Improvements of the bunch purity measurement at PETRA III

A new amplifier for XAPDs and improvements of the bunch purity measurement system at PETRA III

Kai-Oliver Demmler
Hamburg, 07.07.2021 for DEELS Workshop hosted by SESAME (online)

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

DESY.

Agenda

1 Overview Petra III

2 Bunch purity at PETRA III

3 Design of a new detector head

- Description of electronics
- Measured parameters

4 Tests at diagnostic beamline

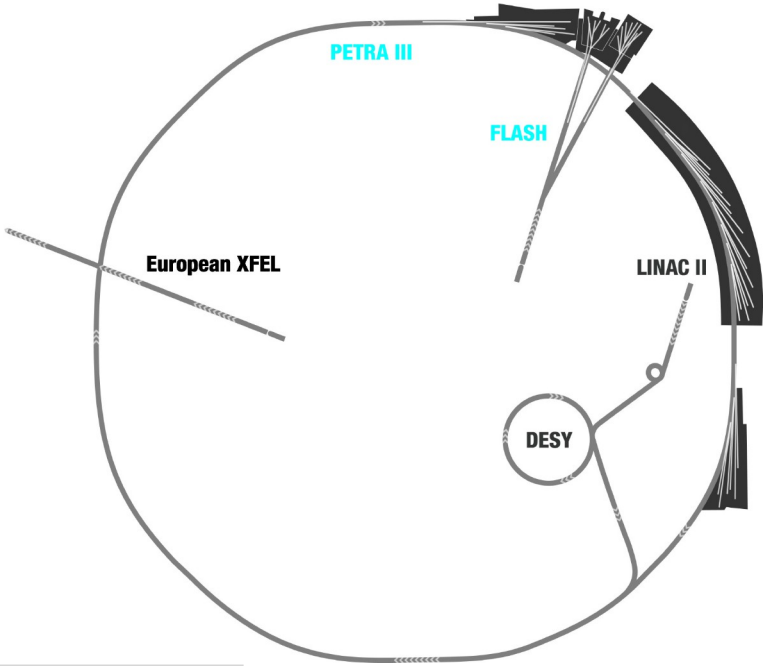
- Description and comparison of actual setup and test setup
- Results and observations
- Substraction of background radiation

