Constraints on compact-object merger rates via (EM) NS-NS observations

GWDAW-9

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Outline

- Population synthesis
  - Review
  - Results: BH-BH, NS-NS, BH-NS rates
- NS-NS observations
  - Merging NS-NS (recycled)
  - Wide NS-NS (recycled)
- Applying Rate Constraints
  - Results

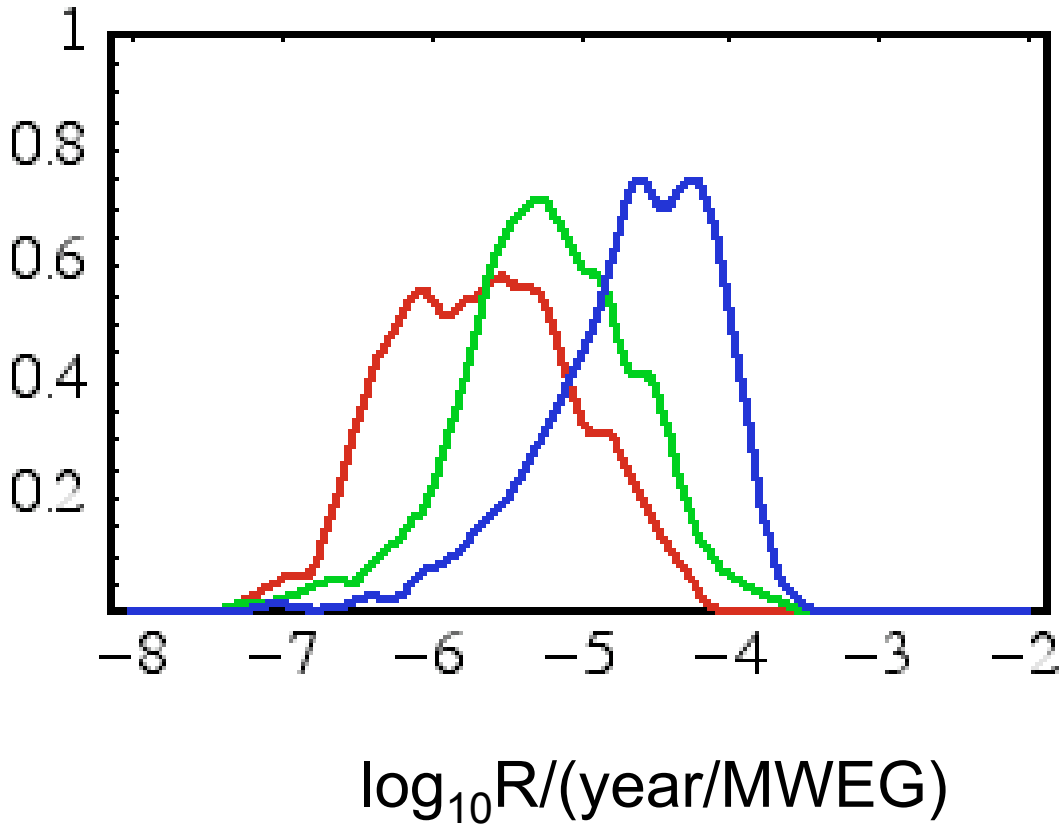
Population synthesis: review

- Method:
  - *Evaluation*:
    Monte Carlo over initial conditions
    Follow binary evolution (w/o interactions)
  - *Uncertainties*:
    parameterize
    …supernova kicks, CE efficiency, wind strength, …

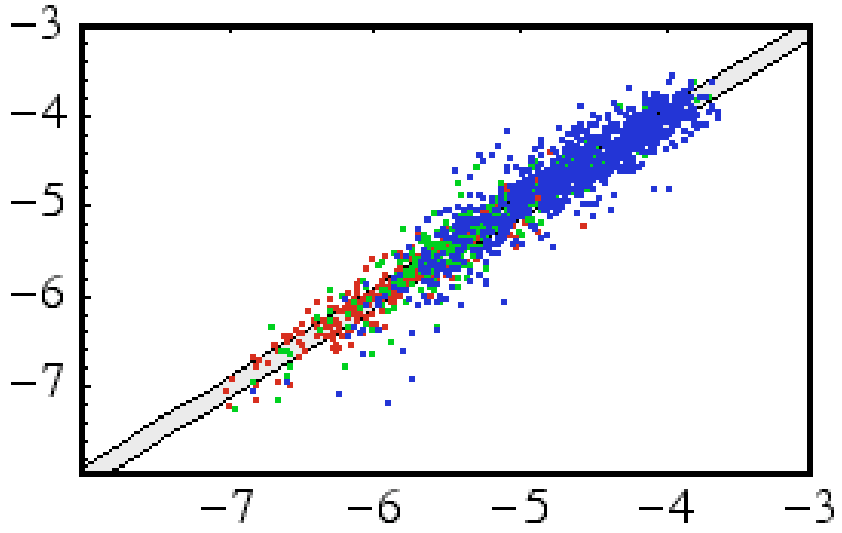
- Details:
  - *Each run* :
    stop when 10 events of interest
    → rates ~ 30% accurate
  - *Many runs* :
    Vary 7 most important parameters
    → **Histogram** and **fit** the event rate
  - *Each type*:
    Repeat for different target types (BH-BH mergers, etc)

