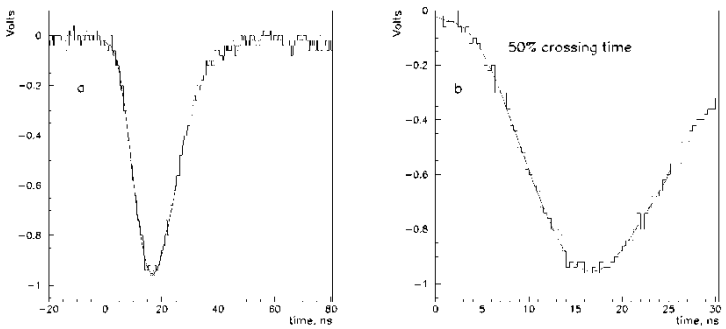
FADC timing resolution

- **Prototype built at IU**
  - **250 MH sampling (4 ns)**
  - **8-bit resolution**
  - **saturates at 1.3 V**
  - **clock not synchronized to external source**
- **User controls**
  - **number of samples to extract from the ring-buffer**
  - **trigger threshold**
  - **trigger offset**
- **Basic idea**
  - **use laser light and FEU-84-3 PMT to send a signal to the FADC**
  - **apply algorithm described in GlueX-doc-426 that utilize maximum-sample time and two preceding times to estimate 50% crossing time**

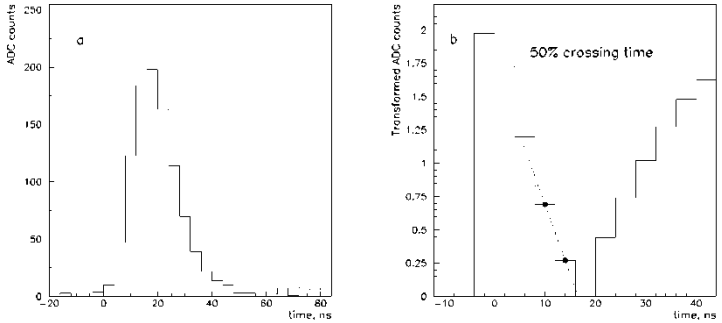
Algorithm description

- **assuming Gaussian shape of the raising edge of the pulse one can use two samples preceding the maximum sample to estimate the 50% of peak crossing time**

Typical PMT pulse



Digitized pulse to mimic FADC response



polynomial fit to determine 50% of peak crossing time

- **transformation to turn a Gaussian edge into a straight line:**

$$aT_i + b = \sqrt{-\ln\left(S_i / S_{\max}\right)}$$

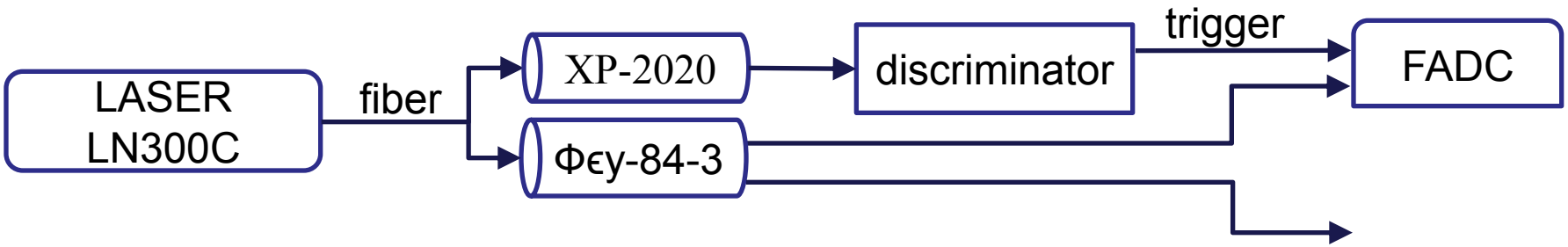
- **two samples needed to obtain *a* and *b***