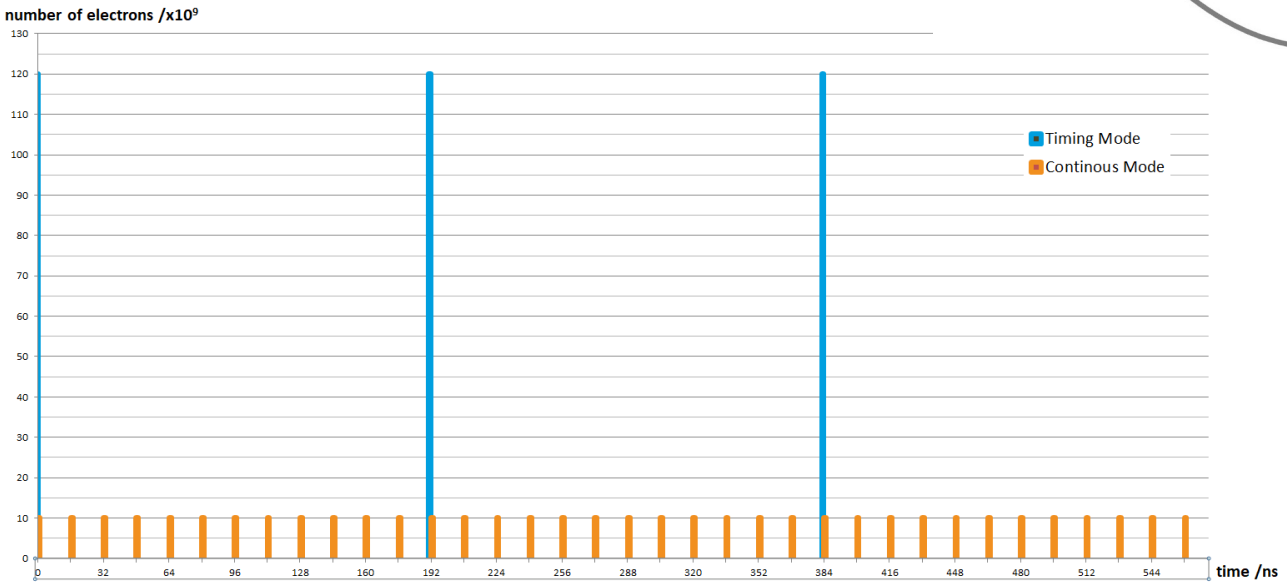
5 Future plans

Overview PETRA III

Main parameters

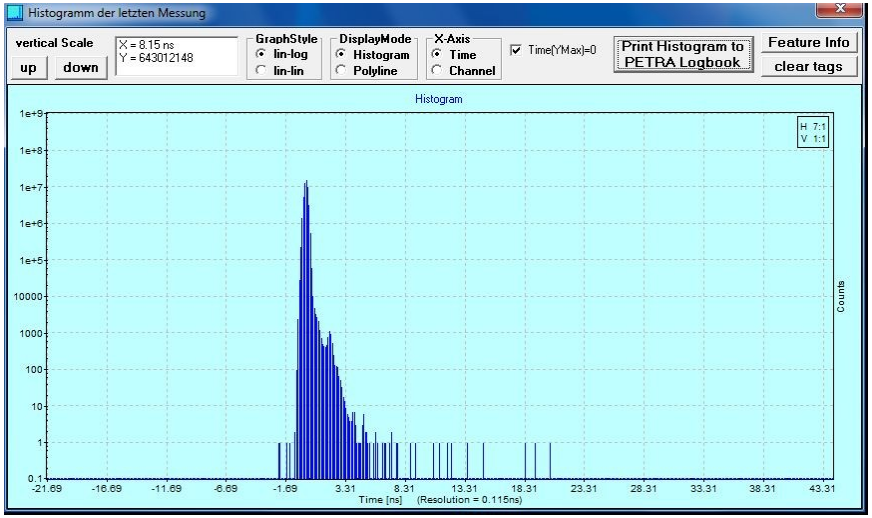
- Circumference: 2304 m
- Energy: 6 GeV
- Emittance: horiz. 1.3 nm rad
- Current: 100 mA / 120 mA
- No. Bunches: 40/480 => 19.2 nC / 1.9 nC
- User Beamlines: 27

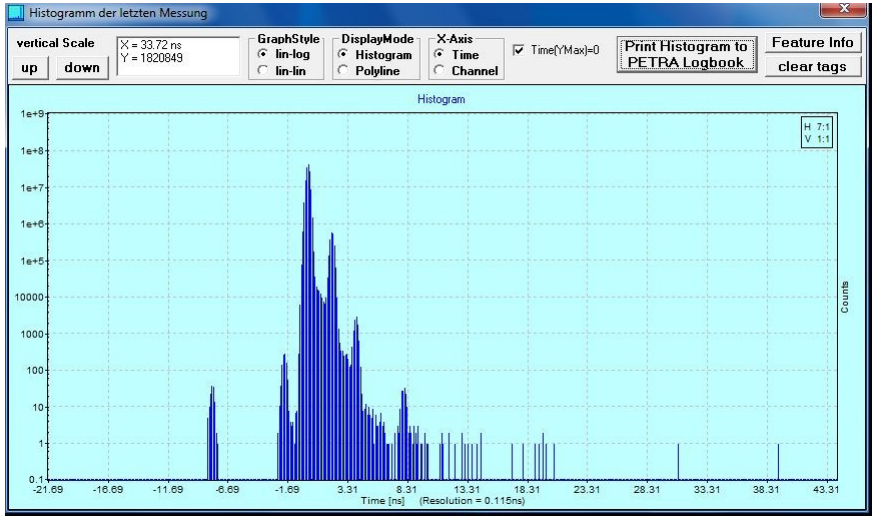




Overview PETRA III

Parasitic bunches





Pre-accelerators generate parasitic bunches at ±8ns

→ are mostly cleaned with Post-Linac-Chopper (PLC)

→ Main reason in storage ring: Touschek scattering, growing with time in ±n*2ns distances[1]

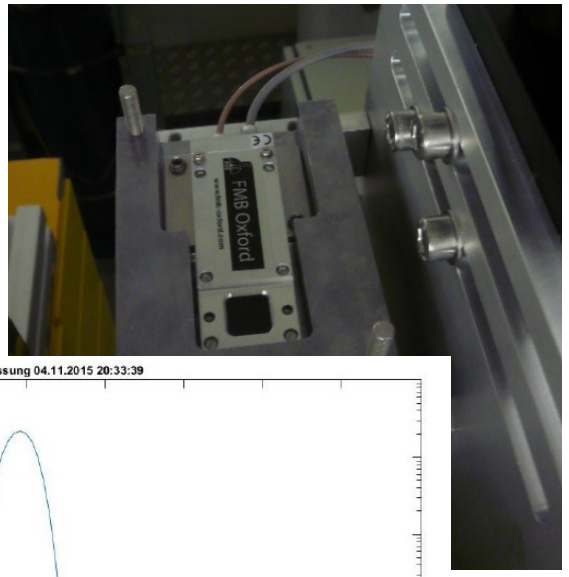
[1] *J. Keil∗, H. Ehrlichmann, Proc. IPAC2016, Busan/Korea,THPMR020, p.3434ff*

