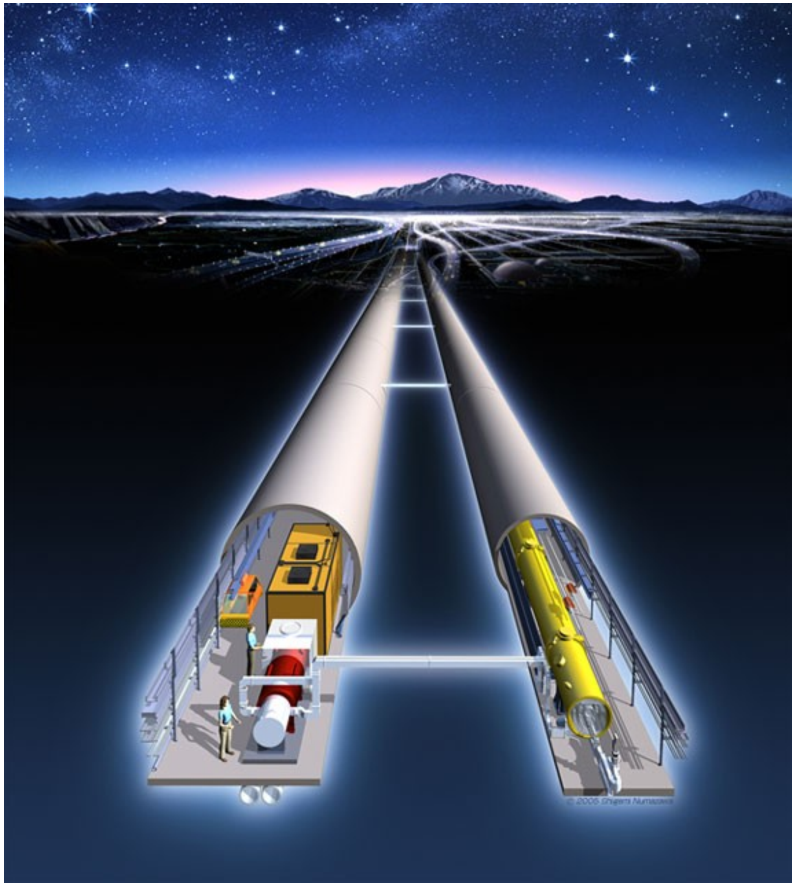
Status of the ILC

Accelerator, detector and directions

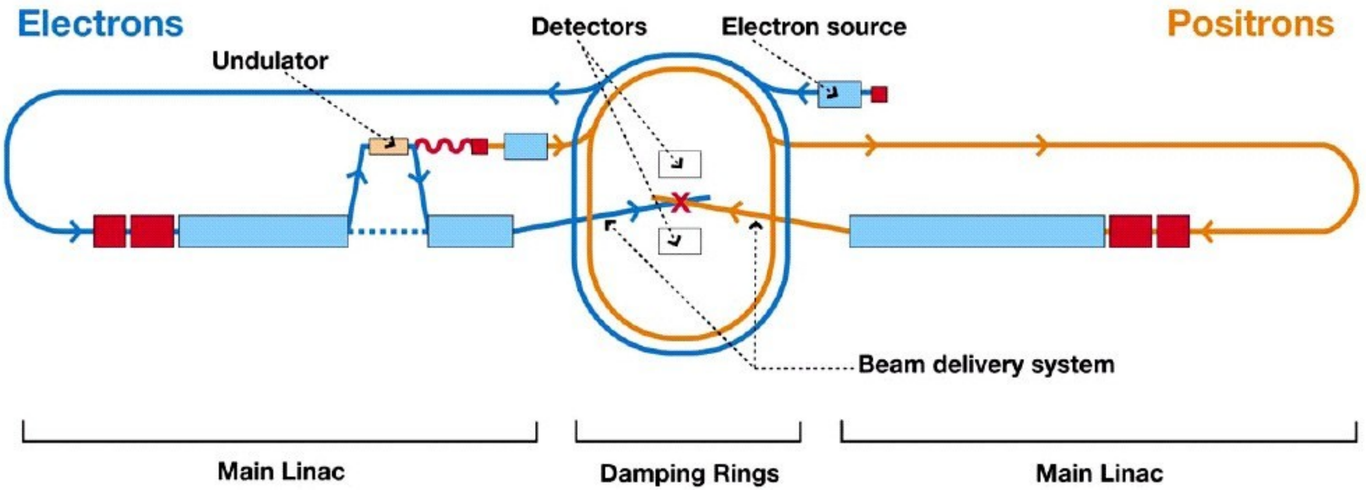


Roman Pöschl

FCPPL Workshop - Paris March 2012

The International Linear Collider ILC

Linear Electron-Positron Collider



Total Footprint 31 km

Main parameters

- √s adjustable from 200 – 500 GeV
- Luminosity → $\int Ldt = 500\ fb^{-1}$ in 4 years
- Ability to scan between 200 and 500 GeV
- Energy stability and precision below 0.1%
- Electron polarisation of at least 80% Option: Polarised Positrons
- To be upgradeable to 1 TeV

Technology for Main Linac

Superconductive RF cavity

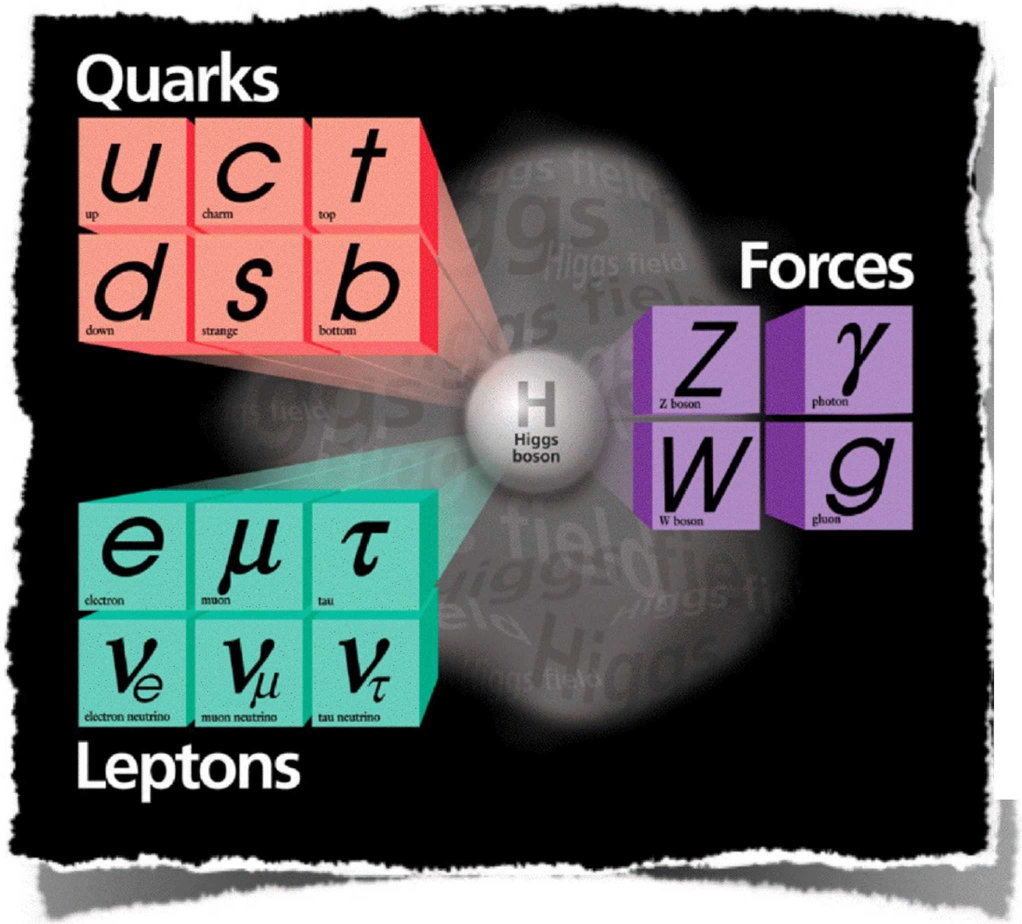
ITRP Recommendation at ICHEP 2004 in Beijing

Present outlook
- → Technical design report 2012
- → R&D Project for higher Energies CLIC

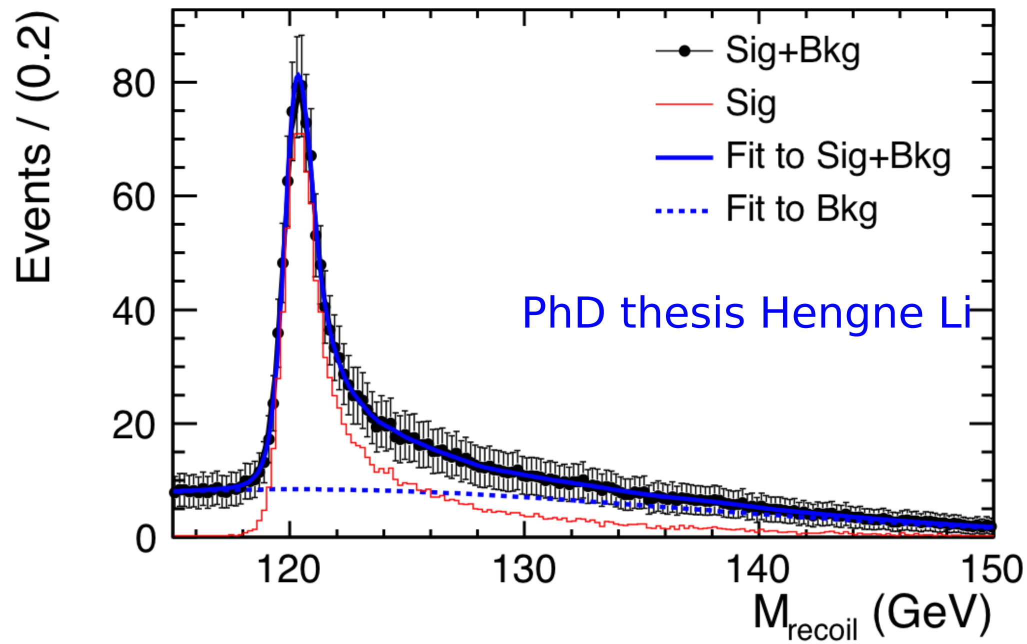
Part I: The physics case

Beyond (?) the Standard Model of particle physics

SM explains elements of ordinary matter as
quarks and leptons – fermions with spin 1/2
interacting via force carriers – bosons with spin 1



