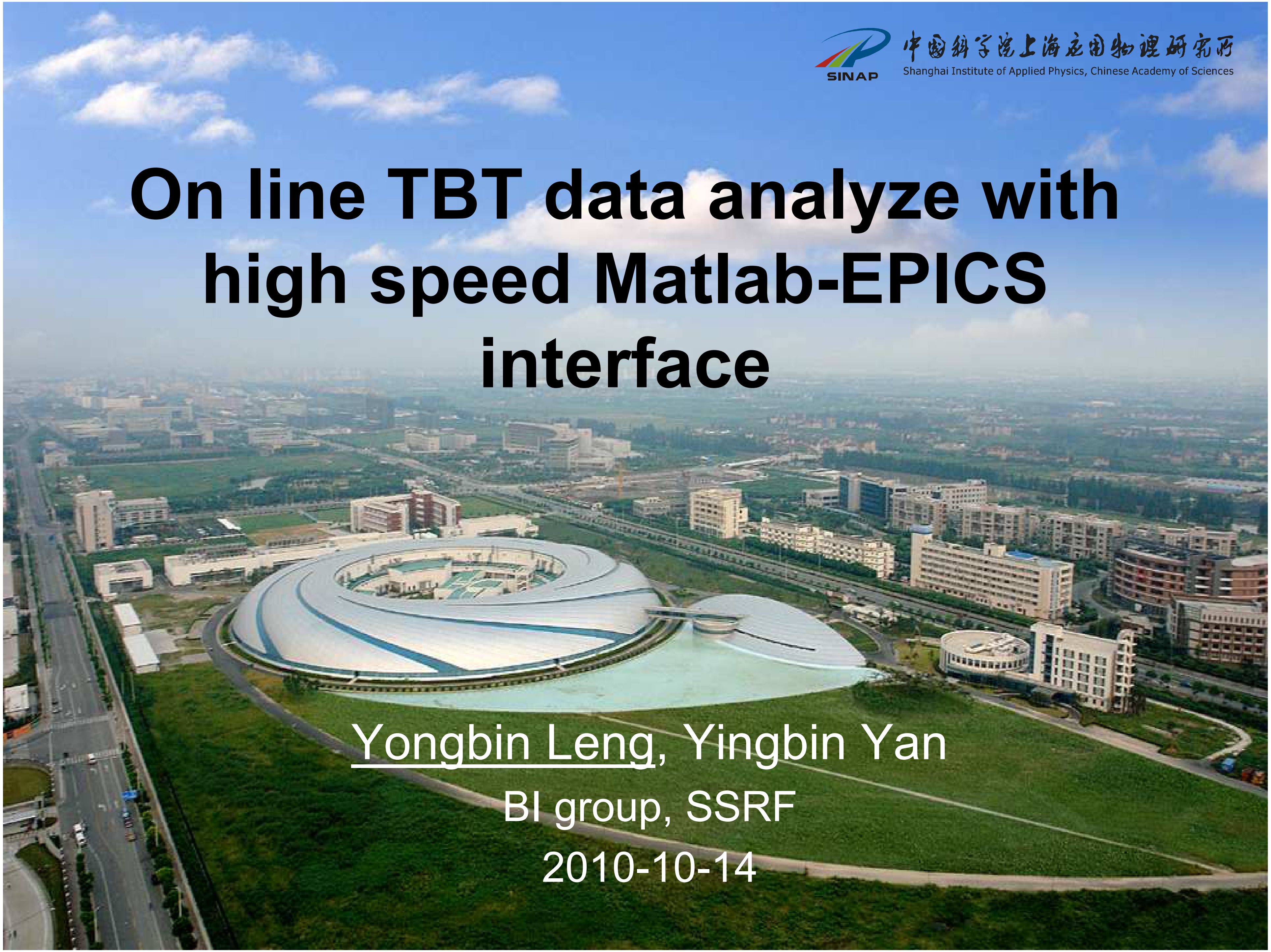

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On line TBT data analyze with high speed Matlab-EPICS interface

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BI group, SSRF

2010-10-14

Outline

- Background
- High speed interface for Matlab-EPICS
- TBT analyze @ SSRF
- Summary

Target

- BI global data warehouse
  - ➢ BPM data (SA, TBT)
  - ➢ Other BI data (current, beam size, bunch length, filling pattern, so on)
  - ➢ Power supply data, RF data and so on

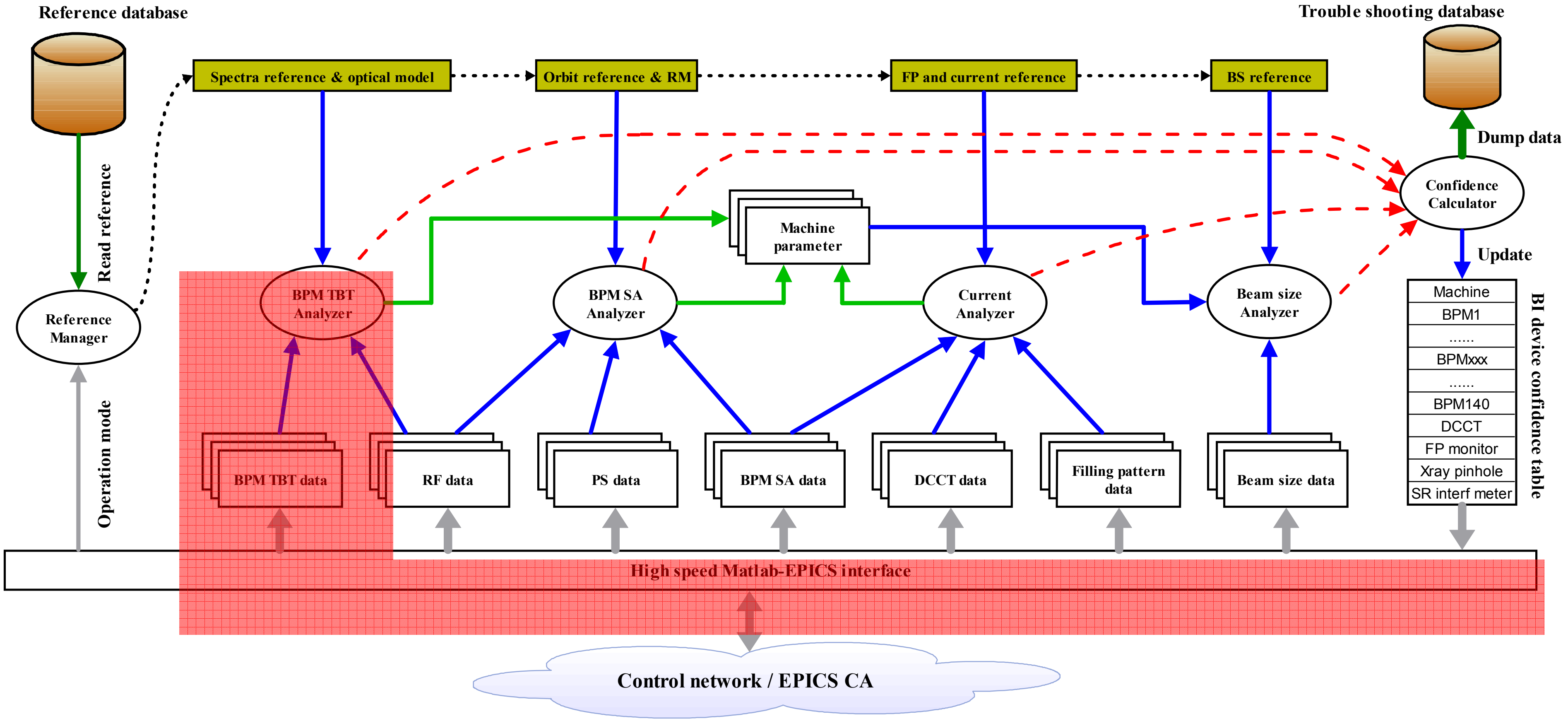
- Online analyze routine
  - ➢ Time domain analyze
  - ➢ Frequency domain analyze

- Machine and devices status monitor
  - ➢ Healthy indicator of machine
  - ➢ Healthy indicator of every diagnostics device
  - ➢ Attach a confidence flag for every set of BI data

Motivation

- No quick tools to do self-check for BI system
  - ➢ Electronics configuration
  - ➢ Cable connection (few hours >> few minutes)
- No good trouble shooting tools
  - ➢ Regular achieved data (SA) not enough for trouble shooting
  - ➢ No way to achieve all broad band data
  - ➢ No way to catch random noise for now
- No quality reference for acquired data
  - ➢ To tell user how good this data is
- Trust list of BPMs for orbit feedback system (dynamically)
  - ➢ Unreasonable glitch and offset jump observed in SA data
  - ➢ Electronics configuration is easy to check, but cable and button not
  - ➢ No hard evidence to locate noise source (mechanical or electrical)

System structure



BI device confidence table
Machine
BPM1
......
BPMxxx
......
BPM140
DCCT
FP monitor
Xray pinhole
SR interf meter

- Orbit, position spectra and machine optics should be stable during user cycle
- Repeatability of machine and instruments should be good for new cycle
  Else new reference needs to be built every cycle
- Average current, bunch charge and sum signals of BPMs should match each other
- Beam size, bunch charge and position spectra should match each other

Why high speed Matlab-EPICS interface

- LCA or MCA
  - Call Matlab sub-routine to send data requests
  - Access BPMs one by one
  - Typically few seconds to get all free-run data at SSRF
  - Synchronization of TBT data broken

- High speed interface
  - Follow the idea of Shared Memory IOCcore interface for LabVIEW
  - Shared memory IOC collecting BPMs data routinely (local mapping)
  - Call dynamic library to get BPMs data locally
  - All BPMs data could be access as one block at Matlab side
  - Typically dozens ms to get all free-run data at SSRF
  - Synchronization of TBT data restored