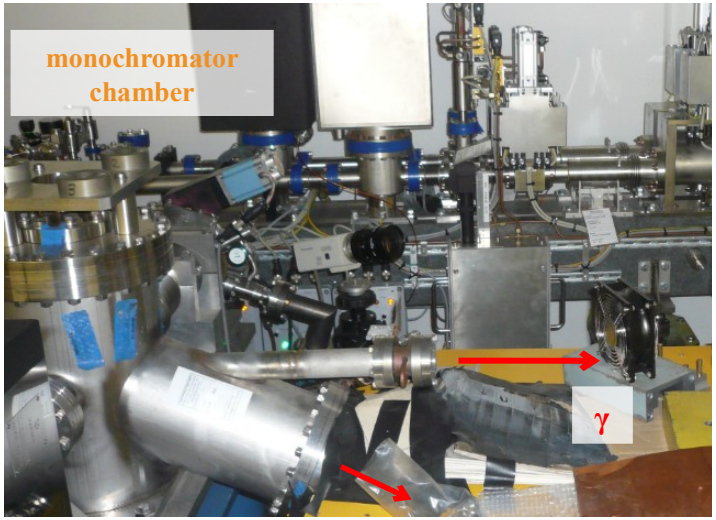
Additional Experience at PETRA III

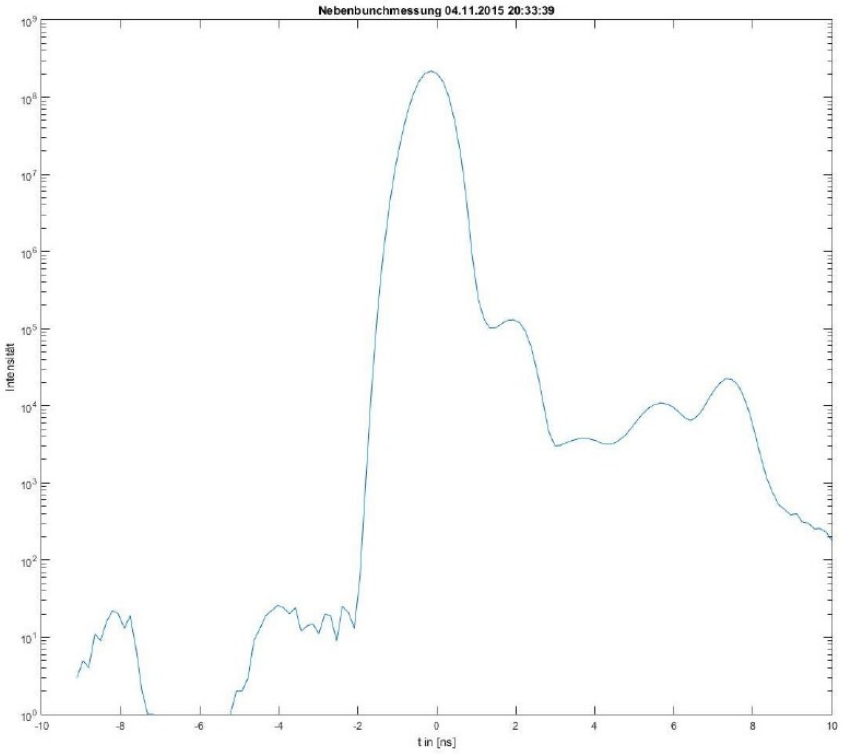
Tests at diagnostic beamline

- Tests were made using a similar system as part of machine diagnostic beamline inside accelerator tunnel, based on commercial system (formerly developed at ESRF)

- no satisfactory results for permanent measurement





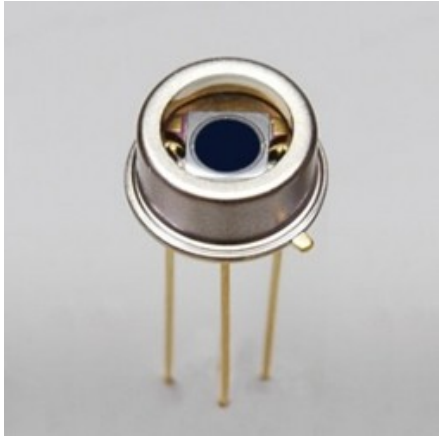


G. Kube, Review of PETRA III Diagnostics, DEELS 2014 Workshop @ESRF

Requirements for the new design

General

- using an much smaller area APD type to reduce influence of background radiation
- minimum influence on curve shape (falling: 600ps, rising 1ns)
- amplification for signals corresponding 4keV to about 26keV
- use actual standard components to reduce costs and extend availability
- small PCB layout
- add temperature sensor



Hamamatsu S5344 APD

https://www.hamamatsu.com/eu/en/product/type/S5344/index.html

General design

Electrical

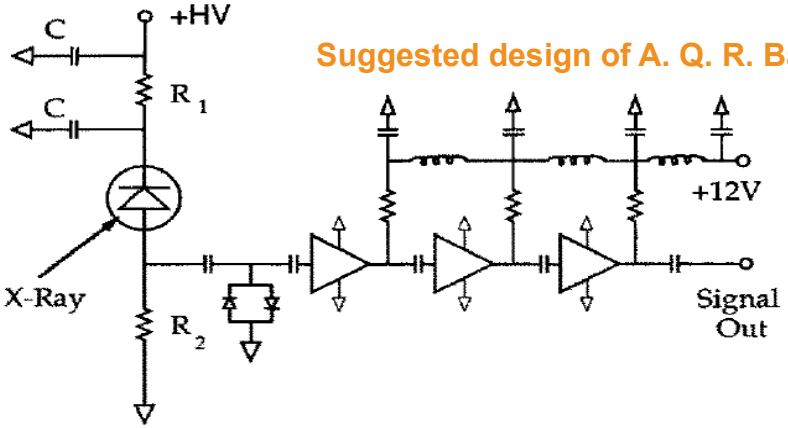
- Transimpedance design to slow with standard parts → Design with gain blocks
- Amplifiers used are low noise, wide bandwidth types
- Amplification: 48.6dB at 1GHz, 33dB at 2GHz
- Bandwidth 50MHz to 1GHz at 3dB compression, but smooth drop