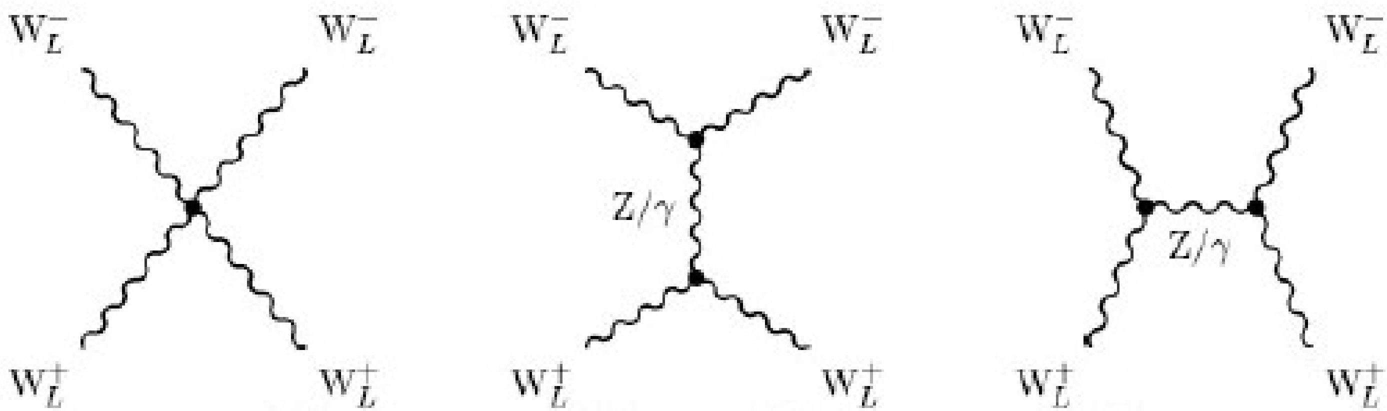
Simulation of Higgs signal at
International Linear Collider



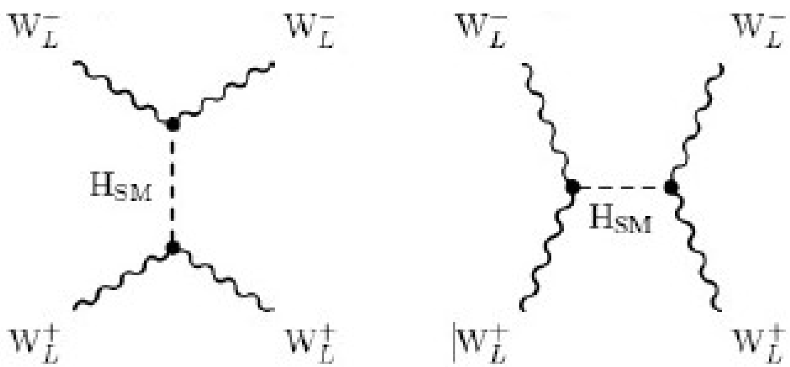
Higgs Boson is missing piece of Standard Model
Chase for Higgs Boson is at full swing at the LHC
Elementary spin 0 particle – Portal to New Physics?
LC would allow complete tomography of Higgs

Why do we need a Higgs Boson?

Scattering of longitudinally polarised W Bosons



Violation of unitarity
@ $\sqrt{s} \approx 1$ TeV

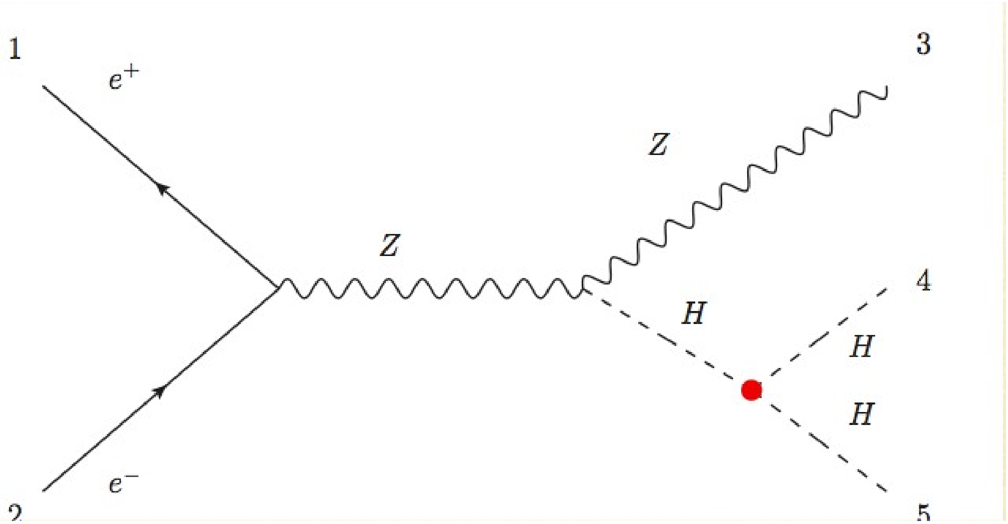


Counter terms

C. Grosjean: “We need a new neutral current!!!!”

Re-establishing of unitarity works only if $m_H \leq 1$ TeV

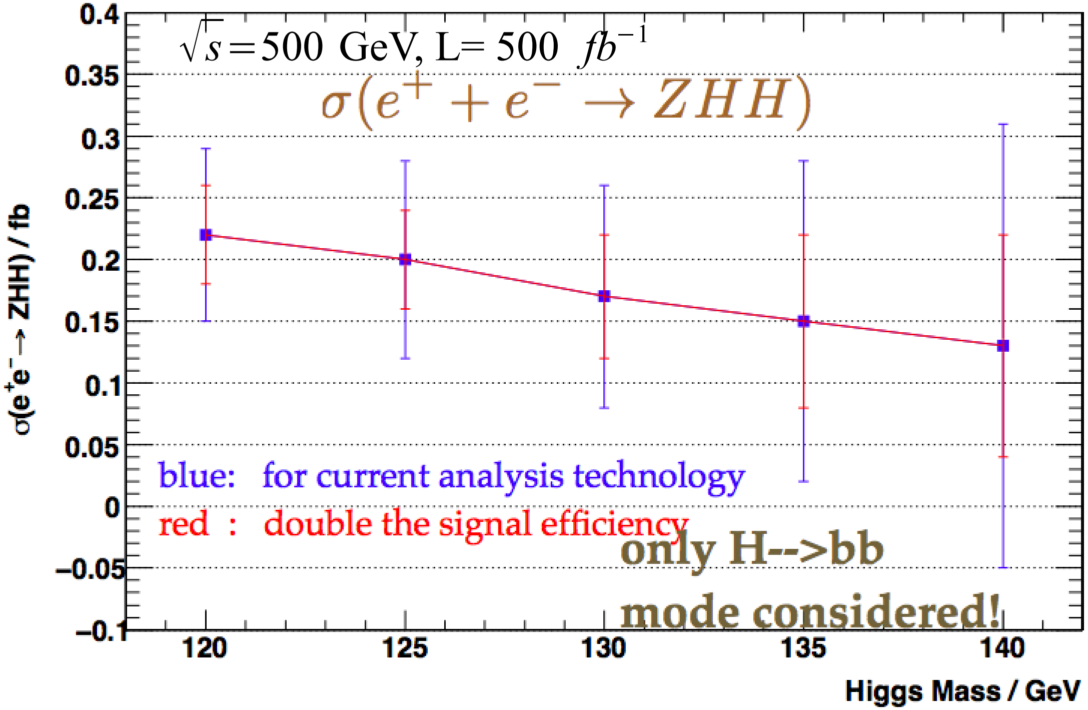
Higgs self coupling



Higgs potential
(after spontaneous symmetry breaking)

$$V(\eta_H) = \frac{1}{2} m_H^2 \eta_H^2 + \lambda v \eta_H^3 + \frac{1}{4} \lambda \eta_H^4$$

$$\lambda = \lambda_{SM} = \frac{m_H^2}{v} \text{ where } v = 246 \text{ GeV}$$



Current status:

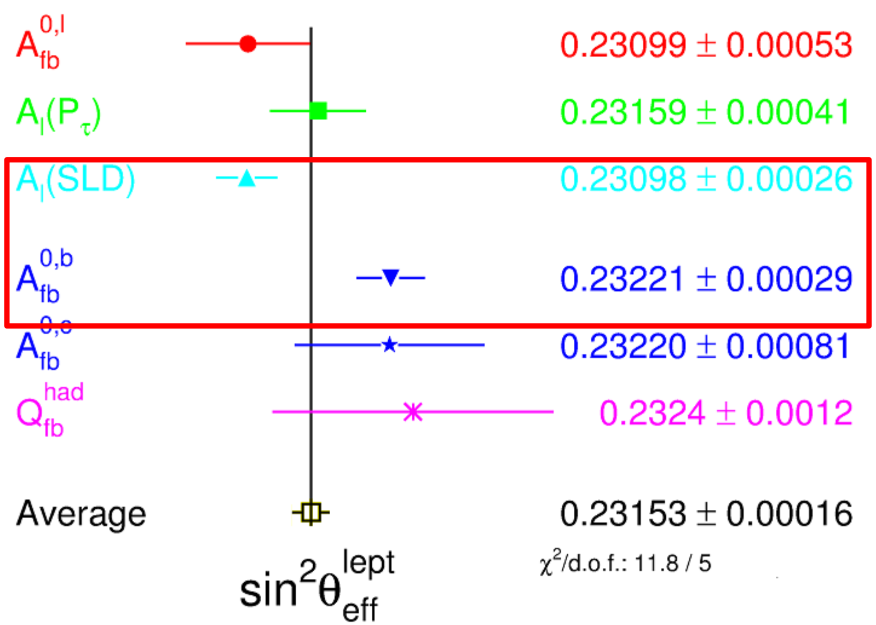
About 40% uncertainty
For m_H = 125 GeV
(Full simulation!!!!)

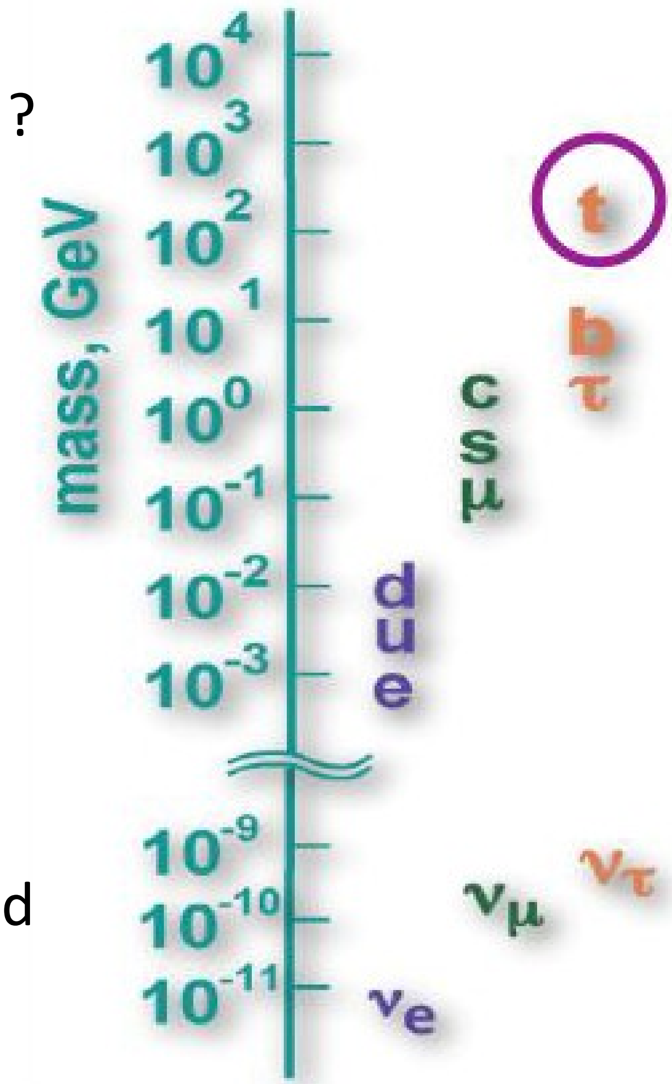
Study aims at 20%

Extremely difficult analysis

The top quark and flavor hierarchy

- Flavor hierarchy ? Role of 3rd generation ?



