results with complete & permanent tests on

# 128 Spark BPM electronics for ESRF's new L-E Ring on real RF-beam signals

*Kees Scheidt*
Diag. group
ESRF

*Libera workshop 2018*

# results with complete & permanent tests on 128 Spark BPM electronics for ESRF's new L-E Ring on real RF-beam signals

**Outline :**

**1) Rapid recall of the situation of ESRF's new Storage Ring**

**2) Configuration of the BPM-system, now (224 Liberas) and later : 192 Liberas + 128 Sparks**

**3) Hybrid-system (Libera / Spark) : → different functionalities & requirements**

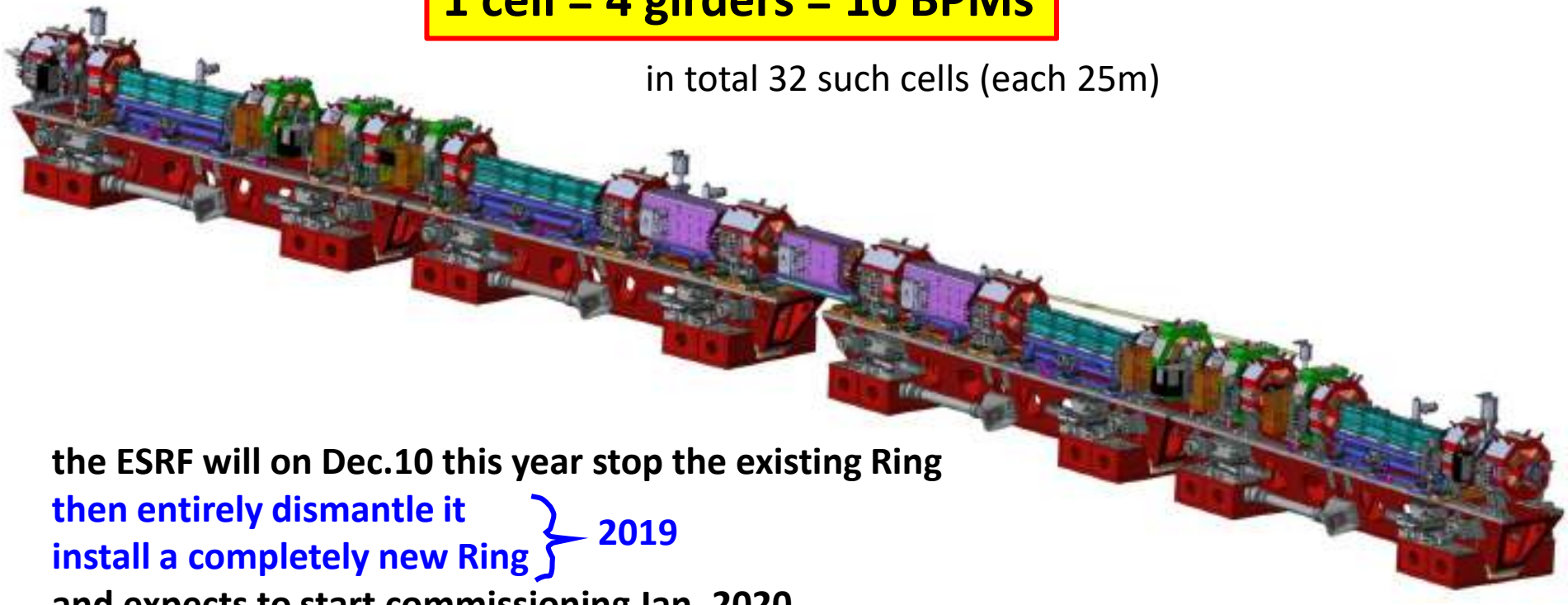
**4) Test set-up of the Sparks → permanent & simultaneous & parallel**

**5) Results : - slow, long-time records of : stability, drift**
**reproducibility, reliability**

**- Turn-by-Turn measurement : synchronization aspects**

**1 cell = 4 girders = 10 BPMs**

in total 32 such cells (each 25m)

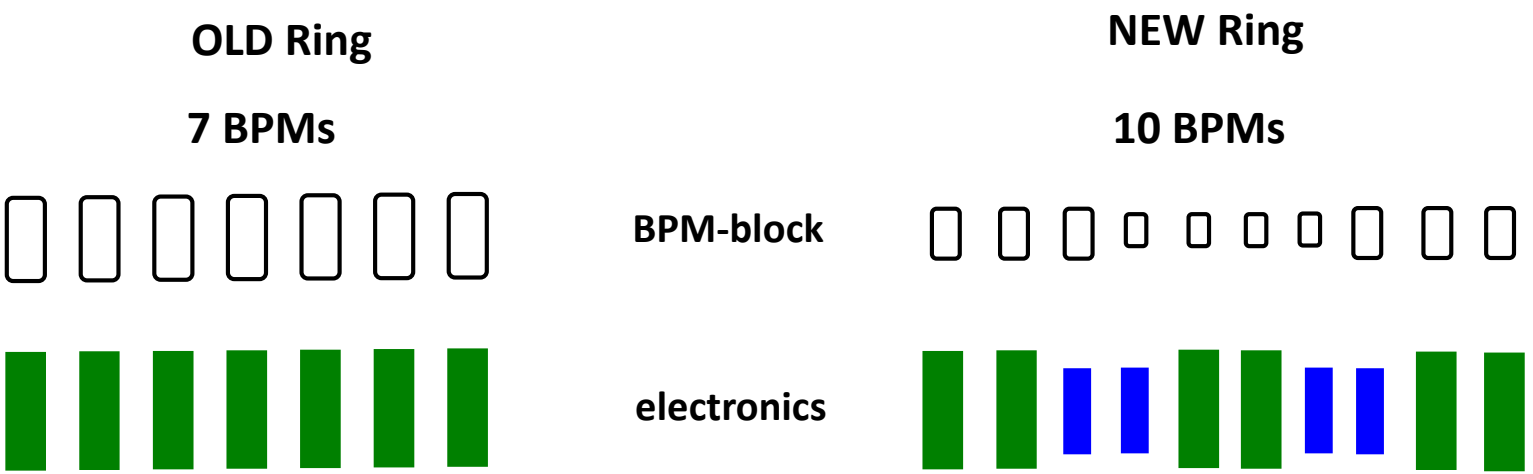


**the ESRF will on Dec.10 this year stop the existing Ring**
**then entirely dismantle it**
**install a completely new Ring** } **2019**
**and expects to start commissioning Jan. 2020**

**of relevance for this talk :** **the number of BPMs will increase for 7 to 10 per cell, i.e. from 224 to 320 BPMs**

**this new Ring is also called :**

**Low-Emittance Ring (LE-Ring) or EBS (Extremely Brilliant Source)**




total: 224 BPMs
all doing Slow & Fast
orbit correction

32 Liberas recup
for extra spares *

* helpful : our Liberas are
10 years old and obsolete

total: 320 BPMs
128 Sparks for Slow
192 Liberas for Fast & Slow
orbit correction

145 Sparks procured
this Spring

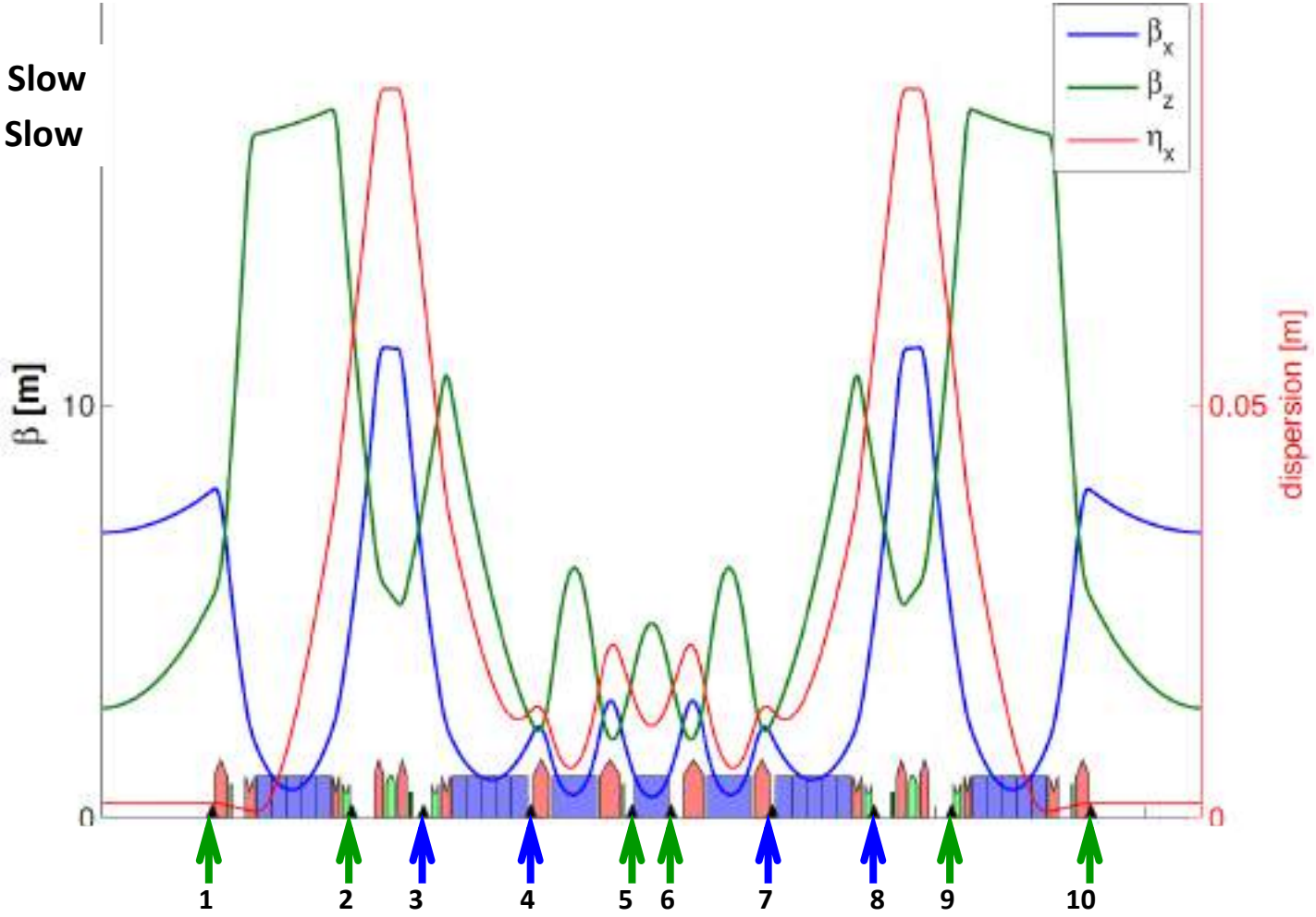
subject of this talk

# Fast & slow Orbit correction : 6 Liberas & 4 sparks per cell

**X-ray beam stability for users will be identical to that of today**

**6 Liberas : Fast & Slow**

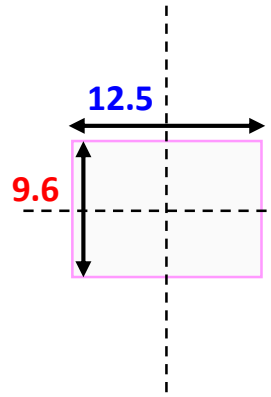
**4 Sparks : only Slow**

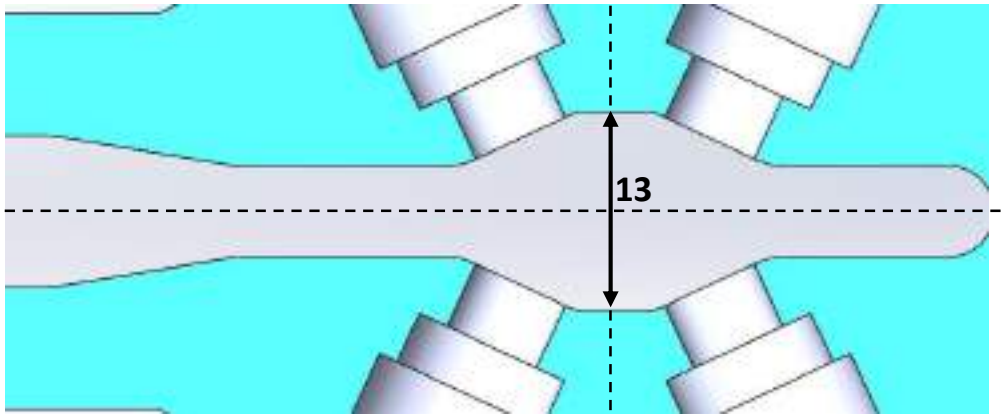



**Libera**

**Spark**

Beam-pipe much smaller than with old ring,
also 2 different geometries : Large & Small

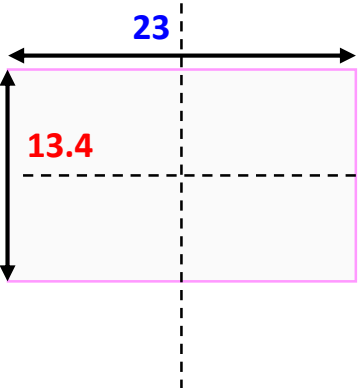


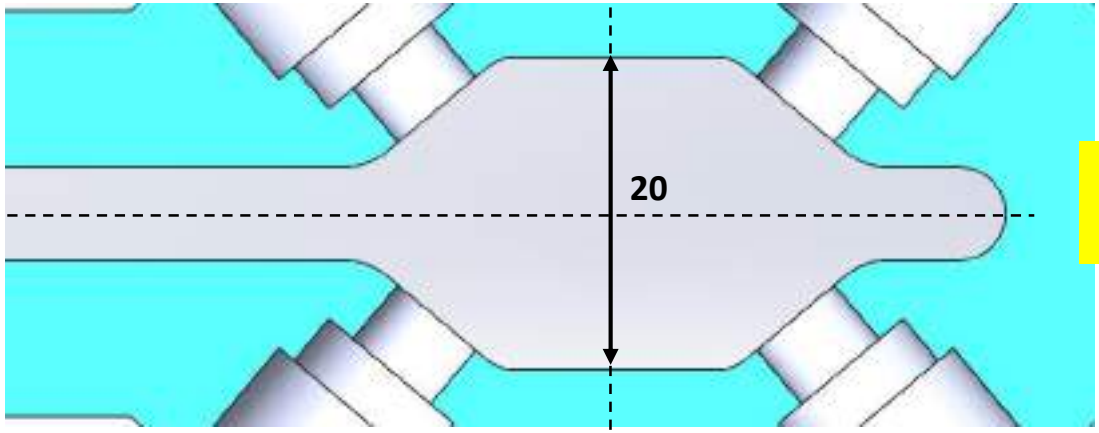




**Kx= 4.7**
**Kz= 7.4**

**BPM no.**
**4 5 6 7**

**H & V distances between the center of the 4 buttons**




**Kx= 6.5**
**Kz= 16.4 . . .**

**BPM no.**
**1 2 3 8 9 10**

## how to test 145 SPARK units ?

**FATs** done at each individual unit by the company (Jan. – April 2018)

followed by :

**SATs** done at ESRF, in the same manner as **FATs** …. ??  **NO !!**

a much **better alternatif** for **SATs** :

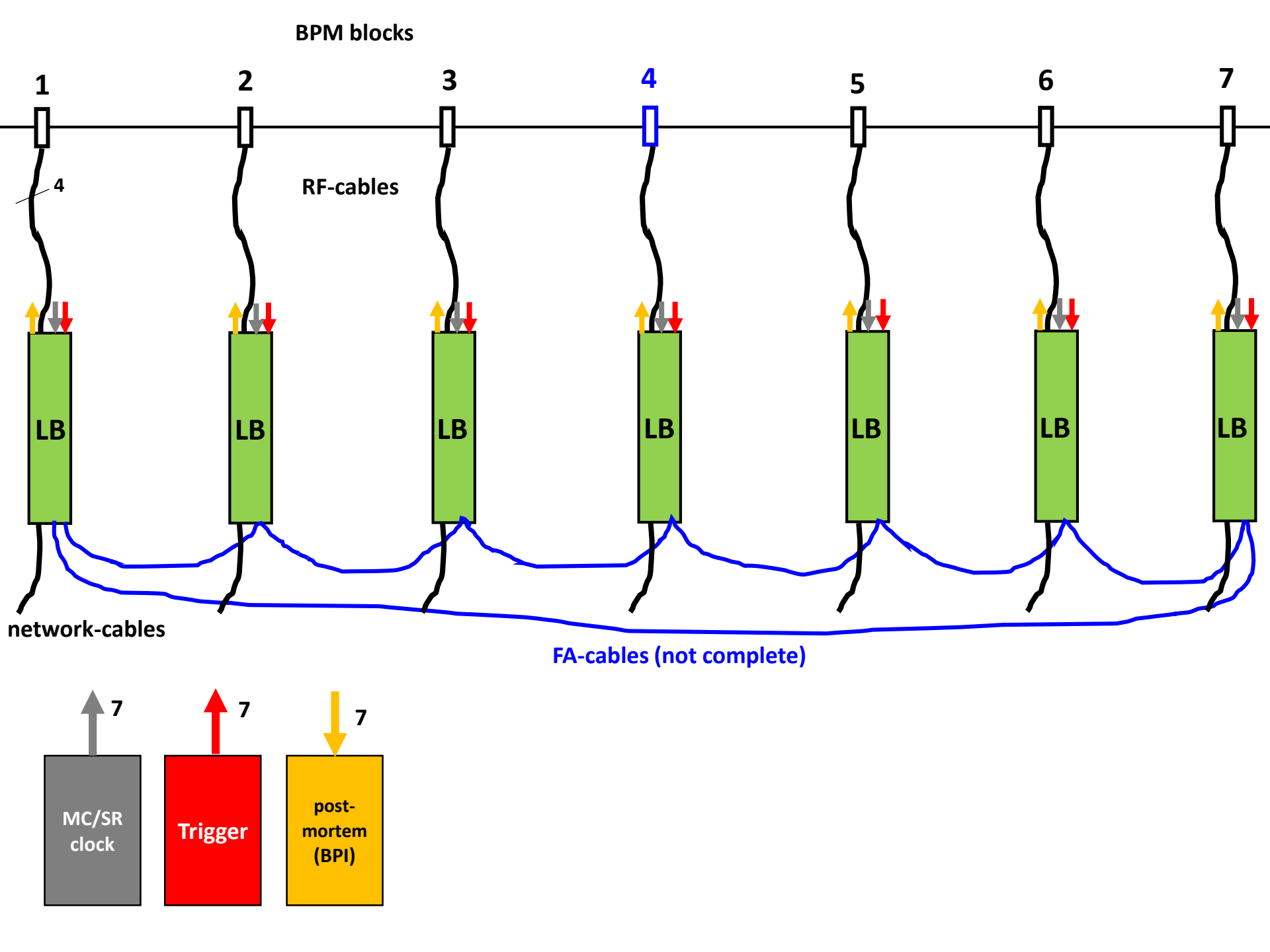
install them on real BPM signals, measuring X, Y, Sum
4 units (per cell) strictly in parallel, seeing identical beam motion
repeat for all 32 cells → test 128 in parallel & simultaneously & permanently
store the A-B-C-D data (SA) at 1Hz in data-base

