Automation of Beamlines and Experimental Stations at the SPring-8

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  - XAFS - BL01B1
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Introduction

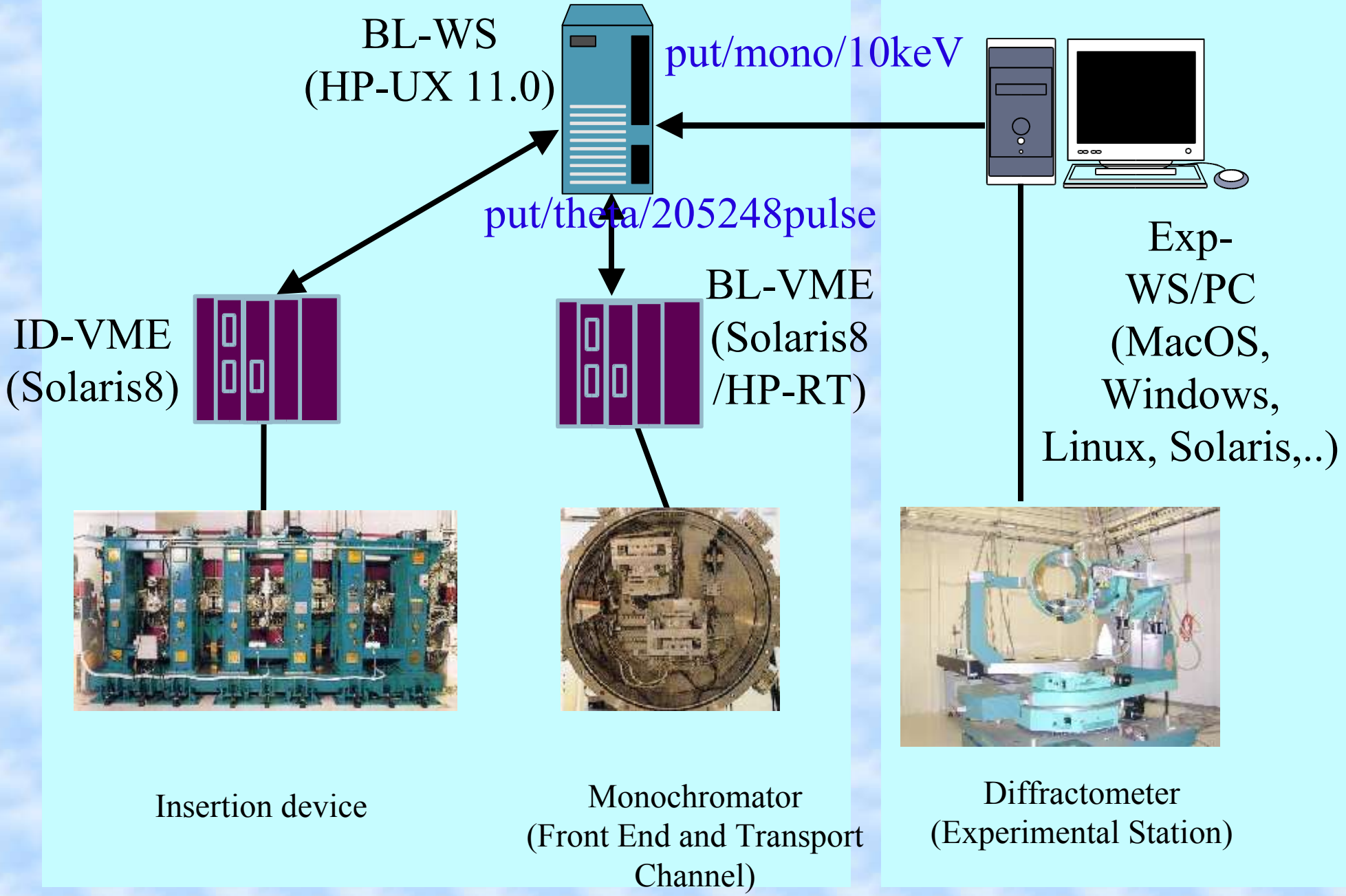
- BL automation system deals with not only beam delivery (optics) but also experimental system.
- Experiment control computer controls
  - experimental appratus/equipments
  - beamline components (including ID)

  to optimize the experimental condition.
- Most x-ray detectors installed in experimental station.

Automation method

- Automatic feedforward using equations or tables
  - Relationship among light source and/or optical devices is well known
  - ex. X-ray energy of monochromator and ID gap
- Automatic tuning
  - Tuning required after motion of devices
  - ex. finding a rocking curve peak of the DXM
- Feedback
  - Supressing vibration or drift.
  - ex. MOSTAB (monochromator stabilization)

