

# Closing Comments



LCWS 2010, Beijing

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ILCSC Chair  
30 March 2010



# Terascale



- Today...

March 30, 2010

... is an important day for the future of our field

- It is the day we begin to light the Terascale ...

$$3.5 + 3.5 = 7 \text{ TeV}$$

... with the first 7 TeV collisions at the LHC





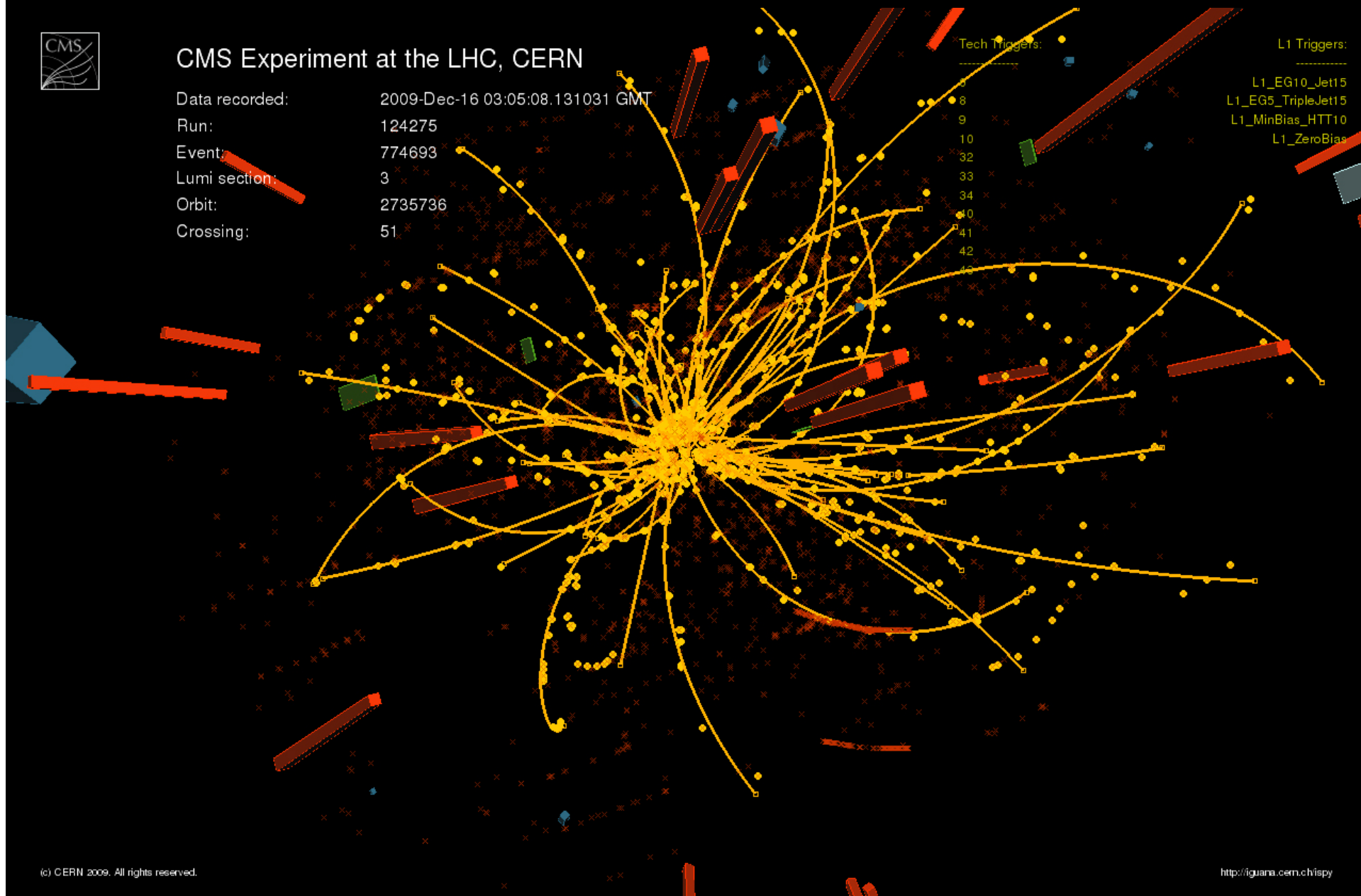
## CMS Experiment at the LHC, CERN

Data recorded: 2009-Dec-16 03:05:08.131031 GMT  
Run: 124275  
Event: 774693  
Lumi section: 3  
Orbit: 2735736  
Crossing: 51

Tech Triggers:

L1 Triggers:

L1\_EG10\_Jet15  
L1\_EG5\_TripleJet15  
L1\_MinBias\_HTT10  
L1\_ZeroBias

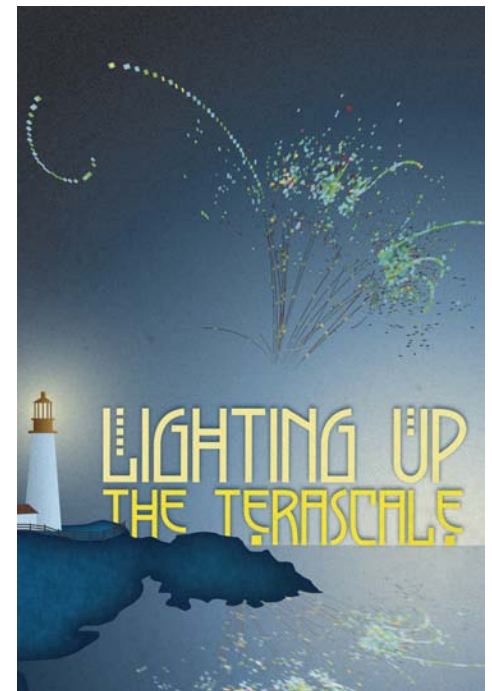




# Terascale



- It is a day for celebration!
  - ◆ Our field needs the breakthrough discoveries that the LHC will provide ...
  - ◆ Nothing will advance our science like the discovery of new phenomena ...
    - Supersymmetry
    - Extra dimensions
    - Dark matter
    - Or something not yet imagined ...





# Terascale



- These discoveries will start to provide scientific answers to deep questions that touch us all ...



Gauguin: *Where Do We Come From? What Are We? Where Are We Going?*



# LCWS 2010



- But this morning, with all eyes on the LHC, there is a second very special event ...
  - ◆ LCWS 2010, right here in Beijing
  - ◆ A conference that is drawing together the linear collider community ...
    - Accelerator and detector ... ILC and CLIC ...  
... to look beyond the LHC
- This is very important work. We are gathered ...  
... to chart our path towards a linear collider



# Outline



- Today, in this concluding talk, I would like to present my summary comments on
  - ◆ Physics and Technology
  - ◆ Political Engagement
  - ◆ Public Outreach
  - ◆ Path Forward
- And in the end, I hope you agree that we have a responsible plan to advance our science and achieve our goals



# Physics & Technology



- Our political fortunes rise and fall ...
- But one thing remains unchanged:

## THE PHYSICS

- The physics case for a linear collider is as strong as it ever was.



