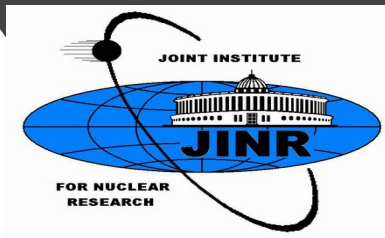


# The Relevance of ATLAS experience and its relevance to the data acquisition of the BM@N experiment at NICA complex

Kehinde Tomiwa  
kehinde.gbenga.tomiwa@cern.ch

On behalf of the HEP group  
University of the Witwatersrand  
Johannesburg  
SQM Conference 2015



# Outline

- Introduction
- WITS HEP at ATLAS
- ATLAS TileCal Detector
- TileCal DAQ Architecture
- Towards Upgrade of ATLAS detector
- NICA Project
- BM@N Detector
- Connections between TileCal/BM@N/MPD detectors
- BM@N DAQ system
- BM@N DAQ Trigger overview
- BM@N Data Flow
- Summary/Outlook

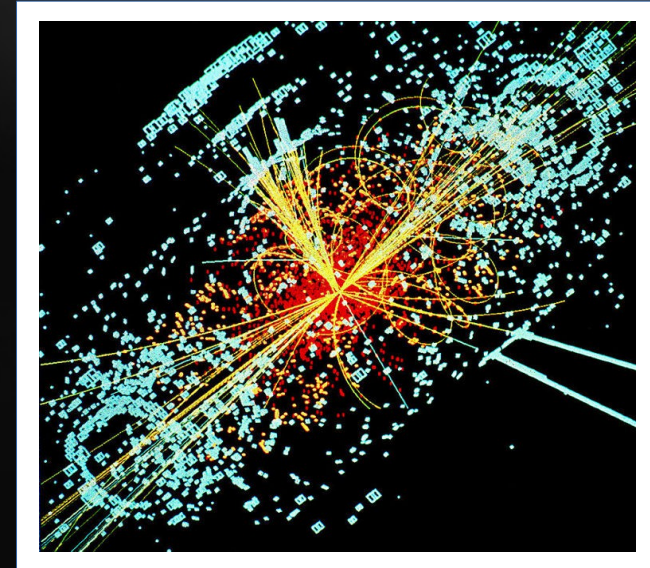


# Introduction

Understanding the Universe



Collision/fixed target experiments



High energy Experiments



Experiments at LHC, proposed MPD/BM@N, etc comes with challenges:

Big data.

Data processing rate (High frequency of acquisition).

**Way out: Development of High-throughput Electronics.**

For data processing

Data reduction at maximum readout efficiency with no dead time

# WITS HEP at ATLAS

Wits HEP group has sustained effort at ATLAS in the following ways:

## Higgs Physics in Di-Photon Channel.

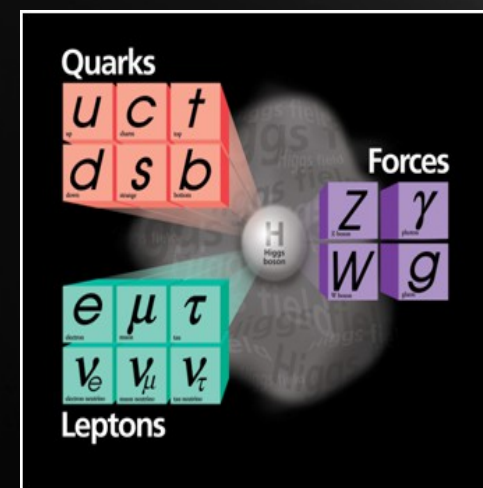
- Understanding the production of jets in association with the new boson.
- Search Higgs boson in the di-photon decay channel in associated with intermediate missing transverse energy.
- A Di-Higgs search in the  $\gamma\gamma b\bar{b}$  decay channel using ATLAS detector
- Search for additional bosons.

## Electronics

- Single Event Upset (SEU) and Reliability
- Mobile Drawer integration checking (MobiDick) system for TileCal Detector
- Super Readout Drivers (sROD) for TileCal Detector

## The Grid

- Wits operates ATLAS Tier-3 site which comprise of over 100's CPU nodes.





# WITS HEP at ATLAS cont.

## Computing

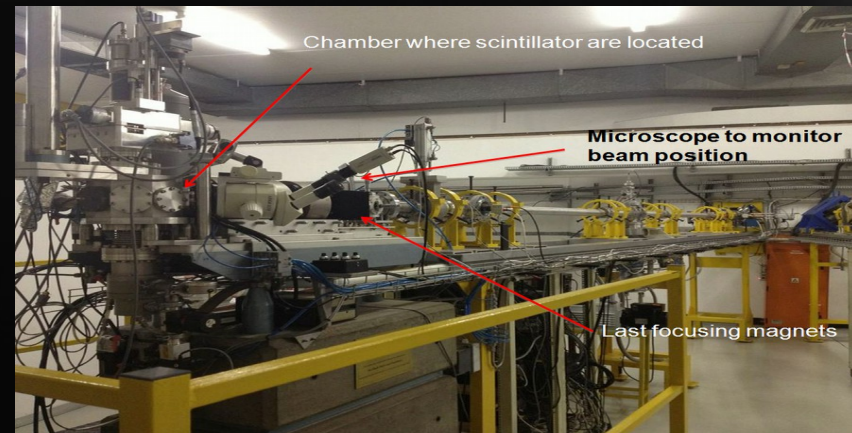
- Massive affordable computing (MAC project)
- Development of modular ARM board,
  - Cheap alternatives for high throughput super computing at high power efficiencies



