



Libera

Full experience with the 75 Spark-BPMs with emphasis on the enhanced features and the associated applications

*Manuel Cargnelutti, Libera Workshop 2015, 28.05.2015*

## Presentation outline

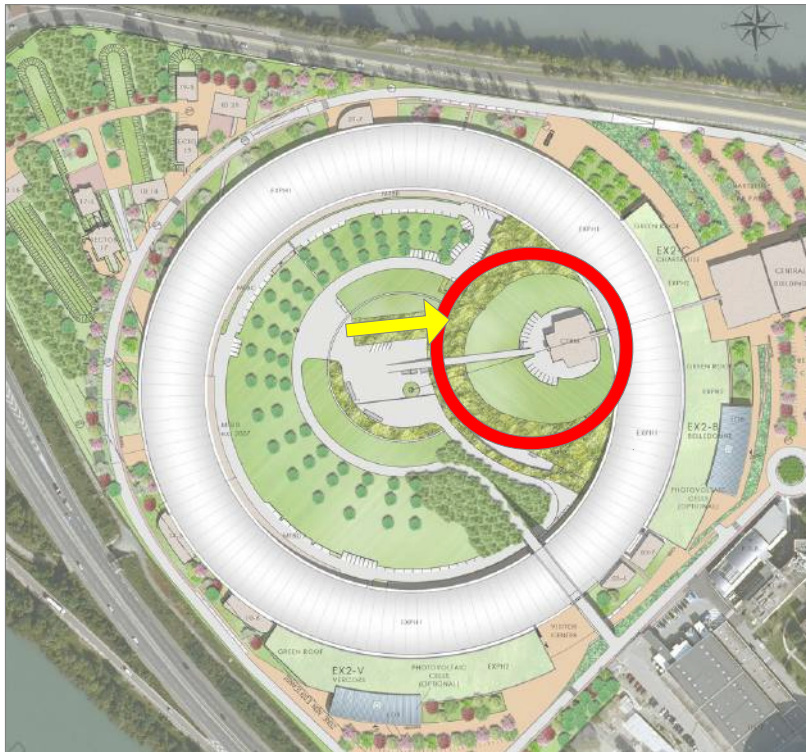
- The ESRF Booster Ring
- Libera Spark BPM electronics
- Installation and CS integration
- First results and Applications
- Conclusions

# The ESRF Booster Ring



Pre-Injector LINAC  
from 0 to 200 MeV

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Pre-Injector LINAC

from **0 to 200 MeV**

Booster Synchrotron

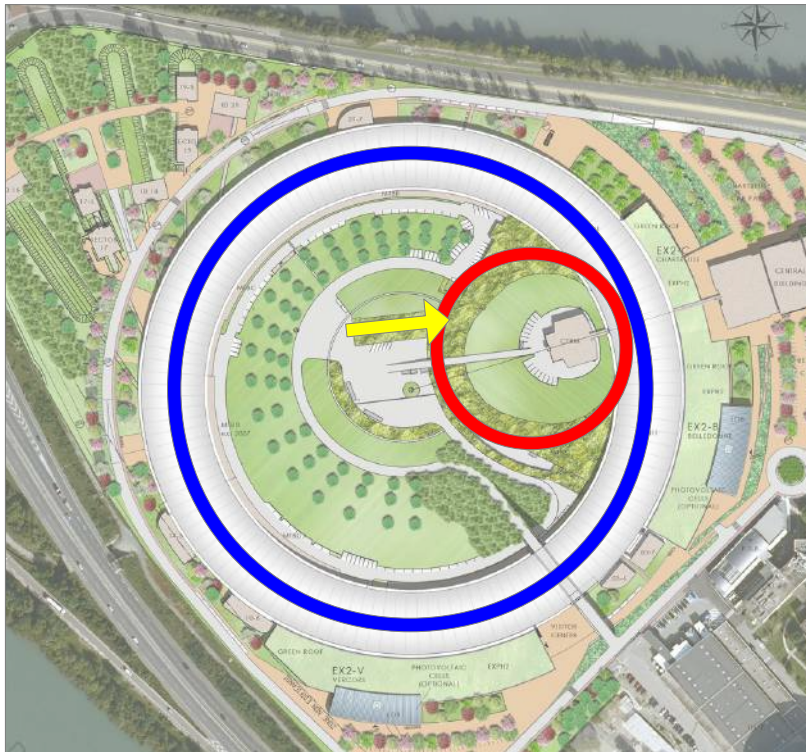
**200 MeV → 6 GeV**

**50 ms** (50000 turns) acceleration cycle

**1  $\mu$ s** orbit time

current from **2.5 mA** down to  **$\mu$ A**

# The ESRF Booster Ring



Pre-Injector LINAC

from **0 to 200 MeV**

Booster Synchrotron

**200 MeV → 6 GeV**

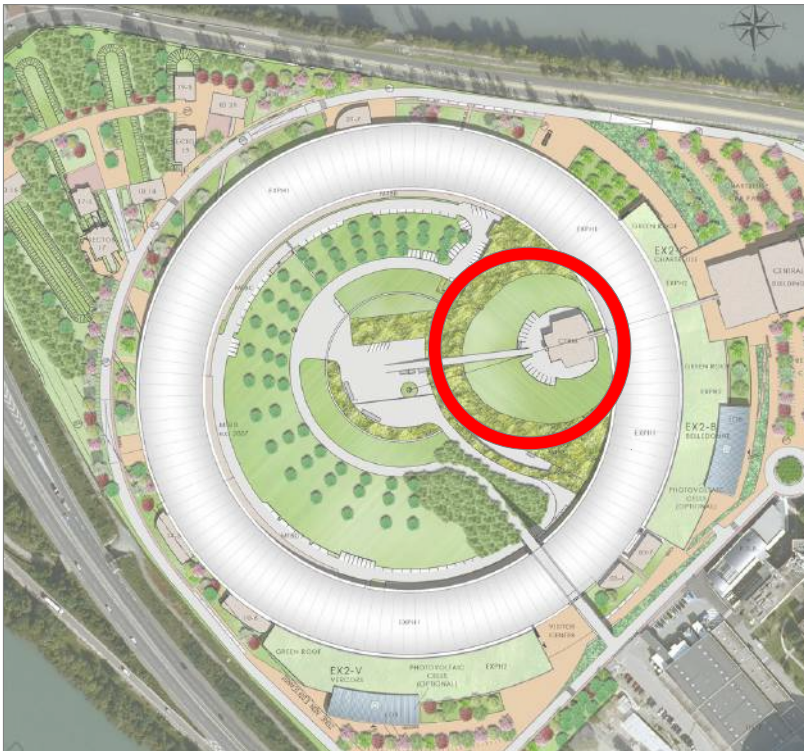
**50 ms** (50000 turns) acceleration cycle

**1  $\mu$ s** orbit time

current from **2.5 mA** down to  **$\mu$ A**

Storage Ring (200 mA)

# The ESRF Booster Ring



**75 BPM blocks**

**25 years old electronics**

**Need new BPM electronics**

## What kind of electronics?

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

## What kind of electronics?

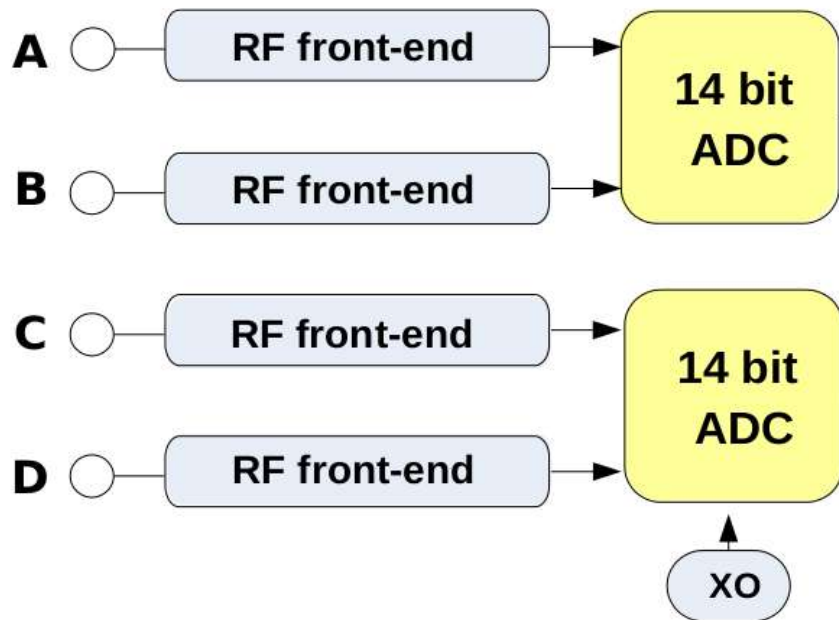
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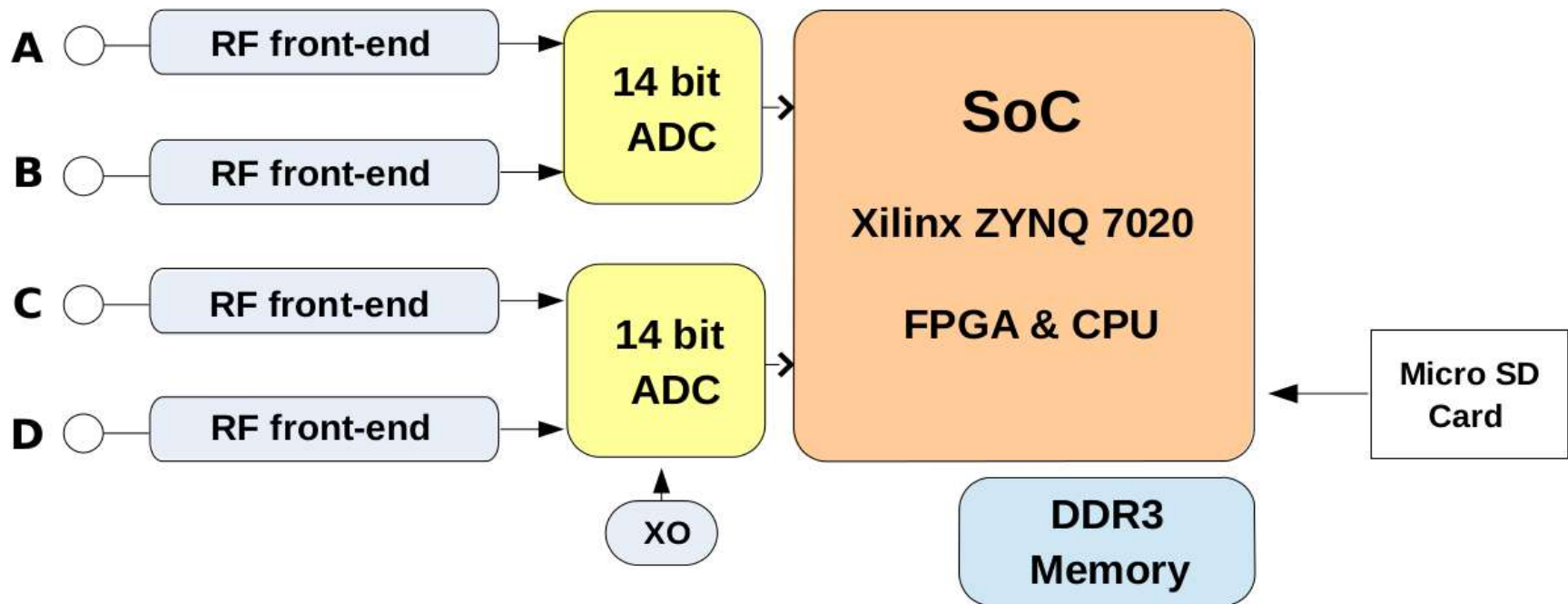
Libera Spark



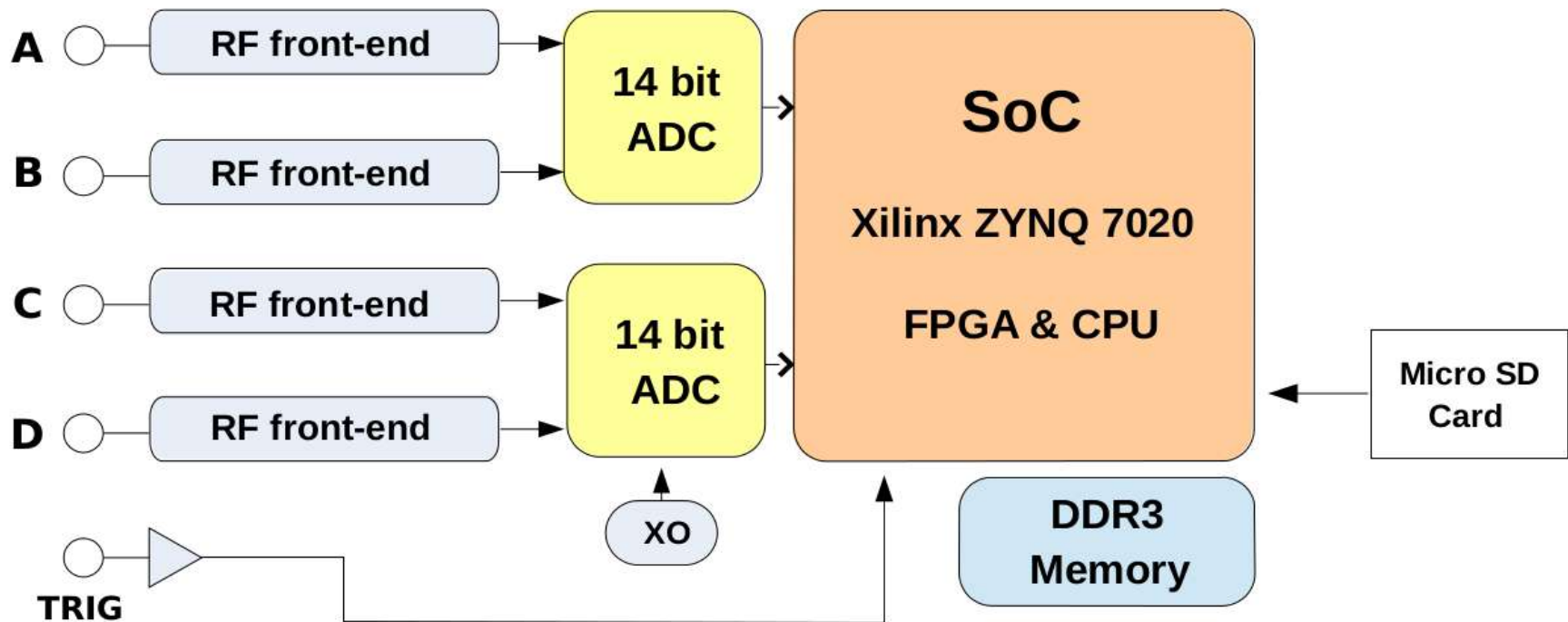
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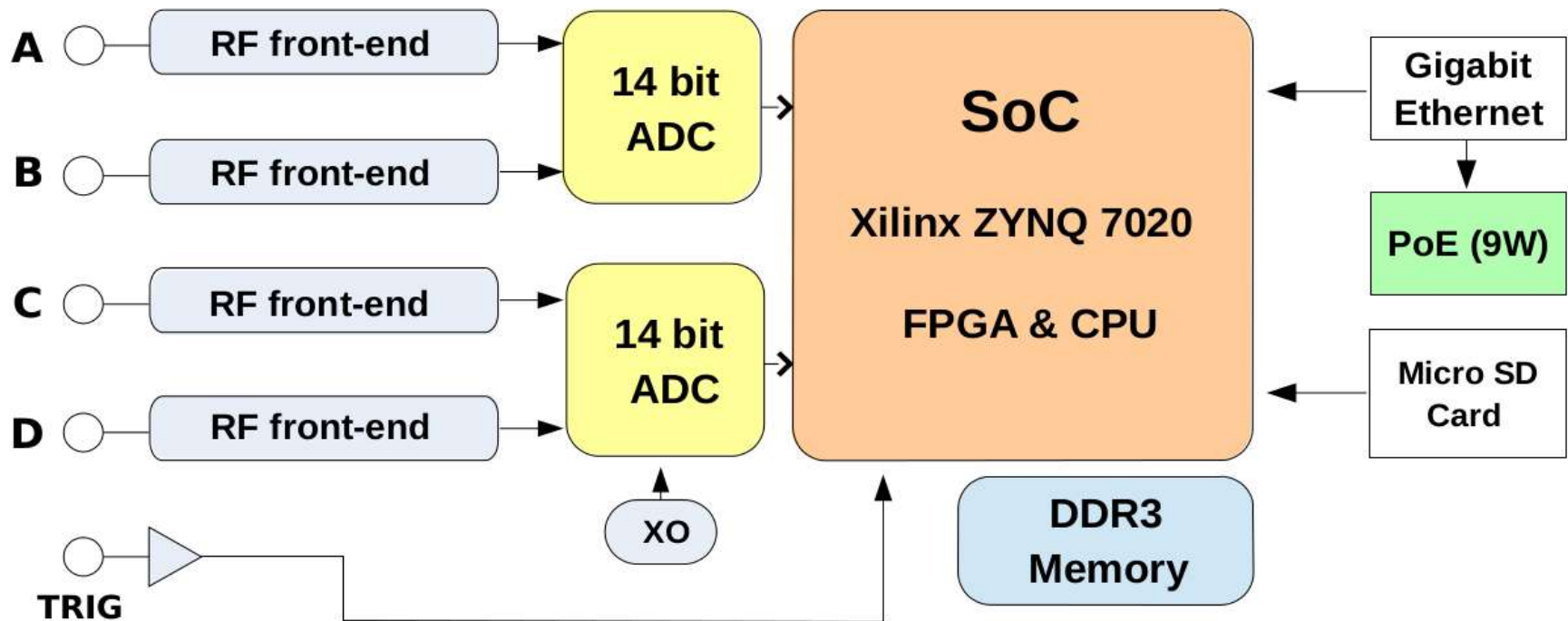
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# What kind of electronics?



