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The Art of Silicon Sculpting

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IEEE802.3cg TF

T1S scrambler & preamble update

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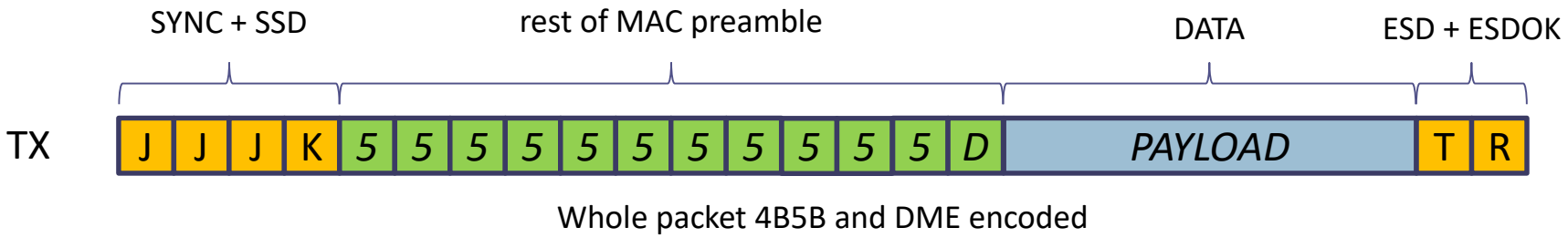
Outline

- Some concerns from Jay Cordaro & Mehmet Tazebay about 10BASE-T1S preamble and synchronization
  - http://www.ieee802.org/3/cg/public/adhoc/cordaro_8023cg_short_reach_new_preamble_proposal_1220.pdf
  - http://www.ieee802.org/3/cg/public/adhoc/cordaro_8023cg_01_0118_v2.pdf
  - http://www.ieee802.org/3/cg/public/Jan2018/tazebay_3cg_01b_0118.pdf
  - http://www.ieee802.org/3/cg/public/adhoc/cordaro_3cg_06_0418.pdf
- There's no general consensus in 802.3cg to redefine a preamble for the T1S PHY
  - No agreement on SNR benefits vs complexity (relative cost) for different implementation approaches that require different preamble properties
  - Scrambler adoption proposals are also affected
    - Some bytes in the preamble are needed for scrambler synchronization
- This presentation suggests a compromise for T1S preamble that wouldn't preclude different implementations
  - Better synchronization performance, matching Cordaro's proposal (Golay sequence)
  - Still good for low complexity receivers and inline with currently specified architecture
  - Not precluding adoption of self-synchronizing scrambler as in http://www.ieee802.org/3/cg/public/adhoc/beruto_3cg_scrambler.pdf

Present Status



- JJJK sequence is good to achieve DME synchronization and alignment on 4B5B boundaries in low complexity receivers
  - Initial 0's are good to discriminate clock from data transitions
  - Starting J sequence can be "stretched" to accommodate PLCA COMMIT requests
- Different implementations could benefit from better autocorrelation properties of the preamble
  - See http://www.ieee802.org/3/cg/public/adhoc/cordaro_3cg_06_0418.pdf slides #9, 11

Golay's sequence proposal from Jay Cordaro

- From http://www.ieee802.org/3/cg/public/adhoc/cordaro_3cg_06_0418.pdf
- Proposed Golay sequence Ga32 + 32 * 0-pad + Gb32 + 16* 0-pad

- Better autocorrelation than JJJK

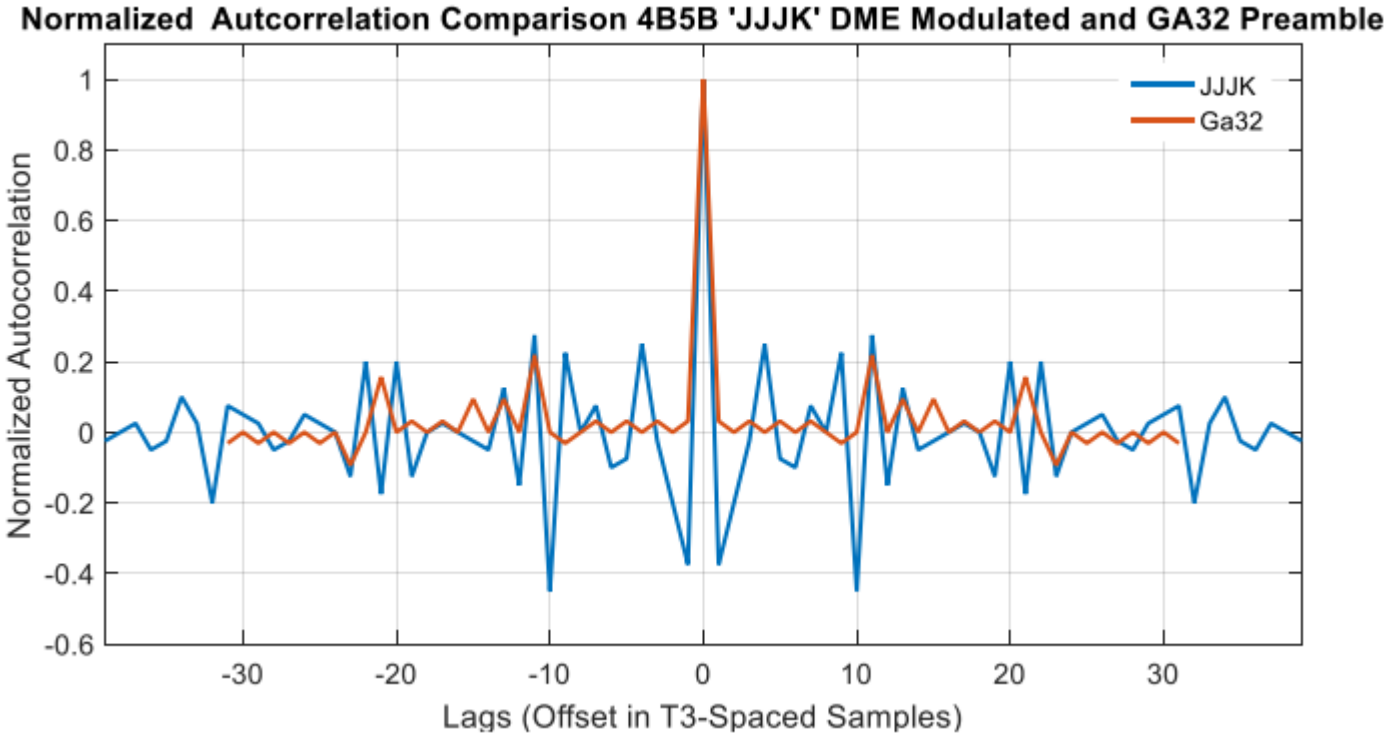
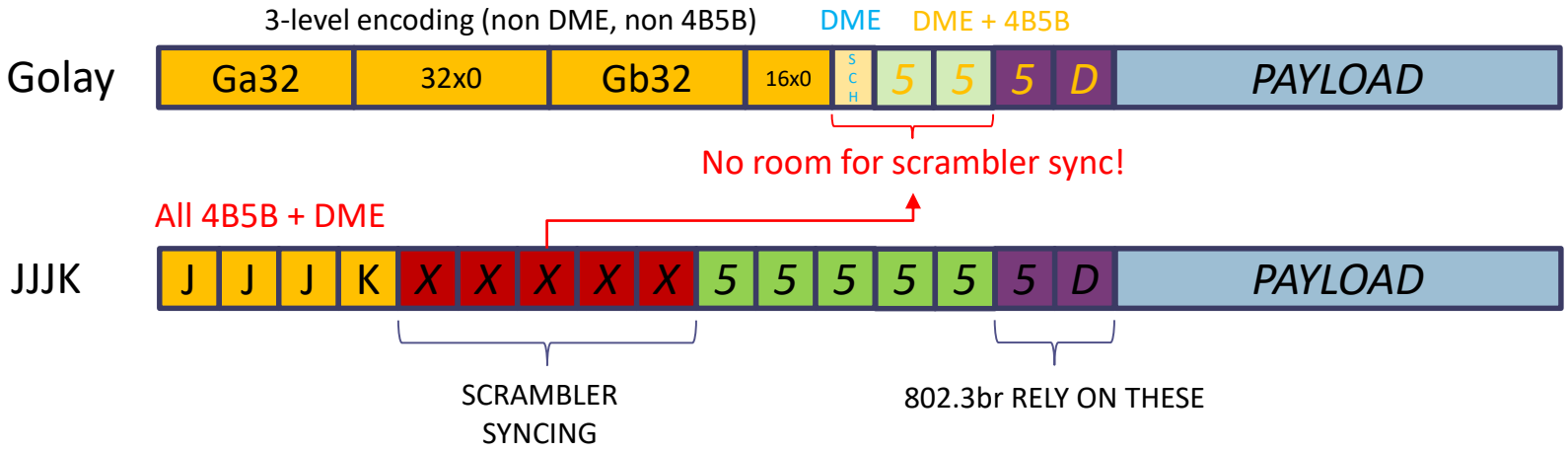


