A New Detector Test Beamline at ELSA

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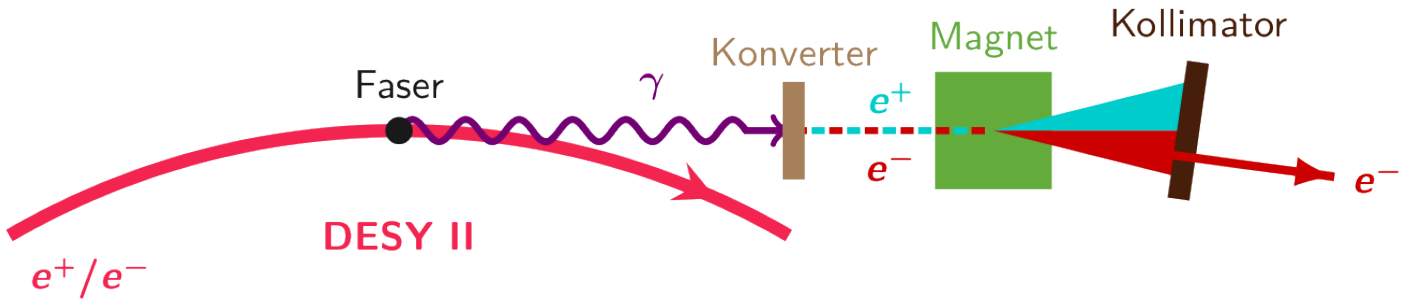
6th Beam Telescopes and Test Beams Workshop 2018

Electron test beams

- most of the test facilities use secondary or tertiary electron beams



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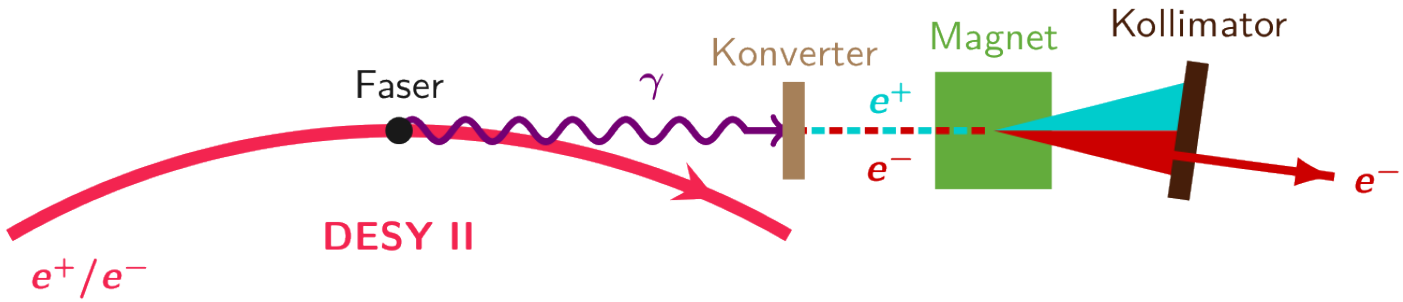
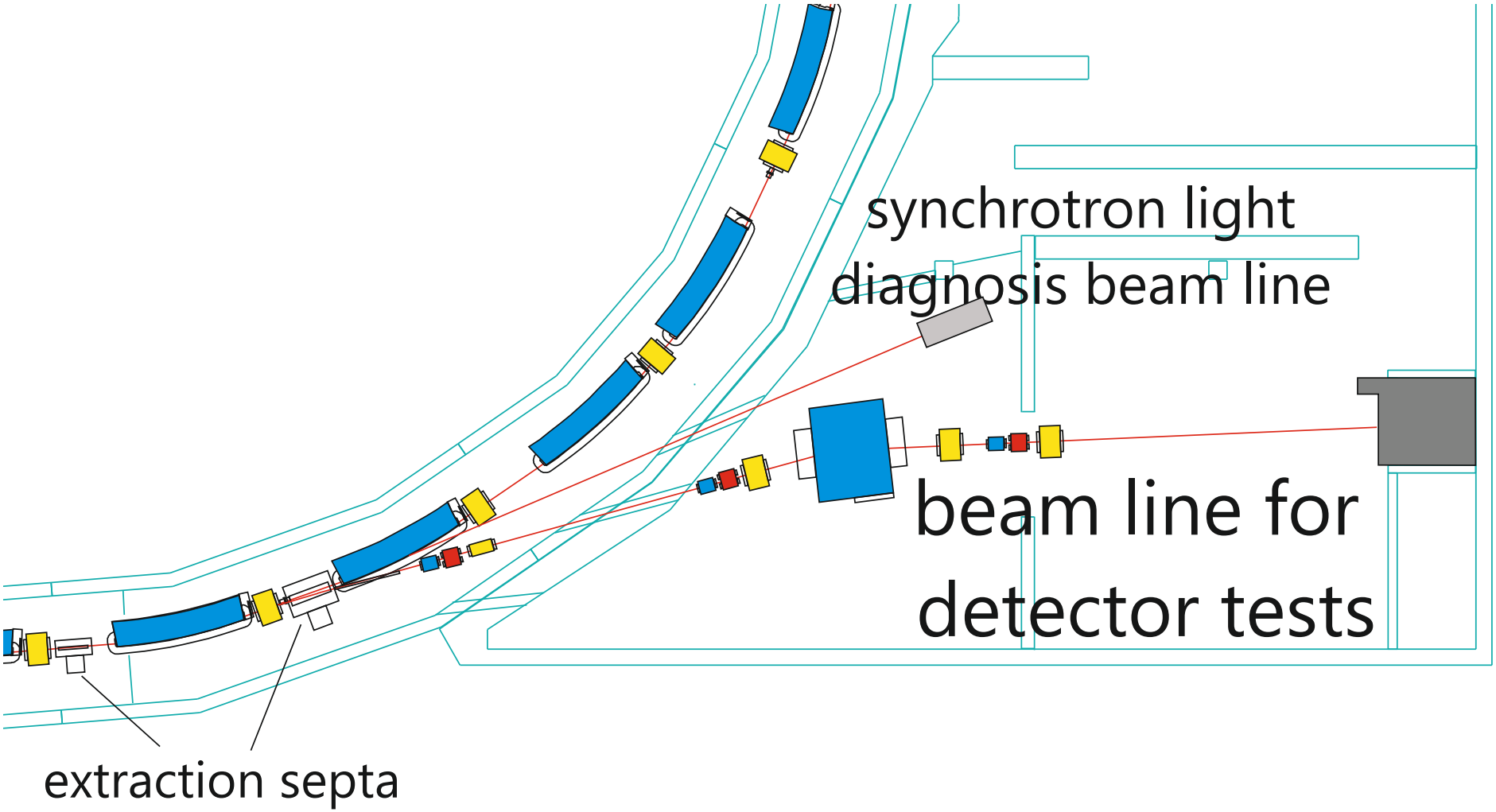