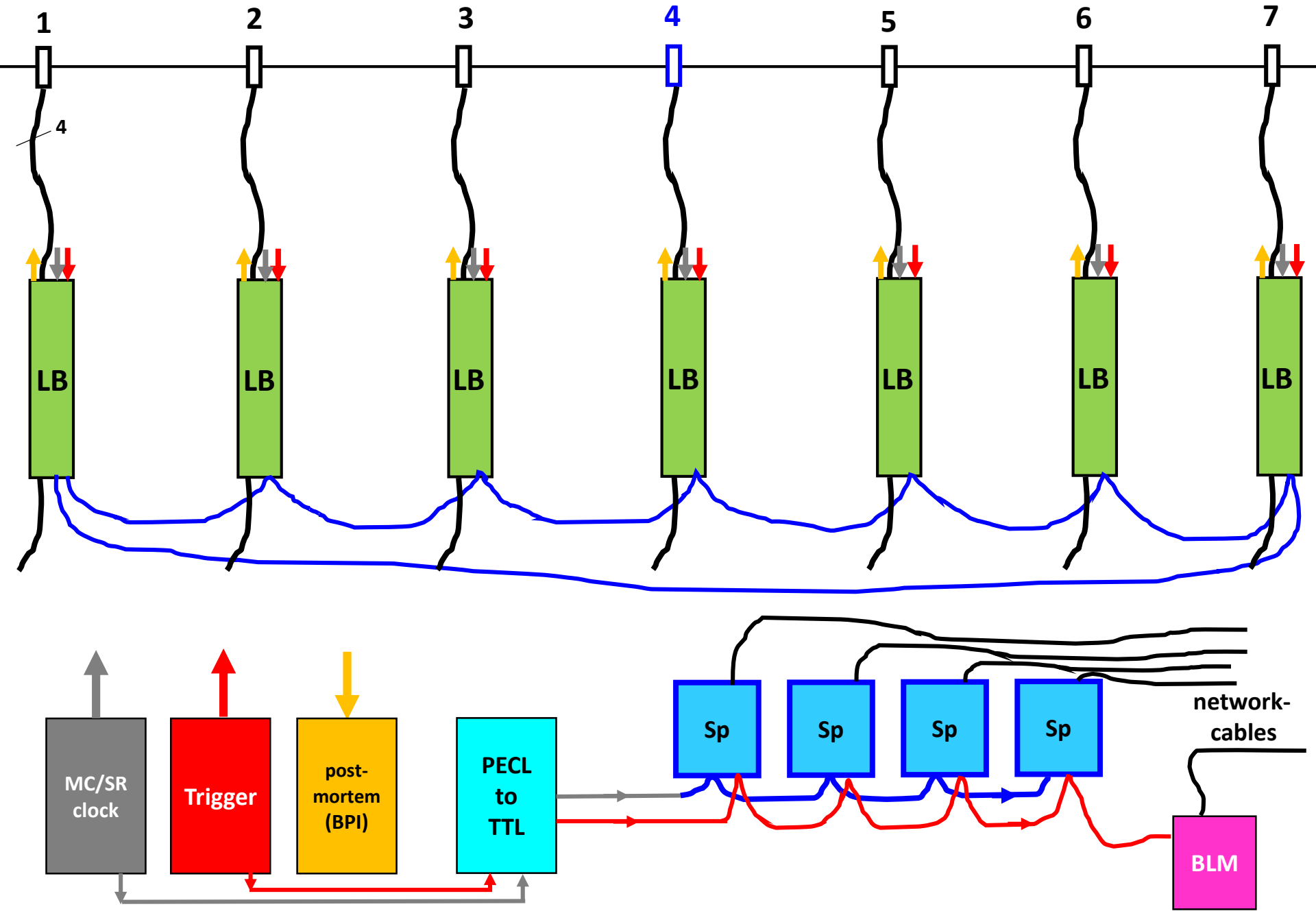
} **more info & checks on behavior & reliability**

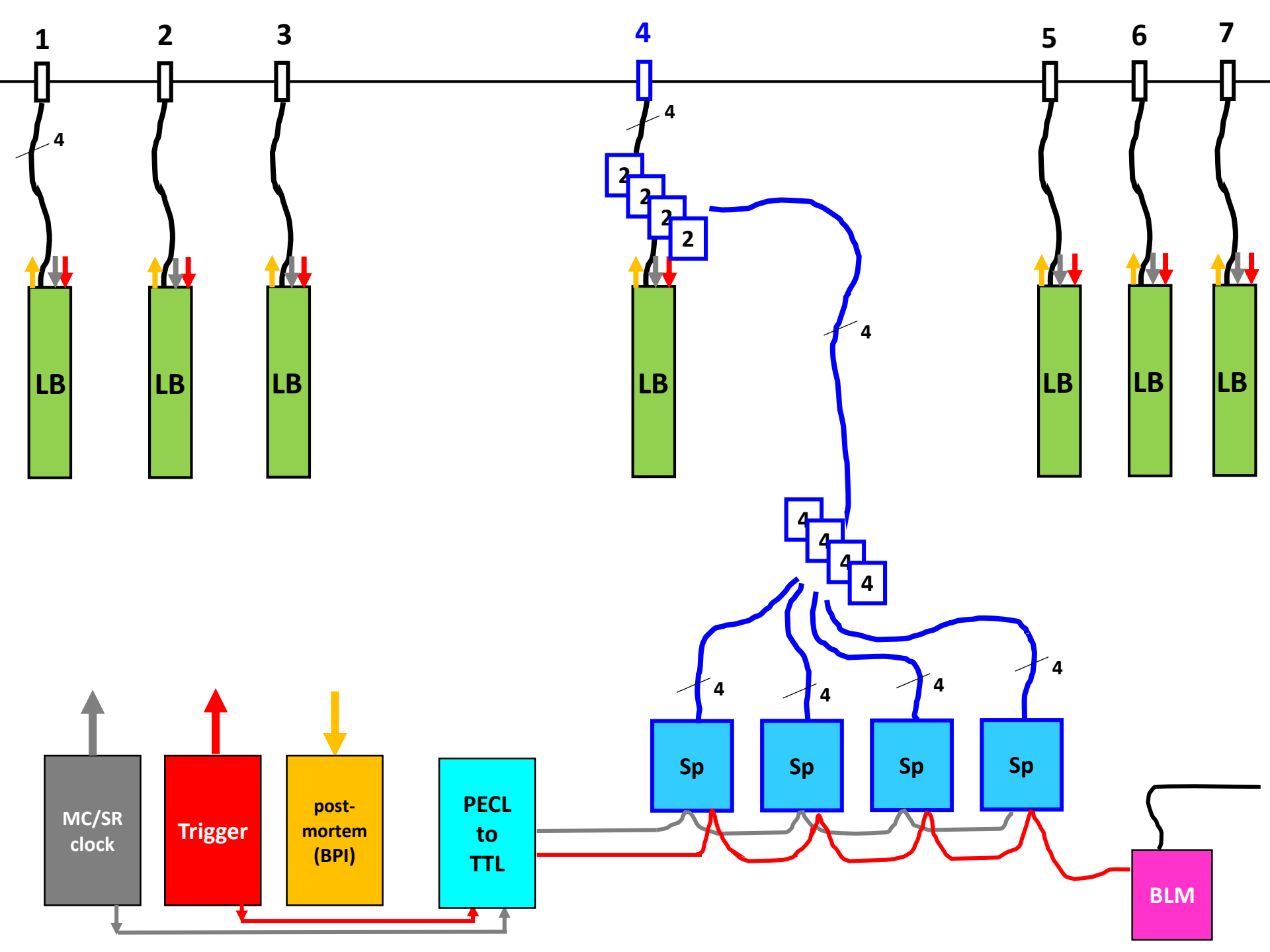
install in same cubicles where they remain for operation in 2020
install & use the timings signals & network connections, as for 2020

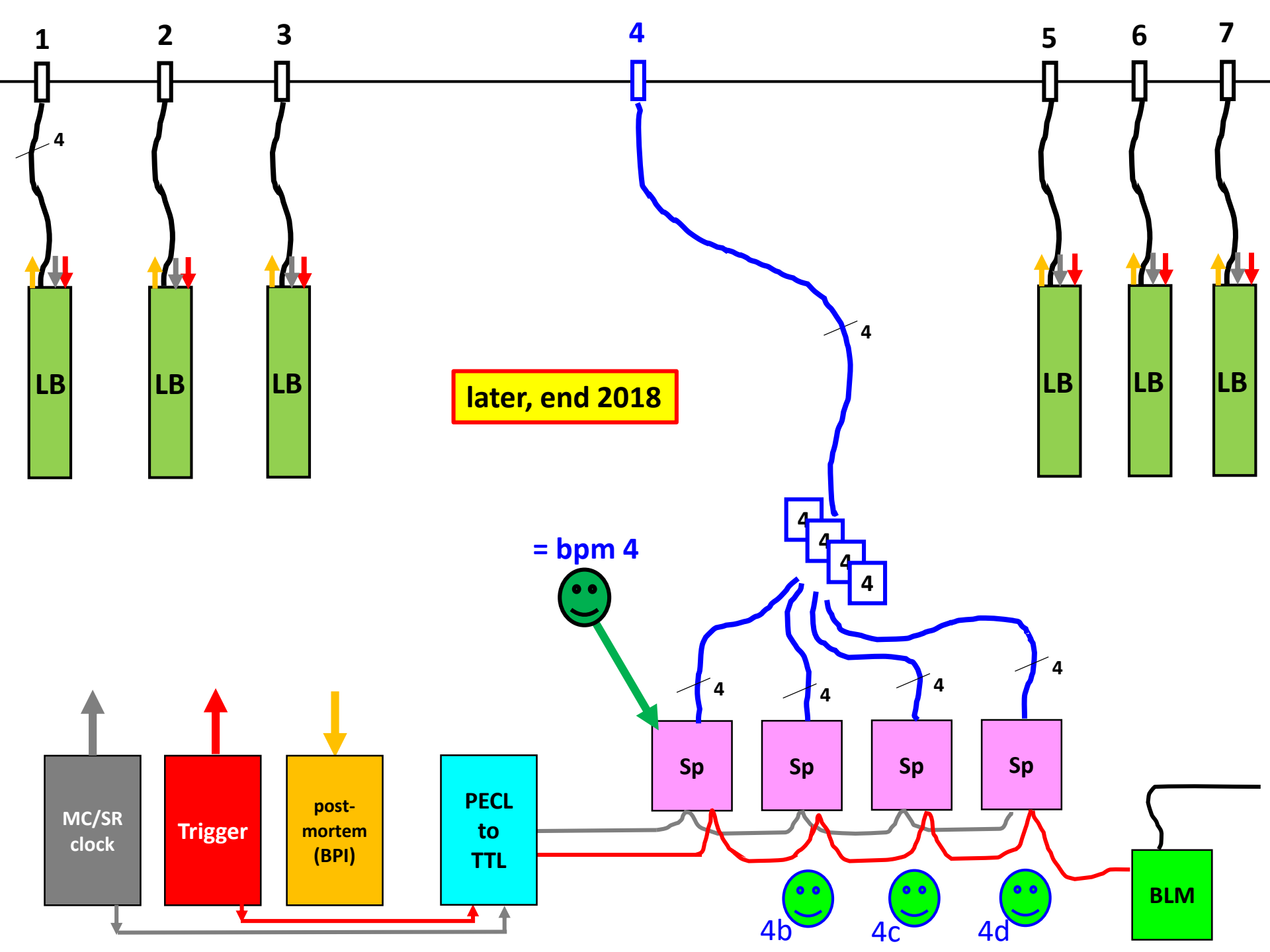
permanent test of software reliability & communication aspects
develop and test the higher level applications

} **job done in 2018 !!**
**impossible in 2019**
**difficult in 2020**


BPM blocks
1
2
3
4
5
6
7
4
RF-cables
LB
LB
LB
LB
LB
LB
LB
network-cables
FA-cables (not complete)
7
7
7
MC/SR clock
Trigger
post-mortem (BPI)


1
2
3
4
5
6
7
4
LB
LB
LB
LB
LB
LB
LB
MC/SR clock
Trigger
post-mortem (BPI)
PECL to TTL
Sp
Sp
Sp
Sp
network-cables
BLM


1
2
3
4
5
6
7
4
LB
LB
LB
LB
LB
LB
LB
2
2
2
2
4
4
4
4
4
4
4
4
Sp
Sp
Sp
Sp
MC/SR clock
Trigger
post-mortem (BPI)
PECL to TTL
BLM


1
2
3
4
5
6
7
LB
LB
LB
LB
LB
LB
later, end 2018
= bpm 4
Sp
Sp
Sp
Sp
MC/SR clock
Trigger
post-mortem (BPI)
PECL to TTL
BLM
4b
4c
4d

