Modern Astrophysics

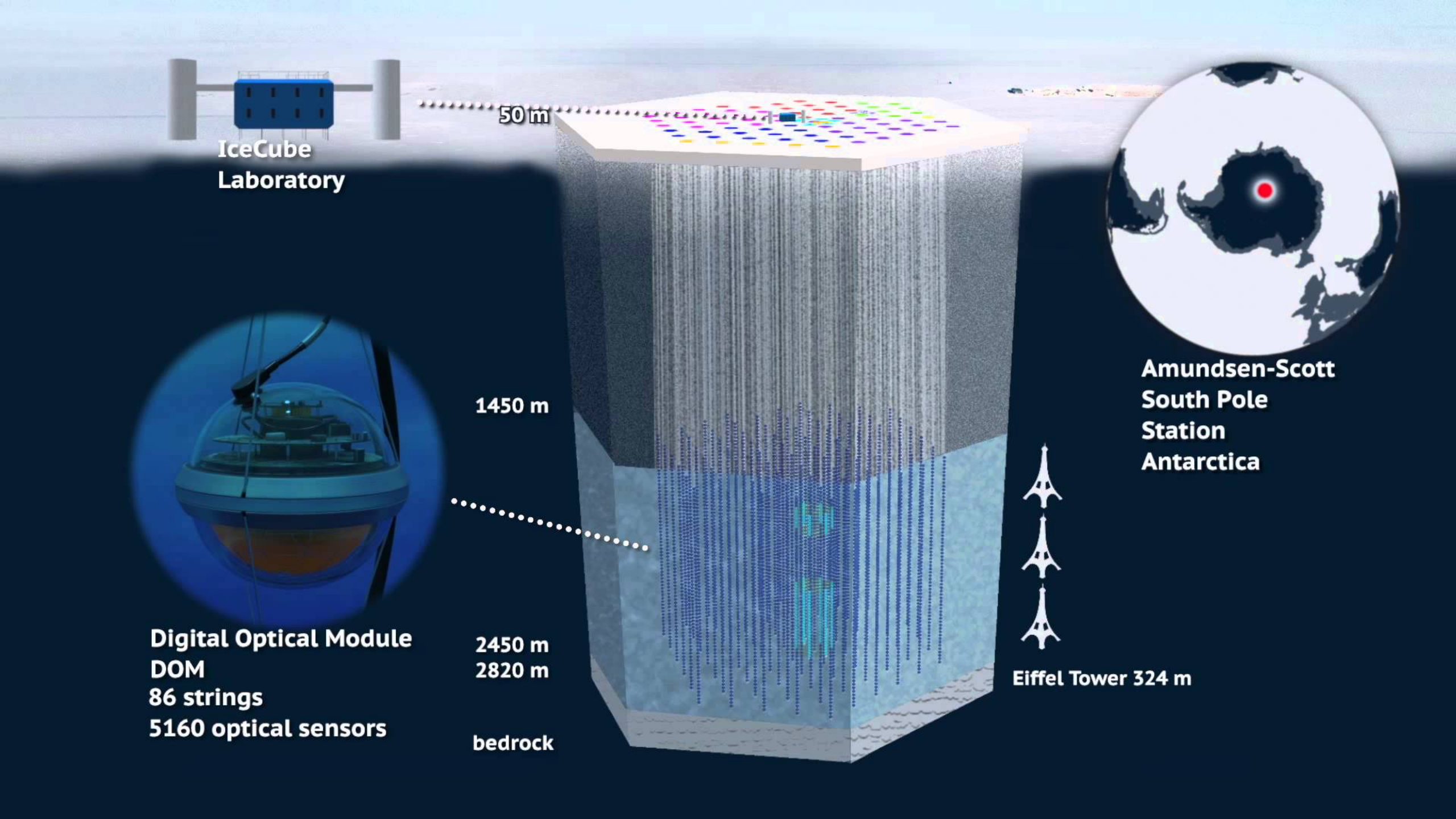
PHY7097 | Fall 2019

Imre Bartos

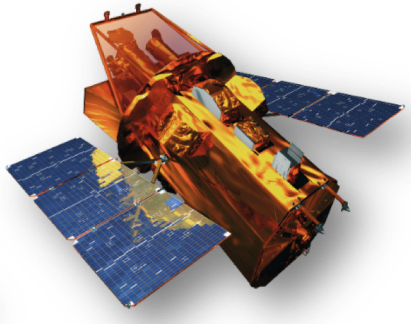
Department of Physics

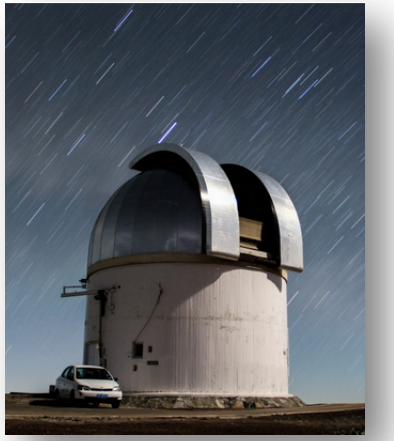
University of Florida

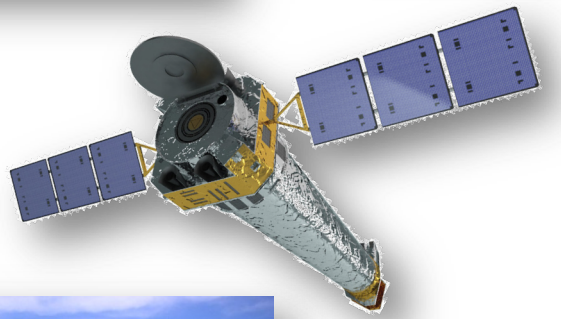
Background

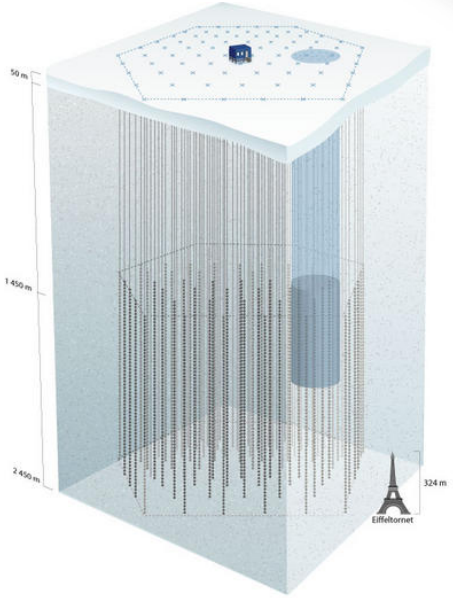

IceCube
Laboratory
50 m
1450 m
2450 m
2820 m
bedrock
Digital Optical Module
DOM
86 strings
5160 optical sensors
Eiffel Tower 324 m
Amundsen-Scott
South Pole
Station
Antarctica

