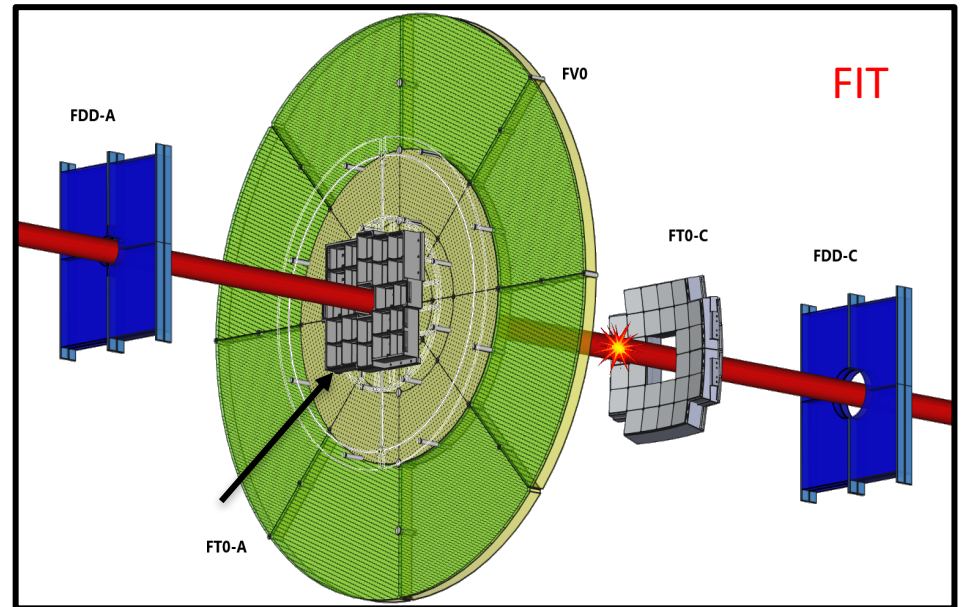


# FIT triggers in Run3/Run4

- FIT trigger requirements
- Detector survey
- FIT triggers
- FPGA firmware status
- Simulation status



**FTO** ( $3,8 < \eta < 5,0$  and  $-3,3 < \eta < -2,2$ );  
**FVO** ( $2,2 < \eta < 5,1$ );  
**FDD** ( $4,7 < \eta < 6.3$  and  $-6,9 < \eta < -4,9$ );

# FIT trigger requirements by Physics Coordination (13 Dec 2016)

- **TRIGGER WITH CHARGE-AMPLITUDE RANGE:** FT0 and FVOA should have a trigger with programmable lower and upper charge-amplitude limits (as we have now in V0).
- **TRIGGER ON FIRED CELLS IN GIVEN TIME WINDOW:** It should also be possible to have, at trigger levels LO and LM, the information of how many CELLS (both for FVOA and FT0) saw a hit, in a given BC, in the time windows corresponding to beam-beam (BB-flag) and beam-gas (BG flags) interactions. The current V0 allows one to use a trigger signal of the type  $(n < BB < N \ \&\& \ m < BG < M)$ , where  $n, N, m, M$  are integer numbers and can be set via DCS.
- **MASKING CELLS FROM THE TRIGGER:** It should be possible to mask out one or more channels from the trigger logic.
- **TRIGGER WITH CHARGE-AMPLITUDE RANGE FROM INDIVIDUAL FVOA RINGS:** It would be very useful if the VOA+ had the possibility to trigger using the signal (or absence of signal) from individual rings; this would open new possibilities, like triggering pp events with high multiplicity in different eta intervals (using the 5 rings).
- **OTHER USEFUL IMPROVEMENTS:** As possible further improvement it would be worth to look into the possibility of storing, in case of multiple hits, the times of all hits for a given cell (for FVOA and FT0). In the present V0, only the leading time is stored. Another interesting possibility would be to decrease the integration time to below 25 ns, again in order to catch multiple hits (as of now, in case of pile-up the measured charge is given by the sum of all hits). All of this is of course subject to what will be the actual detector time resolution.

# Detector survey (31 May 2019)

- Based on the following questions
  - What FIT hardware triggers do you consider?
  - What FIT information (online/offline) do you need?

