# Automated beamline alignment at Elettra Xray Diffraction Beamline

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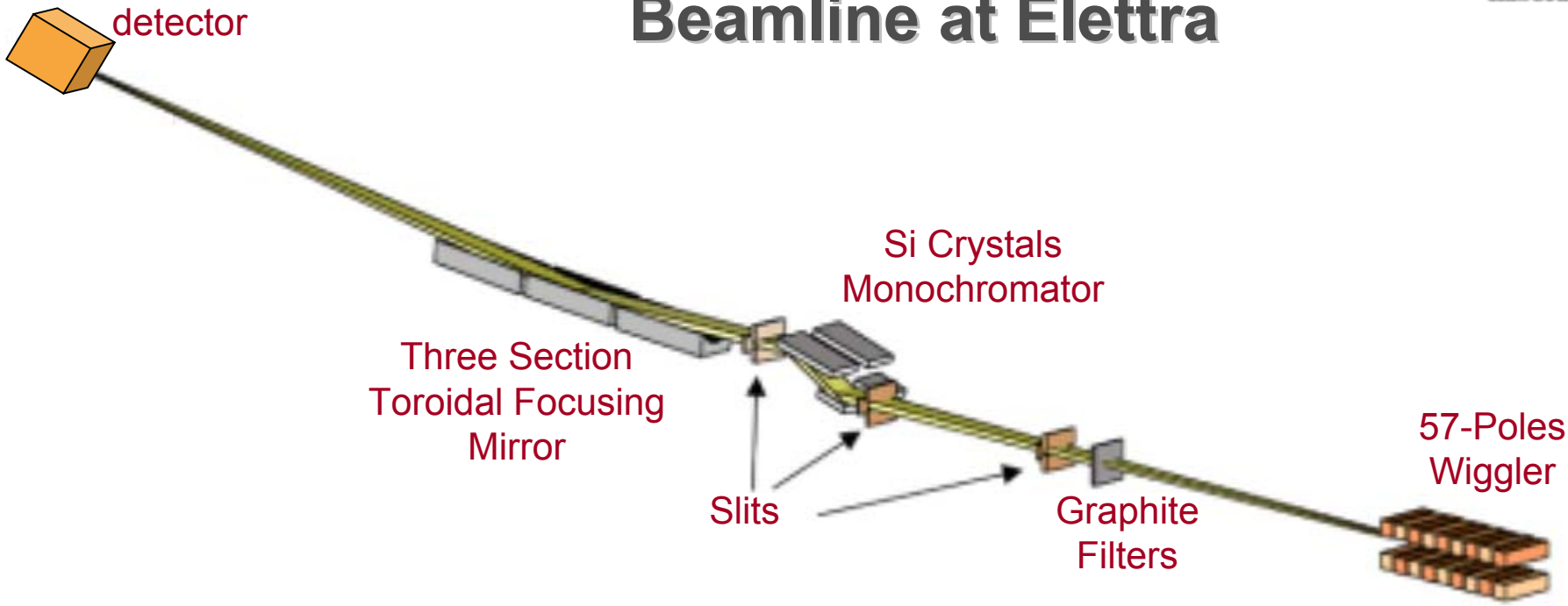
# AGENDA

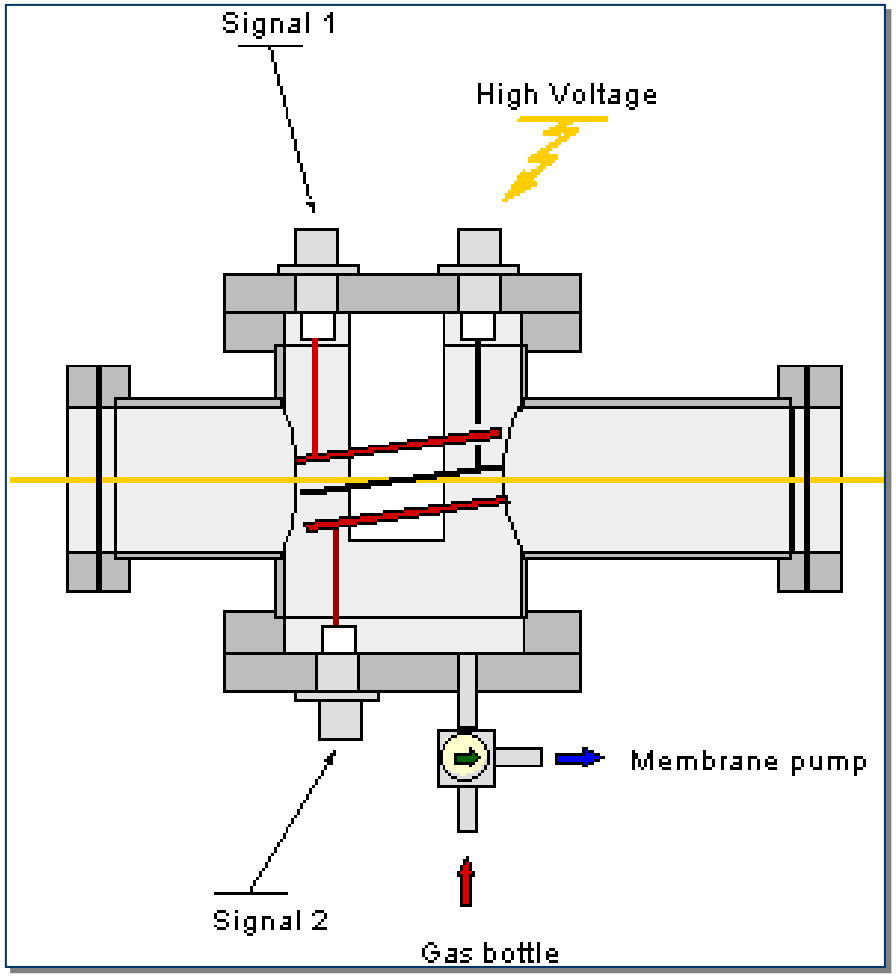
- The XRD beamline automatic alignment problem
- Applying the Teleo-Reactive Control theory
- Implementation and first results
- Future development