Results: Rate Histograms

- NS-NS
  - N=933
- BH-BH
  - N=306
- BH-NS
  - N=357



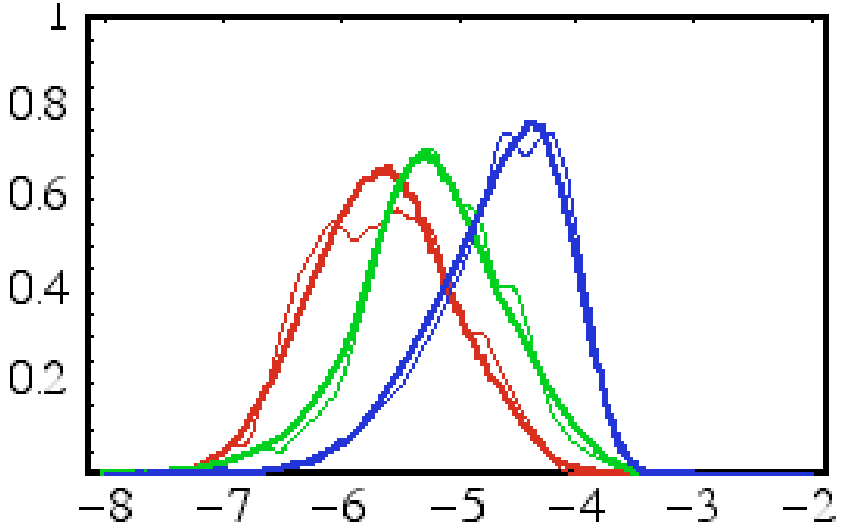
Results: Fits



NS-NS

BH-BH

BH-NS



log10R/(year/MWEG)

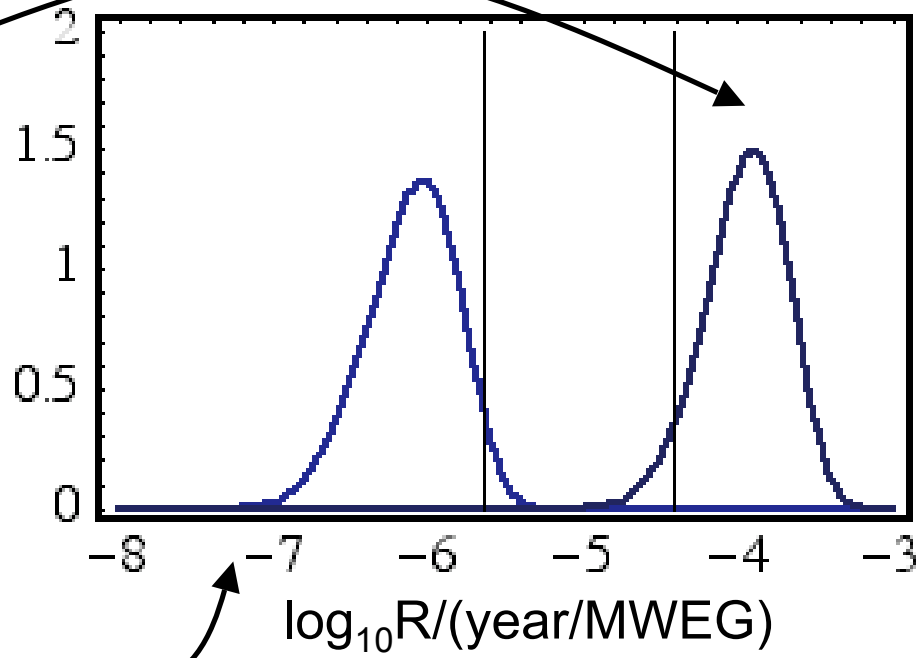
•Fits work over large range

•Monte carlo again…
--> recover ~ **same** distributions

→ Fits ok surrogate for full PS

NS-NS observations

- Merging Binaries (3)
  - 3 seen [**J0737**, B1915, B1534]
  - Will merge through GW emission
  - Recycled pulsars only (selection)
  - Merger rate **lower** limit (95%):
    - R> 39 / Myr



