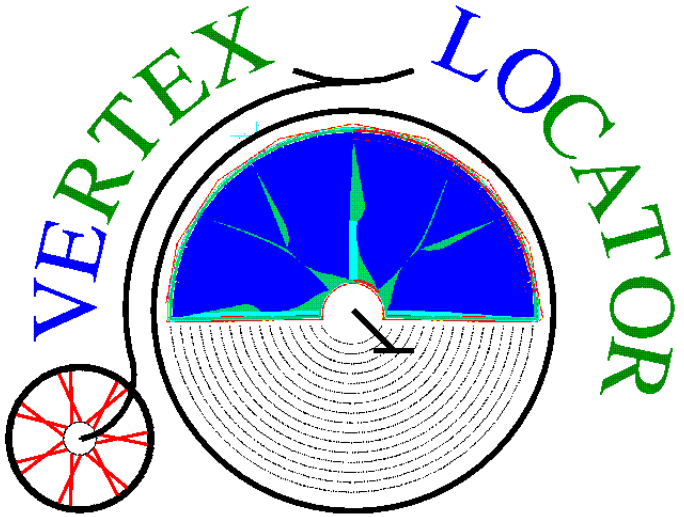
# *Timing the LHCb VELO*

- Outline
  - LHCb & VELO
  - Pulse shape
  - Test Pulses
  - TED data
  - Summary

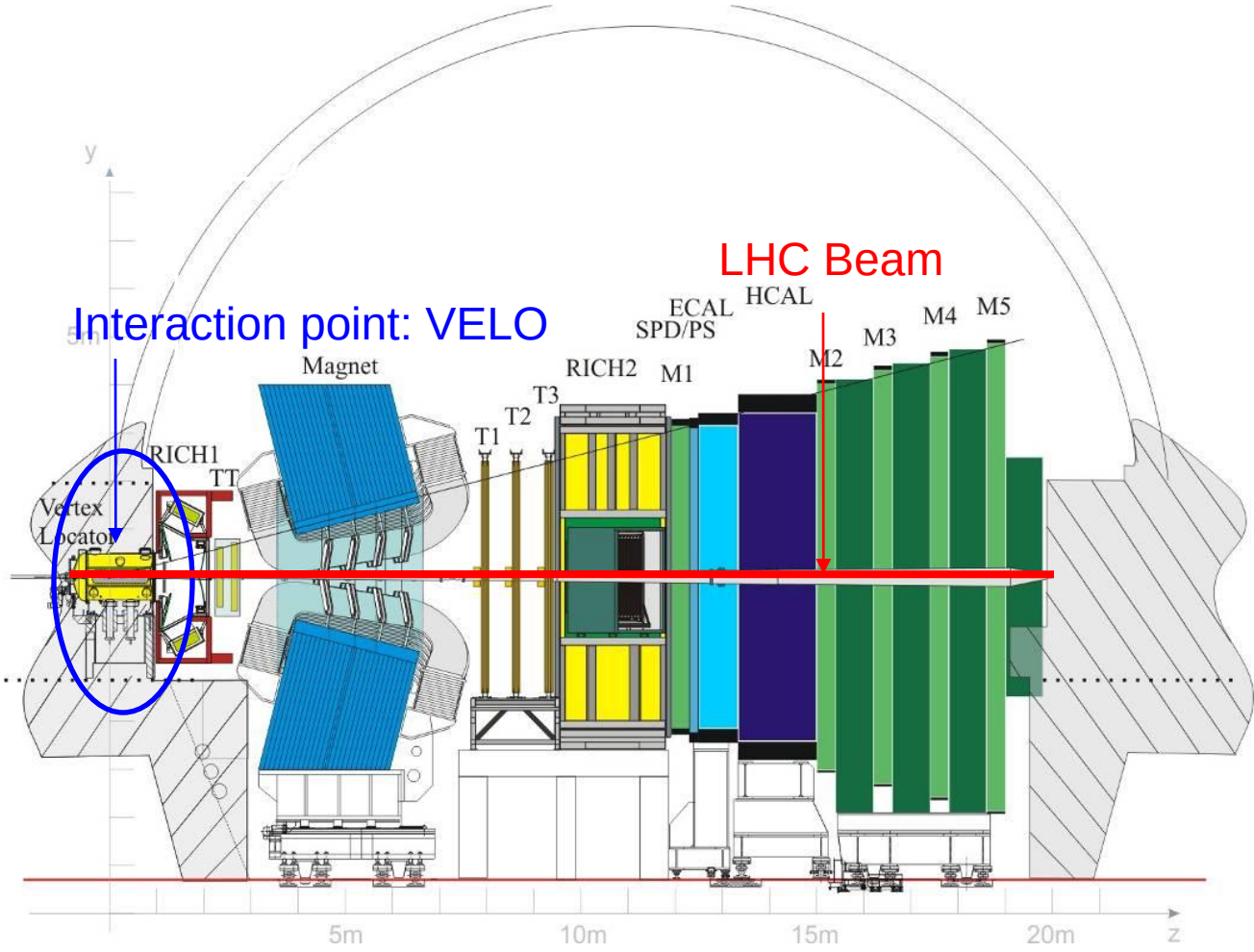




Ivan Mous

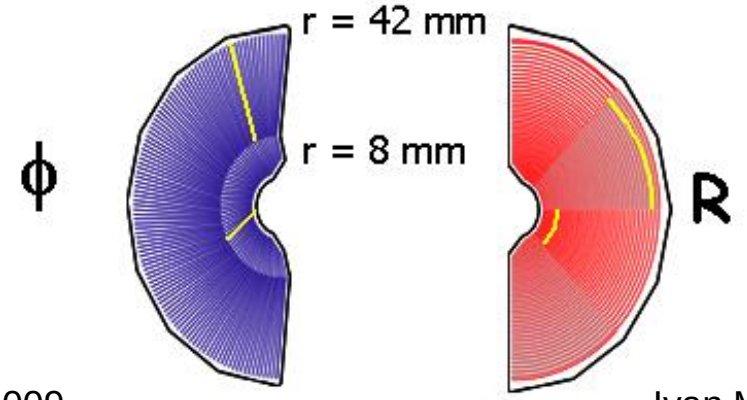
# LHCb

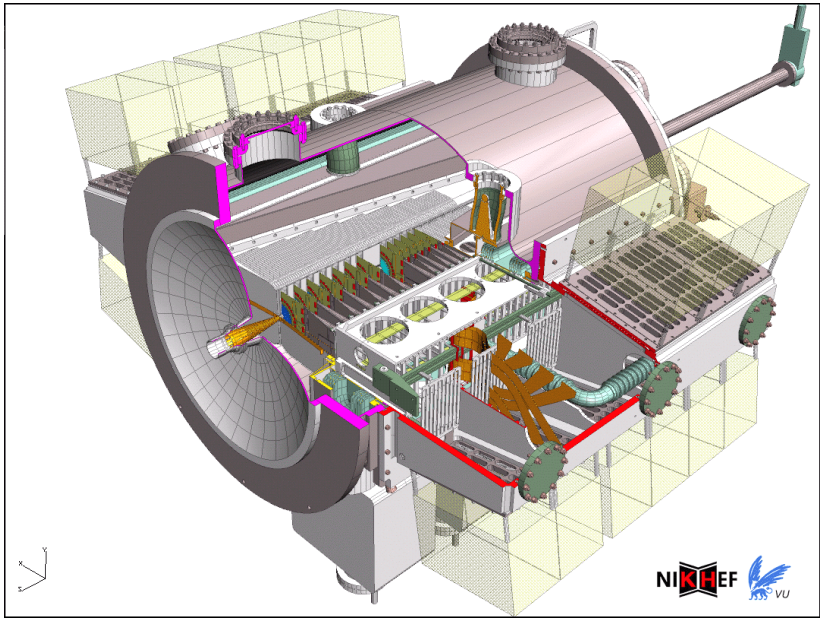
- Forward arm spectrometer, build along the beam line
- VELO located closest to interaction point

