

Middle Layer Services at NSLS II for Beam Commissioning and Operation



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- Virtual Accelerator
- EPICS V4 based Middle Layer Service
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- Beam Commissioning
- NSLS II Construction
- Conclusion

NSLS II Overview

- Injection system

- Turn key: LINAC & Booster

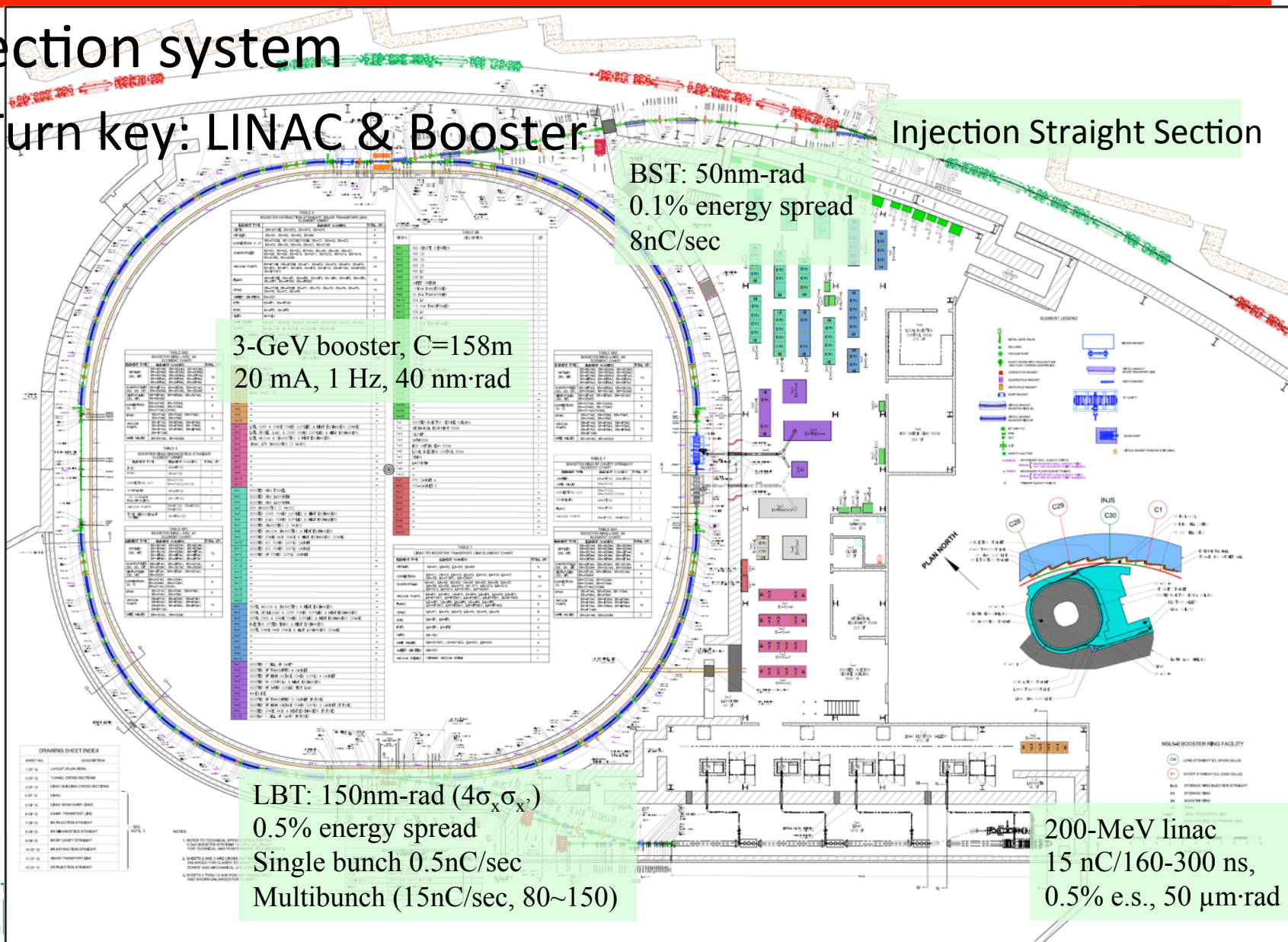
Injection Straight Section

BST: 50nm-rad
0.1% energy spread
8nC/sec

3-GeV booster, C=158m
20 mA, 1 Hz, 40 nm-rad

LBT: 150nm-rad ($4\sigma_x \sigma_x$)
0.5% energy spread
Single bunch 0.5nC/sec
Multibunch (15nC/sec, 80~150)

200-MeV linac
15 nC/160-300 ns,
0.5% e.s., 50 μ m-rad

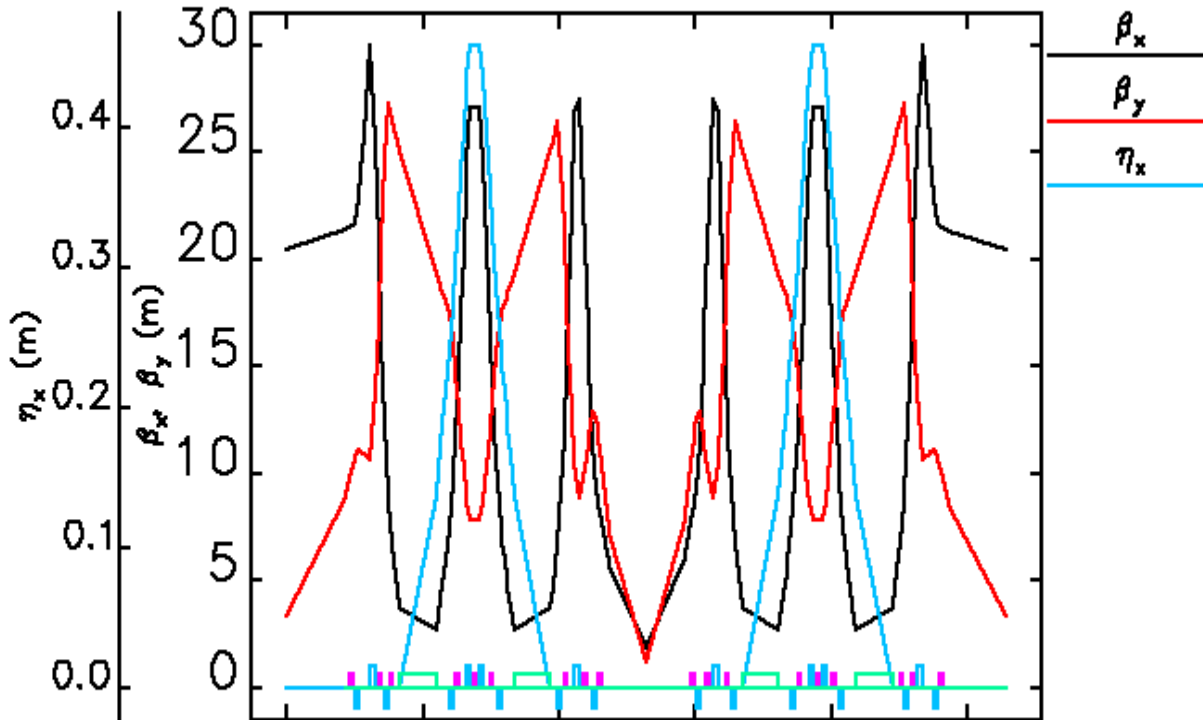


NSLS II Overview

- Storage ring parameters
 - 30 Cell DBA lattice structure

nux: 33.221 nuy: 16.260 ex0: 2.1 nm

Cx: 2.0 Cy: 1.8 ac:3.63e-04

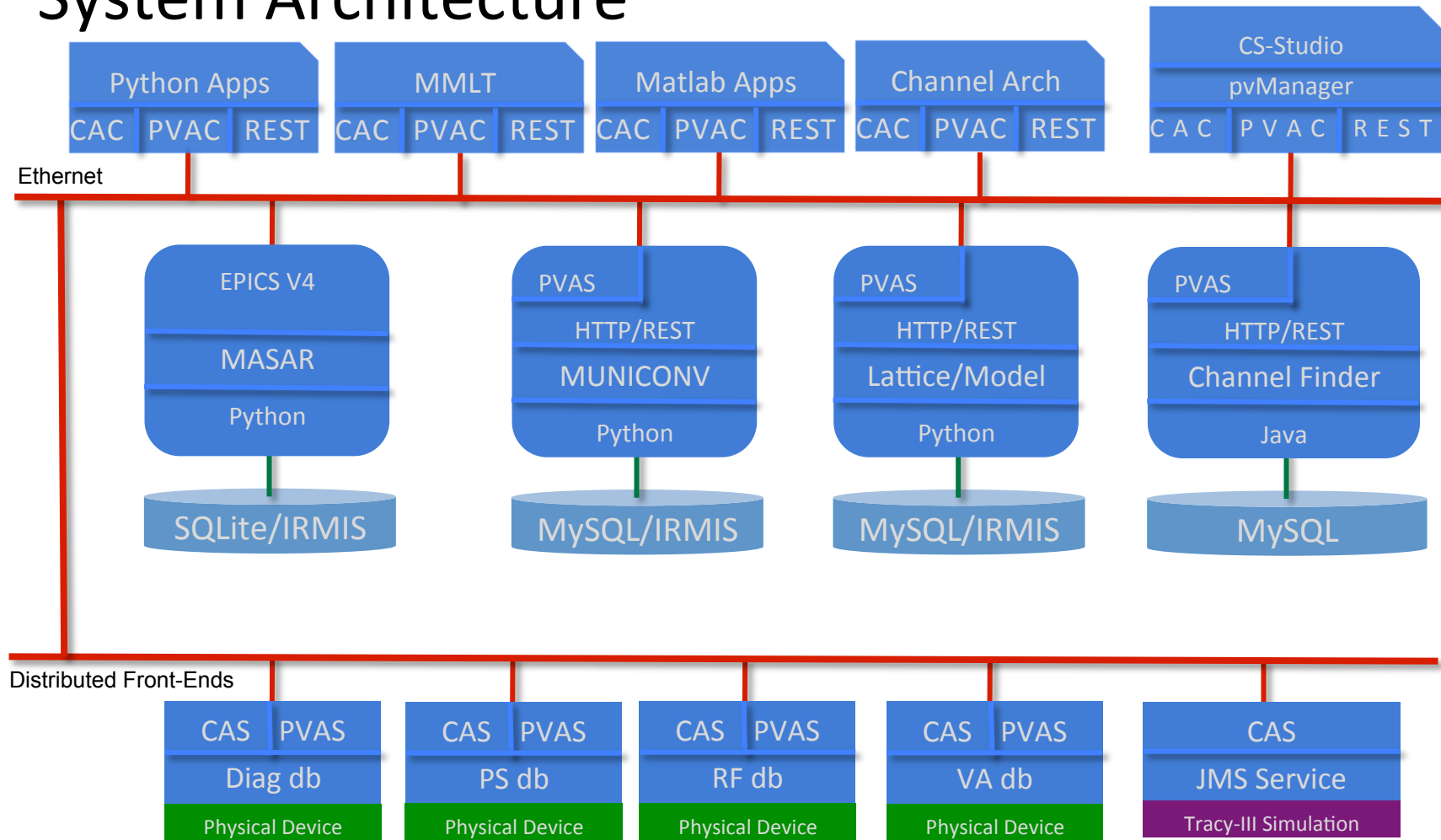


Beam Specifications	
Energy	3.0 GeV
Circumference	792 m
Number of Periods	30 DBA
Straights	6.6/9.3 m
Emittance (h,v)	< 1/0.008 nm
Momentum Compaction	0.00037
Dipole Bend Radius	25 m
Energy Loss per Turn	<2 MeV
Energy Spread	0.09%
RF Frequency	500 MHz
Harmonic Number	1320
RF Bucket Height	>2.5%
RMS Bunch Length	15-30 ps
Average Current	500 mA
Current per Bunch	0.5 mA
Charge per Bunch	1.2 nC
Touschek Lifetime	> 3hrs

0 10 20 30 40 50
 comm Tue Feb 4 16:32:01 EST 2014
 Courtesy of Weiming Guo

NSLS II Controls Brief

- System Architecture



NSLS II Controls Brief

- Control room software
 - Debian/Linux 7 consoles
 - 4 for general operator and 1 for lead operator
 - Python cothread for channel access
 - Version 2.8/Python 2.7
 - Dedicated matlab server
 - 3 for physicist
 - 1 for BPM expert
 - labCa 3.4 support
 - Elegant/SDDS install
 - Limited support

Virtual Accelerator

Ethernet



Distributed Front-Ends

CAS

JMS Service

Tracy-III Simulation

Virtual Accelerator

- An integrated accelerator simulation code
 - Provide real time accelerator simulation results
- A standalone EPICS V3 IOC
- Virtual accelerator at NSLS II
 - Uses Tracy-3 as simulation backend
 - Provide realistic accelerator beam behavior
 - Integrate realistic lattice
 - Integrate misalignment
 - Emulated setting jitter for magnets

Virtual Accelerator

- Main purpose
 - Support high level application development
 - Especially physics application development
 - All simulation results available via EPICS V3 PVs
 - Middle layer service development
 - Channel finder service
 - MASAR service
 - ...
 - Other tool need EPICS V3 PVs

Virtual Accelerator

- What does it do?
 - All data via EPICS PVs
 - Beam Optics
 - Hardware setting & read back
 - Adjust setting of each device individually
 - Magnets: Bend, Quad, Sext, Correctors, ...
 - RF frequency & voltage
 - Insertion device for synchrotron machine
 - Dynamically change hardware setting
 - Real time simulation
 - Simulation performed continuously

Virtual Accelerator

- What does it do?
 - Errors source
 - Engineering ripple
 - magnet setting
 - BPM read back
 - Misalignment
 - Read back beam behavior
 - Beam position at each BPM
 - Beam closed orbit
 - Beam optics TWISS parameters

Virtual Accelerator

- What does it not do or need many effort to do?
 - Other accelerator behavior not available via a simulation code
 - Vacuum reading
 - Mechanical moving
 - Ground vibration
 - Multiple particle tracking
 - Performance issue
 - Synchrotron photon laser behavior

Virtual Accelerator

- Automatic generation
 - Load a lattice file
 - Apply NSLS II naming
 - Generate EPICS .c
 - Generate cmd file
 - Generate a table
 - for physics application
 - For channel finder

