

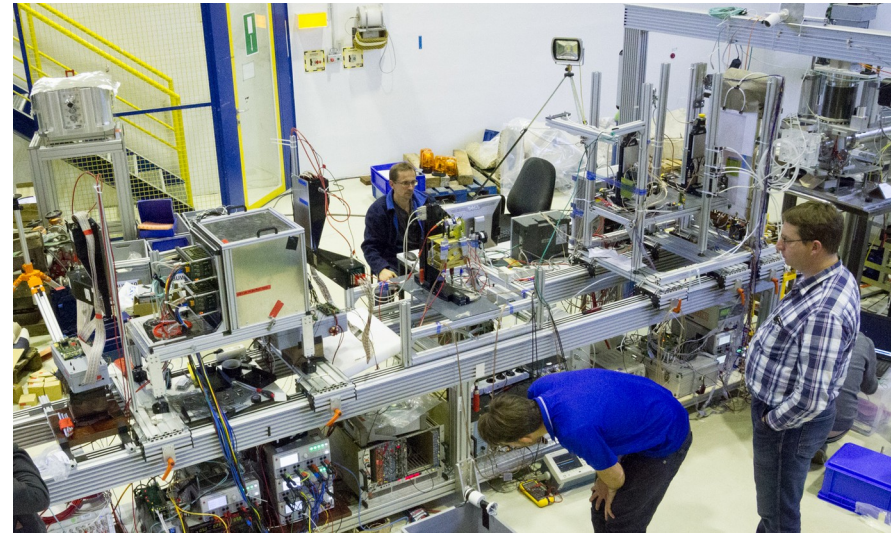
Time resolution of the DiRICH MAPMT readout with and without WLS coverage

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Overview

- Introduction
- DiRICH
 - FPGA based Calibration
- Cosy beamtime
 - RICH Testbox @ COSY
 - Wavelength shifter (WLS) coating
 - Time resolution
 - WLS time constant

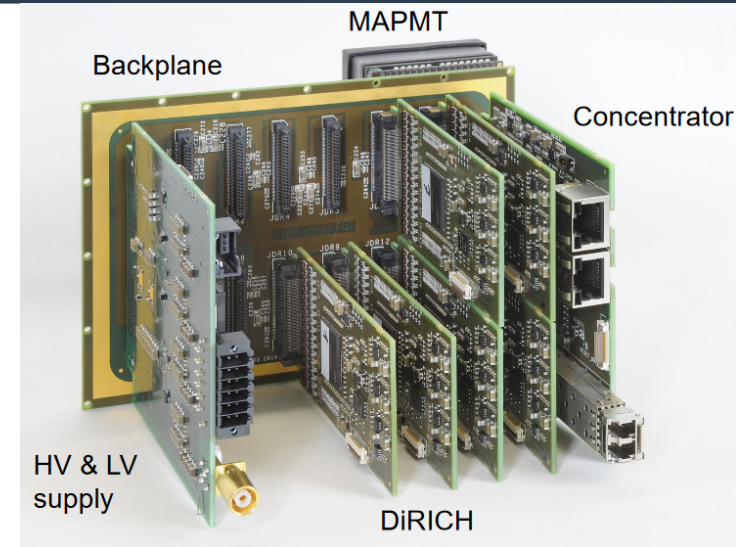


Introduction

- CBM & HADES want to measure the QCD phase diagram at high net baryon densities
- electromagnetic probes are very promising due to their penetrating nature
- need RICH detectors in both experiments for electron identification
- both RICH detectors will commonly use H12700 MAPMTs
 - FPGA based TDC readout ("DiRICH") under development

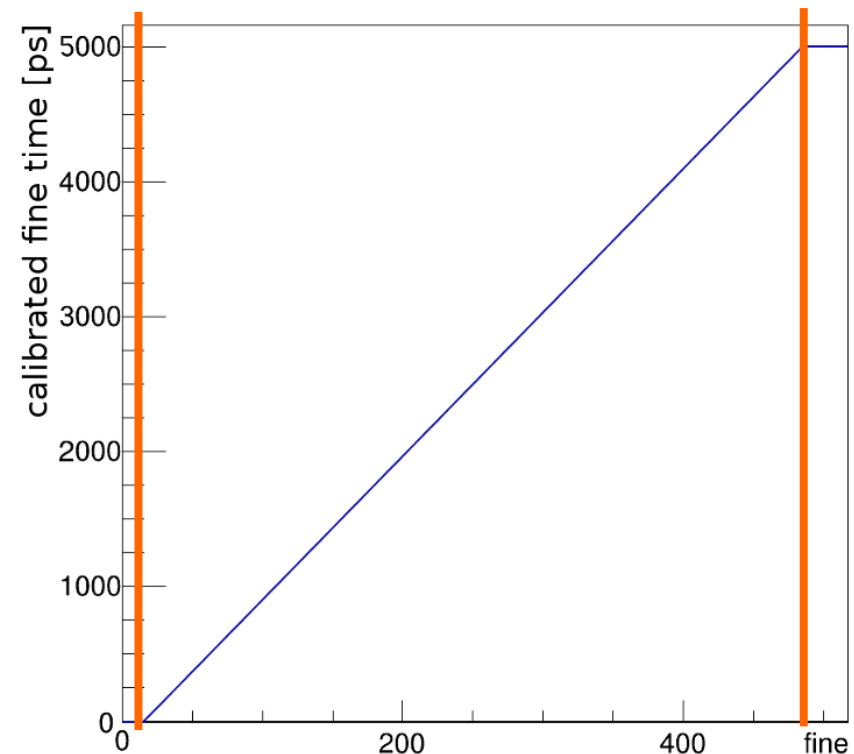
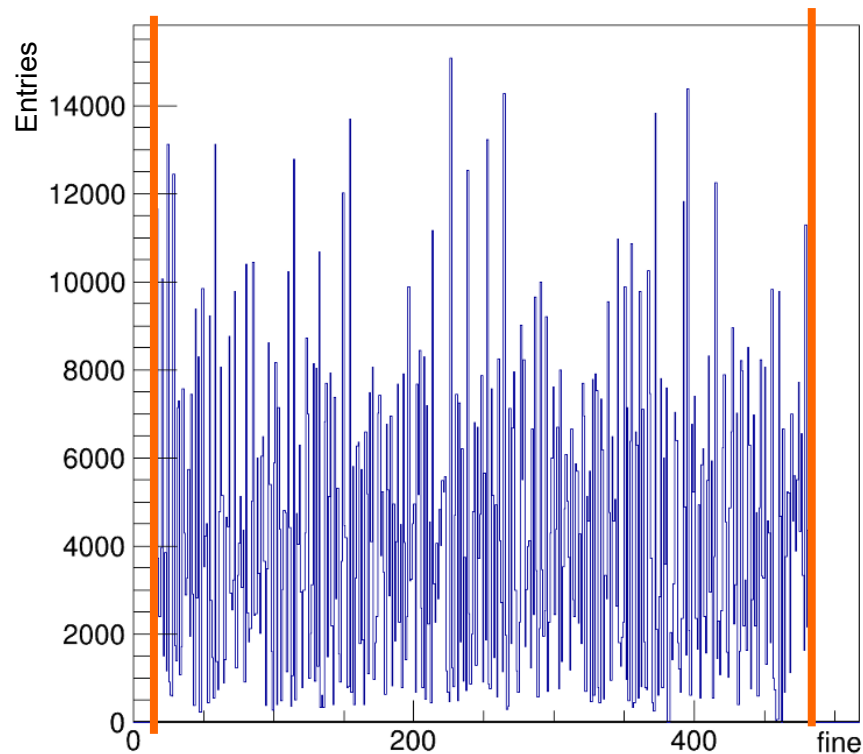
DiRICH TDC calibration

- DiRICH board is FEE of HADES and CBM RICH detector
- Hosts 32 channels with FPGA based Time-to-digital converters (TDCs)
- Each TDC uses delay chain of adder in FPGA
- Change in Temperature influence delay of each adder
 - Temperature calibration for constant TDC functionality
 - Until now: Software based calibration



DiRICH TDC calibration - linear

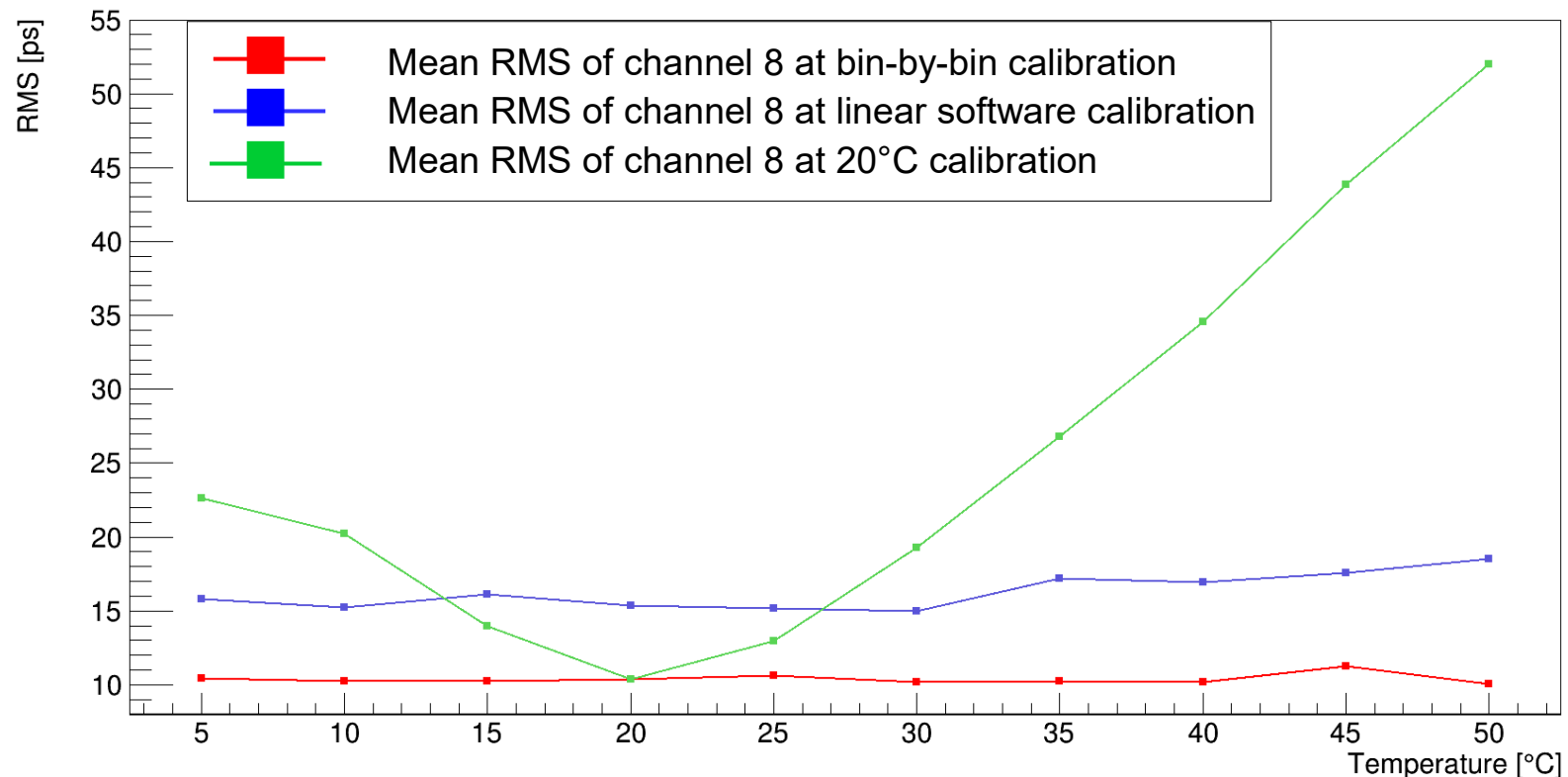
- **Linear Calibration:**
 - calibration with linear curve between lowest and highest fine time value unequal 0
 - Projects this time slot in range between 0 ps and 5000 ps