High speed Matlab-EPICS interface

DLL

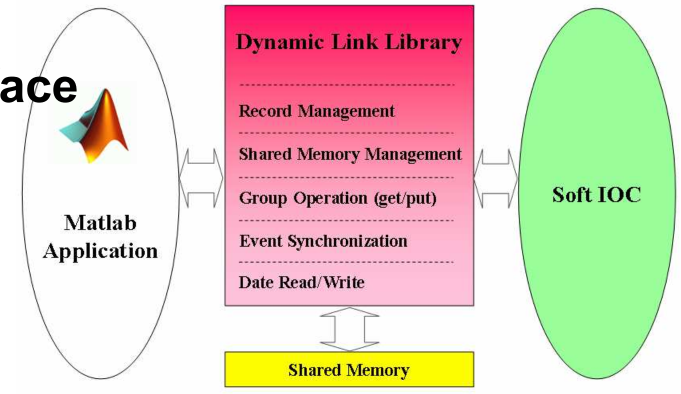
- implemented using standard system functions
- independent with EPICS and Matlab
- share data between the applications attached to the DLL
- provide get/put functions and event handling
- support group operation, very useful for the BPM system
- integers, floats, string and single dimension arrays

IOC

- shared memory is allocated during the IOC initializing
- shared memory is treated as a kind of special devices
- call DLL functions to access data

Matlab Applications

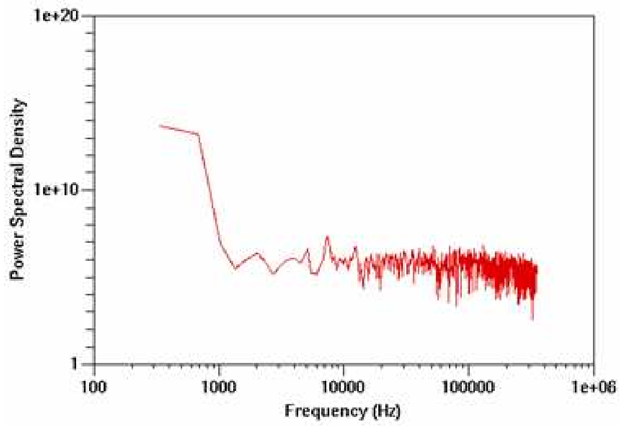
- easy to implement
- only minimal EPICS knowledge to use the interface

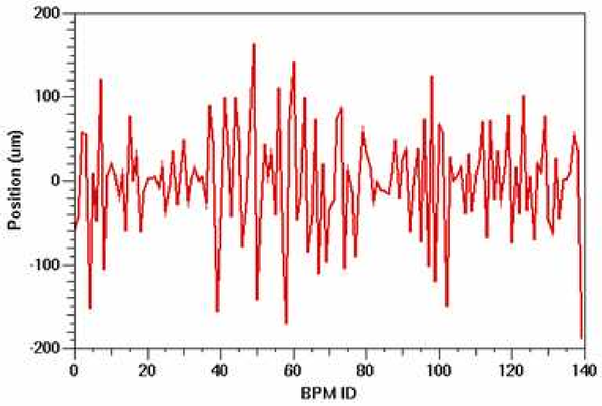


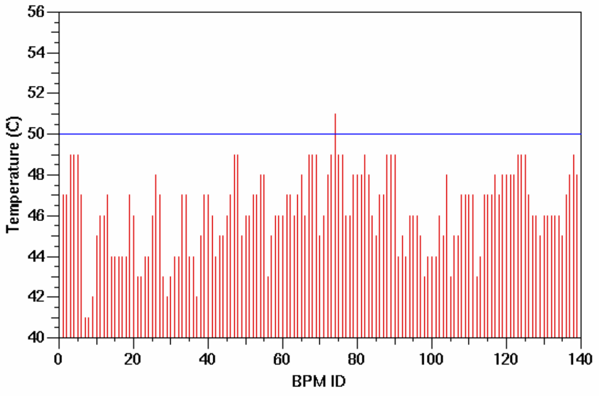
Yingbin Yan, Yongbin Leng, IPAC2010

High speed Matlab-EPICS interface

Array Size	Read Long (usec)	Write Long (usec)	Read Double (usec)	Write Double (usec)
8000	56	54	63	56
4000	36	34	46	40
2000	32	30	33	32
1000	30	27	29	28
100	28	26	27	26
10	27	25	26	25







Warning! C10-5 too hot

TBT data analyze method

- FFT analyze
  - ➢ Easy to realize, good for small number of BPMs
  - ➢ Independent process for every BPM
  - ➢ Correlation analyze for specific frequency component (beta, energy)
  - ➢ Need information of machine parameters or noise source
  - ➢ Good repeatability

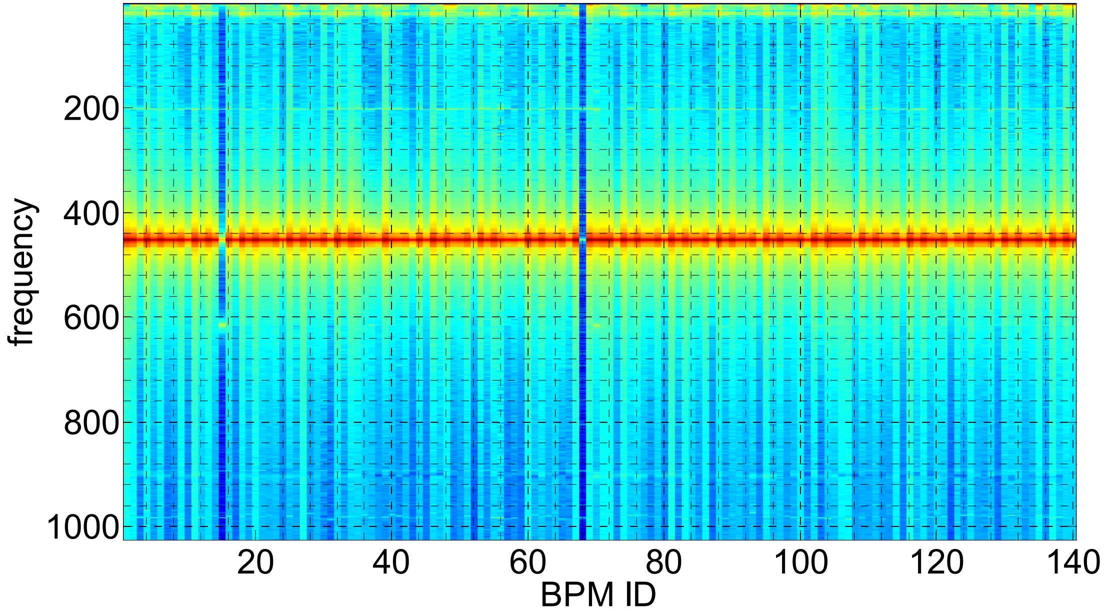
- MIA analyze (Dr. Chun-Xi Wang, APS)

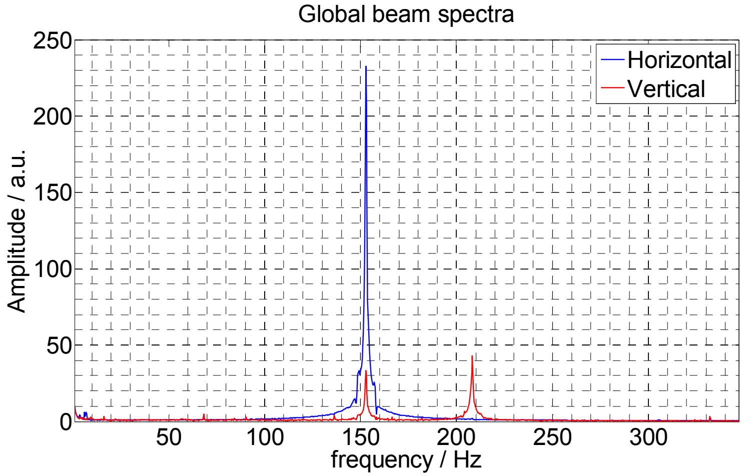
  Techniques to Extract Physical Modes in Model-Independent Analysis of Rings, Chun-Xi, Wang, EPAC2004
  - ➢ Direct correlation analyze, good for large number of BPMs
  - ➢ Time domain
  - ➢ Easy to extract physical mode
  - ➢ Hard to separate mixed mode
  - ➢ Need huge computing resources
  - ➢ Hard to build a baseline for principle component (different for each sample)

Frequency domain analyze

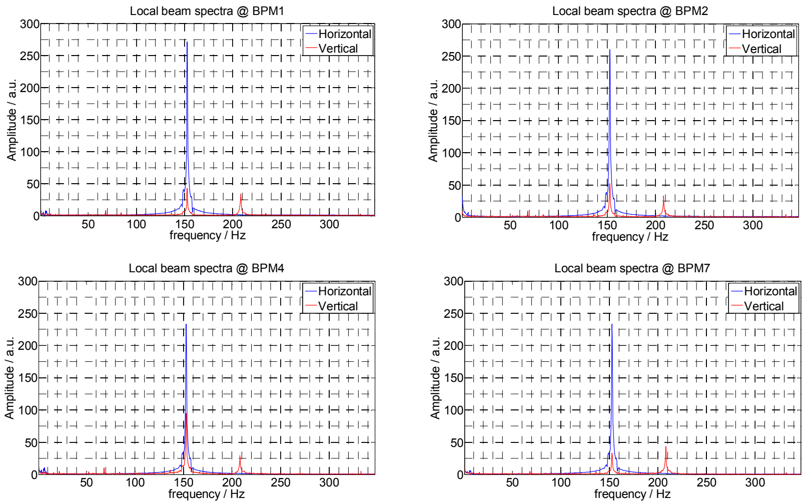
- Define a “normal” state for every operation mode
- Accumulate good data during normal operation
- Build a spectra baseline for machine
  - Calculate spectra baseline and define a reasonable threshold
  - Compare running data with baseline
  - Deviation shows machine state changed
    - Send warning message when threshold exceeded
    - Save data for offline analyze
- Build spectra baselines for all BPMs
  - Calculate spectra baseline and define a reasonable threshold
  - Compare running data with baseline
  - Individual BPM deviation shows device state changed
    - Send warning message, update confidence flag
    - Save data for offline analyze
- Build an amplitude baseline for specific frequency component
  - Beta, synchrotron, other narrow band noise