# Physics & Technology



- The physics case for a linear collider can be made through examples
  - ◆ Higgs and Imposters
  - ◆ Extra Dimensions and Avatars
  - ◆ Alchemy of Dark Matter
  - ◆ Ultimate Unification
- In each case, the particles tell stories that go far beyond the particles themselves
  - ◆ And a linear collider has an important role to play

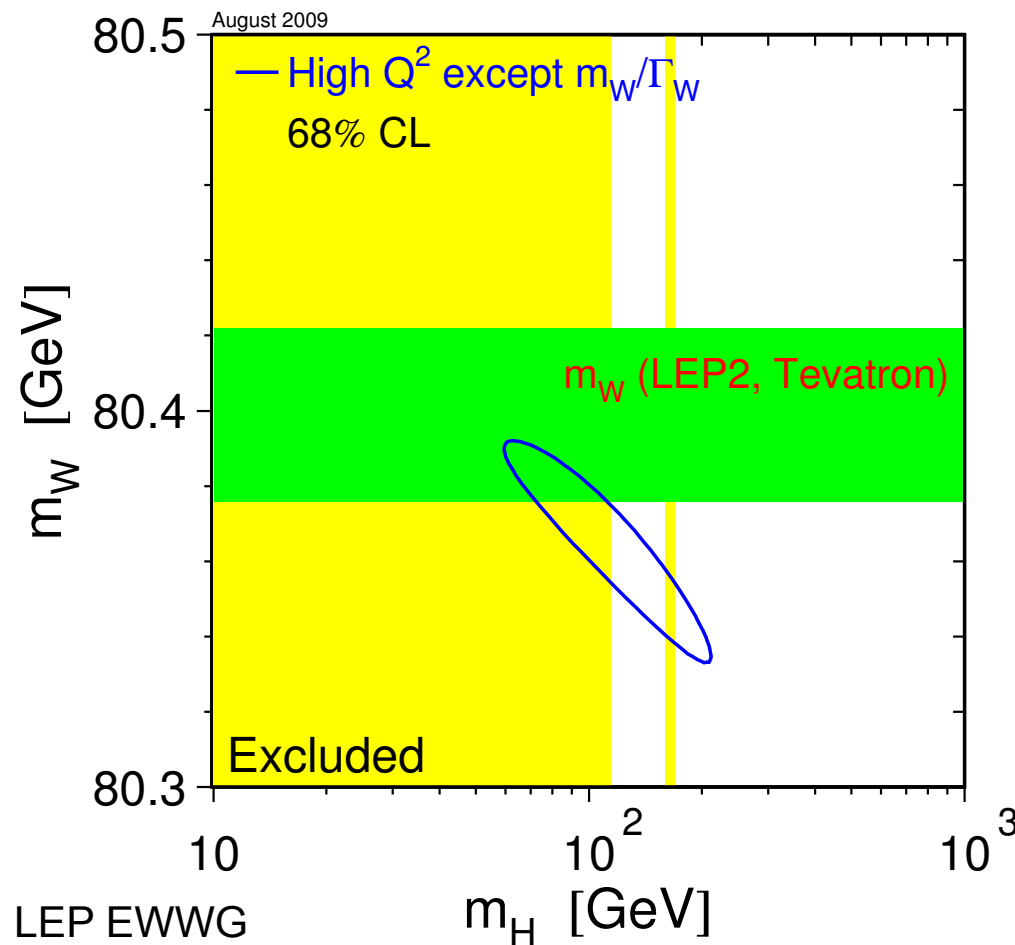




# Physics & Technology



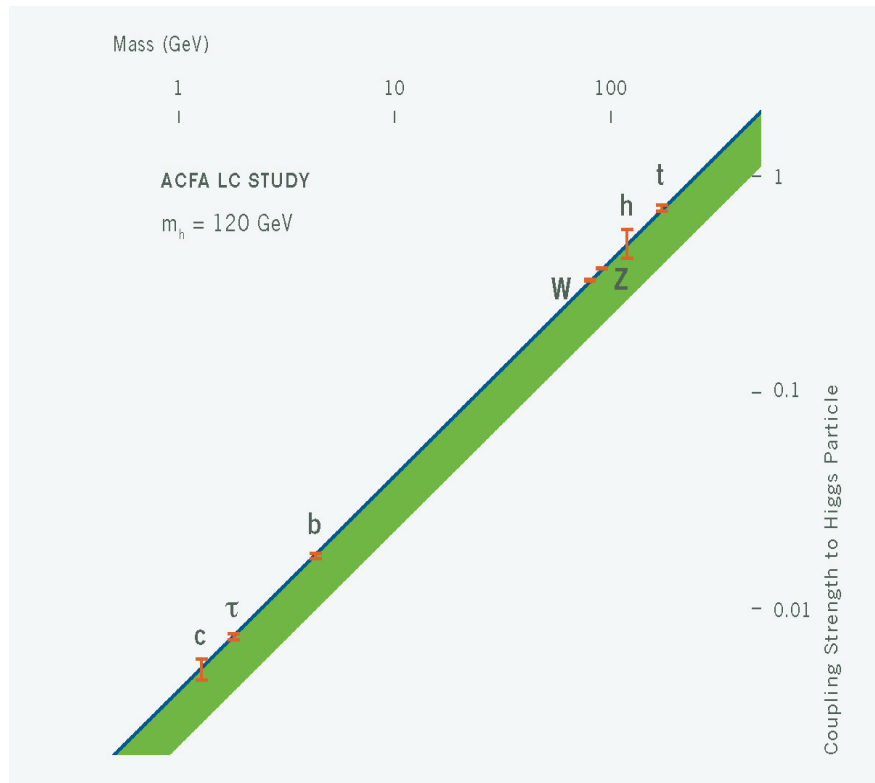
## Precision Measurements



- Higgs physics will be the bread-and-butter of the ILC. Present-day experiments suggest that the Higgs is close at hand
  - ♦ Its mass is below about 200 GeV
- Well within range of the 500 GeV ILC ...



# Physics & Technology



Higgs Couplings at ILC

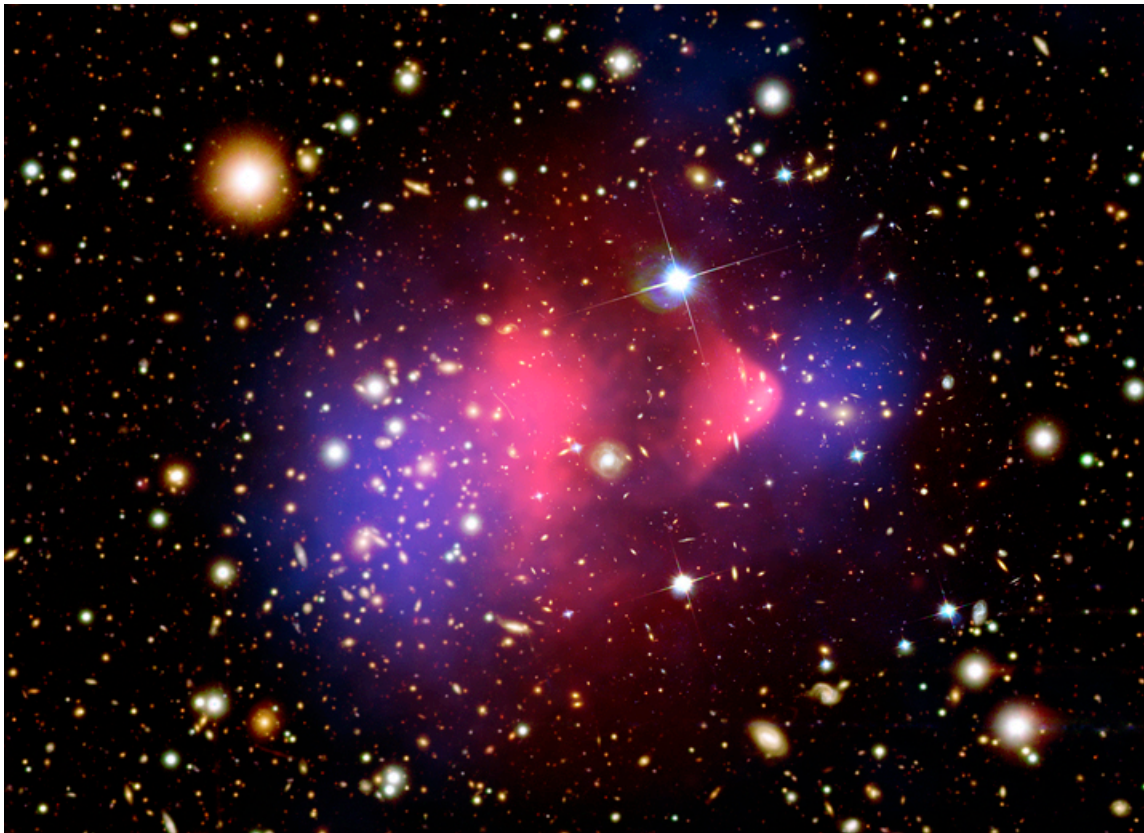
- Is a “Higgs” *the* Higgs?  
Is it the *only* Higgs?
  - ♦ Does it have the correct spin?
  - ♦ Does it have the correct couplings?
  - ♦ Does it mix with other spin-zero particles – such as radions?
- We need experiments to know for sure!



