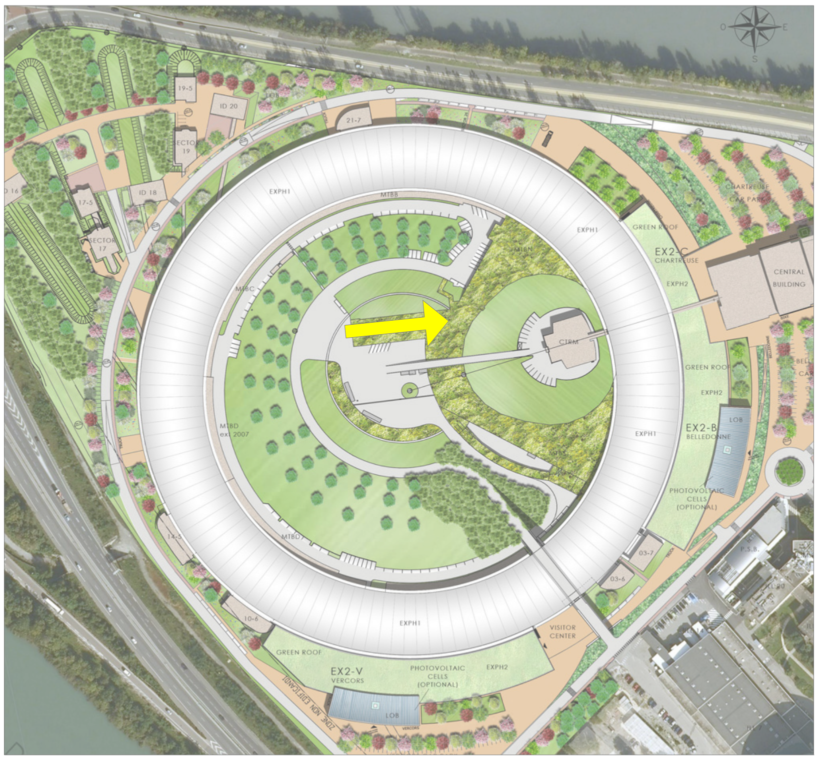
Commissioning of the new BPM Electronics in the ESRF Booster

Manuel Cargnelutti, Instrumentation Technologies, 15.06.2015

Presentation outline

- The ESRF Booster Ring
- Libera Spark electronics
- Commissioning results
- Applications of the BPM electronics
- Conclusions

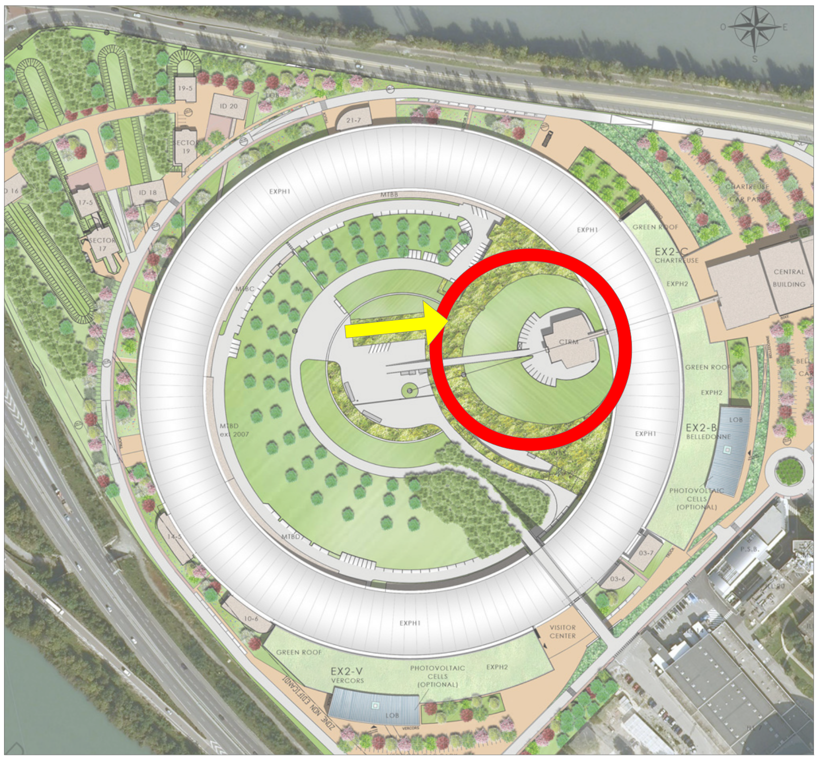
The ESRF Booster Ring



Pre-Injector LINAC

from **0 to 200 MeV**

The ESRF Booster Ring



Pre-Injector LINAC

from **0 to 200 MeV**

Booster Synchrotron

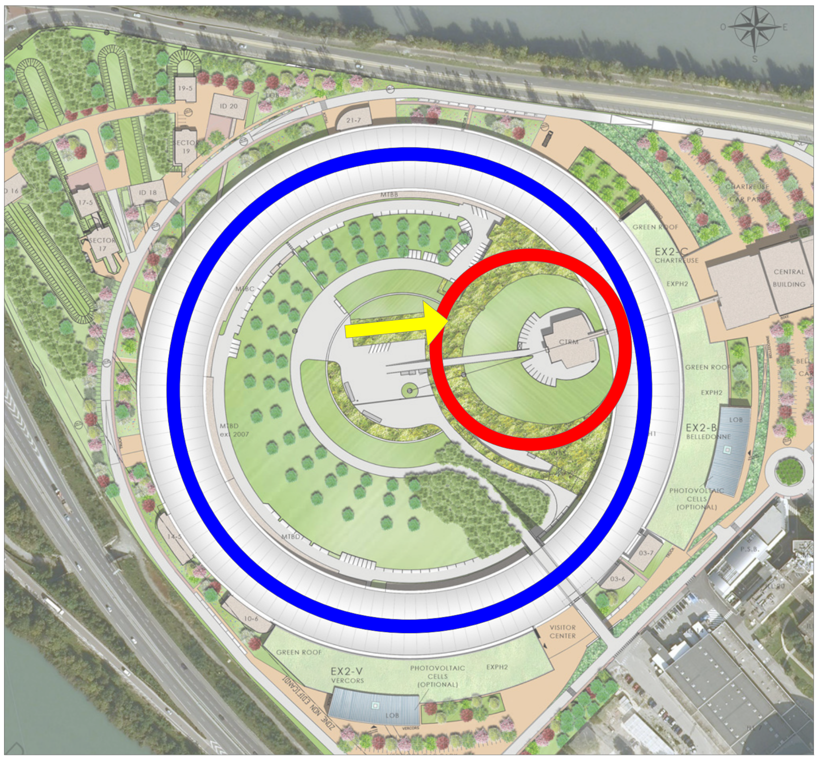
200 MeV → 6 GeV

50 ms (50000 turns) acceleration cycle

1 µs orbit time

current from **2.5 mA** down to **50 µA**

The ESRF Booster Ring



Pre-Injector LINAC

from **0 to 200 MeV**

Booster Synchrotron

200 MeV → 6 GeV

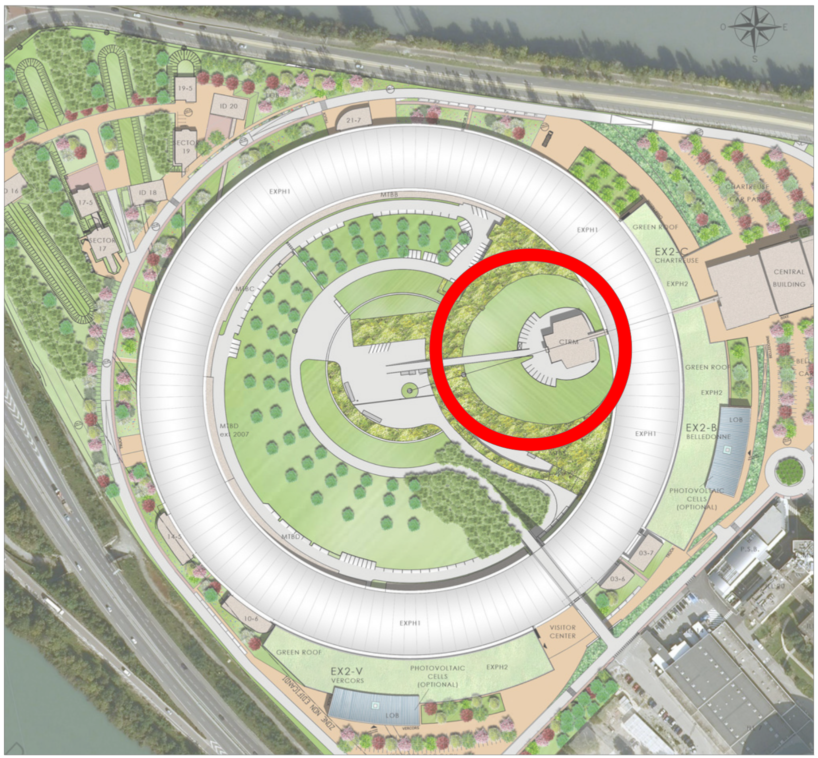
50 ms (50000 turns) acceleration cycle

1 µs orbit time

current from **2.5 mA** down to **50 µA**

Storage Ring (200 mA)

The ESRF Booster Ring



75 BPM blocks

25 years old electronics

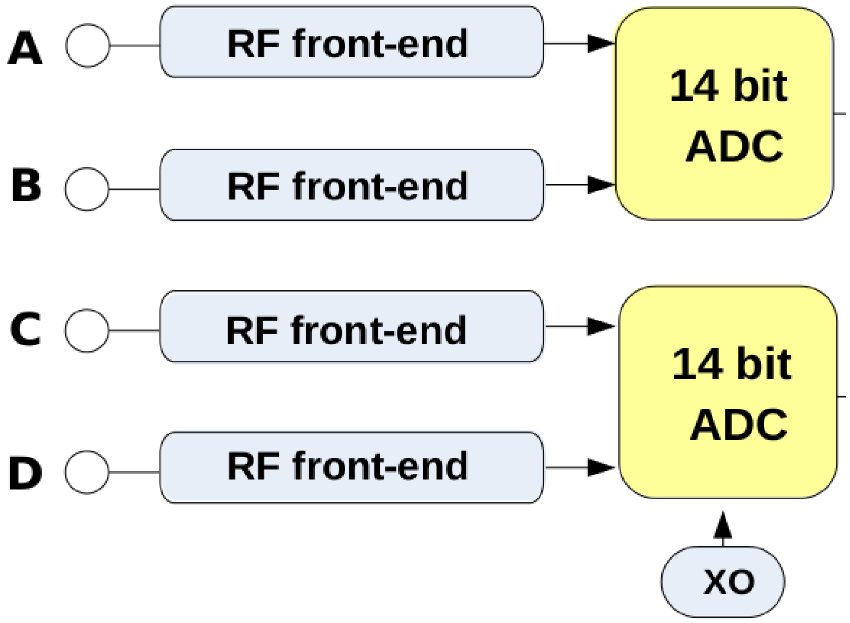
Need new BPM electronics

What kind of electronics?

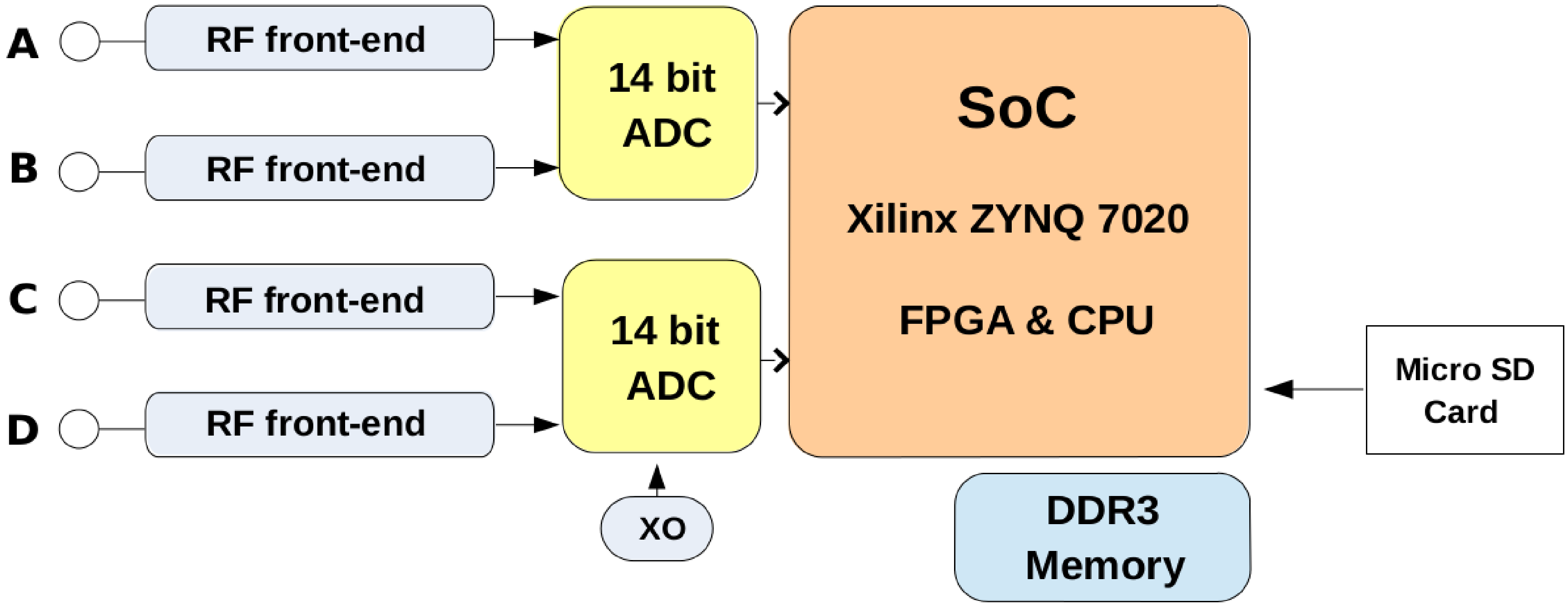
Libera Spark

+ Good Price/Performance
+ Turn-By-Turn data
+ Easy to use
+ No maintenance required

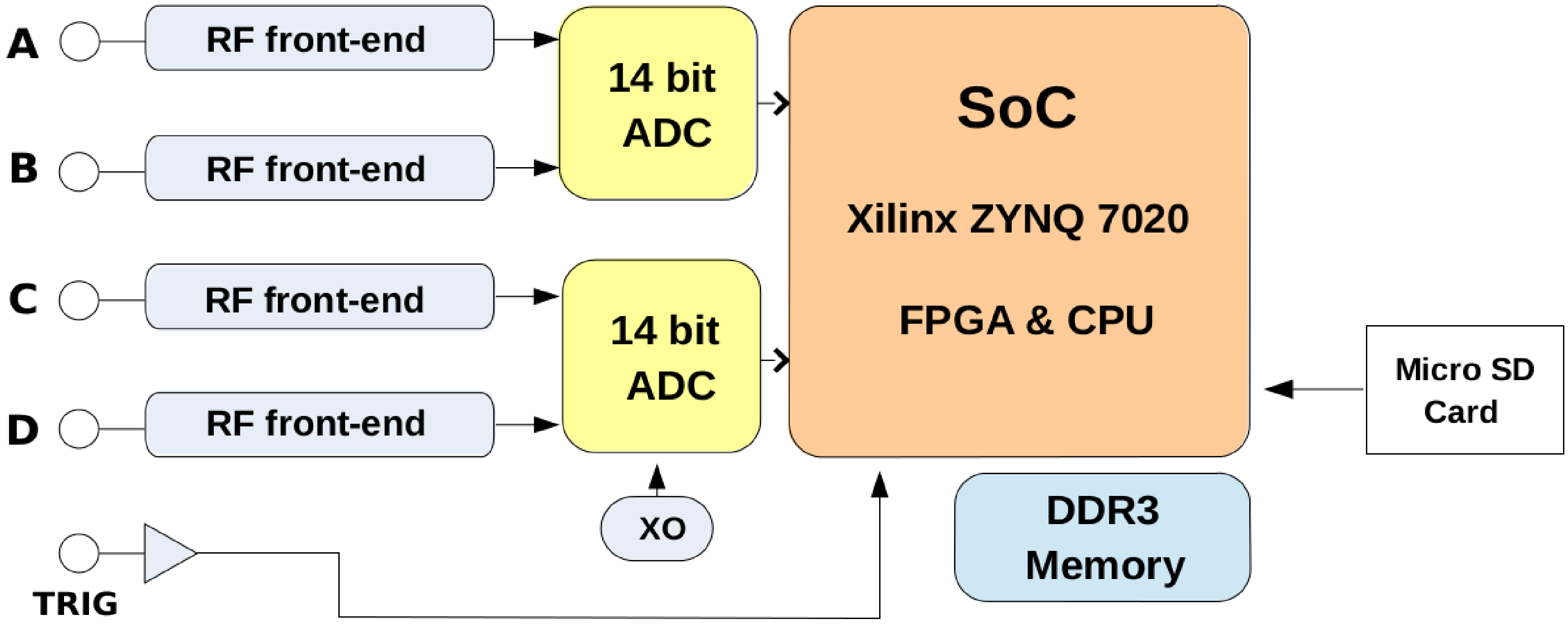
What kind of electronics?



