Fast Transverse Instabilities

U. Wienands

Acknowledging contributions by:

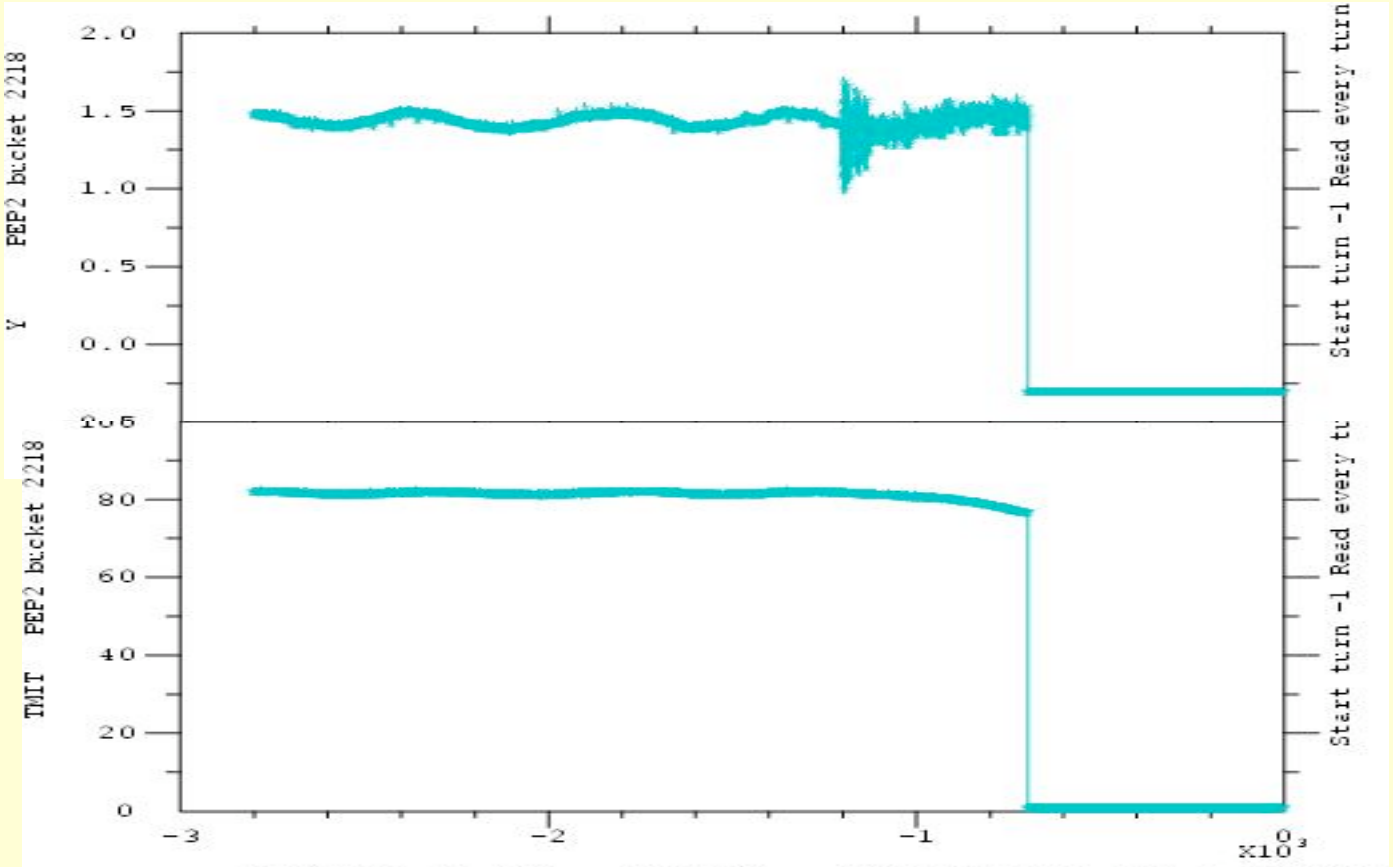
R. Akre, S. Curry, F.-J. Decker, S. Ecklund, S. Heifets, A. Krasnykh, A. Kulikov, A. Novokhatski, J. Seeman, M. Sullivan, D. Teytelman, D. van Winkle, G. Yocky,

History

- During Run 5a an instability with very fast growth, mostly vertical, began to affect LER performance and was subject to investigation.
- In Run 5b, once the vacuum was scrubbed this instability appeared again and became the major current limit by early Dec. 05.
- A long list of investigations was undertaken, during the course of which the TFB systems were reconfigured in an attempt to raise gain and control the motion
- In doing this, the nature of the observed instability began to change and different effects showed up, involving both HER and LER.
- Eventually it was understood that we in fact were dealing with at least two mechanisms different both in character as well as in the location of the originating event.
- I will refer to the original instability as the “fast LER” instability and to the second one as “IR-2” instability.

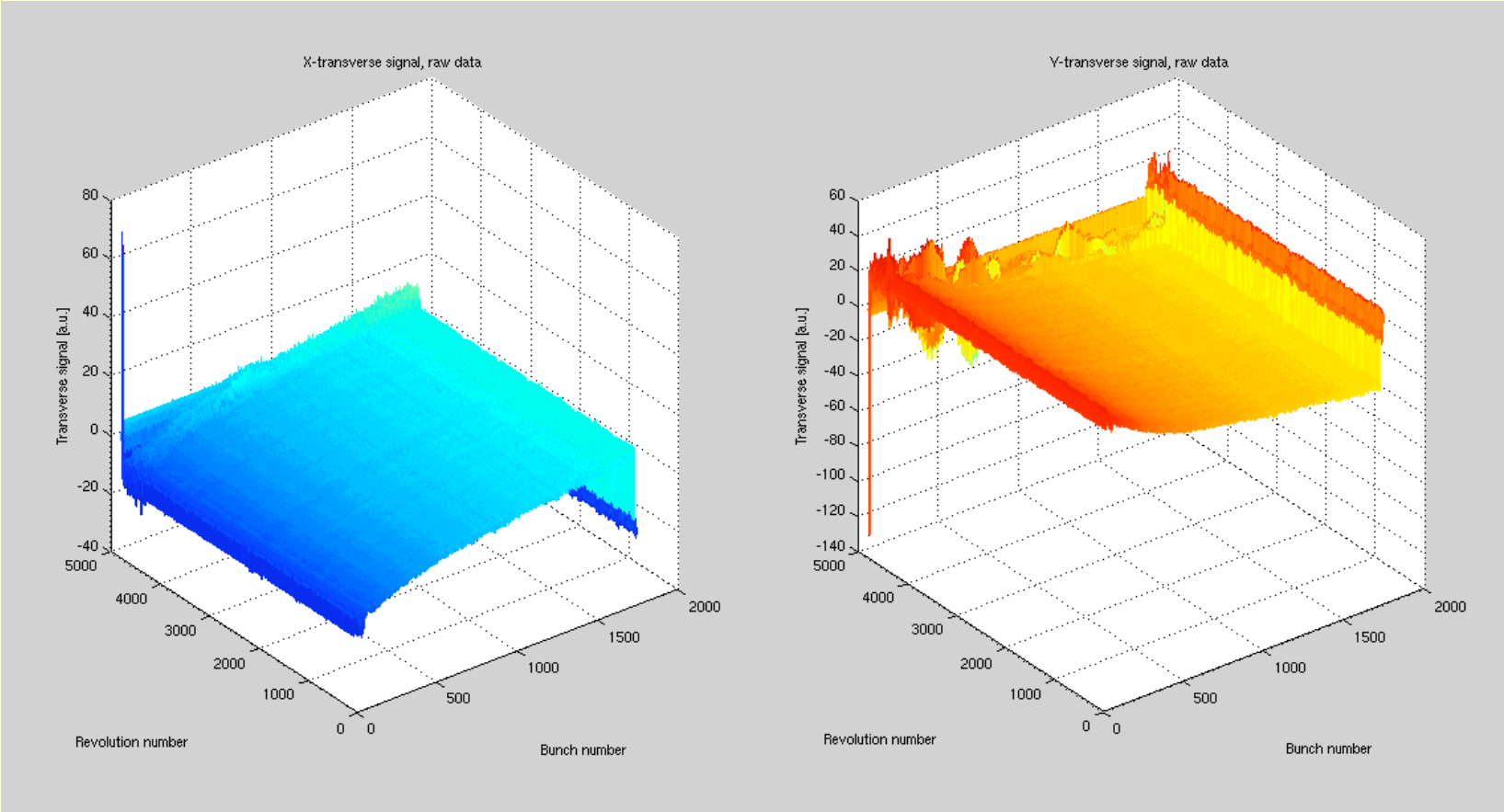
Fast LER Instability

- Characterized by very fast initial growth but limited amplitude of the observable motion while the beam current drops

