Experience with the ZEUS Central Tracking Detector

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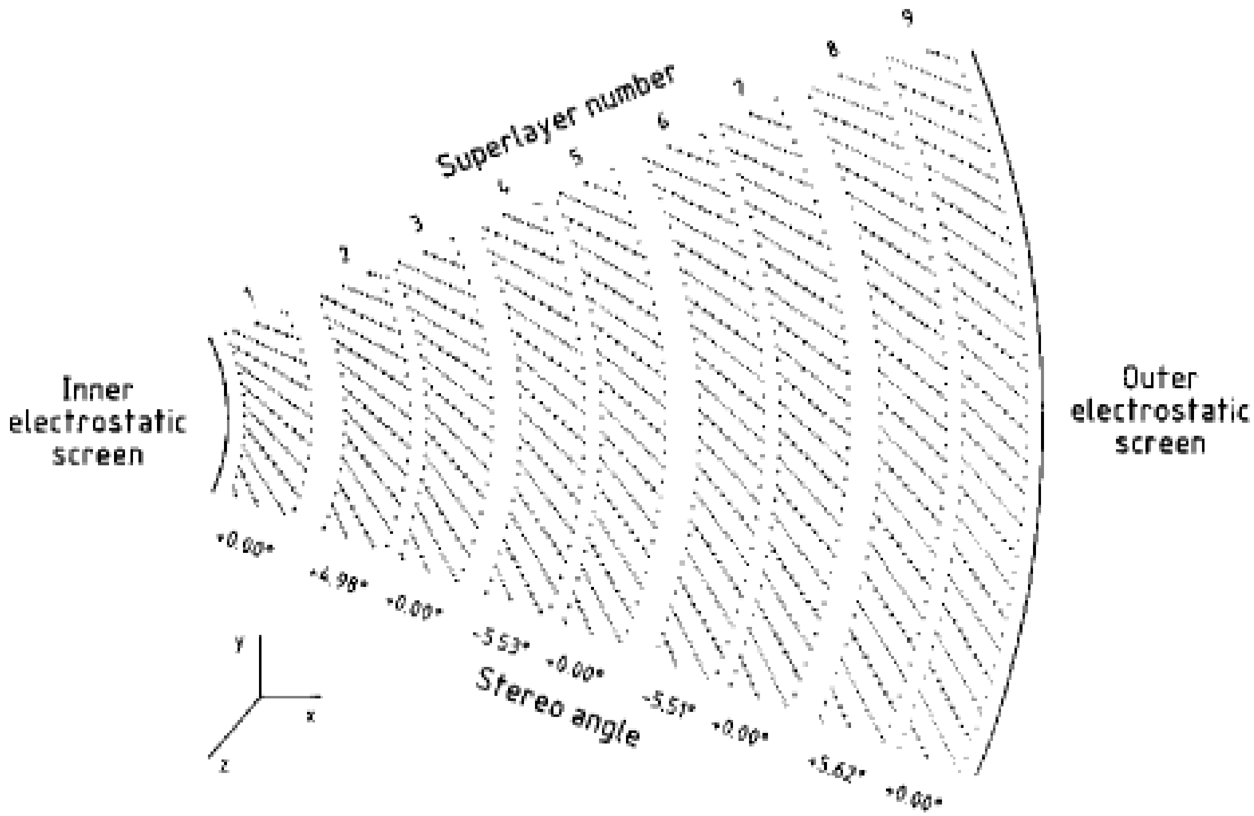
Introduction

- Brief overview of the ZEUS Central Tracking Detector.
- Gain studies
  - Principal aim to determine if there is any long-term degradation.
- Problems and Solutions
  - Operating difficulties in 2000
  - Changes made to CTD parameters to restore operation.

The ZEUS CTD

- The CTD design was based on a “mini-jet-chamber” idea. The JADE jet chamber was a successful example of a large-gap drift chamber, in which anode and cathode wires were gathered together in radial planes. This was adapted for ZEUS to have smaller cells, thus reducing the maximum drift distance (and hence the maximum drift time related to a given beam-crossing). Accurate 3D position information is derived from small-angle stereo layers – correlation between r-ϕ information and z position).
- Since the CTD operates in a 1.43T magnetic field, the Lorenz force produces major deviations from radial drift even over relatively small drift distances.
  - Therefore the cells in the CTD were rotated through 45° w.r.t radial.