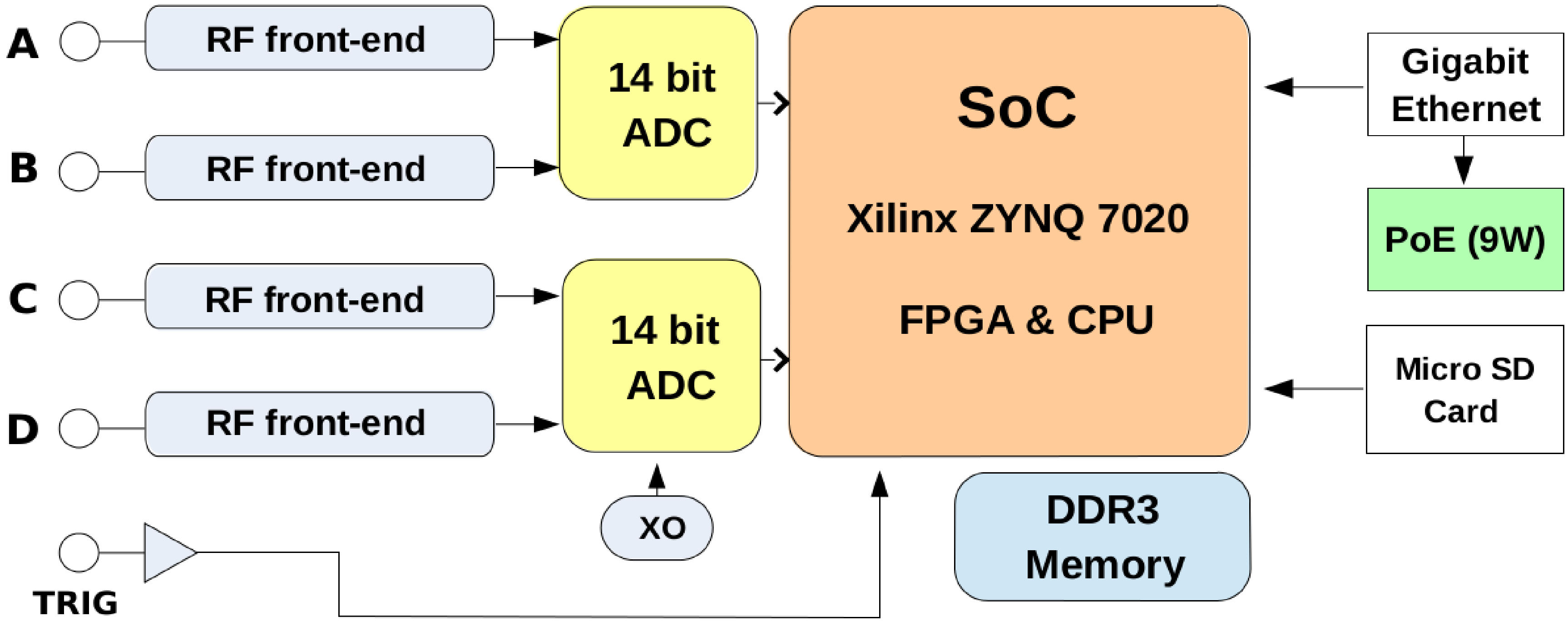
What kind of electronics?



What kind of electronics?



What kind of electronics?



Installation in the tunnel

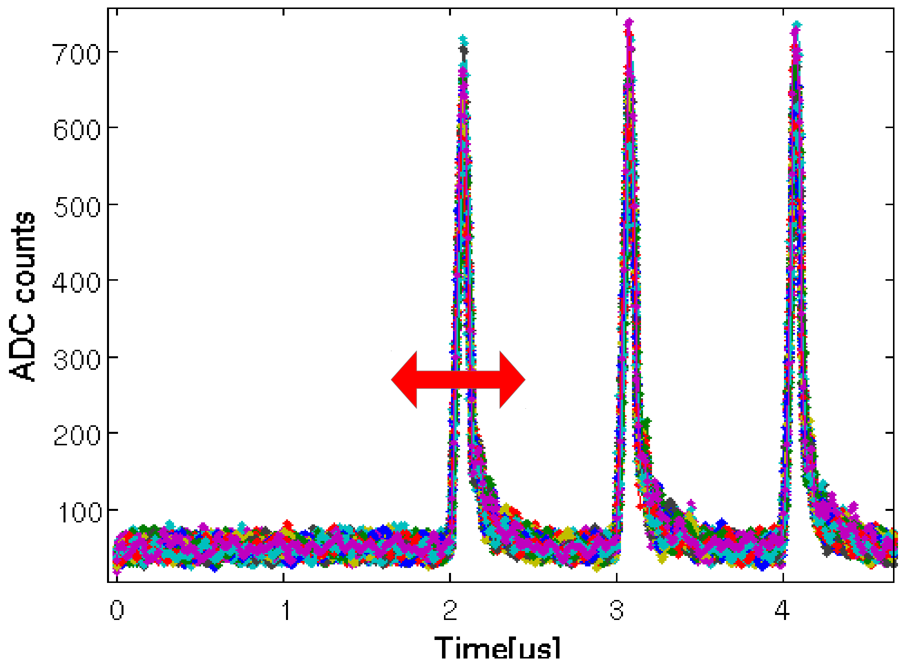
- Radiation dosimetry tests (>6 months) shown very low radiation dose
- 3 m long RF cables
- Powered with Ethernet cable

Commissioning Results

0) Synchronization with the beam arrival

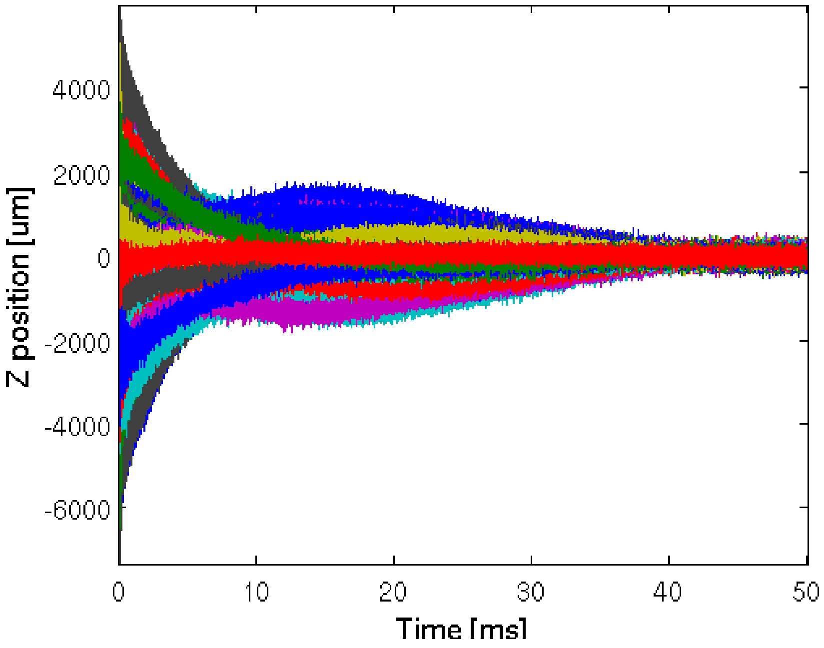
Single Bunch Beam mode

- Data in the ADC buffer synchronized for all the units using the Trigger Delay parameter.



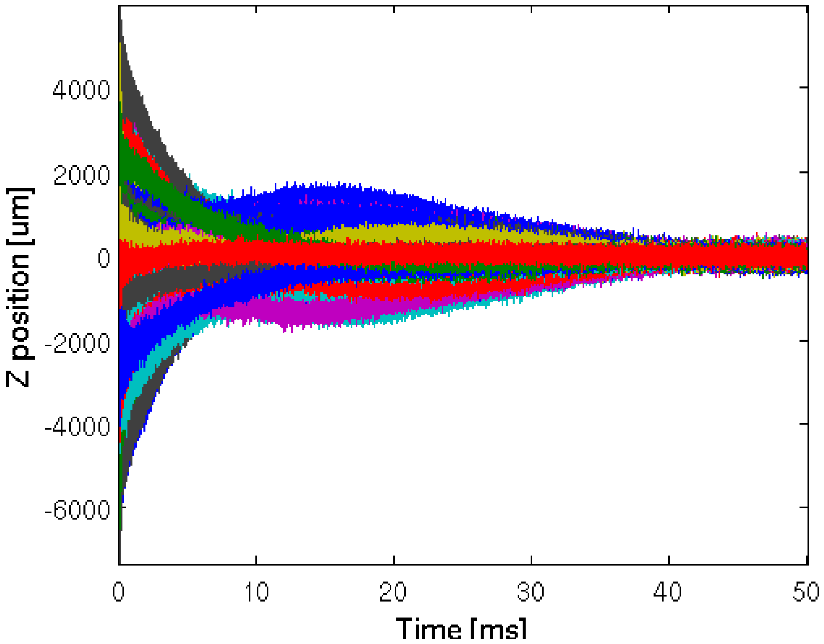
1) Tune monitor with Turn-by-Turn data

Turn-by-Turn position (1 µs)



1) Tune monitor with Turn-by-Turn data

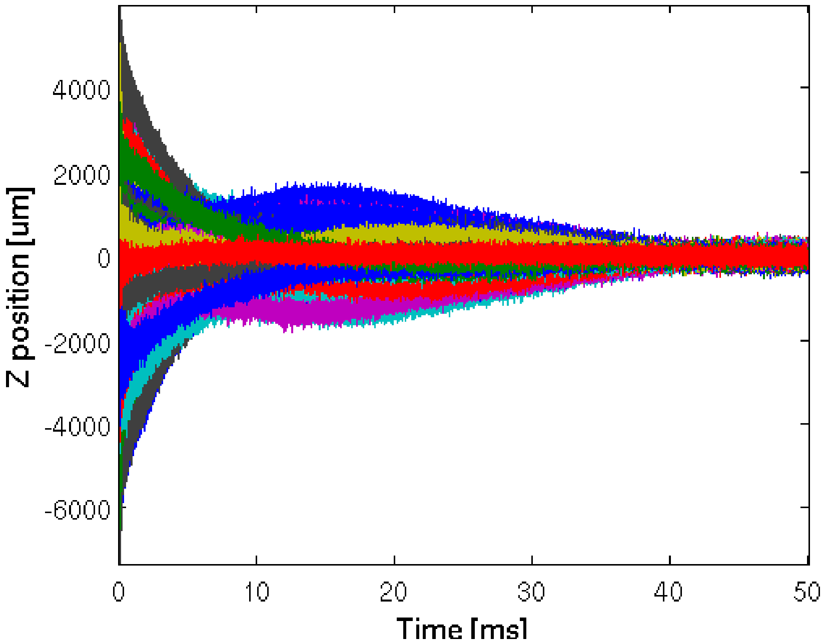
Turn-by-Turn position (1 µs)



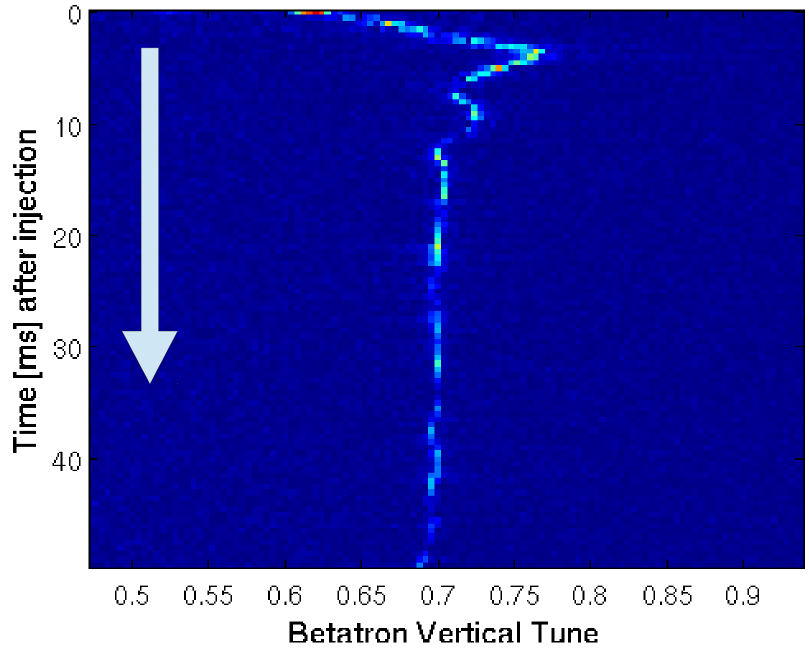
FFT in 0.5 ms data slices

1) Tune monitor with Turn-by-Turn data

Turn-by-Turn position (1 μs)



Vertical Tune monitor



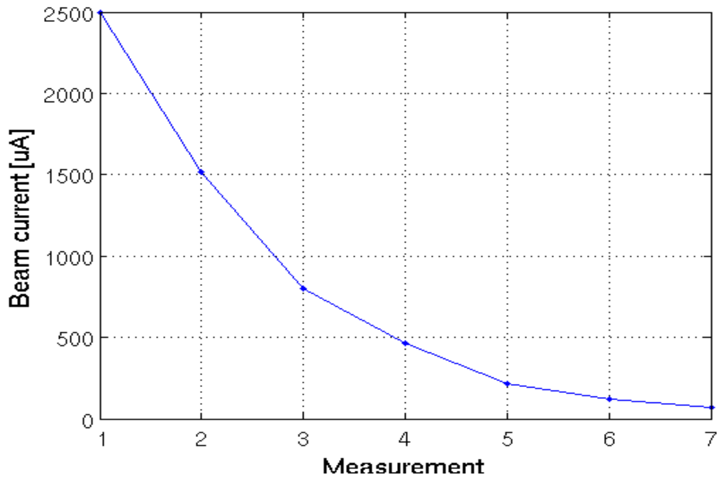
FFT in 0.5 ms data slices

2) Position resolution vs Beam current

- Booster operating with long-pulse mode (80% fill pattern)
- Current was reduced in steps from **2.5 mA** to **50 μA**