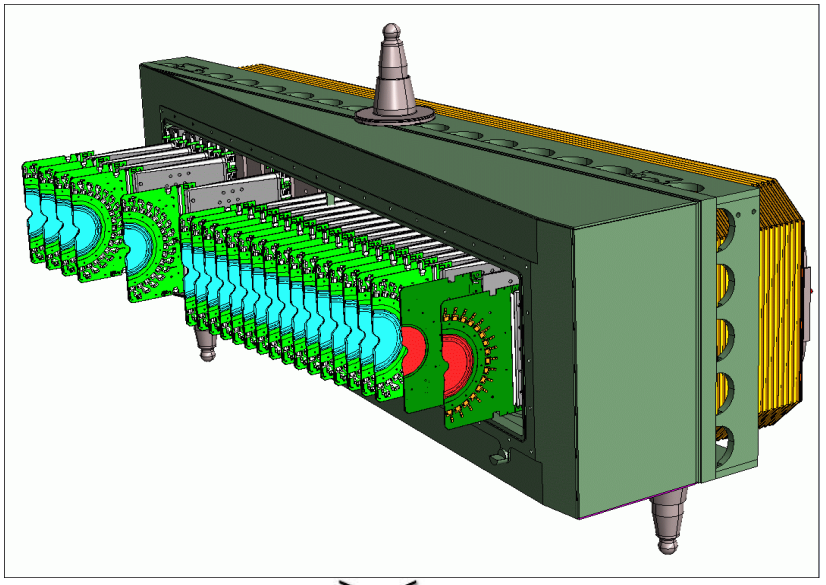


# VELO detector

- VErtex LOcator
  - Sub detector surrounding the interaction point at IP8
  - Part of the LHC beam pipe
  - Contains 2 halves with 21 sensor pairs
    - Each pair contains R and Φ sensor
    - Used for 3D track reconstruction

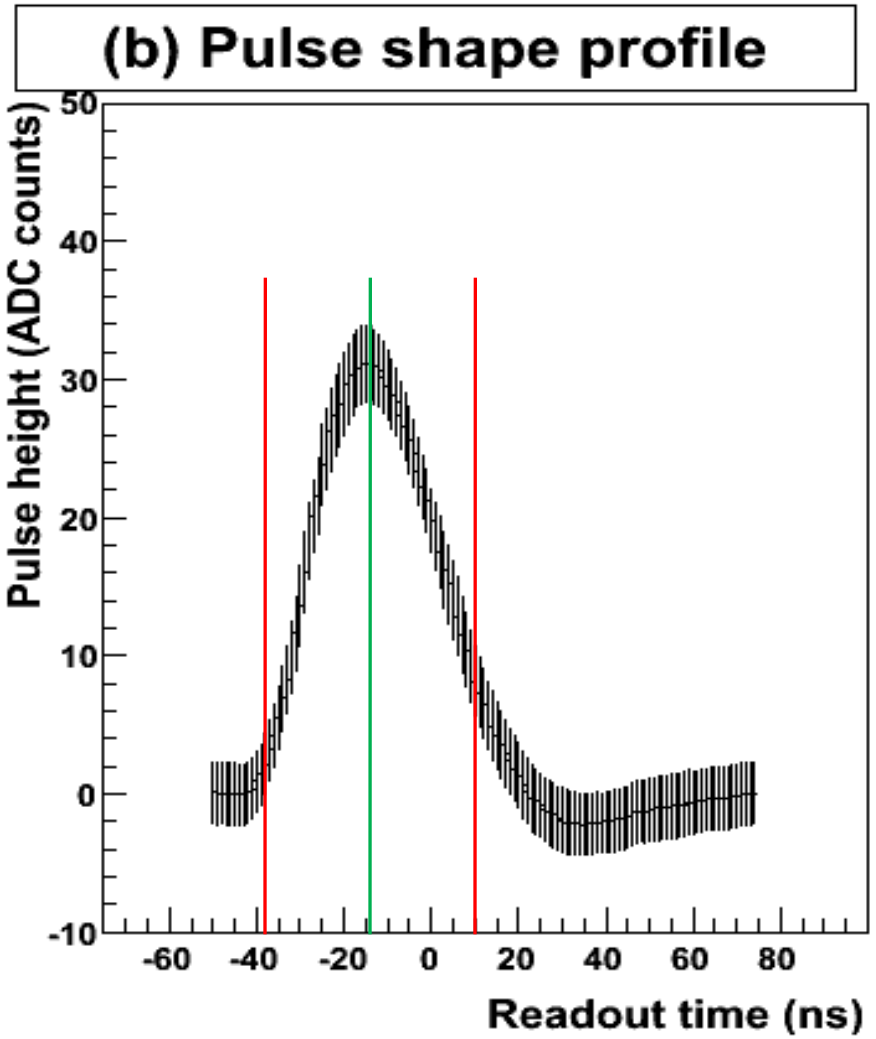


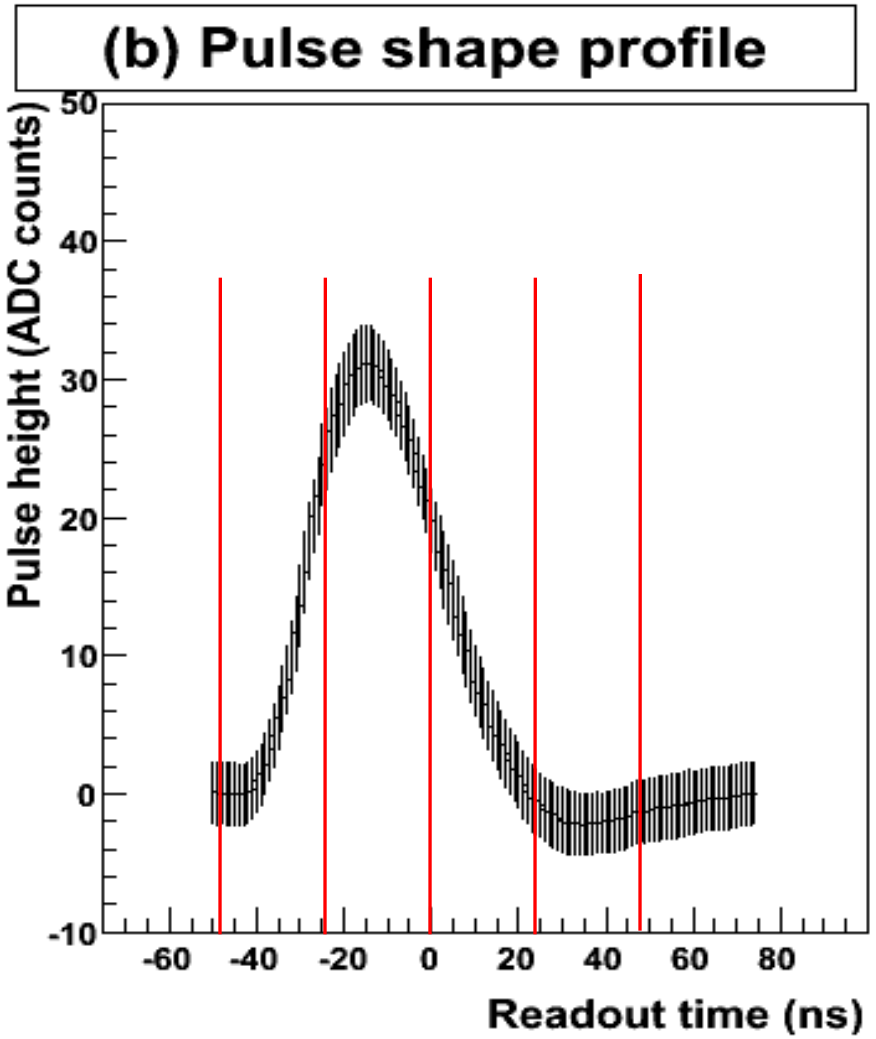
# *Timing the readout: Pulse shape*

- Pulse shape: Signal from a particle as a function of time
- Normal LHC operation: Readout of signal once per bunch crossing (25 ns)
- Optimize time of readout for
  - maximum signal
  - minimum spillover



