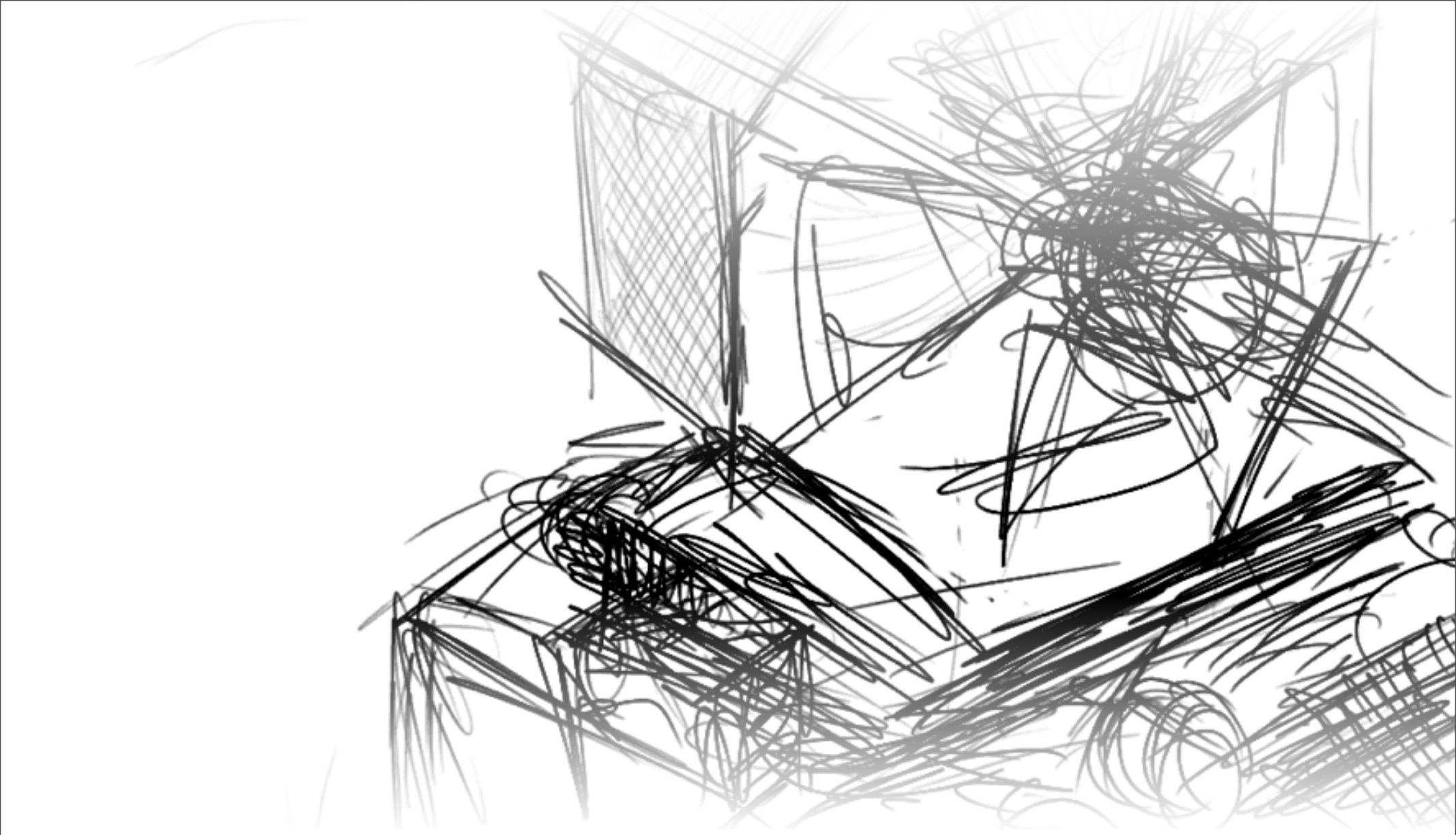


ATF2 Magnet Mover Update

Operation and Commissioning
Justin May

Introduction

- 25 magnets will be installed with magnet movers recovered from the Final Focus Test Beam at SLAC
- Coordinated operation required for BPM calibration, tuning algorithms
  - mechanism for BPM calibration
  - Current studies indicate movement speed will heavily influence tune-up time
  - Beam based alignment

