BCM1F TDCs

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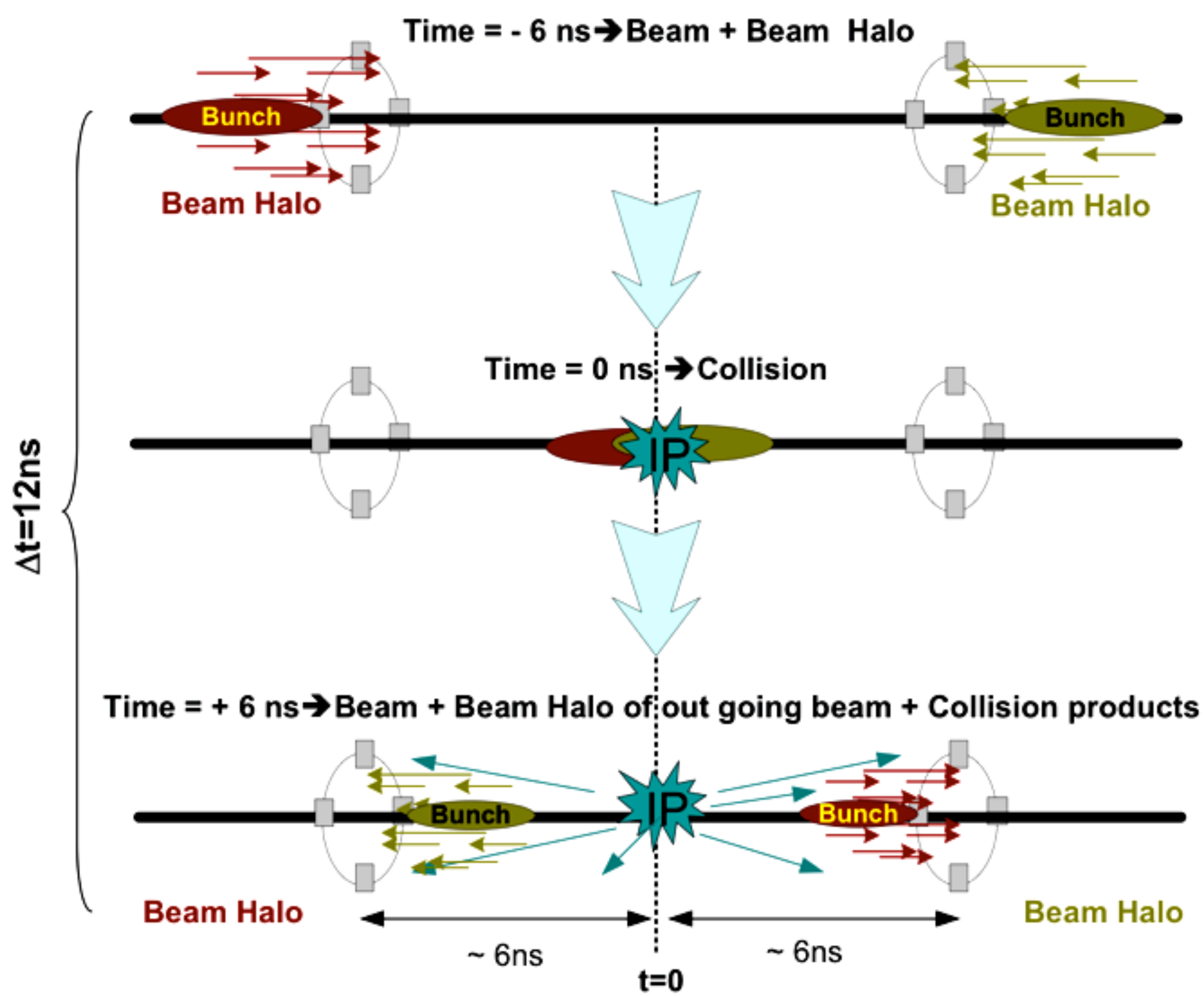
Outline

- Introduction
- Hardware
- Readout and data
- Data analyses
- High performance TDC studies
- Summary

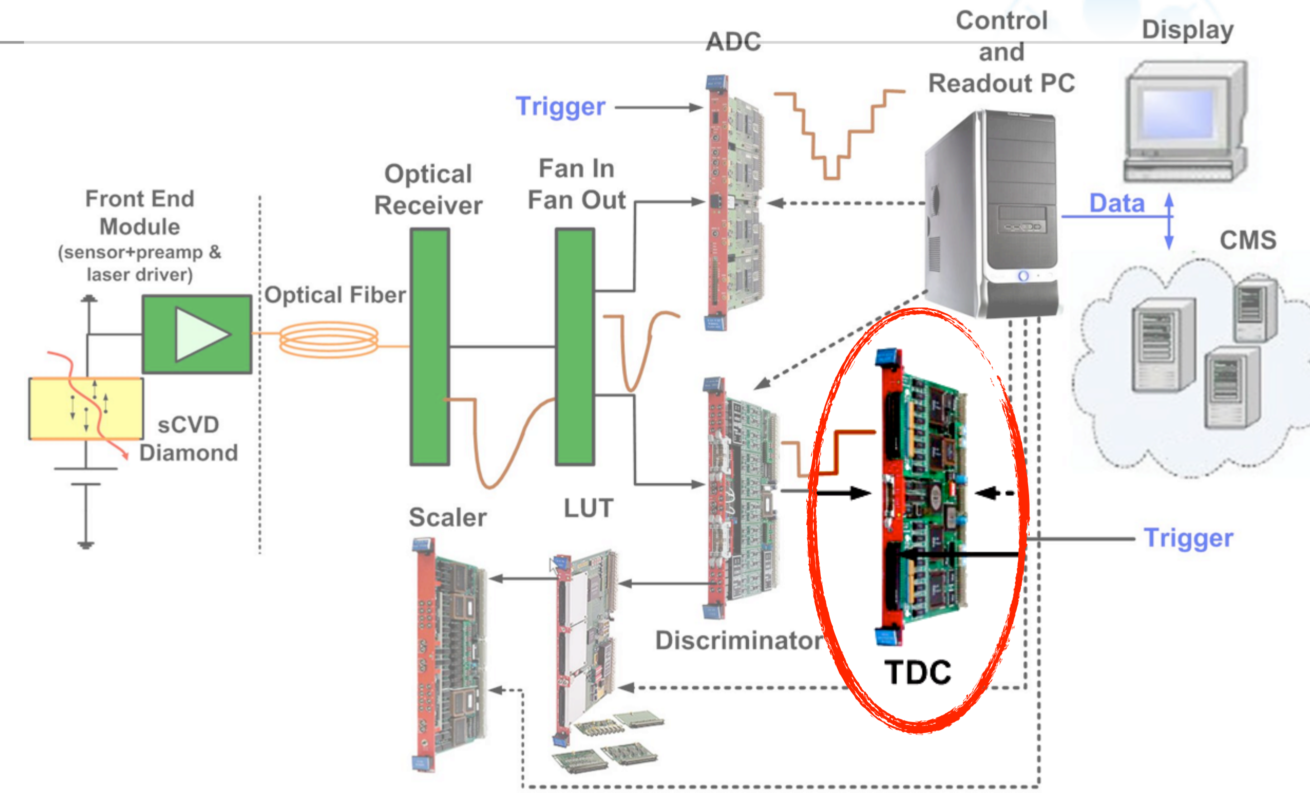
Introduction

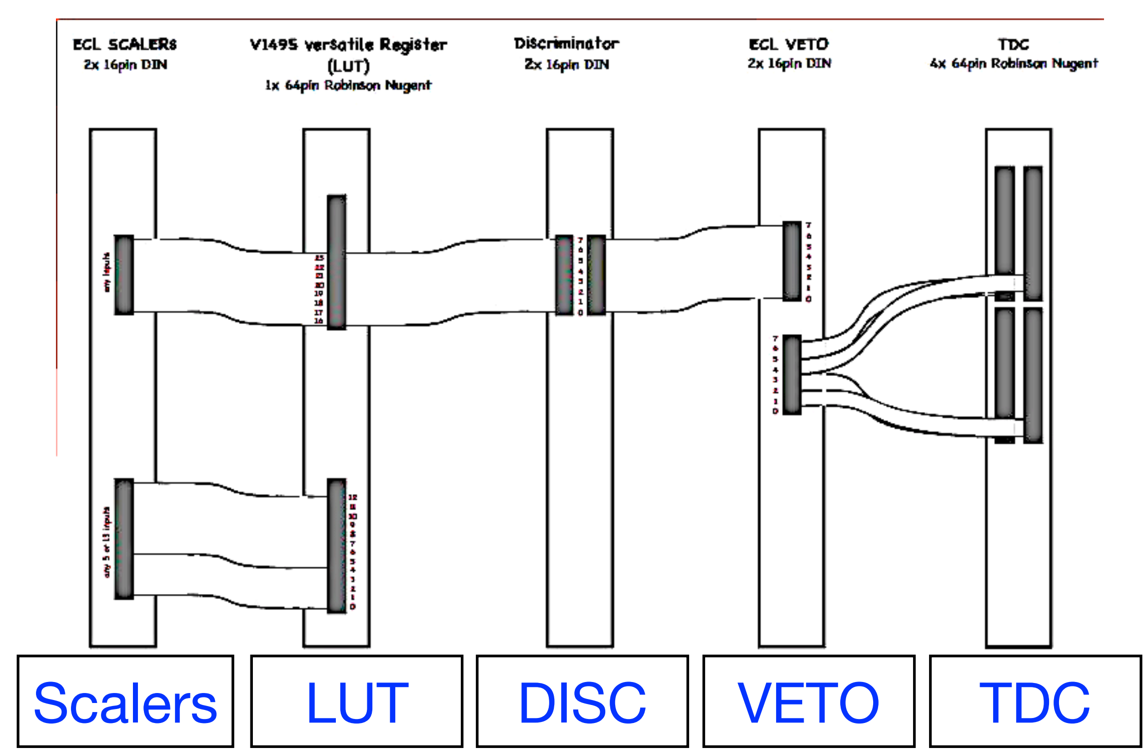
- Aim of the TDCs is to provide time information of individual bunches.
  - Precise measurements of:
    - time-of-flight;
    - bunch identification;
    - detector material decay (see talk on albedo);
    - monitoring beam dumps (see talk on dump studies and ring buffer).



