



# Measurements using the Head-Tail Monitor

BI-Day 2000

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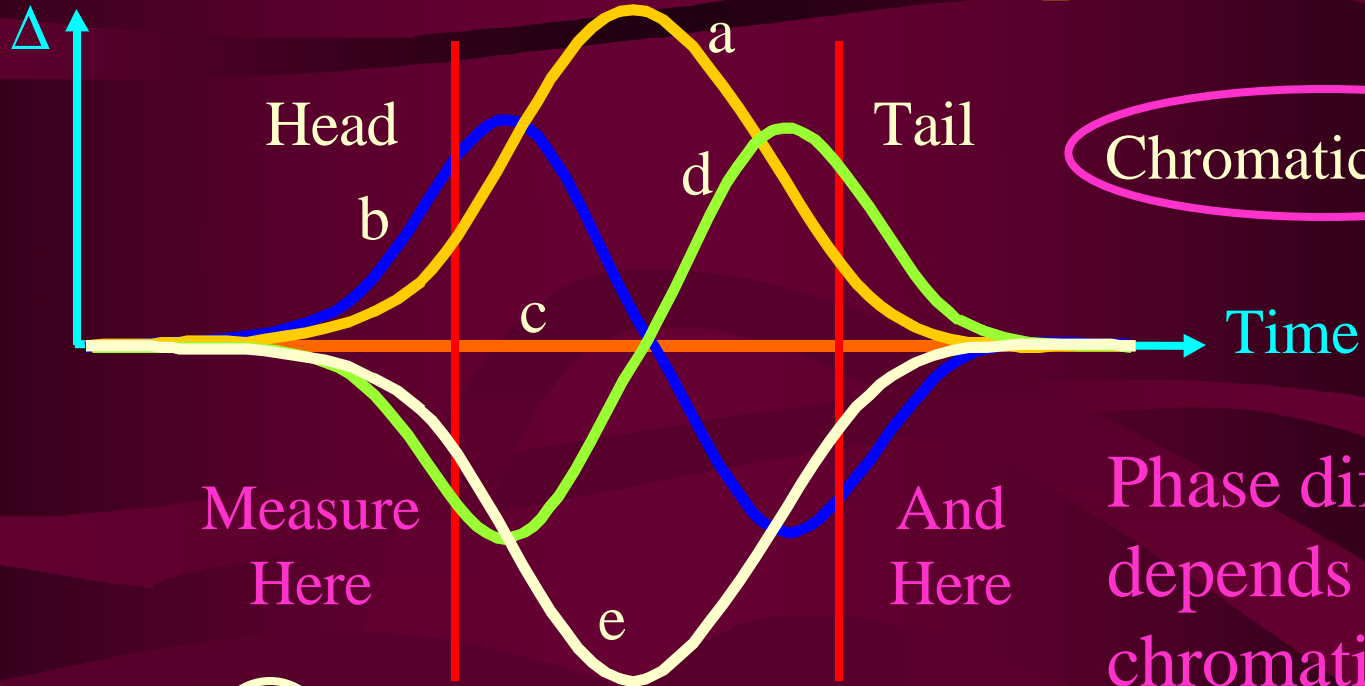


# Outline

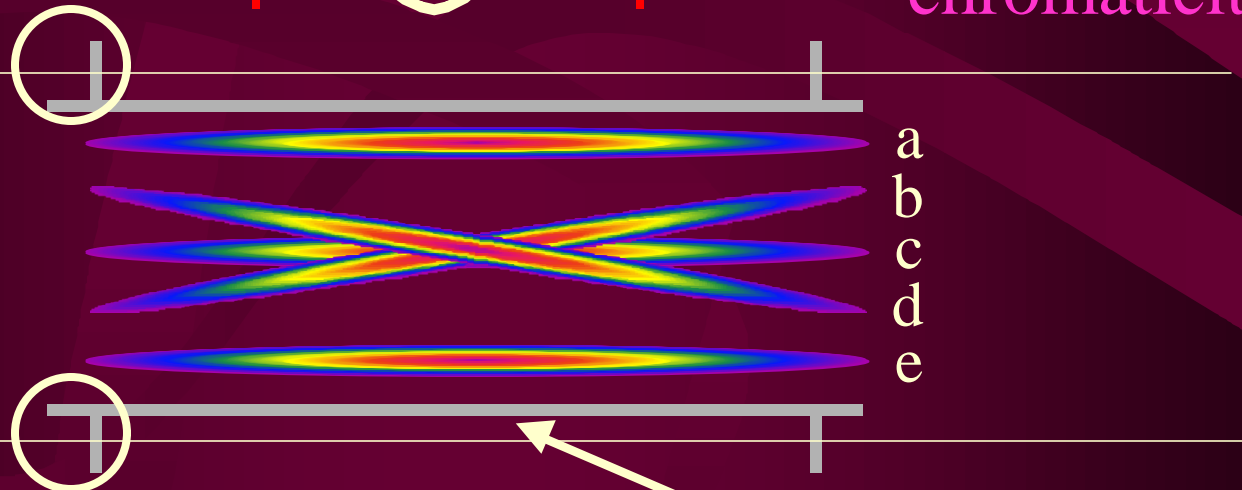
- Recap of Head-Tail principle
- Results in 2000
  - Chromaticity measurement
  - Other uses of the monitor
- Summary and Outlook



