Monitoring of Data/MC discrepancies with MCH cluster maps

QGP FRANCE 2023

Victor Valencia

General Purpose

- Compare for Run3 MC and Data Maps
- Track "unexpected" detector issues
  - Problematic Pads
  - ↓
  - Loose Acceptance of the detector
- Reproduce with simulations a realistic acceptance/efficiency of MCH chambers

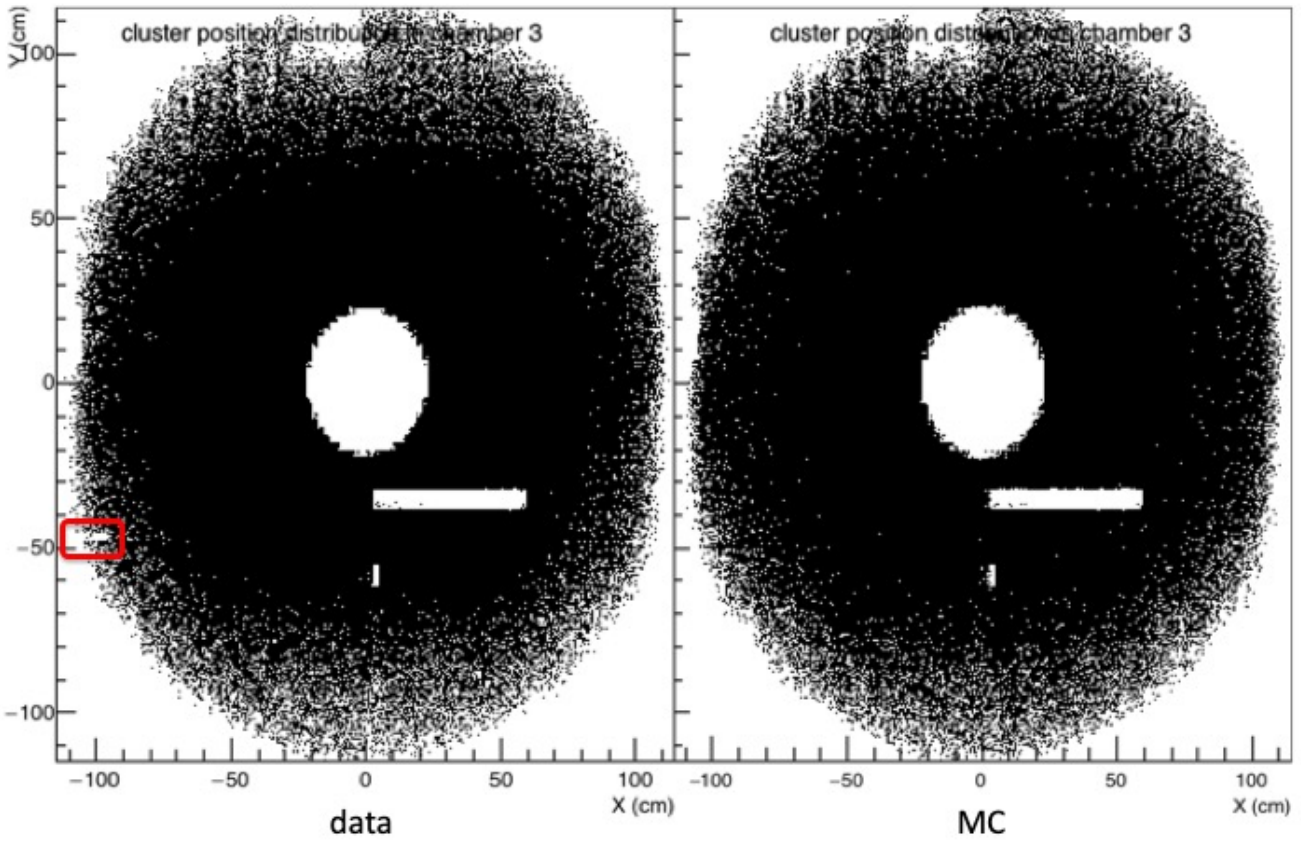
↓

Reduce systematic uncertainties in future measurements.

Cluster Maps in RUN 2:

2018 june 6th

By Philippe Pillot

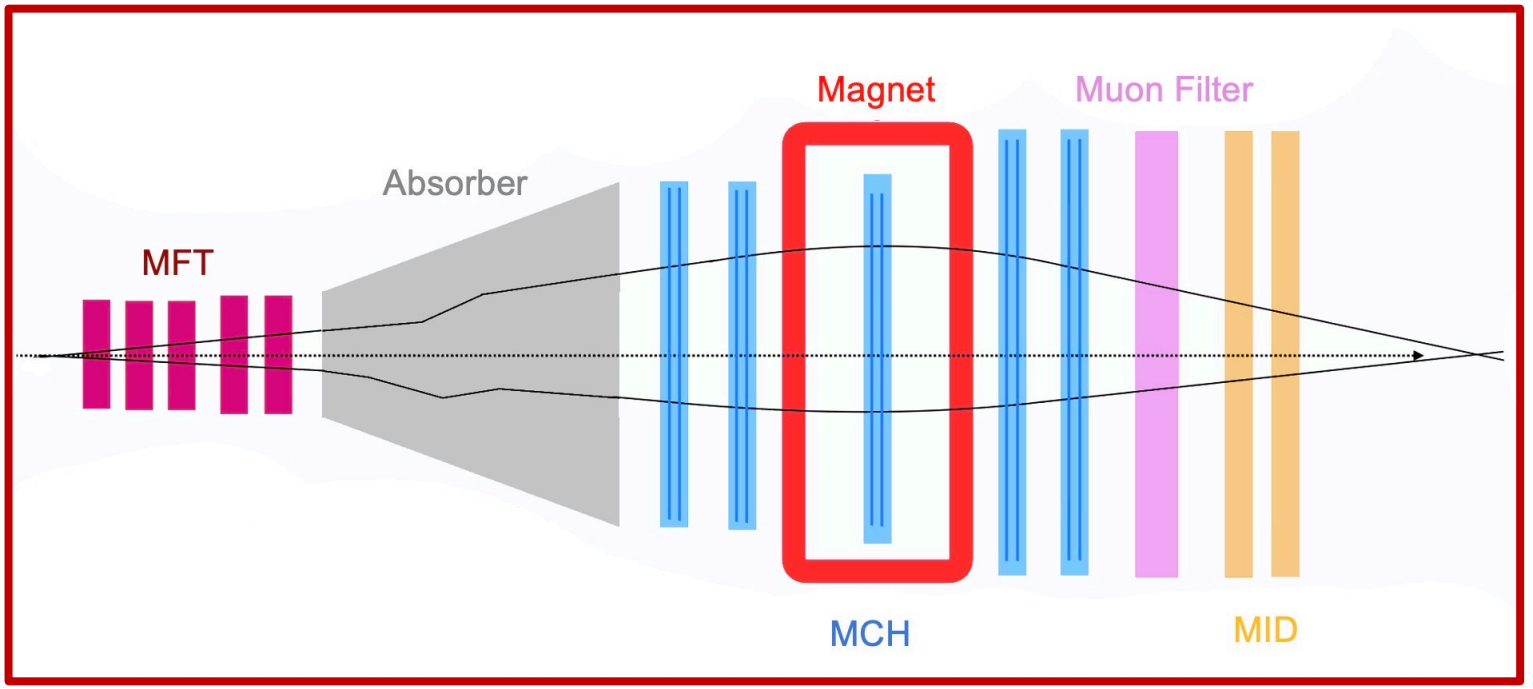


- Each Point represents a cluster

Cluster maps for Run2 DATA and MC (for the old acquisition electronics).

Ref: https://twiki.cern.ch/twiki/bin/viewauth/ALICE/MuonRejectList#How_to_produce_the_cluster_maps

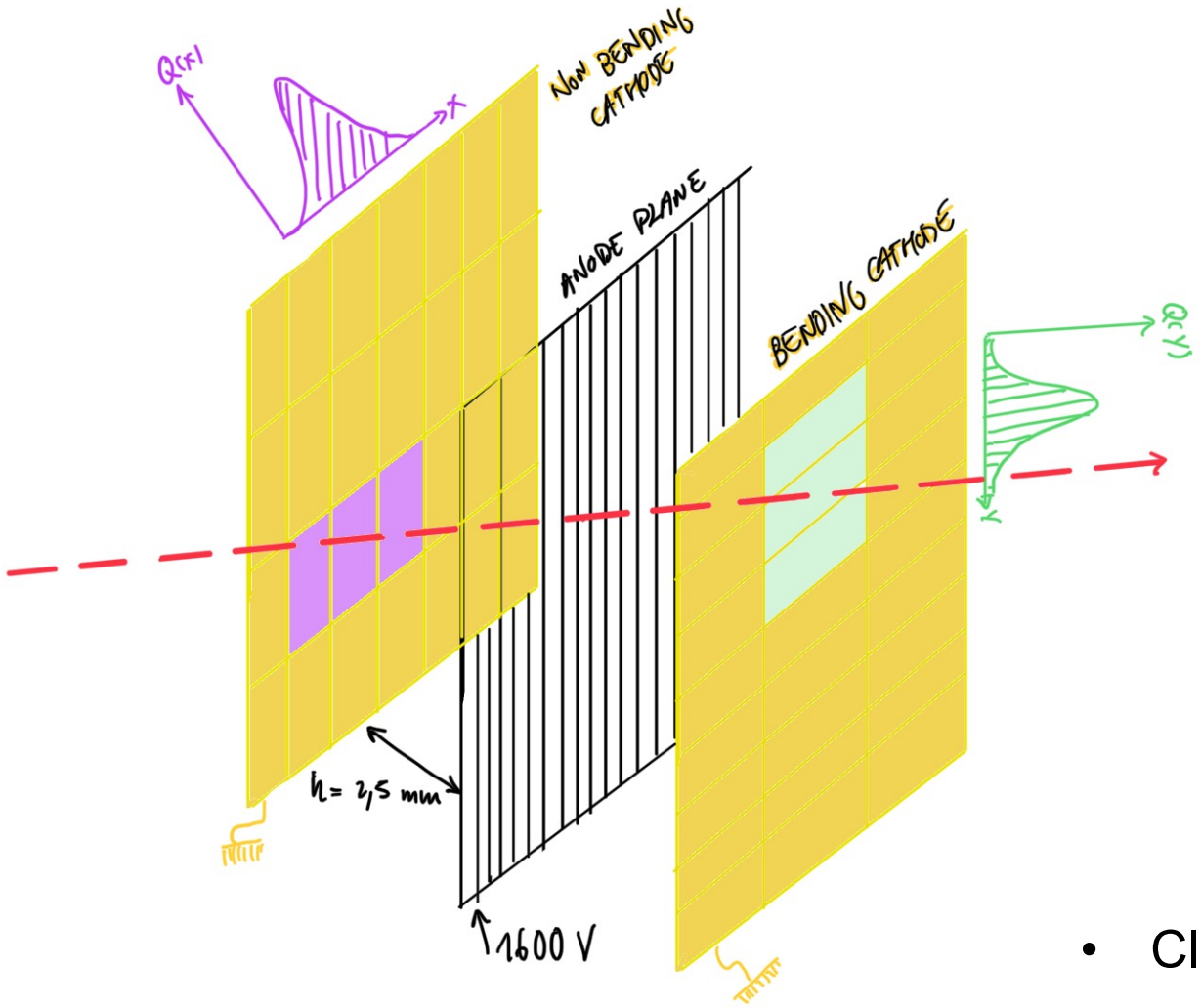
Muon Spectrometer of ALICE



1 MCH Station = 2 Chambers

1 Chamber = N Cathode Pad Chamber

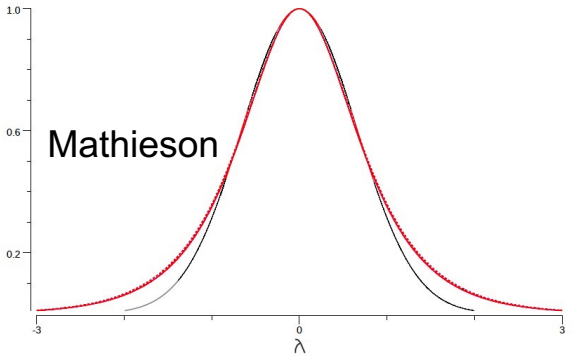
Cathode Pad Chamber



- 1 Anode ⟷ wires
- 2 Cathodes ⟷ pads
- Charge Distribution

↓

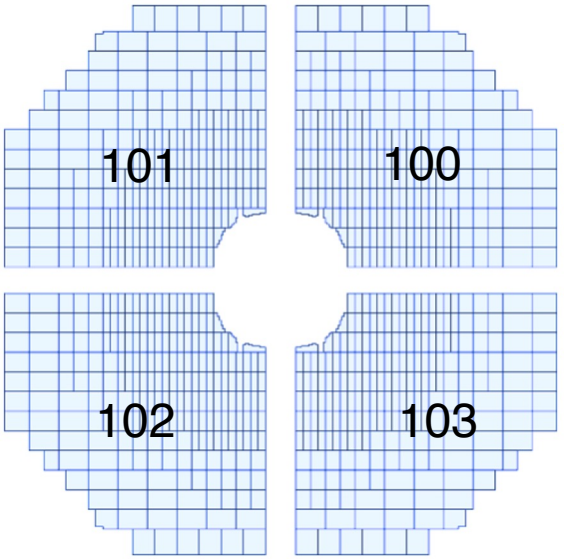
Follows Mathieson function



- Cluster center of Mathieson (x, y)

