



# **Cross-correlation of laser and synchrotron light for longitudinal bunch measurements**

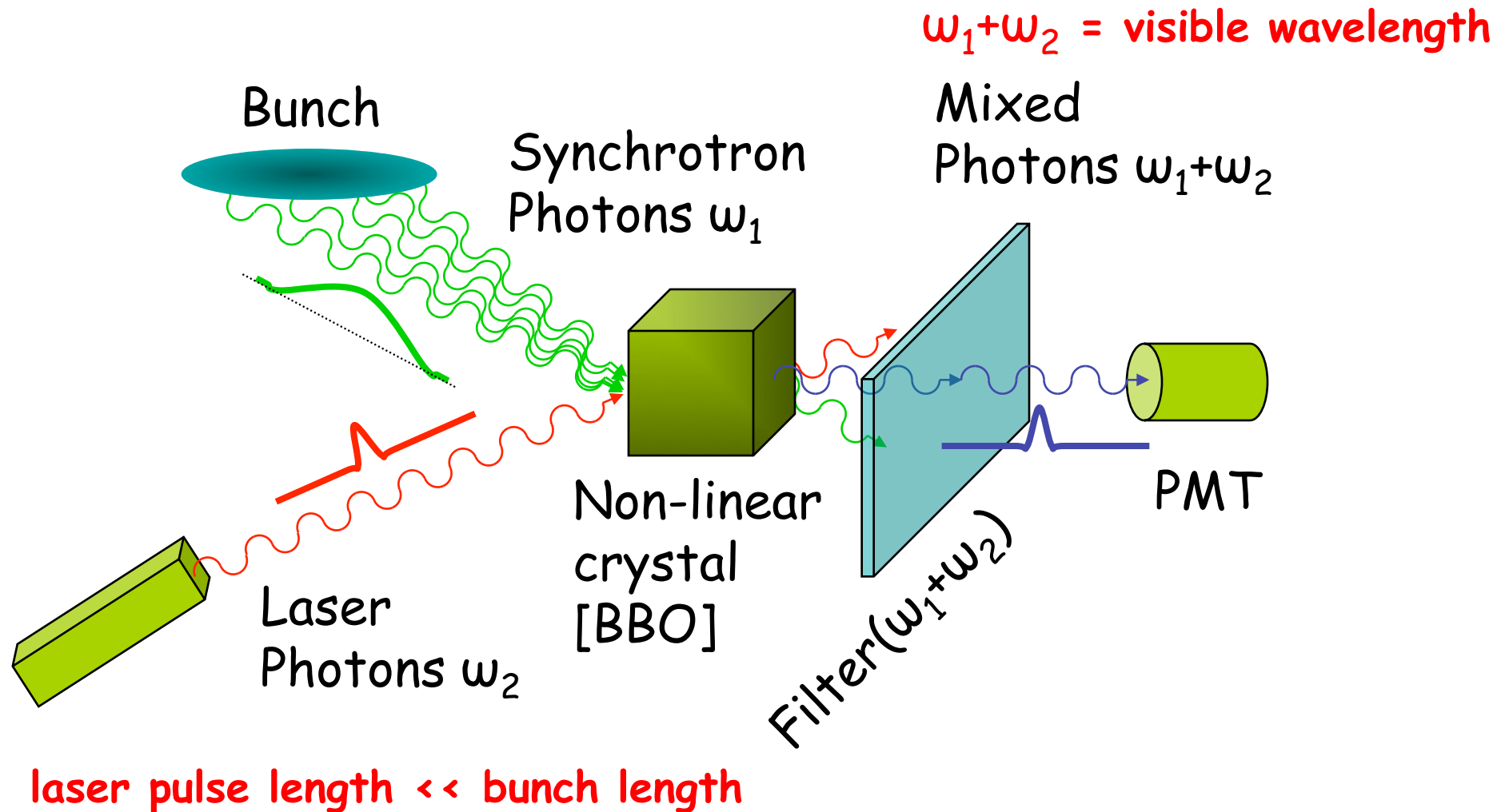
John Byrd

# All-in-One Tool

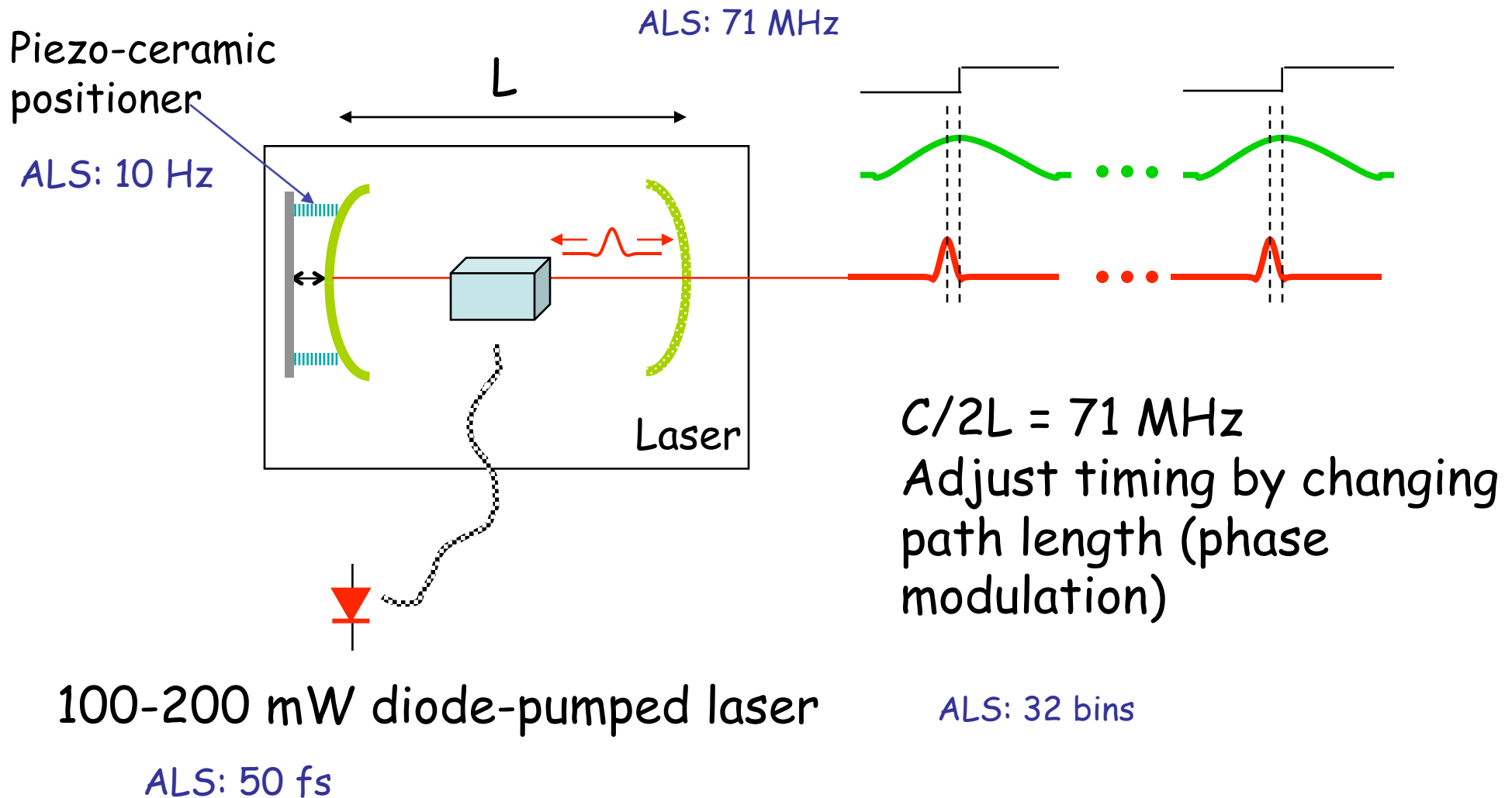


- Online measurement of **bunch length** and **shape**
- **Bunch current** – including nominally unfilled RF buckets (“ghost bunches”)
- **Synchronous bunch position**
- **Fast**: the results shown were accumulated in seconds/minutes
- Very **wide dynamic range** ( $10^4$ )

