

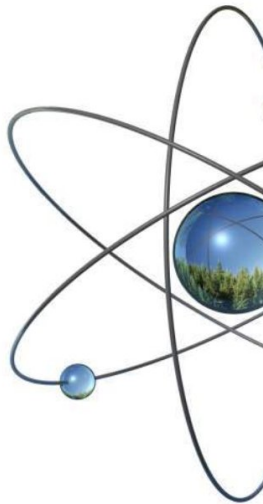
GE Oil & Gas – Reuter-Stokes

GE's Reuter-Stokes NeuAcq®

Next generation data acquisition electronics systems for
neutron scattering instruments

Dr. Mathieu Boucher

19 September, 2016



Reuter-Stokes key milestones

1956 – Reuter-Stokes founded

1984 – Reuter-Stokes acquired by GE

2001 – Tensor (Oil & Gas exploration products) acquired by GE

2008 – ^3_2He shortage

2010 – Commercial ^3_2He available

2010 – Reuter-Stokes launches $^{10}_5\text{B}$ lined proportional counter

2011 – Reuter-Stokes investigates $^{10}_5\text{B}$ for safeguards

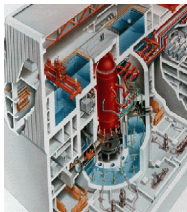


Reuter Stokes Measurement Solutions

Technologies for Harsh Environments

Nuclear Instrumentation

Neutron Monitoring
In-core power monitoring
Ex-core power monitoring
Gamma Thermometer



Radiation Measurements

Homeland Security
Safeguards
Scattering
Environmental monitoring
 ^3He recycling



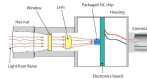
Drilling Tools

^3He Detectors
Oil exploration
Geo-steering



Turbine Instruments

Flame detection sensor
- SiC technologies

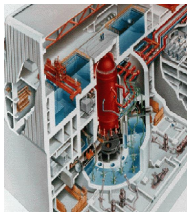


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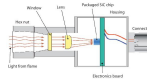
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Turbine Instruments

Flame detection sensor
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NeuAcq® Overview

Introduction and History
System Overview
8-pack Overview
Networking Standards
Communication Protocols



NeuAcq® Overview

Introduction and History

- 2007 GE's Reuter-Stokes licensed electronics from SNS,
- Based on non-proprietary, existing network standards,
 - ↳ achieve higher data rates,
 - ↳ improved reliability,
 - ↳ significant simplification in the overall system interconnections and cables, and
 - ↳ off the shelf network devices.

System Overview

8-pack Overview

Networking Standards

Communication Protocols

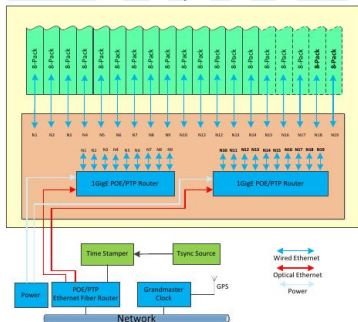


NeuAcq® Overview

Introduction and History

System Overview

- Fully scalable system and electronics
- blue components ⇒ off-the-shelf
 - ↳ mitigated obsolescence
- Network Routers
 - ↳ IEEE 1588-2008 PTP,
 - ↳ IEEE 802.3af PoE,
 - ↳ No. of routers depends on system size.
- Power ⇒ PoE
- Grandmaster clock
 - ↳ time base for the PTP functionality,
 - ↳ typically uses a GPS clock.
- Timestamper
 - ↳ provided by GE,
 - ↳ external synchronization for ToF,
 - ↳ absolute time measurement,
 - ↳ version of the RSPP



NeuAcq® Overview

Introduction and History System Overview

8-pack Overview

- ${}^3_2\text{He}$ PSD,
 - ↳ charge division,
 - ↳ various detector lengths, diameter, and sensitivity.
- Decoupling Capacitors,
 - ↳ HV isolation, while passing pulses
- Preamplifiers,
- ADCs,
 - ↳ very fast and highly accurate,
- ↳ digitizing pulses at 10^7 samples/s.
- Platform Processor,
 - ↳ RSPP \Rightarrow FPGA and ARM processor.
- Waveform Digitization can compensate:
 - ↳ baseline drift,
 - ↳ detection of multiple pulses, and
 - ↳ γ /neutron discrimination.

