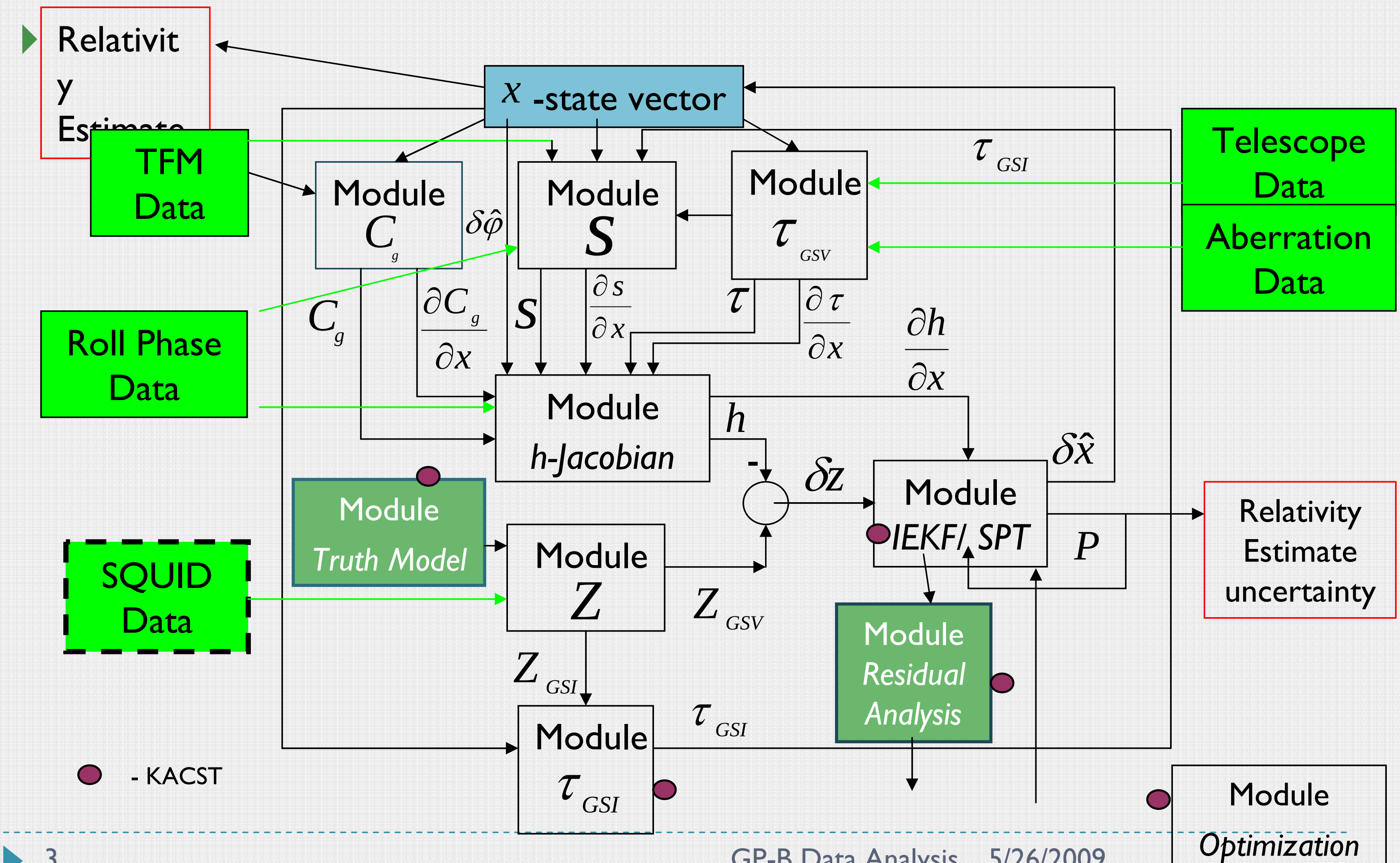
Data Analysis: Truth Model

Badr, M. Heifetz, V. Solomink,

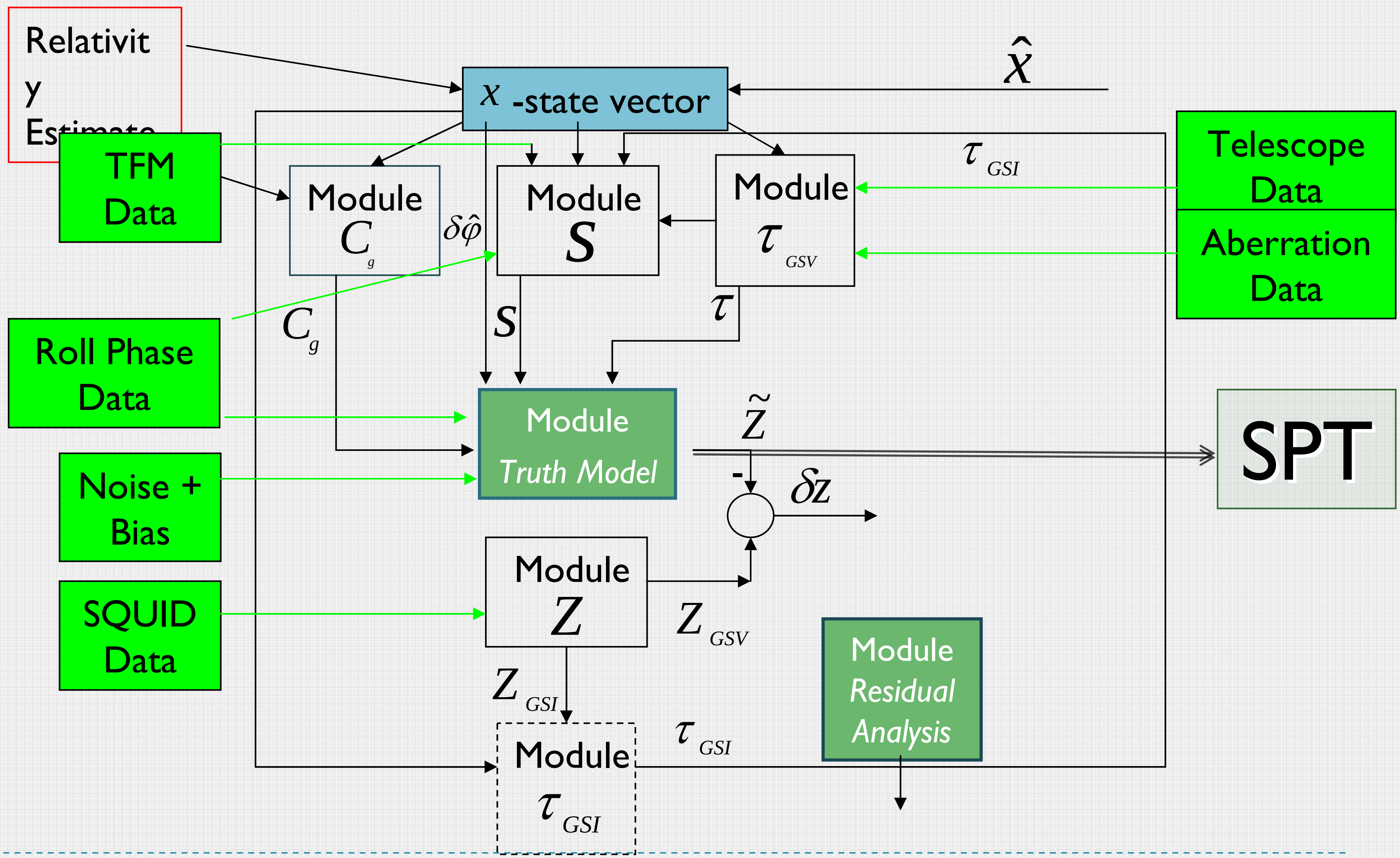
Why We Need Truth Model

- Filter efficiency estimation based on the truth model.
  - Filter properties are easier to be determined when the truth is known.
- Sensitivity to the filter-model mismatch.
- Is the current model a sufficient representation of the real system? Are all parameters need to be determined?
  - Model Identification.
- Model verification. (Tom)

