

Signal digitization in the AGS

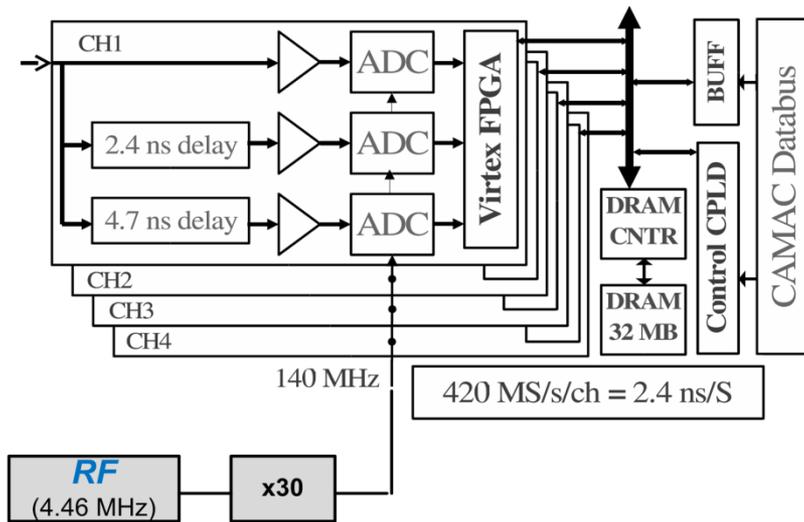
H=8 two bunch operation

AGS harmonics in the Run13

- Previously AGS operated in a single bunch H=12 mode
 - ✓ 12 buckets
 - ✓ RF frequency – 4.46 MHz (224 ns period)
 - ✓ only one bucket was filled
- To fill RHIC faster, AGS in 2013 will operate in 2 bunch H=8 mode
 - ✓ 8 buckets
 - ✓ RF frequency – 2.97 MHz (336 ns period)
 - ✓ two consequent buckets will be filled

The Polarimeter WFD clocks are derived from the RF frequency.
Migration to the H=8 may affect the WFD performance.

Simplified block diagram of one WFD channel



Before Run13

- (RF 4.46 MHz) $\times 30 \rightarrow$ (WFD 140 MHz)
- WFD sampling time is 7.2 ns
- In every channel, input signal is split (with 2.4 ns relative delays) to 3 ADCs ("RBG colors")
- The effective sampling time is 2.4 ns

Firmware algorithm

- **Bunches are separated by counting of clock ticks**
- Only 2 clock ticks per bunch (15 and 30) are **hardcoded** in the firmware
- Signals are processed in every bunch but only in a predefined time window
- Signal smoothing: $a_i \rightarrow \tilde{a}_i = (a_{i-1} + a_i + a_{i+1}) \cdot 5/16$
- Searching for baseline
- Searching for signal maximum A_{max}
- Time determination (at $A_{max}/4$ with a step ~ 1.2 ns)
- Four byte output: T_{max} , t , A_{max} , Int (+ event identification)