CERN data center

## Material

Effects of ionizing radiation on plastic scintillators

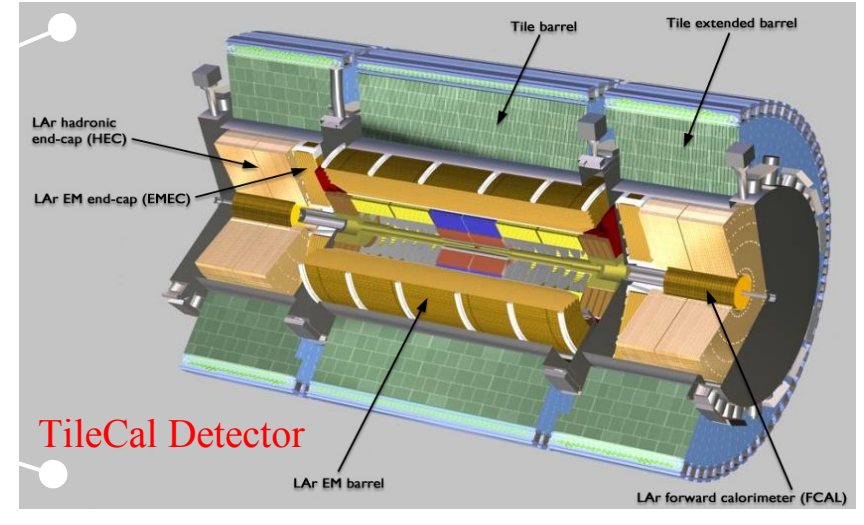
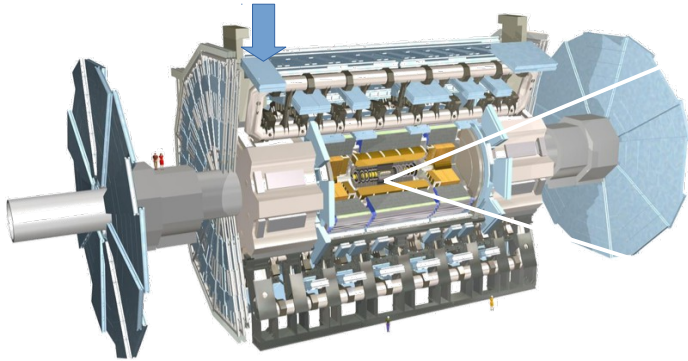


Scintillators study at iThemba Laboratory

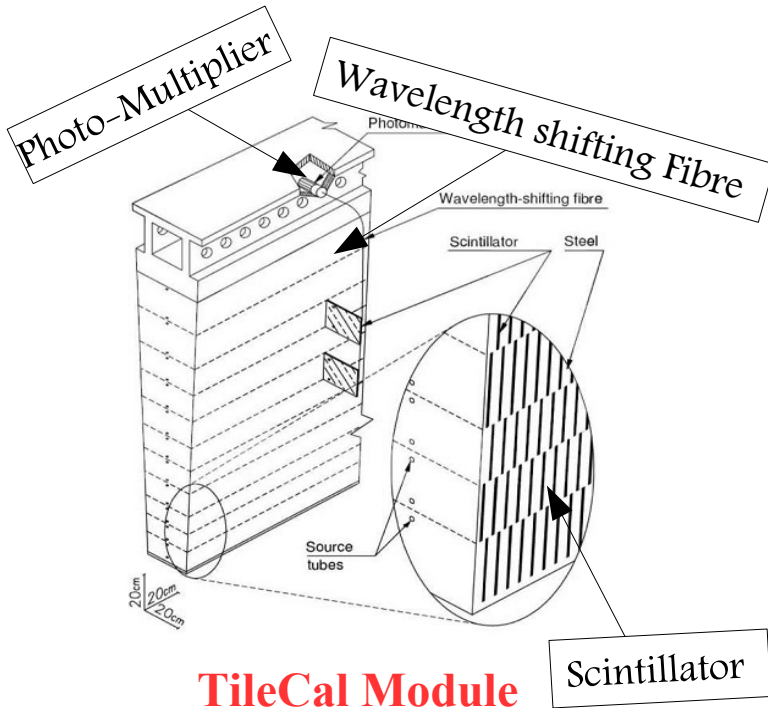
Wits HEP group's **Publications**

# ATLAS TileCal Detector

ATLAS Detector



TileCal Detector

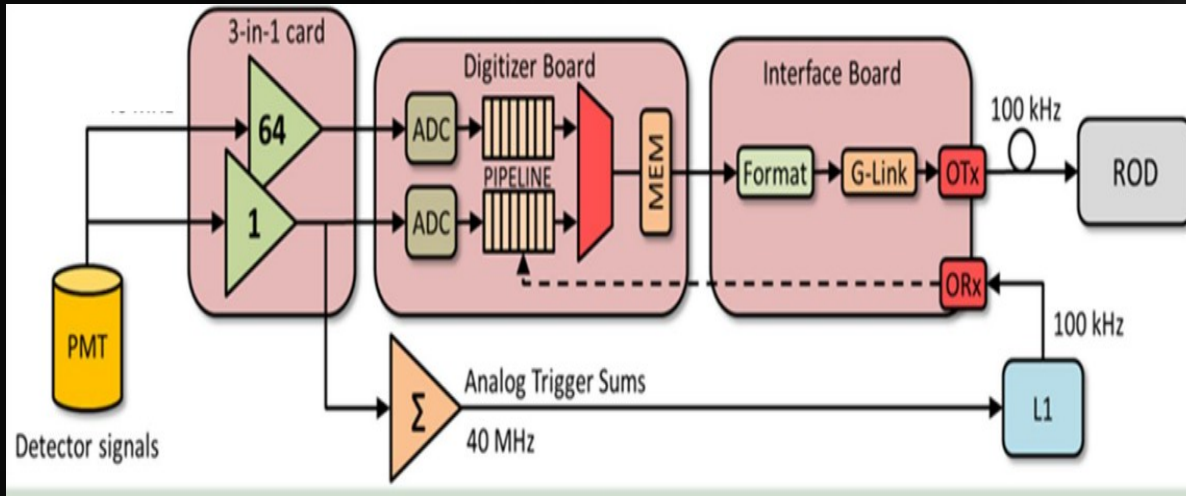


TileCal Module

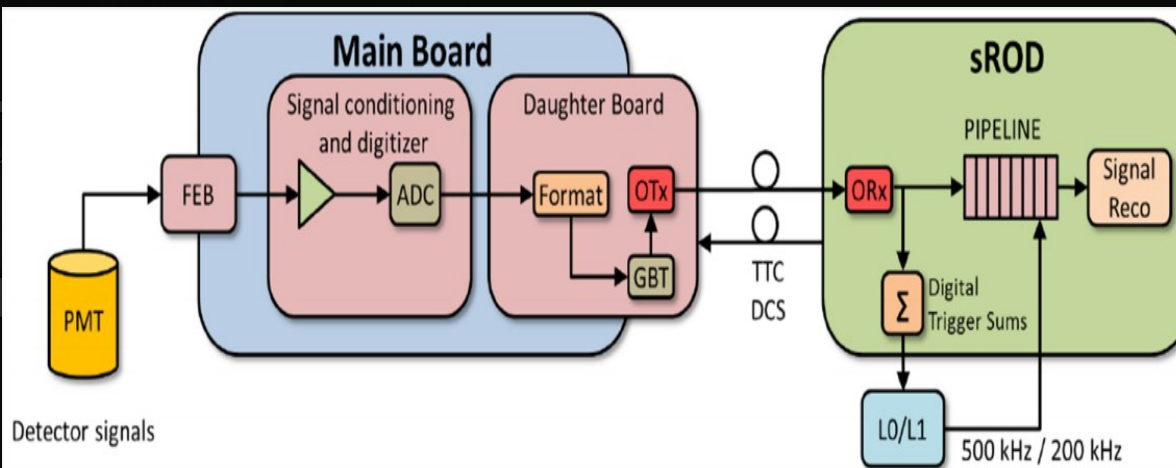
- Measure energy of Hadron and Jet.
- Uses steel absorber and plastic scintillating tiles as active materials
- Wavelength shifting fibres collect light to Photo-multiplier (PMTs).
- More than 10 000 channels.

