Neutrino Detection:

Where are we and what to do next?

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What to do next

Immediate management of a suspected ~~concussion~~ core collapse

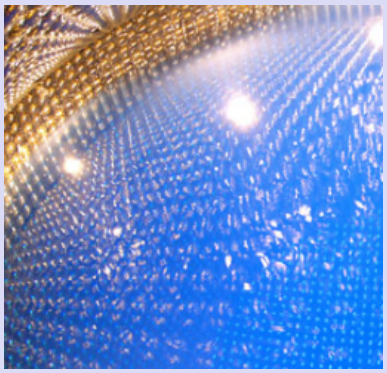
Overall goal for experimentalists:

make sure we are ready to extract physics & astrophysics from the next nearby supernova

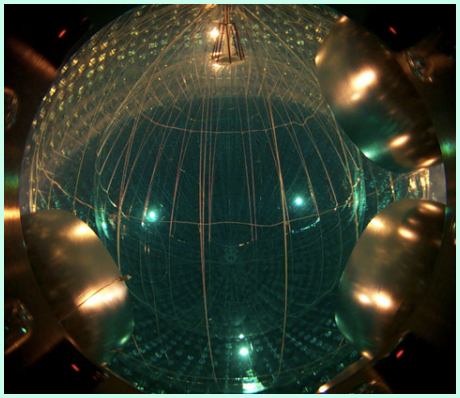
(welcome help from theorists will be models with interesting features, as discussed yesterday)

Current main supernova neutrino detector types

Water



Scintillator



Argon

Lead

+ some others (e.g. DM detectors)

Pros

Water

- electron antineutrino sensitivity
- some other flavors
- potentially good n tagging w/Gd
- decent reconstruction, directionality
- can make large! huge statistics!
- proven technology
- (long string: good timing)

Scintillator

- electron antineutrino sensitivity
- good n tagging
- low energy NC p scattering
- low energy threshold, high light yield
- proven technology

Argon

- electron neutrino sensitivity
- some other flavors
- potentially good tagging
- potentially good reconstruction
- some directionality

Lead

- unique flavor sensitivity, including nue
- some spectral sensitivity (1n vs 2n)
- cheap material, stable

Cons

Water	Scintillator
- Cherenkov threshold limits reco - relatively high threshold - may be hard to disentangle all channels - (long-string: no event-by-event reco)	- poor directionality - low energy signal vulnerable to background
Argon	**Lead**
- unproven technology - capabilities still unknown - statistics limited	- no event-by-event reco, tagging, directionality - currently small mass - expensive to get CC info

Status

Water

- SK will run for a while...
  Gd upgrade likely in next
  ~ few years
- HK also good prospect
- IceCube running...
  (upgrades?)

Scintillator

- Several ~kton scale detectors
  running... most to continue
  in short term
- JUNO very good prospect
  in several years

Argon

- DUNE well underway...
  still working on understanding
  capabilities and defining
  requirements

Lead

- HALO running and stable
- defining path to ~kton scale-up

+ some others (e.g. DM detectors)

For supernova neutrinos, **the more detectors the merrier!** not a competition...

