



The 9th China LHC Physics Workshop (CLHCP2023)
November 16-20, 2023, Shanghai-China



CMS DQM-DC operations and performance during Run3 data-taking

Tahir Javaid
(Beihang University, Beijing)

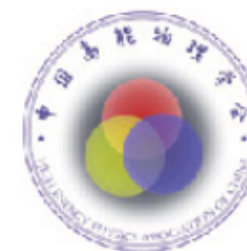
On behalf of the **CMS** collaboration



李政道研究所
TSUNG-DAO LEE INSTITUTE



物理与天文学院
School of Physics and Astronomy



中国高等科学技术中心
China Center of Advanced Science and Technology



An overview of extensive work done by CMS DQM-DC group

- * DQM-DC group organization
 - ♣ DQM-DC group mandate
- * DQM code modernization and tools development
 - ♣ DQM GUI
 - ♣ Run Registry
 - ♣ DQM²
- * Activities during Run3
 - ♣ Online Operations
 - ♣ Data Certification (2022-2023)
 - ♣ Machine learning for DQM

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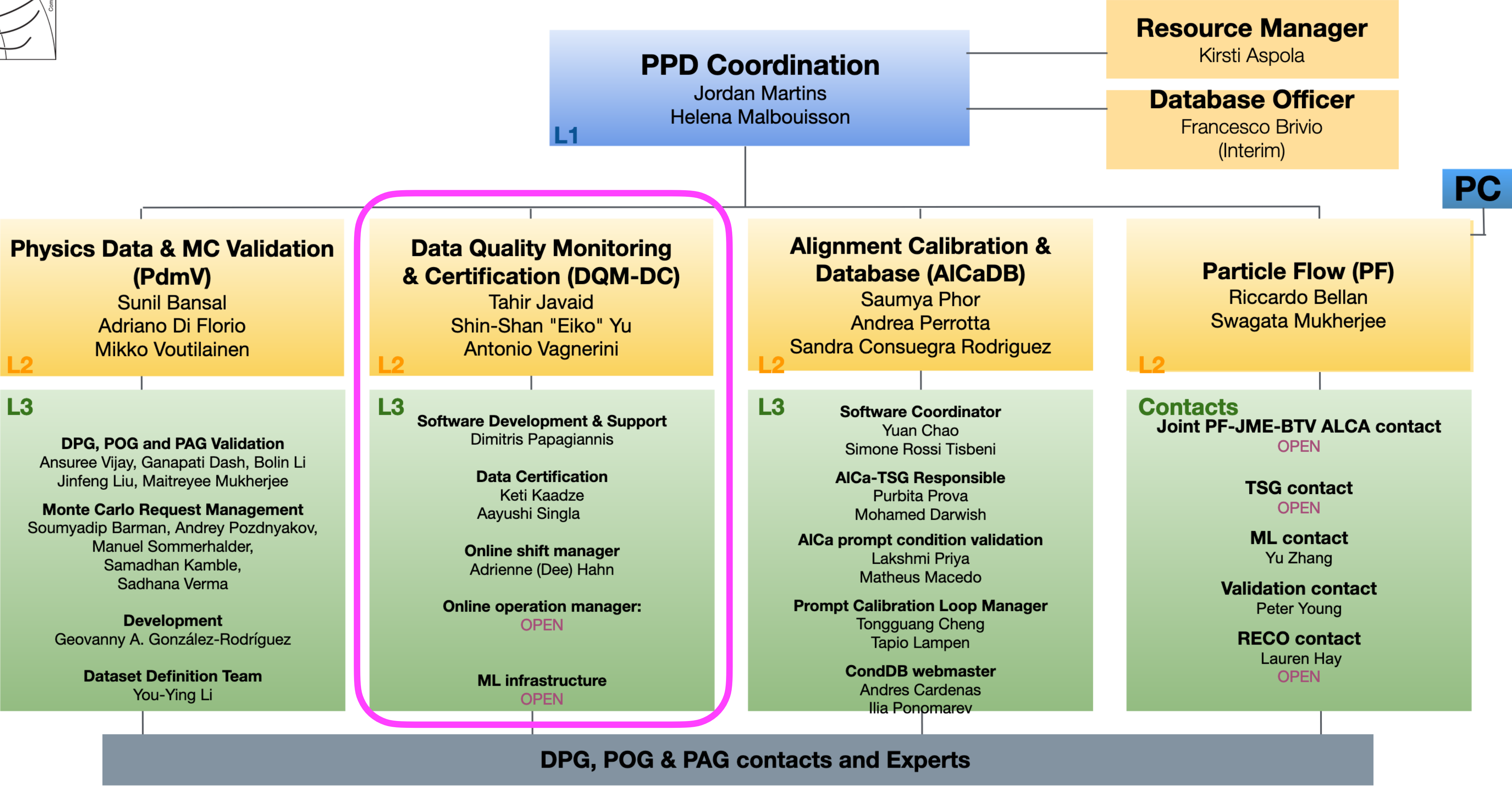
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PPD Organization

From Oct. 2023

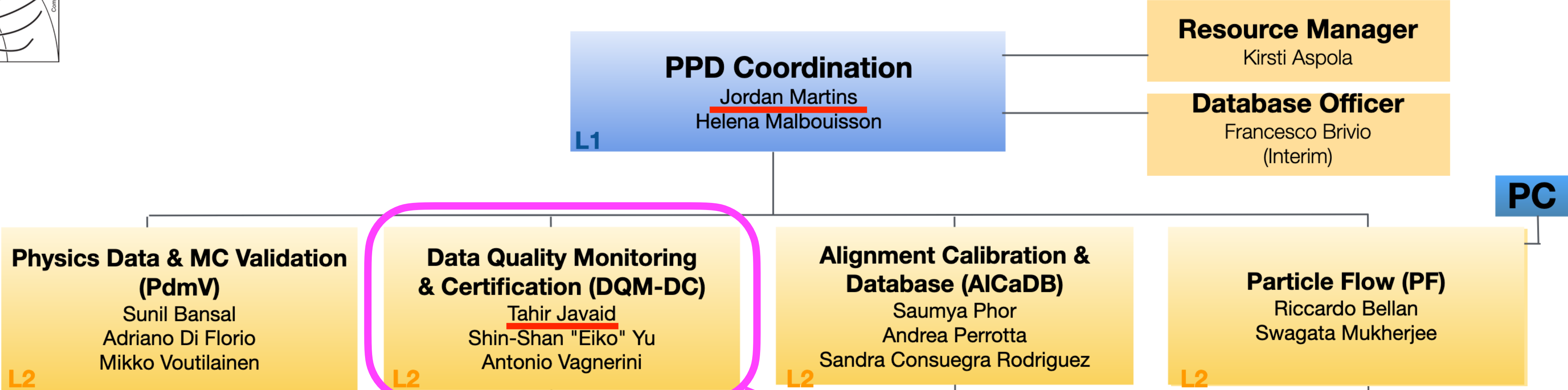


PPD / DQM-DC group organisation



PPD Organization

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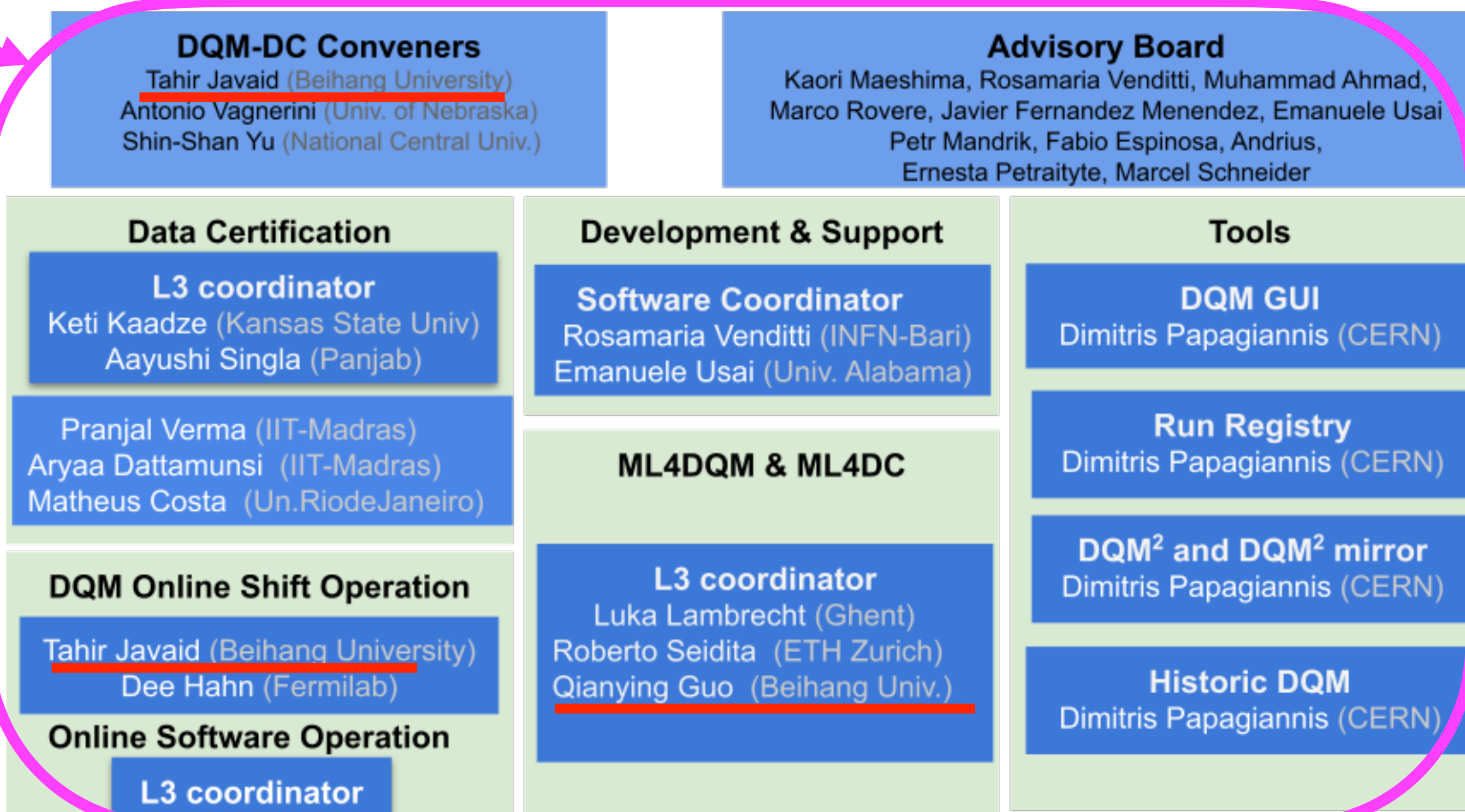