	A	B	C	D	E	F	G	H	I
1	#pv_name	el_idx_va	machine	cell	girder	handle	el_name_va	el_field_va	el_type_va
2	V:2-SR:C30-MG:G1{FXH2:3}Fld:SP	3	V:2-SR	C30	G1	setpoint	FXH2G1C30A		Horizontal Corrector
3	V:2-SR:C30-MG:G1{FXH2:3}Fld:I	3	V:2-SR	C30	G1	readback	FXH2G1C30A		Horizontal Corrector
4	V:2-SR:C30-MG:G1{FYH2:4}Fld:SP	4	V:2-SR	C30	G1	setpoint	FYH2G1C30A		Vertical Corrector
5	V:2-SR:C30-MG:G1{FYH2:4}Fld:I	4	V:2-SR	C30	G1	readback	FYH2G1C30A		Vertical Corrector
6	V:2-SR:C30-MG:G2{SH1:9}Fld:SP	9	V:2-SR	C30	G2	setpoint	SH1G2C30A	K	Sextupole
7	V:2-SR:C30-MG:G2{SH1:9}Fld:I	9	V:2-SR	C30	G2	readback	SH1G2C30A	K	Sextupole
8	V:2-SR:C30-BI:G2{PH1:11}SA:X	11	V:2-SR	C30	G2	readback	PH1G2C30A	X	Beam Position Monitor
9	V:2-SR:C30-BI:G2{PH1:11}SA:Y	11	V:2-SR	C30	G2	readback	PH1G2C30A	Y	Beam Position Monitor
10	V:2-SR:C30-MG:G2{QH1:13}Fld:SP	13	V:2-SR	C30	G2	setpoint	QH1G2C30A	K	Quadrupole
11	V:2-SR:C30-MG:G2{QH1:13}Fld:I	13	V:2-SR	C30	G2	readback	QH1G2C30A	K	Quadrupole
12	V:2-SR:C30-MG:G2{SQHH:15}Fld:SP	15	V:2-SR	C30	G2	setpoint	SQHHG2C30A	K	Quadrupole
13	V:2-SR:C30-MG:G2{SQHH:15}Fld:I	15	V:2-SR	C30	G2	readback	SQHHG2C30A	K	Quadrupole
14	V:2-SR:C30-MG:G2{CXH1:16}Fld:SP	16	V:2-SR	C30	G2	setpoint	CXH1G2C30A		Horizontal Corrector
15	V:2-SR:C30-MG:G2{CXH1:16}Fld:I	16	V:2-SR	C30	G2	readback	CXH1G2C30A		Horizontal Corrector
16	V:2-SR:C30-MG:G2{CYH1:17}Fld:SP	17	V:2-SR	C30	G2	setpoint	CYH1G2C30A		Vertical Corrector
17	V:2-SR:C30-MG:G2{CYH1:17}Fld:I	17	V:2-SR	C30	G2	readback	CYH1G2C30A		Vertical Corrector
18	V:2-SR:C30-MG:G2{SQHH:18}Fld:SP	18	V:2-SR	C30	G2	setpoint	SQHHG2C30A	K	Quadrupole
19	V:2-SR:C30-MG:G2{SQHH:18}Fld:I	18	V:2-SR	C30	G2	readback	SQHHG2C30A	K	Quadrupole
20	V:2-SR:C30-MG:G2{QH2:20}Fld:SP	20	V:2-SR	C30	G2	setpoint	QH2G2C30A	K	Quadrupole
21	V:2-SR:C30-MG:G2{QH2:20}Fld:I	20	V:2-SR	C30	G2	readback	QH2G2C30A	K	Quadrupole
22	V:2-SR:C30-MG:G2{SH3:22}Fld:SP	22	V:2-SR	C30	G2	setpoint	SH3G2C30A	K	Sextupole
23	V:2-SR:C30-MG:G2{SH3:22}Fld:I	22	V:2-SR	C30	G2	readback	SH3G2C30A	K	Sextupole
24	V:2-SR:C30-MG:G2{QH3:24}Fld:SP	24	V:2-SR	C30	G2	setpoint	QH3G2C30A	K	Quadrupole
25	V:2-SR:C30-MG:G2{QH3:24}Fld:I	24	V:2-SR	C30	G2	readback	QH3G2C30A	K	Quadrupole
26	V:2-SR:C30-BI:G2{PH2:26}SA:X	26	V:2-SR	C30	G2	readback	PH2G2C30A	X	Beam Position Monitor
27	V:2-SR:C30-BI:G2{PH2:26}SA:Y	26	V:2-SR	C30	G2	readback	PH2G2C30A	Y	Beam Position Monitor
28	V:2-SR:C30-MG:G2{SH4:28}Fld:SP	28	V:2-SR	C30	G2	setpoint	SH4G2C30A	K	Sextupole
29	V:2-SR:C30-MG:G2{SH4:28}Fld:I	28	V:2-SR	C30	G2	readback	SH4G2C30A	K	Sextupole
30	V:2-SR:C30-MG:G2{CXH2:31}Fld:SP	31	V:2-SR	C30	G2	setpoint	CXH2G2C30A		Horizontal Corrector
31	V:2-SR:C30-MG:G2{CXH2:31}Fld:I	31	V:2-SR	C30	G2	readback	CXH2G2C30A		Horizontal Corrector
32	V:2-SR:C30-MG:G2{CYH2:32}Fld:SP	32	V:2-SR	C30	G2	setpoint	CYH2G2C30A		Vertical Corrector
33	V:2-SR:C30-MG:G2{CYH2:32}Fld:I	32	V:2-SR	C30	G2	readback	CYH2G2C30A		Vertical Corrector
34	V:2-SR:C30-MG:G3{B1:37}Fld:SP	37	V:2-SR	C30	G3	setpoint	B1G3C30A	T	Bending
35	V:2-SR:C30-MG:G3{B1:37}Fld:I	37	V:2-SR	C30	G3	readback	B1G3C30A	T	Bending
36	V:2-SR:C30-MG:G4{CXM1:42}Fld:SP	42	V:2-SR	C30	G4	setpoint	CXM1G4C30A		Horizontal Corrector
37	V:2-SR:C30-MG:G4{CXM1:42}Fld:I	42	V:2-SR	C30	G4	readback	CXM1G4C30A		Horizontal Corrector
38	V:2-SR:C30-MG:G4{CYM1:43}Fld:SP	43	V:2-SR	C30	G4	setpoint	CYM1G4C30A		Vertical Corrector
39	V:2-SR:C30-MG:G4{CYM1:43}Fld:I	43	V:2-SR	C30	G4	readback	CYM1G4C30A		Vertical Corrector
40	V:2-SR:C30-MG:G4{QM1:46}Fld:SP	46	V:2-SR	C30	G4	setpoint	QM1G4C30A	K	Quadrupole
41	V:2-SR:C30-MG:G4{QM1:46}Fld:I	46	V:2-SR	C30	G4	readback	QM1G4C30A	K	Quadrupole
42	V:2-SR:C30-MG:G4{SM1:48}Fld:SP	48	V:2-SR	C30	G4	setpoint	SM1G4C30A	K	Sextupole
43	V:2-SR:C30-MG:G4{SM1:48}Fld:I	48	V:2-SR	C30	G4	readback	SM1G4C30A	K	Sextupole
44	V:2-SR:C30-MG:G4{FXM1:51}Fld:SP	51	V:2-SR	C30	G4	setpoint	FXM1G4C30A		Horizontal Corrector
45	V:2-SR:C30-MG:G4{FXM1:51}Fld:I	51	V:2-SR	C30	G4	readback	FXM1G4C30A		Horizontal Corrector
46	V:2-SR:C30-MG:G4{FYM1:52}Fld:SP	52	V:2-SR	C30	G4	setpoint	FYM1G4C30A		Vertical Corrector
47	V:2-SR:C30-MG:G4{FYM1:52}Fld:I	52	V:2-SR	C30	G4	readback	FYM1G4C30A		Vertical Corrector
48	V:2-SR:C30-BI:G4{PM1:55}SA:X	55	V:2-SR	C30	G4	readback	PM1G4C30A	X	Beam Position Monitor
49	V:2-SR:C30-BI:G4{PM1:55}SA:Y	55	V:2-SR	C30	G4	readback	PM1G4C30A	Y	Beam Position Monitor
50	V:2-SR:C30-MG:G4{QM2:57}Fld:SP	57	V:2-SR	C30	G4	setpoint	QM2G4C30A	K	Quadrupole

EPICS V4 based Middle Layer Service



EPICS V4 based Middle Layer Service

- An international collaboration working group
 - Collaborative institutes
 - APS
 - BNL
 - COSYLAB
 - DLS
 - PSI
 - SLAC
 - ESS
 - Weekly telecon meeting
 - A nominal 4 months face-face meeting rotating between the developer's sites.

EPICS V4 based Middle Layer Service

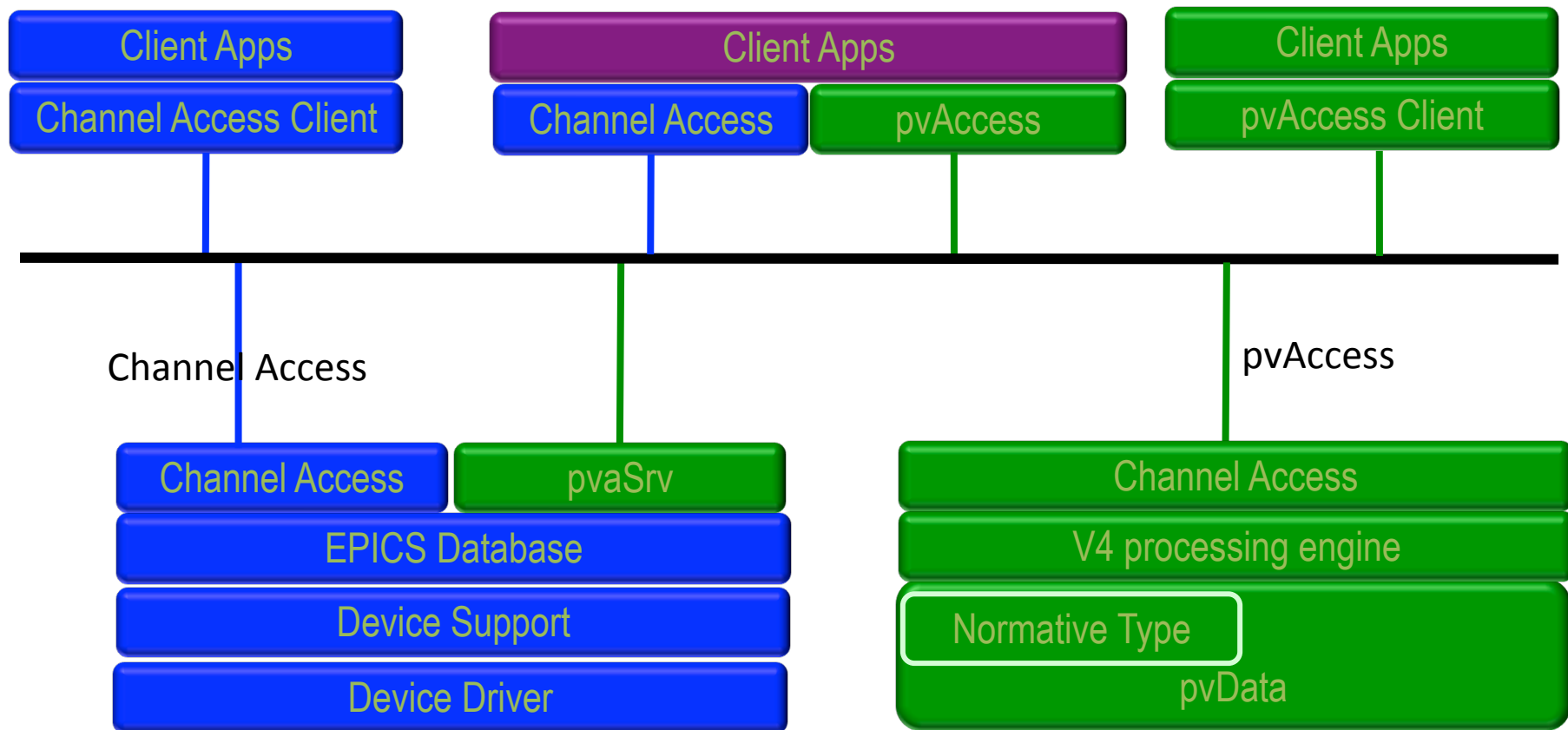
- An open source project for experimental facility
 - Extension of EPICS version 3
 - Complex data structure/data types
 - New communication protocol
 - Expanded to fitting the requirement
 - Physics middle layer server
 - Data acquisition
 - Experimental control
 - Other general service

EPICS V4 based Middle Layer Service

- V4 Modules
 - Core modules:
 - pvData: fundamental data structure
 - pvAccess: communication protocol, carry data on wire
 - pvCommon: common utility library
 - Extensions
 - pvaSrv: EPICS Base IOC plugin interfacing V3 data to pvAccess
 - Normative type: collection of pvData data types that may be used for general purpose
 - Service modules:
 - Developed at each different site for its own purpose
 - Language support
 - C++ & Java mainly
 - Python, but greatly behind because of short of man power

EPICS V4 based Middle Layer Service

- Interoperation with V3



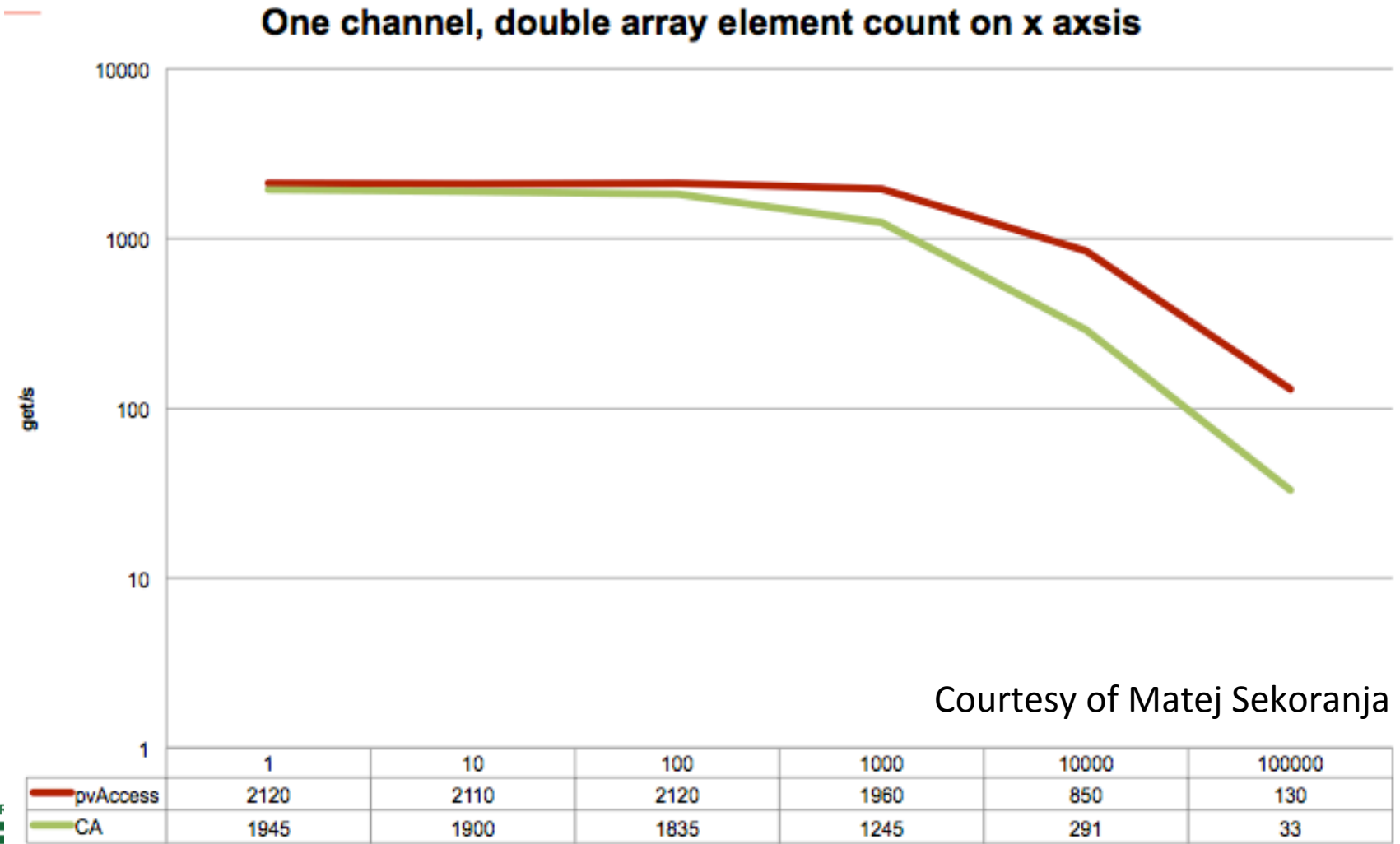
EPICS V4 based Middle Layer Service

- Communication Mechanisms
 - Get, Put, Monitor, Command/Response, Broadcast, Multicast
- Normative types:
 - NT(DBRTypes), NTImage, NTTable, NTMultichannelArray, NTNDArray, NTStatistics,
- pvAccess
 - optimized to send large arrays and structured data.
- pvaSrv
 - reference implementations of middle layer services for relational databases or continuous data sources
 - serves V3 channels from the EPICS process database as does

Channel Access.

