Supernova monitoring with SNO and SNEWS

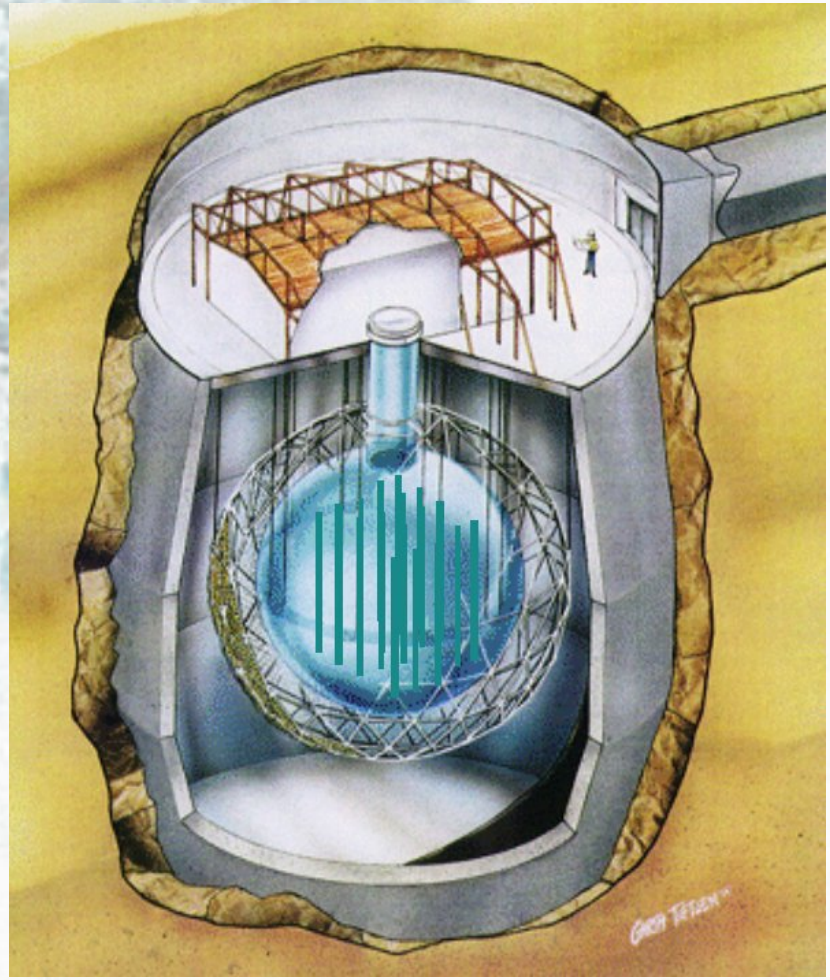
Fabrice Fleurot, Laurentian, Sudbury

- SNO overview
- Type II supernova neutrinos in D_2O and H_2O
- The supernova trigger system
- SNEWS, the SuperNova Early Warning System

