Event Archiving for FLASH-RF

Collect, Store and Display Special Pulses

(Interesting Pulses, Exotic Pulses, Sick…, Challenged…)

A Variant of the Needle-In-a-Haystack Problem

(~ One pulse/day, hiding in 450,000 pulses per day (10^6 at 10 Hz!))

Mark Lomperski, MIN 27.May.09

TINE Archiving “Principles”

- **“Detective work” (Off-line analysis) is done On-line**: simple, fast; answers in “real-time”
- **Data Selection / Filtering:**
  - You can’t / shouldn’t / don’t-really-want-to store ALL data, ALL the time, FOREVER

    -Storage Space (RAM → Disk → Tapes…)

    -Amount of Time to sift /search through data to find what you are looking for

Need Flexible Tools for Different Questions, Different Applications

Filtering / Data Selection Tools

1. **Local** Histories (Server Controlled)
   - "Short Term" (months) – Lots of data in the "recent" past
   - Don't need tolerances
   - Useful for debugging
     - Ring Buffer: MSK for DESY2: 12.5 Hz, 10^6 pulses/day on VxWorks
     - Files: Keep for days/weeks/months
2. **Central** Archiving

   Keep data FOREVER – must increase tolerances, and be more "selective" (e.g. charge of Bunch-1 at 1Hz, of bunch train at 1/min)

Filtering / Data Selection Tools (continued)

3. **Event Archiving:** In case of an “event” (technical interlock, operator button) collect and store ALL of the required data at the highest sampling rate. Store a COMPLETE picture of the “event”.

   Easy to search for (find) a particular event:

   browse through an “event list”

Filtering and Selection (continued)

- It may occur that the same data is archived more than once. So what? Store data optimally for each type of question!
- Use common programs, common APIs, general purpose tools to display live data, local histories, central archive, events, ….
- “Detective Work” should be done by the shift crew, Subsystem Responsibles, etc. The goal is to simplify archive-analysis with standard tools.

Archive Consulting as a Hobby

- Which tools to use for a particular subsystem, data set, operational question?
- Time-Scale of Question:
  - Tech. Problem - Comparing pulses (200 ms)
  - Drifts (seconds/minutes/hours)
  - User Operations: Wavelength-files (months)
- To Paraphrase Classical British Philosophers:

  You can't keep all the data for all time, but if you try, you just might find, you can keep what you need.

- I started studying hera-p operation problems e.g. beam induced quenches -> orbit analysis; "ambulance chasing" (operation-analysis) became a hobby

Request from T. Grevsmuehl, MHF-p for HP-RF

- Torsten asked for help archiving pulses from the High-Power RF for
  - Interlock Trips
  - Switching On (BIS – ACC1 Problem)

- Archive pulses when they CHANGE
  - during normal operations, the curves/signals are very stable
- 500,000 pulses / day! (On average) Less than 1 is “interesting”!
- Store “changes” as an Event
  - One data set with all channels, a few pulses before and a few after, for the entire “system”
- Three Event Groups are implemented (to help “classify” event “types”):
  - HV Event (Kly V or I out-of-tolerance)
  - RF Event (P-forward or P-Reflected out-of-tolerance)
  - Logging event (periodically (1/20 minutes) save a set of traces)
- Pulses can be “analyzed” (now only get amplitude) and store array of values in central archive (for trends versus time)

- Note1: that it has also been suggested: FIRST store all the pulses and THEN sort through them. (Build a GIANT haystack and THEN search for the needle!) This is useful if you ONLY look for interlock-events i.e. when you know where the needle is hiding in the haystack. The most interesting pulses have NOT been when the RF system trips…
- Note 2: R. Jonas had the same wish in 2001 for Linac-2 RF / Shunt-Diode Events. Wish was fulfilled with these archiving tools.

Strategy: Get the data out of the ADC servers, into a "middle layer" which analyzes the data. When a "change" is detected, an "event" is triggered, and the Event Server collects and stores the data.

- Start with a TINE Server (enable the TINE Thread)
  - data can now be collected by the middle layer
- Schedule the Properties (CH01.TD, CH02.TD,…)
  - one line of code in the HW rc = SystemScheduleProperty("DCSEQM","CH00.TD,CH01.TD,GEN.EVENT")
  - data are "broadcast" to any clients with a subscription
  - for "quality control" the buffer number (CURRENT) and pulse number (GEN.EVENT) are also collected
  - The data are "grouped" and sent as a block.
- Client has one "receive" event;
  - analyze, compare new set of pulses to the last "saved" pulses
  - if a pulse is "out of tolerance" then trigger an event

Out-of-Tolerance Criteria
(programmed in Middle-Layer)

- Above Noise (logarithmic -)
- Not close to “edge” of pulse (don’t trigger just because of pulse length jitter)
- not just one sample – spikes (?)

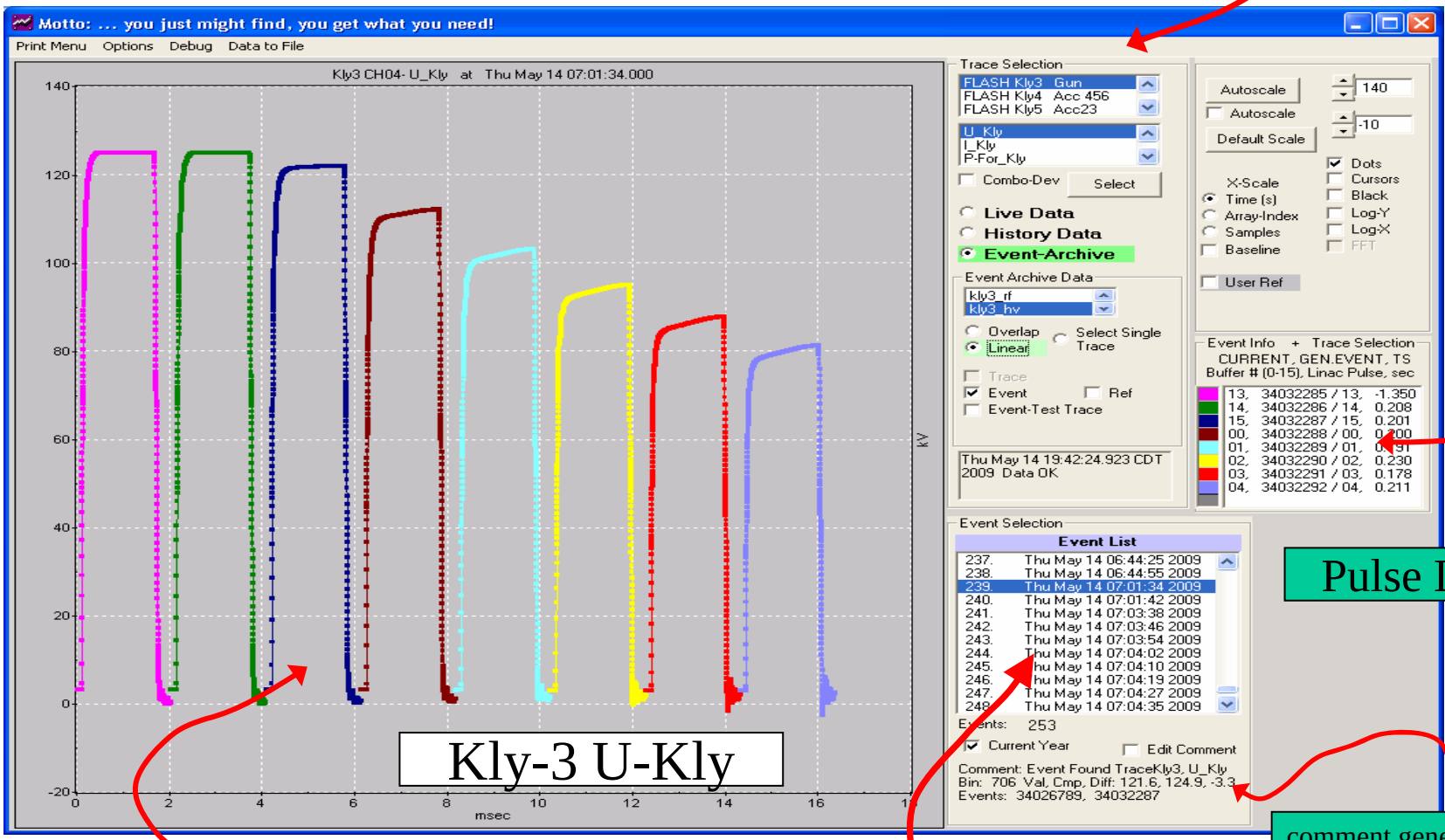
The Viewer

- I started with a tool used to debug “trace”-type data (for LINAC2, DESY,…)
- The Official “Trace-Viewer” is in Java, but event-displays are not implemented yet

- Reminders: An event contains 8 consecutive pulses: 2 pre-pulses, 5 post pulses.