Required DAQ changes for the H=8 operations

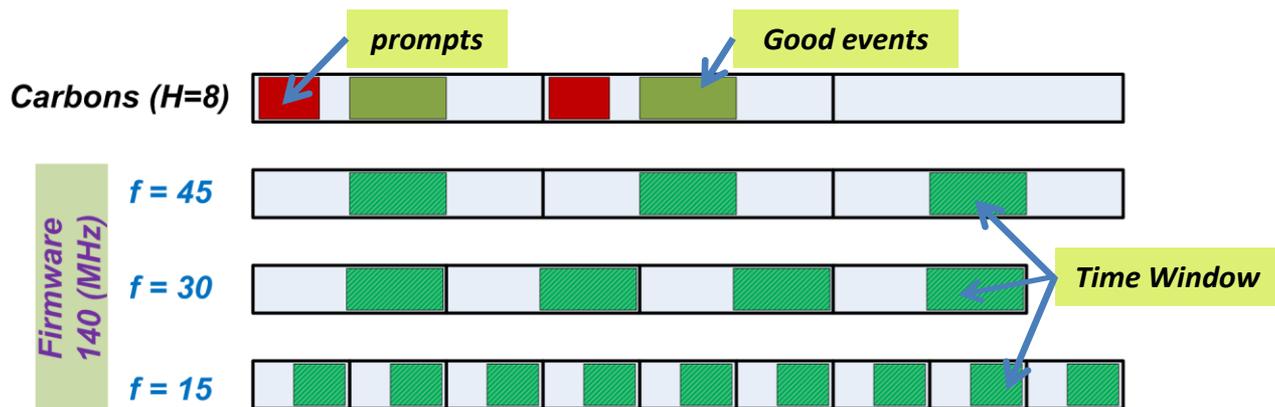
To keep the WFD performance:

- RF to WFD frequency multiplication factor: 30 → 45
- ❖ Number of clock ticks per bunch in the firmware: 30 → 45
- ✓ Some minor changes in online/offline software



- We can easily change from 30 to 45 - this is a question of jumpers in the frequency multiplier module.
- ❖ The number of points per bucket is coded in many places in the firmware. It is quite difficult to change it.
- ❖ I still remember entertainment of just firing new firmware into all WFDs, which I had ~5 years ago.

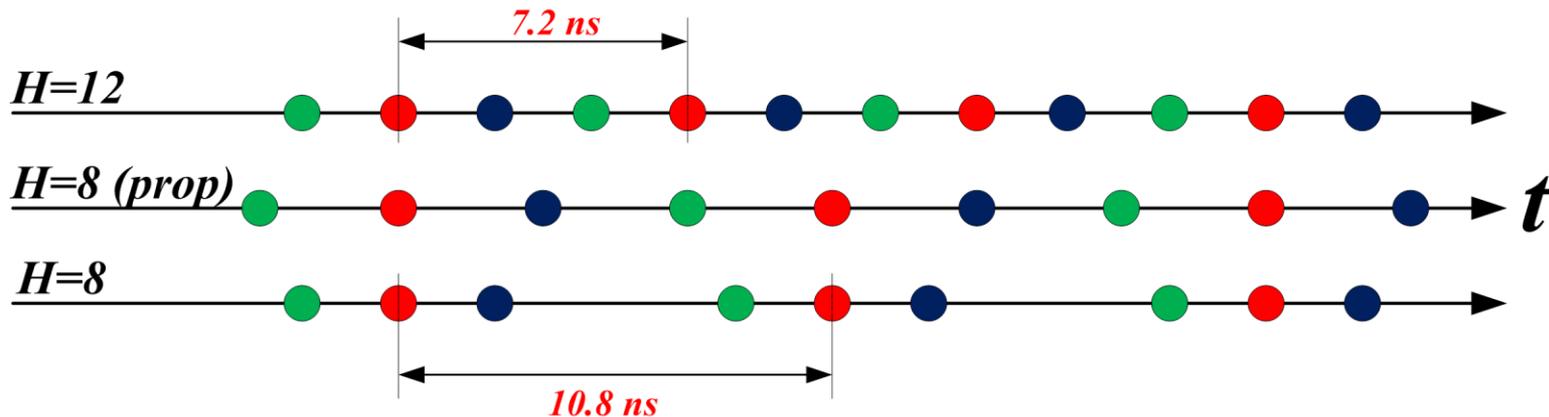
For a single bunch operation we may not need to change firmware, but for two consequent bunches we , perhaps, have to.