Module-based Functional Block Diagram



Truth Model Block Diagram



SQUID Readout Signal Model

SQUID Signal

$$Z_{SQUID}(t) = C_g(t)\{[\tau_{NS}(t) - s_{NS}(t)]\cos(\Phi_r(t) + \delta\varphi) + [\tau_{EW}(t) - s_{EW}(t)]\sin(\Phi_r(t) + \delta\varphi)\} + bias + noise$$

$$C_g(t) = C_L^{LM}[1 + \sum_{m=0}^{M_{cg}} \left(a_m \cos(m\Phi_p(t)) + b_m \sin(m\Phi_p(t))\right)],$$

$$\begin{pmatrix} a_m(t) \\ b_m(t) \end{pmatrix} = \sum_{n=0}^{N_{cg}} \begin{pmatrix} a_{mn} \\ b_{mn} \end{pmatrix} \varepsilon^{m+2n}(t),$$

$$\varepsilon(t) = \tan(\gamma(t)/2)$$

$$\frac{ds_{NS}}{dt} = r_{NS} + k(t)(\tau_{EW} - s_{EW}) + \sum_{m=0}^{Mc}\sum_{n=0}^{Nc} \varepsilon^{m+2n}[a_{mn}^{-}\cos\Phi_m^{-}(t) - b_{mn}^{+}\sin\Phi_m^{-}(t) + a_{mn}^{+}\cos\Phi^{+}{}_m(t) - a_{mn}^{-}\sin\Phi^{+}{}_m(t)]$$

$$\frac{ds_{EW}}{dt} = \;.....$$

Gyroscope Motion: Torque Model

$$k(t)=\sum_{m=0}^{M_k}[k_{1m}(\gamma_0)\cos m\Phi_0(t)+k_{2m}(\gamma_0)\sin m\Phi_0(t)]$$

$$\begin{pmatrix}k_{1m}\\k_{2m}\end{pmatrix}=\sum_{n=0}^{N_k}\begin{pmatrix}k_{1mn}\\k_{2mn}\end{pmatrix}\varepsilon_0^{n+1-\delta_{0m}}(t),\quad m=0,1,\ldots,M_k$$

$$\varepsilon_0=\tan(\gamma_0/2)$$

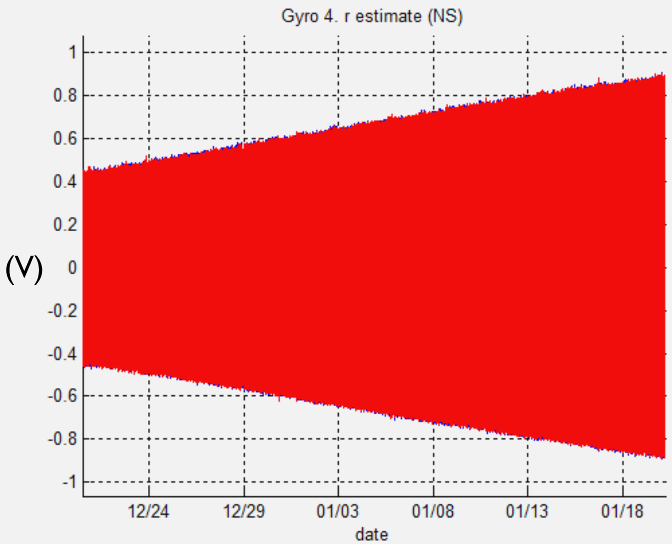
TFM

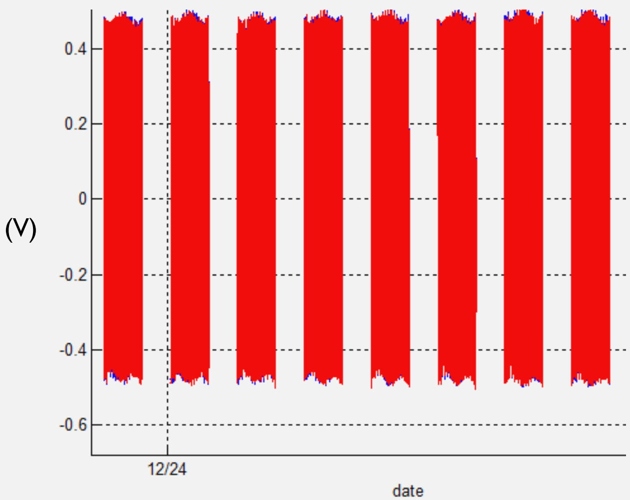
$$c^{\pm}(t)=\sum_{m=0}^{M_c}[c^{\pm}_{1m}(\gamma_0)\cos m\Phi^0_p(t)+c^{\pm}_{2m}(\gamma_0)\sin m\Phi^0_p(t)]$$