# The Head-Tail Principle



Kick the Beam  
&  
Watch it Oscillate





# The SPS Head-Tail Monitor

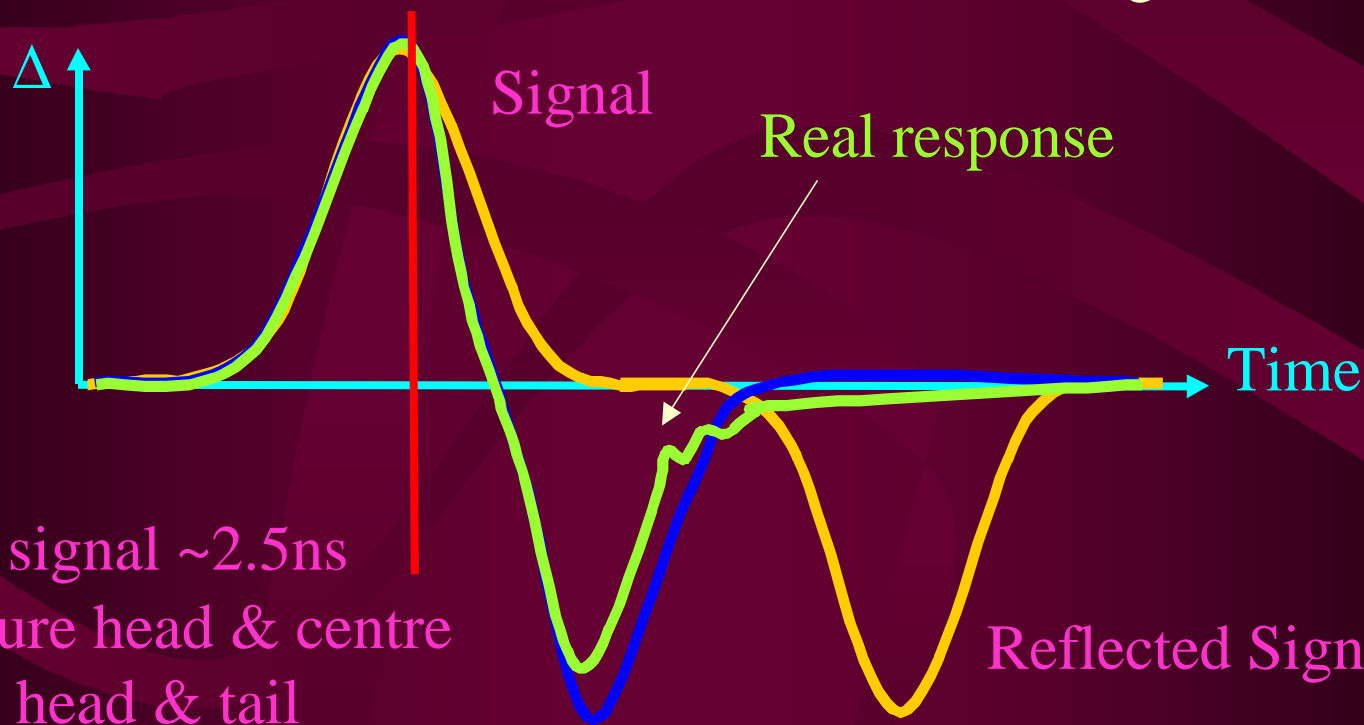
## Pick-up

### BPCR214.36

→ straight stripline coupler - 37cm long

→ completely resolves a bunch < 2.5ns in length

**NOT** the case in the SPS where bunch length is ~4ns



Useable signal ~2.5ns

⇒ measure head & centre

NOT head & tail



# MD Set-up for Q' Measurements

- **Most measurements performed during SPS “25ns Run”**
  - LHC batch of 84 bunches with 25ns bunch spacing
  - Acceleration from 26GeV to 450GeV
  - Intensity of  $\sim 2 \cdot 10^{10}$  protons per bunch
  - Q' measured mainly in the vertical plane (Ver. Damper OFF)
- **Additional measurements on SPS P2 cycle**
  - TSTLHC beam - 84 bunches with 25ns spacing at 26GeV
  - Intensity varied from  $1 \times 10^{10}$  to  $5 \times 10^{10}$  protons per bunch



# Measuring $Q'$ (1/3)

Head-Tail Chromaticity Measurement Interface - 23-05-2000\_133806\_5000ms\_265GeV-R3.0.ht

File Settings Drawing Options Help

**Acquisition:** **VERTICAL**

Acquisition Time: 5000 ms

Bunch Selector: 17400

Bunch Adjust: 61

Acq. Window: 25

Number of Turns: 372

**Make Acq**

Gains:  $\Sigma$  200mV/div  $\Delta$  20mV/div

Head-Tail Analysis:

Chromaticity = 1.8 (0.0659)

Signal Tail: 1.0

Kick Offset (turns): 38

Head-Tail Sep. (ns): 230

Sync. Period (turns): 230

Tune: 0.5838 Energy: 265.02 GeV

Graph Control:

Corrected Sum on 2D/3D

3D Display Offset (ns): 0

3D Display Time (ns): 25

Sep: 23.049 us

Dataviewer Turn

Ready ...