An alternative: not to change DAQ

- 10.8 ns WFD sampling period.
- + Right bunch identification in firmware

Considered sampling schemas:

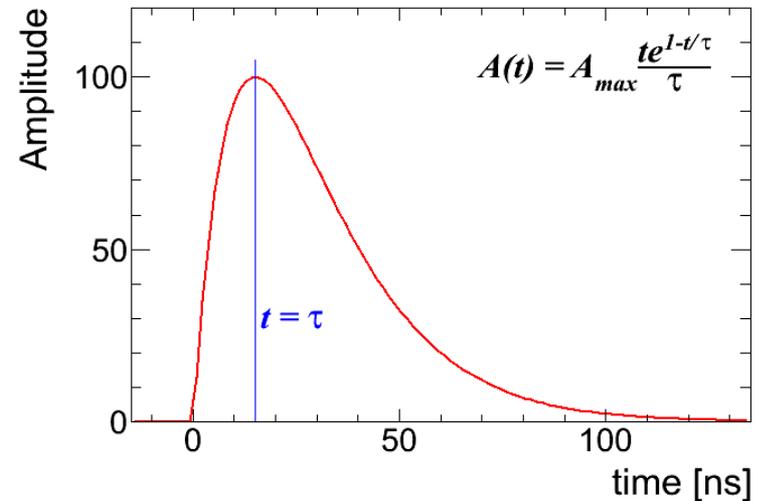


Anticipated problems:

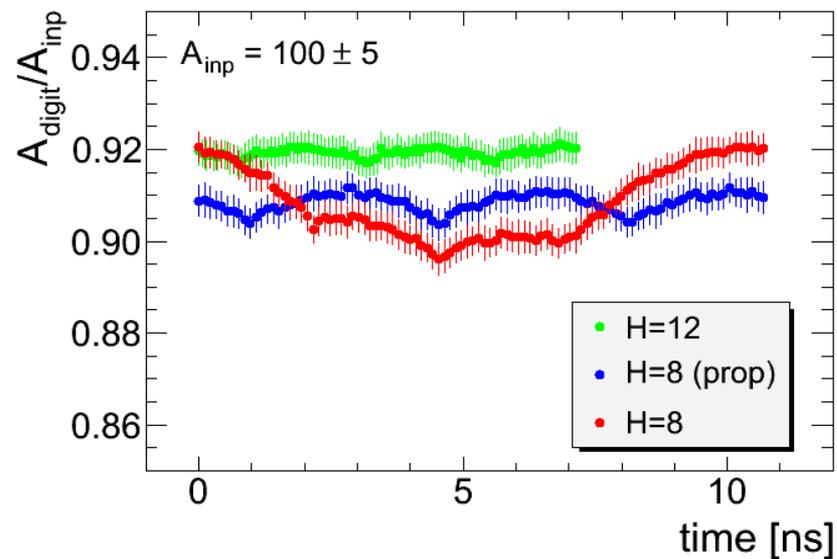
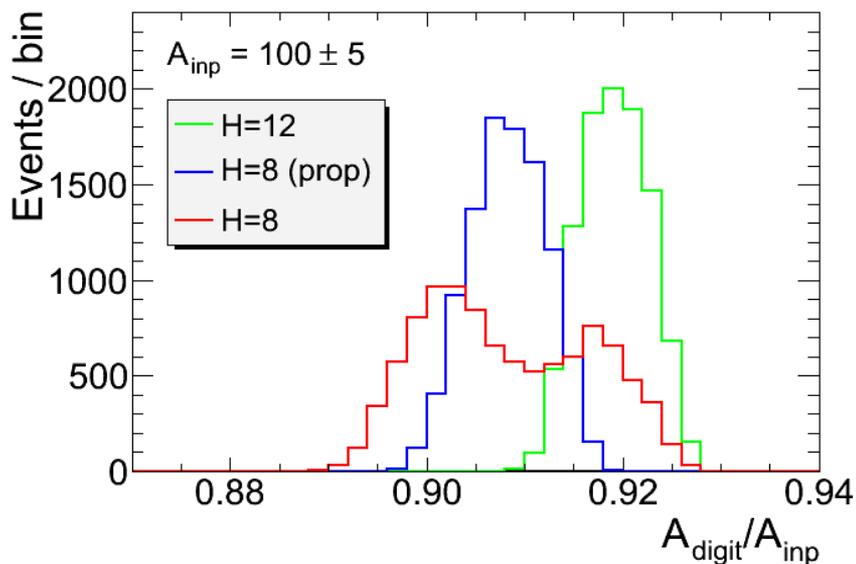
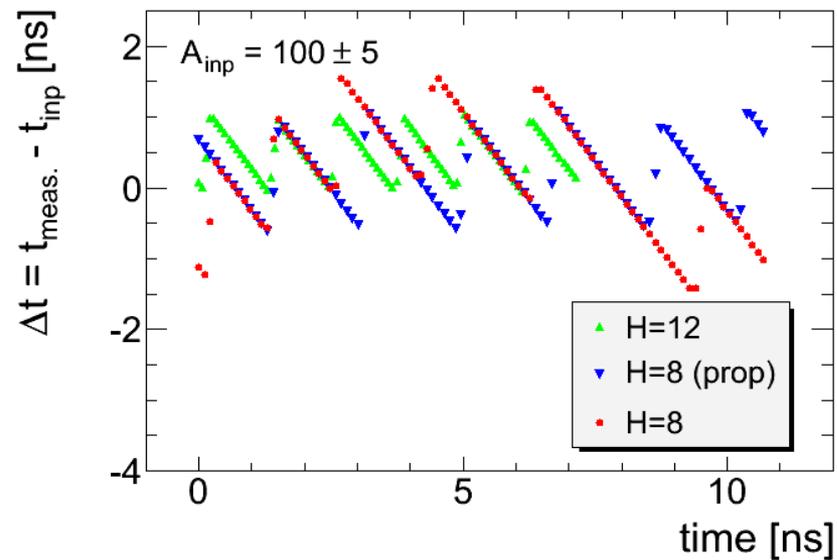
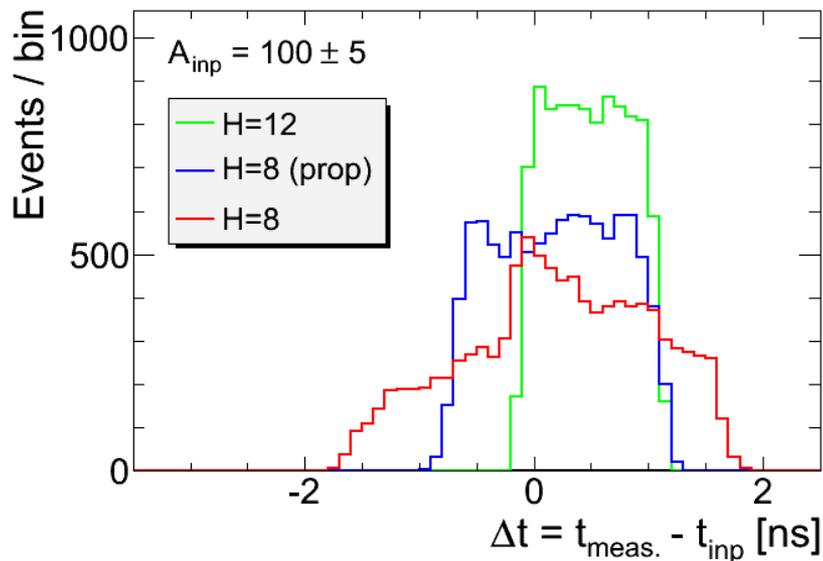
- Irregular sampling structure for $H=8$
- Firmware will “think” that structure is regular ($H=8$ prop)
- Possible degradation of time resolution
- Possible problems with amplitude resolution due to the 6 ns gap.