* **China** has been an active contributor to the PPD body over the years:

- ❖ **Former Conveners:** Tongguang Cheng for AlcaDB (BUAA), Hu Chen and Jordan Martin for PdmV (NNU/TU), and Muhammad Ahmad for DQM-DC (TU)
- ❖ Qianying Guo (BUAA), just joined DQM-DC as L3

* The main twiki ([Link](#)) contains links to all of DQM-DC activities and available documentation

- * DQM-DC meetings:
 - ~ Weekly DQM-DC core meeting on Monday at 15:00
 - ~ Weekly DQM-DC general meeting on Friday at 14:00



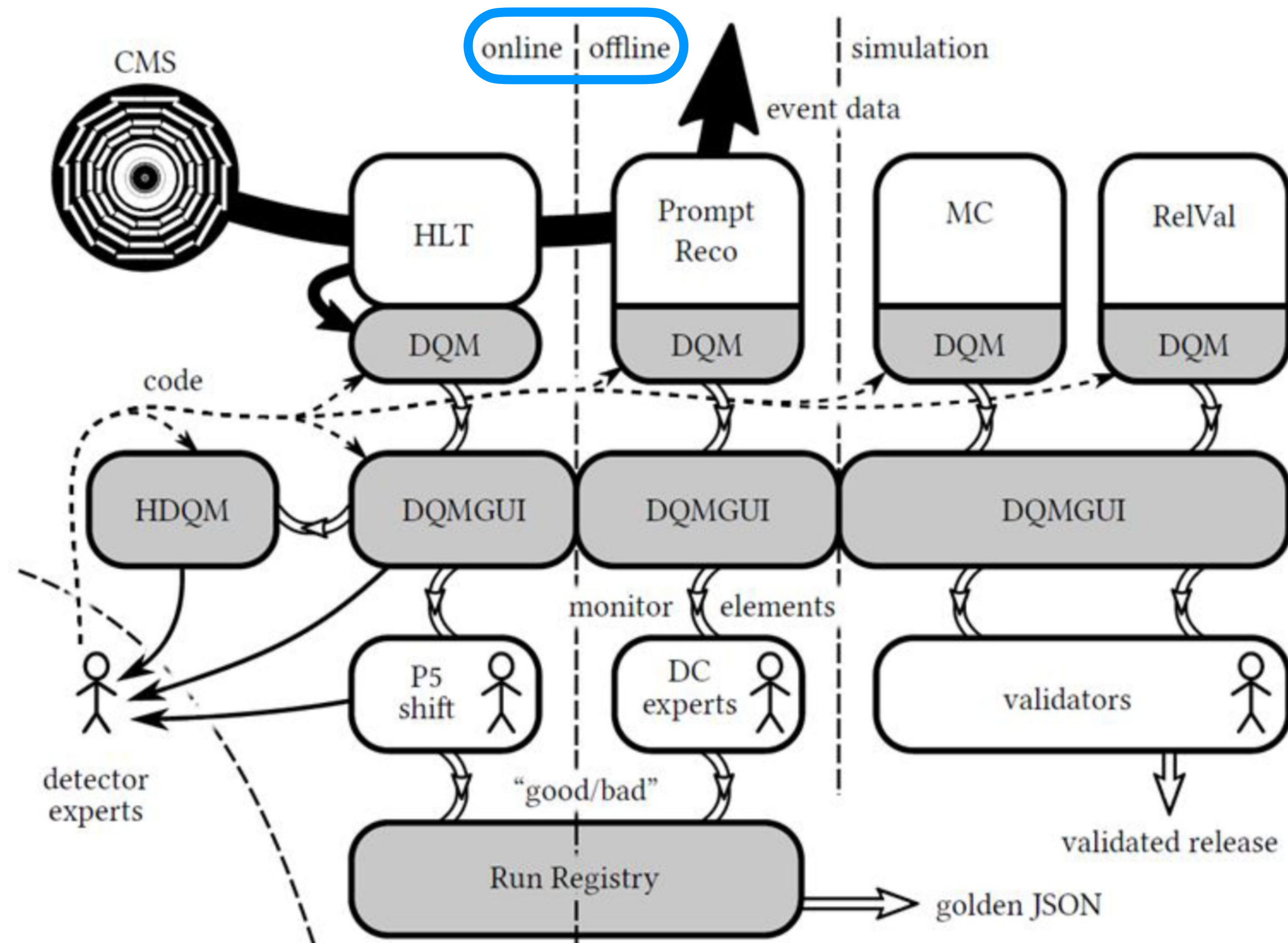
Data Quality Monitoring and (DQM) and Data Certification (DC): Maindate

* Organization of **online** Data Quality Monitoring

- ❖ Centralization of the various online CMSSW monitoring modules, provided by subsystems and DPGs.
- ❖ Execution of the live monitoring applications and visualisation tool (DQM GUI) on the DQM cluster.
- ❖ Organization of the central online DQM shifts.

* Organization of **offline** Data Quality Monitoring and Data Certification

- ❖ Centralization of the various offline CMSSW monitoring modules, provided by DPGs and POGs.
- ❖ Maintenance of the visualisation tool (DQM GUI), used for data certification and release validation.
- ❖ Coordination of the expert certification and publication of the list of data suitable for physics analyses.



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 - ✿ Data Certification (2022-2023)

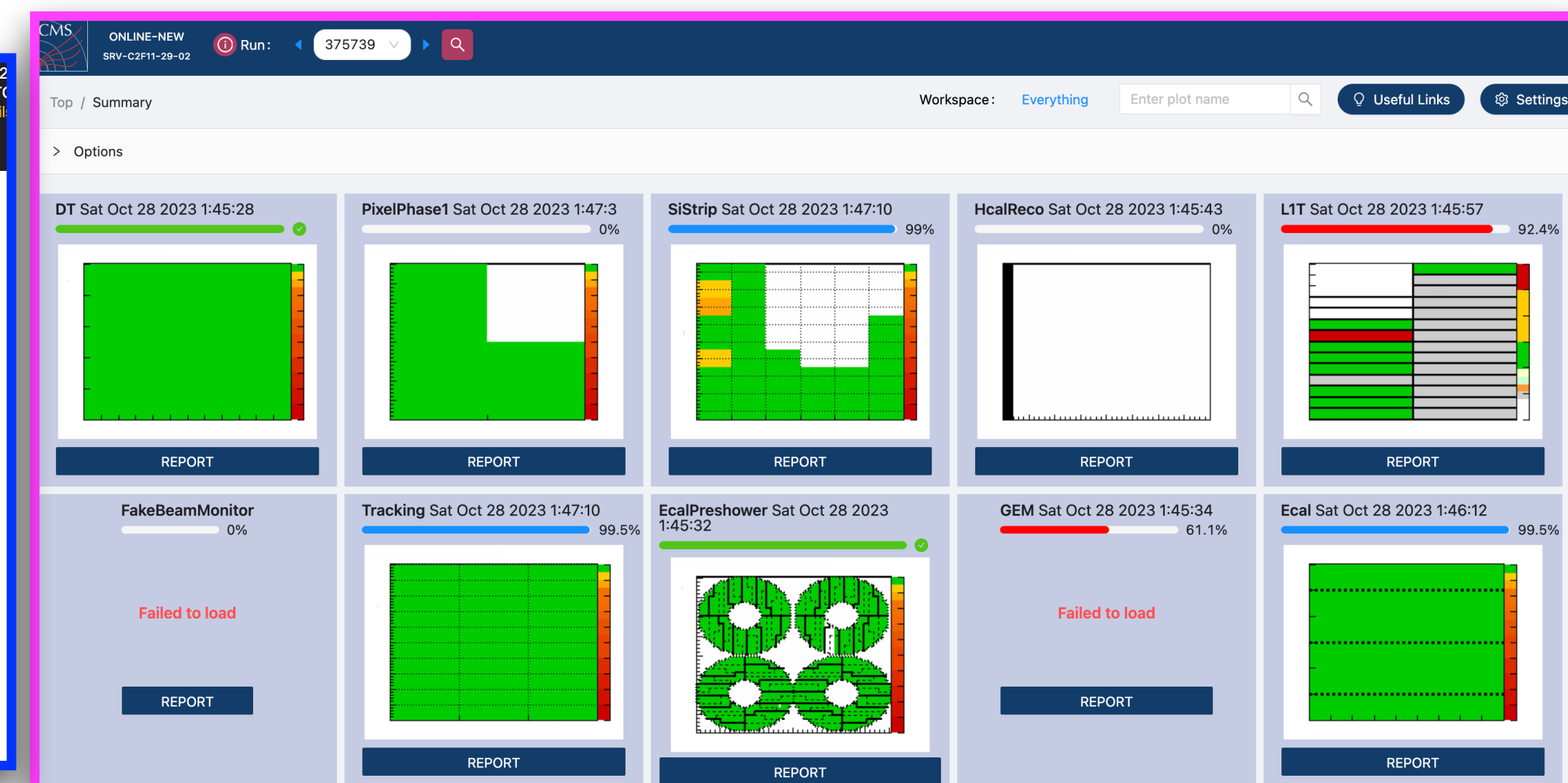
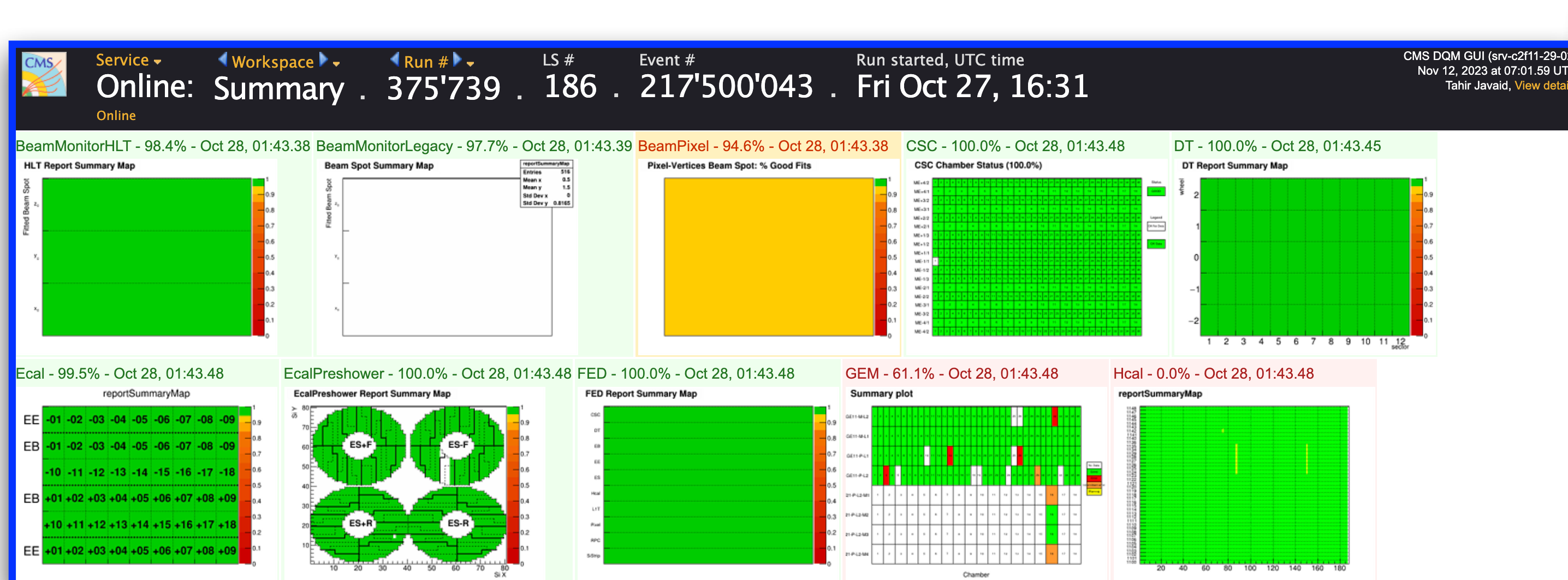
 - ✿ Machine learning for DQM

