Development and commissioning of the ATLAS Semiconductor Tracker (SCT) Performance Analysis Tool (PAT)

12th LHC students poster session
- 29th of November 2022 -

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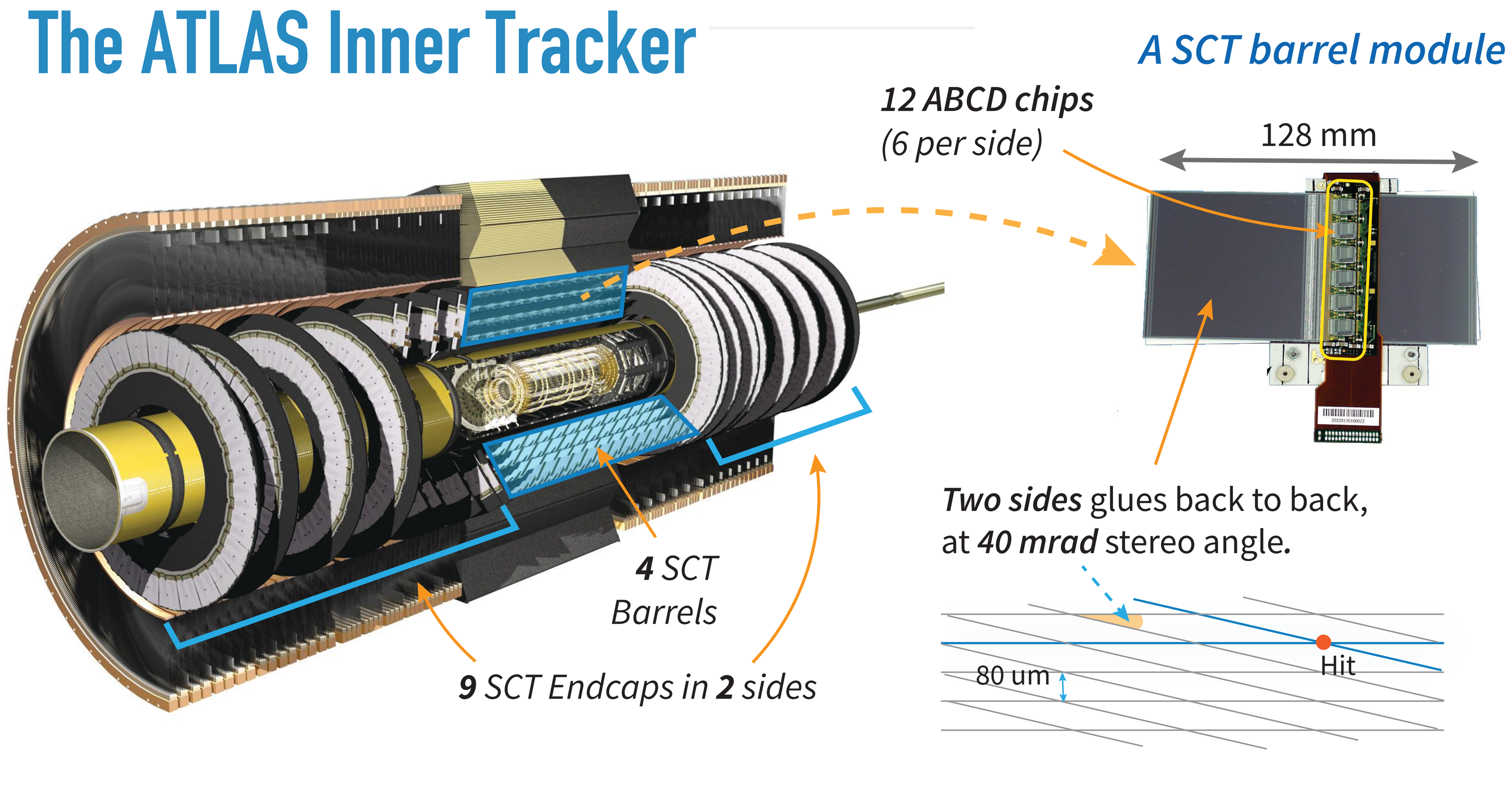
The ATLAS Inner Tracker