CERN/SL XDataviewer 6.4 ZOOMIN:Pick first point Kick Clean Reverse

Views Subview External Editor Load/Save Select

Plot Grid OFF Zeroline OFF OP ONE Zoom In Box

Head Tail Data 30/11/00 15:53:16

Head Data -19.0 390.0

Tail Data -19.0 390.0

Phase Data -19.0 390.0

Chromaticity = 1.8 (0.0659) [sigma=0.164 (0.00618)]

$Q_s^{-1} = 230$  turns

2D View 3D View **Dataviewer** Mountainviewer



# Measuring $Q'$ (2/3)

Head-Tail Chromaticity Measurement Interface - 23-05-2000\_121709\_1000ms\_36GeV-R-2.7.ht

File Settings Drawing Options Help

Acquisition: **VERTICAL**

Acquisition Time: 1000 ms

Bunch Selector: 17400

Bunch Adjust: 40

Acq. Window: 25

Number of Turns: 372

Make Acq

Gains:  $\Sigma$  200mV/div  $\Delta$  20mV/div

Head-Tail Analysis:

Chromaticity = 1.7 (0.0622)

Signal Tail: 1.0

Kick Offset (turns): 39

Synch. Period (turns): 97

Tune: 0.5822 Energy: 36.712 GeV

Graph Control:

Corrected Sum on 2D/3D

3D Display Offset (ns): 0

3D Display Time (ns): 25

Sep: 23.065 us

CERN/SL XDataviewer 6.4 ZOOMIN:Pick first point Kick Clean Reverse

Views Subview External Editor Load/Save Select

Plot Grid OFF Zeroline OFF OP ONE Zoom In Box

Head Tail Data 30/11/00 15:59:57

Head Data -19.0 Turn 390.0

Tail Data -19.0 Turn 390.0

Phase Data -17.99755 Turn 390.0

Chromaticity = 1.7 (0.0622) [sigma=0.103 (0.00386)]

$Q_s^{-1} = 97$  turns

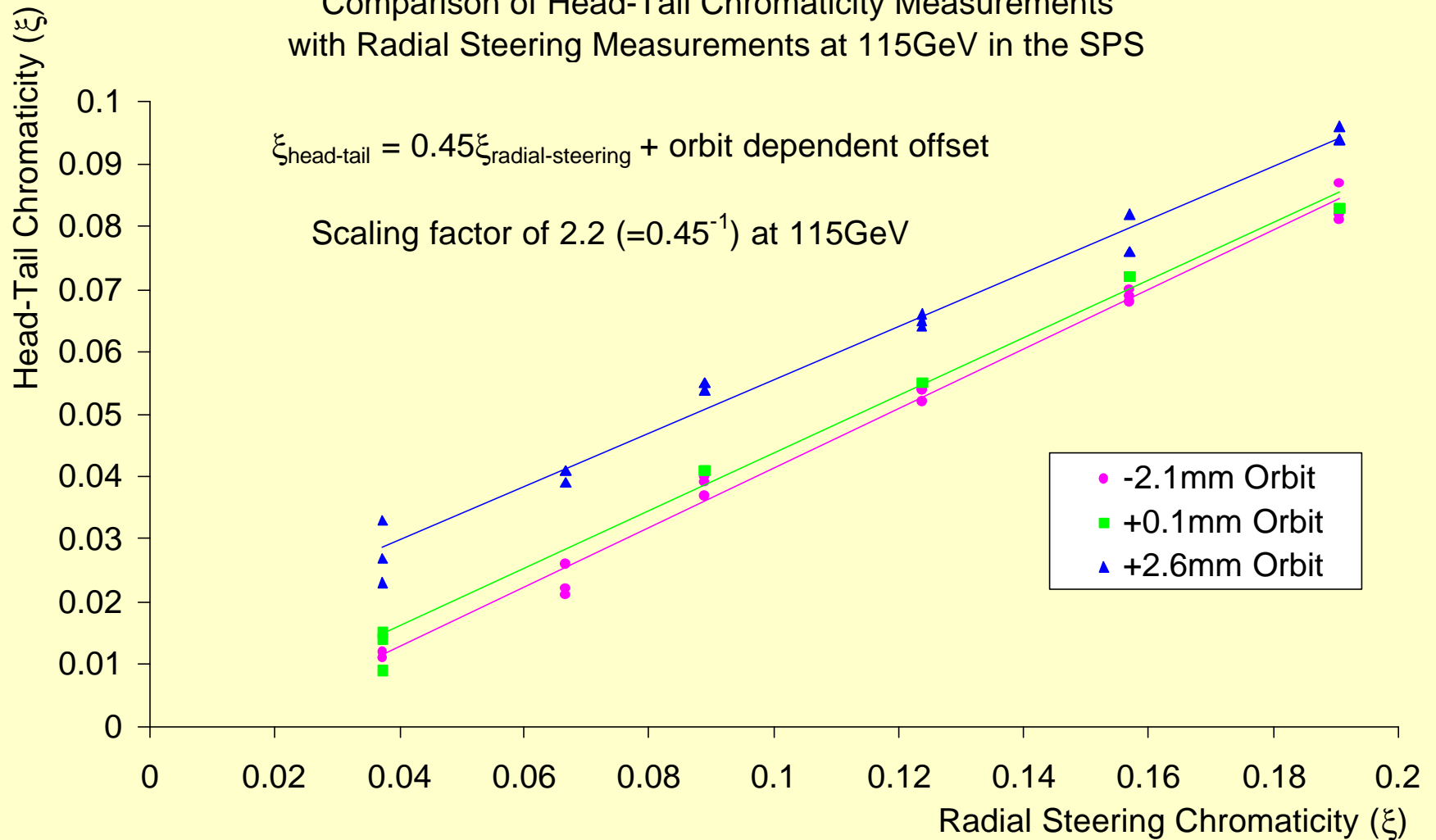
2D View 3D View Dataviewer Mountainviewer

