MID O2: data format and rate

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MRRTF meeting
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Reminder

- Schematic view of MTR

Online people nomenclature:

| Muon tracker | Iron wall | MT11 | MT12 | | MT21 | MT22 |

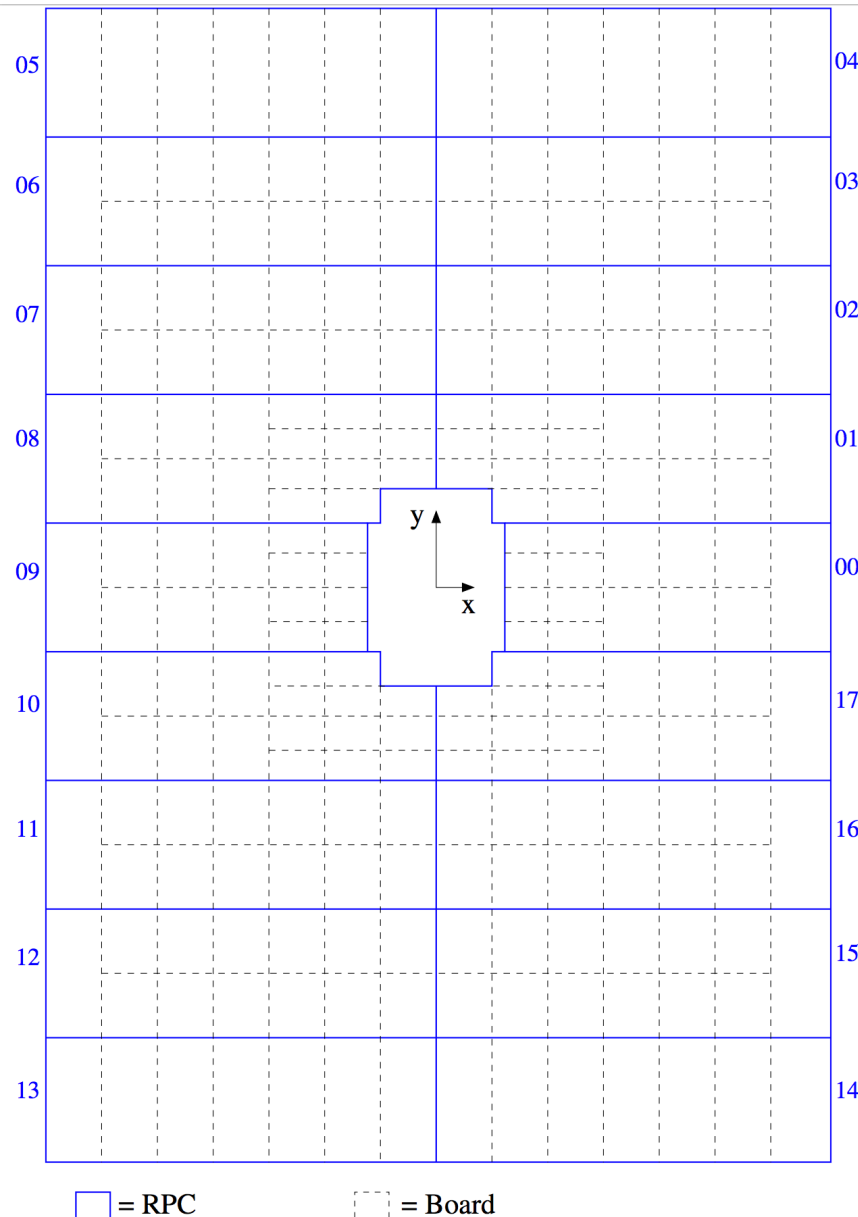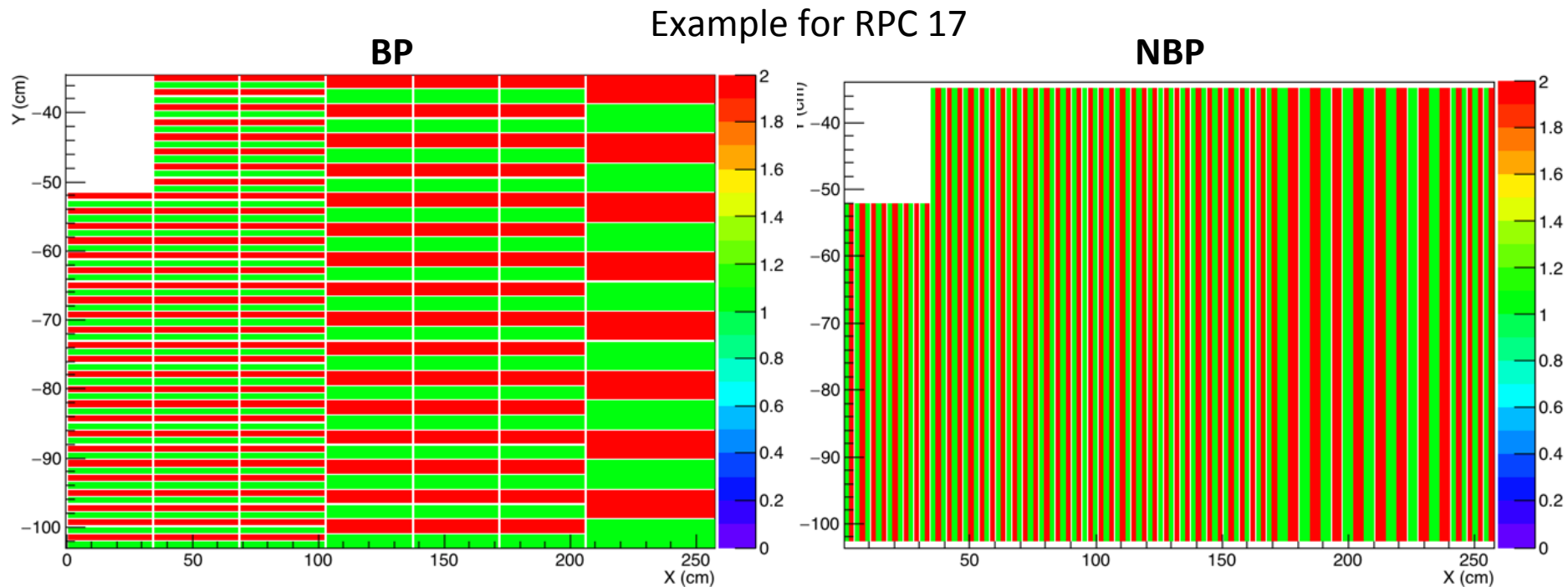Offline people nomenclature:
(we have 10 MCH chambers…)