✱ A web-based **Graphical User Interface** for browsing CMS Data Quality Monitoring information to **monitor the detector status and quality of data reconstruction.** (two versions)

- ♣ **“Old”** ([link](#)): runs smoothly (online/offline), plots are uploaded successfully and monitored by the shifters
- ♣ **“New”** ([link](#)): built with the newest technologies, which provides easier maintenance in comparison with old GUI.

Gives the ability to add more complex features, which improves user experience. Still suffers from significant delay time w.r.t. to the old one in Live mode

◎ Still under the commissioning phase



- * A tool that aggregates online data monitoring and data certification results
 - ❖ **Online** being part of the web application used to record data monitoring results, run by run, by an online [DQM](#) shifter at Point 5
 - ❖ **Offline** being the part later used by shifters and data certification experts to certify the **datasets** from the runs that passed through online.

Keeps the track of the history

Authenticate via e-group

Tahir Javaid

Log out

- ❖ Advanced & user-friendly features
- ❖ Built-in and improved lumi loss statistics tool
- ❖ Lumisection based bookkeeping, compatible to implement the future LS based ML certification

CMS

Run Registry

ONLINE

OFFLINE

ML

JSON PORTAL

LOG

Authenticate via e-group

Tahir Javaid

Log out

WORKSPACES

GLOBAL

BTAG

CASTOR

CMS

CSC

CTPPS

DT

ECAL

EGAMMA

GEM

HCAL

HLT

Online / Global /

JSON creation

live mode off

Feedback is welcome! (JIRA)

Configuration

All runs (276233):

AND

+Rule

+Group

Finished	Run Number	Class	Manage / ...	Significant	State	Started	Hlt Key Descrip...	LS Duration	HLT Event Cou...	GUI	OMS	castor	cms	csc	ctpps
⌚	376063	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-11T0...	/cdaq/cosmic/c...	2		GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376060	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-11T0...	/cdaq/cosmic/c...	312	2406	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376055	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	2625	4549	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376054	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	19	9	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376053	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	6		GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376052	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	19	20	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376051	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	27	24	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376050	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	9		GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376049	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	19	29	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376048	Commissioning23	Manage / LS	✓	OPEN / move	2023-11-10T1...	/cdaq/cosmic/c...	84	39088	GUI	OMS	EXCLUDED	BAD	EXCLUDED	EXCLUD
✓	376047	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	40	6109	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi
✓	376046	Commissioning23	Manage / LS	Make significant	Non Significant(Open)	2023-11-10T1...	/cdaq/cosmic/c...	18	4816	GUI	OMS	No Lumisec	No Lumisec	No Lumisec	No Lumi

Filters

Page 1 of 23020

12 rows

Next

Significant runs (43608):

AND

+Rule

+Group

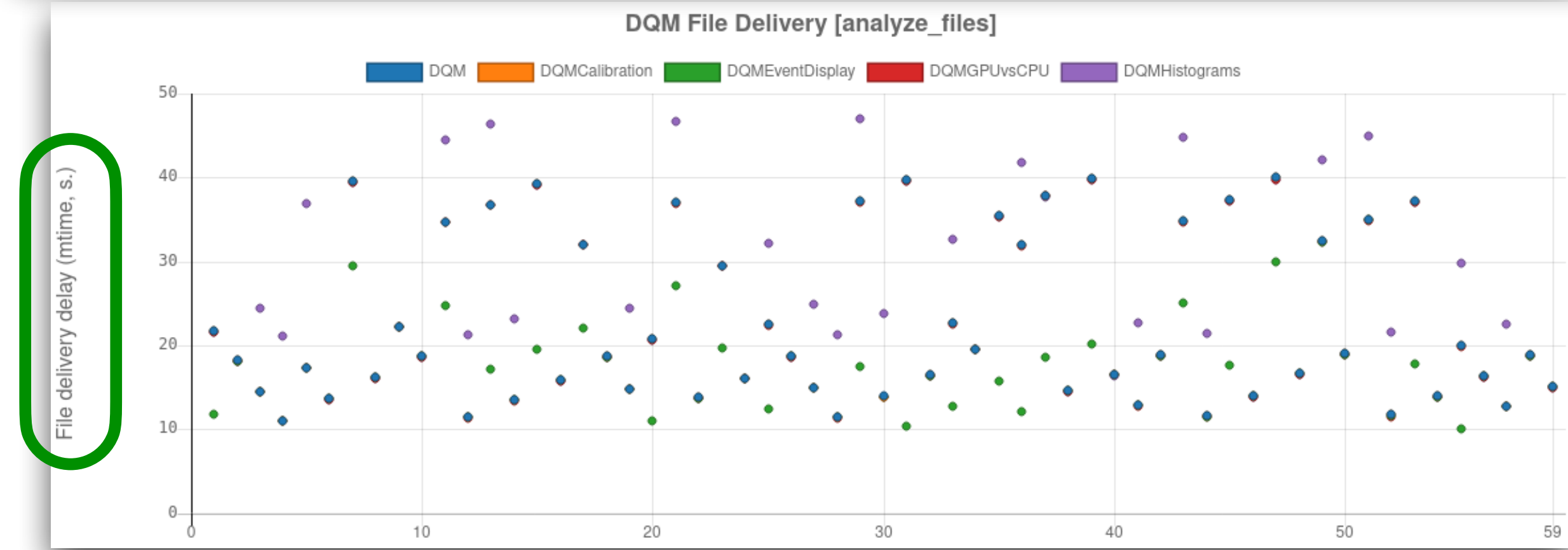
Finished	Run Number	Class	Manage / ...	Significant	State	Started	Hlt Key Descrip...	LS Duration	HLT Event Cou...	GUI	OMS	castor	cms	csc	ctpps
✓	376048	Commissioning23	Manage / LS	✓	OPEN / move	2023-11-10T1...	/cdaq/cosmic/c...	84	39088	GUI	OMS	EXCLUDED	BAD	EXCLUDED	EXCLUD
✓	376045	Commissioning23	Manage / LS	✓	OPEN / move	2023-11-10T1...	/cdaq/cosmic/c...	49	12132	GUI	OMS	EXCLUDED	BAD	EXCLUDED	EXCLUD
✓	376041	Commissioning23	Manage / LS	✓	OPEN / move	2023-11-10T0...	/cdaq/cosmic/c...	182	14701	GUI	OMS	EXCLUDED	BAD	EXCLUDED	EXCLUD
✓	376024	Commissioning23	Manage / LS	✓	OPEN / move	2023-11-09T1...	/cdaq/cosmic/c...	64	30222	GUI	OMS	EXCLUDED	BAD	EXCLUDED	EXCLUD
✓	375859	Commissioning23	Manage / LS	✓	OPEN / move	2023-10-30T1...	/cdaq/cosmic/c...	5000	265867	GUI	OMS	EXCLUDED	BAD	G S	EXCLUD