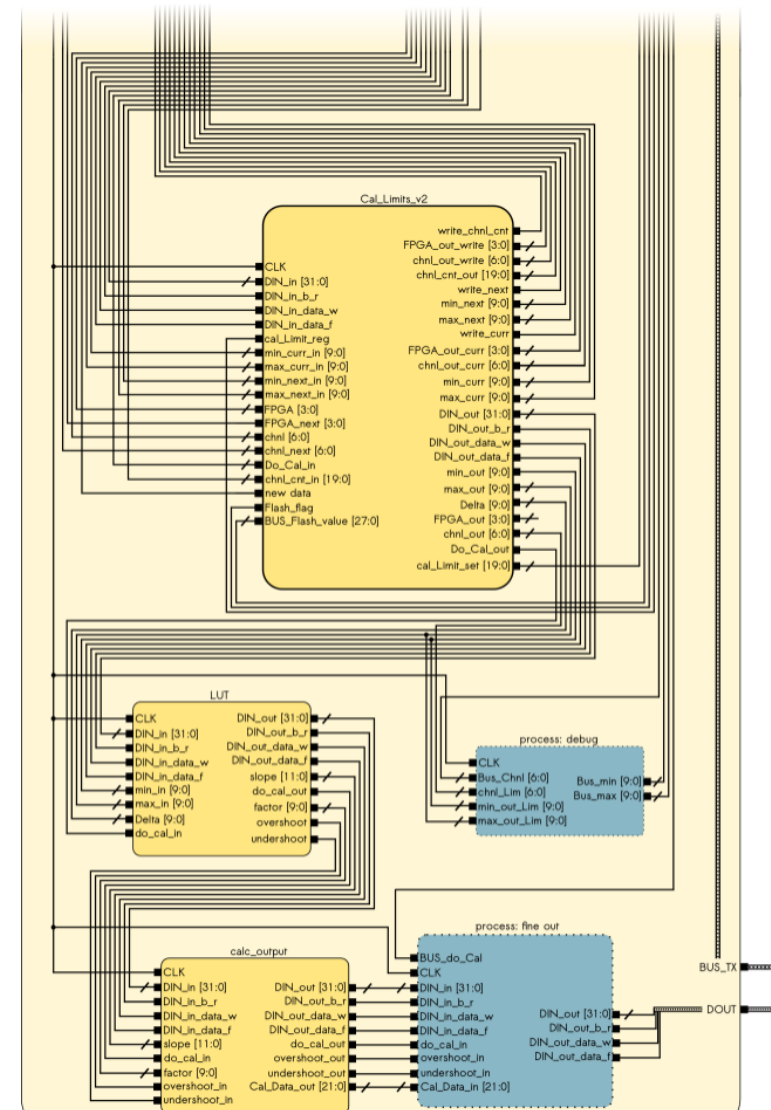
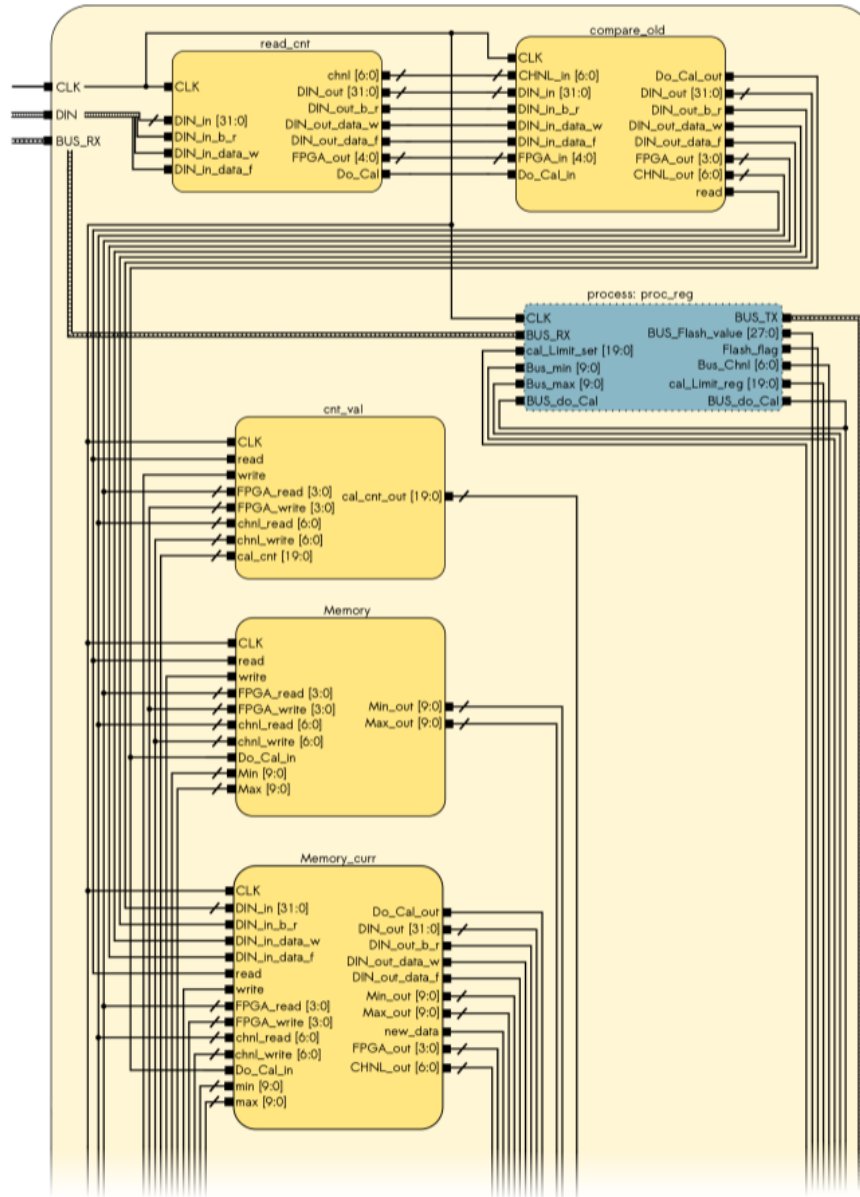
DiRICH TDC calibration

- In software different calibration methods were tested
 - Both calibrations provide constant time precision over a wide temperature range (bin-by-bin calibration has slightly better performance)

