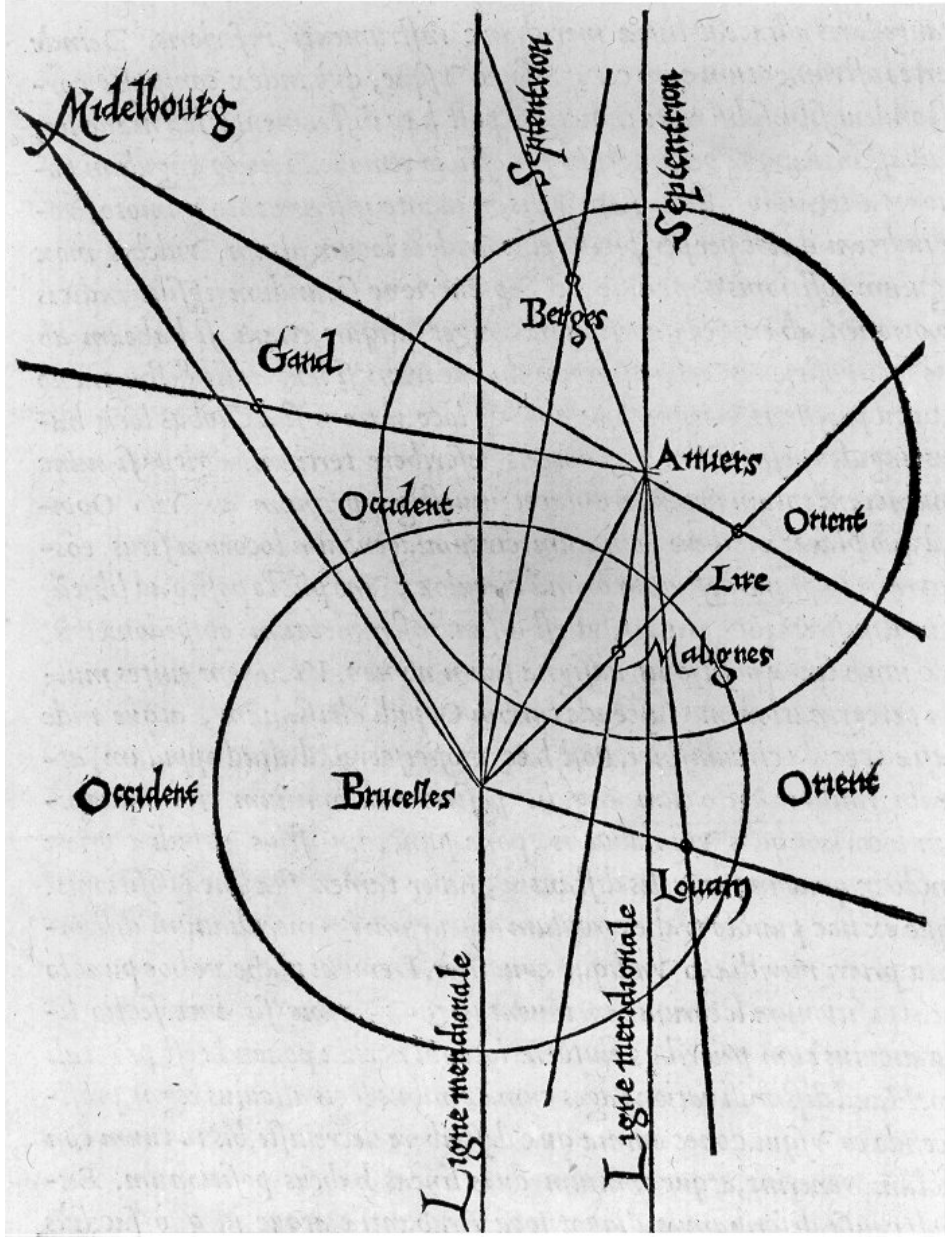
Triangulation with individual t_0's

what information could individual experiments send to SNEWS to accomplish pointing?

