ATF2 Q-BPM commissioning

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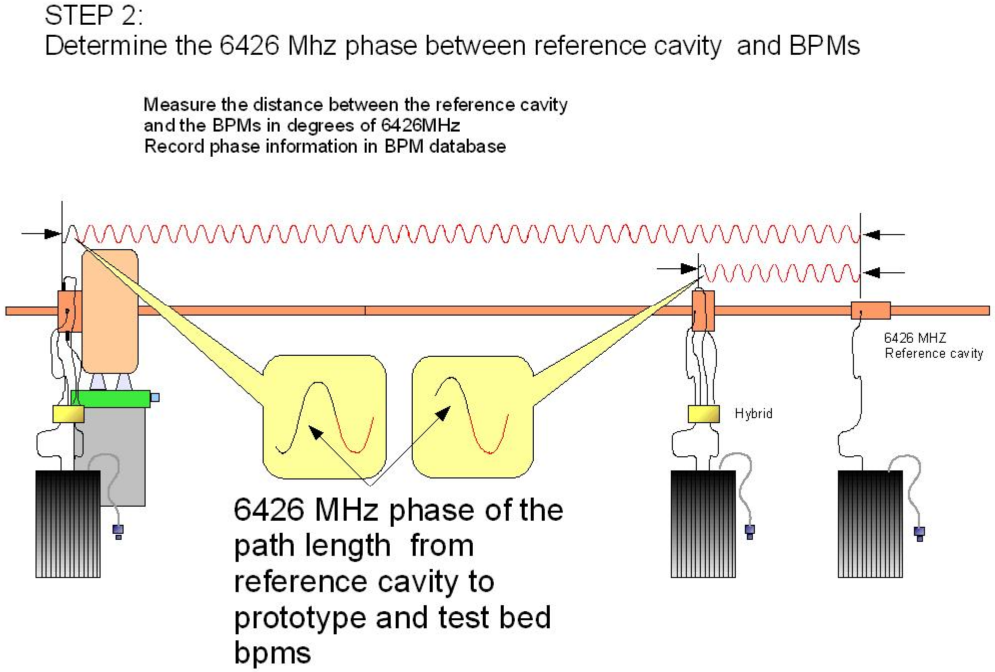
Talk outline

- Cavity BPMs operating 50 to 100nm resolution have previously been preserve of research projects. Not essential operation diagnostics
- First pulse calibration
- Processing algorithms
  - Digital down conversion
  - Waveform fitting
- Integration in ATF2
  - Readout system
  - Calibration
    - Mover system
    - RF cw tone
    - Local oscillator/thermal monitoring
- Implementation
  - Single board VME computer
  - Processing computer
- Current status and mile stones
  - Quad and BPM test stand
  - Integrated readout, processing, calibration test

First pulse calibration (D. McCormick)

- Careful phase matching of cables
  - Between different BPMs
  - Knowledge of distance between BPMs
- Predict the beam arrival time and hence signal phase
- Only phase information to determine direction
- Scale determined from test measurements or calculation
- Requires no changes to analysis



Processing algorithms

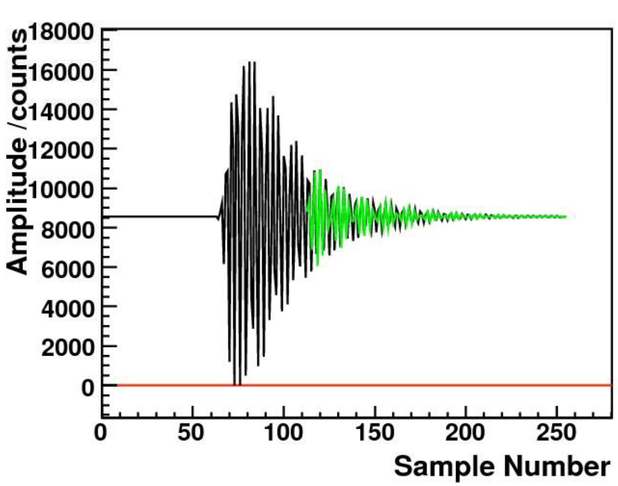
- Two principally used with waveform digitization
  - Digital down conversion
    - Fast, easy to control, robust
  - Full waveform fitting
    - Frequency, decay constants
    - Slow, prone to difficulties with not standard waveforms
- Commissioning specific problems
  - Large amplitude saturated pulses
  - Phase extraction for first pulse calibration
- Integration issues
  - Debugging
    - User changeable codes
    - Display of intermediate results (phase, amplitude, I,Q, etc)
  - Slow control
    - Calibration procedures
  - Calibration database