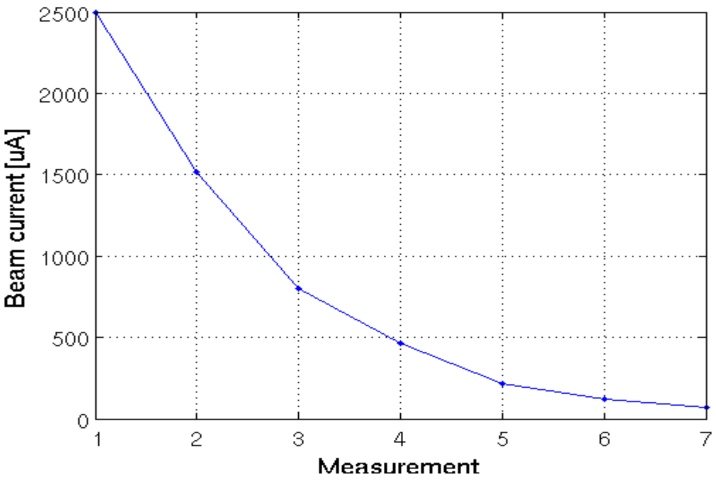
2) Position resolution vs Beam current

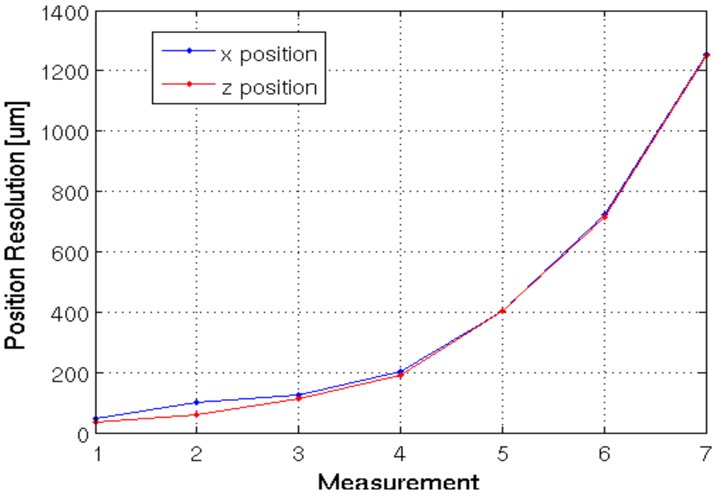
- Booster operating with long-pulse mode (80% fill pattern)
- Current was reduced in steps from **2.5 mA** to **50 µA**
- **Sum signal**: estimate real current intensity



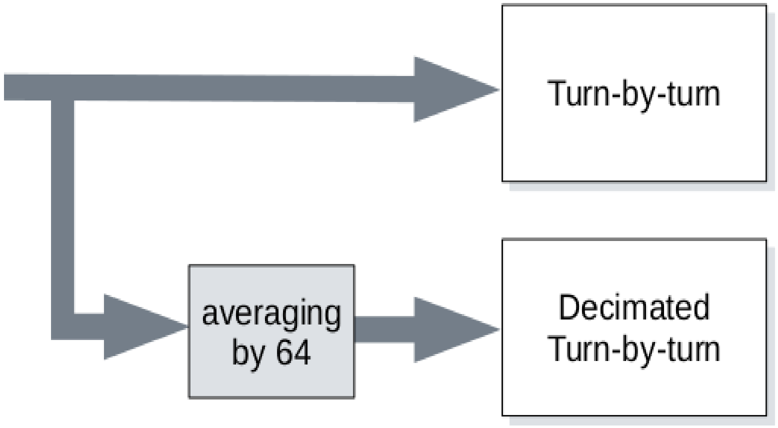
2) Position resolution vs Beam current

- Booster operating with long-pulse mode (80% fill pattern)
- Current was reduced in steps from **2.5 mA** to **50 µA**
- **Sum signal**: estimate real current intensity
- **X Z position**: estimate resolution with RMS





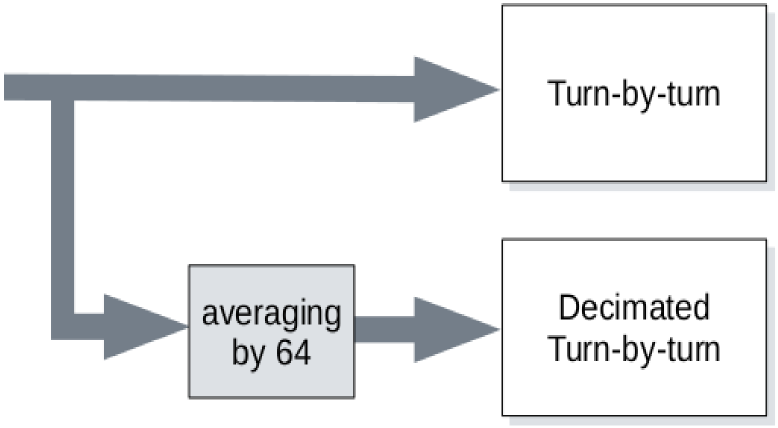
Decimated T-b-T data



1 sample = 1 turn = 1 µs

1 sample = 64 turns = 64 µs

Decimated T-b-T data

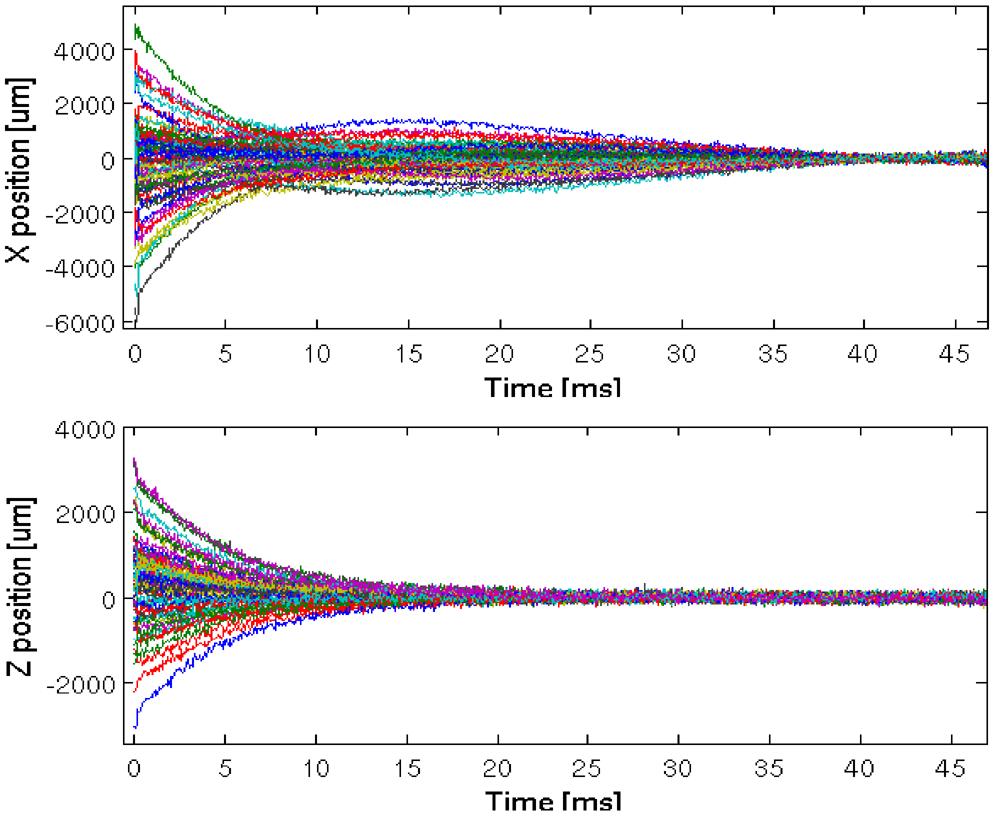


1 sample = 1 turn = 1 μs

1 sample = 64 turns = 64 μs

Motivation?

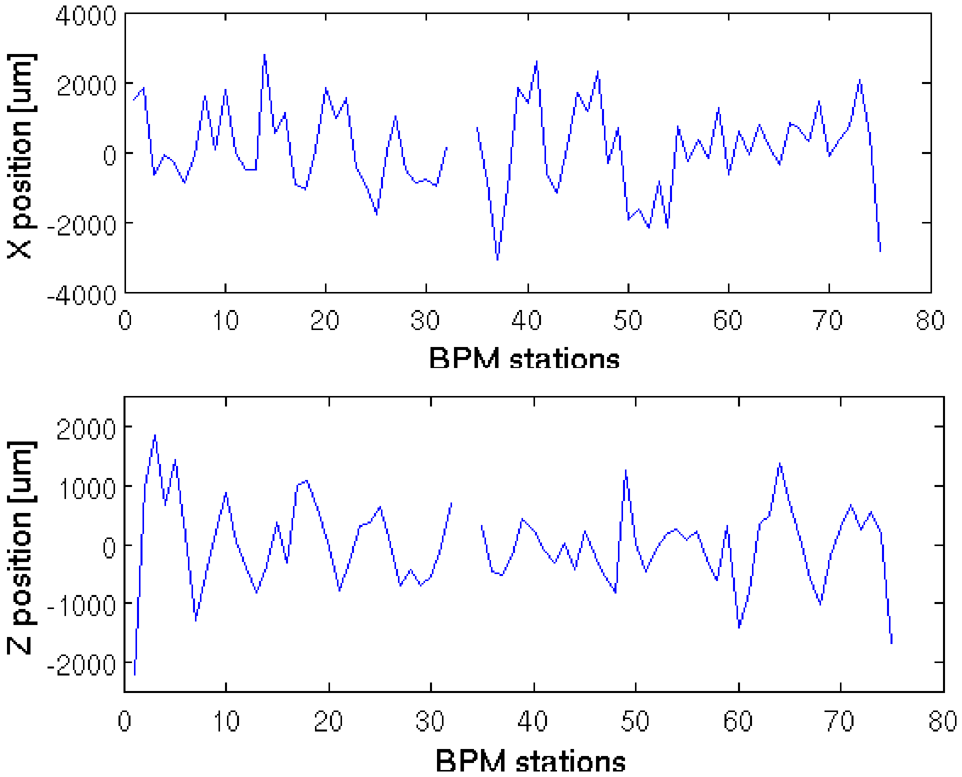
3) Position measurements



Motivation?

Reduced bandwidth means reduced noise contribution

4) Orbit measurements



Motivation?

Reduced amount of data to be transferred over the network

Applications

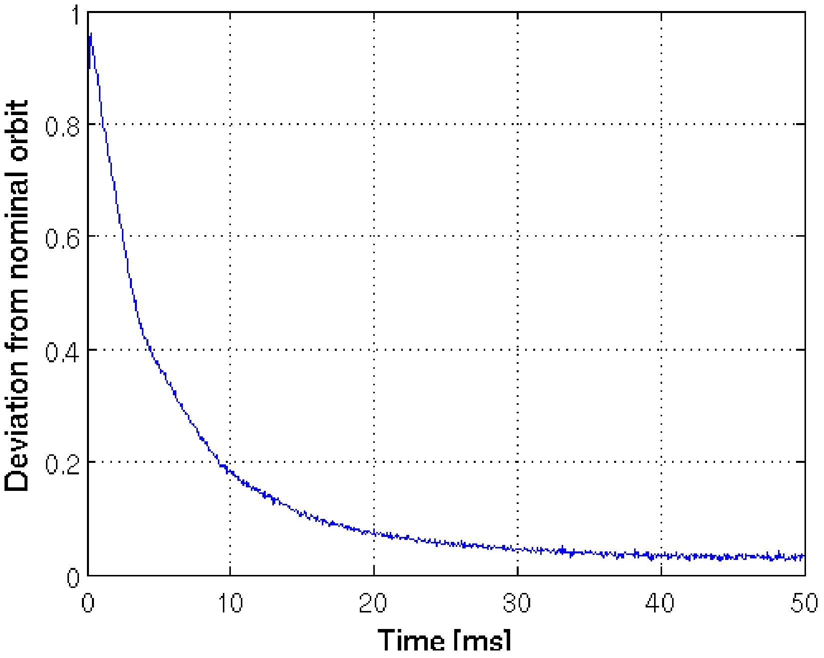
5) Quadrupole orbit correction

- Corrector magnets are not ramped like dipoles and quadrupoles during the booster acceleration

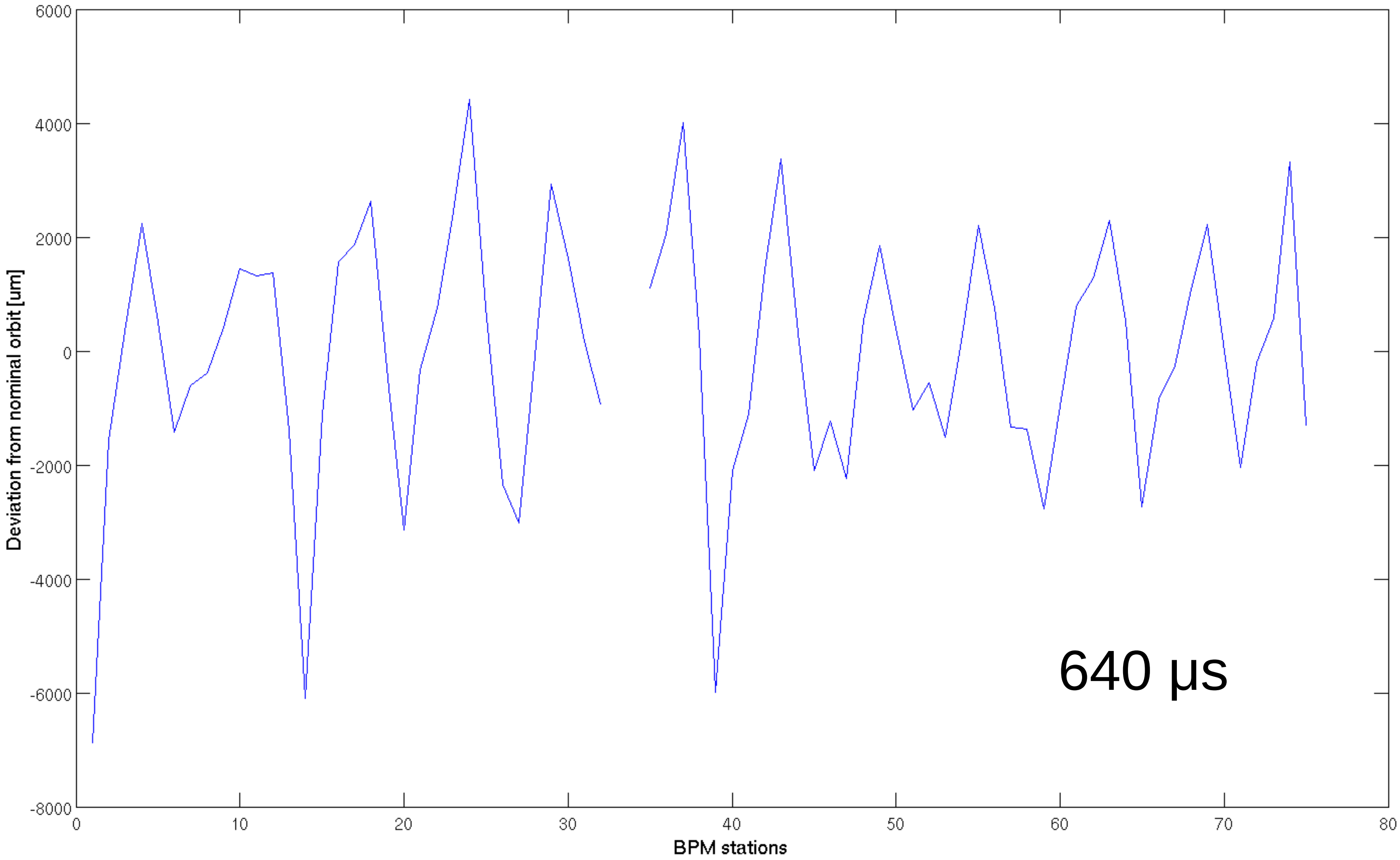
5) Quadrupole orbit correction

- Corrector magnets are not ramped like dipoles and quadrupoles during the booster acceleration
- Possible to correct the orbit only at low energy while at high energy the correction is dumped