## Installation

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

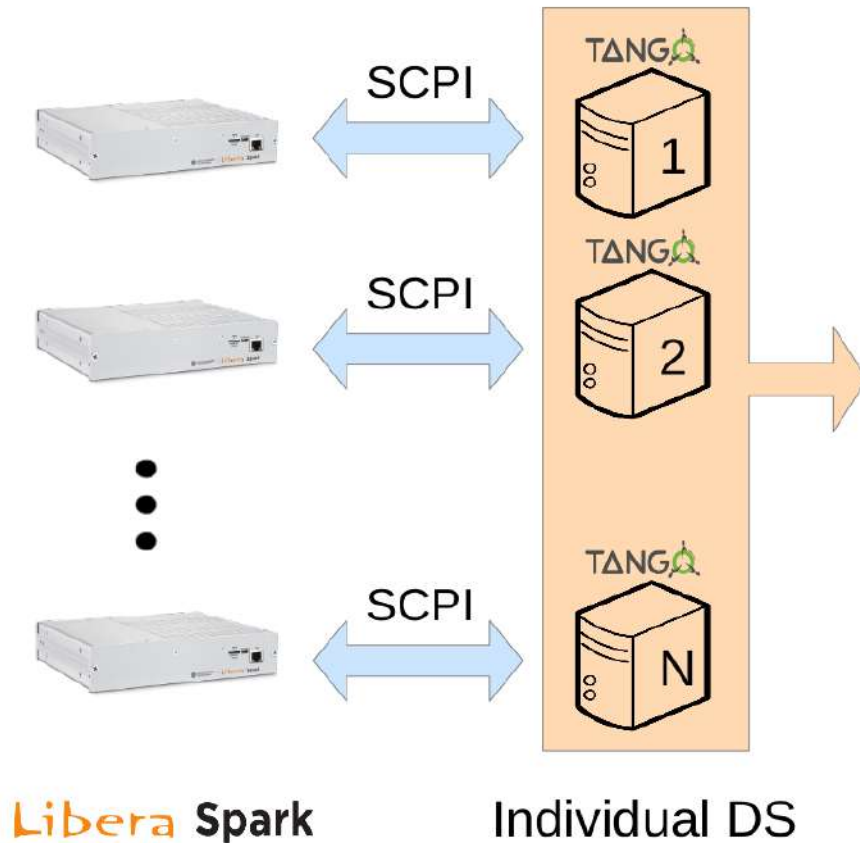


# Integration in the Control System

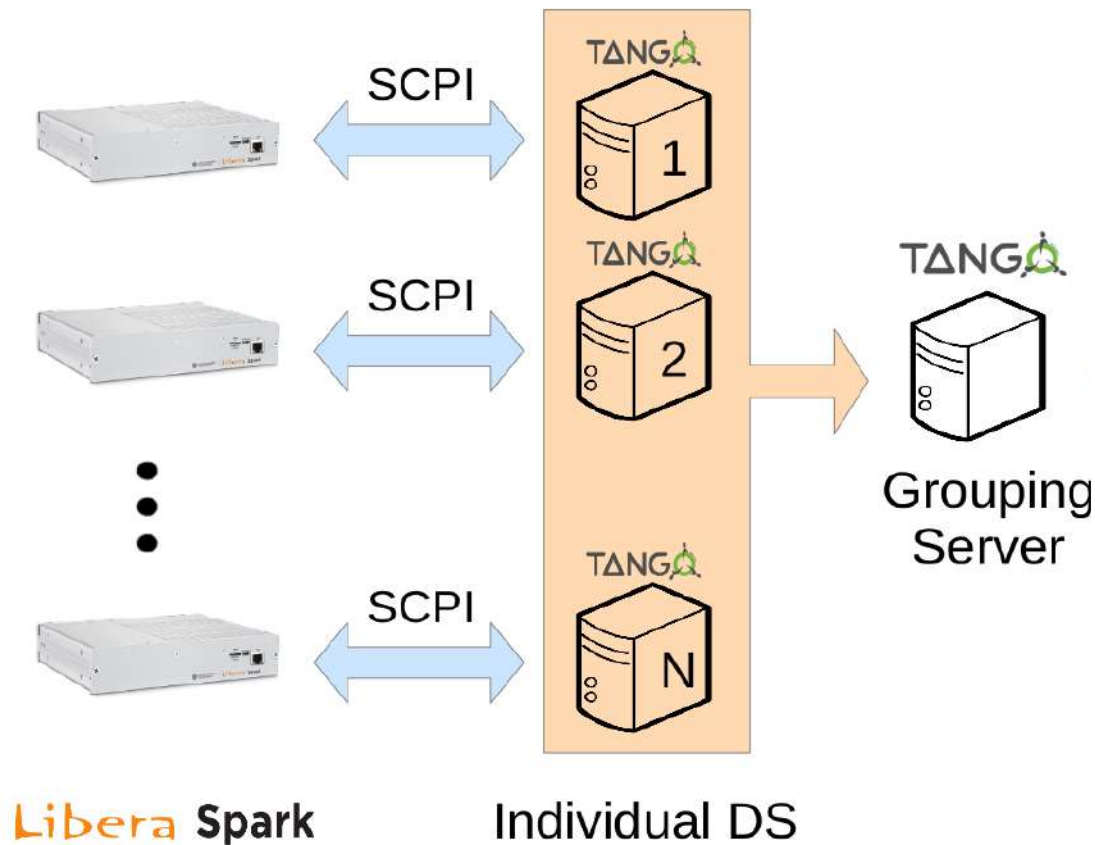


Libera Spark

# Integration in the Control System

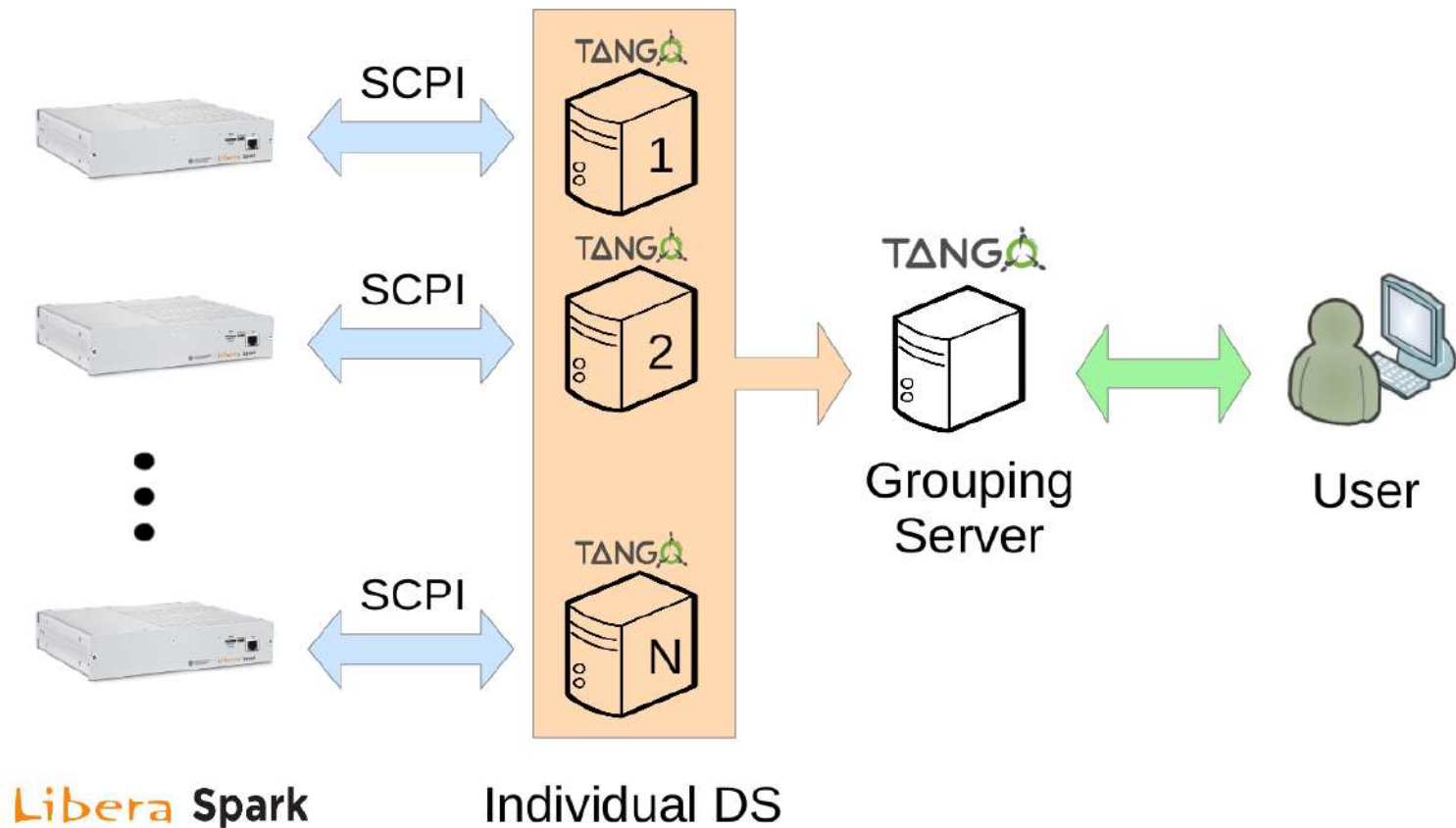


# Integration in the Control System





# Integration in the Control System



# Control room application (Java)

The screenshot displays the Libera control room application interface. At the top, there is a menu bar with 'File', 'View', and 'Expert'. Below the menu, the main window is divided into several sections:

- Status Windows:**
  - Top left: A window titled 'sy/d-bpmlibera-sp/all' showing an 'ALARM: See list of errors with the GetLastErrors() command:'.
  - Top center: A display for 'SR Current' showing '185.908 mA'.
  - Top right: A window titled 'sr/d-bpmlibera/aclock' showing 'forced one shot trigger fired'.
- Detector Grid:** A grid of 39 columns and 2 rows (labeled 'QF' and 'QD') of status indicators. Most cells are green, indicating they are active or in a specific state.
- Configuration Panel:**
  - ConfigurationFilename: `MDT/thomas-1`
  - ADC\_Enable:  Disabled
  - AMPL\_Enable:  Disabled
  - IQ\_Enable:  Disabled
  - QSUM\_Enable:  Enabled
  - Decimation\_Enable:  Disabled
  - TDP\_AMPL\_Enable:  Disabled
  - TDP\_QSUM\_Enable:  Disabled
  - TDP\_XZ\_Enable:  Disabled
  - MAF Filter Length:
  - Acquisition Duration:
  - TBT\_Start\_mean:
  - TBT\_Stop\_mean:
  - read only section:
    - ADC Buffer Size:
    - Fill Counter:
    - SetDivider:
  - ResetFillCounter button

# Control room application (Java)

The screenshot displays the Libera control room application interface. At the top, there is a menu bar with 'File', 'View', and 'Expert'. Below the menu, the application path is shown as 'sy/d-bpmlibera-sp/all'. A central panel displays 'SR Current' at '185.908 mA'. To the right, a status window for 'sr/d-bpmlibera/aclock' shows 'forced one shot trigger fired'. A large red oval highlights a grid of 39 status indicators, with the first two labeled 'QF' and 'QB'. Below this, a 'Settings' tab is active, showing 'ConfigurationFilename' as 'MDT/thomas-1'. The settings include various enable/disable checkboxes (ADC\_Enable, AMPL\_Enable, IQ\_Enable, QSUM\_Enable, Decimation\_Enable, TDP\_AMPL\_Enable, TDP\_QSUM\_Enable, TDP\_XZ\_Enable) and numerical input fields (MAF Filter Length: 108, Acquisition Duration: 10.000, TBT\_Start\_mean: 1, TBT\_Stop\_mean: 10, ADC Buffer Size: 1080619, Fill Counter: 59535, SetDivider: 1). A 'ResetFillCounter' button is also present. The text 'Status of the units' is overlaid in red on the right side of the settings panel.

# Control room application (Java)

The screenshot displays a Java-based control room application. At the top, there is a menu bar with 'File', 'View', and 'Expert'. Below the menu, the application shows two active sessions: 'sy/d-bpmlibera-sp/all' and 'sr/d-bpmlibera/aclock'. The 'sy/d-bpmlibera-sp/all' session displays an 'ALARM: See list of errors with the GetLastErrors() command:' message and a 'SR Current' value of 185.908 mA. The 'sr/d-bpmlibera/aclock' session displays the message 'forced one shot trigger fired'. A central status bar contains 39 numbered units, each with a green indicator light. Below this, the 'Settings' panel is visible, featuring tabs for 'Settings', 'XZ Positions', 'Detailed Settings', and 'Last Errors'. The 'Settings' panel includes a 'ConfigurationFilename' field set to 'MDT/thomas-1'. A list of enable/disable options is shown, with 'QSUM\_Enabled' checked. Numerical input fields for 'MAF Filter Length' (108), 'Acquisition Duration' (10.000), 'TBT\_Start\_mean' (1), and 'TBT\_Stop\_mean' (10) are present. A 'read only' section contains 'ADC Buffer Size' (1080619), 'Fill Counter' (59535), and 'SetDivider' (1). A 'ResetFillCounter' button is also visible. Two red ovals highlight the status bar and the settings panel.

