Begin of user operation at MePS in Rossendorf

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SLOPOS Munich 2013

EPOS (ELBE Positron Source)

MePS
Monoenergetic Positron Spectroscopy

- monoenergetic (slow) positrons
- pulsed system
- LT, CDBS, AMOC

Information Depth:
0…5 µm

CoPS
Conventional Positron Spectroscopy

- LT, CDBS, AMOC
- using ^{22}Na foil sources
- He-cryostat
- automated system
- digital detector system (in future)

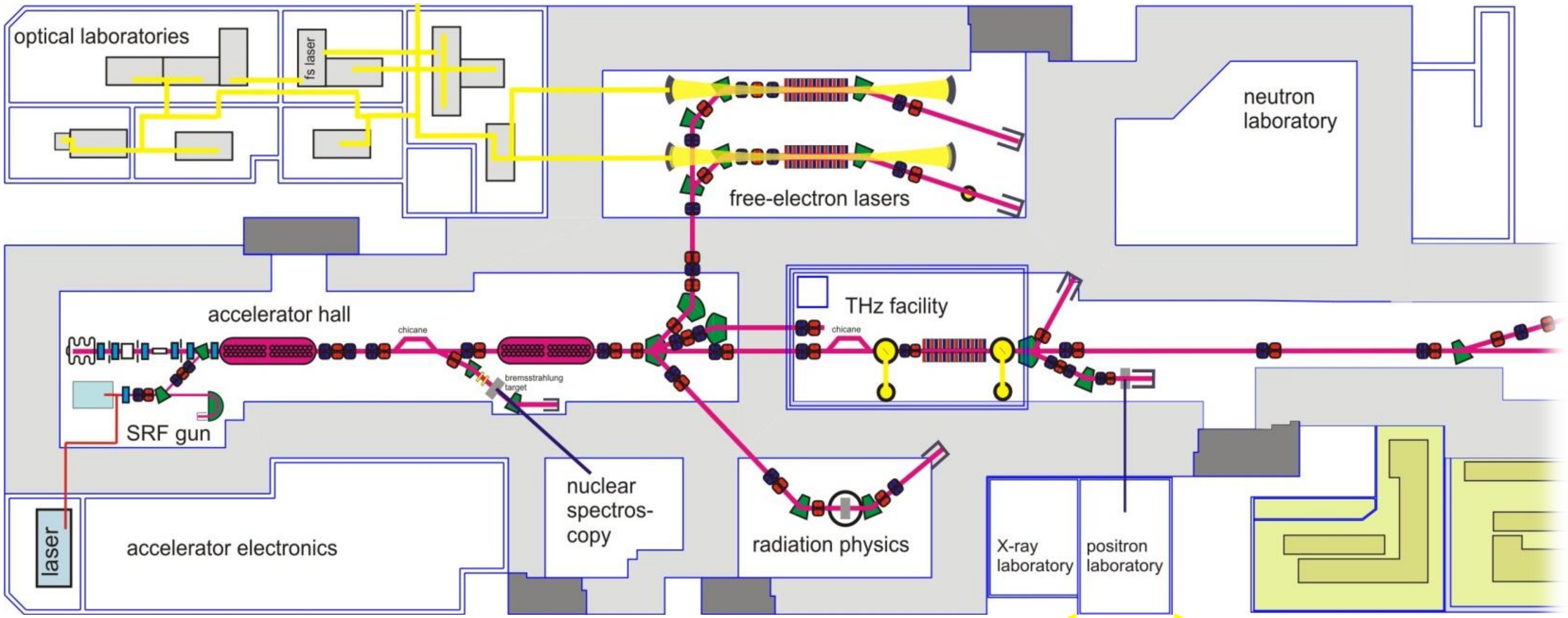
Information Depth:
10…200 µm

GiPS
Gamma-induced Positron Spectroscopy

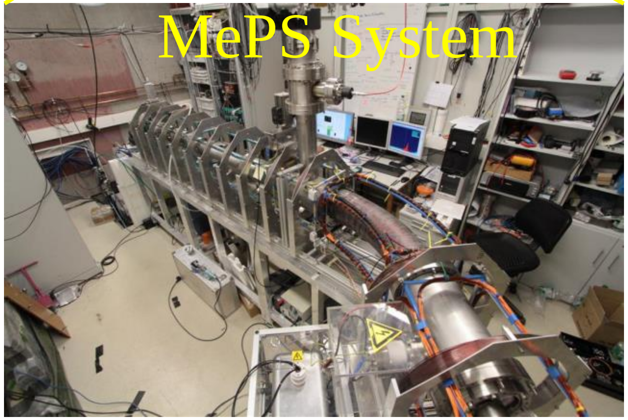
- Positron generation by Bremsstrahlung
- Investigation of bulky samples (up to 10 cm³)
- all relevant positron techniques (LT, CDBS, AMOC)

Information Depth:
0.1 mm …2 cm

ELBE labs

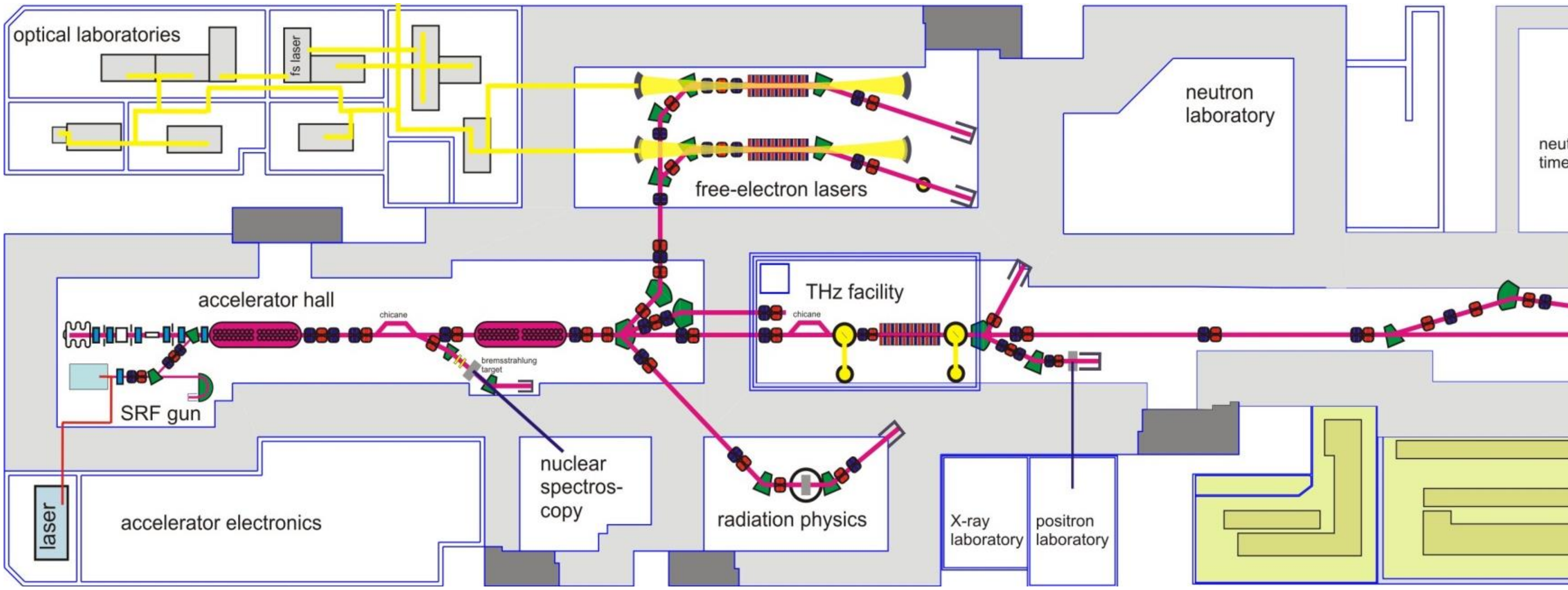


optical laboratories
fs laser
free-electron lasers
neutron laboratory
accelerator hall
chicane
bremsstrahlung target
THz facility
chicane
SRF gun
laser
accelerator electronics
nuclear spectros-copy
radiation physics
X-ray laboratory
positron laboratory



MePS System

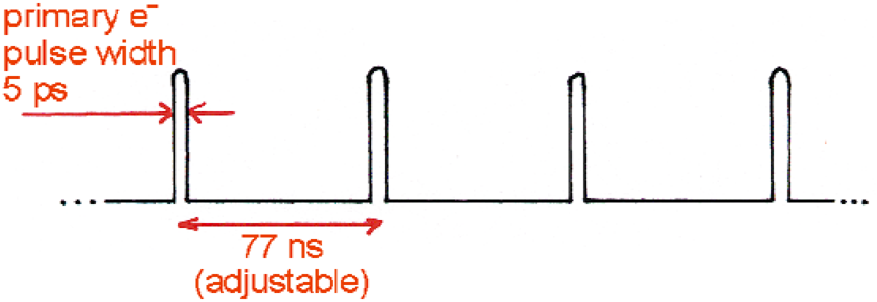
Upgrade of the Dresden ELBE labs



- Extension of ELBE hall started 2011
- electrons back in positron cave in December 2012

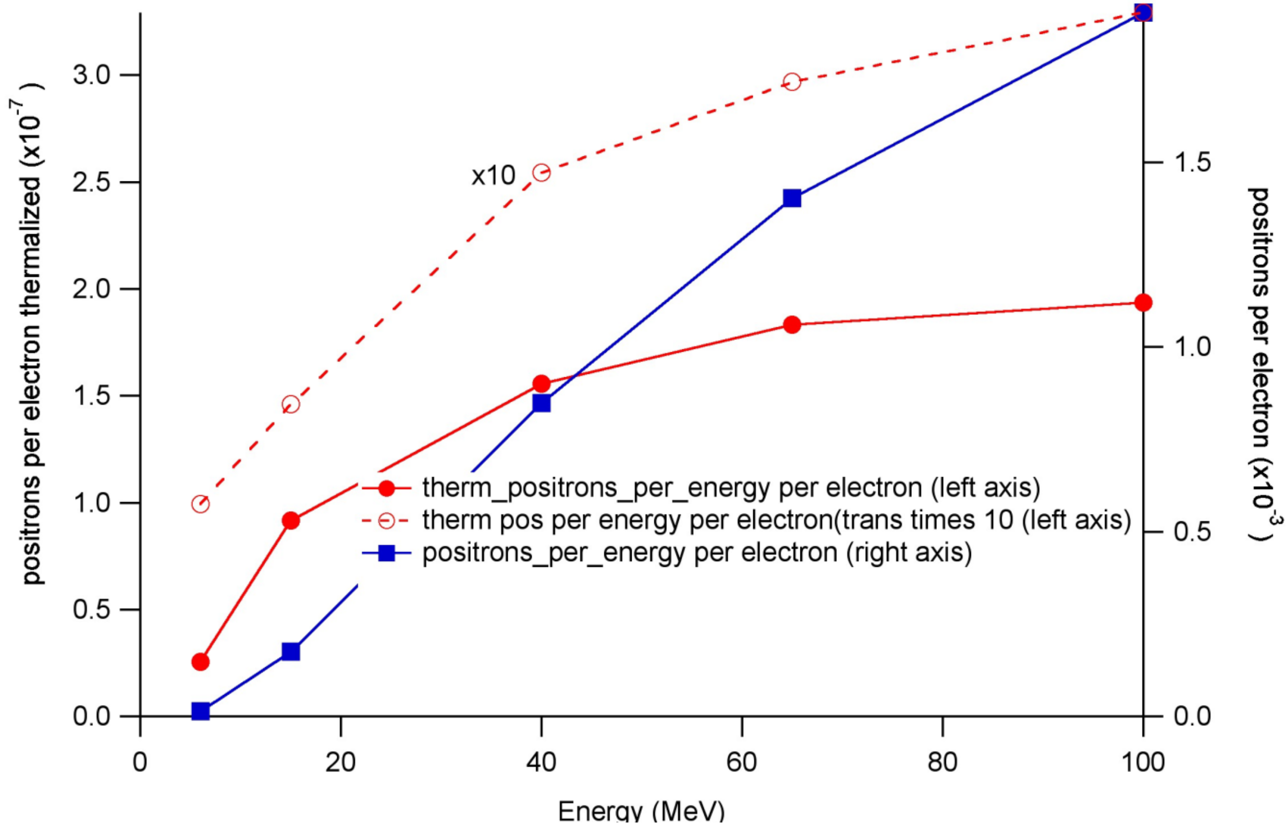
MePS – Mono-energetic Positron Spectroscopy

