LC-ABD 2: WP 9
Future plans for BPM / Spectrometry R&D

Bino Maiheu (University College London)
for LC-ABD2 : WP9

- Spectrometer experiment at ESA, SLAC FY'08 running
- BPM prototype development, status + future
- Turn key operation and accelerator integration
- S-Band ATF2 cavity system development

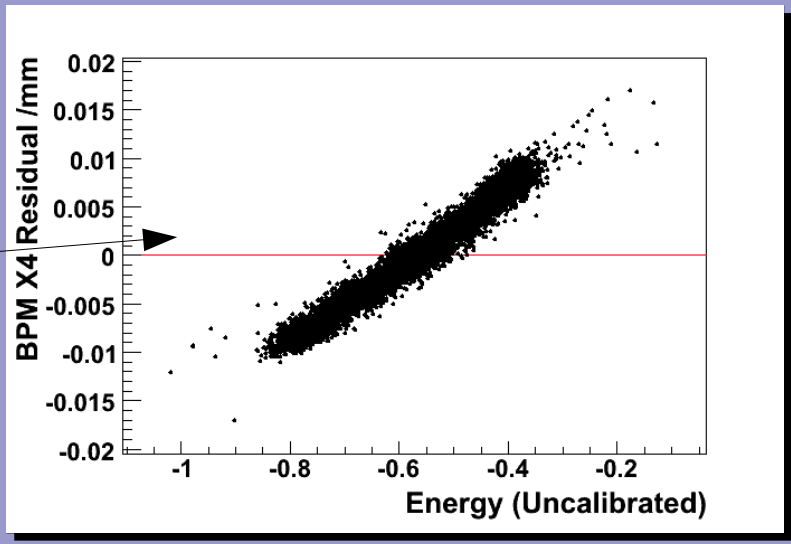
T474/491 at ESA, FY'08, ...

- Continue very active involvement in energy spectrometer in ESA
- Funding at SLAC for FY'08 running looks promising
  - **Tentative**: 3-week run in late April including 1 week setup with LCLS (possible high charge) beam and 2 weeks with 28.5 GeV beam
    2-week run in August with 13.6 GeV beam, possibility 2-2.5 nC running

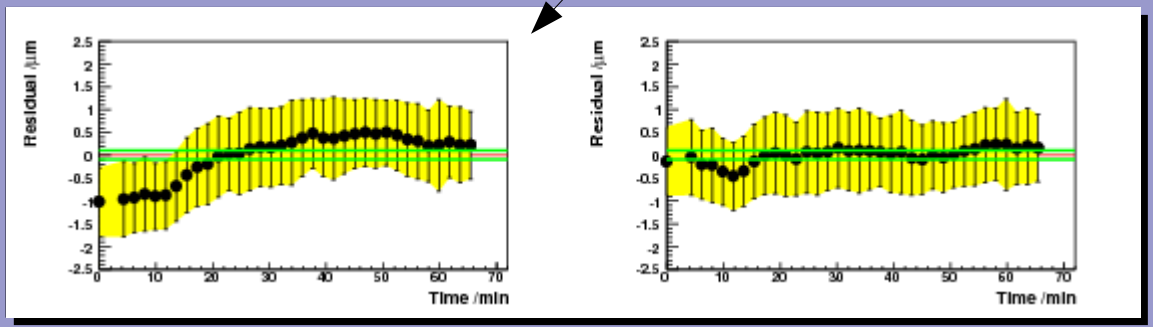
  Scheduling compatibility with LCLS plans looks good !
- T491 Plans for FY'08 running : deciding on upgrades to the system
  - Install additional NMR and Hall probes (DESY)
  - Expand calibration tone system (UK + Berkeley)
  - Investigate mechanical stability, upgrade interferometer (Notre Dame)
  - Replace our first BPM prototype by new one (UK)
- One NIM paper almost ready for submission, more papers in pipeline :
  - Spectrometer studies (main T474/491 result)
  - Commissioning of our BPM prototype

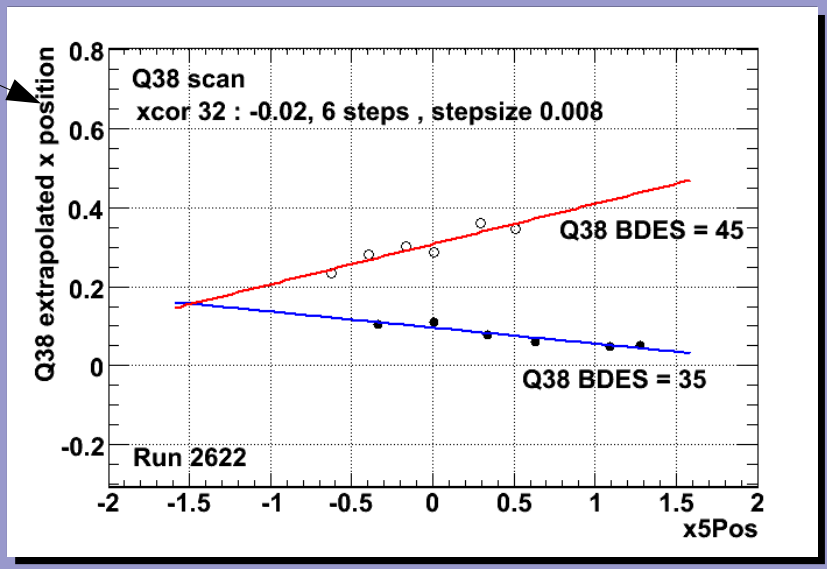
T474/491 at ESA, FY'08, ...

- Core hardware installation finished
- Collect more data with full setup, 1+2 week run !
- Focus more onto
  - the actual energy measurement
  - automation and online display
  - understanding observed effects, drifts
- Beam based quadrupole stability monitoring
- Physics results + ILC spectrometer design studies in years to come...



