How Fermilab and UChicago changed the course of cosmology and brought particle physics and cosmology together and what's next!

Fermilab 50th Symposium

PRC 31 October 2017

Michael S. Turner and Brian Nord

Quark Soup

Da tter

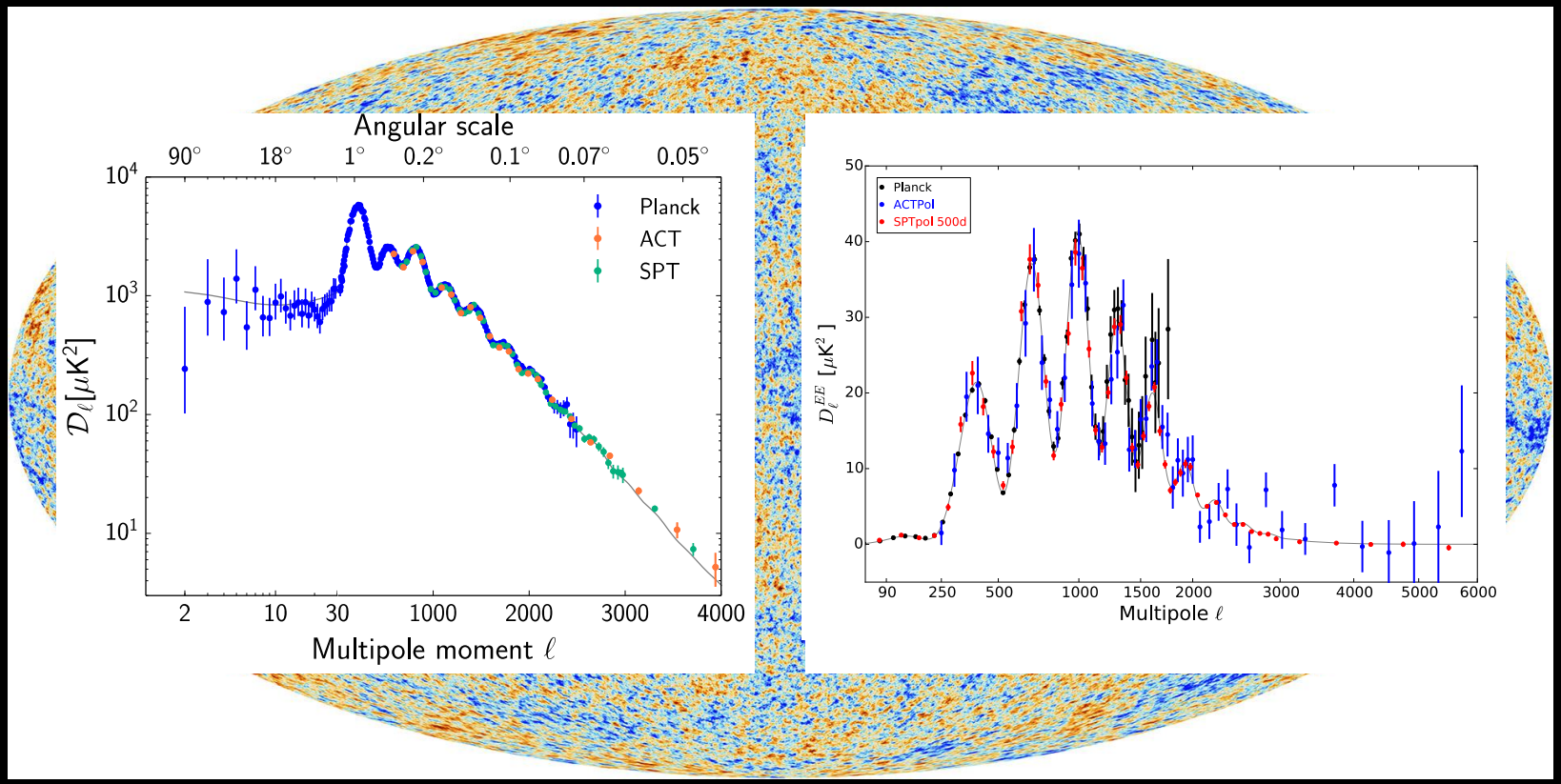
… and thousands of physicists
and astronomers working together
to figure it all out