Mean RMS of channel 8 at Software Calibration



FPGA: Schematic of calibration entity



top-Entität

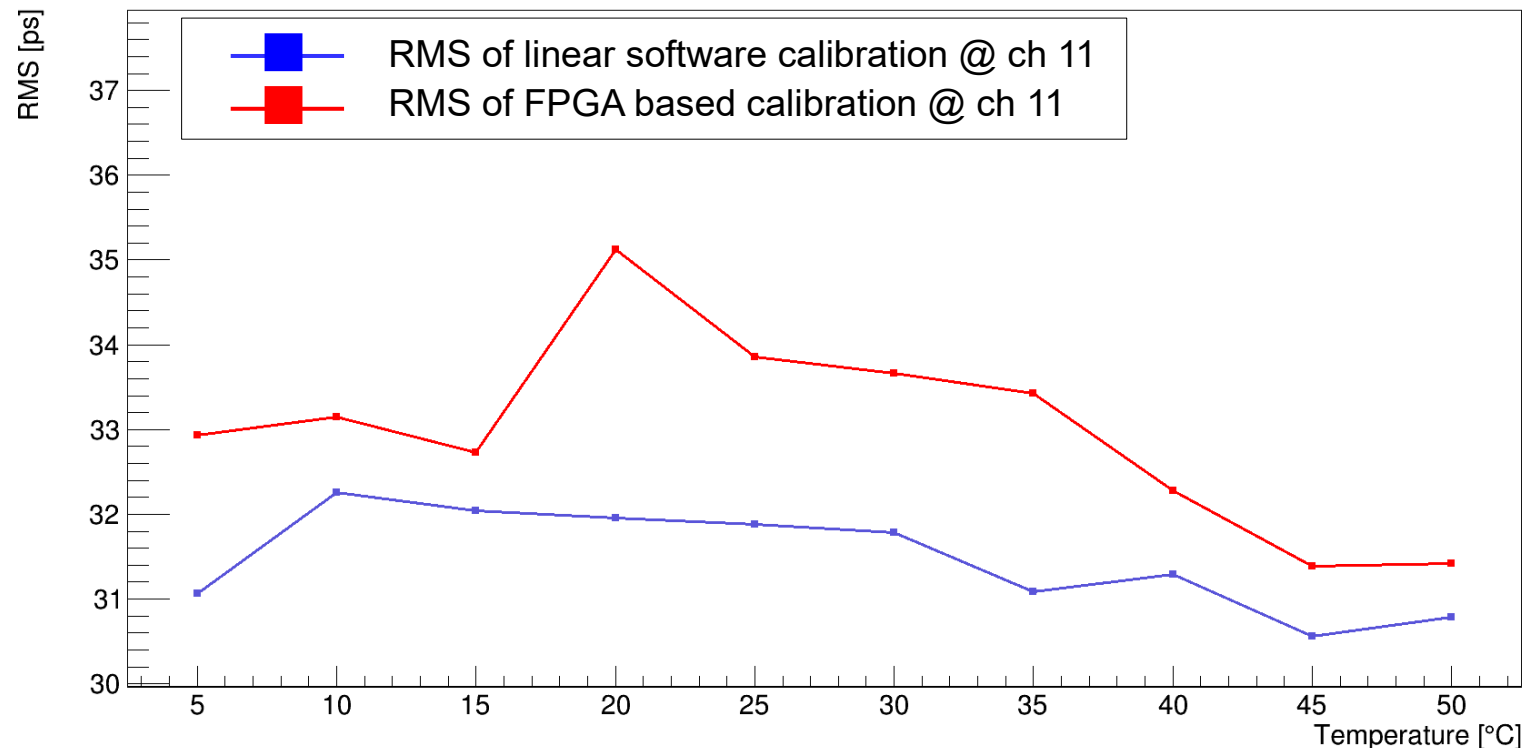
Entitäten

Prozesse

DiRICH TDC calibration

- FPGA based and software based linear calibration are in good agreement
- Precision with high time difference between two channels : 33 ps
- With small time difference: ~ 20 ps precision

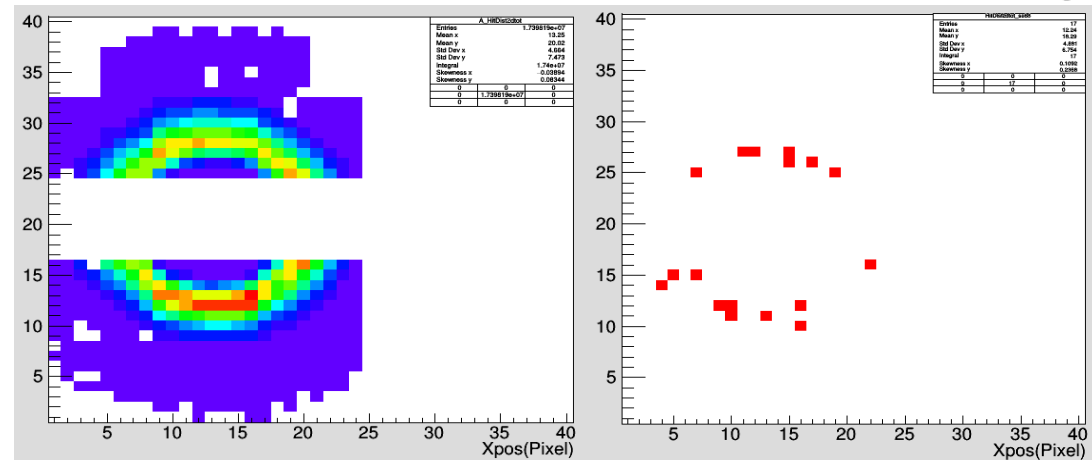
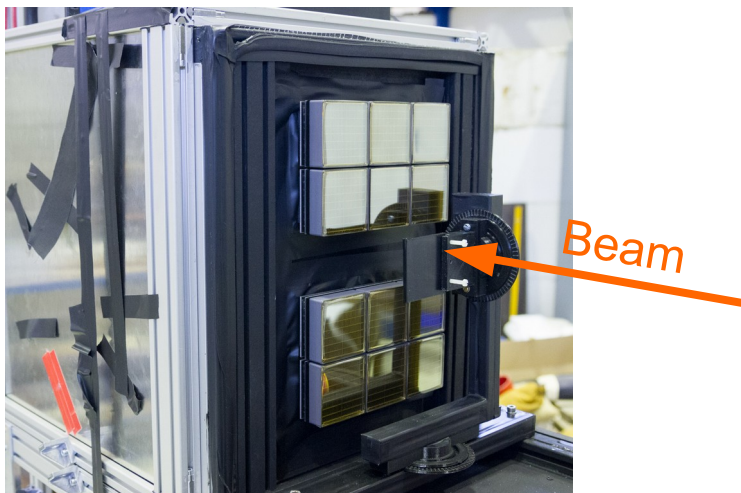
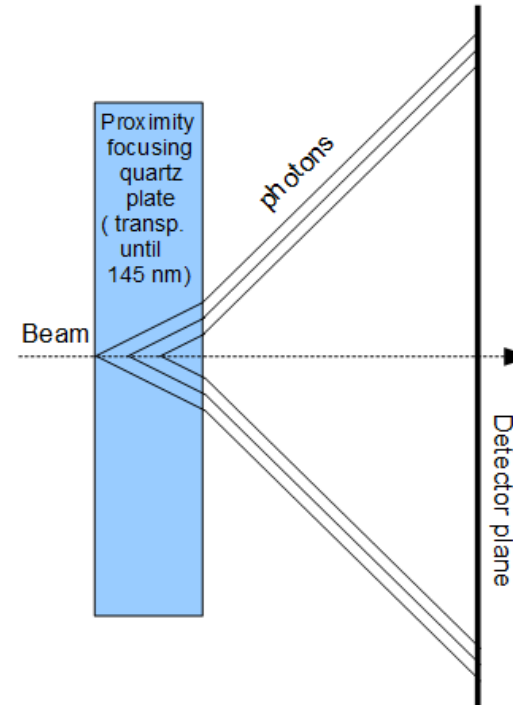
RMS of FPGA based vs linear Software Calibration @ ch 11



RICH testbox @ COSY Nov 2017

- COSY

- Proton beam with $p = 1,25 \text{ GeV}/c$
- proximity focussing setup with quartz plate
- Setup with and without WLS coated MAPMTs
- 2 backplanes á 6 MAPMTs
- 22 DiRICH modules



WLS coating on MAPMTs

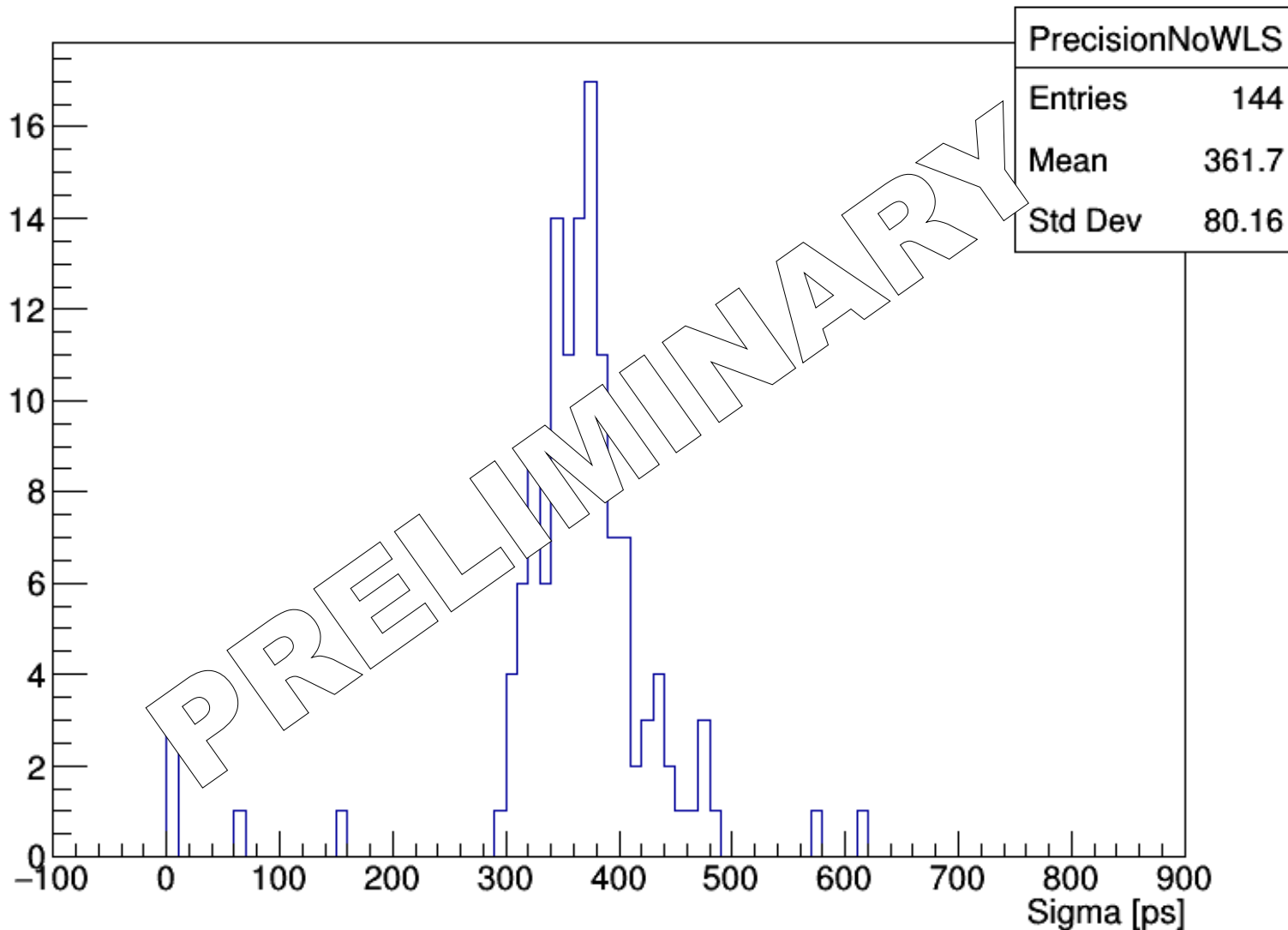
- Wave length shifter (WLS) increases efficiency of the multi-anode-photomultiplier (MAPMT) in the UV-range
 - p-terphenyl
- Increases Number of hits per ring
- Time resolution:
 - Cuts applied: Time range, ToT, ringfinder, ringcenter
 - Channel N to N-1 of one DiRICH are compared
 - distribution with sigma value
 - Sigmas of many of this two channel comparisons give distribution of precision (sigma)
 - Correction with $\sqrt{2}$ due to combination of signals from two channels

