

ATLAS Tile Calorimeter Detector Control Systems

FCT Follow-up meeting

Miguel F. Medeiros (EP-ADE-CA)

Supervisor: Henric Wilkens

December 2018



Agenda

- **Short Bio**
- **Trainee position**
- **ATLAS Tile Calorimeter**
 - Overview
 - From a DCS Expert perspective
- **DCS Developer**
 - Our role & responsibility
 - Finite State Machine (FSM)
 - Library development
 - Scripting
- **Testbeam & Upgrade activities**
- **Final Remarks**

- Natural from **Azores**



Trust me, there is land there...

- Natural from **Azores**



Trust me, there is land there...



ACADEMIC TRACK

- MSc in Electrical and Computer Engineering
→ Focus on Automation & Control
- BSc in Electrical and Computer Engineering
- BSc in Renewable Energy



IT BACKGROUND

- Cisco Certified Network Associate
→ Routing & Switching (CCNA)
→ Security (CCNAS)
→ Wireless (CCNAW)
- Certified Linux System Administrator (LPIC-1 & CompTIA Linux+)

EXTRA

- 1x  Award
- 5x  Publications
- 2x  Research projects

- Natural from **Azores**



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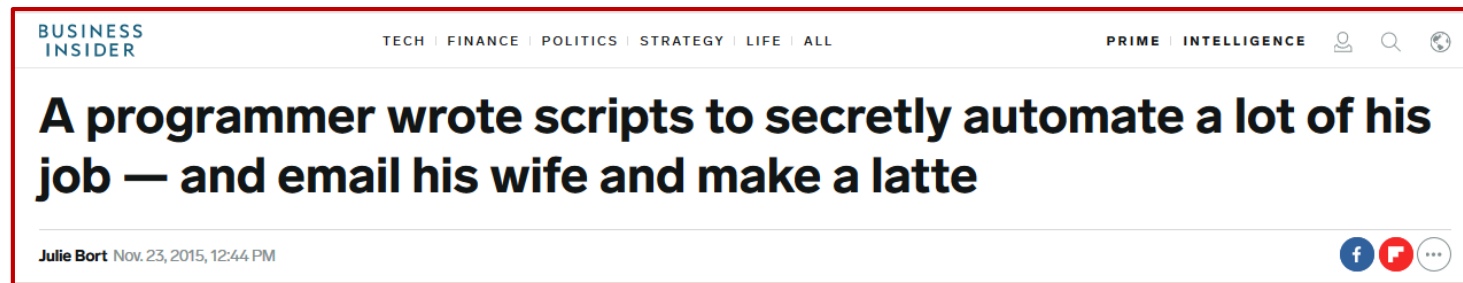
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EXTRA

- 1x Award
- 5x Publications
- 2x Research projects

My motivation [obviously]...



Trainee: ATLAS Tile Calorimeter Detector Control System (DCS)

Traineeship

- Started in May 2017
- Tasks:

- Software developer
- On-Call duties
- Testbeam & Upgrade activities

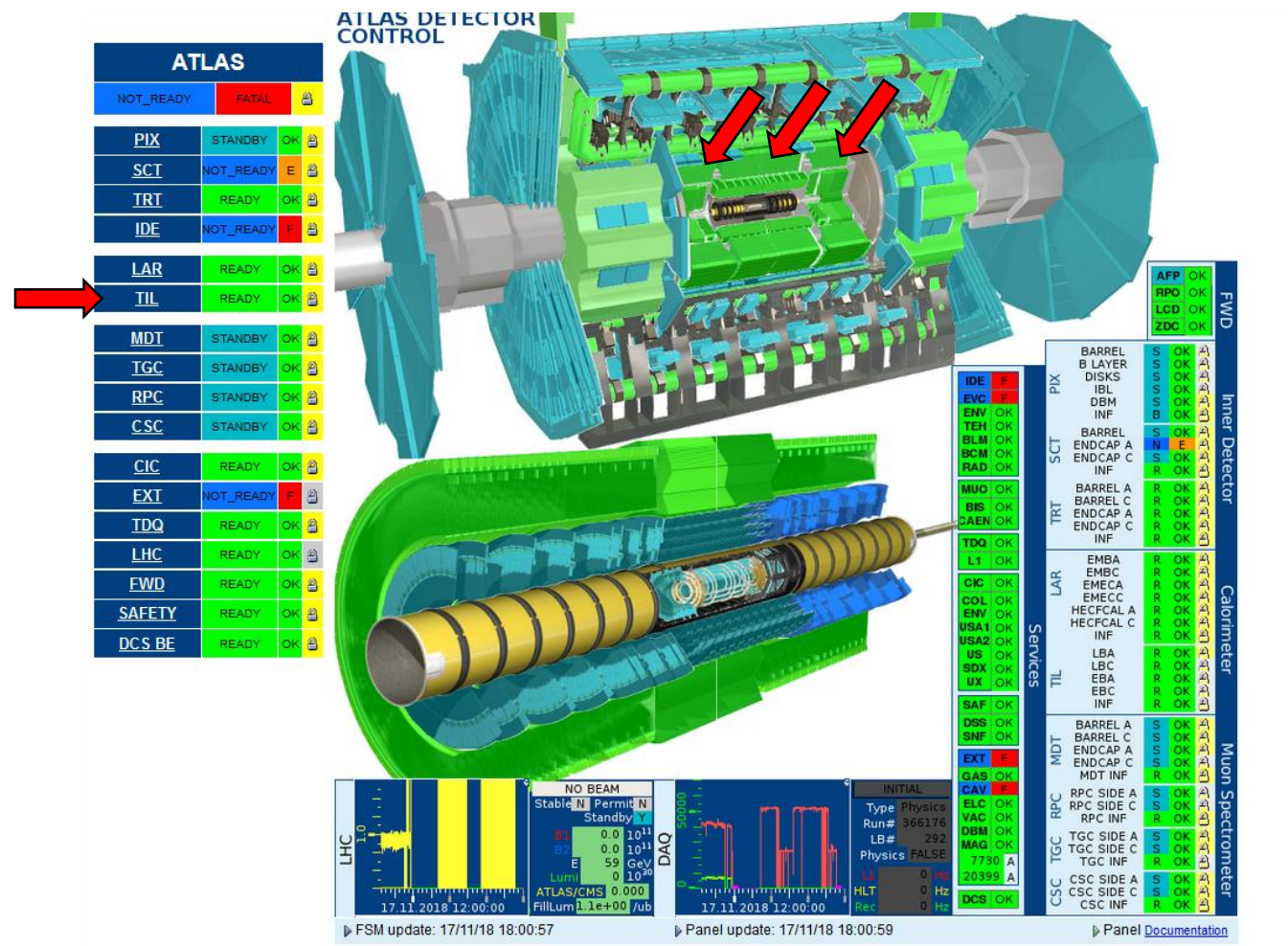
Supervisor:

→ Henric Wilkens

ATLAS Control Room



ATLAS DCS Finite State Machine (FSM)



ATLAS TILE Calorimeter Overview

What is used for?