$$aT_{50} + b = \sqrt{-\ln\left(1/2\right)}$$

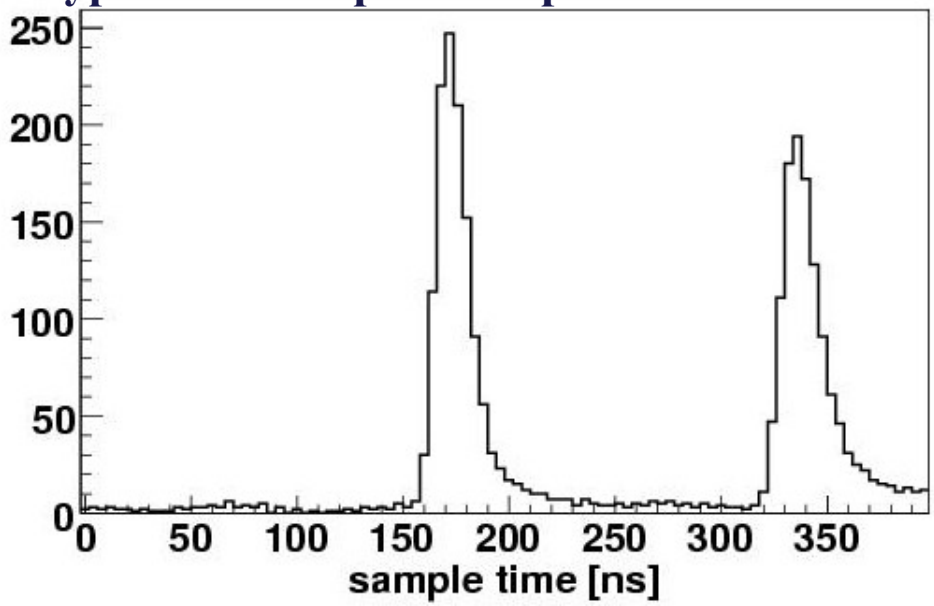
comparison between fit and method yielded 150 *ps* resolution for 1.5 V signal

FADC timing resolution setup

- **using time difference between two cards to extract the intrinsic resolution of the algorithm not feasible: ±16 ns uncertainty (FADC outputs 4 bytes at the time)**

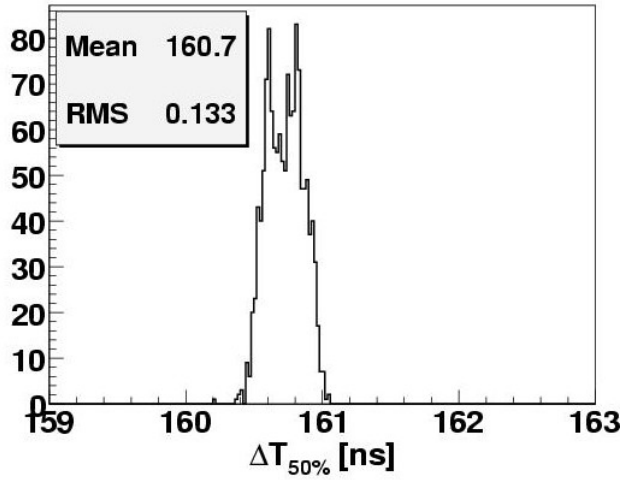


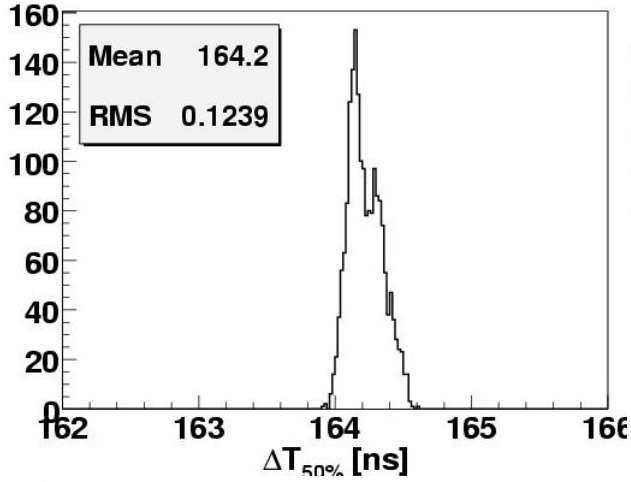
Typical double-pulse shape of the reflection