Detector	FIT hardware trigger	FIT offline information
ACO	NO	signal amplitude & time / channel → collision time, event multiplicity/centrality  time for each hit (in case of multiple hits in the channel) → pileup rejection
ZDC	~L0, MB	
ITS	~LM, MB	
TPC	NO	
TRD	~LM, MB	
TOF	~L1, MB (only cosmics)	
EMCal	~L0, MB, mult.	
PHOS	~L0, MB, mult.	
CPV	~LM, MB, mult.	
HMPID	~LM, MB, mult.	
MCH	~L1, MB	
MID	~L1, MB	
MFT	~LM, MB	

→ MB and multiplicity dependent hardware triggers required

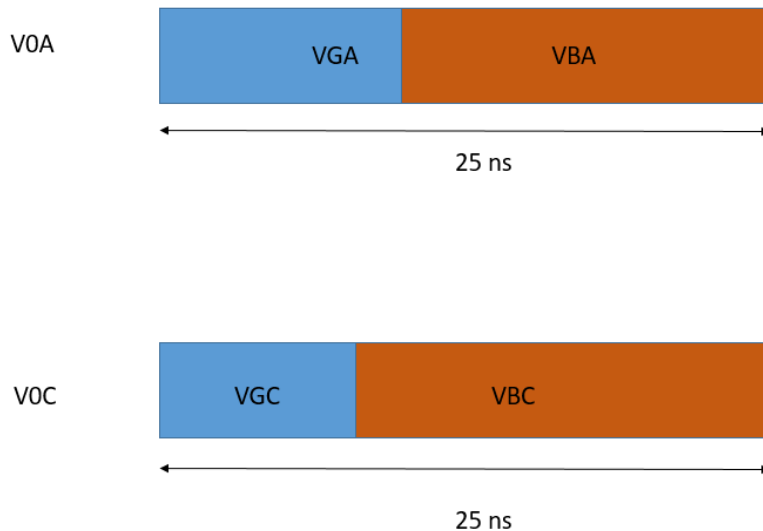
# FIT triggers

- **Luminosity:** FT0, FV0 and FDD (online at  $\sim$ L0 by CTP)
- **Collision time and vertex:** FT0 (online at  $\sim$ LM)
- **Multiplicity:** FV0 (online at  $\sim$ LM)
  - Possibility of using combination of FV0 and FT0 to be studied
- **LHC background (beam-gas):** FV0 and FDD (online at  $\sim$ L0)
  - Triggering in the beam-gas window requires modifications in the FPGA firmware as compared to FT0
- **VETO: UPC, electromagnetic and diffractive interactions?**
  - If not triggering detectors the central barrel (ITS and TOF) the UPC and diffractive events cannot be triggered with the FIT (only software trigger on EPNs)
- **Currently max. 5 trigger outputs per detector (possible extension to 6)**
  - V0 sent  $>5$  different triggers at the same time for 2018 Pb-Pb data
  - AD has never sent  $>4$  triggers at the same time (only 4 trigger outputs)

# LHC background rejection

- FT0 cannot be used for the LHC background (beam-gas) rejection
- FV0 and FDD are considered
  - Information to be provided online to CTP at  $\sim L0$
  - Requires modifications in the FPGA firmware as compared to FT0

