High Level Applications Infrastructure and Current Status

J. Choi, G. Shen, L. Yang

NSLS-II Accelerator Physics Group Meeting

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Outline

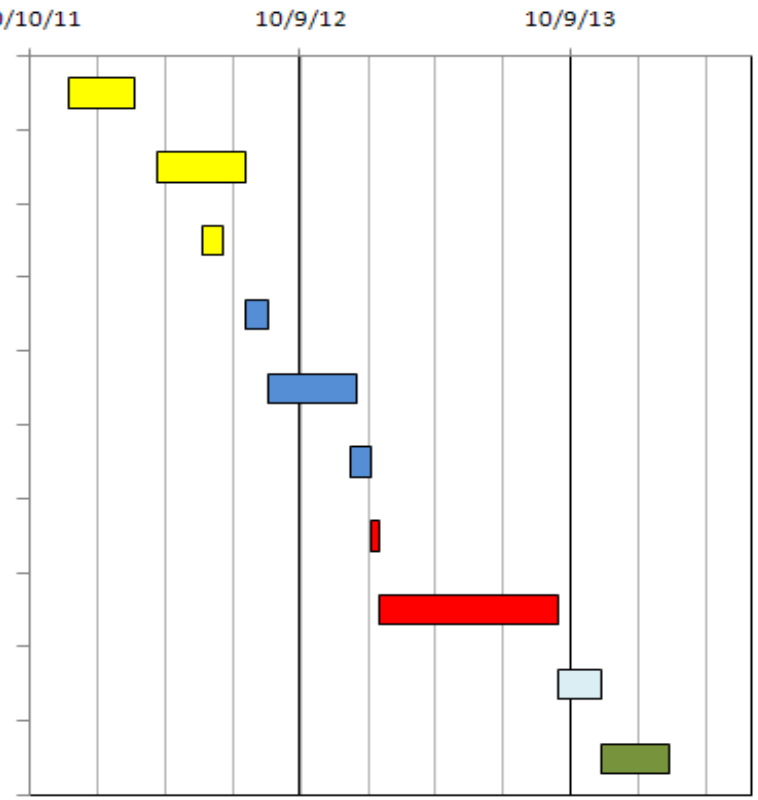
- Software requirement
- Application manual and spec
- System infrastructure
- Current status
- Tools to be provided and developed
- Expanding for further applications
- Remarks

Software Requirement

- References
  1. J. Bengtsson, B. Dalesio, T. Shaftan, T. Tanabe. “NSLS-II: Model Based Control - A Use Case Approach”, Tech-note 51, Oct 2008
  2. F. Willeke, “Assumptions on NSLS-II Accelerator Commissioning”, Nov. 2009
  3. F. Willeke, “The Path to Accelerator Commissioning”, talk on ASD Project Meeting, Jan 2010
  4. S. Krinsky, “NSLS-II Storage Ring Commissioning”, talk on NSLS-II ASD Retreat, May 2010
  5. Other discussions with AP and control group members, and other experts from ALS/SLAC.

Software Requirement

Start	End	Dur	
12/1/2011	2/29/2012	90	LINAC Front end Commissioning
3/30/2012	7/28/2012	120	LINAC Commissioning
5/29/2012	6/28/2012	30	LBTL in LINAc Commissioning
7/28/2012	8/27/2012	30	LBTL Commissioning
8/27/2012	12/25/2012	120	Booster Commissioning
12/15/2012	1/14/2013	30	BSTL in Booster Tunnel Commissioning
1/14/2013	1/24/2013	10	BSTL Commissioning
1/24/2013	9/21/2013	240	Storage Ring Commissioning Part I
9/21/2013	11/20/2013	60	ID Installation
11/20/2013	2/18/2014	90	Storage Ring Commissioning Part II



- Commissioning schedule [2, 3, 4]

Software Requirement

Commissioning Stages

LINAC Frontend (gun pre-buncher) early delivery, commissioning and early tests by NSLS-II staff in RF Lab, Special bunch modes

LINAC commissioning by the vendor (responsible)
LtBTL (LINAC building part) commissioned by NSLS-II-Staff , primary + secondary beam dump

Booster
LBTL commissioning by NSLS-II staff in parallel to booster integrated testing
Booster commissioning by vendor (vendor's responsibility), participation of NSLS-II staff
BSTL (part in booster tunnel) performed by NSLS-II staff with project responsibility