- ELBE -> superconducting electron LINAC (40 MeV and up to 40 kW) in HZDR Dresden-Rossendorf



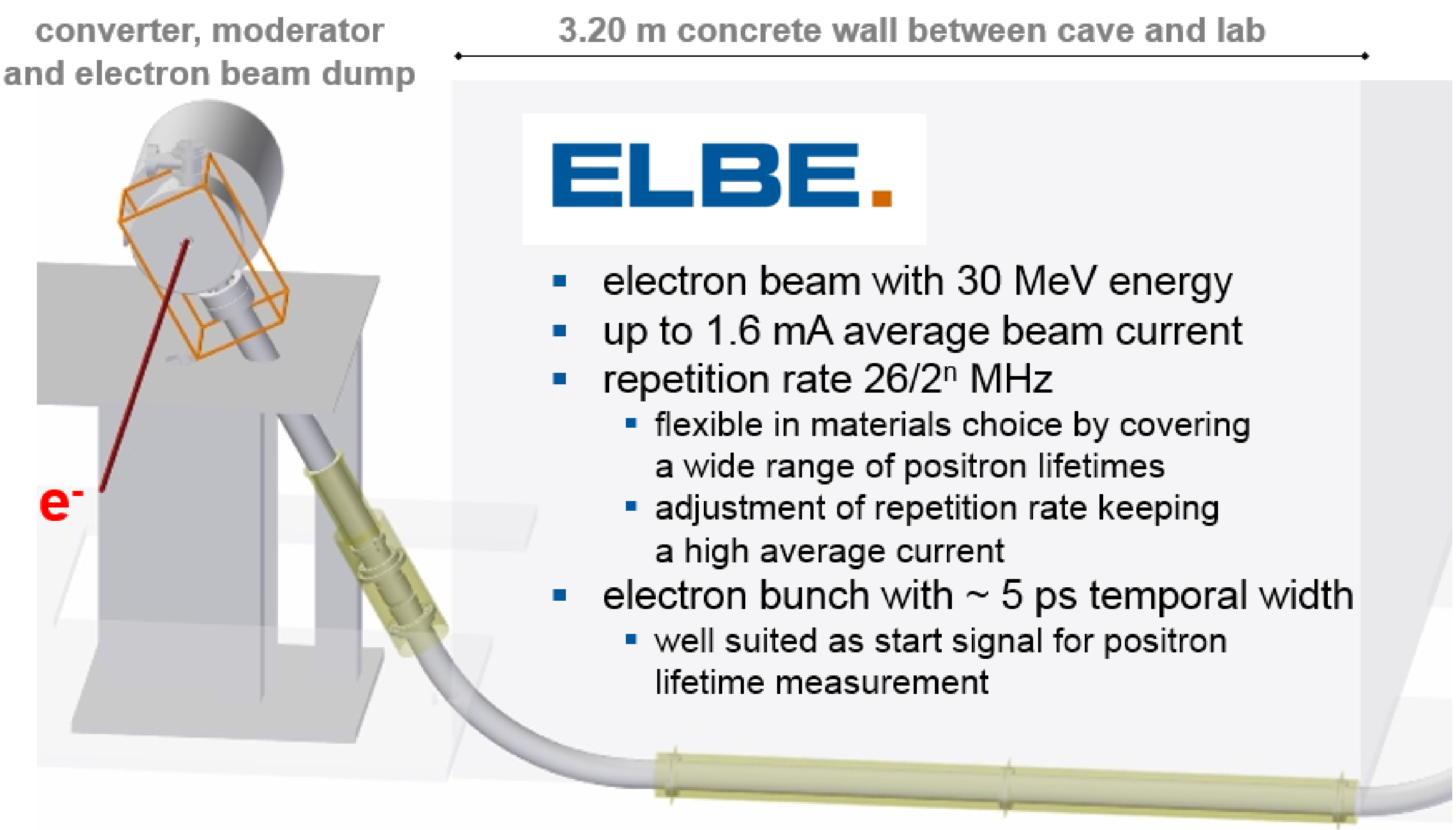
- Repetition time: 38 ns, 77 ns, … , 615 ns, …
- User-dedicated facility
- main features of MePS:
  - high-intensity bunched positron beam (E_+ = 0.5…30 keV)
  - Coincidence Lifetime & Coincidence Doppler Spectroscopy & AMOC

What electron energy for pair production?



Relative yield of positrons as a function of the incident electron energy. The yield of total positrons increases virtually continuously (closed squares) while the number of thermalized positrons appears to approach saturation at about 60 MeV both for reflected moderation (filled circles) or transmitted moderation (open circles). If one is going to design an electron-linac-based positron source the optimal electron energy for positron generation will be in of 40-60 MeV range.

MePS scheme

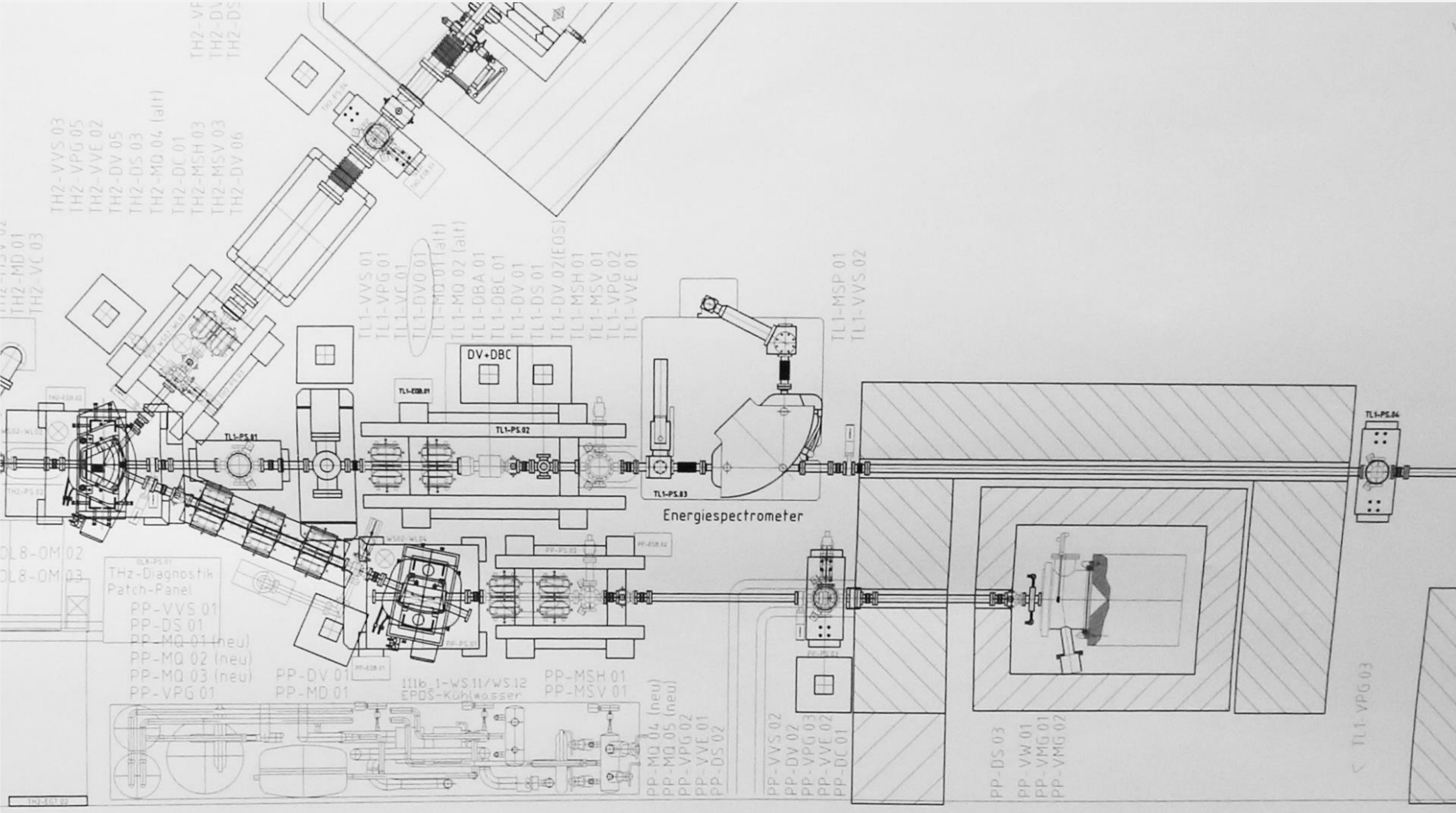


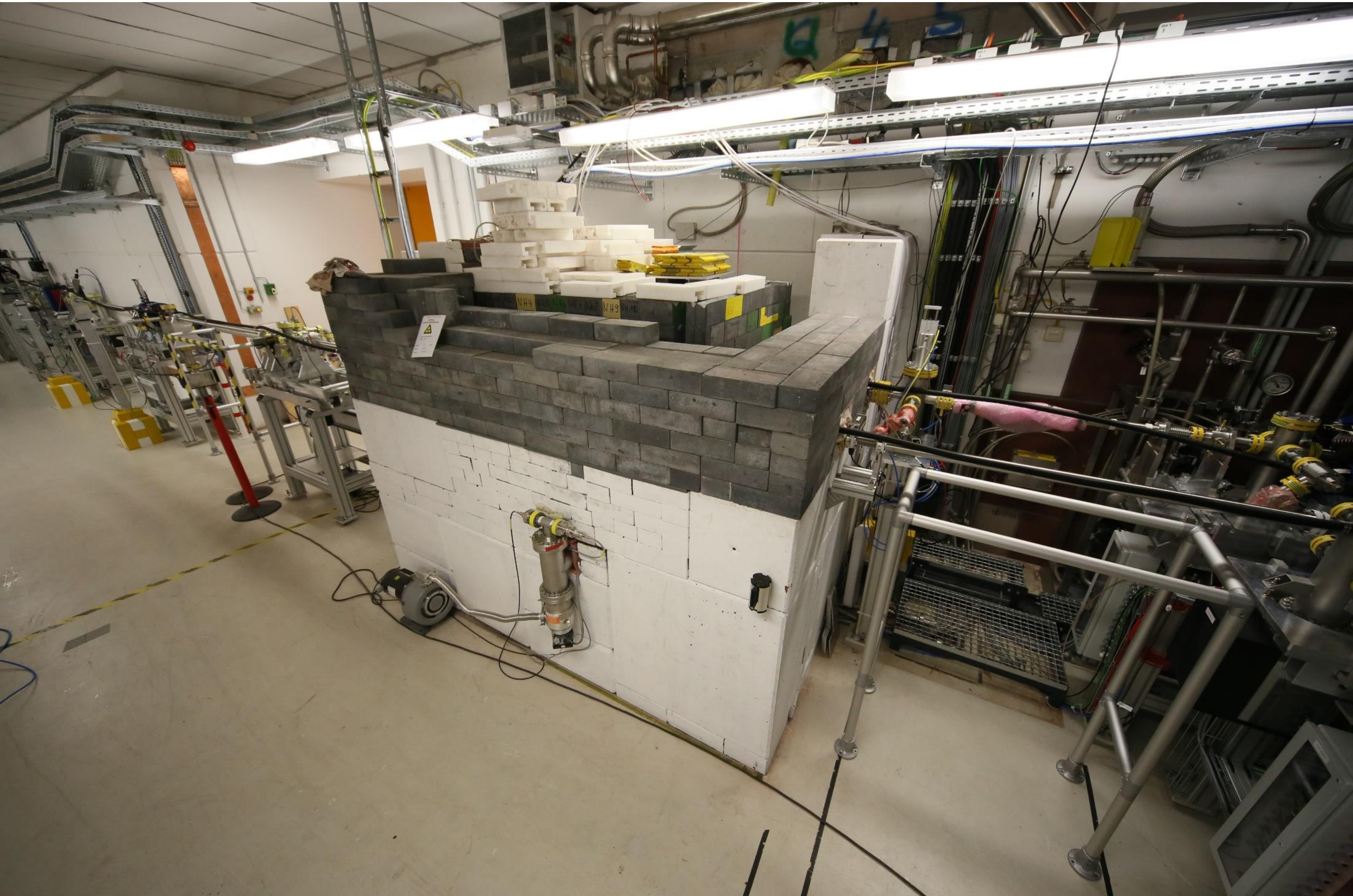
ELBE.

