

Development and test of the DAQ system to readout a Micromegas prototype to be installed into the ATLAS experiment

Ourania Sidiropoulou

CERN, Julius-Maximilians-Universität Würzburg

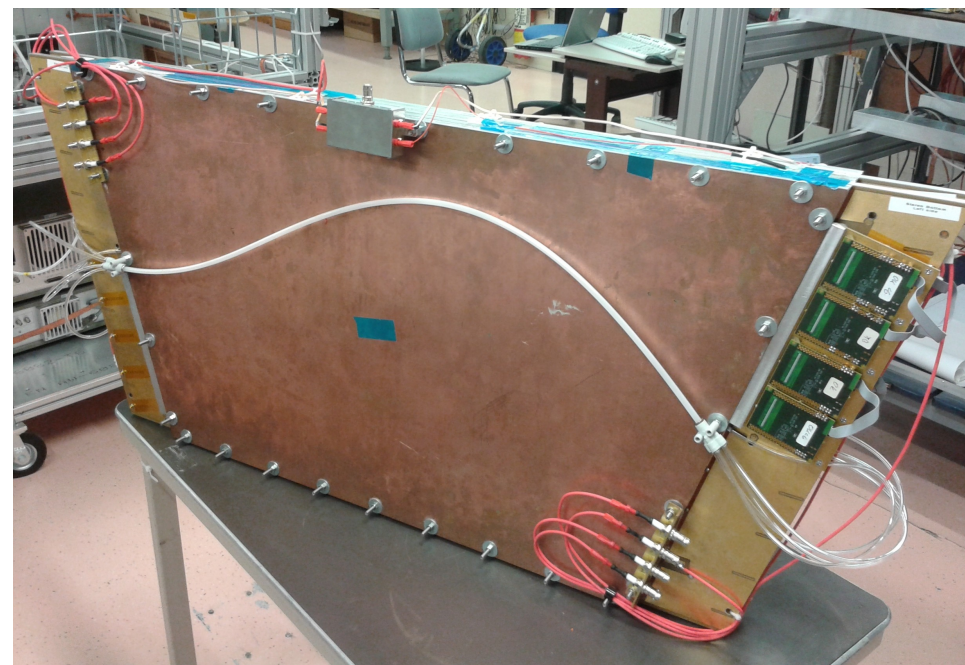


Bundesministerium
für Bildung
und Forschung

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Bundesministerium für Bildung und Forschung (BMBF)*

MicroMegas Small Wheel (MMSW) prototype

- ➔ A Micromegas quadruplet prototype (MMSW) with active area of 0.5 m^2 per plane has been built, following the general design foreseen for the upgrade of the ATLAS Small Wheels (New Small Wheel (NSW) project)
- ➔ Chosen detector technology is the so-called resistive strip Micromegas, using an additional layer of high-resistivity carbon strips on top of the copper readout strips to improve spark-tolerance (The two layers of strips are separated by one $50 \mu\text{m}$ layer of Kapton® Foil)
- ➔ The 4 readout layers have 1024 resistive strips each with a pitch of $415 \mu\text{m}$
 - ➔ 2x horizontal strips
 - ➔ 2x stereo strips inclined by $\pm 1.5^\circ$ to give info for the second coordinate



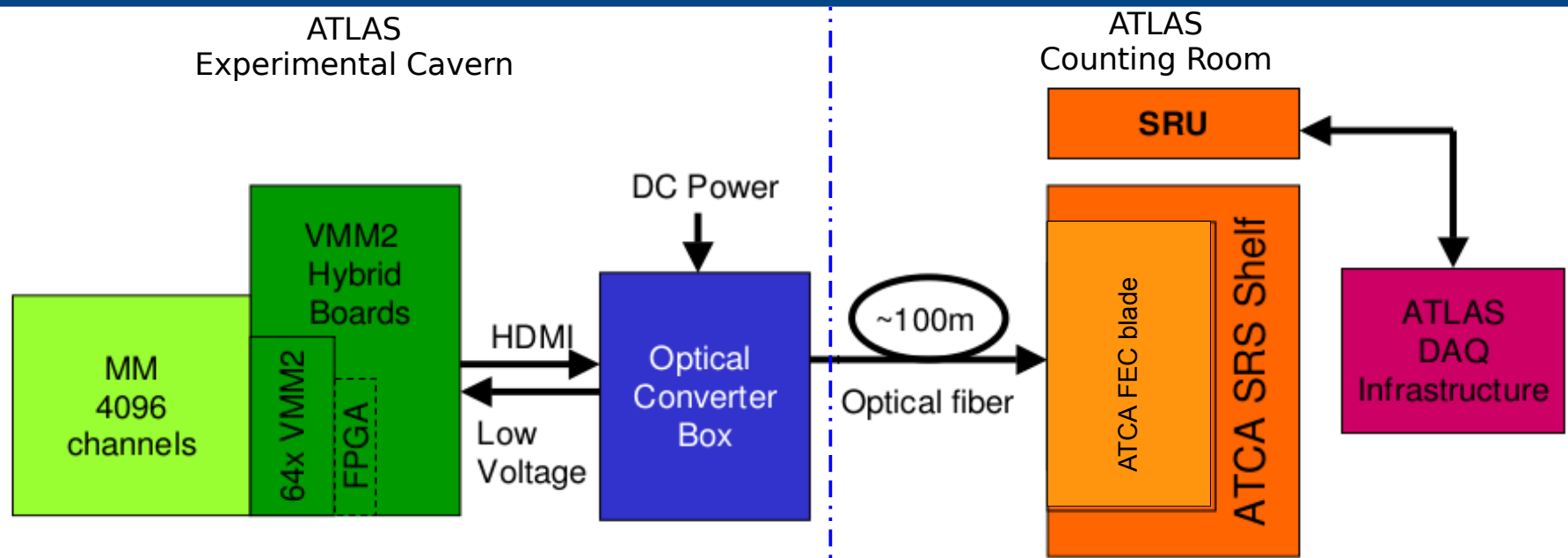
MMSW Installation in ATLAS

- Integration of pre-series Micromegas chamber (MMSW) into the ATLAS TDAQ infrastructure
 - Test of detector & electronics (VMM) under real ATLAS environmental conditions
 - Synchronization with ATLAS muon tracks
 - Event-by-event comparison of MMSW data with ATLAS data during RUN II