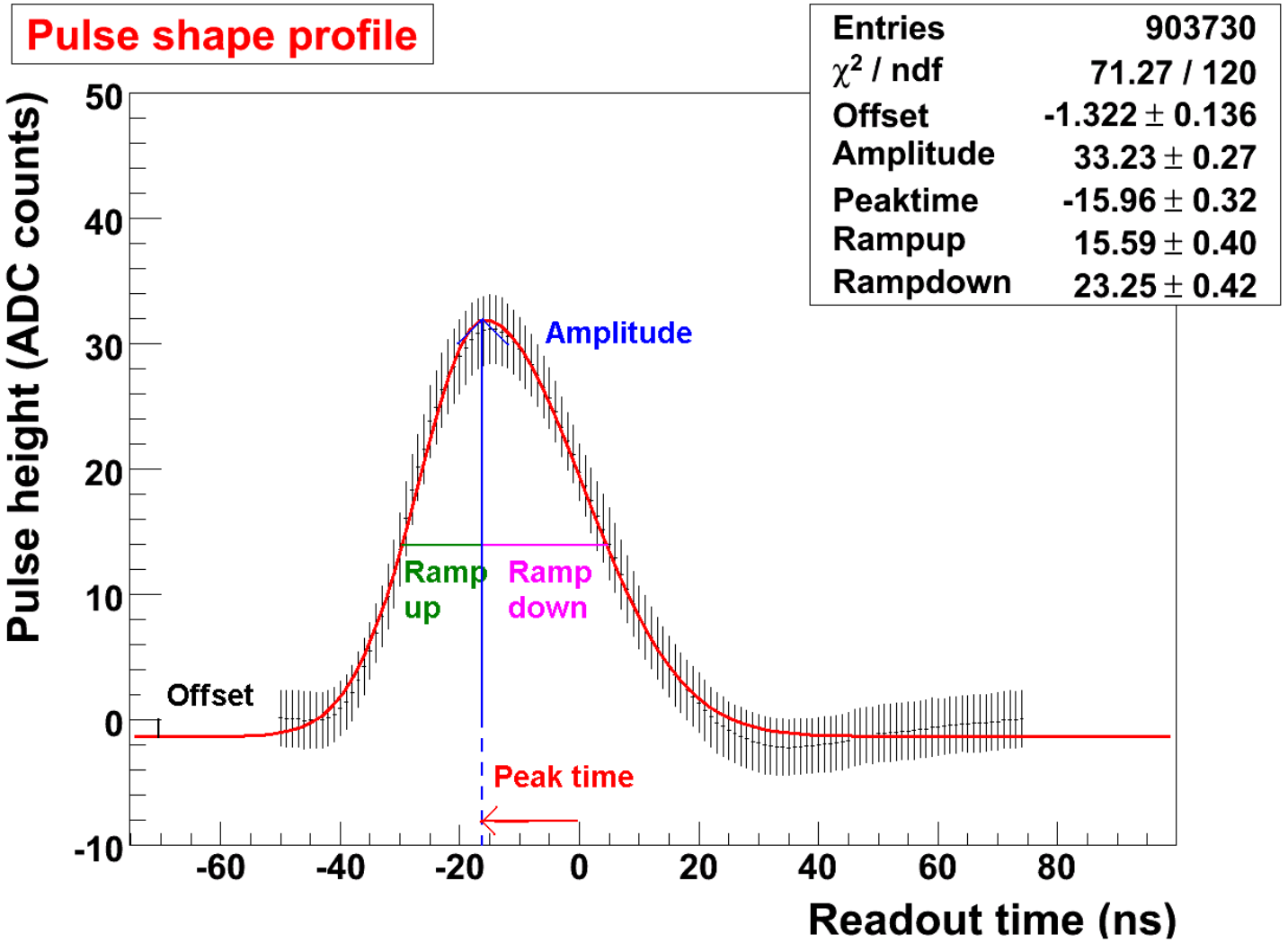
# *Pulse shape reconstruction*

- By design signal readout once every 25 ns (40 MHz)
  - Once per bunch crossing
- To obtain detailed reconstructed pulse shape
  - Take multiple data sets with identical settings but with shifted sample times
  - Combine all data sets with corresponding sample times in one graph
- Example: 25 datasets, steps of 1 ns



