The Great Collider in China

A Future Accelerator to Study the Higgs Boson and to Explore Nature at the Energy Frontier

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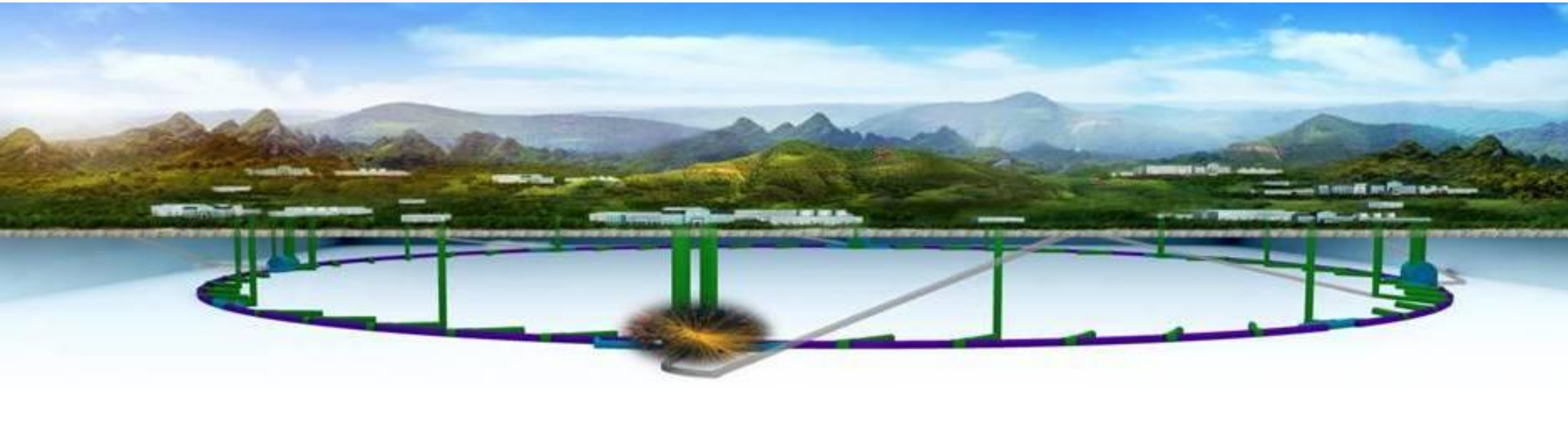
Institute of High Energy Physics, Beijing
&
University of Texas at Dallas



Outline

- Elementary particle physics – an introduction
- The Higgs boson: basics, discovery, study
- The need for new lepton colliders
- Lepton colliders: options, progress, issues, …
- The Great Collider in China: ee and pp options
- Future prospects

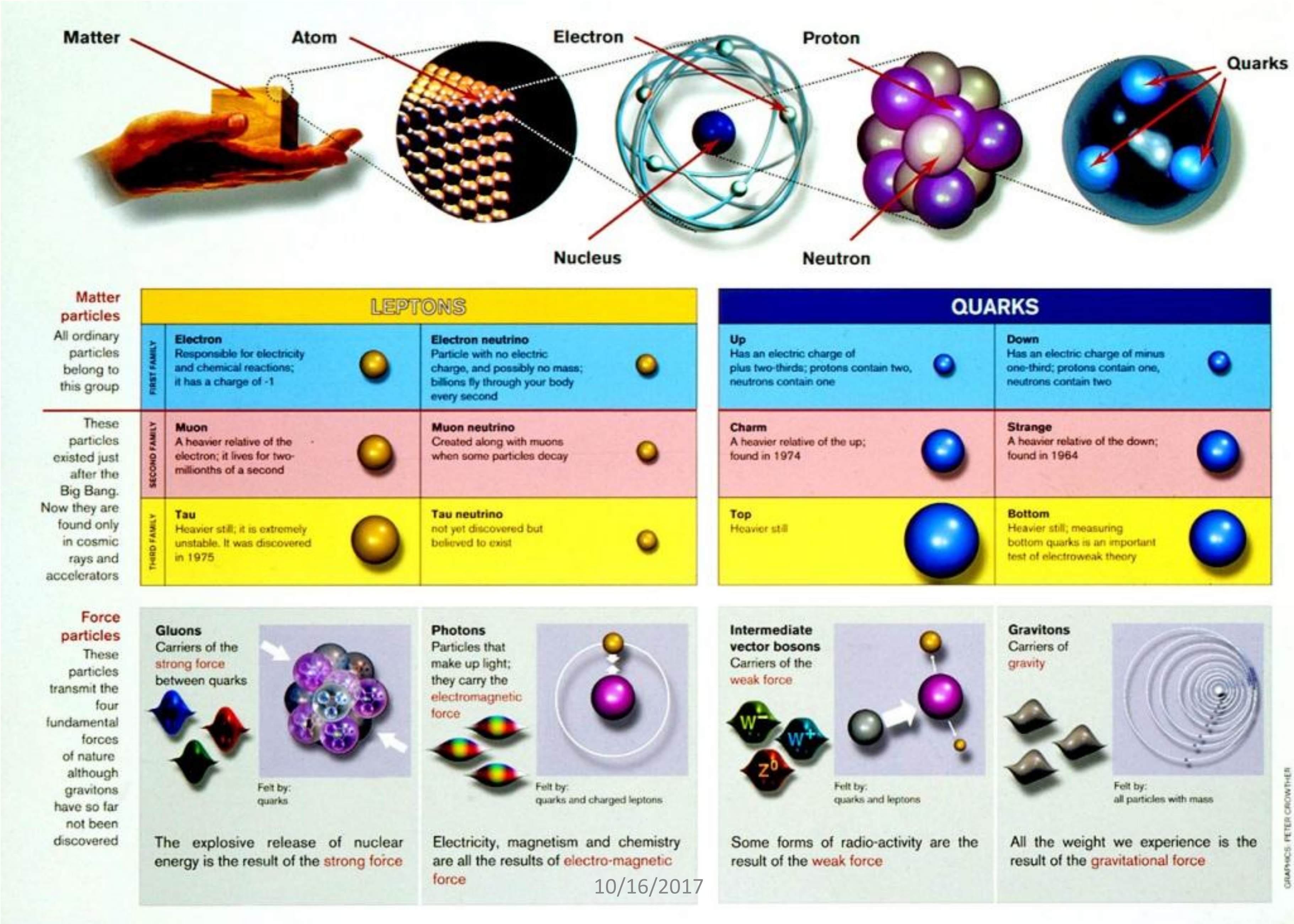
Elementary Particle Physics

- **The Standard Model**

  building blocks, interactions, the Higgs boson

- **Beyond the Standard Model (BSM)**

Elementary Particle Physics



Elementary Particle Physics

The Standard Model and the need for the Higgs boson

generation / particle	I	II	III	gauge bosons
Quarks	u (0.005)	c (1.5)	t (180)	gluon 1
(mass / strength)	d (0.01)	s (0.2)	b (4.7)	γ 1/1,000
Leptons	e (.0005)	μ (0.106)	τ (1.777)	Z^0 **1/10,000** 91 GeV
(mass/ strength)	ν_e $<7\times10^{-9}$	ν_μ <.0003	ν_τ <0.03	$W^\pm$ 80.4 GeV

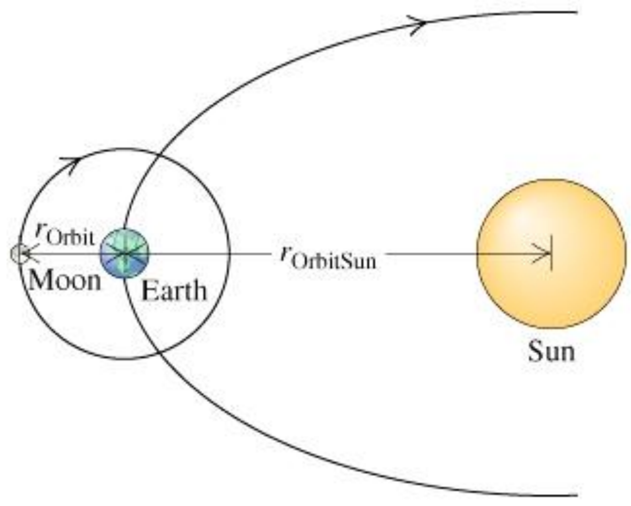
In the Standard Model – particle masses are symmetric to begin with; the data disagree

The Higgs field causes the spontaneous symmetry breaking , through which bosons and fermions acquire different masses

Physics: forces and potentials, and consequences

$$F_G = G\frac{mM}{R^2}$$

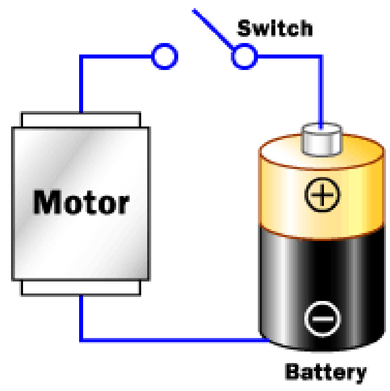
$$U_G = -G\frac{M}{R}$$

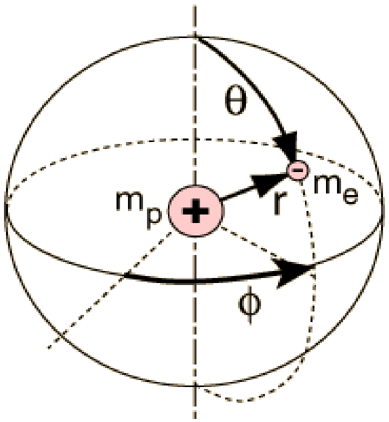


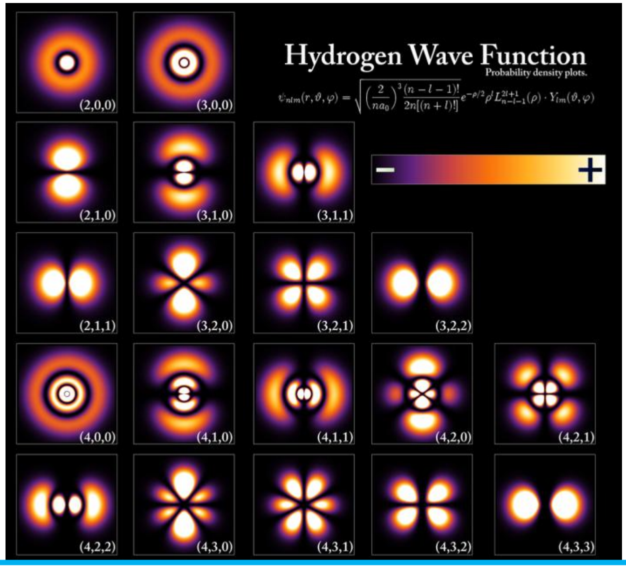
Physics: forces and potentials, and consequences

$$F_C = K\frac{qQ}{R^2}$$

$$U_c = k\frac{Q}{R}$$

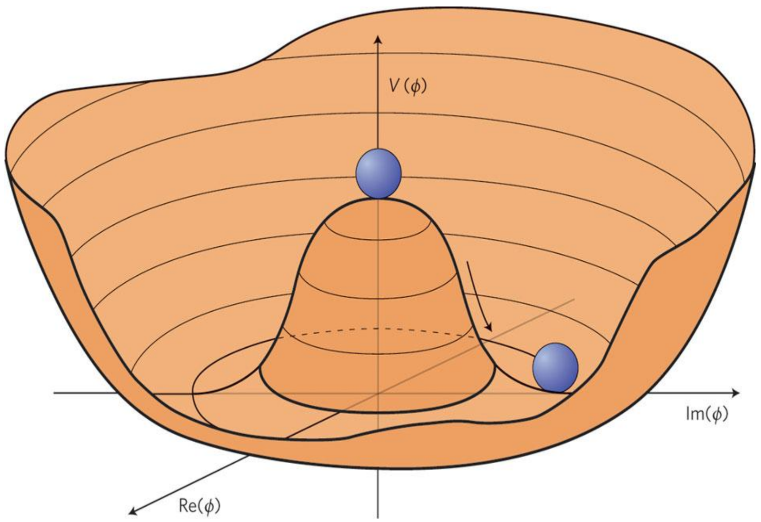






The Higgs Boson

The Higgs Mechanism



Standard Model $SU(2)_L \times U(1)_Y$

one pair of complex scalar potential, the Higgs field, $\Phi = \begin{Bmatrix} \pi^+ \\ \dfrac{\upsilon + h + i\pi^0}{\sqrt{2}} \end{Bmatrix}$

⇒ masses are provided to W, Z & elementary matter particles

The Higgs Boson

The story begins in 1964 . . .

with Englert and Brout; Higgs; Hagen, Guralnik and Kibble

VOLUME 13, NUMBER 9 PHYSICAL REVIEW LETTERS 31 AUGUST 1964

BROKEN SYMMETRY AND THE MASS OF GAUGE VECTOR MESONS*

F. Englert and R. Brout
Faculté des Sciences, Université Libre de Bruxelles, Bruxelles, Belgium
(Received 26 June 1964)

VOLUME 13, NUMBER 16 PHYSICAL REVIEW LETTERS 19 OCTOBER 1964

BROKEN SYMMETRIES AND THE MASSES OF GAUGE BOSONS

Peter W. Higgs
Tait Institute of Mathematical Physics, University of Edinburgh, Edinburgh, Scotland
(Received 31 August 1964)

VOLUME 13, NUMBER 20 PHYSICAL REVIEW LETTERS 16 NOVEMBER 1964

GLOBAL CONSERVATION LAWS AND MASSLESS PARTICLES*

G. S. Guralnik,† C. R. Hagen,‡ and T. W. B. Kibble
Department of Physics, Imperial College, London, England
(Received 12 October 1964)

The Higgs Boson

The Standard Model and the need for the Higgs boson

The mass symmetry is broken by the introduction of the **Higgs boson**, through the so-called **Spontaneous Symmetry Breaking process**

– proposed in 1964 by Higgs, Kibble, Guralnik, Engler & Brout

The Higgs Mechanism –

- **1 complex pair of scalar fields with a non trivial potential;**
- **interactions to all matter particles;**
- **1 new particle = the Higgs boson, H**

  a neutral scalar, with spin =0; a very simple particle

  SM does not predict its mass

$\Rightarrow$ masses are provided to W, Z & elementary matter particles

More on the Higgs Boson

Beyond the Standard Model (BSM)   many variations

- **Extension beyond the SM** – Minimal Supersymmmetric SM (**MSSM**):

  $\Rightarrow$ two parirs of complex fields, several Higgs bosons

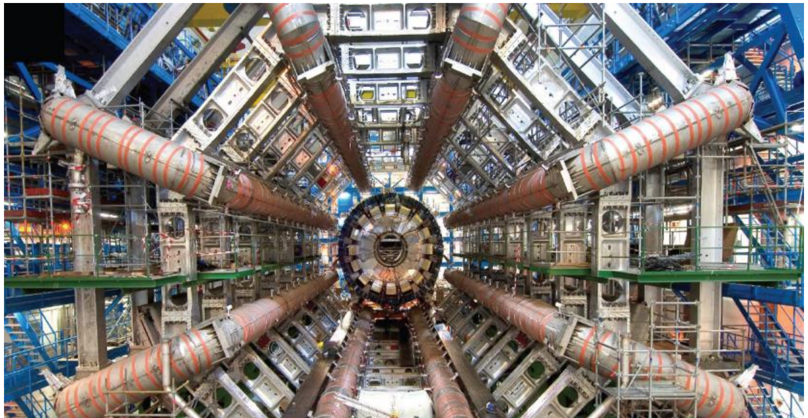
  (h^0, H^0) neutral scalars; A^0 neutral pseudoscalar;, $H^{\pm}$ a charged scalar