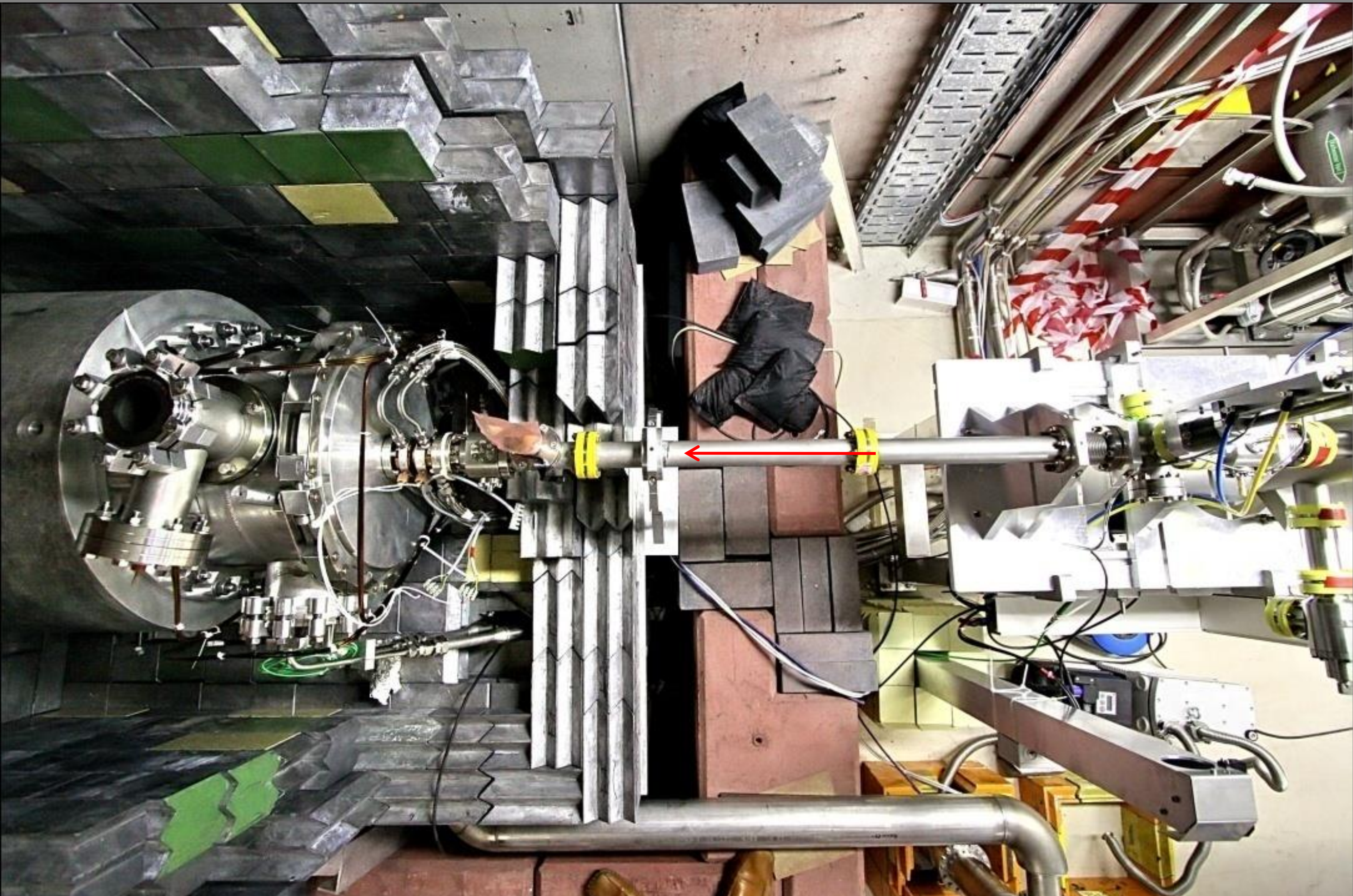
- electron beam with 30 MeV energy
- up to 1.6 mA average beam current
- repetition rate $26/2^n$ MHz
  - flexible in materials choice by covering a wide range of positron lifetimes
  - adjustment of repetition rate keeping a high average current
- electron bunch with ~ 5 ps temporal width
  - well suited as start signal for positron lifetime measurement