A Sequence of 8 Pulses

1. Select System
2. Select Device



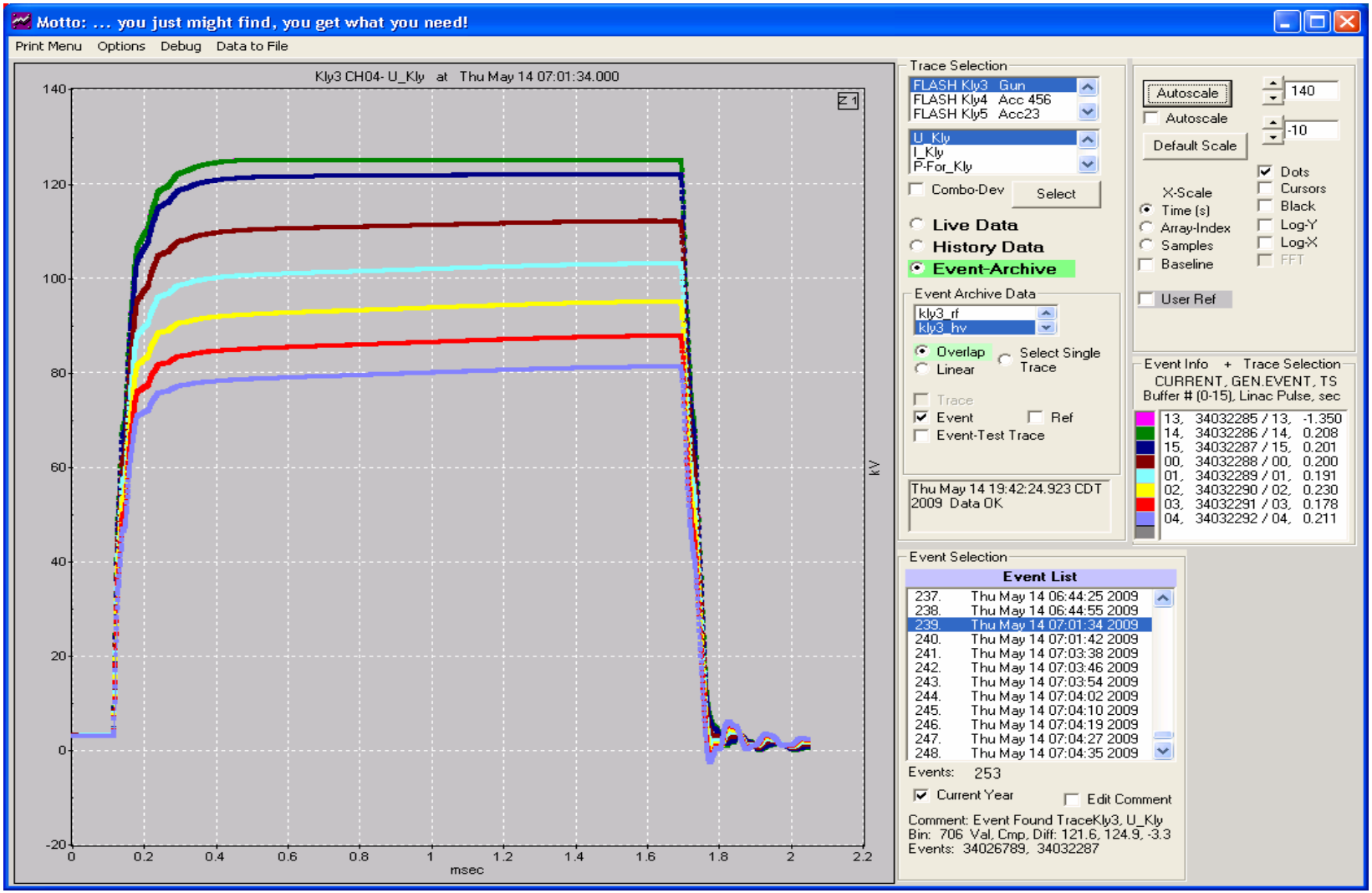
Pulse List

comment generated by middle layer

First Pulse Out of Tolerance

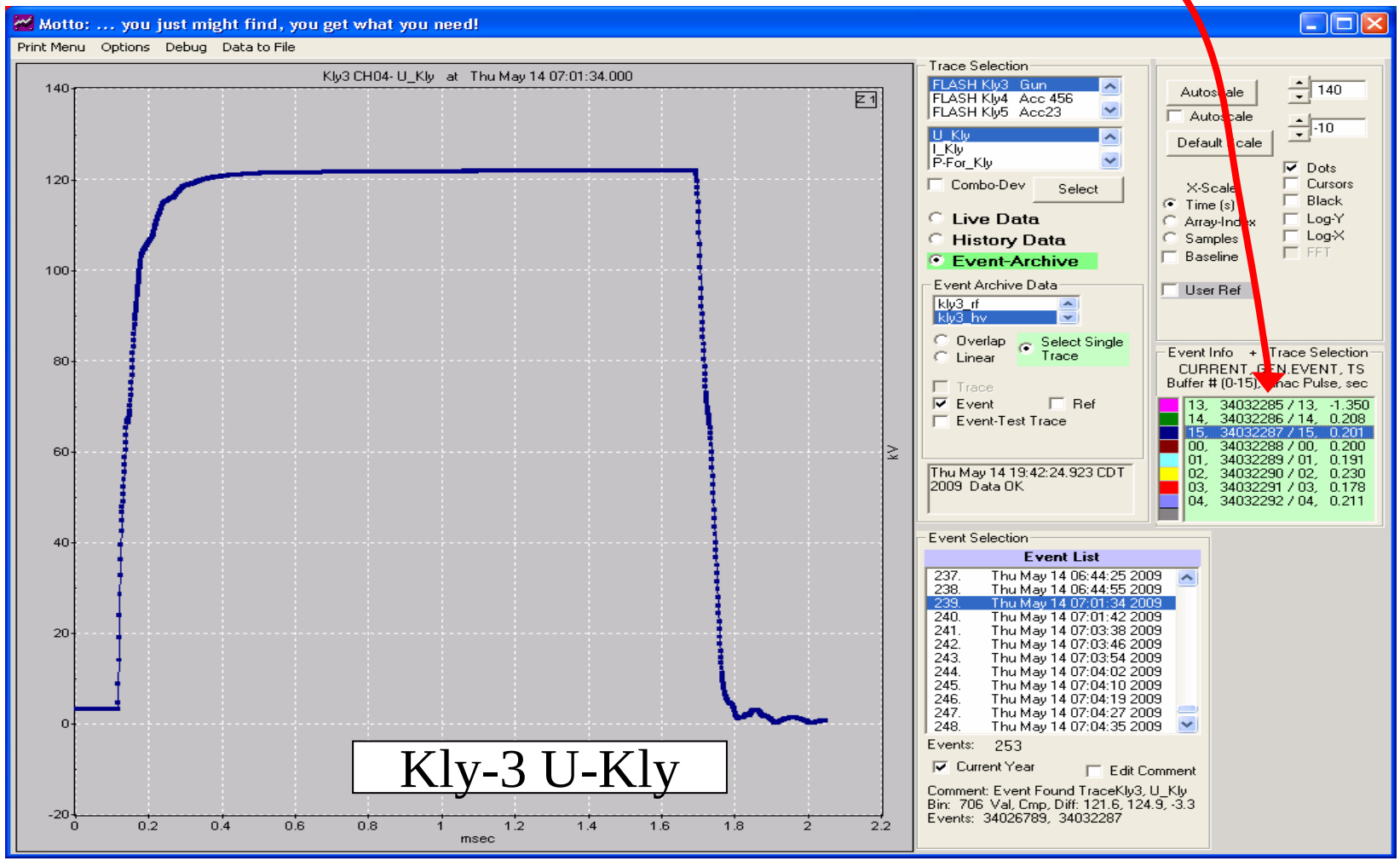
3. Select Event from Event List

Same Sequence, Overlap

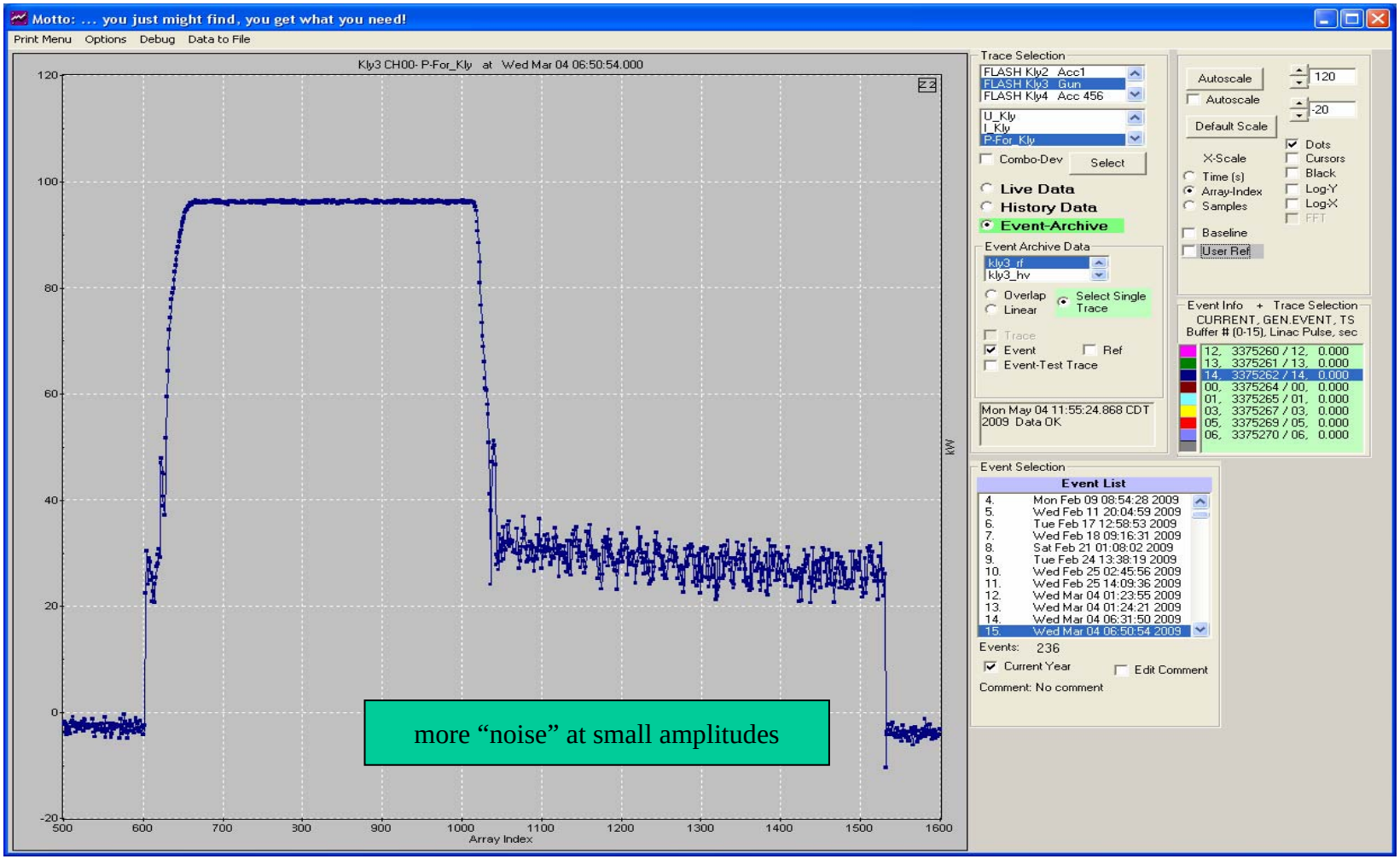


Kly-3 device U-Kly doocs: CH04.TD location KLY3

Select a Pulse

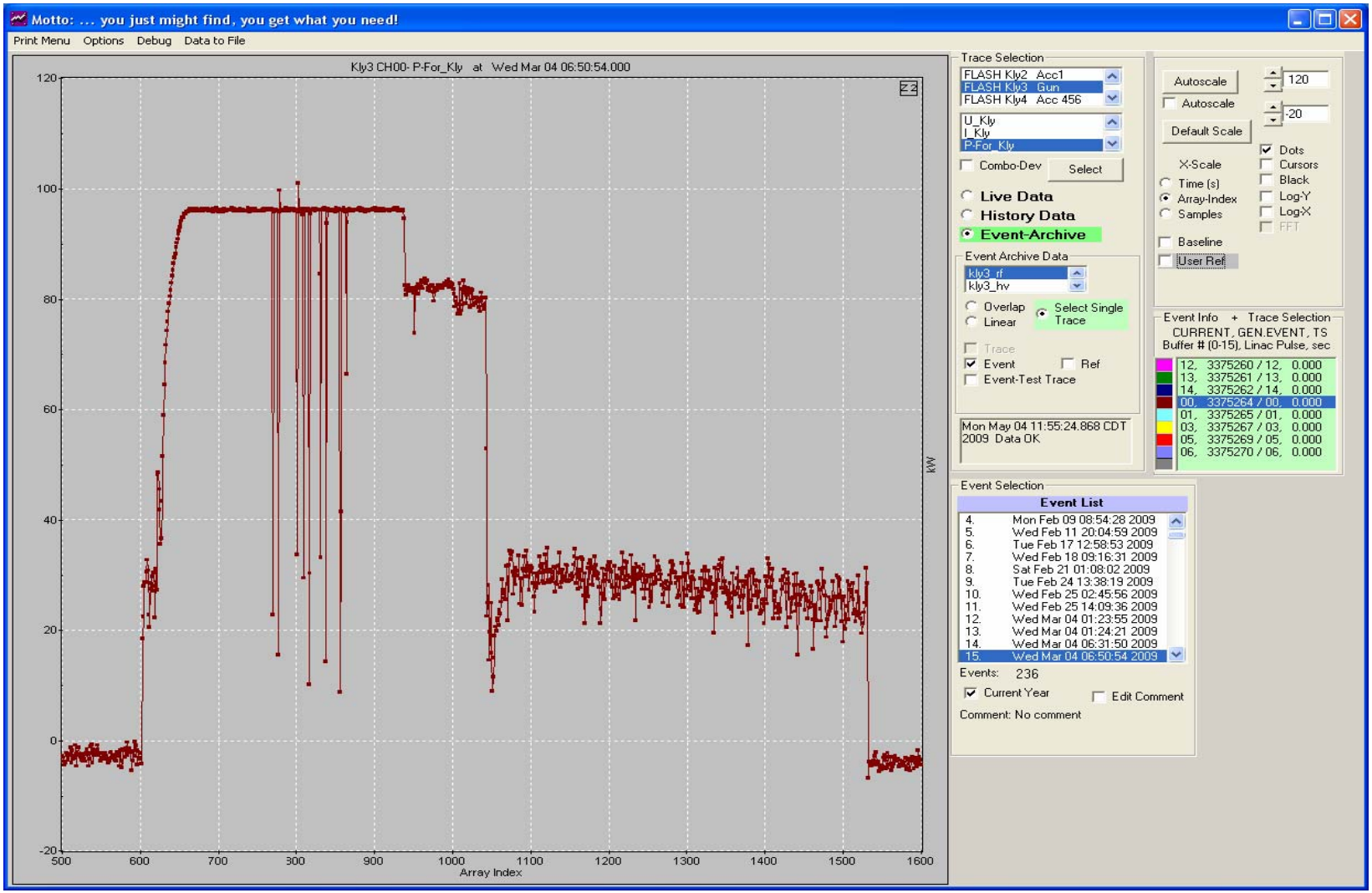


A Healthy Pulse



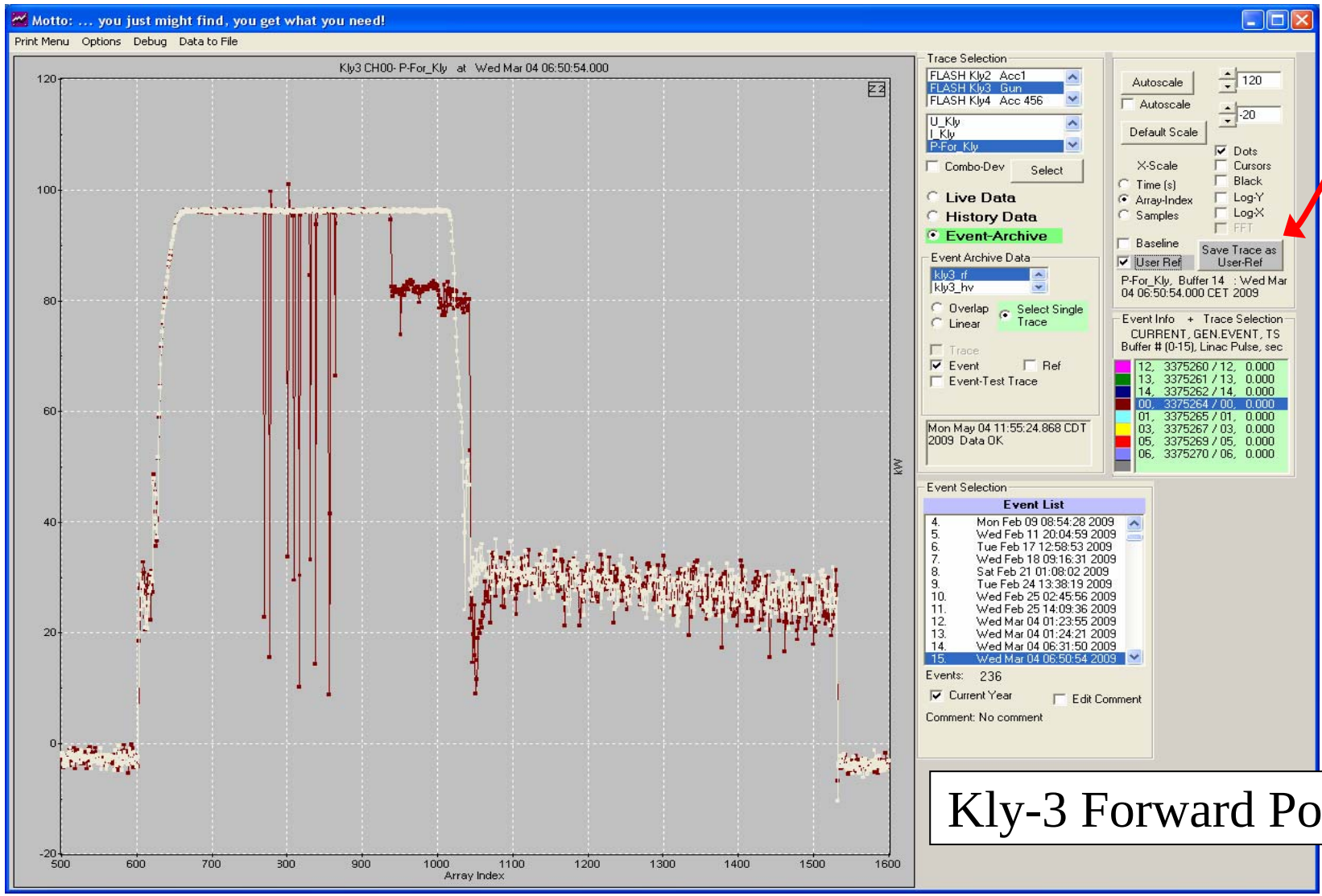
Kly-3 Forward Power doocs: CH00.TD location KLY3

Not so Healthy



Kly-3 Forward Power

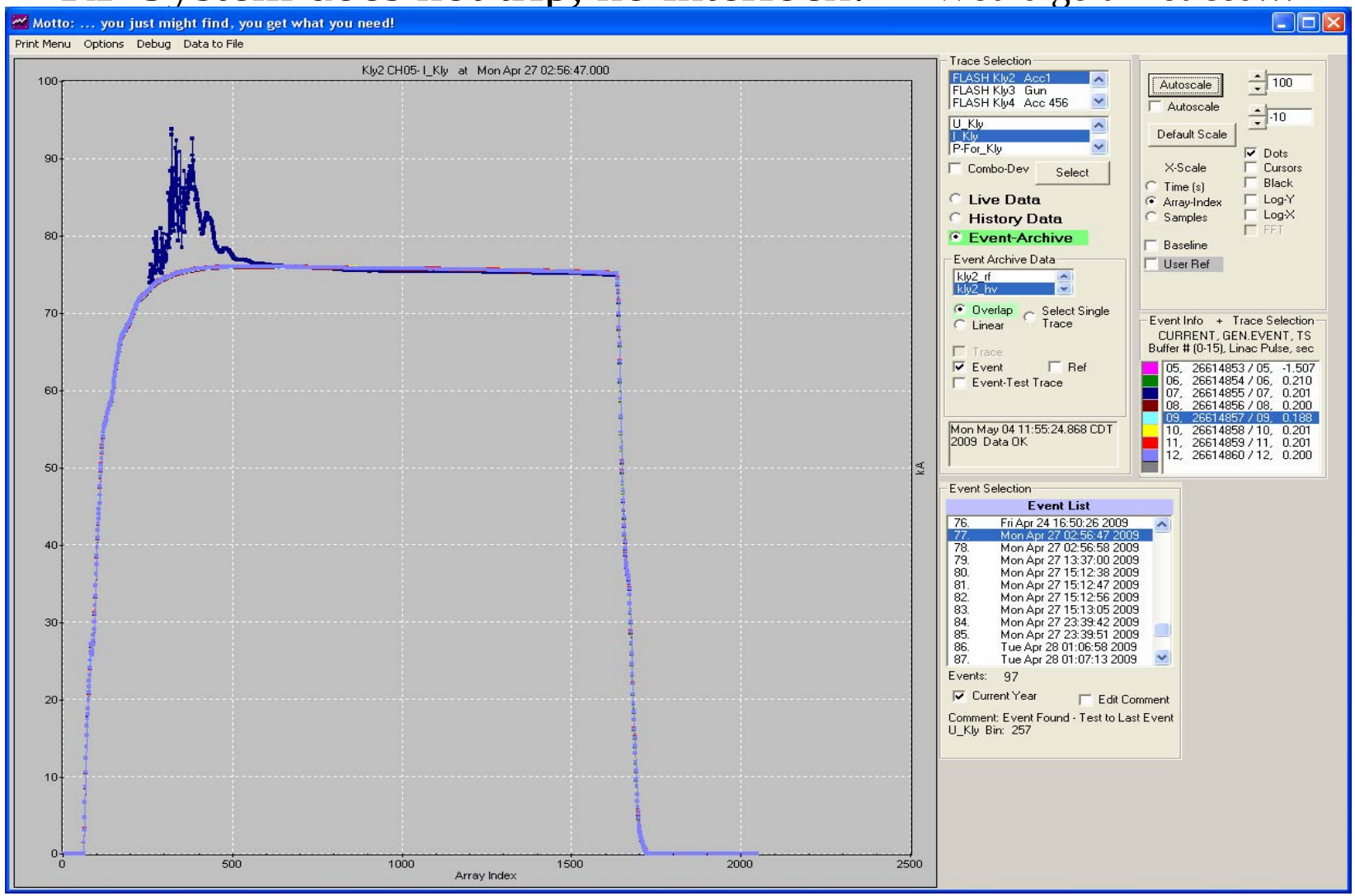
Compare two pulses using a “Reference”



Kly-3 Forward Power

One pulse in the 8 is “not OK”

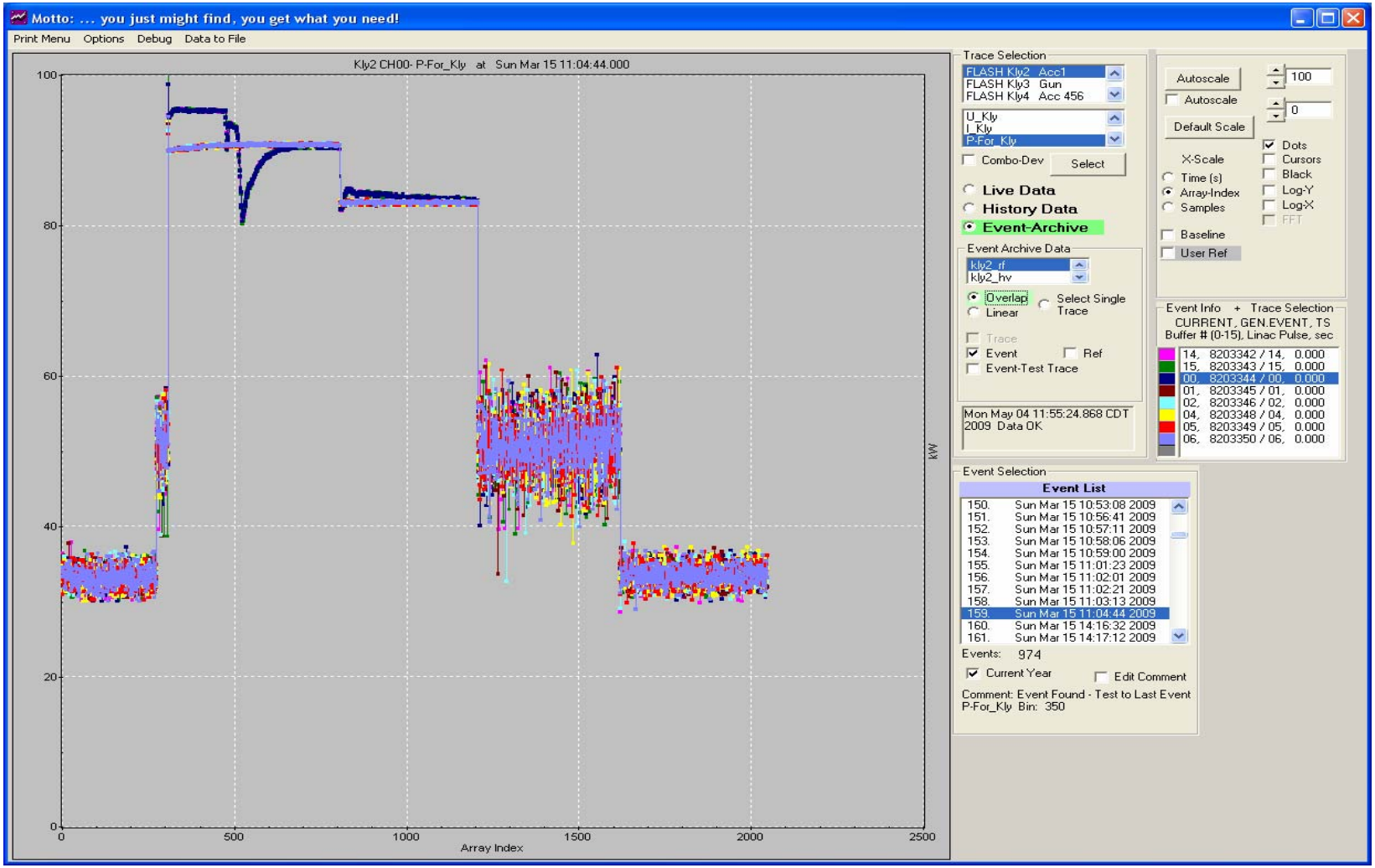
RF System does not trip, no interlock! Would go unnoticed…



Kly-2 I-Kly doocs: CH05.TD location KLY2.1

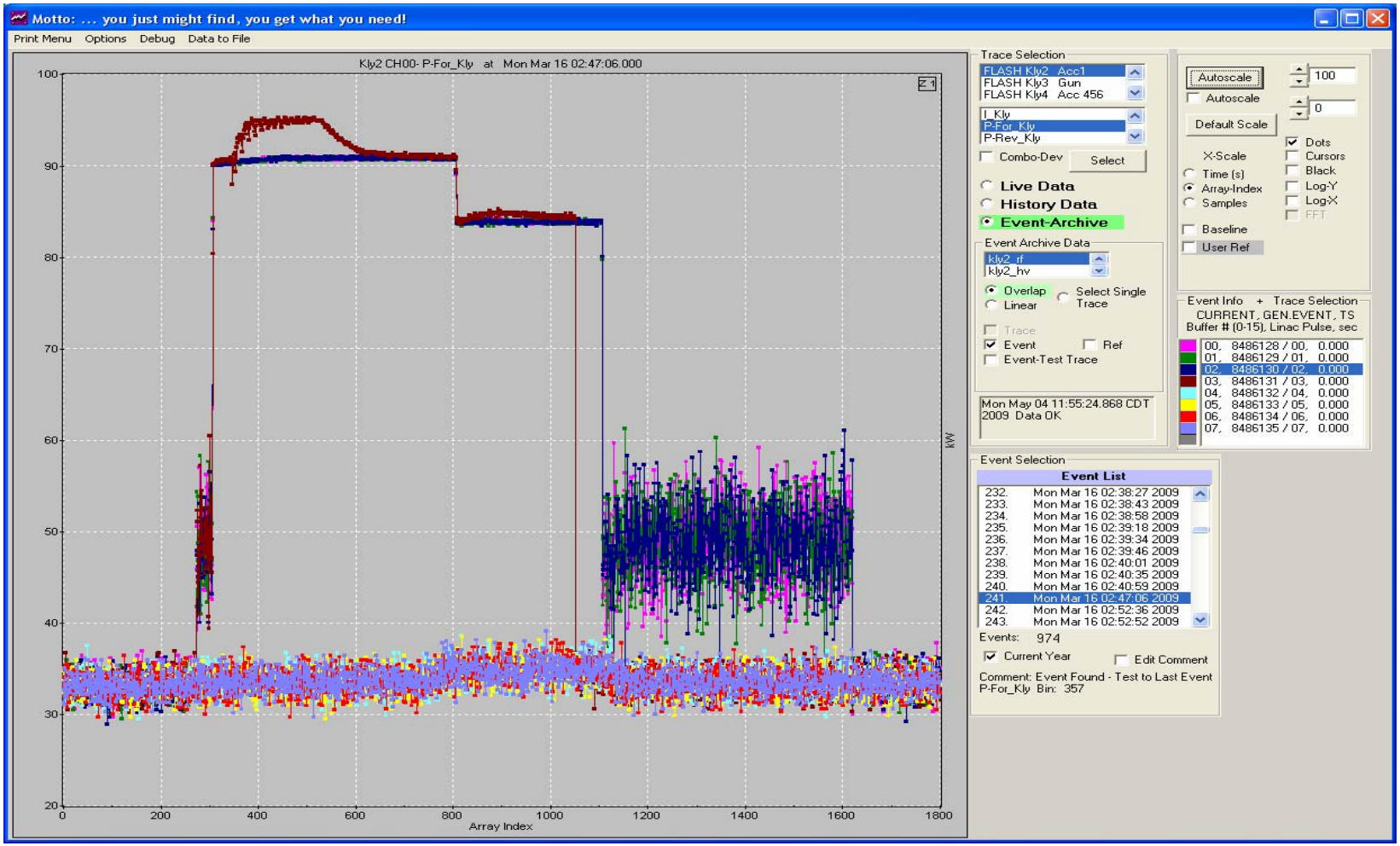
One Exotic Pulse (Kly Operation Continues)