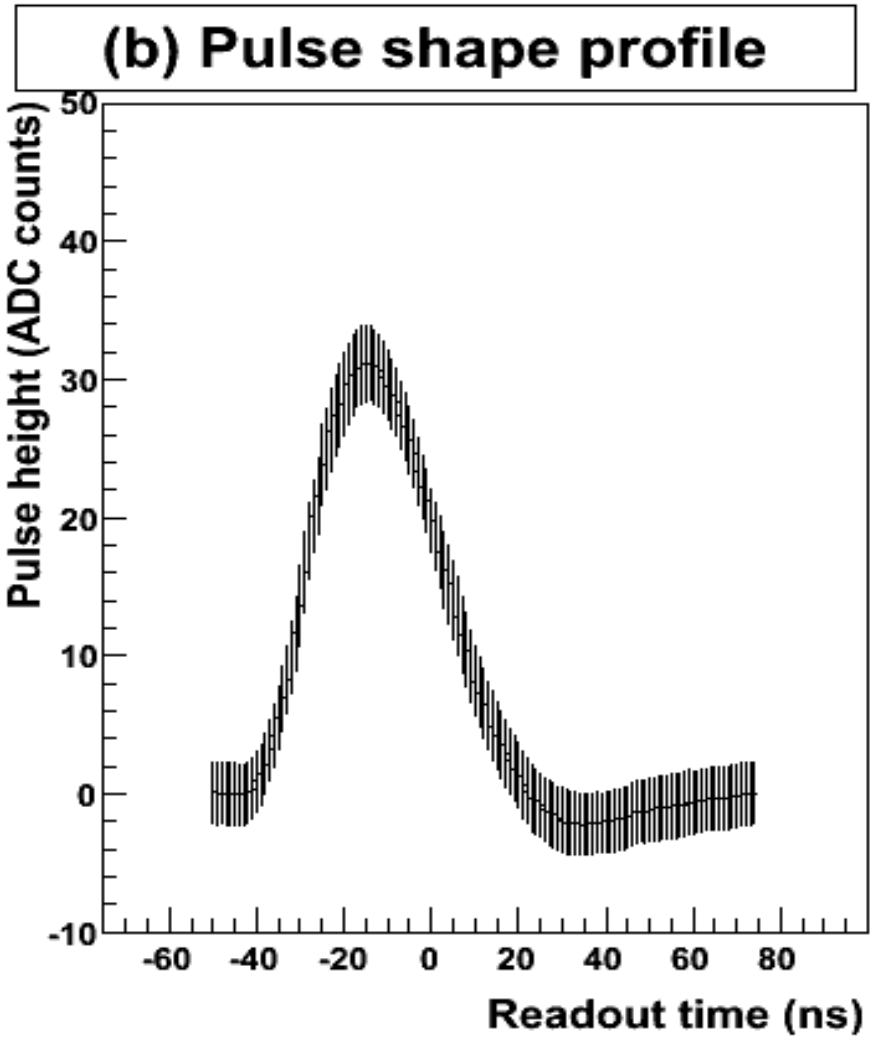
# Pulse shape parameterization

- Asymmetric gauss
- Peak time, Ramp up and Ramp down contain all info



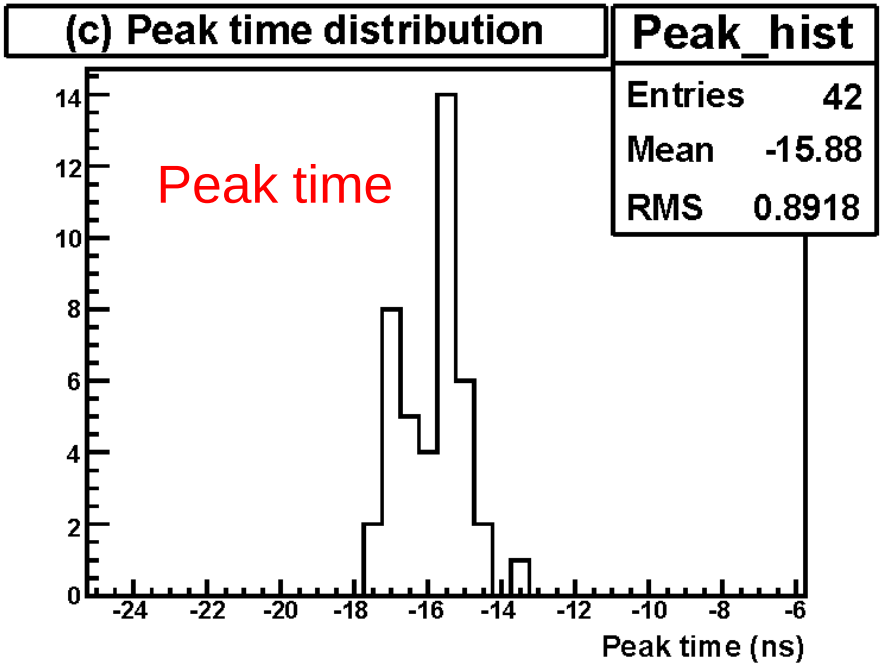
# *Test pulse data*

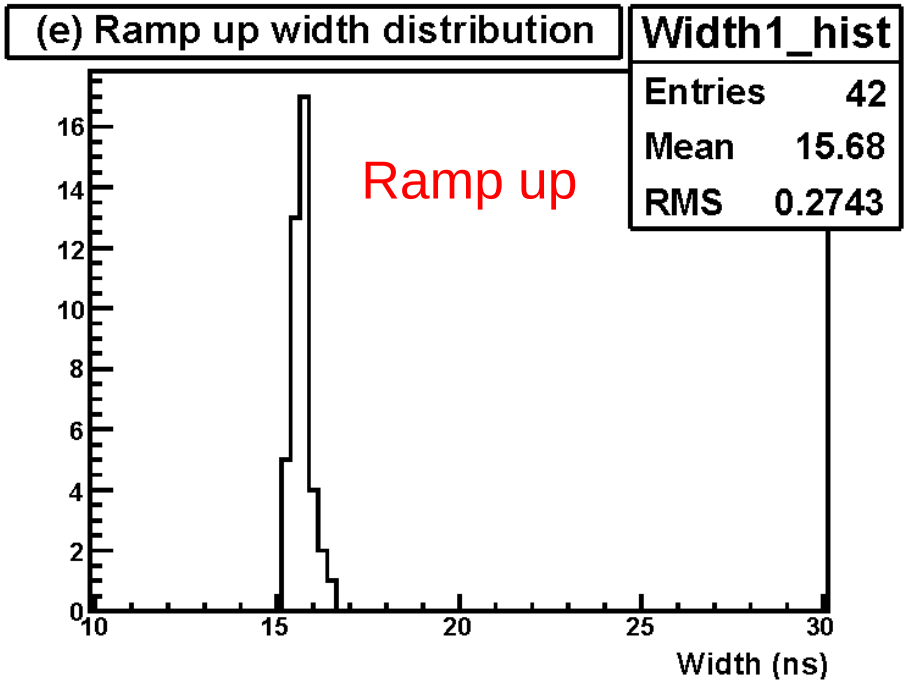
- Test pulses: Signals injected into the readout chip
- Designed to simulate particles
- Quick and cheap way to generate lots of data
- Used to study the pulse shape and test the method

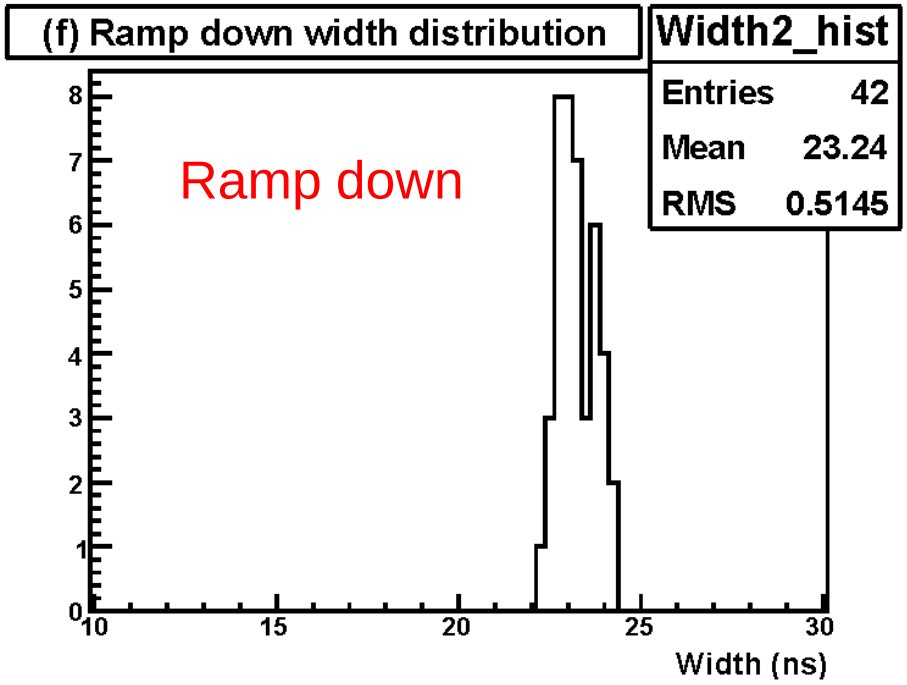


# Test pulse data

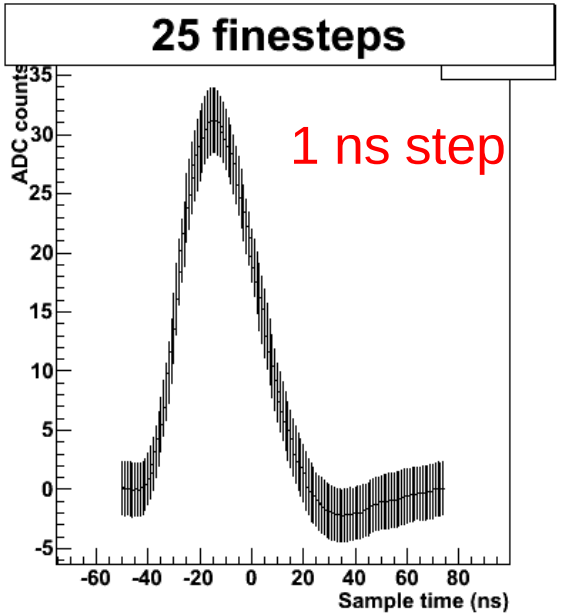
- Average fit values
  - Peak time: -15.9 ± 0.9 ns
  - Ramp-up: 15.7 ± 0.3 ns
  - Ramp-down: 23.2 ± 0.5 ns
- Optional: Fix Ramp-up and Ramp-down to above values