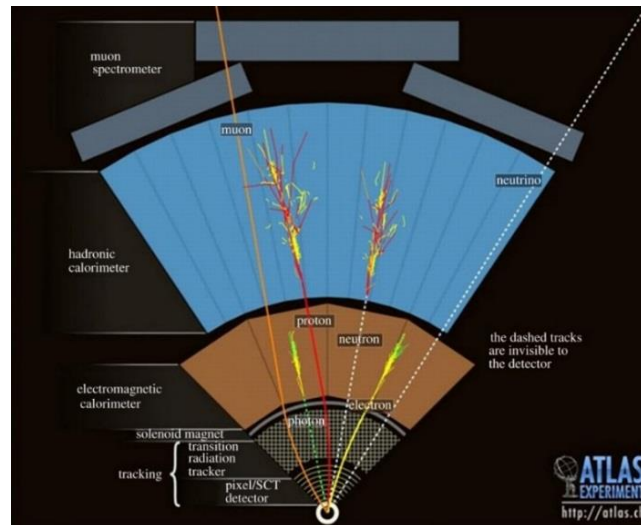
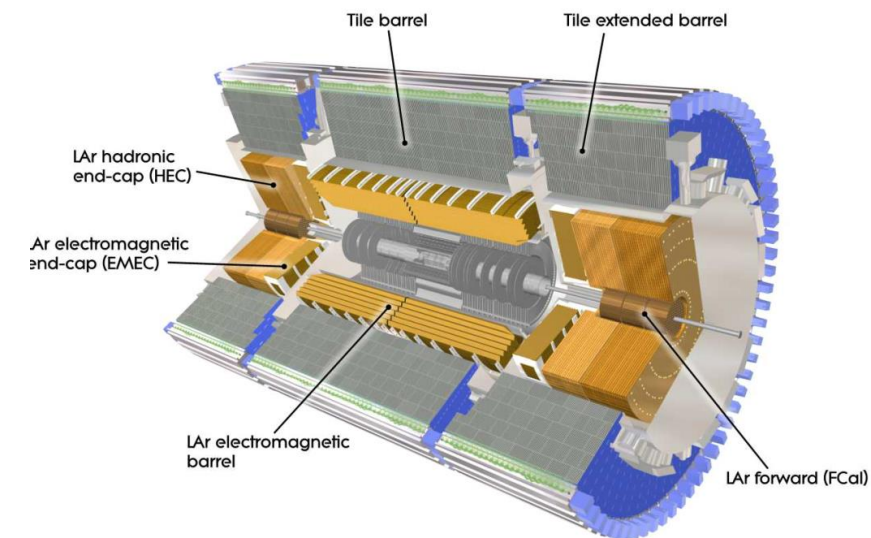
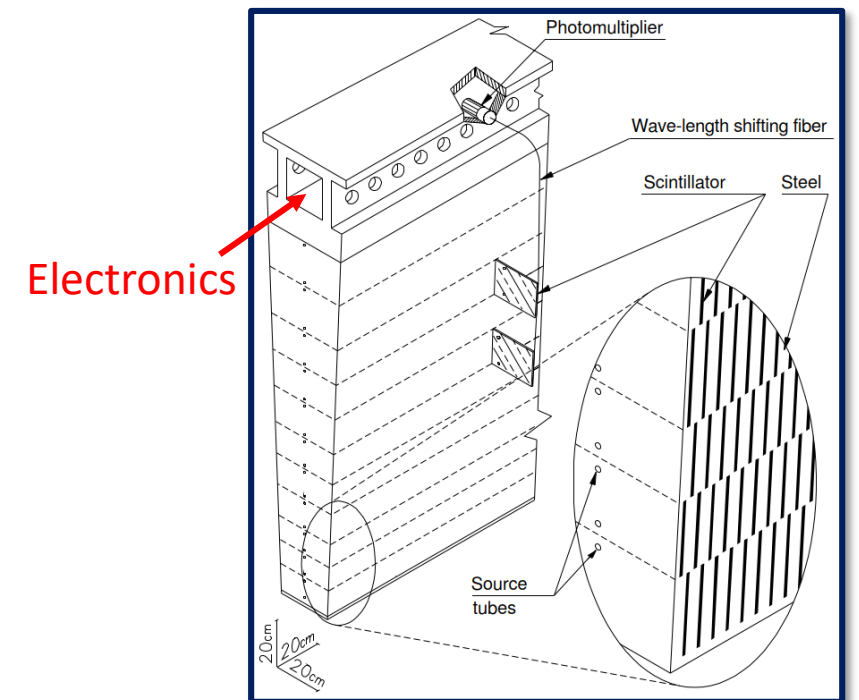
- Measure energy (jet & missing energy)

General Specifications:

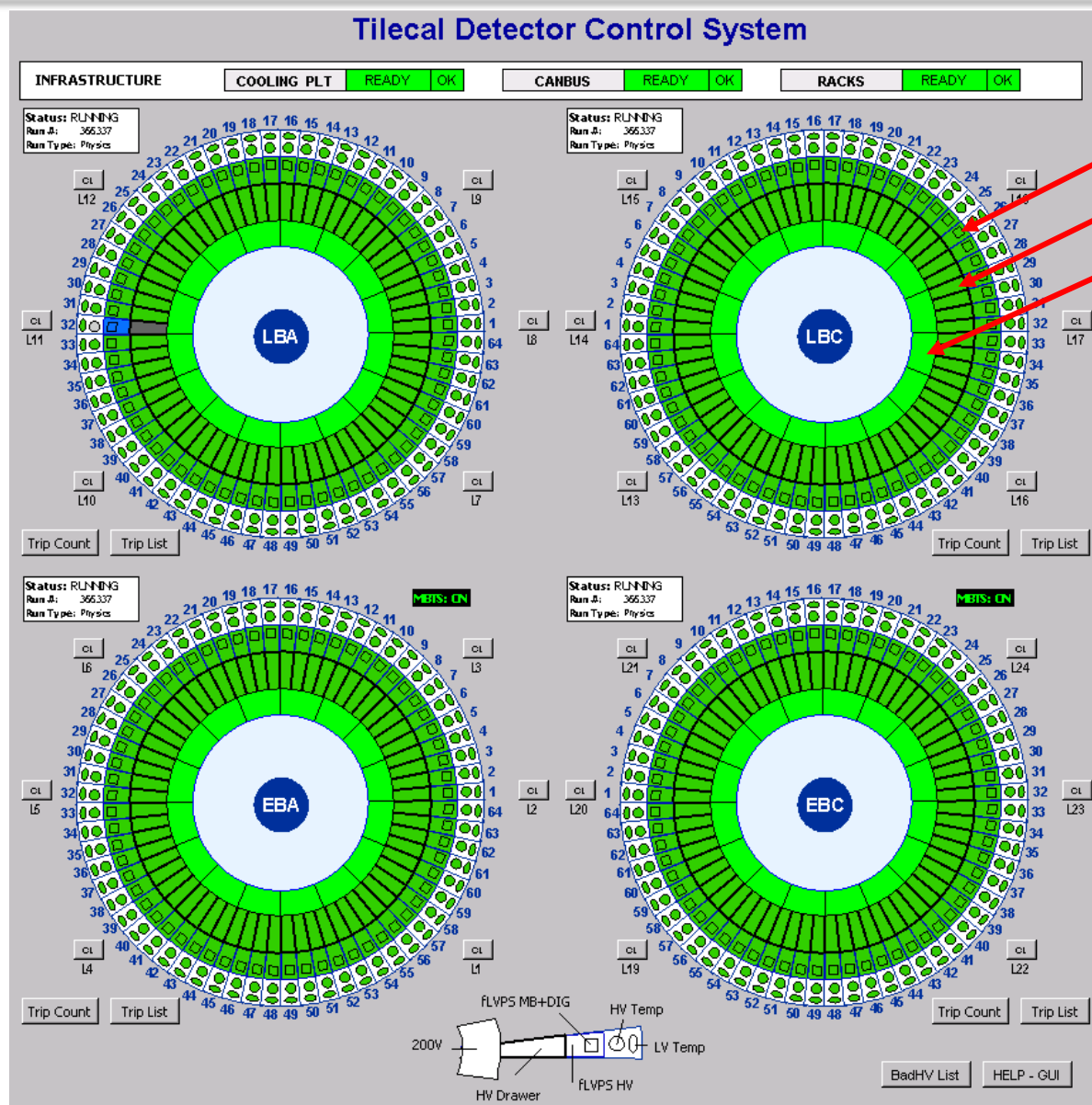
- Steel plates as passive absorber and scintillating tiles as active material
- ~10 000 Photomultiplier tubes (PMTs)
- Splited in 3 physical cylindrical sections (Total length = 12 meters)
 - Divided into 4 operation partitions: EBA, LBA, LBC, EBC
- Each partition is divided in 64 modules