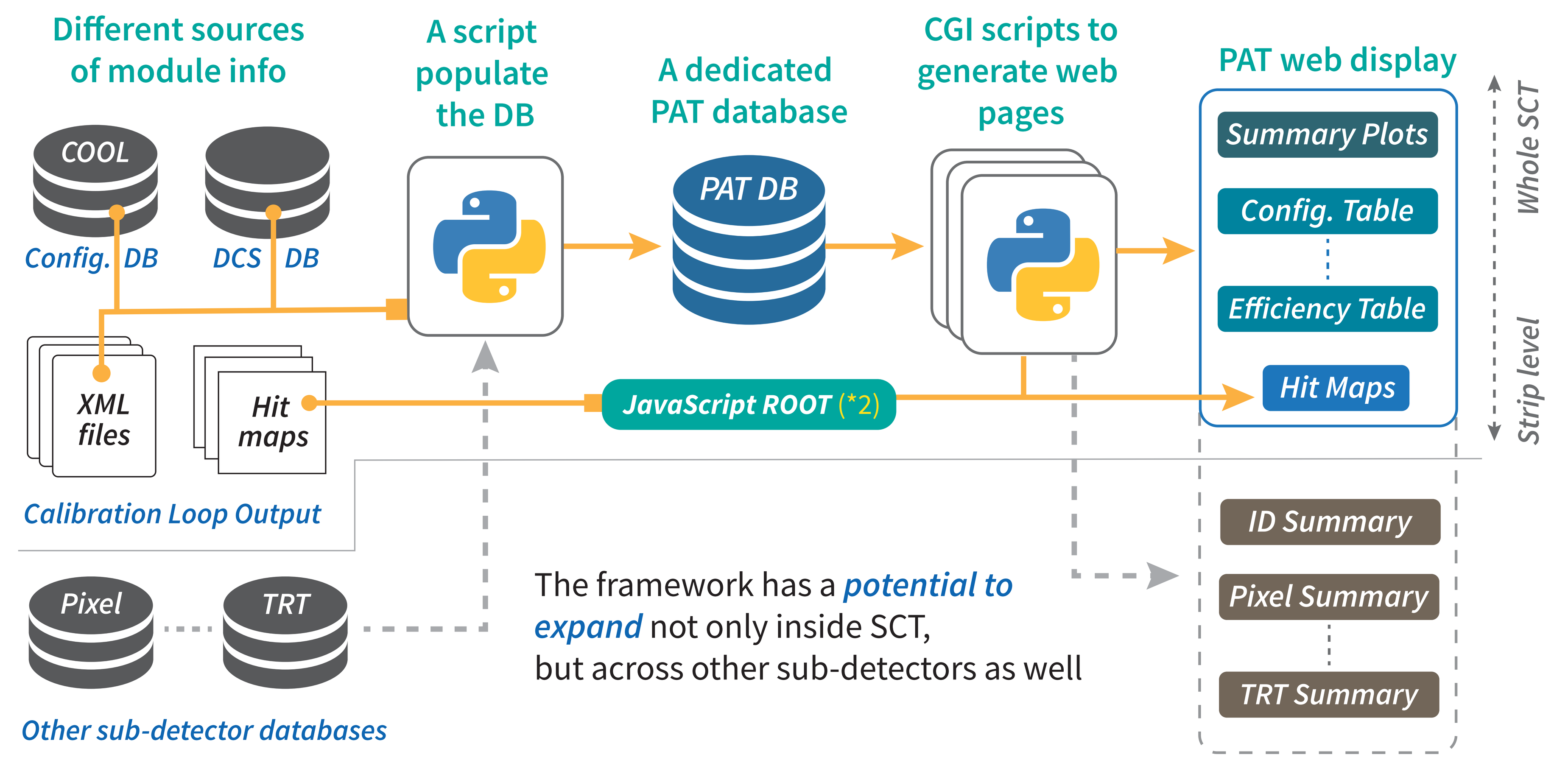
There are *4088 SCT modules* altogether, and each module has *1536 strips*

SCT modules are constantly damaged by radiation, and this affects the SCT performance. Hence, an effective tool to monitor all SCT modules (and take appropriate action) was essential to ensure the SCT is having a good performance when taking physics data.

