CBETA Visit
16^{th} – 27^{th} April 2018

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Aims

- Begin collaboration between the UK and Cornell/BNL on CBETA
- Investigate potential areas of future collaboration
- Take part in commissioning shifts to further understanding of CBETA
- Provide commissioning support in several areas:
  - Beam dynamics
  - High-level software

Beam Dynamics

- Phase Cavities with first dipole to determine phasing resolution
- Determine how and to what accuracy emittance can be measured using a quad scan in S1.
- Devise a method for measuring dispersion in S1
- Develop user knobs (linear combinations of magnet strengths) that will be useful for matching the orbit at the end of S1 into the permanent magnet arc (PMA).

High-level Software

- Open-ended!
- Use of python and (probably) Qt bindings for high-level software development
- Investigate potential areas of future collaboration

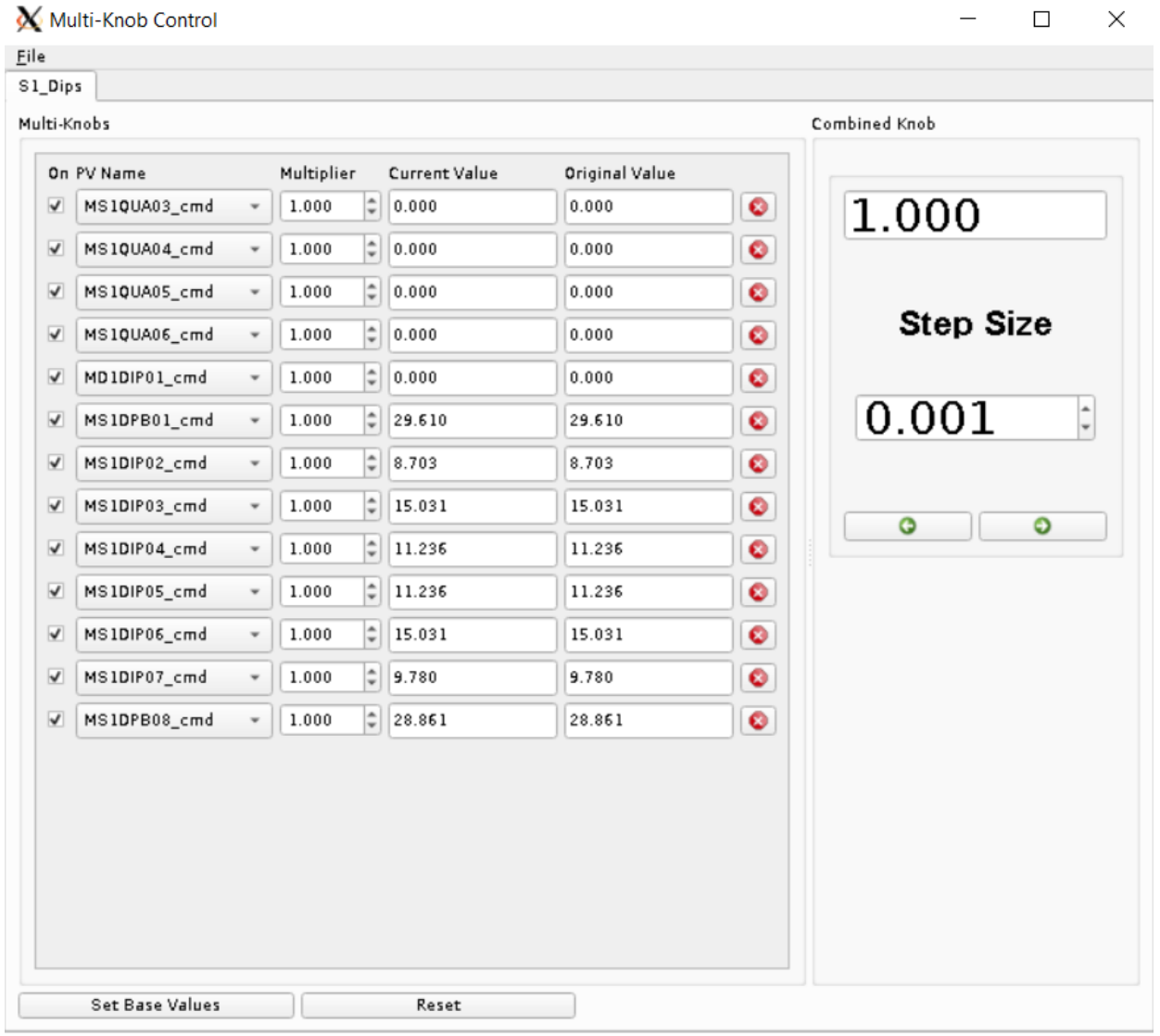
Part 1: This week I have been mostly working on…