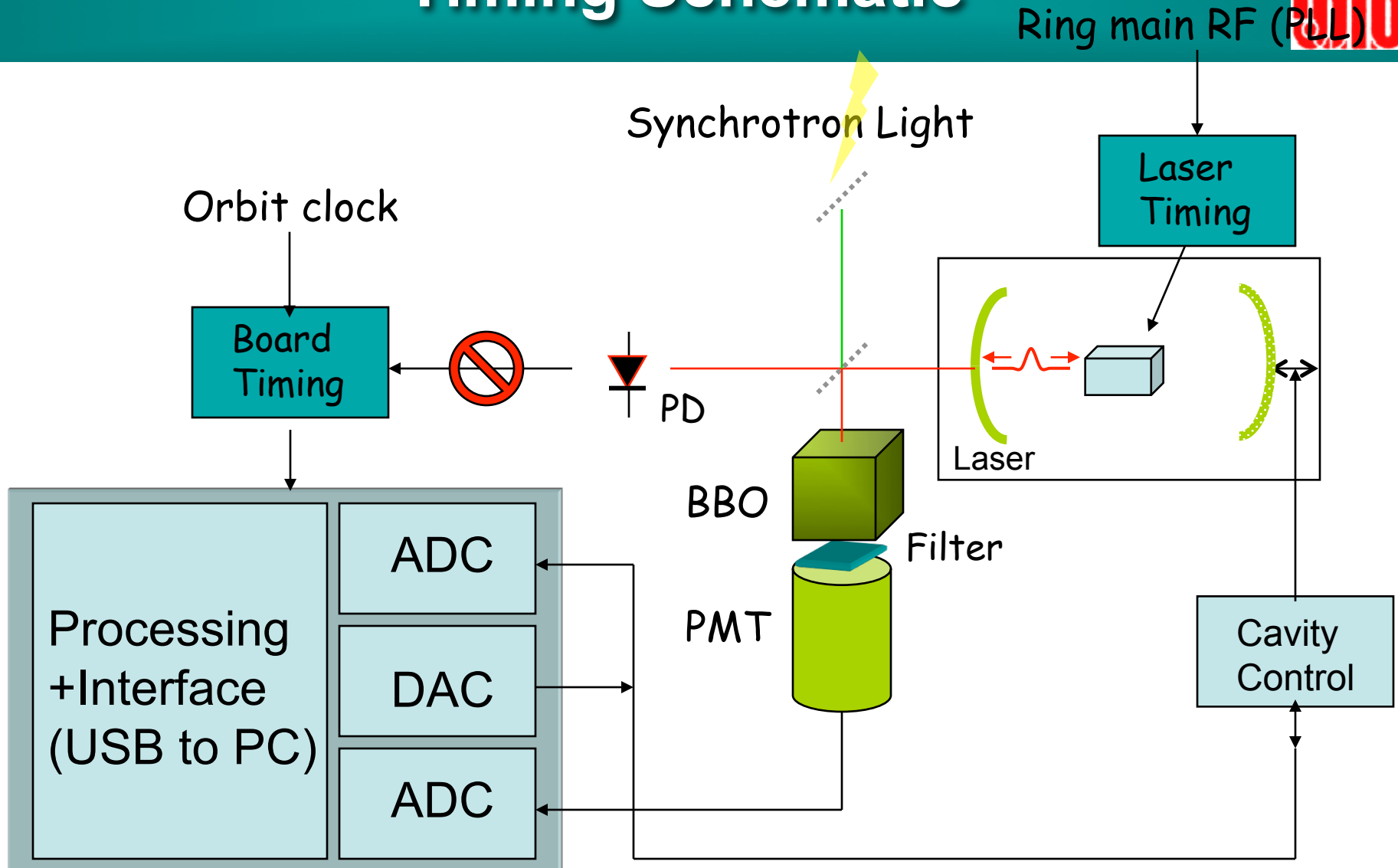
# Cross correlation of laser and synchrotron light



# Scanning the Bunch



# Timing Schematic

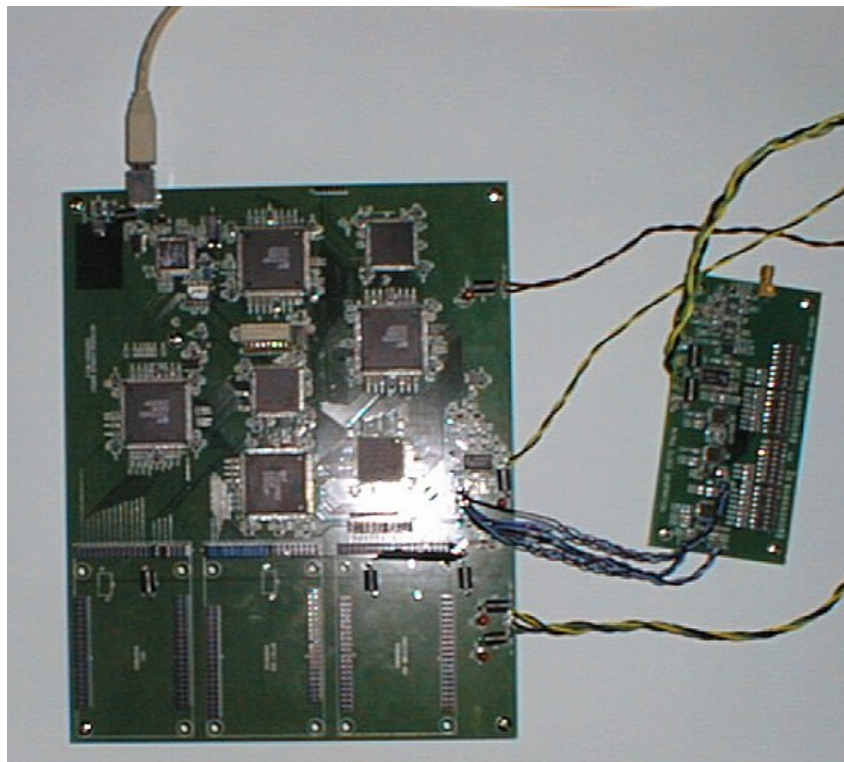


# LDM pros and cons



- Fast sampling rate (laser cavity frequency)
- High dynamic range
- High time resolution (laser pulse length)
- Not limited to optical wavelengths
- Requires multi-turn sampling
- Requires synchrotron light

# Electronics - I.



Mother Board with  
71MHz clock board

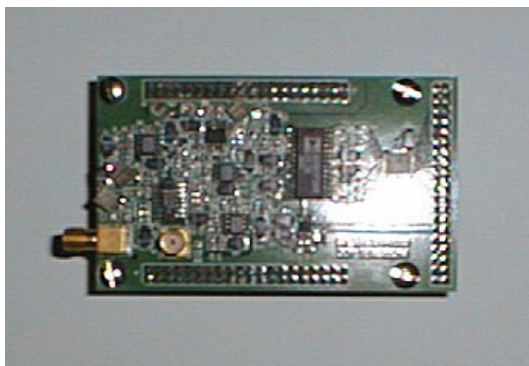
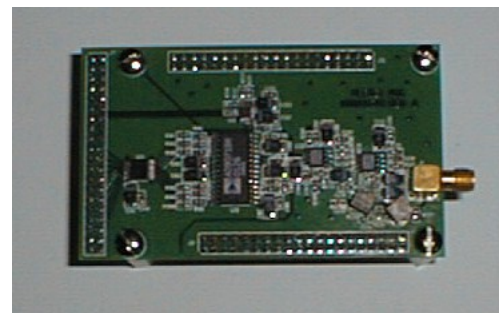
USB Control and  
histogram/average  
is fully operational