# SCENARIO

## X-Ray Diffraction Beamline at Elettra

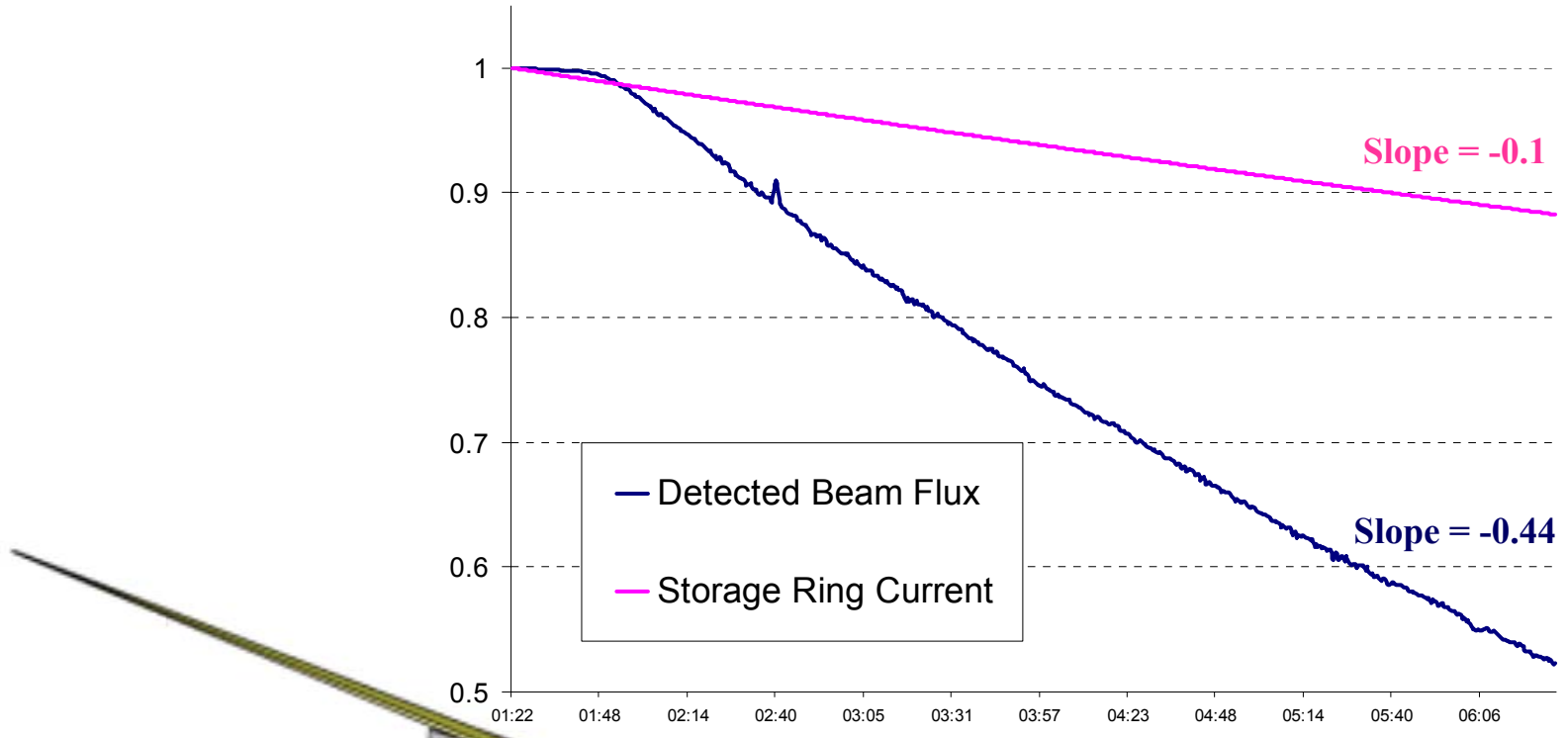


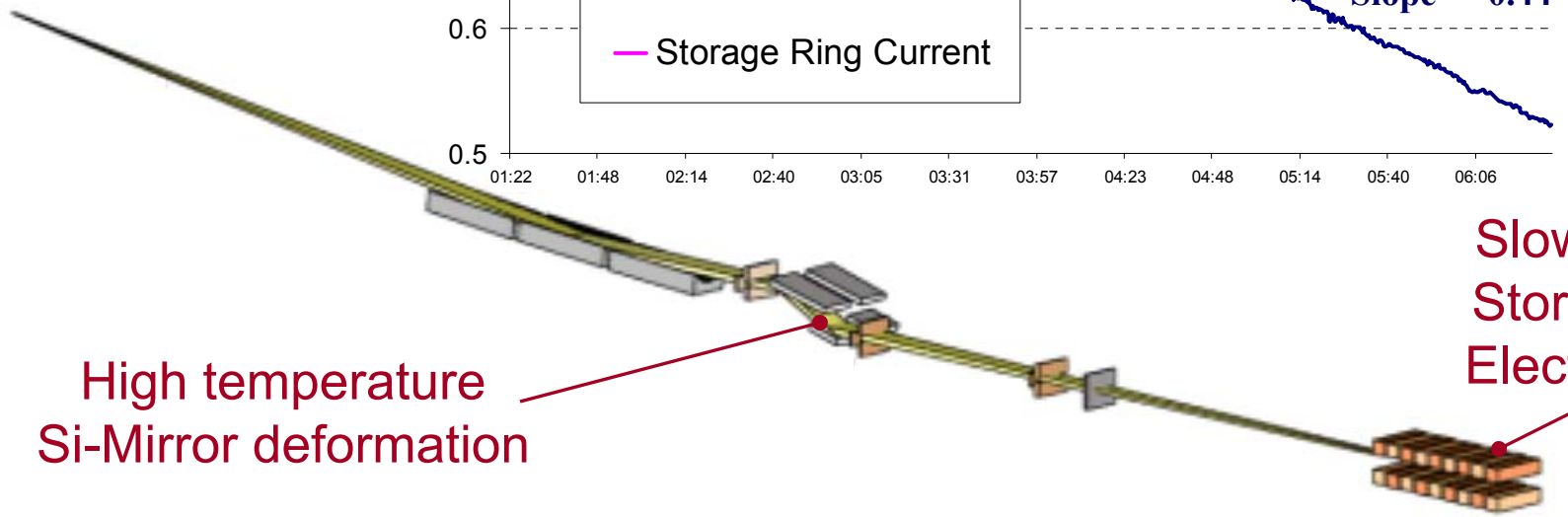
# The Ion Chamber detector




- Two ionisation chambers separated by a thin Beryllium foil
- DIFFERENCE of Signal1 and Signal2 estimates beam vertical position
- SUM of Signal1 and Signal2 estimates beam flux
- **GOAL**: maximize SUM & minimize abs( DIFF )

# Why a Feedback?



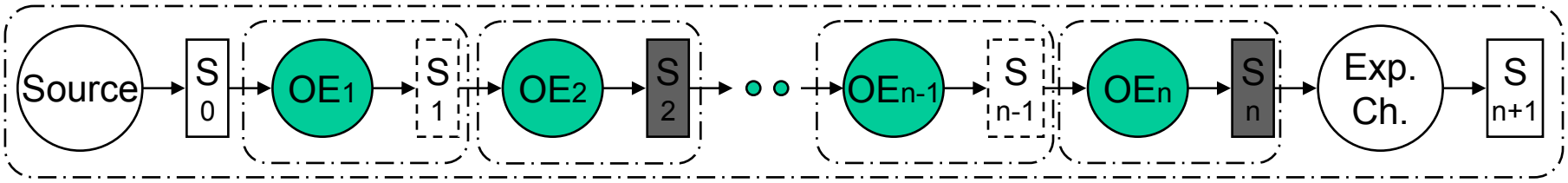



High temperature
Si-Mirror deformation

Slow drifts of
Storage Ring
Electron Orbit

# Automatic Beamline Alignment: problem solving strategy

- Split the alignment problem into small *sub-problems* involving, for example, only one optical element and the associated sensor
- Implement for each *sub-problem* an *alignment module* using traditional or soft computing techniques
- Combine the modules using the strategic, behavioural knowledge of the optics expert