Paper to WLS film:

J. Adamczewski-Musch
et al (J. Kopfer, M. Dürr),
NIM A 783 (2015), 43-50

Time precision w/o WLS

Precision of Channel N - Channel (N-1) | NO WLS



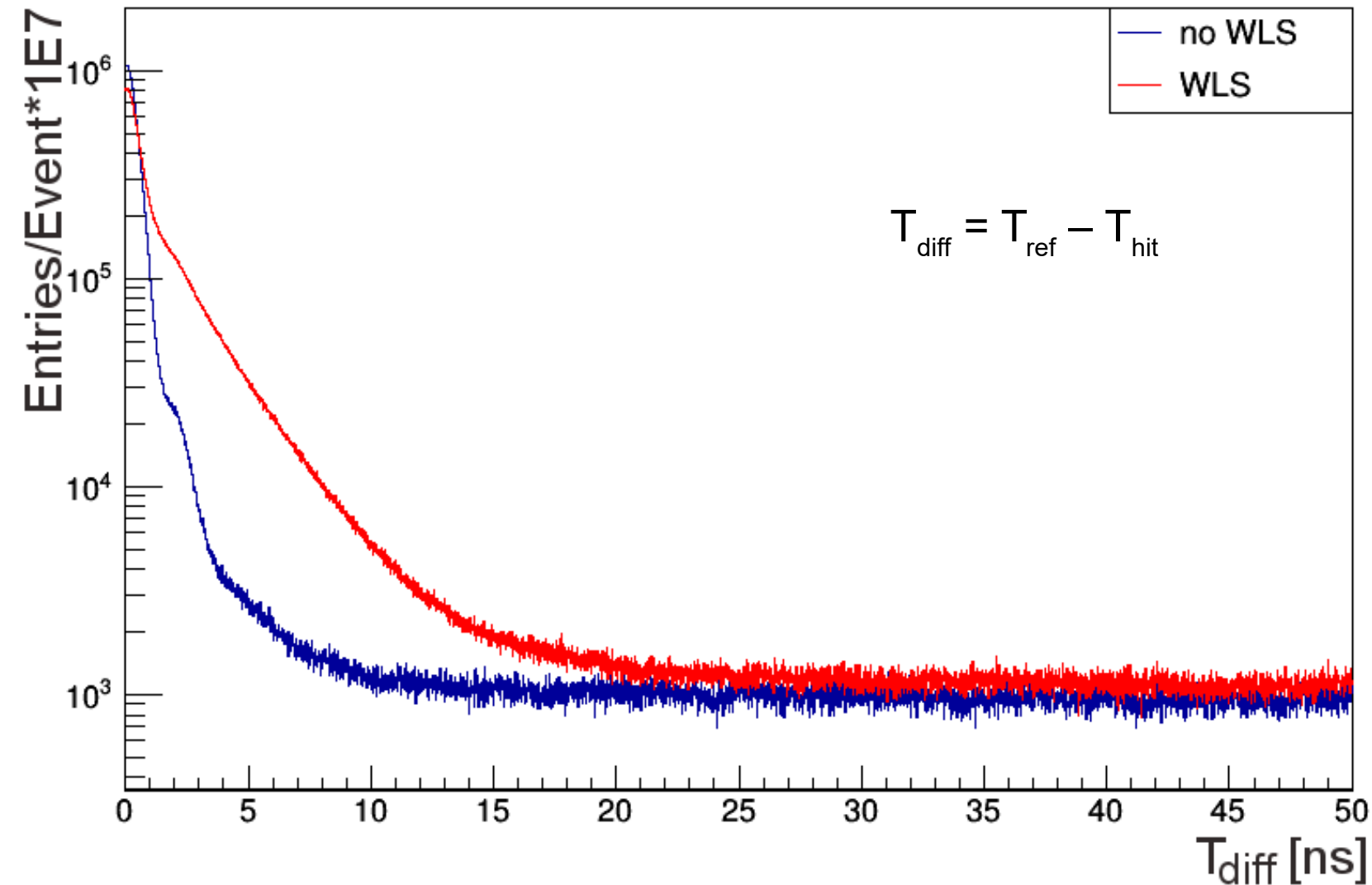
Precision corrected
by $\sqrt{2}$:

255.76 ps

Precision is dominated
by transition time
spread of MAPMTs,
not the DiRICH
electronics