Typical Scheme of BL/Station-Control System

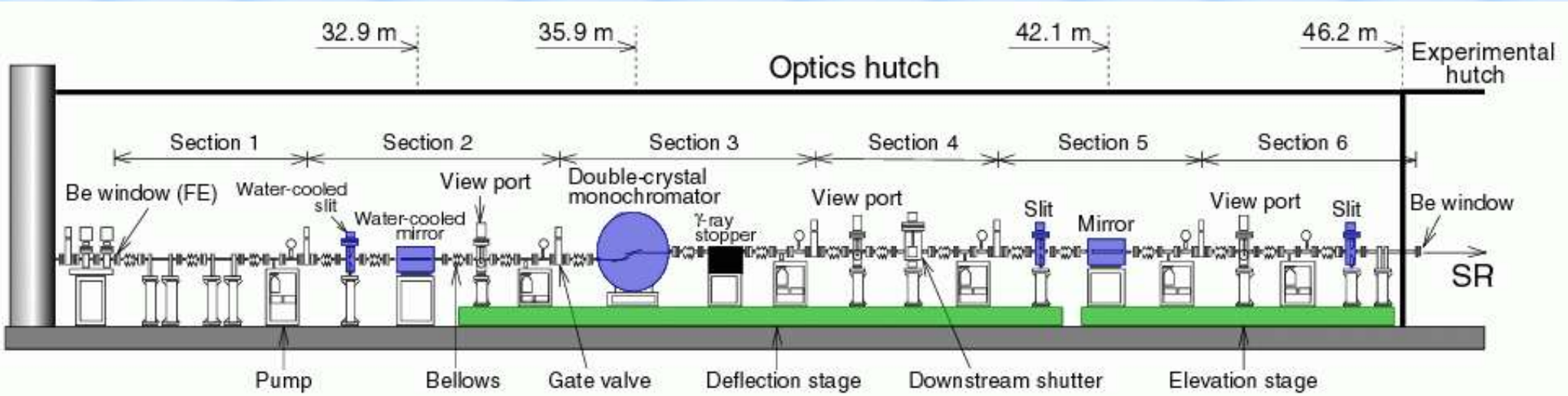


Examples

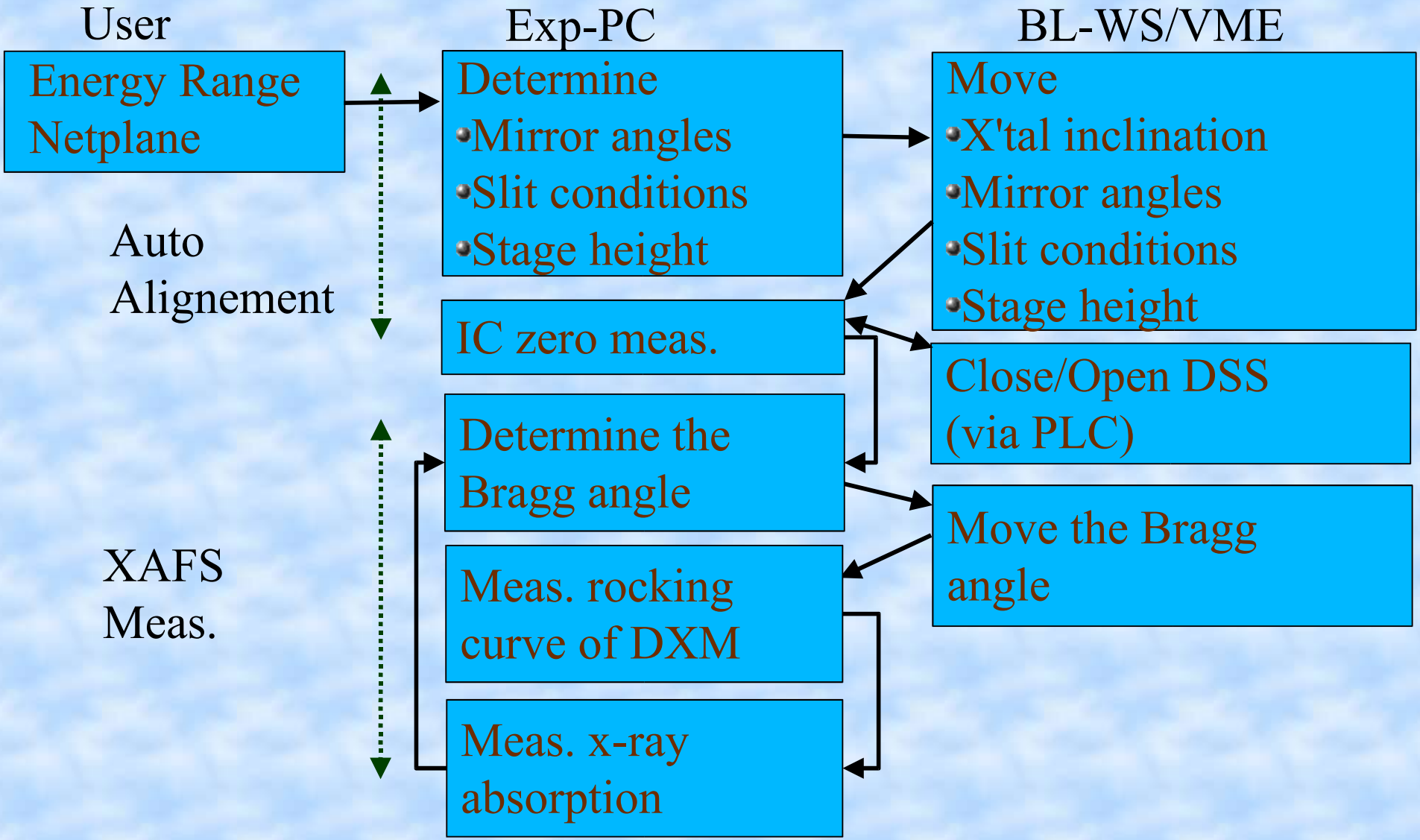
- XAFS (BL01B1)
  - Tables
- HX-MCD (BL39XU)
  - Equation and Tables
- Protein Crystallography(BL26B1/B2, BL32B2, BL38B1)
  - VME crates for the station control

XAFS-BL (BL01B1)

- Using tables, set mirror angles, slit apertures, monochromator angles and stage height for the selected x-ray energy range. (Element and edge selection)
- Using an ionization chamber in the experimental hutch, finding a peak position of the DXM rocking curve for each energy steps.

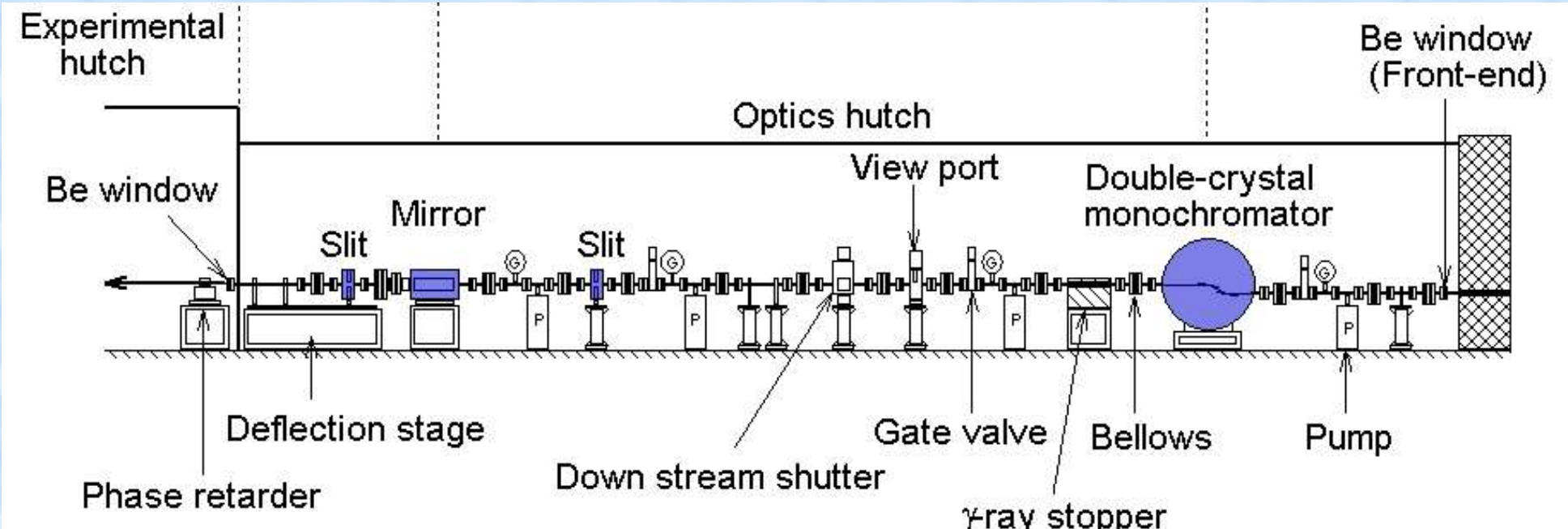


Flow of Changing Optical Parameters and XAFS Meas.



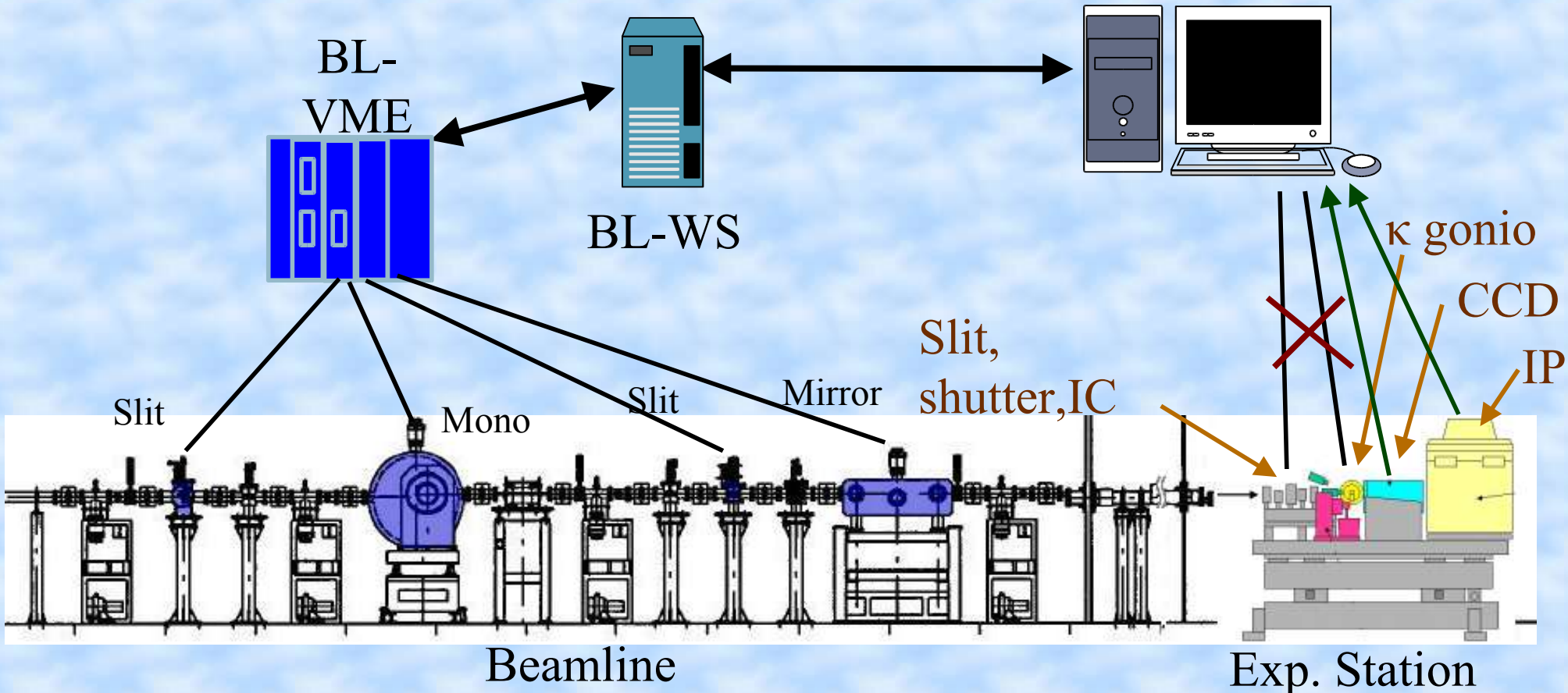
HX-MCD (BL39XU)