Most of the wild-and-crazy pulses are RF Events, with no interlock event



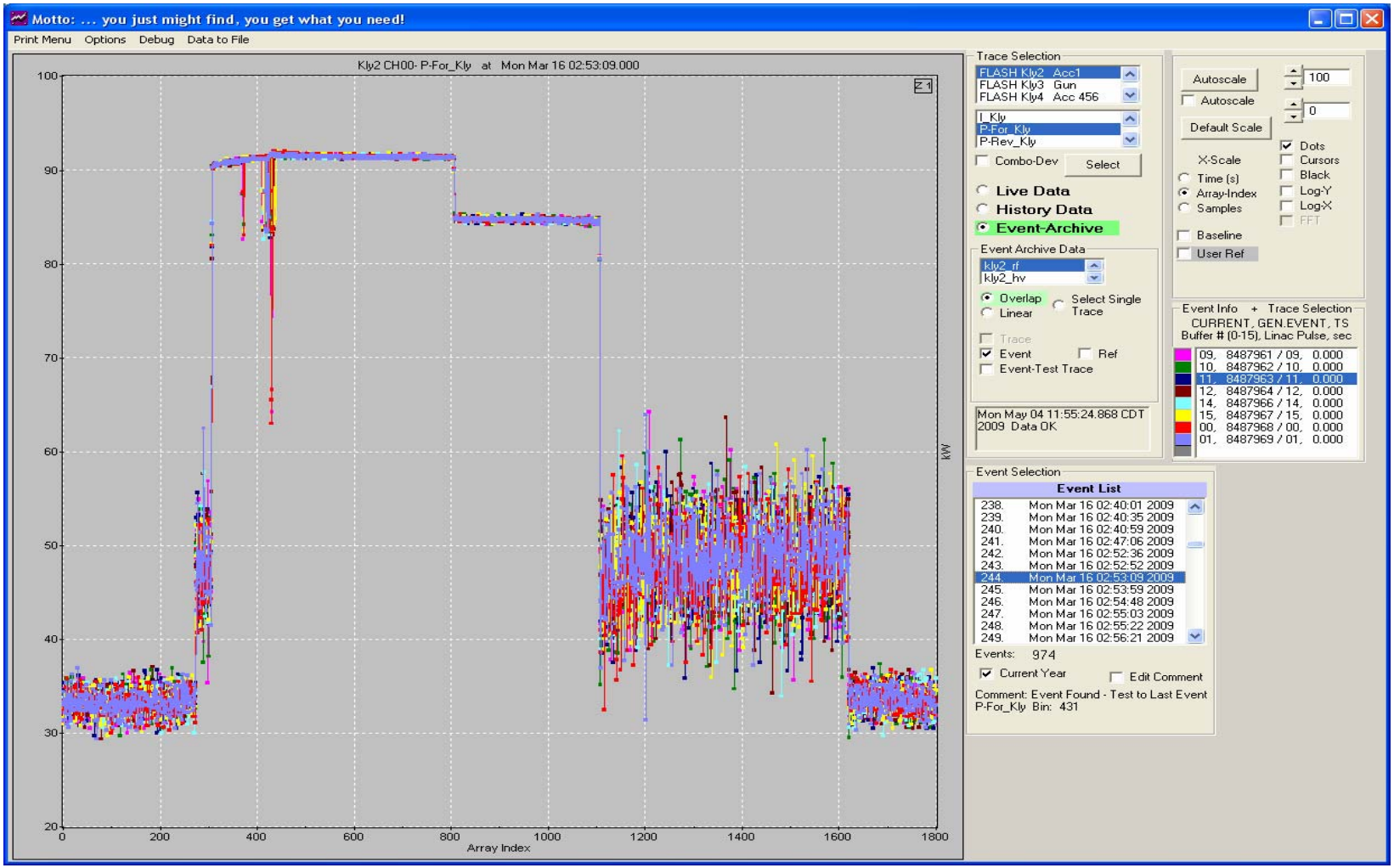
Kly-2 Forward Power

The Last Pulse is Exotic



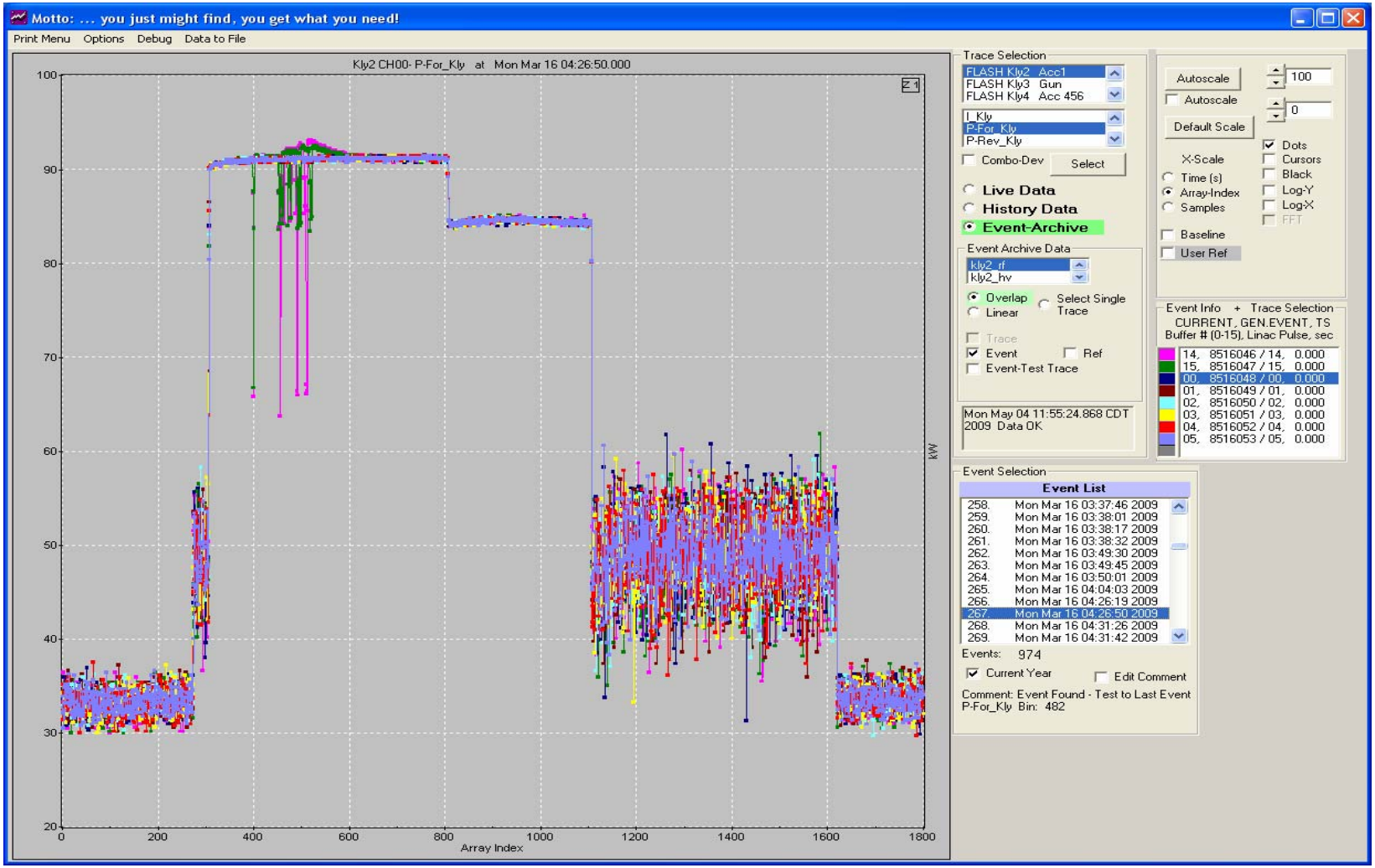
Kly-2 Forward Power

Hmmm….



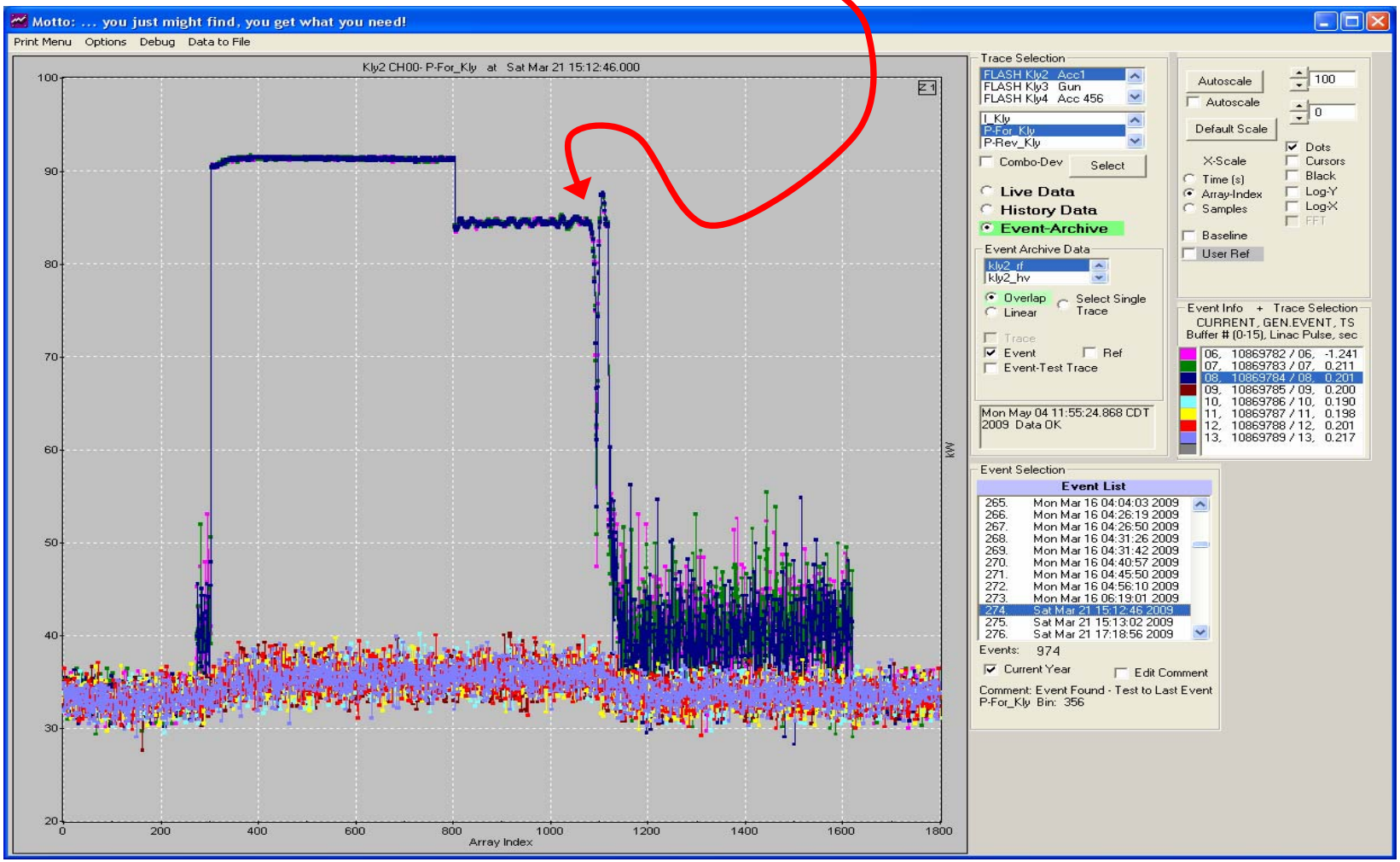
Kly-2 Forward Power

Hmmm….