# TileCal DAQ Architecture

## Current Architecture



## Phase II Upgrade Architecture



- **3-in-1**: shaping, amplification and integration
- **Motherboard**: Programming, powering of FEE
- **Digitizer card**: digitization and pipeline
- **Interface board**: 100KHz to ROD
- **Main-board**: Shaping and digitization
- **Daughter board**: FPGA based board for formatting and data output to sROD at 40MHz
- **sROD**: Pipeline, monitors system functions and detector control



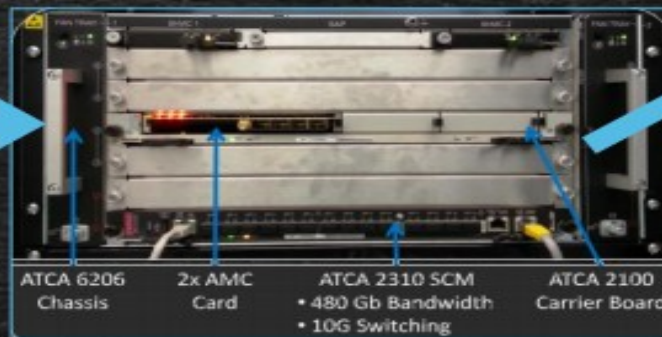
# Toward Upgrade of ATLAS detector

## Development ATCA system

### Infrastructure Upgrade



sROD



ATCA Chassis



- ATCA replacement for VME Crates
- ATCA will house sROD and interface into the Detector Control System
- No software tools for this integration effort

	Present	Phase II
Total BW	~165 Gbps	~40 Tbps (+40 Tbps)
N. fibers	256	4096 (+4096)
BW/drawer	640 Mbps	160 Gbps (+160 Gbps)

TileCal Bandwidth upgrade



# Toward Upgrade of ATLAS detector cont.

## Development ATCA system

QuickTest : fwATCA/snmpDpCreate.pnl (System1 - ATLTLATCA: #1)

Host Name: localhost Agent: System1\_2\_SNMPAgent\_1 Poll Delay: 10 Datapoint Address: Discover...

Atca Content	Name	Name	Value	Thresh	Type	OID
Chassis	asmt001	setPowered	1	-	INT	1.3.6.1
Fru-0	PPS BMC	ipmbAddress	136	-	INT	1.3.6.1
Fru-1	Shell EEPROM 1	present	1	-	INT	1.3.6.1
Fru-2	Shell EEPROM 2	getPowered	1	-	INT	1.3.6.1
Fru-7	FanTray1	manufacturer	RadSys Corp.	-	STRING	1.3.6.1
Fru-8	FanTray2	healthy	1	-	INT	1.3.6.1
Fru-0	SHMM-500	slot	4	-	INT	1.3.6.1
Shell Managers	Absent/Non-Intel	reset	0	-	INT	1.3.6.1
ShellManager1	Absent/Non-Intel	name	ATCA-1200	-	STRING	1.3.6.1
ShellManager2	Absent/Non-Intel					
Power Supplies	None-Found					
Power Entry Mods	None-Found					
Fan Trays	None-Found					
Slots						
Slot1	AT8910					
Slot2	ATCA-2210					
Fru-0	ATCA-4550					
Fru-2	ATCA-5400 RTM					
Slot4	ATCA-1200					
Fru-0	ATCA-1200					
Fru-2	CERN AMC-GLIB					
Fru-5	ATCA-1200 RTM					
Slot5	Absent					
Slot6	AT8404					
Custom Sensors						
Shell(32)/Fru0	PPS BMC					
Shell(32)/Fru1	Shell EEPROM 1					
Shell(32)/Fru2	Shell EEPROM 2					
Shell(32)/Fru7	FanTray1					
Shell(32)/Fru8	FanTray2					
Slot1/Fru0	AT8910					
Slot2/Fru0	ATCA-2210					
Slot3/Fru0	ATCA-4550					
Slot4/Fru0	ATCA-5400 RTM					
Slot4/Fru2	CERN AMC-GLIB					
Slot4/Fru5	ATCA-1200 RTM					
Slot6/Fru0	AT8404					
Shell(252)/Fru0	SHMM-500					

Buttons: Create Standard DataPoints, Create Selected DataPoints, Delete All DataPoints, Delete Selected DataPoints

Key: Data Points Not Found

QuickTest : fwATCA/snmpDpCreate.pnl (System1 - ATLTLATCA: #1)

Host Name: localhost Agent: System1\_2\_SNMPAgent\_1 Poll Delay: 10 Datapoint Address: Discover...