- Using an equation between x-ray energy (E in keV) and ID gap (G in mm),
  - G = a ln(b/E-1)+c
  - wher a,b and c are determinted by ID spectrum measurements.
  - Error in G is within ±10μm (6-16keV)
- Mirror and Slit conditions are determined using tables for the given x-ray energy region.



Protein Crystallography (BL26B1/B2, BL32B2, BL38B1,...)

Station VME is under control of the BL-WS.
Some tuning routines are installed in the BL-WS.



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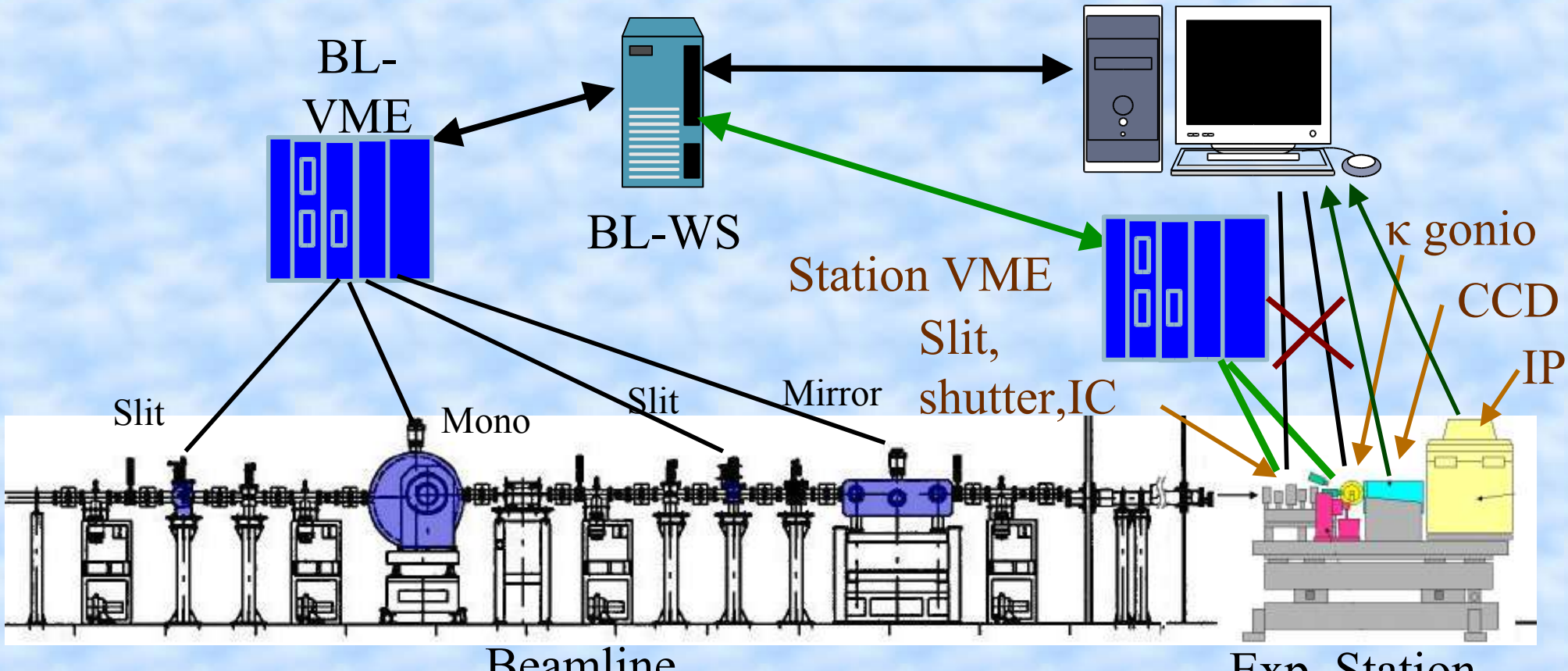
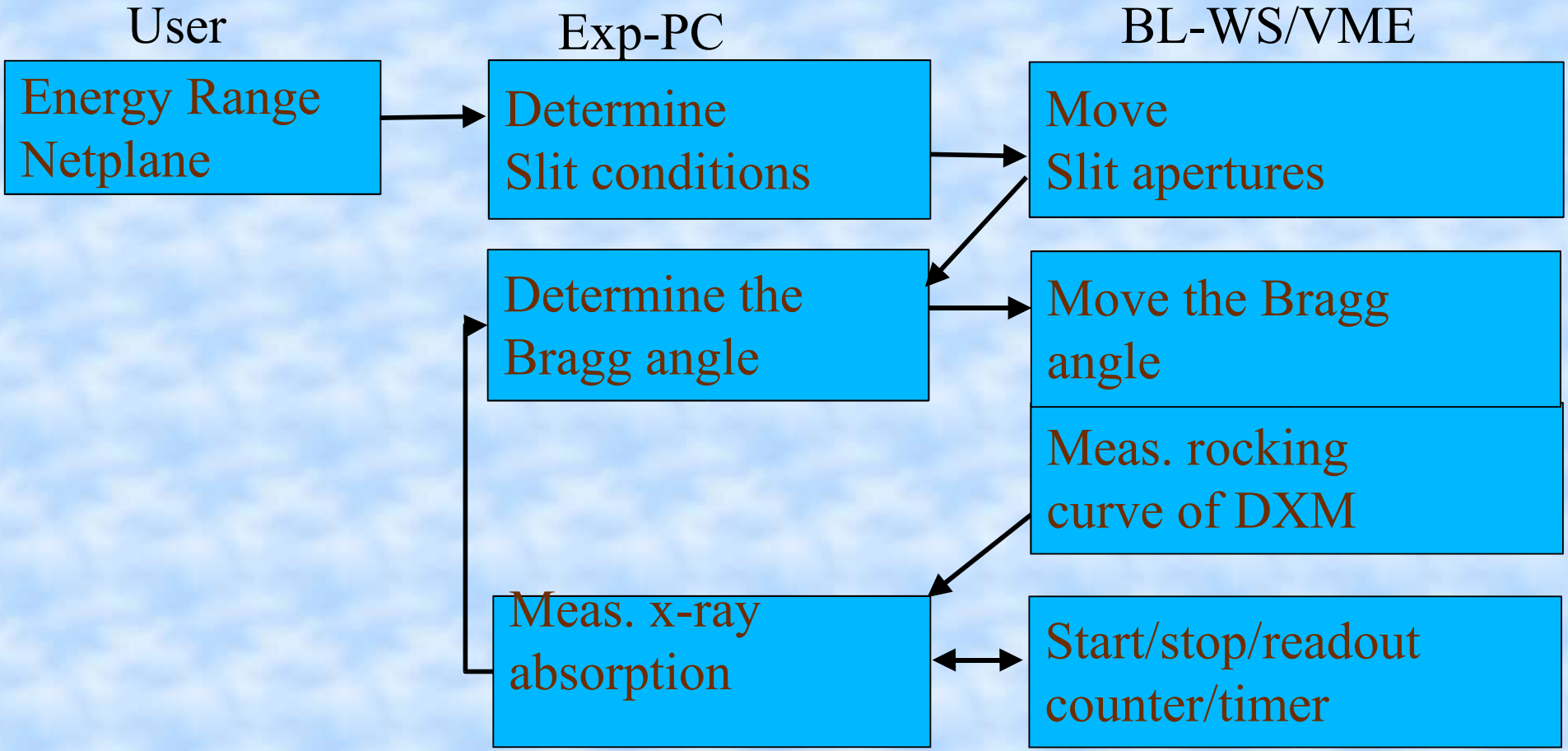