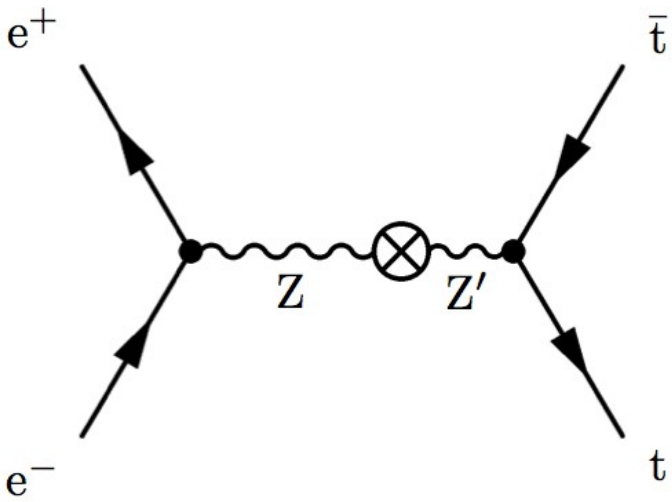


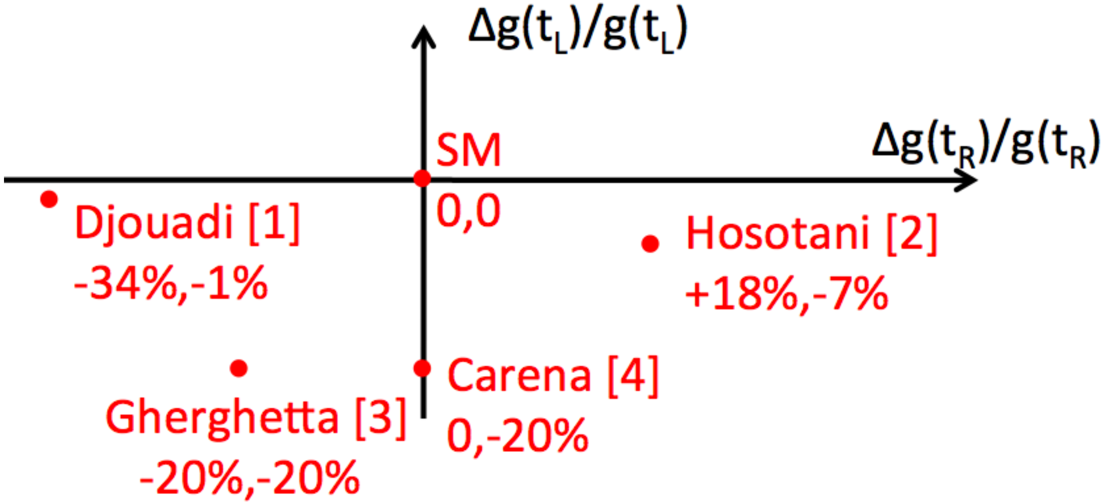
- Top quark : no hadronisation → clean and detailed observations

- Redo measurements of ALR and AFB with the top

Top quark and new physics

New physics modify electroweak couplings to Z





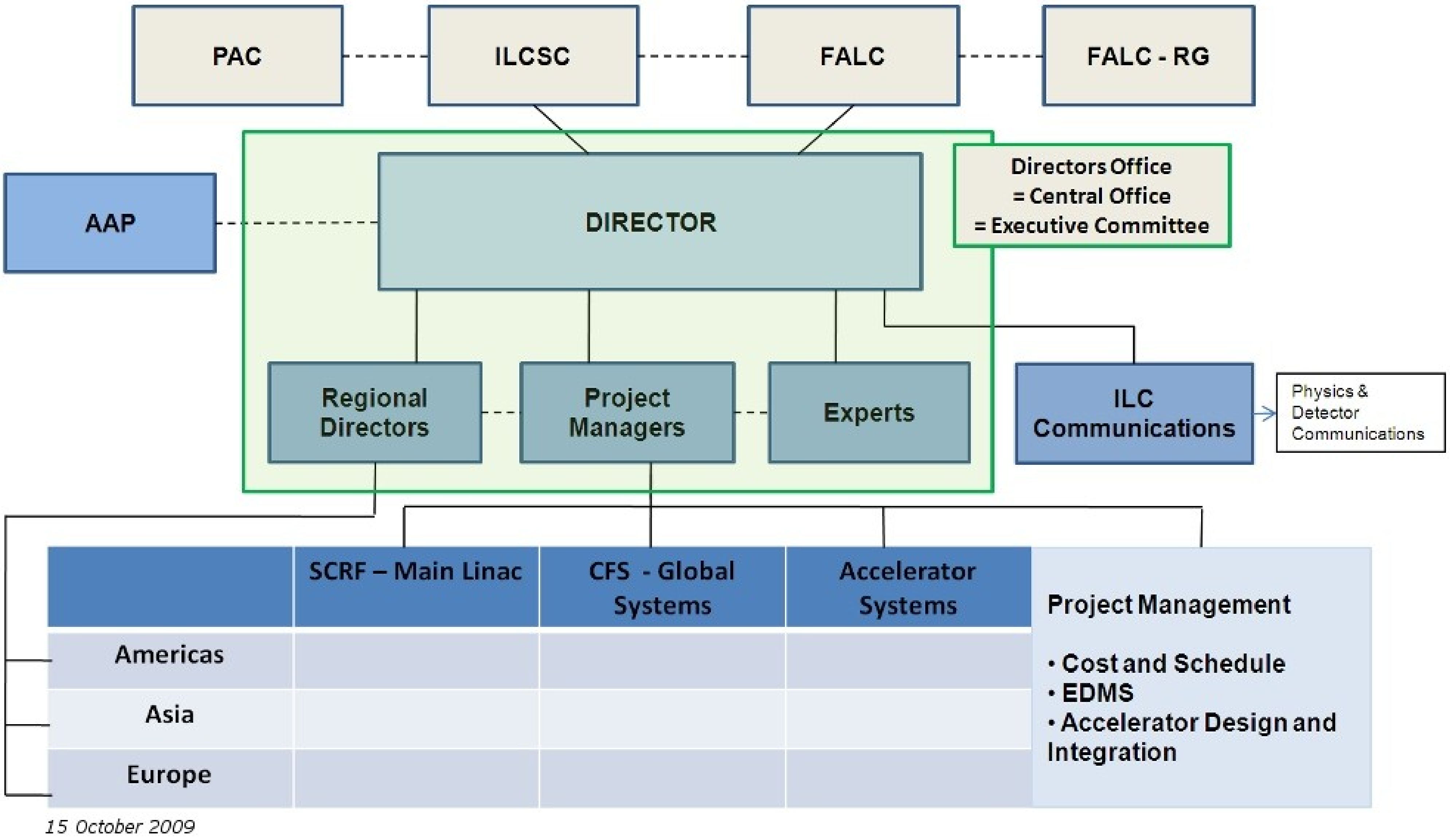
Example: RS models with extra dimensions

- Asymmetries predicted within Standard Model
  New physics modify these asymmetries
  ILC: 'Usual Forward-Backward Asymmetry AFB
  Left-Right asymmetries through polarised beams

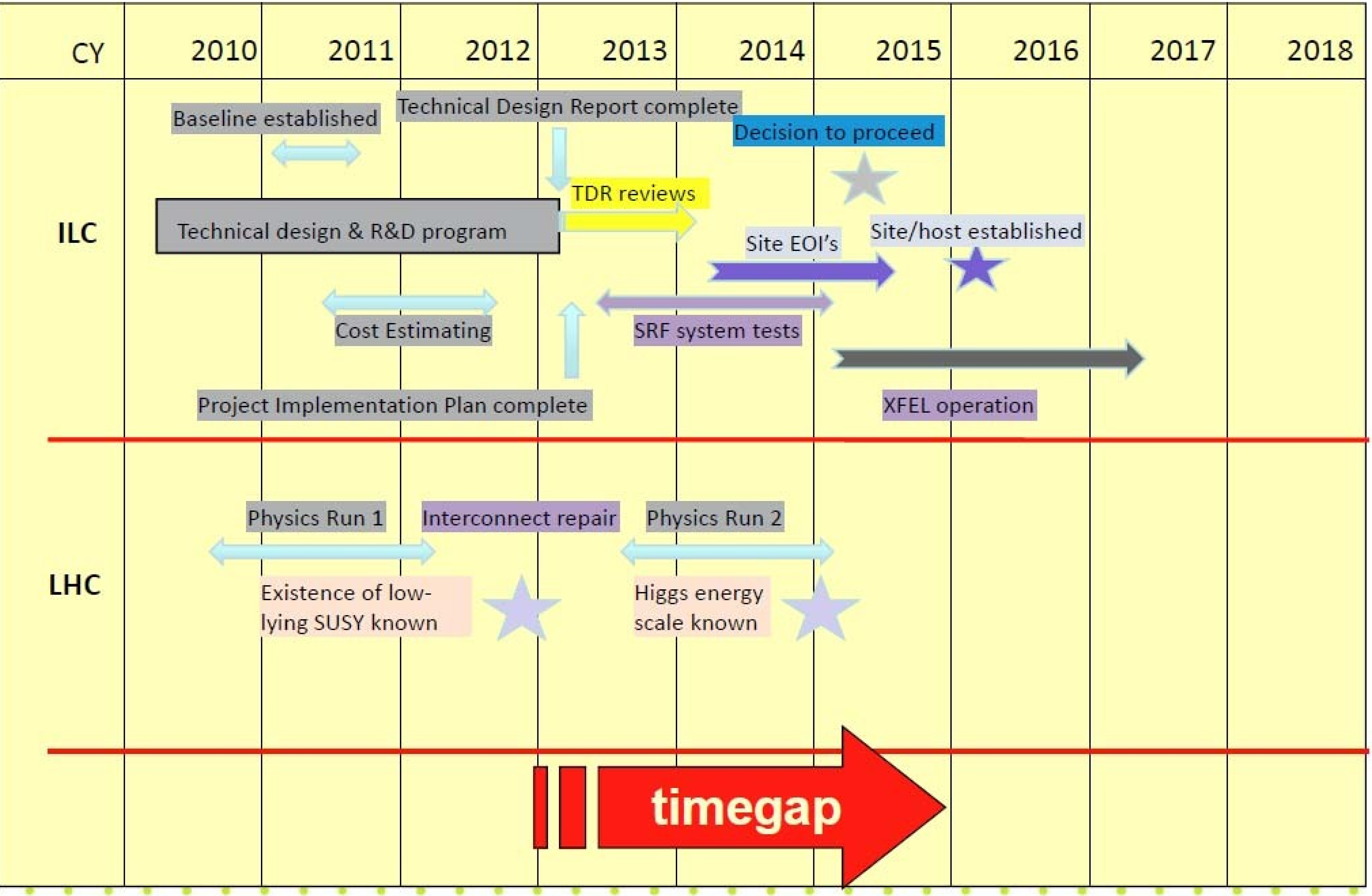
Pe- / Pe+ (80% / 0)	ALR	AFBtR	AFBtL		QZtL	QZtR
stat. error	1.3%	1.2 %	1.4 %		1.0 %	1.9 %