Simulation

- **Only signal digitization in the firmware was studied**
- **The signal wave form: $A(t) \propto t \exp(-t/\tau)$**
 - ✓ **only front edge is relevant for simulation**
 - ✓ **$\tau = 15 \text{ ns}$ (?)**
- **Input amplitude: 100 WFD counts (800-00 keV)**
- **Input amplitude was smeared (Gaussian, $\sigma_A/A=5\%$) to have smooth amplitude distribution**
- **Input signal time was uniformly distributed**

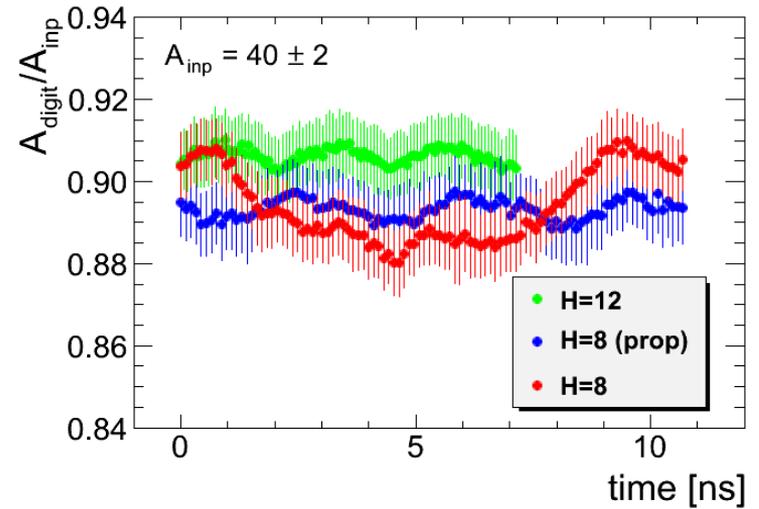
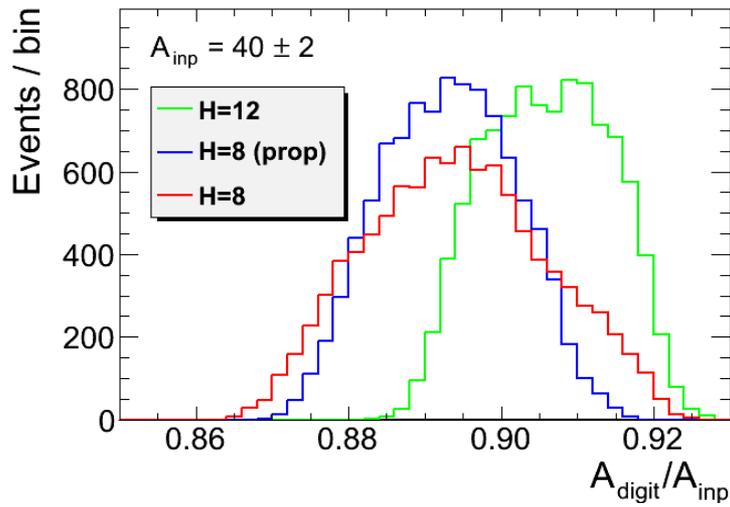


