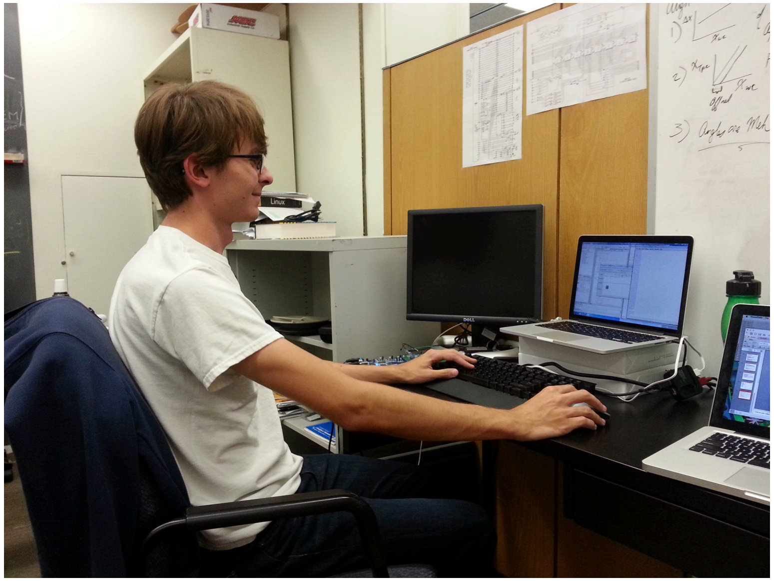
Template Fitting for the TOF signals

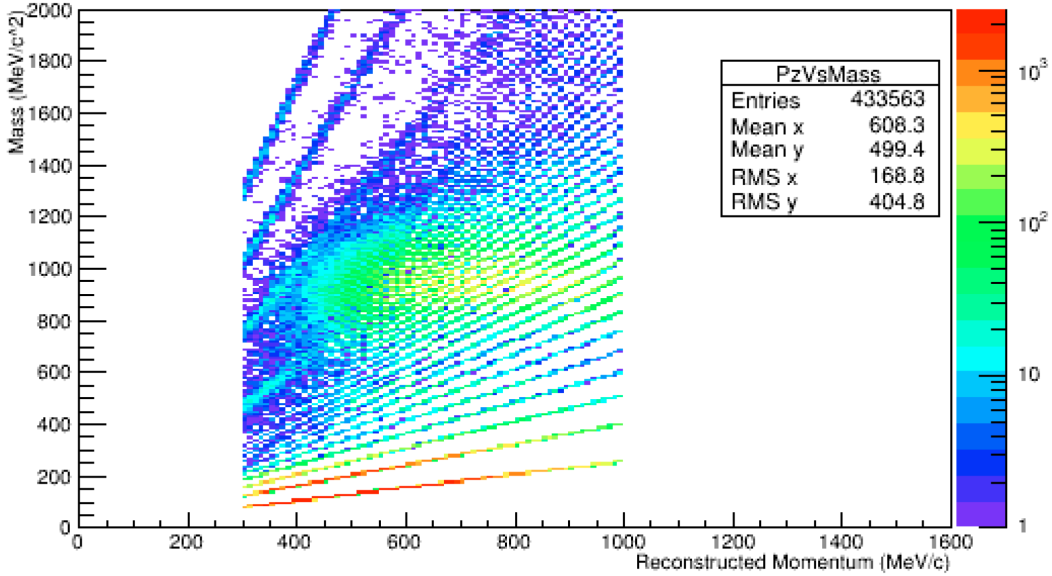


Dan Smith, Rob Carey

Lariat Summit

The problem:

Curious orbits in the momentum distributions



- Dan correctly diagnosed the problem: 1 ns time tick in digitizer. Pulse time coincides with position of maximum sample.
- Dan suggested a solution: Make a continuous determination of the scintillator time

One approach: Template fitting

- If the shape of the pulse is consistent (significant variations in amplitude and offset only), we can use that shape to improve the timing resolution considerably. In BNL E821, we sampled our SCI-FI calorimeter pulses every 2.5 ns but achieved 60 ps resolution. It helps to have limited optical paths and a lot of light!

Muon g-2 pulse fitter: V. Logashenko

- **Find a statistic which characterizes the relative phase of the sampling and the peak of the pulse**