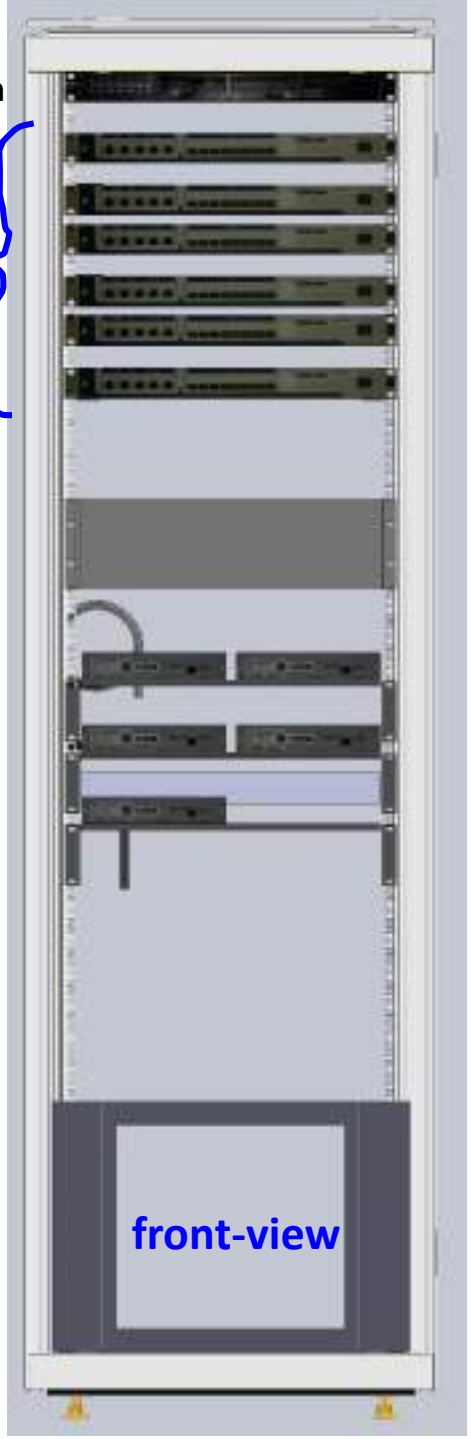
network-switch

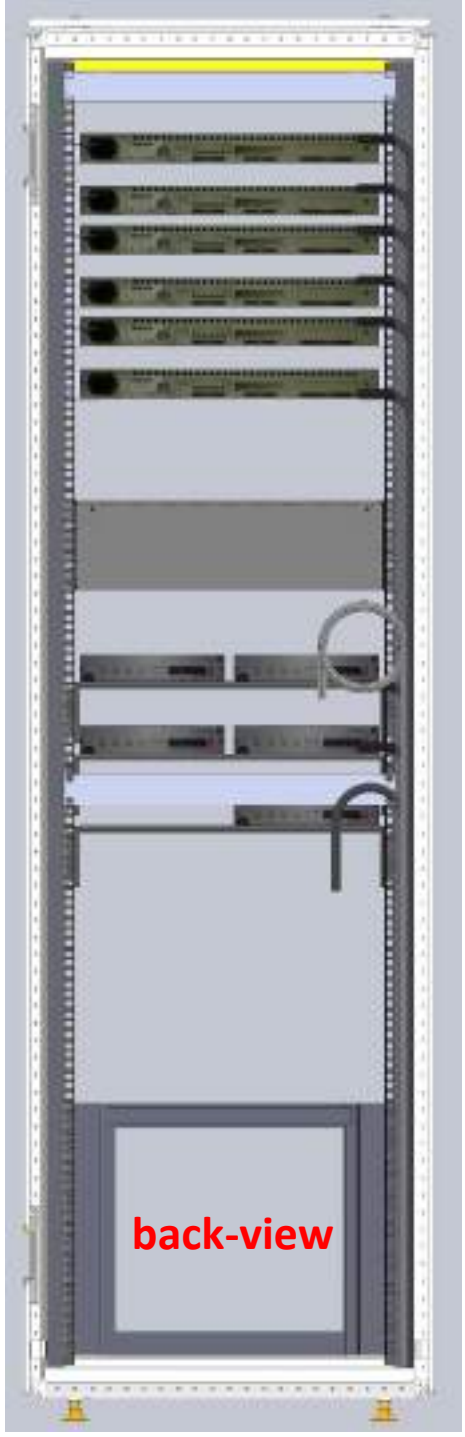
Liberas

timing-rack

4 Sparks

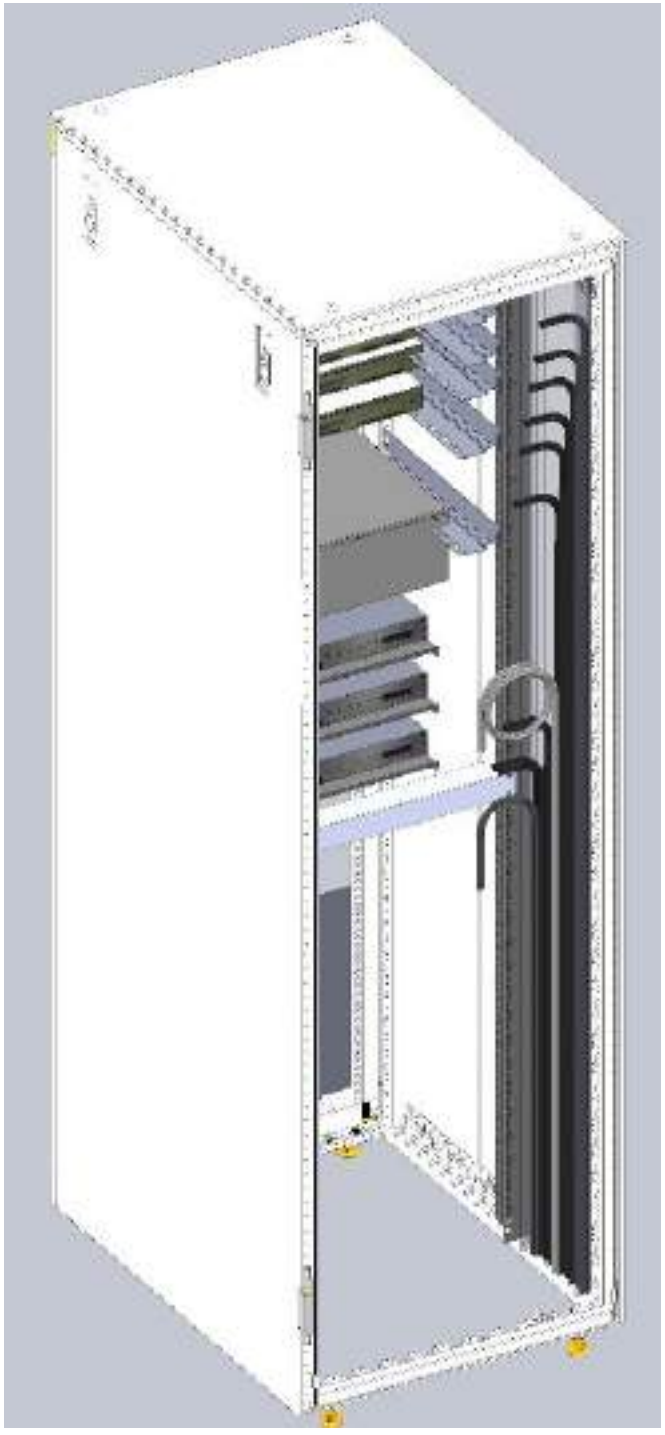
1 BLM

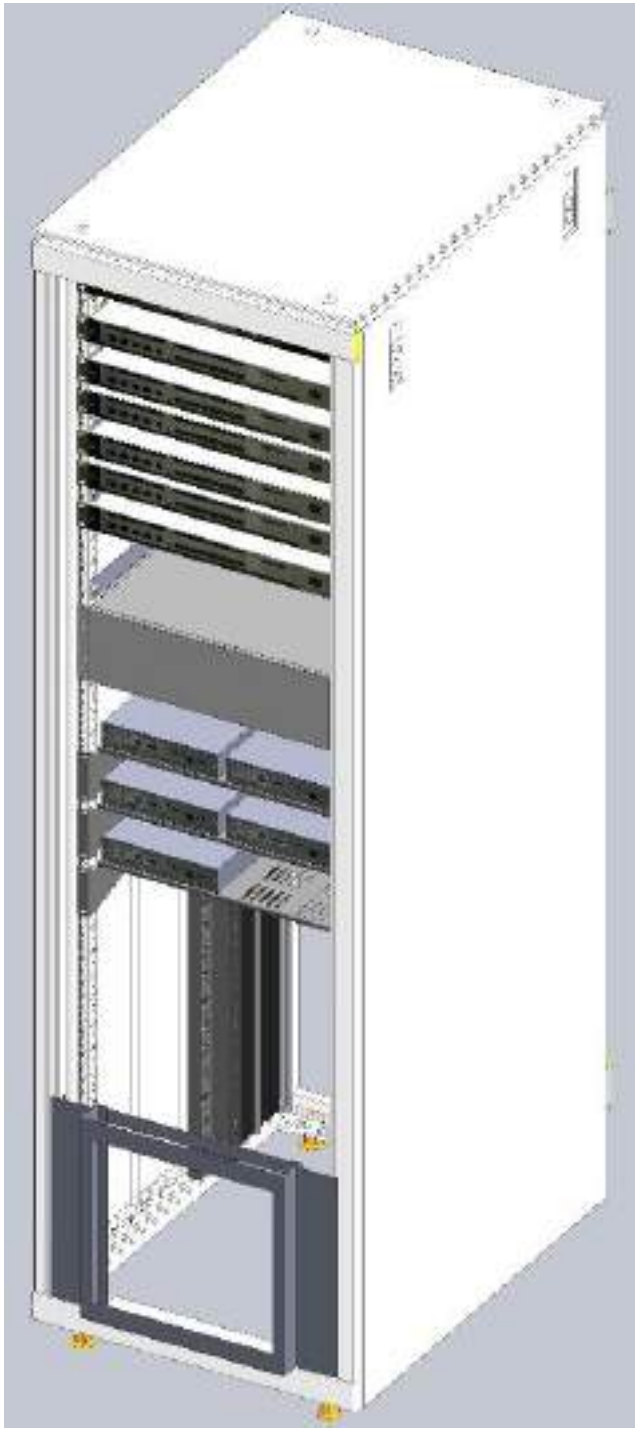


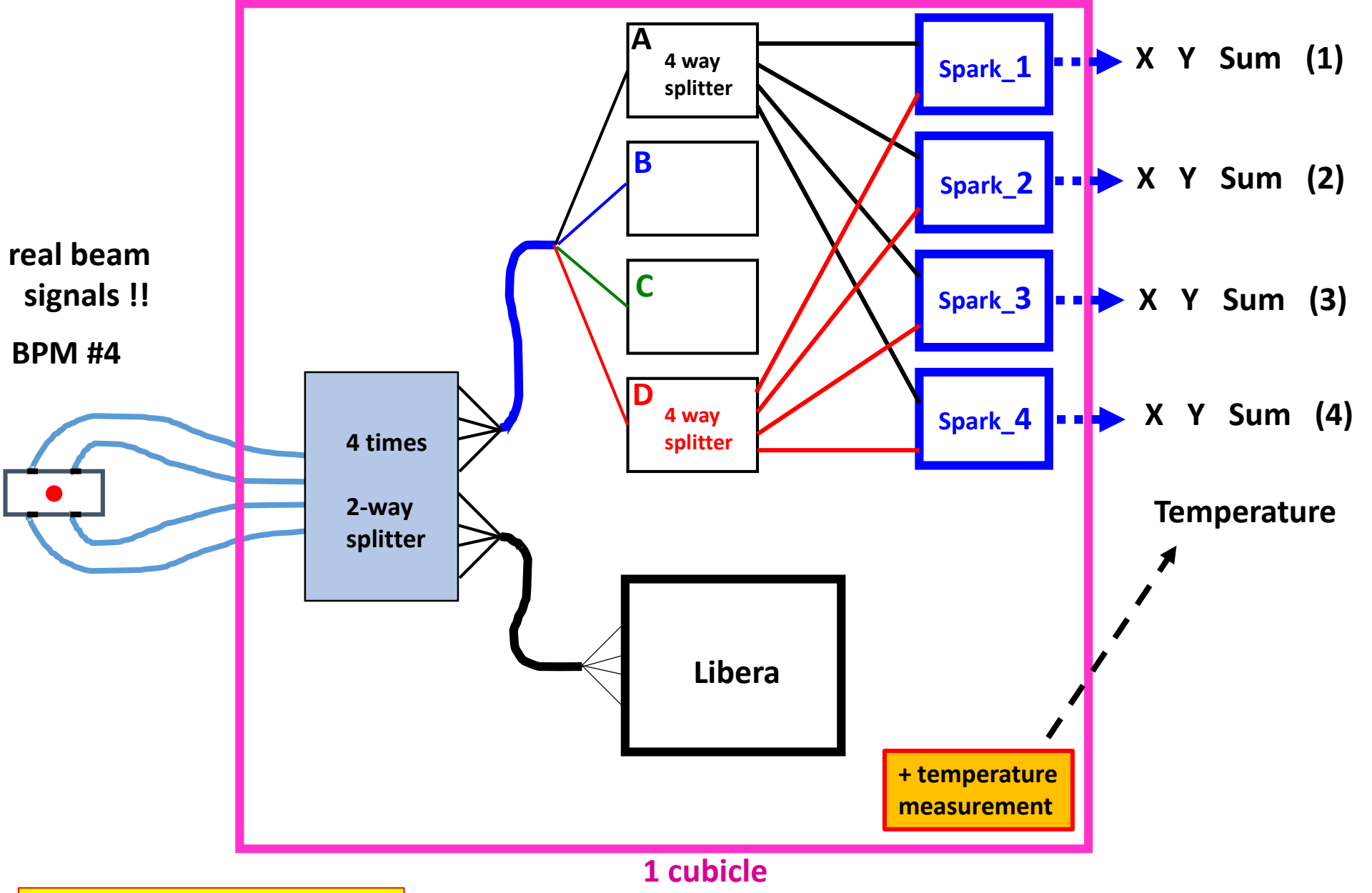




**Cubicle with :**

| | |
|---|---|
| **Liberas** | **7 later 6** |
| **Sparks** | **4** |
| **BLM** | **1** |





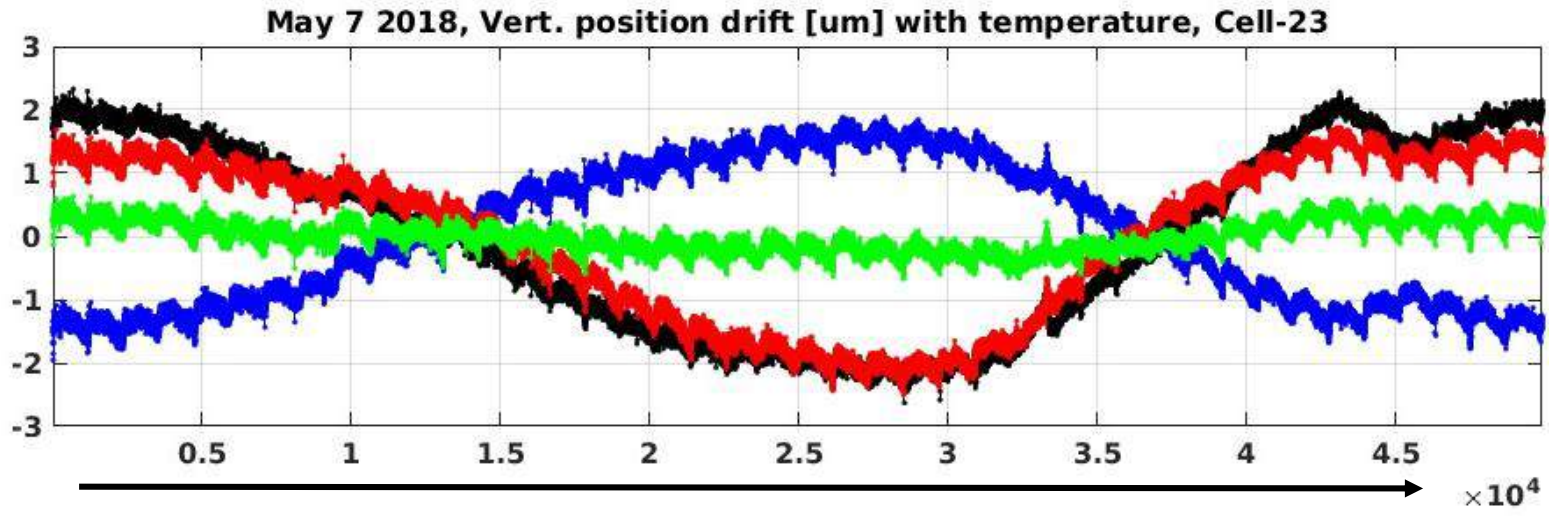



todays state (May 2018) :
22 cells operational = 88 Sparks
so still 10 cells more to do

**analysis of SA-data (40Hz) stored at 1Hz rate in our database, pulled-out & scrutinized by specific routines & scripts**

**results and observations :**

- **stability with temperature**
- **stability over time (long-term drift, typ. 10-24hrs)**
- **short-time stability (typ. a few minutes)**
- **features / aberrations**
- **global reliability**



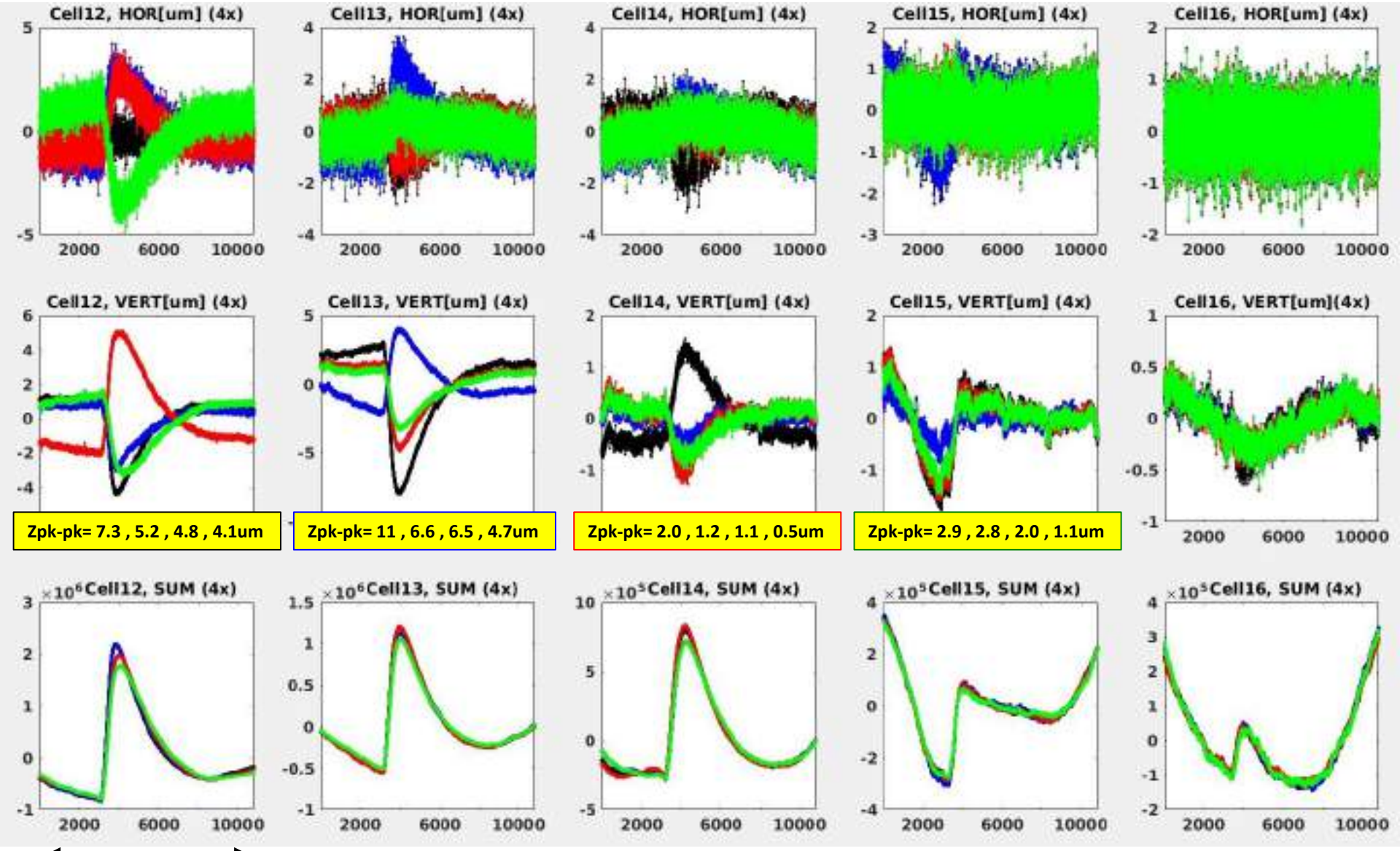

**time, total record=14hrs**

$T_{pk-pk}$= 2.6 C

$T_{pk-pk}$= 1.2 C

$T_{pk-pk}$= 1.0C

$T_{pk-pk}$= 0.6 C




Zpk-pk= 7.3 , 5.2 , 4.8 , 4.1um

Zpk-pk= 11 , 6.6 , 6.5 , 4.7um

Zpk-pk= 2.0 , 1.2 , 1.1 , 0.5um

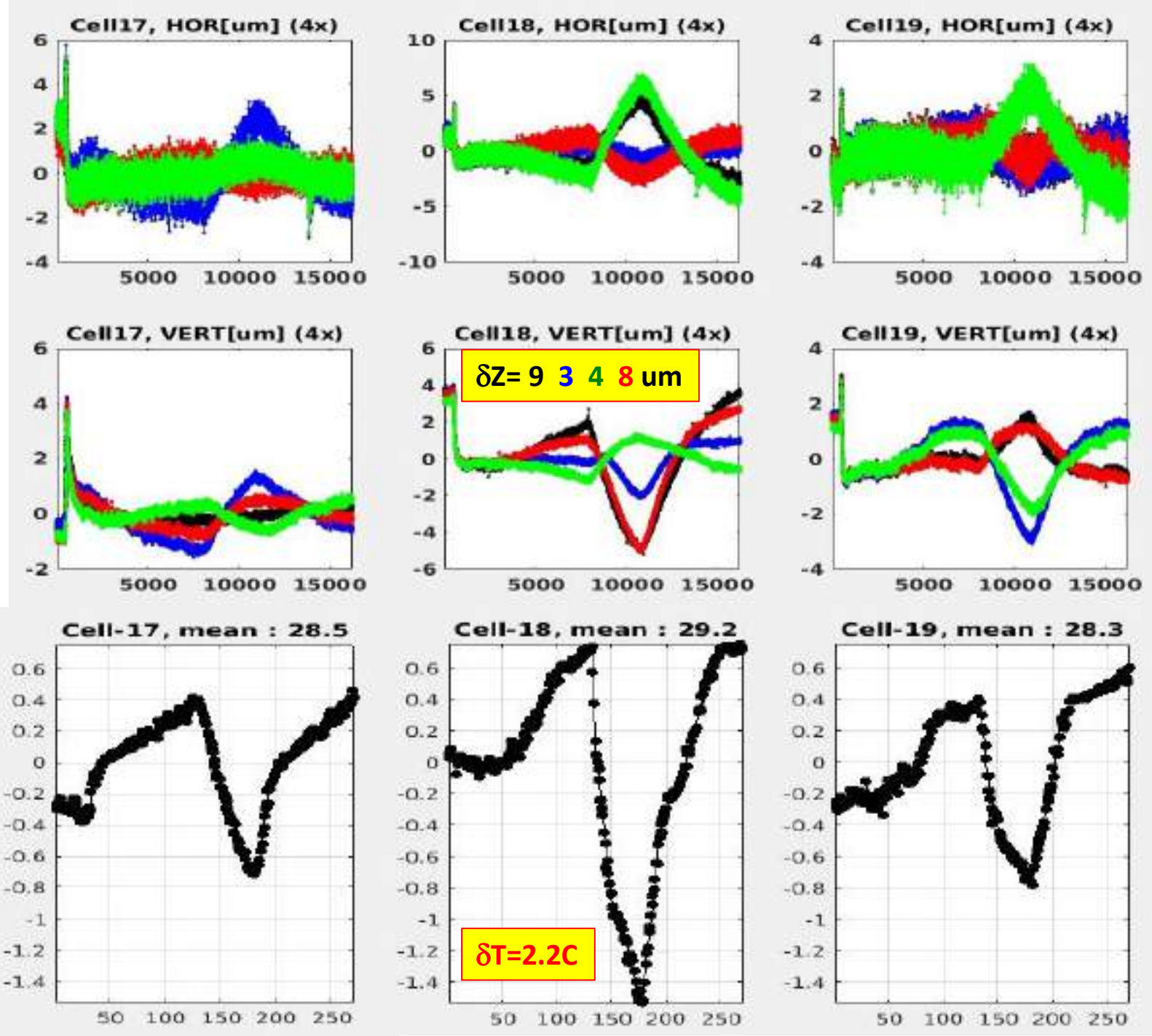
Zpk-pk= 2.9 , 2.8 , 2.0 , 1.1um

3hrs

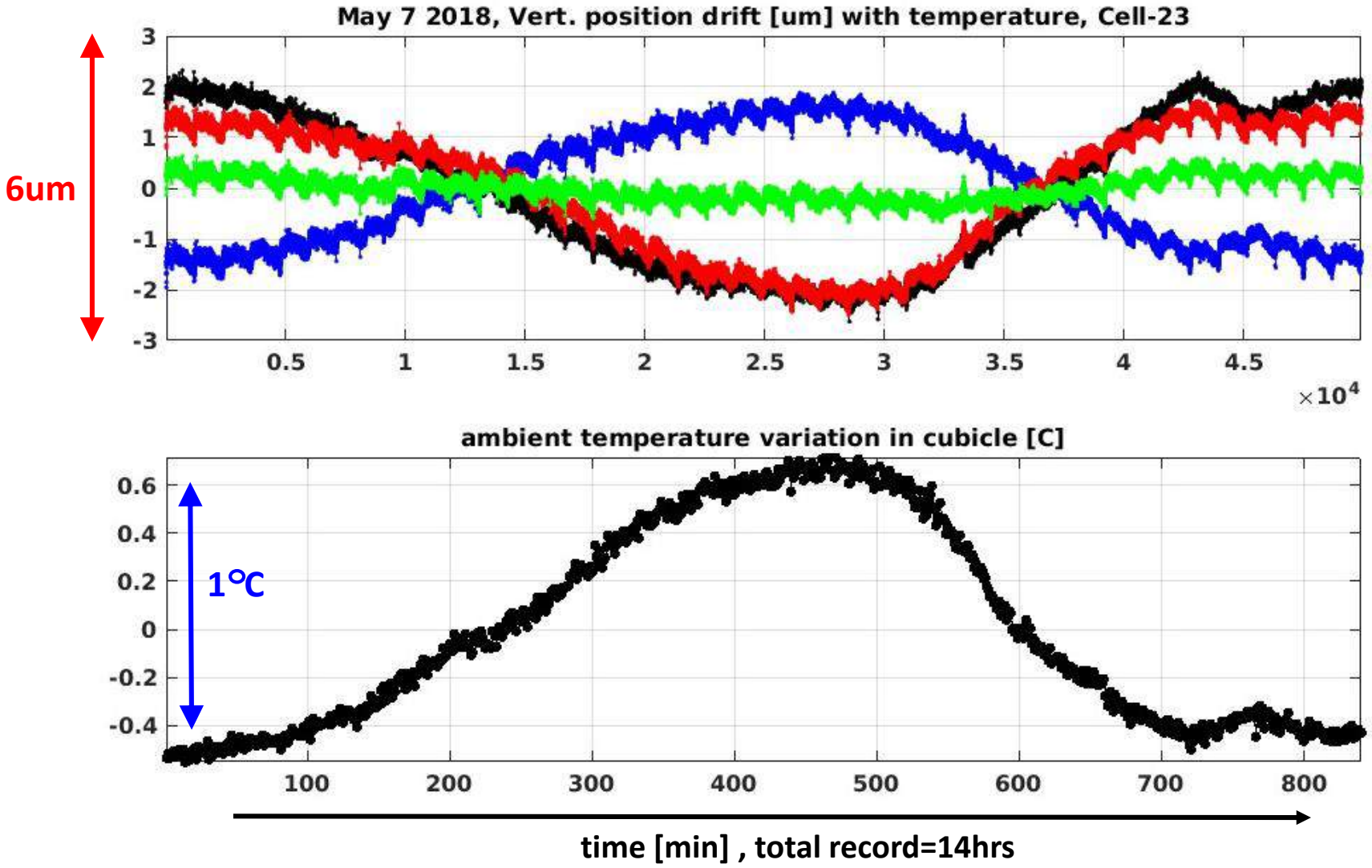
vert. is worse than hor. ?