Summary of supernova neutrino detectors

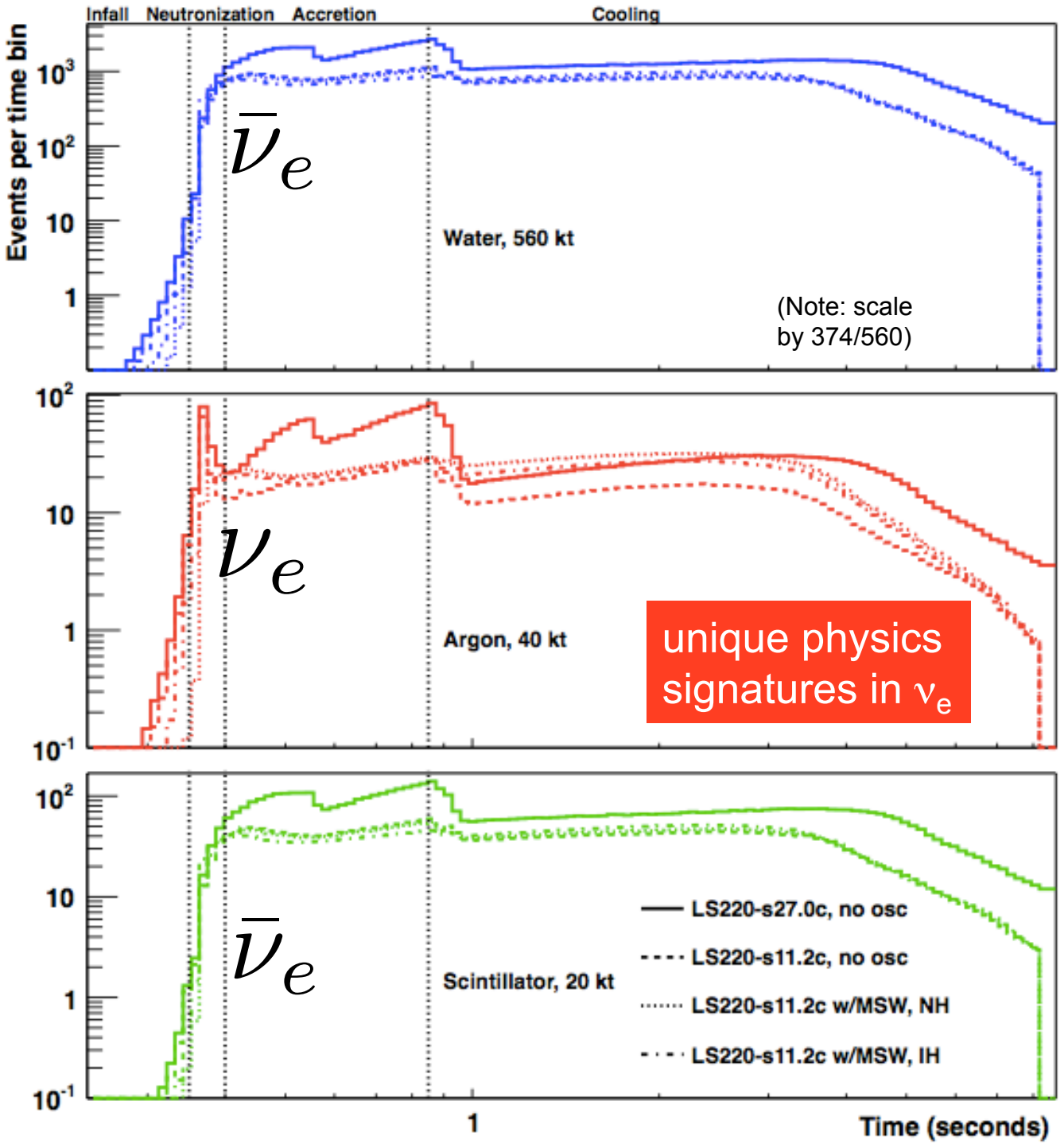
Galactic sensitivity

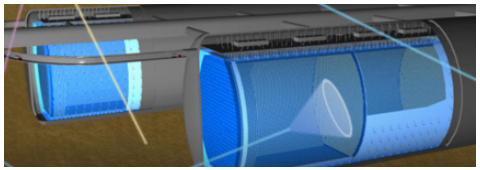
Extragalactic

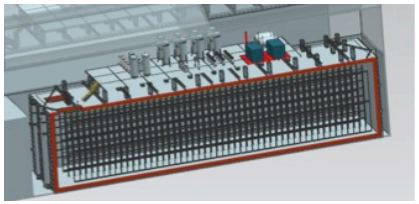
Detector	Type	Location	Mass (kton)	Events @ 10 kpc	Status
Super-K	Water	Japan	32	8000	Running (SK IV)
LVD	Scintillator	Italy	1	300	Running
KamLAND	Scintillator	Japan	1	300	Running
Borexino	Scintillator	Italy	0.3	100	Running
IceCube	Long string	South Pole	(600)	(10^6)	Running
Baksan	Scintillator	Russia	0.33	50	Running
Mini-BooNE	Scintillator	USA	0.7	200	(Running)
HALO	Lead	Canada	0.079	20	Running
Daya Bay	Scintillator	China	0.33	100	Running
NOνA	Scintillator	USA	15	3000	Running
SNO+	Scintillator	Canada	1	300	Under construction
MicroBooNE	Liquid argon	USA	0.17	17	(Running)
DUNE	Liquid argon	USA	40	3000	Proposed
Hyper-K	Water	Japan	540	110,000	Proposed
JUNO	Scintillator	China	20	6000	Proposed
RENO-50	Scintillator	South Korea	18	5400	Proposed
PINGU	Long string	South pole	(600)	(10^6)	Proposed