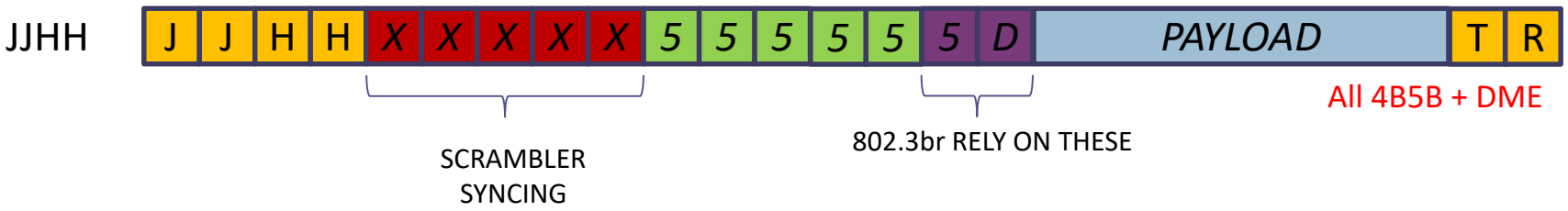
Figure from J. Cordaro's presentation slide #9

Issues with Golay's sequence proposal

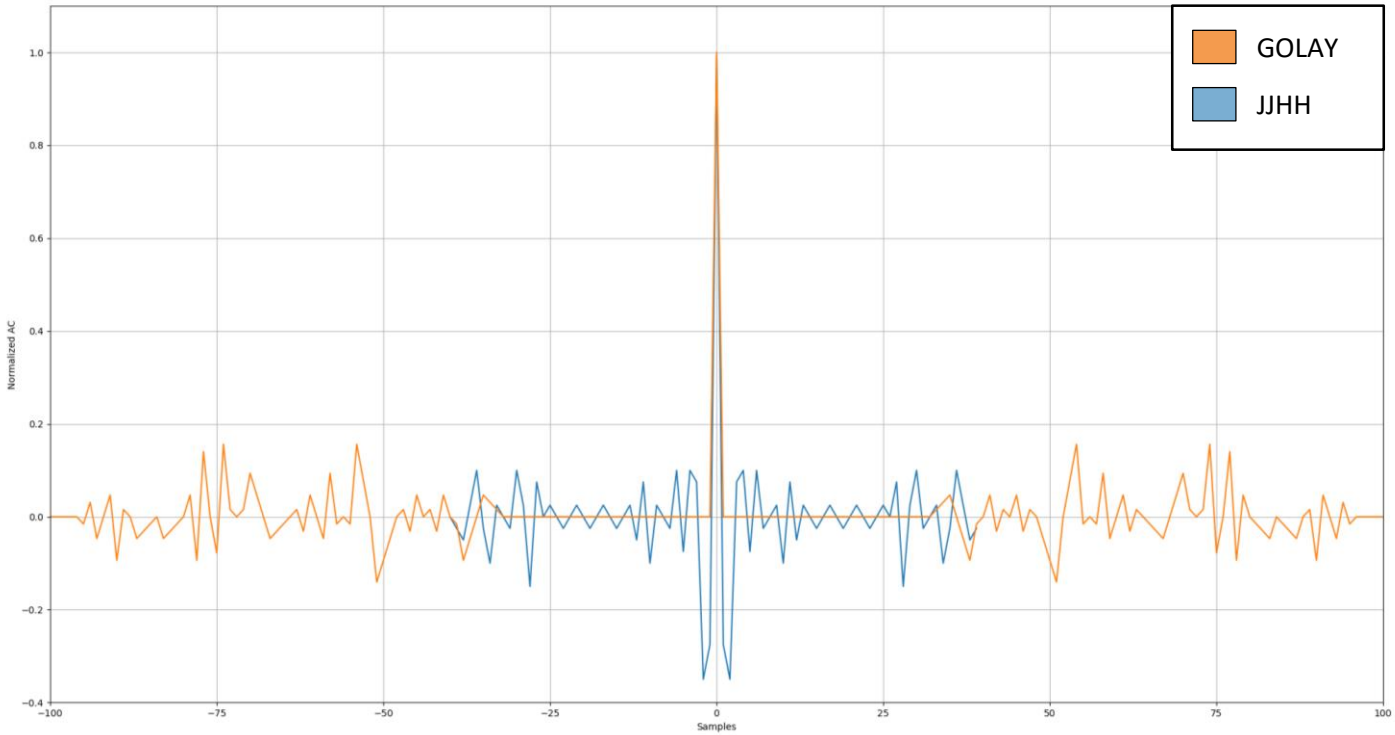
- Requires a three level TX and (at least) three level RX (+1, 0 -1)
  - not 4B5B, not DME (+1, -1)
    - Adds a fair amount of complexity to PMD, PMA
    - Gives a real benefit only if multi-bit ADC and x-correlator is used
- Higher RX latency
  - Longer sequence to sync on
  - degrades PLCA performance
- Breaks PLCA commit request
  - COMMIT requires the PHY to assert carrierSense
- Precludes self-sync scrambler adoption



New preamble proposal (JJHH)



