

Pathways to a Higgs Factory: Intl Linear Collider

SRF 2013 Paris

Hitoshi Murayama (Berkeley, LBNL, Kavli IPMU Tokyo)

September 27, 2013



basic science addresses
fundamental questions

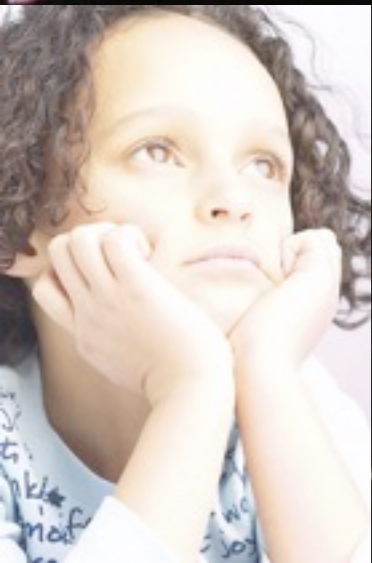
How did the Universe begin?

What is its fate?

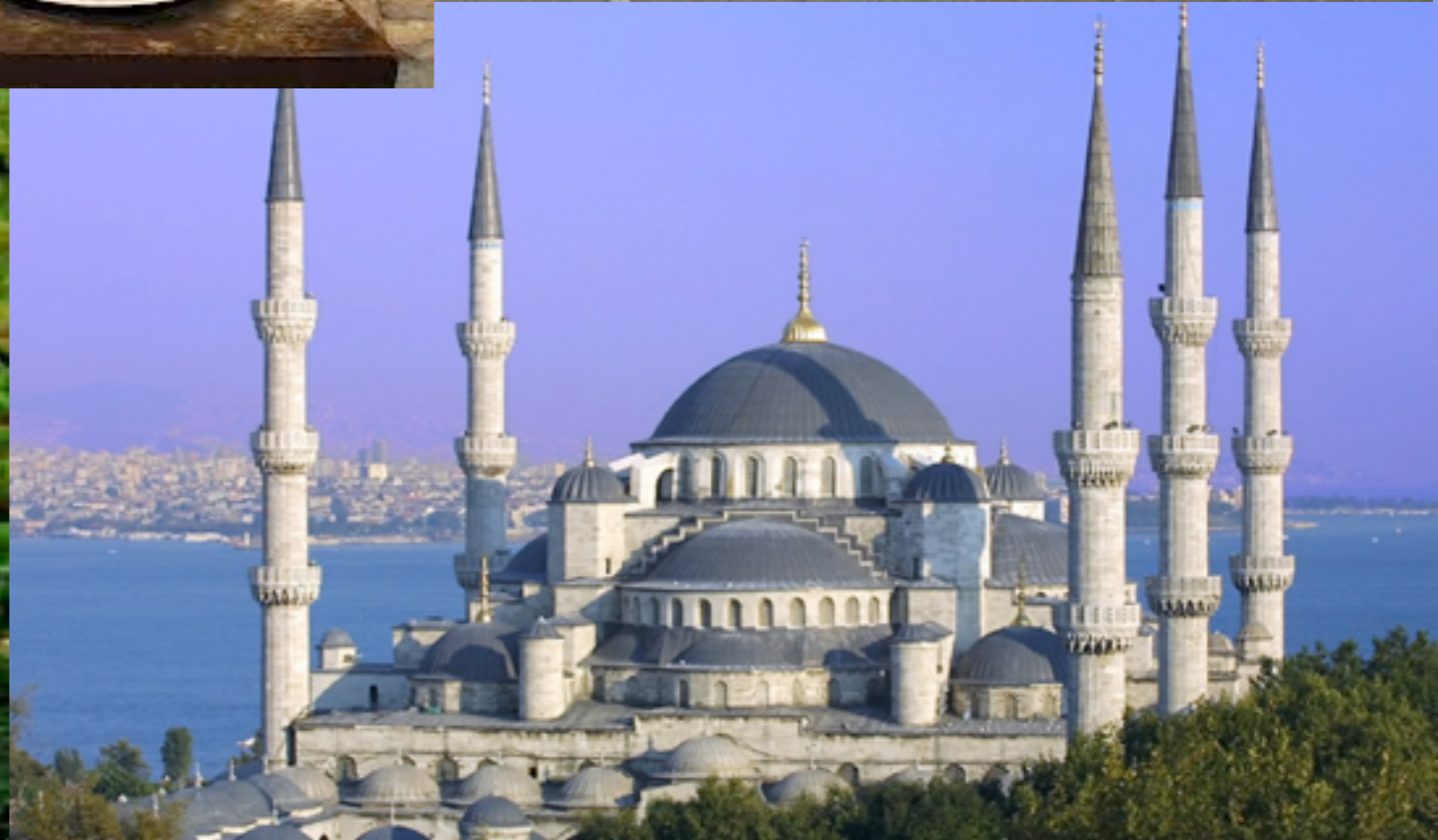
What is it made of?

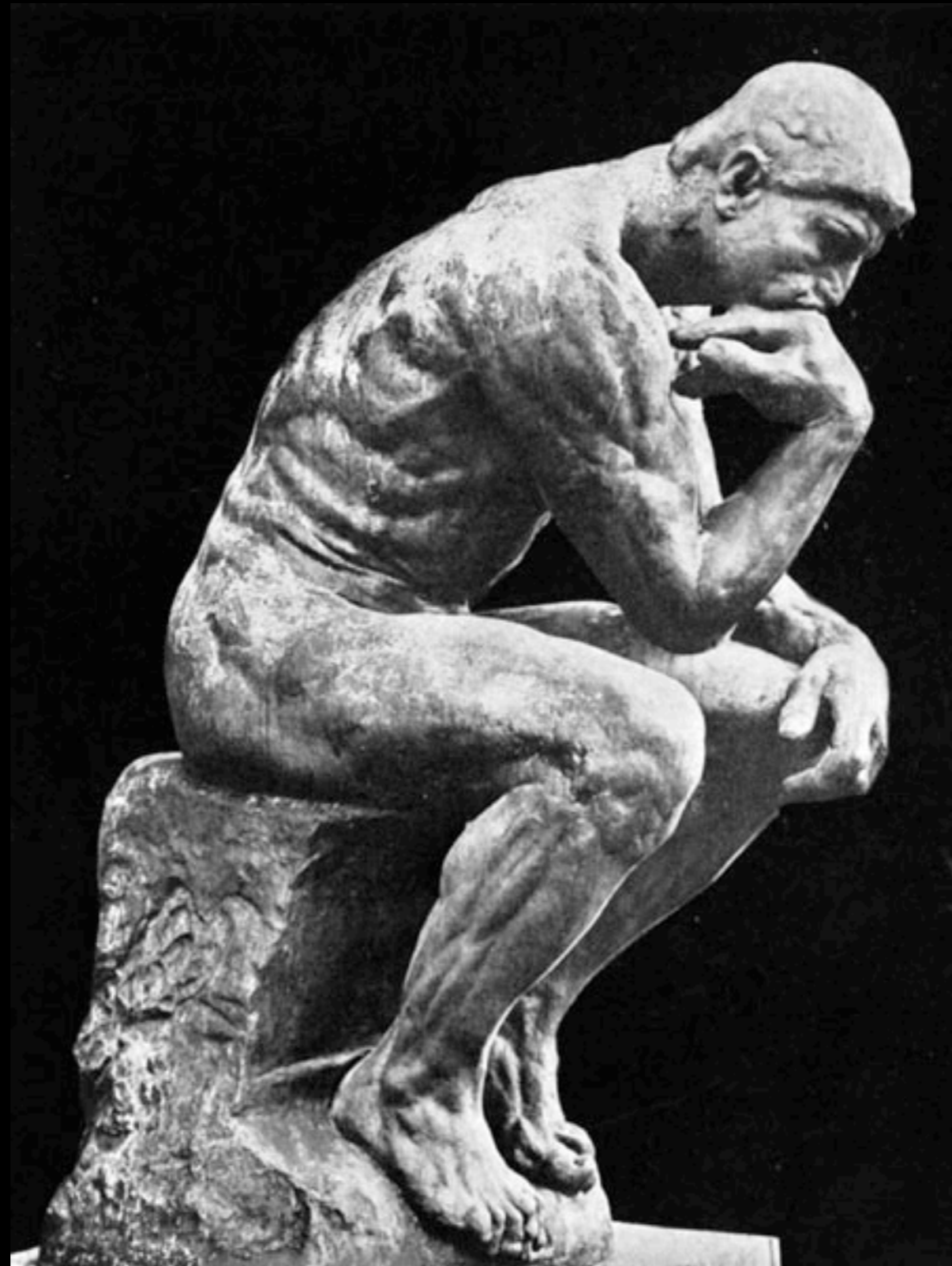
What are its fundamental laws?

→ Where do we come from?



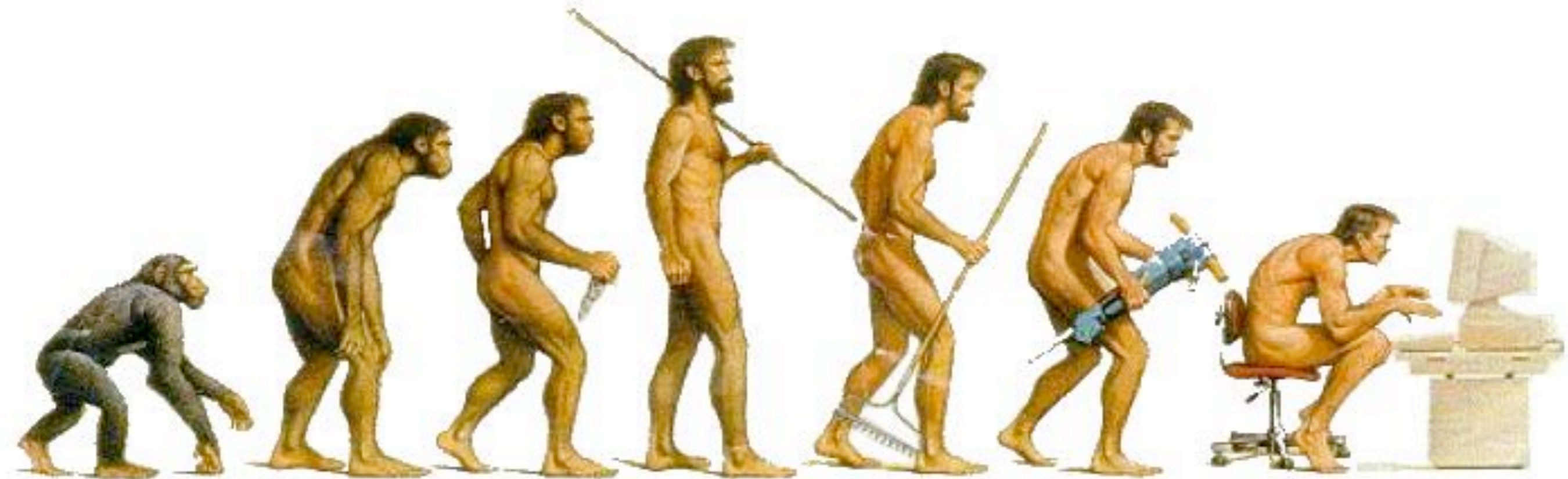
Religions



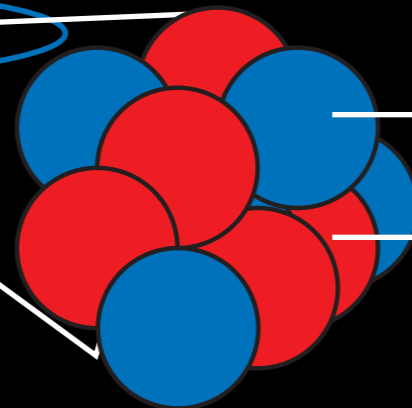
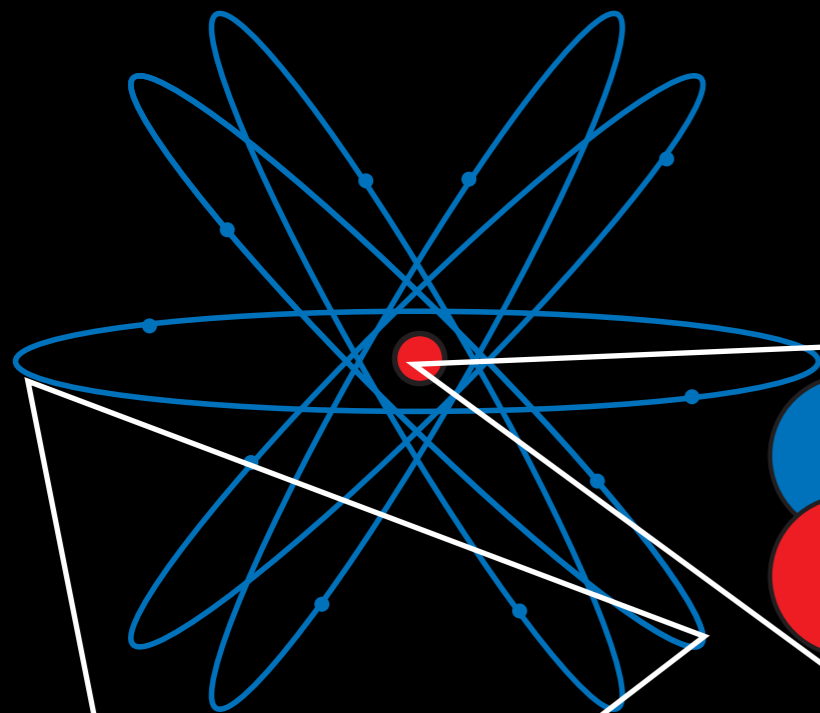


