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The Durability and Fragility of Knowledge Infrastructures: Lessons Learned from Astronomy

Christine L. Borgman

Distinguished Professor and Presidential Chair in Information Studies

University of California, Los Angeles

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@scitechprof



Christine Borgman



Peter Darch



Ashley Sands



Irene Pasquetto



Bernie Randles



Milena Golshan

Borgman, C. L., Darch, P. T., Sands, A. E., & Golshan, M. S. (2016). The durability and fragility of knowledge infrastructures: Lessons learned from astronomy. In *Proceedings of the Association for Information Science and Technology* (Vol. 53, pp. 1–10). ASIS&T. https://doi.org/10.1002/pra2.2016.14505301057

Astronomy Journal Club, UCLA

March 7, 2017

UCLA Center for Knowledge Infrastructures

https://knowledgeinfrastructures.gseis.ucla.edu

Jack Meadows, 1934-2016

The founder of the University of Leicester's astronomy department, who had a minor planet named in his honour, has died

August 18, 2016

By Jack Grove

Twitter: @jgro_the



https://www.timeshighereducation.com/people/obituary-jack-meadows-1934-2016

Meadows, A. J. (1974). *Communication in Science*. London: Butterworths.



UCLA Center for Knowledge Infrastructures

Christine L. Borgman, Distinguished Professor and Presidential Chair in Information Studies at UCLA, is the author of more than 250 publications in information studies, computer science, and communication. She directs the Center for Knowledge Infrastructures with research grants from the Alfred P. Sloan Foundation, the National Science Foundation, and other sources.

Bernie Randles (second from left), a second-year PhD student, brings her expertise in computer science and mathematics to our studies of data and software relationships in Astronomy.



The Center for Knowledge Infrastructures conducts research on scientific data practices and policy, scholarly communication, and socio-technical systems. Their latest project, funded by the Alfred P. Sloan Foundation, is studying data practices, policy, and infrastructure of multiple distributed scientific collaborations, exploring methods of data collection and management, innovations in scaling and workflows, and multidisciplinary approaches to complex problems.

Current Research Sites

Domain	Focus	Topic
Astronomy sky surveys	Place: sky and universe	Survey of night sky
Observational Astronomy	Problem: data infrastructure	Orbits, phenomena, data integration
Deep subseafloor biosphere	Place: under ocean floor	Microbial life and environment
Craniofacial research	Problem: Craniofacial birth defects in humans	Genomics of four model organisms
Computational science	Problem: Data analysis at scale	Computing platform for astronomy, genomics, more…

Knowledge Infrastructures

- What new infrastructures, divisions of labor, knowledge, and expertise are required for data-intensive science?
- How are multi-disciplinary, data-intensive scientific infrastructures established – and dismantled?
- How do data management, curation, sharing, and reuse practices vary among research areas?

UCLA Center for Knowledge Infrastructures

Research Methods

- Document analysis
  - Public and private documents and artifacts
  - Official and unofficial versions of scientific practice
- Ethnography
  - Observing activities on site
  - Embedded for days or months at a time
- Interviews
  - Questions based on our research themes
  - Compare multiple sites over time

Center for Knowledge Infrastructures
UCLA

Astronomy Knowledge Infrastructures

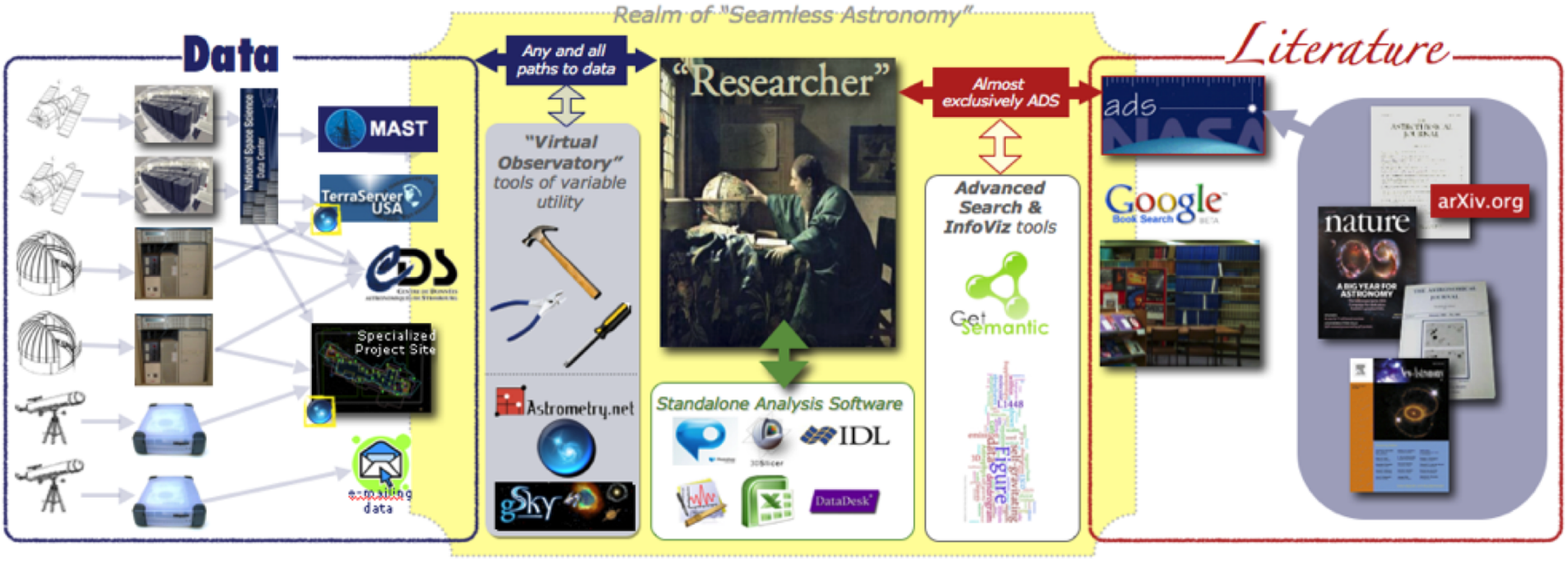


Image: Alyssa Goodman, Seamless Astronomy, Harvard-CfA

Astronomy Knowledge Infrastructures

- Observations: continuity over millennia
- Astronomy became digital: 1970s-
- Array of stakeholders: international
- Private and public funding: renewal
- Consensus mechanisms: Decadal survey



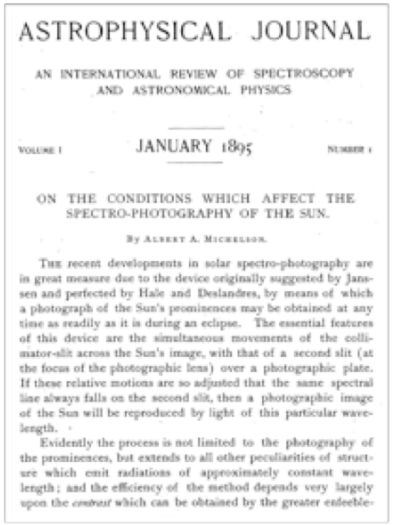
http://www.bbc.com/news/magazine-22105898