WLS vs. no WLS

Timing Analysis WLS ; Thr. 80

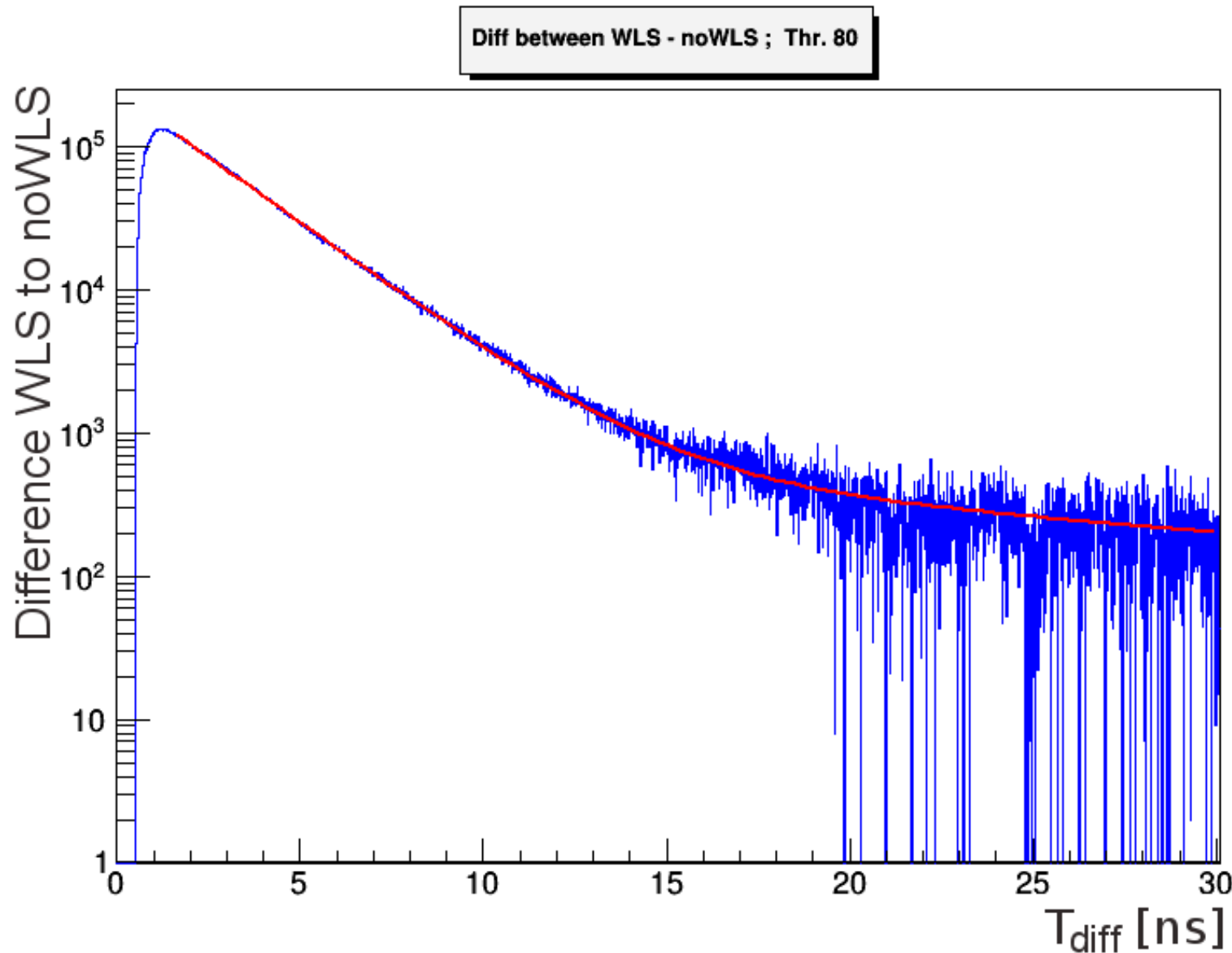


+20% Hits per
Ring with WLS

More informations
in talk of
Vivek Patel

27.2.2018
15:30-15:45
HZO 80

WLS vs. no WLS

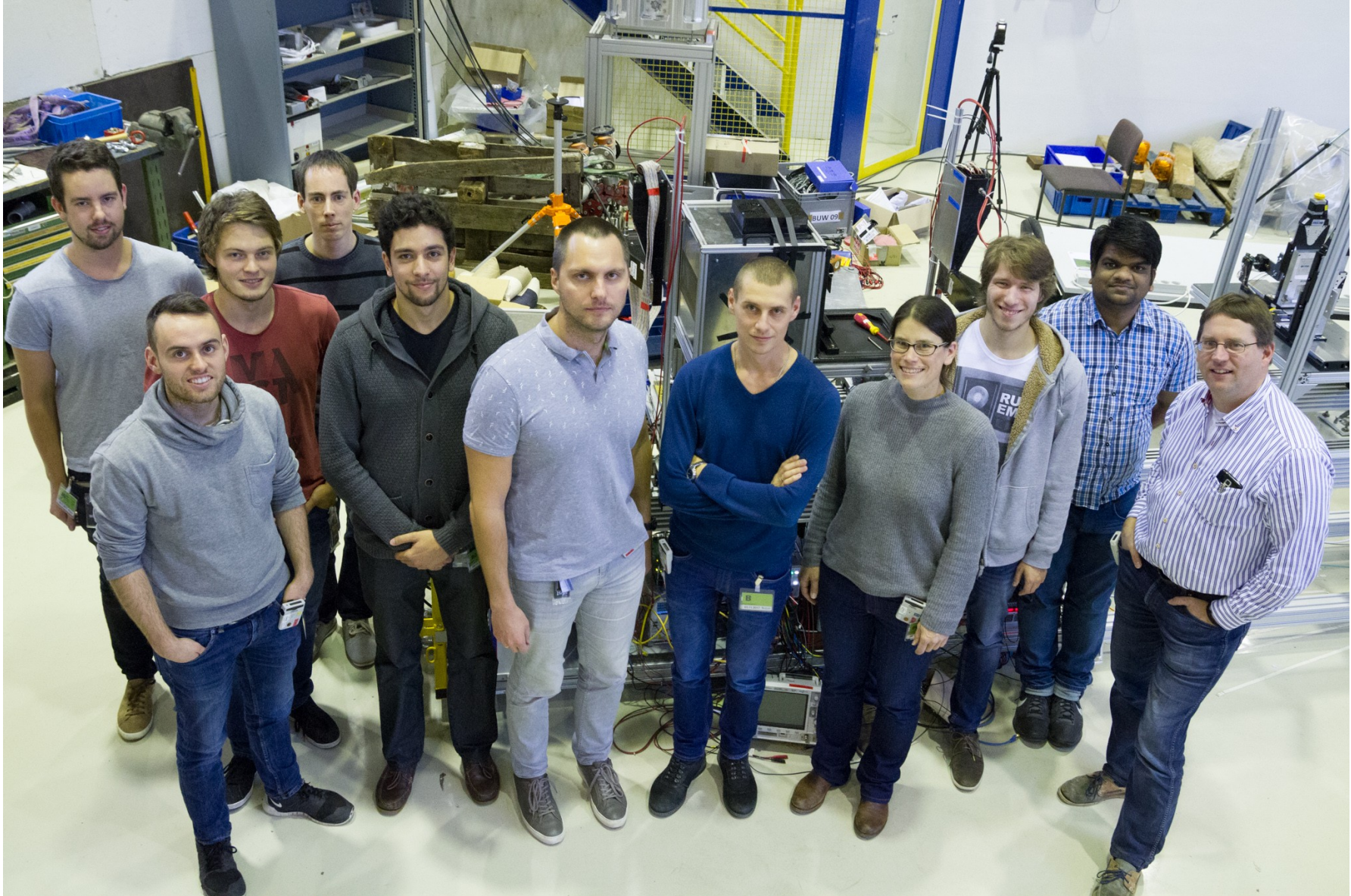


Measured time
constant of WLS:
2.37 ns

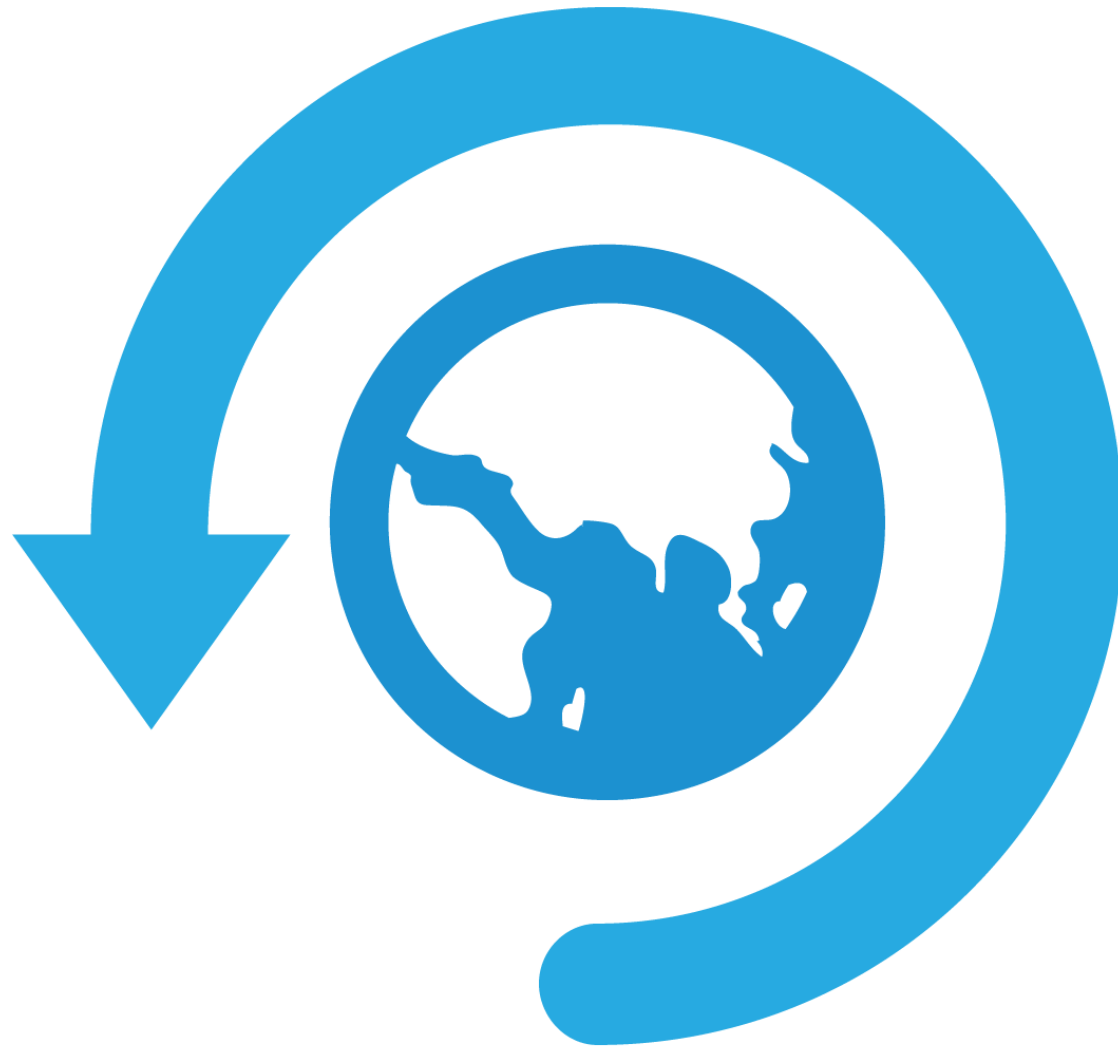
Summary

- **TDC online calibration is working**
 - Will be improved soon
- **DiRICH electronic provides excellent performance**
- **DiRICH for HADES RICH is in mass production**
- **WLS coating works as expected**