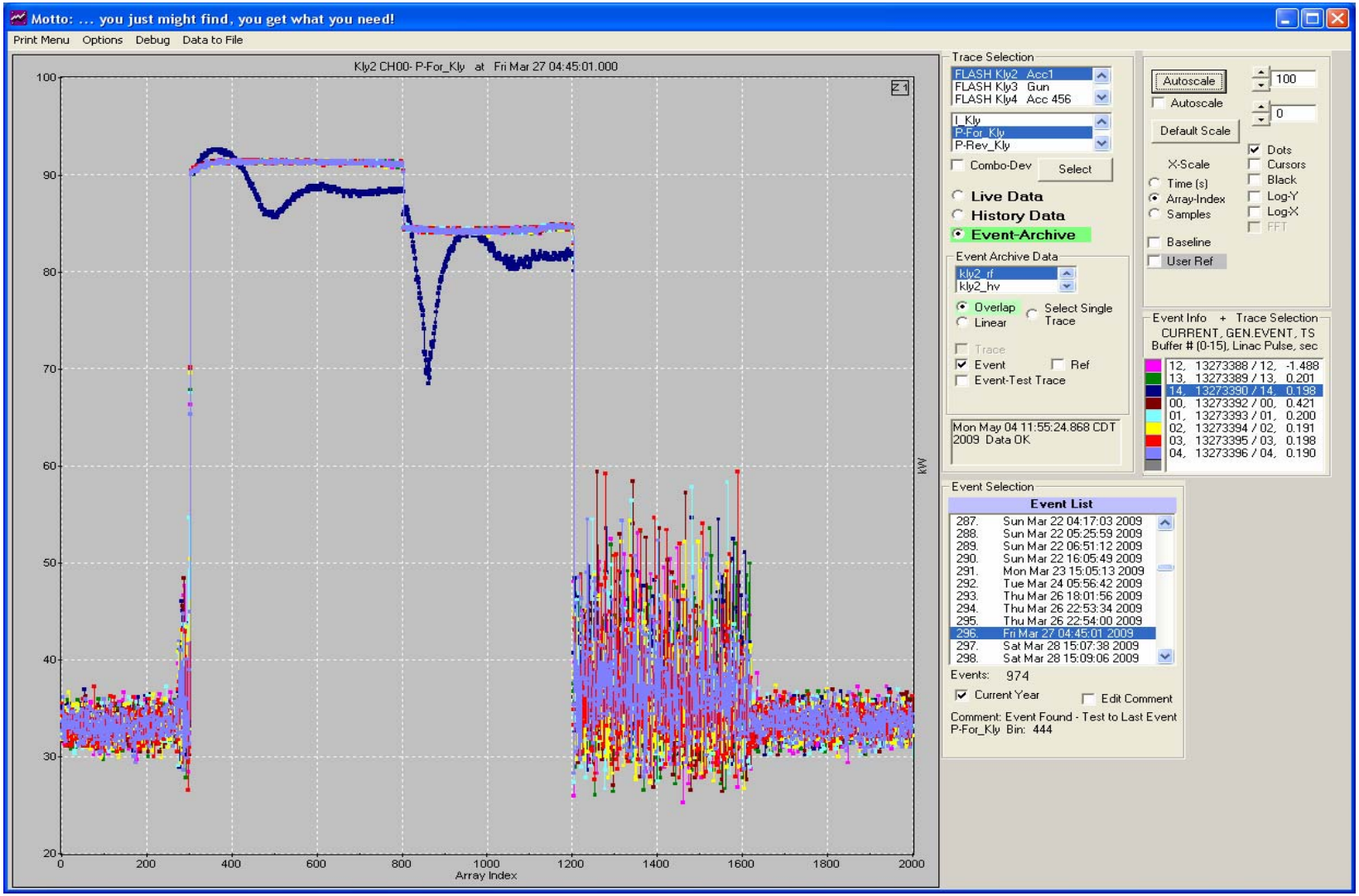
Kly-2 Forward Power

Breakdown near end of pulse



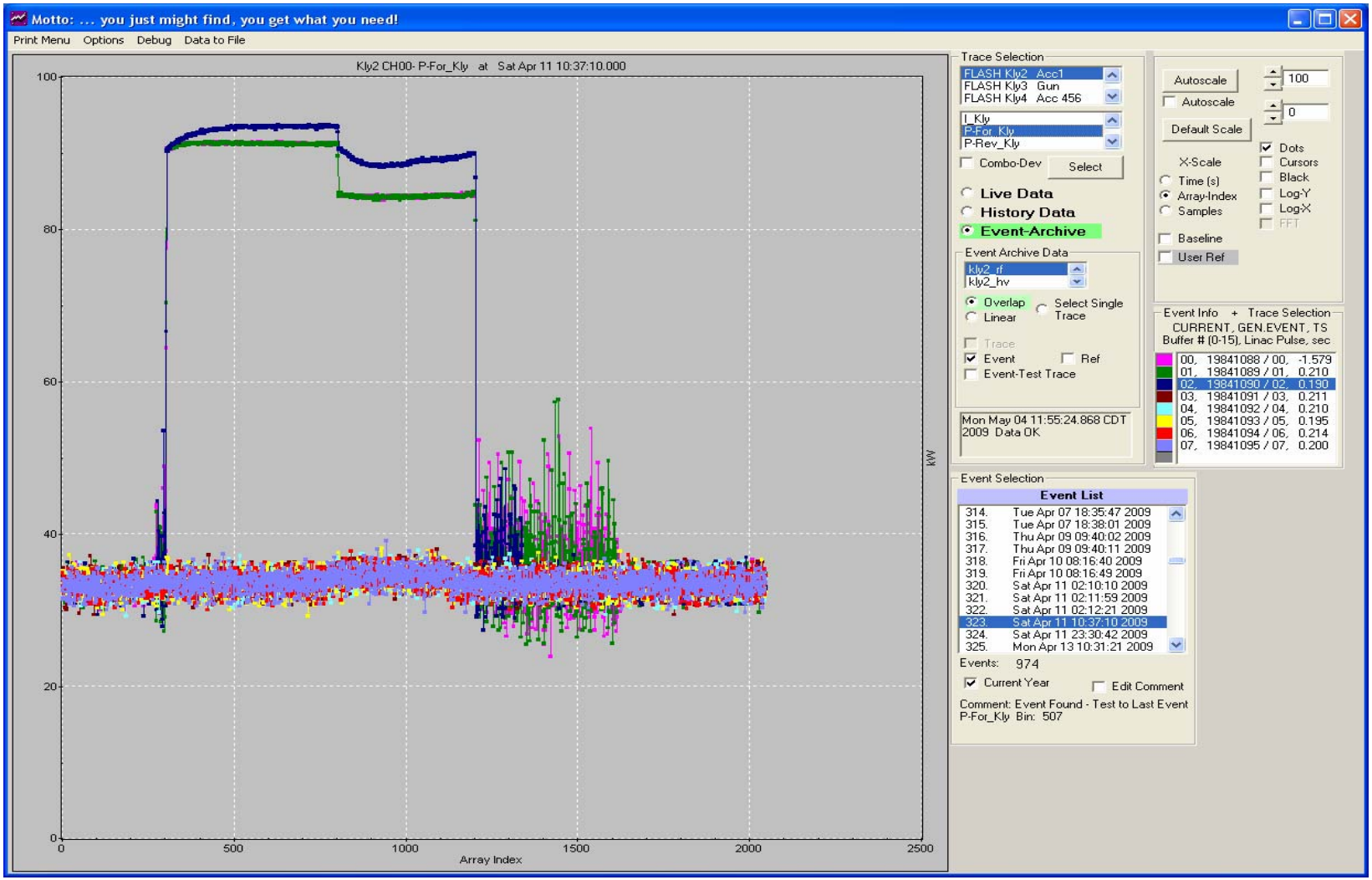
Kly-2 Forward Power

One Exotic Pulse



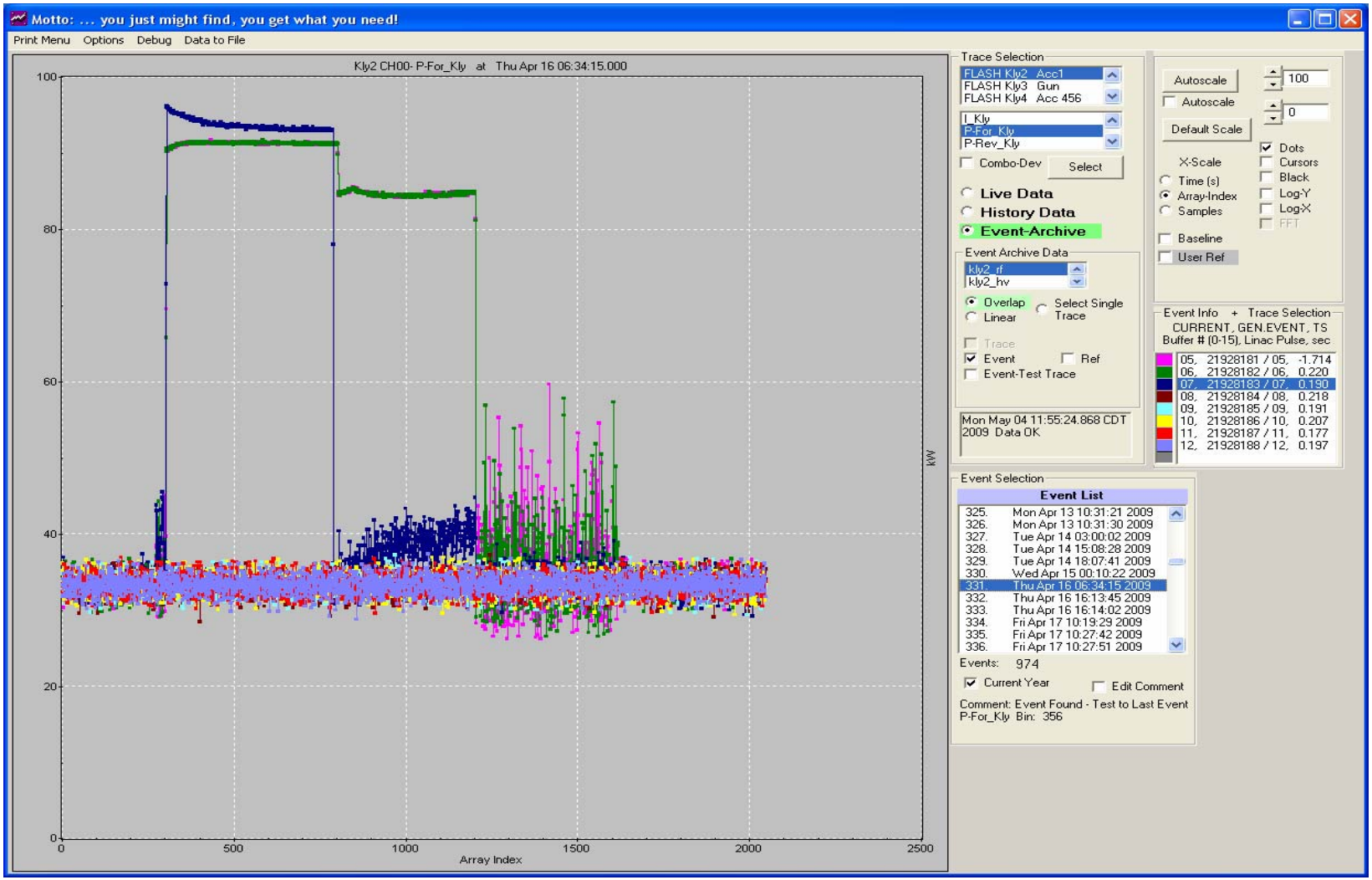
Kly-2 Forward Power

The Last Pulse is Exotic



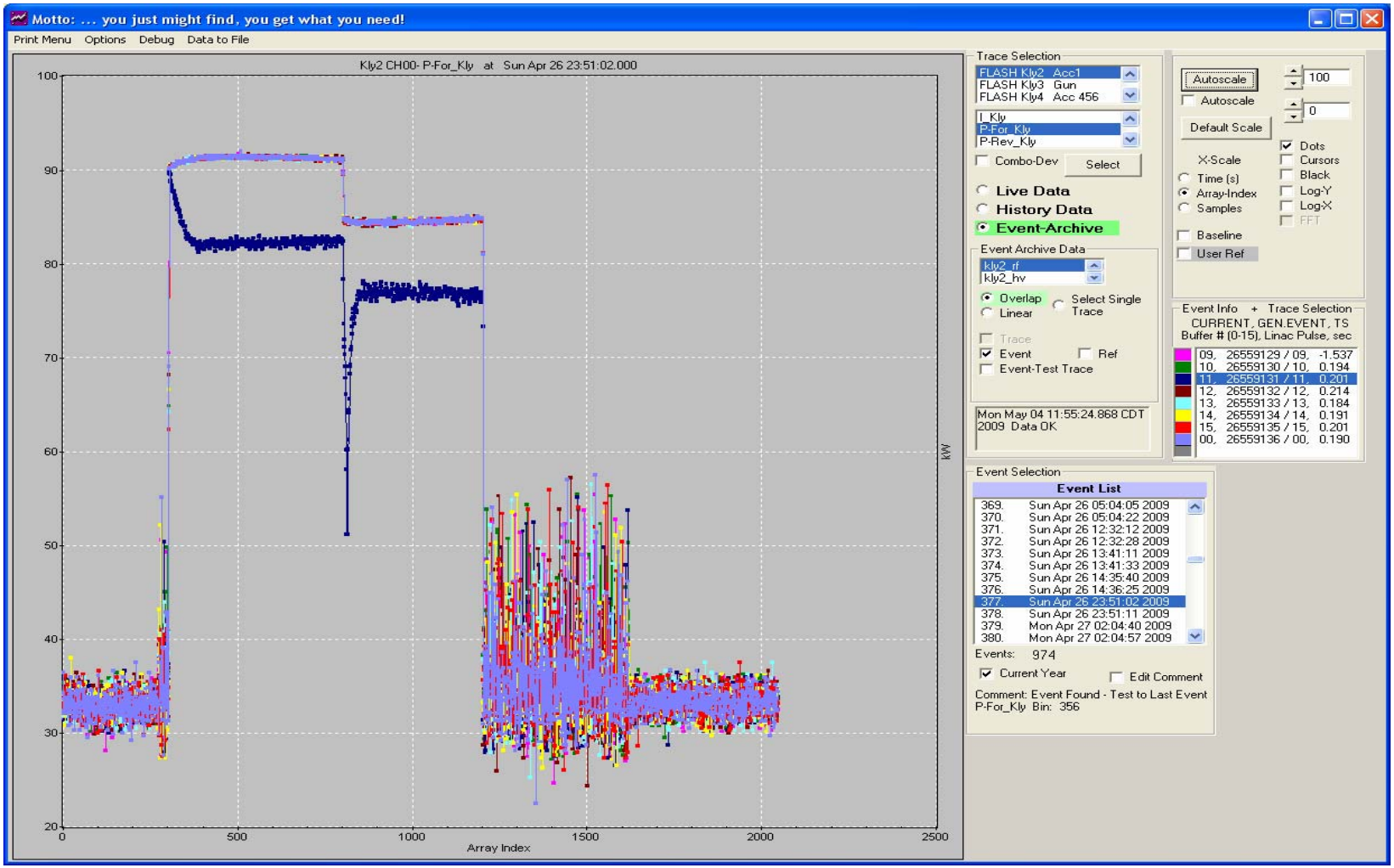
Kly-2 Forward Power

Hmmmm…



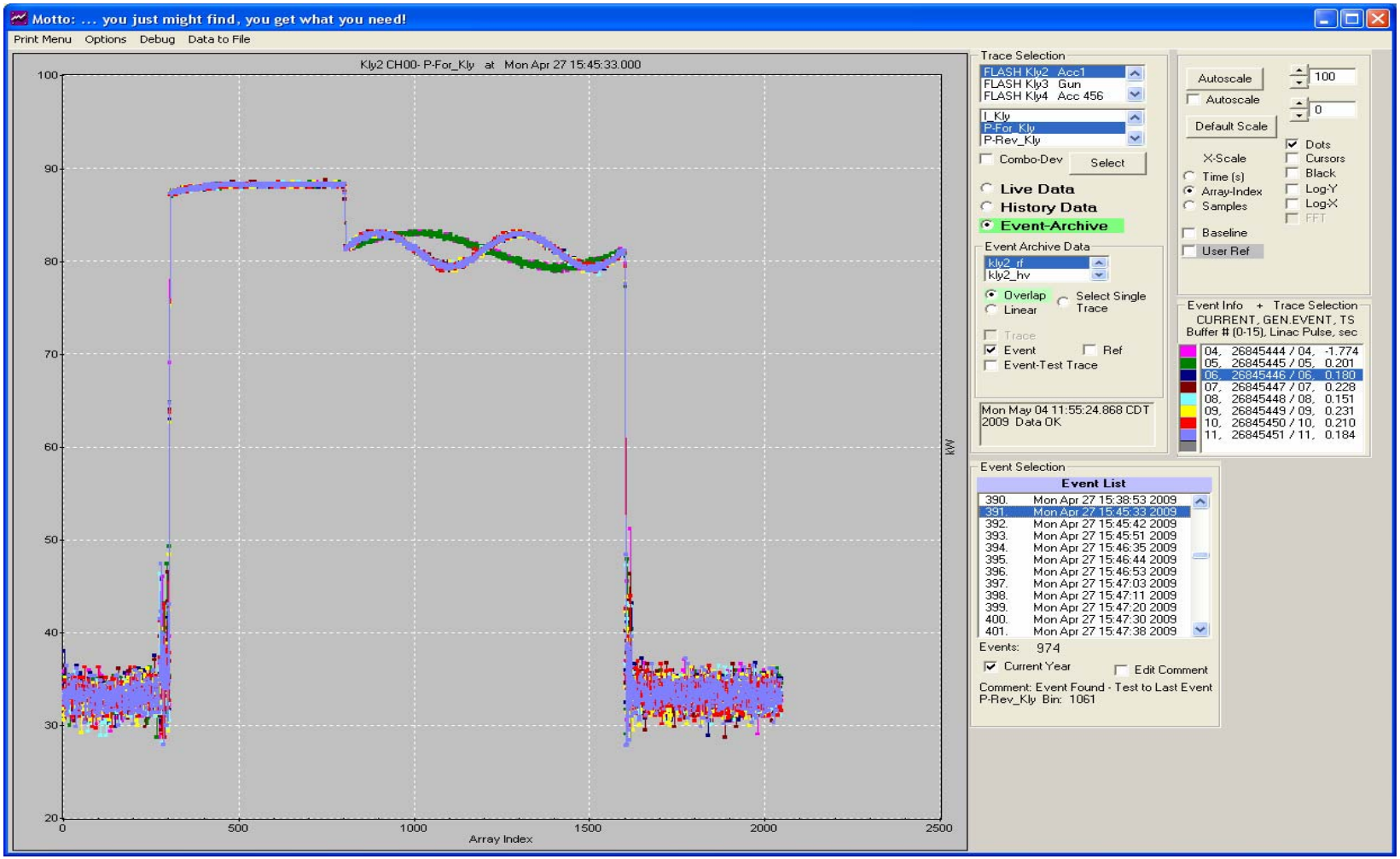
Kly-2 Forward Power

A Strange Pulse



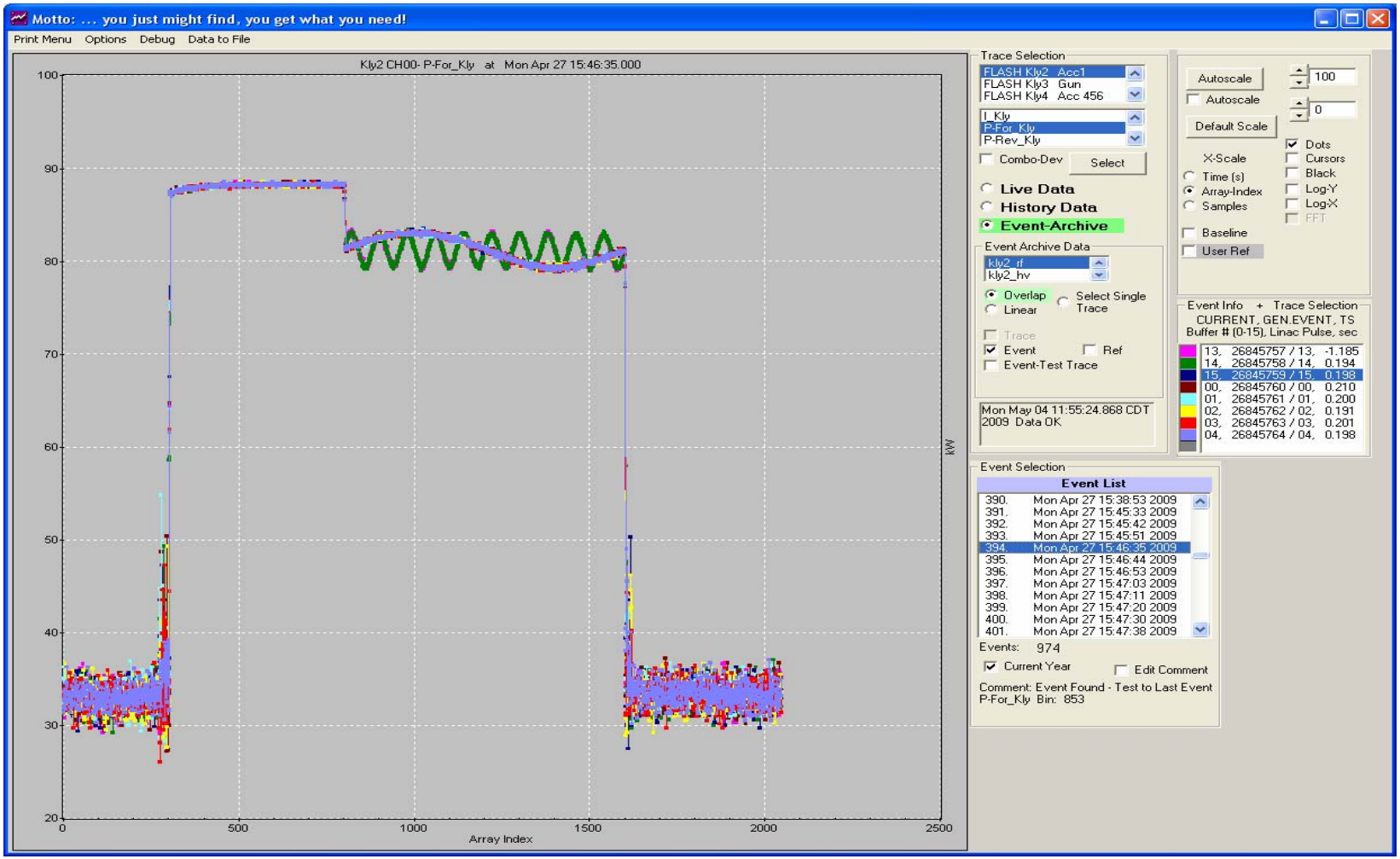
Kly-2 Forward Power

Some Strange Oscillations



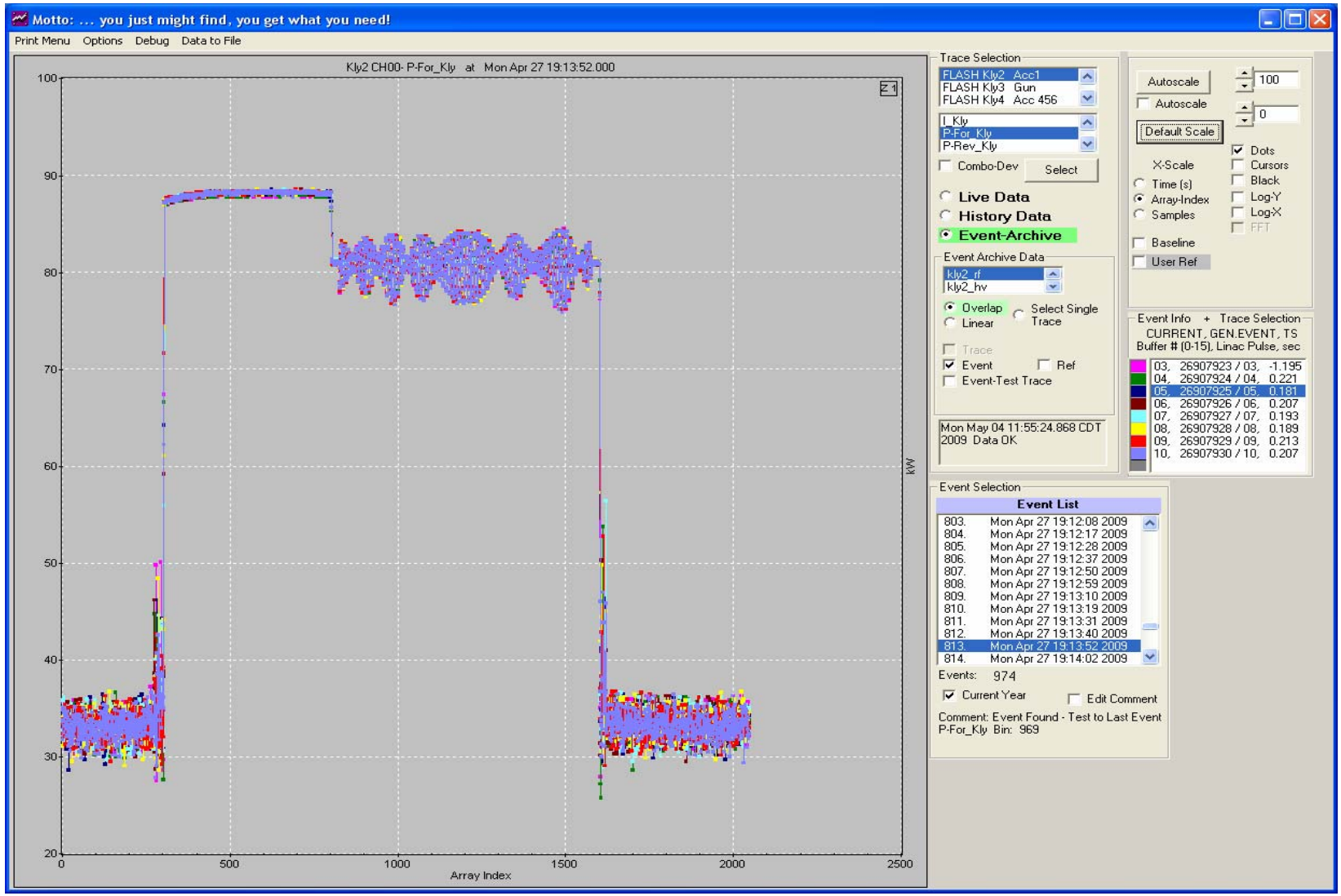
Kly-2 Forward Power

Higher Frequencies…



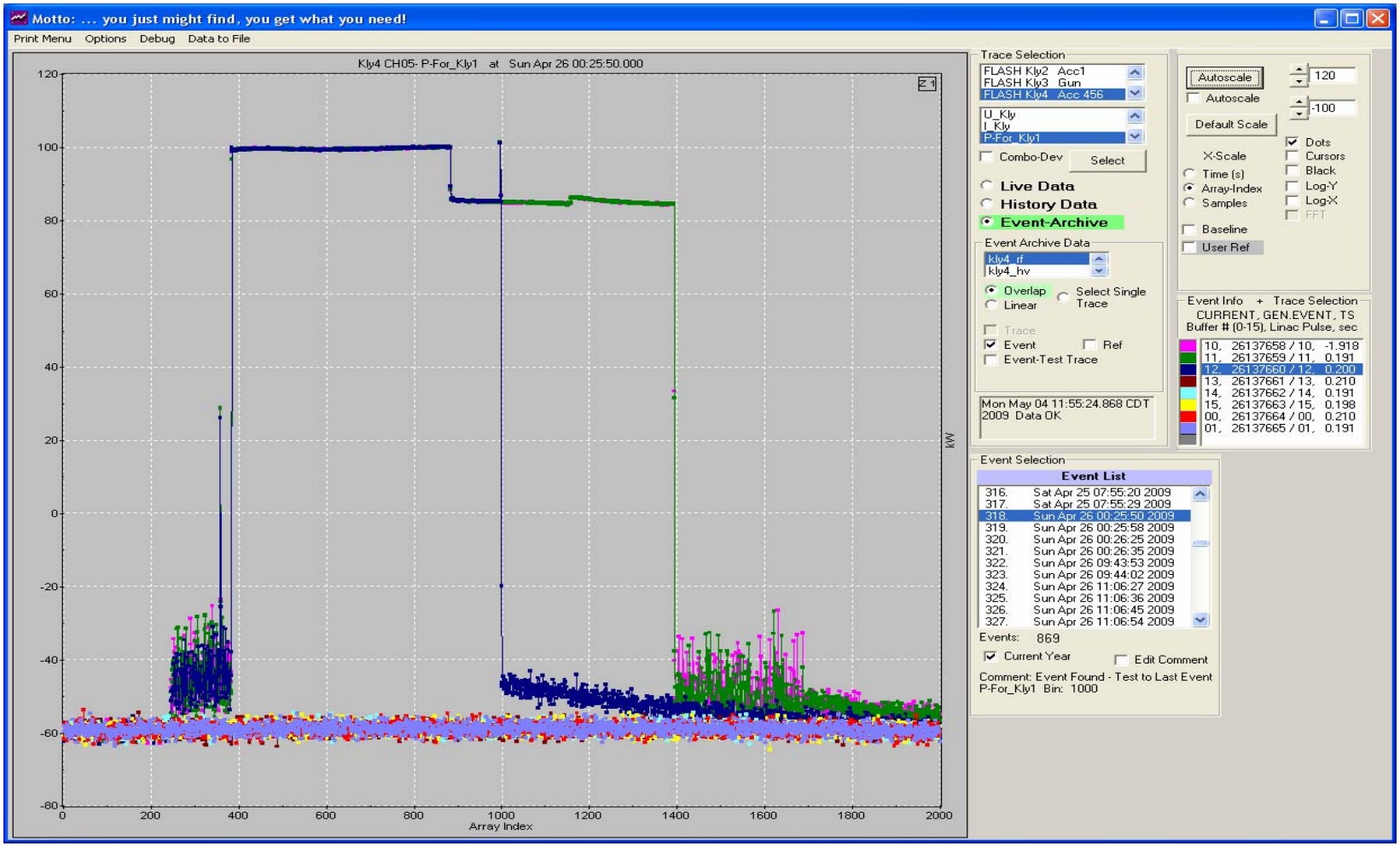
Kly-2 Forward Power