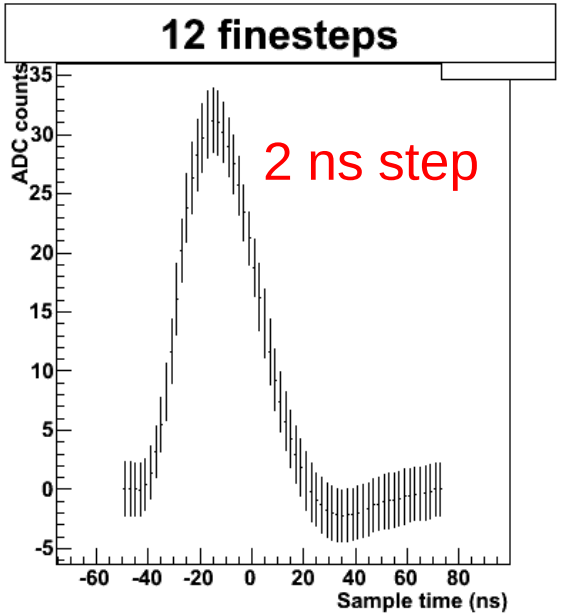


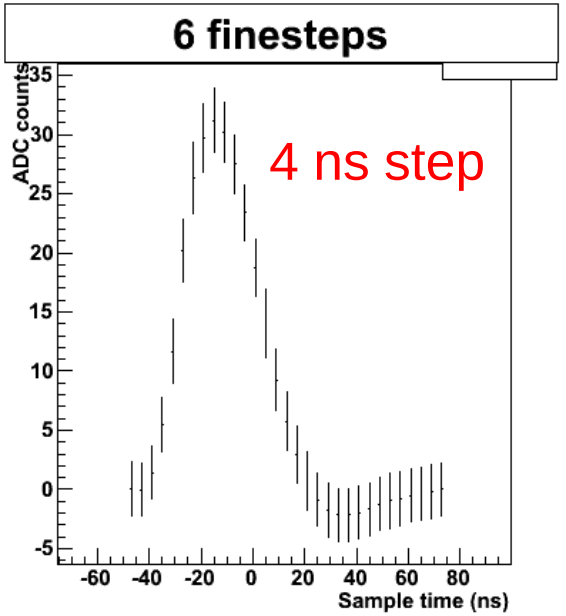



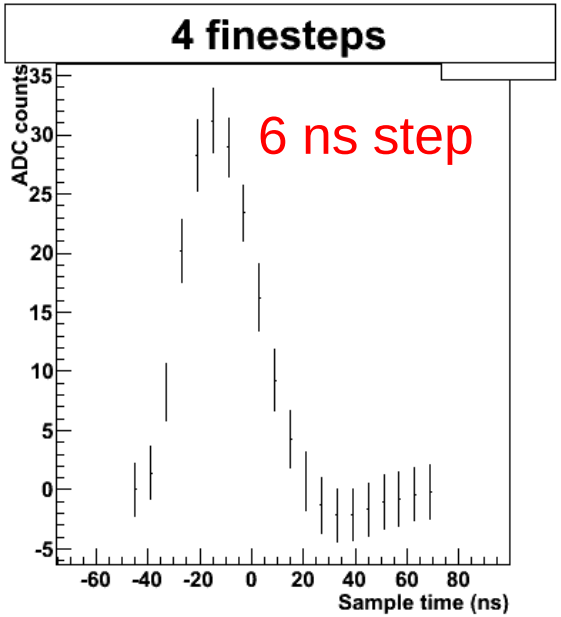



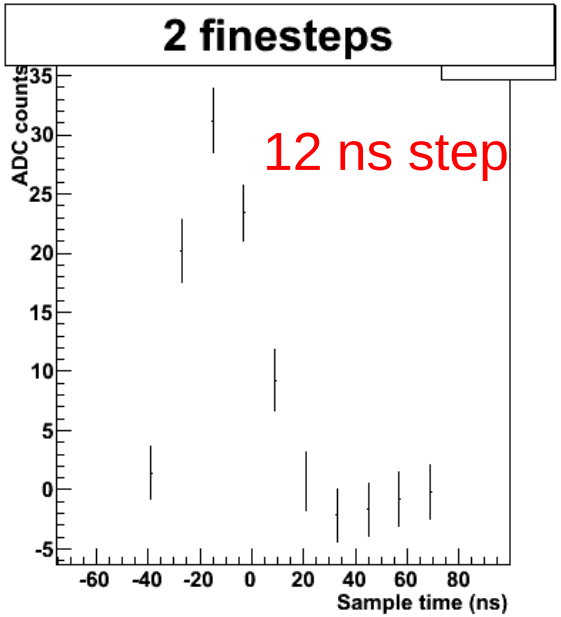
# Reduced reconstruction

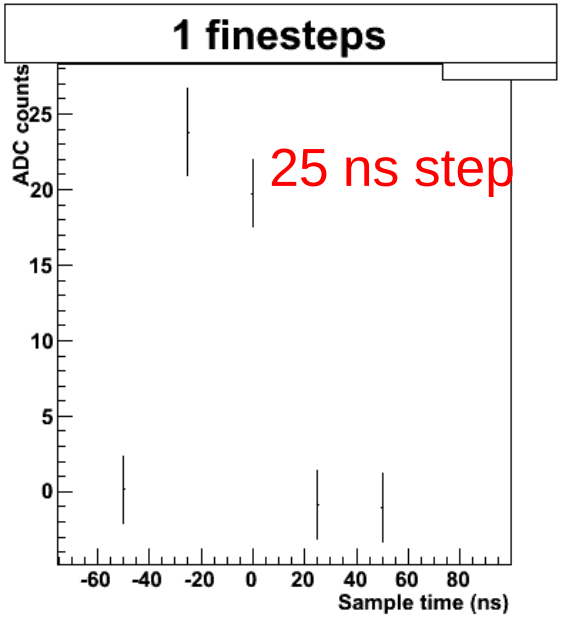


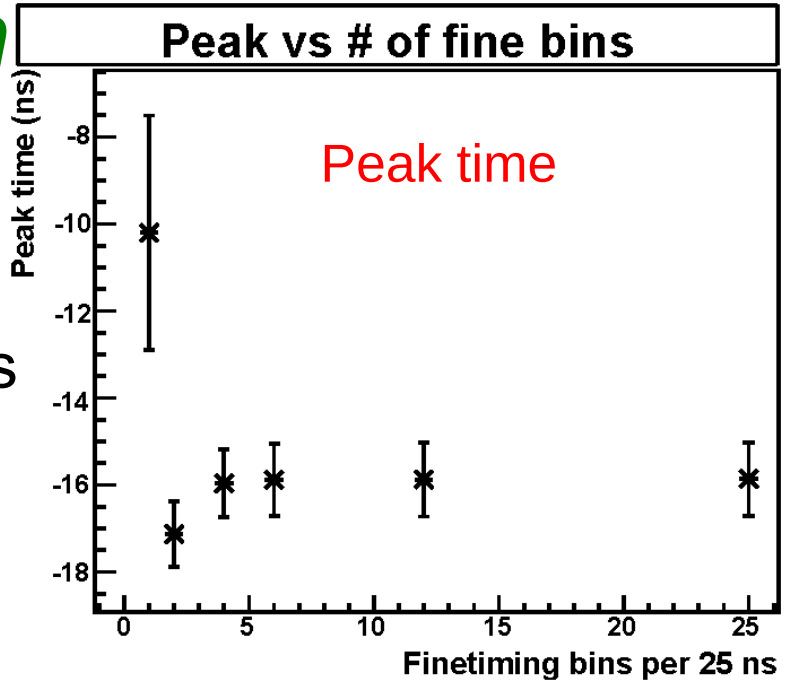



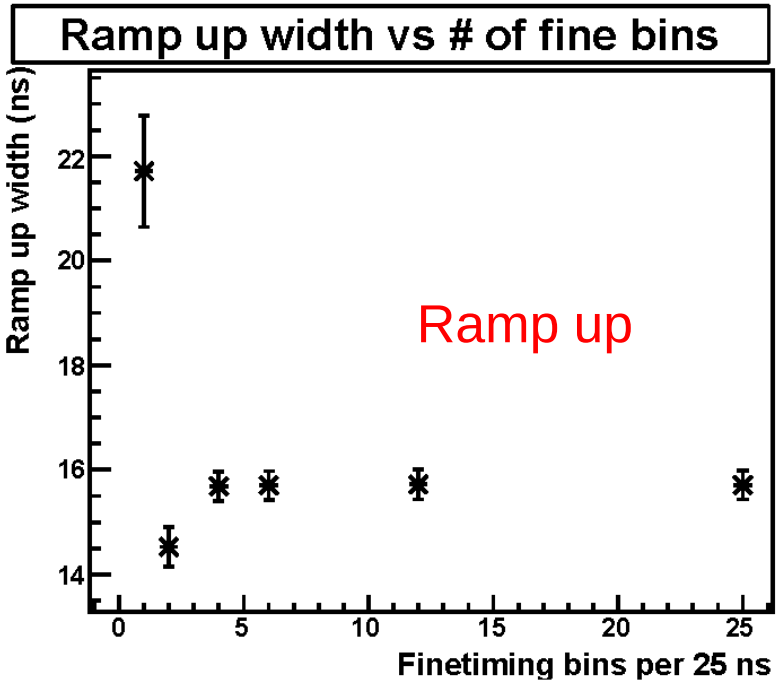



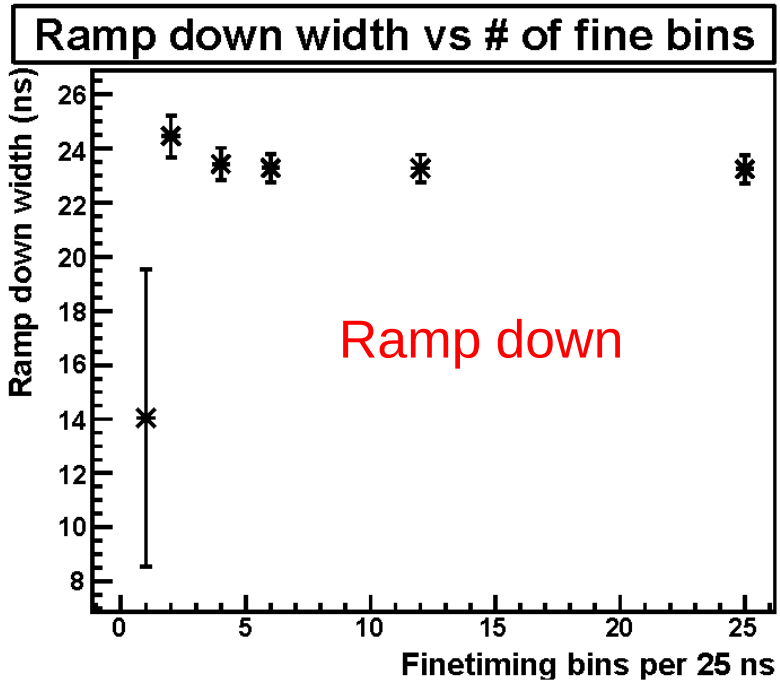



# Reduced reconstruction

- Tested pulse shape reconstruction with varying detail
  - 1,2,4,6,12,25 samples per 25 ns
- Fit parameters stable for ≥ 4 samples per 25 ns
  - Minor instability at 2 samples, major at 1
  - Fixing Ramp up and Ramp down: minor instability at 2 and 1 samples