Inflation

Dark Energy

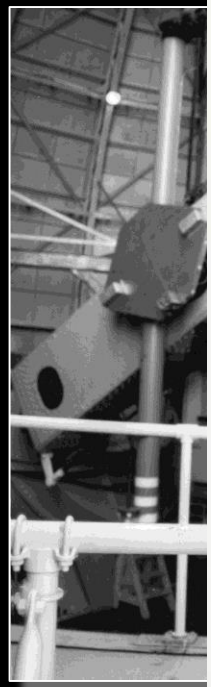
Baryogenesis

CDM



6 numbers describe the Universe from
the big bang and quantum fluctuations until today

circa 1970: The search for two numbers (H_0 and q_0)

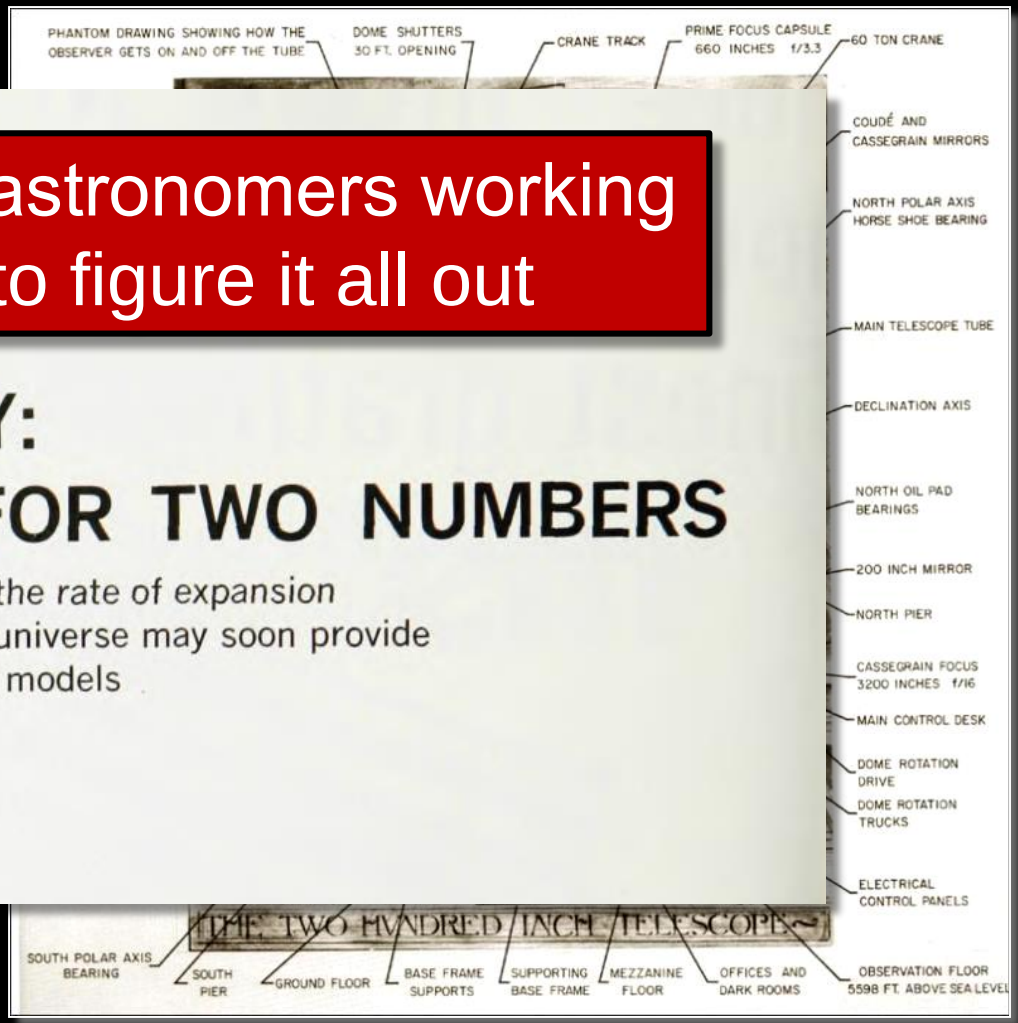


… and tens of astronomers working (together) to figure it all out

COSMOLOGY:
A SEARCH FOR TWO NUMBERS

Precision measurements of the rate of expansion and the deceleration of the universe may soon provide a major test of cosmological models