… even higher



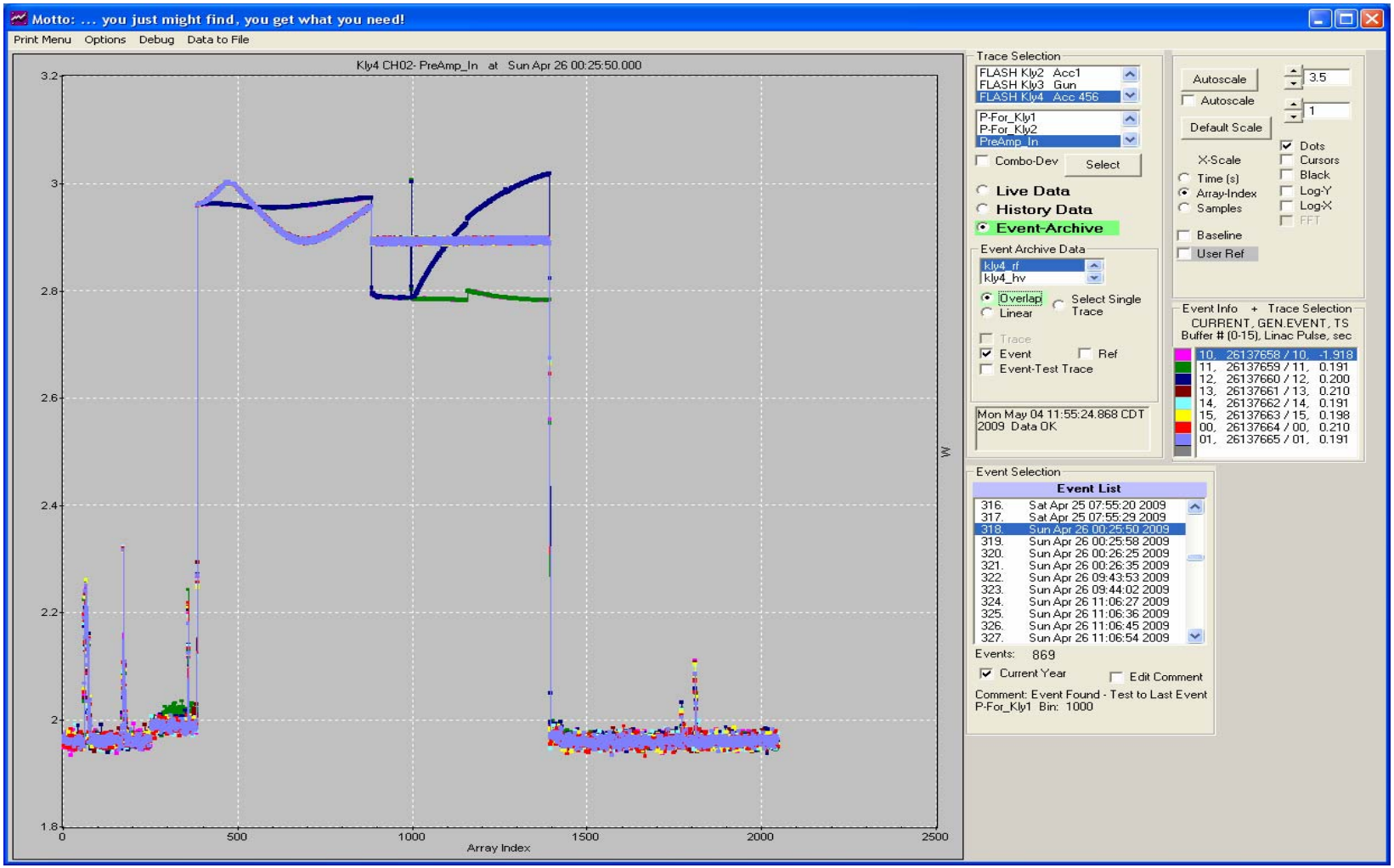
Kly-2 Forward Power

Hmmm…



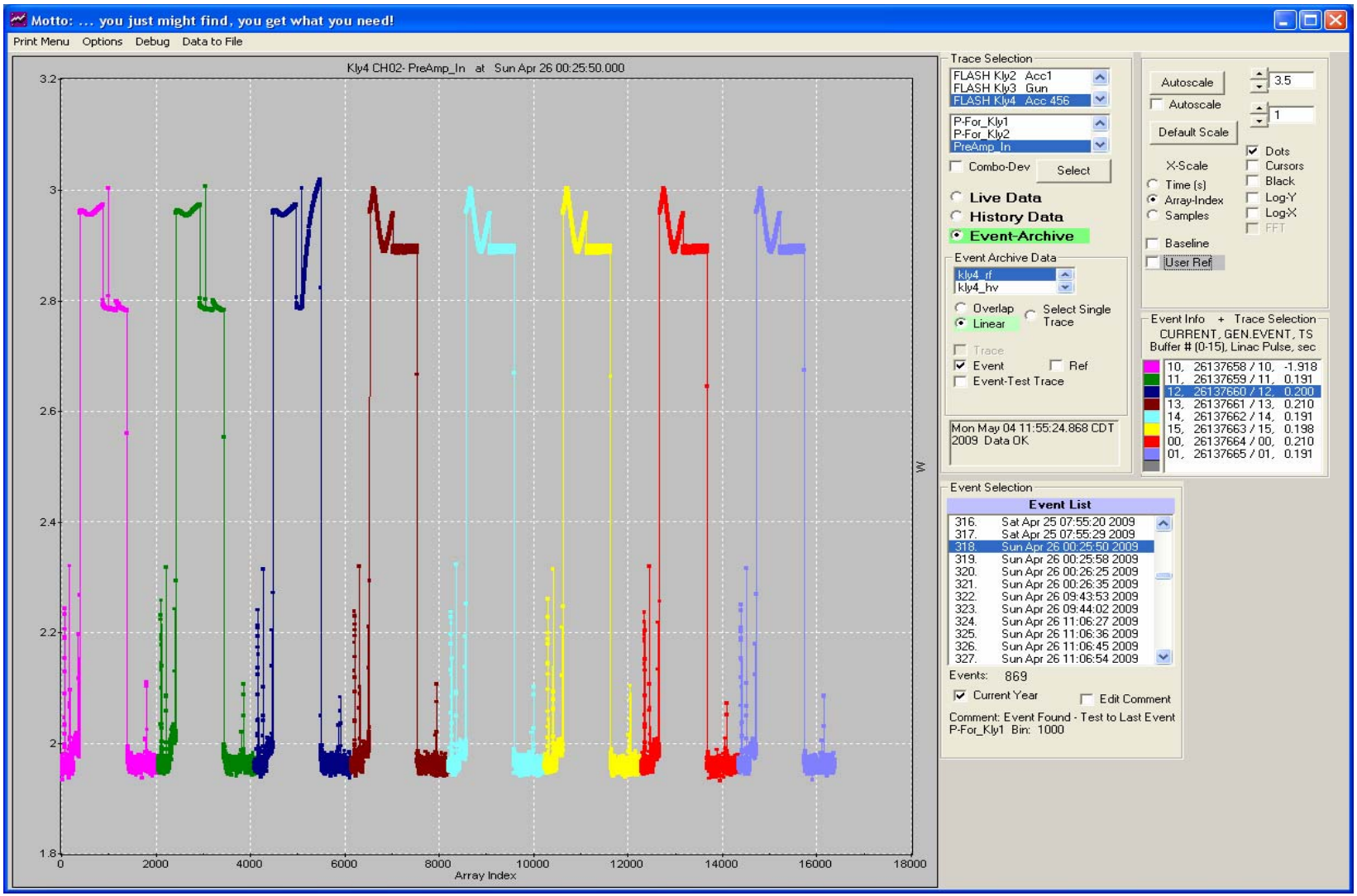
Kly-4 Forward Power

An Interesting Sequence…



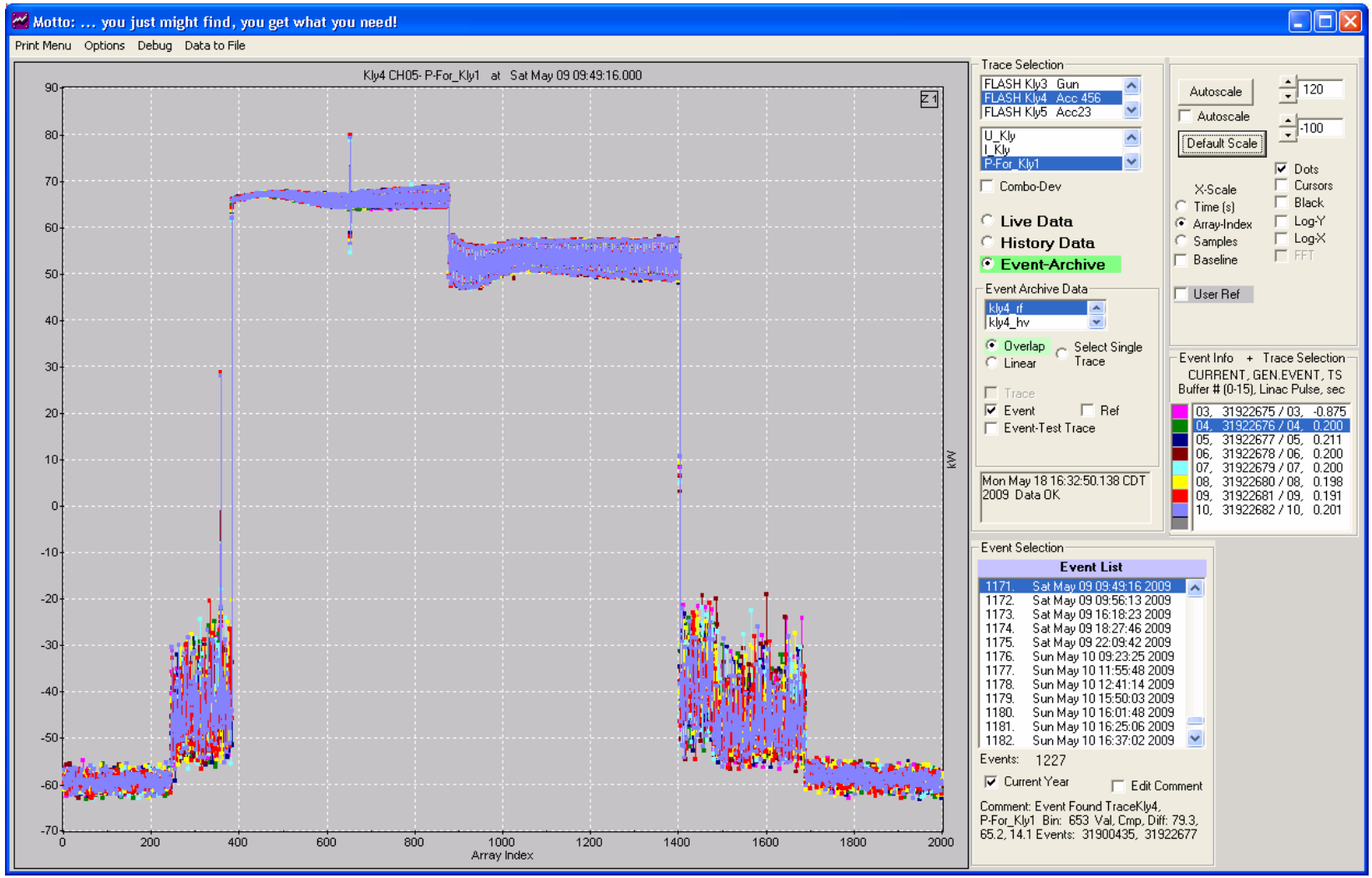
Kly-4 Pre-Amp Input

the same sequence, linear



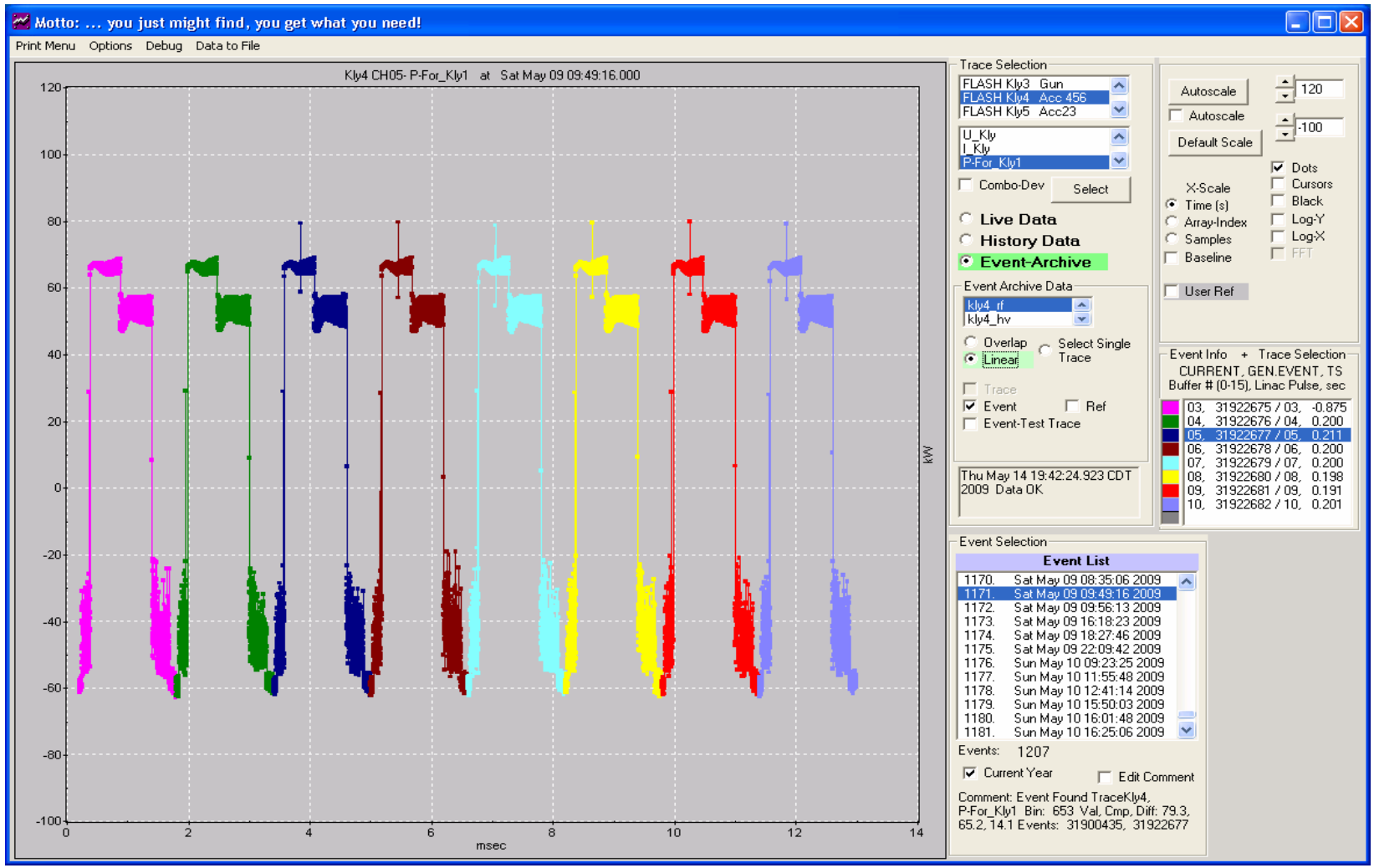
Kly-4 Pre-Amp Input

Strange Spike at sample 650…



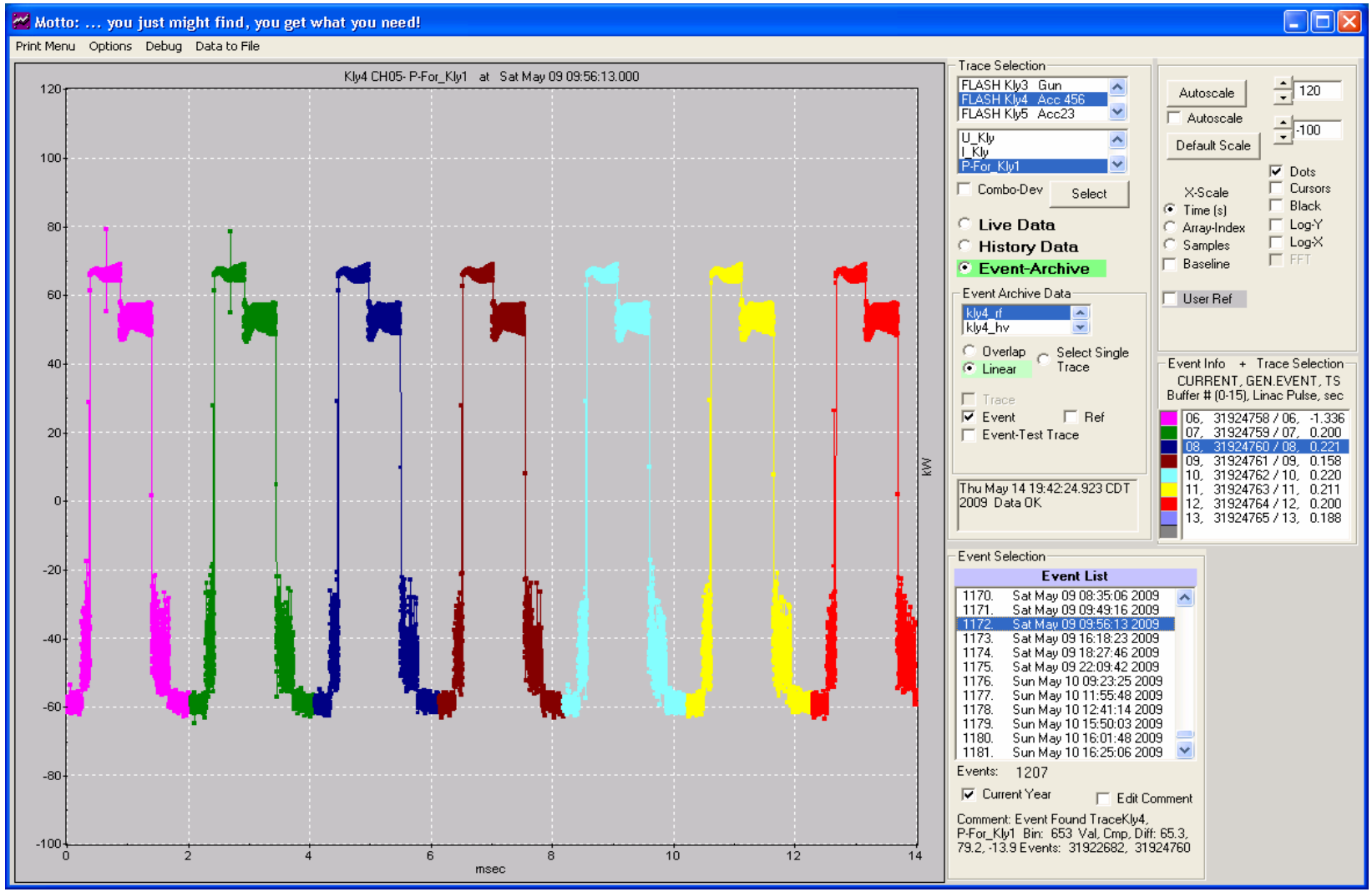
Kly-4 Forward Power

Linear: The Spike appears…



Kly-4 Forward Power

… and disappears after 7 minutes



Kly-4 Forward Power

Use Cases: Situations when an Archive System Comes in Handy

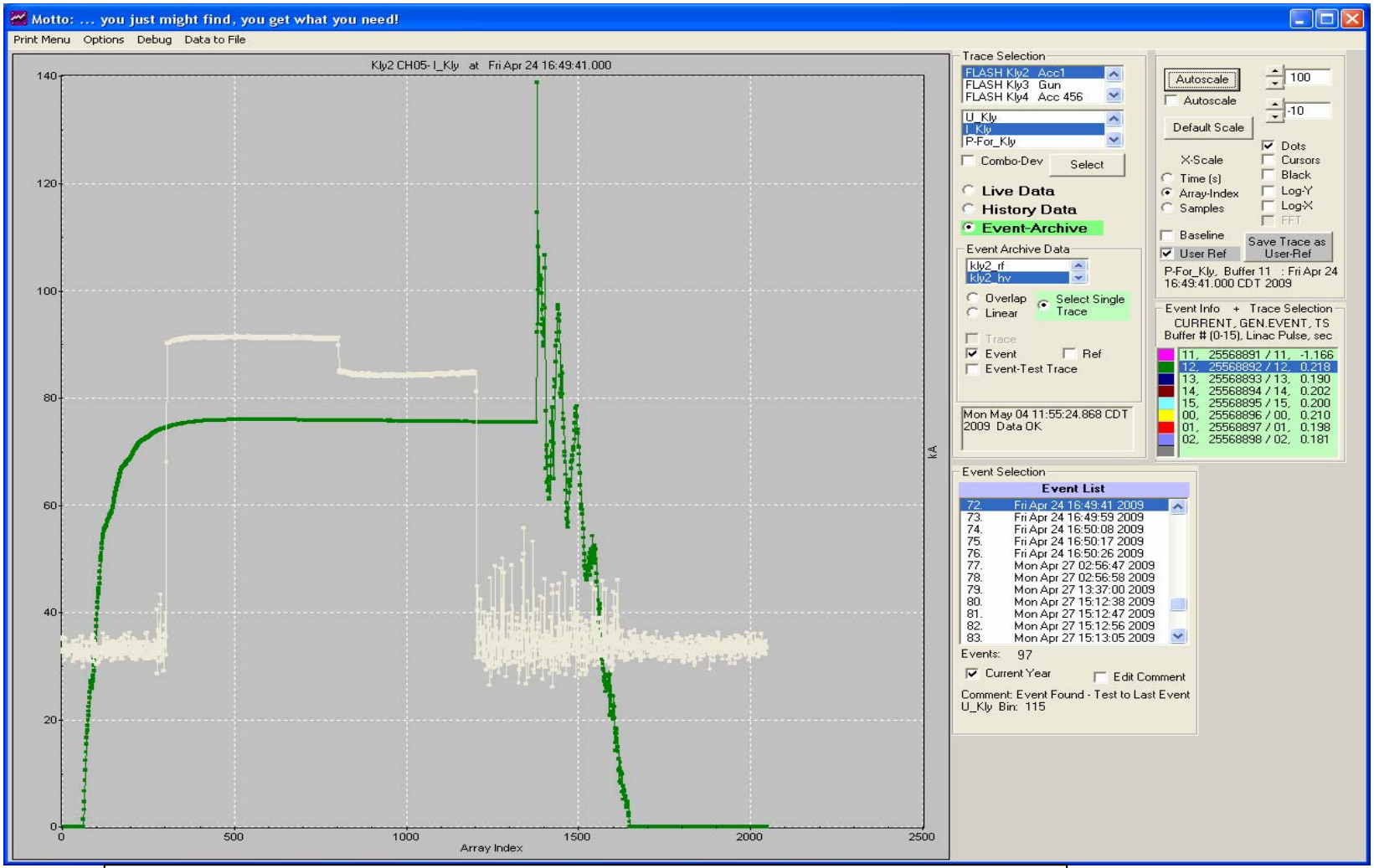
Cases which I have stumbled over while setting things up