Frequency domain analyze: x @ injection

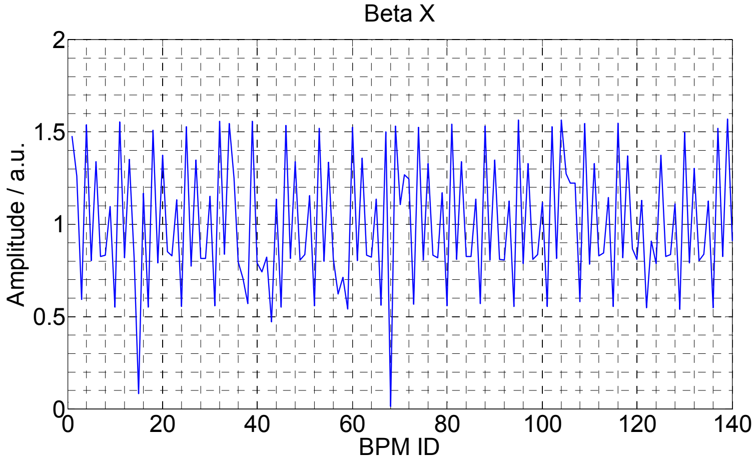




Average of whole machine

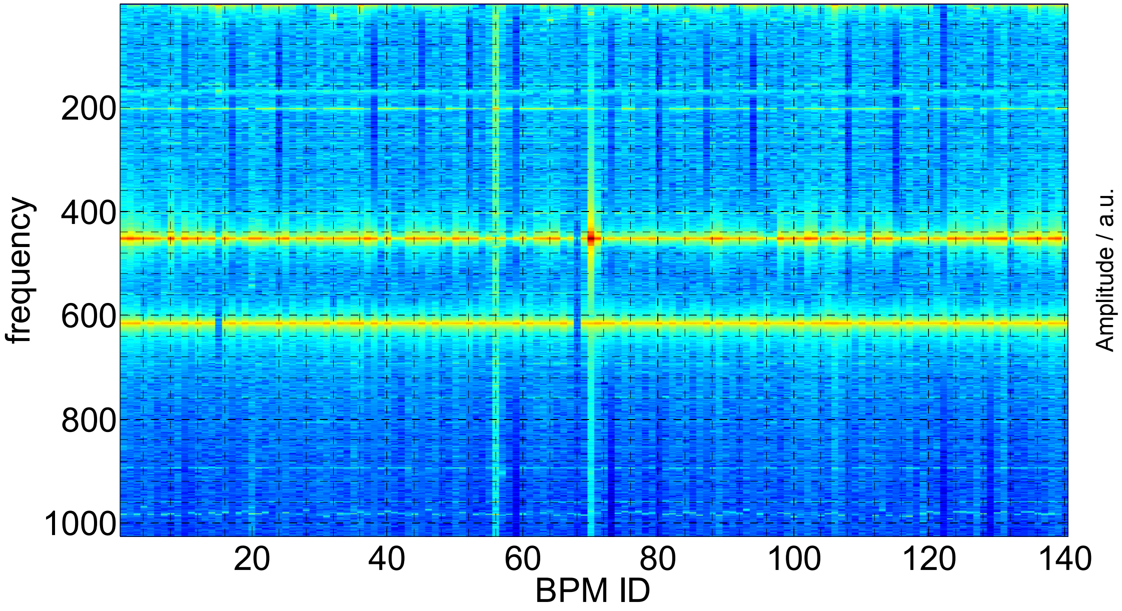


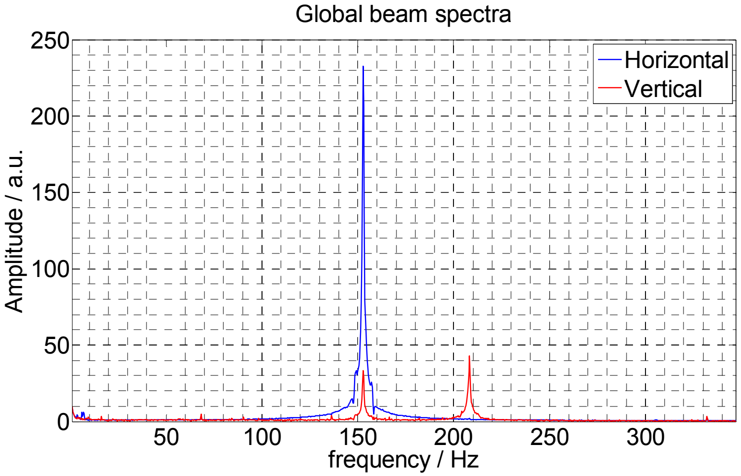
Location slices @ 14BPM1, 2, 4, 7



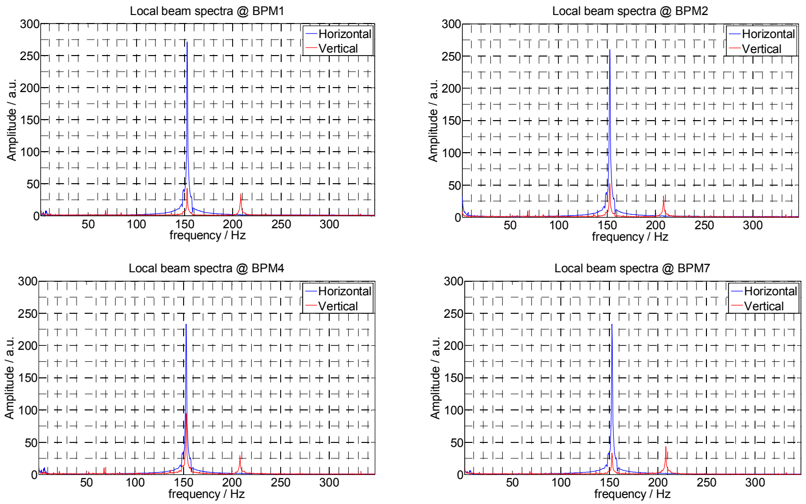
Frequency domain slice @ 0.23

Frequency domain analyze: y @ injection

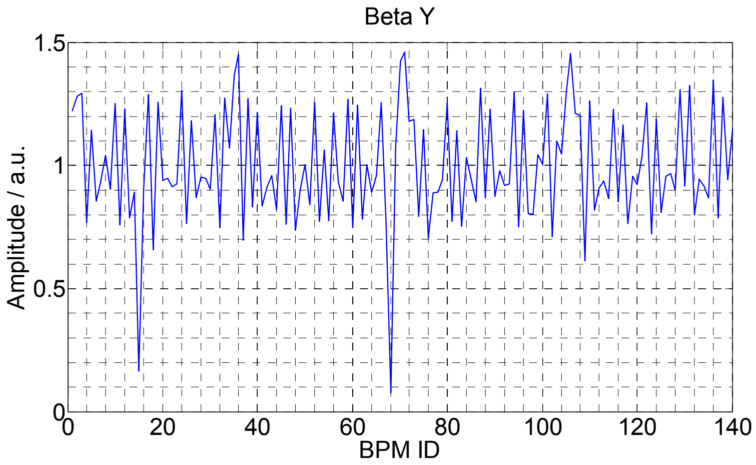




Average of whole machine

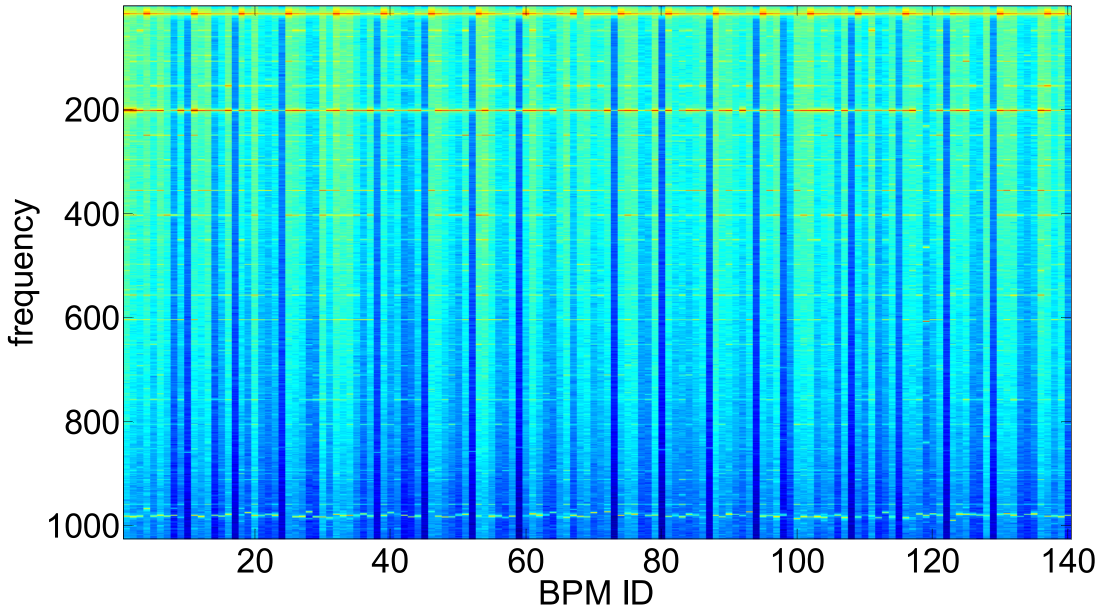