Standard Model $SU(2)_L \times U(1)_Y$

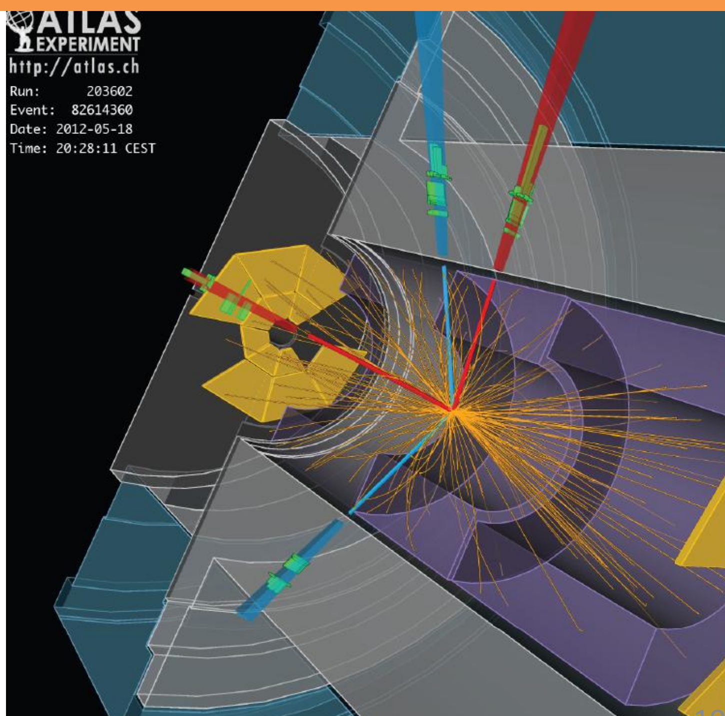
two pairs of complex potential $\Phi_a = \begin{Bmatrix} \phi_a^+ \\ \dfrac{\upsilon_a + h_a + i\eta_a}{\sqrt{2}} \end{Bmatrix}$, a=1,2

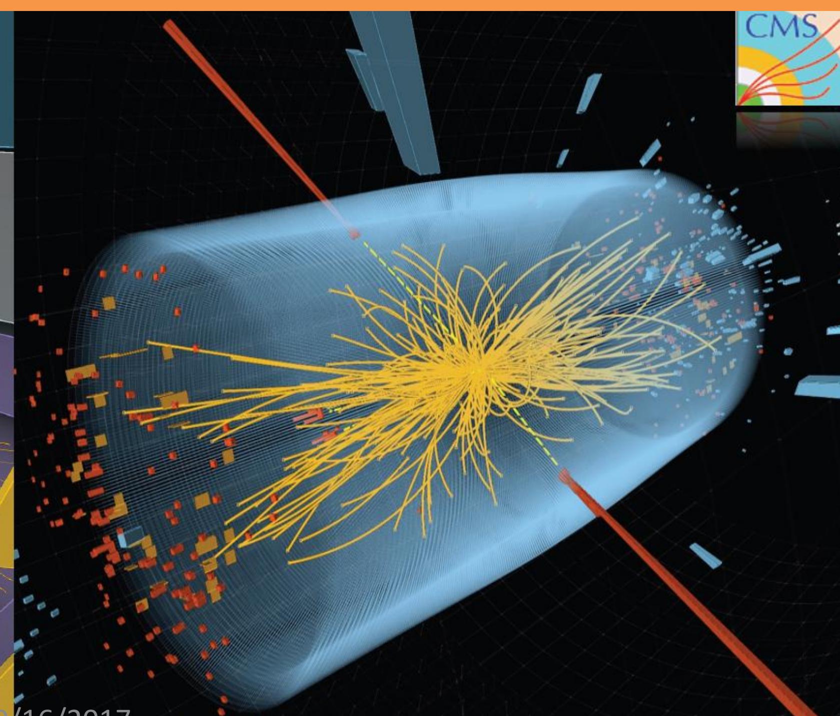
- For complex SU(2) doublet, there are 8 fields, three eaten by $W^{+/-}$ Z
- There are **five** left : **H, h (CP-even), A (CP-odd), $H^{+/-}$**

- **Extension beyond the MSSM** $\Rightarrow$ **richer spectra** of scalar and pseudoscalar particles

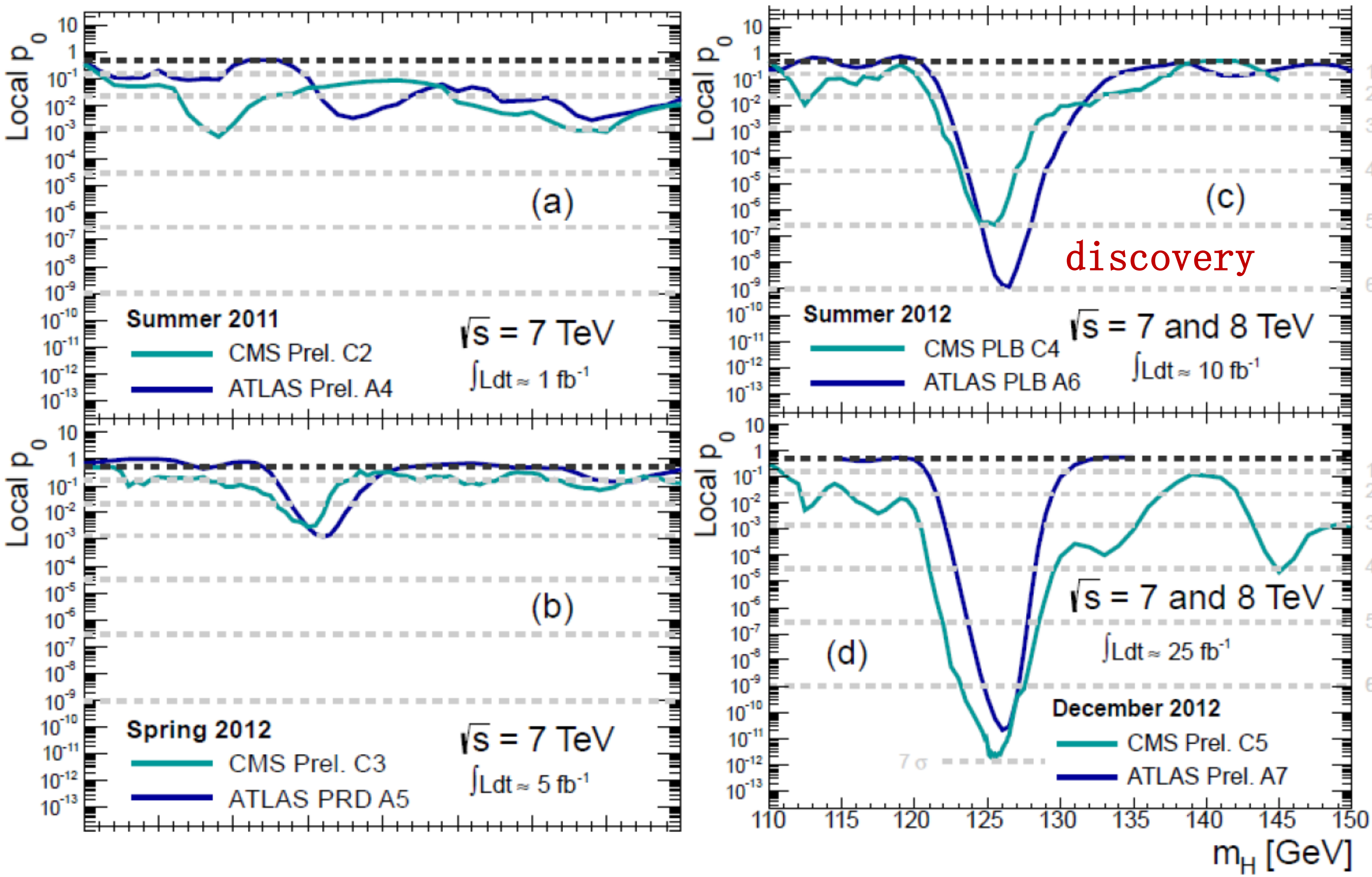


July 4, 2012 was a milestone in the history of particle physics – Higgs was discovered at both ATLAS and CMS at CERN.

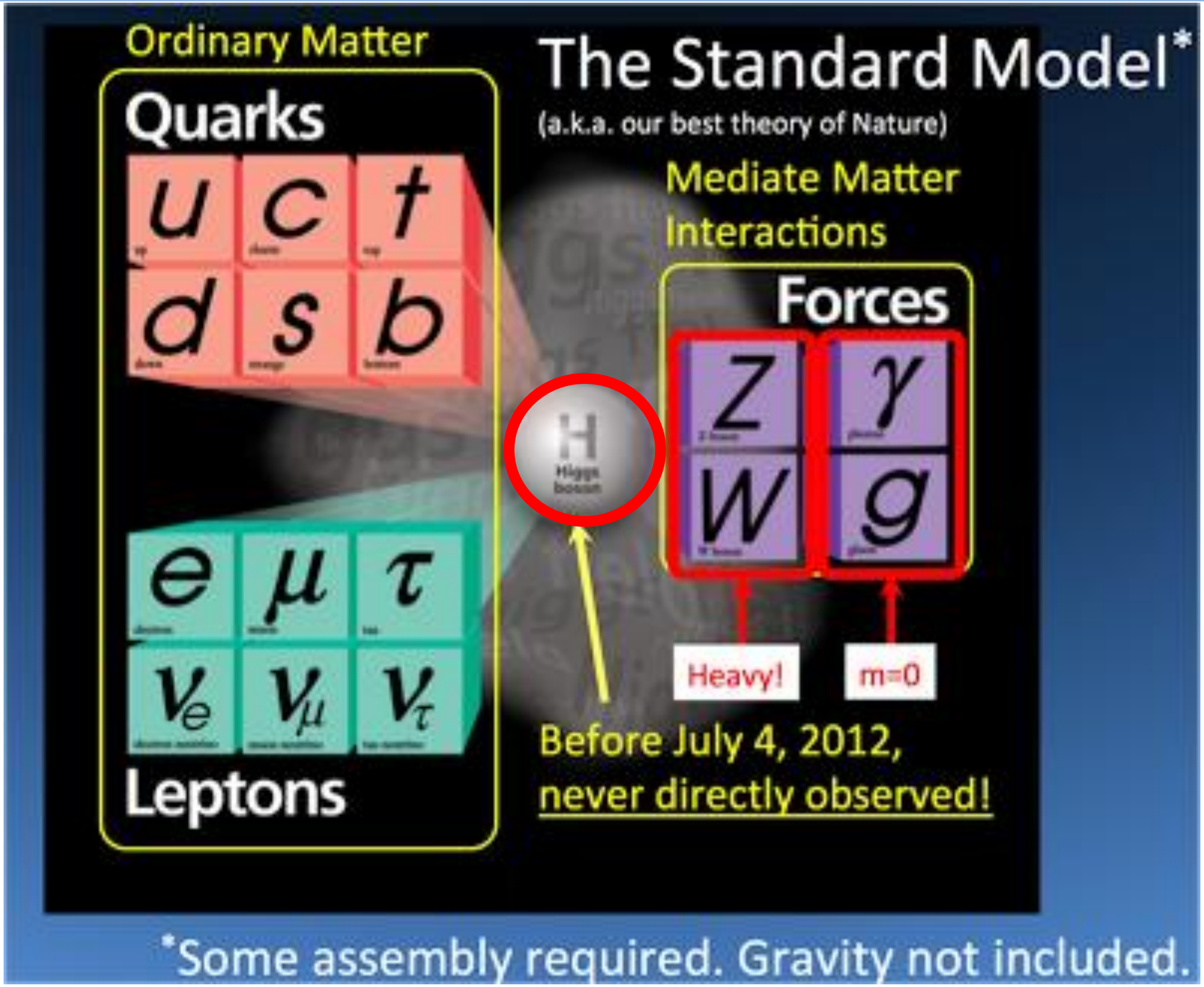




Discovery of new particle at the Large Hadron Collider



Elementary Particle Physics



Higgs interacts with all fermions & W,Z bosons;

- **Does it interact with dark matter/new particles/new physical world?**
- **Is the Higgs a portal to the new world?**

Crucial Physics Questions

- Is the Higgs boson observed at the LHC what SM expects?
- Will the Higgs boson reveal any new BSM physics?
- Is SM right?
- Why the Higgs boson is so light? Is it composite?
- Are there more Higgs bosons?

precision on the Higgs needs better than 1%precision

- Does Naturalness hold?

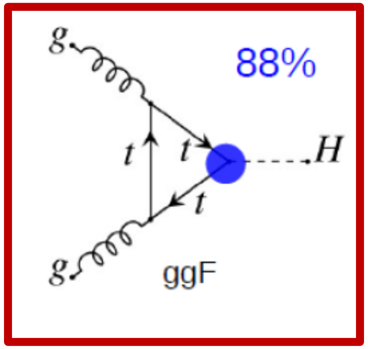
  hierarchy, light Higgs boson
- What about Dark Matter?
- Super-symmetry – what is the scale?

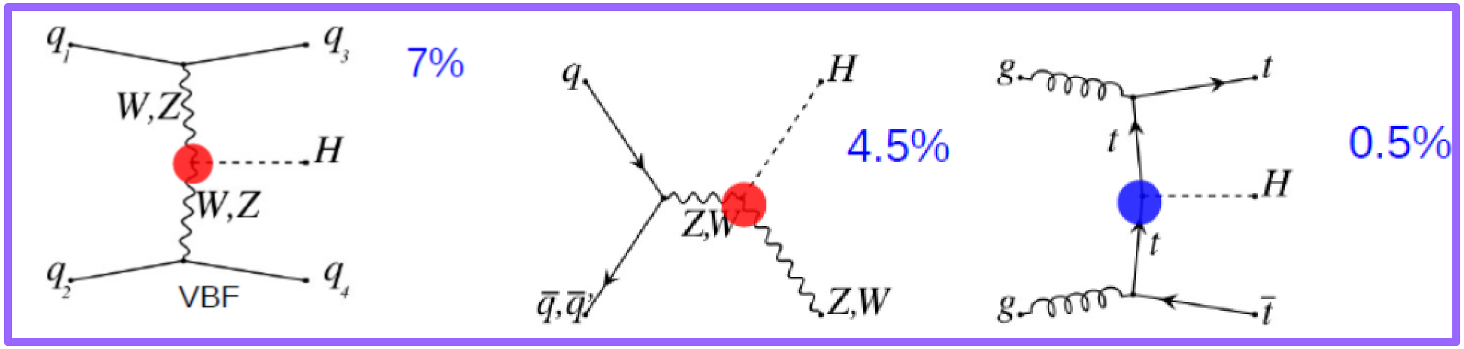
  super partners, easy to incorporate gravity
- ……

Examine the H(125)

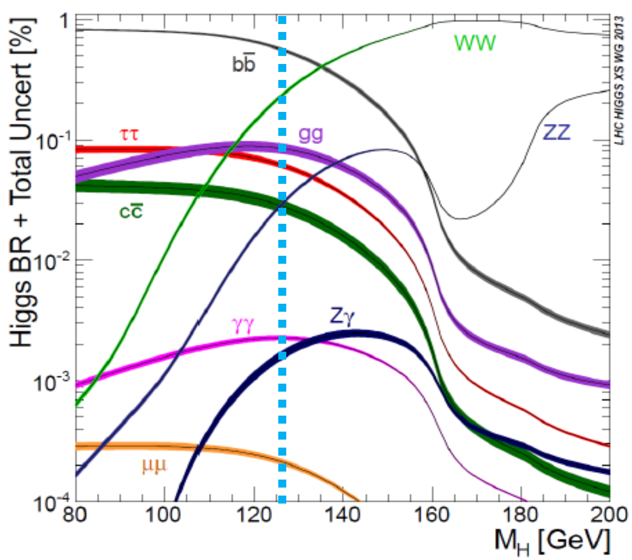
Is the Higgs the one predicted by the Standard Model?