  → higher frequencies will be amplified too – no sharp low pass characteristic

Mechanical

- Small, stackable package
- Socket for APD
- Connectors direct on PCB

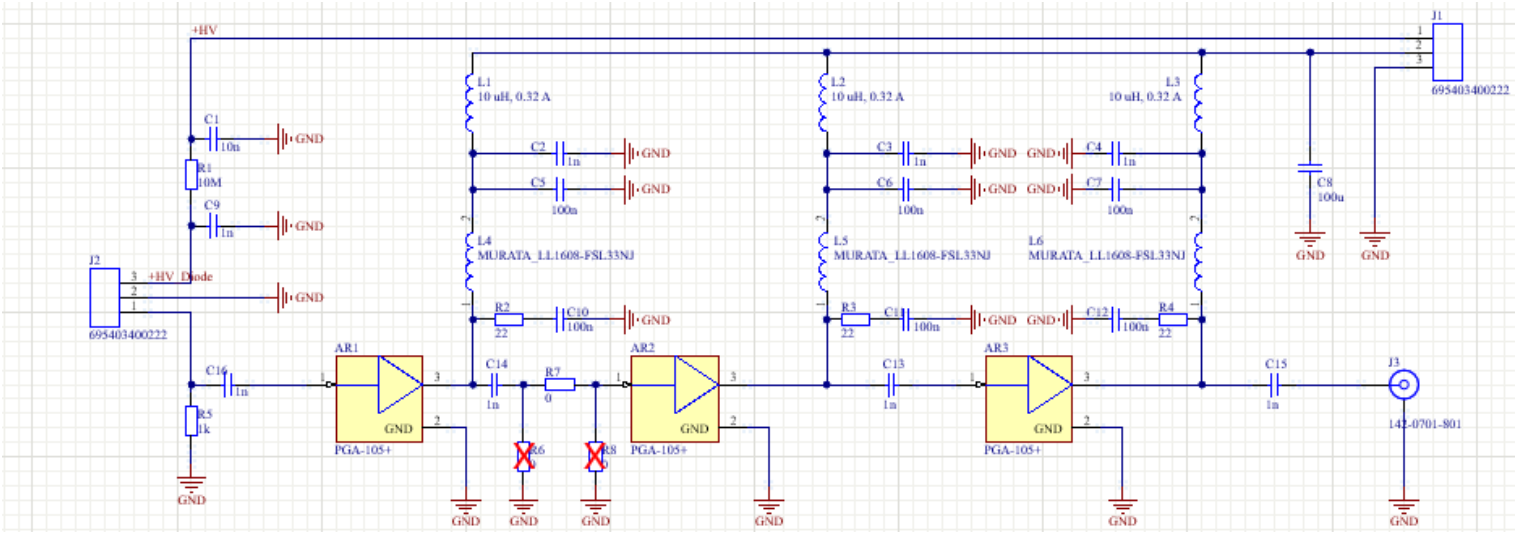
Suggested design of A. Q. R. Baron



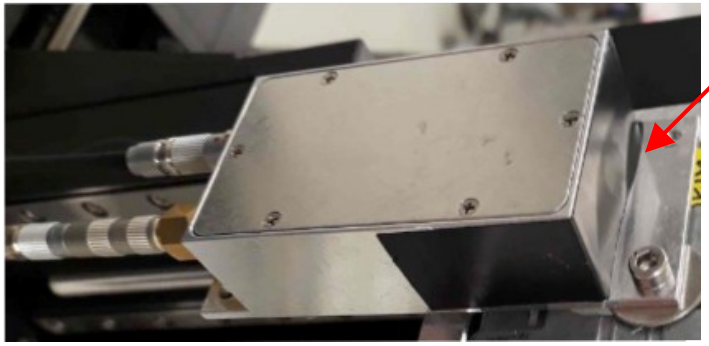
A. Q. R. Baron et al. / Nucl. Instr. and Meth. in Phys. Res. A 400 (1997) p.126