Ready ...



# Measuring Q' (3/3)

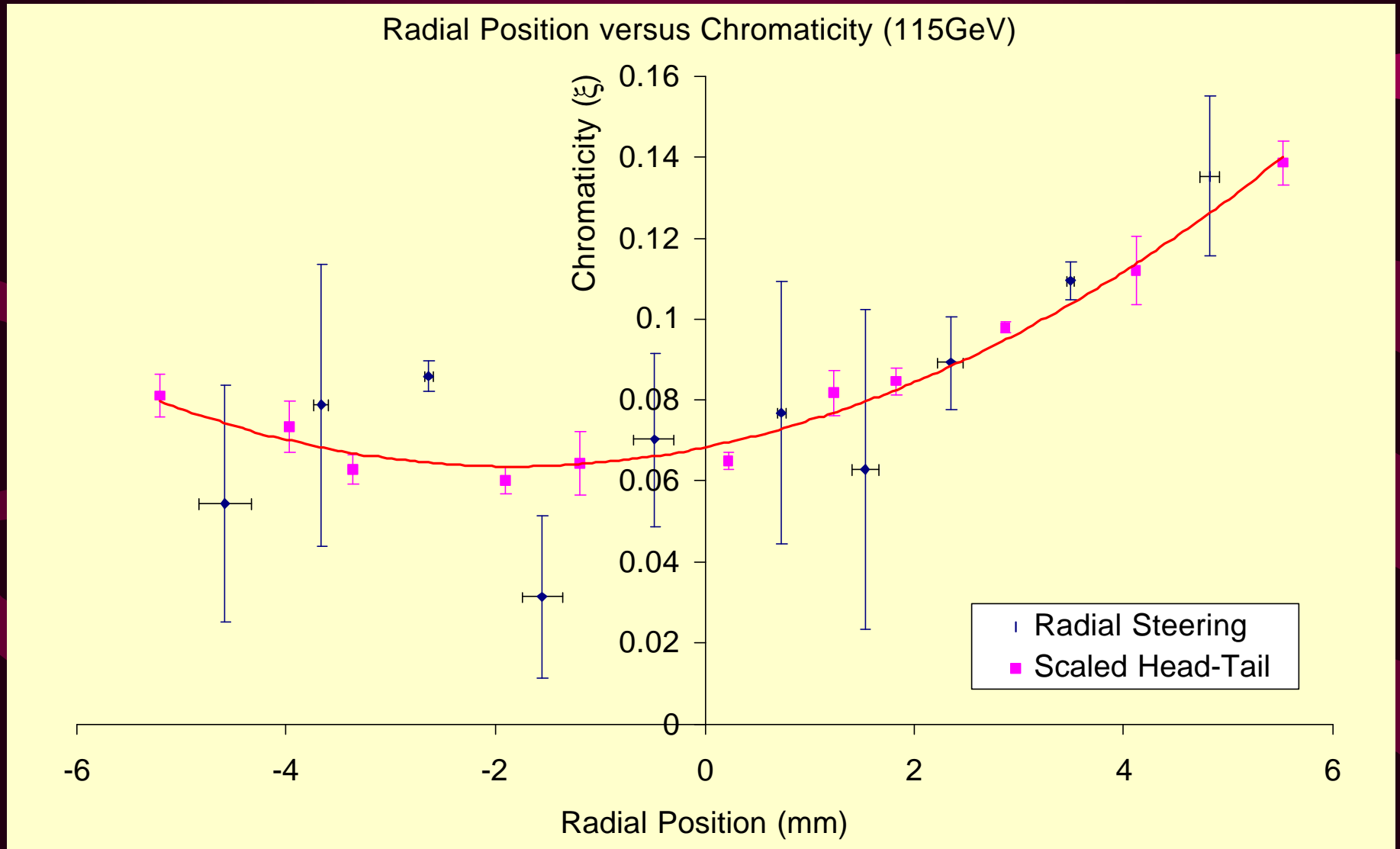
Comparison of Head-Tail Chromaticity Measurements  
with Radial Steering Measurements at 115GeV in the SPS