Astronomy Infrastructure Chronology

Astronomy Infra-structure	**1960-1985**	**1986-1990**	**1991-1995**	**1996-2000**	**2001-2005**	**2006-2010**	**2011-**
NASA funded infrastructure observatories missions centers archives & data tools	GSFC IPAC IRAS STScI	Hubble (HST) NED	ADS IRSA SATC	Chandra HEASARC 2MASS MAST NExScI Spitzer WIRE	SOFIA Spitzer Suzaku Swift	Fermi (FGST) Herschel Kepler Palomar (PTF) Planck WISE	NuSTAR
Other infrastructure observatories centers surveys data tools standards	SAO CfA CDS/ SIMBAD FITS		arXiv VizieR Keck	Aladin NVO IVOA SDSS Gemini Subaru		Dataverse GitHub LSST Pan-STARRS VAO WWT	ADSASS DDT Jupyter Note-book Zenodo DES TMT

Evolution of the Journal Article




ASTROPHYSICAL JOURNAL

AN INTERNATIONAL REVIEW OF SPECTROSCOPY AND ASTRONOMICAL PHYSICS

VOLUME I JANUARY 1895 NUMBER 1

ON THE CONDITIONS WHICH AFFECT THE SPECTRO-PHOTOGRAPHY OF THE SUN.

By Albert A. Michelson.

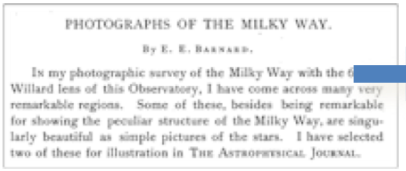
The recent developments in solar spectro-photography are in great measure due to the device originally suggested by Janssen and perfected by Hale and Deslandres, by means of which a photograph of the Sun's prominences may be obtained at any time as readily as it is during an eclipse. The essential features of this device are the simultaneous movements of the collimator-slit across the Sun's image, with that of a second slit (at the focus of the photographic lens) over a photographic plate. If these relative motions are so adjusted that the same spectral line always falls on the second slit, then a photographic image of the Sun will be reproduced by light of this particular wavelength.

Evidently the process is not limited to the photography of the prominences, but extends to all other peculiarities of structure which emit radiations of approximately constant wavelength; and the efficiency of the method depends very largely upon the *contrast* which can be obtained by the greater endeeble-



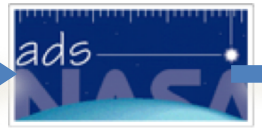


1665 ..230 yr... 1895 ...114 yr... 2009 ...4 yr... 2013


PHOTOGRAPHS OF THE MILKY WAY.

By E. E. Barnard.

In my photographic survey of the Milky Way with the [illegible] Willard lens of this Observatory, I have come across many very remarkable regions. Some of these, besides being remarkable for showing the peculiar structure of the Milky Way, are singularly beautiful as simple pictures of the stars. I have selected two of these for illustration in The Astrophysical Journal.







Slide: Alyssa Goodman, Harvard Astronomy

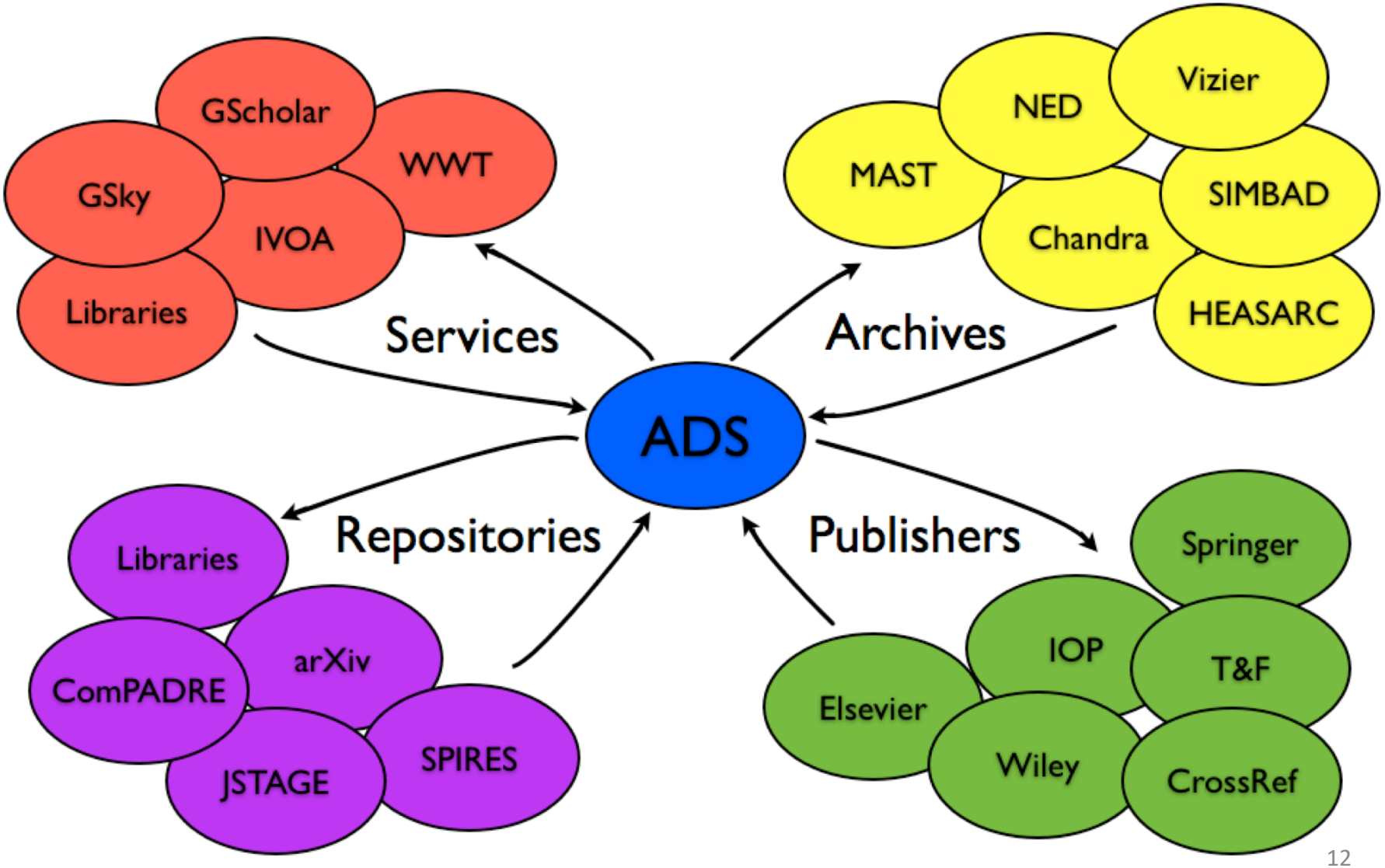
Astrophysics Data System: 20 years

- 1993: Abstract Service launched implementing federated search to SIMBAD object database
- 1994: First web-based version of the ADS Abstract Service released
- 1995: Fulltext of ApJ Letters digitized and online
- 1996: Citation data incorporated in ADS; links between bib records and datasets created; first mirror site online
- 1997: Indexed astronomy preprints from arXiv
- 1998: The online readership via ADS surpasses the worldwide print readership for the main Astronomy journals
- 1999: Extracted and incorporated 1.2M citations from digitized literature via text mining
- 2000: Incorporated usage data and Citation ranking in search engine
- 2001: ADS's 10th mirror site comes online
- 2002: Digitized and placed online 300K historical scans from microfilms online
- 2003: myADS notification service launched
- 2004: Introduced fulltext search, private libraries
- 2005: Introduced daily database updates of arXiv content, RSS feeds
- 2006: Launched the ADS basic search, implemented openURL linking
- 2007: Implemented user login system
- 2008: Upgraded content in ADS with color and grayscale scans
- 2009: Introduced the ADS topic search
- 2010: Developed the ADS recommender
- 2011: The ADS Labs website is launched
- 2012: Incorporated metrics, visualizations in ADS Labs
- 2013: The ADS corpus reaches 10M bibliographic records, 3M fulltext documents, and over 50M citations.