Networking Standards Communication Protocols

NeuAcq® Overview

Introduction and History

System Overview

8-pack Overview

Networking Standards

- POE,
 - ↳ IEEE-802.3.at-2009 (POE+)
 - ↳ up to 25.5 W for 48-44 VDC range,
 - ↳ no need for extra power cable,
 - ↳ power isolated \Rightarrow minimize ground loop issues
- PTP,
 - ↳ very accurate and stable timestamp over Ethernet,
 - ↳ GPS based grandmaster clock,
 - ↳ absolute time stamping.
- TCP,
 - ↳ all event data,
 - ↳ guaranteed correct data delivery,
 - ↳ tests with 1GB Ethernet
 - $\Rightarrow 6 \times 10^6 \frac{\text{events}}{\text{second}}$,
 - ↳ higher rates could be achieved with faster network.
- UDP.
 - ↳ discover mechanism \Rightarrow which modules are on network,
 - ↳ could be eliminated with static IP address.

Communication Protocols



NeuAcq® Overview

Introduction and History

System Overview

8-pack Overview

Networking Standards

Communication Protocols

Compatible with:

- EPICS
- ADARA



NeuAcq® Versatility

NeuAcq® electronics can be used in:

- new or
- existing systems



NeuAcq® Versatility

NeuAcq® electronics can be used to:

- process and
- stream neutron event data



NeuAcq® electronics can be used with the following detector technologies:

- ${}^3\text{He}$ linear PSD,
- ${}^3\text{He}$ non-PSD, ${}^{10}\text{B}$ linear PSD,
- ${}^{10}\text{B}$ non-PSD,
- B10Plus+ linear PSD and non-PSD, and
- multiple neutron sensitive scintillation technologies including:
 - ↳ wavelength shifting detectors and
 - ↳ ${}^6\text{Li}$ loaded glass scintillators.

NeuAcq® Versatility

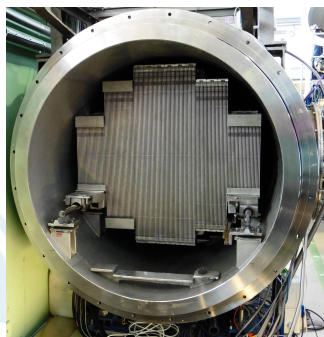
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- ^3He linear PSD,
- ^3He non-PSD, ^{10}B linear PSD,
- ^{10}B non-PSD,
- B10Plus+ linear PSD and non-PSD, and
- multiple new energy sensitive scintillation technologies including:
 - ↳ wavelength shifting detectors and
 - ↳ ^6Li and glass scintillators.

Any output from 0-1 V

GE's Reuter-Stokes partnership with JCNS-KWS-2

- Development of Multi-MHz detector array, in partnership with JCNS
 - ↳ 18 × 8-pack of three (3) different length,
 - ↳ 2 × GB routers,
 - ↳ Grandmaster clock,
 - ↳ timestampers, and
 - ↳ mounting frame



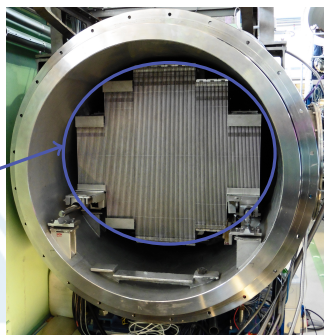
<http://www.fz-juelich.de/SharedDocs/Meldungen/JCNS/EN/2015/2015-11-06-SANS-2-Detector.html>



