Advanced real-time data quality monitoring concept for GEM detector based SXR plasma diagnostics

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Target application

WEST tokamak, CEA, France

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SXR plasma tomography

Assembled T-GEM detector with analog front end for JET plasma diagnostics

SXR plasma tomography camera placement at WEST tokamak

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Soft X-ray measurement system

Remote power control and network switch
High voltage power supply unit
Multichannel modular measurement system
Custom water cooling system
New version of GEM detector

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Simplified data network

- **Parameters control**
- **Tokamak** → **SXRx** → **GEM detector** → **Raw data** → **SXRx measurement system** → **Fast feedback network** → **Control room**

Feedback based control:
- **SXR measurement system**
- **10 ms**
- **FPGA preprocessing**
- **PC postprocessing**

Offline database:
- **Slow network**

- **PCs**

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Data Quality Monitoring

- Reliable data for feedback tokamak control
  - For 1ms histogram min. 1000 events can be expected
  - Malformed data, significant error can occur in:
    - Histogram plots
    - Feedback loop (control systems)

- Data for post-measurement analysis
  - Development of new algorithms
  - Exploring the GEM detector and tokamak environment
  - Discovery of new type of signals – possible only when working in tokamak environment in real-time

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Data Quality Monitoring

- Works on raw data from GEM detector
- Registers data on all available channels (e.g. 128)
- High statistics event acquisition (up to 100k events)
- Real-time signal analysis
- Functional blocks easy to add – modular implementation
- Much more faster than offline analysis (data quality markers)
- Absolute timestamps – correlation with GEM measurement system and external systems working at WEST

Complex offline algorithm verification:
- Diagnostic data
- Correct measurement data
- Mixed – diagnostic data with correct measurement data
Typical SXR event from GEM

Nonstandard signals – CELIA experiment
System response for high rate radiation

LASER: 40 mJ 1000 shots
GEM HV = [900, 357, 700, 362, 700, 367, 1500] V

<table>
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<th>counts</th>
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FPGA standard firmware implementation

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Extended implementation with Data Quality Monitoring

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Channels saturation

- Single or neighbor channels affection
- Correlation between channels

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Multievent signals

- Algorithm verification (high statistics)
- Algorithm development

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Geometrical signal overlap

- Algorithm for proper cluster detection
- Extraction of the events (e.g. peak signal channel identification)
- Channel range for a cluster
Multiframe events

- How often does they occur – system bandwidth influence
- When can occur - correlation with other measurement systems

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Offsets tracing

- Snapshot of all channels
- Fluctuation of offsets
- Information of input dynamic range variation for each channel
- Can be correlated with saturation information
Data rate registration with reference signals

- Event rate on each channel
- Fixed period of time (e.g. 10ms)
- Can be used to compare with postprocessed data (algorithms rejections etc.)
- Can be combined with information about rejected events due to buffers overflow

- Reference signal as second stage of verification – made in software

- Hints for next generation system construction:
  - Hardware optimization
  - Use of data transmission links

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Summary

- DQM as important part of systems working in a feedback loop
- Exploring systems in a real environment
- Algorithm development with test data sets
- Improves measurement quality
- Additional verification of measurement data (qualified data only)
- Design optimization:
  - Algorithms
  - Firmware
  - Hardware construction
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Thank you for attention

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