National University
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Pixel timing adjustment

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Introduction

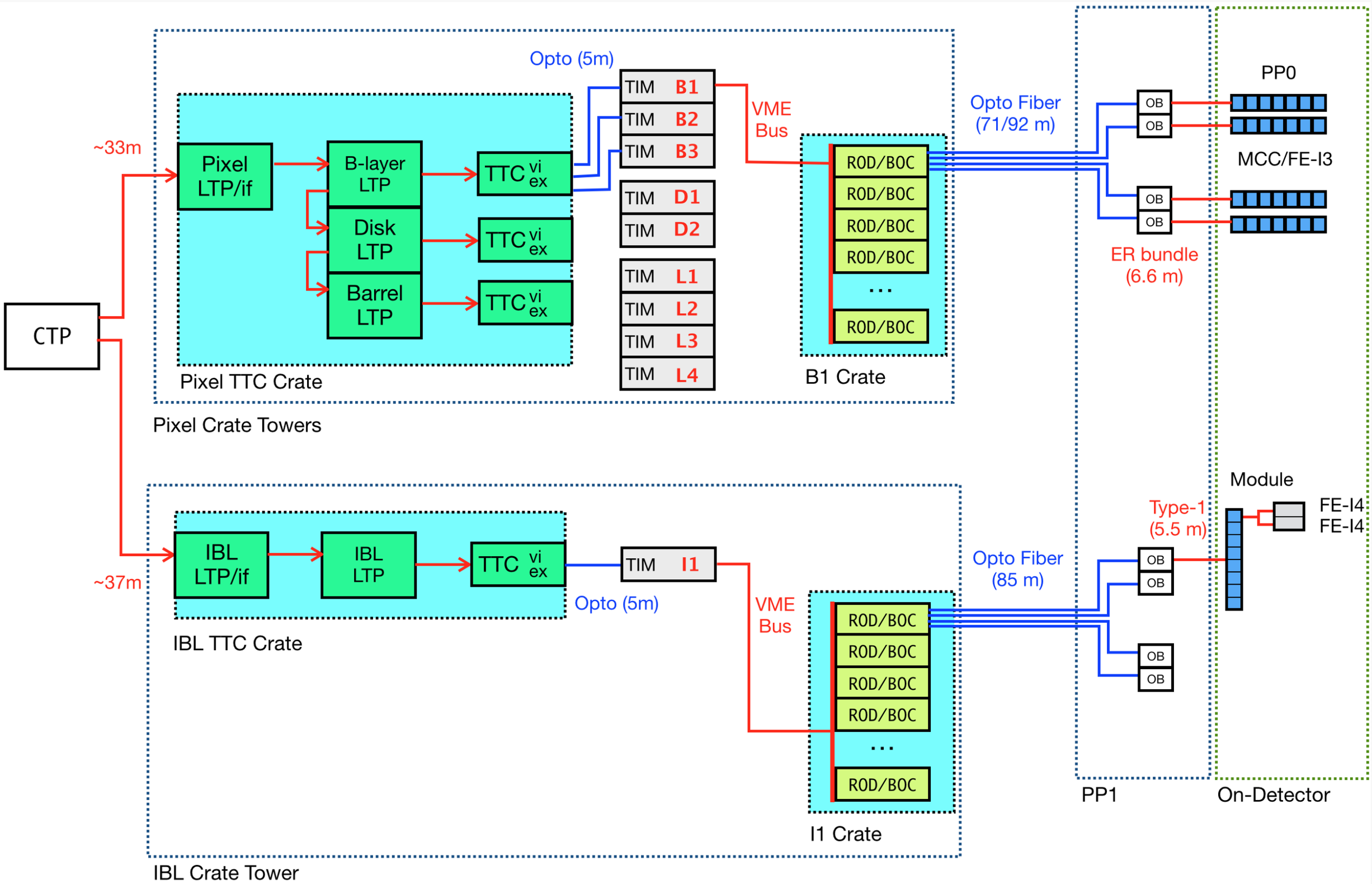
Pixel timing commissioning

- The most fundamental issue for data acquisition
- Imagine if you operate with bad timing
  - ➡ the precious data, time and big money will be lost!!!
  - ➡ super responsible task!!!

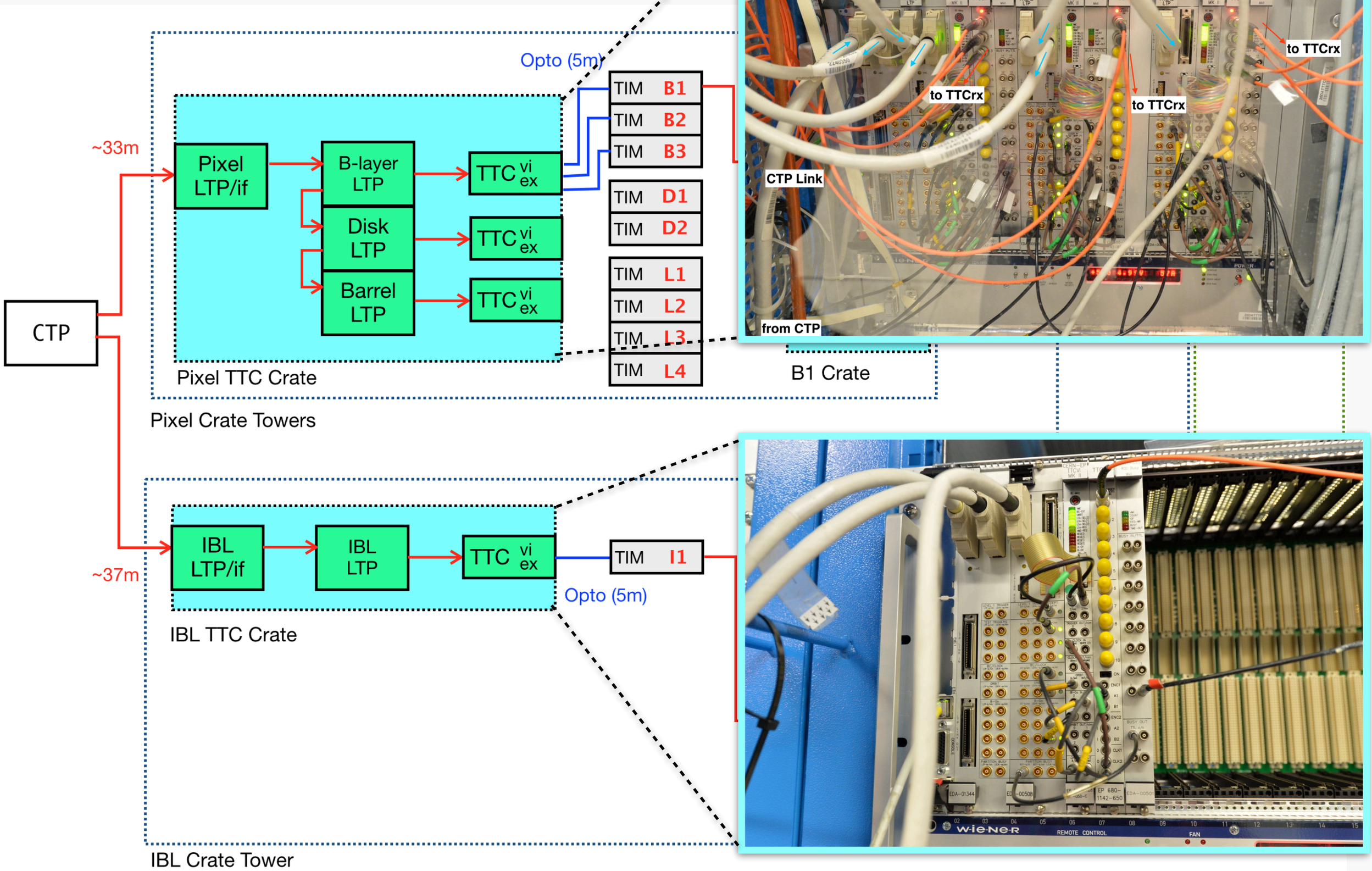
- However you can obtain various skill via the timing task
  - ➡ expertise about the timing-related issue
  - ➡ knowledge of the Pixel readout chain
  - ➡ operation skill
  - ➡ and you will be a raw data analyzer (only a few people can do it)

- Internal note
  - ➡ https://cds.cern.ch/record/2061608 (early 2015 adjustment: the beginning of the Run2)
  - ➡ https://cds.cern.ch/record/2223257 (early 2016 adjustment: right after Layer-2 DAQ upgrade)

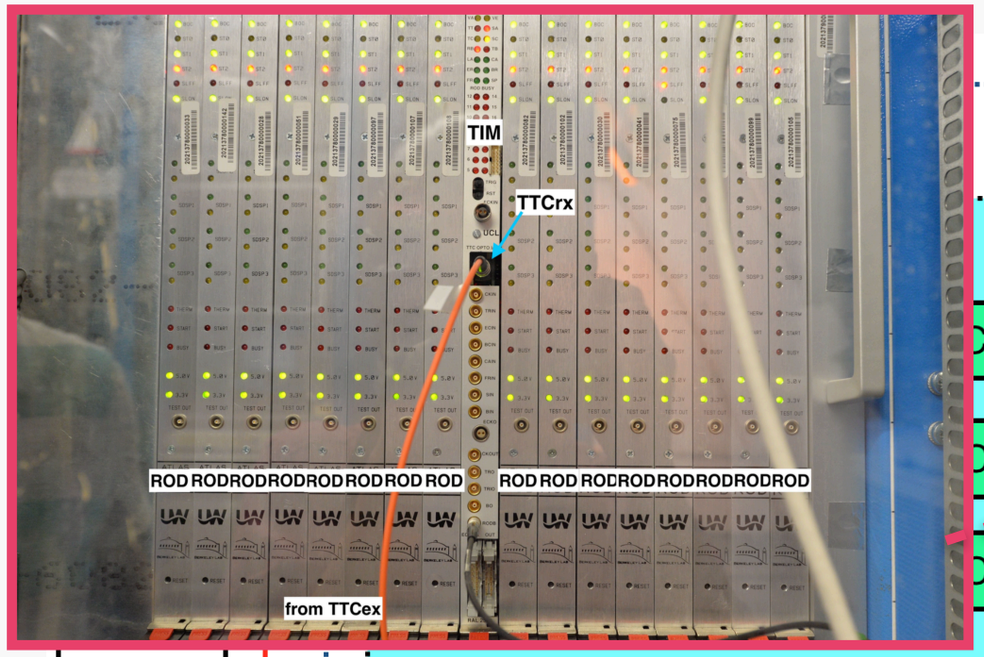
DAQ system


~33m
CTP
Pixel LTP/if
B-layer LTP
Disk LTP
Barrel LTP
TTC vi ex
TTC vi ex
TTC vi ex
Opto (5m)
TIM B1
TIM B2
TIM B3
TIM D1
TIM D2
TIM L1
TIM L2
TIM L3
TIM L4
VME Bus
ROD/BOC
ROD/BOC
ROD/BOC
ROD/BOC
...
ROD/BOC
B1 Crate
Pixel TTC Crate
Pixel Crate Towers
Opto Fiber (71/92 m)
OB
OB
OB
OB
ER bundle (6.6 m)
PP0
MCC/FE-I3
~37m
IBL LTP/if
IBL LTP
TTC vi ex
Opto (5m)
TIM I1
VME Bus
ROD/BOC
ROD/BOC
ROD/BOC
ROD/BOC
...
ROD/BOC
I1 Crate
IBL TTC Crate
IBL Crate Tower
Opto Fiber (85 m)
Type-1 (5.5 m)
OB
OB
OB
OB
Module
FE-I4
FE-I4
PP1
On-Detector

DAQ system


Opto (5m)
~33m
Pixel LTP/if
B-layer LTP
Disk LTP
Barrel LTP
TTC vi ex
TTC vi ex
TTC vi ex
TIM B1
TIM B2
TIM B3
TIM D1
TIM D2
TIM L1
TIM L2
TIM L3
TIM L4
CTP
Pixel TTC Crate
B1 Crate
Pixel Crate Towers
IBL LTP/if
IBL LTP
TTC vi ex
TIM I1
~37m
Opto (5m)
IBL TTC Crate
IBL Crate Tower
LTP if
LTP_B
LTP_D
LTP_L
to TTCrx
to TTCrx
to TTCrx
CTP Link
from CTP
REMOTE CONTROL
FAN

DAQ system



Opto (5m)

TIM B1
TIM B2
TIM B3
TIM D1
TIM D2
TIM L1
TIM L2
TIM L3
TIM L4

VME Bus

ROD/BOC
ROD/BOC
ROD/BOC
ROD/BOC
...
ROD/BOC

B1 Crate

Opto Fiber (71/92 m)

OB
OB
OB
OB

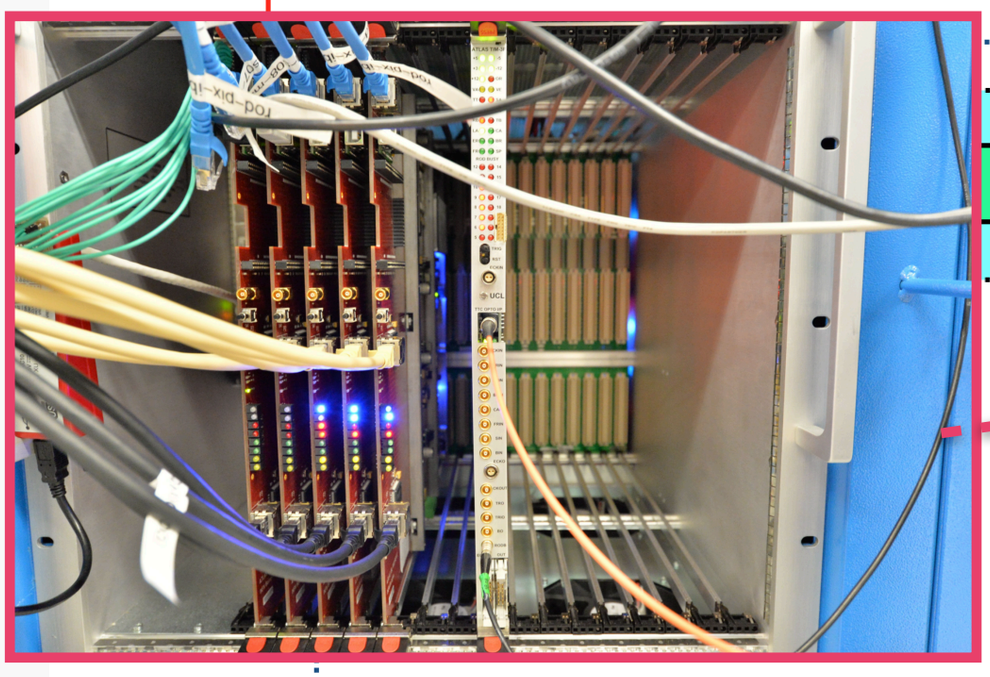
ER bundle (6.6 m)

PP0

MCC/FE-I3

Pixel TTC Crate

Pixel Crate Towers



TIM I1

Opto (5m)

VME Bus

ROD/BOC
ROD/BOC
ROD/BOC
ROD/BOC
...
ROD/BOC

I1 Crate

Opto Fiber (85 m)

OB
OB
OB
OB

Type-1 (5.5 m)