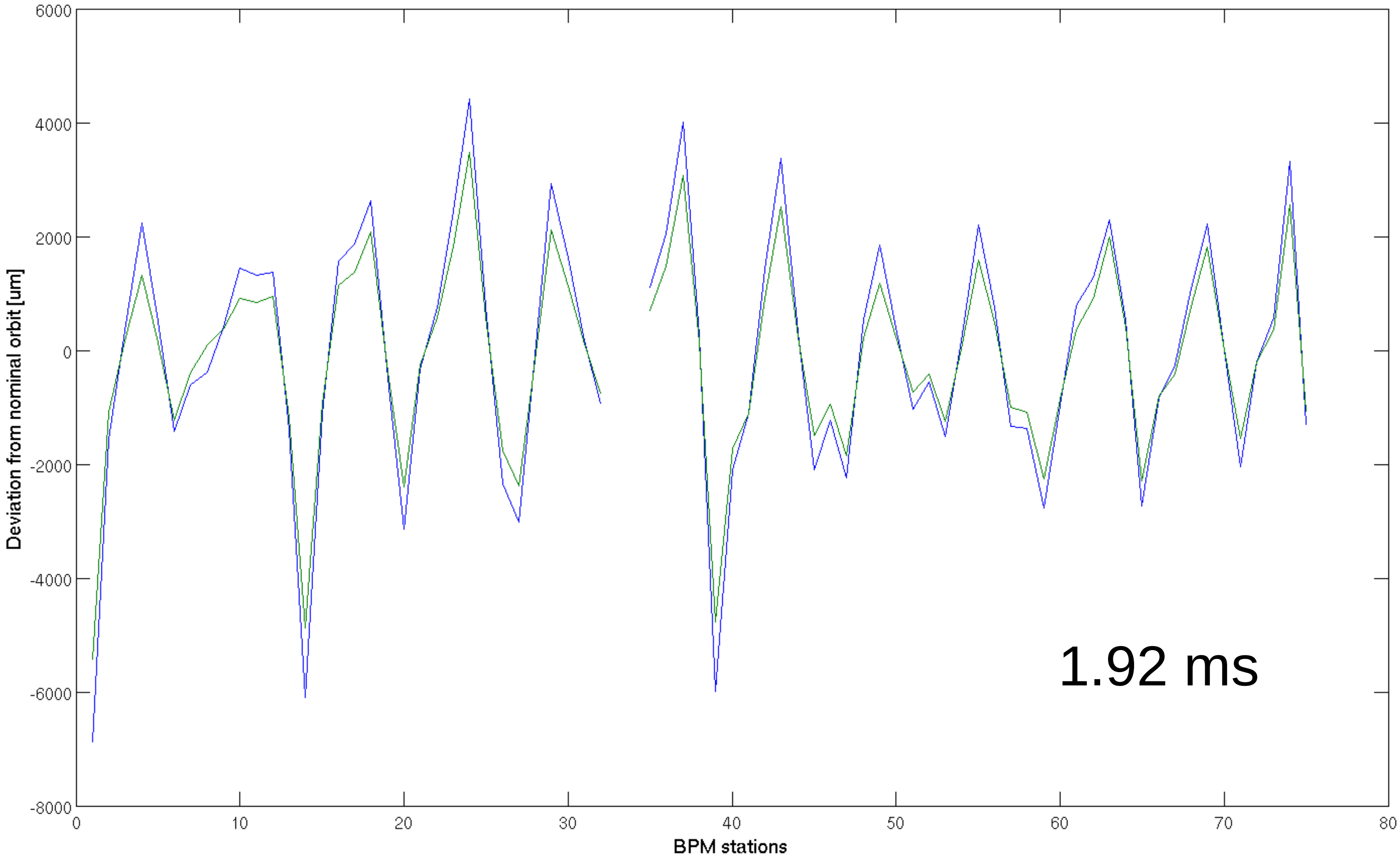
Corrector with +100 mA



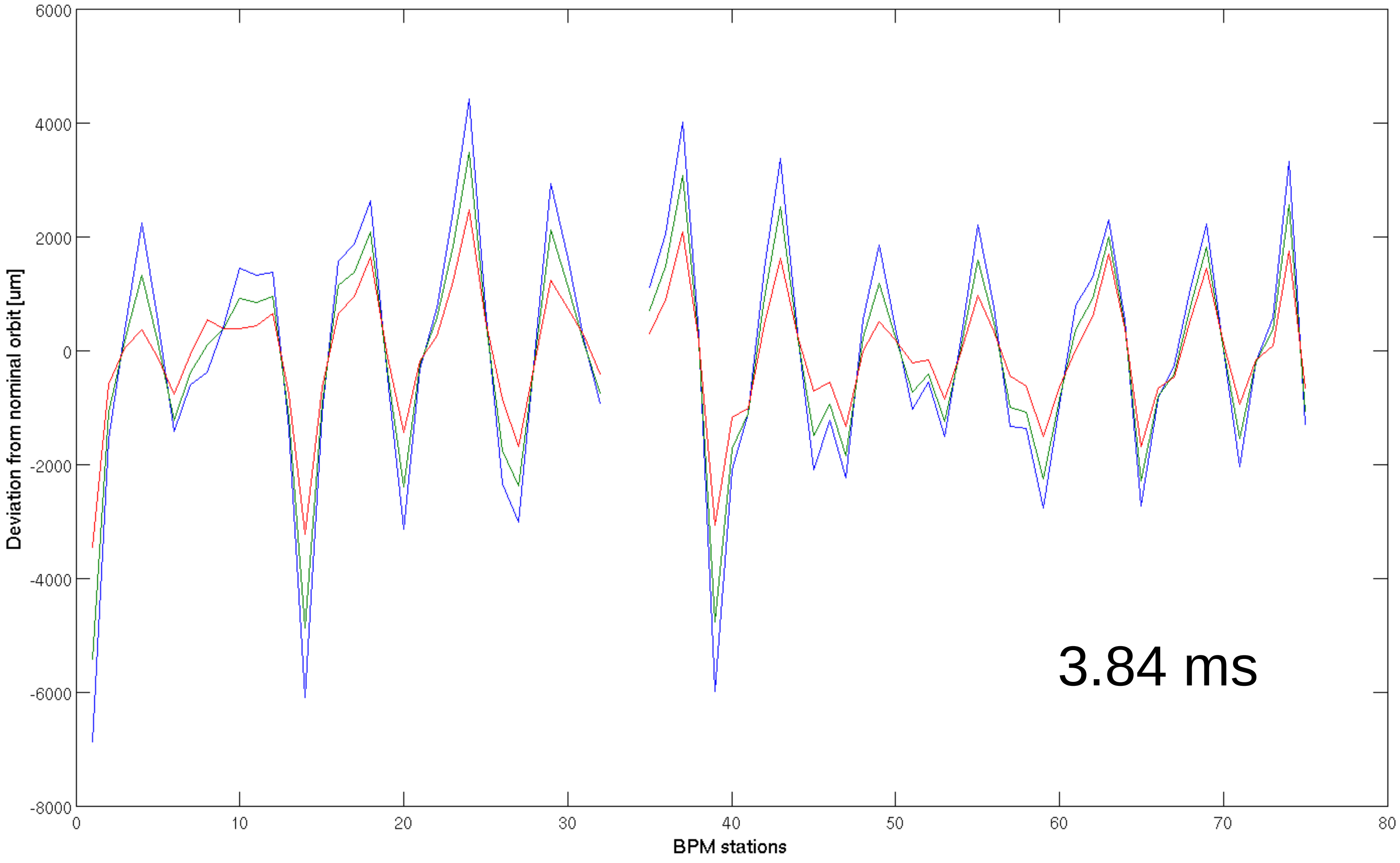
5) Quadrupole orbit correction



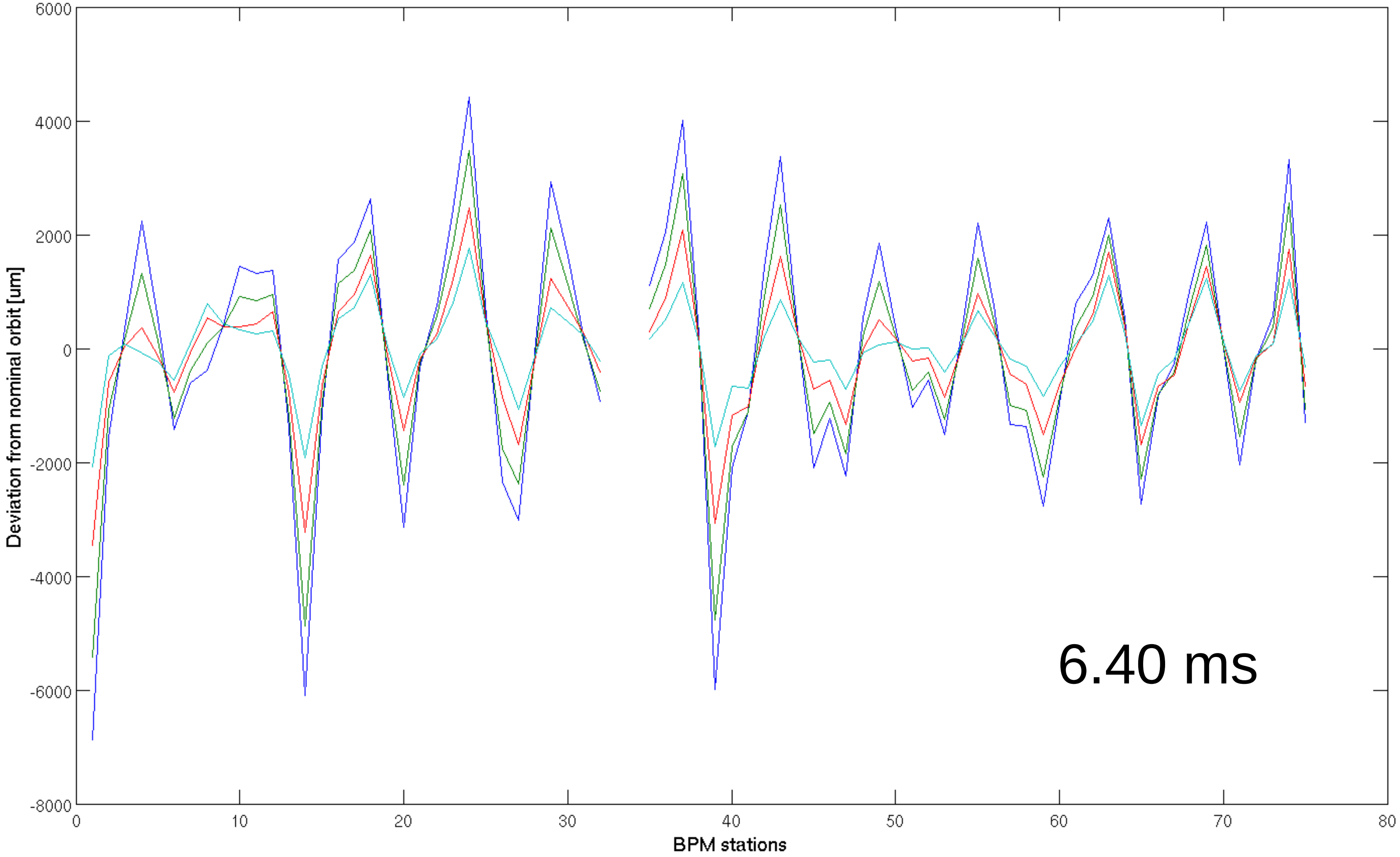
5) Quadrupole orbit correction



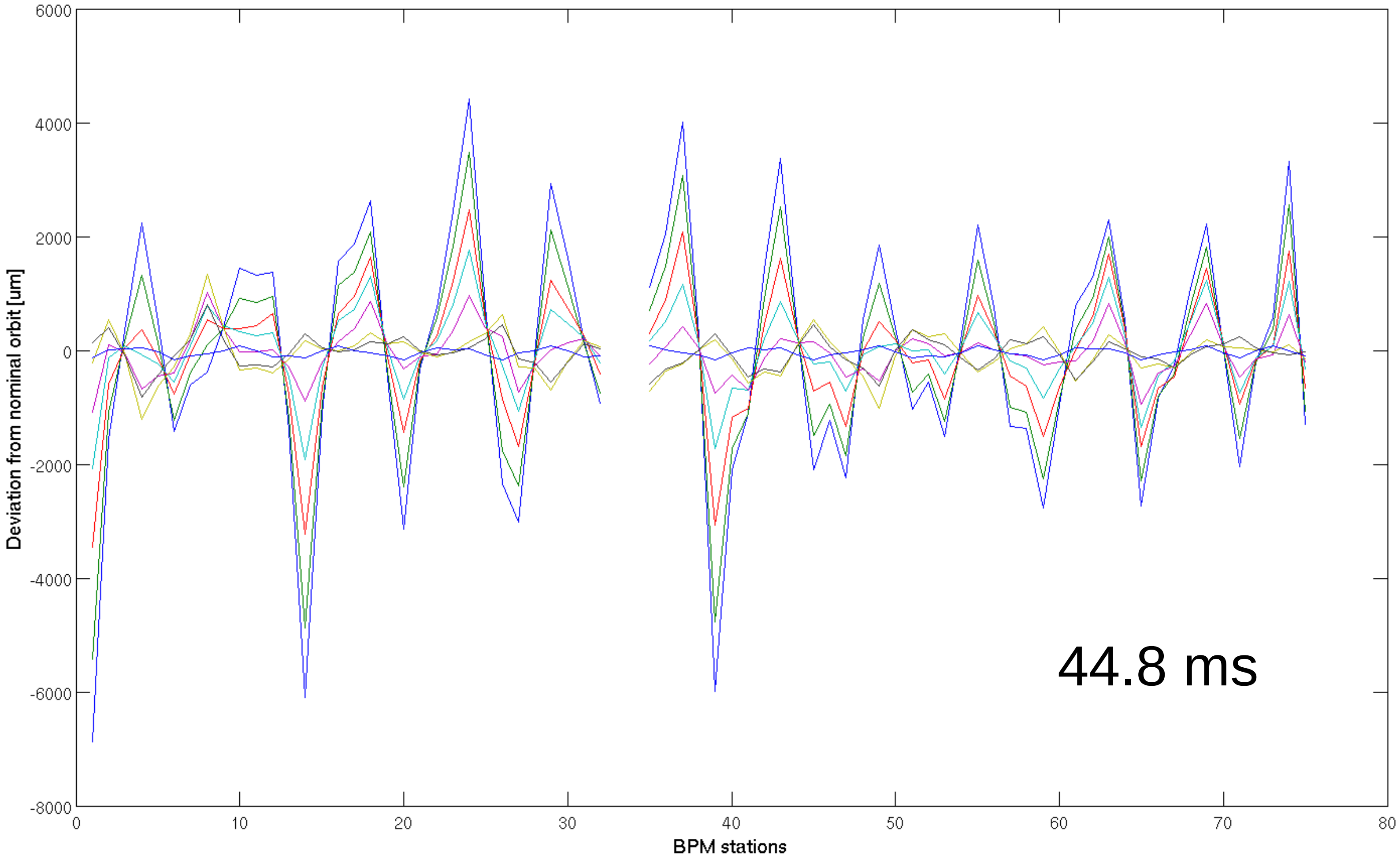
5) Quadrupole orbit correction



5) Quadrupole orbit correction



5) Quadrupole orbit correction



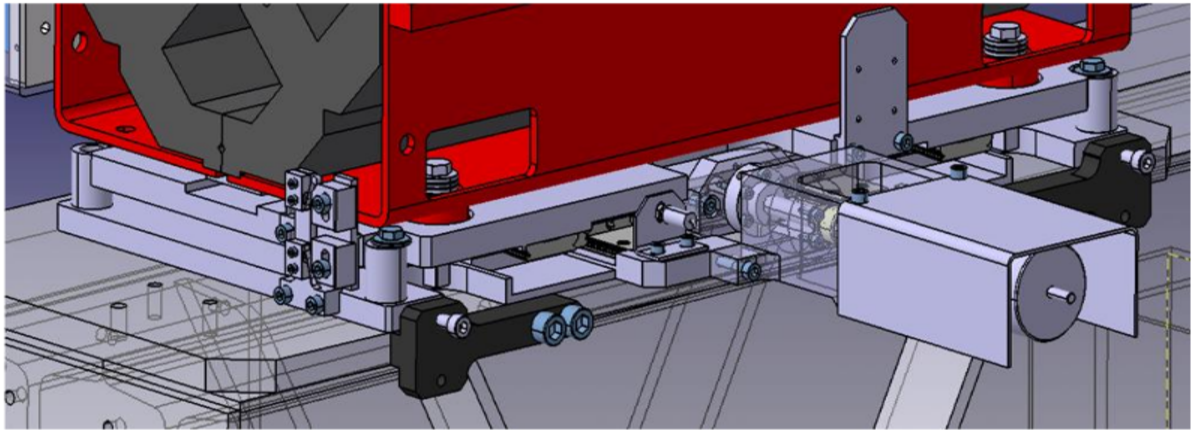
5) Quadrupole orbit correction

a) Buy and install more expensive correctors, ramped during the acceleration

5) Quadrupole orbit correction

a) Buy and install more expensive correctors, ramped during the acceleration

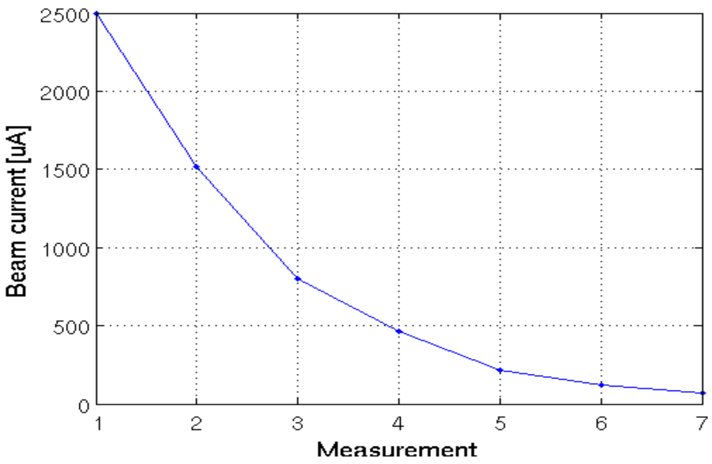
b) Install translation stages under the quadrupoles: efficient and low-cost