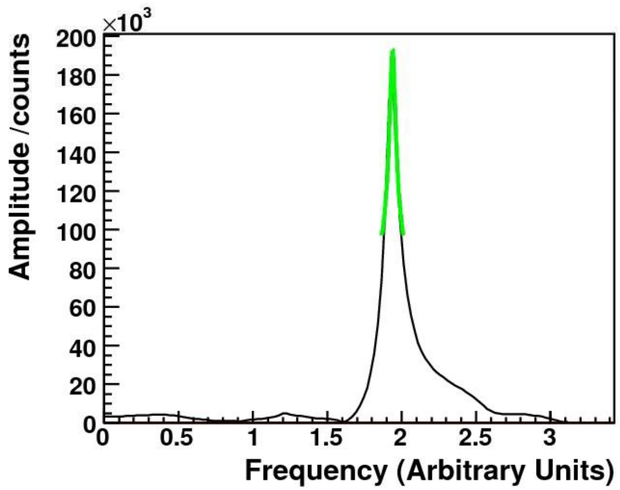
Waveform fitting

- Directly fit to decaying oscillating function

$$f(t;\omega,\Gamma,\phi) = A\exp\left(-\frac{t}{\Gamma}\right)\sin(\omega t + \phi)$$

- Alternatively FT of signal and extract frequency and decay constant
  - More problematic when the signal saturates either RF electronics or digitizer
- Useful cross check of primary algorithm (DDC)

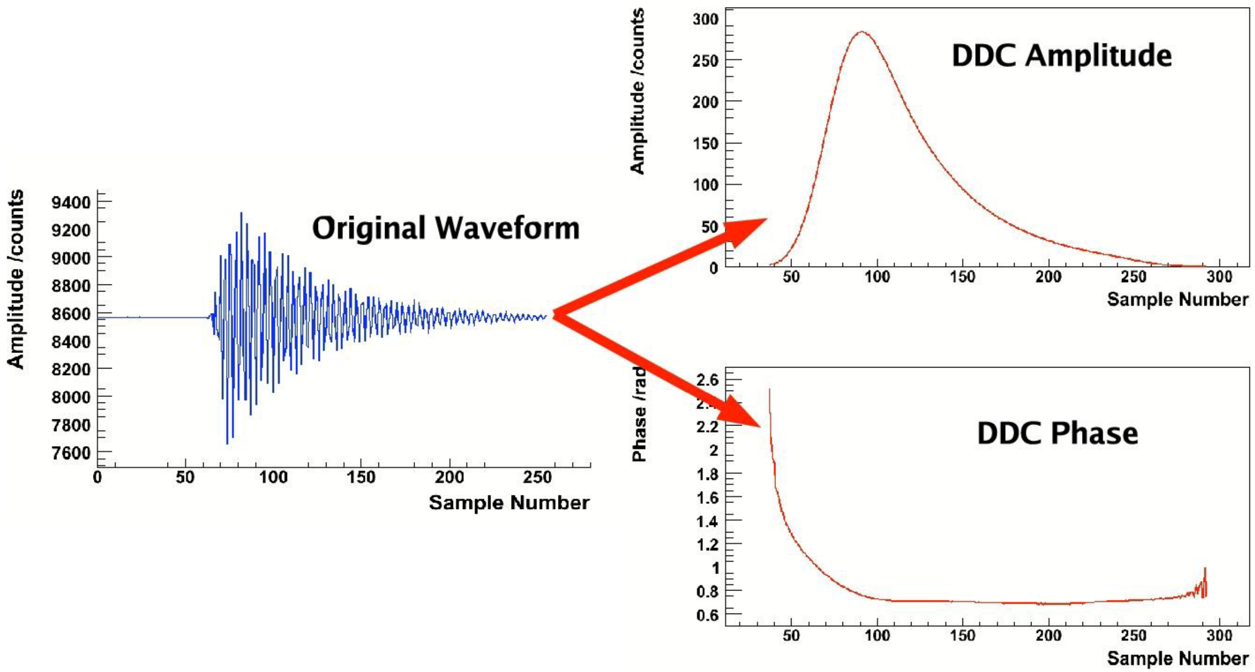




Digital down conversion

- Last phase of mixing performed digitally
- Mix signal with complex local oscillator (require frequency from FT or fit)
- Low pass filter result and sample result at given time (t_0)