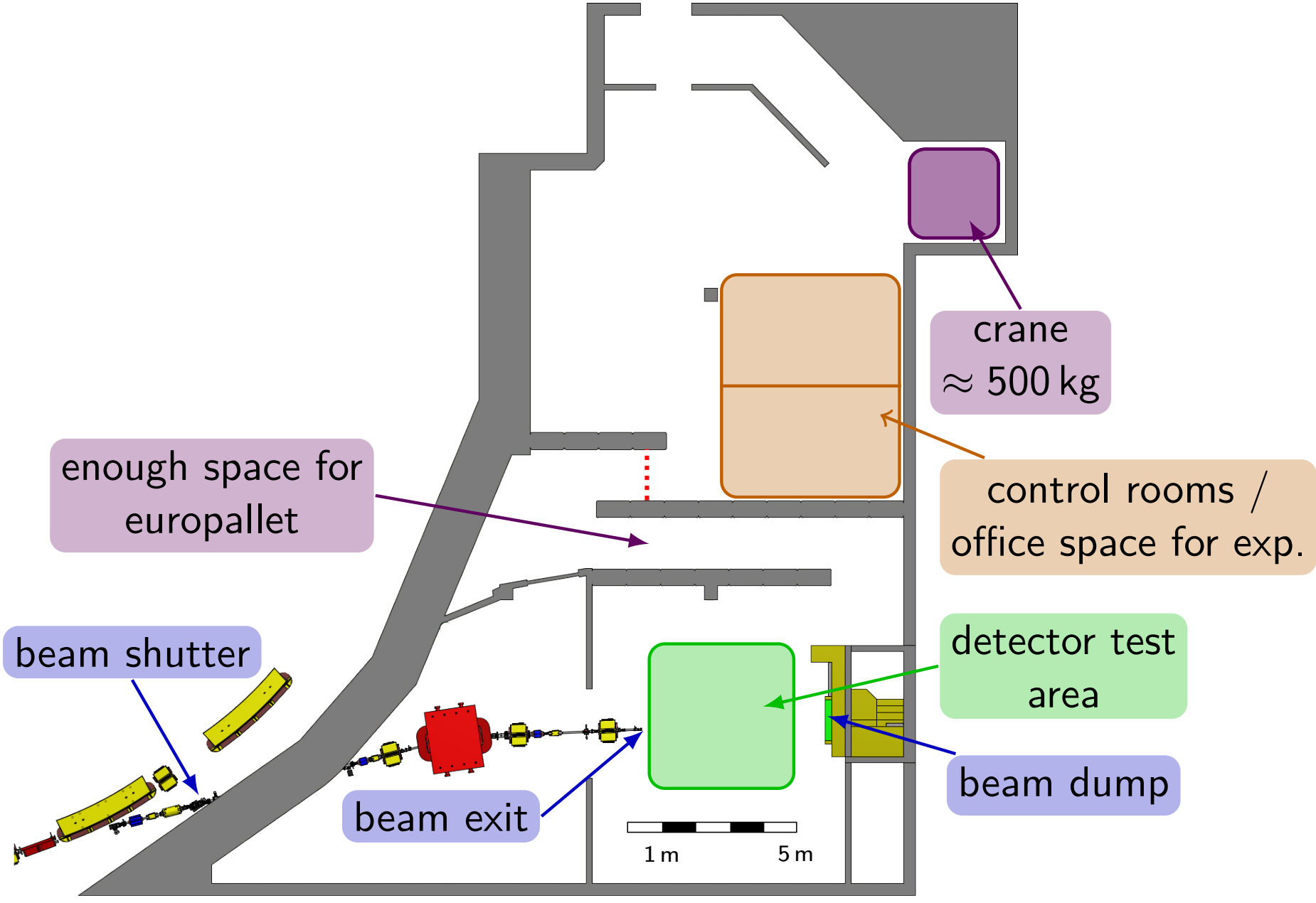
test beam @ ELSA

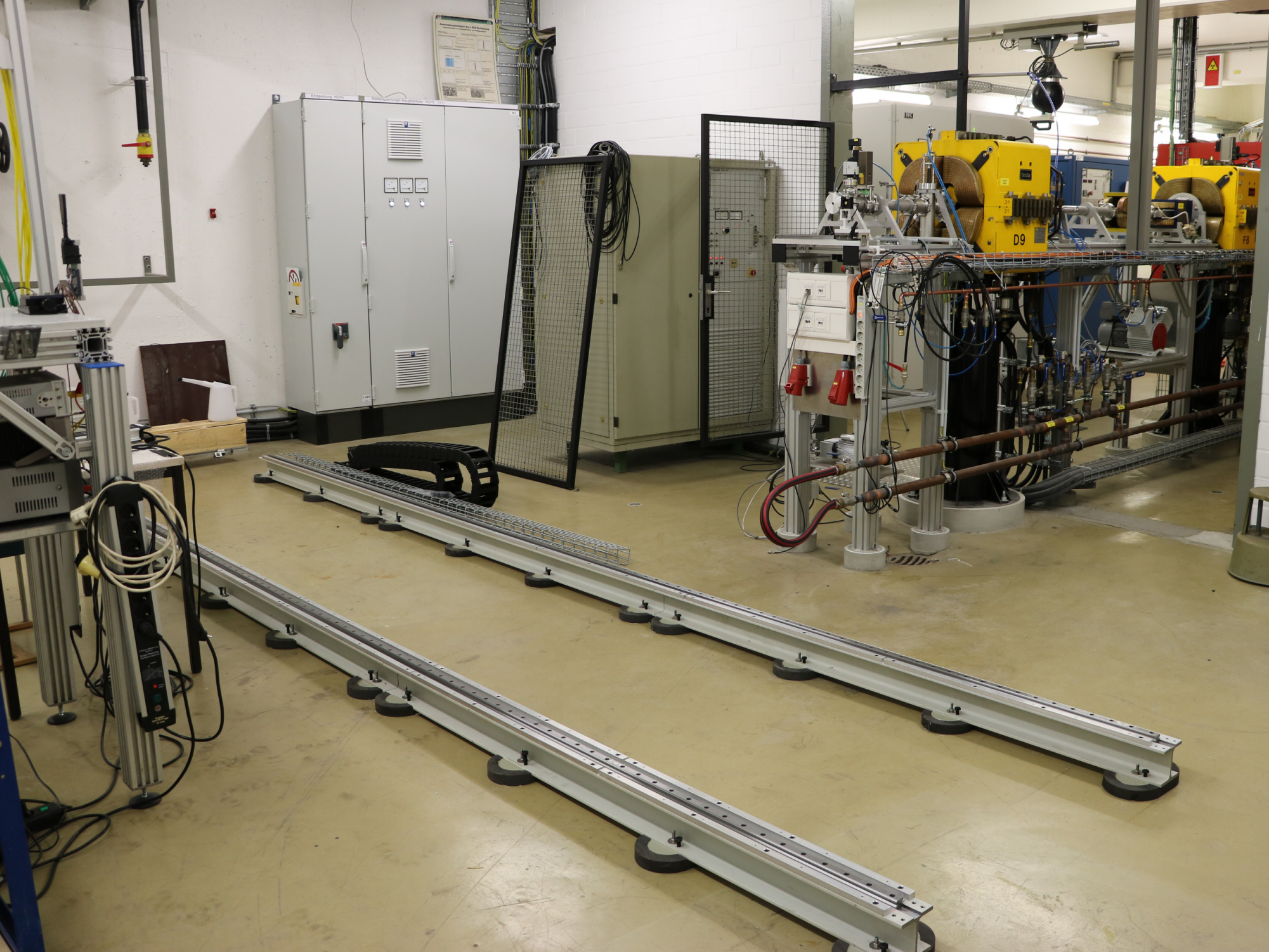
- (polarized) primary electron beam

New beamline for detector tests



Floor plan


crane
≈ 500 kg
control rooms /
office space for exp.
enough space for
europallet
beam shutter
detector test
area
beam dump
beam exit
1 m
5 m

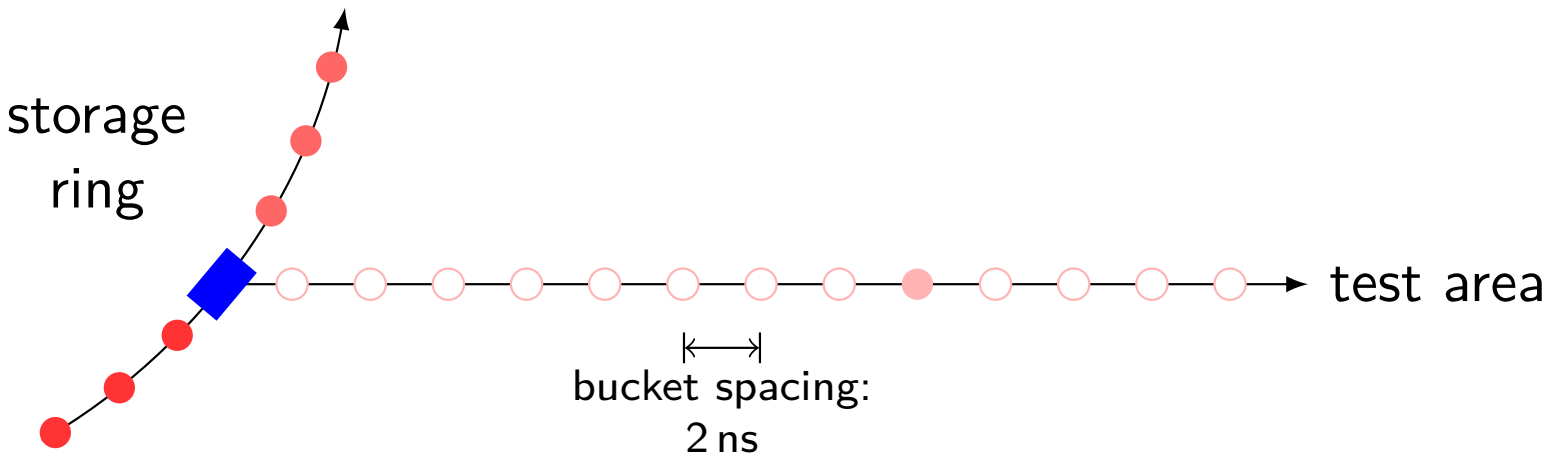

D9

Infrastructure

- $30\,\mathrm{m}^2$ usable experimental area
- nearby office space / control room for experiments
- under construction: 4 movable test stands:
  - 2 guide rail systems
  - each equipped with two tables ($1.2\,\mathrm{m} \times 1.6\,\mathrm{m}$)
  - patch panel (power, gas, Ethernet) for each table
  - ready for use: summer 2018
- planned:
  - movable portal crane
  - compressed air
  - dry nitrogen
  - gas cylinder store for flammable gases
  - cooling (water and liquid nitrogen)
- more requirements?

Beam properties and rates

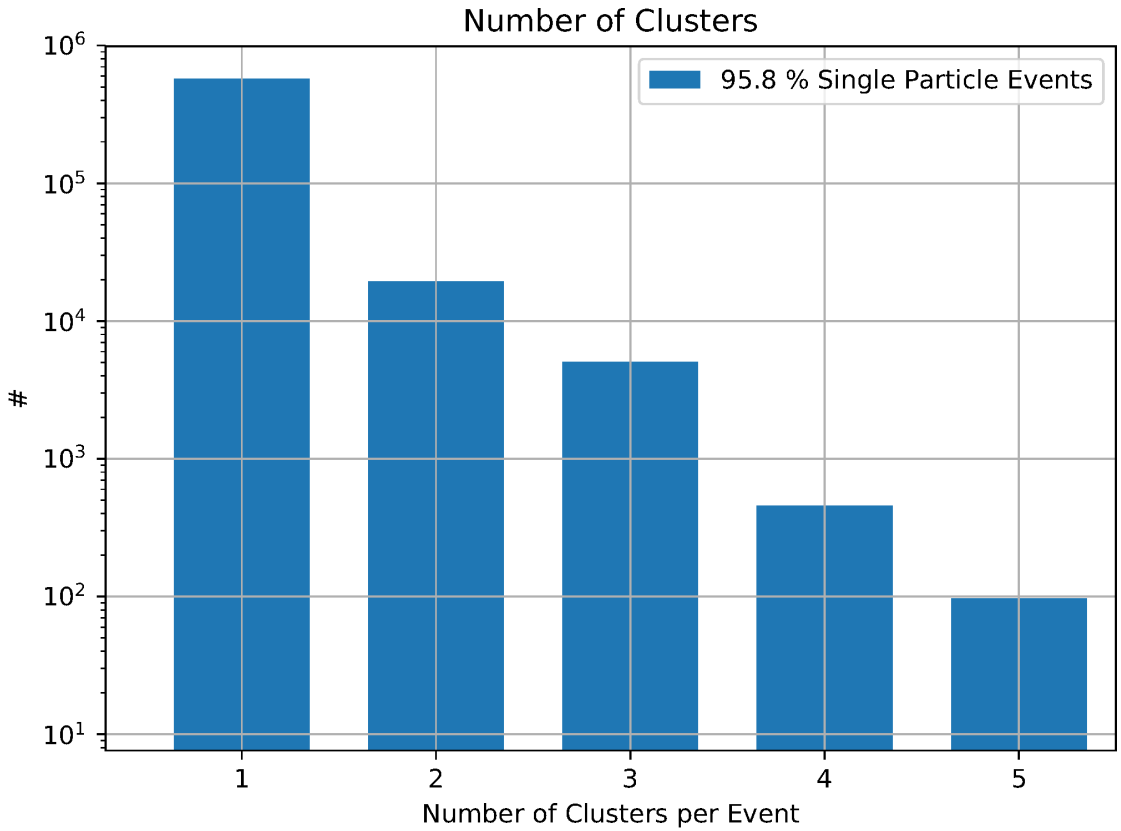
- 0.8 GeV to 3.2 GeV electrons
- energy deviation $< 0.1\,‰$
- 2 ns bucket spacing, continuous beam