Outcomes

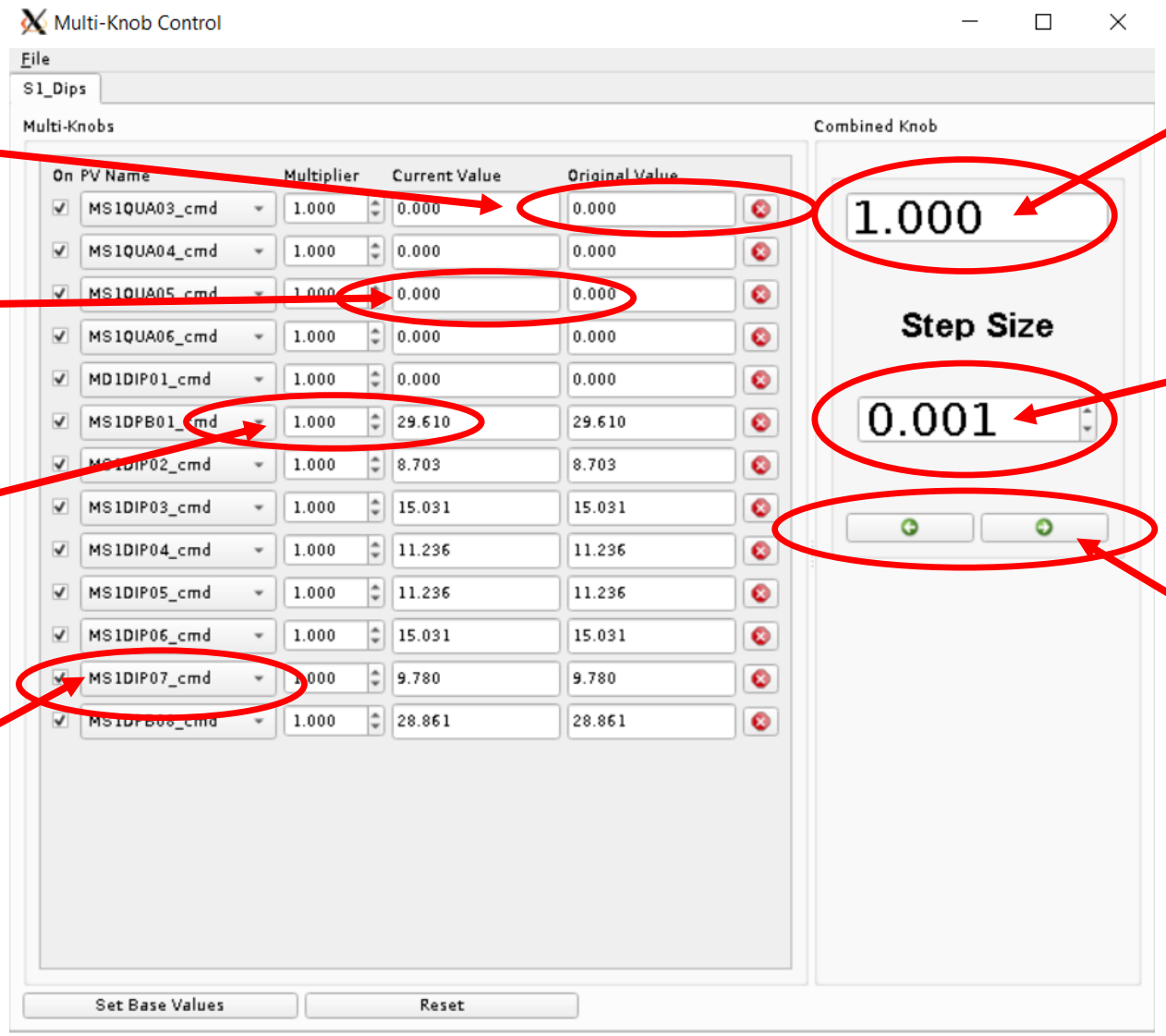
- Generated several high-level software GUIs for use on CBETA
- Provided demonstration python scripts for use in future applications