Atca Content	Name	Sen#	Name	Value	Thresh	Type
Chassis	asmt001	0	ATCA FRU Hotswap	Current State Mask 0x0010	-	MASK
Shell	Shell1	1	ATCAPhysIpmb	Current State Mask 0x0008	-	MASK
Shell Managers	ShellManager1	2	ATCAPhysIpmb-L	Current State Mask 0x0002	-	MASK
ShellManager2	Absent/Non-Intel	3	Ejector Closed	Current State Mask 0x0002	-	MASK
Power Supplies	None-Found	4	-48V Absent A	Current State Mask 0x0001	-	MASK
Power Entry Mods	None-Found	5	-48V Absent B	Current State Mask 0x0002	-	MASK
Fan Trays	None-Found	6	-48V Fuse Fault	Current State Mask 0x0001	-	MASK
Slots		7	IPMC WD Reset	Current State Mask 0x0001	-	MASK
Slot1	AT8910	8	NTS Interrupt	Current State Mask 0x0001	-	MASK
Slot2	ATCA-2210	9	Power Fail	Current State Mask 0x0001	-	MASK
Slot3	ATCA-4550	10	+3.3V_IPMC	3.325000	✓	FLOAT
Slot4	ATCA-1200	11	+12V	11.928000	✓	FLOAT
Slot5	Absent	12	+3.3V	3.325000	✓	FLOAT
Slot6	AT8404	13	+2.5V	2.502500	✓	FLOAT
Shell(32)/Fru0	PPS BMC	14	+1.8V	1.802500	✓	FLOAT
Shell(32)/Fru1	Shell EEPROM 1	15	+1.5V	1.496000	✓	FLOAT
Shell(32)/Fru2	Shell EEPROM 2	16	+1.2V	1.232000	✓	FLOAT
Shell(32)/Fru7	FanTray1	17				
Shell(32)/Fru8	FanTray2	18				
Slot1/Fru0	AT8910	19				
Slot2/Fru0	ATCA-2210	20	+3.3V_PEX	3.264000	✓	FLOAT
Slot3/Fru0	ATCA-4550	21	ZoneA In Temp	28.000000	✓	INT
Slot4/Fru0	ATCA-5400 RTM	22	ZoneB In Temp			INT
Slot4/Fru2	CERN AMC-GLIB	23	ZoneC In Temp			INT
Slot4/Fru5	ATCA-1200 RTM	24	ZoneD In Temp			INT
Slot6/Fru0	AT8404	25	ZoneA Out Temp			INT
Shell(252)/Fru0	SHMM-500	26	ZoneB Out Temp			INT
		27	ZoneC Out Temp			INT

Buttons: Create Standard DataPoints, Create Selected DataPoints, Delete All DataPoints, Delete Selected DataPoints

Key: Data Points Not Found

### Advantages of ATCA system

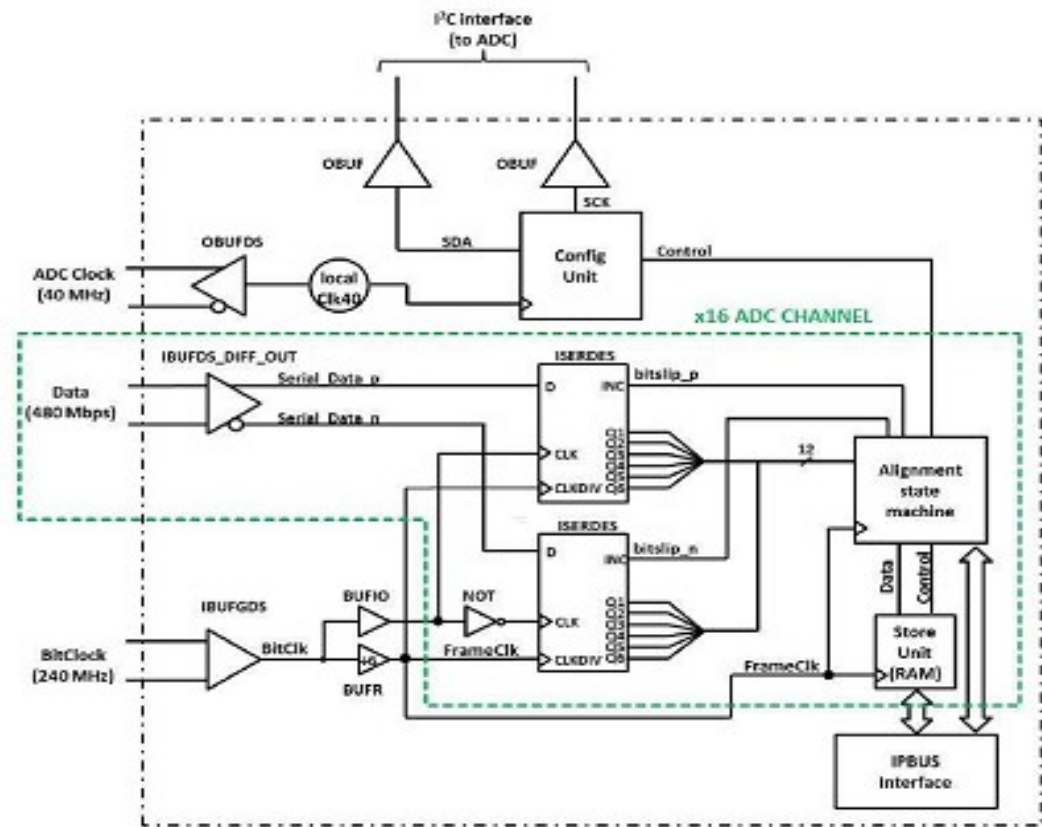
- High Speed back-plane 10G 40G
- Hot Swapping
- Monitoring and control
- Redundancy