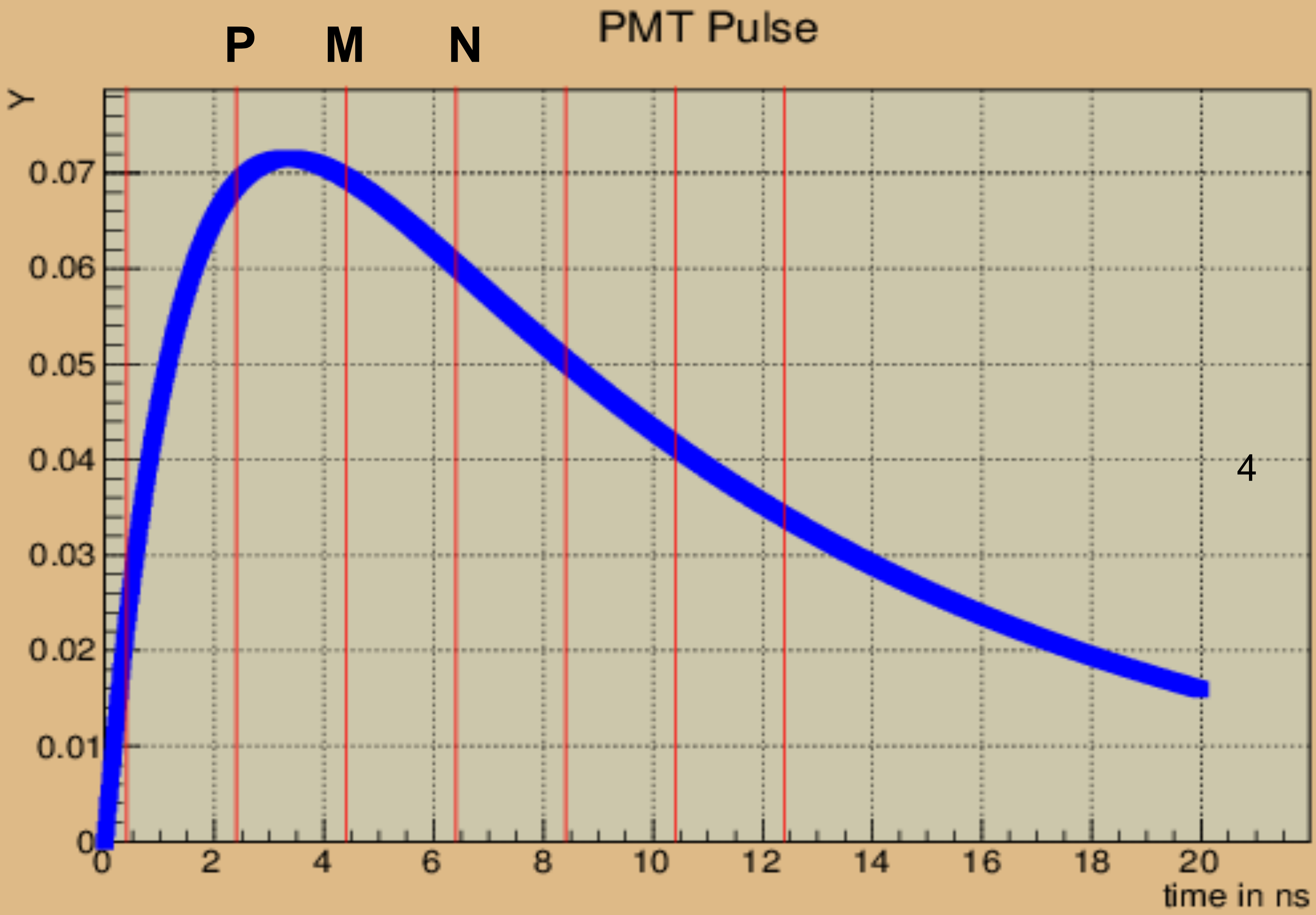
Determining true pulse maximum within the bin

Define the pseudotime:

$\psi = T * (2/\pi)$ atan ((MAX-PREV)/(MAX-NEXT))