Look at its production

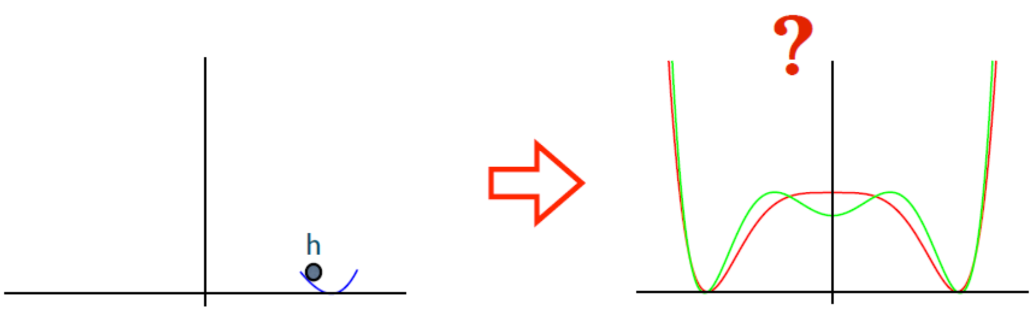




Look at its decays



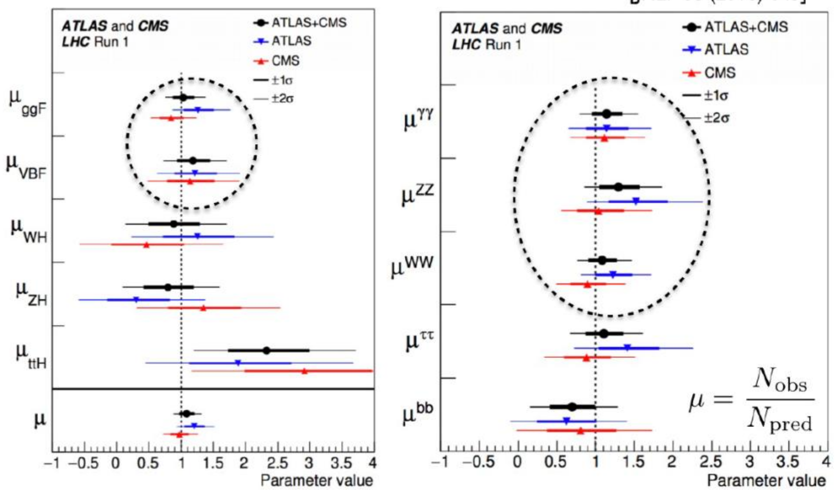
Look at its mass, J^{PC}, and EW phase transition, …



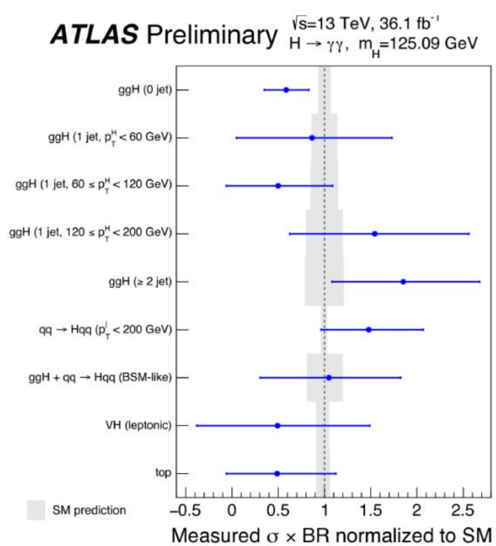
Examine the H(125)

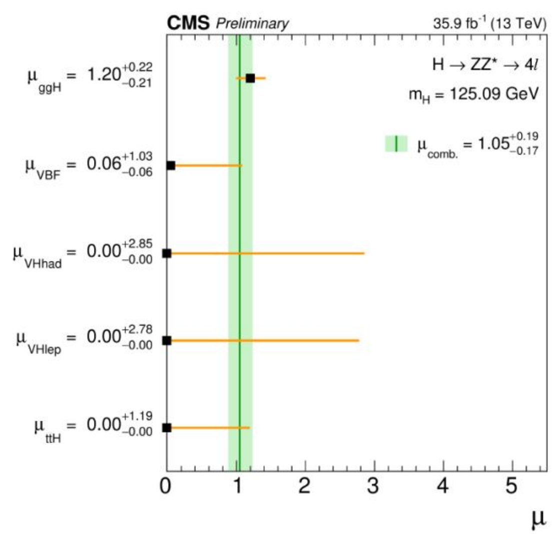
Roughly agree with Standard Model

[JHEP 08 (2016) 045]



Agree to about 10-20%





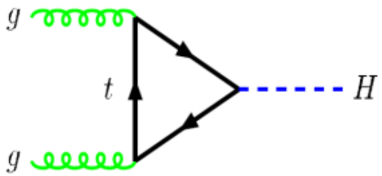
L.T. Wang (LP2017)
August, 2017

The Need for New lepton (e^+e^-) Accelerators

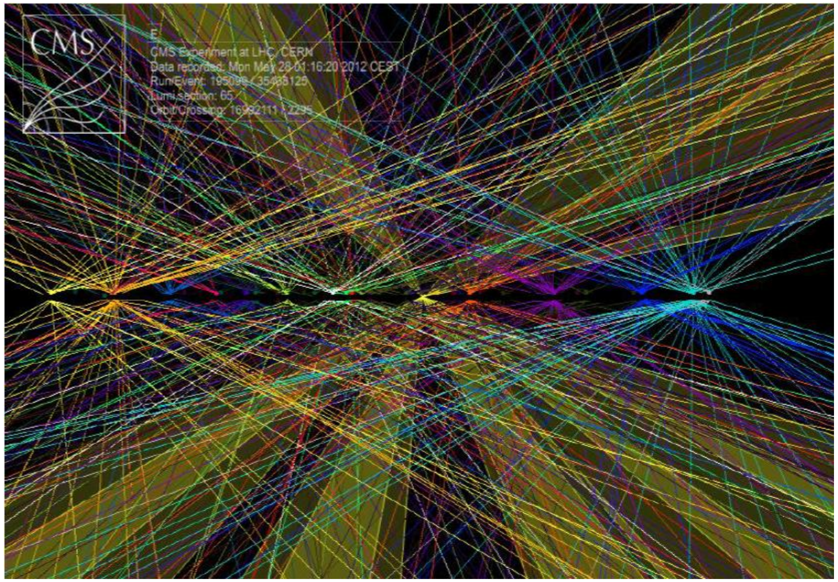
- Need to have clean Higgs events to study it
- Simple kinematics of the e^+e^- collider offers that

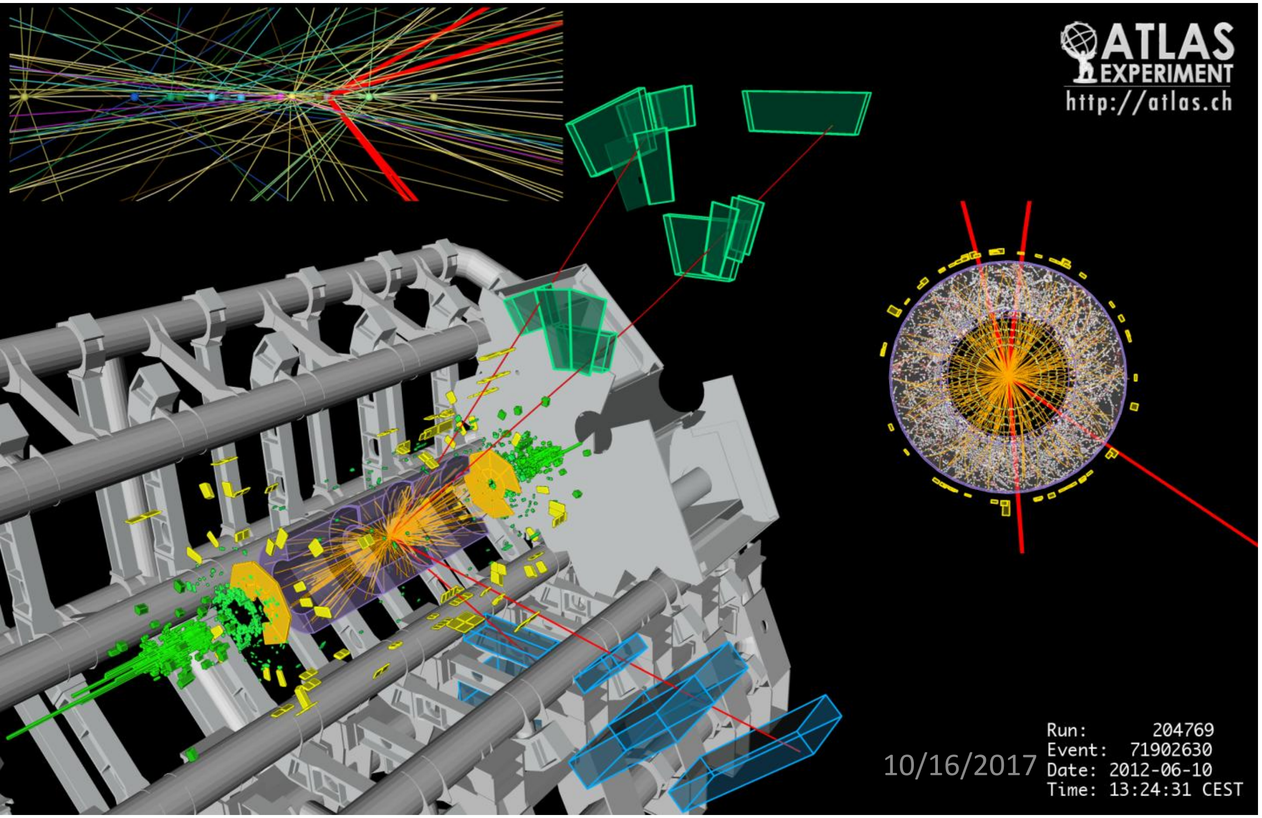
  and to address many of the crucial physics questions
- The e^+e^- collider can be upgraded to a 100 TeV pp collider as a discovery machine (circular collider)

Higgs event at the LHC



pp $\to$ **H** + Anything
mostly through gg fusion

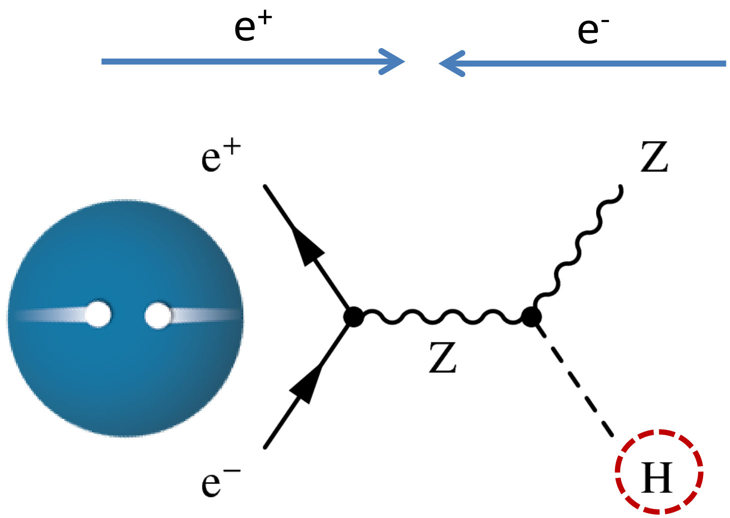


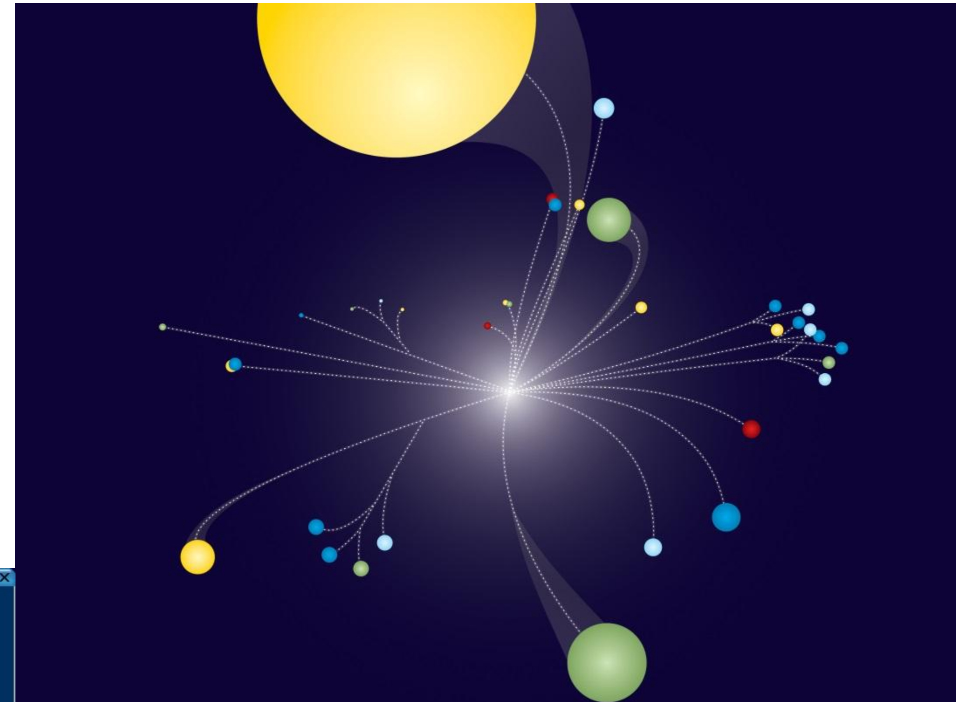


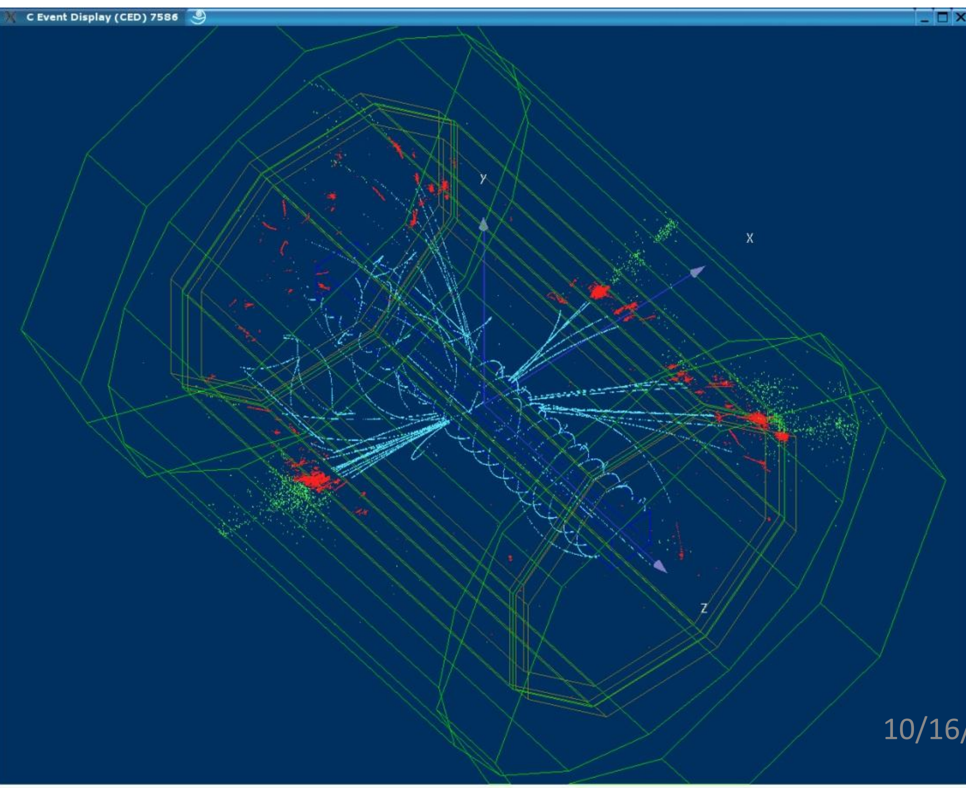
- ☐ initial kinematic is not known
- ☐ background noise very high
- ☐ pile-up of multiple pp annihilation events
- ☐ unable to detect many **H** decays

“messy”