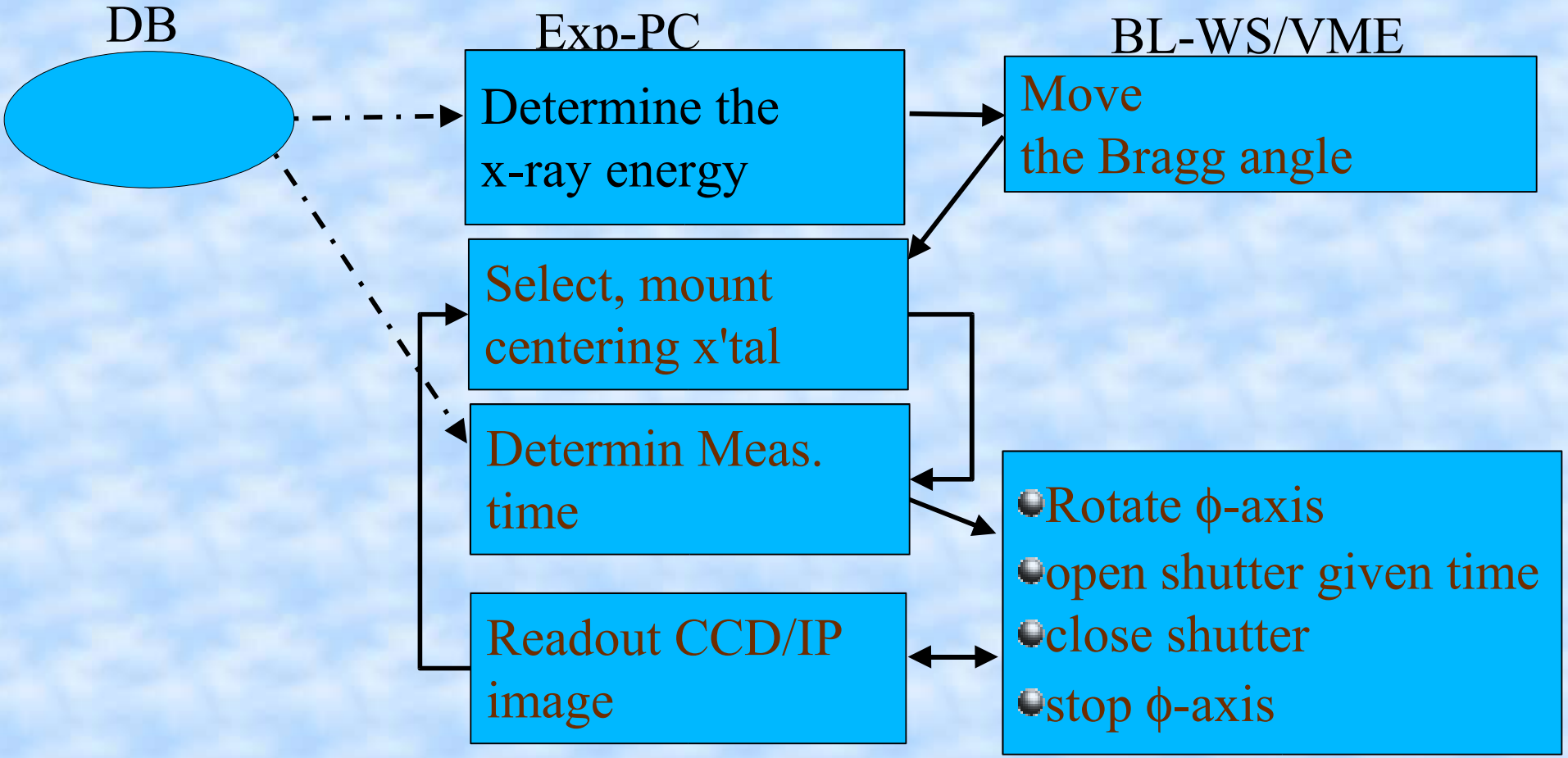
Merit of the scheme

- Station control computor uses same board/system: easy to maintain.
- Programing on the user PC/WS is simplifined: only message exchanging.
- Beamline components and station components are tightly binded: fast combined control to tune the beamline and to measure x-ray diffraction.
- Easy code sharing with other beamlines.

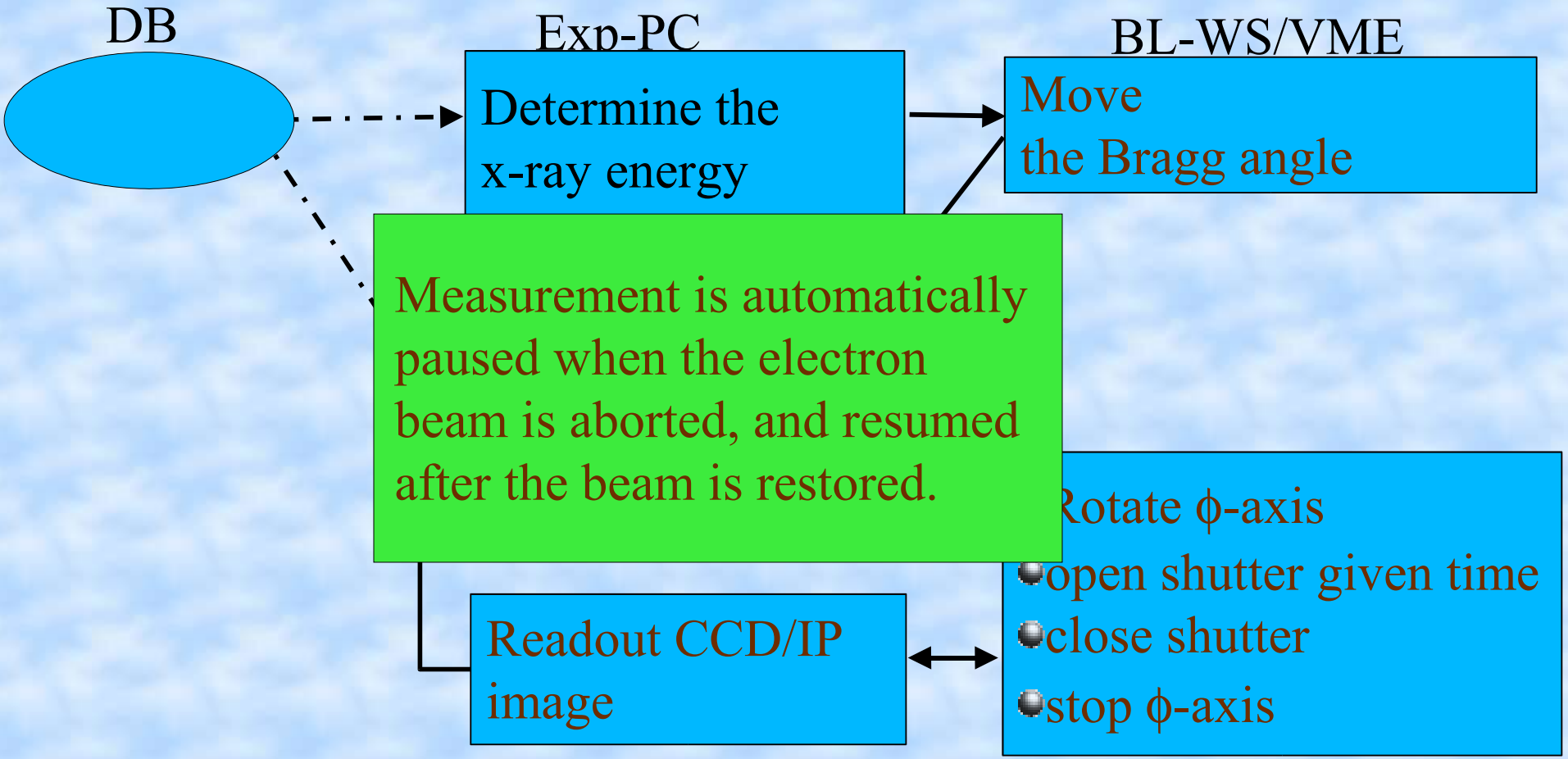
Flow of Changing Optical Parameters and XAFS Meas.(2)



