Cogging and RF signals – report of Week1

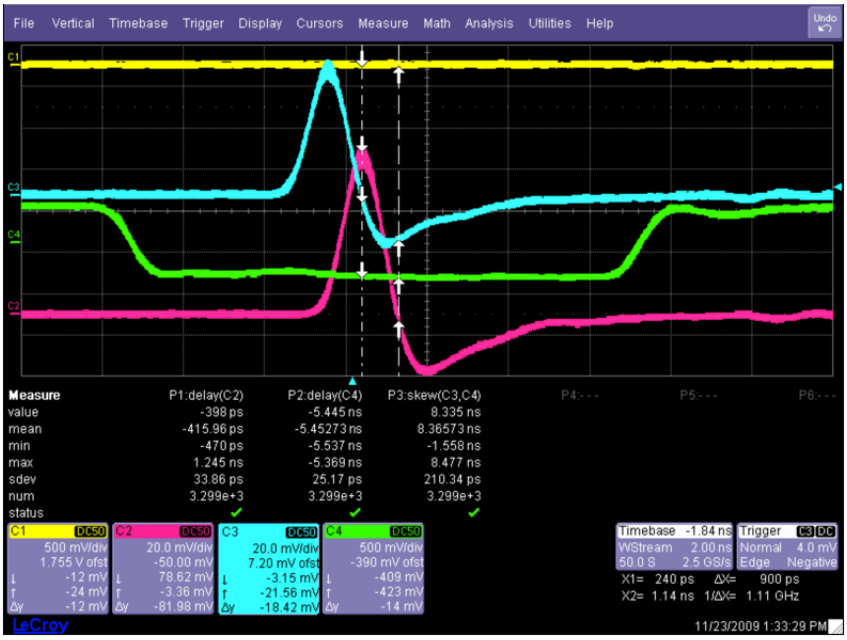
Cogging

Team:

- RF guys!
- ALICE: Antonello Di Mauro, Marian Krivda, Anton Jusko
- ATLAS : Thilo Pauly
- CMS : Jeroen HEGEMAN, Jan Troska, Richard Hall-Wilton
- LHCb: Richard Jacobsson, Federico Alessio
- Massimiliano Ferro-Luzzi (LPC)
- Coordination: Sophie Baron (PH)

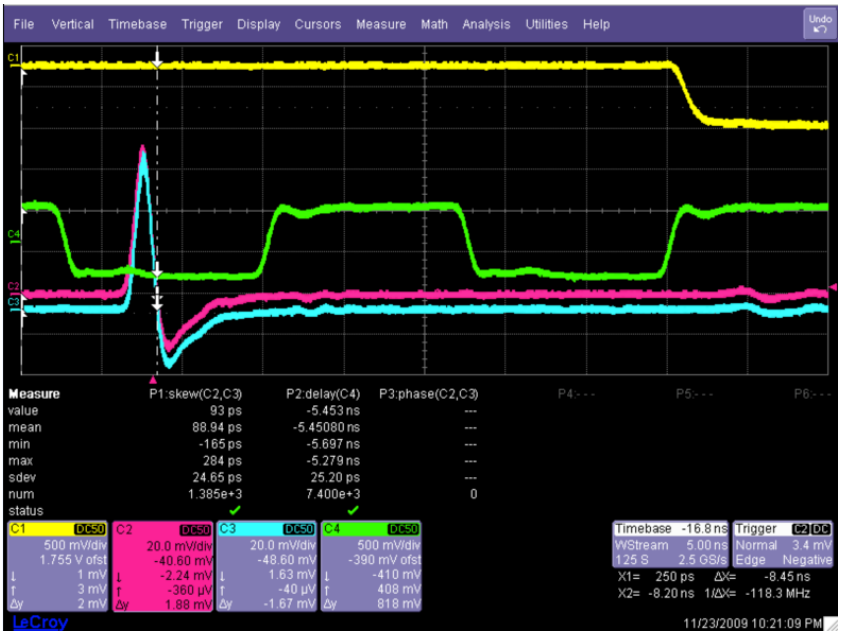
Steps:

1. Friday evening – 6:00 PM- 2:00 AM: first evaluation of the collision point with default injection phase.
    a. Measurement of the phase of the bucket (BPTX) versus the Orbit, one beam after the other, keeping a common reference.
    b. ALICE and LHCb had to compensate for the fact that buckets1 in each beam were not supposed to collide at their IPs.
    c. Agreement on a value with about 1ns precision between the 4 experiments: deltaT = 29.841us, which means that the collisions were virtually happening below Ferney Voltaire and Crozet.
2. Adjustment of Cogging value (bucket phase – step of 2.5ns) made every time there was a resync (Saturday morning, Sunday afternoon and night). Because of the reasons explained later, we had to do it several times before observing the expected effect on the phase. We fine tuned the BPTX measurements using captured beams and used every single shots of B1 and B2 (8 shots of <2s during Sunday).
3. Sunday at 2:00 AM, value was cross check with CMS and theoretically validated (still with one beam).
4. Monday afternoon, we confirmed the adjustment with the 2 beams. We were already in the right bucket for collisions (measured phase of 0.9ns to 1.5ns). Just before 3:00PM, we performed a continuous and fine phase adjustment (still only with the BPTX – not yet cross-checked with the trackers).



Thilo

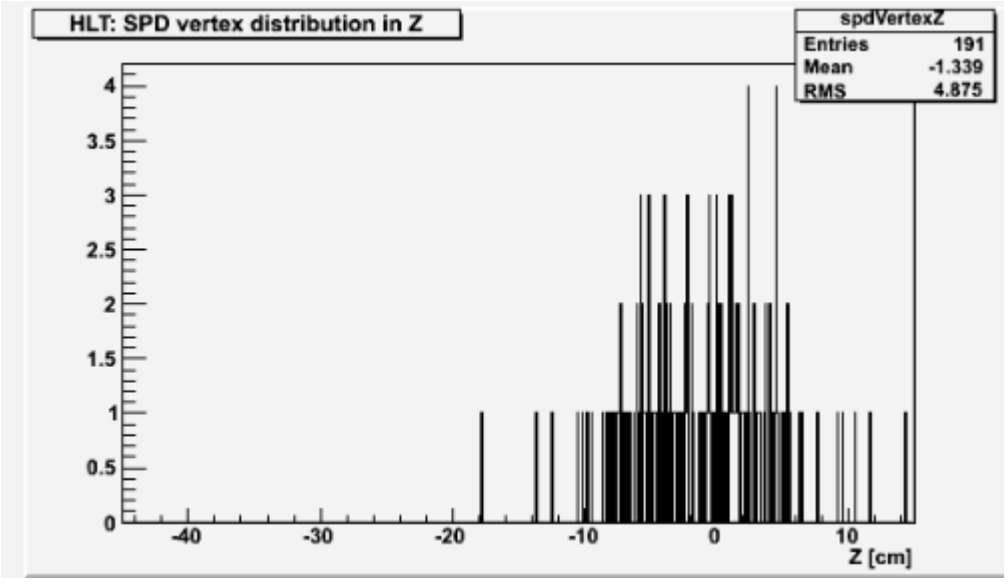
Phase between 2 BPTX at ATLAS after cogging with 2 beams (900ps)



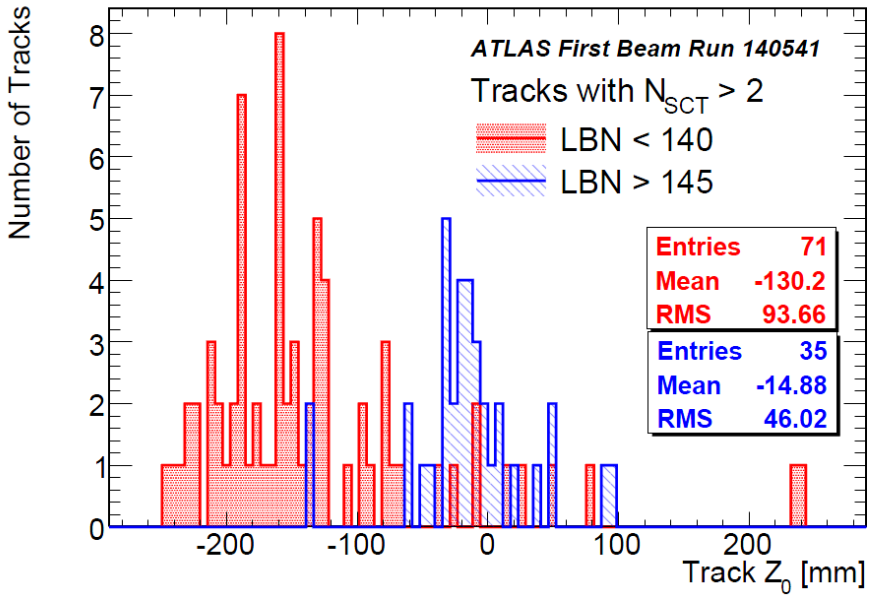
Thilo

Phase between 2 BPTX at ATLAS after fine phase with 2 beams just before injection (90ps)

