

HF Sourcing: FFTs on Sourcing Data

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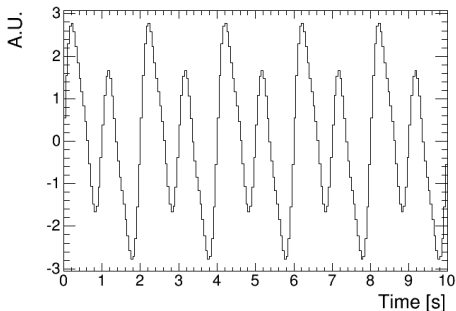
Fourier transforms reminder

- Fourier transform (FT) definition
 - $F(u) = \int_{-\infty}^{+\infty} f(t)e^{-2\pi iut} dt$
- 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: $\phi(F) = \tan^{-1} \frac{\mathcal{R}(F)}{\mathcal{I}(F)}$

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

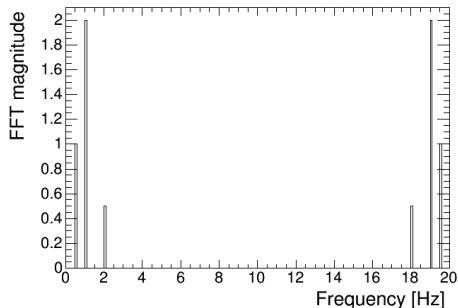
FFT test on sine functions



- Fill a histogram using linear combo of sine functions:

- $f(t) = \sum_{i=0}^3 A_i \cdot \sin(2\pi \cdot f_i \cdot t)$
- $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]
- $f_i = \{0.5, 1.0, 2.0\}$ [Hz]

Look at magnitude of FFT



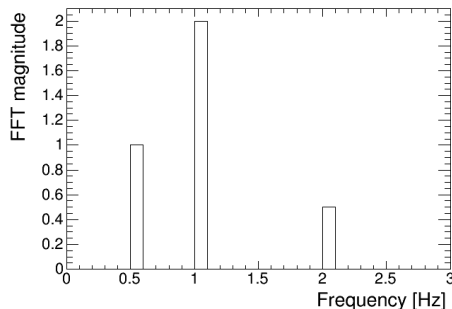
- Recall original linear combo of sine functions:

- $f(t) = \sum_{i=0}^3 A_i \cdot \sin(2\pi \cdot f_i \cdot t)$

- $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]

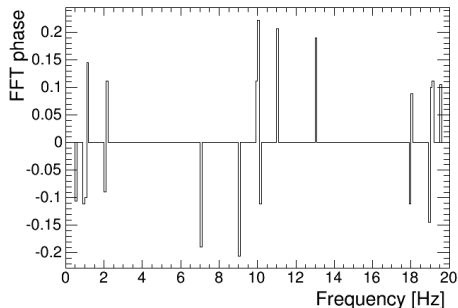
- $f_i = \{0.5, 1.0, 2.0\}$ [Hz]

Look at magnitude of FFT (left side of function)



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

Look at phase of FFT



- Phase information not useful for our purposes. . .

- $f(t) = \sum_{i=0}^3 A_i \cdot \sin(2\pi \cdot f_i \cdot t)$
- $A_i = \{1.0, 2.0, 0.5\}$ [A.U.]
- $f_i = \{0.5, 1.0, 2.0\}$ [Hz]

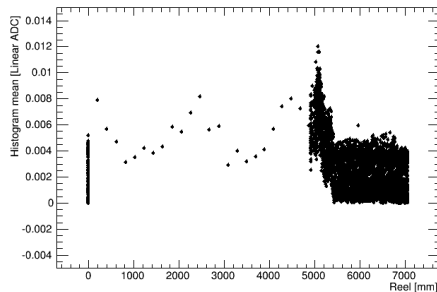
Conclusion of test:

- 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

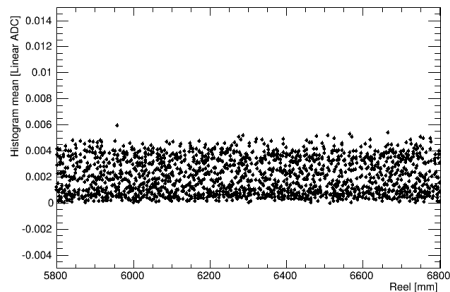
- histogram name:
"HFP13_ETA38_PHI25_T10_SRCTUBE_
Ieta38_Iphi25_Depth2
Run 221509reelPosition"
- x-axis: Reel [mm]
- y-axis: Histogram mean [linear ADC]