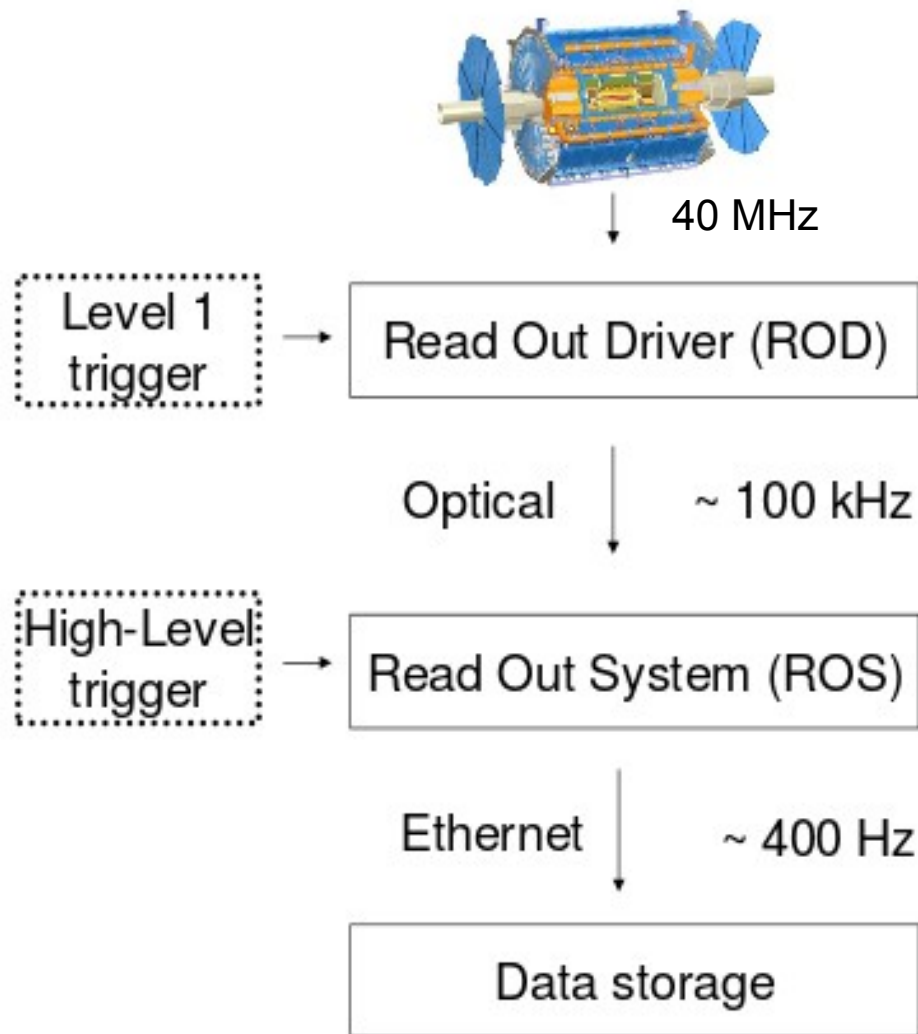
- ➔ Initially will be located in the scaffolding structure of the ATLAS cavern wall
 - ➔ Particles from Interaction Point (IP) at $\sim 20^\circ$ → micro-TPC angular tracking studies
- ➔ Relocation of chamber in one of the two Small Wheels during next shutdown

MMSW Installation in ATLAS



- Scalable Readout System developed within the RD51 collaboration successfully provides the readout of the MMSW prototype (Final NSW electronics under development)
 - Optical Converter (OC) box communicating with FEC blades via optical fiber, allowing to place the back-end electronics in a remote area (counting room) while the detector operates in harsh environment (cavern). An OC box itself is able to represent the functionality of a FEC card, allowing the installation of different mezzanine boards, depending on the frontend electronics in use (*under development*)
 - ATCA FEC blades used to distribute triggers and clock to readout chips, gather respective data, perform additional computing e.g. zero-suppression e.t.c

ATLAS TDAQ chain



RUN II - New two-staged triggering mechanism to reduce initial collision rate of 40 MHz to ~400 Hz for final storage and analysis

Scalable Readout Unit (SRU)

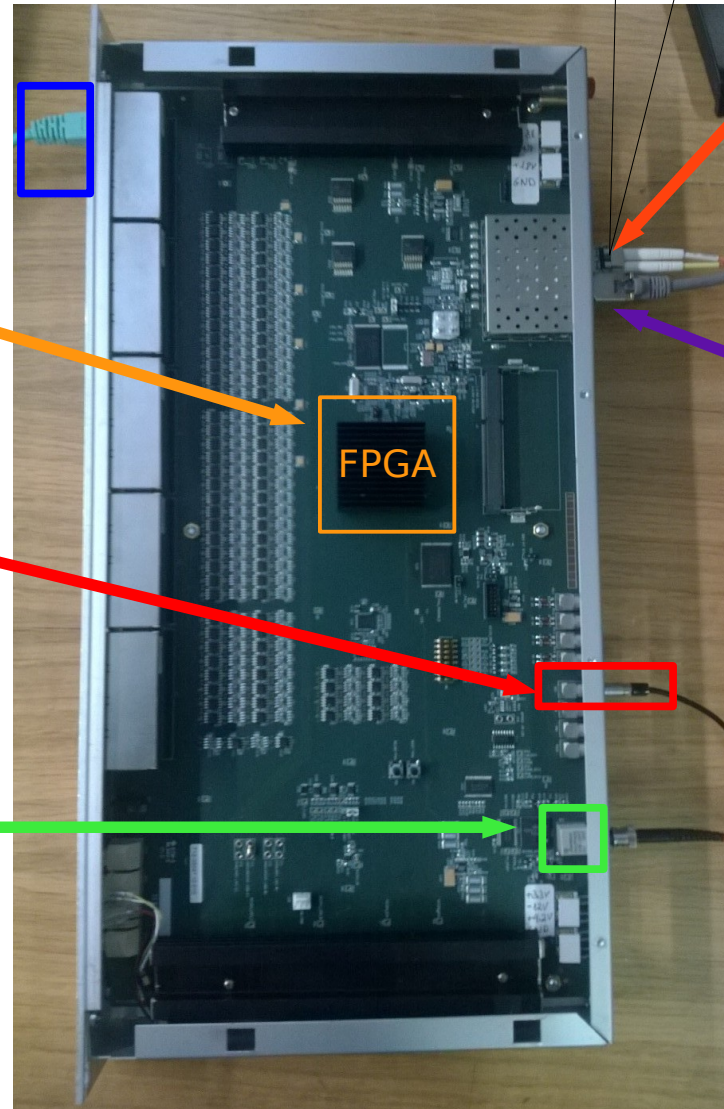
Detector synchronization and data collection via **DTCC** (Data Trigger Clock and Control) links