Analysis work in ESA far from finished !!

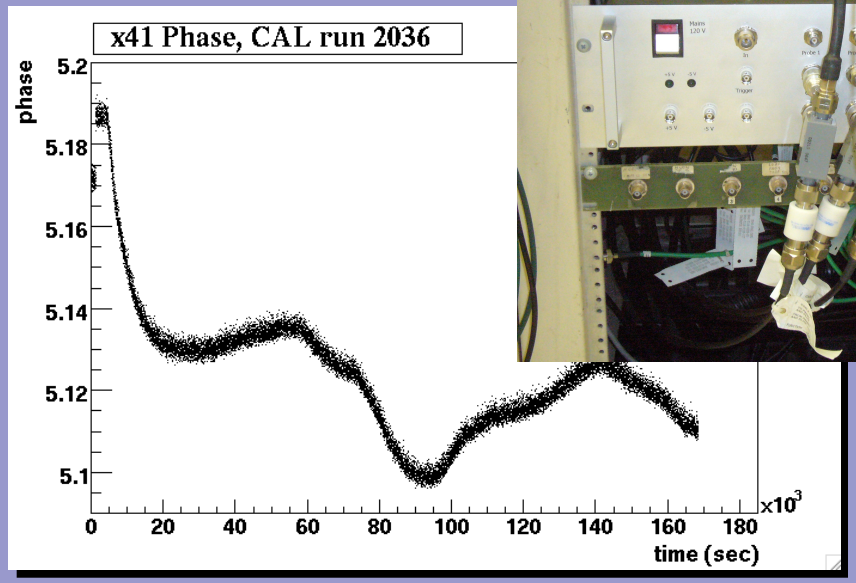




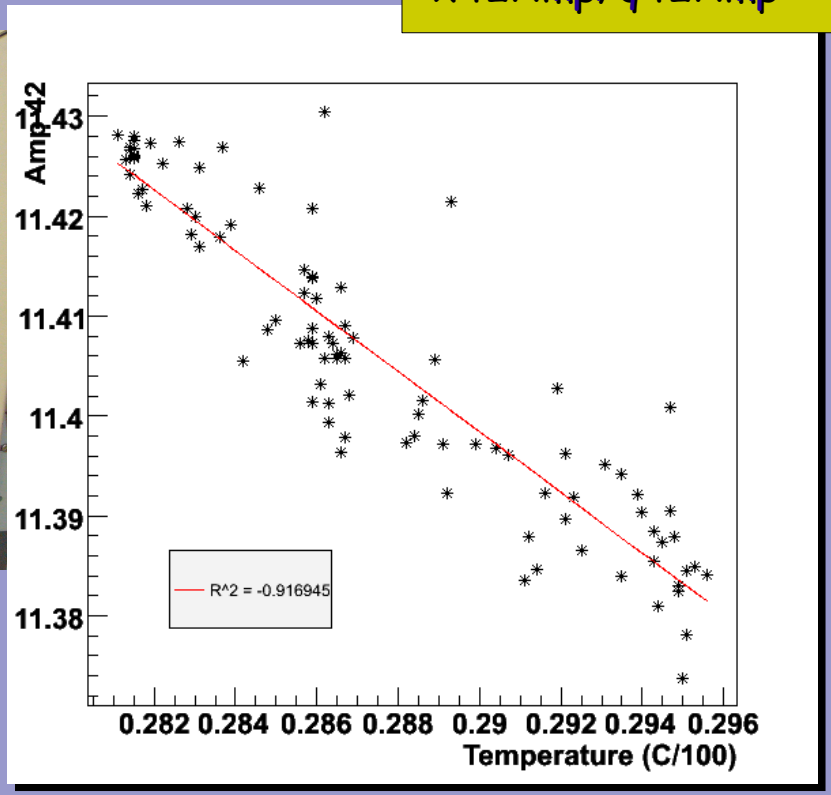
Analyse scans !
study and improve in FY'08

Expanding calibration system...

- Essential component for understanding drifts etc...
- Feed electronics with constant CW tone and monitor level
- Developed in UK in collaboration with LBNL



x42Amp/q42Amp



Future plans :

Need in depth analysis of monitored channels !!!

Upgrade plans : increase number of monitored channels. (now: all x and Q channels)

- Manufacture additional electronics boxes (UCL/RHUL)
- Optimise the signal levels for each channel
  - Acquire more RF amplifiers, RF couplers etc...

Spectrometer BPM prototype, v1.0

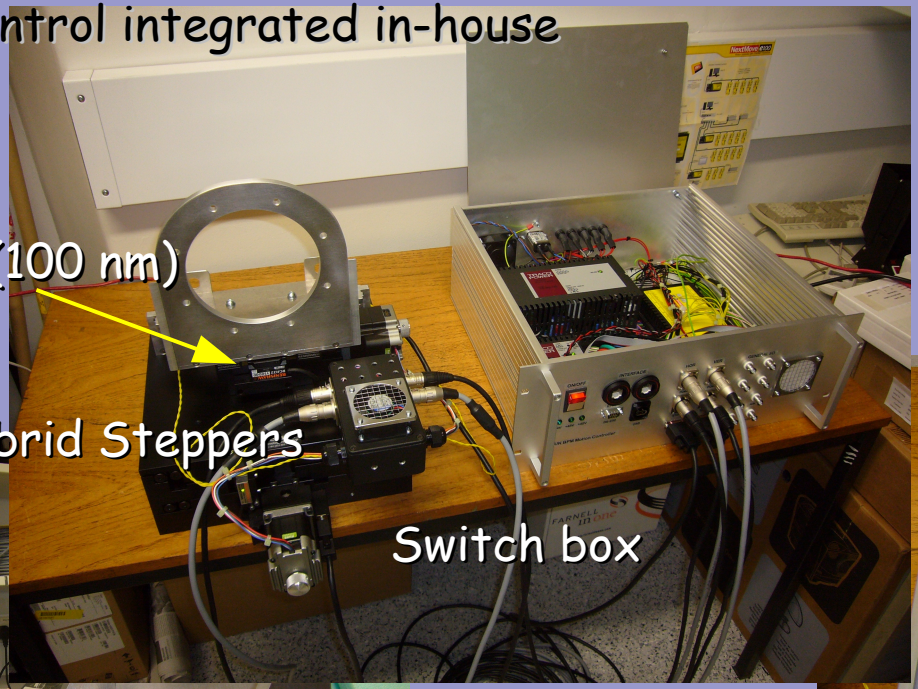
Prototype RF S-band cavity BPM, optimised for energy spectrometer