ALLAN R. SANDAGE



Allan Sandage, Hubble's "student"

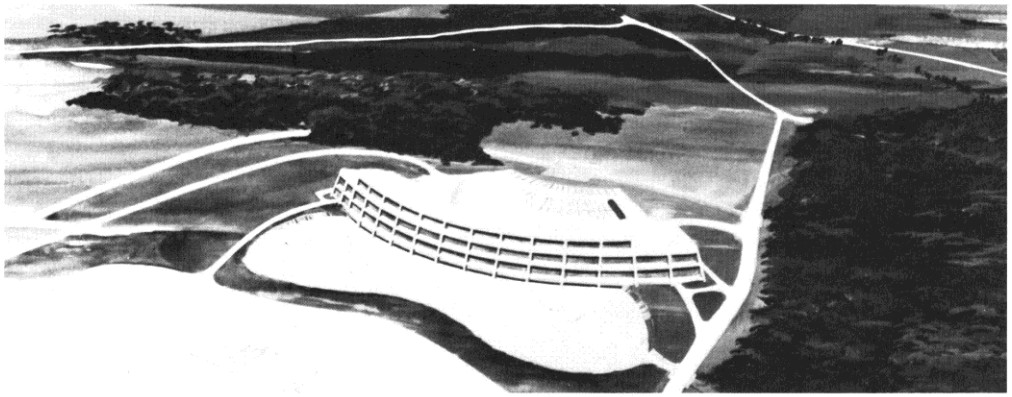
1979: Fermilab proposes for STScI

FERMINEWS

Fermi National Accelerator Laboratory

Operated by Universities Research Association Inc.
Under Contract with the United States Department of Energy

Vol. 2, No. 39 October 4, 1979



Space Telescope Science Institute (artist's concept) looking west from Central Laboratory.

URA BEGINS PREPARING PROPOSAL FOR SPACE TELESCOPE SCIENCE INSTITUTE

Universities Research Association has made the decision to prepare a proposal for locating a Space Telescope Science Institute at Fermilab.

URA is preparing the proposal in cooperation with astronomers from the University of Chicago, in association with astronomers from the University of Wisconsin, University of Illinois, University of Texas and Beloit College.

Work on the proposal has already begun, said James C. Matheson, URA vice president. When completed later this year, the proposal will be submitted to the National Aeronautics and Space Administration, the agency that will

course, we will be competing with other consortia for the institute. However, we are convinced Fermilab offers significant advantages over other sites."

Among these he listed:

A uniquely attractive site with respect to scientific ambience, technical support, central location and proximity to a strong university astronomical community.

The capacity to call on the full potential of URA's existing management strength and broad geographical membership representation.

NASA is expected to formally request proposals for the Space Telescope Science

1981: Schramm & Lederman hike in the Dolomites

1982: Lederman dares Deputy NASA Administrator Hans Mark to fund an outrageous proposal – and he does

Astrophysics Seminars (1983)

