

NORTH AMERICAN NANOHERTZ OBSERVATORY

for

GRAVITATIONAL WAVES



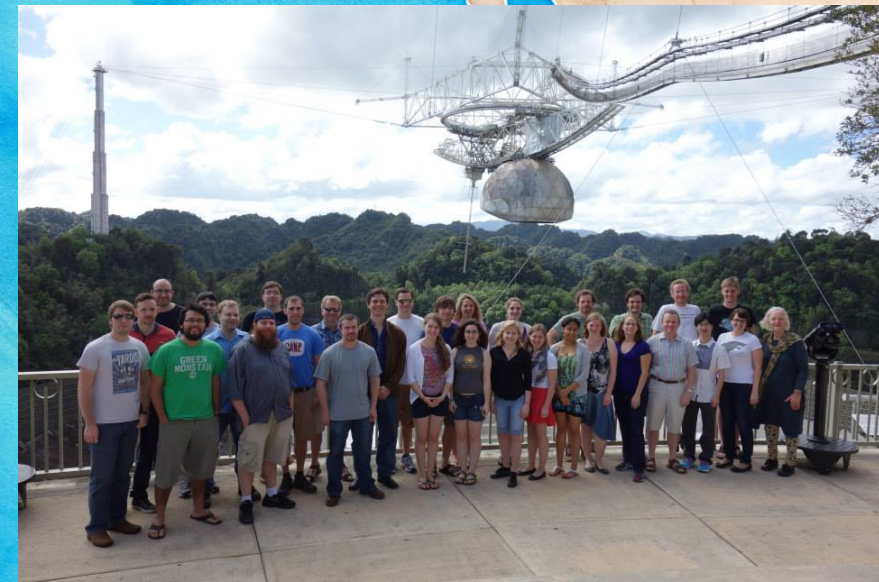
Recent Highlights of the NANOGrav Pulsar Timing Array

Michael T. Lam

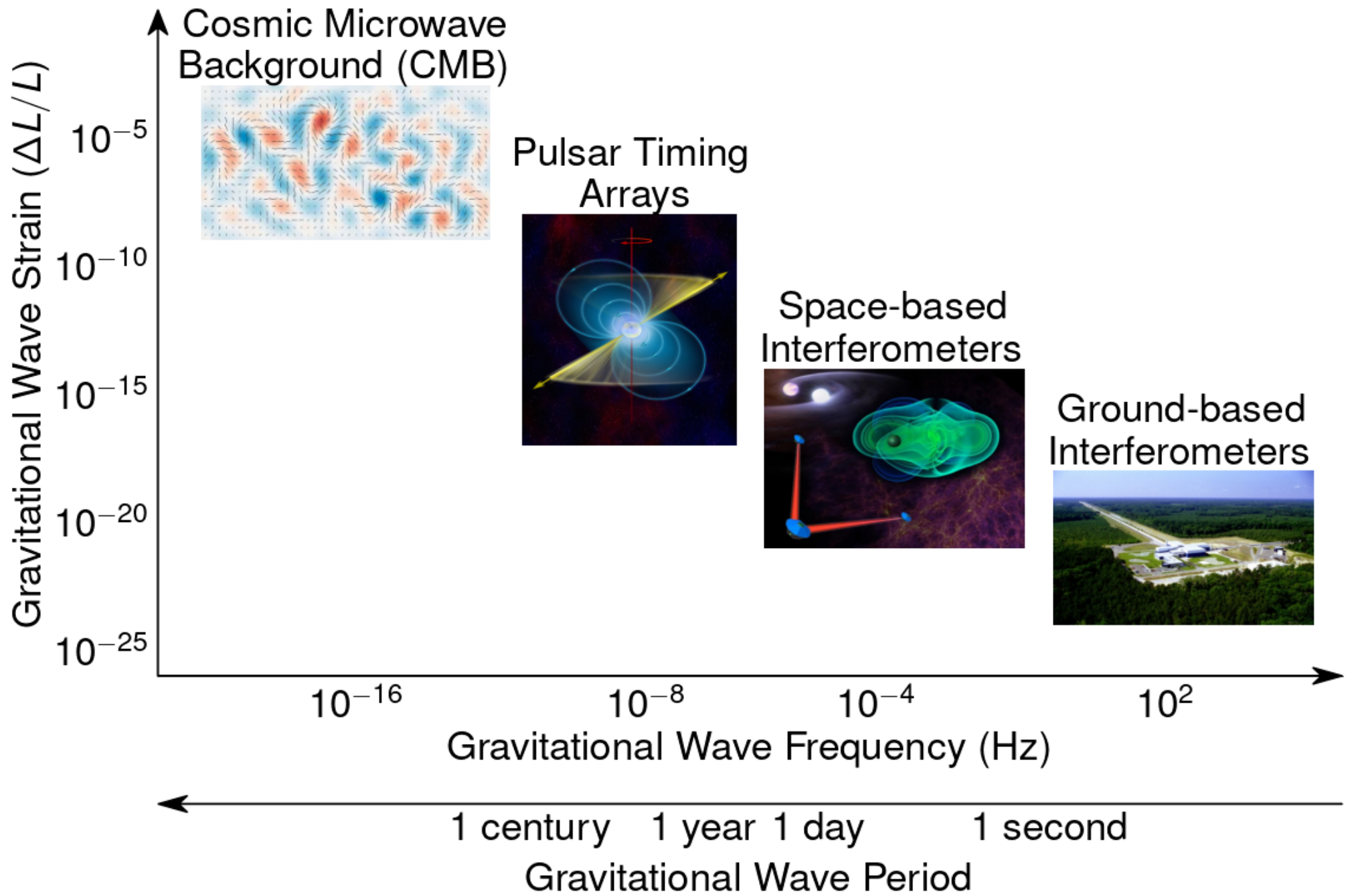
AAS 241 – 9 Jan 2022

RIT

College of Science
**Astrophysical Sciences
and Technology**

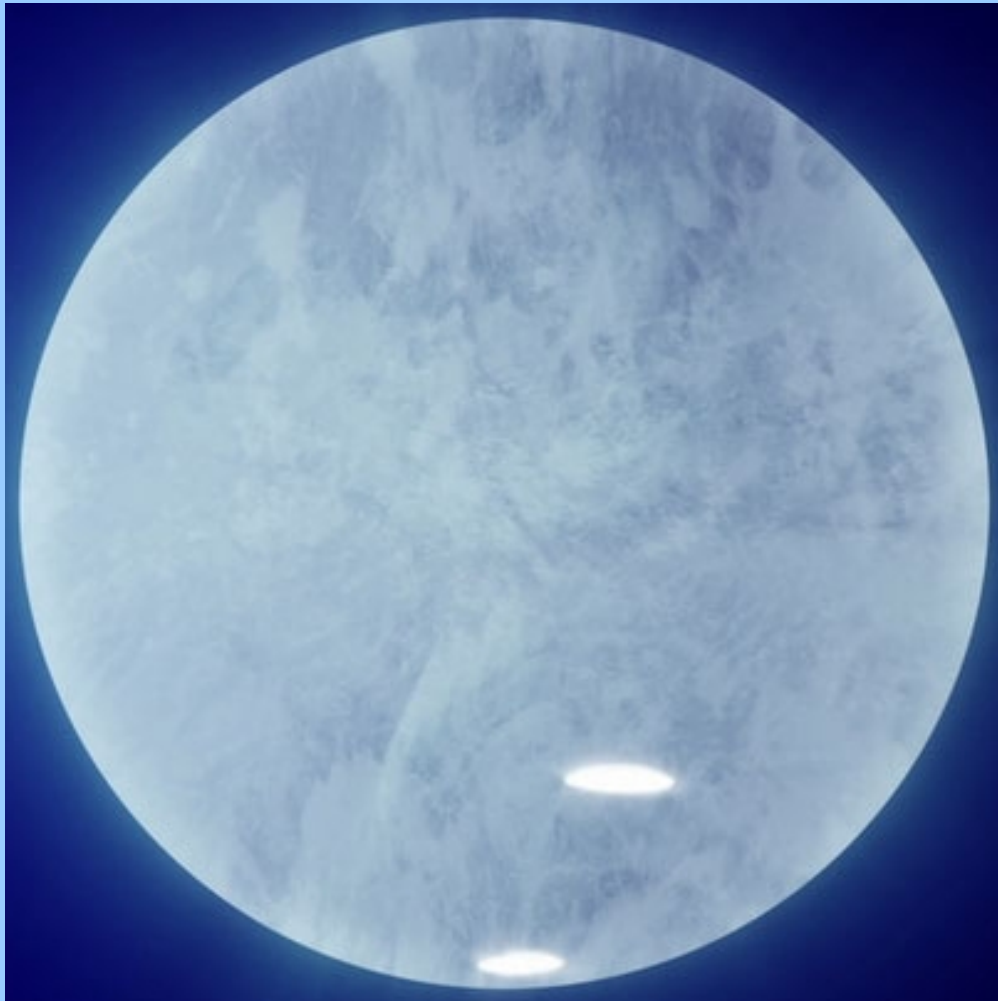


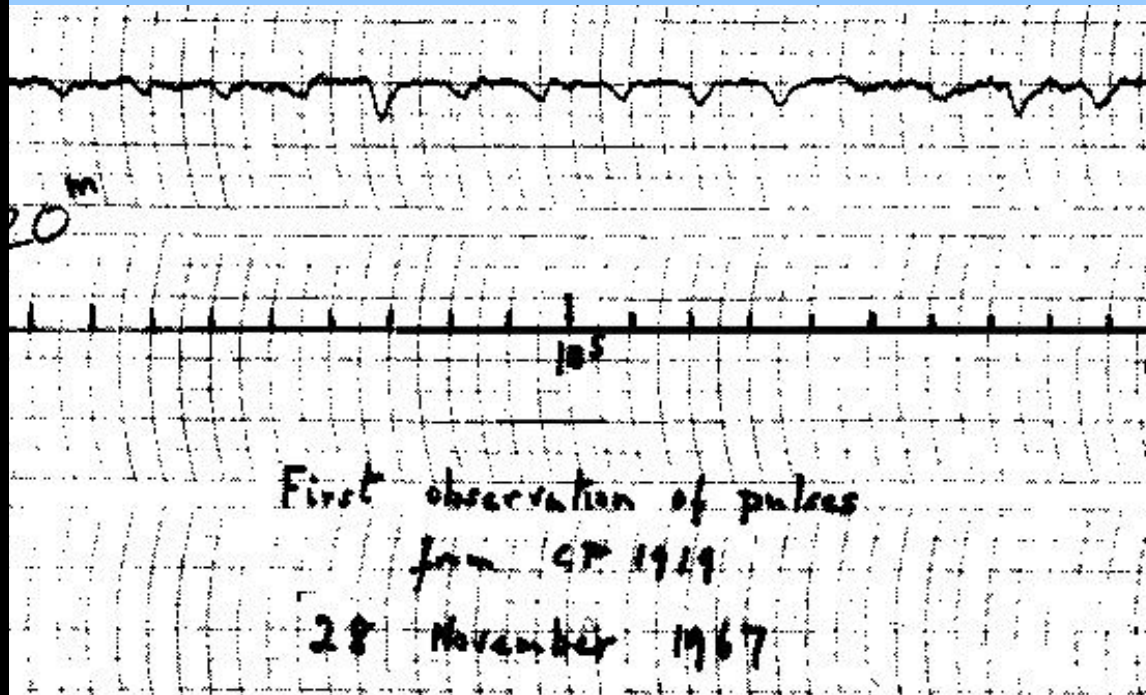
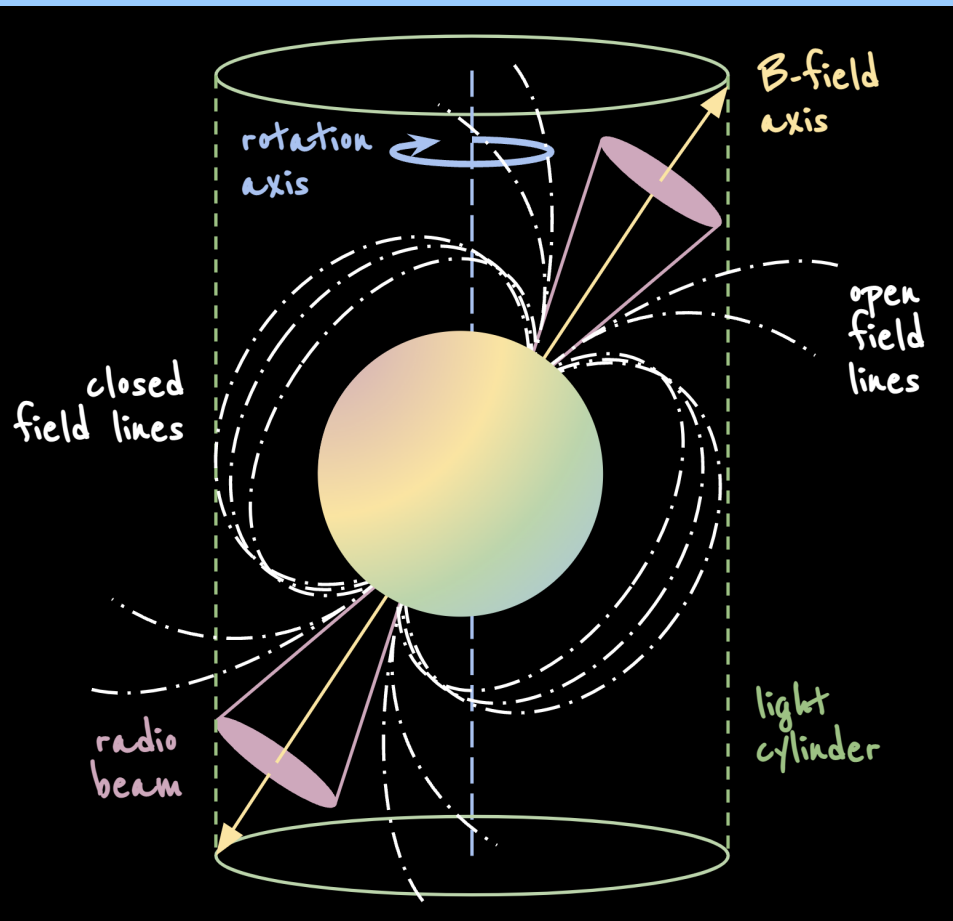
L,M: NRAO/AUI, R: NAIC