“Theory” (of operation)

- Three roller cam system; each cam is an offset circle (unlike automotive cams)
- Magnets have a “v block” resting on two cams, and a flat section on the third
- Move calculated from target position (where you want to go) and the current position
- measuring the current position, and the success of a move are the tricky parts
  - rotation of cam measured by potentiometer, in turn gives you current position
  - however, cam angle (pots) subject to drifts, hysteresis, and limited step resolution
- originally (@FFTB) LVDTs used to reach final position; cam angle used only to calculate the initial move (attempt)
  - Complete move done in small step “blind” iterations until the LVDTs said you’d reached the target position

Theory - Trims

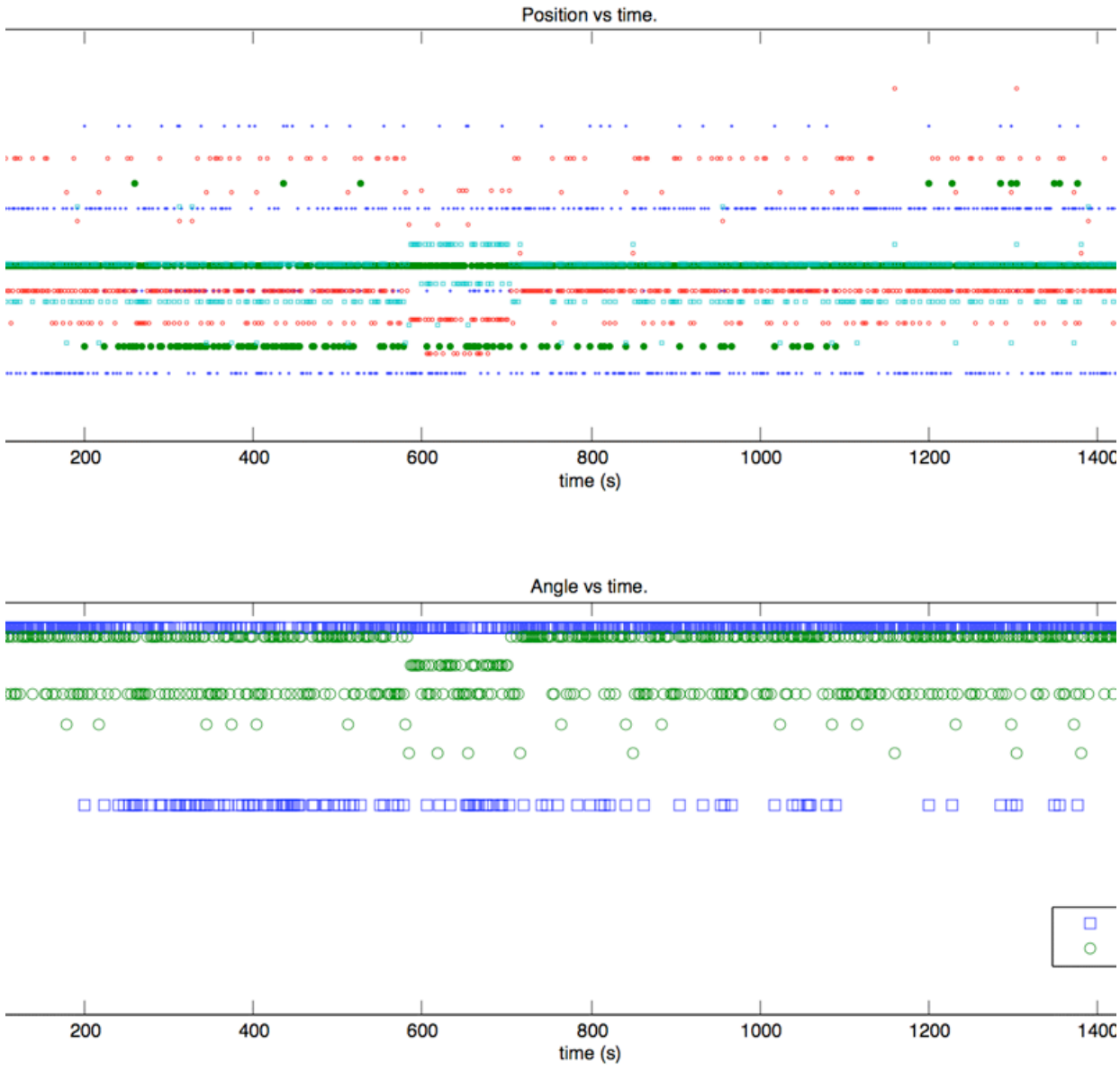
- FFTB : Get close, and make set steps till we’re close
- Currently testing different approaches:
  - Trim (adjust movement to reach desired position) on LVDT position readback
  - Trim on position calculated from cam/angle readback
  - Combine the two in some way to correct trends
    - LVDT Noise and Pot Drift
  - Incorporate hysteresis corrections
- *These are things still needed to be tested (today and tomorrow)*