# Electronics - II.



← DAC Analog board for  
laser phase offset  
modulation

Actual Laser phase  
offset digitization board →



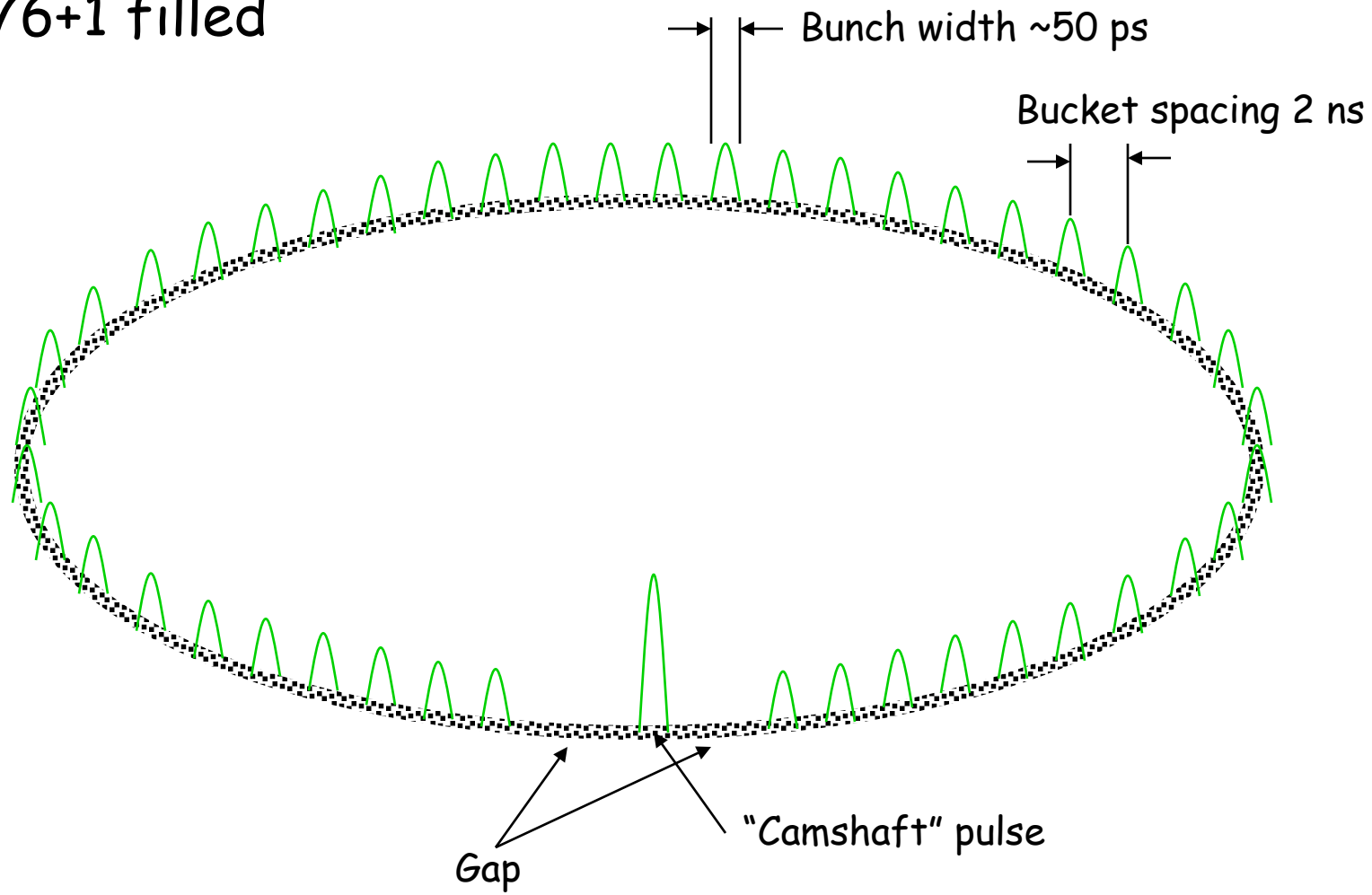
← Track and Hold board with self  
trigger for PMT pulse detection  
(only one bit is used in **single photon  
counting mode**)



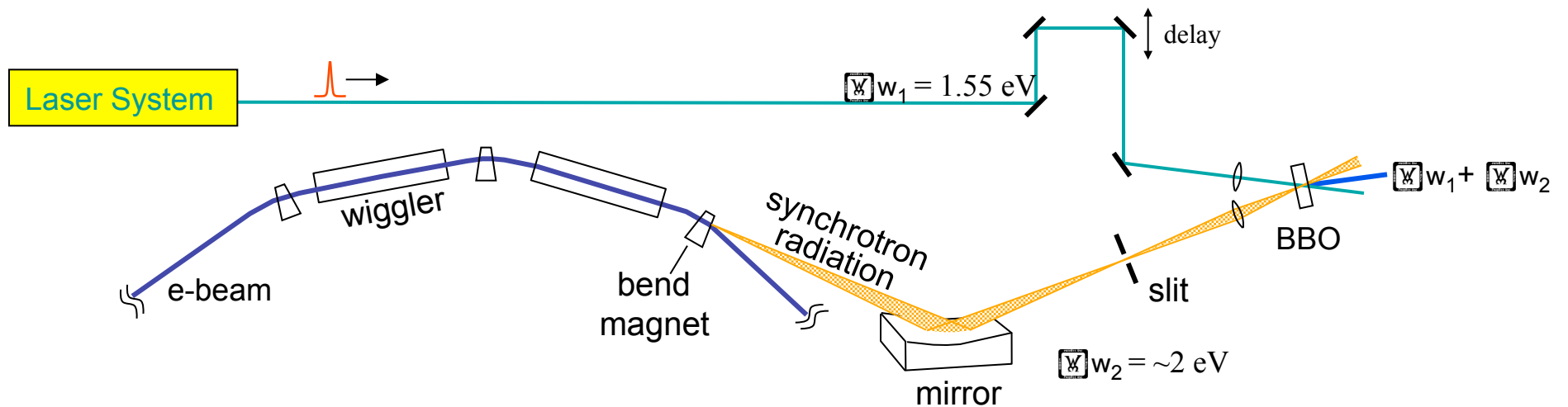


# Tests at the ALS

328 RF buckets  
276+1 filled



# Optical layout at the ALS



# Experimental setup

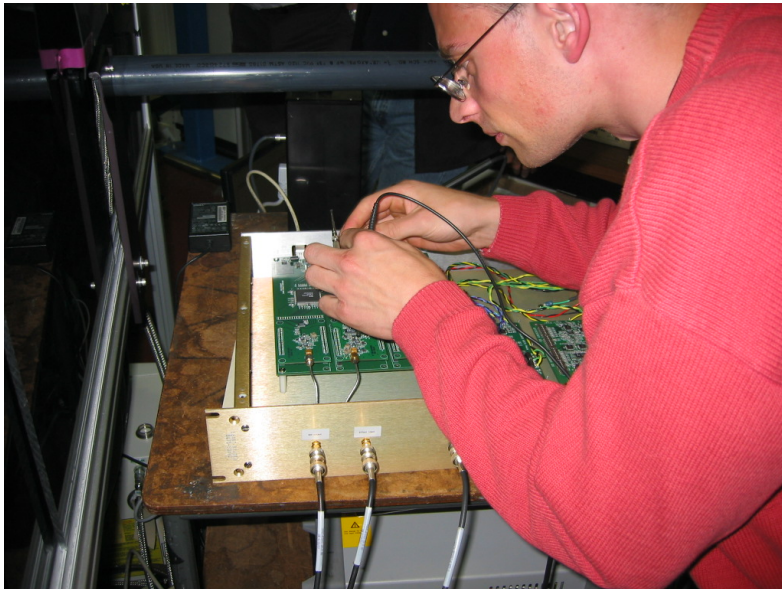


- In Beamline 5.3.1 using existing fs laser
- Laser repetition frequency is 71 MHz (1/7 ALS frequency)
- Scan bunches in groups of 7, then shift 1 bunch  
(0, 7, 14...; 1, 8, 15...; ... ; 6, 13, 20...)

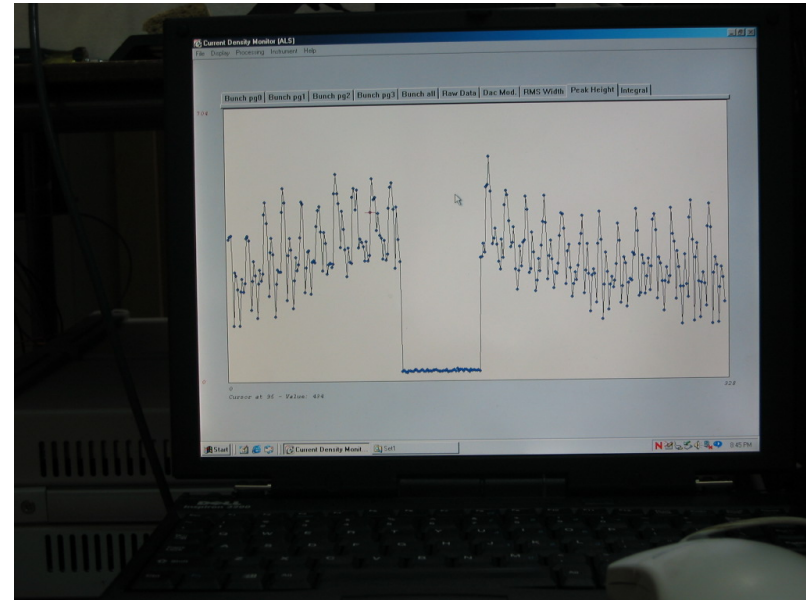
## Electronics, DAQ + Software

- Histograms the signal from each bunch
- Drives mirror with programmable displacement
- Profiles the mirror displacement (for bin position in time)