average temperature drifts (vert.) : 2.1 , 6.0 , 1.2 , 3.7 um/C

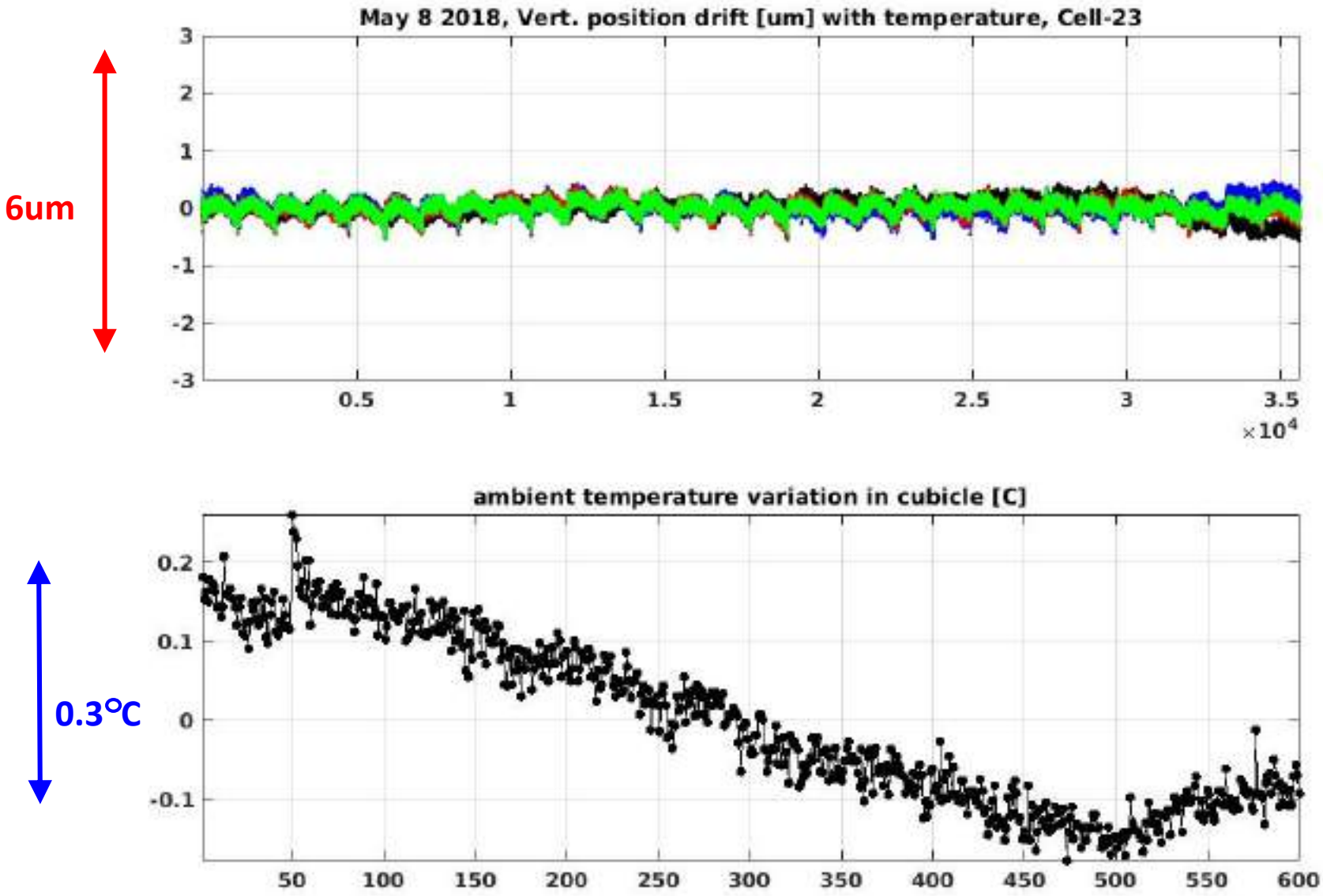
**reminder : stab/temp. specification of Spark = 3um/C**



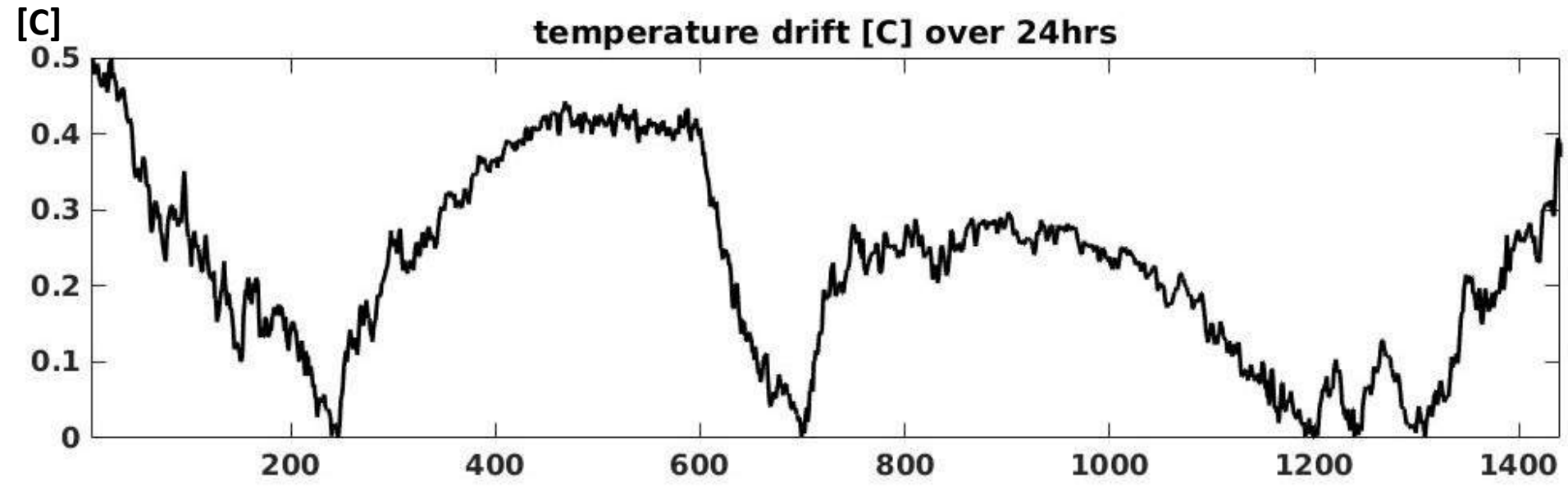
**strong** temperature fluctuations in the cubicles → **difficult** to assess the **long-term stability** i.e. **independent of temperature**



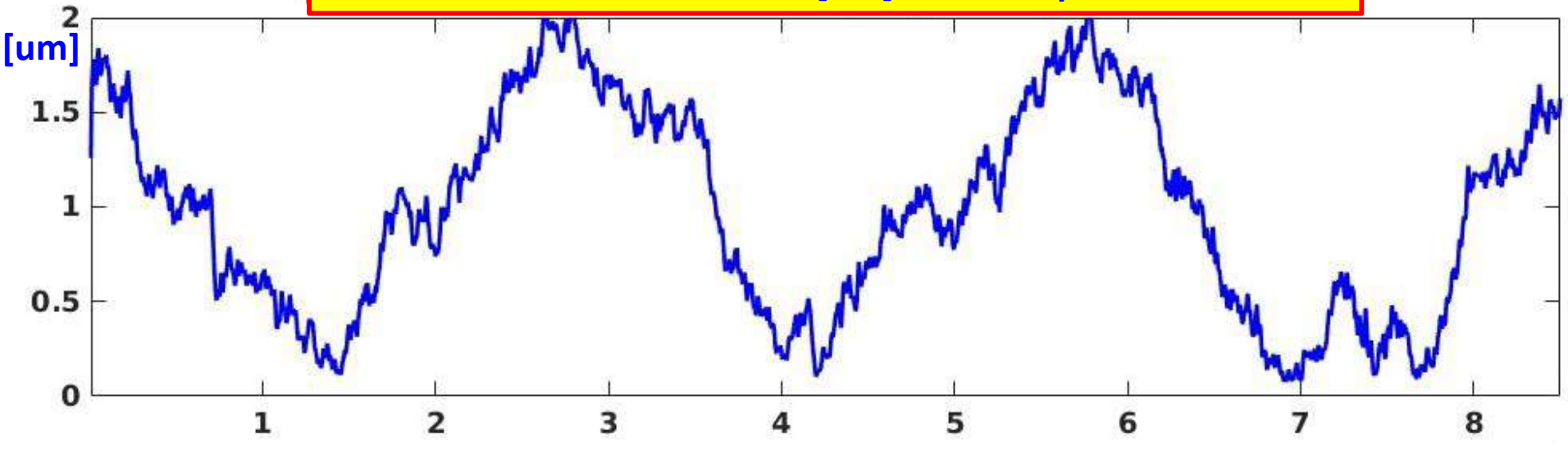
**weaker** temperature fluctuations in the cubicles → trying to assess the long-term stability i.e. independent of temperature



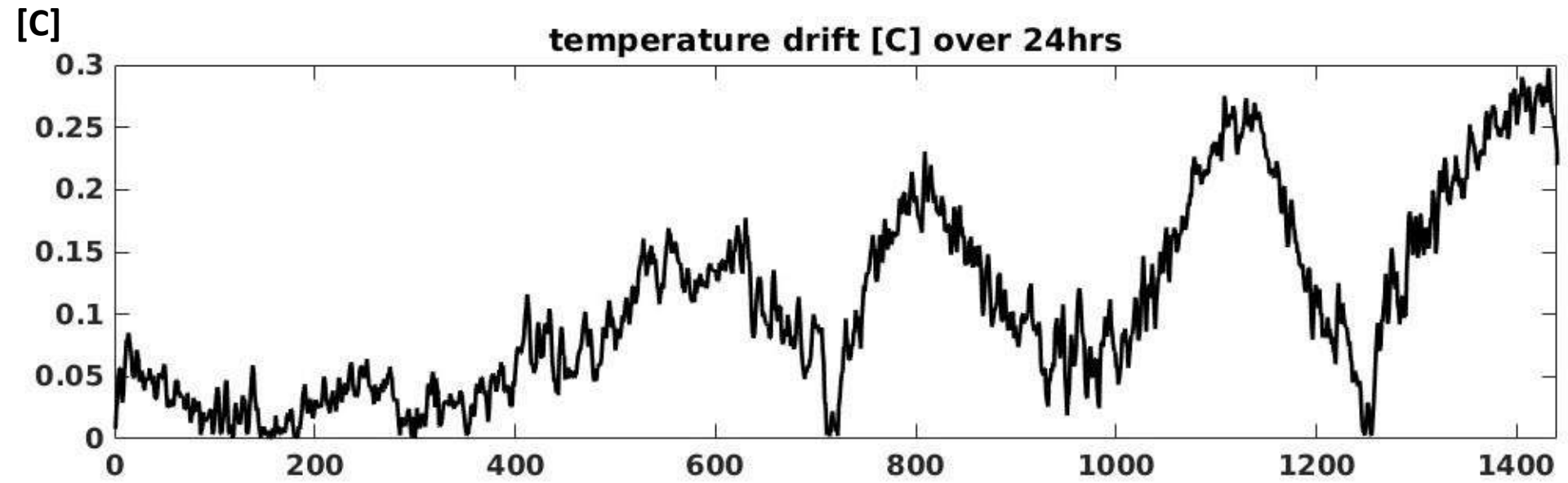
**strong** temperature fluctuations → **difficult** to assess the long-term stability
in the cubicles i.e. independent of temperature

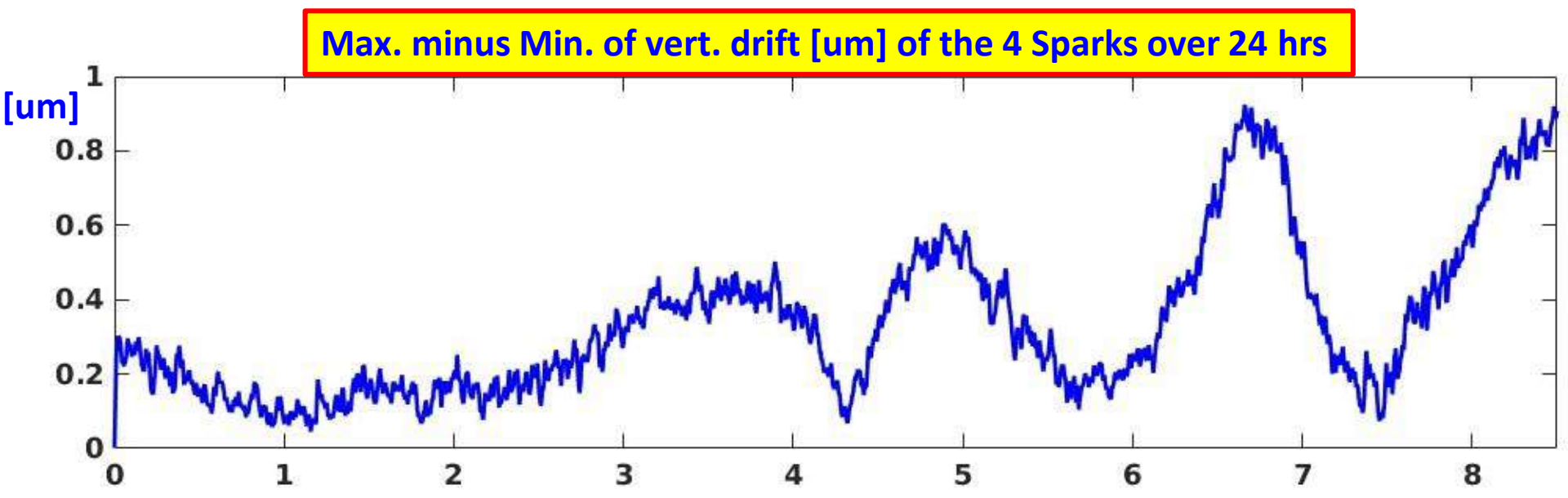



**Max. minus Min. of vert. drift [um] of the 4 Sparks over 24 hrs**

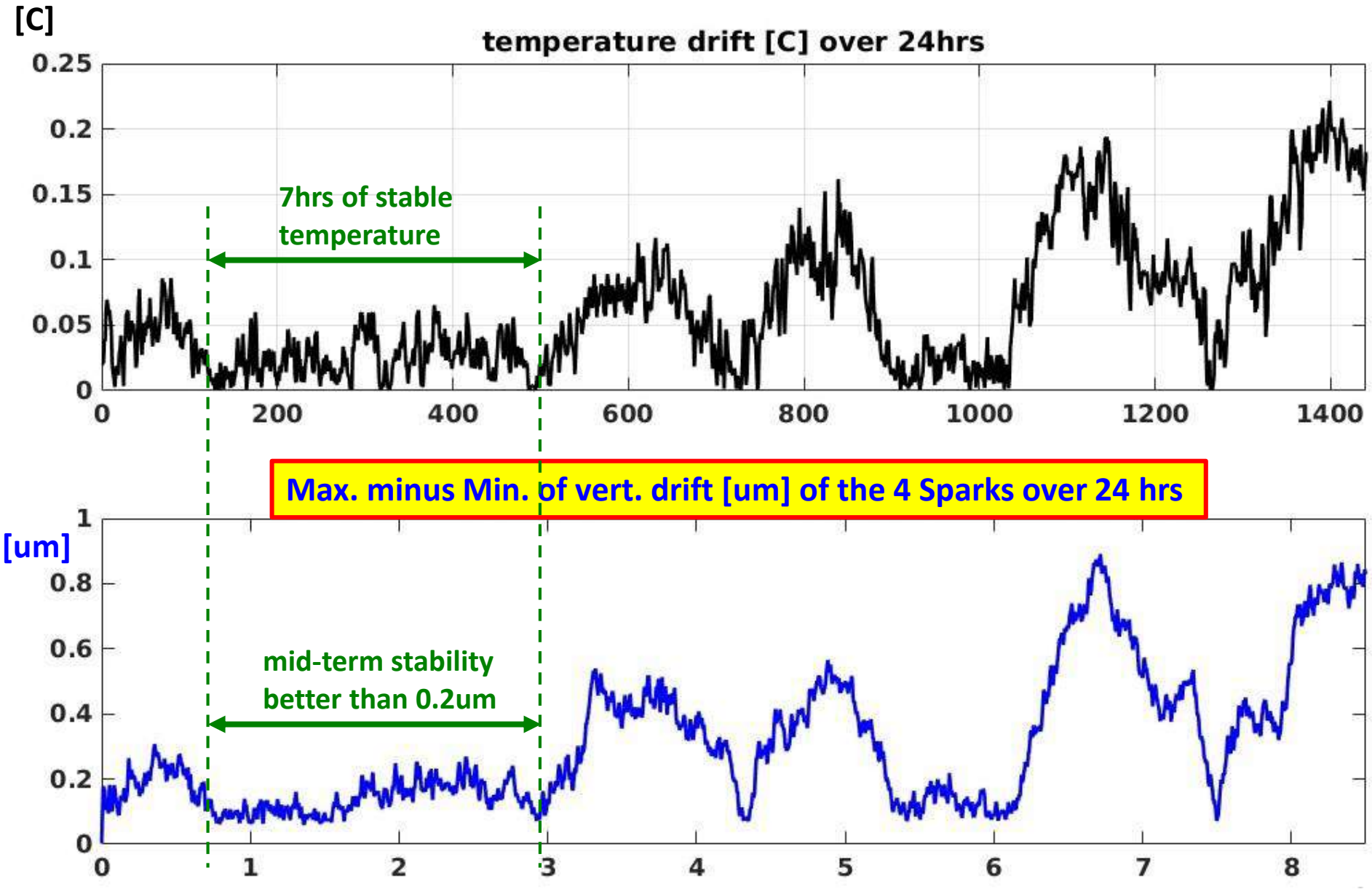


**weaker** temperature fluctuations in the cubicles → trying to assess the long-term stability i.e. independent of temperature



