PROCEEDINGS OF SCIENCE

PoS(LCPS2009)001

Potential Physics Impact of The Linear Collider

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Potential Physics Impact

of

The Linear Collider

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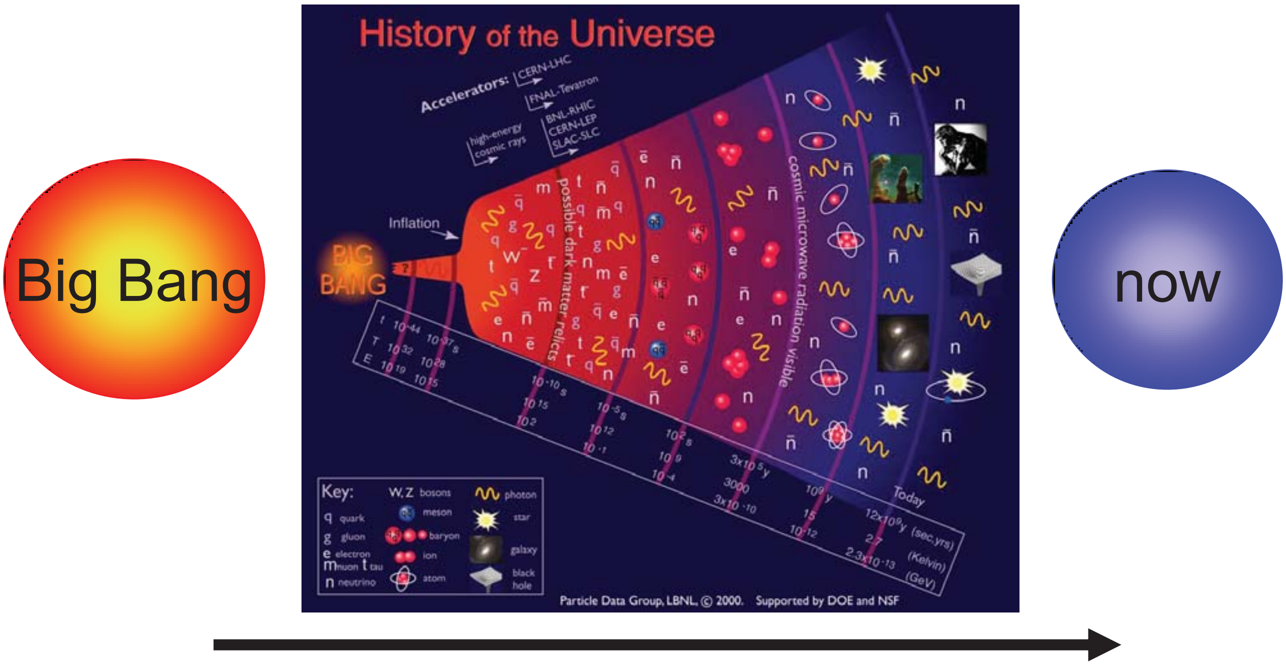
Outline

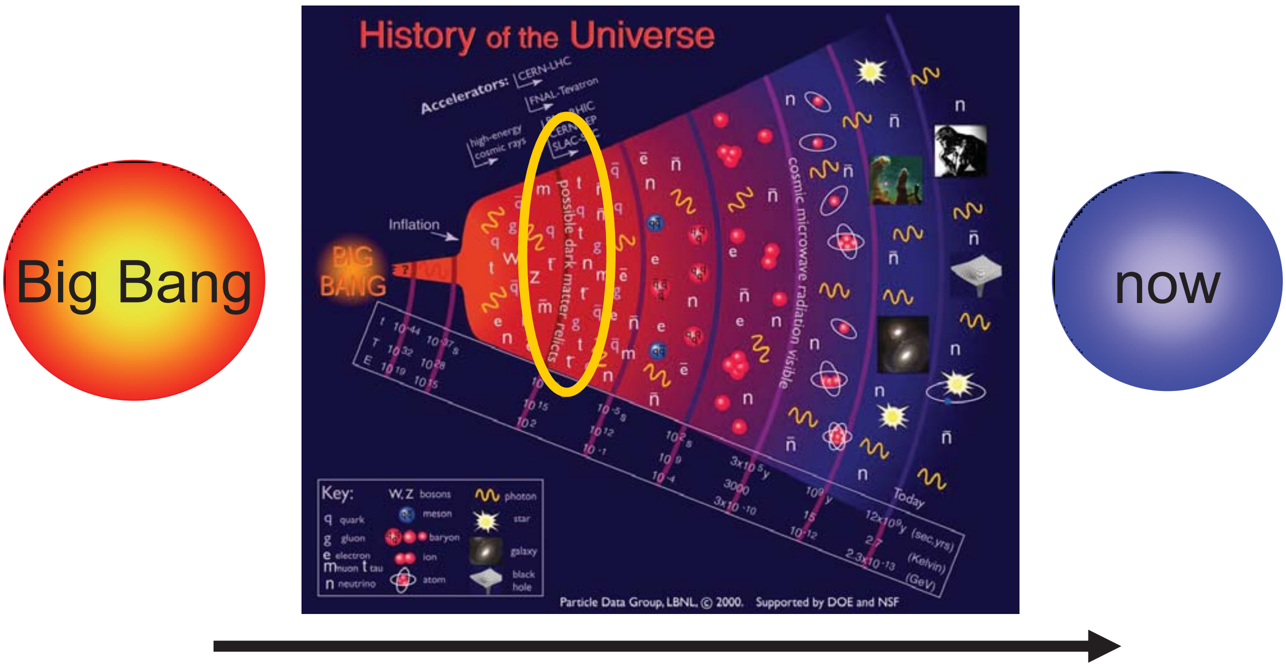
- General motivation
- Electron-positron collisions
- Linear Collider physics overview
- Accelerator issues
- Linear Collider status
- Outlook

Revealing the origin of the universe



Older ….. larger … colder ….less energetic

Telescopes to the early universe



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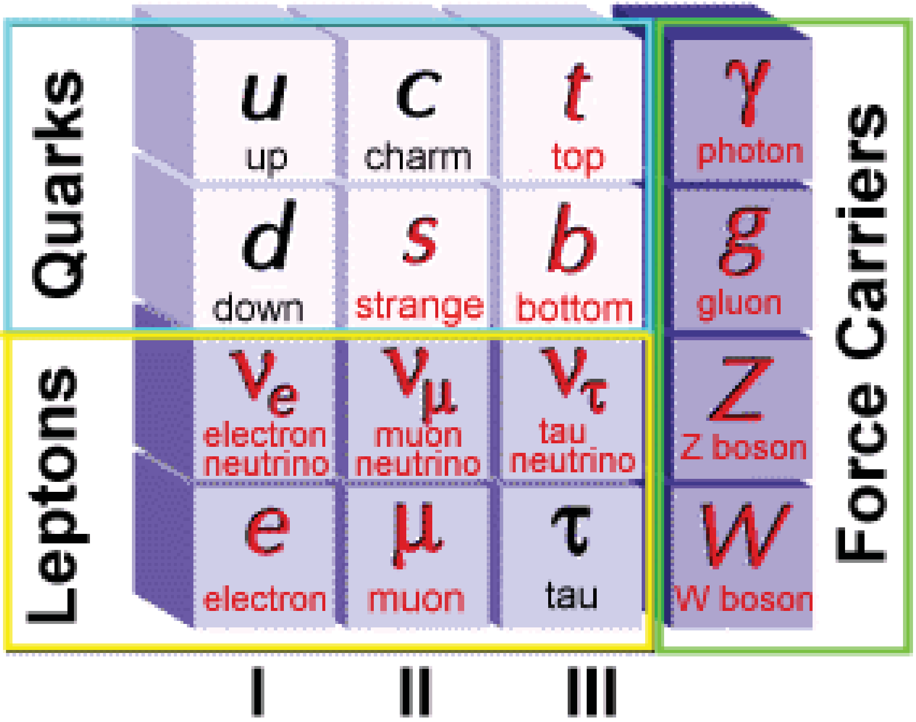
Particle Physics Periodic Table



Profound Questions

- **Why do the particles all have different masses, and where does the mass come from?**

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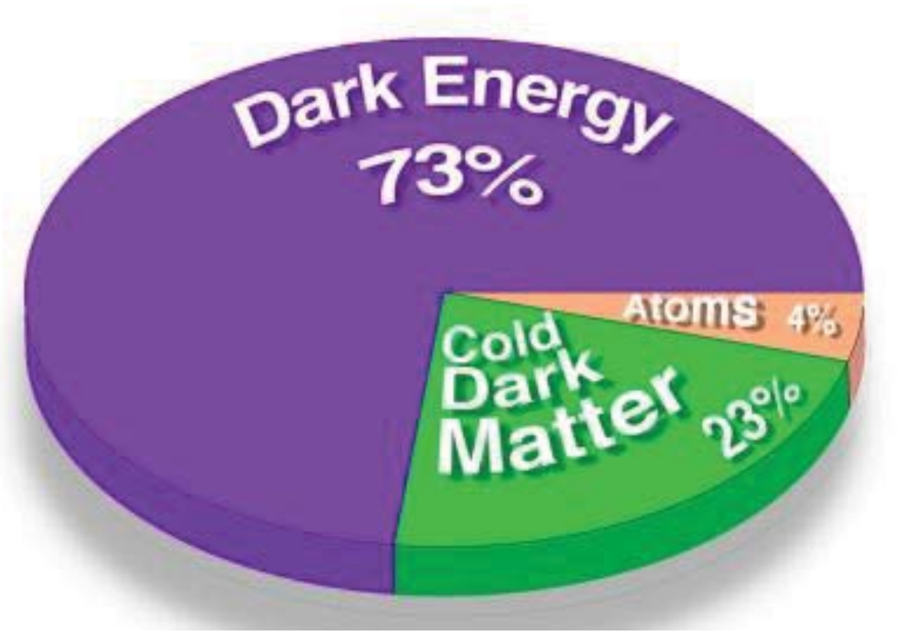
- Why are the building blocks fermions and the force carriers bosons?
- Why are there 3 forces? (+ gravity!)
- Why are there 3 generations of building blocks?
- Where did all the antimatter go?

Composition of the universe



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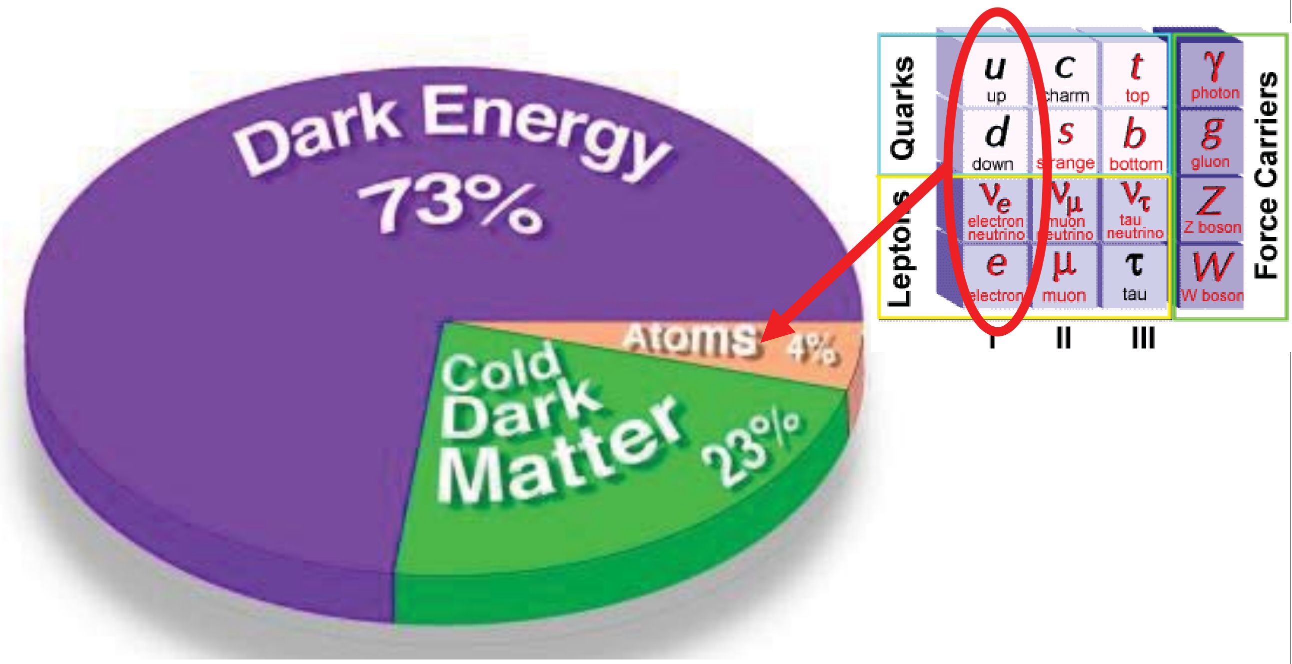

More Profound Questions

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Even More Profound Questions

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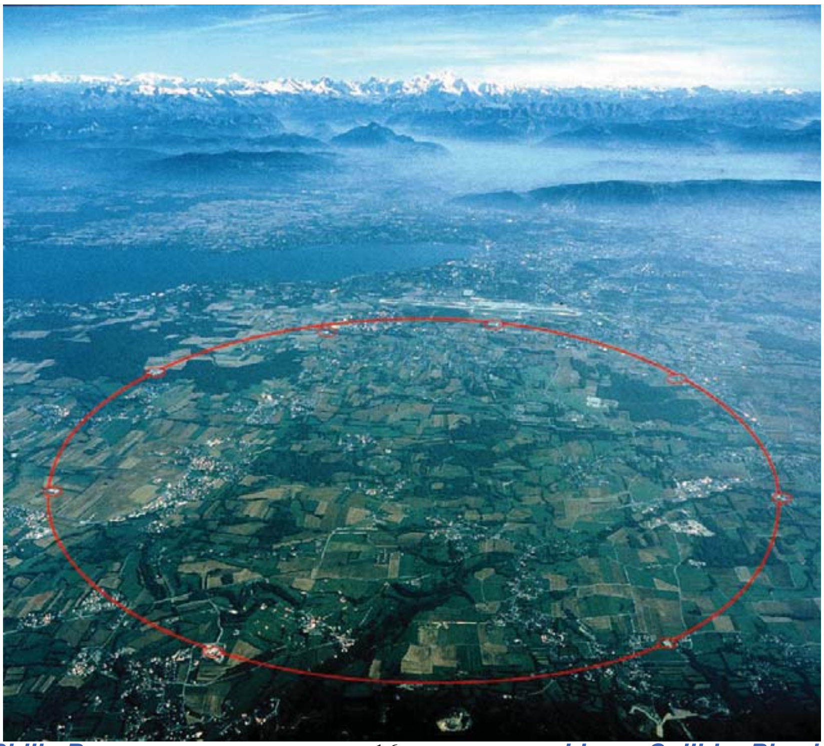
- **What is the 23% dark matter content made of?**
- **What is the 73% 'dark energy'?**

Large Hadron Collider (LHC)



collide proton beams of 7 TeV

ICFA Statement on LC (1999)

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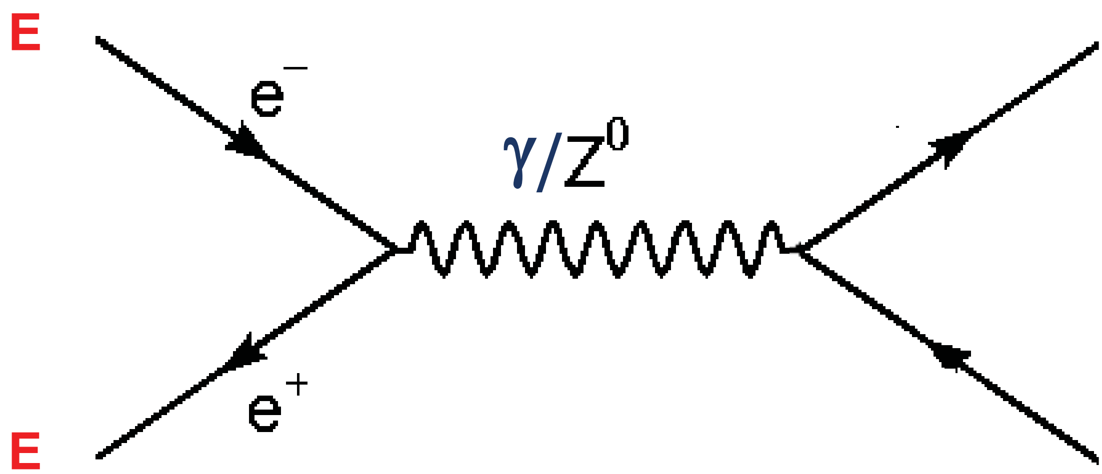
Just as our present understanding of the physics at the highest energy depends critically on combining results from LEP, SLC, and the Tevatron, a full understanding of new physics seen in the future will need both types of high-energy probes.'

e+e- colliders

- **Produce annihilations of point-like particles under controlled conditions:**

e+e- annihilations



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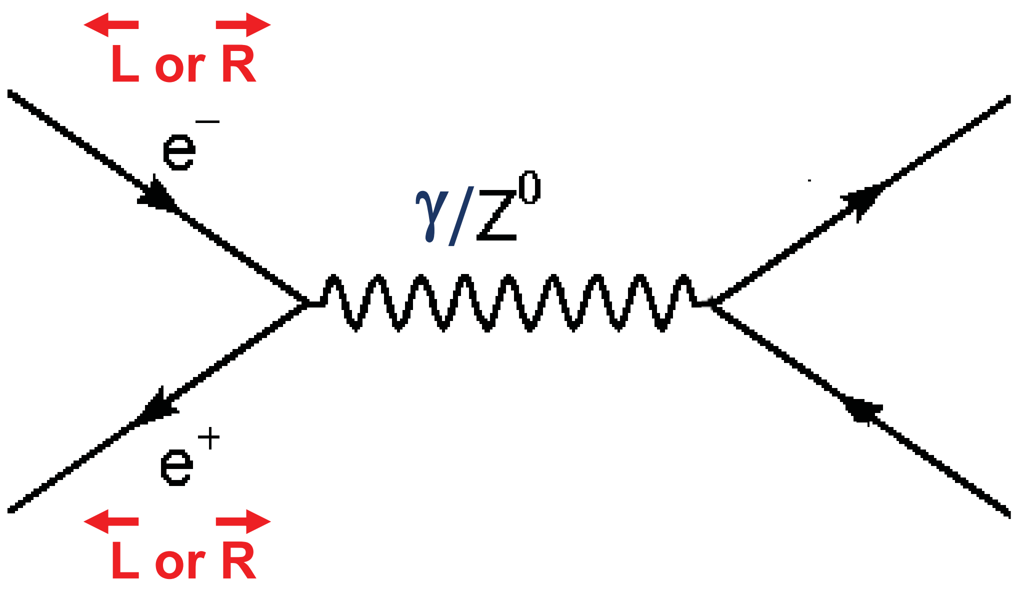

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  complete control of event kinematics: p = 0, M = 2E

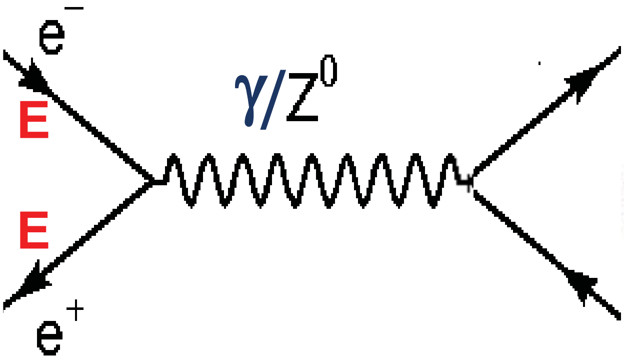
  highly polarised beam(s)

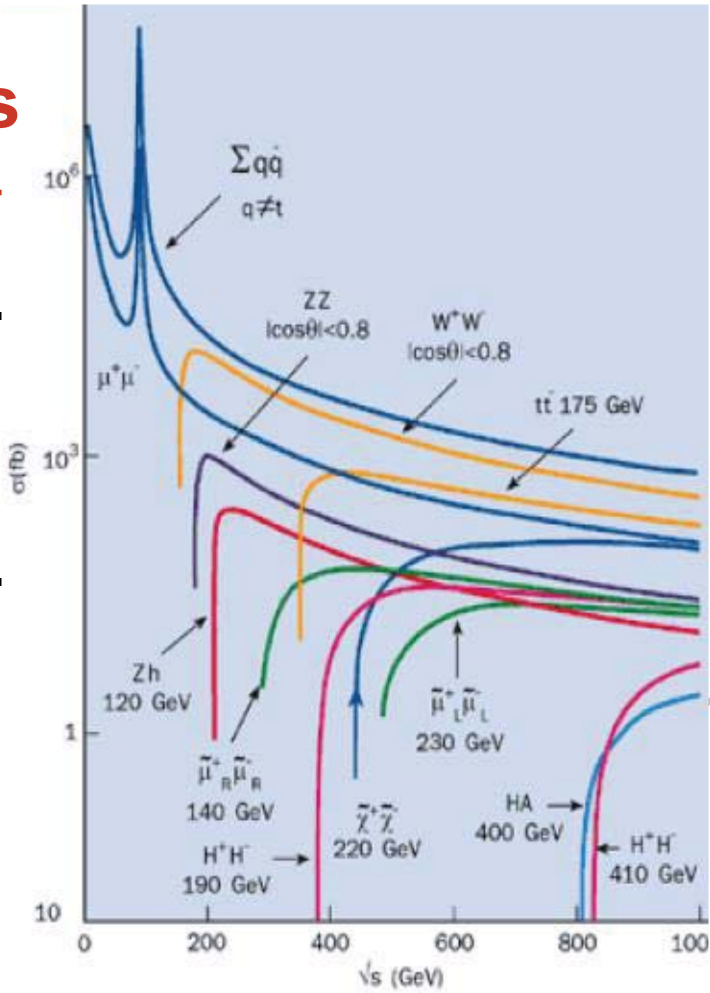
  clean experimental environment

- **Give us a precision microscope:**

  masses, decay-modes, couplings, spins, handedness, CP properties … of new particles

e+e- annihilations





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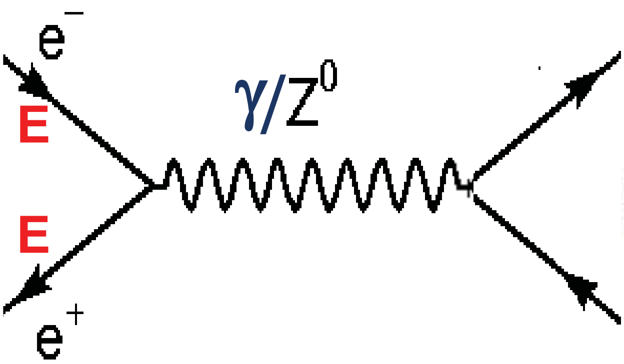

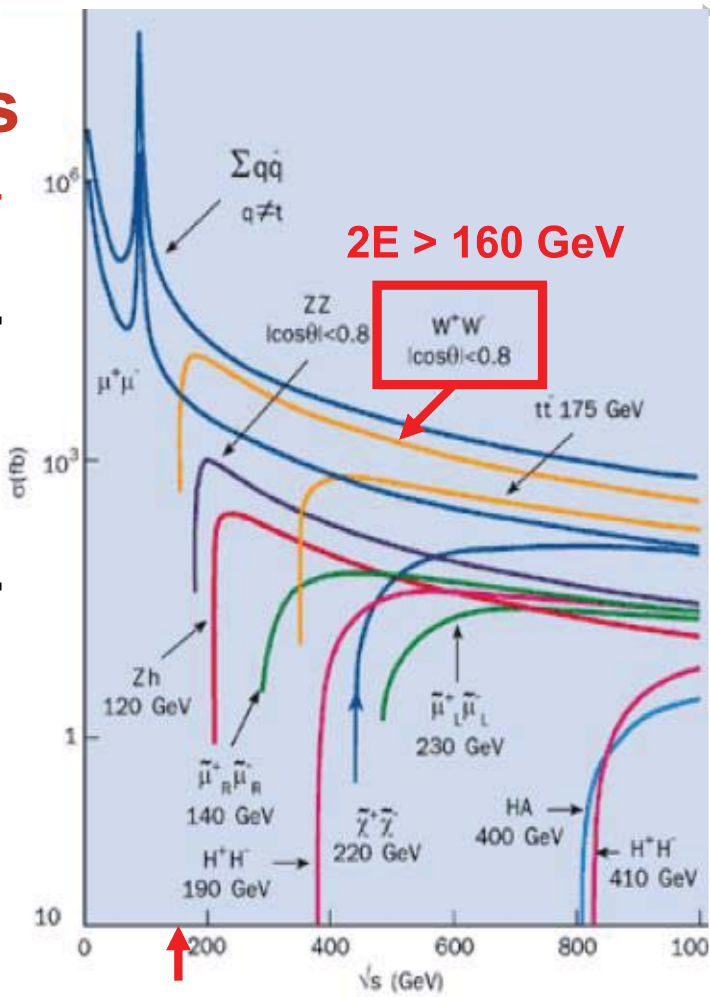

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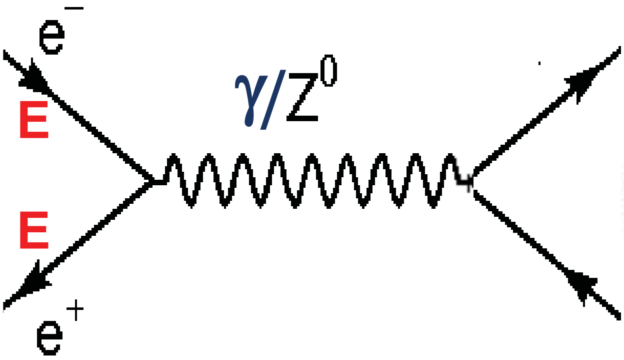