Structure of the SCT Performance Analysis Tool (PAT)

PAT synchronizes SCT module information from different sources to a ***dedicated database***, and renders them in a ***web display***, to make the investigation of problematic modules quick and efficient *(and fun!)*.

Thanks to this synchronization, we can investigate from strips level to the whole SCT, ***inside one tool***.



The framework has a ***potential to expand*** not only inside SCT, but across other sub-detectors as well

SCT Performance Analysis Tool Web Display

The ***Efficiency Table*** is the main table in PAT, and all the other tables are based on the ordering here.

$$\text{Hit Efficiency } (\epsilon) = \frac{N_{cluster}}{N_{cluster} + N_{hole}}$$

The Efficiency Table

Latest run …. Older runs

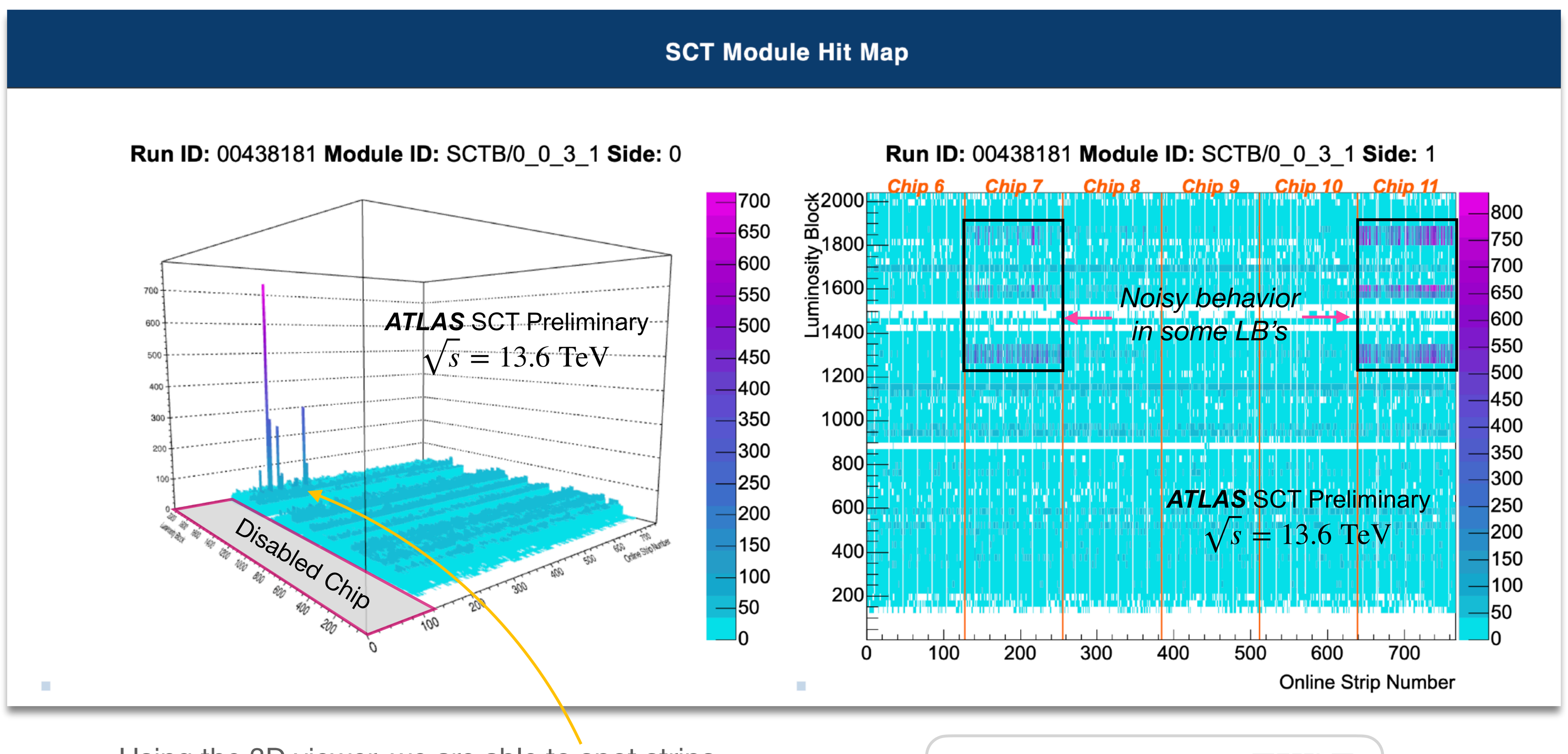
ATLAS SCT Preliminary $\sqrt{s} = 13.6$ TeV

