Tune and Chromaticity

Outline

- Methods
- Focus
- Lessons Learned
- Where We Stand
- Plan for the Next Run

Methods - Tune, Chromaticity, Coupling

	tune accuracy	small chrom req'd?	timing req'd?	coherent /incoh?	chrom on ramp?	coupling	comments
BPMs	10^-3	yes	yes	coh	no?	need big kick	from injection oscillations
ARTUS	10^-3	yes	yes	coh	decoherence (sign?)	closest approach	emittance growth
HF Schottky	10^-3	no	no	incoh	sideband width	from line shape	continuous, non-pert
LF Schottky	10^-4	no	no	incoh	sideband width	from line presence	continuous, non-pert
PLL	10^-5	yes	no	incoh?	1 Hz radial mod	from line presence	continuous, non-pert, sensitive
QMM	?	?	no	incoh			injection matching, sensitivity?
Head-Tail	10^-3	yes	yes	coh	data analysis?		parasitic to ARTUS
AC Dipole	?	?	no?	coh?			add electronics to DX BPMs?

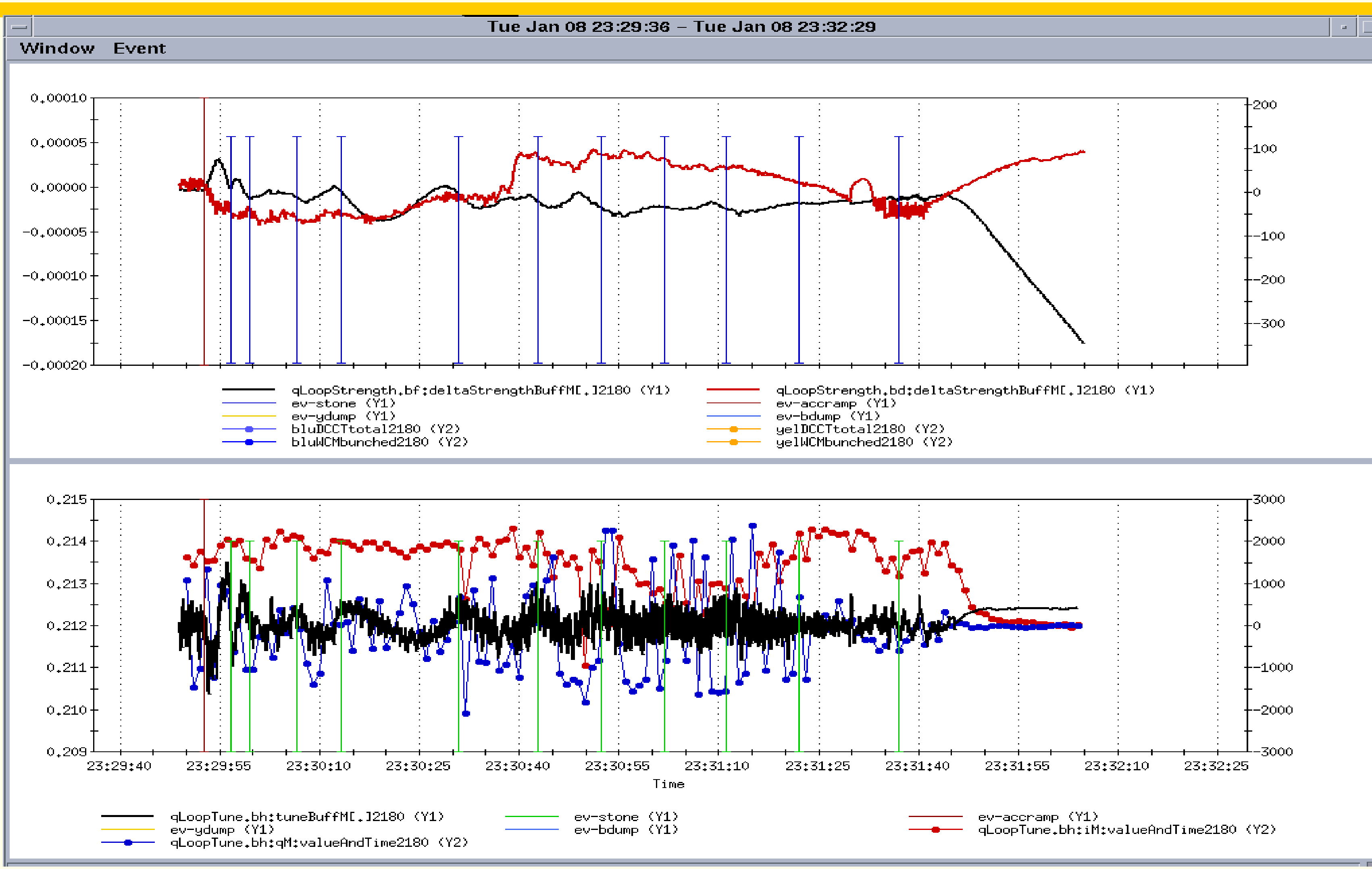
Focus

- ALL tune measurement systems are being improved
- Goal - to assist in providing L and P^2
- Largest potential for improvement is with Tune and Chromaticity Feedback
- Focus of this presentation is PLL tune and chromaticity measurement and feedback.