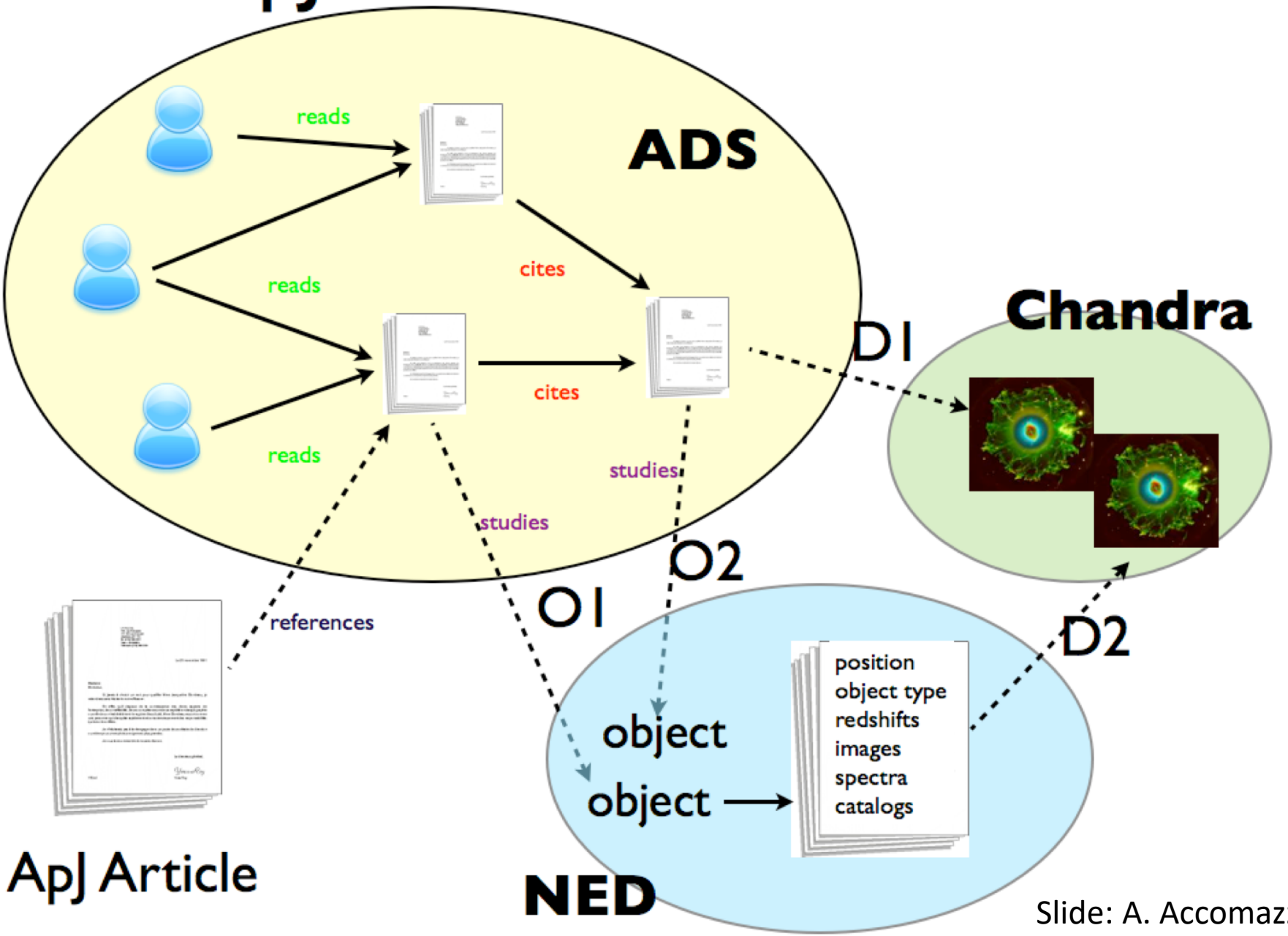
http://conf.adsabs.harvard.edu/ADSXX/

ADS Collaborators



Slide: Alberto Accomazzi, ADS

ApJ/ADS/NED/Chandra



Slide: A. Accomazzi

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- Publication support

- myCDS

Virtual Observatory projects
- IVOA
- Euro VO
  - ASTERICS
  - CoSADIE
  - Past projects:
  - Euro-VO ICE
  - AIDA - DCA - VOTech
- OV France
- Europlanet

Other projects
- RDA Europe
- ARCHES
- ASTRODEEP
- Gaia

Authorities
- Strasbourg astronomical Observatory
- CNRS - INSU
- University of Strasbourg

Links
- ADS
- NED
- CNES
- ESA
- ESO
- NASA

Internal
- Twiki

- Contact us

Cette page en français

Centre de Données astronomiques de Strasbourg

Strasbourg astronomical Data Center

Entry point to all services — Object/position

Object database — Obj/position/bibcode

Catalogue database — Keywords, target, ...

Interactive sky atlas — Object/position

Other services

X-match | Dictionary | Sesame | SimPlay

Hosted services

ADS mirror | A&A | TIPTOPbase | INES

Upcoming events

LISA VIII conference (Library and Information Services in Astronomy)

Astronomy Librarianship in the era of Big Data and Open Science

Keep in touch

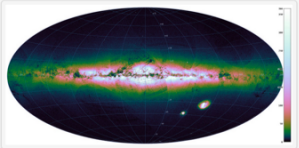
Latest news

- Catalogs added between 18-Feb-2017 and 25-Feb-2017
- Catalogs added between 11-Feb-2017 and 18-Feb-2017
- Catalogs added between 04-Feb-2017 and 11-Feb-2017
- CDS Services interruption on April 3, 2017
- HTTPS support
- New version of CDS Portal
- Server upgrade for portal and annotations service [DONE]
- Link from SIMBAD to VizieR

More news

Featured news

Gaia DR1 at CDS



Gaia Data Release 1 available at CDS - September 14, 2016.