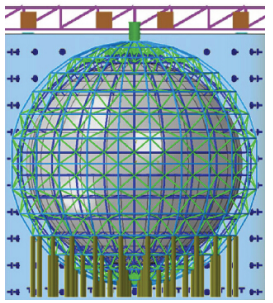
plus reactor experiments, DM experiments...

Two models (11.2 and 27.0 solar masses, NH/IH for former)









arXiv:1508.00785

What do we learn by *combining* information from different detectors?
(nucleosynthesis, LESA... ?)

For physics, and for early alert?
Presupernova? (strengthen statistical significance?)
Pointing? Revisit triangulation?

And combining with GW and other messengers?

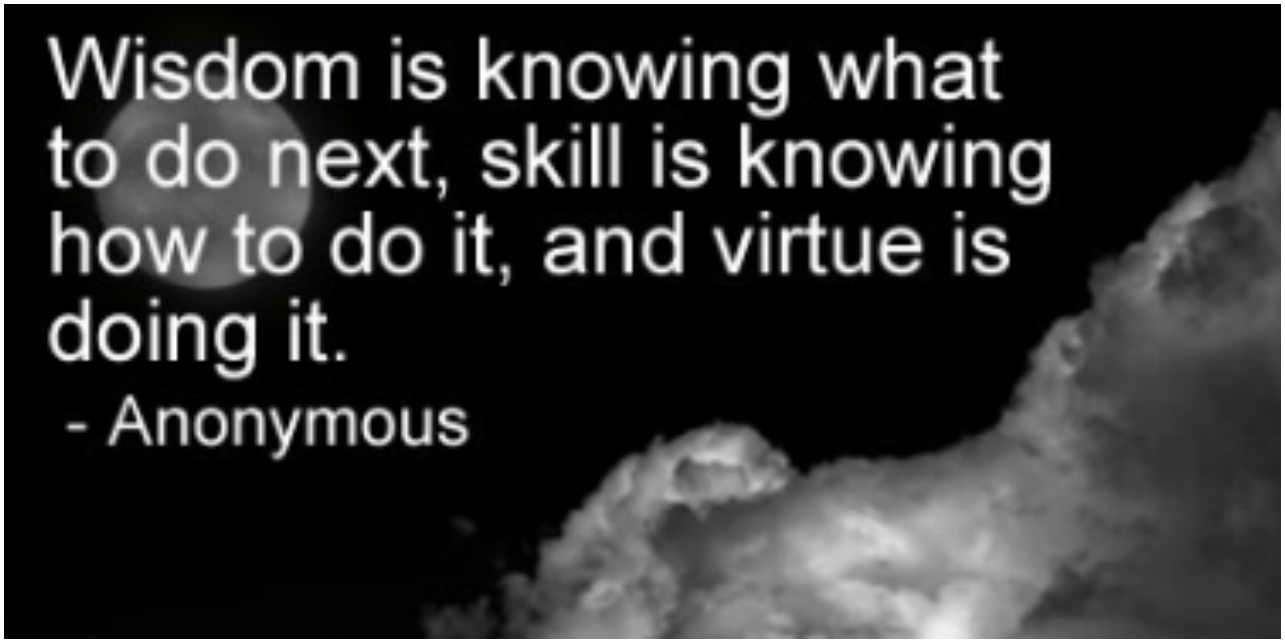
An idea from lunch:

SNARE (SuperNova Advance Readiness Exercise)

- theorists prepare
  model fluxes with
  physics/astrophysics
  "treasure" hidden inside
  (choice of MO, collective
  oscillations, SASI,
  assumed direction, etc.)
- experimentalists simulate
  signals in their detectors
  and analyze the data
- **can we find the treasure?**
- could include GW observatories

- Build on SNEWS and GWnu connections
- Could be ongoing series of events
- Mainz workshop?

(Acronym credit: Chuck, Clarence, Stan, KS)



We are wise and skilled... let’s be virtuous...