Storage Ring Commissioning Phase 1 (without ID)
BSTL commissioning and injection set up ; the storage ring beam optics; adequacy of correction systems; adequacy of safety and ALARA systems; efficient injection; adequacy of beam instrumentation; orbital stability; RF set up and stability; RF conditioning; cryogenic stability; beam stability; vacuum integrity and conditioning; high intensity operations

Storage Ring Commissioning Phase 2
Integrate Insertion devices

- Commissioning stages by F. Willeke [3]

Software Requirement

SR Subsystem Status at Commissioning

- integrated testing complete
- Injectors and transfer lines commissioned
- personal safety system and interfaces thoroughly tested
- equipment protection system is fully implemented and tested via the control system.
- magnets systems installed well before commissioning,
- precision alignment shortly before commissioning
- insertion devices will not be installed
- power supply systems are complete, technical interlocks have been properly tested
- vacuum system has a vacuum of at least 10^{-7} mbar
- two sc RF cavities installed driven by a single 310kW transmitter station.
- full suite of beam diagnostics is installed and tested
- water cooling systems have been installed tested
- timing system implemented
- control system is fully implemented
- relational database is fully functional
- all application programs deemed necessary for commissioning available
- injection systems have been installed and tested
- fast orbit feedback has been implemented
- transverse feedback damper system installed and tested

- SR subsystem status at commissioning by F. Willeke [3]

Software Requirement

Applications needed for Commissioning

Operation Software
overall status page
status, alarm and warning monitor
permit system monitor and control
data logger and data display
electronic logbook

Operations Software
accelerator store/restore
Injection Control
power supply control
RF control
fast orbit feedback control
fast transverse damper control
front-end monitoring and control
machine protection displ &contr
magnet temp. interlock dspl & contr
scraper and collimators
system turn-on, system shutdown

Major Subsystem Control
Power supply page
RF monitor and control
Vacuum display and control
Cryogenics system display and control
pulsed magnet monitor and control
injection element display and control
Insertion device control
Front-end control and status

Beam Diagnostics
Beam Orbit page with
Beam current history and lifetime
bunch intensity display and history
beam emittance display
Timing system display and control
Synchronization system displ & contr
Tune display and control
Temperature monitoring display

Safety Systems
personal protection system status
equipment protection display and control
beam containment display and control
top-off status monitor

Utility Control
tunnel temperature and humidity monitor
mechanical utilities status and control
electrical utilities status and controls
equipment enclosure monitor
water cooling system display
controls network monitor

Accelerator physics applications
•static orbit corrections, first turn steering,
•chromatic correction,
•response matrix measurements,
•phase advance measurements,
•beam base alignment measurement,
•bpm test programs,
•beam optics measurement,
•beam based alignment of sextupoles,
•analysis on nonlinearities
•dispersion measurement and correction,
•closed Orbit bump page

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- Applications needed for commissioning by F. Willeke [3]

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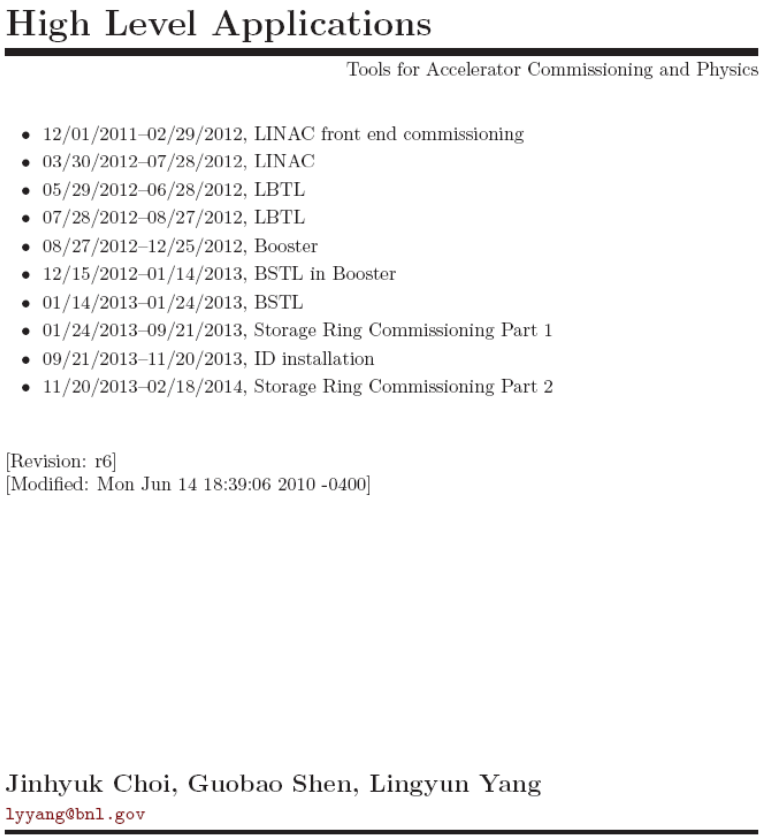
Application Manual and Spec

- Requirements in references
  - Defined in a “one line” form, very brief.
  - Reorganize them as a complete and orthogonal set of functions.
- Application manual and spec
  - Compile from references
  - Examples and usage
  - Algorithm description
  - Data structure
  - API definition and formalize
  - Will be available in webpage form in control room.