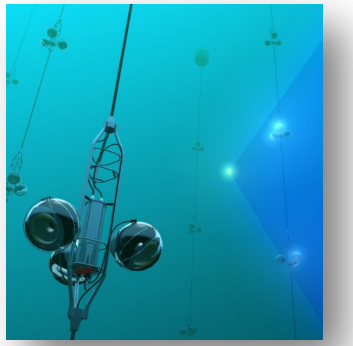
Multimessenger astrophysics











http://www.phys.ufl.edu/faculty/bartos.shtml

Astrophysics

Astronomy and Astrophysics Decadal Survey 2010

https://en.wikipedia.org/wiki/Astronomy_and_Astrophysics_Decadal_Survey

Cosmic Dawn:
Searching for the First Stars, Galaxies, and Black Holes

New Worlds:
Seeking Nearby, Habitable Planets

Physics of the Universe:
Understanding Scientific Principles

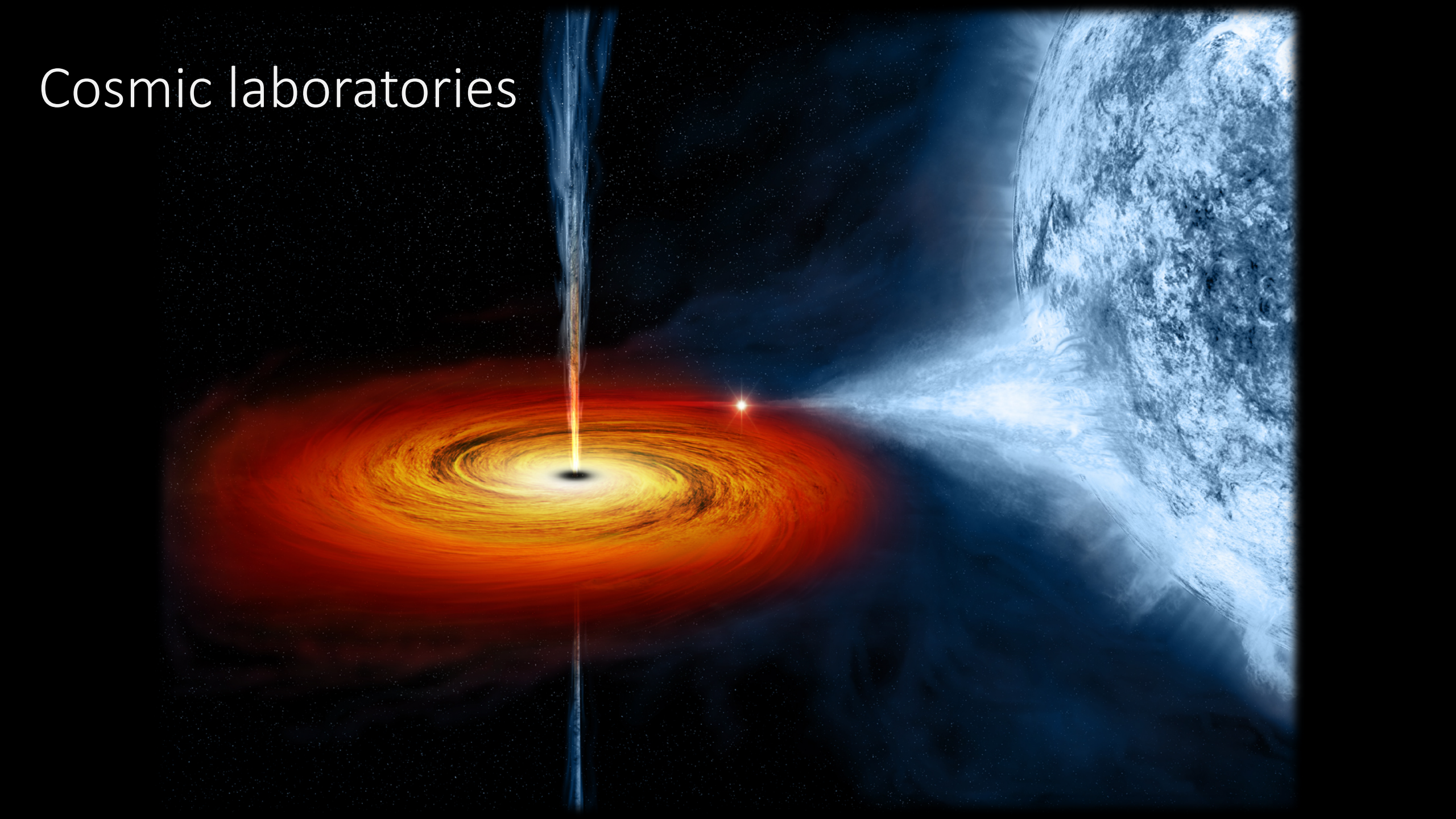
TABLE ES.5 Space: Recommended Activities—Large-Scale (Priority Order)

Recommendation	Launch Date[b]	Science	Technical Risk[c]	Appraisal of Costs[a]		Cross-Reference in Chapter 7
				Total (U.S. Share)	U.S. Share, 2012-2021	
1. WFIRST —NASA/DOE collaboration	2020	Dark energy, exoplanets, and infrared survey-science	Medium low	$1.6B	$1.6B	Page 205
2. Augmentation to Explorer Program	Ongoing	Enable rapid response to science opportunities; augments current plan by 2 Medium-scale Explorer (MIDEX) missions, 2 Small Explorer (SMEX) missions, and 4 Missions of Opportunity (MoOs)	Low	$463M	$463M	Page 208
3. LISA —Requires ESA partnership[d]	2025	Open low-frequency gravitational-wave window for detection of black-hole mergers and compact binaries and precision tests of general relativity	Medium[e]	$2.4B ($1.5B)	$852M	Page 209
4. IXO —Partnership with ESA and JAXA[d]	2020s	Black-hole accretion and neutron-star physics, matter/energy life cycles, and stellar astrophysics	Medium high	$5.0B ($3.1B)	$200M	Page 213

TABLE ES.3 Ground: Recommended Activities—Large Scale (Priority Order)