- Scripts:
  - Generic EPICS PV based classes for use in python scripting
  - PyQt based tuning knob application with several example potential tuning knobs
  - PyQt based multiKnob application for “ganging” epics PVs together
  - PyQt based response matrix generation application
  - PyQt based application for recording data

Multi-Knob Control application



Multi-Knob Control application



Original value

Current read-back

Individual magnet control

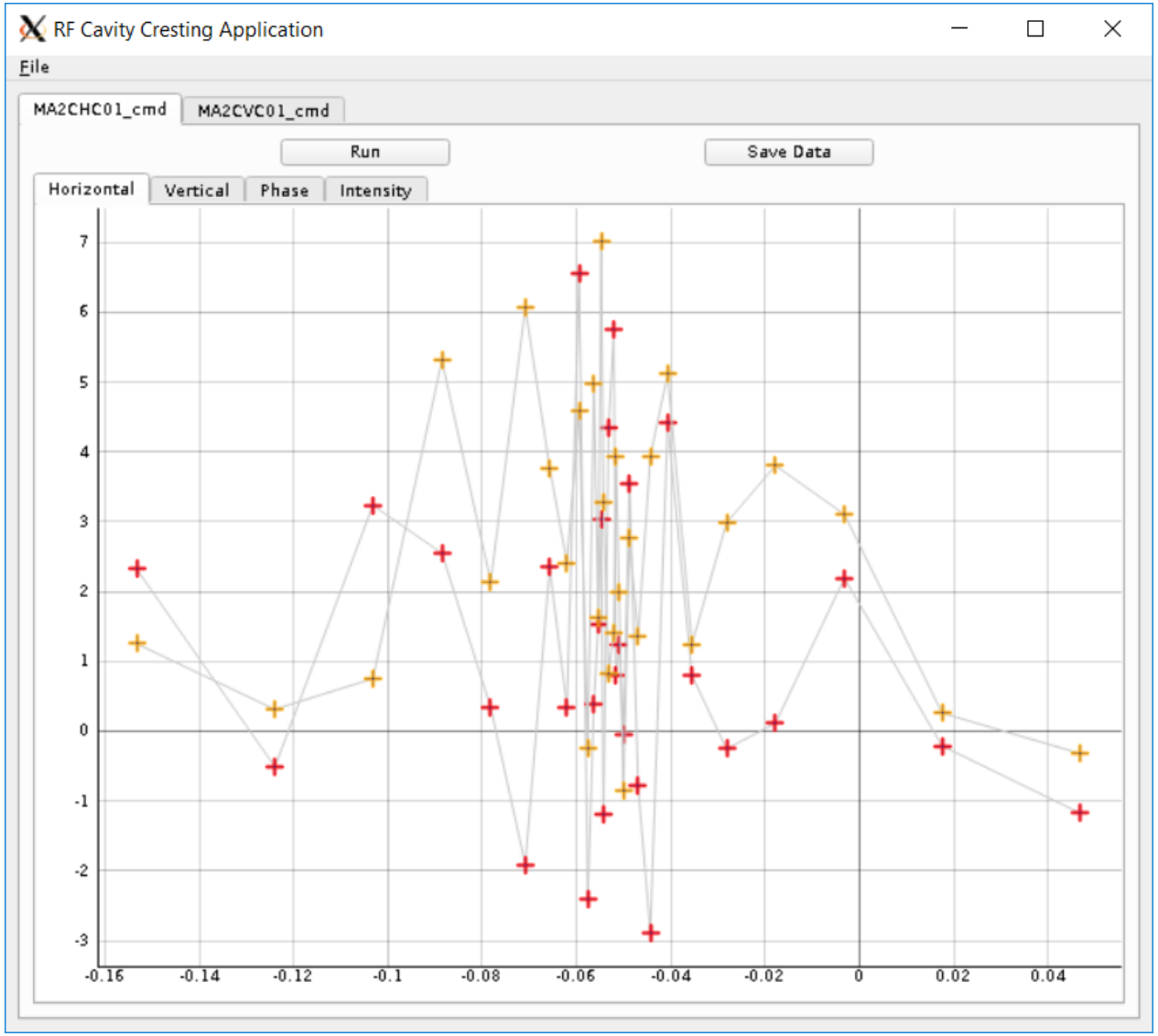
Actuator

Global Ratio