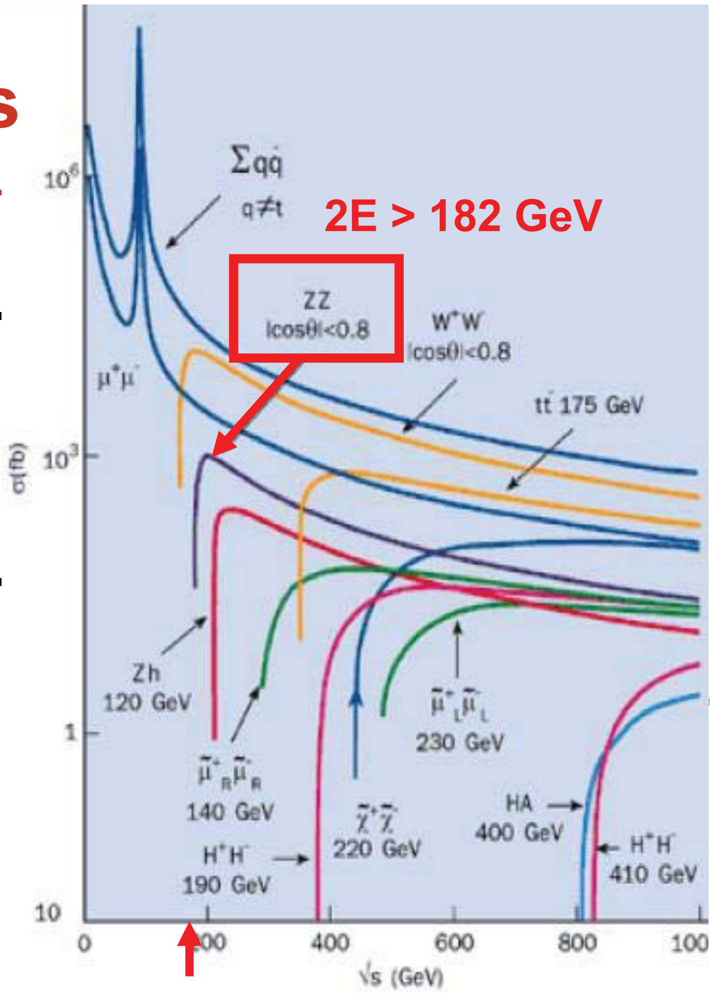

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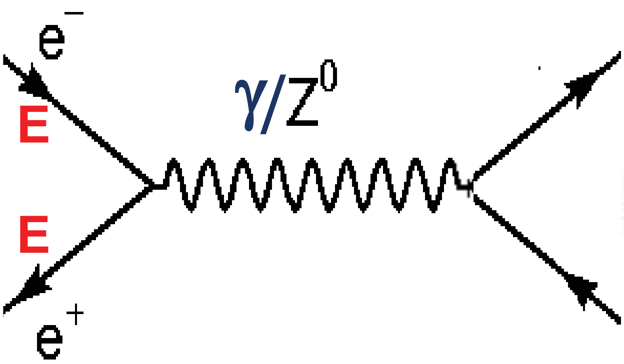
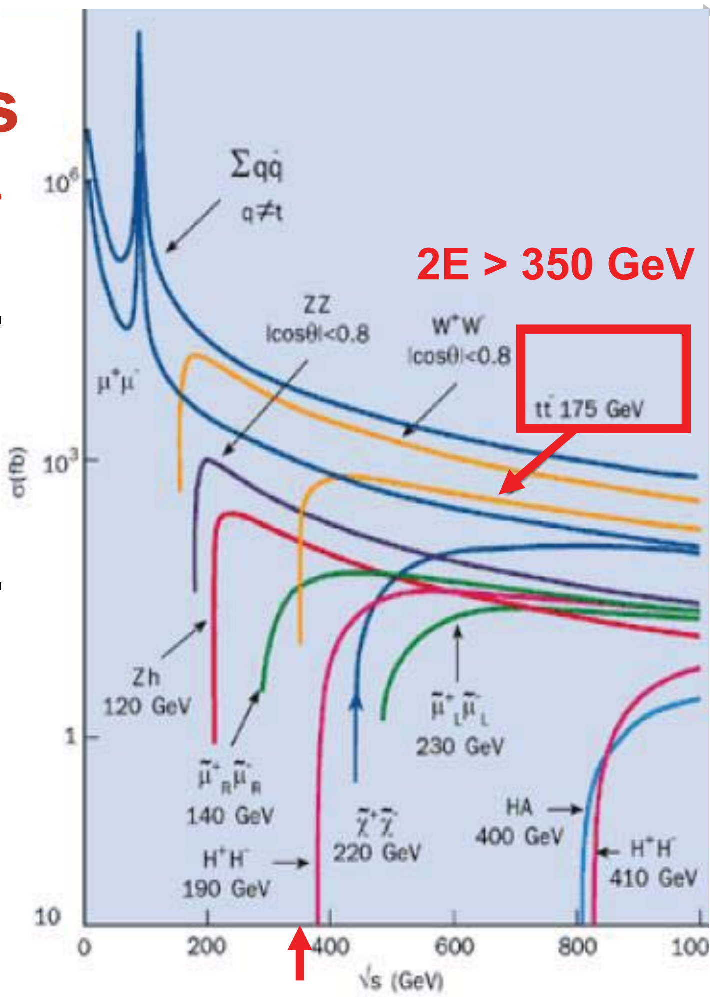


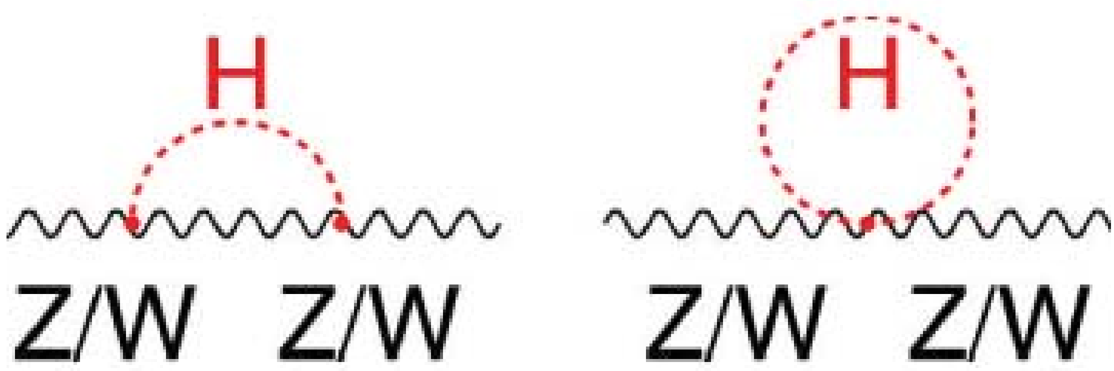


Where to look for the Higgs Boson?

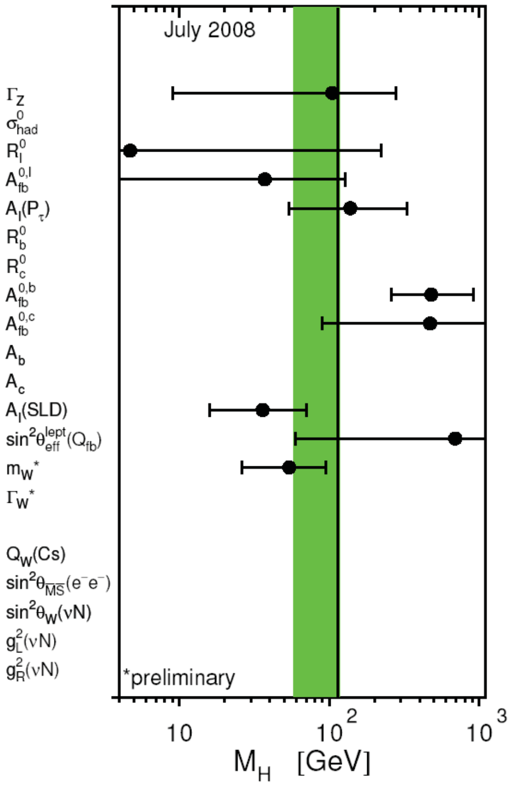
1. Direct production of Higgs bosons in electron-positron annihilations and hadron-hadron collisions

2. Indirect effects of Higgs bosons via radiative corrections to sensitive observables
   ('Lamb shift')

Radiative Corrections



M_H from radiative corrections



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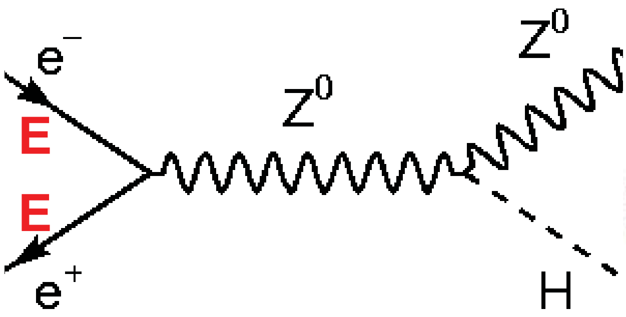
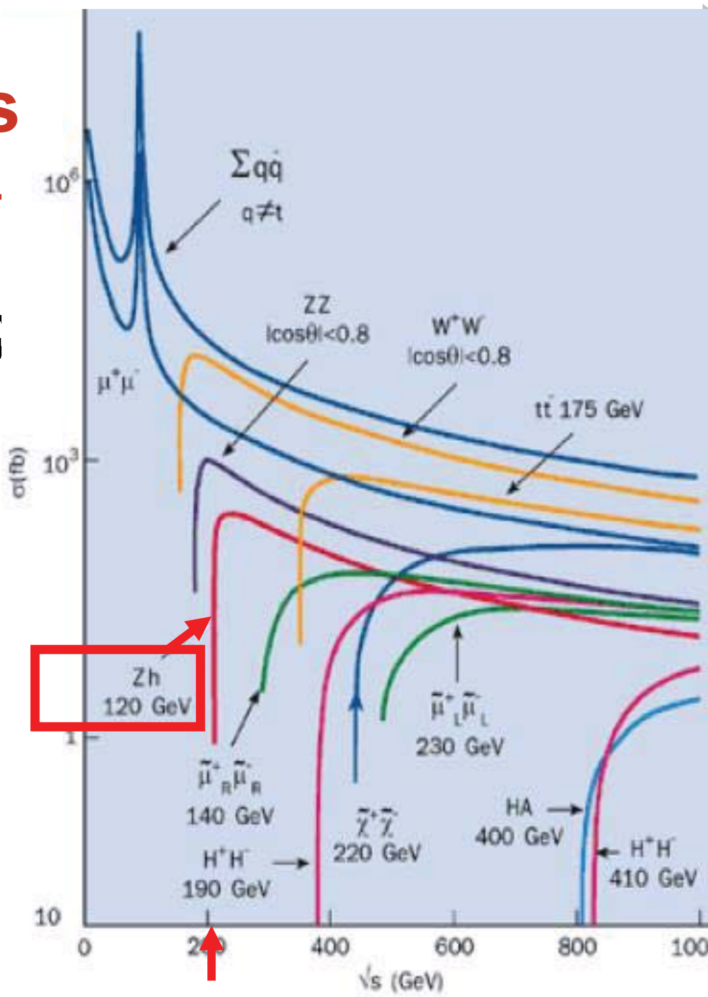
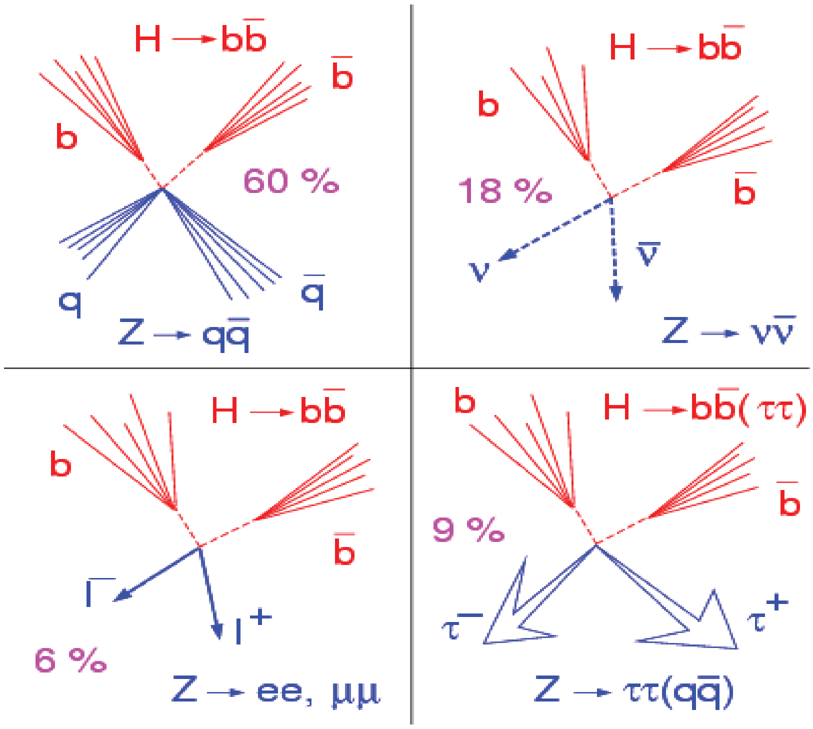


2E > 210 GeV



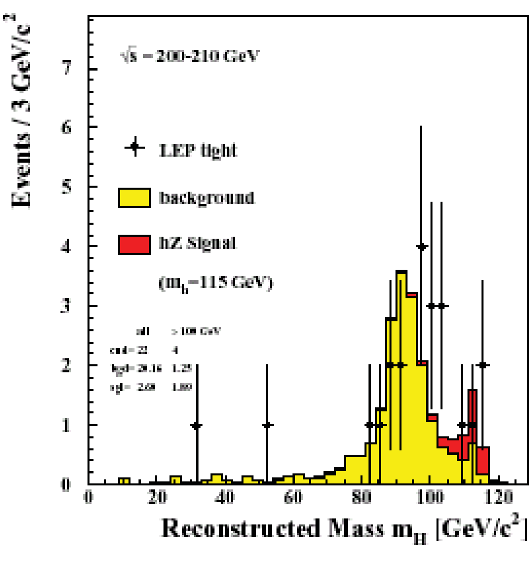
ZH event signatures



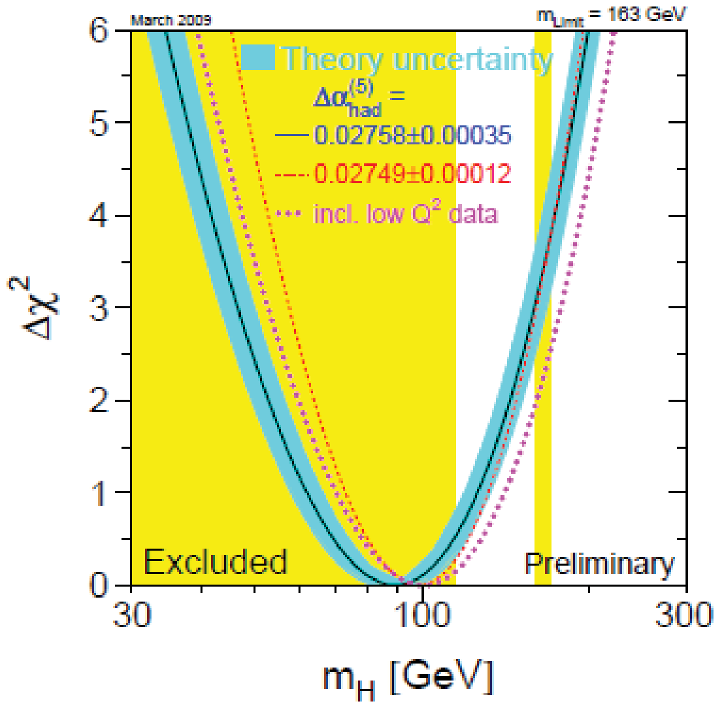
Current Experimental Situation

- **No Higgs boson yet observed directly …**

  (possible hint at LEP: M_H ~ 115 GeV)



Current Experimental Situation

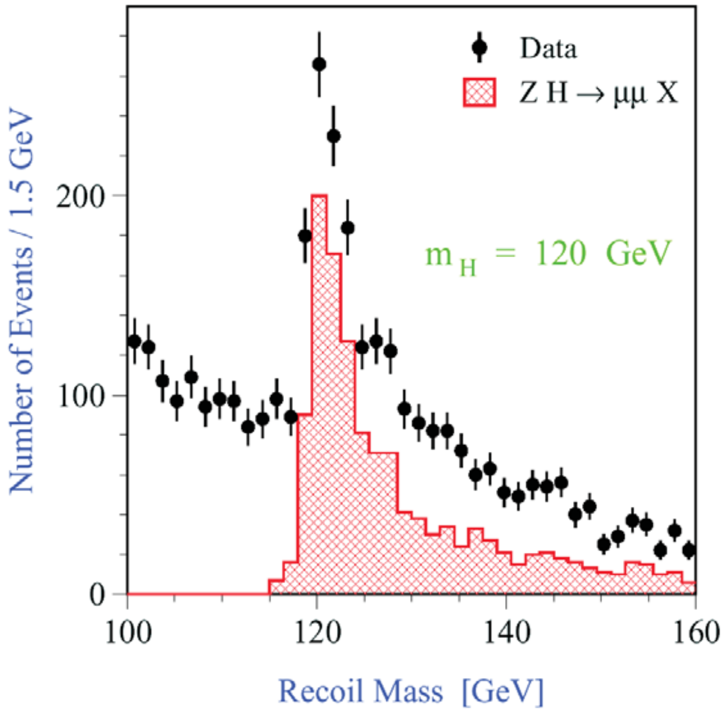


Current Experimental Situation

$m_H = 90^{+36}_{-27}$ GeV

$114 < m_H < 163$ GeV (95% c.l.)

Higgs mass measurement

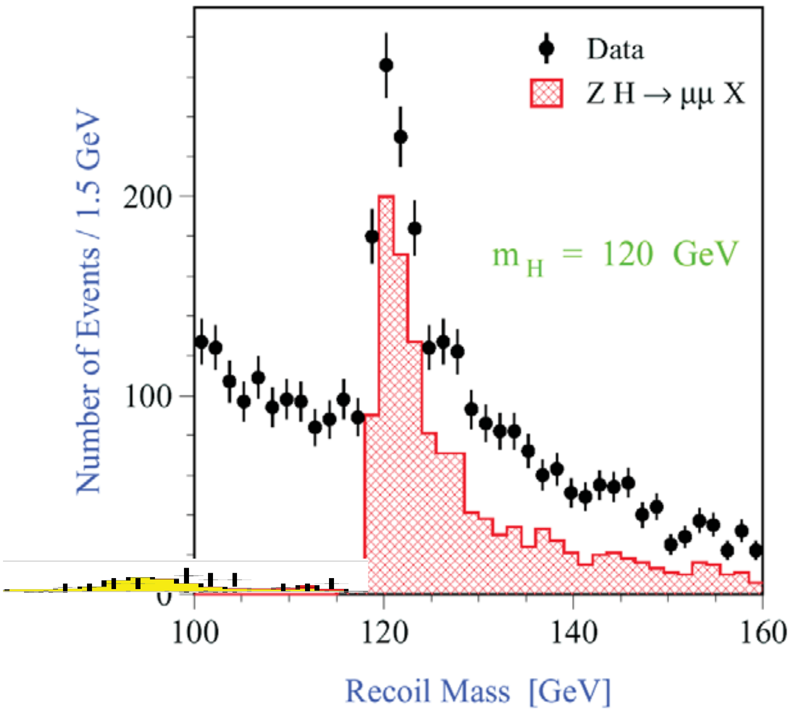


Recoil mass:
- independent of Higgs decay

Discovery mode for 'H' decay to weakly-interacting particles

(TESLA TDR)

Higgs mass measurement



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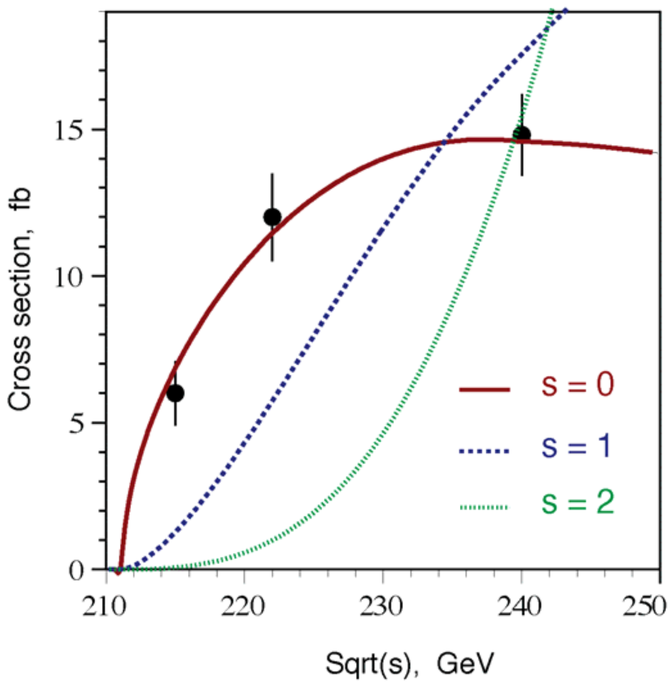
The Higgs Boson: profile

Determine 'Higgs profile':

- **Mass**
- **Width**
- **Spin**
- **CP nature**
- **Coupling to fermions ~ m**
- **Coupling to gauge bosons ~ M**2**
- **Yukawa coupling to top quark**
- **Self coupling → Higgs potential**

Higgs spin determination

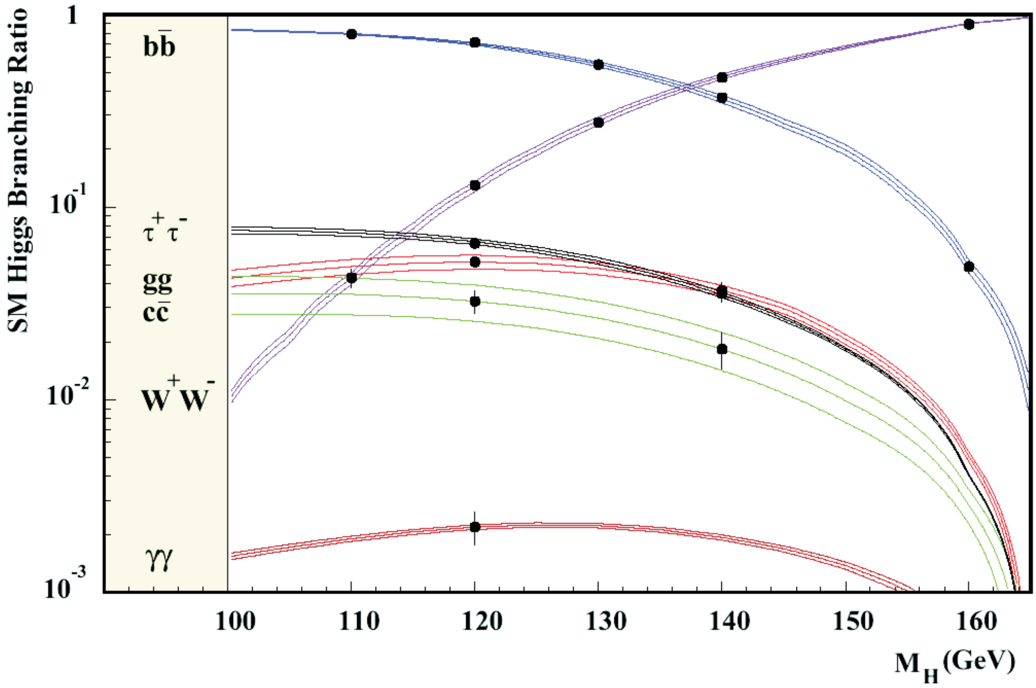
Rise of cross-section near threshold



(TESLA TDR)

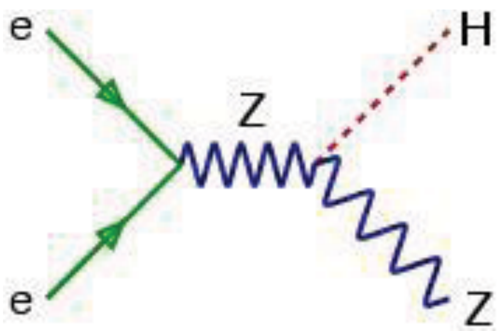
Higgs branching ratios determination

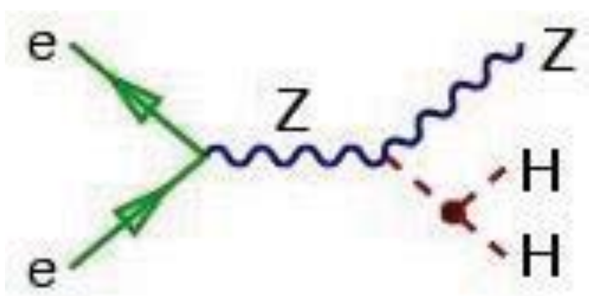
High precision silicon VXD

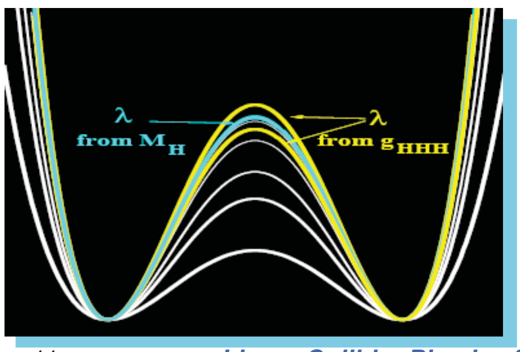


(TESLA TDR)

Higgs self-coupling determination





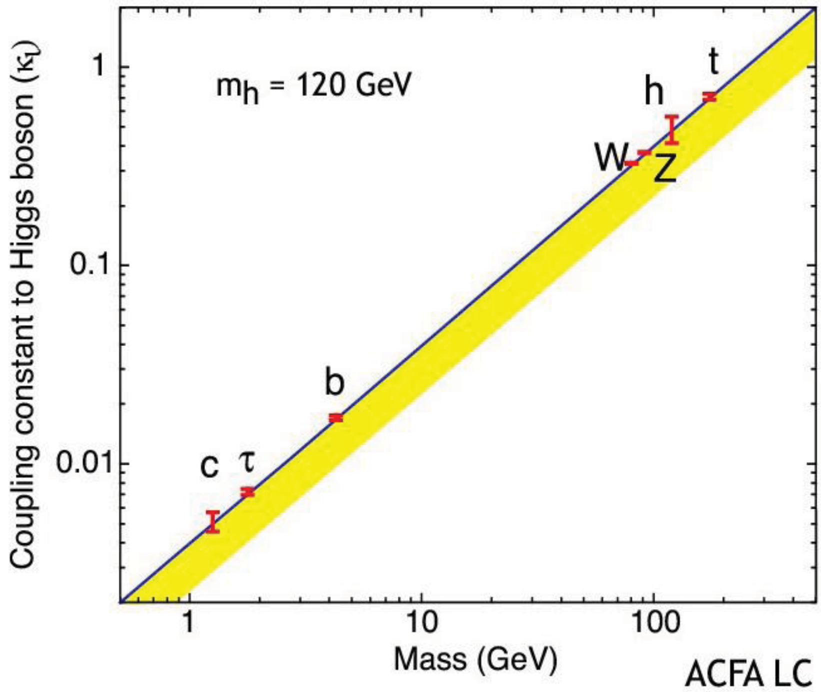


(Nomerotski)