where

1. T: sampling period
2. MAX: maximum sample
3. PREV: sample preceding MAX
4. NEXT: sample following MAX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PMT Pulse
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time in ns
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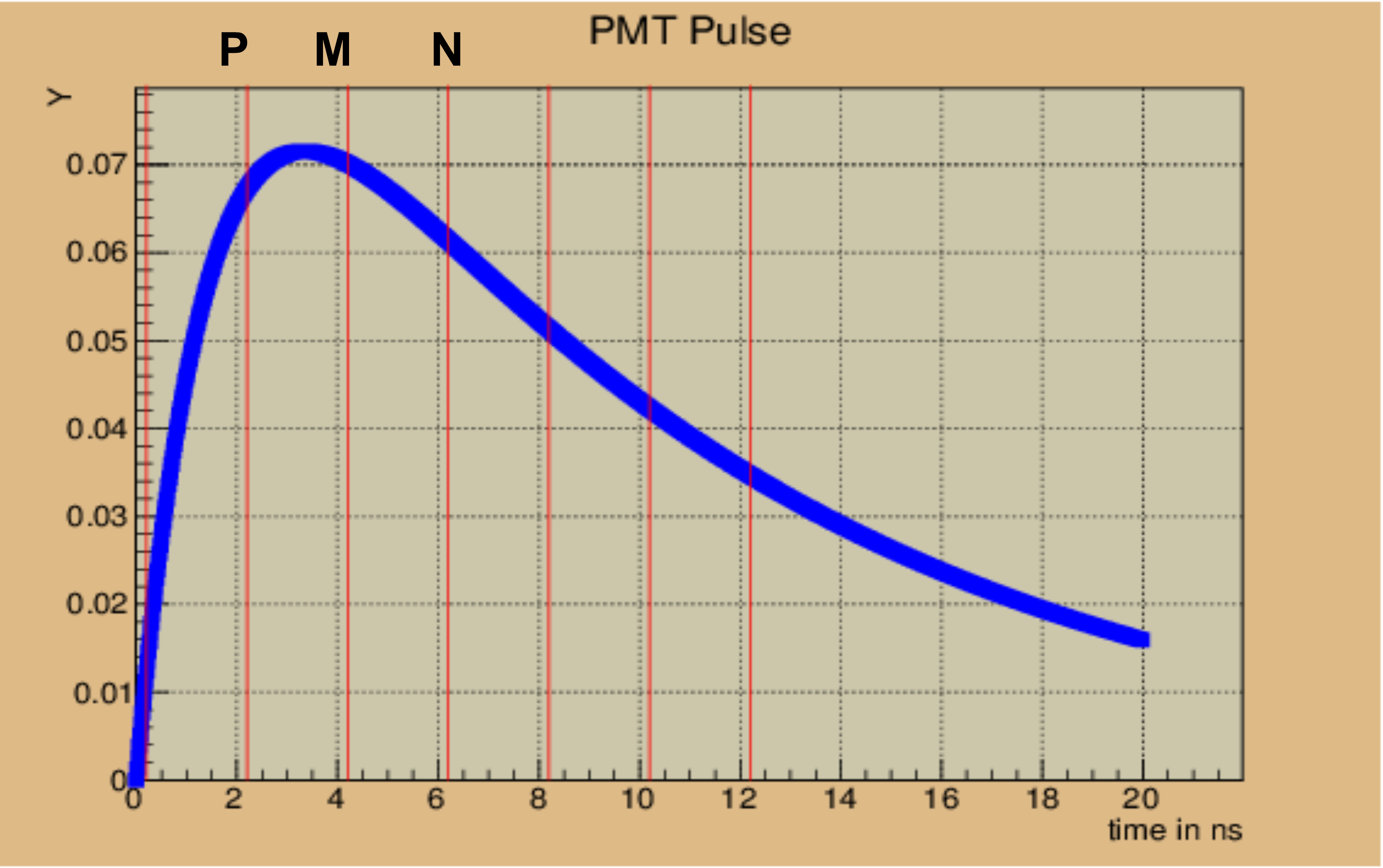
ψ = 0 4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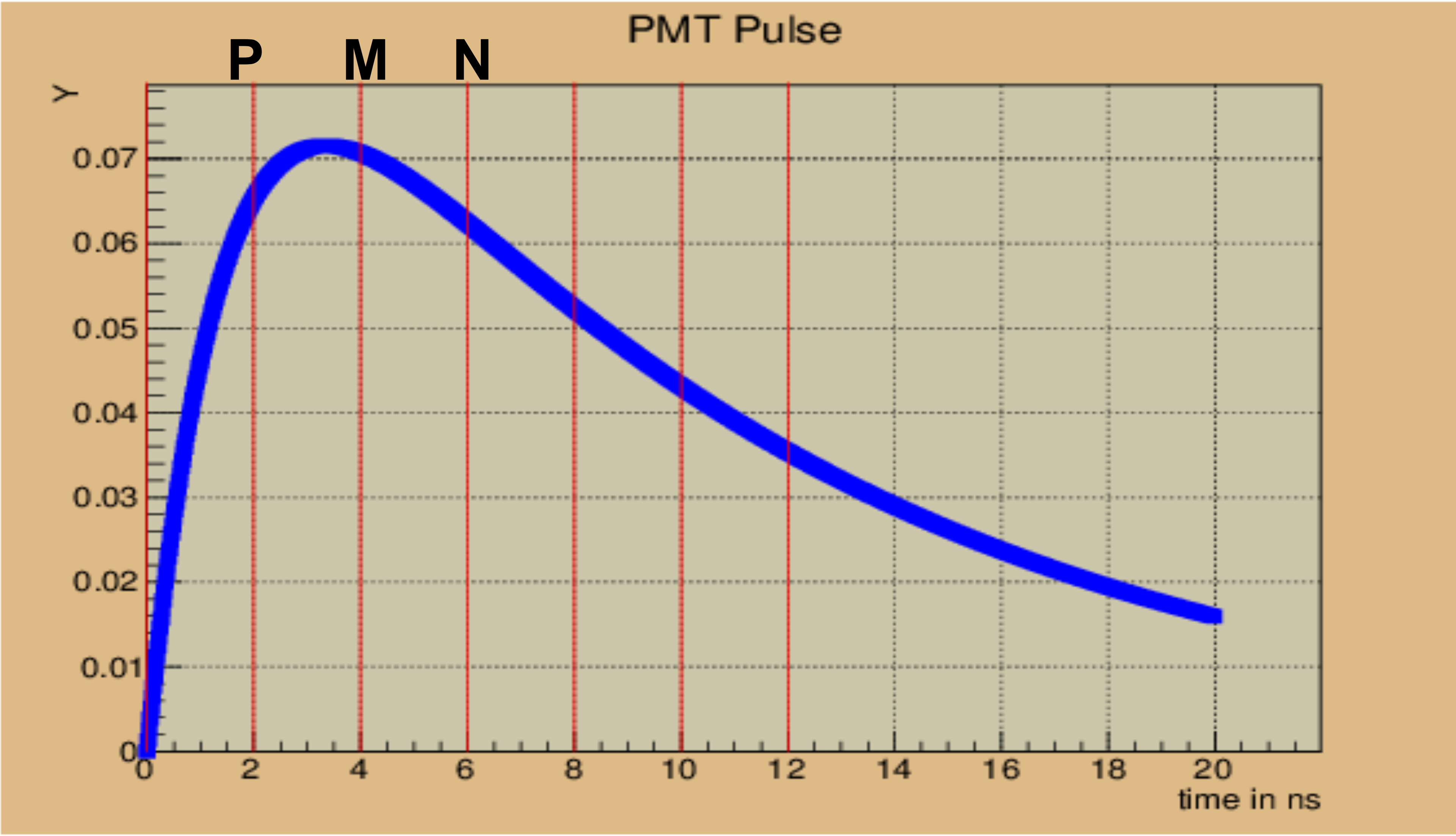
time in ns