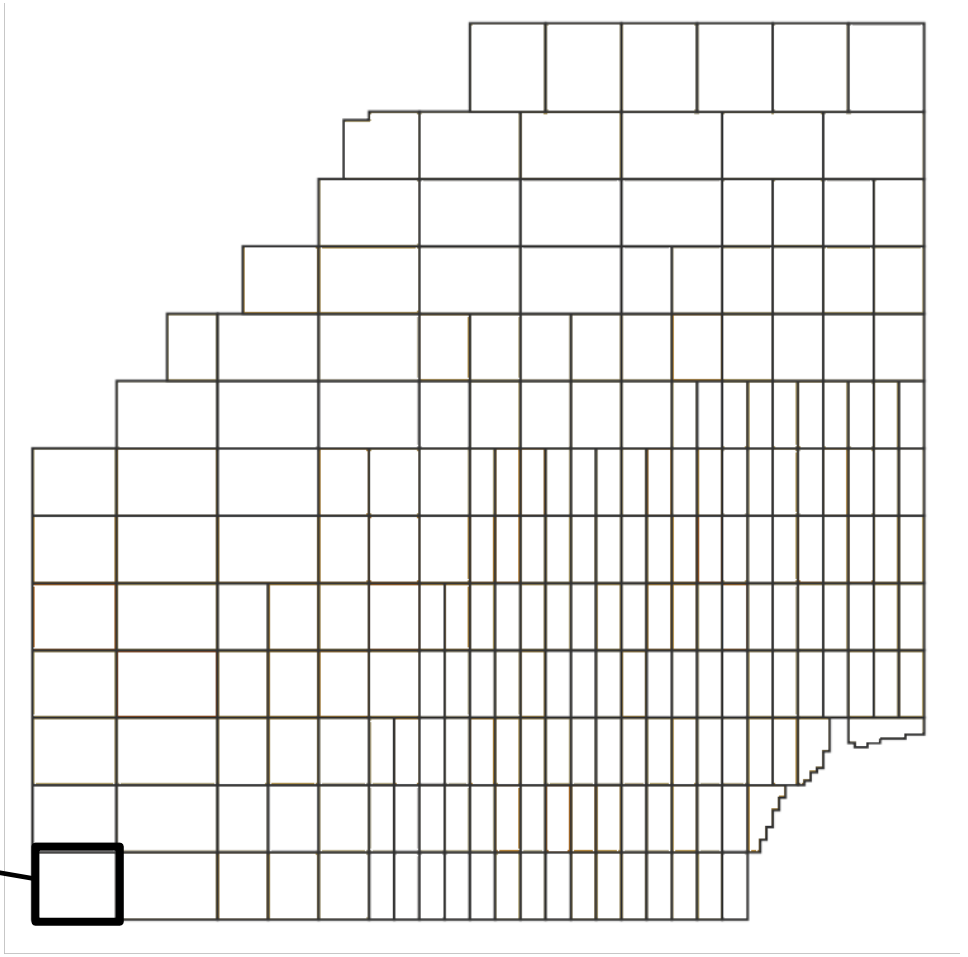
Structure of a Chamber

1st Chamber



DE-101-B-DS-1-BIN-997-DSINDEX-451
SolarId 192
flp148

DeId 101

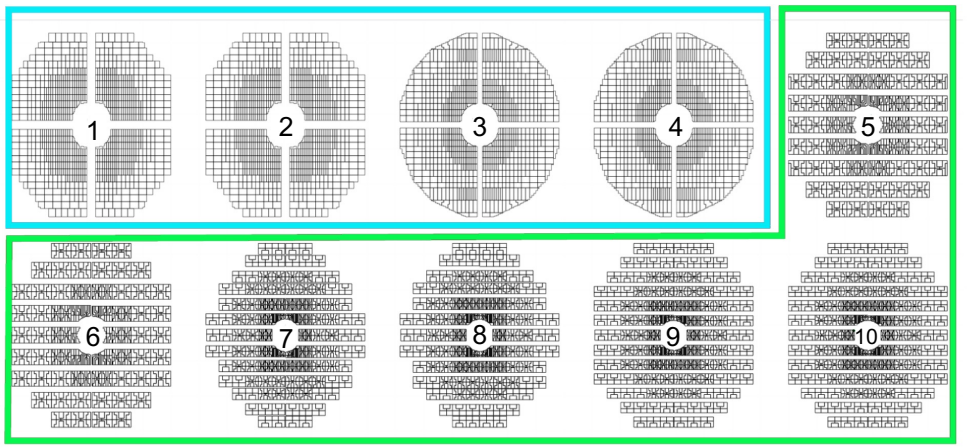


CHARACTERISTICS OF MCH:

- 5 Stations = 10 Chambers
- 156 Detection Elements (DE)
- 30 CRUs
- 624 Solars
- 16820 DualSampa (DS)
- 1063528 Pads

