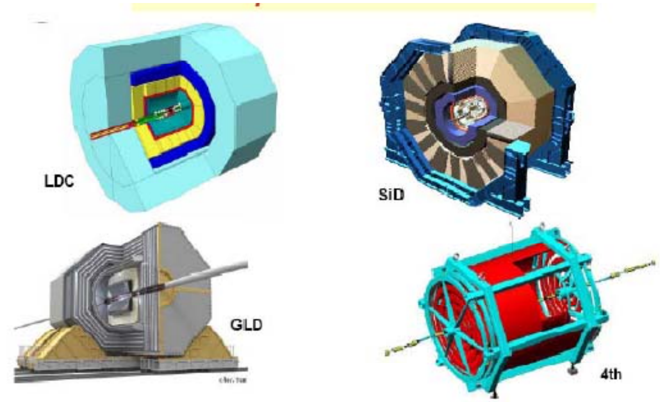
Worldwide Study of the Physics and Detectors for Future Linear e+ e- Colliders



The ILC detector roadmap

EUDET Second Annual Meeting
École Polytechnique, Paris
October 8 - 10, 2007

F. Richard LAL/Orsay

ilc

EUDET

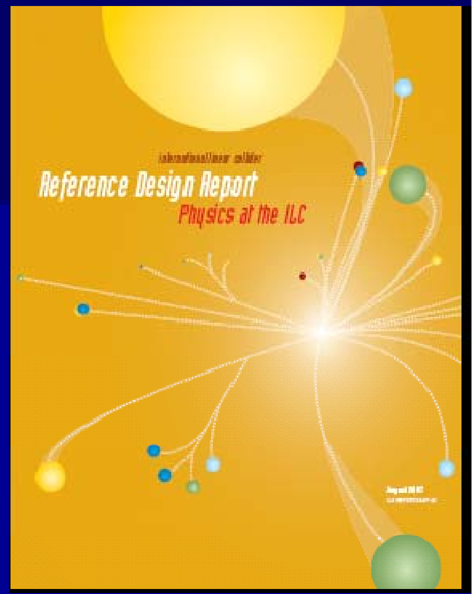
Introduction: what is the WWS ?

- The community working on Detectors and preparing the Physics for ILC has been organized, since 1998, through what is called the **World-Wide-Study** (WWS): 3 co-chairs legitimately (in Europe: ECFA) representing the regions and a WWS-OC of 21 members
- This body organizes the regional and the WW workshops (LCWS), has created several panels, permanent or provisional: R&D, Software, MDI, etc... to respond to the issues faced by this community
- We communicate with the GDE: MDI, overlapping workshops , participation to GDE EC once/month...
- We report to ILCSC which is our oversight body

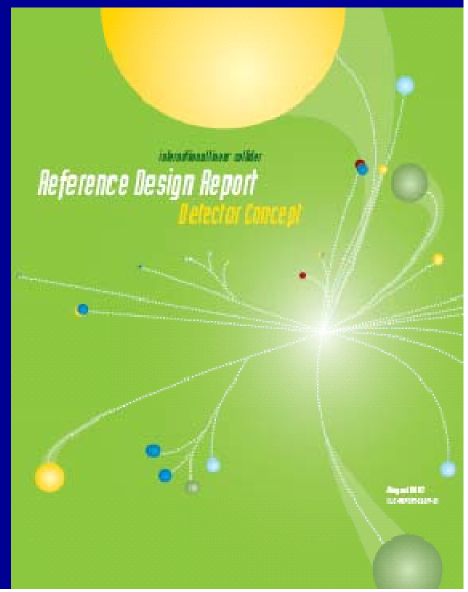
First achievements

- It was shown that one can define a Machine + Detectors with technologies which require a manageable R&D, at affordable costs
- 4 concepts of detectors were studied (see http://physics.uoregon.edu/~lc/wwstudy/)
- First results show that they can reach the physics goals (realistic simulation e.g. for PFLOW)
- These results are summarized in 4 recent documents signed by ~1800 Phys.+Ing. belonging to 320 institutions (http://www.linearcollider.org/cms/?pid=1000437)