DQM^2

- * DQM^2 is a tool to monitor and control the **DQM software** infrastructure (more details)
- * **DQM^2 mirror** used by the DQM online primary shifter to **monitor the status of the applications** and **file transfer delay** (from DAQ)
- * **Control room**: to control the DQM software infrastructure
 - ♣ Used by the DQMDOC and core team for testing PR, checking logs, debugging, etc.
- * **Timeline**: allows to make some stat about clients crashing, CMSSW versions ...
 - ♣ For DQM core team

<-363839 363840

Timestamp	Time Diff	Hostname	State	Tag	LS	RSS	Total Ev.	LOGS
24/02/2023, 10:36:25	0 days 00:04:38	fu..03	0	beam	1	709556 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:25	0 days 00:04:38	fu..03	0	beamhlt	0	335704 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:25	0 days 00:04:38	fu..03	0	beampixel	1	494212 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:24	0 days 00:04:39	fu..03	0	beamspotdip	1	355560 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:25	0 days 00:04:38	fu..04	0	csc	1	970468 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:21	0 days 00:04:42	fu..04	0	ctpps	1	334364 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:23	0 days 00:04:40	fu..04	0	dt4ml	1	344144 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:21	0 days 00:04:42	fu..04	0	dt	0	344268 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:23	0 days 00:04:40	fu..04	0	ecal	1	459496 kB	0 (0.0 ev/s)	->
24/02/2023, 10:36:22	0 days 00:04:41	fu..04	0	ecalcalib	1	343696 kB	0 (0.0 ev/s)	->



DQM² ■ Mirror ■ Control Room ■ Timeline

Runs range:

346077

363838

Apply

☐ exit_code != 0

☐ N(LS) > 0

Production-> Playback->

346077

363838

334138363838

Run	RunKey	CMSSW	beambeambeambeambeambeamcasto	csc	ctpps	dt4m	dt	ecal	ecalcaecal	es	fed	gem	hcal	hcalc	hcalghcalr	hlt_d	hlt	info	l1tstal1	tstamutr	onlin	pixel	pixelu	rpc	s			
363838	cosmic_run	12_6_3_40512_40669_40699_40737	97	-----	0	-----	97	97	-----	97	98	98	98	98	22K	79	98	0	98	98	97	97	97	97	0	97	..	
363837	cosmic_run	12_6_3_40512_40669_40699_40737	15K	-----	0	-----	15K	15K	-----	14K	15K	15K	15K	15K	7K	67K	15K	0	15K	15K	15K	7K	14K	15K	12K	14K	15K	..
363836	cosmic_run	12_6_3_40512_40669_40699_40737	55K	-----	0	-----	54K	55K	-----	55K	55K	55K	55K	55K	26K	236K	55K	0	55K	55K	55K	29K	55K	55K	46K	54K	55K	..
363835	cosmic_run	12_6_3_40512_40669_40699_40737	8K	-----	0	-----	8K	8K	-----	8K	8K	8K	8K	8K	4K	34K	8K	0	7K	8K	8K	4K	7K	8K	5K	8K	8K	..
363833	cosmic_run	12_6_3_40512_40669_40699_40737	1M	-----	0	-----	1M	1M	-----	1M	1M	1M	1M	1M	321K	5M	1M	0	1M	1M	1M	359K	1M	1M	j=1	1M	1M	..
363832	cosmic_run	12_6_3_40512_40669_40699_40737	28K	-----	0	-----	28K	28K	-----	28K	28K	28K	28K	13K	116K	28K	28K	0	28K	28K	28K	14K	28K	28K	23K	28K	28K	..
363831	cosmic_run	12_6_3_40512_40669_40699_40737	1K	-----	0	-----	1K	1K	-----	1K	1K	1K	1K	1K	559	5K	1K	0	1K	1K	1K	505	1K	1K	390	1K	1K	..
363830	cosmic_run	12_6_3_40512_40669_40699_40737	13K	-----	0	-----	13K	13K	-----	13K	13K	13K	13K	6K	51K	13K	13K	0	13K	13K	13K	7K	13K	13K	10K	13K	13K	..
363829	cosmic_run	12_6_3_40512_40669_40699_40737	75K	-----	0	-----	76K	77K	-----	64K	77K	61K	61K	59K	24K	216K	77K	0	77K	77K	74K	29K	55K	77K	40K	77K	77K	..
363828	cosmic_run	12_6_3_40512_40669_40699_40737	144K	-----	0	-----	145K	146K	-----	83K	146K	72K	73K	61K	13K	122K	146K	0	145K	146K	134K	13K	42K	146K	19K	145K	146K	..
363826	cosmic_run	12_6_3_40512_40669_40699_40737	217	-----	0	-----	217	217	-----	217	217	217	3	217	5K	32	217	0	217	217	217	217	217	217	217	0	217	..

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- * Activities during Run3

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 - ✿ Machine learning for DQM

Data Quality Monitoring Online operations

* DQM online shift sign-up procedure

❖ Advertisement of the candidacy form

- ⌚ For 2024, will be announced by end of Nov.

❖ Open the shift slots to sign up in groups:

- ⌚ Experience, whether P5, ROC or **remote**

❖ Monthly tutorials

* DQM-DOC shifts (to assist the online shifters)

❖ Mainly covered by the Core team

* Remote Operation Centers Program (ROC)

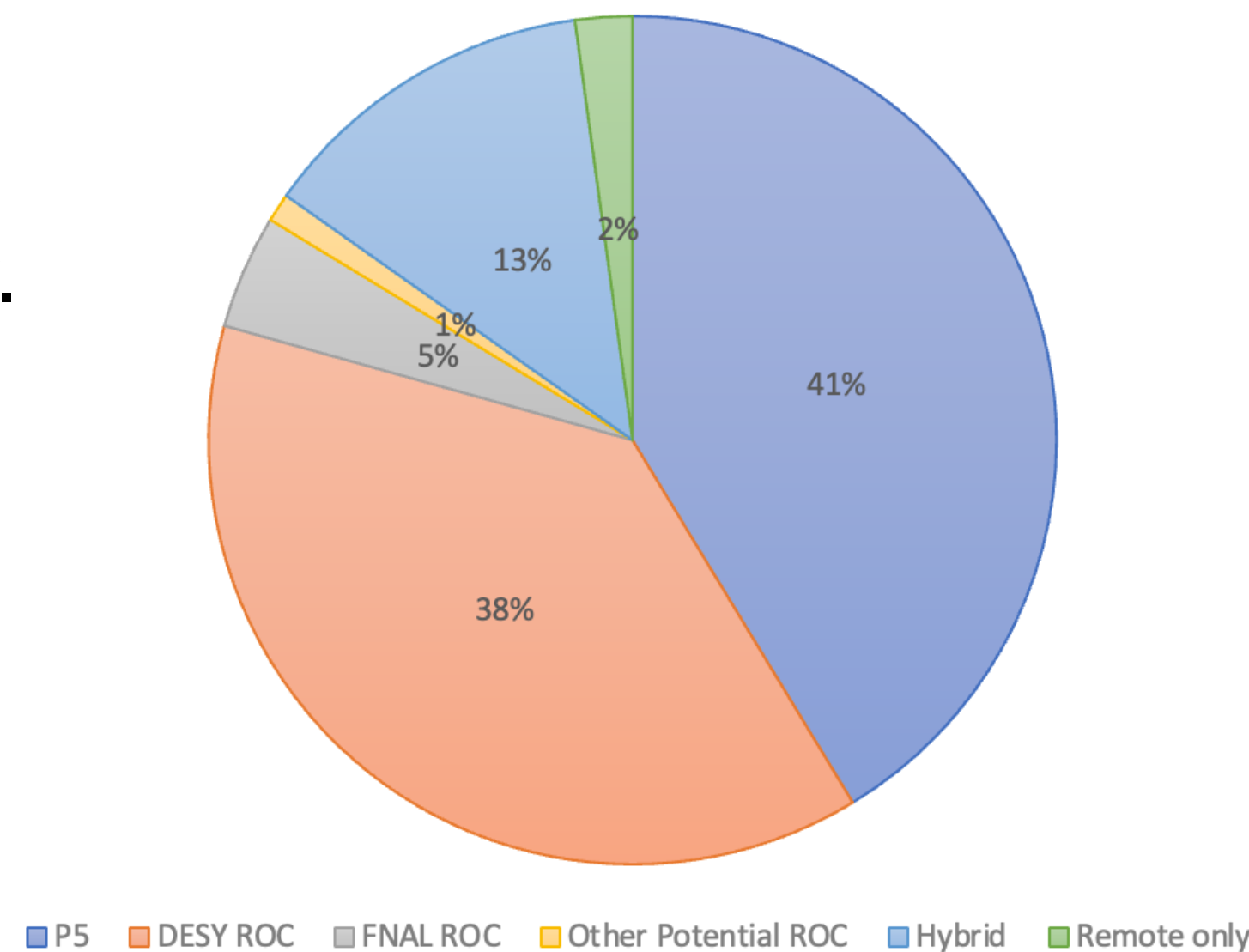
❖ Procedure to enroll new ROC. ([documentation](#))

