

TINE@EMBL

Uwe Ristau

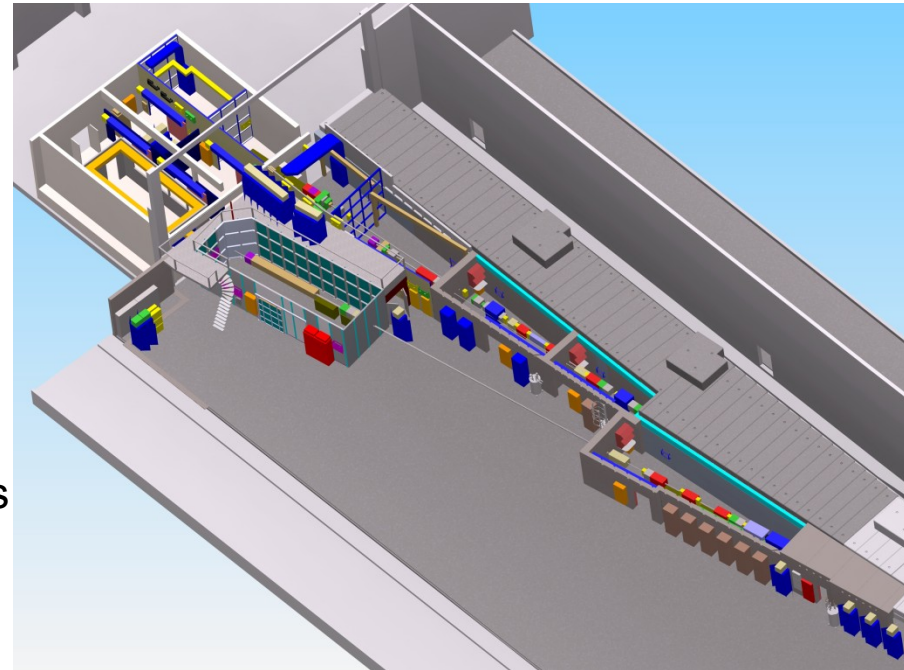
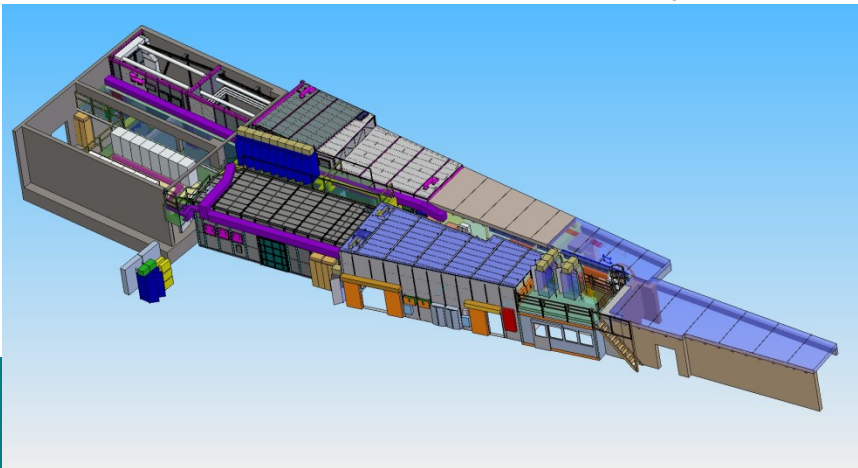


Overview

- Development Tools
- Control Electronic
- Motor/Scan Server
- MotorPlug TwinCat NC
- Example
- Outlook

EMBL @ DESY

- Petra 14 Beamlines
 - EMBL :3 Beamlines @ Petra
 - 7 Beamlines @ Doris
- 3 Beamlines @Petra
 - 2 Protein Cristallographic beamines
 - MX1,MX2 Hasylab:P13/P14
 - 1 Small Angle Scattering Beamine
 - BioSaxs Hasylab: P12



- P12 and P14 in friendly user operation since summer 2011
- P13 first experiment today hopefully

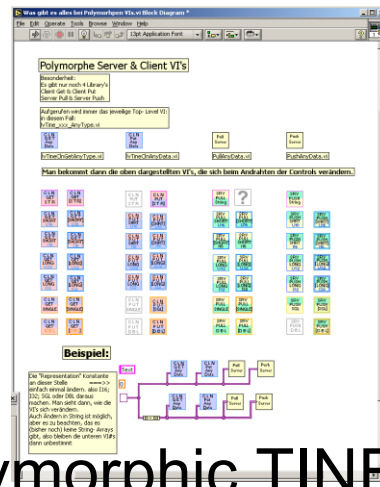
Software

- Hasylab Frontend
 - Vacuum
 - Slits
 - Petra Parameter
 - Undulator
 - Fluorescence screen
- Optical Hutch
 - Diagnostic/Viewer
 - Monochromator
 - Mirrors
 - Slits
 - QBPM's
 - Vacuum
 - IPS
- Experimental Hutch
 - Exp. Table
 - BCU
 - SampleChanger
 - Detector Table
 - Detector
 - ..
- External Devices
 - Detector Tube GKSS
 - MD3
 - MD2
 - BioSaxsSC
 - ..

Instrumentation Software Framework/Tools:

- Labview framework
- TINE DESY/MCS
- TwinCat ADS Lib
- RIO/EtherCat master
- Vision
- Vibration
- Motion
- Mathlab
- PID TOOL
- TCP/IP (Robot)
- ...

- TINE Common Device Interface
CDI
- TwinCat (TwinCat, DIO, DAQ)
 - Beckhoff/TWINCAT
 - TINE Motor Server
 - TwinCat NC
 - PI- E815
 - Attocube
 - PMAC (in progress)
 - Robot (in progress)



Polymorphic TINE API

Instrumentation Software Framework/Tools:

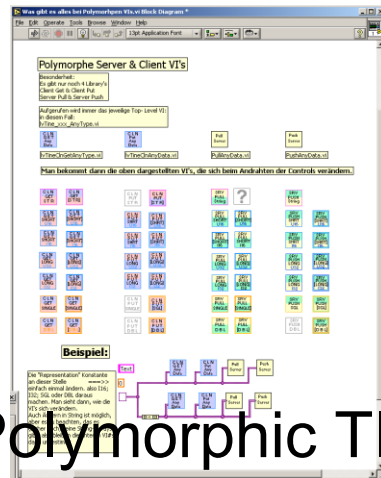
- Labview framework
- TINE Common Device Interface

- Tine I
- TwinC National Instruments

EMBL 13.12.2011 Seminar room 1st floor Building 48e
(Petra Building EMBL Part) 13 Uhr

- Vibrat
- Motio

- Scripting
- Mathlab
- PID TOOL
- TCP/IP (Robot)
- ...