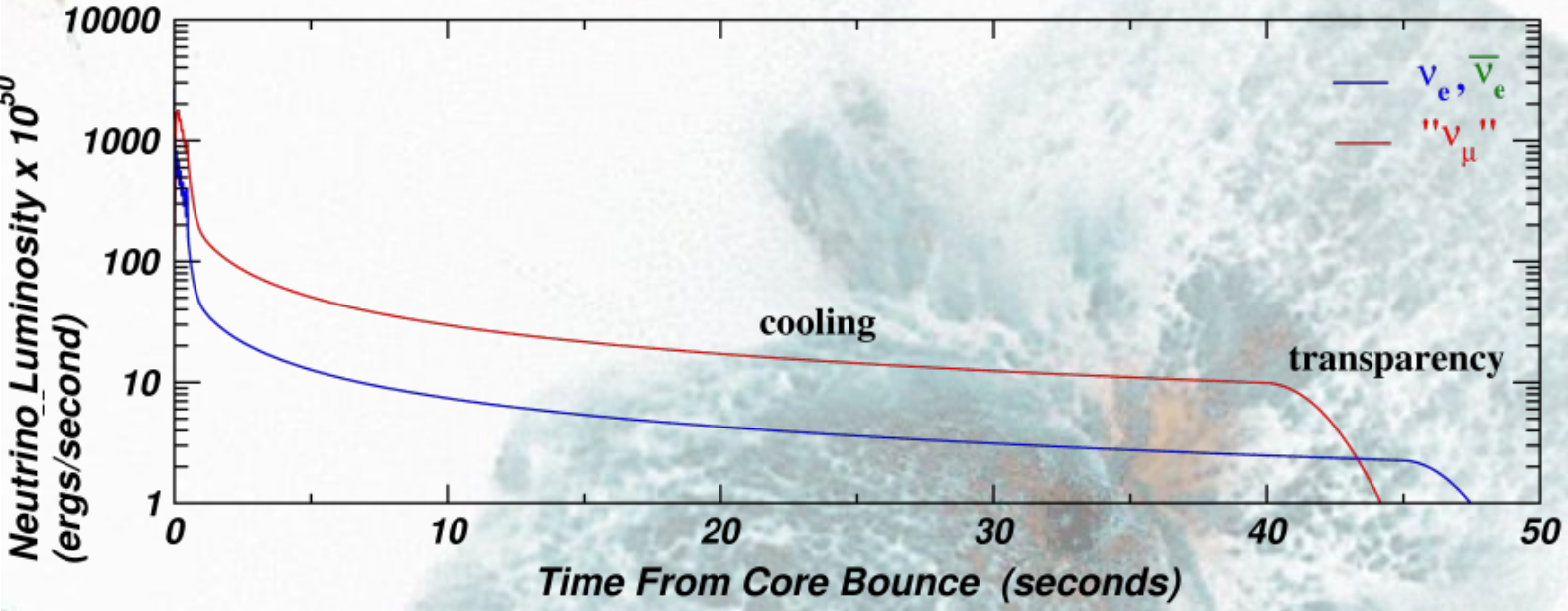
SNO, some numbers

- J. Maneira told (almost) everything last Monday
- 1,000 t D_2O, we know, but also

