Trigger shifter tutorial

Introduction, control, and configuration

Introduction

- This is the first shifter tutorial for 2018
  - Intended mostly for (new) 2018 shifters
- The **slides might be updated** in-between tutorials
  - Watch for updates to these slides (e-mail announcements)
  - They will be posted on the OnlineWBTrigger TWiki
- 2018 first semester call went out in October – **fully subscribed**

- A few important reminders
  - **You are responsible** for the Trigger
  - **Look, listen, and communicate** with the shift crew!
  - Remember your job is to **be on shift for 8 hours**!
  - Limit e-mail, social-networking, analysis work, and please **do not attend meetings by video or phone conference** – otherwise find a replacement shifter
- More information in the trigger Online Workbook TWiki: https://twiki.cern.ch/twiki/bin/viewauth/CMS/OnlineWBTrigger

Your Job is to…

- Ensure **proper, stable, and efficient operation** of the trigger
  - Start-up the basic shifter tools in preparation for global data taking after computer crashes or after a power cut
  - **Monitor** the proper functioning of the Trigger
  - **Keep** yourself, the Shift Leader, and the L1 and HLT DOCs **informed**
  - **Answer operations-related questions** from other central shifters
  - **Choose prescale columns** following provided instructions
- **Troubleshoot** and fix problems
  - **Check alarms** and take the corresponding actions (call expert or perform action)
  - **Check** regularly the **control processes**
  - **Document problems** (in the Elog)

- At the end of the shift, **write a shift report** into the Trigger Elog
- **Help improve documentation** by giving suggestions in the Trigger Elog

Communication is essential!

- **Shift leader**
  - **Coordinator** on duty
  - **Must be informed about everything CMS**, make operational decisions, communicate to outside (CERN Control Center - CCC, Run Field Managers - RFMs)
  - Talk to shift leader about prescale factor changes, etc.
  - Please **tell shift leader if you are calling an expert** so they stay informed
- **L1 DOC** (161958) and **HLT DOC** (165575)
  - Need to be informed of any issues with the Trigger
  - In case of **any questions or problems** you cannot solve, **call** the L1 DOC
    - **Don't be shy about calling at 3 a.m.** if needed
- **Trigger subsystem experts**
  - Contact list in TWiki:
    https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBTriggerContacts
- **Level-1 Trigger Technical Coordinators** (Operations Managers)
  - Dinyar (Rabady, 167806) and Alessandro (Thea, 161800)
  - Please **call the on-duty phone** at 64500

Before your first shift

- **Access** to CMS CR **requires** the following **courses**
  - **Safety at CERN**
  - **CMS** (Former *CMS - Level 4 C*)
  - Both are online via http://sir.cern.ch
- **Request access** via EDH (http://edh.cern.ch)
- To **check your accesses** go to http://adams.web.cern.ch

- **Shift shuttle:** http://smb-dep.web.cern.ch/en/ShuttleService (Circuit 3)

- It is a good idea to **subscribe to the CMS Commissioning hypernews** for announcements about shift cancellations, etc.!

- **Trainee Shifts** - 2-3 shifts shadowing another shifter, contact cms.trig.admin@cern.ch to sign up, they are created just for you!

Please stay informed!

- Attend this Tutorial and ask questions!
  - Questions to: cms-trigger-shifts-online@cern.ch
    - You can also use the egroup to swap/offer shifts
- Trigger Online Workbook
  https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBTrigger
- Trigger Shifter Guide – **read top to bottom!**
  https://twiki.cern.ch/twiki/bin/view/CMS/TriggerShifterGuide
- Trigger Online Issues
  https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBL1OnlineIssues
- Read the instructions at the bottom of the L1 Page
  https://l1page.cms
- Read the TWiki about the prescale columns
  https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBL1CollisionPrescales

- If possible arrive 15 minutes early and talk to departing shifter
- Read the elogs from the last few shifts to get an idea of what is happening
  eLogBook is part of https://cmsonline.cern.ch

The LHC

The 2018 LHC Schedule (draft)

LHC Displays (Page 1)

Mini lumi-scan (rates will fluctuate)

https://op-webtools.web.cern.ch/Vistar/vistars.php?usr=LHC1
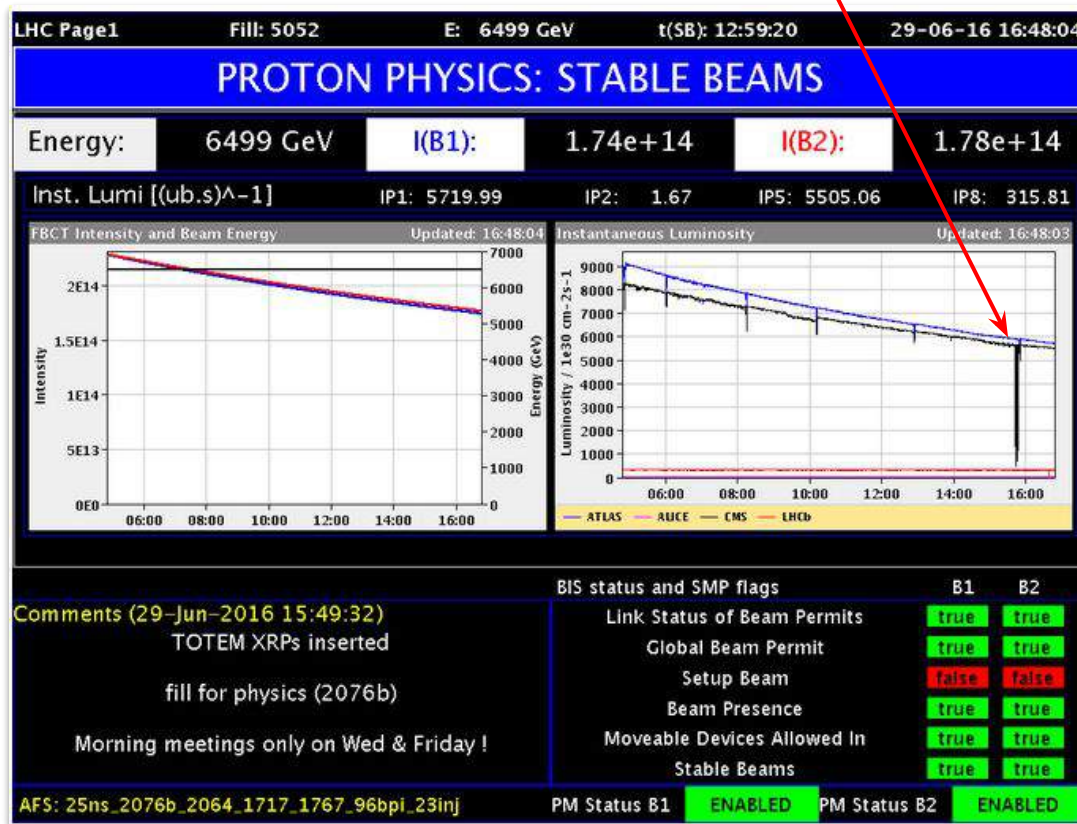
LHC Displays (Page 1)
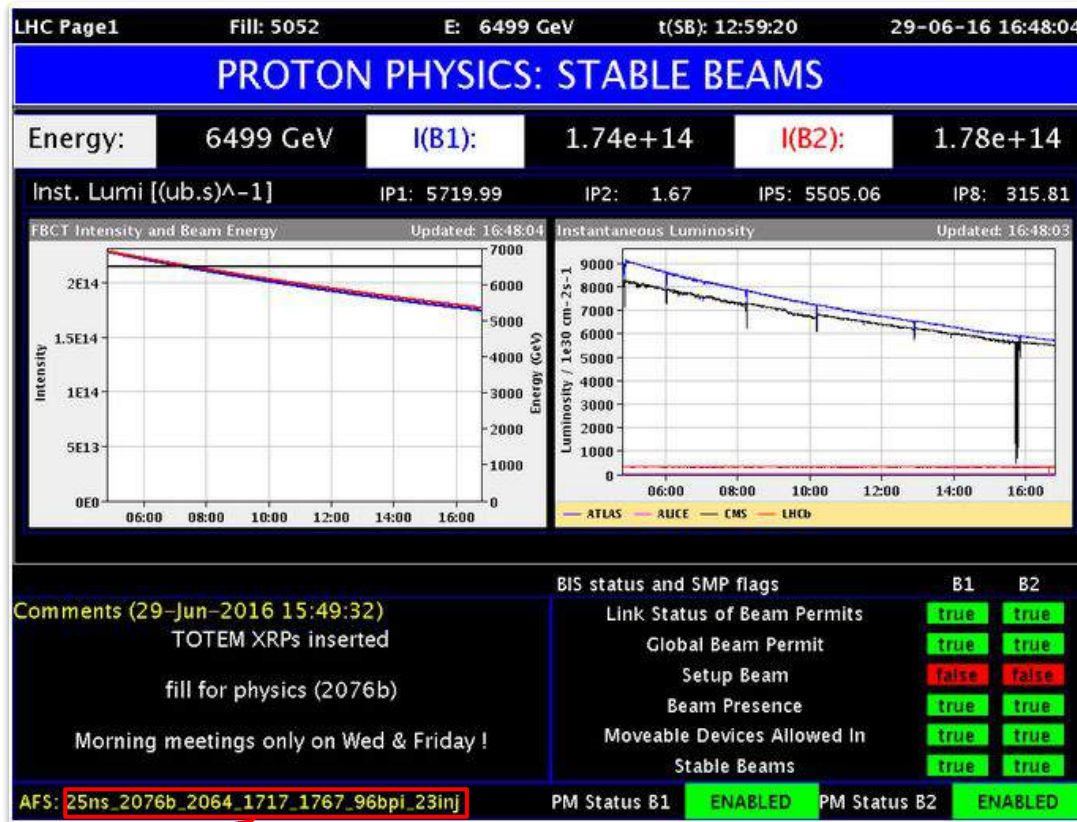
LHC filling scheme: <spacing>_<Nb>b_**<IP1/5>**_<IP2>_<IP8>_<code>