Polymorphic TINE API

- Attocube
- PMAC (in progress)
- Robot (in progress)

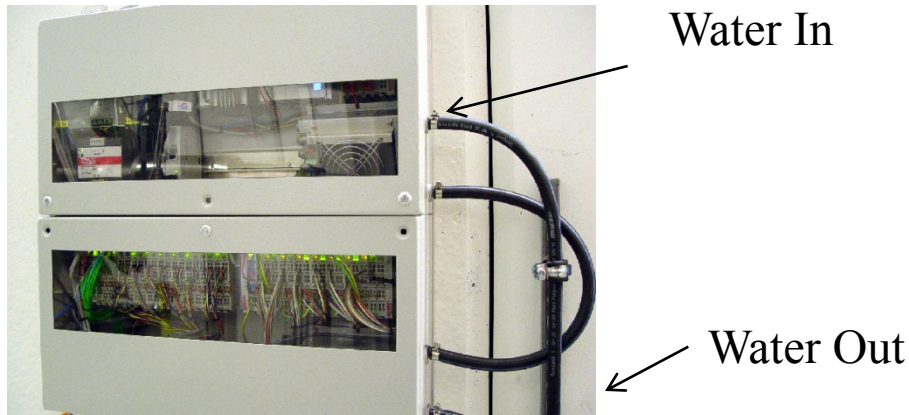
Control Electronic

- GOAL
 - Distributed electronic
 - All Signals, Monitors, Motors synchronized to each other
 - Achieve as good as possible synchronization / timing

Best synchronization is available at the realtime hardware level of the Beckhoff PLC system

- PLC Electronic
 - Connect all devices to the deterministic realtime System TwinCat
 - Scan synchronization and timing
 - Signal synchronization <1ms
 - Acquisition cycle <1ms
 - Timing <10 us

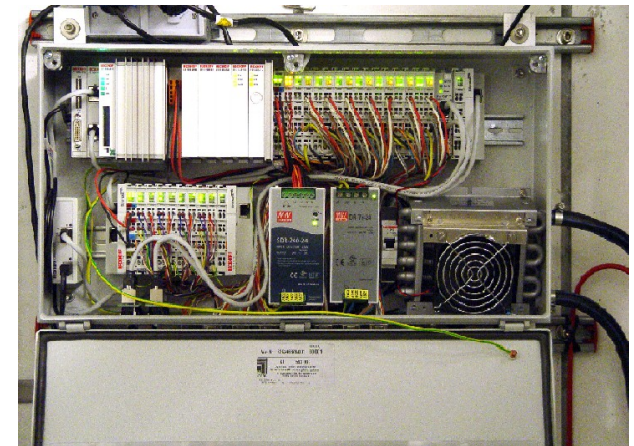
Control Electronic Monochromator DCM



Software installation:
TwinCat, TINE, Labview
PtalkPro, watchdog for Server
restart/maintenance

Controller/Computer Hardware:

- Computer Pentium 2 GHz Processor
- 8GB RAM/ROM
- 2x USB
- 4xEthernet
- UPS
- EtherCat hardware
- Temperature Regulated Fan

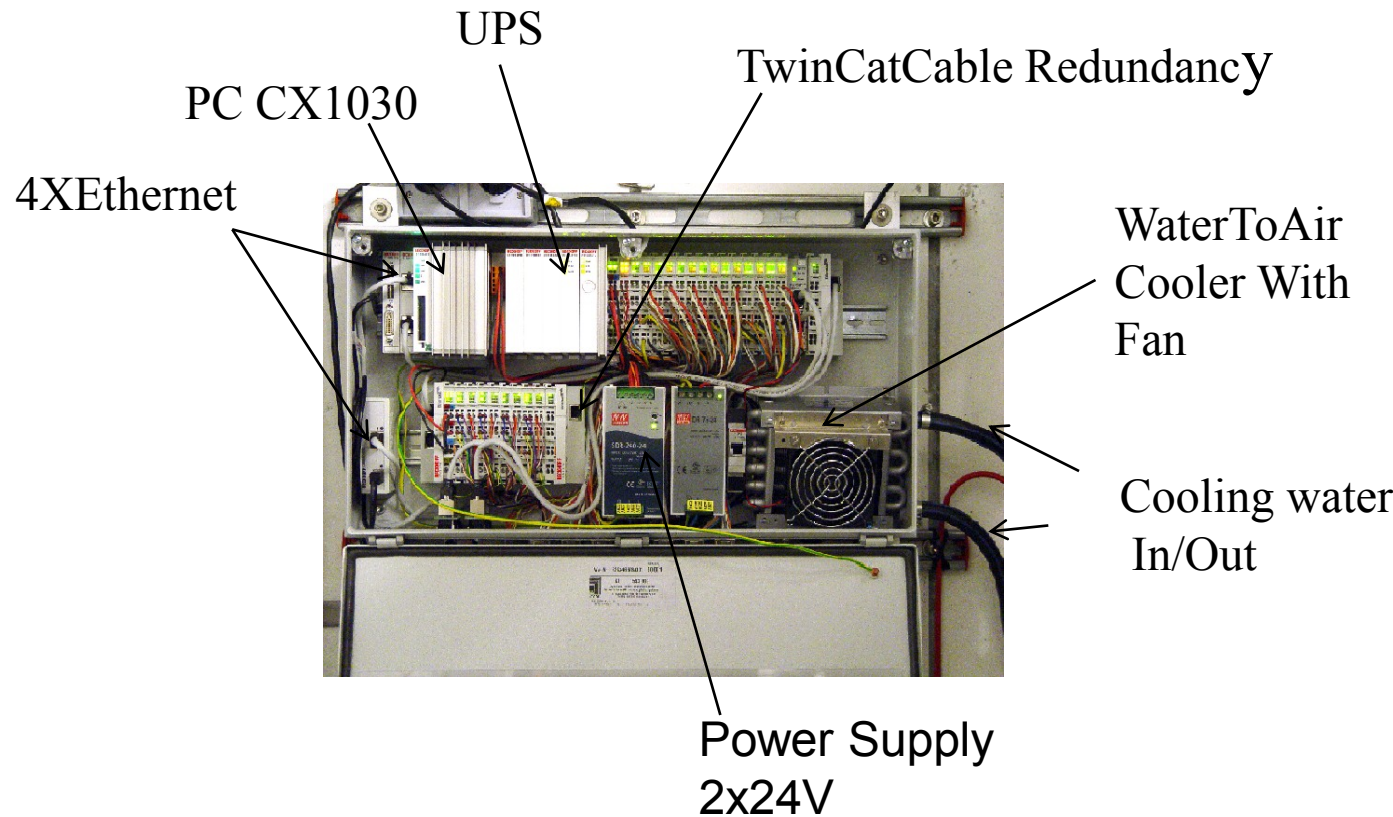


- 16 of 24 Units installed and running

Local EtherCat Master installation

Electronic:

- EL7041 Stepper motor controller
- Counter/Encoder
- AI/AO
- Di/Do
- Rs232
- Temperatur
- Communication Profibus Coupler

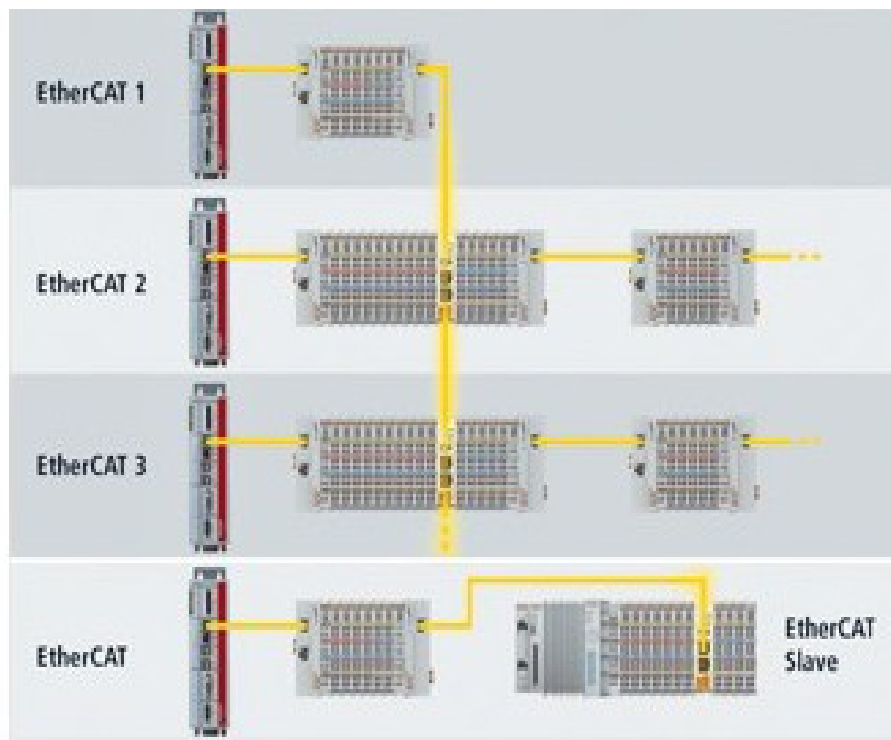


Applications:

Slit Control, HDM, VFM, Bimorph mirrors, BCU, Sample Changer, Experimental Table, Monochromator double size

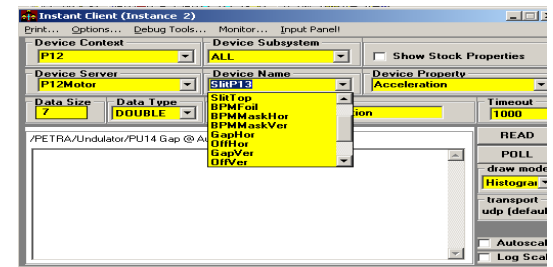
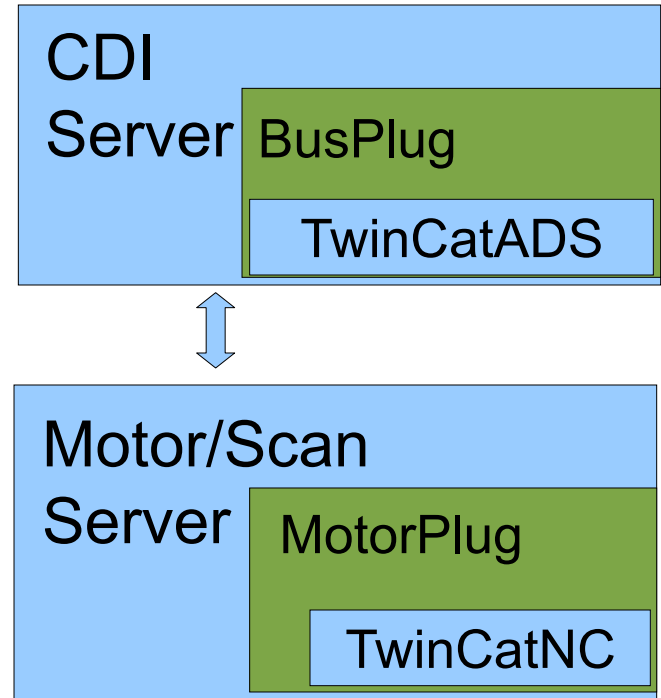
Master to Master synchronization and communication

Solution: Software synchronization via realtime network variables and hardware Synchronization via EL6692

