EPOS - A European Positron Source for Applied Research

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Motivation

- Positron annihilation spectroscopy has been improved over the last decades and is now widely accepted as useful tool for the study of defects in solids.
- However, the laboratory systems available so far are limited due to the low intensity of the positron sources. For the further development of the technique, e.g. for three-dimensional imaging of defects, **high-brightness positron beams are required**.
- These positron facilities must be user-dedicated, so that the menpower of several labs makes the equipment an efficient place for the future positron research.
- Free-electron lasers use an electron beam of at least several tens of MeV and can thus be used for pair production.
- Such very strong electron beams bunched to short pulses of ps length as used for an FEL, is an ideal prerequisite for the generation of a slow positron beam for applied physics.
- Two FEL systems are under construction in Germany: the ELBE source (FZ Rossendorf) and TTF (DESY Hamburg) [1].

Workshop: "Positron Source at TTF" (Hamburg, Sept. 1999)

- The potential and the possible ways for the realization of such a source either in Hamburg or Rossendorf were discussed in a workshop held in September 1999 at DESY, Hamburg [2].
- The participants agreed that such an intense positron source would be a useful supplementation for the existing laboratory positron systems.
- As a result of this meeting, a group of 20 scientists from 8 European countries designed a "European Positron Source for Applied Research - EPOS" which might be realized in the future. The conceptual report of this source is available at the EPOS website [2] and as electronic publication at FZ Rossendorf [3].

EPOS - Conceptual Report

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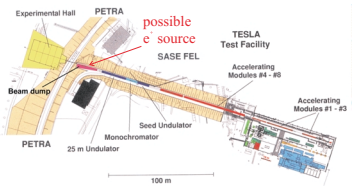
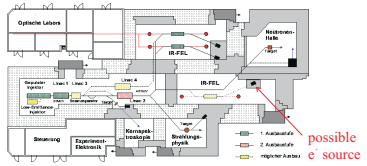
FEL systems under construction



Top view of "TESLA Test Facility - TTF" at DESY in Hamburg. A possible positron beam can be generated in the beam dump area. The experimental setup could be placed to the experimental hall (yellow) or in the small building close to the dump (drawn in black).



The experimental hall of the ELBE source. The possible location of the positron source is the beam dump of the IR-FEL. However, several other experiments will be driven by the same electron beam, so that the positron experiment is not always available.

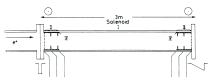
However, it should be noted that presently a slow positron source is not a part of both projects.

Comparison TTF ⇔ ELBE

	TTF	ELBE
electron energy	390 MeV (1. Step) 1000 MeV (2. Step)	40 MeV
beam power:	max. 72 kW	max. 40 kW
bunch load:	~ 1000 pC	77 pC
bunches per train:	7200	min.1176; max.~500 000, (471000)
bunch length:	0,6 ps	(2ps – 10 ps) ~ 3 ps
bunch separation:	100 ns	77 ns (÷ 13 MHz)
repetition rate:	10 Hz	25 Hz (max. 100 Hz)
mean current:	~72 µA	~1 mA
train length:	~0,72 ms	min. ~0,09 ms; max. > ~36,3 ms
train separation:	~2,8 ms	max.< ~39,9 ms; min. < ~ 3,7 ms
duty cycle:	~7 X 10E-3 *	min. ~2,3 X 10E-3; max. ~0,91 `

* (~4,3 X 10E-8 = 0,6 ps X 7 200 X 10) ` (~3,5 X 10E-5 = 3 ps X 47 1 000 X 25)

- The electron beam structure is directly suitable for the lifetime experiment. However, after pair production, moderation, and beam transport, a picosecond post-buncher might be necessary. A very simple lifetime setup is possible this way.
- For most experiments, and to make use of the large total number of positrons, a penning trap is desired.
- An almost continous positron beam could be extracted for different beam tubes which serve different experiments.



Possible experiments at EPOS

- Interesting positron experiments which could be possible at EPOS are listed below. Of course, due to the limited space at both possible locations, only a few of them can be finally realized.
- Most important for material research is the possibility of positron lifetime spectroscopy combined with Doppler-coincidence spectroscopy using a focussed beam (lateral resolution < 1 µm)

Materials science (focussed beam < 1 µm)
- Advanced positron lifetime spectroscopy [4] combined with
- Two-dimensional Doppler broadening coincidence system
- Positron deep level transient spectroscopy
- AMOC

Surface physics
- Positron Annihilation-induced Auger Electron Spectroscopy (PAES)
- Low-Energy Positron Diffraction (LEPD)
- Re-emitted Positron Energy Loss Spectroscopy (REPELS)
- Re-emitted positron spectroscopy (RPS)
- Positron Re-emission Microscopy (PRM)

Atomic physics
- Positron scattering / ionization / bremsstrahlung
- Positronium physics as a test of QED
- Anisotropic phenomena in ortho-positronium decay

Conclusions

- **A high-brightness monoenergetic positron source** for applied research can be easily supplemented to an free-electron laser facility. In particular, the time structure of the electron beam is suitable for a relatively simple setup for positron lifetime spectroscopy.
- An international group of positron researchers including almost all European positron groups agreed to take all necessary effort to establish a "**European Positron Source for Applied Research - EPOS**". A conceptual report for this source has been published [2,3].
- The most important experiment for materials science at such a beam system is to built a fucussed beam for the combined use of advanced positron lifetime [4] and Doppler-broadening coincidence spectroscopy.
- The work at such a system must be organized as a **user-dedicated facility**. This allows the efficient operation and makes sure that many areas of materials research will gain from this unique equipment.

References

[1] http://www.fz-rossendorf.de/ELBE/ and http://tesla.desy.de/
[2] http://www.ep3.uni-halle.de/positrons/EPOS/
[3] Wissenschaftlich-Technische Berichte/Forschungszentrum Rossendorf, Nr. 295, 2000 (http://www.fz-rossendorf.de/)
[4] see poster "Advanced positron lifetime spectroscopy for pulsed positron beams" by R. Krause-Rehberg, S. Eichler, F. Börner, F. Redmann (this conference)

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