e.g. here: 2064 colliding bunches in CMS/ATLAS

https://lpc.web.cern.ch/lpc/fillingschemes.htm

Instantaneous Luminosity

You need to **always** be aware of the **current instantaneous luminosity**.

Used to

- Determine when to change prescale column
- Diagnose potential source of high (or low) rates
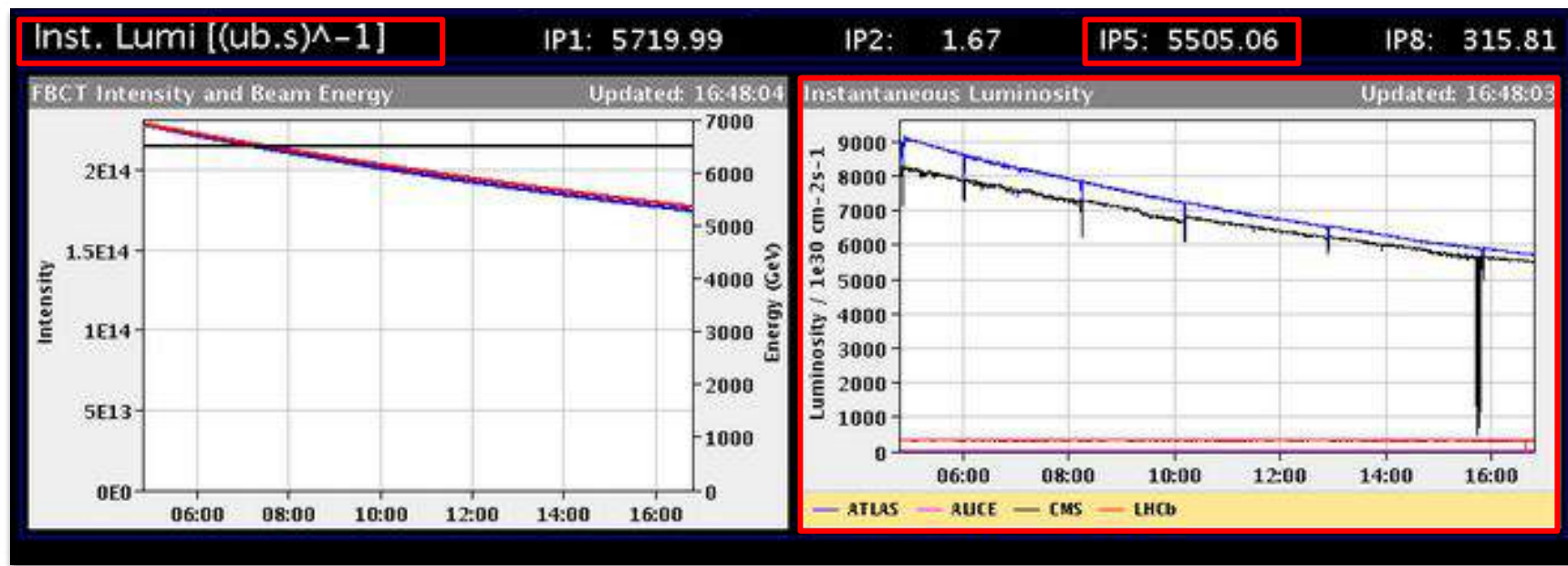
$1 \ (ub.s)^{-1} = 1e30 \ (cm^{-2}s^{-1}) \Rightarrow$ luminosity is 5.5e33 $(cm^{-2}s^{-1})$

Luminosity levelling

Initial high lumi

Luminosity levelling

CMS: Fill 6324 Instantaneous Luminosity ▪ CMS Online Lumi
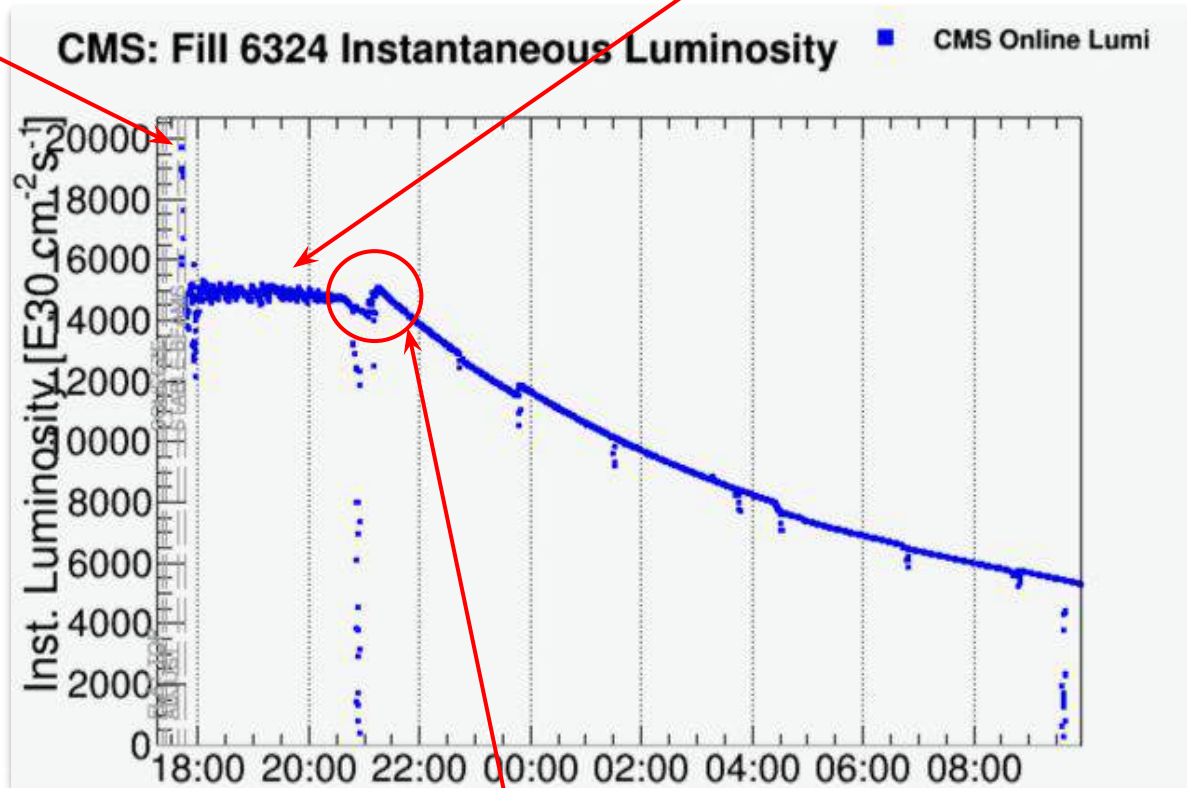
Crossing-angle optimisation will lead to increase in lumi at the end of the luminosity levelling