Higgs Boson profile

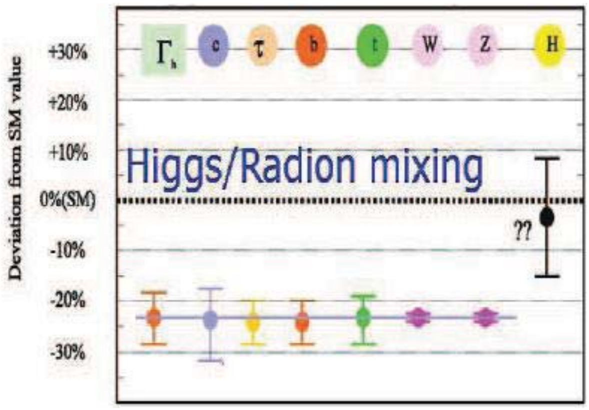
• Mass		50 MeV
• Width		4-13%
• Coupling to fermions:	bottom	0.02
	charm	0.10
	tau	0.05
• Coupling to gauge bosons:	W	0.02
	Z0	0.01
• Yukawa coupling to top quark		0.06
• Self coupling		<20%

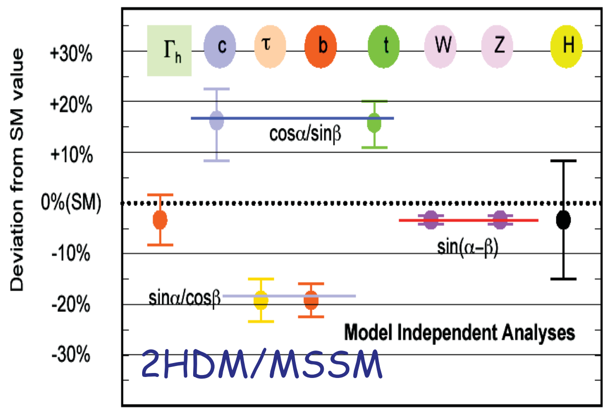
Higgs coupling map



ACFA LC study

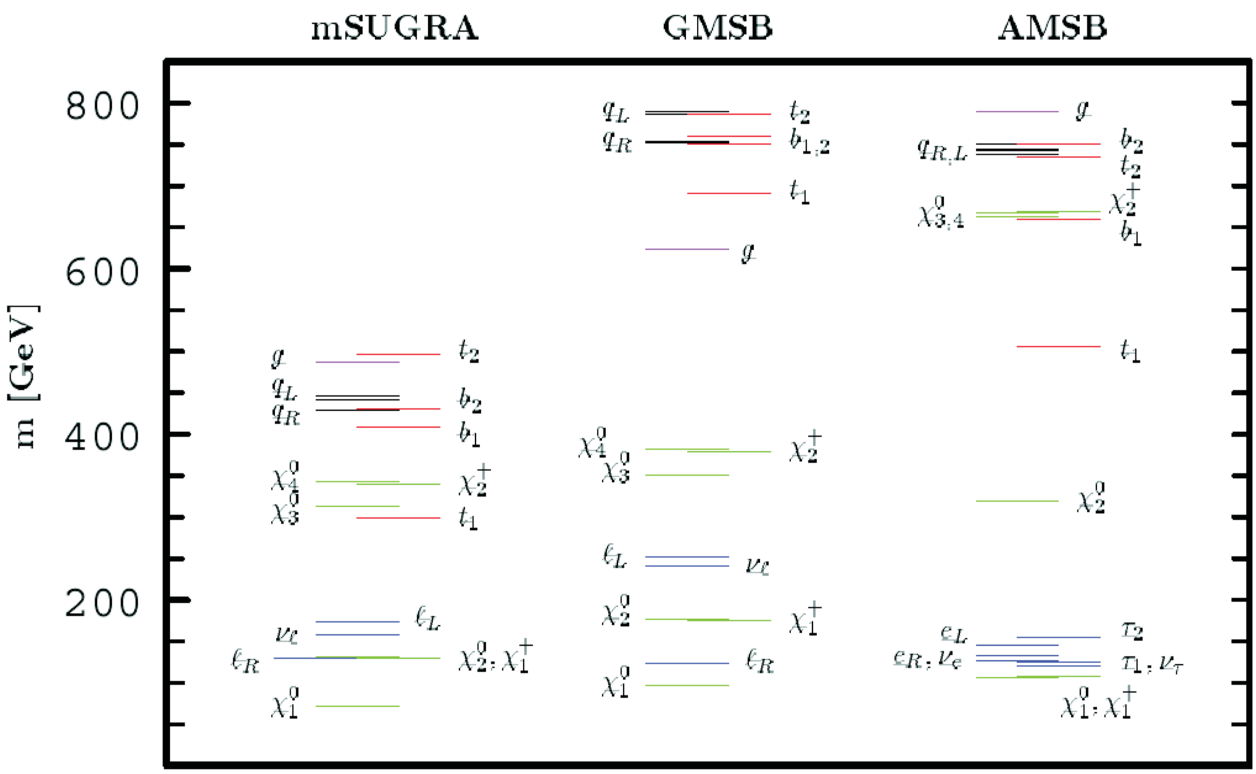
Determining the Higgs nature



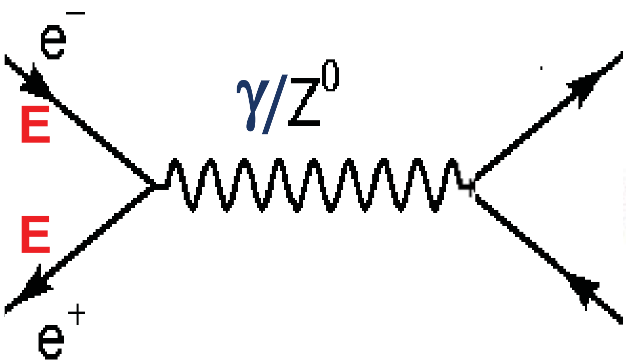


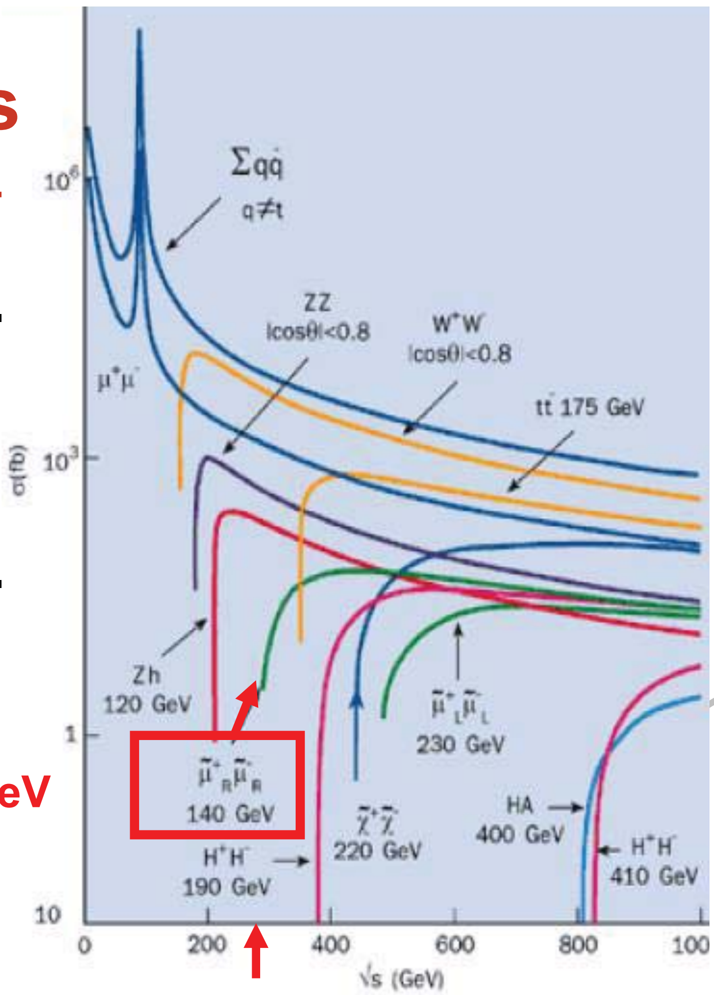
Zivkovic et al

Supersymmetry



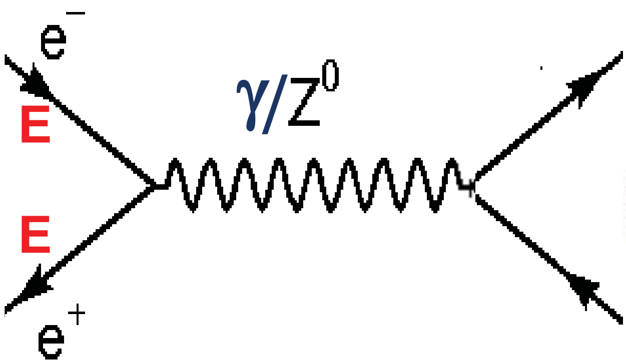
e+e- annihilations

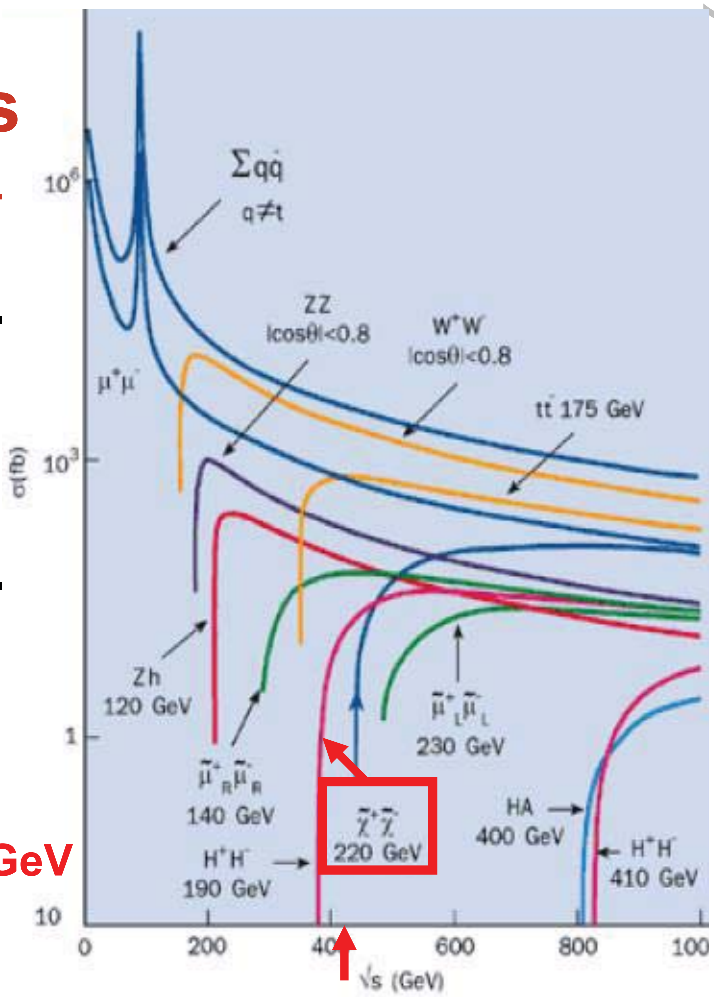




2E > 280 GeV

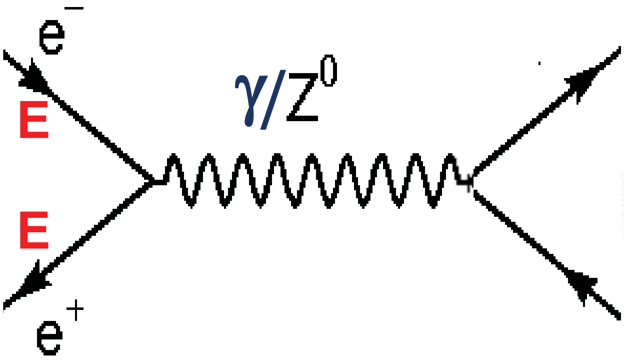
e+e- annihilations

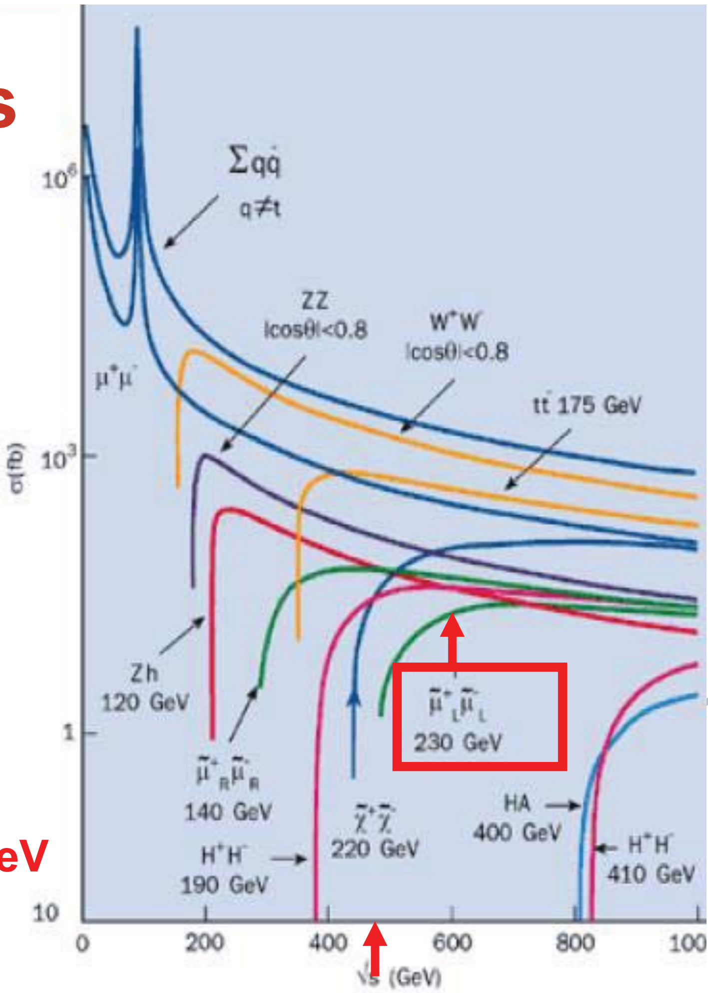




2E > 440 GeV

e+e- annihilations



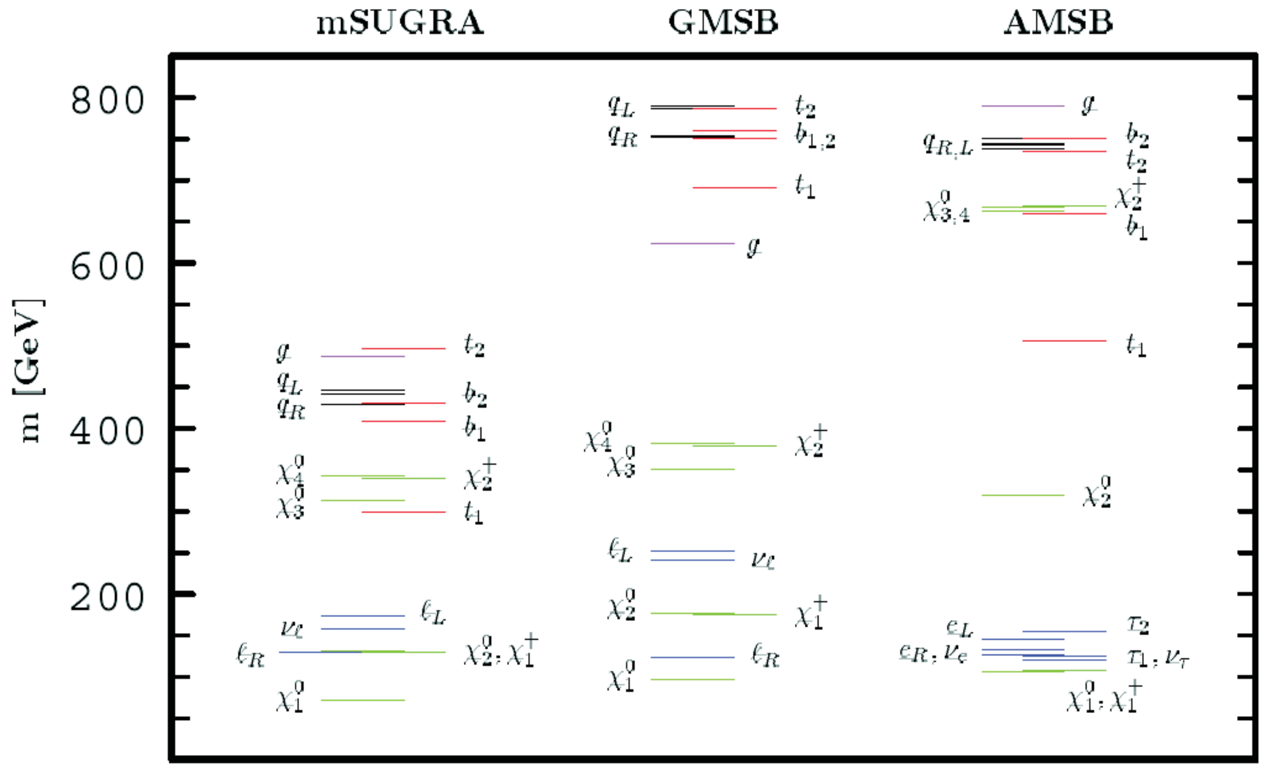


2E > 460 GeV

Is it really Supersymmetry? …

- Does every SM particle have a superpartner?
- If so, do their spins differ by 1/2?
- Are their gauge quantum numbers the same?
- Are their couplings identical?
- Do they satisfy the SUSY mass relations?

…and if so, how is SUSY broken?

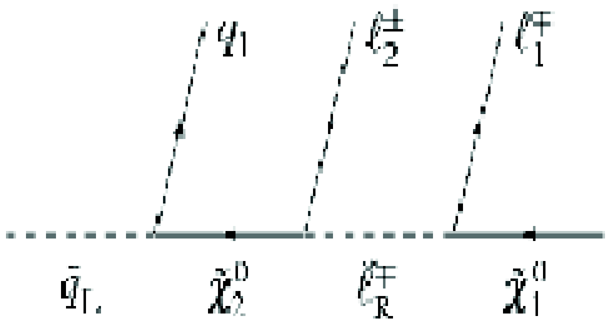


… and furthermore

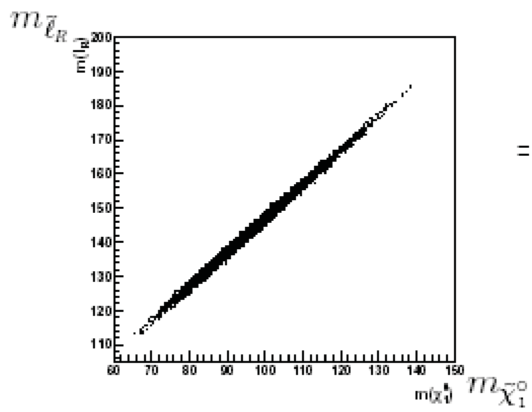
- what are the values of the 105 (or more) parameters?
- is the lightest SUSY particle the neutralino? or the stau? the sneutrino? the gravitino?
- does SUSY give the right amount of dark matter?

SUSY Decay Chains

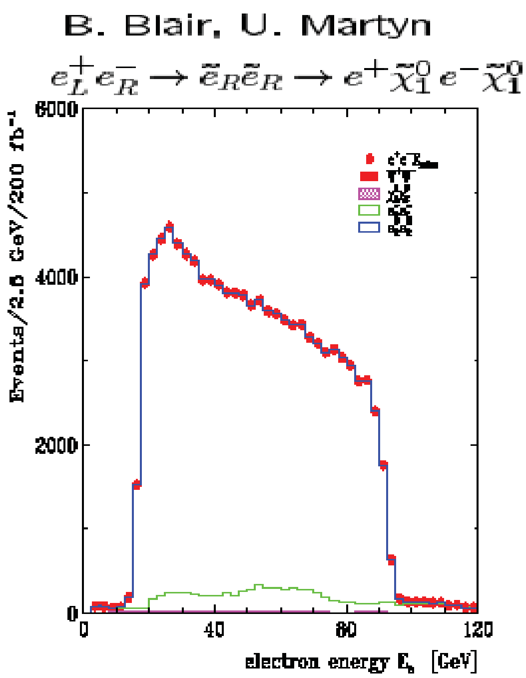
Cascade decay chains, end with LSP, eg:



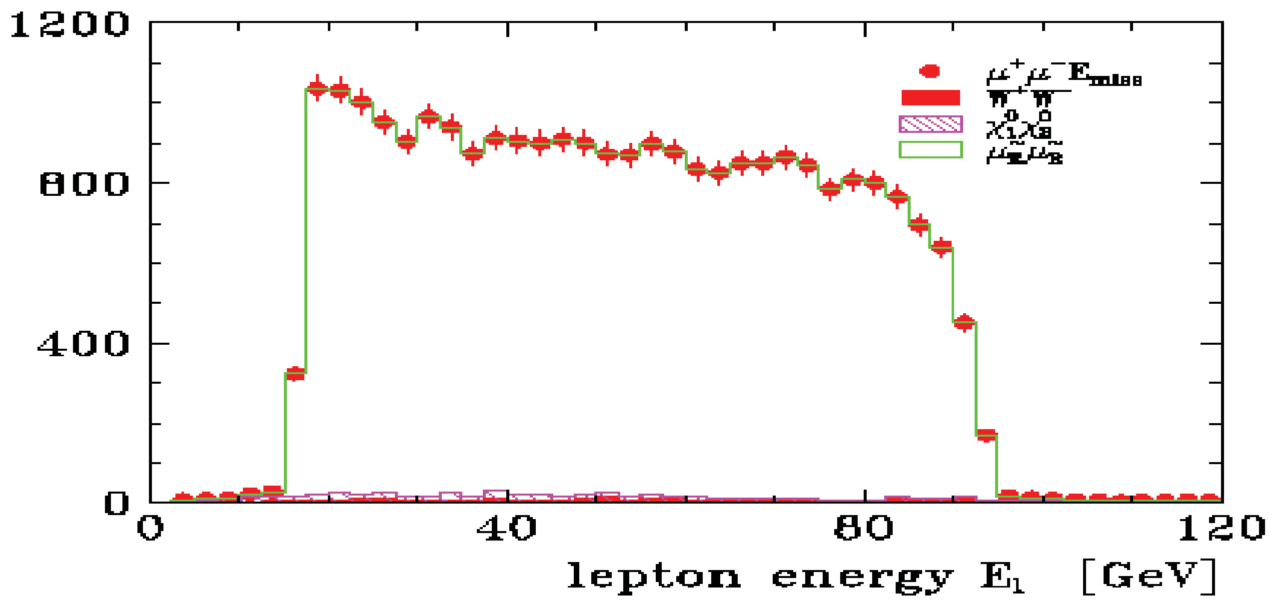
Reconstruction of heavier particles depends on knowledge of mass of LSP:



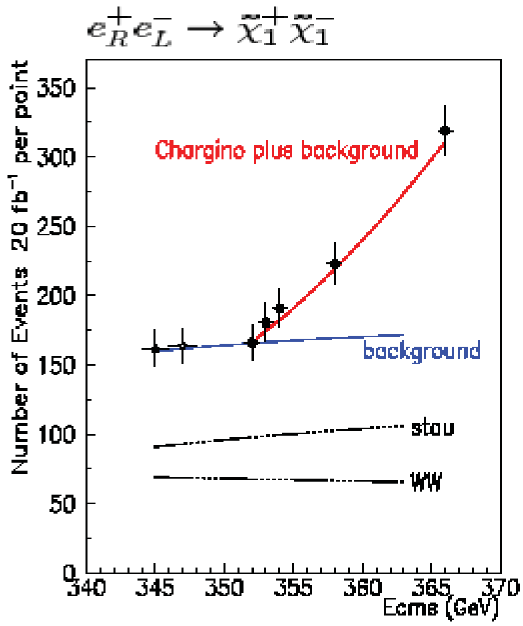
Neutralino production



Neutralino production



Chargino production

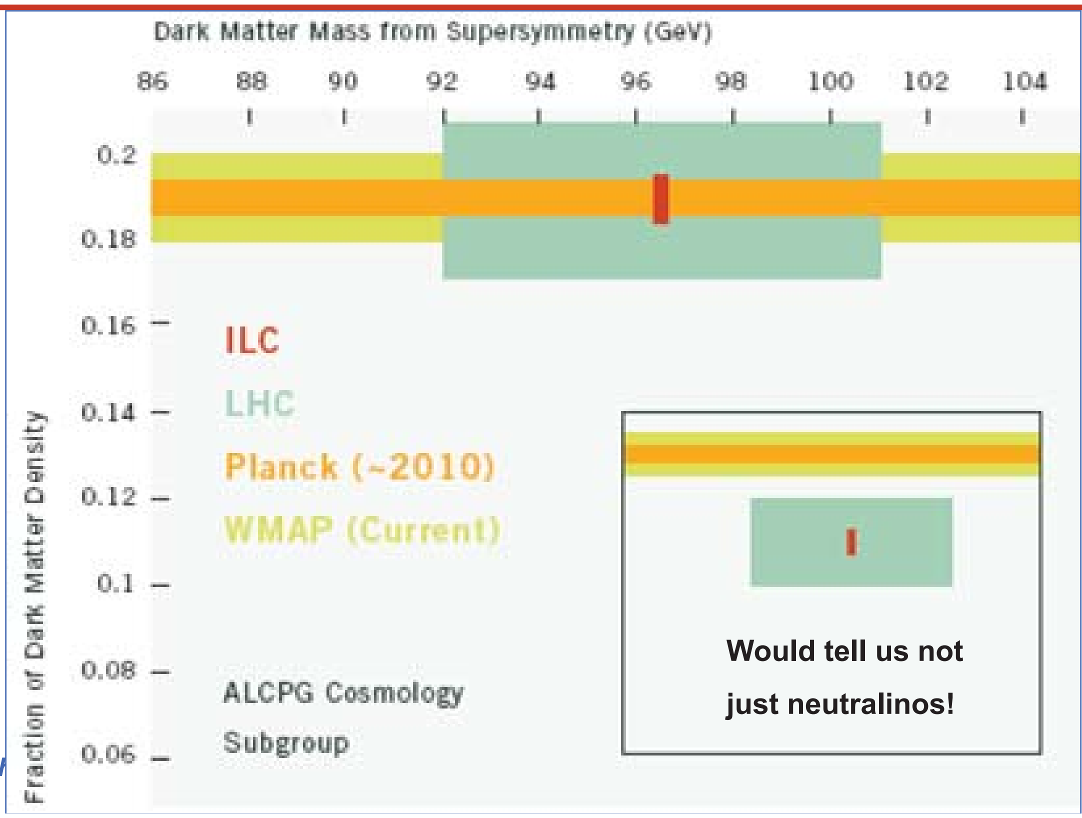


Precision on SUSY Mass Measurements

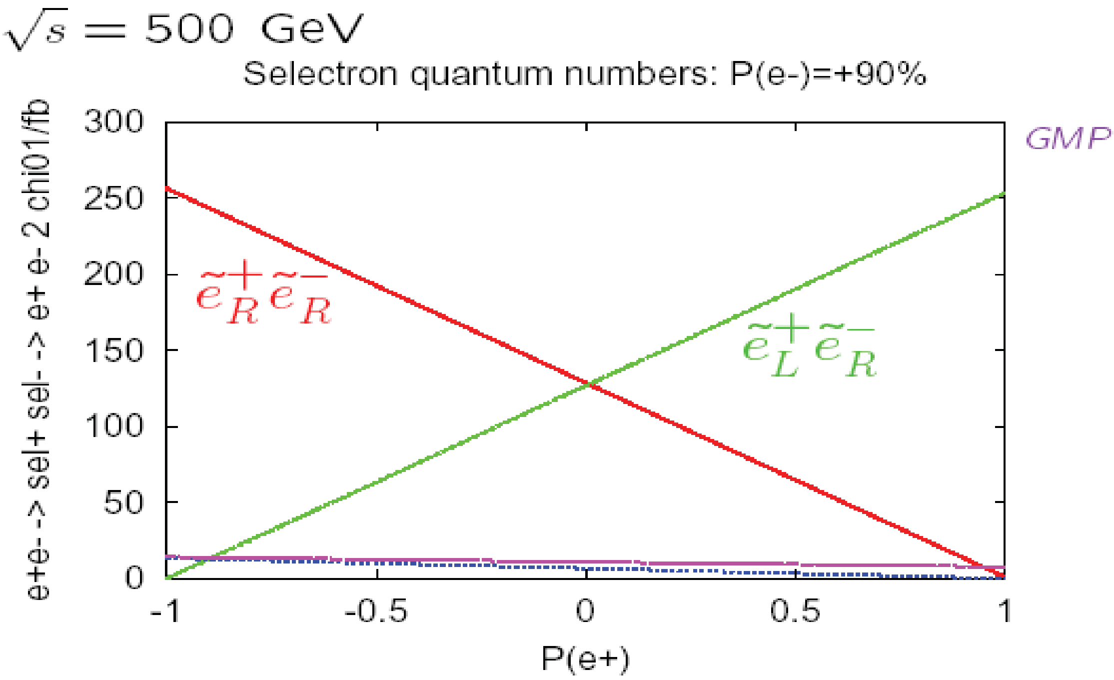
mSUGRA ‘SPS1a’ parameters:

particle	mass(GeV)	LHC	LHC + LC
h0	109	0.2	0.05
A0	359	3	1.5
chi_1+	133	3	0.11
chi_1	73	3	0.15
snu_e	233	3	0.1
e_1	217	3	0.15
snu_tau	214	3	0.8
stau_1	154	3	0.7
u_1	466	10	3
t_1	377	10	3
gluino	470	10	10

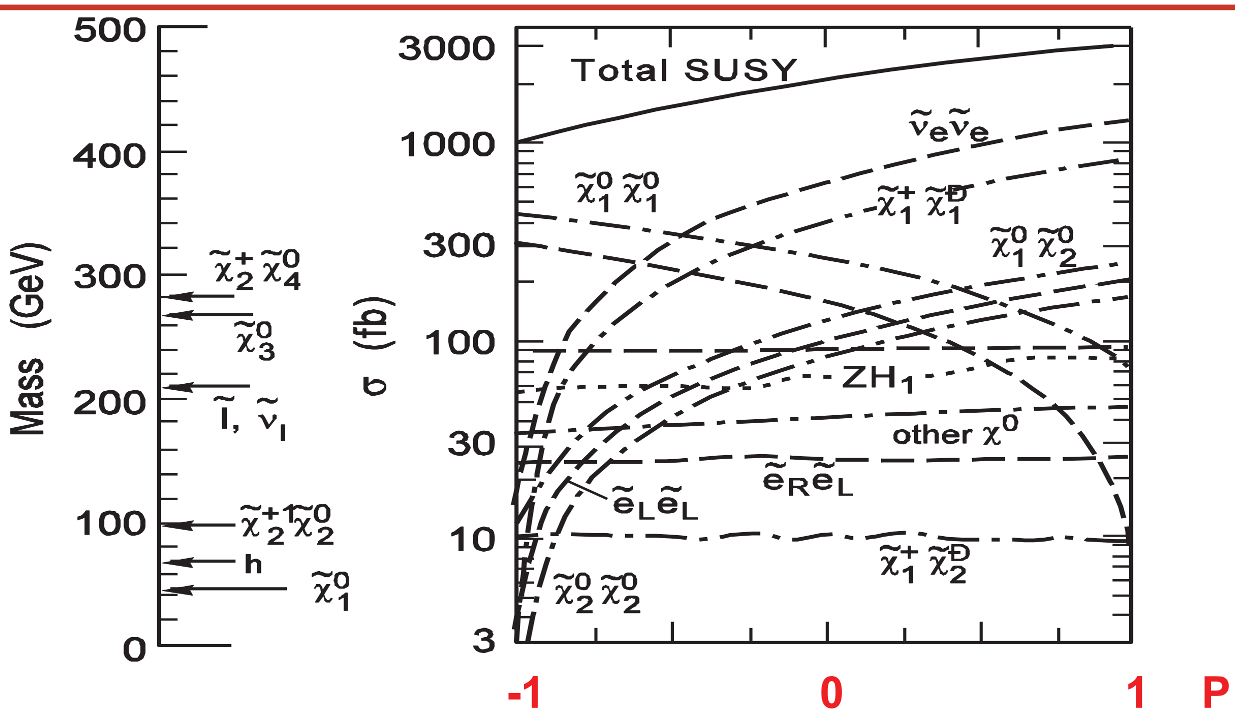
SUSY and dark matter



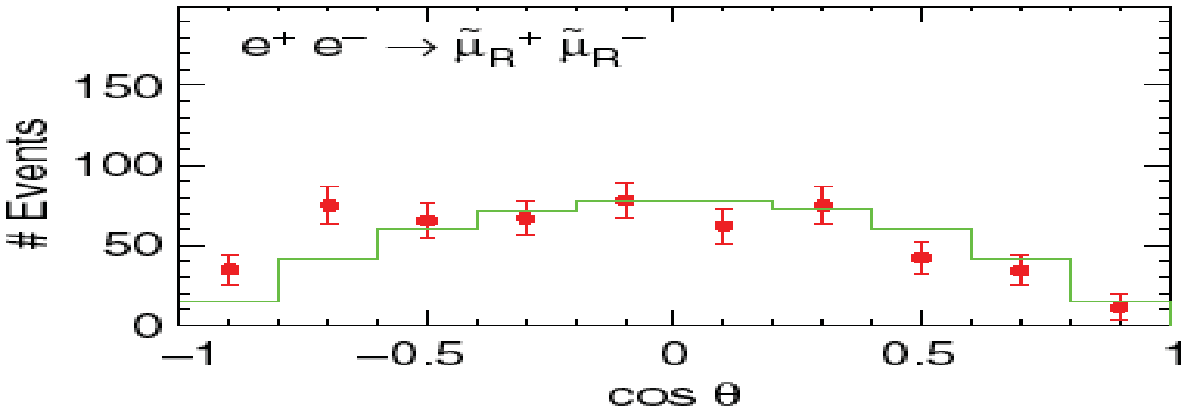
Beam polarisation → handedness



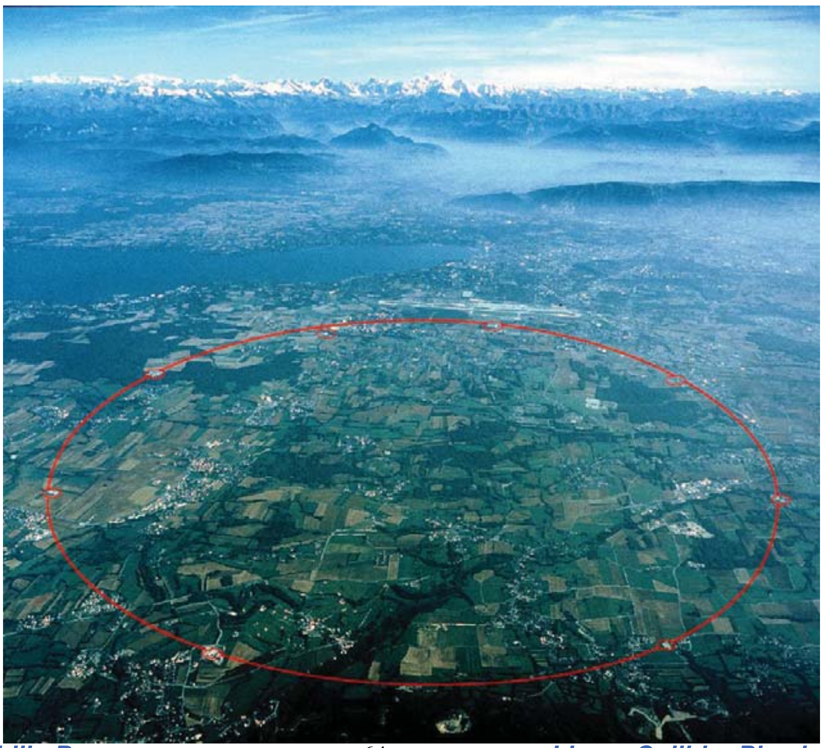
Importance of beam polarisation



Spins from angular distributions



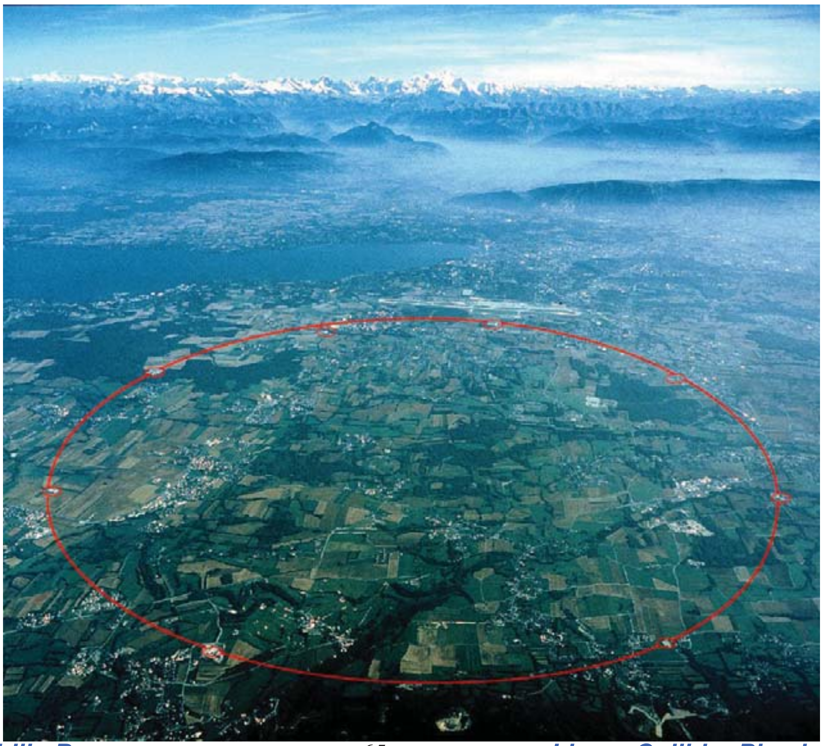
Large Electron Positron collider (RIP)



0.1 TeV

beams

Future circular e+e- collider?



0.25 TeV

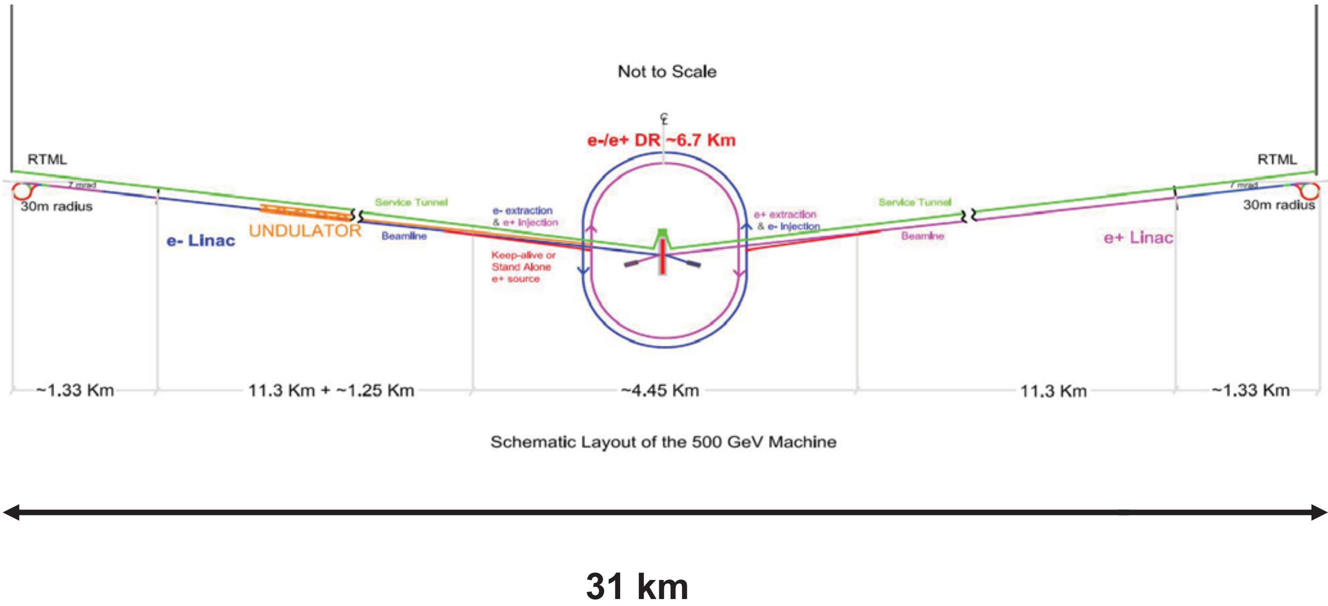
beams?

Future circular e+e- collider?

0.25 TeV

beams

International Linear Collider (ILC)



SLAC Linear Collider

ILC performance specifications

ICFA – ILCSC parameters study:

- 200 < E < 500 GeV
- Energy scan capability
- Energy stability, and precision measurement, < 0.1%
- e- polarisation > 80%
- L ~ 500 fb-1 in 4 years
- Upgrade capability to 1 TeV
- (e+ polarisation desirable)

ILC superconducting RF cavity

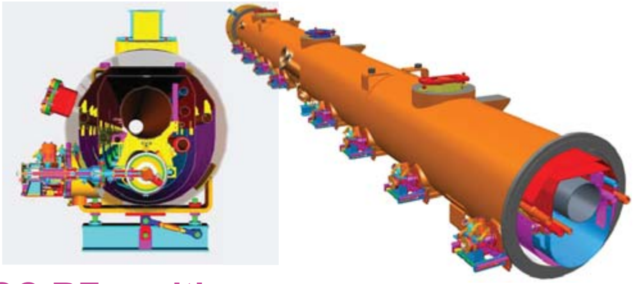
- Achieve high gradient (35MV/m); develop multiple vendors; make cost effective, etc

- Focus is on high gradient; production yields; cryogenic losses; radiation; system performance

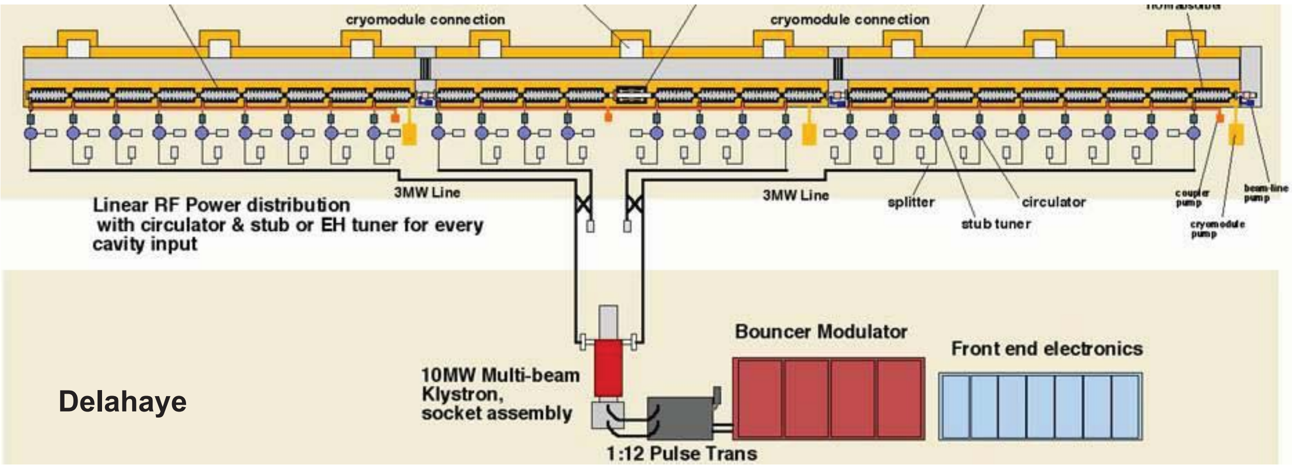
ILC Main Linac RF Overview

560 RF units each one composed of:

- 1 Bouncer type modulator
- 1 Multibeam klystron (10 MW, 1.6 ms)
- 3 Cryostats (9+8+9 = 26 cavities)
- 1 Quadrupole at the center



Total of 1680 cryomodules and 14 560 SC RF cavities

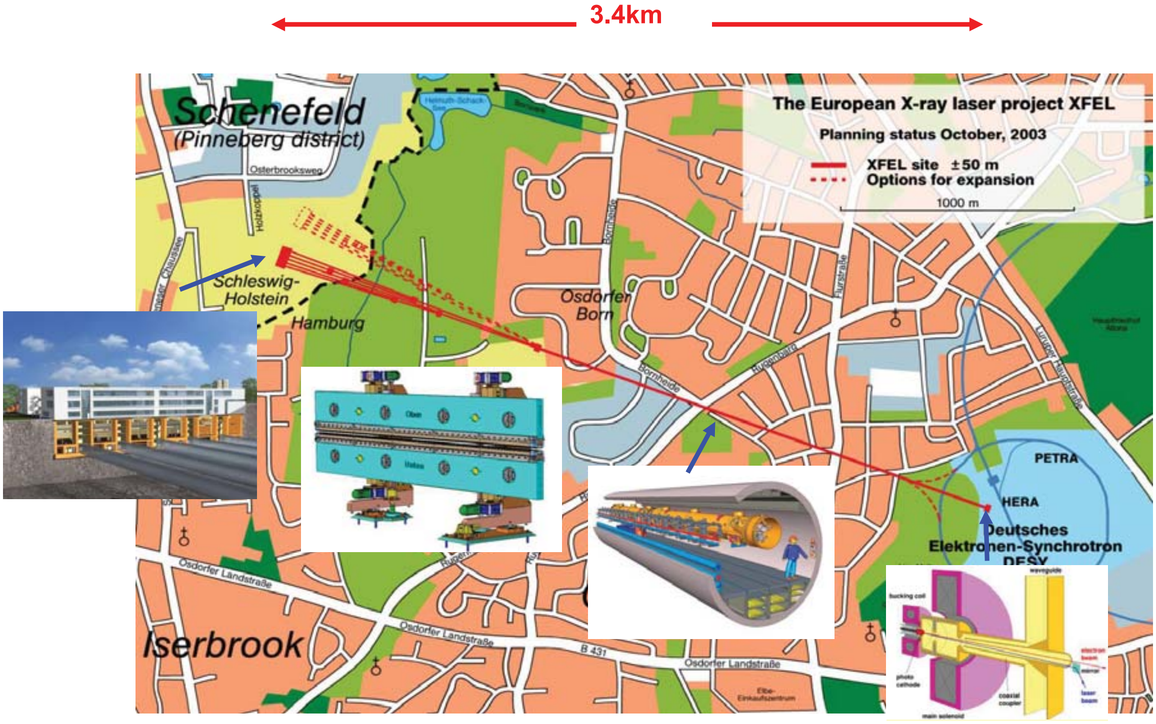


Global SCRF Technology

Emerging SRF

N. Walker - ILC08

European X-FEL at DESY



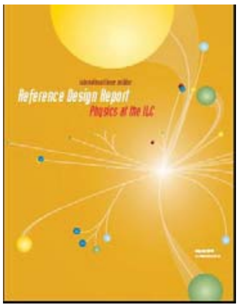
Delahaye

ILC beam parameters

	ILC	
Electrons/bunch	0.75	10**10
Bunches/train	2820	
Train repetition rate	5	Hz
Bunch separation	308	ns
Train length	868	us
Horizontal IP beam size	655	nm
Vertical IP beam size	6	nm
Longitudinal IP beam size	300	um
Luminosity	2	10**34

Reference Design Report (Feb 2007)