Part II: Machine issues

Global Design Effort for ILC - Organisation



ILC possible timeline



2012 – The "TDR Year"

- June 2011: Publication of Interim Report

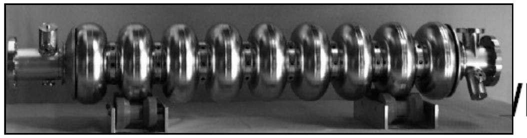
- TDR expected to be published by the end of 2012
  … preceeded by four Baseline Technical reviews

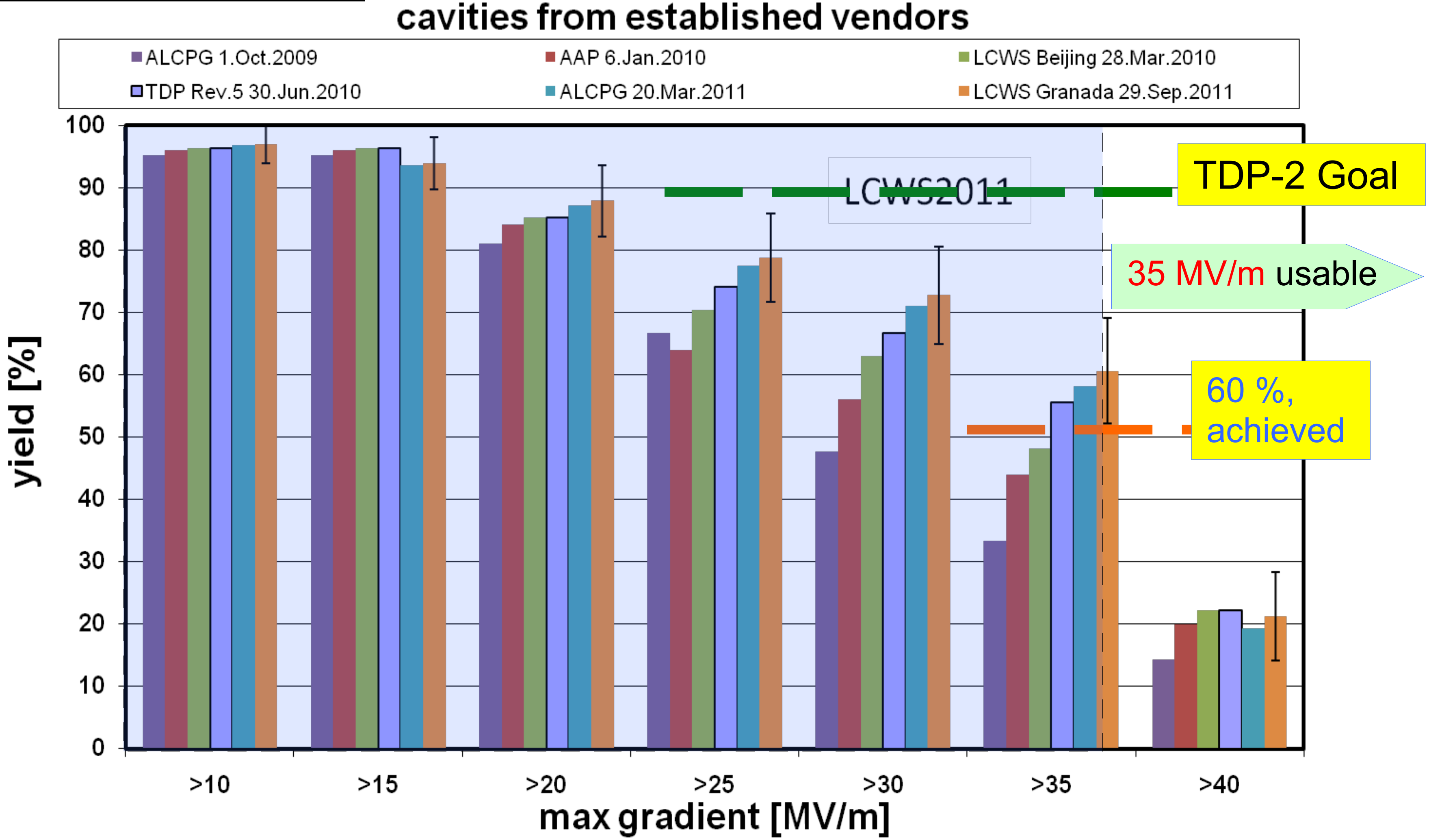
  - Positron source and damping rings
  - Accelerator systems
  - **Main linac and super-conducting radio frequency systems**
  - **Conventional facilities**

- 29/2/12 Release of final version of beam line parameters for TDR
  No travelling focus, optimisation of crab waist shift to regain luminosity

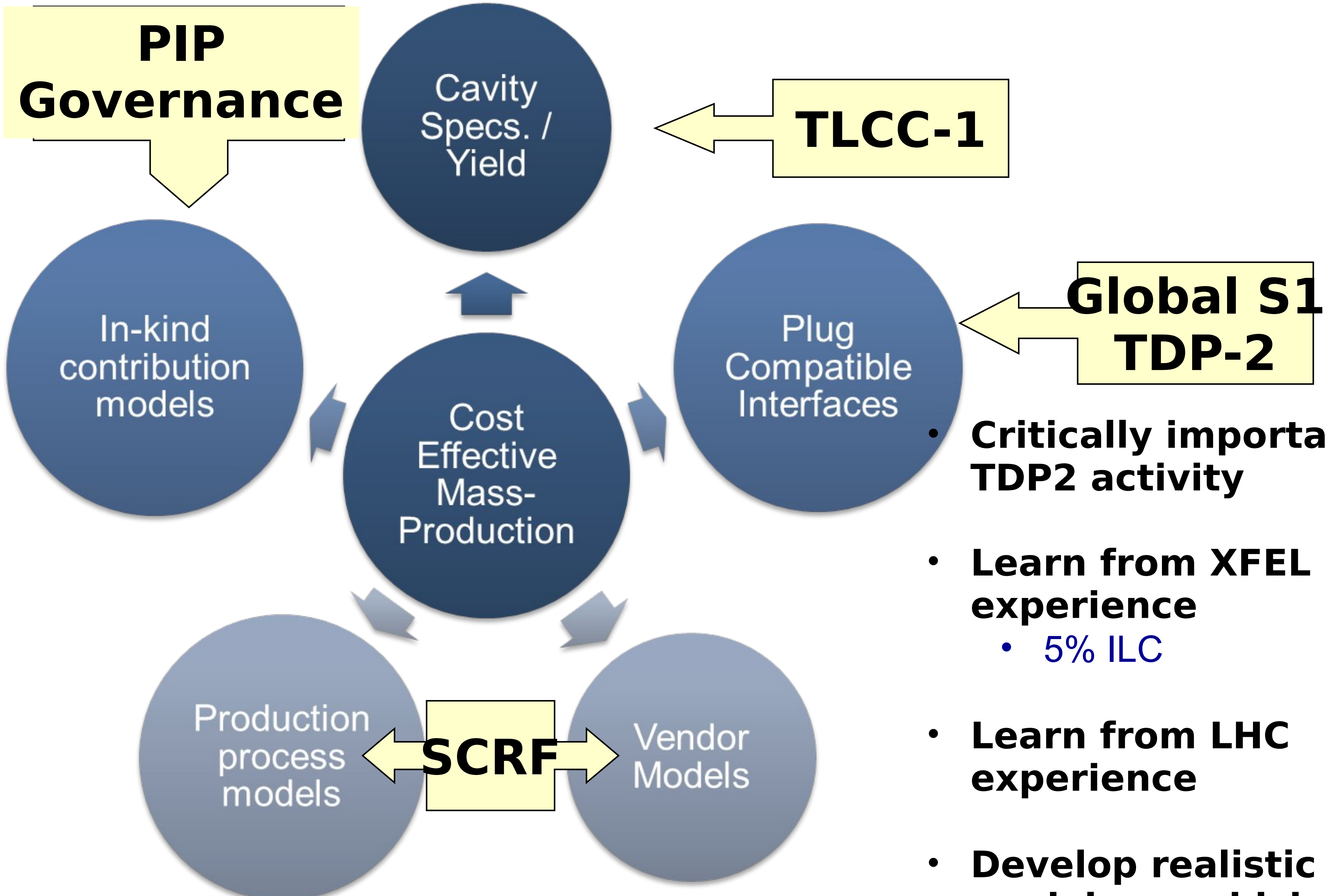
- Final ILC design for TDR expected at LCWS12 in Texas

Progress in Cavity Yield





(Global) Mass Production (SCRF)