# Experimental Setup

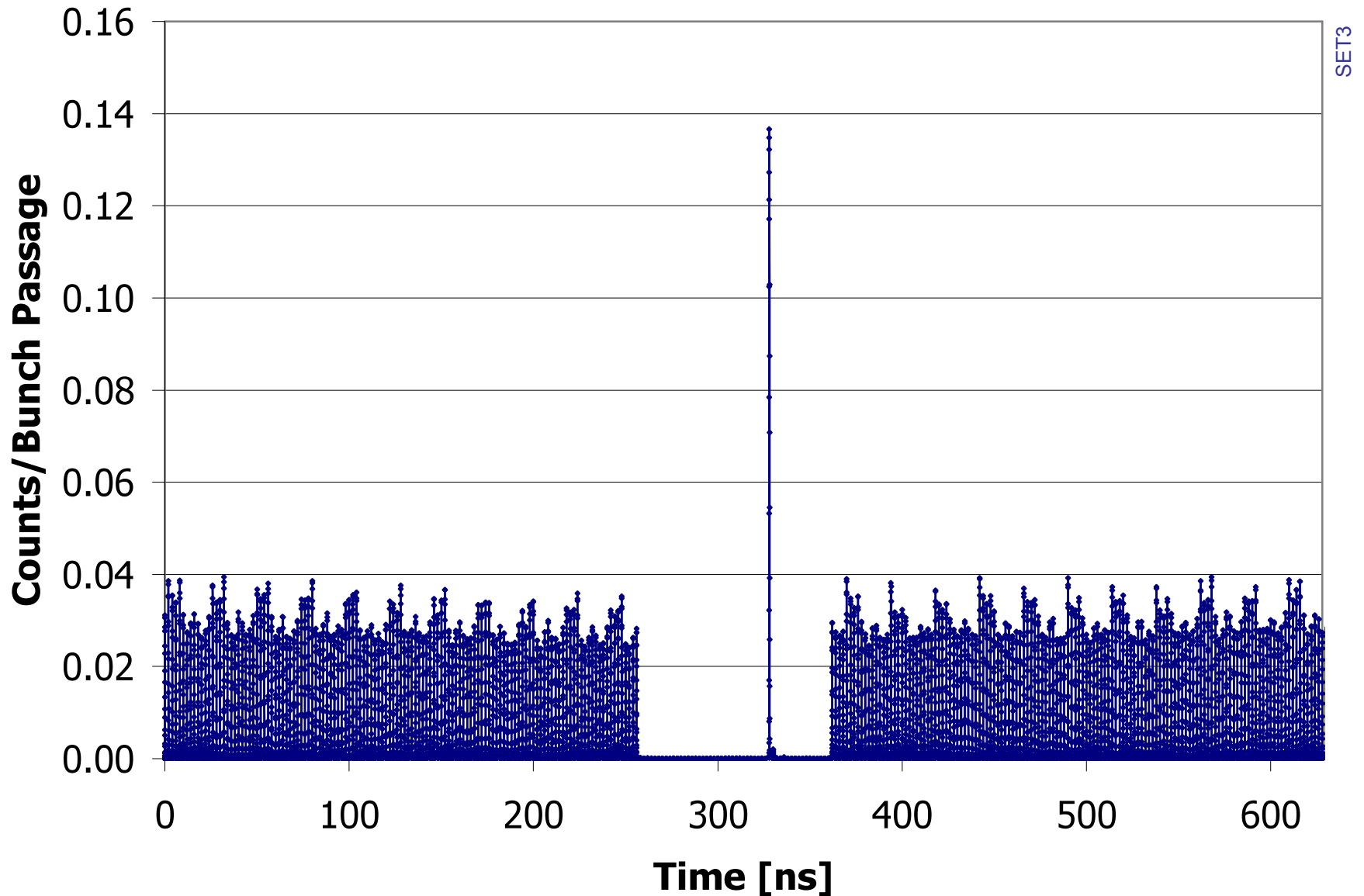


**Electronics Setup**

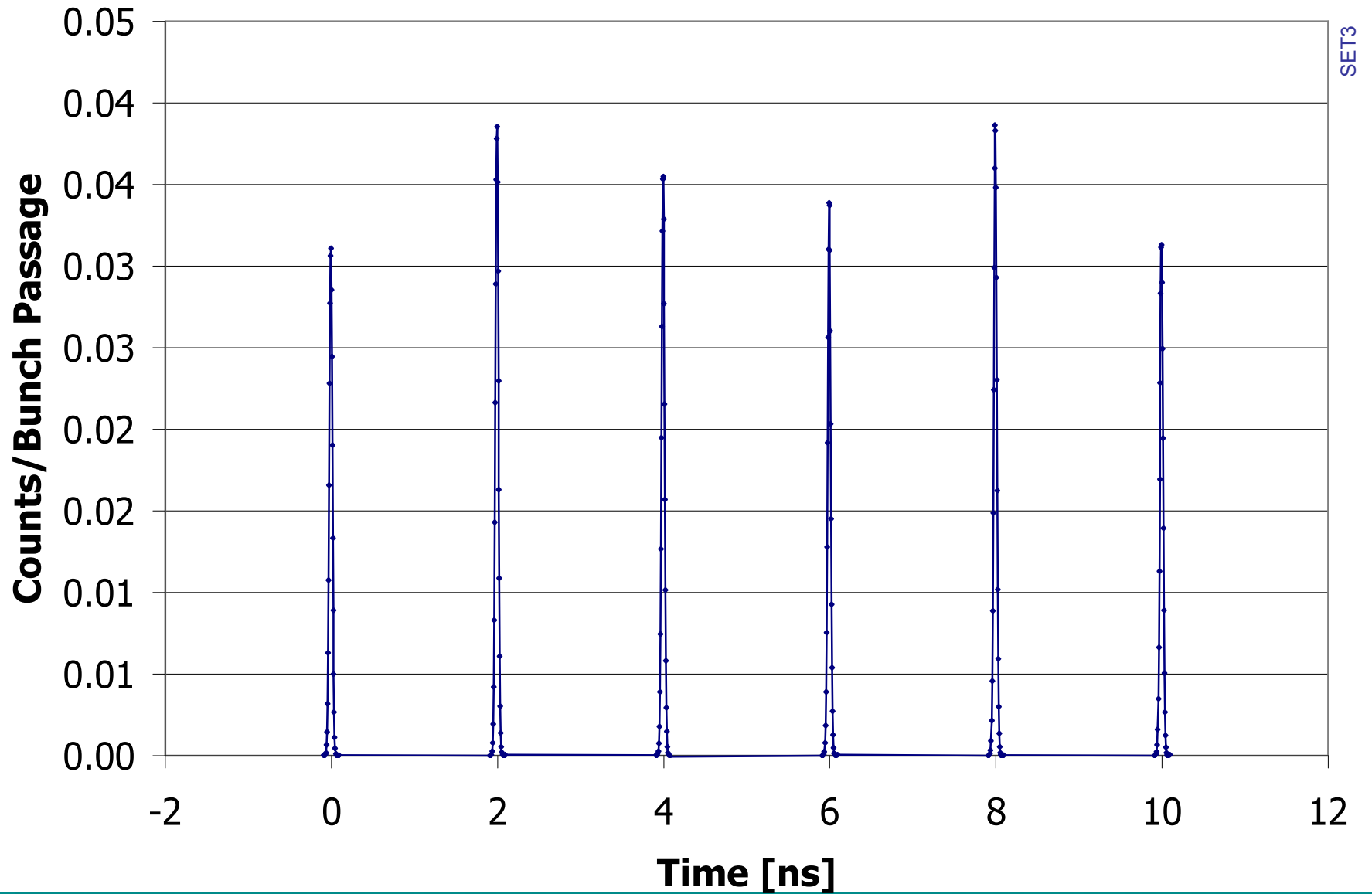