# Physics & Technology



- The astrophysical and cosmological evidence for dark matter is overwhelming. But what is it?

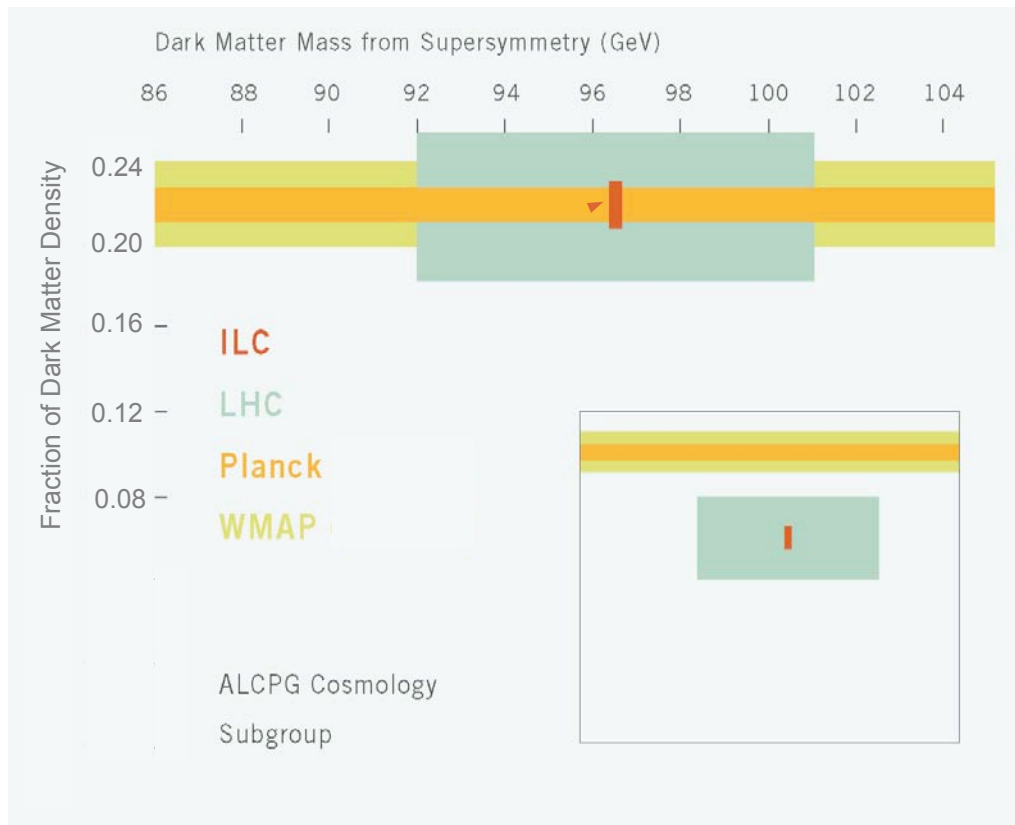


Chandra /  
Hubble images  
⇒ X-ray / optical  
synergy ...

Just like lepton /  
hadron synergy!



# Physics & Technology

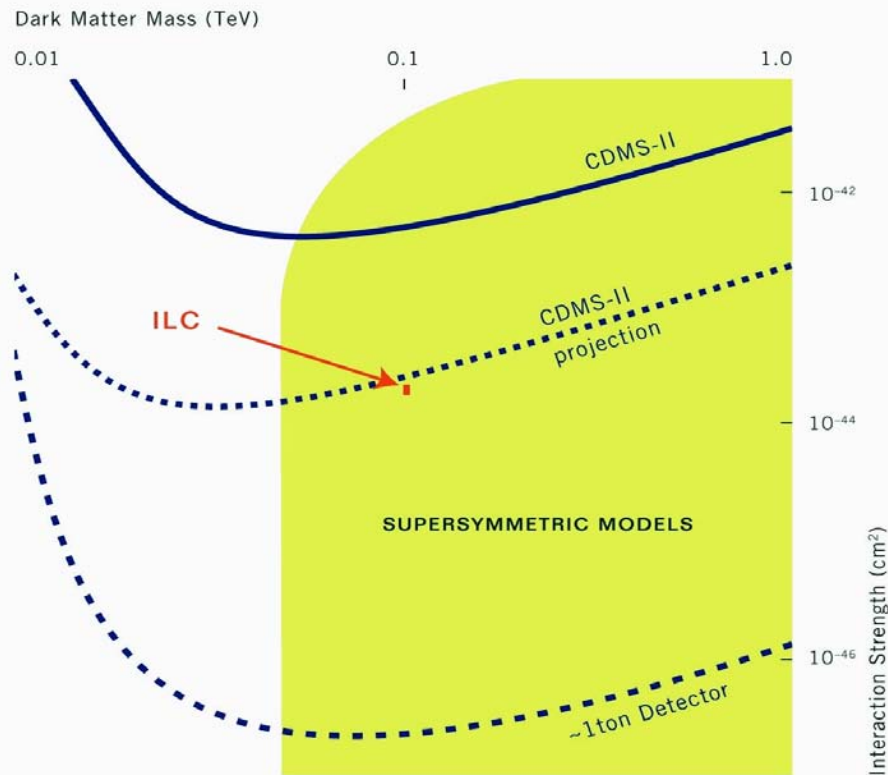


Cosmic Concordance

- Is a random LHC WIMP an official dark matter particle?
  - ♦ What is its mass?
  - ♦ What is its cross section?
- How much of the dark matter does it make up?
- A linear collider is well-suited to the task



# Physics & Technology



## Dark Matter Direct Detection

- We would like to have a triple check:
  - ◆ Astrophysics and cosmology
  - ◆ Accelerator production
  - ◆ Direct detection
- Is the dark matter candidate actually in our galactic halo?