Very likely mode of operation in 2018.

The CMS Level-1 trigger

The L1 Trigger (simplified)
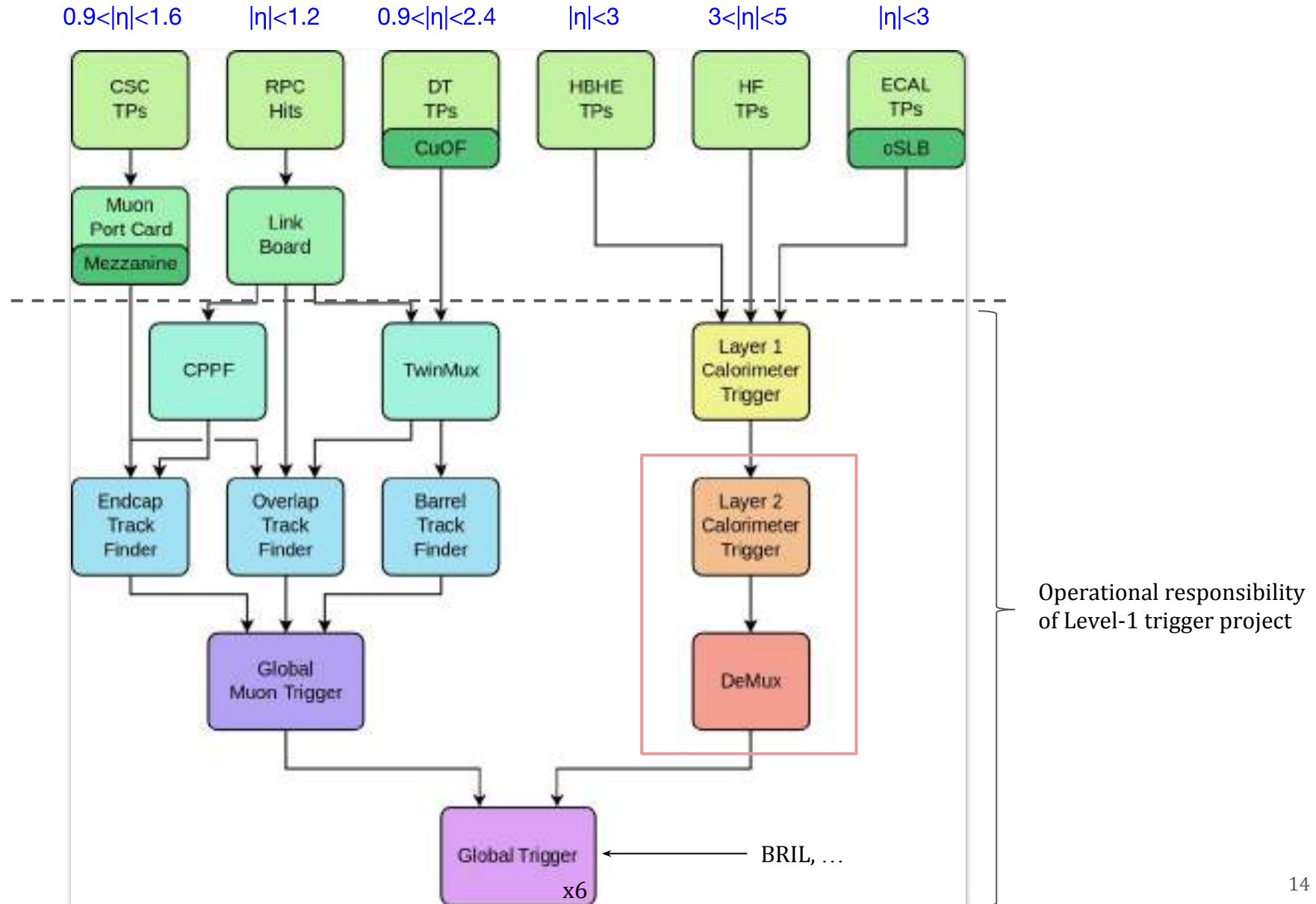
Global Trigger (μGT)

- Represents the final stage of the Level-1 trigger

  - Receives **inputs** from muon trigger chain (**μGMT**), calorimeter trigger chain (**Calo Layer-2**) and "external conditions" (e.g. **BPTX** to determine whether beams are colliding in a bunch crossing)
  - Programmable with up to 512 **trigger algorithms ("algos")**
    - e.g. "DoubleMu_4_4" (checks if two muons with $p_T > 4$ GeV are in an event)
  - Responsible for computing a **"final decision" (FINOR) signal** by combining the results of all trigger algorithms

- Many configurable parts
  - **Level-1 trigger menu**
    - Collection of trigger algorithms available in the firmware at a given time
  - **Prescale columns**
    - A given trigger algorithm can be throttled by a **prescale**.
      - e.g. prescale 2 means this trigger algorithm is throttled by a factor 2
      - **Prescale 0** means the trigger algorithm is entirely disabled
    - A **prescale column** is a collection of prescales for all algos in a menu
      - The prescale column **can be changed during the run** to adapt to changing beam conditions or requirements
  - …

Trigger Control and Distribution System (TCDS)

- Not part of the Level-1 trigger project
  - Nonetheless important to understand basics
- Receives FINOR signal from μGT and uses this (and other internally and externally generated signals) to determine whether to issue readout signal ("L1A") to subdetectors
  - Internally generated signals:
    - Random triggers
      - Used to collect unbiased data
      - Rate can be set by DAQ shifter
    - Calibration triggers
      - Issued at 100 Hz during standard operations in order to take calibration data for calorimeters
    - Trigger rules
      - TCDS blocks multiple L1A signals in a sliding time window (e.g. no two L1A signals within a 3 BX window)
    - ReTri protection system
      - Protection for Tracker system (possibility to physically damage modules at certain readout frequencies)
      - TCDS blocks trigger signals when running with periodic triggers at low L1A rates (e.g. one colliding bunch)
  - Externally generated signals:
    - "Busy" and "Warning" signals from Trigger Throttling System (TTS) indicate that a subdetector cannot cope with the current readout rate $\Rightarrow$ TCDS blocks L1A signals