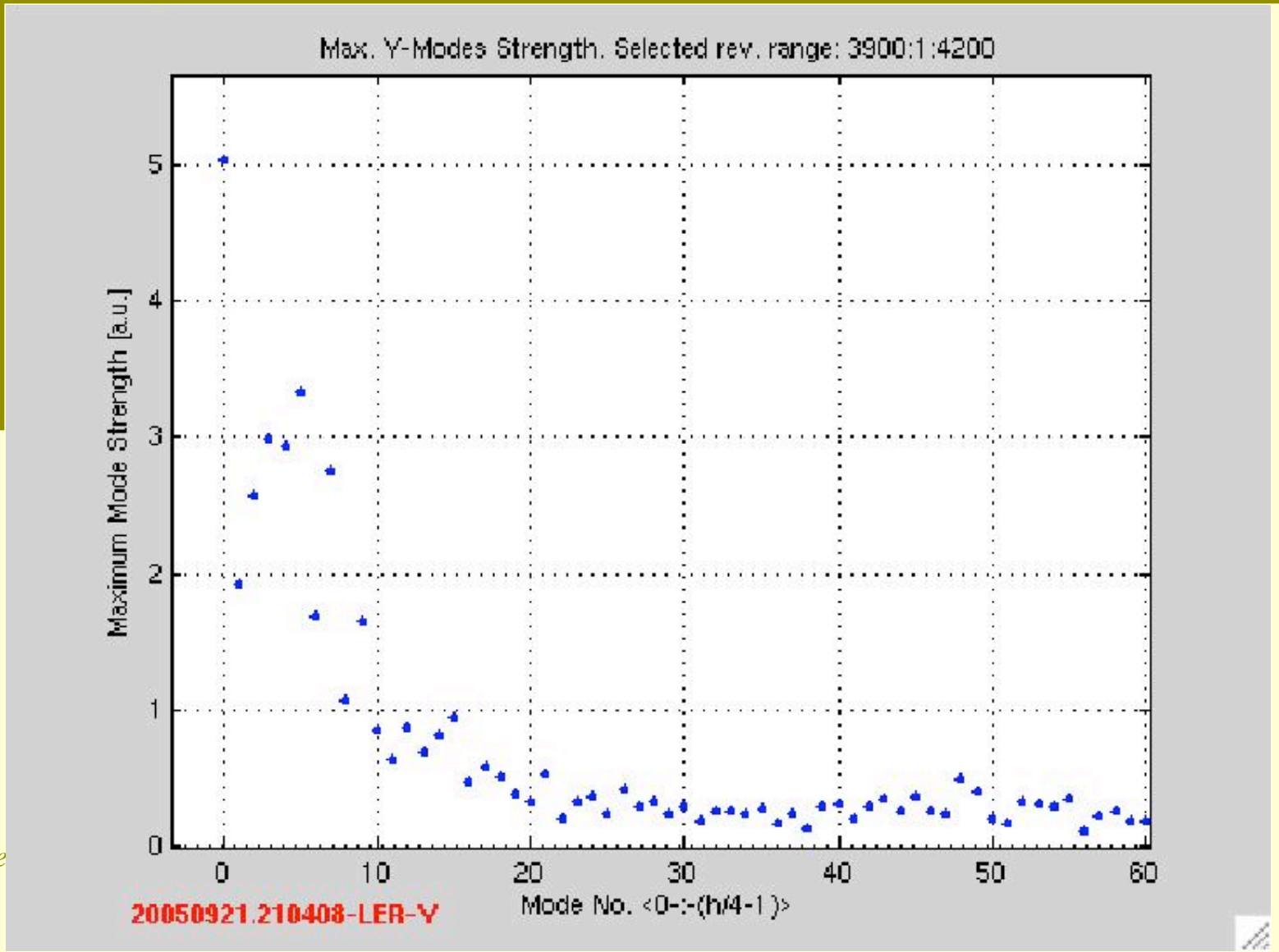


Centroid Motion

TFBgui courtesy of W. Colocho and V. Pacak

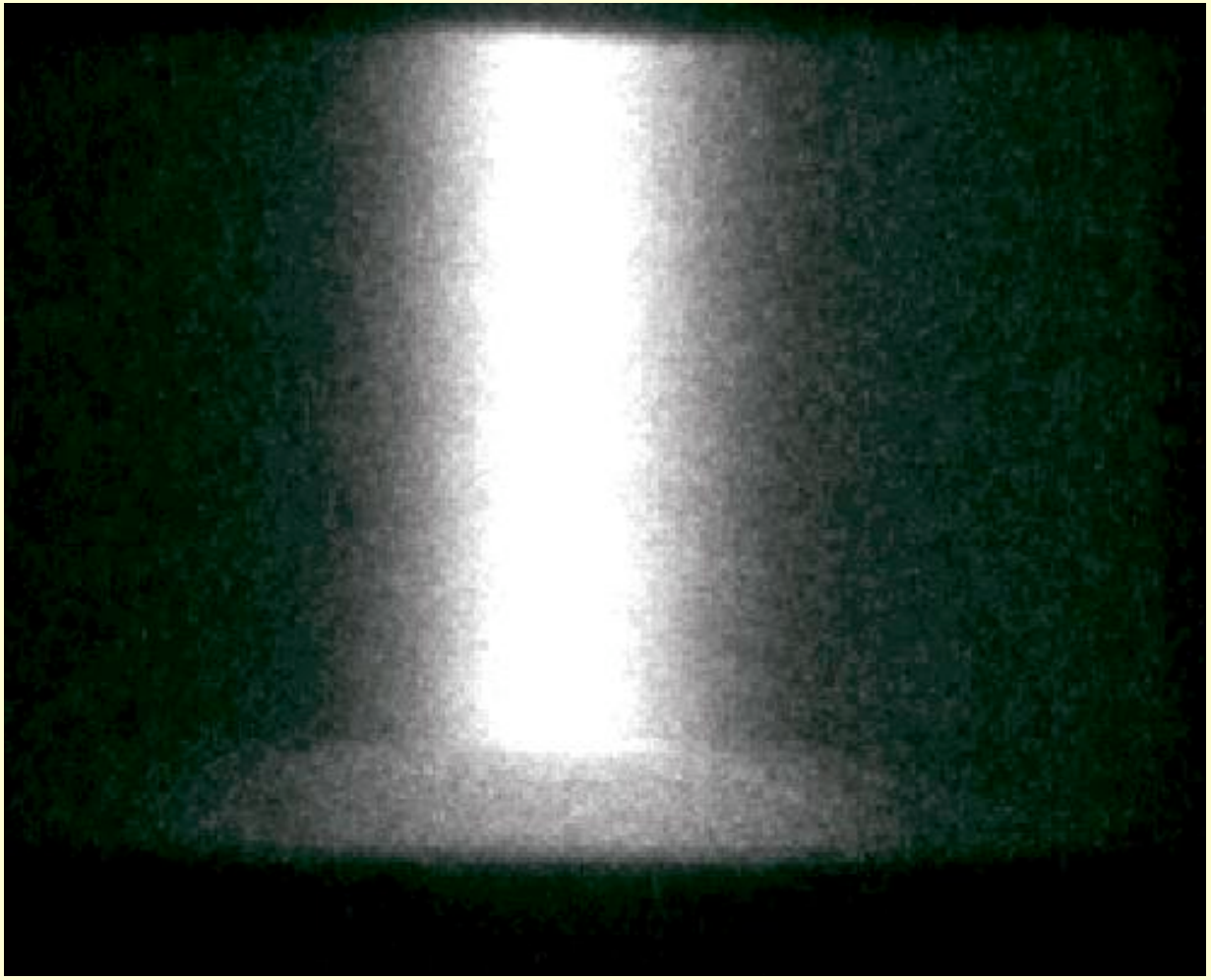


Modal Spectrum



Optical signature

A. Fisher



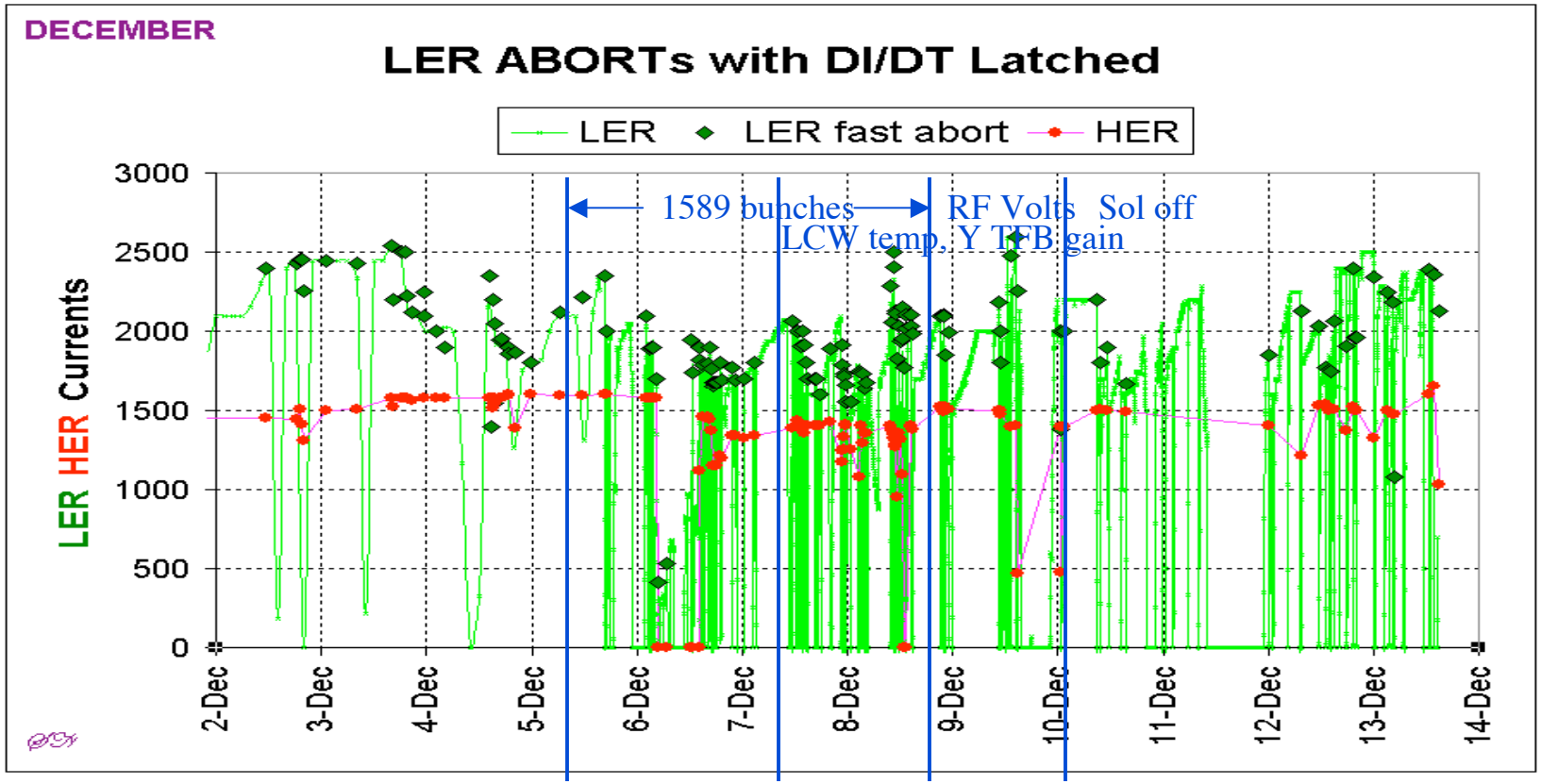
Time

y Direction

Threshold for Instability

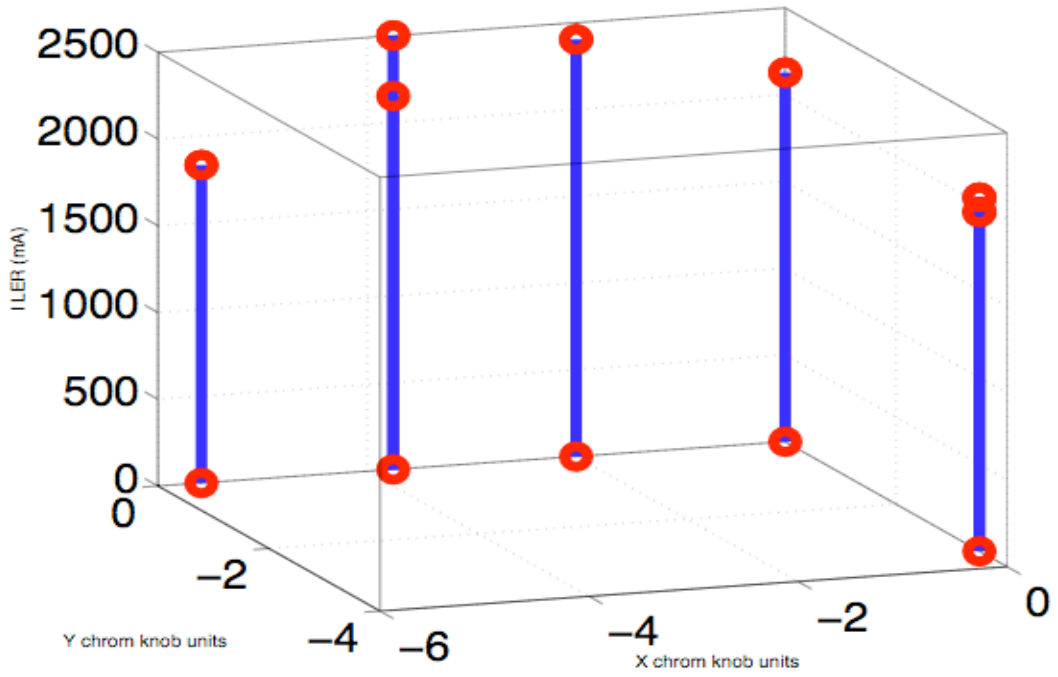
- Threshold is varying between 1600mA and 2500 mA
  - Does not react in a predictive way to chromaticity or tunes
  - Does not react to temperature change in vacuum system