**First data (Peak Height distribution)**

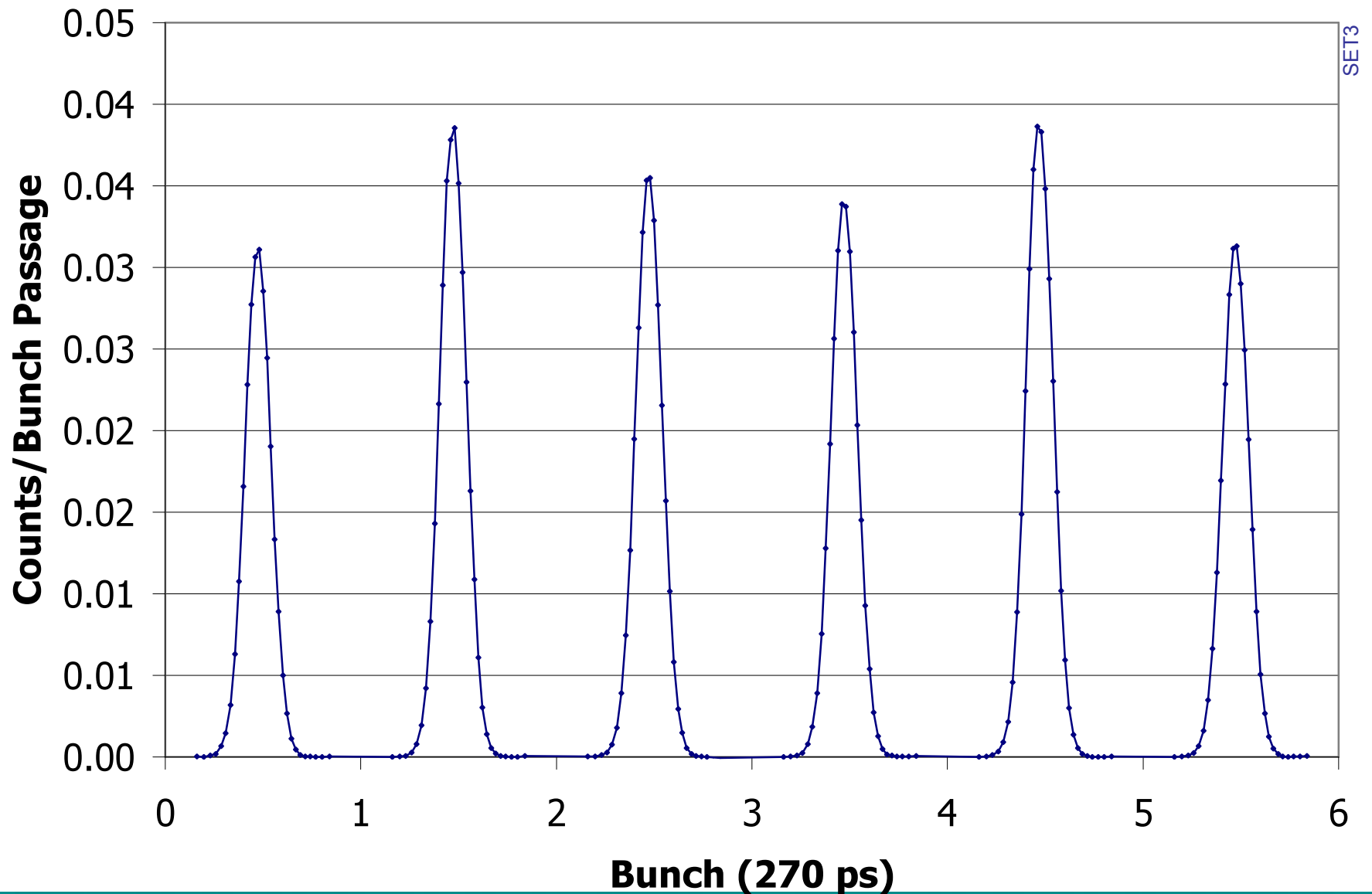
# ALS Bunch Profile in Time



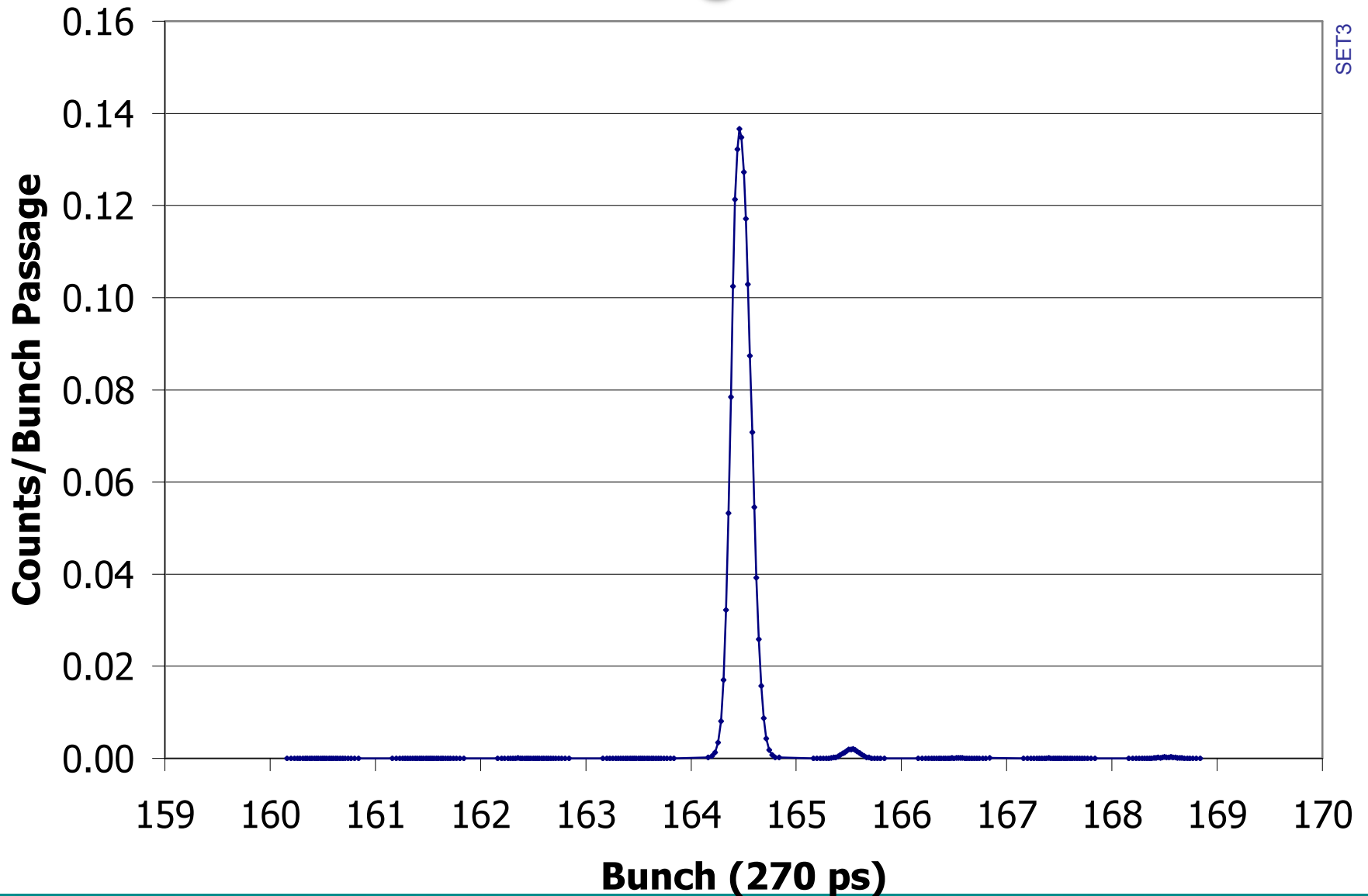
# Zoom in...