Hardware

- TDC board model: CAEN v767.
- Run in continuous storage mode.
- Readout with transfer blocks of 16 kbytes 32 bit words.
- Resolution 0.8 ns/bin.
- Double hit resolution 10 ns.
- Input signals: hits from discriminators and orbit trigger.
- Look-up table (LUT) provides signal to VETO data into the TDCs during readout.



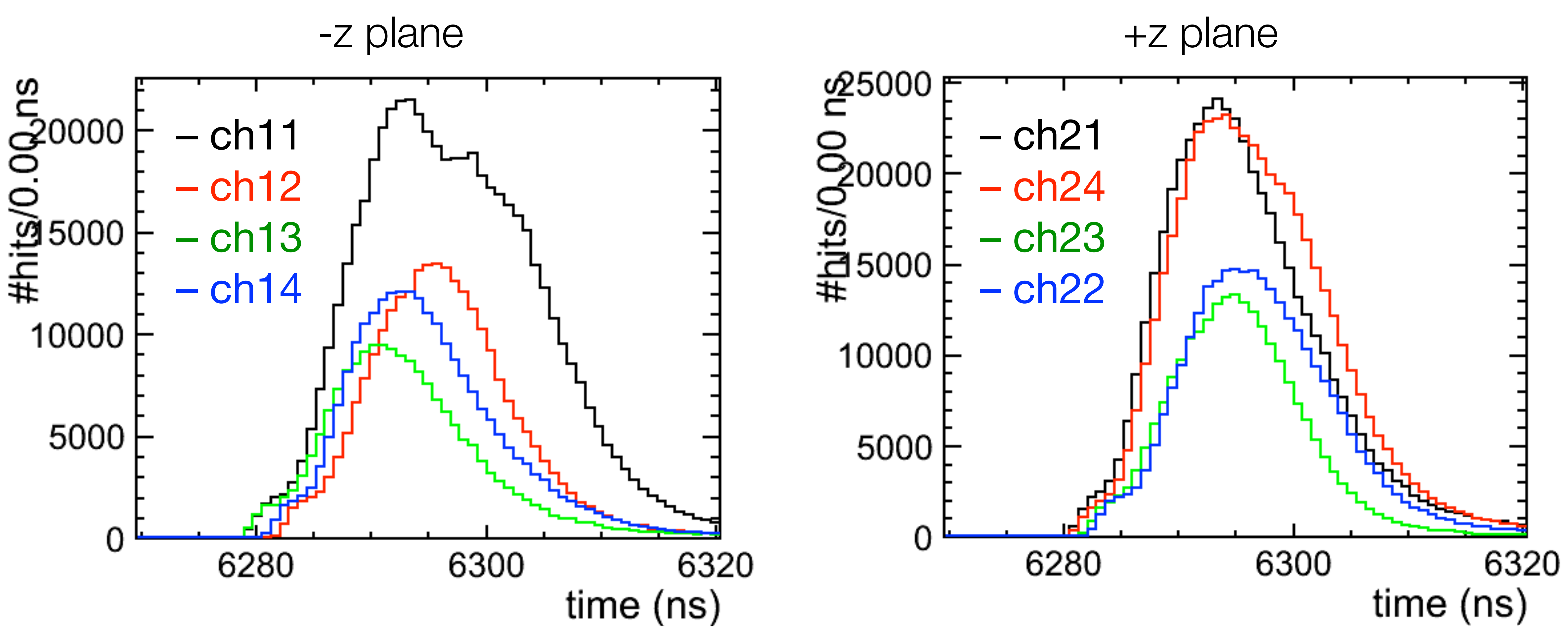


Readout and data

- The readout codes read the information from the TDCs via block transfers (BLT) and store the raw data in root files.
- Source codes are been transferred to an SVN repository at the DESY SVN server (https://svnsrv.desy.de)
- Readout deadtime during a BLT: ~3.5 ms (40 orbits)
- The advantage of root files is that handling large amount of data one has faster I/O and smaller size of the data files, in both cases a factor 10 compared with ASCII.
- Data files have a maximum size of 1.5 Gbytes. A new file is automatically created when this limit is reached or when it turns mid-night, whatever comes first.
- With the fills from end of August the amount of data was ~3 Gbytes/day.
- The data is automatically stored in CASTOR daily together with the other BRM data.

TDCs calibration

- Observed shifts of the peaks of the colliding bunches in the time distributions.



TDCs calibration

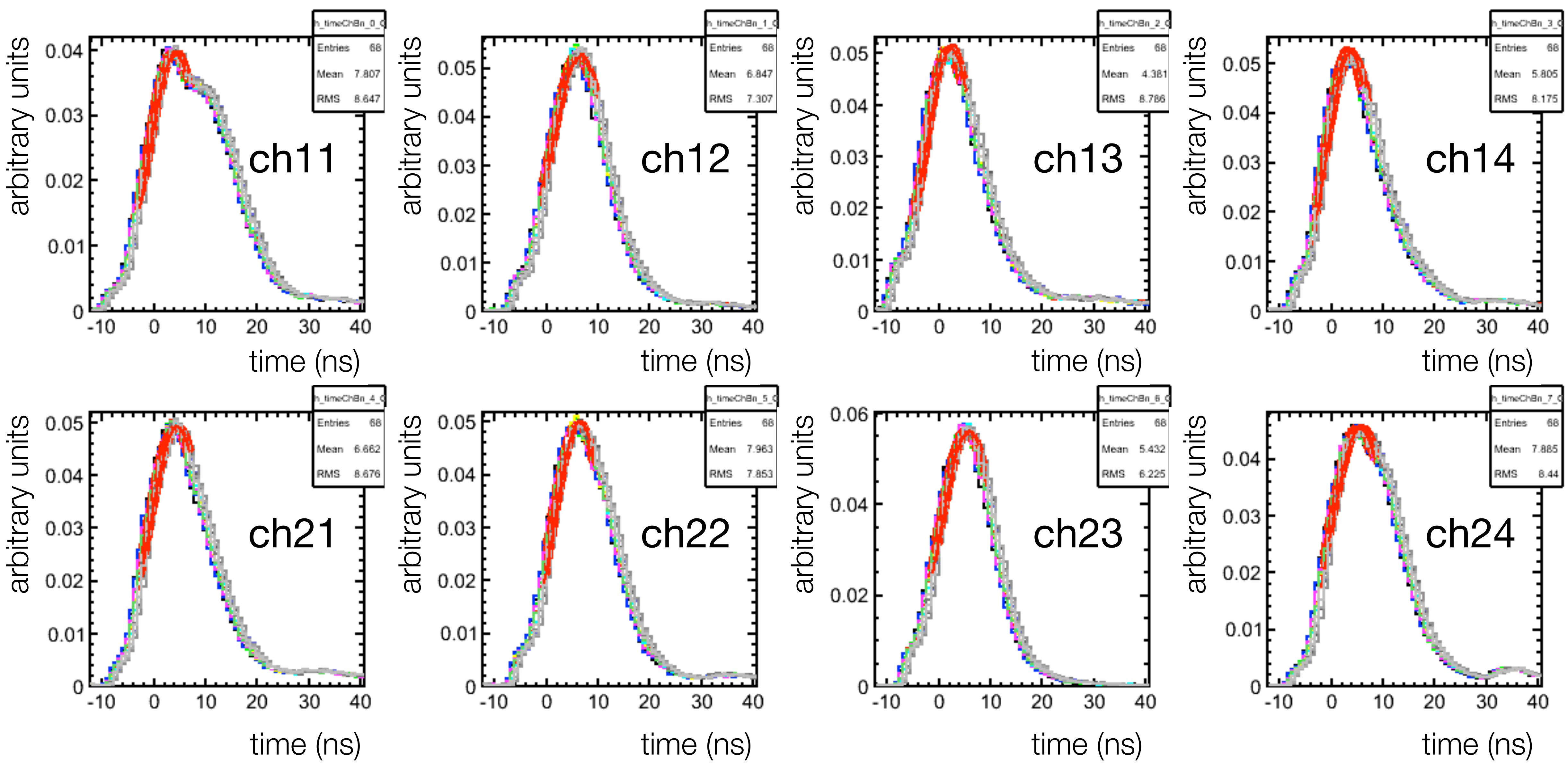
- Correct the peak position with respect to the orbit trigger.
- Fitting a gaussian around the peaks in the time distributions of the colliding bunch.
- Time distributions around each colliding bunch are shifted by a well-defined amount *t* (in ns) given the bunch number provided by the LHC.

$$bn = \frac{t - 6290}{24.9505} + 1$$

- Using only orbits with size in the range (88923,88924) ns reducing jittering effects.
- Using fill 1262 (04-05.08.2010) ...
  - 16 colliding bunches:
    1, 101, 201, 301, 401, 501, 601, 701, 1786, 1886, 1986, 2086, 2186, 2286, 2386, 2486