# Toward Upgrade of ATLAS detector cont.

## Development of ADC trigger board for PROMETEO of ATLAS TileCal

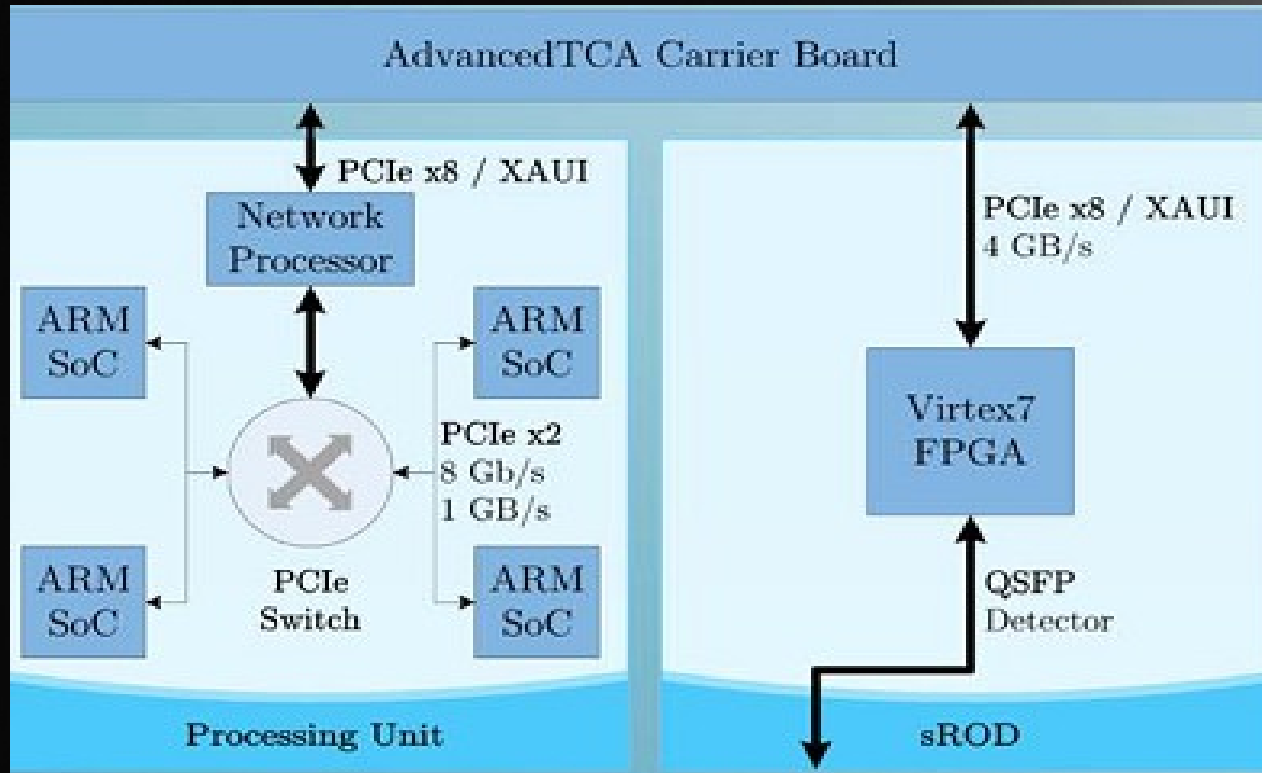
### Architecture

- Modules that are needed:
  - 16 x ADC readout cell
  - configuration unit
    - I2C interface
  - Send 40 MHz Clock (From ADC)
    - ADC and FPGA firmware running in the same clock domain
  - FIFO memories or IPBUS memories
  - State machines
    - Word and Bit Alignment
    - Control and Data Flow



# Toward Upgrade of ATLAS detector cont.

General purpose processing unit for the upgrade of TileCale

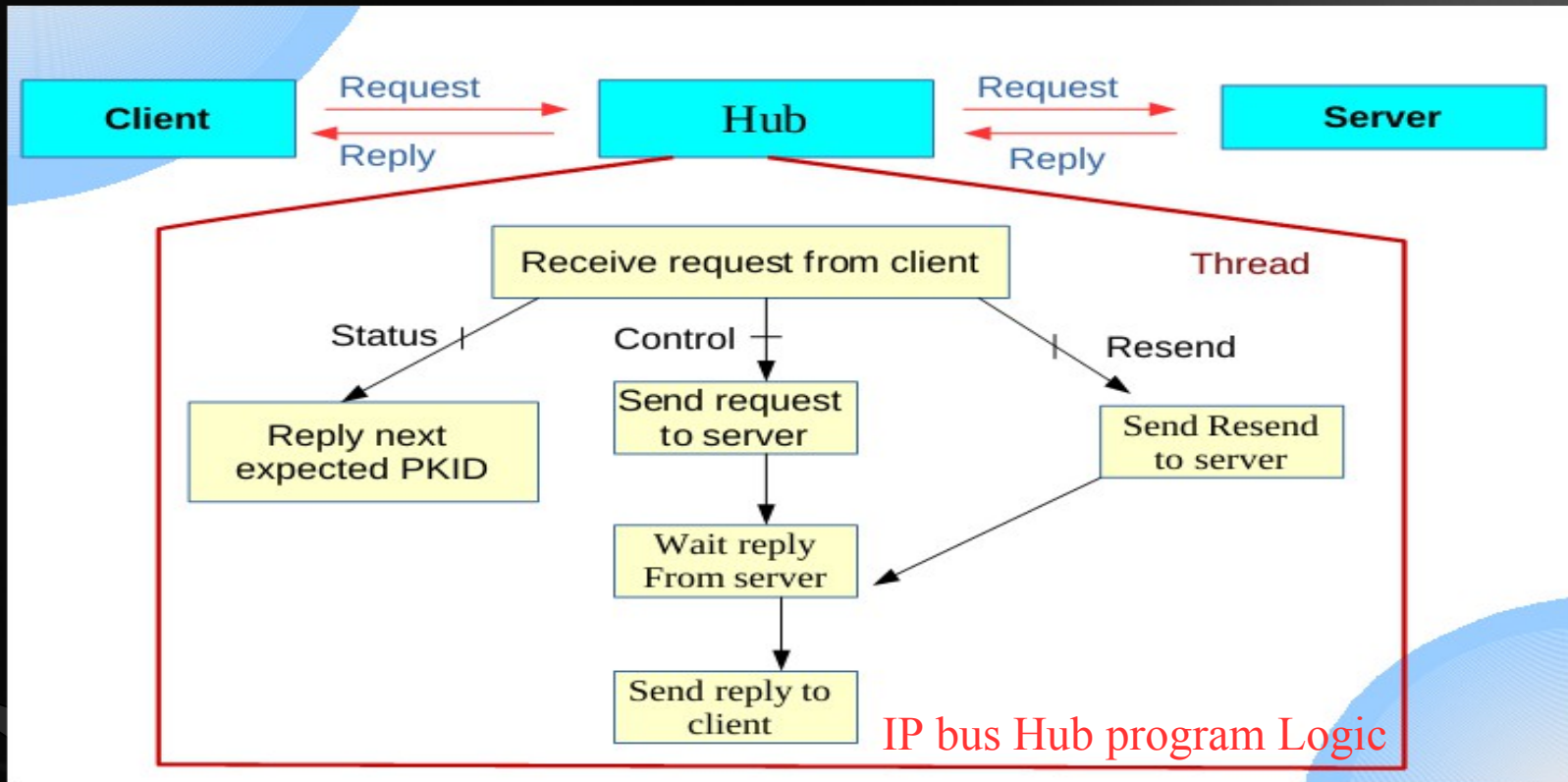


- PU is an ARM based cluster farm, proposed as co-processor to sROD
- Architecture enables efficient online data processing by ensuring high throughput
- Low latency by ensuring fast access to streaming data.