Please see our poster P-39 in session B

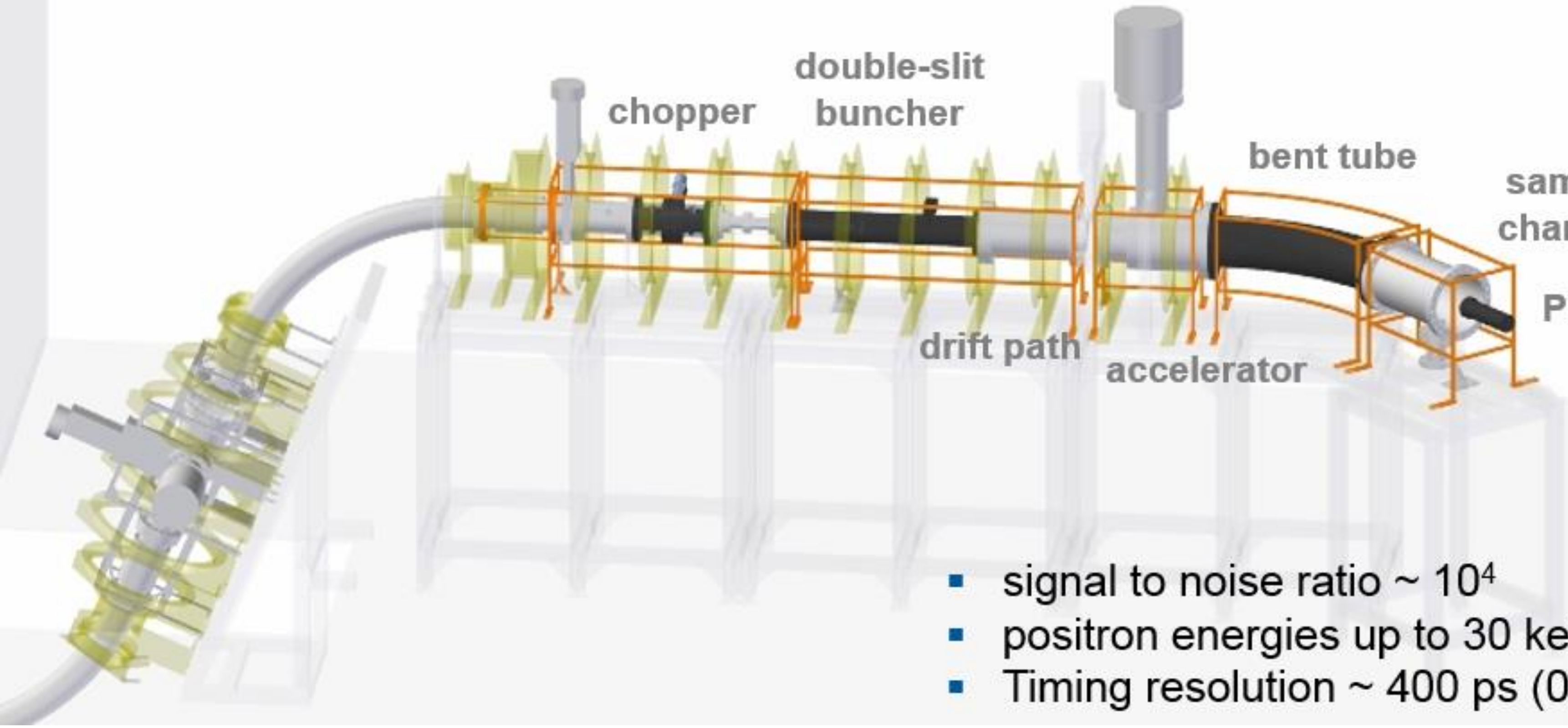
Positron Converter in Cave 111b



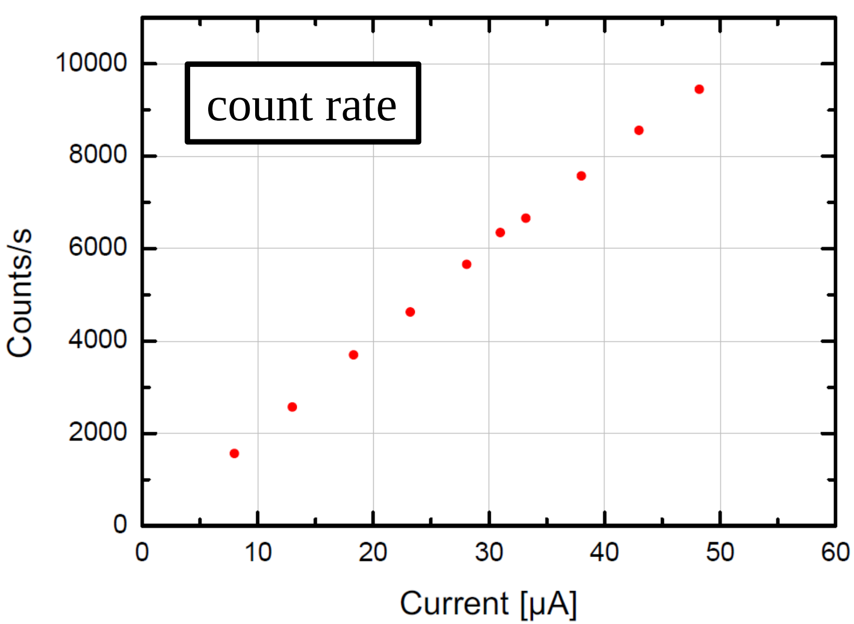


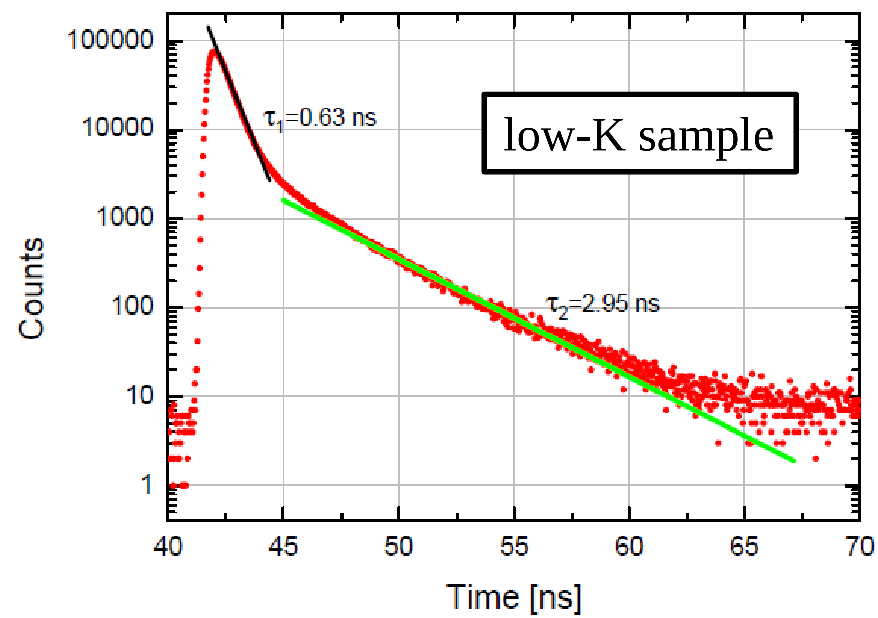


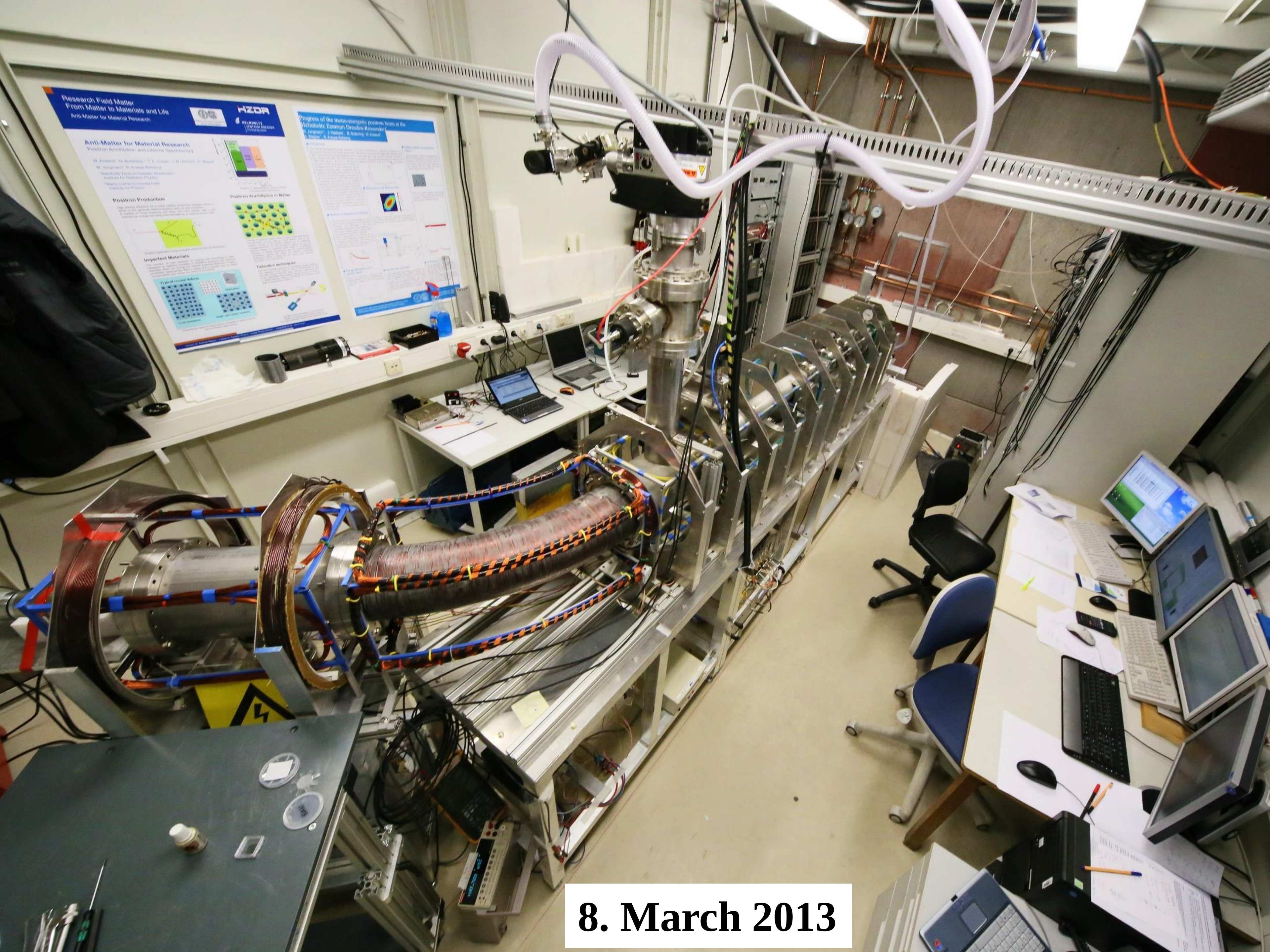

17. December 2007



- signal to noise ratio ~ 10^4
- positron energies up to 30 keV
- Timing resolution ~ 400 ps (08.2013)



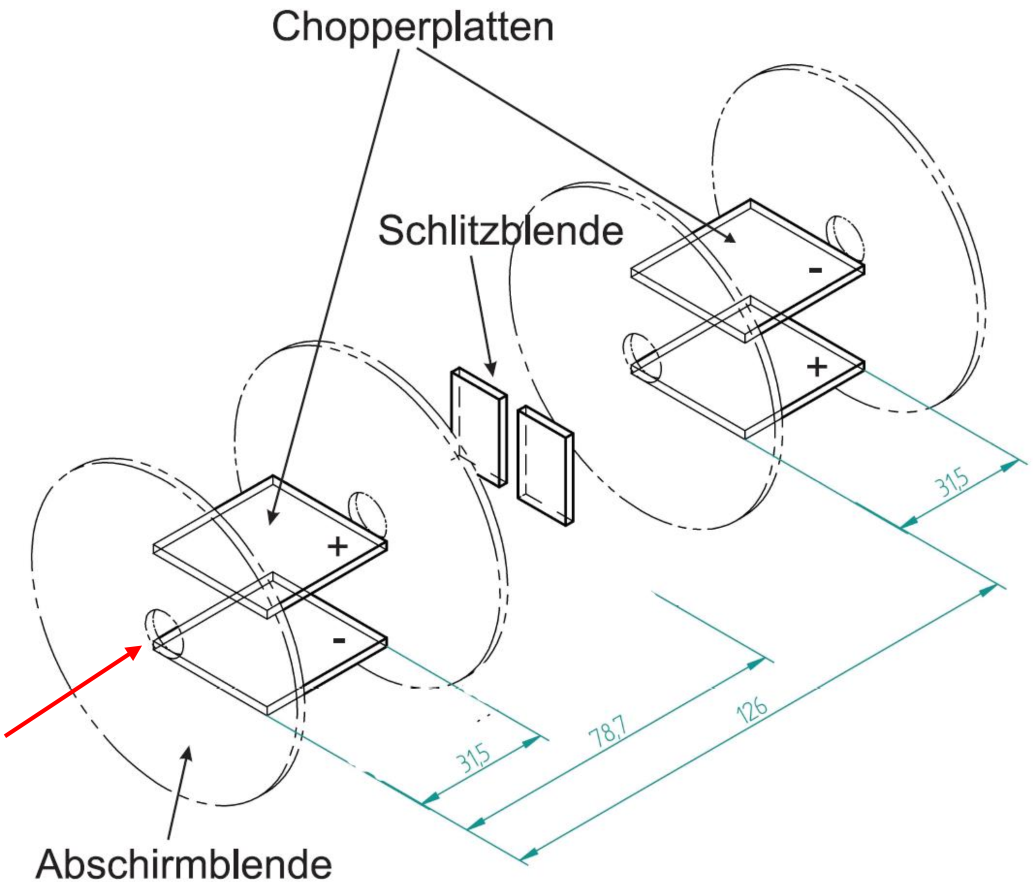


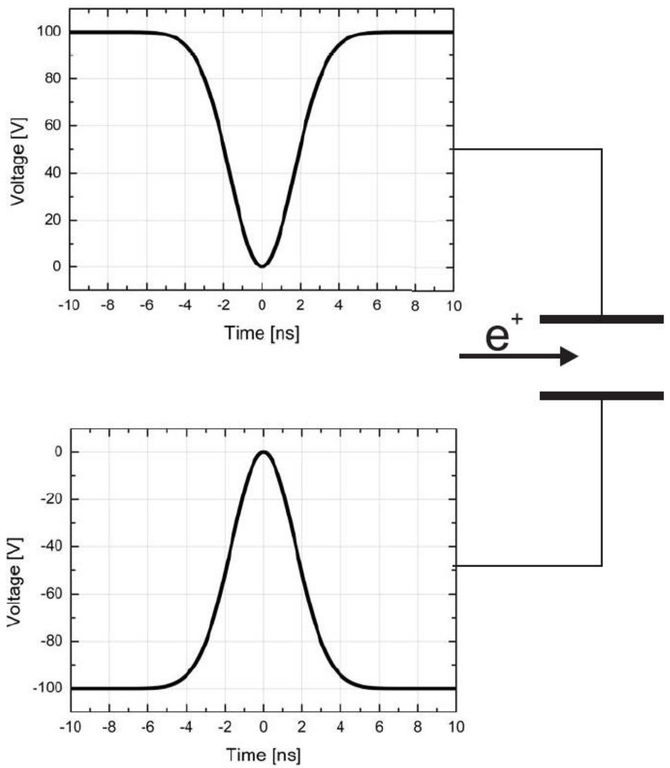

Research Field Matter
From Matter to Materials and Life
Anti-Matter for Material Research
HZDR
Anti-Matter for Material Research
Positron Production
Imperfect Materials
Positron Annihilation in Matter
Detection techniques

8. March 2013

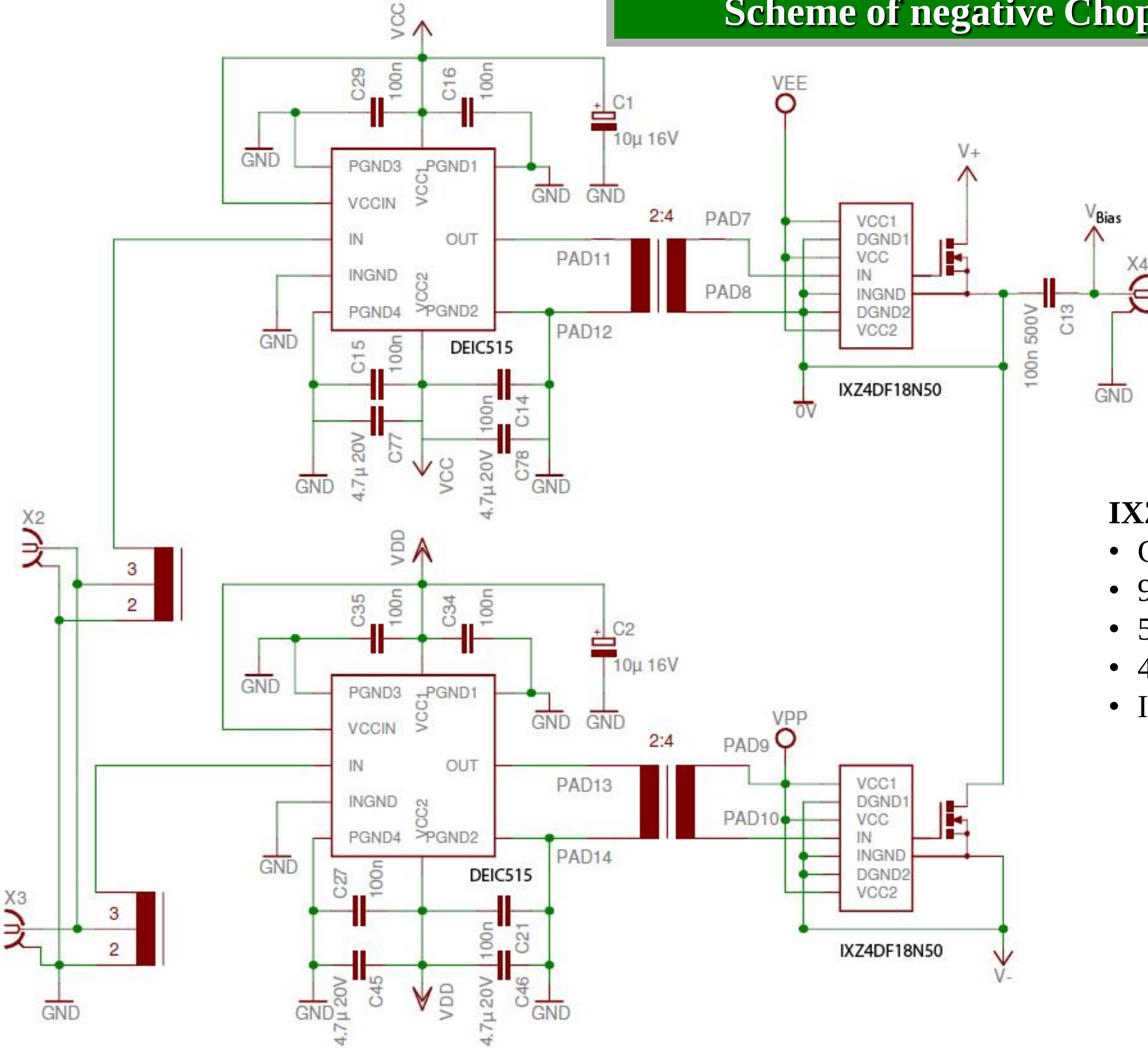
Chopper

- Plate capacitor ≈ 1 pF
- 2 stages -> delay of e^+ bunch ≈ 5 ns
- bias voltage of ≈ 100V keeps the beam deflected -> chopper pulse kicks it in