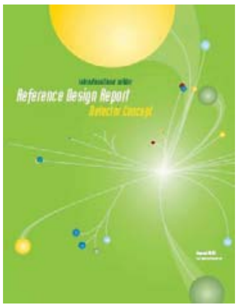
Executive Summary



Physics at the ILC

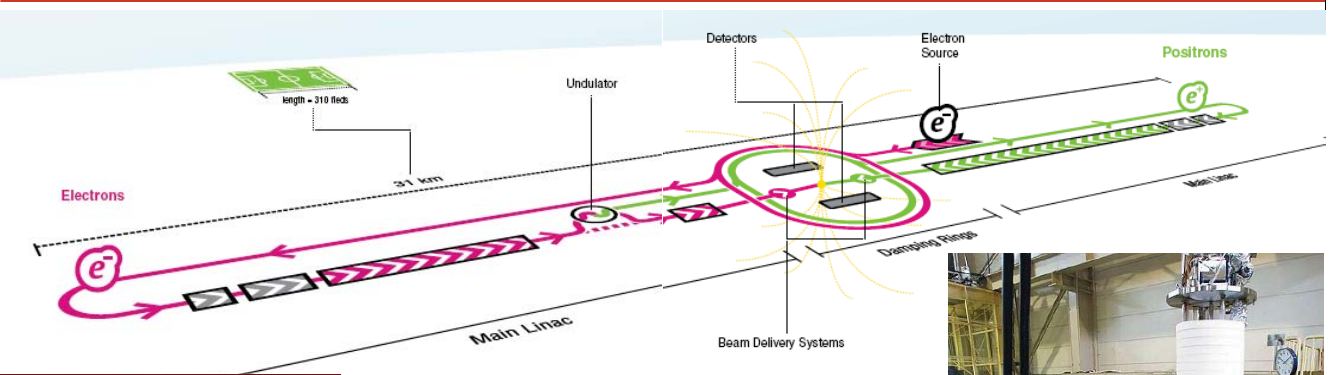
700 authors, 84 institutes

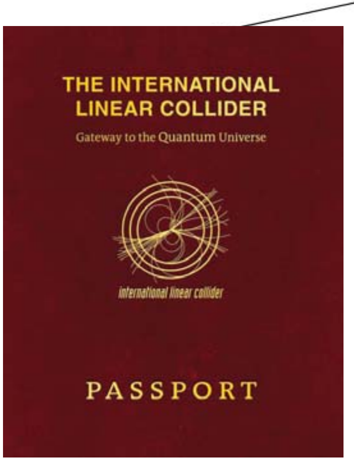
Accelerator



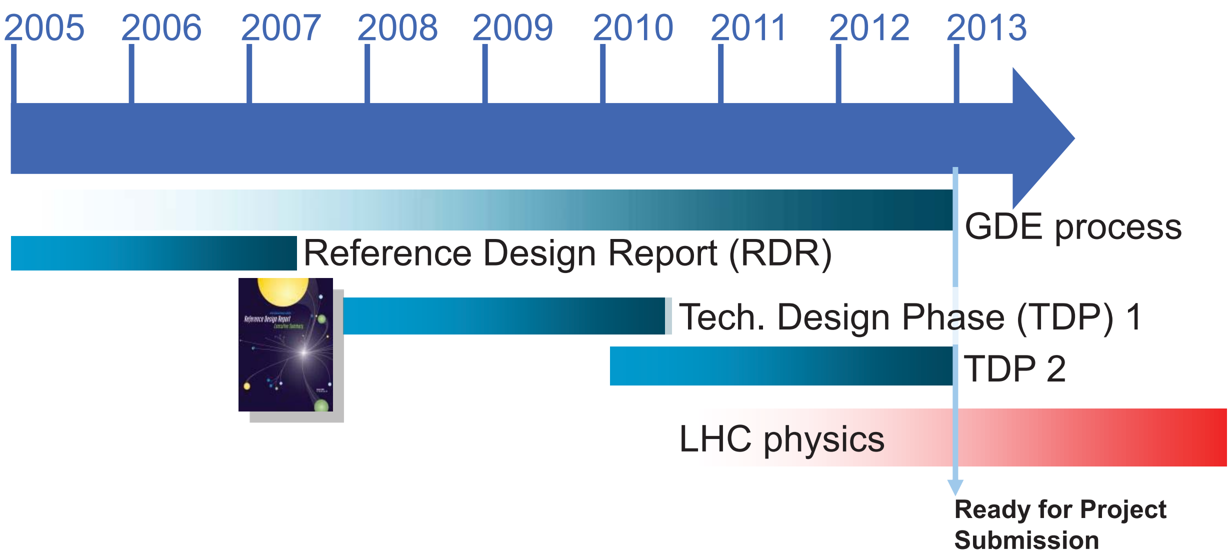
Detectors

www.linearcollider.org





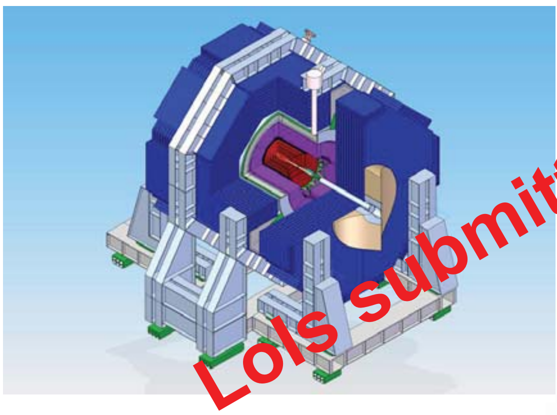
ILC timeline

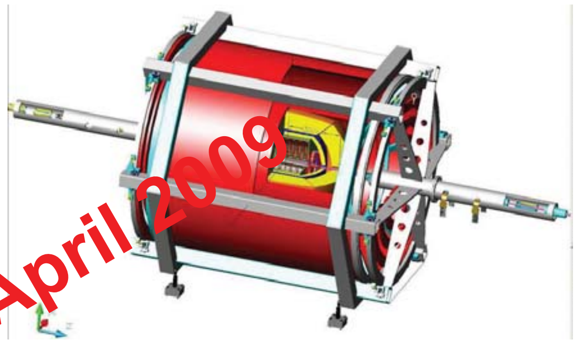


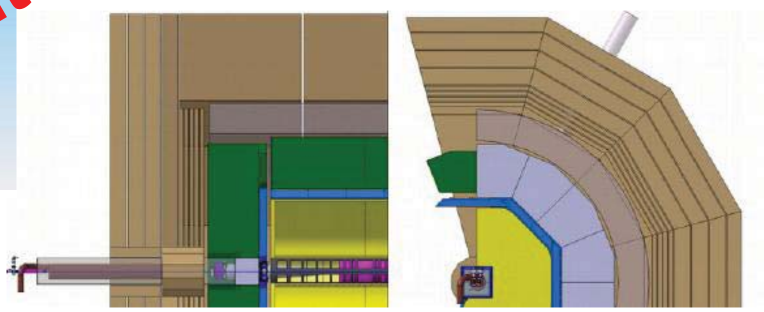
ILC Detectors

3 Detector Concept groups:

SiD, ILD, 4th Concept

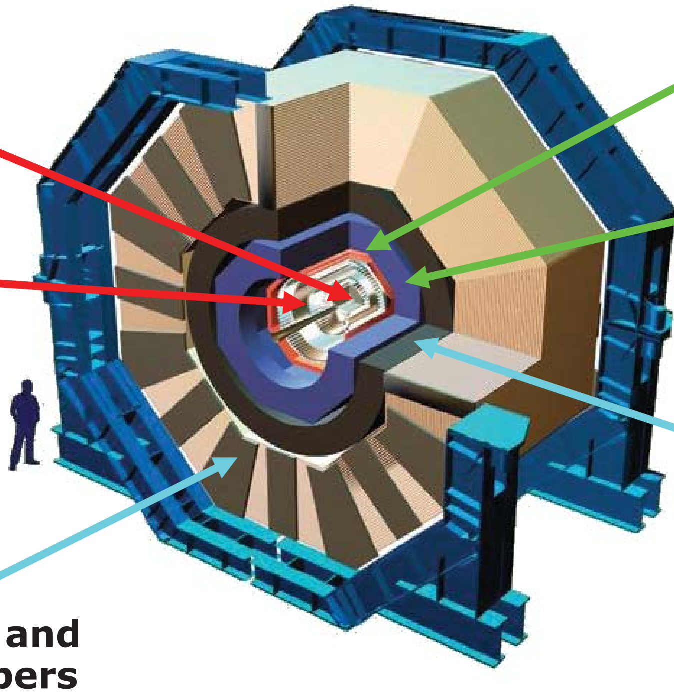




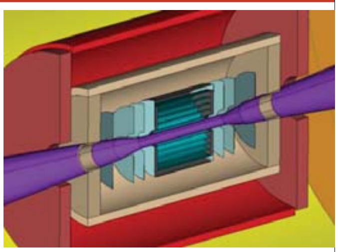


LoIs submitted April 2009

The SiD Detector Concept



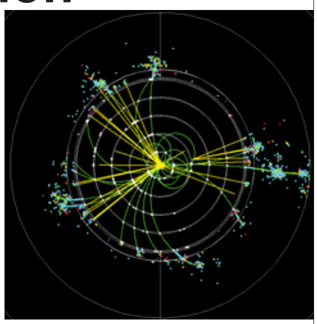
Detector specifications



Designed for precision measurements:

- **Large B-field: 3-5 Tesla**
- **Vertex detector:**

  O(1B) Si pixels, 4um spatial resolution



- **Tracker:**

  momentum resolution < 5 x 10-5
- **Calorimetry:**

  O(100M) channels (EM)

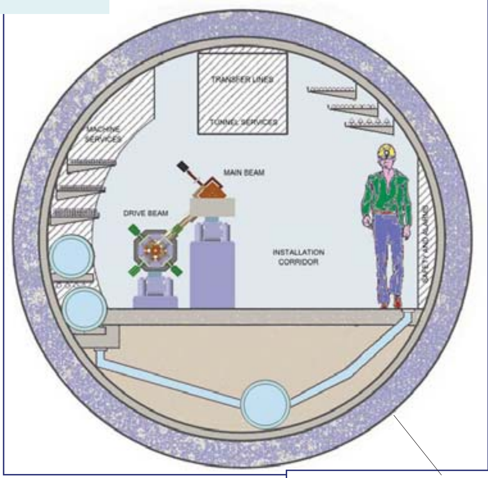
  particle-flow (PFA) approach: W + Z i.d.

CLIC – basic features

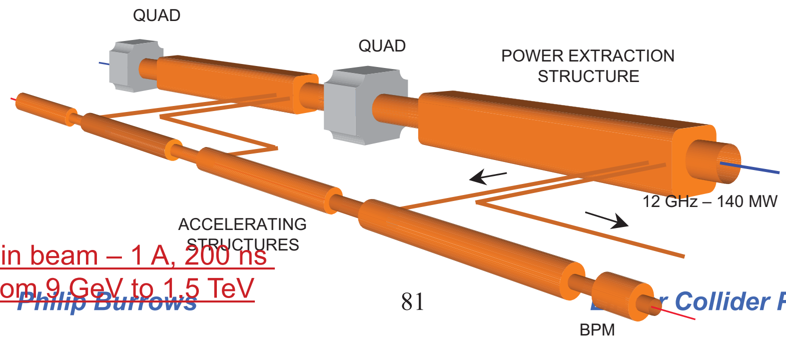
- **High acceleration gradient: > 100 MV/m**
  – "Compact" collider – total length < 50 km at 3 TeV
  – Normal conducting acceleration structures at high frequency

Novel Two-Beam Acceleration Scheme
  – Cost effective, reliable, efficient
  – Simple tunnel, no active elements
  – Modular, easy energy upgrade in stages

CLIC TUNNEL CROSS-SECTION



4.5 m diameter



Drive beam - 95 A, 300 ns
from 2.4 GeV to 240 MeV

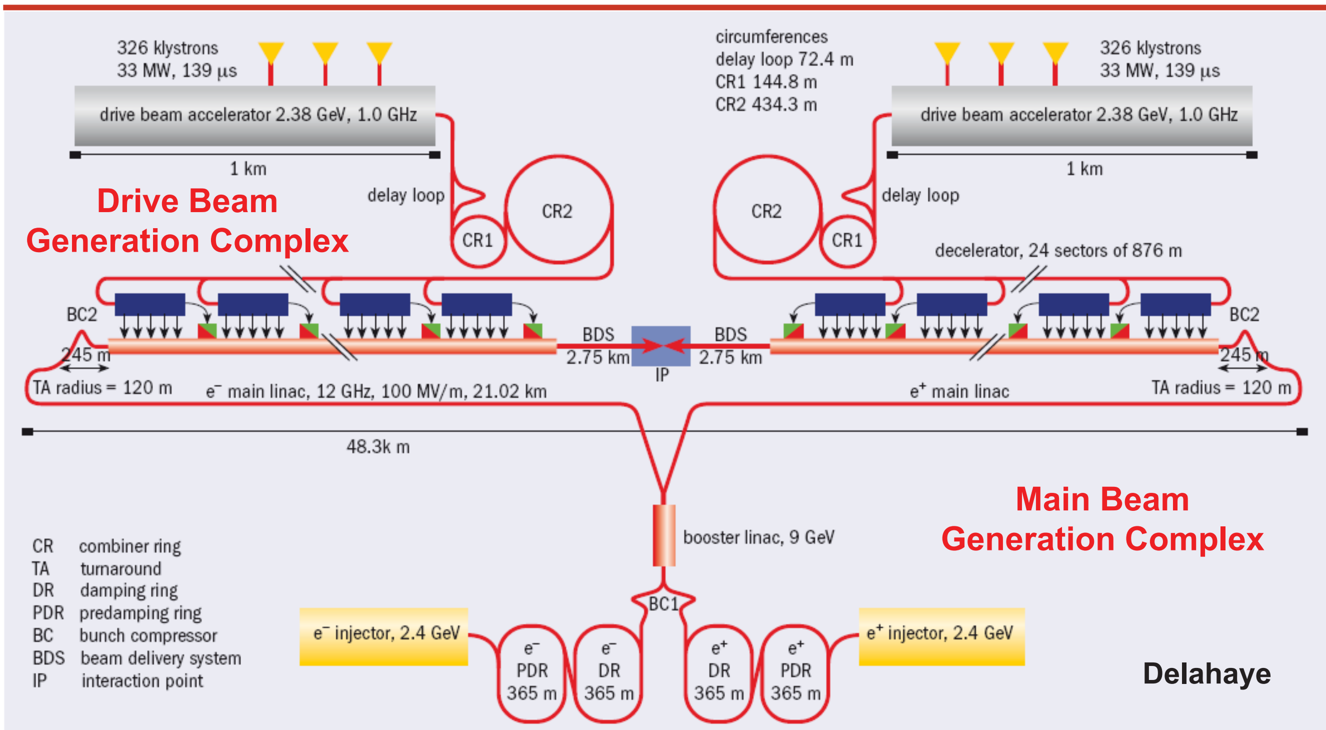
Main beam – 1 A, 200 ns
from 9 GeV to 1.5 TeV

Delahaye

Beam parameters

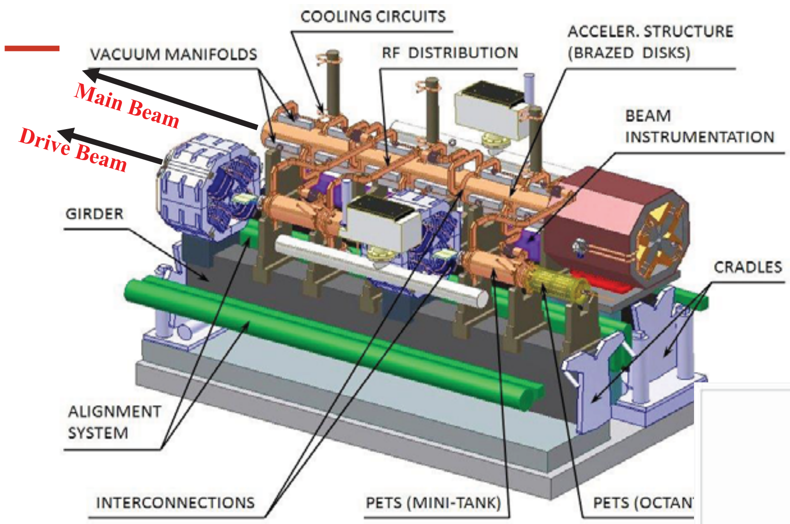
	ILC (500)	CLIC (3 TeV)	
Electrons/bunch	0.75	0.37	10**10
Bunches/train	2820	312	
Train repetition rate	5	50	Hz
Bunch separation	308	0.5	ns
Train length	868	0.156	us
Horizontal IP beam size	655	45	nm
Vertical IP beam size	6	0.9	nm
Longitudinal IP beam size	300	45	um
Luminosity	2	6	10**34

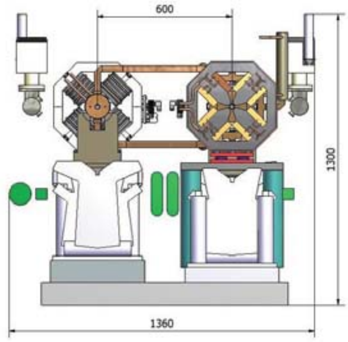
CLIC Layout 3 TeV
(not to scale)

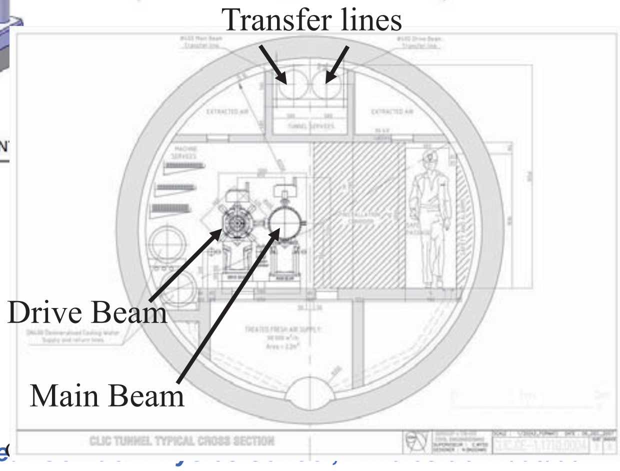


Delahaye

CLIC Two Beam Module







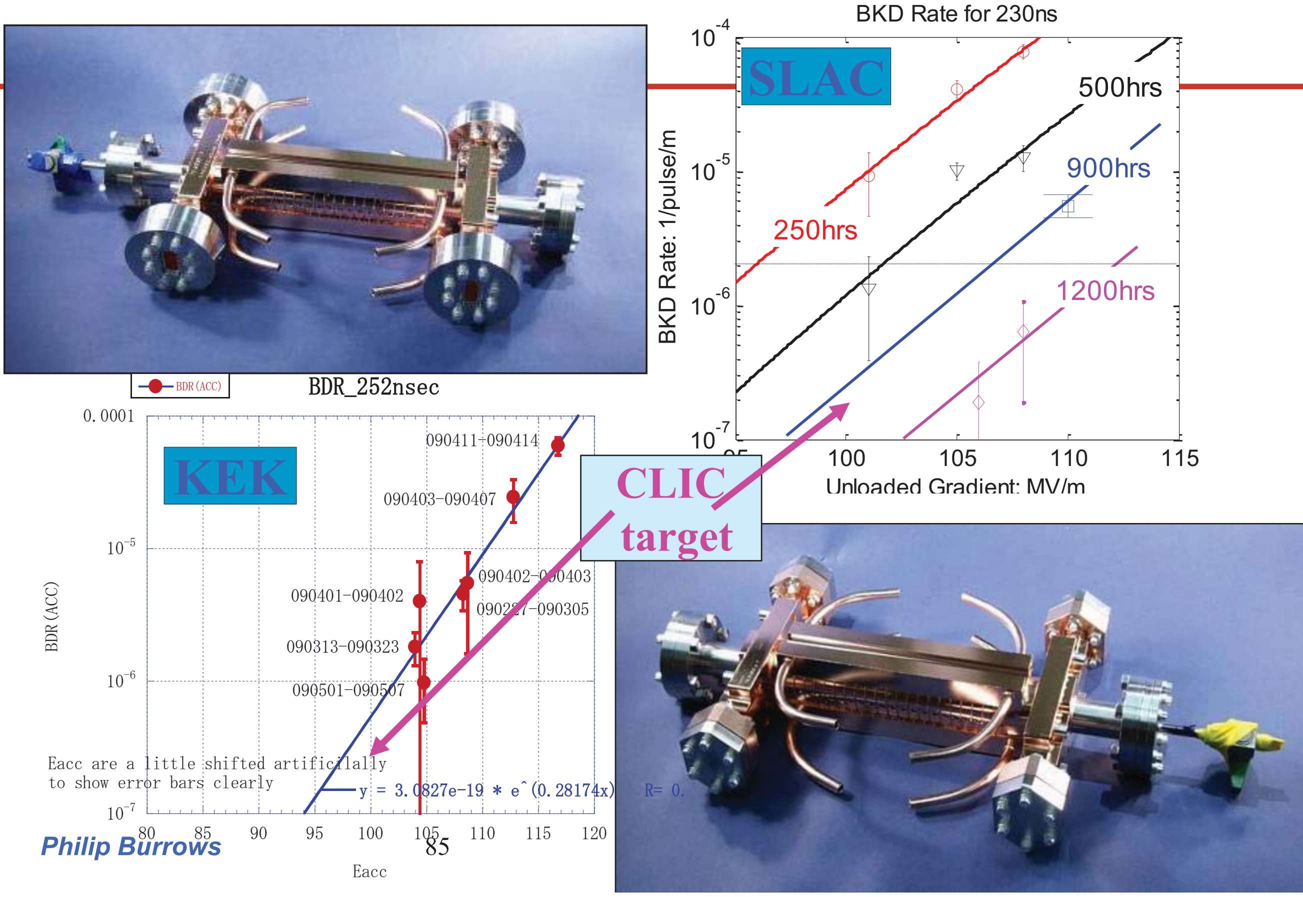
20760 modules (2 meters long)

71460 power production structures PETS (drive beam)

143010 accelerating structures

(main beam)

Nominal performance of Accelerating Structures Design@CERN, Built/Tested @KEK, SLAC



LHC

- Is there a Higgs boson that generates mass?

LHC and LC

- Is there a Higgs boson that generates mass?
  - is it consistent with Standard Model?
  - is it a SUSY Higgs?

LHC

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- Is Supersymmetry realised in nature?

LHC and LC

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  - can the lightest SUSY particle account for dark matter?

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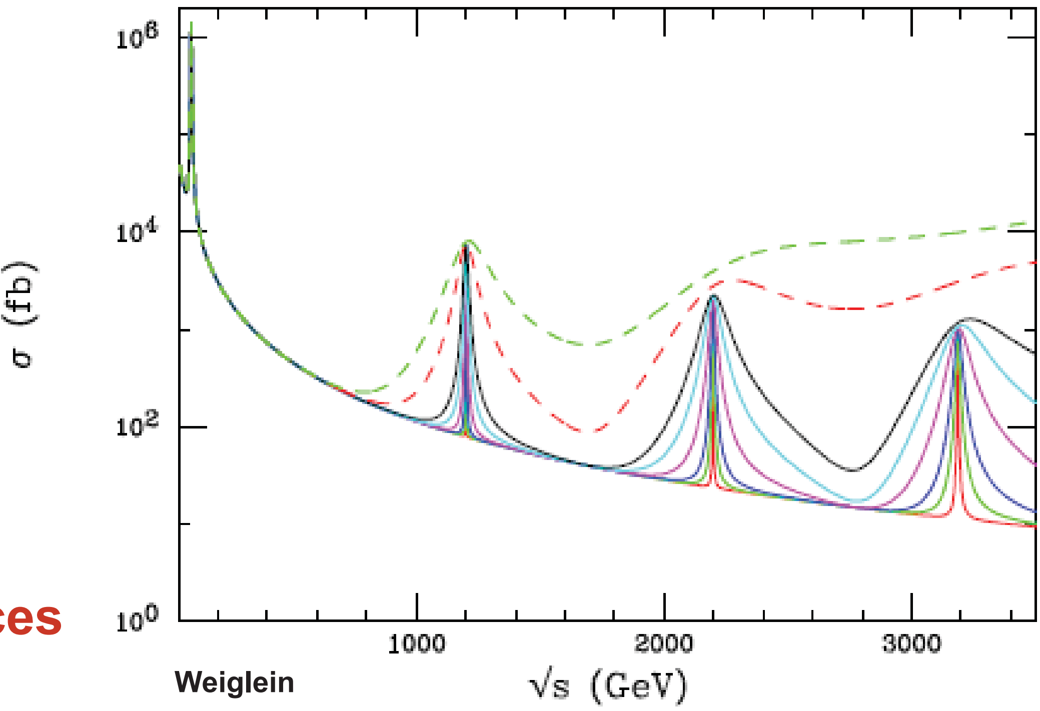
- Are there extra spatial dimensions in nature?
  - how many are there and what is their scale?

Manifestation of extra dimensions

Kaluza-Klein resonances



Weiglein

LHC

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  - how many are there and what is their scale?
- Are the forces of nature unified?

PoS(LCPS2009)001

LHC and LC

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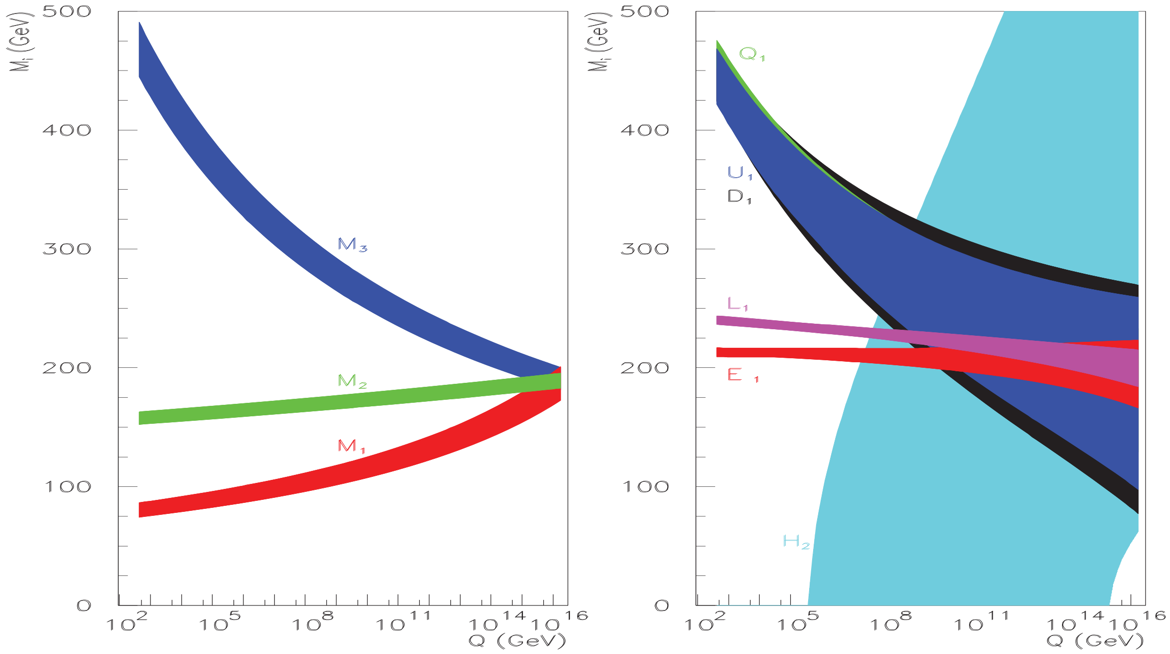
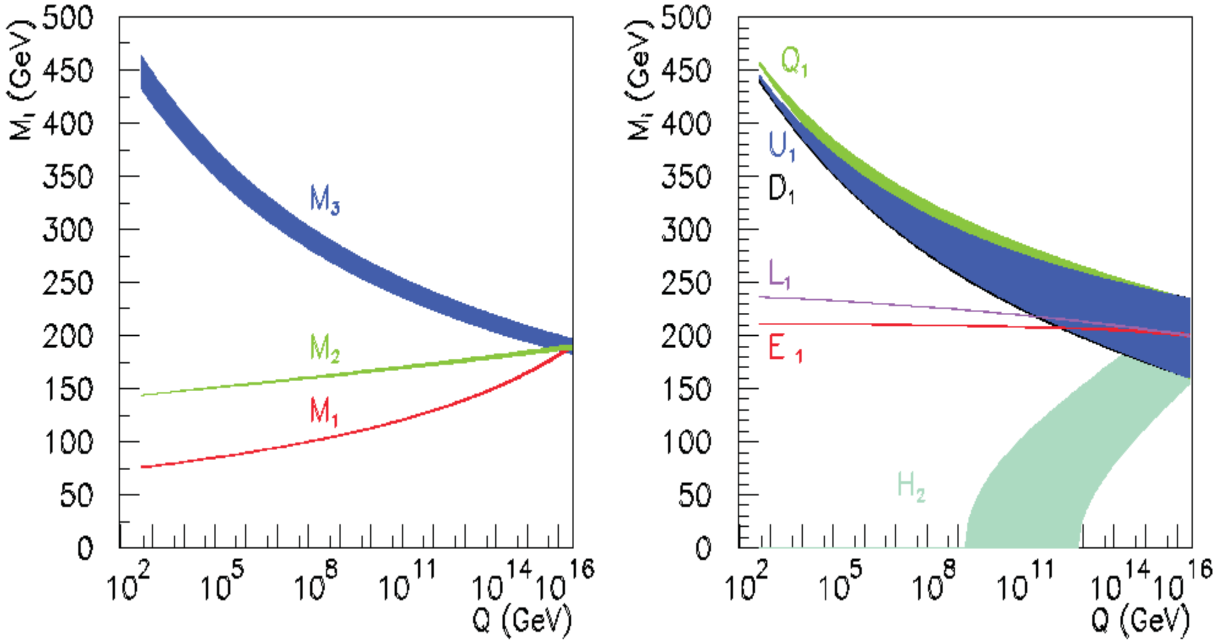
  - how many are there and what is their scale?
- Are the forces of nature unified?
  - at what energy scale?