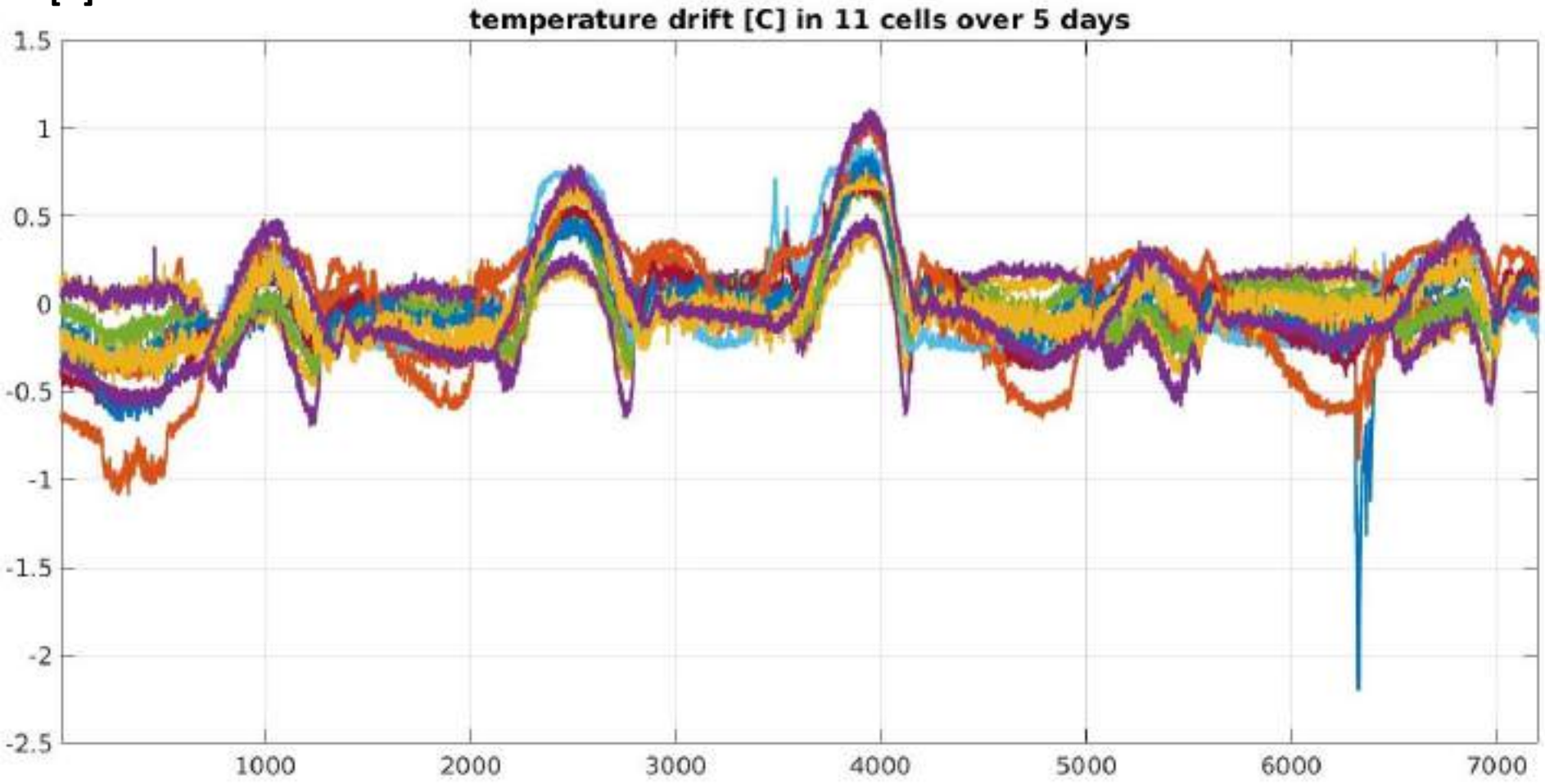



**weaker** temperature fluctuations in the cubicles → trying to assess the long-term stability i.e. independent of temperature



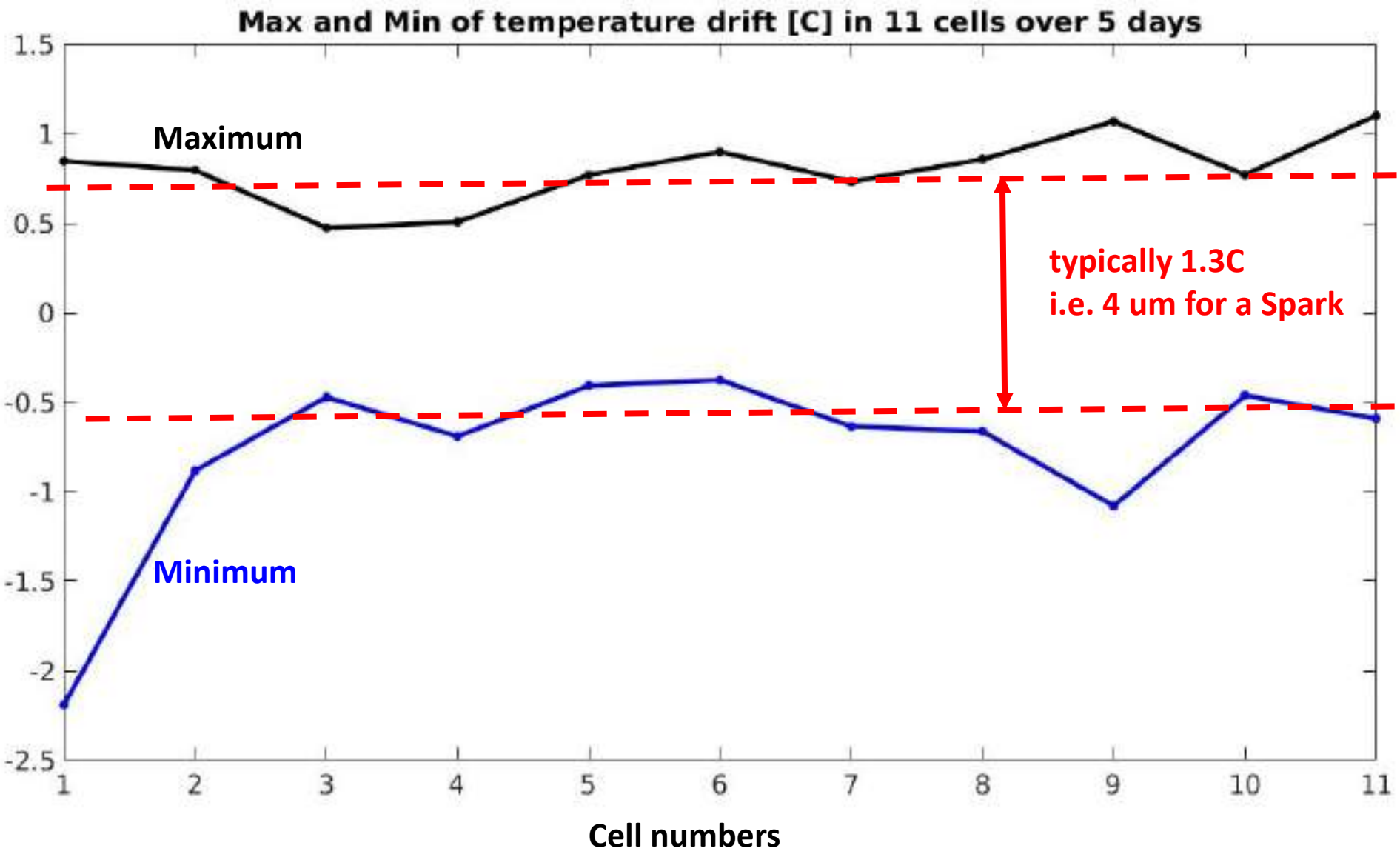
## 5 days temperature-drift recordings in the 11 cubicles

[C]




time, total record = 5 days

obviously ESRF needs better temperature stability in its cubicles



**first conclusions on :**

1) **Stability vs temperature :** **3um/C is respected :** **many much better, some a bit worse**

2) **Mid- Long- term stability :** **excellent, estimation is well below 1um**

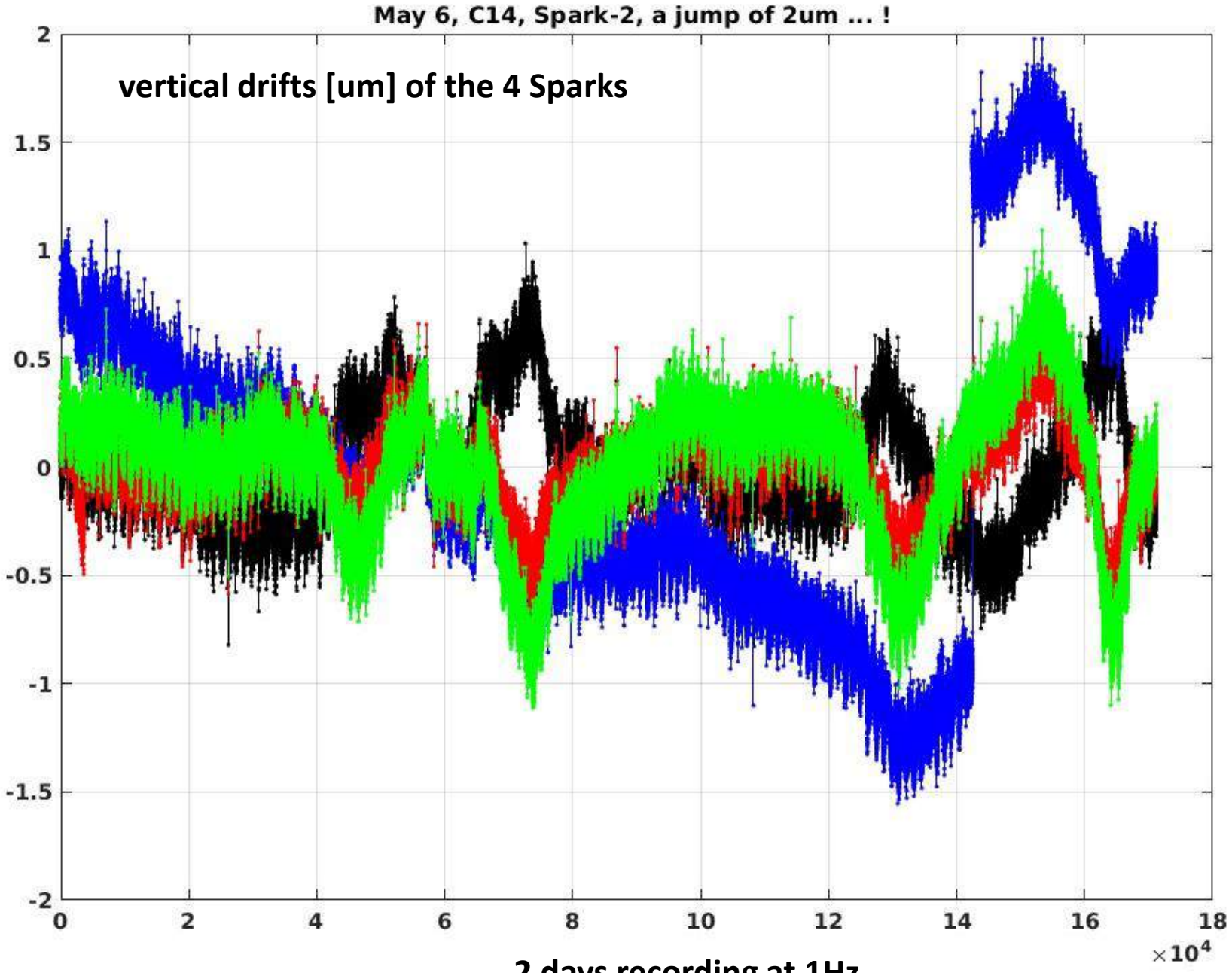
3) **Reliability :** **excellent**

   **incl. software :**
   **I-Tech Tango server inside device**
   **+ ESRF group-server**

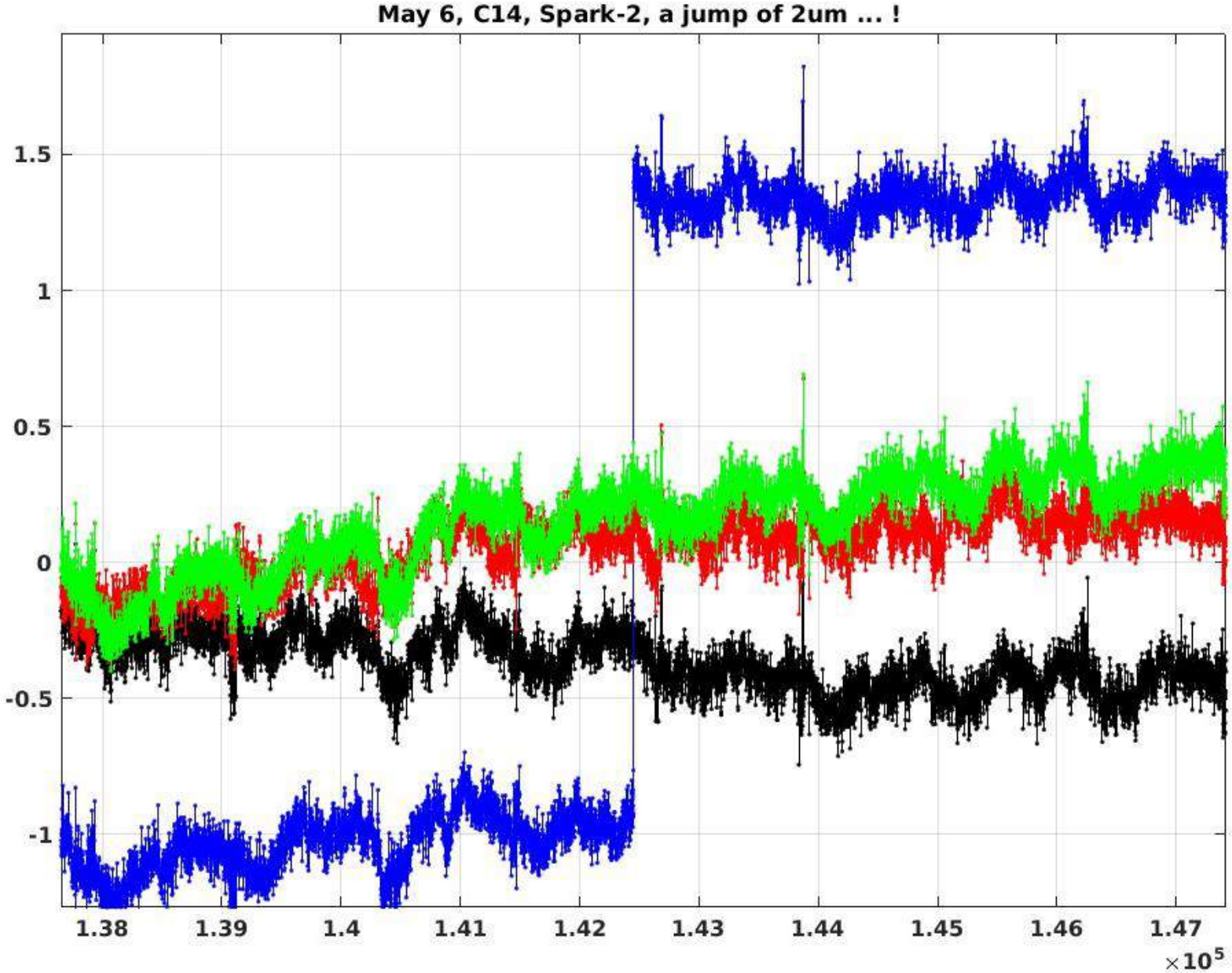
**for the ESRF (at present) : temperature drifts in cubicles dominate stability**
**→ we need to get a better control of that**

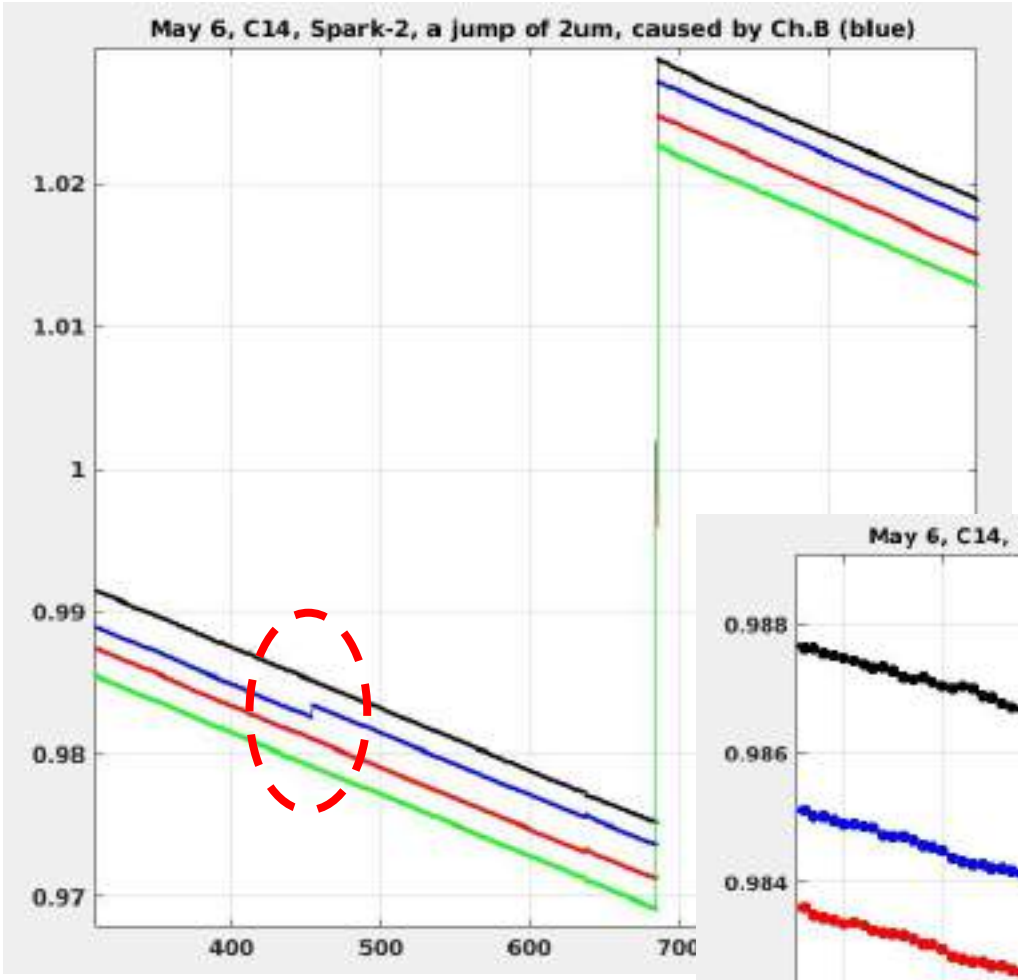
**then stability & reproducibility issues, <u>of the BPM-electronics</u>,**
**will all be minor & negligible, i.e. <1um**