# Physics & Technology



- To bolster the physics case
  - ◆ We can point to a long history of synergy between hadron and lepton colliders
    - In all regions of the world
  - ◆ We already have strong indications that compelling new physics waits at a TeV
    - Higgs, dark matter ...
  - ◆ The LHC will validate our expectations
    - And open our window to the Terascale



# Physics & Technology



- But a strong physics case is not enough
- Realizing a linear collider will require the great success of the LHC
  - ◆ To prove we can construct projects of such a scale
  - ◆ To validate the substantial global investment in our science
  - ◆ To engage policymakers and the public about our science
  - ◆ To demonstrate that important physics lies within reach



# Physics & Technology

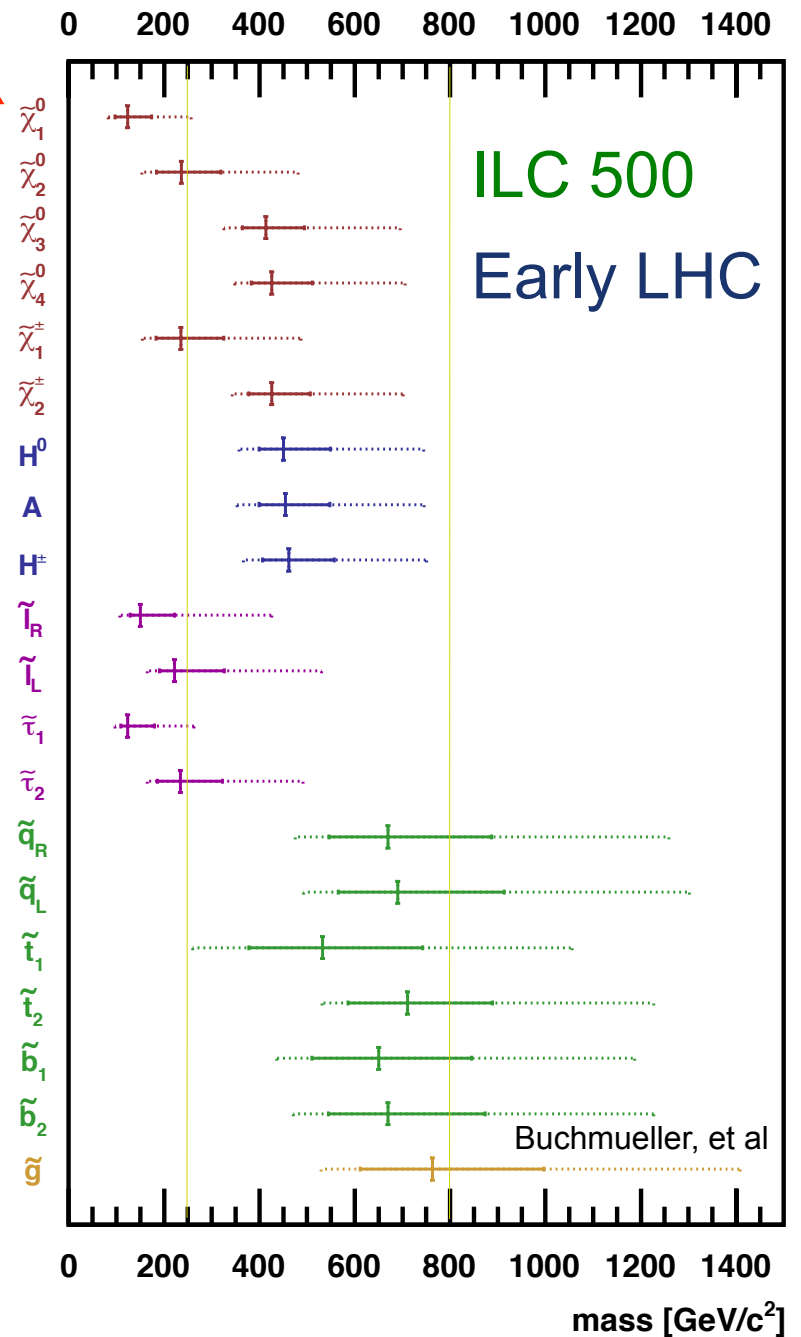


- For all these reasons, the practical case for a linear collider needs to be built on the LHC
  - ◆ At 7 TeV and  $1 \text{ fb}^{-1}$ , the LHC has great reach beyond the Tevatron
    - Approximately double for high-mass states
    - $\sim 800 \text{ GeV}$  squarks,  $\sim 1.5 \text{ TeV}$  Z-prime ...
  - ◆ We can expect the physics case to unfold over time with increasing energy and luminosity
    - The slower-than-expected start of the LHC might delay us – or it might not ... We have to be ready for anything!



# Example

- **Constrained MSSM**
  - ◆ Squarks likely – but not necessarily – within reach of early LHC
  - ◆ Light sleptons likely – but not necessarily – within reach of ILC 500
    - Neutralino LSP within reach of the initial ILC!