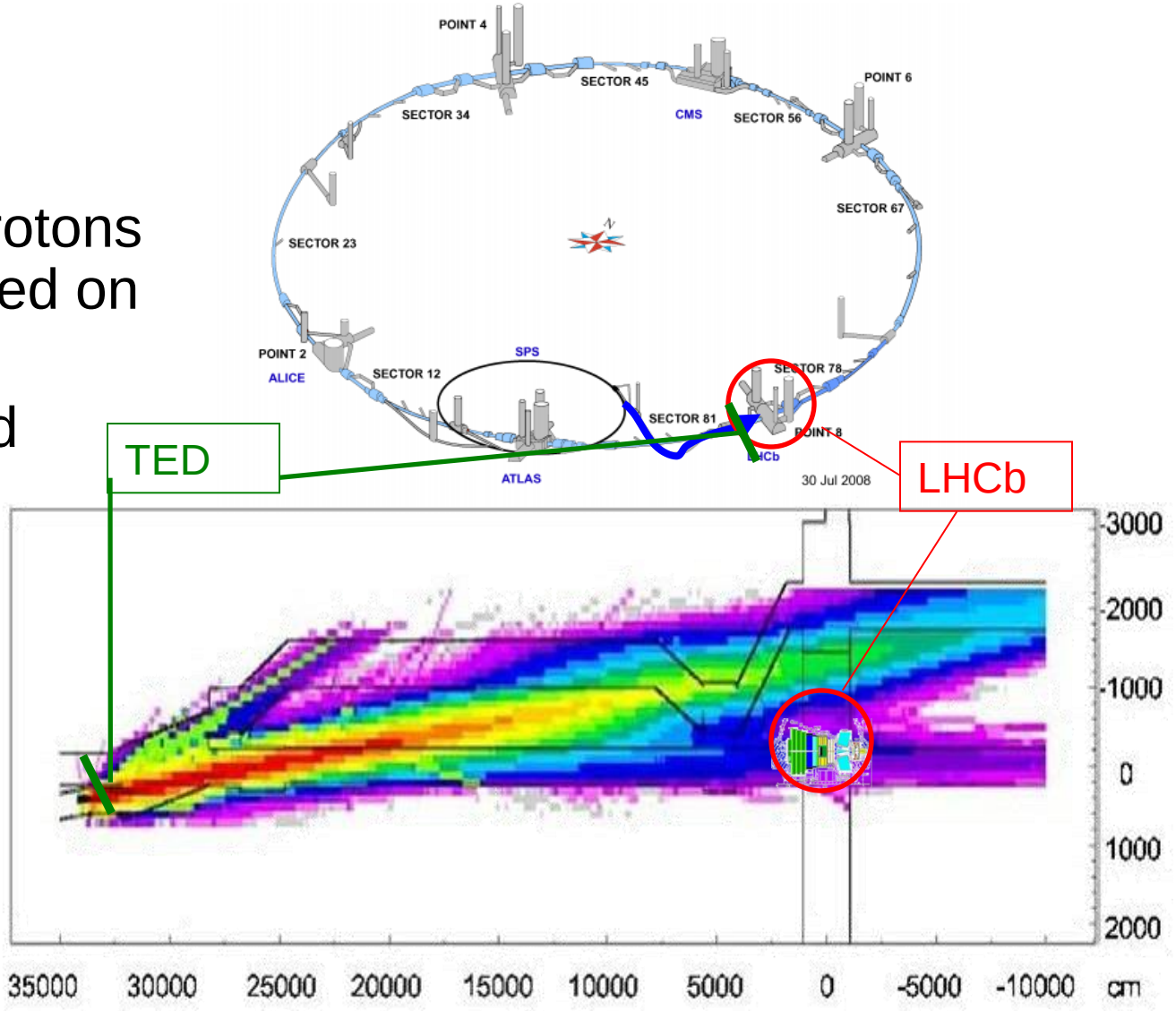


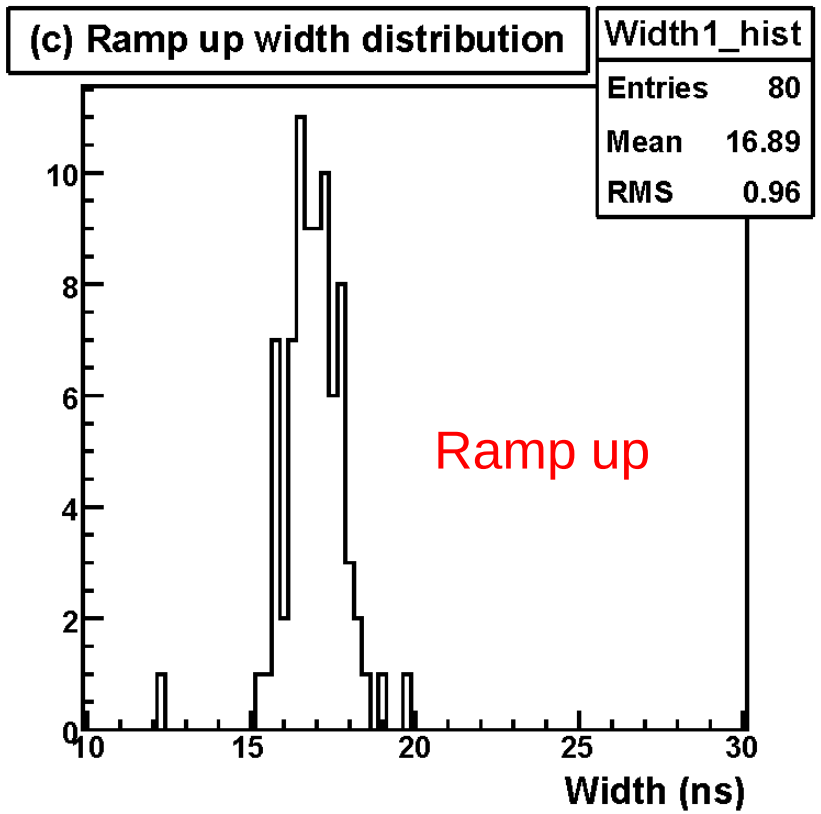
# TED data

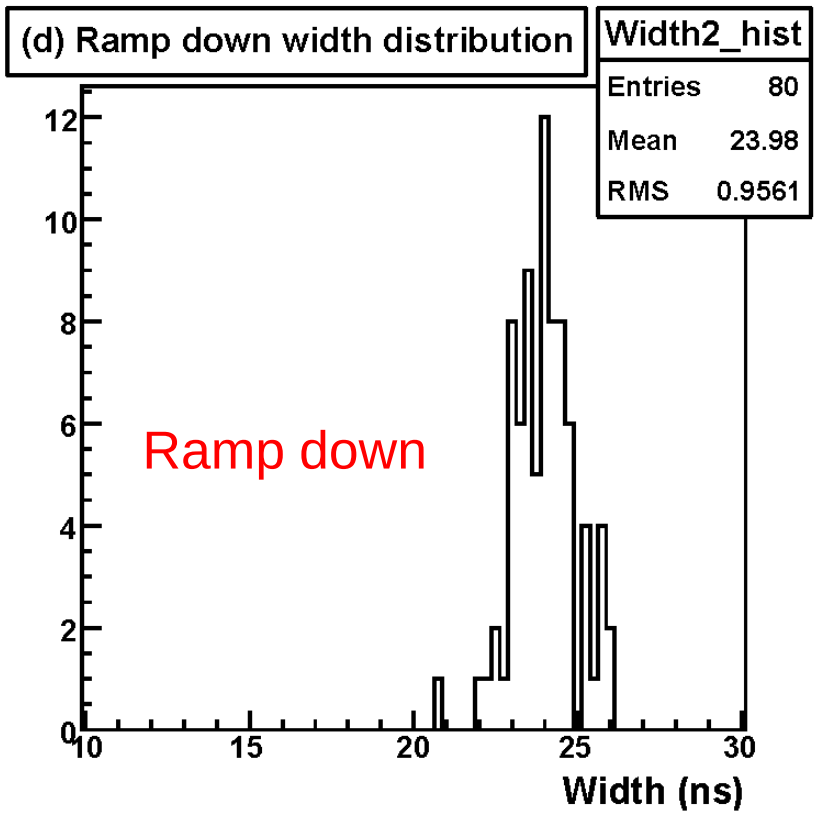
- Trial run, with protons from the SPS fired on TED collimator
- Muons produced detected by LHCb subdetectors
  - Test of timing with real particles
  - Necessary to apply method



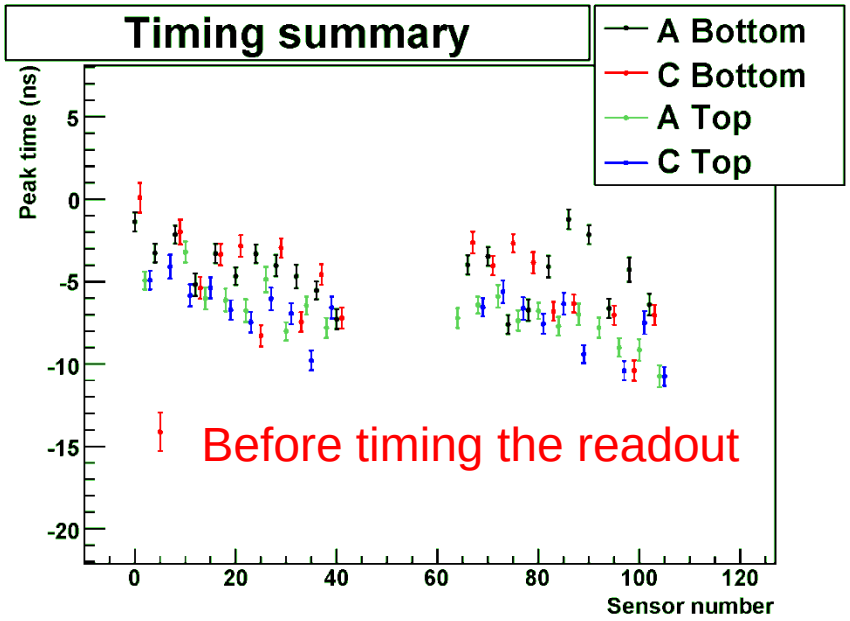
# *TED data*

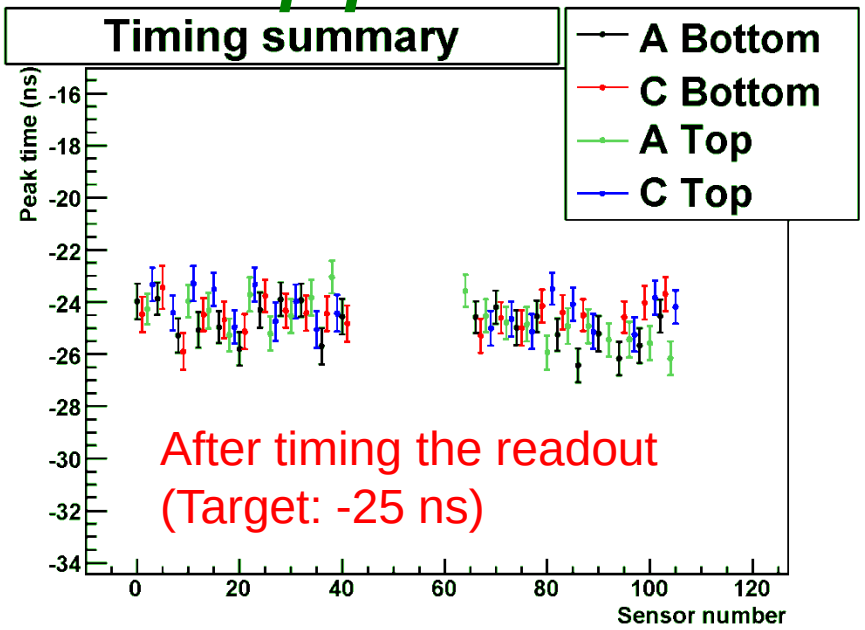