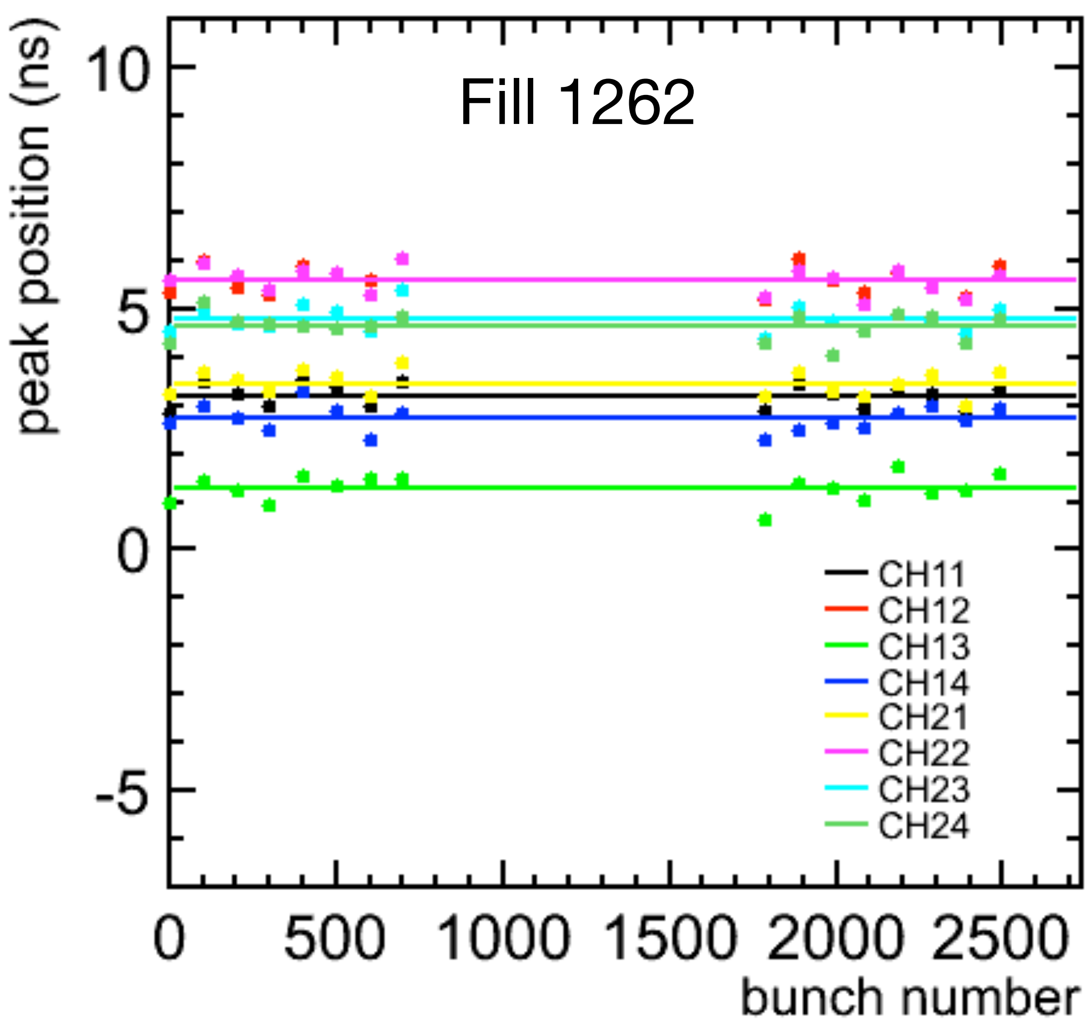
TDCs calibration

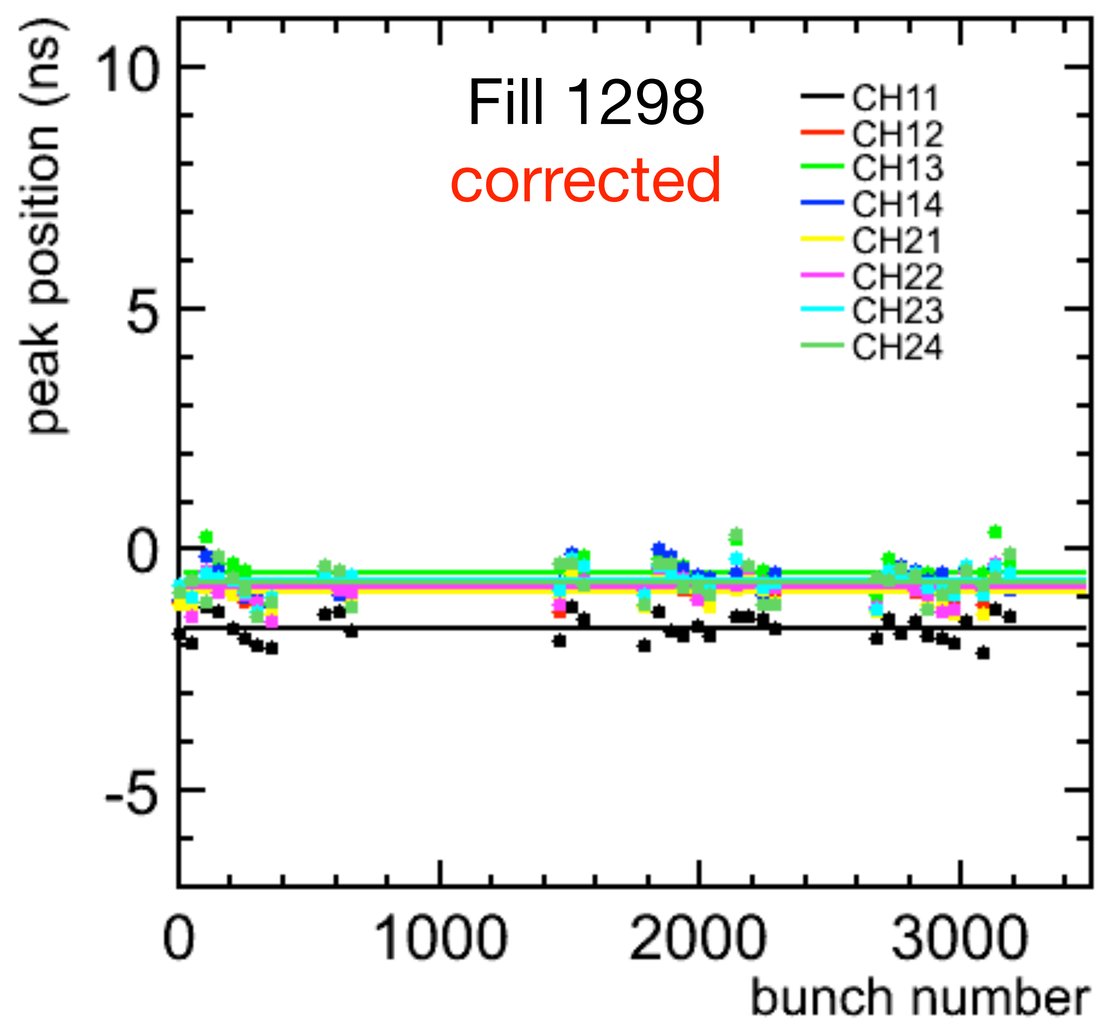
- Time distribution for the shifted peaks of all bunches for each channel.



TDCs calibration

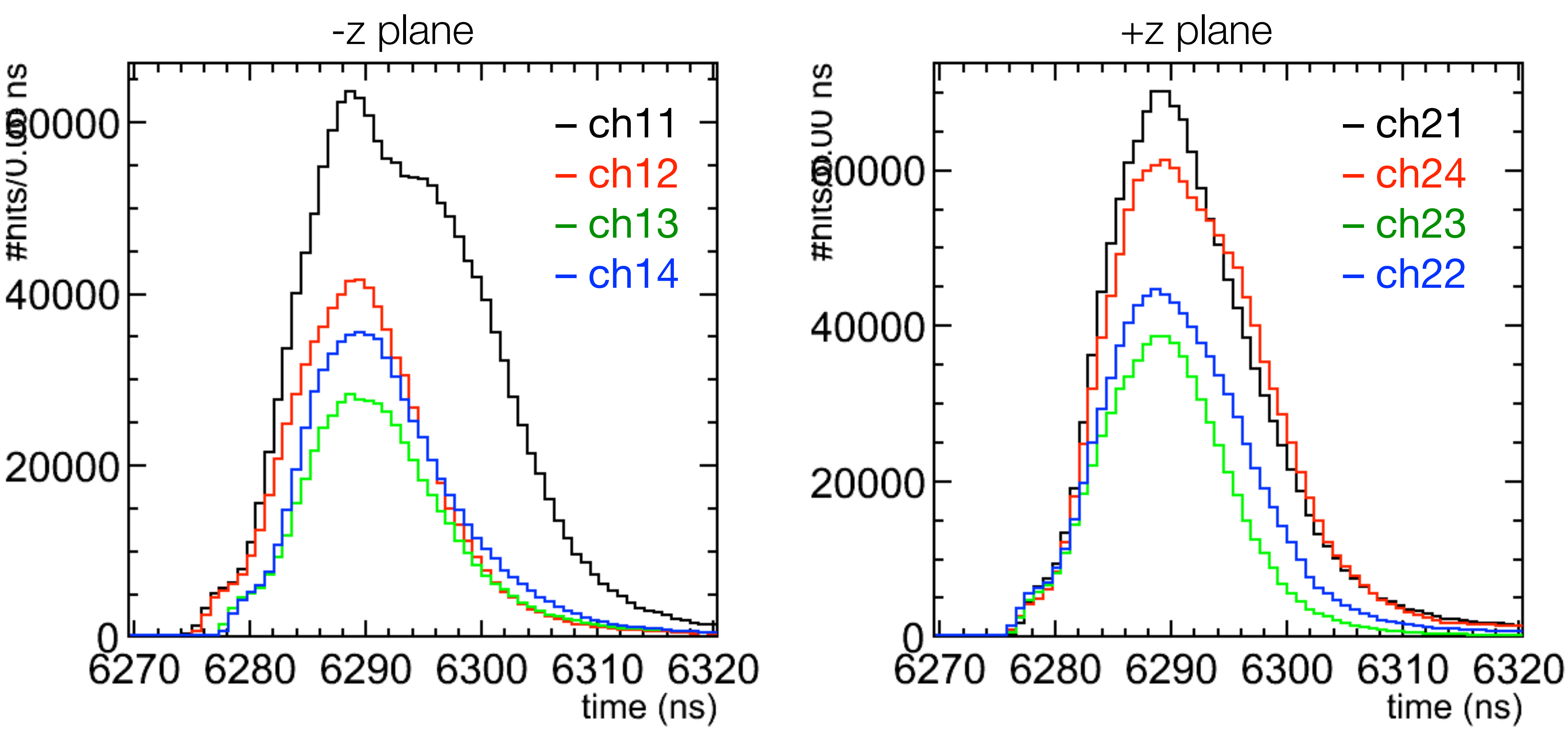
- Large spread of the time of the peaks between channels.
- Time correction factors obtained with data from fill 1262 and applied to data of the fill 1298.





