Clock distribution performance



- Elements of the system
- System performance & How to specify what is needed

RF reference signals





after https://indico.cern.ch/event/202454/

jan.troska@cern.ch

Clock Distribution in CMS today



CERN

Phase Noise & Jitter



System jitter performance can only be fully specified

a well-defined range yields rms jitter

Is the rms the correct metric? The jitter distribution may not be Gaussian...

LHC RF performance

- System jitter at top of CMS distribution tree
 - After receiver and clock selection circuits



Limiting factor for output jitter?

 Does end-point performance improve with cleaner input clock?

-60 RF2TTC Generator -70 -70 Rx A Rx A Rx B Rx B Phase Noise (dBc/Hz) -80 Phase Noise (dBc/Hz) -80 -90 -90 -100 -100 -110 -110 -120 -120 -130 -130 1 kHz 10 kHz 100 kHz 1 MHz 100 Hz 10^{2} 10^{3} 10⁵ 10^{4} 10^{6} Frequency Offset Frequency Offset RF2TTC Generator 120 Rx A Rx A Rx B Rx B 100 80 Count 7.8 ps rms x10³ 24.8 ps rms 60 40 19.6 ps rms 1.5 ps rms 25.3 ps rms 10.6 ps rms 20 0 L -200 -100 0 100 200 -200 -100 0 100 200 Edge deviation (ps) Edge deviation (ps)

Lab measurements

Yes, due to frequency-dependence of jitter-transfer curve of the various PLLs in the distribution chain

For lowest jitter, put lowest-bandwidth PLL at the end of the distribution chain



Relative Accuracy in two branches

- Important also to know instantaneous accuracy of the difference between two clocking destinations
 - If the starting distributions aren't Gaussian, then the result may not simply be a sum of squares of the rms values



ERI

How about future timing Rx?



Early lab measurements, perhaps pessimistic



- Next generation IpGBT will not have crystal-referenced PLL, CDR only
 - No phase noise filtering below ~2 MHz

Elements of a future timing system



CERN

Summary



- The existing timing distribution system can have an rms jitter performance below 10 ps
 - Need to take care when defining what 10 ps means and how to measure it!
 - Should be ready to assess the system-level impact of achieving other (maybe higher) levels of jitter
- Long-term (days, weeks, months) stability defined by environmental stability of whole chain
 - below several hundred ps presently, most likely dominated by P4 to Experiment transmission
 - Does this need to be stabilised (as ATLAS, LHCb, ALICE do today)? To what level?
- Careful front-end system design will be required to maintain timing performance
 - Including the possible addition of a jitter-cleaning PLL after the IpGBT should this become necessary