EPICS V4 based Middle Layer Service

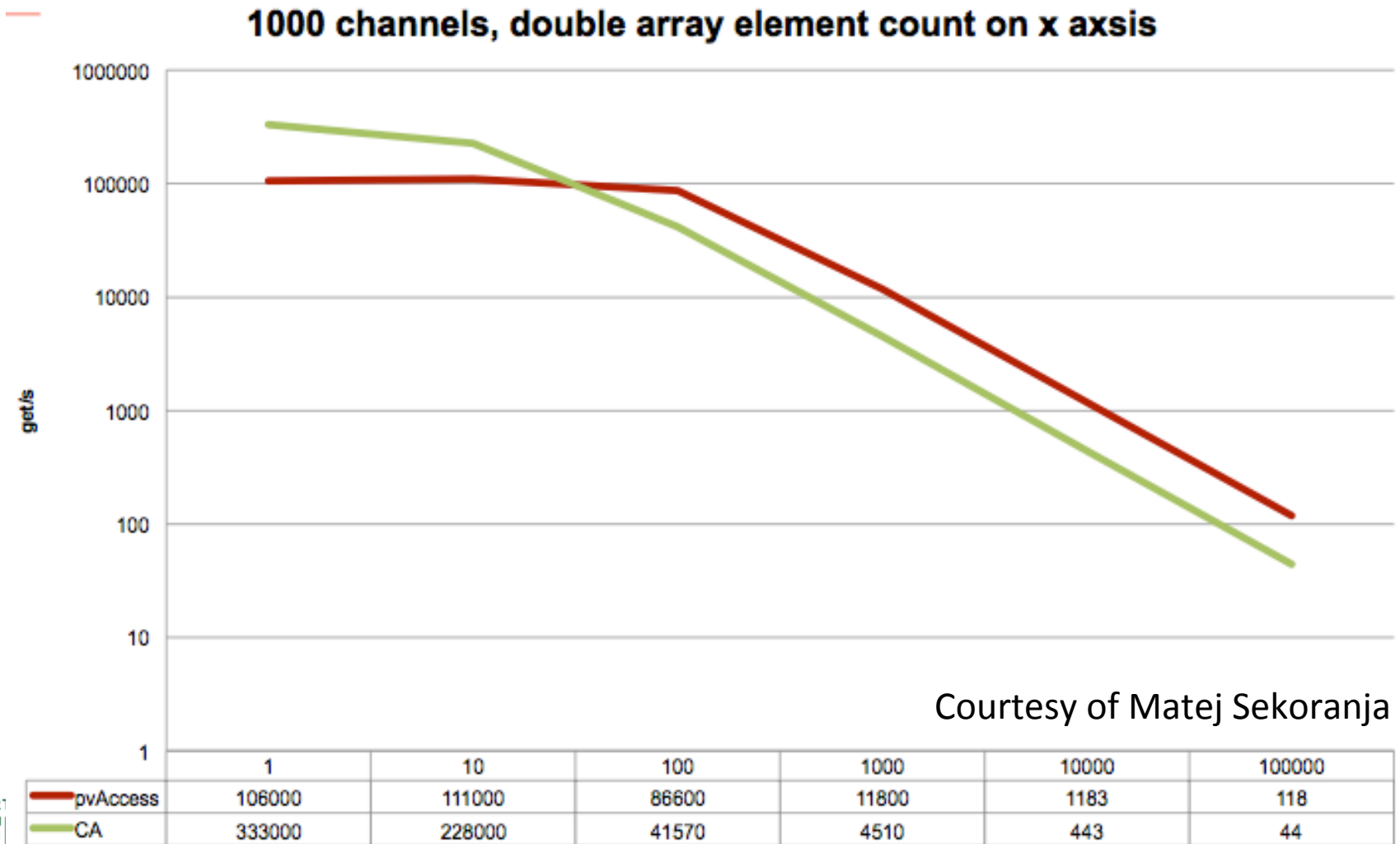
- pvAccess and Channel Access comparative performance (Number of channel value get operations per second), where only one channel's value is got in each get operation, as a function of array size of the channel



Courtesy of Matej Sekoranja

EPICS V4 based Middle Layer Service

- pvAccess and Channel Access comparative performance (Number of channel value get operations per second), where 1000 channels values are got in each get operation, as a function of array size of the channel.

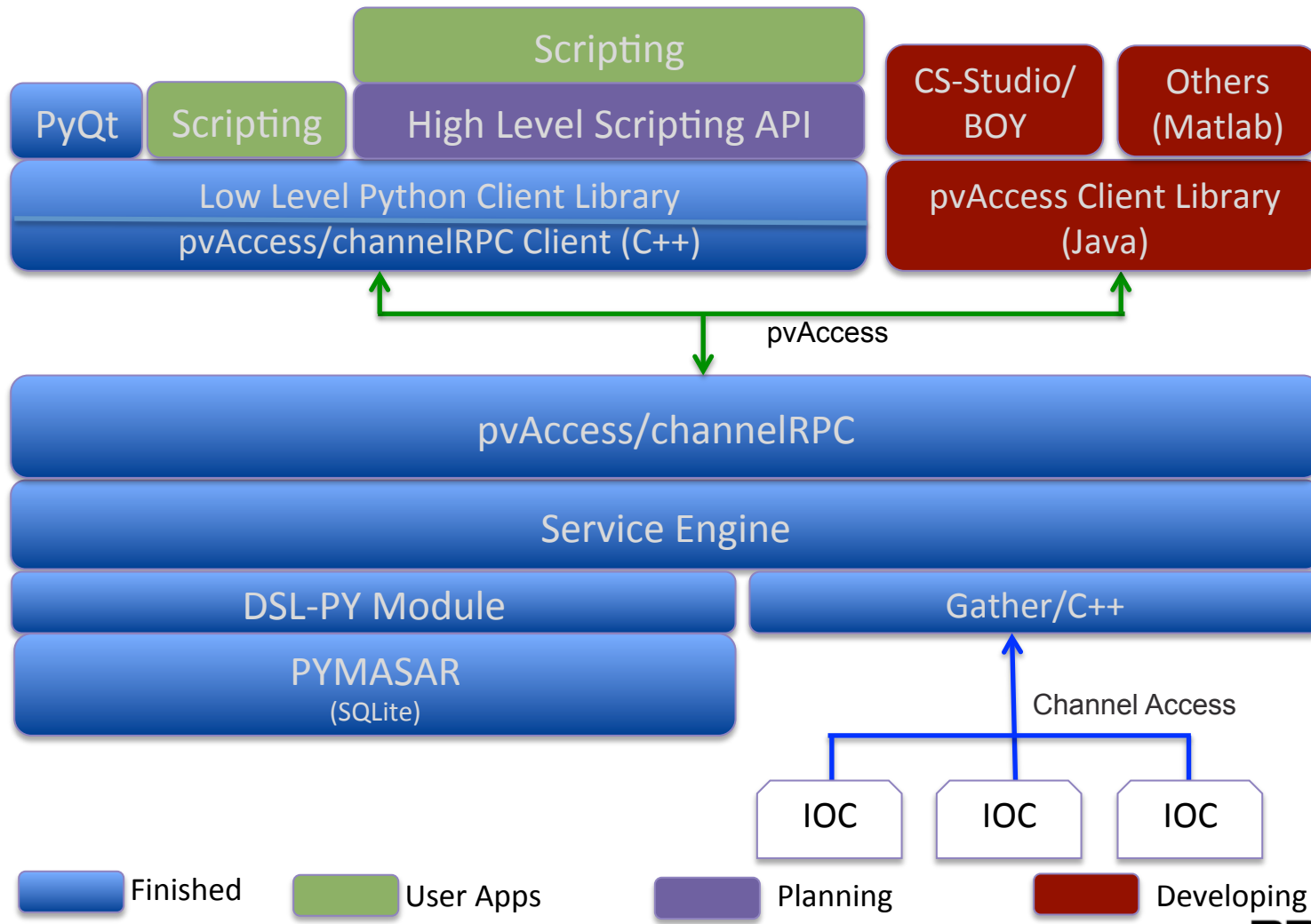


EPICS V4 based Middle Layer Service

- MASAR
 - Machine Snapshot, Archiving, and Retrieve
 - A general purpose tool to snapshot data from V3 PVs
 - Implemented in V4
 - Machine
 - A facility controlled by EPICS, accelerator for example
 - Snapshot
 - Data at specific time point
 - Value, time stamp, connection status, alarm status, alarm severity
- Similar tools, but different purpose
 - IOC automatic save & restore
 - IOC bumpless rebooting
 - Channel Archiving
 - Archive pre-defined configuration periodically
 - All data saved time serially

EPICS V4 based Middle Layer Service

- MASAR Architecture

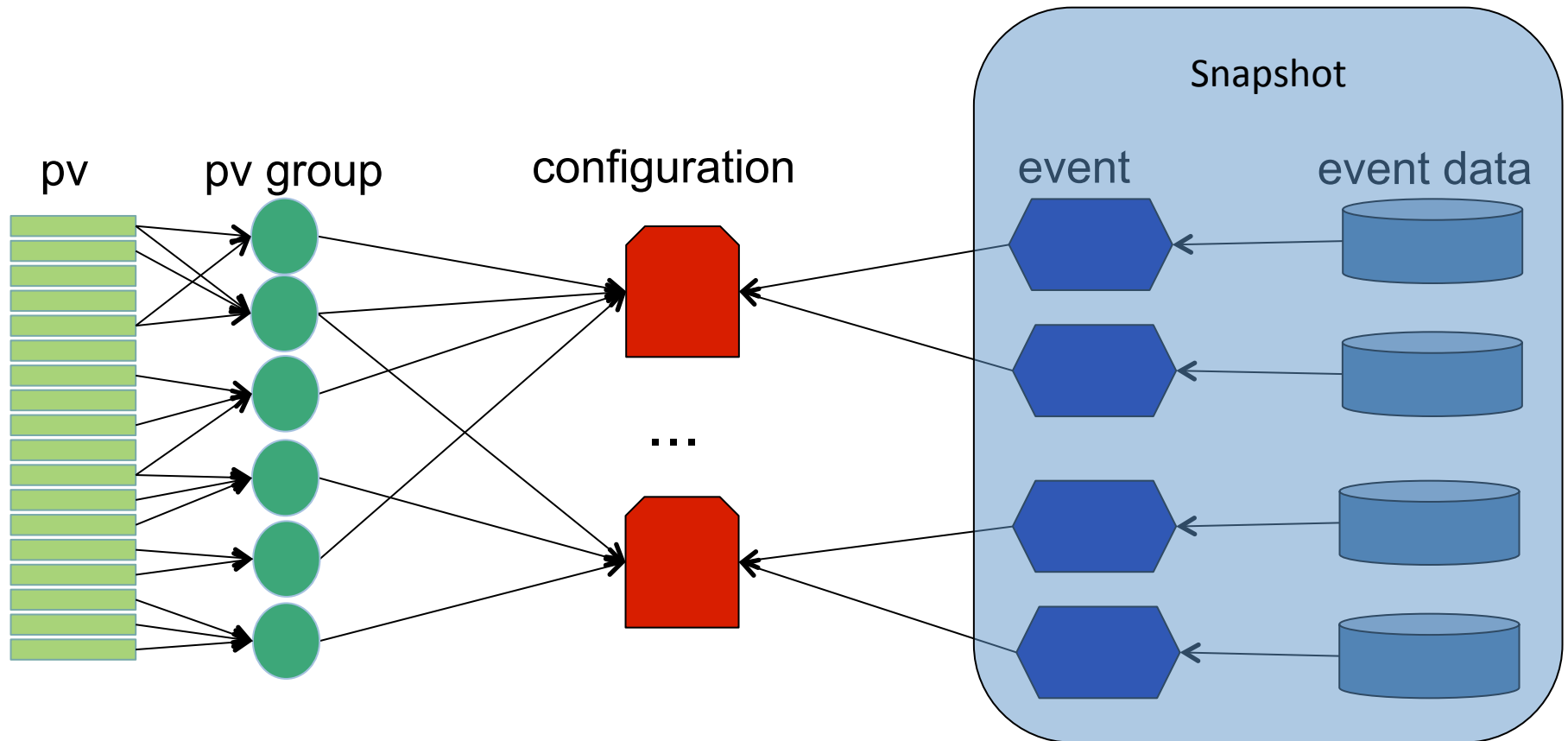


EPICS V4 based Middle Layer Service

- Snapshot configuration
 - EPICS V3 PV orientated
 - Support all scalar and waveform PV types
 - Float, double, string, and enum
 - PV group
 - Collection of PV names
 - Can be a mix of any of the types
 - One PV can be in many PV groups
 - Configuration
 - Collection of PV groups, therefore, collection of PV names
 - One PV group can be in many configurations
- Snapshot
 - An event happened at a particular time
 - Belongs to one configuration
 - One configuration can have many events
 - Each event is one data set
 - Header information + meta data (value, time stamp)

EPICS V4 based Middle Layer Service

- Snapshot configuration



EPICS V4 based Middle Layer Service

- UI PyQt4 based graphic user interface
 - Browse configuration
 - Browse event
 - Take snapshot
 - Retrieve data
 - Compare data
 - Restore machine
 - Export data to external file

The screenshot displays the MASAR Viewer application window. On the left, there is a 'Config Name' table with columns for 'Config Name' and 'Config'. Below the table are fields for 'Snapshot Desc', 'Author', and 'Use time range' (with 'From' and 'To' date pickers). On the right, a 'Welcome to MASAR' message provides a 'Quick Start' guide with three numbered steps, 'Tips', and 'Terminology' for machine, snapshot, config table, and snapshot table. At the bottom, a toolbar contains buttons for 'Display Snapshot(s)', 'Restore Machine', 'Compare Live Machine', 'Save Machine Snapshot ...', 'Compare Snapshots...', and 'Export Snapshot to File ...'.

	Config Name	Config
1	LN-LTB-All-20131219	18
2	Diag-BR-allBPM-1.2.1.3.2013.expert	16
3	Diag-LN_LTB-allBPM-1.2.1.3.2013.expert	17
4	Diag-BR-allBPM-Expert	15
5	LN-LTB-All-20131209	14
6	LTB_PS_SRC_20131206	13
7	BR_RF_SC_20130426	12
8	BR_MG_SCR_20130419	11
9	LN_LTB_BPM_Expert_20120621	10

EPICS V4 based Middle Layer Service

- Event data browsing and comparing with live machine

The screenshot shows the MASAR Viewer interface. On the left, there are two panels: 'Config Name' and 'Snapshot Id'. The 'Config Name' panel shows a list of configurations, with 'LN-ITB-All-20131219' selected. The 'Snapshot Id' panel shows a list of snapshots, with '525' selected. The main table displays the following data:

	PV Name	Saved Connection	Not Restore	Saved Value	Live Value	Diff
1	LN-RF:1 {Mod} State-RB	Disconnected	<input checked="" type="checkbox"/>			N/A
2	LN-RF:2 {Mod} State-RB	Disconnected	<input checked="" type="checkbox"/>			N/A
3	LN-RF:3 {Mod} State-RB	Disconnected	<input checked="" type="checkbox"/>			N/A
4	LN-RF:PB {Cav} Drv:PhaCtrl-SP	Connected	<input type="checkbox"/>	36.0	32.0	-4.0
5	LN-RF:PB {Cav} Drv:ValD-SP	Connected	<input type="checkbox"/>	36.0	32.0	-4.0
6	LN-RF {Mtr:1} Pos-Set	Connected	<input type="checkbox"/>	147.0	151.0	4.0
7	LTB-MG {Quad:9} I:Sp1-SP	Connected	<input type="checkbox"/>	47.8	47.8	
8	LN-RF {Mod:3} E:HVP5-SP	Connected	<input type="checkbox"/>	1165.0	1165.0	
9	LN-RF {Mod:3} Wth:Pulse-SP	Connected	<input type="checkbox"/>	3.0	3.0	
10	LTB-MG {Bend:1} I:Sp1-SP	Connected	<input type="checkbox"/>	85.0	85.0	
11	LTB-MG {Bend:2} I:Sp1-SP	Connected	<input type="checkbox"/>	0.0	0.0	
12	LTB-MG {Bend:3_4} I:Sp1-SP	Connected	<input type="checkbox"/>	60.84	60.84	
13	LTB-MG {Quad:1} I:Sp1-SP	Connected	<input type="checkbox"/>	0.0	0.0	
14	LTB-MG {Quad:2} I:Sp1-SP	Connected	<input type="checkbox"/>	20.0	20.0	
15	LTB-MG {Quad:3} I:Sp1-SP	Connected	<input type="checkbox"/>	0.0	0.0	
16	LTB-MG {Quad:4} I:Sp1-SP	Connected	<input type="checkbox"/>	0.0	0.0	
17	LN-MG {STE}:PS-01:I-SP	Connected	<input type="checkbox"/>	0.2	0.2	
18	LN-MG {STE}:PS-02:I-SP	Connected	<input type="checkbox"/>	0.9	0.9	
19	LN-MG {STE}:PS-03:I-SP	Connected	<input type="checkbox"/>	-0.9	-0.9	
20	LN-MG {STE}:PS-04:I-SP	Connected	<input type="checkbox"/>	-0.6	-0.6	
21	LN-MG {STE}:PS-05:I-SP	Connected	<input type="checkbox"/>	-1.1	-1.1	
22	LN-MG {STE}:PS-06:I-SP	Connected	<input type="checkbox"/>	-1.4	-1.4	
23	LN-MG {STE}:PS-07:I-SP	Connected	<input type="checkbox"/>	-0.6	-0.6	
24	LN-MG {STE}:PS-08:I-SP	Connected	<input type="checkbox"/>	-1.1	-1.1	
25	LN-MG {STE}:PS-09:I-SP	Connected	<input type="checkbox"/>	0.0	0.0	
26	LN-MG {STE}:PS-10:I-SP	Connected	<input type="checkbox"/>	0.0	0.0	
27	LN-MG {STE}:PS-11:I-SP	Connected	<input type="checkbox"/>	-0.8	-0.8	
28	LN-MG {STE}:PS-12:I-SP	Connected	<input type="checkbox"/>	-0.5	-0.5	

At the bottom of the window, there are buttons for 'Display Snapshot(s)', 'Restore Machine', 'Compare Live Machine', 'Save Machine Snapshot ...', 'Compare Snapshots...', and 'Export Snapshot to File ...'. A status bar at the bottom indicates 'Snapshot data of LN-ITB-All-20131219 saved at 2014-01-15 08:40:43'.