A. Novokhatski

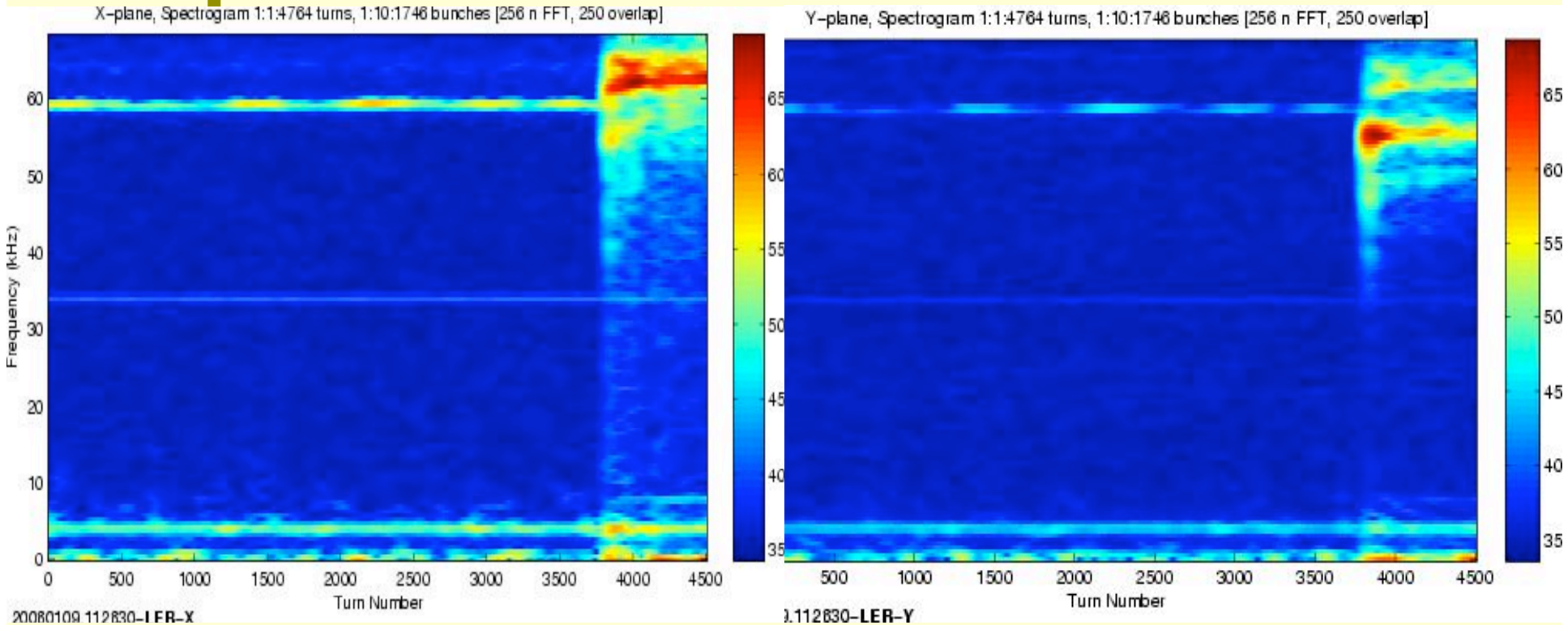


Threshold *vs* Chromaticity

G. Yocky



Spectrogram of Centroid Motion



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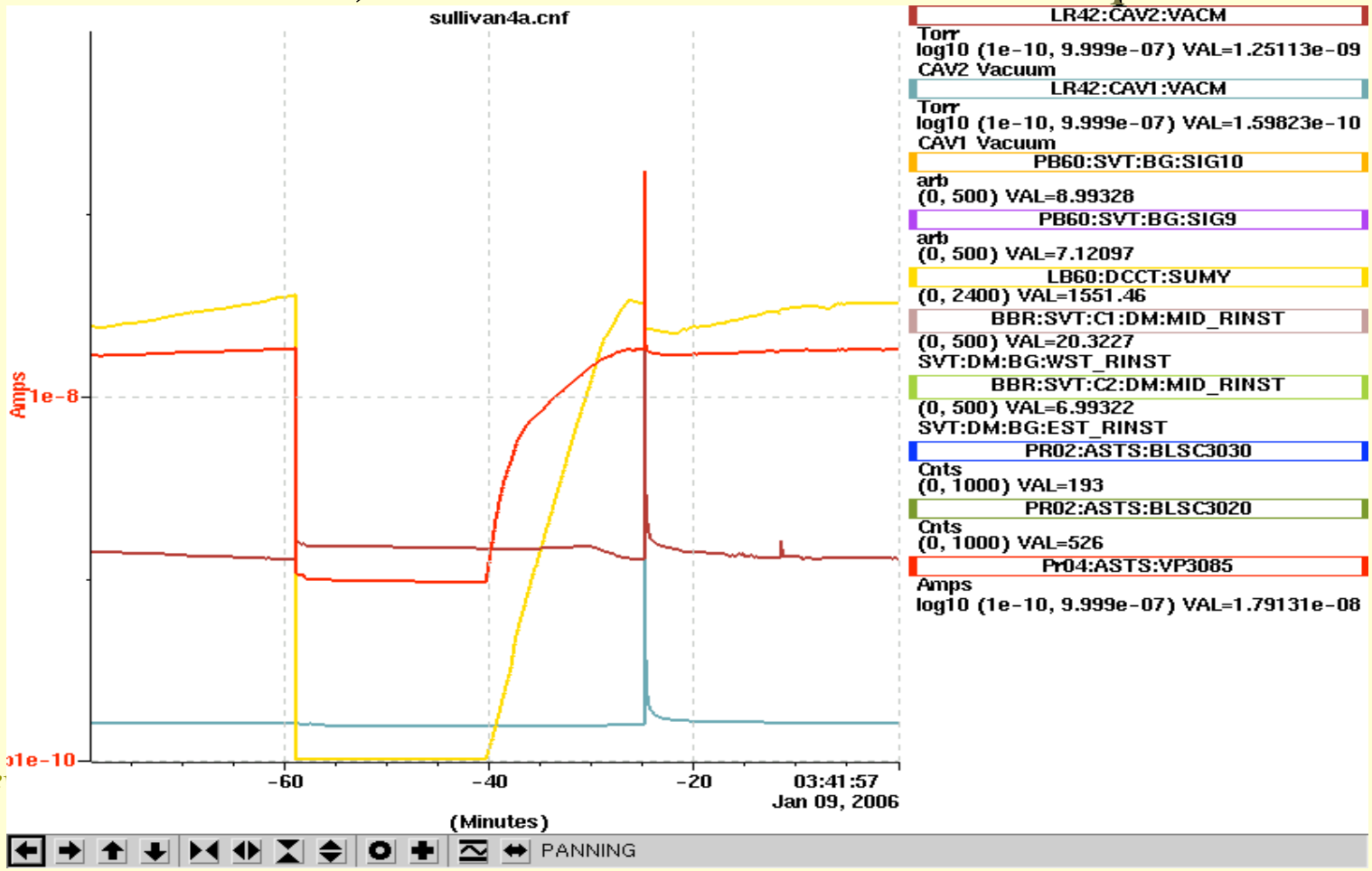
Vacuum Activity near Rf 4-2

- S. Novokhatski first pointed out vacuum activity near Rf station 4-2, later confirmed in controlled experiments



Investigations (excerpt)

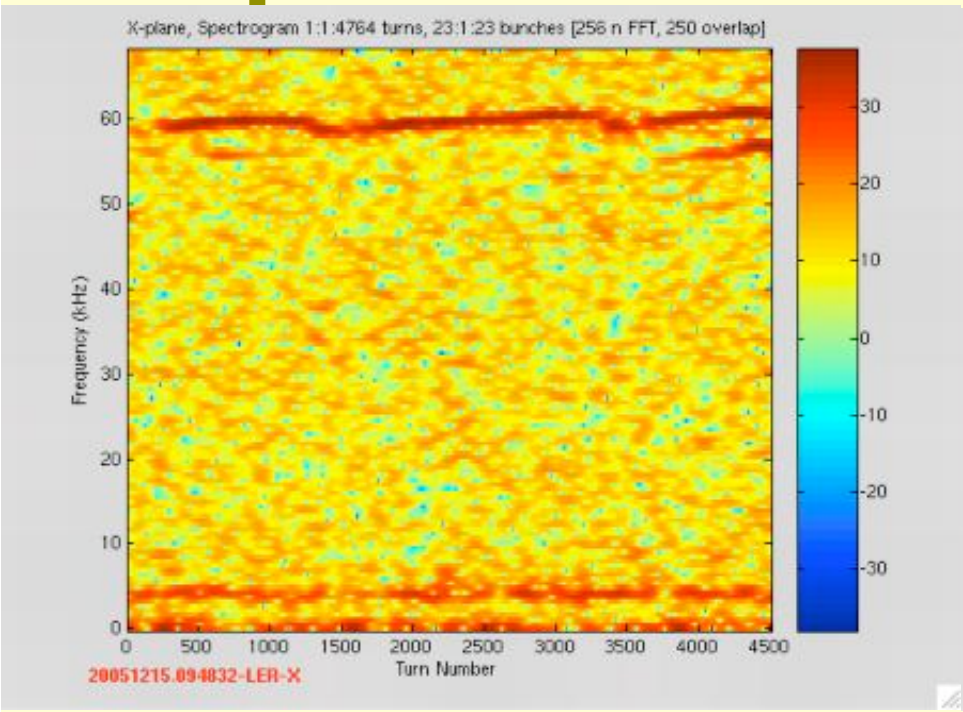
- √ Change LER Chromaticity
- √ Change Rf voltage
- √ Put X angle at IP back to high-current value
  done, awaiting result
- √ Park each rf station (in turn) & see if aborts go away
- √ Vary rf-cavity temperature (in preparation)
- – What is the significance of the vacuum spikes (4-2b) Sasha sees??
  Put G protoboard coefficients back to set 0.
- √ Place Thumper on LER vacuum system
- \ Record bunch lumi during instability phase
- • Readout DIRC scalers into abort logger (Ecklund, Petree)
- √ Instrument some BLMs for fast readout (Mattison, Fisher)
- √ Try a by-4 fill
- \ Put back some of the parameters we have changed (but not yet)
  - – LCW temperature
  - – X Chromaticity
- √ Find a way to diagnose arcing in the fb kickers
  - – Trigger a scope on beam abort?
- √ Check rf distribution in IR 4 for phase glitches (Akre, Himel et al.)
- \ Make a complete list of symptoms
  (Wienands, Sullivan, Teytelman, et al.)
- √ Continue pushing LER beam current
- √ Continue gathering BLM & VACP data for aborts
- √ Continue LER steering
- √ Continue maintaining & tuning the TFB systems
- • Compare X and Y motion normalized to √ß

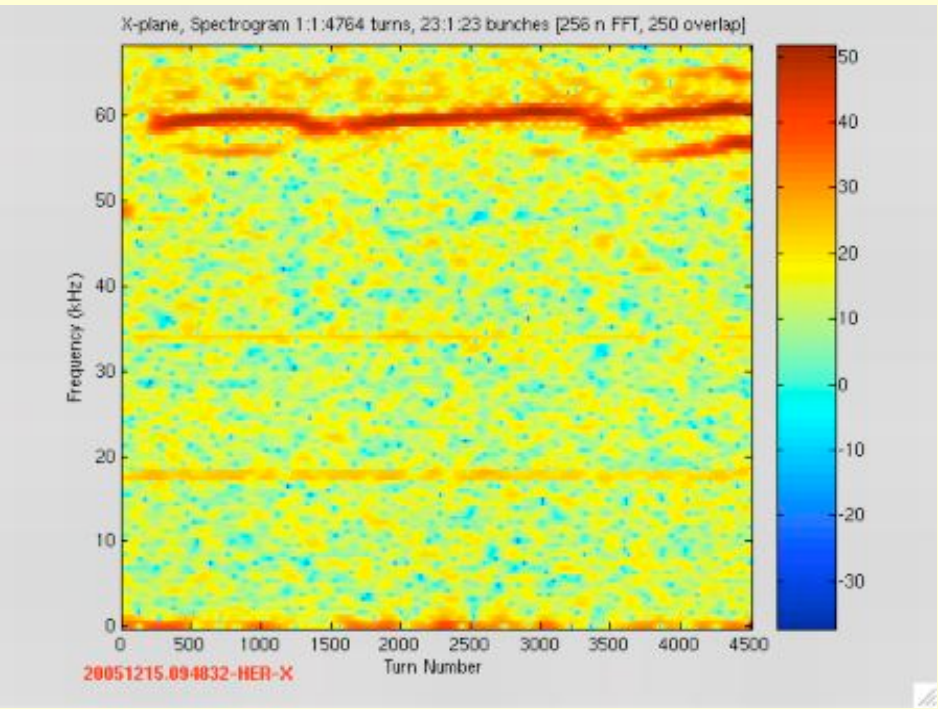
Properties of Fast LER Instability

Property	value	unit	Remarks
First documented occurrence	19-June, 2004		??? See peplog/Turner email of Dec. 17 and...
Growth rate:	10...60	1/ms	initial rate in Y
Duration:	400...800	turns	BOAT trip ends it (100..200 mA beam loss)
max. coherent amplitude	±1	mm	varies by BPM, event
Current threshold	1600...2500	mA	ill defined & varying
highest excited mode	-3, -4		some events may peak at mode -1
Frequencies (tunes) seen	nu_y, nu_s, 2nu_s		2nu_s=quadrupole mode
"apparent energy loss"	140 keV	keV	est'd by Dmitry as source of longitudinal transient, orbit shift (0.1 mm for 2 m dispersion) ??
Plane of beam loss	horizontal		derived from BLM readings around ring
Dependence on chromaticity	small or none		some hint negative X chroma helps
Dependence on tune	small or none		some hint vertical beam size plays a role
Dependence on rf complement	none detected		determined by turning off one station at a time
Dependence on vac. temperature	none detected		arc vacuum lowered by 5 °C with no effect
Accompanying vacuum event?	yes, Rf 4-2		
Dependence on orbit	??		
Dependence on HER beam	none		
Dependence on collimator settings	??		tightened collimators on Dec. 18