Some definitions

- L1 Rate = FINOR + Random (600Hz) + Calibration (100 Hz)
    - Random may be something other than 600 Hz during tests
- L1 Rate (Post-Deadtime) = L1 Rate – Suppressed Triggers
    - This is the rate INTO the HLT
- Deadtime
    - Percentage of time when triggers could not be accepted:
      Number of BX where triggers could not be accepted / Number of BX
    - Triggers suppressed by
        - Trigger Rules – 1 trigger in 3 BX, etc.
        - Trigger Throttling – Subdetector is busy state, in error, etc.
            - This becomes the dominant cause of deadtime at very high (100 kHz) rate
        - Hard reset, resync sequences, calibration sequence
        - ReTri system
            - Mostly relevant when very few bunches colliding

Muon track finder coverage

K. Bunkowski

2 CMS HF Calorimeters mapping onto Trigger System HF Crate

Readout segmentation: $36\phi \times 12\eta \times 2z \times 2F/B$

Trigger Tower segmentation: $18\phi \times 4\eta \times 2F/B$
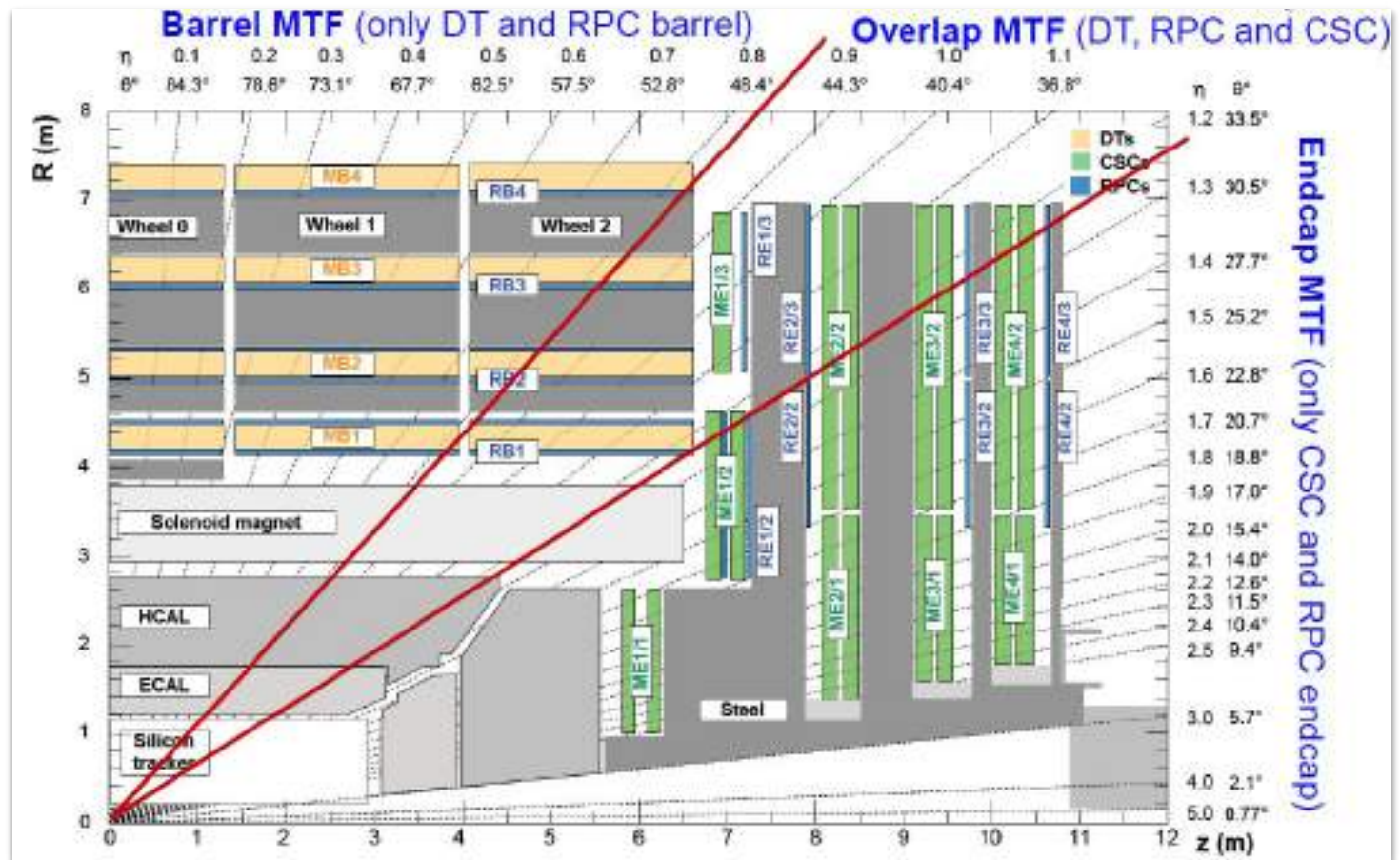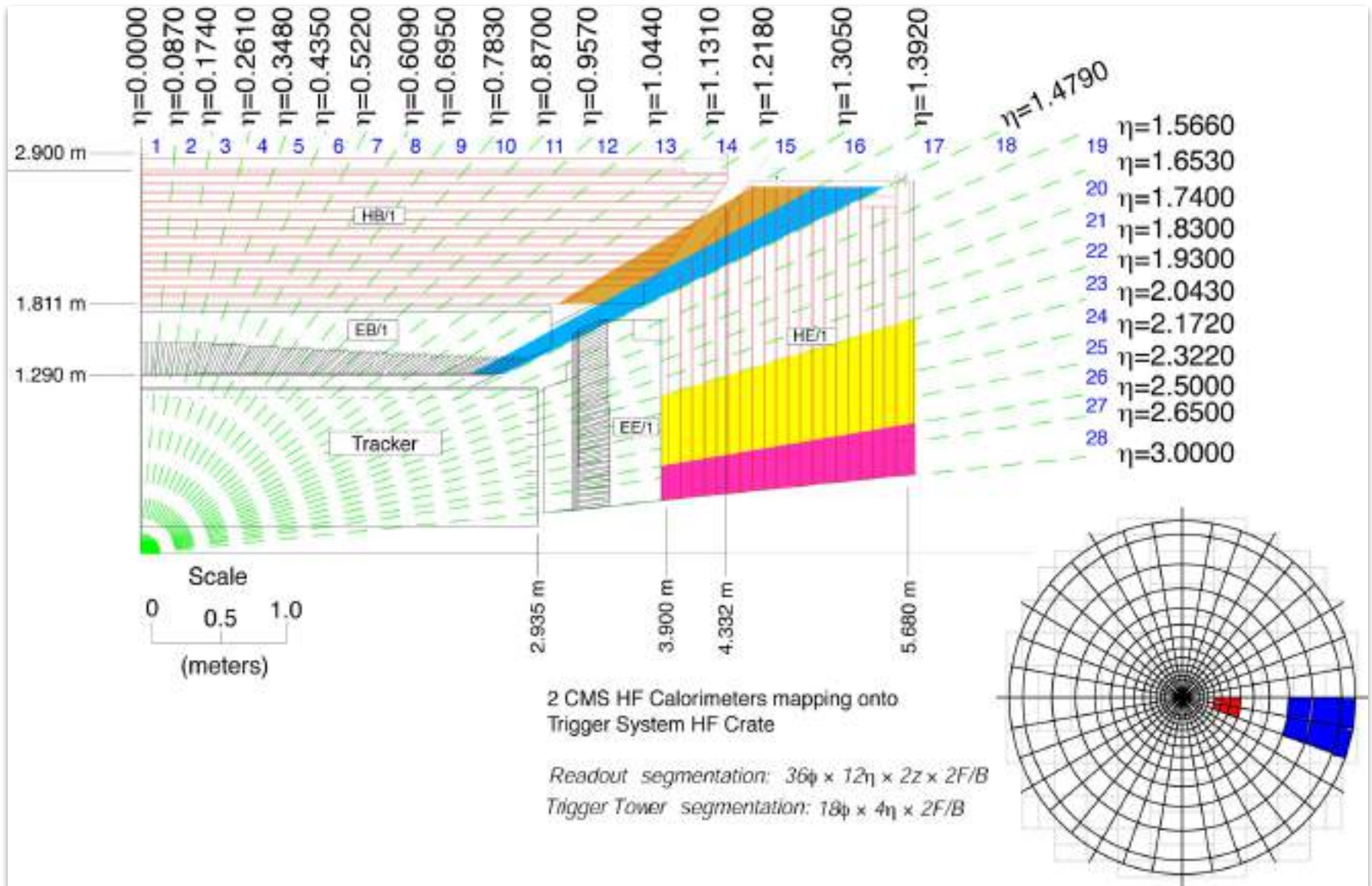
Shift essentials