1 Tile Module



From a DCS Expert perspective



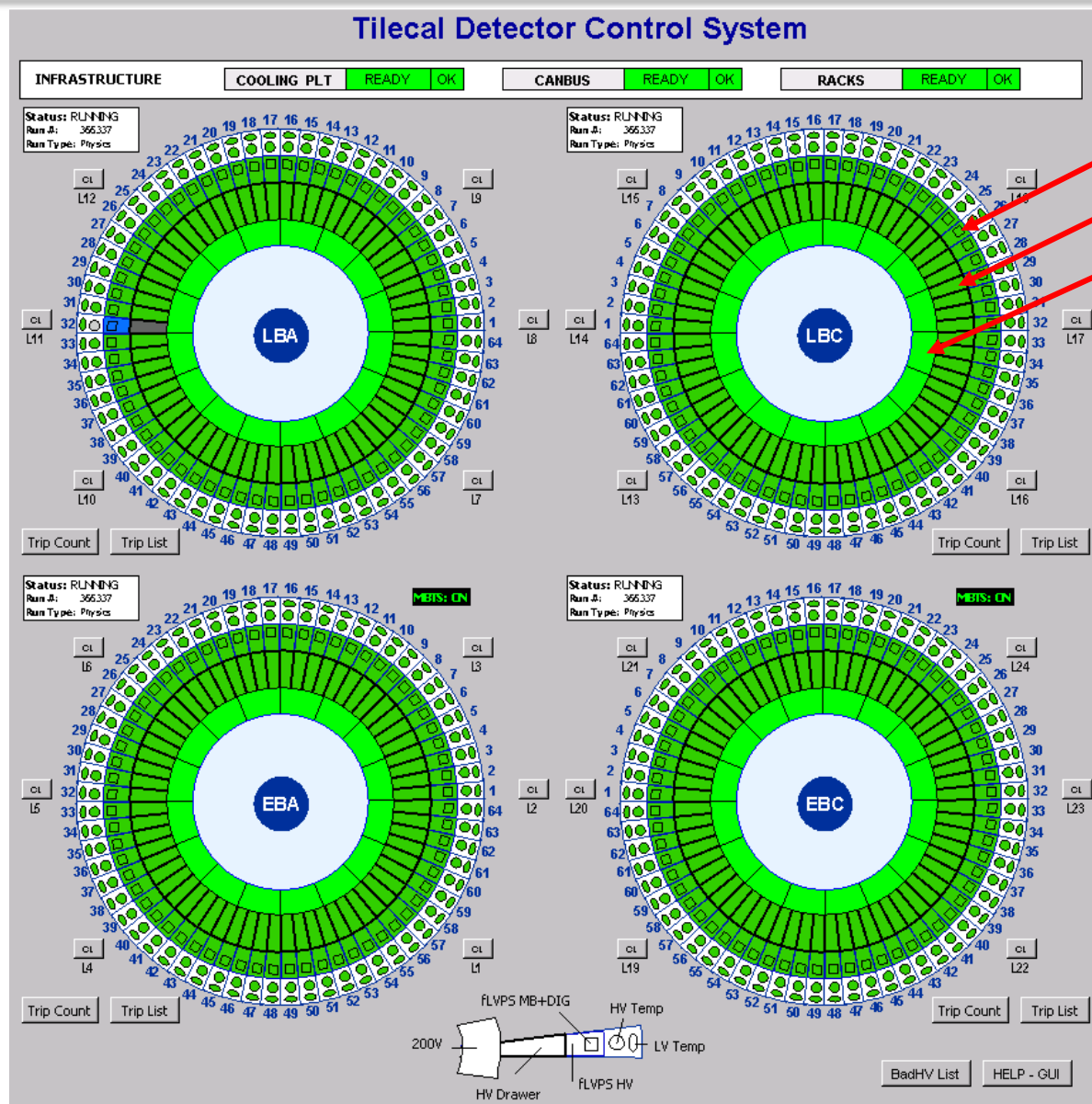
Full control & monitoring of electronics inside detector

Low Voltage Power Supply

Drawer (High Voltage)

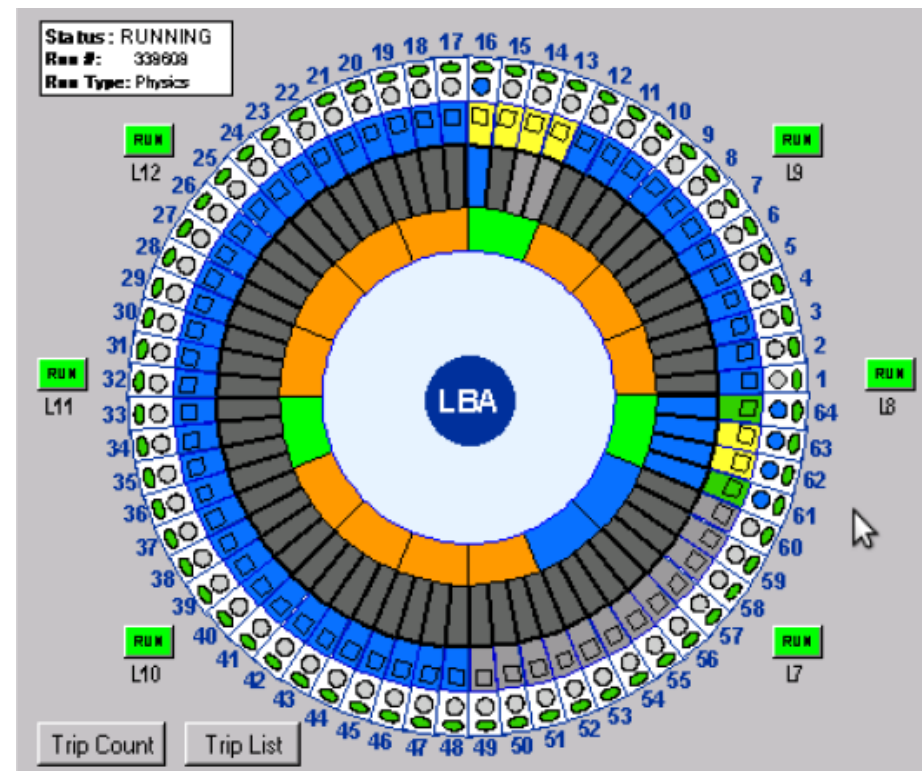
Low Voltage TDK (off-detector)

From a DCS Expert perspective



Full control & monitoring of electronics inside detector

- Low Voltage Power Supply
- Drawer (High Voltage)
- Low Voltage TDK (off-detector)



Our role & responsibility

Hardware that we are responsible for monitor & control:

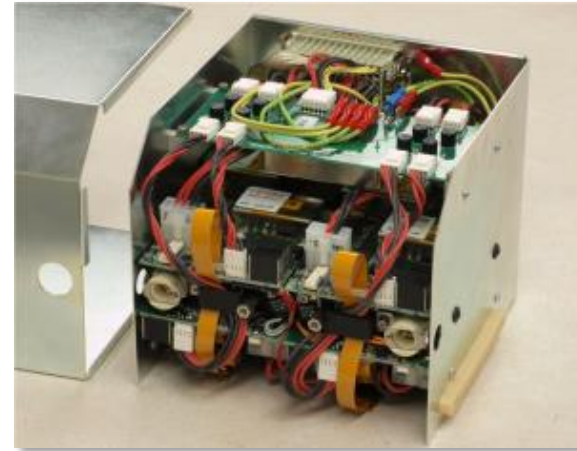
→ Front-End (On-Detector)

- Low Voltage Power Supplies (LVPS)
 - Embeded Local Monitor Board (ELMB)
- High Voltage system:
 - High voltage distribution boards (HV-Opto)
 - High voltage control & monitor (HV-Micro)

→ Back-End (Off-Detector)

- Auxiliary Boards (AUXBoards)
- Power Supplies:
 - High Voltage Power Supply (HVPS)
 - 200V DC TDK Power supply
 - CANbus power supplies (CAN PS)
- Wiener crates (supports Data Acquisition Infrastructure)
- Cooling system
- Laser system