Thank you for your attention

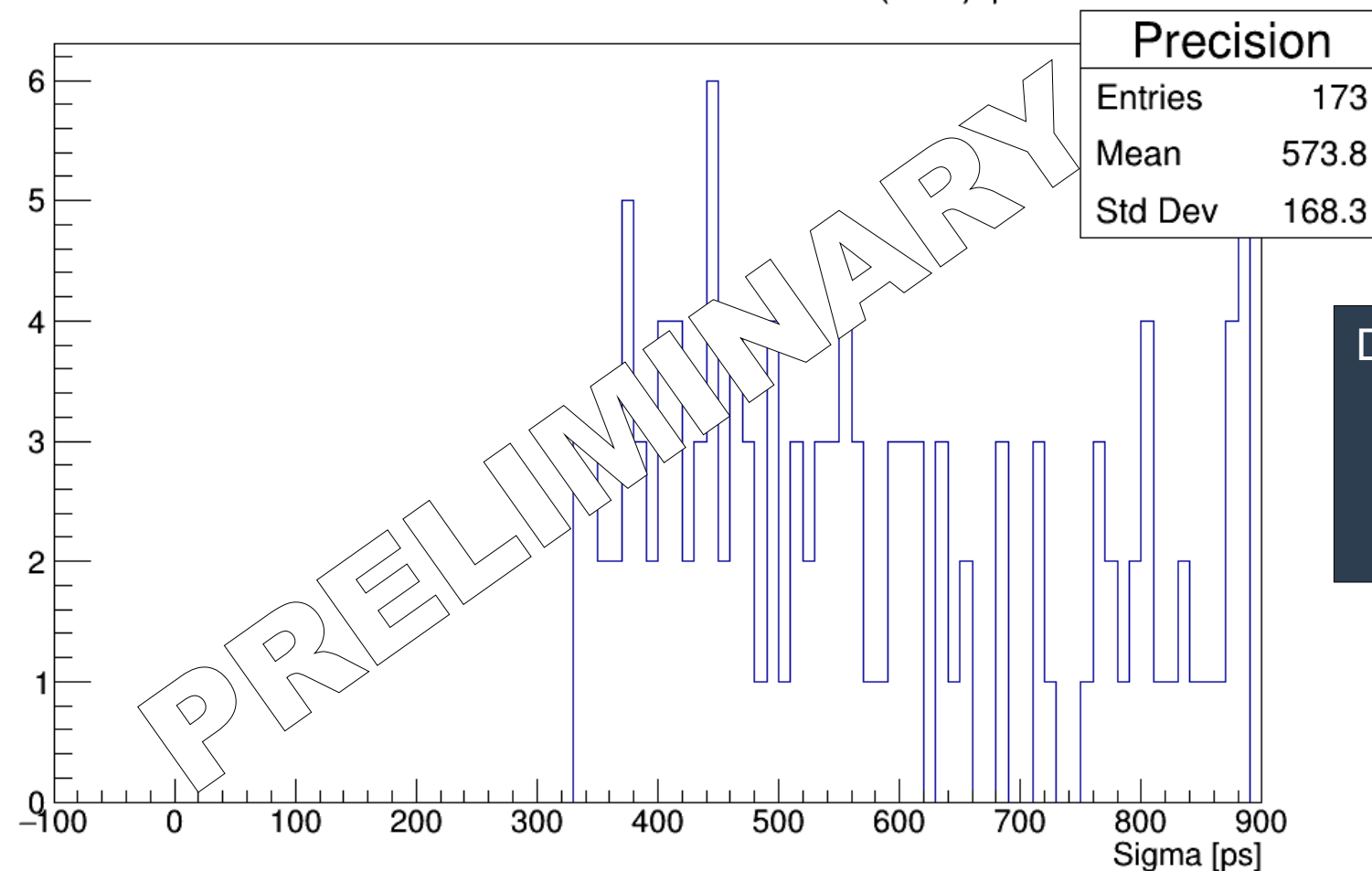


Backup



Time precision w/ WLS

Precision of Channel N - Channel (N-1) |WLS

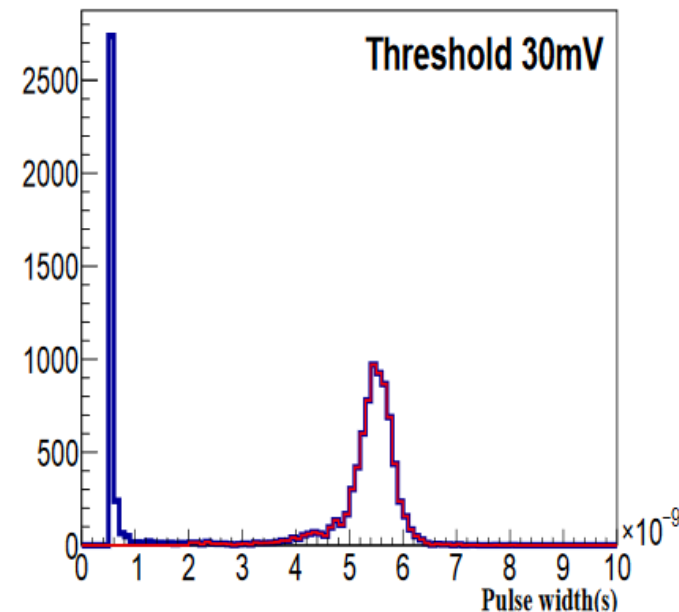
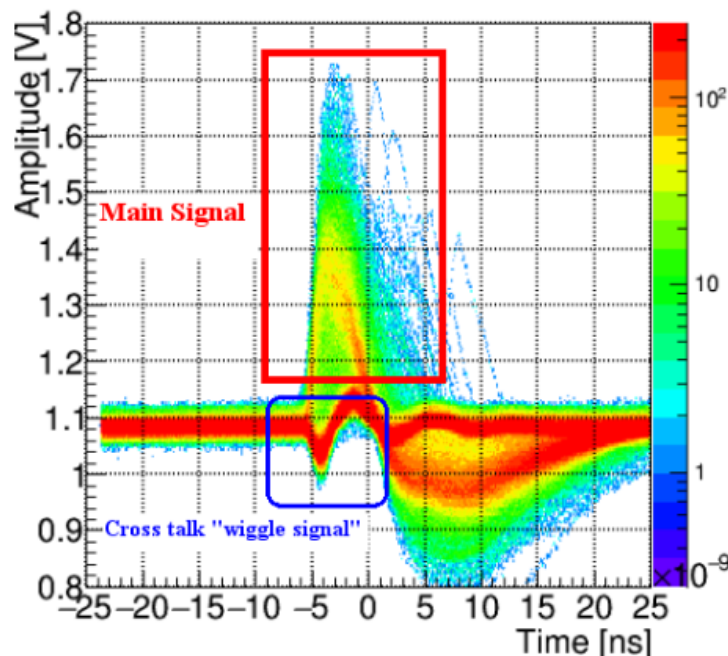


Distribution gets smeared
due to WLS decay time

(slow: 2,37 ns
Fast: 0,8 ns)

Time-over-Threshold (ToT)

- Time over Threshold Cut suppresses
 - Background
 - Cross-talk
- ToT replaces traditional amplitude measurement