11   12   13   14

Segmentation of one chamber

- Each chamber consists of 18 RPCs

- Each RPC (aka Detection Element) can be identified as: detElemID = ch x 100 + RPC_ID with:
  - 11<=ch<=14
  - 0<=RPC_ID<=17

- Each RPC is segmented into local boards
  - 234 local boards in total

□ = RPC   ⌐ ̄ ̄¬ = Board

Segmentation of the RPC

- RPC is segmented on both catode and anode.
  - On one side: horizontal strips => measure y position (deviation due to magnetic field) => **bending plane (BP)**
  - On the other side: vertical strips => measure x position (no deviation due to magnetic field) => **non-bending plane (NBP)**

Example for RPC 17

- CAVEAT: no meaning on code color: only needed to show the strips

Identifying the strips

- Each local board contains:
  - 16 strips for the BP
  - 8 or 16 strips for the NBP
- CAVEAT: NBP strips cover the full width of an RPC => they can cross 1, 2, 3 or 4 local boards, depending on the segmentation

- A strip is currently identified by:
  - Detection element (for segmentation)
  - Local board ID
  - Strip number in board

- However:
  - information is redundant since local board ID is per chamber and not per RPC
  - NBP strips shared by several local boards

☐ = Slat   ⌐ ⌐ = Board

Chamber Read-Out
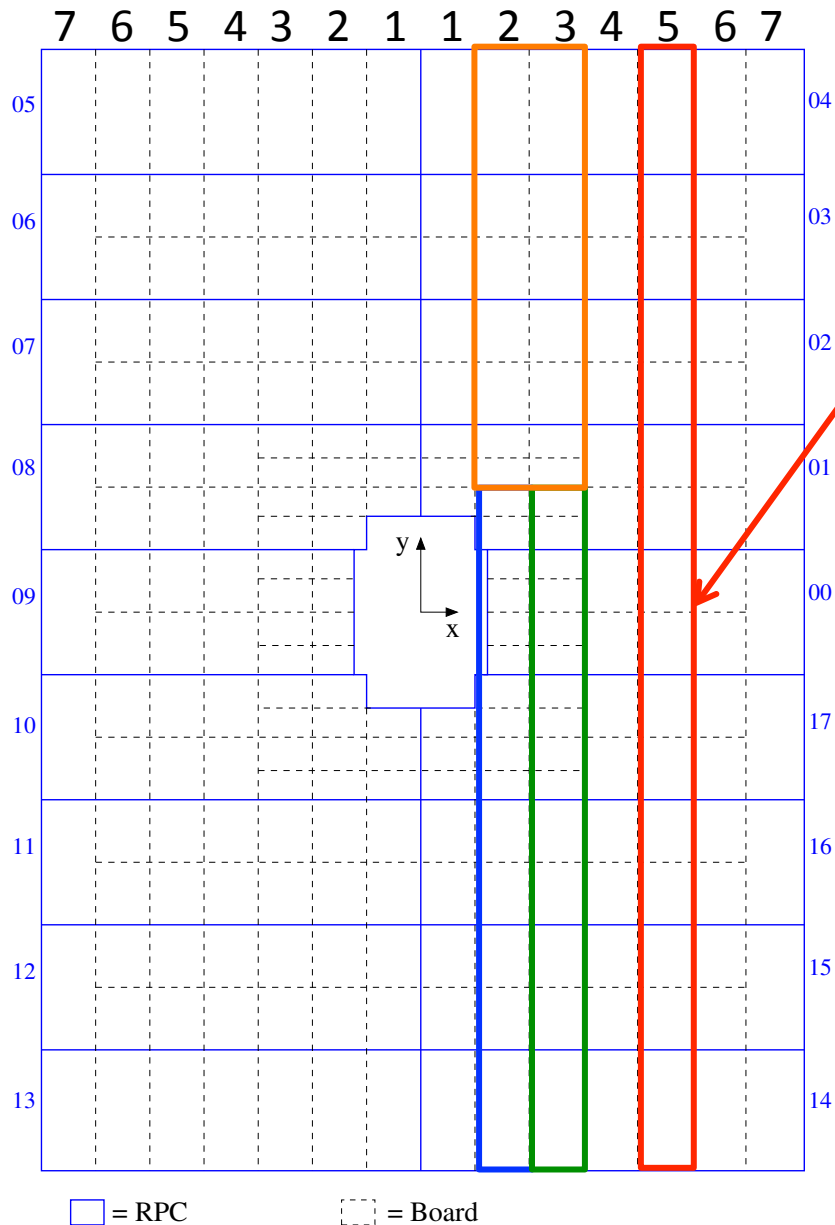
- Local Boards are read-out by Regional Boards
  - typically, 1 regional board reads out one column
  - exception for columns 2, 3 => regionals 2, 3, 2-3

- Reason: trigger algorithm needs to know the info of the local board above and below the current one (to check the deviation along y)