Module

FE-I4
FE-I4

PP1

On-Detector

IBL Crate Tower

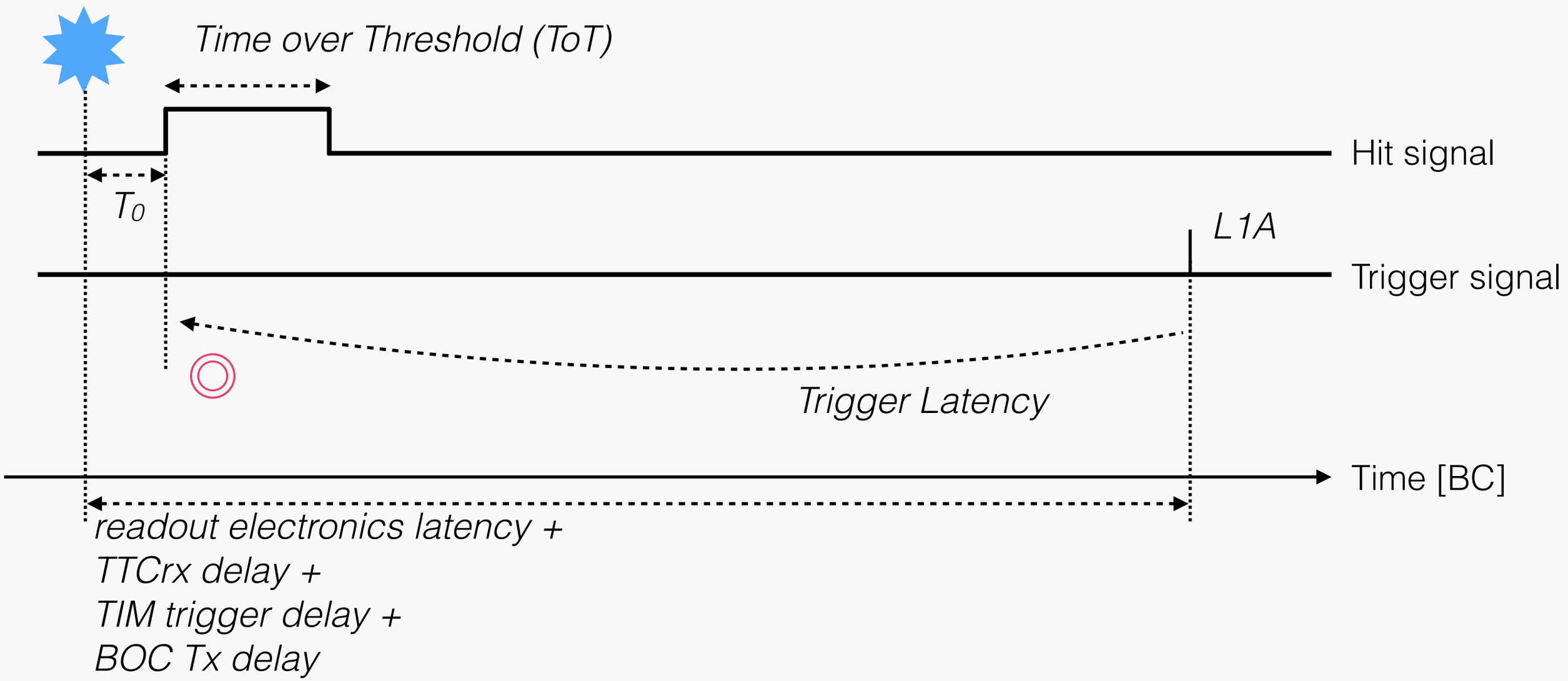
Delay parameters

Category	Tuning parameters	Delay step [ns]	Comments
Common	TTCrx coarse delay	25	Global delay value for the L1A signals, which is applied crate by crate.
	TTCrx fine delay	0.1	Same as above.
	TIM trigger delay	25	Global delay value for the L1A signals, which is applied crate by crate. Note that same values should be set for all crates.
Pixel	BOC coarse dealy	25	Local delay value for the L1A signals, which is applied module by module.
	BOC fine delay	0.3	Same as above.
IBL	BOC coarse delay	3.125	Local delay value for the L1A signals, which is applied module by module.
	BOC fine delay	0.35	Same as above.
	FE-I4 DisVbn	–	FE register parameter for the discriminator bias current. This value is used to decide discriminator delay (called T_0), so it causes the delay for hit signals.

Table 1: Delay parameter list

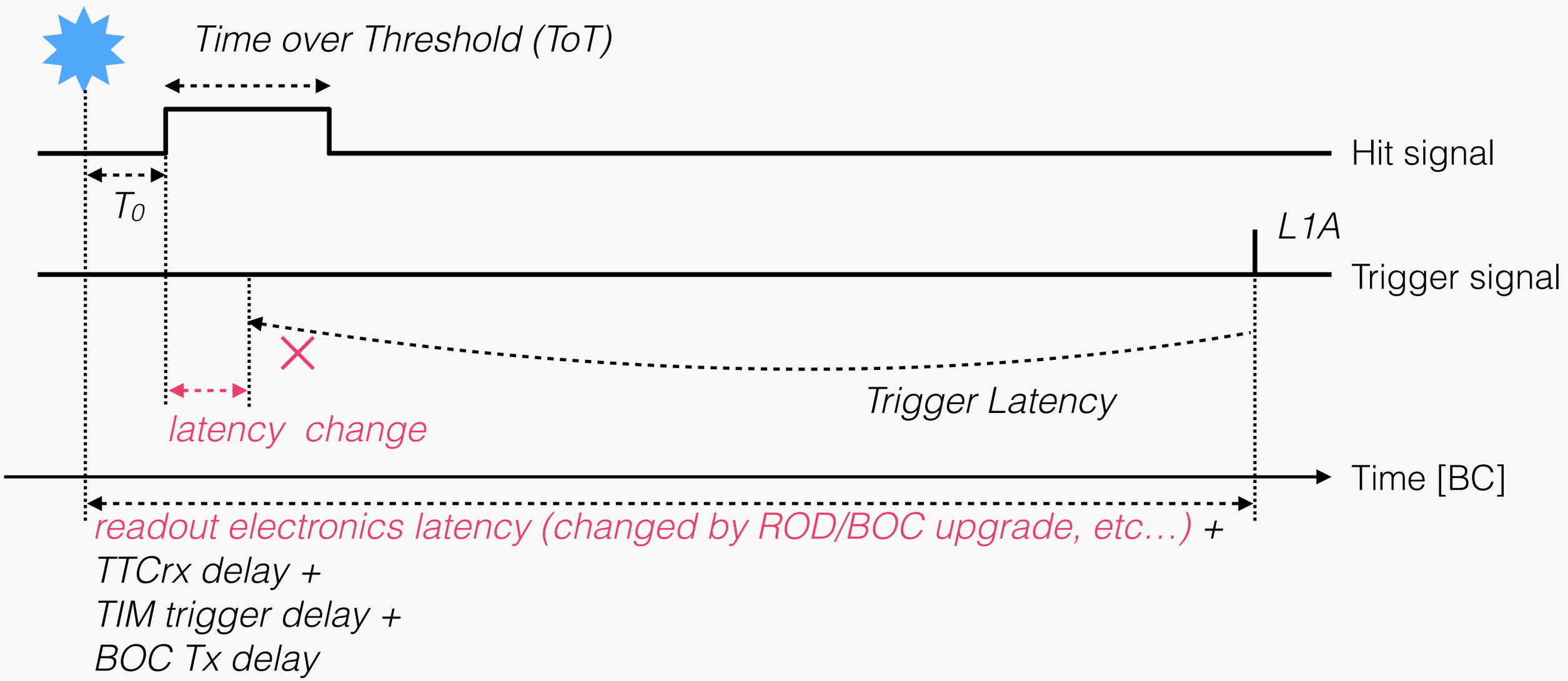
Timing diagram (OK)

Trigger Latency:
150 BC? (B-Layer)
255 BC (Others)



Timing diagram (NG)

Trigger Latency:
150 BC? (B-Layer)
255 BC (Others)



Timing adjustment strategy

- Depends on LHC schedule

  ➡ ***need to check it carefully*** with the ATLAS Run meeting, etc…

Daily meeting Weekly meeting

① Coarse adjustment with cosmic ray in *O*(25 ns)
→global tuning

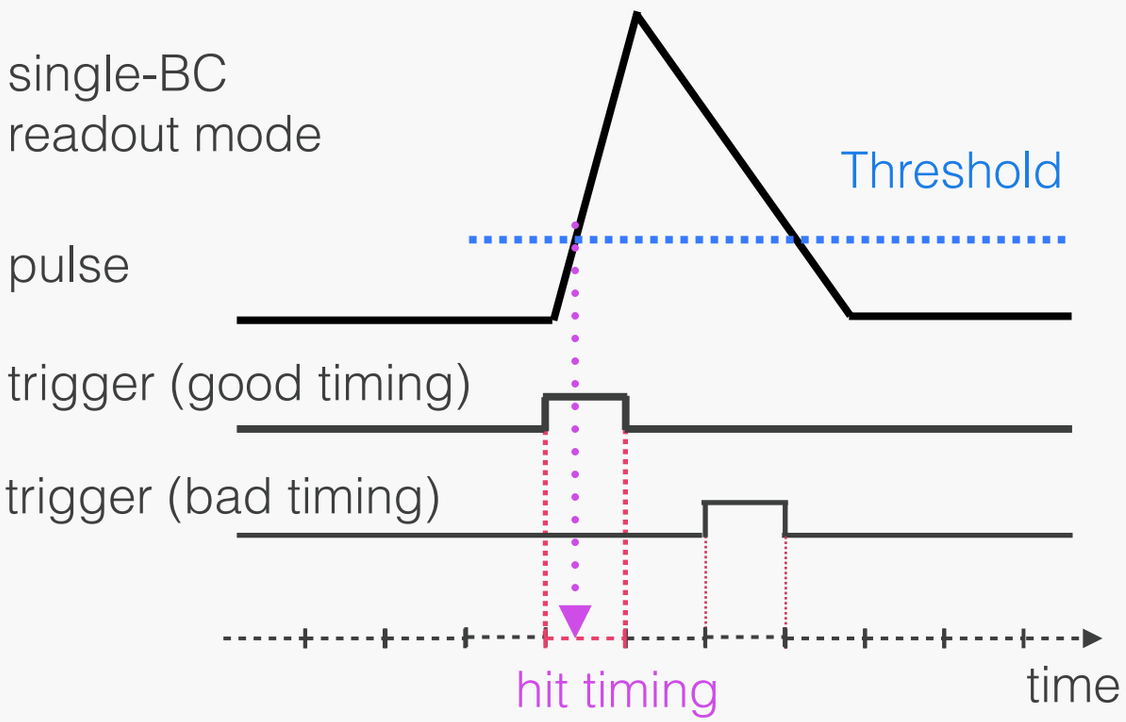
② Fine adjustment with collision beam (***timing scan***) in *O*(1 ns)
→local tuning (module by module)

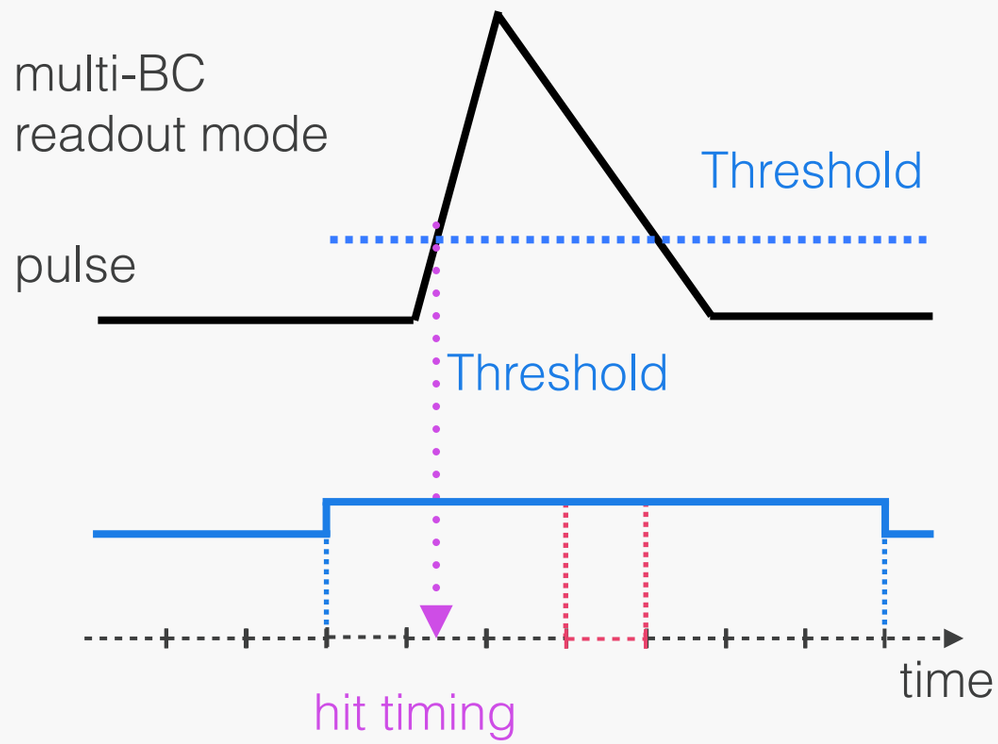
QUICK and ***PRECISE*** analyses were required in this work!

Cosmic ray data analysis

Consecutive L1A mode

- Usually when FEs receive a trigger, only 1BC information is sent to ROD/BOC
- Consecutive L1A mode: multi-BC information is sent from FEs to ROD/BOC
  - ➡ it can provide how many BC the trigger is shifted from proper timing
  - ➡ the data taking length is so-called “readout window”
    - ‣ you have to decide how much you expands the readout window with the Pixel experts!





e.g. readout window = 7 BC

Cosmic ray data taking

- Timing analysis needs additional information to nominal xAOD
  - ➡ special xAOD samples should be prepared (DAOD_IDTRKVALID)
    - https://twiki.cern.ch/twiki/bin/view/AtlasProtected/InDetDerivedxAOD
- Trigger
  - ➡ Muon trigger (Recommended)
    - big data size but low hit rate
  - ➡ TRT trigger
    - trigger timing is not so much sophisticated