Philosophy

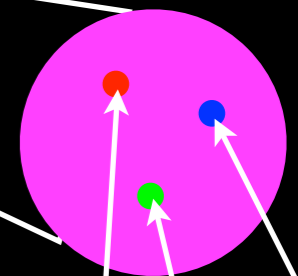
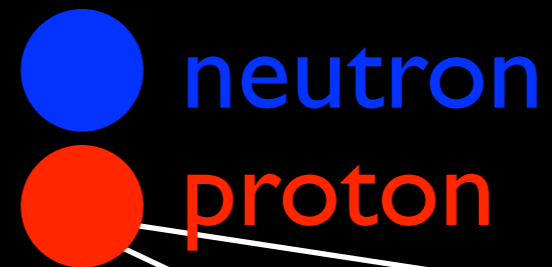
Evolutionary biology



atom



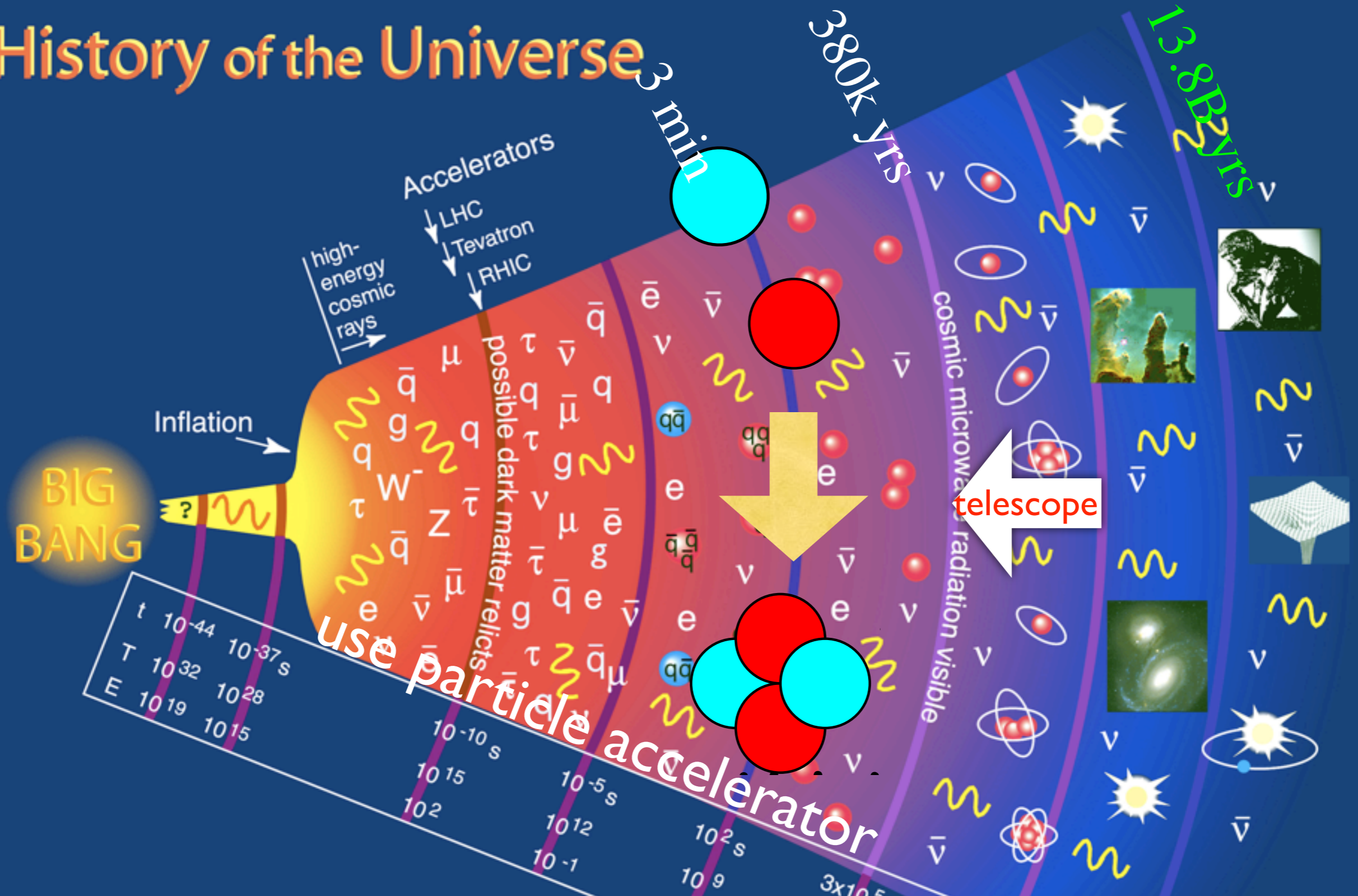
nucleus



quarks



History of the Universe



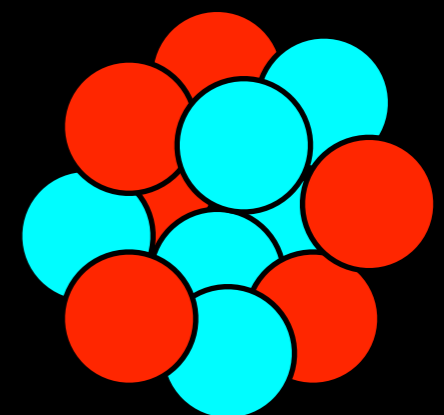
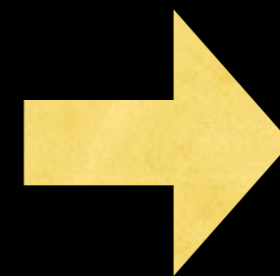
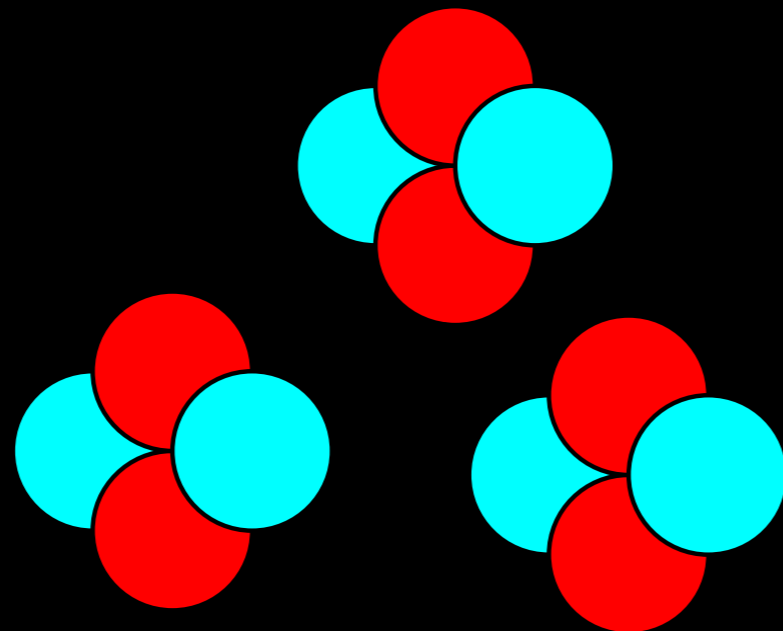
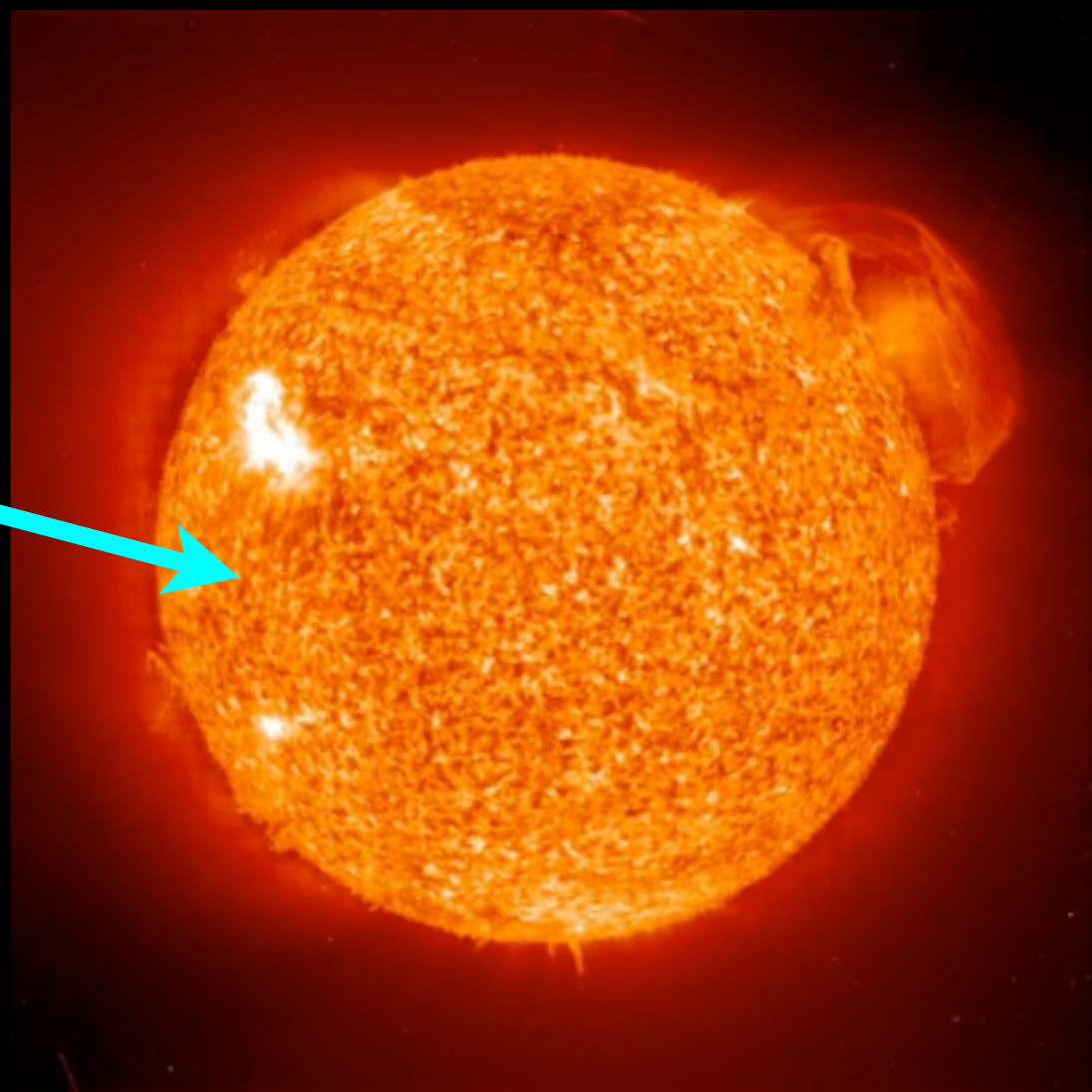
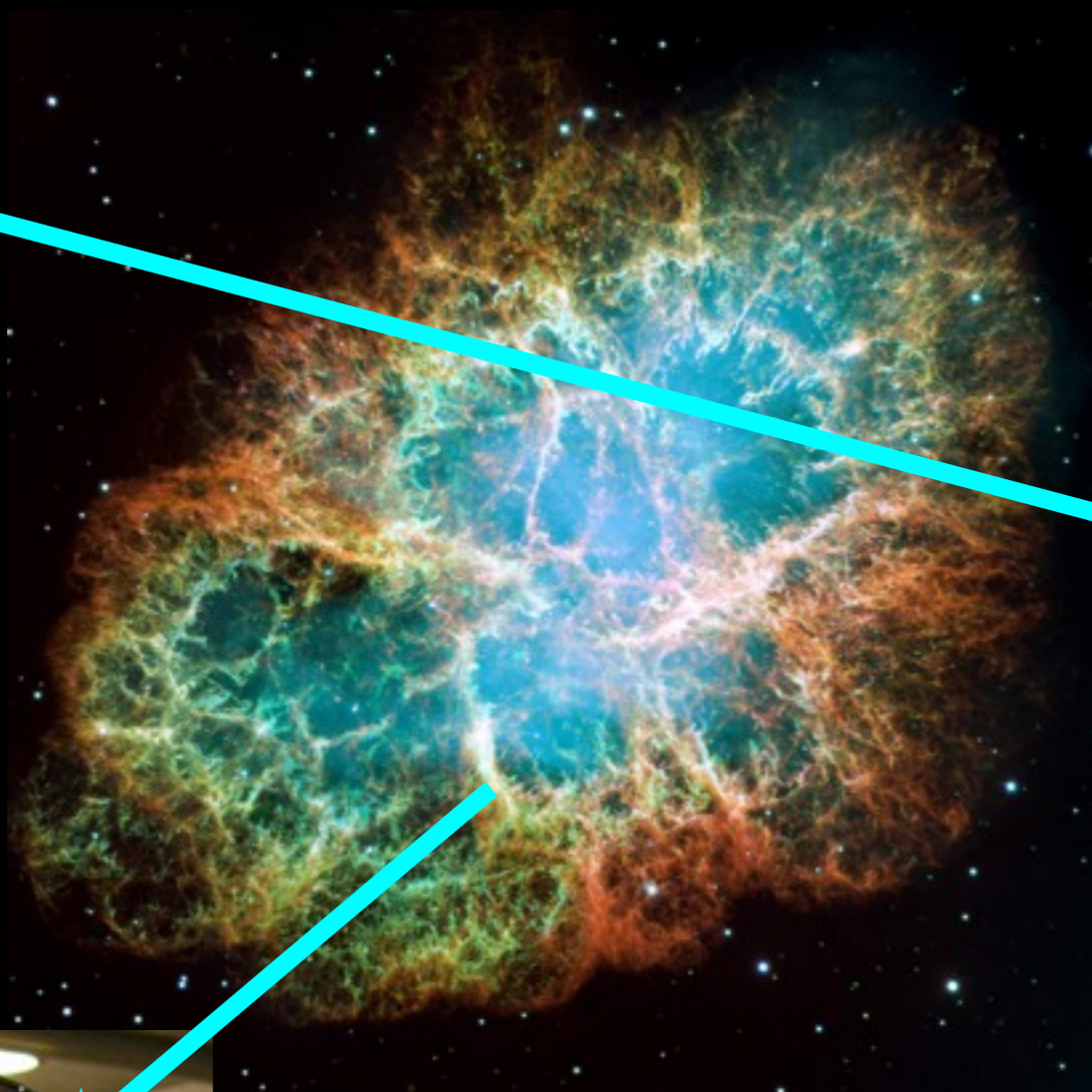
Key:

| | |
|-----------------------|------------|
| W, Z bosons | photon |
| q quark | meson |
| g gluon | baryon |
| e electron | ion |
| μ muon τ tau | atom |
| ν neutrino | black hole |
| | galaxy |
| | star |

atoms built in Big Bang
 H:He ~ 3:1 in mass
 agrees well with observation!

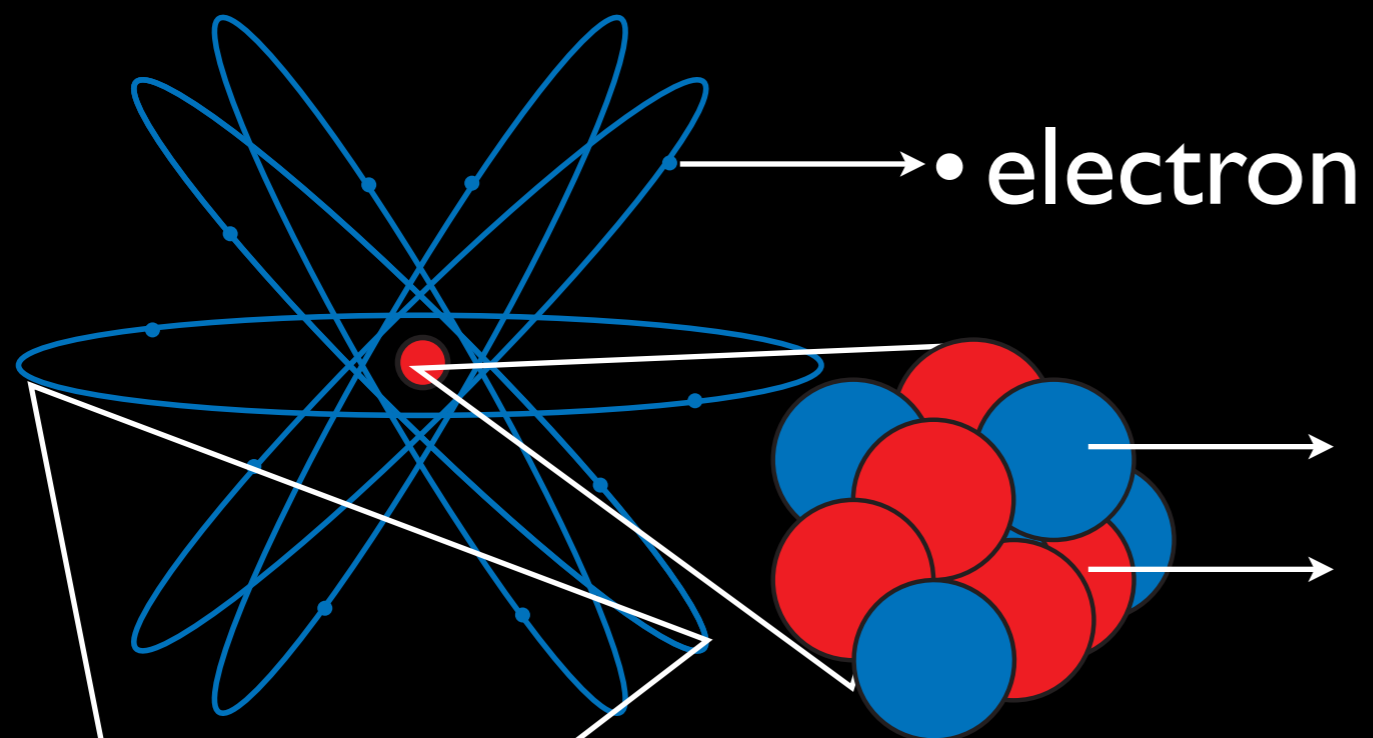
hydrogen
helium

carbon
nitrogen
oxygen
iron



We are star dust

atom



electron

Higgs boson

nucleus

neutron
proton

quarks

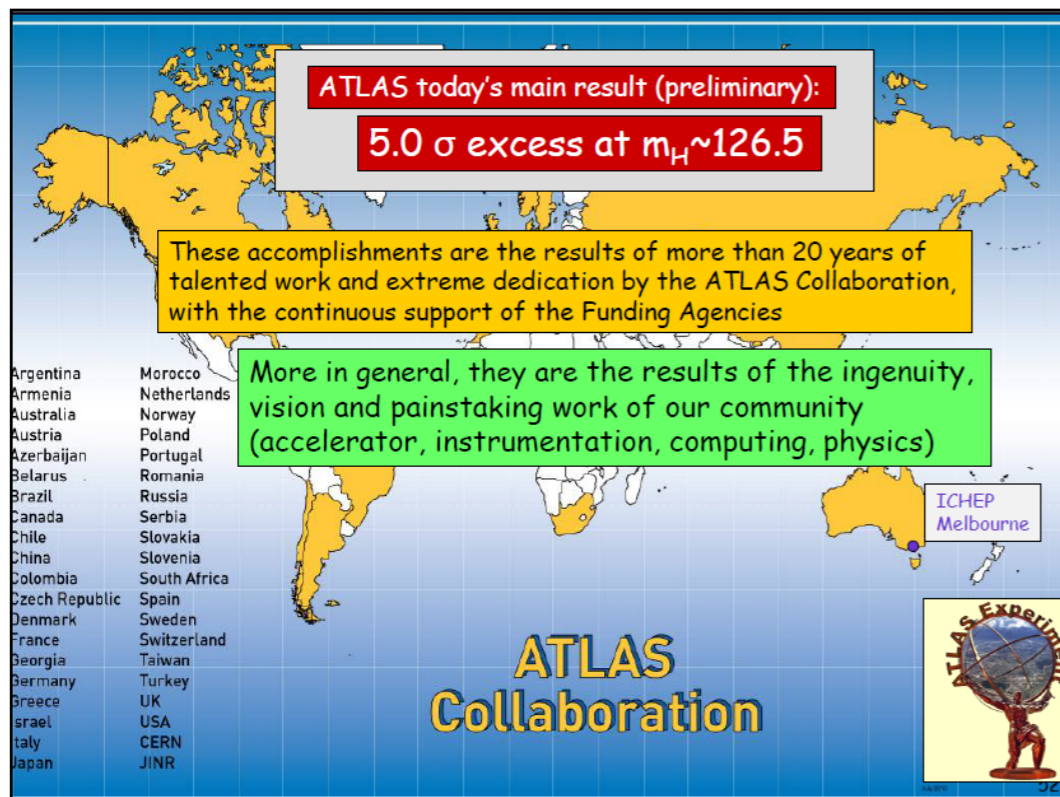


July 4, 2012

In summary

We have observed a new boson with a mass of
 $125.3 \pm 0.6 \text{ GeV}$
at
 4.9σ significance !