1. Pulse-to-Pulse: Understanding Interlock Events (the Chicken-and-the-Egg Type Questions)
2. Long-term Logging of Pulse Details – changes over weeks
3. Other Archive Tools: Time Sequences over minutes, comparing devices:
   Switching-On an RF Station

(1) An Interesting Klystron-Pulse… check in Logbook

Using the Reference: The “distortion” occurs late in the pulse, after the RF pulse!

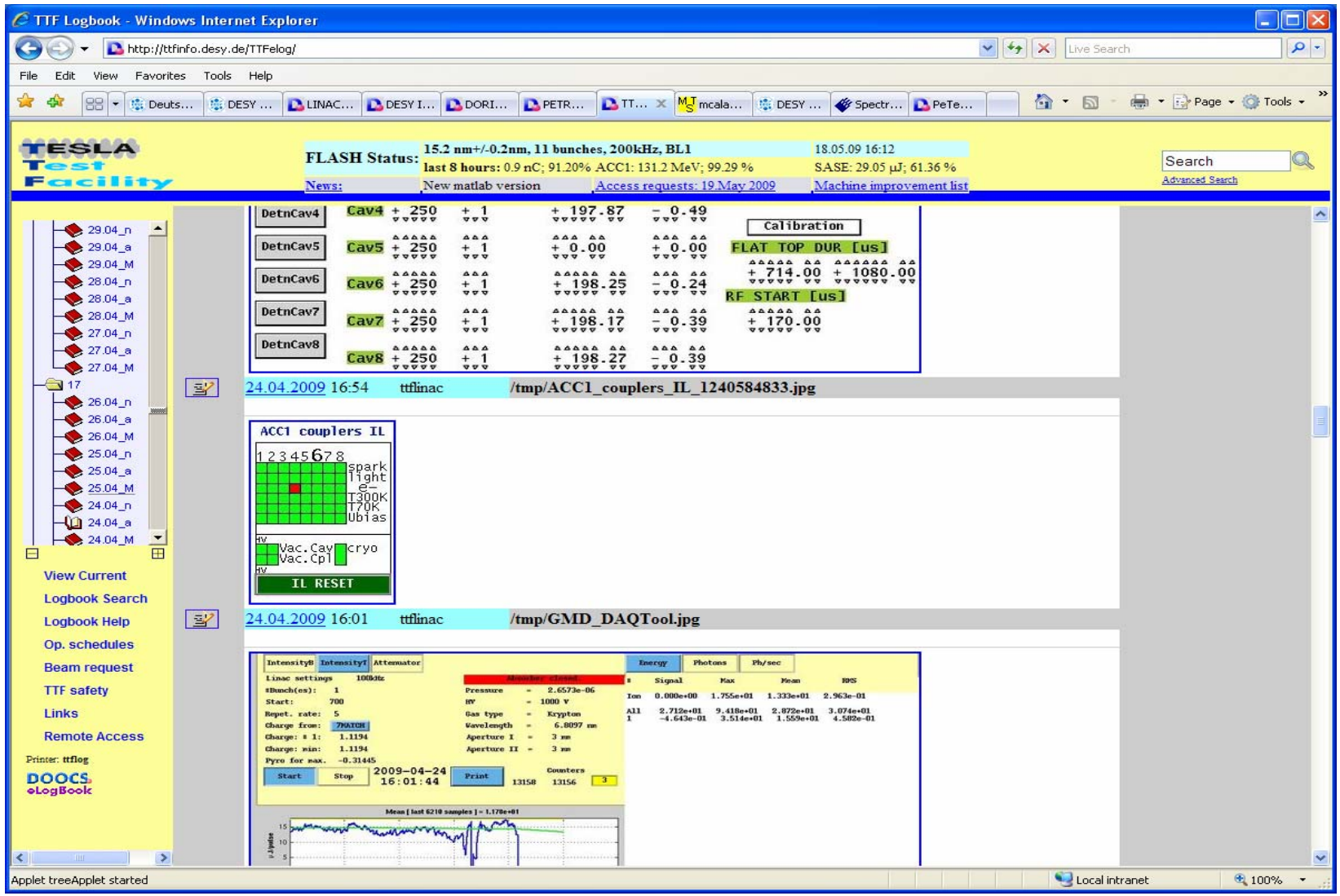
This Kly-I pulse is NOT out of tolerance in the tested sample range!



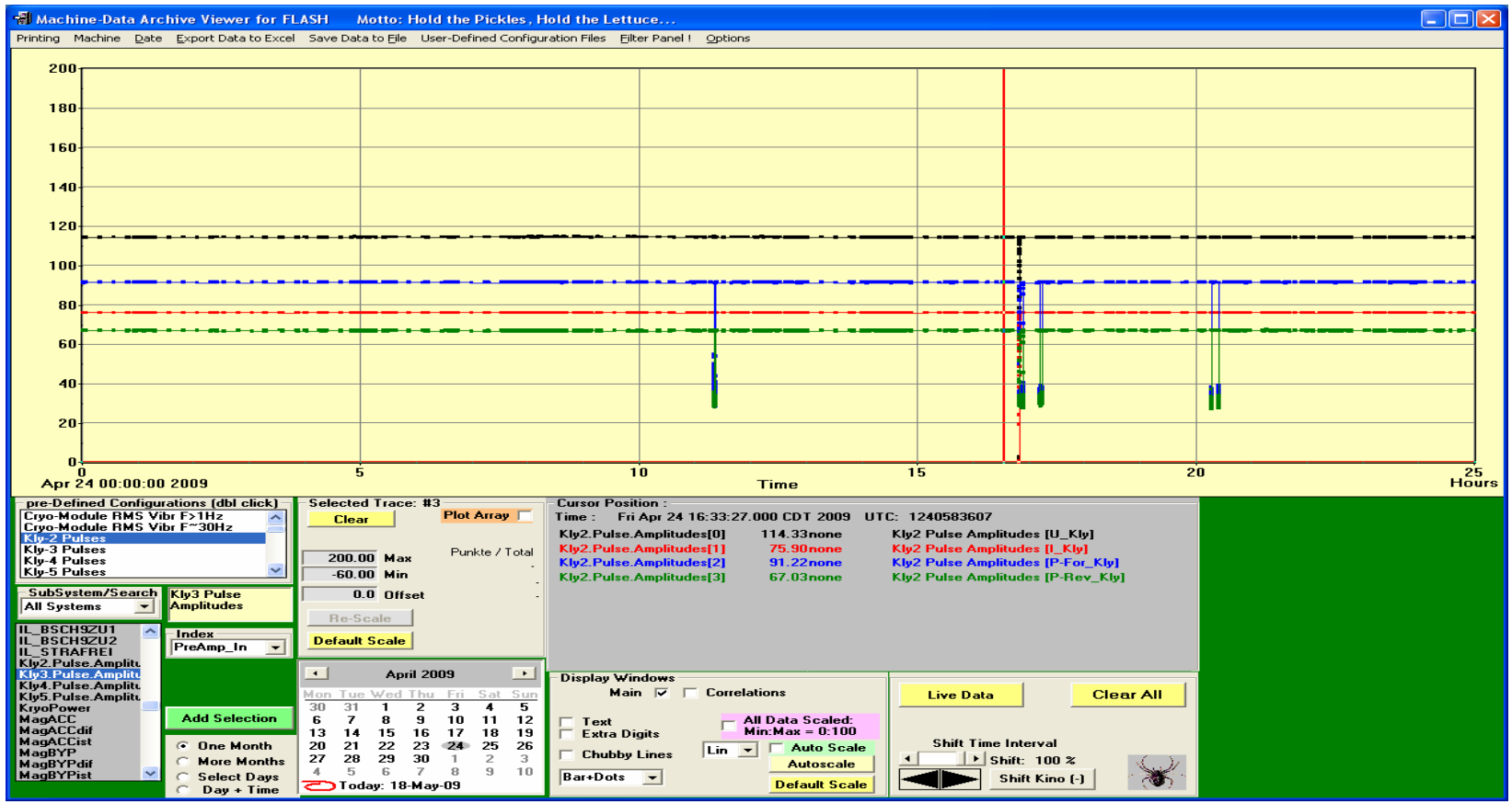
Kly-2 I-Kly (green) P-Forward (white)

“Coupler-Interlock!” … Cannot be the same pulse???