EPICS V4 based Middle Layer Service

- Multiple data sets comparison

Support up to 9 data sets

The screenshot displays the MASAR Compare Snapshots interface. The main window shows a table with columns for PV name, Saved Value 1 (in snapshot 338), Saved Value 2 (in snapshot 335), Saved Value 3 (in snapshot 331), Saved Value 4 (in snapshot 330), Live Value 0, Delta21, Delta31, and Delta41. The table lists 30 rows of data, including PV names like LN-RF:3{Cav}DrvAmpCtrl-SP, LN-RF:3{Cav}DrvValC-SP, and LN-BI{ES}cam1:AcquireTime. The interface also includes a left sidebar with a 'Config Filter' and a 'Select Config(s)' list, and a bottom section with 'Snapshots Desc', 'Author', and 'Use time range' options.

	PV name	Saved Value 1 (in snapshot 338)	Saved Value 2 (in snapshot 335)	Saved Value 3 (in snapshot 331)	Saved Value 4 (in snapshot 330)	Live Value 0	Delta21	Delta31	Delta41
1	LN-RF:3{Cav}DrvAmpCtrl-SP	0.345	0.344	0.326	0.347		-0.001	-0.019	0.002
2	LN-RF:3{Cav}DrvValC-SP	0.345	0.344	0.326	0.347		-0.001	-0.019	0.002
3	LTB-BI{ES}cam1:AcquireTime	0.08	0.02	0.02	0.02		-0.06	-0.06	-0.06
4	LN-BI{BPM:1}Trig:AdcDelay-SP	1173200	0	0	0		-1173200	-1173200	-1173200
5	LN-RF:1{Cav}DrvPhaCtrl-SP	15.0	1.4	0.5	1.2490009027e-16		-13.6	-14.5	-15.0
6	LN-RF:1{Cav}DrvValD-SP	15.0	1.4	0.5	1.2490009027e-16		-13.6	-14.5	-15.0
7	LTB-MG{Quad:1}I:RampEnd1-SP	16.0	0.0	0.0	18.0		-16.0	-16.0	2.0
8	LN-RF{BPS:1}E-Set	86.0	84.0	86.0	86.0		-2.0		
9	LN-RF:PB{Cav}DrvPhaCtrl-SP	29.85	9.45	18.9	23.95		-20.4	-10.95	-5.9
10	LN-RF:PB{Cav}DrvValD-SP	29.85	9.45	18.9	23.95		-20.4	-10.95	-5.9
11	LN-RF{Mtr:3}Pos-Set	56.0	53.0	56.0	56.0		-3.0		
12	LTB-BI{VF:1}cam1:Gain	5.0	1.0	2.0	2.0		-4.0	-3.0	-3.0
13	LTB-BI{VF:2}cam1:Gain	4.0	0.0	5.0	5.0		-4.0	1.0	1.0
14	LN-BI{VF:2}cam1:AcquireTime	1.2e-05	0.00015	0.00015	0.00015		0.000138	0.000138	0.000138
15	LTB-MG{Cor:1}I:RampEnd1-SP	-0.5	0.0	-0.5	-0.5		0.5		
16	LN-RF:1{Mod}E:HVPS-SP	1185.0	1186.0	1185.0	1185.0		1.0		
17	LTB-BI{CT:1}AveVROIOverINOS-LN	10.0	20.0	10.0	10.0		10.0		
18	LTB-MG{Quad:2}I:RampEnd1-SP	0.0	18.0	0.0	0.0		18.0		
19	LN-RF{Mtr:2}Pos-Set	44.0	68.0	44.0	44.0		24.0		
20	LN-RF:BUN{Cav}DrvPhaCtrl-SP	-8.1	31.2	30.25	-114.6		39.3	38.35	-106.5
21	LN-RF:BUN{Cav}DrvValD-SP	-8.1	31.2	30.25	-114.6		39.3	38.35	-106.5
22	LN-RF:3{Cav}DrvPhaCtrl-SP	-16.15	-8.9	-8.55	-9.05		7.25	7.6	7.1
23	LN-RF:3{Cav}DrvValD-SP	-16.15	-8.9	-8.55	-9.05		7.25	7.6	7.1
24	LN-BI{VF:4}cam1:AcquireTime	1.2e-05	0.0001	0.0001	0.0001		8.8e-05	8.8e-05	8.8e-05
25	INJ-TS{EVG}Rate-Sel		1 Hz	1 Hz	1 Hz		N/A	N/A	N/A
26	LTB-MG{Bend:2}I:RampEnd1-SP						N/A	N/A	N/A
27	LTB-BI{ES}Go-Sel						N/A	N/A	N/A
28	LTB-BI{CT:1}Gain1-Sel	+20dB	+0dB	+20dB	+20dB		NotEqual		
29	LTB-BI{CT:1}Gain2-Sel	+6dB	+20dB	+6dB	+6dB		NotEqual		
30	LTB-BI{VF:2}Go-Sel	lightest	no filter	lightest	lightest		NotEqual		



EPICS V4 based Middle Layer Service

- Waveform data

The screenshot displays the MASAR Viewer interface. On the left, there are panels for 'Config Name' and 'Snapshot Id'. The main area shows a table of PVs with columns for 'PV Name', 'Saved Connection', 'Not Restore', and 'Saved'. A 'waveform data' window is open on the right, showing a plot of 'Saved data Value' (blue line) and 'Live data Value' (red line) over 100 data points. The plot shows a signal that fluctuates between approximately 30 and 70, with a sharp drop to 0 at data point 35.

PV Name	Saved Connection	Not Restore	Saved
196 LN-MG{STE}:PS-09:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
197 LN-MG{STE}:PS-10:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
198 LN-MG{STE}:PS-11:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
199 LN-MG{STE}:PS-12:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
200 LN-MG{STE}:PS-13:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
201 LN-MG{STE}:PS-14:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
202 LN-MG{STE}:PS-15:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
203 LN-MG{STE}:PS-16:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
204 LN-MG{STE}:PS-17:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
205 LN-MG{STE}:PS-18:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
206 LN-MG{STE}:PS-19:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
207 LN-MG{STE}:PS-20:Cmd-Pwr	Connected	<input type="checkbox"/>	ON
208 LTB-MG{Cor:6}:I:Sp1-SP	Connected	<input type="checkbox"/>	1.942890
209 LTB-MG{Quad:6}:I:Sp1-SP	Connected	<input type="checkbox"/>	0.0
210 LTB-MG{Cor:5}:I:Sp1-SP	Connected	<input type="checkbox"/>	0.4
211 LN-RF:PB{Cav}Drv:Ampr-SP	Connected	<input type="checkbox"/>	(40, 66, ...)
212 LN-RF:PB{Cav}Drv:Pha-SP	Connected	<input type="checkbox"/>	(40, 66, ...)
213 LN-RF:PB{Cav}Drv:ValE-SP	Connected	<input type="checkbox"/>	40.0
214 LN-RF:PB{Cav}Drv:ValF-SP	Connected	<input type="checkbox"/>	20.8
215 LN-RF:PB{Cav}Drv:ValG-SP	Connected	<input type="checkbox"/>	0.4
216 LN-RF:PB{Cav}Drv:ValH-SP	Connected	<input type="checkbox"/>	10.0
217 LN-RF:PB{Cav}Drv:ValI-SP	Connected	<input type="checkbox"/>	0.05
218 LN-RF:PB{Cav}Drv:ValJ-SP	Connected	<input type="checkbox"/>	0.0
219 LN-RF:PB{Cav}Window:Start-SP	Connected	<input type="checkbox"/>	10.0
220 LN-RF:PB{Cav}Window:Width-SP	Connected	<input type="checkbox"/>	10.0
221 LN-RF:PB{Cav}Trig:Edge-Sel	Connected	<input type="checkbox"/>	Rise
222 LN-RF:PB{Cav}Trig:Dly-SP	Connected	<input type="checkbox"/>	0
223 LN-RF:BUN{Cav}Drv:Ampr-SP	Connected	<input type="checkbox"/>	(40, 66, ...)

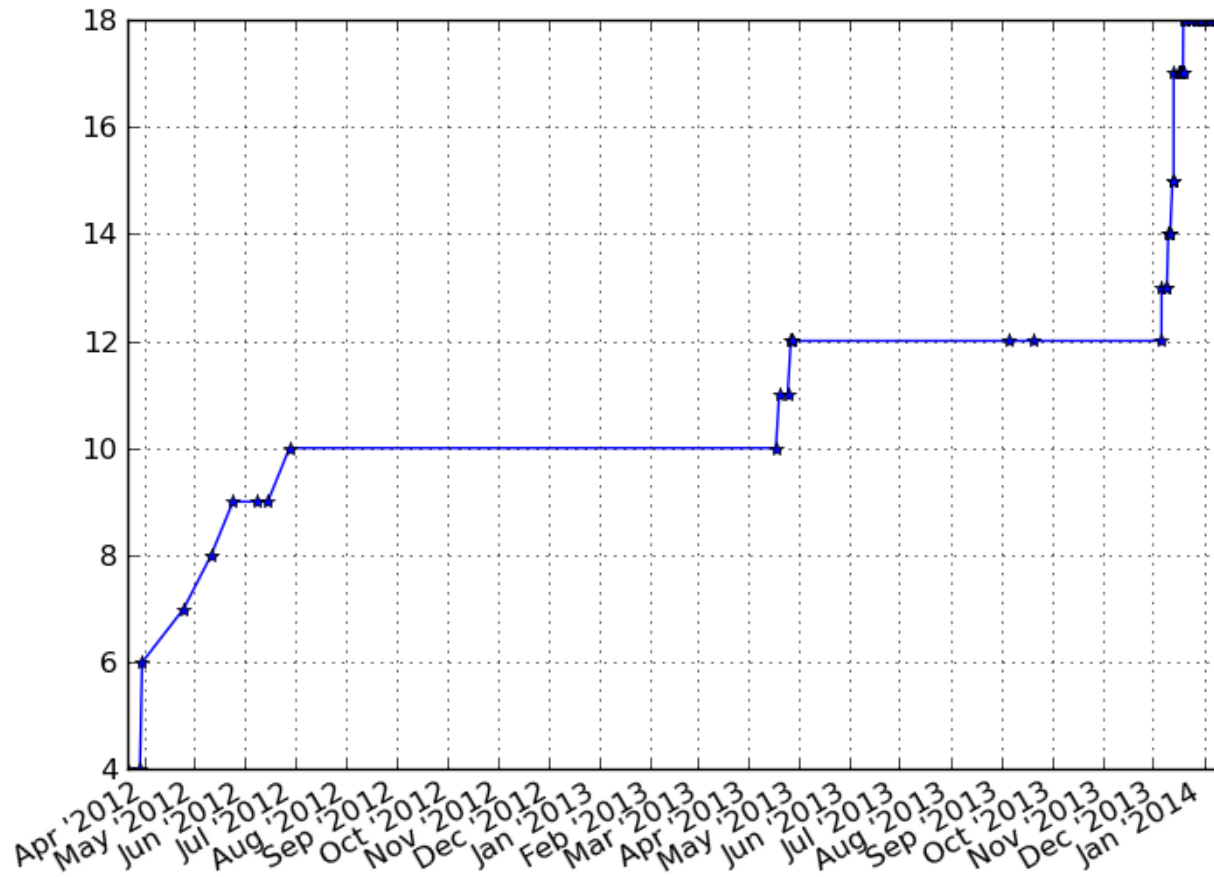
Config Name	Snapshot Id	Snapshot Desc
1 LN-LTB-All-20131219	525	200 MeV
2 LN-LTB-All-20131219	524	200 MeV
3 LN-LTB-All-20131219	523	200MeV
4 LN-LTB-All-20131219	522	200 MeV
5 LN-LTB-All-20131219	521	200 MeV
6 LN-LTB-All-20131219	520	200 MeV
7 LN-LTB-All-20131219	519	Fred Refl
8 LN-LTB-All-20131219	518	Fluctuati
9 LN-LTB-All-20131219	517	200 MEV
10 LN-LTB-All-20131219	516	200 MeV

#	saved value	live data
0	40	40
1	66	66
2	60	60
3	61	61
4	69	69
5	41	41

EPICS V4 based Middle Layer Service

- Deployed in control network from the first day (3/27/2012)
- Configuration increasing over time (by Jan 15 2014 10:51 AM)

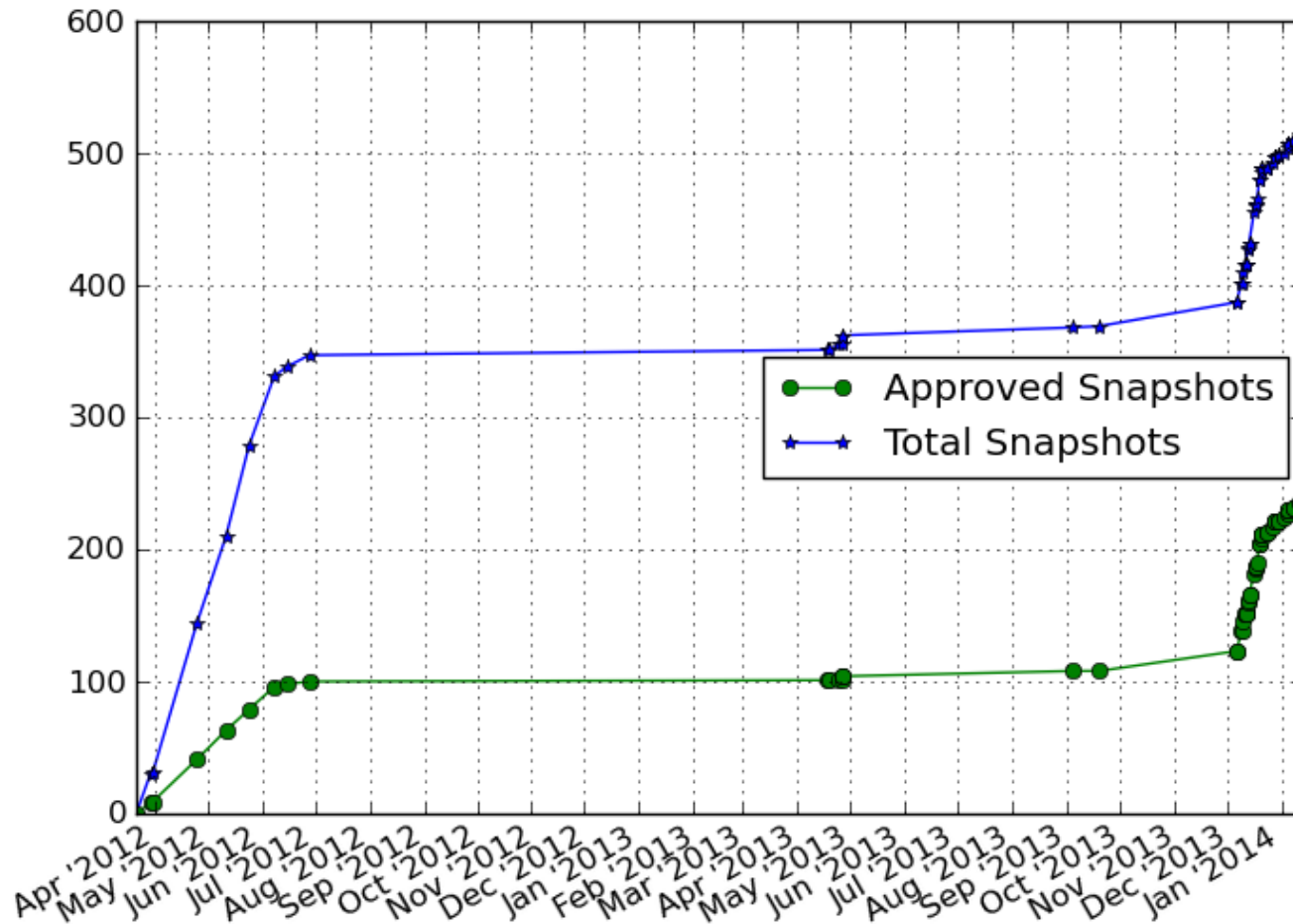
Configurations



EPICS V4 based Middle Layer Service

- Snapshots taken over time (by Jan 15 2014 10:51 AM)