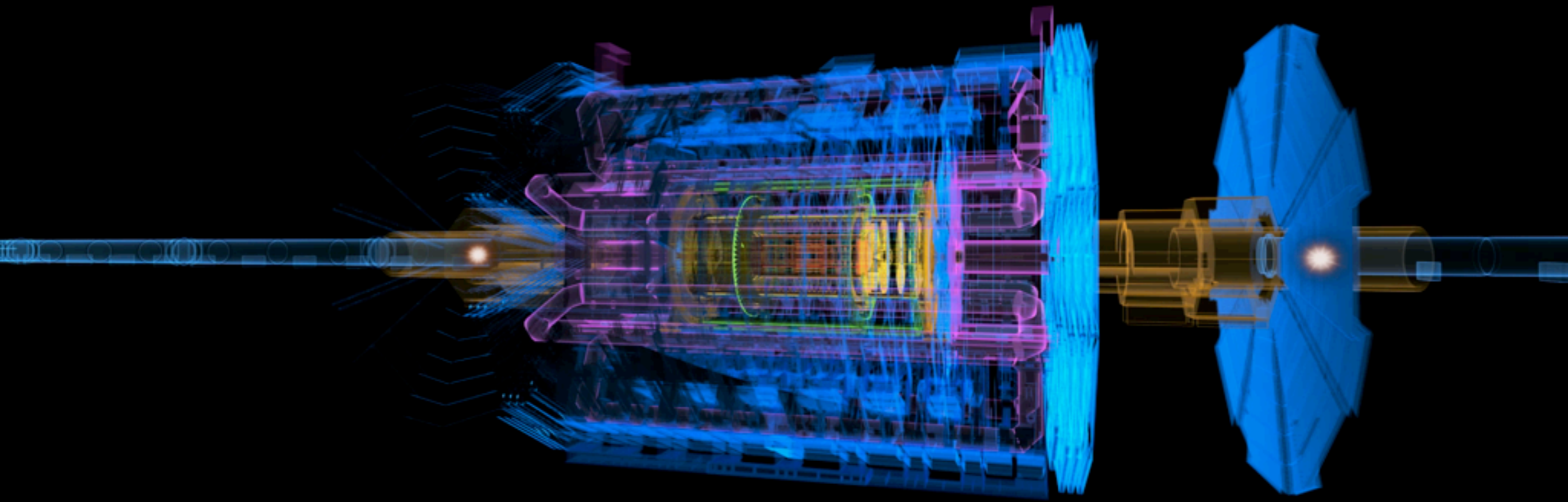
J. Incandella UCSB/CERN
May 18, 2012 Boulder Colorado



~50 years in the works

Higgsdependence Day
July 4, 2012

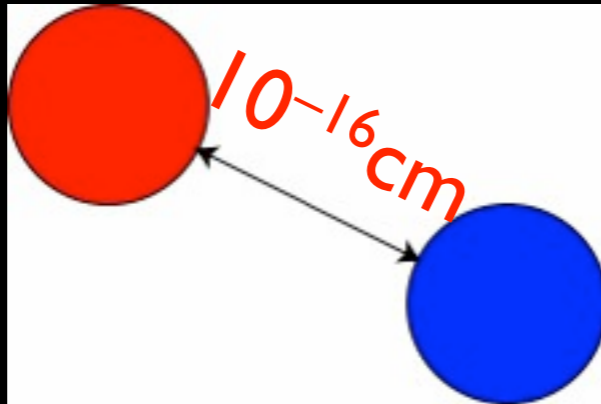




Higgs boson decays into two photons
look for hundreds of cases out of a quadrillion collisions

Cosmic Superconductor

weak force

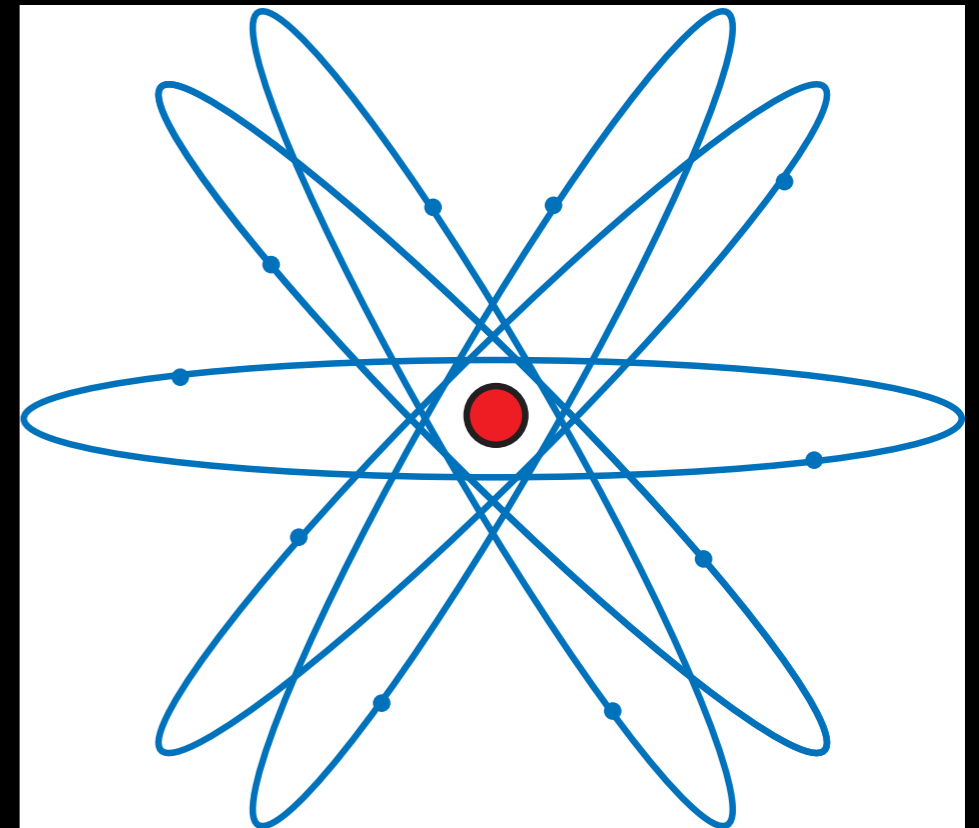
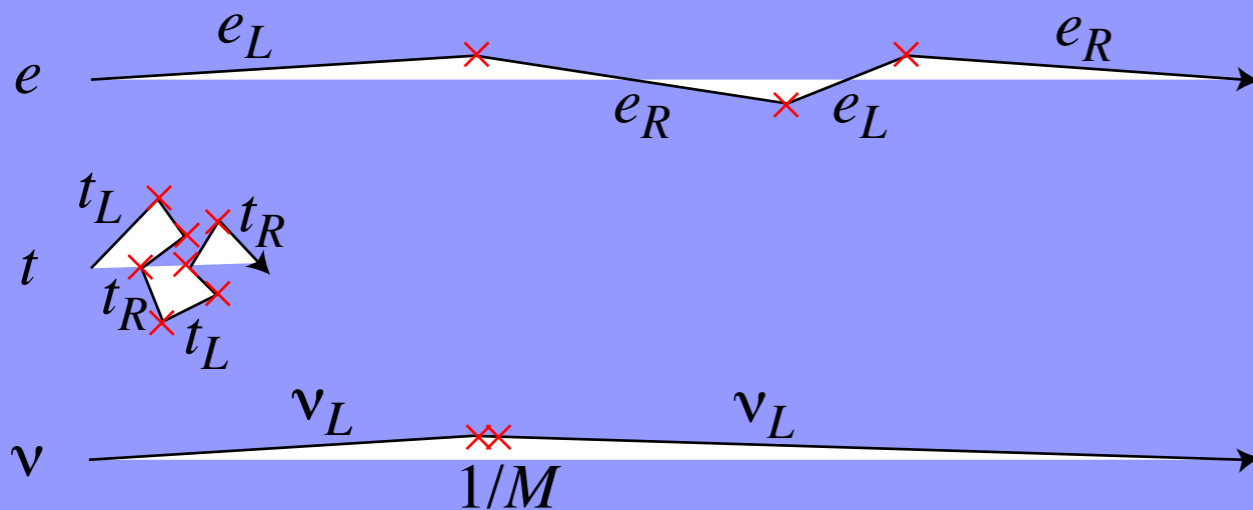


gravity

E&M

weak

ocean of frozen Higgs

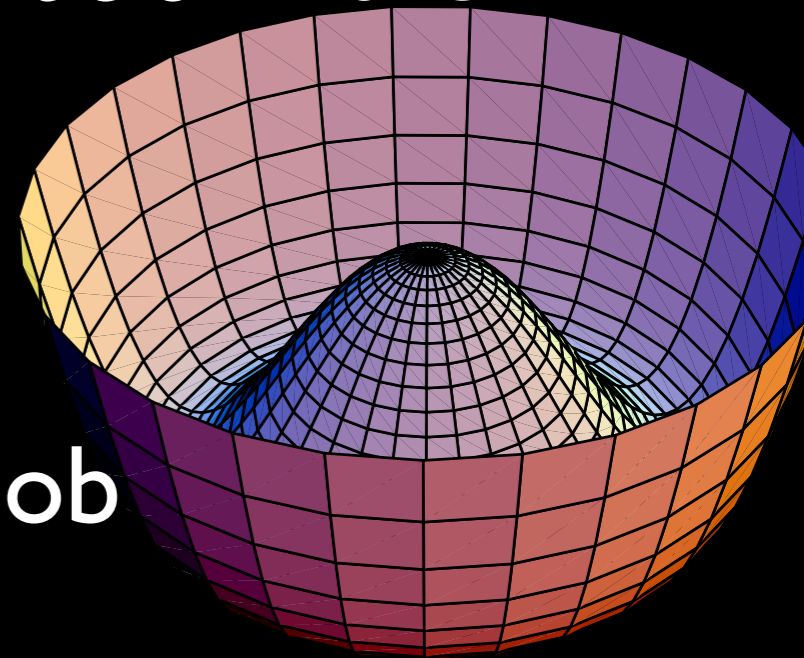




Spin



- Higgs boson is the *only spin 0 particle* in the standard model
 - it is *faceless*
 - one of its kind, no context
 - but does the most important job
- **looks very artificial**
- we still don't know *dynamics* behind the Higgs condensate
- *Higgsless theories*: now dead





Spin

What is Higgs?

Is it alone?

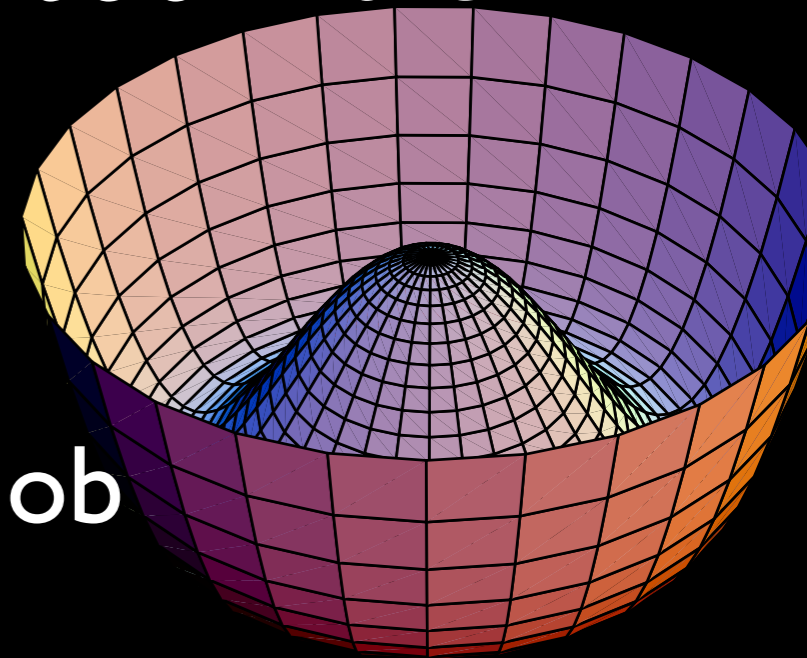
Any siblings?

Any relatives?

Why frozen?

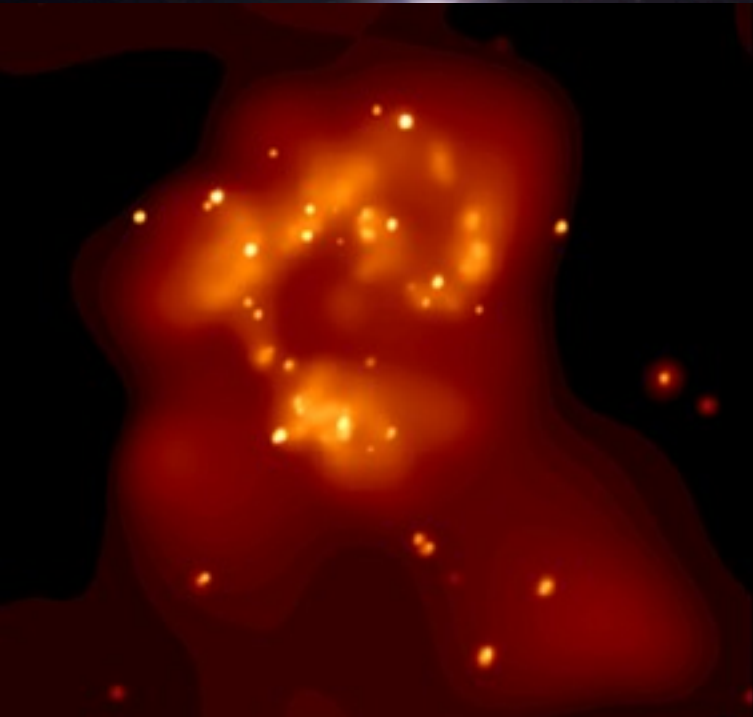


- Higgs boson is the *only spin 0 particle* in the standard model
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- **looks very artificial**
- we still don't know *dynamics* behind the Higgs condensate
- **Higgsless theories**: now dead
- is it composite?
- is it spinning in extra dimensions?






