Creative thought in the era of Big Science

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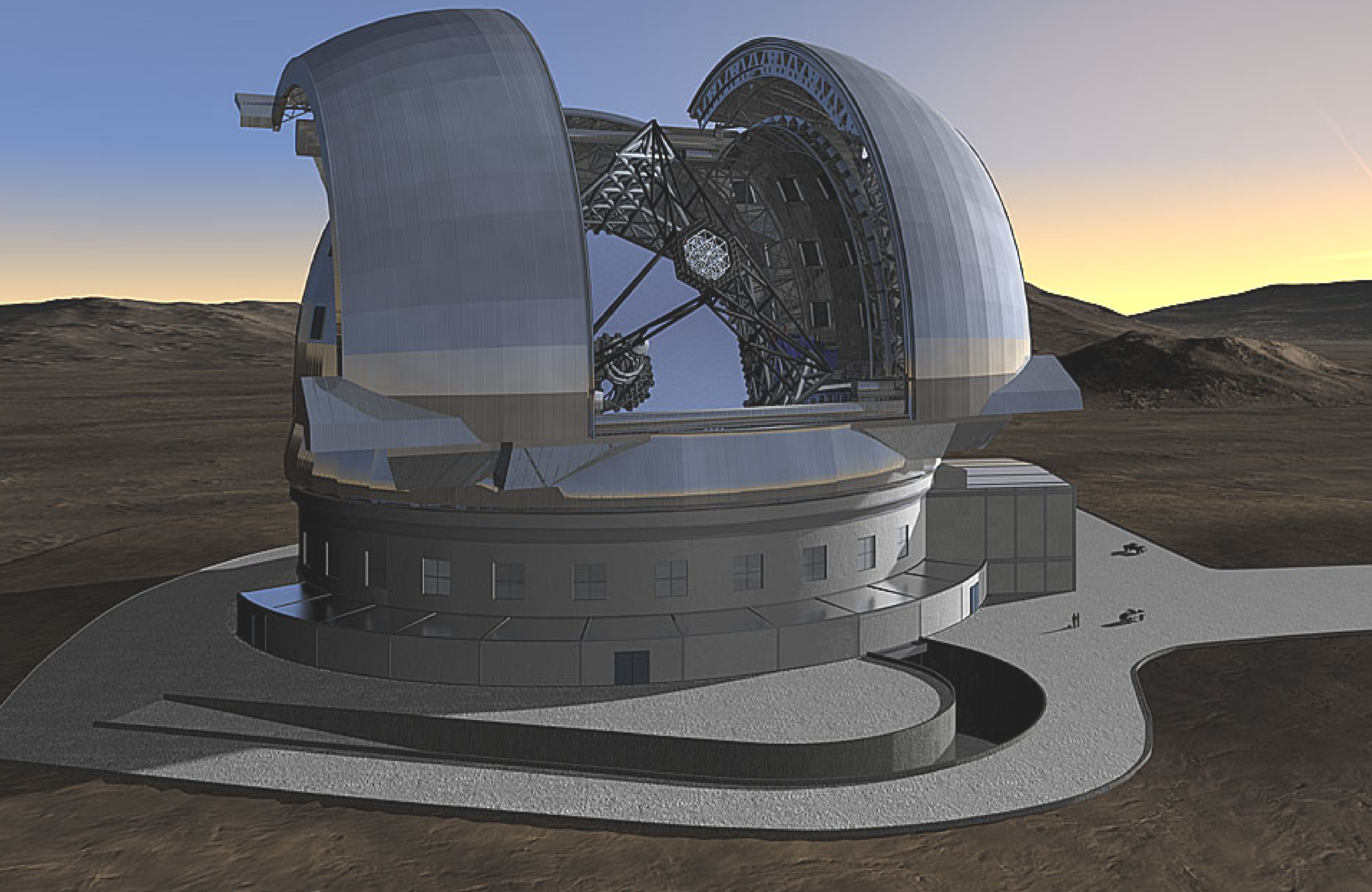
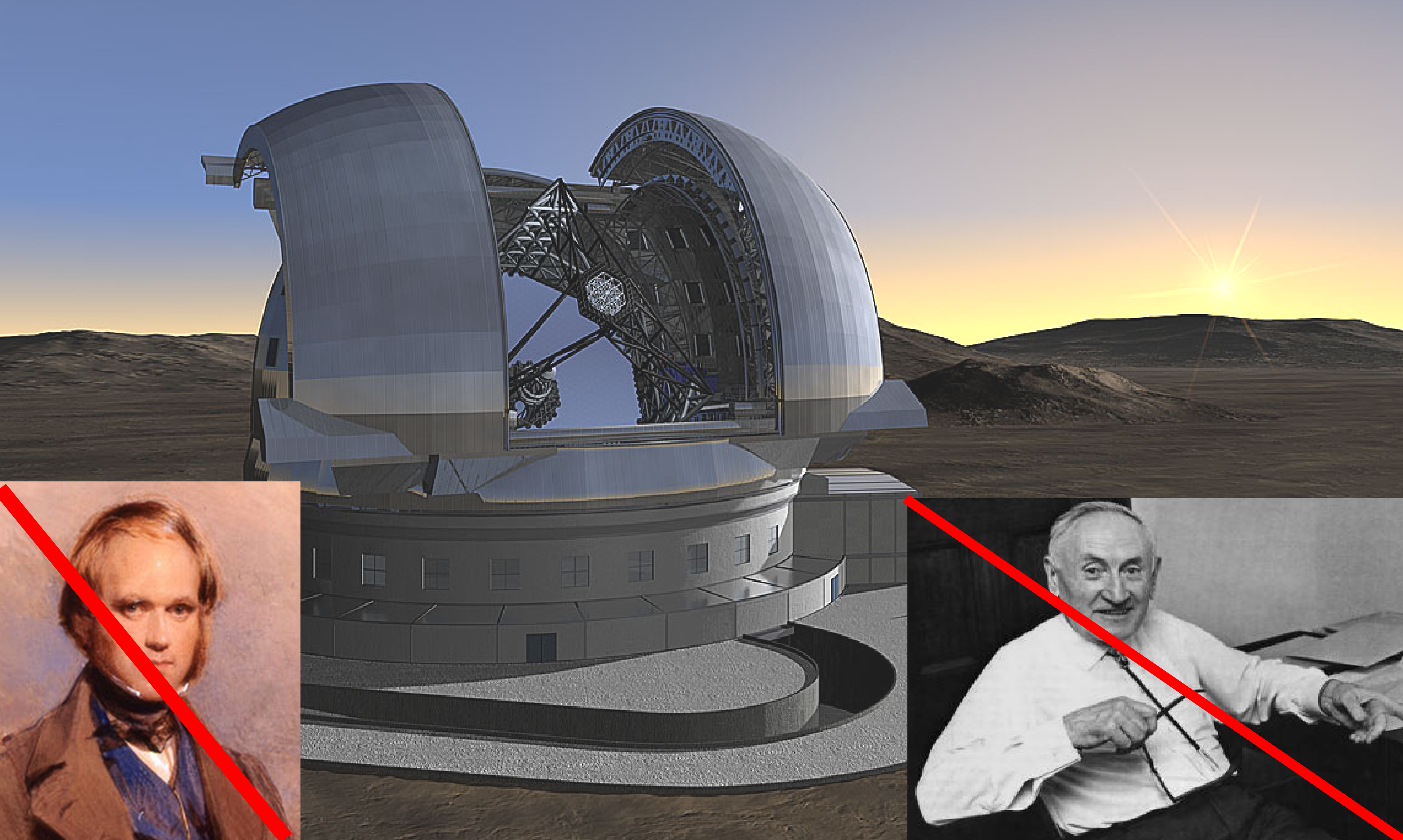
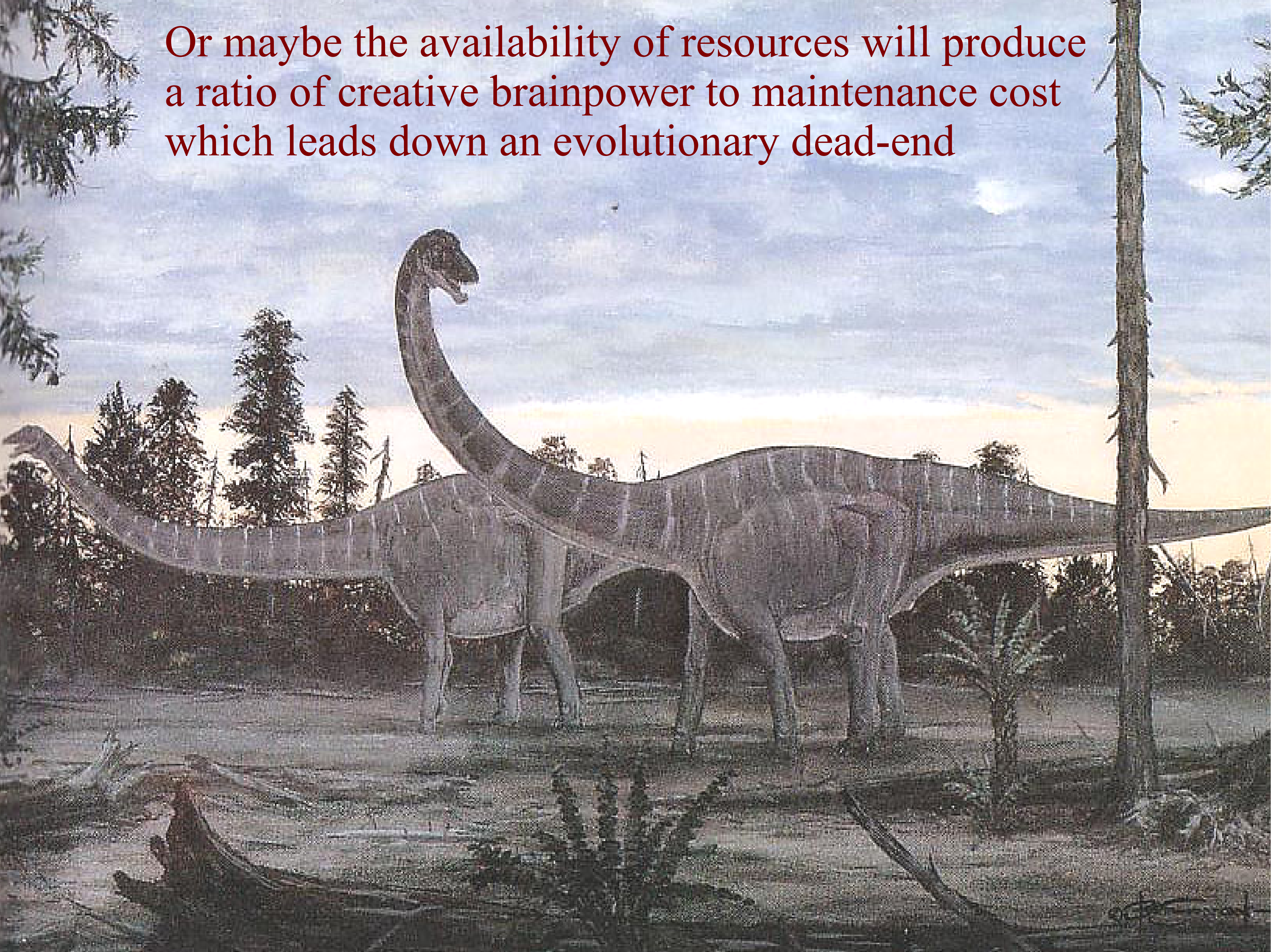


