# FPGA based data acquisition system for COMPASS experiment

Josef Nový

Faculty of Nuclear Sciences and Physical Engineering
Czech Technical University in Prague
&
CERN

| Introduction	Development of the new DAQ	Summary	References
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COMPASS experiment

COMPASS experiment

- ▶ fixed target experiment at SPS accelerator at CERN
- ▶ study of hadron structure and hadron spectroscopy with high intensity muon and hadron beams
- ▶ data-taking started in 2002
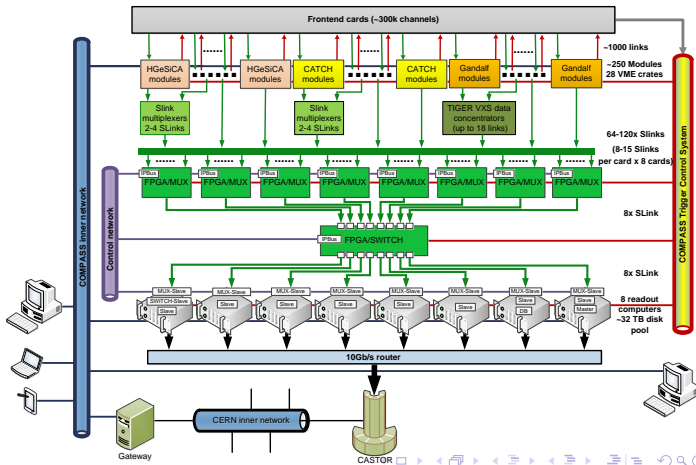- ▶ trigger rate up to 50 kHz, event size 35 kB average
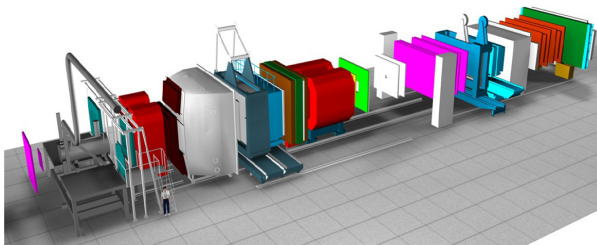
Hardware/Software structure of the old DAQ

- ▶ 50 servers
- ▶ 24 older than 10 years
- ▶ Old HDD performance 30 MB/s
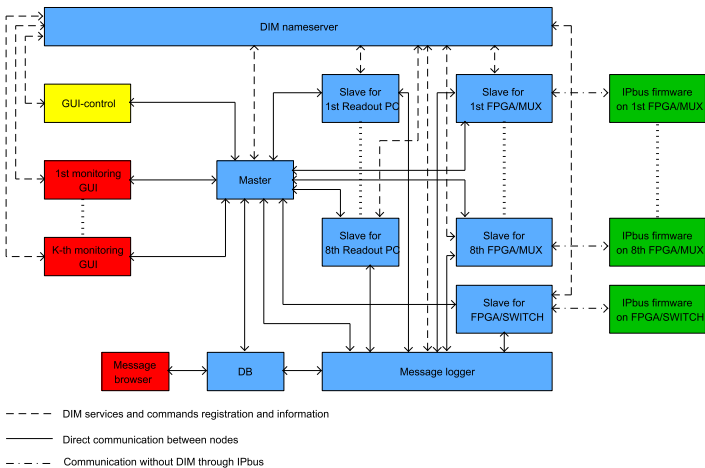- ▶ EB network performance 60 MB/s
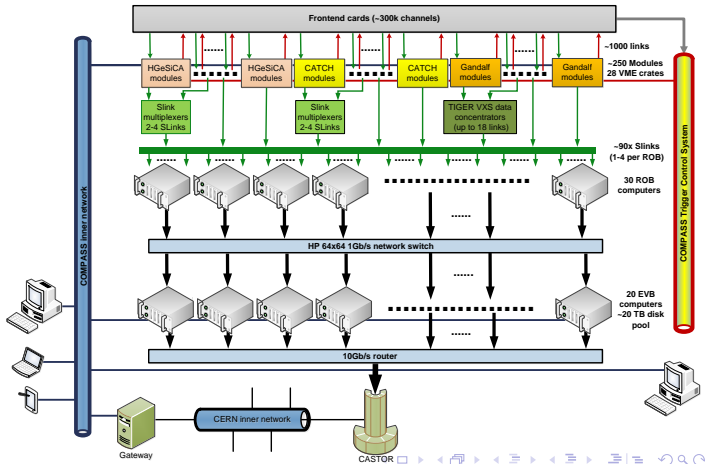
Hardware/Software structure of the new DAQ