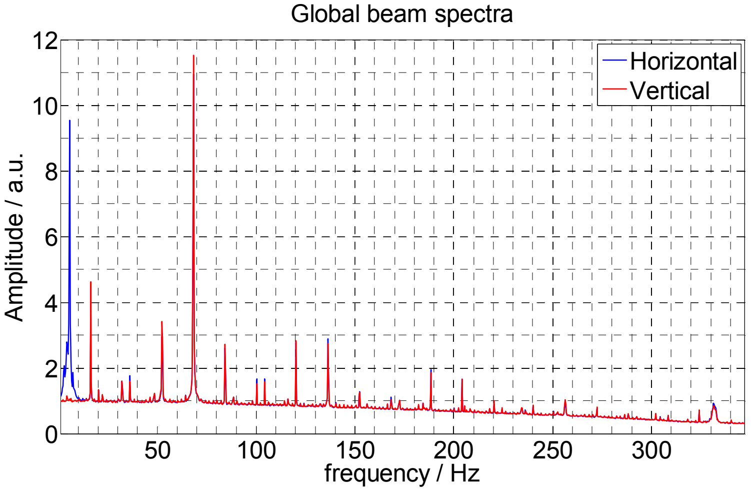
Location slices @ 14BPM1, 2, 4, 7



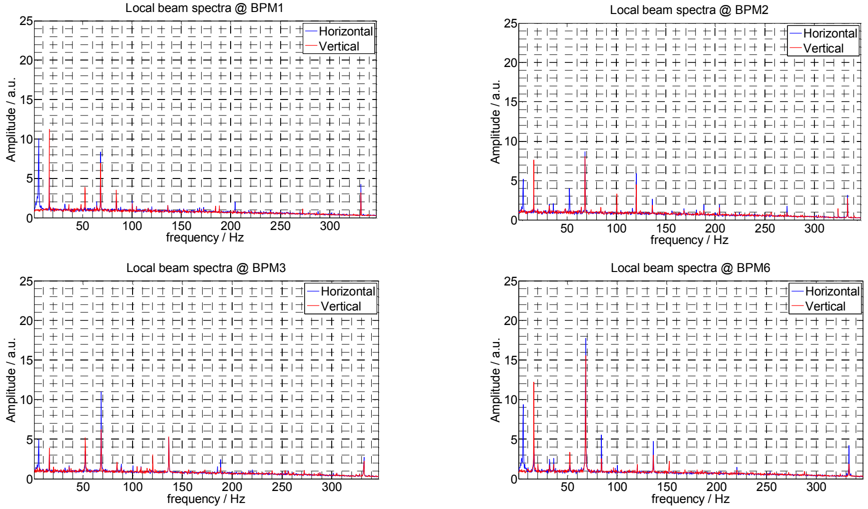
Frequency domain slice @ 0.3

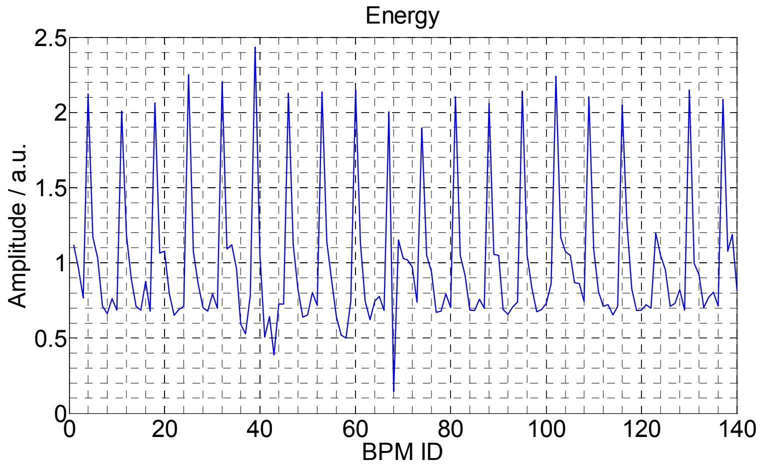
Frequency domain analyze: x @ decaying





Average of whole machine



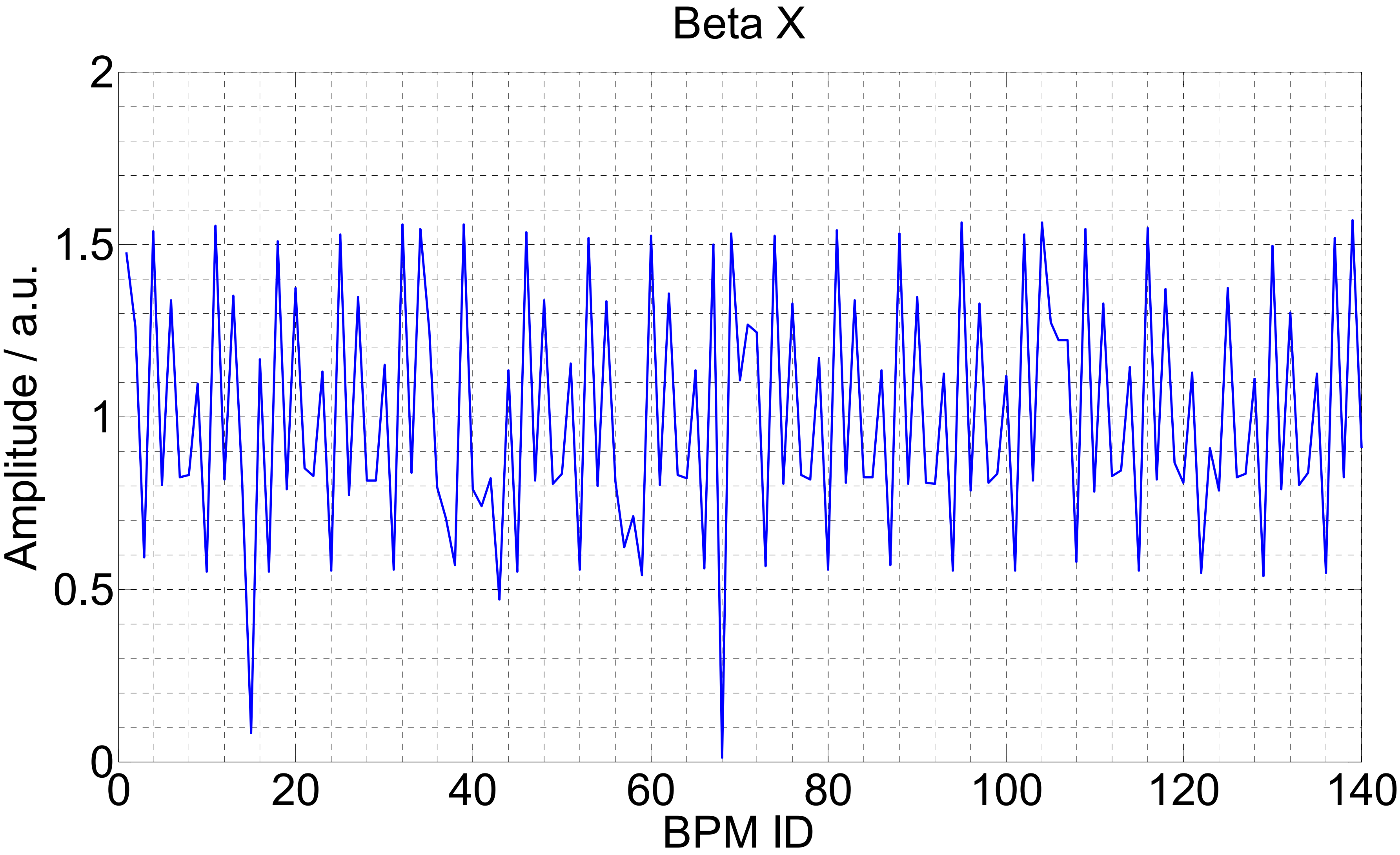


Location slices @ 14BPM1, 2, 4, 7

Frequency domain slice @ 0.008

Frequency domain analyze: application

Locate “bad” BPMs:
BPM3-1, BPM5-7, BPM10-5, BPM10-7, BPM18-4, ……