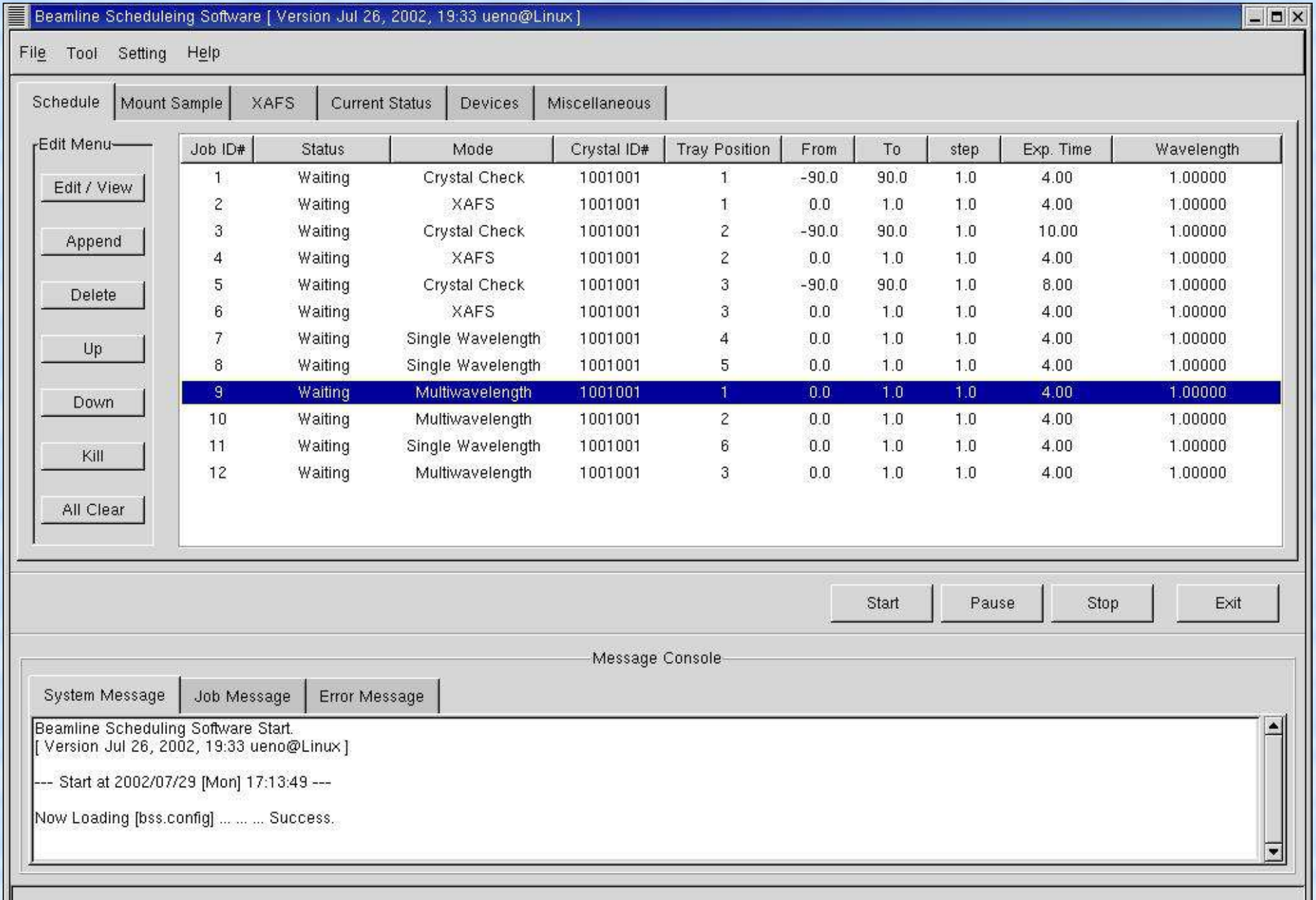
Flow of automatic diffraction profile meas.



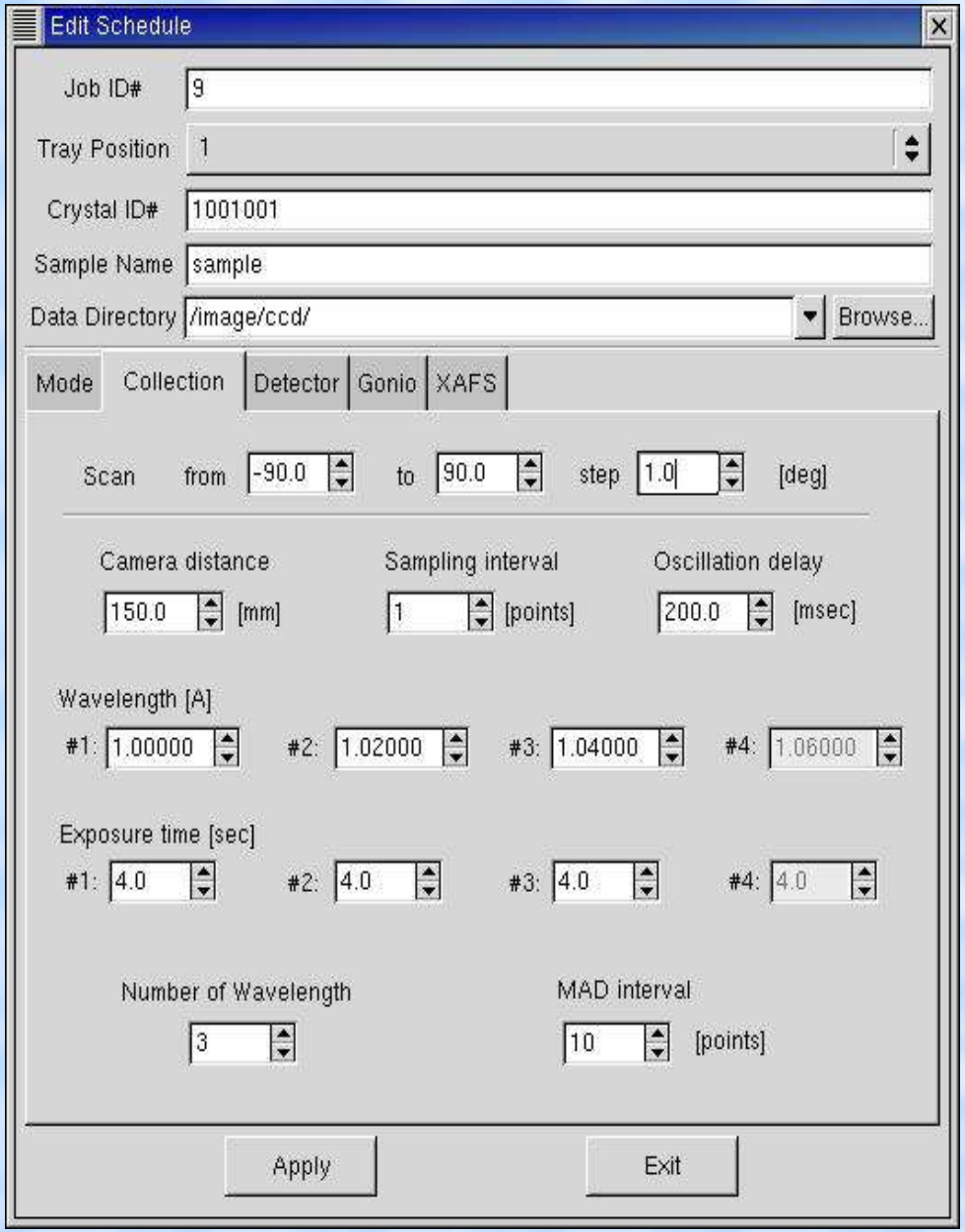
Flow of automatic diffraction profile meas.