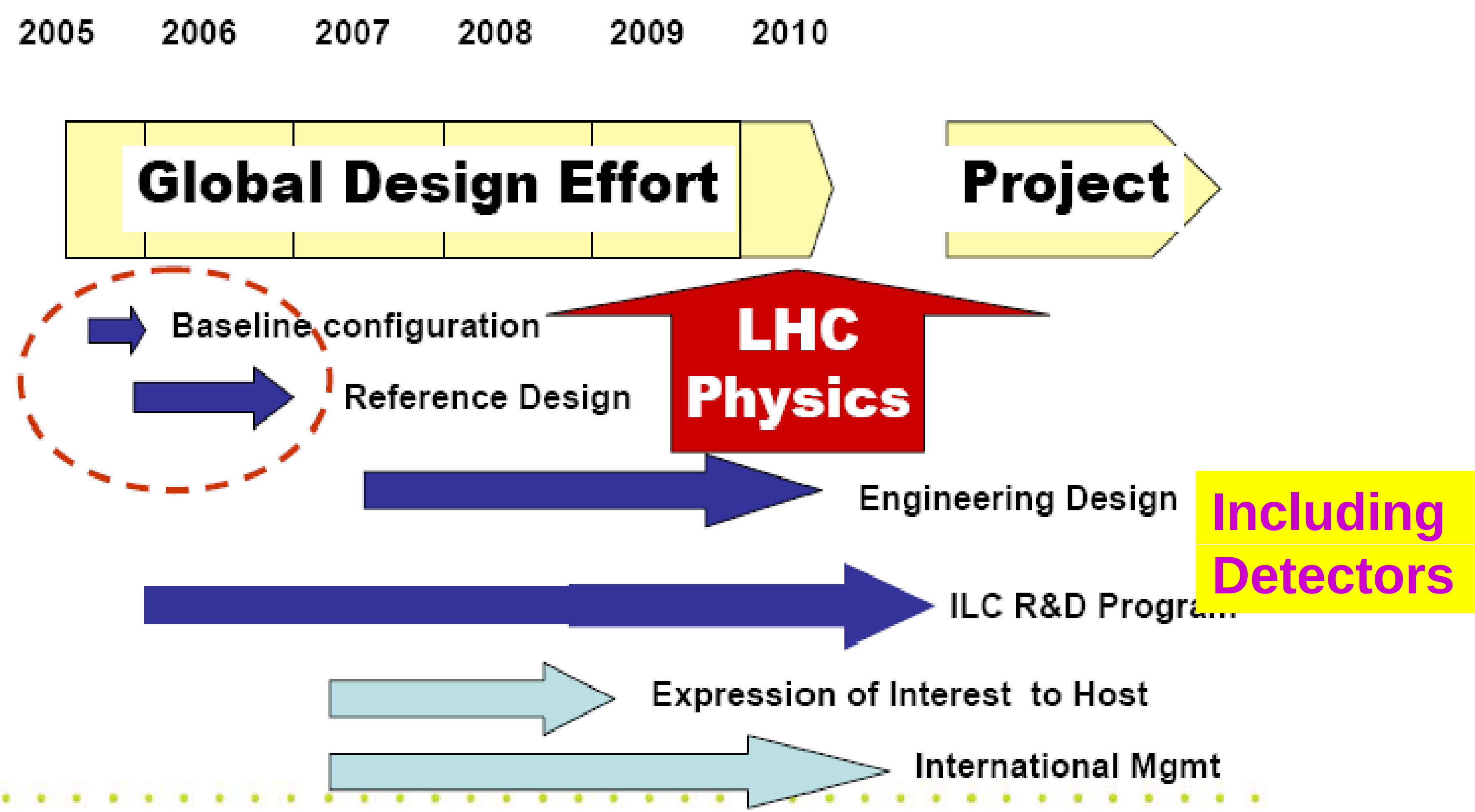
Recent outputs



- Two reference design reports, RDR, together with the machine RDR: the **Physics** and the **Detector RDR** which have been reviewed
- First estimate of the cost (~300 M$ + manpower ~**550 M$/detector** in ILC units) also reviewed
- The next step follows from the GDE roadmap set by B. Barish



The GDE Plan and Schedule



The Detector Roadmap

- Our goal: **two Engineering Designs** (ED) for the detectors in ~2010
- To reach this goal the WWS, in agreement with the GDE and after consulting the community LCWS07, has proposed that ILCSC:

  - Calls for **LOIs** from the teams interested to prepare for an ED due in 2010

  - Appoints a **Research Director** which will be responsible for the Detectors
- This RD should set up, in agreement with ILCSC, an international body (**IDAG**) to help him form 2 teams writing EDs