Xilinx Virtex6 FPGA:

customized firmware performing ATLAS like ROD event building

Busy signal generation in case of back-pressure from the ROS (Lemo plugs)

TTCrX (Trigger, Timing and Control) receiver to pick up LHC bunch crossing clock (synchronous operation), triggers and asynchronous data from ATLAS trigger network



SFP+ plugs

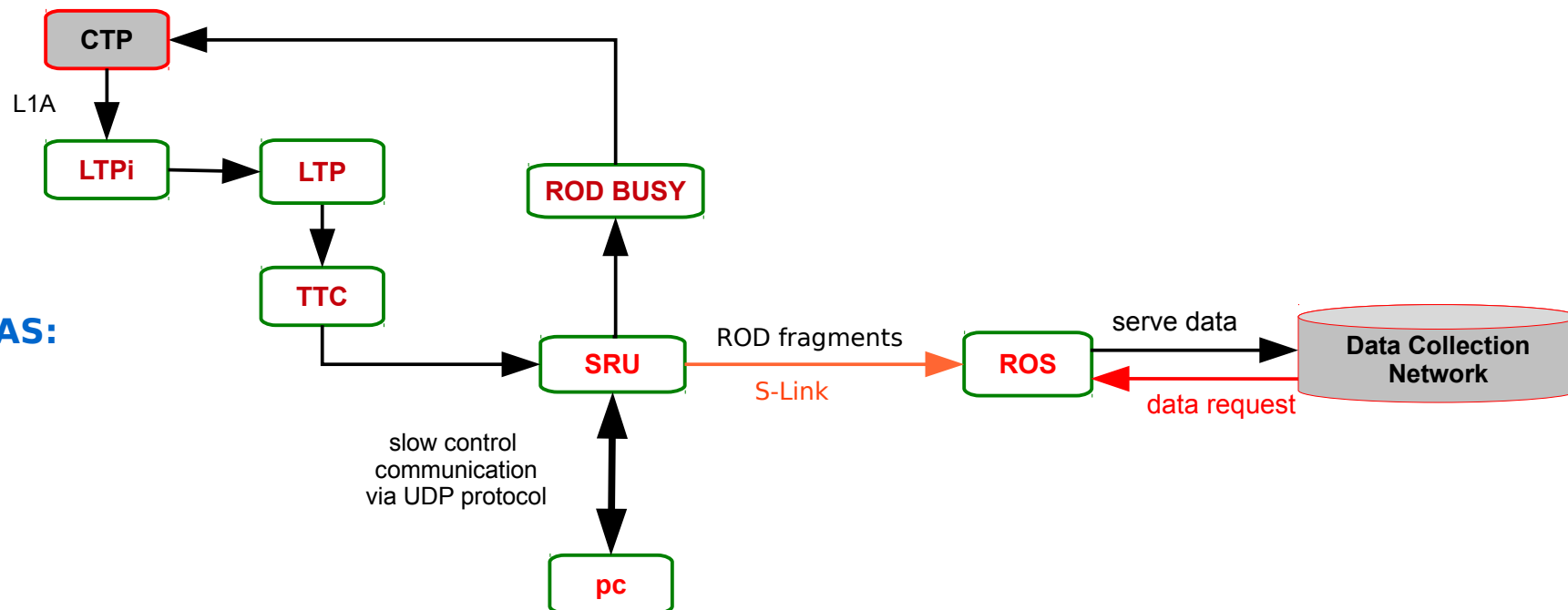
Event data is transferred to ROS pc via the ATLAS standard optical fiber **S-Link**

Slow control commands for configuration of the SRS components via **GbE**

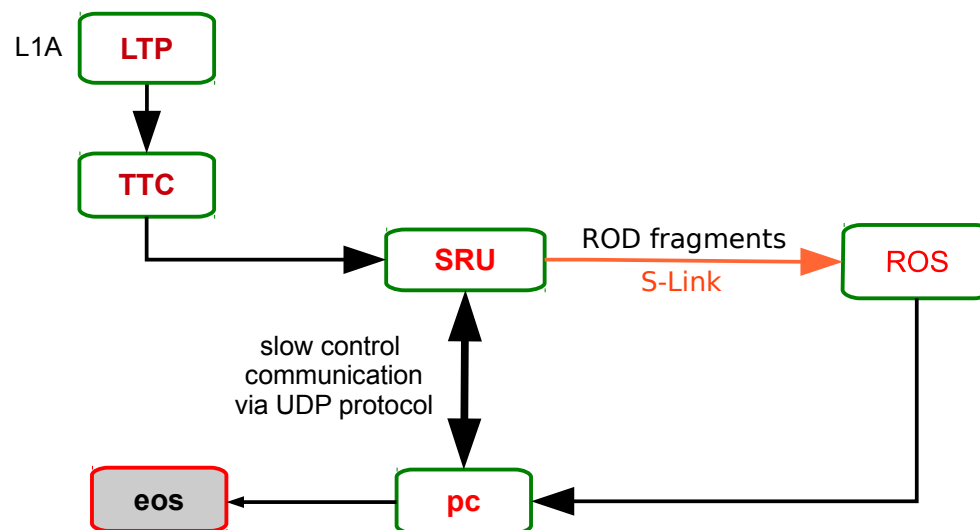
RD51 Custom Unit
Interfaced to ATLAS

DAQ Configuration databases

For ATLAS:



For standalone:



Integration of the MMSW into the ATLAS TDAQ Software

ATLAS TDAQ SOFTWARE - Partition ATLAS

File Commands Access Control Settings Logging Level Help

Commit & Reload Load Panels

RUN CONTROL STATE **RUNNING**

Run Control Commands

SHUTDOWN INITIALIZE

UNCONFIG CONFIG

STOP START

HOLD TRG RESUME TRG

Beam Stable ●

Run Information & Settings

Lumi Block

	Number	Rate
Level 1	<input type="text" value="33343"/>	<input type="text" value="1.60 kHz"/>
HLT	<input type="text" value="0"/>	<input type="text" value="0.00 mHz"/>
Recorded	<input type="text" value="0"/>	<input type="text" value="0.00 mHz"/>