Look at sourcing data: full range of reel vals



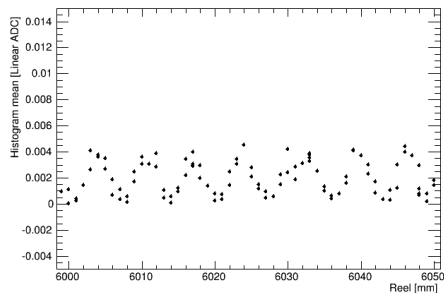
- Next: focus on reel $\in [5800, 6800]$ [mm], where amplitude is stable

Look at sourcing data: zoomed reel vals (TGraph)



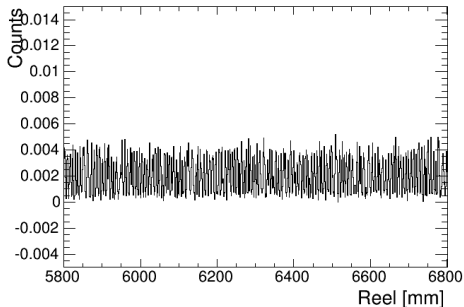
- This looks stable. We can do our FFT on this data.
- Next: zoom in even further ([6000, 6050]) to see what frequency we suspect naively

Look at sourcing data: zoomed reel vals (TGraph)



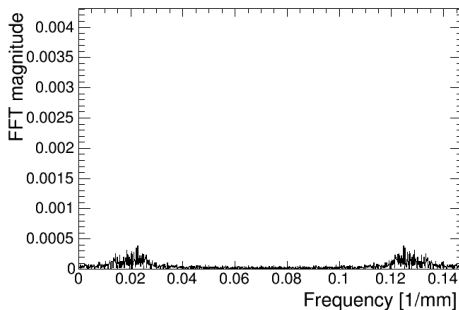
- 7 periods in 50mm:
 - $T = 50 \text{ [mm]}/7 = 7.14 \text{ [mm]}$
 - $f = 1/T = 0.14 \text{ [1/mm]}$
- Only a naive guess for the frequency!

Look at sourcing data: zoomed reel vals (TH1F)



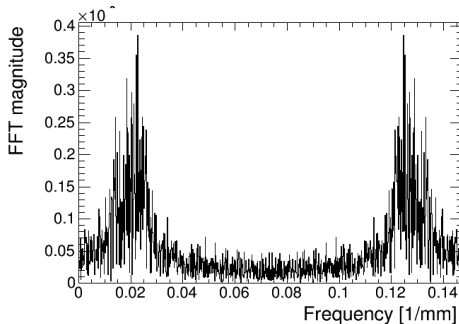
- Now make a histogram from the TGraph (result above)
 - If multiple points in TGraph have the same x-value, use their mean y-value on y-axis for histogram
- Next: do FFT on this histogram

Look at sourcing data: FFT magnitude



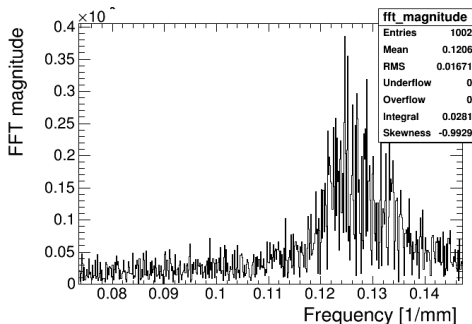
- Magnitude at zero is very large, because y-values of the original histogram are not centered at zero
- Next: remove bin at Frequency = 0

Look at sourcing data: FFT magnitude, no first bin



- Now we can see the structure of the FFT magnitude
- Next: consider only the upper “half” of the magnitude’s range

Look at sourcing data: FFT magnitude, upper half



- FFT magnitude peaks between “reel frequency” (in [1/mm]) of 0.12 and 0.13
- Roughly matches our naive guess (0.14)

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 0.12 - 0.13 [1/mm]
- Would be nice to repeat the study on sourcing data in time (OrN)
 - Need plots for this