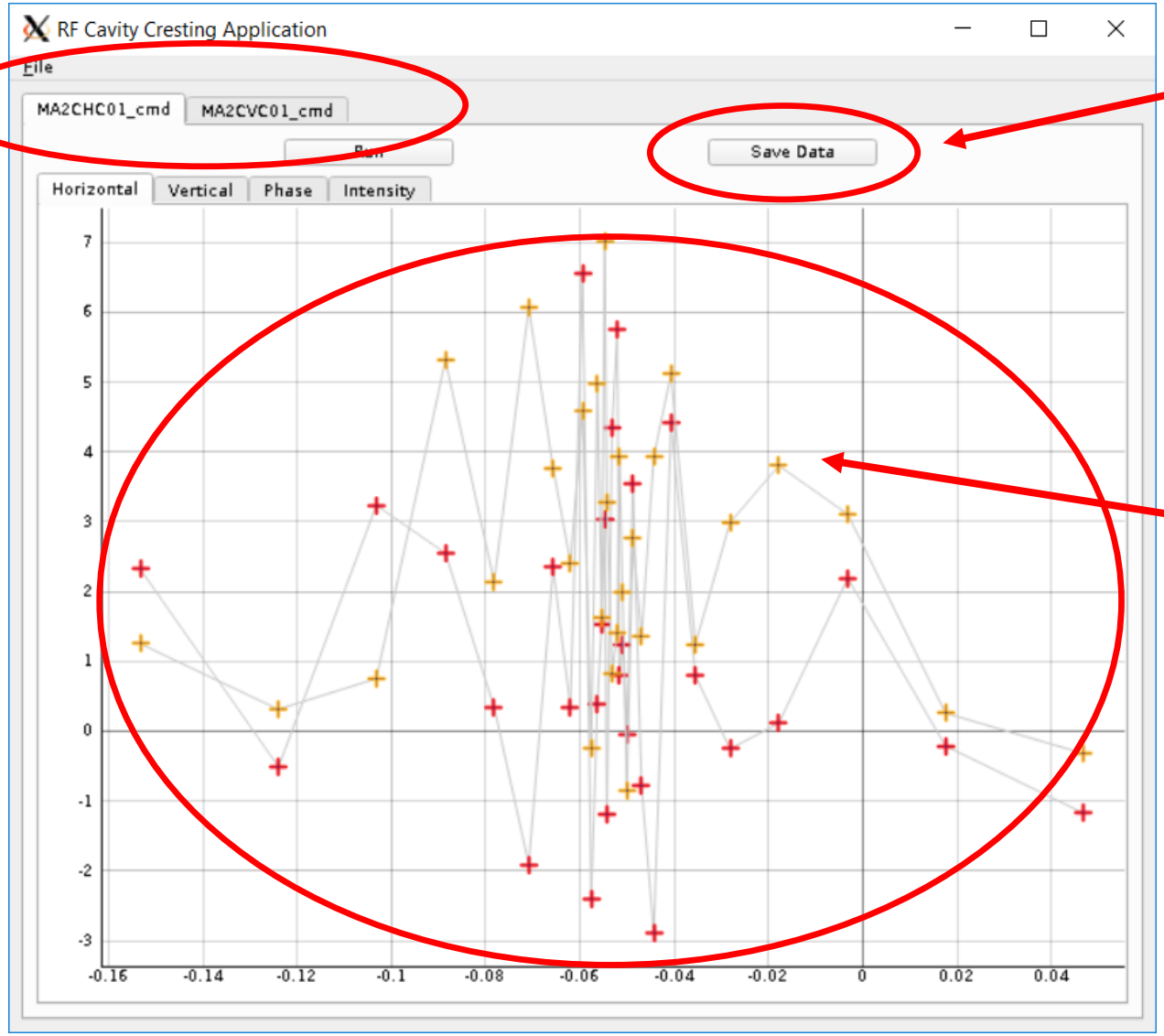
Global Step-size

Global Controls

Response Matrix Application



Response Matrix Application

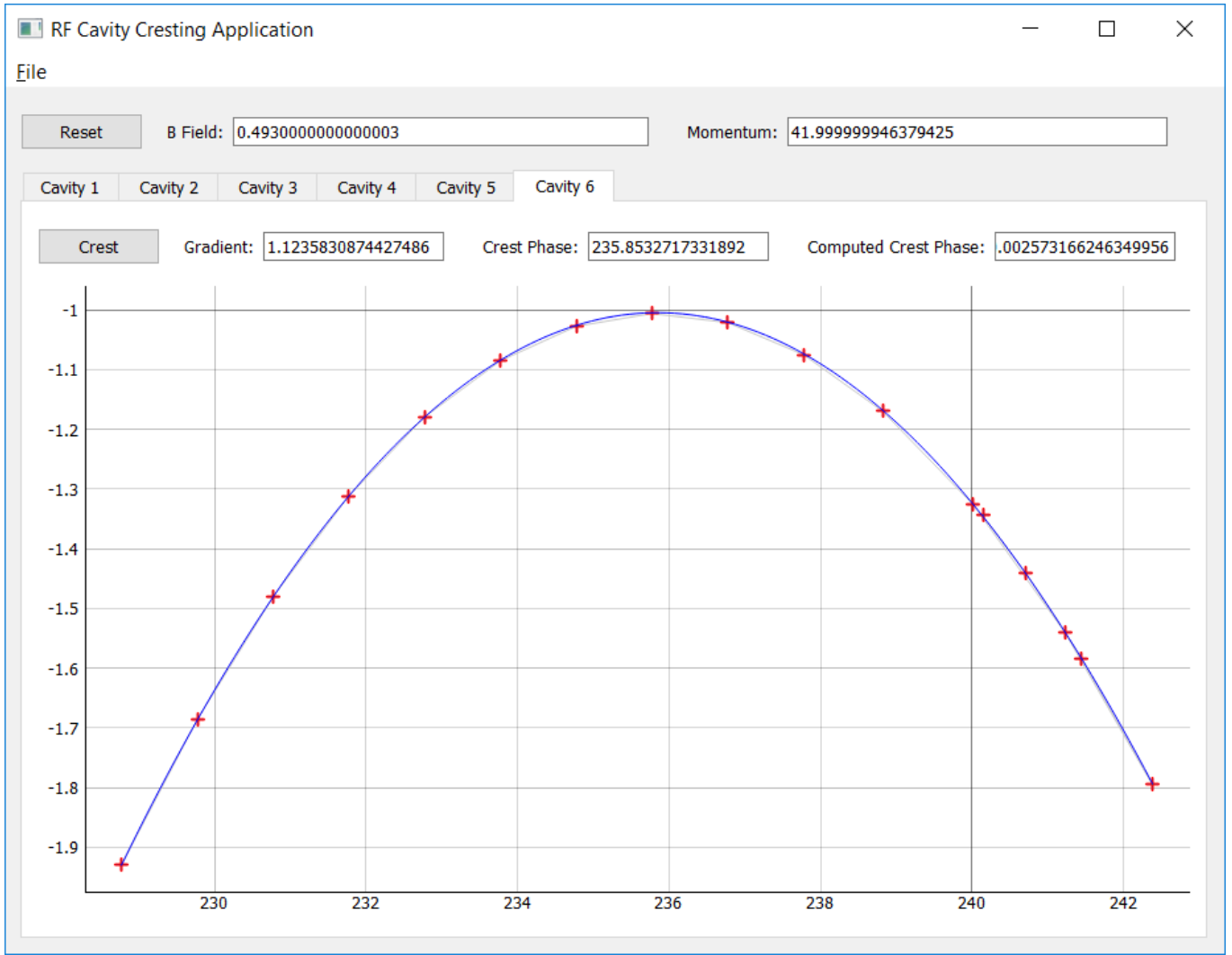


Actuators

Save data to HDF5 format

Response on all Monitors

MLC Cresting Application (Untested!)