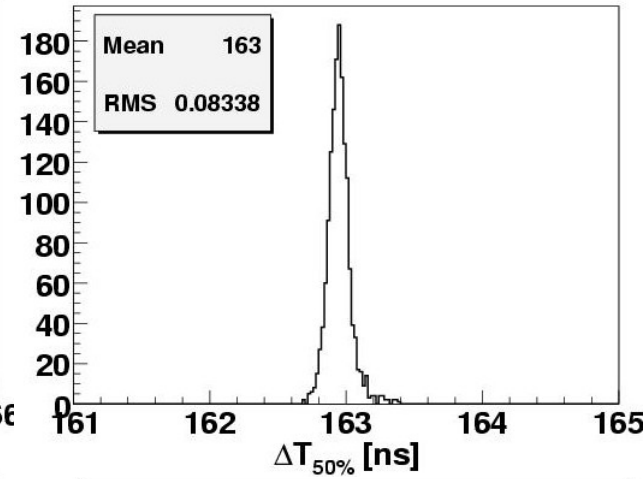


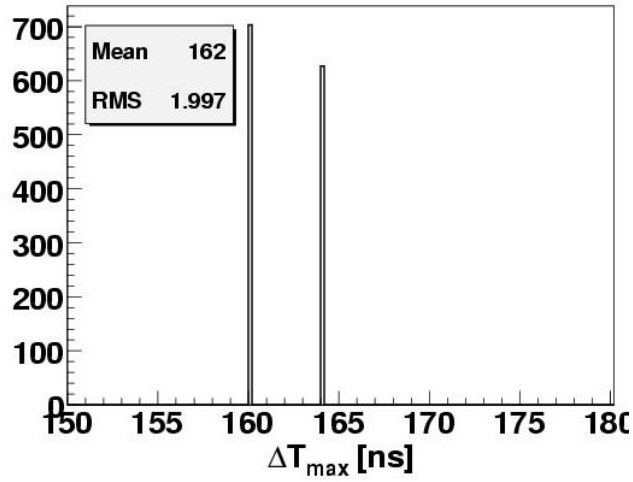
- **instead: leave one branch open to produce reflected signal**
- **advantage: samples always aligned to the same bit**
- **opportunity: examine sensitivity of the algorithm to the sample arrival time by changing the length of the open end**