- ▶ 8 new servers 2x8 core CPU 3.6 GHz
- ▶ 32 TB disk pool
- ▶ 8 HDD in RAID 10 per server
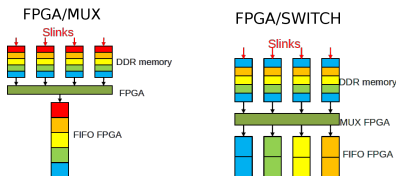- ▶ full events received by servers

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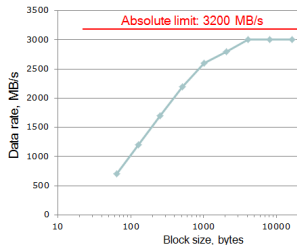Hardware/Software design of the new DAQ

Communication diagram

MX/SW module for the new DAQ

- ▶ AMC module, ATCA standard
- ▶ VIRTEX6 XC6VLX130T FPGA
- ▶ 2 GB DDR3
- ▶ Module programmed as MX (15:1) or SW (8x8)

FPGA/MUX

FPGA/SWITCH

Data Throughput

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Hardware/Software design of the new DAQ

Used technologies

- ► C++, Python
- ► Qt framework
- ► MySQL
- ► Distributed Information Management System
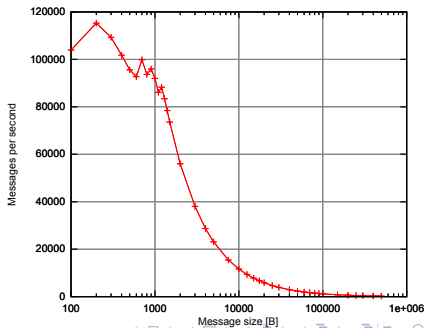- ► DATE (Data Acquisition and Test Environment) data format

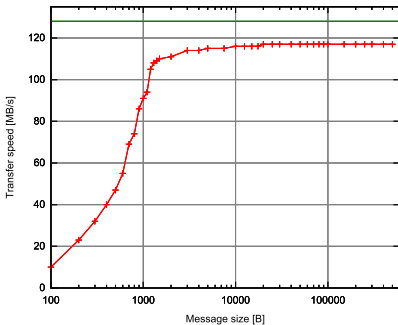| Introduction	Development of the new DAQ	Summary	References
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System tests phase 1 - communication tests

System tests phase 1 - communication tests

- ▶ DIM communication tests
- ▶ basic GUI design
- ▶ state machine design

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System tests phase 1 - communication tests
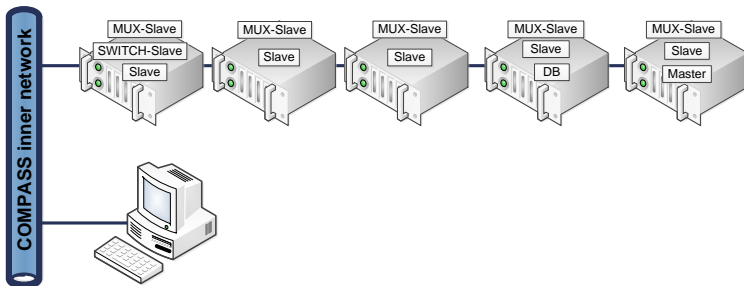
DIM speed test

- ▶ new DAQ message format and random payload
- ▶ more than sufficient performance
- ▶ 1 kB messages → 92 kHz rate

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System tests phase 1 - communication tests

DIM stability test

- ▶ 24-hours test
- ▶ maximum message exchange rate
- ▶ 2 DIM clients/producers
- ▶ 1 DIM server/consumer