In the XIXth and (most of) the XXth centuries scientific progress often came from brilliant individuals formulating and testing new hypotheses from data accumulated using relatively modest means

In the Big Science era such prima donna science is outmoded.
Progress follows from large-scale, team-based implementation of forefront technology according to pre-agreed Road Maps.



Or maybe the availability of resources will produce a ratio of creative brainpower to maintenance cost which leads down an evolutionary dead-end



Fundamentalist physics: why Dark Energy is bad for Astronomy

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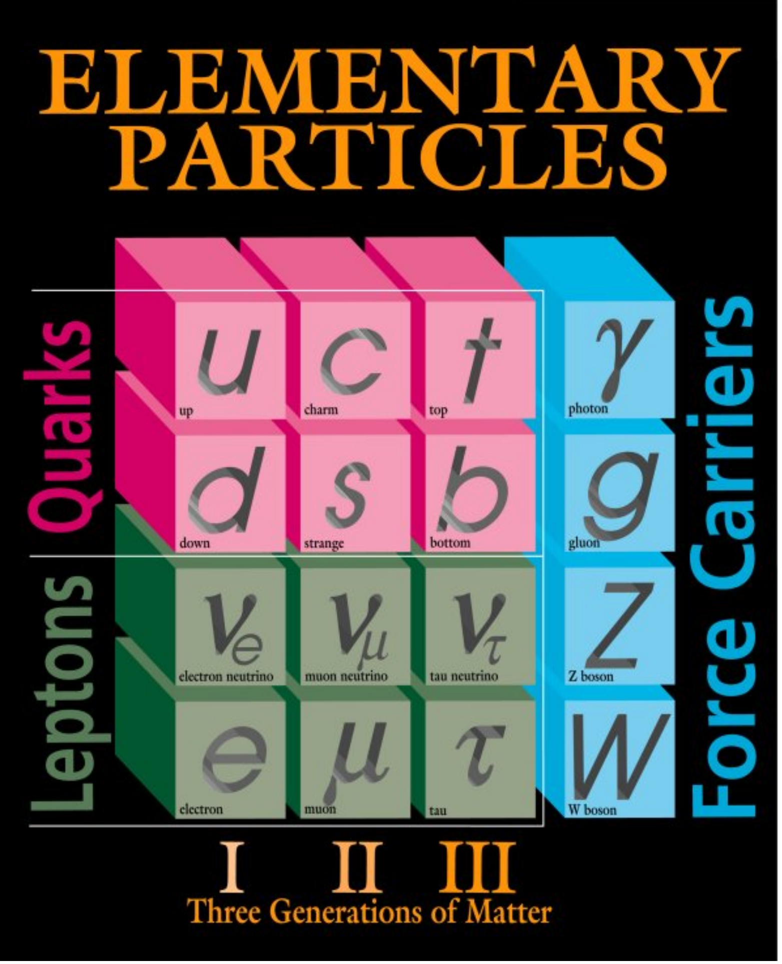
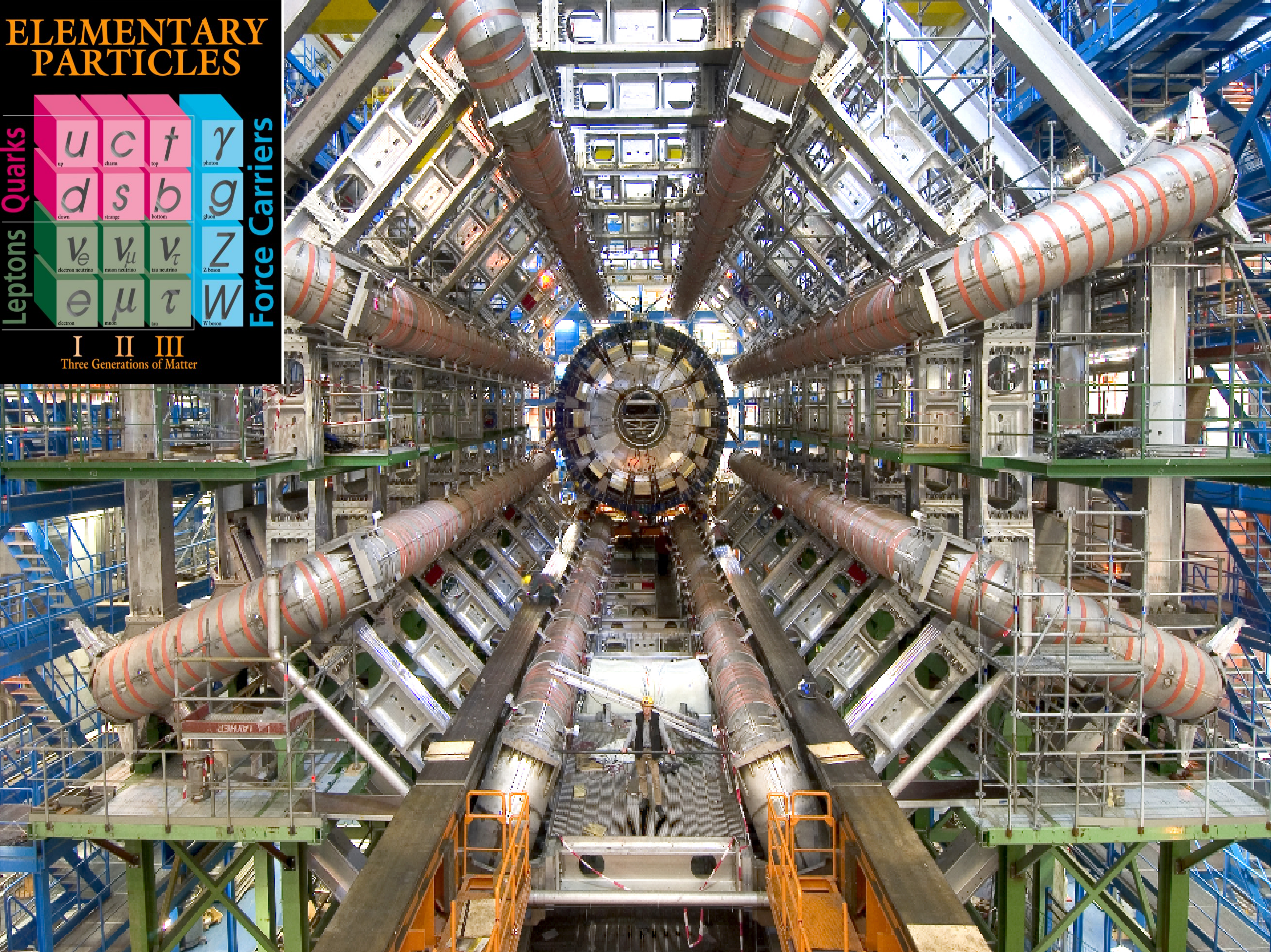
Astronomers carry out observations to explore the diverse processes and objects which populate our Universe. High-energy physicists carry out experiments to approach the Fundamental Theory underlying space, time and matter. Dark Energy is a unique link between them, reflecting deep aspects of the Fundamental Theory, yet apparently accessible *only* through astronomical observation. Large sections of the two communities have therefore converged in support of astronomical projects to constrain Dark Energy. In this essay I argue that this convergence can be damaging for astronomy. The two communities have different methodologies and different scientific cultures. By uncritically adopting the values of an alien system, astronomers risk undermining the foundations of their own current success and endangering the future vitality of their field. Dark Energy is undeniably an interesting problem to attack through astronomical observation, but it is one of many and not necessarily the one where significant progress is most likely to follow a major investment of resources.