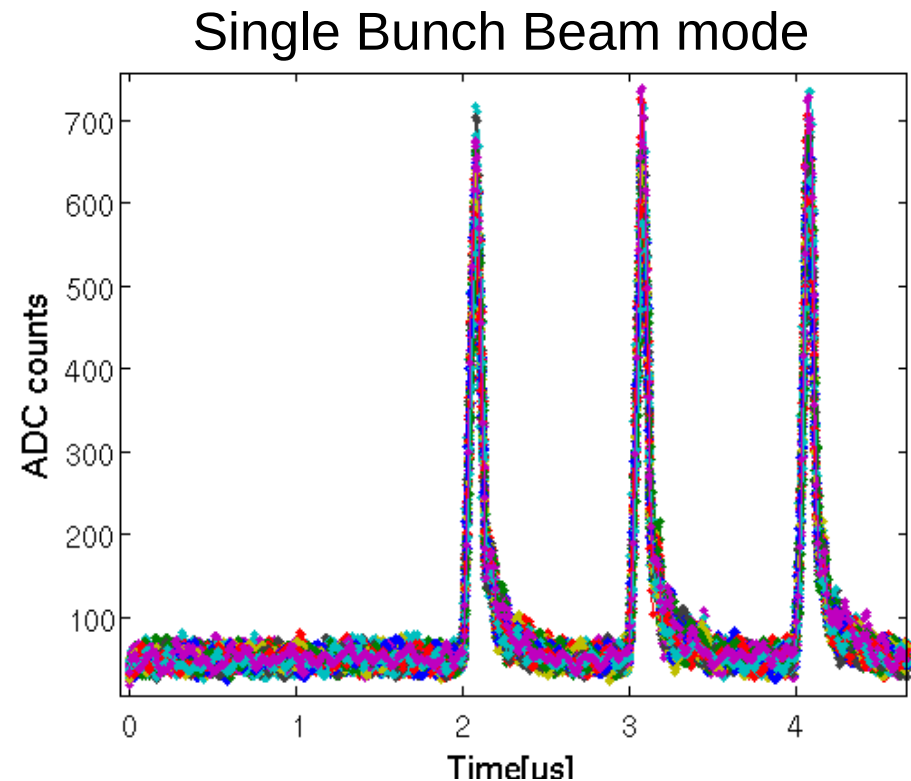
Status of the units

Global parameters

# Synchronization and tuning

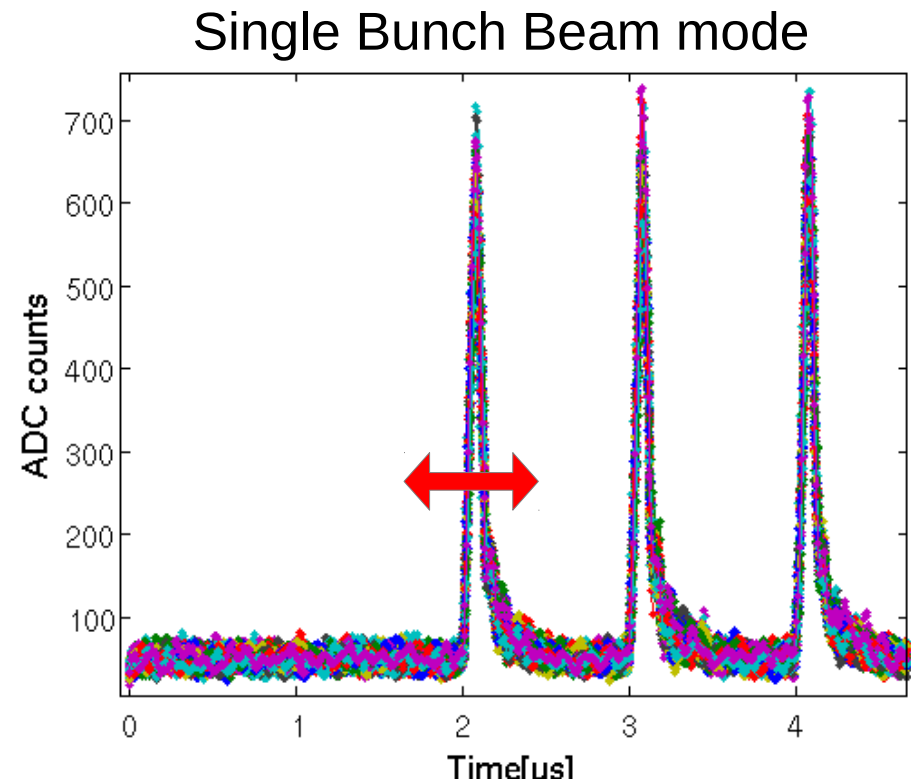
# 1) Synchronization with the beam arrival

- Trigger is the same signal which goes around the ring
- 2  $\mu\text{s}$  difference between fist and last unit (2 turns)

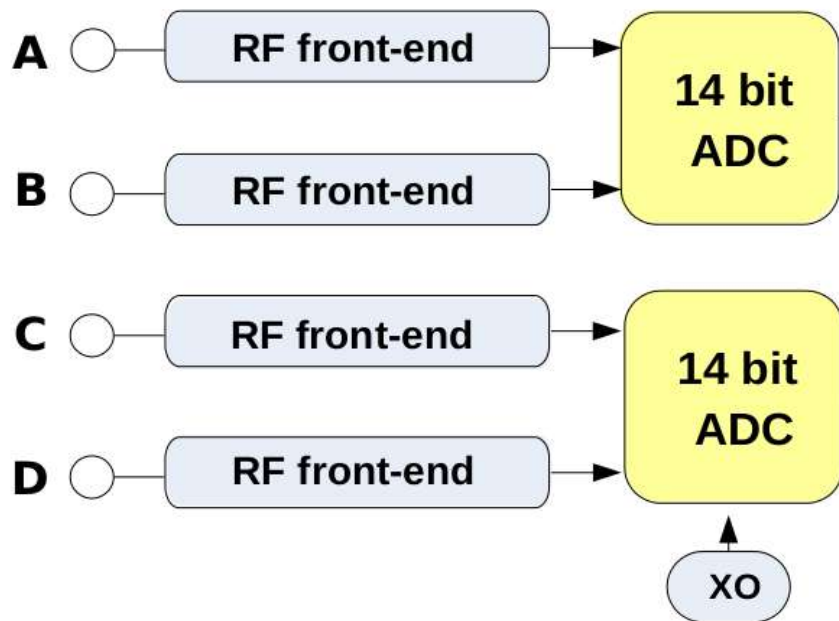


# 1) Synchronization with the beam arrival

- Trigger is the same signal which goes around the ring
- 2  $\mu\text{s}$  difference between first and last unit (2 turns)
- Adjusted with each unit **Trigger Delay** on the ADC buffer

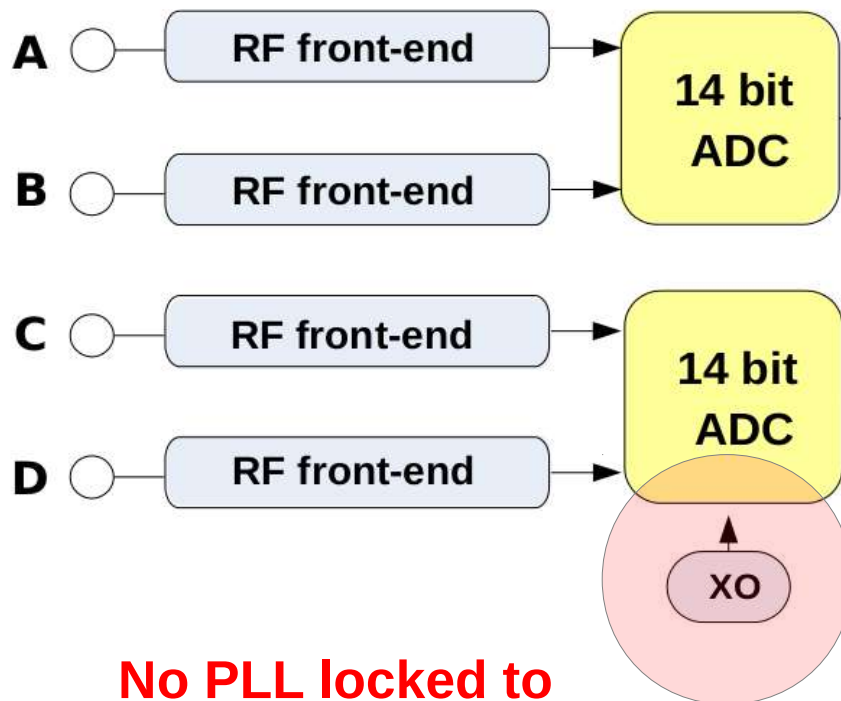


## 2) Tuning of the XOs



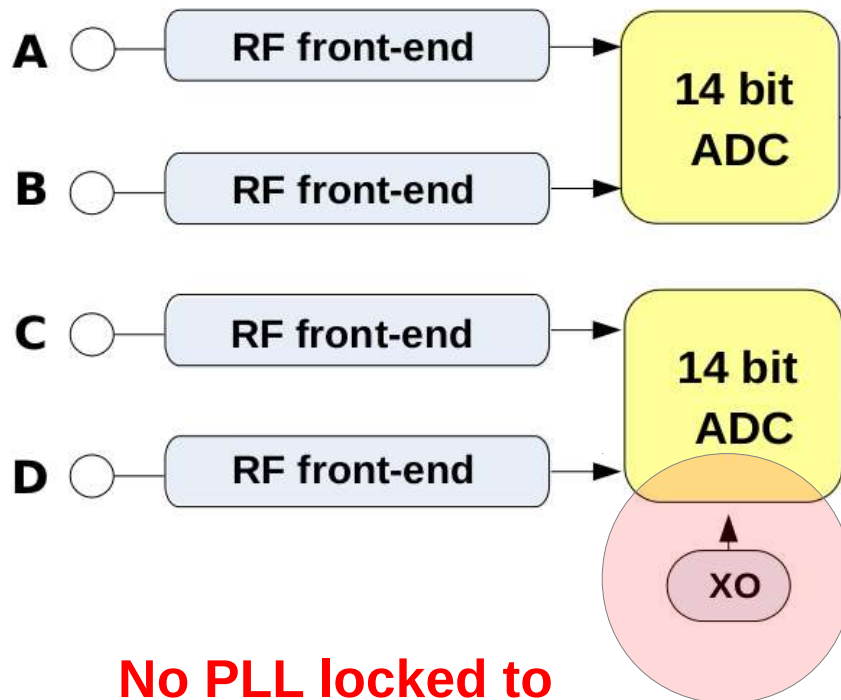


## 2) Tuning of the XOs



**No PLL locked to  
any machine reference!**

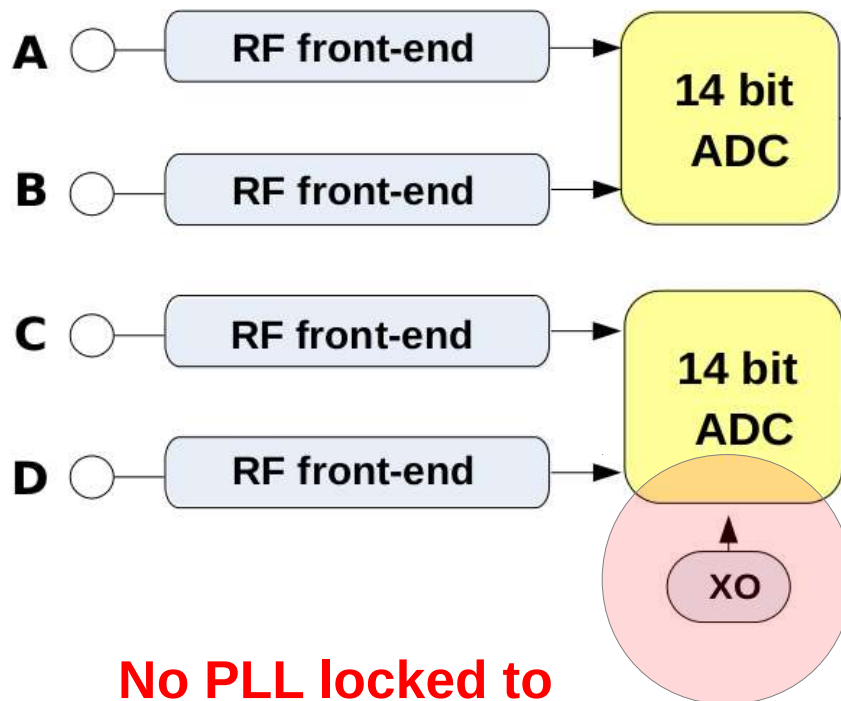
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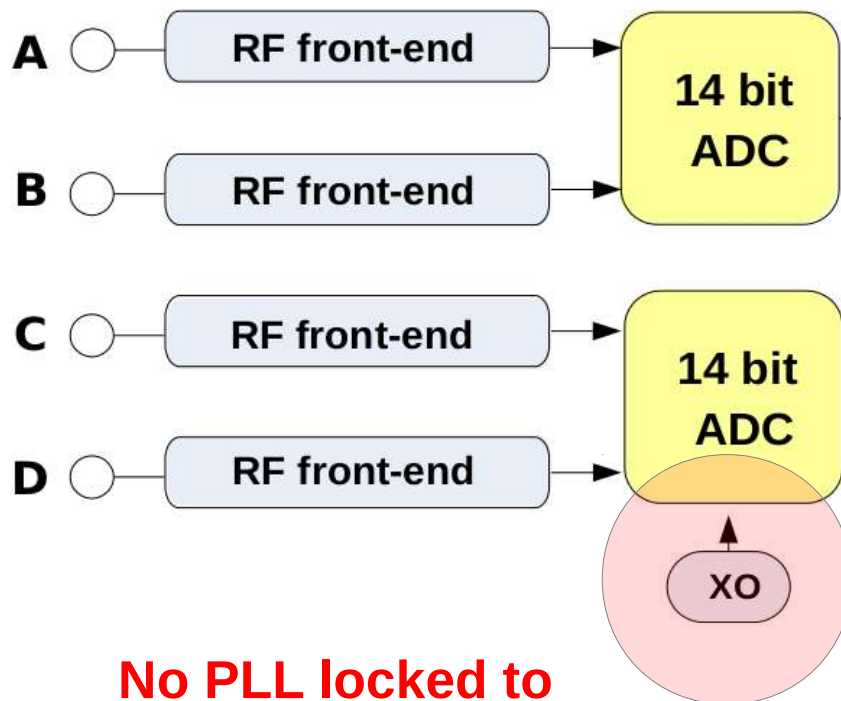
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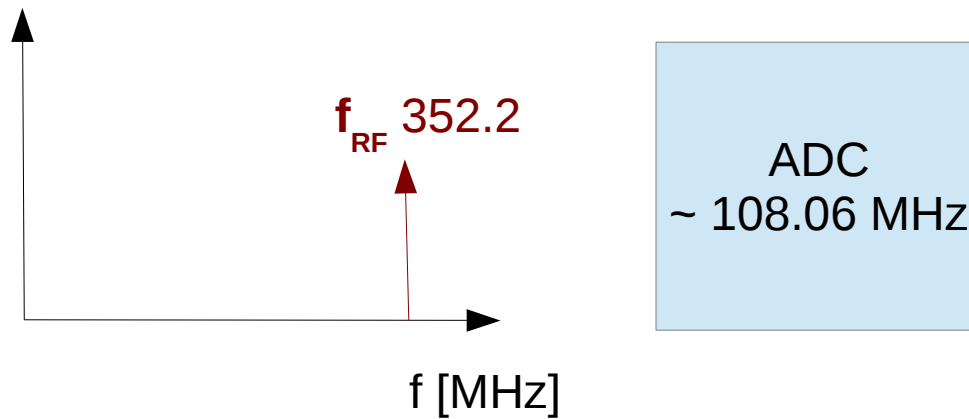
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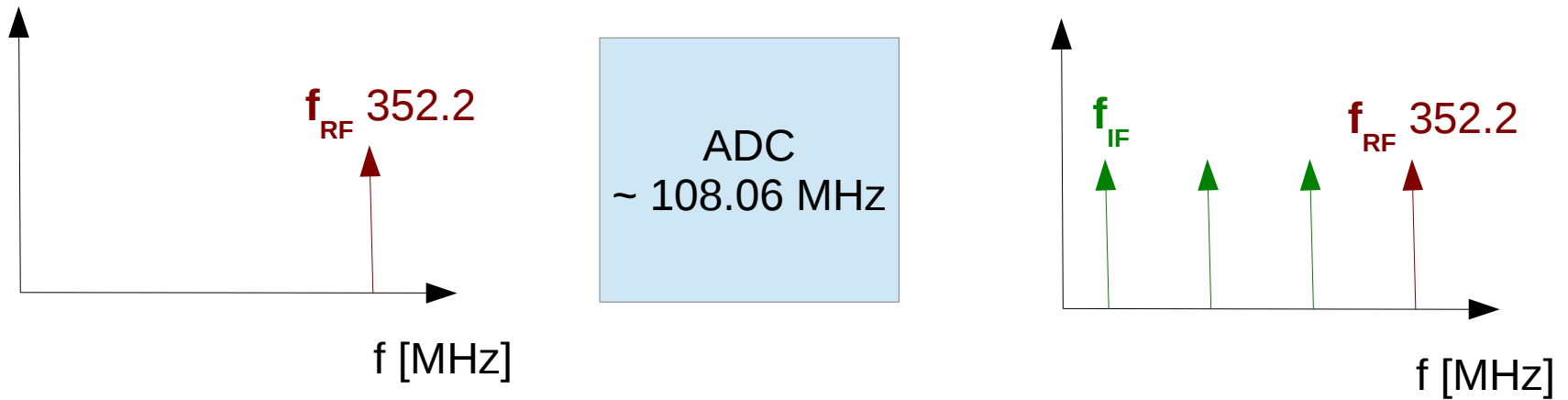