- Simple linear execution time algorithm
- No minimizers or complicated complicated mathematics required



Extracting position (and tilt)

- Compute Quadrature and Inphase

$$I = \frac{A}{A_{REF}} \cos(\phi - \phi_{REF})$$

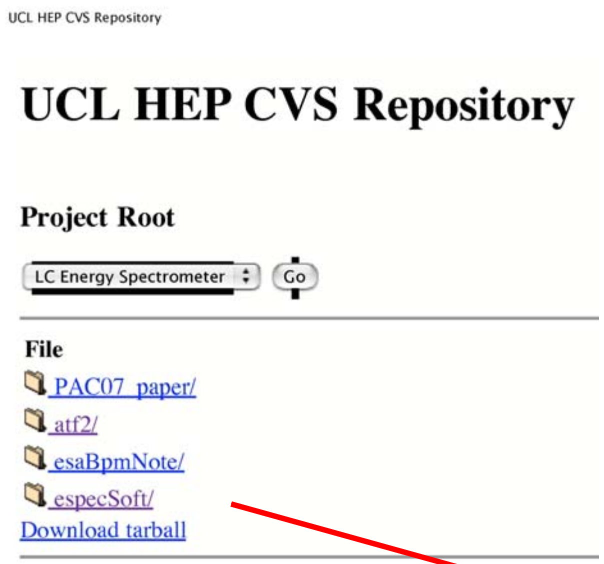
$$Q = \frac{A}{A_{REF}} \sin(\phi - \phi_{REF})$$

- Simple rotation from IQ to position (or tilt)

$$x = S\left(I\cos(\phi_{IQ}) + Q\sin(\phi_{IQ})\right)$$

- S scaling factor to real position, from calibration
  - Beam movement
  - BPM movement