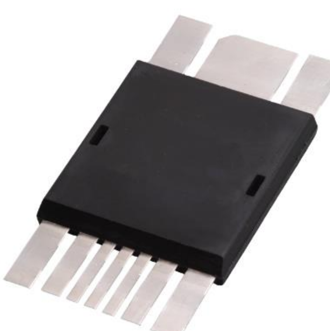


Scheme of negative Chopper Pulser

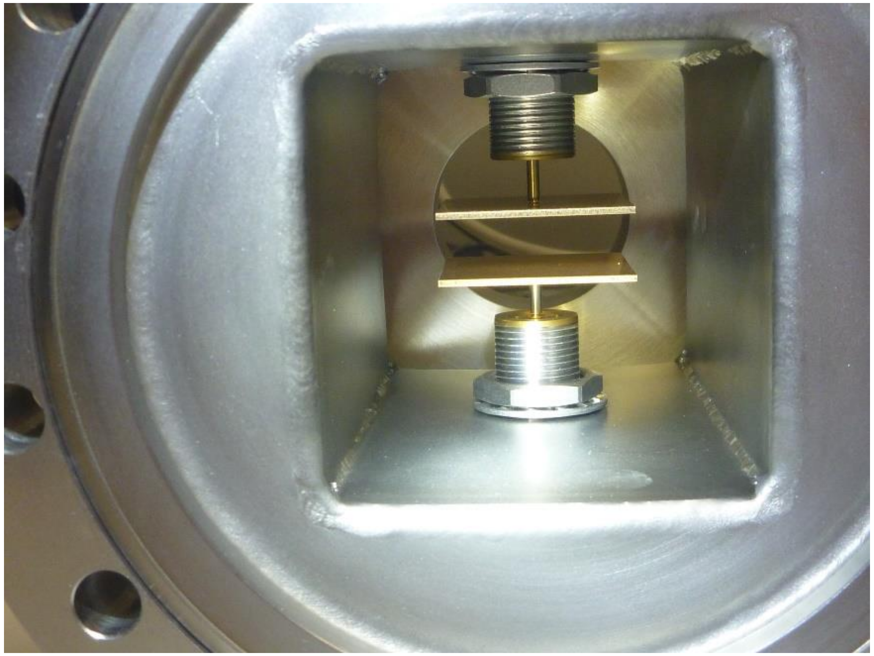


IXZ4DF18N50

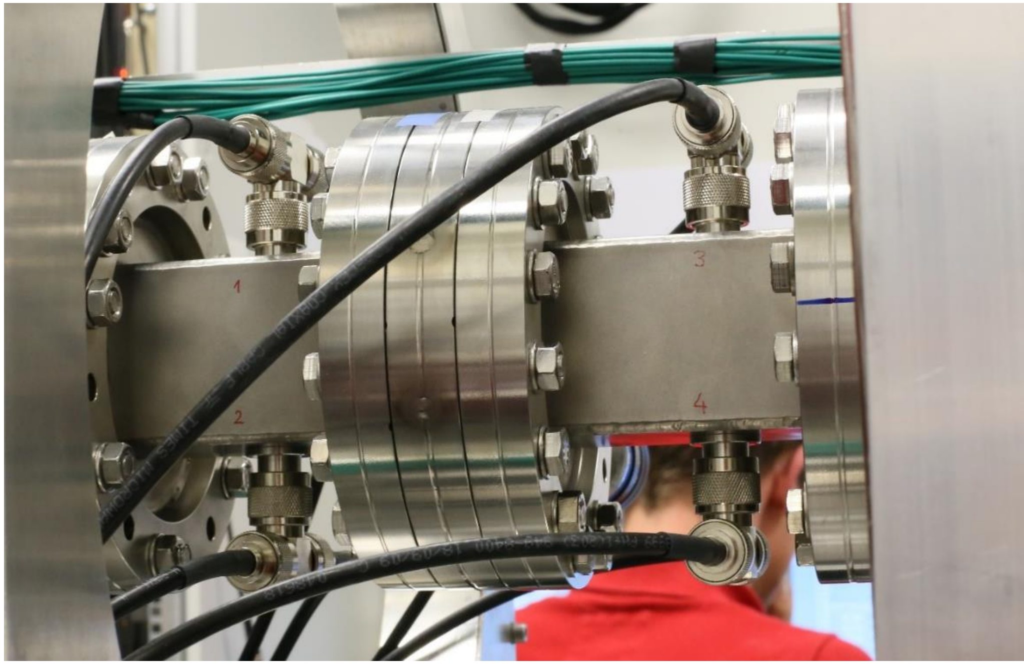
- CMOS FET switch
- 95A peak current
- 500V, 500W
- 40 MHz
- IXYS RF, $50