Courtesy of Kees Scheidt

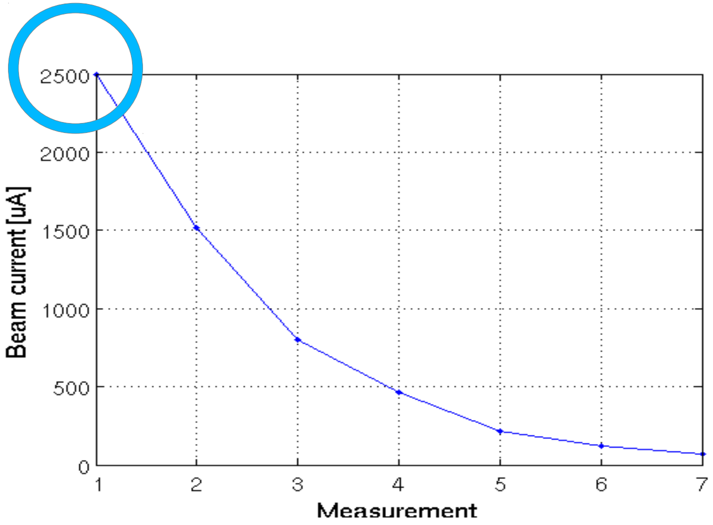
6) Transmission efficiency

- The SUM signal can be used for relative current measurements



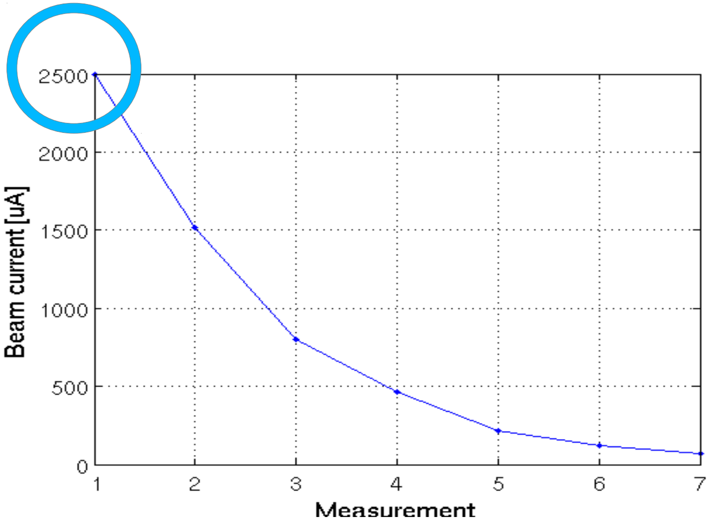
6) Transmission efficiency

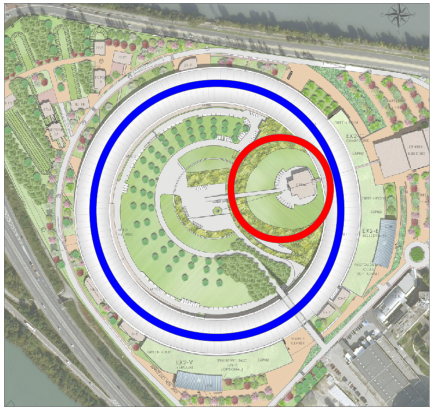
- The SUM signal can be used for relative current measurements
- Once calibrated, all the 75 BPMs act as current monitors



6) Transmission efficiency

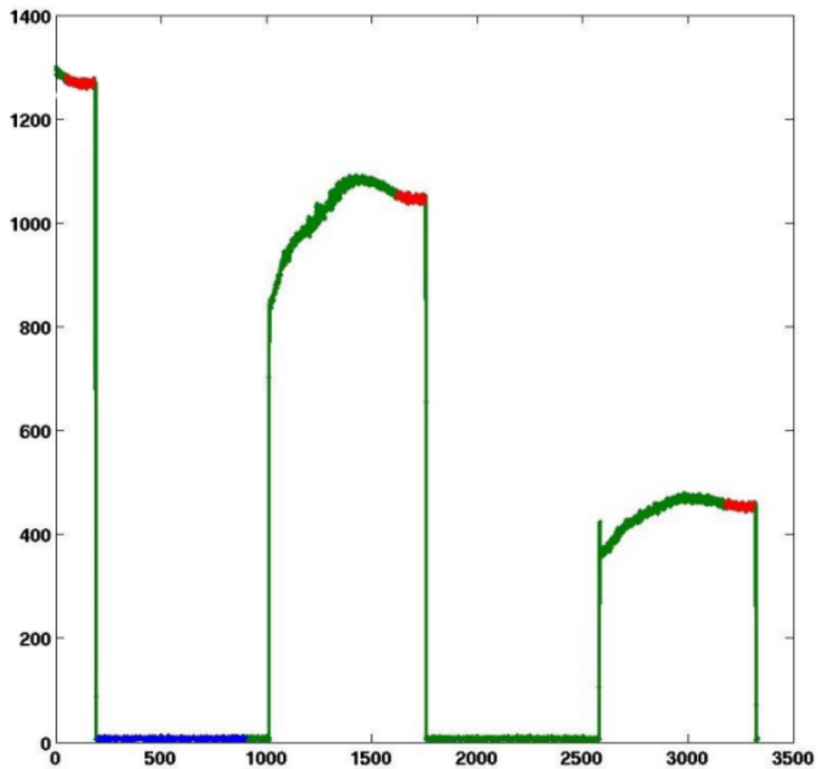
- The SUM signal can be used for relative current measurements
- Once calibrated, all the 75 BPMs act as current monitors
- Together with the storage ring BPMs, they can measure the transmission efficiency





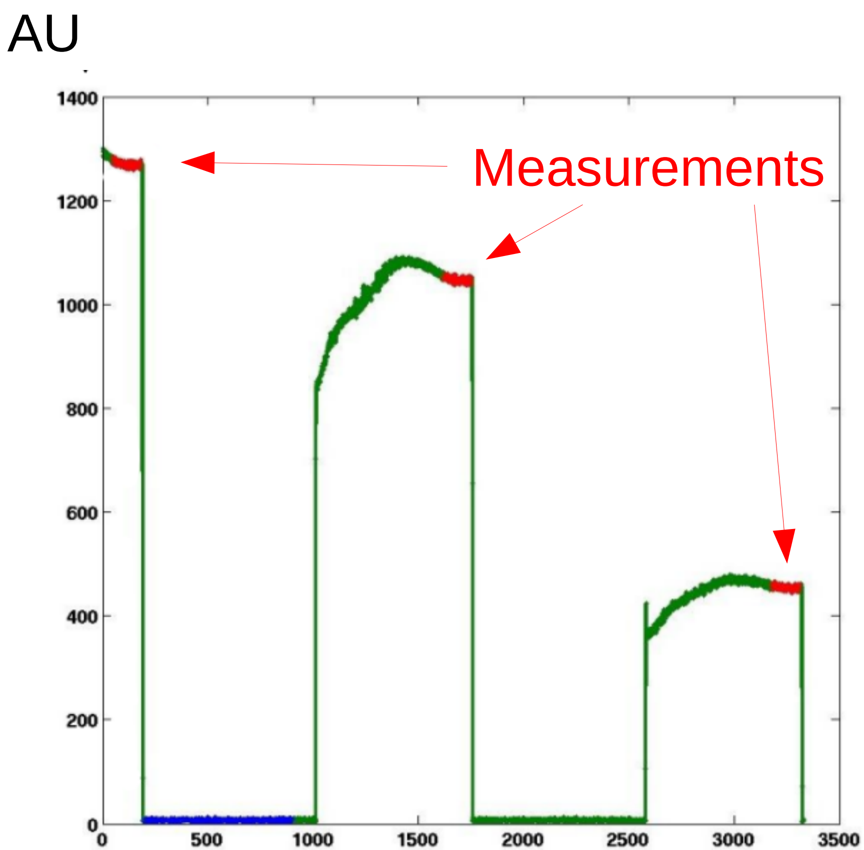
6) Transmission efficiency

AU



Booster ring (Spark)

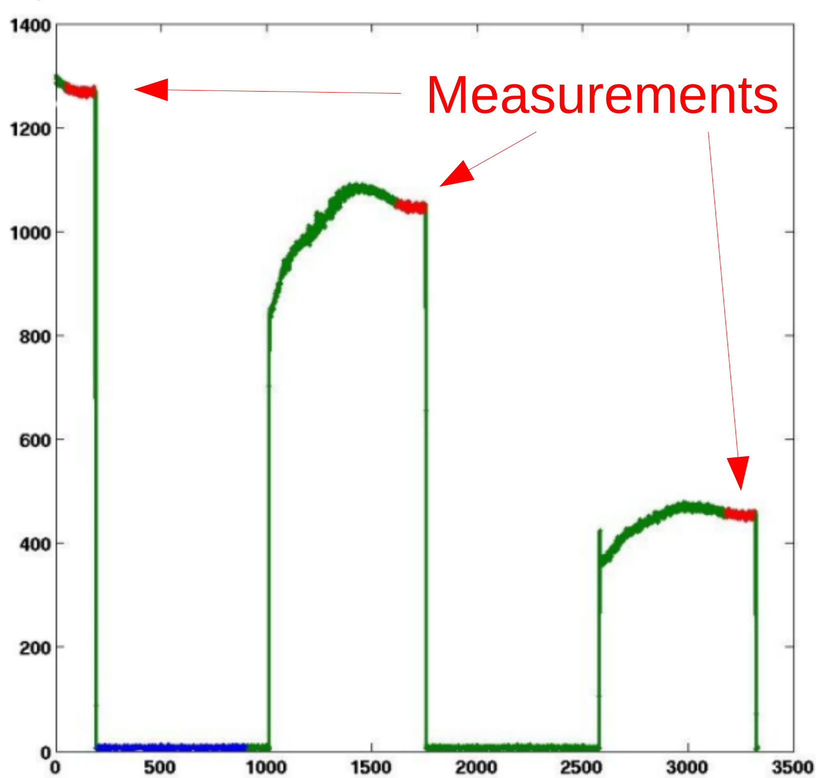
6) Transmission efficiency



Booster ring (Spark)

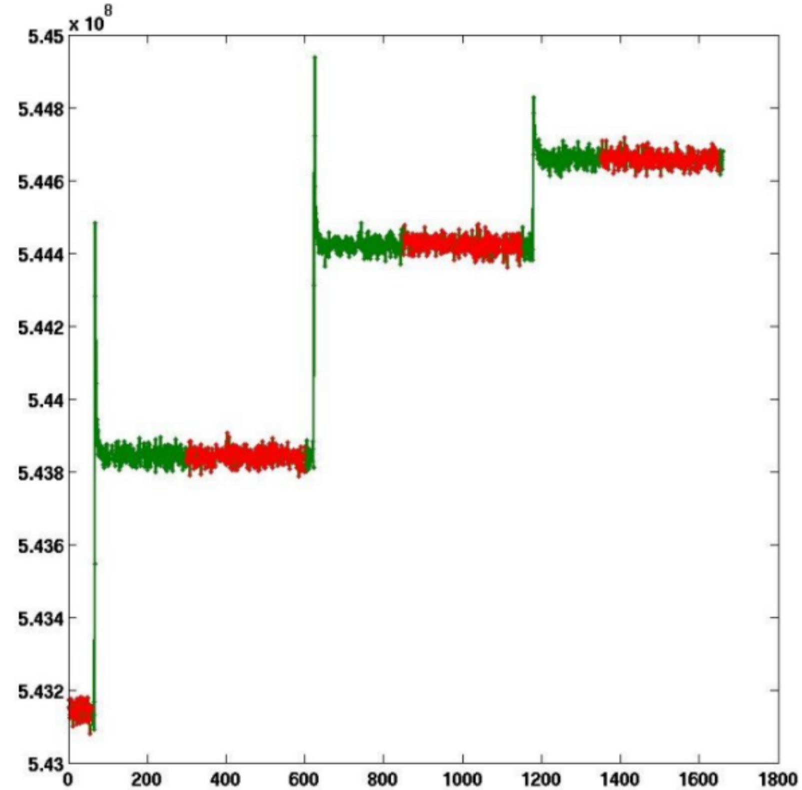
6) Transmission efficiency

AU



Booster ring (Spark)

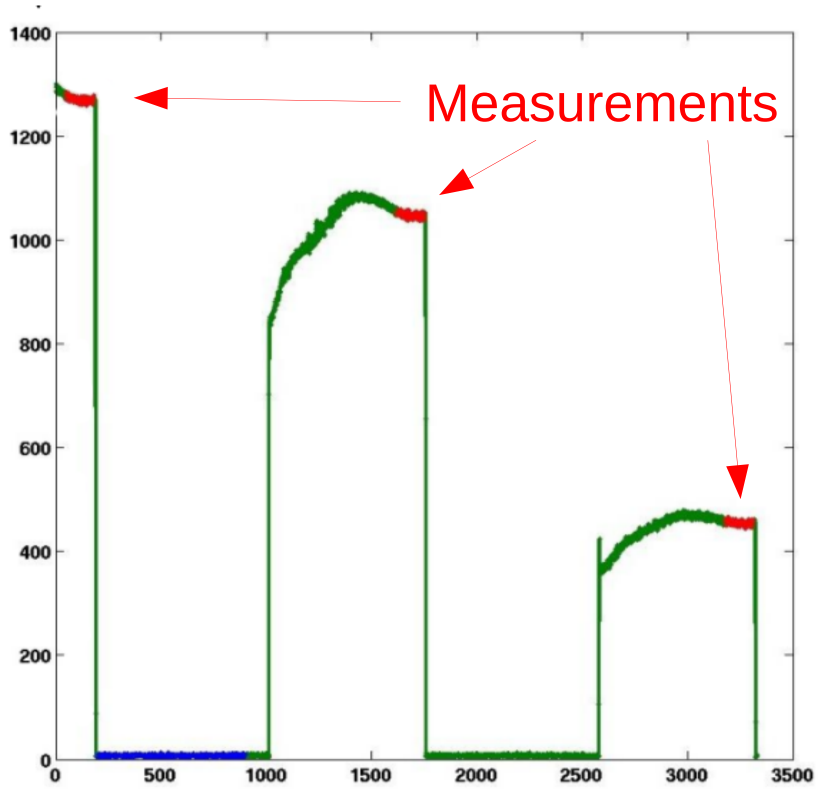
AU



Storage ring (LB)