- aperture, mode rejection, resolution, decay time

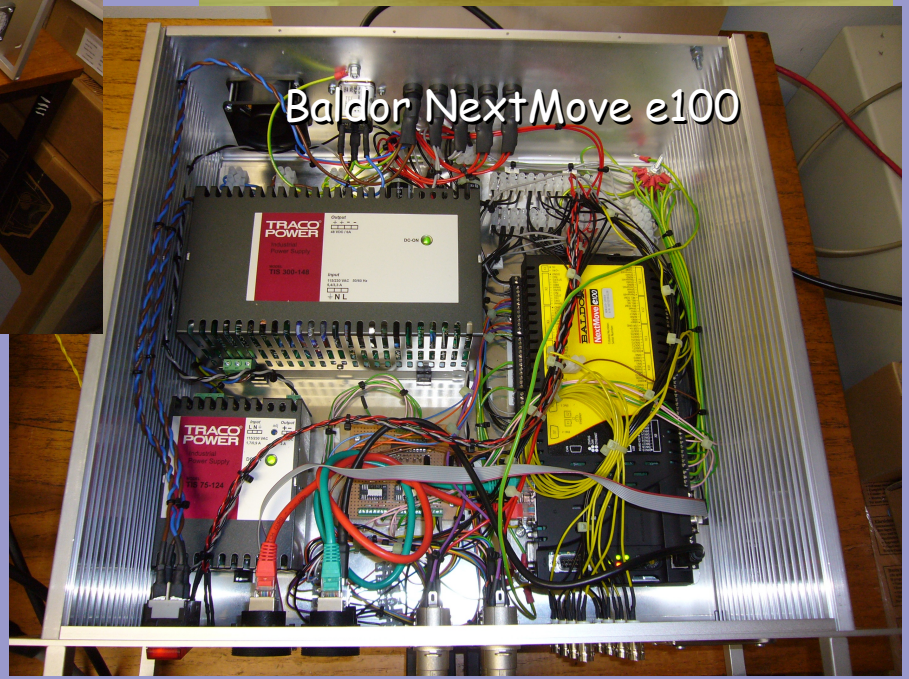
Electronics developed in-house, mechanical design in collaboration with MSSL

Cavity now installed in ESA beamline (July '07)

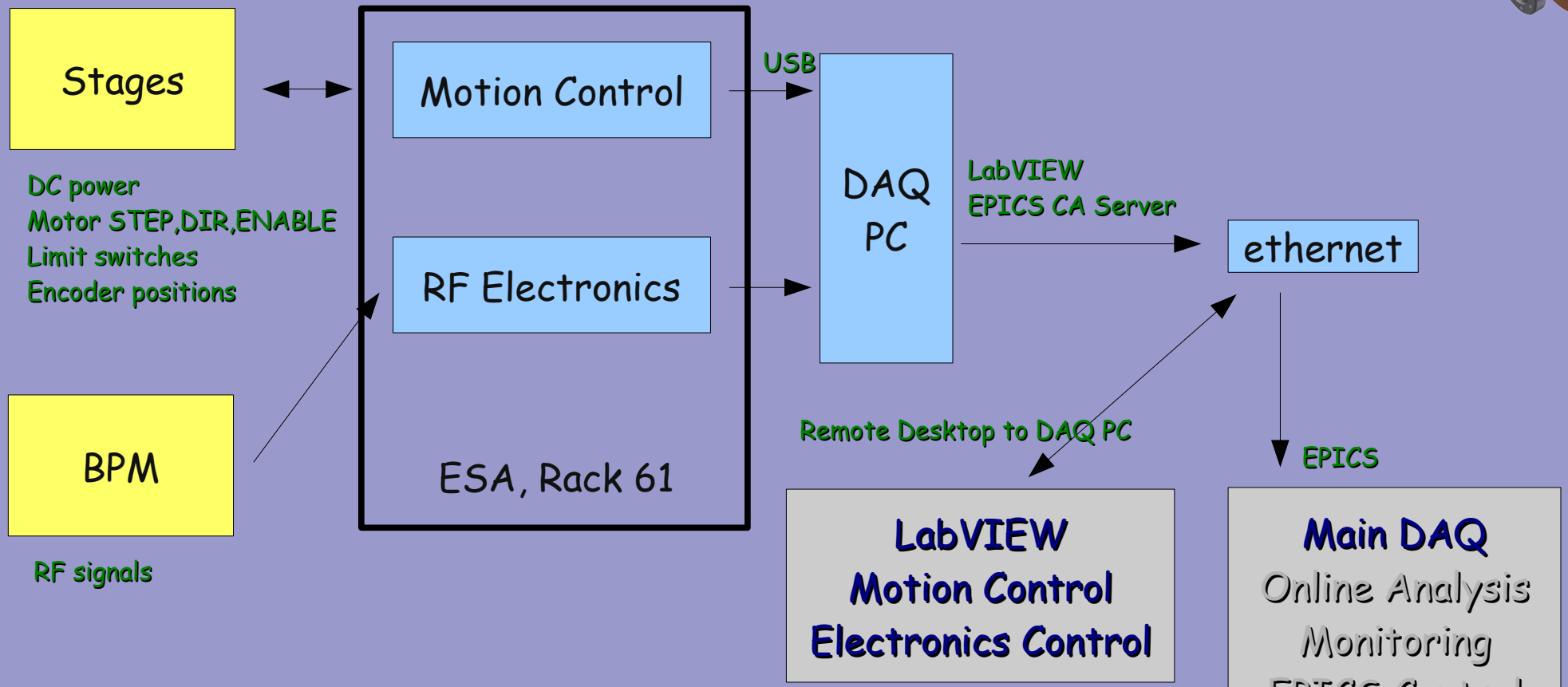
- on xy mover system : NEAT BAZ, TM-200 Stages
- Motion control integrated in-house