- Data contained 4 samples per 25 ns
- Test pulse vs TED data:
  - Ramp up: 15.7 vs 16.9 ns
  - Ramp down: 23.2 vs 24.0 ns
  - Confirmation of deviation sought during next TED run



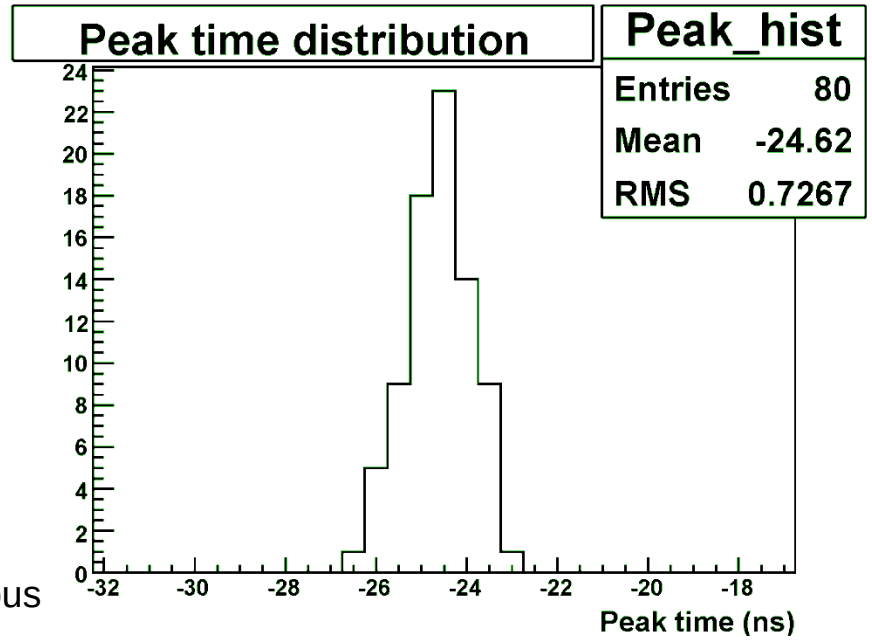



# TED data: Method application




- Prior to setting the timing of readout, large spread of peak times
  - Possible time of flight effect
- Readout timing set with good accuracy
  - Manual corrections needed



