

A detailed wireframe model of a particle accelerator, likely FAIR, is shown in a perspective view. The model consists of a large, circular ring structure with a complex internal layout of pipes and components. The ring is composed of many segments, and the internal structure is intricate, showing various chambers and connecting elements.

Digitization of Analog Signals @ FAIR

– Picoscope Digitizer AFE Performance Evaluation –

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Motivation

- Measurement goals:
 - Verify key specifications of the PicoScope prototype digitizers
 - Concentrate on the analog (ADC) part
 - Tests with realistic RF signals

- Agenda
 - Preliminary bandwidth measurement results
 - Verification of PicoScope 3406DMSO key specifications
 - Verification of PicoScope 5444B key specifications
 - Trigger tests
 - Problems and potential issues
 - Conclusion

PicoScope Prototype Digitizers



PicoScope 3406DMSO

Resolution: 8 bit
 Bandwidth: 200 MHz
 Memory: 512 MS
 Channels: 4 analog + 16 digital
 Additional: Signal generator output
 Connectivity: USB 3.0

PicoScope 5444B

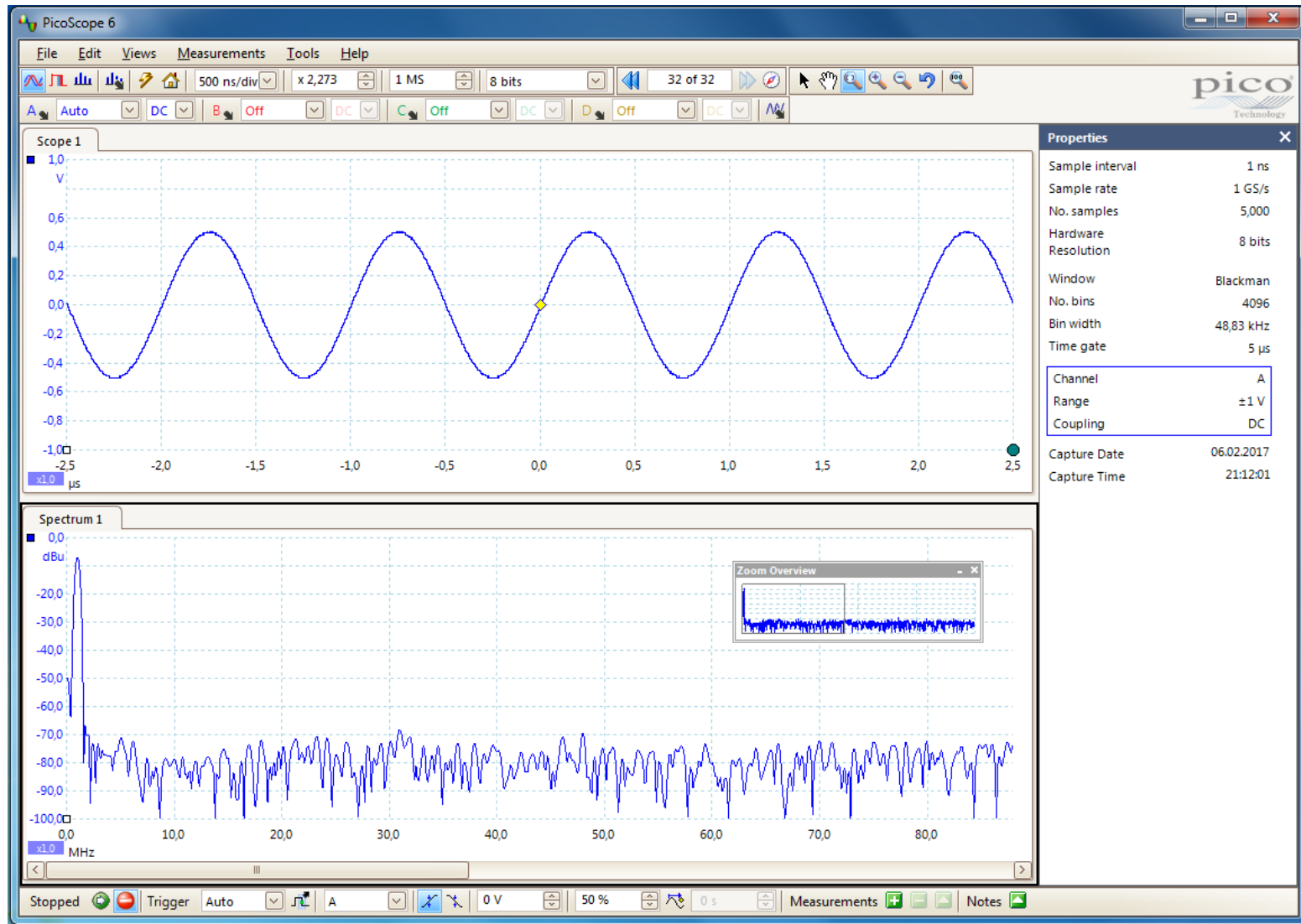
Resolution: 8 ... 14 bit (4 channels),
 15 bit (2 ch.), 16 bit (1 ch.)
 Bandwidth: 200 MHz
 Memory: 512 MS (8 bits),
 256 MS (≥ 12 bits)
 Channels: 4 + External trigger input
 Additional: Signal generator output
 Connectivity: USB 2.0