LVPS



HV-Micro

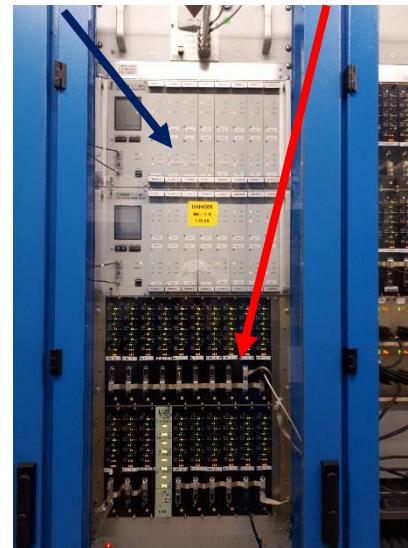


ELMB



HVPS

AuxBoards



200V DC TDK



FSM Panel Examples (1/2)

A major refurbishment of TileCal FSM panels

→ Facilitate the work of ATLAS CR & DCS OnCall Shifters

→ Monitor hardware states & FSM state propagation

Supervisory Control and Data Acquisition (SCADA)

WinCC-OA tool

Tile LBA Module 18
9:59:46 AM 03/08/2018

Infrastructure		
LBA_17_20_200V	ON	OK
Drawer18	ON	OK
AUXboard5	READY	OK

TDK Status

- Output Status
- Over temperature
- AC failure
- Over voltage
- Interlock/ENA
- Output Mode
- Remote Control

Output V 200.03 V

Output I 4.87 A

HV Channel Status

- ADC Overflow
- Overcurrent
- Undercurrent
- Over Tol Limit
- Under Tol Limit

Mode 830V

State ON

Output V 828.50 V

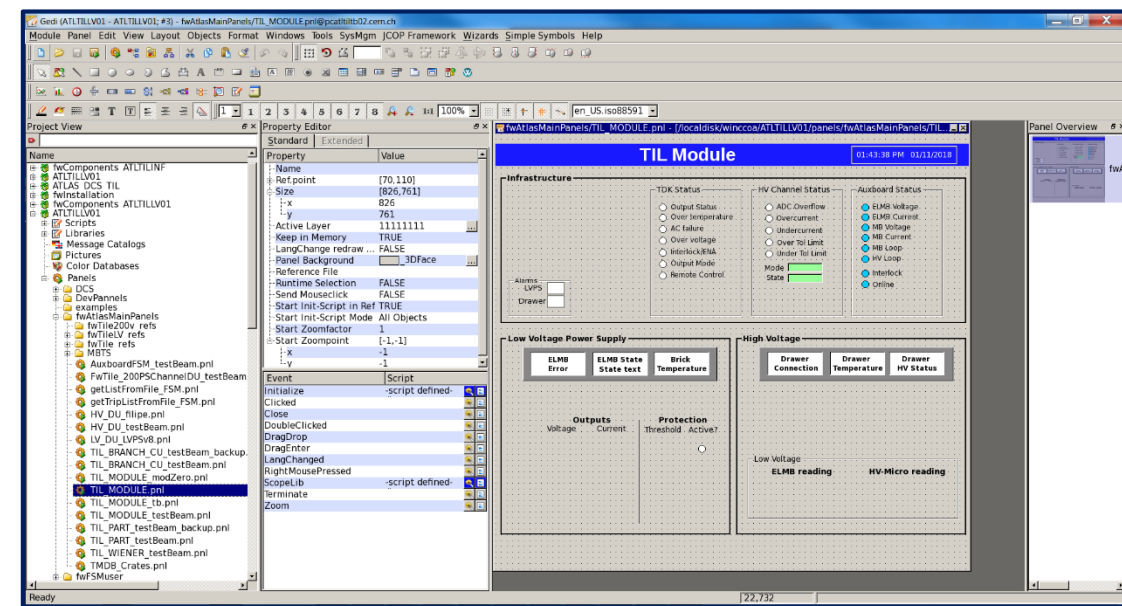
Output I 11.30 mA

Auxboard Status

- ELMB Voltage
- ELMB Current
- MB Voltage
- MB Current
- MB Loop
- HV Loop
- Interlock
- Online

Low Voltage Power Supply		
ELMB Error	ELMB State OP	Brick Temperature
Input V	194.26	V
TH1	20.75	C
TH2	19.96	C
Outputs		
Voltage	Current	
M5VMB	-5.21	V / 6.02 A
5VMB	5.37	V / 12.53 A
15VMB	14.53	V / 0.19 A
3VDIG	3.49	V / 5.06 A
5VDIG	5.25	V / 5.88 A
5VHV	5.00	V / 0.08 A
M15VHV	-14.50	V / 0.31 A
15VHV	14.49	V / 0.14 A
Protection		
Threshold	12.80	A
Active?	<input checked="" type="radio"/>	

High Voltage		
Drawer Connection	Drawer Temperature	Drawer HV Status
HV qrt 1 VIn	829.40	V / 26.00 C
HV qrt 2 VIn	829.00	V / 43.70 C
HV qrt 3 VIn	829.40	V
HV qrt 4 VIn	828.80	V
Low Voltage		
ELMB reading		HV-Micro reading
15VHV VOut	14.49	V / 14.37 V
M15VHV VOut	-14.50	V / 14.61 V
5VHV VOut	5.00	V / 4.95 V



FSM Panel Examples (2/2)

EBA - AUXboard3

Ch1

- ELMB Voltage
- ELMB Current
- MB Voltage
- MB Current
- MB Loop
- HV Loop

Ch2

- ELMB Voltage
- ELMB Current
- MB Voltage
- MB Current
- MB Loop
- HV Loop

Ch3

- ELMB Voltage
- ELMB Current
- MB Voltage
- MB Current
- MB Loop
- HV Loop

Ch4

- ELMB Voltage
- ELMB Current
- MB Voltage
- MB Current
- MB Loop
- HV Loop

- Interlock
- Online

Channel 1

	Voltage	Current
ELMB	10.79 V	30.03 mA
MB	13.96 V	144.51 mA
StartUp-Pulse	0.00 V	0.01 mA

Current Loops	
MB	9.90 mA
HV	9.48 mA

T1 37.26 C

EBA9

Channel 2

	Voltage	Current
ELMB	10.74 V	29.74 mA
MB	14.02 V	142.98 mA
StartUp-Pulse	0.01 V	0.00 mA

Current Loops	
MB	9.84 mA
HV	9.71 mA

T2 38.54 C

EBA10

Channel 3

	Voltage	Current
ELMB	10.82 V	29.58 mA
MB	13.79 V	146.79 mA
StartUp-Pulse	-0.01 V	0.00 mA

Current Loops	
MB	9.61 mA
HV	9.35 mA

T3 36.16 C

EBA11

Channel 4

	Voltage	Current
ELMB	10.76 V	30.13 mA
MB	13.85 V	143.13 mA
StartUp-Pulse	0.01 V	-0.00 mA

Current Loops	
MB	9.77 mA
HV	9.25 mA

T4 35.82 C

EBA12

Interlock current 5.13 mA

Last status update

2018.09.20 09:13:45.502

Expert Actions

Change Temp Alarm Range

TilePlant/Loop09

8:49:10 AM 24/09/2018

Loop State ON

Loop Status OK

Driver status OK

PLC connection OK

	LVPS Temperatures			Drawer Temperatures	
	TH1	TH2	5VMB	HV-Micro	PMT
LBA16	25.8 C	24.3 C	39.6 C	29.2 C	24.3 C
LBA15	24.7 C	26.5 C	44.4 C	29.1 C	26.8 C
LBA14	23.8 C	25.4 C	43.0 C	23.4 C	23.5 C
LBA13	23.3 C	24.5 C	39.9 C	28.5 C	23.0 C
LBA12	23.2 C	24.1 C	38.9 C	30.7 C	24.0 C
LBA11	20.8 C	19.8 C	33.8 C	28.4 C	25.2 C
LBA10	22.1 C	23.1 C	41.7 C	28.0 C	23.3 C
LBA9	22.9 C	21.9 C	37.5 C	28.6 C	23.9 C
LBA8	22.7 C	21.4 C	37.1 C	28.0 C	20.9 C
LBA7	21.9 C	21.2 C	38.2 C	27.8 C	21.5 C
LBA6	21.5 C	22.1 C	46.1 C	27.8 C	21.6 C
LBA5	21.1 C	22.3 C	40.6 C	27.7 C	22.3 C

Outlet_T 16.5 C Inlet_T 18.1 C

PPVCycle 40.8 min

Tile Plant

TilePlant

Loop Status

Pressure bar

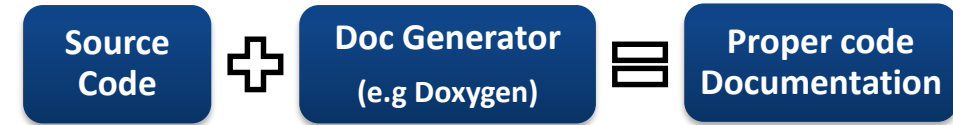
ValveSetPoint

DCS Developer Library development

Behind the user interface layer, there is significant code running on backend...