Snapshots



EPICS V4 based Middle Layer Service

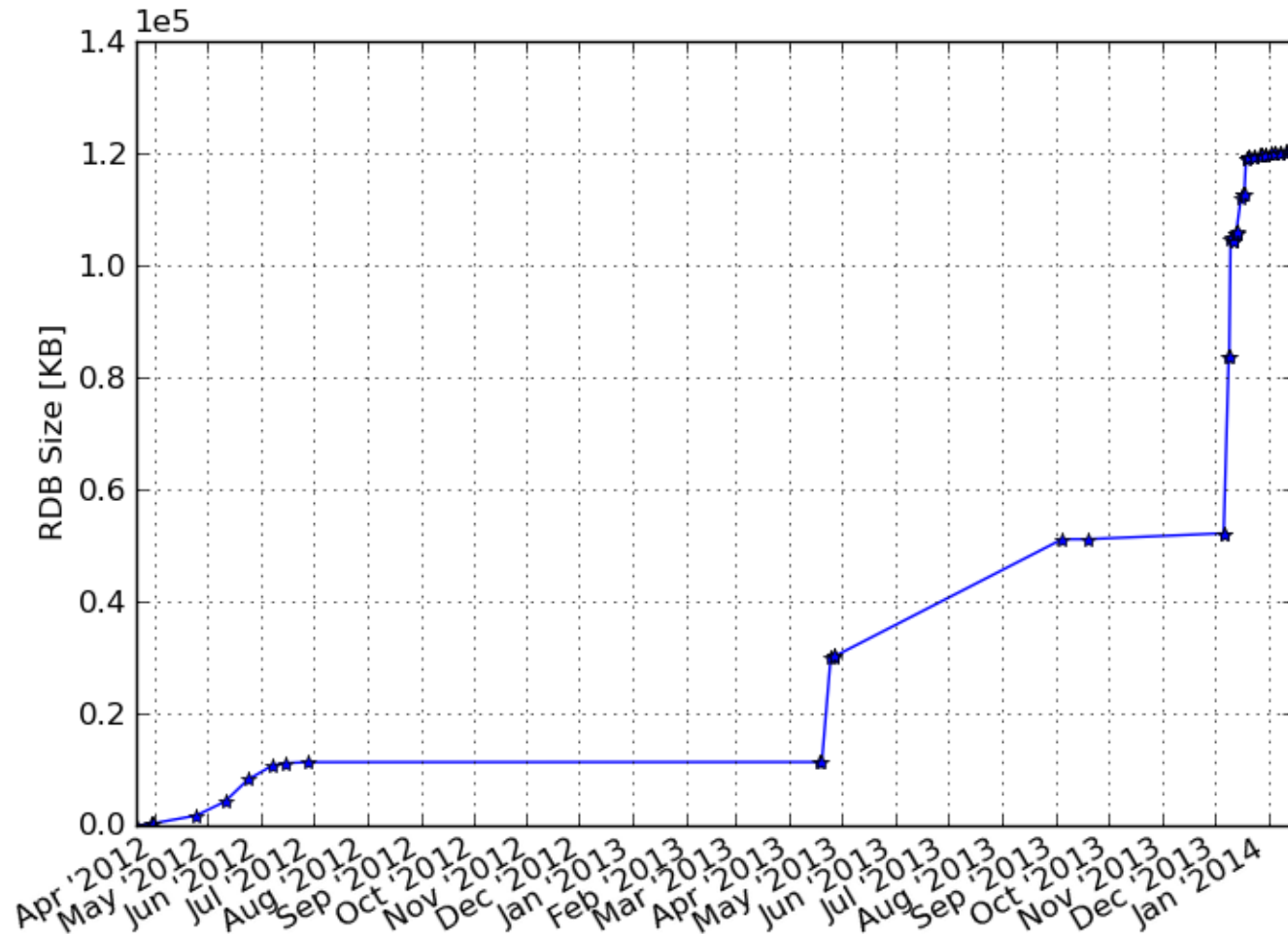
- Snapshots taken with time
 - Events (by Jan 15 2014 10:51 AM) total taken: 525, approved: 246
 - Regular snapshot per shift

Date	Snapshots taken	Snapshots Approved
2012-03-21 9:28	0	0
2012-03-29 10:32	30	8
2012-03-30 18:01	31	9
2012-04-24 20:02	144	41
2012-05-11 10:27	210	63
2012-05-24 14:25	279	79
2012-06-07 18:28	331	96
2012-06-14 16:13	338	98
2013-12-17 7:34	460	186
2013-12-20 16:01	488	212
2013-12-23 14:48	489	213
2013-12-26 18:40	493	217
2013-12-27 18:18	497	221
2013-12-30 13:54	498	222
2014-01-02 12:12	500	224
2014-01-14 2:29	519	240
2014-01-15 8:40	525	246

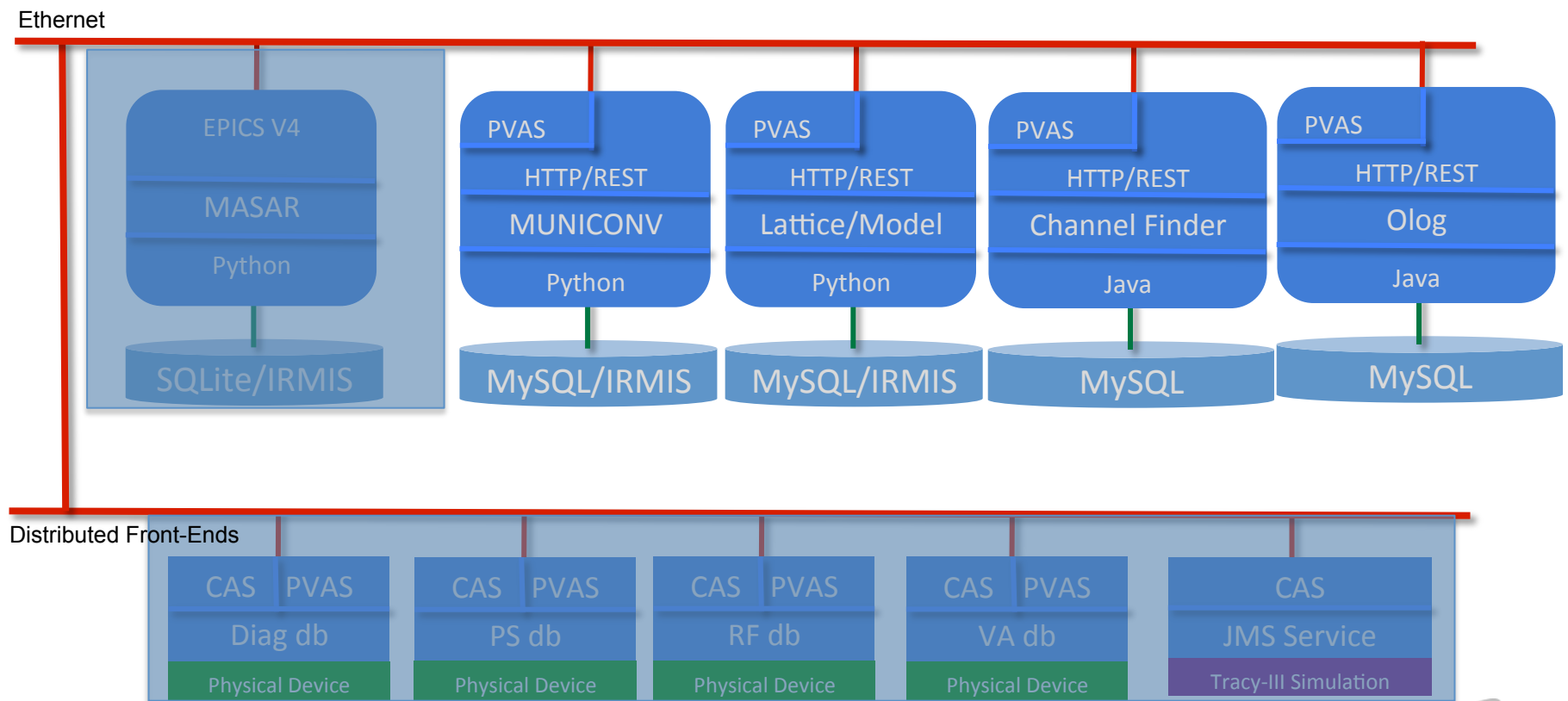
EPICS V4 based Middle Layer Service

- Database size growing over time

(by Jan 15 2014 10:51 AM) MASAR Database Size Growing



RESTful based Middle Layer Services

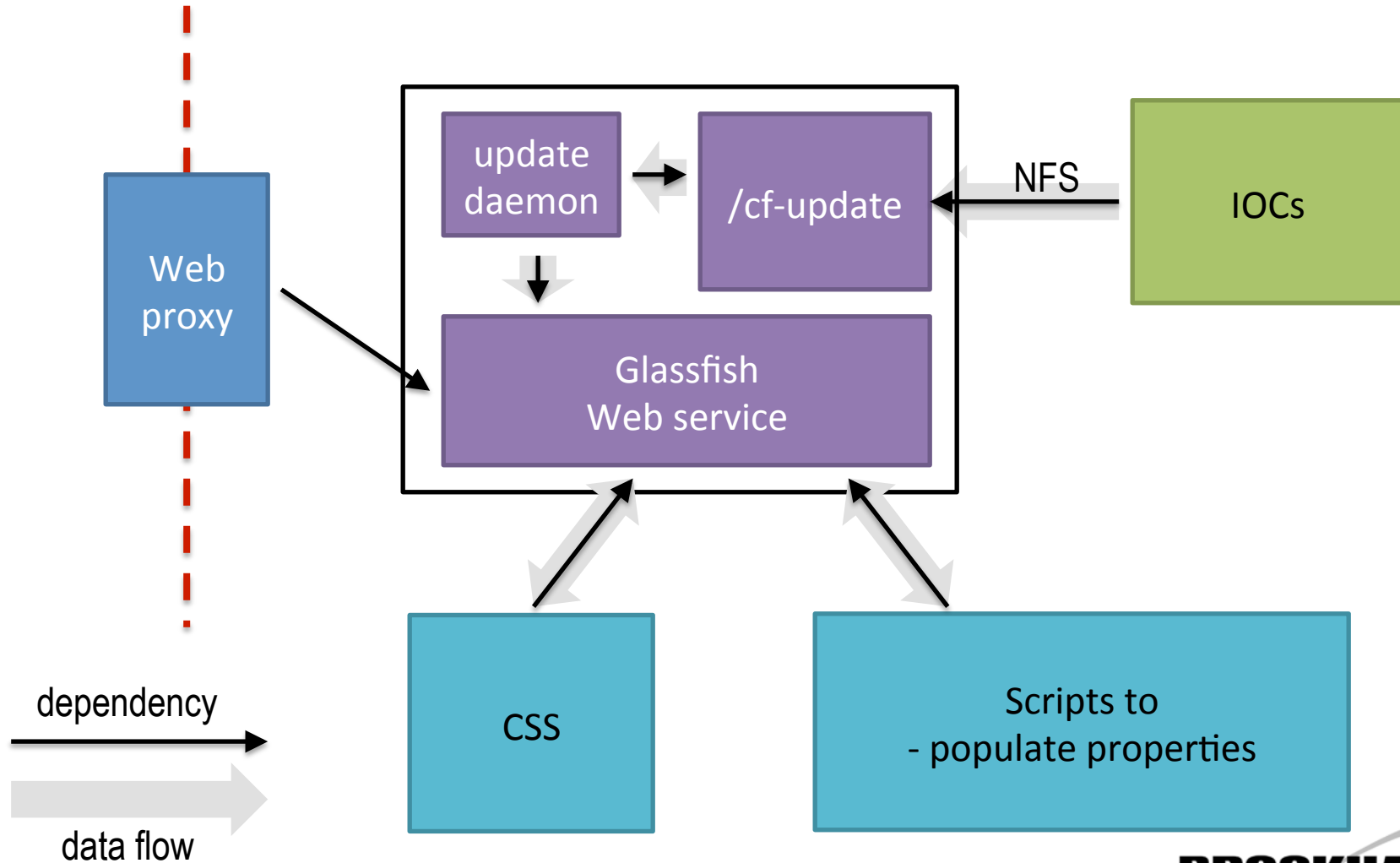


RESTful based Middle Layer Services

- Channel finder services
 - Originally by Ralph Lange
 - Channel name look-up service
 - Support property (name-value pair)
 - Support tags
 - Automatically load EPICS Channels at IOC initialization
 - Client support
 - Python library
 - CS-Studio
 - J2EE service
 - MySQL as RDB backend

RESTful based Middle Layer Services

- Channel finder



RESTful based Middle Layer Services

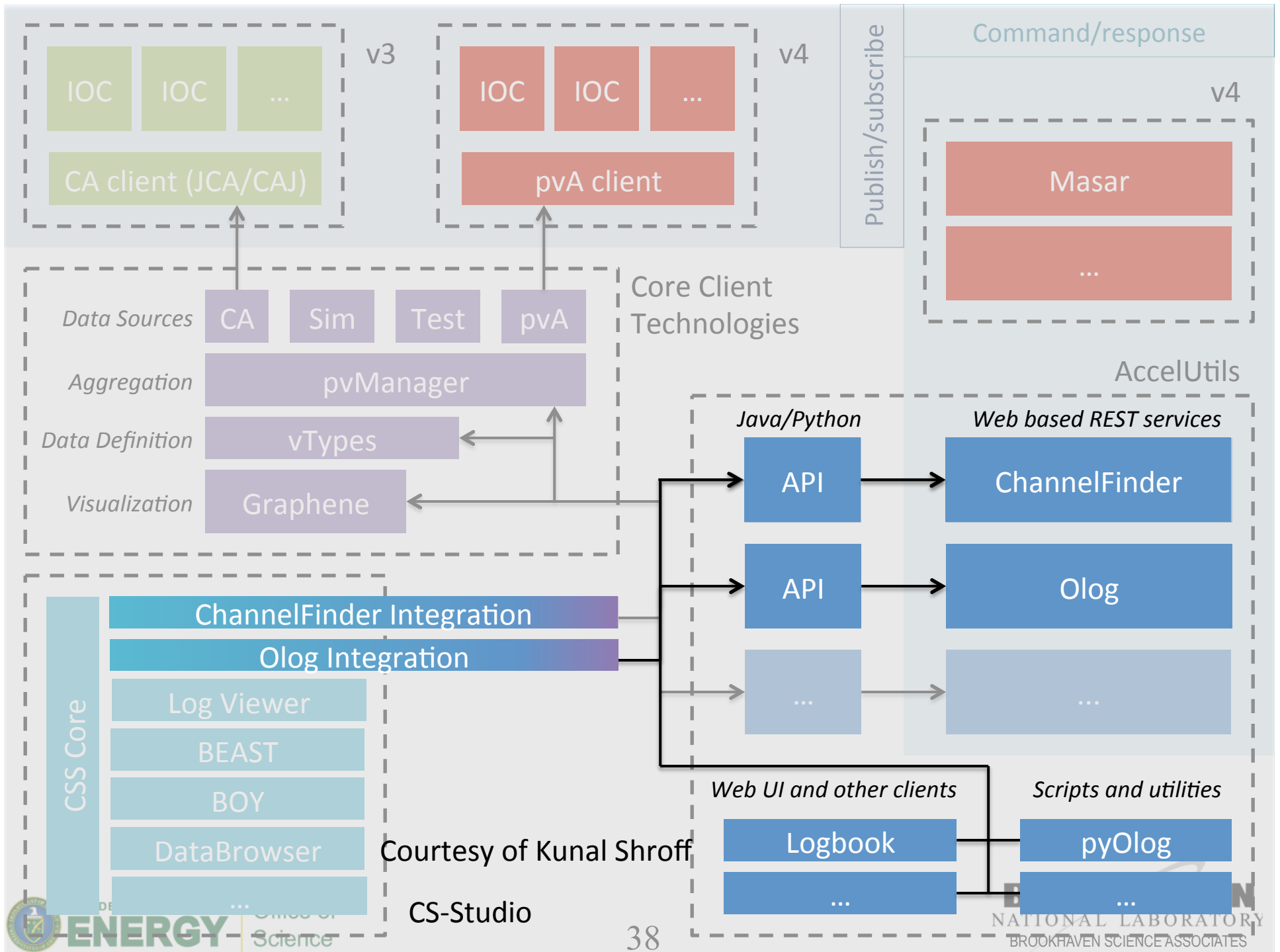
- Virtual accelerator property into channel finder

Channel Name	V2:SR:C02-MG:G04A{HFCor:FM1}		V2:SR:C02-MG:G04A{VFCor:FM1}	
	Fld-I	Fld-SP	Fld-I	Fld-SP
handle	READBACK	SETPOINT	READBACK	SETPOINT
elemName	FXM1G4C02A		FYM1G4C02A	
elemType	HFCOR		VFCOR	
elemField	x		y	
devName	FM1G4C02A			
sEnd	65.5222			
cell	C02			
girder	G4			
symmetry	A			
length	0.044			
ordinal	263		264	
tags	eget	eput	eget	eput
	x		y	
	36		sys.SR	



RESTful based Middle Layer Services

- Olog
 - Collaboration by NSLS II@BNL & FRIB@MSU
 - Log an entry
 - Time, owner, text, attachments, logbooks, tags, properties
 - J2EE service
 - MySQL as RDB backend
 - Client support
 - Python library
 - CS-Studio
 - Web interface



RESTful based Middle Layer Services

- Olog web view

borisp, 12/31/13, 7:25 am [Show details](#)

1.5 mA out 3 mA is boosted all the way to 3 GeV. Also corrected all the loss points passed 30 msec into the ramp.