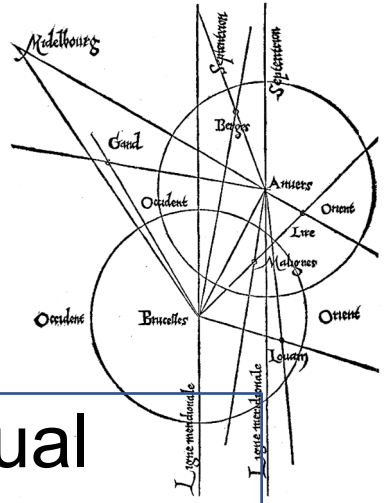
Motivation: what can smaller experiments contribute...

C.J. Virtue



Gemma Frisius' 1533 diagram introducing the idea of triangulation into the science of surveying

Current and evolving situation



- Have variety of detectors / technologies
  - Water / Ice Cherenkov
  - Liquid scintillator
  - LAr
  - Pb
  - CEvNS

- With different responses due to
  - Flavour sensitivity
  - Reaction thresholds
  - Detector thresholds
  - Background levels
  - Tagging purity and efficiency

- Plus individual detectors have different
  - Livetimes
  - Lifetimes
  - DAQ robustness against nearby SNe

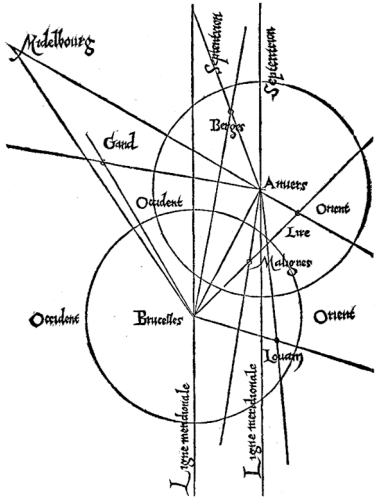
So...

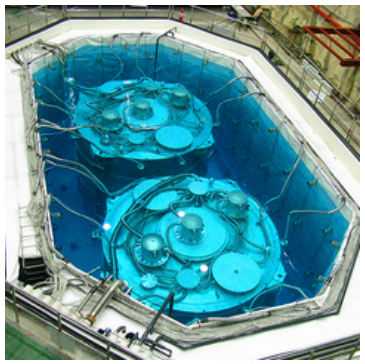
Not “Daya Bay”-like with

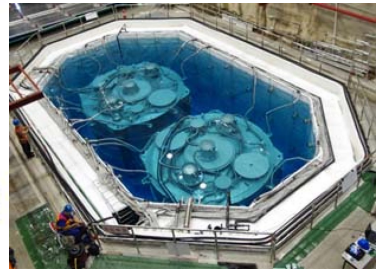
- multiple
- identical
- distributed
- directly comparable

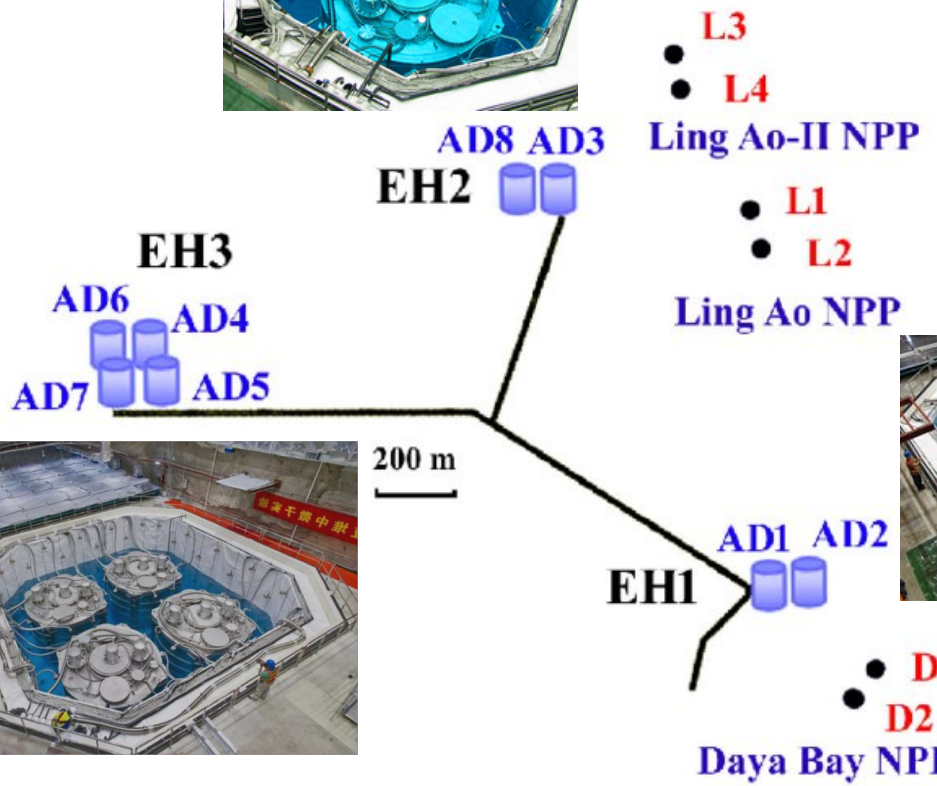
detectors.