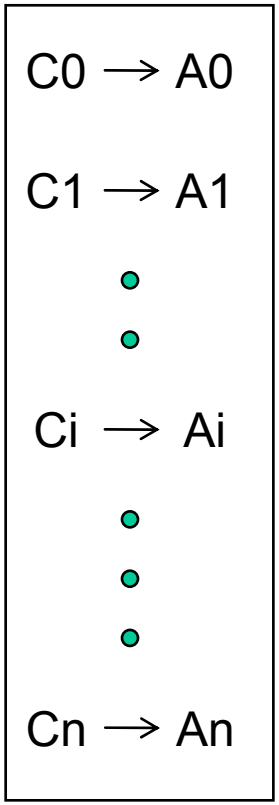


# Applying Intelligent System Concepts to the Automatic Beamline Alignment problem

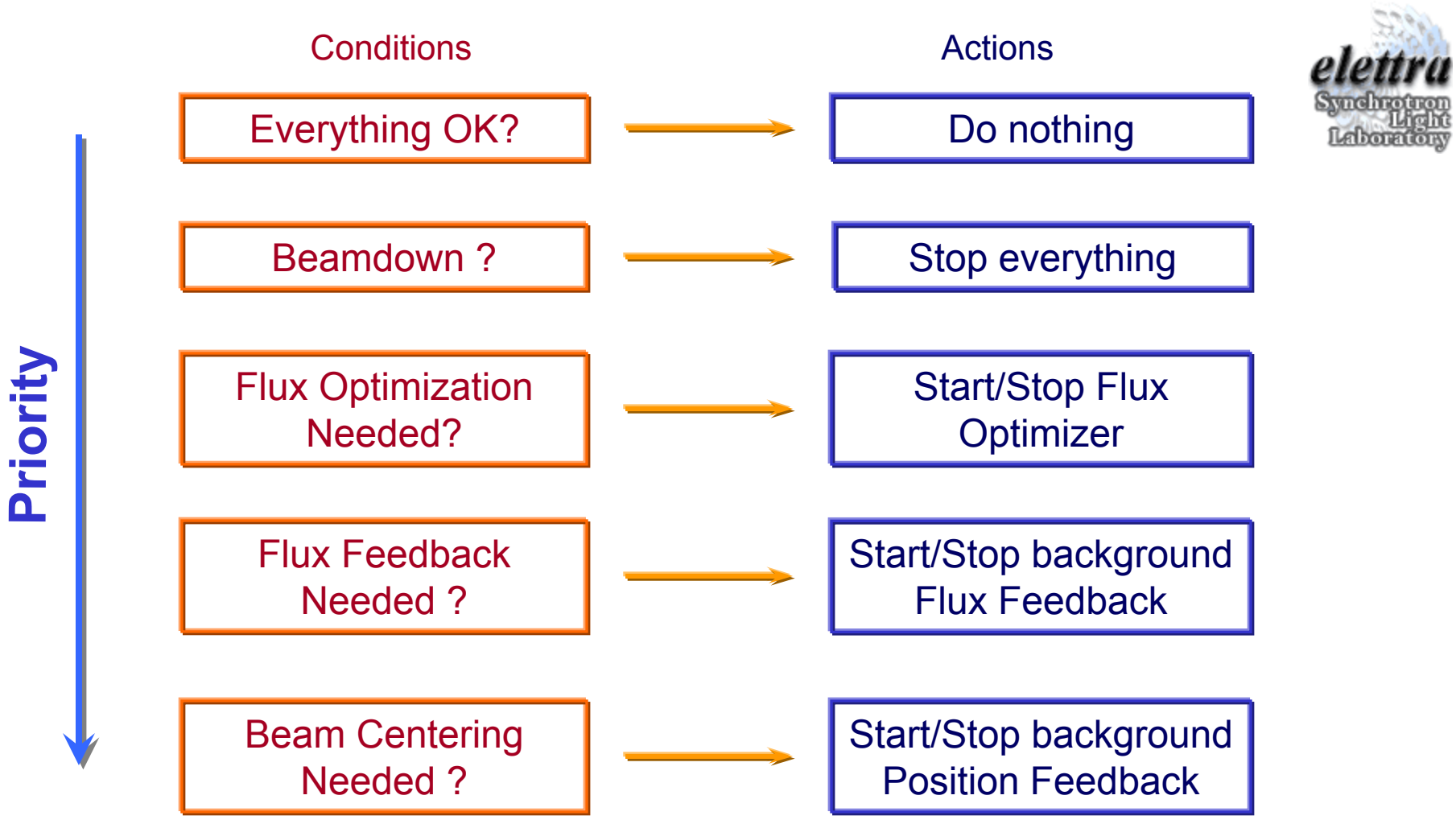
- Intelligent Systems (IS) incorporate the creative, abstract and adaptive attributes of a human while minimising the undesirable aspects such as unpredictability, inconsistency, fatigue, subjectivity and temporal instability
- Hybrid Intelligent Systems integrate Knowledge Based Systems, Neural Network, Fuzzy Systems, Evolutionary Algorithms, Case-Based reasoning, Chaos Theory and traditional techniques to solve effectively complex real world problems.

# Teleo-Reactive (TR) control

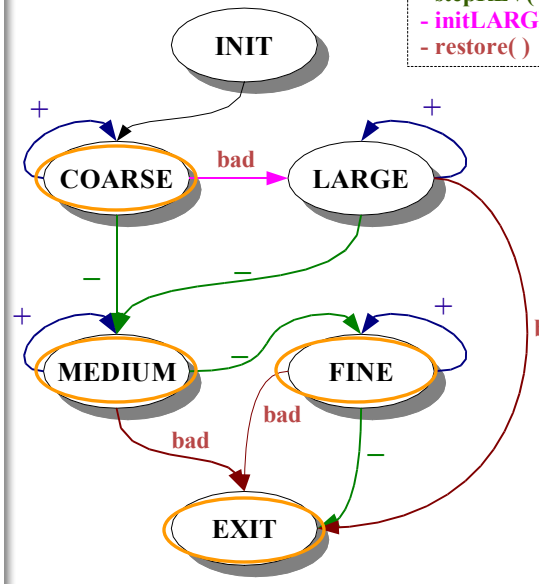
- TR control occupies a region between feedback control and discrete action planning:
  - actions can be either discrete or continuous
  - actions are not guaranteed to achieve their goals
  - actions can be interrupted in response to changes in the environment
- TR plans can be represented as a sequence of condition-action pairs called TR operators.
  - TR plan execution is adaptive and opportunistic: conditions are evaluated from top to bottom and the action associated o the first true condition is performed.