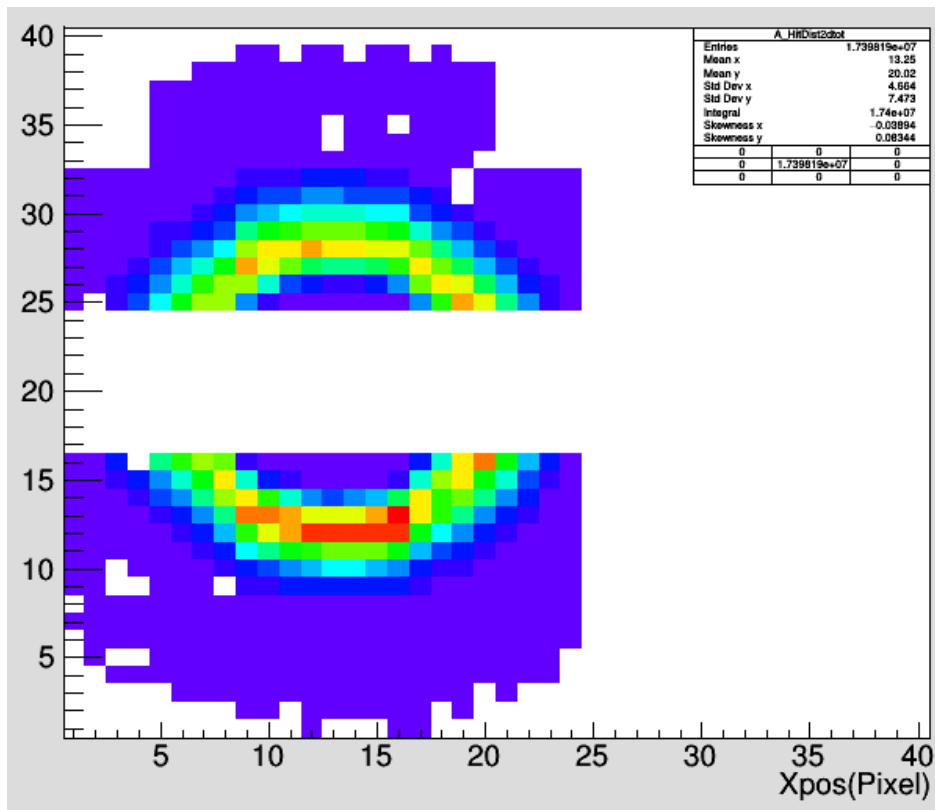
Blue:
no ToT Cut

Red:
ToT cut > 2ns

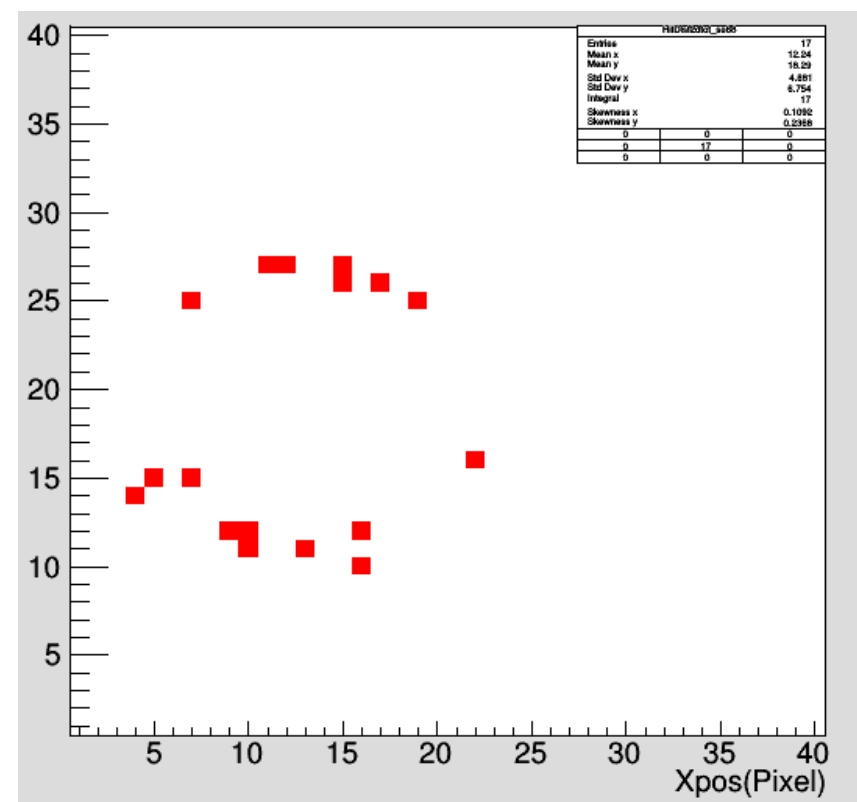
RICH Rings

- Measurement with Quartz plate (proximity focussing)
- With ToT-Cut

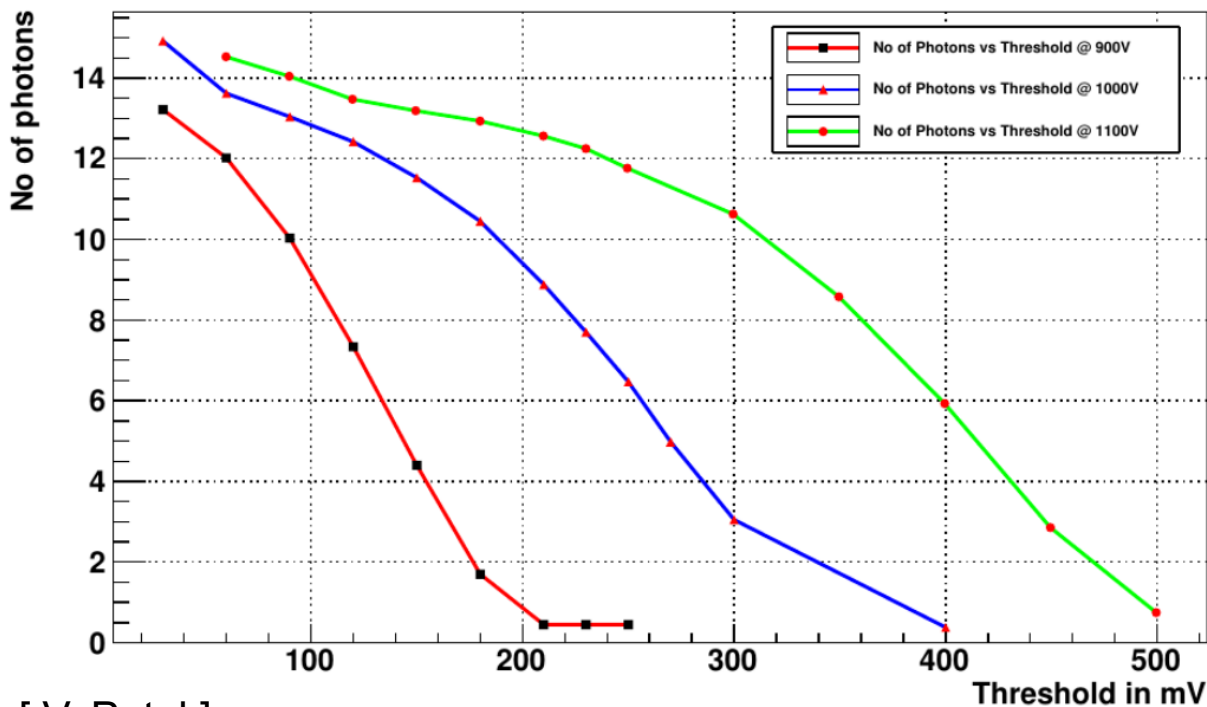
Integrated Rings at thr. 80 w/o WLS



Single event Ring at thr. 80 w/o WLS



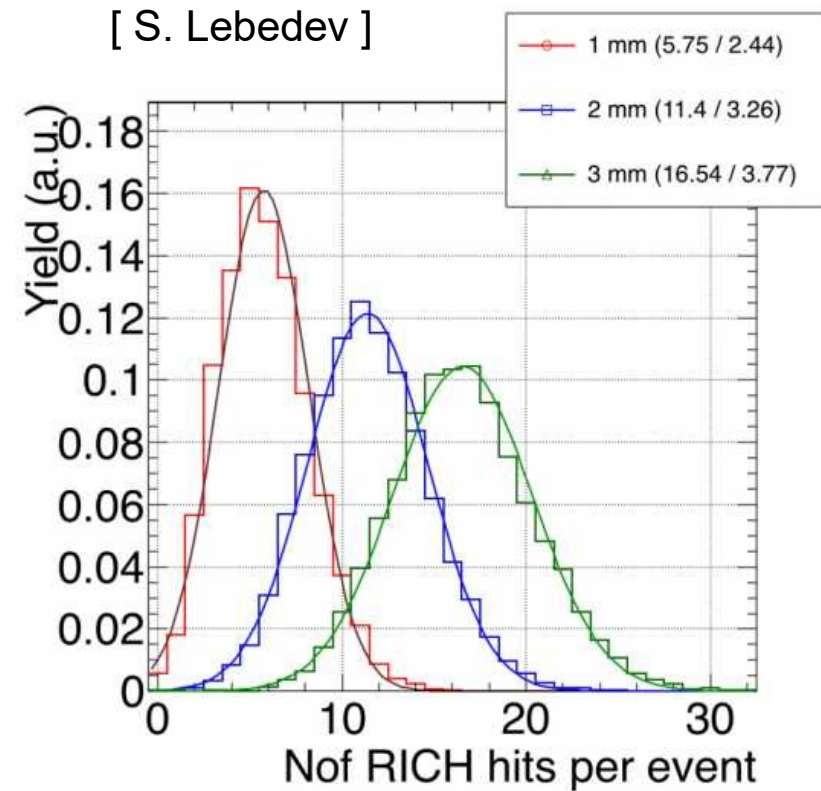
RICH – Photons vs. Threshold



[V. Patel]

Measured number of detected hits/cherenkov ring as function of threshold, for different PMT HV

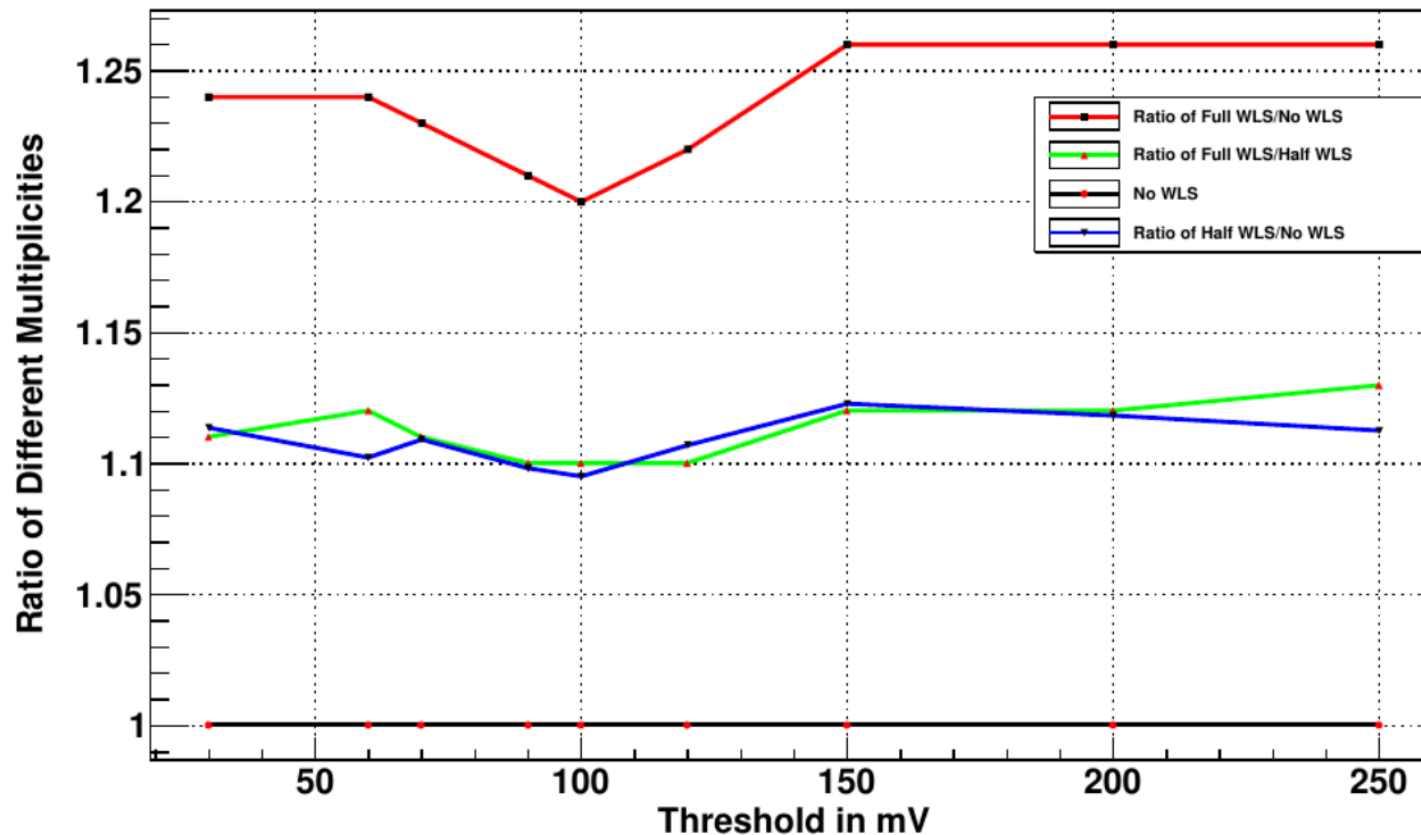
- Up to ~14 detected photoelectrons measured
- Around 16 detected photons expected from simulation (but for 100% coll. efficiency)
- Preliminary result: good agreement ! but need further MC tuning



GEANT Monte Carlo simulation
(collection efficiency 100 %)

WLS hit increase

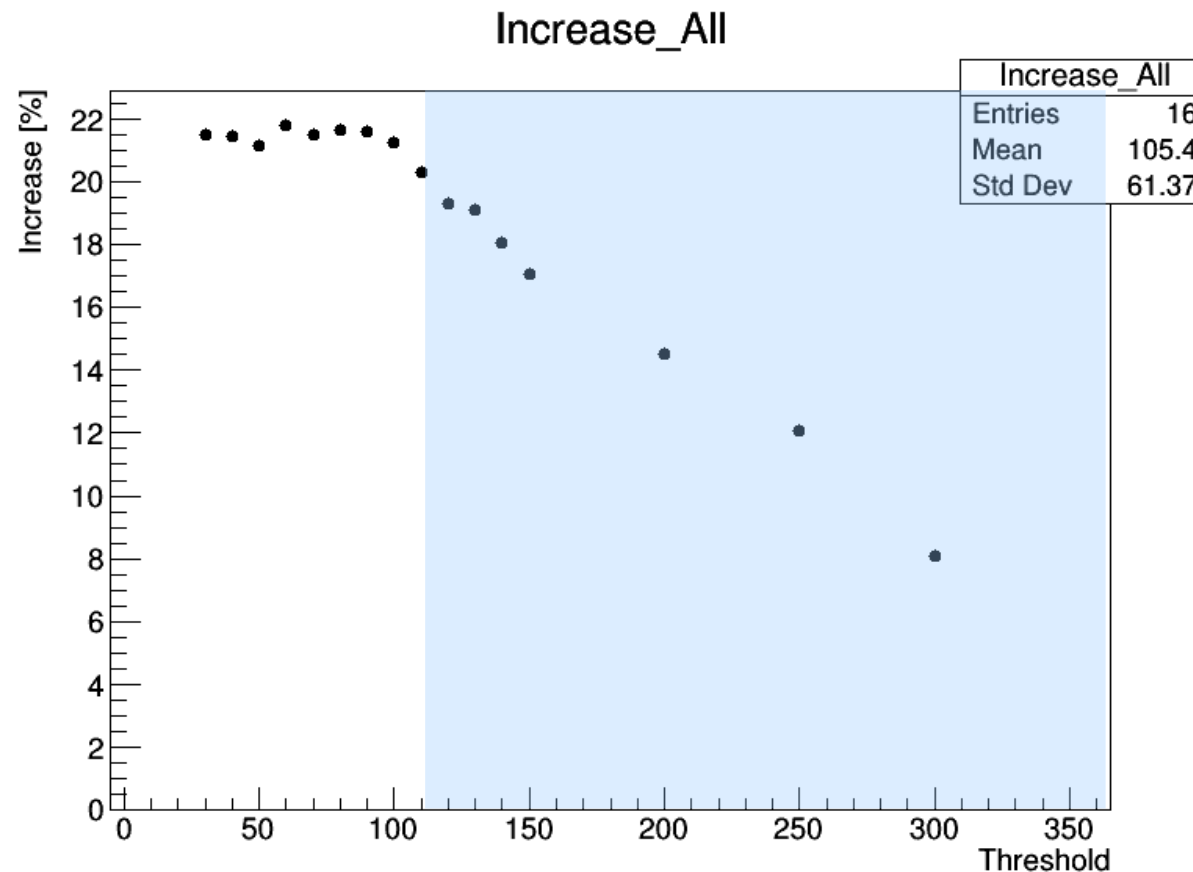
- A wavelength shifter coating (WLS) improves the RICH in UV region
- Increase of number of Hits per Ring/Event