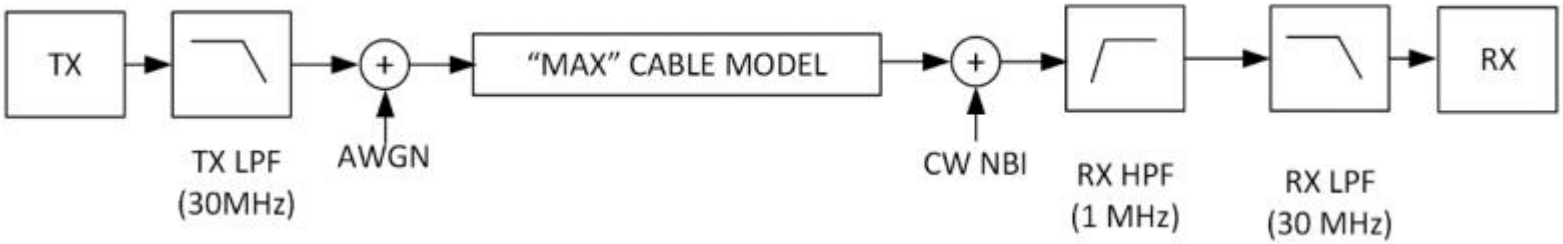
Autocorrelation comparison Golay's vs JJHH



- Still 4B5B + DME
- Autocorrelation properties comparable to Golay's sequence
- Compatible with self-sync scrambler adoption
- **What about noise?**

Simulations test bench

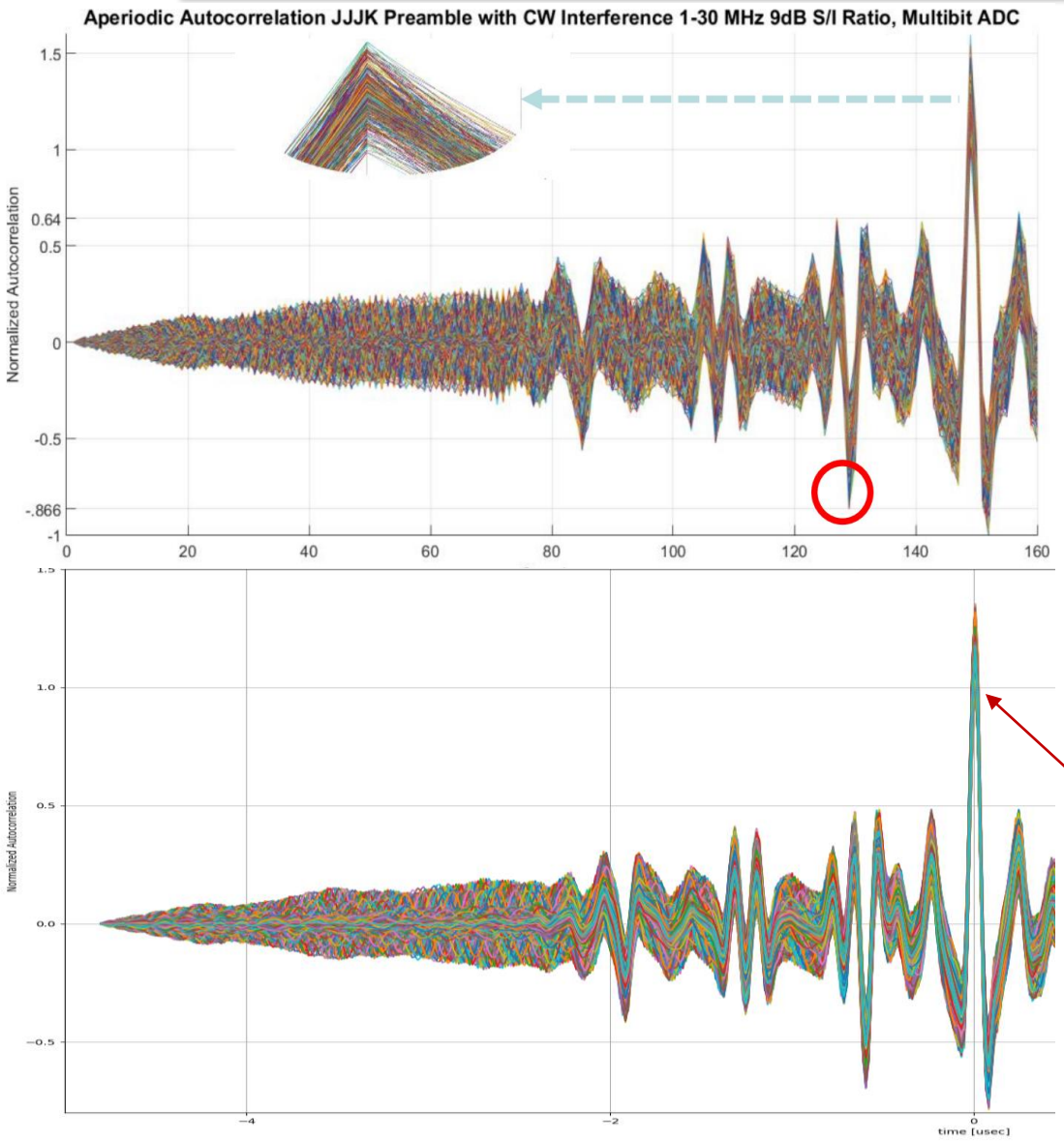
- Replica of http://www.ieee802.org/3/cg/public/adhoc/cordaro_3cg_06_0418.pdf slide #10



- TX: 1 Vp-p
- TX filtering: 2nd order Butterworth Low-Pass @30 MHz fc
- AWGN: -30dBc white noise added
- Cable model matching channel IL and RL
- CW: 500 mVp-p (0.178 Vrms) sweep from 1 MHz to 50 MHz
  - 500 KHz step, $\pi/4$ phase step
- RX High-Pass filter 1st order @1 MHz fc
- RX Low-Pass filter 2nd order Butterworth @30 MHz fc

- Validated reproducing same results for JJJK, Ga32 and full Golay's sequence (Ga32+ 32x0 + Gb32 + 16x0)

Test bench validation (current preamble, JJJK)