Attachments

U.S. DEPARTMENT OF ENERGY Office of Science

RESTful based Middle Layer Services

- Olog CS-Studio view

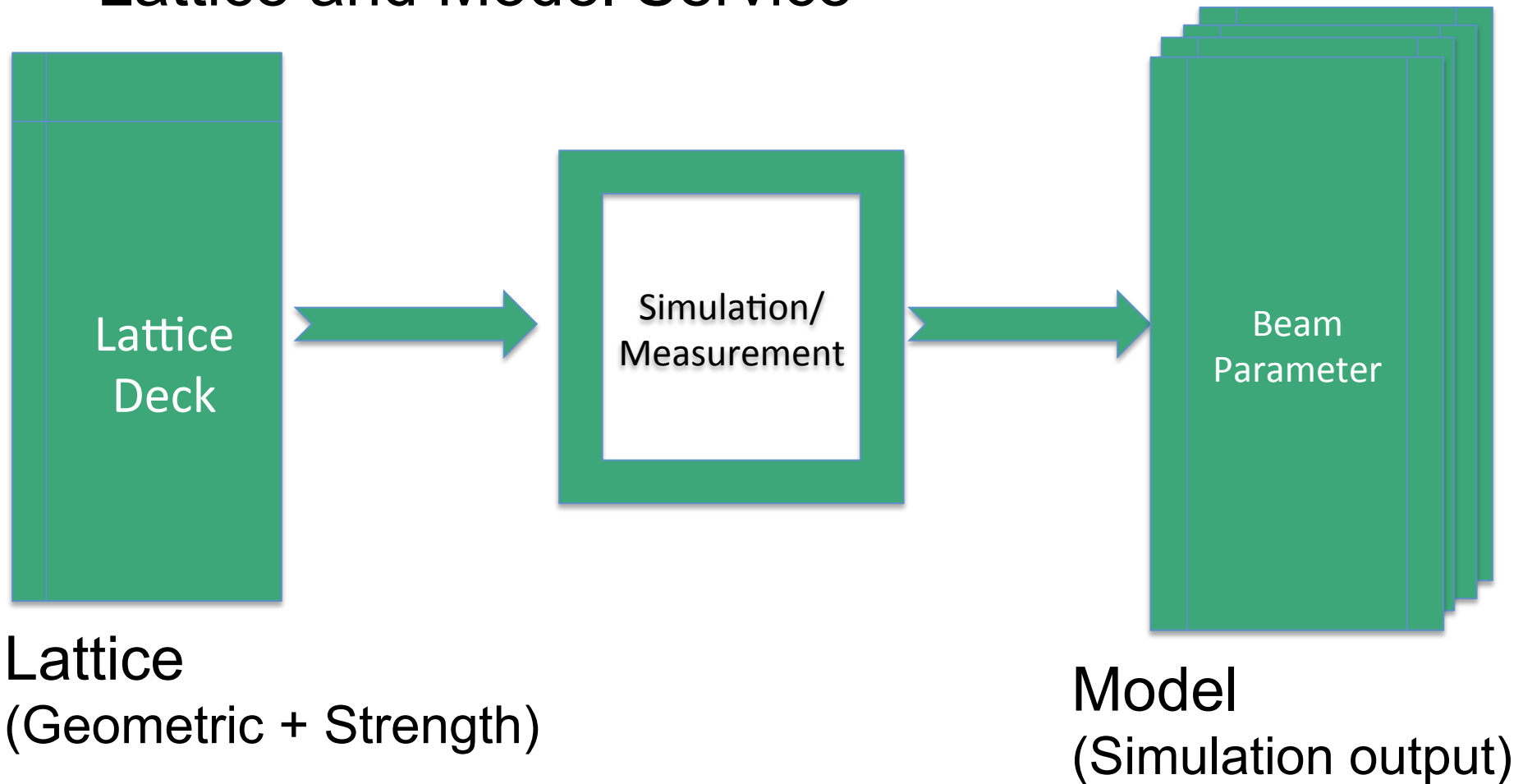
The screenshot displays the Control System Studio (HSL510) interface. The main window is divided into several panes:

- Log Table:** A table listing log entries with columns for Date, Description, Owner, Logbooks, and Tags. The log entries are filtered by the query '* logbook: Operations,DiffractionLog'.
- Log Entry:** A detailed view of a log entry, showing the date (Jul 11, 2013) and the description: 'Linac and Storage Ring Vacuum status screens'. It also includes a 'Logbooks' field set to 'Operations' and a 'Tags' field.
- Diagram:** A schematic diagram of the 'MSL 4-BI Linear Vacuum System'. The diagram shows a complex network of pipes, valves, and components, with various labels and numerical values. A legend on the left side of the diagram identifies different components and their states.

The interface also shows a menu bar (File, Edit, Search, CSS, Window, Help) and a toolbar with various icons. The system tray at the bottom indicates the user is logged in as 'shroffk' and the system is running on 'box32-2'.

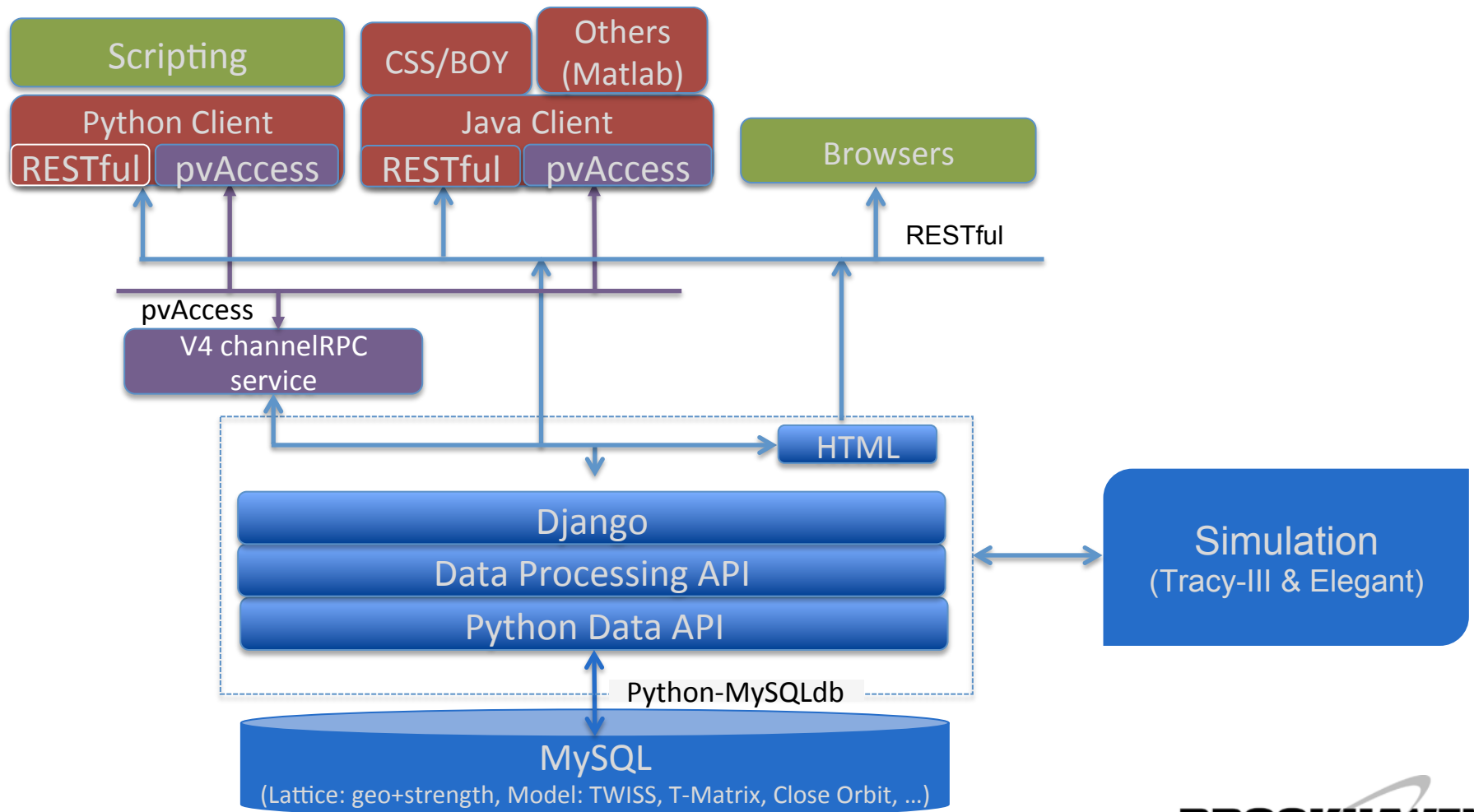
RESTful based Middle Layer Services

- Lattice and Model Service



RESTful based Middle Layer Services

- Lattice Model Service Architecture



RESTful based Middle Layer Services

- Service implemented under Django framework
 - Provide REST service interface
 - Currently, support RESTful GET & POST
 - 3 lattice deck acceptable
 - Predefined tab-separated plain lattice
 - Tracy-3
 - Elegant
 - 2 simulation codes support by server
 - Tracy-3 & elegant
 - Client support
 - Python library
 - Web UI
 - MySQL as RDB backend
 - V4 implementation has been planned on top

RESTful based Middle Layer Services

- Lattice view

Lattice & Model 0.1
Guest

Search

Search for:

Lattice

Model

Name:

Branch:

Version:

Description:

Creator:

Lattice type:

Status:

Search

Filter lattice ...

Select for comparison

Id: 1

Name: CD3-Oct3-12-30Cell-addID-par

Version: 20121003

Branch: Design

Desc: This is a design lattice released on Oct 3rd, 2012

Type: tracy3

Select for comparison

Id: 2

Name: CD3-Apr07-10-30cell-par

Version: 20100407

Branch: Design

Desc: This is a design lattice released on Apr 7th, 2010

Type: tracy3

Select for comparison

Id: 3

Name: mv15-t25c-v1-ring

Version: 20121003

Branch: Design

Desc: This is a design lattice released for test

Type: elegant

Select for comparison

Id: 4

Name: CD3-Oct3-12-30Cell-addID-par-plain

Version: 20121003

Branch: design

Desc: This is a design lattice released on Oct 3rd, 2012 with plain format

Type: plain

Select for comparison

Id: 5

Name: CD3-Oct3-12-30Cell-addID-par-plain2

Version: 20121003

Branch: design

Desc: This is a design lattice released on Oct 3rd, 2012 with plain format

Lattice Info

Id: 3

Name: mv15-t25c-v1-ring

Version: 20121003

Branch: Design

Creator: Weiming

Original Date: 2013-11-14T11:18:50

Lattice Type: elegant

Lattice Format: lte

Description: This is a design lattice released for test

Lattice Models

Creator	Description	Id	LatticeId	Link	Name	OriginalDate
lattice/model service	automatic simulation result performed by server on 2013-11-14 11:18:51.746867 AM	3	3	link to model	default model for mv15-t25c-v1-ring (branch Design, version 20121003)	2013-11-14T11:18:51

[Download the original file](#)
[Download zip with original file and maps](#)

Lattice

Id	Name	Type	Length	Position	ON_PASS	K2	K1	ANGLE	E1	E2
6903	_BEG_	MARK	0	0						
6904	MA1	MALIGN	0	0	1					
6905	MK4G1C30A	MARK	0	0						
6906	DH0G1A	DRIF	4.65	4.65						
6907	GEG1C30A	MULT	0	4.65						
6908	GSG2C30A	MULT	0	4.65						

RESTful based Middle Layer Services

- Model view

Lattice & Model 0.1 Guest

Search

Search for:
 Lattice
 Model

Name:

Status:

Filter models ...

Select for plotting

Mod 1
Id: 1
Name: default model for CD3-Oct3-12-30Cell-addID-par (branch Design, version 20121003)
Desc: automatic simulation result performed by server on 2013-11-14 11:18:41.640925 AM

Select for plotting

Mod 2
Id: 2
Name: default model for CD3-Apr07-10-30cell-par (branch Design, version 20100407)
Desc: automatic simulation result performed by server on 2013-11-14 11:18:44.336483 AM

Select for plotting

Mod 3
Id: 3
Name: default model for mv15-t25c-v1-ring (branch Design, version 20121003)
Desc: automatic simulation result performed by server on 2013-11-14 11:18:51.746867 AM

Select for plotting

Mod 4
Id: 4
Name: default model for test (branch test, version 20121003)
Desc: automatic simulation result performed by server on 2013-12-18 14:37:01.476276 PM

Select for plotting

Mod 5
Id: 5
Name: default model for mv15-t25c-v1-ring-2 (branch design, version 20131010)
Desc: automatic simulation result performed by server on 2013-12-18 14:52:15.846529 PM

SimulationControlFile: mv15-t25c-v1-ring.ele

SimulationAlgorithm: matrix

Tunex: 33.14757

Tuney: 16.27098

Select data to plot

alpha	alphay	betax	betay	etapx	etapy	etax	etay	phasesx	phasesy
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> 1	<input checked="" type="checkbox"/> 1	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/> 10	<input checked="" type="checkbox"/> 10	<input type="checkbox"/>	<input type="checkbox"/>