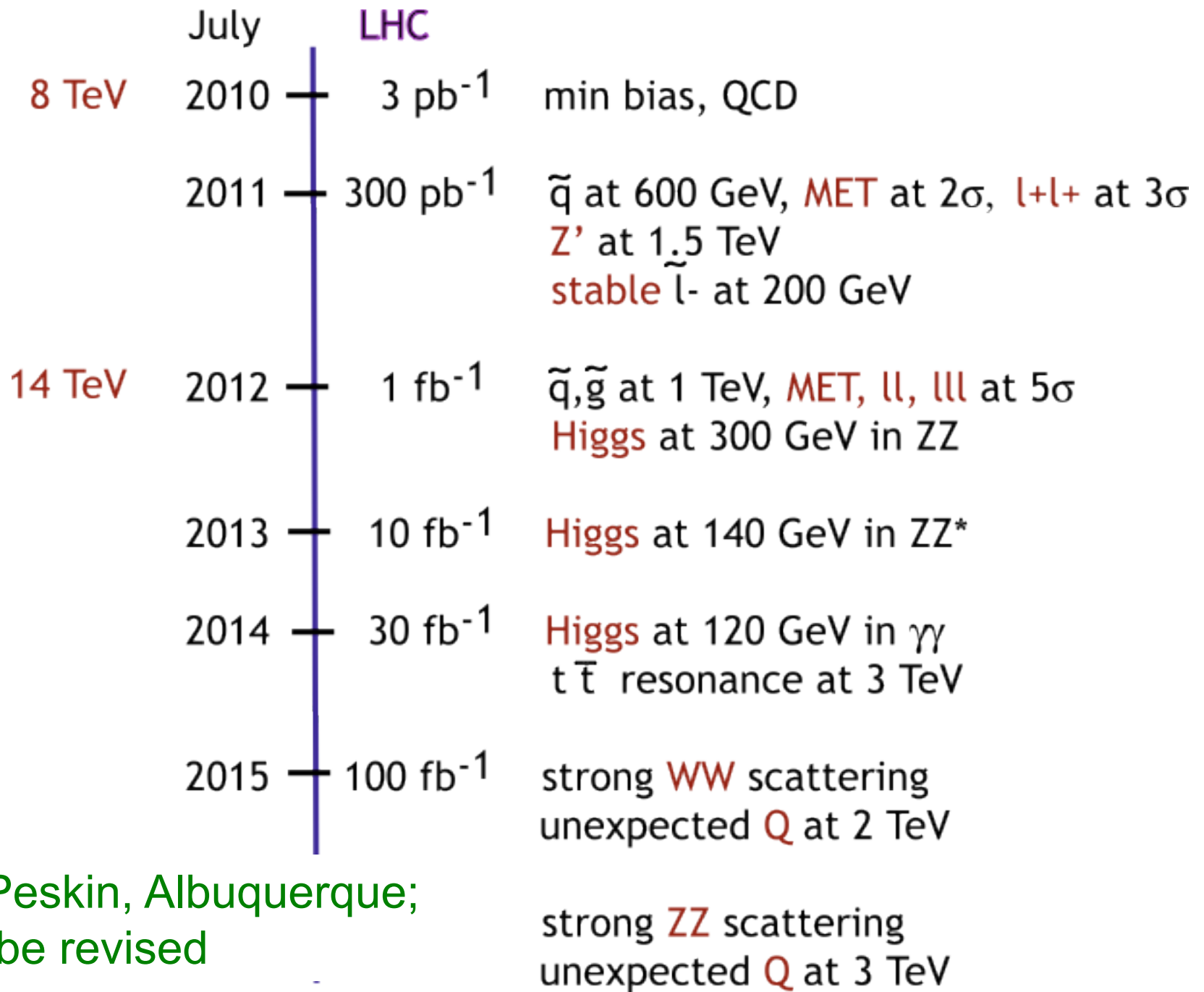


# Physics & Technology



- The RD Physics CTG, under the leadership of Michael Peskin, is taking a phased approach to LHC results
  - ◆ What are the elements of a physics case in 2012?
  - ◆ What can we expect by 2014 or 2016?
- These are precisely the right questions
  - ◆ We need to know the answers, and base our planning accordingly





M. Peskin, Albuquerque;  
will be revised



# Political Engagement



- We are fortunate to have many elements in place
  - ◆ A strong physics case
  - ◆ A credible design
  - ◆ A willingness to make tough decisions
  - ◆ A history of international collaboration
  - ◆ A legacy of broader impacts



# Political Engagement



- A credible design
  - ◆ In 2012 the GDE / RD will deliver a TDR / DBD for a 500 GeV ILC together with its detectors
    - The costs will have been scrubbed and initial optimization will have occurred
    - The accelerator and detector communities are coming together to optimize the design – with a focus on cost, risk, and physics – as well as operating costs
    - Cost containment is essential – but so is physics!



# Political Engagement



- ◆ In 2011 the CLIC collaboration will deliver a CDR to CERN Council. If approved, CLIC will produce a TDR in 2016
  - Over time, this will give a better idea about the costs, risks and physics performance of CLIC
  - CLIC offers the linear collider community a path to higher energies than the ILC can provide
  - There are many points of contact between the two approaches ⇒ Joint Working Groups



# Political Engagement



## ♦ ILC/CLIC Statement of Common Intent

- At this meeting, the collaboration has become real
- “United we stand, divided we fall.”  
(Aesop, 600 BC)

### STATEMENT OF COMMON INTENT

by the CLIC Collaboration Board and the ILC Steering Committee

**Recognising** the need for an electron-positron linear collider to explore the physics that will be revealed by the LHC,

**Considering** the synergies that exist and the opportunities for collaboration that arise between the ILC Global Design Effort and the CLIC collaboration, as well as between the ILC and CLIC physics and detector studies, and

**Building upon** the [CLIC/ILC joint statements](#),<sup>1</sup>

The two parties **agree** to promote and develop scientific and technical preparations for a linear collider, and to exploit wherever possible synergies between ILC and CLIC, including accelerator, detector and physics topics, so the designs are prepared efficiently in the best interest of high-energy physics.

The ILC Steering Committee and the CLIC Collaboration Board will foster this cooperation by agreeing, reviewing and updating a list of topics of common interest. This includes, but is not limited to, the topics listed in the Addendum to this agreement, which already form the subjects of joint ILC-CLIC Working Groups.

Signed Jonathan Bagger

Date January 11<sup>th</sup> 2010

(Jonathan Bagger)

Signed V. J. Leach

Date January 11<sup>th</sup> 2010

(Ken Peach)

on behalf of the ILC Steering Committee

on behalf of the CLIC Collaboration Board



# Political Engagement



- A willingness to make tough decisions
  - ◆ ITRP process
    - The community came together after a wrenching decision
  - ◆ RD Detector Validation process
    - Again, the community has come together to focus its limited resources on two designs
  - ◆ The SB2009 process presently playing out

These decisions stand as testaments to our strength



# Political Engagement



- A history of international collaboration
  - ◆ Look left, look right. Look front, look back.
    - Chances are your neighbors come from other countries
  - ◆ CERN was formed to overcome the divisions of WWII. SESAME is overcoming similar divisions in the Mideast.
    - Iran, Israel, Pakistan, Palestinian Authority are all members. Iraq pending...



# Political Engagement



- ◆ The LHC collaborations are world organizations

- The Olympics of Science!

ATLAS: ~3000 physicists from 37 countries

CMS: ~3000 physicists from 38 countries



同一个世界 同一个梦想  
*One World One Dream*

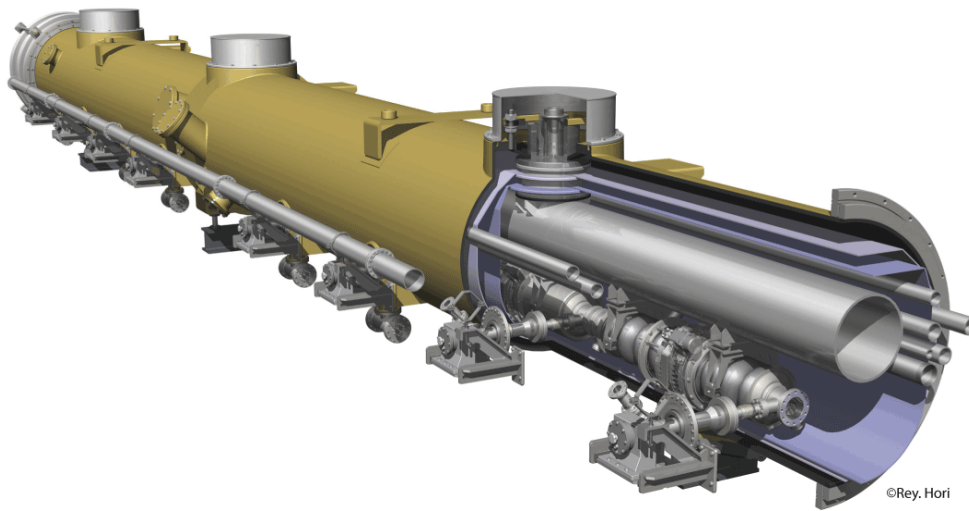




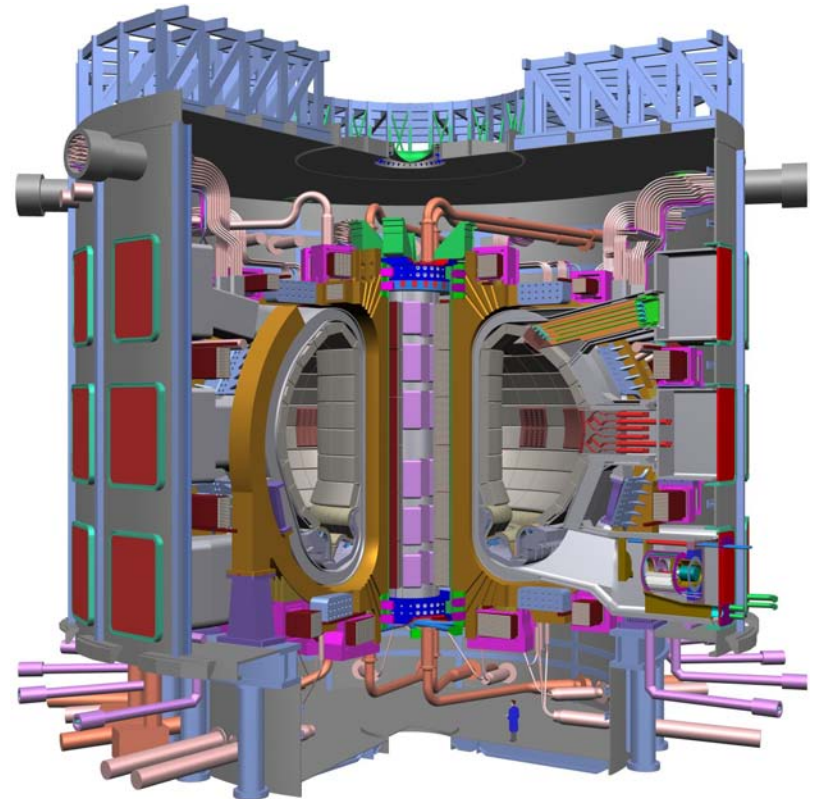
# Political Engagement



- ♦ The ILC design is well-suited to collaboration
  - 2000 identical cryomodules
  - Compare with ITER ...