CTD Cell Layout



- Wires are arranged into 9 concentric superlayers. 8 sense wires in each superlayer
- Even numbered layers have small stereo angles

CTD Requirements

- Cell rotation has additional benefit that it also gives a "prompt" timing signal associated with a particular beam crossing
  - Important as the CTD was required to be a single, combined-function tracking detector
    - Triggering – beam crossing determination and fast 3D hit reconstruction using "*z*-by-timing"
    - High precision charged particle track reconstruction
    - dE/dx measurement

Construction Details

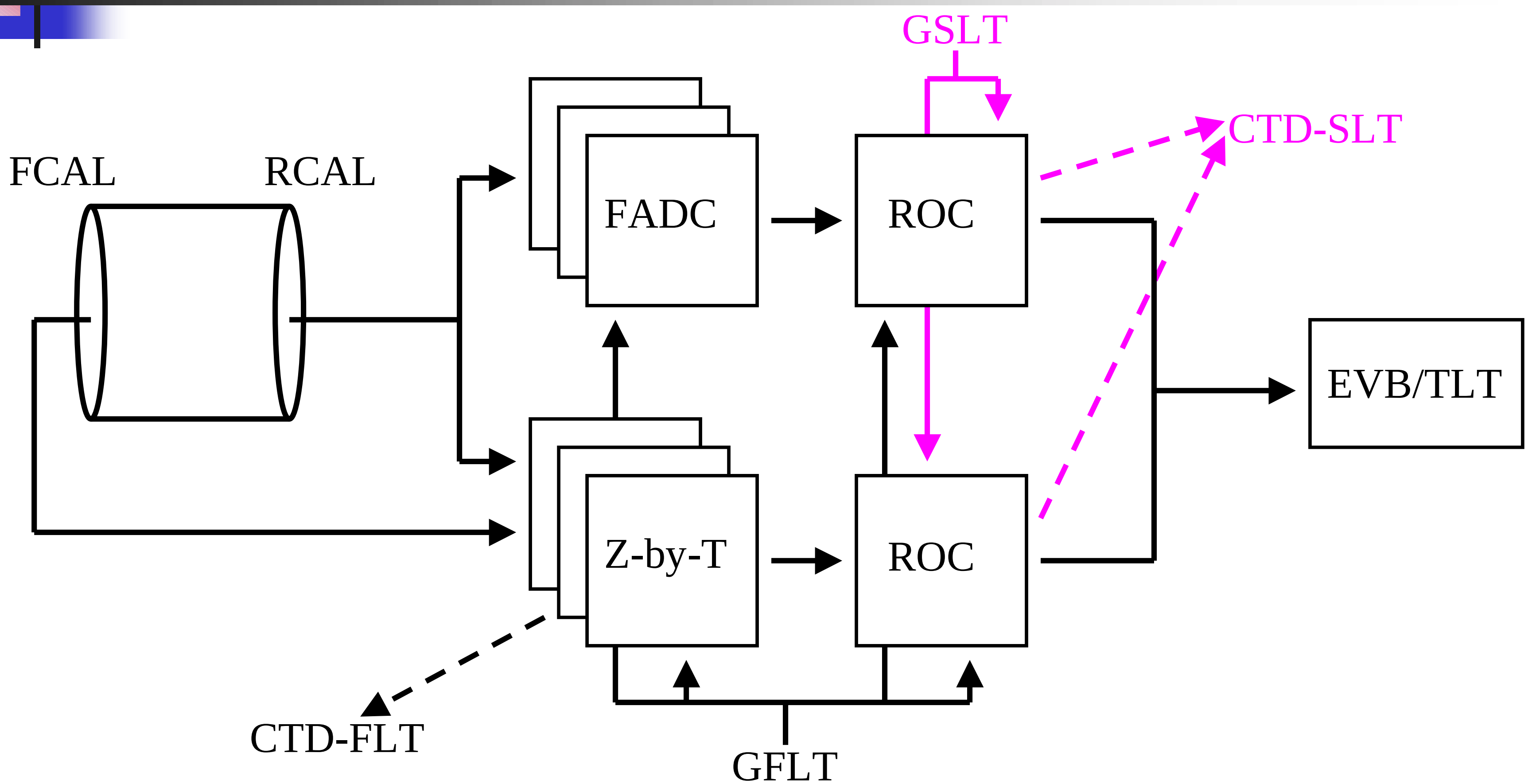
- 30μm tungsten sense wires
  - Reduced dispersion for *z* determination by the trigger
- Cu-Be wires, ranging from 70→200μm for field, shaping and ground wires
- Voltages optimised to avoid fields >30KV/cm
  - Reduced likelihood of whisker growth