Information Counters Settings

Run Control Segments & Resources Dataset Tags Trigger DFPanel

RUNNING RootController

- Online Segment
- Infrastructure
 - RUNNING** TDAQ
 - RUNNING** MMEGA
 - RUNNING** MMEGA-ROD-RCD
 - RUNNING** MMEGA-TTC-RCD
 - RUNNING** ROS-FWD-MMEGA-00

CHIP-ATLAS

DDC

DF

DFConfig

DQM

DQMConfig

Histogramming

ISRepository

L1TriggerRates

MMEGA

MTS

Monitoring

PMG

RDB

RDB-POOL-1

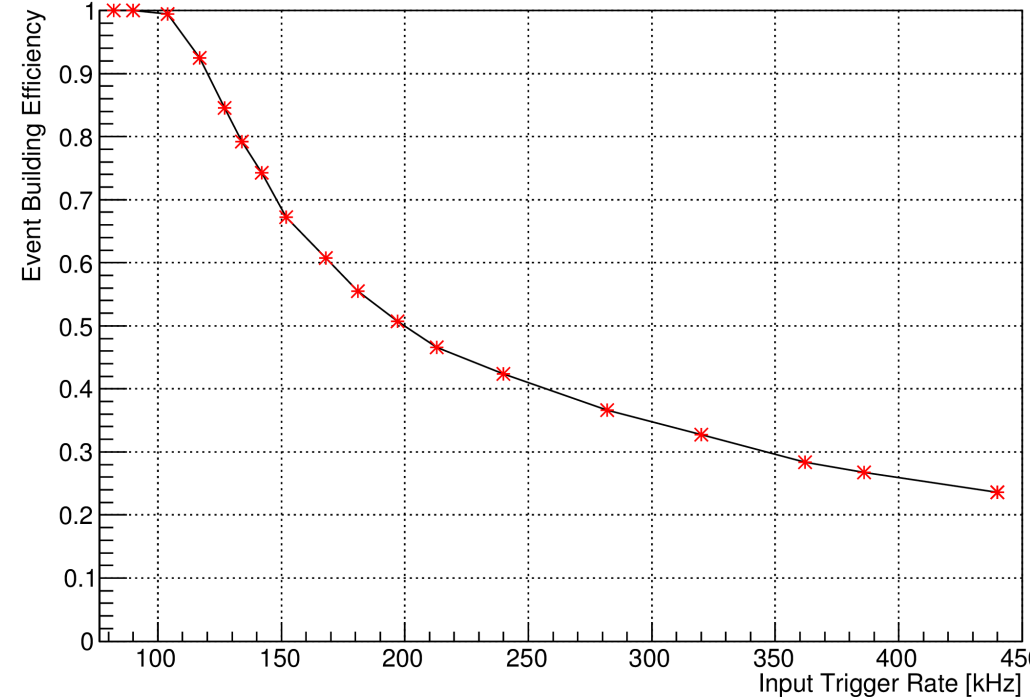
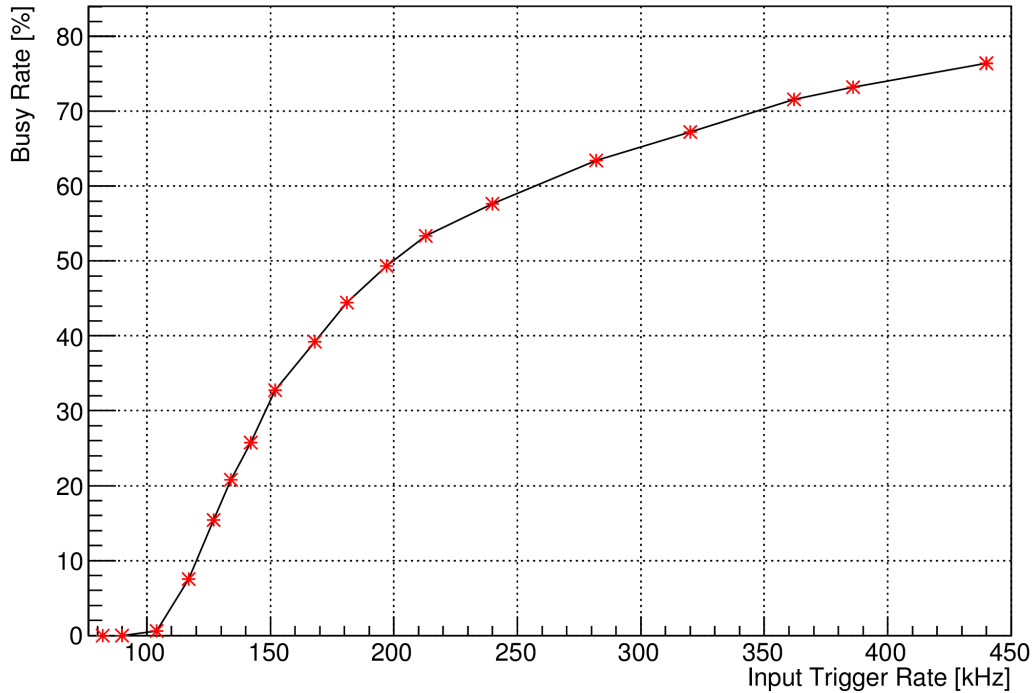
TestResults Advanced

Find: Match Case Repeats

- The Online Software is responsible for:
 - ➔ the overall experiment control,
 - ➔ configuration of the Trigger & DAQ system