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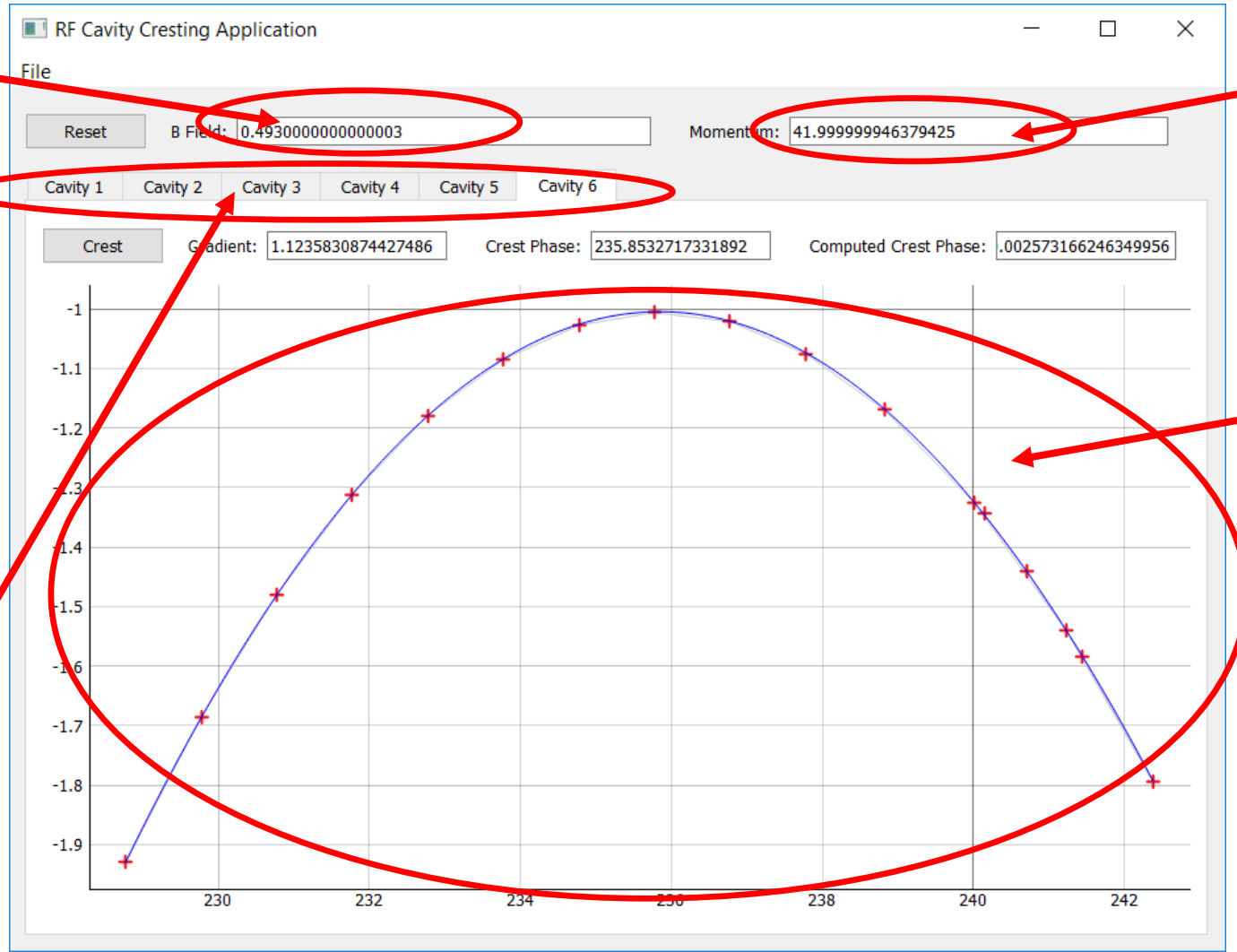