High Level Applications

Tools for Accelerator Commissioning and Physics

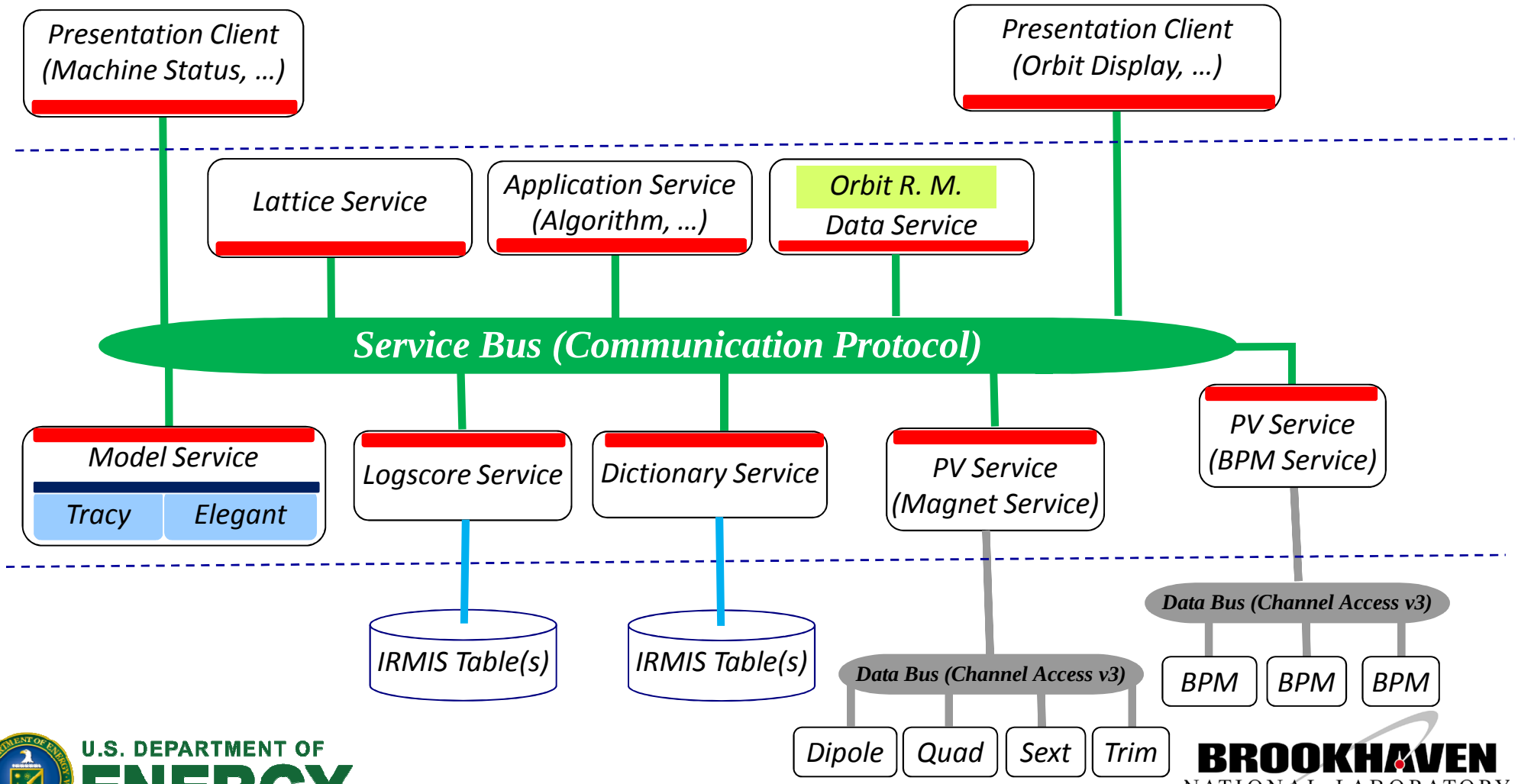
- 12/01/2011–02/29/2012, LINAC front end commissioning
- 03/30/2012–07/28/2012, LINAC
- 05/29/2012–06/28/2012, LBTL
- 07/28/2012–08/27/2012, LBTL
- 08/27/2012–12/25/2012, Booster
- 12/15/2012–01/14/2013, BSTL in Booster
- 01/14/2013–01/24/2013, BSTL
- 01/24/2013–09/21/2013, Storage Ring Commissioning Part 1
- 09/21/2013–11/20/2013, ID installation
- 11/20/2013–02/18/2014, Storage Ring Commissioning Part 2