Results of the simulation: $A=100\pm 5$ and $\tau=15$ ns

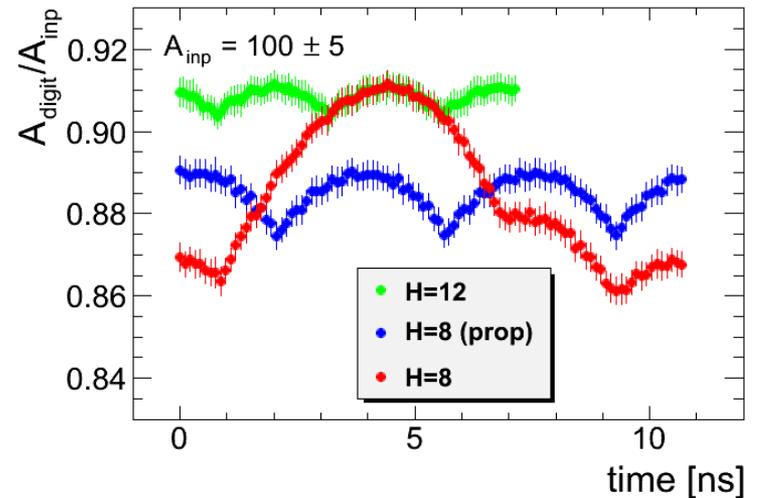
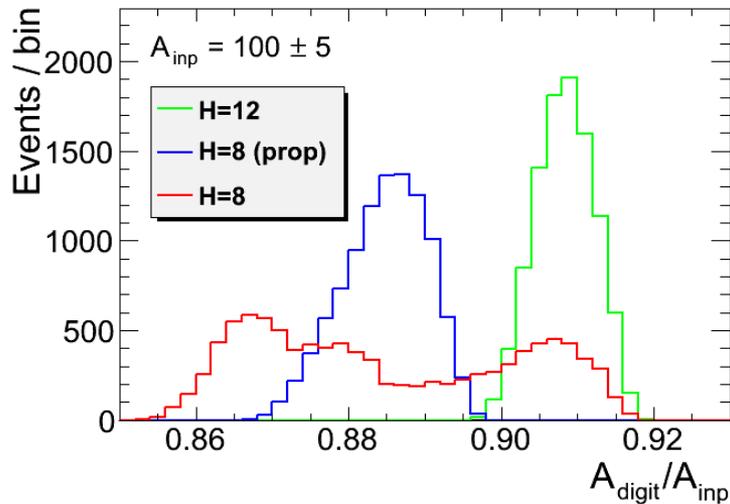