- Sampling frequency is a parameter and can be corrected

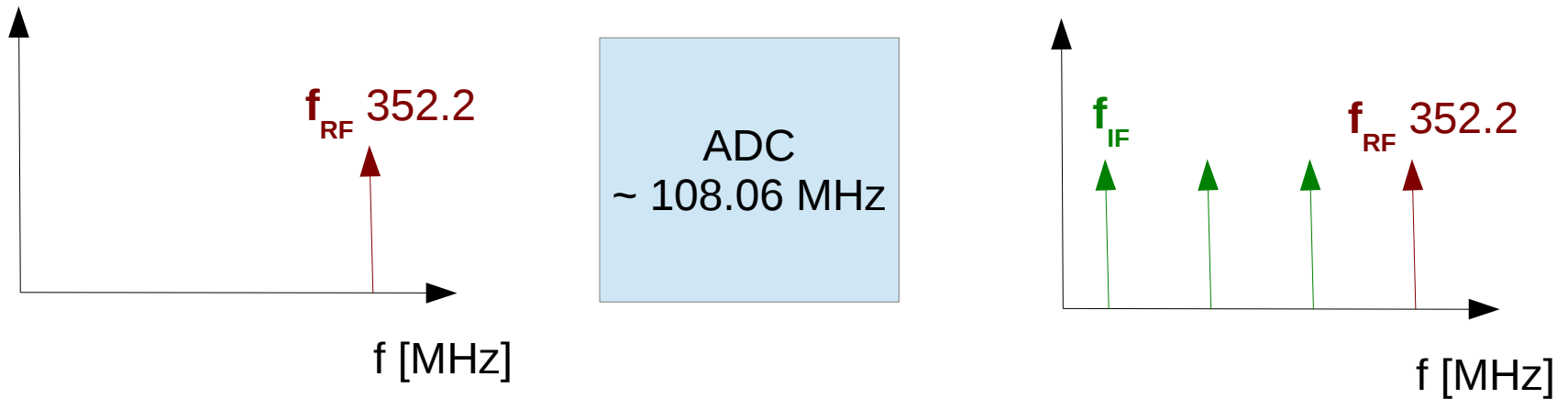
## Estimate the difference



# Estimate the difference

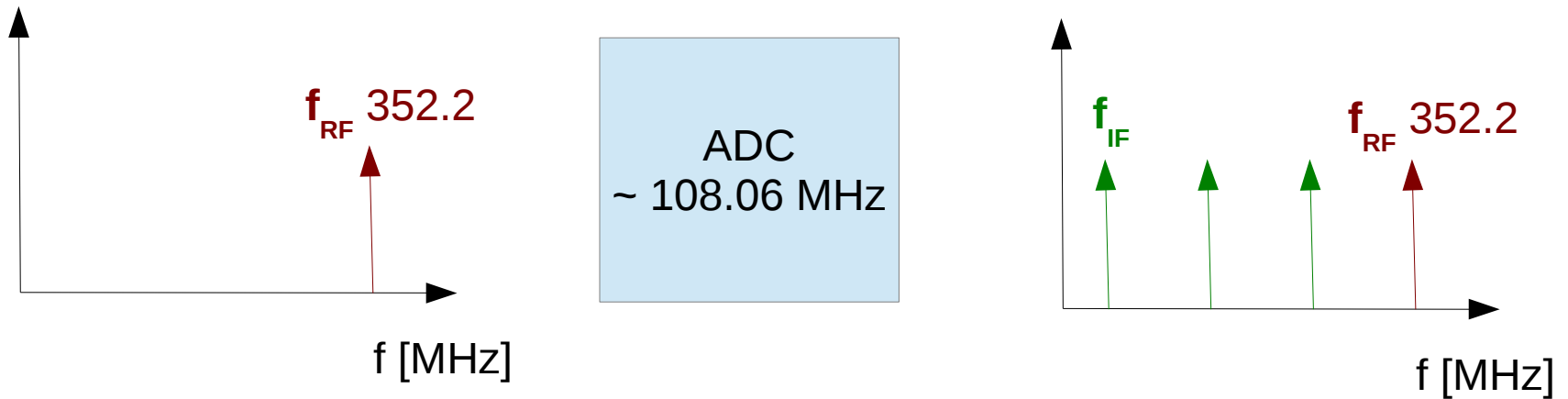


# Estimate the difference



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

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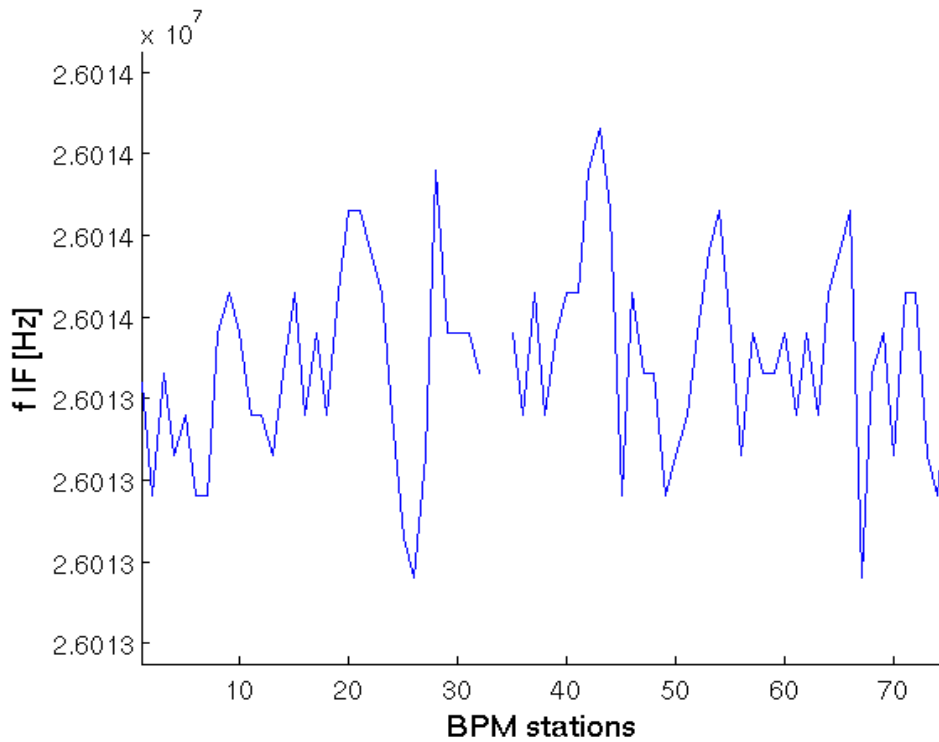


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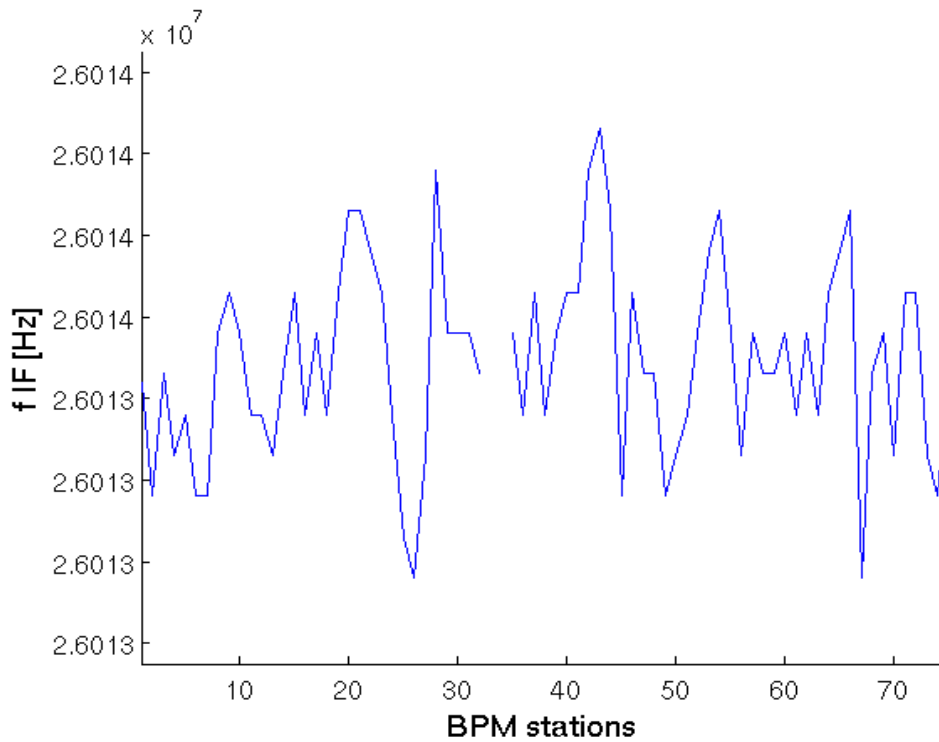
$$\Delta f_{IF} = 3 * \Delta f_{ADC}$$



# Estimate the difference

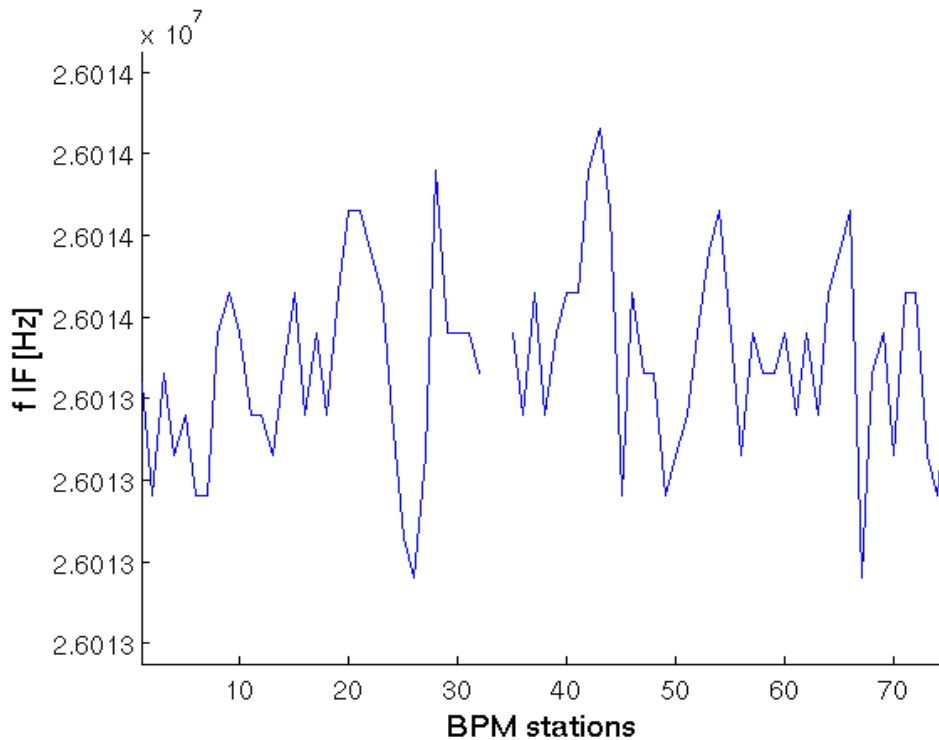


# Estimate the difference



$\Delta f_{IF} = 1100\text{Hz p2p}$

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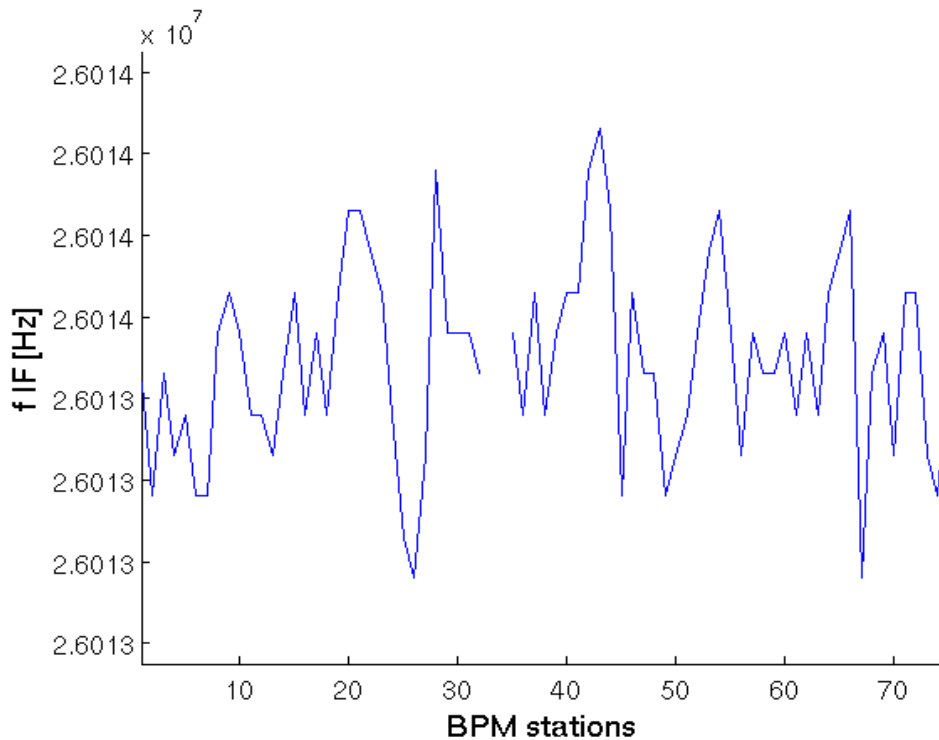


$$\Delta f_{IF} = 1100\text{Hz p2p}$$

:3

$$\Delta f_{ADC} \sim 367\text{Hz}$$

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:3

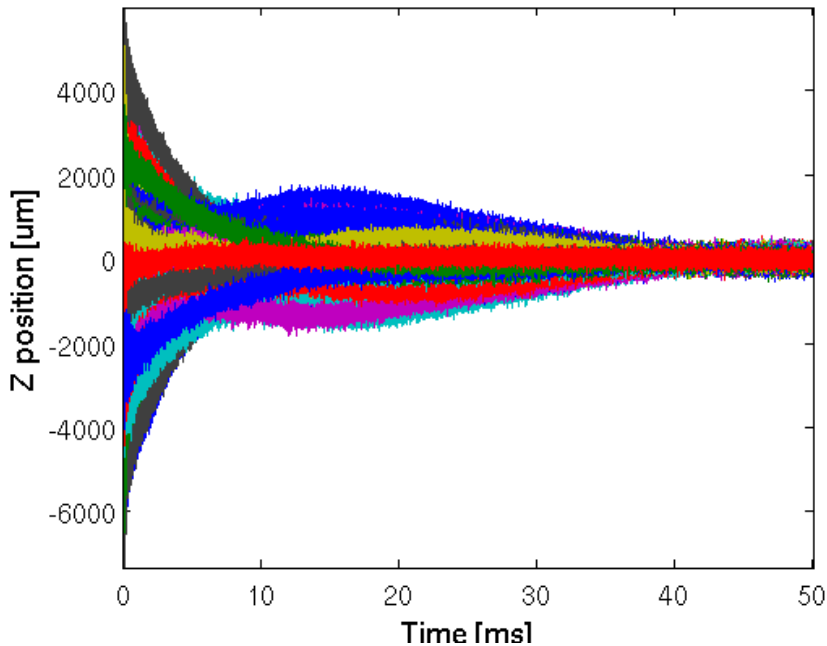
$$\Delta f_{ADC} \sim 367\text{Hz}$$

18 samples in 50ms

# First measurements and applications

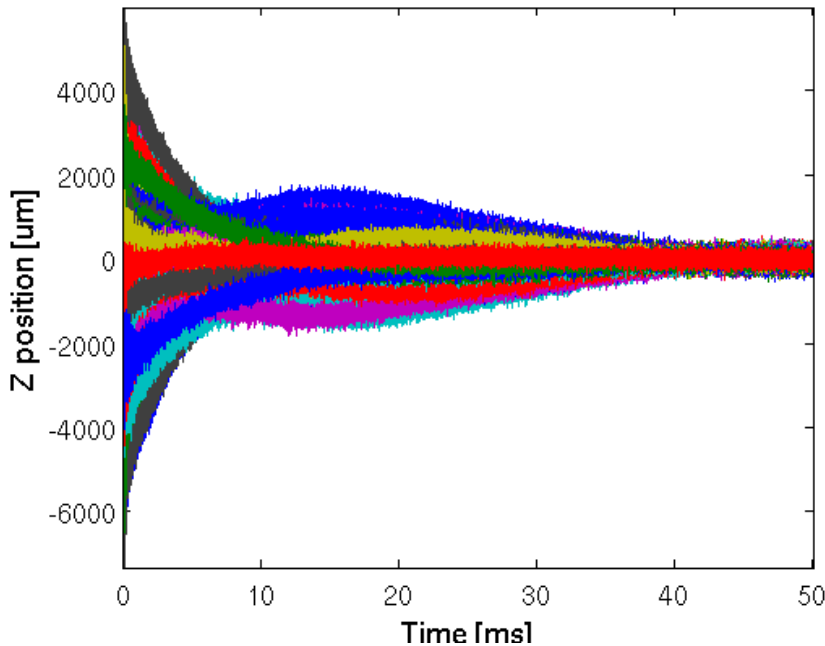
# 1) Tune monitor with Turn-by-Turn data