Neutron Stars

$M \sim 1-2 M_{\odot}$, $R \sim 12 \text{ km}$

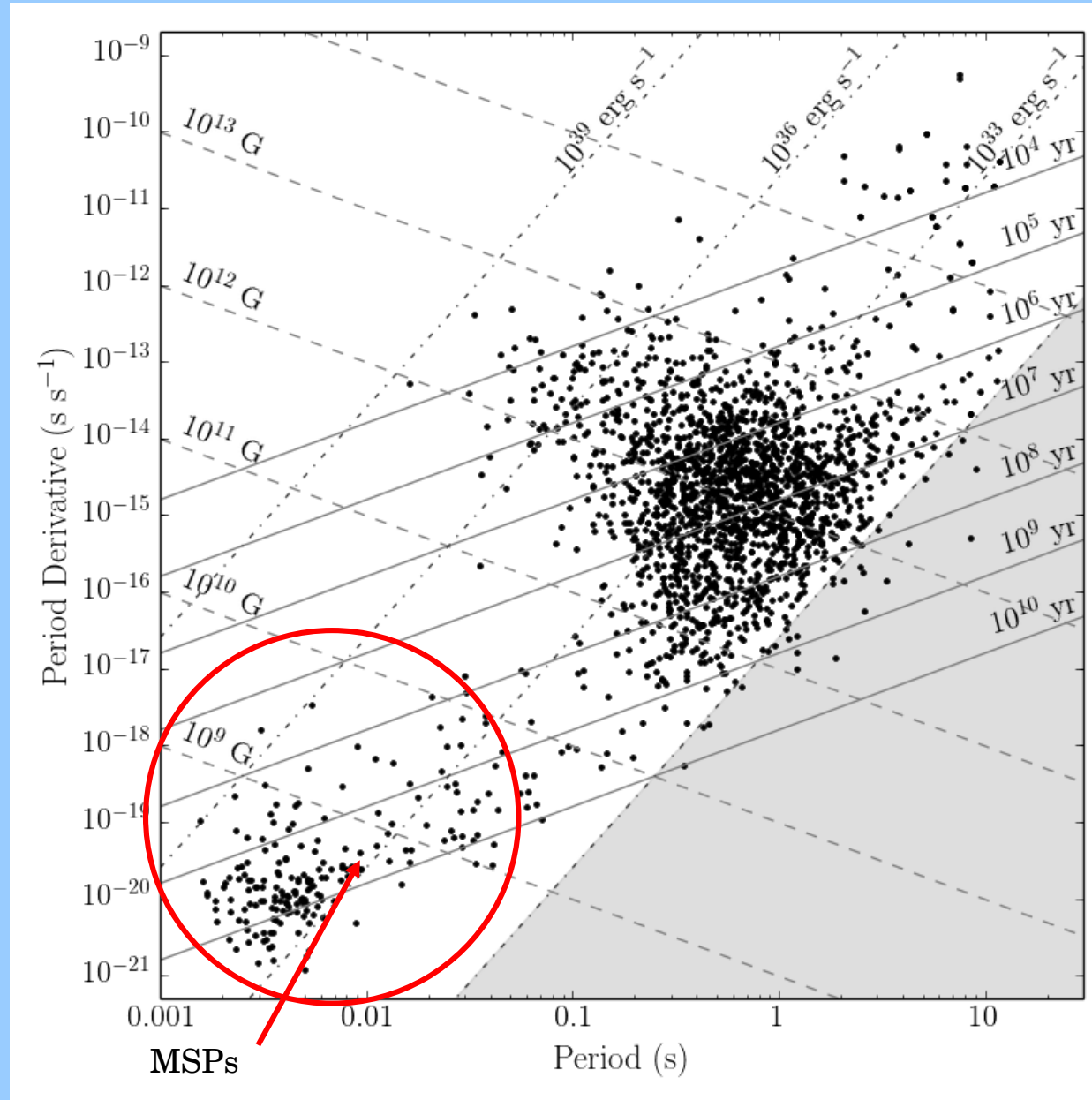




L: Thankful Cromartie

R: http://www.cv.nrao.edu/course/ast534/images/PSRs_discovery.jpg

Millisecond Pulsars

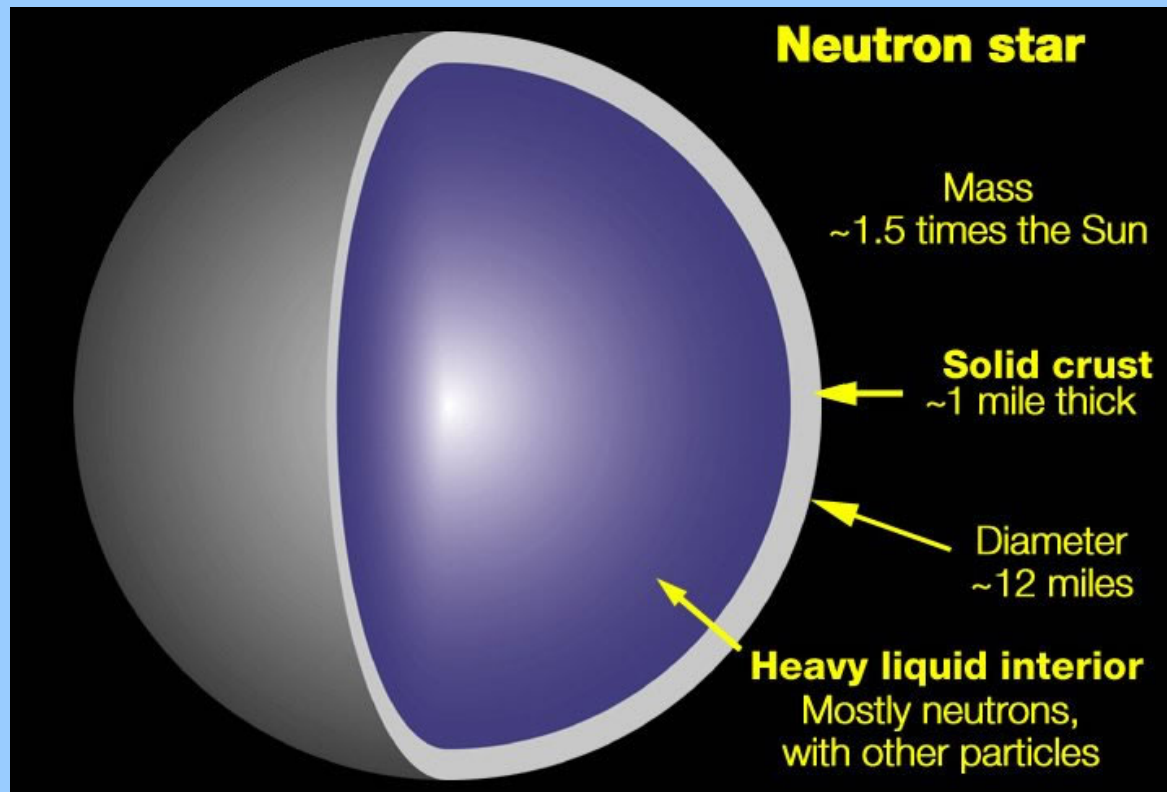


The Tiny Effects of GWs

$L \sim cT \sim 10$ lightyears ($= 3$ pc $= 10^{17}$ m)

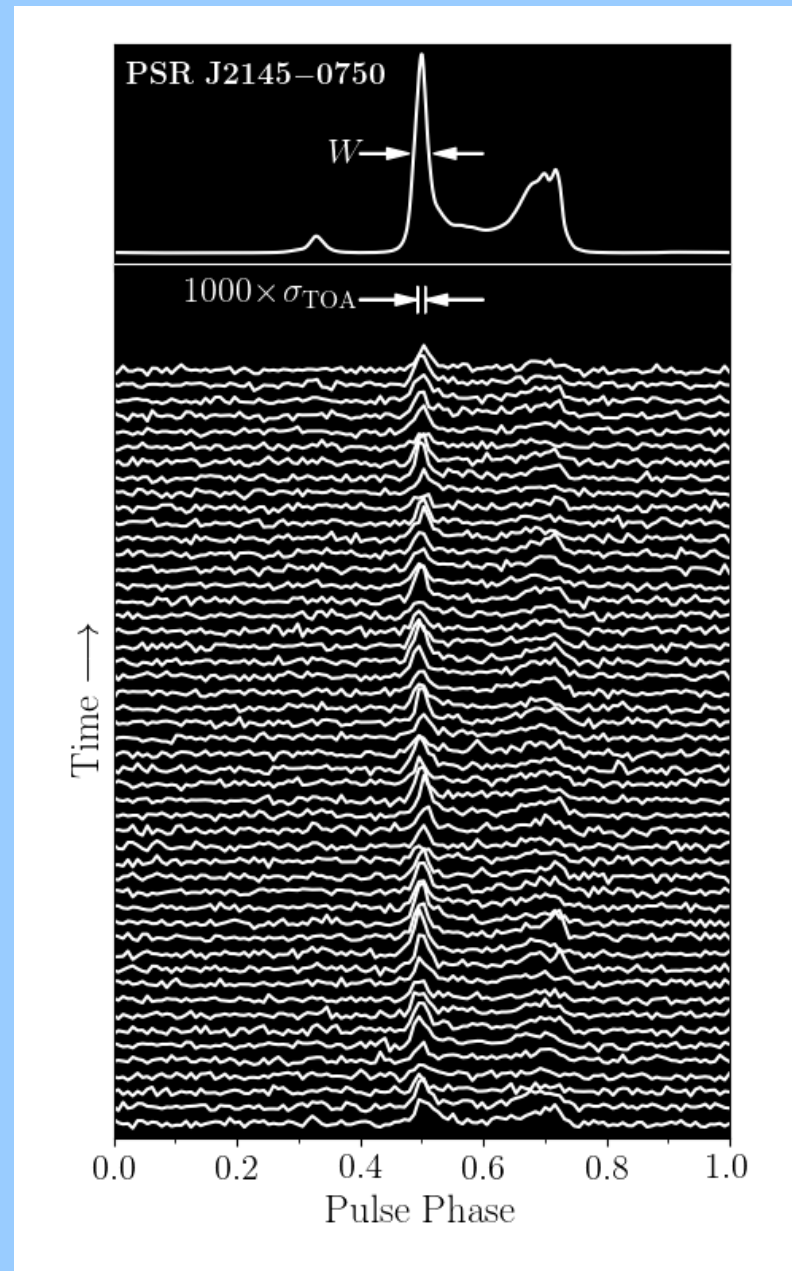
$h \sim 10^{-16} - 10^{-14}$ (for our sources)

$\Delta L \sim hL \sim 10-1000$ m $\rightarrow \Delta t = \Delta L/c \sim hT \sim 30-3000$ ns