The goal is to collect all information for an interlock event.
for a complete description and quick analysis



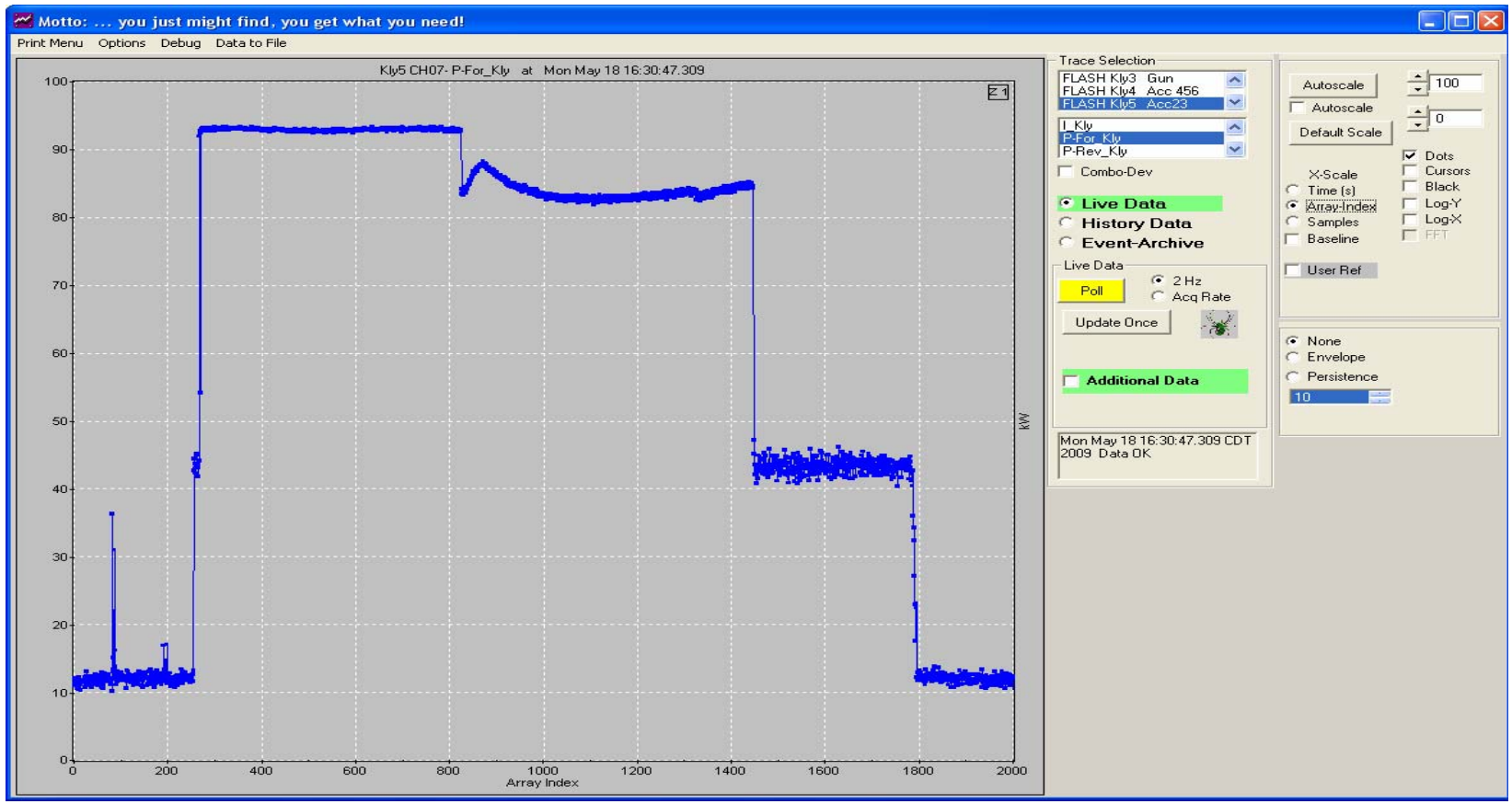
But there was only ONE trip of the HV of Kly-2 on this day….



Time-Development of Kly V, I and P-For during the day.

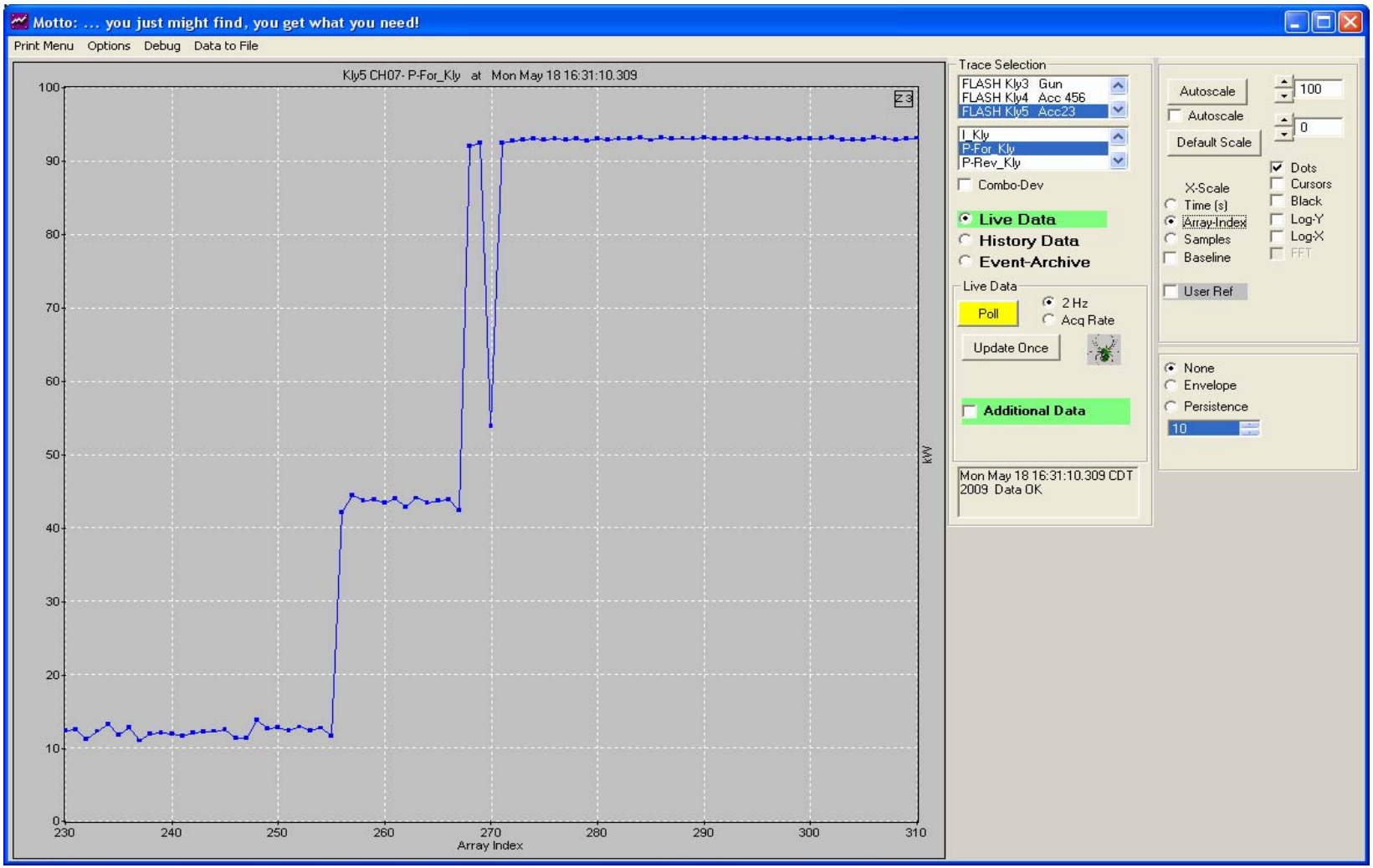
(2) Pulse Details and Their History

Live Data: Looks Good



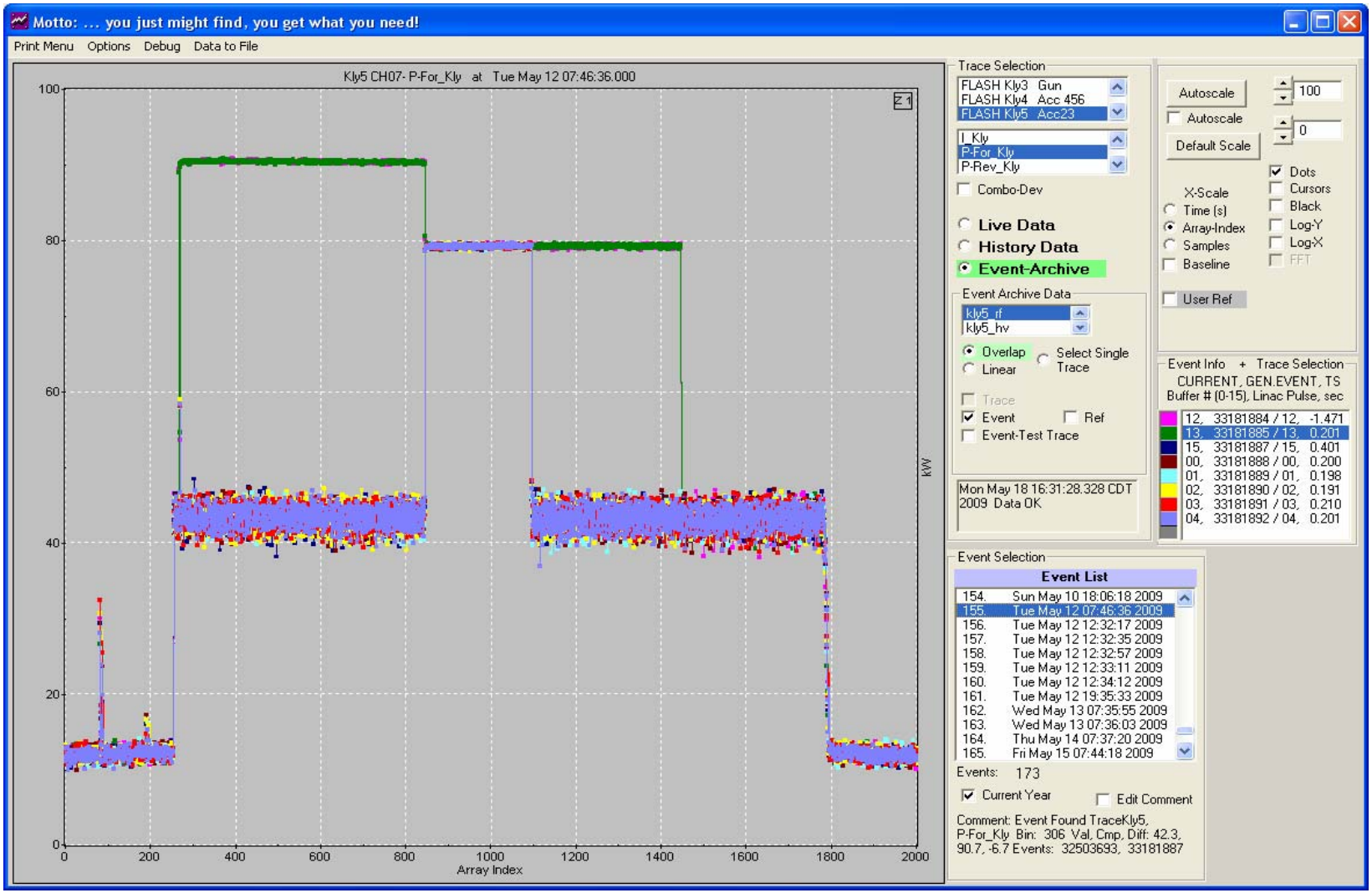
Kly-5 Forward Power

Zoom into the Leading Edge…



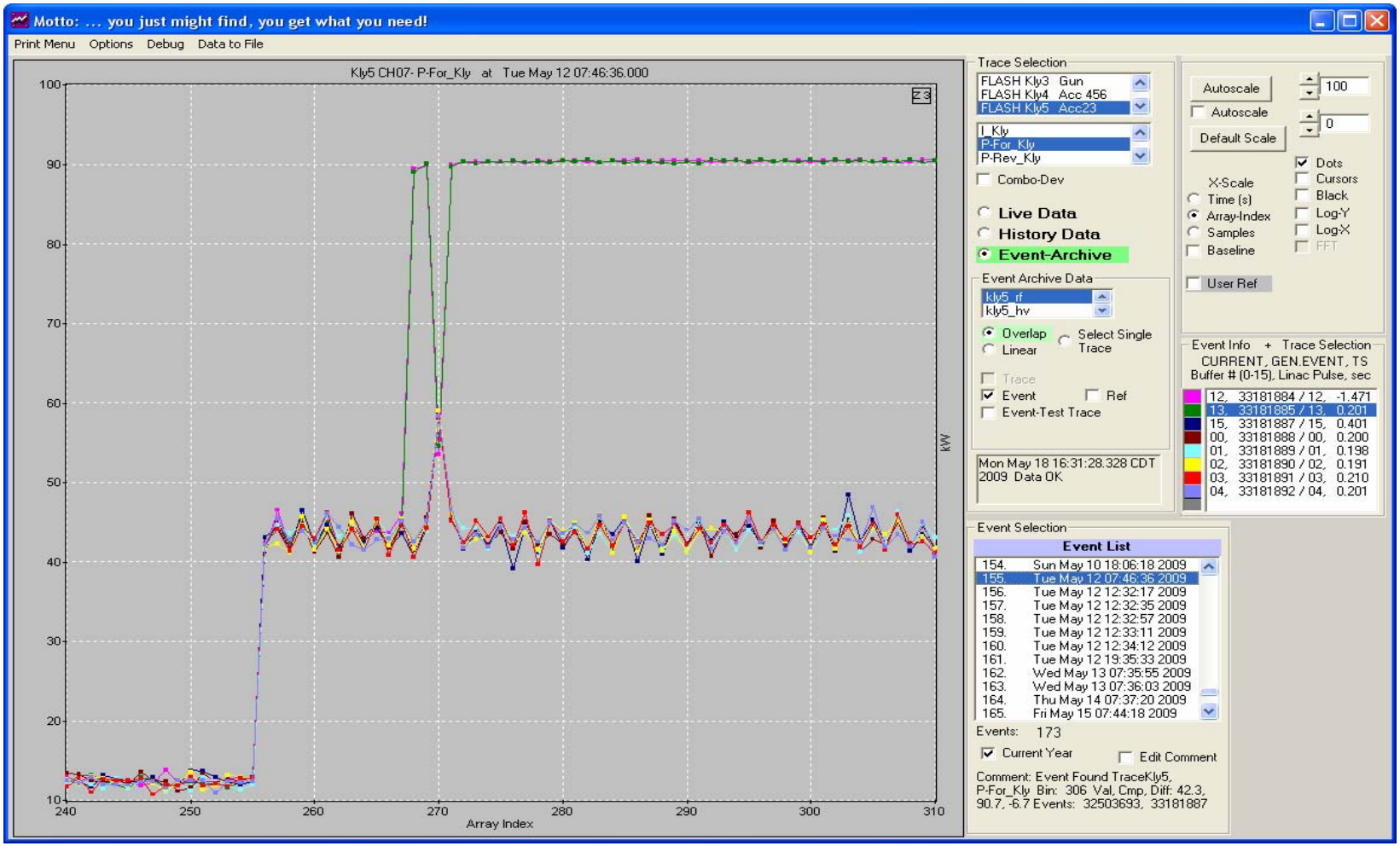
Kly-5 Forward Power

and also check out an “event”….



Kly-5 Forward Power

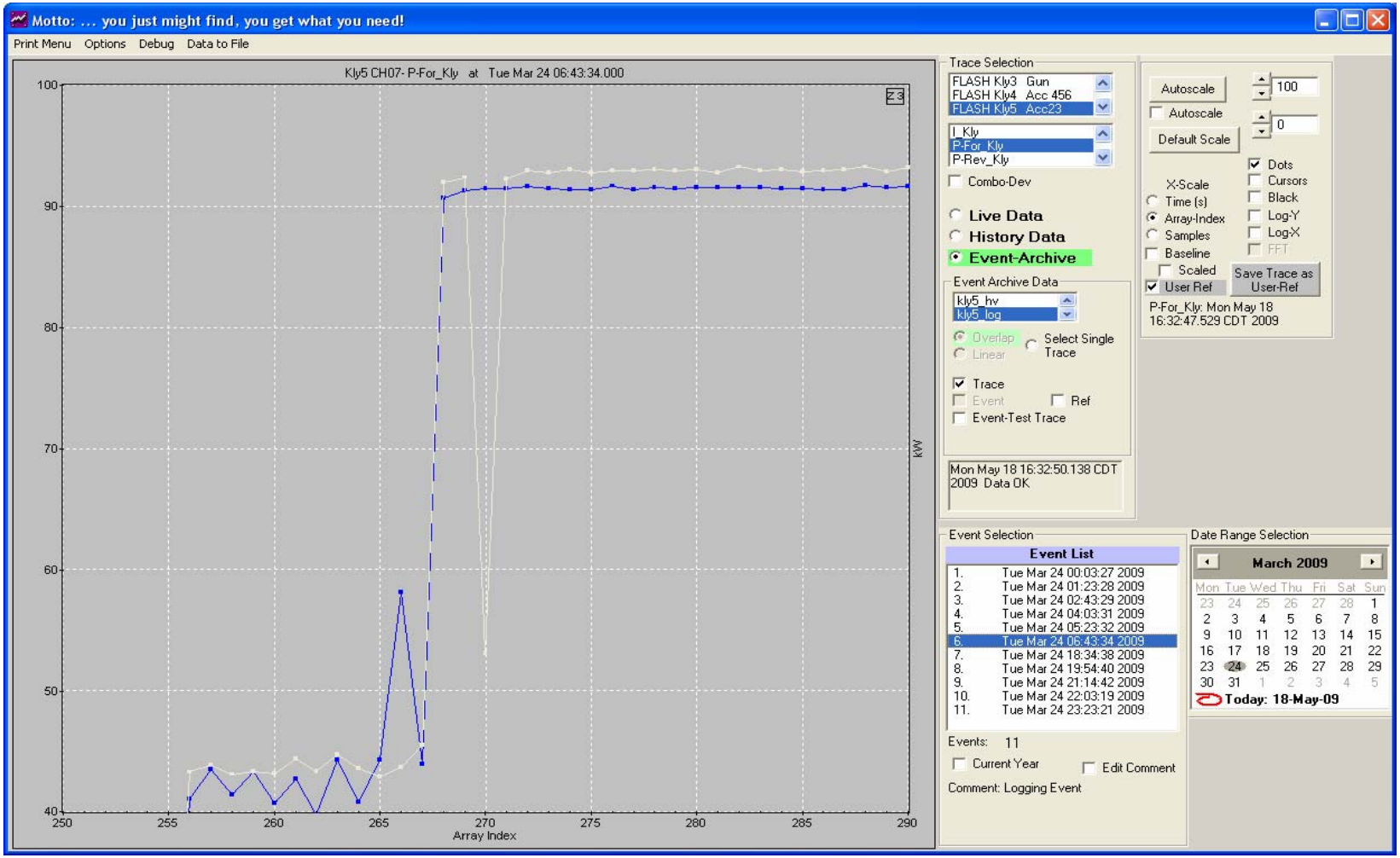
And zoom into the leading edge…



Kly-5 Forward Power

How long has this “feature” been there?