Turn-by-Turn position (1  $\mu$ s)



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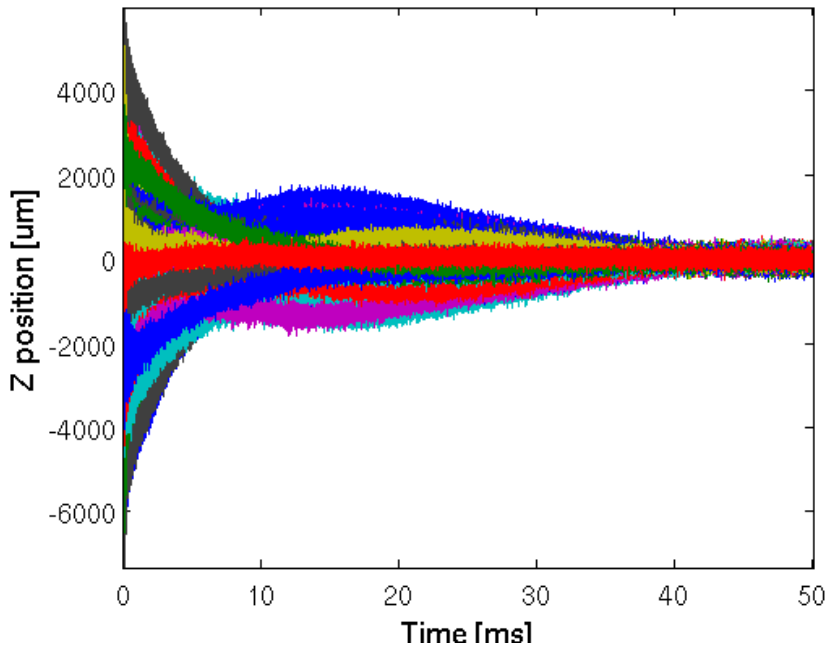
Turn-by-Turn position (1  $\mu$ s)



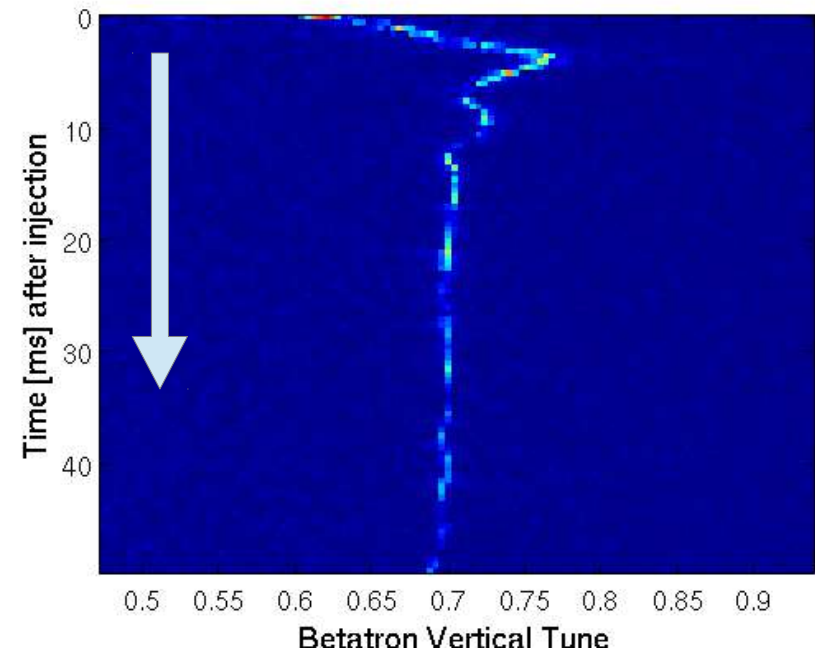
FFT in 0.5 ms data slices

# 1) Tune monitor with Turn-by-Turn data

Turn-by-Turn position (1  $\mu$ s)



Vertical Tune monitor



FFT in 0.5 ms data slices

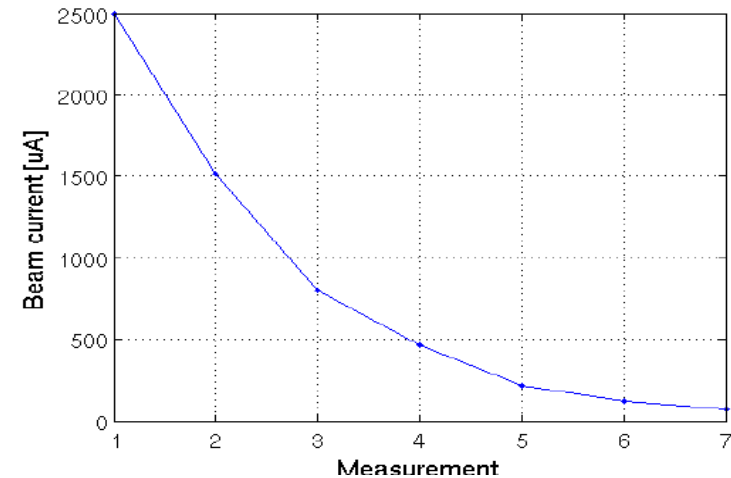


## 2) Position resolution vs Beam current

- Booster operating with long-pulse mode (80% fill pattern)
- Current was reduced in steps from **2.5 mA** to  **$\mu\text{A}$**

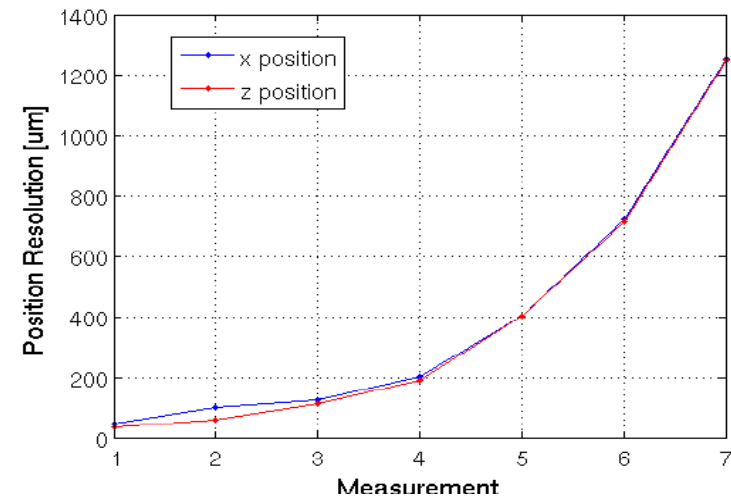
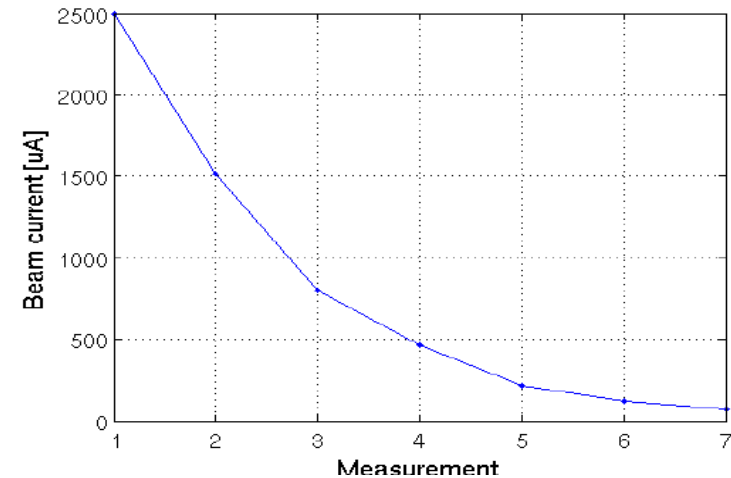
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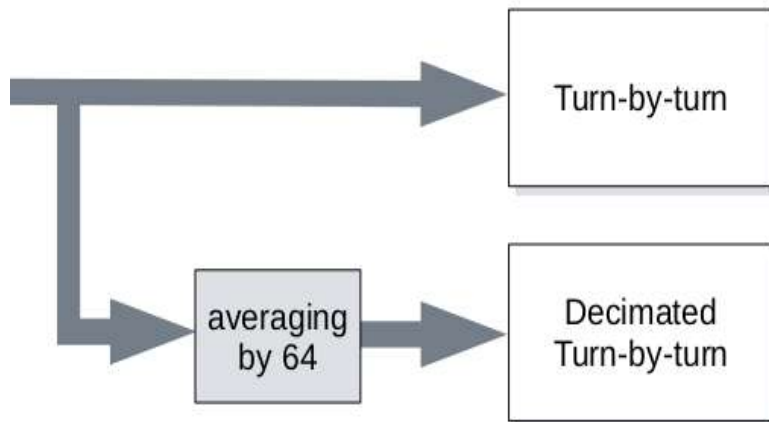


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- Booster operating with long-pulse mode (80% fill pattern)
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- **X Z position**: estimate resolution with RMS



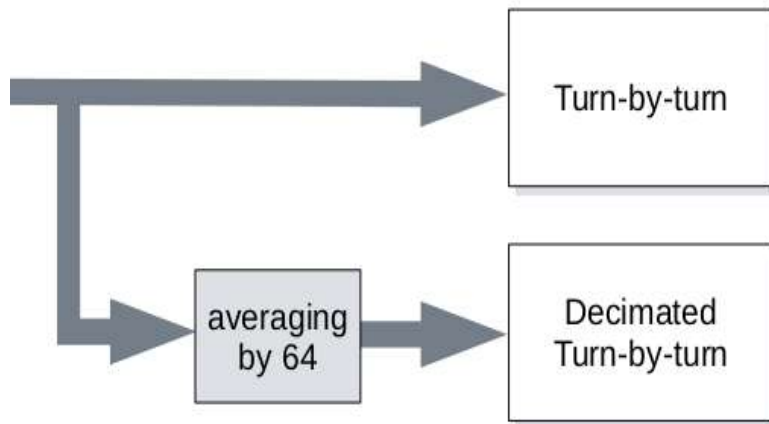
## Decimated T-b-T data



1 sample = 1 turn = 1  $\mu$ s

1 sample = 64 turns = 64  $\mu$ s

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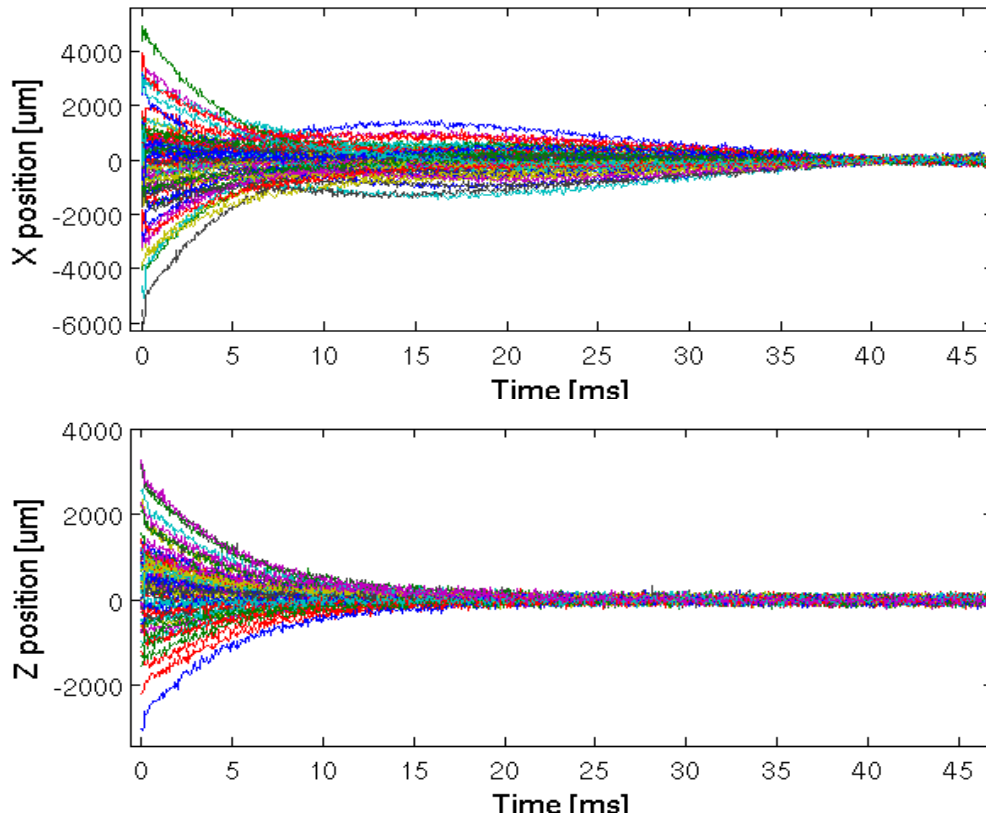


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Motivation?

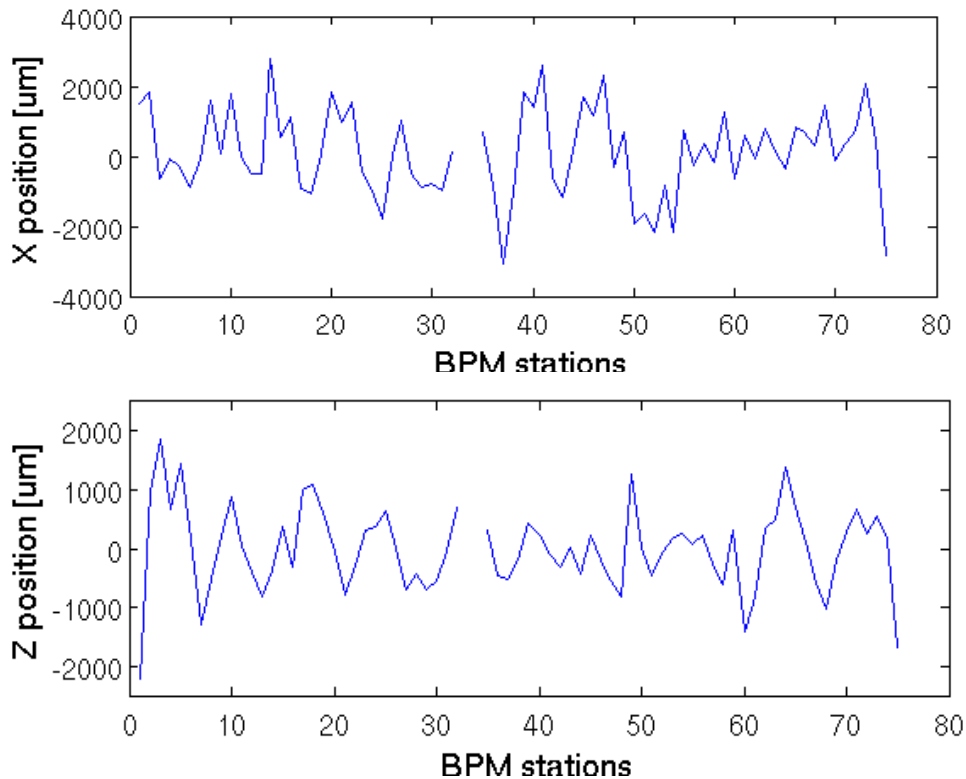
### 3) Position measurements



Motivation?