Multiple Wavebands in Astronomy




X-Ray (NASA/CXC/SAO/G.Fabbiano et al.)

This image shows a galaxy cluster in the X-ray band, appearing as a diffuse, glowing orange-red cloud with numerous bright, point-like sources of emission.



Optical (NASA/STScI/B.Whitemore)

This image shows the same galaxy cluster in the optical band, revealing the individual galaxies as blue and white points of light against a dark background.



Infrared (ESA/ISO/L.Vigroux et al.)

This image shows the galaxy cluster in the infrared band, with the galaxies appearing as bright, glowing blue and white points of light.



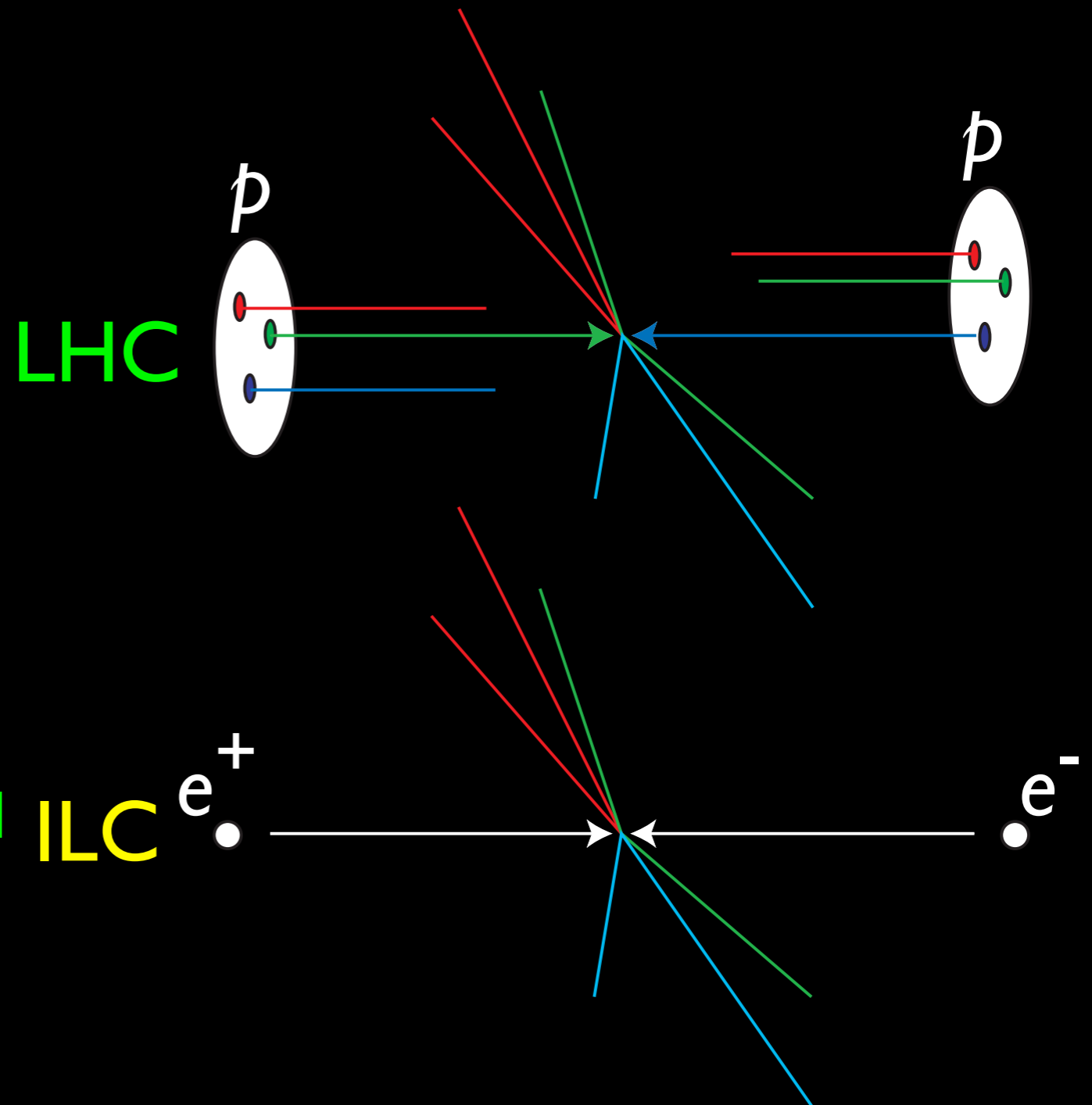
Radio (NRAO/MLA)

This image shows the galaxy cluster in the radio band, with the galaxies appearing as bright, glowing blue and white points of light.



Intl Linear Collider

- e^+ , e^- are elementary particles
- well-defined energy, angular momentum
- uses its full energy
- can produce particles democratically
- can capture nearly full information



Intl Linear Colliders



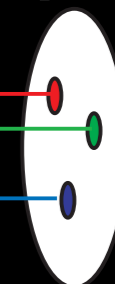
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LHC

p



p



e^+



e^-



ILC

Intl Linear Collider



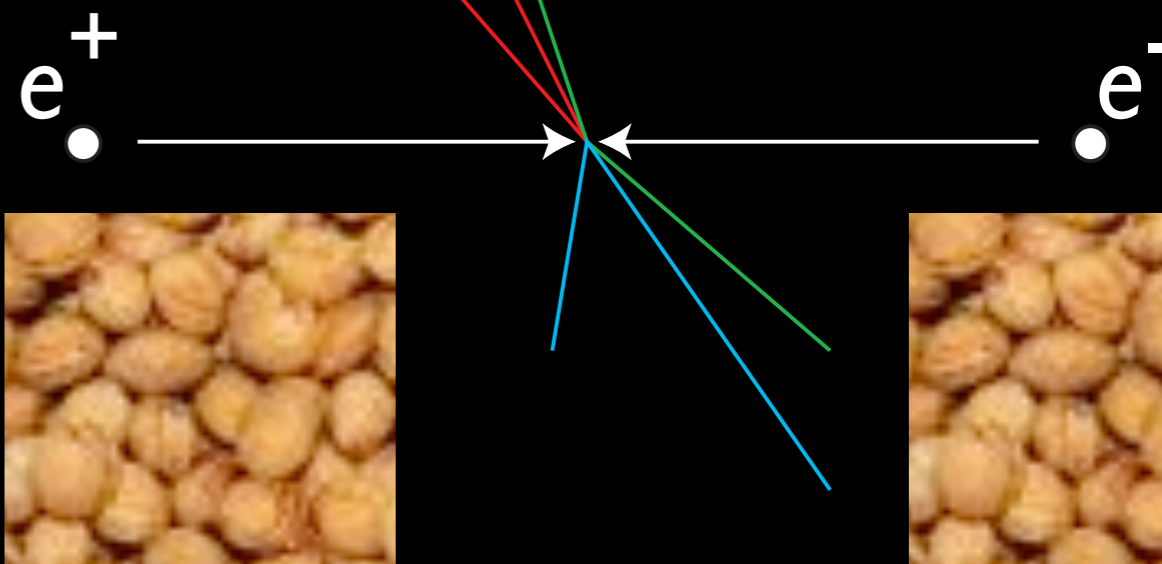
$Z \rightarrow \mu\mu$ event from 2012 data with 25 reconstructed vertices

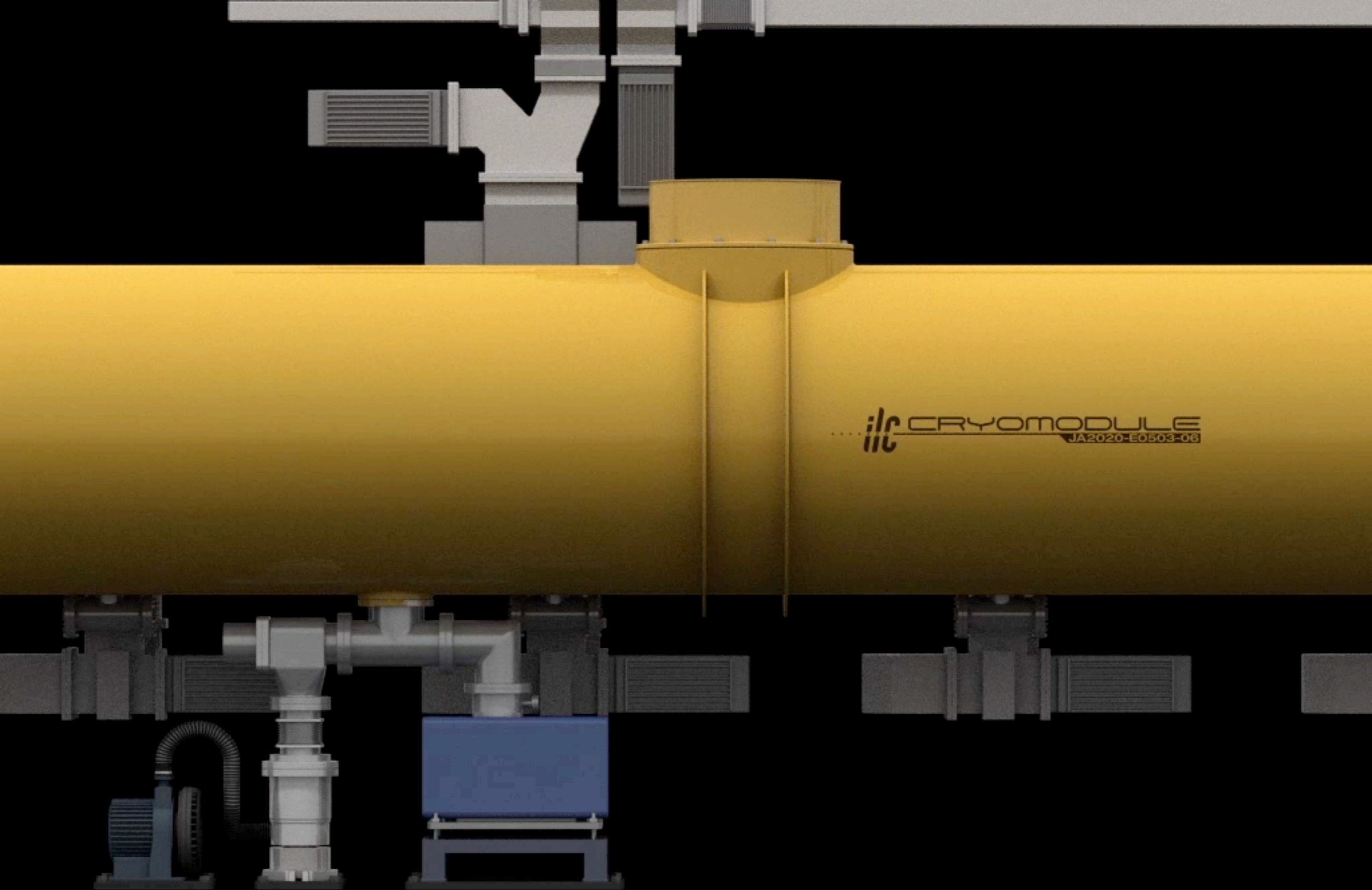


- can produce particles **democratically**

- can capture nearly **full information**

ILC





SRF technology chosen in 2004, TDR in 2013
We now know the energy needed for the Higgs