# Compress Scale...

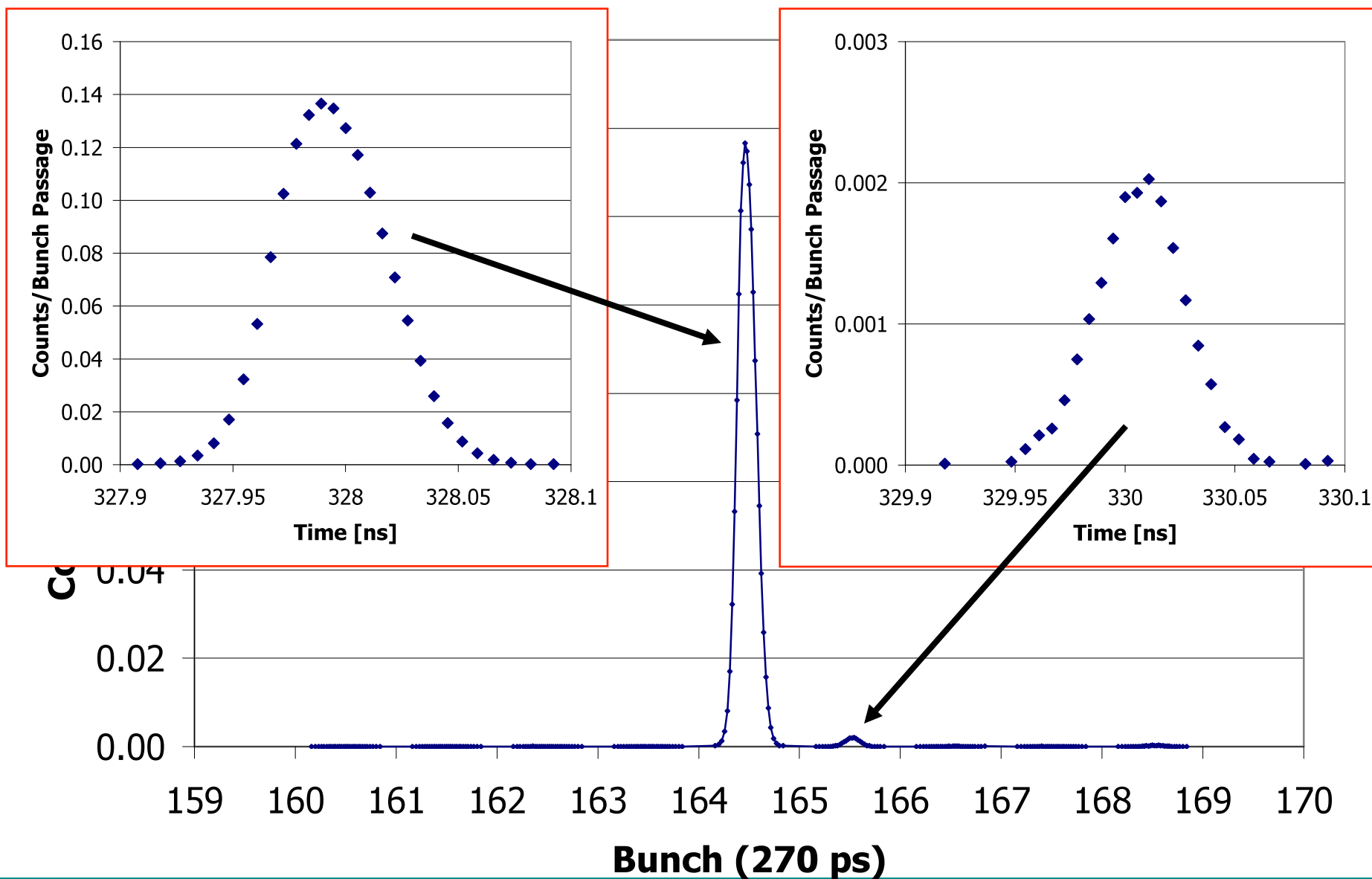


# Large dynamic range





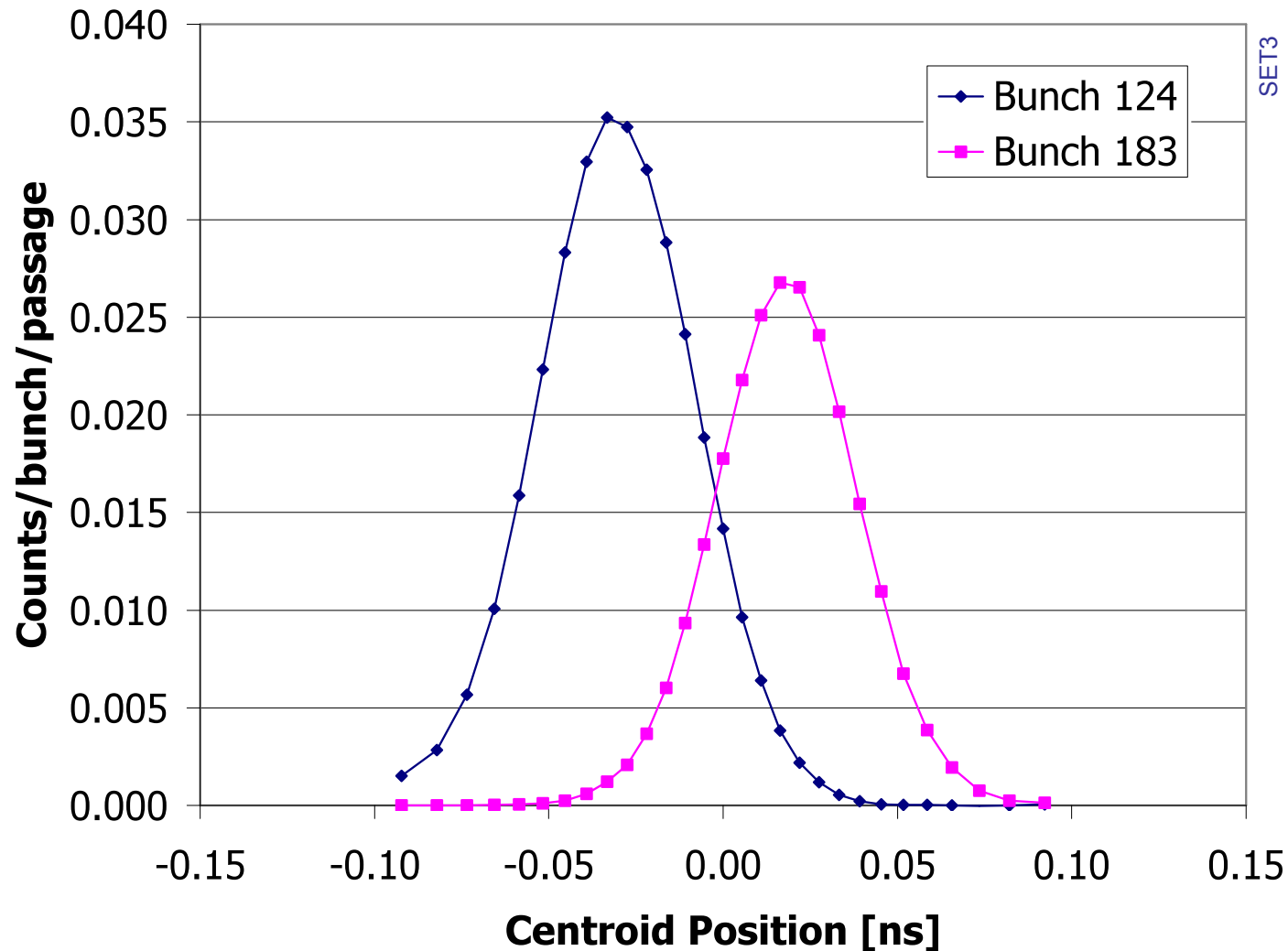
# Details



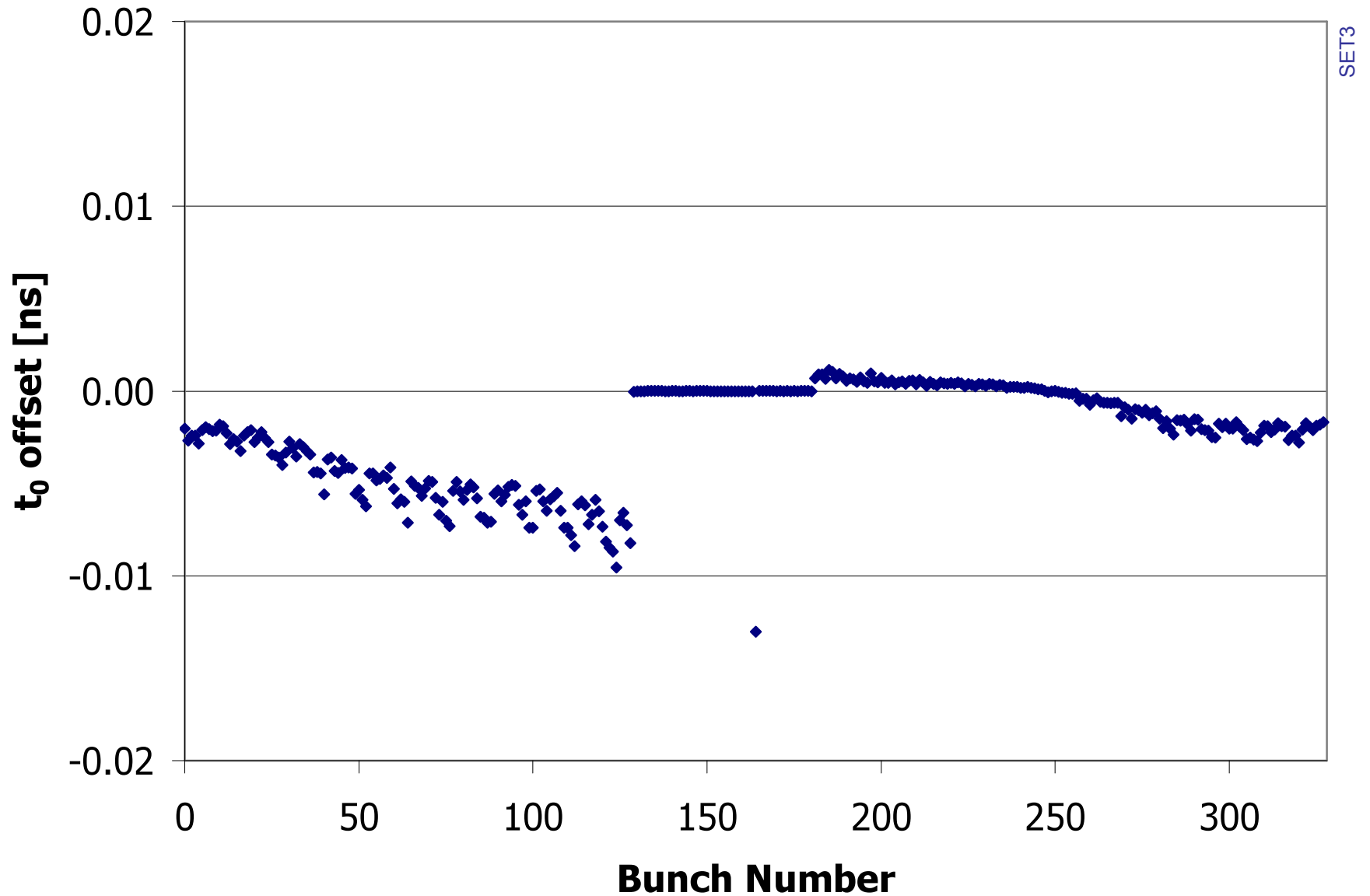