Extrapolation to GUT scale: LHC only



Extrapolation to GUT scale: LHC +LC



LHC and LC

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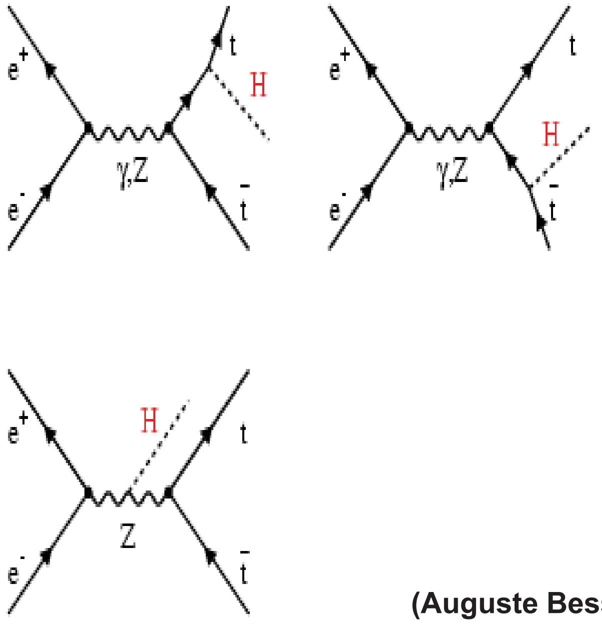
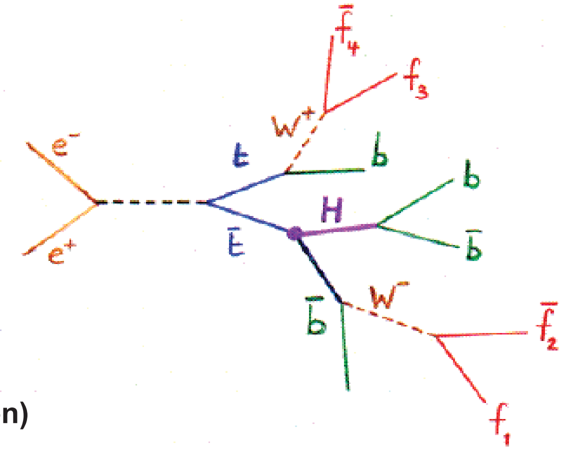
Extra material follows

PoS(LCPS2009)001

Top-Higgs Yukawa Coupling (LC)

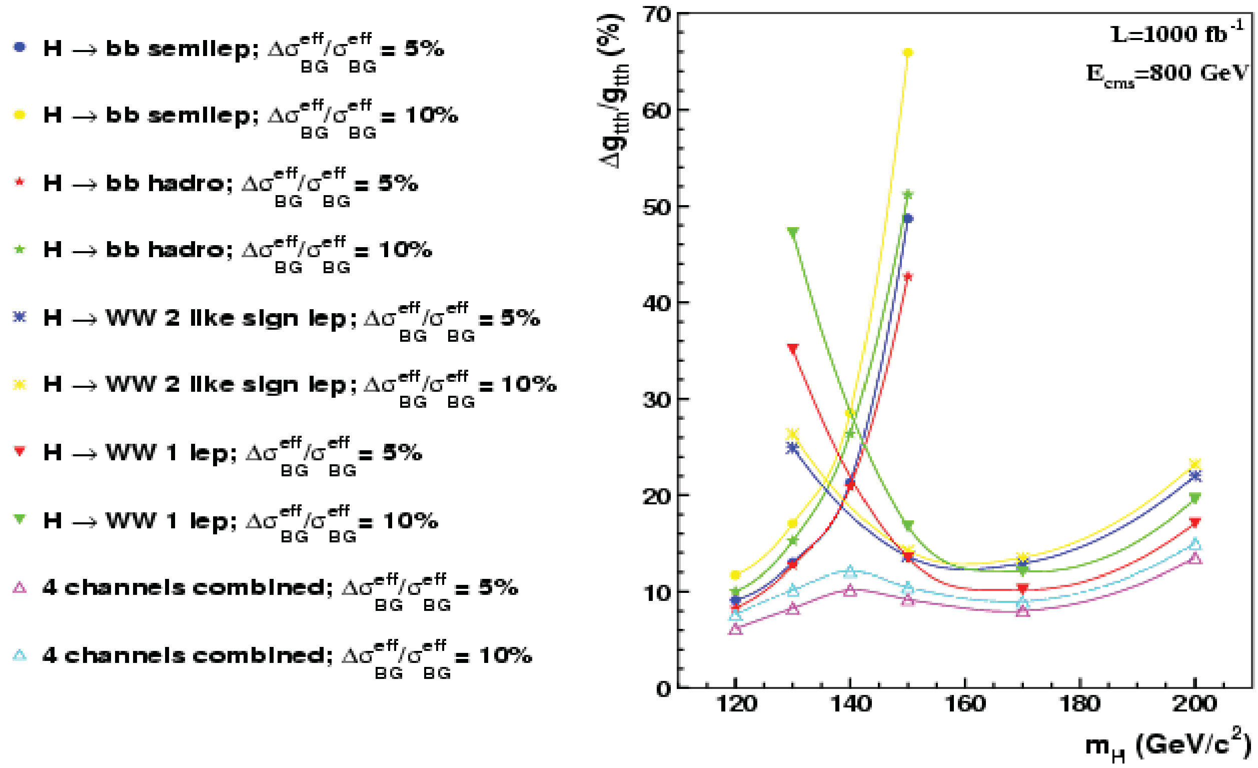


8-jet final state containing 4 b-jets

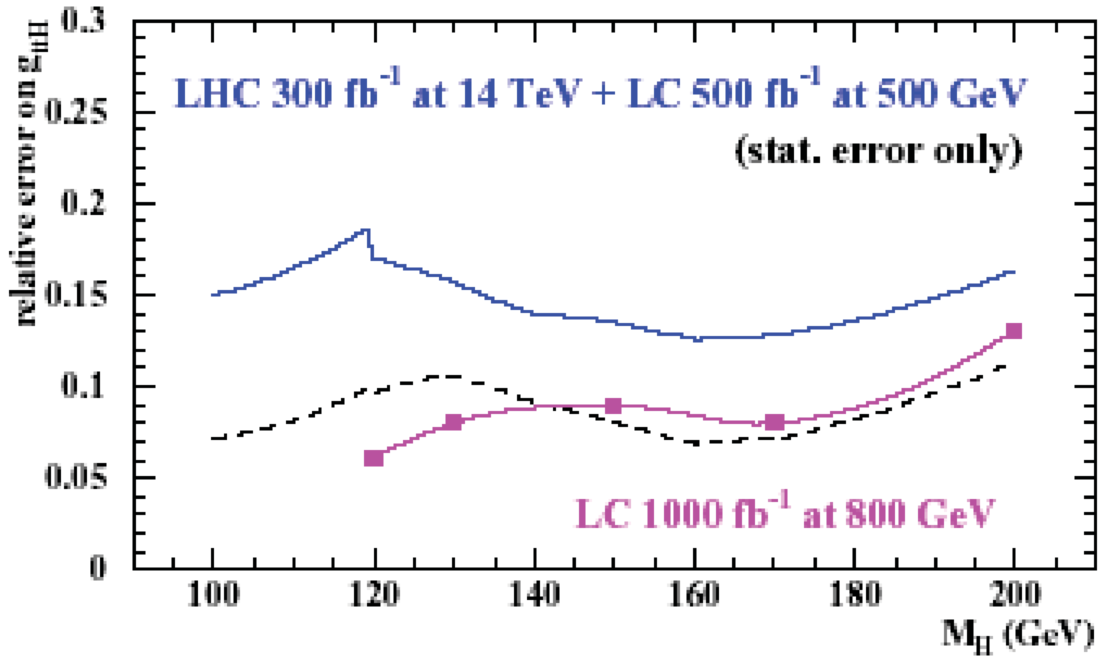


(Auguste Besson)

Top-Higgs Yukawa Coupling: Results (LC)

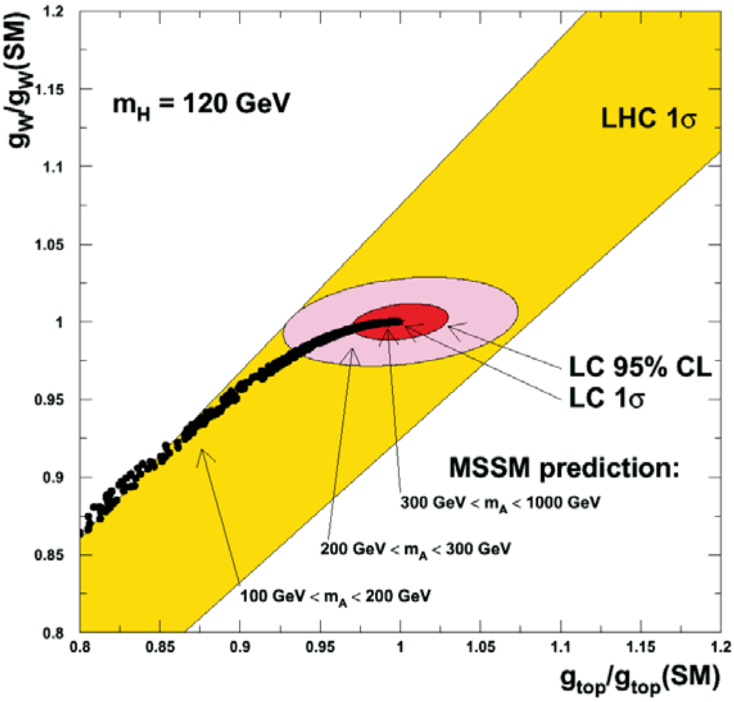


Top-Higgs Yukawa Coupling: LHC + LC



(John Ellis)

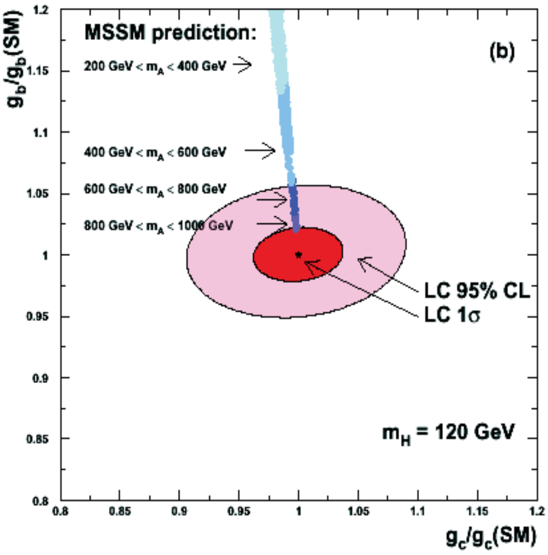
Higgs boson: W vs. top couplings



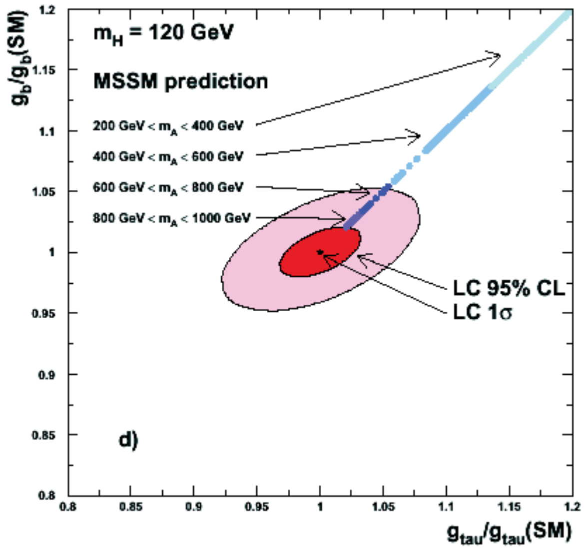
(TESLA TDR)

Higgs Boson: Fermion Couplings

Bottom vs. charm

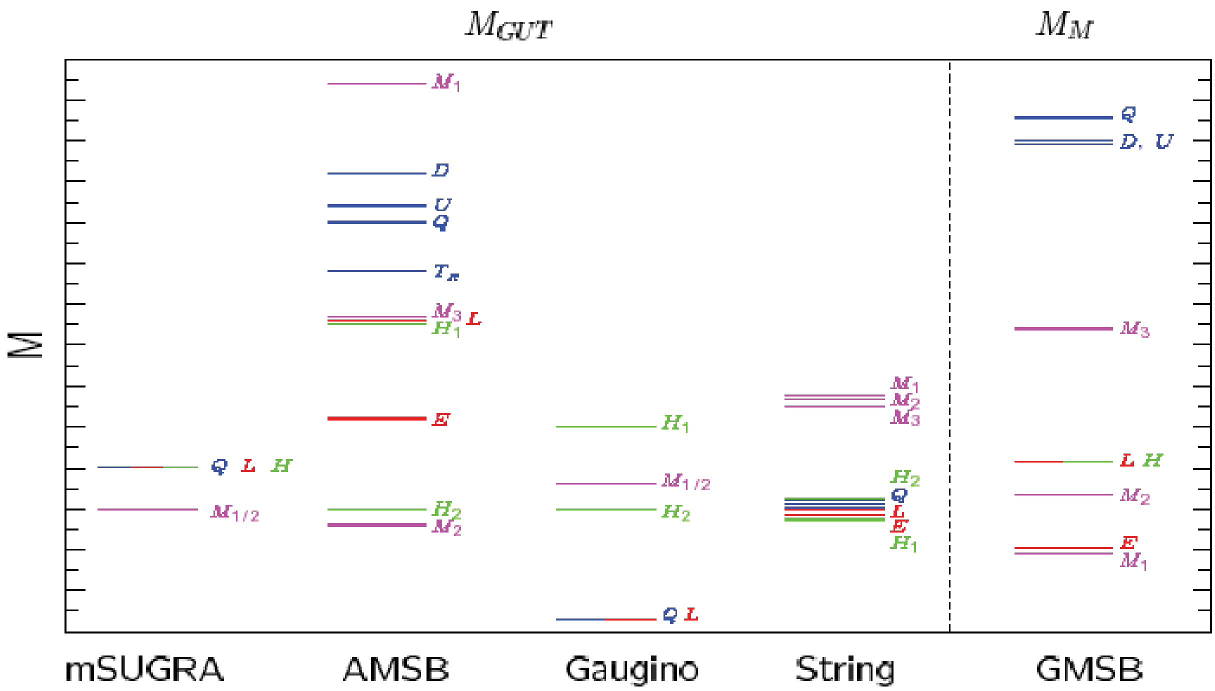


Bottom vs. tau

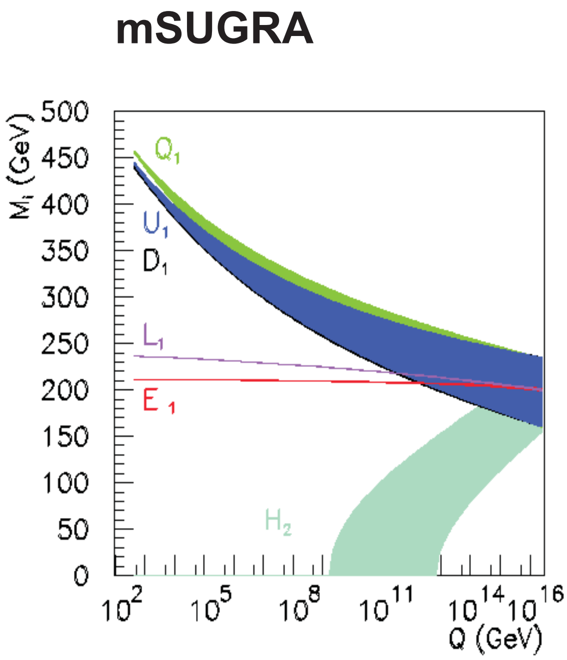


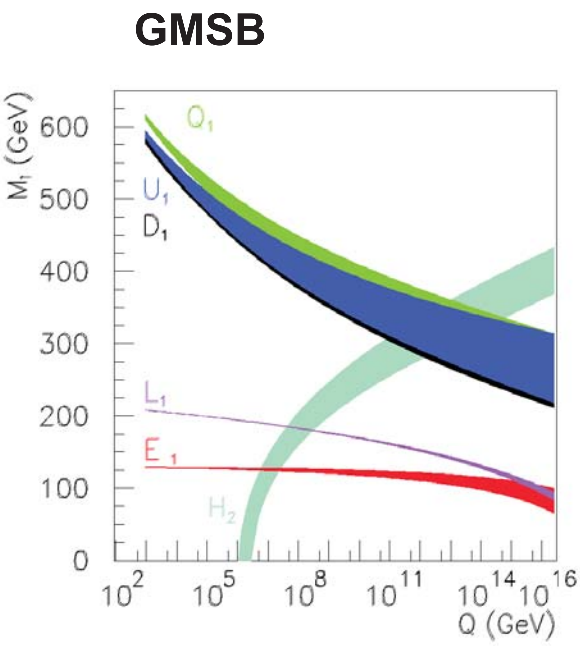
(TESLA TDR)

Primordial SUSY Mass Parameters



Extrapolation of mSUGRA and GMSB





Historical example: Z boson

CERN Super Proton Synchrotron:
540 - 640 GeV

Discovered W, Z in 1983
c. 100 Z (UA2):

M_Z = 91.74+-0.97 GeV

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CERN Super Proton Synchrotron:
540 - 640 GeV

Discovered W, Z in 1983
c. 100 Z:

M_Z = 91.74+-0.97 GeV

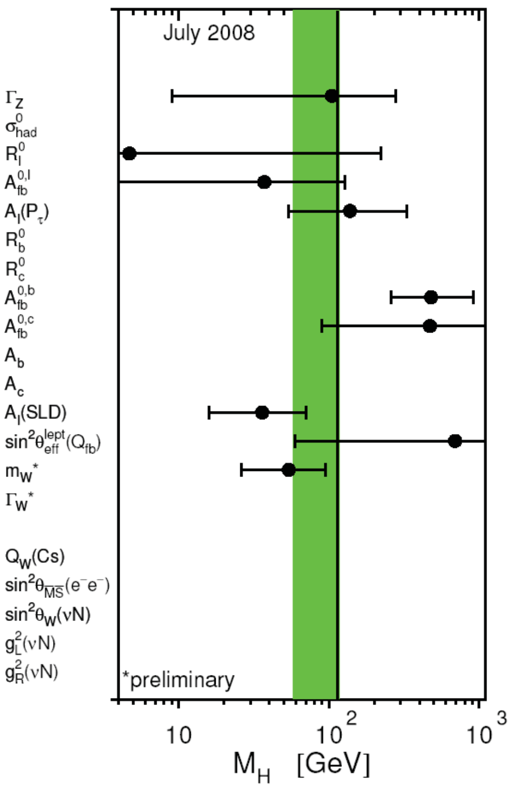
LEP, SLC e+e-:

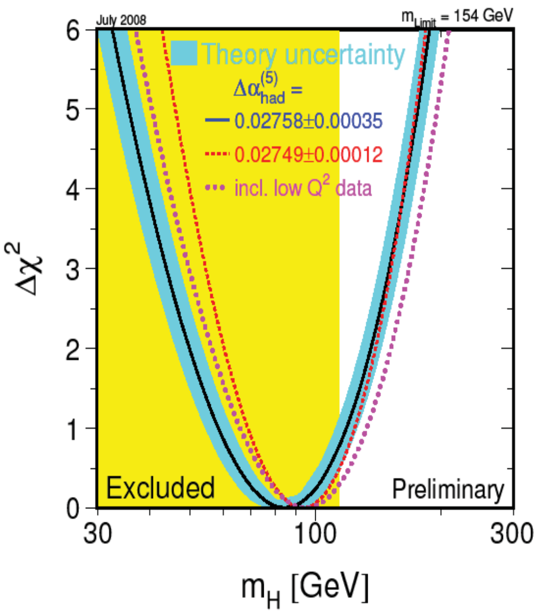
91 GeV

Turned on 1989
16 million Z + polarisation:

M_Z = 91.1876+-0.0021 GeV
width = 2.4952 +- 0.0023 GeV
Couplings to:
e, mu, tau, b, c, s, u/d…

Precision data





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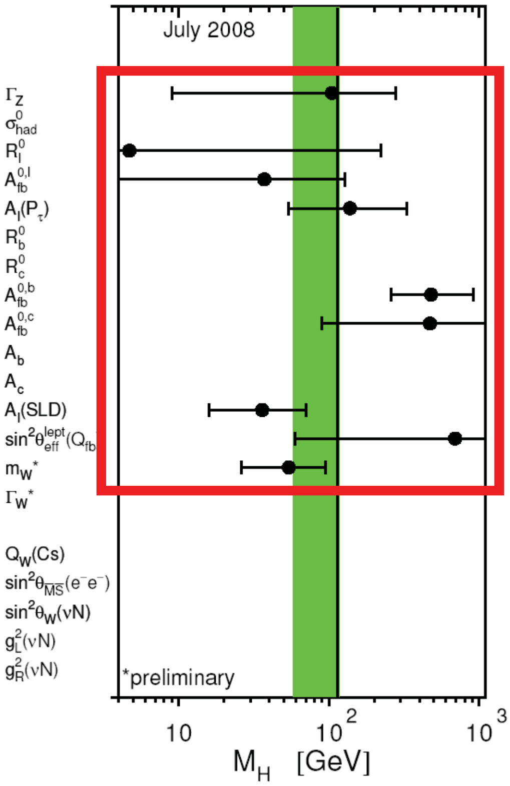

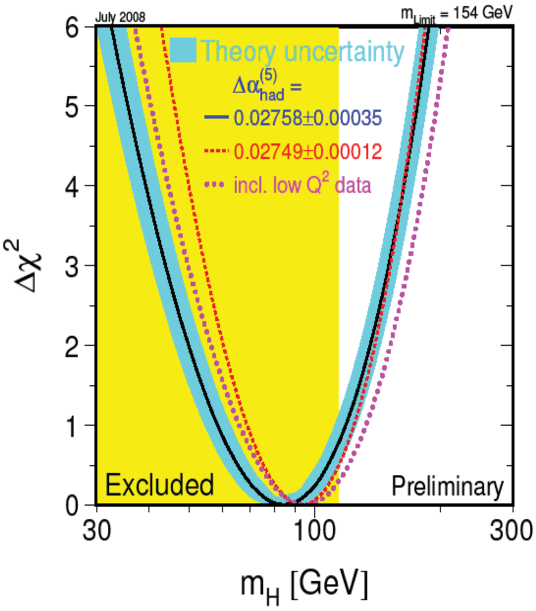

Beam parameters

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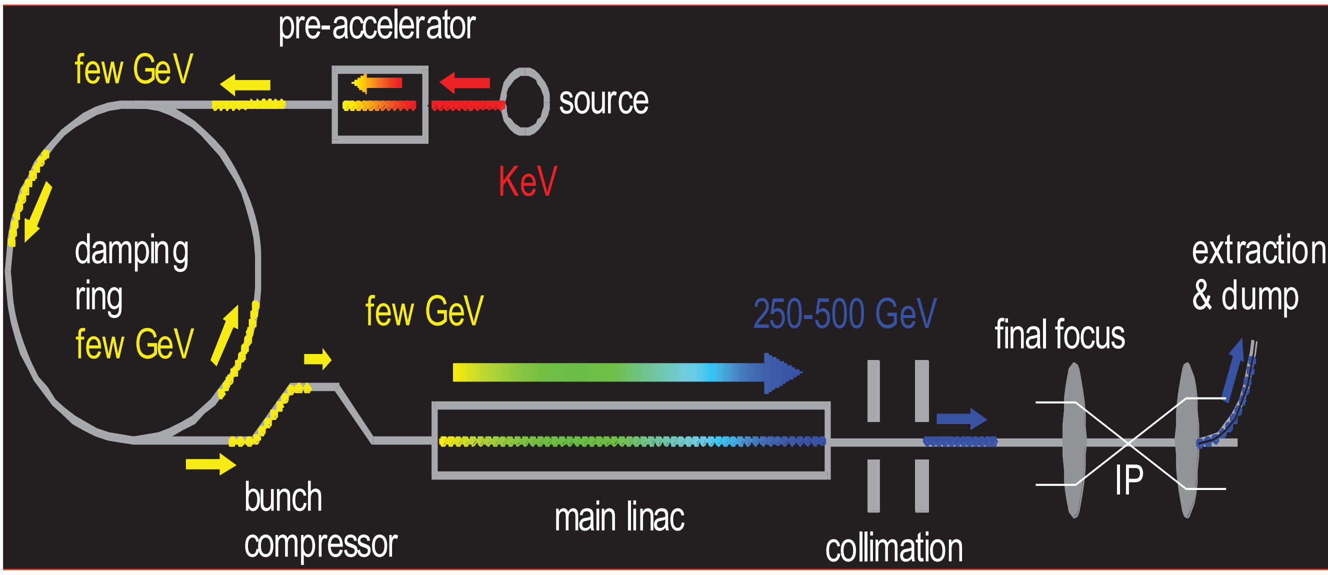
Luminosity	2	10**34