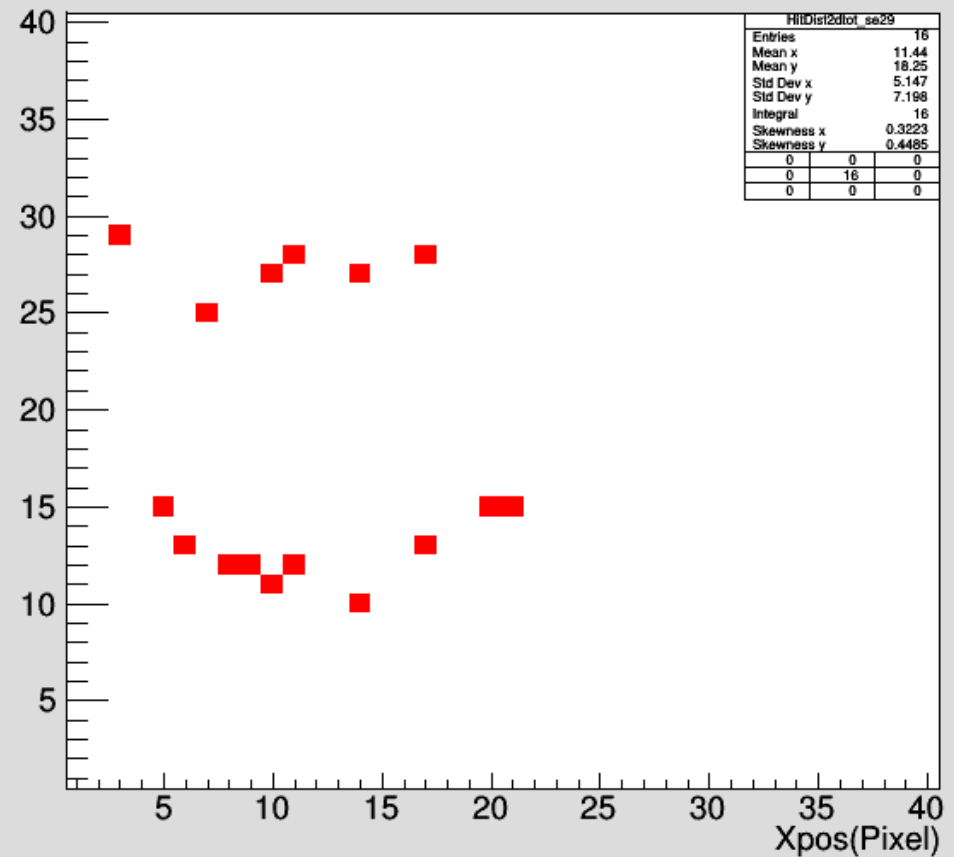
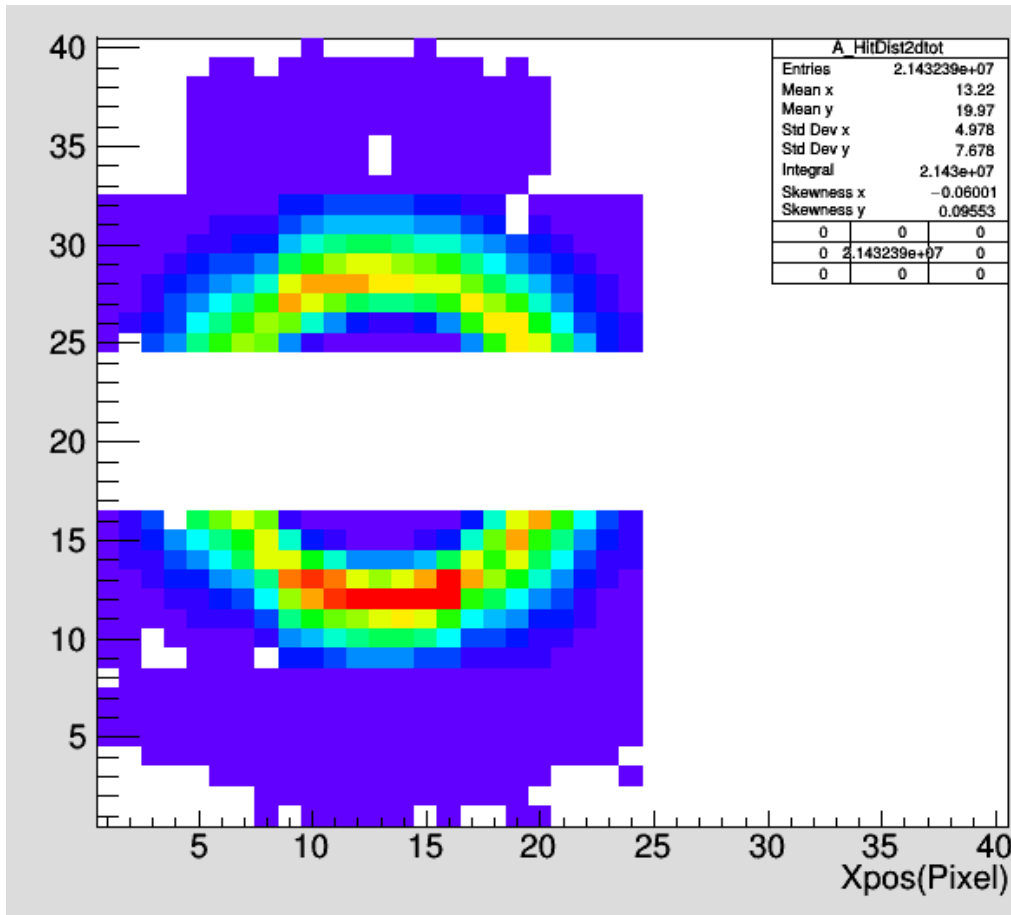
[V. Patel]

WLS hit increase

- Difference at higher threshold in different methods
 - Influence of cuts

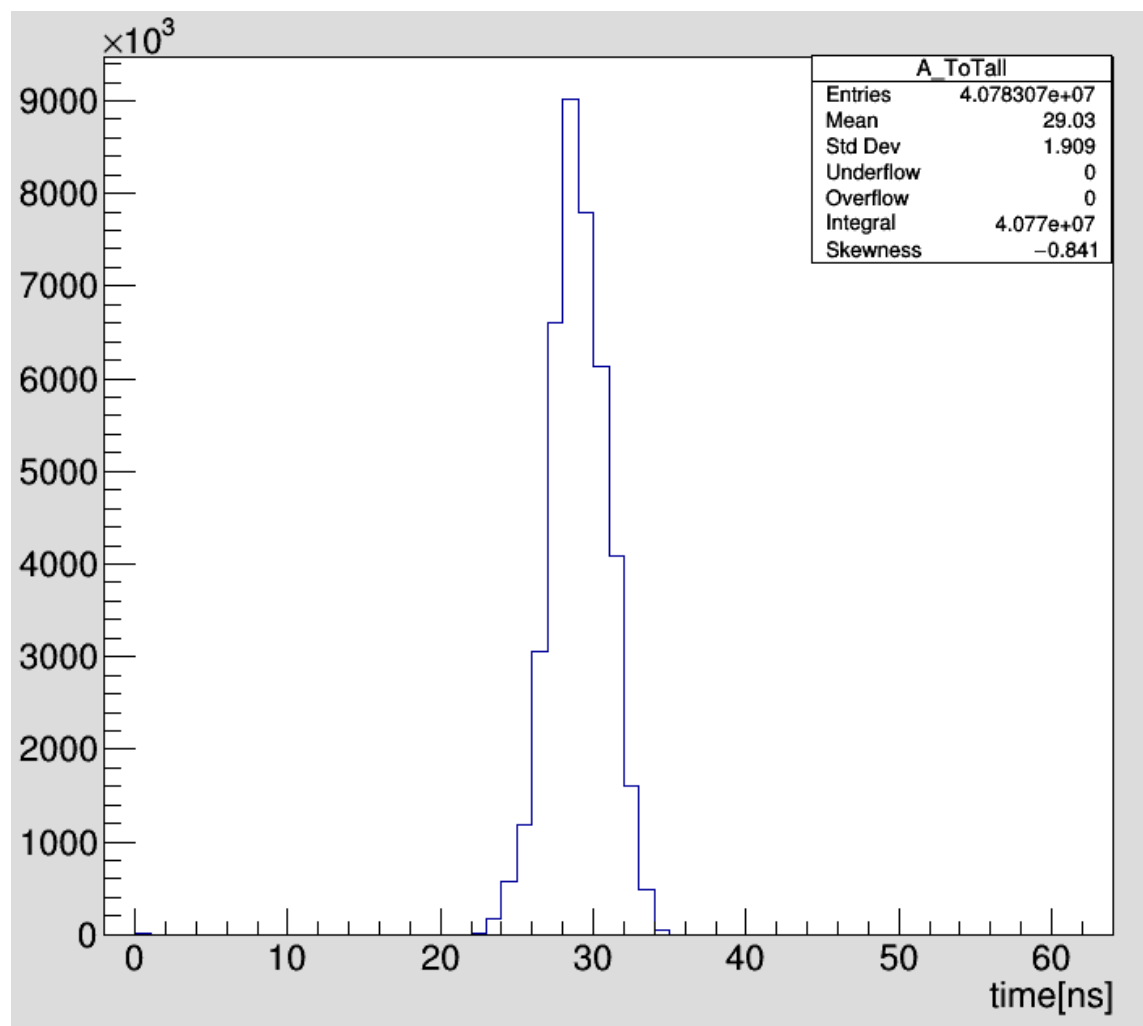


RICH ring w/ WLS



ToT spectra

- ToT is around 30 ns



ToT spectra

- ToT is around 30 ns