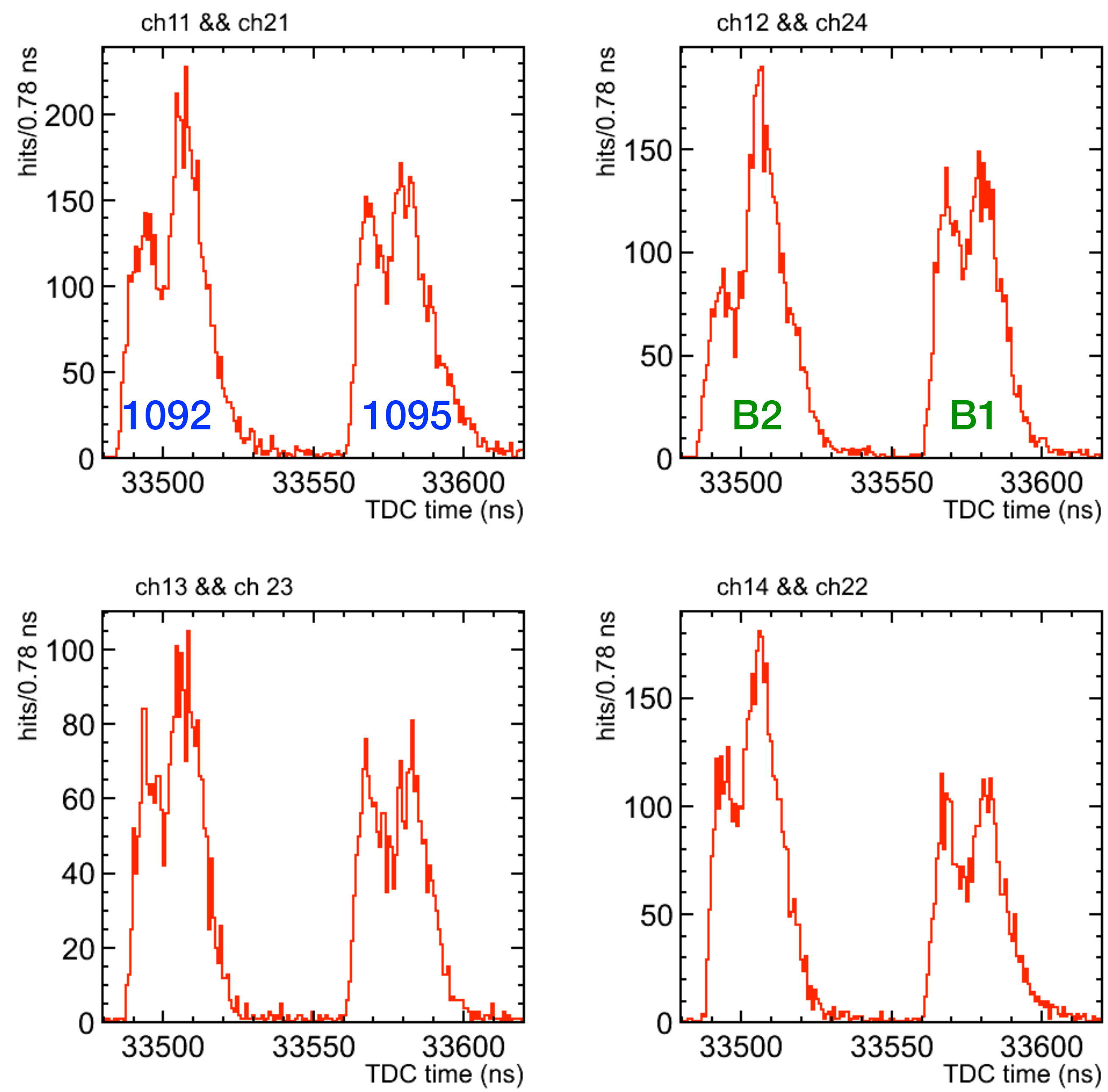
TDCs calibration

- Bunch #1: AFTER calibration. Peaks are at the same position.



Time-of-flight

- For non-colliding bunches the time-of-flight of the beam-halo particles are resolved.
  - Plots show hits versus TDC time of pairs of channels in different planes and same azimuthal angle.
  - ‘Distance’ between peaks of the same bunch: ~12 ns
  - Systematically large rates in +z channels from beam2. Castor?