© UDS/CNRS

Contact

The **HSC v2.1** release (2017 January 26) includes additional spectroscopic matches, median magnitudes, and more. Close ×

Welcome to the Hubble Legacy Archive

The Hubble Legacy Archive (HLA) is designed to optimize science from the Hubble Space Telescope by providing online, enhanced Hubble products and advanced browsing capabilities. The HLA is a joint project of the Space Telescope Science Institute (STScI), the Space Telescope European Coordinating Facility (ST-ECF), and the Canadian Astronomy Data Centre (CADC).

Enter Site here.



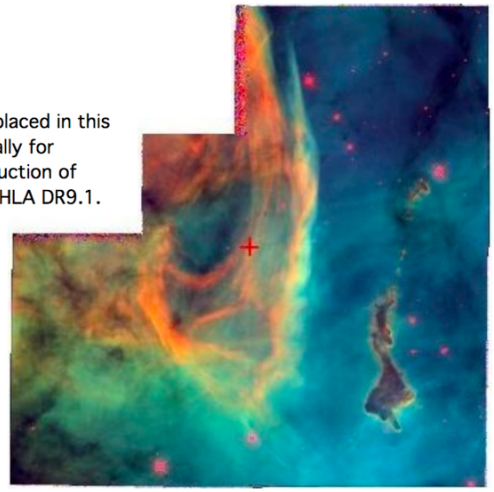
DR9.1 Release (2016 September 29)

NEW DATA PRODUCTS

- Newly processed ACS and WFC3 source lists. Almost all old source lists have been replaced in this catalog. The new source lists have higher quality astrometry and photometry, especially for SExtractor catalogs in crowded fields. These new source lists were used in the construction of version 2 of the **Hubble Source Catalog**, which is being released simultaneously with HLA DR9.1.

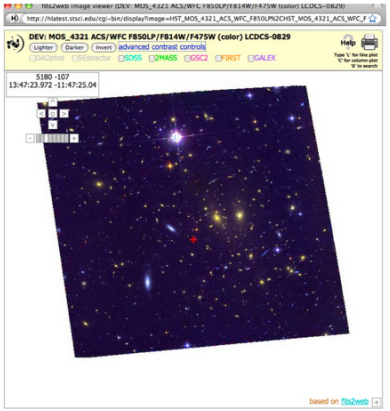
USER INTERFACE ENHANCEMENTS

- The interactive display's advanced HSC controls can be used to show either the current HSCv2 catalog or the previous HSCv1 catalog.
- The **Gaia DR1** catalog is available for overlay in the display.
- New controls can change the catalog overlay region to load sources from only a small part of the image. This greatly improves performance in large images and crowded regions.
- See the **display help** for more information on the new display features.



See the **release notes** for more details on this and past releases.

HLA ESSENTIALS



- The HLA interface runs in **Firefox**, **Safari**, **Chrome**, **Internet Explorer** (versions 8* and 9), and similar compatible browsers. *IE8 limitations - the scatterplot and plotting tools do not work on IE8 as it does not support HTML5.
- To fully realize all of the HLA's functionality, one must have **cookies and popups** enabled.
- The HLA includes enhanced data products (ACS, WFPC2, & NICMOS images, ACS & WFPC2 source lists, ACS & NICMOS extracted grism spectra, prototype ACS mosaics) and also provides access to the standard HST data products when HLA enhanced products have not yet been created.
- **Footprints**, which graphically display the sky coverage on a background image from the Digitized Sky Survey, are available for both standard and enhanced HST data products, including extracted grism spectra and community-contributed high-level science products.
- Here is a matrix describing what is and is not in the HLA:

Instrument/Product	Source	HLA Enhanced Products [1]	Download Format	Interactive Display?
ACS/combined images	STScI	93%[2]	FITS	✔
ACS/source lists	STScI	87%[3]	Ascii	✔
ACS/grism extractions	ST-ECF	70%[4]	FITS	
ACS/mosaic images	STScI	143 images for 67 pointings	FITS	✔

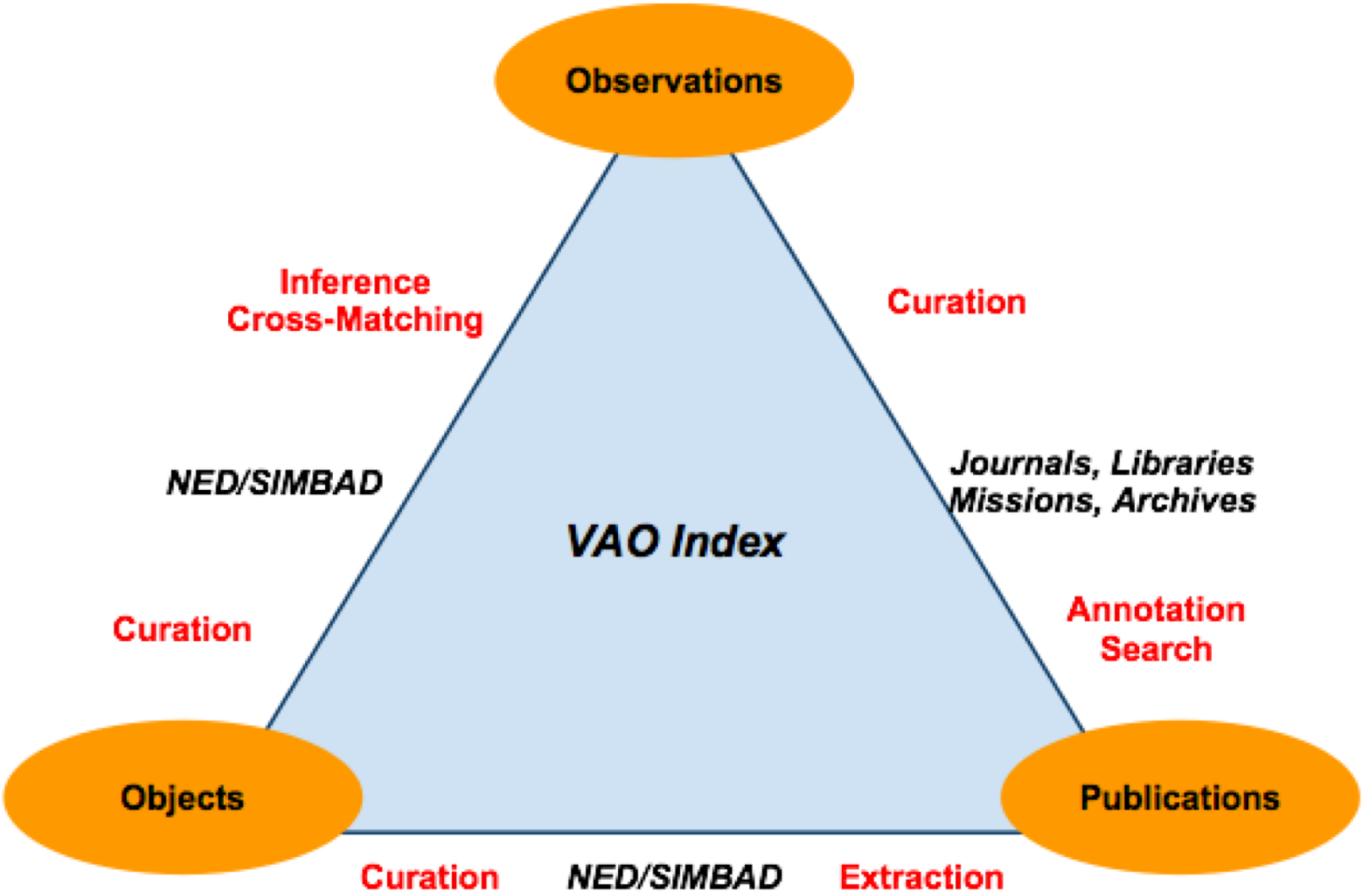


Figure 1. Relationships between Publications, Objects, Observations and the corresponding major actors in the curating process and their activities (in red).