Electron-positron Collider

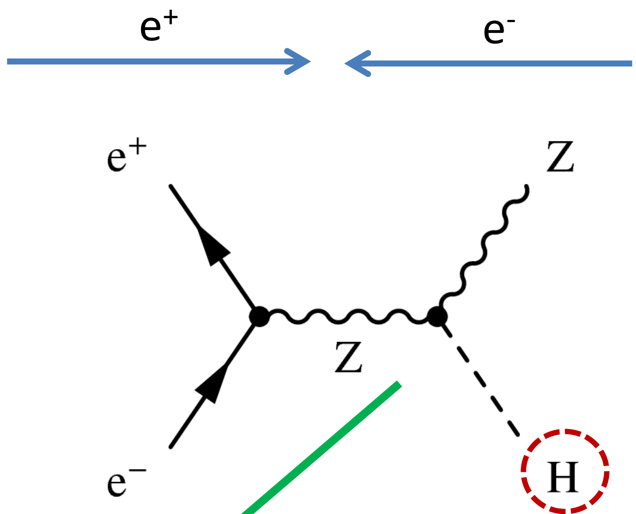


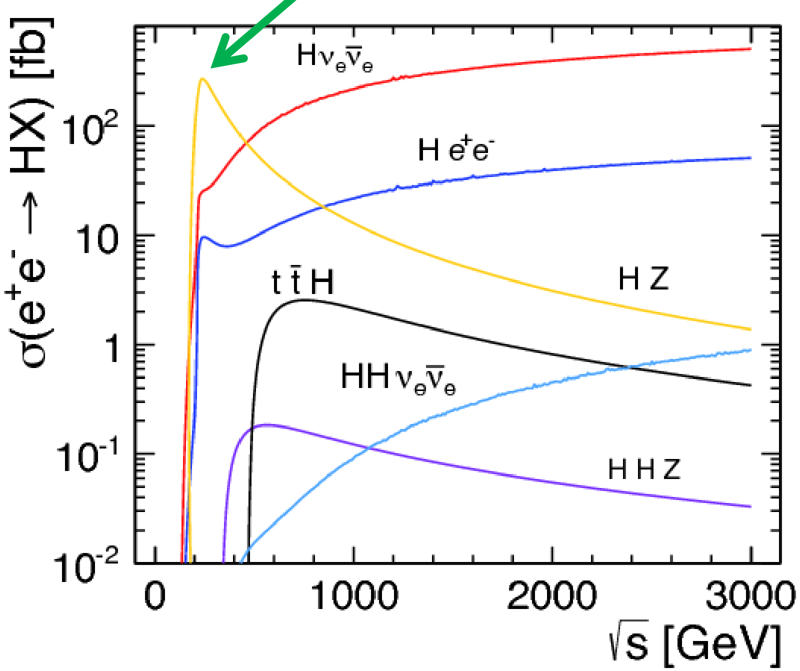




clean H events produced

Electron-positron Collider





Kinematics are very simple

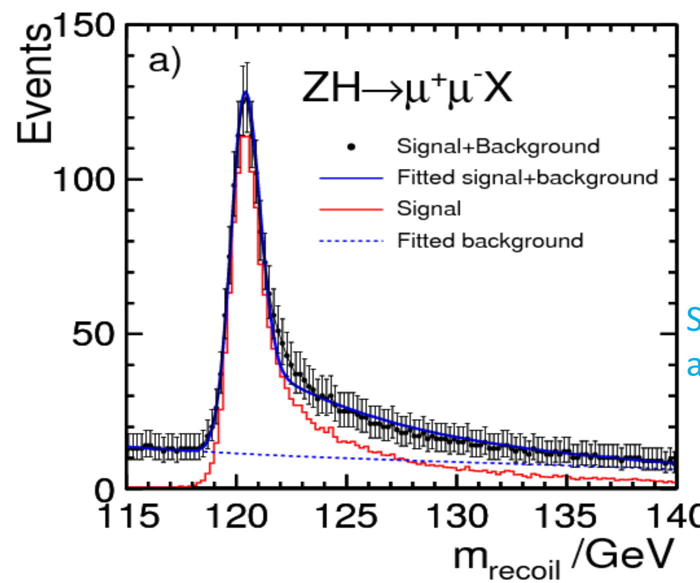
$$e^+e^- \rightarrow ZH$$

$Z \rightarrow \mu^+\mu^-$, **H → Anything,**

momentum-energy vector $(\vec{P}_i, E_i) = (\vec{0}, E_{cm})$

$$(\vec{P}_f, E_f) = (\vec{P}_Z + \vec{P}_H, E_Z + E_H)$$

$$\Rightarrow (\vec{P}_H, E_H) = (-\vec{P}_Z, [E_{cm} - E_Z]), \quad M_H^2 = E_H^2 - P_H^2$$

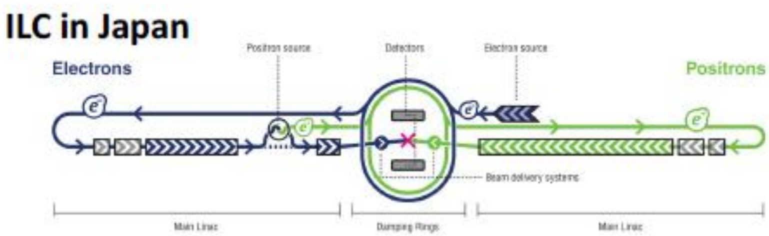


Simon, Frank
arXiv:1211.7242

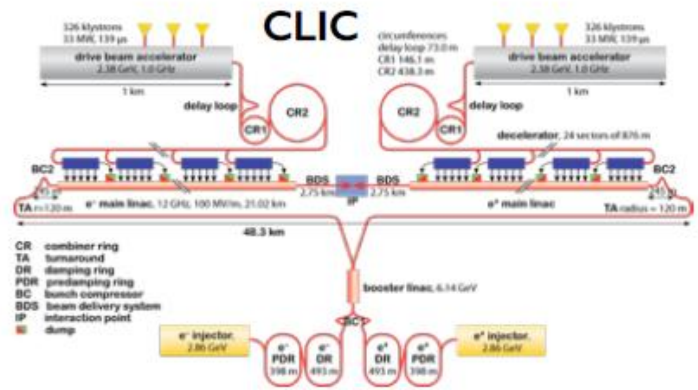
✓ **Can measure H w/o directly detecting it**

✓ **Clean environment for studying H**

Beyond the LHC, future facilities



http://www.linearcollider.org/ILC



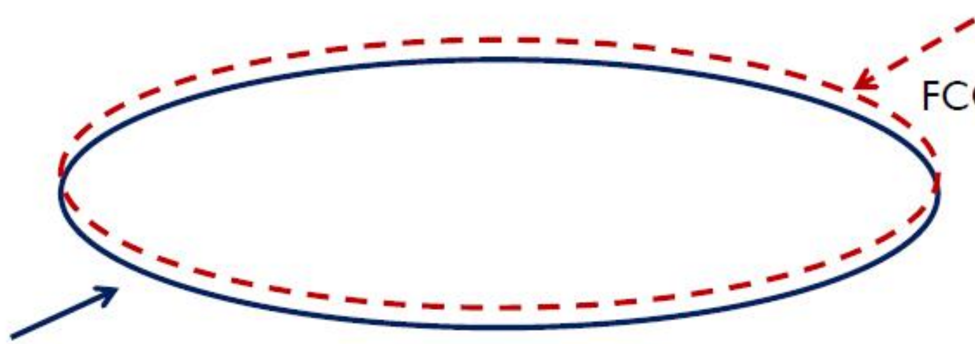
http://clic-study.web.cern.ch/

Circular. "Scale up" LEP+LHC

~100 TeV

pp collider

FCC-hh (CERN), SppC(China)



250 GeV **e^-e^+ Higgs Factory**

FCC-ee (CERN), CEPC(China)

http://cepc.ihep.ac.cn/

https://fcc.web.cern.ch/Pages/default.aspx

Three of the many future accelerator choices

- **A few words about particle accelerators**
- **The International Linear Collider (ILC) in Japan**
- **FCC at CERN in Switzerland**
- **CEPC-SppC in China**

Particle Accelerators

There are two basic types: **linear** accelerators and **circular** accelerators

LINEAR ACCELERATOR

A linear particle accelerator (also called a linac) is an linear electrical device for the acceleration of subatomic particles. The design of a linac depends on the type of particle that is being accelerated: electron, proton or ion.

Easy to accelerate; **large and loses beams after collision**

CIRCULAR ACCELERATOR

In the circular accelerator, particles move in a circle until they reach sufficient energy. The particle track is typically bent into a circle using electromagnets.

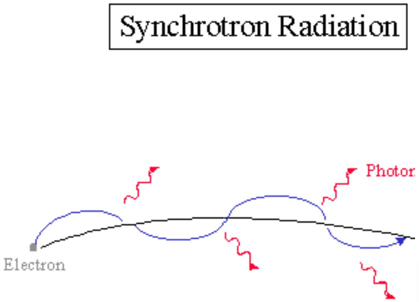
Advantage:

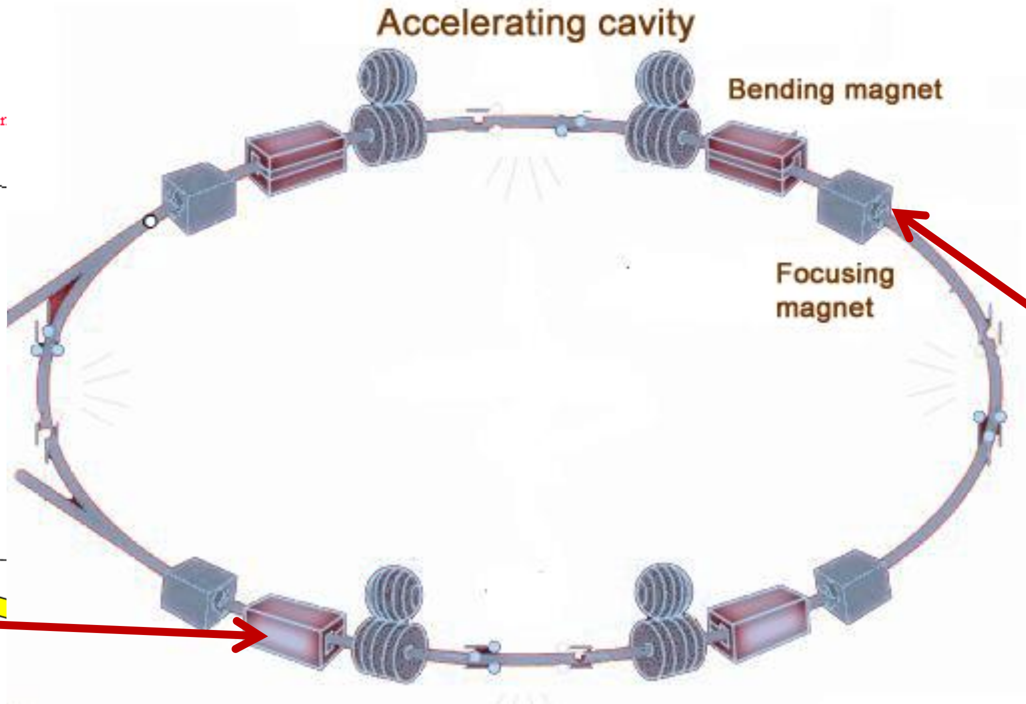
- ✓ **allows continuous acceleration**
- ✓ **can store beams for longer experiment**
- ✓ **is relatively smaller than a linear accelerator of comparable power.**

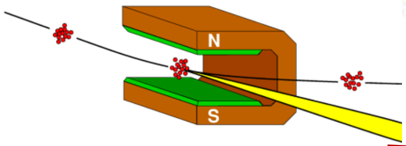
Disadvantage:

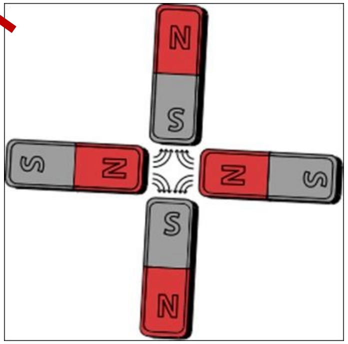
- ◆ **synchrotron radiation energy loss large**

Circular Accelerator









- Energy loss per turn for a single particle in an isomagnetic lattice with bending radius ρ

$$\Delta E[\text{GeV}] = C_\gamma \frac{E^4[\text{GeV}^4]}{\rho[\text{m}]}$$

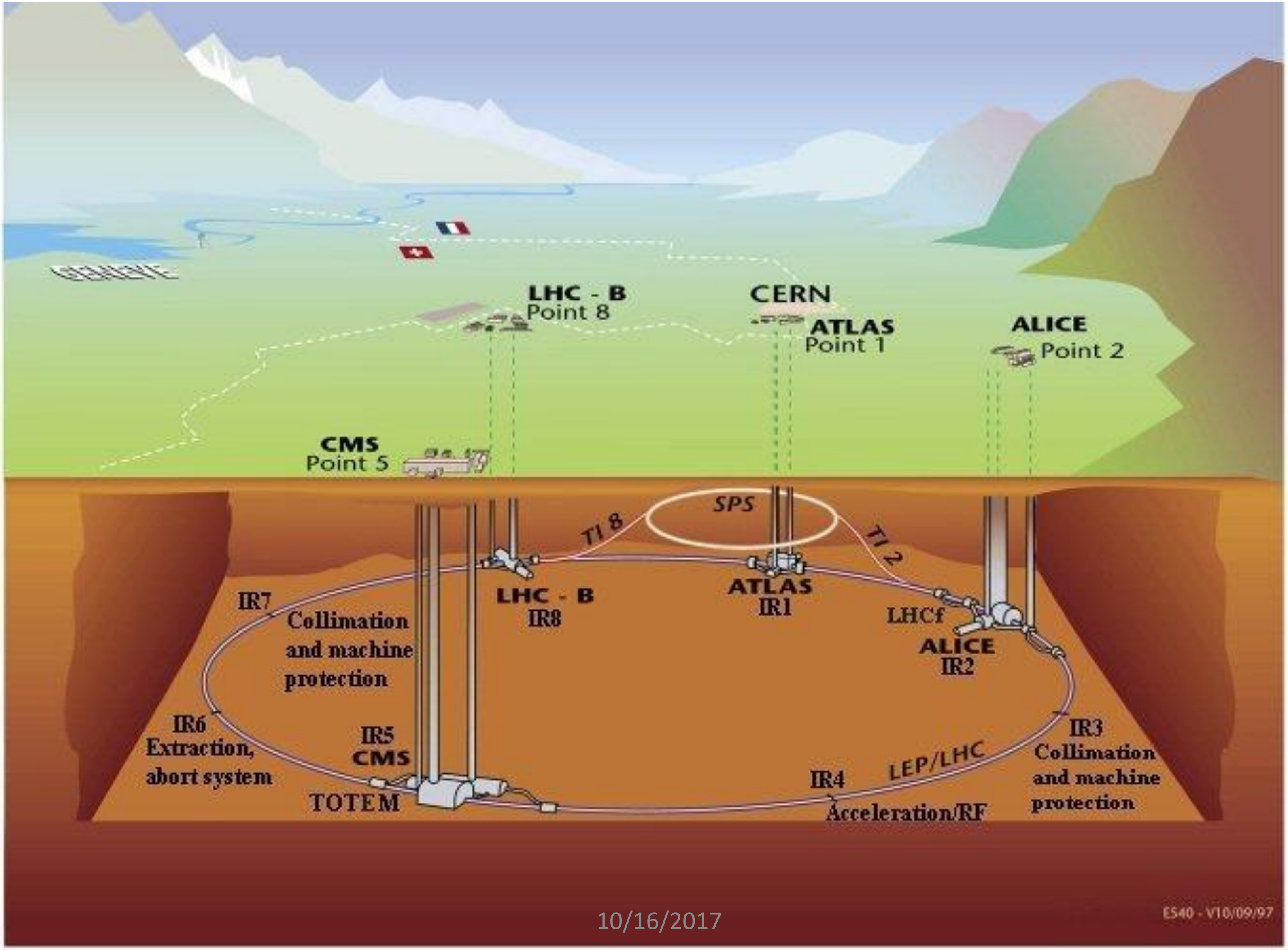
- Radiated Power

$$P_\gamma[\text{MW}] = 8.8575\times 10^{-2} \frac{E^4[\text{GeV}^4]}{\rho[\text{m}]} I[\text{A}]$$

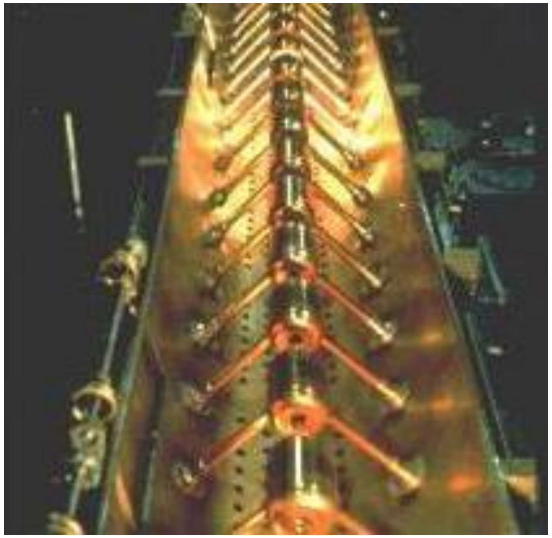
C=27km (LHC tunnel)
E=500GeV, I=10mA

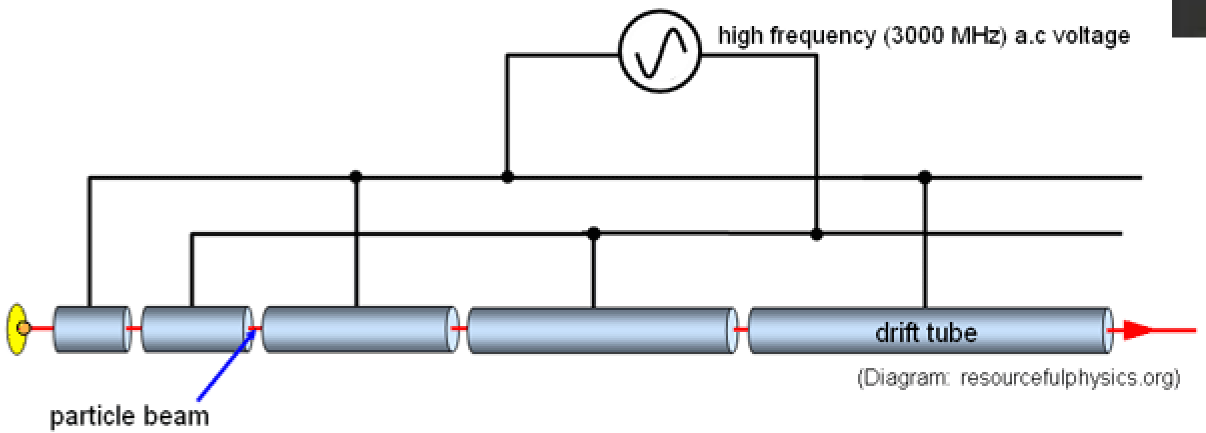
⇒P=13 GW

Circular Accelerator



Linear Accelerator





(Diagram: resourcefulphysics.org)