Two Versions

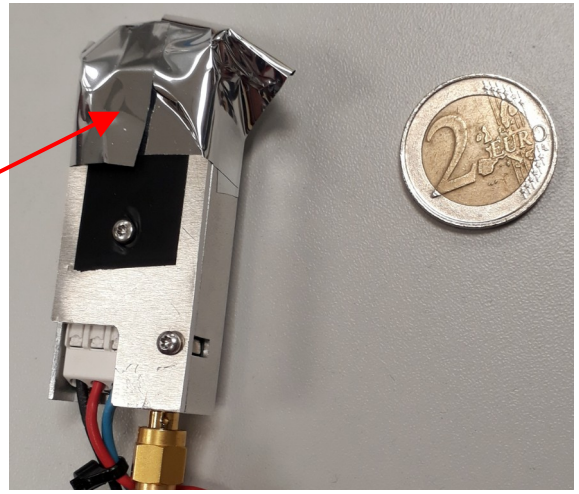
Actual and tested design



Nominal gain: 52dB
Noise pulse: about 100mV
3dB-Bandwidth: 890MHz, 30dB at 2GHz

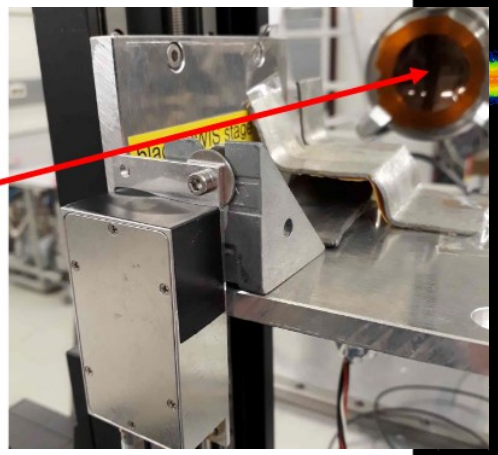


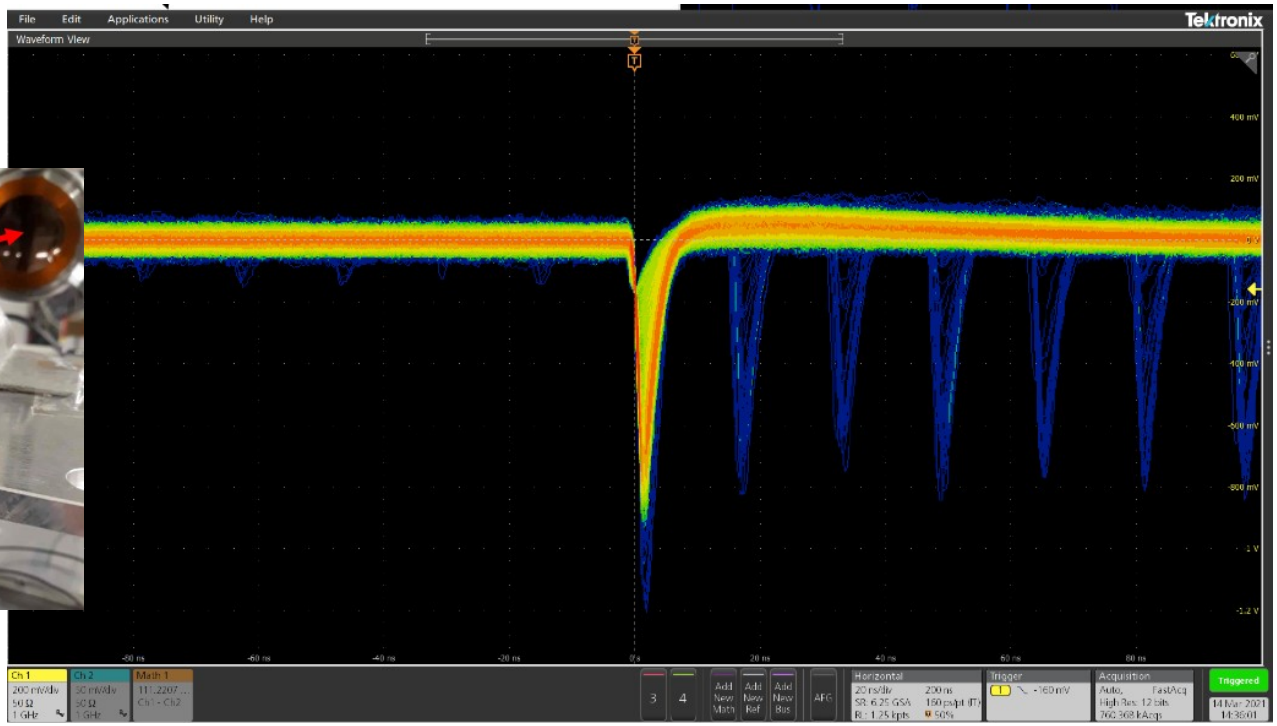
XAPD under foil



Signal shape of single event

Test at PETRA Beamline P01

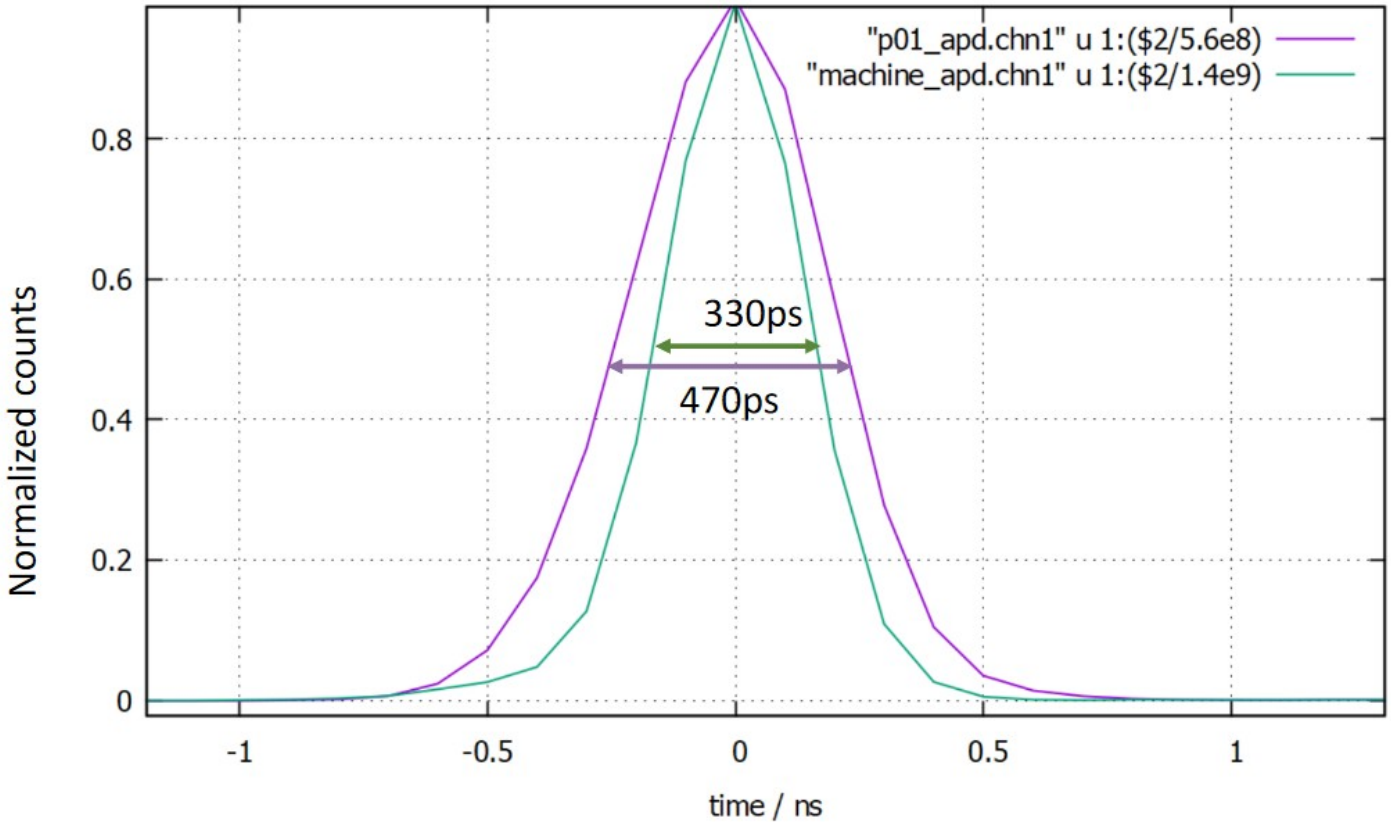




- fall time about 800ps
- Rise time about 7ns
- At 800mV amplitude there is an overshoot of about 50mV