Results of the simulation

$A=40\pm 2$ and $\tau=15$ ns



$A=100\pm 5$ and $\tau=10$ ns



Simulation Summary

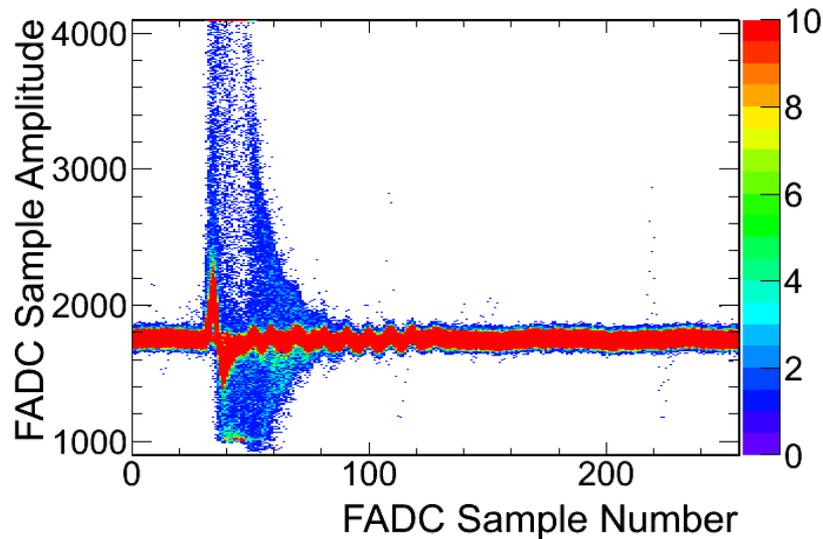
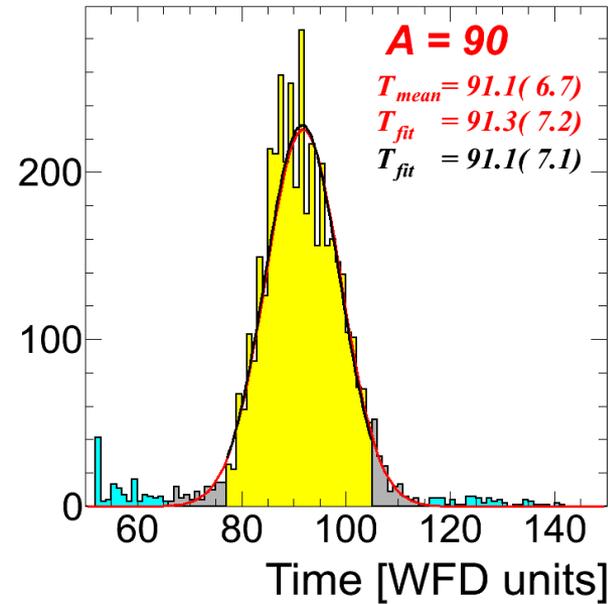
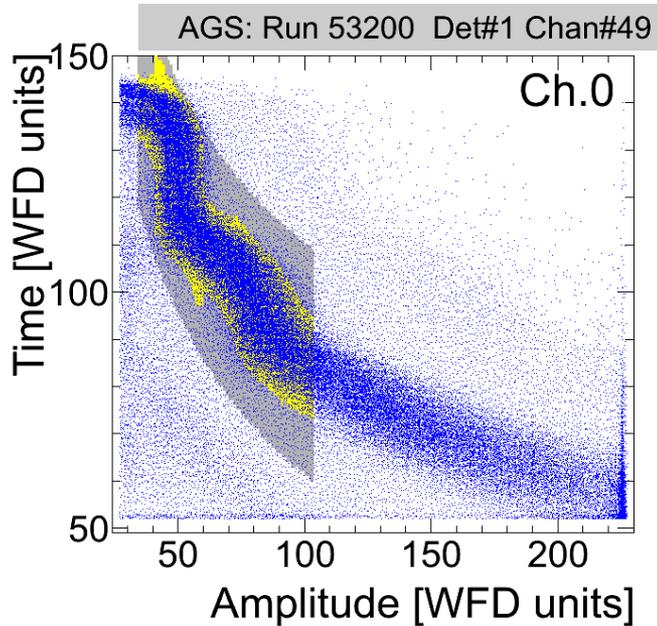
| Schema | A_{inp} | τ (ns) | Time (ns) | | $A_{\text{dig}}/A_{\text{inp}}$ | |
|------------|------------------|-------------|-----------|-------|---------------------------------|----------|
| | | | Mean | RMS | Mean | RMS/Mean |
| H-12 | 100 ± 5 | 15 | 0.490 | 0.349 | 0.919 | 0.004 |
| H-8 (prop) | | | 0.206 | 0.529 | 0.908 | 0.004 |
| H-8 | | | 0.204 | 0.809 | 0.909 | 0.009 |
| H-12 | 40 ± 2 | 15 | 0.615 | 0.358 | 0.906 | 0.009 |
| H-8 (prop) | | | 0.344 | 0.531 | 0.893 | 0.010 |
| H-8 | | | 0.375 | 0.776 | 0.894 | 0.013 |
| H-12 | 100 ± 5 | 10 | 0.132 | 0.354 | 0.908 | 0.004 |
| H-8 (prop) | | | -0.237 | 0.591 | 0.885 | 0.006 |
| H-8 | | | -0.428 | 0.902 | 0.885 | 0.019 |

- **Time measurement:** extra error $\sigma_{\tau} \approx 1 \text{ ns}$
- **Amplitude measurement:** extra error $\sigma_A/A \approx 1.5\%$

Small compared to the bunch width contribution

Small compared to the noise contribution (both white and induced)

A reminder about current performance



***It will be hardly to notice
H=8 problems***

Conclusion

After turning AGS to the two bunch H=10 operation mode:

- **The Best** is to adjust WFD sampling rate and reprogramm the firmware
- **Acceptable** is to do nothing (except for minor corrections to the analyzing software)