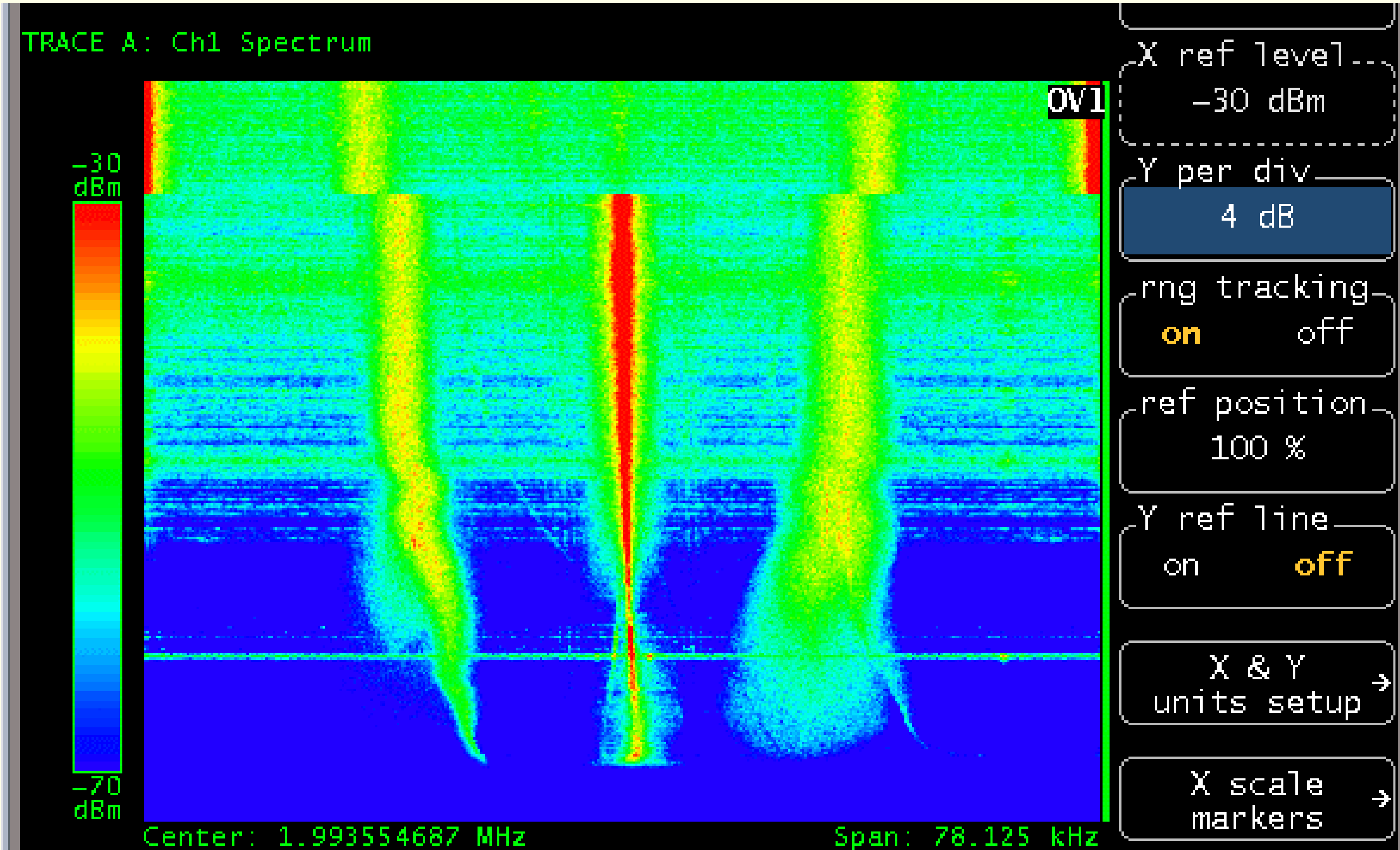
Lessons Learned

- It ain’t easy, persistence pays,…
- Good approach - resonant pickup above coherent spectrum
- Only one NCO per phase loop!
- RF Leakage requires careful attention - 1/4 heliax connectors, resonant BPM capacitive trimmers,...
- Pay attention to details of P-I algorithm
- Optimize DSP code for speed
- Control phase compensation from VME
- Autolock at constant phase is essential
- Filter, filter, filter,…
- Chromaticity control is ESSENTIAL
- Coupling correction is highly desirable