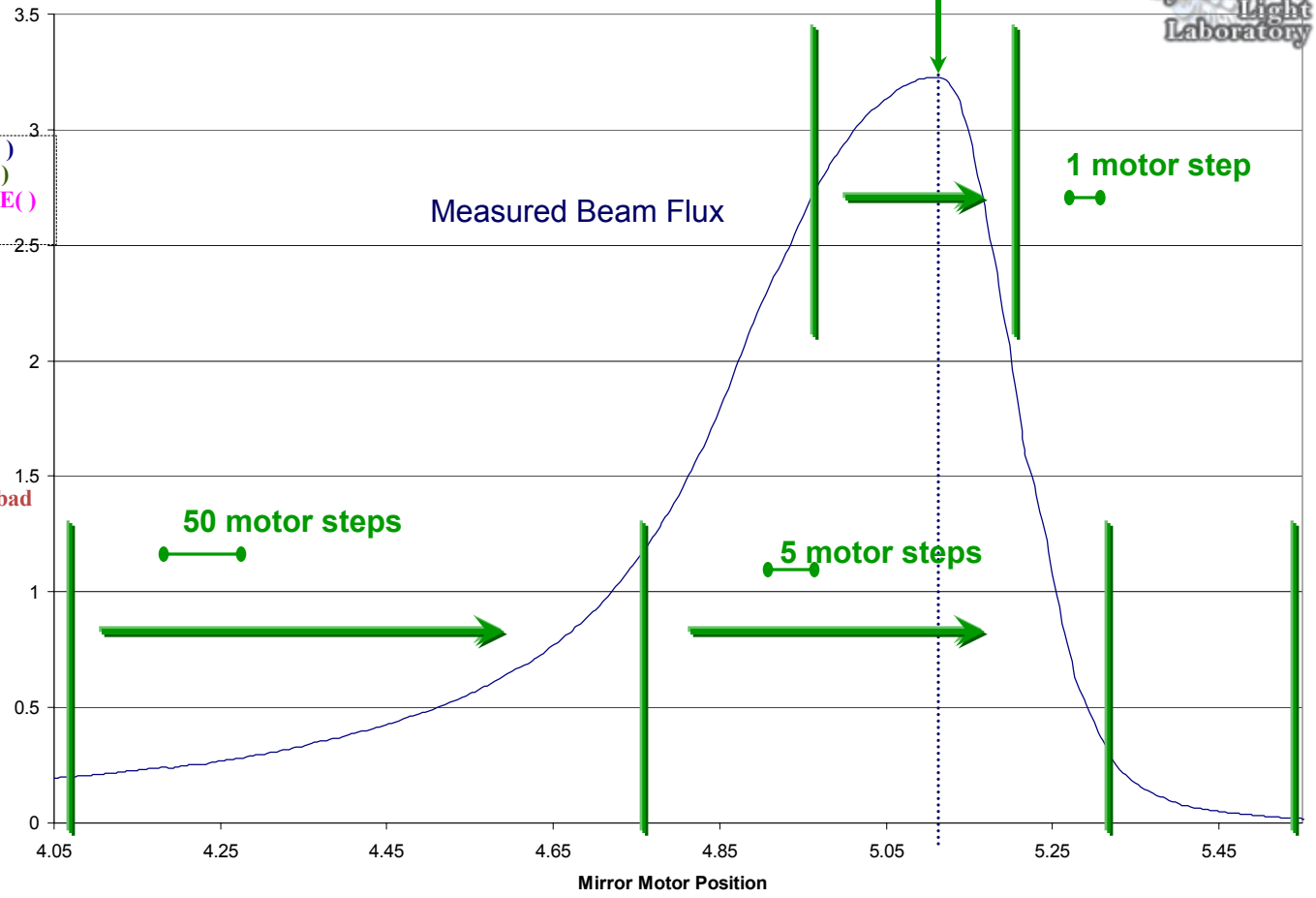
# TR control plan



# The actions: Off-line Flux Optimizer

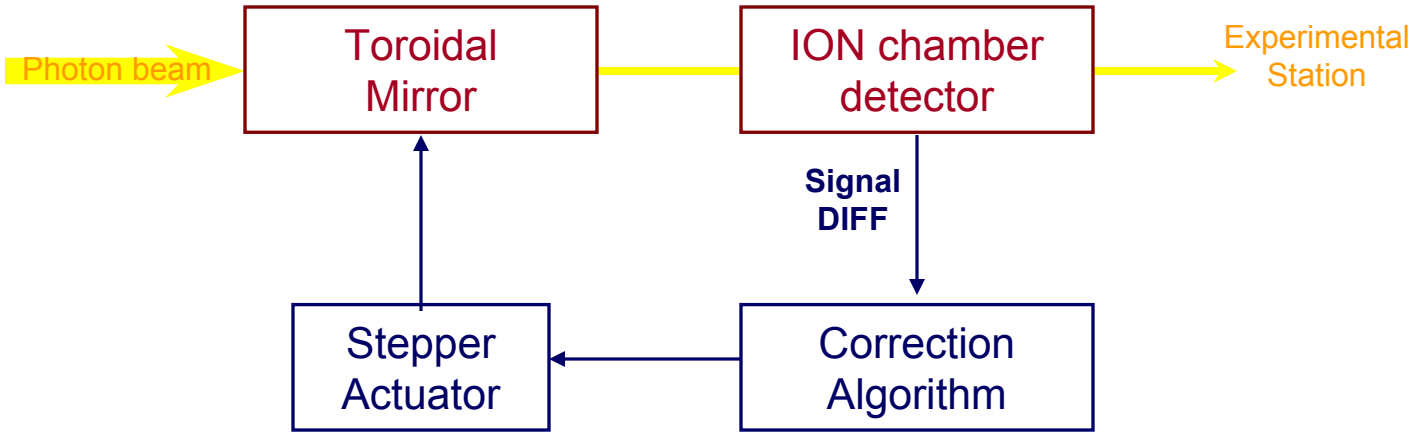



- stepFWD( )
- stepREV( )
- initLARGE( )
- restore( )