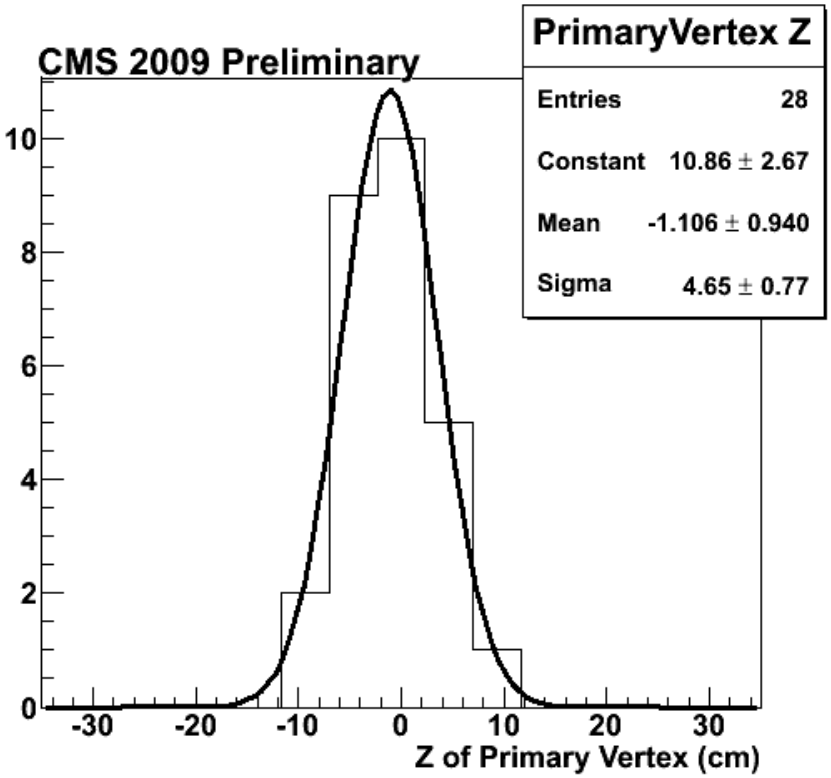
5. The 4 experiments reported Vertices within 1.5cm from the IP!!!!


HLT: SPD vertex distribution in Z
spdVertexZ
Entries 191
Mean -1.339
RMS 4.875
Z [cm]