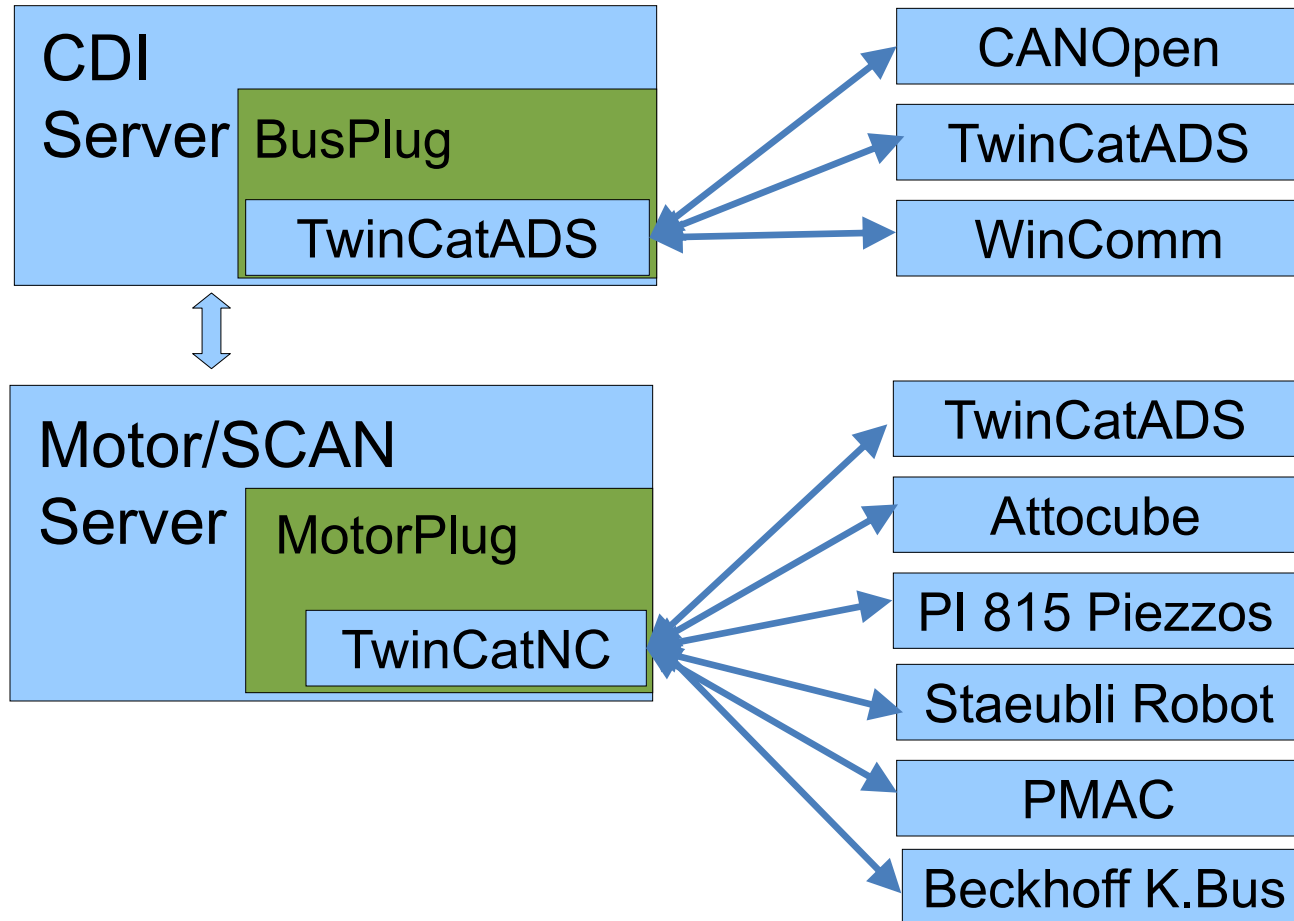


Motor/Scan Server Architecture

- Build on Top of the low level CDI TINE server
 - Bus plugs:
 - TwinCatADS
 - RS232
 - ...
- Generic server with Support of 'Motor Plugs'
 - Motor plugs:
 - TwinCat NC
 - TwinCat k-Bus
 - PI – 815 serial
 - Attocube TCP/IP
 - PMAC TCP/IP OCX (in progress)
 - Robot (in progress)

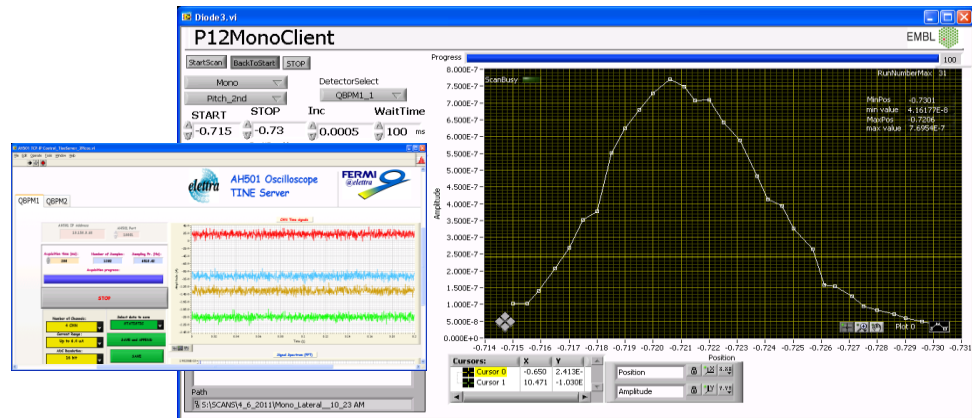


Motor/Scan Server Architecture



Motor/Scan Server Features

- Scans
 - Single axis step scan versus a monitor signal which needs to be available as TINE call. Synchronized by the motor/scan server
 - Multiple axis step scan against single or multiple monitor signals. Synchronized by the motor/scan server
 - Step scans or on the fly scans synchronized by the PLC of TwinCat.
 - Saving/loading of the scan files via motor server property



Motor Server

- Motor :
 - Velocity: Min- Max- default
 - Acceleration: Min – Max –default
 - MicroSteps – Steps/Millimeter –Steps/Radian
 - Reset
 - Status
- Axis:
 - Steps/mm Steps/Radian
 - Online
 - Calibrate
 - Position ->/ Offset /Scale
 - StatusInfo
 - TargetPosition



Piezzo Motor
Attocube ANT200
Translation table
Travel: 0-5mm
Resolution: 10nm

Motor/Scan Server Movements

- Absolut Move:
`Move.Start/Move.Stop/Move.Status/Move.Resume/Move.Progress/Move.PAUSE`
- RelativeMove -> `IncrementMove`
- Continous Move -> `Free Move`

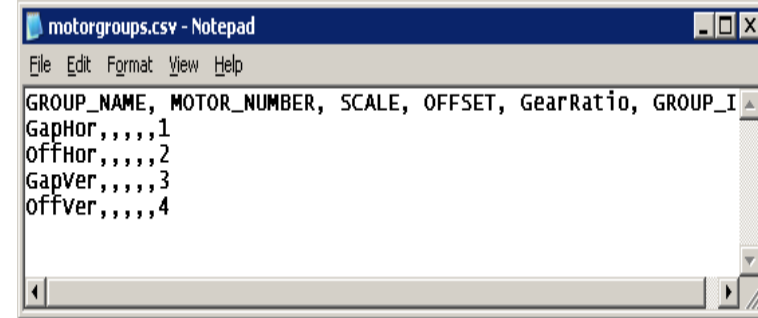
- Combined Motor motions / pseudo axis / Grouped Motions:
 - `GroupMove`
 - `IncrementGroupMove`
 - `Free Move`-> Continous Move

- GroupMoves of multiple on the fly grouped motors

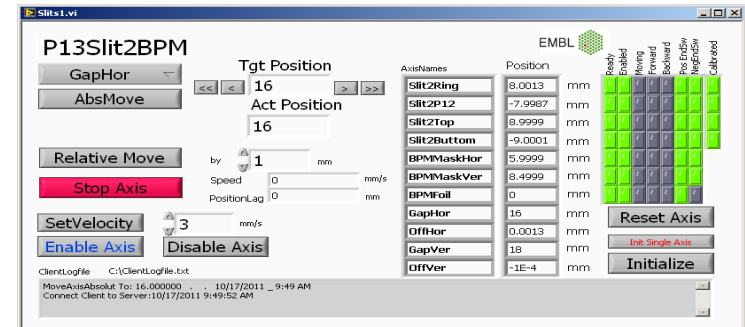
TINE Motor/Scan Server Group Moves

- On the fly defined group moves
- Move.Start -> Mot1,Mot2,Mot3,10,10,20
- Synchron Coupled Axis move synchronized
- by TwinCat defined in motorgroups.csv

- Pseudo axis move Pseudo axis defined in motorgroups.csv. Calculations of Positions and movements to be implemented into the PLC of TwinCat per case.



```
motorgroups.csv - Notepad
File Edit Format View Help
GROUP_NAME, MOTOR_NUMBER, SCALE, OFFSET, GearRatio, GROUP_I
GapHor,,,,,1
OffHor,,,,,2
GapVer,,,,,3
offVer,,,,,4
```