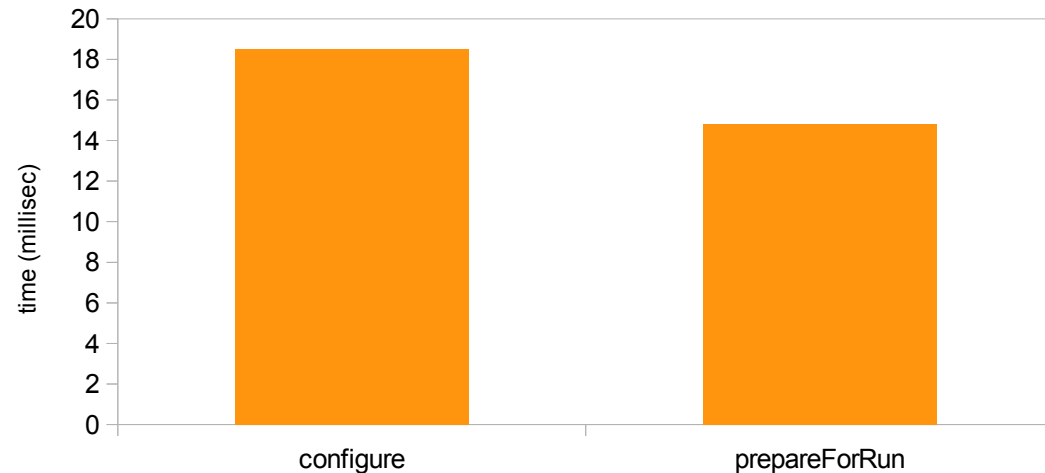
- The MMSW DAQ supports the execution of recovery commands that can be issued by a human operator or by the software itself:
 - ➔ A part of the readout that is blocking the trigger due to a fault can be excluded during RUNNING state (**Stop-less removal**)
 - ➔ Re-align of ECR/L1ID counters if they went out of sync (**Resynchronization**)
 - ➔ Complete restart and reconfiguration of the system during RUNNING in case the system is blocking the data acquisition (**TTC restart**)

SRU Performance

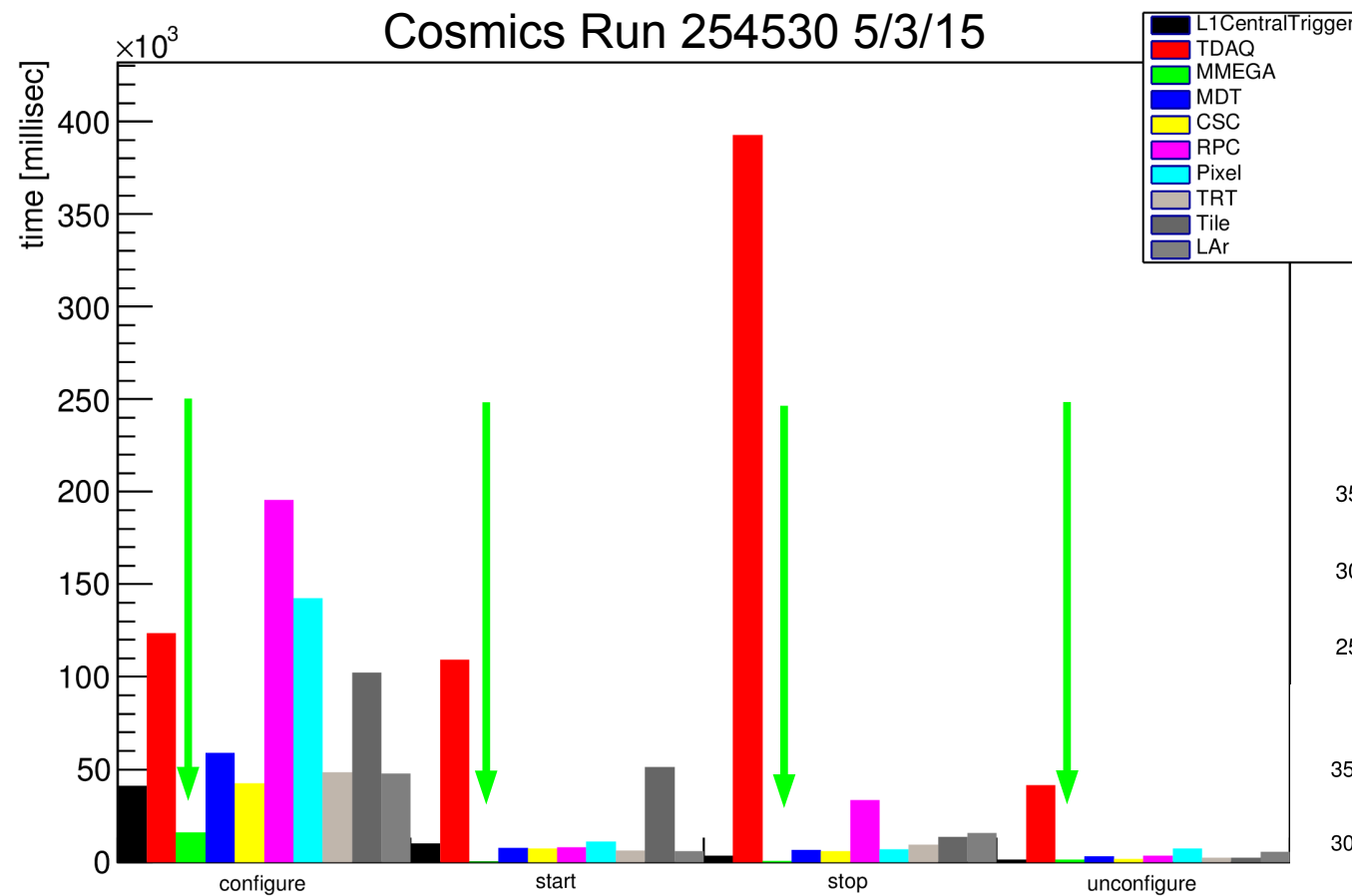


- Expected Level-1 trigger rate during RUN II is ~100 kHz
 - ROD performance depends on ROS back-pressure, all detectors need to raise “busy” in order not to loose events
 - SRU performance → below 1% at ~100 kHz