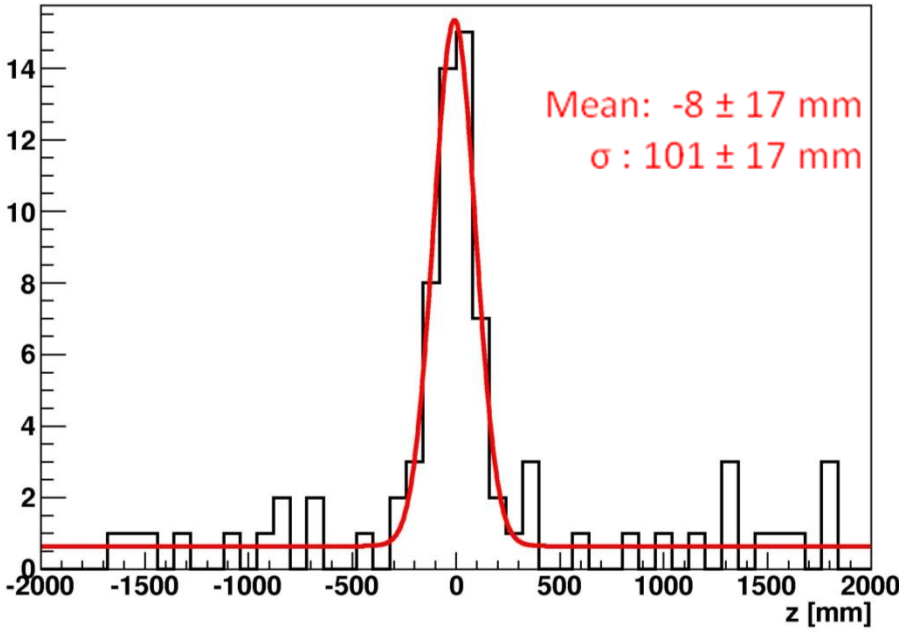
ALICE


ATLAS First Beam Run 140541
Tracks with $N_{SCT} > 2$
LBN < 140
LBN > 145
Entries 71
Mean -130.2
RMS 93.66
Entries 35
Mean -14.88
RMS 46.02
Number of Tracks
Track Z_0 [mm]

ATLAS



CMS



LHCb (beam gas & collisions)

Progress and information exchanges can be found here:
www.cern.ch/cogging and here

http://lhc-experiments-timing.web.cern.ch/lhc-experiments-timing/Cogging%20operation.htm
Thanks to all the members of the team, who were using every beam opportunity to check the measurements and report feedback.
Looking at what next chapter, we can say as well that we had some luck on Monday, as everything could have changed right before the collisions…At this time, there were many parameters which could have changed the phase!

Phase and Frequency jumps:

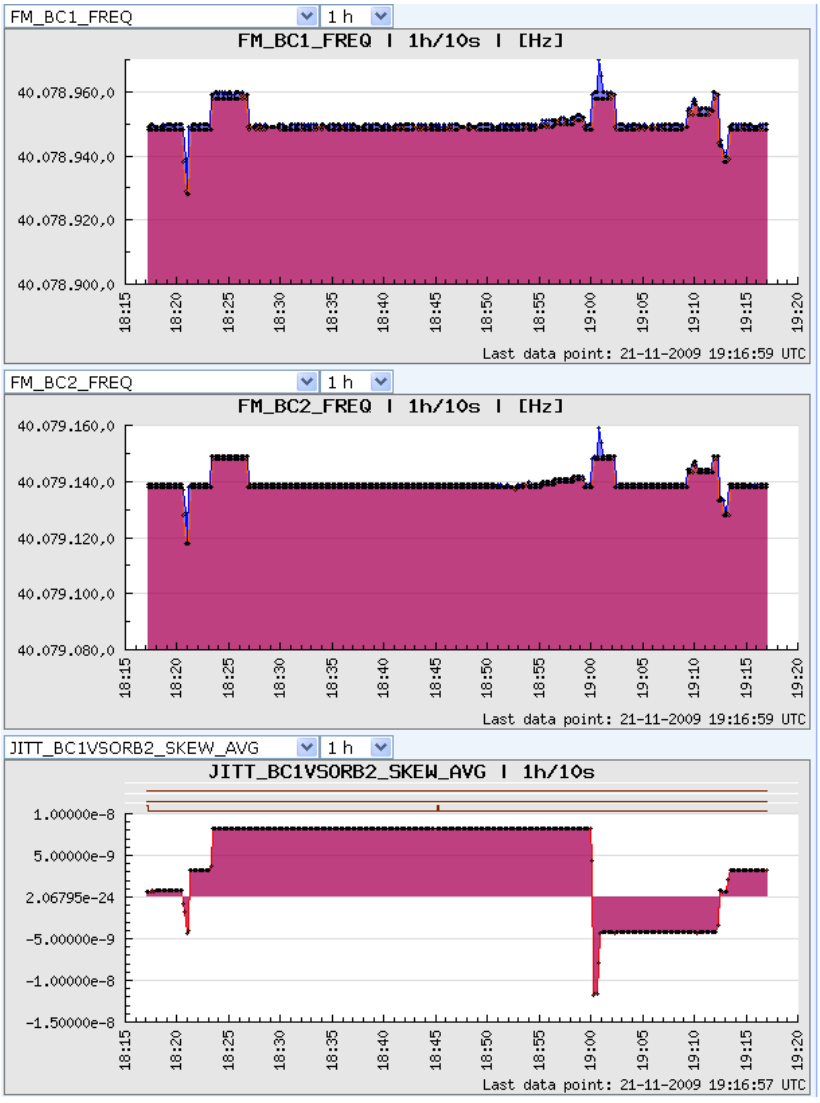
Several actions have been understood to cause phase jumps:

Trims (chromaticity tests, dispersion):

'brutal' change of frequency by +-50Hz or +-100Hz.