Frequency domain analyze: application

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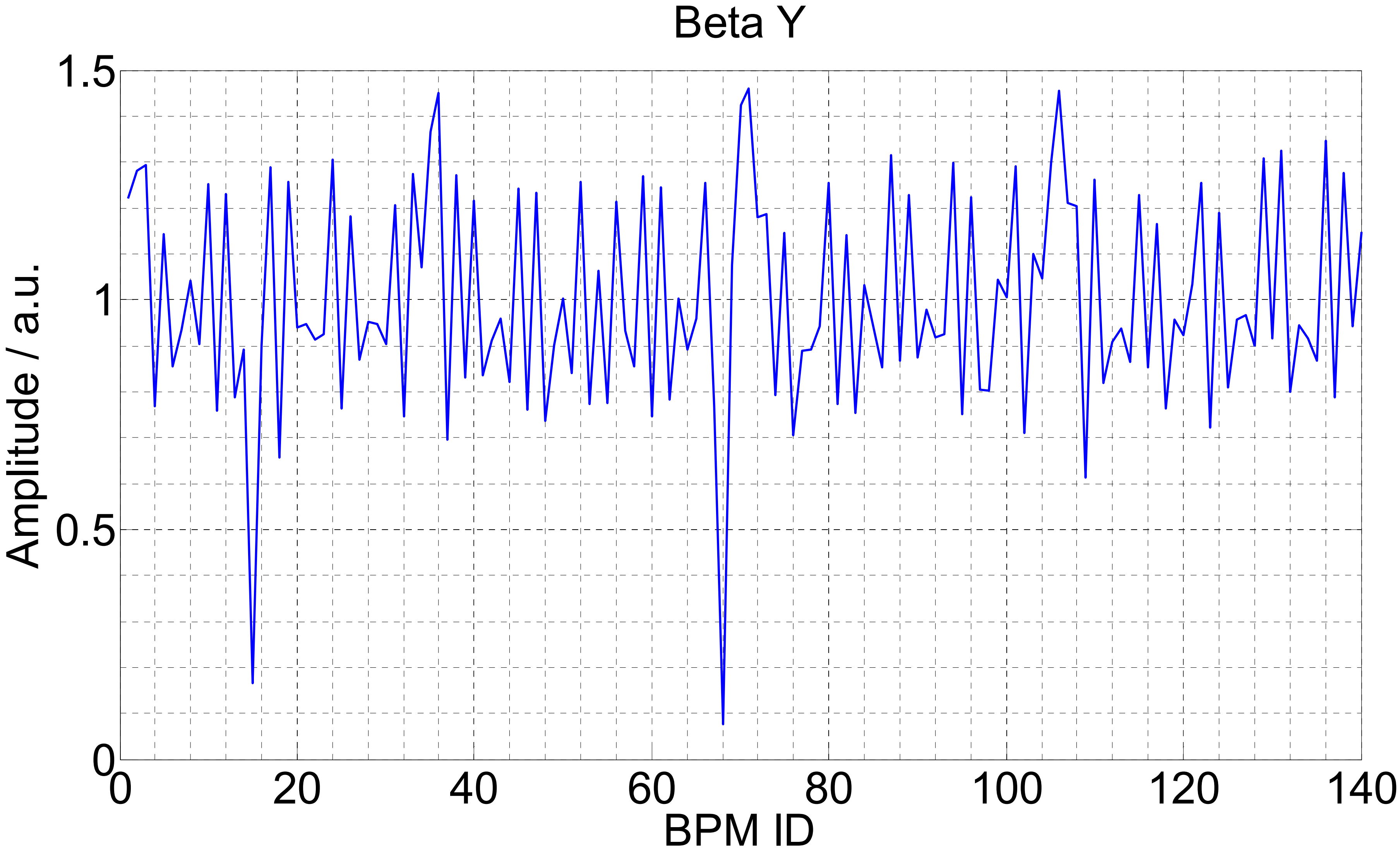
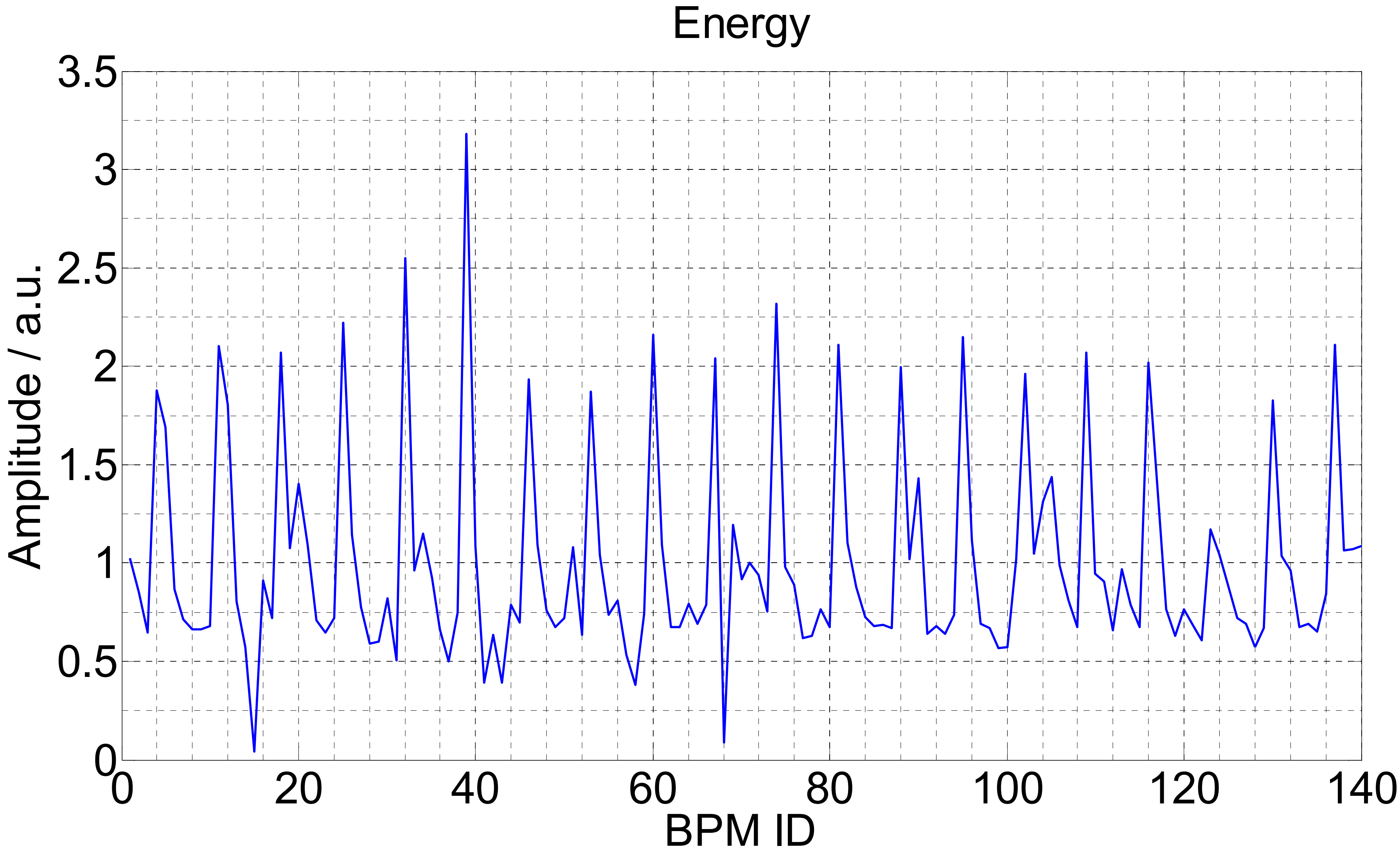
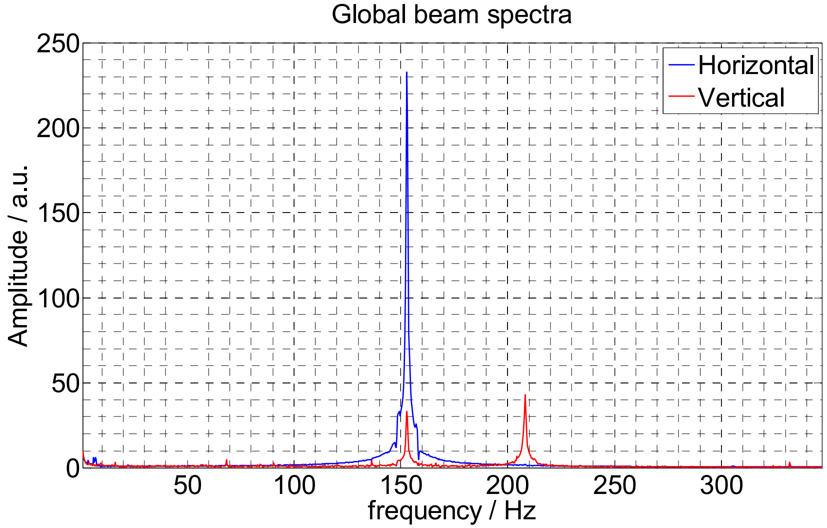


Frequency domain analyze: application

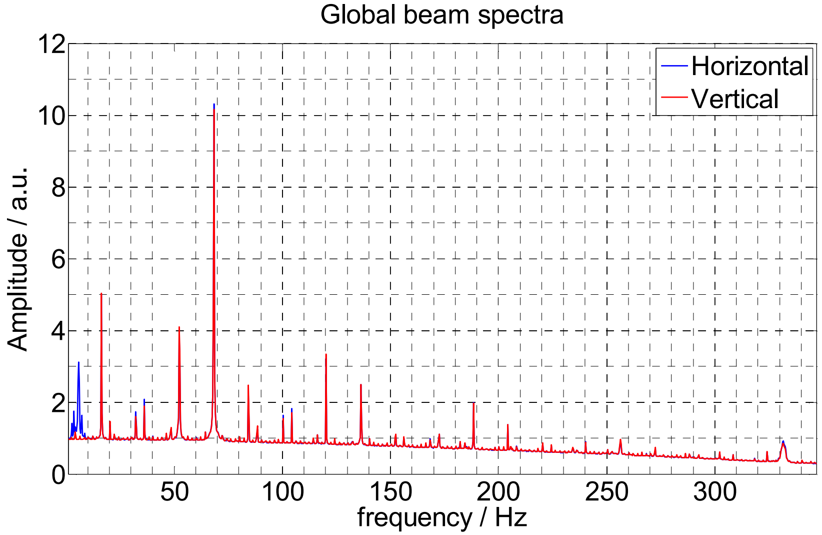
Locate "bad" BPMs:
BPM3-1, BPM6-4, BPM10-5, BPM10-7, BPM18-4, ……



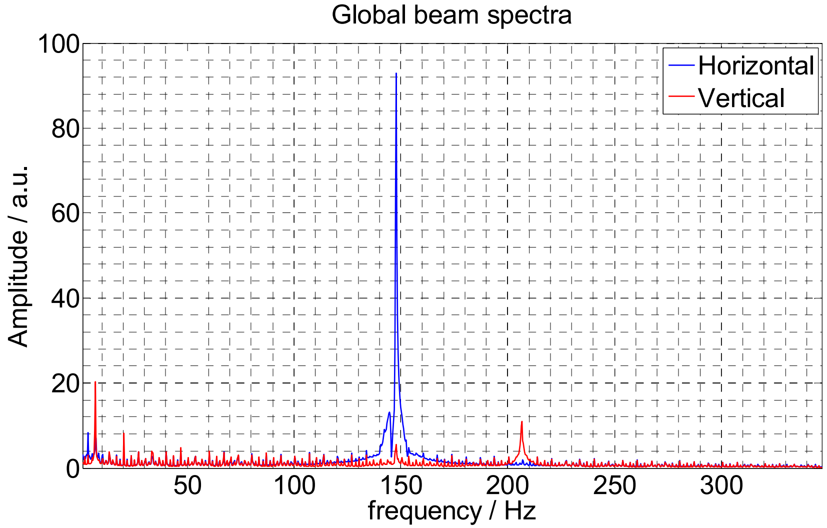
Frequency domain analyze: Machine state monitor