Model details

0 Twiss

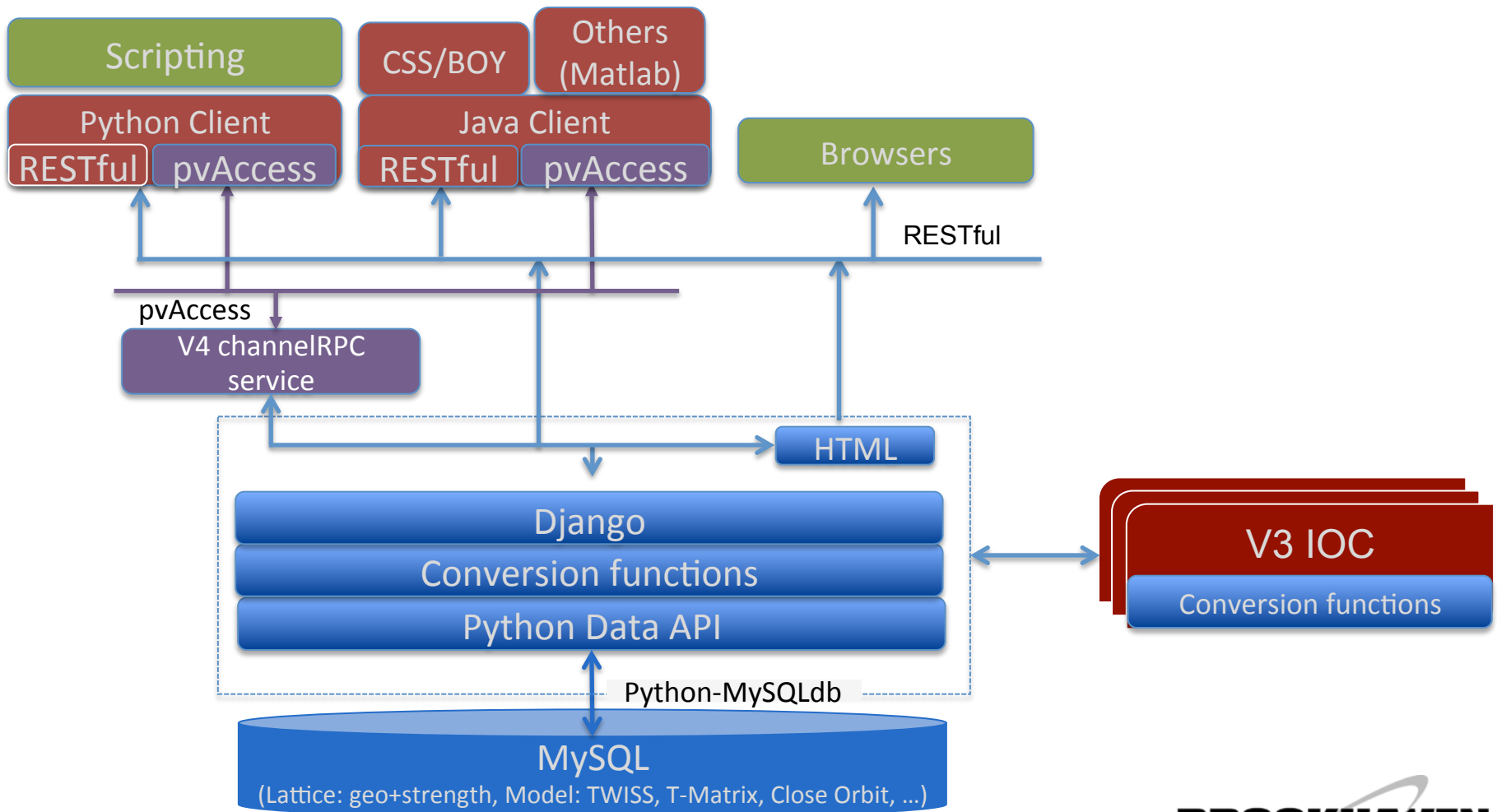
Decimal precision

RESTful based Middle Layer Services

- **MUNICONV Service**
 - Multiple unit conversion
 - First implementation targeting on magnets
 - Convert value between different unit systems
 - i: power supply current
 - b: magnetic fields
 - k: value in model/lattice domain
 - RESTful service interface under Django
 - Currently, support GET method
 - MySQL as RDB backend
 - Client support
 - Python library
 - Web UI
 - V4 implementation has been planned on top

RESTful based Middle Layer Services

- MUNICONV Architecture



RESTful based Middle Layer Services

- MUNICONV Data stored in RDB
 - Capture interested raw data
 - Measurement data, fitting parameters, fitting algorithm
 - Serial #, device name, installation info
 - Component type
 - Measurement data
 - For each individual magnet
 - For magnet type

RESTful based Middle Layer Services

- MUNICONV Capability
 - Convert value between predefined unit system
 - Unit is determined usually by magnet measurement
 - Conversion algorithm pluggable
- MUNICONV Support magnets
 - Standalone function magnet
 - Function combined magnet
 - A skew quadrupole with H&V correctors for example
 - Serial powered magnet chain

RESTful based Middle Layer Services

- Pluggable and extendable conversion algorithm

```
{'i2b': {'auxInfo': 1,           # auxInfo: an additional information,
        'function': "",        # could be used for example the fitting order
        'algorithmId': 1,     # of polynomial fitting,
        'initialUnit': "",    # 0: not use; 1: linear fit; 2: 2nd order poly
        'resultUnit': ""},   fit; ...
'b2i': {'auxInfo': 1,           # or the order of fitting result, for example
        'function': "",        # 1: kick angle, rad/degree;
        'algorithmId': 1,     # 2: K1, 1/m2;
        'initialUnit': "",    # 3: K2, 1/m3;
        'resultUnit': ""},   # 4: K3, 1/m4; ...
'b2k': {'auxInfo': 2,           # algorithmId: id to show which algorithm to use,
        'function': "",        # 0: linear fitting with given function
        'algorithmId': 0,     # 1: high order polynomial fitting with given function
        'initialUnit': "",    # 2: polynomial fitting using raw data
        'resultUnit': ""},   # 3: interpolating with raw magnetic data
...                             # 4: ...
}
```

RESTful based Middle Layer Services

- MUNICONV WEB View

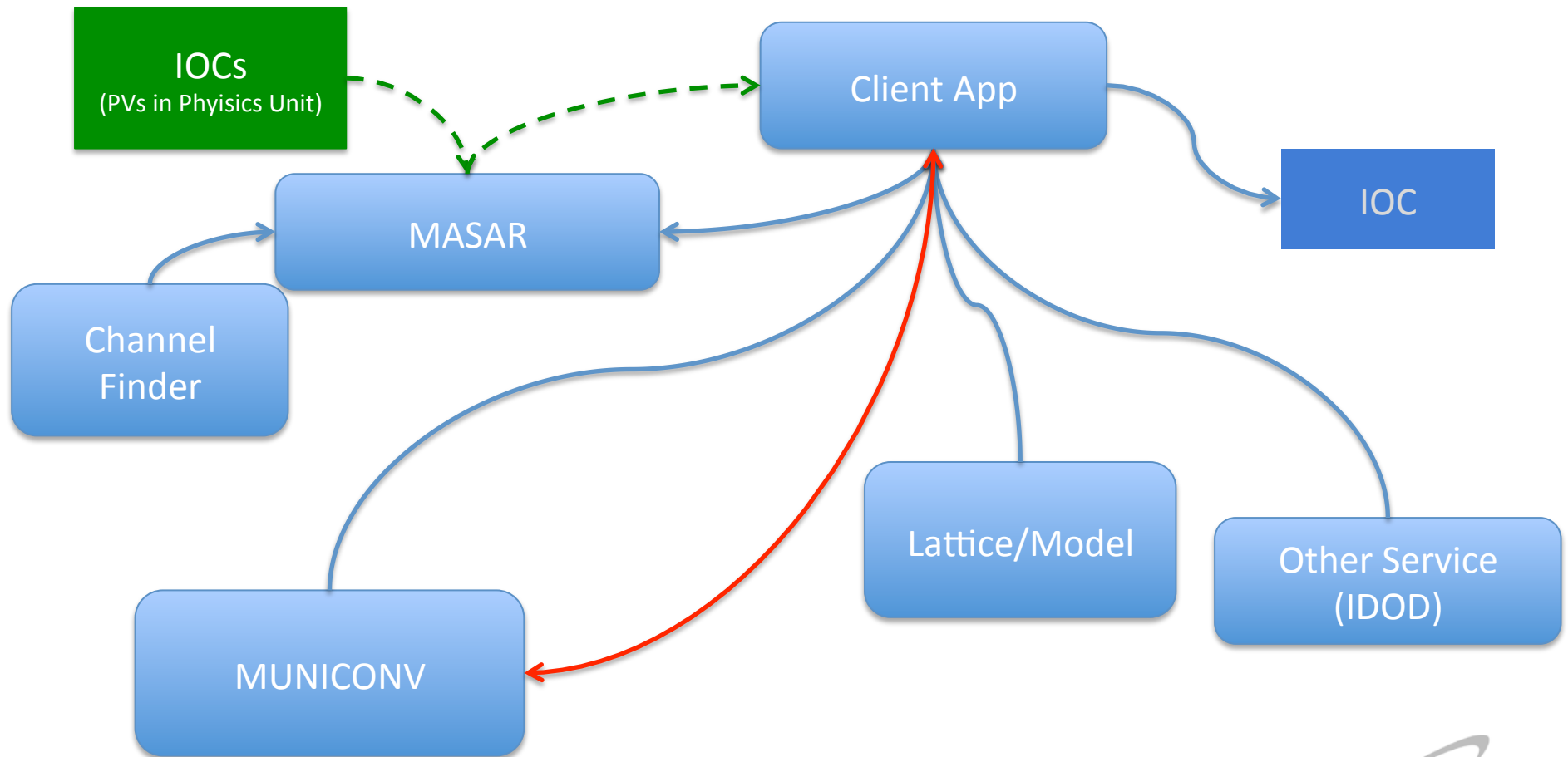
The screenshot displays the MUNICONV WEB View interface in a Mozilla Firefox browser. The page title is "Unit Conversion - Mozilla Firefox". The address bar shows the URL: `phyweb.cs.nsls2.local/magnets/web/#/type/install/system//name/QH*/cmpnt_type//serialno/jid/QH1G2C04A/0/results#QH1G2C04A`. The interface is divided into several sections:

- Search for devices:** Includes search filters for "Inventory" and "Installation", and input fields for "System", "Name" (containing "QH*"), and "Component type". A "Search" button is located at the bottom of this section.
- Filter devices ...:** A list of search results for "Quad D" components. The selected device is Ser No: 55, Name: QH1G2C04A, System: Storage Ring, Vendor: Tesla, England, Desc: 66mm, DBL COIL, SHORT QUAD.
- Conversion results:** A table showing conversion data for "i2k" and "i2b" algorithms. The table has columns for Algorithm, Initial value, Initial unit, Converted value, and Converted unit. A "Clear table" button is above the table.
- Plot:** A line graph showing "field" on the y-axis (ranging from 0.0000 to 0.1750) versus "current" on the x-axis (ranging from 0 to 120,000). The plot shows a linear relationship with data points and a legend for "Up" and "Conversion results". A "Redraw plot" button is located above the graph.

RESTful based Middle Layer Services

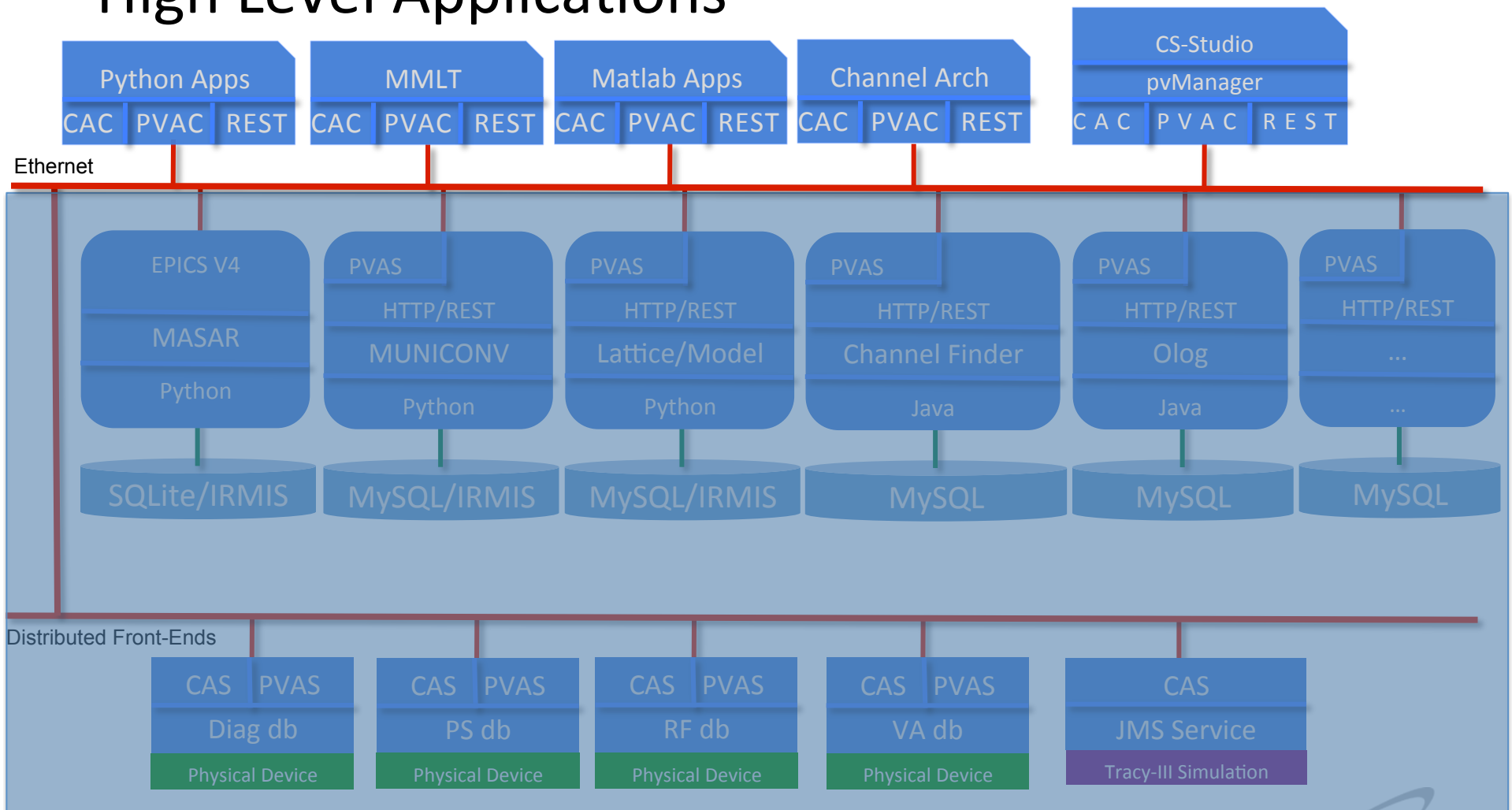
- IDOD service for insertion device
 - Data service to store both online data and offline data
 - Same architecture to be implemented using django
 - Under active development, and should be released soon
- Data service for beam based fast interlock
 - Provide a data warehouse
 - Keep all history data
 - Under design

Middle Layer Services Integration



Beam Commissioning

- High Level Applications

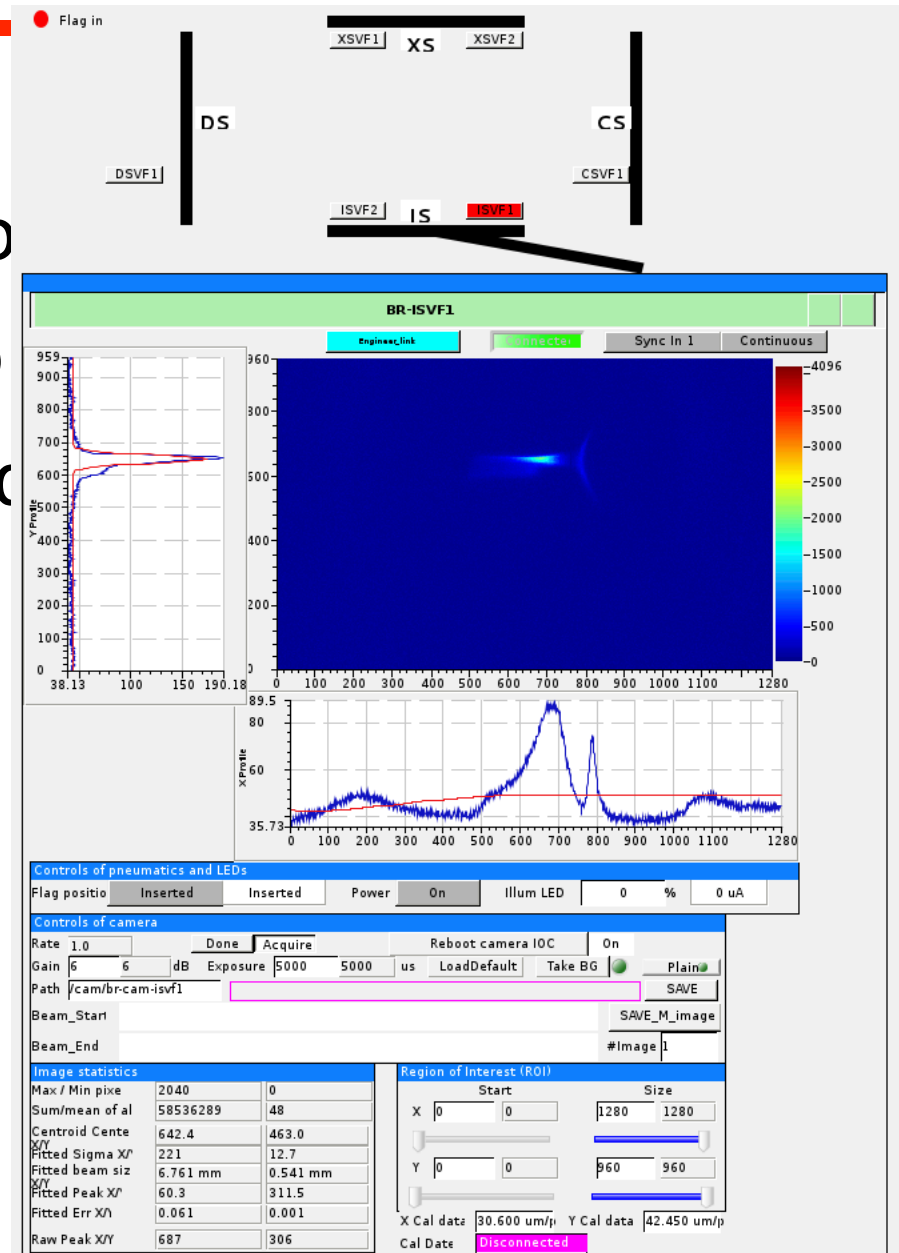


Beam Commissioning

- 2013-11-27: restart beam commissioning
- 2013-11-29: accelerate to 200 MeV in single

