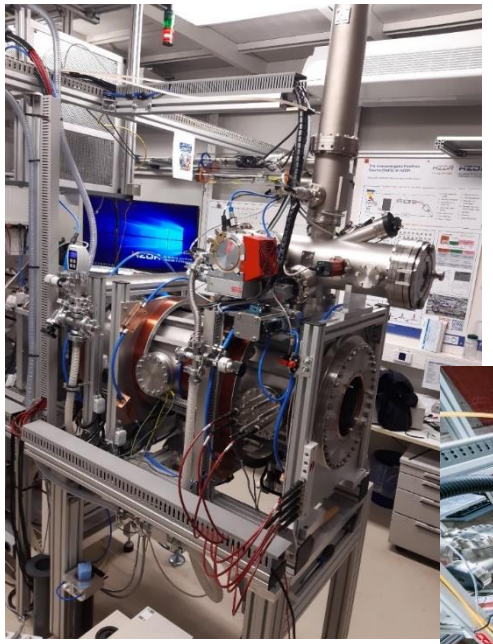


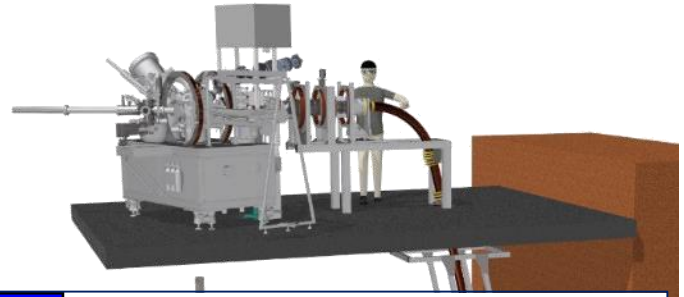


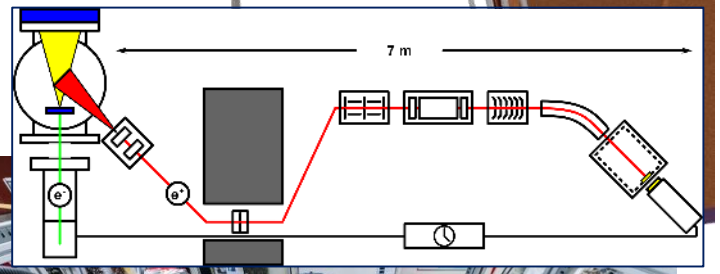


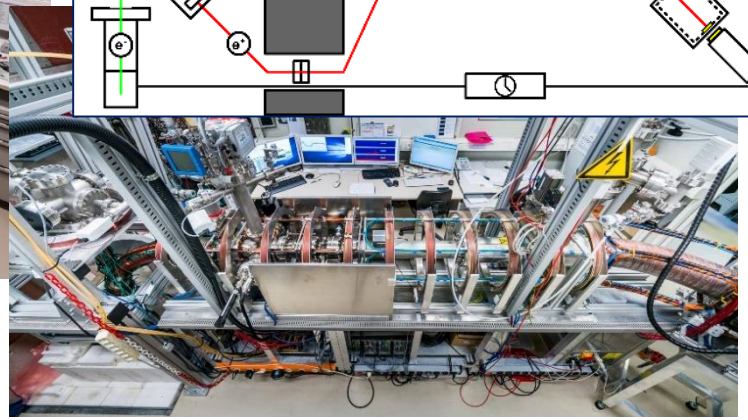
Positron User Facilities

MePS / AIDA-II







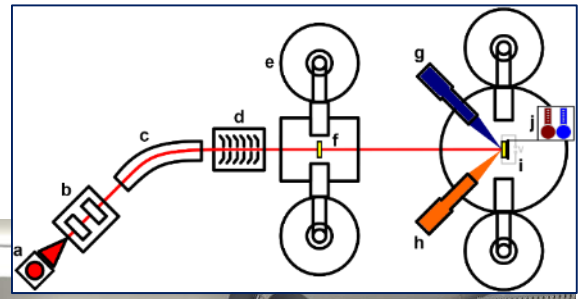


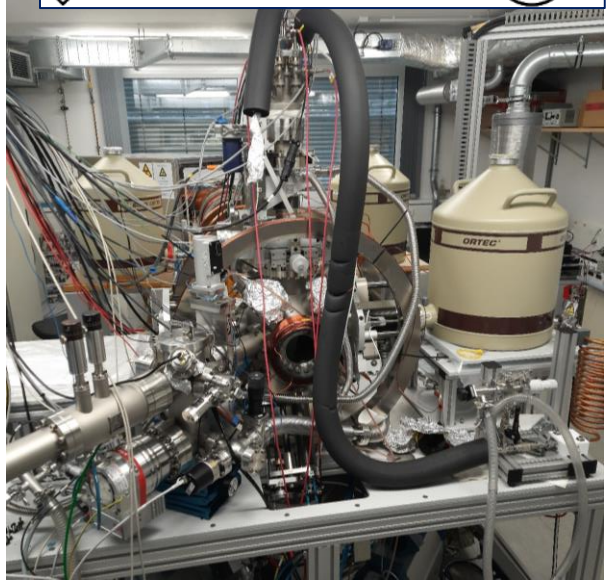
A. Wagner, et al., AIP Conf. Proc. 1970, 040003 (2018)