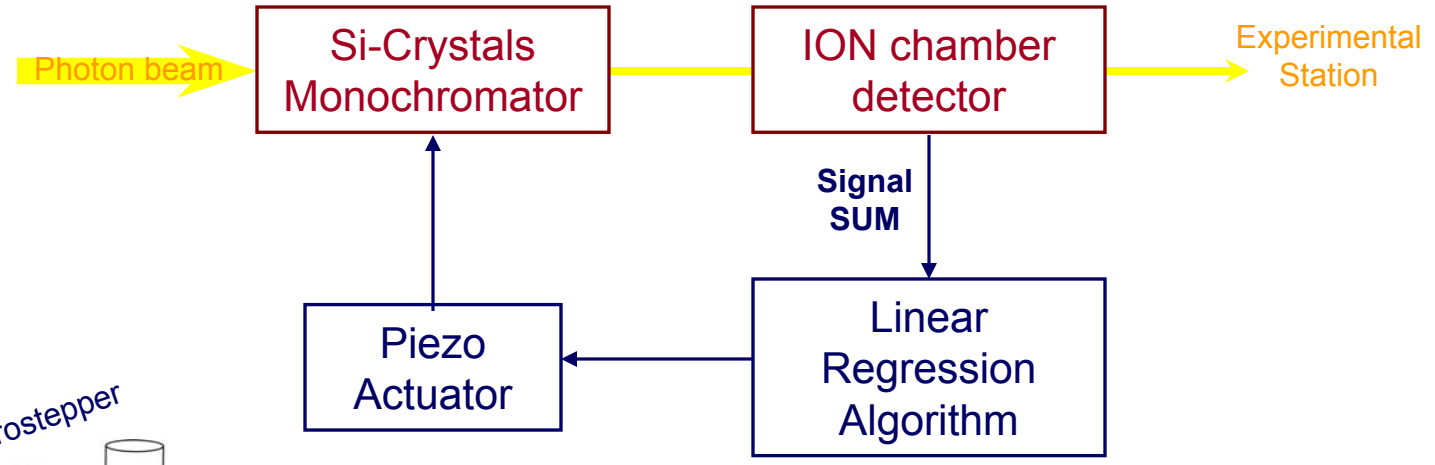


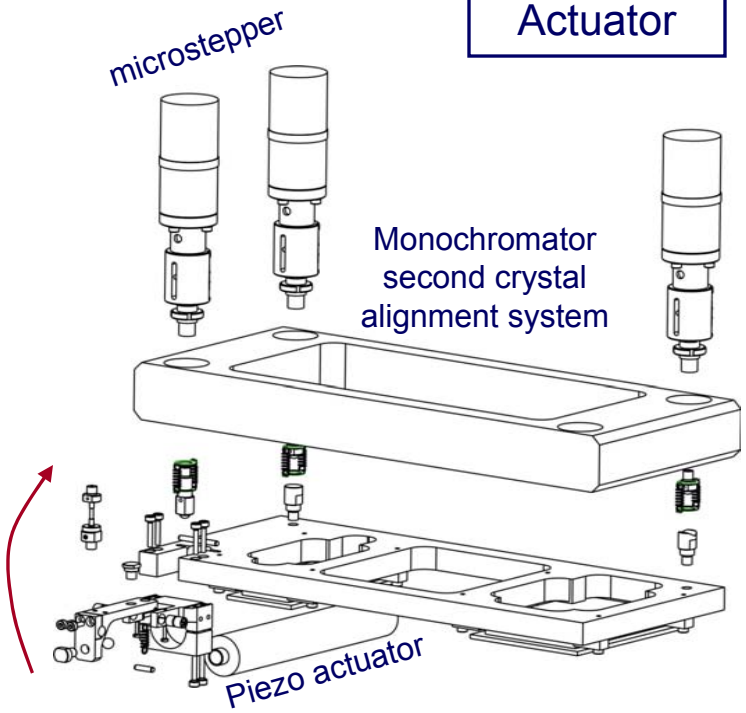
# The actions: Position Feedback

- Background Continuous feedback minimize abs(DIFF)
- Correction Algorithm is not enabled if DIFF < threshold
- Backlash recovery procedure for Stepper Actuator
- Not a fast feedback (period = 2 sec)