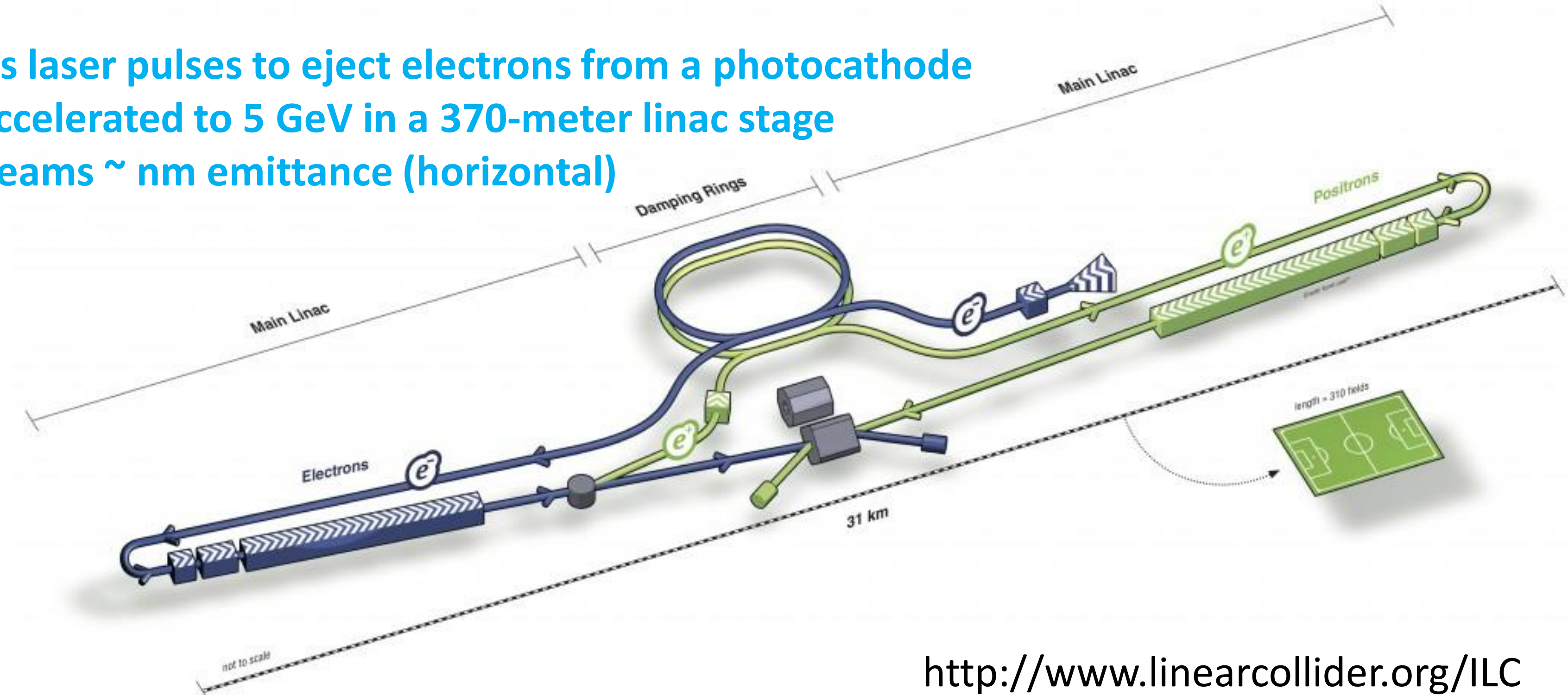
No major energy loss due to synchrotron radiation

The World HEP Planning – a Circle

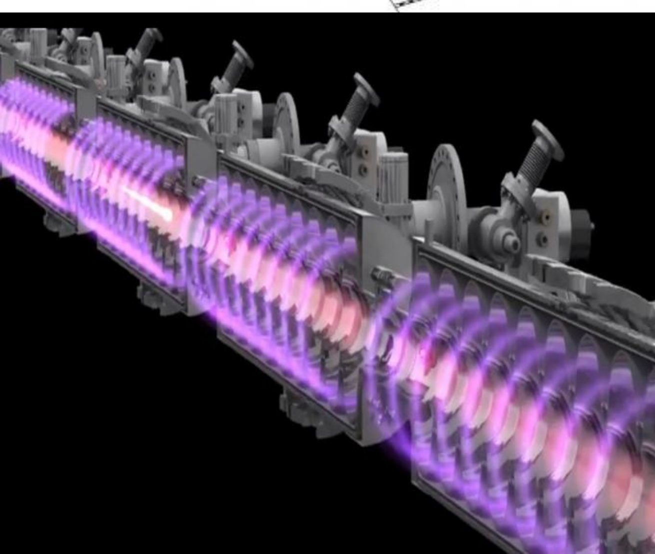
2001 Snowmass →	2004 ICFA →	After 4th of July 2012
• Linear e+e- ➢ Cold (TESLA) ➢ Warm (NLC/JLC) • Circular e+e- • VLHC / VLLC • Muon collider • High intensity proton source (aka Proton Driver)	• **Cold Linear e+e- (ILC)**	• Linear e+e- ➢ ILC ➢ CLIC ➢ X-band klystron based • Circular e+e- ➢ Fermilab site filler ➢ TLEP, FCC (CERN) ➢ SuperTRISTAN ➢ CEPC (China) ➢ VLLC • Muon collider • Photon cillider ➢ ILC-based ➢ CLIC-based ➢ SAPPHiRE ➢ SLC-type ➢ ERL-based

Linear e^+e^- Collider as a Higgs Factory

- 2-ns laser pulses to eject electrons from a photocathode
- e accelerated to 5 GeV in a 370-meter linac stage
- e beams ~ nm emittance (horizontal)



http://www.linearcollider.org/ILC



Energy ~ 250 – 1,000 GeV

Cost ~US$6.75 billion (?)
Japan willing to pay 50%

Construction 2015-16
Commission >2026

TDR Technical Volumes

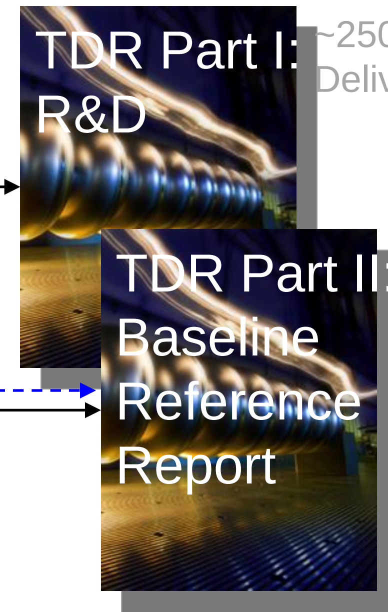
2007

2011

2013*

ILC Technical Progress Report ("*interim report*")

AD&I



~250 pages
Deliverable 2

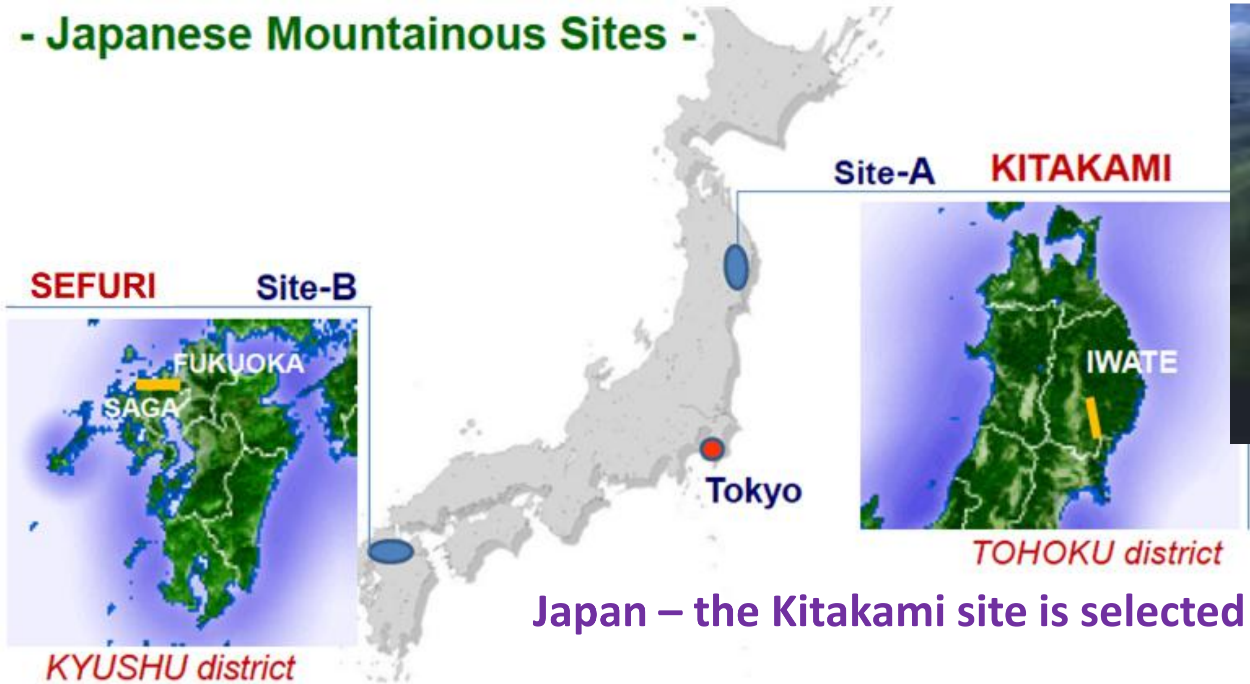
~300 pages
Deliverables 1,3 and 4

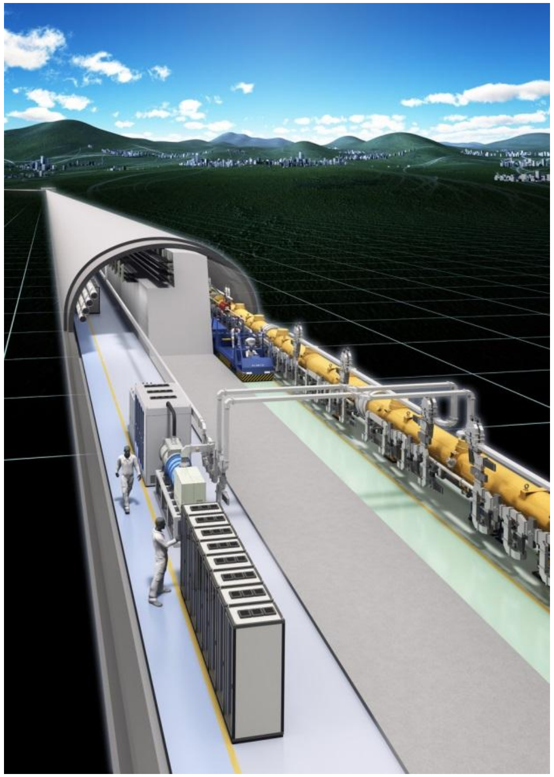
Technical Design Report

Reference Design Report

* end of 2012 – formal publication early 2013

International Linear e⁺e⁻ Collider





Japan – the Kitakami site is selected

Sachio Komamiya

Lyn Evans

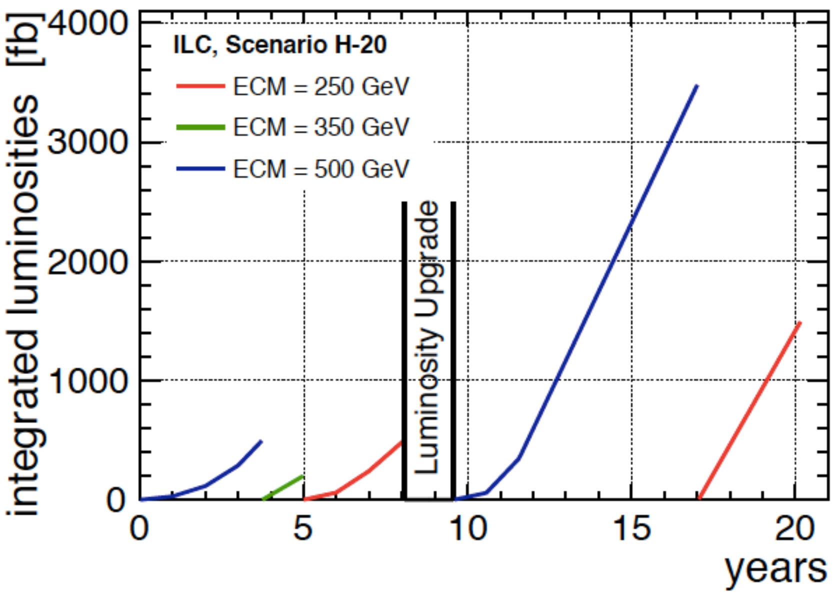
Status:
- review by Japan's government
- 50% cost unfunded
- active

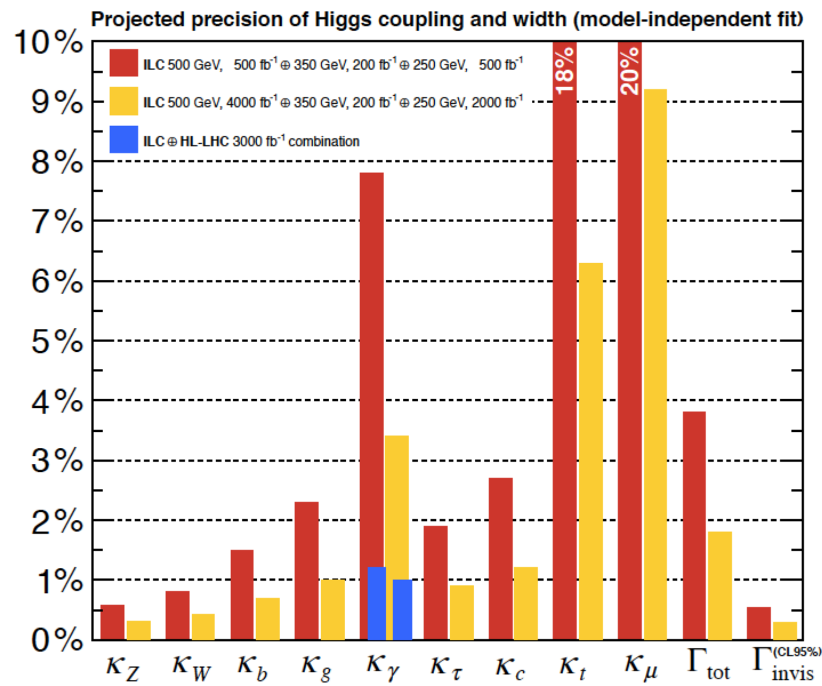
International Linear e^+e^- Collider

	Stage	500			500 LumiUP		
Scenario	$\sqrt{s}$ [GeV]	500	350	250	500	350	250
G-20	$\int \mathscr{L} dt$ [fb^{-1}]	1000	200	500	4000	-	-
	time [years]	5.5	1.3	3.1	8.3	-	-
H-20	$\int \mathscr{L} dt$ [fb^{-1}]	500	200	500	3500	-	1500
	time [years]	3.7	1.3	3.1	7.5	-	3.1

Higgs Couplings
model independent

Integrated Luminosities [fb]