We have the easier job!





# Political Engagement



- ◆ Our funding agencies are experienced in international collaboration
  - The LHC accelerator and detectors required global collaboration on an unprecedented scale
  - FALC provides a forum for personal interactions and private discussions between the relevant government officials
    - Mumbai: Started discussions about global projects, their funding and governance



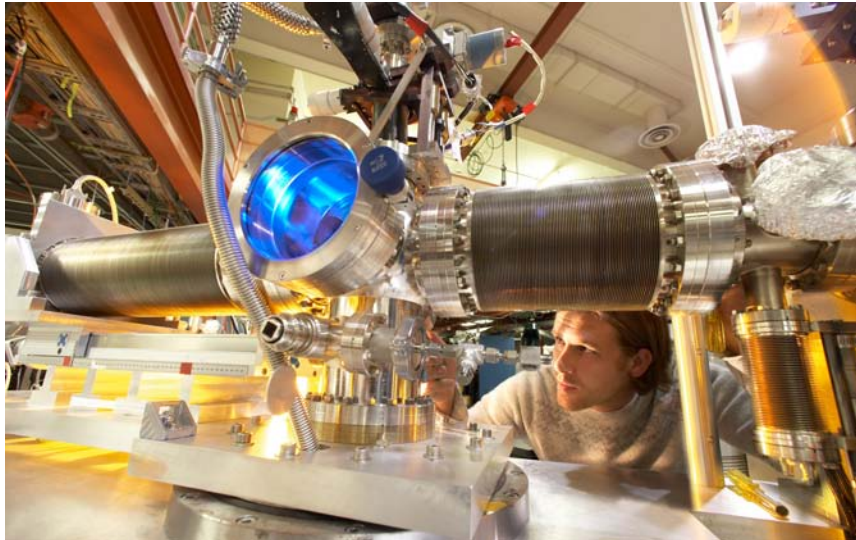
# Political Engagement



- A legacy of broader impacts
  - ◆ From medical technology to the world wide web
  - ◆ From preschool to university and beyond ...



YAHOO! Google™





# Public Outreach



- To realize the linear collider, we need to engage the public
  - ◆ We need to tell a story – one that connects our science to our deepest humanity ...
  - ◆ We live in a time with many challenges ...
    - Medicine and public health
    - Climate and environment
    - Finance and trade
  - ◆ The public is paying for our science ...
    - Politicians have a choice of investments ...  
Why should they choose us?