look more closely

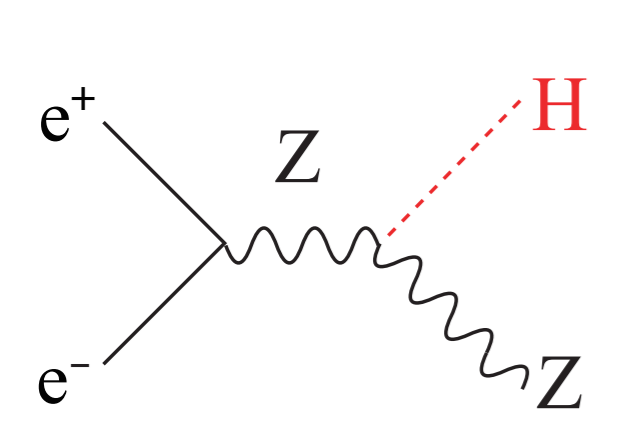
need a sharper image



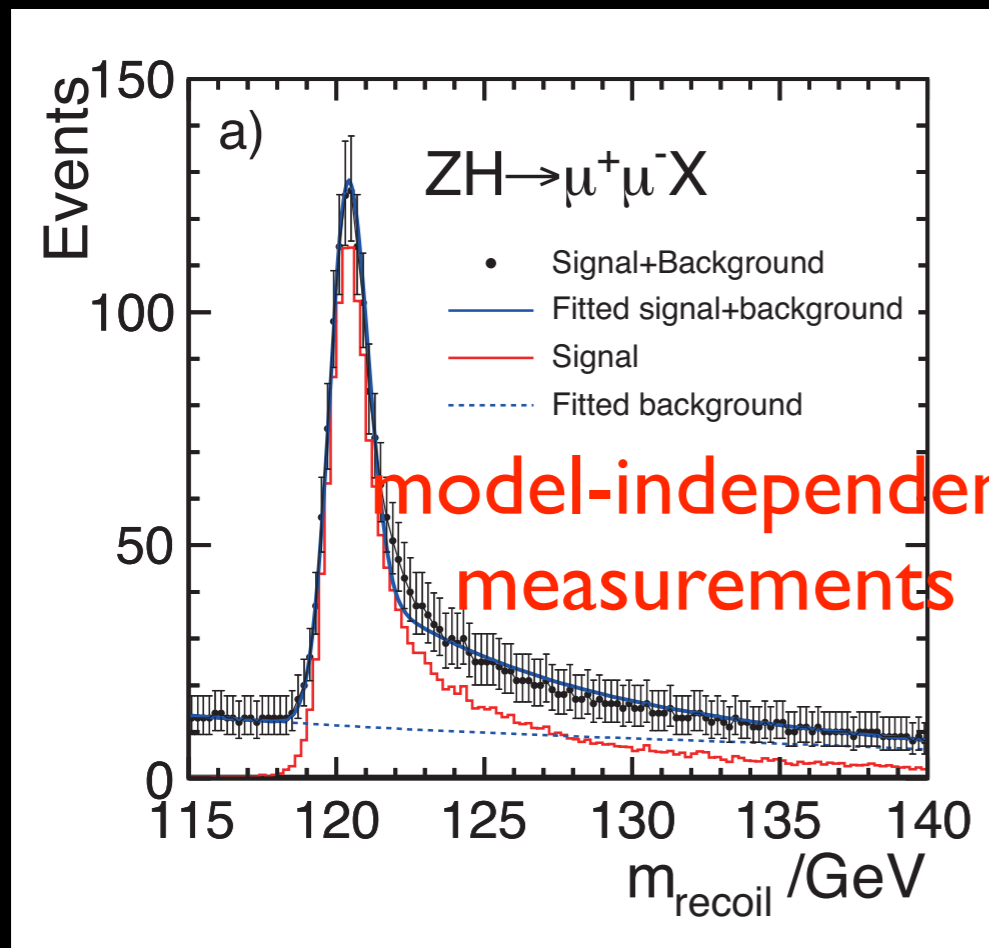
Einstein?



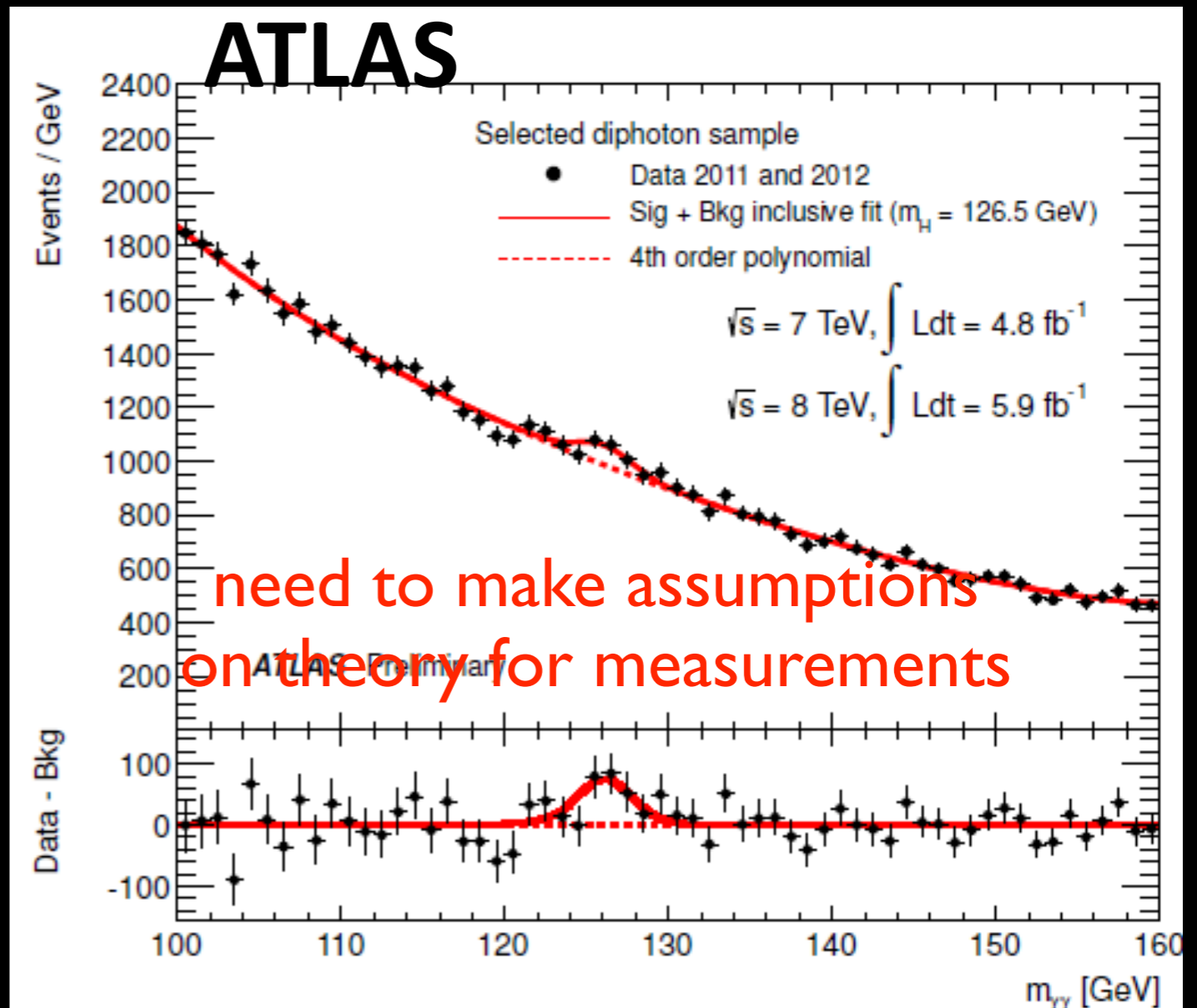
My son on Halloween!



Very clear signal



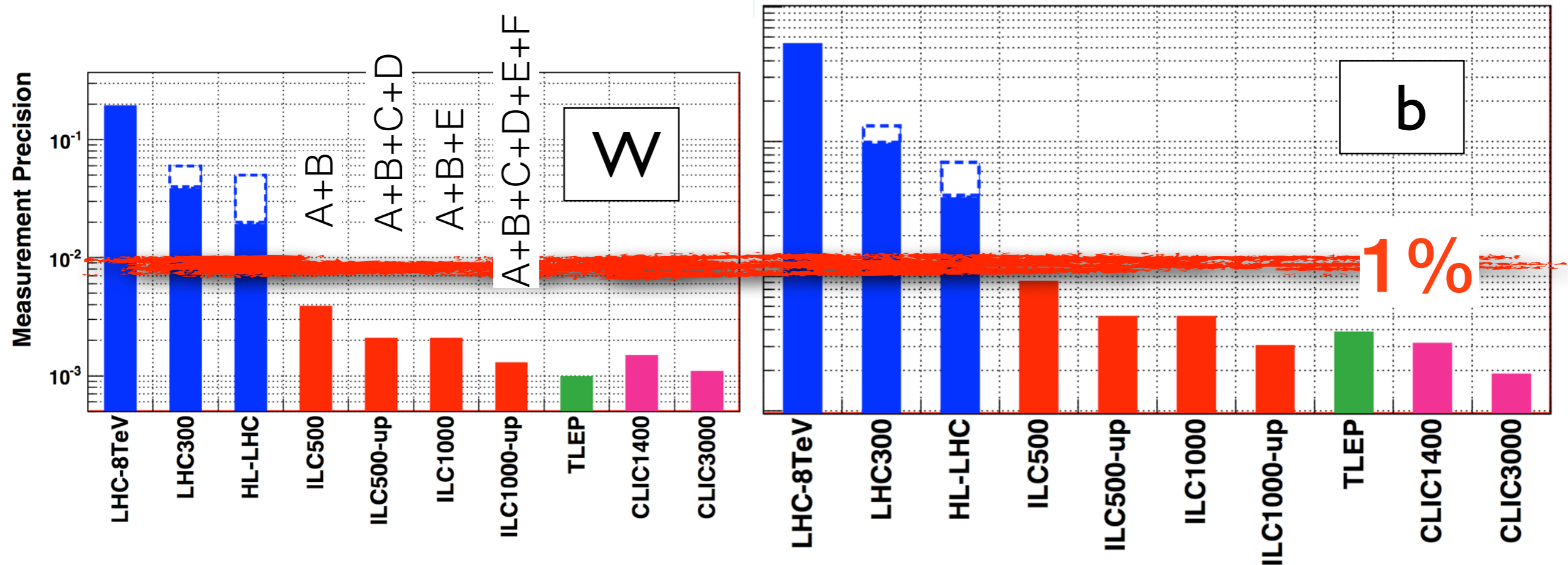
$$E_Z = \frac{\sqrt{s}}{2} \left(1 + \frac{m_Z^2}{s} - \frac{m_h^2}{s} \right)$$



Milk every drop

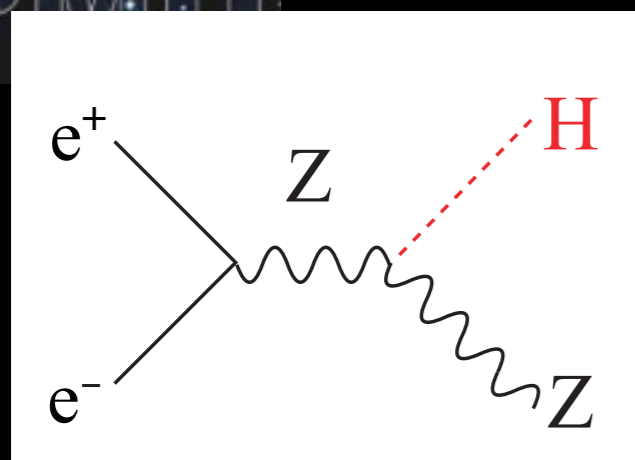
Snowmass Energy Frontier WG Chip Brock

Precision in kappa by facility



$$\frac{BR(h \rightarrow b\bar{b})}{BR(h \rightarrow b\bar{b})_{\text{SM}}} \sim 1 + \mathcal{O}(10\%) \left(\frac{400\text{GeV}}{m_A} \right)^2 \rightarrow \text{Discover siblings of Higgs boson } > \text{TeV}$$