Higher ϵ module …. Lowest ϵ module

Module \ Run	438219 (516185 events) 2022-10-27 12:26:50	438181 (2087801 events) 2022-10-26 17:46:01	437991 (546027 events) 2022-10-25 22:40:47	437971 (259608 events) 2022-10-25 15:31:30	437944 (29843 events) 2022-10-25 13:49:22
Serial: 20220380200227 **BEC:** 0 **Layer:** 3 **Eta:** 3 **Phi:** 22 **PS:** 8139 **Crate:** 1 **Slot:** 10 **Channel:** 38	Efficiency: 0.5024 Hit Map Noise Map Effside0 0.9815 Effside1 0.0232 Noisy 2 Bad 1 Dead 1	Efficiency: 0.5032 Hit Map Noise Map Effside0 0.9859 Effside1 0.0205 Noisy 2 Bad 1 Dead 1	Efficiency: 0.5044 Hit Map Noise Map Effside0 0.9832 Effside1 0.0257 Noisy 2 Bad 1 Dead 1	Efficiency: 0.503 Hit Map Noise Map Effside0 0.9848 Effside1 0.0213 Noisy 2 Bad 1 Dead 1	Efficiency: 0.5022 Hit Map Noise Map Effside0 0.9765 Effside1 0.0279 Noisy 2 Bad 1 Dead 1
Serial: 20220330200394 **BEC:** 0 **Layer:** 0 **Eta:** 1 **Phi:** 3 **PS:** 2430 **Crate:** 3 **Slot:** 16 **Channel:** 30	Efficiency: 0.7788 Hit Map Noise Map Effside0 0.7839 Effside1 0.7738 Noisy 0 Bad 25 Dead 3	Efficiency: 0.679 Hit Map Noise Map Effside0 0.6804 Effside1 0.6775 Noisy 62 Bad 25 Dead 3	Efficiency: 0.8839 Hit Map Noise Map Effside0 0.8863 Effside1 0.8815 Noisy 2 Bad 23 Dead 3	Efficiency: 0.961 Hit Map Noise Map Effside0 0.9618 Effside1 0.9602 Noisy 1 Bad 23 Dead 3	Efficiency: 0.9672 Hit Map Noise Map Effside0 0.9676 Effside1 0.9667 Noisy 1 Bad 23 Dead 3

We can check the ***hit map*** of this entry for example. We notice Chip 7 and Chip 11 shows a noisy behavior in some luminosity blocks ➡ Further investigation.