Some guidelines

- These ED can only claim limited resources to comply with some reservations expressed at FALC (funding authorities)
- These resources (as was the case for LHC) will not be explicit in the LOIs
- Note however that FALC says: ‘The Group agreed that the focus of work for the detectors should be on the issues relevant to the accelerator EDR program’
- We certainly need engineering (push-pull, construction) FTE only ?
- What else? Industrialisation for major components -> Funding

Where do we stand

- Our proposal has been accepted by ILCSC
- The Research Director Sakue Yamada has been appointed by ILCSC
- The call for LOIs has been sent (and you should have received it or else please consult http://physics.uoregon.edu/~lc/wwstudy/lois/)
- These LOIs are due for October 2008
- The RD is discussing with the WWS about the composition of IDAG to be proposed to ILCSC
- We will discuss with the concepts a choice of Reference Reactions (hep-ex/0603010)

IDAG composition (Preliminary)

- Experienced experts for physics in large-scale experiments at high energy colliders like LEP, TEVATRON, HERA, LHC or B/phi-factories
- Experienced detector expertise for Calorimeters, Tracking devices, PID, DAQ and data handling
- Theorists on phenomenology who may provide some wisdom on physics
- Machine experts (push pull aspects, relation to the machine EDR)
- + ex officio members

Some critical issues

- The matrix organisation: R&D vs ED
- Find the right balance between these two activities (RD+IDAG)
- Avoid freezing the choice of sub-detectors before completing the R&D
- Openness issues (ILCSC statement)

The process we are presently envisaging by no means precludes the possibility for an emerging collaboration to provide an alternate EDR after 2008 and it will be the task of the worldwide lab emerging during the approval phase of ILC (period starting in 2010) to make final choices about the final two detectors accepted.

- Relationship of the ED effort with GDE to be sharpened

Conclusions

- Clear goal: 2 ED by 2010
- Not an easy task
- Limited resources which therefore require an optimised approach to reach this goal without compromising the present R&D effort
- The WWS needs your input to avoid mistakes

FOR DISCUSSION

Cost of the machine

Summary
RDR "Value" Costs

Total Value Cost (FY07)
4.80 B ILC Units Shared
+
1.82 B Units Site Specific
+
14.1 K person-years
("explicit" labor = 24.0 M person-hrs @ 1,700 hrs/yr)
1 ILC Unit = $ 1 (2007)

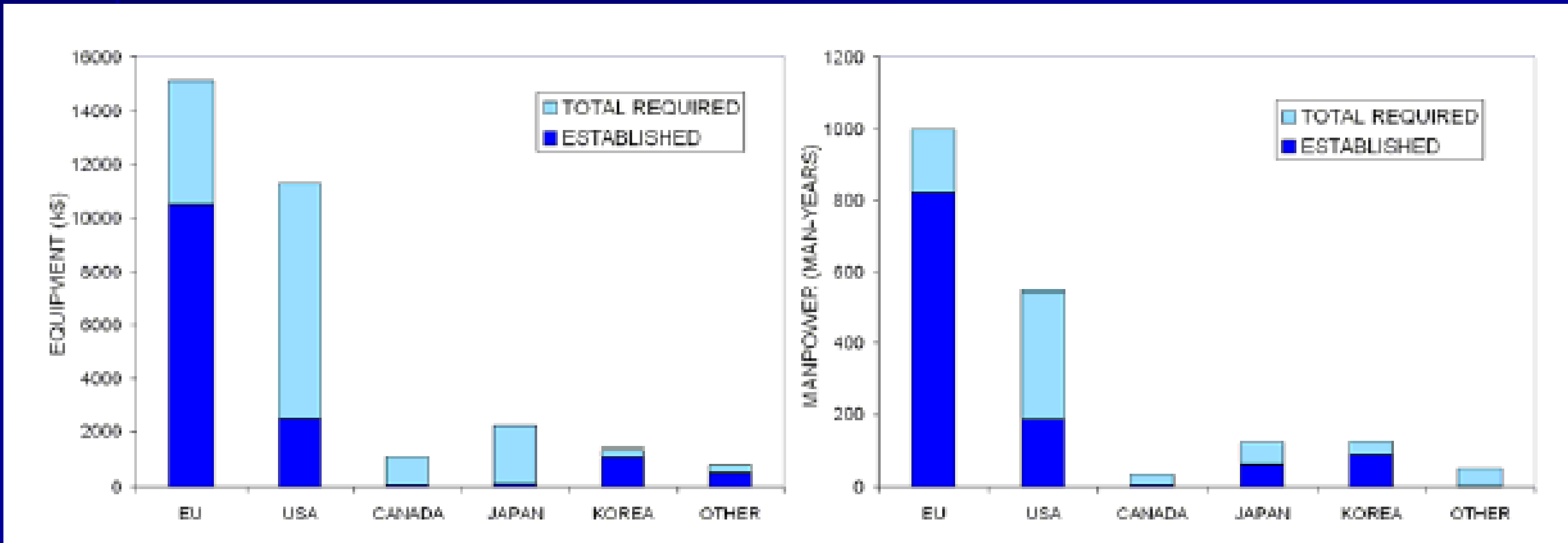
- ~1.6 B /region + labor
- + 1.82 B paid by host
- No inflation
- No contingency
- Can be regionally translated
- Has been checked by an external panel and found realistic/conservative
- There is room for savings (tunnels)
- Detectors in addition ~12.5%