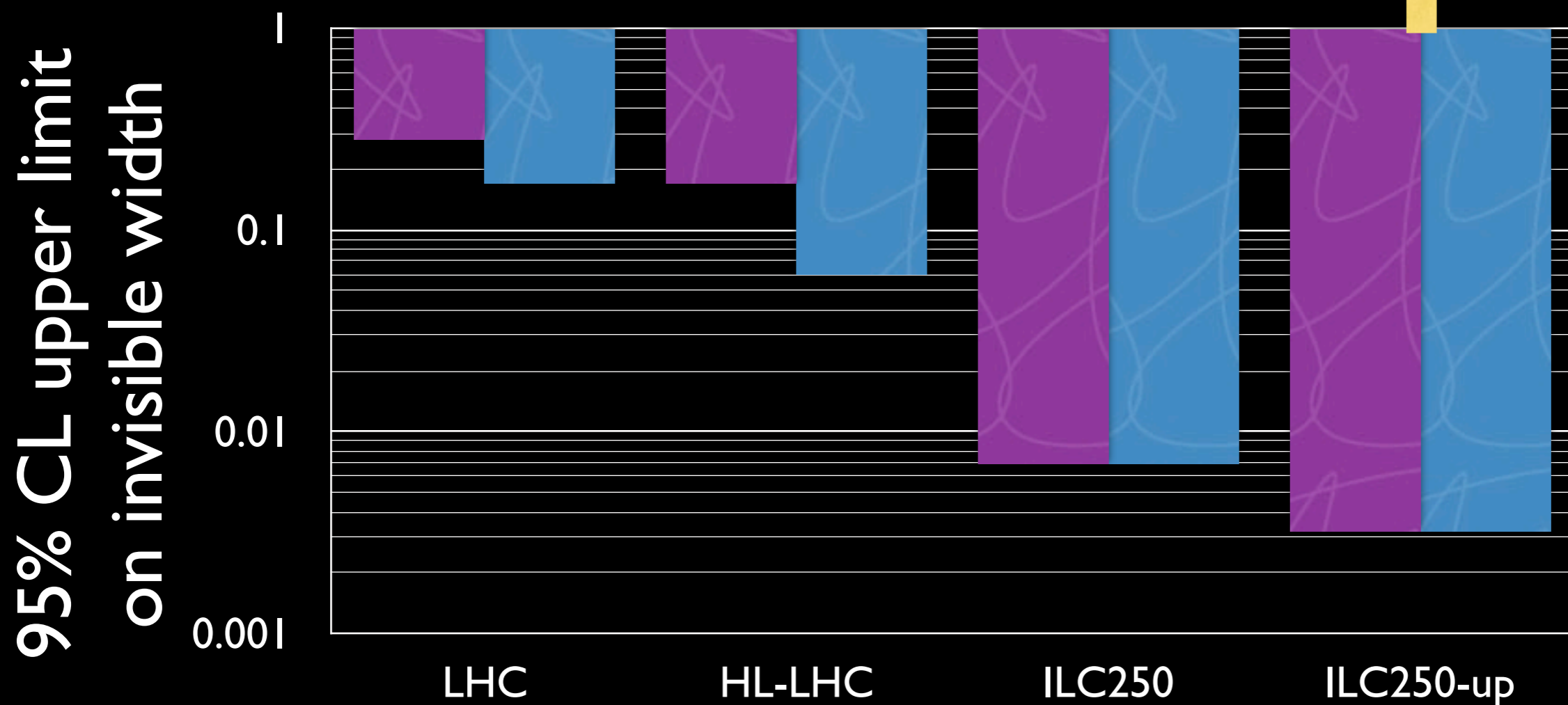
$$\text{energy reach} \propto (\text{precision})^{-1/2} \rightarrow \text{composite? } 4\pi f \sim 100\text{TeV}$$



Higgs as a portal

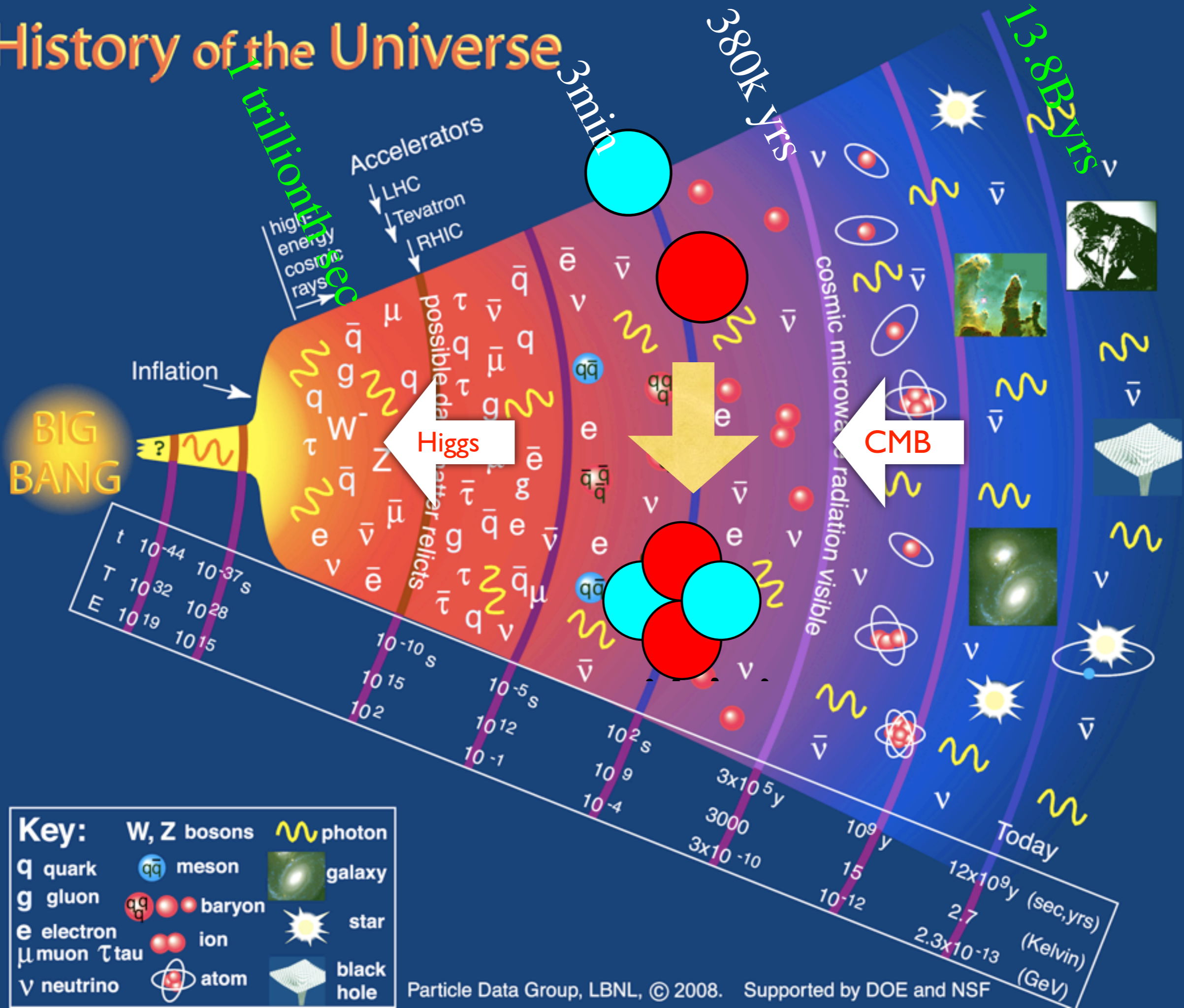
dark matter?

conservative optimistic



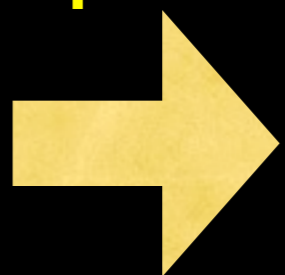
also precision top physics, search for new EW particles

History of the Universe



History of Colliders

1. **precision measurements** of neutral current
(i.e. polarized e^+d) predicted m_W, m_Z
2. UA1/UA2 **discovered** W/Z particles
3. LEP **nailed** the gauge sector
 1. **precision measurements** of W and Z (i.e. LEP + Tevatron) predicted m_H
 2. LHC **discovered** a Higgs particle
 3. LC **nails** the Higgs sector?
 1. **precision measurements** at ILC predict ???

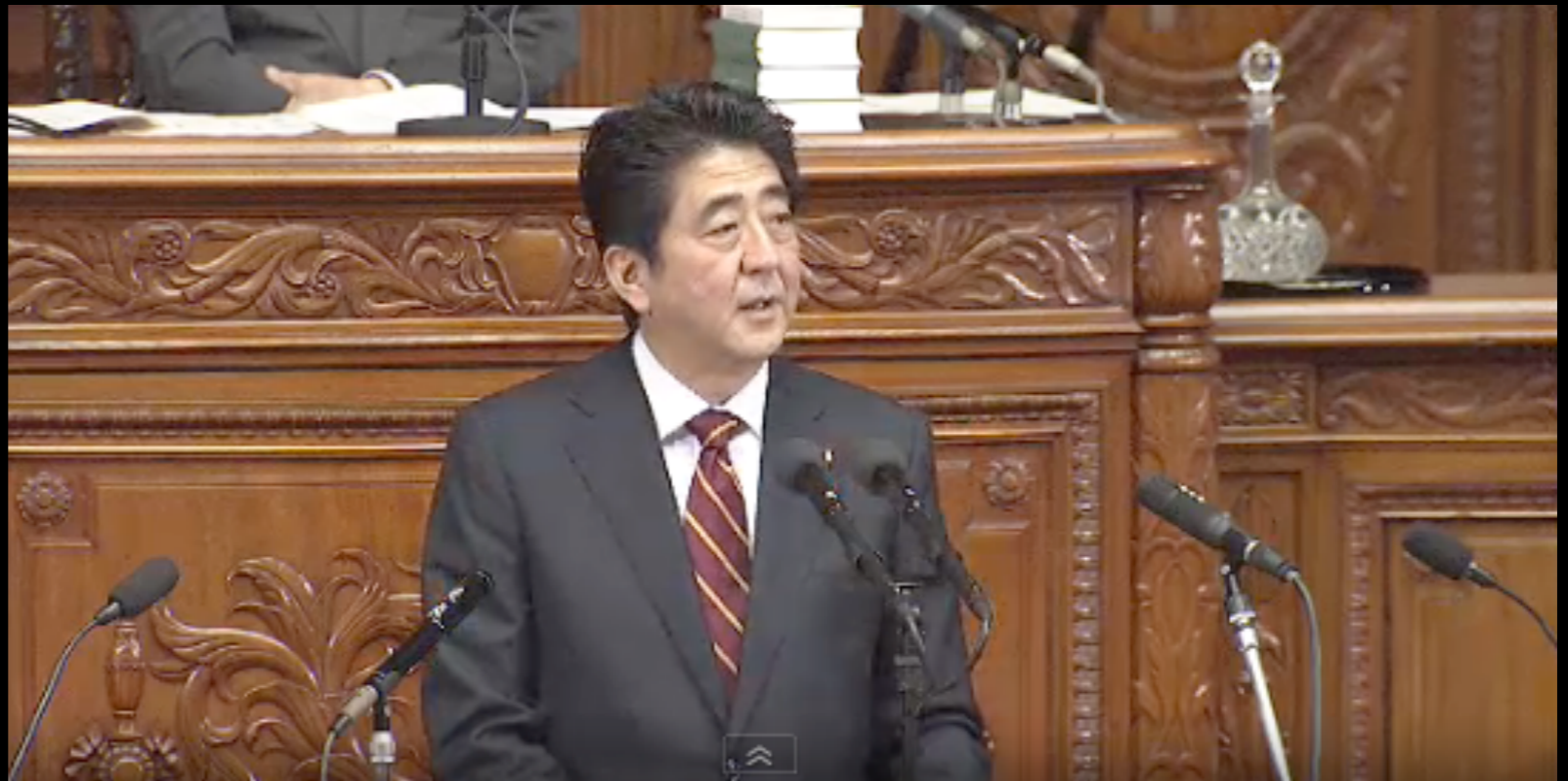


ILC points to the future of the field

“State of the Union” address 2013/2/28

*Japan is driving global innovation in cutting-edge areas, including among others the world's first production test of marine methane hydrate, a globally unparalleled rocket launch success rate, and **our attempts to develop the most advanced accelerator technology** in the world.*

the 183rd
congress



July Election

- Election of the Upper House on July 21
- LDP campaign pledge document mentions ILC twice among 356 bullets
- “leading role in developing technology for ILC”
- LDP won by a land slide