BSS GUI

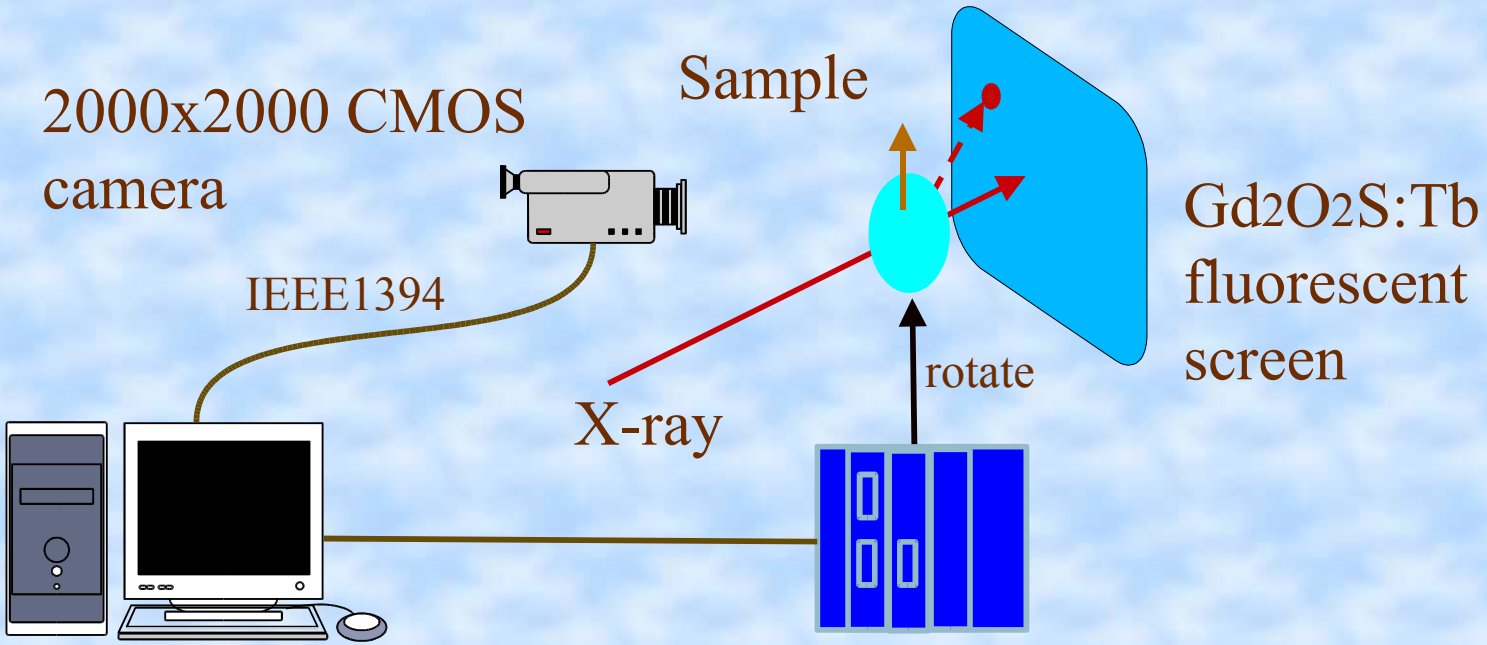

Beamline Scheduleing Software [Version Jul 26, 2002, 19:33 ueno@Linux]
File Tool Setting Help
Schedule Mount Sample XAFS Current Status Devices Miscellaneous
Edit Menu
Edit / View
Append
Delete
Up
Down
Kill
All Clear
Job ID# Status Mode Crystal ID# Tray Position From To step Exp. Time Wavelength
1 Waiting Crystal Check 1001001 1 -90.0 90.0 1.0 4.00 1.00000
2 Waiting XAFS 1001001 1 0.0 1.0 1.0 4.00 1.00000
3 Waiting Crystal Check 1001001 2 -90.0 90.0 1.0 10.00 1.00000
4 Waiting XAFS 1001001 2 0.0 1.0 1.0 4.00 1.00000
5 Waiting Crystal Check 1001001 3 -90.0 90.0 1.0 8.00 1.00000
6 Waiting XAFS 1001001 3 0.0 1.0 1.0 4.00 1.00000
7 Waiting Single Wavelength 1001001 4 0.0 1.0 1.0 4.00 1.00000
8 Waiting Single Wavelength 1001001 5 0.0 1.0 1.0 4.00 1.00000
9 Waiting Multiwavelength 1001001 1 0.0 1.0 1.0 4.00 1.00000
10 Waiting Multiwavelength 1001001 2 0.0 1.0 1.0 4.00 1.00000
11 Waiting Single Wavelength 1001001 6 0.0 1.0 1.0 4.00 1.00000
12 Waiting Multiwavelength 1001001 3 0.0 1.0 1.0 4.00 1.00000
Start Pause Stop Exit
Message Console
System Message Job Message Error Message
Beamline Scheduling Software Start.
[Version Jul 26, 2002, 19:33 ueno@Linux]
--- Start at 2002/07/29 [Mon] 17:13:49 ---
Now Loading [bss.config] ... ... Success.

BSS GUI(2)


Edit Schedule
Job ID# 9
Tray Position 1
Crystal ID# 1001001
Sample Name sample
Data Directory /image/ccd/
Browse...
Mode
Collection
Detector
Gonio
XAFS
Scan from -90.0 to 90.0 step 1.0 [deg]
Camera distance
150.0 [mm]
Sampling interval
1 [points]
Oscillation delay
200.0 [msec]
Wavelength [A]
#1: 1.00000 #2: 1.02000 #3: 1.04000 #4: 1.06000
Exposure time [sec]
#1: 4.0 #2: 4.0 #3: 4.0 #4: 4.0
Number of Wavelength
3
MAD interval
10 [points]
Apply
Exit

Crystal orientation determination

- Using a fluorescent screen and CCD/CMOS video camera.
- Rotationg φ-axis of 4-circle diffractometer and finding diffraction spots automatically.