- at 50 kHz extraction rate: approximately one out of 10 000 buckets is filled with a single electron

Beam properties and rates

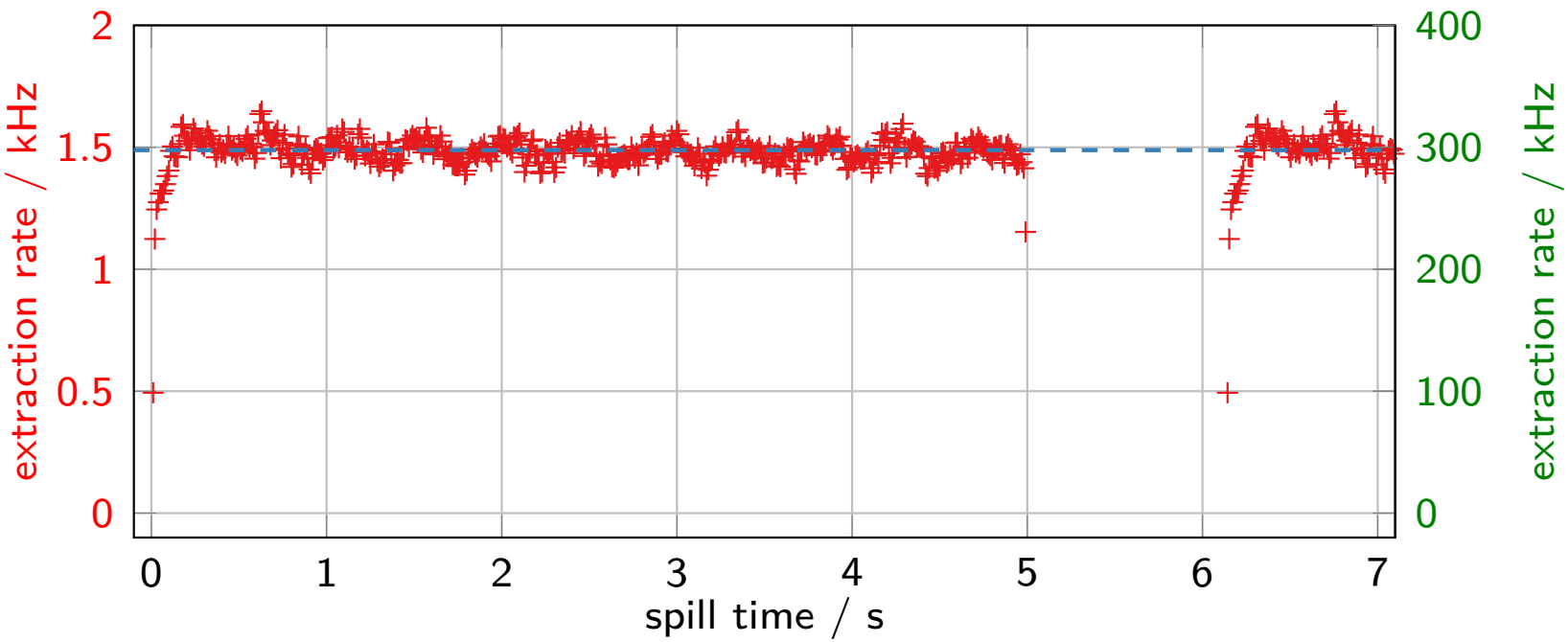
- 0.8 GeV to 3.2 GeV electrons
- energy deviation $< 0.1\,‰$
- 2 ns bucket spacing, continuous beam
- **single electrons**
  - 95.4 % single cluster events in a 400 ns time window
  - rates up to 30 kHz



[1] "Setup and Characterization of the Test Beam Area for Pixel Detector Tests at ELSA", Y. Dieter, 2017, Universität Bonn

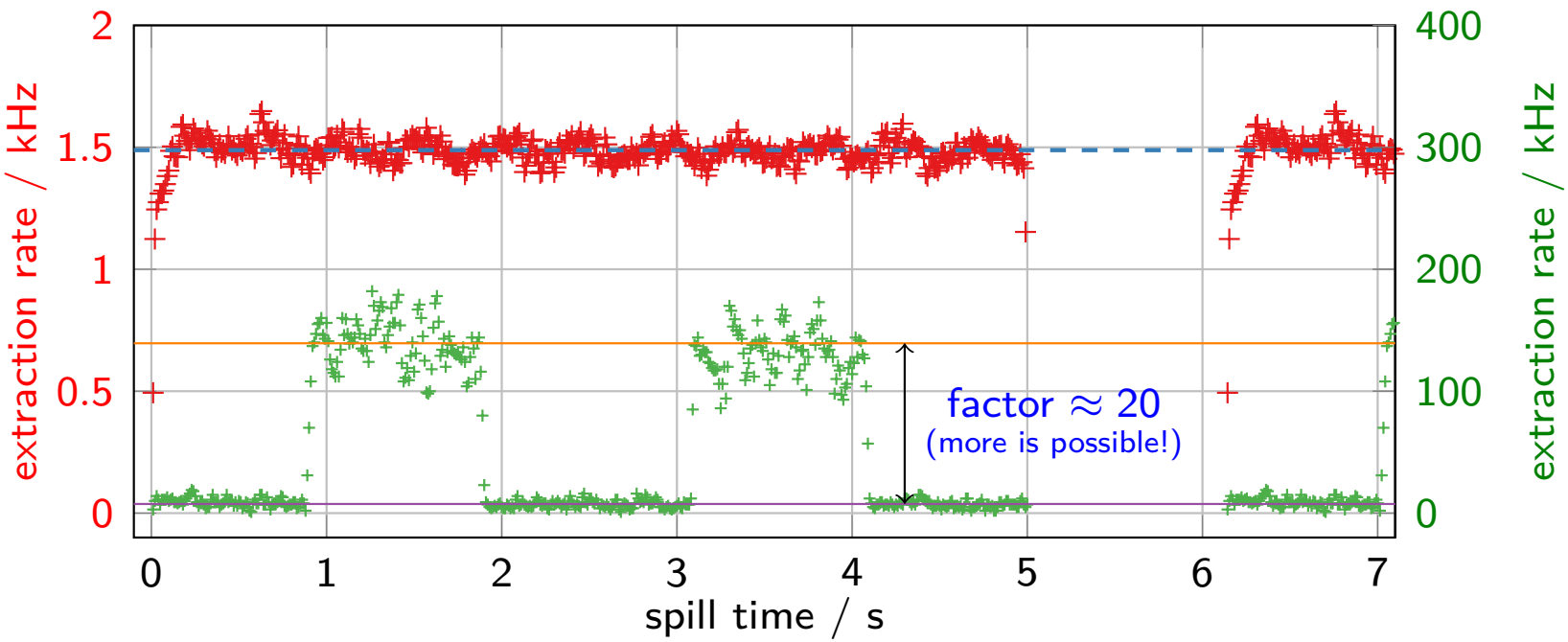
Extraction rate

- user-controllable between 1 Hz and 625 MHz
- $<$ 200 Hz: feed forward
- $>$ 200 Hz: feedback for rate stabilization
  - software PID, sampling rate 100 Hz
  - input from scintillating fiber
  - or **your signal**



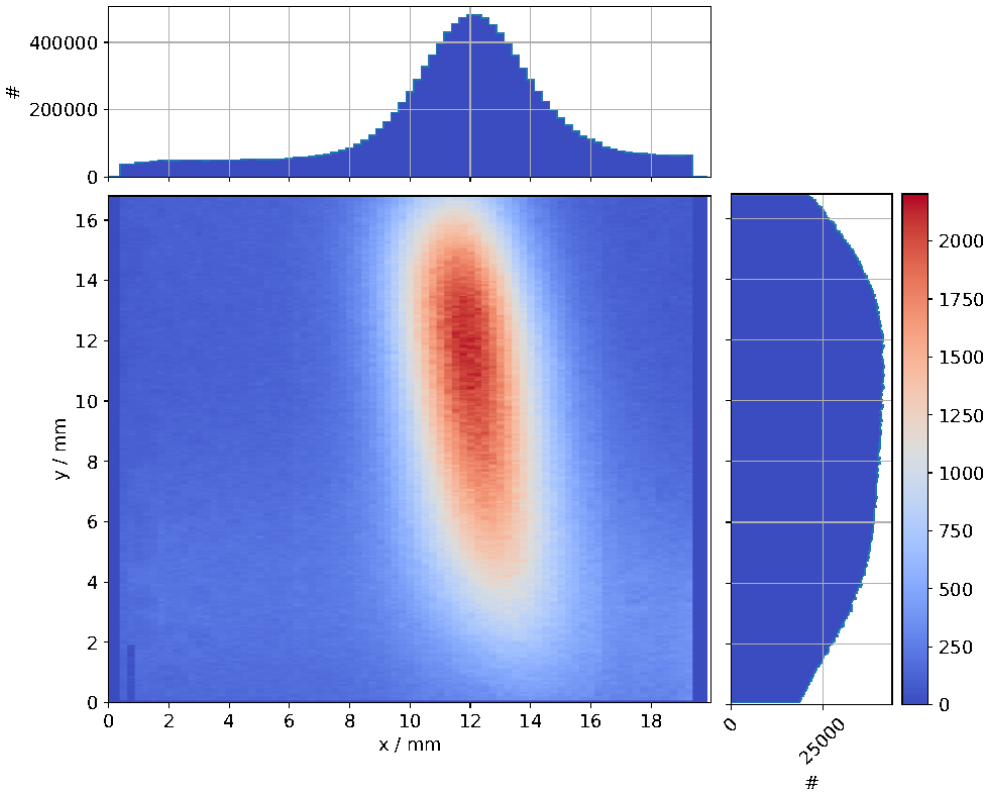
Extraction rate

- user-controllable between 1 Hz and 625 MHz
- $<$ 200 Hz: feed forward
- $>$ 200 Hz: feedback for rate stabilization
  - software PID, sampling rate 100 Hz
  - input from scintillating fiber
  - or **your signal**
- arbitrary patterns
- bursts, i.e. $\approx$ 1 ms length