# Toward Upgrade of ATLAS detector cont.

An IP bus protocol for ATLAS TileCal

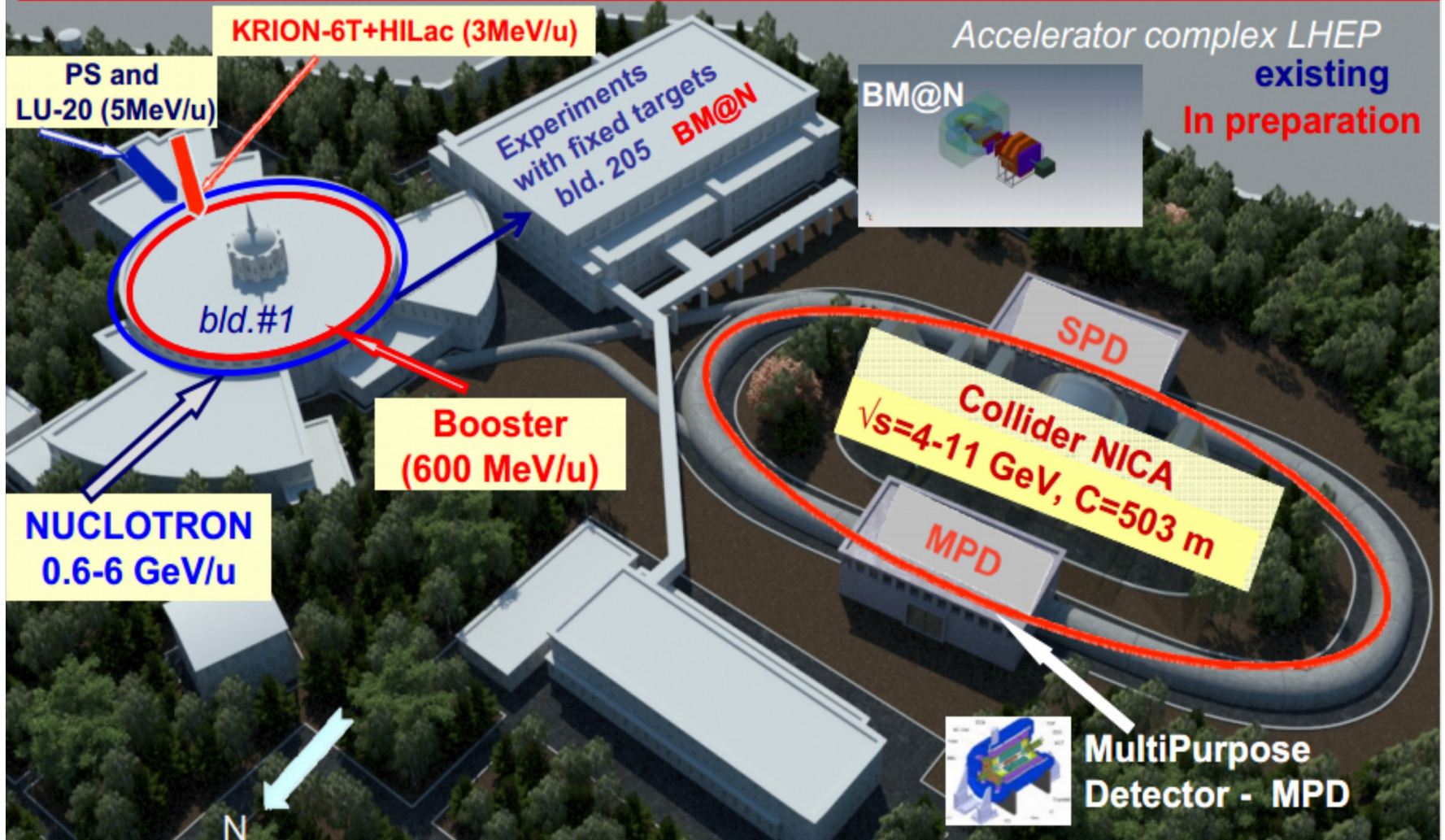


- IP bus Hub is implemented in C++
- It is a software instance of packet manager

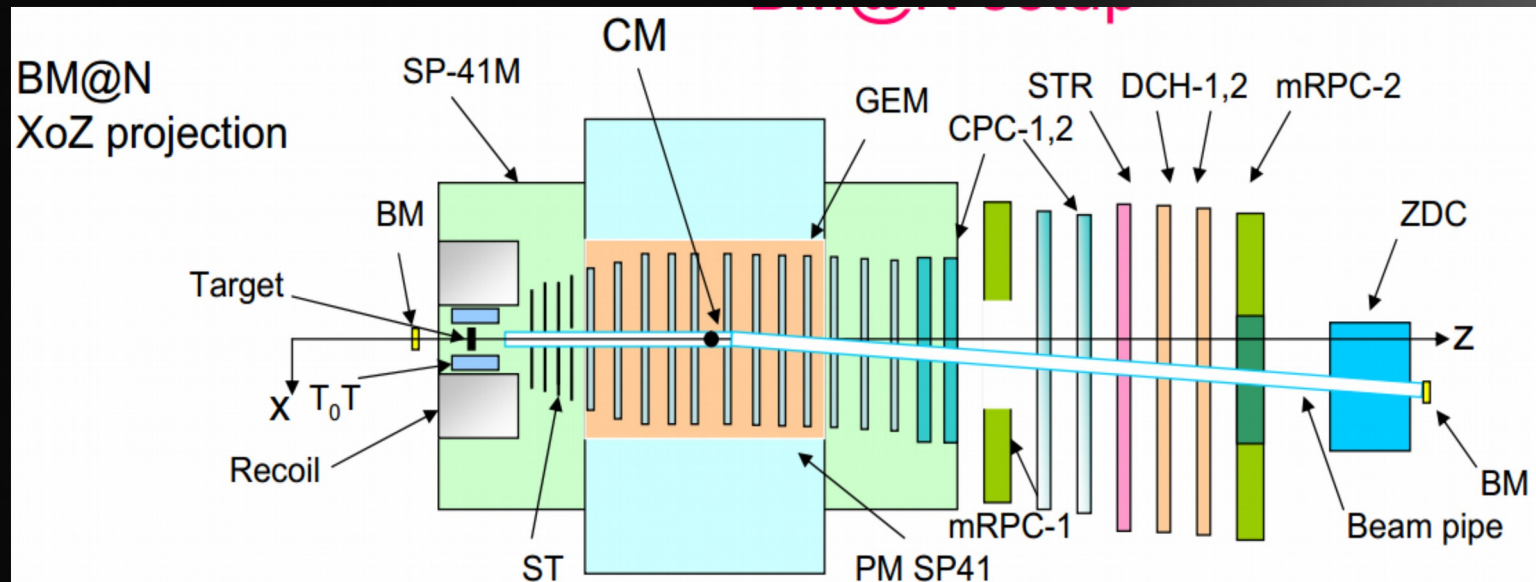
- Acts a mediator between single hardware device and multiple clients
- It allows simultaneous access to one device from one or more client applications