Ramp with Tune Feedback



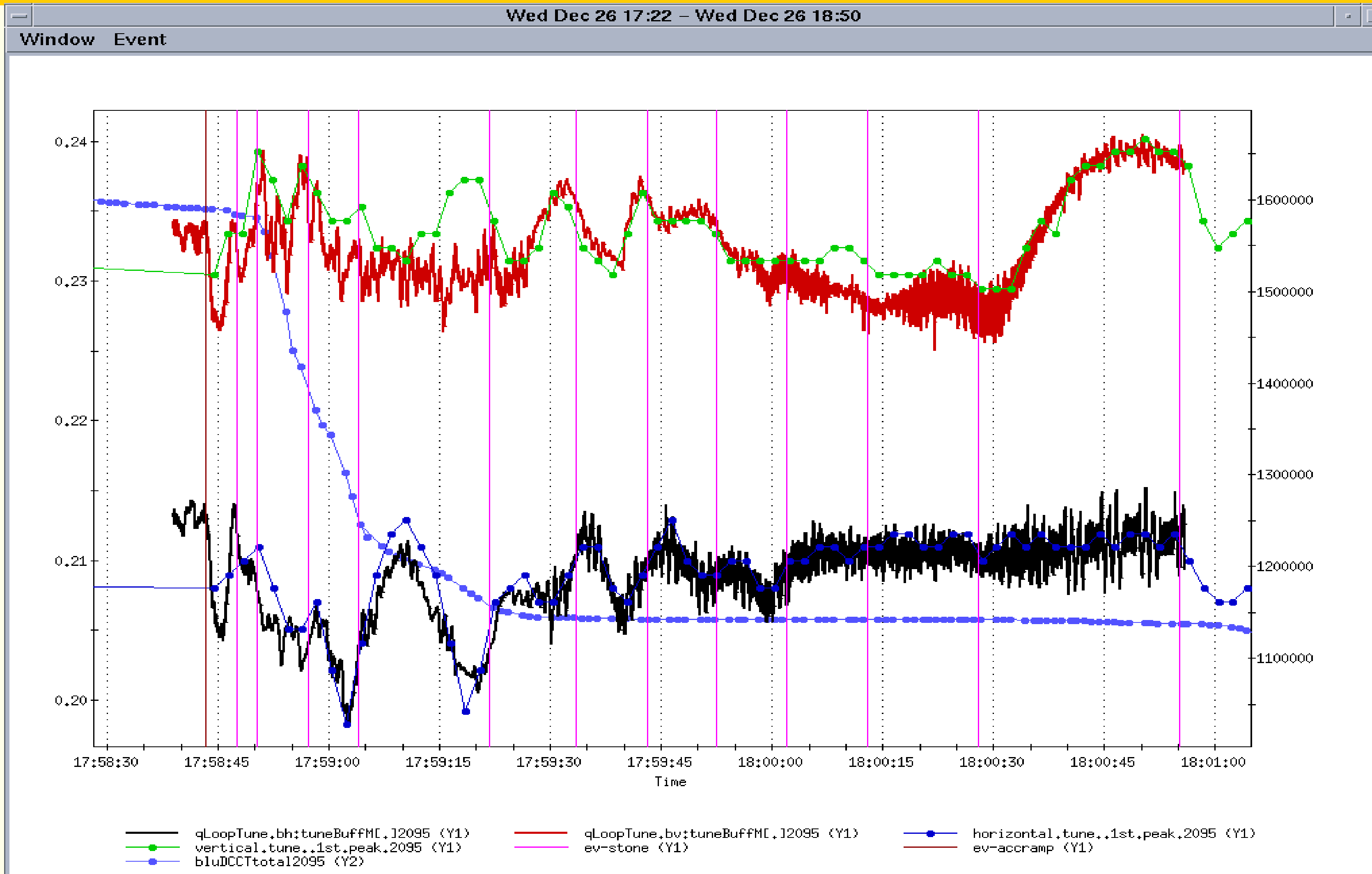
Down Ramp Chromaticity



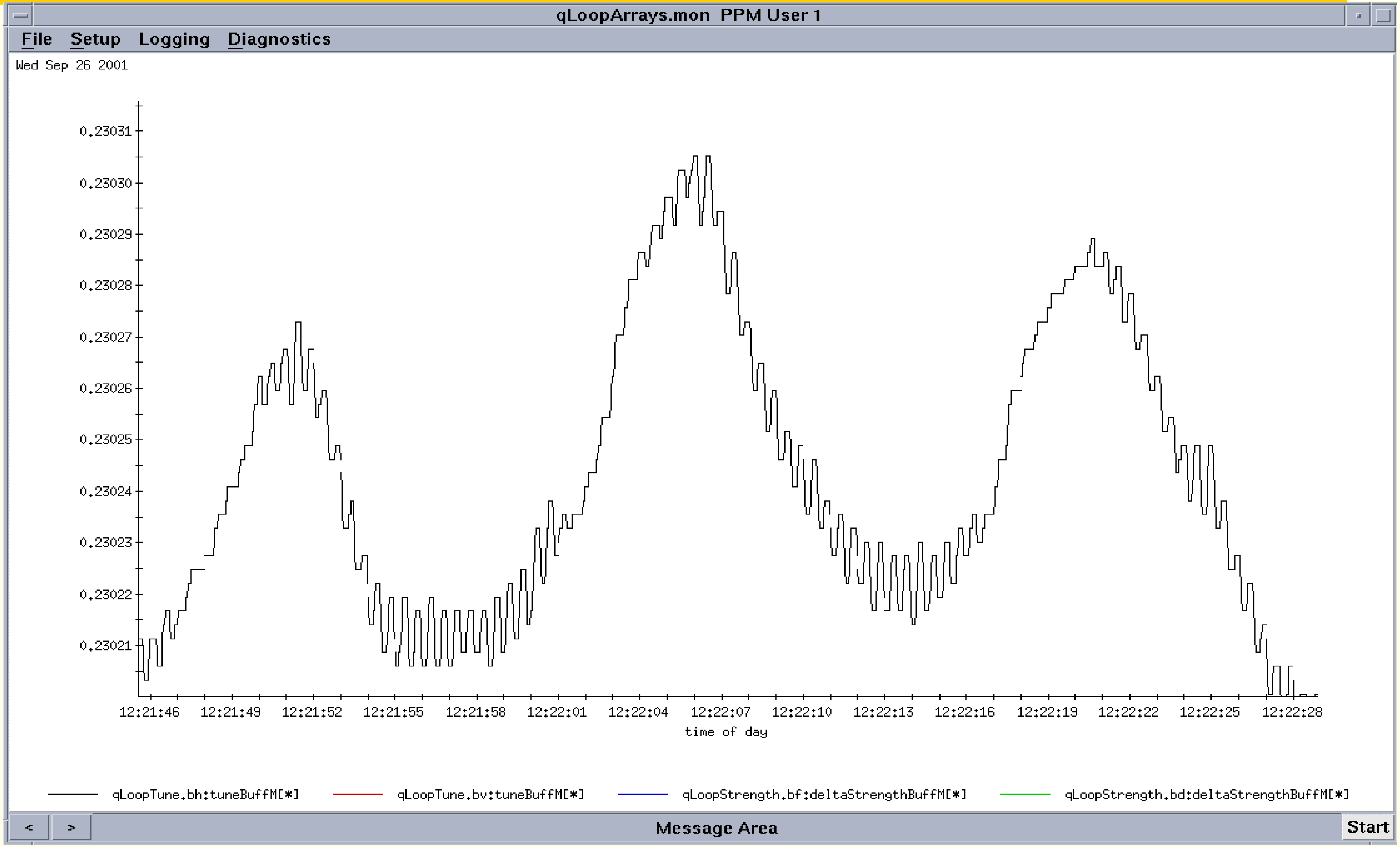
Where We Stand

- Defined state of the art in tune accuracy ($<10^{-5}$) and resolution ($\sim10^{-6}$)
- Autolock in good shape
- Up Ramps after 'lessons learned':
  - Three successful tune feedback up ramps in blue - no failures
  - One up ramp with yellow successful, blue lost at flattop due to chromaticity
- Down Ramps
  - Four attempted with tune feedback, none successful due to chromaticity
- By end of run system was stable, repeatable, reliable as a specialist tool
- Qloop is stable with ARTUS kicking
- Agreement with ARTUS is generally good, can be understood in terms of chromaticity and coupling when it is not
- Preliminary results with radial modulation for chromaticity are encouraging. Loop gains were set very high to compensate for poor chromaticity control.

Radial Modulation on the Ramp



Radial Modulation During Studies



Plan for the Next Run

- Implement Tune and Chromaticity Feedback early on, need small coupling
- Chromaticity at γ_t - Jorg's elegant plan
- Tool Training - develop awareness of how to use this tool
- System Plans
  - Position control of moveable BPM via Q3 and Q4 BPMs
  - Improved shielding, analog filtering, ver. 2 mixer boxes, add analog AGC
  - improved digitizer, DSP/FPGA and digital filtering
  - MATLAB modeling of PLL
  - UAL model of Beam Transfer Function
- Interface and Integration
  - Operation from MCR - polarized beam, Landau damping not effective near γ_t
  - Integration with Applications
  - Unified Data Display