A strength and a weakness

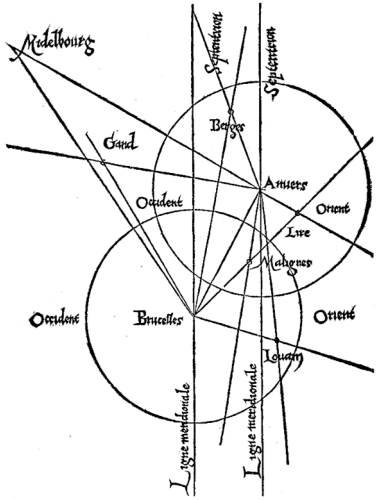








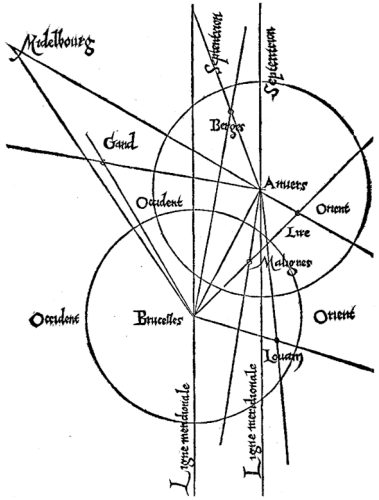
Triangulation approaches – Pros & Cons



(in the end I'm advocating for "all of the above")

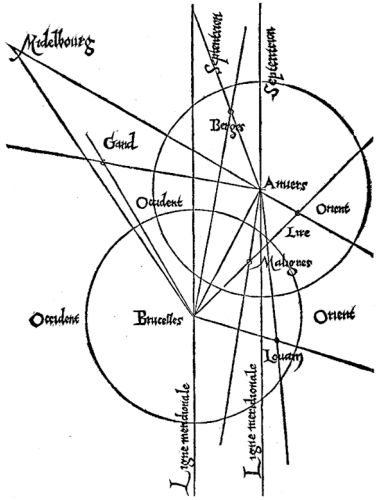
- anisotropic reactions pointing (Kate & Cecilia)
  - IBD directional prompt-delayed spatial separation
  - ES direction after IBD tagging and removal
  - Pros
    - Difference in response matter much less if at all
    - No SN model dependence
    - Direction extraction handled by the detector experts
    - SNEWS could aggregate and combine multiple
  - Cons
    - WC & LS only
    - Sophisticated / analysis required
    - Longer latency / pointing power?

Triangulation approaches – Pros & Cons



- Full neutrino “lightcurve” comparison
  - Pros
    - Greatest potential to accomplish pointing
    - Doesn’t rely on or could be confirmed by direction from asymmetric reactions
  - Cons
    - Requires high statistics → limited to the largest (mostly future) detectors
    - Sensitive to differences in response? (not Daya Bay) works best for similar/identical pairs of detectors
    - Second order SN model dependence for dissimilar detectors?
      - Cooler SN accentuates response differences leading to systematic errors?
    - Requires sharing of “full” data (difficult MOUs / less than full participation?)
    - Latency in data sharing? Event cleaning before transmission of data?
    - Interpretation out of the hands of the individual detector experts

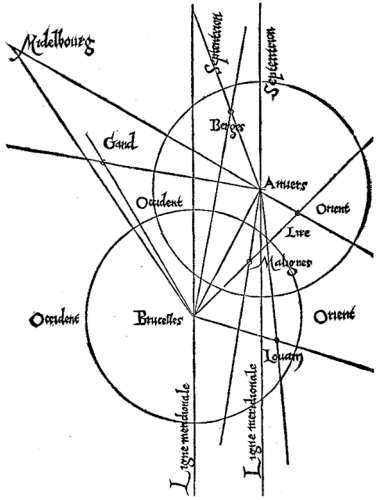
What's a current small detector to do?