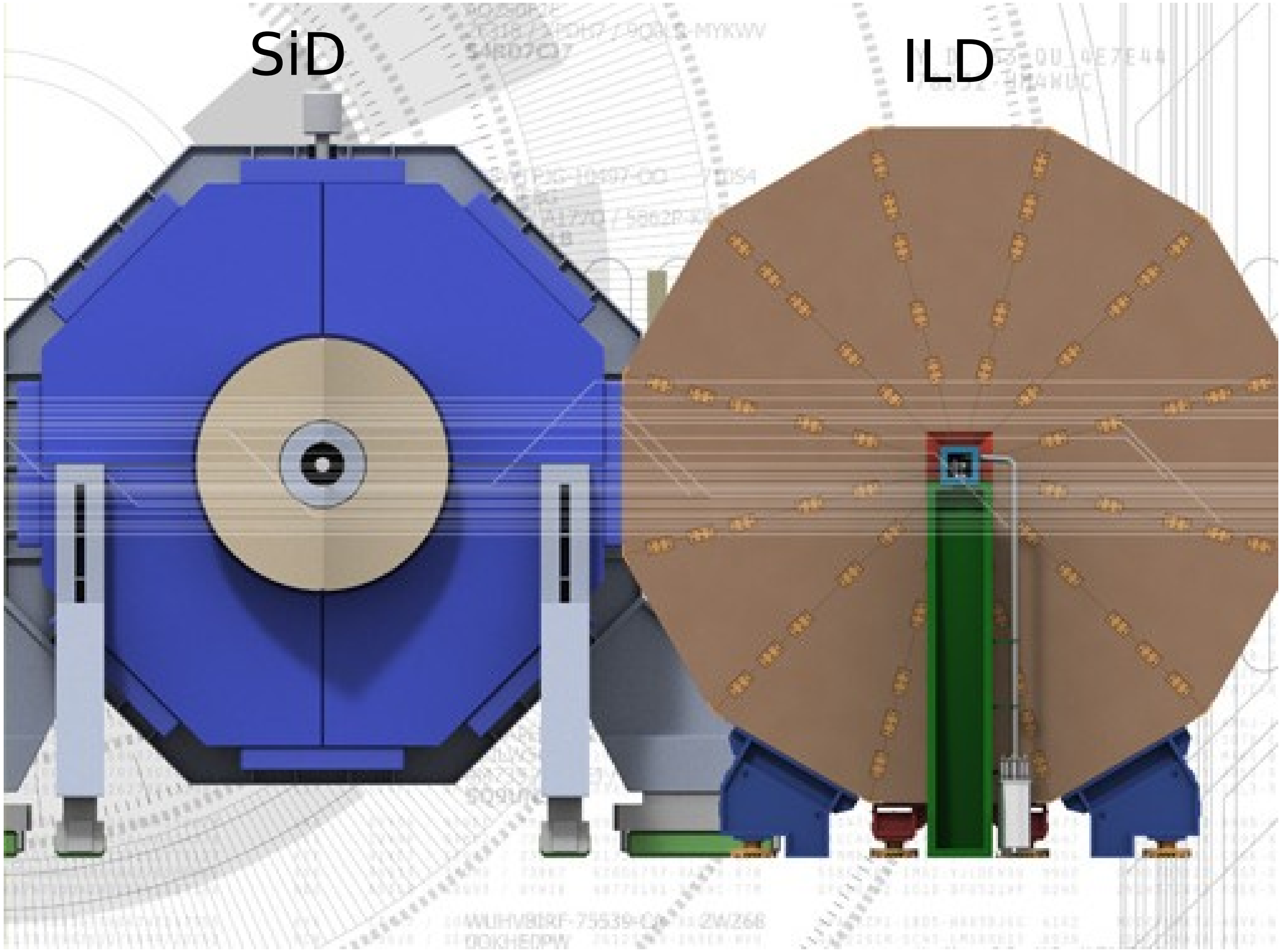
- **Critically important TDP2 activity**
- **Learn from XFEL experience**
  - 5% ILC
- **Learn from LHC experience**
- **Develop realistic models on which to base cost estimate**
  - With industry

Extending the reach of the ILC

- **Upgrade option for study:**
  - Power < 300MW AC
  - New linac grad = 45 MV/m
  - $Q_0 = 2\ 10^{10}$
- **Strawman TeV parameters**
- **Post-TDR program:**
  - Improve cavity gradient
  - Cost effective production
- **Flexibilty: Initial ILC energy: higher or lower energy, as informed by LHC results**

		500GeV Reference		Straw-man TeV	
		no TF	TF	300MW 5% BS	300MW 10% BS
Ecm	GeV	500	500	1000	1000
gamma		4.89E+05	4.89E+05	9.78E+05	9.78E+05
N	e10	2.0	2.0	2.0	2.0
frep	Hz	5.0	5.0	4.0	4.0
Nb		1312	1312	2280	2280
PB	MW	10.5	10.5	29.2	29.2
sigz	mm	0.3	0.3	0.25	0.15
enx	m	1.0E-05	1.0E-05	1.0E-05	1.0E-05
eny	m	3.5E-08	3.5E-08	3.0E-08	3.0E-08
betax	mm	11.00	11.00	30.00	18.00
betay	mm	0.48	0.20	0.25	0.15
sigx	nm	474.2	474.2	553.7	428.9
sigy	nm	5.9	3.8	2.8	2.1
theta_x	ur	43.1	43.1	18.5	23.8
theta_y	ur	12.2	18.9	11.1	14.3
Dx		0.3	0.3	0.1	0.1
Dy		24.6	38.2	18.7	18.7
Upsilon		0.1	0.1	0.1	0.3
Ngamma		1.7	1.7	1.4	1.7
deltaB		4%	4%	5%	11%
HDx		1.1	1.1	1.0	1.0
HDy		6.1	2.8	3.5	3.5
HDy		2.0	1.5	1.5	1.5
∆p/p e+	%	0.087	0.087	0.033	0.048
∆p/p e-	%	0.22	0.22	0.20	0.20
P e+	%	22	22	30	30
P e-	%	80	80	80	80
L				1.55E+34	2.58E+34
Lgeo		7.51E+33	1.16E+34	1.89E+34	3.16E+34
L (formula)		**1.47E+34**	**1.75E+34**	**2.89E+34**	**4.82E+34**
Simulation (noTF)					
Ngamma				1.443	1.753
deltaB(%)		4.30		5.284	9.823
L		1.49E+34		2.825E+34	4.76E+43
L(1%)		62.5		62.1	50.2
Simulation (TF)					
Ngamma				1.444	1.759
deltaB(%)			4.33	5.258	9.826
L			2.05E+34	3.375E+34	5.639E+43
L(1%)			60.8	60.7	48.5
L(TR)/L(no)				1.19	1.18

Detector R&D



- LOI's Validated by IDAG in 2009
- Now moving towards **D**etector **B**aseline **D**esign
- Publication at the end of 2012, i.e. in phase with TDR
- Concepts based on input from physics studies and detector R&D organised in R&D collaborations

Examples for detector R&D collaborations

Time Projection Chamber
for Linear Collider

Highly granular calorimeters
for Linear Collider

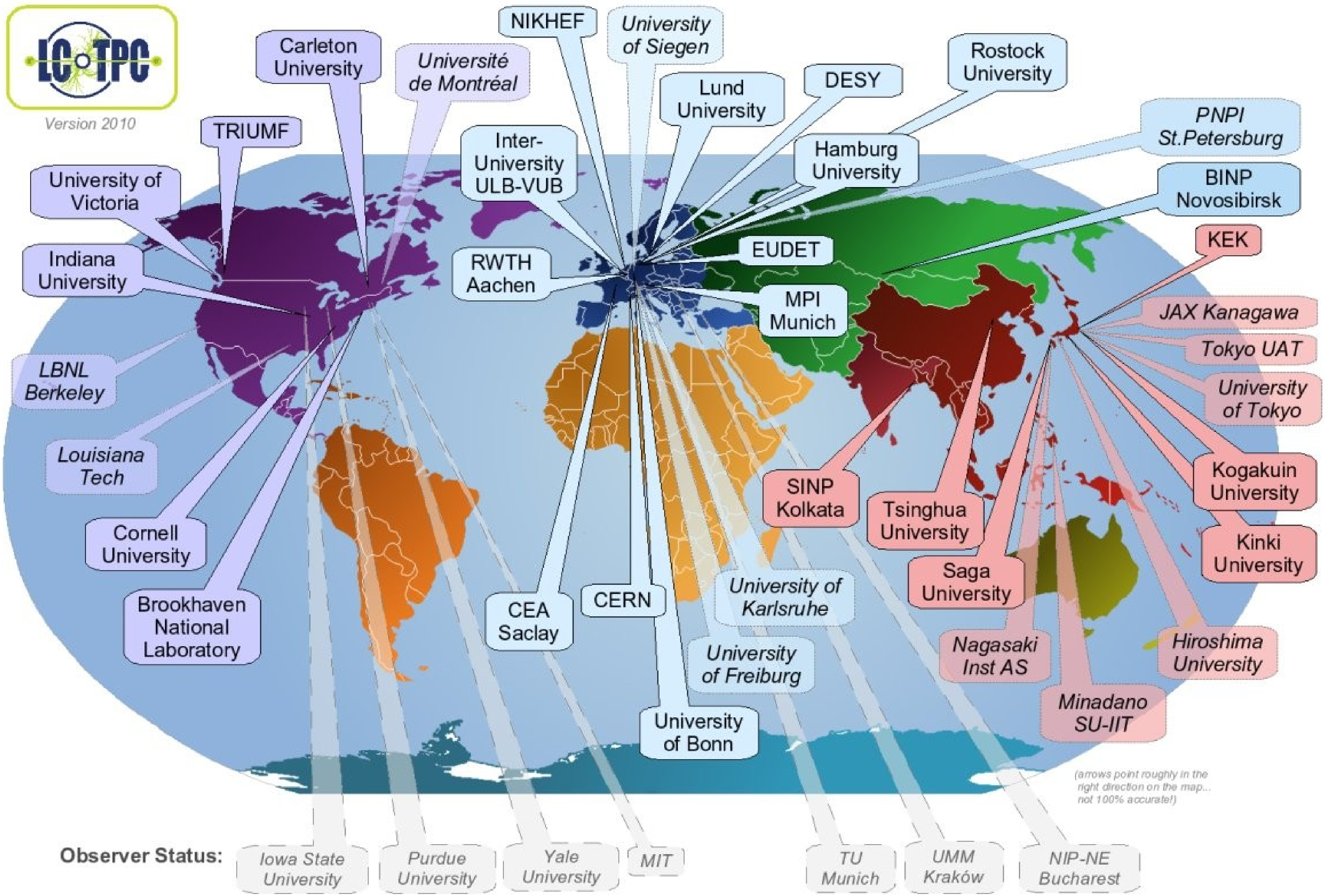
Forward calorimeters
for Linear Collider

Silicon tracking for the
International
Linear
Collider

- Oriented towards LC but very generic R&D

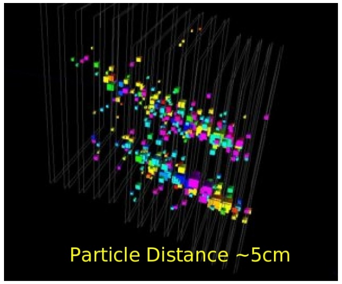
R&D RPCs, Micromegas, SiPMs, ultrathin vertex layers, diamond sensors
Large scale integration of electroncis, small power consumption
See e.g. talks by Laktineh, Martin-Chassard and Winter