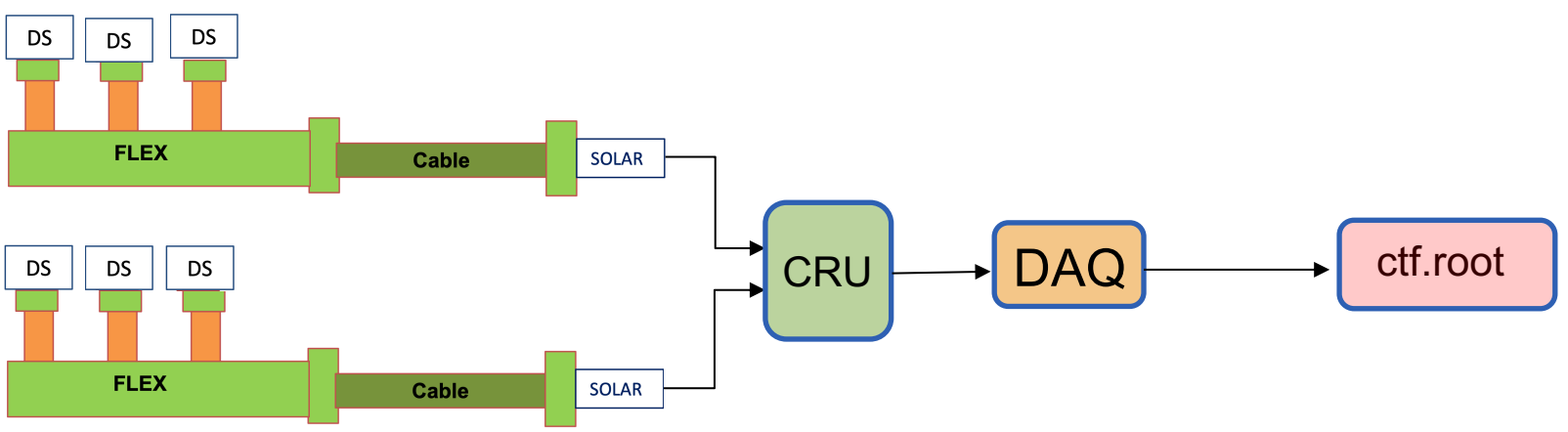
16 quadrants
43% of pads

140 slats
67% of pads

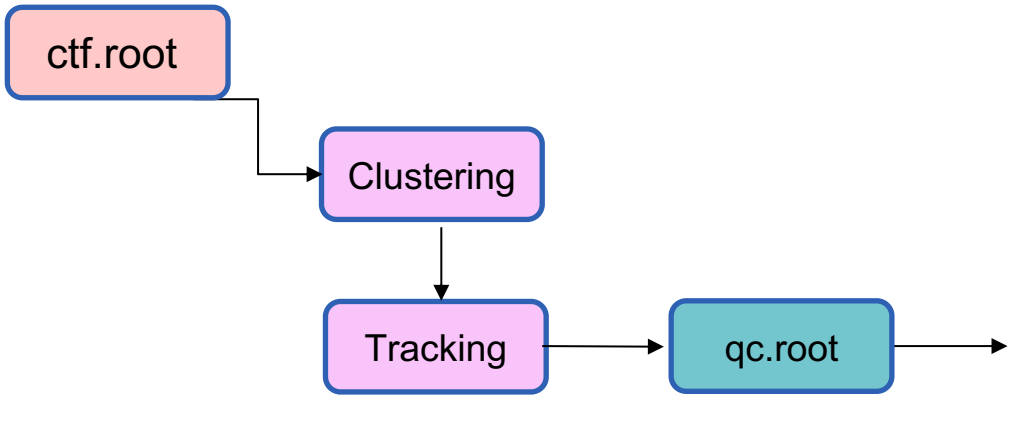


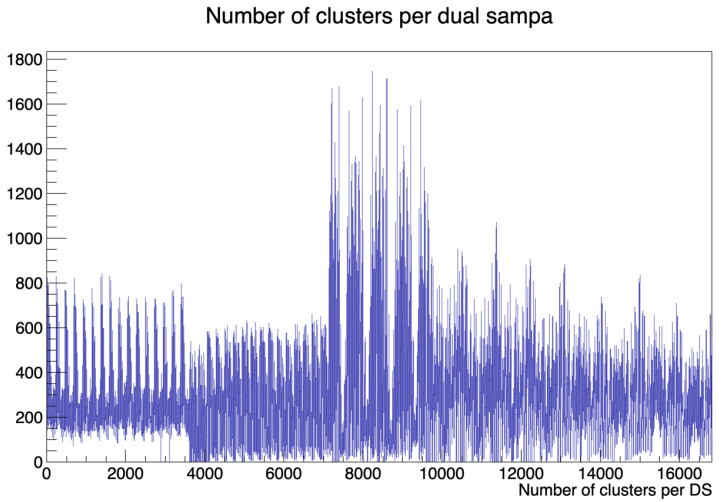
Clusters per Dualsampa in QC

DATA TAKING



RECONSTRUCTION



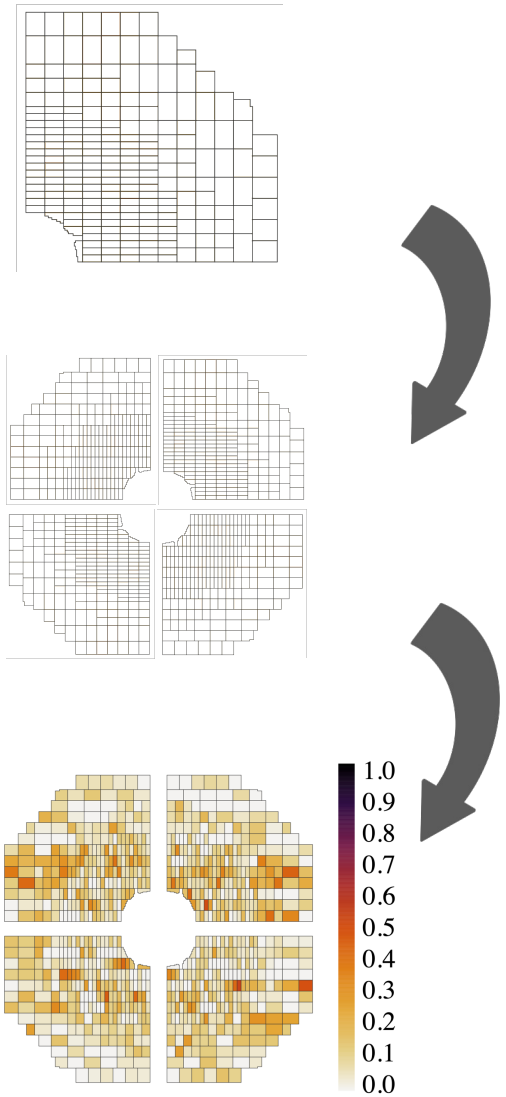


About my work ⟷ Cluster map at DualSampa level

1) First produce a DeId

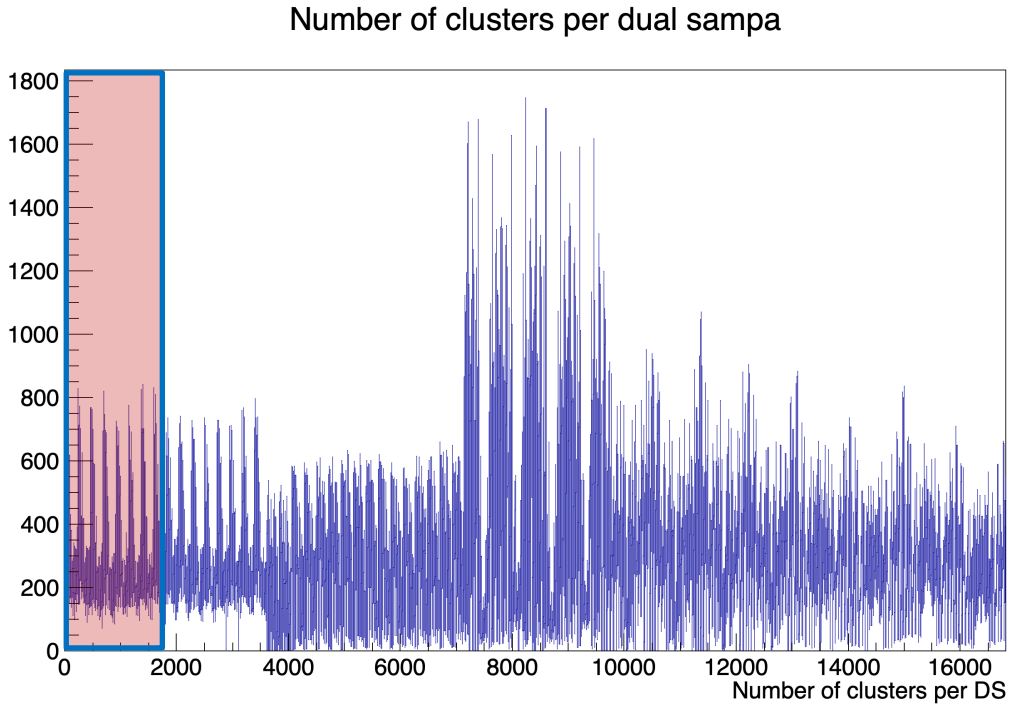
2) Rotations + Translations of all DeId

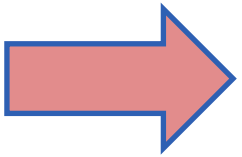
3) Create a color map

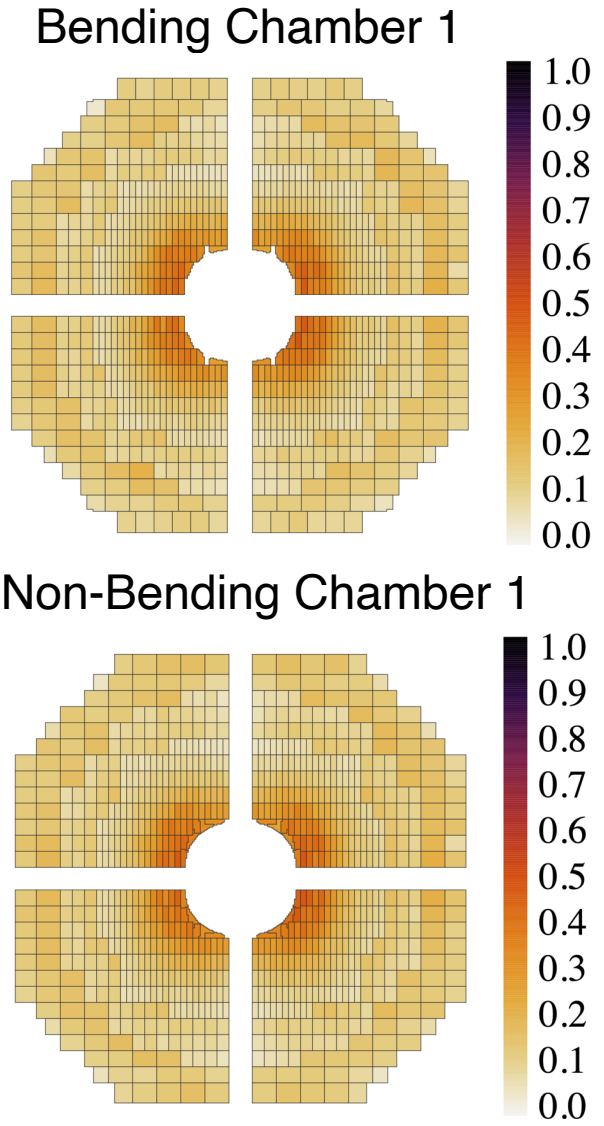


p-p data from LHC22t period

1000 TF of run 529691







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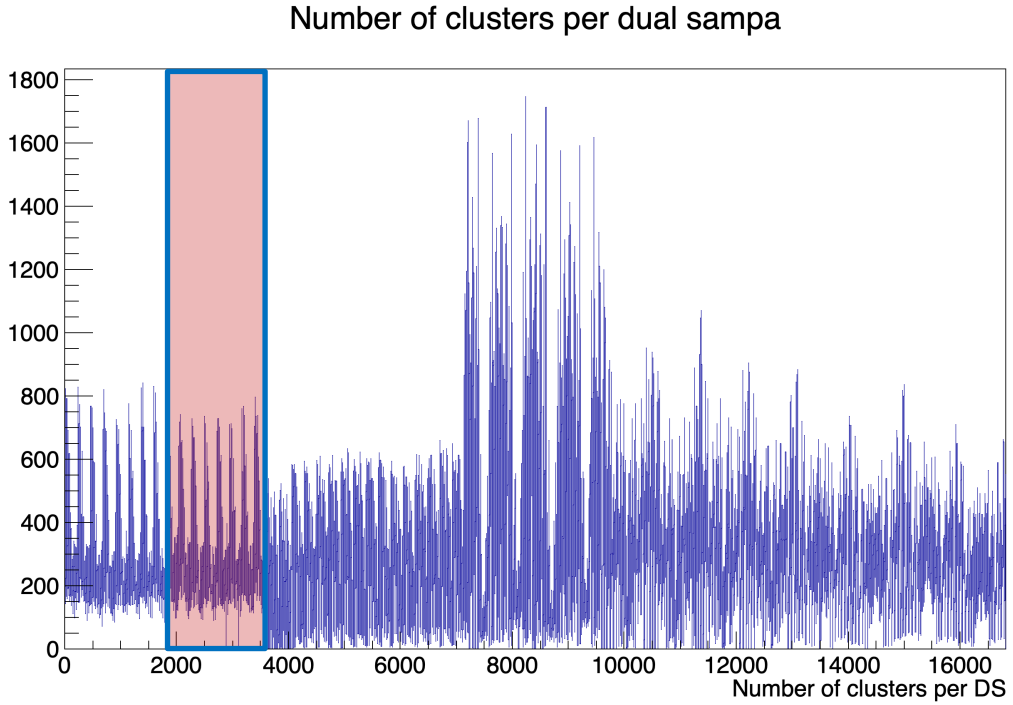
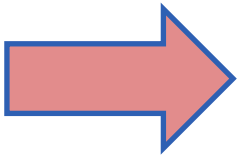
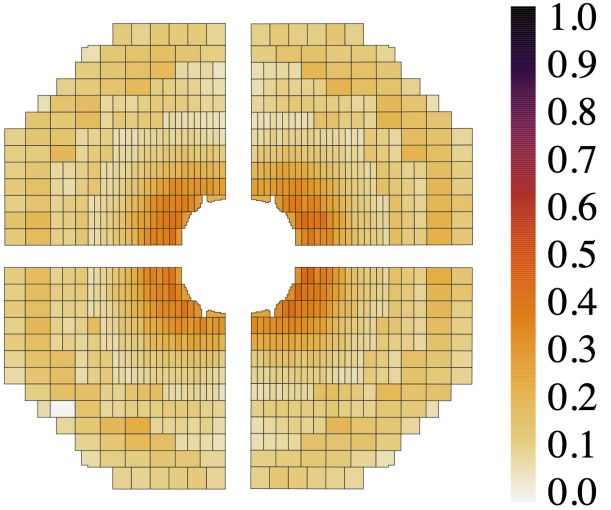
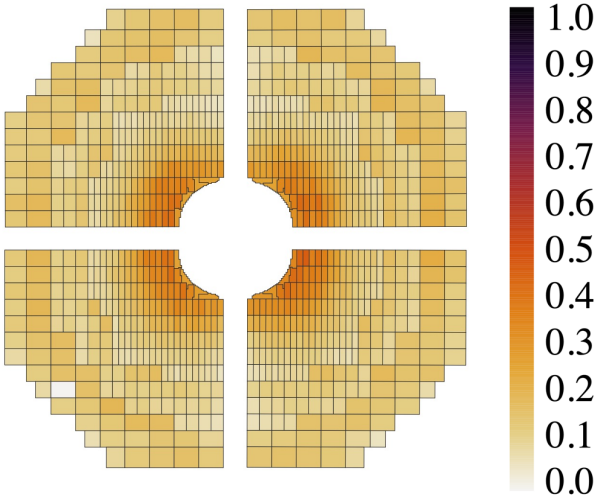