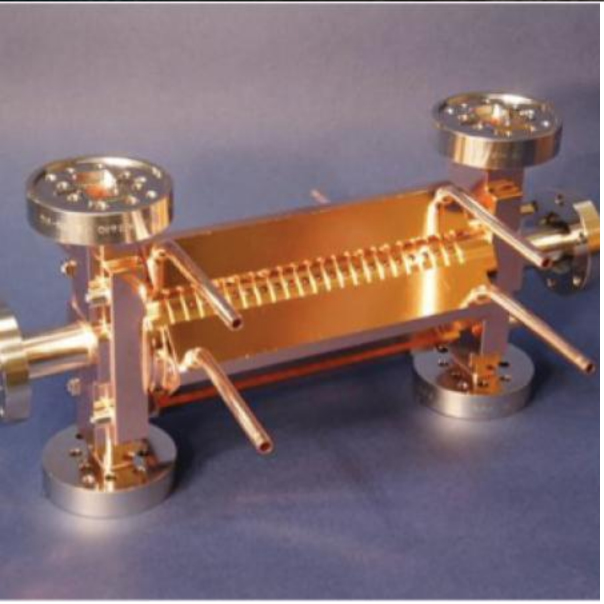
FCC: Future Circular Collider at CERN

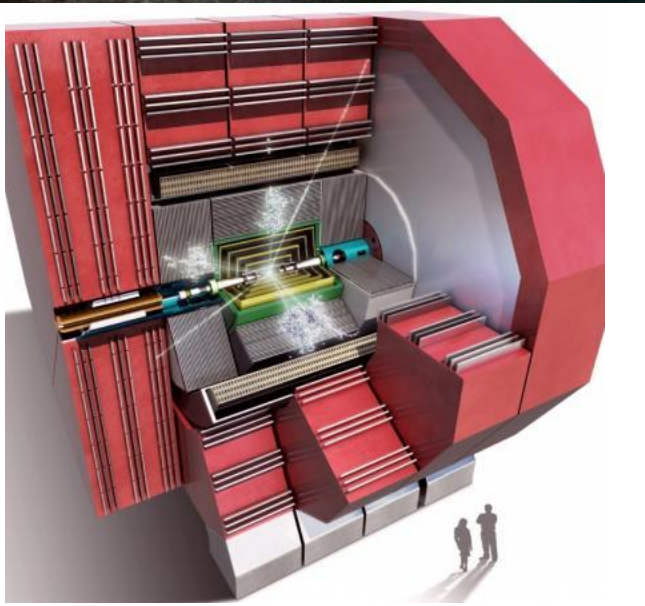
CERN, Geneva

Design, cost, physics reaches understudy; Conceptual Design Report due 2017

CLIC: Compact Linear Collider at CERN

CERN, Geneva





CDR completed; 2018 decision, 2024-25 construction starts
P_{tot} = 852 MW;

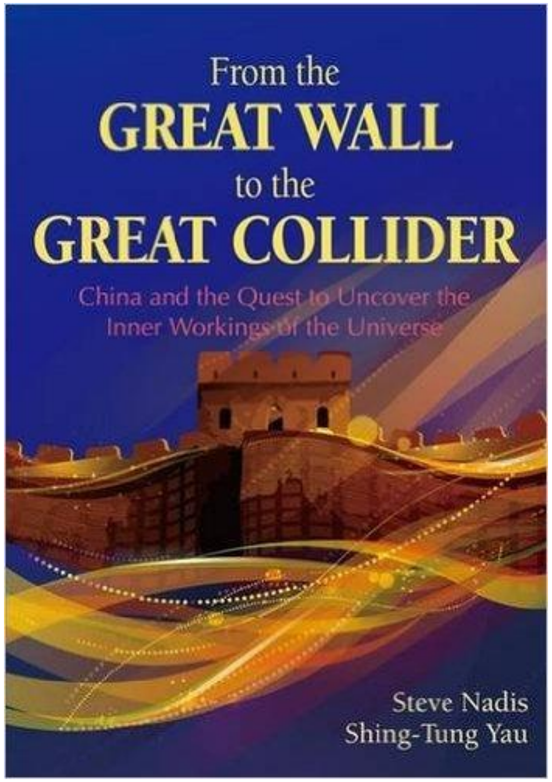
The Great Collider in China

- **China is inspired to consider a new collider**

  the Higgs boson, interactions

- **Nobel Laureate David Gross names it**

  the great collider



The CEPC and SppC projects

The R&D program
Funding and support
Site selection
IAC and International collaboration
Reach-out & engagement with the public

CEPC-SppC

Phase 1: **e^+e^- Higgs (Z) factory** **two detectors, 1M ZH events in 10yrs**

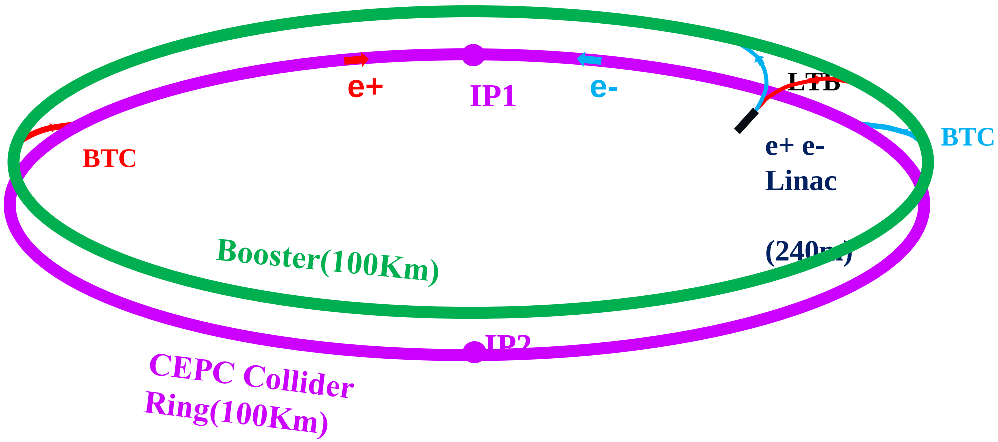
E_{cm}≈240GeV, luminosity ~$2\times10^{34}\ cm^{-2}s^{-1}$, can also run at the Z-pole

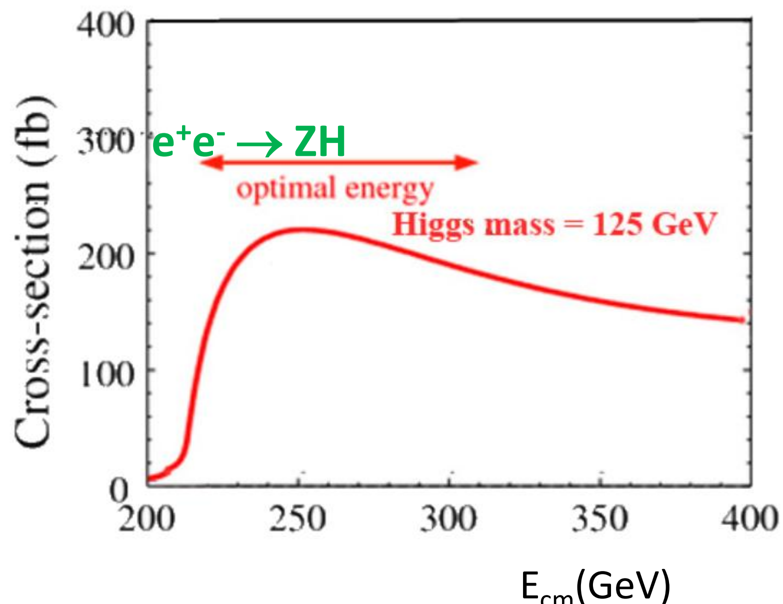
Precision measurement of the Higgs boson (and the Z boson)

Higgs precision 1% or better

Phase 2: **a discovery machine**; pp collision with E_{cm} ≈ 50-100 TeV; ep, HI options

Discovery machine for BSM



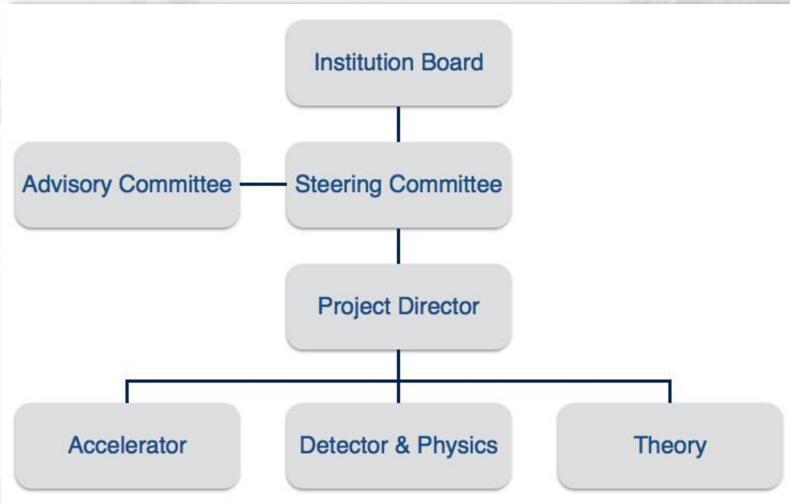


favored post BEPCII accelerator based particle physics program in China

How do they stack up against each other?

	CEPC	ILC	CLIC	Muon collider
E_{cm} (ee) GeV	90-350	**90-500**	**3 TeV**	~4 TeV
Luminosity	**high**	high	high	X?
Upgrade to pp ?	**Yes (50-100 TeV)**	No	No	?
Cost	**medium**	high	high	medium-high

CEPC Organization



- Institution Board and Steering Committee formed in the kick-off meeting in September 2013; conveners appointed for the three working groups: Accelerator, Theory and Detector & Physics
  - Find out more: http://cepc.ihep.ac.cn/index.html
- International workshops and regular group meetings to coordinate efforts
- Schools and hand-on tutorials to train students – important to inspire more young people to directly participate in the activities

➢ The CEPC management was reorganized in May 2015, after the preCDR, to move forward with the CDR process;

Baseline CEPC

- **Baseline design & options for the Conceptual Design Report**

  circumference=100km， E_{cm}=240 GeV, power per beam≤30MW，

  design luminosity ~$2\times10^{34}cm^{-2}s^{-1}$ (240 GeV)

  $1\times10^{34}cm^{-2}s^{-1}$ (91 GeV)

  two layouts:

  double ring as the default;

  advanced local double ring as an option

  two independent detectors

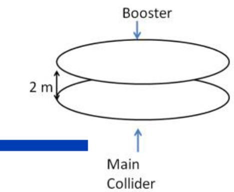
- **Benefits**

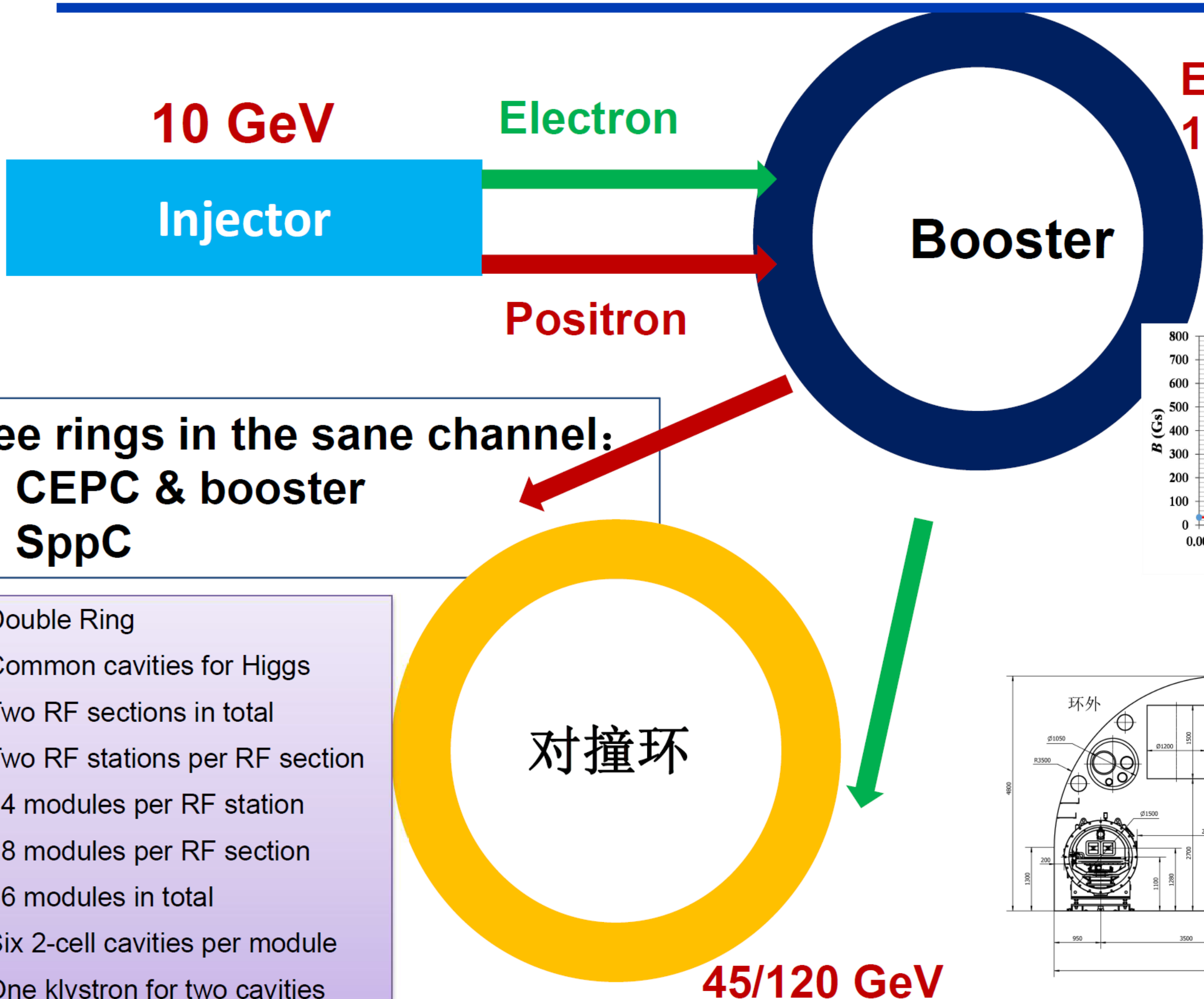
  mature technologies, Z+ZH program

  high energy pp option

  γ synchrotron light source (?)

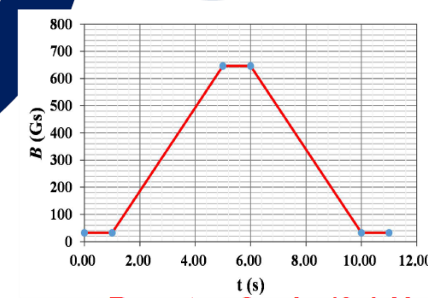
CEPC Accelerator Chain



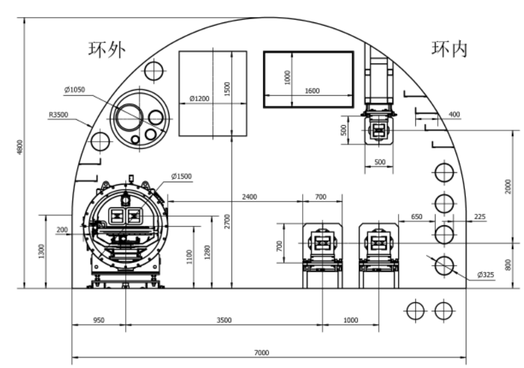


Three rings in the sane channel:
- ➢ **CEPC & booster**
- ➢ **SppC**

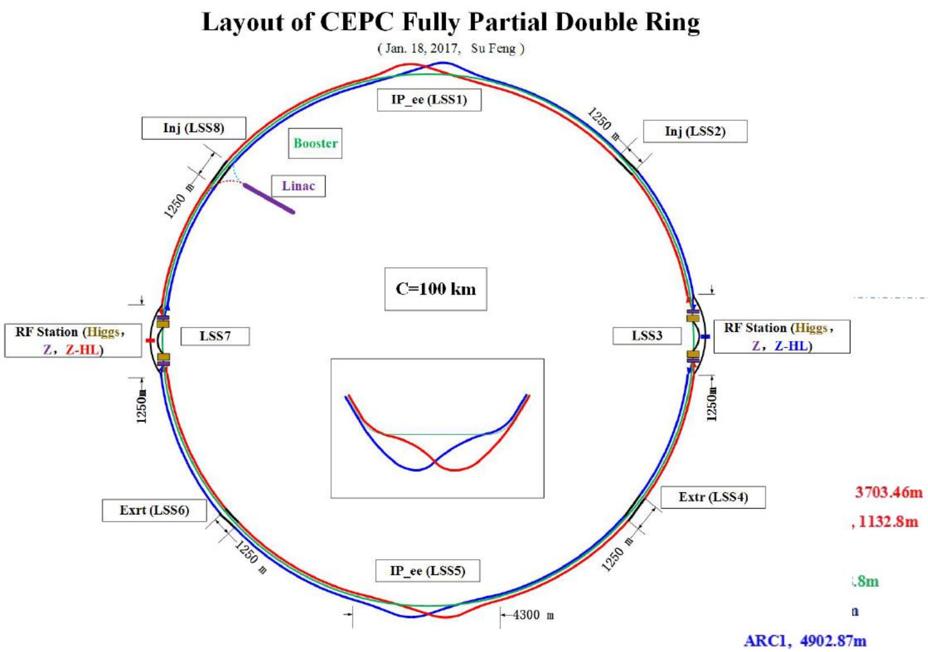
- Double Ring
- Common cavities for Higgs
- Two RF sections in total
- Two RF stations per RF section
- 14 modules per RF station
- 28 modules per RF section
- 56 modules in total
- Six 2-cell cavities per module
- One klystron for two cavities