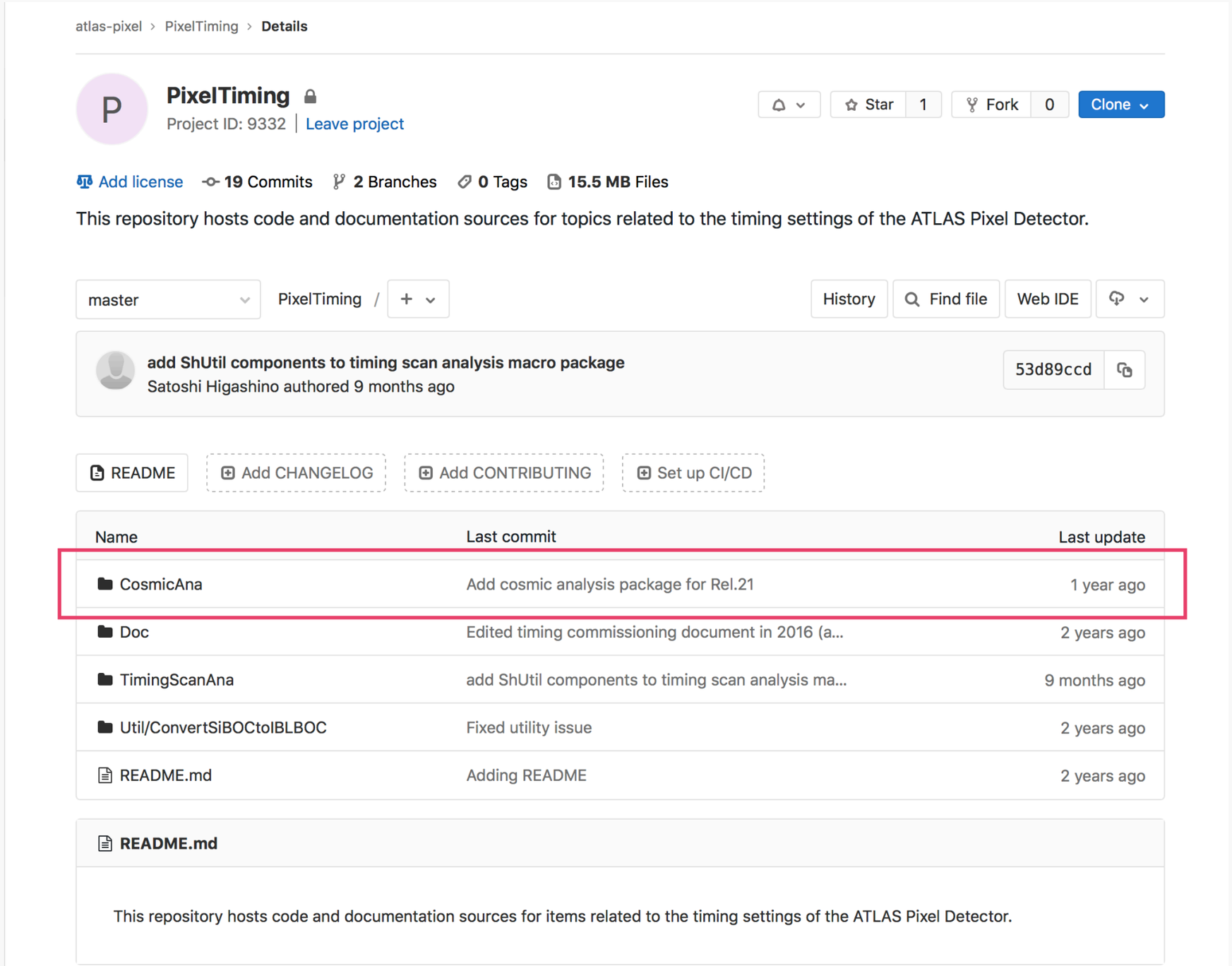
DAOD production

- (under construction…)

  the current xAOD format might be changed for the Run3 analysis…

Analysis framework

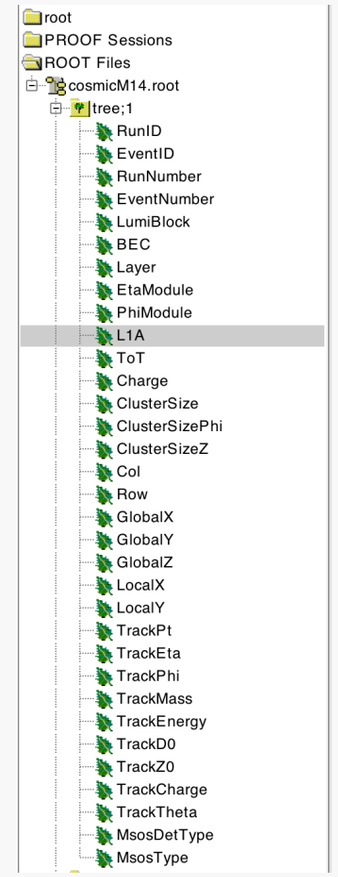
- https://gitlab.cern.ch/atlas-pixel/PixelTiming

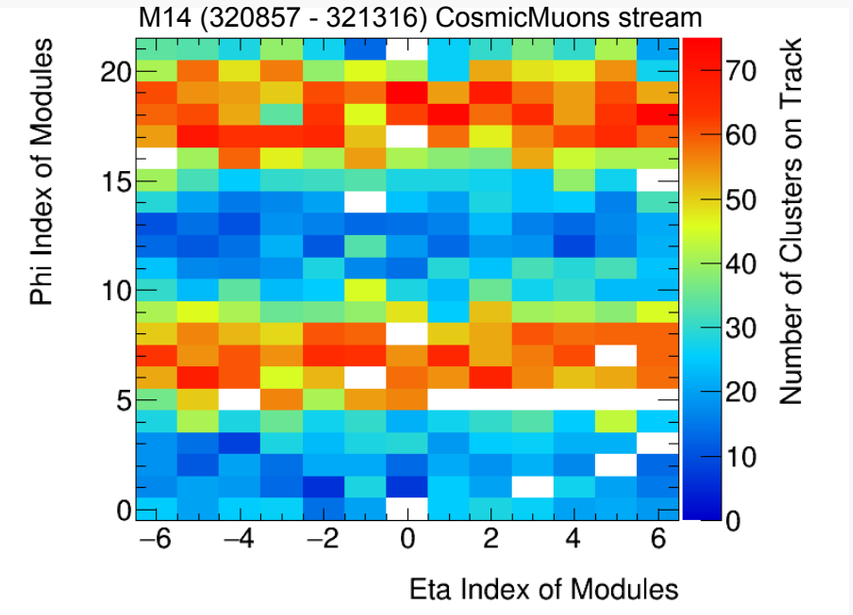


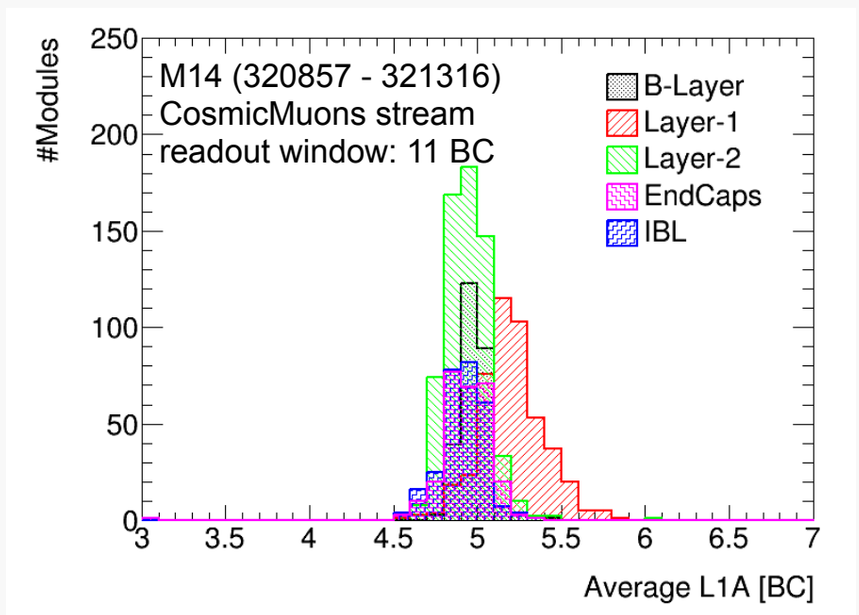
check “README”!

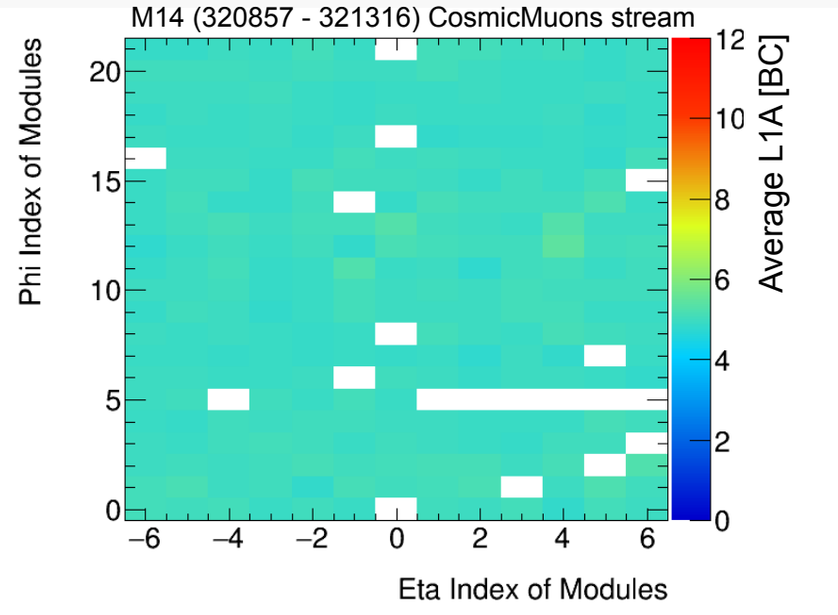
Some distributions getting from NTuple

- Basic detector information is stored in the NTuple
  - ➡ L1A distribution is the most useful from the view point of the timing
  - ➡ And also recommended to have a look at the basic hit maps
    - *since you may be a first person to check the cosmic data in offline!!!*
  - ➡ example plots: for M14 (Milestone 14) run at the beginning of 2017
    - right after Layer-1 DAQ upgrade
    - because of this reason the Layer-1 timing is slightly shifted





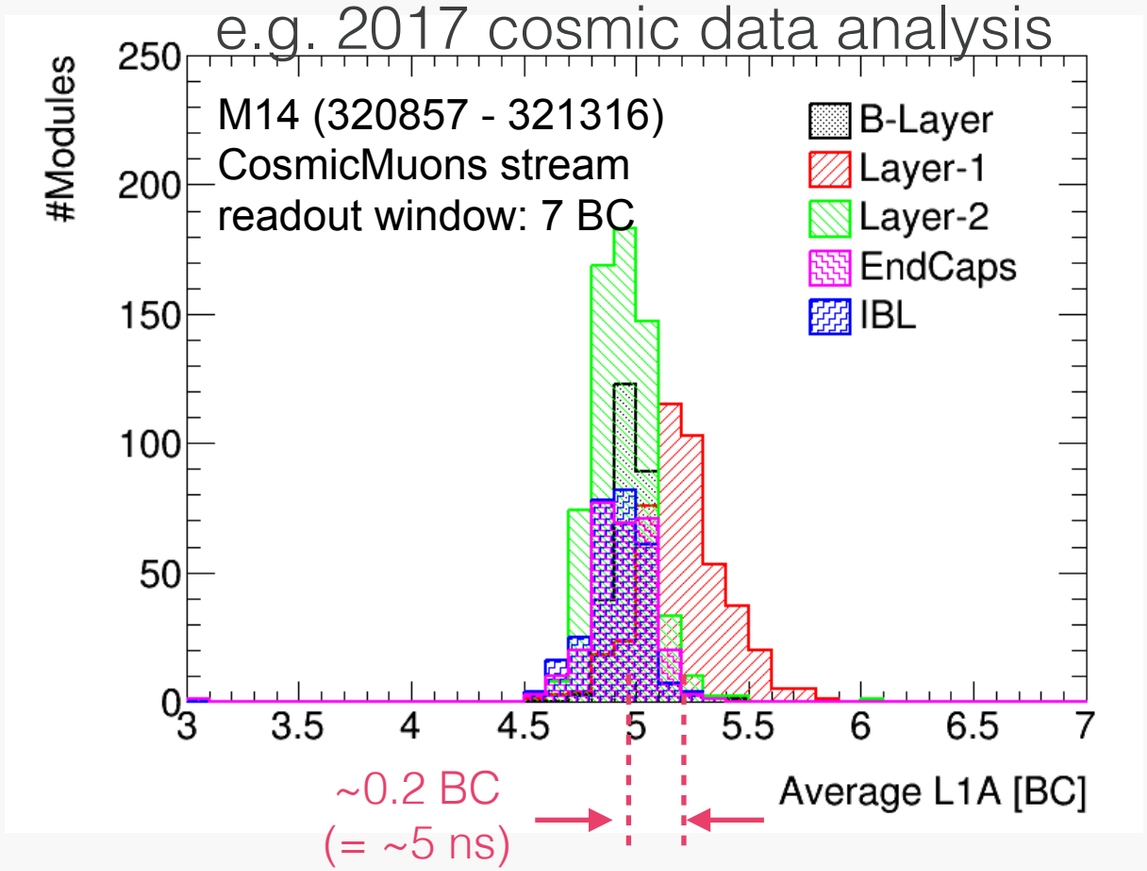




Timing adjustment before timing scans

- Timing shift can be observed from L1A distributions
  - ➡ corresponding delays should be applied before the next fine adjustment using collision data (timing scan)
    - more precise adjustment may reduce costs of timing scans (delay step and range)
  - ➡ Also the finer granularity should be considered if you can collect much more statistics
    - module by module? stave by stave?? layer by layer???

e.g. 2017 cosmic data analysis

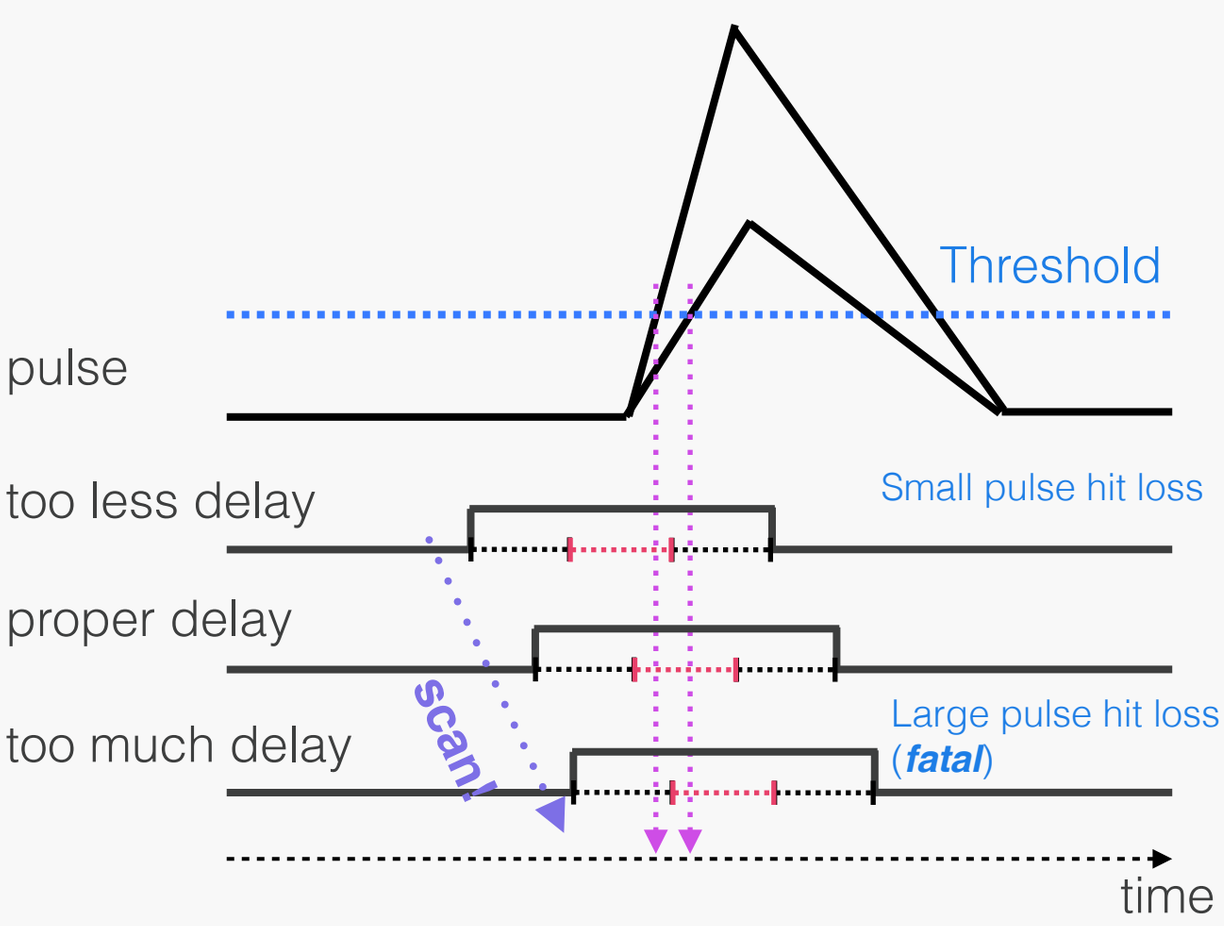


*We decided that ~0.2 BC difference is much small, so the delay was not applied at that moment in 2017 timing adjustment