- MID: same read-out schema… but **no online trigger algorithm**

The MID case
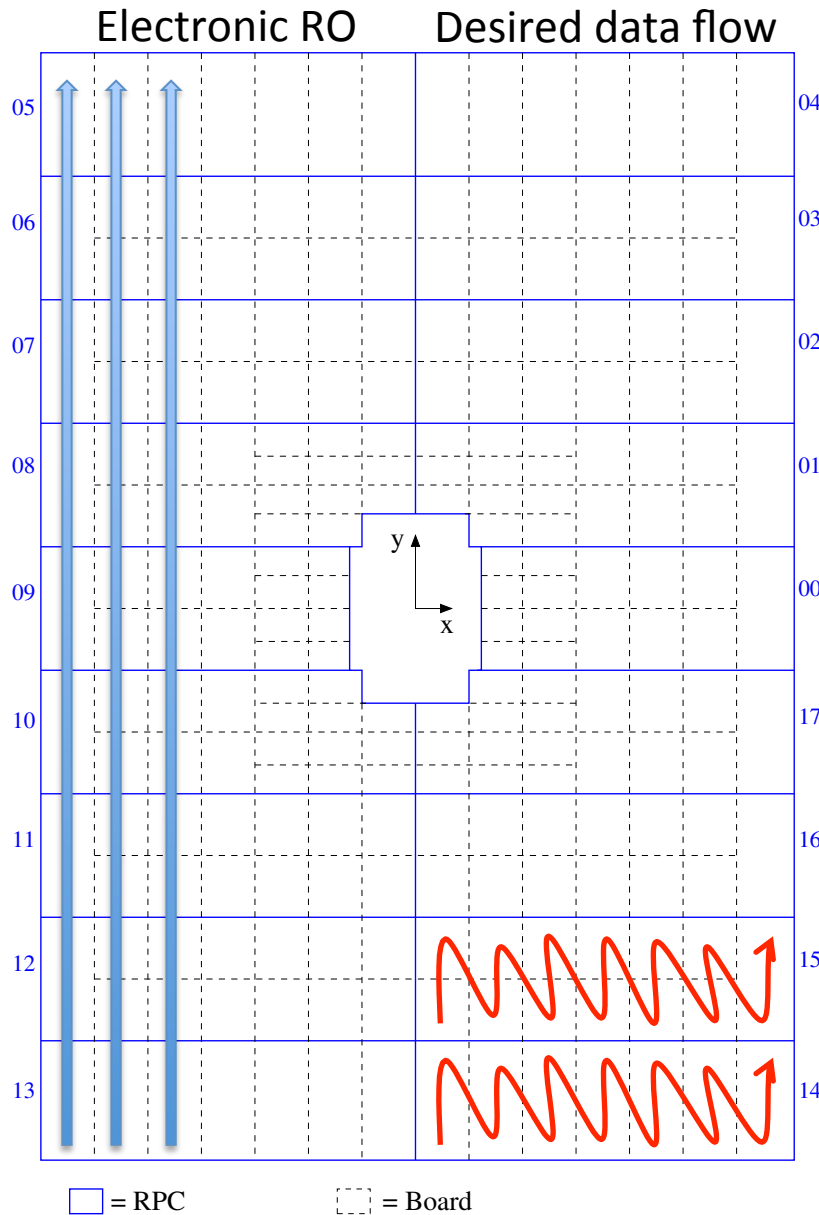
- In MID, the 4 trigger chambers will be used to perform **tracking** => need to perform clustering

- RPCs are independent among each others => clustering can be done **per RPC**

- Needed info:
  - fired strips in RPC (bending + non-bending plane)

- Order for each RPC:
  - Fired strips from bottom to top, from inside to outside (symmetric for left/right)
  - RO bending plane first and non-bending plane later (or viceversa)

Data format

- For each RPC:
  - Header with number of fired strips (zero suppression)
  - List of fired strips in BP and NBP

- Strip unique ID (current implementation):

	Range	Bits	Mask
DetElemID	1100 - 1417	[0-11]	0xFFF
Local board ID	1-234	[12-23]	0xFFF000
Channel	0-15	[24-29]	0x3F000000
Cathode (BP,NBP)	0-1	[30]	0x40000000

- Strip unique ID (best case for O2):
  - Detection element ID (chamber + RPC) => in the header
  - Column (1-7) => this info is very useful for clustering because we know that if a strip in the bending plane is in the same column as the one in non-bending plane they overlap
  - Strip number in column (?) => 0-63 (up to 4 boards per column in one RPC)

O2 data format per RPC: first proposal

Nathan, Sehlabaka
https://indico.cern.ch/event/644234/

- For each RPC

HEADER number of fired strips	16 bits
List of fired strips i n bending plane (BP)	up to 576bits (strip pattern + ID x max number of local boards per RPC)
List of fired strips in non-bending plane (NBP)	up to 576bits
TOTAL	up to **1.168kb/RPC**

- Strip pattern per local card per plane

16 bits	1 bit	2 bits	4 bits	1 bit	8 bits
Strip pattern	Plane (0=BP; 1=NBP)	Local Board Position	Column ID	Half-plane (0=left; 1=right)	Detection element (4 bits Chamber ID and 4 bits RPC ID)

31   0

Rate estimation

- Basing on PbPb 2015 we expect:
  - Average cluster size: < 2 (see https://aliceinfo.cern.ch/Figure/node/8928)
  - Average number of tracks per MB event: < 2 (see http://aliqamu.web.cern.ch/aliqamu/)

- From previous slide:
  - 32 bits per fired local board per plane
  - 16 bits RPC header
  - header with number of fired RPCs (global MID header) => 7 bits

- Expected event size per MB event:
  - 7 bits [global MID header] + 8 touched RPCs x (32 bits [fired local boards pattern] x 2 bits [BP,NBP] + 16bits [header]) = 647b/event