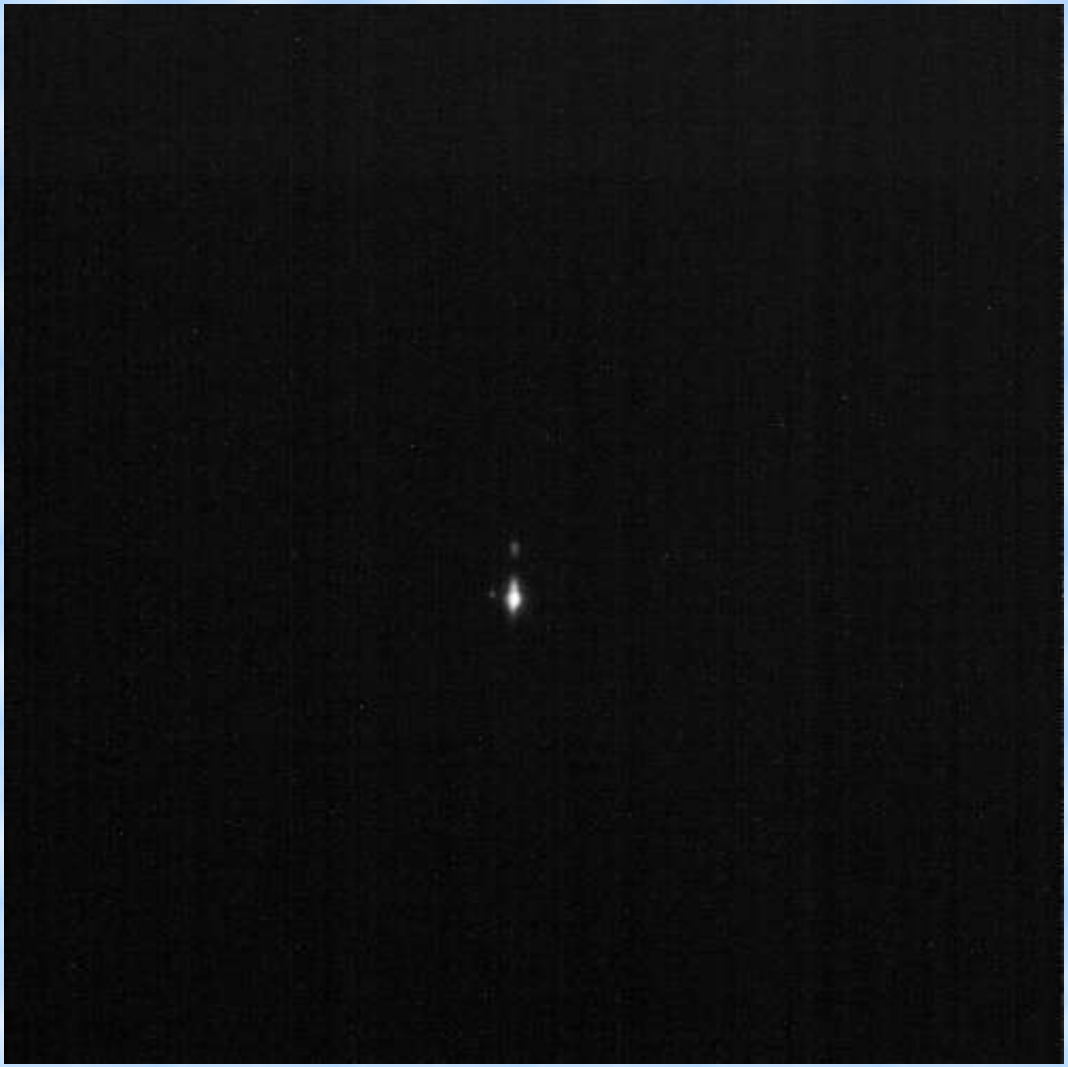


Crystal orientation determination (2)

- 800x600 pixels data with ~6 frames/sec.
- Rotate φ-axis about 0.1degrees/sec continuousely.
- After finding spot, step scan φ-axis and find peak φ angle.
- Calculate 2θ and inclination angle from spot position.
- From two independent diffraction, crystal orientation is determined.

Crystal orientation determination (3)

Before start φ rotation, background image is obtained.



Diamond (111)

Crystal orientation determination (3)

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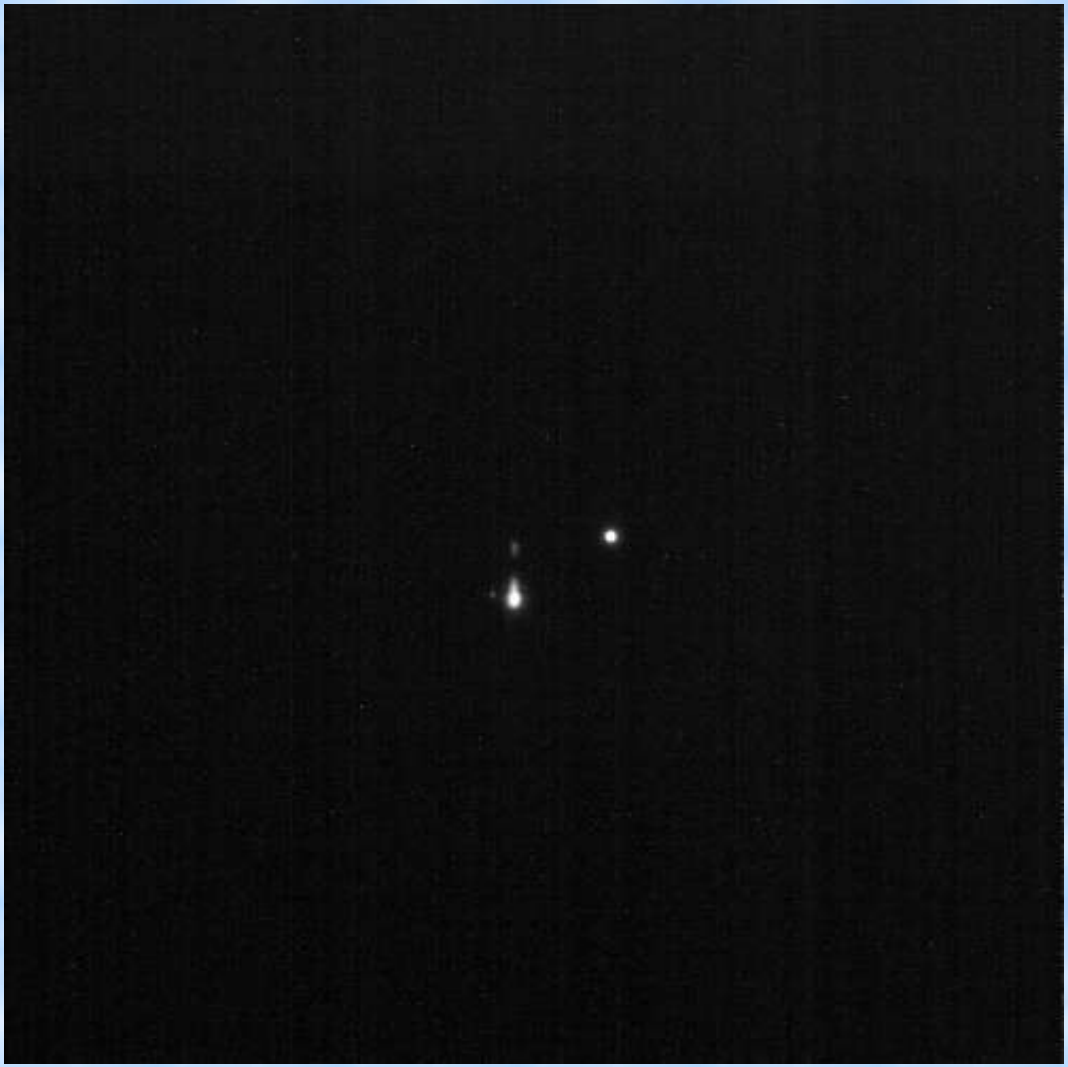


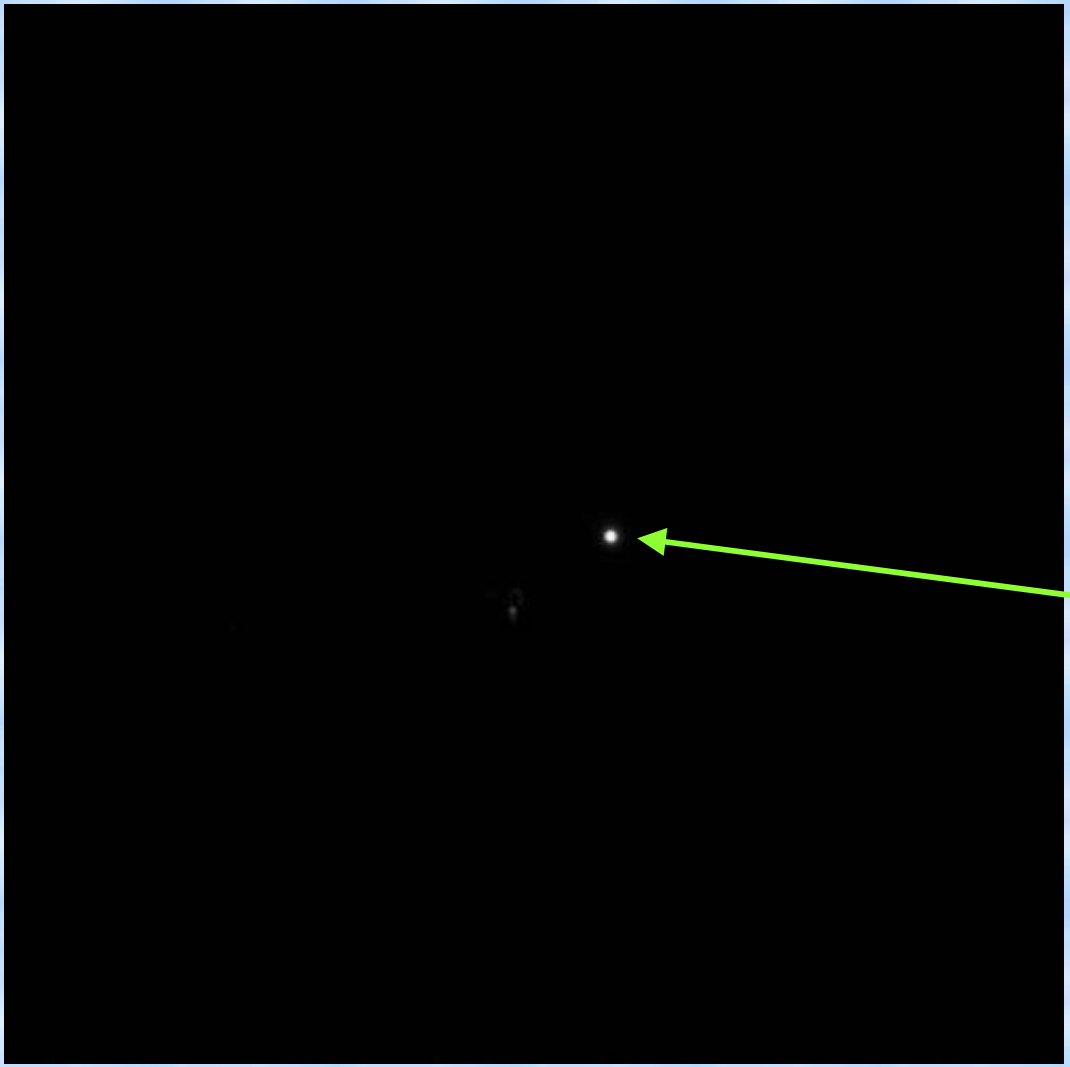
By each frame obtained,...