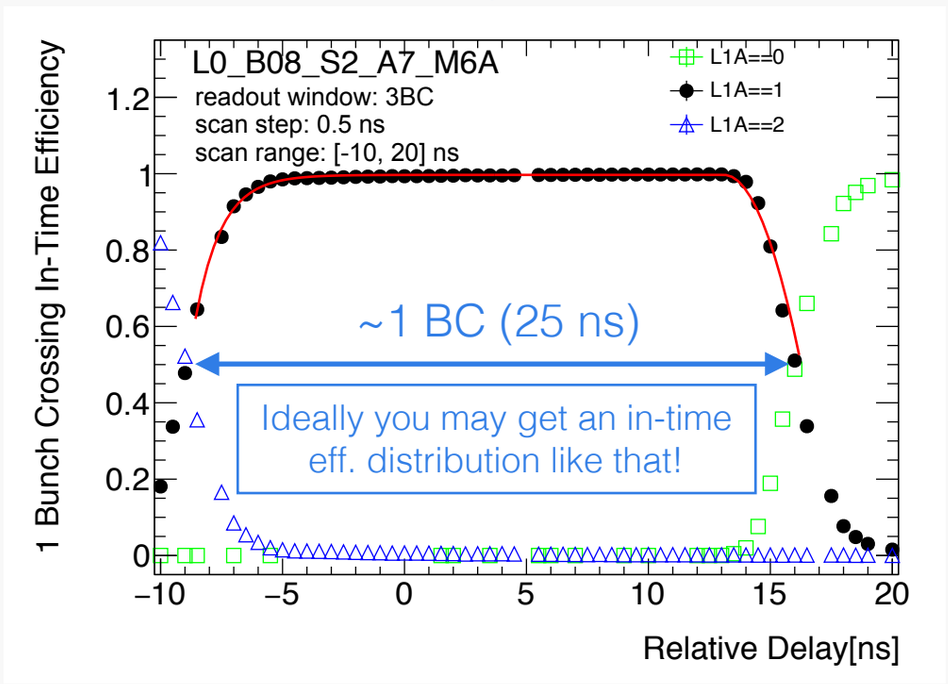
Collision data analysis (***Timing scan***)

Timing scan

- Keep consecutive L1A mode (readout window ≥ 3)
- Delay is changed within a particular range and step
  - ➡ e.g. [-10 ns, 10 ns] w.r.t. the nominal delay setting with 0.5 ns step
- “In-time efficiency” is the most useful variable to extract current timing situation

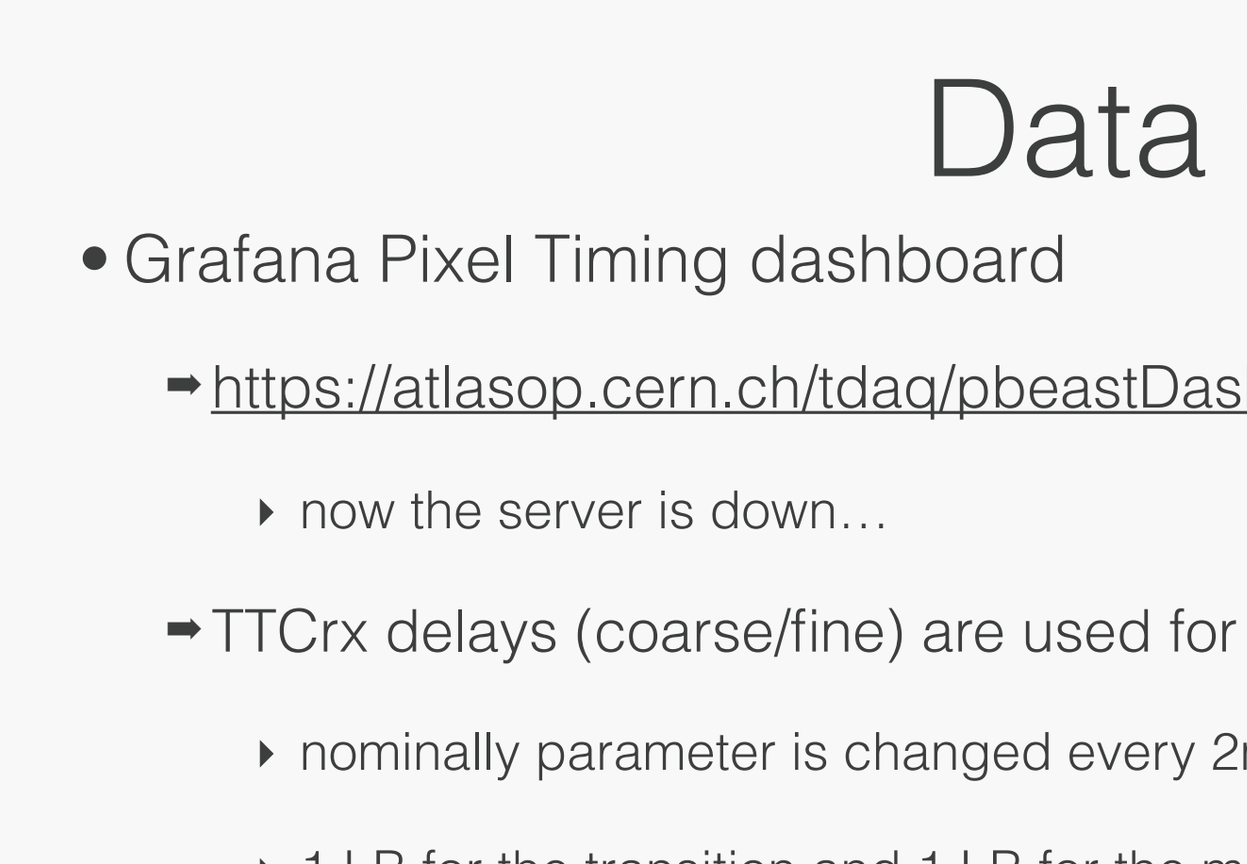


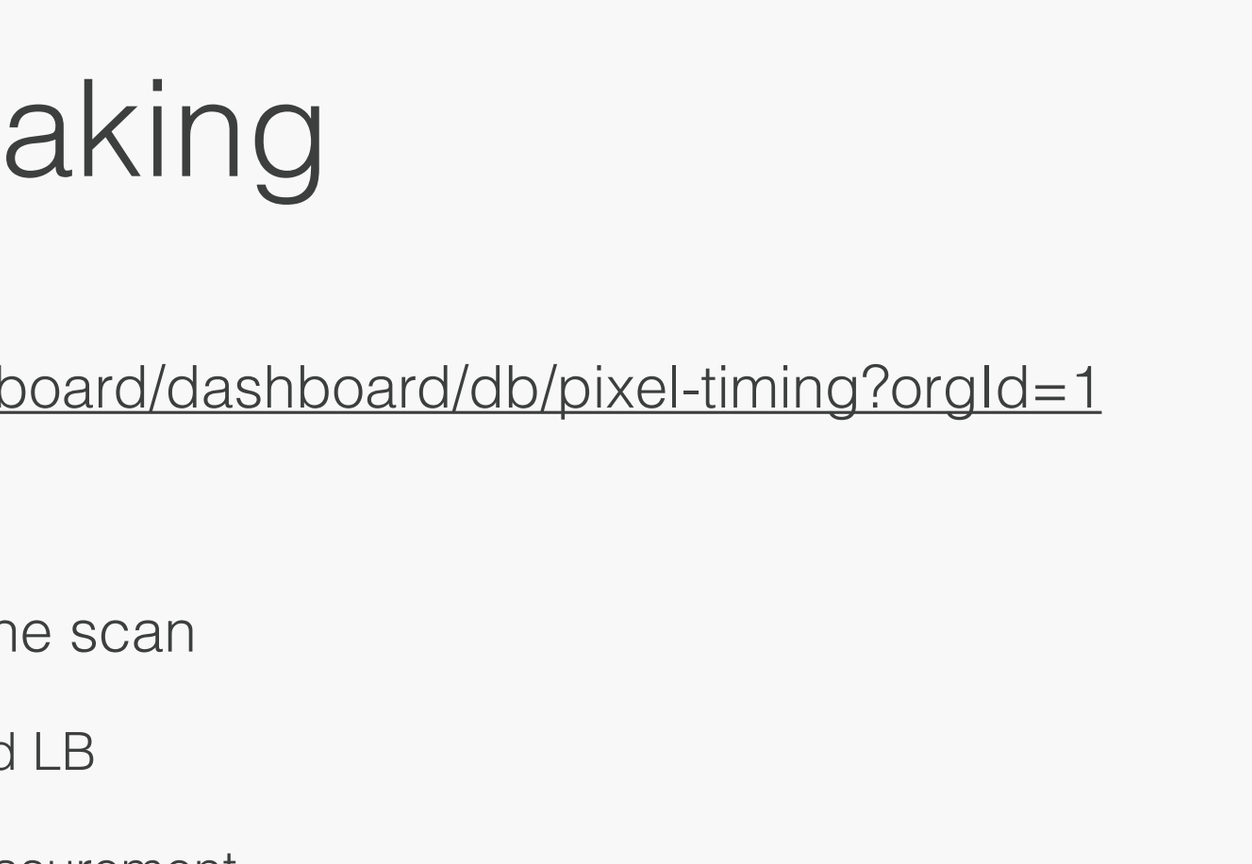
In-time eff. = *#event in the target BC* / *#event in all BCs*



Data taking

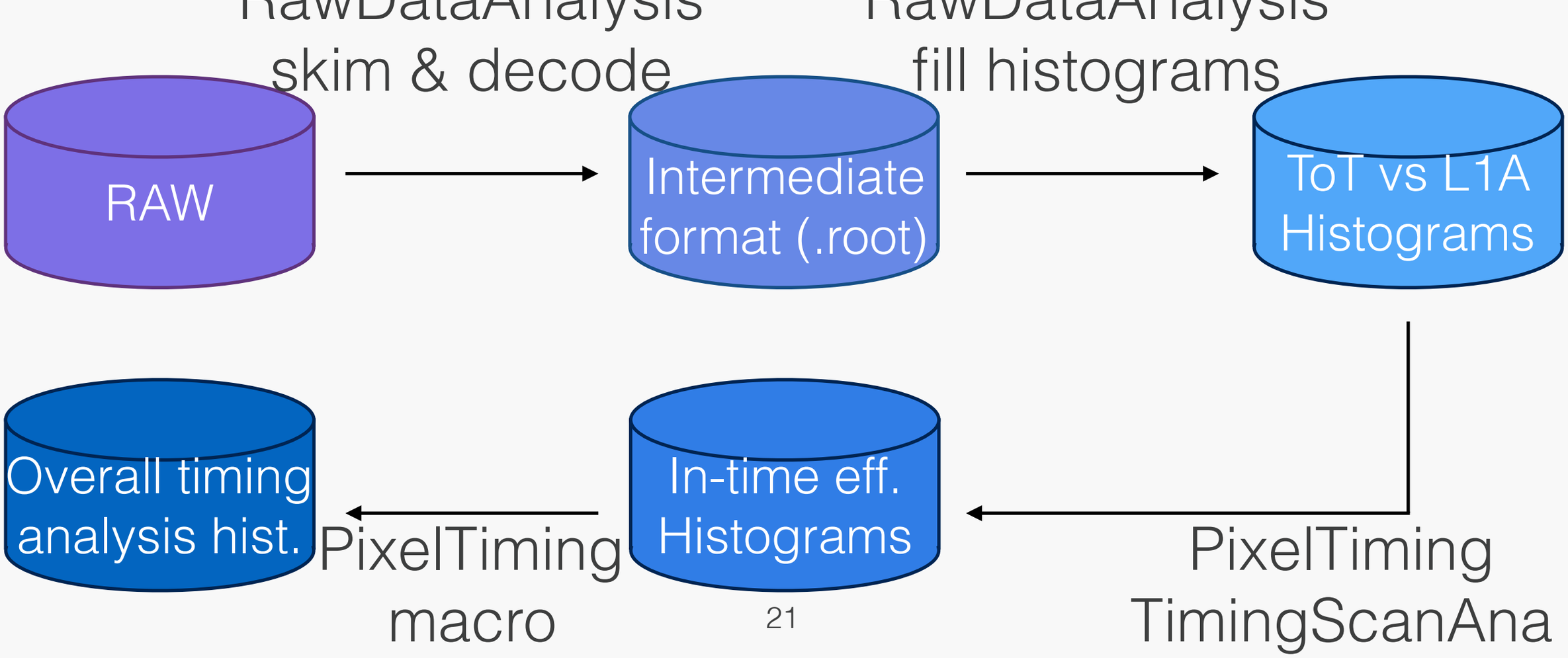
- Grafana Pixel Timing dashboard
  - ➡ https://atlasop.cern.ch/tdaq/pbeastDashboard/dashboard/db/pixel-timing?orgId=1
    - now the server is down…
  - ➡ TTCrx delays (coarse/fine) are used for the scan
    - nominally parameter is changed every 2nd LB
    - 1 LB for the transition and 1 LB for the measurement





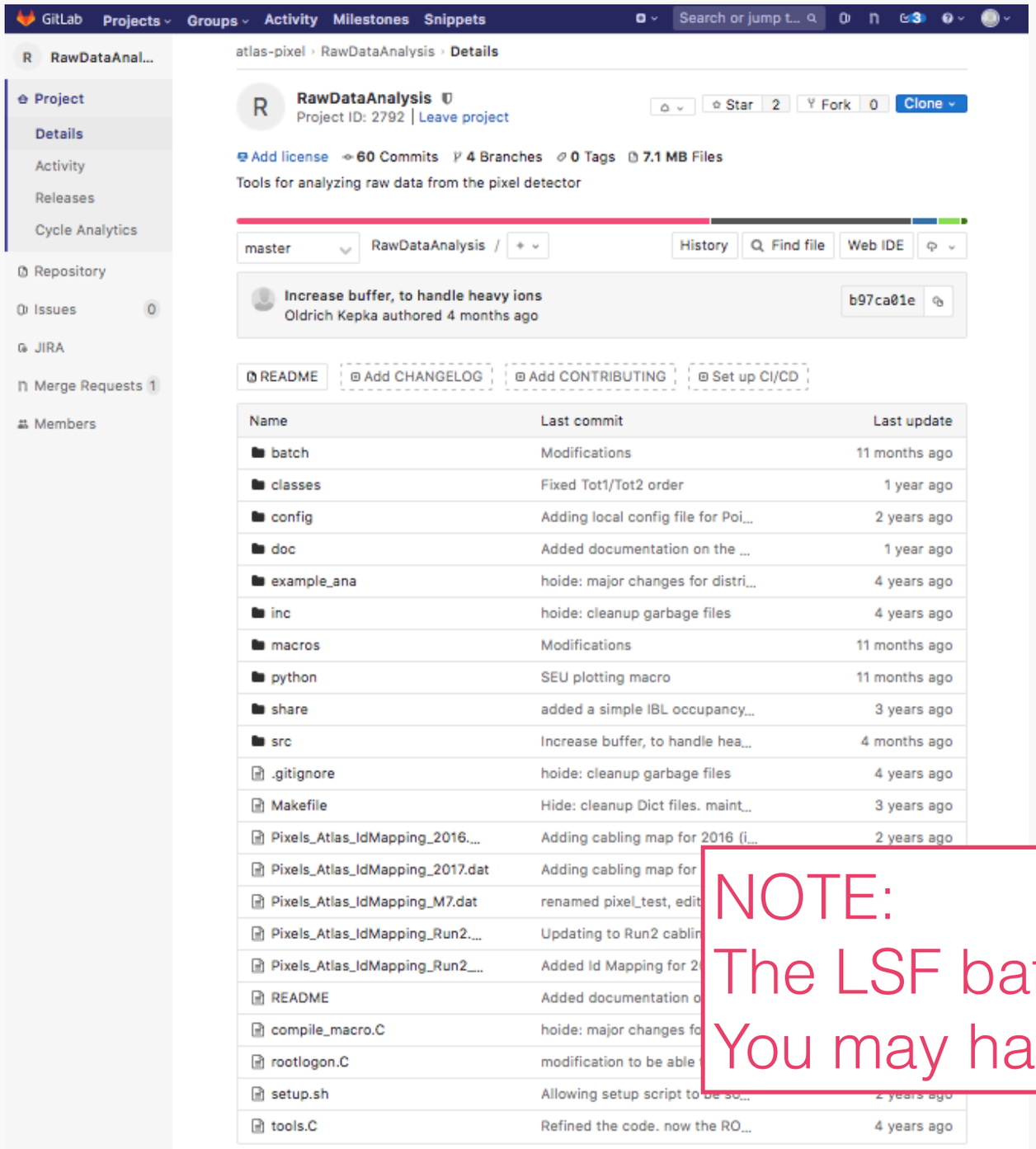
Timing scan data analysis

- Multi-stage processes starting from RAW data
  - ➡ due to lack of detector information in xAOD format
  - ➡ and we cannot wait for reprocessing in the central!!!
- Two analysis packages are already prepared
  - ➡ “RawDataAnalysis” and “PixelTiming” in the GitLab



RawDataAnalysis

- https://gitlab.cern.ch/atlas-pixel/RawDataAnalysis



the README helps you!