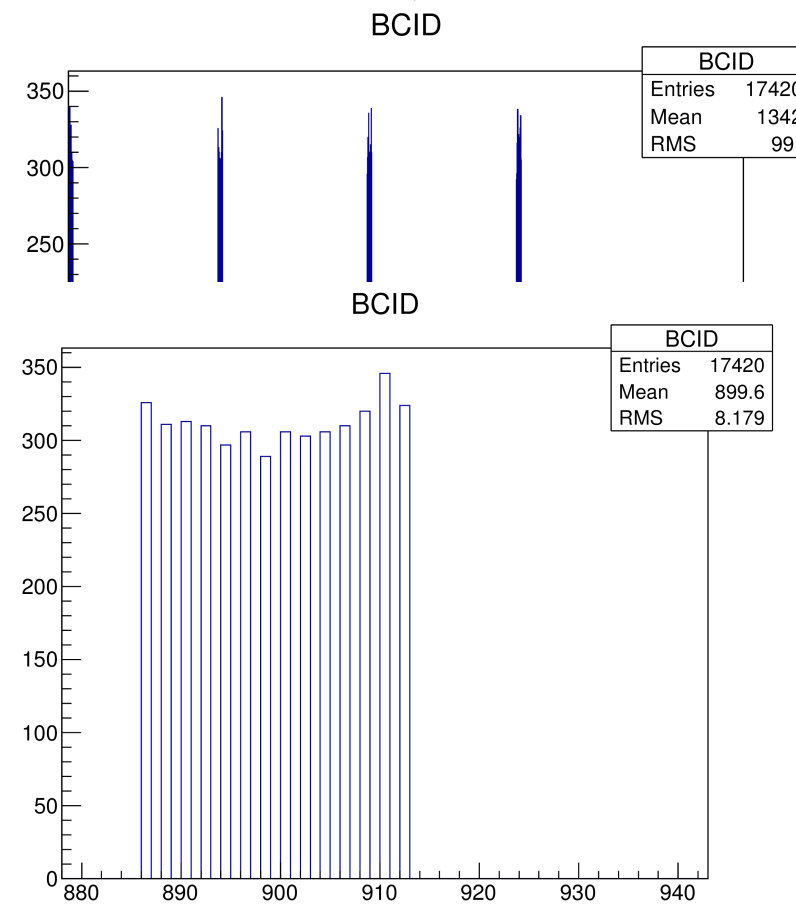
SRU times



DAQ Performance



**Bunch structure
visible in data →
TTC & DAQ
integration works**



Summary

- A MicroMegas quadruplet prototype chamber with a structure similar to the one foreseen for the NSW has been built and tested in several test-beams during summer 2014
 - ➔ will be installed and integrated into the ATLAS DAQ infrastructure during the RUN II period (2015-2017)
 - ➔ OC box under development
 - ➔ ATCA FEC firmware under development
- The MM DAQ system based on the ATLAS Online TDAQ Software has been developed and tested
 - ➔ Two different configurations exist for both standalone and ATLAS partition
 - ➔ Tested in the ATLAS TDAQ infrastructure successfully during cosmic combined runs & will be tested also during splash events until physics collisions start
 - ➔ Recovery actions have been implemented and can be executed by the shifter or by the software itself

Thank you!

BACK UP SLIDES

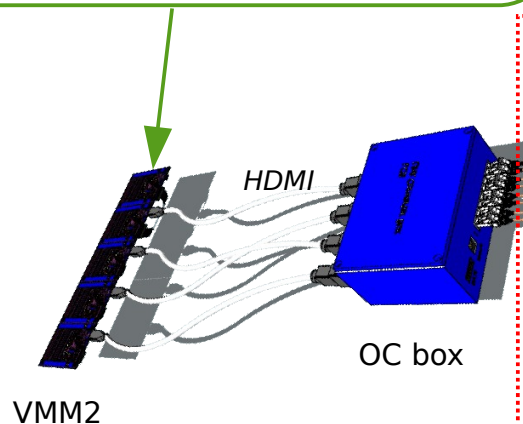
Integration of the MMSW into the ATLAS DAQ System

VMM2 hybrid

analogue ASIC with digital output, 64 front-end channels, spark protected. Provides charge and timing measurements along with:

- ➔ The address of the first event in real time for trigger information
- ➔ Time-over-Threshold measurements with zero suppression

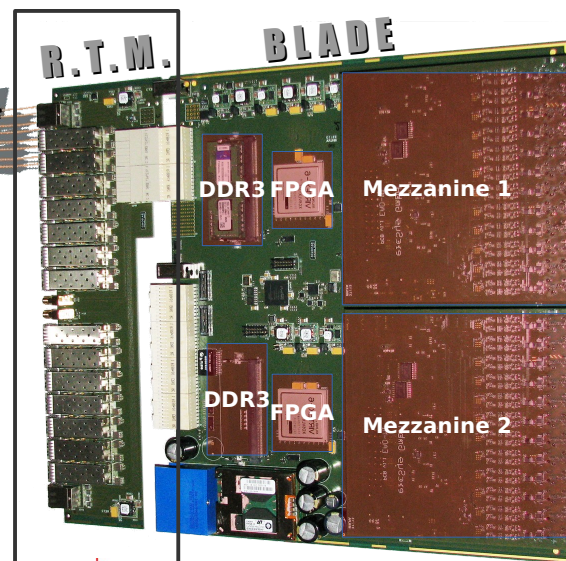
(BNL development)



- ➔ The ATCA based on high bandwidth fiber point-to-point technology was adopted the last years by many experiments and is about to replace VME off-detector equipment in the LHC experiments

Scalable Readout System

(RD51 collaboration)



Rear Transition Module (RTM) I/O extension card

- 2 x 7 SFP+ (up to 5Gbps at the moment)
- 2 x RJ45 (DTCC)
- 2 x NIM (LEMO 00)

Blade main board

- 2 x Virtex-6 FPGA
- 2 x DDR3 up to 4GB
- 2 x Mezzanine ports (work independently)
- ➔ The 2 FPGAs can also be interconnected



ATLAS Combined Cosmic Run

ATLAS TDAQ SOFTWARE - Partition ATLAS

File Commands Access Control Settings Logging Level Help

Commit & Reload Load Panels

RUN CONTROL STATE **RUNNING**

Run Control Commands

SHUTDOWN INITIALIZE

UNCONFIG CONFIG

STOP START

HOLD TRG RESUME TRG

Beam Stable ●

Run Information & Settings

Lumi Block 2

	Number	Rate
Level 1	9135	495.80 Hz
HLT	3417	260.19 Hz
Recorded	4650	225.00 Hz

Information Counters Settings

Run Control Segments & Resources Dataset Tags

RUNNING **RootController**

- Online Segment
- Infrastructure
 - RUNNING** TDAQ
 - RUNNING** Pixel
 - RUNNING** LUCID
 - RUNNING** TRT
 - RUNNING** Tile
 - RUNNING** CSC
 - RUNNING** MDT
 - RUNNING** MMEGA
 - RUNNING** MMEGA-ROD-RCD
 - RUNNING** MMEGA-TTC-RCD
 - RUNNING** ROS-FWD-MMEGA-00
 - RUNNING** RPC
 - RUNNING** TGC
 - RUNNING** SCT
 - RUNNING** LAr
 - RUNNING** GlobalMonitoringSegment
 - RUNNING** BCM
 - RUNNING** ALFA
 - RUNNING** ID-Monitoring
 - RUNNING** TDAQ_Monitoring
 - RUNNING** DQMSegment