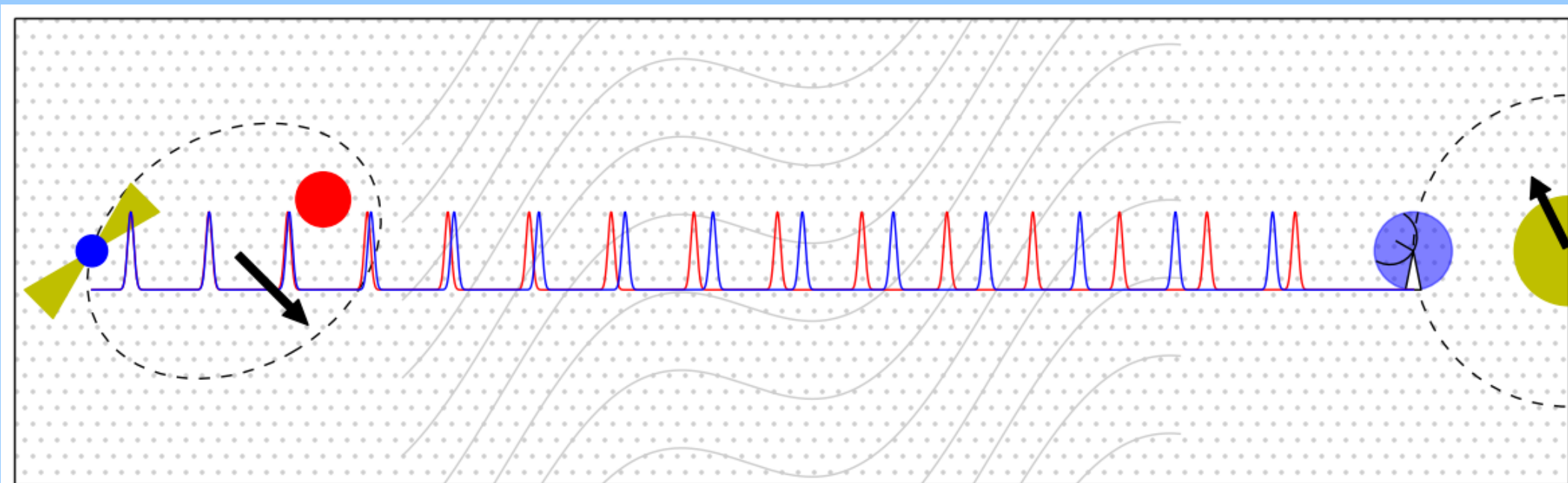


0.001 – 0.1 R_{NS}

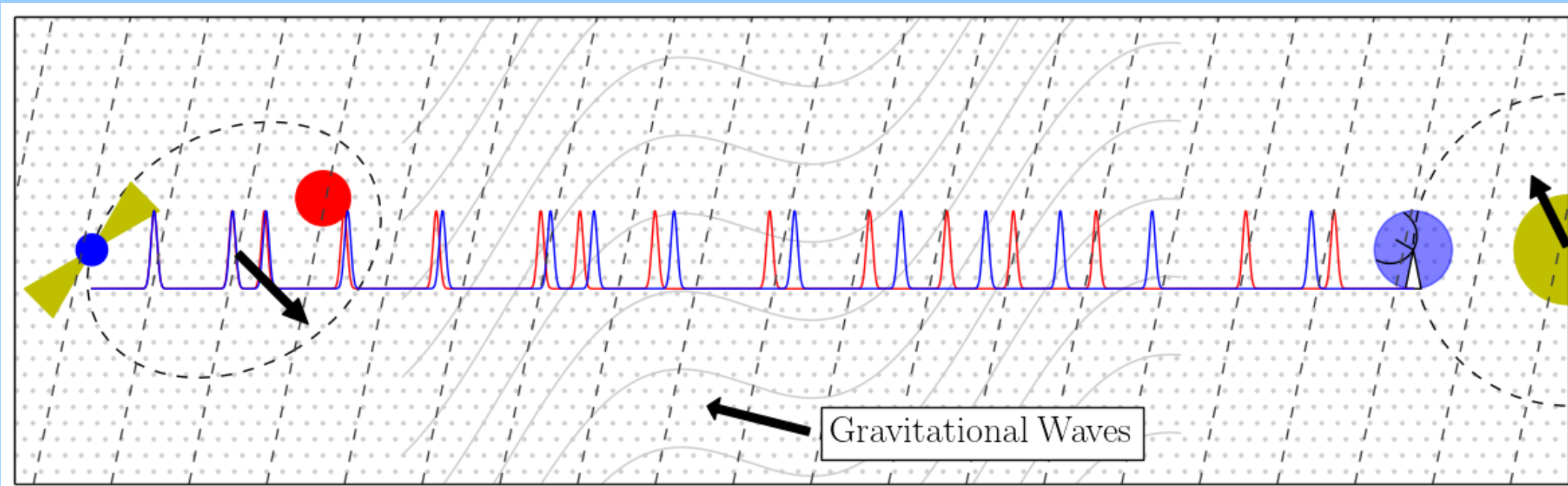
Measuring Pulses



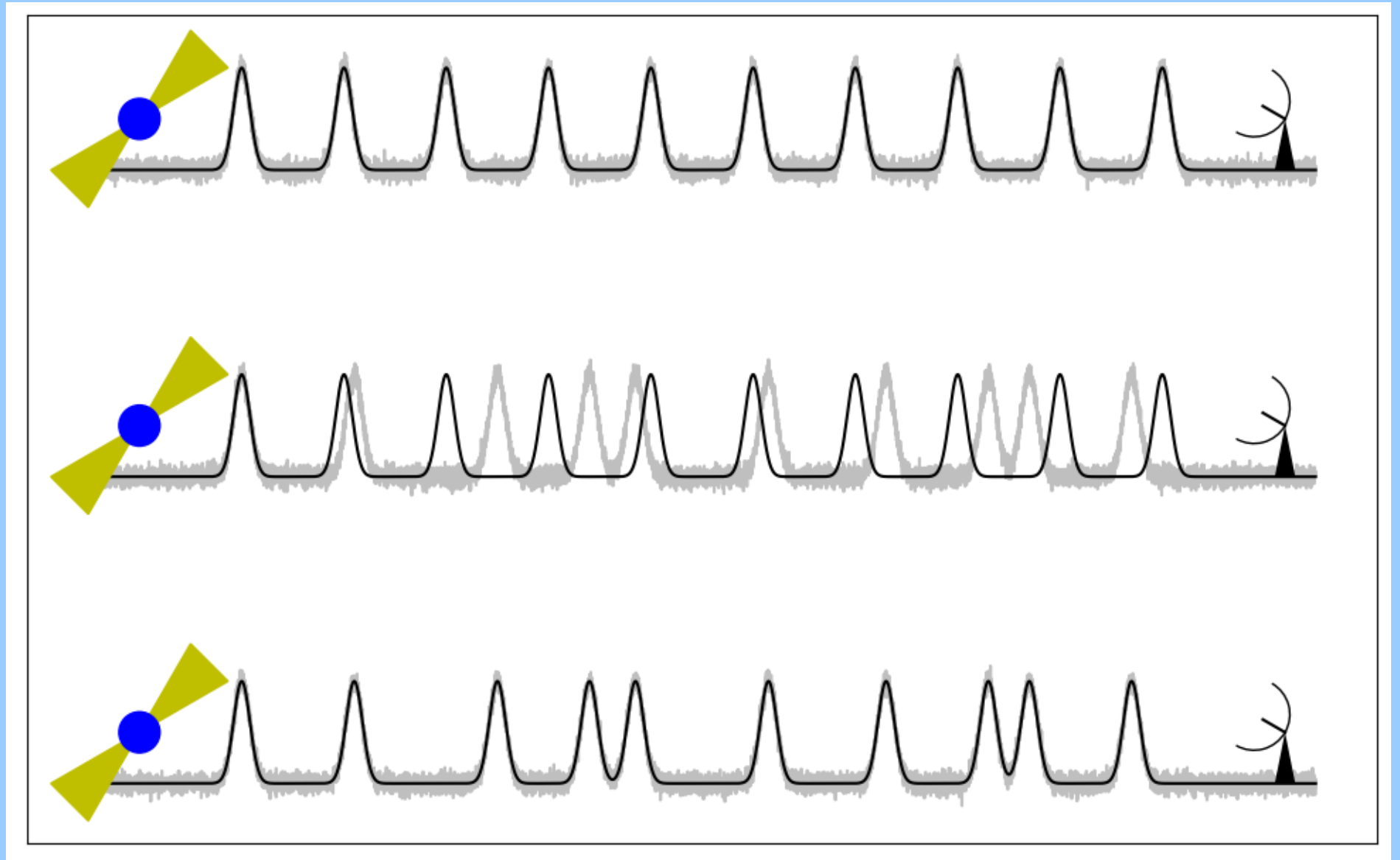
Timing Model



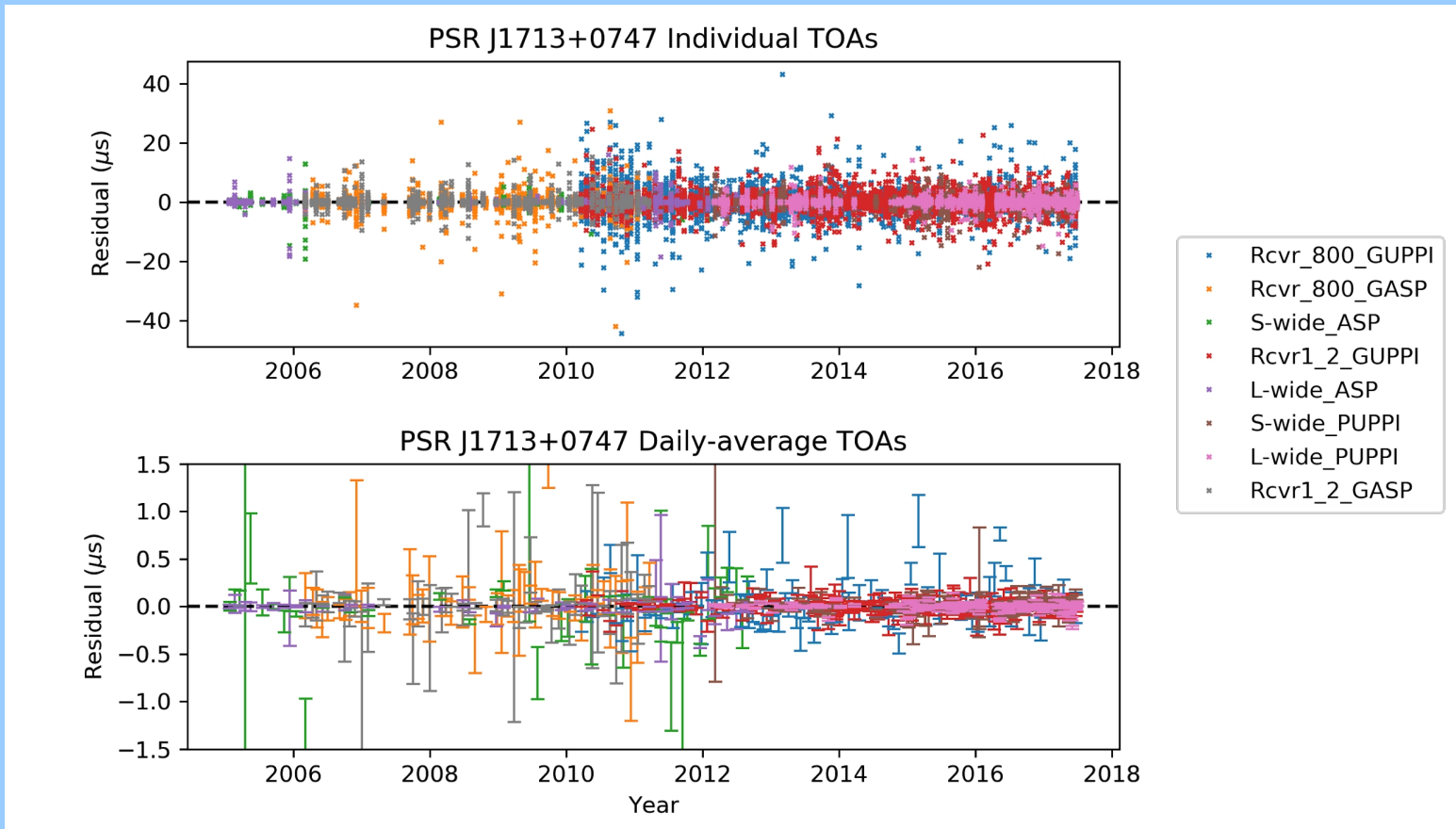
Timing Model



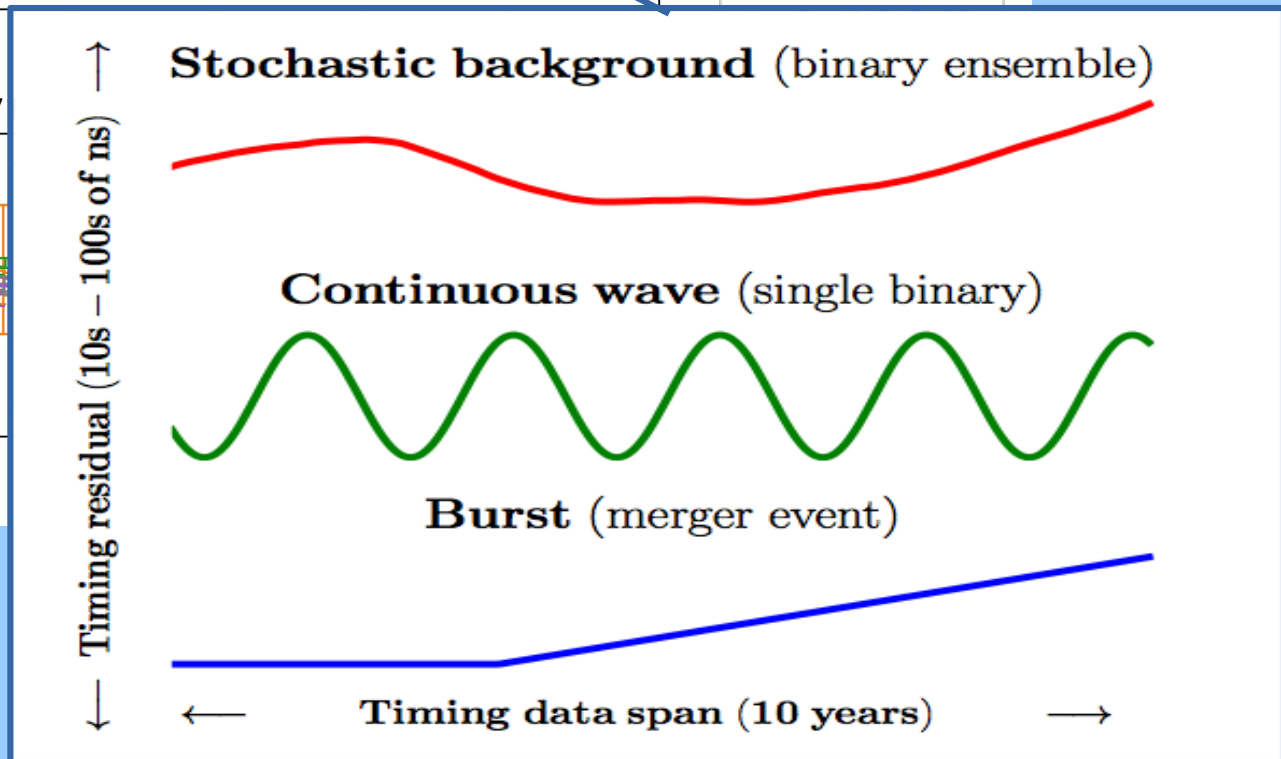
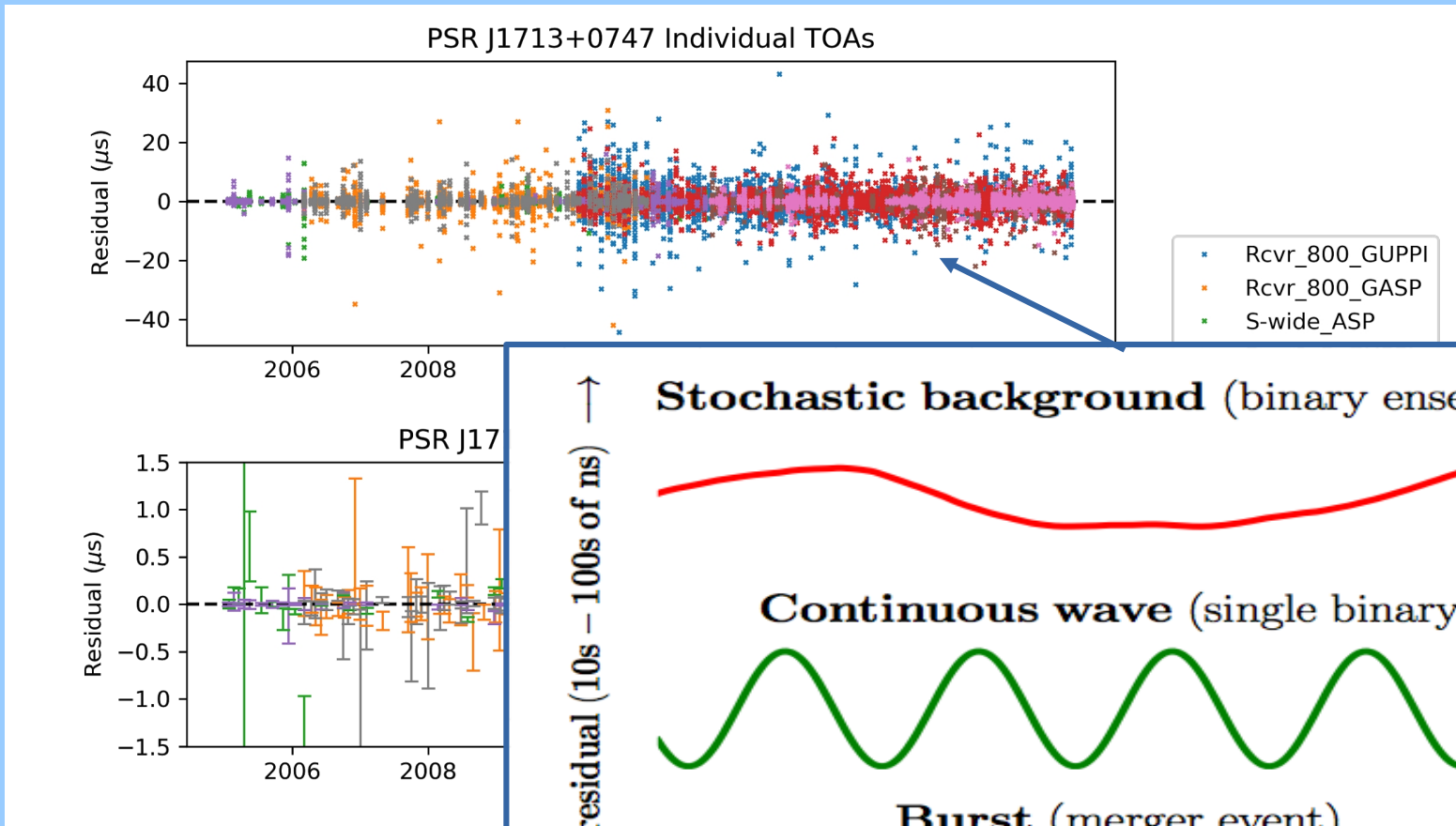
Pulsar Timing