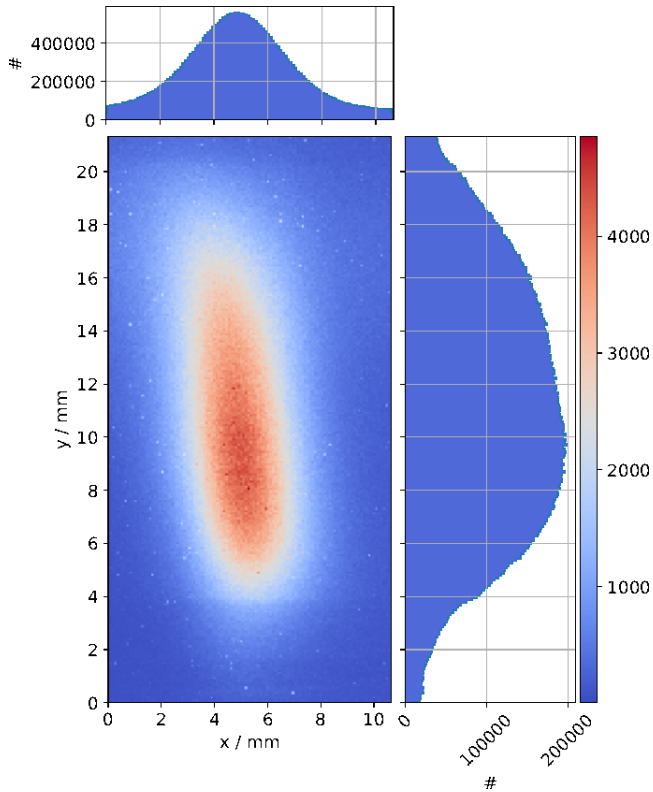


Beam profile

FE-I4



Mimosa26



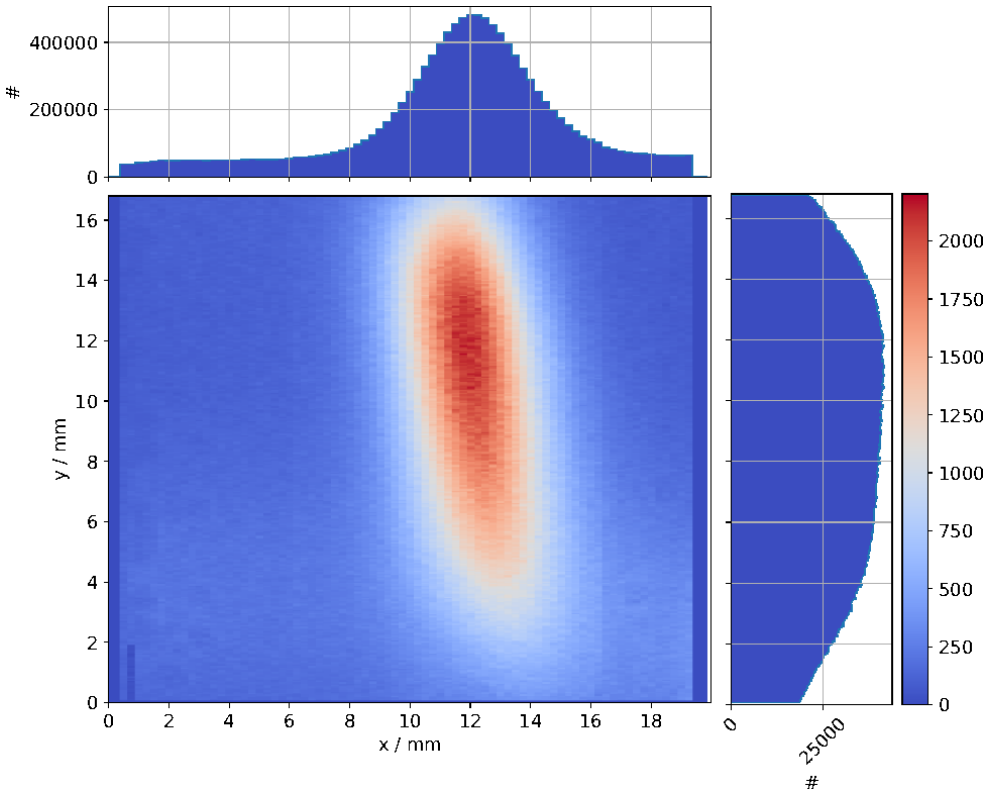
- $E = 2.5\,\mathrm{GeV}$
- $\sigma_x \approx 2.6\,\mathrm{mm}$, $\sigma_z \approx 4.4\,\mathrm{mm}$
- $\sigma'_x \approx 0.88\,\mathrm{mrad}$, $\sigma'_z \approx 0.92\,\mathrm{mrad}$

- beam parameters changeable by our staff

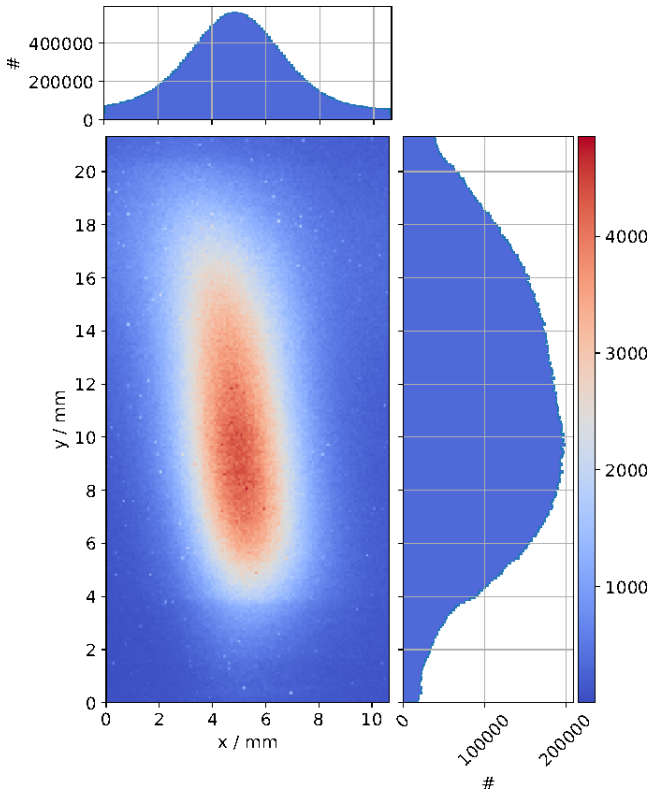
[1],[2] “Setup and Characterization of the Test Beam Area for Pixel Detector Tests at ELSA”, Y. Dieter, 2017, Universität Bonn

Beam profile

FE-I4



Mimosa26

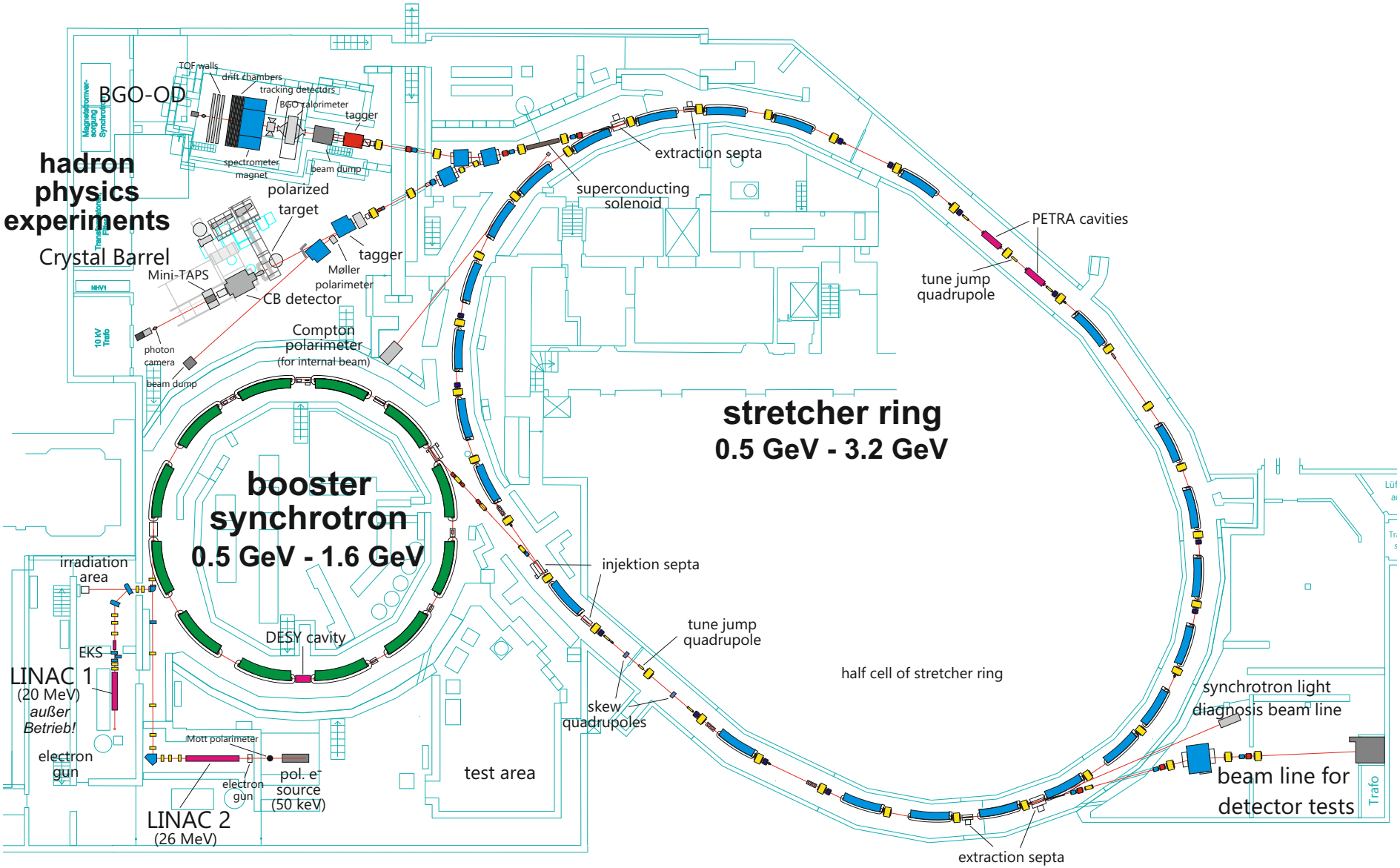


→ "A Triggerless Readout System for Mimosa26 Based Telescopes and a Python Based Test-beam Analysis Software"