SNEWS 2.0 NSF grant application said...

- "Determine what really can be done in terms of triangulation with all of the **acceptance-corrected** light curves. The case of black hole formation causing a step function as the neutrinos get swallowed by the event horizon adds an additional timing marker in that scenario that we will attempt to exploit. We will perform a **model-independent**, un-binned auto-correlation of experimental data online to prepare for the online case.
- Enable the fully functional coincidence server SNEWS2.0 which will perform model independent un-binned auto-correlation of the acceptance-corrected experimental data **in real time**."

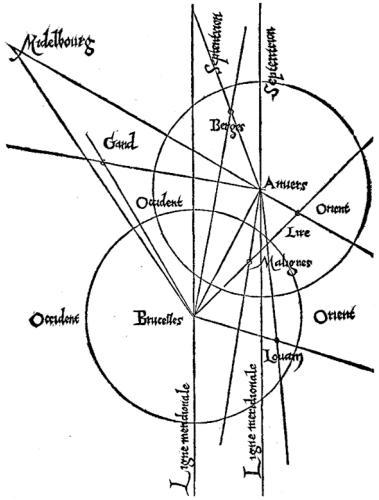
Acceptance-corrected / Model-independent / Real-time?



- Real-time → near-time
- Acceptance-corrected would be detector / model-independent...
  - Anyone doing that? (or ignoring & relying on effects being second-order)
  - Non-trivial on moderate statistics data
  - Not possible (?) on sparse un-binned data

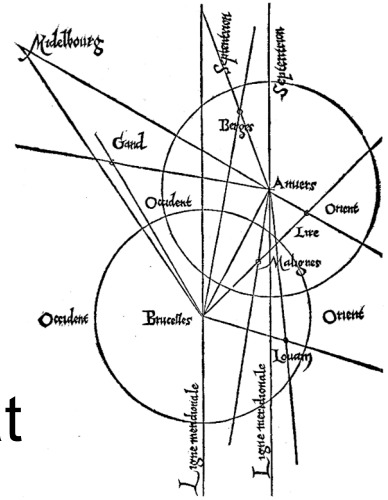
- **Alternatively...** Study what is possible in model-dependent approaches
  - Extract t_0 and uncertainties per SNEWS-adopted model and pass to SNEWS server in place of sparse un-binned data
  - Understand systematics and biases through study of a range of models
  - Map out SN distance dependence of uncertainties and at what range small detectors might contribute

Study underway....



- Currently for HALO-1kT, next for SNO+
  - Using Garching pinched-flux model in SNOwGLoBES
    - For a given distance, Poisson-fluctuate flux per timebin, run through GEANT MC
    - Repeat, build cumulative pdf
    - Repeat with shifted t_0 and do un-binned maximum likelihood fit against pdf to extract t_0 and uncertainty
  - Repeat as a function of distance
  - Repeat with other “standard” SN models as they are added to SNOwGLoBES or otherwise become available
  - Study biases, extracted uncertainties, model-dependence
- Machinery for this study is almost complete
- Remington Hill will be presenting some preliminary results in a future Pointing Working Group meeting

Direction...



- Assuming that the study shows that t_0's for pointing become useful at some distance for these examples of more modest detectors
- And, assuming SNEWS provides a set of "standards" in SNOwGLoBES, spanning a range of models out to seconds, then
  - Machinery can be in place to fit real SN data in seconds to each of the set of models
- Returning to SNEWS server for triangulation
  - t_0 and σ_t_0 per model
  - Locally aggregated, "model-independent" t_0 and σ_t_0?
  - model independent t_{BH} and $\sigma\ \_t_{BH}$ (different but related local analysis)
- And, for information
  - likelihood of fit to each of the standard set of models
  - model dependent d_{SN} estimates and uncertainties

End

Thanks for your attention....

Questions?