Bending Chamber 2

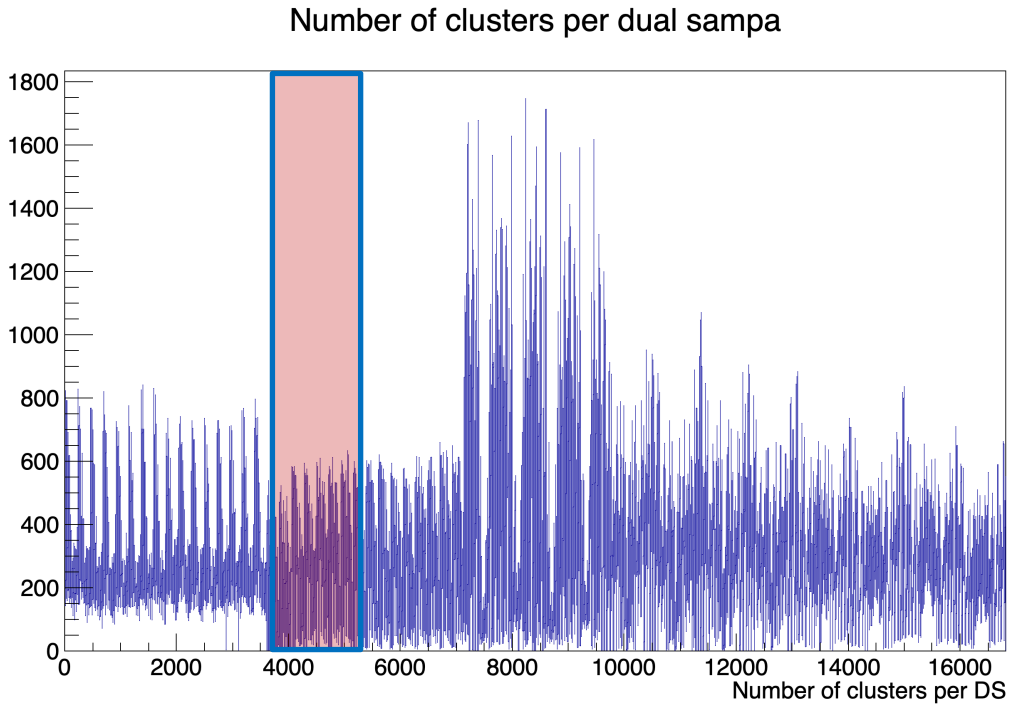


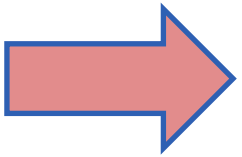
Non-Bending Chamber 2



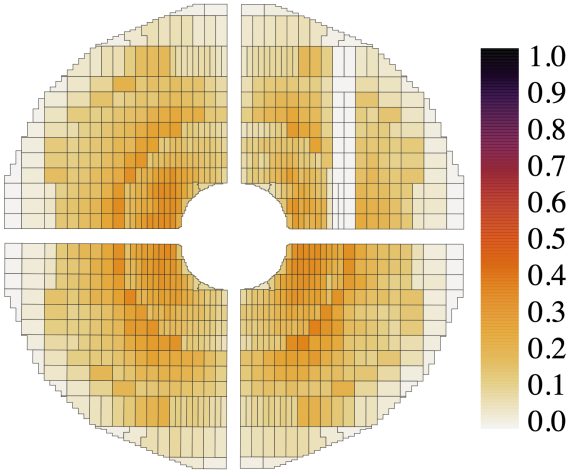
p-p data from LHC22t period

1000 TF of run 529691

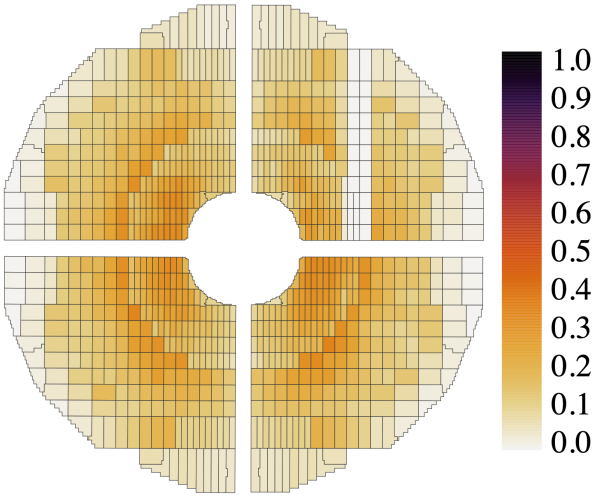




Bending Chamber 3

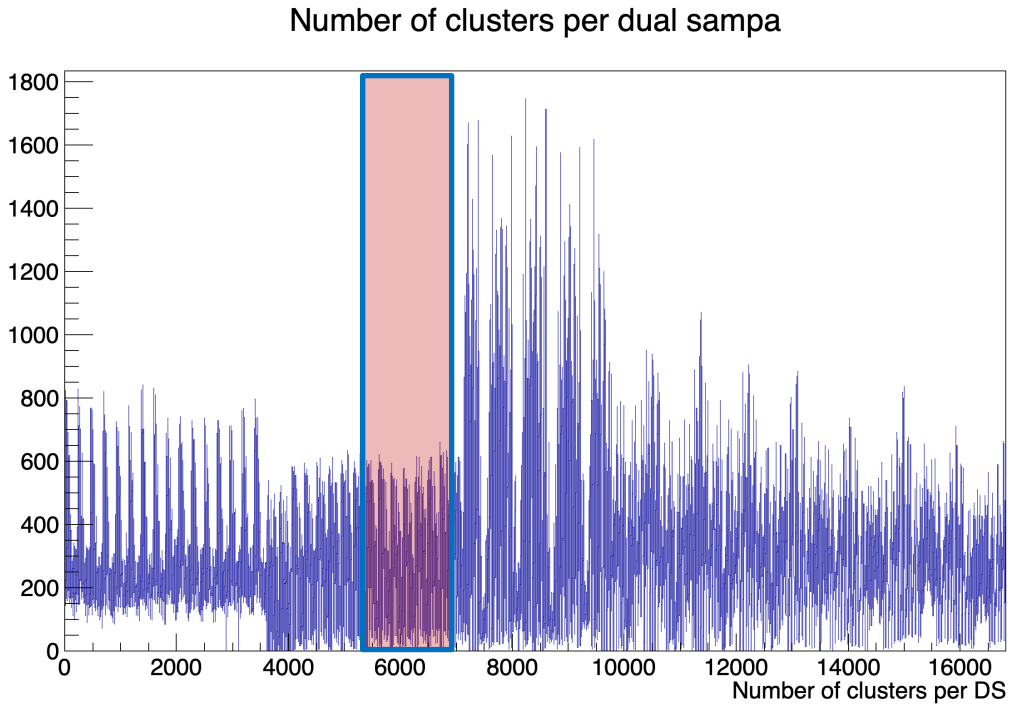


Non-Bending Chamber 3

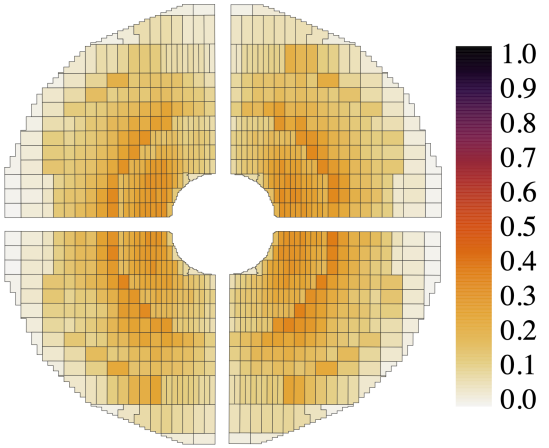


p-p data from LHC22t period

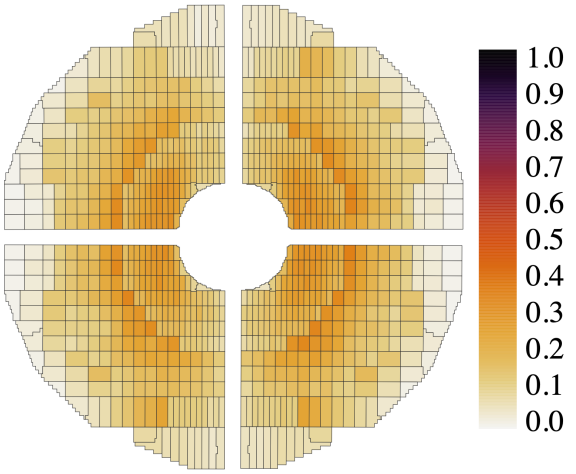
1000 TF of run 529691



Bending Chamber 4

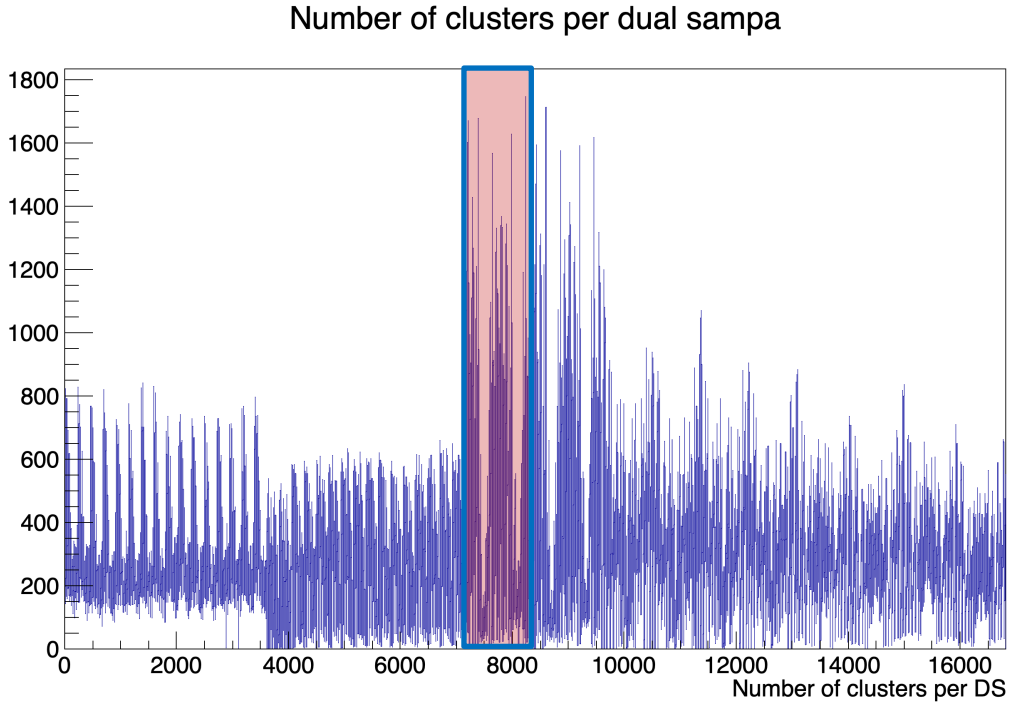


Non-Bending Chamber 4

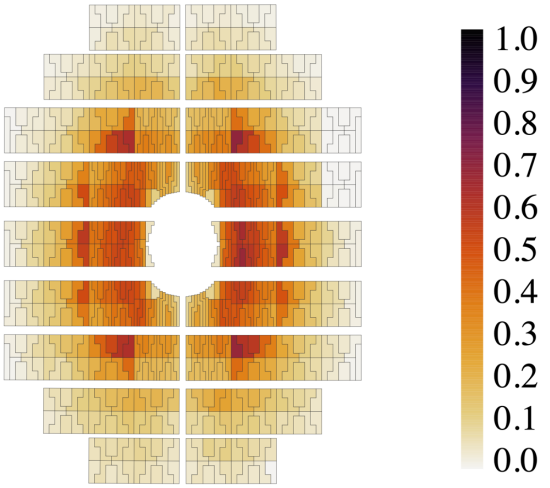


p-p data from LHC22t period

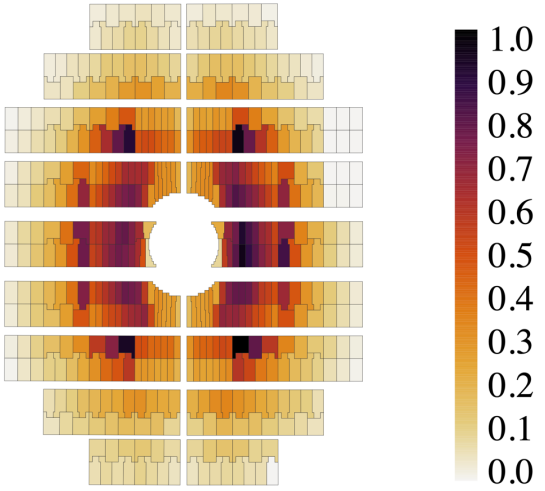
1000 TF of run 529691



Bending Chamber 5

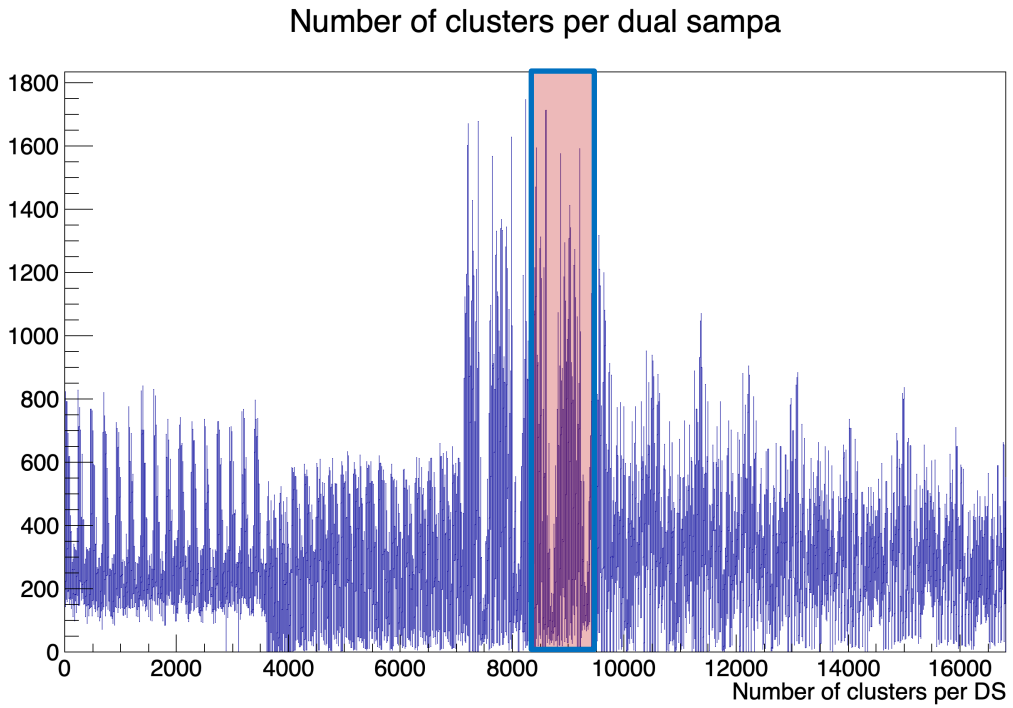


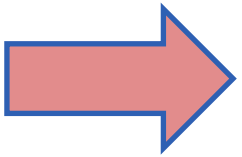
Non-Bending Chamber 5

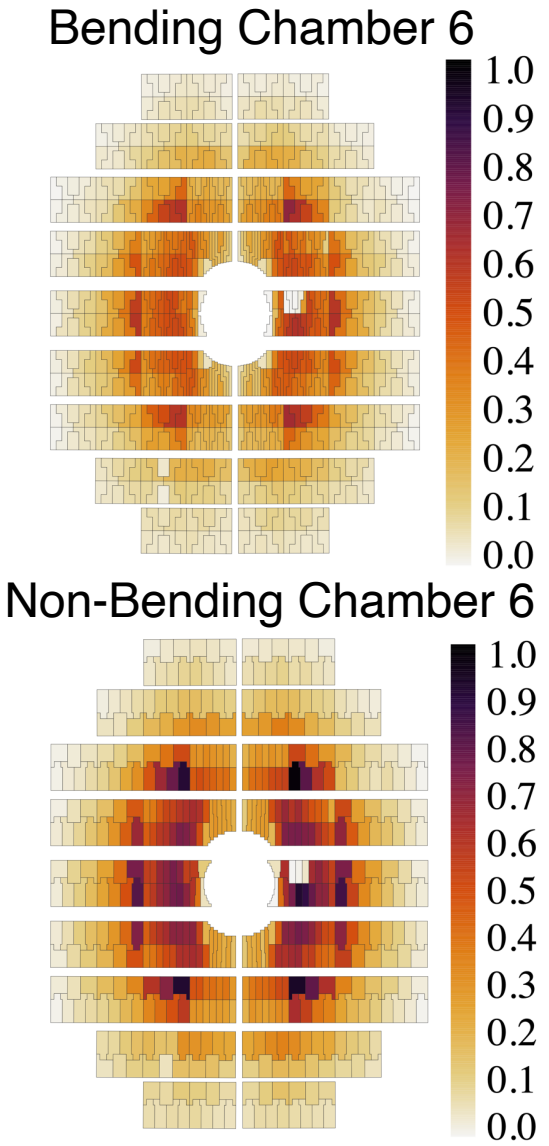


p-p data from LHC22t period

1000 TF of run 529691