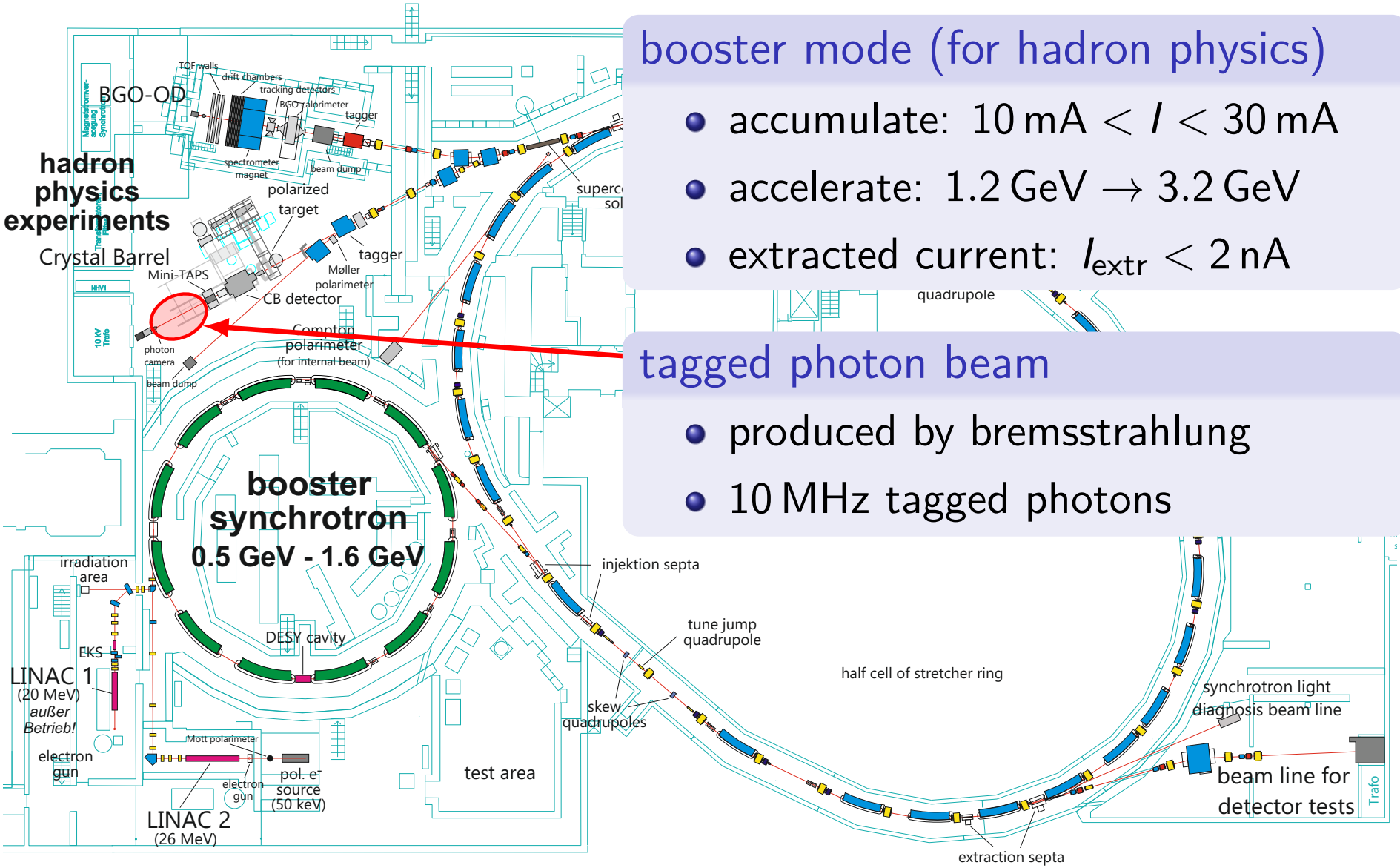
Yannick Dieter, *Wednesday, 14:10*

[1],[2] "Setup and Characterization of the Test Beam Area for Pixel Detector Tests at ELSA", Y. Dieter, 2017, Universität Bonn

ELektronen **S**tetcher **A**nlage: ELSA



Hadron physics experiments



booster mode (for hadron physics)

- accumulate: $10\,\text{mA} < I < 30\,\text{mA}$
- accelerate: $1.2\,\text{GeV} \rightarrow 3.2\,\text{GeV}$
- extracted current: $I_{\text{extr}} < 2\,\text{nA}$

tagged photon beam

- produced by bremsstrahlung
- 10 MHz tagged photons

Dedicated beam times for detector tests

booster mode (for hadron physics)

- accumulate: $10\,\text{mA} < I < 30\,\text{mA}$
- accelerate: $1.2\,\text{GeV} \rightarrow 3.2\,\text{GeV}$
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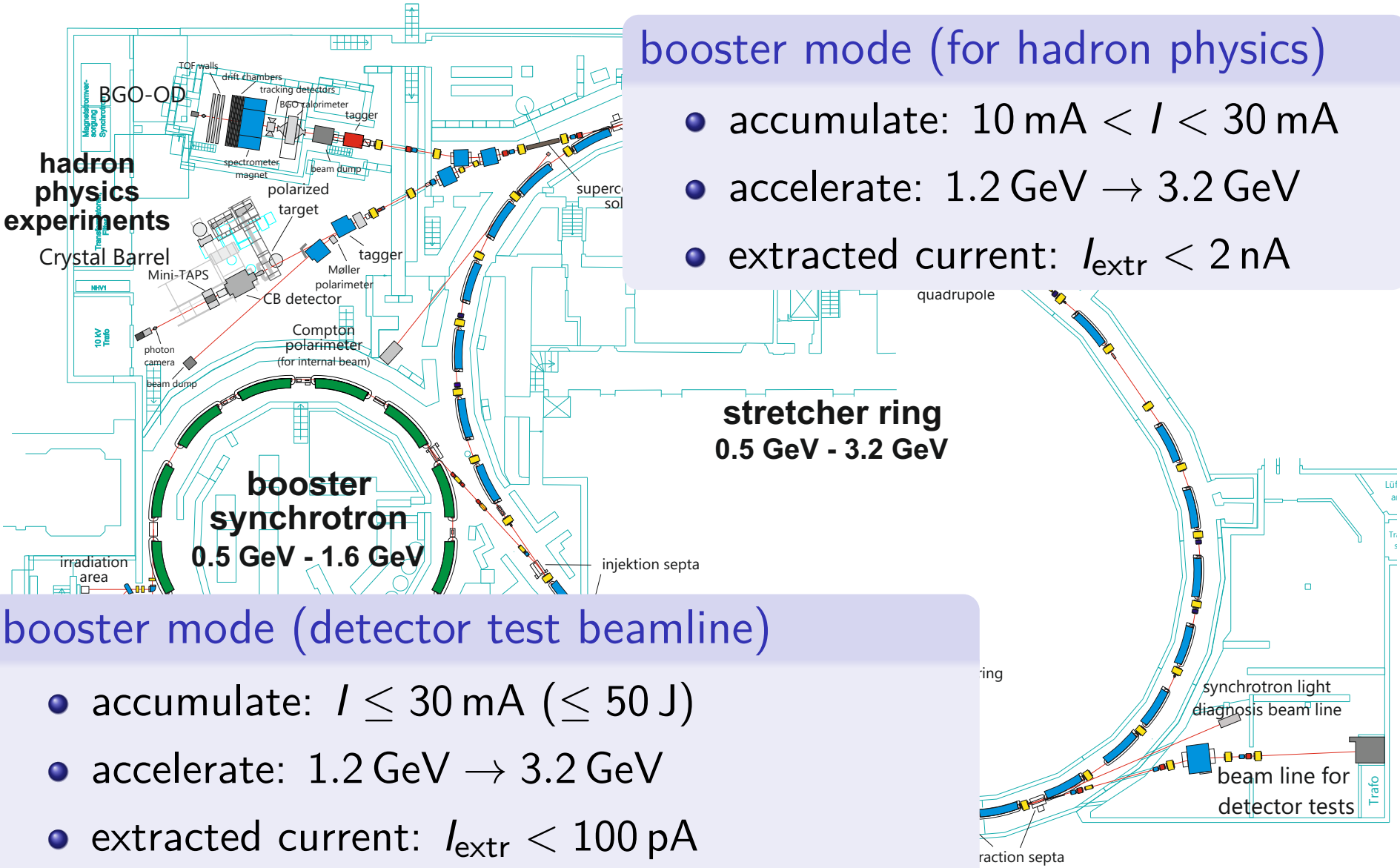
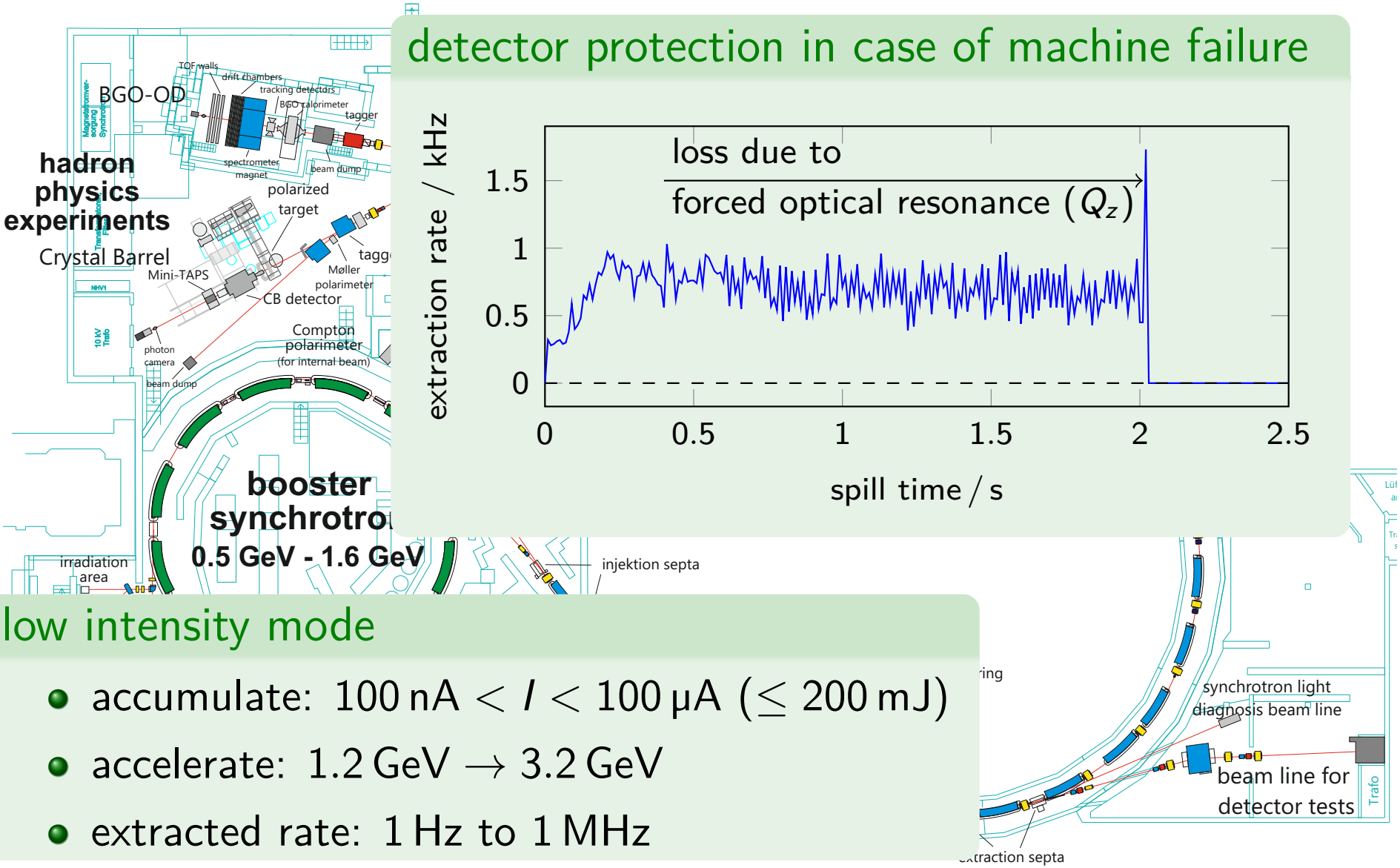