The CMS control room

Control Room

Trigger Shifter desk
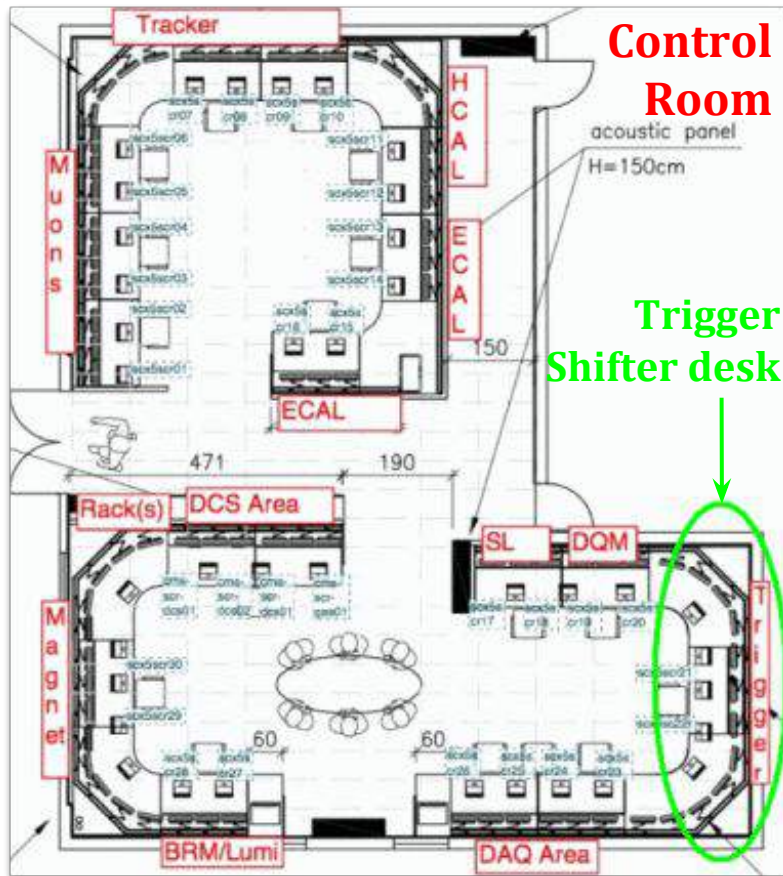
Trigger Shifter phone: 75257

CMS DAQ and DCS Information
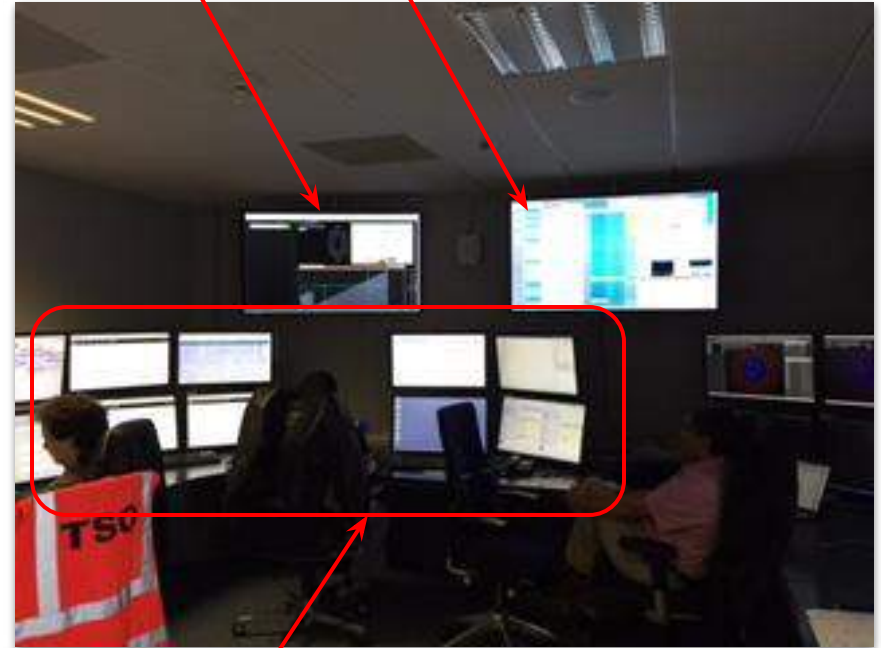
Two PCs to be used by you:
- 4 large high-res screens per PC
  - Keep **operational windows on right PC**
- 2nd is for DQM and monitoring

Chromium icon on each desktop

The L1 Page

Run information

Useful links

Errors and Warnings

you deserve a coffee break
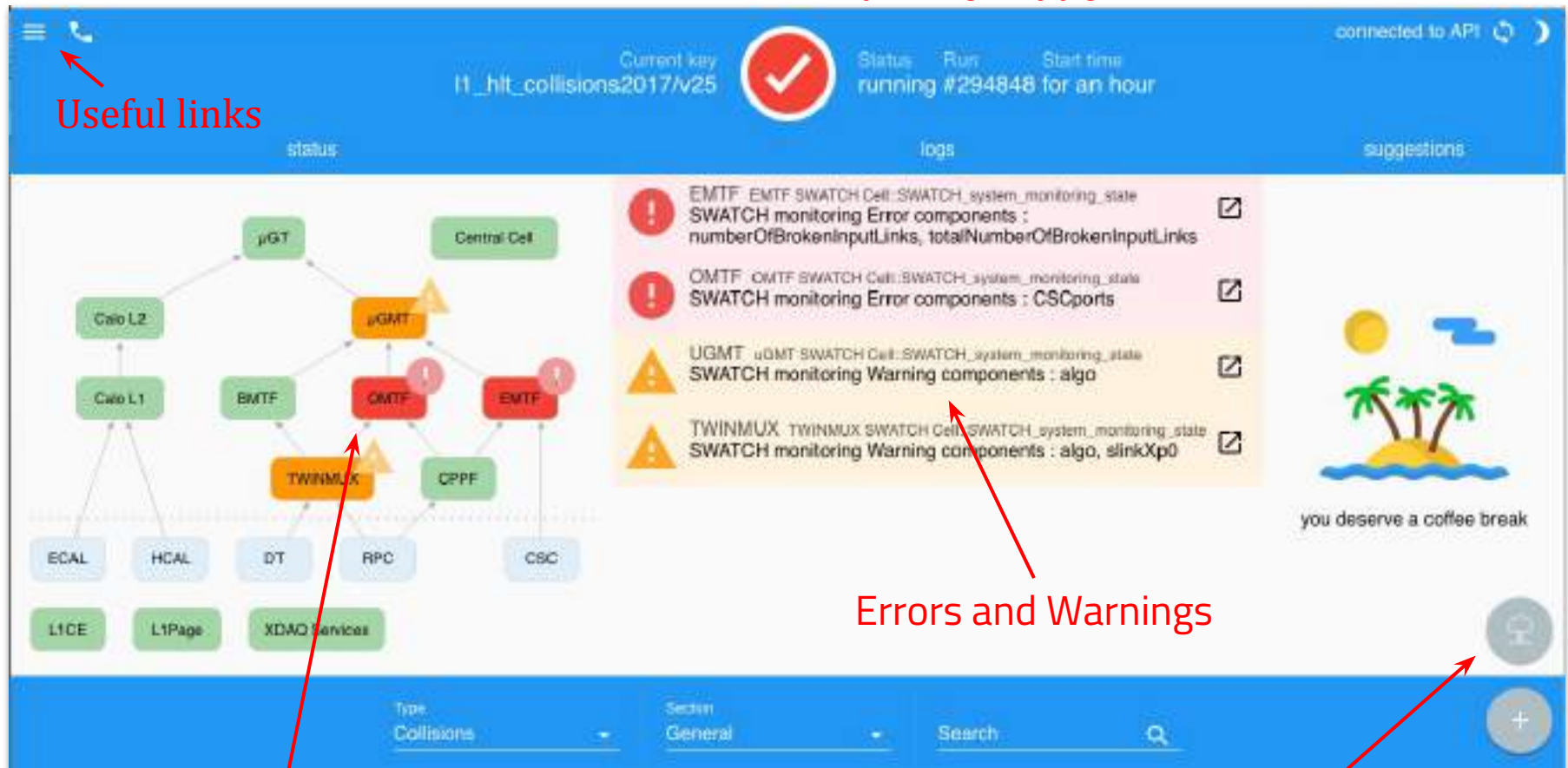
↓Scroll down for short-term instructions ↓