James Hartle - January 7
Quantum Dynamics of the Early Universe

George Fuller - January 14
Evolution of Supermassive Stars

Richard Kron - January 21
Evolution of Distant Galaxies and Quasars

Don York - January 28
Measuring Big Bang Artifacts: D, ^{3}He, ^{4}He

Joan Centrella - February 14
The Large-Scale Structure of the Universe

Katherine Freese - February 11
Cosmological Constraints on Neutrino Masses

Robert Kirshner - February 18
The Texture of the Universe

Marc Davis - February 25
The Structure of the Universe

Peter Meyer - March 4
A Space Shuttle Experiment

Joe Taylor - April 1
Pulsars

John Ellis - April 8
Supersymmetry, Cosmology and Inflation

David T. Wilkinson - April 15
Anisotropies in the Background Radiation

Jon Arons - April 29
The Fast Pulsar

Pat Palmer - May 6
Interstellar Molecules

Eugene Loh - May 13
The Fly's Eye

David S. P. Dearborn - May 20
Astronomy of the Incas

Gary Steigman - May 27
Messengers from the Big Bang

Fall 1983: Turner and Kolb arrive

ASTROPHYSICIST REVEALS RECIPE FOR QUARK SOUP

by Jane Green

Understanding the origin of the universe is a goal as old as humanity and an on-going challenge to scientists. Research has led to the general belief that the universe began with a "big bang." Our current understanding of this history of the universe will be examined by Michael S. Turner in the next Lecture Series program. His talk, "Big Bang Cosmology: From Quark Soup to the Expanding Universe," will be presented on Friday, March 16, at 8 p.m. in Ramsey Auditorium.

Michael Turner (right) and Megatest Engineer Robert J. Miller check a proposed site for the SSC.

Michael Turner received his doctorate from Stanford University and serves as co-leader of the Astrophysics Group at Fermilab. In addition, he is Associate Professor of Astronomy, Astrophysics and Physics and the University of Chicago.

In his talk, Turner will discuss what happened in the earliest moments of the universe. He will describe the "big bang" model and an account of the history of the universe from about a millionth of a second after "the bang." Then the universe was a hot, formless soup of quarks and other elementary particles--very different from today, some fifteen billion years later. Further, Turner will explain discoveries made at accelerator laboratories which are beginning to provide cosmologists with the knowledge to unravel what happened in the first millionth of a second after the "big bang."

Admission to the lecture is $2, $1 for senior citizens, and tickets are available at the Information Desk in the atrium of Wilson Hall, ext. 3353. Phone reservations are held for five days.

GET READY FOR SPRING CLEAN UP

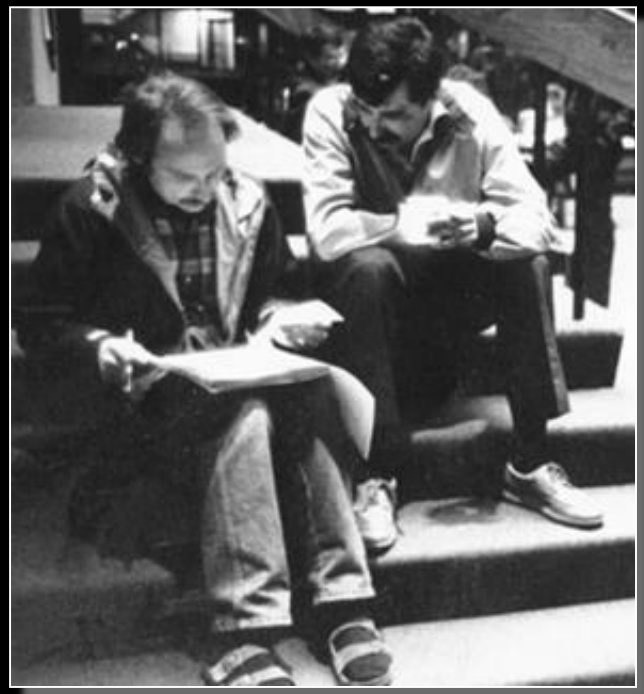
Bob Kraft, Head of Roads and Grounds, asks everyone to get ready for a site-wide Spring Clean Up April 2-6. Any trash or excess materials that are set outside will be picked up and hauled away. These dates were chosen so that the Laboratory will look good for the Saver Dedication on April 28.

The following guidelines apply: separate recoverable copper, aluminum, and steel from the trash; place refuse in piles outside of buildings; materials from Accelerator and Experimental Areas should be monitored by a local Radiation Safety Officer. Other areas concerned about radiation should call Chuck Zonick, ext. 3458. For disposal of liquids, chemicals, and toxic substances, call Bob Allen, ext. 4498; to place materials in storage, call Fred Assell, ext. 3577; for questions or haul-away of trash or metals, call Bob Kraft, ext. 3303.