Gas Choice

- Designed to use 50:50 Argon:Ethane at ambient pressure
  - In reality we have used a “safer” mixture
    - Argon:Ethane:CO_2 83:12:5
    - Trace amount (~0.5%) ethanol added to prevent whisker growth
      - Really a black art...
- Gas properties give acceptable performance
  - dE/dx resolution ~10%

$$\sigma_{p_T} / p_T = 0.0058\, p_T \otimes 0.0065 \otimes 0.0014 / p_T$$

CTD Electronics

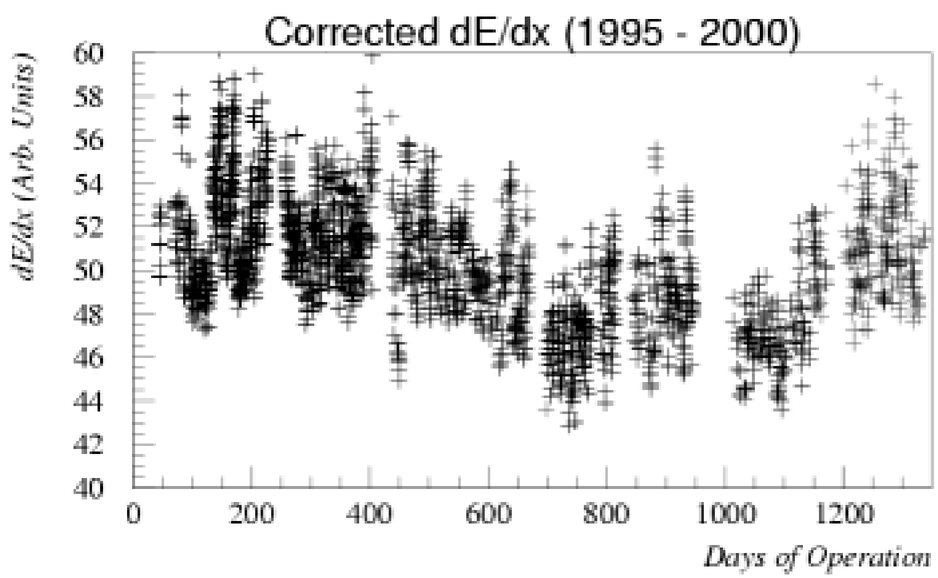


- Pulse height information provided by FADC electronics

Long-term Aging Study

- Idea to use pulse height information over a period of time to check if there was any sign of overall reduction in pulse heights under comparable operating conditions
  - Problem due to variations with external conditions such as atmospheric pressure and track sample
  - Decided to use dE/dx measurement as that would select a reasonable data sample which could be corrected for environmental factors.