Performance

- Theoretically, the LVDTs in use should have something like 100-200 nm resolution.
    - In practice, more like 600 nm is the actual limit. However, in operation at FFTB, mover positioning accuracy (dependent on LVDTs for position measurement) was not typically pushed beyond 1-5 μm
        - (meaning, operations did not expect operation performance better than 1-5 μm)
- Both LVDTs and pots drift and are noisy. In addition, single step pot resolution is something like 4-6 steps
    - ie. it takes 4-6 steps before the analog readback sees a change

Measured positions (top) and angles (bottom) from LVDT and Cam readbacks, 1 hour

At the moment, one does not appear better than the other



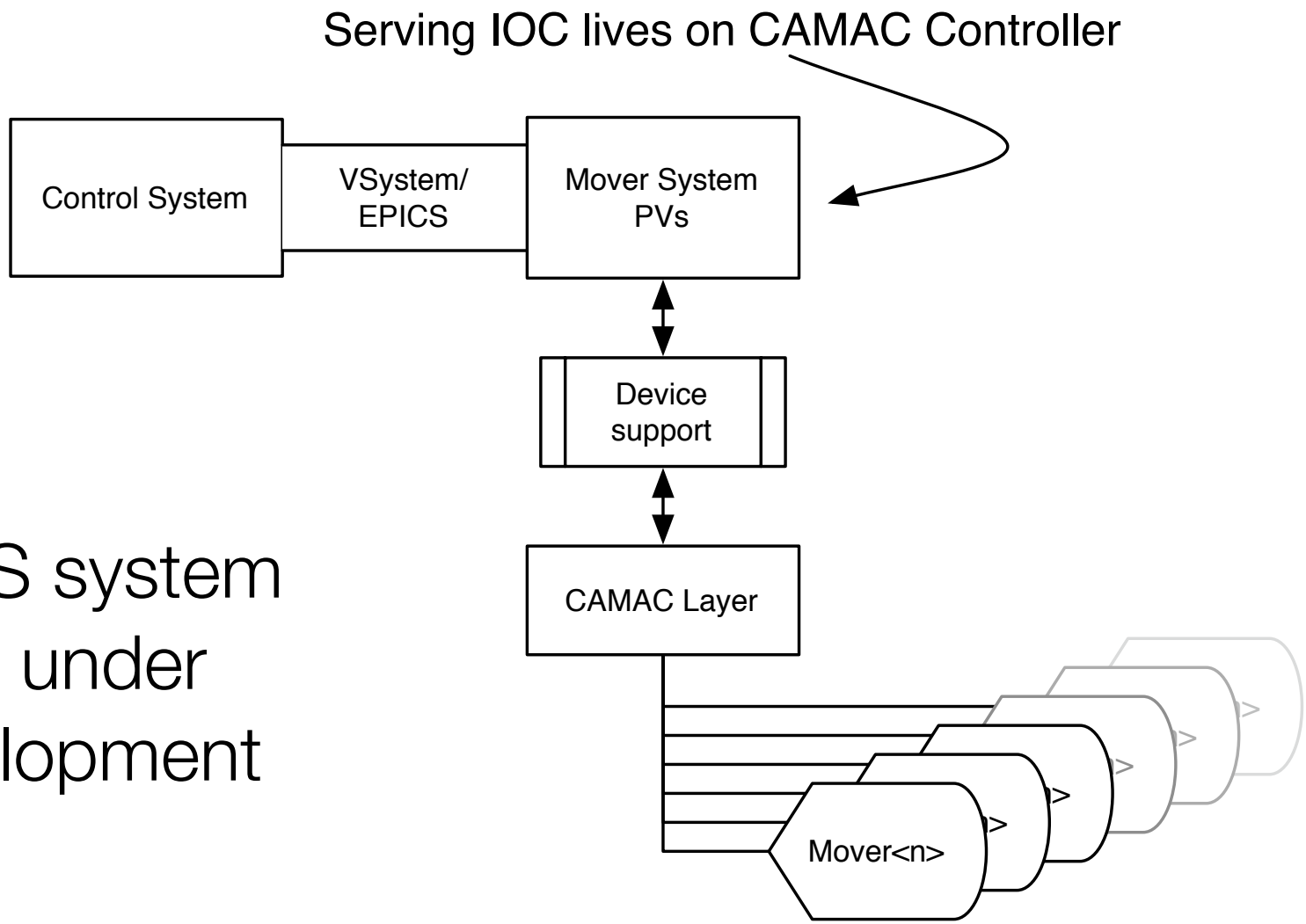
Tests during remaining two shifts

- Test first set of trim algorithms
    - The code is finished, just need data
- Test automated LVDT calibration routine using laser displacement monitors provided by Araki-san
- Take >24 hours of trend data

Control Architecture

- FFTB system CAMAC based. ATF2 system will separate CAMAC layer from control system by using CC/NET Pipeline CAMAC controller running an EPICS IOC
  - Accessed through the same mechanisms as the high availability power supplies, QBPMs, DR BPMs;
    - equals, in a word, EPICS
    - movers available in simulation
  - Currently maintain a separate (non EPICS) database with all geometrical and calibration constants that is loaded upon system initialization
  - A look at this shows the measurements we'll need for the commissioning...
    - will return to this in three slides

Control System



EPICS system still under development

Control, continued

- Primary EPICS (and VSystem) PVs for current position and desired position
  - Either: executes moves autonomously (operator simply inputs a desired position, if different, mover system activates
  - or system waits for operator to issue additional “move now” command
- Calculations, where possible, performed in EPICS layer
  - keep “sub-EPICS” layer responsible only for device support
  - results in a lot of additional PVs
- currently, file I/O would be on the support layer below EPICS
  - hardware log file, hardware calibration loading...>