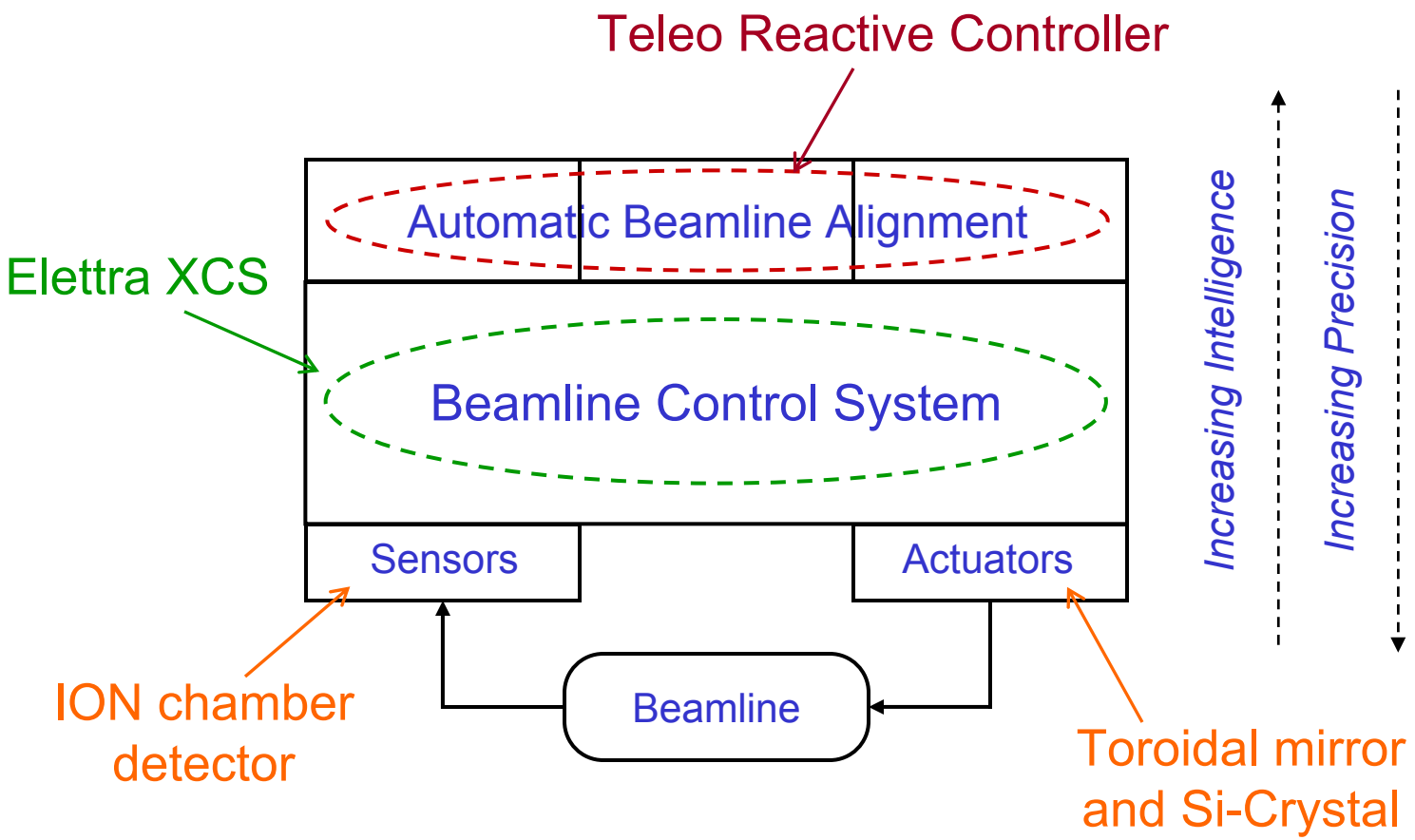
# The actions: Flux Feedback



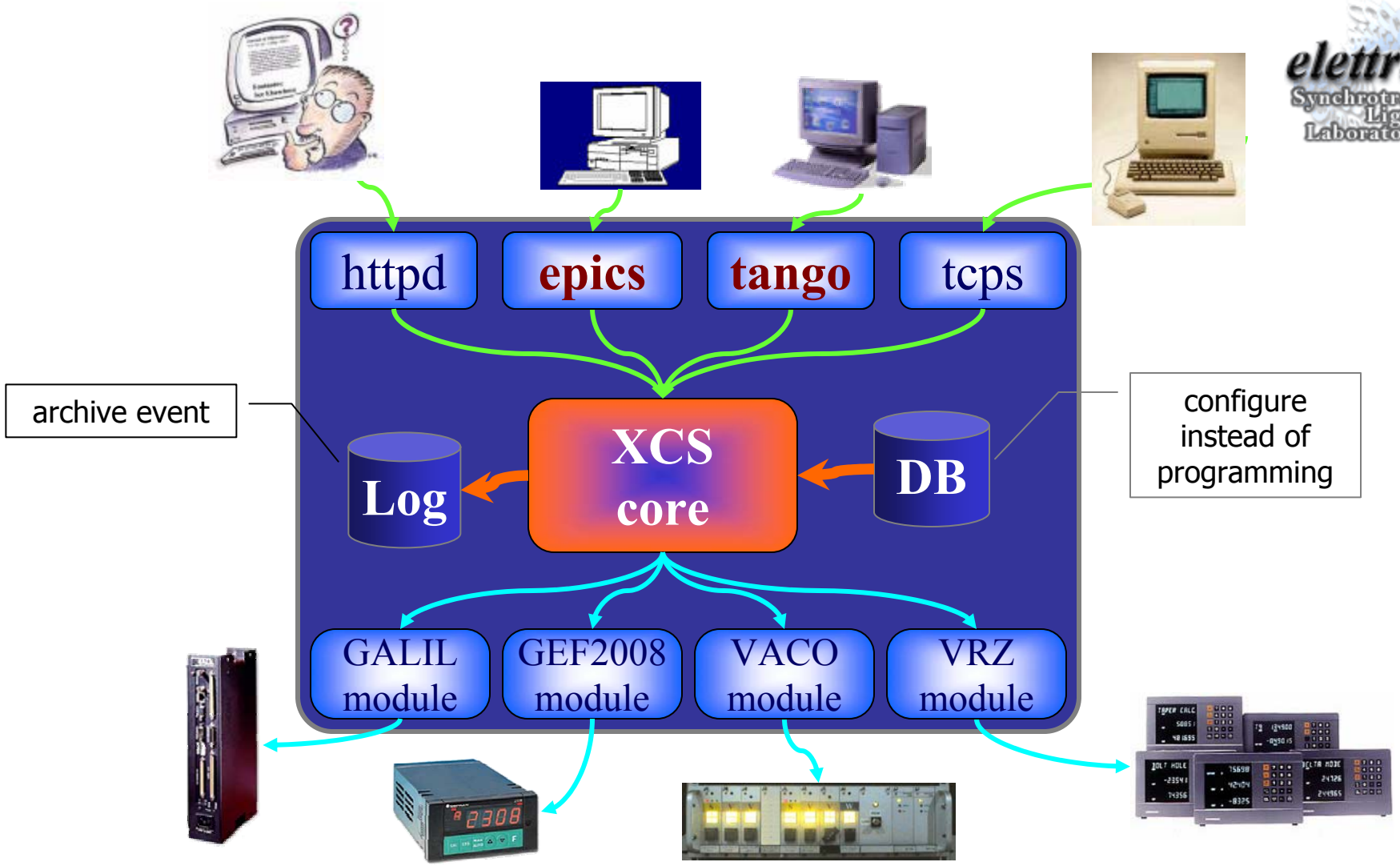




- Background Continuous feedback
- Linear Regression Algorithm calculates sign and gain of the correction signal
- Buffer size for LR: 5 samples
- Piezo Actuator avoids backlash problems
- Not a fast feedback (period = 1 sec)

# Applying the Model Reference architecture to beamline

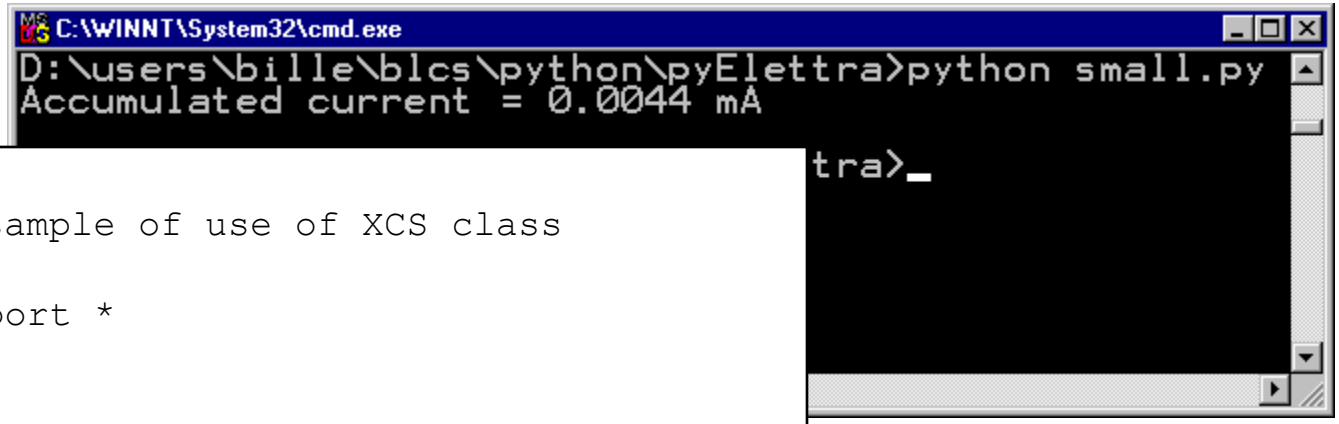


# XCS : Elettra beamline control system



# XCS python libraries

- **pyXCS**: Very easy access to XCS
- **pyFSM**: Finite State Machine library
- **pyTRC**: Teleo Reactive Control library