  1,700 t H_2O seen by the PMTs
- Hardware buffer for 1M events

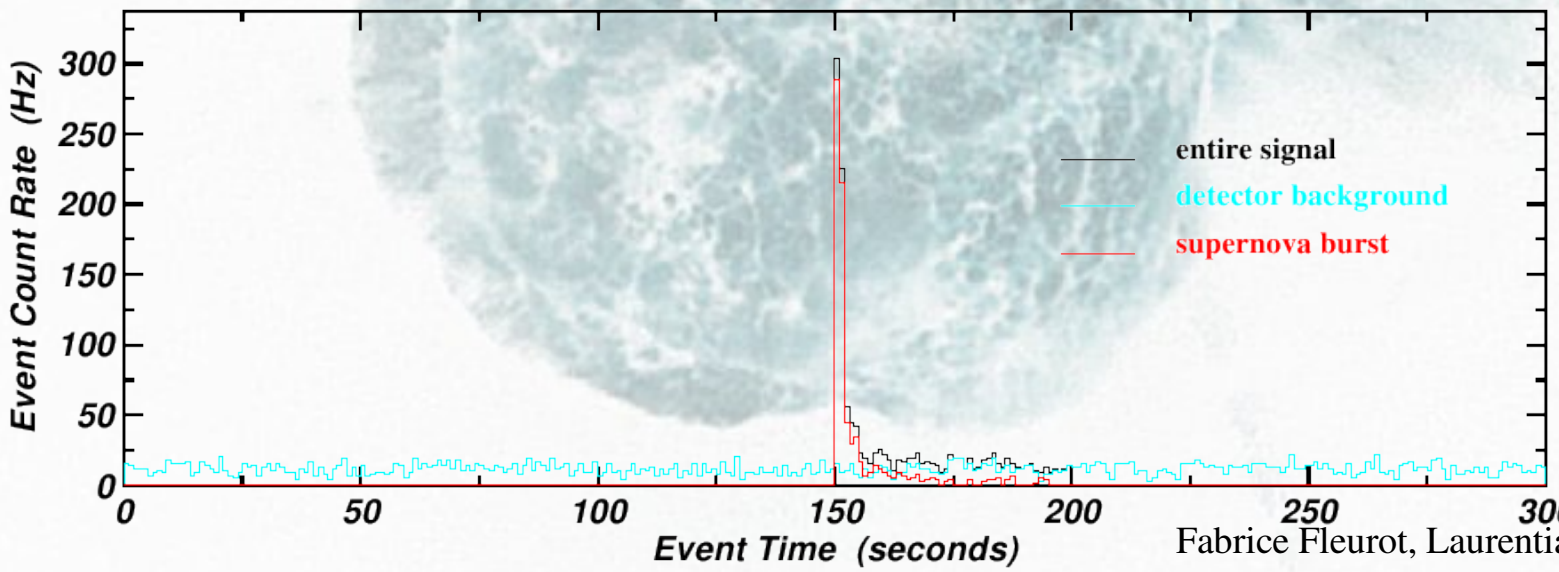


A search for neutrino bursts



Burrows' model
~60% 1 s
Beacom & Vogel:
~30% 1s

generic “burst”
threshold:
> 50%/2s



BG:1-3/min
at 3.8 MeV

Signal in SNO
Monte Carlo by
J. Heise

Main SN reactions in SNO

- H_2O, charged current (40%)

$$\bar{\nu}_e + p \rightarrow n + e^+$$

- D_2O, charged current (25%)

$$\nu_e + d \rightarrow p + p + e^-$$

$$\bar{\nu}_e + d \rightarrow n + n + e^+$$

- D_2O, neutral current (30%)

$$(\bar{\nu})_{e\mu\tau} + d \rightarrow (\bar{\nu})_{e\mu\tau} + p + n$$

- both, elastic scattering (5%)

$$(\bar{\nu})_{e\mu\tau} + e^- \rightarrow (\bar{\nu})_{e\mu\tau} + e^-$$

How many events?

- For a 10-kpc away supernova (10^{58} neutrinos):
  - 900 reactions in 1 min in SNO. Once folded with efficiency:
    - 600 in the pure-D_2O phase (ε = 30% for neutrons),
    - 800 in the dissolved-salt phase (85%),
    - 700 in the NCD phase (57%).
  - For our 50%-in-2 s threshold: 50-75 events from at the far edge of the Galaxy

    -> Chose a 30/2 s threshold, where “background bursts” still rare

SNO Real-time automated SN analysis

Looking for bursts of interests
"3+1" levels, on Red Hat Linux machines

- Level 1: ≥35 PMTs events (3.8 MeV) from datastream stored in a circular buffer.
- If ≥30 such events in sliding 2 s windows: Level-2 is called.

SNO Real-time automated SN analysis

- Level 2:
  Automated analysis, data cleaning cuts:
  - similar to Solar analysis (rm flashers, electrical, light, spallations...), no fiducial volume.
  - burst identification
  - Analysis summary e-mailed to SN working group.
- If >35% survival, calls Level-3

SNO Real-time automated SN analysis

- Level 3:
  - Event reconstruction;
  - SN direction ±25° (from elastic scattering);

  E-mails, text msg, auto phone to SN groups -> conference call
- Final tests on burst:

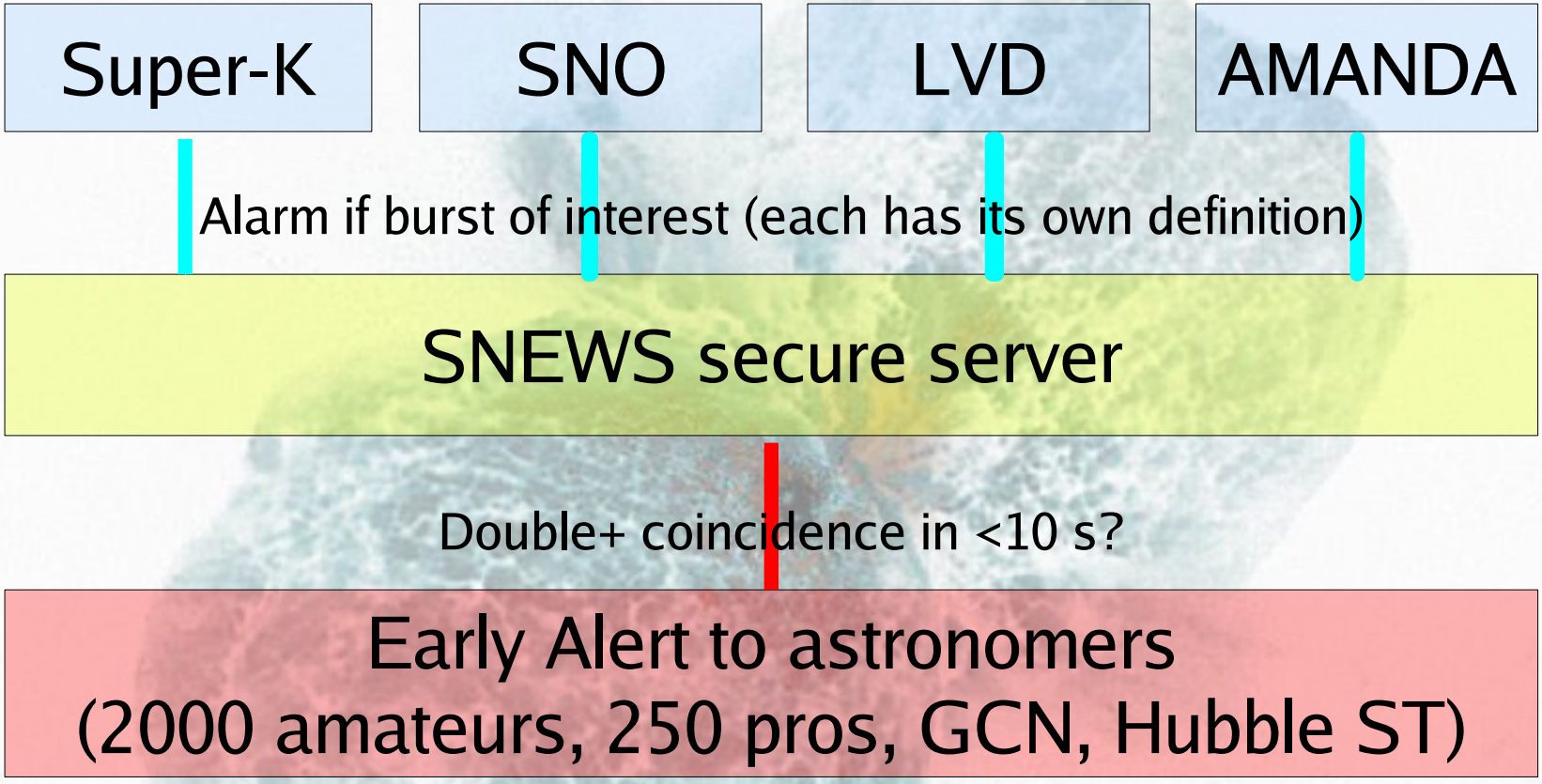
  Isotropy, D_2O/H_2O event ratio (~50/50), high-rate (>2 b in 9h?)...

If passed: automated alarm to outside world (SNEWS); followed by manual confirmation (or retraction).

- So far: 0 false alarm from SNO!

SNEWS: SuperNova Early Warning System

Neutrinos arrive hours before photons!



- The 3+1 Ps:

Prompt, Pointing (amateurs), Positive (<1 false/100y => <1/10d/detector)

Privacy (PGP, highly-secure network at BNL)

What to expect for the future?

- The SNO SN system should be adapted to SNO+
- SN-specific ν detector at SNOlab (HALO)
- SNEWS must grow: you are welcome to join us:

http://snews.bnl.gov

Burst History

- Level 2: (>35 PMT, >30 ev / 2s)
  ~25,000 bursts/year, mostly in calibration, maintenance
- Level 3: (>35% survival)
  very conservative => 1,500 bursts/y (94% efficiency)
  30 b/y off calibration/maintenance (mostly dying PMTs)
- Final tests to SNEWS:
  0!
  Isotropy and D_2O/H_2O tests are very effective