Subsystem process information

Process controller

The L1 Page

Current key
l1_hlt_collisions2017/v25

Status   Run   Start time
running #294848 for an hour

connected to API

status   logs   suggestions

All is good!

μGT   Central Cell

Calo L2   μGMT

Calo L1   BMTF   OMTF   EMTF

TWINMUX   CPPF

ECAL   HCAL   DT   RPC   CSC

L1CE   L1Page   XDAQ Services

EMTF EMTF SWATCH Cell::SWATCH_system_monitoring_state
SWATCH monitoring Error components :
numberOfBrokenInputLinks, totalNumberOfBrokenInputLinks

OMTF OMTF SWATCH Cell::SWATCH_system_monitoring_state
SWATCH monitoring Error components : CSCports

UGMT uGMT SWATCH Cell::SWATCH_system_monitoring_state
SWATCH monitoring Warning components : algo

TWINMUX TWINMUX SWATCH Cell::SWATCH_system_monitoring_state
SWATCH monitoring Warning components : algo, slinkXp0

you deserve a coffee break

Type
Collisions

Section
General

Search

Subsystem in error
(red and exclamation mark)

Subsystem in warning
(orange and warning sign)

The L1 Page

Subsystem not in the global run

Overall trigger status
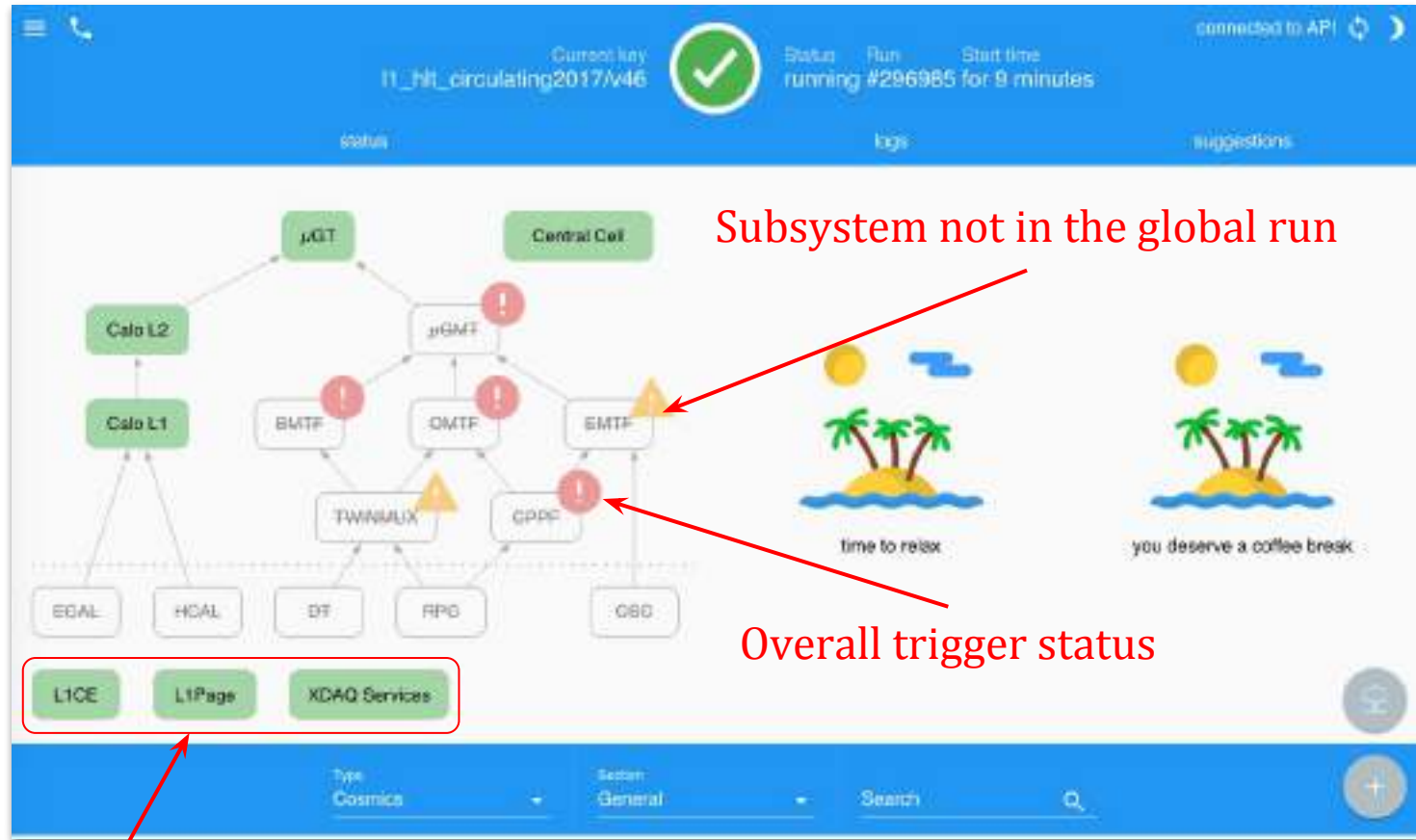
L1CE, L1Page, XDAQ Services
should always be green

The L1 Page

Contacts Page

https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBTriggerContacts

The L1 Page

Click on Subsystem box to open detail view

The L1 Page --- Detailed subsystem view

Process control

Process Control

If you get a request from an expert, restart the processes (SWATCH software) for the subsystem with the process control

If a status box is red or yellow and there is a skull ☠☐, check the TWiki below for the rules about restarting a subsystem's processes.