Module Hit Maps

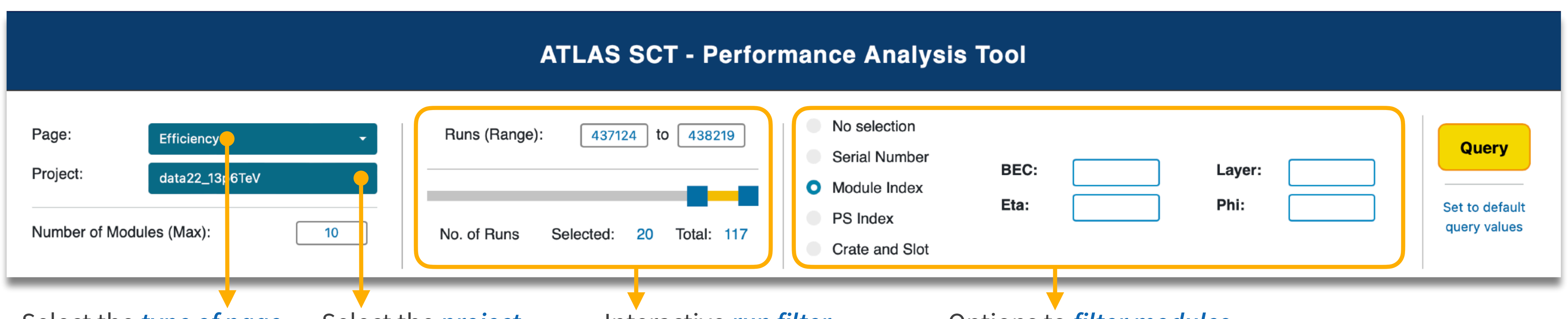


Using the 3D viewer, we are able to spot strips like these in a specific chip that seems noisy

Module hit map page - Demo

PAT Dashboard

PAT has an interactive navigational panel



Select the *type of page* Select the *project* Interactive *run filter* Options to *filter modules*

The Module Config Table

One side of the module was disabled during Run 2

Let's say we want to investigate the configuration values of this module during Run 2.

ATLAS SCT Preliminary $\sqrt{s} = 13$ TeV

Module \ Run	364485 (479581 events) 2018-10-25 18:34:17	364292 (861498 events) 2018-10-23 12:56:06	364214 (924142 events) 2018-10-22 20:31:24
Serial: 20220380200227 **BEC:** 0 **Layer:** 3 **Eta:** 3 **Phi:** 22 **PS:** 8139 **Crate:** 1 **Slot:** 10 **Channel:** 38	**Dis. Chips:** 0 **IOV since:** 2018-10-19 09:34:49 **Dis. Strips:** 2 **Trim DAC 0 strips:** 771 **V.Thr:** [46, 46, 46, 46, 46, 46, 62, 62, 62, 62, 62, 62] **Trim-Range:** ['0-120', '0-120', '0-120', '0-120', '0-120', '0-120', '0-60', '0-240', '0-240', '0-60', '0-60', '0-60'] **Rdt. Mode:** ['Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge'] **Delay:** [14, 14, 14, 15, 16, 15, 0, 0, 0, 0, 0, 0]	**Dis. Chips:** 0 **IOV since:** 2018-10-19 09:34:49 **Dis. Strips:** 2 **Trim DAC 0 strips:** 771 **V.Thr:** [46, 46, 46, 46, 46, 46, 62, 62, 62, 62, 62, 62] **Trim-Range:** ['0-120', '0-120', '0-120', '0-120', '0-120', '0-120', '0-60', '0-240', '0-240', '0-60', '0-60', '0-60'] **Rdt. Mode:** ['Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge'] **Delay:** [14, 14, 14, 15, 16, 15, 0, 0, 0, 0, 0, 0]	**Dis. Chips:** 0 **IOV since:** 2018-10-19 09:34:49 **Dis. Strips:** 2 **Trim DAC 0 strips:** 771 **V.Thr:** [46, 46, 46, 46, 46, 46, 62, 62, 62, 62, 62, 62] **Trim-Range:** ['0-120', '0-120', '0-120', '0-120', '0-120', '0-120', '0-60', '0-240', '0-240', '0-60', '0-60', '0-60'] **Rdt. Mode:** ['Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge', 'Edge'] **Delay:** [14, 14, 14, 15, 16, 15, 0, 0, 0, 0, 0, 0]

Another example from Run 2 showing a module having a trend in the efficiency dropping.
We can also investigate if the efficiency drop is related to ***byte-stream (BS) errors***.