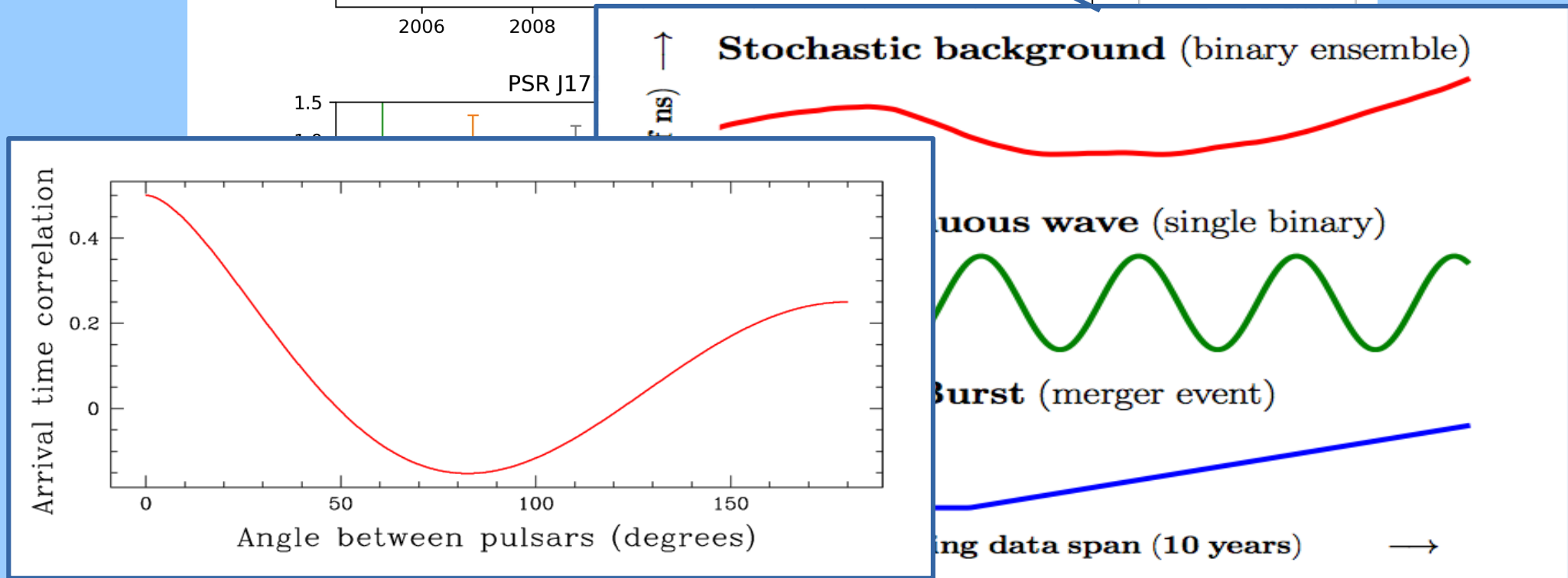
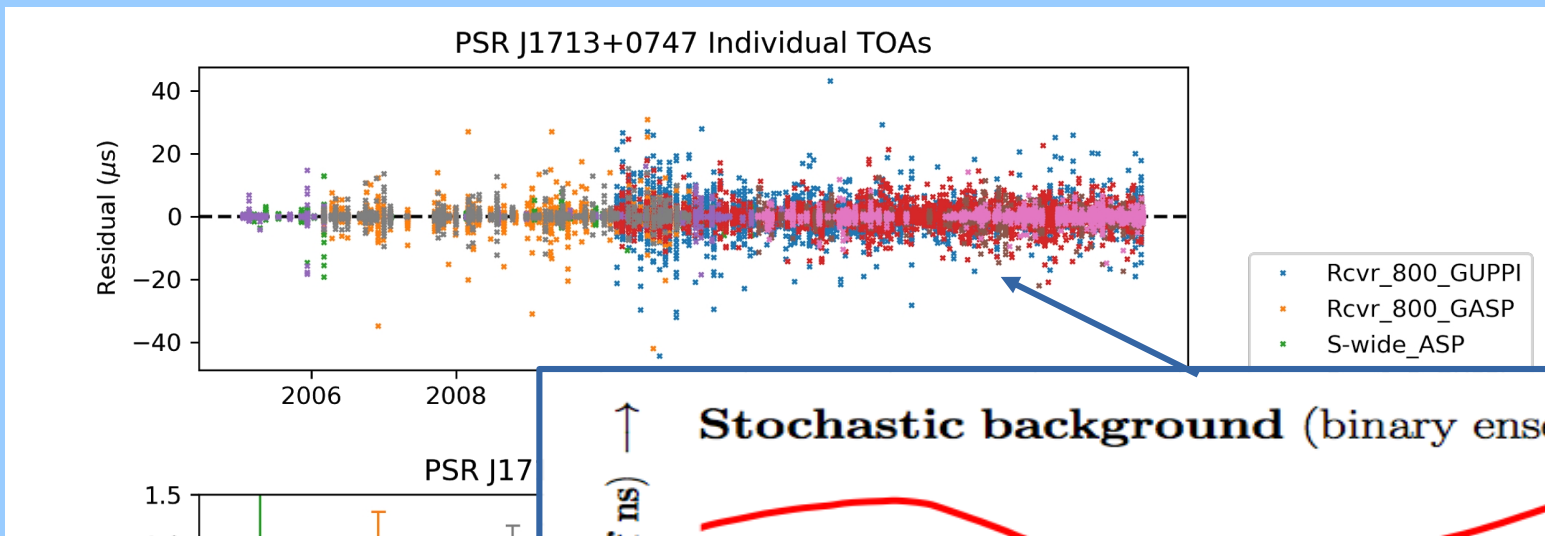
Residuals and GW Signatures