[Revision: r6]
[Modified: Mon Jun 14 18:39:06 2010 -0400]

Jinhyuk Choi, Guobao Shen, Lingyun Yang
lyyang@bnl.gov

System Infrastructure

- System infrastructure to satisfy the requirement and support AP software development

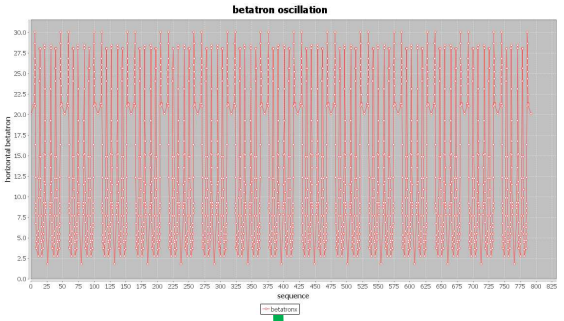


Current Status

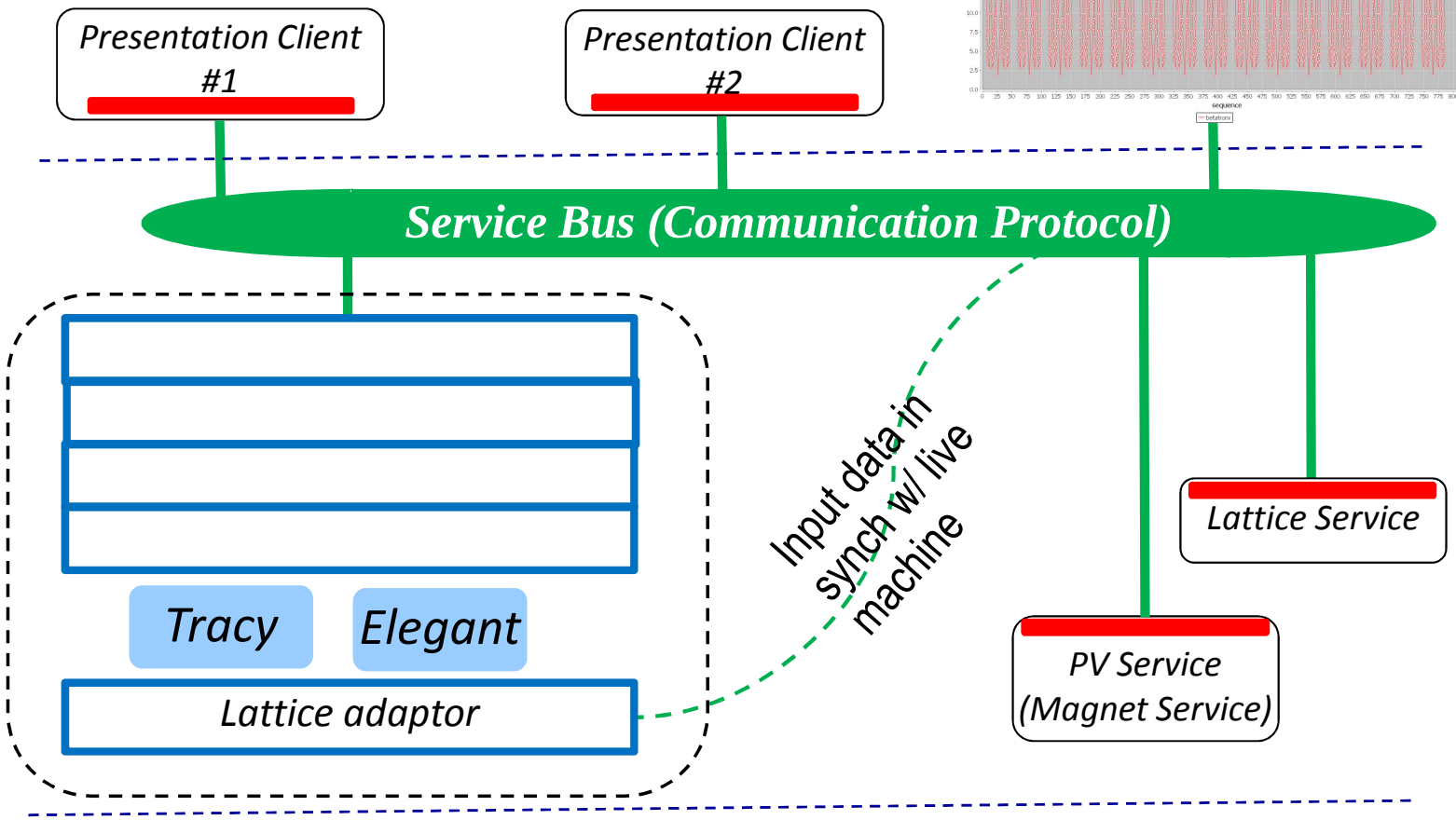
- Model service prototype
- PV service so-called gather prototype
- Directory service so-called channel finder prototype
- Demo application developed against the architecture
  - Orbit display
  - Local bump
  - BBA (ongoing)