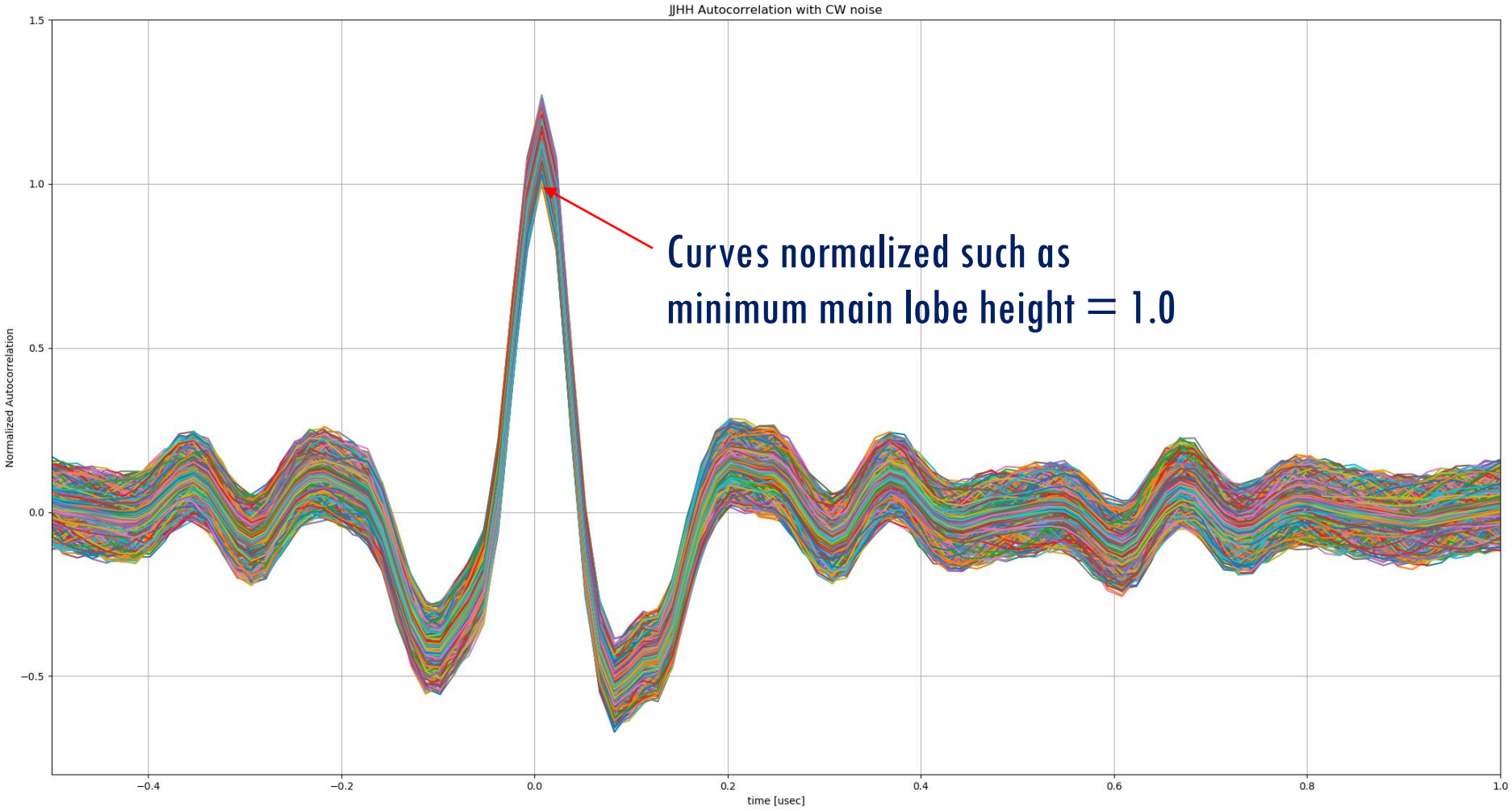
From Jay Cordaro's presentation:
http://www.ieee802.org/3/cg/public/adhoc/cordaro_3cg_06_0418.pdf
slide #11