Accomazzi, A., & Dave, R. (2011). Semantic Interlinking of Resources in the Virtual Observatory Era. *arXiv:1103.5958*

Data Standards and Infrastructure Fabric





VO Standards

- Standard Format: VOTable
- Access Protocols: ADQL, TAP, SIAP, SSAP











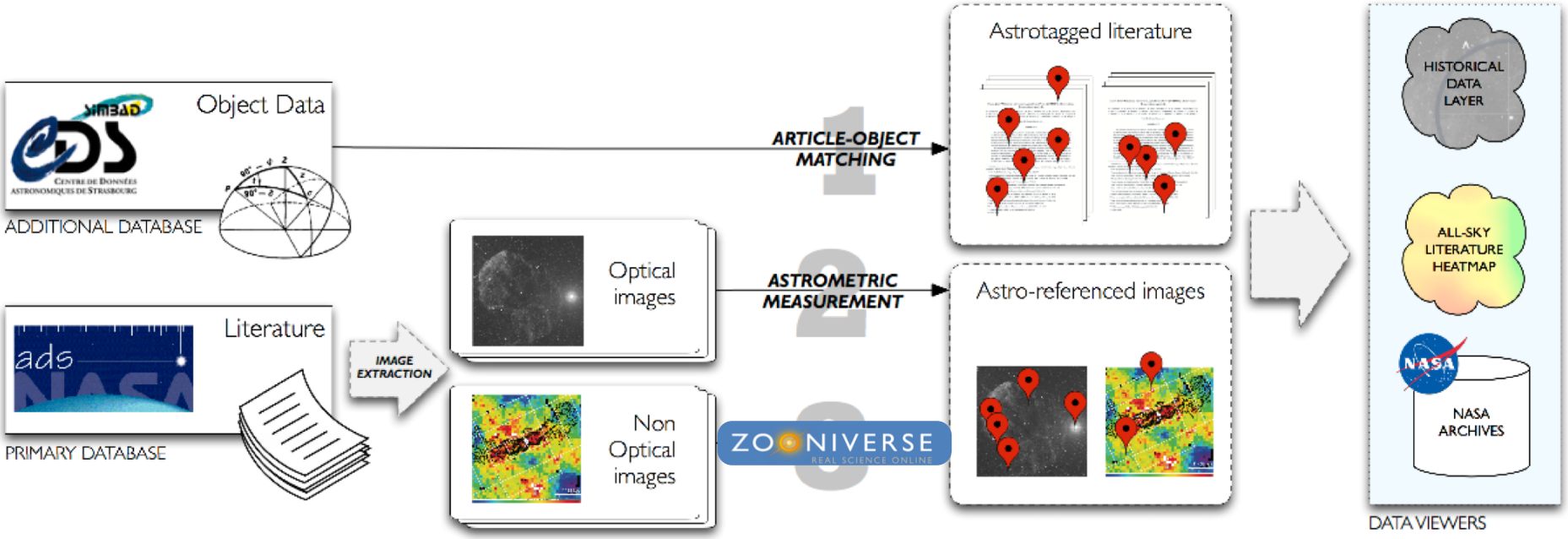






and others

Seamless Astronomy: ADS All Sky Survey

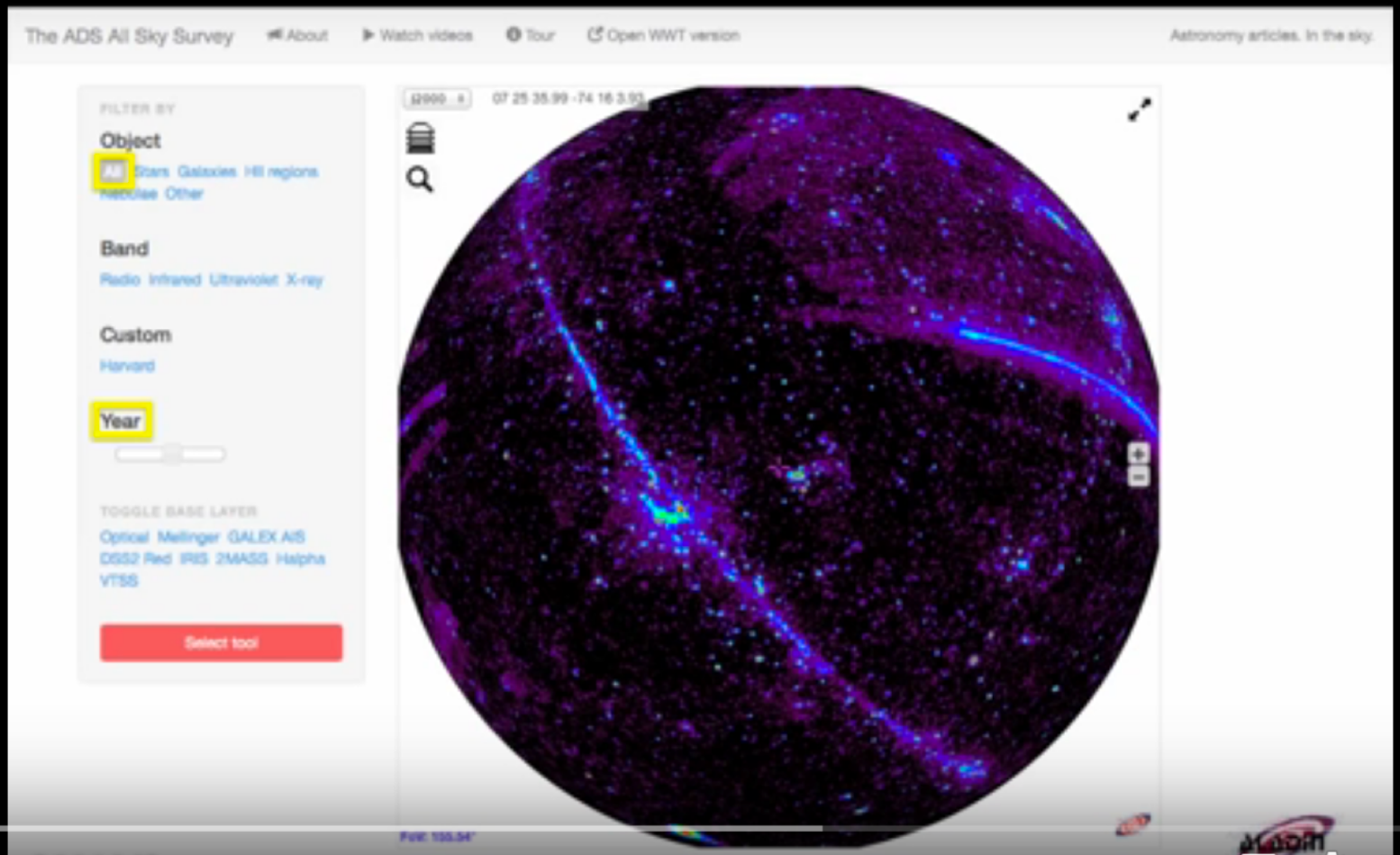


Slide: Alberto Pepe

What's hot in the heavens? The NASA ADS All Sky Survey

What's Hot in the Heavens? The NASA ADS All-Sky Survey

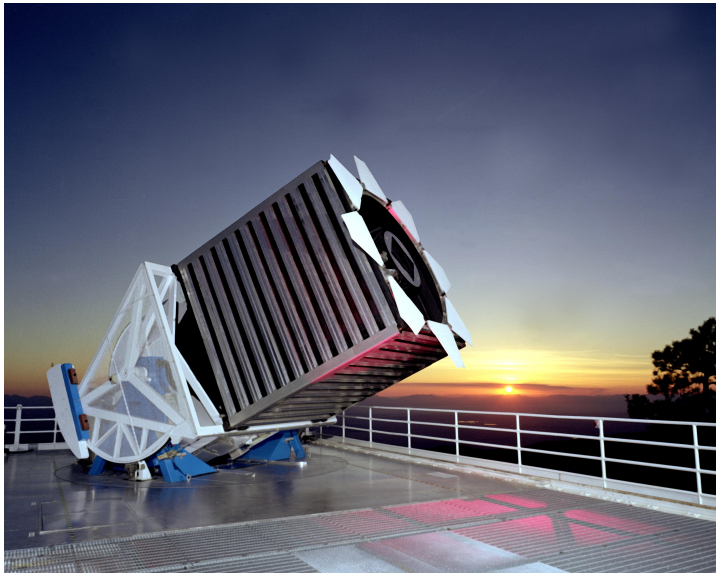
A slideshow demo of the ADS All-Sky Survey



0:14 / 4:48

Sloan Digital Sky Survey (SDSS-I/II)



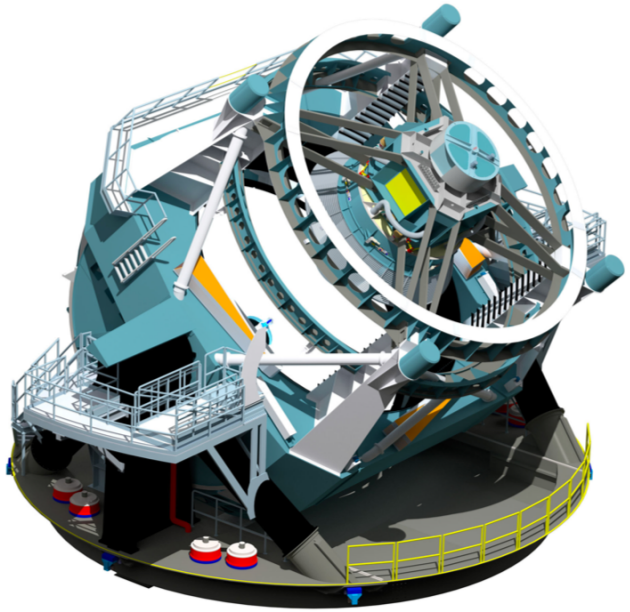