Long-term Aging Study

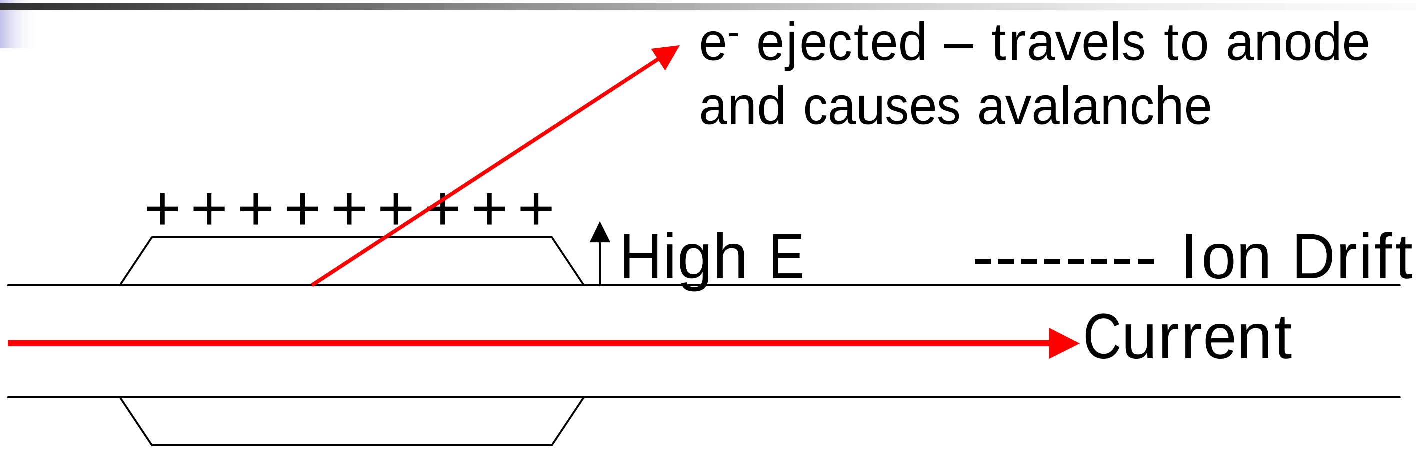


- dE/dx corrected for environmental effects
  - Atmospheric pressure
  - Drift velocity variations
- Possible (~10%) effect seen, but spread is too large to be conclusive

Problems encountered in 2000

- CTD high voltage began to trip off continuously in the outer superlayers
  - Only way to recover affected regions of the chamber was to disconnect HV for several days
  - Trips were not related to beam conditions
  - Extensive studies could find no correlations with environmental conditions
  - Anecdotal evidence suggested that there was a correlation between trips and the integrated luminosity that the detector had been exposed to
  - Outer superlayers also have highest electric fields

