HF Sourcing:
FFTs on Sourcing Data

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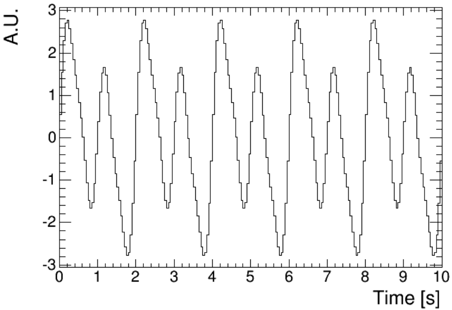
Fourier transforms reminder

- Fourier transform (FT) definition
  - $F(u) = \int_{-\infty}^{+\infty} f(t) e^{-2\pi i u t} dt$
- FTs have real and imaginary components
  - Real: $\mathcal{R}(F)$
  - Imaginary: $\mathcal{I}(F)$
- FTs have magnitude and phase in complex space:
  - Magnitude: $|F| = |\mathcal{R}(F)^2 + \mathcal{I}(F)^2|^{1/2}$
  - Phase: $\phi(F) = \tan^{-1} \frac{\mathcal{R}(\mathcal{F})}{\mathcal{I}(\mathcal{F})}$

Method

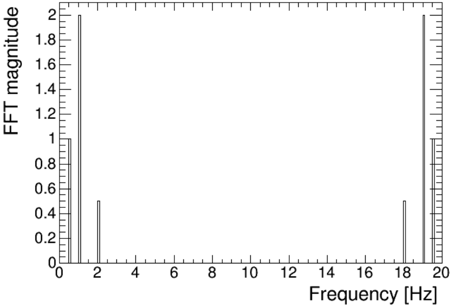
- Two very simple steps
  1. Use sine functions to test ROOT FFT software
  2. Use ROOT FFT software to analyze sourcing data
- All of this code is on git:
  1. Link to code for testing FFTs
  2. Link to code for running FFTs on sourcing data

FFT test on sine functions



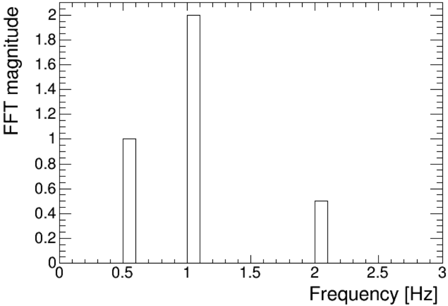
- Fill a histogram using linear combo of sine functions:
  - $f(t) = \sum_{i=0}^{3} A_i \cdot \sin(2\pi \cdot \omega_i \cdot t)$
  - $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]
  - $\omega_i = \{0.5, 1.0, 2.0\}$ [Hz]

Look at magnitude of FFT



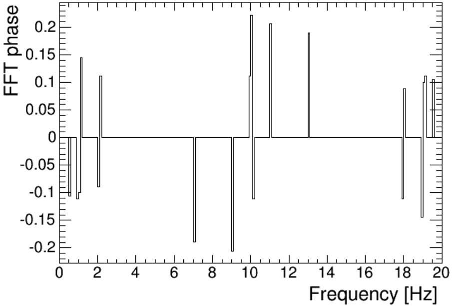
- Recall original linear combo of sine functions:
  - $f(t) = \sum_{i=0}^{3} A_i \cdot \sin(2\pi \cdot \omega_i \cdot t)$
  - $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]
  - $\omega_i = \{0.5, 1.0, 2.0\}$ [Hz]

Look at magnitude of FFT (left side of function)



- Magnitude (even function) returns A_i and ω_i
  - $f(t) = \sum_{i=0}^{3} A_i \cdot \sin(2\pi \cdot \omega_i \cdot t)$
  - $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]
  - $\omega_i = \{0.5, 1.0, 2.0\}$ [Hz]

Look at phase of FFT



- Phase information not useful for our purposes...
  - $f(t) = \sum_{i=0}^{3} A_i \cdot \sin(2\pi \cdot \omega_i \cdot t)$
  - $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]
  - $\omega_i = \{0.5, 1.0, 2.0\}$ [Hz]