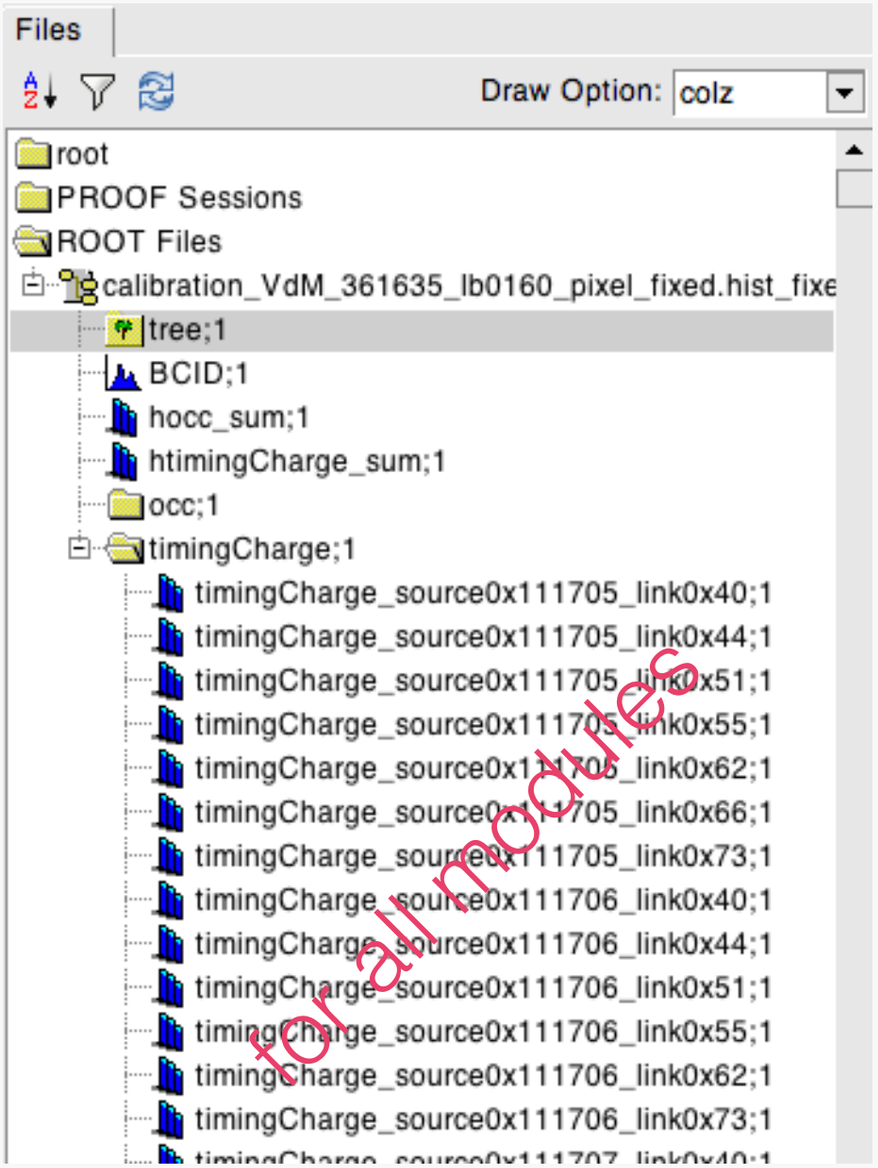
- batch/submit_pixel_timing.sh
- batch/submit_IBL_timing.sh

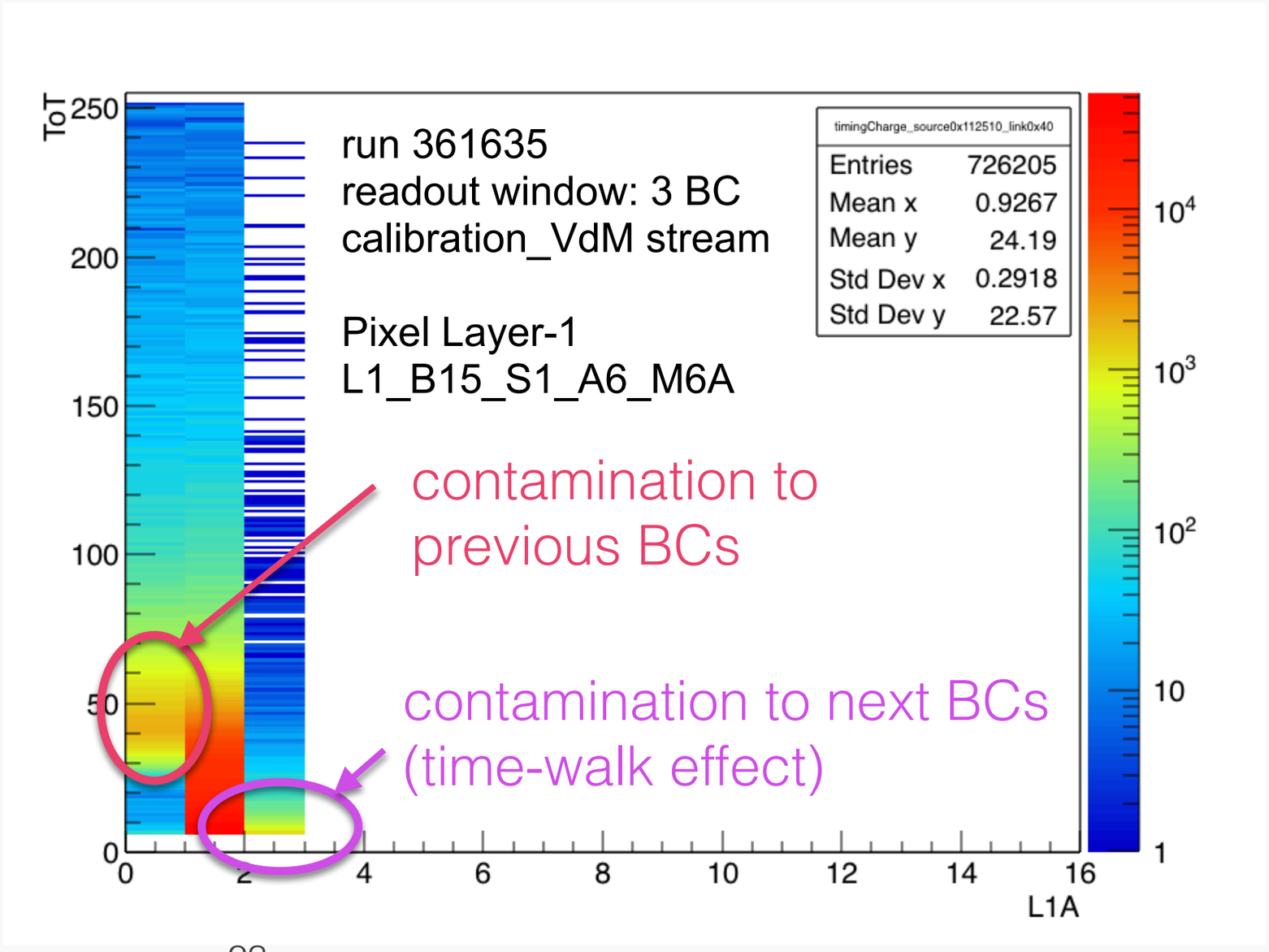
scripts use the LSF batch system to submit raw data skim/decode and making ToT vs L1A histograms (show these scripts!)

NOTE:
The LSF batch system may be already obsolete!
You may have to convert to the HTCondor format

Products of the RawDataAnalysis

- The main product is ToT vs L1A histograms for each module (PixeI/IBL)
  - ➡ in-time efficiency can be calculated from it
  - ➡ basically such plots should be made scan step by step

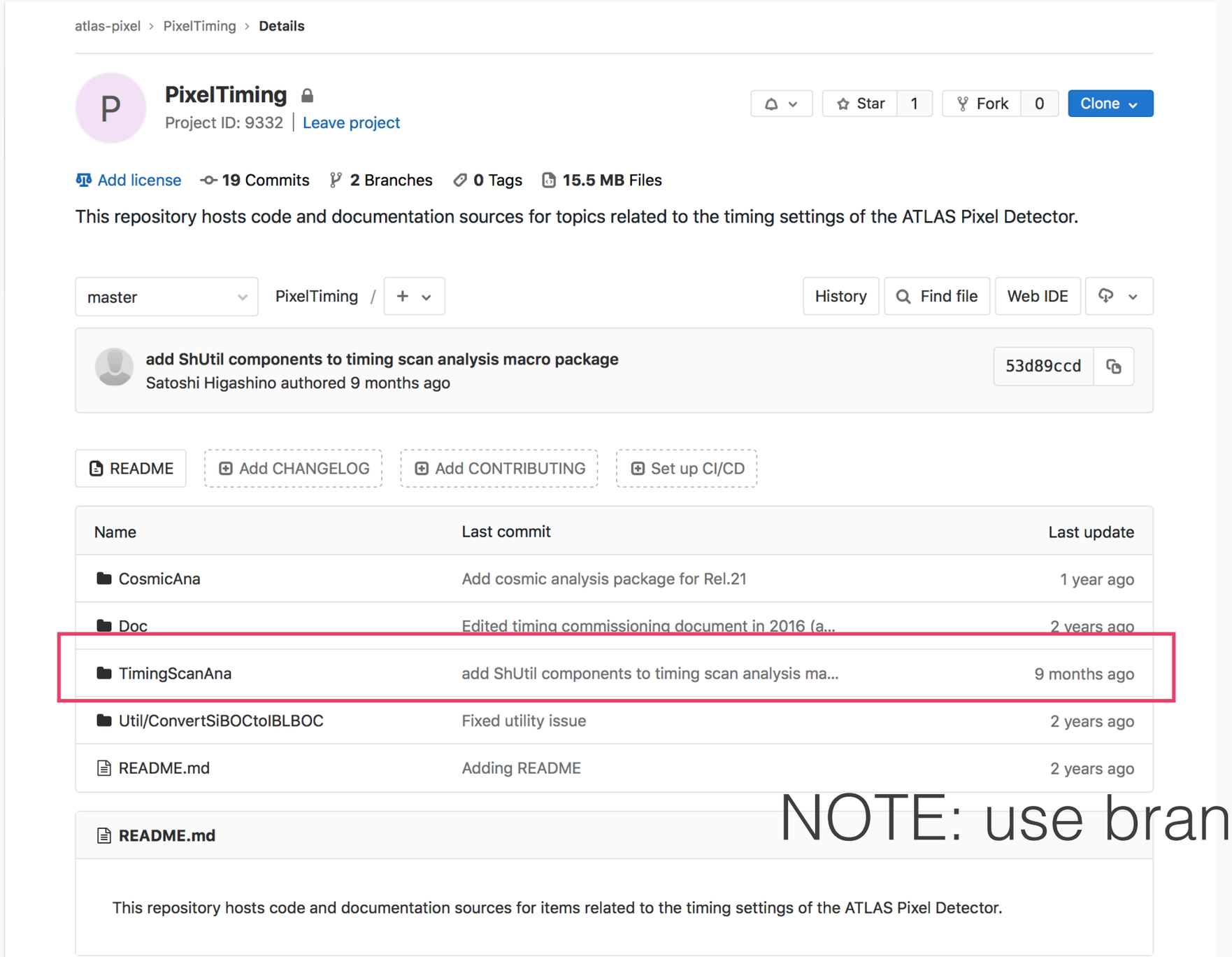




*see backup about this format

PixelTiming

- https://gitlab.cern.ch/atlas-pixel/PixelTiming



same package as the cosmic ray data analysis

NOTE: use branch “v1.1” or later!

Configuration file

- Configuration files are prepared for Pixel and IBL, respectively
  - ➡ TimingScanAna/data/scanConfigPix.txt
  - ➡ TimingScanAna/data/scanConfigIBL.txt

scanConfigPix.txt 7.04 KB

Edit | Web IDE | Replace | Delete

```
# Output File
OUTPUT_FILE: timingScanAnaPix348197.root

# Scan Configuration
SCAN_RANGE: -10 20
READOUT_WINDOW: 3
SCAN_STEP: 0.5

# Analysis Configuration
### note!!!
### "TOT_CUT_XXX: 10" means that you select TOT >= 10!
TIMING_CHARGE_DIR: timingCharge
TOT_CUT_BLAYER: 10
TOT_CUT_LAYER_1: 25
TOT_CUT_LAYER_2: 25
TOT_CUT_DISK: 25

# Scan Points
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0112_pixel.hist.root  -9
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0116_pixel.hist.root  -7
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0120_pixel.hist.root  -5
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0122_pixel.hist.root  -4
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0124_pixel.hist.root  -3
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0126_pixel.hist.root  -2
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0131_pixel.hist.root  0
SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0134_pixel.hist.root  2
# SCAN_POINT: /eos/atlas/unpledged/group-tokyo/users/sahigash/pix/timing/Timing348197/physics_Main_348197_lb0136_pixel.hist.root  3
```

←set output file name (.root format)

←set timing scan configuration

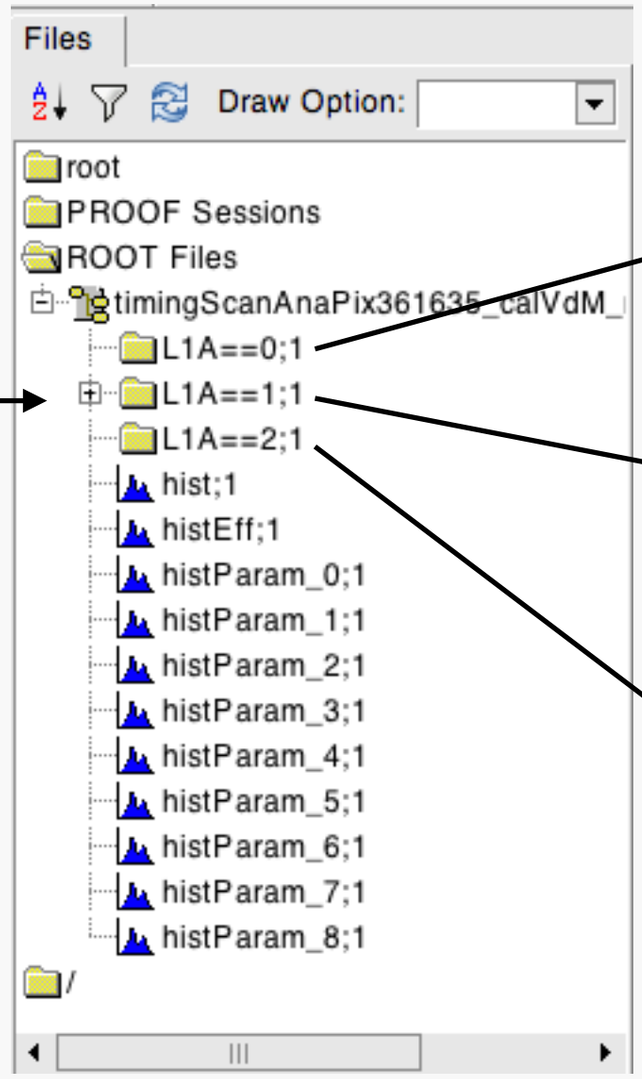
←ToT cut (in case of ignoring time-walk effect)
if you just want to check timing status,
you can waste low-ToT hits