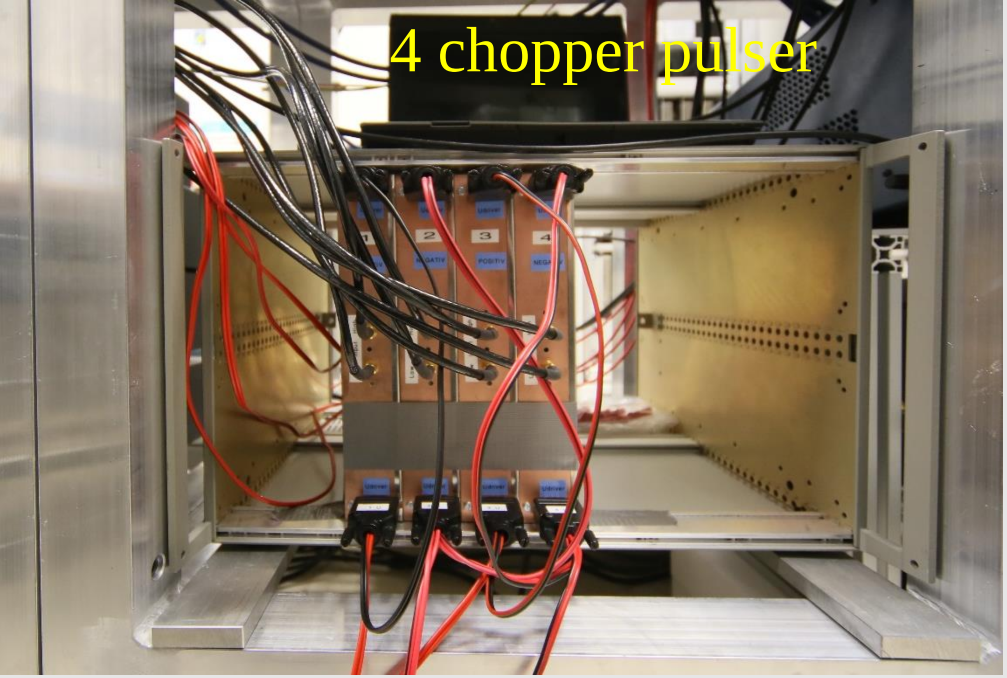
Chopper



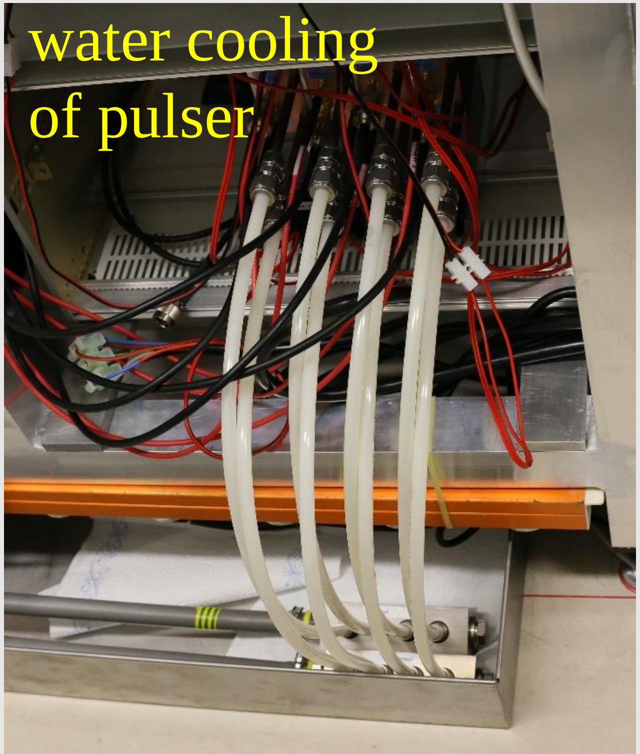
chopper stage

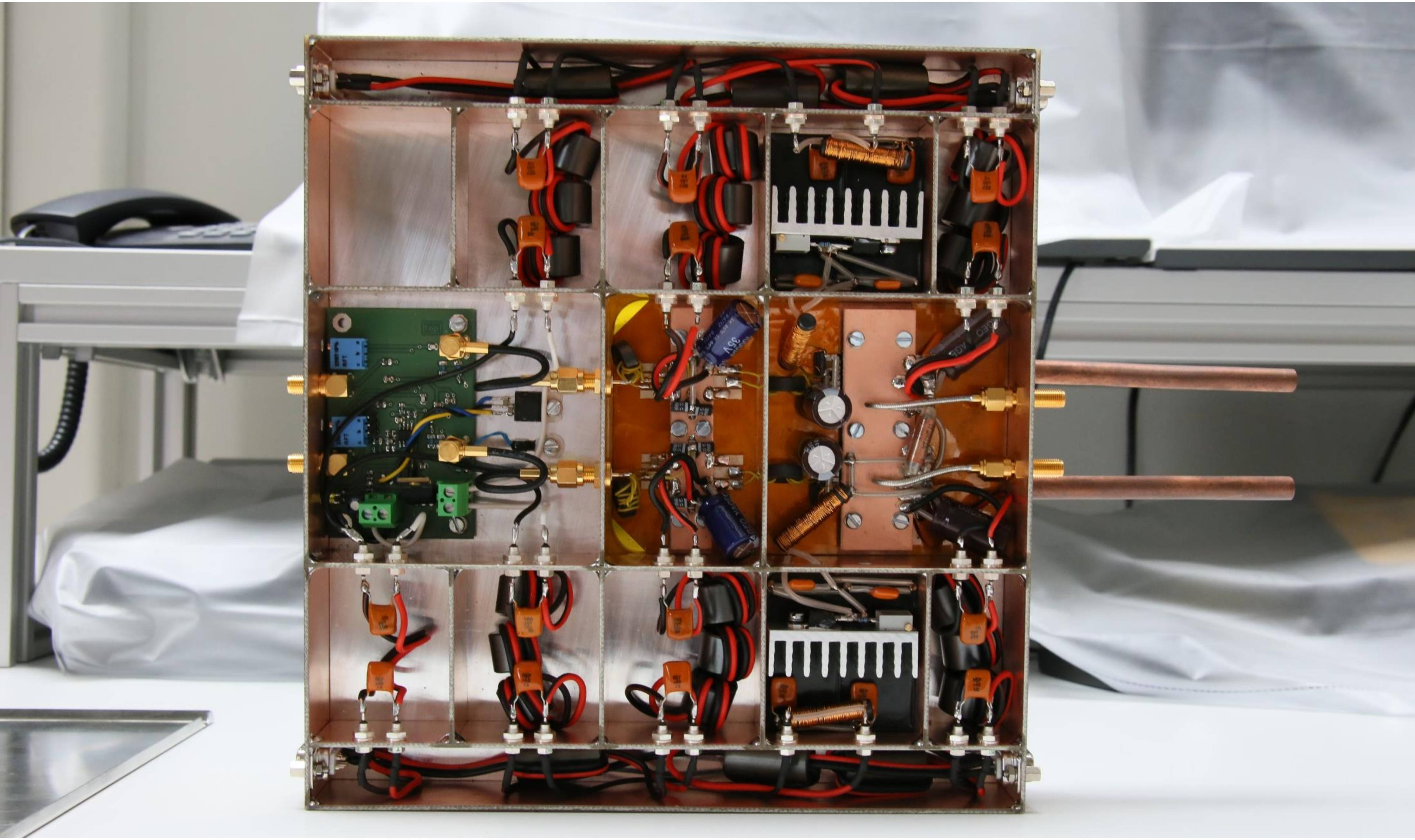


wiring of all 4 chopper plates


4 chopper pulser

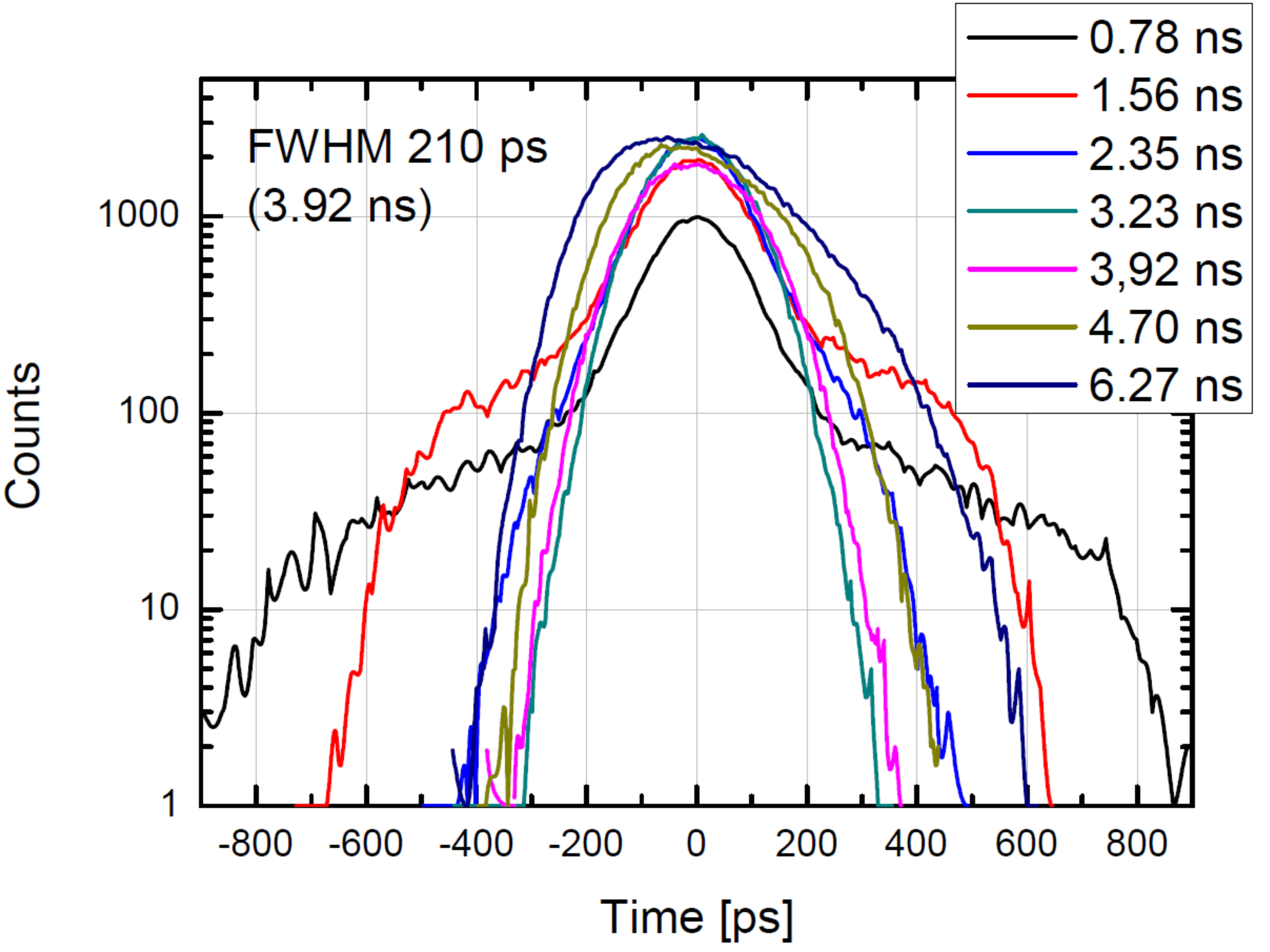

terminating resistors
and 60 dB attenuators


water cooling
of pulser

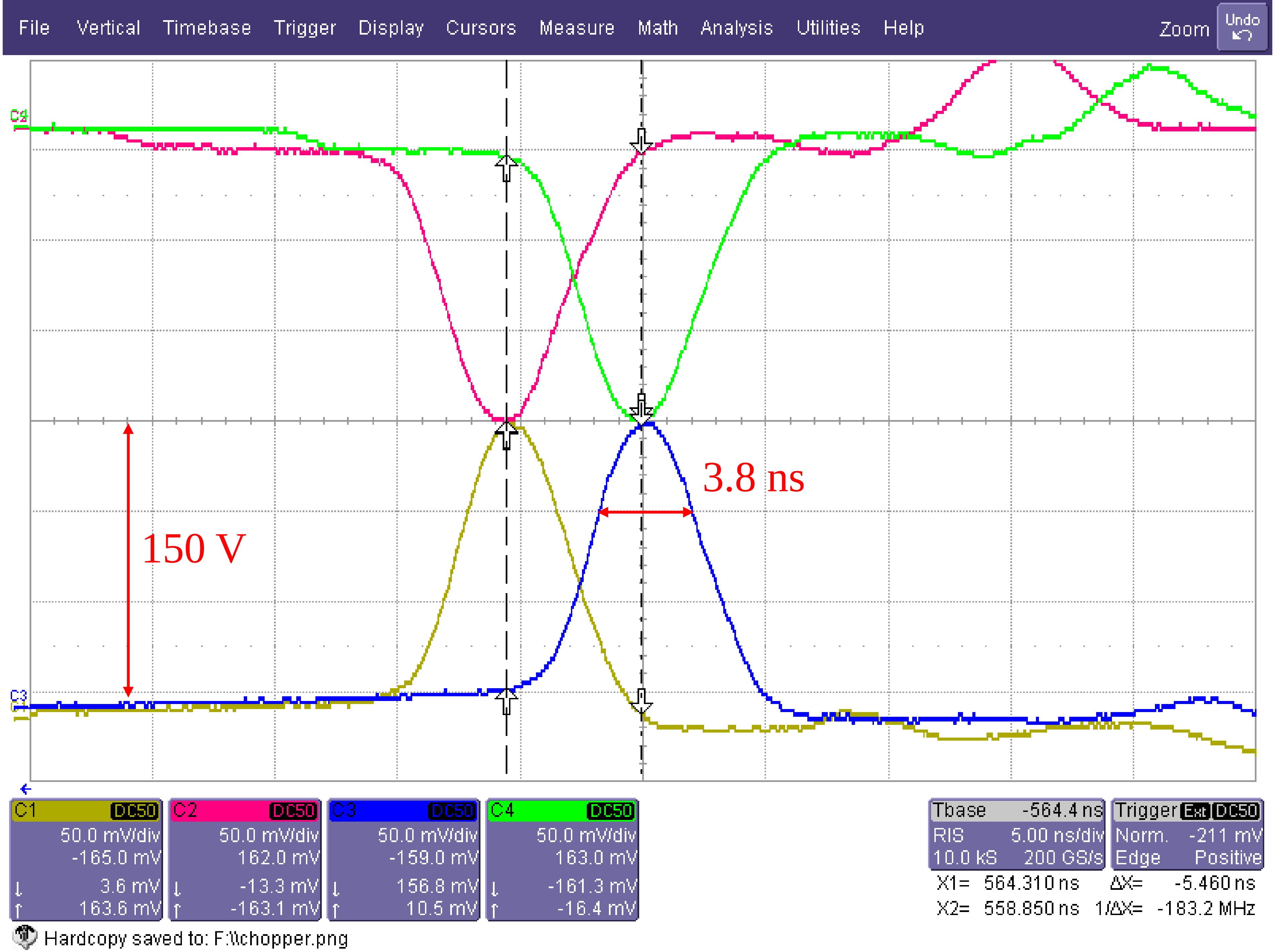


- single chopper pulser; water-cooled
- dissipates 200W @ 13 MHz; only 25W @ 1.6 MHz
- constructed by Dr. G. Staats (HZDR)