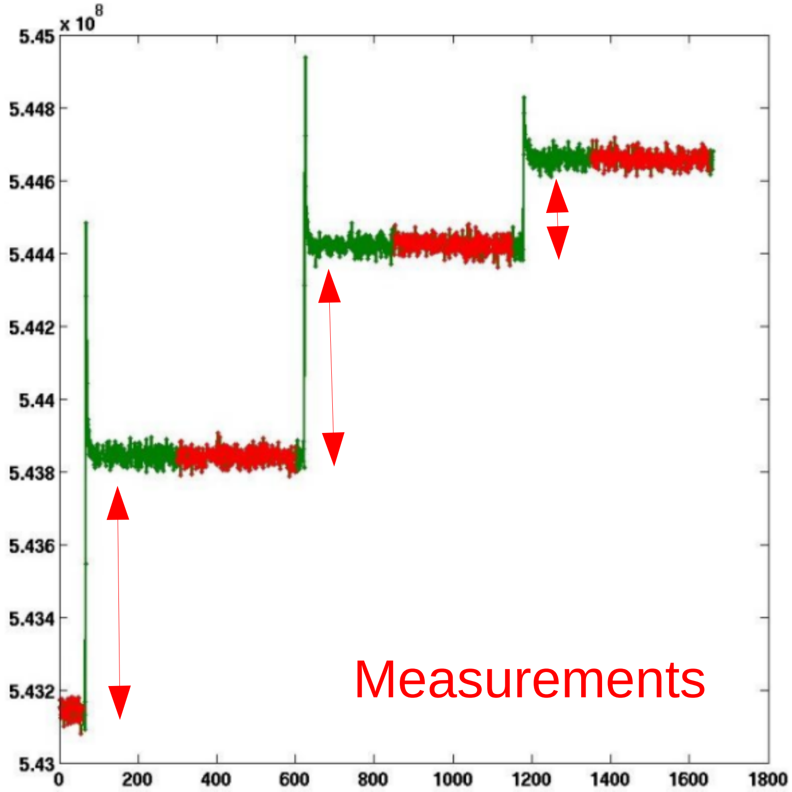
6) Transmission efficiency

AU



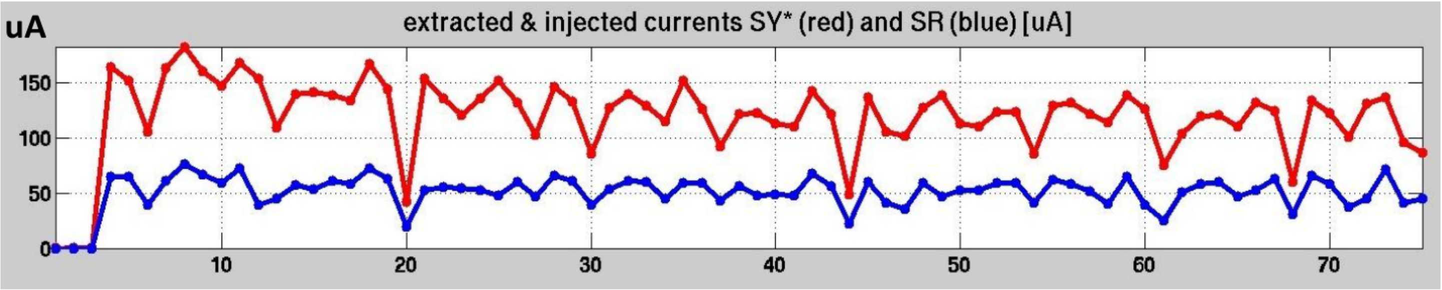
Booster ring (Spark)

AU



Storage ring (LB)

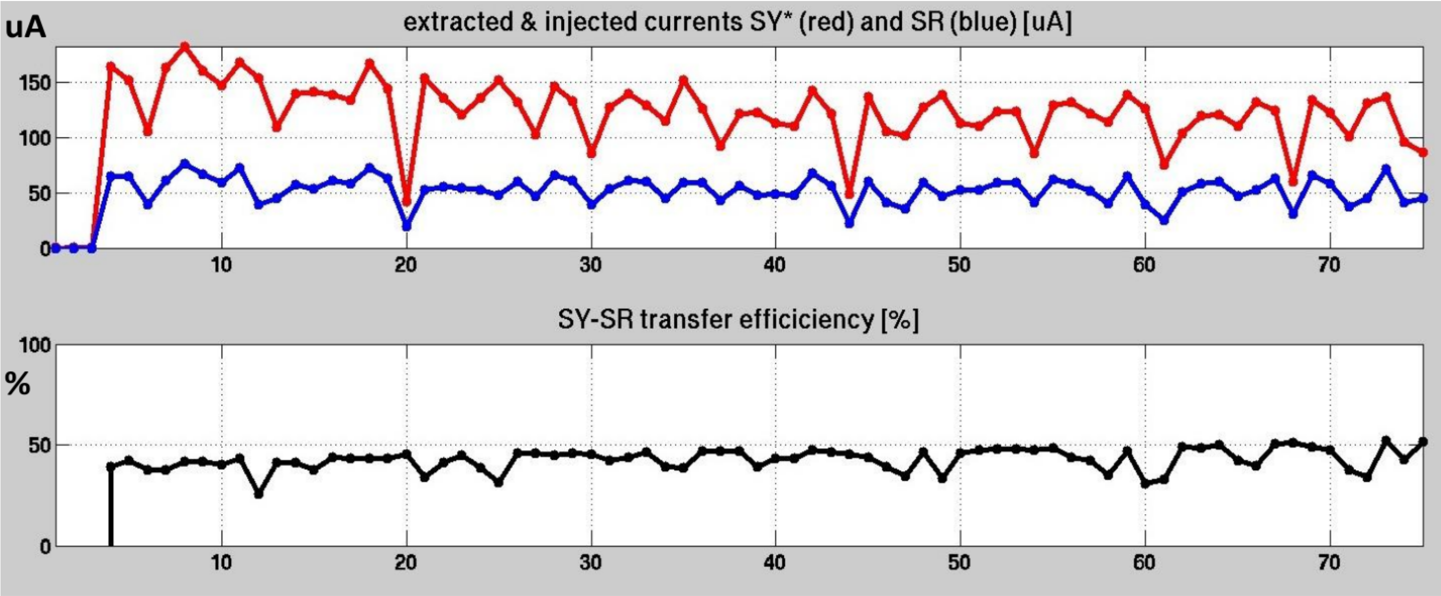
6) Transmission efficiency



Booster

SR

6) Transmission efficiency

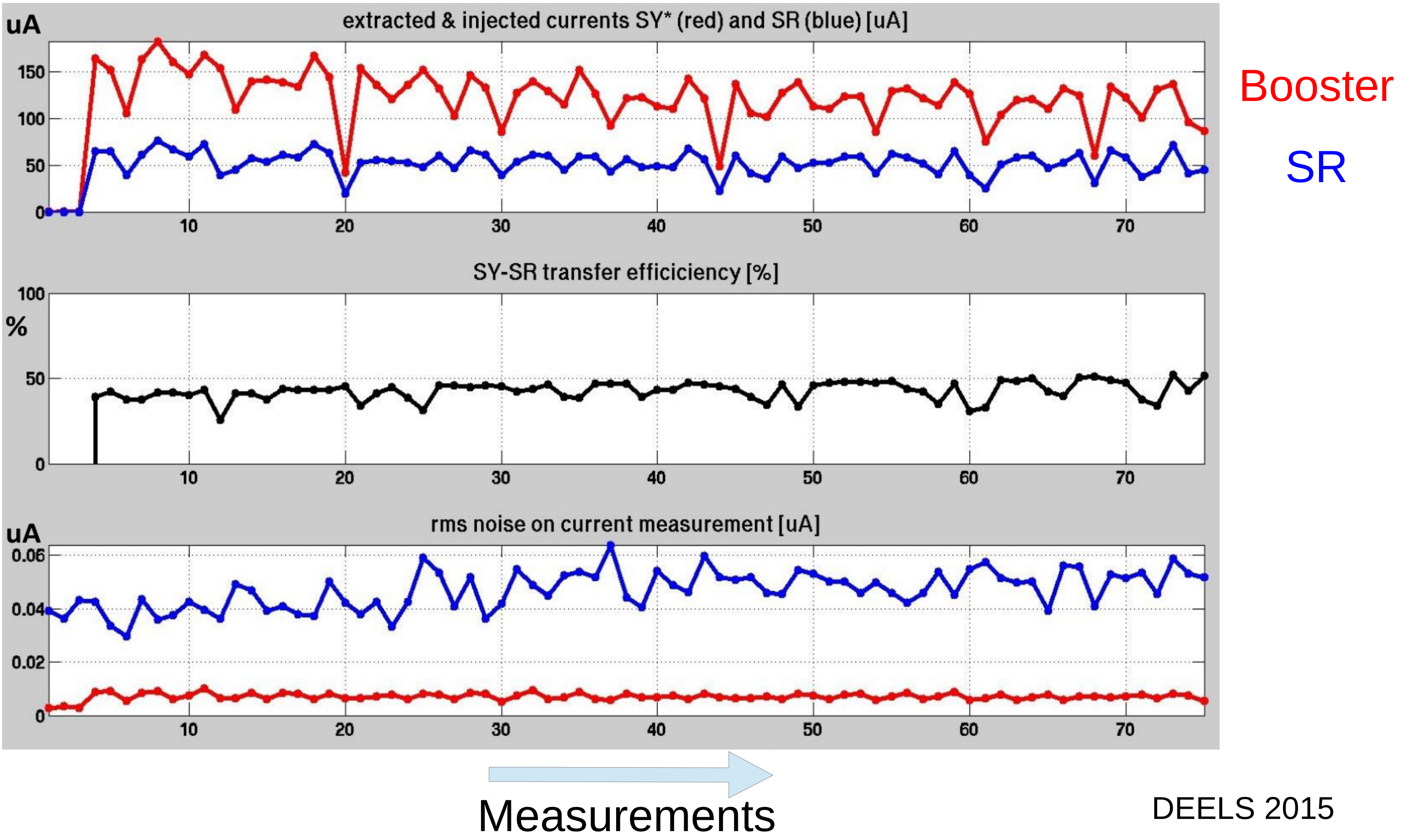


Booster

SR

Measurements

6) Transmission efficiency



Instrumentation Technologies

Conclusions

- Commissioning of **75** new BPM electronics
- Installation, Integration and Measurements: **2 weeks**
- ADC, T-b-T and Decimated data proven to be very useful
- Libera Spark is a cost-effective and valuable solution

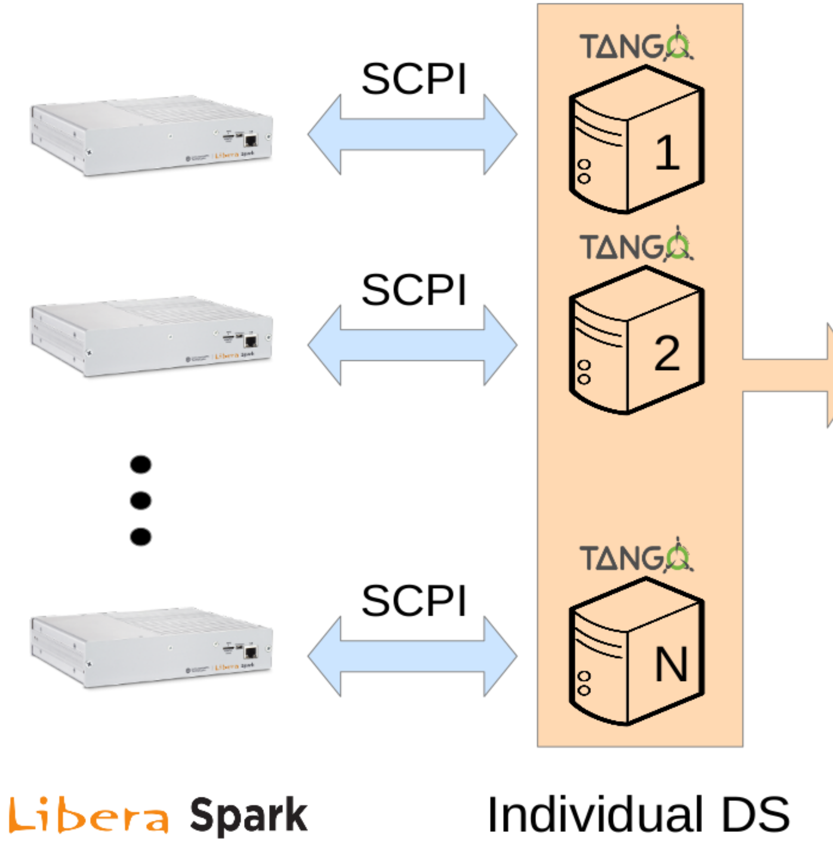
Libera Spark

Instrumentation Technologies

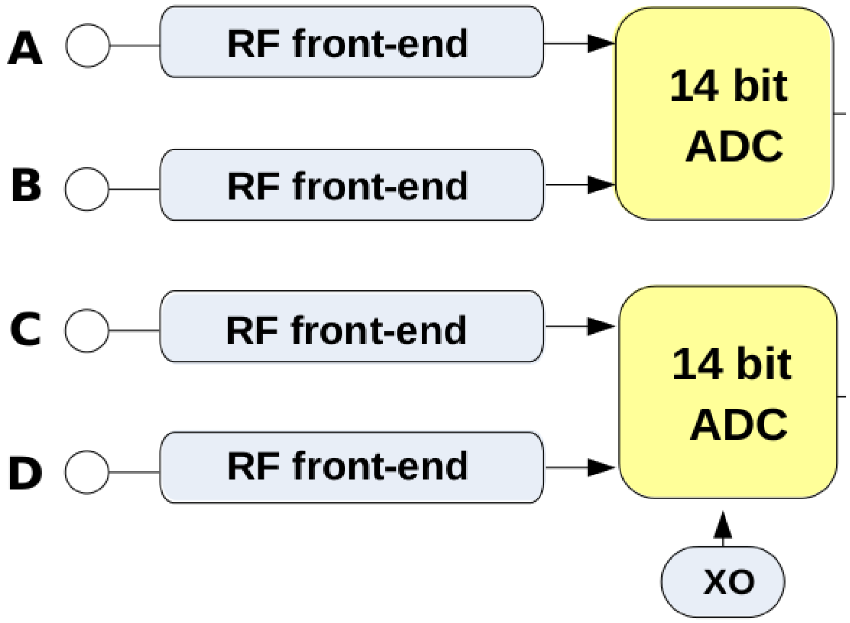
Thanks for your attention!

manuel.cargnelutti@i-tech.com

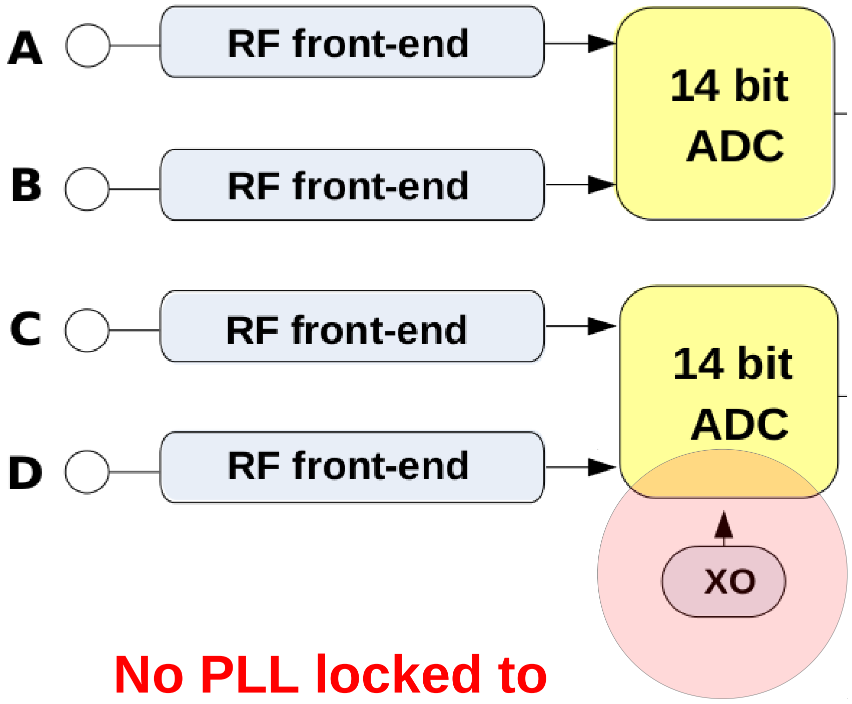
a) Integration in the Control System



2) Tuning of the XOs

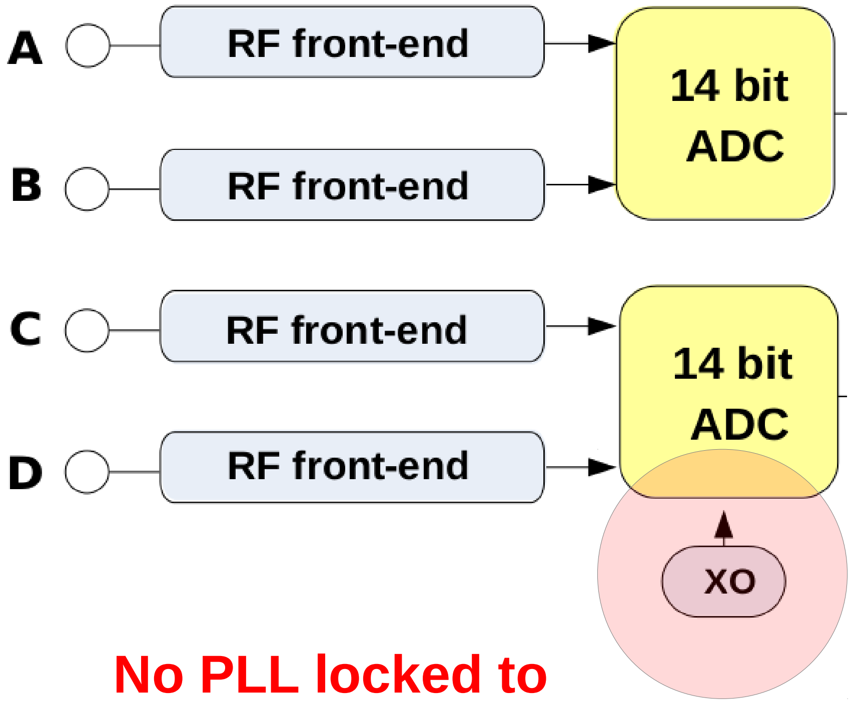


2) Tuning of the XOs



No PLL locked to any machine reference!