## V0 and beam-gas trigger in Run2



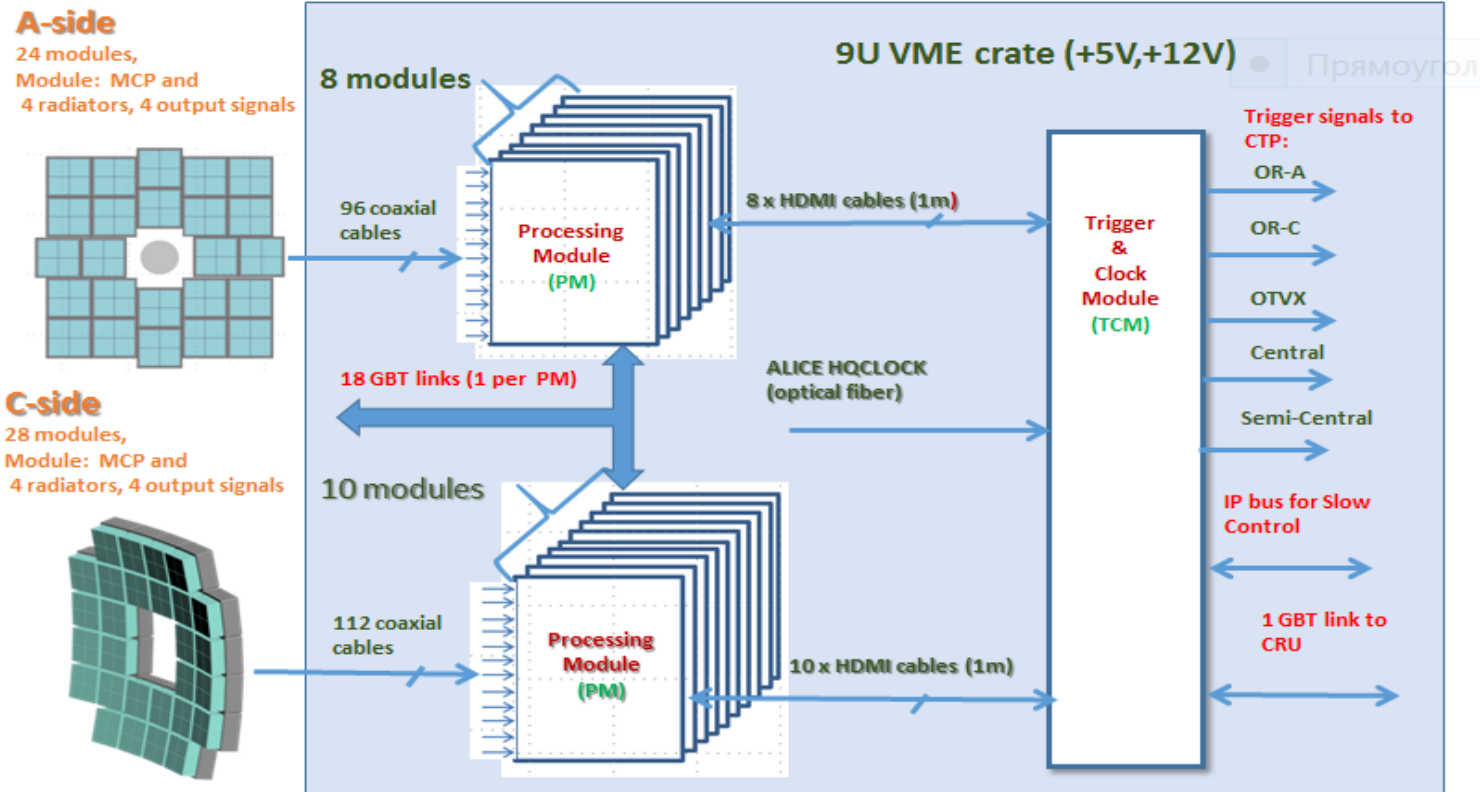
Bunch crossing is split into 2 windows

- beam-beam trigger (VGA and VGC)
- beam-gas trigger (VBA and VBC) (early hits)

In Run2 V0, each channel was able to issue two triggers.

There was then a circuit summing up the trigger flags from various cells, and producing triggers of the type  $(x < N\_VGA < y \ \&\& \ x' < N\_VBC < y')$   
 $x, y, x', y'$  – limits for beam-gas events

# PM and TCM FPGA status



- PM firmware is implemented and ready for tests (the same for all FIT detectors)
- TCM firmware implementation started (FT0 – INR Moscow, FV0, FDD – IFJ & AGH Cracow )

# Simulation status in O2

- FT0 digitization and conversion to the raw format implemented (Alla Mayevskaya)
  - Full geometry to be completed
- FV0 digitization implemented; PR soon after massive tests (Arvind Khuntia, Maciej Slupiecki)
  - Full geometry is implemented
- FDD digitization implemented (Michal Mroz)
  - Only sensitive volumes

Zlatko Saldic

Pb+Pb at 5.02 TeV

Detector	FT0	FV0
<b>Hit generation</b>	1660 seconds ~16 sec/event	843 seconds ~8 sec/event
<b>Digitization</b>	2110 seconds ~21 sec/event	(ESTIMATE) +3h +108 sec/event

# Backup



# Detector survey (31 May 2019)

## Additional information

- ZDC – trigger at  $\sim$ L0 in MB Pb-Pb collisions
- ITS – trigger at  $\sim$ LM in MB collisions
- TPC – trigger mode is foreseen (TPC time buffer including previous and next time intervals  $\pm 100 \mu\text{s}$ ), but not FIT required
- TRD - pre-trigger at LM
- TOF - during commissioning FIT trigger required at  $\sim$ L1 in MB events
- EMCAL – trigger at  $\sim$ L0 in MB and with centrality selection
- PHOS - trigger at  $\sim$ L0 in MB and with centrality selection
- CPV – trigger at  $\sim$ LM in MB and with centrality selection
- HMPID – trigger at  $\sim$ LM in MB and with centrality selection (mistake in the CTP table 5.2 below)
- MCH – trigger at  $\sim$ L1 in MB (buffers big enough)
- MID – trigger at  $\sim$ L1 in MB (buffers big enough)
- MFT –  $\sim$ LM in MB