Tevatron achieves 512 GeV

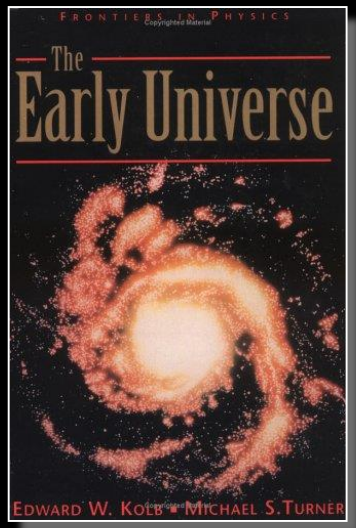
1980s: Go Go junk bond days of early Universe cosmology

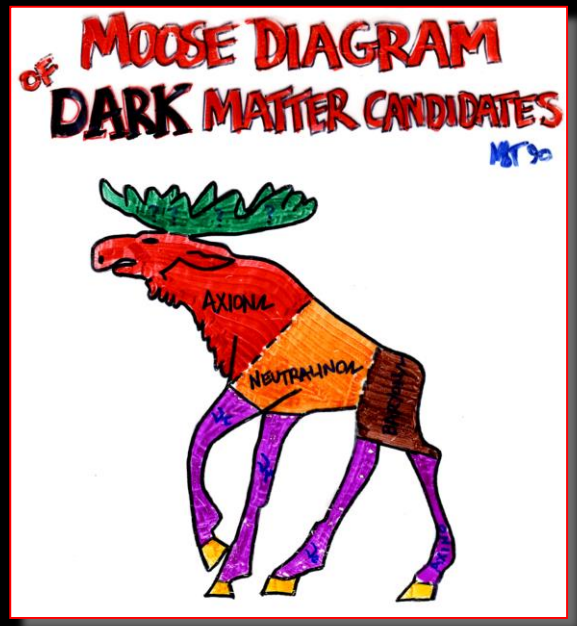
Chicago at the center, Fermilab = the mother church



Turner & Kolb
Inner Space/Outer Space
May 1984

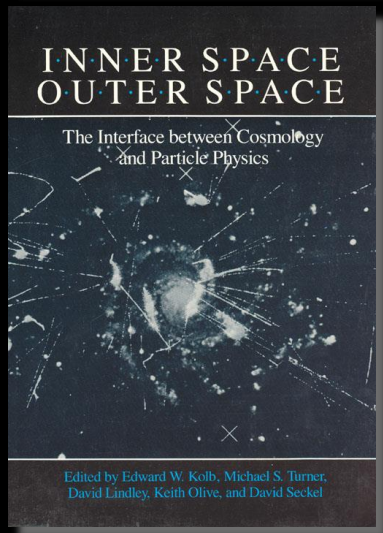
Explore the consequences of bold ideas in particle physics about unification to the early Universe