TABLE II: Benchmark reactions for the evaluation of ILC detectors

	Process and Final states	Energy (TeV)	Observables	Target Accuracy	Detector Challenge	Notes
Higgs	$ee \to Z^0h^0 \to \ell^+\ell^- X$	0.35	M_{recoil}, σ_{Zh}, BR_{bb}	$\delta\sigma_{Zh} = 2.5\%$, $\delta BR_{bb} = 1\%$	T	{1}
	$ee \to Z^0h^0$, $h^0 \to b\bar{b}/c\bar{c}/\tau\tau$	0.35	Jet flavour , jet $(E, \not{p})$	δM_h=40 MeV , $\delta(\sigma_{Zh} \times BR)$=1%/7%/5%	V	{2}
	$ee \to Z^0h^0, h^0 \to WW^*$	0.35	M_Z , M_W , σ_{qqWW^*}	$\delta(\sigma_{Zh} \times BR_{WW^*})$=5%	C	{3}
	$ee \to Z^0h^0/h^0\nu\bar{\nu}$, $h^0 \to \gamma\gamma$	1.0	$M_{\gamma\gamma}$	$\delta(\sigma_{Zh} \times BR_{\gamma\gamma})$=5%	C	{4}
	$ee \to Z^0h^0/h^0\nu\bar{\nu}$, $h^0 \to \mu^+\mu^-$	1.0	$M_{\mu\mu}$	5σ Evidence for $M_h = 120$ GeV	T	{5}
	$ee \to Z^0h^0, h^0 \to invisible$	0.35	σ_{qqE}	5σ Evidence for $BR_{invisible}$=2.5%	C	{6}
	$ee \to h^0\nu\bar{\nu}$	0.5	$\sigma_{h\nu\nu}$, M_{bb}	$\delta(\sigma_{\nu\nu h} \times BR_{bb}) = 1\%$	C	{7}
	$ee \to t\bar{t}h^0$	1.0	σ_{tth}	δg_{tth}=5%	C	{8}
	$ee \to Z^0h^0h^0$, $h^0h^0\nu\bar{\nu}$	0.5/1.0	σ_{Zhh}, $\sigma_{\nu\nu hh}$, M_{hh}	δg_{hhh}=20/10%	C	{9}
SSB	$ee \to W^+W^-$	0.5		$\Delta\kappa_\gamma, \lambda_\gamma = 2 \cdot 10^{-4}$	V	{10}
	$ee \to W^+W^-\nu\bar{\nu}/Z^0Z^0\nu\bar{\nu}$	1.0	σ	$\Lambda_{*4}, \Lambda_{*5} = 3$ TeV	C	{11}
SUSY	$ee \to \tilde{e}^+_R\tilde{e}^-_R$ (Point 1)	0.5	E_e	$\delta M_{\tilde{\chi}^0_1}$=50 MeV	T	{12}
	$ee \to \tilde{\tau}^+_1\tilde{\tau}^-_1$, $\tilde{\chi}^+_1\tilde{\chi}^-_1$ (Point 1)	0.5	E_π, $E_{2\pi}$, $E_{3\pi}$	$\delta(M_{\tilde{\tau}_1} - M_{\tilde{\chi}^0_1})$=200 MeV	T	{13}
	$ee \to \tilde{t}_1\bar{\tilde{t}}_1$ (Point 1)	1.0		$\delta M_{\tilde{t}_1}$=2 GeV		{14}
-CDM	$ee \to \tilde{\tau}^+_1\tilde{\tau}^-_1$, $\tilde{\chi}^+_1\tilde{\chi}^-_1$ (Point 3)	0.5		$\delta M_{\tilde{\tau}_1}$=1 GeV , $\delta M_{\tilde{\chi}^0_1}$=500 MeV,	F	{15}
	$ee \to \tilde{\chi}^0_2\tilde{\chi}^0_2$, $\tilde{\chi}^+_1\tilde{\chi}^-_1$ (Point 2)	0.5	M_{jj} in $jj\not{E}$, $M_{\ell\ell}$ in $jj\ell\ell\not{E}$	$\delta\sigma_{\tilde{\chi}_2\tilde{\chi}_2} = 4\%$, $\delta(M_{\tilde{\chi}^0_2} - M_{\tilde{\chi}^0_1})$= 500 MeV	C	{16}
	$ee \to \tilde{\chi}^+_1\tilde{\chi}^-_1/\tilde{\chi}^0_i\tilde{\chi}^0_j$ (Point 5)	0.5/1.0	$ZZ\not{E}$, $WW\not{E}$	$\delta\sigma_{\tilde{\chi}\tilde{\chi}}$=10%, $\delta(M_{\tilde{\chi}^0_2} - M_{\tilde{\chi}^0_1})$ =2 GeV	C	{17}
	$ee \to H^0A^0 \to b\bar{b}b\bar{b}$ (Point 4)	1.0	Mass constrained M_{bb}	δM_A=1 GeV	C	{18}
-alternative	$ee \to \tilde{\tau}^+_1\tilde{\tau}^-_1$ (Point 6)	0.5	Heavy stable particle	$\delta M_{\tilde{\tau}_1}$	T	{19}
SUSY	$\tilde{\chi}^0_1 \to \gamma + \not{E}$ (Point 7)	0.5	Non-pointing γ	$\delta c\tau$=10%	C	{20}
breaking	$\tilde{\chi}^\pm_1 \to \tilde{\chi}^0_1 + \pi^\pm_{soft}$ (Point 8)	0.5	Soft $\pi^\pm$ above $\gamma\gamma$ bkgd	5σ Evidence for $\Delta\tilde{m}$=0.2-2 GeV	F	{21}
Precision SM	$ee \to t\bar{t} \to 6$ *jets*	1.0		5σ Sensitivity for $(g-2)_t/2 \leq 10^{-3}$	V	{22}
	$ee \to f\bar{f}$ $(f = e, \mu, \tau; b, c)$	1.0	σ_{ff}, A_{FB}, A_{LR}	5σ Sensitivity to $M_{Z_{LR}} = 7$ TeV	V	{23}
New Physics	$ee \to \gamma G$ (ADD)	1.0	$\sigma(\gamma + \not{E})$	5σ Sensitivity	C	{24}
	$ee \to KK \to f\bar{f}$ (RS)	1.0			T	{25}
Energy/Lumi	$ee \to ee_{fwd}$	0.3/1.0		δM_{top}=50 MeV	T	{26}
Meas.	$ee \to Z^0\gamma$	0.5/1.0			T	{27}