- positron lifetime = defect size and density
- depth resolved measurements
- high intensity → prerequisite for kinematic experiments

SPONSOR / AIDA-I

W. Anwand, et al., Def & Diff. Forum 331 (2012) 25





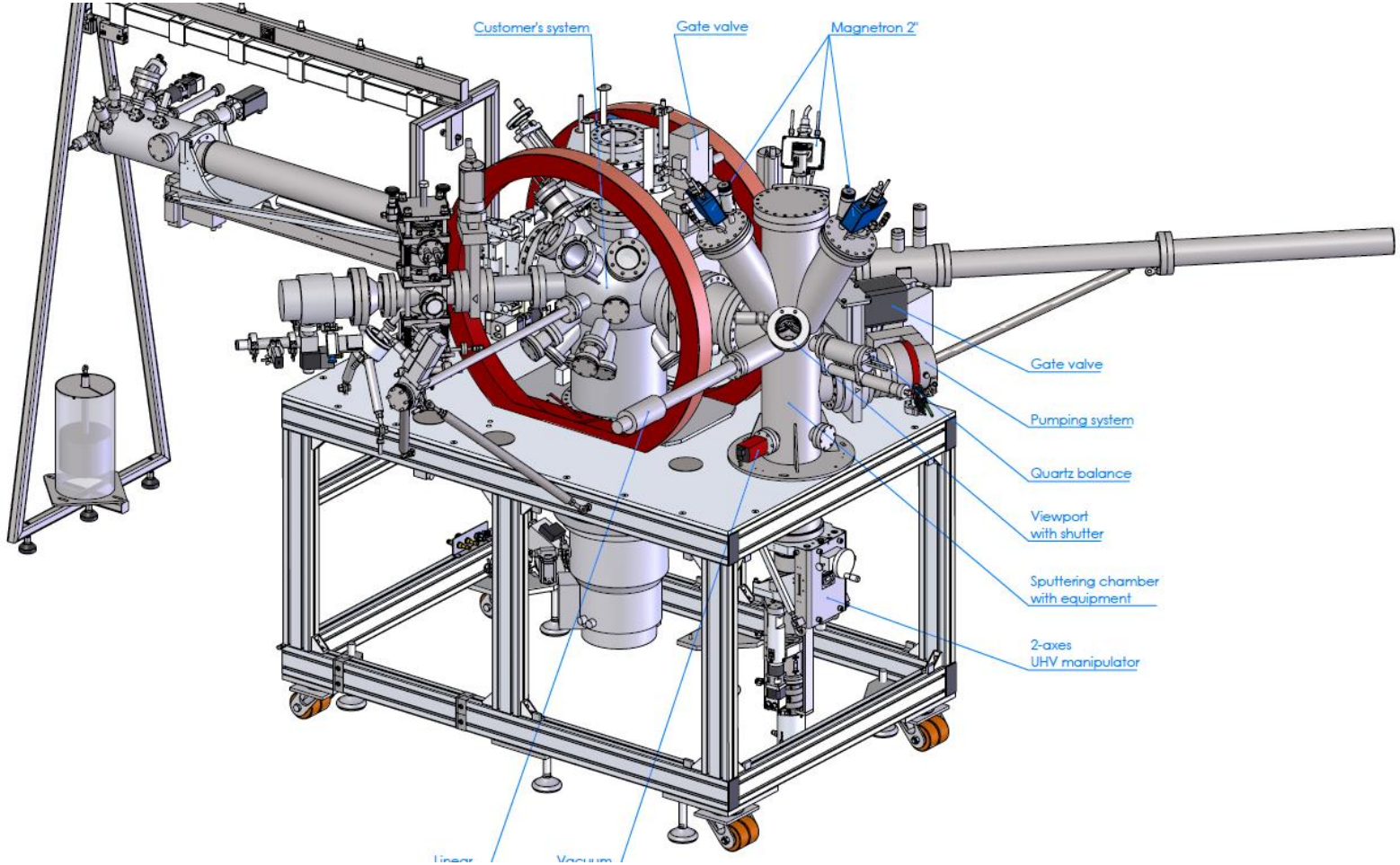
M.O. Liedke et al., J. Appl. Phys. 117 (2015) 163908