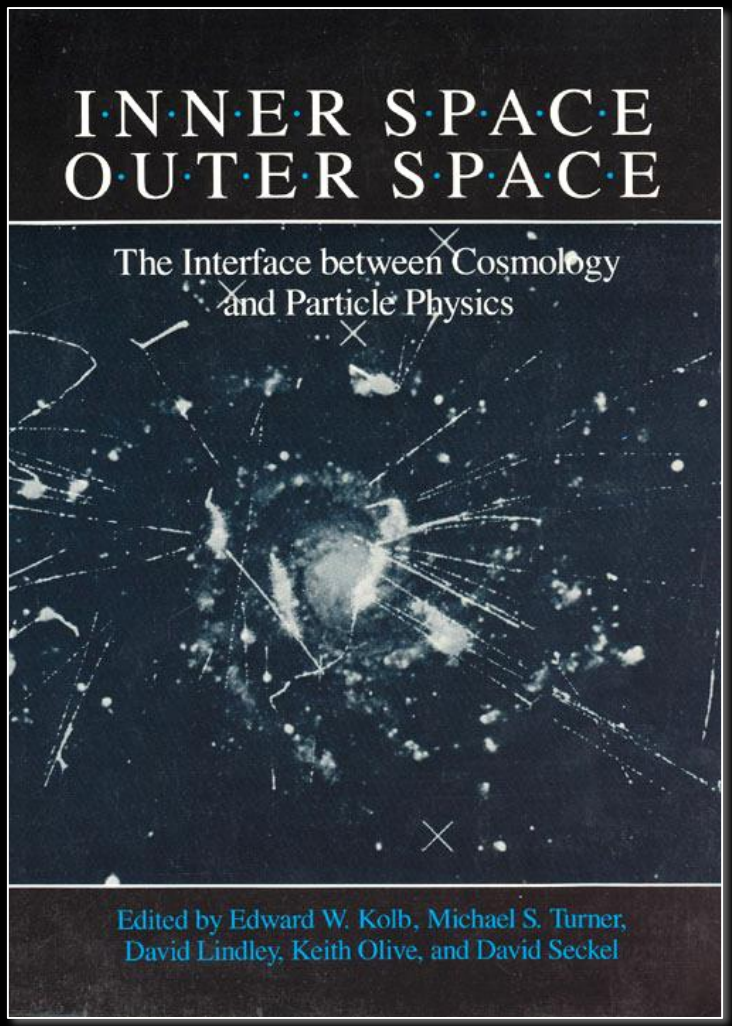
Beginnings of ΛCDM

InnerSpace/OuterSpace at Fermilab (1984)



Inflation,
Monopoles,
CDM rising,
HDM falling,
CMB limits only,
LSS: CfA1,
Cosmic Strings,
Axions,
SUSY dark matter
still to come

UChicago doesn't publish conference proceedings, …




MICHAEL TURNER
CO-CHAIRMAN
INNER SPACE/OUTER SPACE
THE OFFICIAL CONFERENCE OF
THE 1984 SUMMER OLYMPICS

1990s: Sloan Digital Sky Survey

UChicago, Fermilab, JHU, Princeton, UWash

SDSS transformed astrophysics: birth of survey science!

High-Impact Astronomical Observatories

Juan P. Madrid[1] and F. Duccio Macchetto[2]

[1] *McMaster University, Hamilton, Canada*

[2] *Space Telescope Science Institute, 3700 San Martin Dr., Baltimore, MD 21218*

Abstract

We derive the ranking of the astronomical observatories with the highest impact in astronomy based on the citation analysis of papers published in 2006. We also present a description of the methodology we use to derive this ranking. The current ranking is lead by the Sloan Digital Sky Survey, followed by Swift and the Hubble Space Telescope.

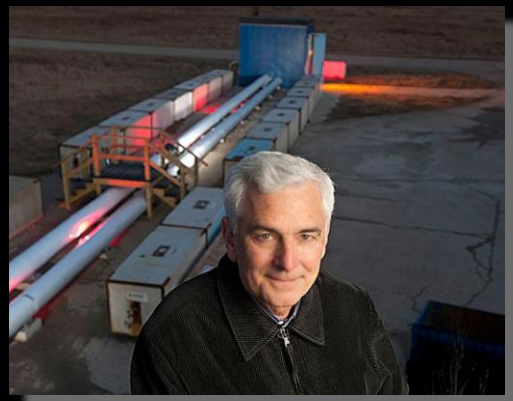
TABLE 1

HIGH-IMPACT OBSERVATORIES

Rank	Facility	Citations	Participation
1	SDSS	1892	14.3%
2	Swift	1523	11.5%
3	HST	1078	8.2%
4	ESO	813	6.1%
5	Keck	572	4.3%
6	CFHT	521	3.9%
7	Spitzer	469	3.5%
8	Chandra	381	2.9%
9	Boomerang	376	2.8%
10	HESS	297	2.2%

