

### Stability and low power signal challenges Spark & PilotTone and Libera Brillance Plus considerations

Libera Workshop 2021

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SOLEIL is to upgrade its eBPM system from the obsolete Libera Electron.

Main challenges for the new eBPM system:

- Long term stability
  - Day drift < 500 nm, Week Drift < 1  $\mu$ m
  - Signal power dependency <  $10\mu m$  over 55 dB range.
- Low signal power capacities (commissioning)
  - 1 μm rms, 10Hz BW, -65dBm (25% filling)
  - 100 µm rms, 846 kHz BW, -65dBm (25% filling)

### **Considered systems**

- Libera Brillance Plus
- Modified Spark with Elettra PilotTone Injector





#### On beam tests, first half 2020

- Connected on a test BPM : not water-cooled, fixed on the vacuum chamber not fixed on the girder.
- No splitter.
- Conclusion: dominance of temperature effect on chamber.

### On beam tests, end of 2020

- On water cooled BPM, with and without splitter
- Bad fadatatype parameter  $\rightarrow$  Inactive compensation ?
- − 3 weeks data worth nothing ⊗







## Spark & PT: Stability

#### On beam tests, end of 2020

- Unexplained steps on position, coming from pilot.
- Except that, stability in bounds.





Temporal Evolution. Filter 30 minutes.



# Spark & PT: Stability

### On beam tests, end of 2020

- During week 1: AC problem provoking local temperature oscillation
  - Seen on Sum Signals (both pilot and original) : Amplitude oscillation 20x the top up oscillation.
  - Probably participate to position fluctuation : Spark & PT dependency to signal power







7.5 µm

5 μm 2.5 μm 0 m × -2.5 μm -5 μm -7.5 μm

7.5 µm

-7.5 µm -

-10 µm

5 μm 2.5 μm 0 m ~ −2.5 μm ~ −5 μm pilot comp

rf

12:00

pilot

and some man sure sure

Dec-16

12:00

Dec-17

12:00

Dec-18

12:00

Dec-19

## Spark & PT: Stability

Temporal Evolution. Filter 1 minutes.

#### On beam tests, end of 2020

- New PTI (v2)
- Important jump and relaxing effect
- Back to original value, itself...
- A few hours of jumps just before shutdown.

Temporal Evolution. Filter 1 minutes.

- No explanation by dose, sum signal ...





#### On beam tests, start of 2021

- Back to test BPM
- Still unexplained small jumps (<1µm) (More on that later...)







### On beam tests, start of 2021

- Visualization of <u>compensation</u> (= correction of position)
- Temperature compensation visible when temperature variation ~1°C (Hall and rack closet)





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On splitter

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On beam, dedicated session, November 2020

For low power: PLL attenuator to max

Manual adjust : Pilot Power and PTI Attenuator

Compensation reduces dependency, but still over specs

Beam Current Dependency

Uniform filling

•  $0 \text{ mA} \rightarrow 500 \text{ mA}$ 

## Spark & PT: BCD

Pilot tone injector attenuation and gain settings for increased beam current







#### On beam, March 2021

- Injection failure: Beam current decay ~10%
- No effect on original and compensated data.







## Spark & PT: Conclusions

- Long term stability
  - Hard to conduct tests : duration, environment, parameters...
  - Pilot scheme effective, but PilotTone Injector needs improvement.
  - Without unexplained events, performances are in bounds.
  - BCD
    - no AGC, need a scheme for current ramp up.
    - Tables for several pilot powers ?
    - Ok for nominal operation, small variations.
- Low signal power
  - Need higher tone attenuation dynamic ?
  - TBT without tone. (Not tested)







#### Lab eval, April 2021

- Test on several LBP. LBP #2 with 0dB attenuation input.
- Gated RF signal
- DDC SA meets requirements, DDC TBT approaches requirements
- TDP offset for low power. ADC offset become important for low ADC count. (TDP = sum of square)





#### Lab eval, April 2021

- DSC for TDP
  - DSC coeffs worsen TDP offset
  - coefficient computation not reliable for such low powers.







## Libera Brillance Plus: Low signal power

#### Lab eval, April 2021

- This is not the case for DDC
  - Again explainable by ADC offset





## Libera Brillance Plus: Stability

#### On beam tests, start of 2021

- Parallel measure : same BPM button, split to 2 then 4 : Spark & PTI and LBP
- Remember those jumps ?
  - Cause still under investigation....
- Stability performance comparison
  - PilotTone does not overperform switching.
  - Cable induced drift < eBPM drift ?







### Libera Brillance Plus: Stability

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#### On beam tests, start of 2021

- Switching OFF : 1µm/°C
- Without filters, Spark is very less sensitive



Temporal Evolution. LBP SA data, filter 10s. Spark SA data, filter 2min. Curve is mean, area +-std, on 10 minutes.



### Libera Brillance Plus: Stability

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#### On beam tests, start of 2021

- Switching ON : much much better
- Square variation, jumps in Spark compensated position -> probably same unknown cause as before.







## Libera Brillance Plus: Conclusion

- Long term stability
  - Switching performance are in bound.
  - Need a clean test setup : more parallel measures, cancel external parasites.
- Low signal power
  - DDC : almost sufficient (TBT precision)
  - TDP : offset not suitable for low signal power.

### Our next steps

- Increase FA datarate to 100 kHz (lower latency)
- Increase FA bandwidth to 10kHz
  - Increase switching frequency to avoid in band noise.









# **Bonus slides**



## Libera Brillance Plus: DSC

### Lab test, November 2020

- Gated, split RF signal
- DDC
- DSC Settings
  - ADC threshold for DSC lowered to 200 (hysteresis 20).
  - Quality threshold increased to 10 % (intentionally high)
- Observations
  - Power level estimator does not depend on filling pattern. Probably based on MaxADC value.
  - Quality estimator depends on filling pattern.
  - Quality estimator = variance of I and Q signals

Estimated Power level (dBm)	Multibunch, current per bunch	Single bunch, current
-60	0,7 µA	
-55	2 μΑ	
-50	5 µA	170 µA
-45	9 µA	325 µA







### Libera Brillance Plus: DSC

### Lab test, November 2020

- Quality estimator vs SA RMS
  - Quality estimator is a good indicator for SA quality
  - Independent to filling pattern (Power level and maxADC are not)