❖ Current ROCs: FNAL, DESY

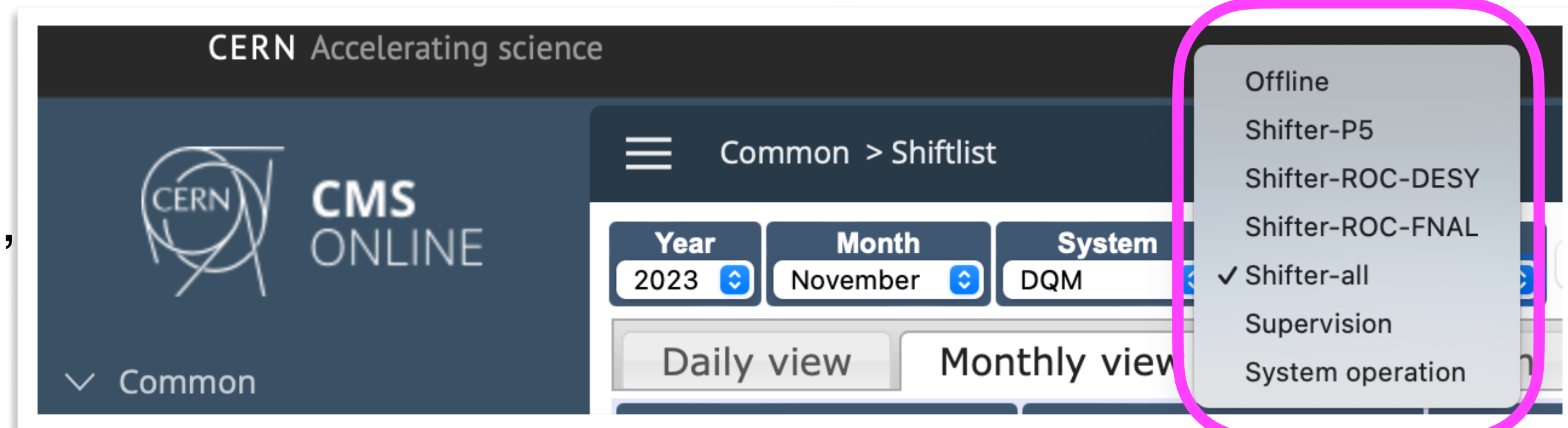
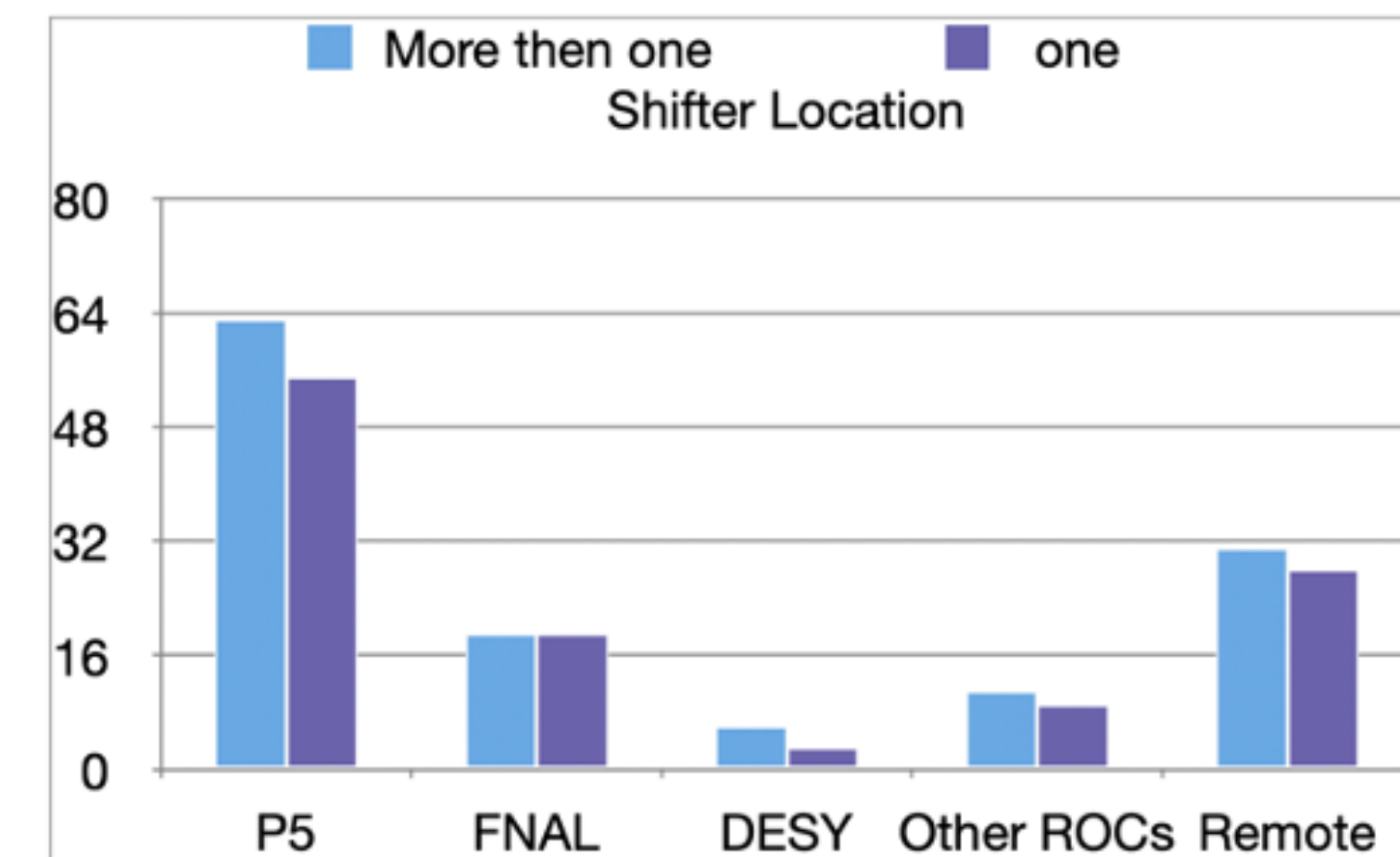
❖ Potential ROCs: China(IHEP, [see talk from Dr. Chen Ye](#)), Brazil, India ([link](#))

❖ **Shift selection tool** updated to accommodate ROCs

July - Oct 2023 Shifters' stat



Feb-June, 2023 Shifters' stat



Data Quality Monitoring Online operations: Upgrade of P5 machines

* Current configuration

✿ Production:

- 1 x **BU** (Receives data streams from HLT/DAQ).
- 4 x **FUs** (Run CMSSW jobs, producing DQMGUI Histograms).
- 2 x **DQMGUI** servers (One for P5, one for the outside world).

✿ Playback

- **A duplicate** of all Online BU and FU machines, for testing CMSSW versions and PRs. The BU *simulates* data arriving from HLT/DAQ.
- 1 x **DQMGUI** server.

✿ Development

- 1 x **BU**
- 8 x **FUs** (One per subdetector)

* Transition of the present DQM computing infrastructure to new machines (**RHEL8** instead of **CentOS7**)

- ✿ Decommissioning of old/existing P5 machines by 22nd December, 2023



Production system

- fu-c2f11-11-01
- fu-c2f11-11-02
- fu-c2f11-11-03
- fu-c2f11-11-04

- bu-c2f11-09-01

Playback system

- fu-c2f11-15-01
- fu-c2f11-15-02
- fu-c2f11-15-03
- fu-c2f11-15-04

- bu-c2f11-13-01

New Production

- dqmfu-c2b03-45-01
- dqmfu-c2b04-45-01
- dqmrubu-c2a06-01-01

New Playback

- dqmfu-c2b01-45-01
- dqmfu-c2b02-45-01
- dqmrubu-c2a06-03-01

Legend:

FU: Filter Unit

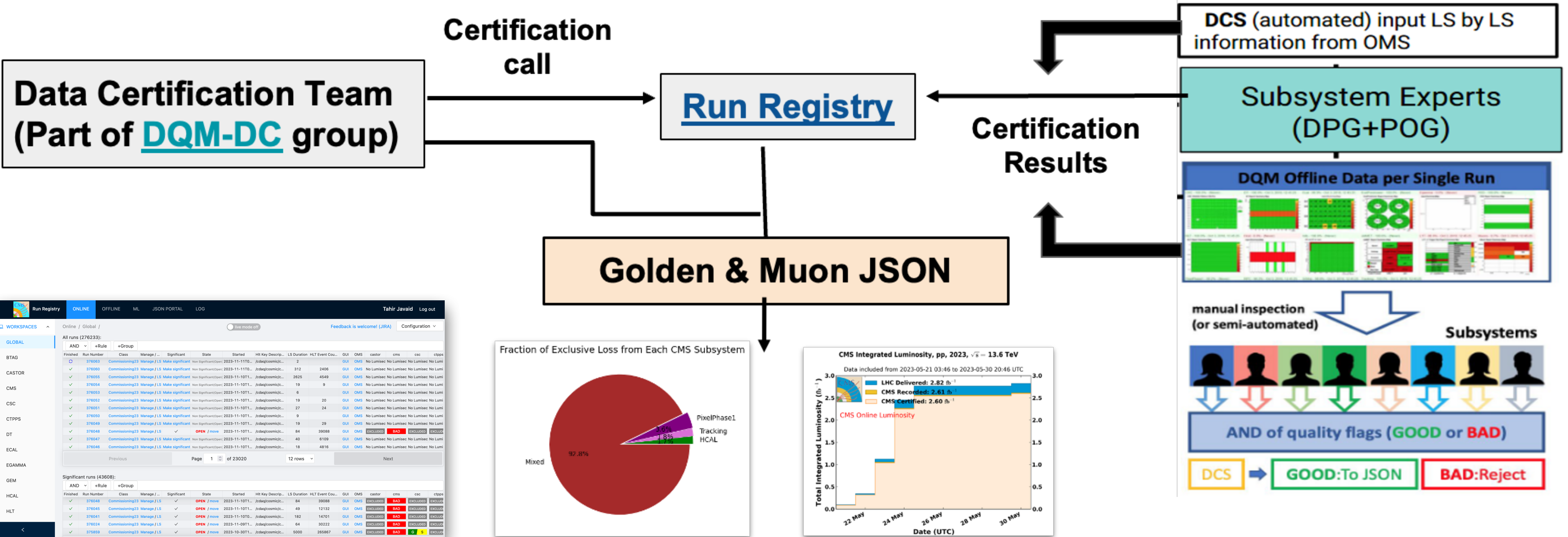
BU: Build Unit

RU: Readout Unit

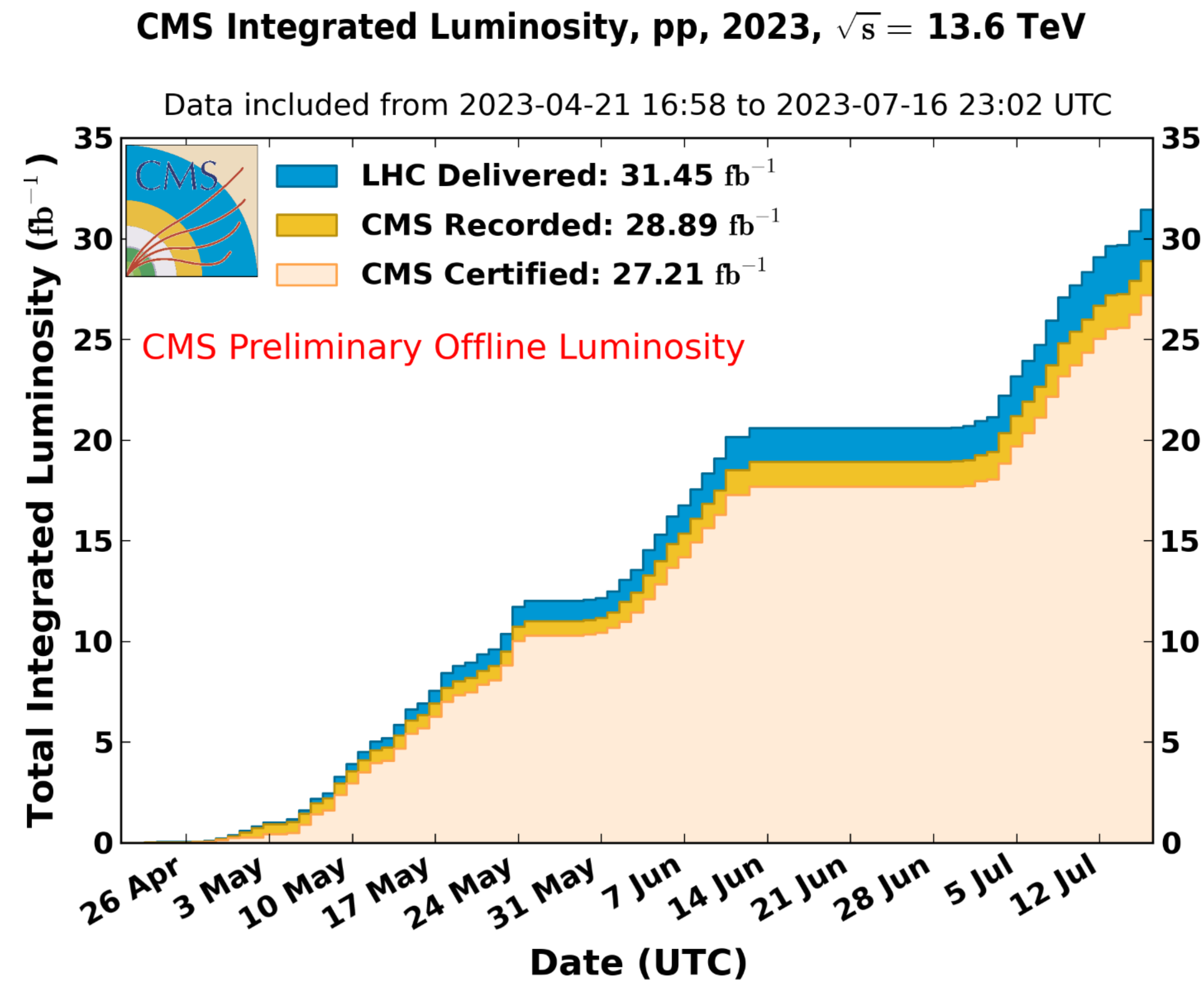
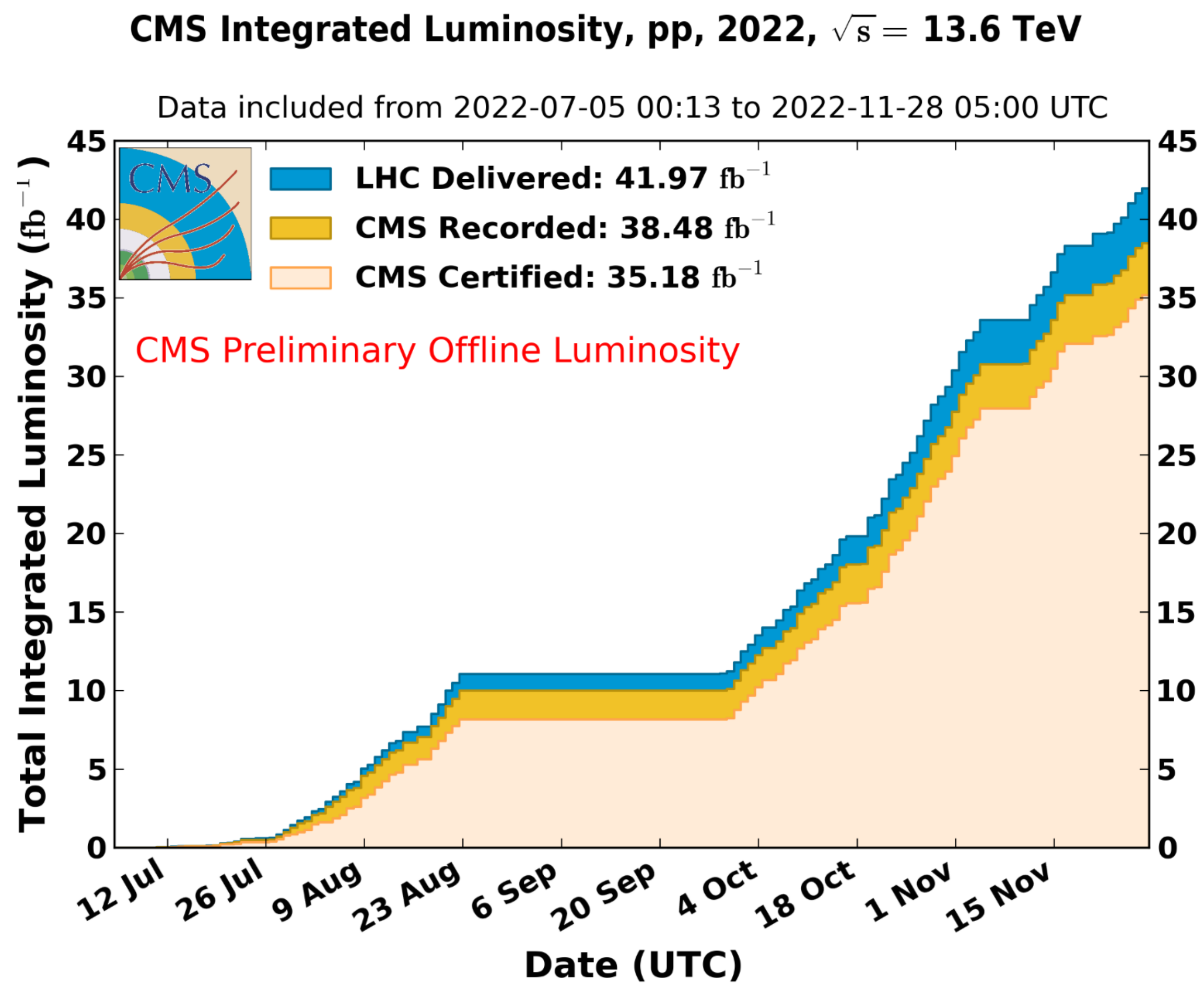
Note: Each Upgrade machine has ~**twice** as **many resources (CPU, Memory, Storage)** as its current counterpart.

Data Certification (2022-2023)

- ✳ Information used for producing JSON file
 - ♣ Data quality (DQM) flags marked by DPG and POG experts
 - ♣ Detector status from sub-detectors (DCS)