B-Field
(Un-calibrated)

Calculated Energy
(Un-calibrated)

Screen/BPM
position read-back

Cavity Control

Model Independent Analysis

- Plan to take data for MIA analysis (Friday)
- Record BPMs in steady-state conditions, under several scenarios:
  - On crest on all cavities
  - At ±20° on each cavity
  - Other scenarios??
- Using SVD:
  - Reconstruct dominant Eigen-modes of the system
  - Differentiate between:
    - laser jitter + other jitter (on-crest)
    - RF + laser jitter + other (off-crest)
  - Analysis done after IPAC

Conclusions

- Very productive 2 weeks
- Some applications have been created that I hope will be useful to the CBETA team
- There is a general cross-facility benefit to this type of high-level software work:
  - Nearly everything is facility independent!
  - All applications will be useful on my home facility
  - Everything on GitHub

- ***Many thanks to the whole team for helping me and providing a friendly environment to work in!***

Part 2: How we do things wrong at Daresbury

From an AP/Operations perspective

The Daresbury Way…

- At DL we have commissioned (in the last 10-15 years):
  - A SC ERL (ALICE)
  - A ns-FFAG (EMMA)
  - A linear accelerator for industrial applications (VELA)
  - An FEL test-facility (CLARA) – ongoing!
- We have made many mistakes…
- But, we are trying to learn from them:
  - Changes to operating procedures
  - Changes to reporting procedures
  - Changes to documentation procedures
  - …

The Daresbury Way…

- Lessons from ALICE and EMMA:
  - Too few people could “run” the machine well
  - We did not have consistent procedures
  - Beam quality dependent on shift operator
  - No documentation
- Lessons from VELA and CLARA:
  - People were too “silo”-ed
  - Technical groups were not well integrated with Operations
  - Users…
  - …not enough time to actually commission the machine

The Daresbury Way…

- ***Most*** staff should be available for shifts
  - Not all are “first”/”lead” commissioners, but heading that way
- Each shift must/should include 1 AP, 1 RF, 1 Laser
  - Others (diagnostics, controls etc.) when available
- For experiments we have Principle Investigators (PIs)
  - Define and run experiments during commissioning
  - Are not (in general) operators
- For continuity we have Beam Operations Coordinators:
  - One week “in charge” of machine (***not*** experiments)
  - Provide continuity from day-to-day
  - Lead commissioners with broad knowledge
  - Generally AP, but could be RF/Laser/Other

The Daresbury Way…

- ***Everybody*** *more or less* is responsible for (at least) one high-level "application":

Tasks

Below is a list of requested tasks for machine characterisation and development.

(NOTE, the priorities are in draft form and based on the assumption that we have to be able to deliver beam to BA1(2) for exploitation and we would like to / should try and, characterise, understand and develop the machine!) Some tasks have been assigned as parasitic, meaning we expect to be able to progress them without having dedicated beam time. Parasitic tasks could take the beam for short periods time where appropriate, but won't be scheduled as main activities for the shift.

- Principal Investigator (PI) is a new role (see end of document for more information.)
- Deepa is the overall PI *and the* PI for all AP tasks. PIs for AP tasks have been delegated.
- Ed Sneddon is the overall PI for laser, timing and synchronisation tasks. (?)
- Yuri Saveliev is the PI for BA1 tasks (?)
- Alan Wheelhouse is the PA for RF tasks. (?)