Suspected Cause

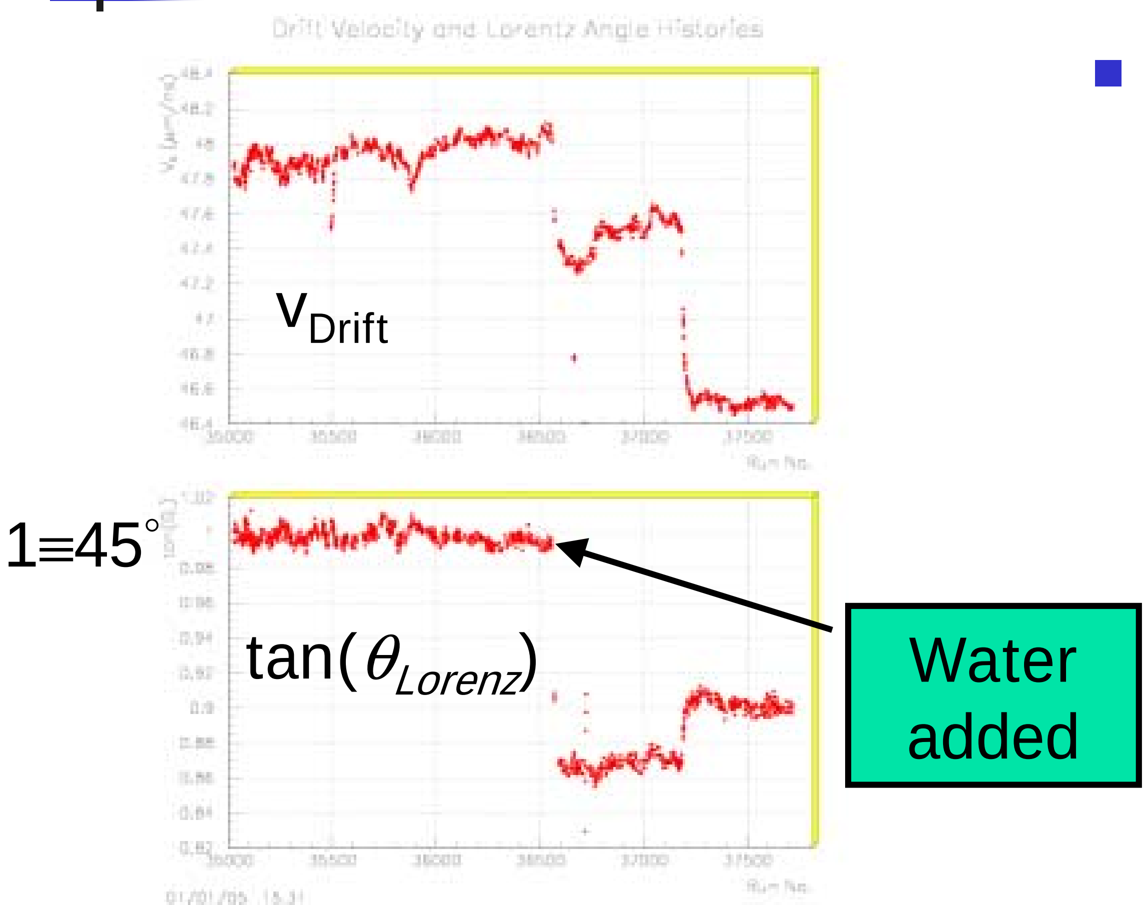


- Suspected “Malter Effect”
  - Insulating deposits on cathode wires
  - Symptoms
    - Exponential growth of standing currents irrespective of beam conditions
    - Charge leaks away over time when no HV is applied → recovery over ~ days/hours

Solution and Effects

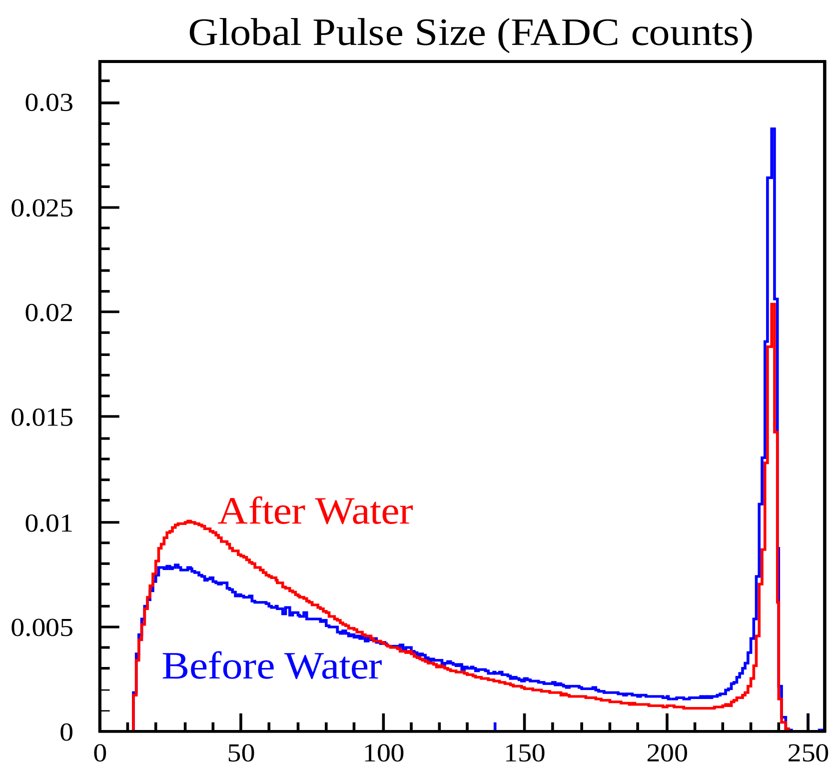
- For some reason, adding water vapour to the gas mixture seems to alleviate this effect
  - Worked for Tasso vertex detector
    - But don't ask me why... more black magic
    - Possibly the polar properties of water cause it to concentrate in the high field regions giving accumulated charges a path to leak away...