P13Slit2BPM

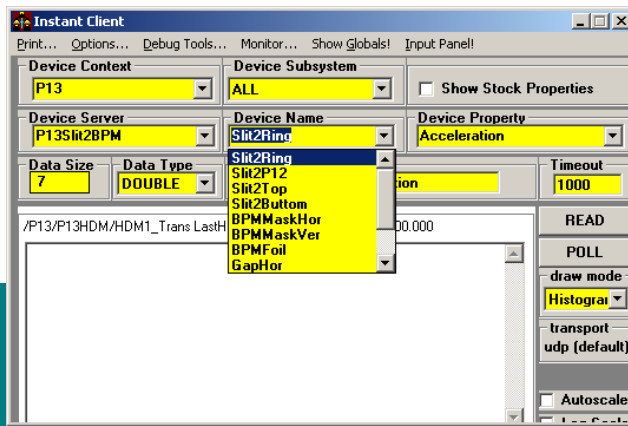
GapHor Tgt Position 16
AbsMove Act Position 16

Relative Move by 1 mm
Stop Axis Speed 0 mm/s PositionLag 0 mm
SetVelocity 3 mm/s
Enable Axis Disable Axis

AxisName	Position	Ready	Seeked	Moving	Forward	Backward	Pos. Error	Mag. Error	Calibrated
Slit2Ring	8.0013 mm	Y	Y	N	Y	Y	Y	Y	Y
Slit2P12	-7.9987 mm	Y	Y	N	Y	Y	Y	Y	Y
Slit2Top	8.9999 mm	Y	Y	N	Y	Y	Y	Y	Y
Slit2Bottom	-9.0001 mm	Y	Y	N	Y	Y	Y	Y	Y
BPMMaskHor	5.9999 mm	Y	Y	N	Y	Y	Y	Y	Y
BPMMaskVer	8.4999 mm	Y	Y	N	Y	Y	Y	Y	Y
BPMFoil	0 mm	Y	Y	N	Y	Y	Y	Y	Y
GapHor	16 mm	Y	Y	N	Y	Y	Y	Y	Y
OffHor	0.0013 mm	Y	Y	N	Y	Y	Y	Y	Y
GapVer	18 mm	Y	Y	N	Y	Y	Y	Y	Y
OffVer	-1E-4 mm	Y	Y	N	Y	Y	Y	Y	Y

Reset Axis
Init Single Axis
Initialize

Client logfile C:\Client\Logfile.txt
MoveAxisAbsolute To: 16.000000 . 10/17/2011 9:49 AM
Connect Client to Server: 10/17/2011 9:49:52 AM



Instant Client

Print... Options... Debug Tools... Monitor... Show Globals! Input Panel!

Device Context: P13
Device Server: P13Sli2BPM
Data Size: 7
Data Type: DOUBLE

Device Subsystem: ALL
Device Name: Sli2Ring
Device Property: Acceleration

Timeout: 1000

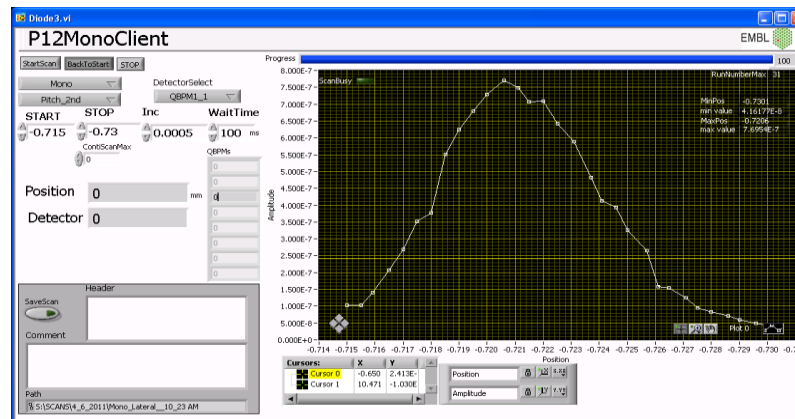
READ
POLL
draw mode: Histogram
transport: udp (default)
Autoscale

Motor/Scan Server Scan Options

- One motor per axis 1..n monitors
- N-Motors per axis defined as „pseudo axis“ 1..n monitors
- Scan of single motors against n-monitor signals
- „Fast Scan“ On the fly Scan
 - Start Motor and get every PLC cycle (1ms) Motor position and monitor signal
- „Slow“ Step Scans
 - Start Position– integrate Intensity monitor signal – Move by increment – integrate Intensity monitor signal

Step Scan performed by the Scan Server

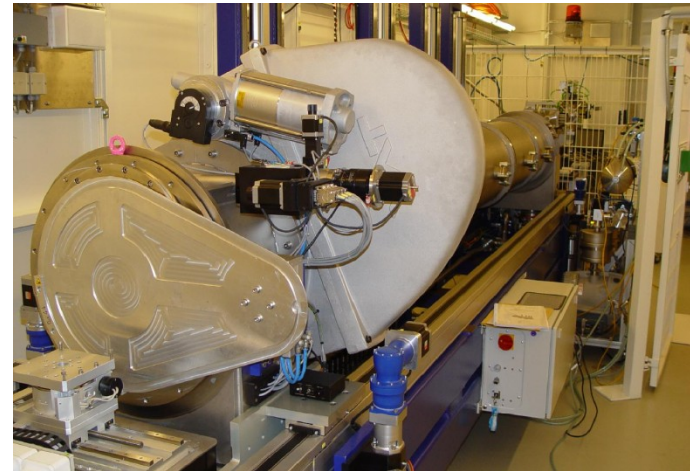
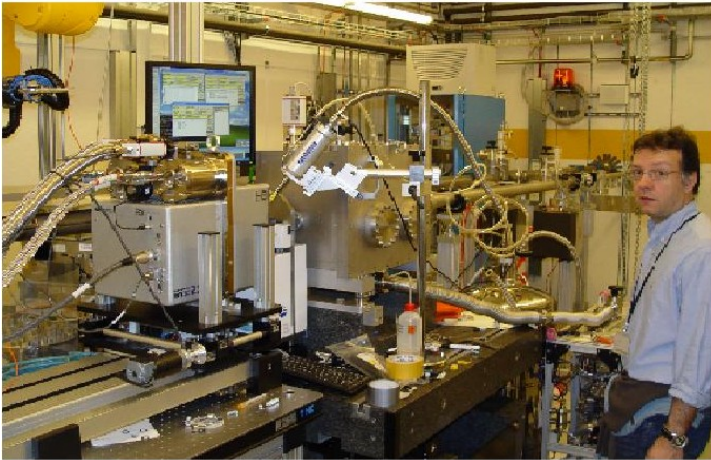
- `StepMove.START/STATUS/PARAMS/PAUSE/RESUME/START/STATUS/STOP/.X/.Y/SAVE/PPROGRESS`
- `ScanMonitor.START/STATUS/PARAMS/PAUSE/RESUME/START/STATUS/STOP/.X/.Y/SAVE`
Mon scan move m=tgtName p=pos g= gr s=size f=fmt t=tmr
- Which ScanFiles are available Property-> `ScanFile.List`
- Read the Scan File-> `ScanFile.X ScanFile.Y`
- Save Scan-> `ScanSave`