**but there is a snake …**



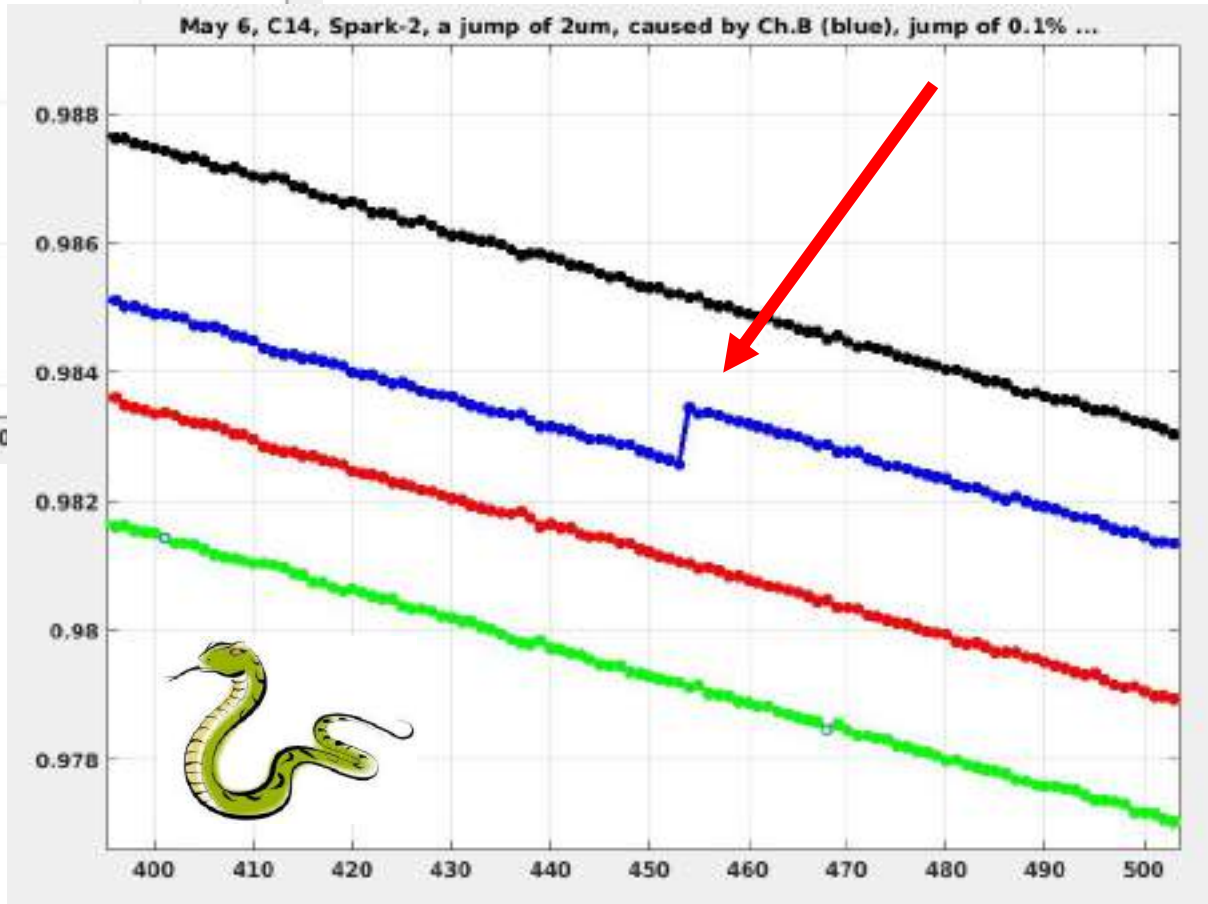

2 days recording at 1Hz

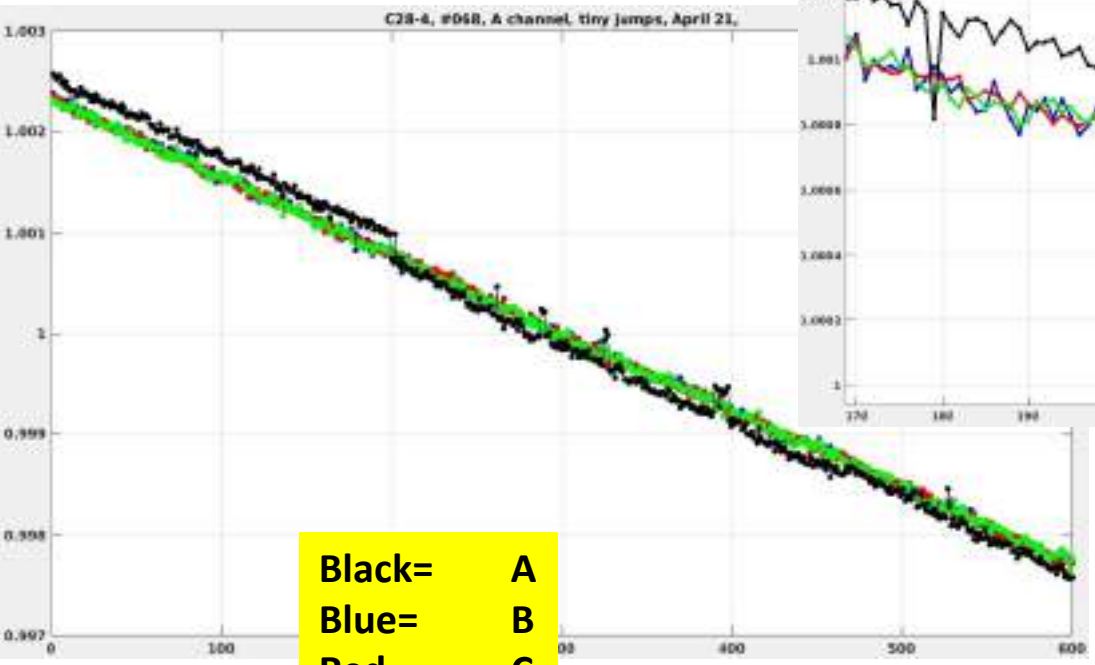

May 6, C14, Spark-2, a jump of 2um ... !
1.5
1
0.5
0
-0.5
-1
1.38
1.39
1.4
1.41
1.42
1.43
1.44
1.45
1.46
1.47
×10^5

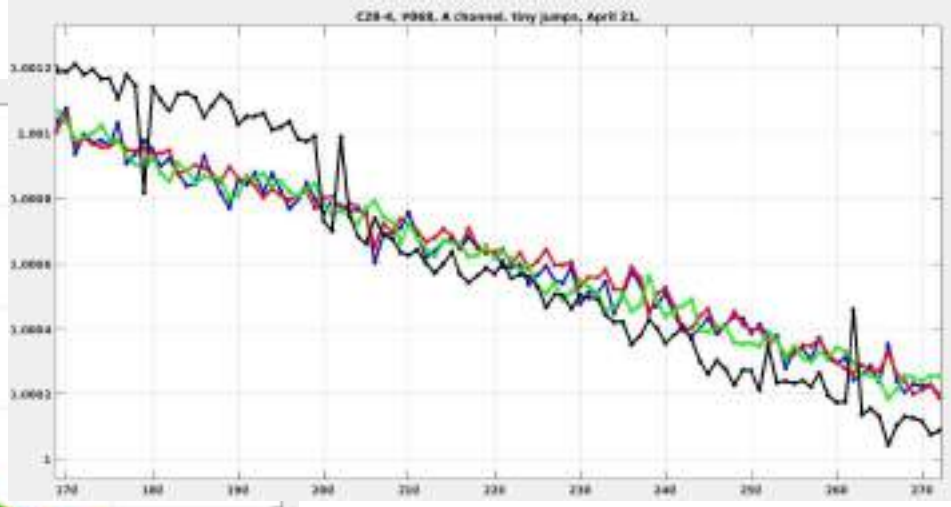



**then we look at the**
**A B C D data**
**of that Spark ….**

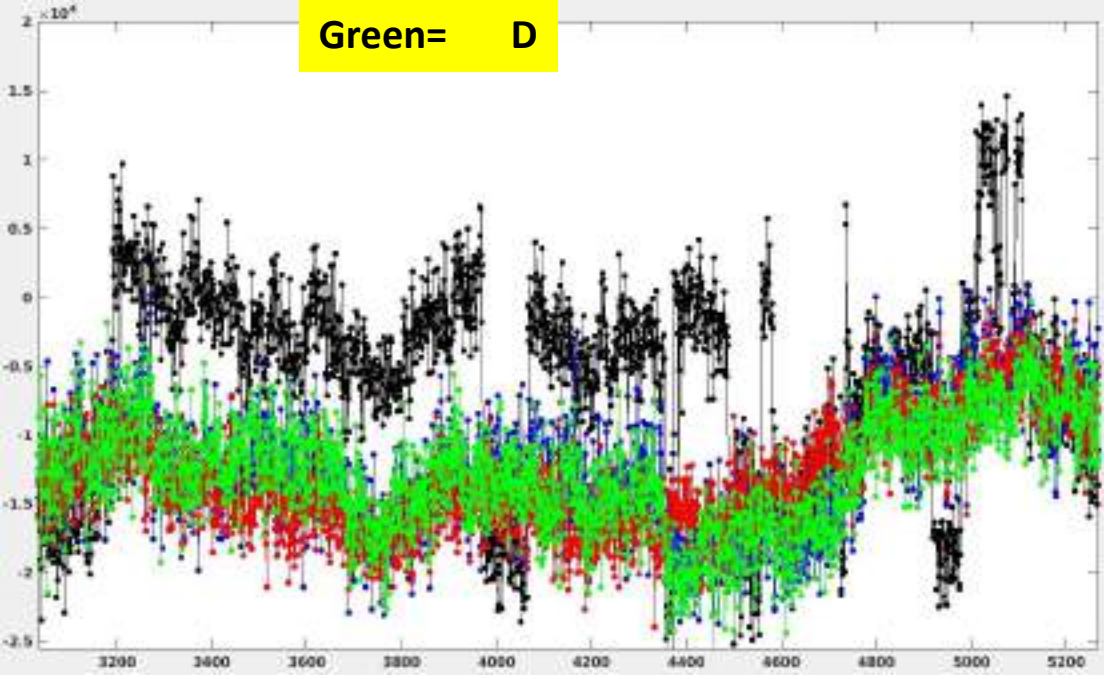
**0.1% jump at Ch. B**

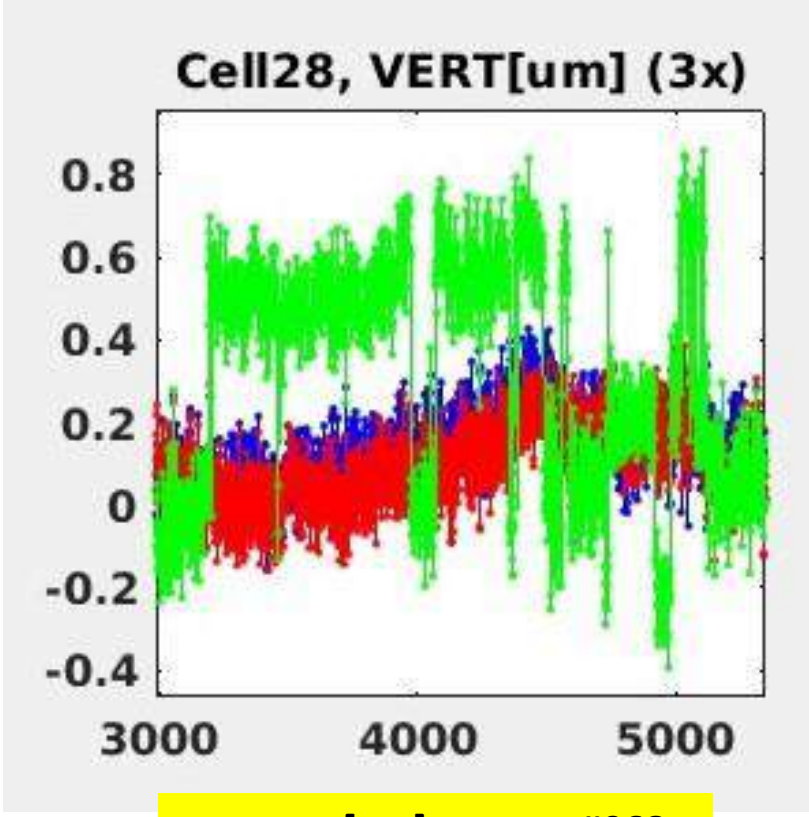




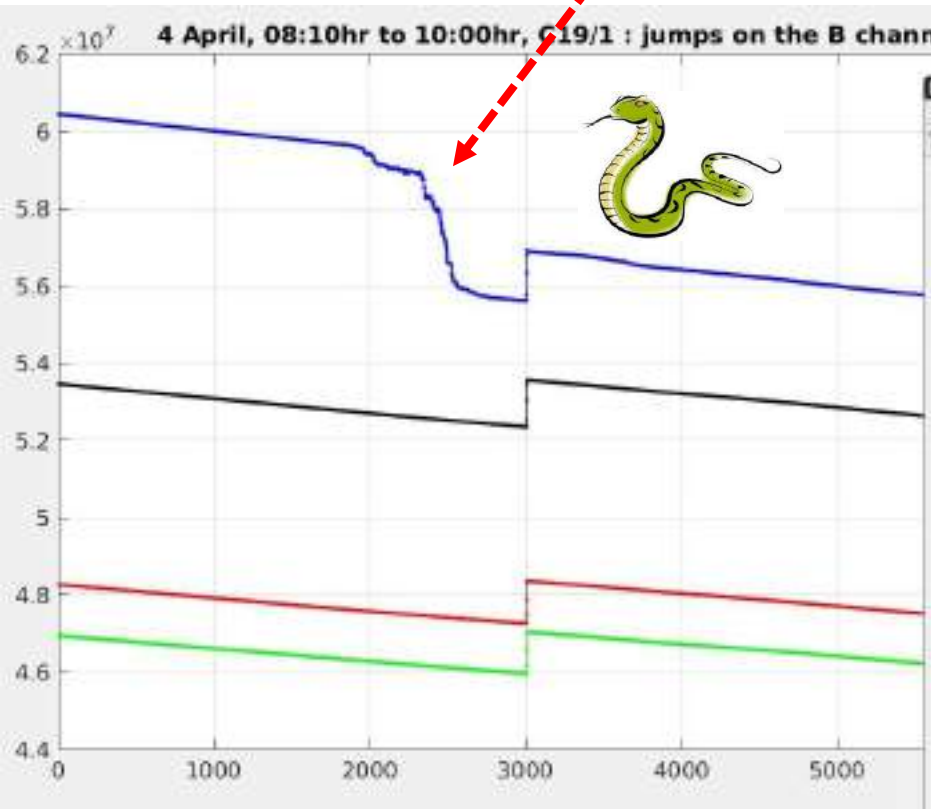

**Black= A**
**Blue= B**
**Red= C**
**Green= D**

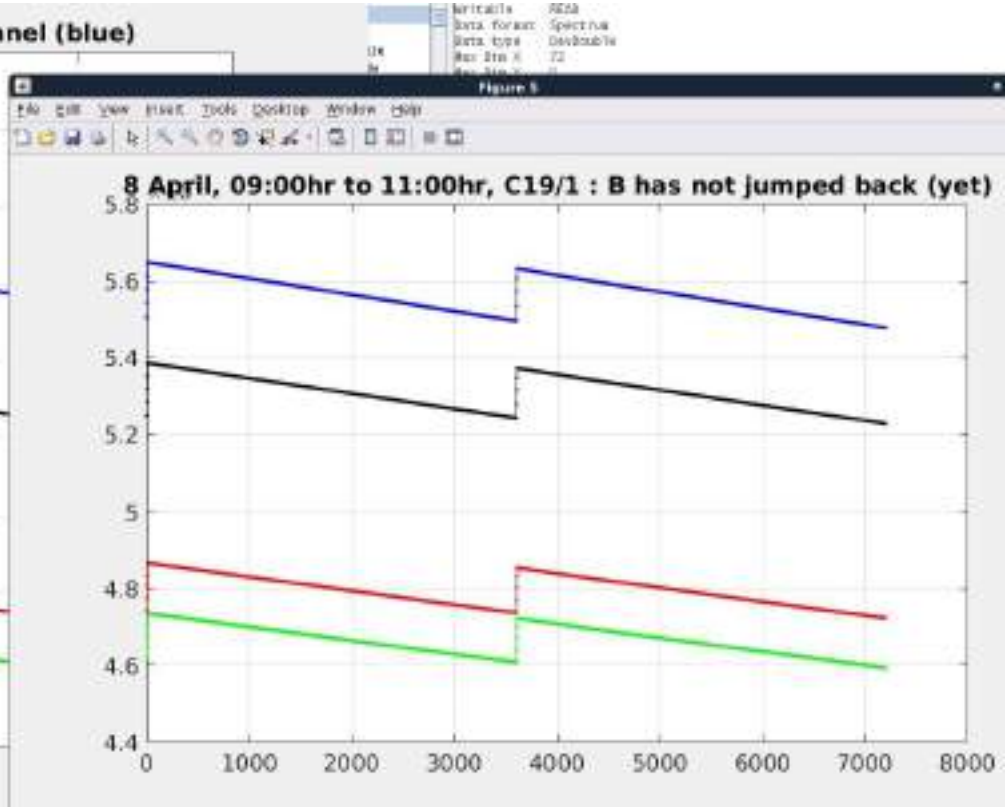




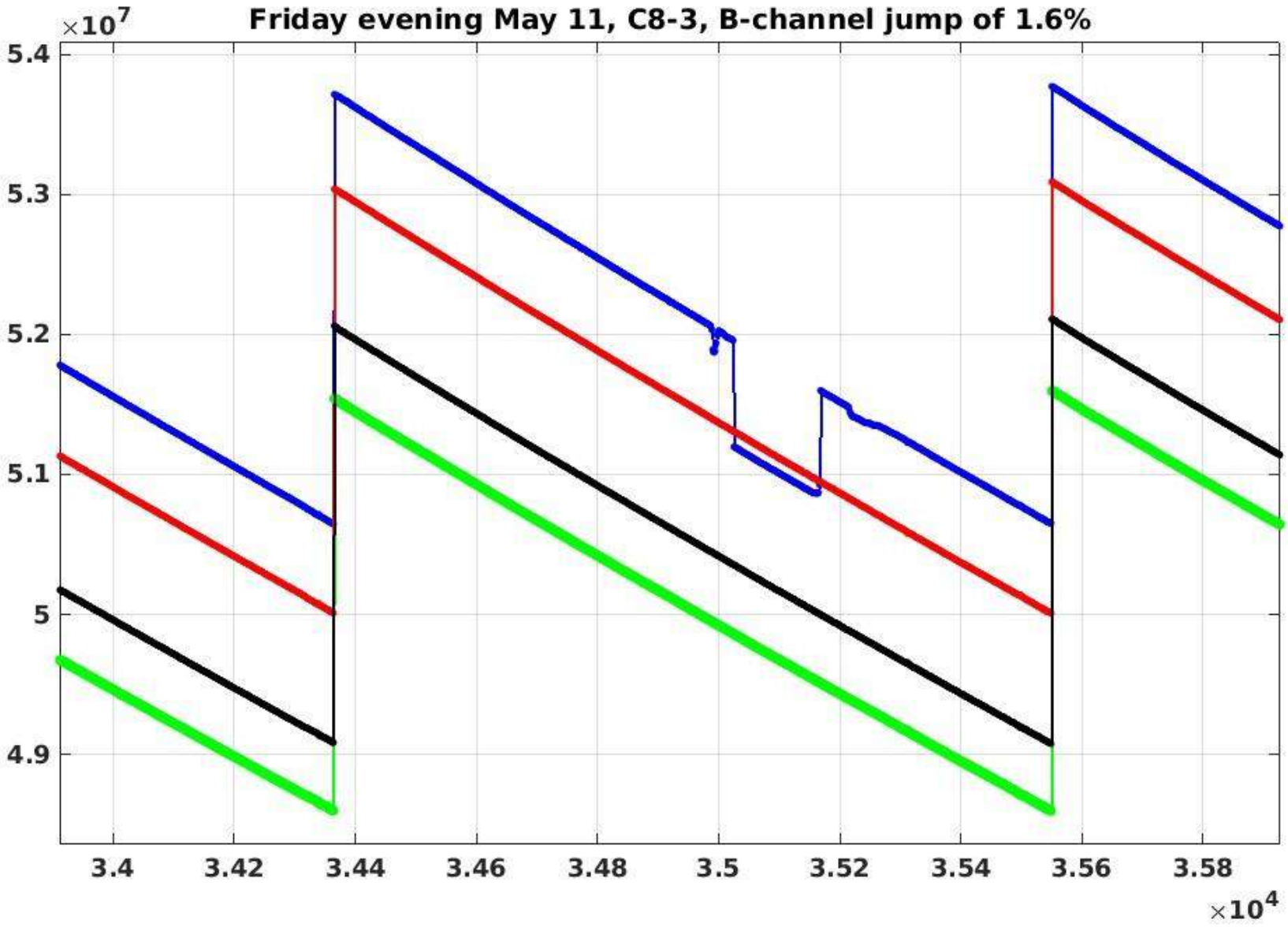

**vert. pos [um] : green=#068, blue & red are neighbours**

## 6% “jump” at Ch. B

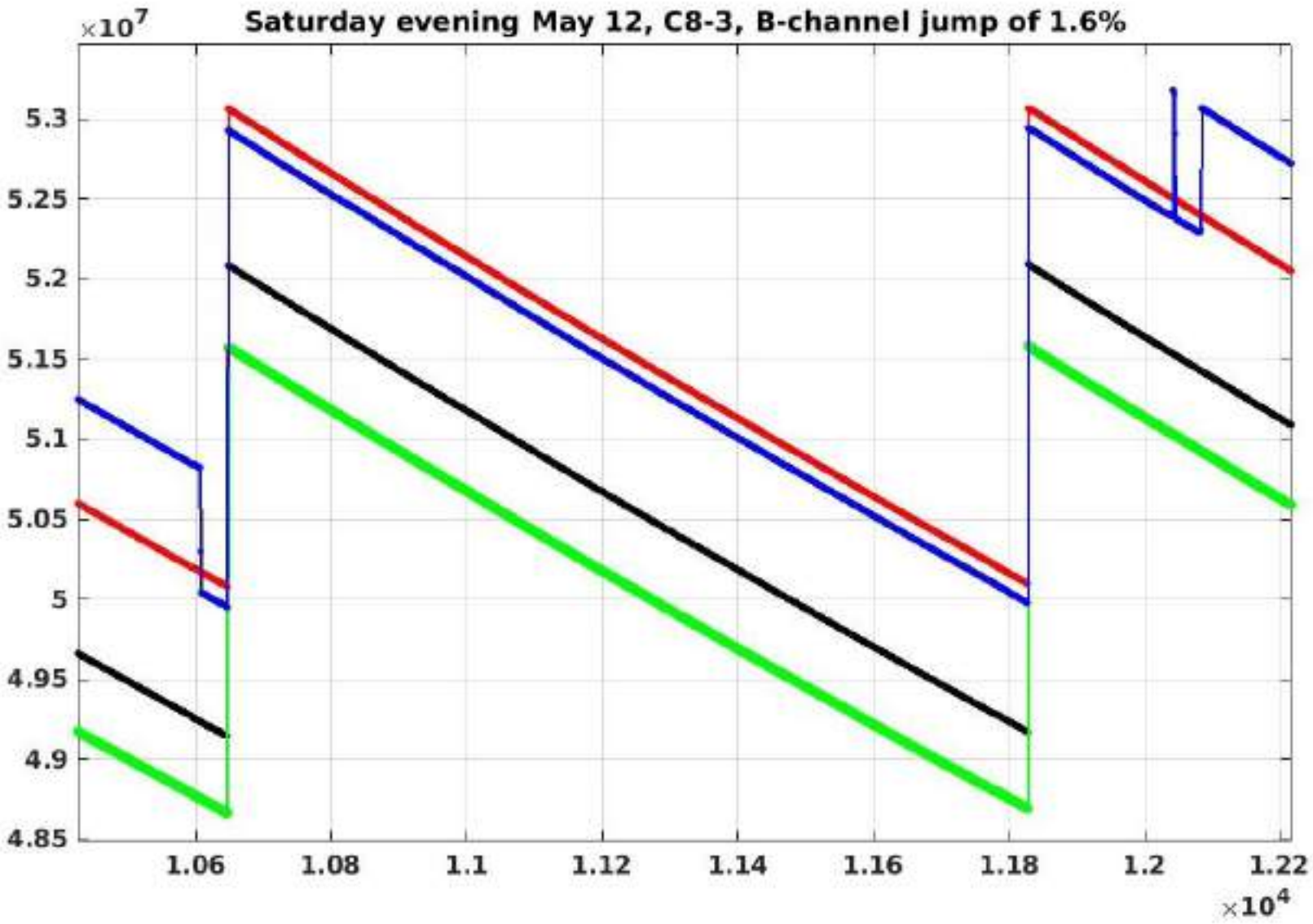

4 April, 08:10hr to 10:00hr, C19/1 : jumps on the B channel (blue)
×10^7
6.2
6
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
0
1000
2000
3000
4000
5000