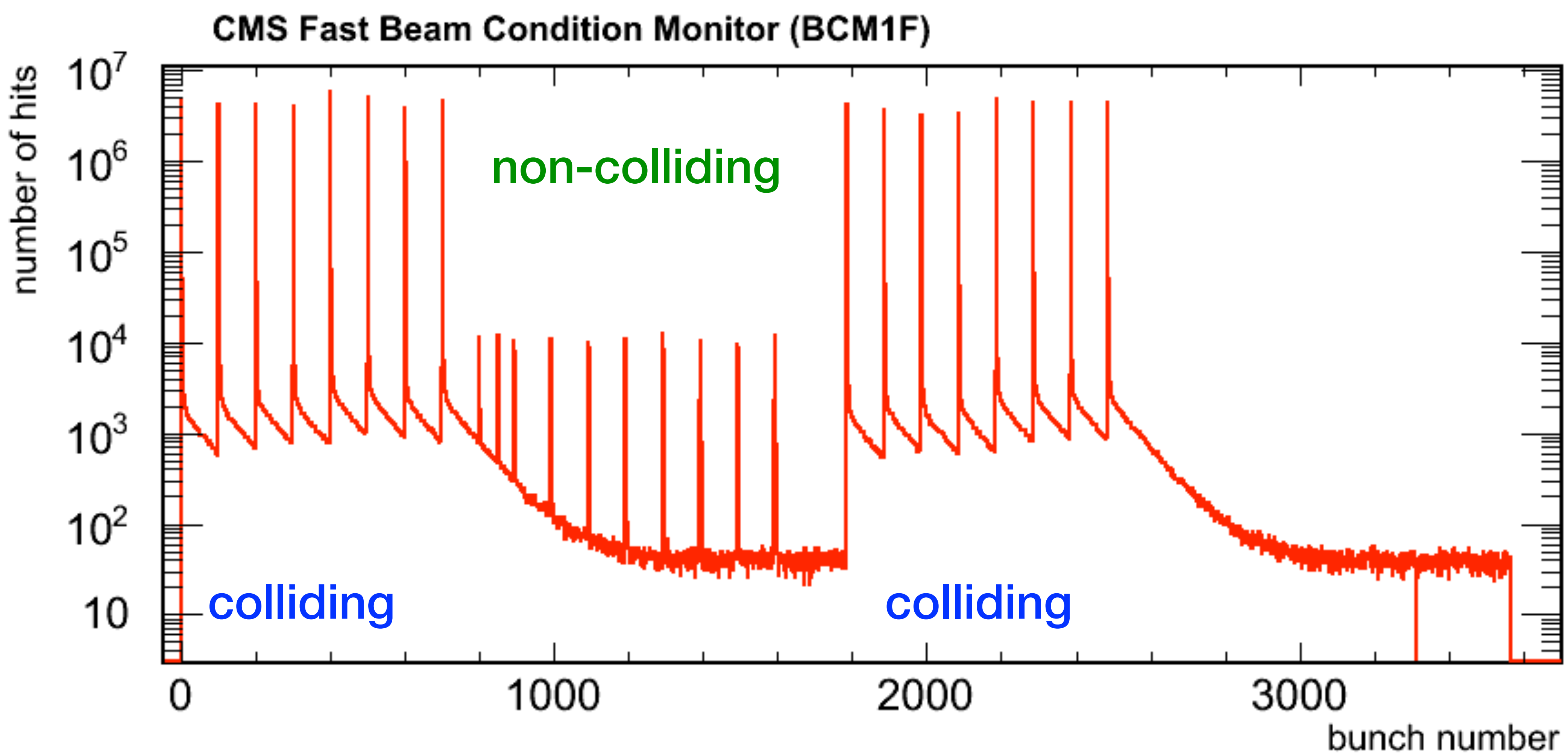


Bunch structure

- Bunch structure extracted using BCM1F time information

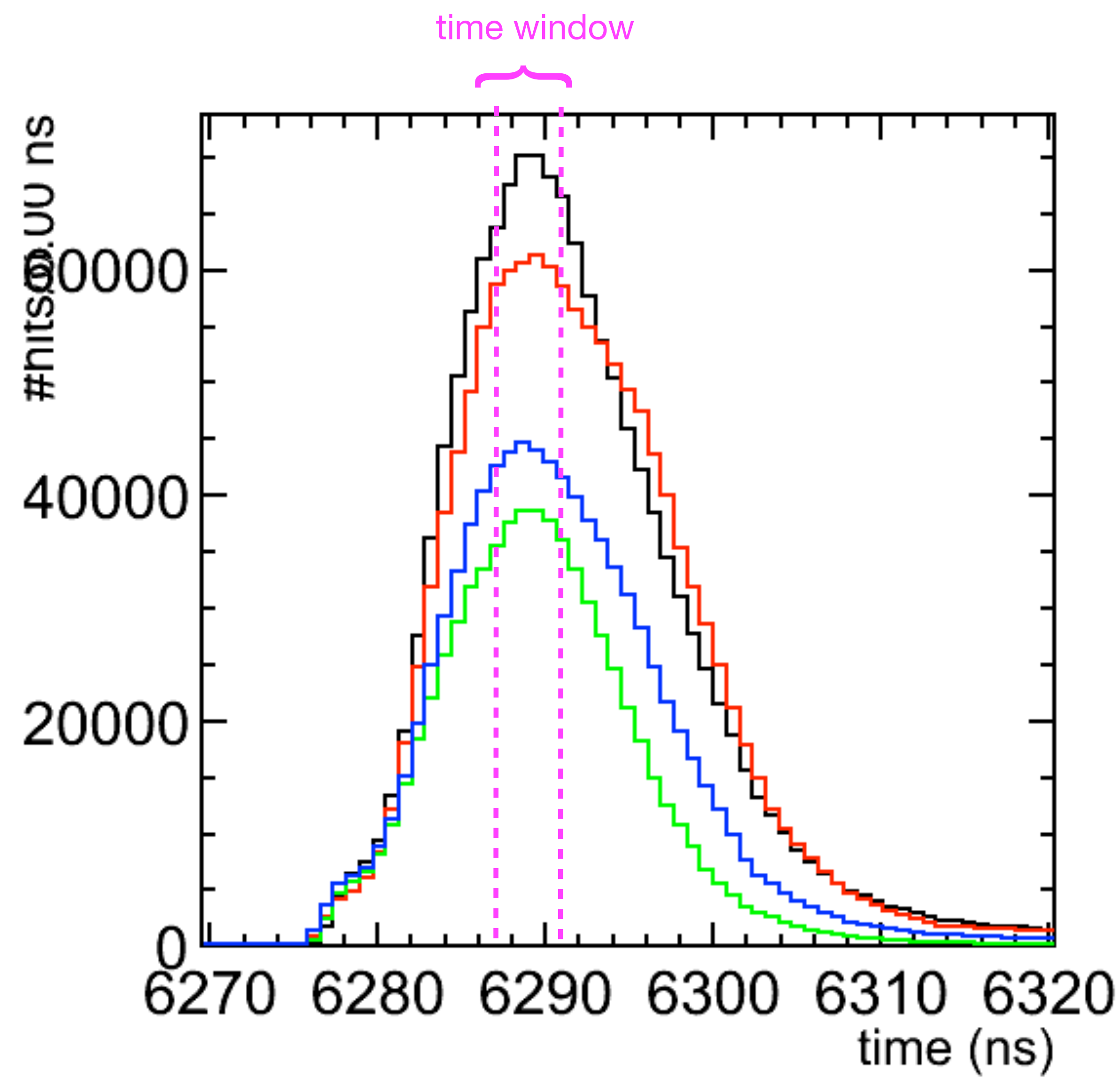
$$bn = \frac{t - 6290}{24.9505} + 1$$

- Spot bunches producing larger background.
- Information provided ‘semi-online’ to the BRM shifters.



Coincidences from collisions

- Coincidences of back-to-back channels.
    - Coincident hits time difference, for pairs with the <u>smallest</u> time difference.
    - Define a time window close/ around the colliding peak.
    - To do: Define a small time window (~4ns) and scan the whole colliding distribution.



Coincidences from collisions

- Time resolution
- VERY PRELIMINARY!
- Time window of ±2 ns around de colliding peak.

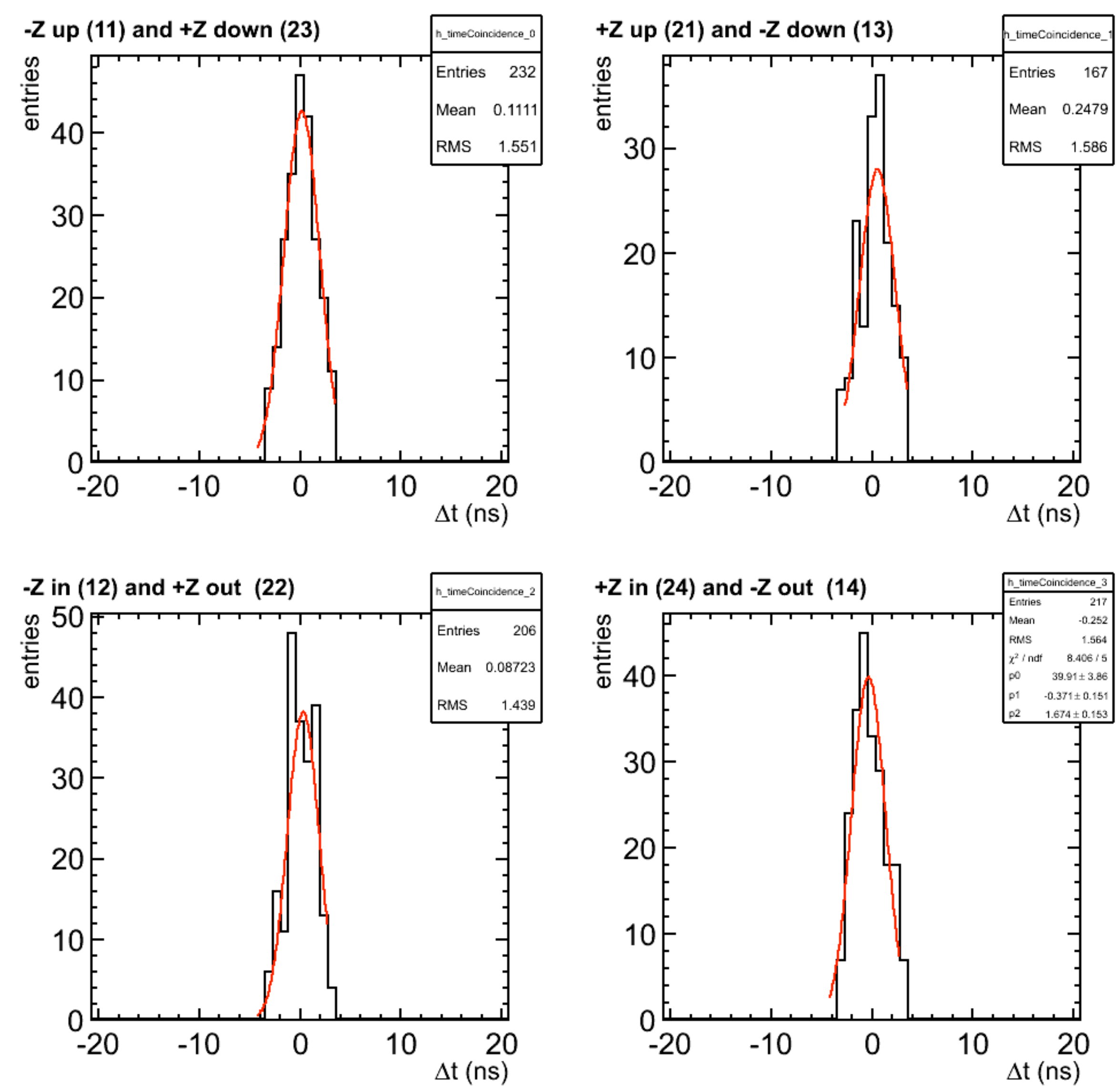
Gaussian fit (ns)

$\mu = 0.15 \pm 0.13$ $\sigma = 1.76 \pm 0.14$	$\mu = 0.52 \pm 0.18$ $\sigma = 1.77 \pm 0.14$
$\mu = 0.28 \pm 0.14$ $\sigma = 1.58 \pm 0.16$	$\mu = -0.37 \pm 0.15$ $\sigma = 1.67 \pm 0.15$