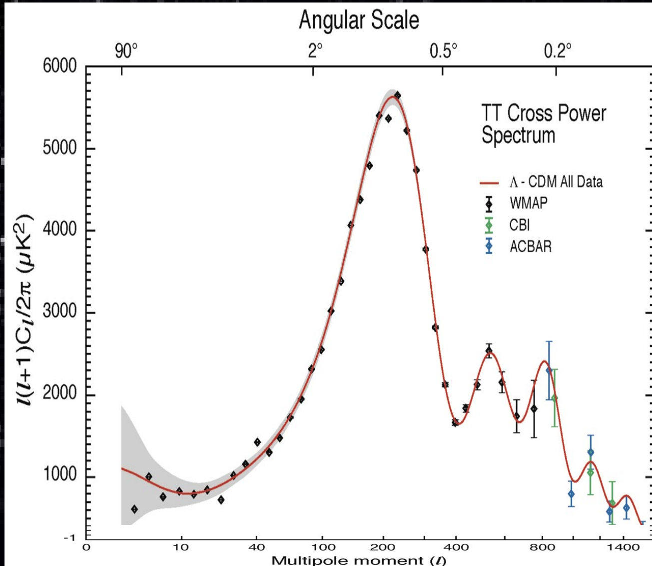


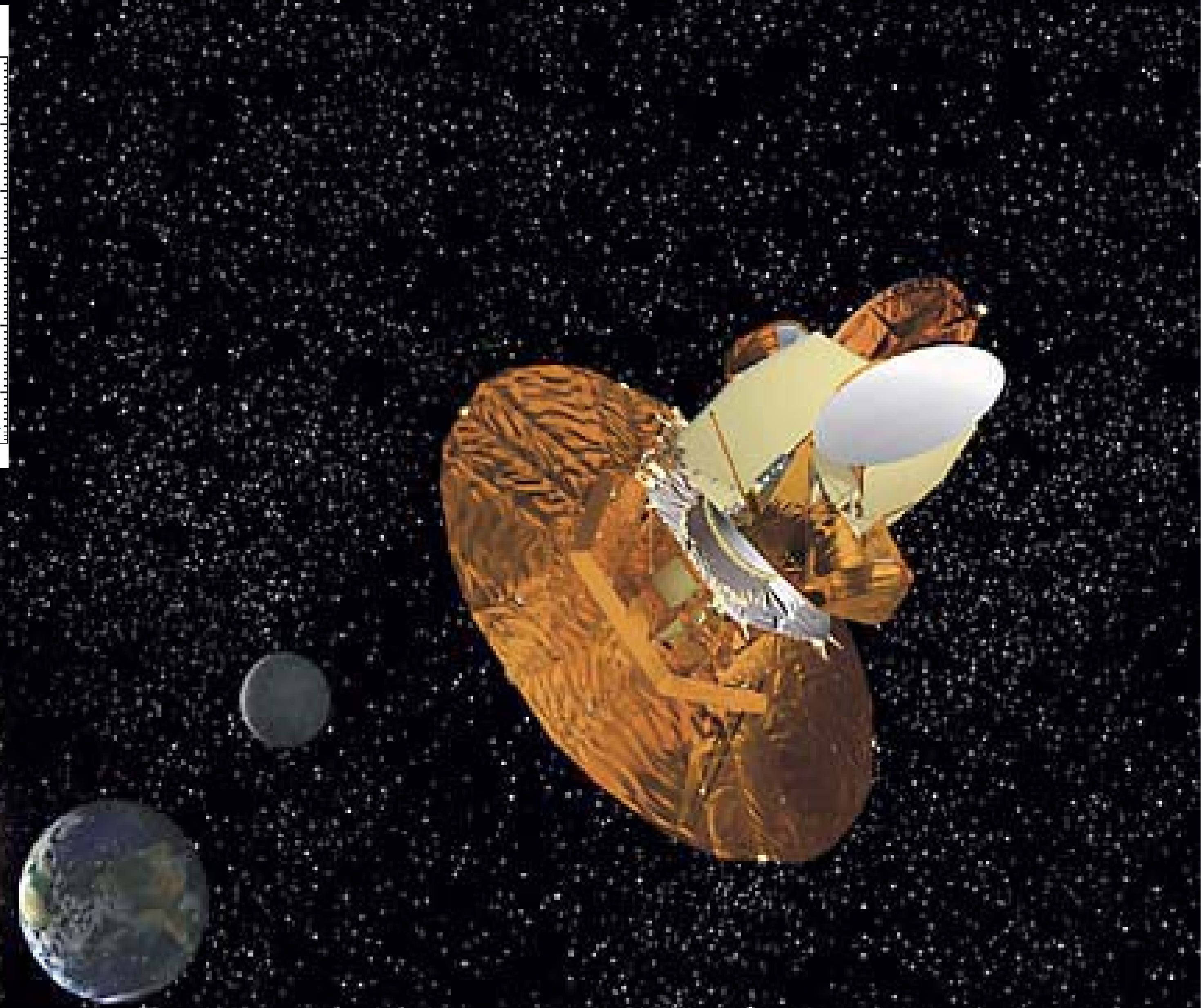
Fundamentalist physics

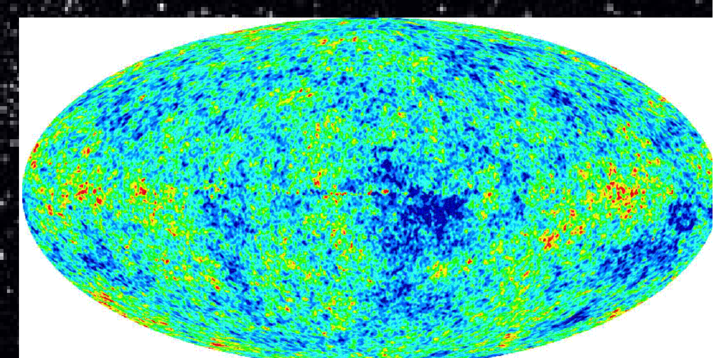
or..