RootController

- ALFA
- BCM
- CHIP-ATLAS
- CSC
- DDC
- DF
- DFConfig
- DQM
- DQMConfig
- DQMSegment
- DefRDB:RPC
- GlobalMonitoringSegment
- Histogramming
- Histogramming-CombinedInDet-1-iss
- Histogramming-CombinedInDet-2-iss
- Histogramming-Global-iss
- Histogramming-MDT
- Histogramming-Pixel
- Histogramming-SCT-iss
- Histogramming-TRT

TestResults Advanced

Find: Match Case ☐ Repeats ☒

Subscription criteria ☐ WARNING ☐ ERROR ☐ FATAL ☐ INFORMATION ☒ Expression ((QUAL=TGC or QUAL=CSC or QUAL=RPC or QUAL=MDT) and (sev=ERROR or sev=WARNING or sev=FATAL)) or APP=MMEGA

TIME	SEVERITY	APPLICATION	NAME	MESSAGE
22:36:56	WARNING	TGC-RCD-C10	TgcRod:exception	0x99908025 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x01 SL Bcid=5 SB Bcid=2
22:36:56	WARNING	ROS-CSC-ECC-00	ROS::ROSRobinNPExceptions	: RobinNP::clearRequest: The RobinNP could not delete 1 events because they were not in its buffer. The first failed delete was for L1ID = 0x5000053 for Rol 7 Most Recent ID = 0x500014f Pre Delete MriD 500014f
22:36:56	WARNING	TGC-RCD-A08	TgcRod:exception	0x99928014 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x05 SL Bcid=4 SB Bcid=1
22:36:56	WARNING	ROS-CSC-ECC-00	ROS::ROSRobinNPExceptions	Fragment error: RobinNP::processIncomingFragment: ROL 7 Fragment out of sequence: L1 ID = 0x40008d6, Most Recent ID 0x5000052
22:36:56	WARNING	ROS-CSC-ECC-00	ROS::ROSRobinNPExceptions	Fragment error: RobinNP::processIncomingFragment: ROL 7 Fragment out of sequence: L1 ID = 0x5000054, Most Recent ID 0x40008d6
22:36:56	WARNING	TGC-RCD-A12	TgcRod:exception	0x99908003 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x01 SL Bcid=3 SB Bcid=0
22:36:55	WARNING	TGC-RCD-C09	TgcRod:exception	0x99910061 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x02 SL Bcid=1 SB Bcid=6
22:36:55	WARNING	TGC-RCD-A03	TgcRod:exception	0x8a330005 E SBid does not match SBinfo table ssw=0x3 sbid=0x06 rrid=0x05
22:36:55	WARNING	TGC-RCD-A11	TgcRod:exception	0x99908036 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x01 SL Bcid=6 SB Bcid=3
22:36:55	WARNING	TGC-RCD-A10	TgcRod:exception	0x99900072 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x00 SL Bcid=2 SB Bcid=7
22:36:55	WARNING	TGC-RCD-A11	TgcRod:exception	0x99900036 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x00 SL Bcid=6 SB Bcid=3
22:36:54	WARNING	TGC-RCD-C08	TgcRod:exception	0x99910036 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x02 SL Bcid=6 SB Bcid=3
22:36:54	WARNING	TGC-RCD-C11	TgcRod:exception	0x99918072 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x03 SL Bcid=2 SB Bcid=7
22:36:54	WARNING	TGC-RCD-A09	TgcRod:exception	0x99918013 E SL Bcid[2:0] does not match SB Bcid ssw=0x9 sbid=0x03 SL Bcid=3 SB Bcid=1
22:36:54	WARNING	ROS-CSC-ECC-00	ROS::ROSRobinNPExceptions	Lost Fragment: RobinNP: Lost fragment detected. The L1ID is 0x4000541. The last ID is 0x40005fb. The Channel ID is 0x4 MRE is 0x40005fb
22:36:54	WARNING	ROS-CSC-ECC-00	ROS::ROSRobinNPExceptions	: RobinNP::clearRequest: The RobinNP could not delete 1 events because they were not in its buffer. The first failed delete was for L1ID = 0x4000541 for Rol 4 Most Recent ID = 0x4000609 Pre Delete MriD 4000609

Clear Message format Visible rows 10,000 Current ERS subscription ((QUAL=TGC or QUAL=CSC or QUAL=RPC or QUAL=MDT) and (sev=ERROR or sev=WARNING or sev=FATAL)) or APP=MMEGA

TTC restart test

ATLAS TDAQ SOFTWARE - Partition ATLAS

File Commands Access Control Settings Logging Level Help

Commit & Reload Load Panels

RUN CONTROL STATE **RUNNING**

Run Control Commands

SHUTDOWN INITIALIZE

UNCONFIG CONFIG

STOP START

HOLD TRG RESUME TRG

Beam Stable ●

Run Information & Settings

Lumi Block

	Number	Rate
Level 1	24269048	59.36 kHz
HLT	29	0.00 mHz
Recorded	0	0.00 mHz

Information Counters Settings

Run Control Segments & Resources Dataset Tags Trigger DFPANEL

Common Rates Others

IS Information

☒ L1 ☐ HLT ☐ RE

Rate (Hz)

Time

Maximum period to plot: Days Hours Minutes

Subscription criteria ☒ WARNING ☒ ERROR ☒ FATAL ☐ INFORMATION ☐ Expression Subscribe

TIME	SEVERITY	APPLICATION	NAME	MESSAGE
12:56:10	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:10	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:10	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:10	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:05	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:05	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:05	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:05	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:00	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:00	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:00	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:56:00	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:55:55	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:55:55	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:55:55	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:55:55	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:55:50	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist
12:55:50	WARNING	MMEGA-ROD-RCD	is::RepositoryNotFo...	IS repository " does not exist