- Compatible with published value using the ADCs (1.8 ns)

bunch #1 – corrected

±2 ns around the peak

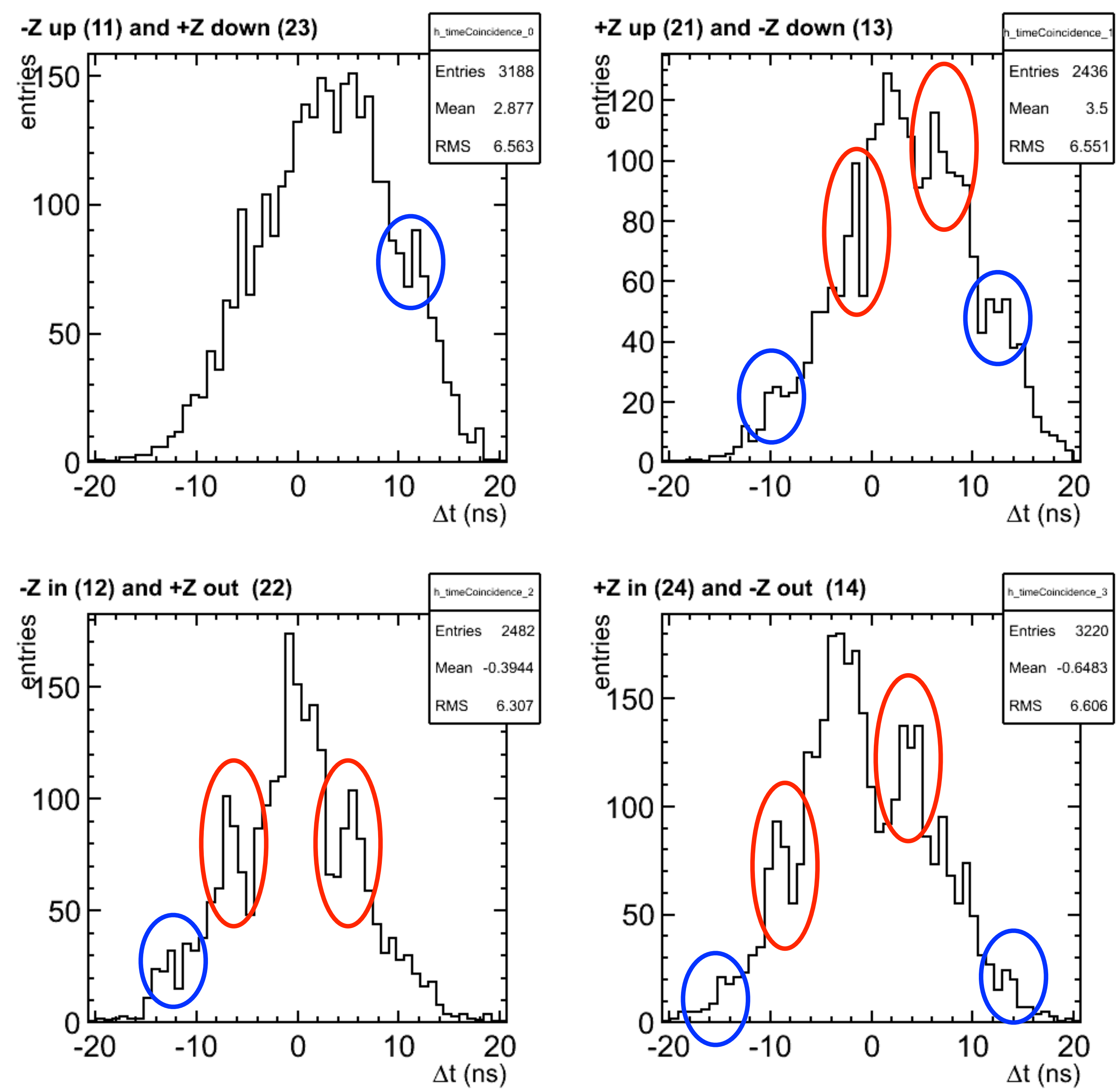


Coincidences from collisions

- Time window ±10 ns around peak: t = (6280,6300) ns
- Secondary peaks at ±6 ns!?
  - Extra bucket?
  - $e^{\pm}$ clusters predicted in simulation?
  - ???
- Secondary peaks at ±12 ns.
  - Beam halo
  - Beam halo + collision
  - Aren't the rates high?

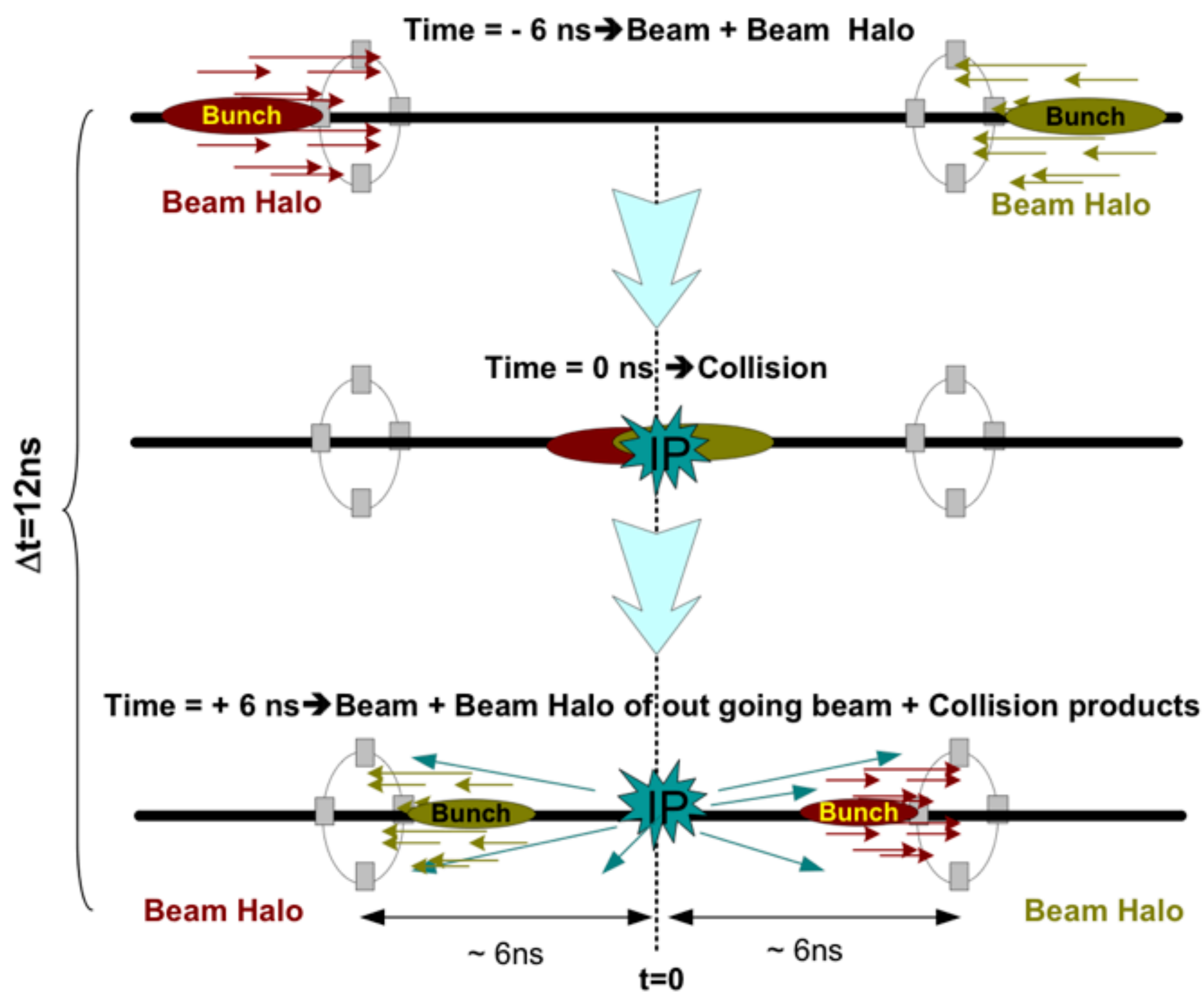
bunch #1 – corrected

±10 ns around the peak



What BCM1F should see

Here is $\Delta t = 0$ → of coincident hits



HPTDC studies

M. Hempel & E. Castro

- Studies of a high performance TDC (HPTDC) were performed in Zeuthen.
- Board model: CAEN v1290
- Characteristics:
  - Block transfers of maximum 1 kbyte (vs 16 kbytes of v767)

Module	LSB	double hit resolution	FIFO size	BLT
v1290 (HPTDC)	800 ps	5 ns	32k	1k
	200 ps			
	100ps			
	20 ps			
v767 (TDC)	800 ps	10 ns	32k	16k

Table 1: Resolution Modes

time resolution (LSB)	# bits for time measurements	TDC counter range
800 ps	17 bit	104 μs
200 ps	19 bit	104 μs
100 ps	19 bit	52 μs

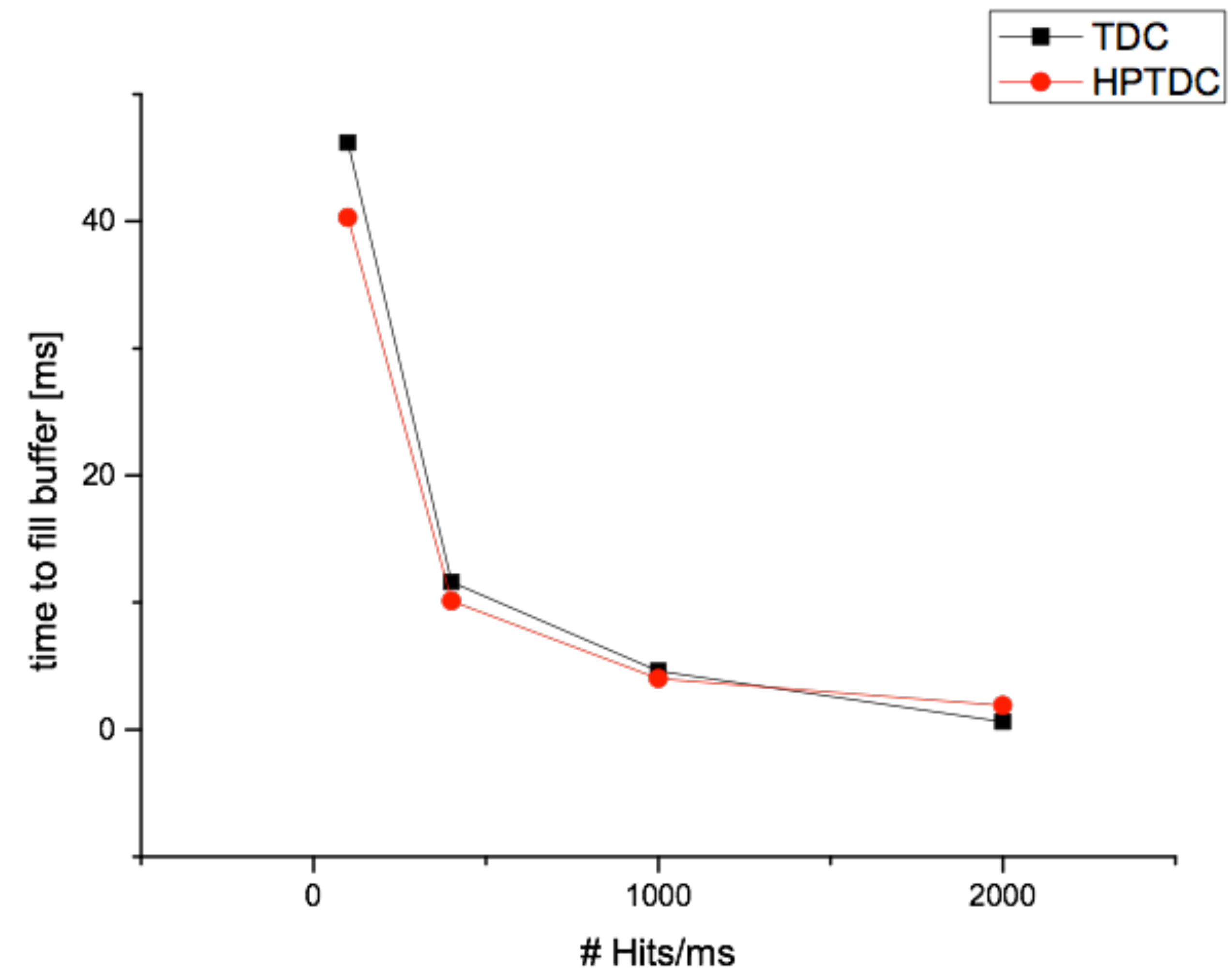
Table 2: Time resolution of HPTDC and counter range