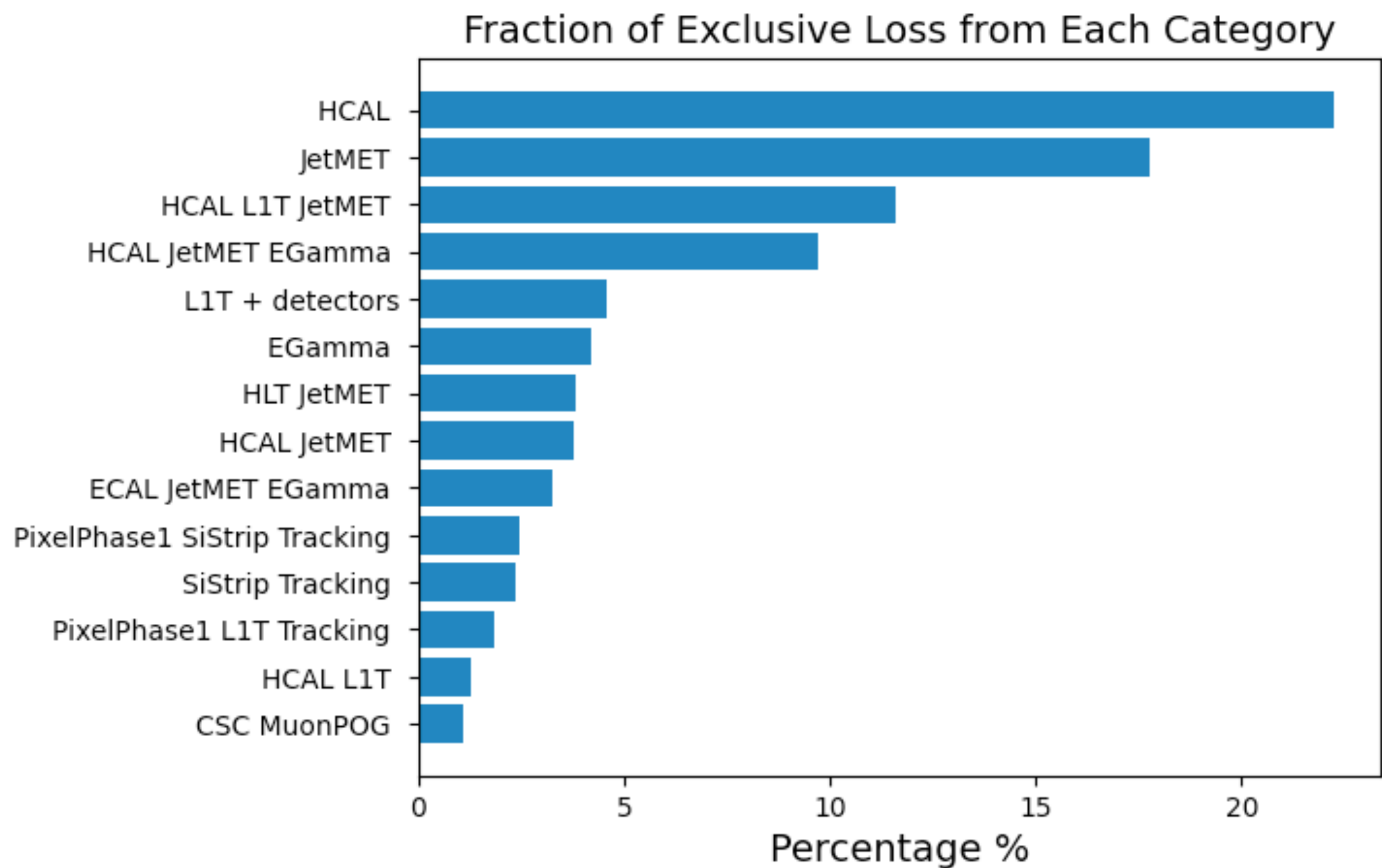
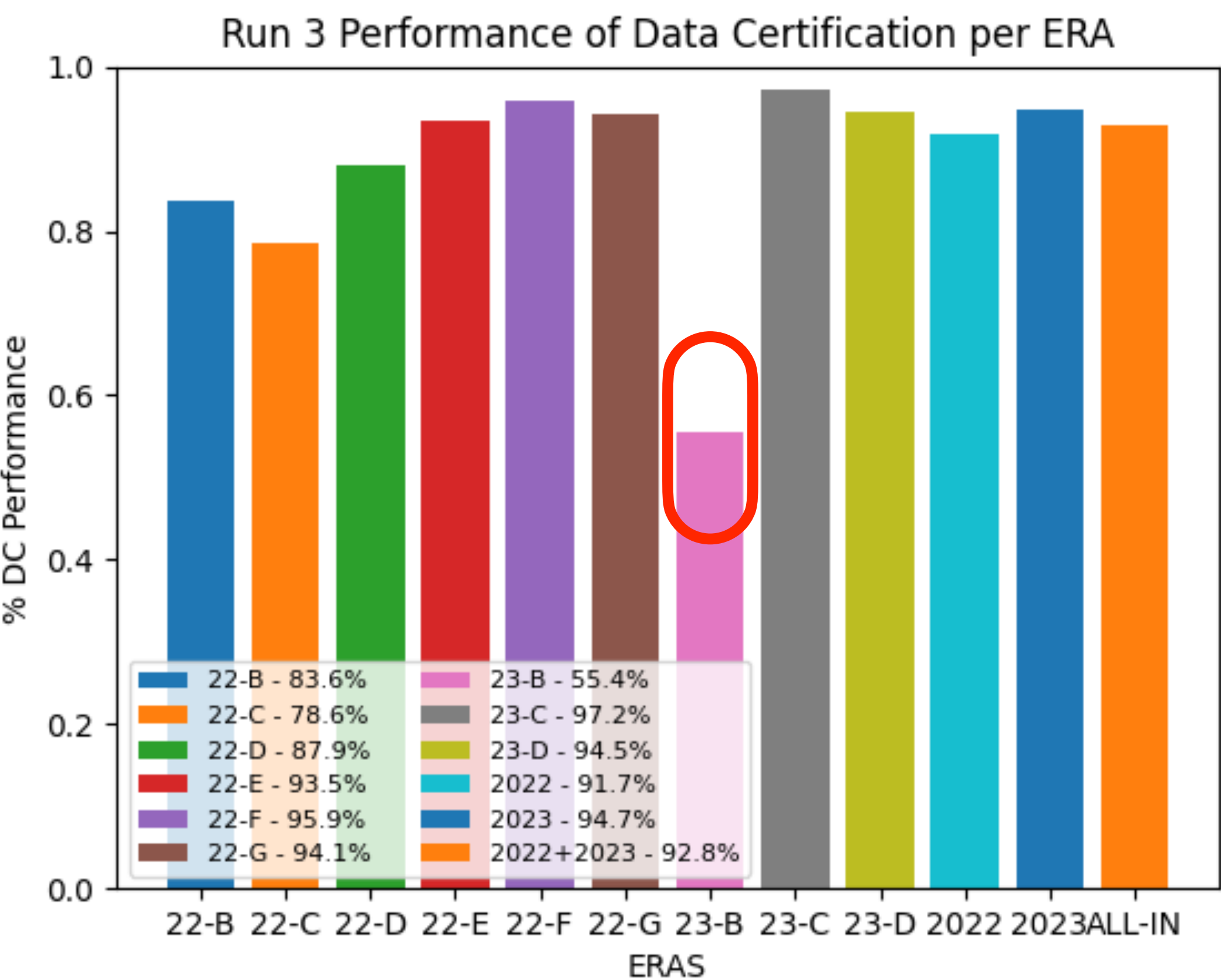
Data Certification (2022-2023): Golden JSON - Integrated Luminosity



- * Consistent with a high fraction of good data in the individual years
 - ♣ Data-taking efficiency: ~92% (2022/2023),
 - ♣ DC efficiency: ~92%(2022), ~95%(2023)

<https://twiki.cern.ch/twiki/bin/view/CMSPublic/DataQuality>

Data Certification (2022-2023): Era efficiencies and Luminosity Losses



* Consistent with a high fraction of good data in the individual years

♣ Data-taking efficiency: ~92% (2022/2023),

♣ DC efficiency: ~92%(2022), ~95%(2023)

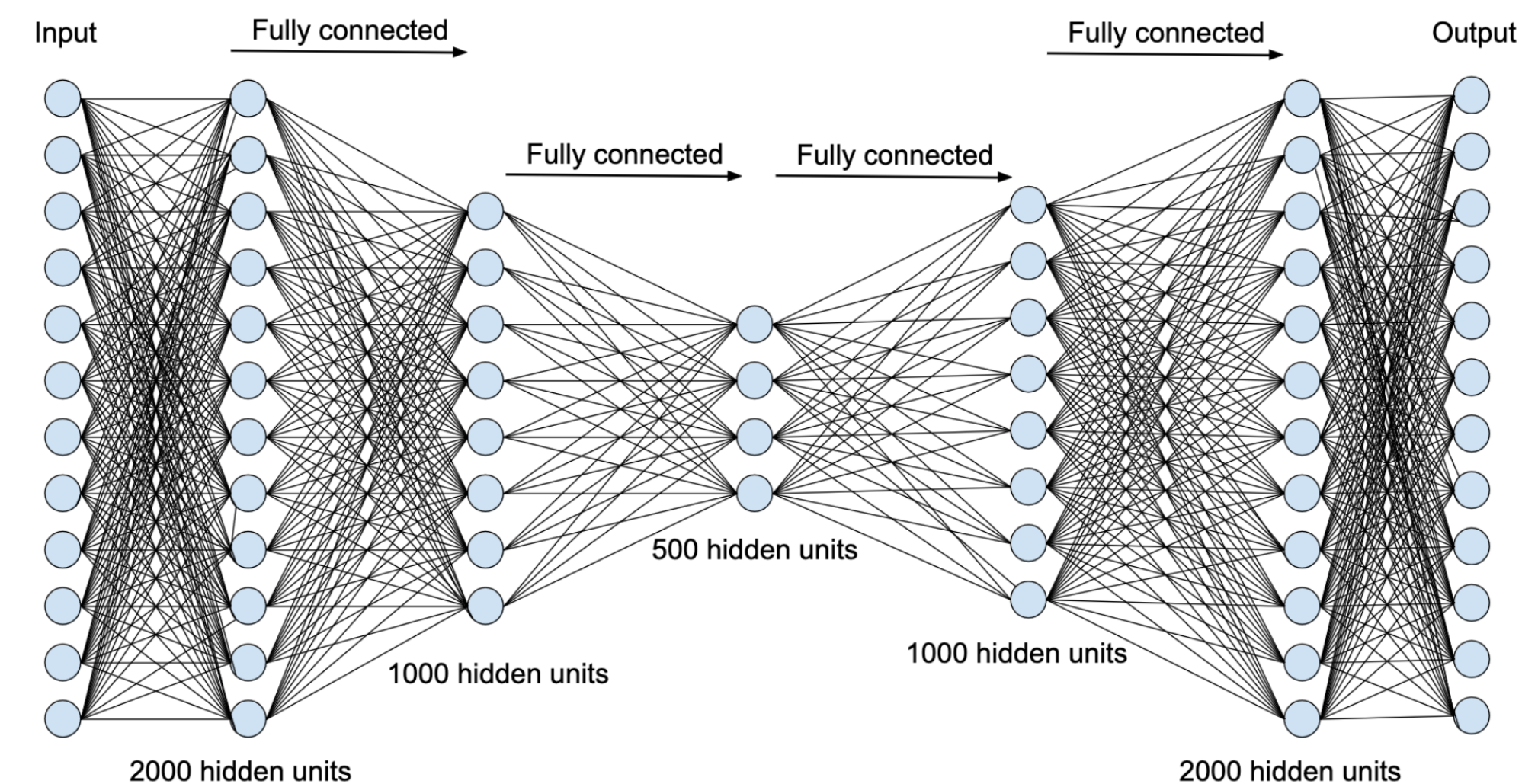
<https://twiki.cern.ch/twiki/bin/view/CMSPublic/DataQuality>