# NICA Project

$E_{\text{beam}} = 1\text{-}6 \text{ GeV/u}$ ; *beams: from p to Au*; Intensity  $\sim 10^9 \text{ c}^{-1}$  (Au),  $\sim 10^{12} \text{ c}^{-1}$  (p)



# BM@N detector



BM@N Schema

**GEM** → Gaseous Electron Multipliers

**ZDC** → Zero Degree Calorimeter

**TOF** → Time of Flight Detector

**CPC** → Cathode pad chamber

**TOT** → Fast Start Detector

**ECal** → Electromagnetic Calorimeter

**DCH** → Drift Chamber

**ST** → Straw tubes

Photo: BM@N project



# Connections between TileCal/BM@N/MPD detectors

Systems were built to detect particles

Particle react with medium in the detector

Transfer energy in some recognized ways (e.g Energy loss in material  
is a signature) ★

Systems were designed to measure particle interaction at high speed..

Systems require Detector readout electronics to shape, amplify and digitize signal produced by detectors medium.

Due to collision rate and volume output data, they rely on High throughput electronics for maximum readout efficiency.

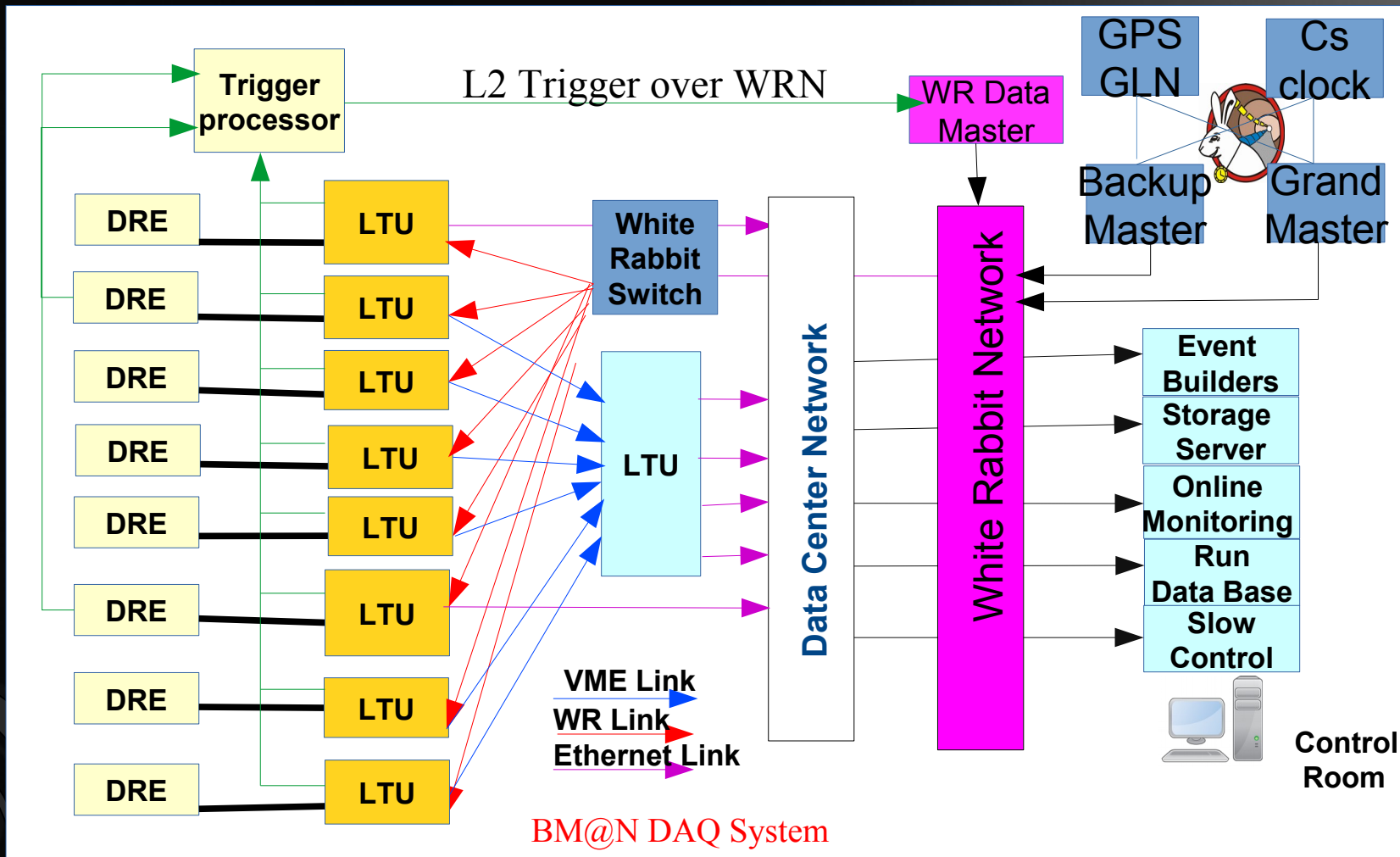
High throughput electronics

Maximum readout efficiency

No dead time with data selection and compression.

Reduces Large volume of data to scientific data with the help of fast and low latency triggers.