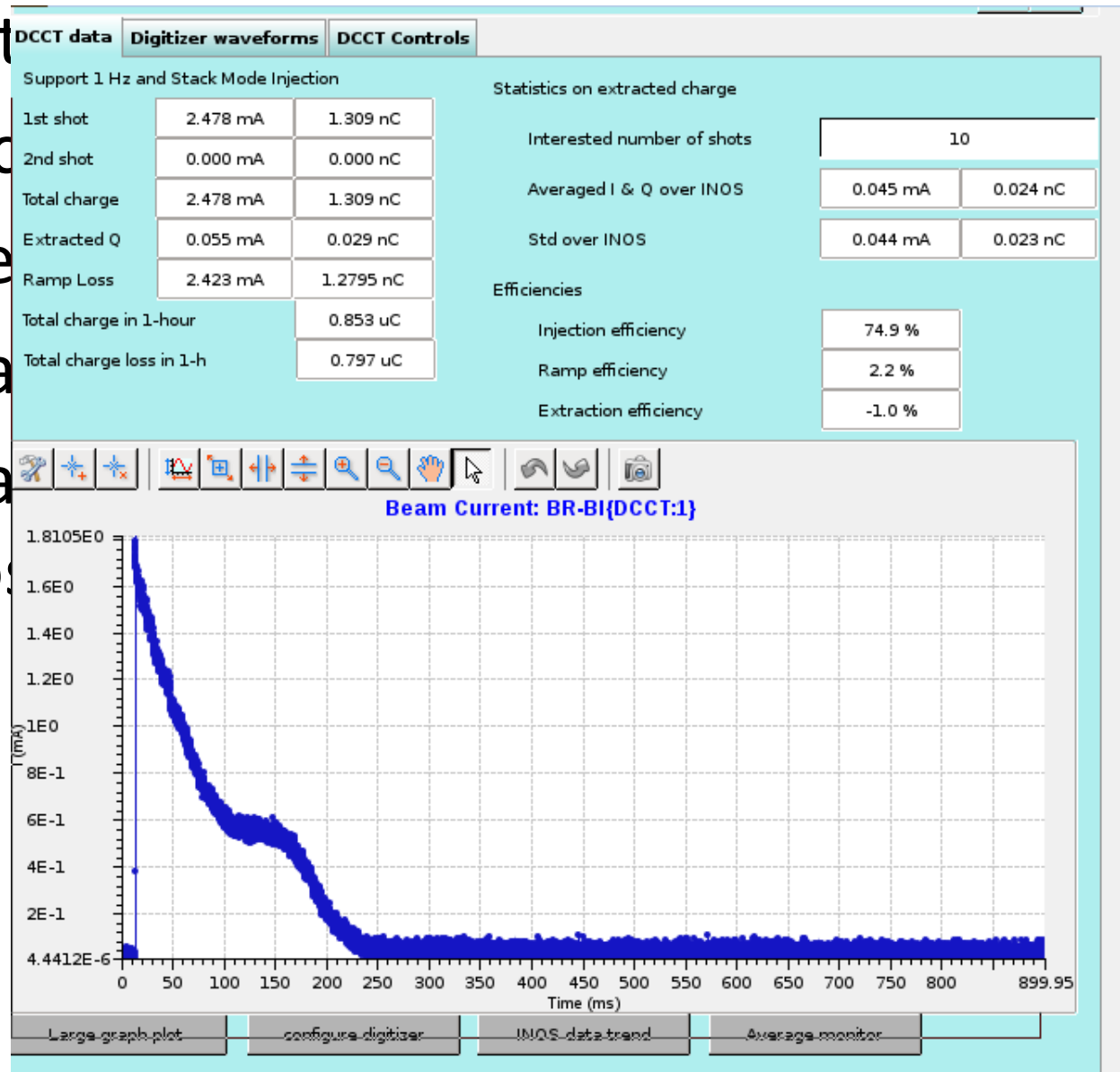
Beam Commissioning

- 2013-11-27: restart beam
- 2013-11-29: accelerate to
- 2013-12-07: injection into
- 2013-12-10: beam spinne



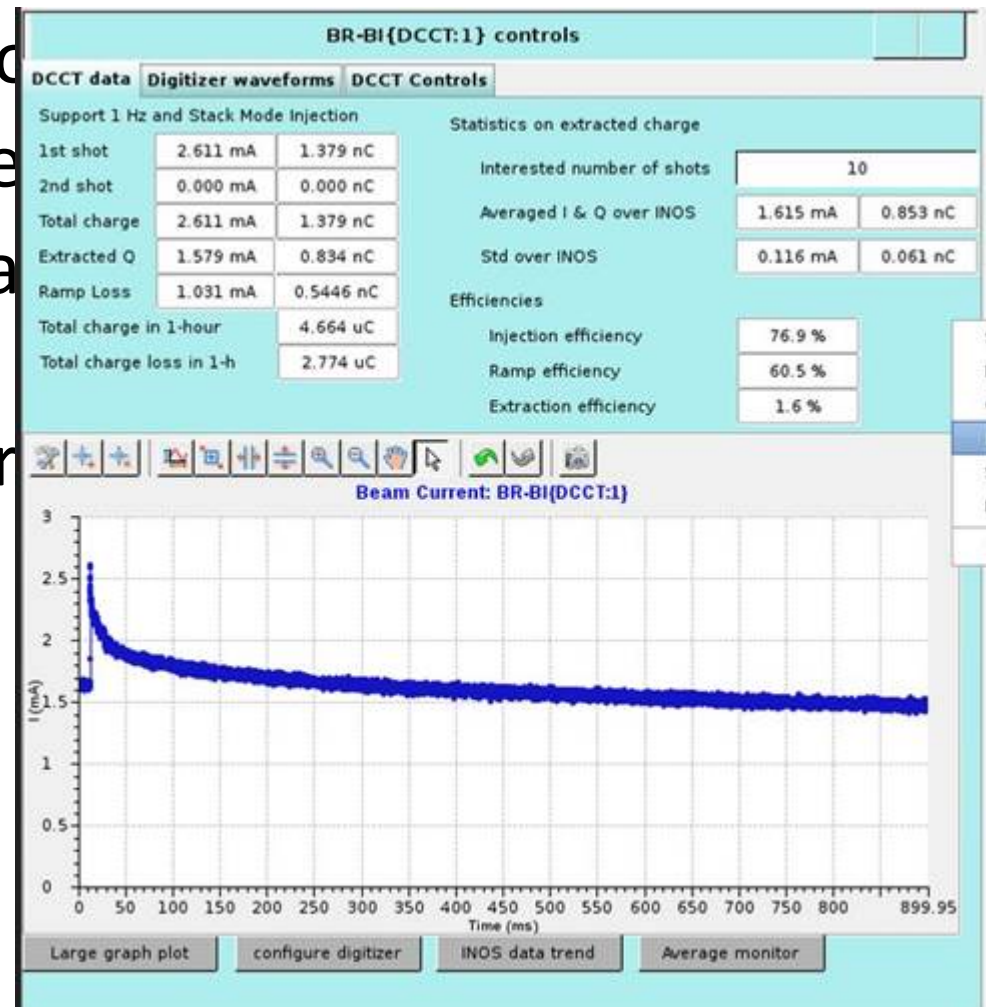
Beam Commissioning

- 2013-11-27: rest
 - 2013-11-29: acc
 - 2013-12-07: inje
 - 2013-12-10: bea
 - 2013-12-16: bea
- turns in the boos



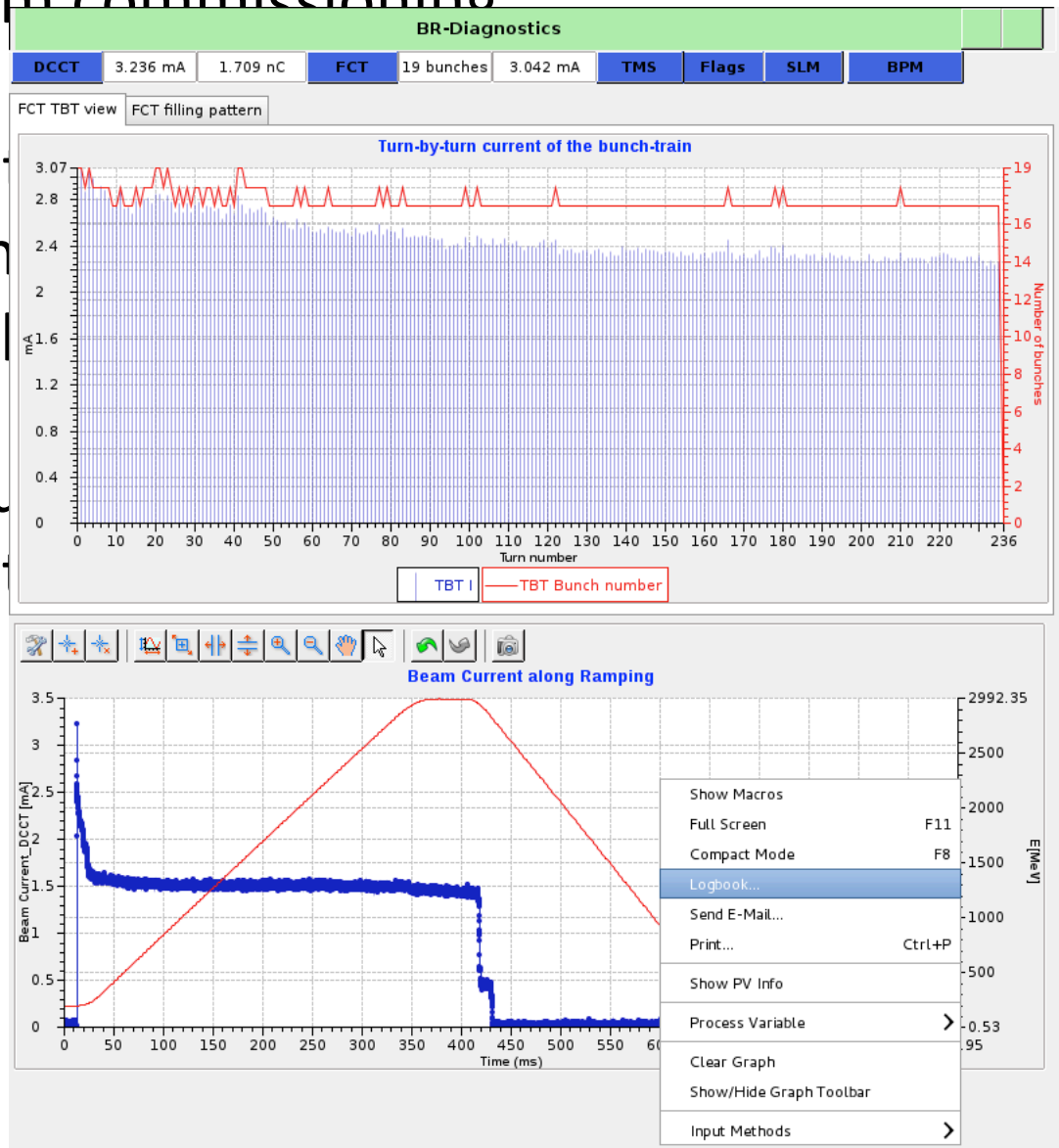
Beam Commissioning

- 2013-11-27: restart beam commissioning
- 2013-11-29: accelerate to 200 MeV in single
- 2013-12-07: injection into
- 2013-12-10: beam spinne
- 2013-12-16: beam circula
in the booster ring
- 2013-12-21: beam captur



Beam Commissioning

- 2013-11-27: restart beam commissioning
- 2013-11-29: accelerate
- 2013-12-07: injection in
- 2013-12-10: beam spinn
- 2013-12-16: beam circul
booster ring
- 2013-12-21: beam captu
- 2013-12-31: beam boost



NSLS II Construction

- Oct 2009



NSLS II Construction

• Oct 2010



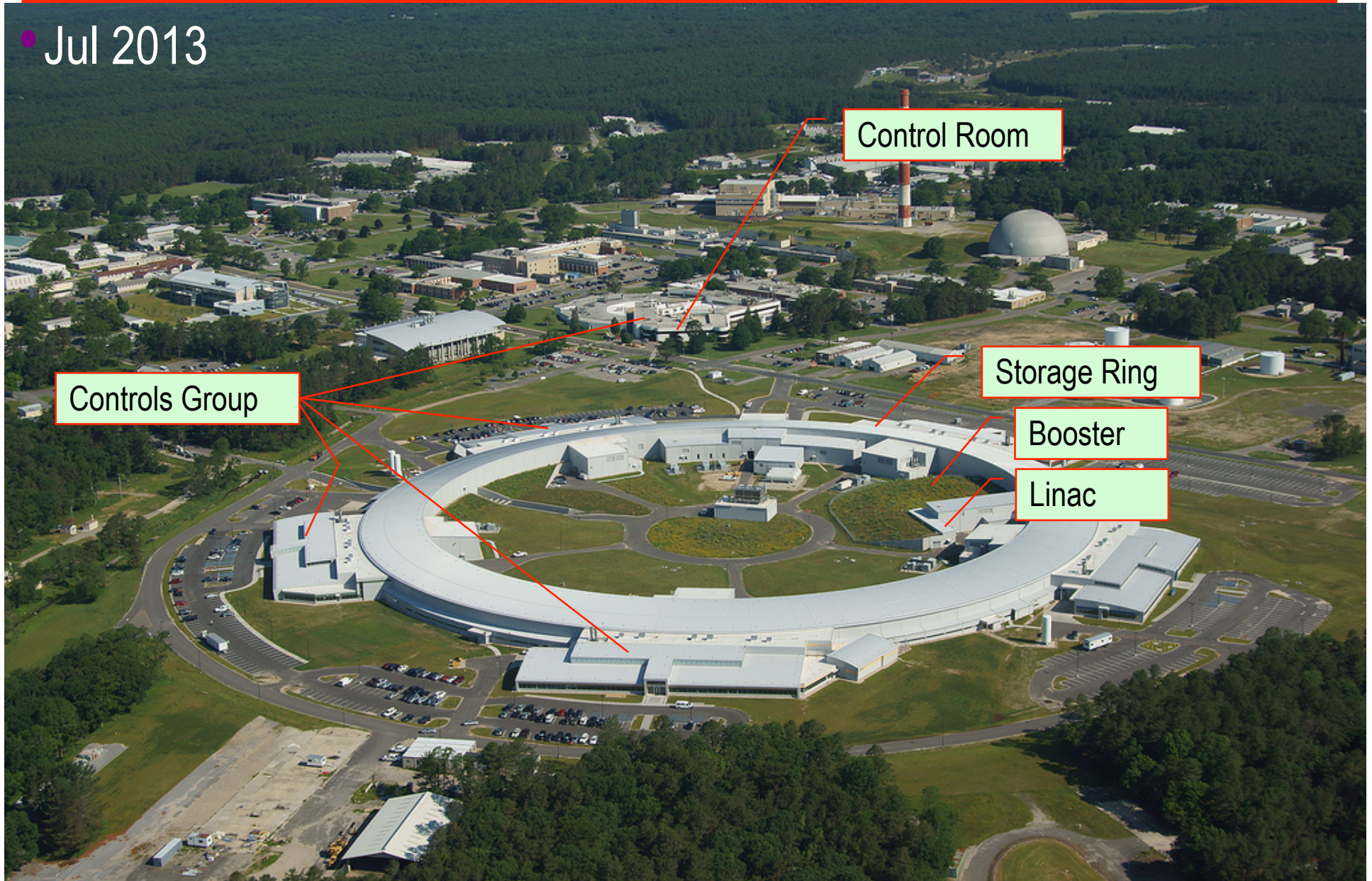
NSLS II Construction

• Oct 2011



NSLS II Construction

Jul 2013



Conclusion

- Overviewed NSLS II project
- Virtual accelerator provided solid support
- 2 technologies for middle services
 - V4 service, and RESTful web services
 - Satisfy various requirement
 - Play critical role during commissioning
- Support beam commissioning well
 - Beam to 3GeV on 2013-12-31