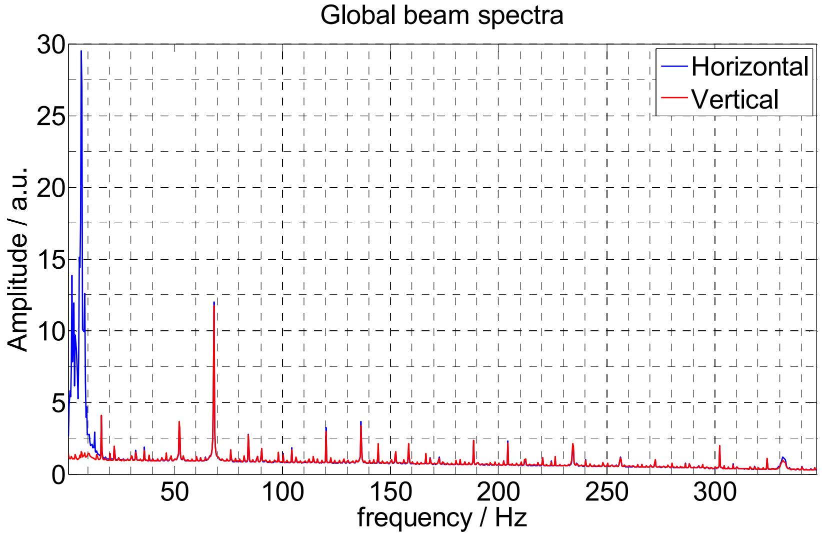
2010.09.07, 10mA @ injection



2010.10.01, 10mA @ decaying

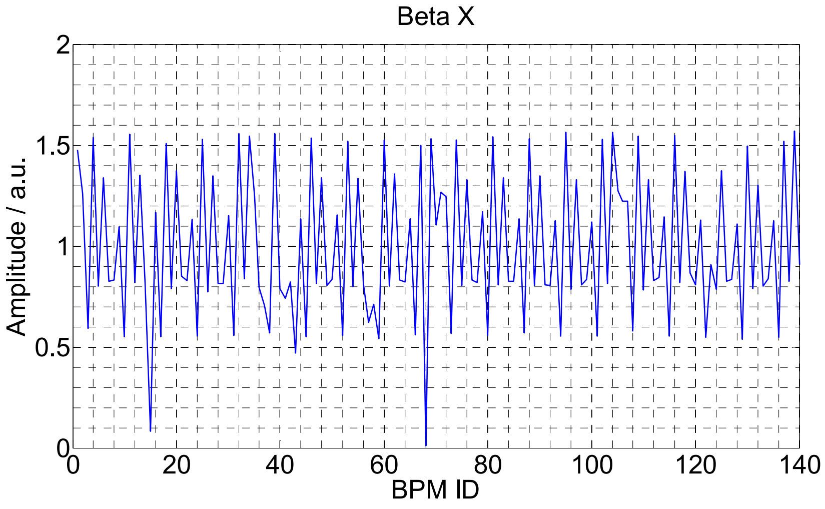


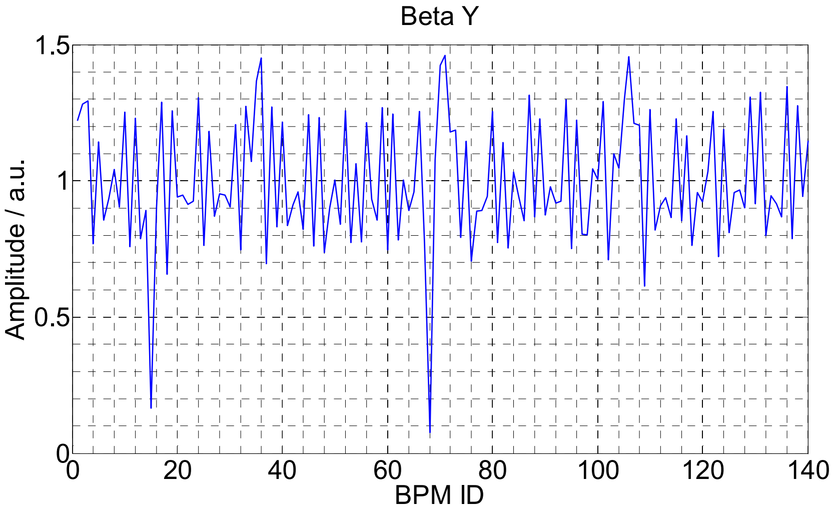
2010.09.27, 10mA @ injection, CB SW on

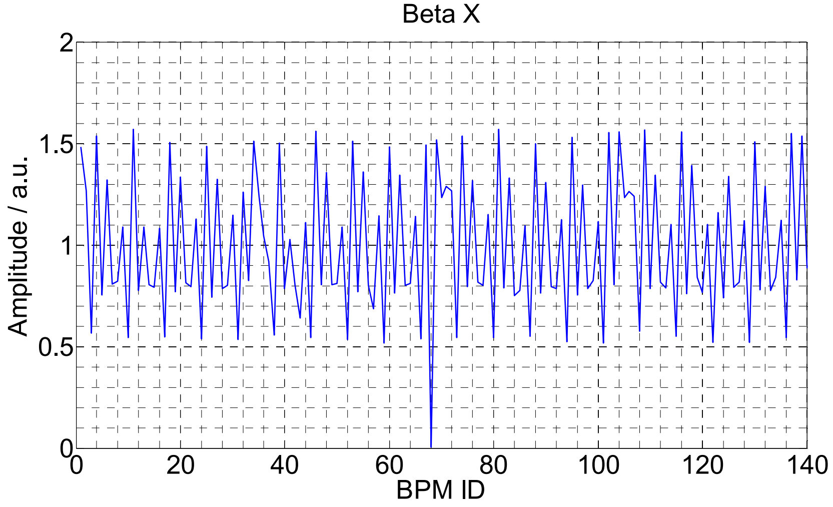


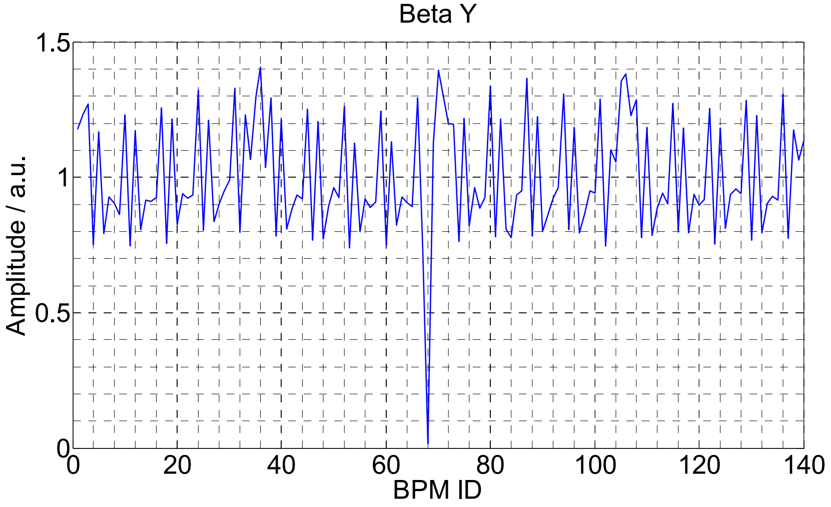
2010.10.01, 210mA @ decaying

Frequency domain analyze: Machine state monitor

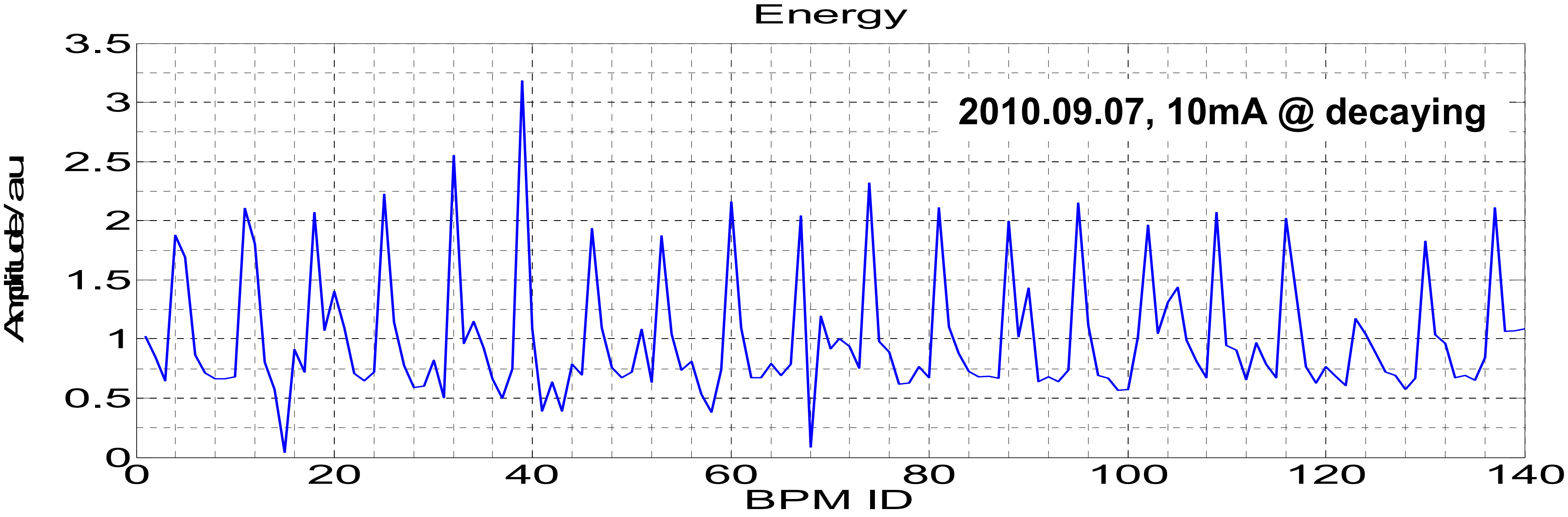




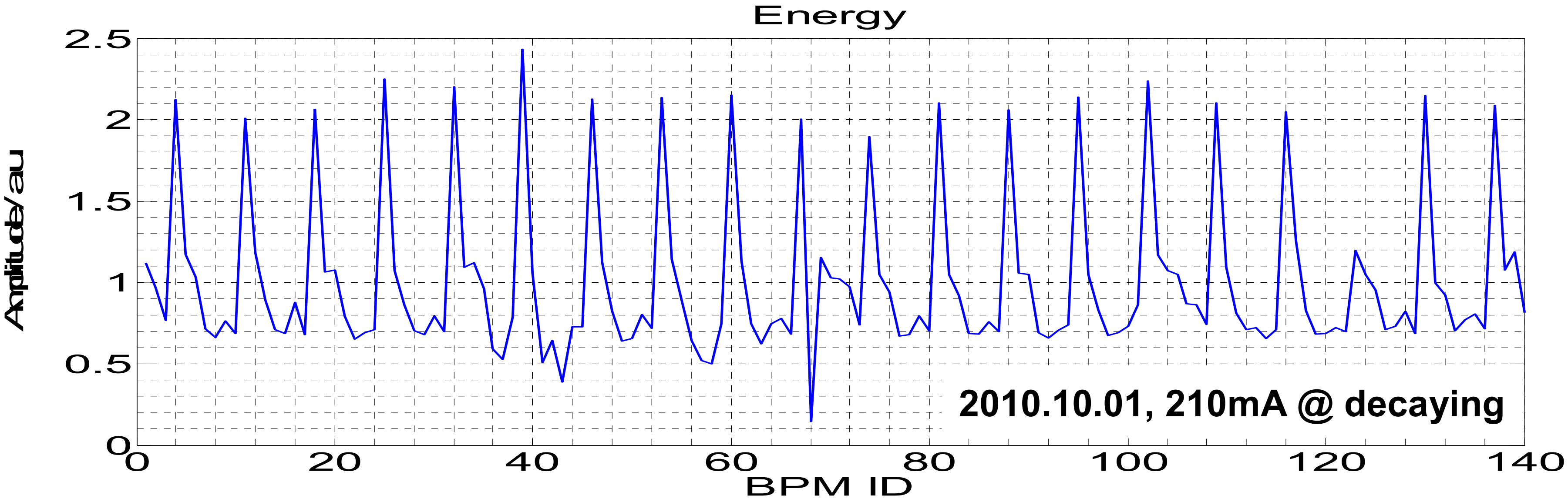




Frequency domain analyze: Machine state monitor



2010.09.07, 10mA @ decaying



2010.10.01, 210mA @ decaying