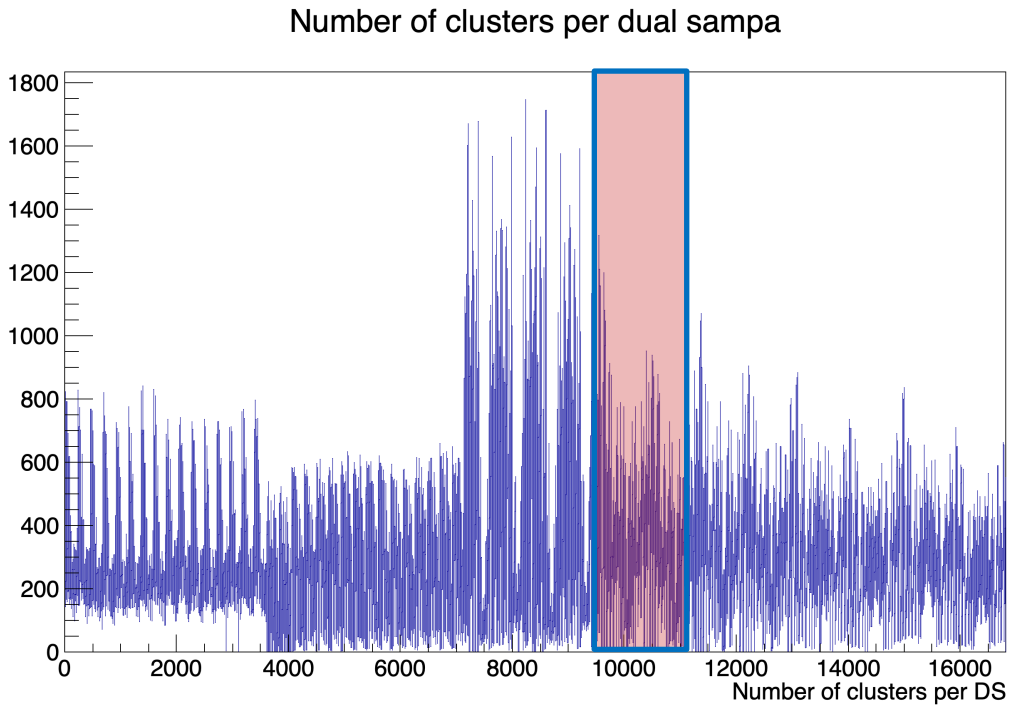


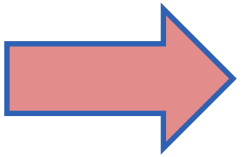




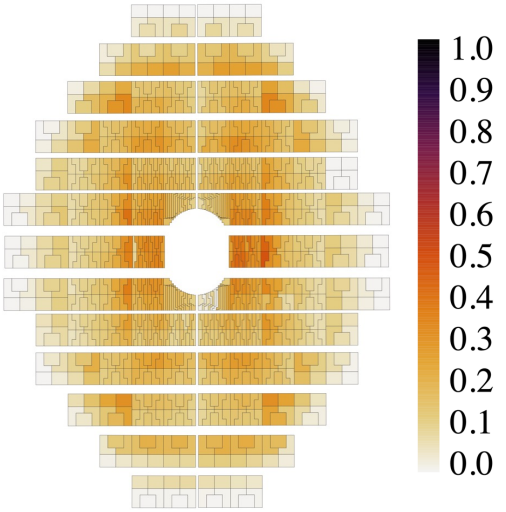
p-p data from LHC22t period

1000 TF of run 529691

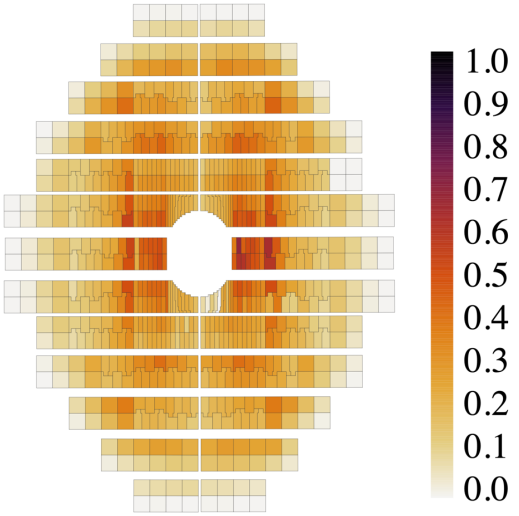




Bending Chamber 7

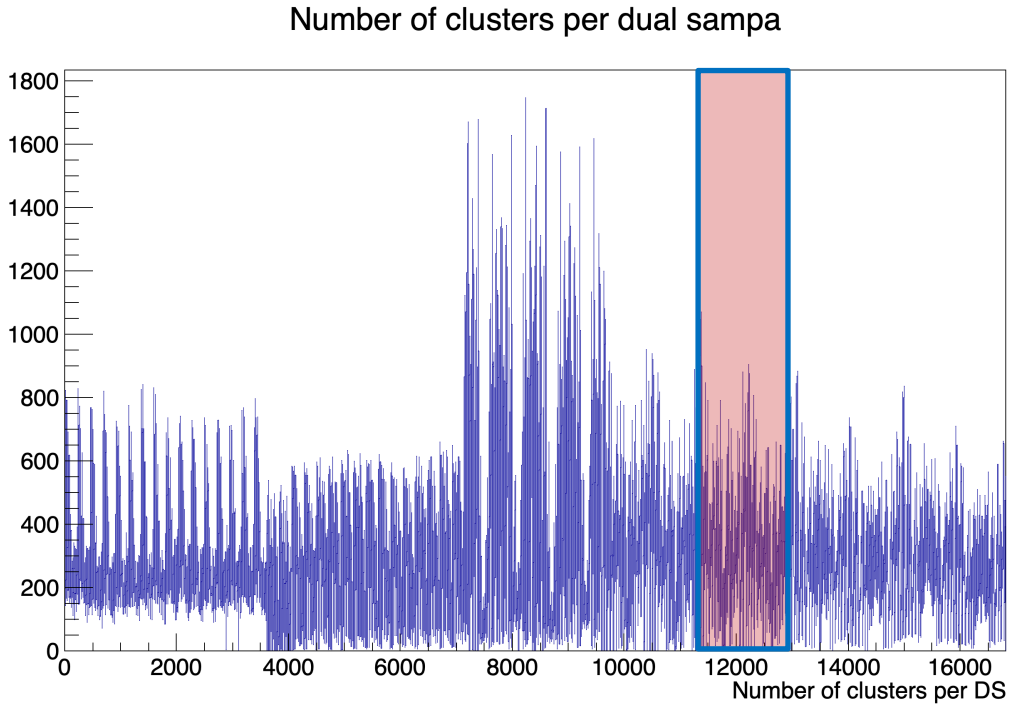


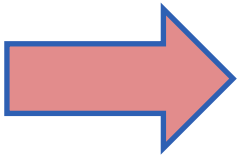
Non-Bending Chamber 7

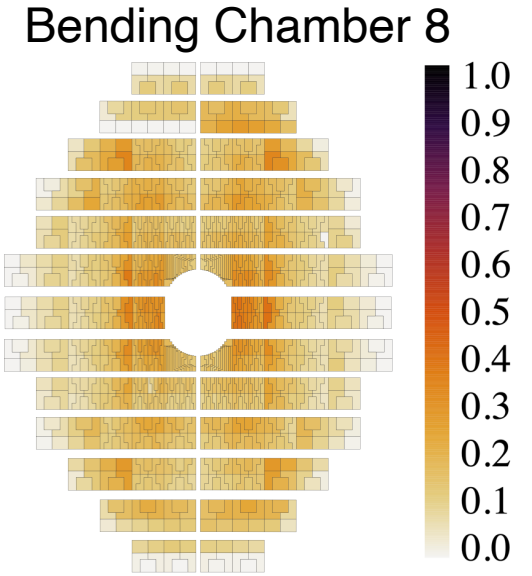


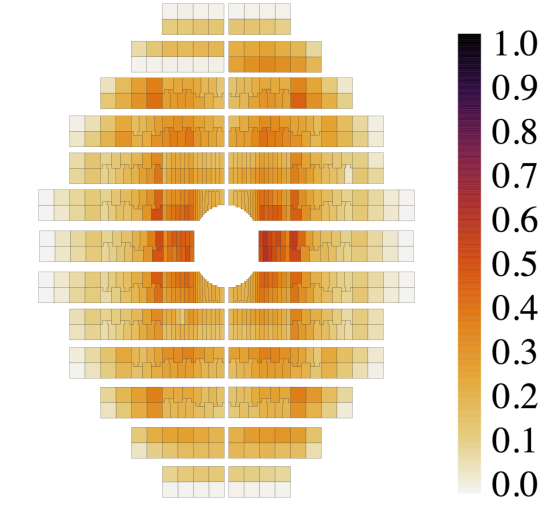
p-p data from LHC22t period

1000 TF of run 529691



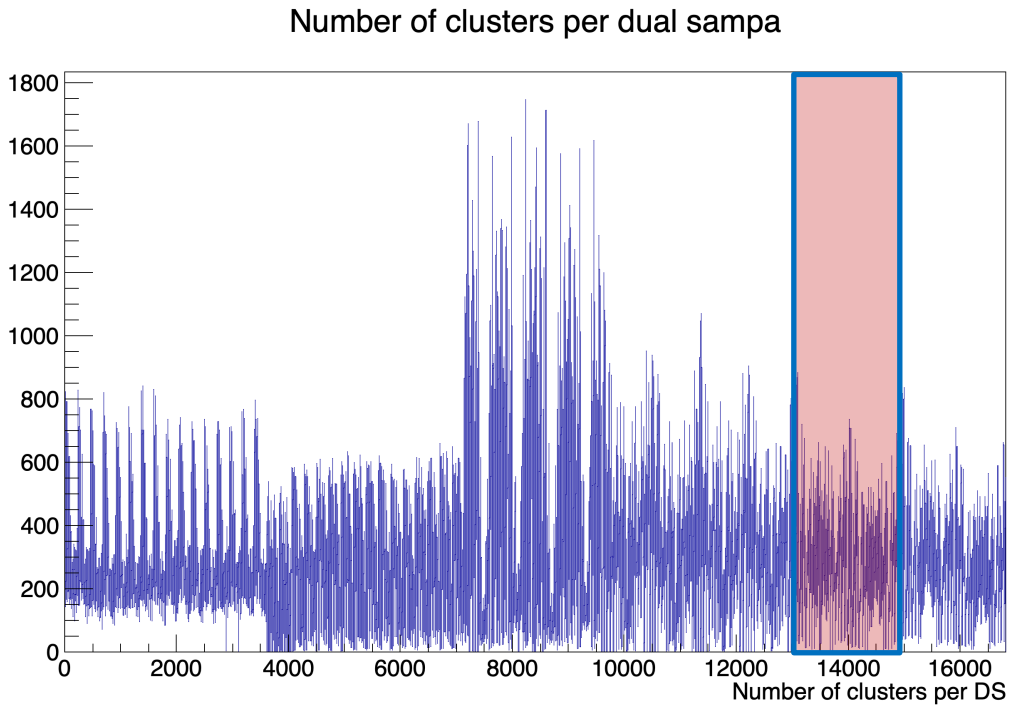


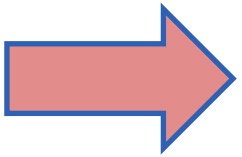


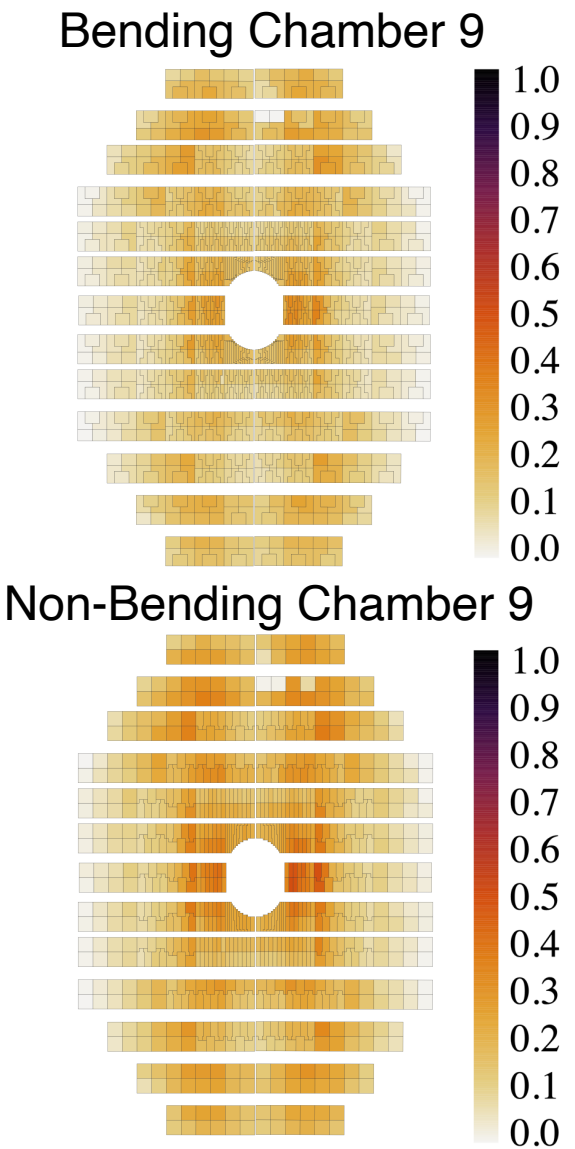


p-p data from LHC22t period

1000 TF of run 529691

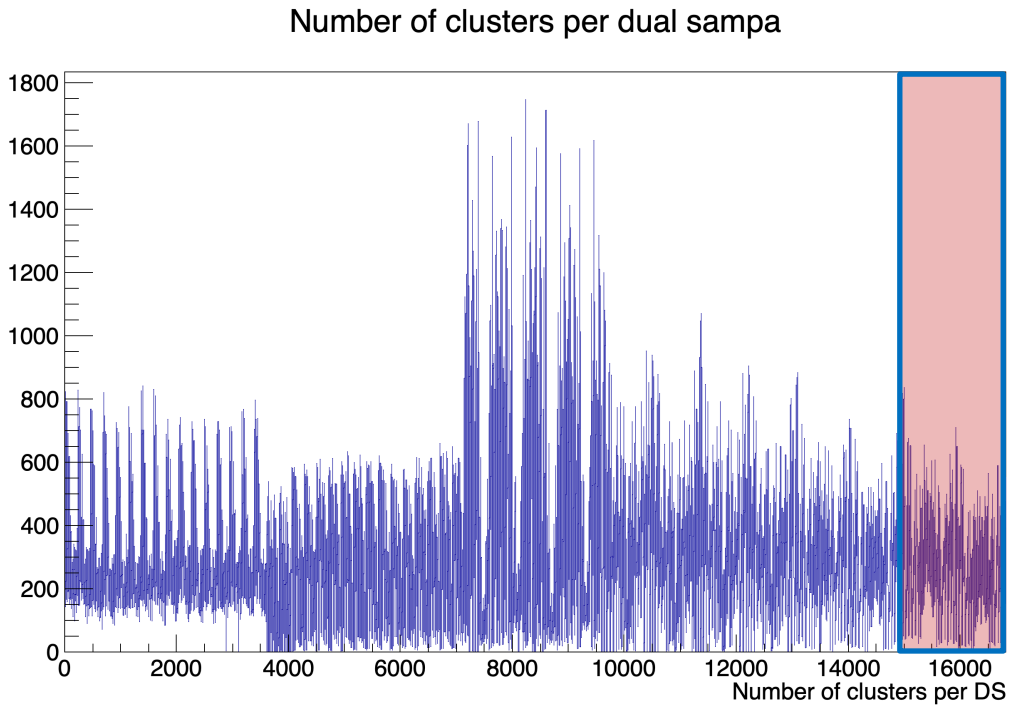


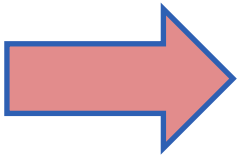


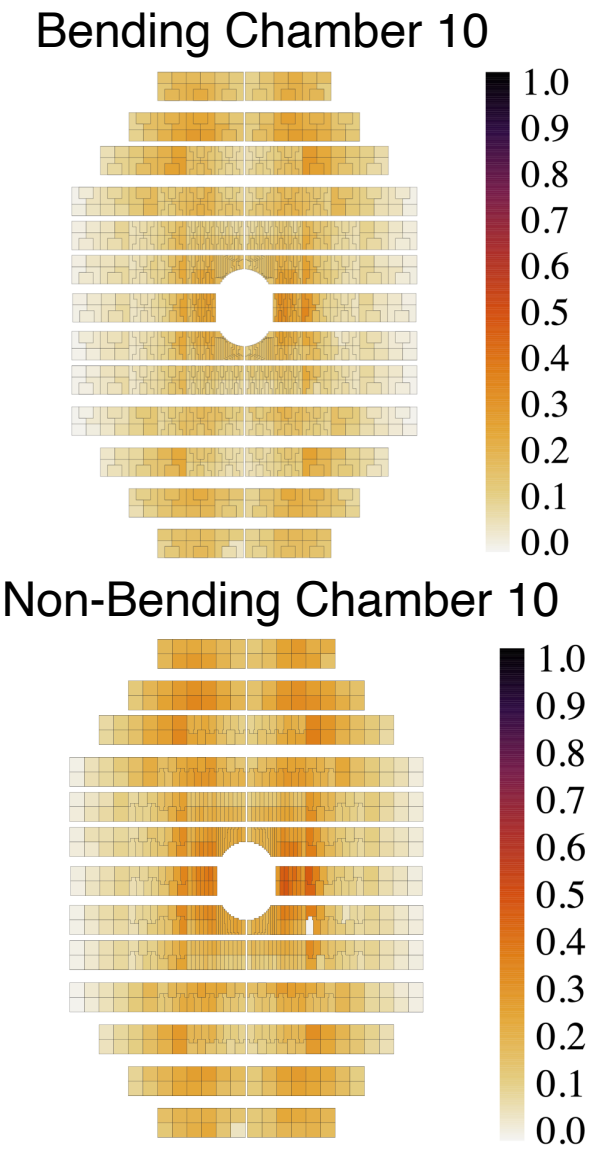


p-p data from LHC22t period

1000 TF of run 529691

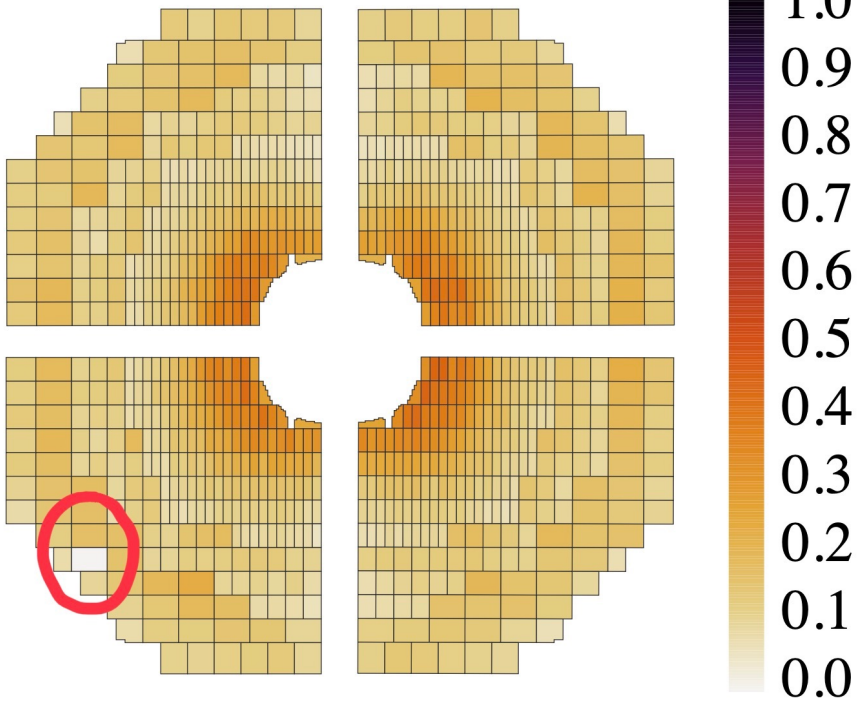




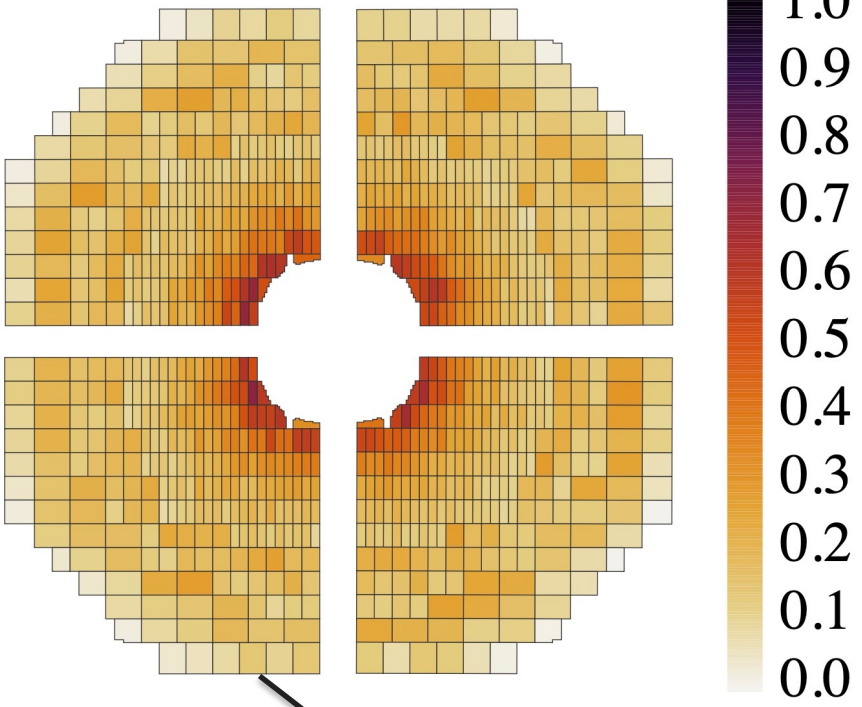