From CT replicated test-bench

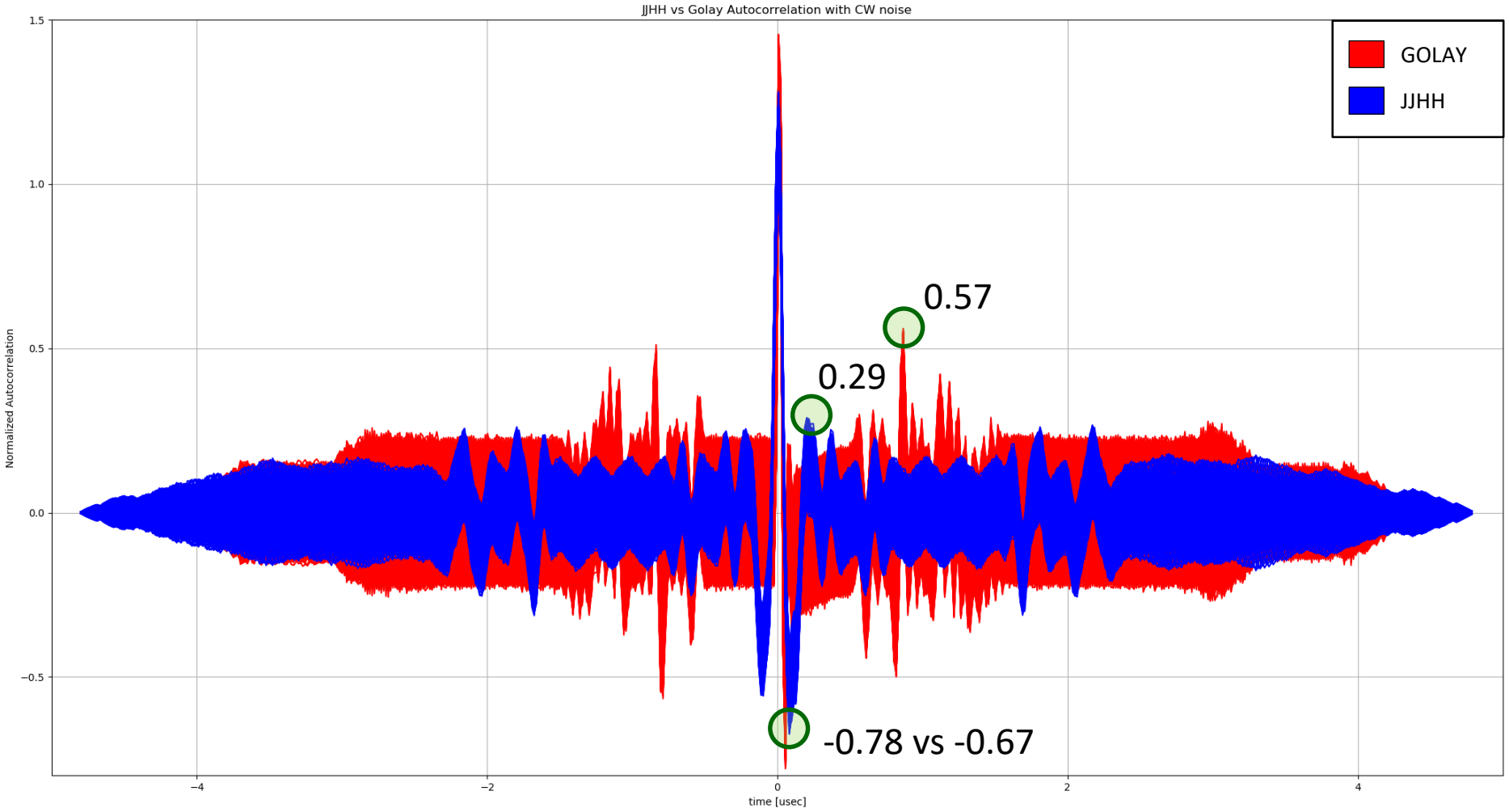
- Results are compatible

Curves normalized such as minimum main lobe height = 1.0

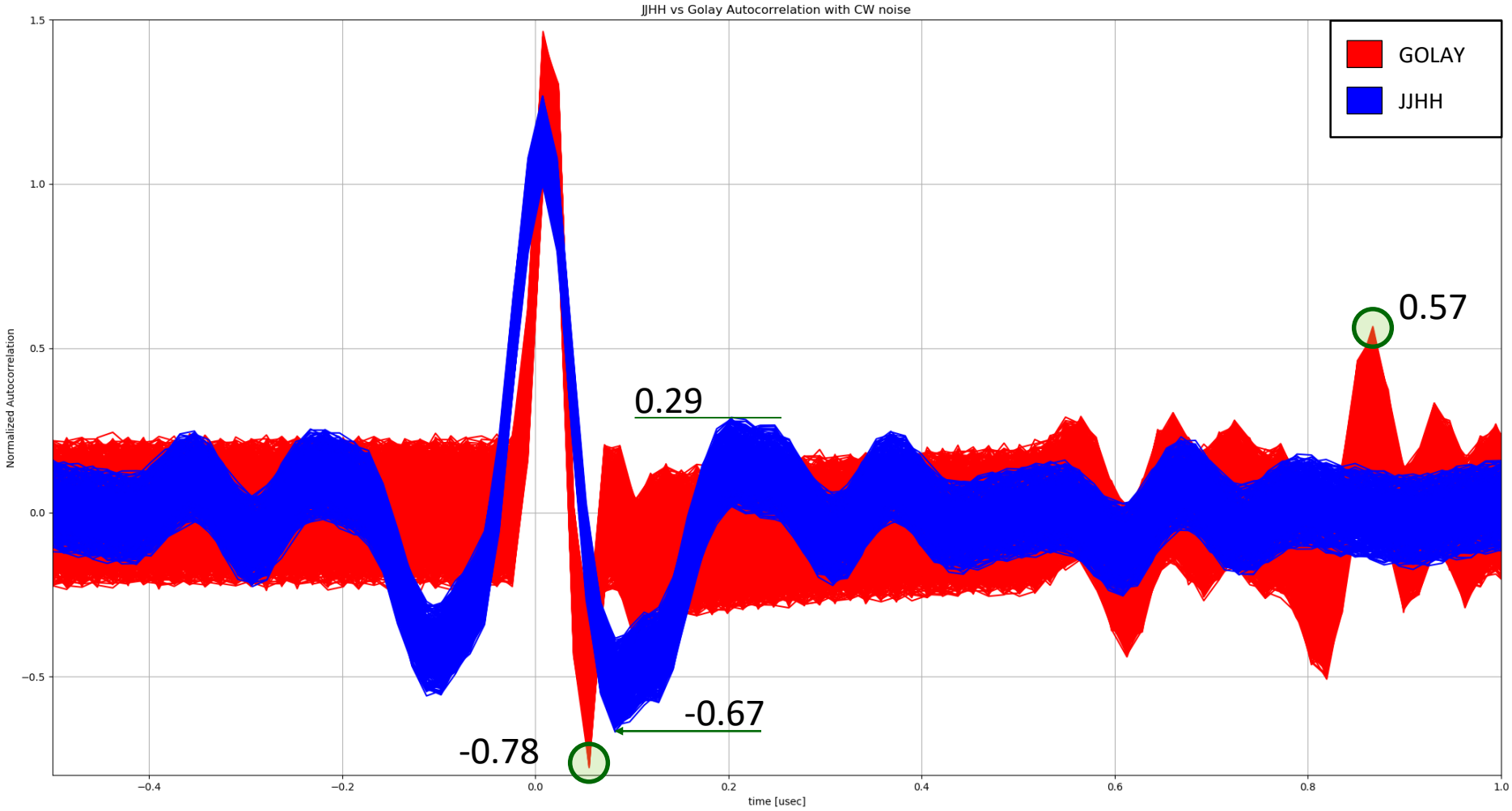
JJHH Autocorrelation with CW noise



JJHH vs Golay Autocorrelation with CW noise



JJHH vs Golay Autocorrelation with CW noise



Results

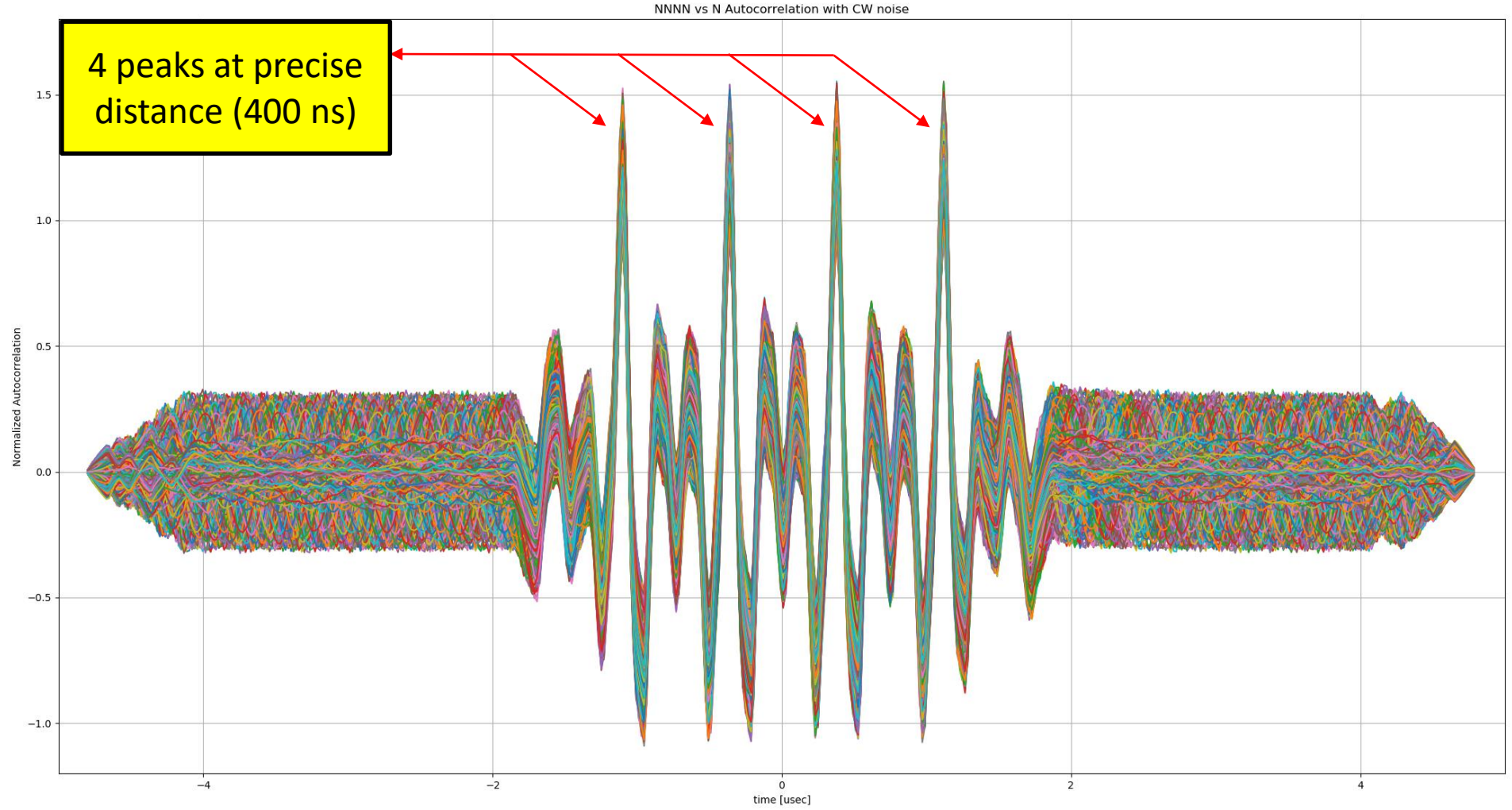
- Golay's sequence has a normalized sidelobe peaks height of +0.57 and -0.78
- JJHH has a normalized sidelobe peaks height of +0.29 and -0.67
- JJHH (5B and DME encoded) exhibits even better autocorrelation properties than Ga32 + 0-pad + Gb32 + 0-pad Golay's sequence for preamble detection in 10BASE-T1S with multi-bit ADC and CW noise
  - Also matches Ga32 and Gb32 separately
- What about PLCA BEACON?