8 April, 09:00hr to 11:00hr, C19/1 : B has not jumped back (yet)
5.8
5.6
5.4
5.2
5
4.8
4.6
4.4
0
1000
2000
3000
4000
5000
6000
7000
8000

**latest events (May 11), another unit ….**



**latest events, one day later, May 12, same unit ….**



- in total now : 88 Sparks in operation = 352 channels
- started in February with 20 Sparks, followed by progressive installation
- A B C D data stored at 1Hz

→ estimation of 4500 Spark · Days recordings
→ equals : 4500 x 24 x 3600 x 4 = **1.5 E9 samples**

we found about **8** "jumps" : twice on C14-2, Ch.**B**
twice on C8-3, Ch.**B**
and 4 other units (Ch.**A** or Ch.**B** …)

**only channels A or B … so far !**

these "jumps" are tiny or small (a um to 100um)

RF-splitters and/or RF-cabling an unlikely possible cause (but not 100% excluded)

how to deal with this ? :

**1) keep on checking in 2018**, some units may be removed/repaired

**2)** once with beam (2020 and beyond) any detection of these jumps will be difficult, i.e. to clearly distinguish from real beam motion, but **surveying** the **Q** * will allow to detect the worst ones

**3) trouble-shooting** the real cause by **the company, by lab tests & manipulations**

* **Q = A+C-B-D / (A+B+C+D)** → does NOT vary (much) with beam motion
→ but jumps when one channel jumps

**other (non-) features :**

**1)** for EBS the **BPM-interlocks** will (only) be dealt with by Liberas
i.e. NO implementation of interlocks in Sparks
same for **Post-Mortem buffers** : NONE in Spark

**None !**

**2) Gain / Attenuator control** :
NO AGC inside Spark (individually) → will be dealt with by external server/application
one common attenuator setting for each of the 4 channels (0 to 31 dB)

**Keep it Simple !**

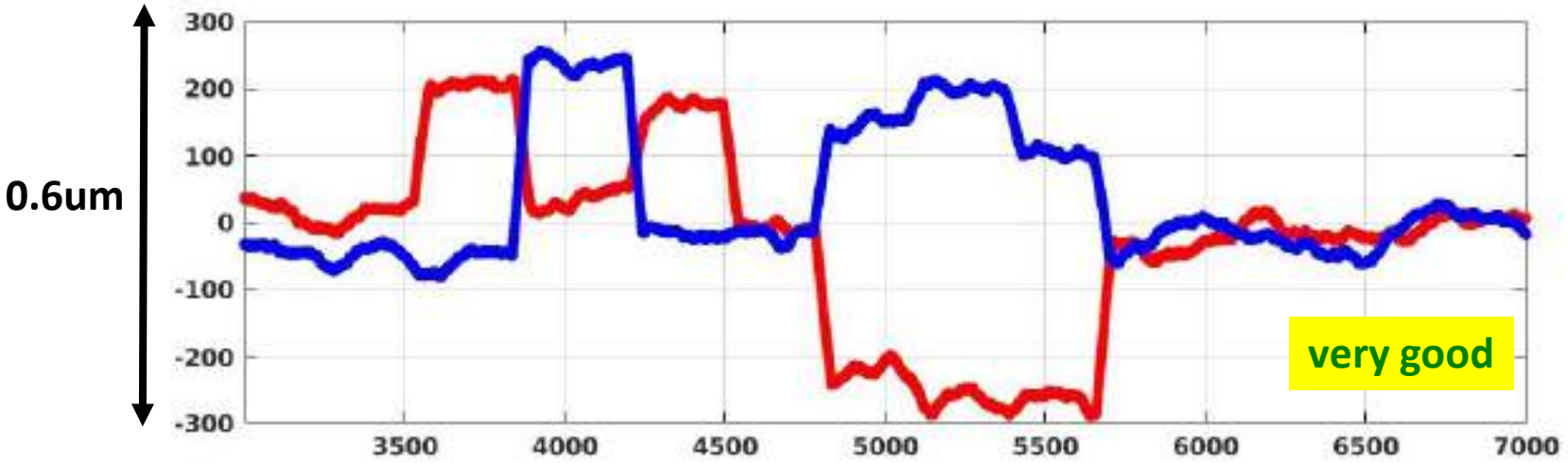
**3) minimizing steps/jumps** in position results when **changing attenuation**
**calibration feature** implemented :
is **simple** & **efficient** but requires **particular RF input signals**
how stable is this with time ?

**simple & efficient !**

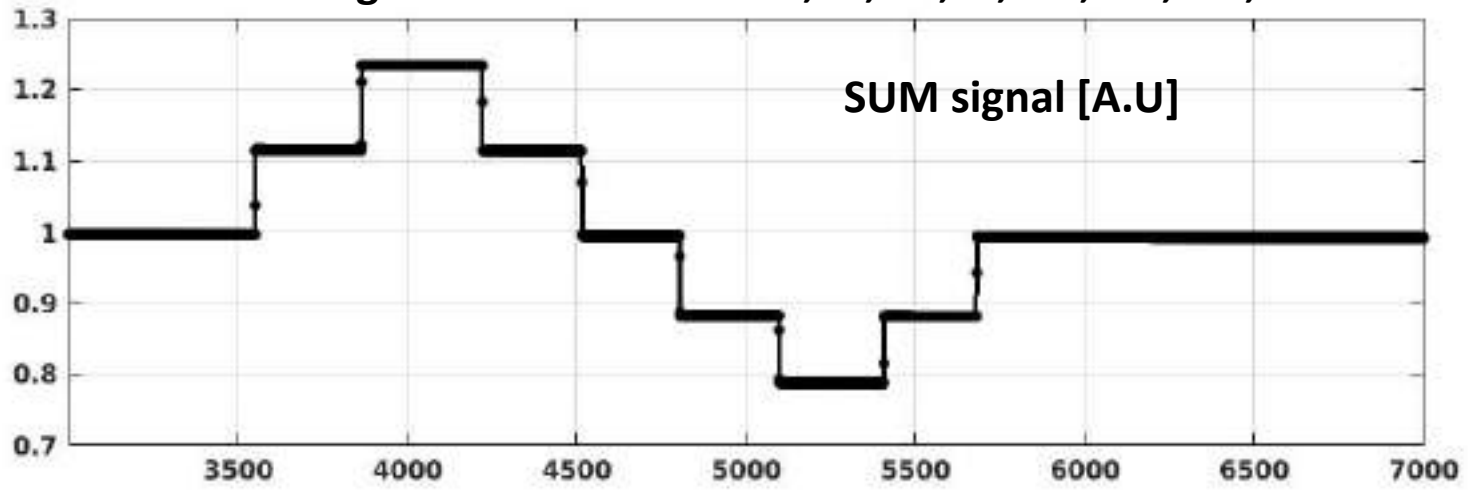
see next slides :
calibration data on all 4 x 32 attenuator settings were defined at SATs
we did NOT change (recalibrate) them, so let's see the effect now (months later)

**let's check ….**

2 units , among the best ones, vertical position [nm]



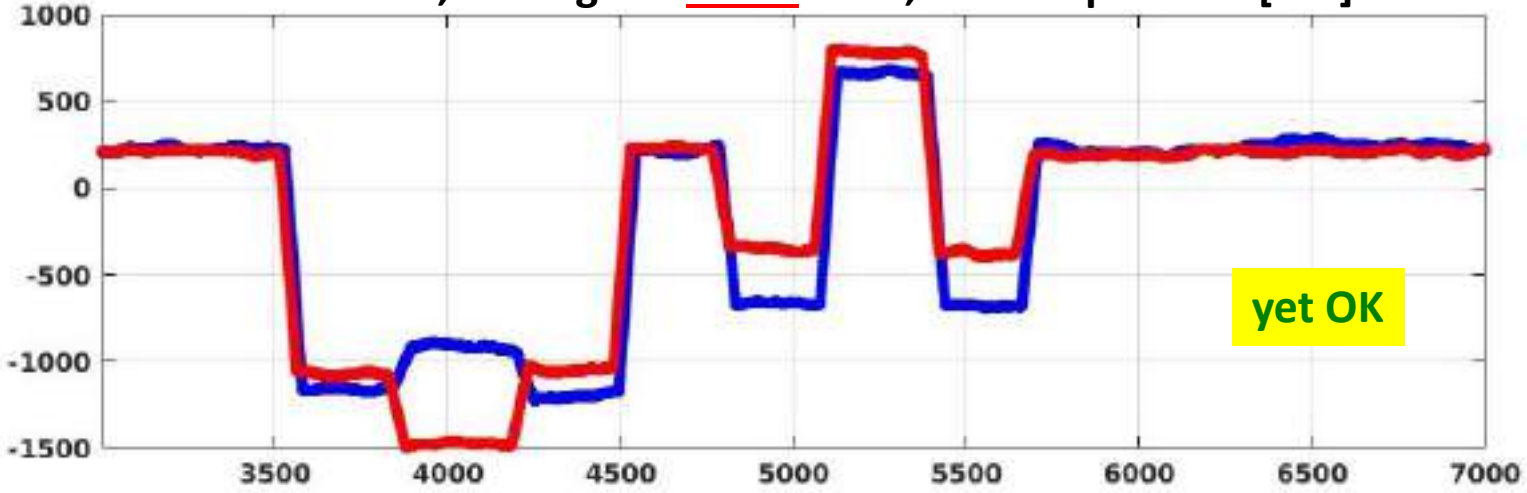

7 changes of attenuation : -1 , -2, -1, 0, +1, +2, +1, 0 dB



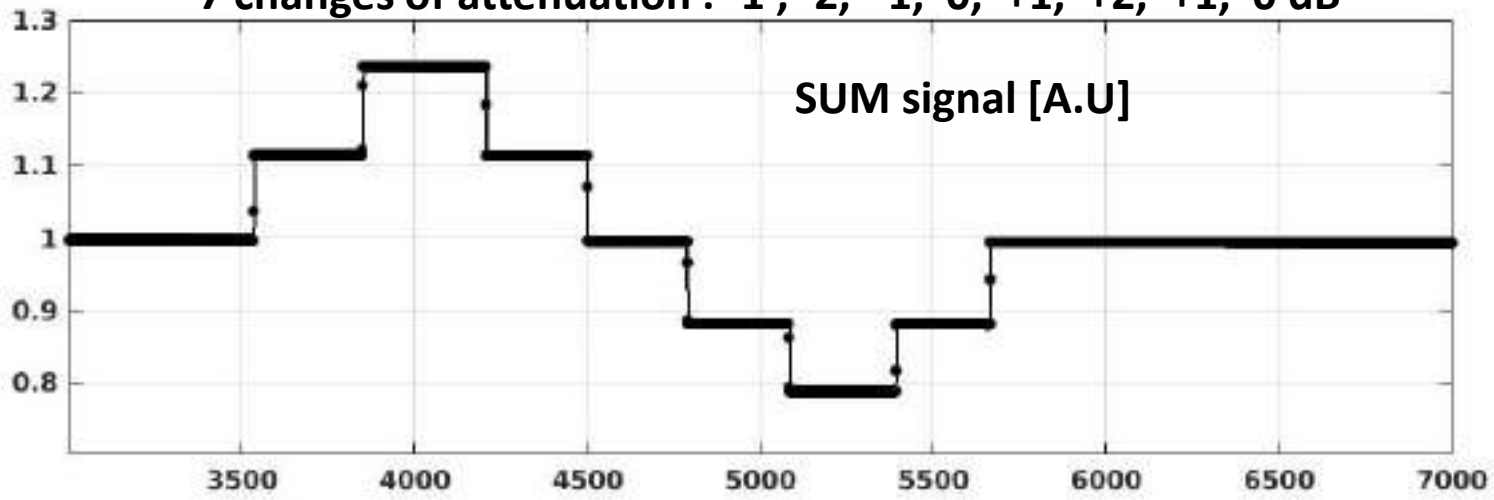

time, about 2 minutes

2 units , among the worst ones, vertical position [nm]