Processing algorithms


UCL HEP CVS Repository

UCL HEP CVS Repository

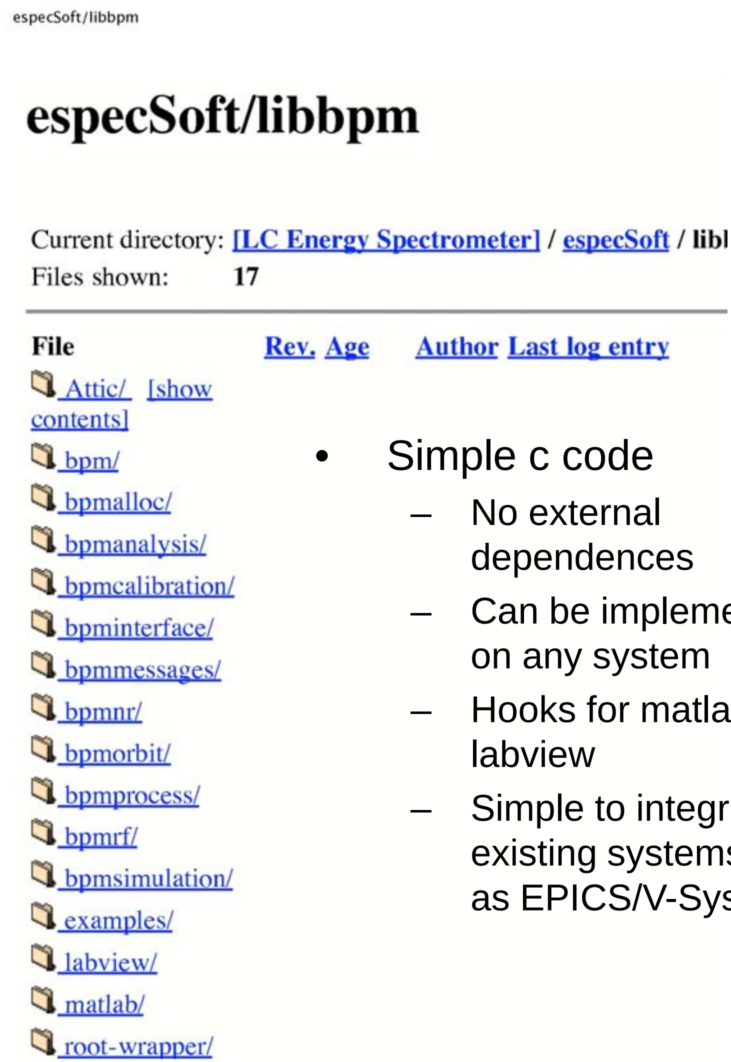
Project Root

LC Energy Spectrometer | Go

File

- PAC07_paper/
- atf2/
- esaBpmNote/
- especSoft/

Download tarball


especSoft/libbpm

especSoft/libbpm

Current directory: [LC Energy Spectrometer] / especSoft / libl

Files shown: 17

File	Rev.	Age	Author	Last log entry
Attic/ [show contents]				
bpm/				
bpmalloc/				
bpmanalysis/				
bpmcalibration/				
bpminterface/				
bpmmessages/				
bpmnr/				
bpmorbit/				
bpmprocess/				
bpmrf/				
bpmsimulation/				
examples/				
labview/				
matlab/				
root-wrapper/				

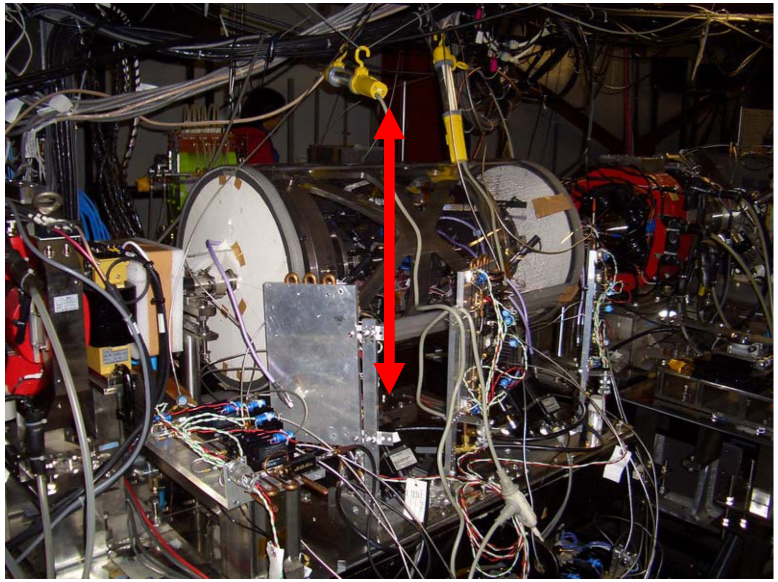
- All nanoBPM algorithms have been refactored into simple
- http://cvs.hep.ucl.ac.uk/viewcvs/

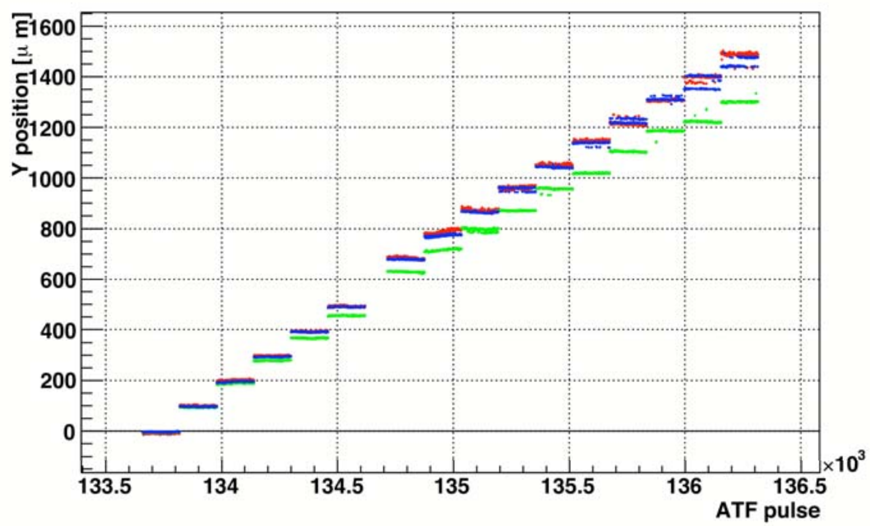
- Simple c code
  - No external dependences
  - Can be implemented on any system
  - Hooks for matlab and labview
  - Simple to integrate into existing systems such as EPICS/V-System

Saturated pulses

- Post shutdown possible to have orbits ~mm from BPM electrical centers
  - Test algorithms at large beam offset
- Tests performed in December 06
  - BINP designed c-band cavities
  - ATF2 processing electronics
  - Resolution ~50nm
- Moved BPMs to 1.5mm
  - Position reconstruction reasonable out at 1.5mm
  - Must verify algorithms or develop modified algorithms for large amplitude pulses