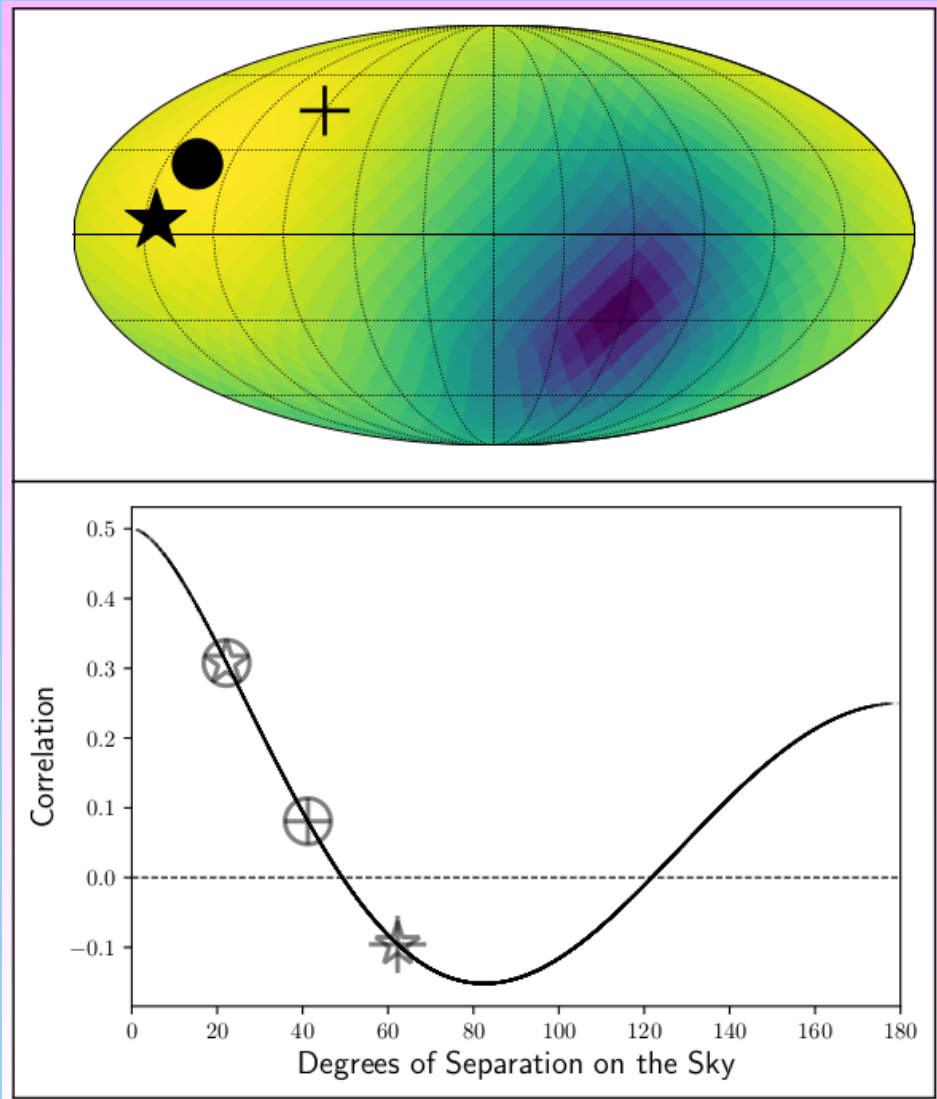
Residuals and GW Signatures



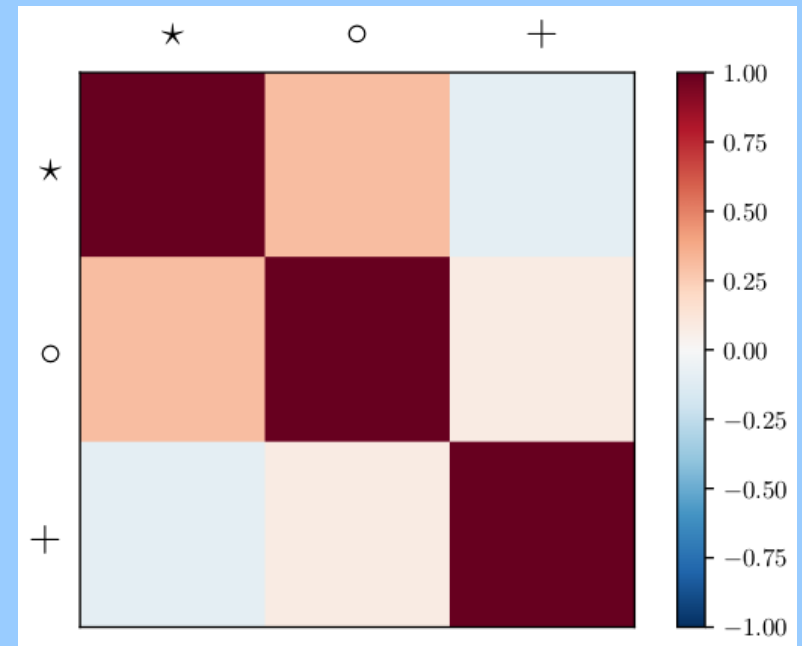
Residuals and GW Signatures



PTAs and Angular Correlations

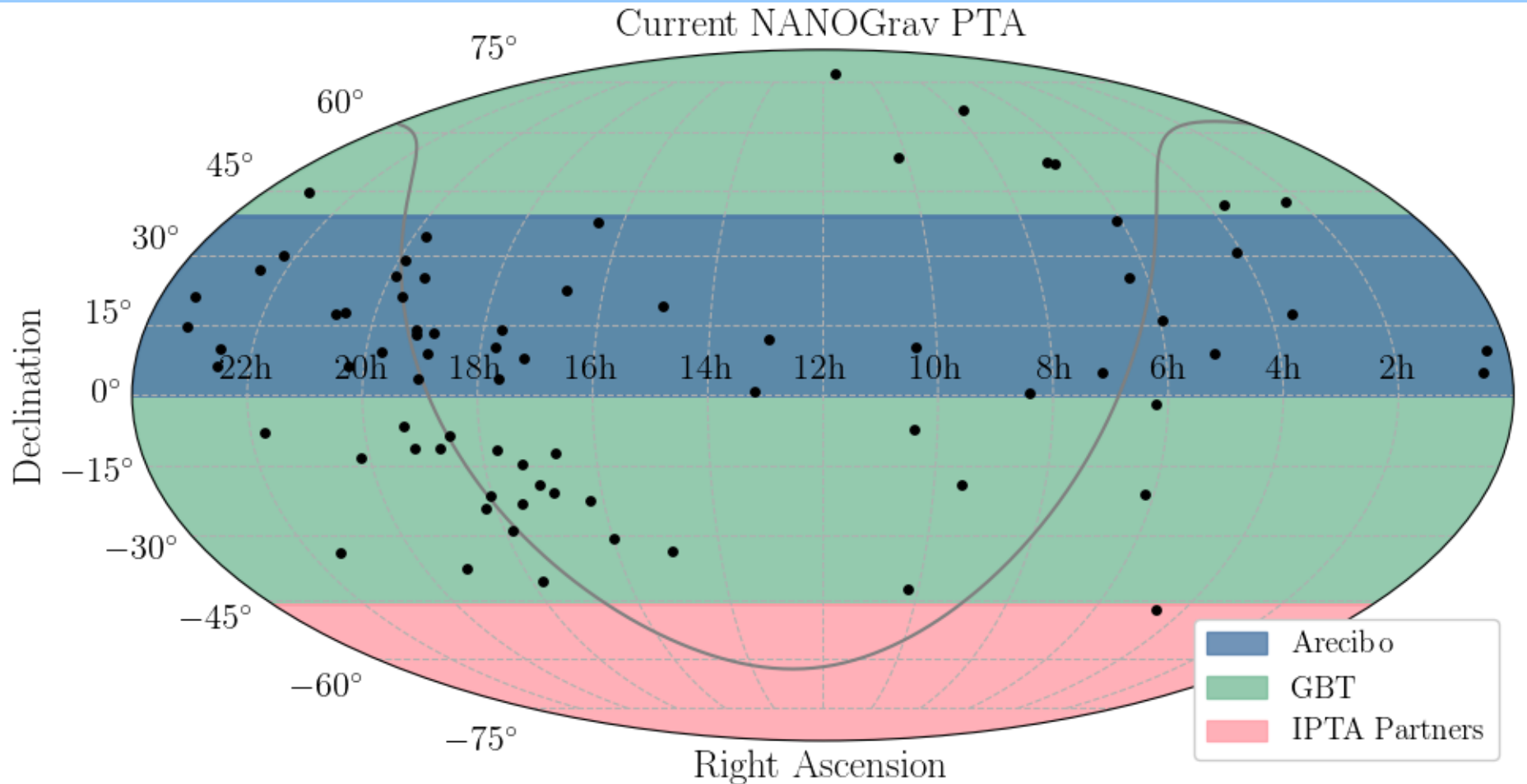


Correlation Matrix

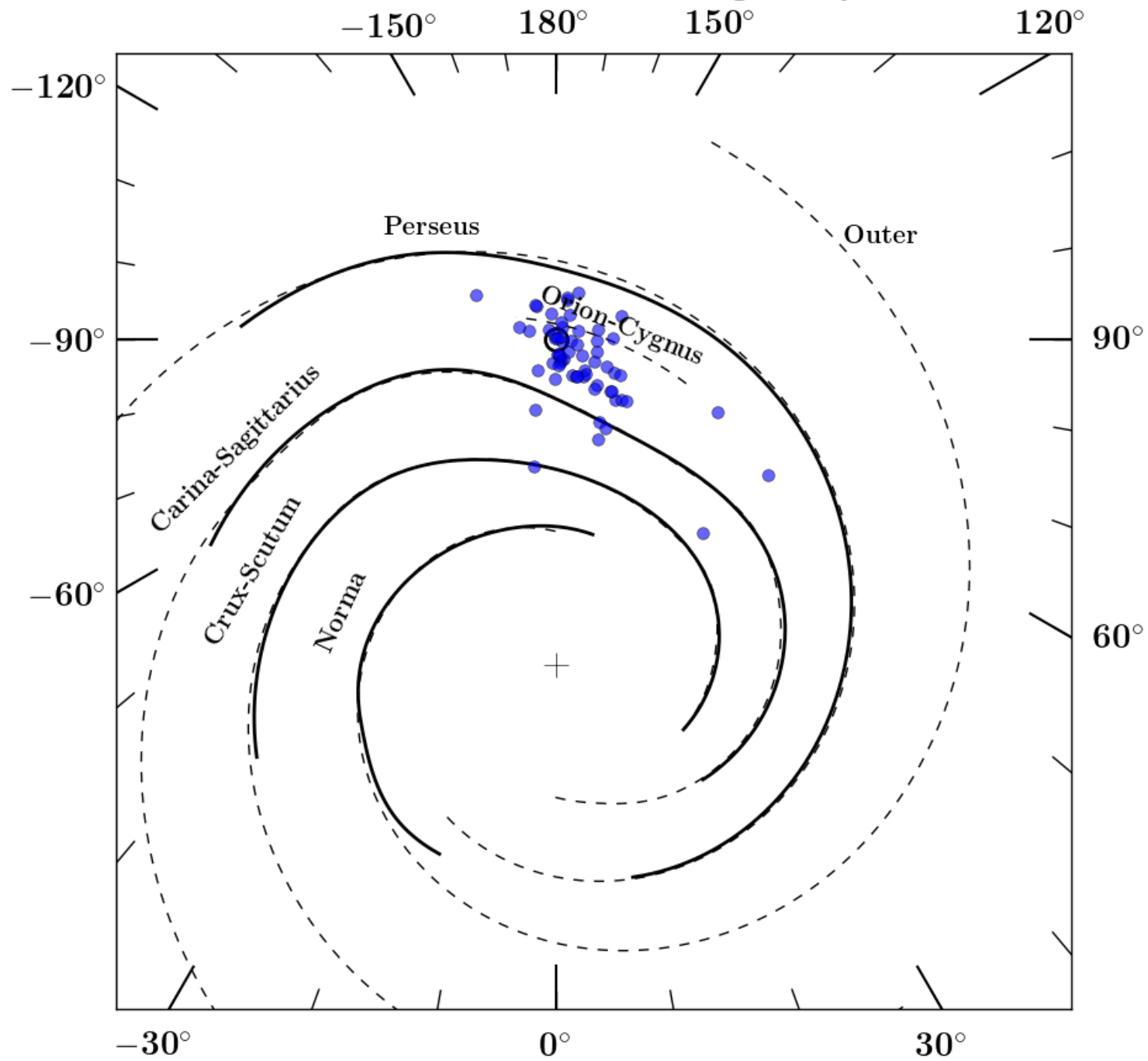


The Pulsar Timing Array

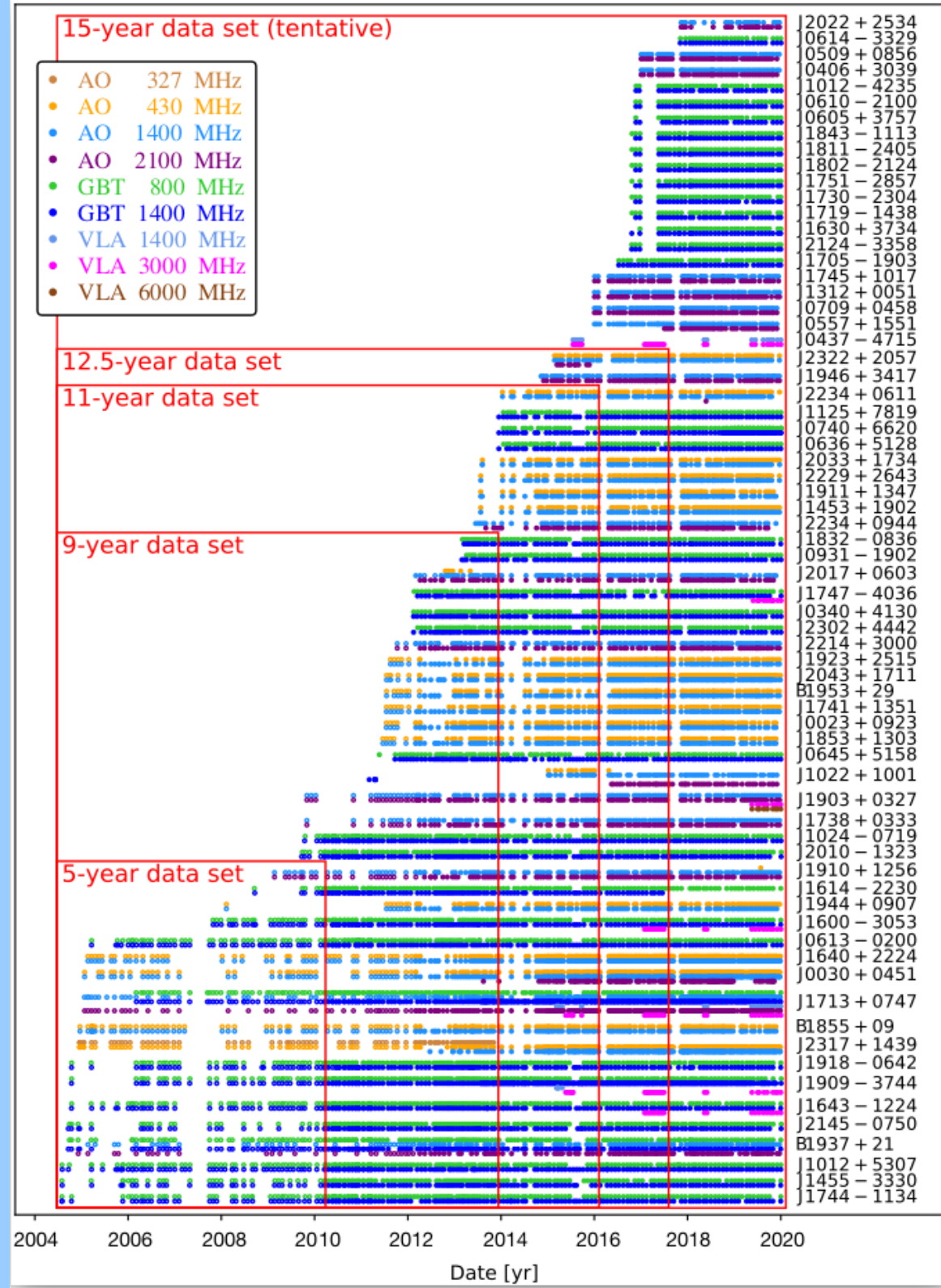
Current NANOGrav PTA



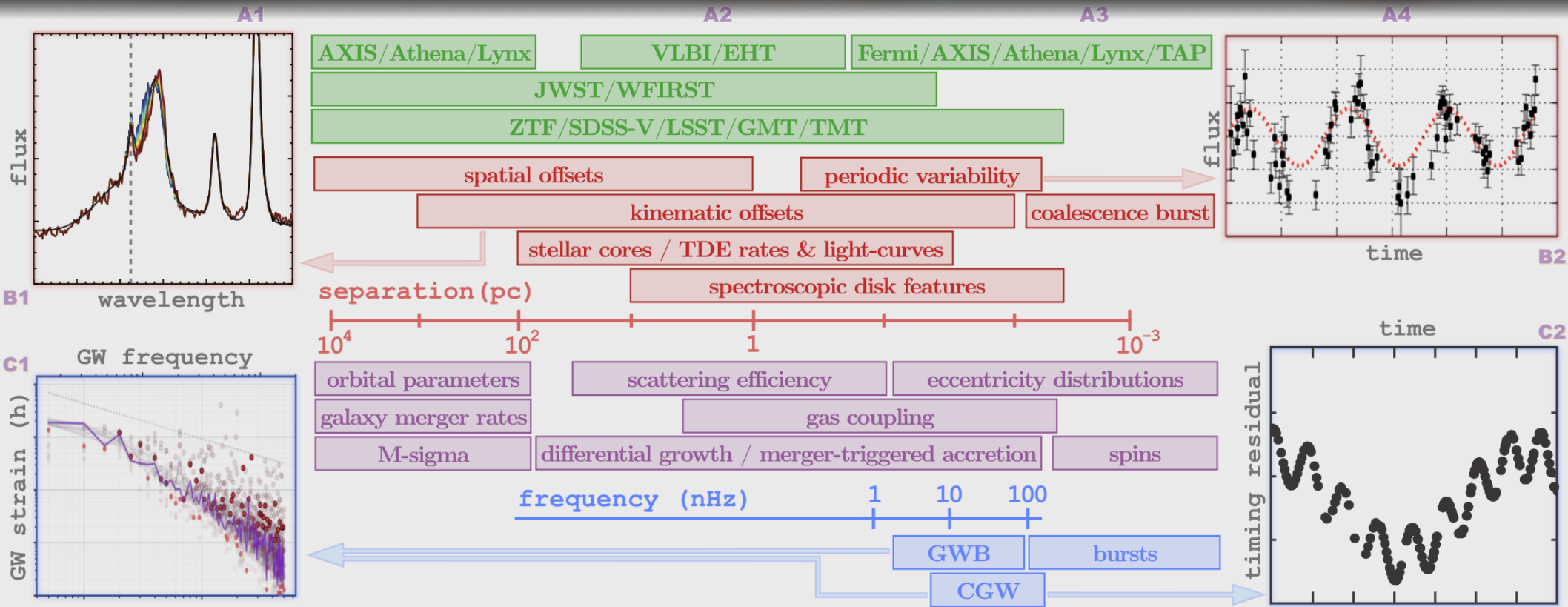