ATLAS SCT Preliminary $\sqrt{s_{NN}} = 5.02$ TeV

Module \ Run	367365 (285037 events) 2018-12-02 05:38:40	367364 (503536 events) 2018-12-01 18:54:13	367363 (42224 events) 2018-12-01 16:04:26	367321 (484554 events) 2018-12-01 03:57:52	367318 (493535 events) 2018-11-30 19:06:51
Serial: 20220130000370 **BEC:** -2 **Layer:** 3 **Eta:** 0 **Phi:** 5 **PS:** 3235 **Crate:** 5 **Slot:** 6 **Channel:** 35	Efficiency: 0.5895 Hit Map Noise Map Effside0 0.9621 Effside1 0.2169 Noisy 0 Bad 1 Dead 2	Efficiency: 0.7935 Hit Map Noise Map Effside0 0.9633 Effside1 0.6238 Noisy 0 Bad 1 Dead 2	Efficiency: 0.9522 Hit Map Noise Map Effside0 0.9718 Effside1 0.9326 Noisy 0 Bad 1 Dead 2	Efficiency: 0.8102 Hit Map Noise Map Effside0 0.9651 Effside1 0.6554 Noisy 0 Bad 1 Dead 2	Efficiency: 0.9835 Hit Map Noise Map Effside0 0.9828 Effside1 0.9842 Noisy 0 Bad 1 Dead 2