⚠ WORK IN PROGRESS ⚠

DATA



MC SIMULATIONS



Monitoring discrepancies in cluster maps for Run3 DATA and MC.

Simulations done by Emilie Barreau

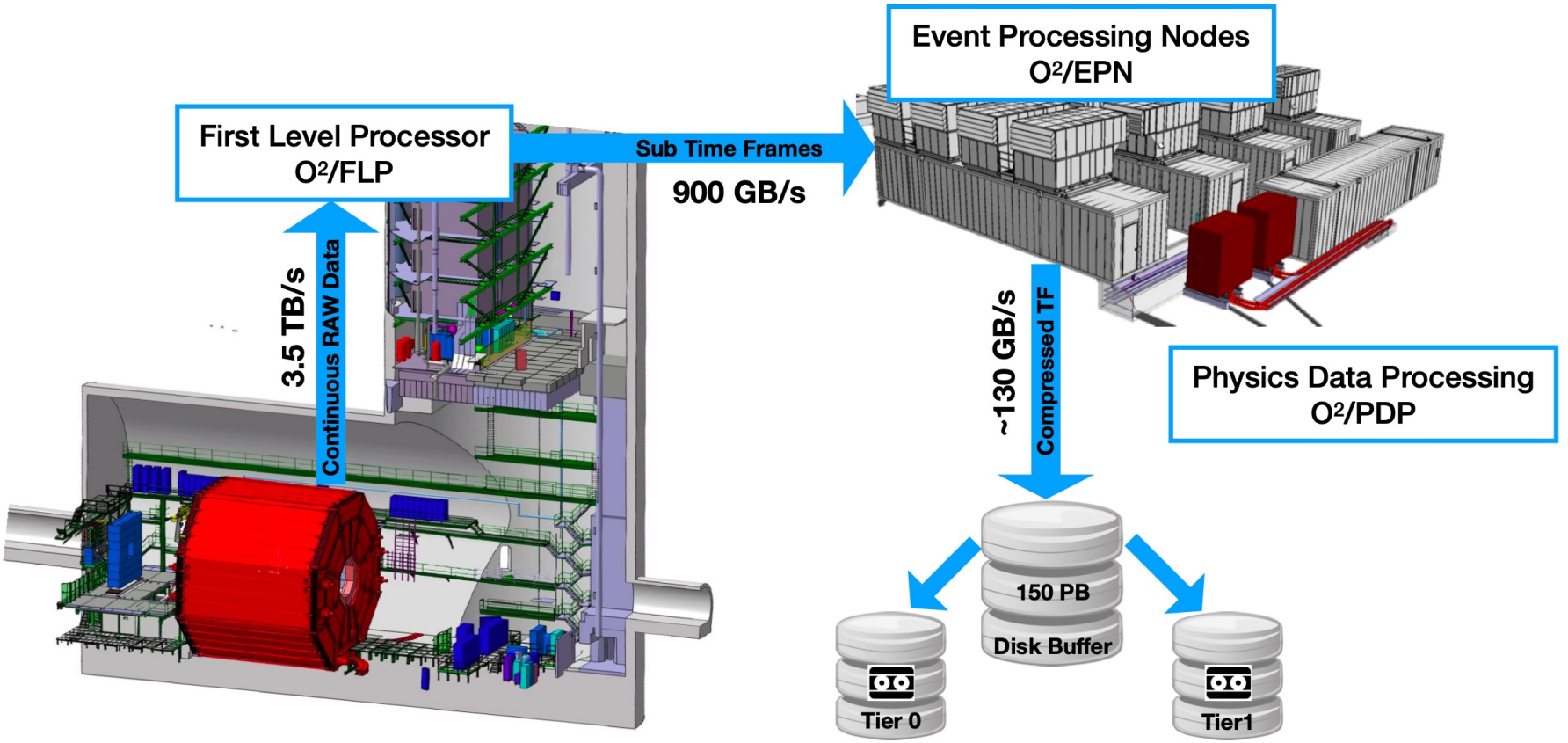
Perspective

- Spot different unexpected detector issues (not included in the CCDB status map) and investigate their origin.
- Developpe an automated method to detect and incorporate all problematic spots.

Thanks for your attention!

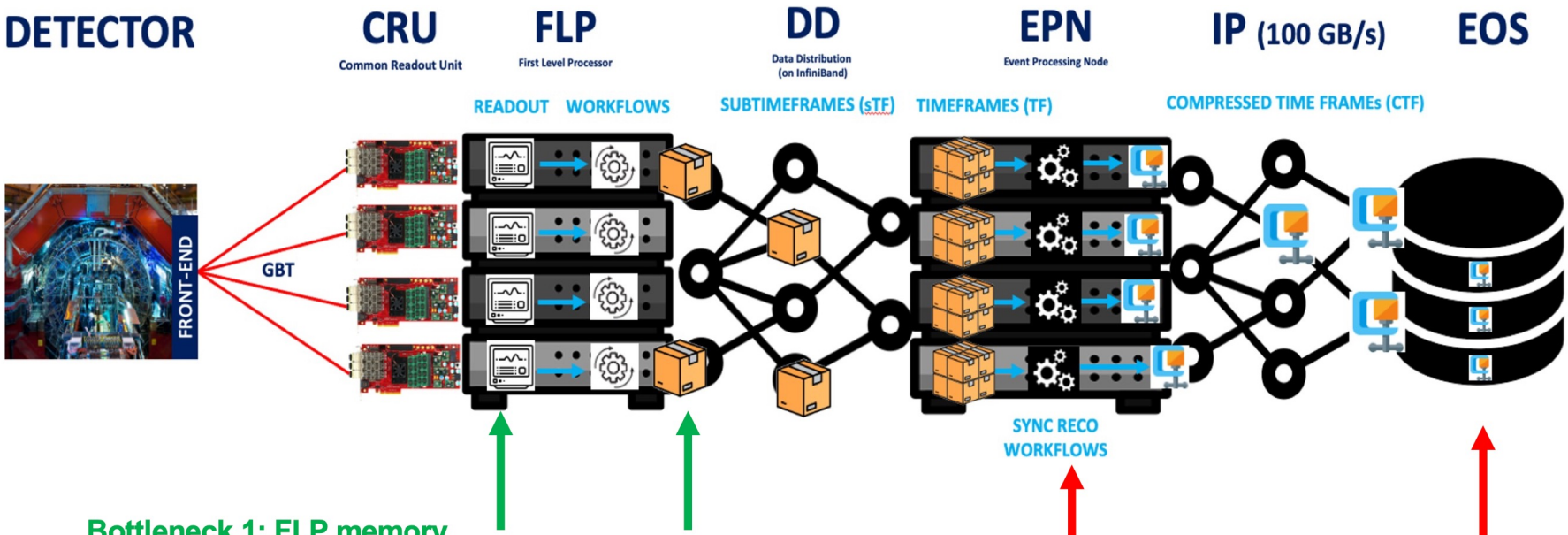
Back Up

Data Taking



Ref: https://arxiv.org/pdf/2302.01238.pdf

Data Taking



Bottleneck 1: FLP memory

- **Optimization of memory buffers**
- **Increase RAM + rebalancing load for ITS adding extra FLP**

Bottleneck 2
11 GB/s per FLPs
Expected maximum FLP output with TPC DLBZS:
7.8 - 9.75 GB/s

Bottleneck 3
TPC clusters x 1.3
More processing power needed

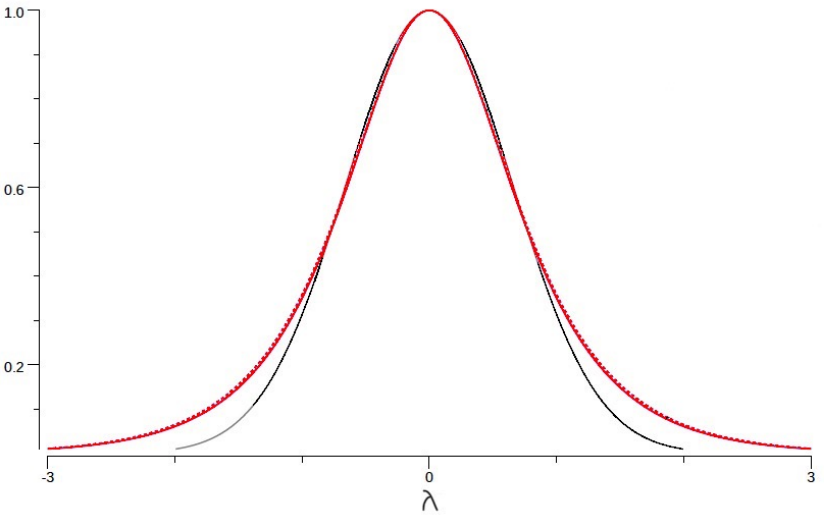
Bottleneck 4
With increase data size
Need more PB