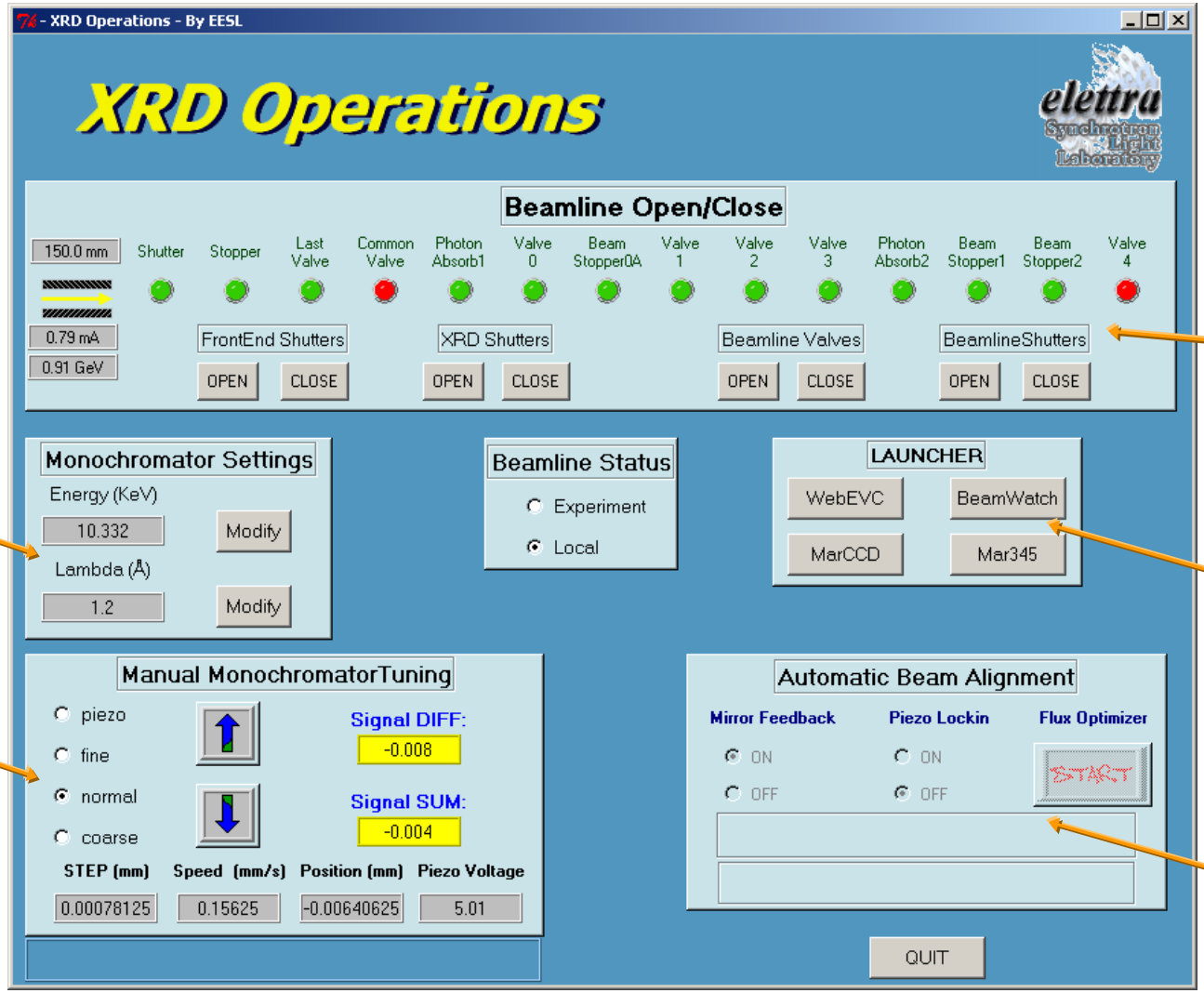



```
# very small sample of use of XCS class

from pyXCS import *

x = XCS()
x.open('bcs102.elettra.trieste.it')
a = x.get('frontend_machine_machine_1_accucurr')
print 'Accumulated current =', a[0], a[1]
x.close()
```