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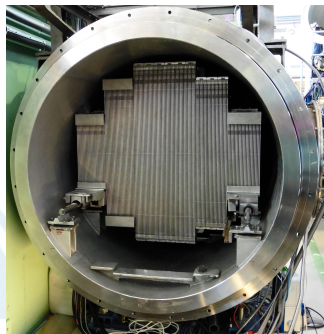
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GE's Reuter-Stokes partnership with JCNS-KWS-2

System Characteristics

- 0.9m² array of 8mm ³He detectors
- dead-time constant of 25ns
- count rate as high as 5MHz at 10% dead-time
- 25× improvement compared to old detector



To improve the read-out characteristics and reduce noise, the electronics is mounted in a closed container at the rear of the detector.

<http://www.fz-juelich.de/SharedDocs/Meldungen/JCNS/EN/2015/2015-11-06-SANS-2-Detector.html>



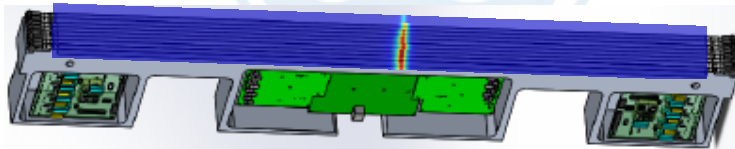
NeuAcq® Performance

Instrument View

GE's Reuter-Stokes evaluated the performance of the NeuAcq® electronics

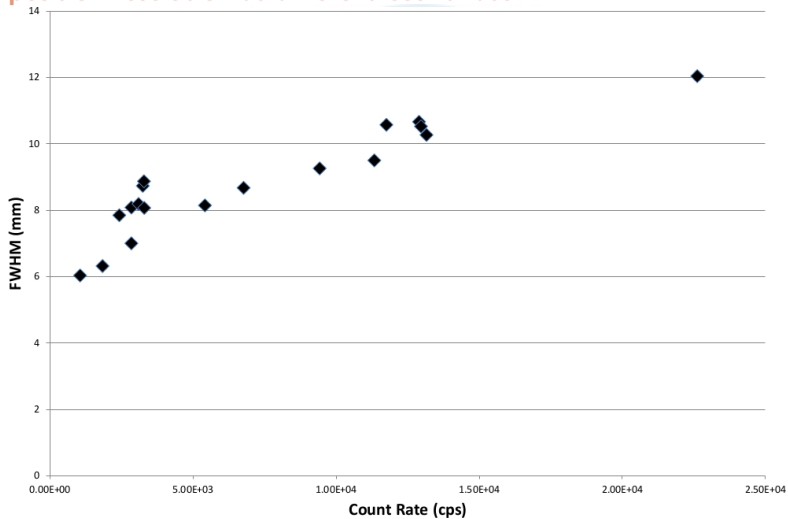
- ↳ position resolution
- ↳ deadtime evaluation
- ↳ linear response
- ↳ space-charge effect
- ↳ γ discrimination

A neutron beam was shining the 8-pack module as follows:



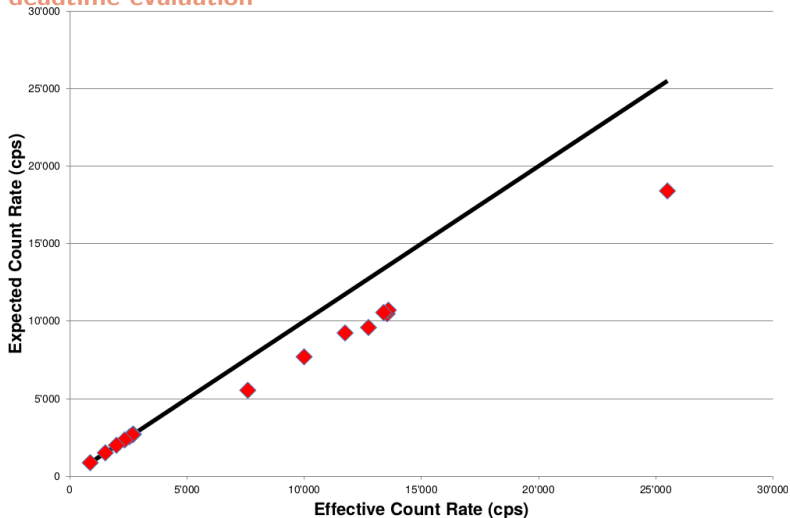
NeuAcq® Performance

position resolution at different count rate



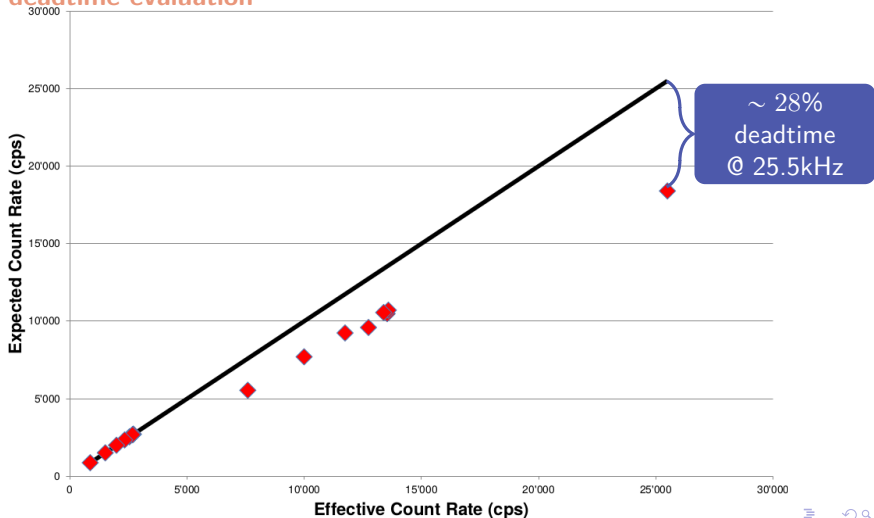
NeuAcq® Performance

deadtime evaluation



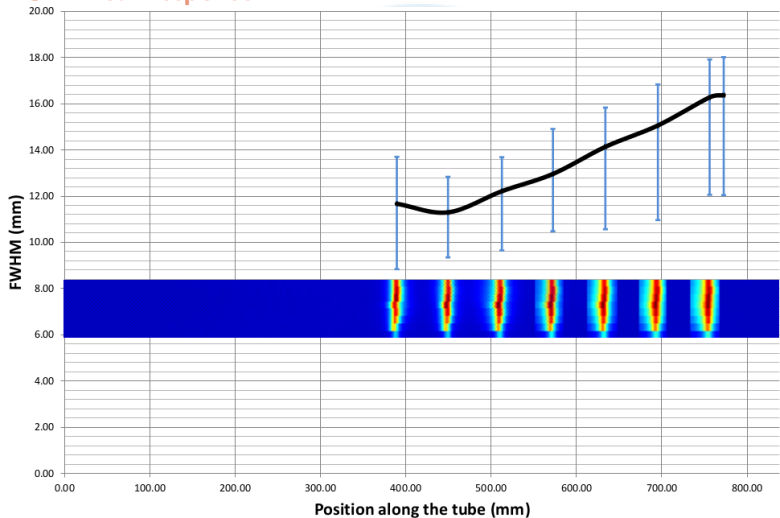
NeuAcq® Performance

deadtime evaluation