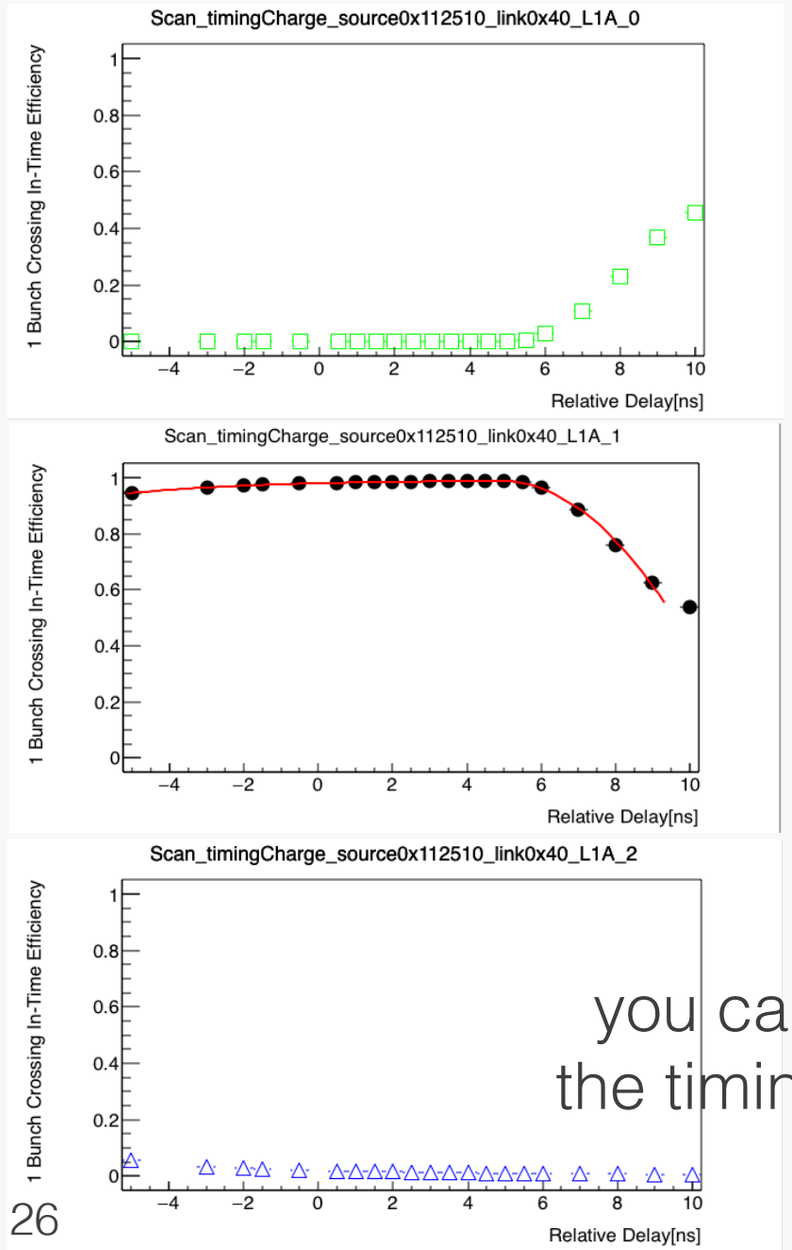
↑list up the ToT vs L1A hist files step by step

Products of the TimingScanAna

- $ cd PixelTiming/TimingScanAna
- $ source setup.sh
- $ ./bin/TimingScanAnaPix data/scanConfigPix.txt

Target BC





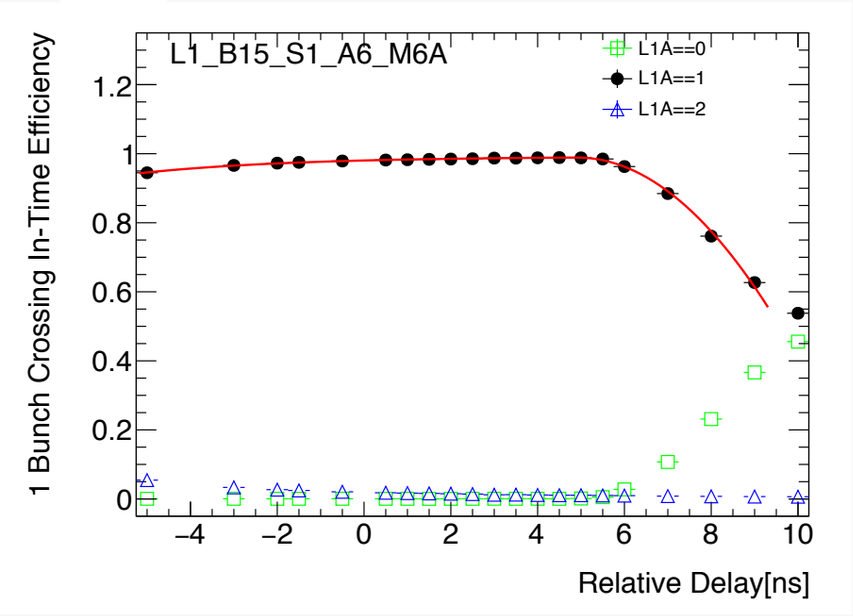
you can already check
the timing status roughly!

Timing analysis macros

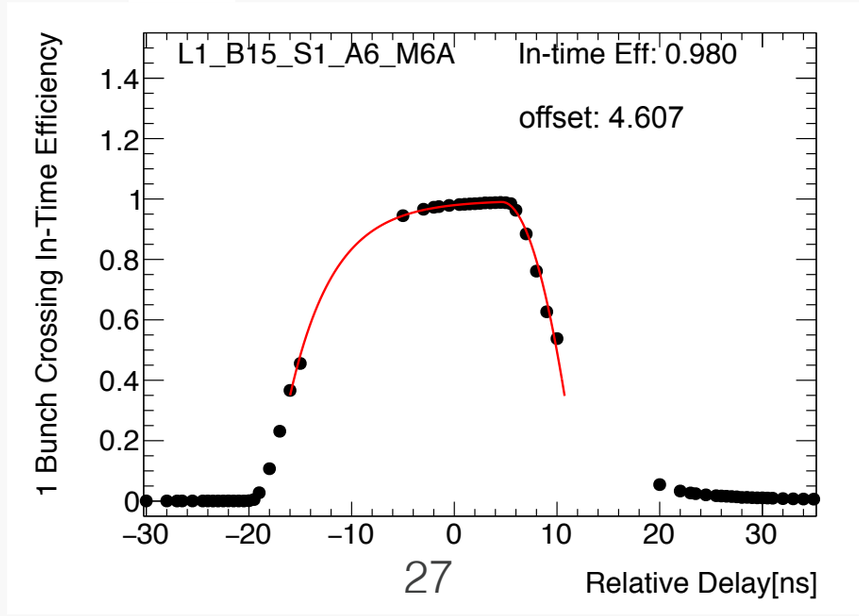
- Visualize and quantify the timing status
  - ➡ $ cd PixelTiming/TimingScanAna/macros/makePlot
  - ➡ $ root -l -q -b ‘drawHistPix.cc("[inputFile]", “[configFile]”, “[output]”)’
    - [inputFile] … output file of the TimingScanAna process
    - [configFile] … config file in the data/ directory (e.g. scanConfigPix.txt)
    - [output] … postfix of output directories

products

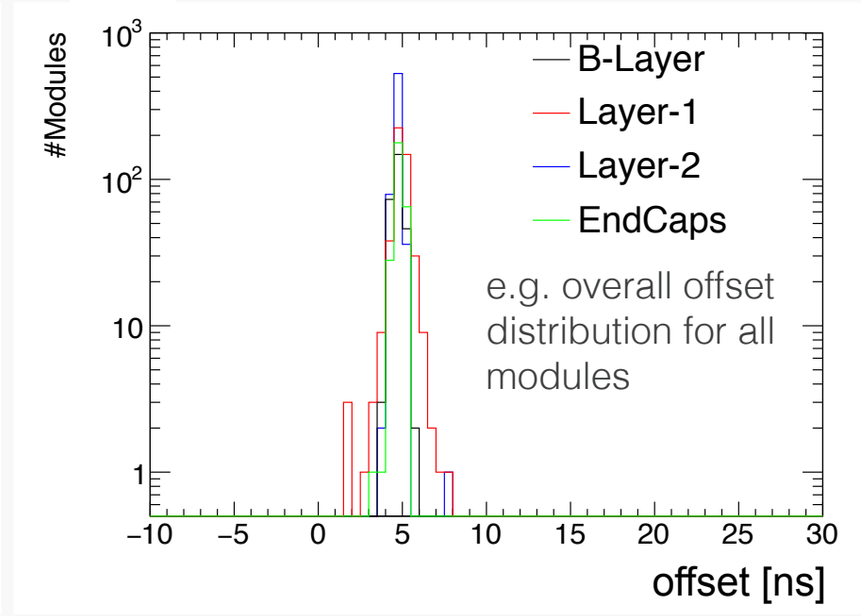
outputPix[output]



fitPix[output]



overallPix[output]



Create new delay set

Pixel/IBL BOC Tx - Module connectivity

- Each module is identified with the IP Address and Tx channel from the view point of BOCs

TxInfo.txt

RODName	IpAddress	ConnName	TxCh
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M0	6
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M1A	5
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M2A	4
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M3A	3
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M4A	2
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M5A	1
ROD_B2_S10	10.145.104.110	L0_B04_S2_A7_M6A	0
ROD_B2_S10	10.145.104.110	L0_B04_S2_C6_M1C	17
ROD_B2_S10	10.145.104.110	L0_B04_S2_C6_M2C	18
ROD_B2_S10	10.145.104.110	L0_B04_S2_C6_M3C	19
ROD_B2_S10	10.145.104.110	L0_B04_S2_C6_M4C	20
ROD_B2_S10	10.145.104.110	L0_B04_S2_C6_M5C	21
ROD_B2_S10	10.145.104.110	L0_B04_S2_C6_M6C	22
ROD_B2_S11	10.145.104.111	L0_B08_S1_A6_M1A	1
ROD_B2_S11	10.145.104.111	L0_B08_S1_A6_M2A	2
ROD_B2_S11	10.145.104.111	L0_B08_S1_A6_M3A	3
ROD_B2_S11	10.145.104.111	L0_B08_S1_A6_M4A	4
ROD_B2_S11	10.145.104.111	L0_B08_S1_A6_M5A	5
ROD_B2_S11	10.145.104.111	L0_B08_S1_A6_M6A	6
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M0	22
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M1C	21
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M2C	20
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M3C	19
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M4C	18
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M5C	17
ROD_B2_S11	10.145.104.111	L0_B08_S1_C7_M6C	16
ROD_B2_S12	10.145.104.112	L0_B08_S2_A7_M0	6
ROD_B2_S12	10.145.104.112	L0_B08_S2_A7_M1A	5

New delays

- You need to calculate new delays from a nominal delay set
  - ➡ need to dump the old delay before any tunings!
  - ➡ and also need to check if the format is proper for the person who will apply the delays (you can ask it to the run coordinator)

old

delayL1L2_2018.txt

#ModuleID	Coarse	Fine
L1_B10_S2_A7_M0	41	5
L1_B10_S2_A7_M1A	42	1
L1_B10_S2_A7_M2A	42	0
L1_B10_S2_A7_M3A	42	2
L1_B10_S2_A7_M4A	42	6
L1_B10_S2_A7_M5A	42	6
L1_B10_S2_A7_M6A	42	2
L1_B10_S2_C6_M1C	41	8
L1_B10_S2_C6_M2C	41	4
L1_B10_S2_C6_M3C	41	5
L1_B10_S2_C6_M4C	41	7
L1_B10_S2_C6_M5C	42	2
L1_B10_S2_C6_M6C	42	1
L1_B11_S1_A6_M1A	41	7
L1_B11_S1_A6_M2A	41	8
L1_B11_S1_A6_M3A	42	2
L1_B11_S1_A6_M4A	42	2
L1_B11_S1_A6_M5A	42	5
L1_B11_S1_A6_M6A	42	8
L1_B11_S1_C7_M0	41	3
L1_B11_S1_C7_M1C	41	6
L1_B11_S1_C7_M2C	40	7
L1_B11_S1_C7_M3C	41	3
L1_B11_S1_C7_M4C	41	5
L1_B11_S1_C7_M5C	42	2
L1_B11_S1_C7_M6C	41	7
L1_B11_S2_A7_M0	41	8
L1_B11_S2_A7_M1A	41	8
L1_B11_S2_A7_M2A	42	4

new

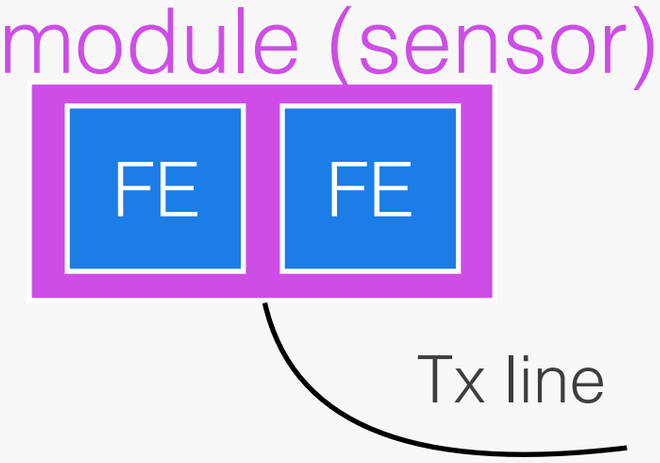
delay_Ly1Ly2_2018.txt

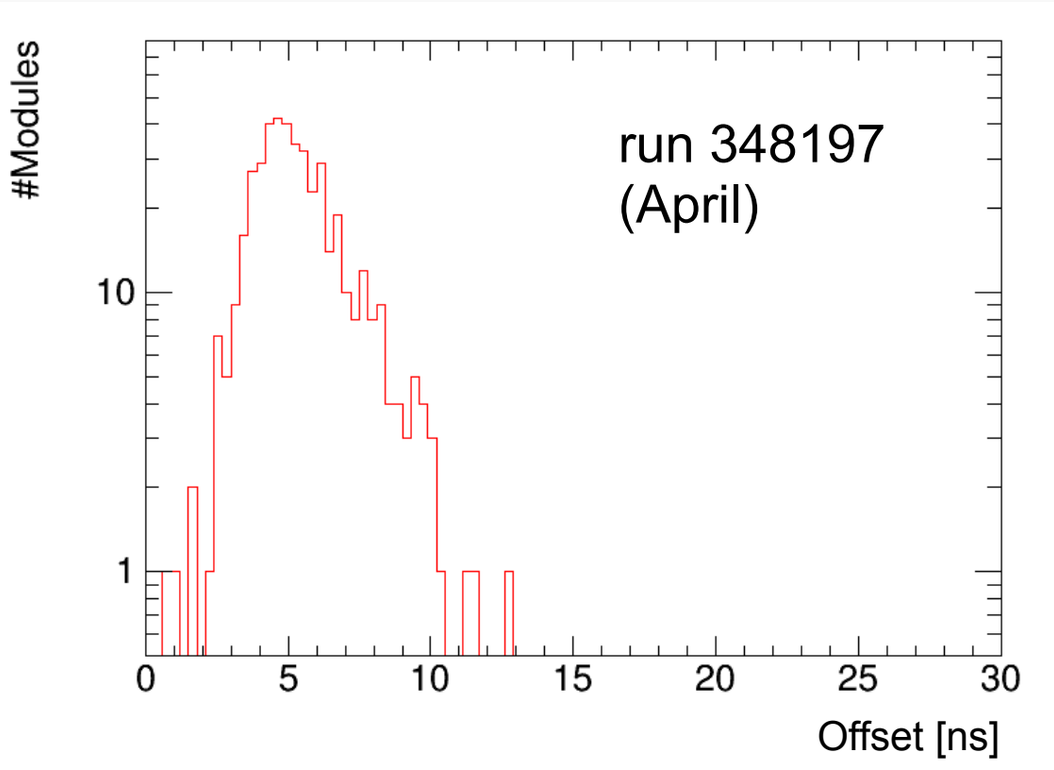
#ModuleID	Coarse	Fine
L1_B03_S1_A6_M6A	7	0
L1_B05_S1_C7_M6C	6	8
L1_B06_S2_C6_M1C	37	7
L1_B07_S1_A6_M2A	38	3
L1_B08_S1_A6_M5A	40	0
L1_B12_S1_C7_M6C	40	2
L1_B12_S2_A7_M6A	40	7
L1_B13_S2_A7_M6A	40	0
L1_B17_S1_A6_M6A	7	1
L1_B18_S2_C6_M6C	6	6
L2_B01_S2_A7_M0	5	6
L2_B02_S2_A7_M0	5	6
L2_B02_S2_A7_M1A	5	6
L2_B02_S2_A7_M2A	5	6
L2_B02_S2_A7_M3A	6	0
L2_B03_S2_A7_M1A	5	3
L2_B08_S2_A7_M0	40	3
L2_B13_S1_C7_M1C	40	8