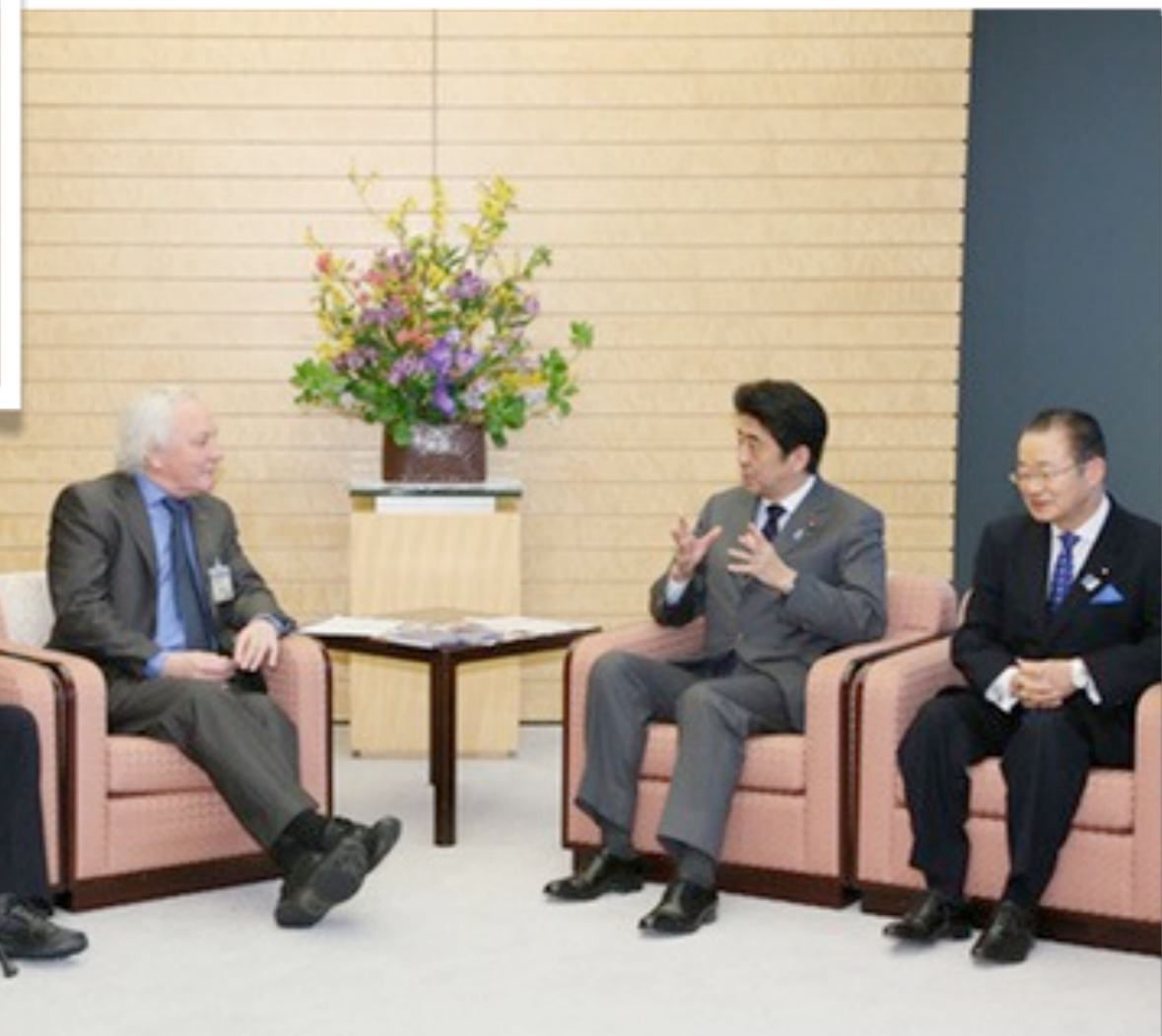


Lyn Evans meets Prime Minister

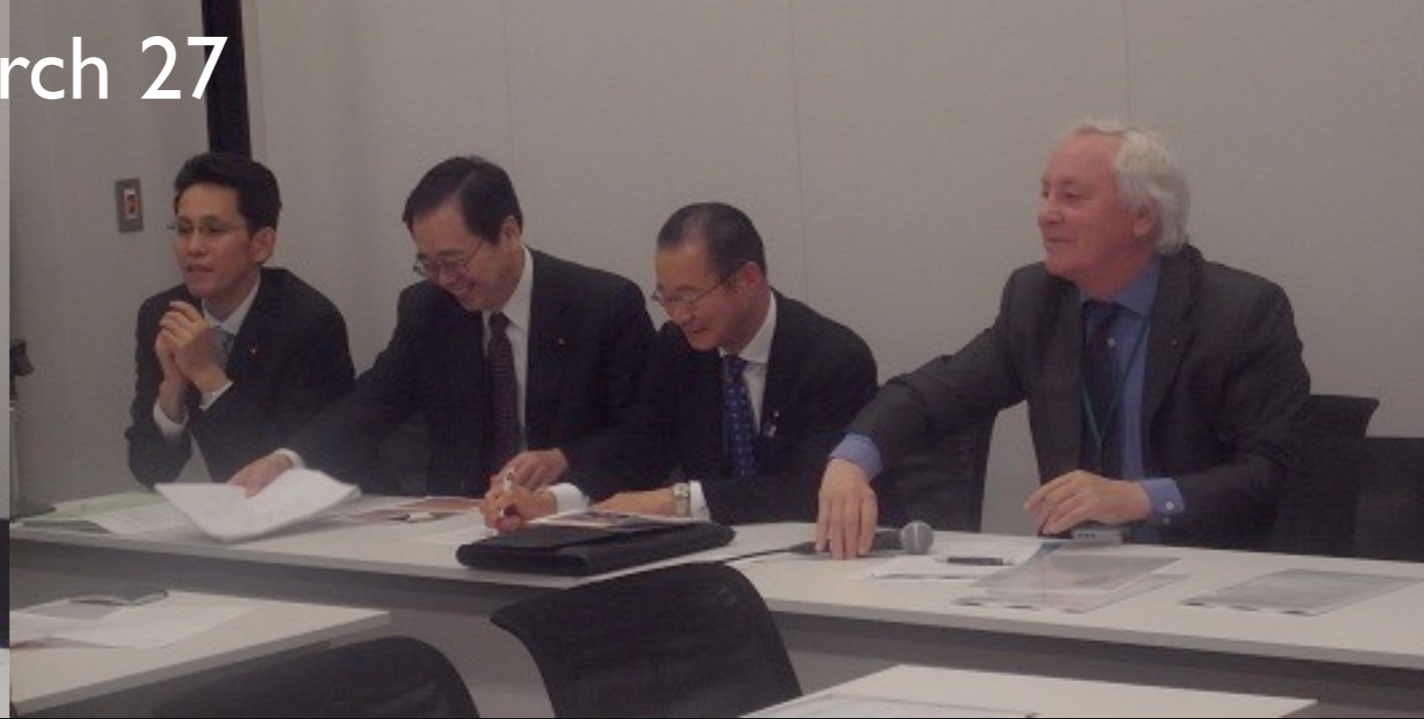
Mar 27, 2013



I understand ILC is a dream for humankind.
I need to monitor the developments
carefully to see what role Japan can play.



March 27



Federation of Diet members to promote a construction of international laboratory for LC (non-partisan)

>20% of Diet members signed up to support ILC



They passed a resolution on June 12

国際リニアコライダー計画推進に関する決議

リニアコライダー(先端線型加速器)

国際研究所建設推進議員連盟

- ✓ 1. The site must be chosen purely based on scientific reasons.
- ✓ 2. After the selection, we provide nationwide support.
3. Government must start a process to decide whether to host the ILC ASAP.
4. Government must create a headquarter within the cabinet to work across the ministries.
5. Government must announce its process to relevant countries.
6. Further studies must be conducted to maximize the technological and economic benefits.

我々は、国際リニアコライダー（ILC）計画が人類の新たな知の地平を切り拓き、
社会を創るものであると、先端の技術利用によりオ
ミダシと、海外からの頭脳
の育成」を加速すること
となモデルとすること
「ナンバーワン」を取
本誘致の是非の検討を
国と分担する交渉の早
理解を得ることが必須
り、世界から本計画実
プロジェクトとして、
を見据えて推進すべき

1. ILC建設国内候補地は、科学的、学術的観点からのみ決定されるべきこと。
2. 候補地決定後は地域を超えたオールジャパンで推進すること。
3. 政府は、ILC日本誘致の是非を可及的速やかに検討を開始すること。
4. 政府は、ILC日本誘致の実現のために、内閣に司令塔を設置し、日本の科学技術外交の総力戦で臨むこと。政府は文科省だけでなく外務省、経産省も含めたチーム体制で、中長期の視野に立ち交渉を進めること。
5. 政府は、ILC日本誘致の是非の検討を開始することを関係国へ発信すること。
6. ILCの技術波及・経済波及について、最大限の効果が得られるよう、ILC推進と並行して調査研究を推進すること。

ILCの国内候補地として
最適と評価する。

なお、北上サイトにおける中央キヤン
パスは、仙台・東京へのアクセス利便
性を有し、研究・生活環境に優れる新
幹線沿線の立地を強く推奨する。

recommends
Kitakami site to have a good
living and research and to be loca
Shinkansen line for convenient a
Sendai and Tokyo.

(Signatures)

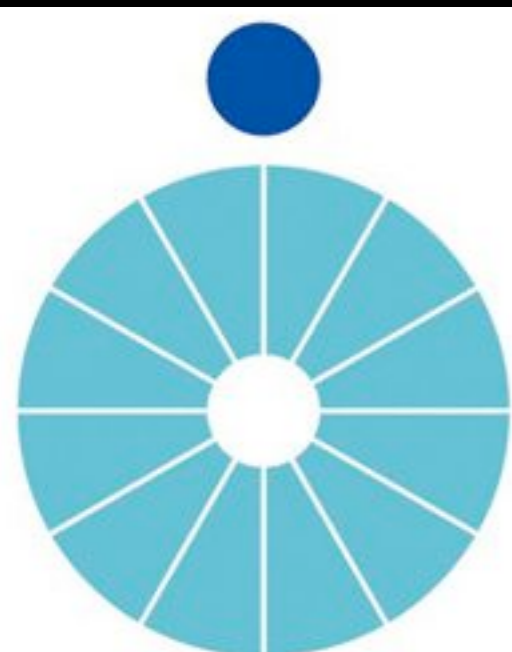
(署名) 62 reporters

Aug 23 press conference

HM



MEXT budget request



文部科学省

MEXT

MINISTRY OF EDUCATION,
CULTURE, SPORTS,
SCIENCE AND TECHNOLOGY-JAPAN

- MEXT \approx DoE+DoEd in US
- So far, ILC effort in Japan has been funded through KEK operating budget *unofficially* (approx. \$10M/year M&S)
- MEXT submitted an *official budget line for ILC for the first time* in August, ~\$0.5M
- *chosa-hi* is always the beginning of any projects
- to be approved by MoF by end of Dec



Science Council

- MEXT asked SCJ to evaluate case for ILC on: science, society, readiness
- official report will be released Sep 30
- Then MEXT can be set in motion
- crucial question is whether SCJ will recommend Japanese government to initiate international negotiations



I WANT YOU
FOR THE ILC

NEAREST RECRUITING STATION

The Jump-Start Scenario

(Very optimistic but not impossible)

- 2013 July Site evaluation by scientists will be completed in Japan
- 2013 fall New organization within Japanese government is expected to be formed and in preparation to bid to host the ILC
- 2014-15 Intergovernmental negotiation
Linear Collider Collaboration (Lyn Evans and ILC sector) continue to refine the design and organization of the global lab for ILC
- 2015 International Review of the ILC project (LHC physics @13-14 TeV)
- 2016 Construction starts (accelerator + detectors)
- 2026 Commissioning of the ILC machine

Sachio Komamiya, LCB Chair, EPS2013@Stockholm





SRF2013 PARIS

International conference on RF Superconductivity

September 23-27, 2013

Cité Internationale Universitaire, PARIS

Workshops : September 19-21, 2013

GANIL, CAEN (France)

<http://www.srf2013.fr>

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contact@srf2013.fr

LCWS13

11-15 November 2013, The University of Tokyo

Website:

<http://www.icepp.s.u-tokyo.ac.jp/lcws13/>

Contact:

lcws13@icepp.s.u-tokyo.ac.jp

The workshop will be devoted to the study of the physics case for a high energy linear electron-positron collider, taking into account the recent results from LHC, and to review the progress in the detector and accelerator designs for both ILC and CLIC projects.

11-15 November (registration is open)
<http://www.icepp.s.u-tokyo.ac.jp/lcws13/>





mysteries
of the
Universe

ILC