Solution and Effects



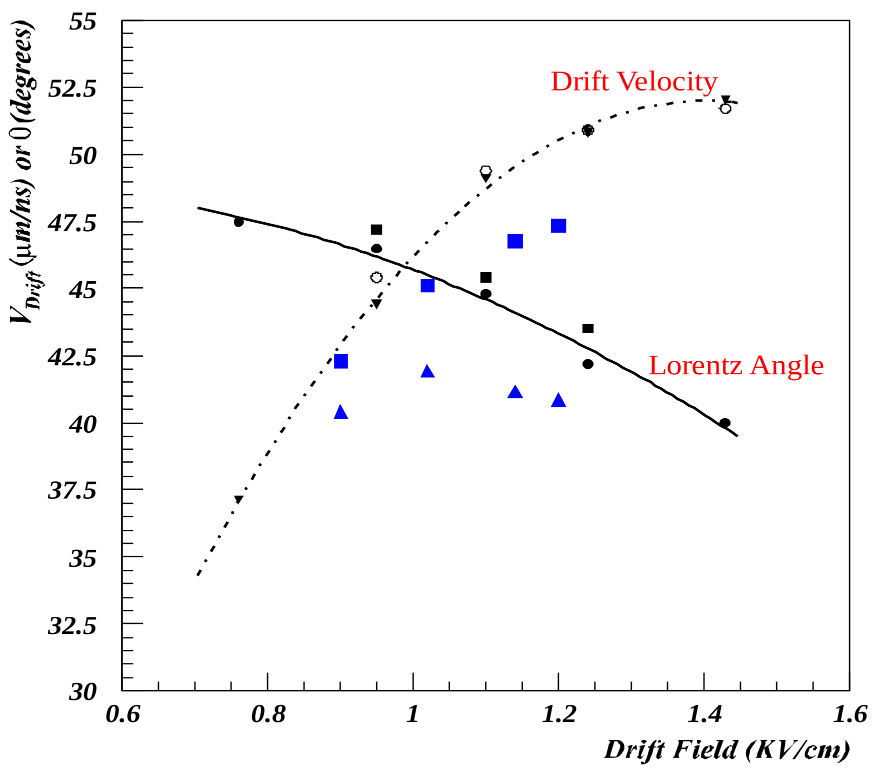
- Added water to the gas mix
  - Tripping seems cured
    - Ongoing test really
  - Operating parameters shifted and required adjustment

Effects cont.



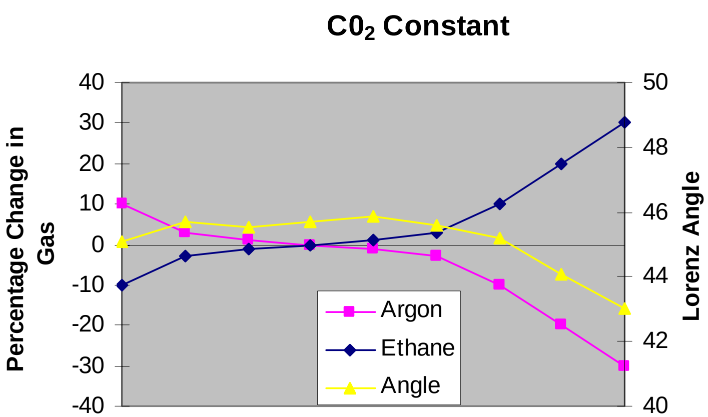
- Addition of water reduced pulse sizes
  - Addressed by increasing voltages applied
  - Question: Can Lorenz angle be returned to 45° by adjusting HV?

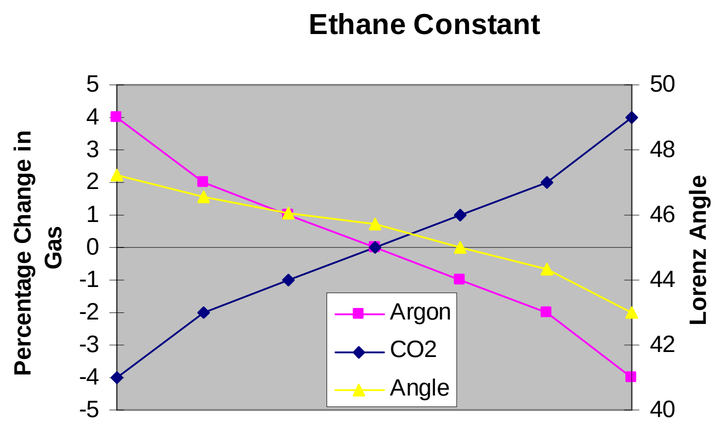
Effects cont.