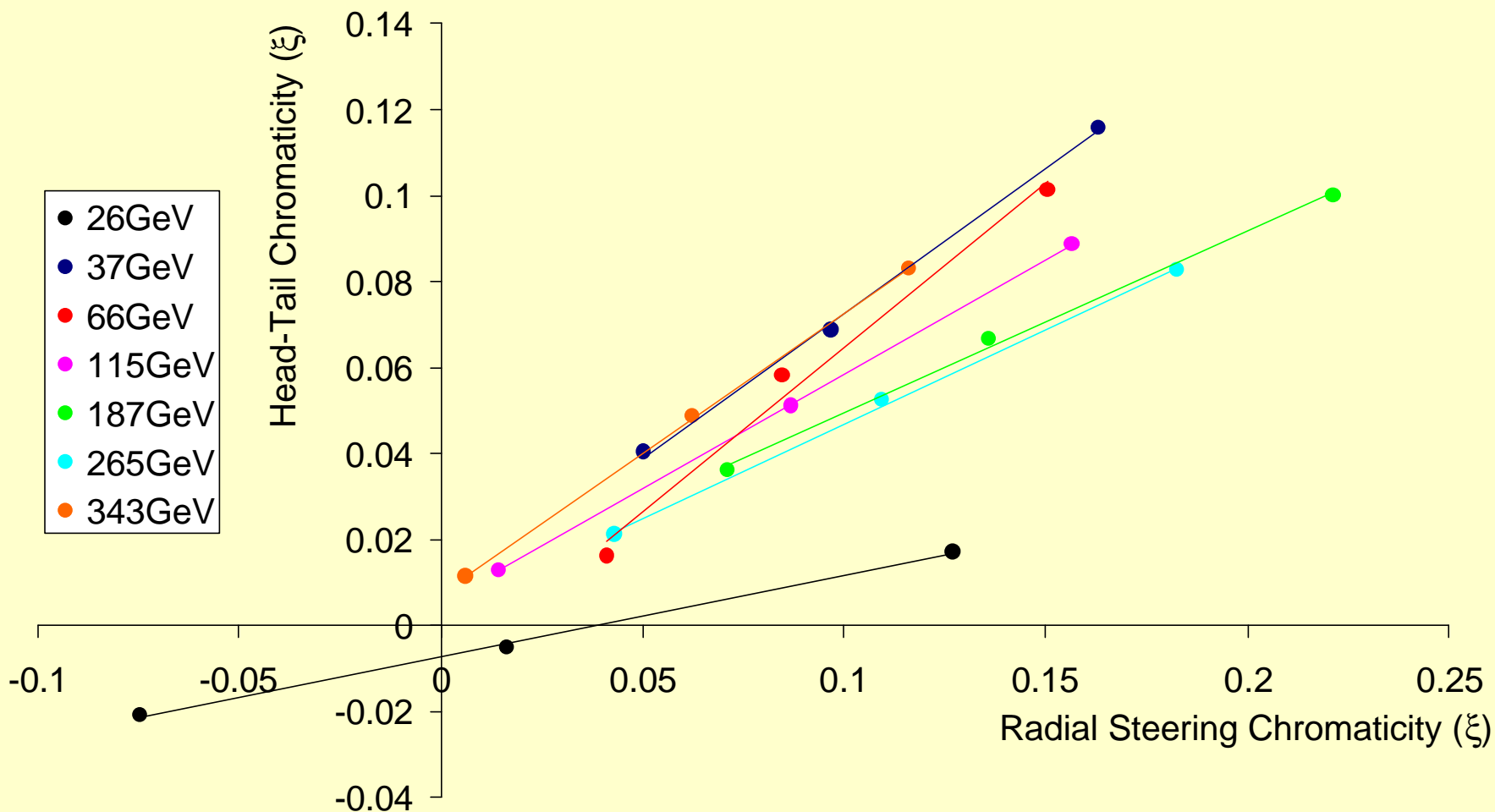
# Measuring Q''