# LHC background rejection

- FT0 cannot be used for the LHC background (beam-gas) rejection
- FV0 and FDD are considered
  - Information to be provided online to CTP at  $\sim L0$
  - Requires modifications in the readout electronics as compared to FT0

<https://www.sciencedirect.com/science/article/pii/S016890021002259X>

## V0 and beam-gas trigger in Run2

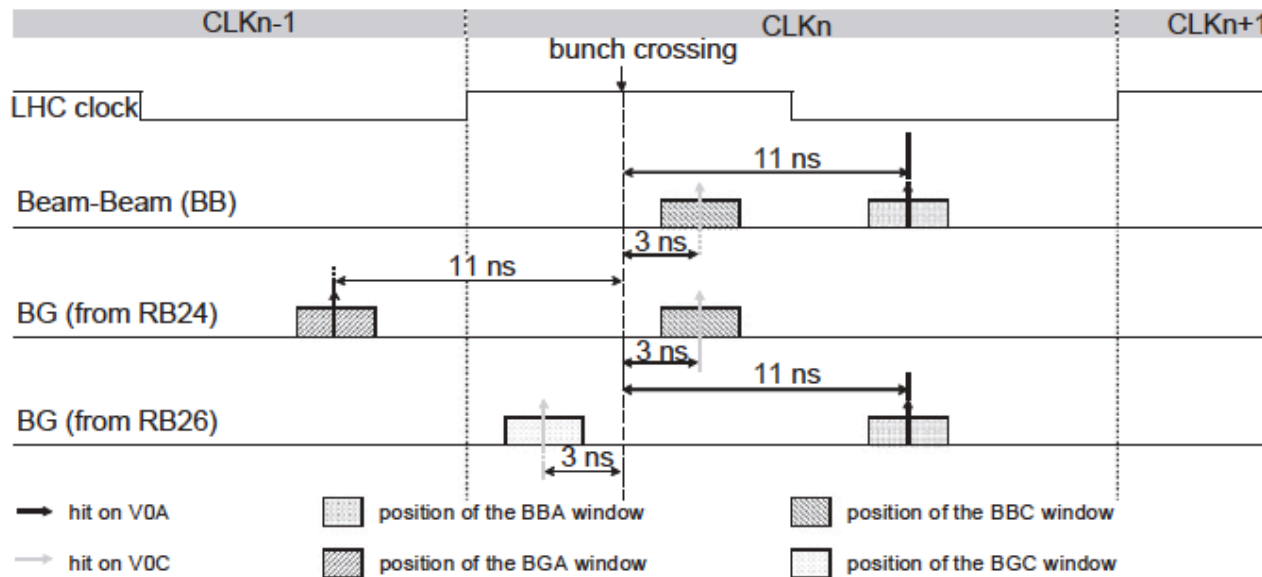


Fig. 5. Time alignment diagram for BB, BGA and BGC type events.

# LHC background rejection

- FT0 cannot be used for the LHC background (beam-gas) rejection
- FV0 and FDD are considered
  - Information to be provided online to CTP at  $\sim L0$
  - Requires modifications in the readout electronics as compared to FT0

<https://www.sciencedirect.com/science/article/pii/S016890021002259X>

## V0 and beam-gas trigger in Run2

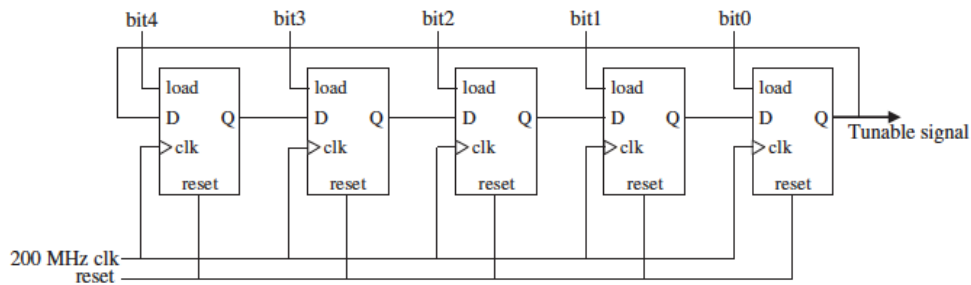


Fig. 6. Shift register for the window profile generation.