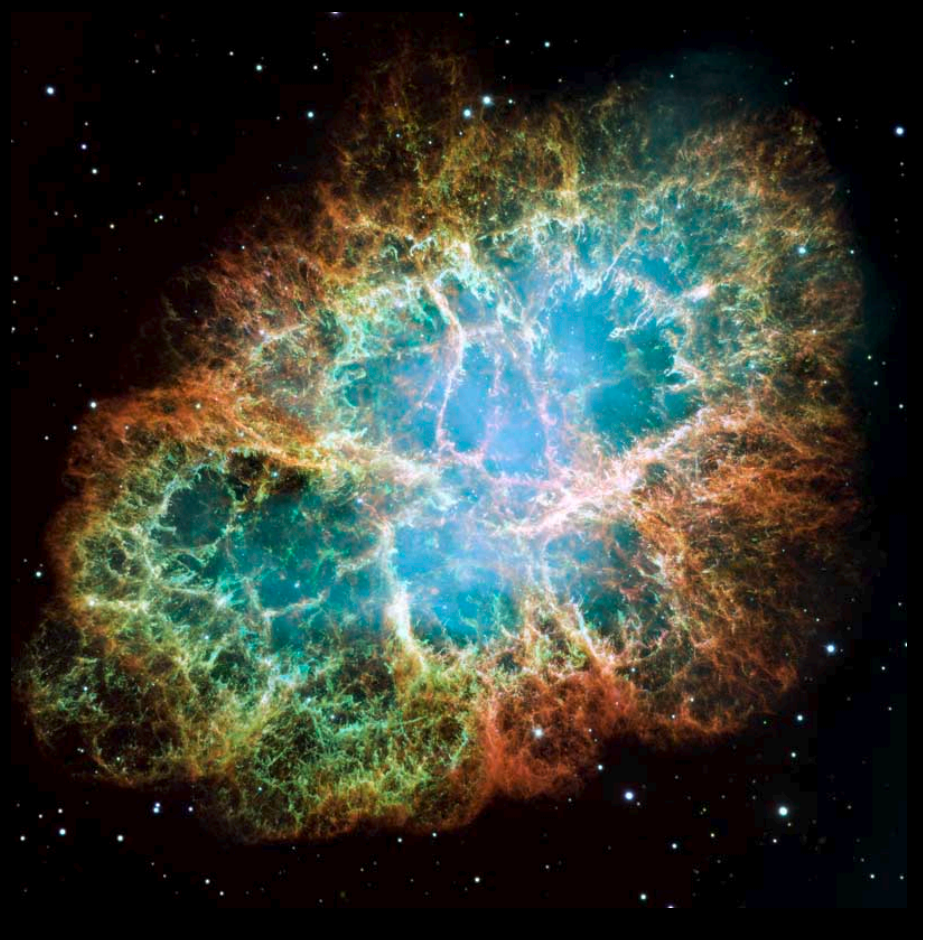
# Public Outreach



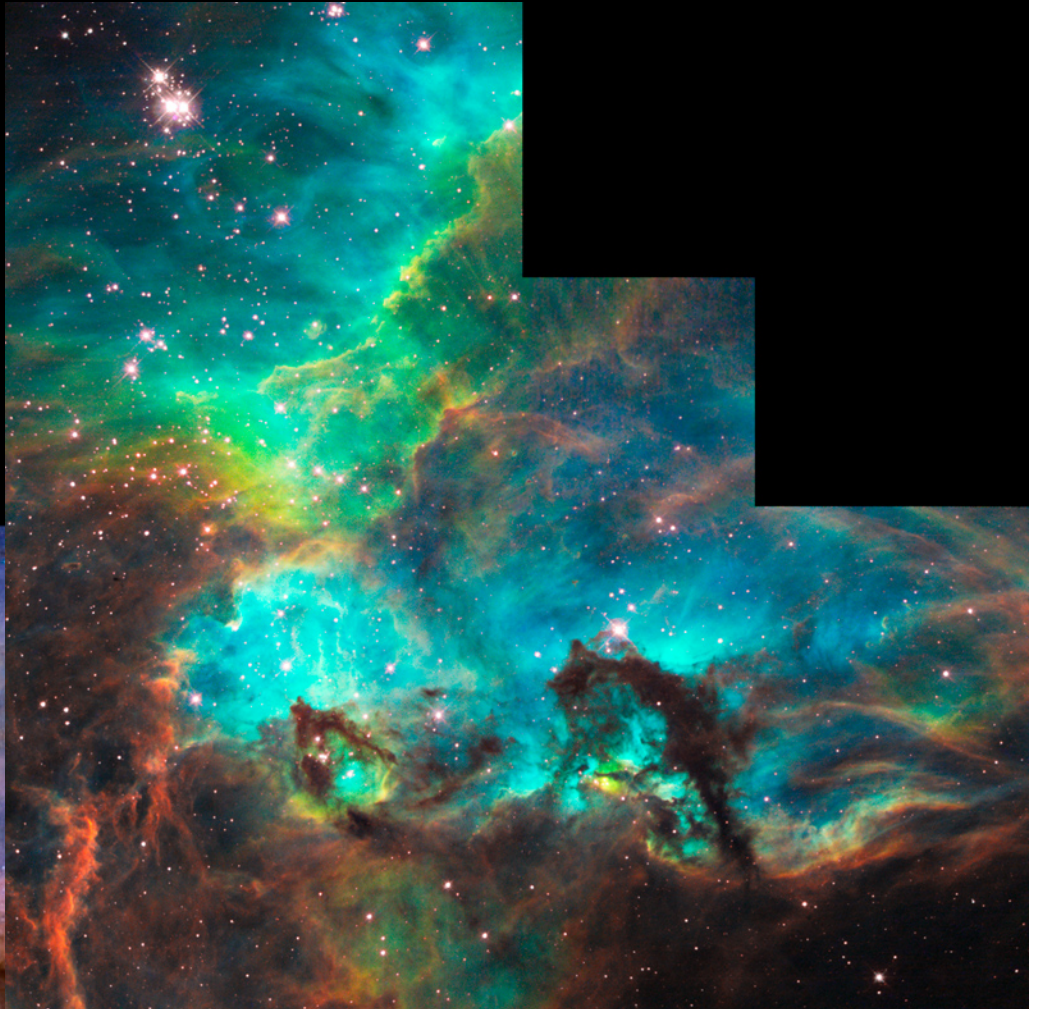
- We stand in awe of astronomers ...
  - ◆ But their pictures do not happen by accident
  - ◆ They are the result of a comprehensive strategy



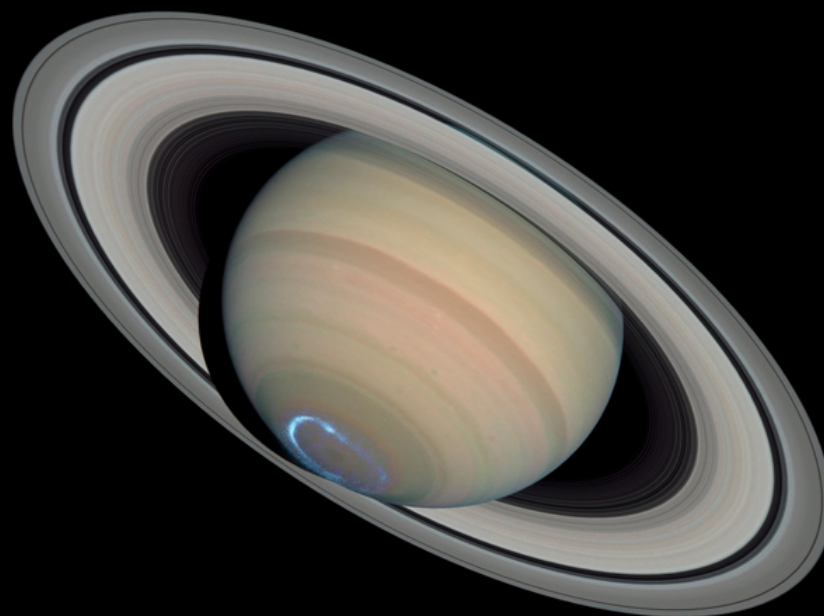














# Public Outreach



- These are iconic images
  - ◆ They have made Hubble into the People's Telescope
  - ◆ The public rose up to save it after the Columbia space shuttle disaster
    - Can you imagine the public rising to save the SSC?
- We have our own story to tell
  - ◆ But we need to tell it better than we ever have before ...



# HST Public Outreach



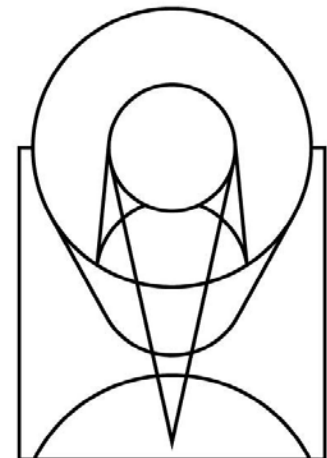
- Hubble Space Telescope outreach
  - ◆ Hubble was a \$4B project
  - ◆ Each year the Space Telescope Science Institute spends 0.1% of that amount on outreach
  - ◆ \$4.5M per year, approximately 35 FTE's
- STScI serves the schools, the press, the public
  - ◆ All while propagating a clear, coherent and consistent message



# HST Public Outreach



- View Space
  - ◆ 100 installations, changing daily, viewed by 40M visitors per year
- Amazing Space
  - ◆ K-12 and informal education materials used at over 1400 sites across the United States
- Hubble Site
  - ◆ 1.2M web views per month
- National Air and Space Museum
  - ◆ 765,000 visitors per month





# Particle Physics?



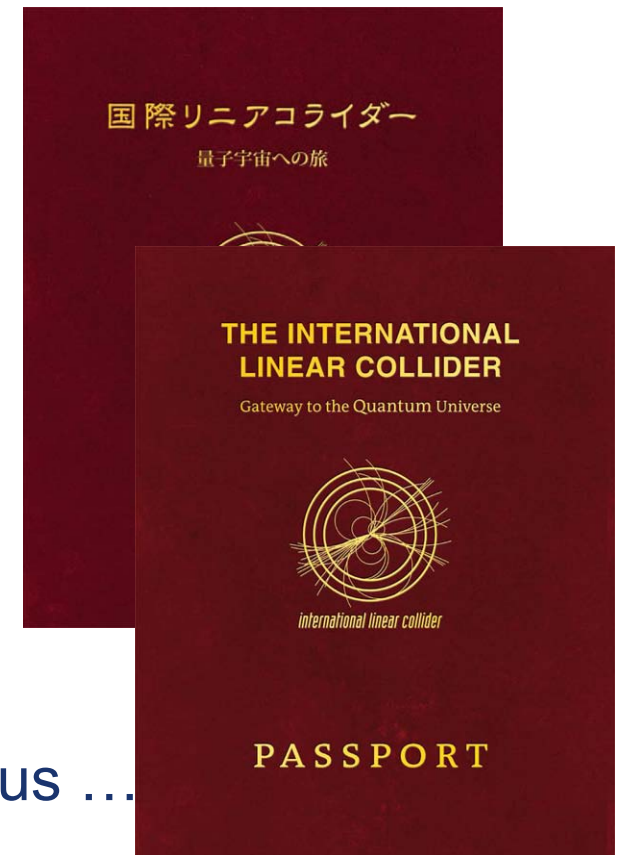
- Our story is a good one!
  - ◆ We do incredibly compelling science
    - Uncovering the elements that make up the Universe
  - ◆ We drive important technologies
    - Including accelerators, detectors, computing
  - ◆ We transcend international boundaries
    - Uniting people towards a common goal
  - ◆ We inspire the public
    - Drawing students into science and technology



# Public Outreach



- We have important pieces in place
  - ◆ Science
    - The LHC will frame the story ...
      - Just like Hubble did for JWST
  - ◆ Technology
    - The focus on risk reduction, optimization and industrialization is appropriate ...
  - ◆ Public
    - The GDE communicators are fabulous ...