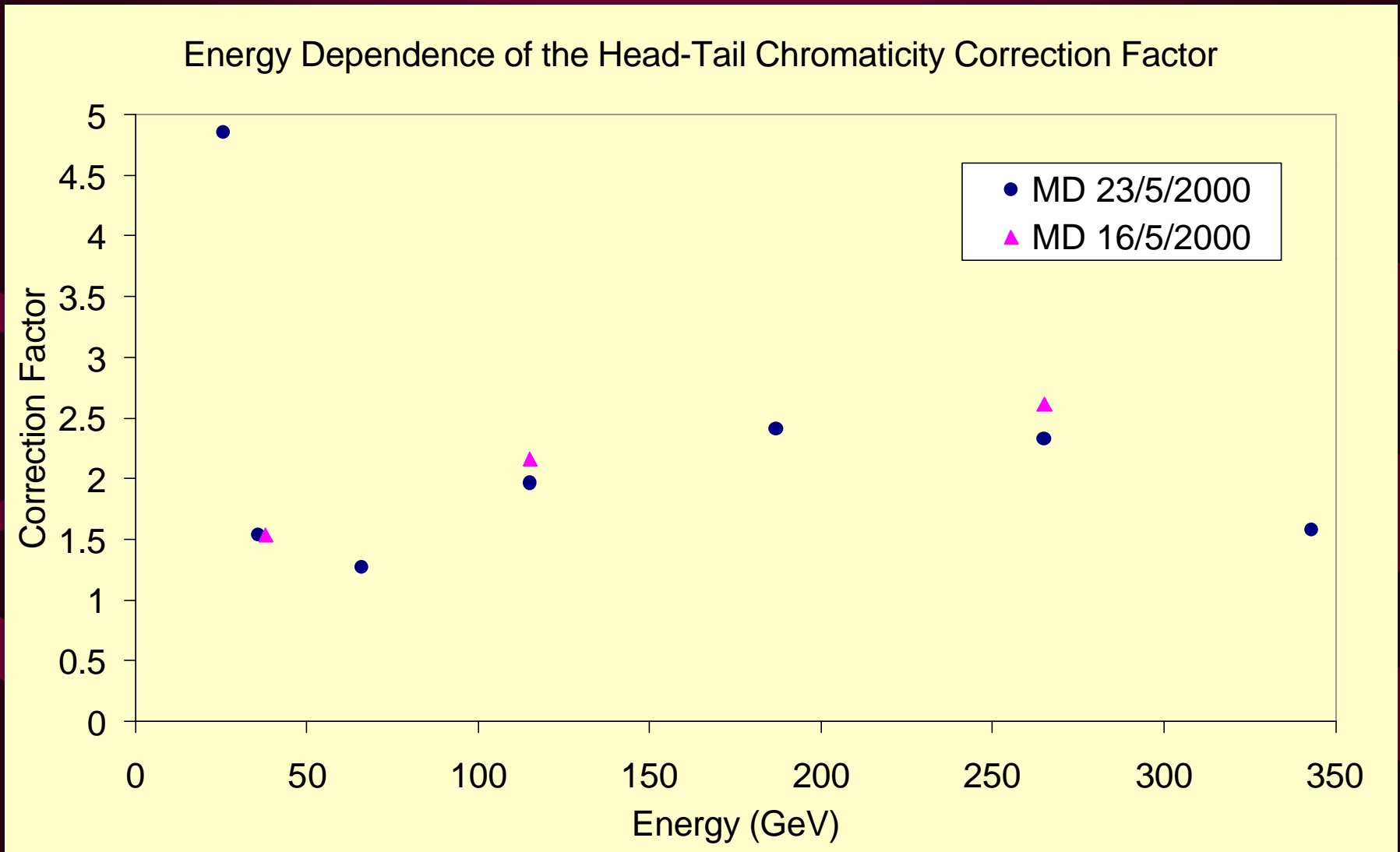
# Q' Measurement along the Ramp (1/2)

Comparison of Head-Tail Chromaticity Measurements with Radial Steering Measurements along the SPS Ramp