Baldor DSM Hybrid Steppers



BPM motion/electronics control



RF Electronics control : attenuation / amplifiers / switches

- NI multi-purpose ADC/DAC/DIO card, breakout box, GSBus, controlled via LabVIEW

Motion Control :

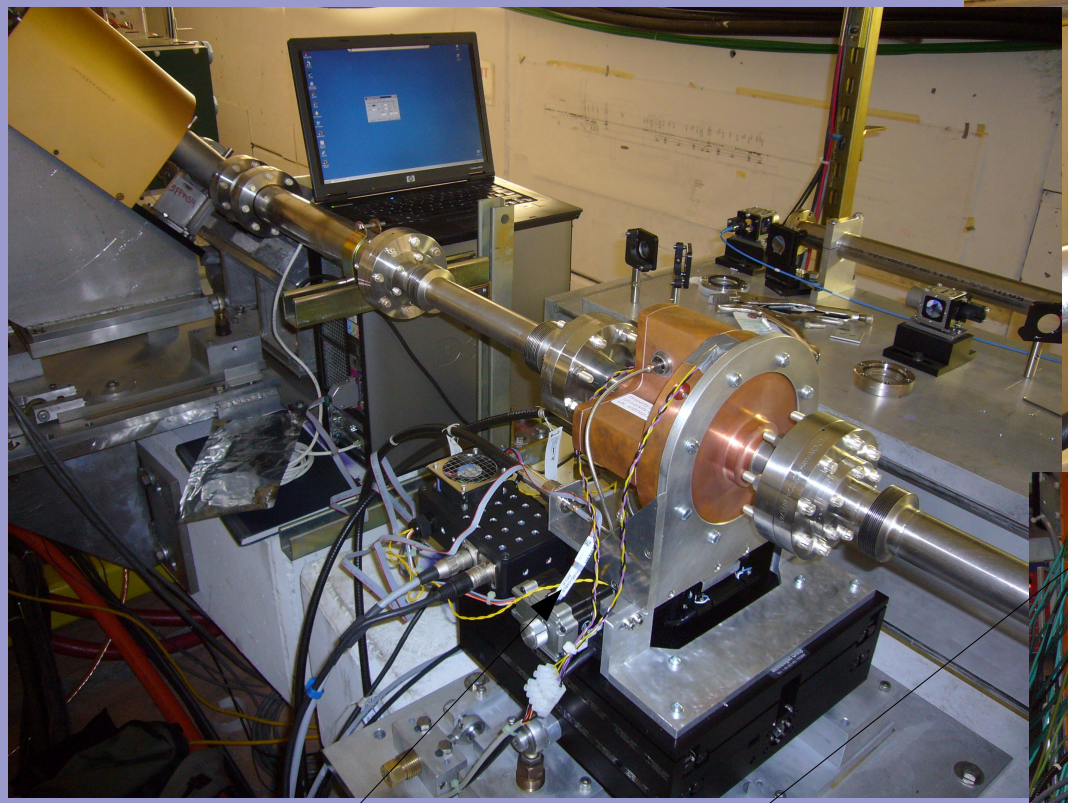
- runs on controller FPGA (MINT) : highly flexible and can make it robust
- semi closed loop with stepper motor in MINT using encoder information
- interface via LabVIEW ActiveX objects that talk to running FPGA program

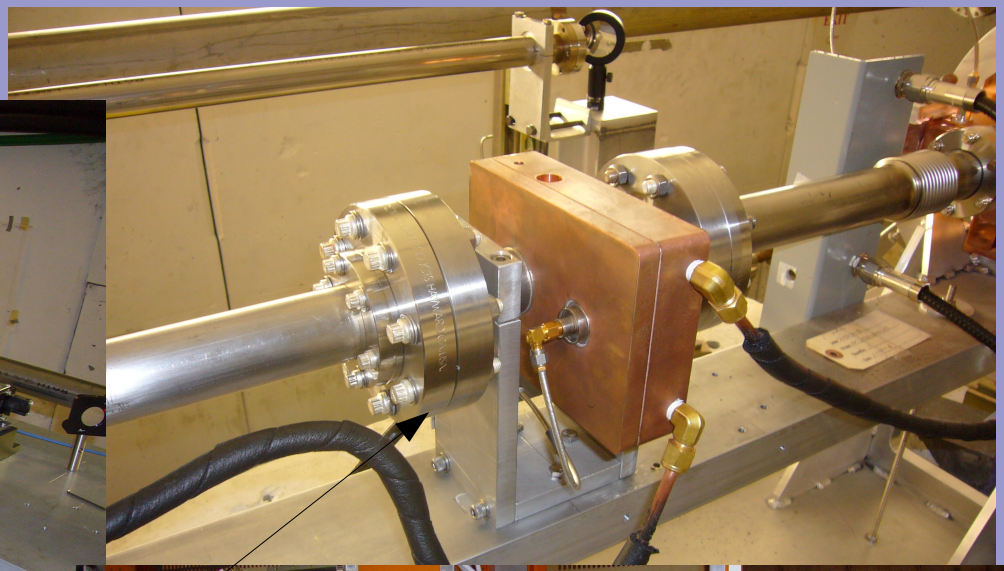
Modular setup, our DAQ can run standalone