Fermilab Center for Particle Astrophysics

8 December 2004

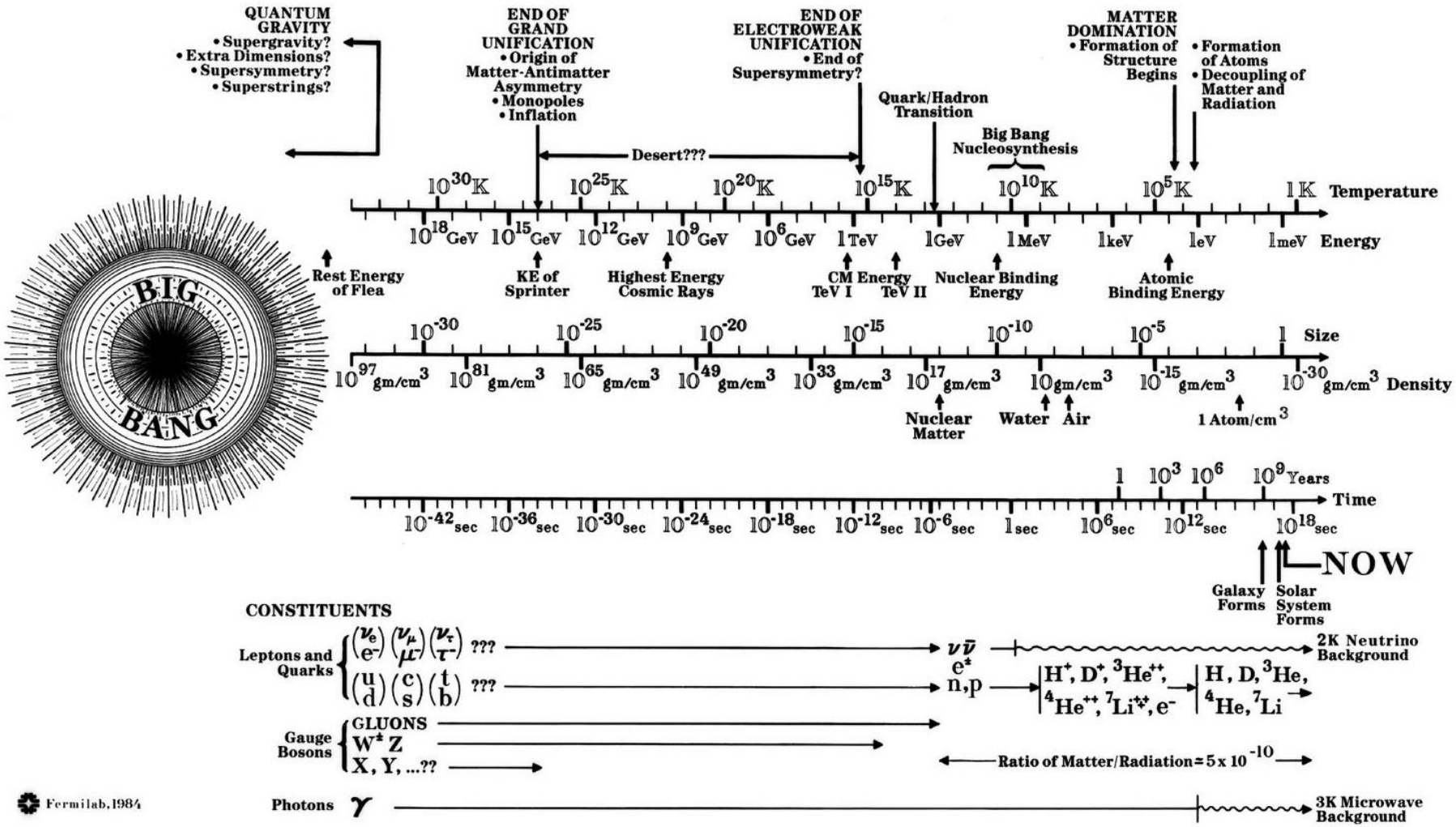


Craig Hogan arrives as 1st Director 2008

FCPA Portfolio

- Theoretical Astrophysics (1983)
- Survey Science
  - SDSS (1990s) → DES (2005s) → DESI (2015) → LSST (2020s) → ??
- Pierre Auger Observatory (1995)
- Dark Matter
  - CDMS (2004), COUPP/PICO (2006), DAMIC (2010s), DarkSide, ADMX (2016), LZ (2016), ??
- Cosmic Microwave Background
  - QUIET (2007), SPT 3G (2015), CMB-S4 (2020s)
- Holometer (2010s)

What does success look like for a Fermilab?



Angela Gonzales, ID#11 and Michael Turner

29 May 2008

US Particle Physics:
Scientific Opportunities
A Strategic Plan
for the Next Ten Years

Report of the Particle
Physics Project
Prioritization Panel