booster mode (detector test beamline)

- accumulate: $I \leq 30\,\text{mA}$ ($\leq 50\,\text{J}$)
- accelerate: $1.2\,\text{GeV} \rightarrow 3.2\,\text{GeV}$
- extracted current: $I_{\text{extr}} < 100\,\text{pA}$
- extracted rate: $\leq 625\,\text{MHz}$

Dedicated beam times for detector tests



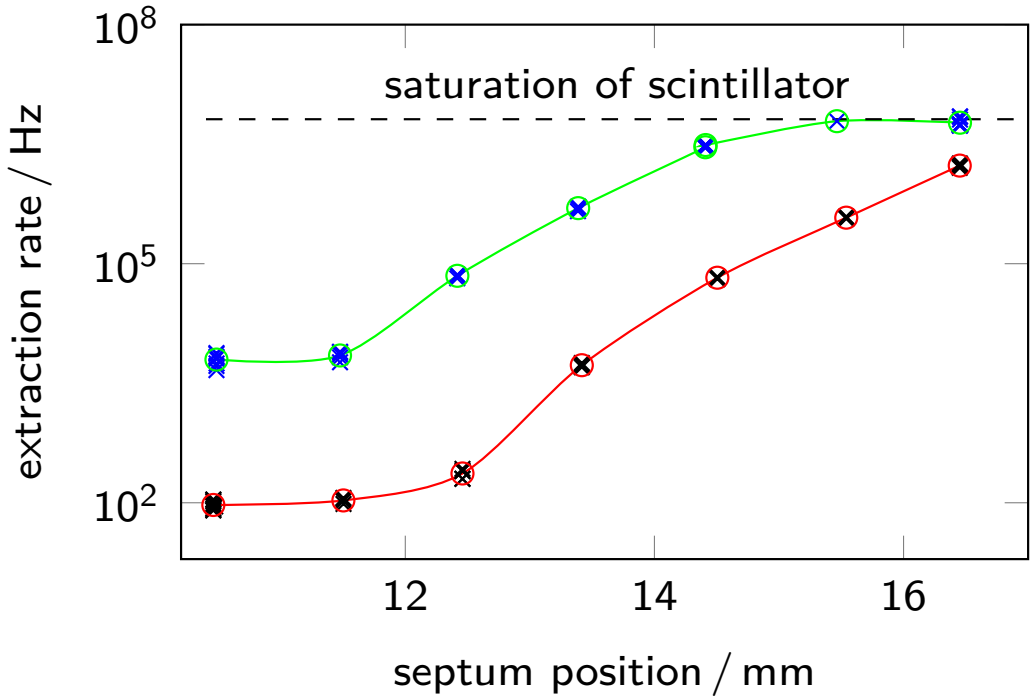
detector protection in case of machine failure

low intensity mode

- accumulate: $100\,\text{nA} < I < 100\,\mu\text{A}$ ($\leq 200\,\text{mJ}$)
- accelerate: $1.2\,\text{GeV} \rightarrow 3.2\,\text{GeV}$
- extracted rate: $1\,\text{Hz}$ to $1\,\text{MHz}$

Possible parasitic mode

- hadron physics experiments $\rightarrow$ 1 nA extracted current
- operate detector tests in parallel:
  - no direct rate control possible
- but: rate dependent on septum position



- influence on the beam properties at the hadron physics site unclear
  - needs to be investigated first!

Summary

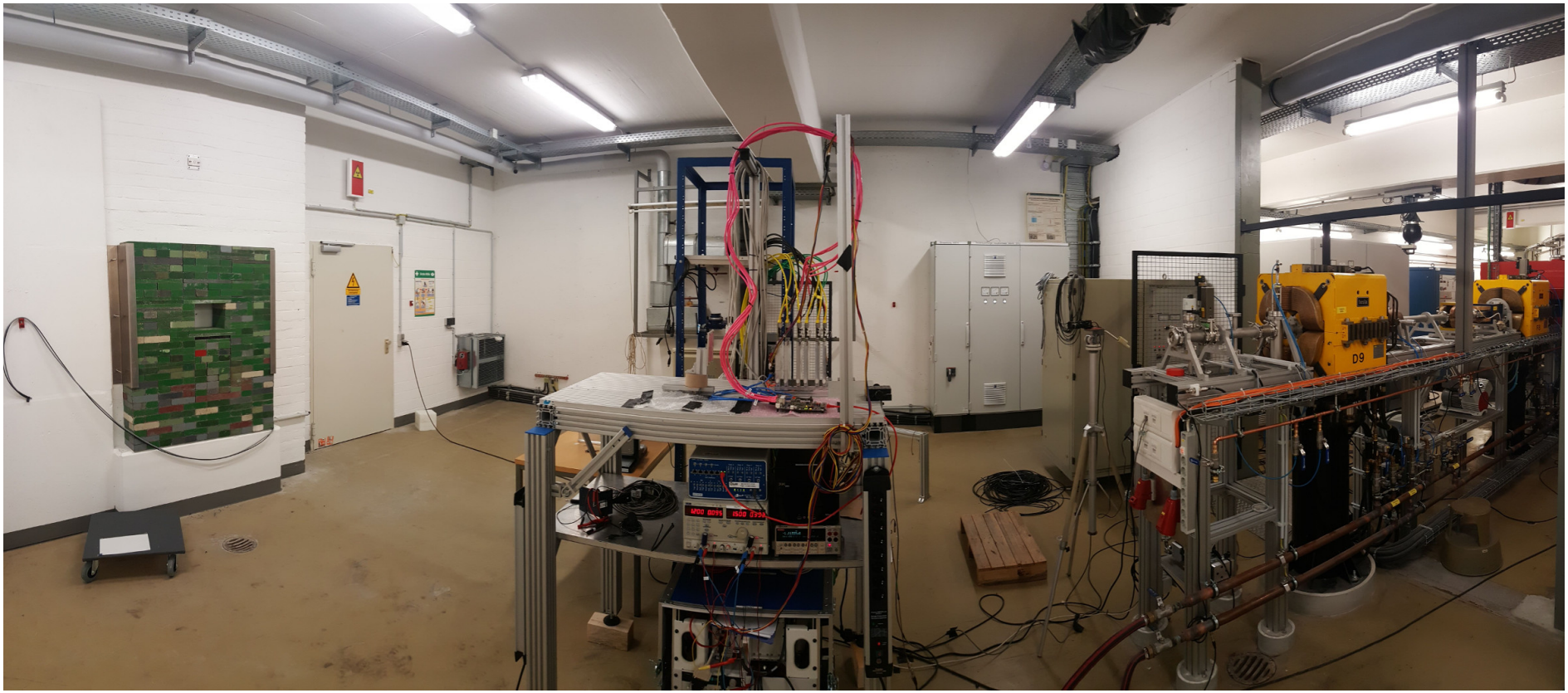
- beamline is fully operational since end 2016
- infrastructure is being improved
- recent test beams:
  - 6 times in 2017
  - 1 external user
  - 2 to 4 consecutive days (24 h)

  } 500 h
- beam parameters:

	width†/mm	divergence†/mrad	rate	current
Min	$\sigma_x = 1.3$ $\sigma_z = 1.0$	$\sigma'_x = 0.13$ $\sigma'_z = 0.01$	1 Hz	≈ 0 A
Max	$\sigma_x = 9.0$ $\sigma_z = 6.0$	$\sigma'_x = 2.5$ $\sigma'_z = 3.0$	625 MHz	100 pA

†dependent on machine parameters

Requests for beam time?