Simulation of Chopper Performance

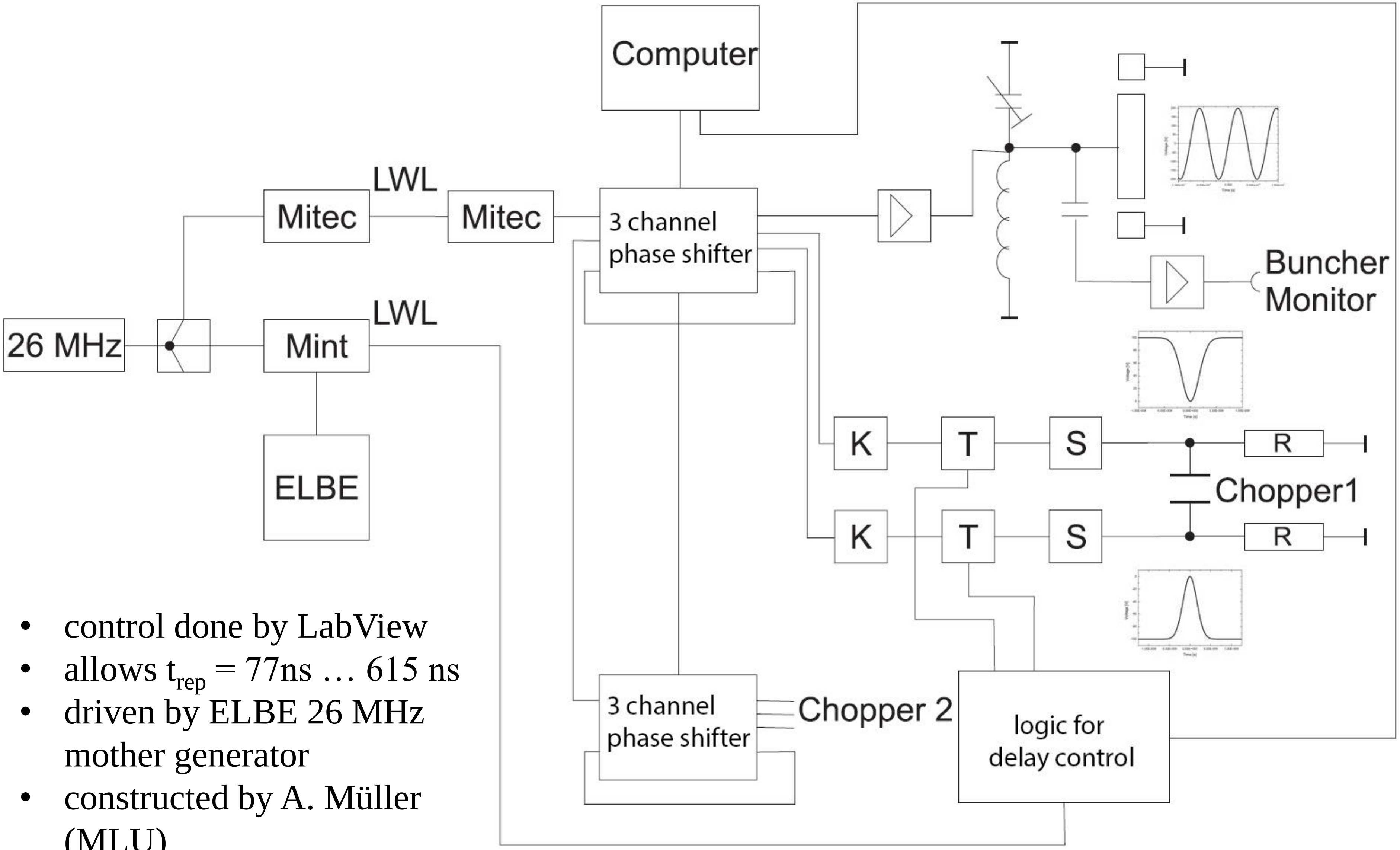


- simulation done by SIMION-8
- BaF_2-PMT included



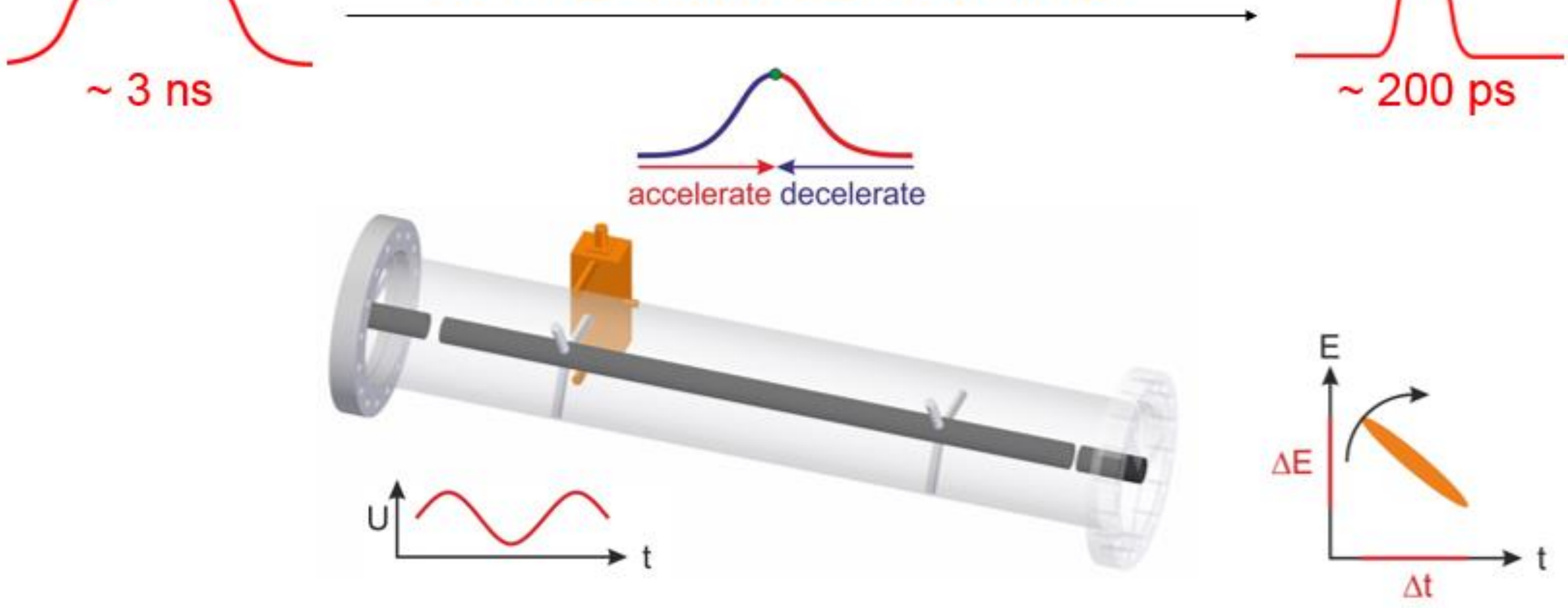
File
Vertical
Timebase
Trigger
Display
Cursors
Measure
Math
Analysis
Utilities
Help
Zoom
Undo
150 V
3.8 ns
C1 DC50
50.0 mV/div
-165.0 mV
3.6 mV
163.6 mV
C2 DC50
50.0 mV/div
162.0 mV
-13.3 mV
-163.1 mV
C3 DC50
50.0 mV/div
-159.0 mV
156.8 mV
10.5 mV
C4 DC50
50.0 mV/div
163.0 mV
-161.3 mV
-16.4 mV
Tbase -564.4 ns
RIS 5.00 ns/div
10.0 kS 200 GS/s
Trigger Ext DC50
Norm. -211 mV
Edge Positive
X1= 564.310 ns
ΔX= -5.460 ns
X2= 558.850 ns
1/ΔX= -183.2 MHz
Hardcopy saved to: F:\\chopper.png

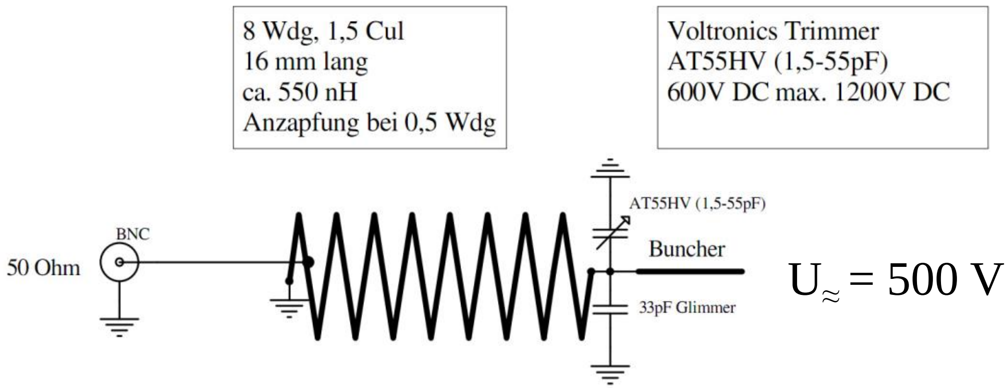
Delay Control for Chopper and Buncher



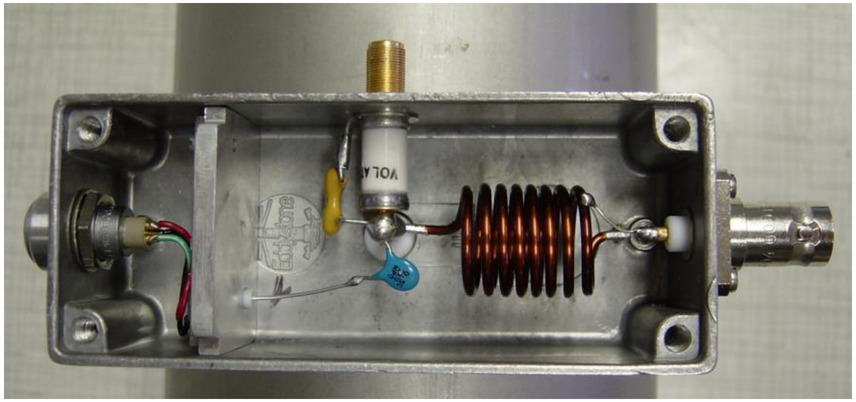
- control done by LabView
- allows t_{rep} = 77ns … 615 ns
- driven by ELBE 26 MHz mother generator
- constructed by A. Müller (MLU)

26 MHz double-slit buncher

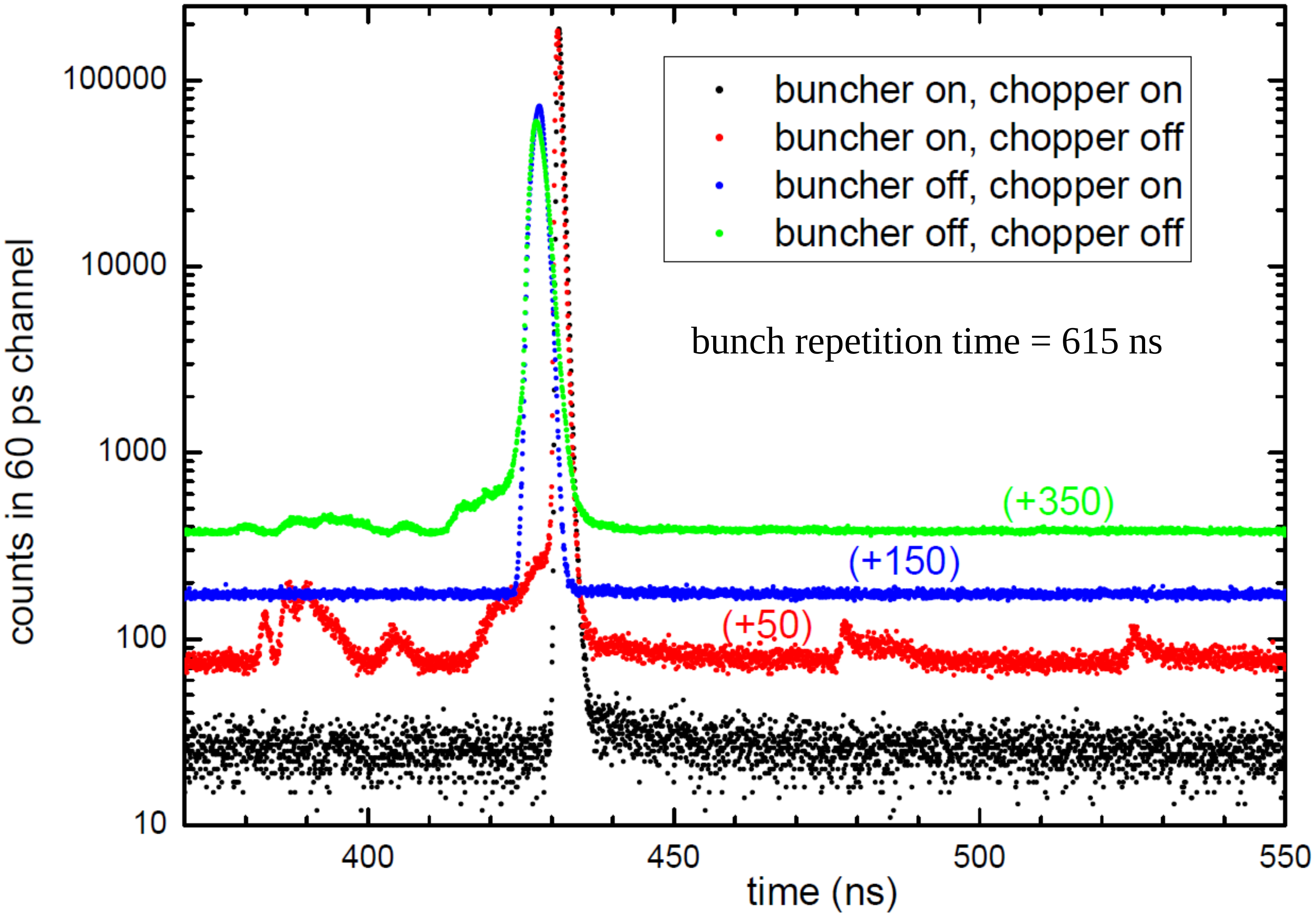




$U_{\approx} = 500$ V

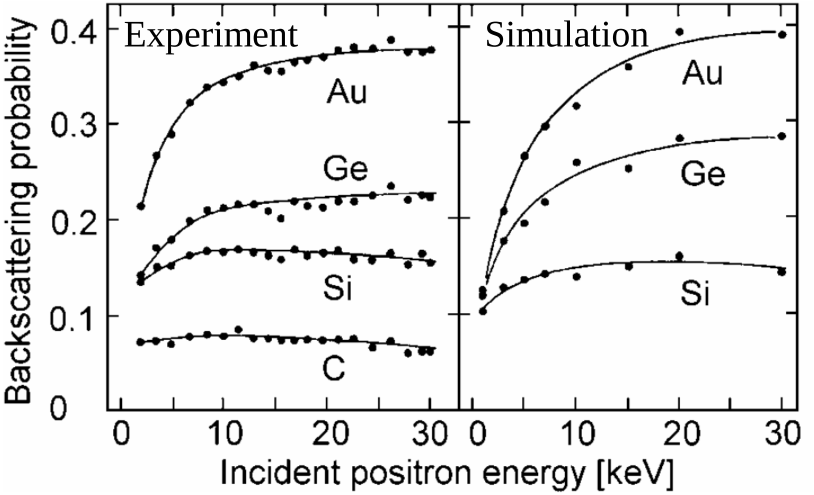


Action of Chopper and Buncher



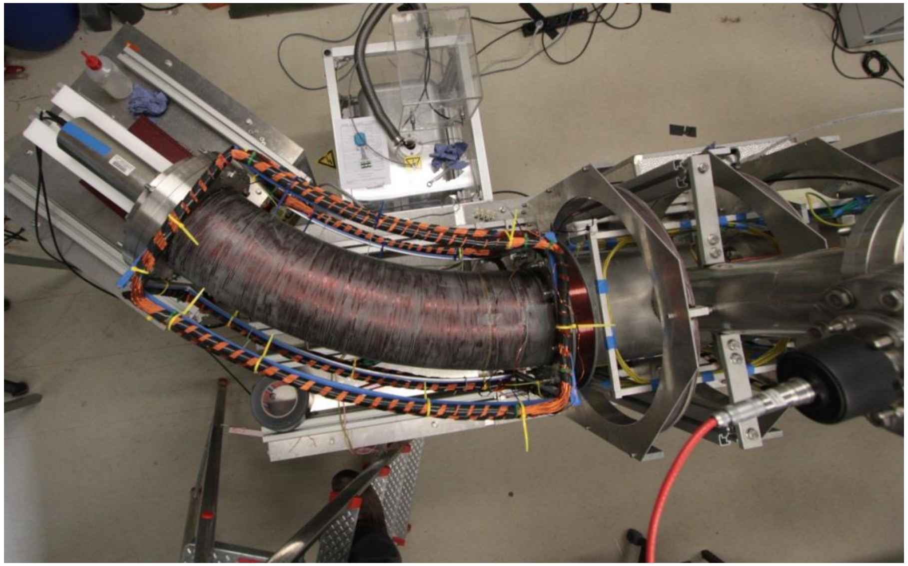
Backscattered Positrons

- Problem: large fraction of positrons will be **backscattered** from for high-z sample