Why should we care about libraries?

- Avoid duplicated code → Improves System Integration
- Centralizes code → Eases feature deployment
- Better documentation! → Avoids “pain” for future developers



```
Functions # x
tileMain_getDAQInfo 211
tileMain_getLVCAN 213
tileMain_getModulesCoolingLoop 214
tileMain_getPart 215
tileMain_getRepoPath 216
tileMain_getSysName 217
tileMain_getSystemNameClean 218
tileMain_printInfo 219
tileMain_sendSMS 220

221 @param[out] daqInfo returns dynamic string with daq information [State, RunNumber, RunType, Lumblock].
222 @return returns 0 if success and -1 if failed
223 /
224 int tileMain_getDAQInfo(dyn_string &daqInfo, string sysName=""){
225     if(sysName=="") sysName=getSystemName();
226     const string PART_NAME = tileMain_getPart(sysName);
227     const string DP_DAQ_STATE="ATLILSCS:DAQ"+PART_NAME+".DAQstate:online:.._value";
228     const string DP_RUN_NUMBER="ATLILSCS:DAQ"+PART_NAME+".runNumber:.._value";
229     const string DP_RUN_TYPE="ATLILSCS:DAQ"+PART_NAME+".runType:.._value";
230     const string DP_LUMBLOCK="ATLILSCS:DAQ"+PART_NAME+".LumblockNumber:original:.._value";
231
232     dyn_string DAQ_STATES = makeDynString("ERROR","NONE","INITIAL","CONFIG","CONNECT",
233     "READY","RUNNING","PAUSED","ROSTOPPED",
234     "LVSVSTOPPED","EBSTOPPED","EFSTOPPED");
235
236     int DAQ_state, DAQ_runNumber, DAQ_runType, DAQ_lumblock ;
237     int ret=0;
238     string runType;
239     daqInfo=makeDynString("", "", "", "");
240
241     if (dpExists(DP_DAQ_STATE) && dpExists(DP_RUN_NUMBER) && dpExists(DP_RUN_TYPE) && dpExists(DP_LUMBLOCK)){ // check connection to ATLILSCS
242
243         ret=dpGet(DP_DAQ_STATE, DAQ_state,
244         DP_RUN_NUMBER, DAQ_runNumber,
245         DP_RUN_TYPE, DAQ_runType,
246         DP_LUMBLOCK, DAQ_lumblock);
247
248         if{ret!=0} { // Failed dpGet
249             DebugTN(_FUNCTION_, "Error: Failed to dpGet DAQ info.");
250             return -1;
251         }
252
253         //--- Run type translation
254         switch(DAQ_runType){
255             case 0: runType="Unknown"; break;
256             case 1: runType="Physics"; break;
257             case 2: runType="LED/Laser"; break;
258             case 4: runType="Pedestal"; break;
259         }
260     }
```

tileMain.c File Reference

Functions

string	tileMain_getSysName	(string part)
string	tileMain_getSystemNameClean	(string sysName="")
string	tileMain_getPart	(string sysName)
int	tileMain_printInfo	(string file_path, string message, bool timeStamp=true)
int	tileMain_sendSMS	(string network, string send_group, string send_subject, string send_message)
int	tileMain_getDAQInfo	(dyn_string &daqInfo, string sysName="")
string	tileMain_getLVCAN	(int boxNumber)
string	tileMain_getRepoPath	()
int	tileMain_getModulesCoolingLoop	(int loop, dyn_int & modulesInLoop)

Detailed Description

Description:
This is the master library of TileCal DCS. All common tools should be placed here.

NOTE: DO NOT CALL OTHER LIBRARIES FROM THIS ONE (Except Framework Libraries)

Dependencies:
email.ct

Usage:
LIBRARY

Author:
Tile DCS Team

Function Documentation

int tileMain_getDAQInfo (dyn_string & daqInfo, string sysName = "")

Description:
Get the TileCal Run information from the DAQ system.

Parameters:
[out] daqInfo returns dynamic string with daq information [State, RunNumber, RunType, Lumblock].

Returns:
returns 0 if success and -1 if failed

string tileMain_getLVCAN (int boxNumber)

Description:
Get the LVCAN for a specific LVPS box.

Parameters:
boxNumber the number of the LVPS box

Returns:
the LVCAN of the LVPS box

int tileMain_getModulesCoolingLoop (int loop, dyn_int & modulesInLoop)

Why should we care about logs?

- System Health monitoring
- Contributes to system improvement (bug fixes, etc)
- In case of issues:
 - “Re-live” the event → Understand how & why it happened
 - Improve the *post-mortem* analysis
 - Avoid issue in the future

Issue: No timestamps

Makes event tracking impossible

```
[ "Start ramping > " ] [ "oldDAC=" ] [ 4095 ] [ "DAC=" ] [ 3350 ]
[ "Trim (box, a, DACvalue) " ] [ "ELMB/LVCAN3/LVPS_44" ] [ "MSV
[ "Start ramping > " ] [ "oldDAC=" ] [ 4095 ] [ "DAC=" ] [ 3545 ]
[ "Trim (box, a, DACvalue) " ] [ "ELMB/LVCAN3/LVPS_44" ] [ "MIS
```

Issue: No message context

Message belongs to which process?

```
2014.09.14 12:17:20.235 [ "Running version with ls delay" ]
```

Issue: Developer Debug messages

Populating Logs → Disk Filling

```
5: "ELMB/LVCAN4/LVPS_1"
6: "ELMB/LVCAN4/LVPS_2"
7: "ELMB/LVCAN4/LVPS_3"
8: "ELMB/LVCAN4/LVPS_4"
] [ "ELMB/LVCAN3/LVPS_44" ]
2014.09.14 12:17:31.858 [ dyn_string 8 items
1: "ELMB/LVCAN2/LVPS_37"
2: "ELMB/LVCAN2/LVPS_38"
```

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8: "ELMB/LVCAN4/LVPS_4"
] [ "ELMB/LVCAN3/LVPS_44" ]
2014.09.14 12:17:31.858[dyn_string 8 items
1: "ELMB/LVCAN2/LVPS_37"
2: "ELMB/LVCAN2/LVPS_38"
```

Continuous effort on improving our logging system

- Log anything that can be useful in the future
- Several new tools & logs available

```
2018.08.09 21:00:11.575, ATLTILLV02:ELMB/LVCAN4/LVPS_7,8100,44,28,1,0,CAN communication
2018.08.09 21:00:11.575, ATLTILLV02:ELMB/LVCAN4/LVPS_8,8100,44,28,1,0,CAN communication
2018.08.24 07:17:04.231, ATLTILLV02:ELMB/LVCAN2/LVPS_39,5000,1,35,0,0,ADC conversion timeout
2018.09.09 03:25:47.012, ATLTILLV02:ELMB/LVCAN3/LVPS_41,5000,1,3b,0,0,ADC conversion timeout
```

Operations routine? Automate it! (1/2)

DCS Data Viewer (DDV) → ATLAS DCS web interface tool that allows user to check DCS data & alarms

1. Select Alarms

2. Select Time

3. Select Sub-detector

4. Yet another Select... (System)

5. Query the data

6. Check the data

The routine:

1. Select Alarms
2. Select Time
3. Select Sub-detector
4. Yet another Select... (System)
5. Query the data
6. Check the data
7. Repeat steps 4-5 to check full TileCal...

Imagine doing it several times a day...

Not compliant with “my automation mantra”...

Operations routine? Automate it! (2/2)

```
[mfontesm@lxplus007 alarmsGet]$ ./PullAlarms.py -h
usage: PullAlarms.py [-h] [-p [partition [partition ...]]]
                  [-t [period [period ...]]]