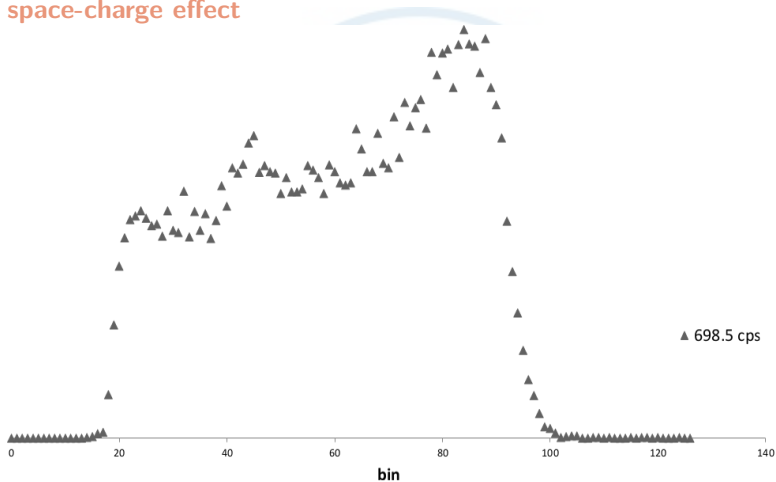
NeuAcq® Performance

PSD linear response



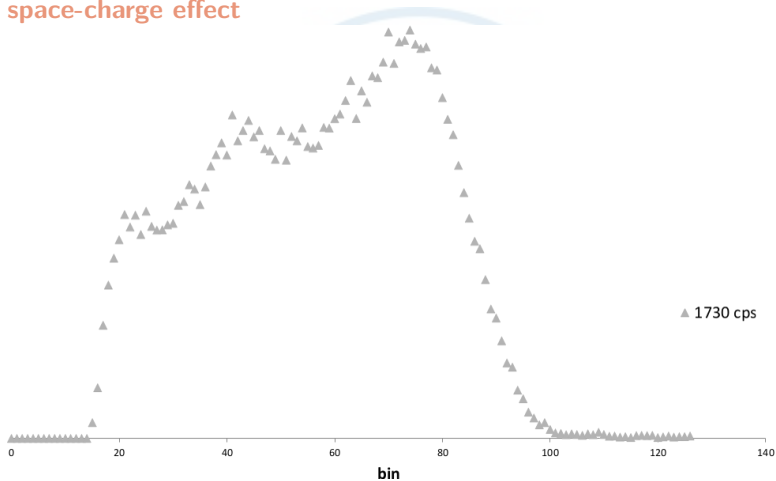
NeuAcq® Performance

space-charge effect



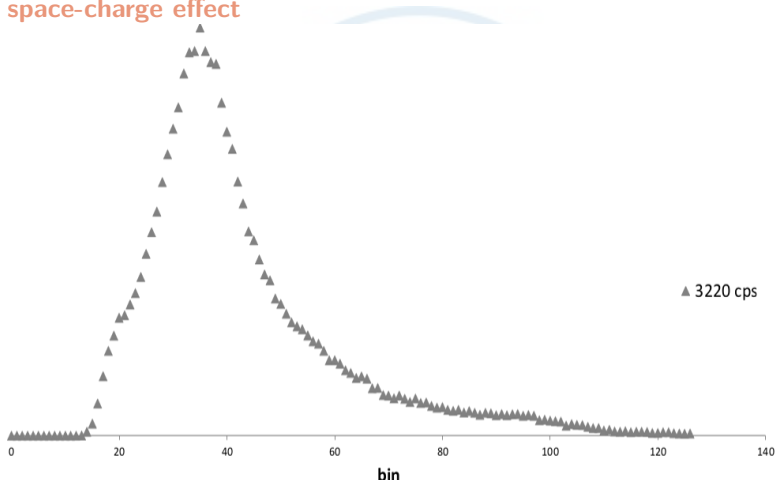
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space-charge effect