Reduced bandwidth  
means reduced  
noise contribution

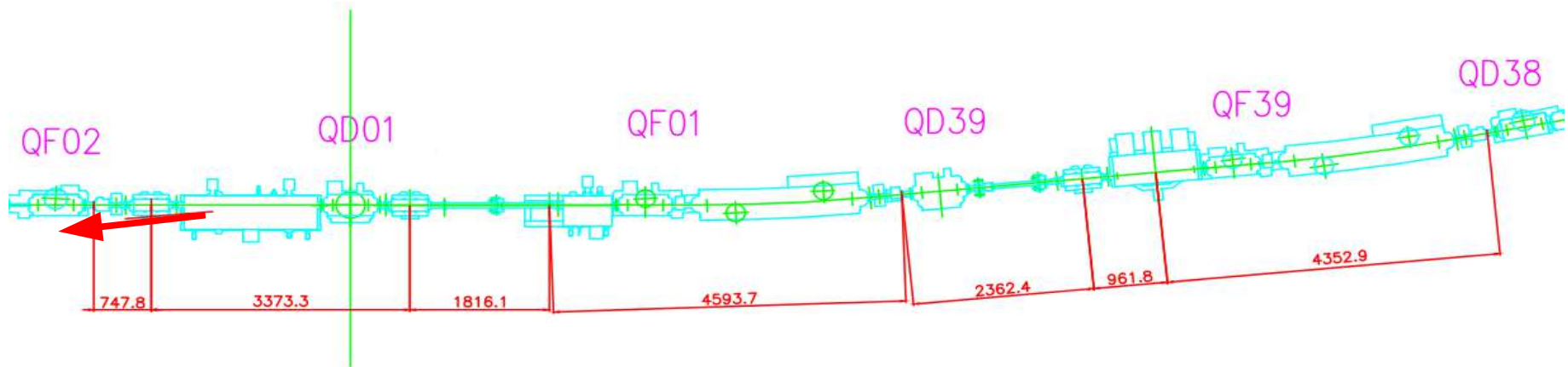
## 4) Orbit measurements



Motivation?

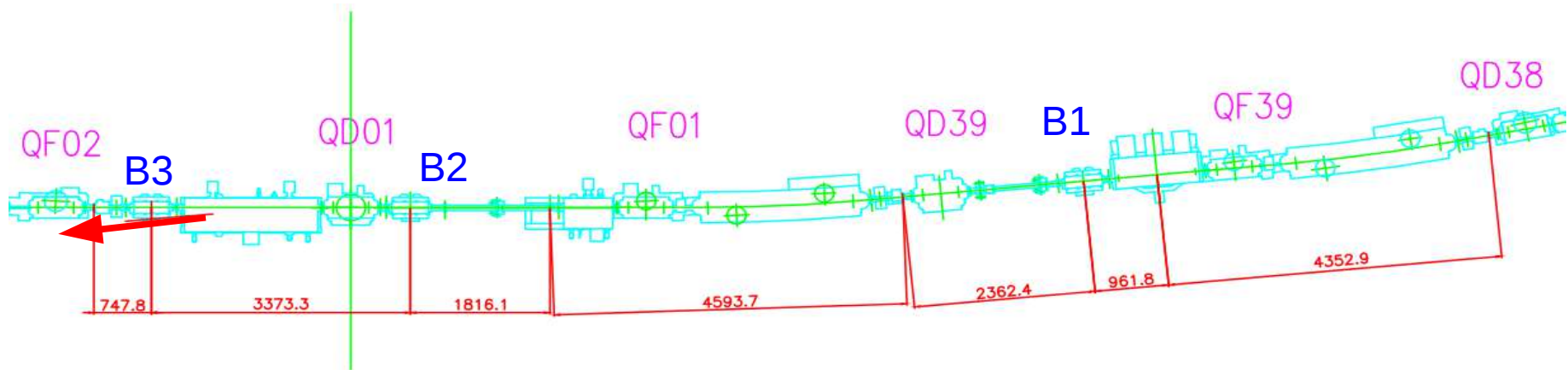
Reduced amount of data to be transferred over the network

## 5) Extraction process



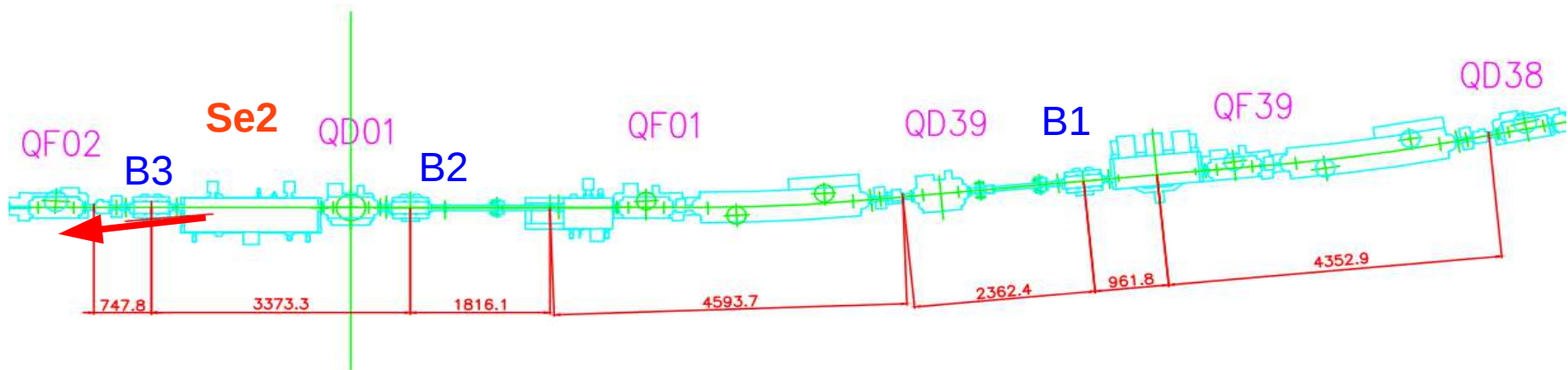


## 5) Extraction process



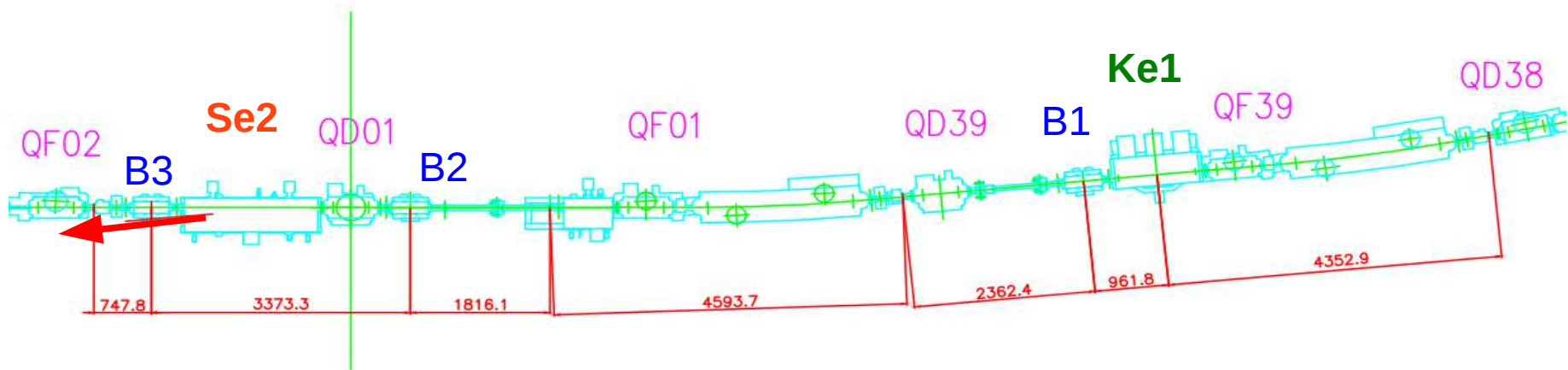
- Three bumpers (**B1**, **B2** and **B3**) create an horizontal bump 1.5 ms before extraction

## 5) Extraction process



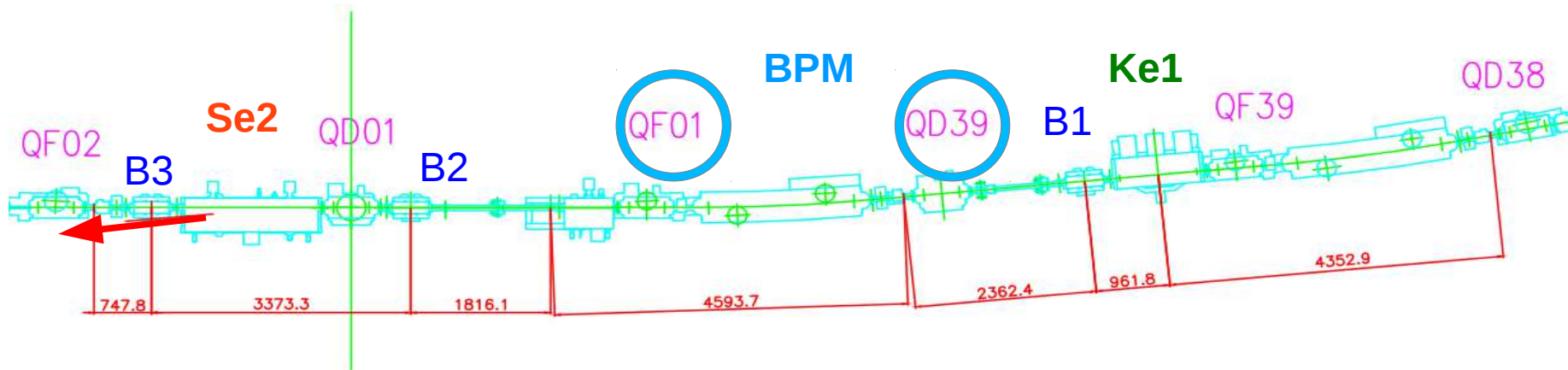
- Three bumpers (**B1**, **B2** and **B3**) create an horizontal bump 1.5 ms before extraction
- This moves the beam closer to the extraction septum magnet **Se2**

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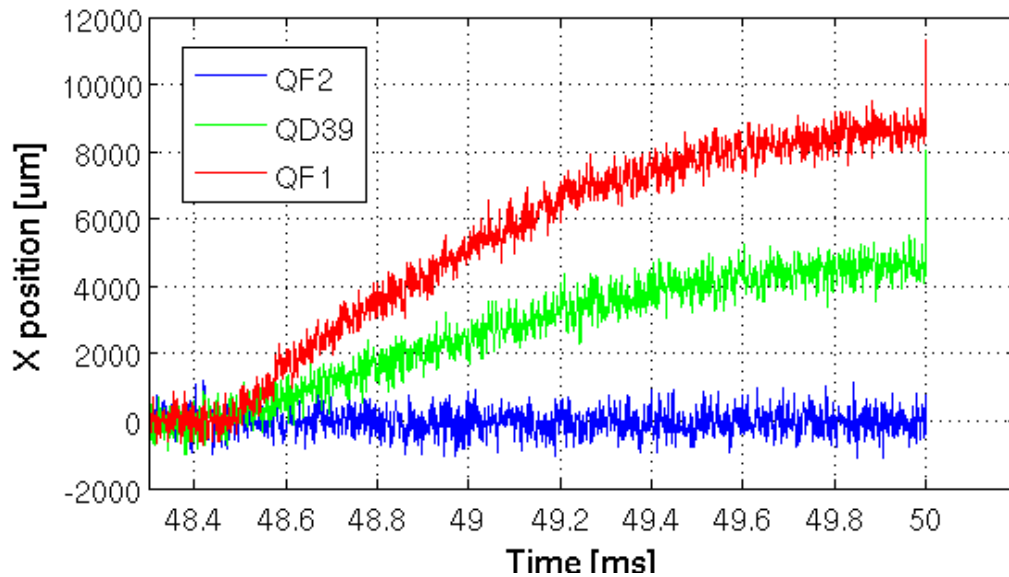
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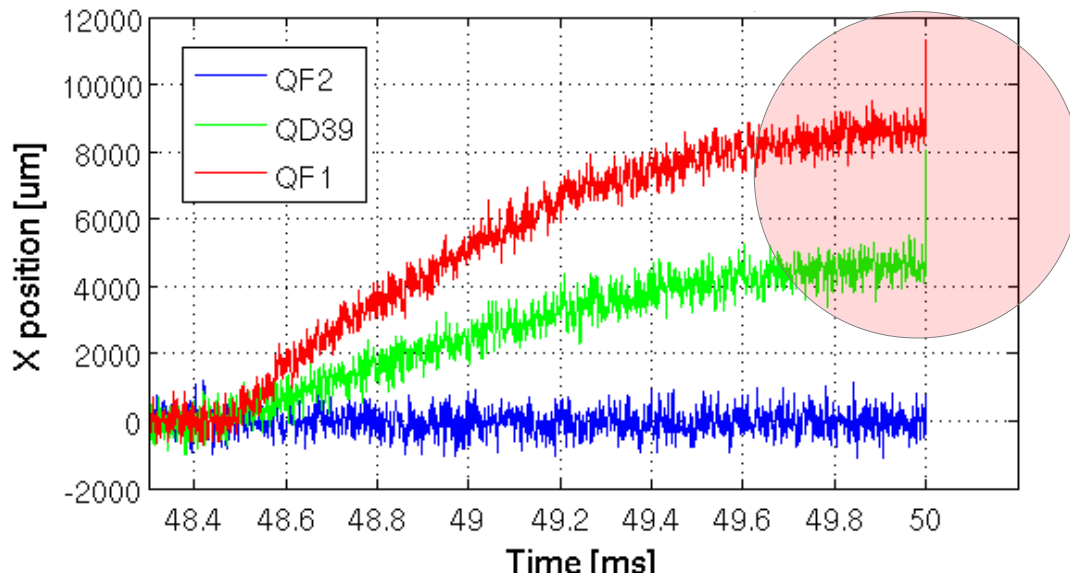
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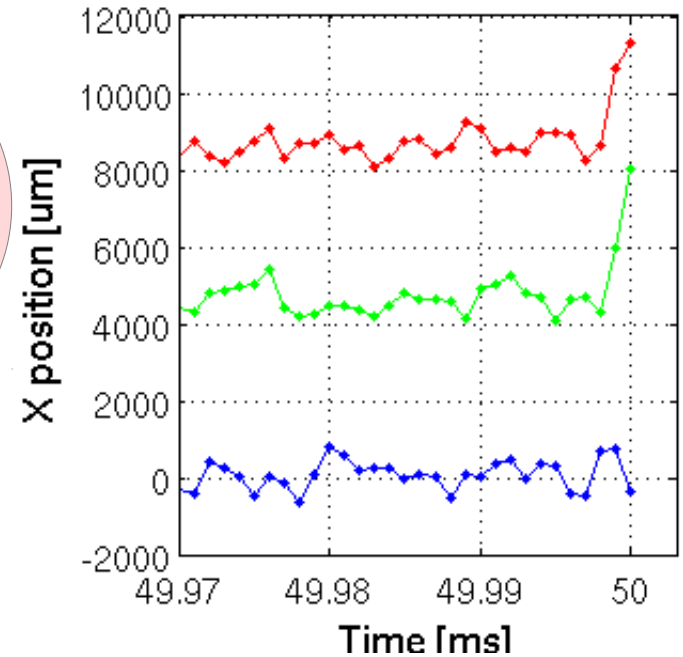
1.5 ms local bump