-----
This script gets the Alarms for TileDCS from DDV
-----
@author: Miguel F. Medeiros
@contact: miguel.fontes.medeiros@cern.ch

optional arguments:
  -h, --help            show this help message and exit
  -p [partition [partition ...]]
                        Select partition: EBA, LBA, LBC, EBC. (default=ALL)
  -t [period [period ...]]
                        Time period:
                        -t (from "dd-mm-year" (to) "dd-mm-year"
                        -t 3 (last 3 days)
                        -t 1 (last day) [default]
-----
```

The full sequence of previous page is replaced by:

```
[mfontesm@lxplus007 alarmsGet]$ ./PullAlarms.py
```

```
TIL EBC Drawer 7 PMT 17 Output Voltage status W fwWarningNack WARNING 0.000 28-04-2018 13:06:03:498 went
TIL EBC Drawer 7 PMT 18 Output Voltage status E fwErrorNack ALERT 0.000 28-04-2018 13:06:03:507 went
TIL EBC Drawer 7 PMT 18 Output Voltage status W fwWarningNack WARNING 0.000 28-04-2018 13:06:03:507 went
TIL EBC AUXboard AUXboard2 noToggle E fwErrorNack no toggle != 5 127.000 28-04-2018 13:06:05:021 came
TIL EBC LVCAN4 LVPS_7 noToggle E fwErrorNack no toggle != 5 5.000 28-04-2018 13:06:05:040 went
TIL EBC Drawer 7 State E fwErrorNack NO CONNECTION -1.000 28-04-2018 13:06:05:246 went
TIL EBC Drawer 7 PMT 21 Output Voltage status E fwErrorNack ALERT -5.000 28-04-2018 13:06:09:261 went
TIL EBC Drawer 7 PMT 21 Output Voltage status W fwWarningNack WARNING -5.000 28-04-2018 13:06:09:261 went
TIL EBC Drawer 7 PMT 22 Output Voltage status E fwErrorNack ALERT -5.000 28-04-2018 13:06:09:279 went
TIL EBC Drawer 7 PMT 22 Output Voltage status W fwWarningNack WARNING -5.000 28-04-2018 13:06:09:279 went
TIL EBC Drawer 7 PMT 23 Output Voltage status E fwErrorNack ALERT -5.000 28-04-2018 13:06:09:288 went
TIL EBC Drawer 7 PMT 23 Output Voltage status W fwWarningNack WARNING -5.000 28-04-2018 13:06:09:288 went