Time resolution

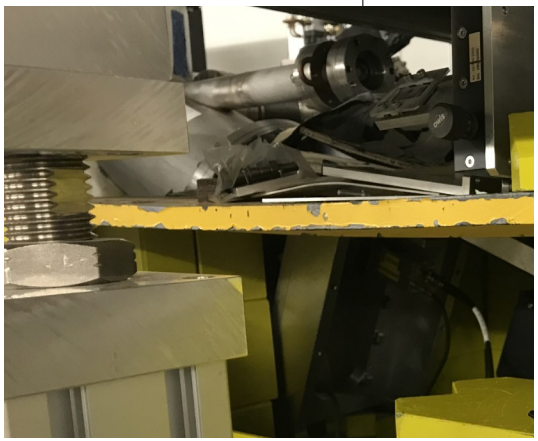
Measurement of timing resolution

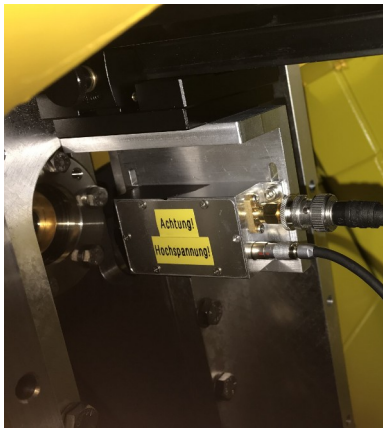


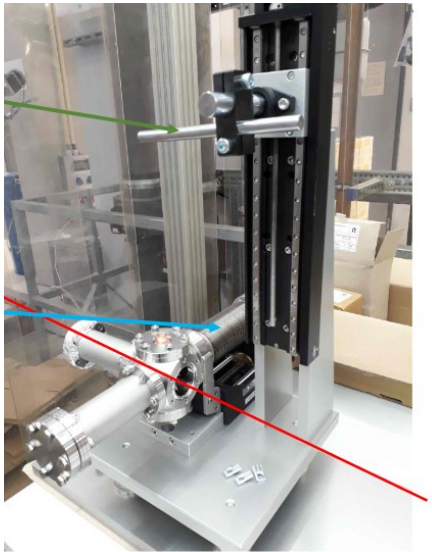
Test setup vs. actual measurement

Installation at User Beamline P01

	Diagnostic beamline	Standard diagnostic at user beamline
Source	Bending magnet	Undulator
Count reduction	20keV monochromator	Aluminium/ Copper foil in vakuum
Detector	S5344 APD from Hamamatsu + custom amplifier	
Time measurement	TimeHarp 260 from PicoQuant	