Ref: https://indico.cern.ch/event/1247651/contributions/5271282/attachments/2600384/4489966/ALICE_RC_AW_20230227.pdf

Mathieson Probability Density Function (MPDF)

CATHODE CHARGE DISTRIBUTIONS IN MULTIWIRE CHAMBERS:

$$\frac{\rho(\lambda)}{q_a} = K_1 \frac{1 - tanh^2(K_2\lambda)}{1 + K_3 tanh^2(K_2\lambda)}$$



$\lambda = x/h$ or $\lambda = y/h$

h = anode-cathode distance

q_a anode charge

$K_1, K_2 = f(K_3)$

$K_3 = f(r_a, h, s)$ =chamber geometry

$$\int (2D) = 4 \int_{x_1}^{x_2} \frac{\rho(\lambda_x)}{q_a} d\lambda_x \int_{y_1}^{y_2} \frac{\rho(\lambda_y)}{q_a} d\lambda_y$$

where $$\int_{\lambda_1}^{\lambda_2} \frac{\rho(\lambda)}{q_a} d\lambda = K_4 \left[\arctan u \right]_{\sqrt{K_3}\tanh(K_2\lambda_1)}^{\sqrt{K_3}\tanh(K_2\lambda_2)}$$

Ref: http://doi.org/10.1016/0168-9002(88)90736-X

Cross Check for deID 100

```
dsId: 1, nClusters: 0
dsId: 2, nClusters: 45
dsId: 3, nClusters: 14
dsId: 4, nClusters: 54
dsId: 5, nClusters: 28
dsId: 6, nClusters: 21
dsId: 7, nClusters: 10
dsId: 8, nClusters: 3
dsId: 9, nClusters: 24
dsId: 10, nClusters: 6
dsId: 11, nClusters: 3
dsId: 12, nClusters: 0
dsId: 13, nClusters: 34
dsId: 14, nClusters: 11
dsId: 15, nClusters: 23
dsId: 16, nClusters: 13
dsId: 17, nClusters: 0
dsId: 18, nClusters: 6
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dsId: 20, nClusters: 10
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dsId: 28, nClusters: 7
dsId: 29, nClusters: 24
dsId: 30, nClusters: 20
```

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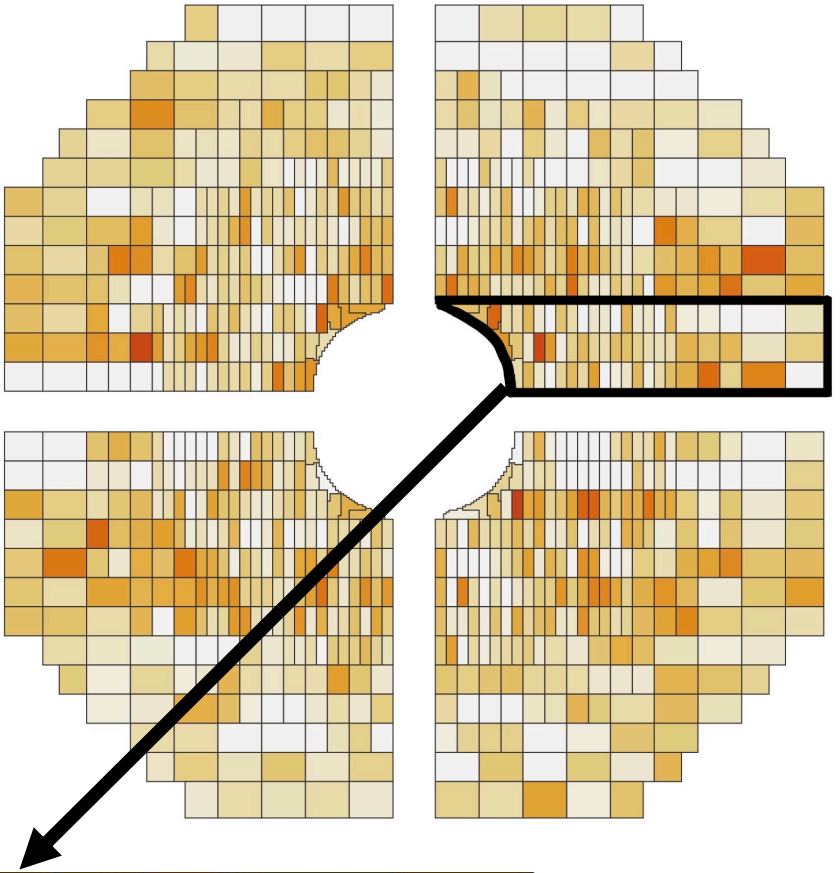
dsId: 33, nClusters: 8
dsId: 34, nClusters: 9
dsId: 35, nClusters: 14
dsId: 36, nClusters: 20
dsId: 37, nClusters: 21
dsId: 38, nClusters: 9
dsId: 39, nClusters: 13
dsId: 40, nClusters: 23
dsId: 41, nClusters: 14
dsId: 42, nClusters: 3
dsId: 43, nClusters: 36
dsId: 44, nClusters: 66
dsId: 45, nClusters: 6
dsId: 46, nClusters: 18
dsId: 47, nClusters: 37
dsId: 53, nClusters: 8
dsId: 54, nClusters: 0
dsId: 55, nClusters: 0
dsId: 56, nClusters: 3
dsId: 57, nClusters: 3
dsId: 58, nClusters: 24
dsId: 59, nClusters: 0
dsId: 60, nClusters: 6
```

```
dsId: 61, nClusters: 5
dsId: 62, nClusters: 25
dsId: 63, nClusters: 0
dsId: 64, nClusters: 5
dsId: 65, nClusters: 6
dsId: 66, nClusters: 0
dsId: 67, nClusters: 10
dsId: 68, nClusters: 19
dsId: 69, nClusters: 0
dsId: 70, nClusters: 5
dsId: 71, nClusters: 24
dsId: 72, nClusters: 10
dsId: 73, nClusters: 10
dsId: 74, nClusters: 56
dsId: 75, nClusters: 21
dsId: 76, nClusters: 20
```

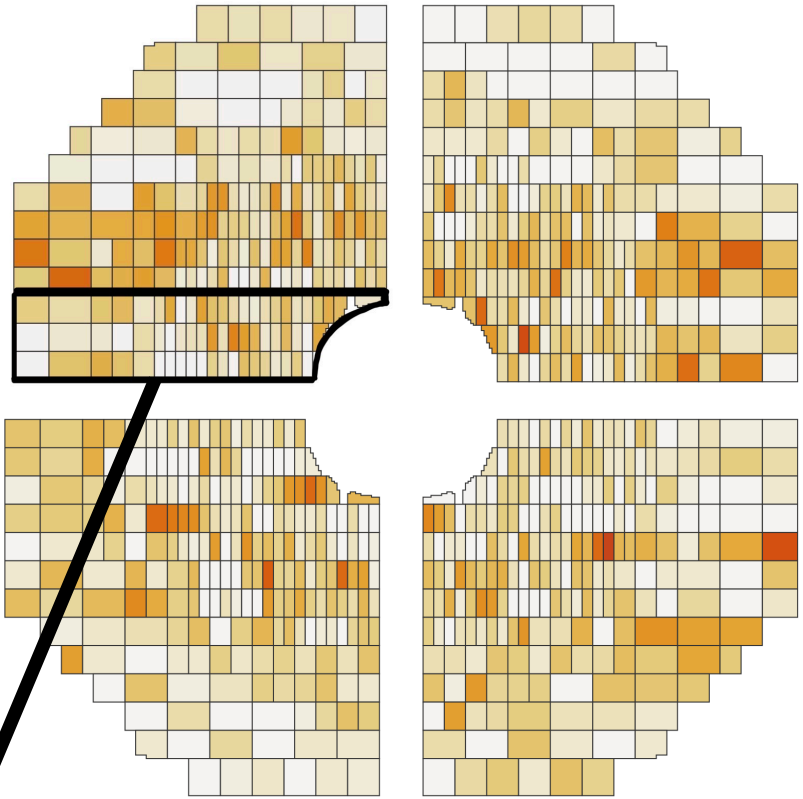


Cross Check for deID 101

```
dsId: 1, nClusters: 0
dsId: 2, nClusters: 20
dsId: 3, nClusters: 28
dsId: 4, nClusters: 20
dsId: 5, nClusters: 10
dsId: 6, nClusters: 0
dsId: 7, nClusters: 0
dsId: 8, nClusters: 0
dsId: 9, nClusters: 0
dsId: 10, nClusters: 0
dsId: 11, nClusters: 14
dsId: 12, nClusters: 7
dsId: 13, nClusters: 0
dsId: 14, nClusters: 21
dsId: 15, nClusters: 17
dsId: 16, nClusters: 13
dsId: 17, nClusters: 5
dsId: 18, nClusters: 8
dsId: 19, nClusters: 15
dsId: 20, nClusters: 0
dsId: 27, nClusters: 0
dsId: 28, nClusters: 5
dsId: 29, nClusters: 5
dsId: 30, nClusters: 0
```

```
dsId: 31, nClusters: 10
dsId: 32, nClusters: 5
dsId: 33, nClusters: 0
dsId: 34, nClusters: 6
dsId: 35, nClusters: 8
dsId: 36, nClusters: 8
dsId: 37, nClusters: 36
dsId: 38, nClusters: 8
dsId: 39, nClusters: 45
dsId: 40, nClusters: 34
dsId: 41, nClusters: 25
dsId: 42, nClusters: 5
dsId: 43, nClusters: 9
dsId: 44, nClusters: 23
dsId: 45, nClusters: 6
dsId: 46, nClusters: 0
dsId: 47, nClusters: 30
dsId: 53, nClusters: 15
dsId: 54, nClusters: 10
dsId: 55, nClusters: 18
dsId: 56, nClusters: 23
```

```
dsId: 57, nClusters: 6
dsId: 58, nClusters: 10
dsId: 59, nClusters: 30
dsId: 60, nClusters: 0
dsId: 61, nClusters: 5
dsId: 62, nClusters: 33
dsId: 63, nClusters: 20
dsId: 64, nClusters: 18
dsId: 65, nClusters: 10
dsId: 66, nClusters: 5
dsId: 67, nClusters: 4
dsId: 68, nClusters: 9
dsId: 69, nClusters: 14
dsId: 70, nClusters: 24
dsId: 71, nClusters: 7
dsId: 72, nClusters: 9
dsId: 73, nClusters: 18
dsId: 74, nClusters: 28
dsId: 75, nClusters: 23
dsId: 76, nClusters: 6
```



- dsId
- nClusters

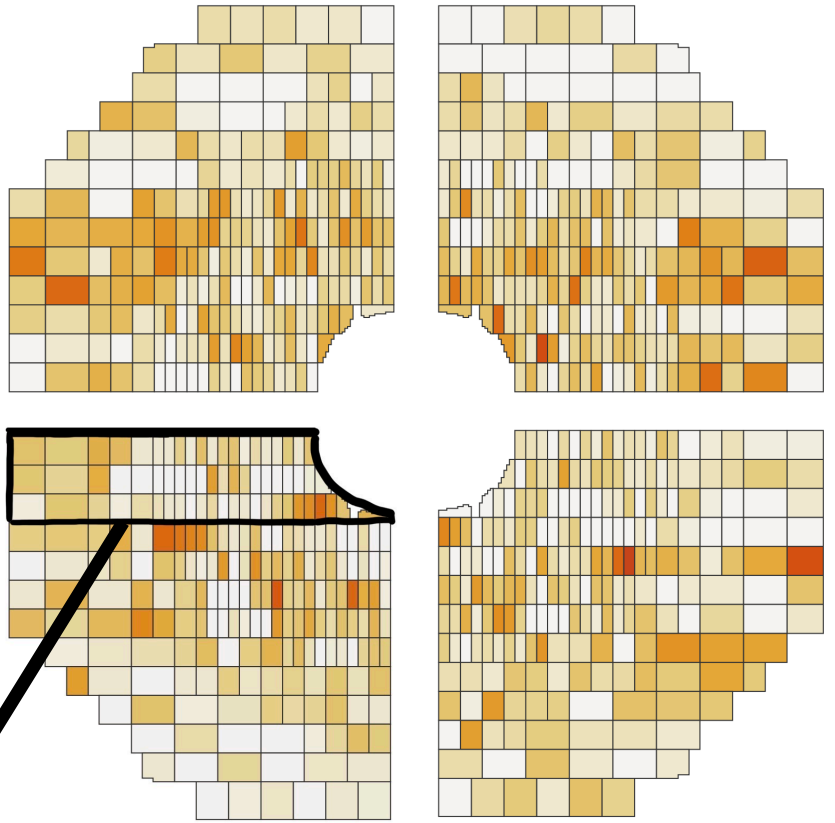
15 (53)	10 (54)	18 (55)	23 (56)	6 (57)	10 (58)	30 (59)	0 (60)	5 (61)	33 (62)	20 (63)	18 (64)	10 (65)	5 (66)	4 (67)	9 (68)	14 (69)	24 (70)	7 (71)	9 (72)	18 (73)	28 (74)	23 (75)	76 6
0 (27)	5 (28)	5 (29)	0 (30)	10 (31)	5 (32)	0 (33)	6 (34)	8 (35)	8 (36)	36 (37)	8 (38)	45 (39)	34 (40)	25 (41)	5 (42)	9 (43)	23 (44)	6 (45)	0 (46)	30 (47)			
0 (1)	20 (2)	28 (3)	20 (4)	10 (5)	0 (6)	0 (7)	0 (8)	0 (9)	0 (10)	14 (11)	7 (12)	0 (13)	21 (14)	17 (15)	13 (16)	5 (17)	8 (18)	15 (19)	0 (20)				

Cross Check for deID 102