Look in the Logging Event List (1/20 minutes, a few an hour)



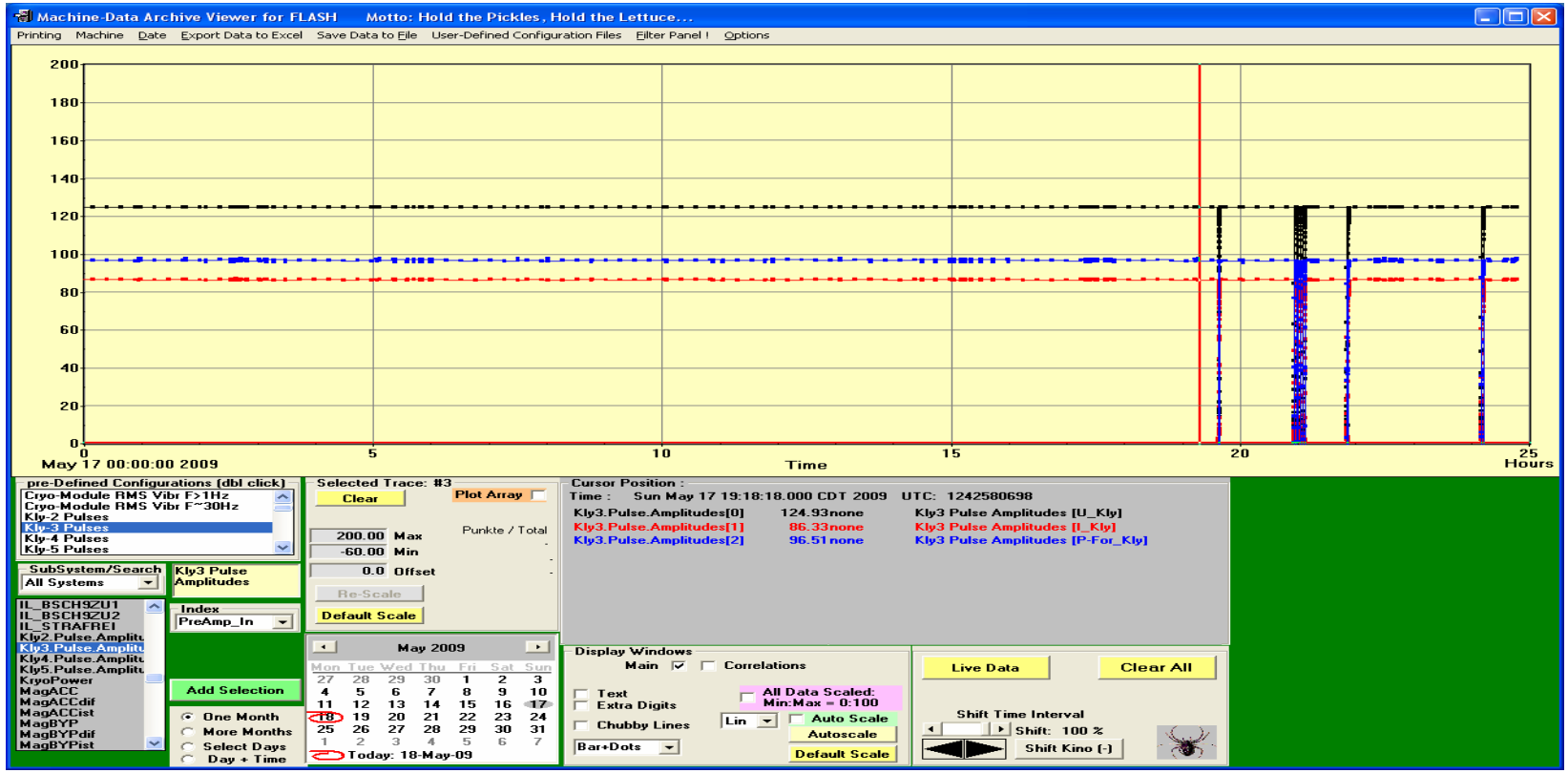
Kly-5 Forward Power

(3) Trend Displays:

Comparing the time development of different devices

The Switching-On Procedure for Kly-3

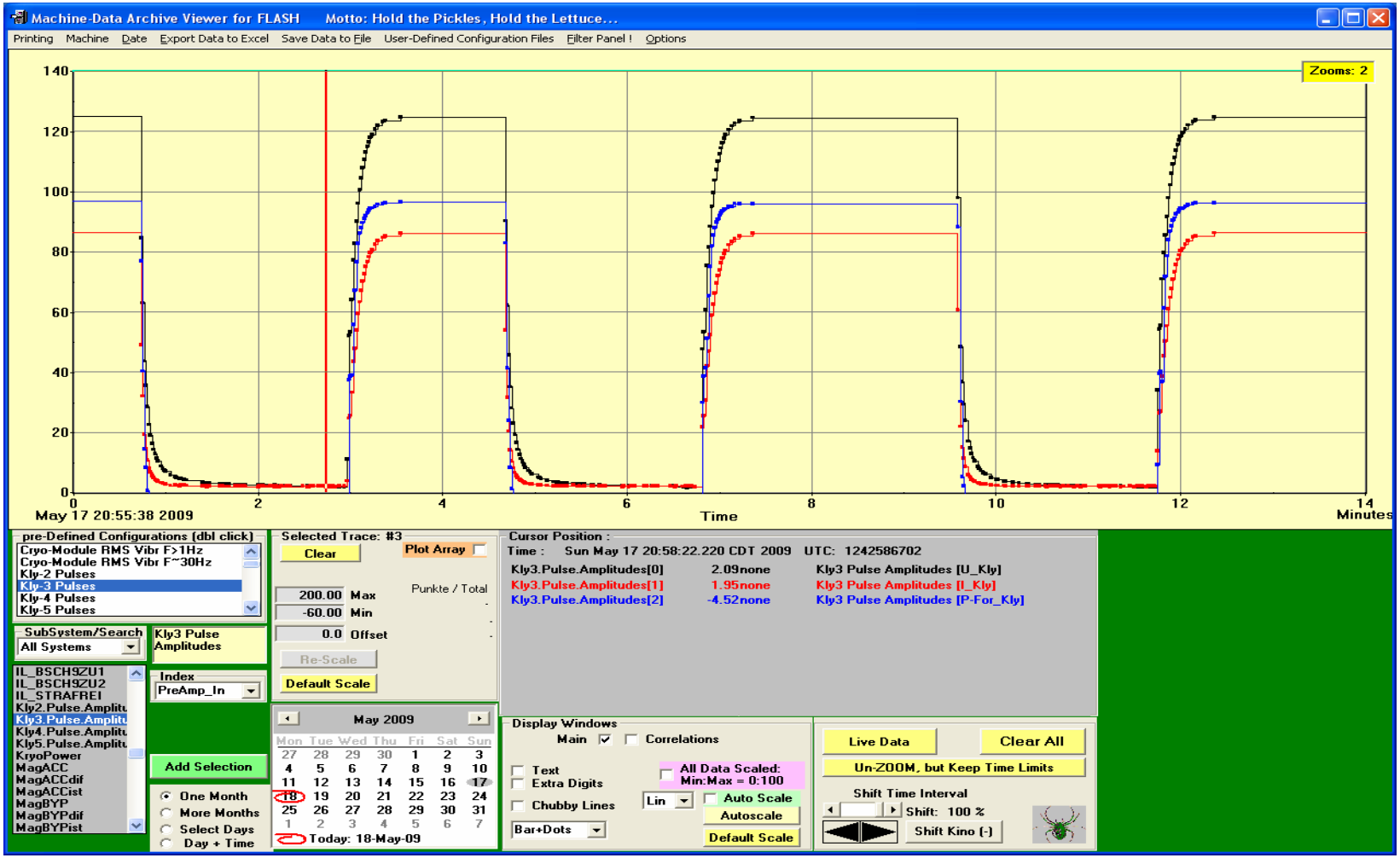
Calculated parameters (pulse-amplitudes) from middle-layer, stored as an array in Central Archiver, plotted as device-value versus time



Time-Development of Kly V, I and P-For during the day.

“Contactor”: Ramp down, then back up

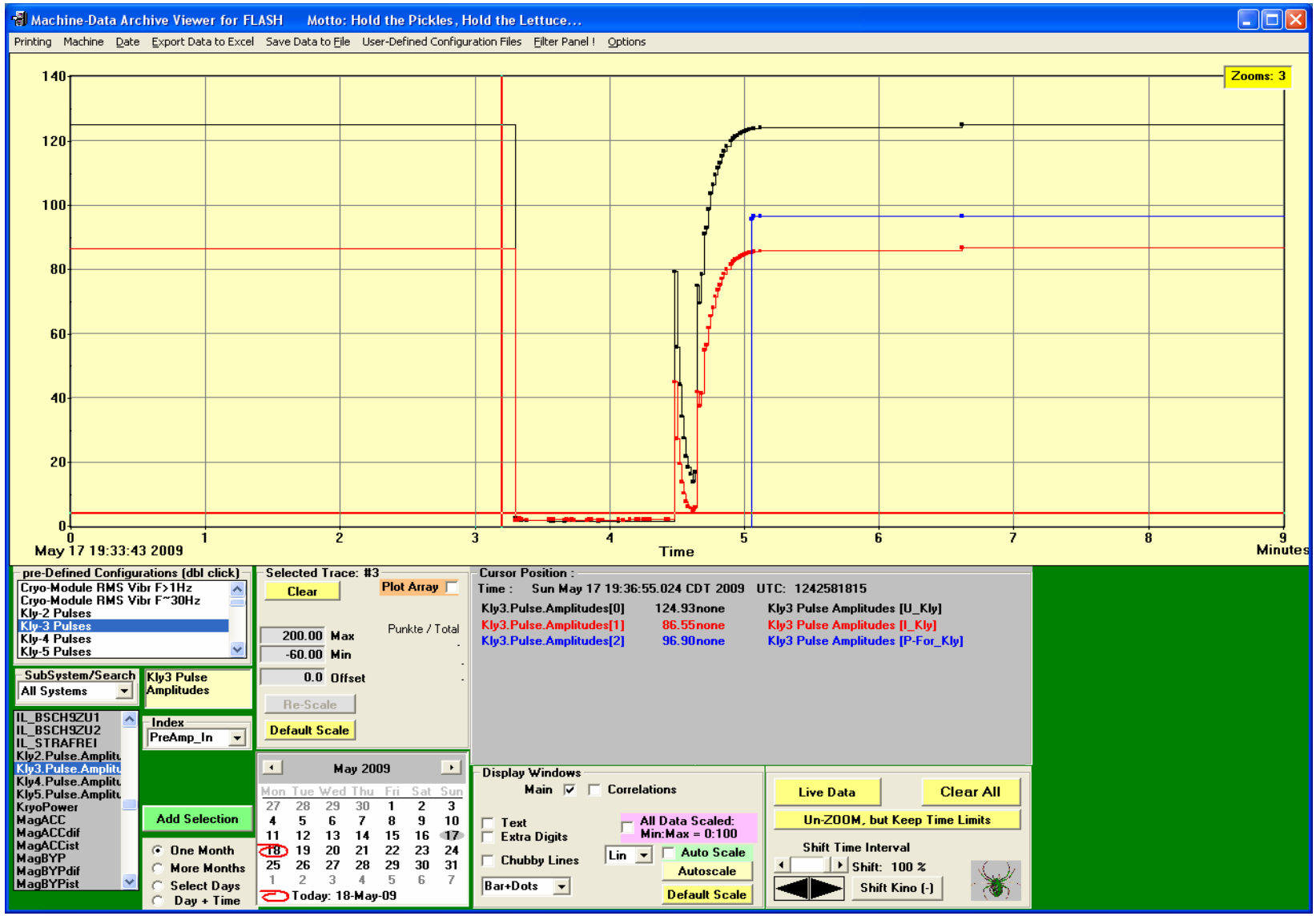
Notice “out-of-tolerance” for storage of entire array.



Time-Development of Kly V, I and P-For 3*contactor.

Interlock: coupler? (not clear to me from logbook)

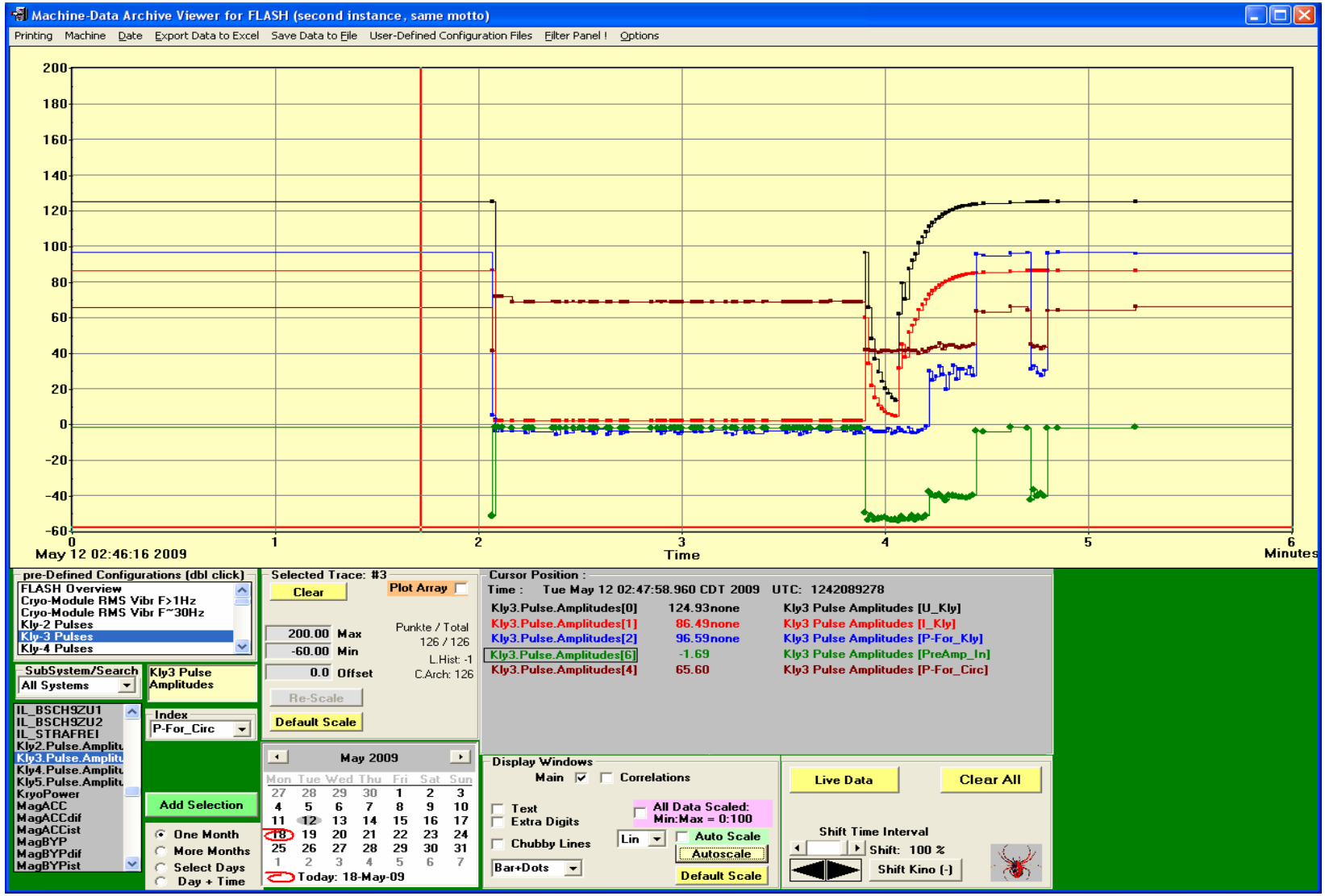
This switch-on procedure is NOT the same as after a “contactor”!



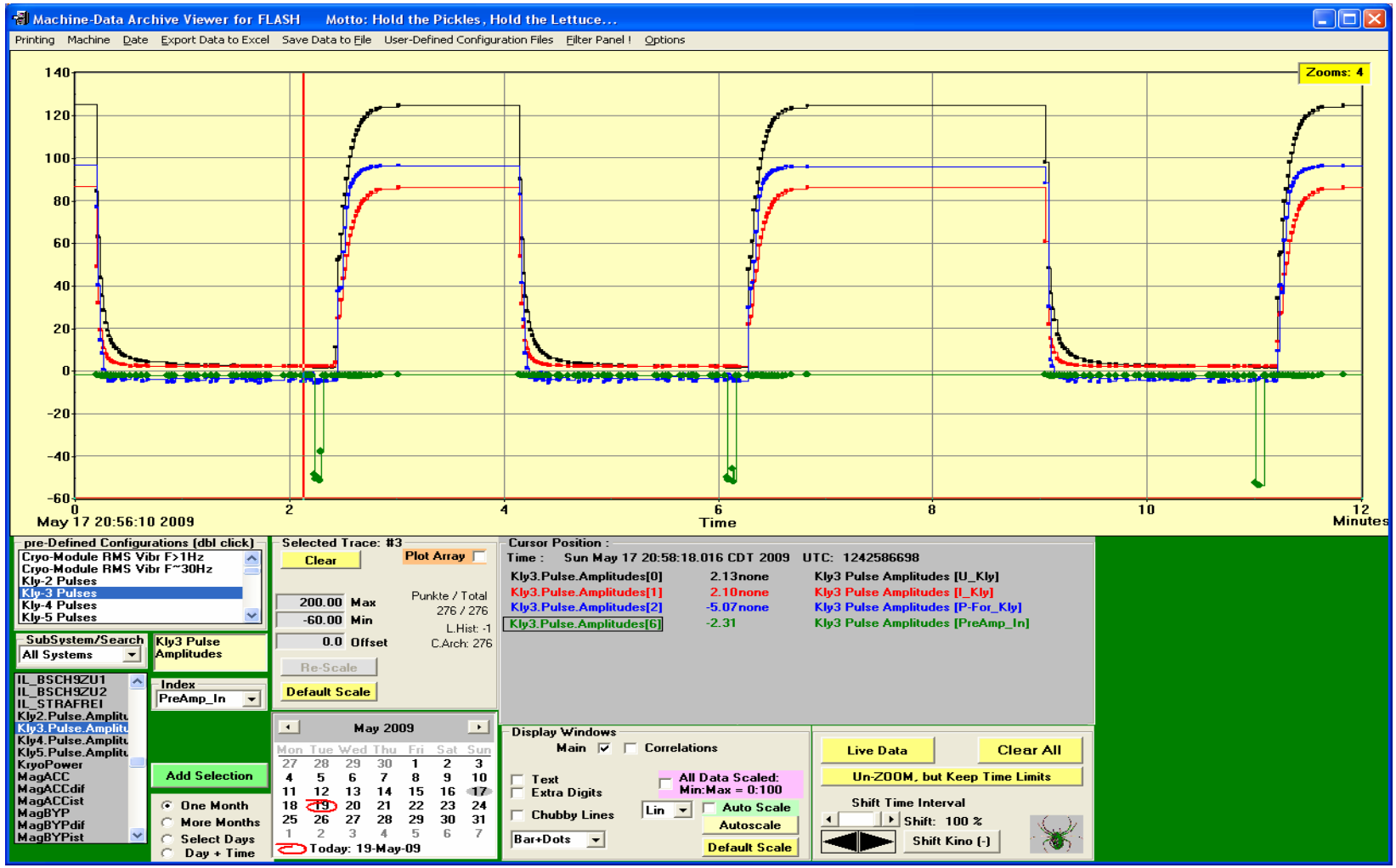
Fast Switch-Off, and Fast Switch-On! Kly-3 I and V

Check other channels: add the “Pre-Amp In” (green)

The Pre-Amp is switched off after the fast switch-on.



Back to Contactor Switch-On



Event Archiving for FLASH RF

- Archiving is very important for operations, for technical-systems. For RF: need to archive “pulses” (a.k.a. traces, Time-Domain data)
- Applied TINE Archive-Tools for flash HP RF
- Use “out-of-tolerance” criteria to generate “events”
- Data stored in Event- and Central- Archivers
- Running on Kly-2, 3, 4, and 5, Test and Halle-2.
- Started “production” Jan 09.

- Prototype display tool (goal: Java)
- Have found many unexpected “exotic” pulses
- If the tools could be of use, just ask!
  - Time for a demo?