# 5) Extraction process

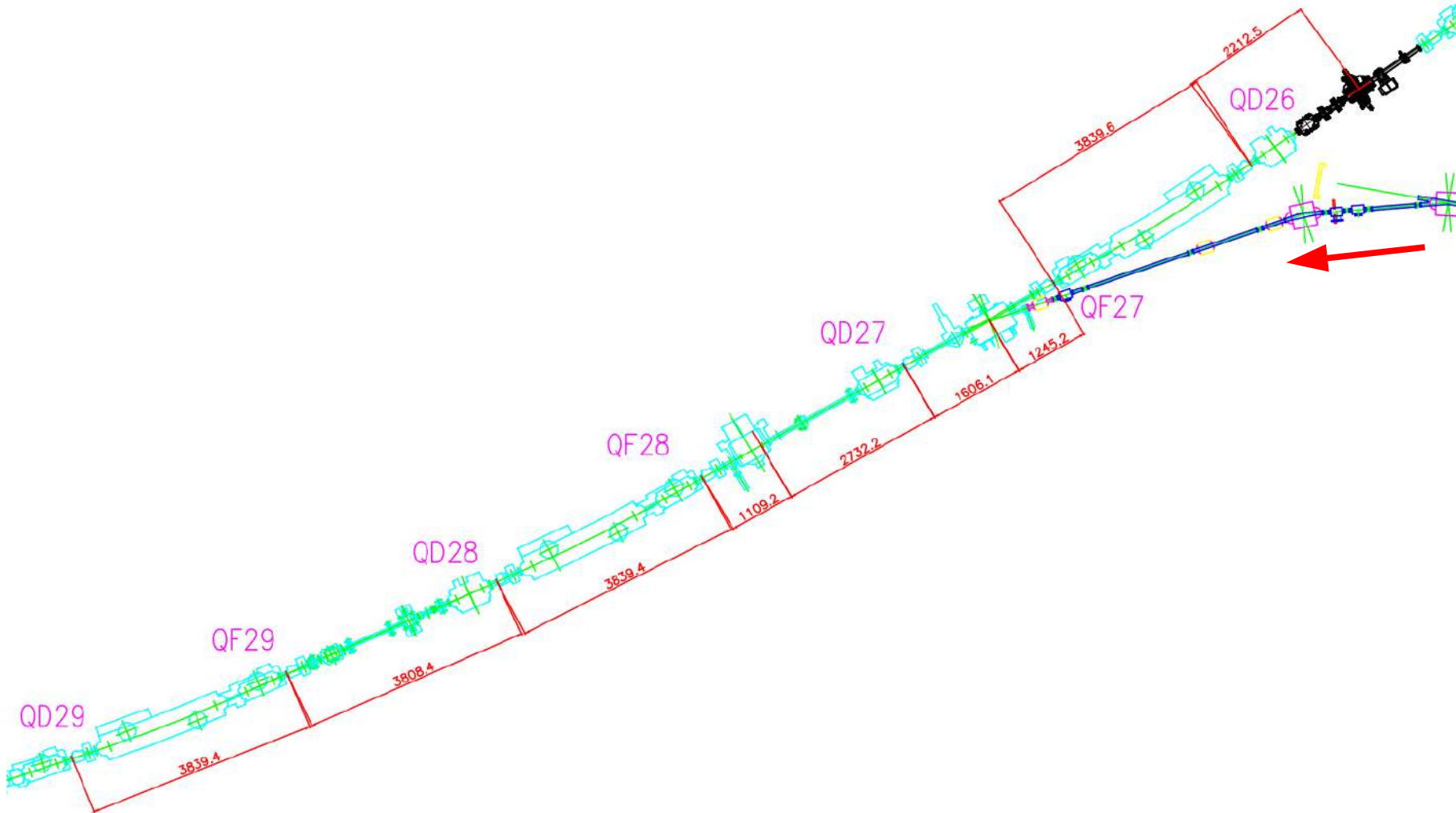


1.5 ms local bump

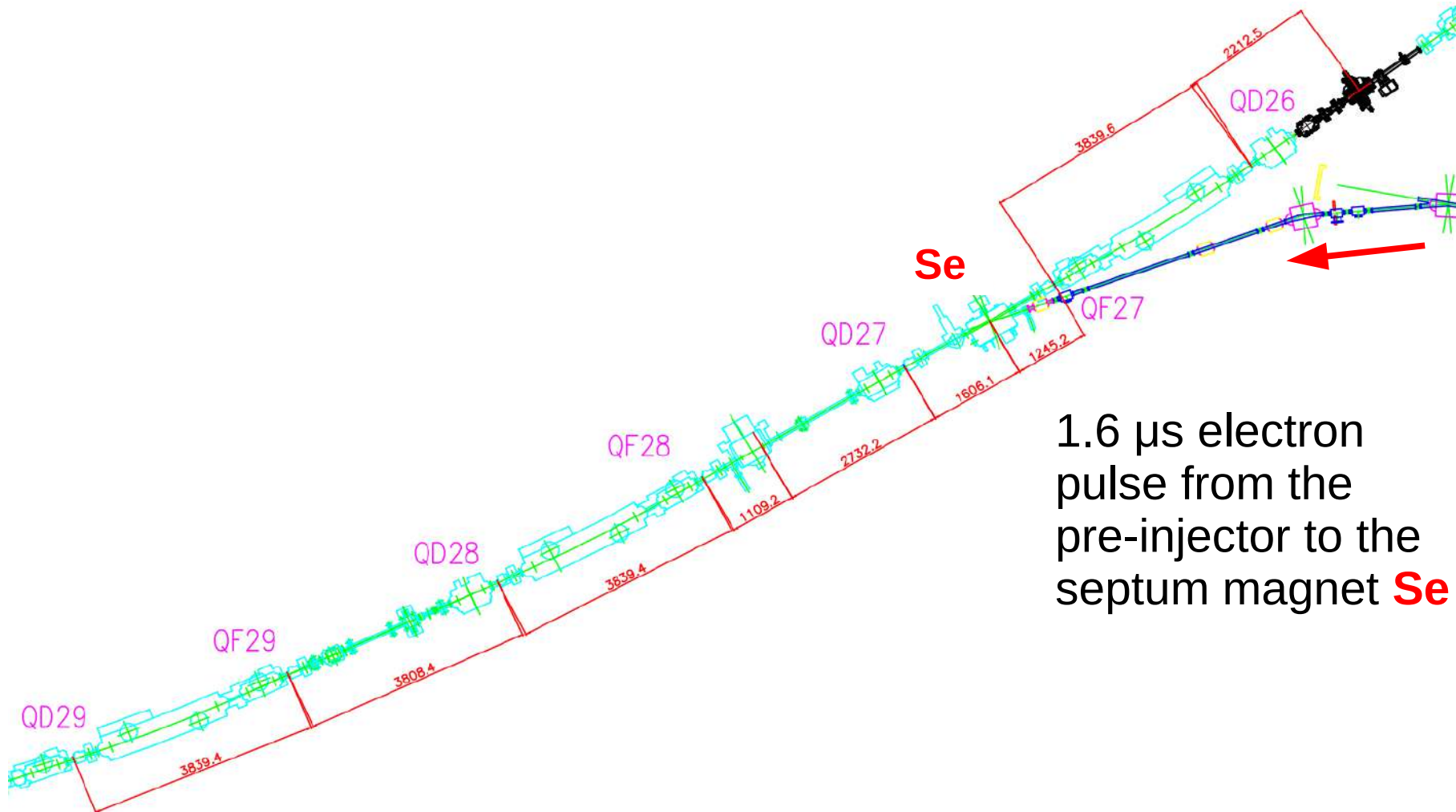
1  $\mu$ s fast kick



## 6) Injection process



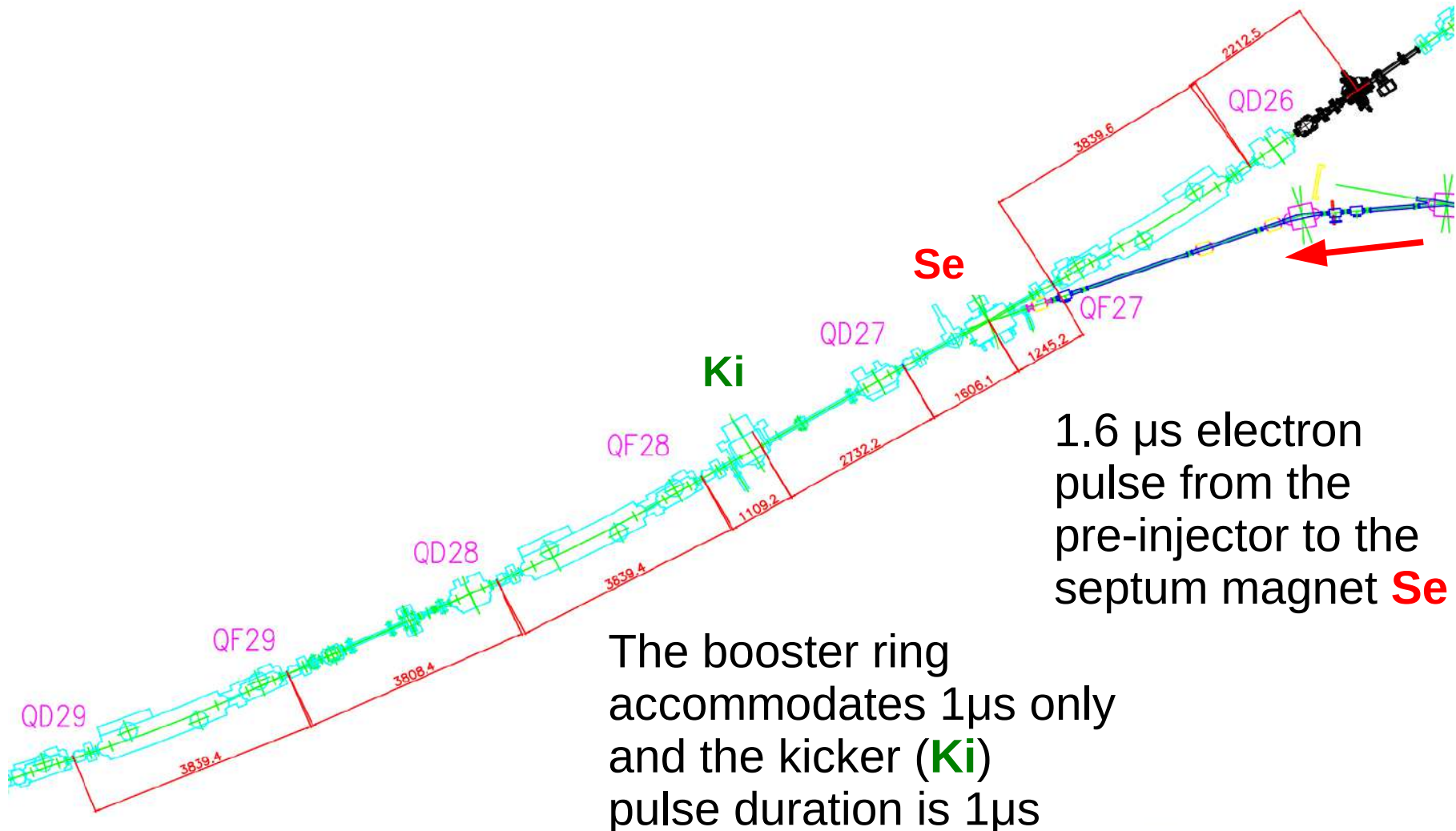
## 6) Injection process



1.6  $\mu$ s electron pulse from the pre-injector to the septum magnet **Se**

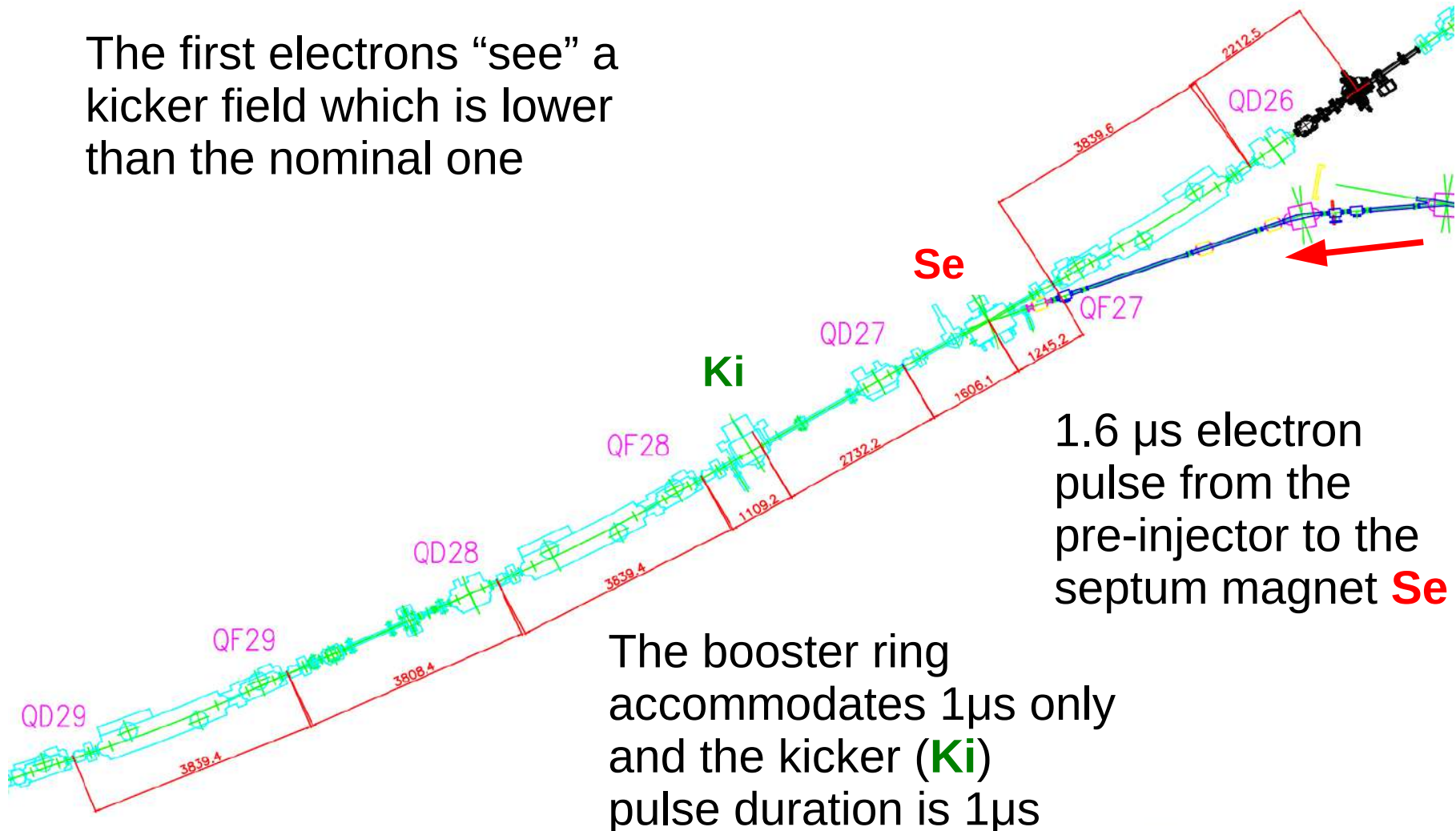


## 6) Injection process



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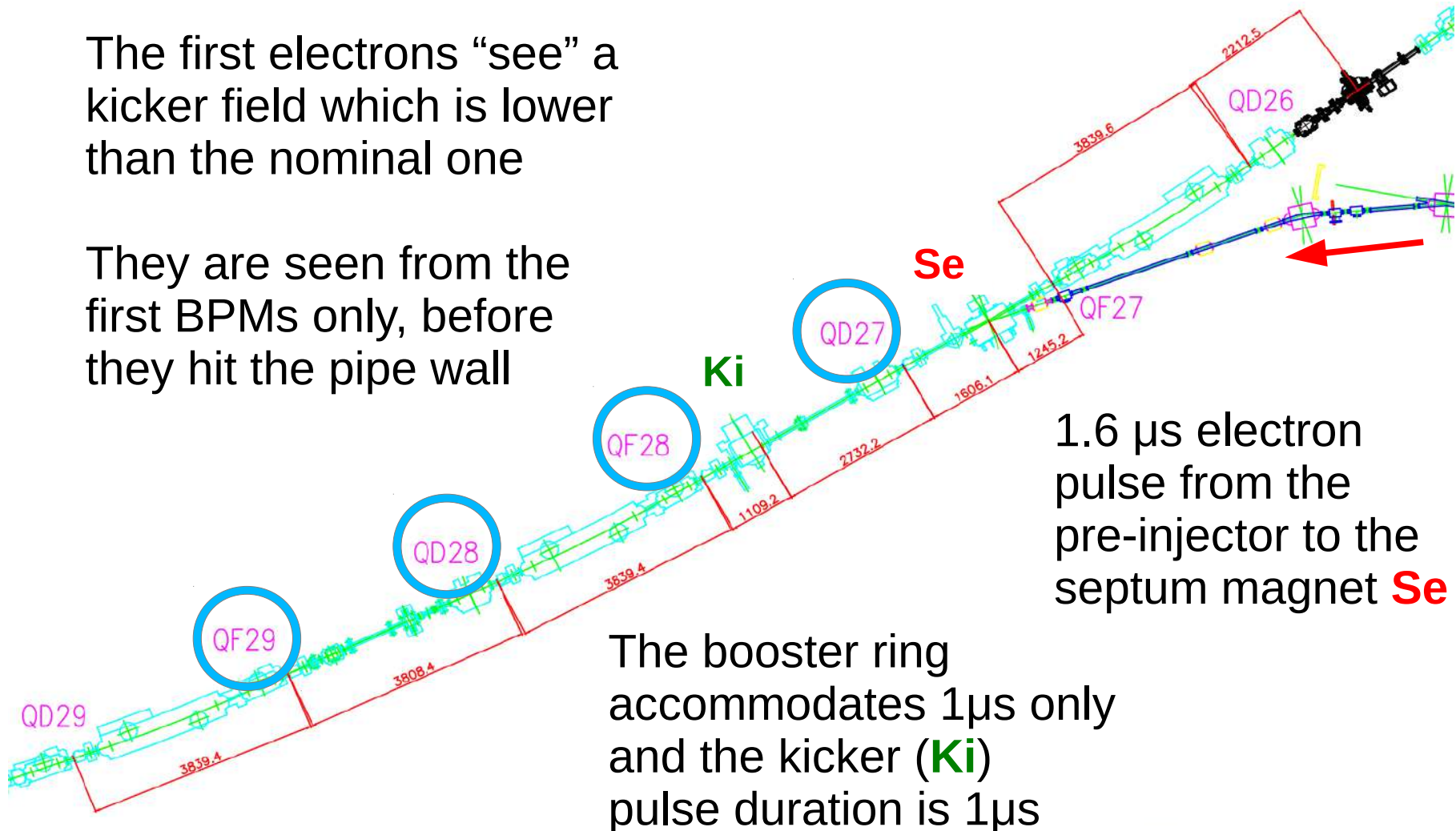
The first electrons “see” a kicker field which is lower than the nominal one