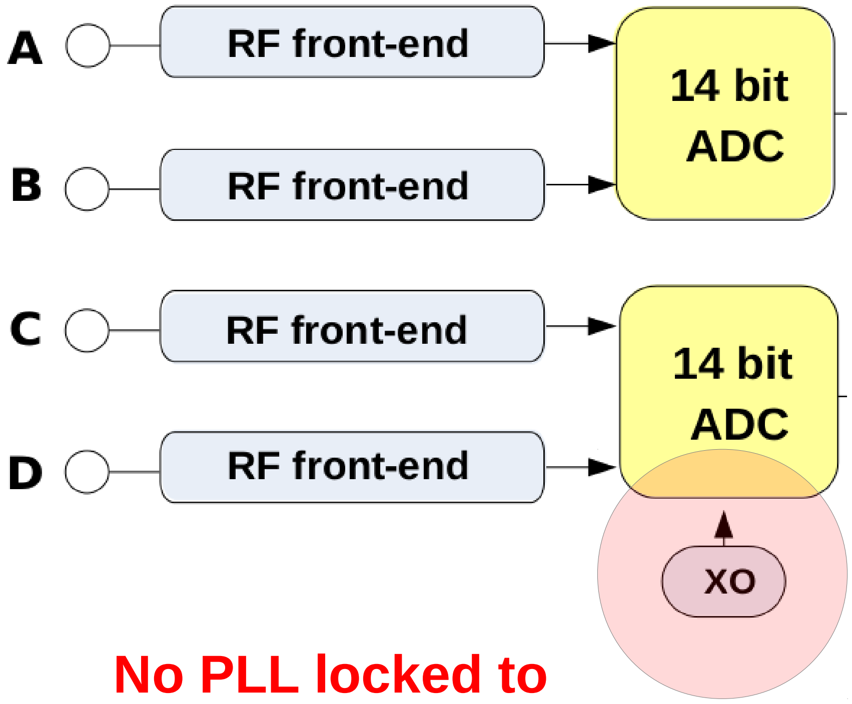
2) Tuning of the XOs



No PLL locked to any machine reference!

- Every device have a different sampling rate

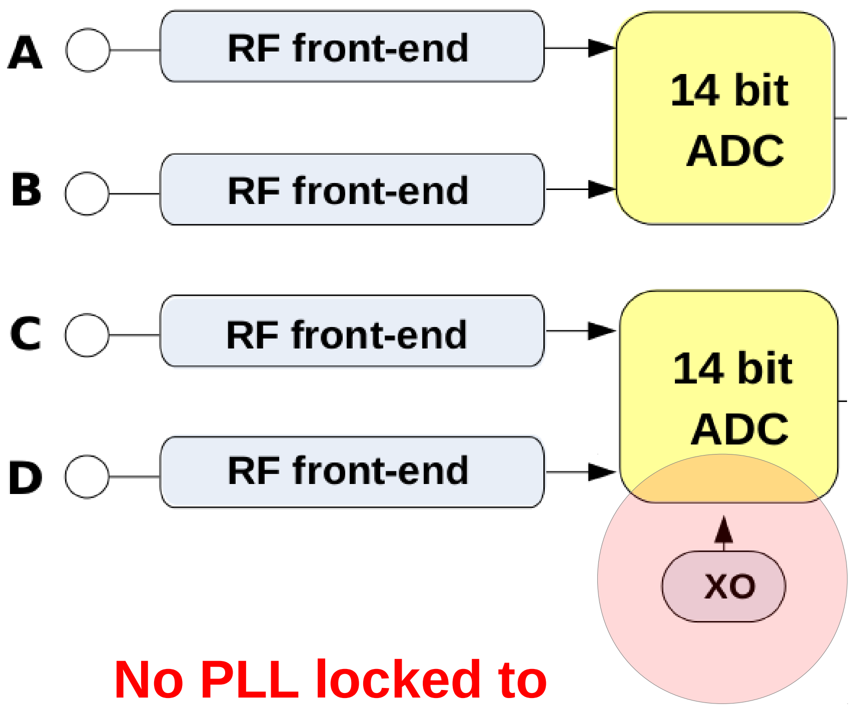
2) Tuning of the XOs



No PLL locked to any machine reference!

- Every device have a different sampling rate
- If rates are to different
  →misalignment in time
  →MAF filtering issues

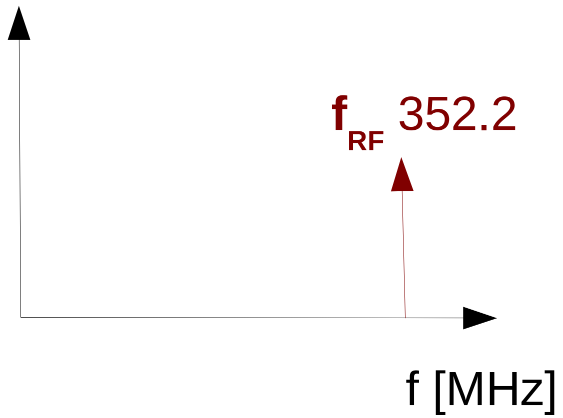
2) Tuning of the XOs



No PLL locked to any machine reference!

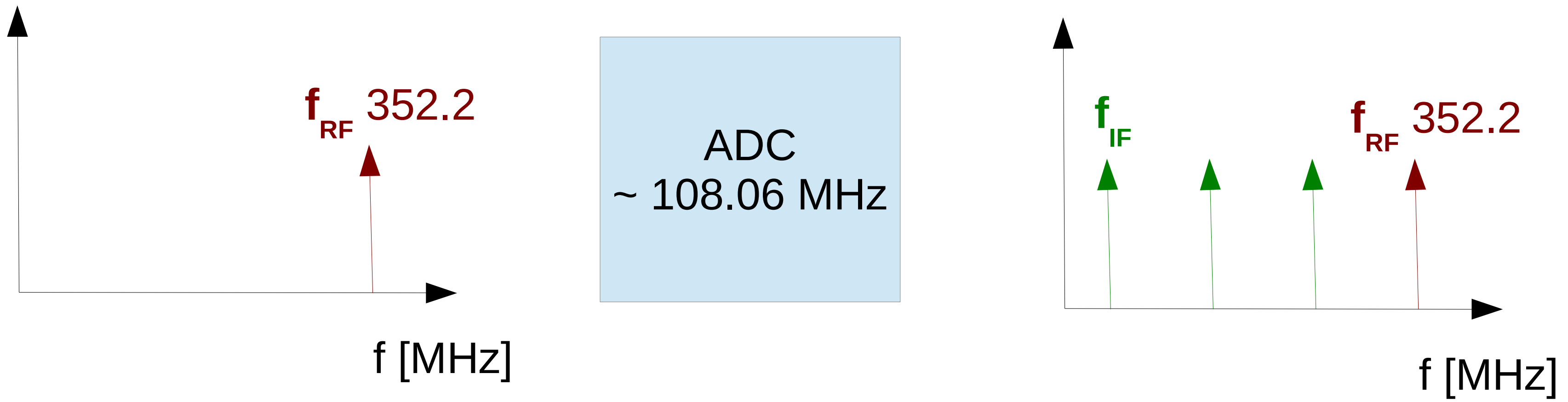
- Every device have a different sampling rate
- If rates are to different
  →misalignment in time
  →MAF filtering issues
- Sampling frequency is a parameter and can be corrected