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  Techniques to Extract Physical Modes in Model-Independent Analysis of Rings, Chun-Xi, Wang, EPAC2004
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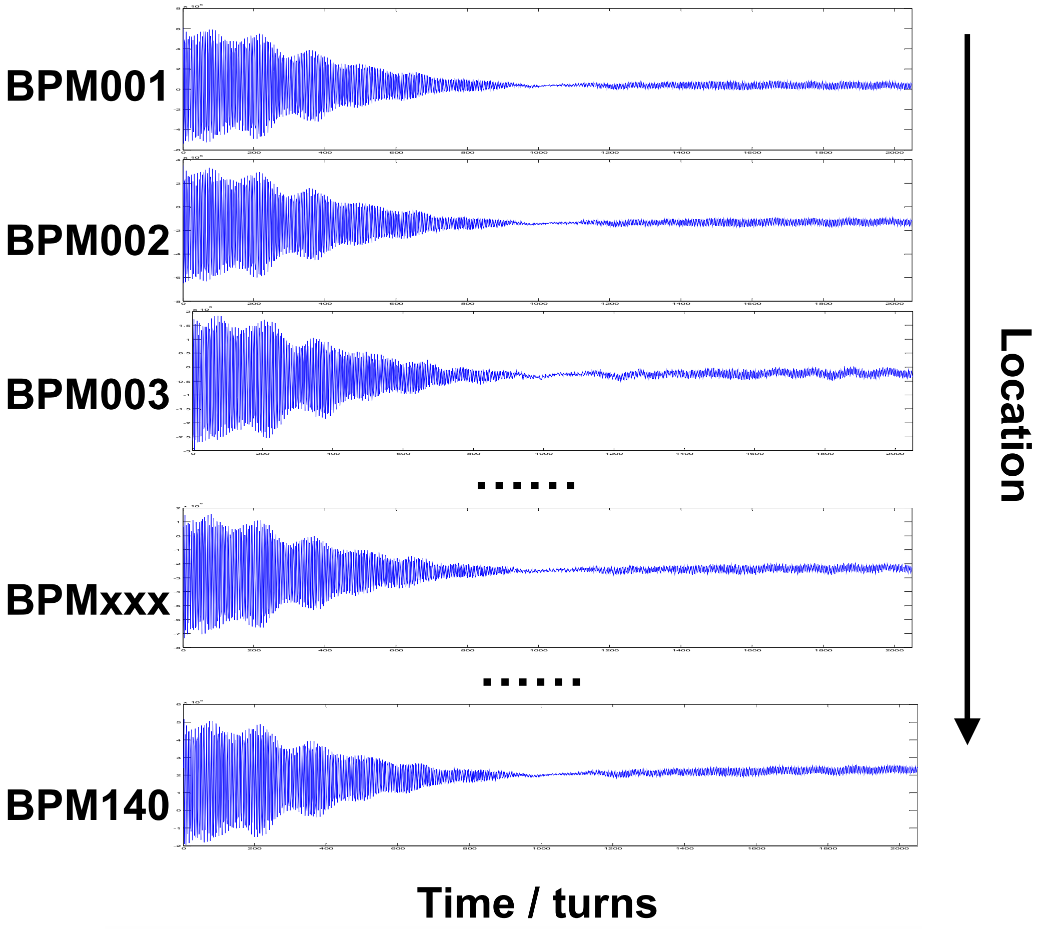
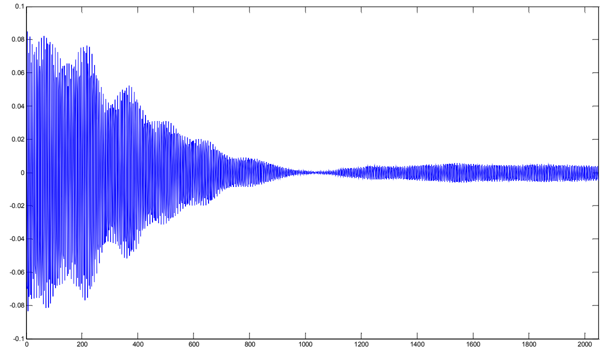
MIA analyze

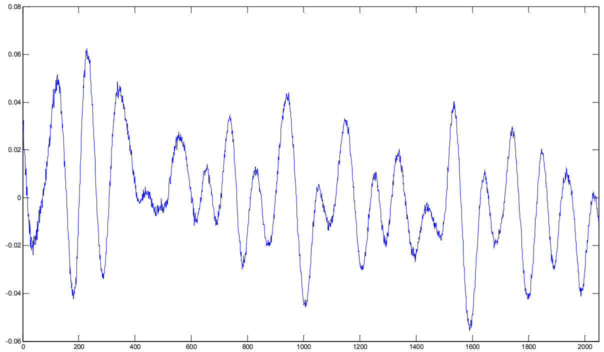


$$B = \hat{U} S \hat{V}^T = \sum_{\text{modes}} \sigma_i \hat{u}_i \hat{v}_i^T \,,$$

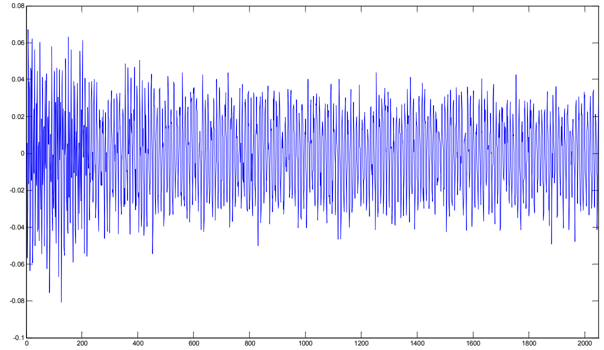
Easy to understand what really happened



Damped betatron osc.

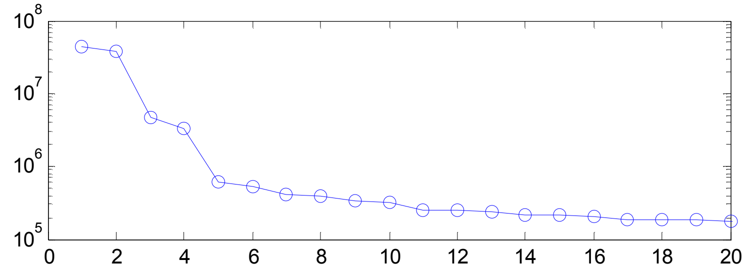


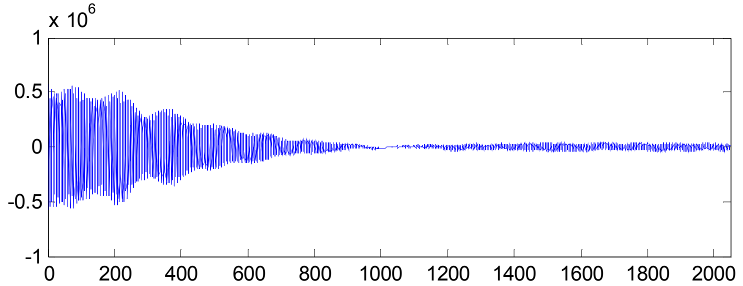
Energy osc.