If a system is white (out) – **do not restart**, local work may be going on

Process controller ⟶

Instructions and guidelines can be found at:
https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBL1OnlineIssues
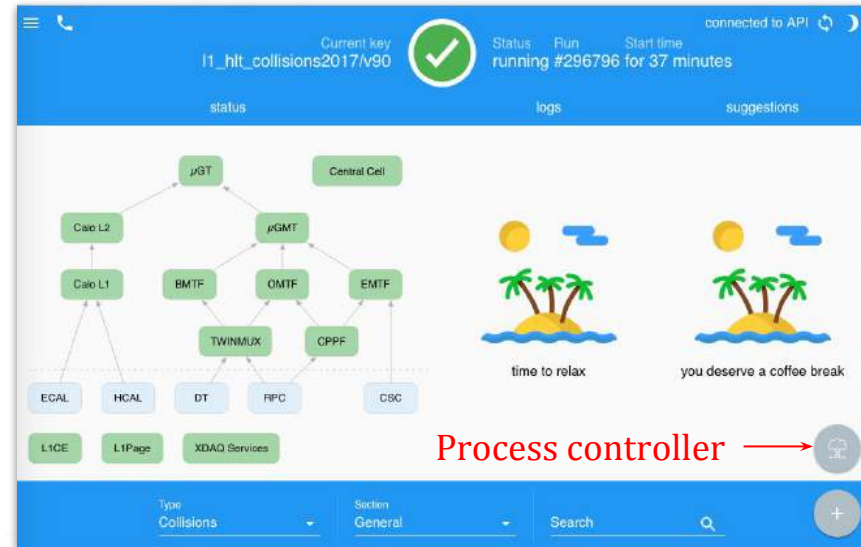
Process Control - how to

1. Click the icon
2. Select subsystem
3. Click RESTART
   (or stop/start)
4. Wait for result
5. If the process fails to restart, follow instructions to the right
6. Write an elog
7. Close the window

If a process fails to restart the PC may be down, so please call:
- The subsystem expert
- L1 DOC

If they cannot restart the PC the DAQ DOC must be called.
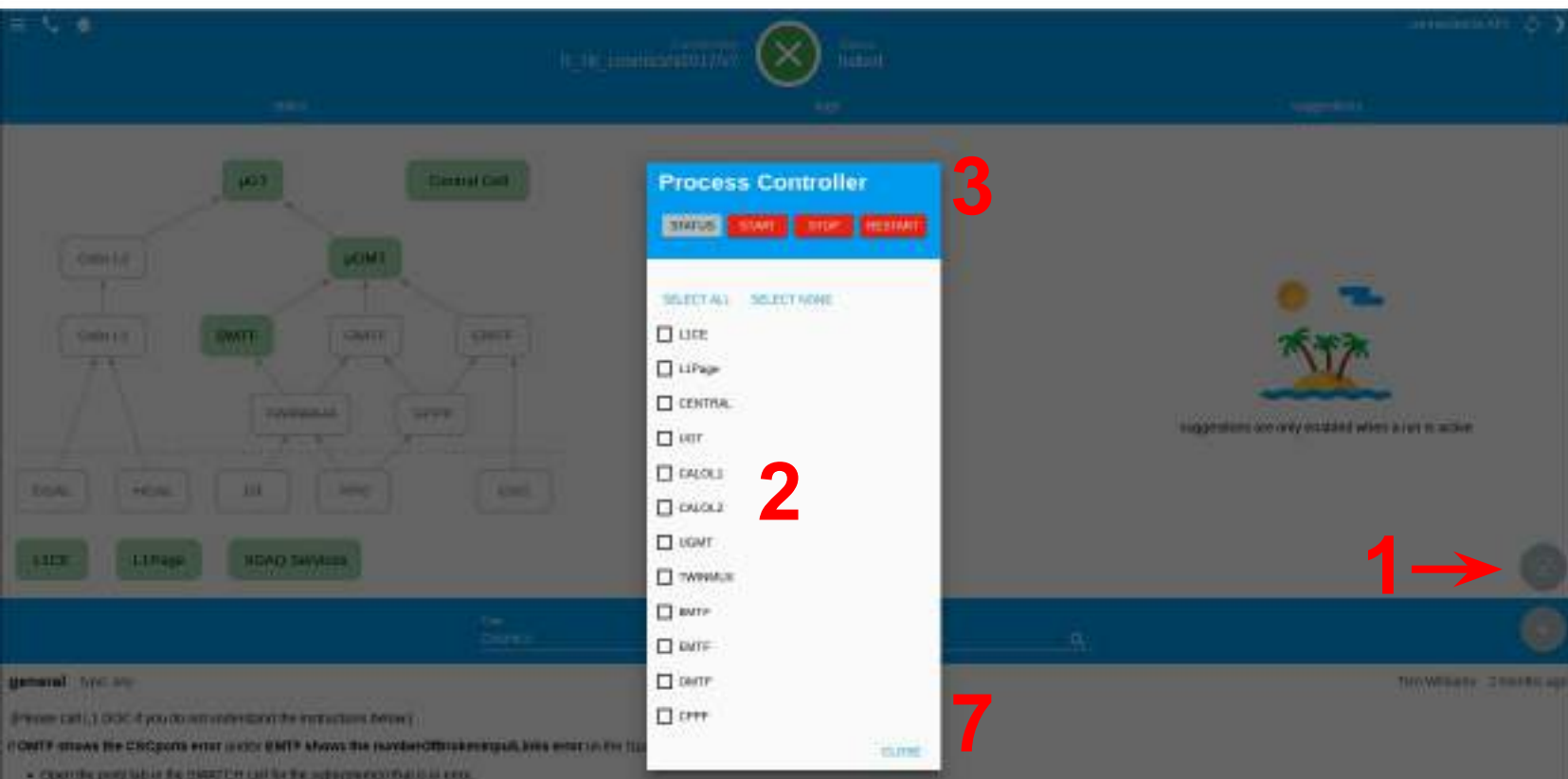
Software process status
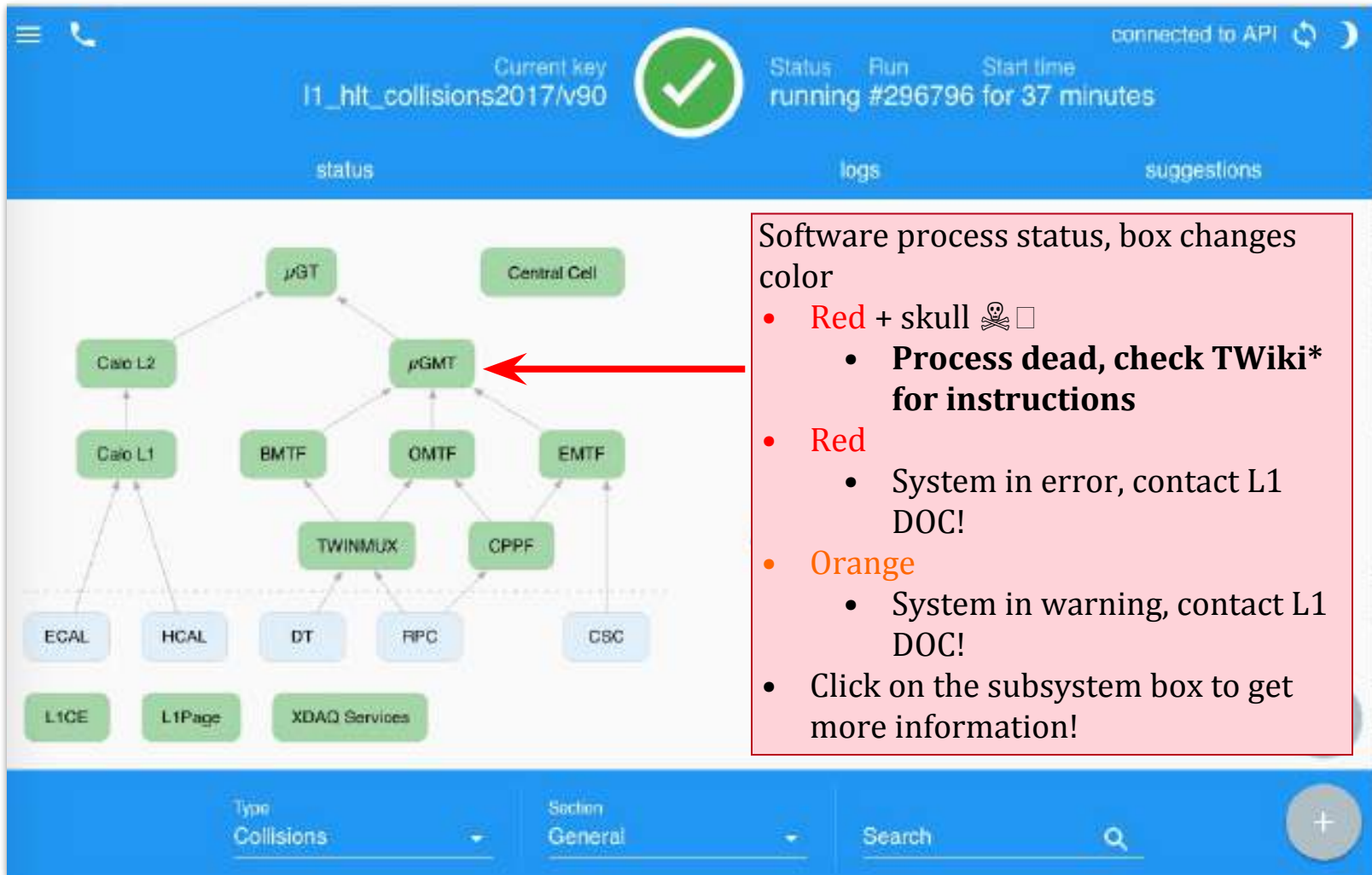
Software process status, box changes color
- Red + skull ☠⬚
  - **Process dead, check TWiki* for instructions**
- Red
  - System in error, contact L1 DOC!
- Orange
  - System in warning, contact L1 DOC!
- Click on the subsystem box to get more information!