TASK	PI	Priority	Deliverable/Outcome (Red: stretched goal)
Gun / Solenoid / PI Laser alignment	Frank Jackson	MUST	RF Centre, magnetic centre of gun measured, vs charge Physically move solenoid to overlap magnetic and RF centre
Gun / Linac 1 Cresting	Julian McKenzie	MUST	Automated Measurement of Phase vs momentum & momentum spread vs charge
Momentum & Momentum Spread Measurement	Tim Noakes	MUST	Automated Momentum & Spread measurement vs RF amplitude, phase, & Charge vs RF amplitude, phase, Laser pulse length & Charge
100% Charge Transport To BA1(BA2)	Neil Thompson / James Jones	MUST	"Good' Steering, minimum dispersion, through magnetic / RF centres Orbit / magnet misalignments, quantified,
45 MeV Beam to BA1(BA2)	Neil Thompson / James Jones	MUST	"Good' Steering, minimum dispersion, through magnetic / RF centres Orbit / magnet misalignments, quantified,
Optimise dogleg optics / dispersion cancellation	Peter Williams	MUST	Measure and minimise dispersion on VELA YAG5 and YAG6 (with QUAD07,08 off)
Charge Measurement Devices Cross Calibration	Alex Brynes	MUST	Q measuring devices cross calibrated (ICT, Fcup and WCM)
BPM Calibration	Alex Brynes	MUST	BPM attenuation tracks Charge

23/04/2018 v0.1, DA-K & DJS

			BPM DLY parameters optimised BPM charge measurements
Develop start-up procedures to provide beam to BA1	-	MUST	
Train *enough* Staff to apply start-up procedure	-	MUST	Enough staff to fulfil exploitation programme can operate machine to deliver beam BA1. ***HOW MANY IS ENOUGH?***
BA1 Commissioning (essential systems)	Yuri Saveliev	MUST	Magnets, cameras, screen, bpms, Q measurements commissioned and working
BA1 spectrometer Momentum and Momentum Spread	Yuri Saveliev	MUST	Momentum & Spread measurement
NIR laser profile	Calum Tollervey	SHOULD	Understanding of impact of laser amplifier on transverse beam quality (currently poor) Mitigation of poor laser transverse profile.
Measurement of gun phase jitter	Ed Sneddon	SHOULD	Quantify current CLARA performance, establish repeatable beam setup for phase jitter measurement Correlation of gun jitter/drift with environmental parameters, including gun temperature, hall temperature laser energy
Testing and implementation of pi-shaper	Calum Tollervey	SHOULD	Insertion of pi-shaper on UV beam line, characterisation of transverse profile ('Gaussian' and 'Square') on VC. Emittance measurement (before and) after implementation, sign-off on device for general exploitation.
Laser transport characterisation and improvement	Ed Sneddon	SHOULD	Understanding of impact of laser transport on transverse beam quality (currently poor), benchmarking of optical simulation code Mitigation of poor laser transverse profile.
Demonstrate Unmanned RF Conditioning	Alan Wheelhouse (??)	SHOULD	Be able to do: overnight unmanned conditioning of HRRG @~100Hz, following latest procedure Start HRRG conditioning
Transverse emittance measurements	Boris Militsyn	SHOULD	4D emittance vs charge vs solenoid, vs laser pulse length
Measure Charge / Momentum Stability	James Jones	SHOULD	time series data over different times (shot-to-shot, minutes, hours), on different shifts / time of day vs different Charge Setpoints
BA1 Commissioning (desirable systems)	Yuri Saveliev	SHOULD	Interferometer, CTR, jitter studies

The Daresbury Way…

- High-level software can be written in anything
  - Very strong preference for Python+PyQt or C++
  - Legacy software in Mathematica/Matlab/Labview
- Algorithms/procedures developed in Python
- Once prototyped and useful:
  - Pushed onto controls group to be implemented in lower layers (i.e. EPICS)
- Every application must be useable by “anyone”
  - Pushes people towards GUI development
  - Individuals are “responsible” for application – implies lots of complaints if software unusable…

The Daresbury Way…

- Conclusions:
  - We are moving away from a single “super” operator
  - Make everyone/as many people as possible to be lead operators
  - Encouraged through responsibility to some high-level aspect of the machine
- Documentation:
  - By forcing people to be responsible for “applications” we encourage documentation
  - This also encourages “good” programming practices

Final aim is to engender “buy-in”/”Ownership” of everyone towards a common goal