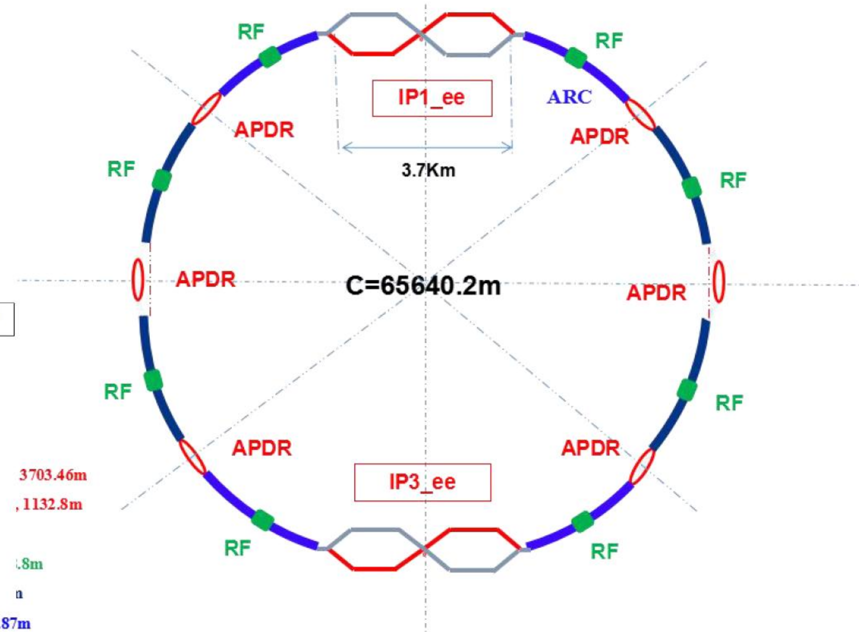
Booster Cycle (0.1 Hz)



CEPC two shcemes towards CDR



CEPC Advanced Partial Double Ring Option II



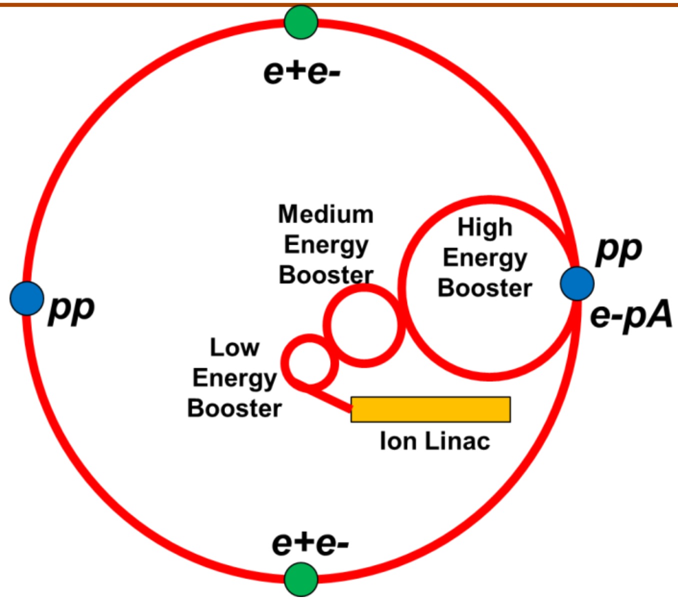
CEPC Baseline Design

Better performance for Higgs and Z compared with alternative scheme, without bottle neck problems, but with higher cost

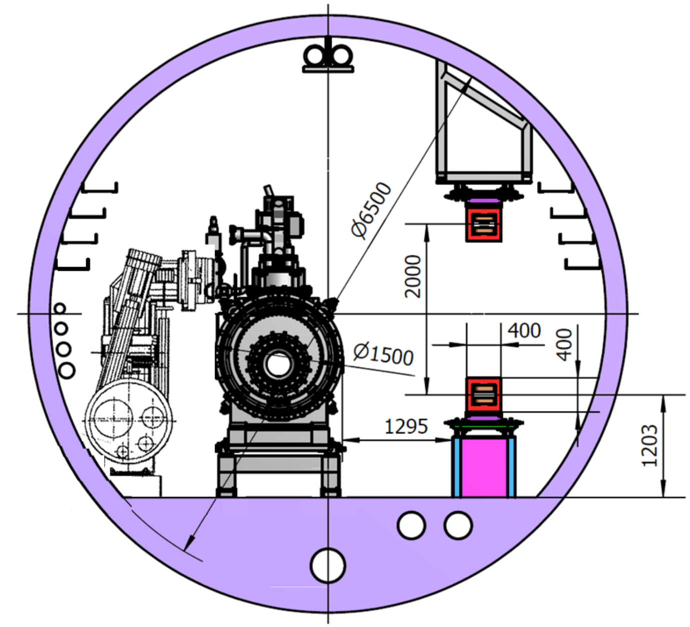
CEPC Alternative Design

Lower cost and reaching the fundamental requirement for Higgs and Z luminosities, under the condition that sawtooth and beam loading effects be solved

SppC Accelerator Design considerations



cross section of CEPC tunnel



- Proton-proton collider luminosity

$$L_0 = \frac{N_p^2 N_b f_{rep} \gamma}{4\pi \varepsilon_n \beta_{IP}} F \qquad \left(F = \sqrt{1 + \left(\frac{\theta_c \sigma_z}{2\sigma_{x,IP}}\right)^2}\right) \qquad \xi = \frac{N_p r_p}{4\pi \varepsilon_n} \le 0.004$$

- Main constraint: high-field superconducting dipole magnets
  - **50 km**: B_{max} = 12 T, E = 50 TeV
  - **50 km**: B_{max} = 20 T, E = 70 TeV
  - **70 km**: B_{max} = 20 T, E = 90 TeV

$$B_{\min} = \frac{2\pi(B\rho)}{C_0}$$

Parameters for CEPC double ring for CDR Goal

(wangdou20170426-100km_2mmβy)

	Pre-CDR	Higgs	W	Z	
Number of IPs	2	2	2	2	
Energy (GeV)	120	120	80	45.5	
Circumference (km)	54	100	100	100	
SR loss/turn (GeV)	3.1	1.67	0.33	0.034	
Half crossing angle (mrad)	0	16.5	16.5	16.5	
Piwinski angle	0	3.19	5.69	4.29	11.77
N_e/bunch (10^{11})	3.79	0.968	0.365	0.455	0.307
Bunch number	50	412	5534	21300	2770
Beam current (mA)	16.6	19.2	97.1	465.8	408.7
SR power /beam (MW)	51.7	**32**	**32**	**16.1**	**1.4**
Bending radius (km)	6.1	11	11	11	11
Momentum compaction (10^{-5})	3.4	1.14	1.14	4.49	1.14
β_{IP} x/y (m)	0.8/0.0012	0.171/0.002	0.171 /0.002	0.16/0.002	0.171 /0.002
Emittance x/y (nm)	6.12/0.018	1.31/0.004	0.57/0.0017	1.48/0.0078	0.18/0.0037
Transverse σ_{IP} (um)	69.97/0.15	15.0/0.089	9.9/0.059	15.4/0.125	5.6/0.086
ξ_x/ξ_y/IP	0.118/0.083	0.013/0.083	0.0055/0.062	0.008/0.054	0.006/0.054
RF Phase (degree)	153.0	128	126.9	165.3	136.2
V_{RF} (GV)	6.87	**2.1**	**0.41**	**0.14**	**0.05**
f_{RF} (MHz) (harmonic)	650	650	650 (217800)	650 (217800)	
Nature σ_z (mm)	2.14	**2.72**	**3.37**	**3.97**	**3.83**
Total σ_z (mm)	2.65	2.9	3.4	4.0	4.0
HOM power/cavity (kw)	3.6 (5cell)	0.41(2cell)	0.36(2cell)	1.99(2cell)	0.12(2cell)
Energy spread (%)	0.13	0.098	0.065	0.037	
Energy acceptance (%)	2	1.5			
Energy acceptance by RF (%)	6	2.1	1.1	1.1	0.68
n_γ	0.23	0.26	0.15	0.12	0.22
Life time due to beamstrahlung_cal (minute)	47	52			
F (hour glass)	0.68	0.96	0.98	0.96	0.99
L_{max}/IP ($10^{34}cm^{-2}s^{-1}$)	2.04	2.0	5.15	11.9	1.1

Preliminary results shows co-existence of Z/H programs are possible

Reconfiguration of CEPC can lead to much better luminosity at the Z pole → Z factory

CEPC-SPPC Timeline (preliminary)

design issues
R&D items
preCDR

design, funding
R&D program
Intl. collabration
site study

seek approval, site decision
construction during 14th 5-year plan
commissioning

- CEPC data-taking starts before the LHC program ends
- Possibly con-current with the ILC program

SppC Design Scope (201701 version)

Top priority: reducing cost!
Instead of increasing field

- **Baseline design**
  - Tunnel circumference: 100 km
  - Dipole magnet field: 12 T, iron-based HTS technology (IBS)
  - Center of Mass energy: >70 TeV
  - Injector chain: 2.1 TeV
- **Upgrading phase**
  - Dipole magnet field: 20 -24T, IBS technology
  - Center of Mass energy: >125 TeV
  - Injector chain: 4.2 TeV (adding a high-energy booster ring in the main tunnel in the place of the electron ring and booster)
- **Development of high-field superconducting magnet technology**
  - Starting to develop required HTS magnet technology before applicable iron-based wire is available
  - ReBCO & Bi-2212 and LTS wires be used for model magnet studies and as an option for SPPC: stress management, quench protection, field quality control and fabrication methods

Collaboration on HTS

"Applied High Temperature Superconductor Collaboration (AHTSC)" was formed in Oct. 2016. with >13 related institutes & companies and 50 scientists & engineers to advance HTS R&D and Industrialization.

- **Goal:**
  1) To increase the J_c of IBS by 10 times, reduce the cost to 20 Rmb/kAm @ 12T & 4.2K in 10 years, and realize the industrialization of the conductor;
  2) To reduce the cost of ReBCO and Bi-2212 conductors to 20 Rmb/kAm @ 12T & 4.2K in 10 years;
  3) Realization and Industrialization of iron-based SRF technology.
- **Working groups:** 1) Fundamental science investigation; 2) IBS conductor R&D; 3) ReBCO conductor R&D; 4) Bi2212 conductor R&D; 5) performance evaluation; 6) Magnet and SRF technology.
- **Collaboration meetings**: every 2~3 months.

Funded by CAS, more expected from MOST

执行委员会 (姓氏拼音排序)	
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马衍伟	中科院电工研究所
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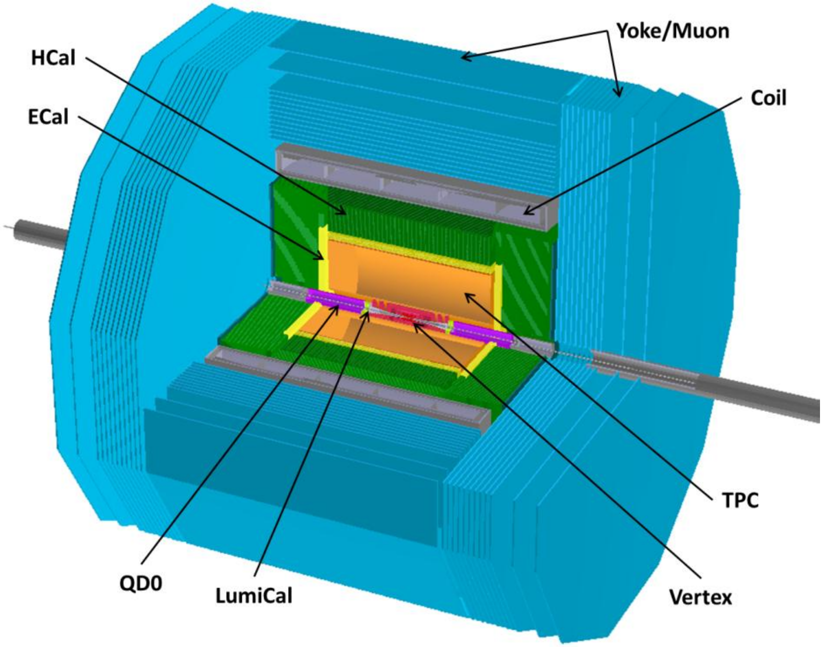
周廉	西北有色院

CEPC Detector considerations



ILD-like detector with additional considerations (*incomplete list*):

- Shorter L* (**1.5**/2.5m) → constraints on space for the Si/TPC tracker
- No power-pulsing → lower granularity of vertex detector and calorimeter
- Limited CM (up to 250 GeV) → calorimeters of reduced size
- Lower radiation background → vertex detector closer to IP
- …

- **Similar performance requirements to ILC detectors**
  - Momentum: $\sigma_{1/p} < 5\times10^{-5}\ \mathrm{GeV}^{-1}$ ← recoiled Higgs mass
  - Impact parameter: $\sigma_{r\phi} = 5 \oplus 10/(p\cdot\sin^{\frac{3}{2}}\theta)\ \mu\mathrm{m}$ ← flavor tagging, BR
  - Jet energy: $\frac{\sigma_E}{E} \approx 3-4\%$ ← W/Z di-jet mass separation

Sub-detector groups consider design options, identify challenges, plan R&D

CEPC simulation & physics - precisions

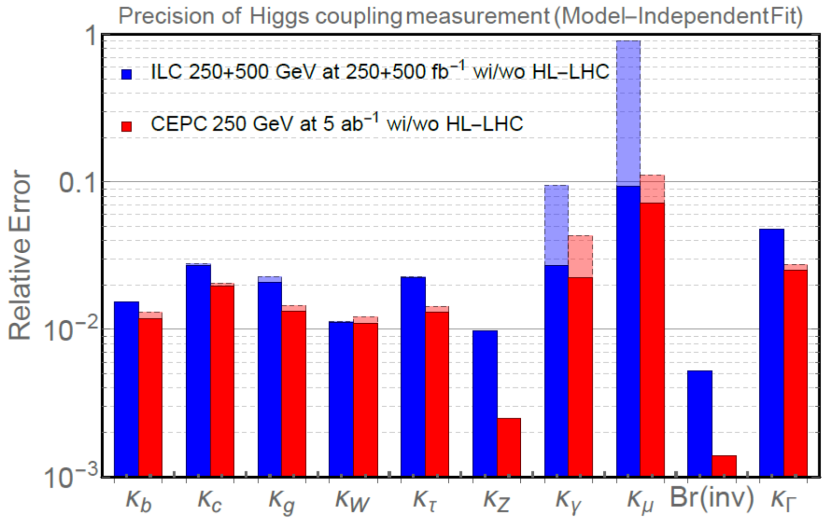
ΔM_H	Γ_H	$\sigma(ZH)$	$\sigma(\nu\bar{\nu}H) \times \mathrm{BR}(H \to b\bar{b})$
5.9 MeV	2.8%	0.51%	2.8%

Decay mode	$\sigma(ZH) \times \mathrm{BR}$	BR
$H \to b\bar{b}$	0.28%	0.57%
$H \to c\bar{c}$	2.2%	2.3%
$H \to gg$	1.6%	1.7%
$H \to \tau\tau$	1.2%	1.3%
$H \to WW$	1.5%	1.6%
$H \to ZZ$	4.3%	4.3%
$H \to \gamma\gamma$	9.0%	9.0%
$H \to \mu\mu$	17%	17%
$H \to \mathrm{inv}$	–	0.28%