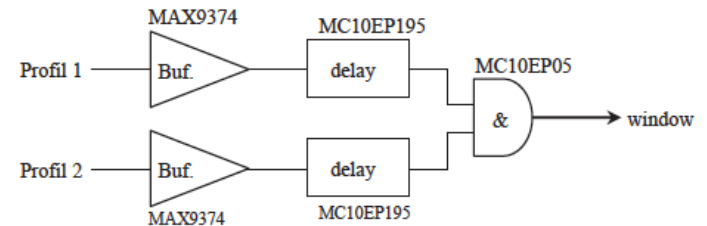


Fig. 7. Final stage for the generation of the observation window.

# LHC background rejection

- FT0 cannot be used for the LHC background (beam-gas) rejection
- FV0 and FDD are considered
  - Information to be provided online to CTP at  $\sim L0$
  - Requires modifications in the readout electronics as compared to FT0

<https://www.sciencedirect.com/science/article/pii/S016890021002259X>

## V0 and beam-gas trigger in Run2

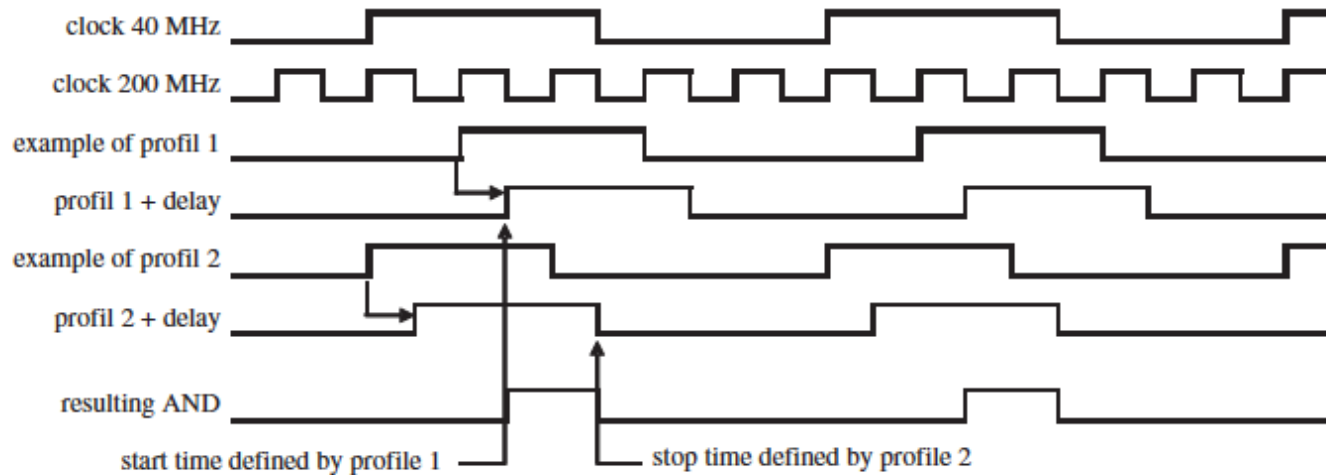


Fig. 8. Timing diagram.

# FIT channel data format (40 bit), two channels data per GBT word

bit	name	bits	min	max	description
0	.. Time value	12	-2048	2047	Time with sign bit. (Relative to IP center time value). 13.02ps per unit (1200 MHz × 64)
11					
12	.. Charge value	13	-100	4095	Charge with sign bit (base line/range corrected), a.u.
24					
25	ADC number	1	0	1	ADC number (0/1)
26	double event	1	0	1	Double event (two CFD pulses during one BC period)
27	event 1 time lost	1	0	1	Event 1 time lost (TDC FIFO overflow on 1st event in BC period)
28	event 2 time lost	1	0	1	Event 2 time lost (TDC FIFO overflow on 2nd event in BC period, if applicable)
29	ADC in gate	1	0	1	ADC in gate (CFD pulse time is inside ADC gate)
30	Time information too late	1	0	1	Time information too late (TDC outputs data too late to include in trigger)
31	Amplitude too high	1	0	1	Amplitude too high (CFD saturated, time may be incorrect)
32	Event included in TVDC trigger	1	0	1	Event included in TVDC trigger
33	Time information lost	1	0	1	Time information lost (TDC data did not arrive for any reason)
34					
35					
36					
37	Channel ID (1-12)	4	1	12	0x0 means no data
38					
39					