- analysis of the annihilation spectrum = defect size, density, and local defect **chemistry**
- depth resolved measurements
- **AIDA**: in-situ manipulation of defects: temperature, ions, MBE, high power light

Positron User Facilities

AIDA-II + sputtering chamber

- 3 Magnetrons: 1 x DC, **1 x DC-HiPIMS**, 1 x RF; 400W
- 2 inch targets, 1-6 mm thick
- base pressure <10^{-8} mbar
- alloy-C-276 sample holder for operation with reactive gases
- temperature range -180°C to 800°C
- working gases: Ar, N_2, O_2 + mixtures
- **the AIDA-II system is commissioned and ready for material deposition**



PhD project of Sebastian Klug (overlap with SESAME)

- ✓ **PhD university supervisor Prof. Kornelius Nielsch (TU Dresden / IFW) secured**

- main focus: Nb, NbN, and Nb3Sn on Si and Cu combined later as SIS

- films will be manufactured using magnetron sputtering in DC and DC-HiPIMS modes

- ex-situ defect analysis will be run at MePS
- in-situ defect analysis should be possible directly at AIDA-II later on (current time resolution not sufficient)

- started investigations XRD, AFM, PAS on Uni Siegen samples
- planned investigations: SEM, SQUID/VSM, Hall Effect

Collaboration with Hamburg and Siegen

3 recent proposals related to NOVALIS has been submitted and executed:

- **“Magnetic flux-expulsion studies on and S-I-S / S-S Structures” by Marc Wenskat (POS24203546):**

- **“The role of point defects in NbTiN thin film deposited by DC/HiPIMS magnetron sputtering” by Aleksandr Zubtsovskii (POS24203543)**

- **“Exploring the Role of Point Defects in NbTiN Thin Films for Enhanced SRF Cavity Performance” by Bharath Venkata (POS25103677)**

The analysis of data and the results will be presented by Sebastian

Summary

! HZDR provides the access to the positron ELBE facility in order to study defect microstructure in the novel superconducting materials

! sample preparation by sputtering (including HiPIMS) combined with in-situ defect characterization

➢ direct collaboration with Hamburg and Siegen (several successful beamtimes)

➢ **new call for proposal submission to ELBE: 24.03.2025**