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TOF Aging Discussion

- Background information
- Summary of results so far
- Examples of gain loss mechanisms
- Diagnostics
- Possible scenarios for 2006
- Discussion

May 24, 2006

Background Information

Time-of-Flight at CDF CDF Detector Lecture, August 19, 2004

- Overview of the TOF system and PMTs

TOF Aging Issues (1) Precursor to talk on April 6th

- Lots of detailed information

Status of the TOF Detector Presentation at CDF meeting

- Only a summary

http://www.physics.purdue.edu/~mjones/tof

- My current web page for various studies

http://higgs.hep.upenn.edu/~mjones

- Previous web page, many useful details

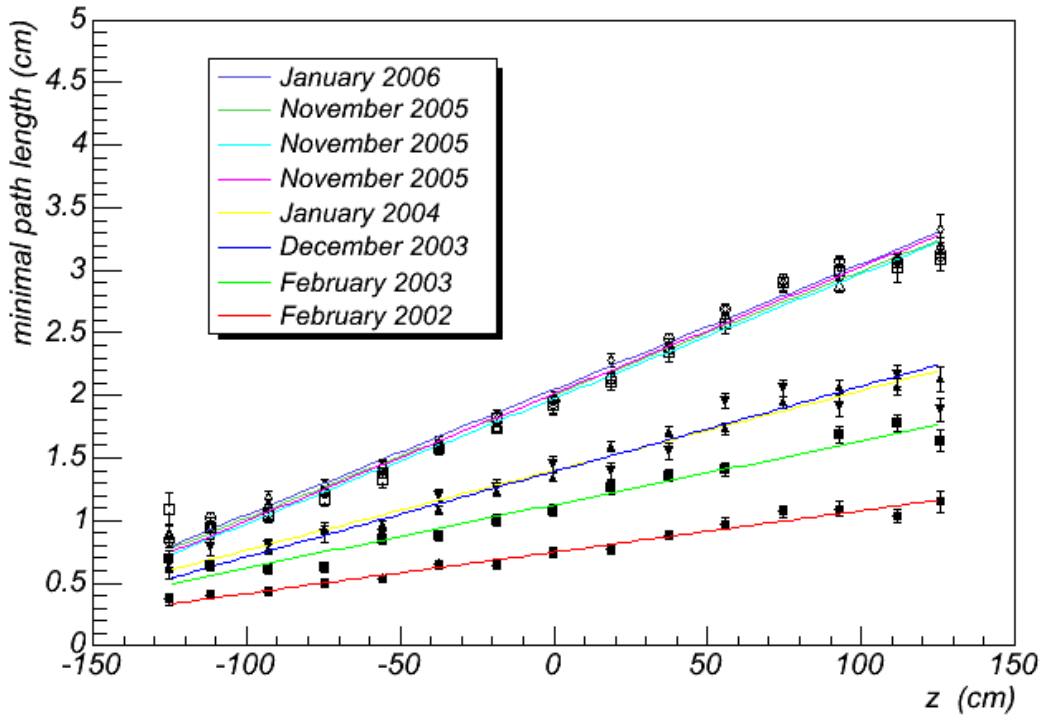
Brief Summary

- Gradual loss of response since system was first installed
- Now affecting performance
- Appears to be loss of response (“gain”) in a significant fraction of PMT’s
- Still some unanswered questions:
  - Did we recently cross a threshold where things stop working?
  - Did aging accelerate with higher luminosity in 2005?
- Need to decide how to operate system in 2006.