Integration in main DAQ via EPICS CA Server on DAQ PC

Spectrometer BPM prototype, v1.0

Some installation pictures

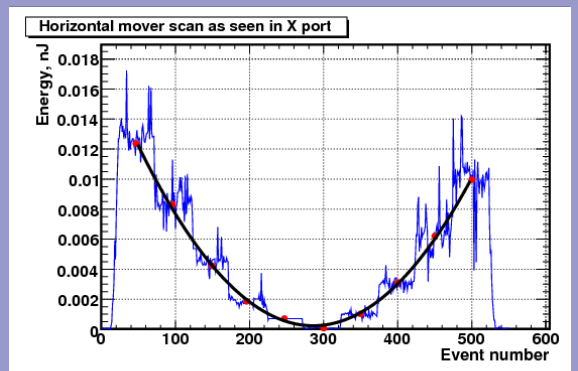


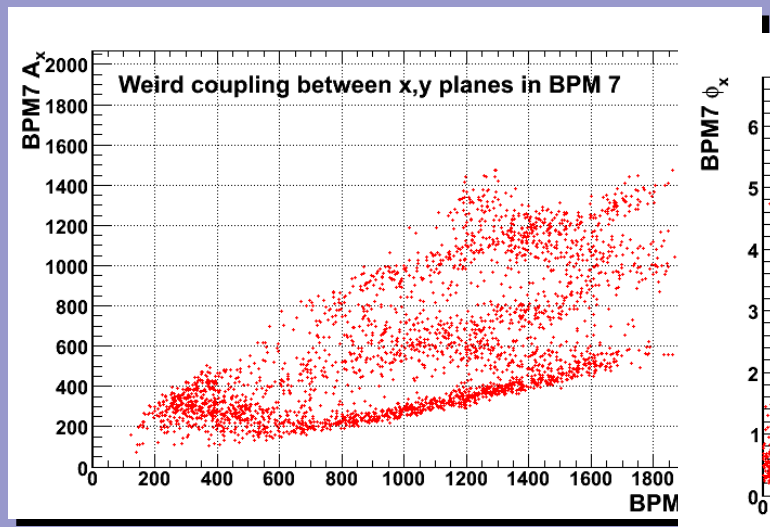


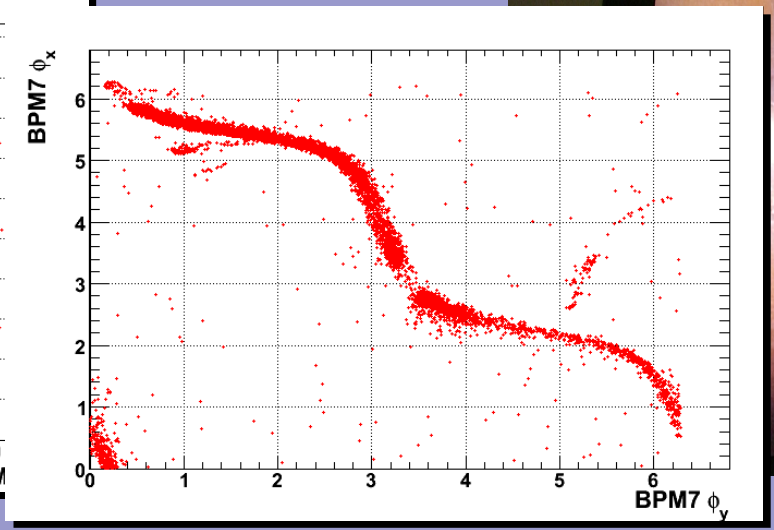
- Dipole cavity on xy mover system
- Reference cavity
- Temperature sensors
- Electronics and motion control

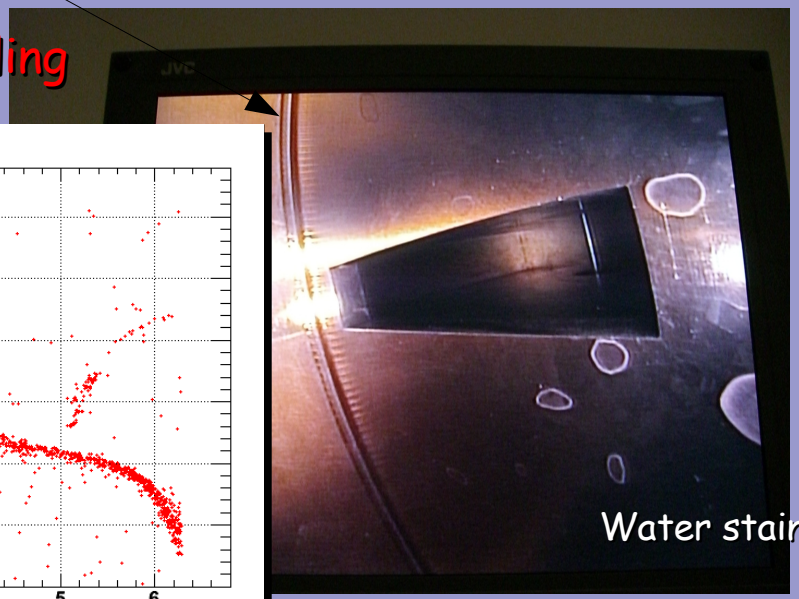
Performance of our first BPM

- VNA measurements of copper prototype :
  - Reference cavity frequency off by 90 MHz (fixed : tuned)
  - Excellent monopole rejection in position cavity
  - Dipole mode coupling < 20 % in one and 50 % in other
  - Al prototype was fine, manufacturing needs improvement !!
- Bad brazing on tuning screws
- Endoscope pictures revealed several problems
  - Gaps between parts on brazed joints (material flow)
  - Cleaning issues : water stains, finger prints
- Beam data
  - Dipole sensitivity: -0.42 V/mm/nC, 0.47 V/mm/nC (design value : +/-0.69 V/mm/nC)
  - Resolution of 2-3 μm, Very large xy cross coupling