NANOGrav Pulsar Timing Array



Upcoming

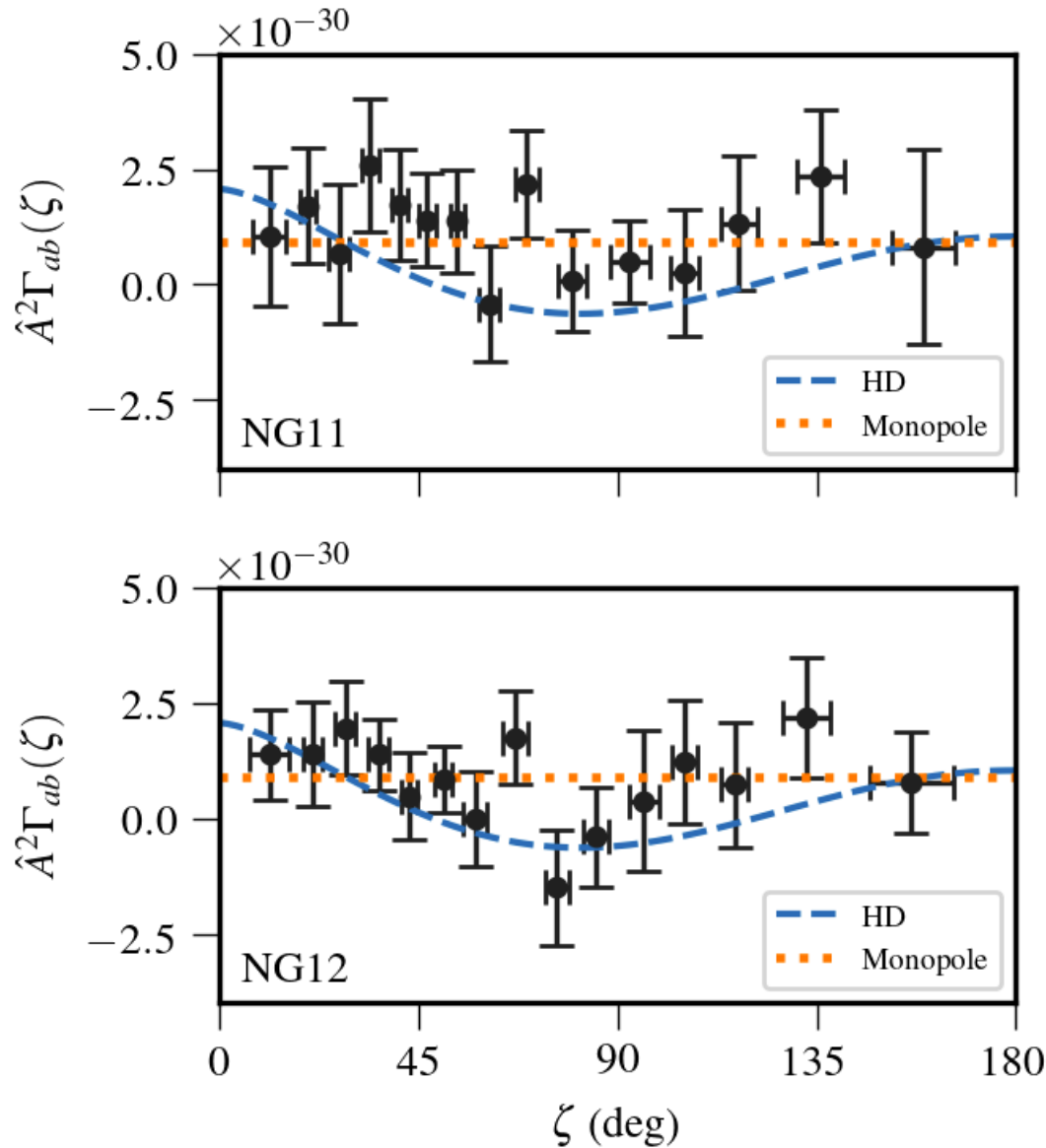


Multimessenger Science

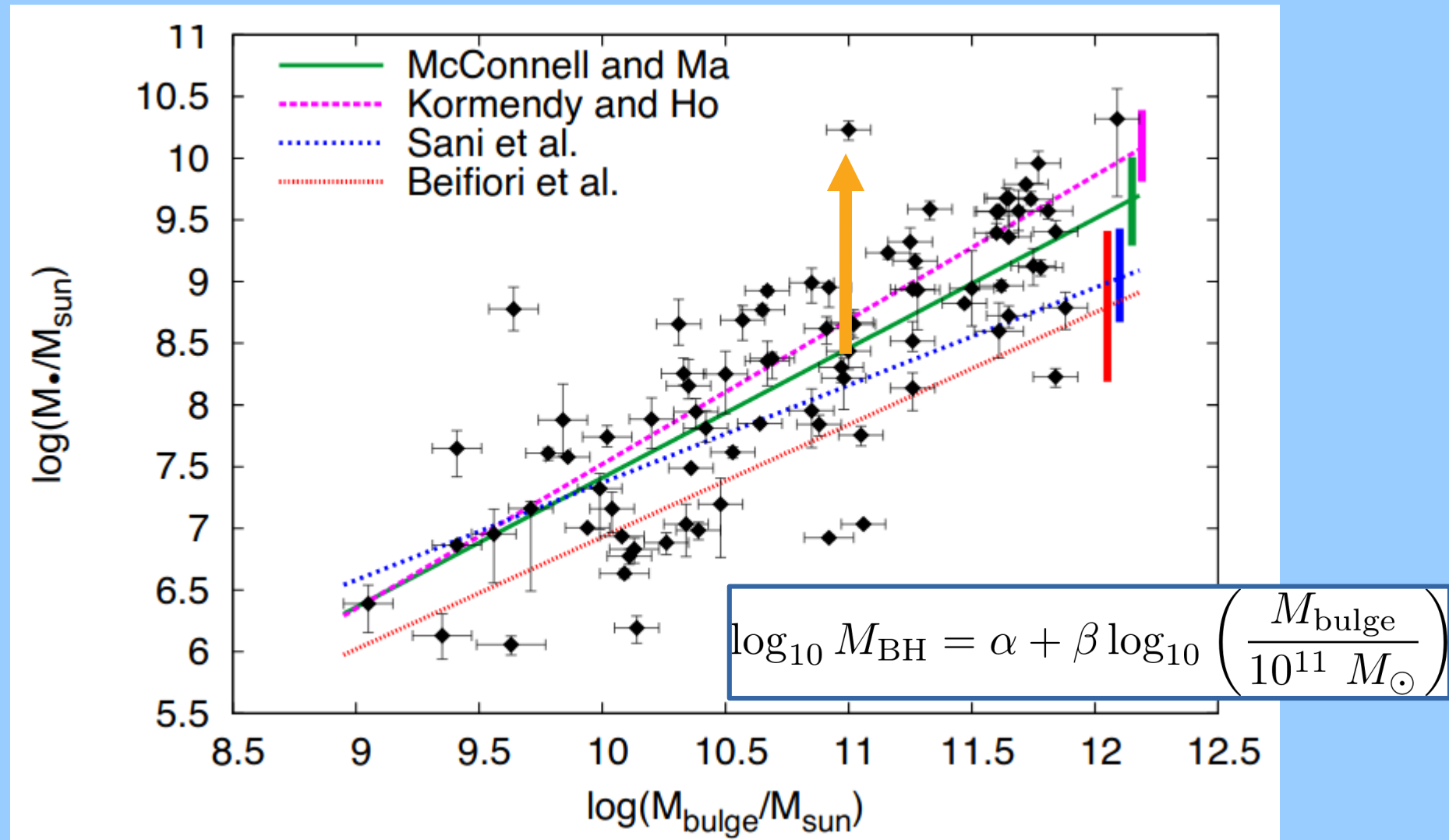


12.5-Year Data Set GWB Analysis

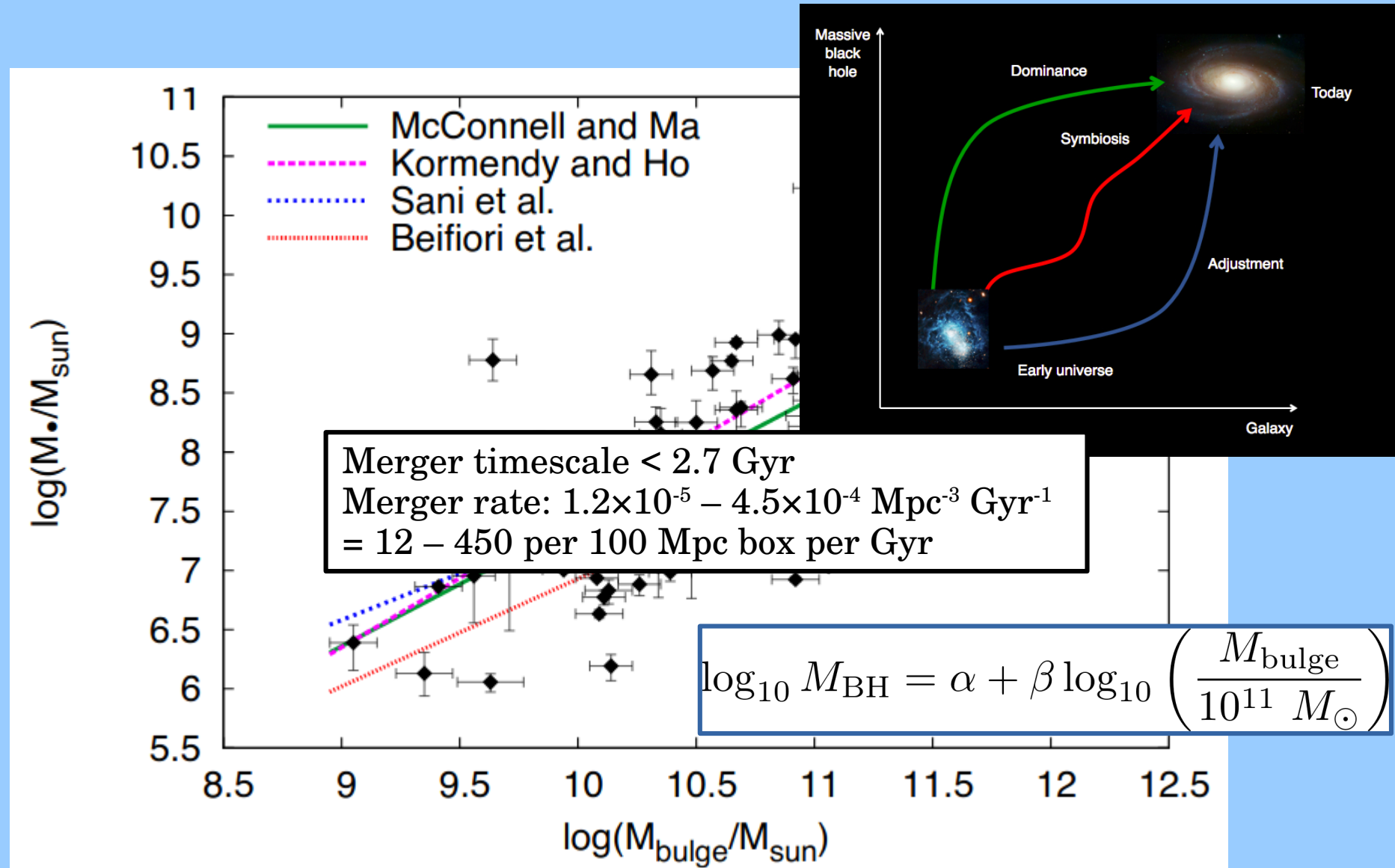
BF ~ 10000 for Common Process,
BF ~ 2 for Hellings-Downs



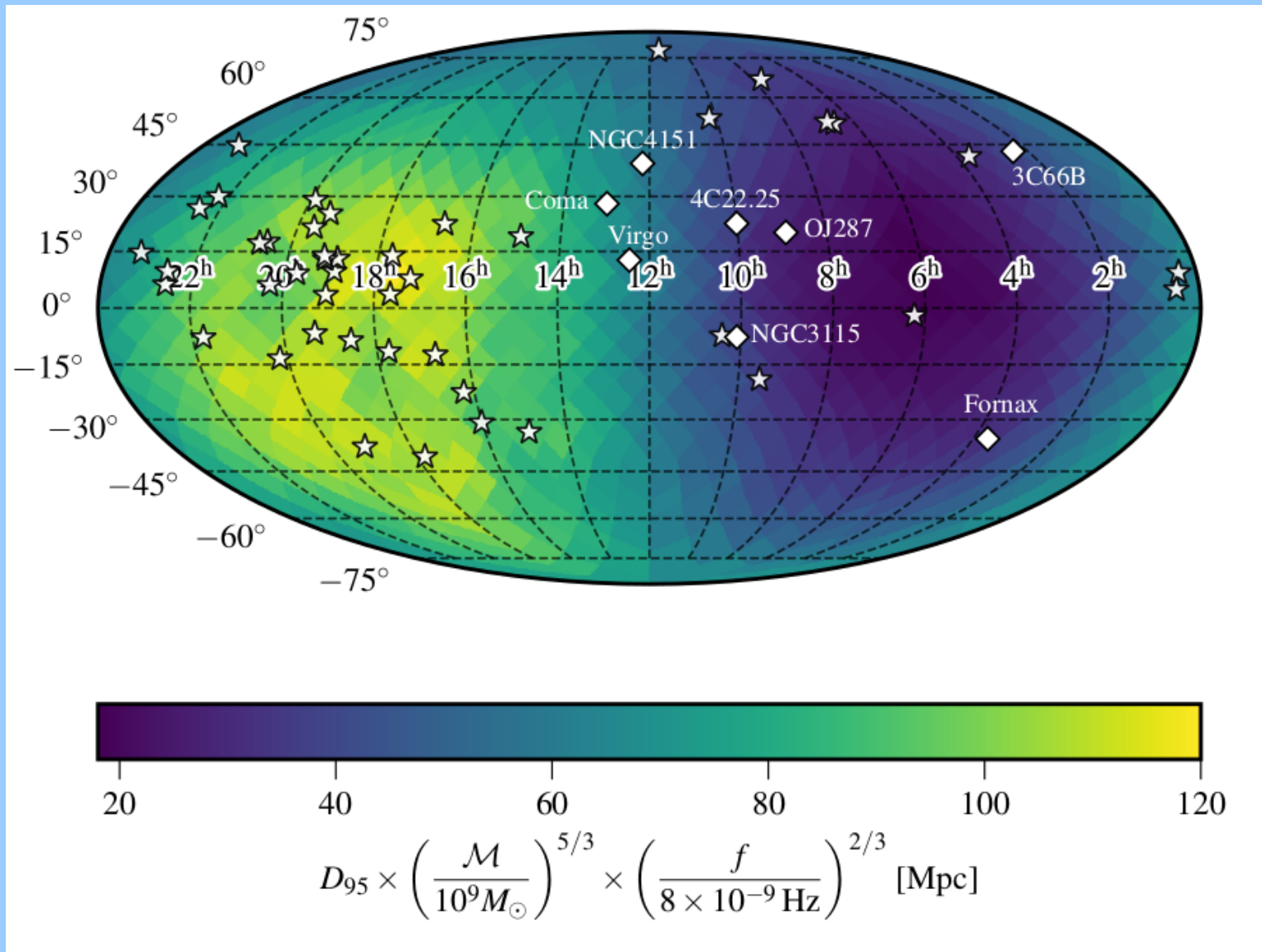
Astrophysics: $M_{BH} - M_{Bulge}$ Relation