BEACON

- PLCA BEACON is different from the packet preamble in the following sense:
  - There is no data after the BEACON signaling
    - No need for very precise synchronization: the PHY needs to reliably detect the **end** of a BEACON (TO_TIMER is synchronized on the end of a BEACON)
  - BEACON can be reliably detected by synchronizing on the four autocorrelation peaks within the 'NNNN' sequence
    - Important thing is not to confuse a JJHH for a NNNN sequence

Correlation of ‘N’ within ‘NNNN’ with CW noise

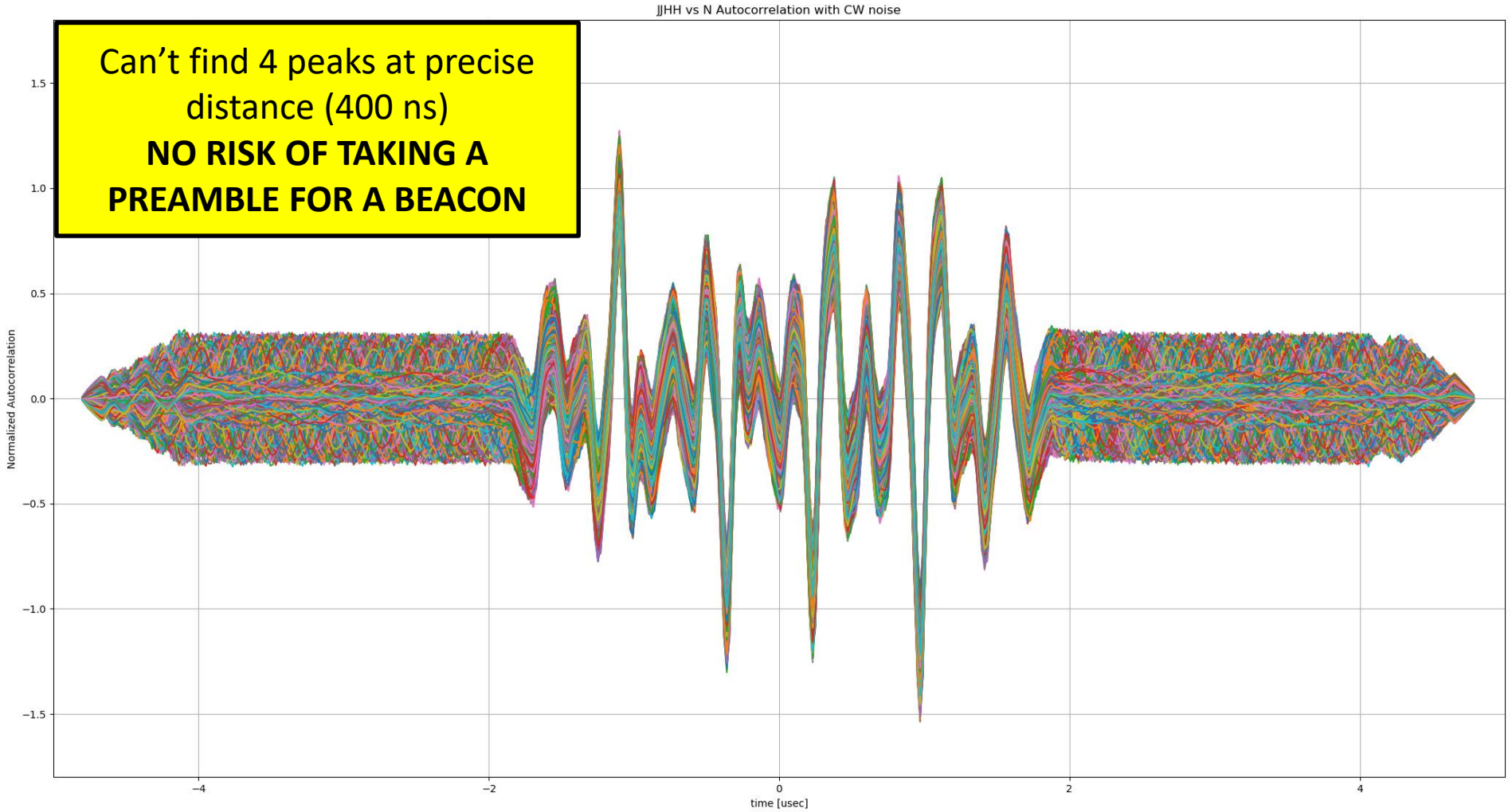
TX: NNNN



Correlation of ‘N’ within ‘JJHH’ with CW noise

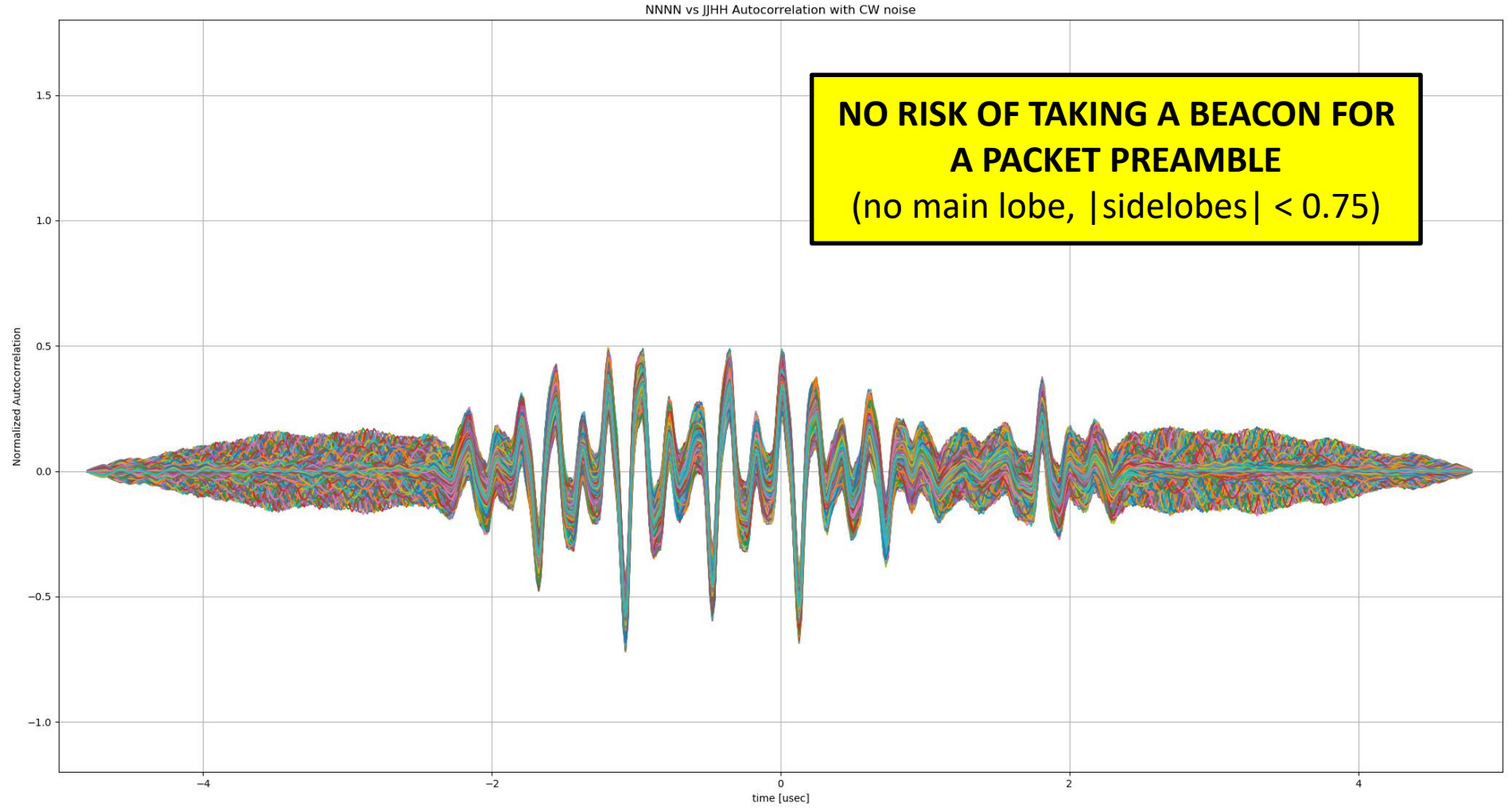
TX: JJHH

Can’t find 4 peaks at precise distance (400 ns)
NO RISK OF TAKING A PREAMBLE FOR A BEACON