```
dsId: 1, nClusters: 20
dsId: 2, nClusters: 16
dsId: 3, nClusters: 28
dsId: 4, nClusters: 23
dsId: 5, nClusters: 5
dsId: 6, nClusters: 5
dsId: 7, nClusters: 5
dsId: 8, nClusters: 14
dsId: 9, nClusters: 4
dsId: 10, nClusters: 20
dsId: 11, nClusters: 5
dsId: 12, nClusters: 15
dsId: 13, nClusters: 19
dsId: 14, nClusters: 3
dsId: 15, nClusters: 10
dsId: 16, nClusters: 5
dsId: 17, nClusters: 5
dsId: 18, nClusters: 16
dsId: 19, nClusters: 5
dsId: 20, nClusters: 19
dsId: 27, nClusters: 18
dsId: 28, nClusters: 13
dsId: 29, nClusters: 29
dsId: 30, nClusters: 0
```

```
dsId: 31, nClusters: 0
dsId: 32, nClusters: 0
dsId: 33, nClusters: 0
dsId: 34, nClusters: 0
dsId: 35, nClusters: 0
dsId: 36, nClusters: 0
dsId: 37, nClusters: 34
dsId: 38, nClusters: 9
dsId: 39, nClusters: 25
dsId: 40, nClusters: 13
dsId: 41, nClusters: 0
dsId: 42, nClusters: 0
dsId: 43, nClusters: 0
dsId: 44, nClusters: 0
dsId: 45, nClusters: 0
dsId: 46, nClusters: 4
dsId: 47, nClusters: 4
dsId: 53, nClusters: 3
dsId: 54, nClusters: 18
dsId: 55, nClusters: 13
dsId: 56, nClusters: 3
```

```
dsId: 57, nClusters: 10
dsId: 58, nClusters: 8
dsId: 59, nClusters: 5
dsId: 60, nClusters: 5
dsId: 61, nClusters: 0
dsId: 62, nClusters: 5
dsId: 63, nClusters: 11
dsId: 64, nClusters: 0
dsId: 65, nClusters: 5
dsId: 66, nClusters: 5
dsId: 67, nClusters: 0
dsId: 68, nClusters: 6
dsId: 69, nClusters: 14
dsId: 70, nClusters: 18
dsId: 71, nClusters: 37
dsId: 72, nClusters: 41
dsId: 73, nClusters: 56
dsId: 74, nClusters: 40
dsId: 75, nClusters: 19
dsId: 76, nClusters: 26
```



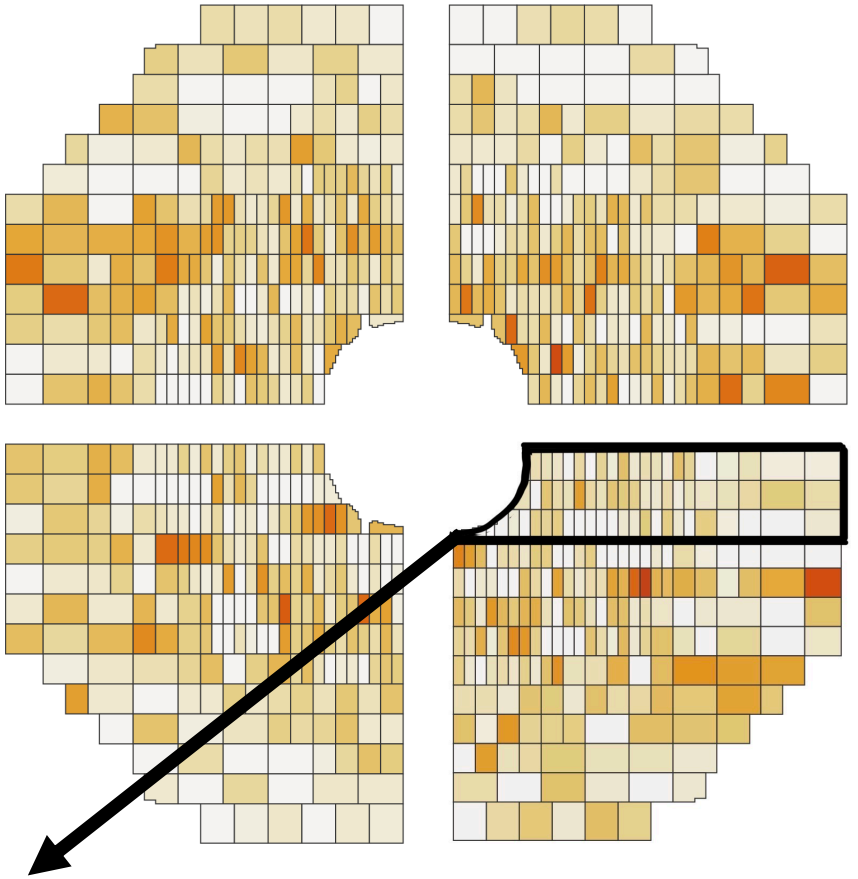
- dsId
- nClusters

Cross Check for deID 103

```
dsId: 1, nClusters: 3
dsId: 2, nClusters: 3
dsId: 3, nClusters: 8
dsId: 4, nClusters: 4
dsId: 5, nClusters: 0
dsId: 6, nClusters: 13
dsId: 7, nClusters: 20
dsId: 8, nClusters: 3
dsId: 9, nClusters: 8
dsId: 10, nClusters: 9
dsId: 11, nClusters: 5
dsId: 12, nClusters: 20
dsId: 13, nClusters: 4
dsId: 14, nClusters: 13
dsId: 15, nClusters: 0
dsId: 16, nClusters: 11
dsId: 17, nClusters: 0
dsId: 18, nClusters: 6
dsId: 19, nClusters: 8
dsId: 20, nClusters: 9
dsId: 27, nClusters: 10
dsId: 28, nClusters: 16
dsId: 29, nClusters: 11
dsId: 30, nClusters: 8
```

```
dsId: 31, nClusters: 6
dsId: 32, nClusters: 8
dsId: 33, nClusters: 3
dsId: 34, nClusters: 10
dsId: 35, nClusters: 5
dsId: 36, nClusters: 6
dsId: 37, nClusters: 14
dsId: 38, nClusters: 16
dsId: 39, nClusters: 18
dsId: 40, nClusters: 8
dsId: 41, nClusters: 11
dsId: 42, nClusters: 34
dsId: 43, nClusters: 8
dsId: 44, nClusters: 10
dsId: 45, nClusters: 18
dsId: 46, nClusters: 0
dsId: 47, nClusters: 8
dsId: 53, nClusters: 5
dsId: 54, nClusters: 0
dsId: 55, nClusters: 0
dsId: 56, nClusters: 3
```

```
dsId: 57, nClusters: 15
dsId: 58, nClusters: 0
dsId: 59, nClusters: 5
dsId: 60, nClusters: 15
dsId: 61, nClusters: 0
dsId: 62, nClusters: 16
dsId: 63, nClusters: 5
dsId: 64, nClusters: 5
dsId: 65, nClusters: 0
dsId: 66, nClusters: 0
dsId: 67, nClusters: 0
dsId: 68, nClusters: 0
dsId: 69, nClusters: 0
dsId: 70, nClusters: 15
dsId: 71, nClusters: 13
dsId: 72, nClusters: 14
dsId: 73, nClusters: 0
dsId: 74, nClusters: 4
dsId: 75, nClusters: 0
dsId: 76, nClusters: 0
```



Vocabulary

AFS: Active Filling Scheme
ALF: ALICE low-level front-end
AliECS: ALICE Experiment Control System,
set of various pieces of well integrated software to control the acquisition
ALPIDE: ALICE PIxel DEtector, name of the pixel sensors
that make the sensitive parts of the detector
AOD: Analysis Object Data
ARC: Alice Run Control Centre
ASIC: Application Specific Integrated Circuit
BC: Bunch Clock, its frequency is in sync with LHC radiofrequency
(RF) generators: usually 25 ns.
BCM: Beam Condition Monitors
BE: Back End
BIC: Beam Interlock Controller
BLM: Beam Loss Monitors
BP: Beam Pipe
BRU: Backend Readout Unit
CA: Cellular Automaton
CCDB: Computer Center DataBase
CFRP: Carbon Fiber Reinforced Polymer
CIS: CMOS Imaging Sensor
CMM: Control Measuring Machine
CMOS: Complementary Metal Oxide Semiconductor
CP: Cold Plate
CPS: CMOS monolithic Pixel Sensor
CPU: Central Processing Unit
CPV: Charged-Particle Veto detector

CRORC: Common Readout Receiver Card.
Run2 legacy card still used by HMPID, PHOS and EMCAL for Run 3.
CRU: Common Readout Unit, complex PCIe electronic board,
that can communicate and gather the data from several RUs, through optical links
CTP: Central Trigger Processor
DAQ: Data Acquisition
DCS: Detector Control System
DIM: Distributed Information Management system
DMA: Direct Memory Access
DPL: Data Processing Layer
DSS: Detector Safety System
DTU: Data Transmission Unit
DZS: Dense link based Zero Suppression FW for the TPC CRU UL fully optimized for GPU processing
EASY: CAEN Embedded Assembly System
EMCAL: Electromagnetic Calorimeter
EOD: End Of Data
EOR: End Of Run
EOS: End of Shift
EOS: CERN disk-based service providing a low latency storage infrastructure
EOT: End Of Trigger
EPN: Event Processing Node, Linux server (in CentOS8), possibly equipped with GPU, that runs O2 driven workflows that process the data sent by the FLPs (for e.g. raw data decoding and clusterisation). In standard operations, one EPN receive the data from the same TF coming from all FLPs. ALICE has a farm of 250 EPNs.
ESD: Event Summary Data
FairMQ - Framework for high throughput distributed data processing
FDD: Forward Diffractive Detector

Ref: https://indico.cern.ch/event/1247651/contributions/5271282/attachments/2600384/4489966/ALICE_RC_AW_20230227.pdf

Vocabulary

FEE: Front End Electronic
FEM: Finite Element Method
FIT: Fast Interaction Trigger
FLP: First Level Processor, Linux server (in CentOS8) equipped with up to 3 CRUs, exploited thanks to AliECS to drive the readout of the detector and the acquisition
FPC: Flexible Printed Circuit
FPGA: Field Programmable Gate Array
FRED: Front-End Device. Part of the DCS data stream.
Control commands are transmitted from WinCC OA to the MFT through the FRED and the FLP.
FSM: Finite State Machine
GEM: Gas Electron Multiplier
GLIMOS: Group Leader in Matters of Safety
GPU: Graphics Processing Unit
GUI: Graphical User Interface
HBFs: Heart Beat Frames
HMPID: High Momentum Particle Identification Detector
GBT: Giga-Bit Transceiver
IP2: Interaction Point 2 (ALICE)
ITS: Inner Tracking System.
IZS: Improved link based Zero Suppression: Intermediate version of the TPC FW with data packing not completely optimized for GPU processing
JSON: JavaScript Object Notation
L3: ALICE solenoid magnet
LACS: LHC Access Control System
LHC IF: LHC Interface
LTU : Local Trigger Unit
LVDS: Low Voltage Differential Signaling
MB: Minimum Bias
MCH: Muon Chambers
MFT: Muon Forward Tracker
MID: Muon Identifier
MS: Muon Spectrometer composed of MCH + MID
NIEL: Non Ionizing Energy Loss
O2: Online-Offline, ALICE software starting Run 3
ODC: Online Device Control
ODH: Oxygen Deficiency Hazard
PCB Printed Circuit Board
PDP: Physics Data Processing
PHOS: Photon Spectrometer
PIXAM: PIXel sensor for ALICE Muon spectrometer
PL: Project Leader
PM: Post Mortem
PON: Passive Optical Network
PRBS: Pseudo Random Bit Sequence
PX24: Main access shaft to the eXperimental area at Point 2
QA: Quality Assurance
QC: Quality Control
QCD: Quantum ChromoDynamics
QED: Quantum ElectroDynamics
QGP: Quark Gluon Plasma
RAM: Random Access Memory
RAMSES: Radiation Monitoring System for the Environment and Safety
RC: Run Coordinator/ Run Coordination
Release Coordination: board in charge of reviewing changes and new features to the online software and sign off the software upgrade at P2
RF: Radio Frequency
RHIC: Relativistic Heavy Ion Collider
ROF: Readout Frame
RSSI: Received Signal Strength Indicator

Ref: https://indico.cern.ch/event/1247651/contributions/5271282/attachments/2600384/4489966/ALICE_RC_AW_20230227.pdf

Vocabulary

RU: Readout Unit, complex electronic board designed to handle the configuration and readout of detector active elements. Used by ITS and MFT.
SAMS: Shift Account Management System
SCA: Slow Control Adapter
SEE: Single Event Effect
SEL: Single Event Latch-up
SEU: Single Event Upset
SMD: Surface Mounted Device
SL: Shift Leader
SOD: Start Of Data
SOR: Start Of Run
SOT: Start Of Trigger
SRAM Static Random Access Memory
SRC: System Run Coordinator, person in charge of a subsystem or detector operation
STF: Sub Time Frame. A Time Frame containing data from a FLP
SWT: Single Word Transaction
TF: Time Frame, used to cut data into chunks, to be able to distribute them for parallel processing in the EPN farm. It is divided into Heart Beat Frames (HBFs). The CTP configuration can be customised to reject some of the HBF (hence not propagating them to the acquisition system). The accepted ones are named HBa, and the rejected ones HBr.
TOF: Time of Flight detector
TPC: Time Projection Chamber
TRD: Transition Radiation Detector
TTC (or TTS): system Trigger and Timing distribution System
UL: User Logic. FPGA area reserved for detector specific data processing on the CRU FPGA. See CL (Common Logic)
vdM scan: Absolute luminosity measurement obtained by moving the beams relatively to each other in different ways.
VTRx: Versatile Trans Receiver
VTTx: Versatile Twin Transmitter
YETS: Year End Technical Stop
ZDC: Zero Degree Calorimeters

Ref: https://indico.cern.ch/event/1247651/contributions/5271282/attachments/2600384/4489966/ALICE_RC_AW_20230227.pdf