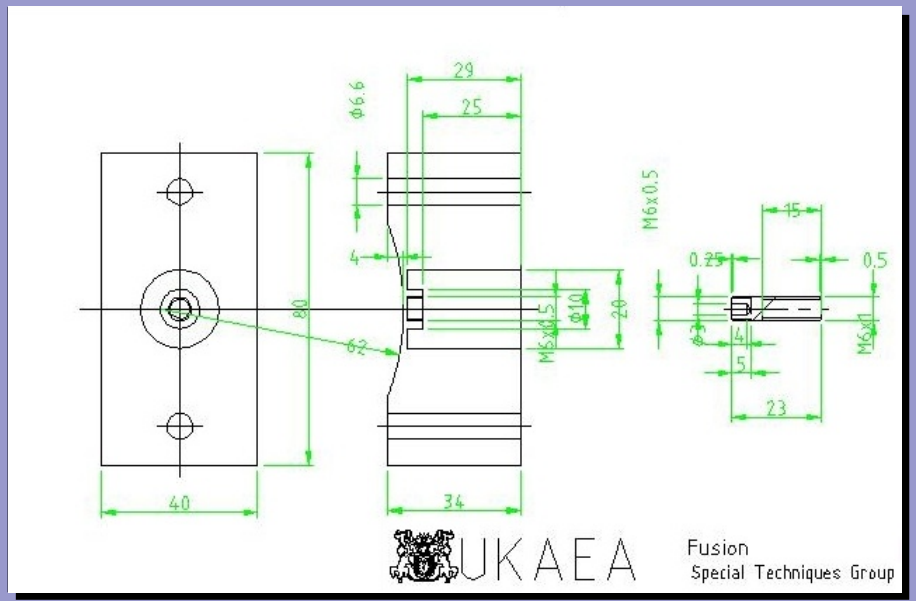


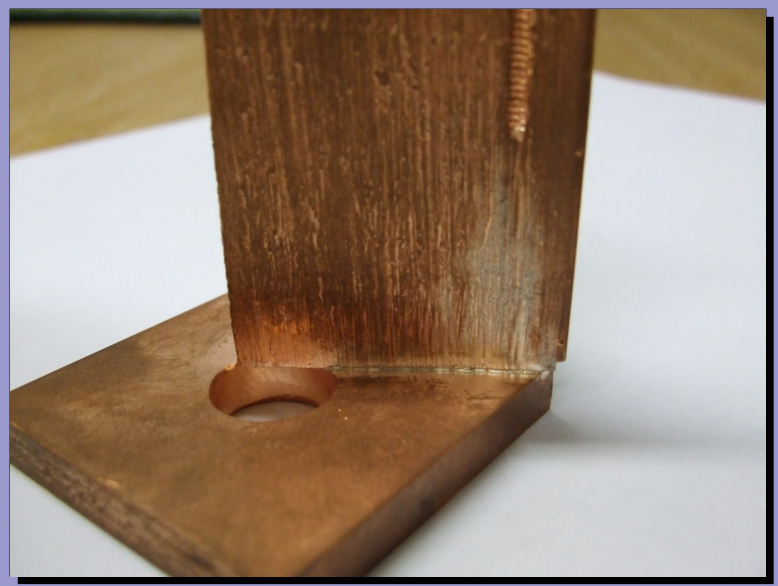




What now ?

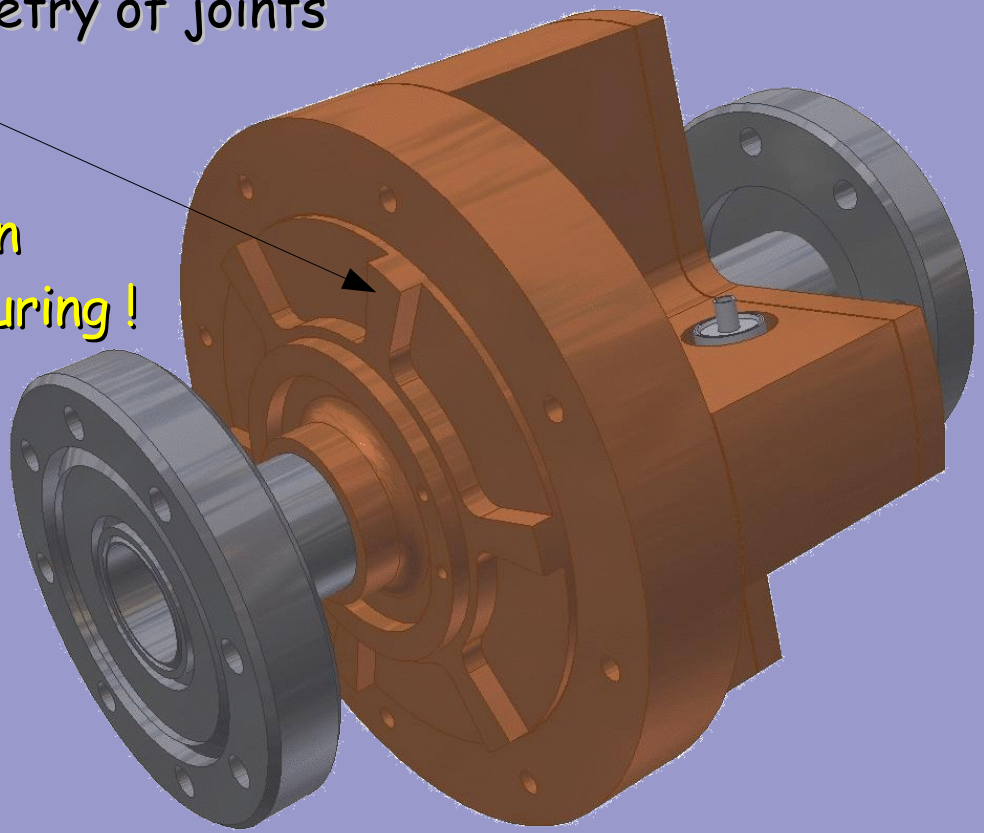
- Analyse beam data of old cavity to understand and learn (paper) !
  - All information is still present in the waveforms : find rotation of xy plane by analysis of 2D mover data, axis rotation -> uncouple !
  - Specialised analysis of faulty cavity very important for understanding mechanical tolerances on RF BPMs, faulty cavity quite interesting :)
- Focus on manufacturing new cavity with improved mechanical design, replace first prototype in ESA in April, but without compromise on performance tests !!
- Monitor the manufacturing process more closely, demand quality check step by step, talking directly to brazers (UKAEA, Culham)
  - manufacture brazing test pieces, e.g. tuning screw
  - study flow of brazing material, optimise technique/quantity of material