# Political Engagement



Le Monde.fr

Sciences

Un effort mondial est requis pour le dernier des accélérateurs géants

LE MONDE | 15.02.07 | 15h52 • Mis à jour le 15.02.07 | 15h52

INTERNATIONAL  
Herald Tribune

宇宙創生解明へ、巨大粒子加速器は7780億円

YOMIURI ONLINE | 読売新聞

Physicists plan costly look at the beginnings of the universe

DIE ZEITUNG

国际科学家联合发布最新一代高能加速器设计报告

Wer soll das bezahlen?

Un accélérateur pour éclairer le big bang

5,5 Milliarden kostet einem neuen Bericht zufolge der modernste Teilchenbeschleuniger der Welt. Deutsche Physiker würden ihn gerne nahe Hamburg aufbauen. Von Björn Schwentker

CYRILLE VANLERBERGHE.

Publié le 10 février 2007

Actualisé le 10 février 2007 : 22h22

NEWS OF THE WEEK

PHYSICS:

International Team Releases Design, Cost for Next Great Particle Smasher

Adrian Cho



WIRED NEWS

全球物理学家准备共建新一代高能加速器

Nachrichten > Wissen > Forschung

TEILCHENPHYSIK DIE NÄCHSTE GENERATION DER LINEAR-BES  
Milliarden-Projekt für Hamburg?



# Public Outreach



- But we need to do more!
- LHC is a \$5B - \$10B project. HST was \$4B
  - ◆ Will the public get as much value from LHC?
    - Very encouraging initial signs ...
  - ◆ Are we investing enough?
    - Using the Hubble 0.1% rule, we need 50-100 FTE's worldwide to help us develop, propagate and sustain our story ...
    - We are not there yet ...





# Public Outreach



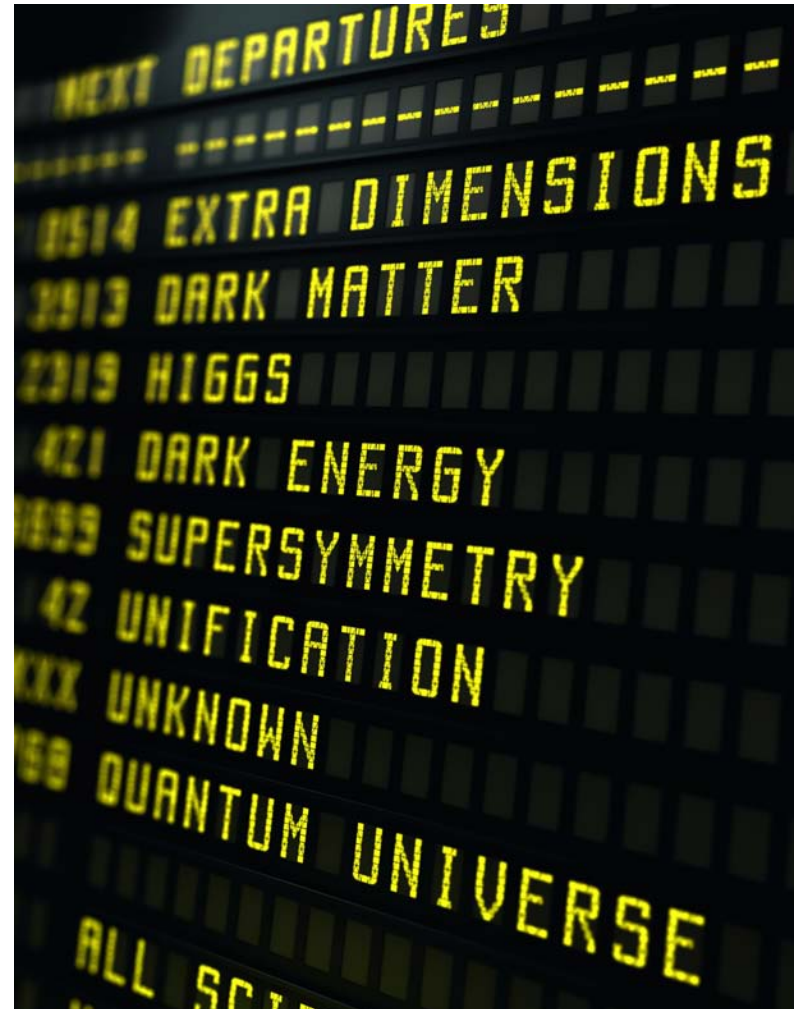
- It is important to develop a single narrative, one that reflects the global nature of our science
  - ◆ CERN, FNAL, KEK, SLAC, DESY ...
    - Again, encouraging signs ... [interactions.org](http://interactions.org)
- We need a seamless tale, one that touches the soul and builds from LHC to LC and beyond
  - ◆ Public engagement is one of our most important products ...
    - We can learn from the astronomers ...



# Path Forward



- Keep head down
  - ◆ Rocky global economy
  - ◆ Don't risk a “no”
- Celebrate the LHC
  - ◆ And all its success!
- Prepare for 2012 +
  - ◆ Accelerators *and* detectors...





# Path Forward



- Before 2012
  - ◆ Finish TDR / DBD for accelerator and detectors
    - Balance cost, risk, operations and physics
    - Contain costs while retaining essential physics
      - ... Remembering that Hubble cost \$4B
  - ◆ Prepare Project Implementation Plan
    - Governance, project structure, financing models, and siting
      - ... Emphasizing parts where physicists have special expertise



# Path Forward



- Post 2012

- ◆ Keep our momentum!

- Continue work on ILC accelerator and detectors
- Push towards CLIC TDR in 2016

So we are ready, no matter what the LHC finds

- ◆ Prepare for news from the LHC

- Higgs in ~2015, new physics possibly earlier
- Prepare to be flexible
- Be ready to move quickly – when the time is right



# Path Forward



- Post 2012

- ◆ Engage our funding agencies
  - Through ILCSC, ICFA and FALC
- ◆ Reach out to the public and fellow scientists
  - But beware of hubris ...

See Barry Barish's recent talk at AAAS

- ◆ Stay together
  - We are one global community





- In the next few years, and particularly after 2012, we will need nerves of steel ...
  - ◆ We will need to be nimble to adapt quickly to a changing landscape
  - ◆ In this way we can marshal support for the linear collider we know we need ...

Be it ILC or CLIC

... to light the Terascale



- The ILCSC represents you
  - ◆ It is ILCSC's job to guide this difficult process to a successful conclusion. But it needs your help
- Please share your thoughts with the Committee
  - ◆ Jonathan Bagger (Chair), Carlos Avila, Hesheng Chen, Persis Drell, Juan Fuster, Rolf Heuer, Sachio Komamiya, Joachim Mnich, Tatsuya Nakada, Won Namkung, Pier Oddone, Satoshi Ozaki, Roy Rubinstein (Secretary), Alexander Skrinsky, Atsuto Suzuki, Harry Weerts