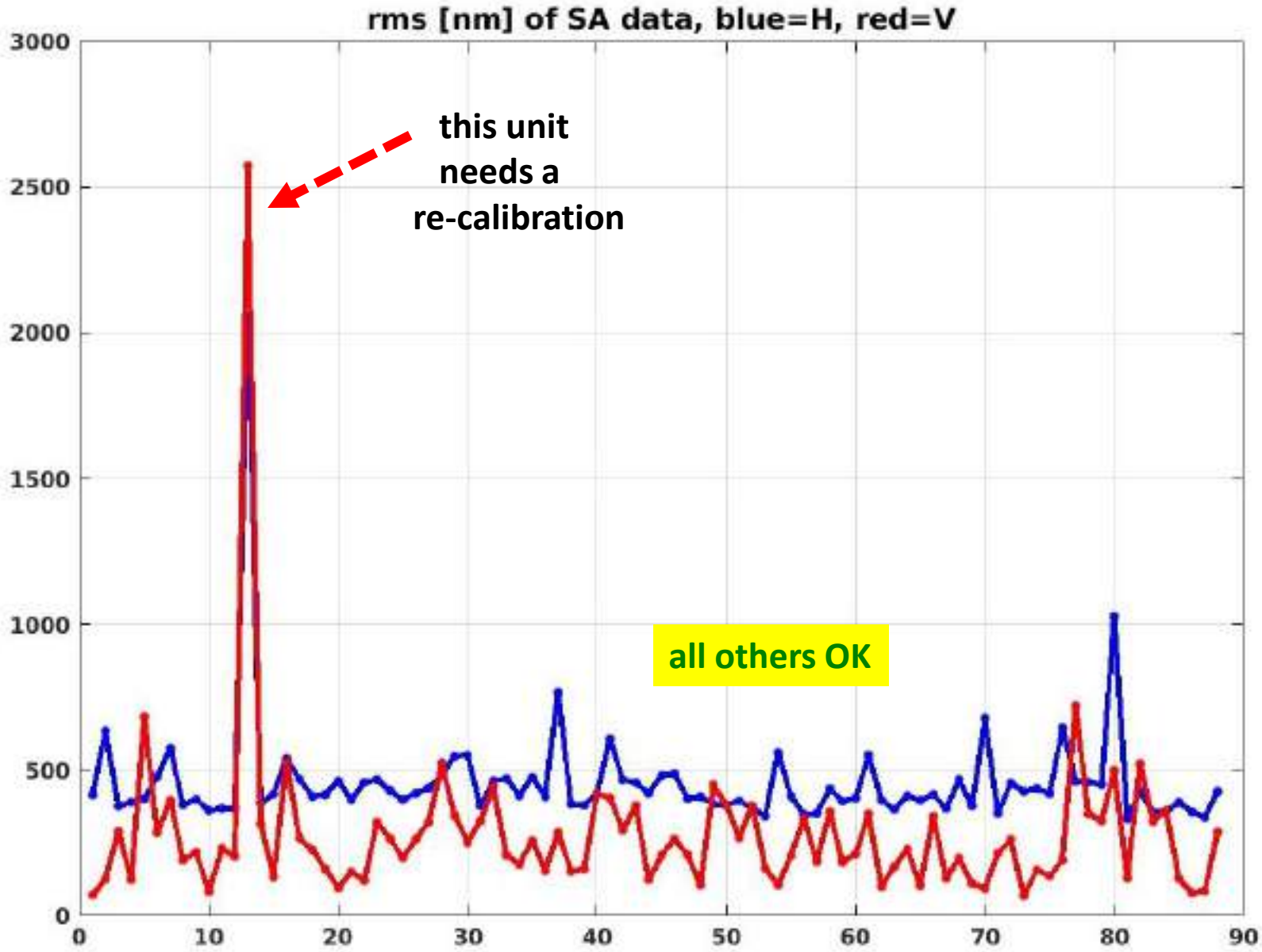
2.5um




7 changes of attenuation : -1 , -2, -1, 0, +1, +2, +1, 0 dB

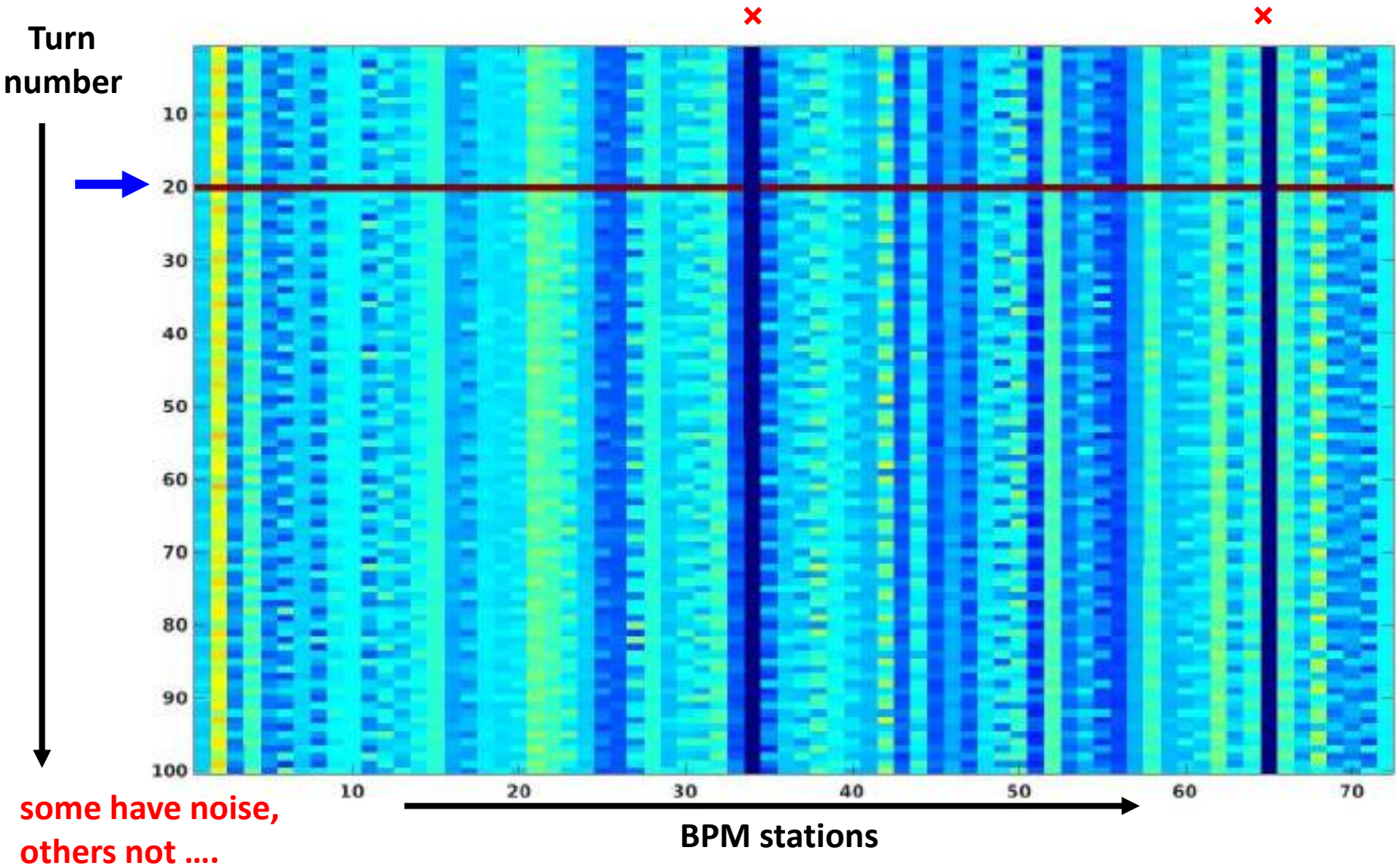



time, about 2 minutes

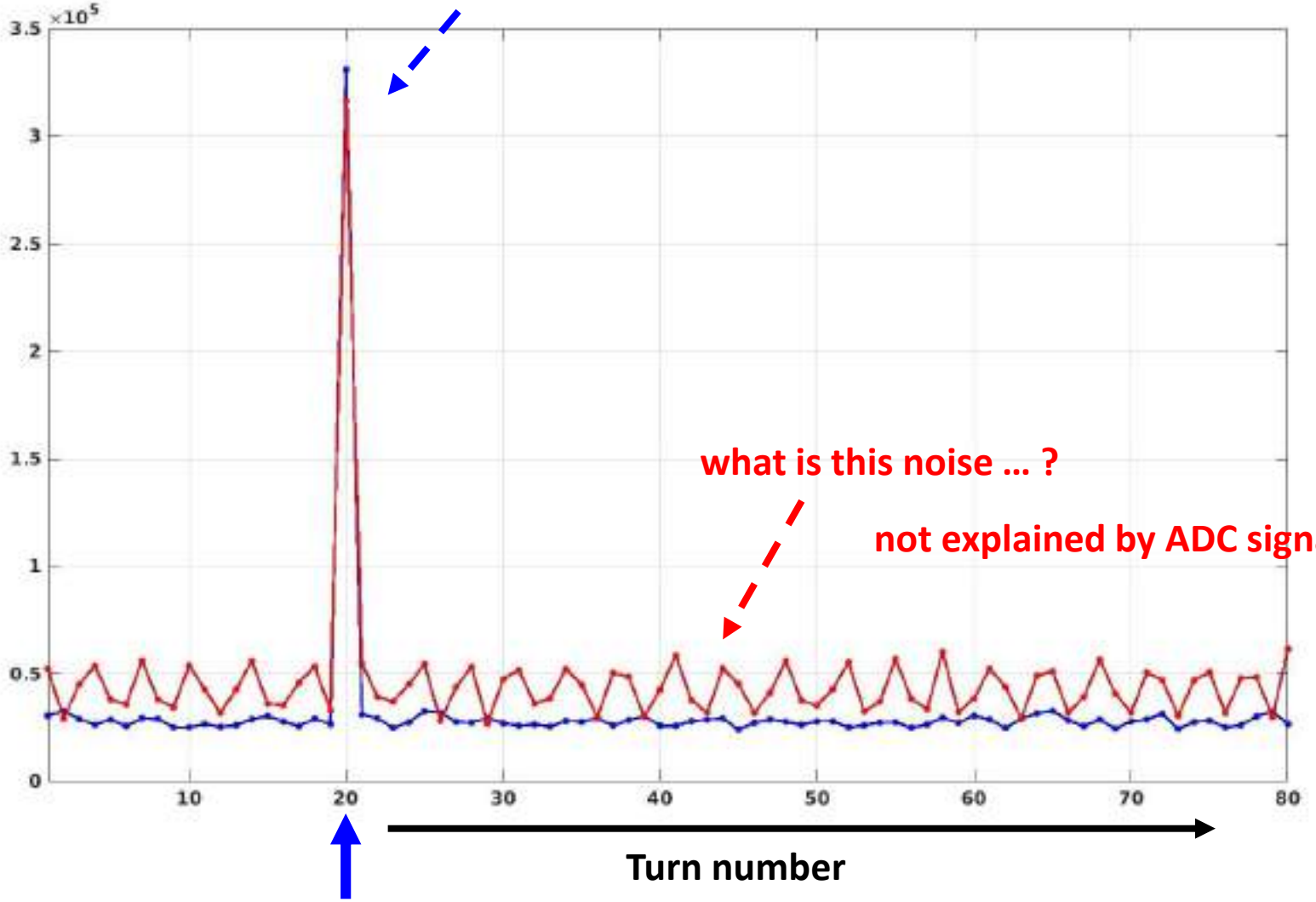

rms [nm] of SA data, blue=H, red=V
this unit
needs a
re-calibration
all others OK
3000
2500
2000
1500
1000
500
0
0
10
20
30
40
50
60
70
80
90
88 units

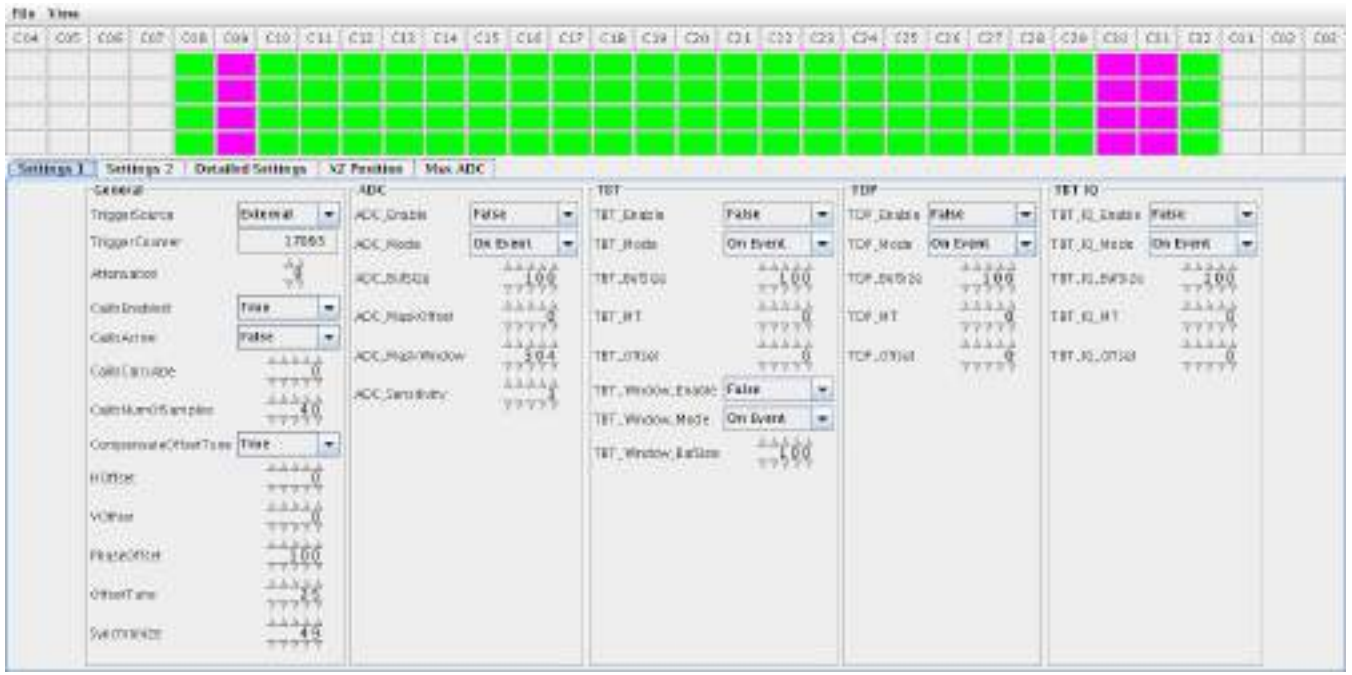
**Turn-by-Turn data, synchronization OK, but …. weird effect when buffers enabled**

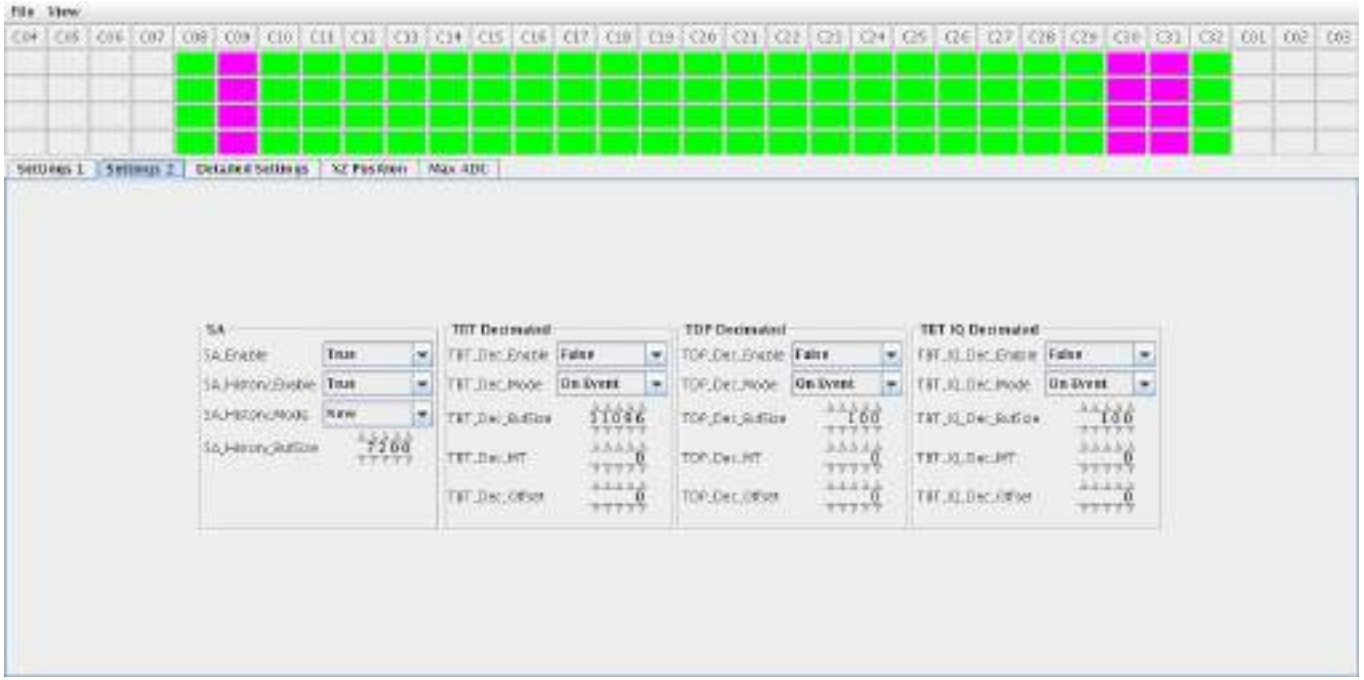
**SUM TDP at Injection, making only one Turn**



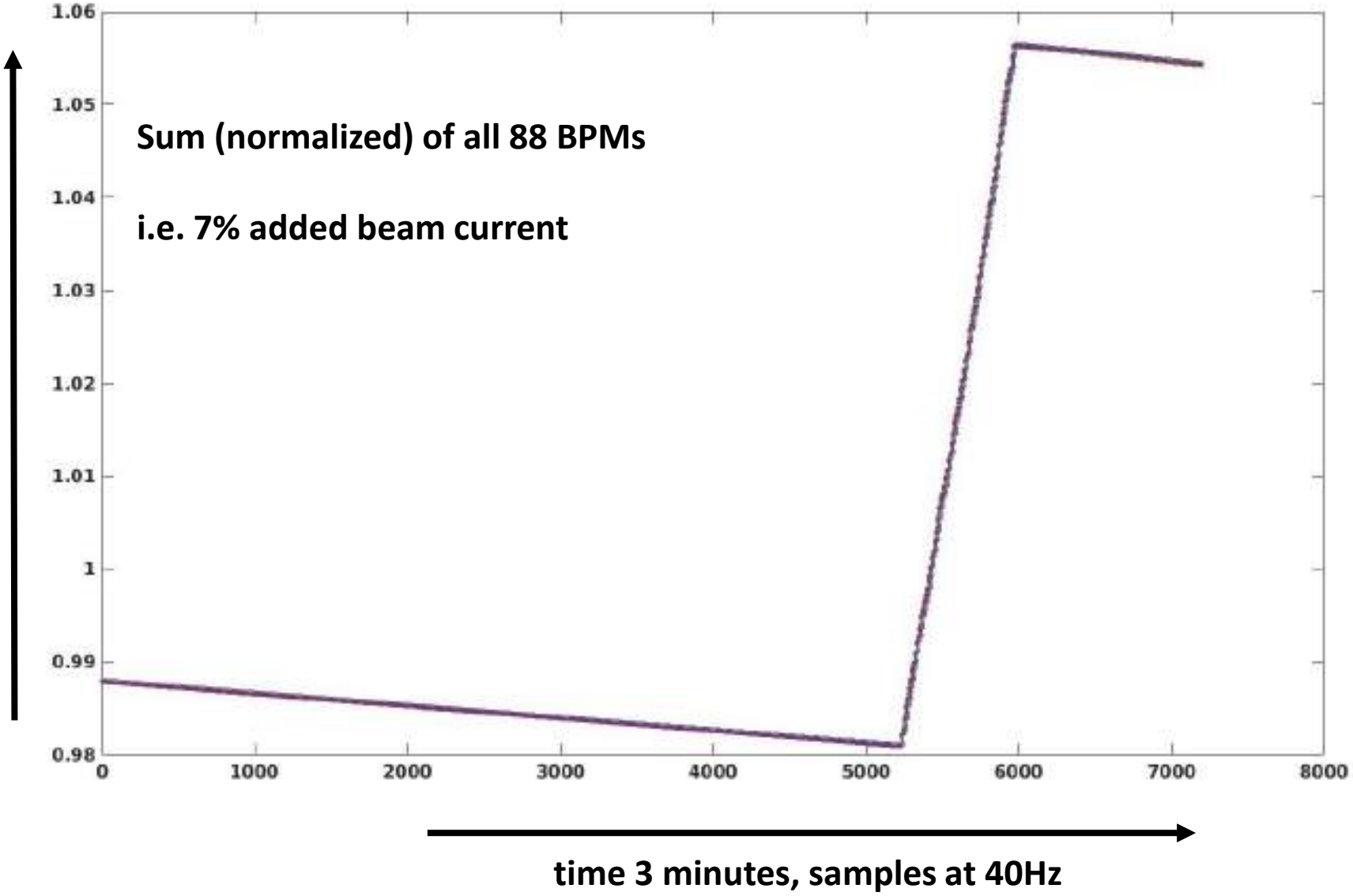
SUM TDP at Injection, making only one Turn




File View
Settings 1
Settings 2
Detailed Settings
XZ Position
Max ADC
General
ADC
TBT
TDP
TBT IQ


File View
Settings 1
Settings 2
Detailed Settings
XZ Position
Max ADC
SA
TBT Decimated
TDP Decimated
TBT IQ Decimated

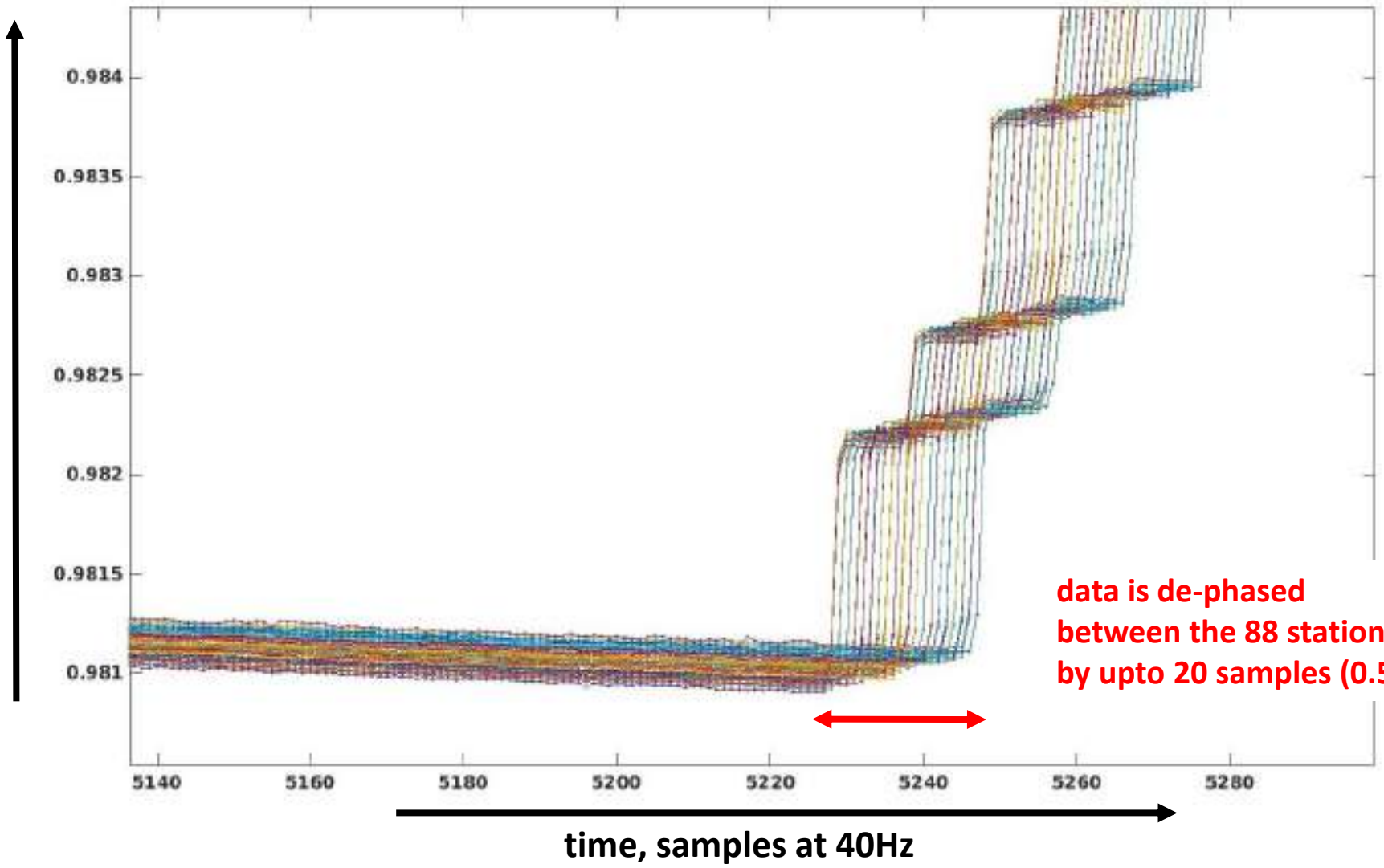
**SA-SUM-History data buffer, 40Hz, all 88 stations, at Injection**



# SA-SUM-History data buffer, 40Hz, all 88 stations, at Injection

this de-phased data in the 88 History buffers is annoying
is it produced by the ESRF group-call server … ?
can it be avoided ? how ?

Sum (normalized)
of all 88 BPM




data is de-phased
between the 88 stations
by upto 20 samples (0.5sec)

results with complete & permanent tests on

**128 Spark BPM electronics for ESRF's new L-E Ring**
**on real RF-beam signals**