In the mean time…

- Early December, after we changed the TFB configurations, we began seeing different signatures:

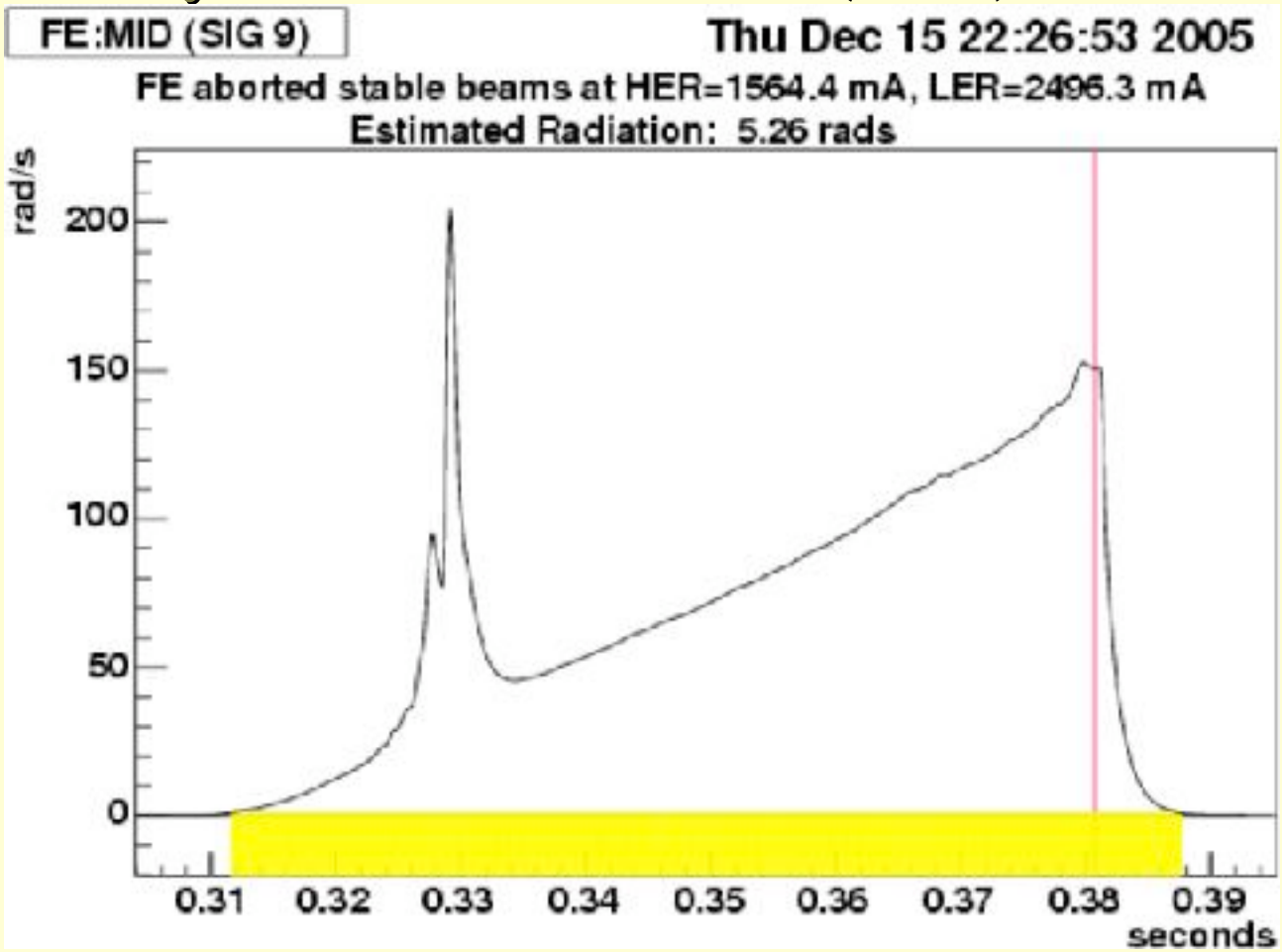




SVT Diode Signal

- They cause BaBar aborts (LER)