World wide R&D effort – Example LCTPC



Detector R&D

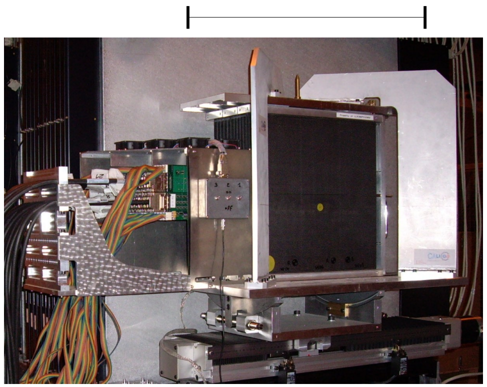
Precision physics at LC require highly granular calorimeters



Physics Prototypes

Proof of principle

2003 - 2011

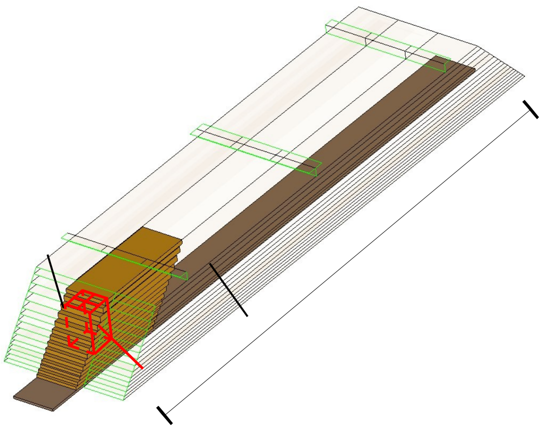


- **Number of channels : 9720**
- **Weight : ~ 200 Kg**

Technological Prototypes

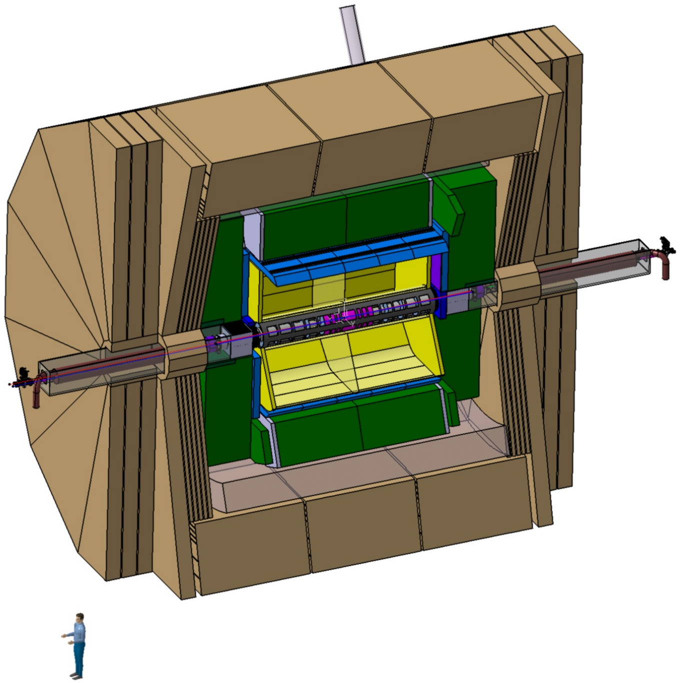
Engineering challenges

2009 - ...



- **Number of channels : 45360**
- **Weight : ~ 700 Kg**

LC Detector



Electromagnetic Calorimeter :

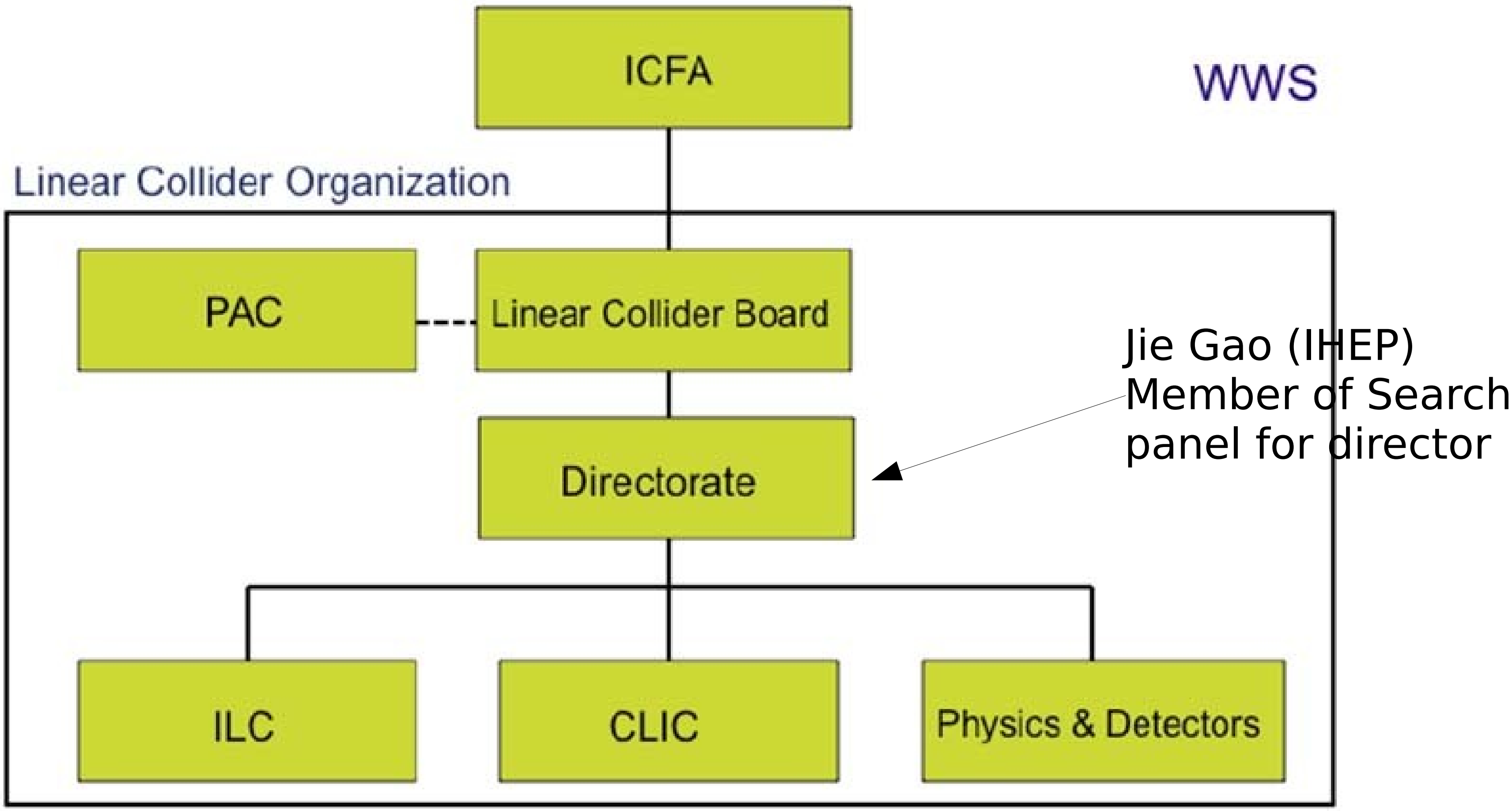
- **Channels : 110 10^6**
- **Total Weight : ~130 t**

2012 prototypes for DBD are taking shape

Next steps?

Mandate of GDE will end at the end of 2012

Possible organisation after 2012 – To be worked out by ILCSC



Transitional organisation to assure continuity of activities until project approval

13/12/11 - Encouraging developments in Japan

Annual Symposium hosted by AAA jointly with the Federation of Diet Members (December 15, 2011)

This and following slides courtesy of K. Kawagoe

Prime minister Noda talked about the Higgs search at the LHC, importance of the accelerator science and its application, and concerns on the ILC:

- International framework to realize the ILC
- Issues to be solved one by one, with discussion between the world scientists
- Understanding and support from the public

In last December, the government approved a few hundred million JPY budget for the geological survey of the two candidate sites.

The ILC has reached the point where the Japanese government is starting to consider it as a possible future project in the context of Japan's national policy.

Two candidate sites in Japan

- One in the Northern part of Japan
  The other in the south-west

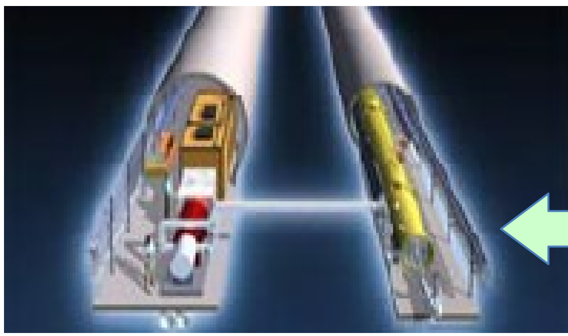
- Both are mountain sites
  solid rock suited for ILC construction