TwinCat NC MotorPlug specific

Closed loop motor control for stepper/servo and other motors

- Group moves synchronized by the Beckhoff PLC as coupled motors
- Group moves synchronized by the Beckhoff PLC.
- Scan of Group motors on the fly or StepScans - synchronized by the Beckhoff PLC (1ms)

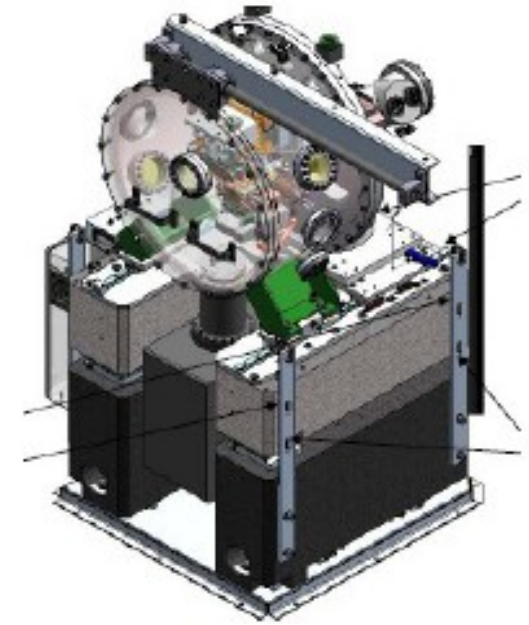


EMBL – FMB Oxford Monochromator

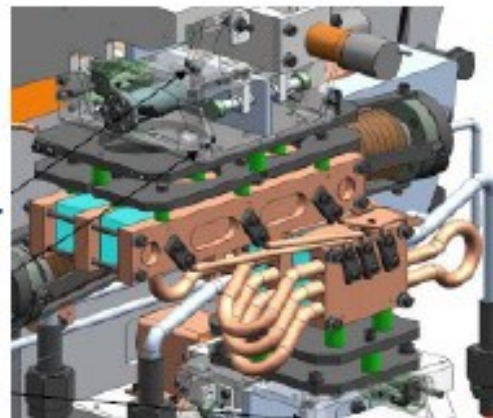


FMB Oxford
Bragg axis: PMAC

Fine adjustment :
Piezo motors,
PI controller



Crystal stage



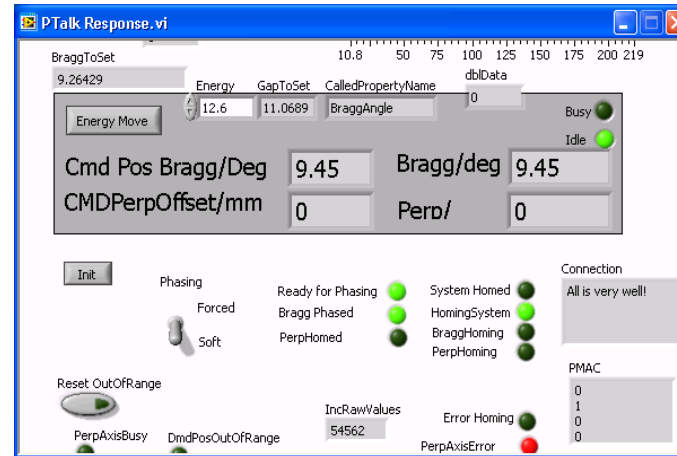
Motor

Stepper Motor control
Ethercat motor control
Renishaw encoder



Monochromator Server Applications

- PMAC Server
 - Bragg angle
 - Perp motor
- Beckhoff Motor Server
- Piezo Motor Server
- LIPS Server
- Undulator
- Cryo Cooler Server
- Server for Energy change of Undulator Gap and Bragg angle and Perp motor Position



Monochromator Server Applications

- PMAC Server
- Beckhoff Motor and CDI Server
 - Motor control
 - Temperatur readout
 - LIPS
- Piezo Motor Server
- LIPS Server
- Undulator
- Cryo Cooler Server
- Server for Energy change of Undulator Gap and Bragg angle and Perp motor Position

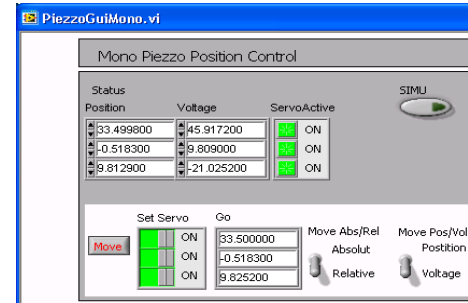
The image shows two software interfaces. The top window, titled 'MonoClient.vi', is a control panel for 'P12MonoClient' (dated 10/13/2011 2:54:24 PM). It features a table of axes with their names and current positions, and a grid of status indicators for each axis. The bottom window, titled 'ThermoCouples.vi', is a 'P12DCM TEMP Logger' showing temperature readings for various components.

Axis	AxisNames	Position	Ready	Enabled	Moving	Forward	Backward	Pos EndSw	NegEndSw
Piezo1	Jack1	0	Green	Grey	Grey	Grey	Grey	Green	Green
AbsMove	Jack2	0	Green	Grey	Grey	Grey	Grey	Green	Green
Stop Axis	Jack3	0	Green	Grey	Grey	Grey	Grey	Green	Green
	Lateral	0	Green	Grey	Grey	Grey	Grey	Green	Green
	Roll_1st	2.3025	Green	Grey	Grey	Grey	Grey	Green	Green
	Roll_2nd	0.191	Green	Grey	Grey	Grey	Grey	Green	Green
	Pitch_2nd	-0.7206	Green	Grey	Grey	Grey	Grey	Green	Green
	Perp	0	Green	Grey	Grey	Grey	Grey	Green	Green
	BraggAngle	9.45002	Green	Grey	Grey	Grey	Grey	Green	Green
	Piezo1	33.5008	Green	Grey	Grey	Grey	Grey	Green	Green
	Piezo2	-0.5183	Green	Grey	Grey	Grey	Grey	Green	Green
	Piezo3	9.8138	Green	Grey	Grey	Grey	Grey	Green	Green

Component	Temperature (K)	Flexure	Temperature (K)
1stCrystalSi111	92.43	Flexture1	256.93
1stCrystalSi311	92.43	Flexture2	256.73
2ndCrystalSi111	115.03		
2ndCrystalSi311	138.93		