# Synchronous Phase Transients



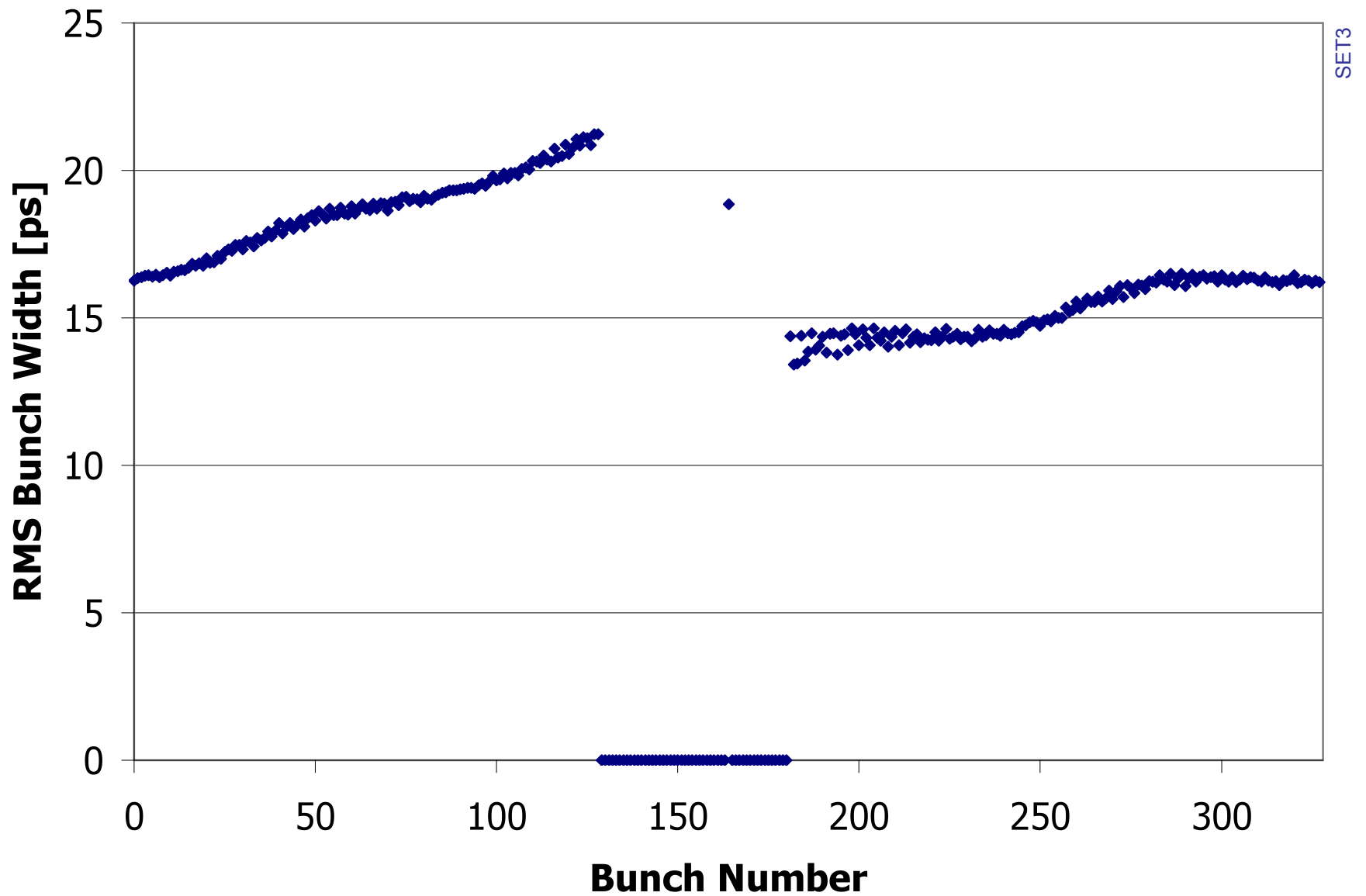
Bunch centroid phase



# Synchronous Phase Transients



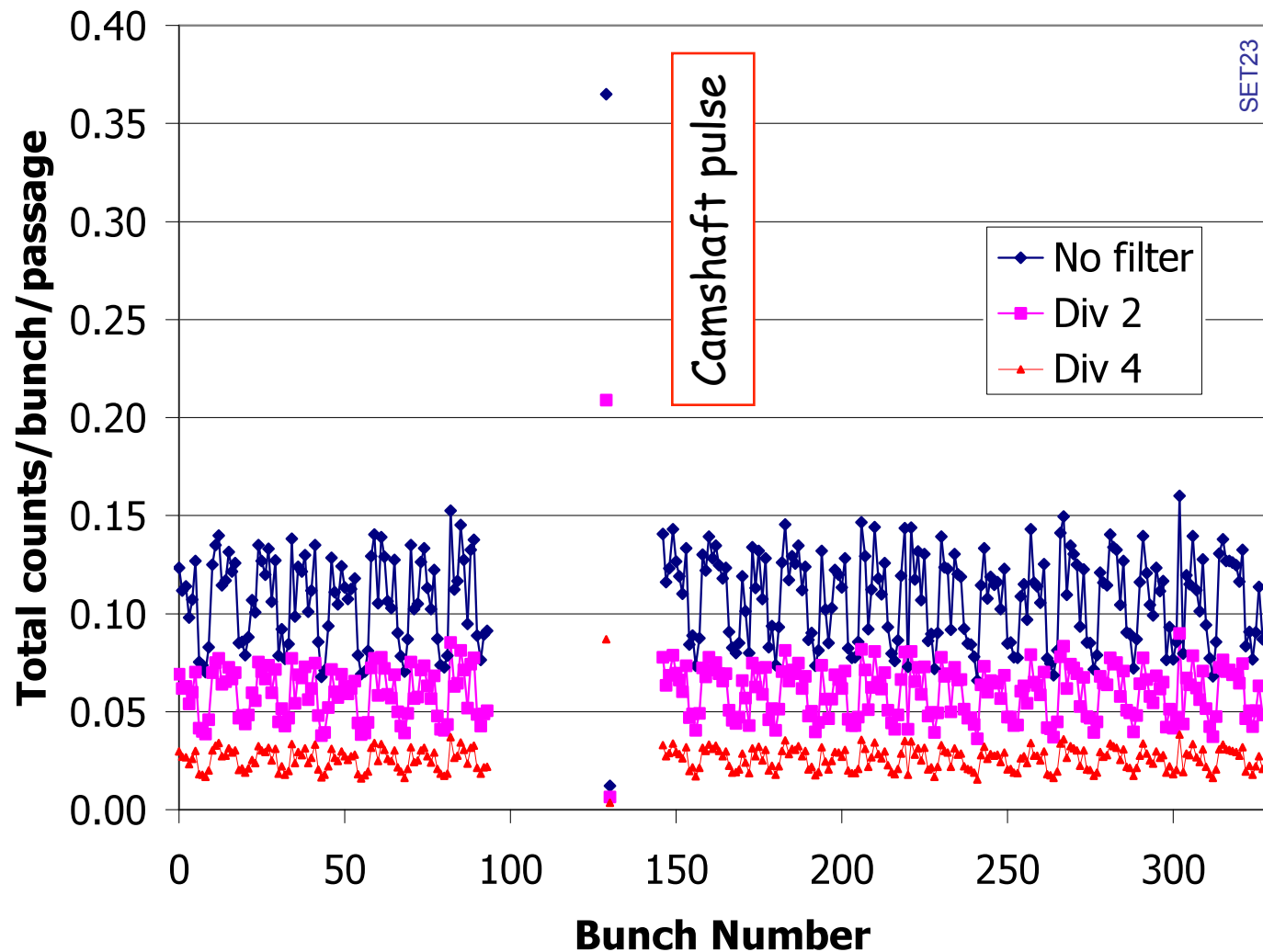