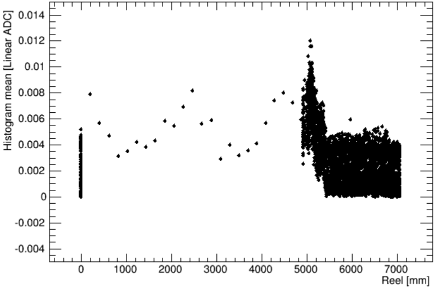
Conclusion of test:

- Can use ROOT FFT software
- ROOT FFT software can reconstruct parameters of sines
  - FT magnitude contains useful information for analysis
  - FT phase not useful for this analysis (?)
  - Can use FT phase to reconstruct original function (inverse FFT)
- Ready to try sourcing data

Look at sourcing data

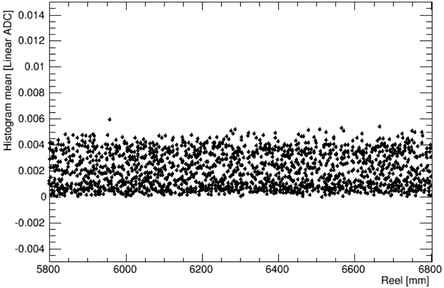
- histogram name:
  “HFP13_ETA38_PHI25_T10_SRCTUBE_
  Ieta38_Iphi25_Depth2
  Run 221509reelPosition”
- x-axis: Reel [mm]
- y-axis: Histogram mean [linear ADC]

Look at sourcing data: full range of Reel values



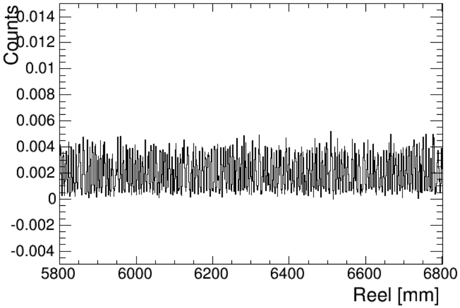
- Next: focus on Reel ϵ $[5800, 6800]$ [mm]

Look at sourcing data: zoomed Reel values (graph)



- Next: make a histogram from this TGraph

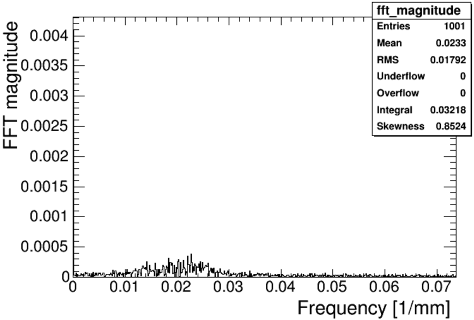
Look at sourcing data: zoomed Reel values (hist)



- If 2 points have same x-value, use mean y-value on y-axis

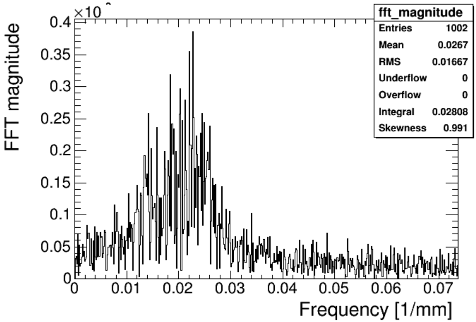
Next: do FFT on this histogram

Look at sourcing data: FFT magnitude



- "Spike" at zero is from y-axis of original histogram being centered at $y \neq 0$. You can remove it.

Look at sourcing data: FFT magnitude, no first bin



- "Frequency" peaks around 0.02 - 0.03 [1/mm]

Conclusion

- We can use ROOT software to do FFTs
  - Tests done on sine waves in time / frequency space
  - Prelim. results on data in reel / "reel frequency" space
- Prelim. results show peak in "reel frequency"
  - Around 0.02 - 0.03 [1/mm]
- Would be nice to repeat the study on sourcing data in time (OrN)
  - Need plots for this