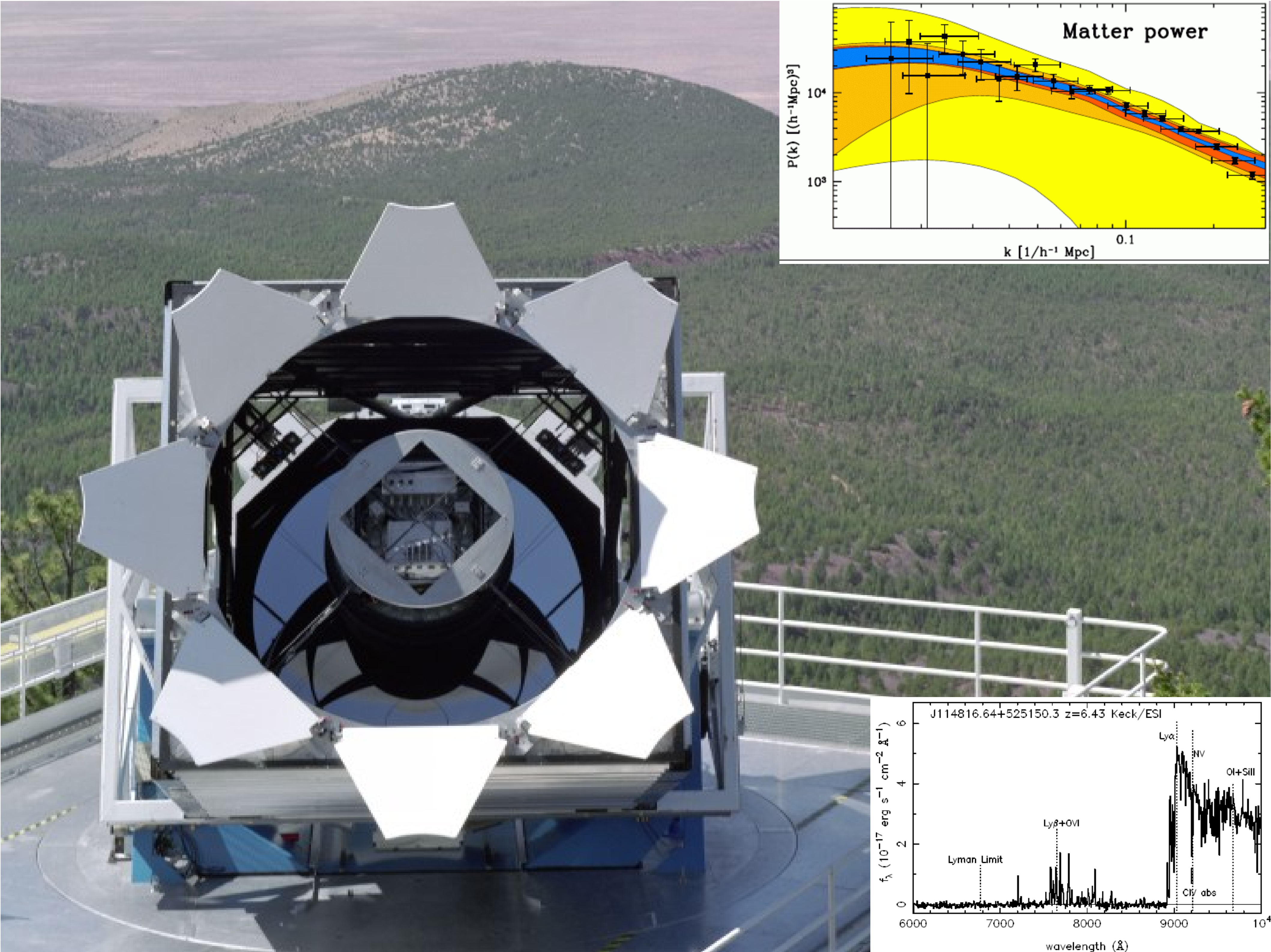
Butterfly collecting


ELEMENTARY PARTICLES
Quarks
Leptons
Force Carriers
u
up
c
charm
t
top
γ
photon
d
down
s
strange
b
bottom
g
gluon
ν_e
electron neutrino
ν_μ
muon neutrino
ν_τ
tau neutrino
Z
Z boson
e
electron
μ
muon
τ
tau
W
W boson
I II III
Three Generations of Matter


Angular Scale
90°
2°
0.5°
0.2°
6000
5000
4000
3000
2000
1000
$l(l+1)C_l/2\pi$ (μK^2)
TT Cross Power Spectrum
Λ - CDM All Data
WMAP
CBI
ACBAR
0
10
40
100
200
400
800
1400
Multipole moment (l)