TIL EBC Drawer 7 Voltage Reference vFix1 W fwWarningNack WARNING 2.000 28-04-2018 13:06:09:855 came
TIL EBC Drawer 7 Voltage Reference vFix1 E fwErrorNack ALERT 2.000 28-04-2018 13:06:09:855 came
TIL EBC AUXboard AUXboard2 noToggle E fwErrorNack no toggle != 5 5.000 28-04-2018 13:06:15:021 went
TIL EBC Drawer 58 PMT 22 Output Voltage status W fwWarningNack WARNING 1.000 28-04-2018 19:49:19:753 came
TIL EBC Drawer 58 PMT 22 Output Voltage status W fwWarningNack WARNING 0.000 28-04-2018 19:49:29:747 went
TIL EBC Drawer 7 Voltage Reference vFix1 E fwErrorNack ALERT 0.000 28-04-2018 21:24:07:528 went
TIL EBC Drawer 7 Voltage Reference vFix1 W fwWarningNack WARNING 0.000 28-04-2018 21:24:07:528 went
TIL EBC Drawer 58 PMT 22 Output Voltage status W fwWarningNack WARNING 1.000 28-04-2018 22:09:20:314 came
TIL EBC Drawer 58 PMT 22 Output Voltage status W fwWarningNack WARNING 0.000 28-04-2018 22:09:30:300 went
TIL EBC Drawer 58 PMT 22 Output Voltage status W fwWarningNack WARNING 1.000 29-04-2018 00:24:20:550 came
TIL EBC Drawer 58 PMT 22 Output Voltage status W fwWarningNack WARNING 0.000 29-04-2018 00:24:30:572 went
```

After you have them in plain text...

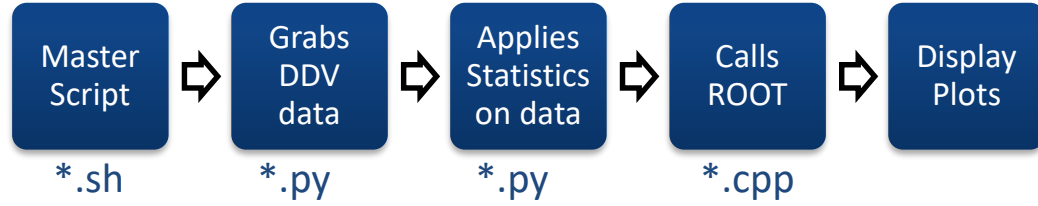
- Apply meaningful statistics
- Better reports for maintenance
- Go beyond in the automation...



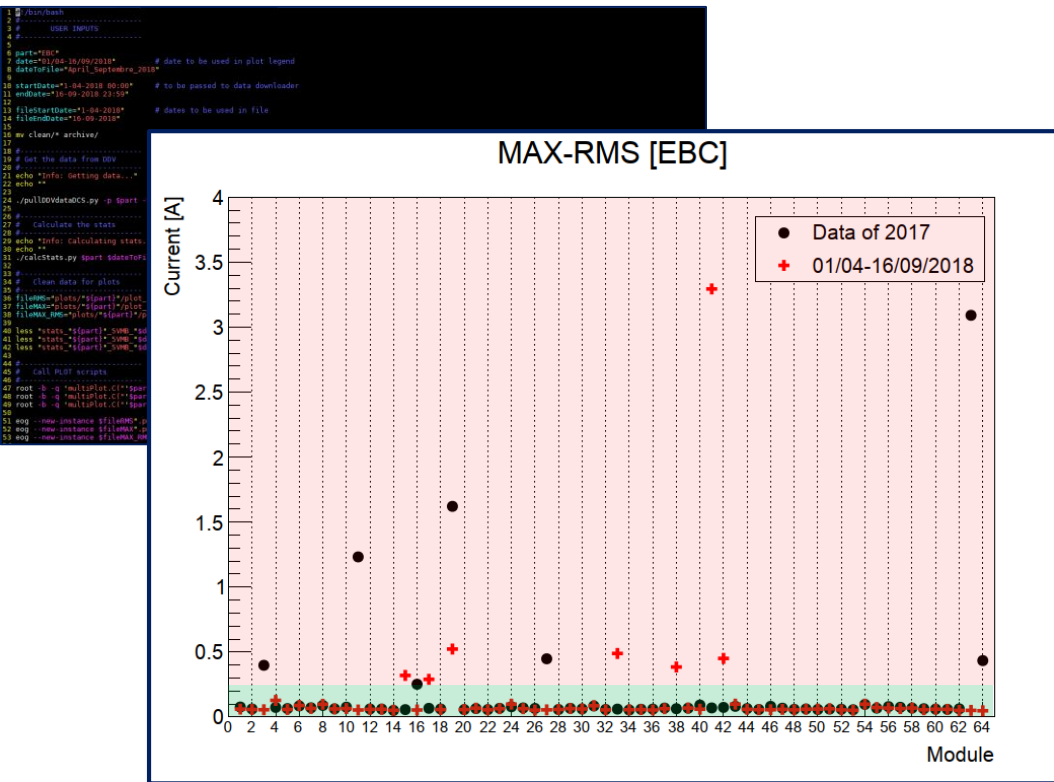
<https://gitlab.cern.ch/mfontesm/public>

→ You can also find there a script for sending Emails & SMS using shell

Spotting overcurrents of LVPS [Offline]



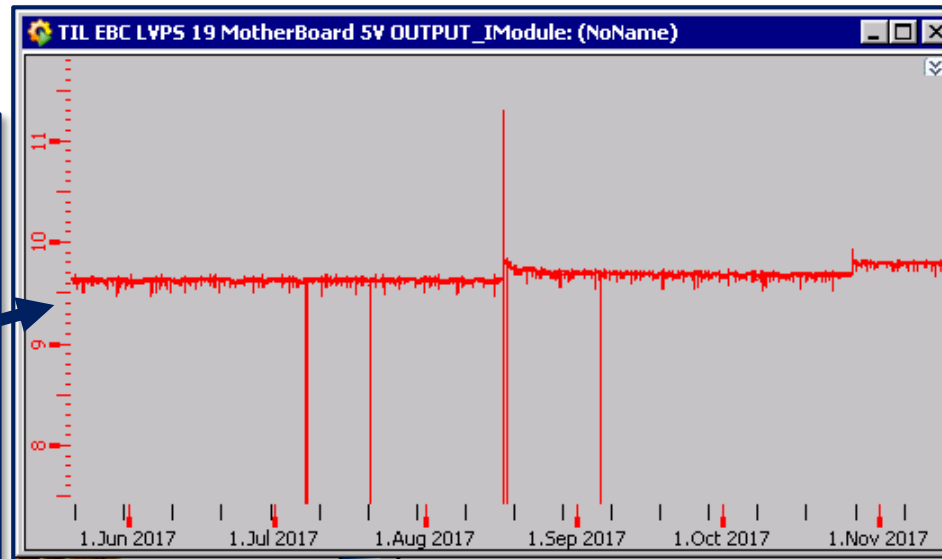
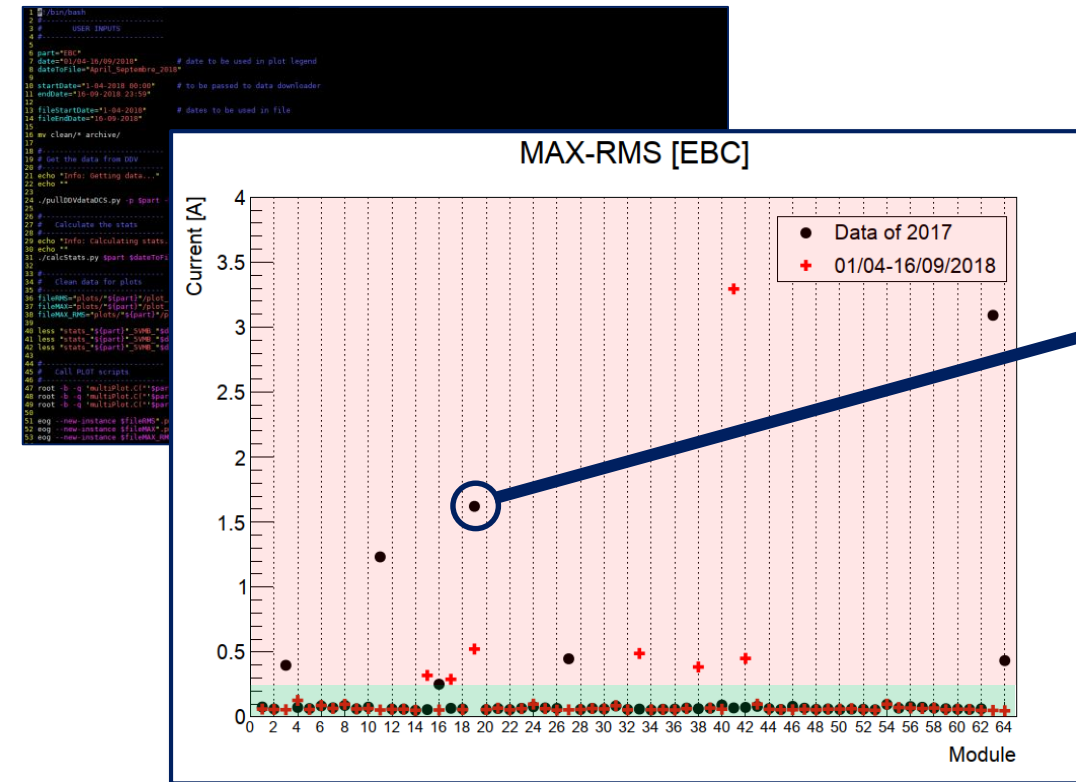
Spot overcurrents (and activates DCS protection) of Low Voltage Power Supply (LVPS) 5V Output Current



Spotting overcurrents of LVPS [Offline]



Spot overcurrents (and activates DCS protection) of Low Voltage Power Supply (LVPS) 5V Output Current



We report to calibration experts (crosscheck) If Bad → Flag for maintenance