Designing the future LC

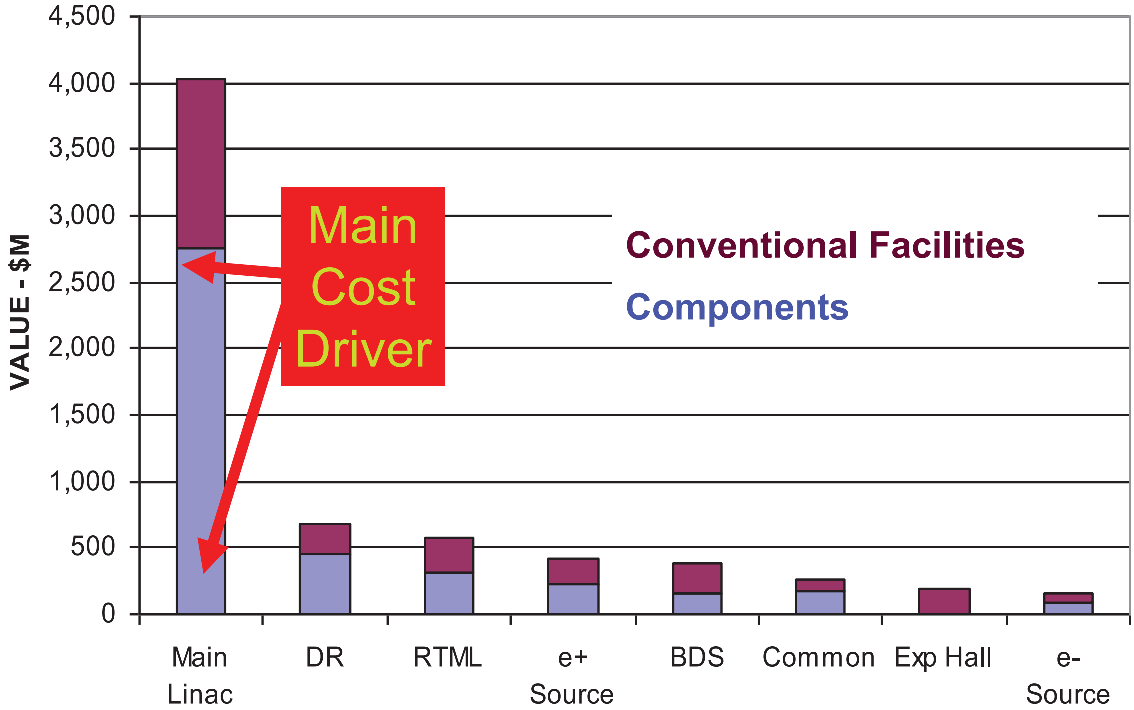


Key challenges

- **Energy:**

- **Luminosity:**

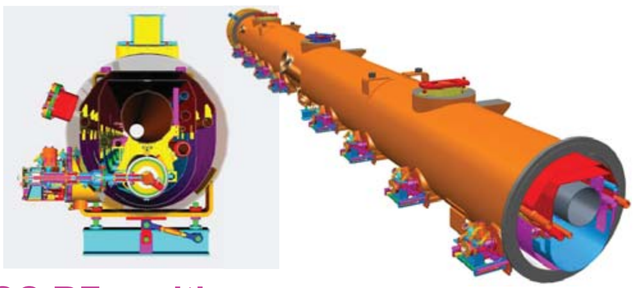
ILC value breakdown



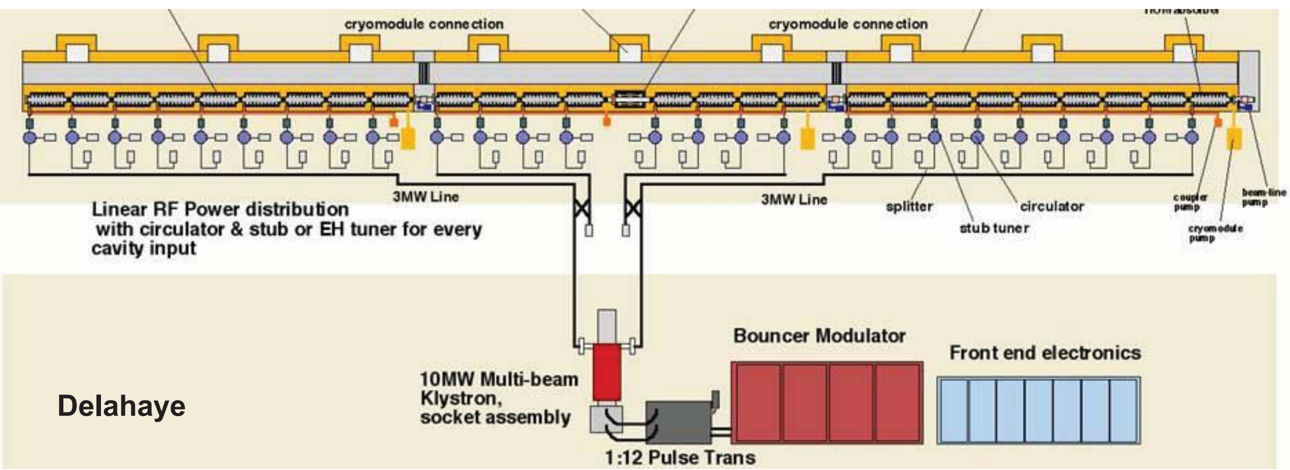
Main Linac RF Overview

560 RF units each one composed of:

- 1 Bouncer type modulator
- 1 Multibeam klystron (10 MW, 1.6 ms)
- 3 Cryostats (9+8+9 = 26 cavities)
- 1 Quadrupole at the center



Total of 1680 cryomodules and 14 560 SC RF cavities

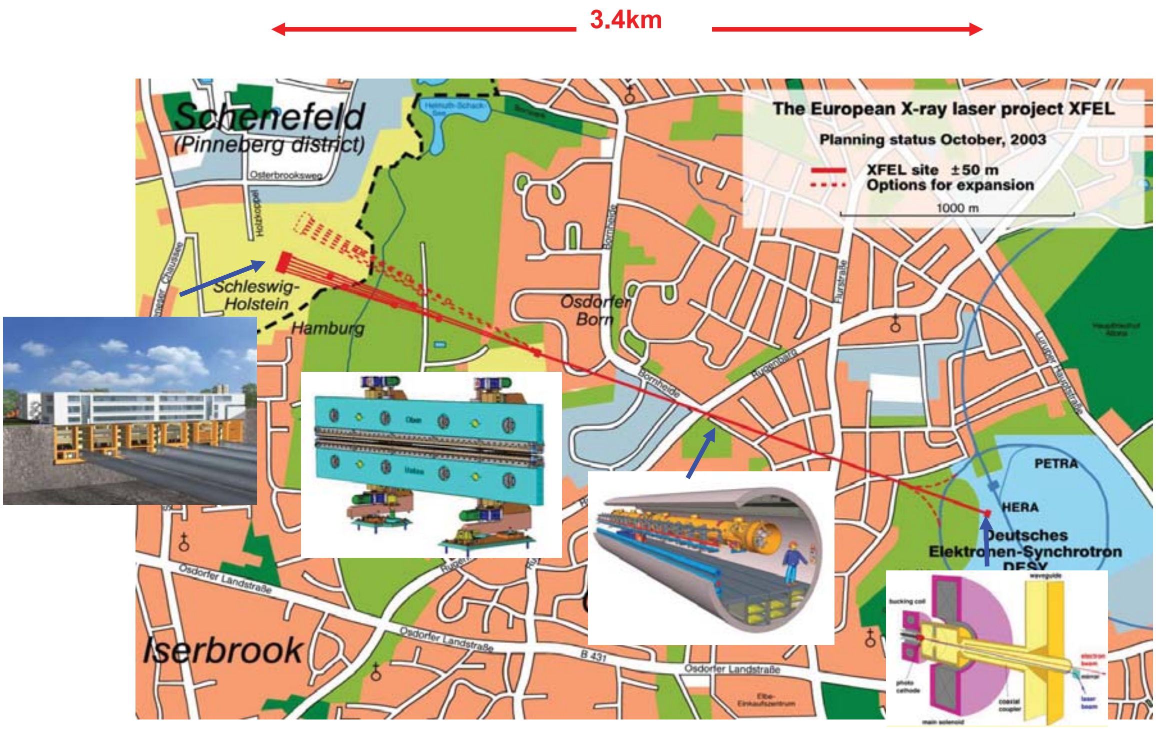


ILC SC RF cavity

- Achieve high gradient (35MV/m); develop multiple vendors; make cost effective, etc

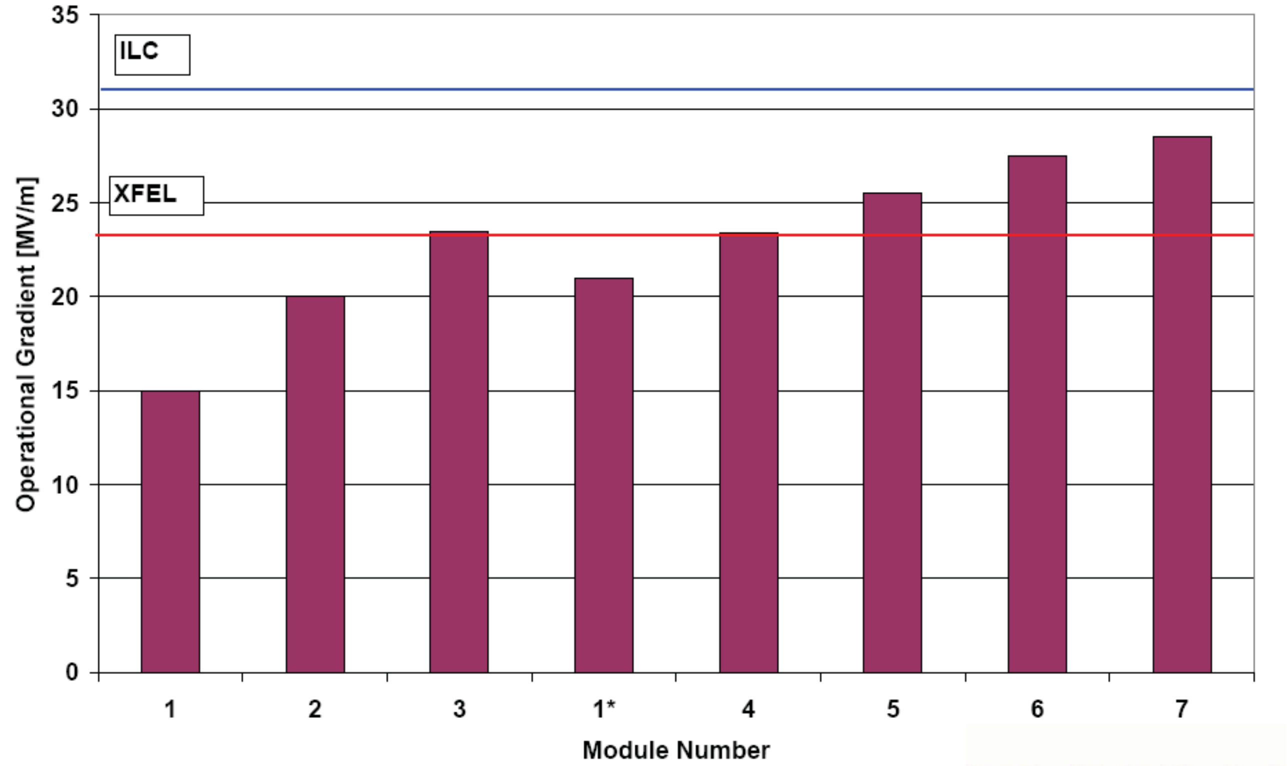
- Focus is on high gradient; production yields; cryogenic losses; radiation; system performance

European X-FEL at DESY



Delahaye

TESLA module results (FLASH)



Global SCRF Technology

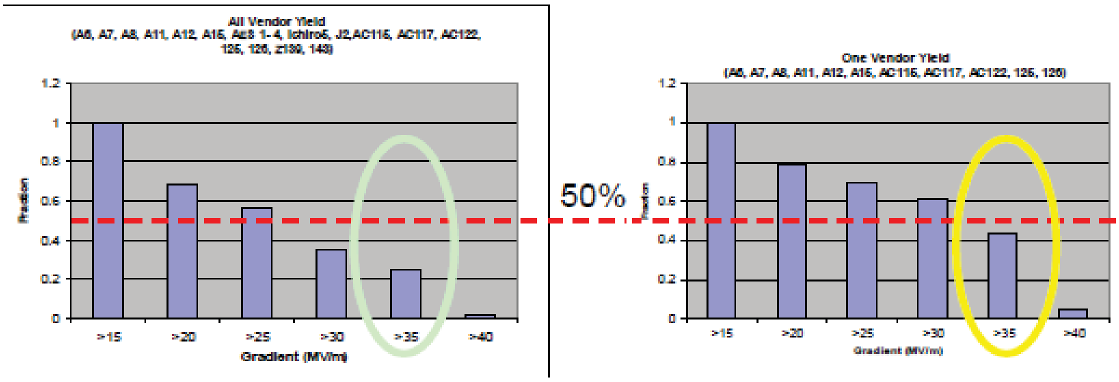
Emerging SRF

N. Walker - ILC08

Status of 9-Cell Cavity R&D

48 Tests, 19 cavities
ACCEL, AES, Zanon, Ichiro, Jlab

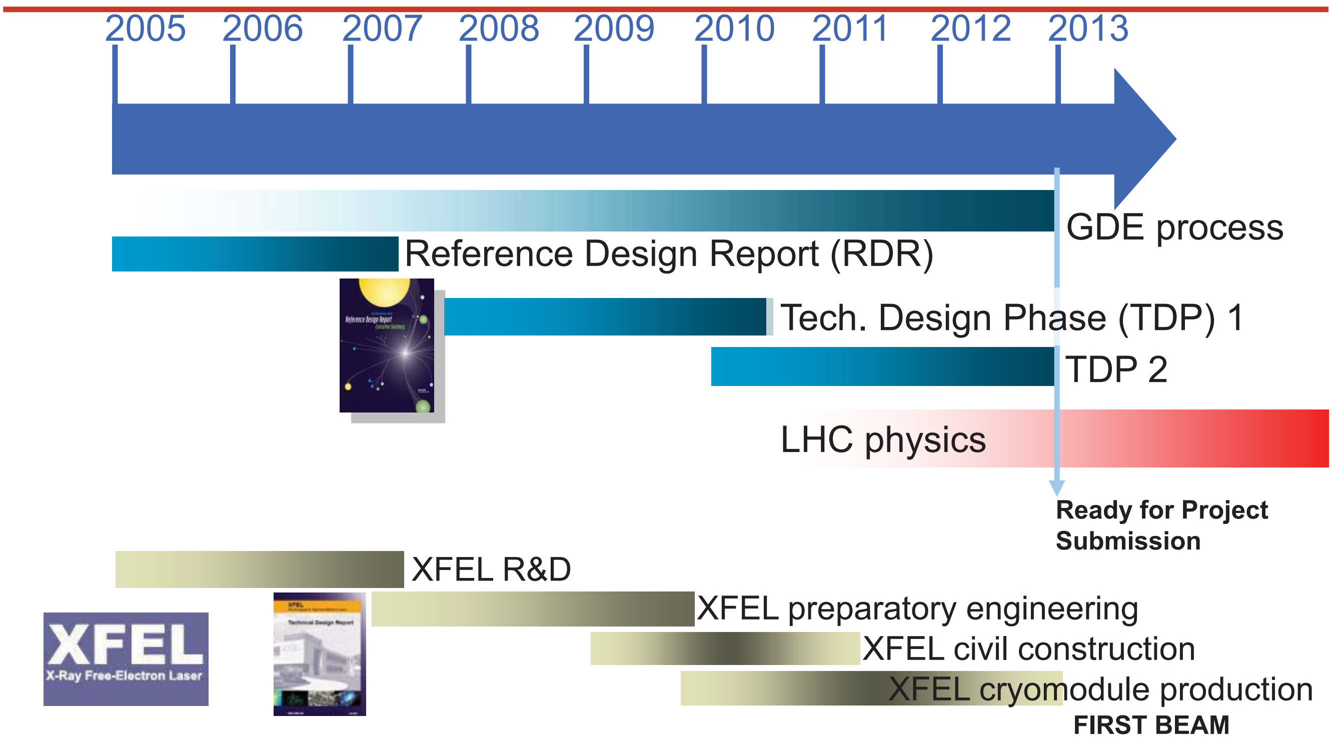
23 tests, 11 cavities
One Vendor



Yield 45 % at 35 MV/m being achieved
by cavities with a qualified vendor !!

Barish

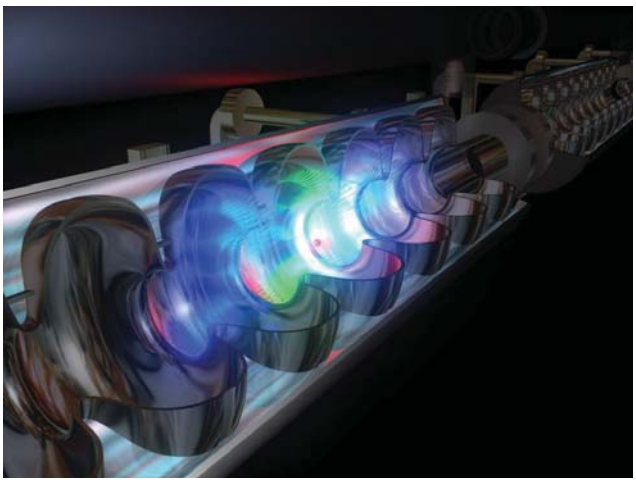
ILC & XFEL timelines



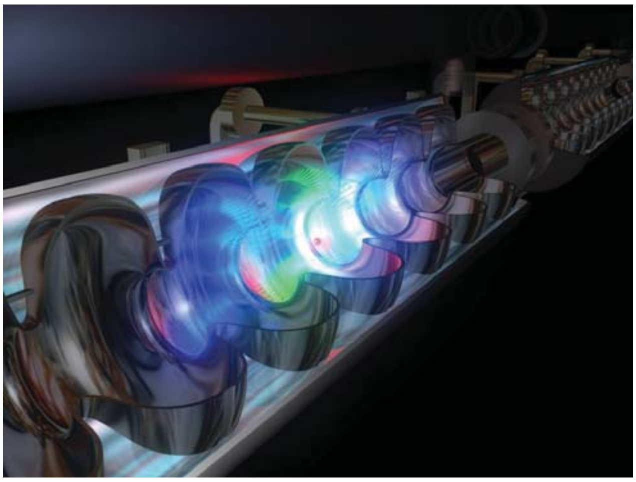
Key challenges

- **Energy:**
  sustain high gradients
  ILC: > 30 MeV/m
  CLIC: c. 100 MeV/m

Niobium Accelerating Cavities



Niobium Accelerating Cavities



c. 20,000 needed

Luminosity challenge

- **ILC luminosity goal 2 x 10** 34 /cm**2/s**

  Tiny beams: 5 nm (y) x 500 nm (x) at IP

  Long trains of bunches: 3000

  Bunch spacing 150 ns
- **Trains come every 5 Hz**
- **Making and colliding such beams not easy!**

Luminosity challenge

- ILC (CLIC) luminosity goal 2 (6) x 10** 34 /cm**2/s

  Tiny beams: 5 (1) nm (y) x 500 (50) nm (x) at IP

  Long trains of bunches: 3000 (300)

  Bunch spacing 150 (0.5) ns
- Trains come every 5 (50) Hz
- Making and colliding such beams not easy!

A shaky accelerator

- ‘static’ effects:

  misalignments …
- diffusive effects:

  settling, hydrology …
- ‘seismic’ motion:

  earthquakes, ocean waves …
- cultural/facilities noise:

  traffic, pumps, water flow…
- slow drifts:

  temperature, pressure …

LC status

- ILC is being run by Global Design Effort (Barish)
- C. 1000 accelerator scientists worldwide are involved
- A Baseline Design (BCD) was completed 2005
- A Reference Design Report (RDR) was released in 2007

  including a first cost estimate

Cost estimate

Not to scale!

ILC Cost Estimate (February 2007)

- shared value = 4.87 Billion ILC Value Units
- site-dependent value = 1.78 Billion ILC Value Units
- total value = 6.65 Billion ILC Value Units
  (shared + site-dependent)

- labour = 22 million person-hours = 13,000 person-years
  (assuming 1700 person-hours per person-year)

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1 ILC Value Unit = 1 US Dollar (2007) = 0.83 Euros = 117 Yen

This was noticed!

News
***Nature* 445, 694 (15 February 2007)** Published online 14 February 2007
Physicists pitch biggest accelerator

Collider costed - atom smashers don't come cheap
17 February 2007
From New Scientist Print Edition

Dark matter and 'God particle' within reach
Thursday, 15 February 2007
by Frederic Garlan
Agençe France-Presse

News of the Week
PHYSICS:
International Team Releases Design, Cost for Next Great Particle Smasher

Multibillion-dollar collider plans unveiled
8 February 2007
***PhysicsWeb* 8 February 2007**

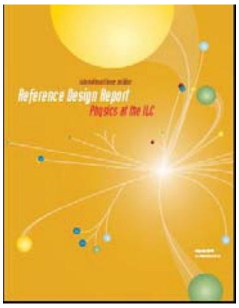
$7b proposed for particle study
By Jia Hepeng
Updated: 2007-02-09 06:45

Physicists plan costly look at the beginnings of the universe
International Herald Tribune

Next-Gen Smasher to Cost $6.6B
Wired News
8 February 2007

Reference Design Report (Feb 2007)

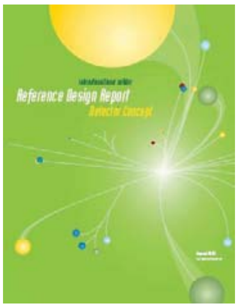
Executive Summary



Physics at the ILC

700 authors, 84 institutes

Accelerator



Detectors

ILC project status

- ILC is being run by Global Design Effort (Barish)
- C. 1000 accelerator scientists worldwide are involved
- A Baseline Design (BCD) was completed 2005
- A Reference Design Report (RDR) was released in 2007

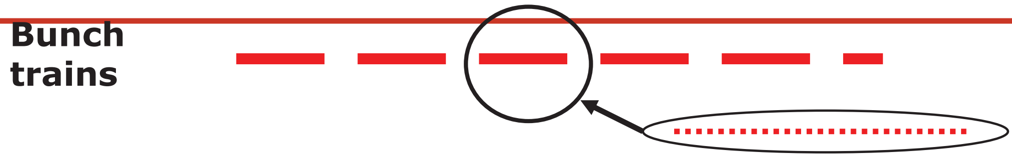
  including a first cost estimate
- 2008-12 Technical Design Phase (TDP)

  major focus is on design optimisation + cost reduction
- Ready for 'construction decision' by 2012, in light of LHC results …

ILC Detectors

- Reference Design Reports provided by 4 concept groups in 2007
- A Research Directorate was formed in 2007
- Letters of Intent to the ILC Research Director (Sakue Yamada) are due by 31/3/09
- International Detector Advisory Group (Chair: M. Davier) will review LoIs: outcome Autumn 2009
- Those concepts 'validated' will proceed to a Technical Design as a companion to machine TDR in 2012
- Detector R&D ongoing; CLIC detector work started

Bunch Structure



CLIC : 1 train = 312 bunches 0.5 ns apart 50 Hz rate

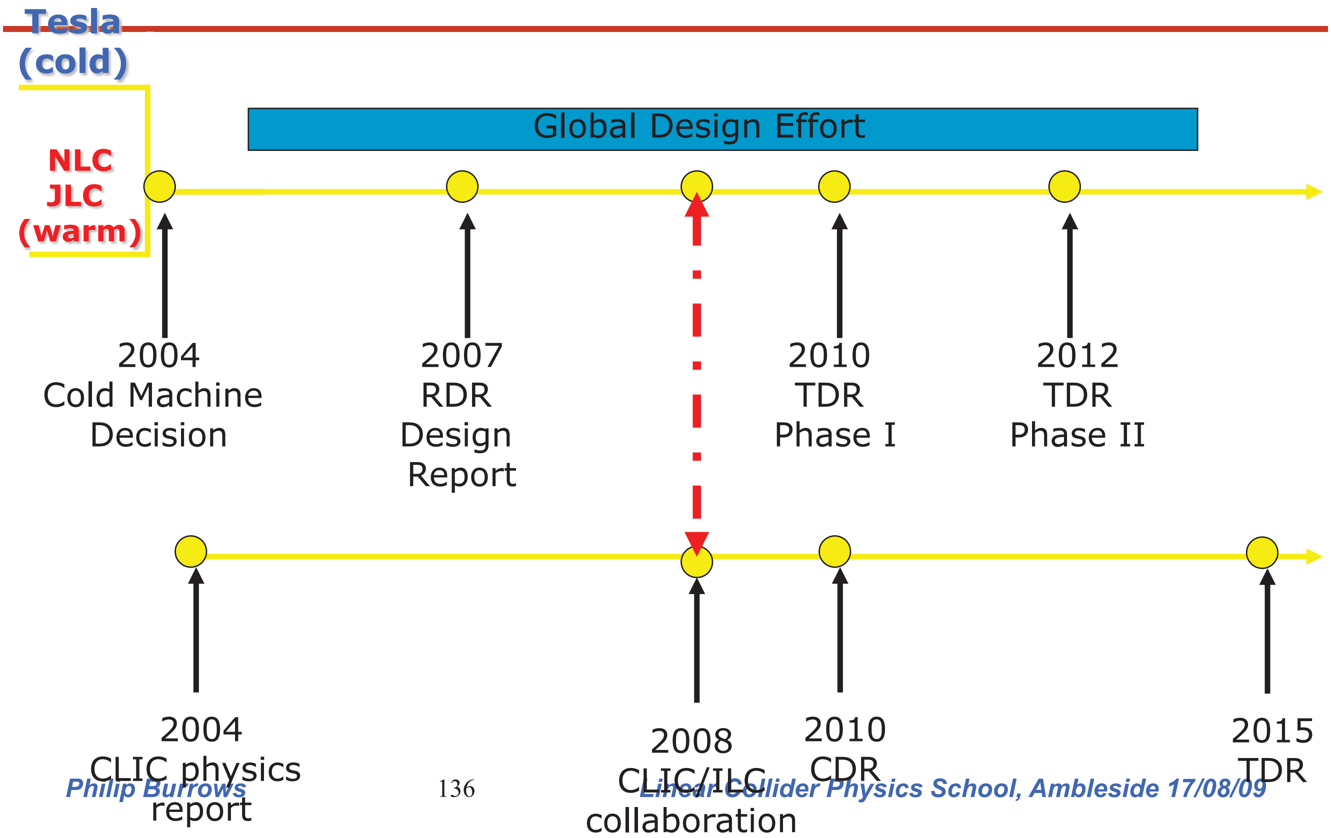
ILC : 1 train = 2680 bunches 337 ns apart 5 Hz rate

Huge number of e^+e^- pairs produced in strong fields of beams (beamstrahlung)

Need time-slicing within bunch trains to reduce detector occupancy

- Trade-off of power and material
- Difficult at CLIC

Accelerators Roadmap



Worldwide Status: Europe

New CERN DG: LC is part of CERN strategy and objectives

- CERN sees a Linear Collider as the logical next machine and promotes CLIC studies and ILC-CLIC collaboration

CERN hosted CLIC studies since long time

- ILC and CLIC formed a common study group in 2008

CERN also has now an official LC Detector R&D project

Worldwide Status: US

After 'black December' 2007 budget restored for ILC work by Congress

- FY09 & FY10 budget $35M + some from stimulus packages

Detector R&D package approved by DOE and NSF

P5 encourages "R&D on the ILC"

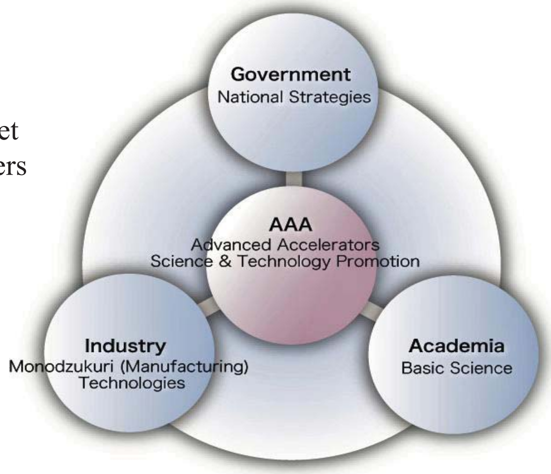
PoS(LCPS2009)001

Worldwide Status: Japan

ILC has strong support from the government and industry

- Formed Advanced Accelerator Association Promoting Science & Technology (AAA)
- Takeo Kawamura (Minister of State, Chief Cabinet Secretary, secretary of "Federation of Diet members to promote the realization of ILC"),

".. will go over the ILC project as a national strategy."