Clear ✖ Message format ERROR LONG Visible rows Current ERS subscription sev=ERROR or sev=WARNING or sev=FATAL

Busy connection to CTP

crmuon : busy_display.si - Konsole

File Edit View Bookmarks Help

Partition: ATLAS 4/12/14 12:18:48

Dead-time.....	99.72%	subdetectors.....	0.00%	Dead-time settings: Simple: Size: 25000 Complex: Size: 8 Rate: 380
		Simple.....	99.72%	
		Complex.....	0.00%	
Runcontrol.....	0.00%			RoIB busy: L1Calo RoI-0... masked L1Calo RoI-1... masked CTP..... 0.00% MuCTPi..... 0.00%
LUCID.....	masked	CSC.....	masked	RoIB status (HLTSV): ---- --00 ----
Pixel.....	masked	ALFA.....	masked	Color legend: okay Warning Error
SCT.....	masked	TGC.....	masked	
TRT.....	masked	RPC.....	masked	
L1Calo.....	masked	MUCTPI.....	0.00%	
BCM.....	masked	CBL0.....	masked	
IBL.....	masked	CBL1.....	masked	
LAr H/F.....	masked	CBL2.....	masked	
LAr EMEC.....	masked	CBL3.....	masked	
LAr EMB.....	masked	CBL4.....	masked	
Micromegas.....	0.00%	CTP-MON.....	0.00%	IS expired
MDT B.....	masked	CTP-RDT.....	0.00%	
MDT EC.....	masked	ECR.....	0.00%	
Tile EB.....	masked	VTO0.....	masked	
Tile LB.....	masked	VTO1.....	masked	

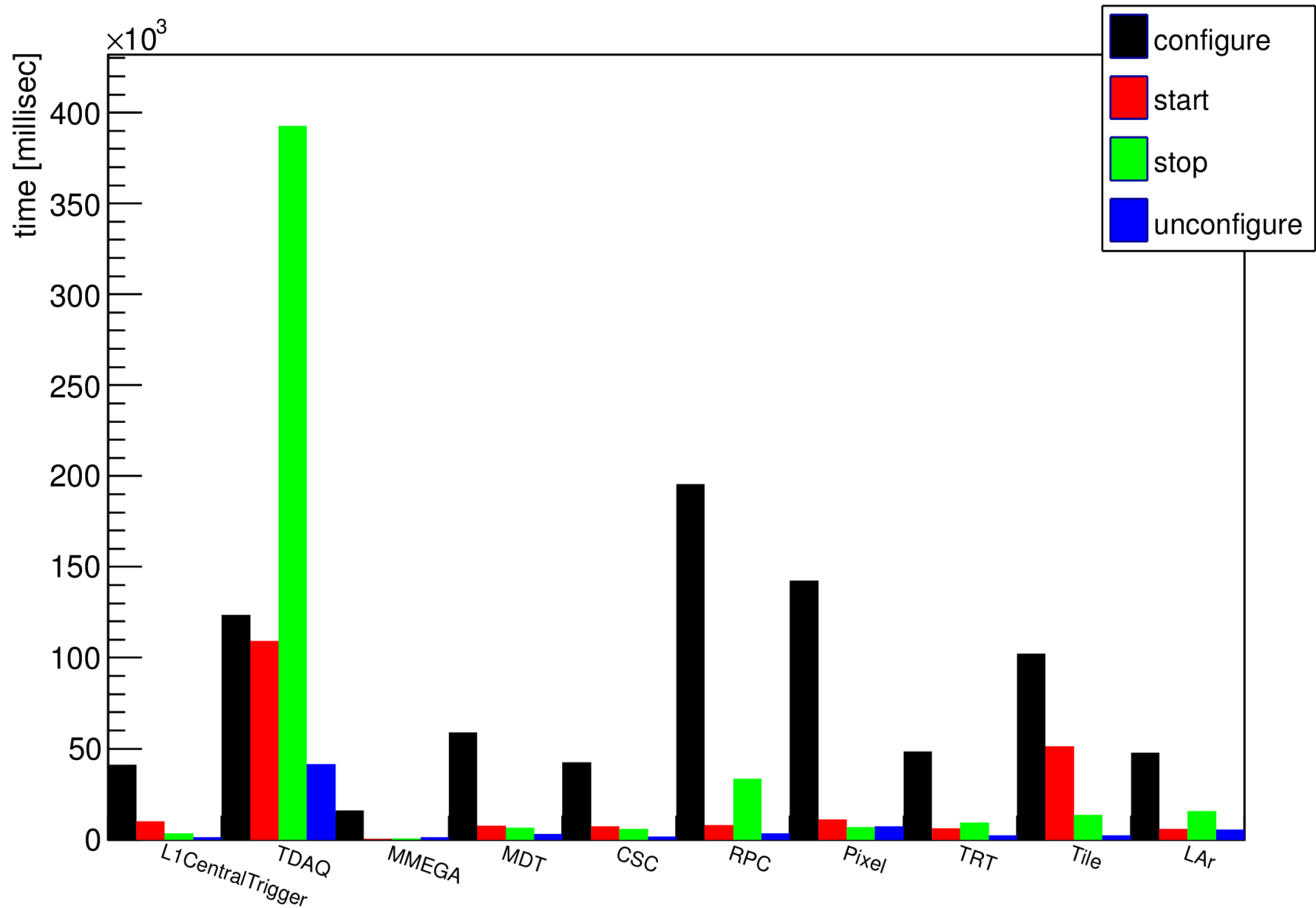
F1 Busy status F2 IS status q Quit

crmuon : busy_display.si

Busy channel connected to the CTP

Controllers Times

Cosmics Run.Num:254530 5/3/15



Expert Panel

Run Control		Segments & Resources	Dataset Tags	MMPanel
SRU registers values, port:6010		Commands to MMEGA ROD		
Address	Value	HARDWARE ERROR		
0x00	241b	RECOVER HARDWARE		
0x01	1	ASSERT BUSY		
0x02	6b0001	RELEASE BUSY		
0x03	8034f21	GET NEW REG VALS		
0x04	0			
0x05	0			
0x06	34ab6c4			
0x07	60004000			
0x08	0			
0x09	0			
0x10	21b58f			
0x11	21b59a			
0x12	1			
0x0a	61a7f01			
0x0b	1			
0x0c	3fa2c			
0x0d	0			
0x0e	ff1000			
0x0f	55256270			