# XRD Control Panel




elettra Synchrotron Light Laboratory

Beamline Valves Control

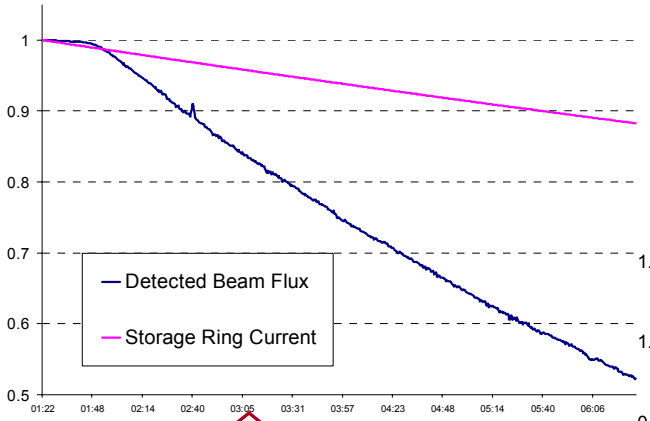
Monochromator Control

Tool Launcher

Manual Flux Optimizer

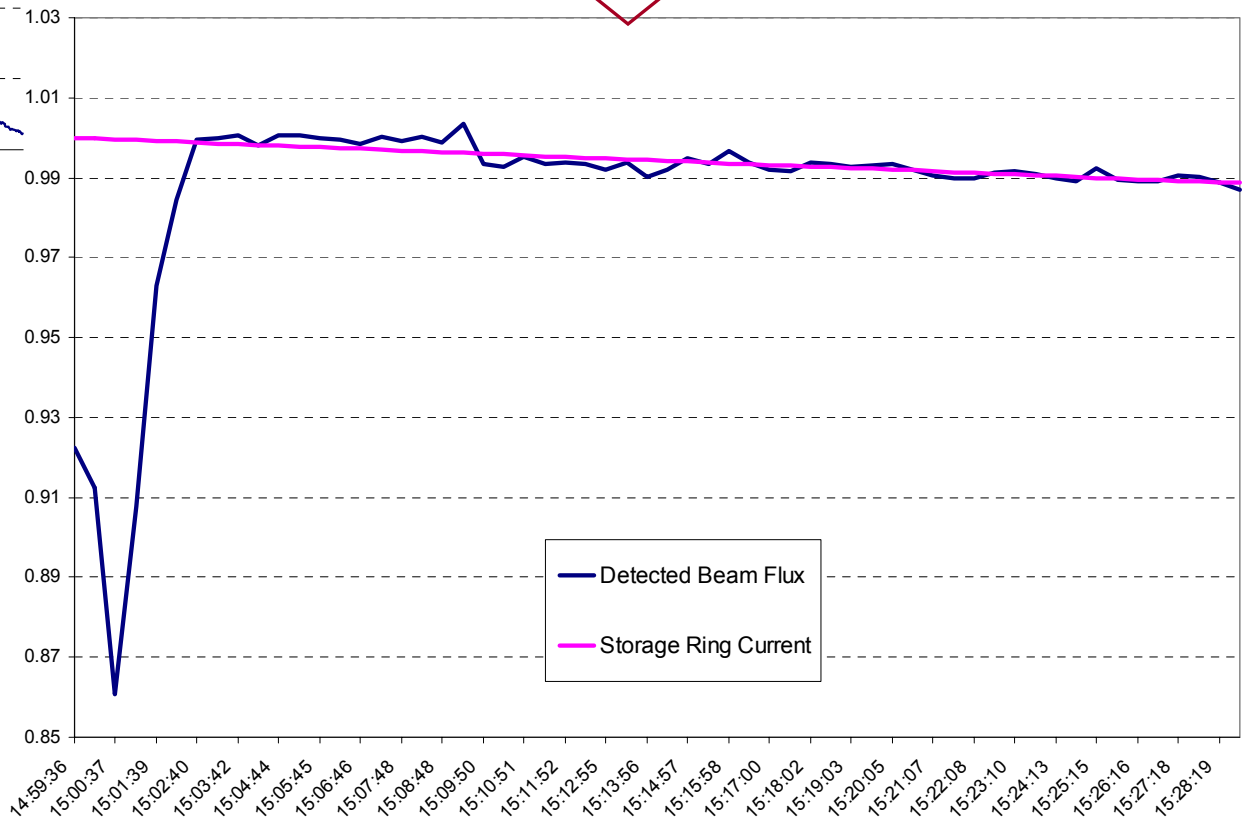
Automatic Beamline Alignment Control

# First Results

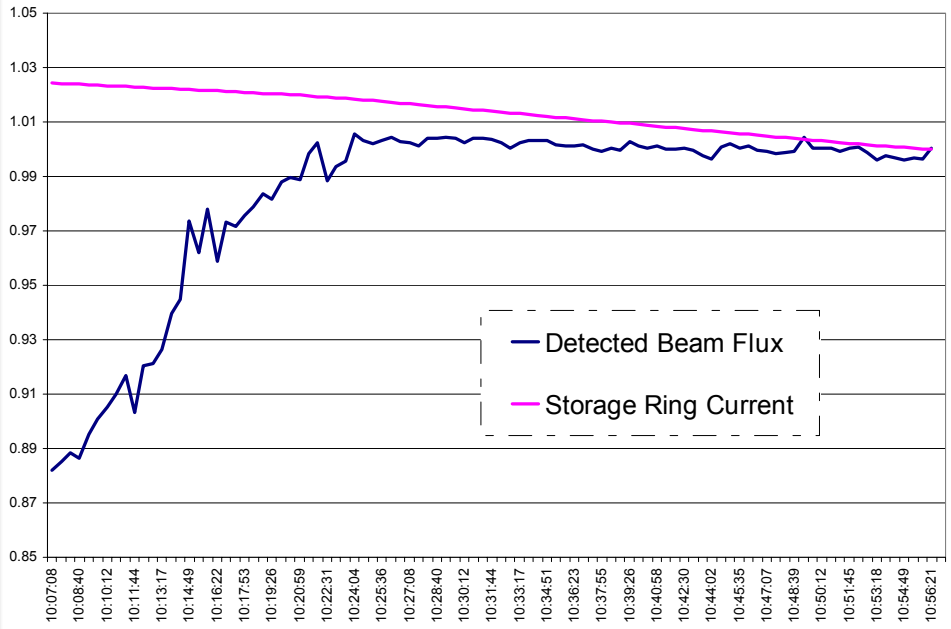



WITHOUT
Automatic Alignment

WITH
Automatic Alignment

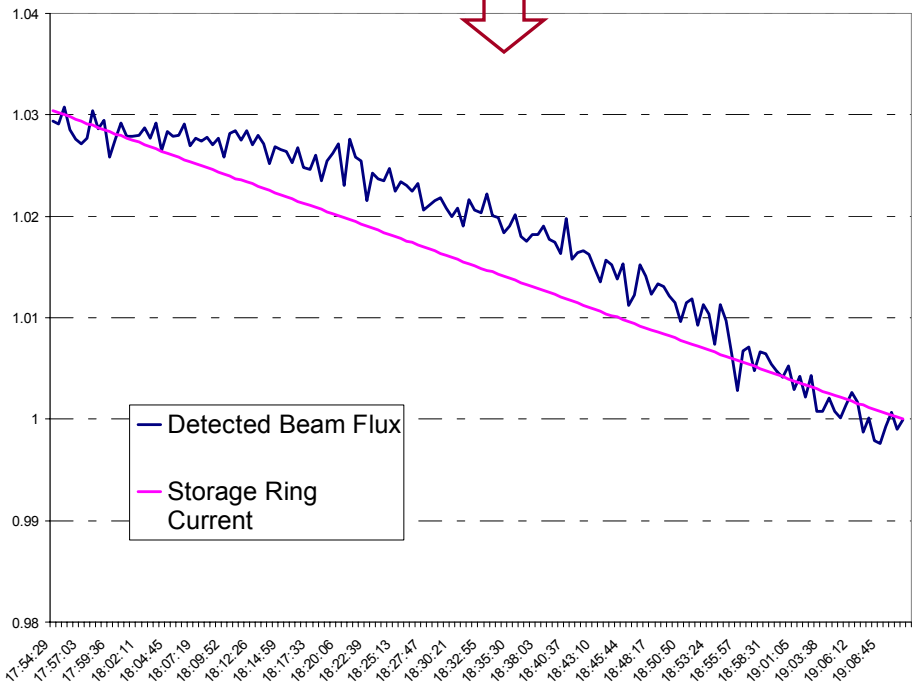


# First Results




Automatic Alignment
"ramping"

Non Linearity due to
mirror deformation



# Future Developments

- Refactoring of the software libraries in order to be BIOXHIT ready
- Integration with BLU-ICE
- Towards the one button beamline and EVC integration
- Integration of MarrResearch Cryogenic Sample Changer ?!?

# Acknowledgements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