LC Detector: Physics Requirements

b/c-tagging with high purity/efficiency
- e.g. Higgs branching ratios

Precision Tracking
- Recoil mass measurements

Jet energy resolution
- Multi jet final states e.g. ttbar
- Separation of WW/ZZ
- Particle Flow algorithms

Forward region very important
- ILC physics becomes forward boosted at higher energies

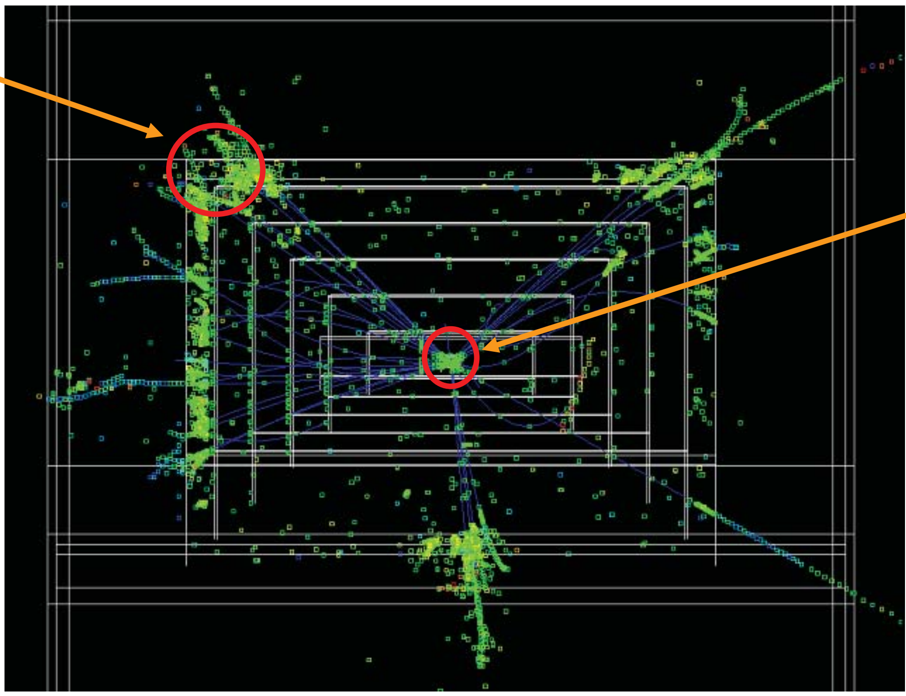
LC Detector

LC detector is challenging

Challenge is in precision

- Calorimeter granularity ~200 better than LHC
- Vertex detector:
  - Pixel size ~20 smaller than LHC
  - Material budget, central ~10 less than LHC
  - Material budget, forward ~ >100 less than LHC

UK Working Areas

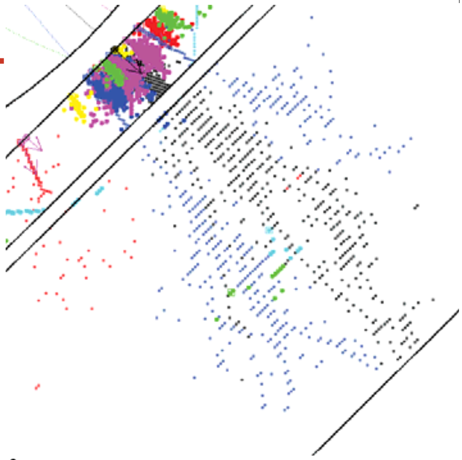


Particle Flow Algorithm & CALICE

PFA: measure energy of
- Charged particles in the tracker
- Photons in ECAL
- BUT: need to disentangle contribution of each particle to avoid double counting

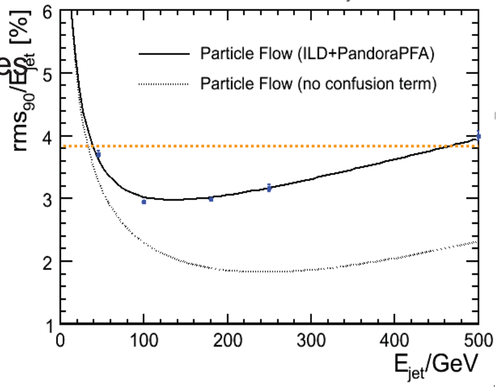
Requires excellent segmentation of CAL

PFA can deliver desired energy resolution: $\sigma(E_{jet})/E_{jet} < 4$ %



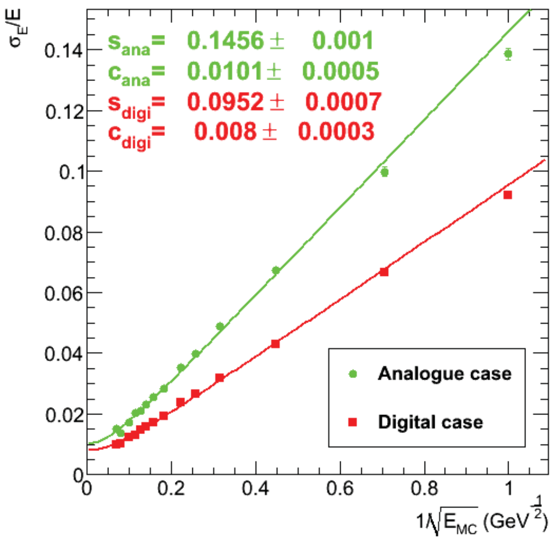
CALICE is covering several alternative PFA technologies for both ECALs and HCALs
- Proof of concept prototypes
- 2010: realistic "technical" prototypes with a reasonable size and shape for LC detectors

CALICE conclusions will dominate the ILC design choices



CALICE UK

Digital ECAL
- Number of charged particles is a better estimate than deposited energy
  - No Landau fluctuations or angular smearing
  - "digital" ECAL resolution ~50% better than "analogue"



Data Acquisition
- Software and hardware components for CAL control and readout
- Challenging data rates

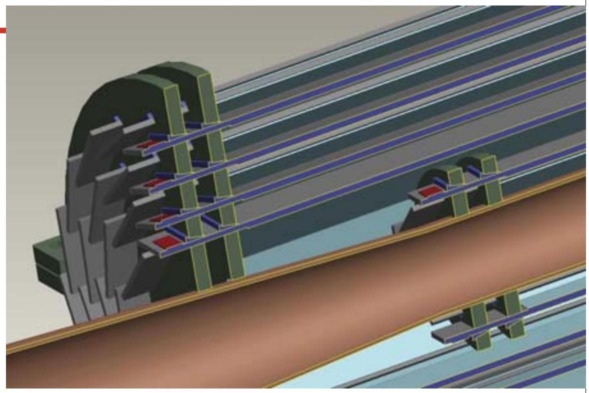
LCFI: Vertex Detector

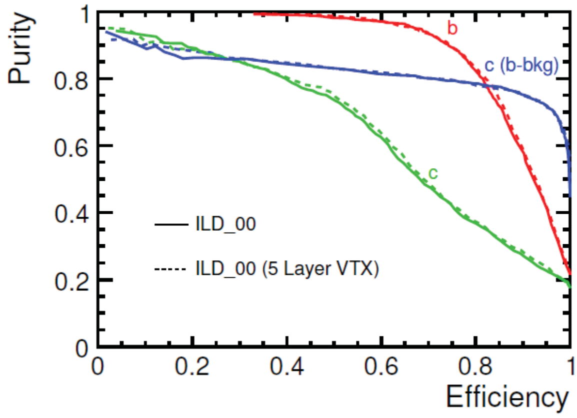
1 Giga channels of 20×20 µm pixels in 5 layers with fast readout

- 3 µm resolution
- Low material budget 0.1% X_0 per layer

LCFI Vertex Package used by entire ILC community

- Topological vertex finder & flavour tagging
- Excellent performance for b- and c-tagging

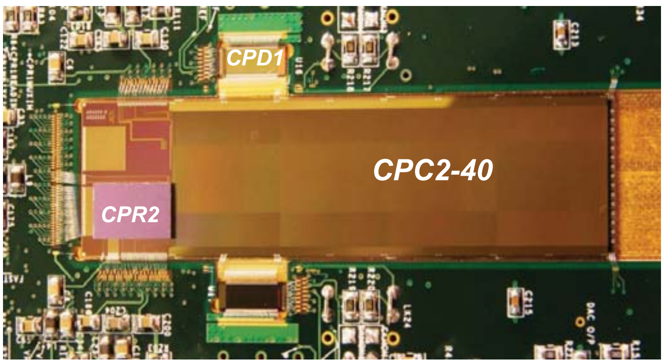




LCFI: Sensor R&D

Produced 10 cm long Column Parallel CCD sensors, readout and driver chips, CPR2A & CPD1

- Achieved low-noise operation at 30 MHz



ISIS sensors with internal charge storage

Detector R&D Status in UK

Both CALICE-UK and LCFI were told to terminate in 2008

Re-established funding for "Generic Detector R&D" at dramatically reduced level
- Still relevant for LC detectors

Three successful projects
- LSSSD: Low mass structures
- SPiDeR: Silicon Pixel Detector R&D
- Particle Flow: Particle Flow Algorithms

Approved to start in 2009 but SPIDER on hold until April 2010

Work on LC physics, DAQ and VD sensors (ISIS) was not funded at all

LCFI vertexing software will be supported by japanese groups

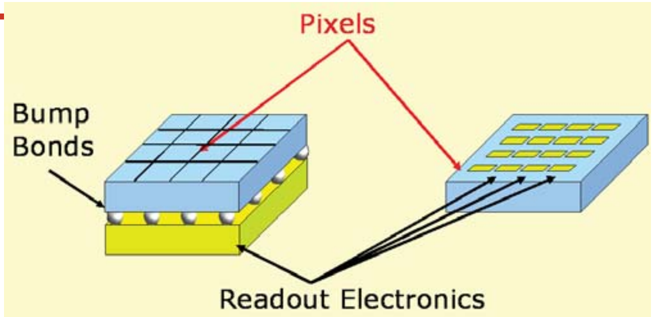
SPiDeR

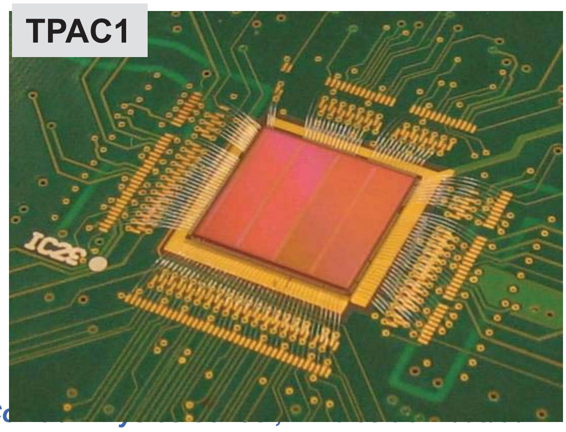
Silicon Pixel Detector R&D for future detectors
- Birmingham, Bristol, Imperial, Oxford, RAL

Integration of sensor and readout electronics in monolithic detector
- CMOS technology
- Target calorimetry, tracking and vertexing

CALICE-UK developed small MAPS sensors for Digital ECAL
- TPAC1

Goal for Digital CAL: large scale sensor to demonstrate advantages in test beam



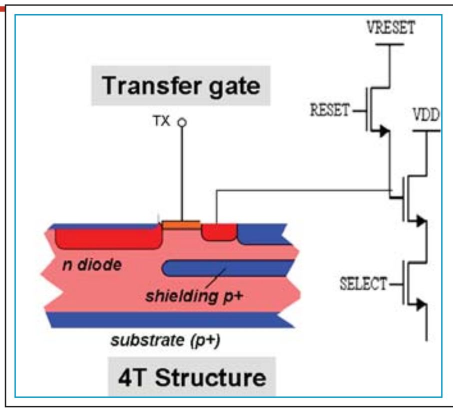


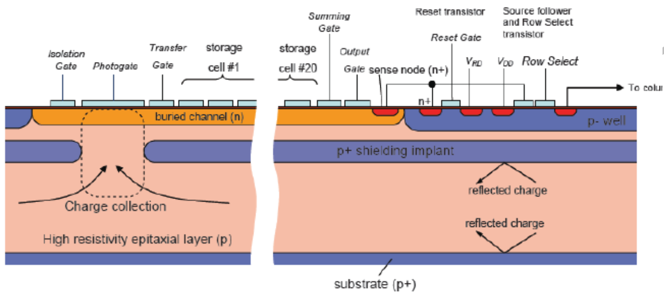
SPiDeR Sensors: Cherwell and ISIS

Cherwell uses INMAPS process and 4T architecture
- Distributed functionality with 100% sensitive area

4T (four transistors) structure allows efficient charge capture and amplification
- Better noise performance due to transfer gate

ISIS: enhancement of CMOS
- Storage of raw charge: noise immunity and no need for pulsed power
- ISIS2: first ever implementation of CCD buried channel in a CMOS process
- Currently not funded





LSSSD

Low-mass Structures for Supporting Silicon Detectors
- Bristol, Glasgow, Liverpool and RAL
- Follow-up to LCFI mechanical work

Lightweight elements in silicon carbide foam
- Few % fill factor
- Studying properties, processing, building modules
- Designing all foam VXD, investigate embedded cooling

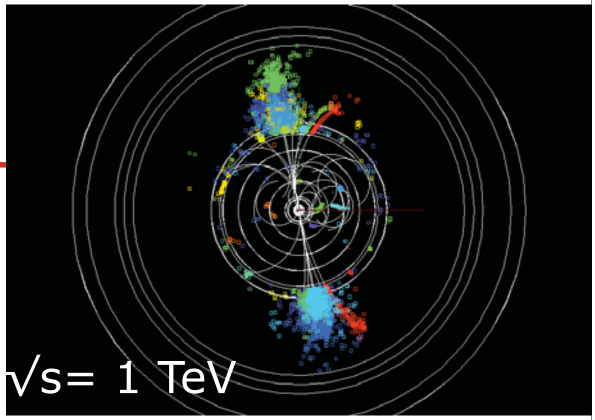
Particle Flow

Proposal to advance particle flow algorithms for future Colliders

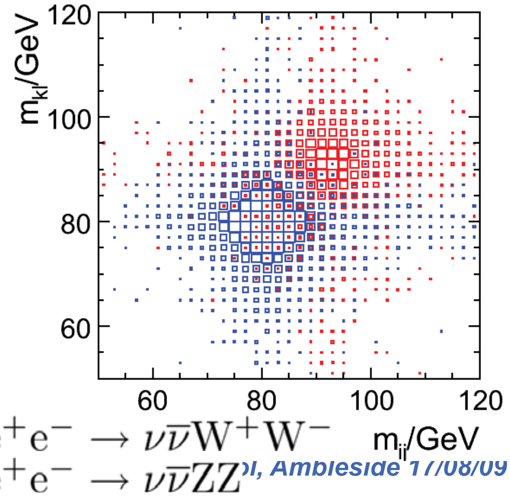
- Cambridge, RAL
- CERN joined the effort

Will study

- Digital calorimetry and PFA's
- PFA at TeV energies



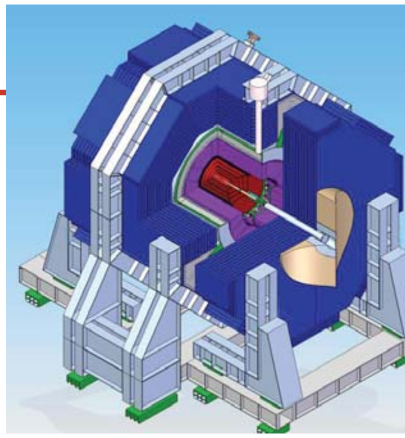
- Example: separation of WW and ZZ signals at 1 TeV



Detector Concepts: SiD and ILD

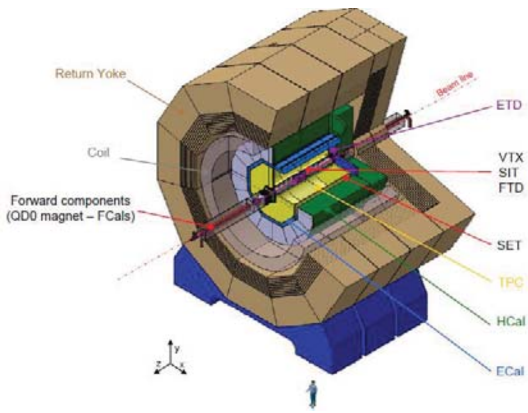
SiD: Compact, 5 T field

- All silicon tracking
  - 5 layers of pixels & 5 layers of strips
  - Single bunch time stamping for strips
- Highly granular PFA calorimetry
  - SiW ECAL
  - Fe-RPC digital HCAL

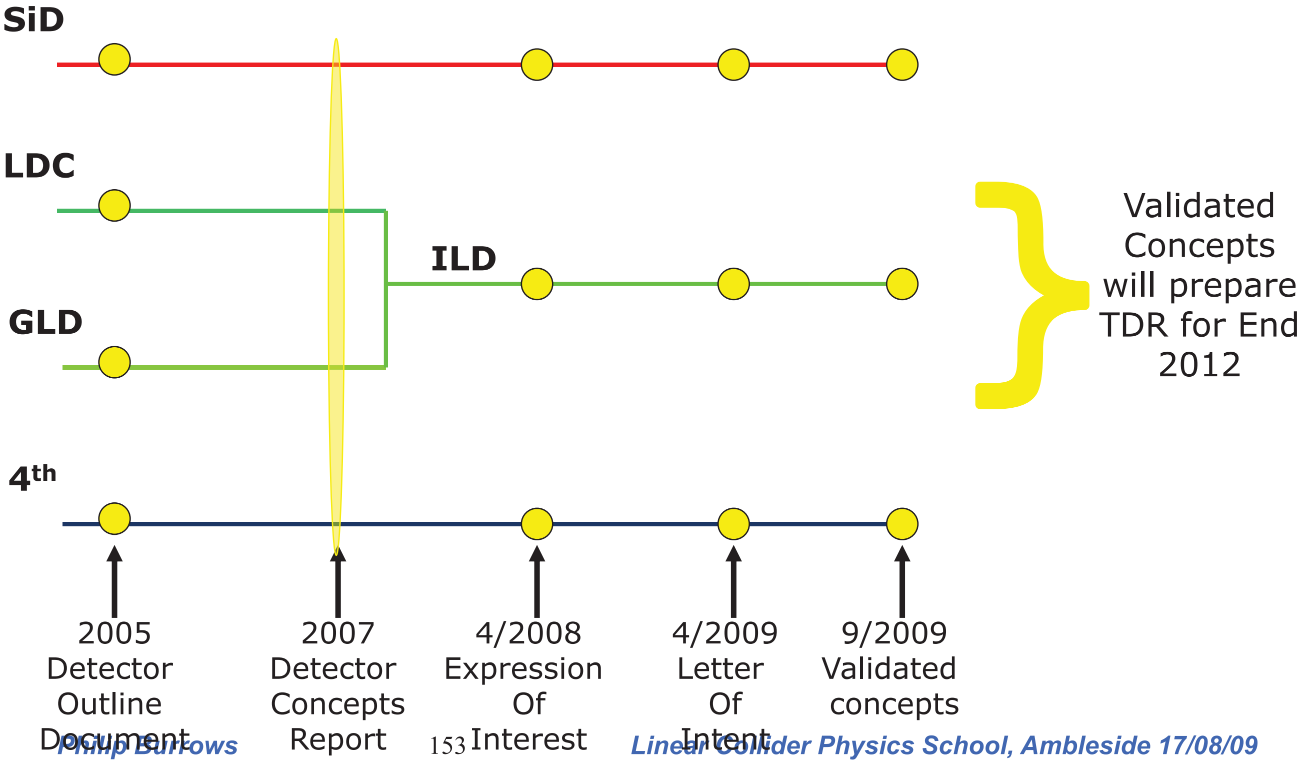


ILD: Large Volume, 3.5 T field

- Silicon +TPC tracking
  - 5 layer pixels & Si Tracking layers
  - Large TPC
- Highly granular PFA calorimetry
  - SiW ECAL
  - Fe-Scint HCAL



Detector Roadmap



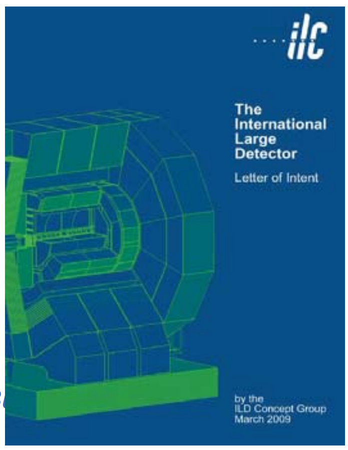
Detector Concept Letters of Intent

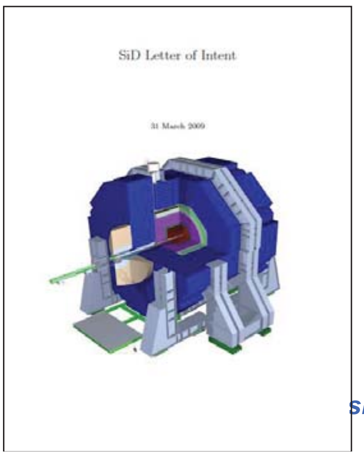
Submitted in April 2009
- ILD: 148 institutions; SiD: 77 institutions; CERN signed all three LoIs
- ~60 signatures from UK

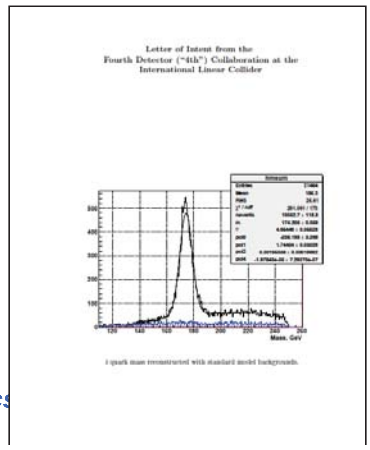
Benchmarking studies
- For first time used full simulation and reconstruction for optimization

Studies of Machine Detector Interface (MDI) and push-pull scheme

Leading role of UK physicists in PFA and vertexing software, benchmarking and MDI







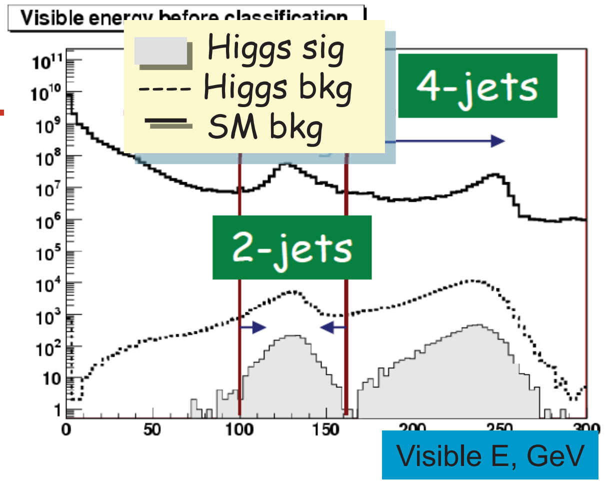
Examples of Benchmarks

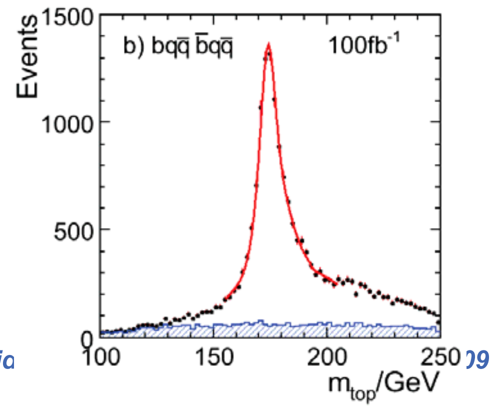
SiD Higgs→cc analysis

- Signatures: 2 jets + Missing E or 4 jets
- Two charm jets: c-tagging
- Br(h→cc) = ± 10%

ILD top analysis

- Fully hadronic: 6 jets final state
- Employ invariant masses
- Two bottom jets: b-tagging
- $\delta m = \pm 30$ MeV

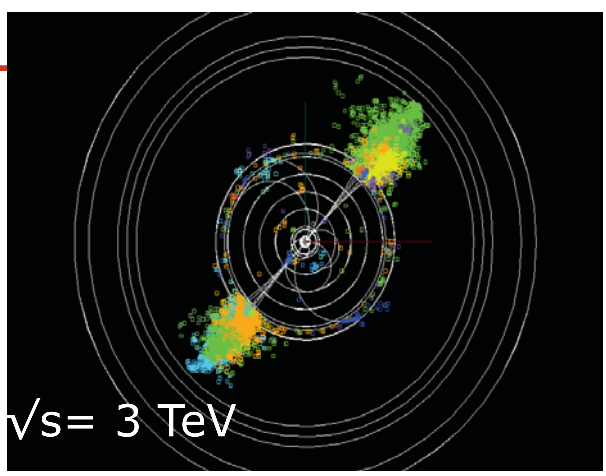


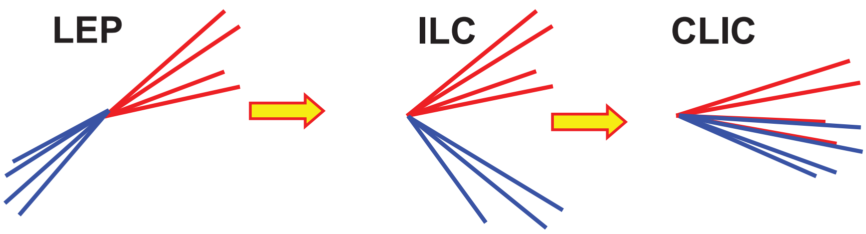


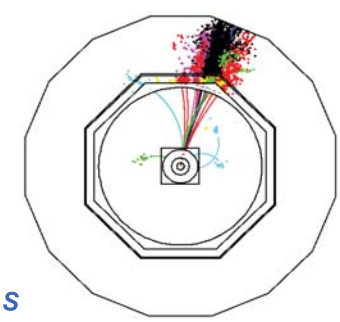
Particle Flow at TeV scale?

Issues to study

- Performance at TeV energy
- Merging of jets
- Flavour tagging: most b-quarks decay beyond vertex detector







Rolf Heuer (LCWS08 closing talk)

We are NOW entering a new exciting era of particle physics
Turn on of LHC
allows particle physics experiments
at the highest collision energies ever

Expect
- revolutionary advances in understanding the microcosm
- changes to our view of the early Universe

Results from LHC will guide the way
Expect
- period for decision taking on next steps in 2010 to 2012
  (at least) concerning energy frontier
-(similar situation concerning neutrino sector Θ_{13})

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