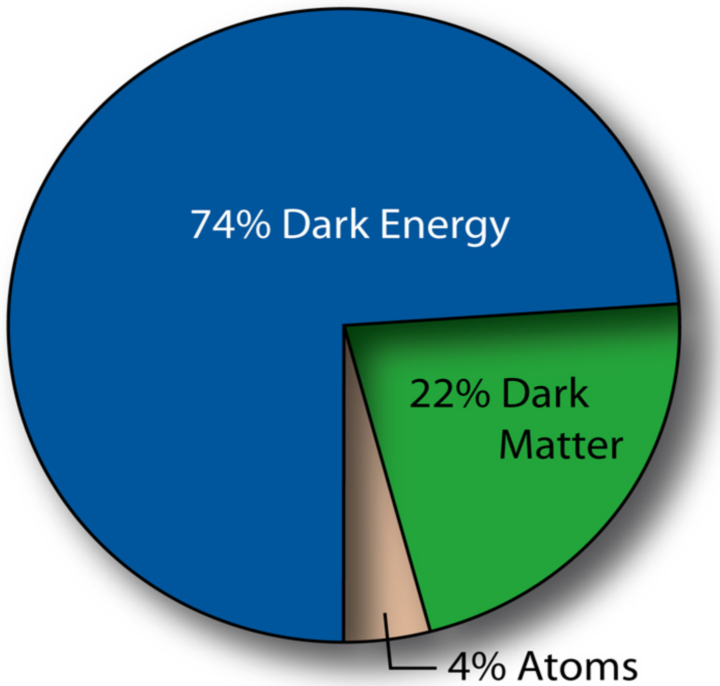



Matter power
P(k) [(h⁻¹Mpc)³]
10⁴
10³
0.1
k [1/h⁻¹ Mpc]
J114816.64+525150.3 z=6.43 Keck/ESI
Lyα
NV
OI+SiII
Lyβ+OVI
Lyman Limit
CIV abs
f_λ (10⁻¹⁷ erg s⁻¹ cm⁻² Å⁻¹)
0
2
4
6
6000
7000
8000
9000
10⁴
wavelength (Å)

Observatories vs Experiments

Observatories	Experiments
(HST or SDSS)	(ATLAS or WMAP)
Designed for general tasks	Optimised for a single task
Serves a diverse community	Serves a coherent community
Program built through proposals	Program set at design
Many teams of all sizes	A single team
Many results unanticipated	Main results “planned”
Synthetic/astrophysics skills	Analytic/data-process. skills
Public support as a facility	Public impact through results

Dark Matter and Dark Energy



Both are unknown

DM affects all aspects of cosmic structure formation and may be detectable directly, indirectly, or at accelerators

DE (apparently) affects only a(t) and g(t), both of which are already known to fairly high precision → can be investigated only by "precision" astronomy

Dangers of Dark Energy

- Inappropriate risk assessment
  - --- likelihood of an “uninteresting” result
  - --- likelihood of limitation by unanticipated systematics
- Overly narrow investment strategy
  - --- optimisation for the primary “experimental” goal
    - → elimination of ability to address other issues
- Undermining astronomy's cultural foundation
  - --- Division of labour/ role and power of “teams”
  - --- Allocation of scientific credit
  - --- Attraction for creative young scientists
  - --- Attraction for the general public