Generated a brief unlock of the synchro loop. The VCXO in the loop relocked almost instantaneously, but the phase slipped by a few buckets, generating a dephasing of the 2 beams (and a displacement of the collision point)

Action: the frequency rate applied during the TRIMS has been reduced to 200Hz/s @ 400MHz (ie 20Hz/s for the experiments) to avoid an un-lock of the synchro loop.

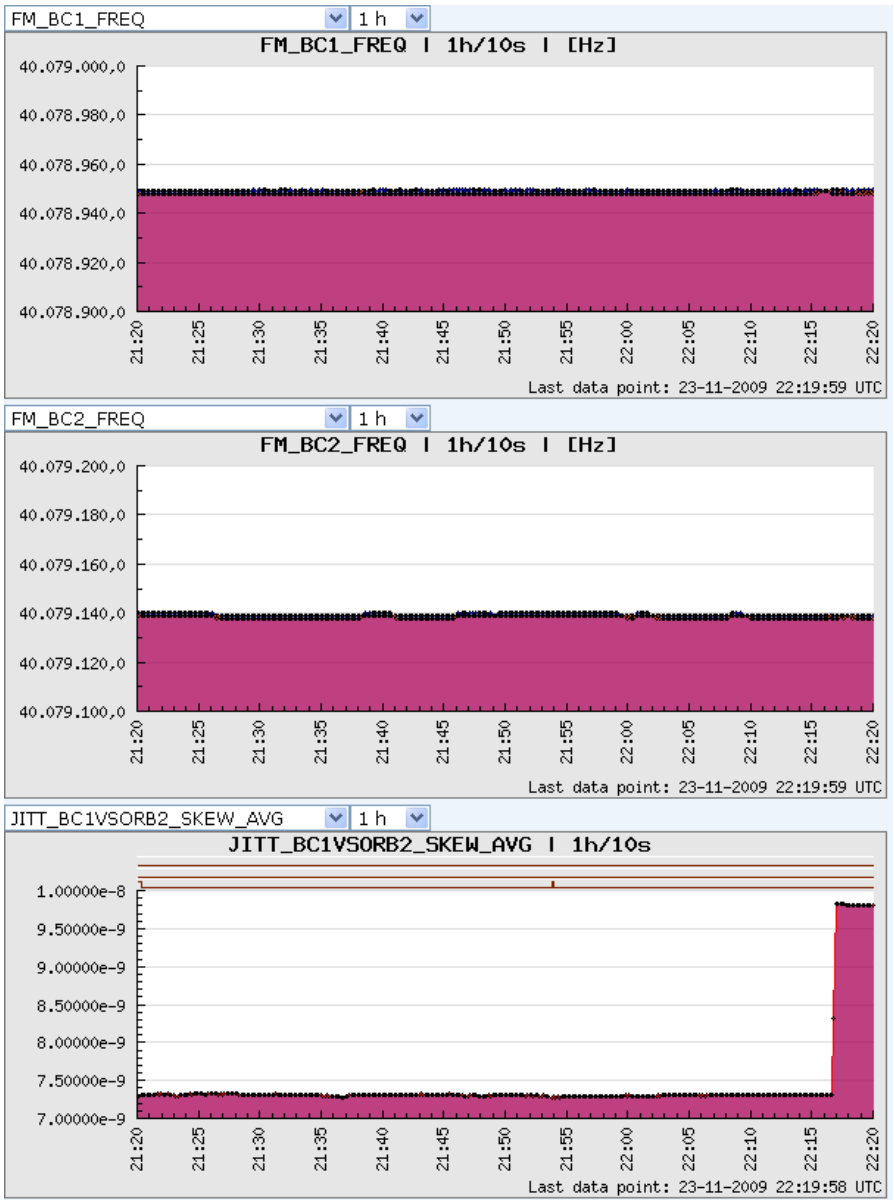


Effect of TRIMS on beam phase

Injection with RF OFF (frequently used for Inj&Dump):

This was creating a phase error on the synchro loop which was, as well, unlocking the VCXO and generating a phase jump.

The problem has been solved and should not happen anymore.