Estimate the difference

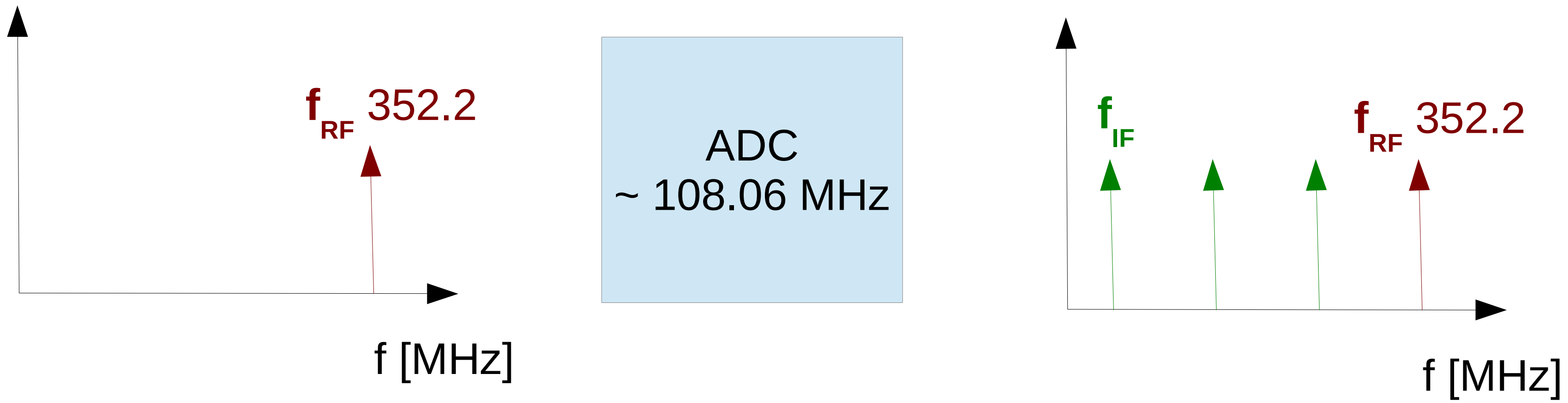


ADC
~ 108.06 MHz

Estimate the difference

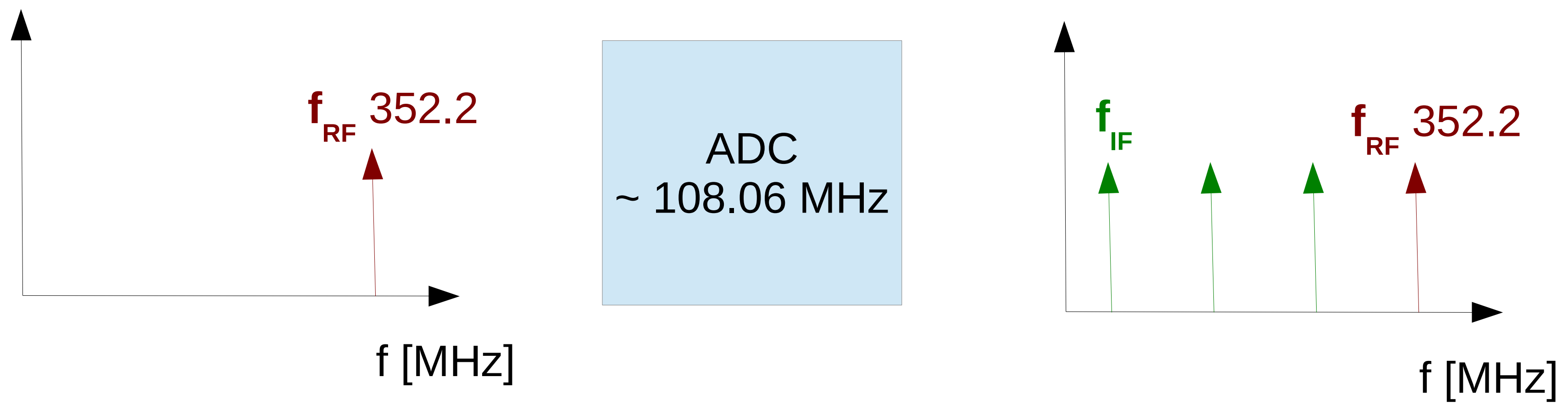


Estimate the difference



$$f_{IF} = f_{RF} - 3^* f_{ADC}$$

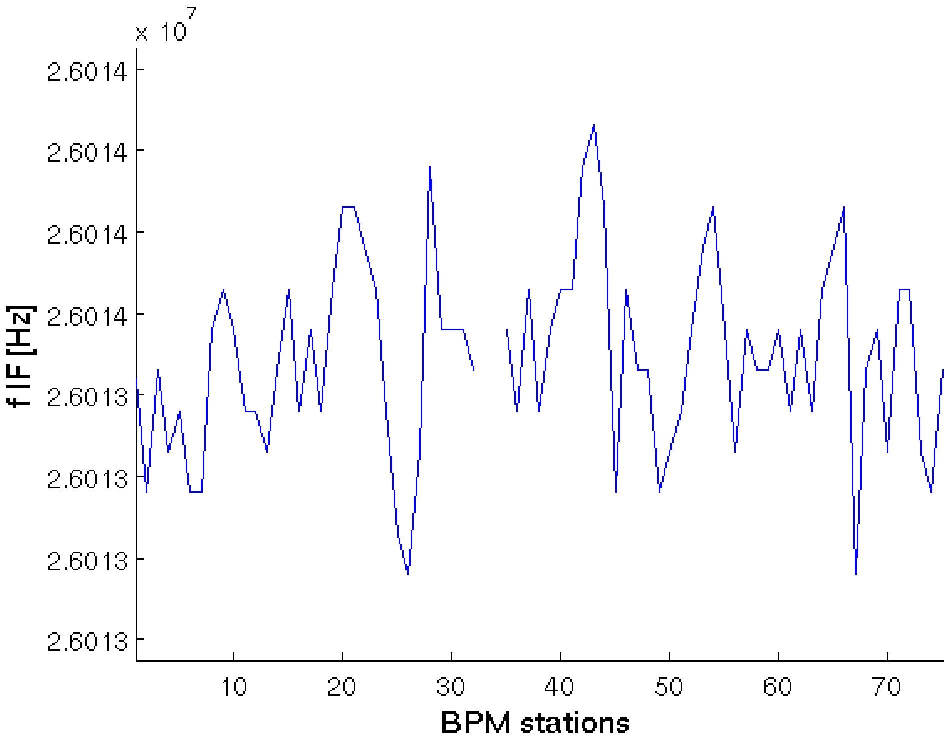
Estimate the difference



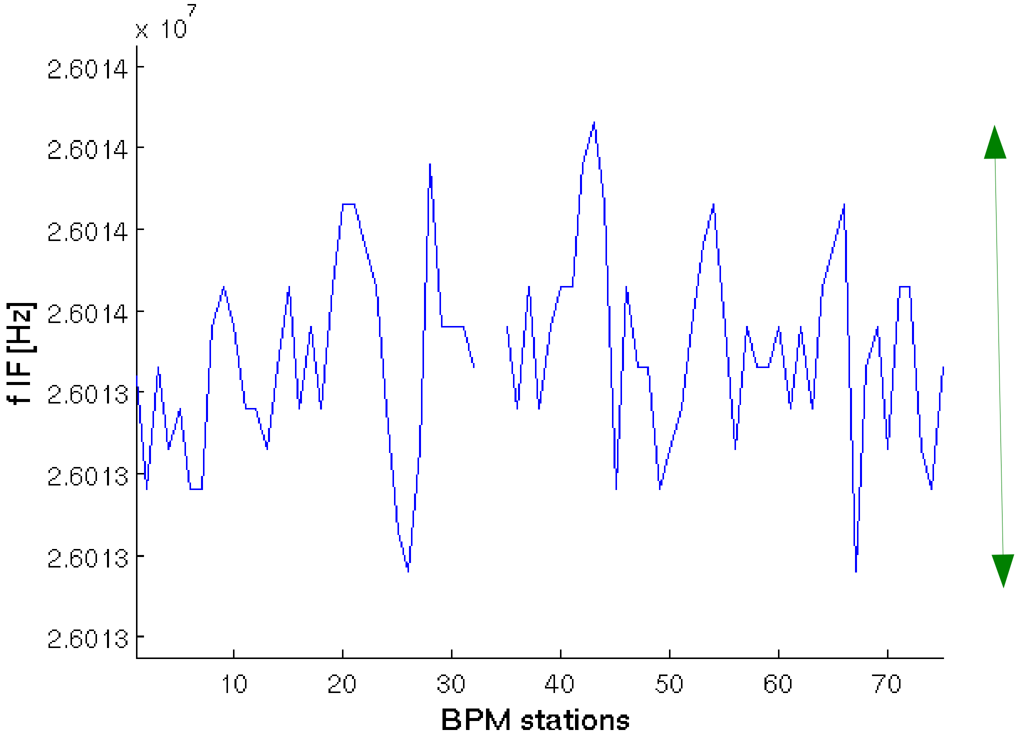
$$f_{IF} = f_{RF} - 3^* f_{ADC}$$

$$\Delta f_{IF} = 3^* \Delta f_{ADC}$$

Estimate the difference

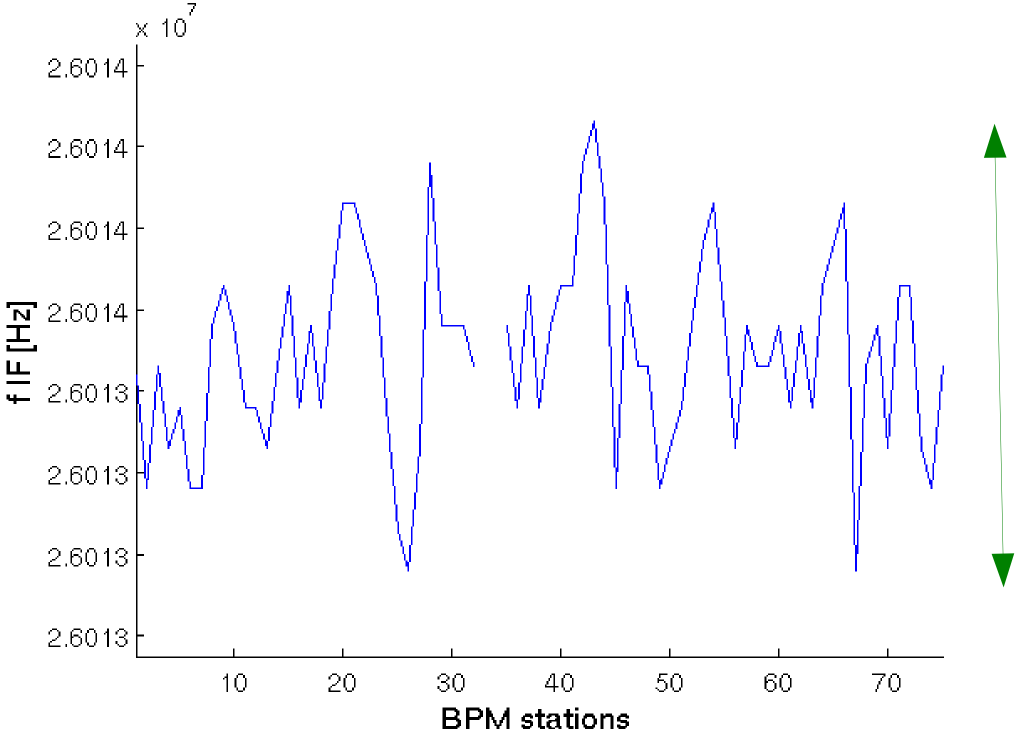


Estimate the difference



Δf_{IF} = 1100Hz p2p

Estimate the difference

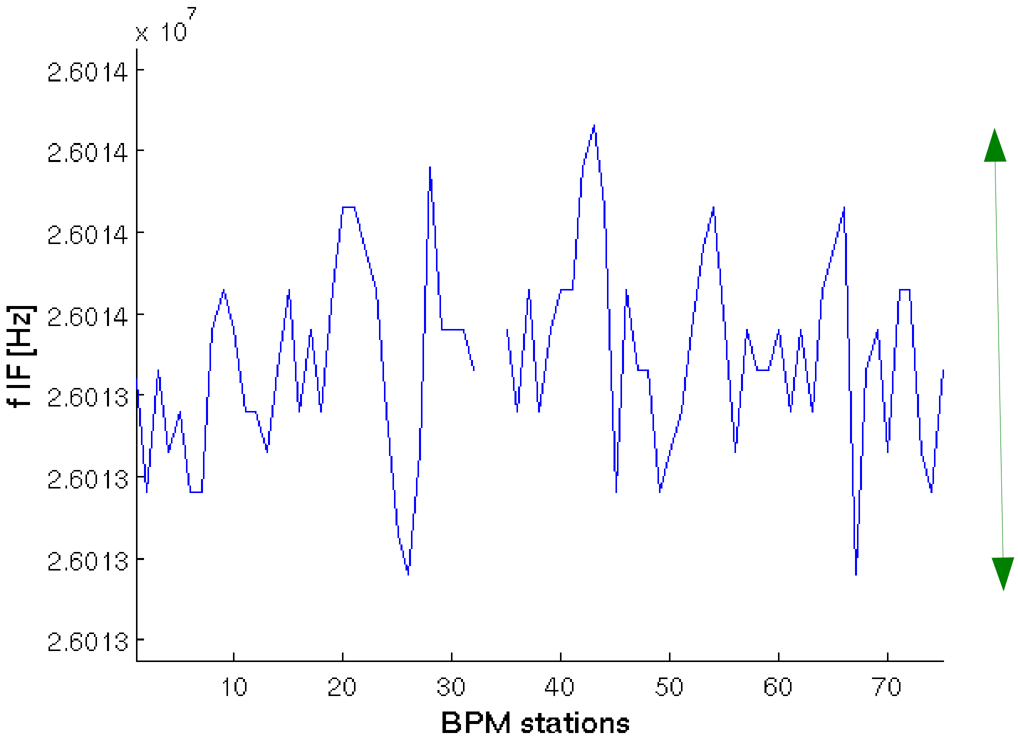


Δf_{IF} = 1100Hz p2p

:3

Δf_{ADC} ~ 367Hz

Estimate the difference



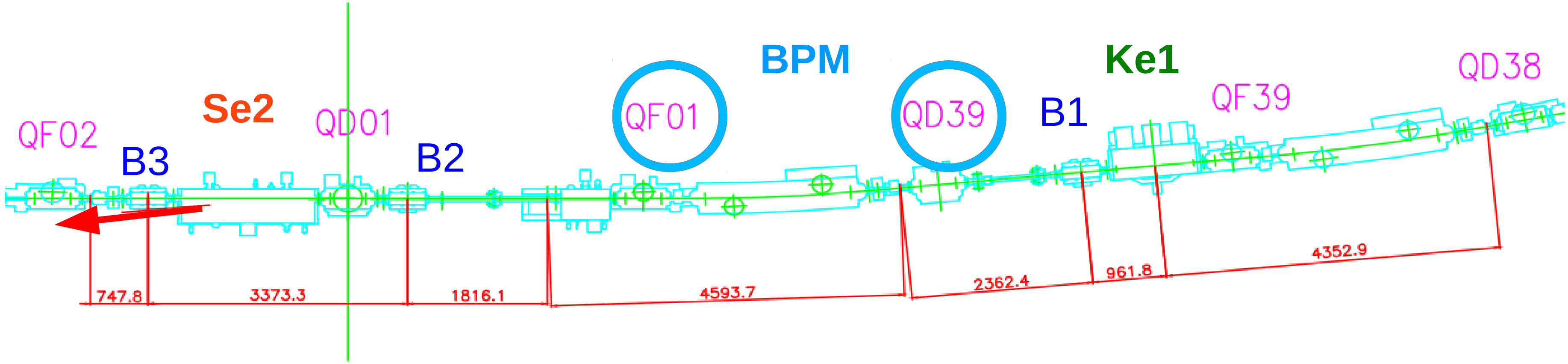
Δf_{IF} = 1100Hz p2p

:3

Δf_{ADC} ~ 367Hz

18 samples in 50ms

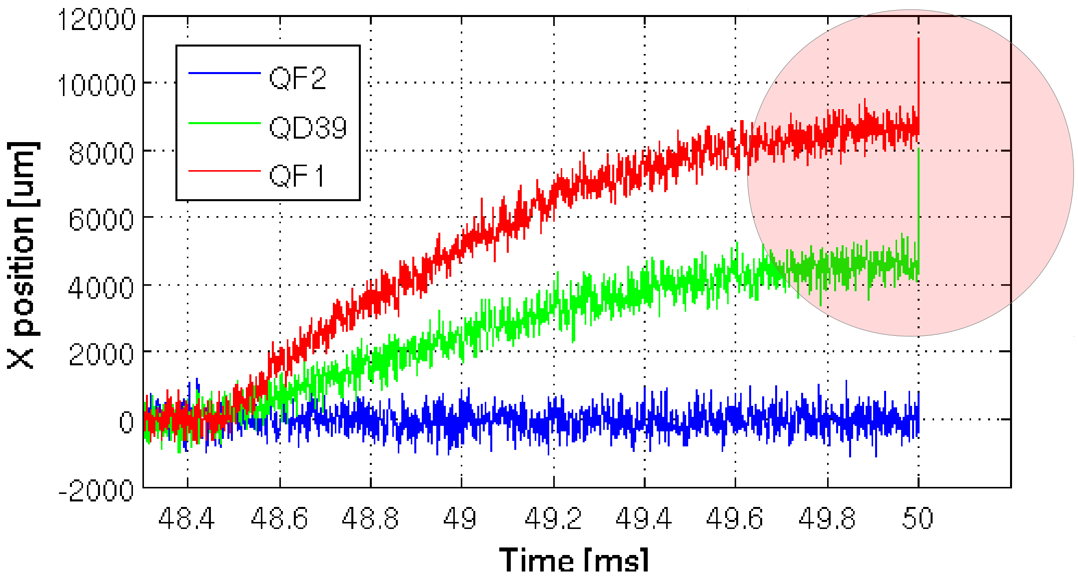
c) Extraction process

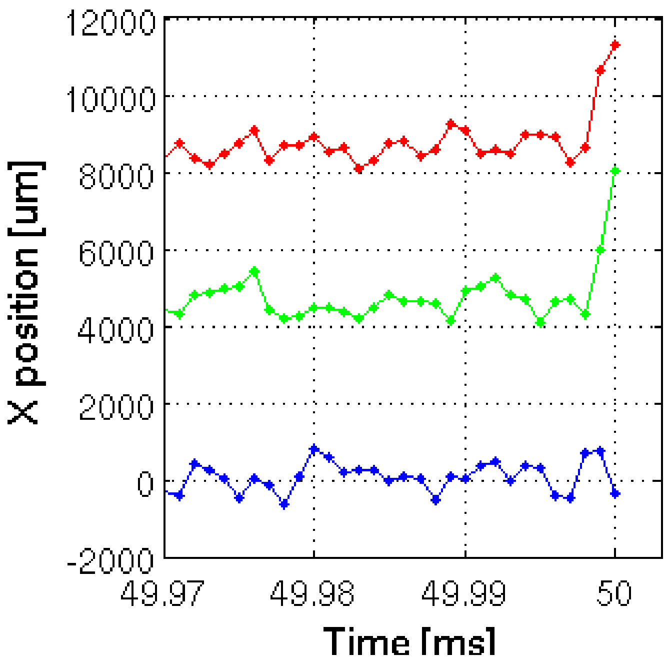


- Three bumpers (B1, B2 and B3) create an horizontal bump 1.5 ms before extraction
- This moves the beam closer to the extraction septum magnet **Se2**
- The fast kicker **Ke1** extracts the beam in one turn

c) Extraction process

1 µs fast kick



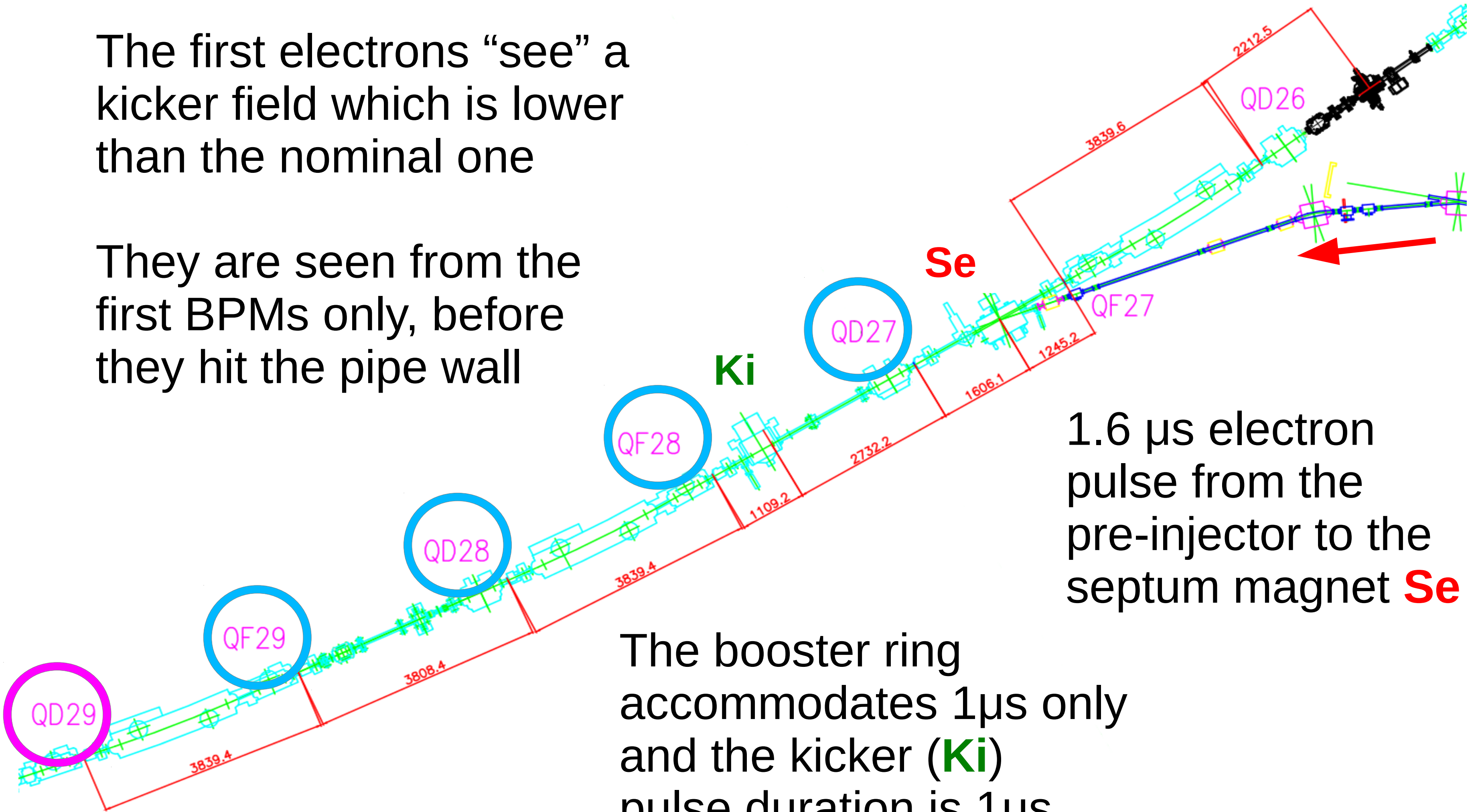


1.5 ms local bump

d) Injection process

The first electrons “see” a kicker field which is lower than the nominal one

They are seen from the first BPMs only, before they hit the pipe wall



1.6 μs electron pulse from the pre-injector to the septum magnet **Se**

The booster ring accommodates 1μs only and the kicker (**Ki**) pulse duration is 1μs

Instrumentation Technologies

d) Injection process