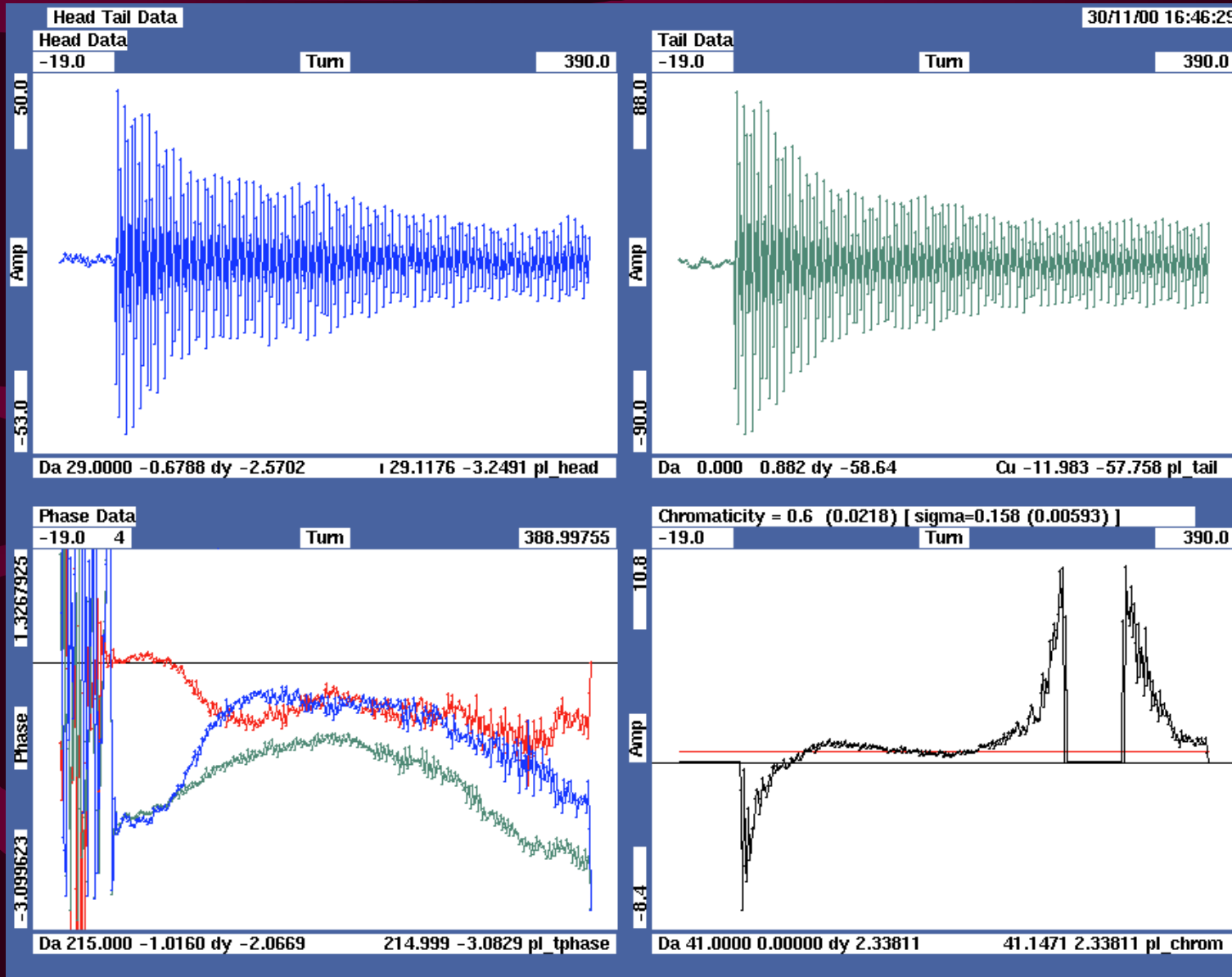


# Q' Measurement Along the Ramp (2/2)





# Impedance Influence at 26GeV?





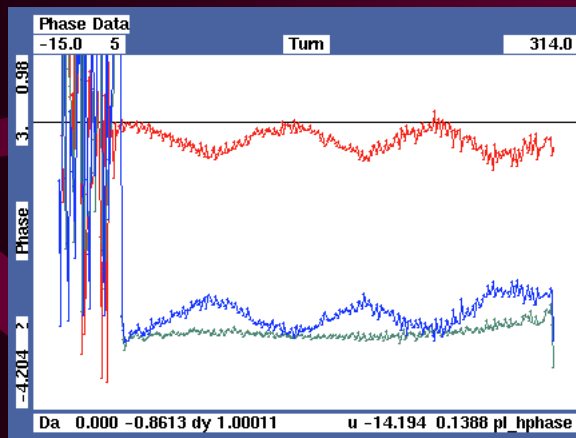
# Multi-Chrom Measurements

- Several Q' Measurements on **SAME** SPS elementary cycle
  - repetition rate limited to **0.5Hz** by GPIB data transfer
  - demonstrated on LHC cycle using 3 Q-kickers