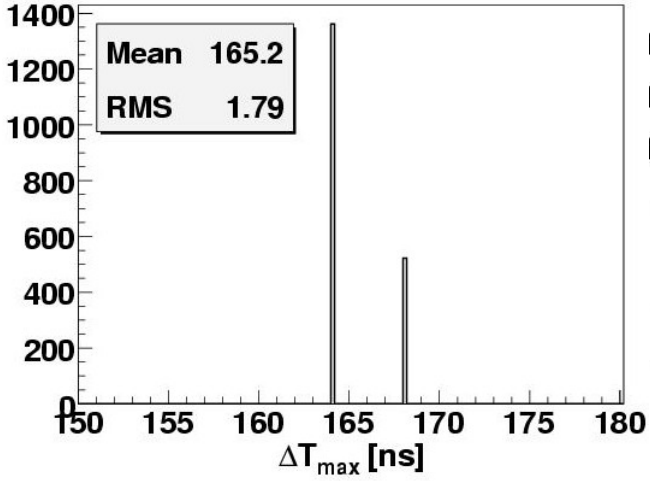
Difference in 50% peak crossing time

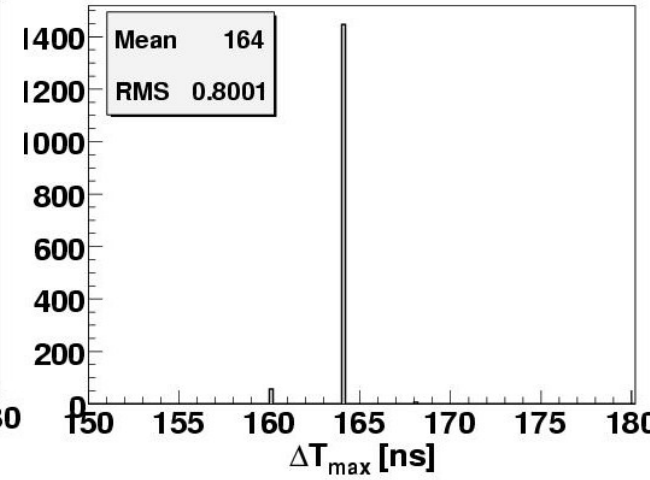








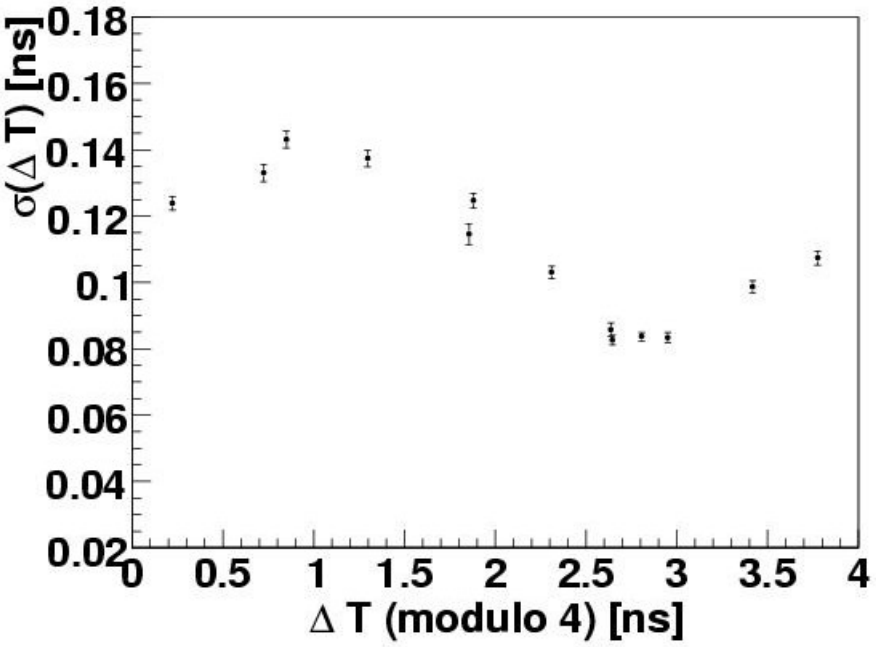




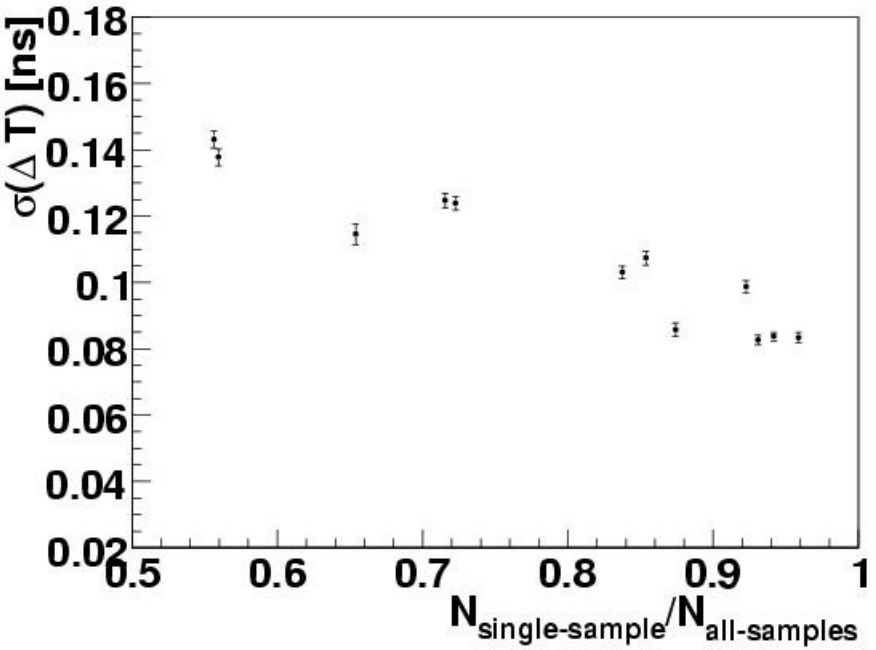
- **the timing info depends strongly on maximum sample**
- **what would be the resolution if signals' maxima are always sampled at the same time?**

Single-channel time resolution

Double-pulse time resolution vs. time delay



Double-pulse time resolution vs. fraction of single-sample events



$\delta T^2 = \delta T^2_A + \delta T^2_{OT}$ → $\delta T_A = 115$ ps

A – algorithm
OT- other factors (delay variations, PMT transition times)