Correlation of ‘JJHH’ within ‘NNNN’ with CW noise

TX: NNNN

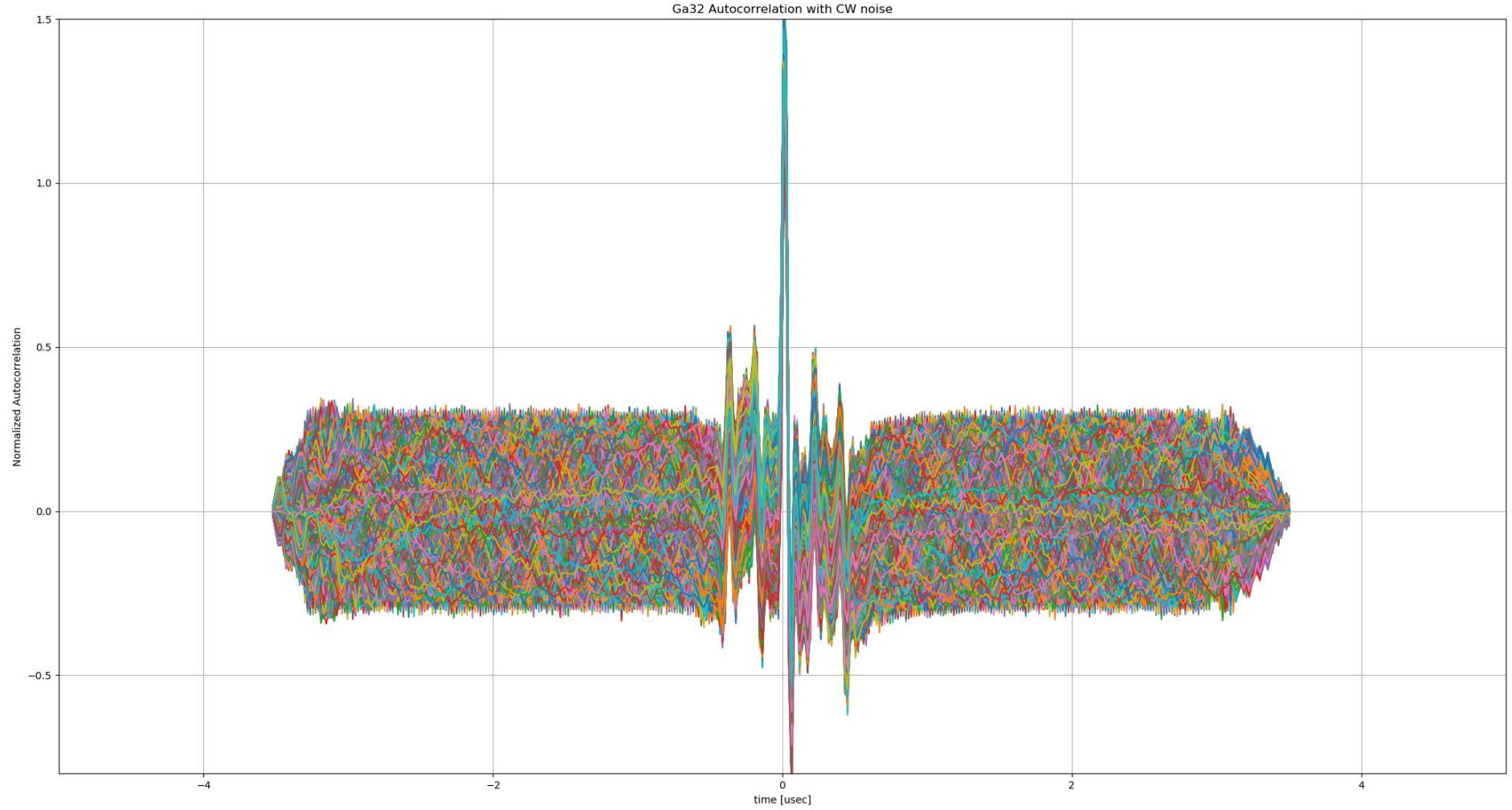


Conclusions

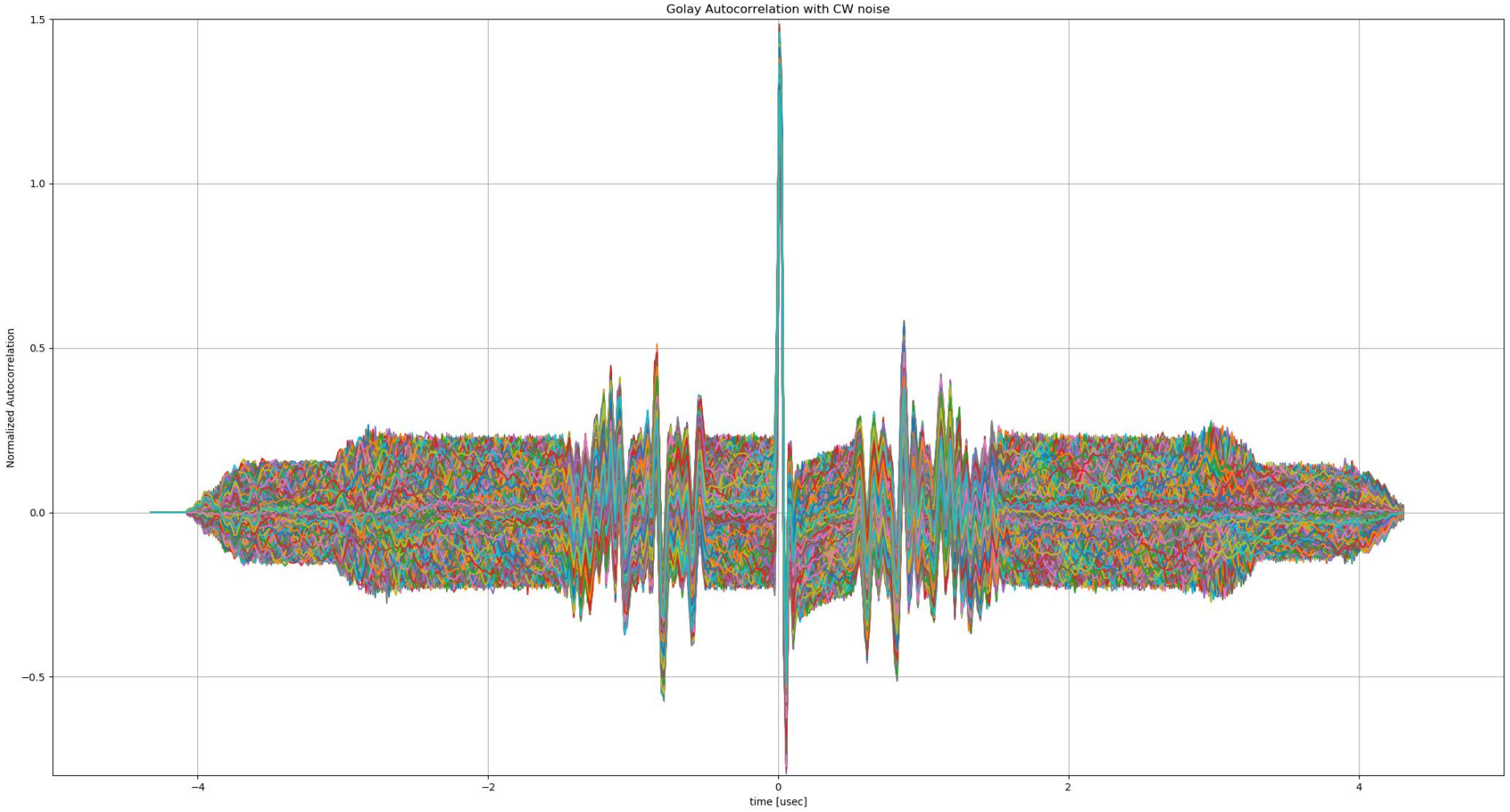
- JJHH 5B sequence (DME encoded) shows autocorrelation properties matching those of the Golay's sequence proposed by Jay Cordaro in http://www.ieee802.org/3/cg/public/adhoc/cordaro_3cg_06_0418.pdf for 10BASE-T1S preamble
  - Still 4B5B and DME encoded (preserves current architecture)
    - Does not require a three level TX / RX
    - Does not add complexity to the currently defined PHY
    - Minimizes RX latency
    - Keeps compatibility with PLCA support definition in c147
      - does not break PLCA commit