Brief Summary

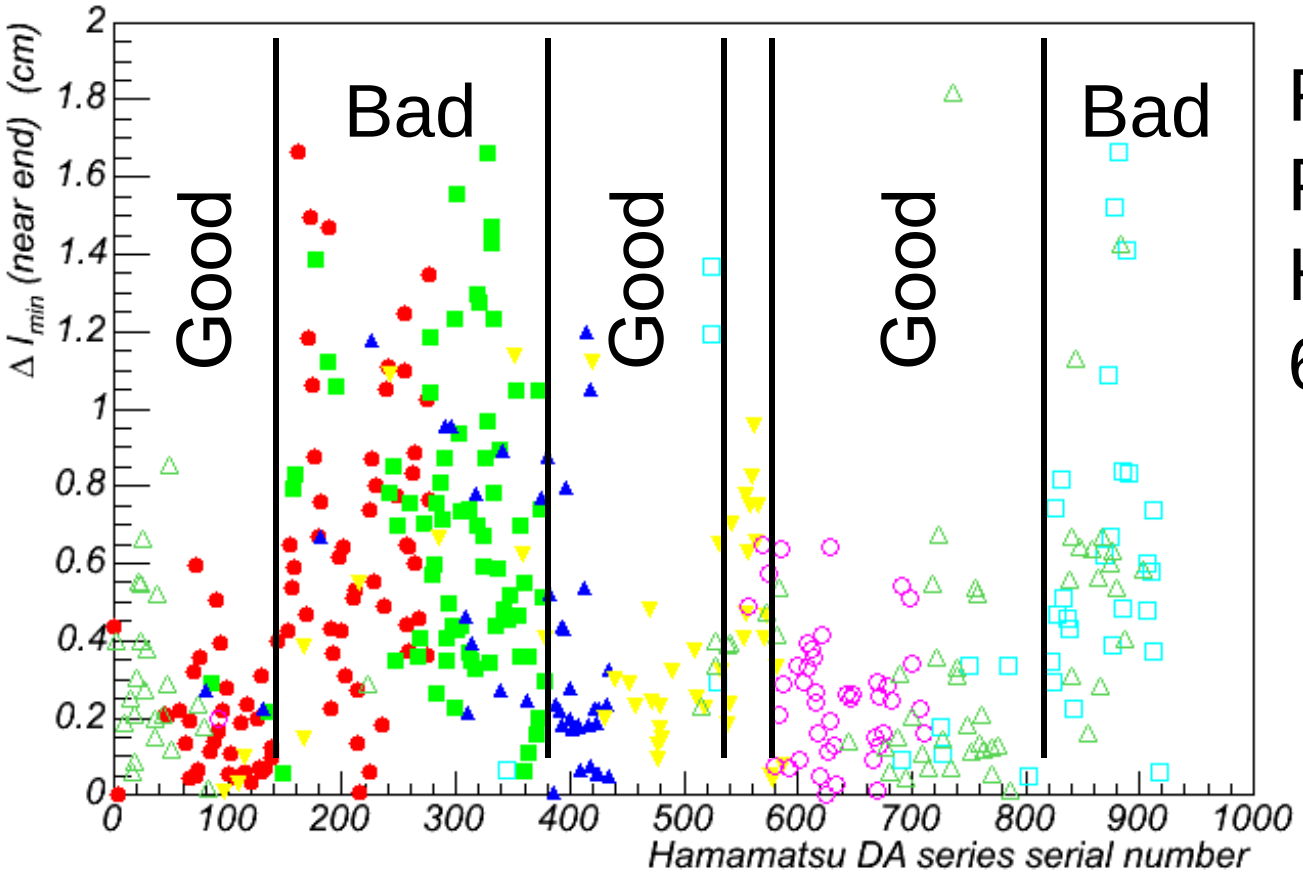
- A useful way to quantify PMT response:
  - Minimal path length through scintillator traversed by a MIP at a given z needed to fire fixed threshold discriminator.

$l_{\min}$



Gain loss *vs* PMT serial number

- Assumes that serial numbers correlate to manufacturing date (probably reasonable).



Received PMT's from Hamamatsu in 6 batches.

Other Information

- Past experience from Belle:
  - Different PMT's, but may have suffered from something similar
  - Magnetic field important?
- Studies at Tsukuba:
  - Different light/gain, same anode current
  - Changes related to cathode/early dynode stages?

PMT Damage Mechanisms

- Correlation with serial numbers → mechanism related to construction
- Dynode heating
  - Large currents could heat dynodes and evaporate secondary emissive coating?
- Cathode heating
  - Evaporate bi-alkali coating
  - Secondary effect of dynode heating?
- These are working examples, not necessarily anything more than guesses.

Available Information

1. Test results during PMT assembly
   - Includes scope traces
2. Monitor analog pulses from PMT's in situ
   - Could be used to study after pulsing
3. Offline analysis
   - Dependence on luminosity?
4. PMT's removed from detector
   - Cathode uniformity
   - Gain from separate dynodes
   - Destructive tests (presumably done by Hamamatsu)
5. Others?

One Possible Scenario

(Mainly to promote discussion)

- Suppose gain loss is due to later dynode stages (heating due to larger currents)
- Expect gain loss to eventually stabilize?
- Increase HV to keep response acceptable
  - Affected PMT's currently operated at lower voltages
- No changes to earlier dynode stages
  - Timing resolution, single p.e. response unchanged

Another Scenario

(To promote more discussion)

- Anode heating evaporates secondary emissive coating on later dynodes
- Coating material migrates in PMT and poisons cathode
- Increasing HV would evaporate more and result in further gain loss
- Might observe increase in after pulsing throughout a store?

Plans for Early Operations

- Measure response as a function of HV for all channels
  - restore initial response if we choose to do so
  - equalize gains at some other point
- Study performance of calibration for different operating parameters
  - discriminator threshold
  - ADC gate width

Summary

- We can get very quantitative answers to a limited number of questions
- Other things we should probably just do:
  - Finer time sampling of response
  - Contact Belle/Hamamatsu for further insight
- Need to decide on operating plan for 2006
  - Just turn up the HV?
  - Turn off HV when luminosity too high?