Recommendation[b]	Science	Technical Risk[c]	Appraisal of Costs Through Construction[a] (U.S. Federal Share, 2012-2021)	Appraisal of Annual Operations Costs[d] (U.S. Federal Share)	Cross-Reference in Chapter 7
1. LSST —Science late 2010s —NSF/DOE	Dark energy, dark matter, time-variable phenomena, supernovae, Kuiper belt and near-Earth objects	Medium low	$465M ($421M)	$42M ($28M)	Page 223
2. Mid-Scale Innovations Program —Science mid-to-late 2010s	Broad science; peer-reviewed program for projects that fall between the NSF MRI and MREFC limits	N/A	$93M to $200M		Page 225
3. GSMT —Science mid-2020s —Immediate partner choice for ~25% federal share	Studies of the earliest galaxies and galactic evolution; detection and characterization of planetary systems	Medium to medium high	$1.1B to $1.4B ($257M to $350M)	$36M to $55M ($9M to $14M)	Page 228

Cosmic laboratories



Schedule

Week 1.	**Stars' end.** -	Possible ends of stellar life cycles, including white dwarfs, core collapse, and disintegration.
Week 2.	**Neutron Stars.** -	What neutron stars are, how they are formed, and their properties. Neutron star equation of state.
Week 3.	**Black holes** -	What black holes are, how they are formed, and their properties. Schwarzschild radius, spin, charge, mass, hair.
Week 4.	**Supernovae** -	Types, explosion mechanisms, emission properties, remnants.
Week 5.	**Accretion** -	Gas accretion onto black holes or neutron stars. Origin of accreted gas, geometry (Bondi/disk).
Week 6.	**Astrophysical particle acceleration** -	Relativistic outflows, their formation, and how they accelerate particles. Cosmic rays, gamma rays, high-energy neutrinos.
Week 7.	**Gamma-ray bursts** -	History, properties, populations.
Week 8.	**Afterglow emission** -	Origin, properties.
Week 9.	**High-energy observatories** -	Most important observatories that detect cosmic rays, gamma rays, and high-energy neutrinos; observation principles.
Week 10.	**The high-energy Universe** -	What has been observed, observational techniques, open questions. Cosmic rays, gamma rays, high-energy neutrinos.
Week 11.	**Gravitational waves** -	Definition, detection, astrophysical production.
Week 12.	**Compact binaries** -	Formation channels, properties, eccentricity.
Week 13.	**Searching for gravitational waves** -	Search techniques, challenges.
Week 14.	**Kilonovae** -	...and other emission from compact binary mergers.
Week 15.	**Cosmology with gravitational waves**	
Week 16.	**Multimessenger astrophysics and open questions**	

Compact objects and their formation

Week 1.	**Stars' end**. -	Possible ends of stellar life cycles, including white dwarfs, core collapse, and disintegration.
Week 2.	**Neutron Stars. -**	What neutron stars are, how they are formed, and their properties. Neutron star equation of state.
Week 3.	**Black holes -**	What black holes are, how they are formed, and their properties. Schwarzschild radius, spin, charge, mass, hair.
Week 4.	**Supernovae -**	Types, explosion mechanisms, emission properties, remnants.

High-energy emission and its observation

Week 5.	**Accretion -**	Gas accretion onto black holes or neutron stars. Origin of accreted gas, geometry (Bondi/disk).
Week 6.	**Astrophysical particle acceleration -**	Relativistic outflows, their formation, and how they accelerate particles. Cosmic rays, gamma rays, high-energy neutrinos.
Week 7.	**Gamma-ray bursts -**	History, properties, populations.
Week 8.	**Afterglow emission -**	Origin, properties.
Week 9.	**High-energy observatories -**	Most important observatories that detect cosmic rays, gamma rays, and
Week 10.	**The high-energy Universe -**	What has been observed, observational techniques, open questions. Cosmic rays, gamma rays, high-energy neutrinos.

Gravitational waves – sources, detection, use

Week 11.	**Gravitational waves -**	Definition, detection, astrophysical production.
Week 12.	**Compact binaries -**	Formation channels, properties, eccentricity.
Week 13.	**Searching for gravitational waves -**	Search techniques, challenges.
Week 15.	**Cosmology with gravitational waves**	

Multimessenger astrophysics and questions at the frontier

Week 14. **Kilonovae** - ...and other emission from compact binary mergers.

Week 16. **Multimessenger astrophysics and open questions**

Logistics

- Course website: http://phys.ufl.edu/courses/phz7097/spring20/
- Main course requirement: classroom participation, homework and final presentation
- Office hours: Friday 1pm-2pm, or please email and we'll set up a time
- Textbook: none (optional)