Current Infrastructure Status

- Structure of model service

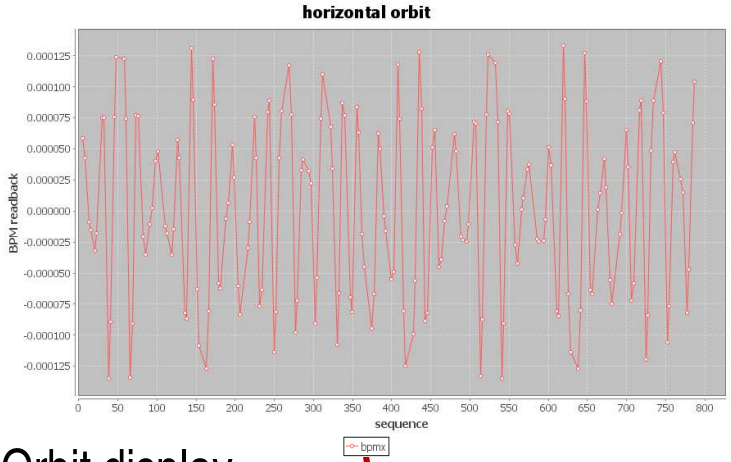


Beta function

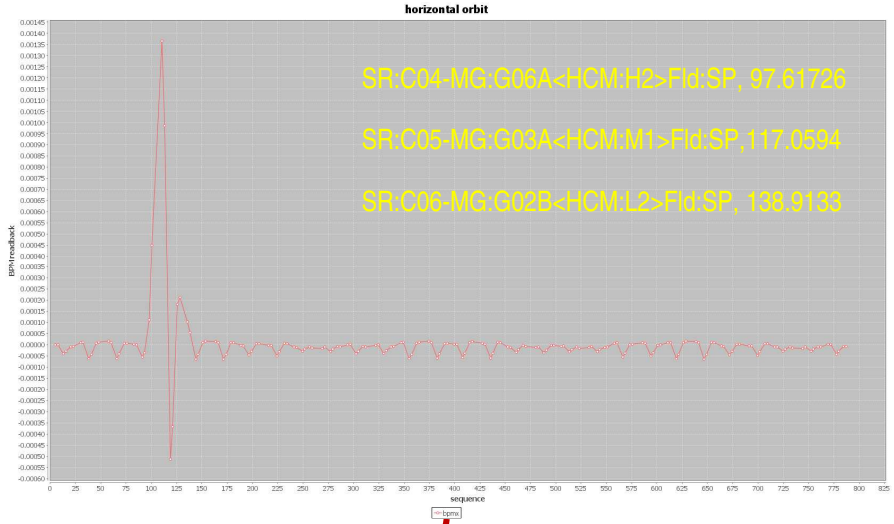


Current Infrastructure Status

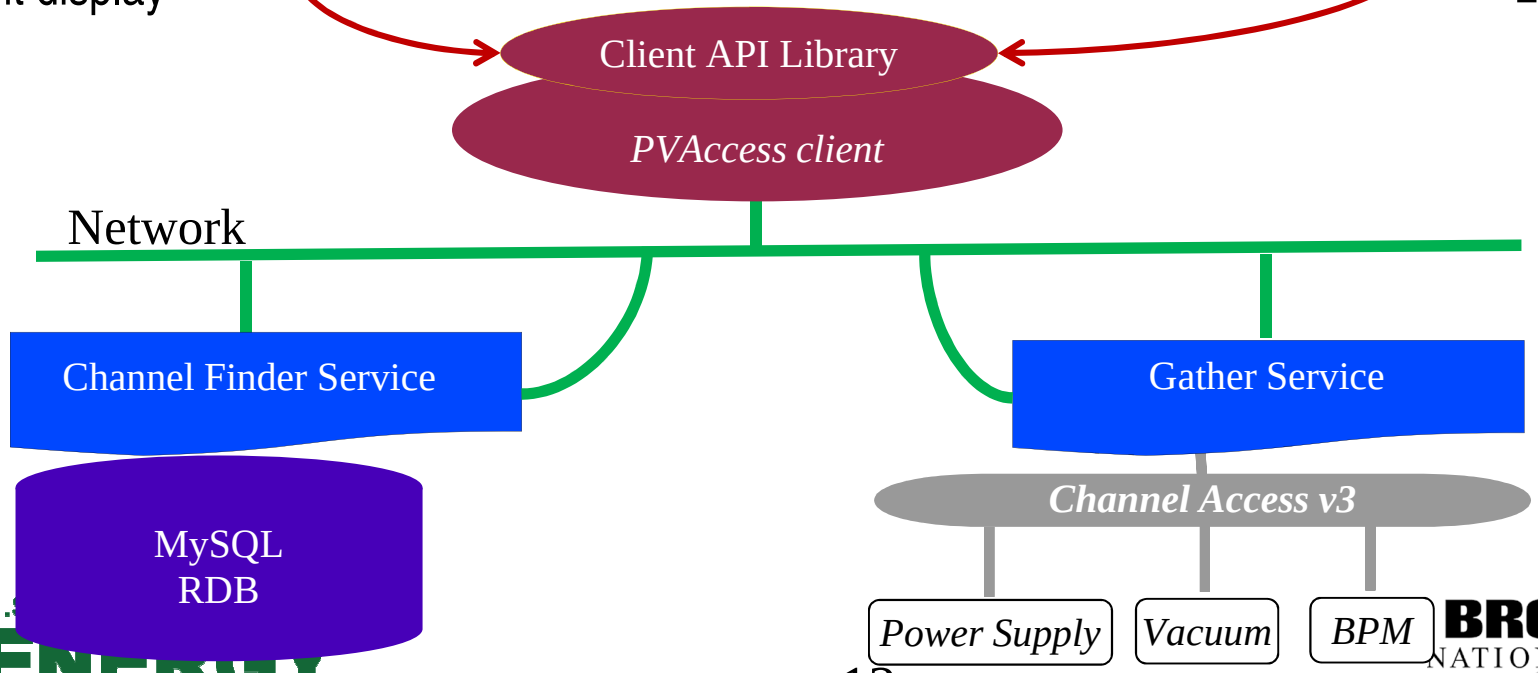
- Combining 2 services



Orbit display



Local bump



Tools to be provided and developed

- Complete and Orthogonal set of tools
  - Complete: the basic subroutines can meet all requirement, including foreseeable future applications.
  - Orthogonal: subroutines/functions do not overlap much. This will be easier for maintenance.
- Data management
  - lattice layout, organization, dependence, measured data, history data, revision history.
- Control and Diagnostic
  - write/read hardware (in both low/high level).
- Analysis routines
  - fitting, FFT, visualization, statistics, linear algebra.
- *Standalone applications based on the above function calls.*

Tools to be provided and developed

- MATLAB Middle Layer (LOCO included)
- New development
  - Python language
    - interactive environment, visualization, full set of numerical routines, scripting, glue FORTRAN and C/C++ easily.
  - API set comparable to MML
  - Manual of APIs.
  - Integrated data management
    - magnet measurement, ID field, magnet relations.