## 6) 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



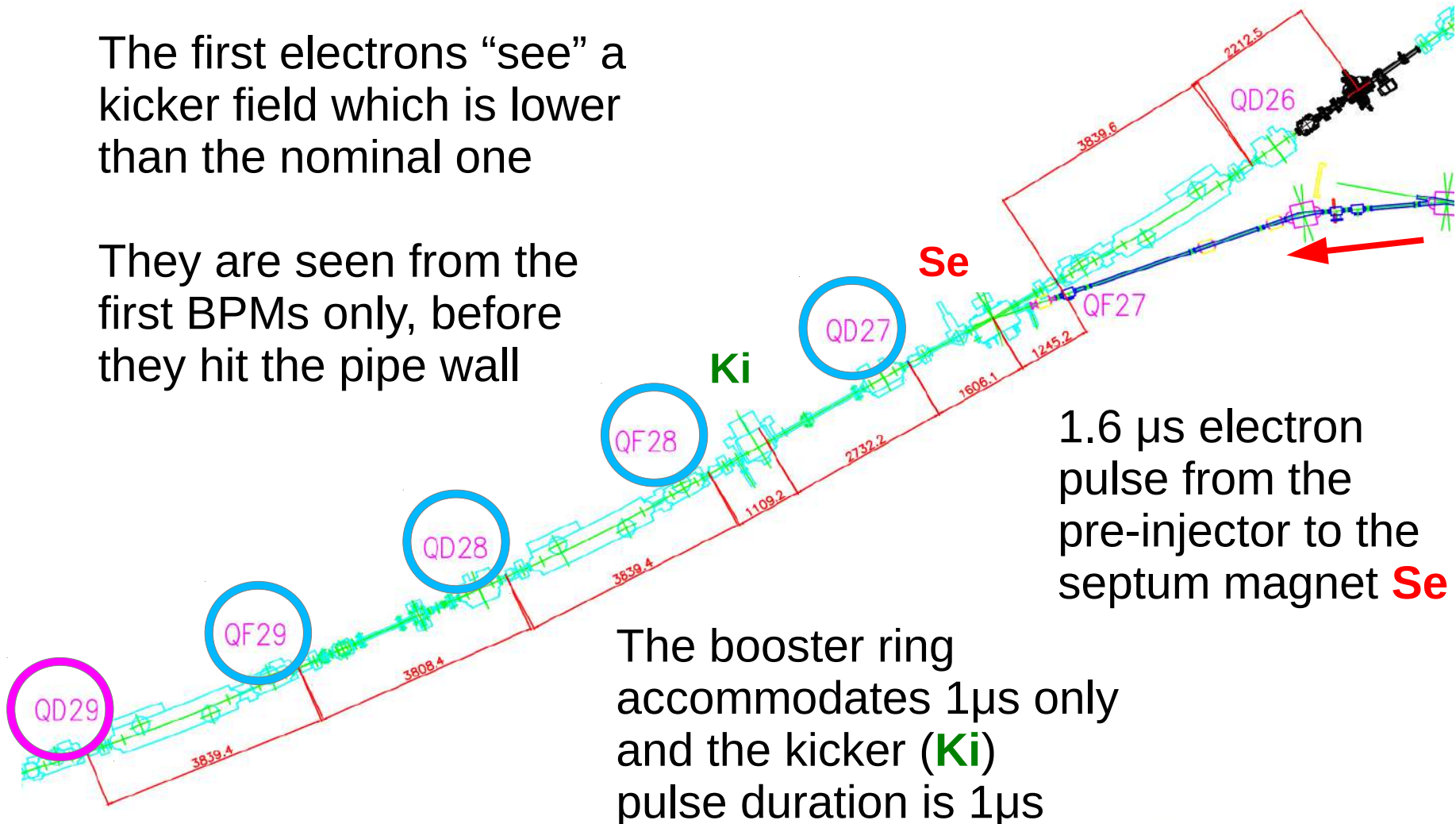
1.6 μs electron pulse from the pre-injector to the septum magnet **Se**

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

## 6) Injection process

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

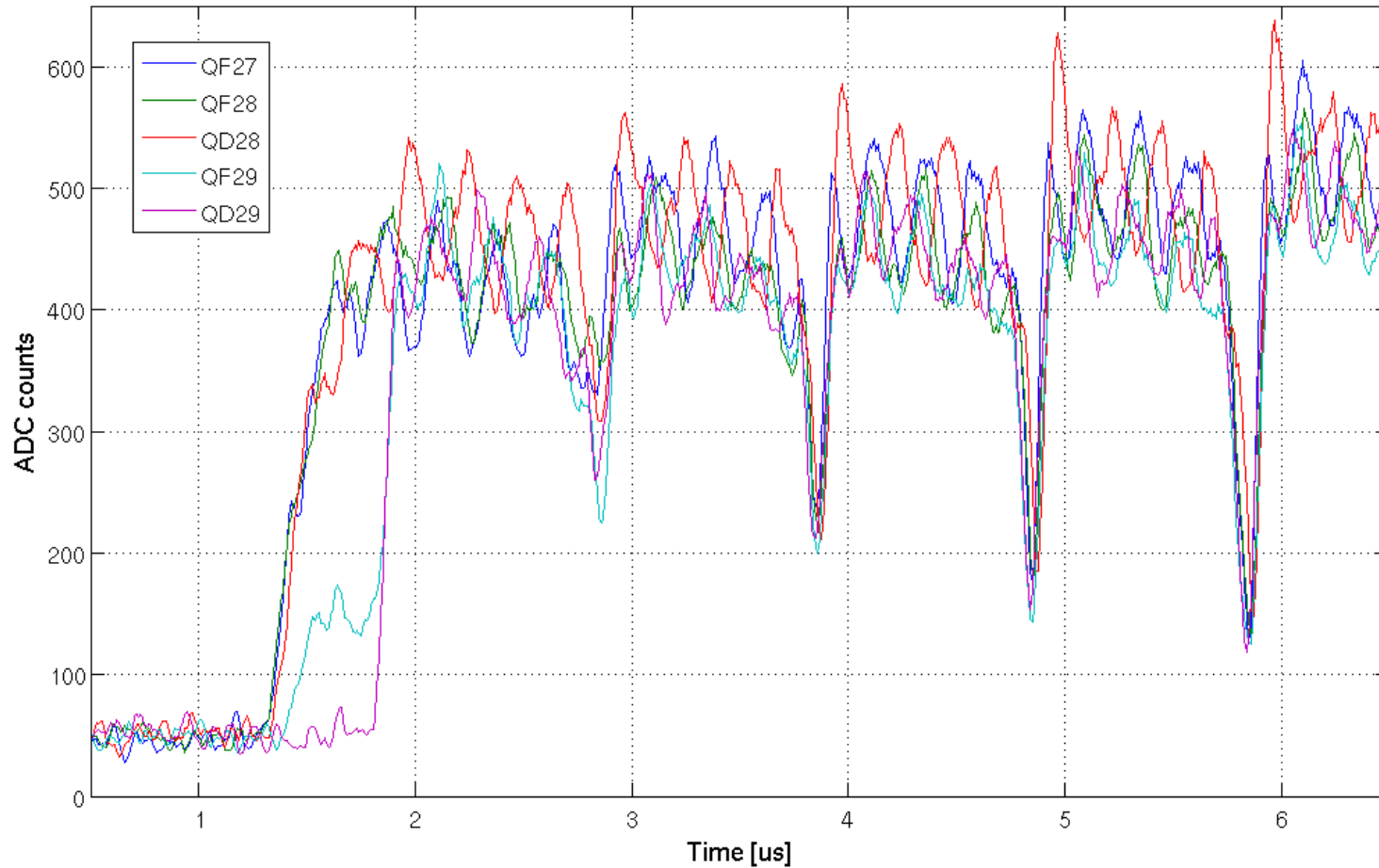
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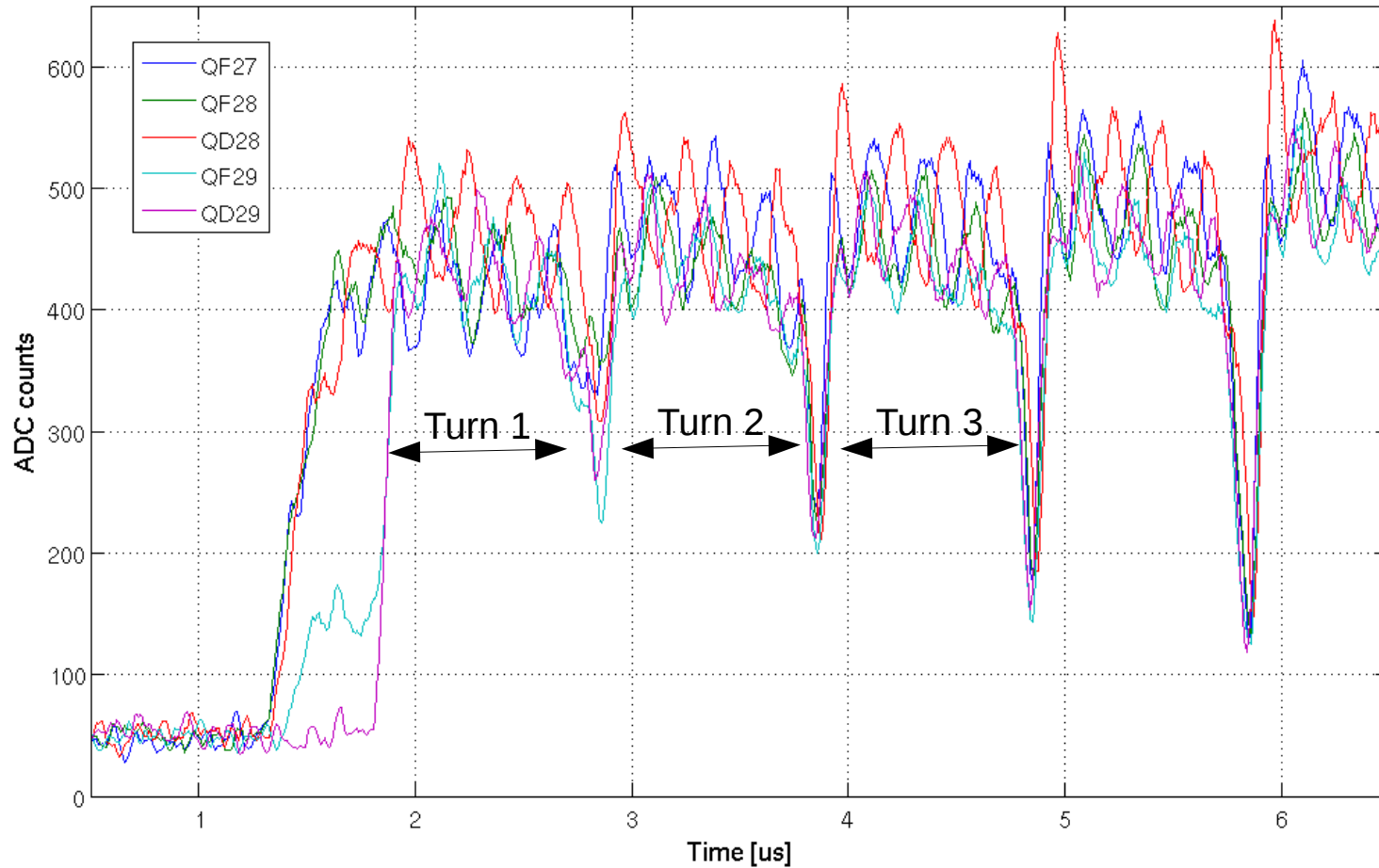
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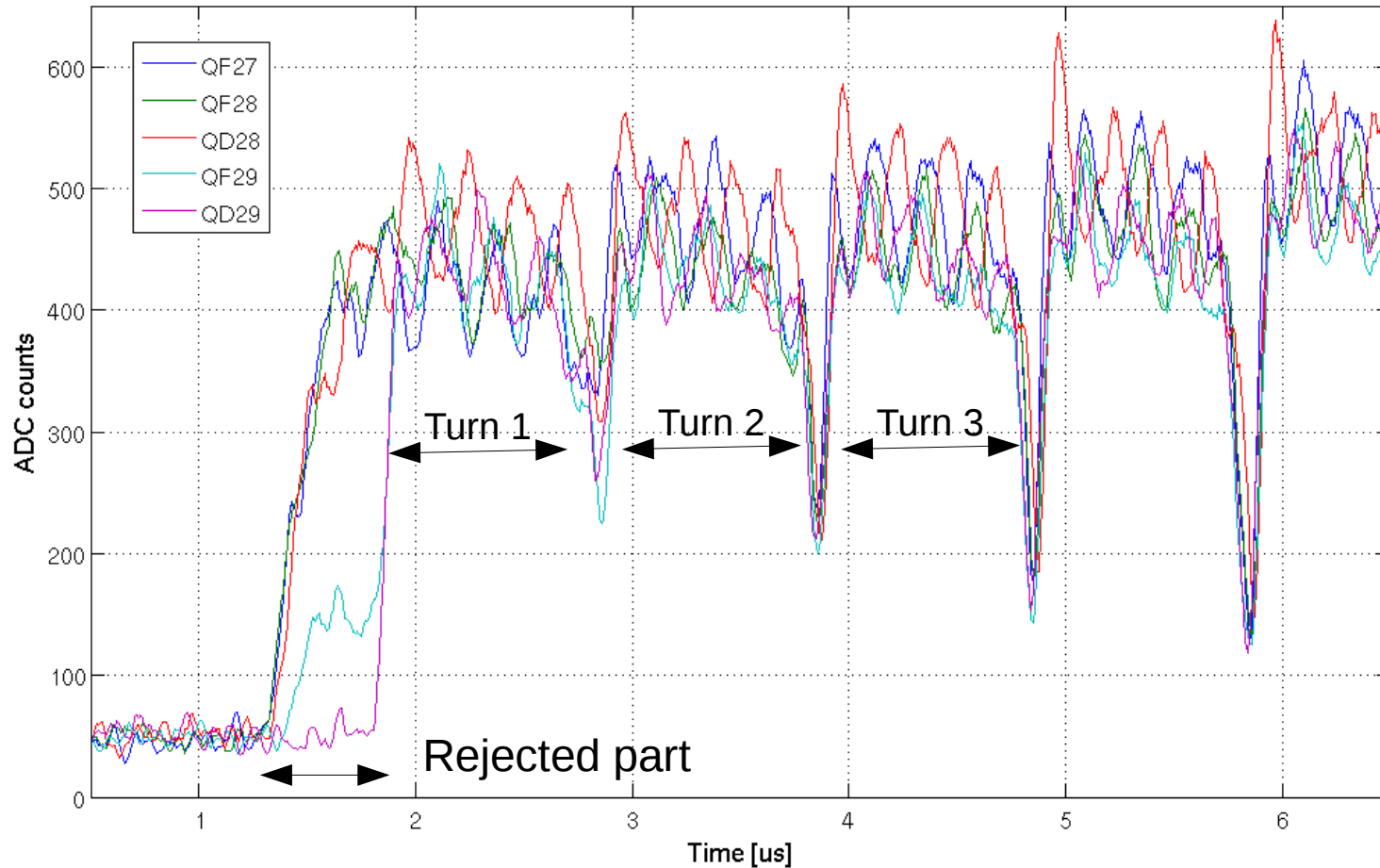
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## 6) Injection process



## 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





Libera

Thanks for your attention!

[manuel.cargnelutti@i-tech.com](mailto:manuel.cargnelutti@i-tech.com)