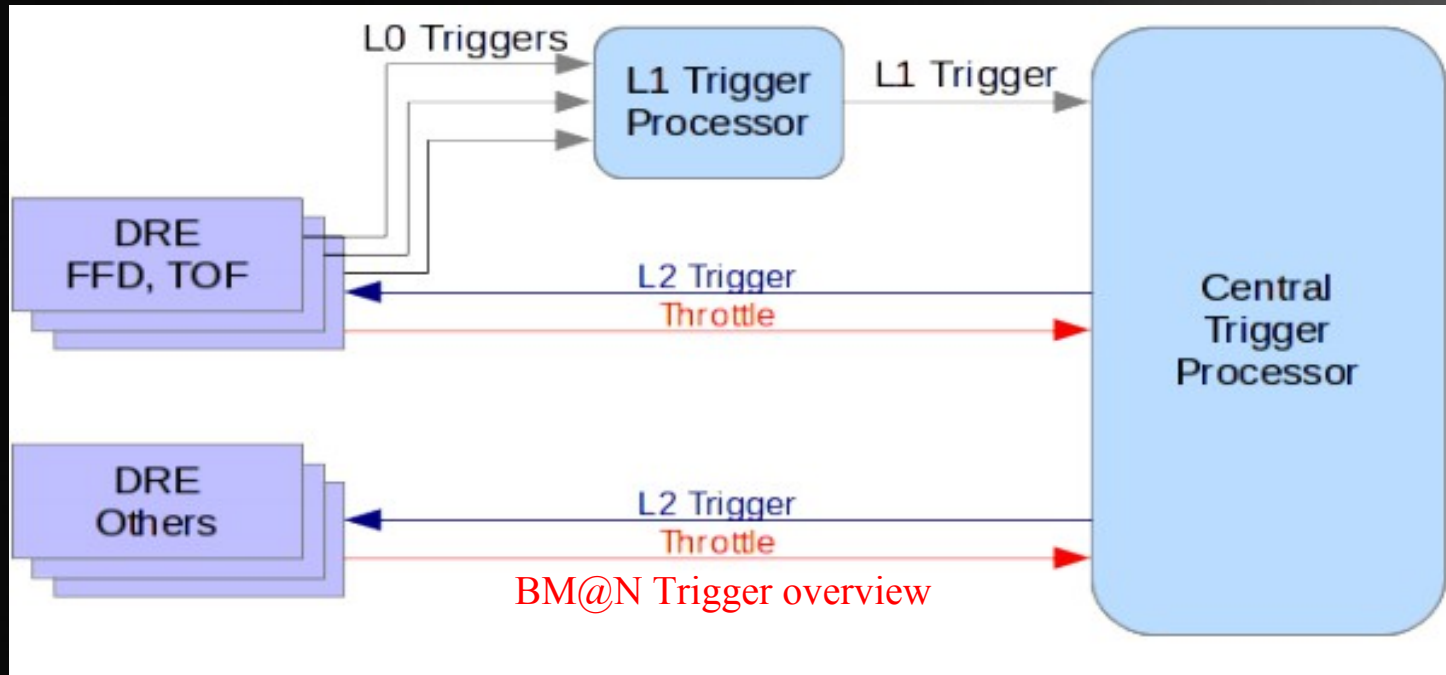
# BM@N DAQ System



**Detector Readout Electronics(DRE):** Time-stamping Time to digital converter(TDC), Amplitude to digital converter (ADC) and TQDC discrete signal counter.

**Local Trigger Unit(LTU):** Trigger signal distributor.

# DAQ trigger overview



**L1TP** and **CTP** are Hardware based trigger

**L1TP**: Processes logical level 0 trigger signals to produce L1 trigger

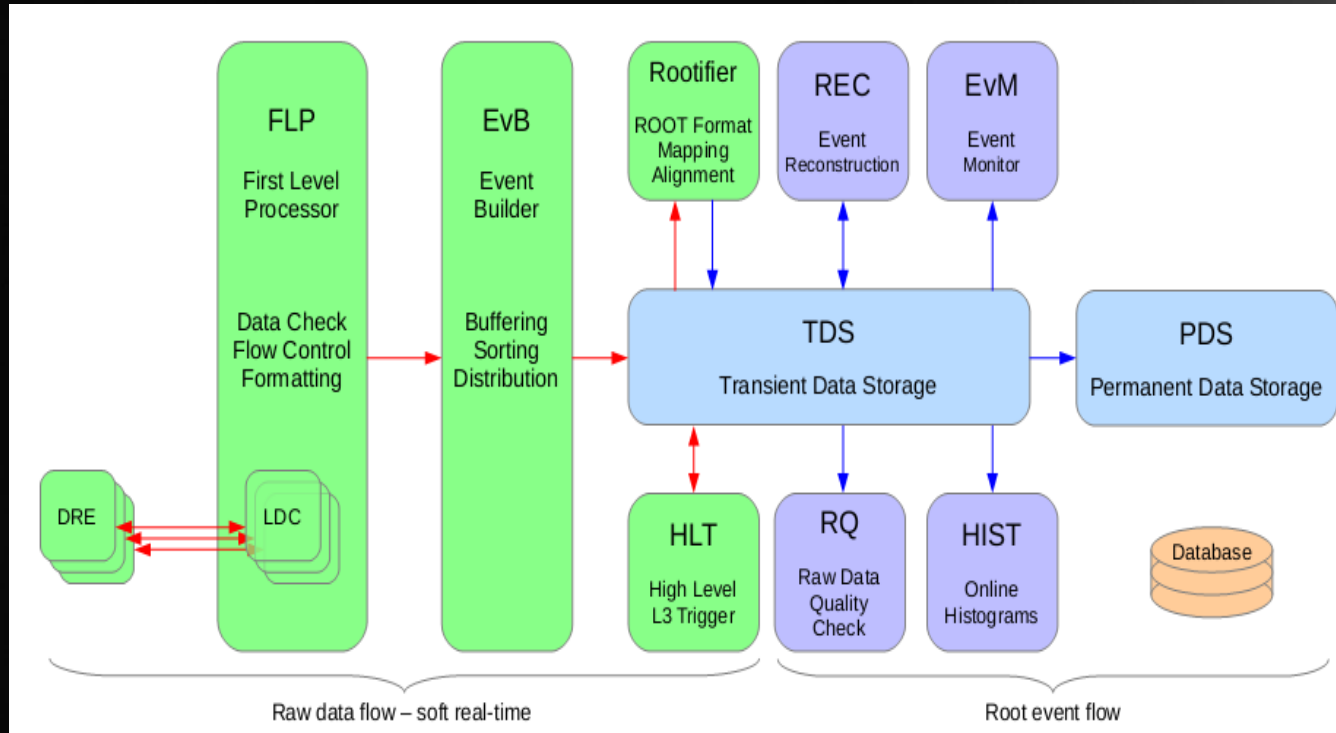
**CTP**: Uses the Level 1 trigger to issue L2 trigger to the DAQ system.

Performs time-stamping of incoming L1 trigger signal.

Time reference by GPS/GLONASS receivers and Cesium clock



# Data Flow



BM@N Data flow

**First Level Processor:** Runs basis data check and reduction algorithm.

Zero Suppression waveform compression.

Wits Proposed A general **purpose processing unit** used with ATLAS sROD for FLP and EvB. (work in progress)

# Summary/Outlook

Experiments to understand the universe produce big data with high event rate

High data throughput electronics are required:

To cope with event rate

To reduce data size to scientific data

Wits HEP group has sustained involvement in ATLAS Experiment

Detector

Software development

Physics analysis

## Outlook

Development of general purpose ARM-based processing unit for BM@N DAQ system

Contribution to physics analysis

**Thanks for listening :)**