- 4 beam time meetings per year
- main user: hadron physics experiments

- contact person: Daniel Elsner: elsner@physik.uni-bonn.de
- website: https://www-elsa.physik.uni-bonn.de

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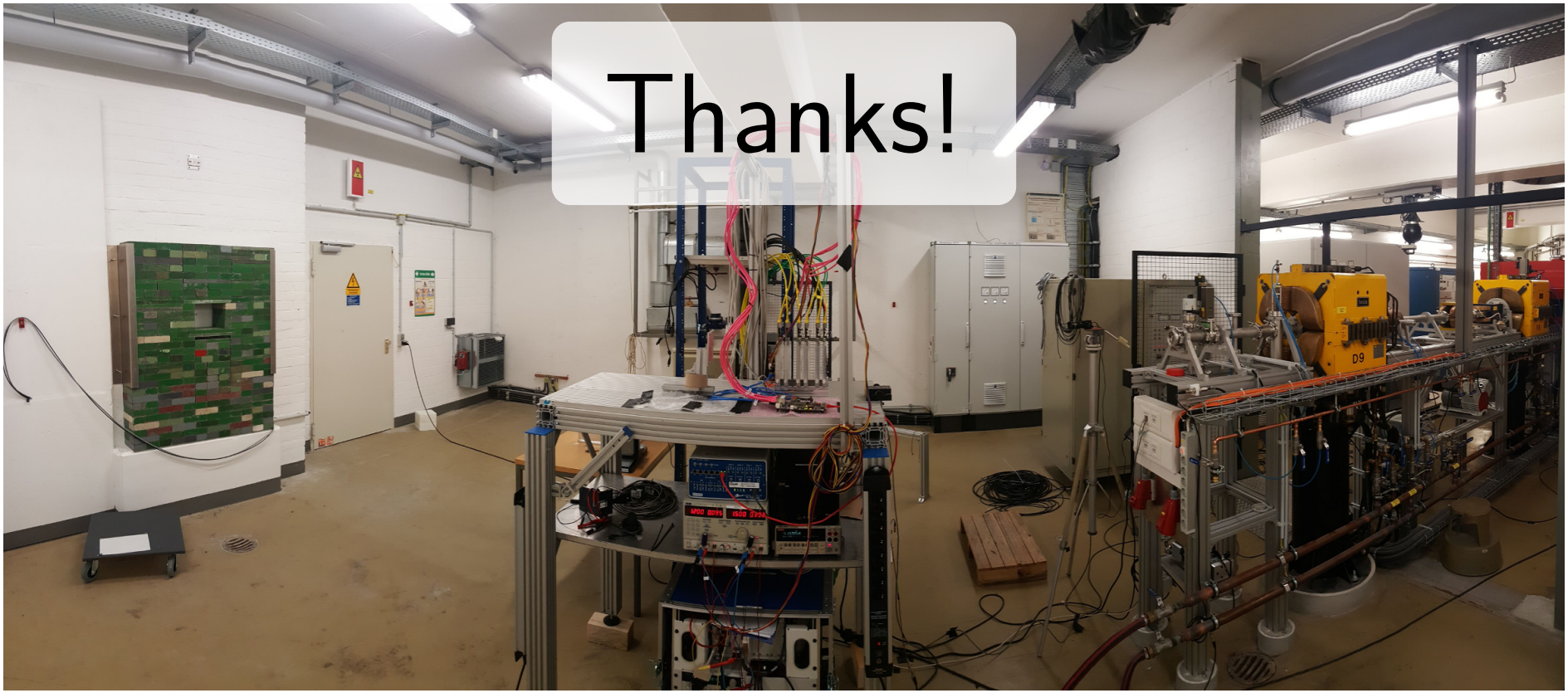

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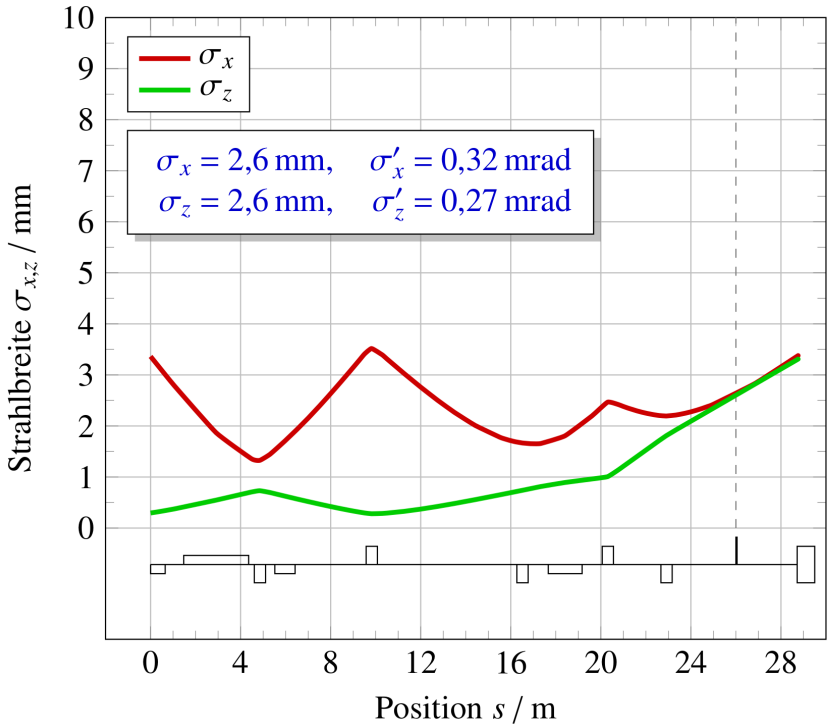
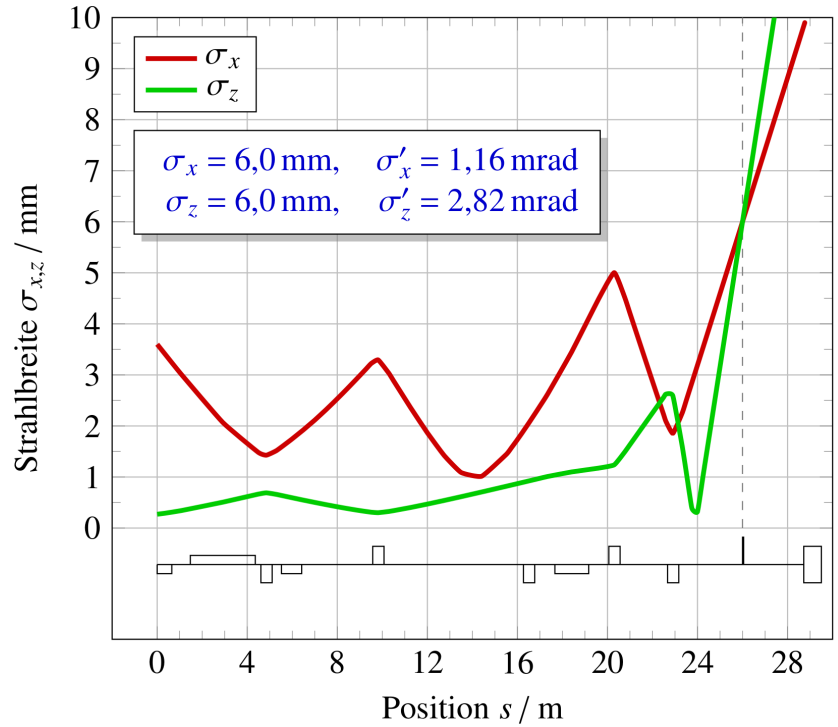
Additional slides

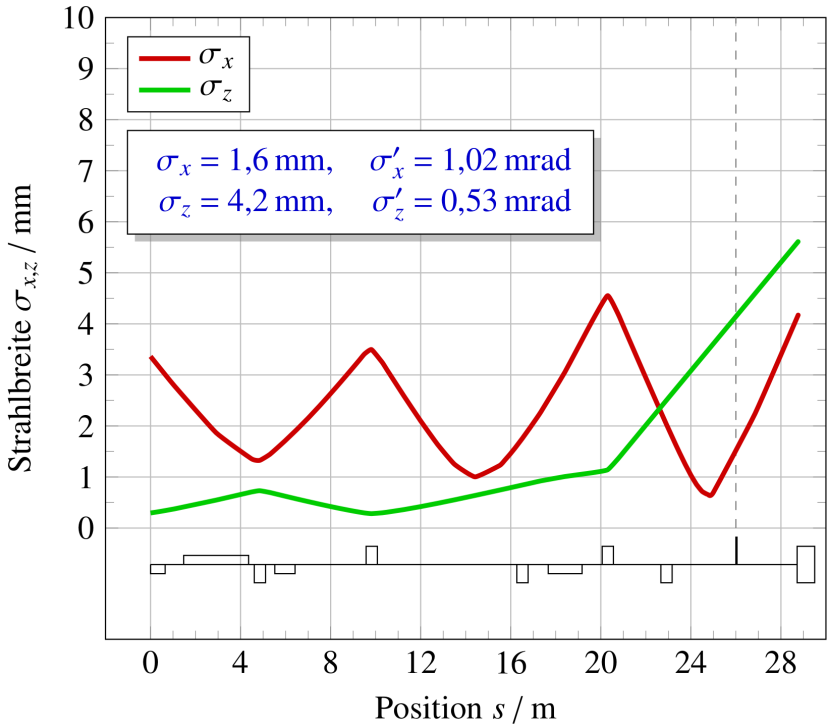
Beamline simulation I (average beam size)