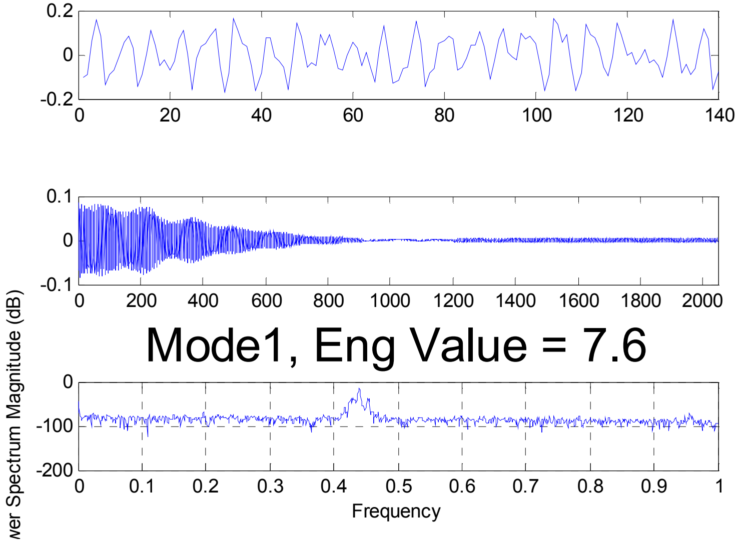


68kHz NB noise

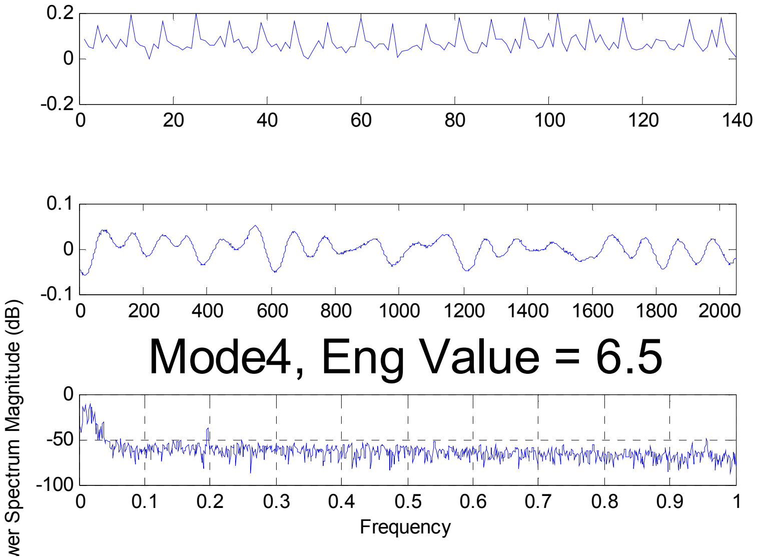
MIA analyze @ injection



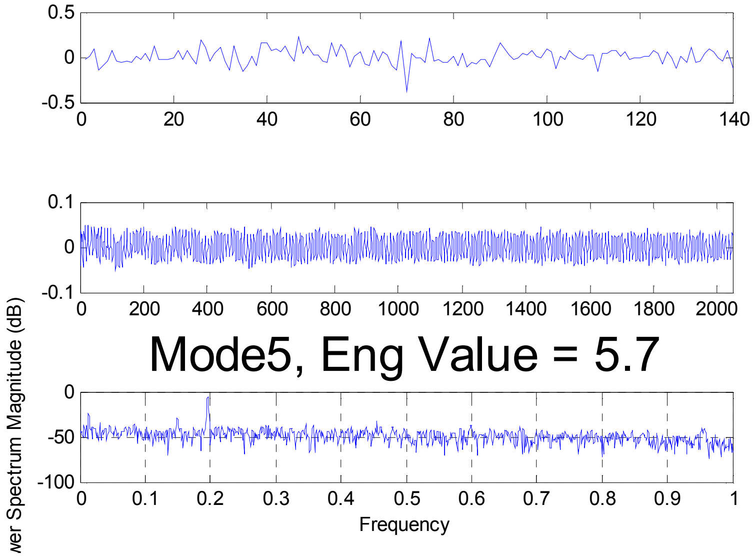




Mode1, Eng Value = 7.6

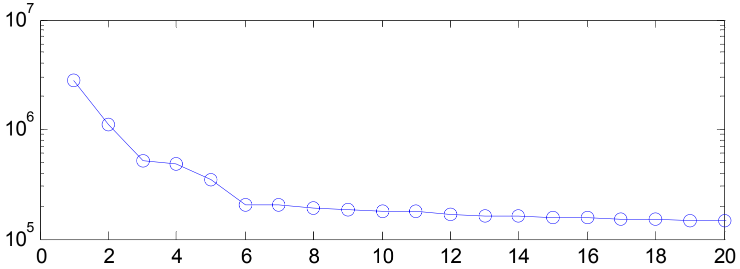


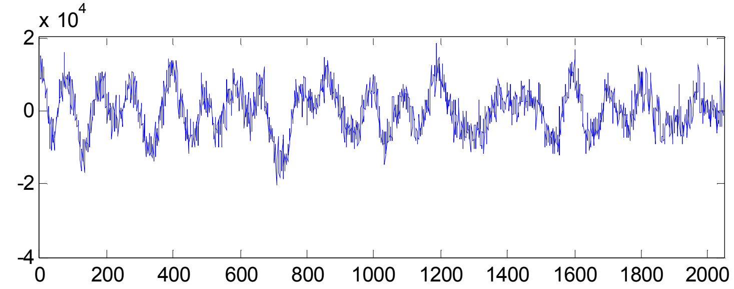
Mode4, Eng Value = 6.5

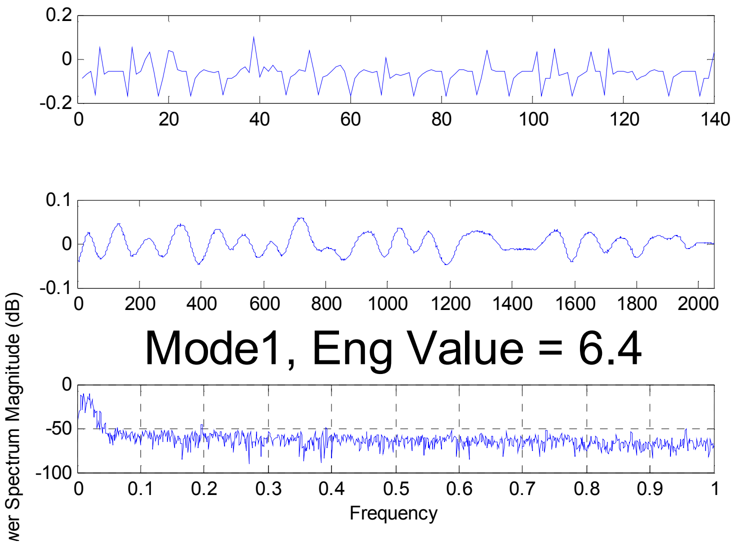


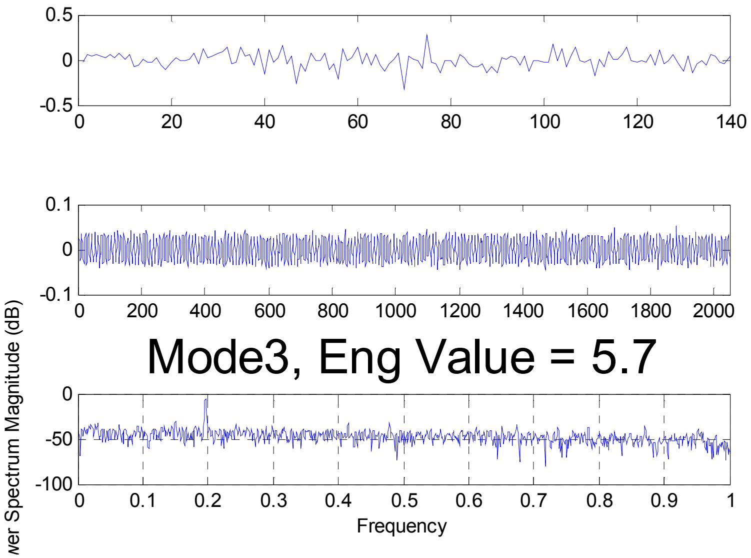
Mode5, Eng Value = 5.7

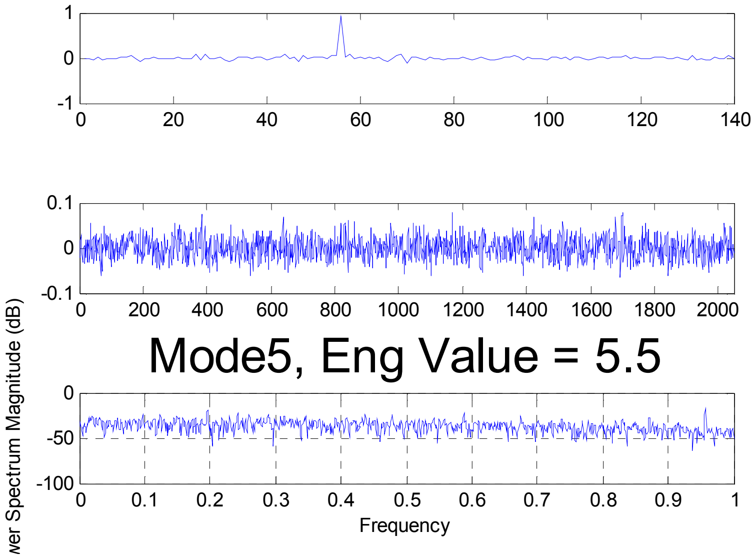
MIA analyze @ decaying






Mode1, Eng Value = 6.4


Mode3, Eng Value = 5.7


Mode5, Eng Value = 5.5

Summary

- Beam diagnostics data warehouse is in plan
- Online TBT analyze is very important part
- High speed Matlab-EPICS interface has been developed for this purpose
- Spectra monitor is online

  but correlation analyze and confidence calculation is not yet
- Offline analyze shows this method is useful for BI system self-check and machine status monitoring
- Reasonable reference and threshold need to be defined
- Find a good way to use MIA result online
- Phase advance analyze will be included soon