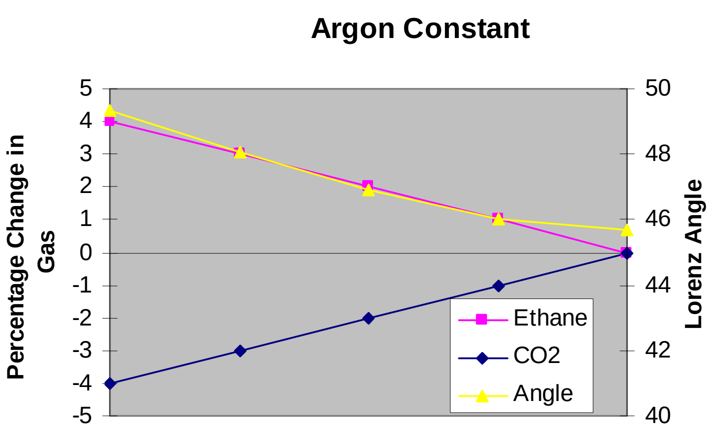


- Answer
  - No
  - Need something more drastic

Fixes – Garfield Simulations

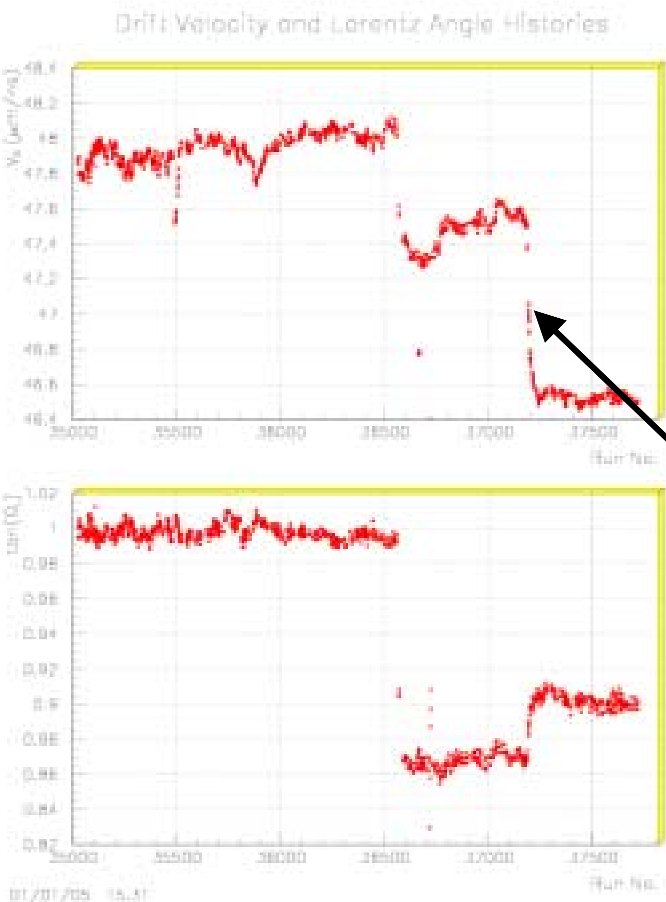






- Only possibility to return Lorenz angle to 45° was to reduce CO_2 by 2% and increase Ethane by 2%
  - Gas mix still “safe”

Results of Gas Change



Gas Changed

- Gas change had significant effect on Lorenz angle
  - Didn't return it back to 45° but operation is possible under these conditions

Summary

- CTD has performed well over the last 8 years
  - No conclusive long-term loss of gain
- HV problems encountered in 2000
  - Attributed to “Malter Effect”
  - Water added to gas mix has, to date, fixed the problem
  - Operational parameters needed adjustment after water introduced
    - HV increased to restore pulseheights
    - CO_2 reduced to restore Lorenz angle