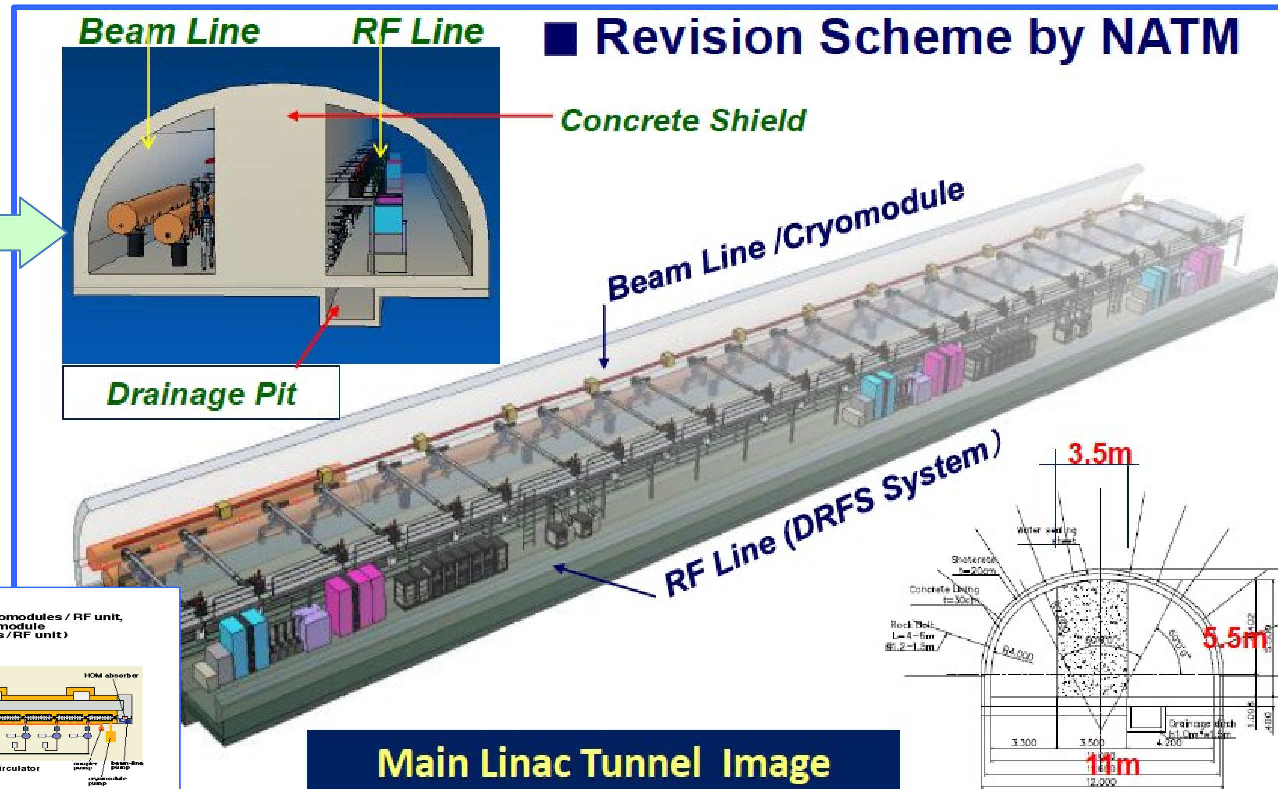
- Strong support by local governments

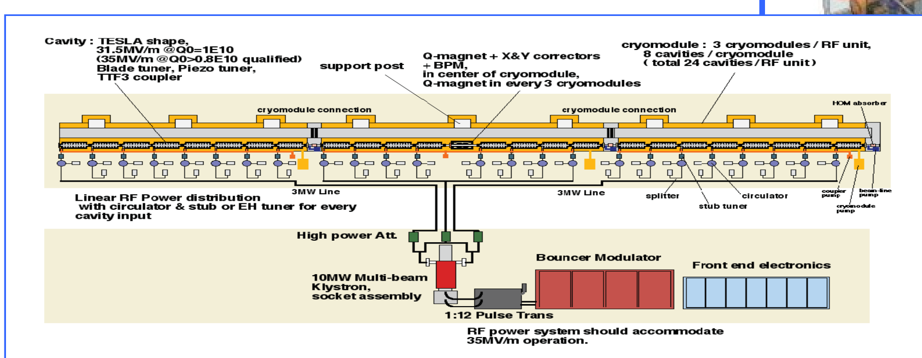
- Visit by GDE broadcasted by
  Japanese Television Channel NHK
  Reached about 30 million people

Tunneling Study for Mountain Regions in Japan

Courtesy: Enomoto/Miyahara
Study supported by KEK-DG







RDR RF unit :
3 Cryomodule (9+8+9 = 26 cavity),
operated by using 10 MW Klystron

DRFS RF unit:
2 cavities operated by 800 kW Klystron

ILC in a staged approach

- If LHC discovers a light Higgs it is the “duty” of the ILC to determine all the relevant parameters

This would favor a machine at initially 250 GeV

(at initially lower cost)

Higgs Factory

- ILC @ 500 GeV could then be considered as a first upgrade (Crossing the) tt-threhsold, ZHH final states

- ILC @ 1 TeV would be then the second upgrade phase
  ttH, unitarity bounds,
  new particles (?), e.g. colorless supersymmetric particles
  Sensitivity versus extra dimensions up to several TeV

Summary and conclusions

- The ILC is the right machine for precision physics in the range m_z – 1 TeV

  Particularly it can be operated as a Higgs-Factory

  High precision top quark studies

- Publication of machine TDR and detector DBD will prove maturity of project

- Mandate of GDE will end with TDR

- Transition into new (and again) world wide organisation

  ILC and alternatives plus detectors under one roof

  Search for director in full swing

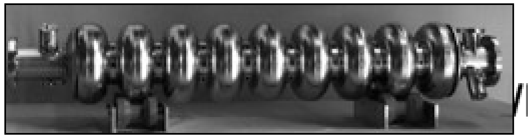
- The sun rises in the East

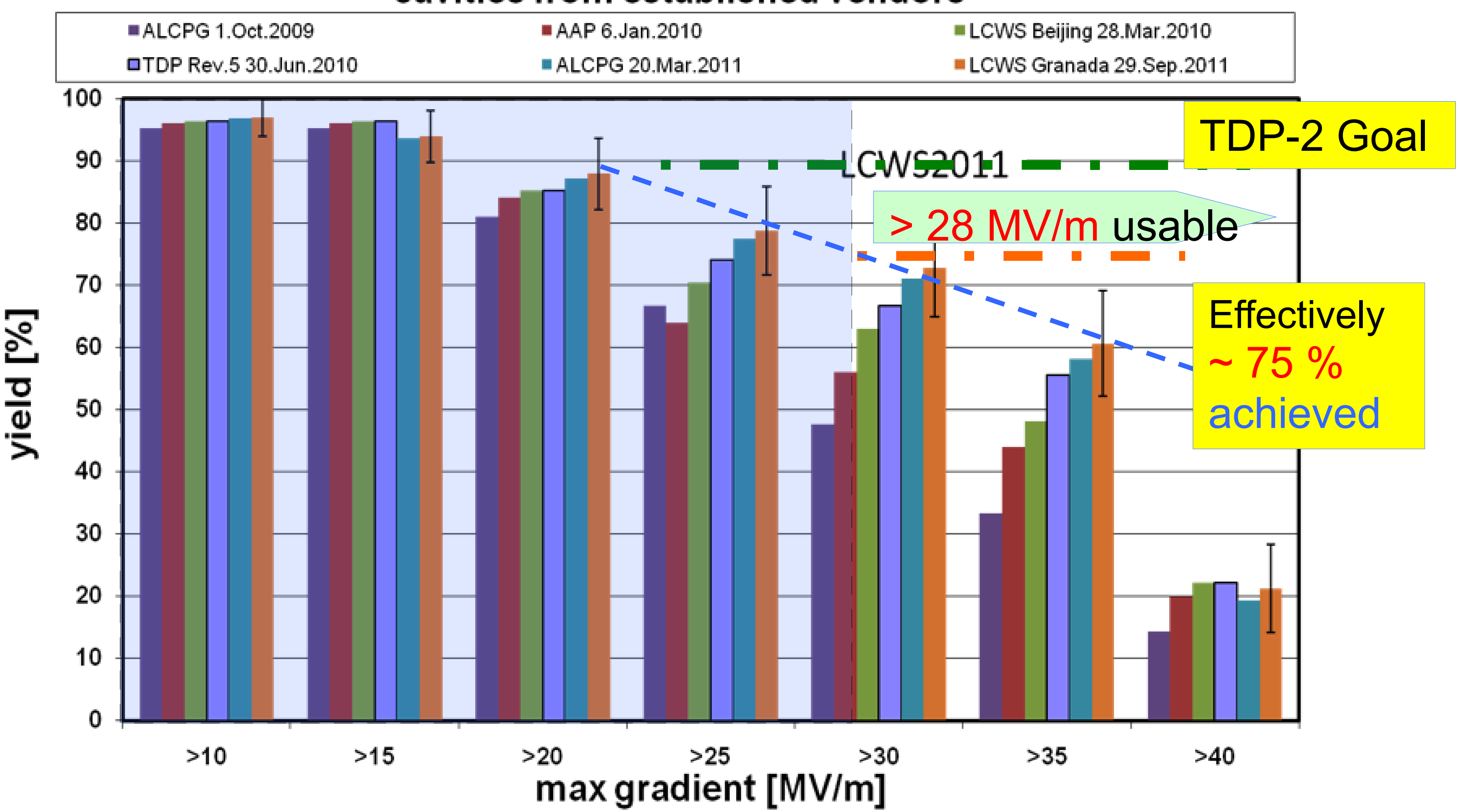
- Be always well informed through www.linearcollider.org