← Minimum resolution that can be possibly used in BCM1F is 0.2 ns

HPTDC studies

M. Hempel & E. Castro

- Block transfer
    - 1 kbyte BLTs
    - 40k acquisitons
    - trigger: 100 μs
    - 8 channels



T_{Hit}	HPTDC time for BLT [μs]	TDC time for BLT [μs]
10 μs	264	301
2.5 μs	259	293
1 μs	262	306
500ns	257	297
200ns	258	313

Table 6: Time for Block Transfer

BLT deadtime 40 μs (1/2 orbit) faster for HPTDC. Independent on the rate.

Summary

- BCM1F TDCs are full operational and performing well.
- Many important information can be extracted from the TDCs data: time-of-flight, bunch structure, after-glow etc.
- Calibration and analysis of the data are ongoing. Many questions have been raised that need to be answered.
- Tests with a new board with a high performance TDC (HPTDC) were done. There are advantages using HPTDC but there limitations of the board make restrict its usage in the LHC environment with high luminosity.

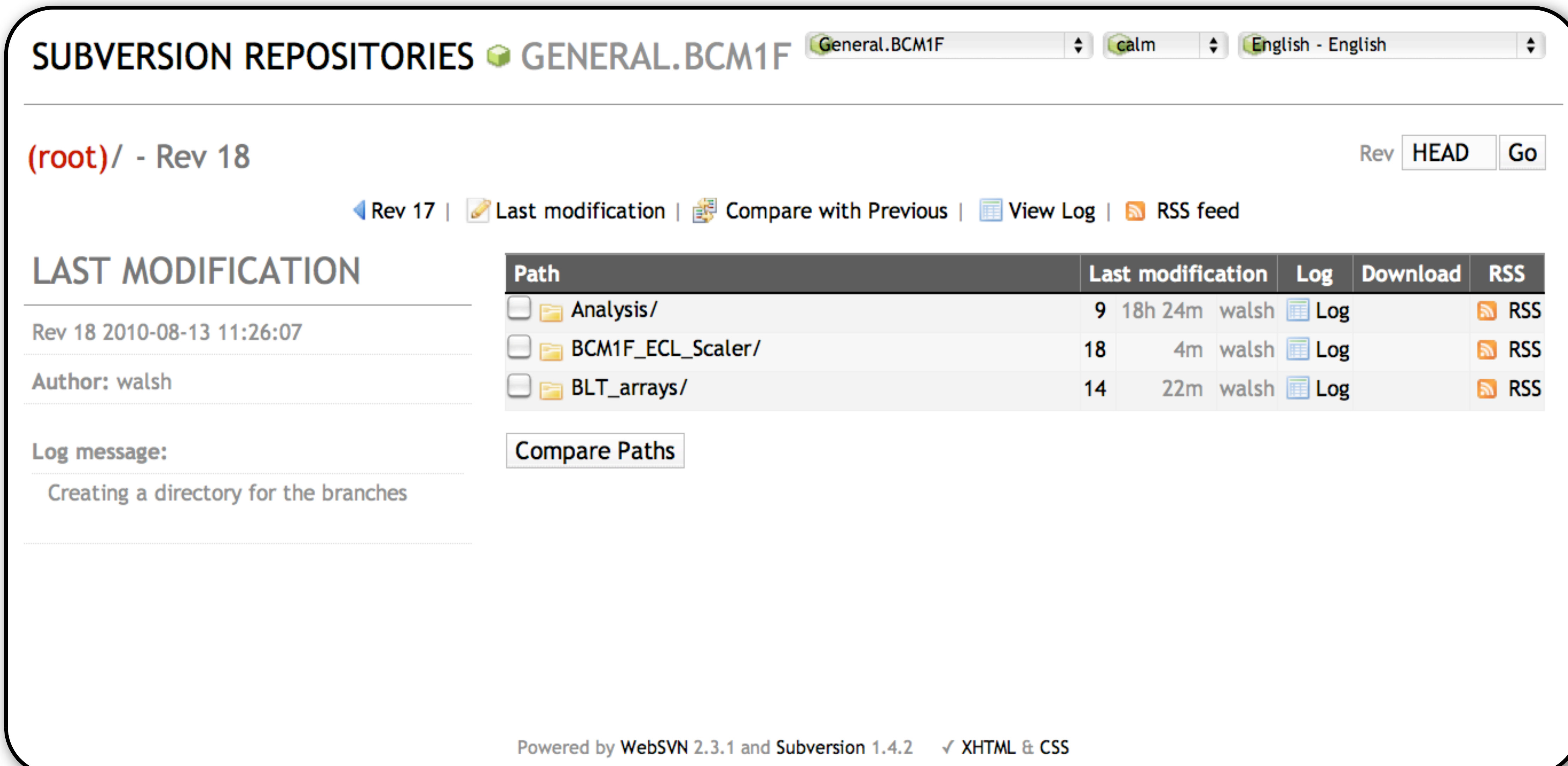
Additional slides

BCM1F code repository

- BCM1F repository created at DESY SVN Server (https://svnsrv.desy.de).
- Developers need to register first depending on the authentication...
  - For DESY people: Login using AFS account at https://svnsrv.desy.de/admin/desy
  - For others: Register at https://svnsrv.desy.de/admin/basic
- … then select to join the BCM1F repository. I should receive a notification to approve your request to join.
- A wiki page is under construction with more instructions and basic SVN commands.
  - https://znwiki3.ifh.de/CMS/Bcm1fRepository

BCM1F code repository

- Web view of repository at https://svnsrv.desy.de/websvn/wsvn/General.BCM1F?
- Projects for TDCs, Scalers and Analysis codes are already available.