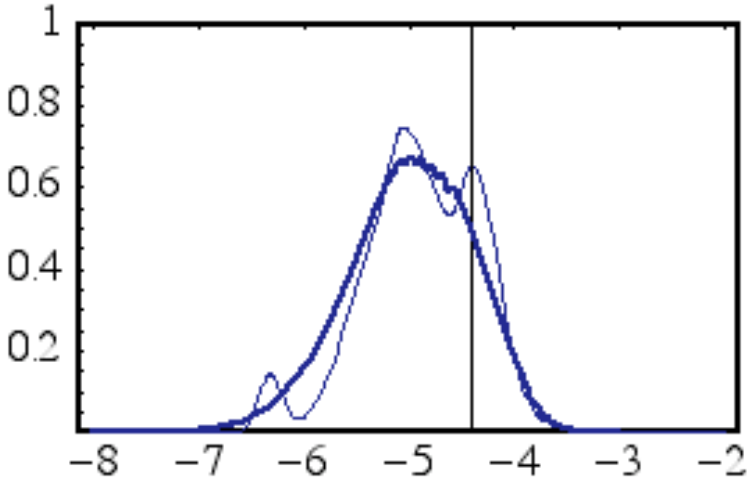
- Wide Binaries (3)
  - 3 seen [**J1811**, J1518, J1829]
  - Not merging w/in age of galaxy
  - Recycled pulsars only (selection)
    - …and **few recycled pulsars occur in wide binaries**
  - Merger rate **upper** limit (>>95%):
    - R < 2.5 / Myr

R=formation rate

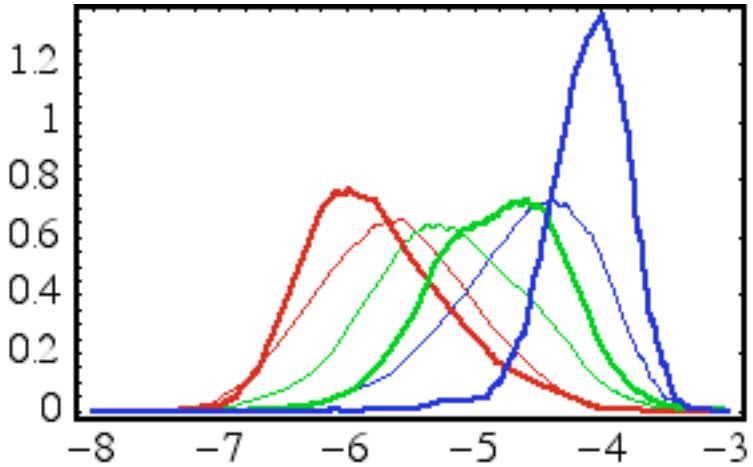
Constraining rate 1: Merging NS-NS

- Method
  - Use data for **recycled** merging NS-NS binaries
  - Fit rate for above
  - Monte carlo +
    Reject inconsistent models
    [= outside 95% confidence interval of **observed** merging NS-NS]
    - Excludes **83%** of models
  - Regenerate histograms
- Results:
  - $\langle R_{bh} \rangle$ = 1.7 / Myr
    - down x 0.75
  - $\langle R_{ns} \rangle$ = 78 / Myr
    - up x 3.2
  - $\langle R_{bh\text{-}ns} \rangle$ = 16/ Myr
    - up x 2.6

Merging **recycled** NS-NS



Constrained results

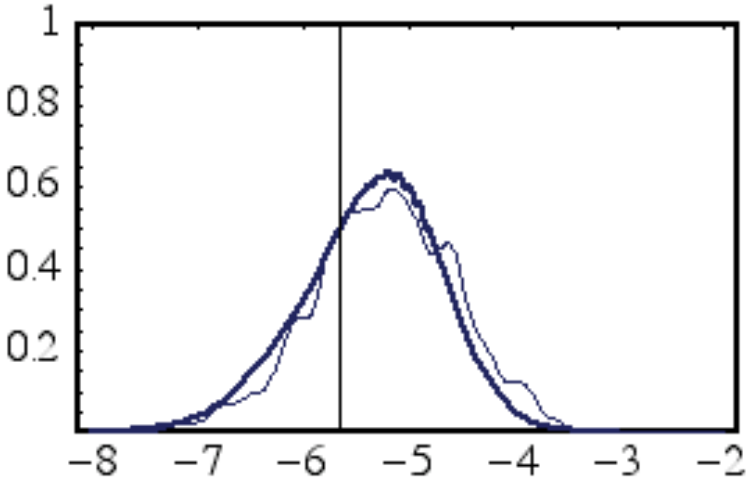


Constraining rate 2: Wide NS-NS

- Method
  - Find (rare) **wide recycled NS-NS** in data
  - Fit rate for above
  - Monte carlo + reject
    - Excludes **70%** of models
  - Regenerate histograms