S. Curry



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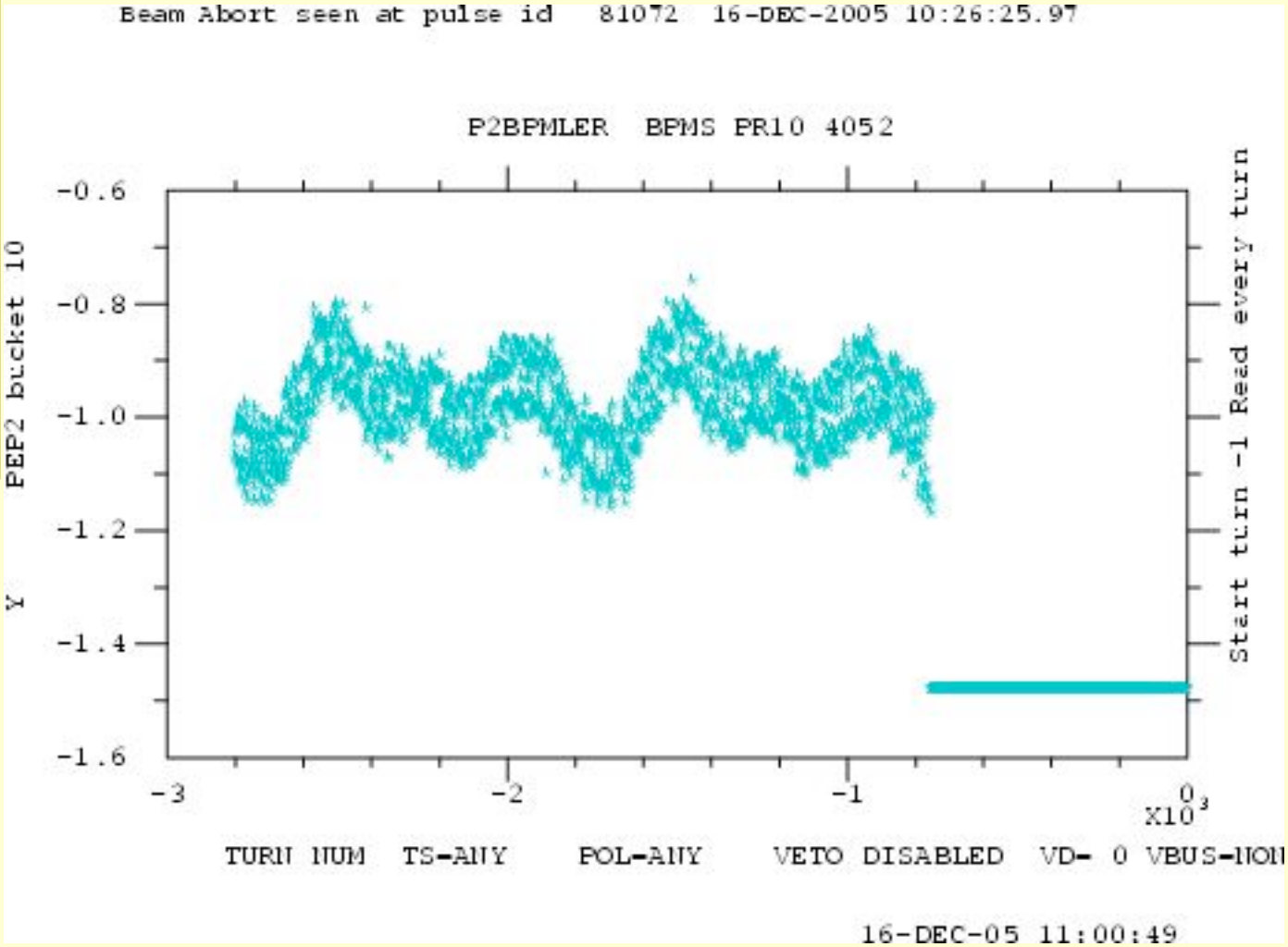
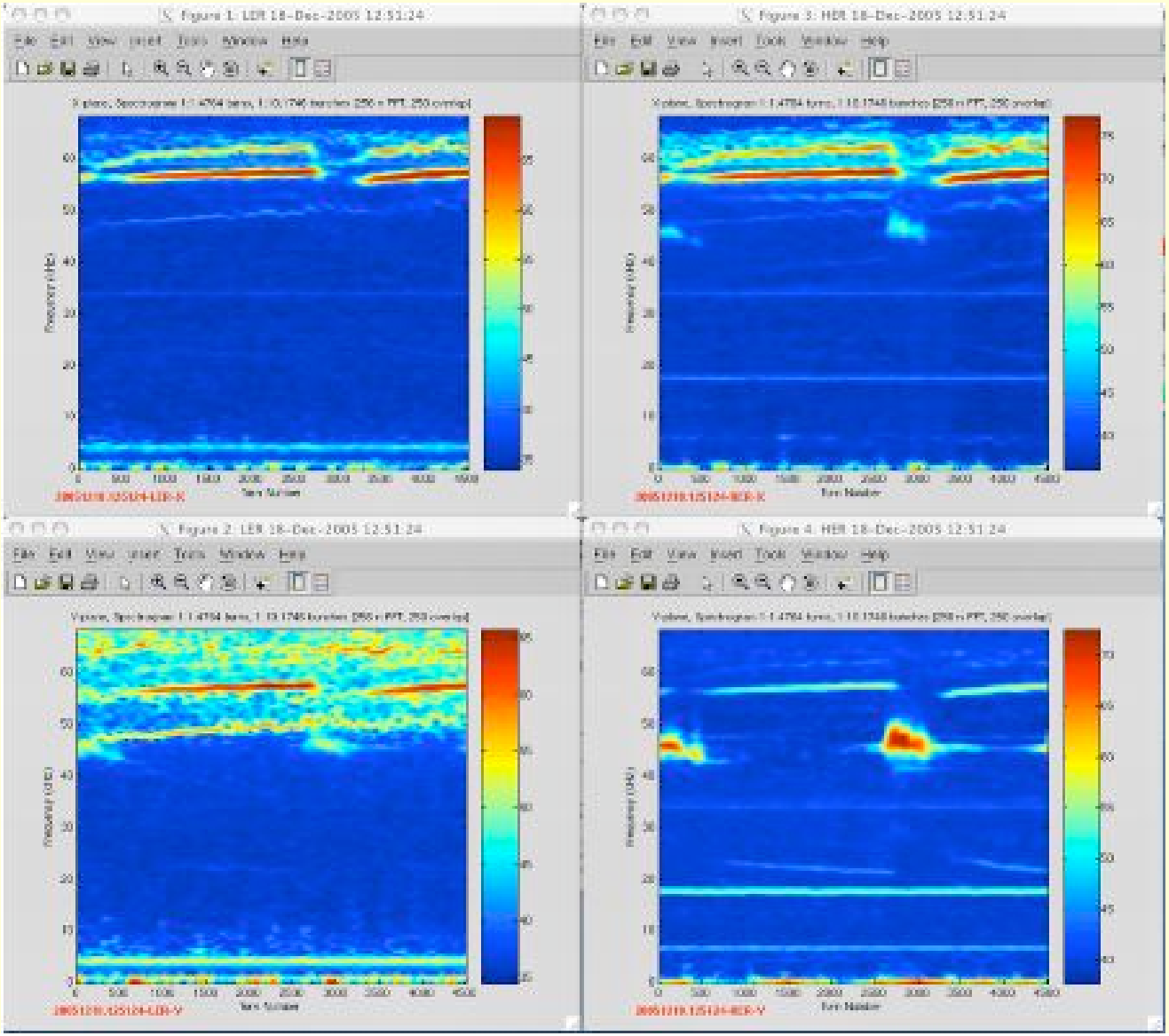
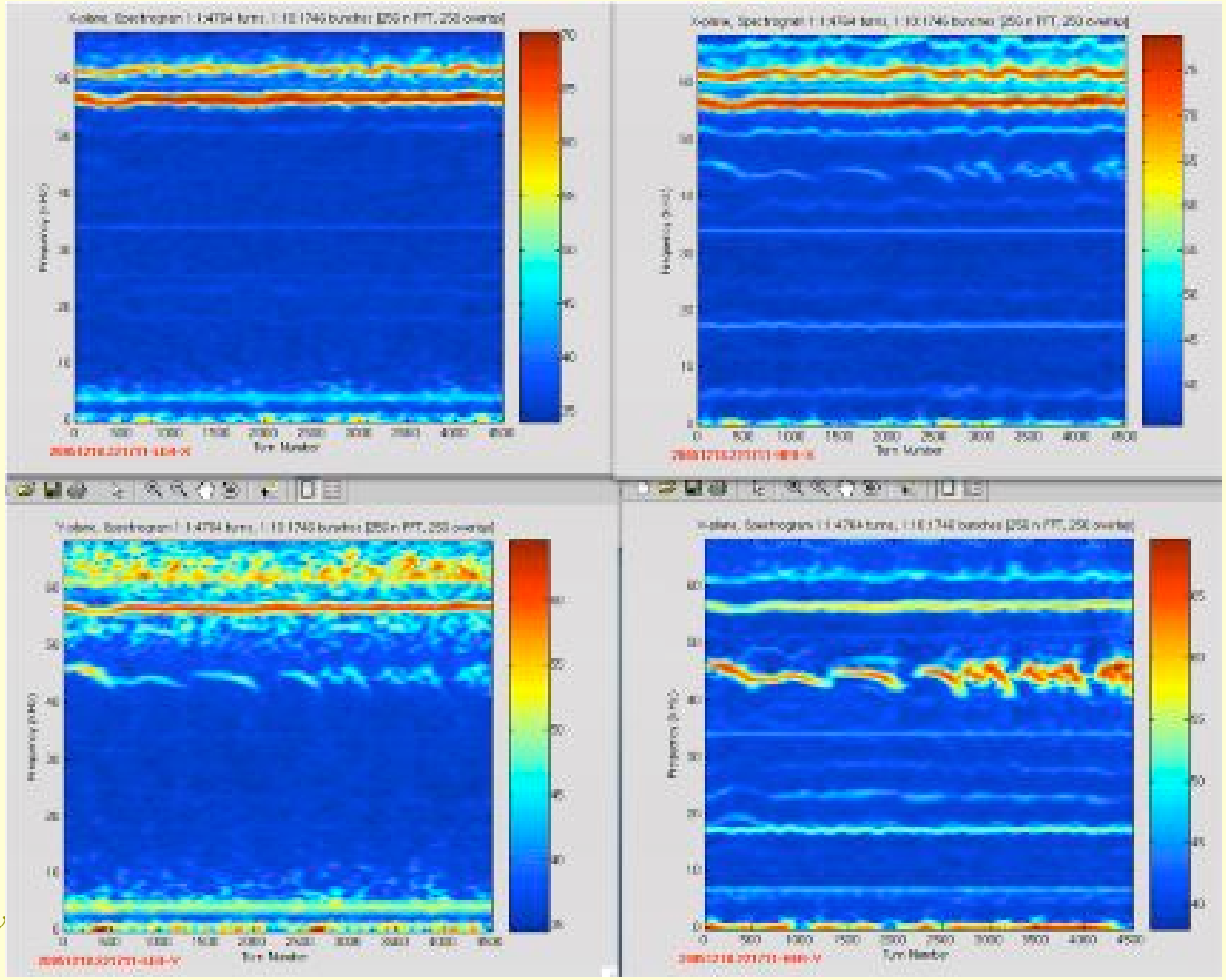