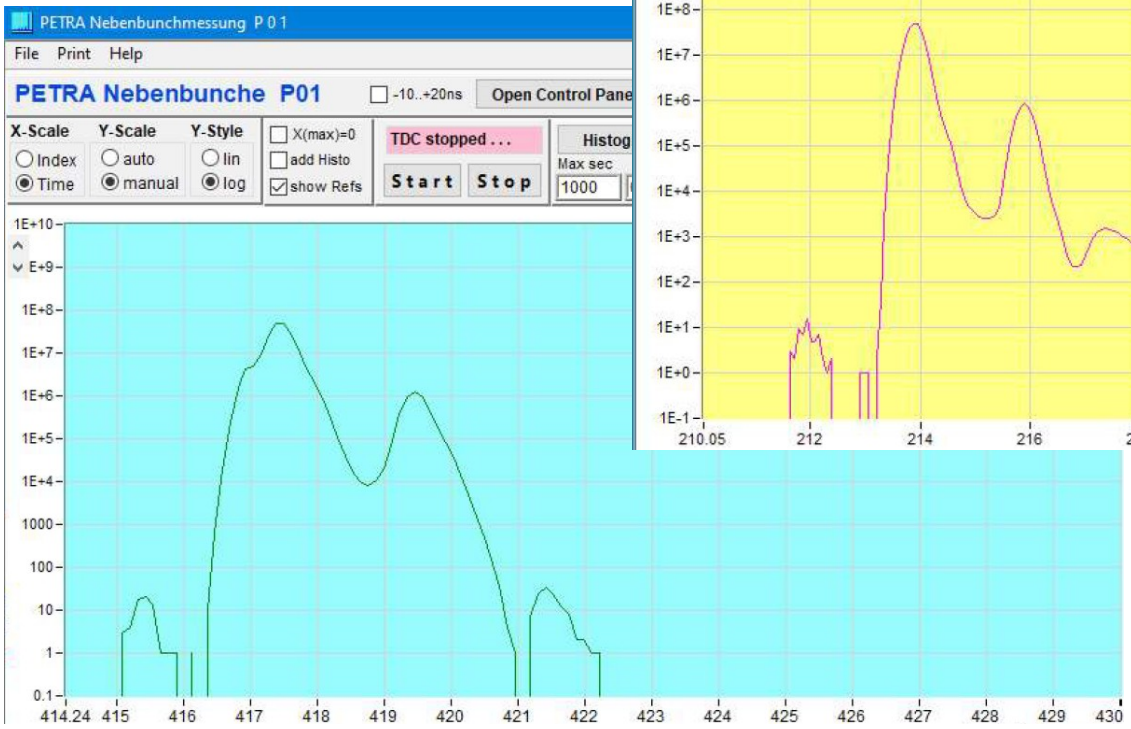






Comparison of Histograms

Histogram of Diagnostic beamline in tunnel



Histogram of User Beamline

Substracti

Idea: Substra able
monochromat

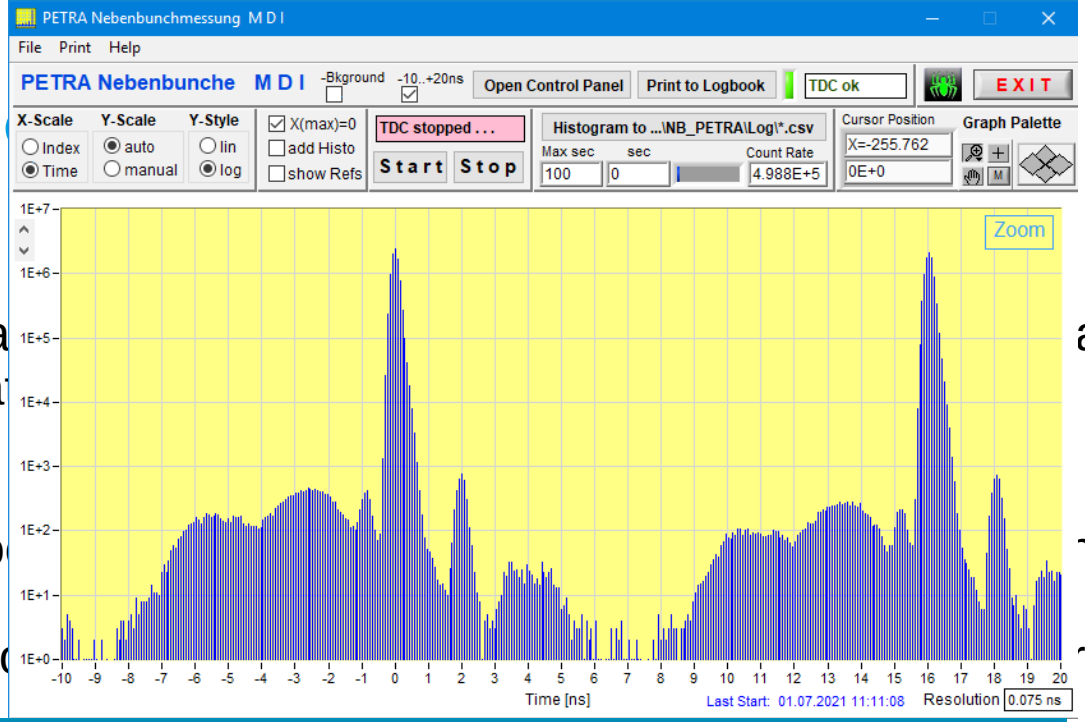
Procedure:
- Move mono ny counts

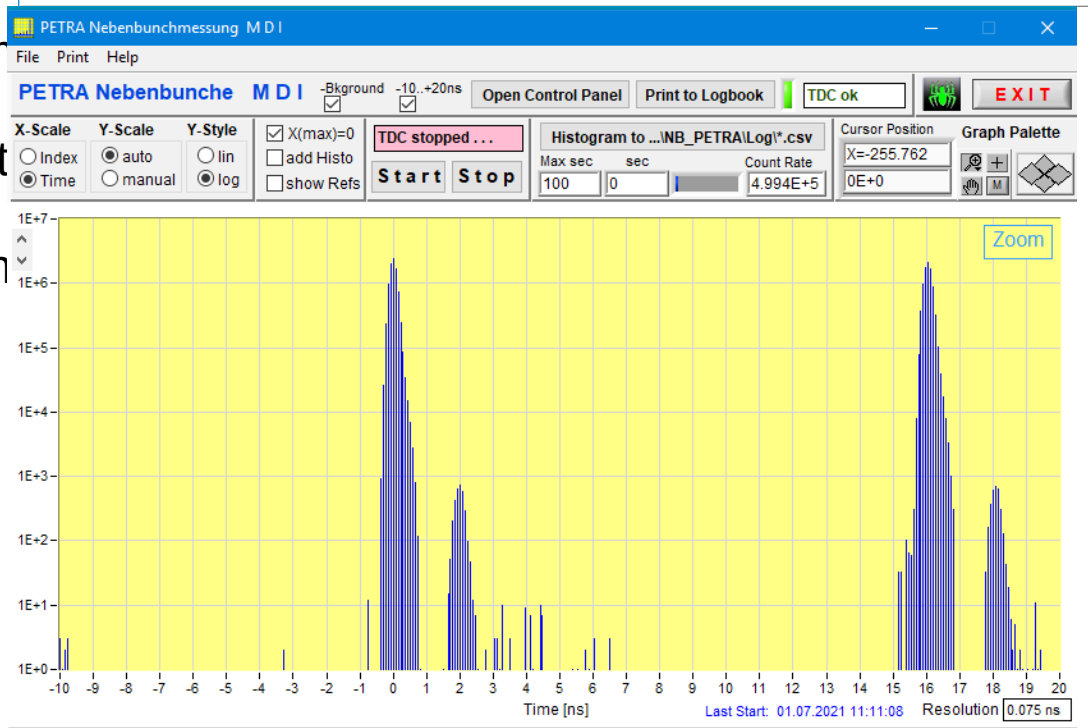
- take an histo rate)

- move the m

- take an hist

- substract th





Results: Substraction of background counts

Pro:
- background doesn`t change significantly with monochromator position

- in static mode a very convient way to make parasitic bunches visible

Contra:
- at the beginning small parasitic bunches are not visible

Issues:

- you can’t be sure to only remove background – small parasitic bunches (e.g. 4ns) will maybe deleted,too

Conclusion and Future ideas

=> an amplifier for small APDs for bunch purity measurements was developed

- next steps: reduce overshoot, make suitable for short timescale decay measurements

=> tried to reduce background radiation counts in measurement system

- working, if you know what you get
- open questions to be answered: how is the detection level affected
- test other ways to reduce background radiation (positioning, shielding,...)

Thanks for listening and special thanks to the DEELS team to organize this workshop

Contact

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Kai- Oliver Demmler
MDI Machine Diagnostic and Instrumentation
kai.demmler@desy.de