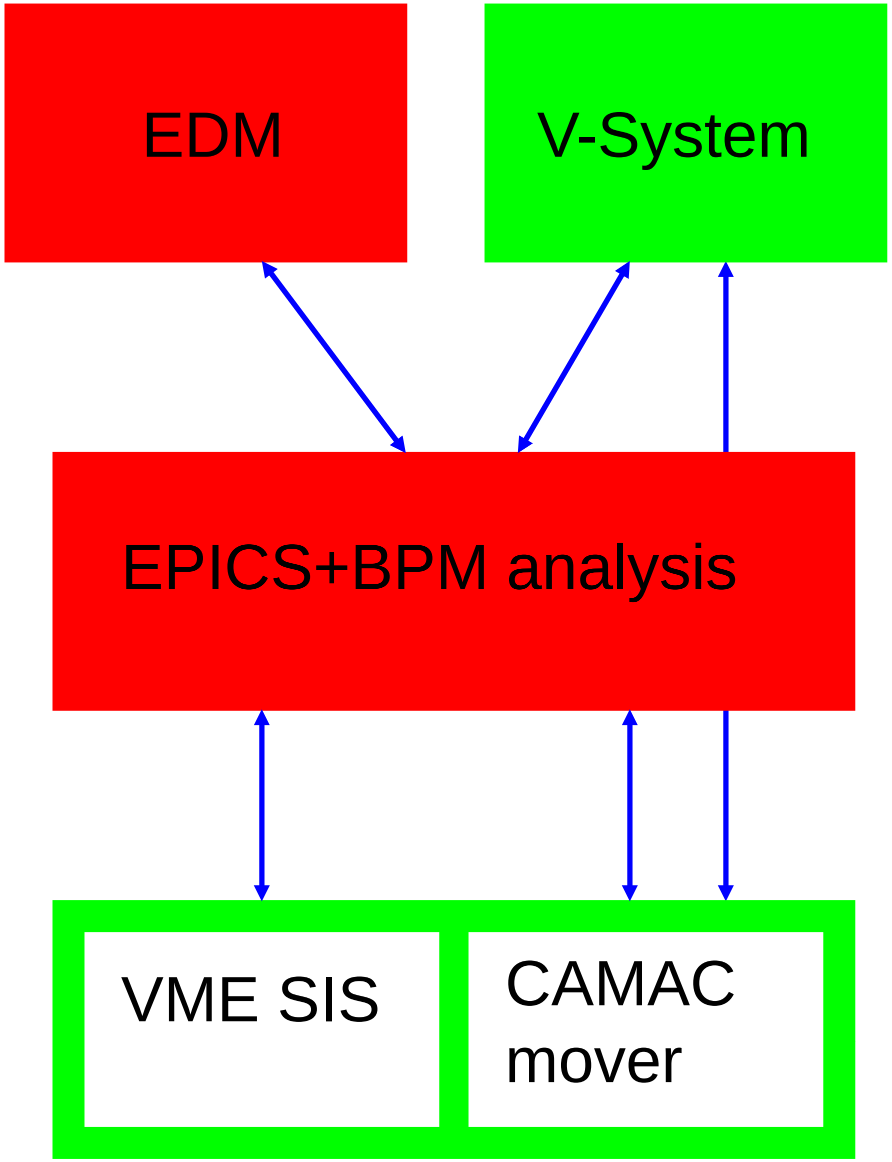
- Groups focused on resolution/cross coupling etc not large signal regime





Readout models

- EPICS control of
  - SIS digitizer modules
  - FFTB mover system
    - Camac controller IOC
  - What about temperature and LO power monitoring
    - Direct to ATF control system?
- Require design of low level EPICS database
  - Use existing VX works
  - RTEMs
  - Camac interface underway (G. White)
- Calibration requires
  - Readout
  - Control of mover system
- Warnings alarms
  - During calibration
  - Analysis problems
  - Signal saturation



Database design

- Start development of EPICS database
  - Example given right
- What warnings/error checking should be implemented
  - During calibration?
  - Definitely saturation
  - Problems with analysis
- Links to calibration database
  - Ability to populate EPICS database with stored values from ATF
  - First pulse
  - After long shutdowns