"Blurble Abort" (LER)



"HER-LER" Aborts



"HER-LER" at different Y tune



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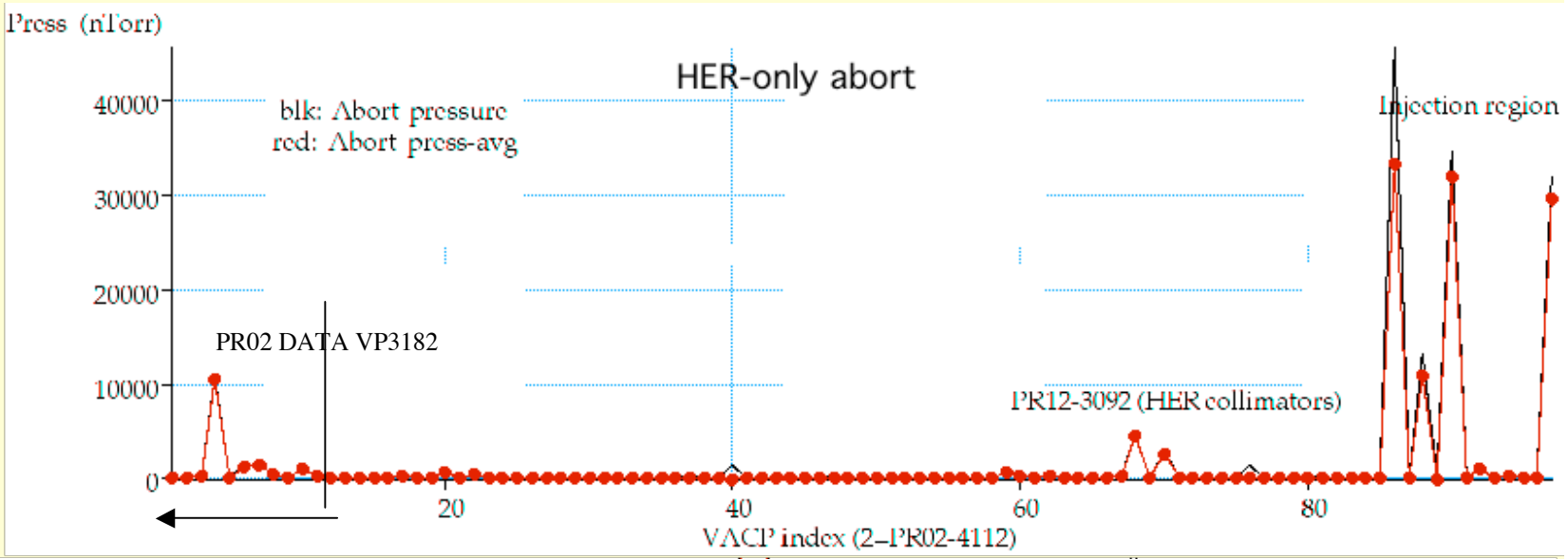
How this got Resolved