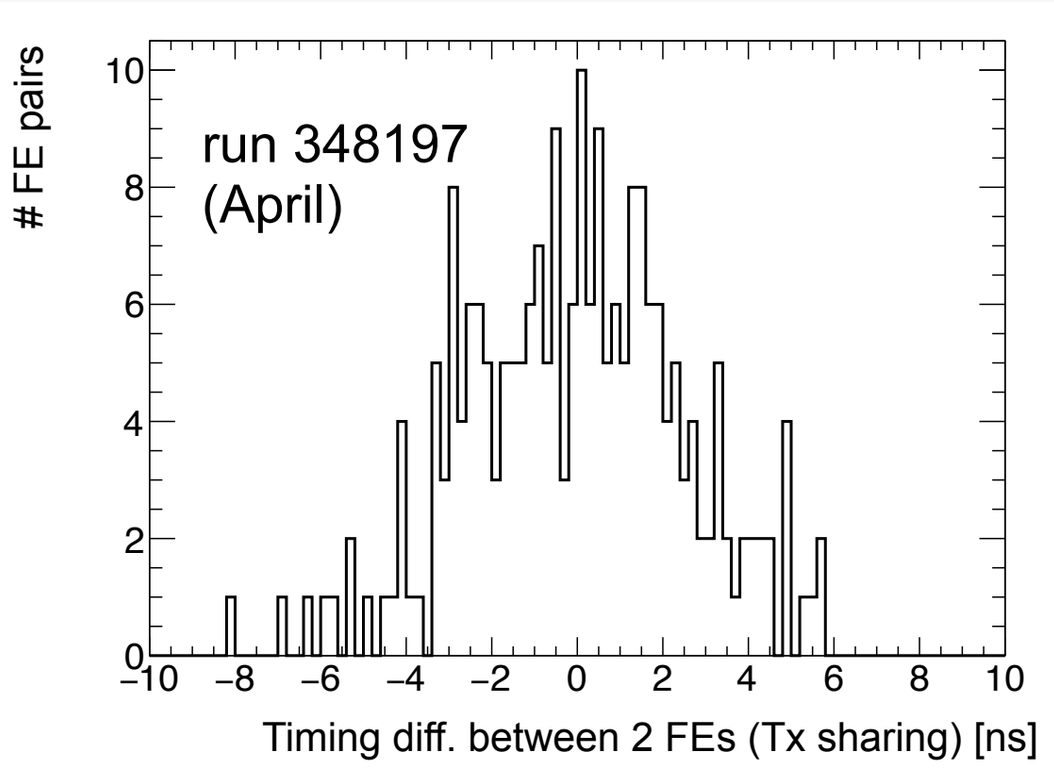
IBL DisVbn issue

Introduction - IBL timing detuning

- IBL timing was not completely fixed from the beginning of Run2!
- This is due to Tx sharing issue: 1 Tx line connects 2 FEs
  - ➡ only for IBL planar
  - ➡ in order to adjust FE by FE, DisVbn tuning should be performed



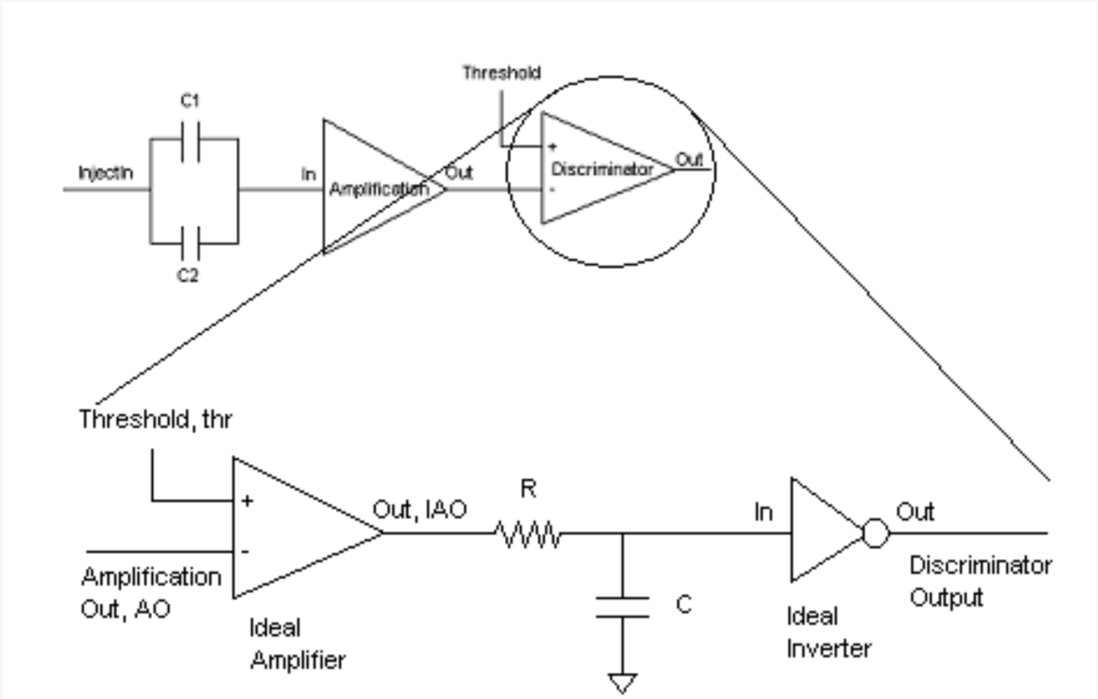




DisVbn Register in FE-I4

- DisVbn: to adjust discriminator bias

  ➡ adjust jitter of the discriminator (can be explained with the transient effect)



$$V_C + V_R = V_{IAO} \rightarrow R\dot{q} + q/C = V_{IAO}$$

$$t = RC \ln \frac{V_{IAO}}{V_{IAO} - V_C} \quad , \quad R = \frac{V_R}{DisVbn}$$

Origin of timing variance in FE: DisVbn

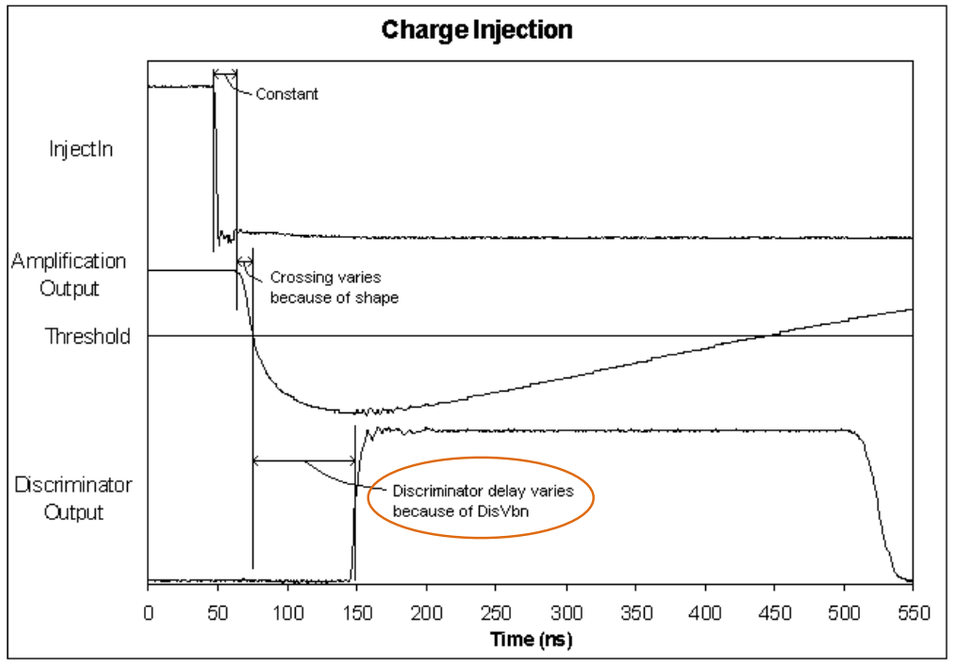


Fig. 2: A time graph of the charge injection, amplification output and discriminator output. There is a constant time delay between charge injection and the response of the amplification stage. The output of the amplifier crosses the threshold at a variable time depending on the shape of the amplifier output, and the discriminator fires at a variable time depending on the DisVbn.

Hideyuki Oide May 28, 2015 12

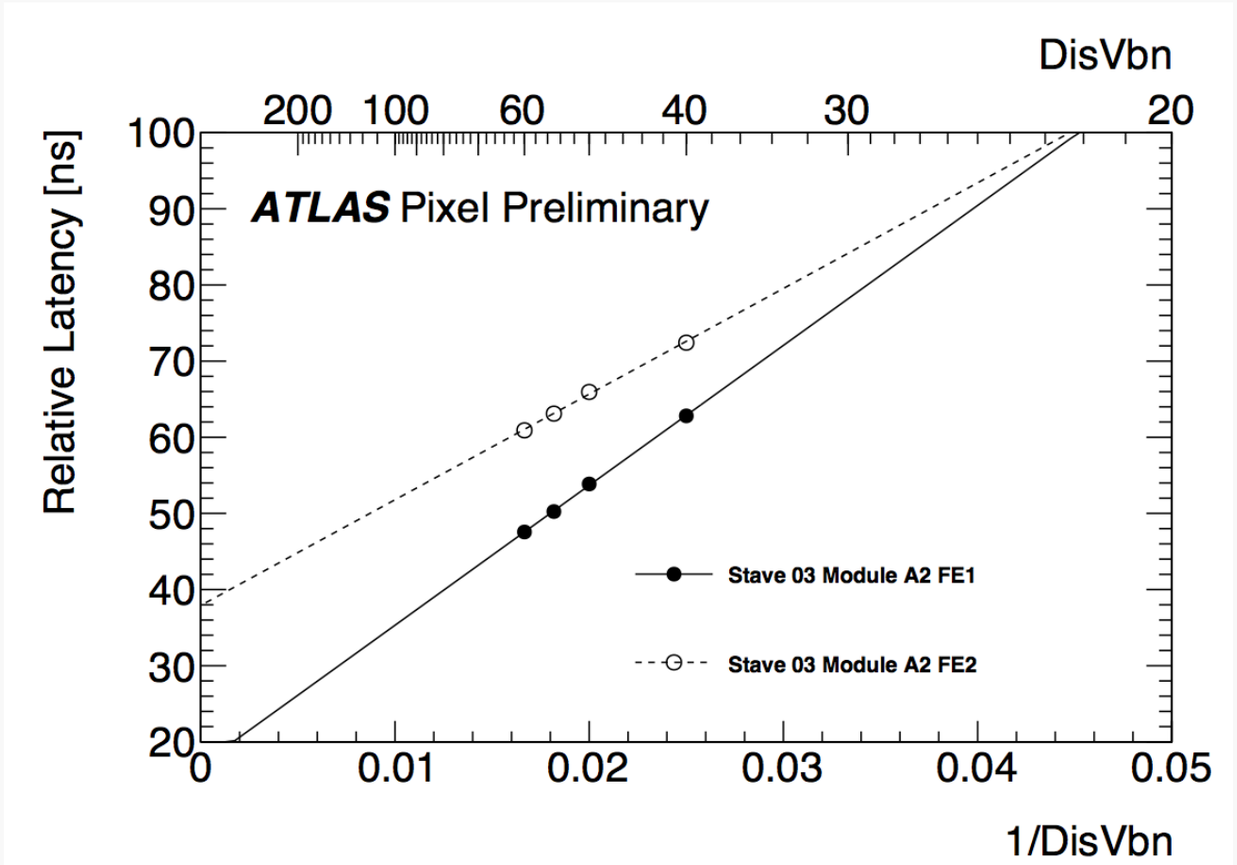
Presented by Hide

https://indico.cern.ch/event/397242/contributions/943789/attachments/796379/1091561/20150528_scan_IBL.pdf

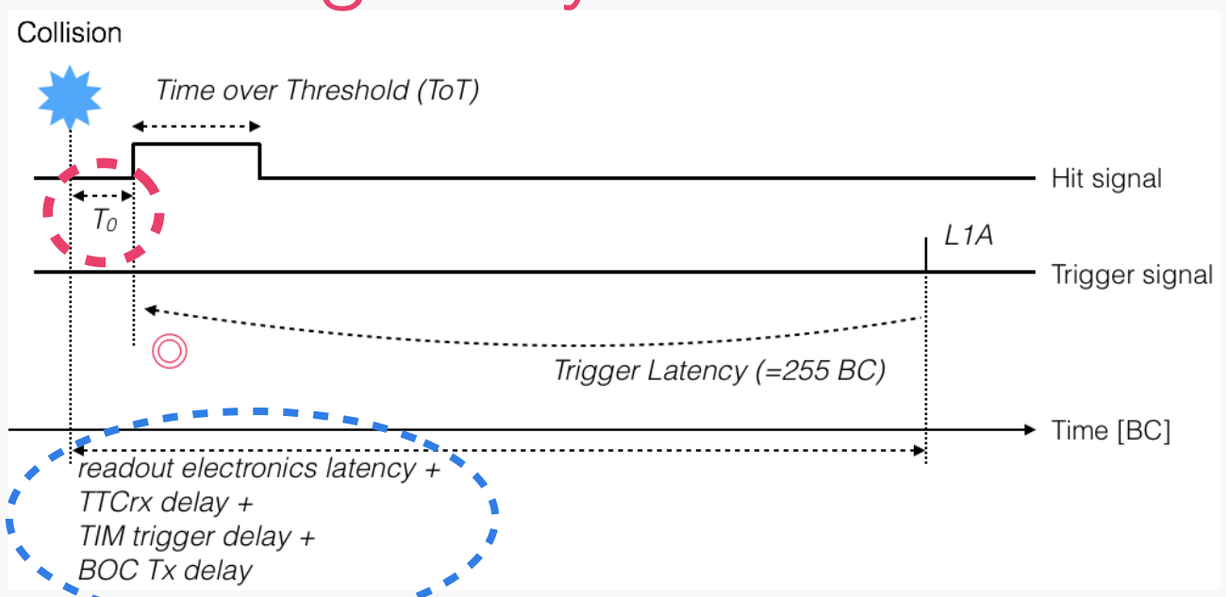
DisVbn vs Delay

- The relation between DisVbn and delay varies for each FE
- delay is applied to **physics hit**