- Expected data flow (100kHz) => 64.7 Mb / s

Optimization

- Write DetElemId in the header (not on each strip) => save 8 bits/strip

- Remove half-plane info (is in the DetElemId) => save 1bit/strip

- For each RPC

HEADER number of fired strips	16 bits
List of fired strips i n bending plane (BP)	up to 576bits (strip pattern + ID x max number of local boards per RPC)
List of fired strips in non-bending plane (NBP)	up to 576bits
TOTAL	up to **1.168kb/RPC**

- Strip pattern per local card per plane

16 bits	1 bit	2 bits	4 bits	1 bit	8 bits
Strip pattern	Plane (0=BP; 1=NBP)	Local Board Position	Column ID	Half-plane (0=left; 1=right)	Detection element (4 bits Chamber ID and 4 bits RPC ID)

31   0

June 2017 | SA-ALICE | MID/O2 Brainstorming

- Change RPC ID

  - currently: from 1100 ro 1417 => 12 bits
  - Could be from 1 to 72 => 7 bits => save 5bits / RPC

Data format: option 1

- Global header (number of fired RPCs): 7 bits
- For each RPC:

HEADER DetElemID + number of fired boards	12 bits
List of fired boards patterns	up to 18 boards => 666bits
TOTAL	up to **0.67kb/RPC**

Header		Fired strips pattern			
5 bits	7 bits	16 bits	16 bits	2 bits	3 bits
Number of boards (up to 18)	DetElemID (1-72)	Fired strip pattern BP	Fired strip pattern NBP	Local board in column (0-3)	Column ID (0-6)

- Expected event size per MB event:
  - 7 bits [global MID header] + 8 touched RPCs x (37 bits [fired strips] + 12bits [header]) = 399bits/event
- FET event: 7 bits [global MID header] + 72 RPCs x 12 bits + 234 boards x 4 chambers x 37 bits = 35.5 kb/event

Data format: option 2

- Global header (number of fired RPCs): 7 bits
- For each RPC:

HEADER DetElemID + number of fired strips	17 bits
List of fired strips in bending plane (BP)	up to 288 strips => 2.88kb
List of fired strips in non-bending plane (NBP)	up to 288 strips => 2.88kb
TOTAL	up to **5.76kb/RPC**

Header		Strip ID			
10 bits	7 bits	4 bits	1 bit	2 bits	3 bits
Number of strips (up to 576)	DetElemID (1-72)	Strip # (0-15)	Plane (0=BP, 1=NBP)	Local board in column (0-3)	Column ID (0-6)

- Expected event size per MB event:
  - 7 bits [global MID header] + 8 touched RPCs x (10 bits [fired strips] x 2 [cluster-size] x 4 [chambers] x 2 [planes] + 17bits [header]) = 1423bits/event
- FET event: 7 bits [global MID header] + 72 RPCs x 16 bits + ~21k strips x 10bits = 211 kb/event

Comparison

	Option 1	Option 2
Pro	Minimum data size	Ready to use in O2
	BP and NBP info sent at the same time (correspondence with what sent by the FE => easier for QA?)	
Cons	Need to extract the fires strip from the strip pattern (loop on 32 bits)	Large data size (especially for large occupancy/FET)

- Option 1 seems to be better data-flow wise

Further info

- For MTR, the scalers (counting of the number of times an element was fired) provided important information (ageing, etc.)
  - Many type of scalers: global board, local board, strips

- For MID: keep only strip scalers
- Trivial operation => count input fired strips from CRU and store info
  - can be done with the proposed data format

- However, in the ideal case of an extremely performing CRU:
  - move clusterization to CRU => output clusters (DetElemId, x, y, sigma_x, sigma_y) to FLP
  - need to provide counters as well

Conclusion/discussions

- MID ~ MTR segmentation-wise => probably similar conventions for RO

- No online trigger for MID. Focus on tracking
  - clustering should be performed per RPC
  - no need to follow the "local board" order (from bottom to top, crossing 9 RPCs)

- Best/fastest option for FLP:
  - zero suppression
  - clustering could in principle be parallelized per RPC => transmit only fired boards following RPC order (if possible)

- First try to go with previous option…if clustering fast enough => clustering in the CRU!!! ;-)
  - CAVEAT: strip counters need to be transferred (and QA should be probably needed…at CRU level)

Backup