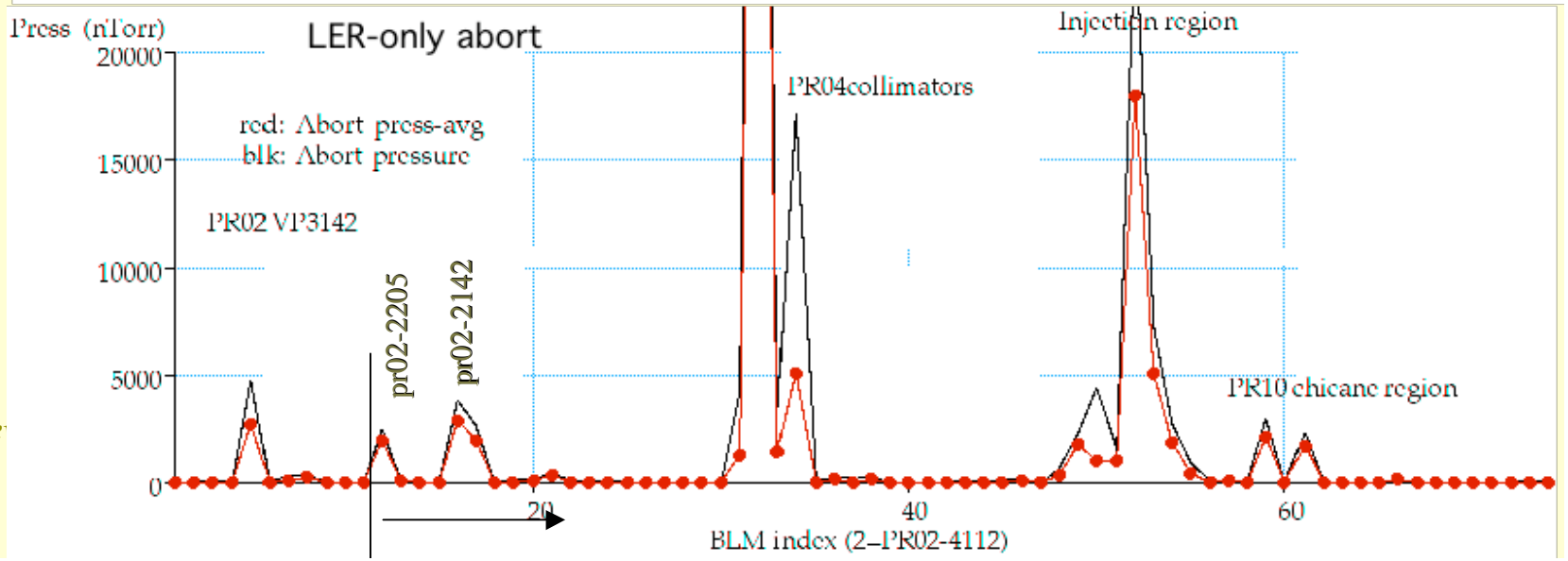
- We put the TFB system back to its Oct-9 config
  - 3 A LER beam, 1E34 luminosity machine
  - verified the TFB changes did not create the aborts
- Began focusing on the "HER-LER" (or "Blurble") aborts
  - Realized that they coincided with IR-2 vacuum activity
  - Earlier observations of vacuum activity in IR 4 during the fast LER aborts were confirmed and ≈100% correlation found

IR-2 Instability Properties

- IR event can be triggered by HER and LER at comparable beam current
  - HER-induced events seem less severe.
- IR event is accompanied by pressure spikes in VGCC3027 (highest), VP3027 and VGCC2187 and,
  - for severe events, VGCC7039 (HER Q5L chamber).
- IR event produces beam-loss pattern consistent with a source near the forward end of the detector, acting on each beam.
- IR event threshold appears to be independent of the (common) Y angle at the IP, over a range of roughly +/- 3 mm.
- IR event threshold may be higher for negative LER X angle at the IP, although initially such angles appeared to produce vacuum spikes.
  - HER angle has not been varied yet.
- IR events clearly show unstable HER, LER beam gets "pushed around" by HER.

IR-2 Instability Loss Pattern

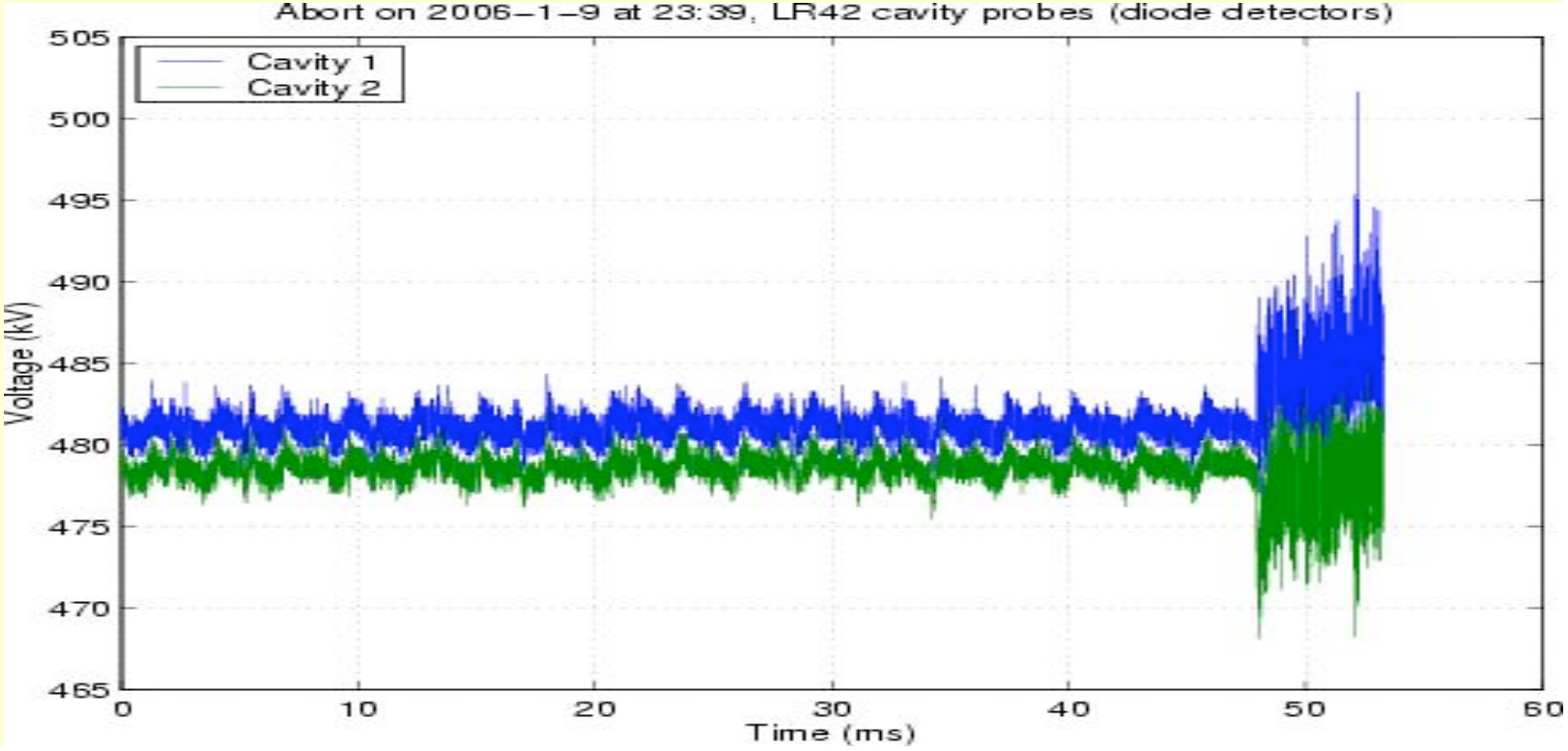




Back to the original Fast LER Inst.