Spectrometer BPM prototype, v2.0

- Electrical design almost identical
  - New feedthroughs, lower loss model is available (Kyocera)
  - Minimise length of waveguides (reduce mass)
  - Round corners : allow CNC machining instead of wire erosion
- Improved mechanical design
  - Smaller flanges
  - Positioning of brazing groves, geometry of joints
  - Addition of water cooling fingers
  - Cleaning the cavity...
- In general : simplify mechanical design
  for more easy and cheaper manufacturing !

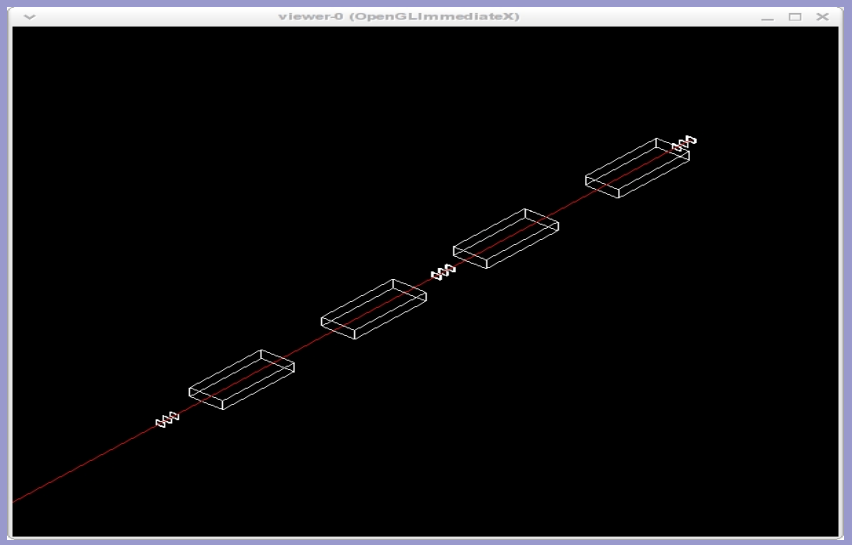


Spectrometer simulation work...

What have we learned from T474, how can we extrapolate to the ILC ?

- Important for ILC EDR ! : simulation of energy spectrometer
- Energy systematics affected by
  - Different chicane layouts
  - Magnet imperfections, non-uniformity, fringe fields, misalignments, ...
  - Residual dispersion, beam jitter (orbit subtraction), halo, ...
    - Real measurements here !!!
  - Beam orbit behind the spectrometer chicane
- Do we understand BPM response well enough -> simulate !
- Compute SR integrals and emittance change for different chicane layouts
- Effect on transverse and longitudinal phase space
- Track energy measurement down to IP through the rest of BDS

Knowledge and software (libbpm, standalone spectrometer simulation) present !
Need time and manpower for in depth analysis !!!



Turn key, accelerator integration

- During LC-ABD 1 : expertise in RF Cavity BPMs
  - signal processing and analysis
  - design/manufacturing
  - installation and operation (ATF/ESA)

- However : Obvious R&D context !!
  - Bulky processing electronics (30 km of racks... ?)
  - Rather expensive
  - Connectorised individual RF components
  - Very modular processing chain... integration !!
  - Data taking in "R&D mode" inefficient !!
  - Only first attempts at automation

R&D Phase → **Real System**

- LC-ABD 2 : continue gain in expertise, but evolve towards "Turn Key" operation and accelerator integration
  - Want to be able to get BPM readings fast, reliable and easy to use
  - Obviously goes for spectrometry as well !!!