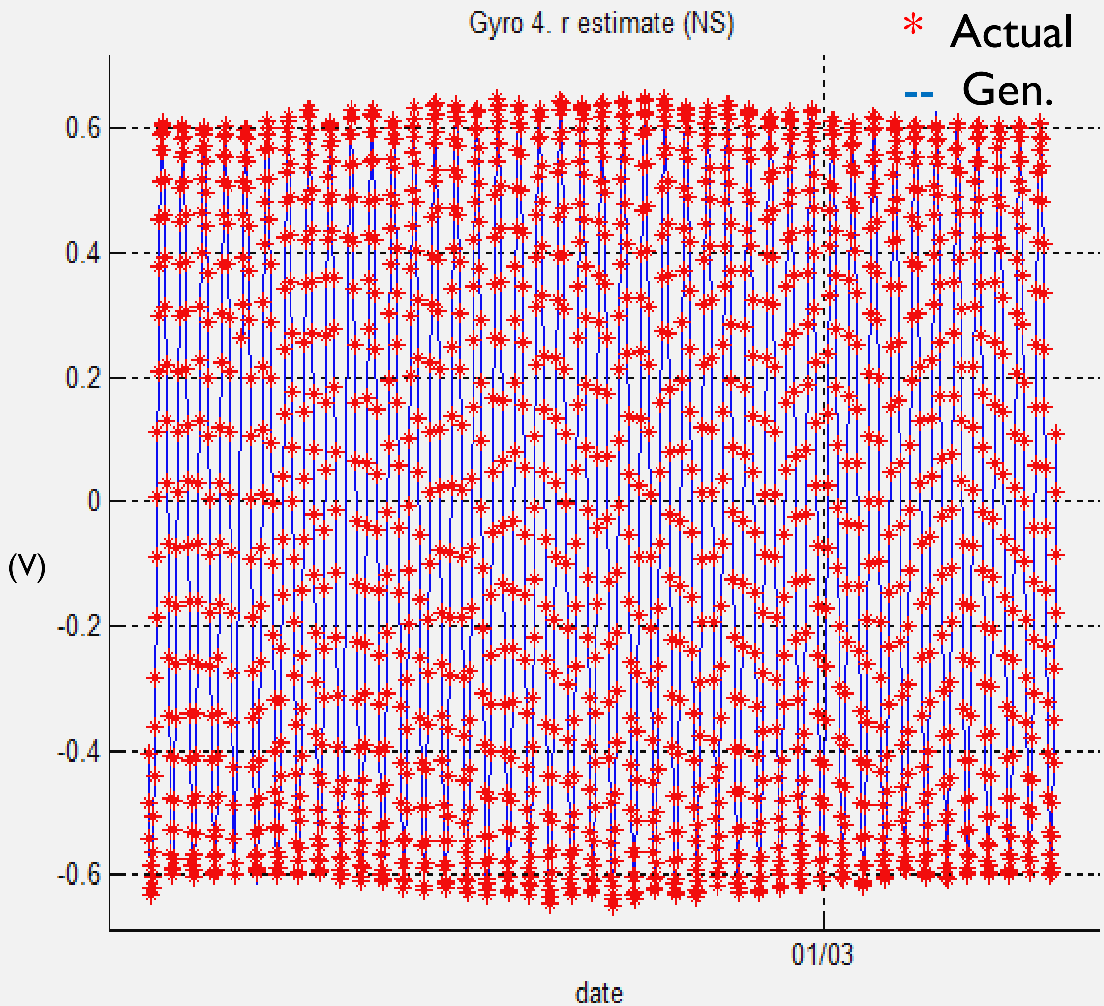
$$\begin{pmatrix}c^{\pm}_{1m}\\c^{\pm}_{2m}\end{pmatrix}=\sum_{n=0}^{N_c}\begin{pmatrix}c^{\pm}_{1mn}\\c^{\pm}_{2mn}\end{pmatrix}\varepsilon_0^{n+1-\delta_{0n}}(t),\quad m=0,1,\ldots,M_c$$

$$\begin{pmatrix}S_{NS}\\S_{EW}\end{pmatrix}_t=\psi(t,t_0)\begin{pmatrix}S_{NS}\\S_{EW}\end{pmatrix}_{t_0}+\psi(t,t_0)\int_{t_0}^{t}\psi(t',t_0)\begin{pmatrix}U_1(t')\\U_2(t')\end{pmatrix}dt'$$