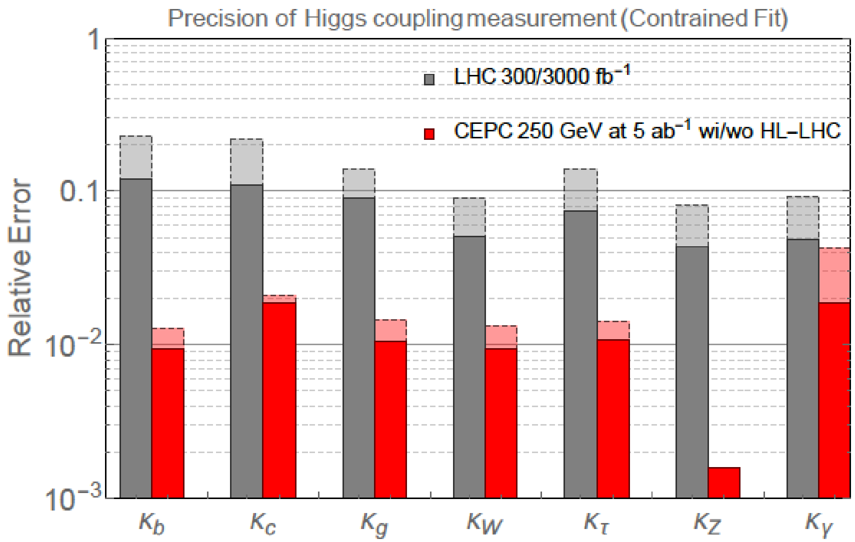
CEPC Combination group:

Model independent result compared to ILC

Model dependent result compared to LHC
(LHC: very limited access to model Independent measurement)



preliminary



preliminary

IHEP-CEPC-DR-2015-01

IHEP-EP-2015-01

IHEP-TH-2015-01

IHEP-CEPC-DR-2015-01

IHEP-AC-2015-01

Can be downloaded from

http://cepc.ihep.ac.cn/preCDR/volume.html

CEPC-SPPC

Preliminary Conceptual Design Report

Volume I - Physics & Detector

403 pages, 480 authors

The CEPC-SPPC Study Group

March 2015

CEPC-SPPC

Preliminary Conceptual Design Report

Volume II - Accelerator

328 pages, 300 authors

The CEPC-SPPC Study Group

March 2015

International Review of Pre-CDR

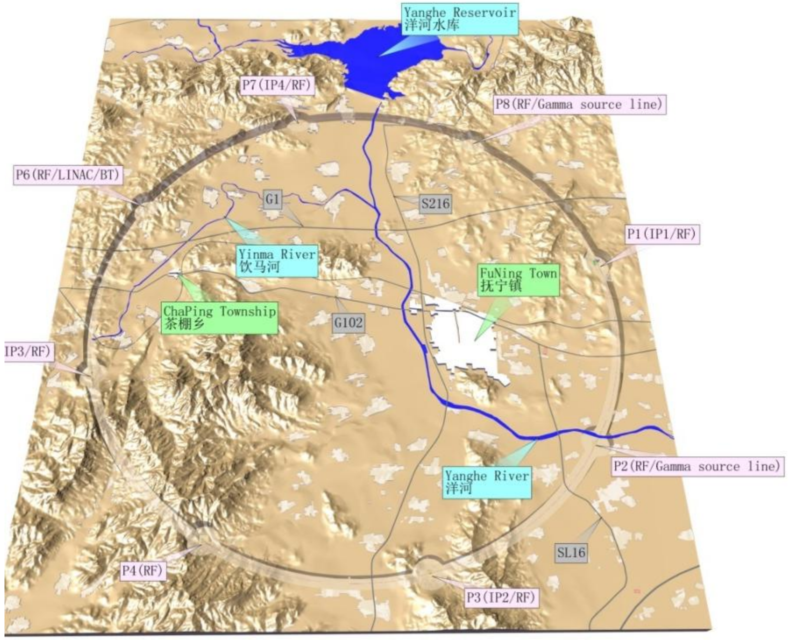
Site Consideration & Civil Engineering

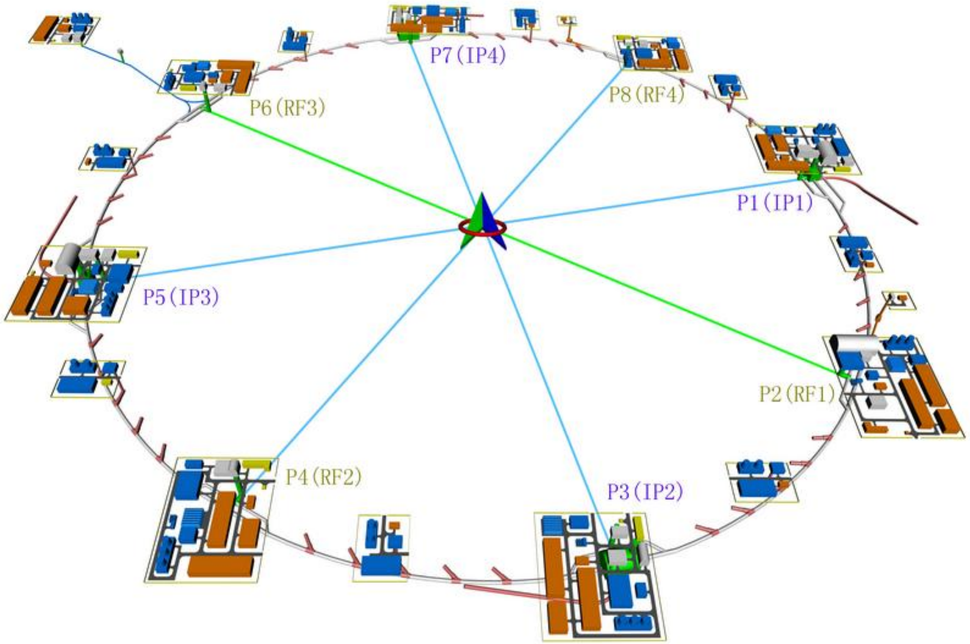
- Current IHEP campus is too small to accommodate a large facility
- Is there any well suited site for a large lab (>800 acres) in northern China?
- Does the local government display strong support for the lab?

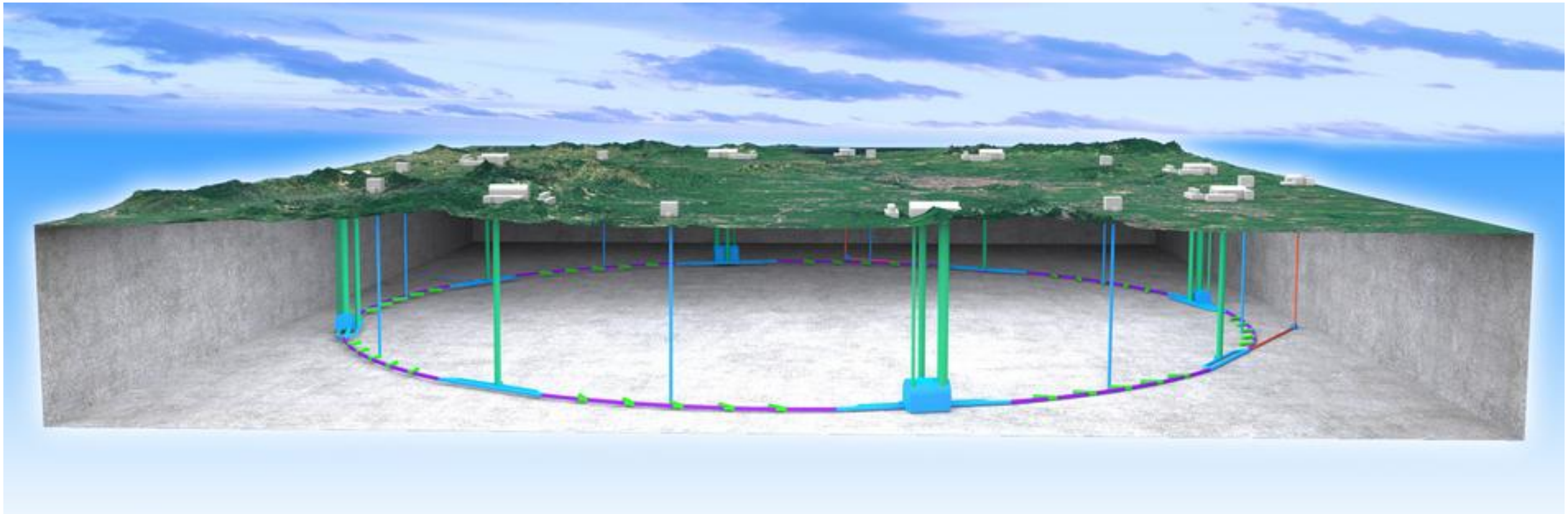
IHEP management visited 16 sites in northern China (Hebei, Henan provinces)

Use "Qing Huang Dao" as an example –

CEPC “Qinghuandao Site” Investigation

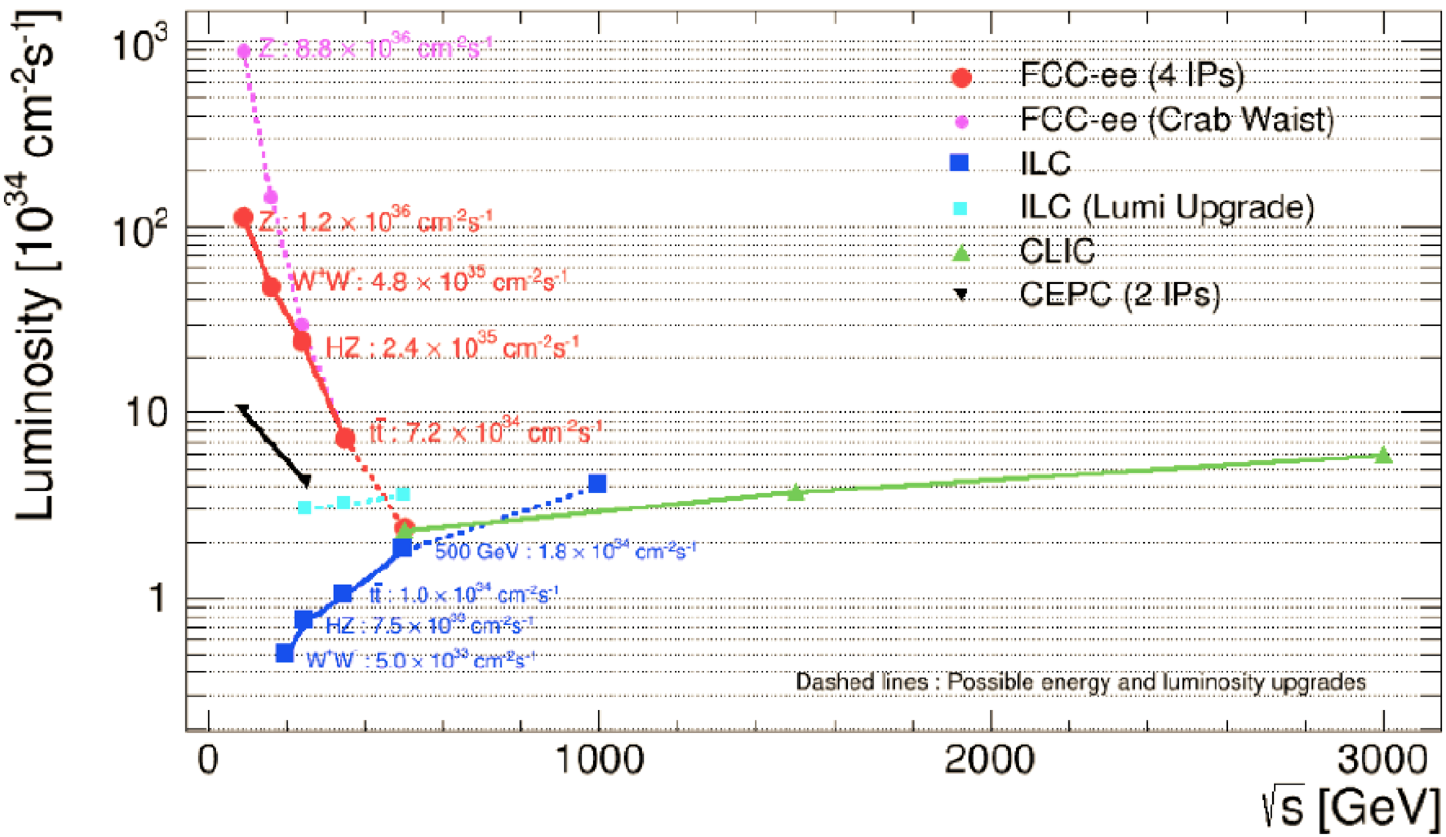






Design Goal of CEPC/FCC-ee

- Limit SR power to 50 MW per beam
- CEPC: single ring, head-on collision, up to 250 GeV
- FCC-ee: double ring, large crossing angle, up to 350 GeV



CEPC:
- 10^6 Higgs
- 10^{10} Z

FCC-ee:
- 10^7 Higgs
- $10^{12\text{-}13}$ Z

Funding for Design and R&D

- IHEP seed money

  12 M RMB/3 years (2015-2017)

- Chinese Ministry of Sci. & Technology

  ~ 90 M / 6 years (2016-2021)

  1st grant of 36M RMB approved; 2nd grant in 2018

- China National Commission on Dev. & Reform

  No funding in 13th 5-year plan

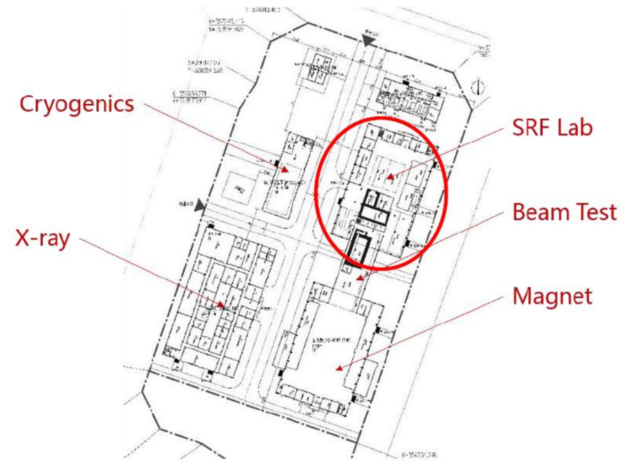
- Other Sources (CAS, MOST, NSFC, …)

  seeking ~0.5 B RMB / 5 years for critical R&D

A New SRF Facility

Platform of **A**dvanced **P**hoton **S**ource Technology R&D, Huairou Science Park, Huairou, Beijing

Construction: 2017 - 2019
Ground Breaking: May 31, 2017



4500 m² SRF lab

- 500M RMB funded by city of Beijing
- Construction: May 2017 – June 2020
- Include RF system & cryogenic systems magnet technology, beam test, etc.

To pull off a mega project

goals of science, design & technologies, funding, team, project management, fiscal discipline, community unity, international collaboration, …

Face up to the challenges at CEPC

sharp focus on physics objectives,

attempt to unify within HEP,

channel to top leaders,

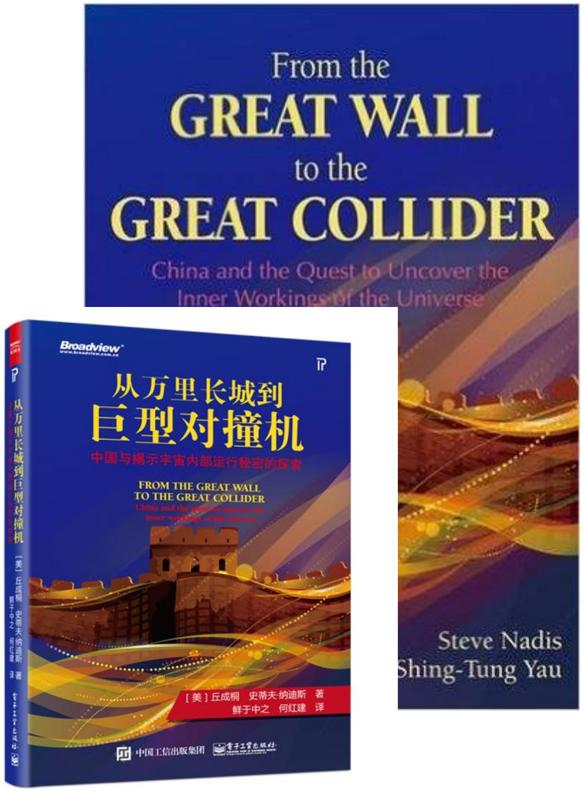
funding requests,

seek support of local government,

recruiting & training

international collaborations,

books and outreach, ….



Future prospects

Wonderfully exciting and challenging

Much work to be done