Turn key, accelerator integration

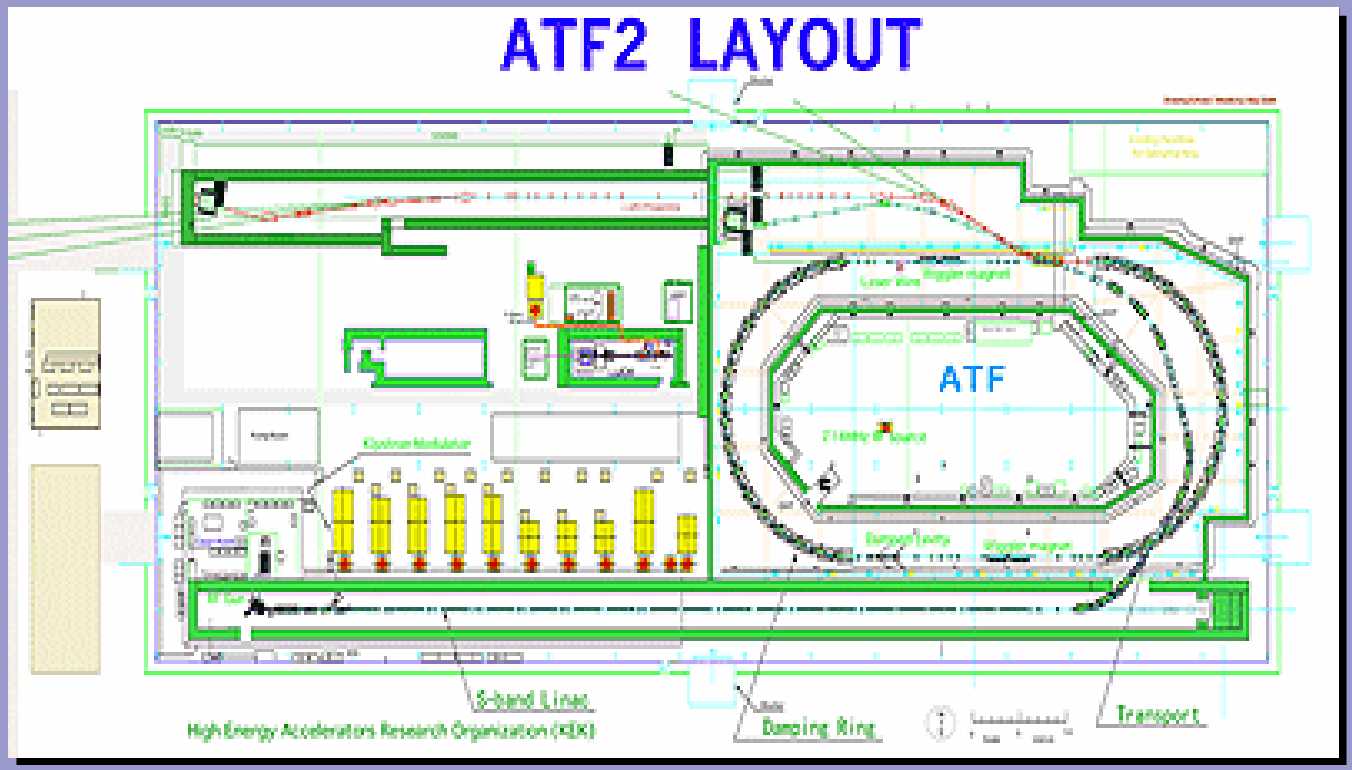
Plans to reach this state will be implemented during LC-ABD 2 !

- Electronics
  - Replace connectorised components by PCB versions
    - Develop simple test pieces : e.g. RF amplifier on PCB and compare to commercially available connectorised components
    - Gradually add more complexity : downmixing, filtering, FPGA, ...
    - Modern PXI interface
  - Reduce costs of electronics
  - Come to integrated RF BPM processing board : ultimate goal !
    - Filtering, downmixing, maybe even integrate system state (calibration trigger)
    - Digitising, processing code on FPGA ... : RF in, Position/Tilt out !
  - New testlab at RHUL perfect for development and testing

- Software processing
  - BPM processing library in plain C, can run on e.g. FPGA, EPICS IOC
  - "libbpm" exists and used in ESA BPM analysis framework, needs extending !!
    - Document performance (publication ?!)
    - Implement additional features : filtering, simulation
  - Deploy for BPMs in ATF2 beam line

ATF2 commissioning

- Collaboration with KNU (Kyungpook National University, Korea) to design new ATF2 cavities (along with SLAC, KEK)
- Possible re-use electronics developed for ESA
  - design frequency to be agreed
  - check multi-bunch response (~150 ns spacing)
- Active participation in commissioning of ATF2 beamline
- EPICS / libbpm based BPM control system



In summary...

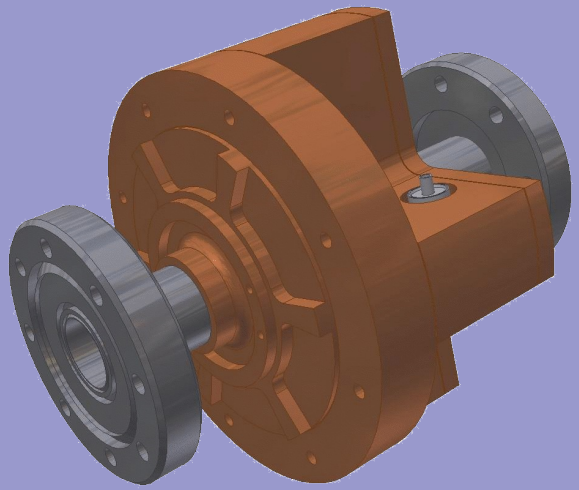
- Continue involvement in ESA FY'08, round-up spectrometer work on the way to the EDR
  - small hardware upgrades
  - detailed BPM systematics analysis and energy measurement

- Simulation work : BPM spectrometer, transport to IP

- Spectrometer BPM prototype
  - first prototype installation finished, electronics and mover system
  - learn from manufacturing problems : cavity tolerances
  - improved design for prototype, brazing test pieces

- Turn key operation and accelerator integration
  - integration and miniaturisation of BPM signal processing
  - software processing

- Involvement in ATF2 commissioning of BPM system



Quite diverse, challenging, but very exciting program !