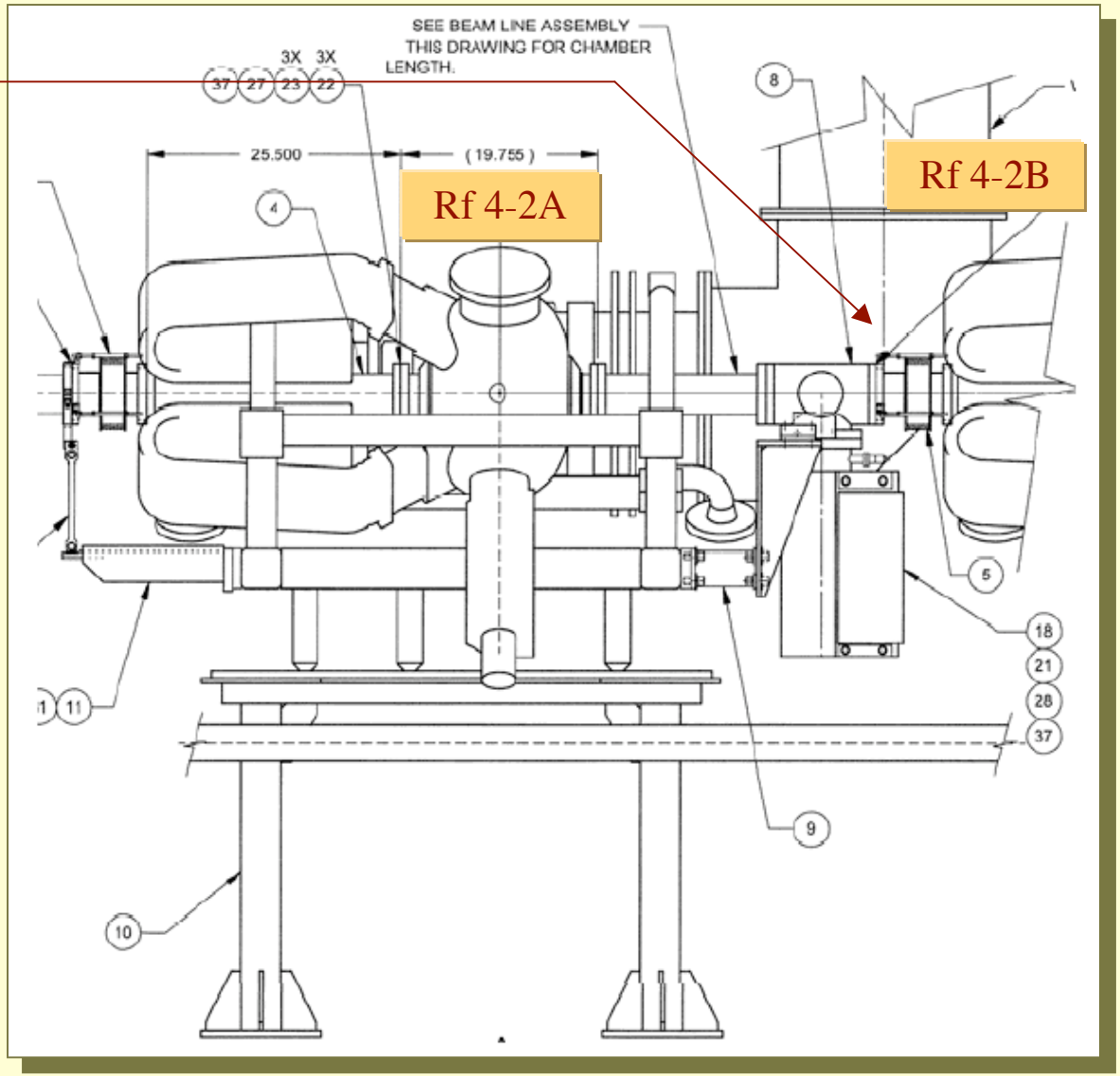
D. Teytelman

- The vacuum activity observed at the Rf 4-2 cavities prompted another look at the rf fault files
  - Found a signature in the cavity probes when looking at wideband detectors



Possible location of Effect

Bellows between cavities



Knowledge as of Yesterday

- 2 types of events have been identified & localized:
  - Fast LER instability coincident with vac. spikes in 4-2 cavities and beamline in between ("Rf4-2 events"); reacts to total beam current, has $2\nu_s$ signature
  - LER aborts coincident with IR-2 vacuum spikes and HER instability ("IR events");
    reacts to bunch current, can be triggered by either beam.
- We verified that the vacuum events are *not* triggered by beam loss itself
  - Unstable beam of either polarity does not cause comparable vacuum events.

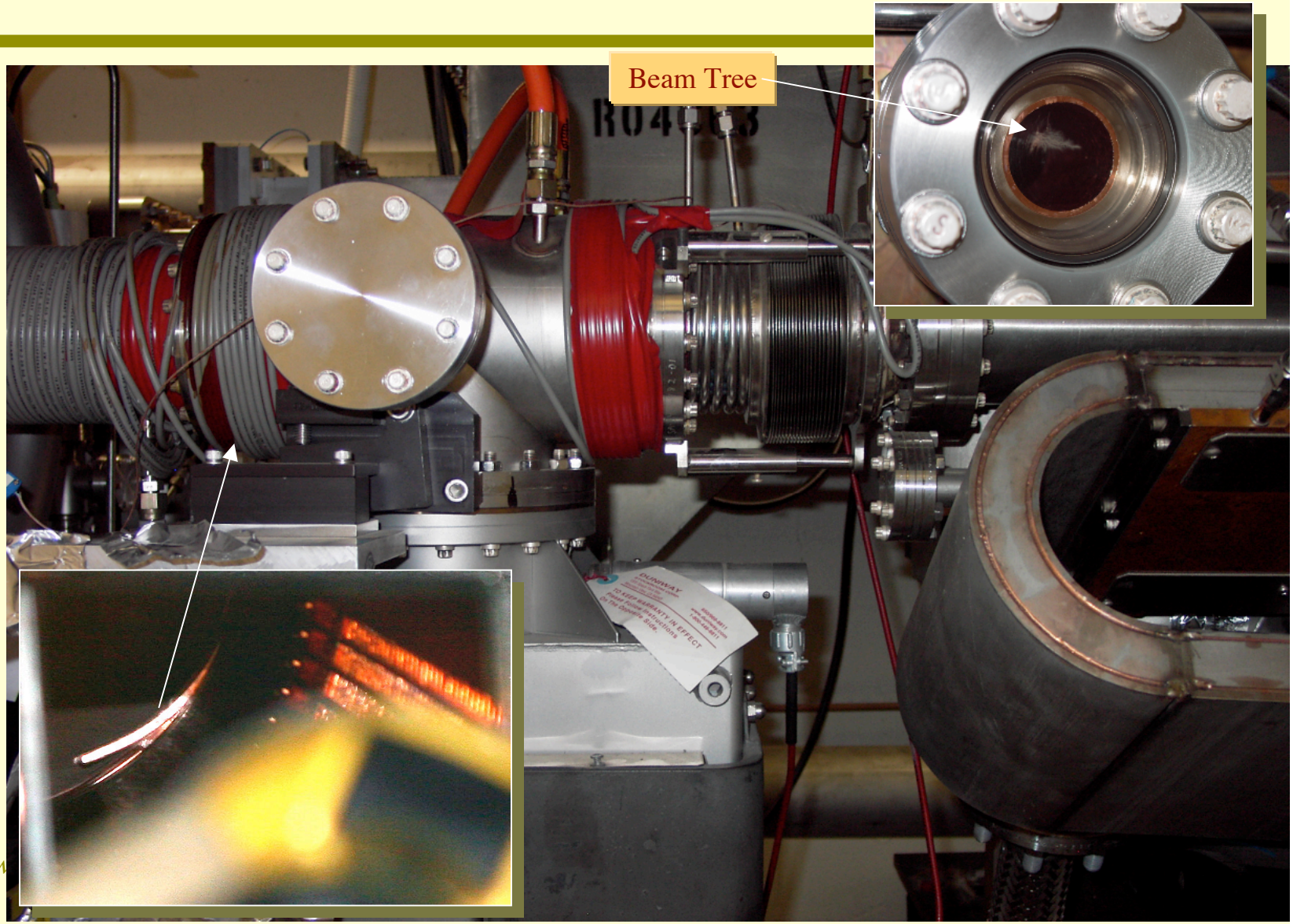
Late News (IR 4)

- A misplaced and burned "gap ring" was found at a flange in between the Rf cavities
  - close to the expected location
  - clear signs of discharge and sputtering of Cu
- A second gap ring not as badly misplaced was also found downstream of Rf 4-2 cavity B & will be replaced.
- Very likely that these caused the instability.

The Culprit…

M. Sullivan

D. v. Winkle



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Late News (IR 2)

- Boroscoping in IR 2 revealed some irregularities in the rf seals of the "Frangible Link" and an irregular looking "Ω-seal" between Q4 and Q2.
  - Not quite "smoking guns"
- We will fix the Frangible link and remove the Ω-seal.
- The suspect Q2 bellows so far looks good & no irregularities with the tiles has been seen
  - but can't see the whole thing.
- The vertex bellows on this side looks pristine.

Conclusion

- A candidate for the IR-4 problem has been uncovered.
- In IR-2 we are still exploring.
- Plan:
  - Replace gap rings in IR 4 & close vacuum
  - Remove, inspect & replace Q4-Q2 Ω-seal
  - Repair Frangible Link
  - More boroscoping of Q2 bellows.
  - Might look at the other side as well…