Backup

Progress Integrated in Cavity Gradient Yield

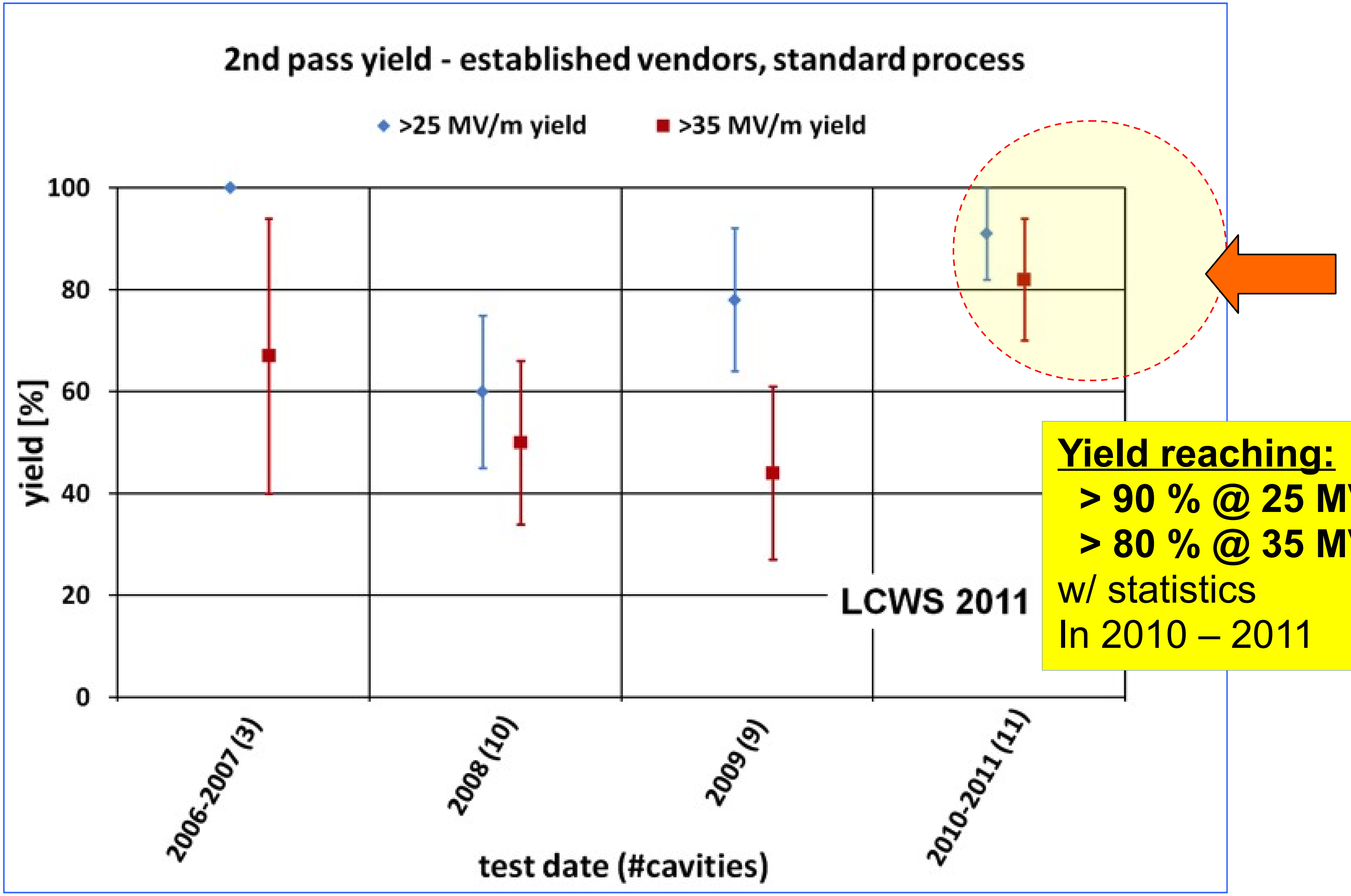
Updated, Sept., 2011





AAA-120215, Yamamoto ILC-ml-scrf-Progress 27

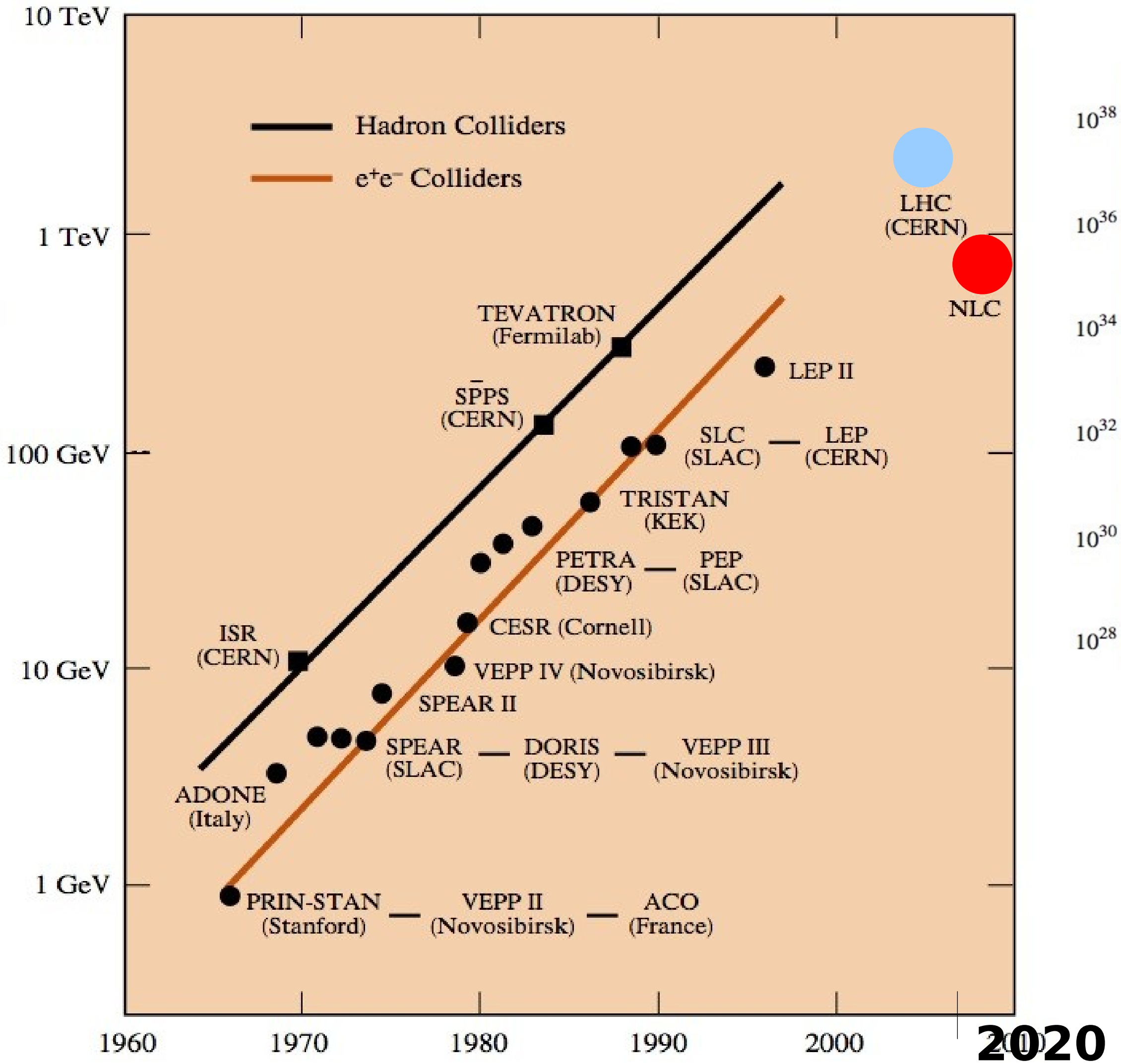
Yearly Progress in Cavity Gradient Yield



Yield reaching:
> 90 % @ 25 MV/m
> 80 % @ 35 MV/m
w/ statistics
In 2010 – 2011

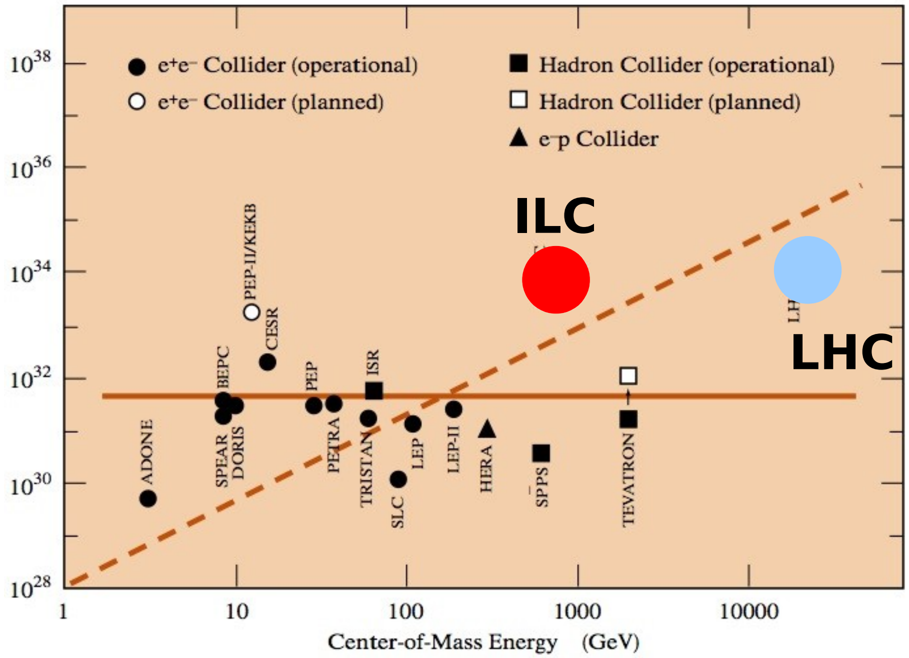
Accelerators of yesterday, today and tomorrow

Energy



Start of operation

Luminosity

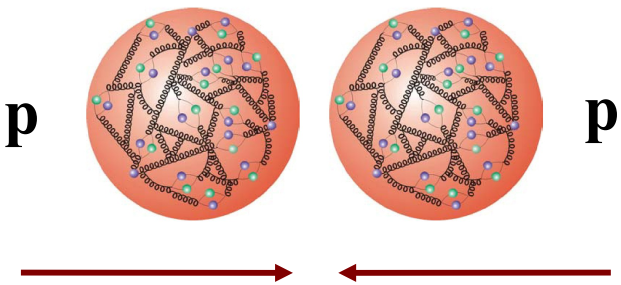


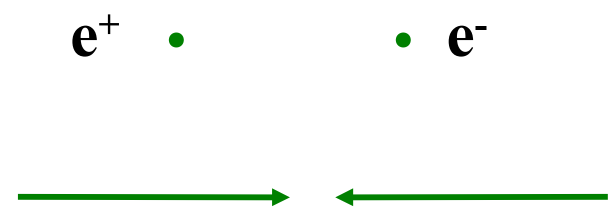
Énergy

Parallel Running of Hadron and Electron Machines

Why Electron Positron Machine?

Note: **ILC will probably be put into operation after major LHC discoveries. Why is the ILC still needed?**





- **p = composite particle:**
  unknown √s of IS partons,
  no polarization of IS partons,
  parasitic collisions
- **p = strongly interacting:**
  huge SM backgrounds,
  highly selective trigger needed,
  radiation hard detectors needed

- **e = pointlike particle:**
  known and tunable √s of IS particles,
  polarization of IS particles possible,
  kinematic contraints can be used
- **e = electroweakly interacting**
  low SM backgrounds,
  no trigger needed,
  detector design driven by precision

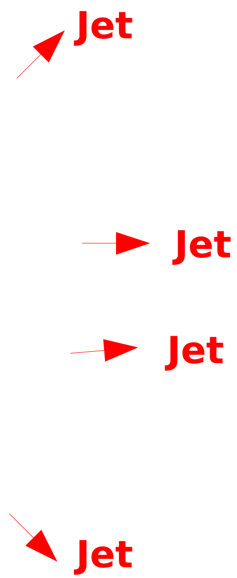
Electron Positron Collider – Best premises for precision measurements

Hadronic Decays of W and Z Bosons

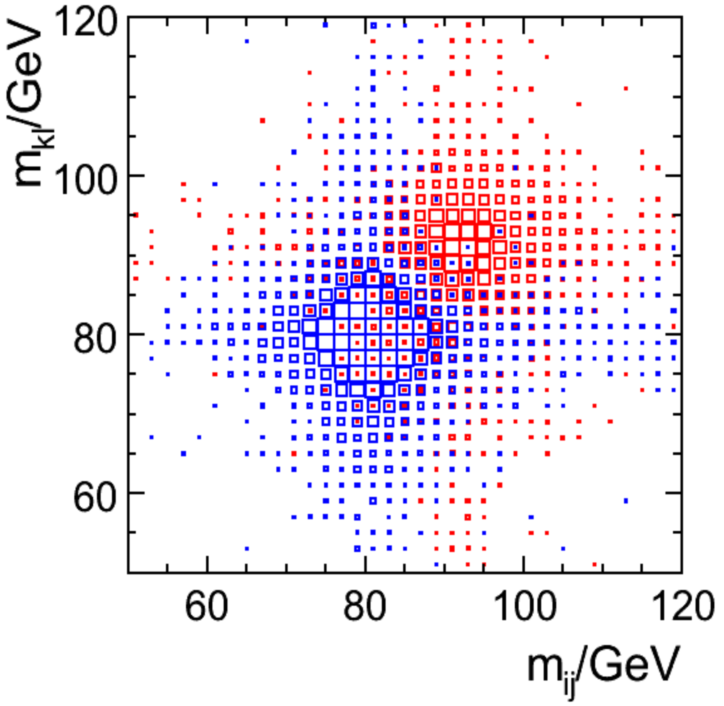
Boson Boson Scattering

What if no Higgs?

Manifestation of new physics
Strong Electroweak Symmetry Breaking



W, Z separation in the ILD detector



Remember: $M_Z - m_W \approx 10$ GeV

- Need excellent jet energy resolution to separate W and Z bosons in their hadronic decays