- Survey from 2000-2008
- 160+ TB data total
- Tens of millions of dollars
- Open data
- Proprietary software

Telescope for the Sloan Digital Sky Survey, Apache Point, New Mexico

Large Synoptic Survey Telescope (LSST)

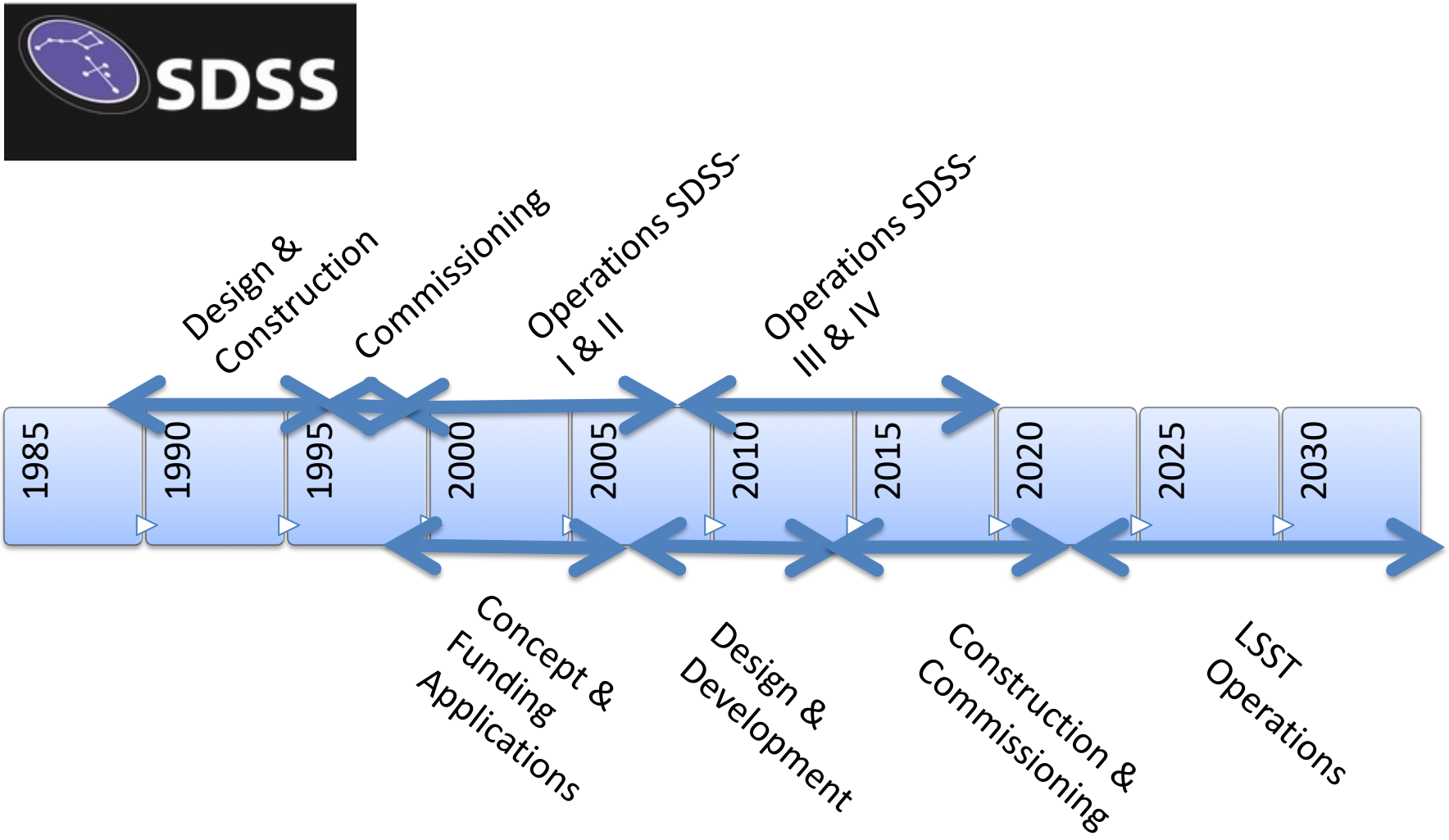
- Survey from 2022-2032
- 15 TB data per night
- 1+ Billion dollars
- Data open to partners
- Open source software



https://news.slac.stanford.edu/sites/default/files/images/image/lsst_h_0.jpg

LSST telescope, Chile

Project Timelines



UP ABOVE THE WORLD SO HIGH

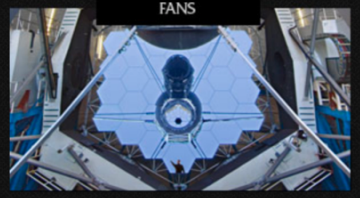
Exploring the local and distant Universe from the largest and most scientifically productive telescopes on Earth.