Returning to calibration constants

Sample operation database - LVDT Constants and cam geometry relative to magnet bore

```
• ! UNITS ARE IN METERS, RADIANS, VOLTS !
*****************************
DATABASE_TYPE    :   SAMPLE
LAST_UPDATED     :   121906
CREATED_BY       :   jemay
***************************** -->
<entry>0001</entry>
    <object_ID>1060</object_ID>
    <type>mov</type>
    <subtype>01</subtype>
    <entry_updated>020907</entry_updated>
    <!-- mover_details -->
        <moverch_n>10</moverch_n>
        <potch_n>14</potch_n>
    <!-- bore details -->
        <bore_offsetX>145250</bore_offsetX>
        <bore_offsetY>123952</bore_offsetY>
        <bore_offsetRot>0</bore_offsetRot>
    <!-- cam1 -->
        <cam1_add>0</cam1_add>
        <cam1_offsetX>290500</cam1_offsetX> <! -
                    combines default offset with
                    correction -->
        <cam1_offsetY>0</cam1_offsetY>
        <cam1_offsetRot>0</cam1_offsetRot>
        <cam1_potadd>0</cam1_potadd>
        <cam1_potMin>-0.2</cam1_potMin>
        <cam1_potMax>10.2</cam1_potMax>
        <cam1_potZeroAngle>0</cam1_potZeroAngle>
    <!-- cam2 -->
        <cam2_add>1</cam2_add>
```

```
...
    <!-- lvdt_details -->
        <lvdtch_n>6</lvdtch_n>
        <lvdt1_add>0</lvdt1_add>
        <lvdt1_X>82050</lvdt1_X>
        <lvdt1_Y>0</lvdt1_Y>
        <lvdt1_cal>0</lvdt1_cal>
        <lvdt1_n1>0.096914</lvdt1_n1>
        <lvdt1_n2>-0.00015516</lvdt1_n2>
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        <lvdt2_n3>-6.934e-10</lvdt2_n3>
        <lvdt2_n4>-4.0016e-13</lvdt2_n4>
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        <lvdt3_n3>1.6908e-09</lvdt3_n3>
        <lvdt3_n4>-8.1794e-13</lvdt3_n4>
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        <lvdty_offset>0</lvdty_offset>
        <lvdtr_offset>0</lvdtr_offset>
```
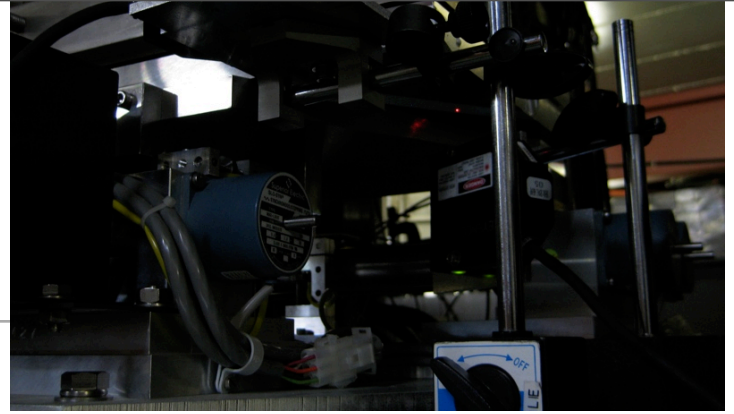

Measurement Requirements

- Primary Geometry "Alignment"
  - Cam separation verification - especially with any new plates/geo like the sextupoles: not a big deal
  - Bore position relative to bearing surfaces
    - alignment structures and v-block/flat positions are new, introduce small or large differences in geometry
  - Both of these can be corrected by precise calibration, but the more information known, rather than inferred, the better
    - Especially since we are trying to do better than FFTB operational accuracy

Measurement Plan



- Cam zero check
  - Best to be done before magnets and magnet support plates are in place
    - Possible after installation with precision flats
- calibration rig
  - Keyence Laser Displacement System tested this trip
    - Would like to use this in a more robust system for the actual installation
    - Measures x and y displacement, with proper design of rig, can get roll as well
  - LVDT and system calibration
    - Now an automated routine when used with Laser Displacement Monitors
- Operation Check Out
  - Pre-beam: Automated position calibration using rig
  - First beam: BPM Calibration

Schedule

- Installation Plan
  - Primary components:
    - Cable termination and installation (need to produce drawings for installation, since it is not clear how many SLAC personnel will be available at this phase)
    - Rack installation (easy, just one or two crates)
    - [Laser Rig] Calibration (Can we use the Keyence laser displacement system)
- Commissioning Plan
  - First-Pulse establish beam to dump
  - Ballistic calibration of movers
    - Then ready for full program (BBA, BPM calibration)

Conclusion and summary

- The majority of low level development and testing complete
    - A few more tests to do in 2007
- EPICS system needs to completed
- Commissioning will involve cable plant and control electronics installation, Pre-beam calibration of each mover, and check out during first beam
- Need measurements where possible for magnet and mover geometries (especially where pieces added or movers modified)