ψ >= 0 2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time in ns

ψ < T/2 0

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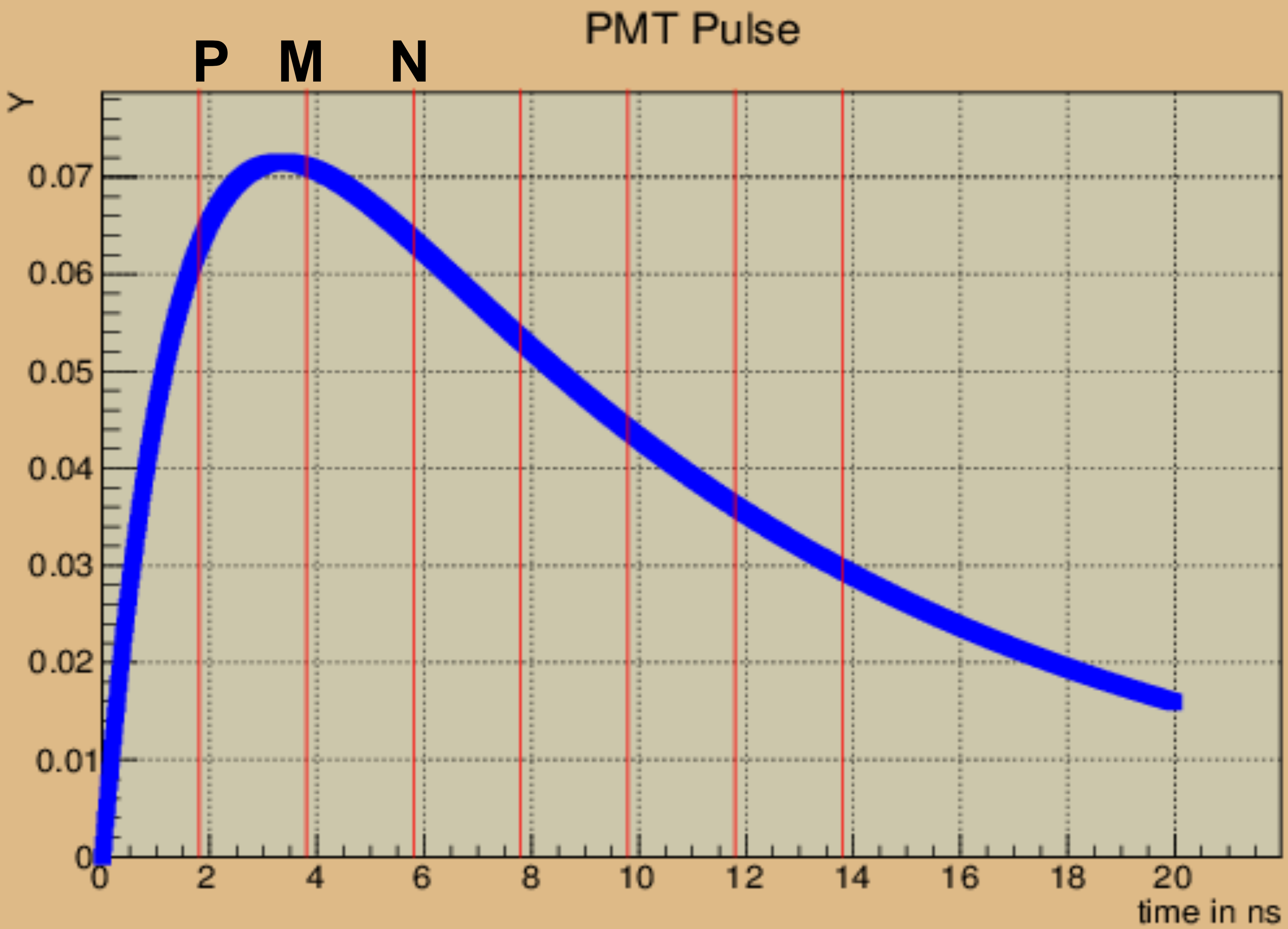
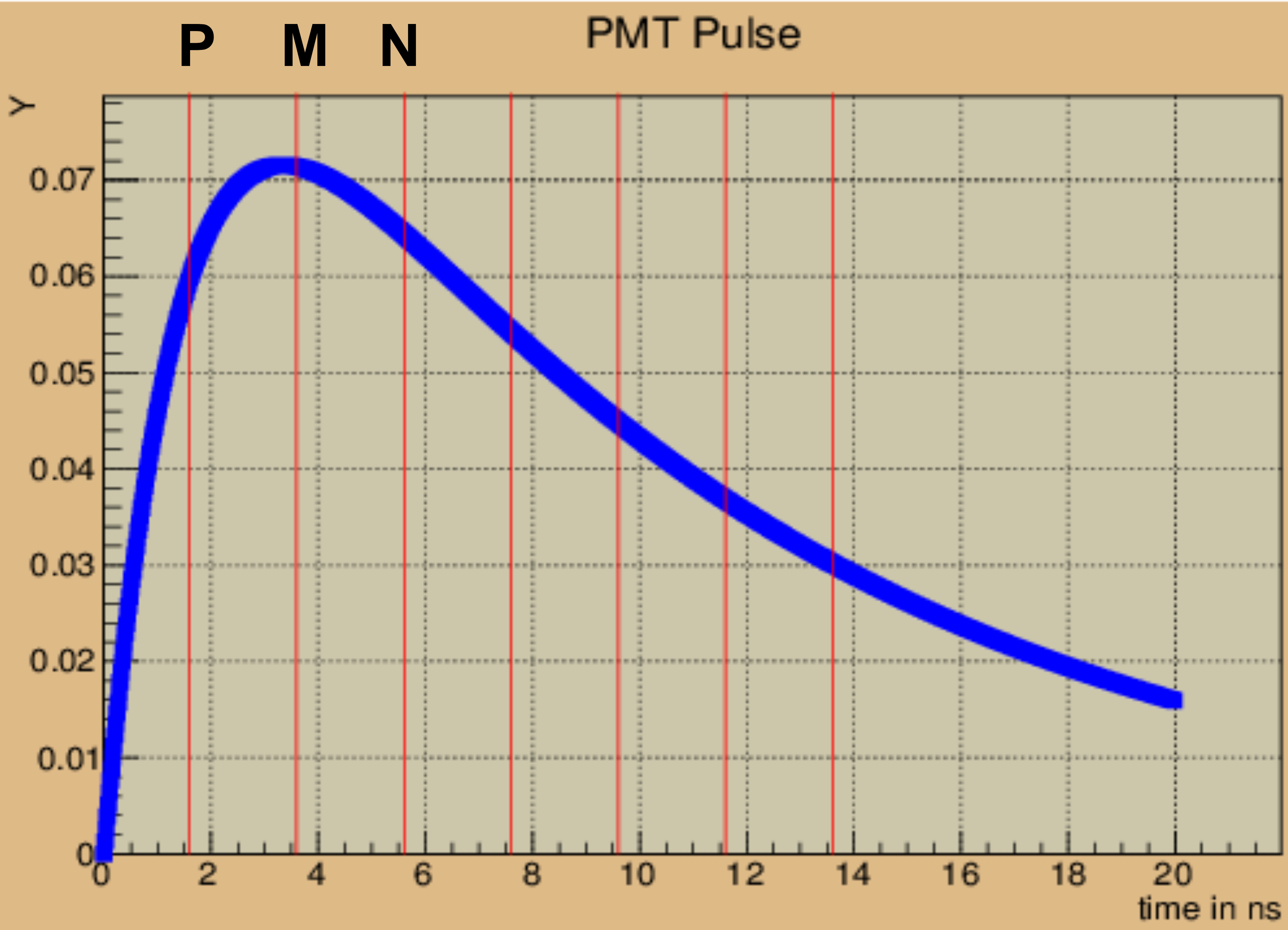