    - Allows self-sync scrambler to be adopted as in http://www.ieee802.org/3/cg/public/adhoc/beruto_3cg_scrambler.pdf
      - seems to have good consensus in 802.3cg group for this proposal already
- PLCA BEACON is not a concern
  - 'NNNN' sequence is detectable and can't be confused with proposed JJHH preamble
- Harness defect detection, if needed, is not precluded by proposed preamble
- JJHH proposal requires only minimal changes to c147 to be adopted
- Implementations with different performance/complexity trade-offs are not precluded

Thank You !

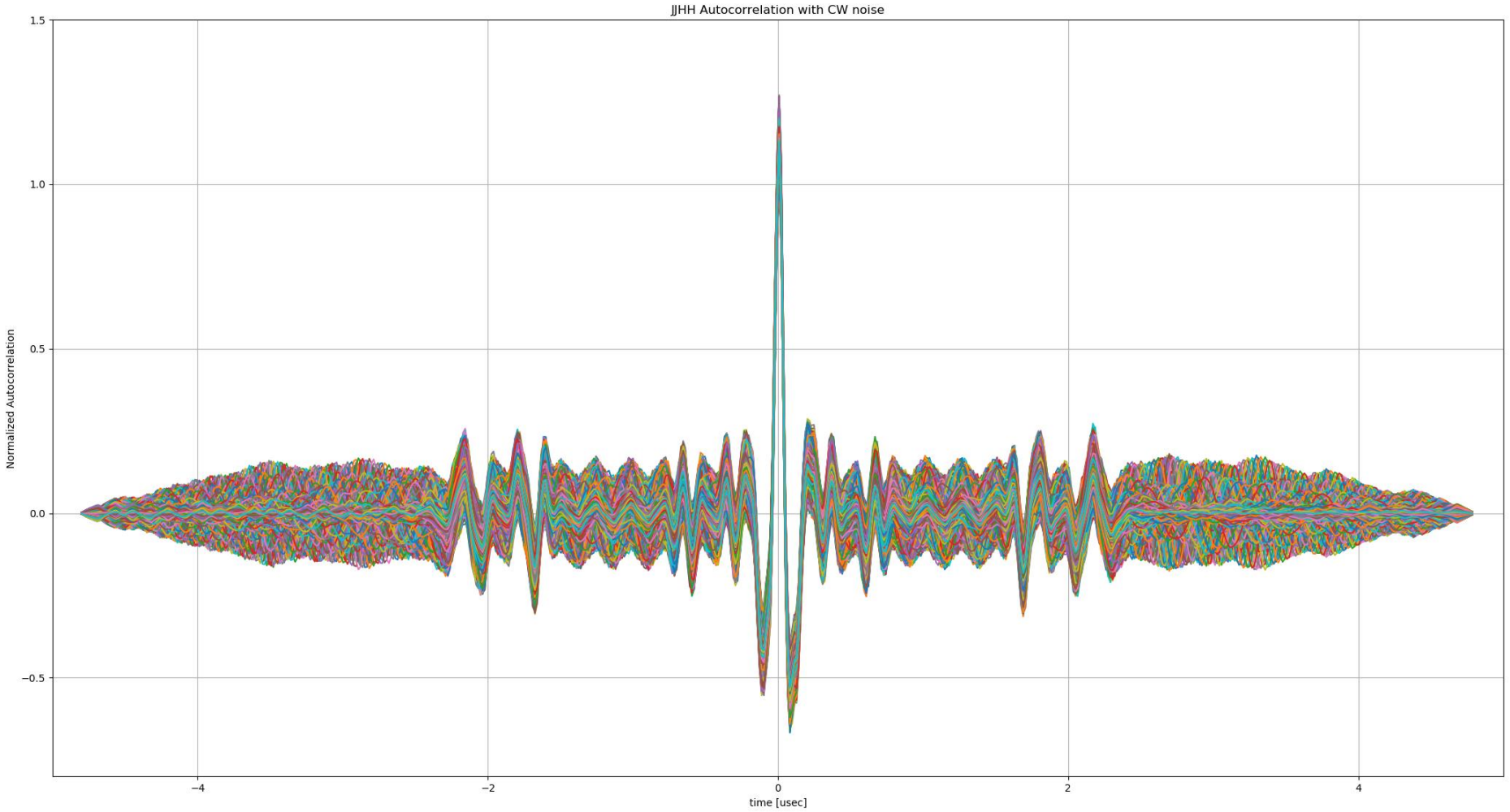
Ga32 Autocorrelation with CW noise



Full Golay's Sequence Autocorrelation with CW noise



JJHH Autocorrelation with CW noise



NNNN vs JJHH crosscorrelation