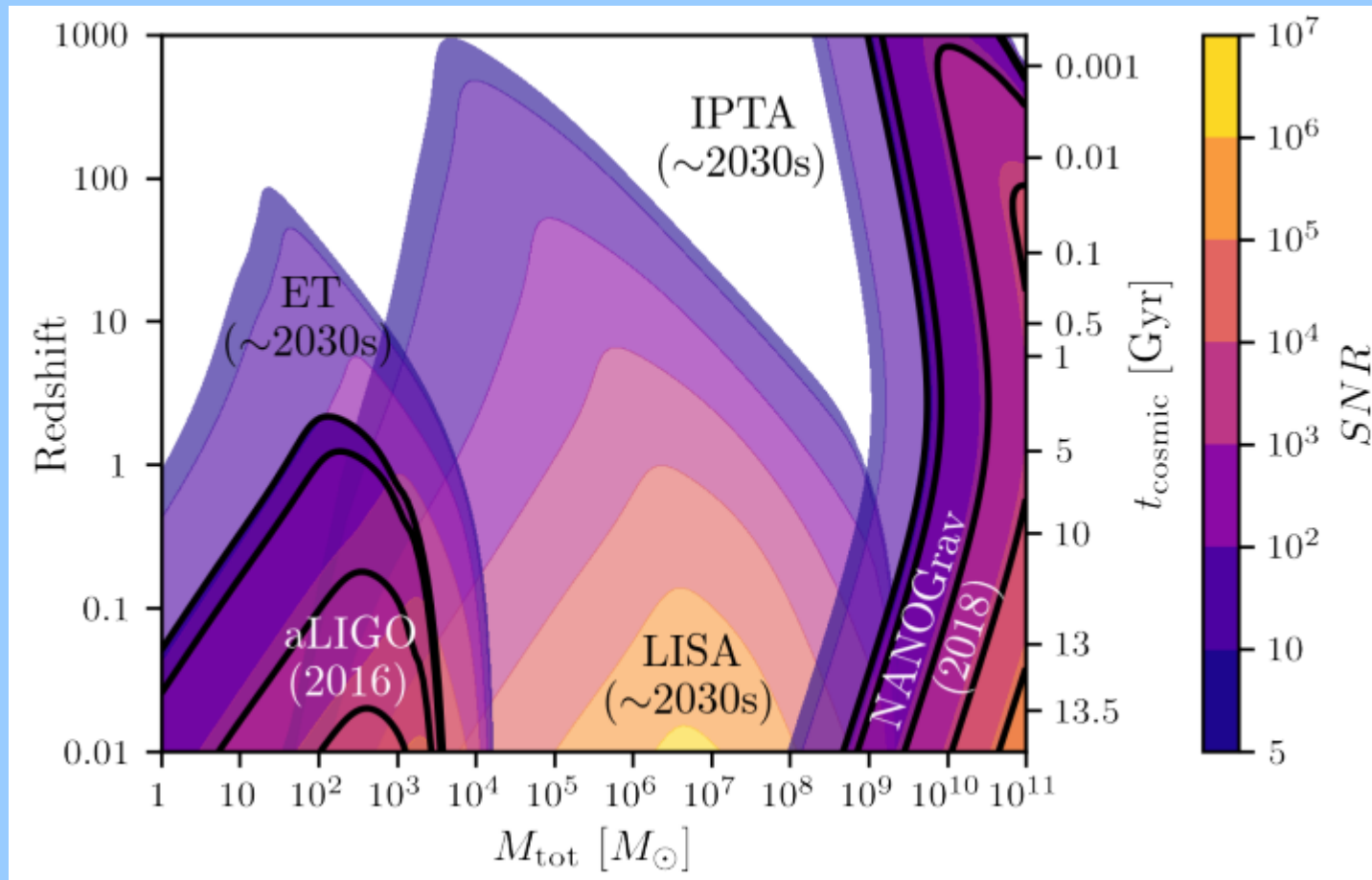
$M_{BH} - M_{Bulge}$ Relation

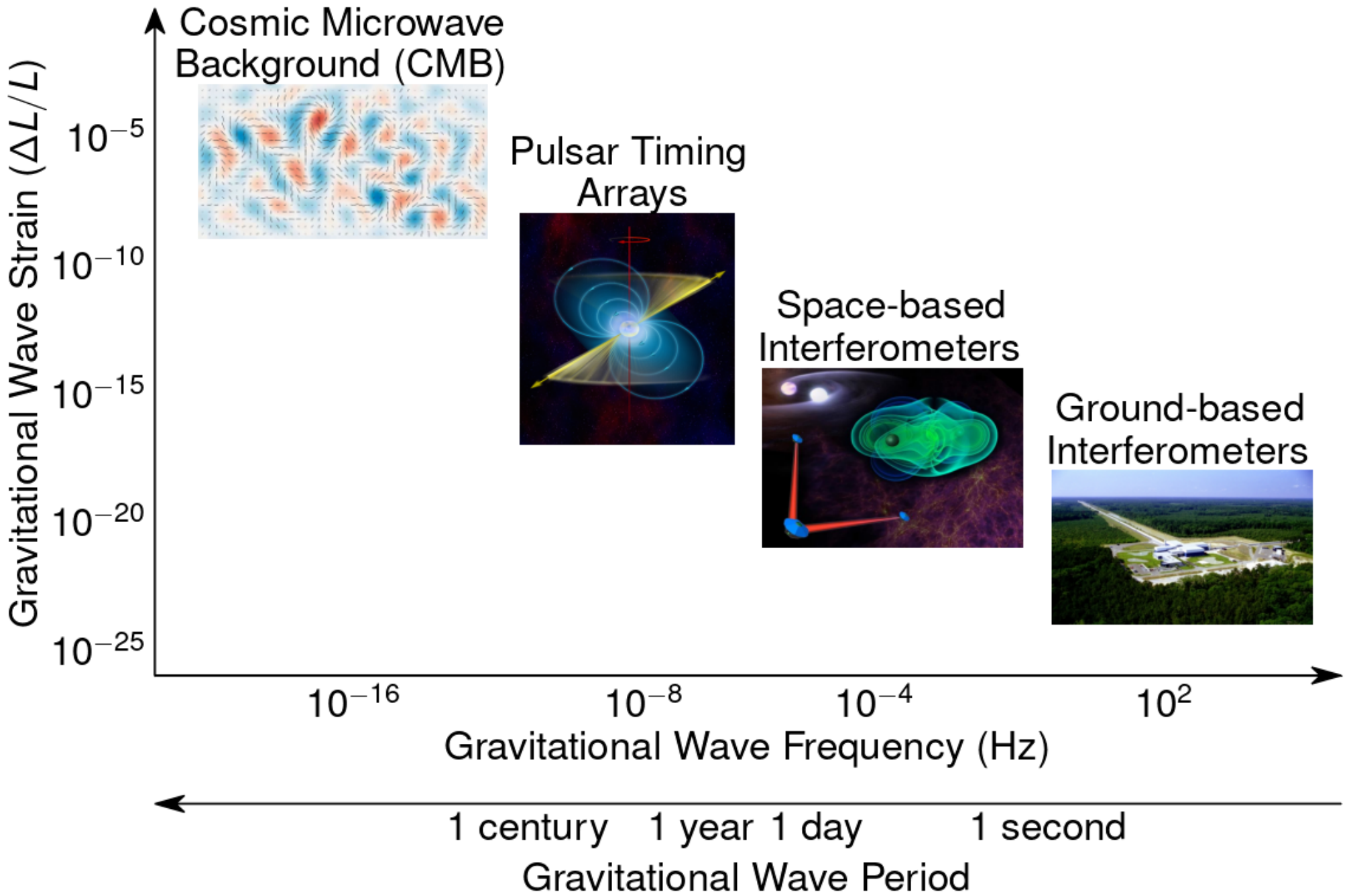


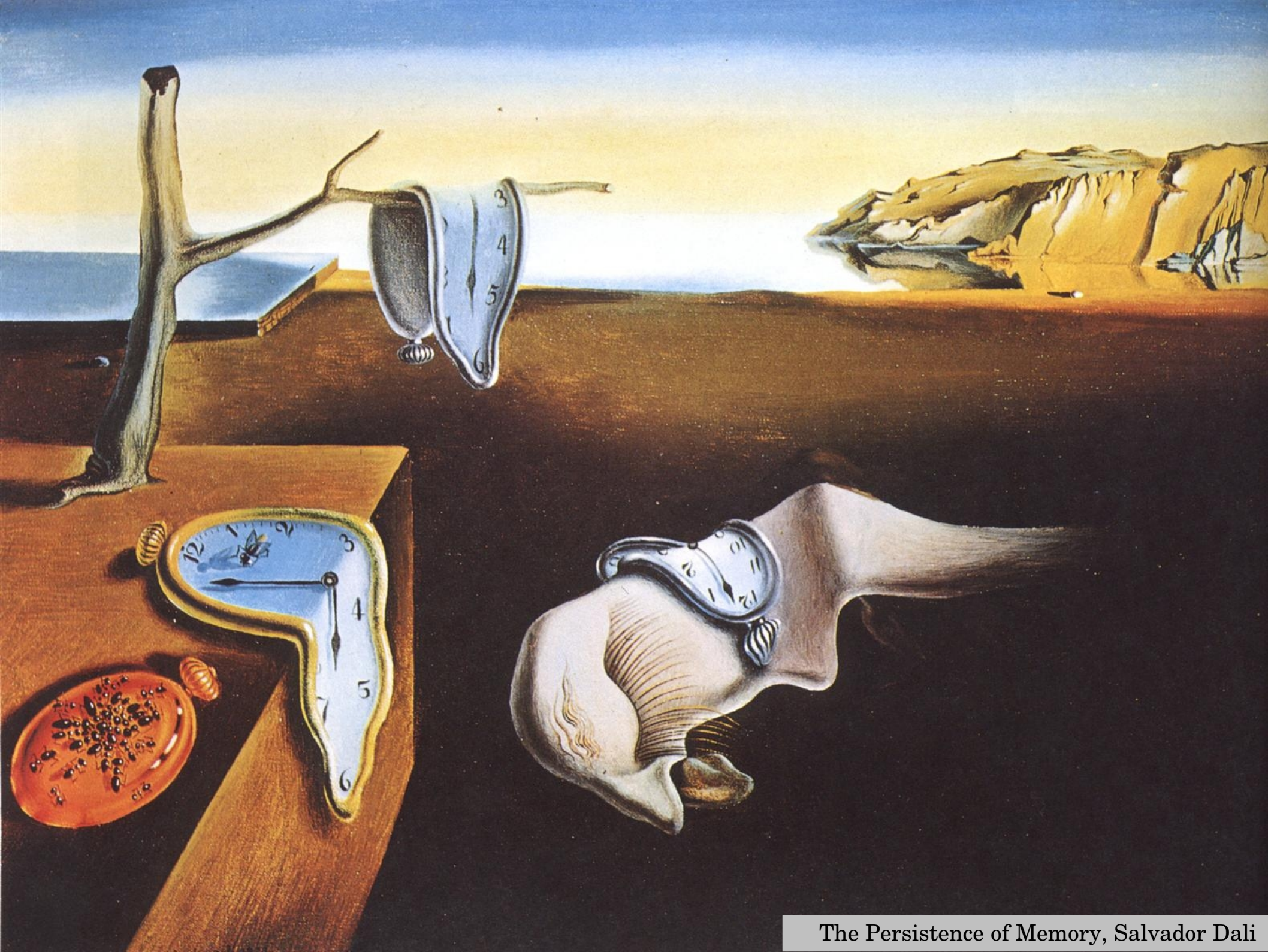
11-Year Data Set CW Analysis



Source Sensitivity





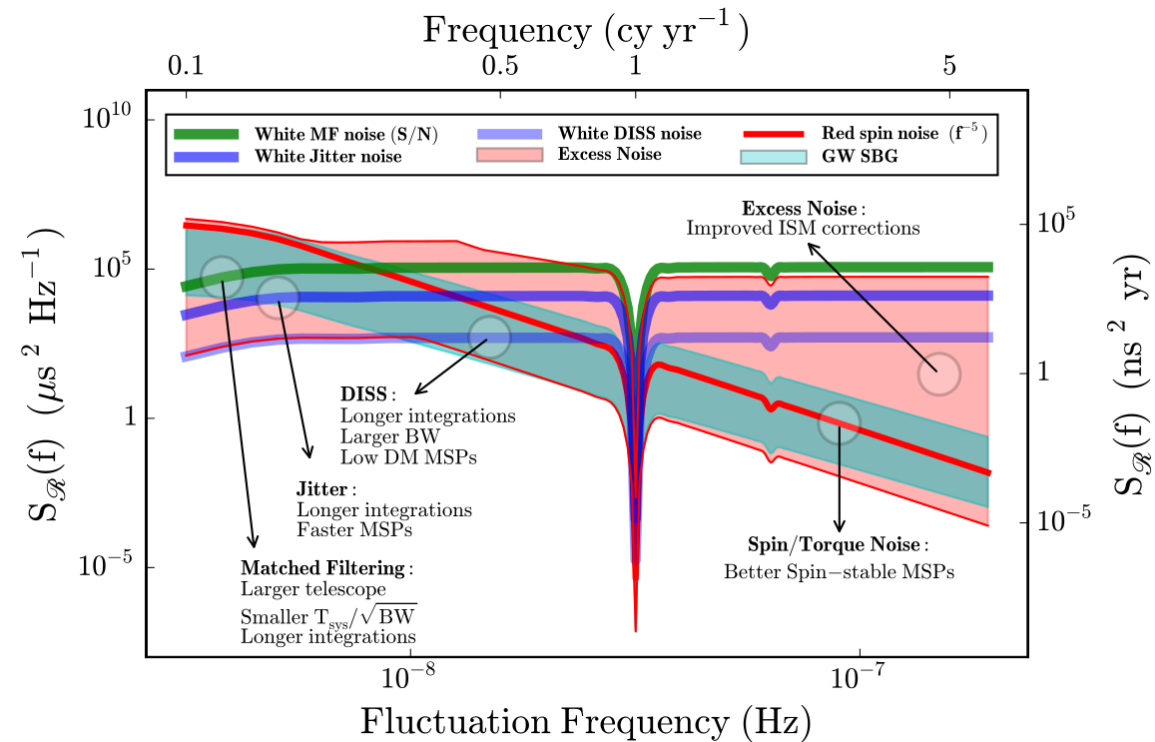
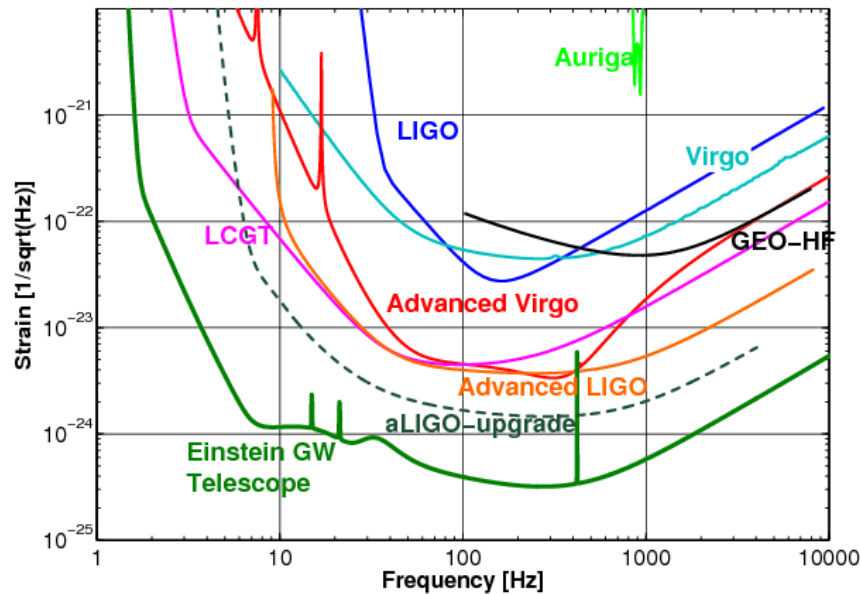


The Persistence of Memory, Salvador Dali

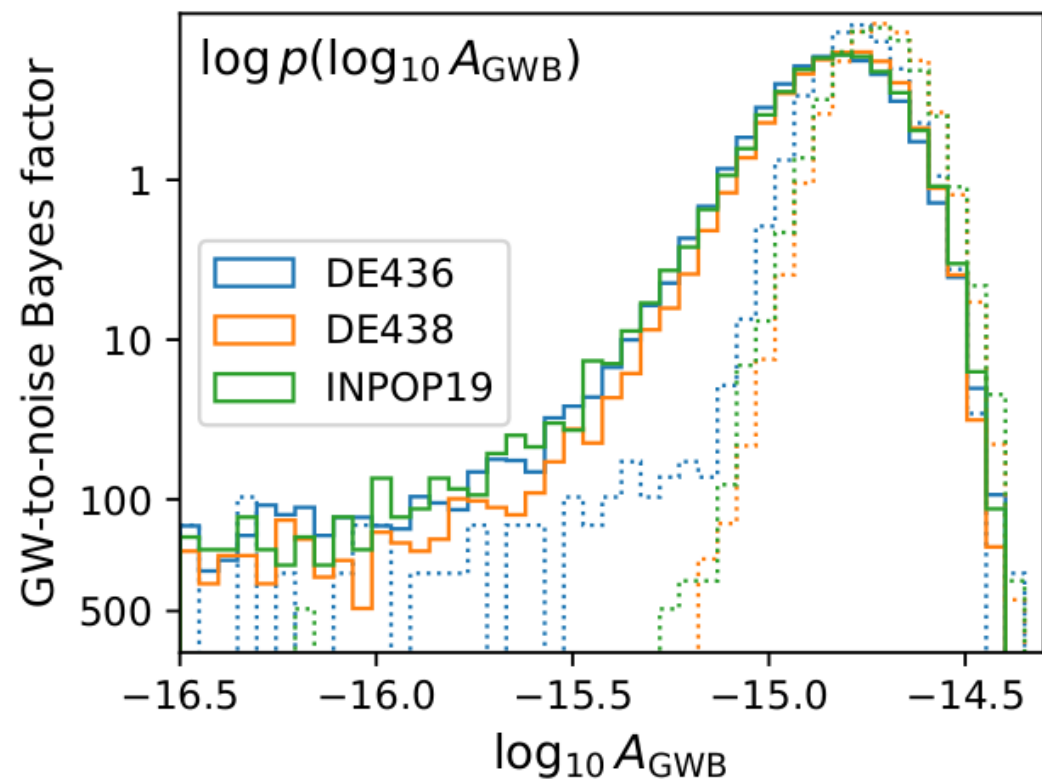
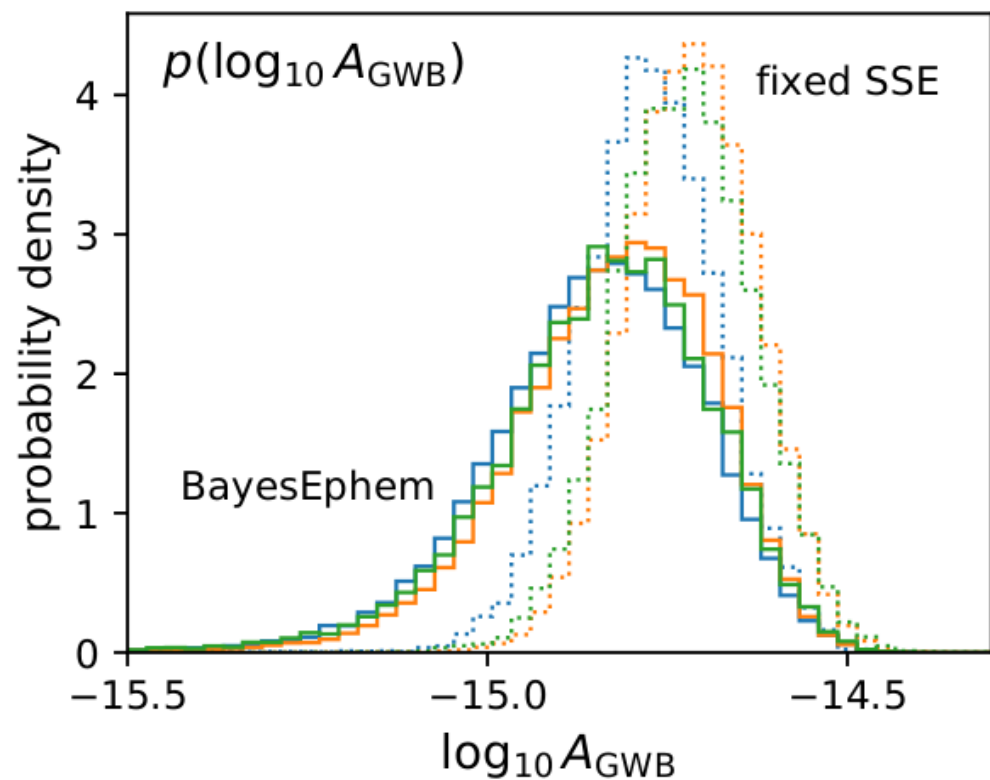
The Next Generation