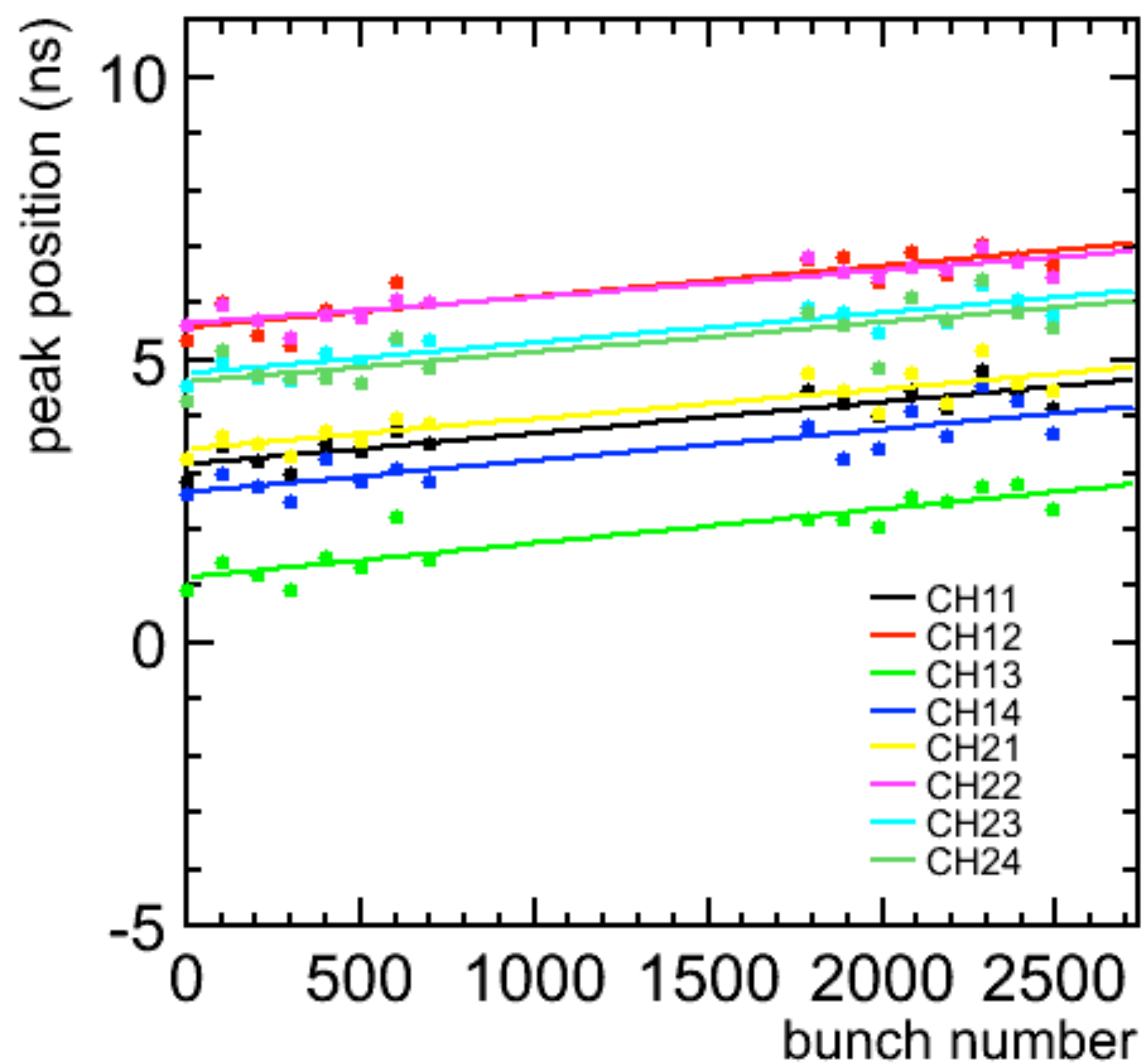
TDCs calibration

- For different bunches expected that the peak positions fluctuate around a constant value.
- But found a slope!
- The factor 24.95 ns in

$$bn = \frac{t - 6290}{24.95} + 1$$

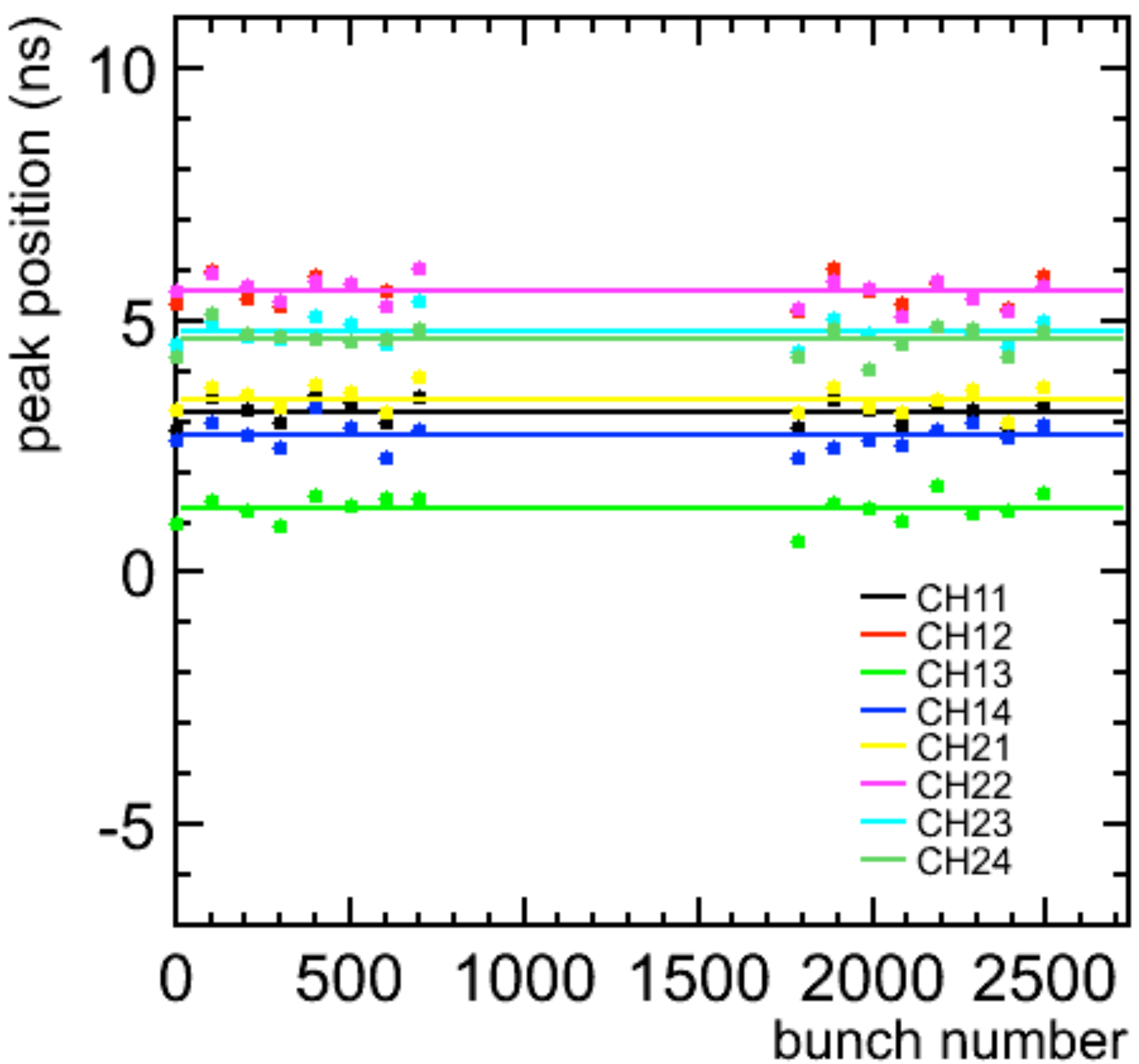
still is an approximation.

- Using 24.9505 ns instead...

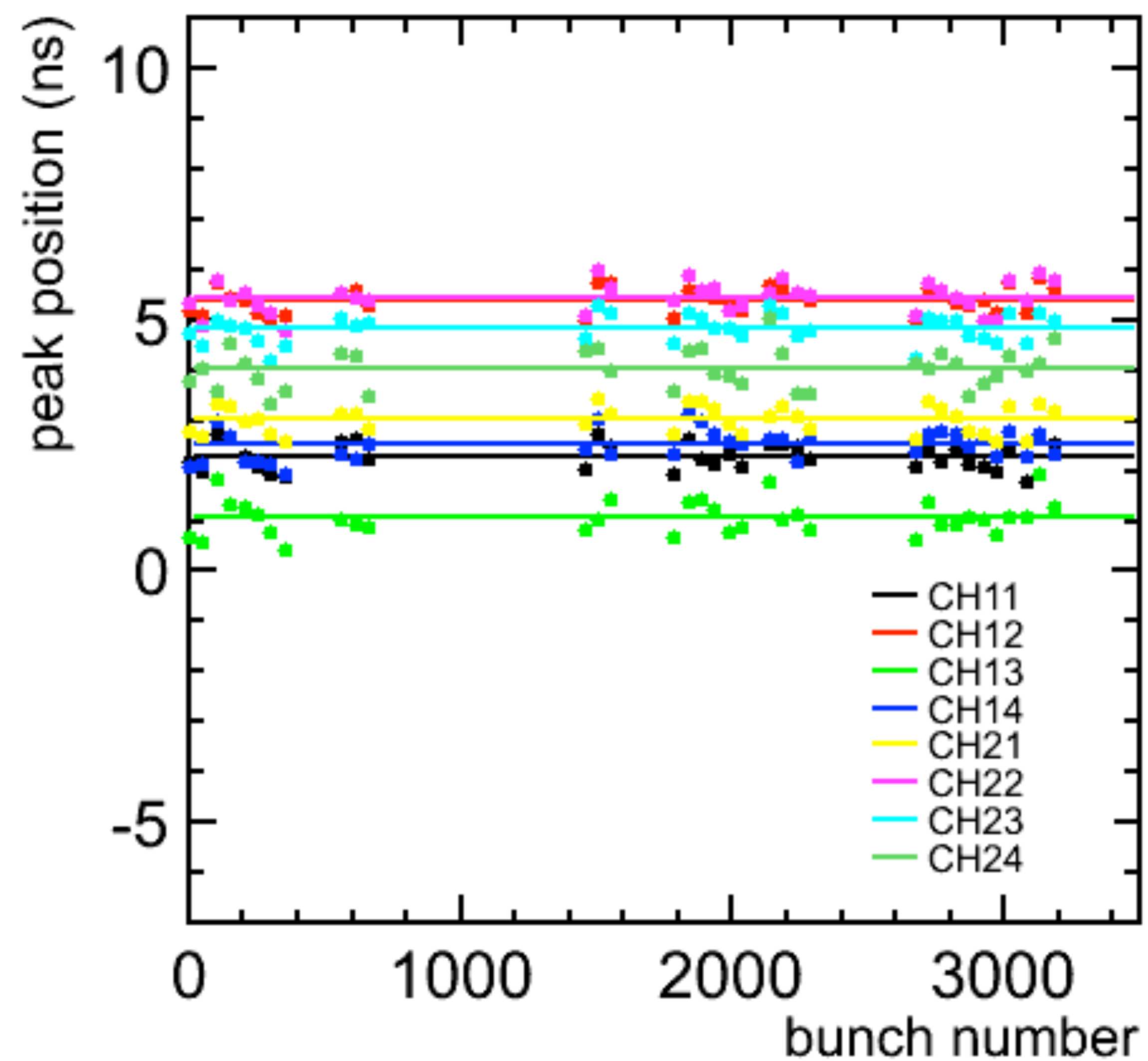


TDCs calibration

Fill 1262



Fill 1298



- Channels 11 and 24 show the larger differences. The bumps should have an effect on the fits.

Coincidences from collisions

- Using Fill 1262
  - Bunch #1: calibration applied. Peaks are at the same position.