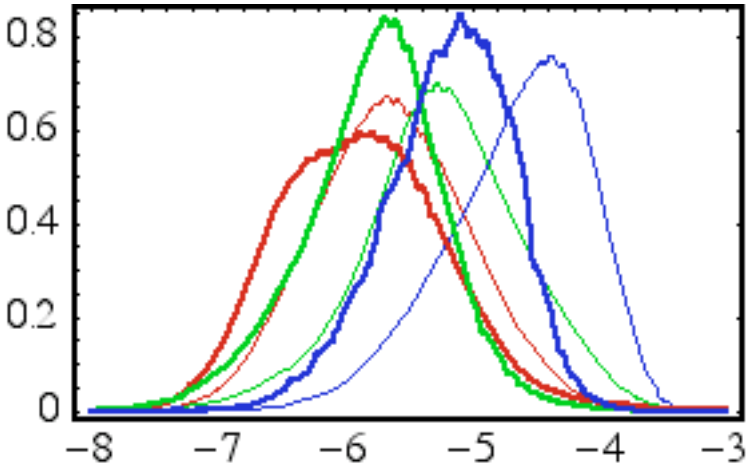
- Results:
  - $\langle R_{bh} \rangle$ = 1.4 / Myr
    - down x 0.6
  - $\langle R_{ns} \rangle$ = 6.6 / Myr
    - down x 0.3
  - $\langle R_{bh\text{-}ns} \rangle$= 1.6/ Myr
    - down x 0.3

Wide **recycled** NS-NS



$\log_{10}$(R/yr/MWEG)

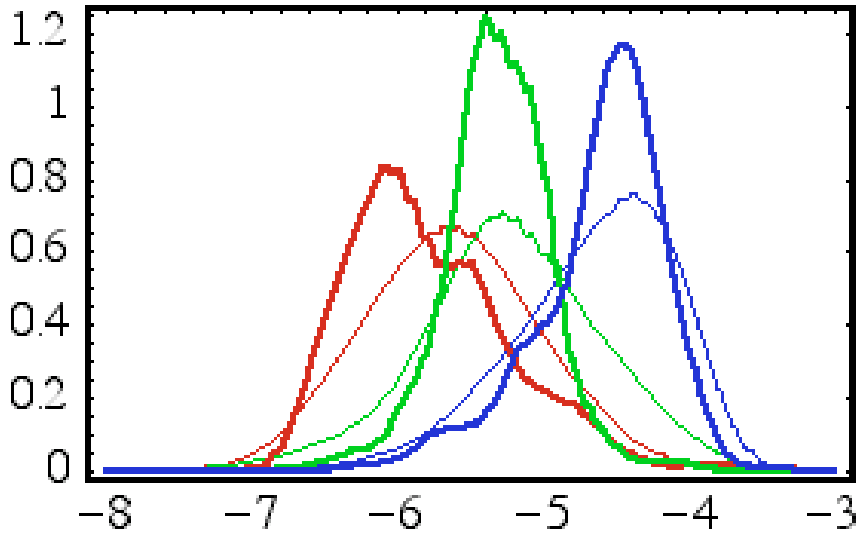
Constrained results



Constraining rate 3: All (recycled) NS-NS

- Method:
  - Monte carlo + reject
    …**require both** constraints satisfied

Extremely preliminary!



$\log_{10}$(R/yr/MWEG)

- Results:
  - $\langle R_{bh} \rangle$ = 1.6 / Myr
    - down x 0.6
  - $\langle R_{ns} \rangle$ = 24 / Myr
    - up x 1.1
  - $\langle R_{bh\text{-}ns} \rangle$= 4.9/ Myr
    - down x 0.84

…consistent with prior
…narrower distributions

Conclusions

- Status
  - PS for merger rates complete
  - Applying constraints from NS-NS observations
    - Merging
    - Wide
    - Both simultaneously

- Future Directions
  - Additional observational constraints
  - Further constraints on PS model input parameters
    (e.g. tighter constraints on SN kicks)