BPM raw data

- bpm1:waveform$_X$
- bpm1:waveform$_Y$

BPM processed data

- bpm1:A_X,A_Y
- bpm1: $\phi_{X,}$ ϕ_Y
- bpm1:I_X,I_Y
- bpm1:Q_X,Q_Y
- bpm1:x,y
- bpm1:$\omega_{X,}\omega_Y$
- bpm1:Γ_X,Γ_Y
- bpm1:calibrating
- bpm1:saturation
- bpm1:analysis

BPM calib ration

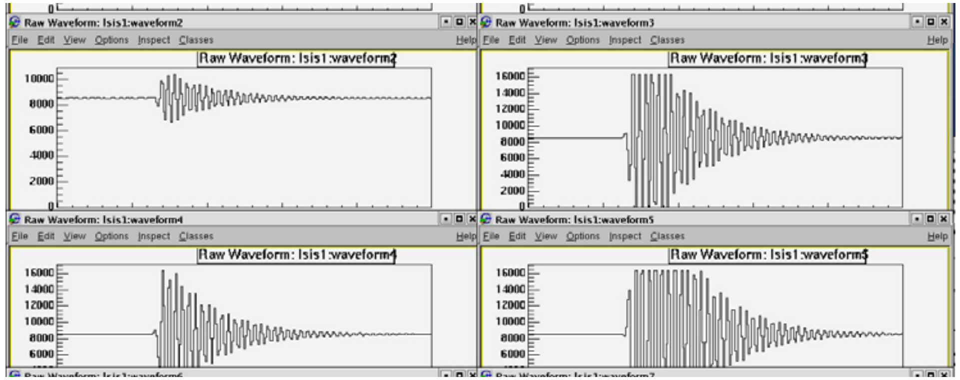
- bpm1:scale$_X$,scale$_Y$
- bpm1:Φ_{IQ},Φ_{IQ}

Quad related

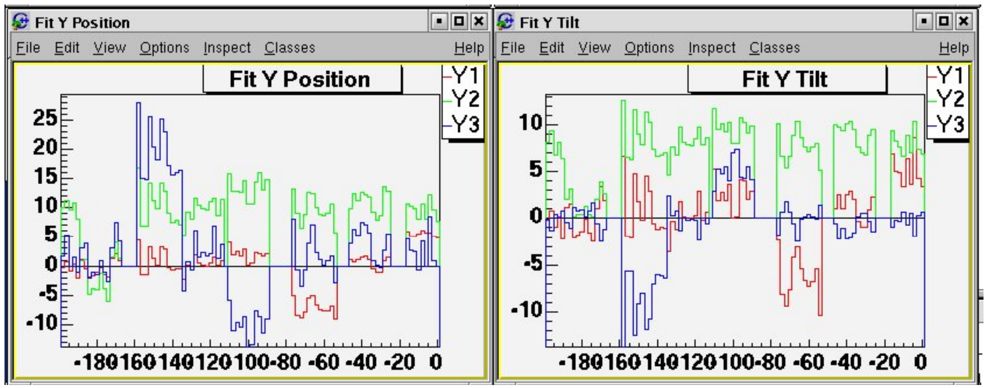
- quad1:x,y
- quad1:lvdt$_i$

Calibration and monitoring

- Online monitoring found essential is cavity BPM operation
  - Waveform viewers
  - Strip-charts



- Calibration algorithms exist
  - Best results obtained when the beam jitter is subtracted
  - This is more complicated in the presence of quad fields
  - Switch off quads (so that a straight orbit fit is possible)
  - Perform beam jitter subtraction in presence of quads



- Must develop sustainable solution
  - EDM
  - Strip tool
  - Other solution

Quad + BPM package test measurements

- Quad+BPM package measurements
- Calibration
  - Frequency and decay constants
  - Range of mover calibration
  - Number of position points
  - Machine pulses per position
  - Automated frequency and decay constant extraction
- Large offset measurements
  - Repeat large offset measurements
- Repeat with quad on and off

Summary

- Test control/readout system Fall 2007
- Need to make basic design choices (UK and SLAC have some manpower)
  - EPICS controller (RTEMS, Vxworks)
  - Calibration database
  - Monitoring and controls
    - Clear V-system with drive EPICS side
    - Debug/expert monitoring
  - Separate CPUs for BPM processing
    - Part of ATF-infrastructure
    - Dedicated machine?
- Algorithms and techniques well tested
  - First pulse (just phase, should not be a problem)
  - DDC and fitting will be implemented