LIGO → aLIGO

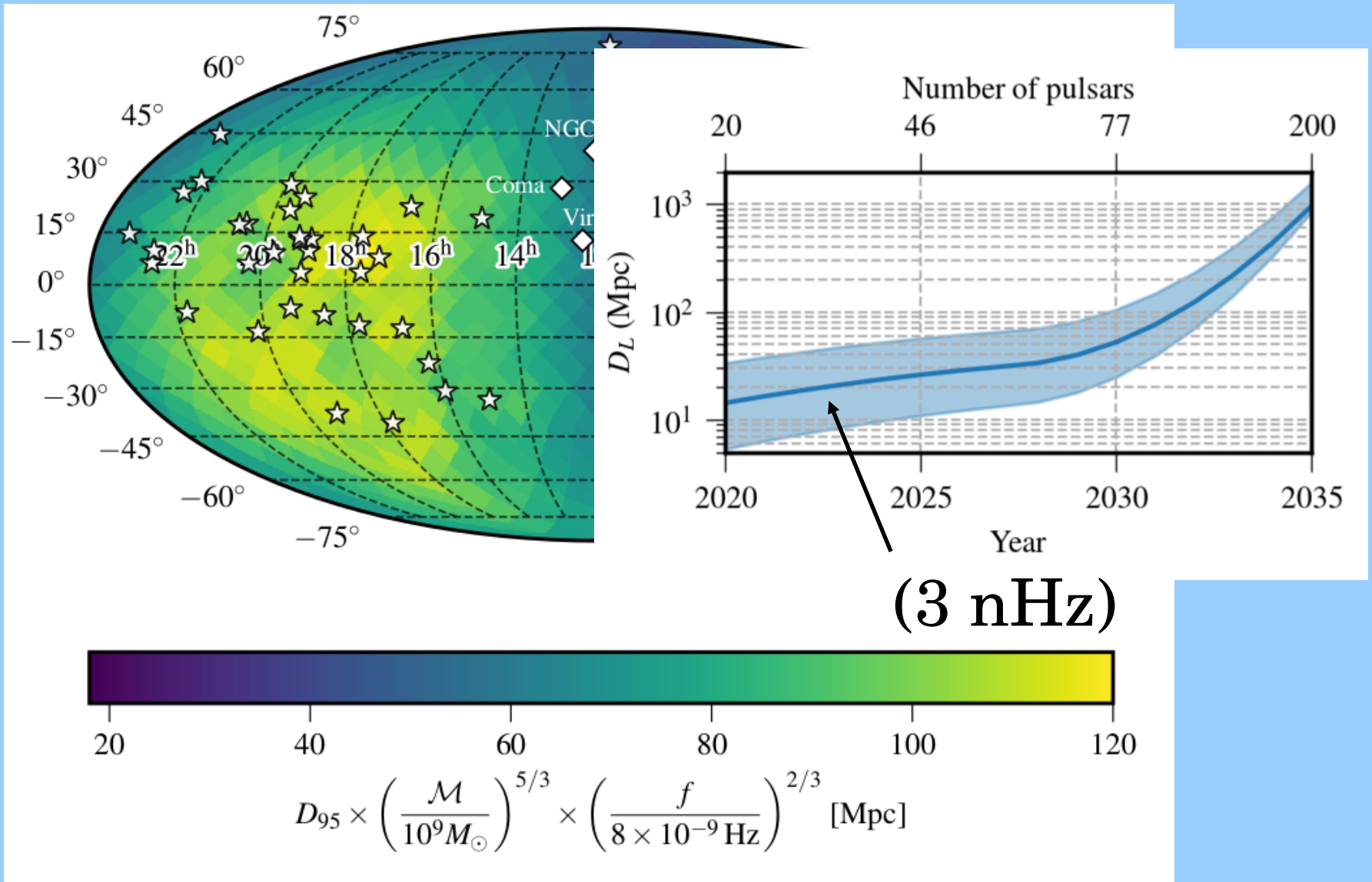
NANOGrav → “aNANOGrav”



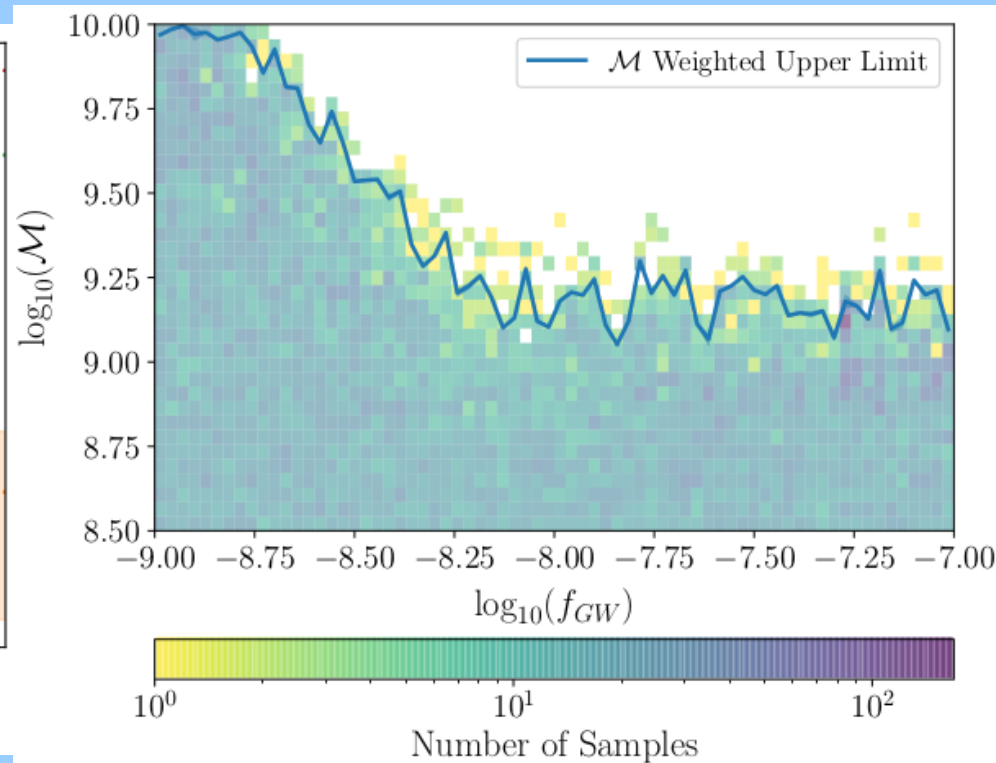
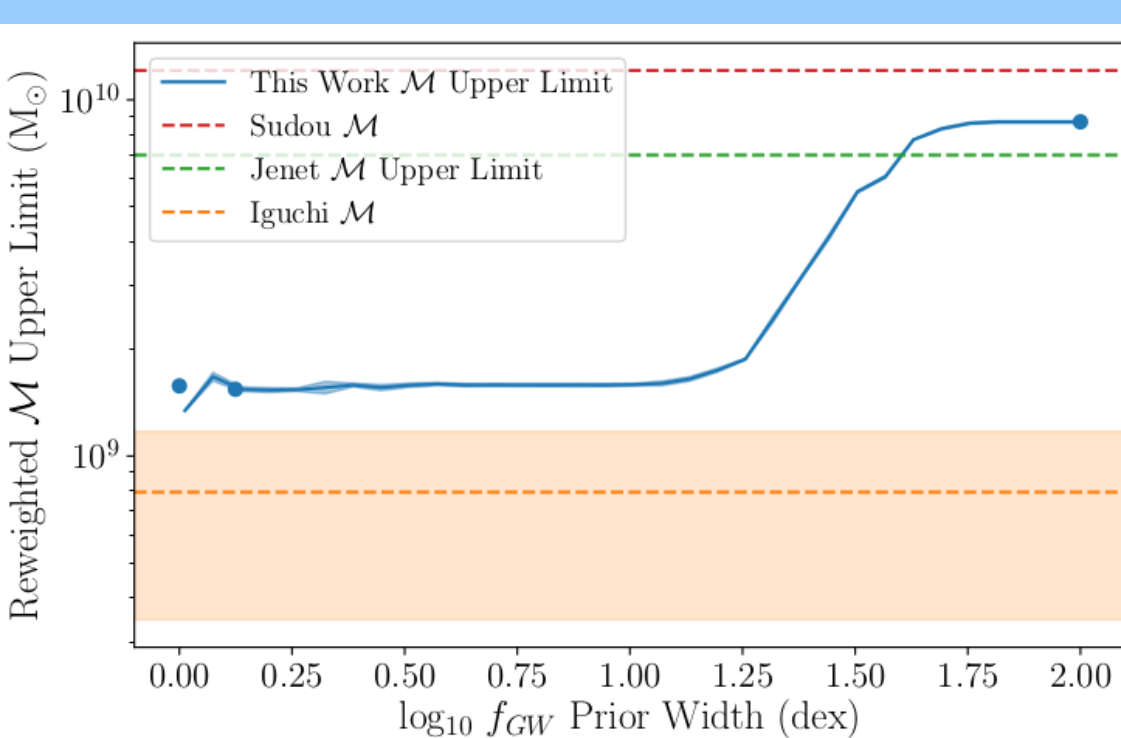
12.5-Year Data Set GWB Analysis



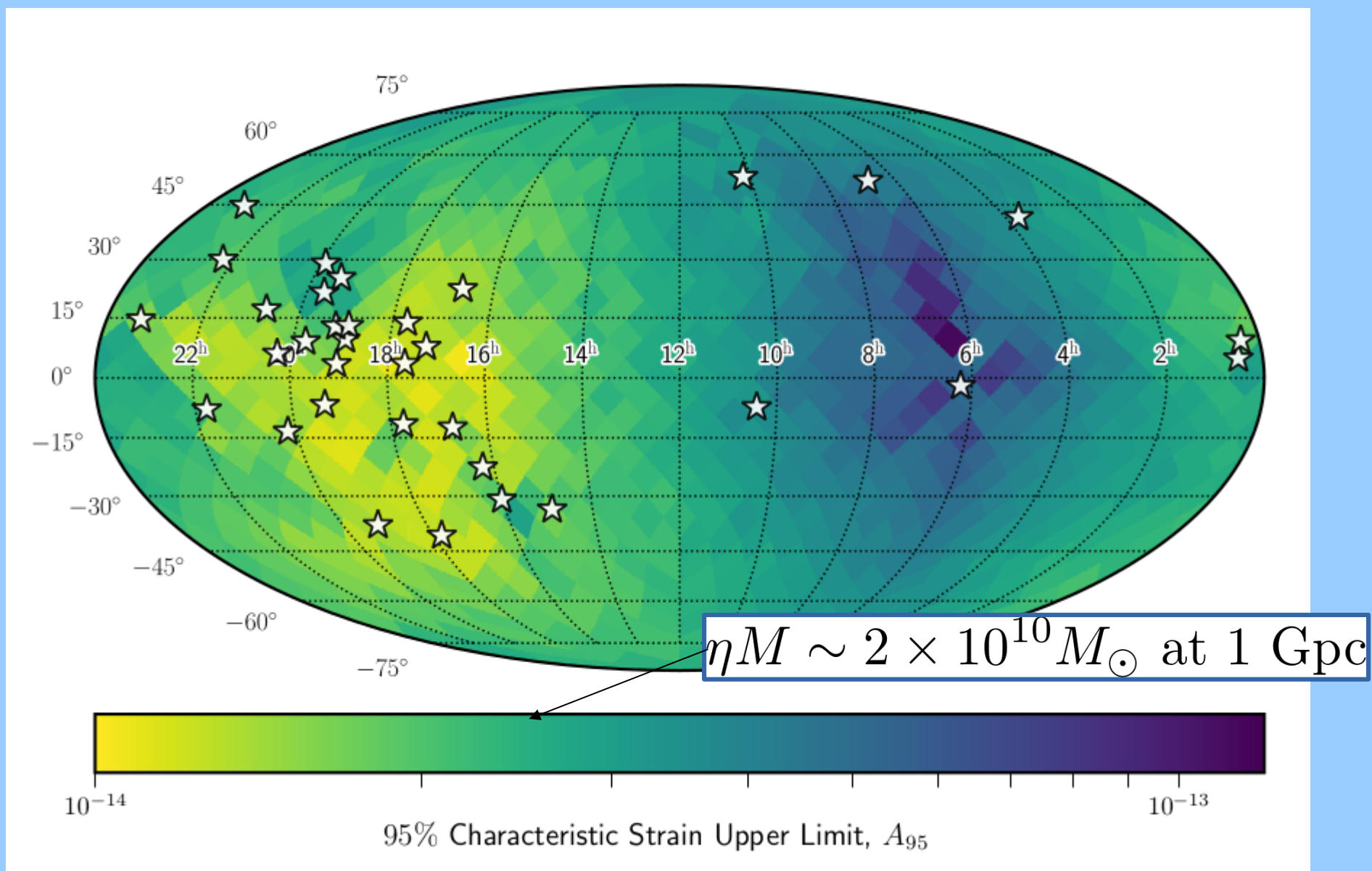
Continuous Wave Projections



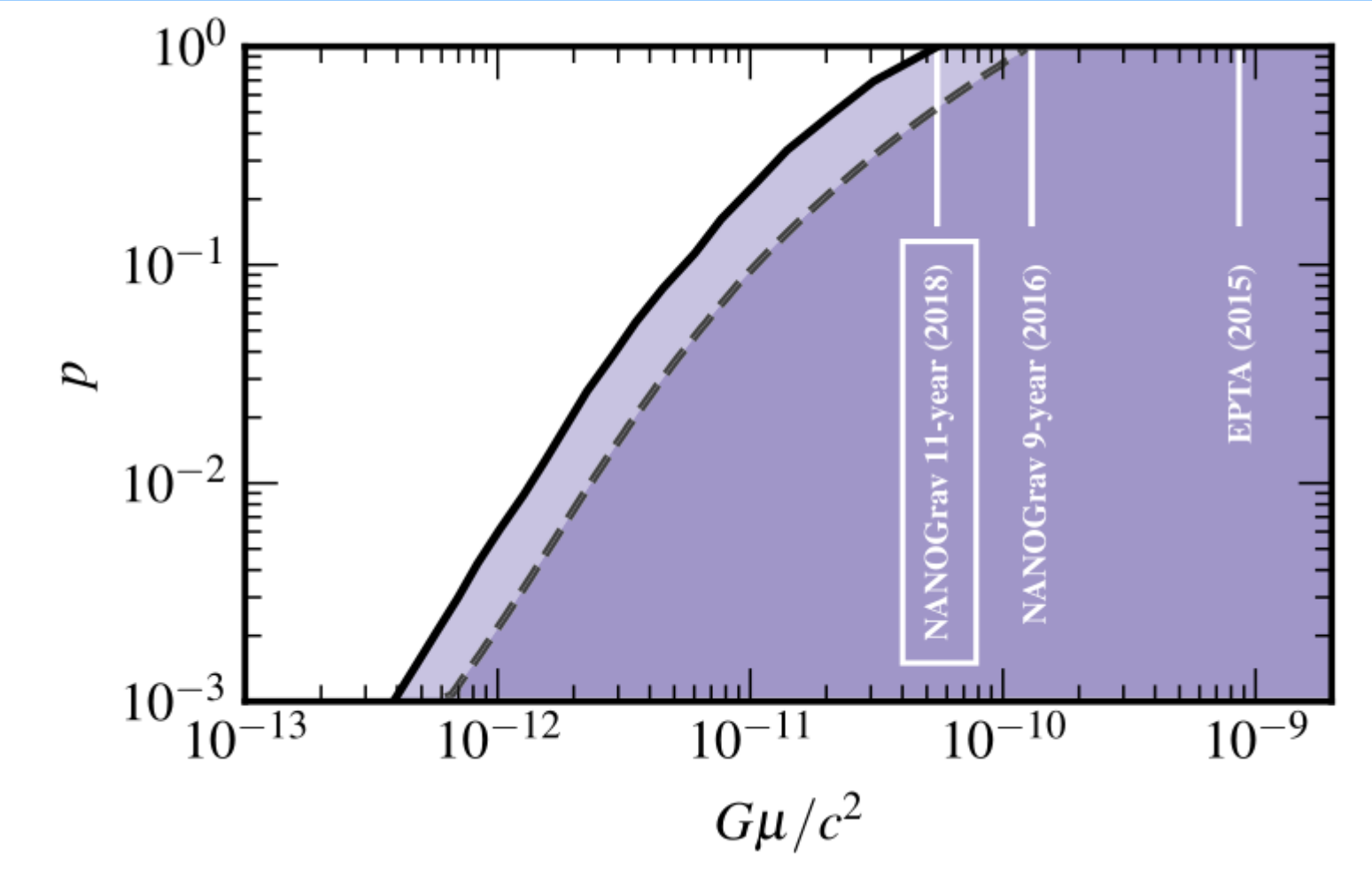
Continuous Wave Directed Searches



11-Year Data Set BWM Analysis



Cosmic Strings/Phase Transitions



Cosmological Constraints