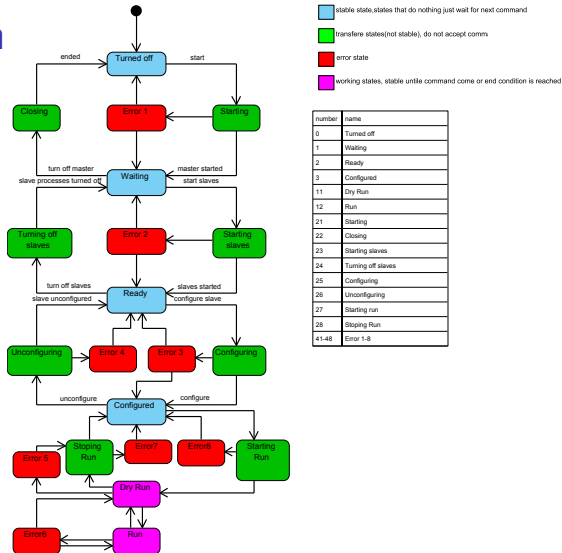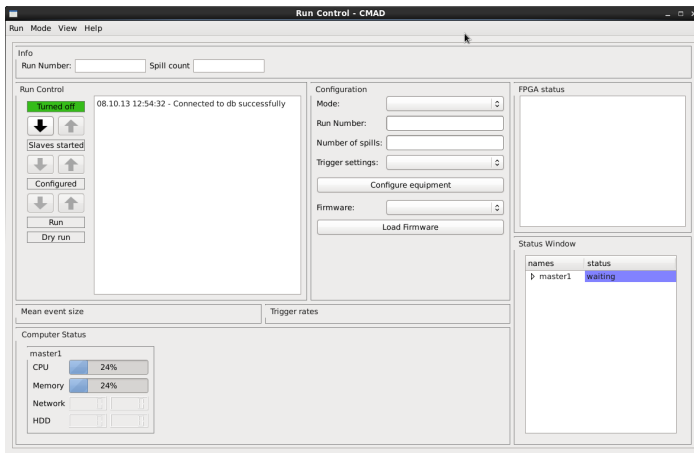| Introduction | Development of the new DAQ | Summary | References |
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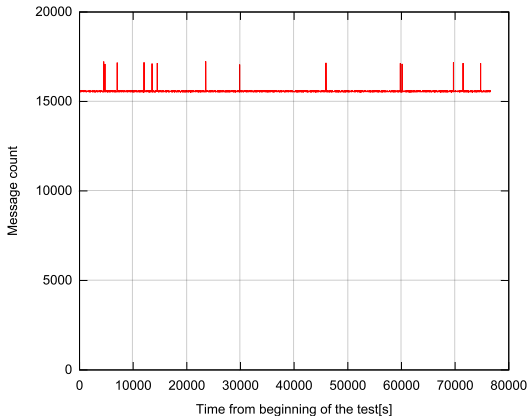
System tests phase 1 - communication tests

State machine design

- ▶ reworked state machine design
- ▶ four types of states
- ▶ error tolerant run state

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Run control GUI prototype

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System tests phase 1 - communication tests

MessageBrowser

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System tests phase 2 - readout tests

System tests phase 2 - readout tests

- 2xPCI-express spillbuffers
- fixed size events generated by HGeSiCa

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System tests phase 2 - readout tests

Readout speed test

- ▶ readout speed limited by SLink transfer speed
- ▶ final DAQ with 8 spillbuffer cards speed up to 1200 MB/s
- ▶ maximum CPU usage around 40% with 4 core 2 GHz Xeon E5405

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Future system tests
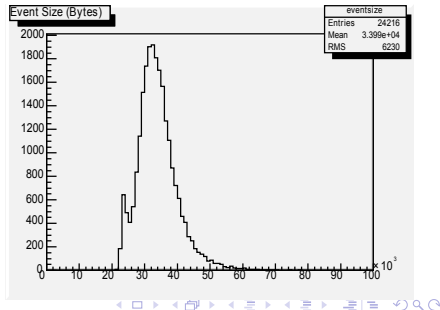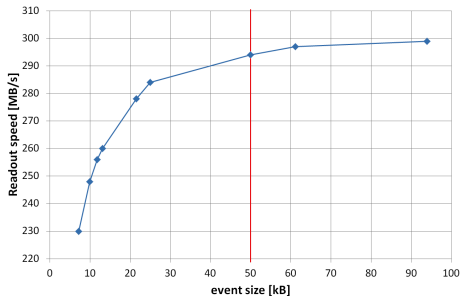
System tests phase 3