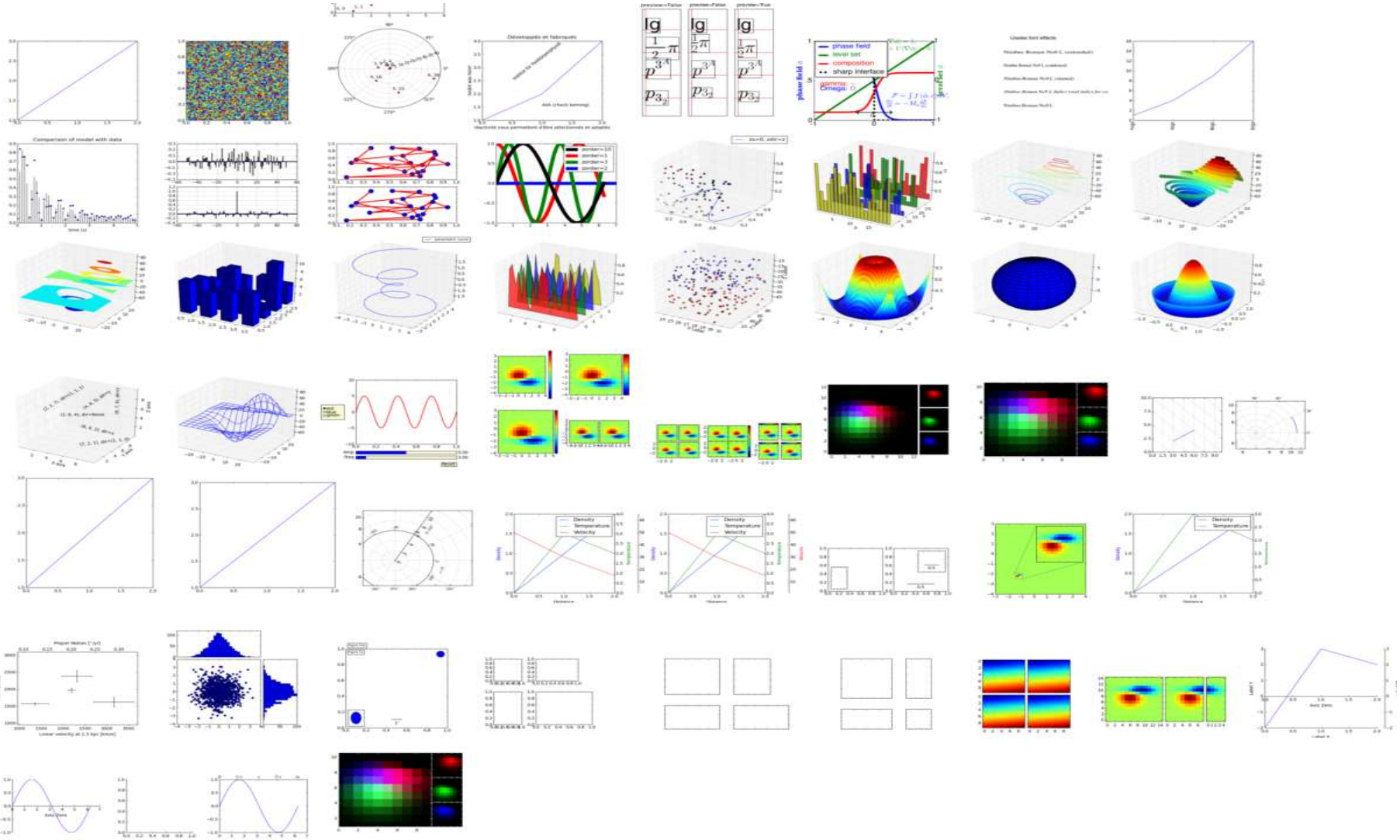
Tools to be provided and developed

the Script looks like …

```
#!/usr/bin/env python
import nsls2hla as sr
import matplotlib.pylab as plt
import numpy as np
import time
s, orbit1 = sr.getOrbit(group="CELL30")
time.delay(0.1)
s, orbit2 = sr.getOrbit(group="CELL30")
plt.plot(s, np.var(orbit1-orbit2), '-o')
plt.savefig("orbit-var.png")
```

