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Landscape 2020 David Silva (NOAO)

Very Wide Field Surveys in the Light of Astro2010 June 13-16, 2011





















Spectro in LSST Era, Silva, Apr 13 (D3)



A somewhat idiosyncratic presentation...

- What else is going on?
- What facilities will be on-line (or close)?
- What is the LSST follow up problem domain?
- Meta-thoughts
 - Must ask "good" science questions before we can design and implement the "appropriate" follow up capabilities and strategies
 - The implementation horizon for new "stuff" is closer than it appears



Big Science Questions 2020

- Is there life on other worlds?
- What is dark matter?
- What is dark energy?
- What lies beyond the Standard Model?
- What will opening the gravitational wave window reveal?



Is SUSY in trouble? And so goes dark "matter"?

[The] discovery of the 125 GeV Higgs boson, and nothing else at LHC, caught [SUSY theorists] by surprise dramatically changing the overall picture and the state of minds in the community...**one could feel the mood of perplexity in** *the audience.* – Shifman, Oct 2012







Spectro in LSST Era, Silva, Apr 13 (D3)



LSST survey Single visit depth, 5σ limits



Spectro in LSST Era, Silva, Apr 13 (D3)

Aura

NOAO

LSST survey Full depth, 5 σ limits



Aura





LSST survey Survey depths, implications

- Depth (5 σ), one visit, r-band = 24.7 (range: 18 24.7)
 - Time domain follow up accessible to 4-m and larger
 - Which "interesting" objects lie at bright and faint ends? How does that affect followup strategies?
 - What are efficient triage strategies to separate rare time-domain events from time-variable background?
- Depth (5 σ), full survey, r-band = 27.5
 - Spectroscopy at full-depth lies in domain of ELTs
 - Follow up of time-invariant objects expensive
 - Follow up of time-variable objects really expensive
 - In any magnitude range, how much effort is driven by curiosity and how much effort is driven by pre-planned strategy?



An embarrassment of riches The sample selection problem

- "Static" universe
 - Billions of objects in range r = 18 28
 - Cannot observe everything
 - How are samples selected?
 - How does that constrain needed follow up capabilities?
- "Variable" universe
 - Background vs. rare
 - How are samples selected?
 - How does that constrain needed follow up capabilities?



Follow up capabilities Build, buy, or re-purpose?

- Build = expensive, takes time
 - Some things are easier to implement than others
 - It's 2013.5, some new "stuff" is needed in 6.5 years...
 - Resources limited, what are our priorities?
 - Takes 0 3 years to deliver a new operations process
 - Takes 3 5 years to deliver a new data system
 - Takes 5 7 years to deliver a new instrument
 - Takes 10 20 years to deliver a new telescope
- Buy or re-purpose = less expensive, faster
 - Time trades also in this category



LSST

GMT

TMT

US Optical-Infrared System

The ensemble of <u>all</u> Federal and non-Federal observatories World leader in research, education and public outreach



AURA The System lives!

Key result from System Roadmap Survey (N = 1178) Bubble size = relative number of users in last 3 years Lines = users of multiple facilities Red lines = most frequent connections Yellow (solid) = NSF investment, ≥ \$1M/year Yellow (border) = NSF investment, less





Southern facilities, 2020 Optical/Infrared (3-m and up)

- NOAO Blanco 4-m
- SOAR 4.2-m
- Gemini South 8.2-m
- Las Campañas Observatory
 - Giant Magellan Telescope 24-m (under construction)
 - Magellan Baade 6.5-m
 - Magellan Clay 6.5-m
 - Du Pont 2.5-m



Southern facilities, 2020 Optical/Infrared (3-m and up)

- ESO (A = Armazones, P = Paranal, L = La Silla)
 - (A) E-ELT 38-m (under construction)
 - (P) VLT 4 x 8-m = general purpose (+ VLTI outriggers)
 - (P) VISTA 4-m = NIR wide-field telescope (4MOST, operational?)
 - (P) VST 2.6-m = optical wide-field telescope
 - (L) 3.6-m = spectroscopic survey telescope (HARPS)
 - (L) NTT 3.5-m = general purpose optical
 - (L) MPIE 2.2-m = general purpose optical
- U. of Tokyo
 - − TAO 6.5-m (under construction) = 5500-m altitude, NIR \rightarrow MIR
- Southern Africa Large Telescope (SALT, 11-m)
- Australian Astronomical Telescope (AAT, 4-m)



Northern facilities, 2020 Optical/Infrared (3-m and up)

Large fraction of LSST survey footprint accessible from key northern sites

- Mauna Kea (TMT, Keck, Subaru, Gemini North)
- Mt Locke (HET)
- Mt Graham (LBT)
- Happy Jack (DCT)
- Kitt Peak (Mayall, WIYN)
- Apache Point (ARC)
- Mt Hamilton (Lick)



Southern facilities, 2020 Radio

- Llano de Chajnantor science preserve (5200-m)
 - ALMA = mm-smm interferometric array
 - APEX = single-dish mm-smm (12-m)
 - APSE = single-dish mm-smm (10-m)
 - NANTEN2 = single-dish mm-smm (4-m)
 - ACT = single-dish microwave (6-m)
 - CCAT (planned) = single-dish smm (25-m)
- Square Kilometer Array (SKA) (planned)
 - Parts in Australia, New Zeeland, and Sub-saharan Africa





OK, what about data systems?

- Lots of survey "providers"
- Too few "data discovery" tools
- Few (no?) survey "amalgamation" tools, systems, providers



- VAO is dying, the right vision too soon?
- What tools do we really want in 2020?
- What tools do we really need in 2020?
- How do science cases drive the design?



To tie it all together...

It's not just about follow up hardware (new or old) It's about follow up <u>systems</u>

- Grok what information already exists
- Ask the questions, build the teams, implement the process
- Build the samples (often in near real-time)
- Re-purpose existing "stuff" as much as possible
- Build = last resort (?)
 - Data systems, instruments, telescopes
- Publish data, amalgamate with other data sets
- Lather, rinse, repeat



And so keep the following in mind...

- What else is going on?
- What facilities will be on-line (or close)?
- What is the LSST follow up problem domain?
- What do we need to do now? And what can wait?
- Must ask "good" science questions before can design and implement appropriate follow up "systems"
- The implementation horizon for new "stuff" is very close