R&D 3/5 years budget (3 for expensive parts)

1163 man-yrs established, 1873 man-yrs required
Equipment cost ~ 15% of manpower (>50 M$/year in total)



What about R.O. ?

Remarks Prepared for Delivery by
Under Secretary for Science Raymond L. Orbach
to the High Energy Physics Advisory Panel
February 22, 2007

"Completing the R&D and engineering design, negotiating an international structure, selecting a site, obtaining firm financial commitments, and building a machine could take us well into the mid-2020s, if not later,"

NB: ~ 80 M$ invested in FY 2008 by the US on ILC

The answers

- Define a strategy to start the construction by ~2012
- Use the ED phase to finalize R&D, optimize costing on the conventional parts (72.5 km of tunnels, 150m deep, 13 shafts)

  -> shallow tunnel or even 'cut and cover' solution
- Start the political procedure by defining realistic financing scenarios (ILCSC) and interact with governments (FALC) for legal aspects
- Encourage site initiatives for an early choice
- Outreach at multiple levels (with your help!)

R&D

ED

Sub-detector	VDET	Tracker	ECAL	HCAL
	A,B,C…	TPC Si strips Pixels	WSi Crystals …	AHACAL DHCAL Cu, Pb, Fe…
RO	A,B,C…	A,B,C..	A,B,C…	A,B,C…