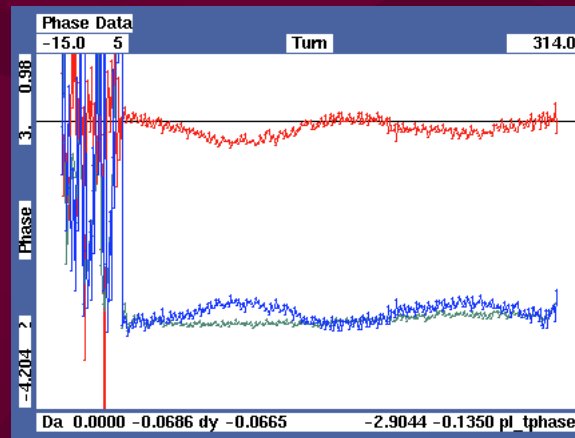
1000ms : 36GeV

3000ms : 115GeV

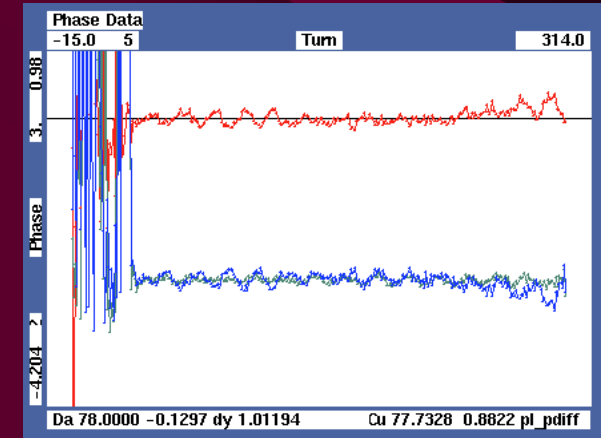
5000ms : 265GeV



$\xi=0.036$



$\xi=0.037$

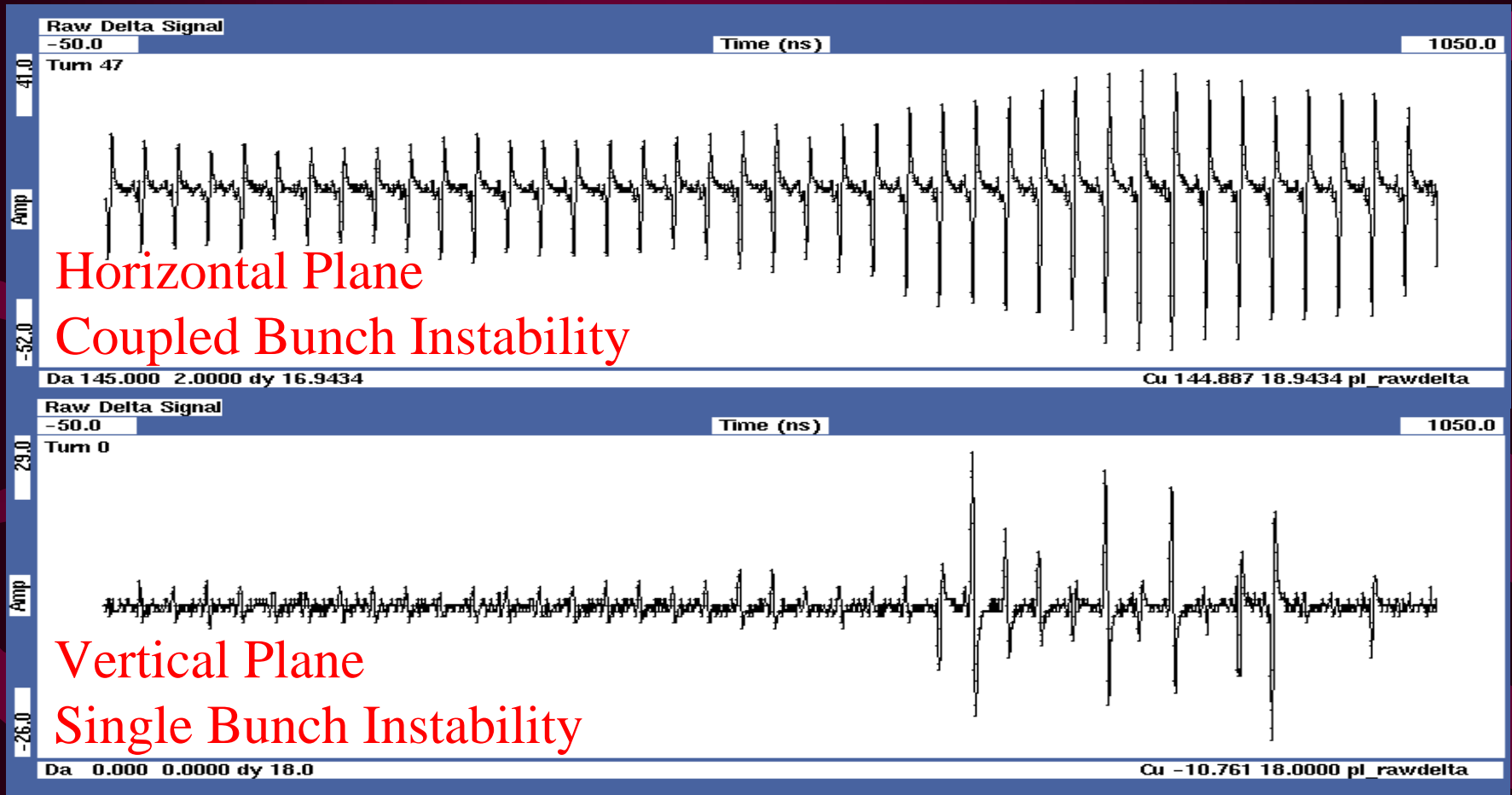


$\xi=0.005$



# Other uses of the H-T Monitor

- Investigating Transverse Instabilities (K. Cornelis)



- Impedance Issues - data still to be analysed (F. Zimmermann)



# Summary

## Results for 2000

- **‘Operational’ Head-Tail  $Q'$ -Meas. system demonstrated**
  - only available for single bunch or LHC type beams
  - correction factors have to be understood & implemented
  - more studies required on impedance/intensity effects
- **$Q''$  measurement possible**
  - orbit position observed to affect  $Q'$
- **Multi-Chrom demonstrated at 0.5Hz**
- **Useful instrument for other applications**
  - transverse instabilities
  - possible use for impedance measurements



# Outlook

## What will be available in 2001

- **New 60cm long stripline coupler to be installed in LSS4**
  - should separate signal & reflection for 4ns long bunches
  - will allow head & tail to be measured
  - shorter cables  $\Rightarrow$  less attenuation at high frequency
- **Acquisition system will remain the same**
  - number of turns limited to:
    - 372 for a single bunch
    - 24 for a complete batch
  - still limited to 0.5Hz for Multi-Chrom
  - no possibility of simultaneous Hor & Ver measurements





# Acknowledgements

- General thank-you to: SL/OP  
SL/BI EM,TD & SW
- Special mention for Antoine Ferrari, the “OP Link-man” for this instrument, for all his patience in performing hundreds of Chromaticity Measurements during these MDs!