Generated Squid Signal

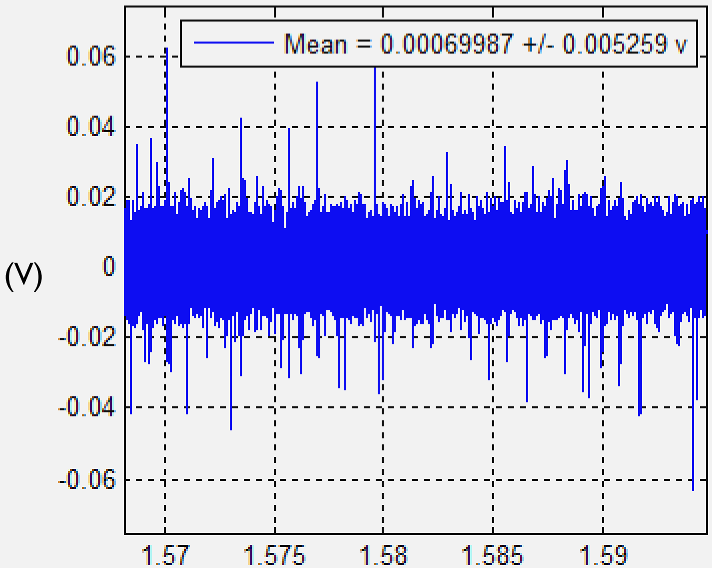




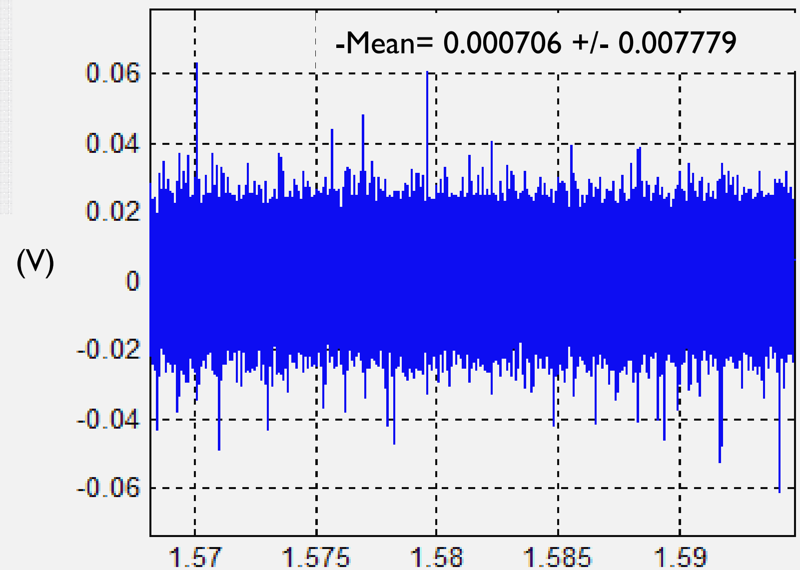


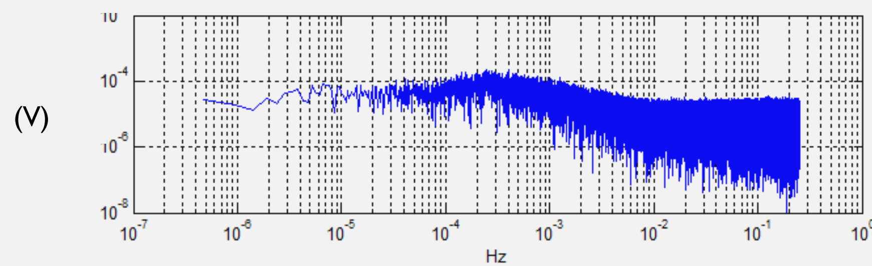
Generated vs. Actual Squid

Actual and Generated Squid signal difference



Actual and Generated Squid signal difference plus noise

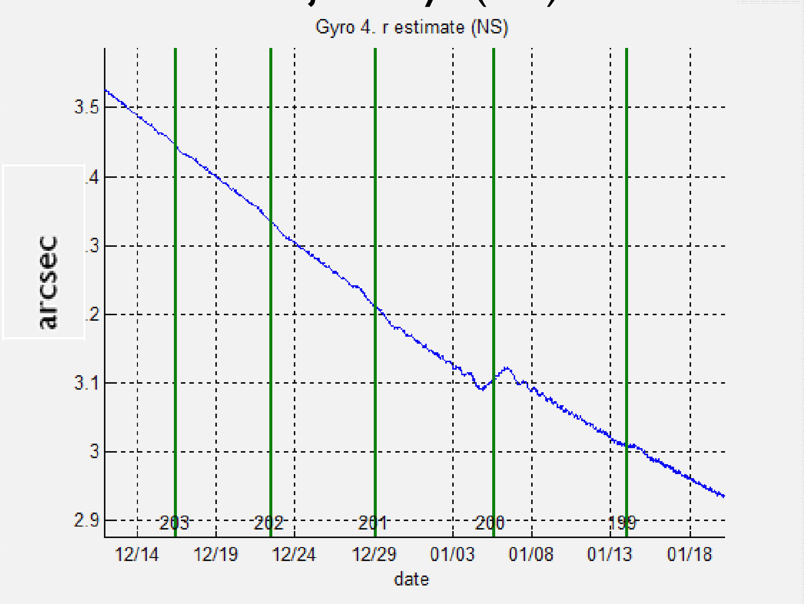




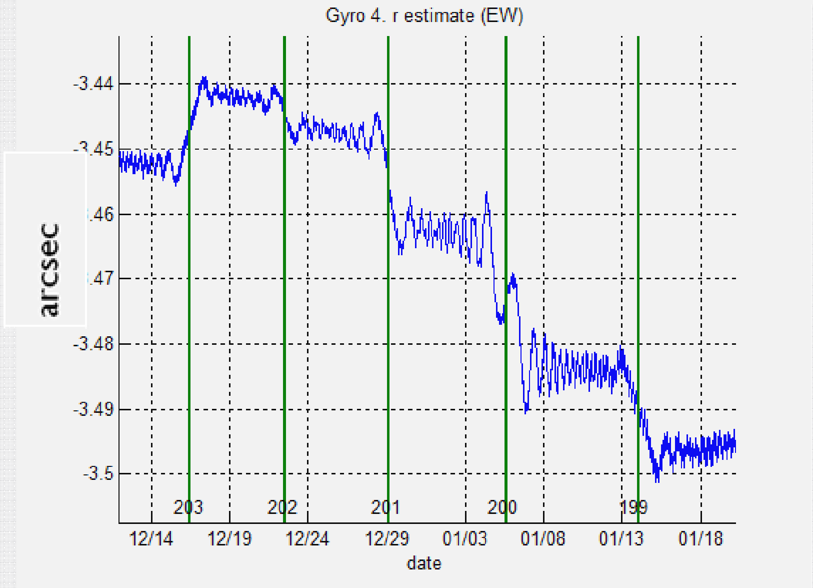
1/f generated noise (Tom)

Result

Generated Trajectory (NS)



Generated Trajectory (EW)



- Similar results were obtained for all four gyros.

MATLAB Calls

- S0= ZsquidTruth2go(‘initi’, X, iXc, iXg, GYROS);
  - Inputs: Assigned state vector, state index, and Gyro properties.
  - Outputs: Initial position (each segment), and stores the state vector.
- [SO, Z]= ZsquidTruth2go(‘getZ’, ‘GSV / GSI’, S0, tSpan, …. GYROS);
  - Inputs: Initial position, time, and case.
  - Output: last trajectory, and Z{gyro#}= [t, Hnom, H, S];
- It calls existing functions: any changes can be easily updated.

The truth model is integrated in the 2 sec. Filter.