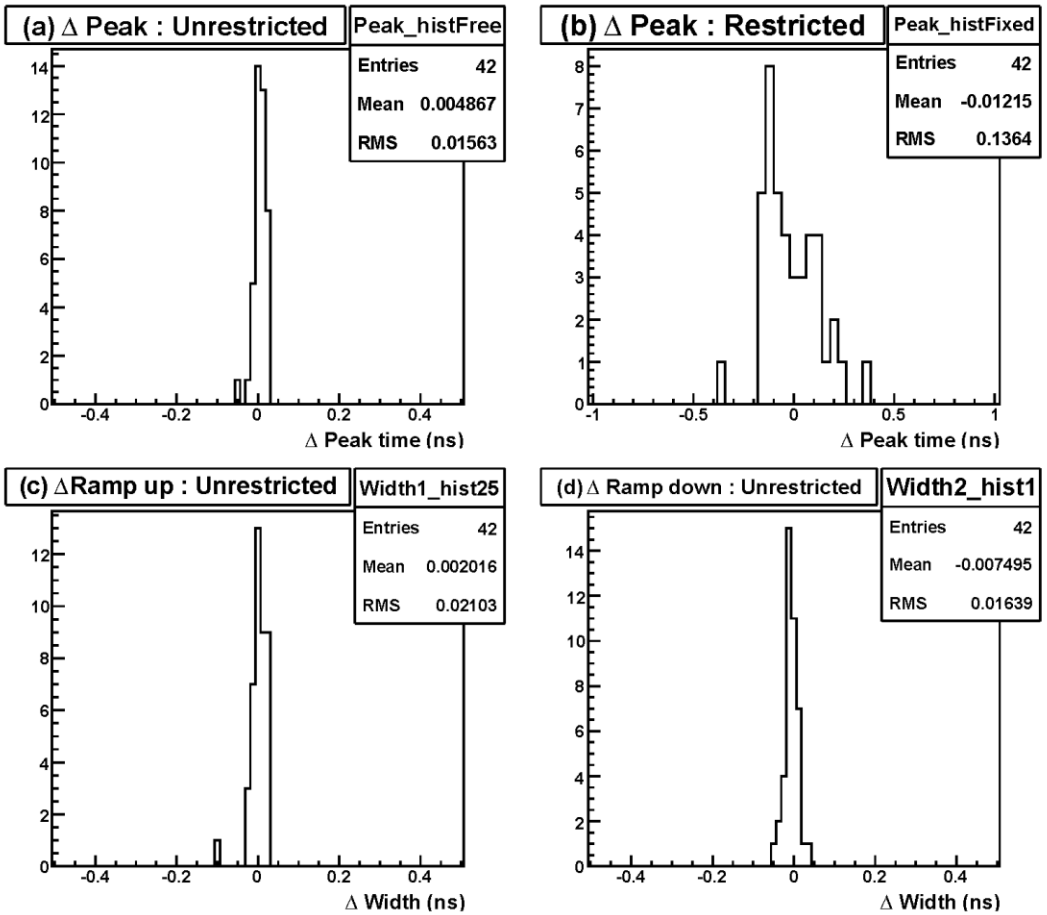
# *Summary*

- Method needed for quick and accurate timing of the VELO readout
- Parameterization of pulse shape with asymmetric gauss effective
- Reconstructed pulse shape with a signal sampling every 6 ns (4 samples) allows accurate parameterization
- Timing of the readout set accurately within 1-2 ns
- To do:
  - Confirm different ramp up/down for real particles
  - Test refined automated timing
  - Improve user-friendliness
  - **Apply it to proton-proton collisions**

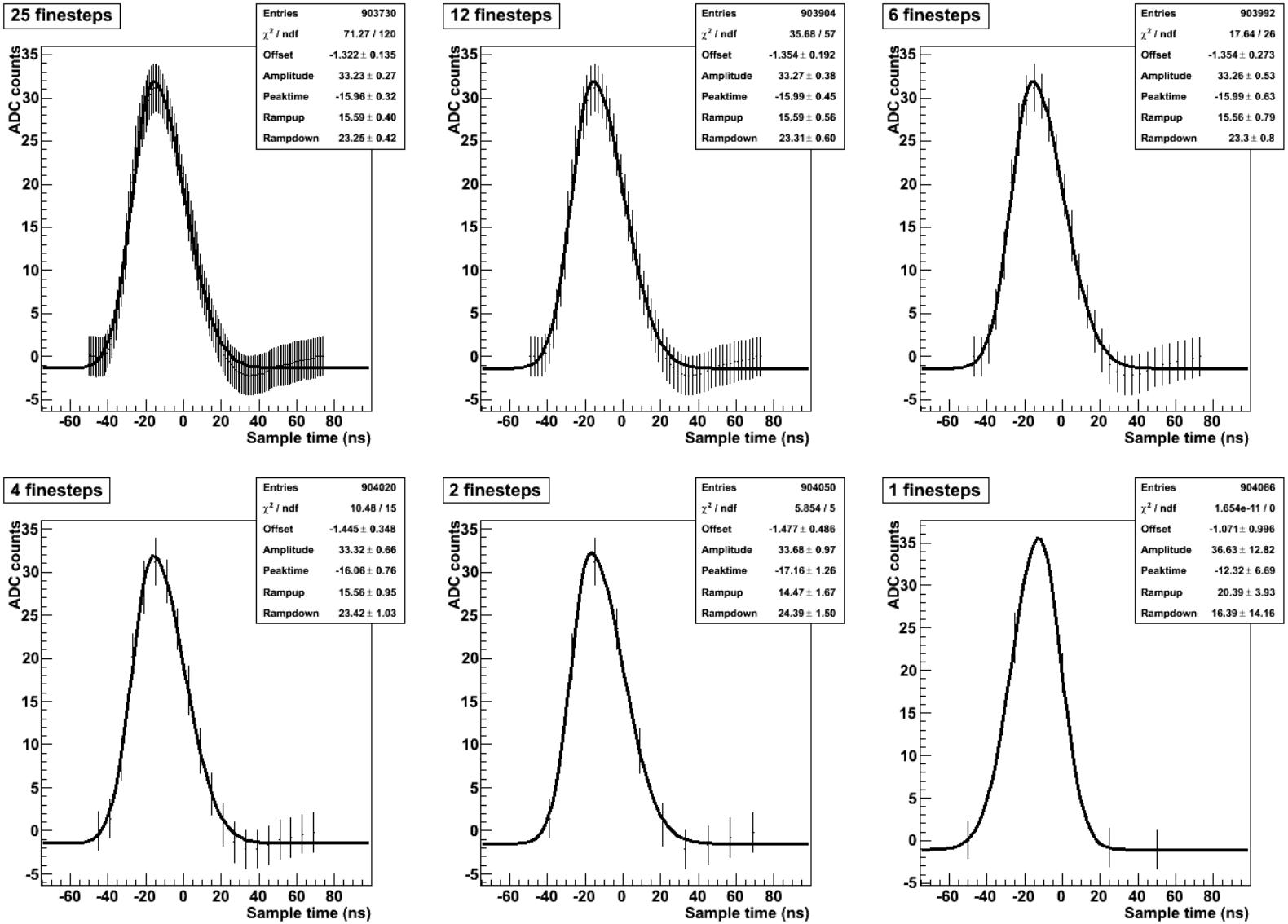
# *Backup slides*

# Consistency check

- Second set of test pulse data
  - Identical settings
  - Used to check consistency of pulse shape reconstruction
  - Both unrestricted (all parameters free) and restricted (Offset and widths fixed)
  - Deviations << 0.1 ns



# Fixed reduced reconstruction



# *Fixed reduced reconstruction*