Data Certification: based on LS and Machine Learning Approach

- * Currently, DC performed inspecting plots (**DQMIO** data format) **run by run in DQM Offline GUI**
 - ❖ The outcome reported in the RR, which can record the results per LS
 - ❖ Golden JSON: List of LS (within a given run) declared GOOD for physics
 - ⦿ DPG can qualify a run with per-LS granularity using the DCS info.
 - ⦿ POG can just rely on per-run histograms stored in the DQMIO dataset
 - ❖ Still not possible to anticipate all failure modes!
- * **nanoDQMIO** dataset, per LS data format
 - ❖ Can be used for LS by LS certification of data
 - ❖ Huge multiplicity of monitoring elements
 - ⦿ Large shift crew and increased tendency of human error etc.
- * **Machine learning** approach
 - ❖ Autoencoders: Learn patterns of good data and make its own quality assessments
 - ❖ Algorithmic insight to the shifters
 - ❖ Robust mechanism with minimized human error and much more!
- * Ongoing efforts on a common ML-based DC (& online monitoring)
 - ❖ Subsystems have developed individual infrastructures
 - ⦿ See reports in recent PPDive session ([link](#))



1525 (2020) 012045



✱ Extensive work done (& in progress) by the DQM-DC group during early Run3 (2022-2023) data-taking

- ✿ Maintenance and upgradation of DQM Tools

- ✿ Online DQM Operations

- ✿ Data Certification of CMS data for physics

- ✿ ML approach in mainstream DQM infrastructure

- ✿ Ongoing upgradation of the P5 DQM infrastructure machines

✱ Currently observing End of Year Technical Stop (EYETS)

- ✿ Several activities to be done by LHC and CMS to resume early next year!

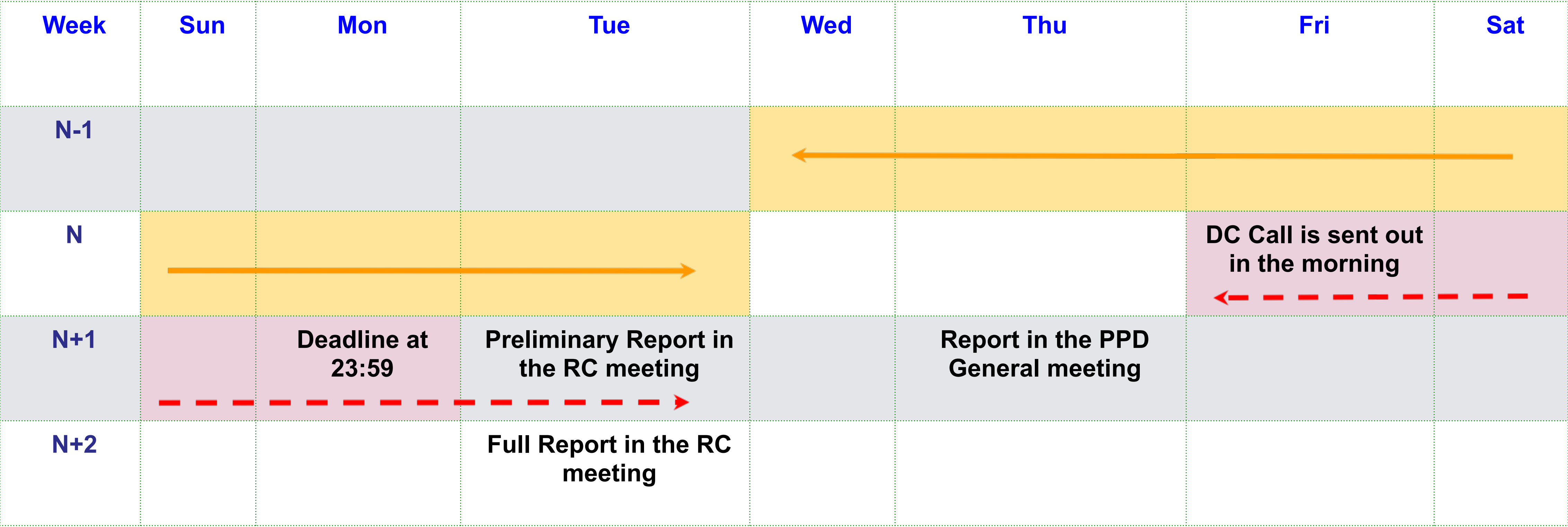
*Thank
you*



BACKUP SLIDES

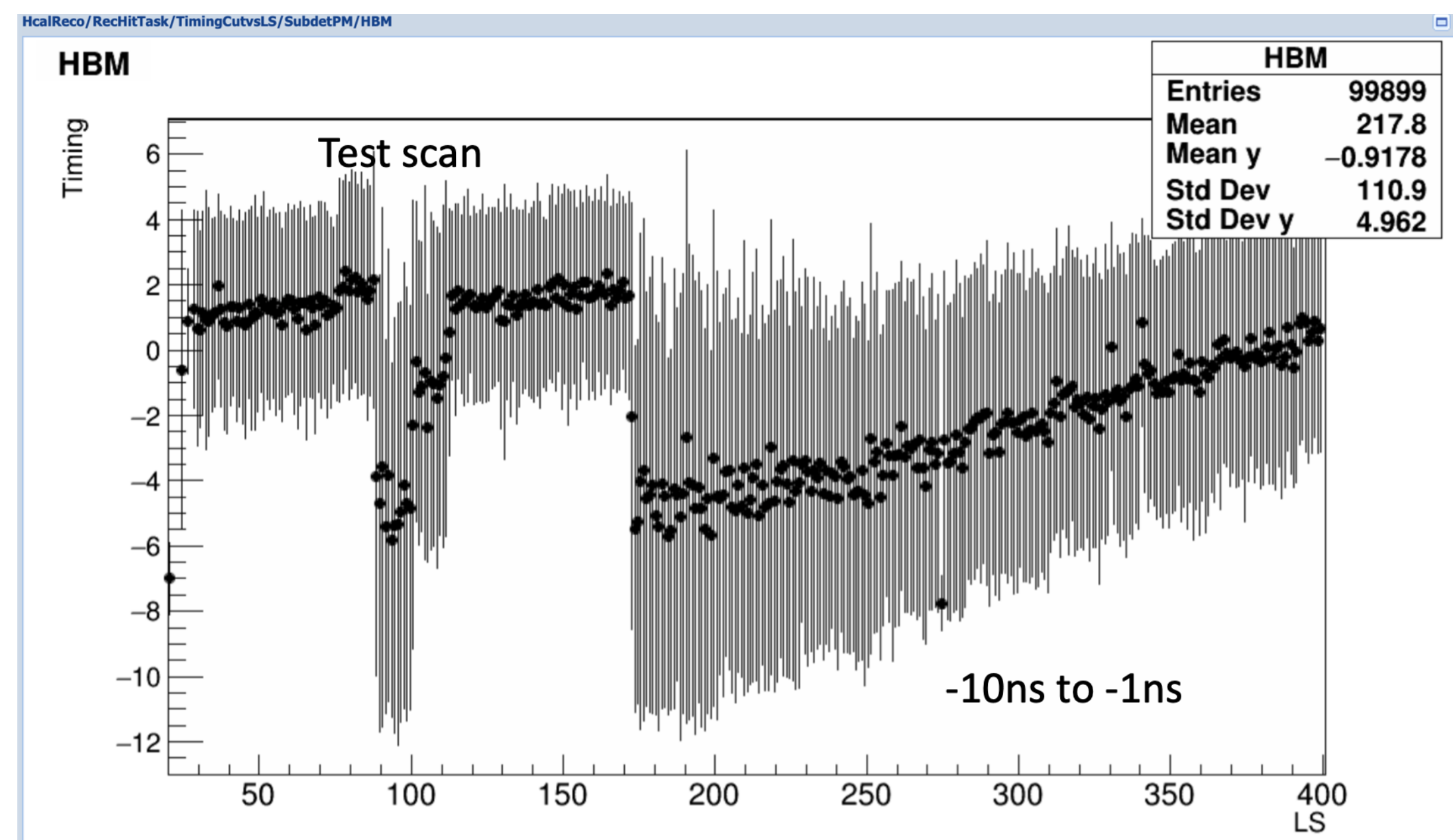
Data Certification Schedule

PromptReco dataset is available ~48 hours after data taking



Example for reason of lumi Loss: HCAL

- HCAL
 - eraB: 366873 366874 366876 366891 366895 (415/pb)
 - HCAL Phase Scans from -10 ns to +20 ns with 900-bunch (fill 8695, 8696)
 - Reports by the HCAL DPG: [\[link 1\]](#), [\[link 2\]](#)
 - eraC: 367615 LS=485-523 (13/pb)
 - DCS bit HBHEc* status RED → the bias voltage of multiple SiPMs (HBM17-RM1) was out of tolerance range: [\[e-log\]](#)
 - Effects are also seen in L1_SingleJet trigger rates and JetMET Distributions



- At the beginning of 2023 data-taking, Pixel started having a high number of Soft Error Recoveries (SERs)
 - High number of automasked channels triggers a soft error recovery
 - Most automasked channels came from BPix Layer 1
 - 10-12% of Layer 1 was automasked in high PU fills
- After several tests we determined that the number of automasked channels increased with higher L1 Trigger Rate and Pileup
- SERs accounted for the most pixel downtime during this period
- Pixel was powered off for MD, while Pixel was off there was a TCDS update
- Detector was powered ON at the beginning of TS1:
 - A few powering issues in both BPix and FPix: trips of LV digital currents solved by increasing V_0 from 10V to 11V
 - Configuration issues due to bad FED phases, solved by power-cycling all AMC13s (needed after TCDS update)
 - Issue with portcard of BPix Bml Sector 7 Layers 3-4, still unable to configure
- During TS1 (with Bml Sector 7 Layers 3-4 masked)
 - Threshold and PH Optimization for FPix and BPix
 - Ran a full gain calibration with new optimized settings
 - HV in L1 changed from 400 to 450 V and L2 from 300 to 350V