ψ ~= T/2 18

P M N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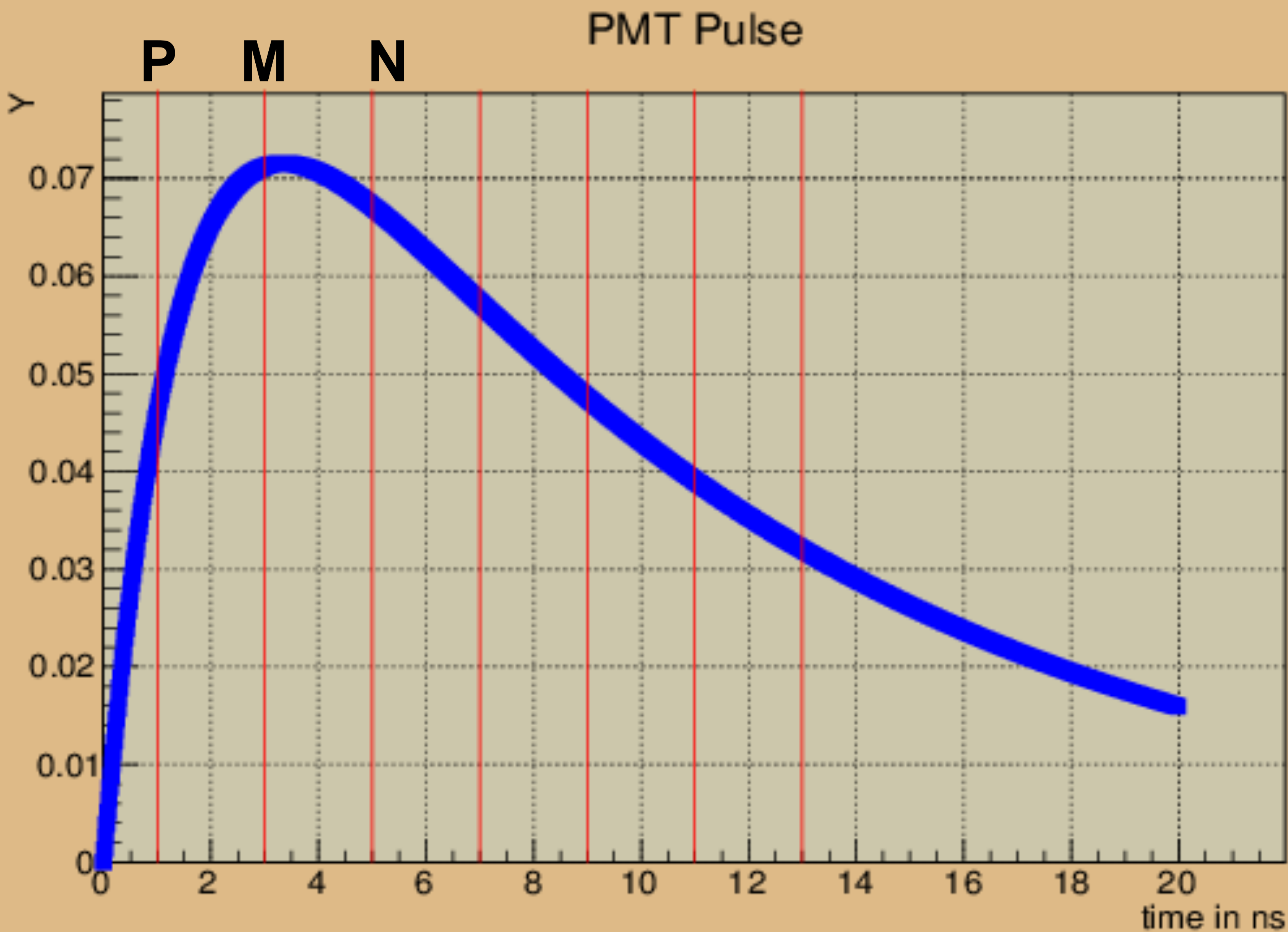
time in ns

ψ > T/2

16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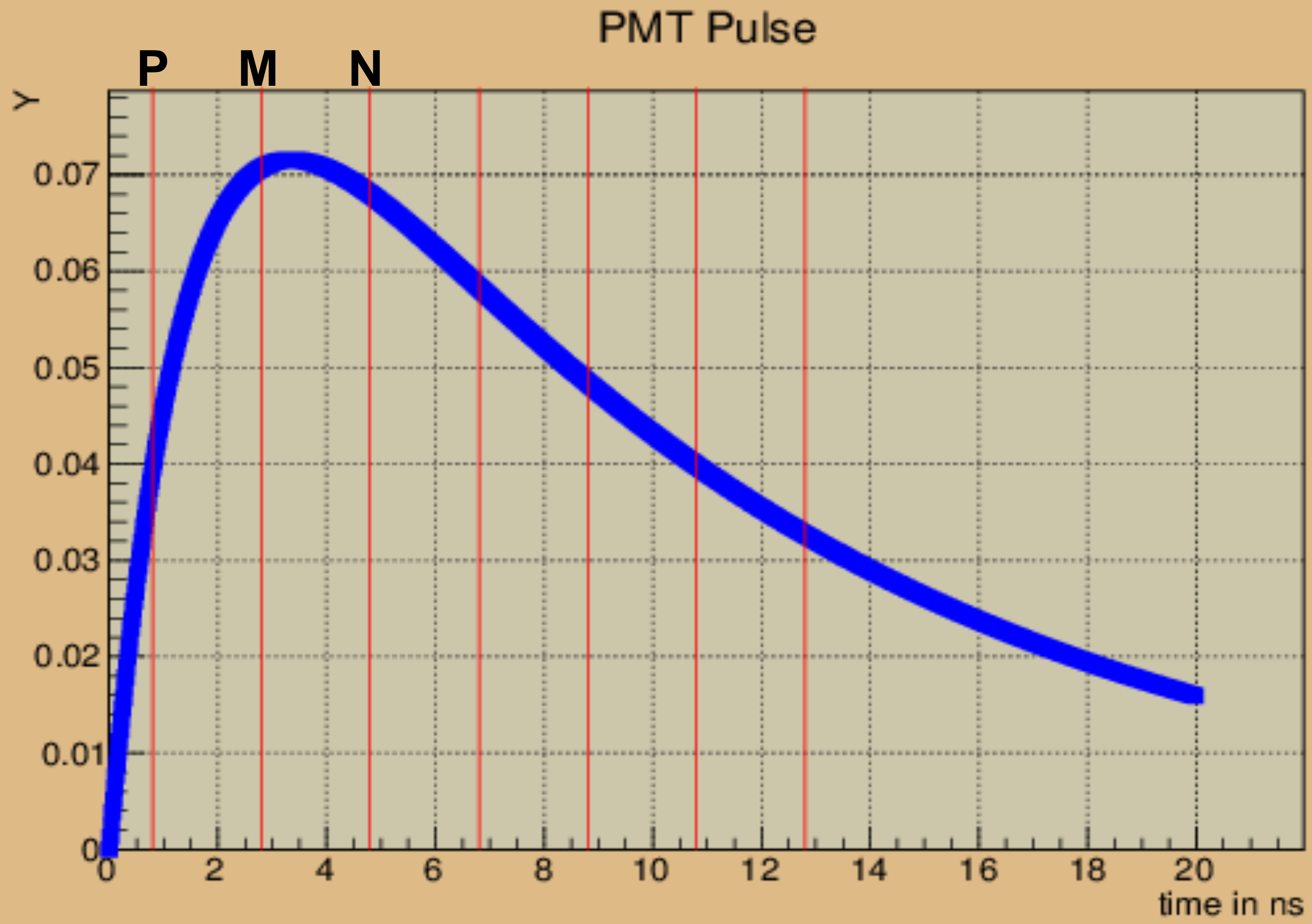
time in ns