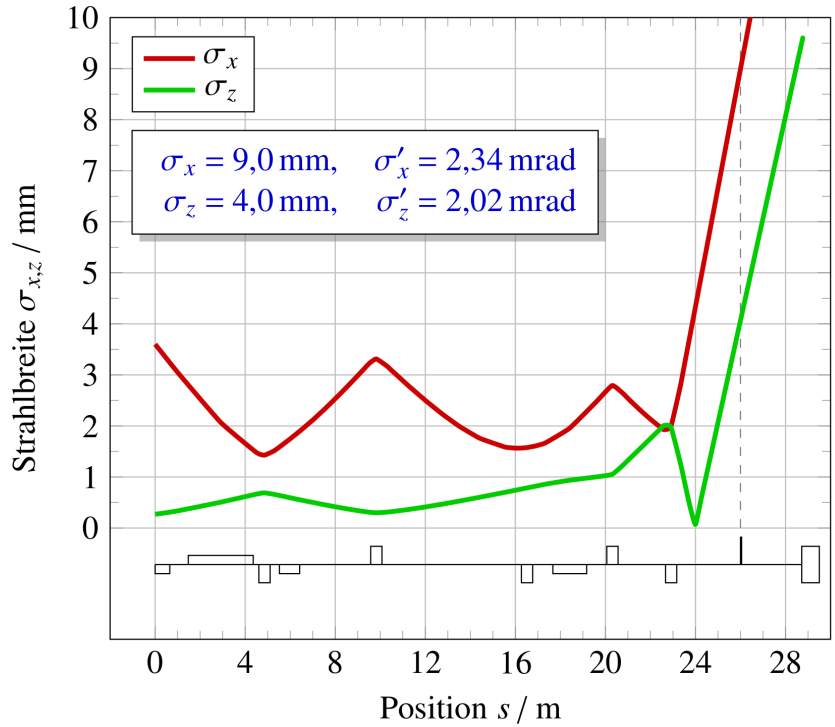




[1] “Die externe Strahlführung für Detektortests X3ED an der Elektronen-Stretcher-Anlage ELSA”, N. Heurich, 2017, Universität Bonn

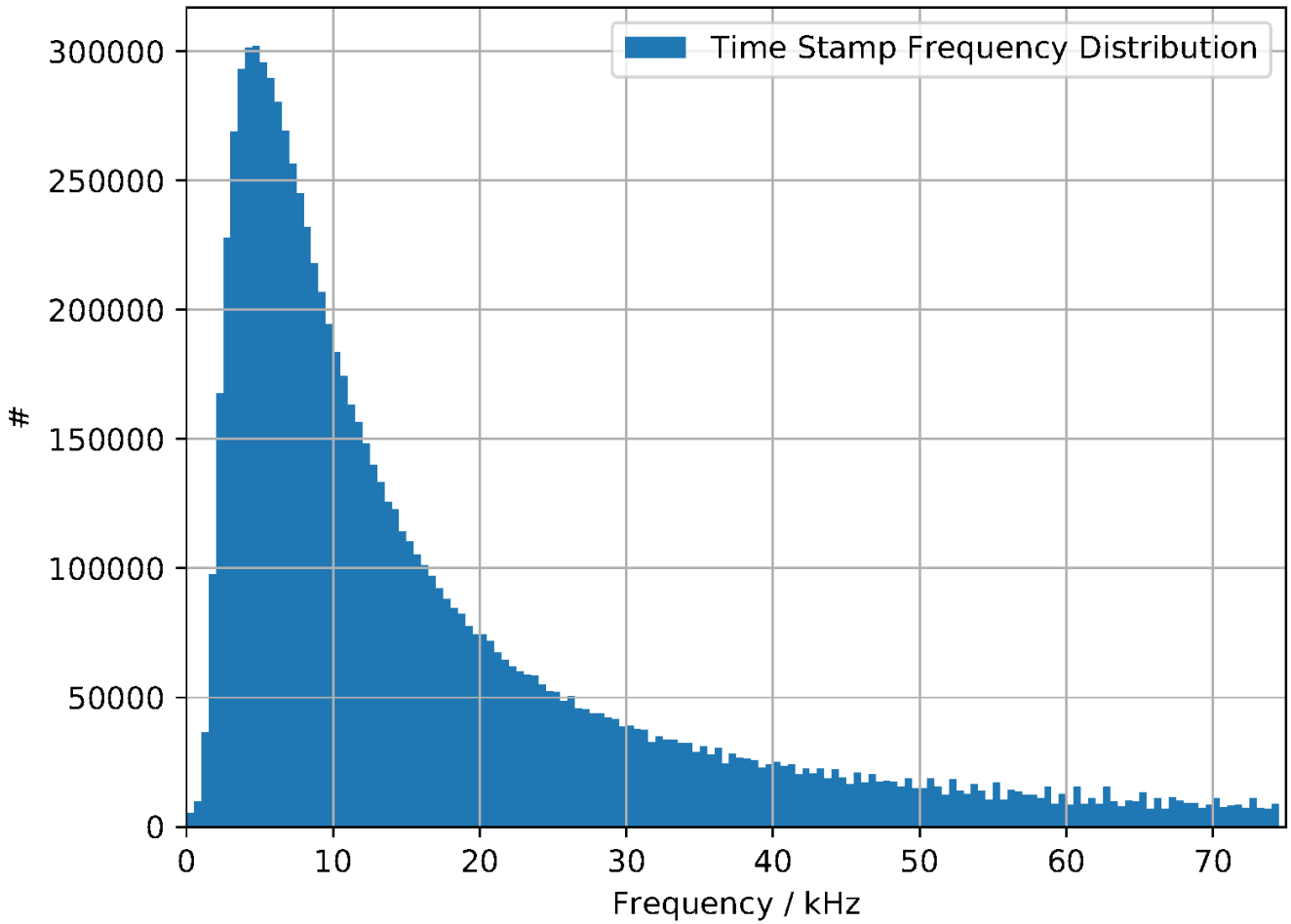
Beamline simulation II (large beam size)





[1] "Die externe Strahlführung für Detektortests X3ED an der Elektronen-Stretcher-Anlage ELSA", N. Heurich, 2017, Universität Bonn

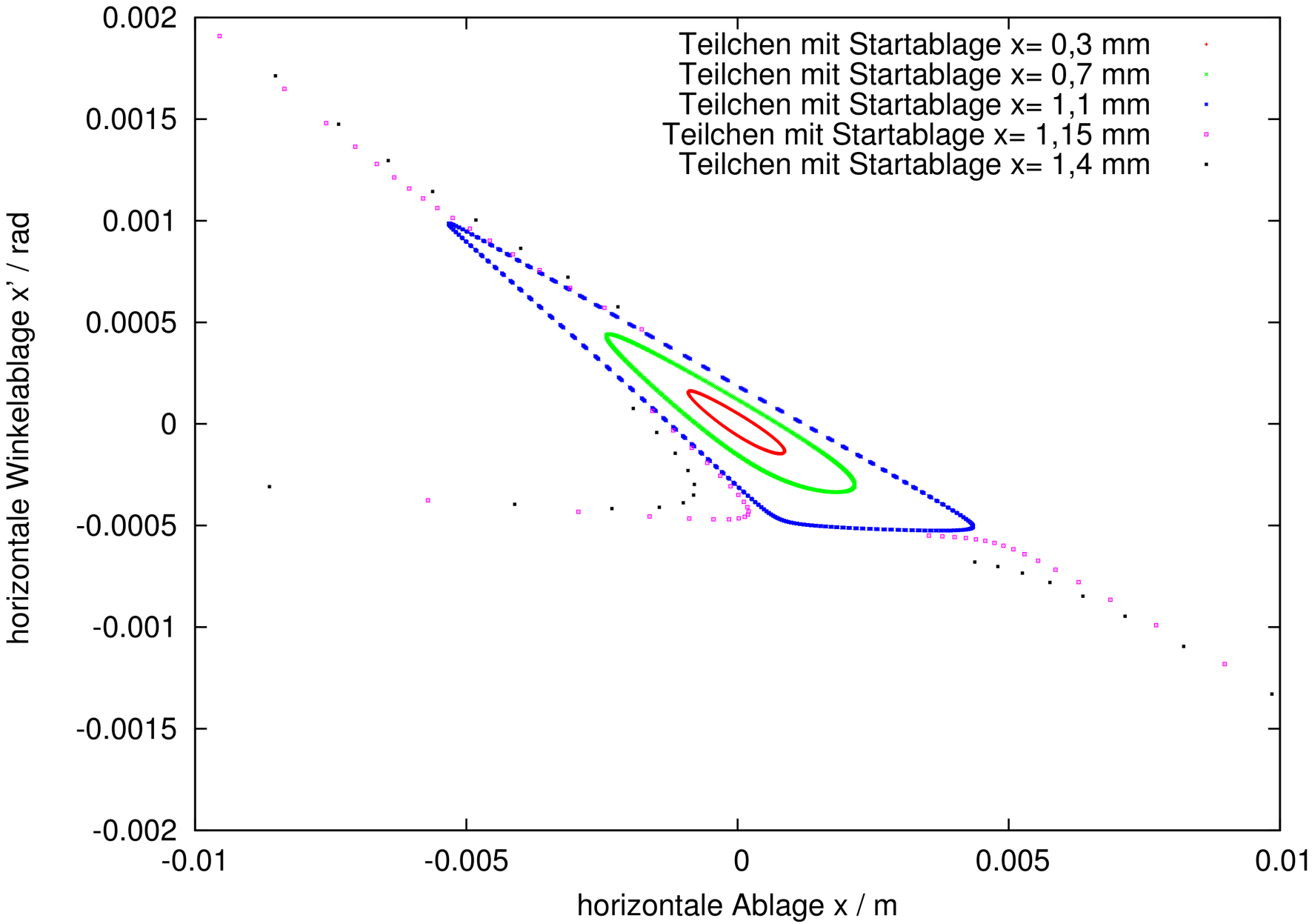
Frequency distribution of electron rate



@ 9 kHz average rate (measured by scintillating fiber)

[1] "Setup and Characterization of the Test Beam Area for Pixel Detector Tests at ELSA", Y. Dieter, 2017, Universität Bonn

Extraction



[1] "Optische Strahldiagnose an der Elektronen-Stretcher-Anlage ELSA", S. Zander, 2013, Universität Bonn