Tools to be provided and developed

Visualization …



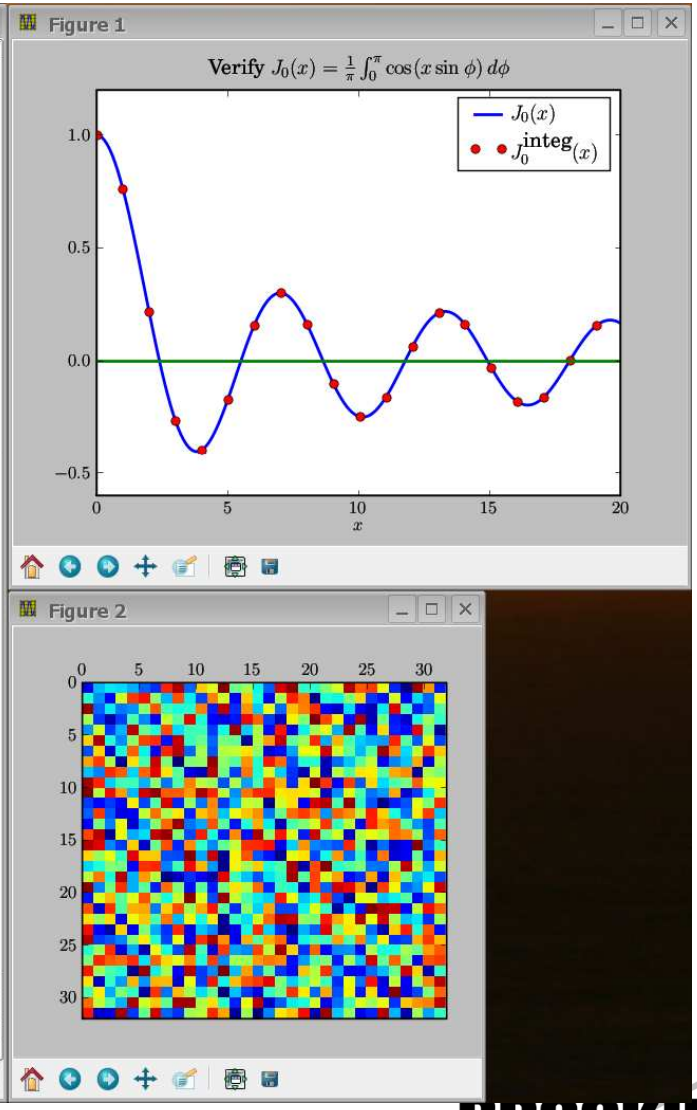
Tools to be provided and developed

Interactive …

fperez@longs:/home/fperez - Shell - Konsole

```
longs[~]> ipython -pylab
Python 2.4.3 (#2, Apr 27 2006, 14:43:58)
Type "copyright", "credits" or "license" for more information.

IPython 0.7.3.svn -- An enhanced Interactive Python.
?       -> Introduction to IPython's features.
%magic  -> Information about IPython's 'magic' % functions.
help    -> Python's own help system.
object? -> Details about 'object'. ?object also works, ?? prints more.

  Welcome to pylab, a matplotlib-based Python environment.
  For more information, type 'help(pylab)'.

In [1]: import math, numpy

In [2]: from scipy.integrate import quad

In [3]: from scipy.special import j0

In [4]: def j0i(x):
   ...:     """Integral form of J_0(x)"""
   ...:     def integrand(phi):
   ...:         return math.cos(x*math.sin(phi))
   ...:     return (1.0/math.pi)*quad(integrand,0,math.pi)[0]
   ...:

In [5]: x = numpy.linspace(0,20,200) # sample grid: 200 points between 0 and 20

In [6]: y = j0(x)  # sample J0 at all values of x

In [7]: x1 = x[::10]  # subsample the original grid every 10th point

In [8]: y1 = map(j0i,x1)  # evaluate the integral form at all points in x1

In [9]: # Make a plot with these values (the ; suppresses output)

In [10]: plot(x,y,label=r'$J_0(x)$');

In [11]: plot(x1,y1,'ro',label=r'$J_0^{\textrm{integ}}(x)$');

In [12]: axhline(0,color='green',label='_nolegend_');

In [13]: title(r'Verify $J_0(x)=\frac{1}{\pi}\int_0^{\pi}\cos(x \sin\phi)\,d\phi$');

In [14]: xlabel('$x$');

In [15]: legend();

In [16]: matshow(numpy.random.random((32,32)))
Out[16]: <matplotlib.figure.Figure instance at 0x4630042c>
```

Shell



Expanding for Further Applications

- Documentation:
  - Be prepared for new requirements
  - Terminology definition in a unified form, easy to read/understand.
  - Manual and spec document under development
- Code development, functions or algorithms
  - For “getOrbit”, “getTune”, “measureChromaticity”, …
- Development policy
  - First implement those functions with an algorithm we know
  - Review on those implementations.
    - Can be in the both casual (discussion) or formal forms (meeting)

Remarks

- Application manual and spec under development
  - Good progress, initial revision finished
- Infrastructure to support HLA development
  - Basic services ready
  - More services development or complete on requirement
    - Lattice management, Magnetic-Current conversion, logscore, …
- Plan on tools development are clear, and ongoing
  - Scripting requirement
  - Virtualization requirement
- We are glad to report new progress and train people with these tools (physics and programming).

Question

- Current discussion focus on storage ring
  - Good agreement between AP and control group
  - Processing well
- However, for injector?
  - Infrastructure has capacity for them
    - Good for both injector and storage ring
  - Application requirement?
    - To be provided by vender?
    - Transport line?
  - Data structure for injector?
  - API interface requirement?