➡ ***BE CAREFUL of the delay direction!!!***



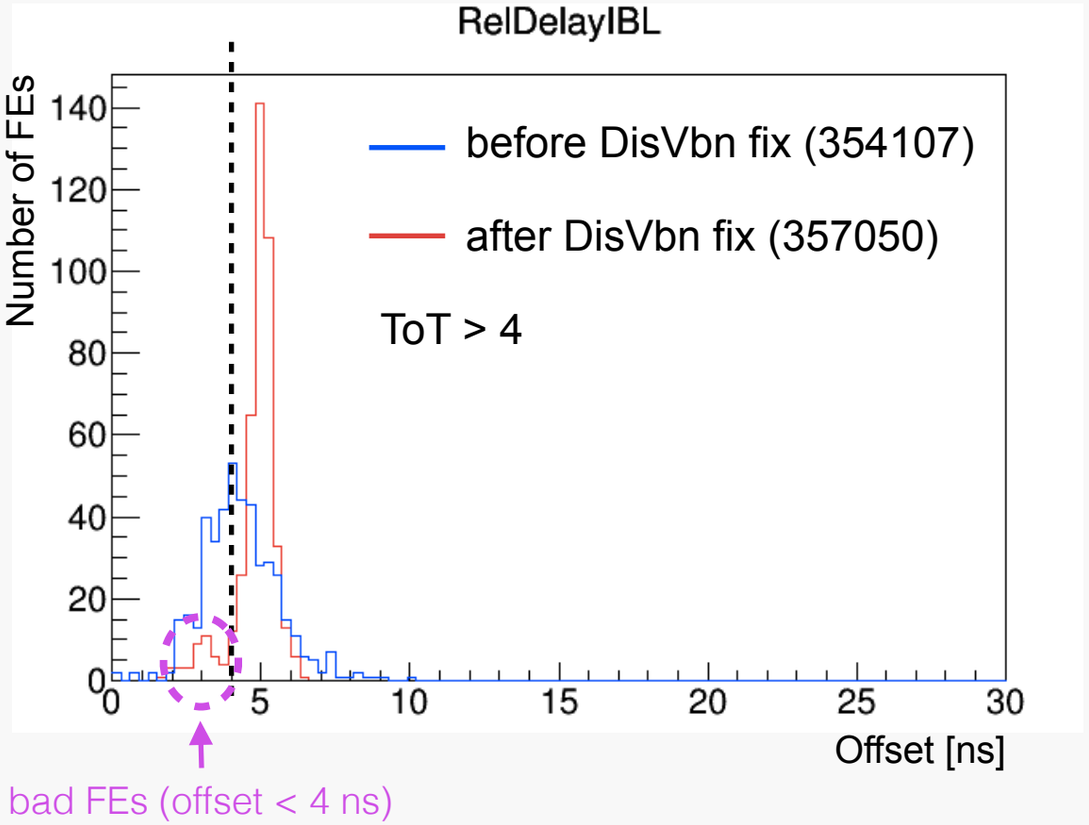
changed by DisVbn

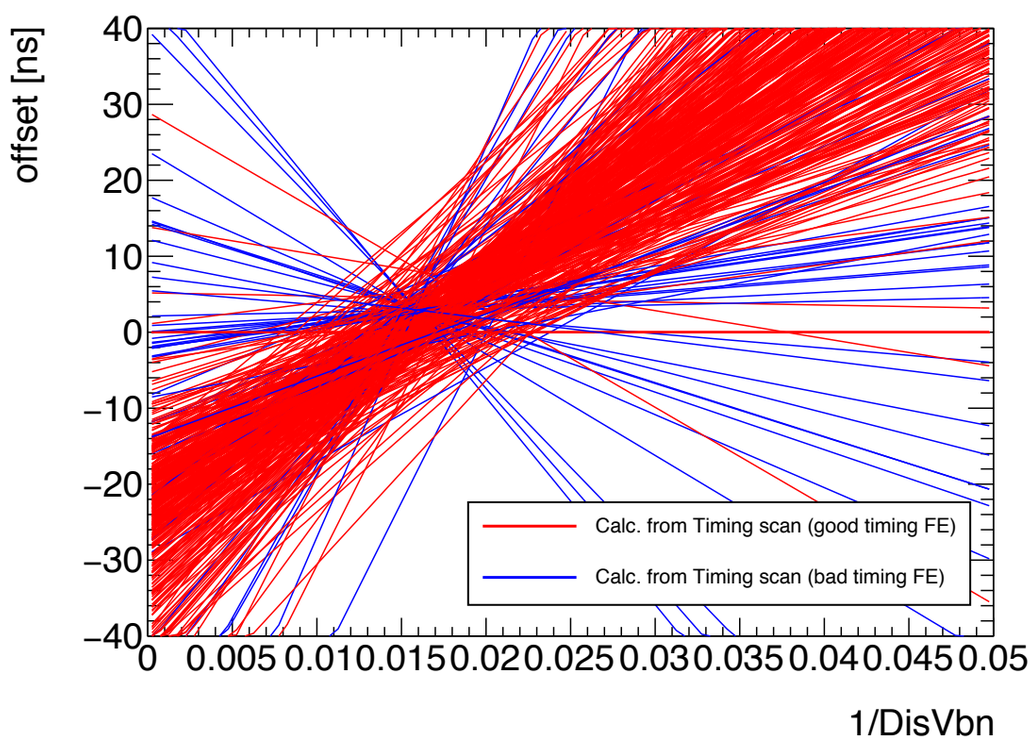


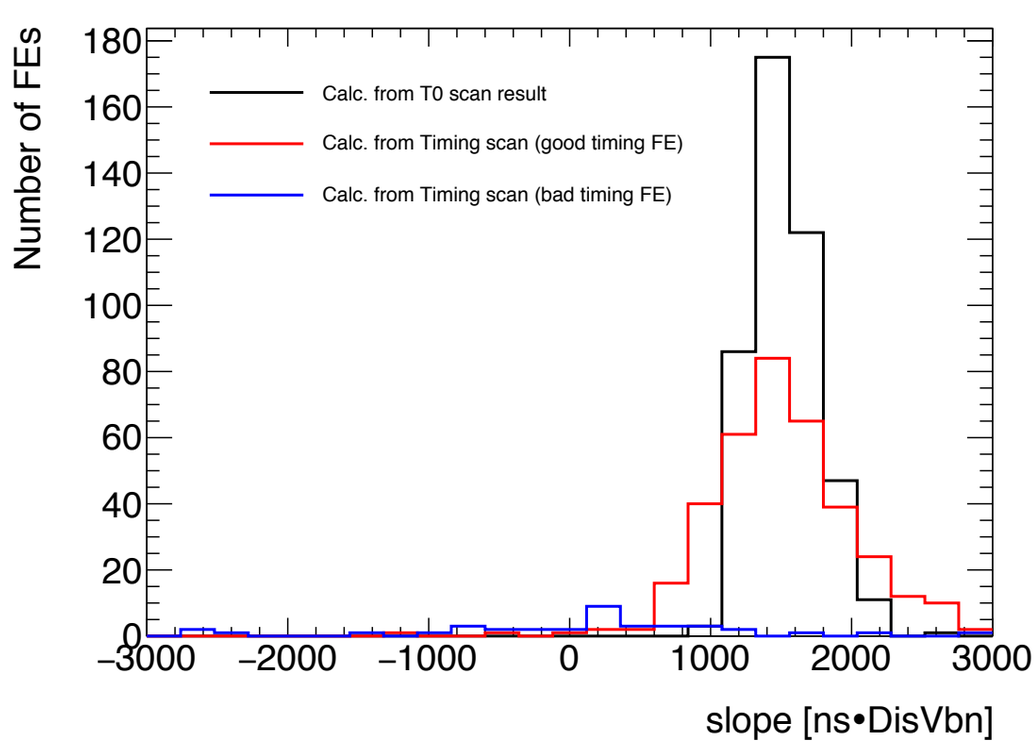
changed by BOC Tx, TIM or TTCrx delay

DisVbn tuning and remaining issue

- DisVbn tuning
  - ➡ the slope for each FE is extracted by the T0 scan result
    - https://cernbox.cern.ch/index.php/s/facDnQdNV9p31q2
- Issue was found in the 2018 adjustment
  - ➡ New delay vs 1/DisVbn linear function using 2 point of the timing scans (354107 and 357050)
  - ➡ Bad timing FEs are defined to “offset < 4 ns”
    - good FEs: slope is consistent with T0 scan result (except for several FEs)
    - bad FEs: not consistent and slope sign is opposite for some FE…







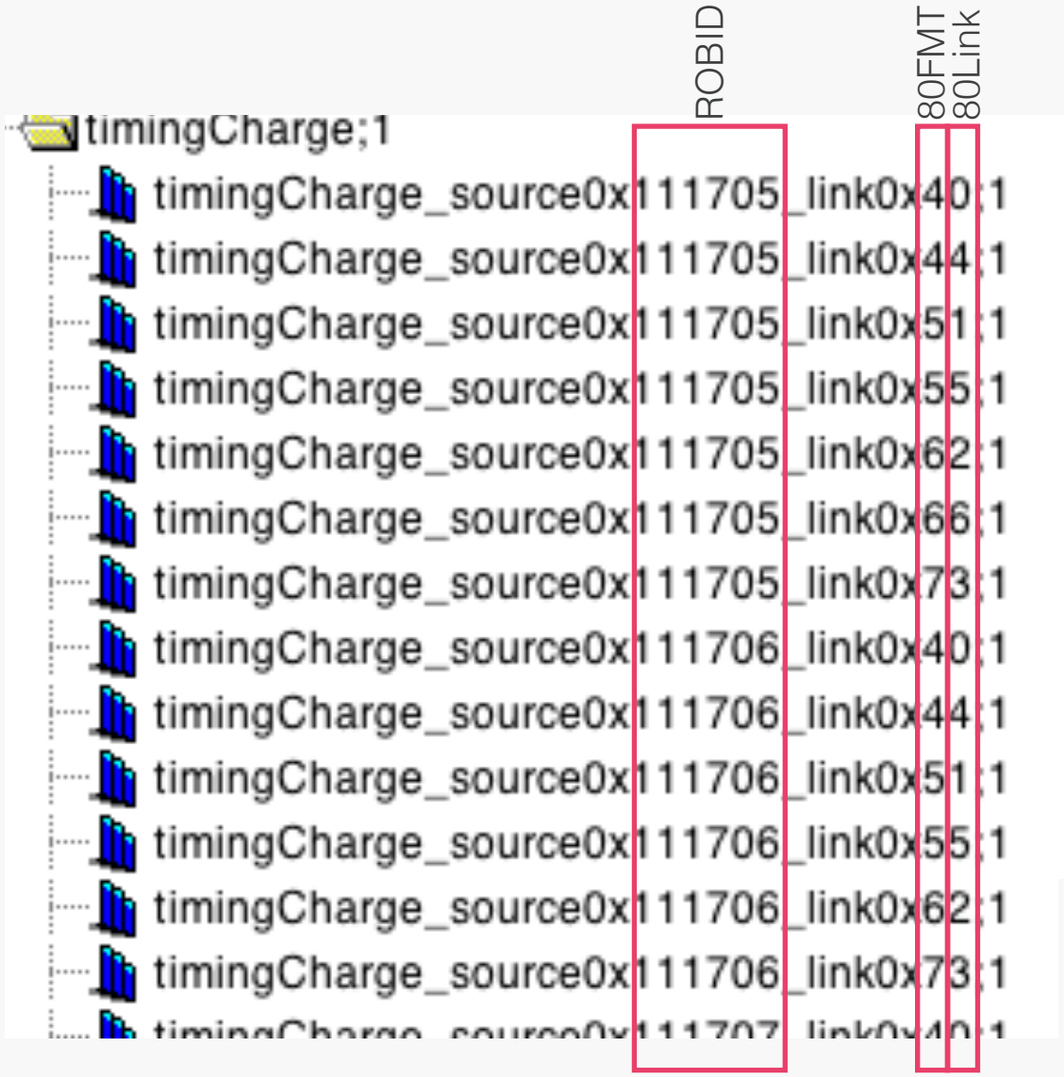
And finally, …

- Experts will help you!
  - ➡ Pixel (Deputy) Project Leader
  - ➡ Pixel Technical Coordinator
  - ➡ Run Coordinator, DAQ expert, …
    - ‣ Don’t hesitate to ask anything to them!

Backup

Pixel module ID mapping

- The latest version is available in the PixelTiming and RawDataAnalysis
  - ➡ Pixels_Atlas_IdMapping_Run2_2018.dat
  - ➡ *Check if it won't be changed every year!!!*



Pixels_Atlas_IdMapping_Run2_2018.dat 99.7 KB

Edit | Web IDE | Replace | Delete

	#Barrel_EC	Layer_Disk	Phi_module	Eta_module	ROBID	RODID	40FMT	40Link	80FMT	80Link	DCS Geographical ID
2	0 1	13 0	130147 130107	6 6	6	6	L0_B07_S1_C7_M0				
3	0 1	13 -1	130147 130107	5 5	5	5	L0_B07_S1_C7_M1C				
4	0 1	13 -2	130147 130107	4 4	4	4	L0_B07_S1_C7_M2C				
5	0 1	13 -3	130147 130107	7 3	7	3	L0_B07_S1_C7_M3C				
6	0 1	13 -4	130147 130107	6 2	6	2	L0_B07_S1_C7_M4C				
7	0 1	13 -5	130147 130107	5 1	5	1	L0_B07_S1_C7_M5C				
8	0 1	13 -6	130147 130107	4 0	4	0	L0_B07_S1_C7_M6C				
9	0 1	13 6	130107 130107	6 6	6	6	L0_B07_S1_A6_M6A				
10	0 1	13 5	130107 130107	5 5	5	5	L0_B07_S1_A6_M5A				
11	0 1	13 4	130107 130107	4 4	4	4	L0_B07_S1_A6_M4A				
12	0 1	13 3	130107 130107	7 3	7	3	L0_B07_S1_A6_M3A				
13	0 1	13 2	130107 130107	6 2	6	2	L0_B07_S1_A6_M2A				
14	0 1	13 1	130107 130107	5 1	5	1	L0_B07_S1_A6_M1A				
15	0 1	14 0	130108 130108	6 6	6	6	L0_B07_S2_A7_M0				
16	0 1	14 1	130108 130108	5 5	5	5	L0_B07_S2_A7_M1A				
17	0 1	14 2	130108 130108	4 4	4	4	L0_B07_S2_A7_M2A				
18	0 1	14 3	130108 130108	7 3	7	3	L0_B07_S2_A7_M3A				
19	0 1	14 4	130108 130108	6 2	6	2	L0_B07_S2_A7_M4A				
20	0 1	14 5	130108 130108	5 1	5	1	L0_B07_S2_A7_M5A				
21	0 1	14 6	130108 130108	4 0	4	0	L0_B07_S2_A7_M6A				
22	0 1	14 -6	130148 130108	6 6	6	6	L0_B07_S2_C6_M6C				
23	0 1	14 -5	130148 130108	5 5	5	5	L0_B07_S2_C6_M5C				
24	0 1	14 -4	130148 130108	4 4	4	4	L0_B07_S2_C6_M4C				
25	0 1	14 -3	130148 130108	7 3	7	3	L0_B07_S2_C6_M3C				
26	0 1	14 -2	130148 130108	6 2	6	2	L0_B07_S2_C6_M2C				
27	0 1	14 -1	130148 130108	5 1	5	1	L0_B07_S2_C6_M1C				
28	0 1	15 0	130151 130111	6 6	6	6	L0_B08_S1_C7_M0				
29	0 1	15 -1	130151 130111	5 5	5	5	L0_B08_S1_C7_M1C				
30	0 1	15 -2	130151 130111	4 4	4	4	L0_B08_S1_C7_M2C				
31	0 1	15 -3	130151 130111	7 3	7	3	L0_B08_S1_C7_M3C				