Other dangers of Big Science

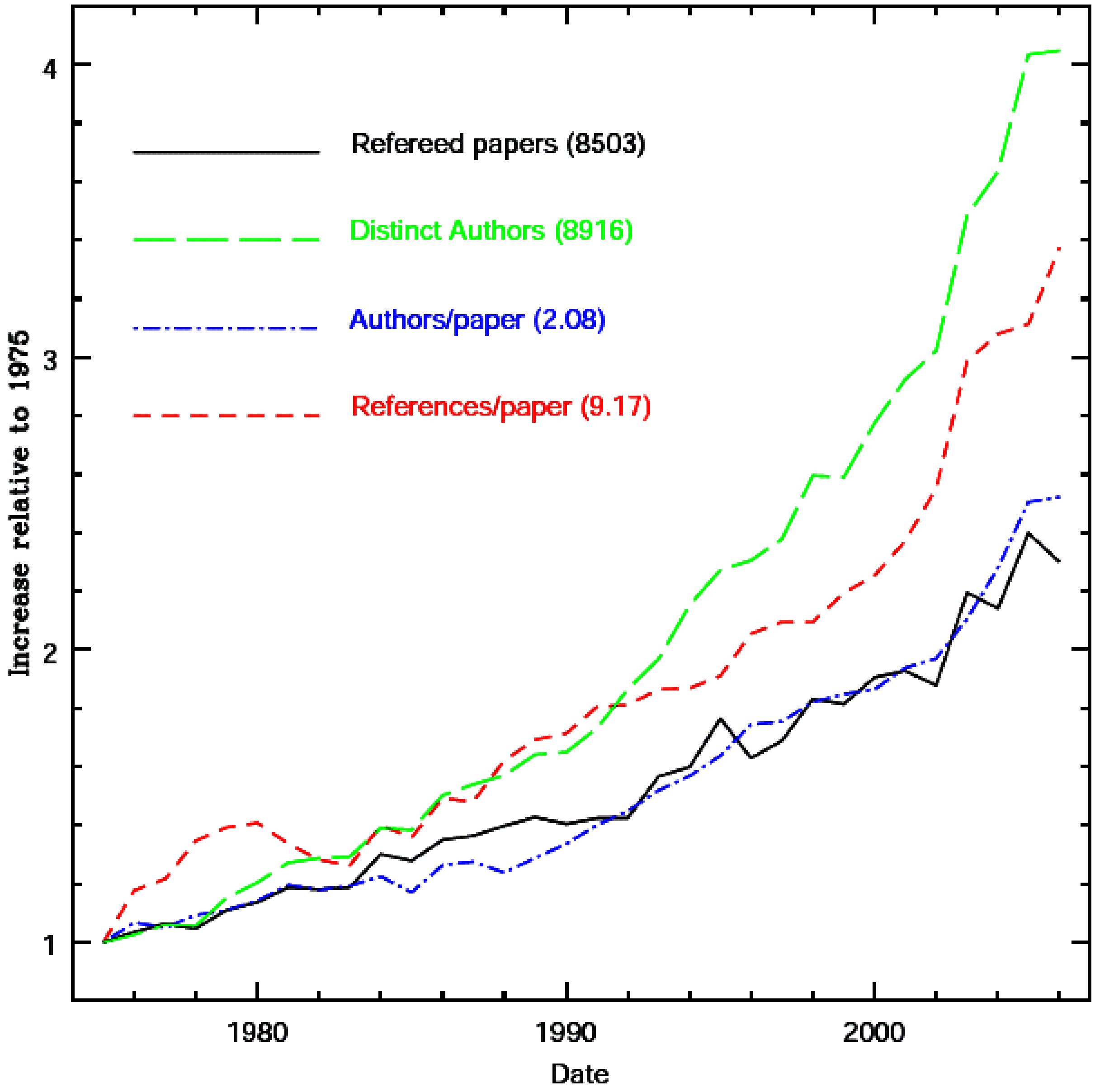
- Major emphasis on management
  --- coordination of delivery from subprojects
  --- maintenance of motivation/schedule throughout project
  --- marketing to peers and resource providers

- High value placed on loyalty to project/project members
  --- required to maintain "momentum" and motivation

- Corporate assessment structure
  --- outsiders cannot judge individual's creative contributions
  --- dependence on references from line managers
  --- production of citation "clubs"

- Long timescales
  --- young scientists cannot obtain the independent scientific results needed to promote their own careers
  --- advancement often based on functional contributions

Cultural shifts in astronomy publishing since 1975



August 2003

The MOST-CITED Researchers In: Space Science

Previous | 2006 Field Menu | 2005 Field Menu | 2004 Field Menu | 2003 Field Menu

Ranked by total citations. (10 of 621)

RANK	SCIENTIST	PAPERS	CITATIONS	CITATIONS PER PAPER
1	FILIPPENKO, AV	212	8,484	40.02
2	FABIAN, AC	268	6,953	25.94
3	FRENK, CS	104	6,866	66.02
4	WHITE, SDM	100	6,850	68.5
5	ELLIS, RS	113	6,138	54.32
6	KOUVELIOTOU, C	190	5,228	27.52
7	HUCHRA, JP	124	5,207	41.99
8	SCHNEIDER, DP	173	5,088	29.41
9	VANPARADIJS, J	193	4,902	25.4
10	KULKARNI, SR	161	4,560	28.32

"Essential Facts" contains very useful information to help you understand how the *ISI Essential Science Indicators*[SM] Web product works such as citation thresholds, etc.

SOURCE: *ISI Essential Science Indicators* Web based product from the November 1, 2003 update covering a ten year plus eight month period, January 1993 - August 31, 2003. This is the fourth bimonthly period.

August 2007

Ranked by total citations. (10 of 731) (with ≥5 papers published)				
RANK	SCIENTIST	PAPERS	CITATIONS	CITATIONS PER PAPER
1	FILIPPENKO, AV	231	15,219	65.88
2	SCHNEIDER, DP	303	14,790	48.81
3	BRINKMANN, J	271	14,250	52.58
4	YORK, DG	206	12,803	62.15
5	IVEZIC, Z	152	12,030	79.14
6	ELLIS, RS	143	11,859	82.93
7	GUNN, JE	128	11,502	89.86
8	FRENK, CS	132	11,410	86.44
9	STRAUSS, MA	154	11,392	73.97
10	FUKUGITA, M	128	11,177	87.32

What should be done?

- Recognise (and exploit) astro./H.E. cultural differences
- Design instruments to address a wide spectrum of issues
- Prioritise based on broad impact as well as primary goal
- Promote creative "secondary" science within large projects
- Assign students such science projects, not functional work
- Assign <u>scientific</u> credit based on <u>intellectual</u> contribution
- Assign credit separately for infrastructure work
- Ensure "astro" projects enhance <u>creativity</u> in astrophysics
- Make high value data usefully available to all
- Give scientists, especially young ones, time to think