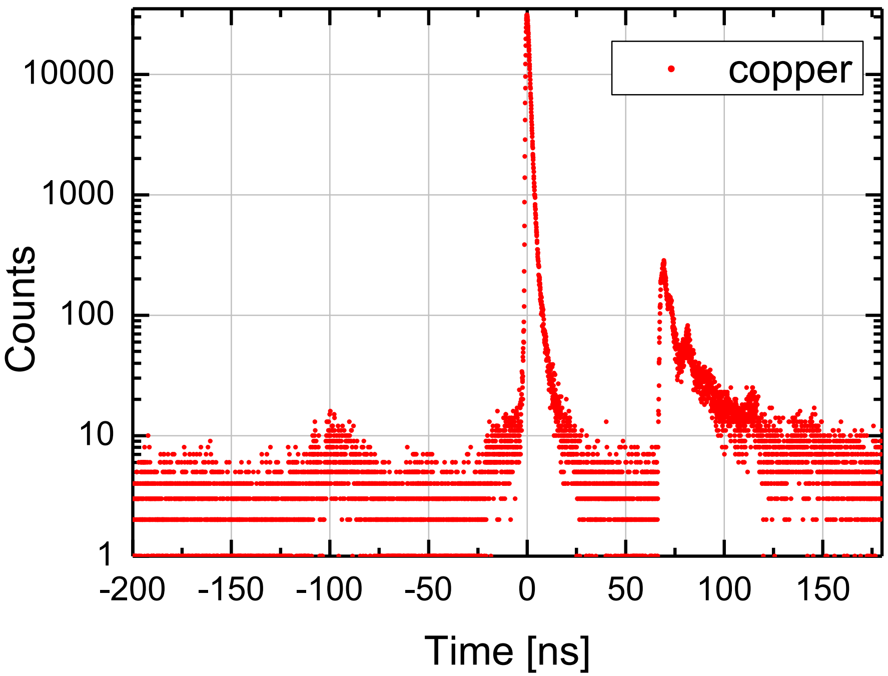
Mäkinen et al., 1992

- in many systems: E×B filter in beam line prevents backscattered positrons from being re-accelerated
- in spite of this ⇨ often **side peaks** in spectrum
- **our solution: a bent beamline** ⇨ steering coils guide positrons to sample but backscattered to the wall in some distance

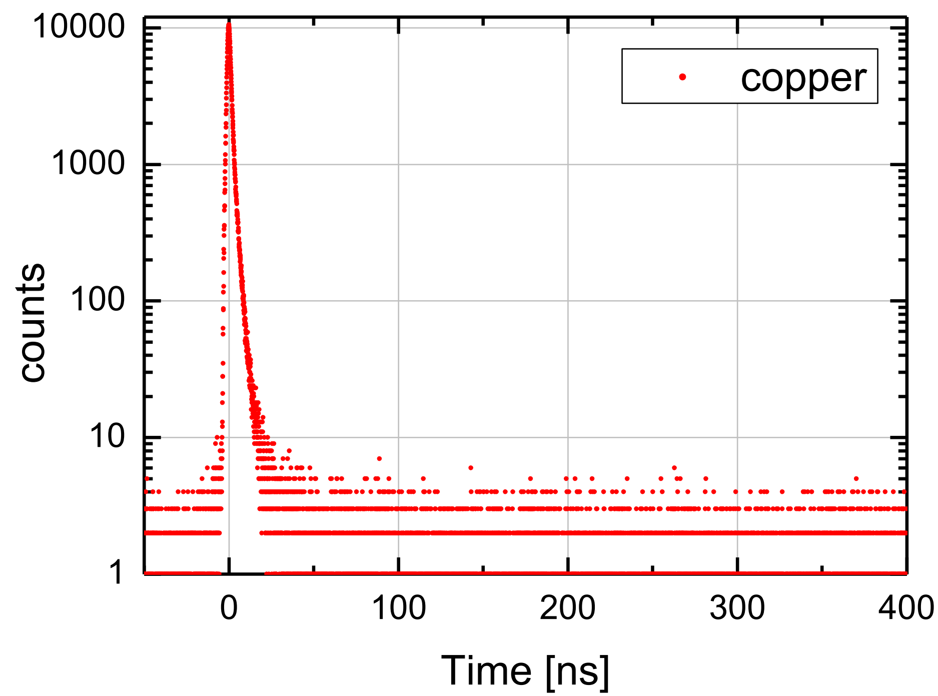


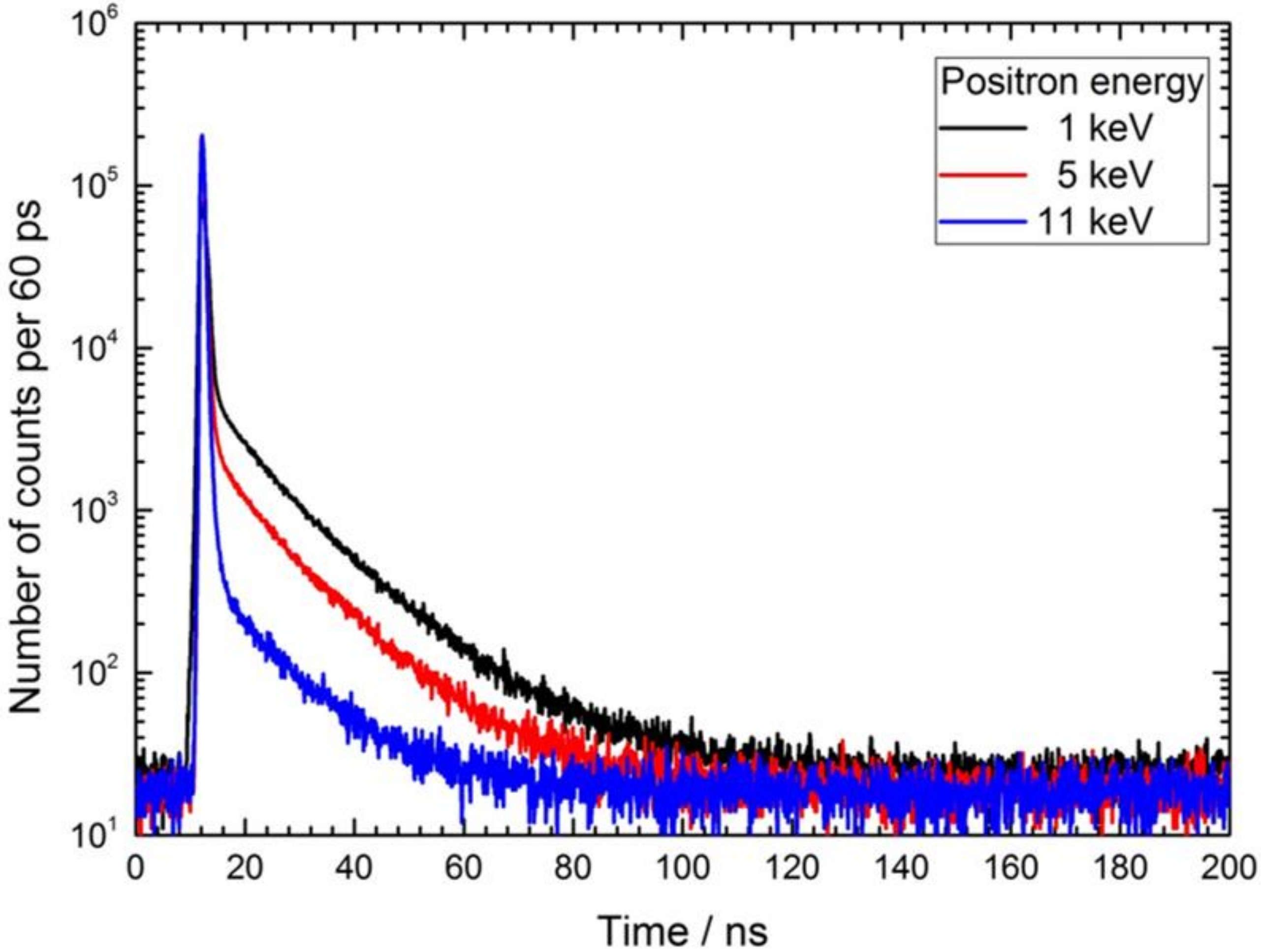
Bent beam line: no disturbance due to backscattered positrons

- straight beamline
- accelerator is on
- strong side peak due to re-acceleration of backscattered positron



- bent beamline: 45°
- accelerator is on
- no side peaks
- less background ≈ 1 : 10^4
- no chopper in use for test





Positron lifetime spectra of a 400 nm low-k layer on Si measured at different positron implantation energies.

Please see the MELT analysis of these spectra on our poster P-39 in session B

User operation started in February 2013

Up to now (Run 1 – 2 2013) we studied mainly **porous materials**

- low-K dielectrics (Fraunhofer ENAS Chemnitz)
- low-K dielectrics (Fraunhofer Dresden)
- gas separation membranes (FZ Jülich)

	Run III	Run IV	Summe
Free Shifts	85	90	175
All Shifts	119	133	252
NP	10	4	14
NEP	17	25	42
RP	3	12	15
FEL	39	30	69
POS	15	14	29
AP	0	4	4
THZ	0	3	3
WT/MD	34	41	75

- ELBE time schedule for 2013 Run 3 and 4 (July – Dec)
- GiPS and MePS gain 11%
- interested in own beam time?
- applications twice a year – just contact one of us
- Next application deadline: 4th November
- http://www.hzdr.de/db/Cms?pNid=1732

ELBE.

HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

Application for ELBE beam time

in the period July–December 2013

Project number...............

FELBE

wayforlight

1. Title of the project:

2. Project leader

Name.

Gender .... Year of Birth .... Nationality Germany ...... Researcher Status: [1] ....

Affiliation ....

Address. ....

E-mail address. ....

Phone number ....

3. Spokes person for the proposal

Name. ....

Gender .... Year of Birth .... Nationality Germany ...... Researcher Status: ....

If different form affiliation of project leader:

Affiliation ....

Address. ....

E-mail address. ....

Phone number ....

Mobile number [2] ("emergency number") ....

4. Collaborating partner from HZDR (*if appropriate, please specify leading scientist of the collaborating group at HZDR*):

....

Conclusions

- MePS and GiPS now ready for external users
- Further developments of MePS:
  - improvement of time resolution
  - complete automation of measurement by LabView (handling by users should be possible)
  - digital lifetime and Doppler measurement
  - sample magazine in vacuum
  - temperature stage