*https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBL1OnlineIssues#Restarting_a_subsystem_s_process

Software process status

Service is required for correct trigger operation.

Service is up and running.

*https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBL1OnlineIssues#Restarting_a_subsystem_s_process

Configuration

Configuration Basics

In normal running, everything is configured from the Data Acquisition (DAQ) System based on a CMS Run Mode which determines the L1_HLT key

Trigger Shifter however should confirm that correct key has been chosen

The L1_HLT key contains three subkeys:

- **Configuration key**
  - Static configuration parameters for L1 trigger
- **Run settings key**
  - Masks, prescale factors, enables trigger bits, etc.
- **HLT key**
  - Sets HLT parameters, paths, and prescale factors

These keys have to match!

These keys are made by the L1 DOC or HLT DOC
CMS usually has 3-4 types of keys available:

- **Collisions** – for normal data taking with stable beams
- **Circulating** – for circulating beam in the machine
- **Cosmics** – for taking cosmic-ray calibration/alignment data with no beam in the machine
- **Special keys** for high rate tests, van der Meer scans, etc.

Selecting prescale columns

During Collisions, prescale columns will need to be set according to the instantaneous luminosity or the number of colliding bunches (see LHC section) at CMS

Reminder: Prescales throttle or shut down rate of trigger bits (see L1 Trigger section)

Instructions on which columns to choose:
https://twiki.cern.ch/twiki/bin/view/CMS/OnlineWBL1CollisionPrescales (maintained by HLT DOC)

Example: You should see the following type of list for collisions:

Column Index	Column Name	Lumi Range
column 0	emergency	> 1.28e34
column 1	1.25e34	1.15e34 to 1.28e34
column 2	1.15e34	1.06e34 to 1.15e34
column 3		9.5e33 to 1.06e34
column 4	9.5e33	8.8e33 to 9.5e33
column 5	8.5e33	7.9E33 to 8.8e33
column 6	7.5e33	6.0E33 to 7.9E33
column 7	5e33	4.4E33 to 6.0E33
column 8	3.5e33	2.7E33 to 4.4E33
column 9		1.5E33 to 2.7E33
column 10	1e33	9E32 to 1.5E33
column 11	7e32	5E32 to 9E32
column 12	5e32	4E32 to 5E32
column 13	3.5e32	2.5E32 to 4E32

LHC Page1	Fill: 5052	E: 6499 GeV	t(SB): 12:59:20	29-06-16 16:48:04

PROTON PHYSICS: STABLE BEAMS

Energy:	6499 GeV	I(B1):	1.74e+14	I(B2):	1.78e+14
Inst. Lumi [(ub.s)^-1]		IP1: 5719.99	IP2: 1.67	IP5: 5505.06	IP8: 315.81

(Top of LHC Page 1, should always be visible on your workstation)

$1\ (\mathrm{ub.s})^{-1} = 1e30\ (\mathrm{cm}^{-2}\mathrm{s}^{-1}) \Rightarrow$ use column 7 (named "5e33")

Please inform the shift leader if you want to change the prescale!

Prescales -- cheat sheet

As luminosity decreases, the prescale column should be changed according to the luminosity using the table linked to the L1 Page.

- Expect 0.8 to 1.3 kHz for HLT (Stream Physics) rates
  - Average over the fill of ~1 kHz
  - Prescale columns are tuned to do this
  - For studies occasionally there is extra or only ZeroBias rate

Always monitor the deadtime (see section on monitoring):
- Rates of 95 kHz or more are okay if
  - **Deadtime is below 10%**
    - Rule of thumb: ~<5% is normal, ~>5% above normal, >10% is a problem

Possible problems:
- High deadtime and pre-deadtime L1 Rate < 90 kHz
  - Problem most likely not trigger, but confirm this!
    - Talk to the the shift crew, e.g. DAQ, Shift Leader
- High deadtime and pre-deadtime rate >100 kHz
  - May have a hot trigger detector, check DQM and indiv. L1 Triggers

How to change the prescale column

Open the uGT Swatch Cell
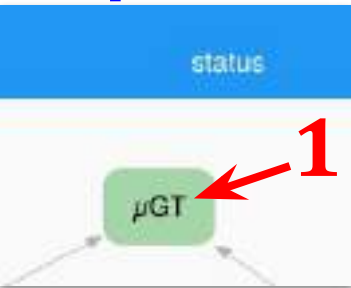
Note: After (re-)configuration the uGT goes to its default prescale column!
Please check that it is correct before starting a new run.

1

2
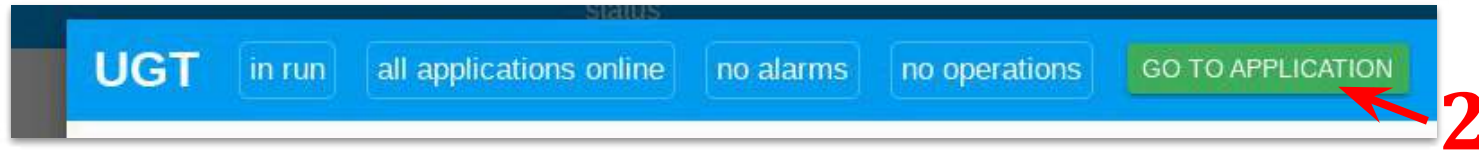
3 Choose uGT Prescales

4 Refresh table and check Index

5 Select the correct column from the drop-down menu

6 Click to change prescale Updates after 23 s (one Lumi Section)

Preview effect of different prescale column

Open the uGT Swatch Cell

1

UGT | in run | all applications online | no alarms | no operations | GO TO APPLICATION

2
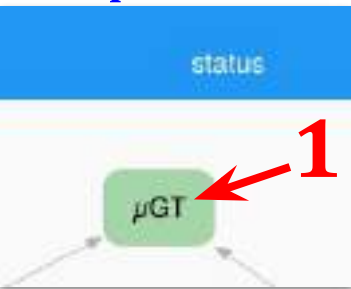
Choose uGT Preview Rates **3**

Preview Rates

Current Preview Prescale: 3.7832_p99f (1)

4 Check current column

5 Select the correct column from the drop-down menu

CHANGE PREVIEW PRESCALE

6 Click to change prescale
Updates after 23 s
(one Lumi Section)