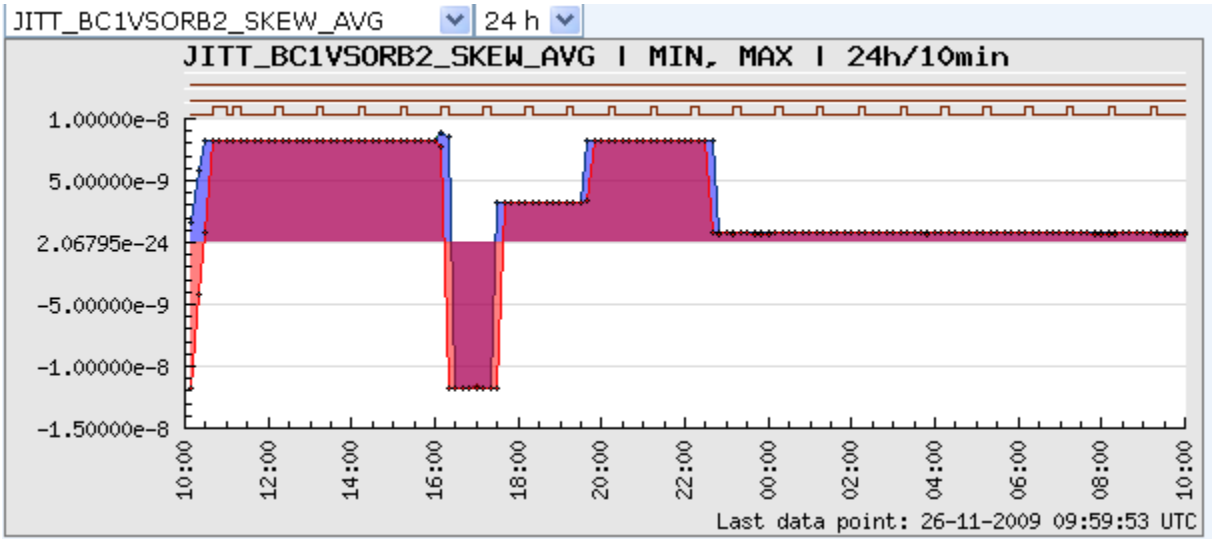
Effect of injection with RF OFF

Master Frev 40MHz not resynchronized during beam control resynchro:

At each injection, the phase of the 40MHz could be in each of the 10 positions of the 2.5ns bucket. This created a **random** phase offset that the synchro loop was trying to correct. It resulted in the displacement of the bucket by + or – one or several buckets. The resynch of these 40MHz have now

been integrated in the sequencer. However, as soon as the sequencer is not used to reset the RF, this has to be carefully checked.

This means that the parameters obtained for the capture during the first week-end had to be re-adjusted Sunday 29. The phase between FrevProg and Frev have changed, all the settings have been slightly modified, and the cogging will have to be rechecked as soon as beam is back.



Typical effect of injections with 40MHz not resynchronised

Miscellanea:

- Reset of the FGC: human mistake
- The phase accumulator of the 2 DDS may not have been reset before first injection (could have add an error of 0 to 1ns). The reset has been done now, and this should not be required anymore.

Still to do:

Re-check cogging and fine adjust with 2 beams @ 450GeV

Fine adjust @ 1.2 TeV

It is expected that there will be a shift of the phase. See bellow the measurement of the phase shift during the RF ramp done Monday 23 night (although the energy did not pass 600GeV, the RF went up to 7TeV):

Thilo

Expected values:

```
IP 1
   diff beam 1 (inj-top) = -0.120310847588 ns
   diff beam 2 (inj-top) = -0.072186508547 ns
   diff beam 1-beam2     = -0.048124339041 ns

IP 2
   diff beam 1 (inj-top) = -0.144373017095 ns
   diff beam 2 (inj-top) = -0.048124339034 ns
   diff beam 1-beam2     = -0.096248678061 ns

IP 5
   diff beam 1 (inj-top) = -0.024062169517 ns
   diff beam 2 (inj-top) = -0.168435186615 ns
   diff beam 1-beam2     = 0.144373017098 ns

IP 8
   diff beam 1 (inj-top) = -0.096167660661 ns
   diff beam 2 (inj-top) = -0.096329695475 ns
   diff beam 1-beam2     = 0.000162034814 ns (Thilo)
```