DONORS



Visit our Donors section to read the latest news, view upcoming events, get updates on the latest campaigns, or to get involved!

FANS



Are you a fan of Keck Observatory? Come see what's new, signup to get updates from Keck Nation, or order your Keck Wear!

SCIENTISTS



The Scientists area provides you with resources, including accessing the observer login area, telescope schedule, and more.

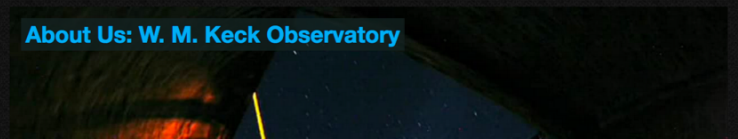


LATEST NEWS

SCIENCE NEWS

February 13, 2017

Over 100 New Exoplanet Candidates Discovered With W.



W. M. KECK OBSERVATORY

UCO acts a managing partner
of the Keck Observatory on Mauna Kea, Hawaii.

Learn More



The University of California Observatories (UCO) is a multi-campus research unit. We operate the Lick Observatory, the technical labs at UC Santa Cruz and UCLA, and we are a managing partner of the Keck Observatory in Hawaii. We are the center for the UC participation in the Thirty-Meter Telescope (TMT) project.

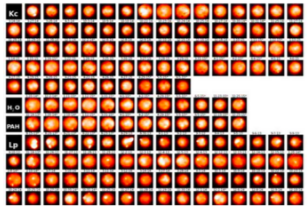
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Information for Observers: Call for Proposals

Featured News



Gillian Wilson appointed Interim Deputy Director

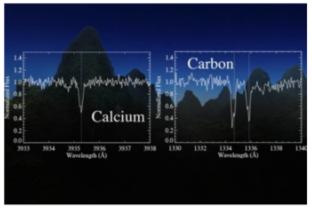


Tracking volcanos on Jupiter's moon Io

OCTOBER 24, 2016



Follow-Up Of Kepler Data Yields More Than 100 Confirmed



Planet-Devouring Star Reveals Possible Limestone Crumbs



KOA STATUS

Archive is running normally.

KOA LINKS

- User Interface
- FAQ
- Filename translator
- Reducing Keck Data
- HIRES News
- HIRES Data Description
- HIRES Keywords
- HIRES Page
- NIRC2 News
- NIRC2 Data Description
- NIRC2 Keywords
- NIRC2 Page
- NIRSPEC News
- NIRSPEC Data Description
- NIRSPEC Keywords
- NIRSPEC Page
- LRIS Keywords
- MOSFIRE Keywords
- DEIMOS Keywords
- ESI Keywords
- OSIRIS Keywords
- NIRC Keywords
- LWS Keywords
- Help Desk

NEW! First Release of KODIAQ Data, and Public Release of LWS Data Now Available: Data Access

Funded by NASA, the *Keck Observatory Archive (KOA)* is a joint development between the W. M. Keck Observatory (WMKO) located in Waimea, Hawaii and the NASA Exoplanet Science Institute (NExScI) located in Pasadena, California. Currently, KOA archives data taken with HIRES, NIRSPEC, NIRC2, LRIS, KI (Keck Interferometer), MOSFIRE, DEIMOS, ESI, OSIRIS, NIRC, and LWS.

The process by which data are archived is as follows:

- Locate all FITS files taken in the previous 24 hour period
- Determine the validity and data integrity of each file
- Add meta-keywords to the FITS header
- Archive the metadata (native + meta-keywords) for each FITS header
- Archive the data for each FITS file
- Archive ancillary data associated with each night's data
  Ancillary data include Keck nightly plots of weather and image quality trends and, when available, all-sky images and photometric data

The physical location of the archive is at NExScI. Both metadata and raw FITS files are transferred via the internet from WMKO to NExScI, and are available through a User Interface within hours of the end of observations. Both the data files and the metadata are subject to a proprietary period policy. During the proprietary period, program PIs will be able to access their data via a user login/password protected site. The data are released to the public upon expiration of the proprietary period.

Septemb
Public re
July 06,
Public re
May 15,
First rele
Decemb
Public re
Septemb
LWS data
July 2, 2
Public re
April 1, 2
Public re
March 0
more new

18,469

MOSFIRE Home Page

MOSFIRE
Home Page
NEWS
Temps
Troubleshooting
Index

Keck
Instrument Ready?
Archive (KOA)
Observer Home Page
Tel Schedule
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Keck Home
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ToO Policies

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MK Forecast
CFHT SkyProbe
MK Seeing
All Sky Cam
CFHT Cloudcam
Summit Cams
KeckCam

Planning Tools
AO Guide Stars
Finding Charts
IRSA Finder Charts
Observing Planning Tool
Atmospheric Trans
Twilight, Moonrise, etc.
Offset/PA Tool

Contact Us
Contact Info
Post-Observing
Comment Form

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WWW Keck Web Site

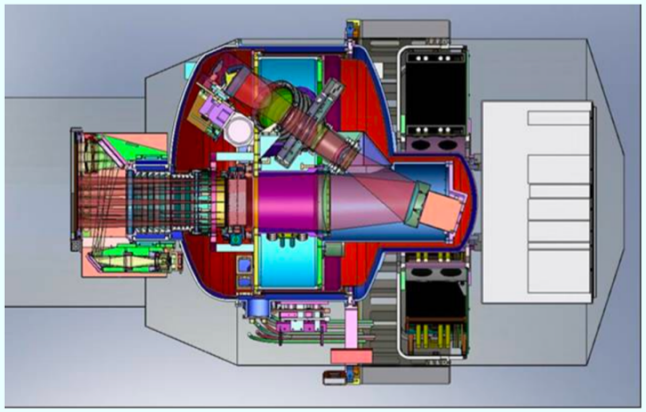
Instrument Master: **Marc Kassis**
Secondary Instrument Master: **Jim Lyke**
Email Contact: MOSFIRE Support

Pre-Observing	Observing	Pos
Follow this link for information about pre-observing activities: proposal preparation, mask design and submission, pre-run activities, etc.	Follow this link for information about your observing run: instrument and telescope setups, scripts, software, procedures, etc.	Follow this link for information about your post-observing a
Trouble Shooting	**Technical Pages**	
Trouble Shooting pages and links.	Portal to the technical pages: for the initiated only!	A listing of the instrument pages.