- ▶ new hardware module
- ▶ new input data format

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Future system tests
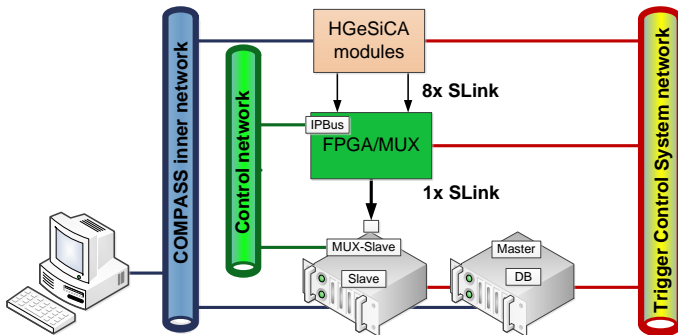
System tests phase 4

- ▶ hardware event building

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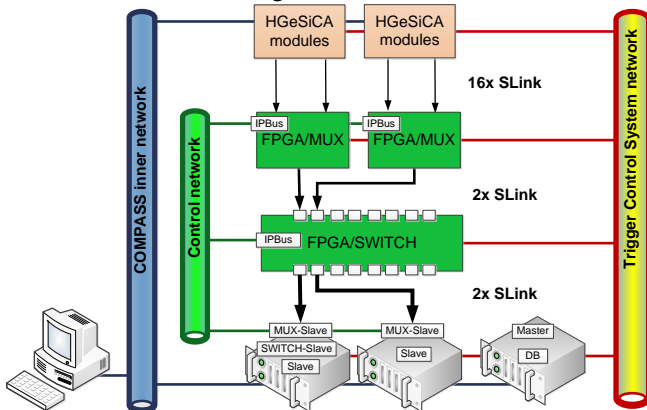
- ▶ System tests phase 1 - communication tests → DONE
- ▶ System tests phase 2 - readout tests → DONE
- ▶ System tests phase 3 - FPGA/MUX test → autumn 2013
- ▶ System tests phase 4 - FPGA/SWITCH test → winter 2013
- ▶ Full scale system test → spring 2014
- ▶ Pilot run → autumn 2014

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📄 J. Novy: *COMPASS DAQ - Basic Control System* Prague, 2012, Master thesis, Czech Technical University in Prague

📄 T. Anticic, et al. (ALICE DAQ Project): *ALICE DAQ and ECS User's Guide* CERN, EDMS 616039, January 2006.

Legend:
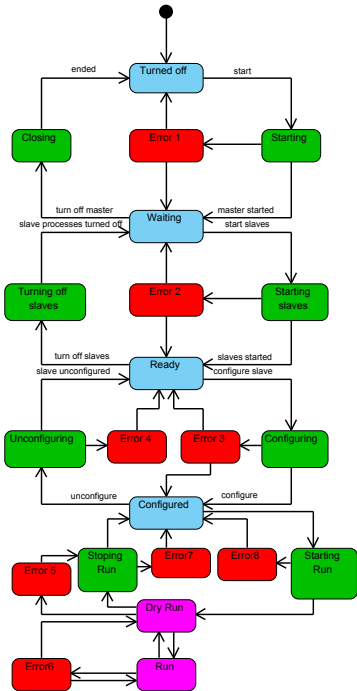
- stable state, states that do nothing just wait for next command
- transfere states(not stable), do not accept comm
- error state
- working states, stable untile command come or end condition is reached

number	name
0	Turned off
1	Waiting
2	Ready
3	Configured
11	Dry Run
12	Run
21	Starting
22	Closing
23	Starting slaves
24	Turning off slaves
25	Configuring
26	Unconfiguring
27	Starting run
28	Stoping Run
41-48	Error 1-8

Diagram states and transitions:

- Turned off
- Closing
- Error 1
- Starting
- ended, start
- turn off master, master started
- Waiting
- slave processes turned off, start slaves
- Turning off slaves
- Error 2
- Starting slaves
- turn off slaves, slaves started
- Ready
- slave unconfigured, configure slave
- Unconfiguring
- Error 4
- Error 3
- Configuring
- unconfigure, configure
- Configured
- Error 5
- Stoping Run
- Error7
- Error8
- Starting Run
- Dry Run
- Error6
- Run

number	name
0	Turned off
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3	Configured
11	Dry Run
12	Run
21	Starting
22	Closing
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26	Unconfiguring
27	Starting run
28	Stoping Run
41-48	Error 1-8

ended   Turned off   start

Closing   Error 1   Starting

turn off slave   slave started
Ready
slave unconfigured   configure slave

Unconfiguring   Error 4   Error 3   Configuring

unconfigure   Configured   configure

Error 5   Stoping Run   Error7   Error8   Starting Run

Dry Run

Error6   Run