# Bunch Length



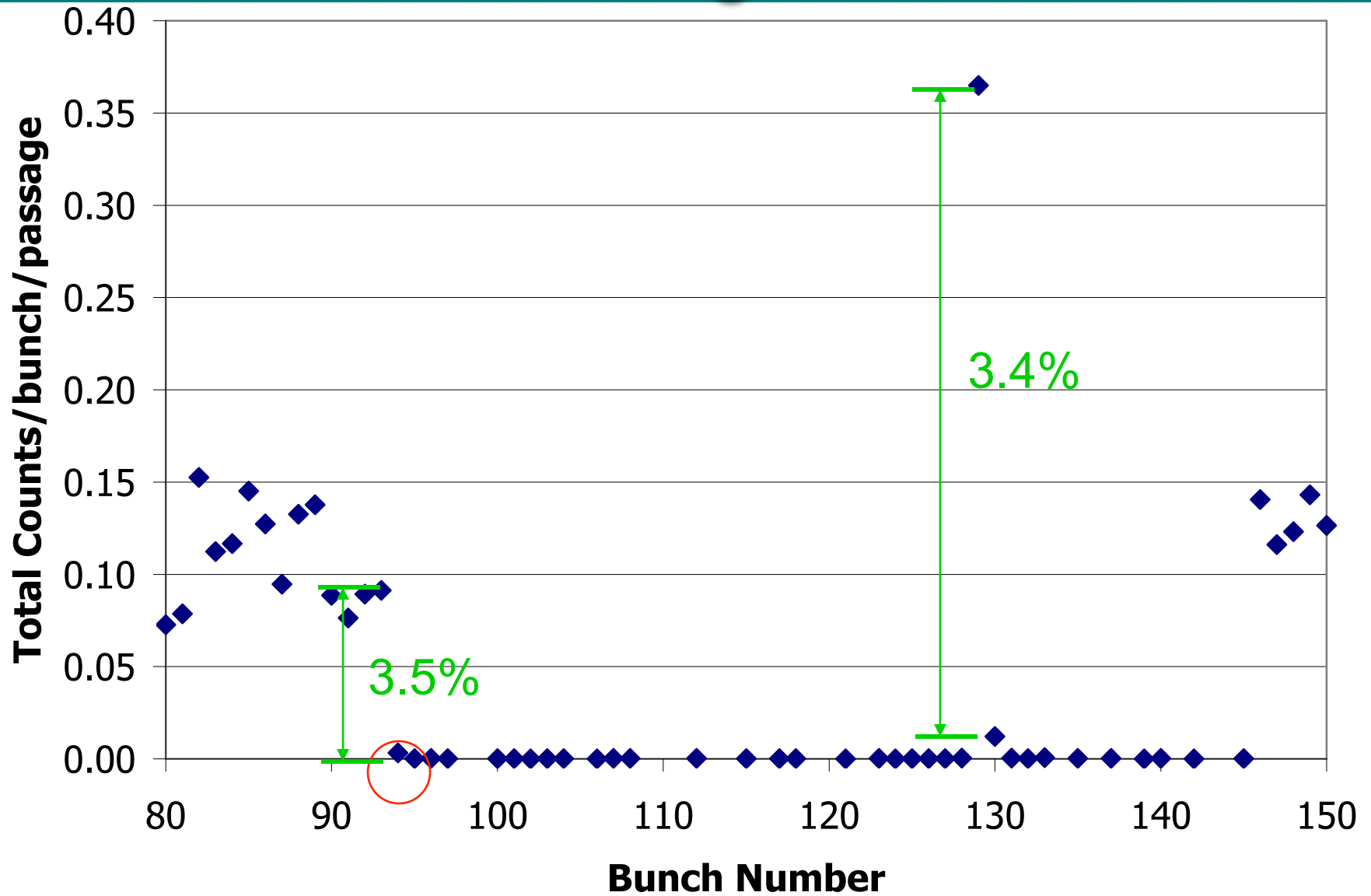
# Linearity



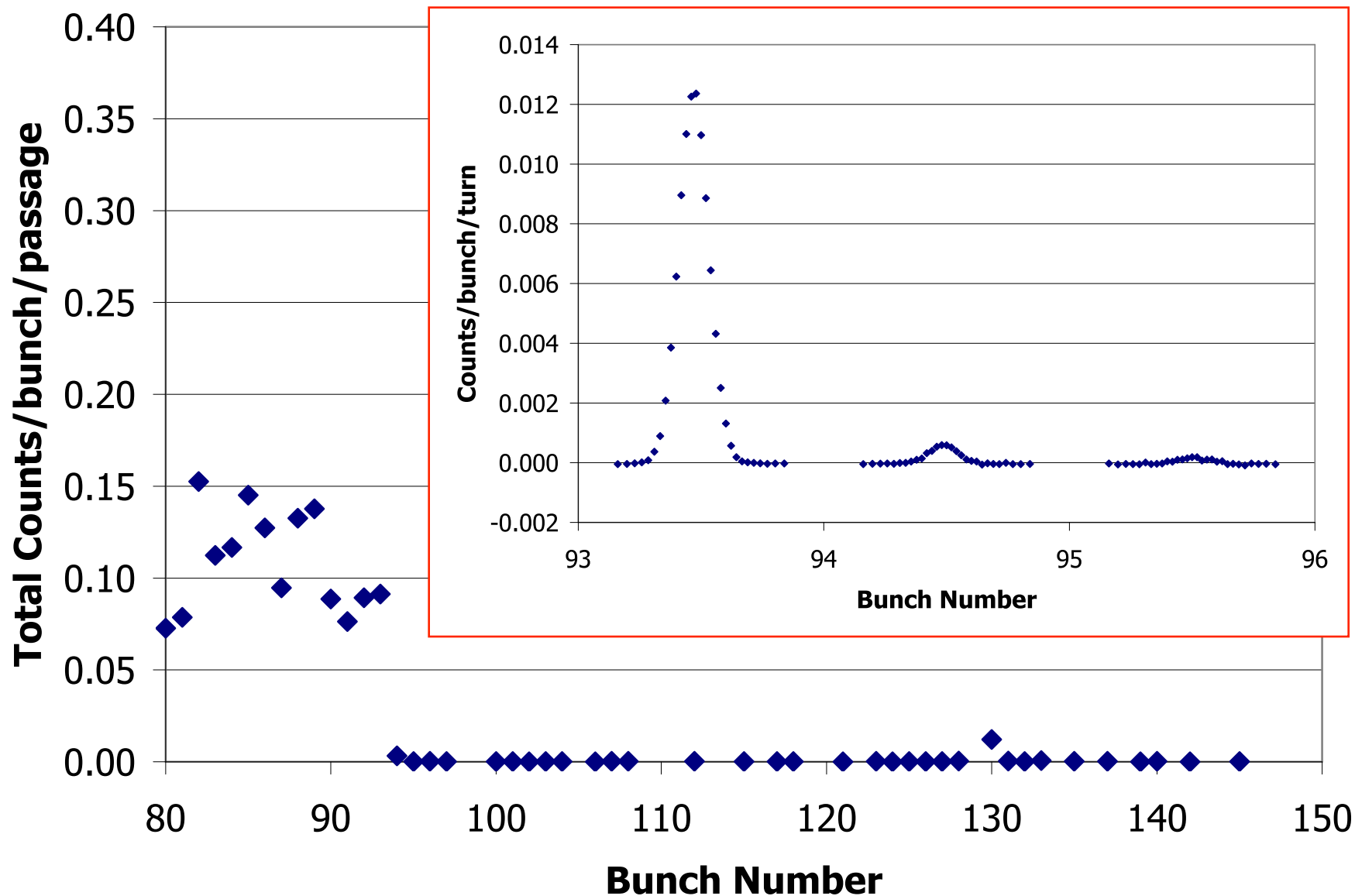
3 runs - same fill conditions a filters in front of PMT



# Dynamic Range



# Zoom - I.



# Zoom – II.