ψ > T/2

10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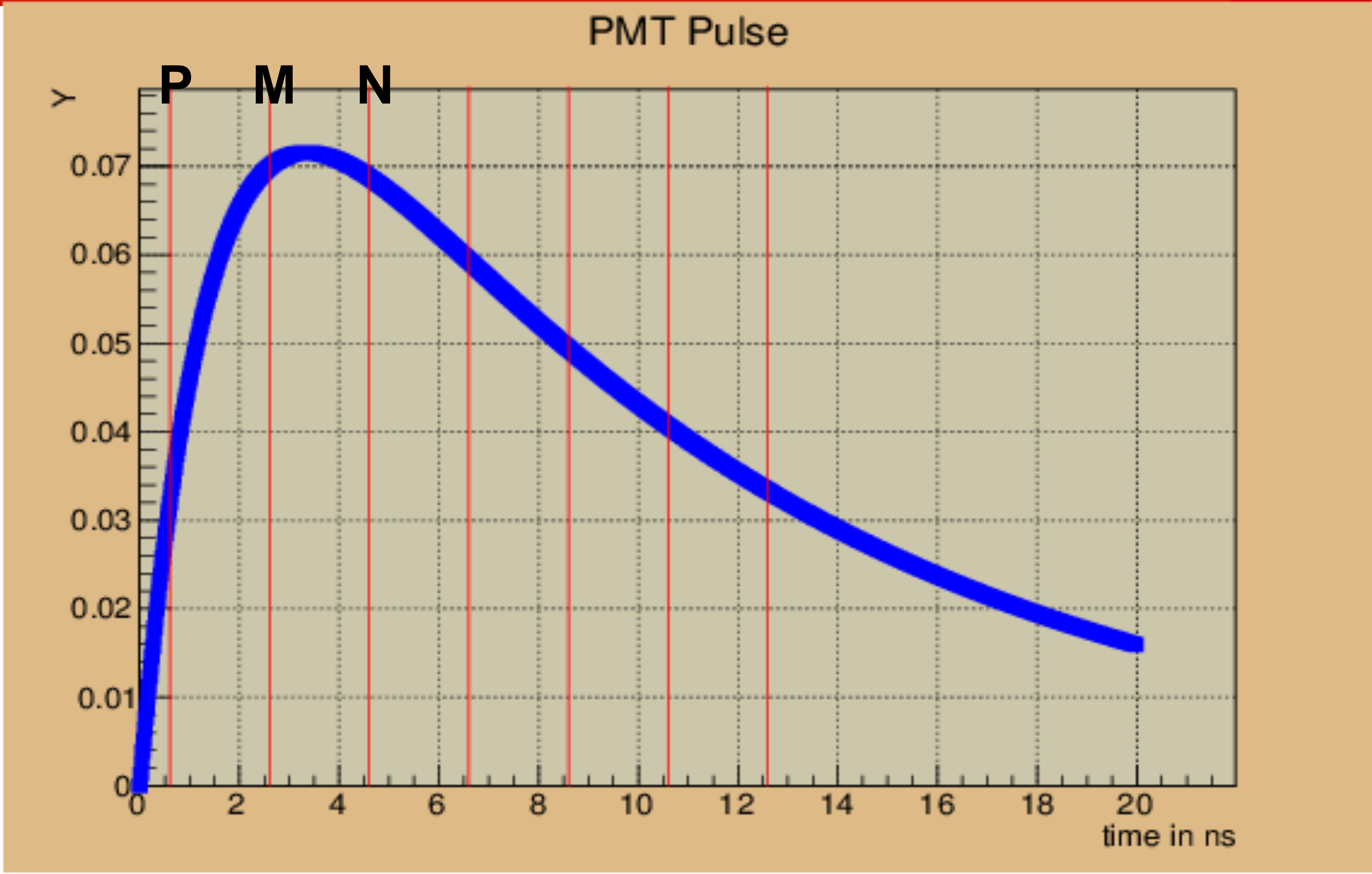
time in ns

T > ψ > T/2 8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time in ns

ψ => T

6

Why ψ is useful

- ψ tells us how we sampled the pulse

1. => T: true pulse maximum comes between max sample and previous
2. ~T/2: PREV and NEXT are the same size
3. => 0: true pulse maximum comes between MAX and NEXT