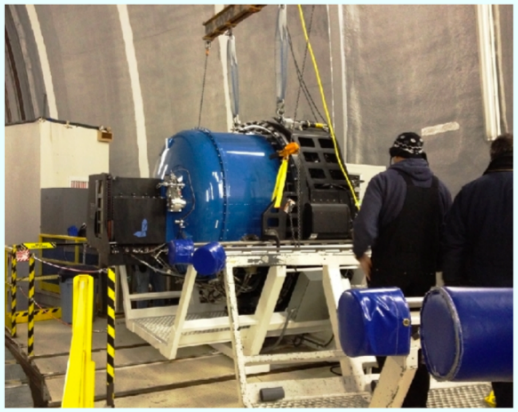
MOSFIRE is a NIR multi-object spectrograph in operation at the Cassegrain focus of the Keck I telescope since 2012. MOSFIRE was designed and built by a collaboration among UCLA, CIT, and UCSC under the direction of co-Prin
Notable features of MOSFIRE include:

- 6.1' x 6.1' field of view
- Teledyne H2RG HgCdTe detector with 2K x 2K pixels
- Up to 46 slits using a unique cryogenic robotic slit mask system that is reconfigurable electronically in under 5 minutes

Co-Principal Investigators:	Ian McLean (UCLA) Chuck Steidel (CIT)	MOSFIRE References
Optics Lead	Harland Epps (UCSC)	
Instrumentation Lead	Keith Matthews (CIT)	

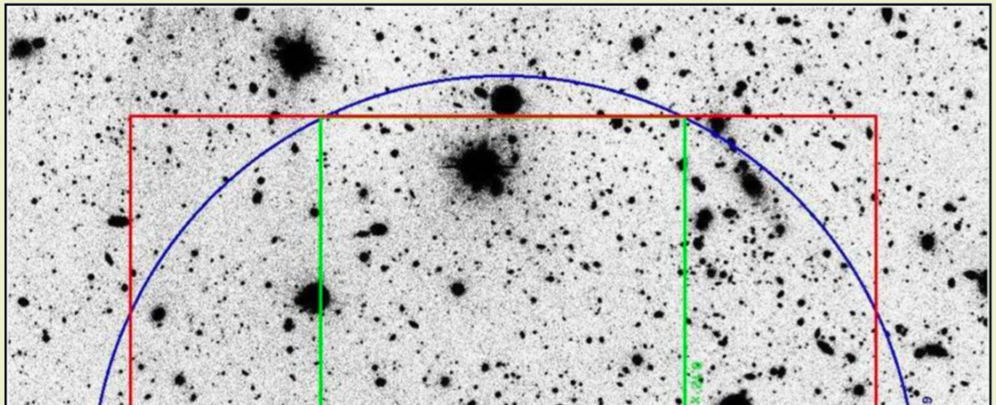


MOSFIRE optical layout.



MOSFIRE landing at the K1 Deck.

Keck newsletter article



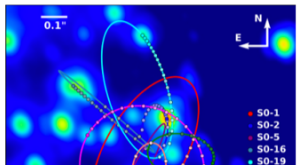


Members outside ULCA Royce Hall.

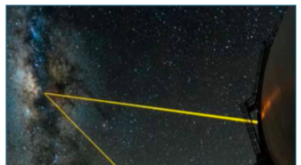
WELCOME TO THE GALACTIC CENTER GROUP AT UCLA

The Galactic Center Group (GCG) is dedicated to researching the innermost regions of the Milky Way at the highest angular resolution possible in order to understand the formation and evolution of galaxies and their central supermassive black holes.

SCIENCE



TECHNOLOGY



EDUCATION & OUTREACH



Astronomy Infrastructure: Durability

- Collaboration and openness
- International coordination
- Long term value of data
- Agreed standards
  - Units of measurement
  - Coordinate systems
  - Data structures
- Shared resources
  - Missions, instruments
  - Data Archives
  - Tools and technologies



The Library of Congress
Operating a hand drill at Vultee-Nashville, woman is working on a "Vengeance" dive bomber, Tennessee (LOC) Palmer, Alfred T., photographer. 1943 Feb. Title from FSA or OWI agency caption. Transfer from U.S. Office of War Information, 1944.

Astronomy Infrastructure: Fragility

- Investment in data stewardship
  - Varies by mission
  - Varies by type of research
    - Space-based vs ground based
    - Large missions vs observing proposals
    - Shared instruments vs custom instruments
- Access to data varies
  - Public archives
  - Local websites
  - Derived data



National Library of Scotland View from north end of gap Photograph of wrecked piers after collapse of part of the first Tay Bridge digital.nls.uk/74585062

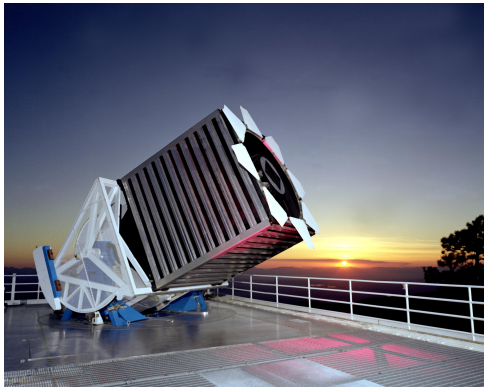
Astronomy Infrastructure: Fragility

- Curation of tools and technologies
  - Shared investments
  - Open source
  - Proprietary tools
  - Local tools, scripts
- International coordination
  - Investment in new instruments, missions
  - Investment in archives, infrastructure

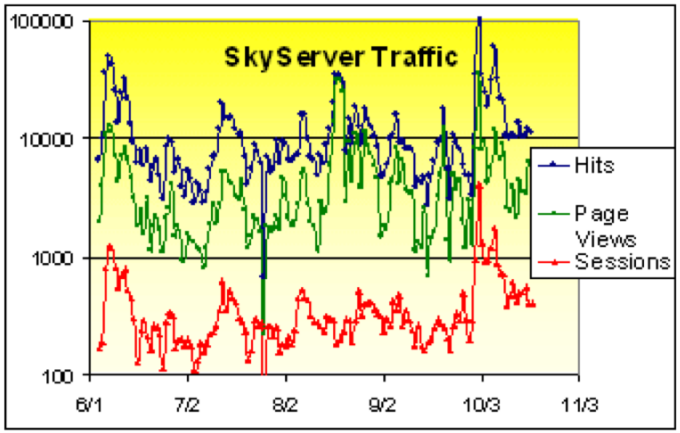


National Library of Scotland View from north end of gap Photograph of wrecked piers after collapse of part of the first Tay Bridge digital.nls.uk/74585062

Conclusions



- Infrastructures are fragile
- Durability is an accomplishment
- Visible infrastructure
  - Instruments
  - Institutions
- Invisible infrastructure
  - Data, metadata, provenance…
  - Information work





Telescope for the Sloan Digital Sky Survey, Apache Point, New Mexico

LSST All Hands Meeting, August 2014, Arizona State University. Arrow to Peter Darch

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Irene Pasquetto



Bernie Randles



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