How will theory, observation and instrument development interact within the field?

Patrick Brady
University of Wisconsin-Milwaukee
My charge

- **Finn:**
  “would you be willing to speak ...... a session with Peter Saulson and you, as speakers to the question "How will theory, observation, and instrument development interact within the field?" would be a good line-up to spur thinking and discussion.”

- **Brady:**
  “Sure, I could give a talk on that subject. I haven't given it a lot of thought recently, but I generally have an opinion ;) and there's enough time to come up with something to say.”

- **What I came up with**
  “More of the same”
Observers

• **Primary science objectives**
  » Identify (non-)interesting objects
  » Classify these objects
  » Publish spectra
  » Publish waveforms
  » Publish parameters <-- Theory
  » Establish populations <-- Phenomenology
  » What else?

• **Other aspects**
  » Data reduction
  » Data analysis methods & implementation
  » Explore new observational regimes <-- Instrument Design
  » Non-GW observers
Case Study: Compact Binary Systems

Inspiral Phase
Post-Newtonian approx gives accurate waveforms

Ringdown Phase
Black hole perturbation gives accurate waveforms

Merger Phase
Need numerical relativity
Sky maps

Spatial distribution of Galaxies accessible to LIGO S2 analysis for binary neutron stars

Reminder of Peter's talk about position localization ......
Example of position information from LIGO

Figure: K Rawlins
Theorists/Phenomenologists

• **Primary science objectives**
  » Model physical processes in the Universe
    <--> Observation
  » Develop methods to determine the gravitational signals
  » Understand failures of current theories
    <--> Observation
  » Understand how sources imprint physics on signals
    <--> Observation
  » How do the populations arise/evolve?
    <--> Observation

• **Other aspects**
  » New instruments to answer new questions?
    <--> Instruments Design
  » Special observations to do the same?
Parameter Estimation Accuracy

1. L1 Injected Distance vs. L1 Recovered Effective Distance (Mpc)
2. L1 Injected M_{\text{chirp}} vs. L1 Recovered M_{\text{chirp}}
3. L1 Injected End Time vs. L1 Recovered End Time (hours since 729273613)
4. L1 \Delta D / D
5. L1 \Delta M_{\text{chirp}} / M_{\text{chirp}}
6. L1 \Delta t (ms)
Instrument Designers and Developers

• Primary science objectives
  » Develop precision measurement
  » Overcome fundamental science obstacles <-> Theory
  » Many instrumentalists will also be observers
  » Design to match science drivers, target sources
    <-> Observation
    <-> Theory
    <-> Phenomenology

• Other aspects
  » Instrument design pushes (and is pushed by) engineering
  » Space-based instruments present unique challenges/opportunities
LISA and LIGO

Gravitational Wave Amplitude vs Frequency (Hz)

- LISA
- LIGO
- Coalescence of Massive Black Holes
- NS-NS and BH-BH Coalescence
- SN Core Collapse
- Resolved Galactic Binaries
- Unresolved Galactic Binaries

10/8/2004
U. Florida Gainesville
How will we manage our science and data?

- Publish raw or processed GW channel(s)?
- Publish only highly processed data
  » Triggers, etc?
- Global Network
  » Database of objects. Do we vet them? How?
  » How to prioritize modifications and observing targets?
  » How to try new ideas?
  » Global forum? Advocacy? Proposals?
- What do I think?
  » Encourage global network collaboratory (in long term)
  » Publish objects in catalog; publish processed data
  » Design database tools to interact with object catalogs