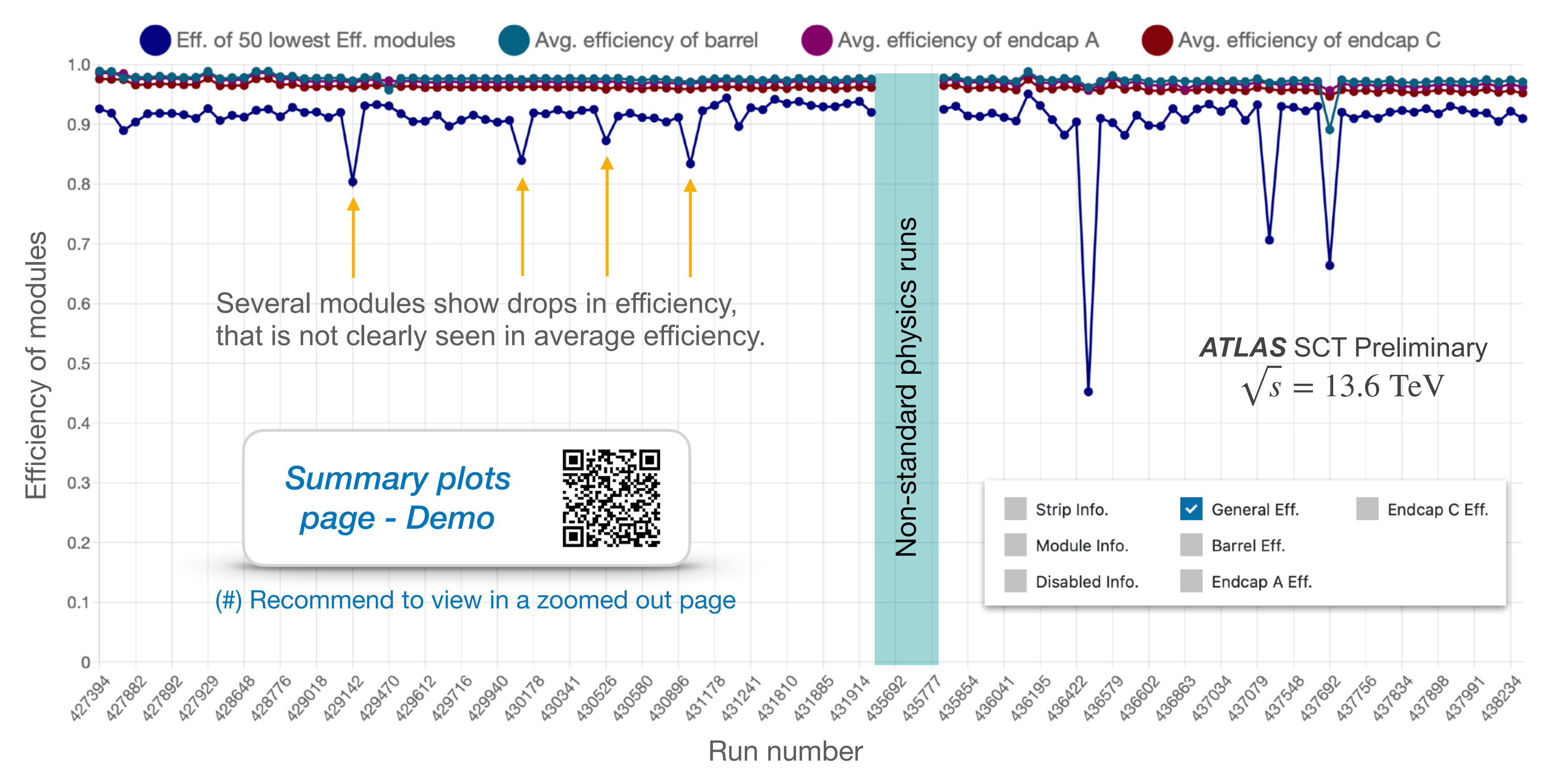
The Byte-Stream Errors Table

A sudden increase in BS errors

ATLAS SCT Preliminary $\sqrt{s_{NN}} = 5.02$ TeV

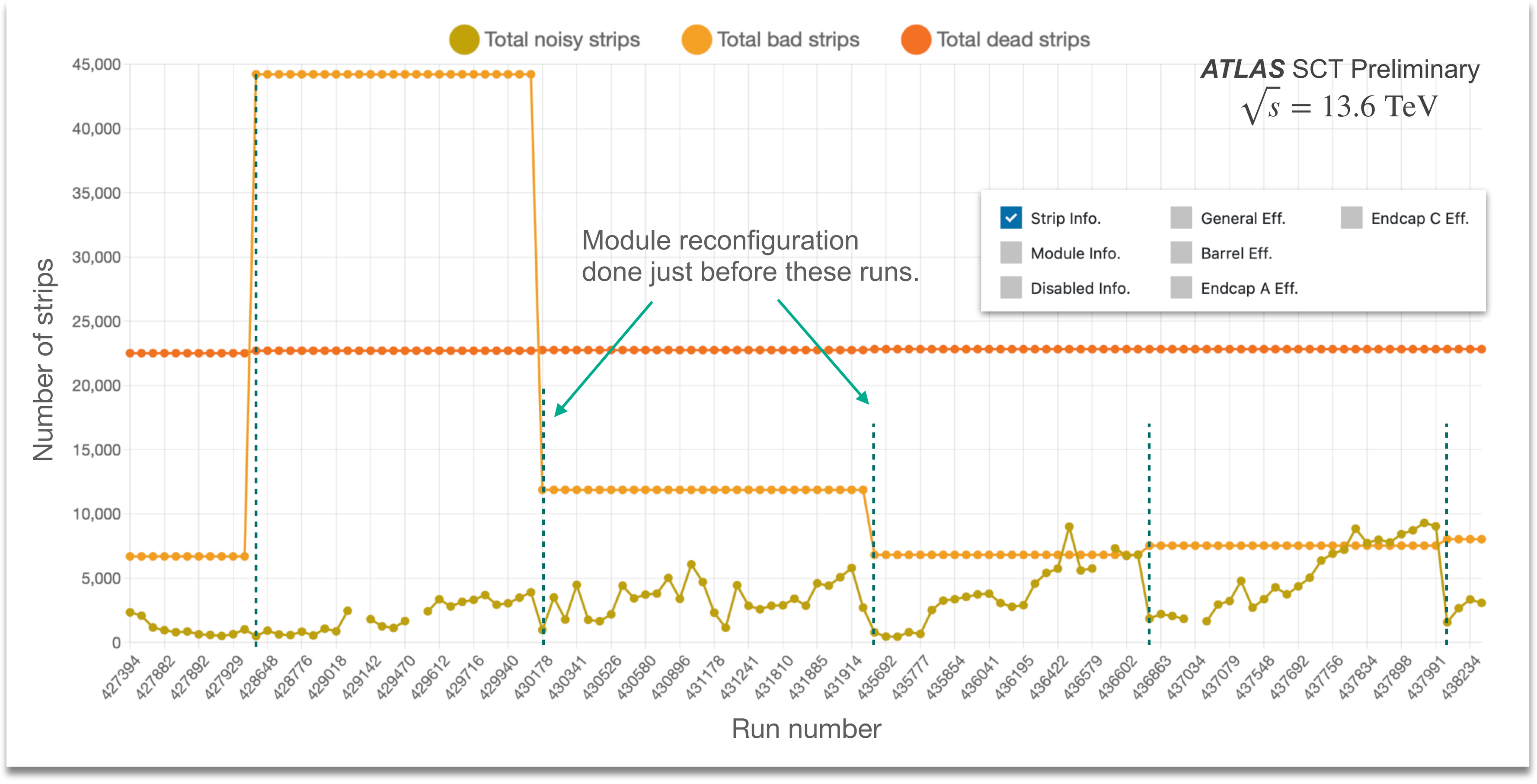
Module \ Run	367363 (42224 events) 2018-12-01 16:04:26	367321 (484554 events) 2018-12-01 03:57:52	367318 (493535 events) 2018-11-30 19:06:51	367273 (515704 events) 2018-11-30 06:28:05
Serial: 20220130000370 **BEC:** -2 **Layer:** 3 **Eta:** 0 **Phi:** 5 **PS:** 3235 **ROD:** 1 **Slot:** 6 **Channel:** 35	BS Parse: 3 Time Out: 8715 BCID: 9518 LVL1 ID: 9294 Preamble: 14967 Formatter: 0 ABCD: 79 Raw: 3764 Mskd Link: 0 ROD Clk: 0 Trunc.ROD: 0 ROB Frag: 0	BS Parse: 211 Time Out: 206443 BCID: 123794 LVL1 ID: 120385 Preamble: 131643 Formatter: 0 ABCD: 1667 Raw: 100241 Mskd Link: 0 ROD Clk: 0 Trunc.ROD: 0 ROB Frag: 0	BS Parse: 47 Time Out: 27921 BCID: 32207 LVL1 ID: 32084 Preamble: 136484 Formatter: 0 ABCD: 1911 Raw: 17087 Mskd Link: 0 ROD Clk: 0 Trunc.ROD: 0 ROB Frag: 0	BS Parse: 0 Time Out: 0 BCID: 0 LVL1 ID: 128 Preamble: 0 Formatter: 0 ABCD: 1 Raw: 0 Mskd Link: 0 ROD Clk: 0 Trunc.ROD: 0 ROB Frag: 0

The SCT Summary Plots



Summary plots page - Demo

(#) Recommend to view in a zoomed out page



References:

(1) ATLAS Collaboration, Operation and performance of the ATLAS semiconductor tracker in LHC Run 2, JINST 17 (2022) P01013

(2) Sergey Linev et al, *js ROOT*, https://github.com/root-project/jsroot/