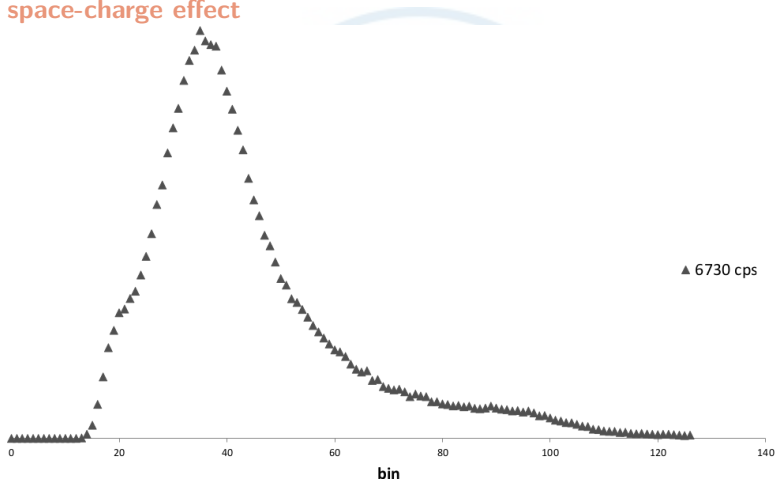
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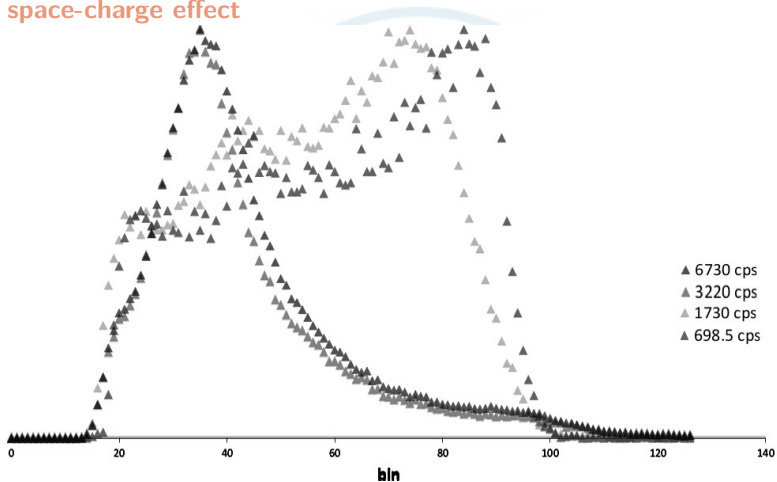
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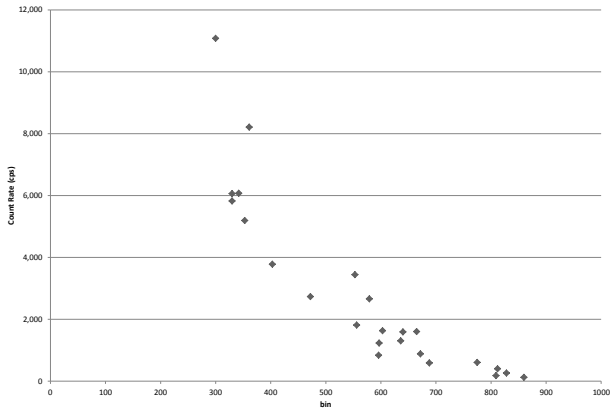
NeuAcq® Performance

space-charge effect



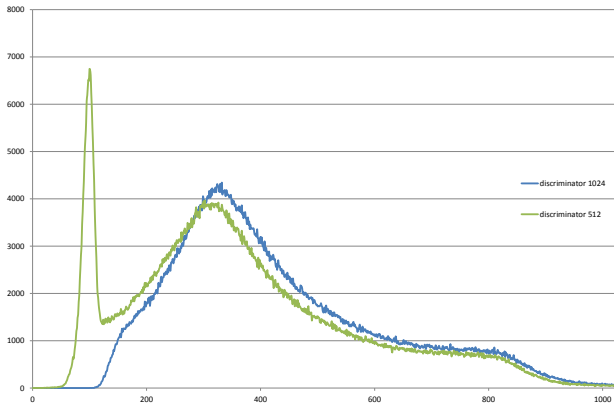
NeuAcq® Performance

space-charge effect



NeuAcq® Performance

γ discrimination





GE imagination at work