After maintenance...



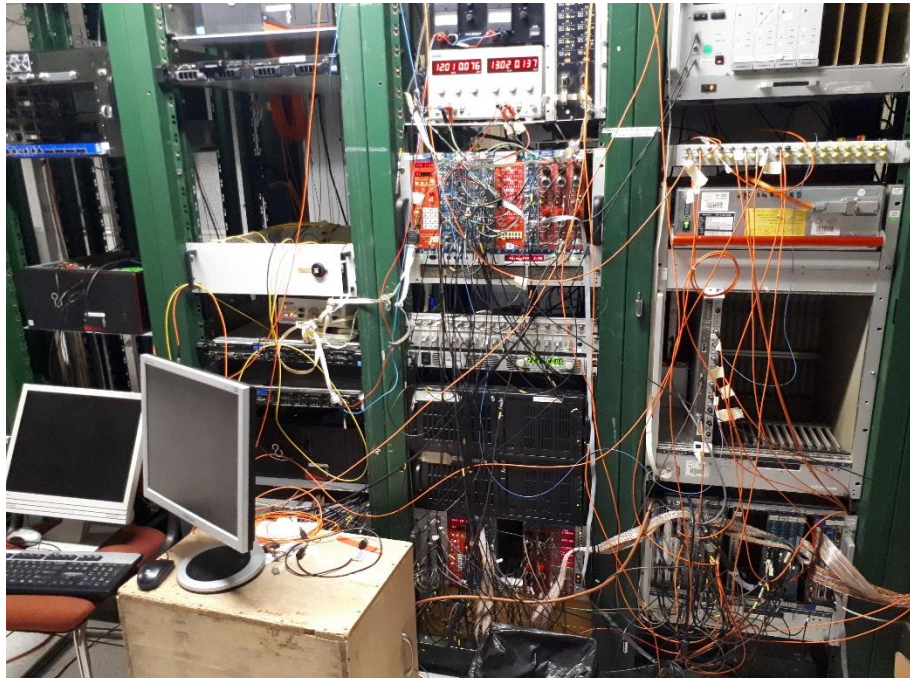
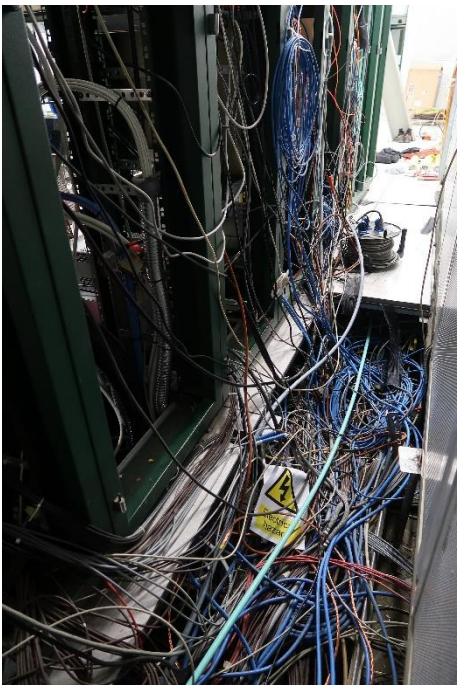
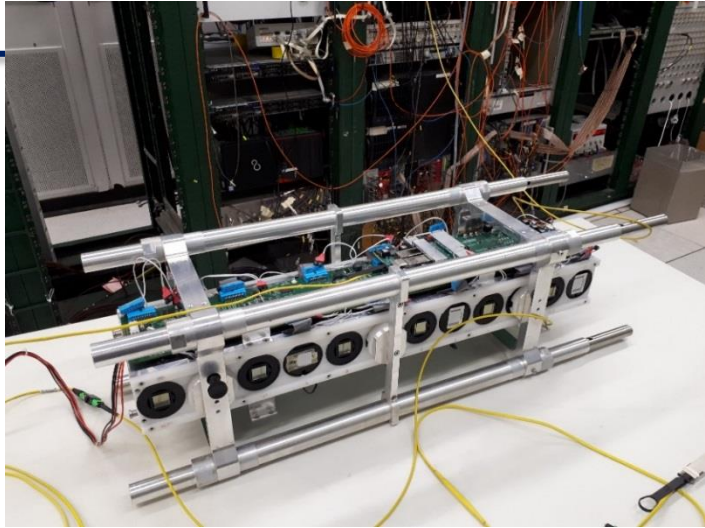
Testbeam & Upgrade Activities (1/2)

What do we do at Testbeams? ... and why?

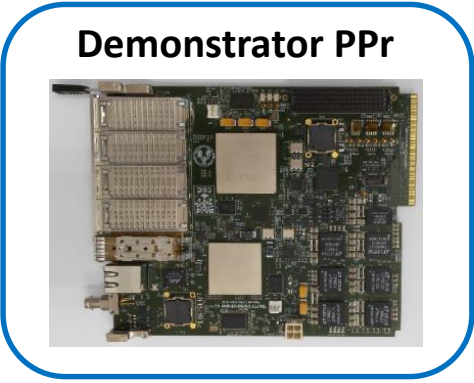
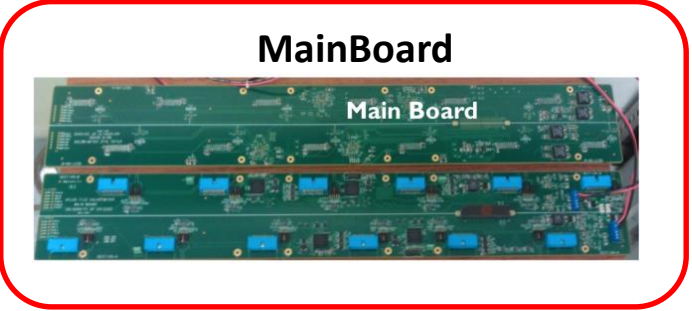
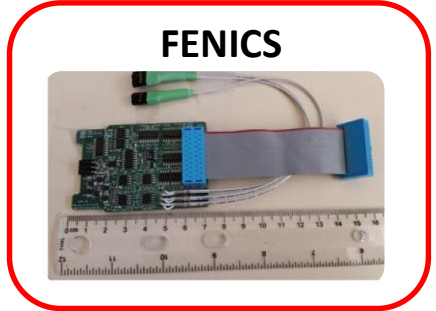
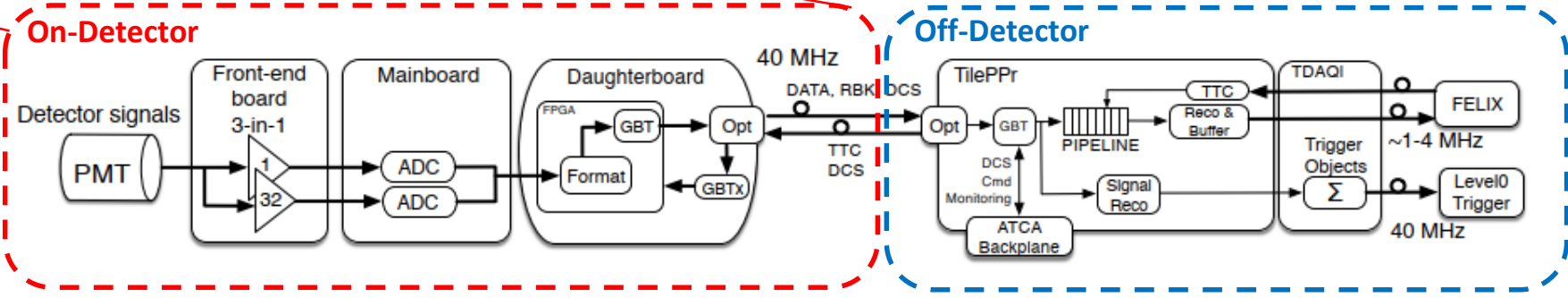
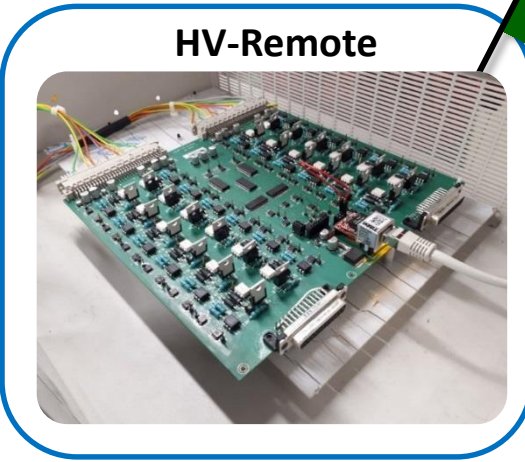
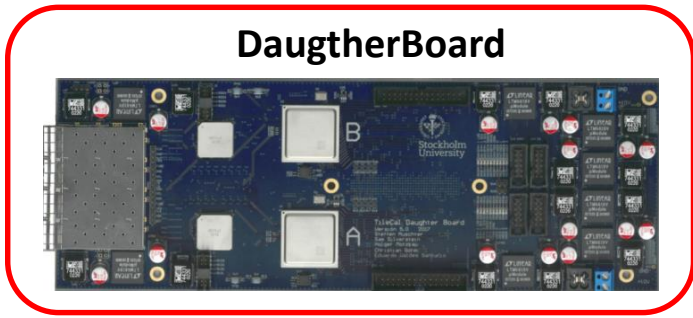
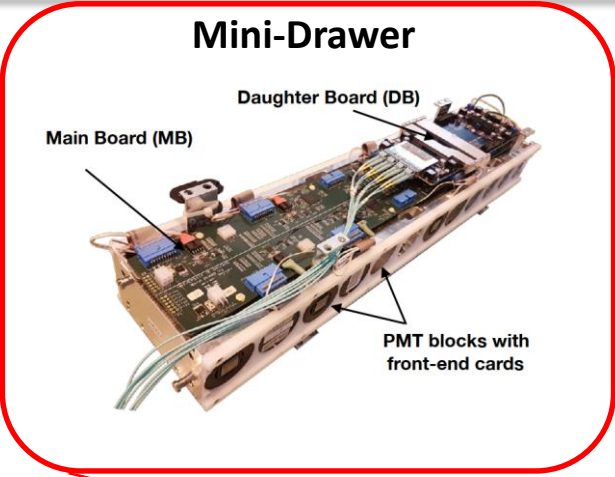
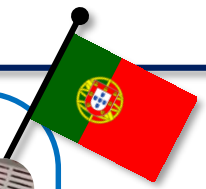
*“There are known knowns. These are things we know that we know.
There are known unknowns. That is to say, there are things that we know we don't know.
But there are also unknown unknowns. There are things we don't know we don't know.”*

-Donald Rumsfeld

Objective → Validate TileCal electronics for Phase-II Upgrade




Testbeam & Upgrade Activities (2/2)



Training & Other opportunities

“Learning never exhausts the mind.”
— Leonardo da Vinci

Formal training

- JCOP Framework and WinCC-OA
- JCOP Finite State Machines
- International School of Trigger and Data Acquisition (ISOTDAQ18)
- C++ Part 1: Hands-On Introduction
- First Aider 
- Self-Rescue Mask



Other learnings

- LabVIEW workshop
- Summer Student Lectures
- Academic Lectures
- CERN Computer Security (CERN WhiteHats)

ISOTDAQ18 Vienna, Austria



12-Dec-18

TileCal Week Tbilisi, Georgia



Miguel F. Medeiros

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- Henric Wilkens
- Filipe Martins & LIP colleagues
- TileCal colleagues
- Jennifer Dembski
- Portuguese community @ CERN
- University Professors
- Friends
- Family

Thank you all for this experience!

“As we express our gratitude, we must never forget that the highest appreciation is not to utter words, but to live by them.”

—John F. Kennedy

Thank you for your attention!

Questions?