Power Supply

USB interface

Operating the PicoScopes via PicoScope 6



Bandwidth Measurements with BuTiS

200 MHz signal (Preliminary)

LeCroy WaveRunner, 5 GS/s

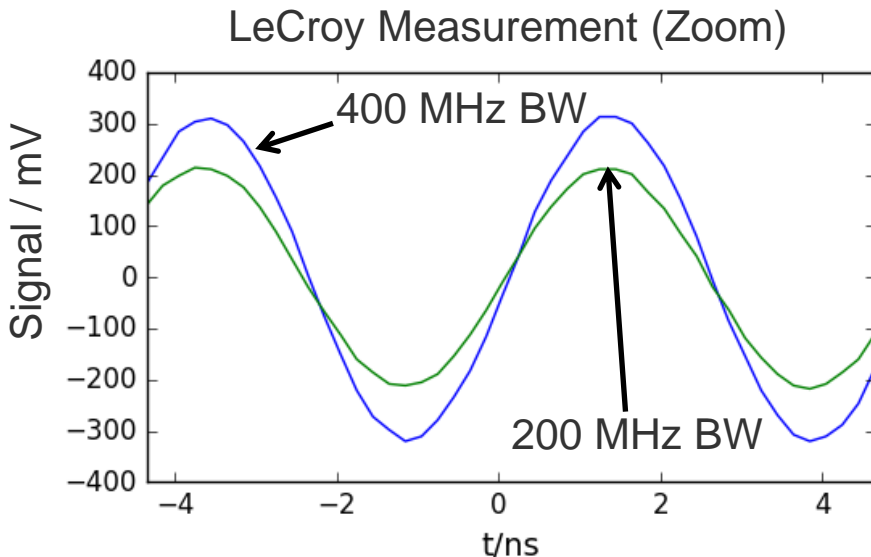
- Full bandwidth of 400 MHz: amplitude of 315 mVp (sine fit)
- Limited bandwidth of 200 MHz: amplitude of 214 mVp (sine fit)
→ -3.4 dB w.r.t. full BW

Pico 3406DMSO, 1 GS/s






- Bandwidth of 200 MHz
- Estimated amplitude (sine fit): 267 mV → -1.4 dB w.r.t. LeCroy with full bandwidth



Pico 5444B, 1 GS/s

- Bandwidth of 200 MHz
- Estimated amplitude (sine fit): 251 mV → -2 dB w.r.t. LeCroy with full bandwidth
- Not measured: bandwidth flatness of PicoScopes
- Spec: (+0.3 dB, -3 dB) from DC to full bandwidth









PicoScope 3406DMSO: Key Specifications




	Specified	Measured	OK?
Crosstalk	Better than 400:1 to full bandwidth (equal voltage ranges)	Typ. 600:1 (measured for 20 MHz and 200 MHz)	
Harmonic distortion	< -50 dB at 100 kHz full scale input	-59 dB	
Spurious-free dynamic range	52 dB typical at 100 kHz full scale input	58 dB	
Noise	160 μ V typical on \pm 20 mV range	170 μ V	
Trigger rearm time	< 0.7 μ s at 1 GS/s sampling rate	< 0.6 μ s at 500 MS/s	

- ? Only preliminary results are available
-  Within the specification
-  Outside the specification, could be still acceptable

PicoScope 5444B: Key Specifications

	Specified	Measured	OK?
Crosstalk	Better than 400:1 to full bandwidth (equal voltage ranges)	Typ. 600:1 (measured for 20 MHz and 200 MHz)	
Harmonic distortion	8-bit mode: > 60 dB at 100 kHz full scale input	68 dB	
Harmonic distortion	≥12-bit mode: > 70 dB at 100 kHz full scale input	72 dB	
Spurious-free dynamic range	8 and 12-bit: > 60 dB at 100 kHz full scale input	65 ... 70 dB	
Spurious-free dynamic range	14 and 16-bit: > 70 dB at 100 kHz full scale input	65 ... 70 dB	
Spurious-free dynamic range	12-bit mode at 1 MHz full scale input: not specified	72 dB	

PicoScope 5444B: Key Specifications

	Specified	Measured	OK?
Noise	On 50 mV range 8-bit mode: 120 μV RMS 12-bit: 110 μV RMS 14-bit: 100 μV RMS	230 μV RMS 135 μV RMS 125 μV RMS	
Noise	On 50 mV range 15-bit mode: 85 μV RMS 16-bit: 70 μV RMS	115 μV RMS 88 μV RMS	
Trigger rearm time	< 2 μs on fastest timebase	< 0.7 μs , analog channel < 0.9 μs , external trigger input	

Trigger Tests

PicoScope 5444B manual information:

- „The **Ext input** uses dedicated circuitry with a software-configurable threshold to detect a trigger signal.“
- „If trigger timing accuracy is critical, we recommend using one of the **main input channels** as the trigger source.“
- The main input channels „use digital triggering (accurate to one sample period) and have a vertical resolution of 1 LSB.“

Measurement results:

- Typical results for the PicoScope 5444B:
 - „Ext“ input as trigger channel: jitter < 260 ps (RMS)
 - Main input channel as trigger channel: jitter < 20 ps (RMS)
- Typical results for a LeCroy WaveRunner:
 - „Ext“ input as trigger channel: jitter < 3.5 ps (RMS), Spec: ≤ 3 ps typ.
 - Main input channel as trigger channel: jitter < 8 ps (RMS)

Problems and Potential Issues

Problems during testing:

- A constant trigger delay problem appeared for the 5444B for the 8-bit mode, but this was not reproduced during later measurements.

Potential Issues:

- No software tests with the Software Development Kit (SDK) were performed. This study focussed on the analog part of the digitizers. Therefore, no reasonable evaluation can be given here concerning potential issues or the necessary workload for software integration.
- The prototype digitizers are not directly suitable for mounting in a standard 19" crate
 - OEM version
- No reliable tests or experience during this study with nonstop operation (long-term usage) so far

Conclusion

- The analog part of the digitizers seems to be suitable in principle for the digitization of typical signals of RF systems at FAIR (gap voltage, reference signals).
- Some measured performance parameters were above their specified values. It has to be discussed whether this is still acceptable.

Thank you for your attention!