Diamond (111)

Crystal orientation determination (3)

Before start φ rotation, background image is obtained.

By each frame obtained,...



a subtracted image is calculated and check bright area.

If there is bright are, 2θ and inclination angles are calculated.

Diamond (111)

Crystal orientation determination (4) (Plan)

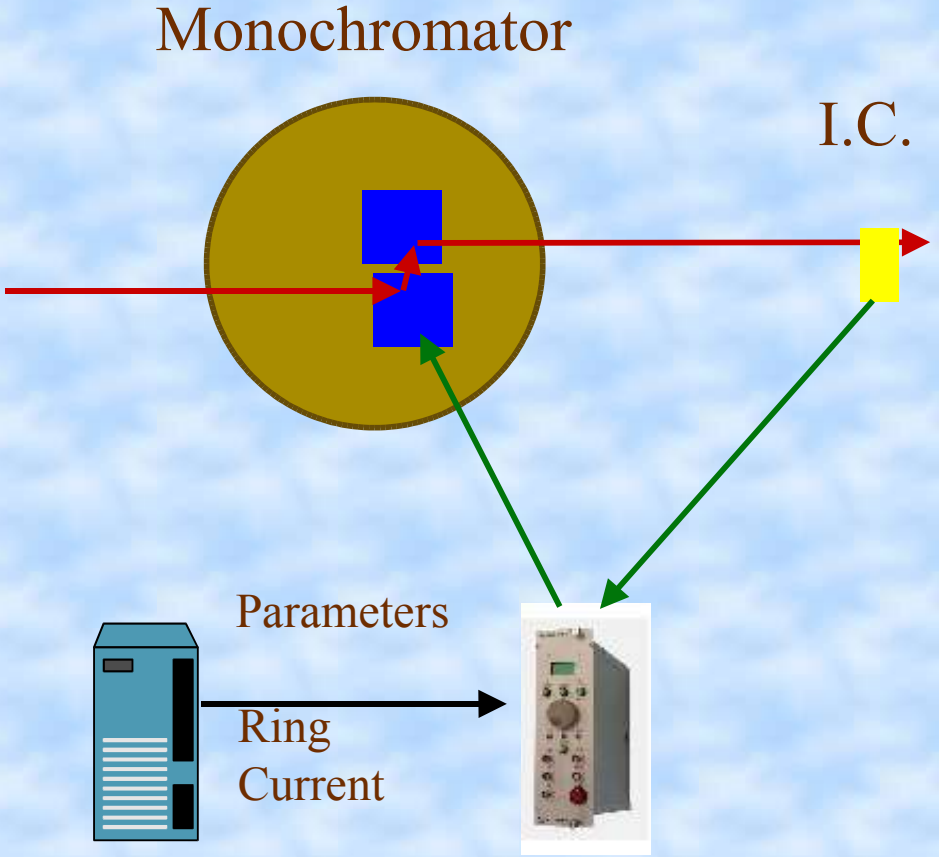
This method can be applied to beamline tuning.

- Bent crystal, bent mirror parameters for fucusing.
- Crystal alignment for rotated inclined monochromator (installed in ID-BLs).

MOSTAB (monochromator stablization)

- X-ray beam stabilization.
- Intensity or beam position at exp. station is feedback to first crystal angle of the DXM.
- This module can be controlled via network. Parameters and ring current are set from host (BL-WS) computor.

MOSTAB(2)



Three control modes

- Intensity constant mode
- Intensity/(Ring current) constant mode
- Beam position constant mode

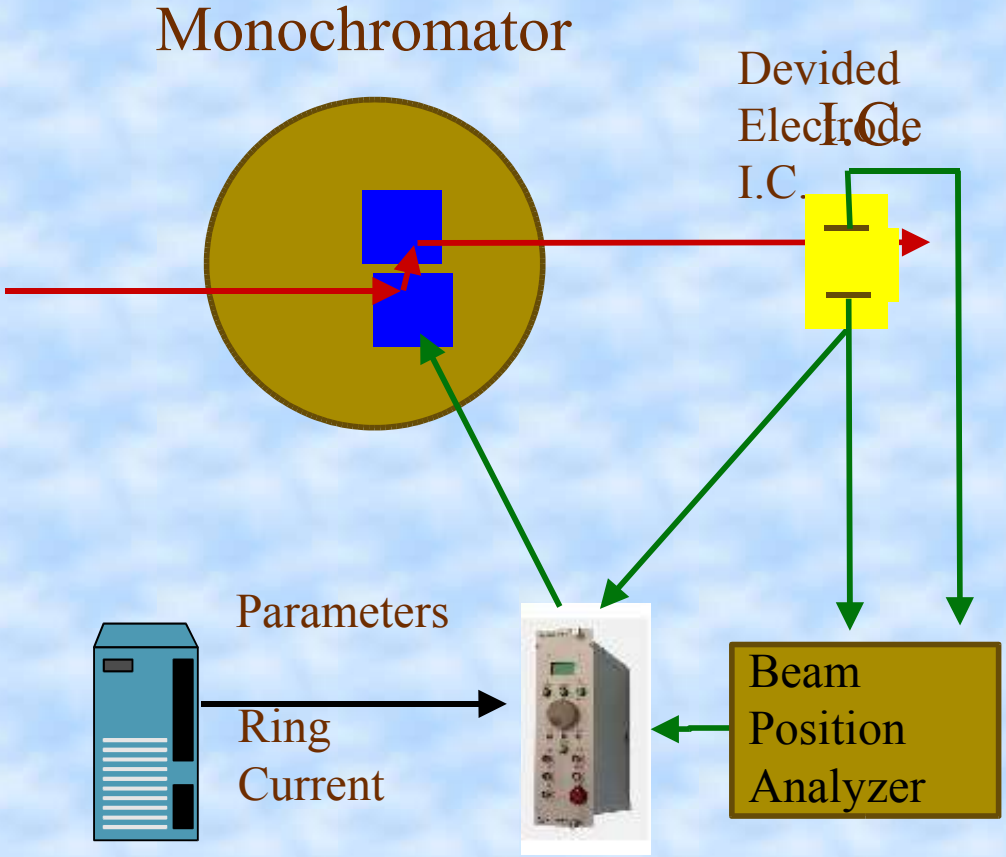
Control software installed in the BL-WS

Automatically measures rocking curve gradient at control point and calculates feedback parameters.

Automatically pauses feedback control when the DSS is closed and resumes feedback control after the DSS is opened.

Automatically stops feedback control when the stored beam is lost.

MOSTAB(2)



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Summary

- Some examples of automation including experimental station were introduced.

- We use proper automation method from
  - Feedforward with tables or equations
  - Tuning only after motion of optical devices
  - Feedback.