- ψ is insensitive to time offsets, voltage offsets and scaling factors

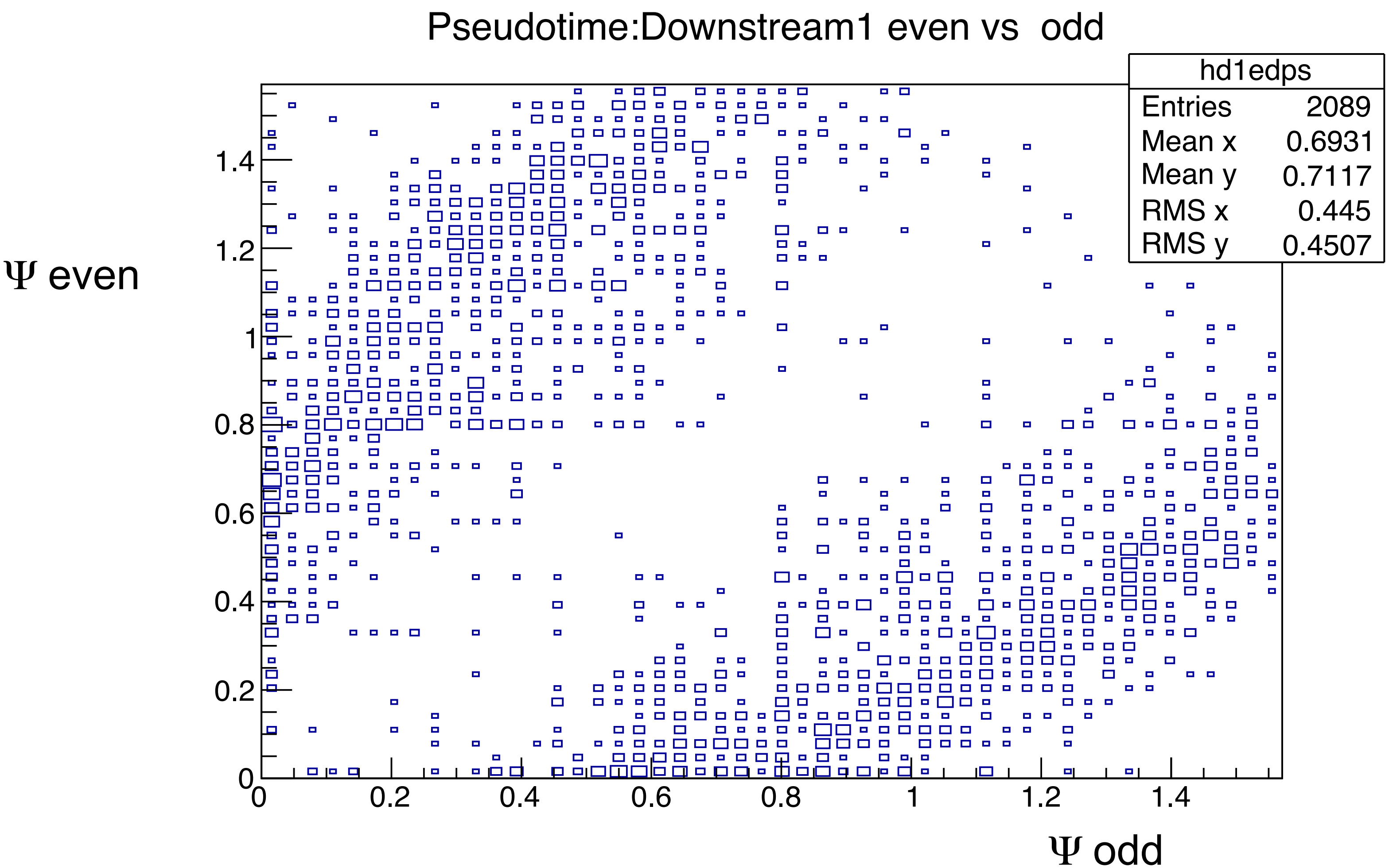
We can make the connection more precise and more useful

- ψ is a proxy for the time-within-the-time-bin
- ψ changes monotonically with sampling phase
- If the pulses arrive at random times WRT to the sampling clock, we can immediately construct a mapping $\mathcal{M}$ from pseudotime to “time-within-the-time-bin”
- With the assumption of random arrival and armed with $\mathcal{M}$, we can construct the average pulse shape

Considerations for LArIAT

- 1 ns sampling => Make two ψ measurements (odd and even samples)
- Baseline ~ 900, negative going pulses? Not a problem for the formalism
- Pulses pinned to the edges of the dynamic range cannot be used in the average pulse shape determination. They can be fit – but not as well.
- Time determination: $\mathcal{M}$ requires only a look up table(LUT), crafted from antiderivative of ψ distribution
- Amplitude determination probably not critical for LArIAT
- Pedestal (DC offset) is irrelevant
- Need a reasonably large sample of pulses to make good LUT, or to determine well the average pulse shape – Lucas is working on this data set now

Any correlation between pseudotimes(*π/2) computed from odd and even-numbered samples? Yes



Plans for a Larger (Run II) Data set

- Create ψ distributions for all four paddles
- Write LUT/interpolation machinery for $\mathcal{M}$
- Determine average pulse shape
- If there's interest, perform (closed-form) fits for amplitude, pedestal
- Check out correlations between H and V paddles
- See effect on mass/momentum distributions