Monochromator Server Applications

- PMAC Server
- Beckhoff Motor and CDI Server
- Piezo Motor Server
 - Fine Pitch
 - Fine Roll
 - Fine Perp
- LIPS Server
- Undulator
- Cryo Cooler Server
- Server for Energy change of Undulator
- Gap and Bragg angle and Perp motor Position



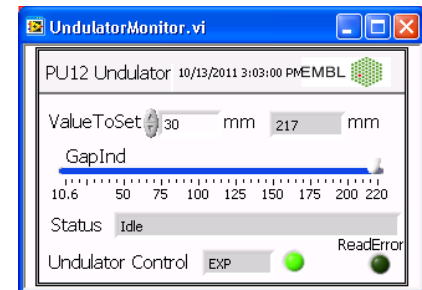
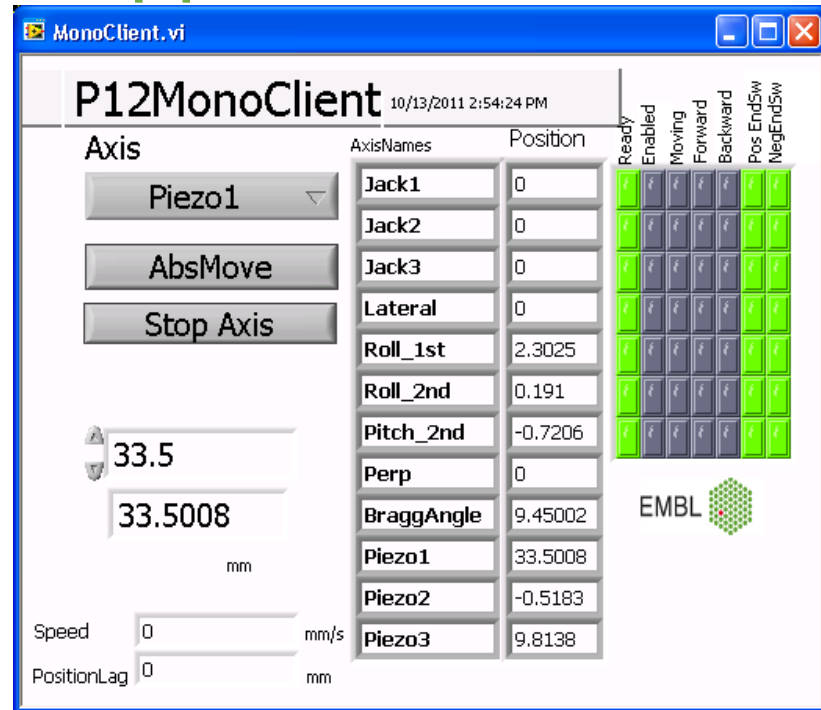
Monochromator Server Applications

- PMAC Server
- Beckhoff Motor and CDI Server
- Piezo Motor Server
- **LIPS Server**
- Undulator
- Server for Energy change of Undulator
- Gap and Bragg angle and Perp motor Position

```
Monochromator.LIPS:
// Monochromator LIPS:
//README START
//Checks for the following conditions
1. BraggAngleSafe > BraggAngleIn in degree -> FlagBraggAngle
2. Vacuum threshold of the TorgettenpumpController (Piezo operation safe)-> FlagPiezooperation
3. MotorTemperatures of the motors RollCrystal, Roll2ndCrystal and the pitch motor-> FlagM
4. CrystalTemperatures are compared with the CrystalTempLimit-> FlagCrystalTemp
5. FluxorTemperatures are compared with the FluxorTempLimit-> FlagFluxorTemp
to DO: 6. Check of the lateral position of the Monochromator. Switch crystal1 or crystal2 to b.
if the conditions are all TRUE FlagNeuenBeamShutter := TRUE
else FlagNeuenBeamShutter := FALSE
//README END
//Variables START
int NumMotor;
//BitPattern Status
int Status; // StatusNumber: 1-> IDLE, StatusNumber: 2-> BraggAngleTooSmallValue, StatusNumber: 3->
int VacuumDCM
//Variables END
//Helper conditionFlags START
bool FlagDCMOutOfRange;
bool FlagPiezooperationSafe;
bool FlagMotorTemp;
bool FlagCrystalTemp;
bool FlagFluxorTemp;
bool FlagLateralPosition;
bool FlagStatus;
bool FlagCryocoolerAlarm;
//Helper conditionFlags END
//Constants default Limit definitions START
LReal BraggAngleLimit:=2;
LReal CrystalTempLimit:=-160;
LReal MotorTempLimit:=75;
LReal VacuumHighLevel:=0.000001;
LReal VacuumLowLevel:=0.0000000001;
//Constants default Limit definitions END
//Condition check MotorTemperatures start
for (i=0 TO NumMotor,i++)
  if MotorTemp[i]>MotorTempLimit
```


Monochromator Server Applications

- PMAC Server
- Beckhoff Motor and CDI Server
- Piezo Motor Server
- LIPS Server
- Undulator
- Cryo Cooler
- Server for Energy change of Undulator
- Gap and Bragg angle and Perp motor Position



Monochromator Undulator synchronization

Undulator
Hasylab/Desy control network

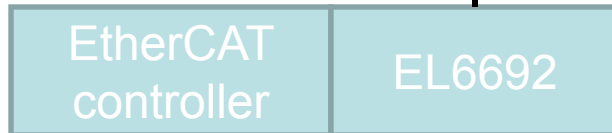


Oxford DCM
EMBL control network



PLC Cycle precise
synchronization

Cat5
cable



SLIT Application

- TwinCat/PLC
- CDI
- EtherCat Motor Plug
- Universal Motor Client
- (Init, Setup, Log, History, Alarms)

```

motorgroups.csv - Notepad
File Edit Format View Help
GROUP_NAME, MOTOR_NUMBER, SCALE, OFFSET, GearRatio, GROUP_ID
GapHor,,,,,1
OffHor,,,,,2
GapVer,,,,,3
offVer,,,,,4
    
```

P13Slit2BPM

GapHor: 16 mm (Tgt Position), 16 mm (Act Position)

AxisNames	Position
Slit2Ring	8.0013 mm
Slit2P12	-7.9987 mm
Slit2Top	8.9999 mm
Slit2Bottom	-9.0001 mm
BPMMaskHor	5.9999 mm
BPMMaskVer	8.4999 mm
BPMFoil	0 mm
GapHor	16 mm
OffHor	0.0013 mm
GapVer	18 mm
OffVer	-1E-4 mm

Grouped move -> Gap Vertical = Motor Top Slit and Motor Bottom Slit Gap to be Scanned

Instant Client (Instance 2)

Device Context: P12

Device Name: SIRP13

Device Property: Acceleration

Data Points:

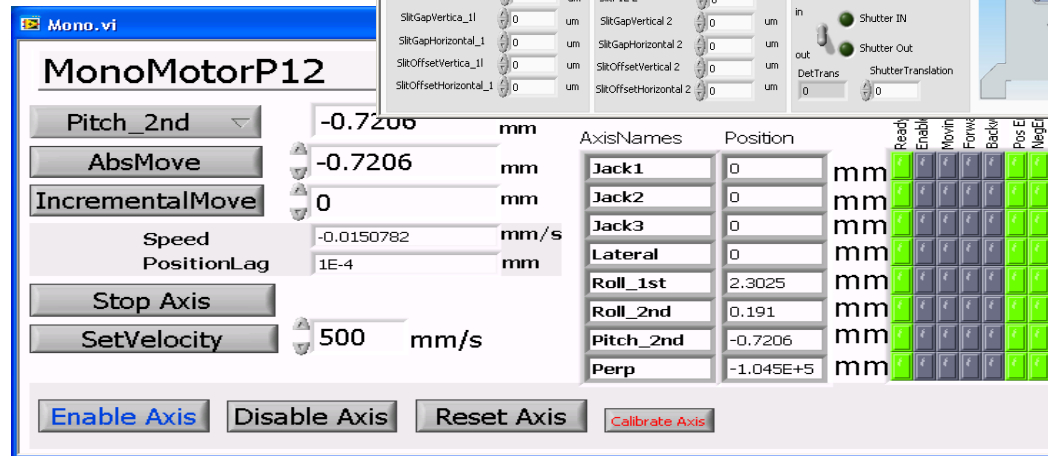
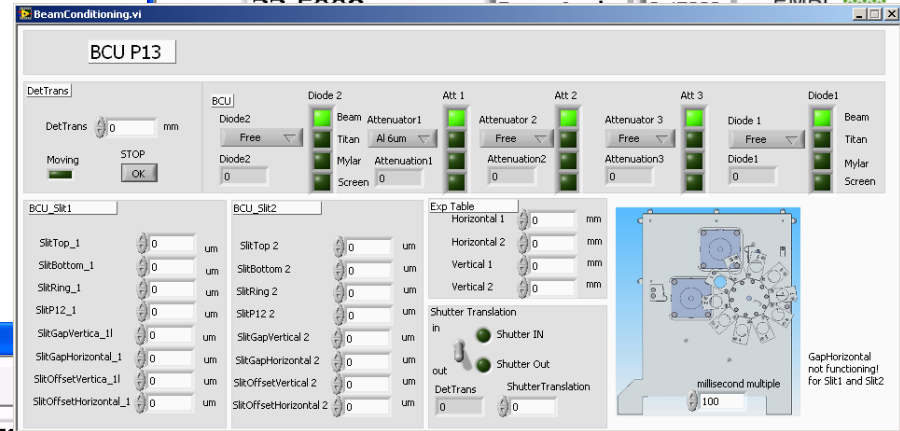
- SlitTop
- BPMFoil
- BPMMaskHor
- BPMMaskVer
- GapHor
- OffHor
- GapVer
- OffVer

```

mstecat.csv - Notepad
File Edit Format View Help
TARGET, TYPE, MOTOR, UNITS, MSTEPS_MM, MSTEPS_CYCLE, MSTEPS_STEP, POSITION_MAXIMUM, POSITION_MINIMUM, POSIT
/localhost/cdi, LINEAR, 1, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 0.5, 0.01, 1
/localhost/cdi, LINEAR, 2, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 0.5, 0.01, 1
/localhost/cdi, LINEAR, 3, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 0.5, 0.01, 1
/localhost/cdi, LINEAR, 4, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 0.5, 0.01, 1
/localhost/cdi, LINEAR, 5, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 300, 0.01, 1
/localhost/cdi, LINEAR, 6, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 300, 0.01, 1
/localhost/cdi, LINEAR, 7, mm, 12800, 12800, 64, 1.64e+006, -1.64e+006, 0, 1, 0.1, 0.01, 300, 0.01, 1
    
```

Software

- Undulator
- Vacuum Frontend
- BeamConditioningUnit
- ...
- Mono
- QBPM
- HDM



EMBL Hamburg Plate Screening



ClickCentering.vi

EMBL-Hamburg Plate Screening

089d485 32-bit RGB image 279,175,79 (367,450)

Pos 1	Pos 2	Pos 3	Pos 4	Pos 5
Pos 2 1	Pos 2 2	Pos 2 3	Pos 2 4	Pos 2 5
Pos 3 1	Pos 3 2	Pos 3 3	Pos 3 4	Pos 3 5
Pos 3 1	Pos 3 2	Pos 3 3	Pos 3 4	Pos 3 5
Pos 4 1	Pos 4 2	Pos 4 3	Pos 4 4	Pos 4 5

CameraFocus: 31 32 40 45 52 55 62

XPlateMove: -750 -720 -700 -680 -660

ZPlateMove: 41745 45 475 480

RateOut Adjust focus: MoveBy: 0.02

```
<EMBL_RafPlateMove> X=0.052208 Y=0 Z=0.086800_10/12/2011 11:53 PM
<EMBL_RafPlateMove> X=0.079408 Y=0 Z=0.226080_10/12/2011 11:53 PM
<EMBL_RafPlateMove> X=0.277208 Y=0 Z=0.308080_10/12/2011 11:53 PM
<EMBL_AbsPlateMove> X=498.5 Y=43.5 Z=451.1_10/12/2011 11:53 PM
<EMBL_AbsPlateMove> X=498 Y=43 Z=451.1_10/12/2011 11:53 PM
<EMBL_RafPlateMove> X=0.057400 Y=0 Z=0.236080_10/12/2011 11:53 PM
<EMBL_RafPlateMove> X=0.021400 Y=0 Z=0.238080_10/12/2011 11:53 PM
<EMBL_RafPlateMove> X=0 Y=1 Z=0_10/12/2011 11:53 PM
<EMBL_Start_Server>
```

Robot Status: X=498.995 | Y=43.9 | Z=450.77 | robot idle | grip undef | lid undef | magnet undef | crystal undef | cell loose undef | wait

Commands:
<EMBLMoveAbsPlateScrY>

Click Centering tool

MoveAbsPlateScrY(x,0,z)

Range check(x,y,z) of move command

Move AbsolutePosition
Relative Z

Robot World Z

RobotStatus

ServerLogFile

Outlook

- Finish AttoCube MotorServer integration
- Finish PI-Piezzo MotorServer integration
- PMAC MotorServer integration ?
- Staeubli Robot MotorServer integration ?

Acknowledgments

- Stefan Fiedler
- Marina Nikolova Software Engineer
- Jochen Meier Electronic
- Daniel Franke
- PETRAIII Instrumentation Team
- MCS