>300 participants

Good intercontinental participation

A. De Roeck

Contents

Main themes

- Preparation for the technology decision
  - Comparisons of machines at various levels
  - Benchmarking physics channels
  - Detector IP issues, luminosity, polarization
  - Public discussions
- Progress on physics channels
  - Physics case for the LC already made: refinements and new models
- Progress on detectors
  - Results from testbeam data
  - New developments on calorimetry and tracking
  - Roadmap for detectors
- The roadmap to a LC

Conference mood: mixed feelings…
Grabbed slides from speakers

http://polywww.in2p3.fr/actualites/congres/lcws2004/

International Conference on Linear Colliders

Colloque international sur les collisionneurs linéaires

LCWS 04 : 19–23 April 2004 – "Le Carré des Sciences", Paris, France

09:30–>*12:35* **Plenary Session** (Auditorium Gay Lussac) — Main conference page

09:30	Welcome address (15')	
09:45	Charge to the Colloque (25') (transparencies)	**Jim Brau** *(Univ. of Oregon)*
10:15	Theoretical introduction (40') (transparencies)	**John Ellis** *(CERN)*
10:55	coffee break	
11:25	Experimental Introduction (40') (transparencies)	**Raymond Frey** *(Univ. of Oregon)*
12:05	Detector technologies (30') (transparencies)	**Hitoshi Yamamoto** *(Tohoku Univ.)*

12:35–>*14:00* — Main conference page

12:35	LUNCH

14:00–>*18:40* **Plenary session** (Auditorium Gay Lussac) — Main conference page

14:00	Synergy between LHC and LC (30') (transparencies)	**Rohini Godbole**
14:30	Present Status of R&D for the warm linacs (X and C band) (50') (transparencies)	**Kiyoshi Kubo (KEK) & Tom Markiewicz (SLAC)**
15:20	Present Status of R&D for the Superconducting linac (40') (transparencies)	**Carlo Pagani** *(INFN Milano and DESY)*
16:00	Present Status of R&D for CLIC (40') (transparencies)	**Jean-Pierre Delahaye** *(CERN)*
16:40	collation	
17:10	Introduction to the US Technology Options Report (20') (transparencies) **click here for a full report**	**Gerald Dugan** *(Cornell Univ.)*
17:30	Some European thoughts on technology options (20') (transparencies)	**A. Wagner** *(DESY)*
17:50	Report from the International Linear Collider Steering committee (30') (transparencies)	**Maury Tigner** *(Cornell Univ.)*
19:00	Welcome cocktail at the Palais de la Decouverte	

13:30–>*17:00* **Plenary discussions** (Auditorium Gay Lussac) Main conference page

13:30	Chair: Sachio Komamiya Questions and discussion on the accelerator technology option (30') (following Monday's afternoon talks)	**Panel:G. Dugan, A. Wagner**
14:00	Short presentations on detector related warm/cold issues. Chair : J. Jaros Energy Luminosity and polarization measurement (10') (transparencies)	**M. Woods**
14:10	Timing and bunch structure (10') (transparencies)	**K. Desch**
14:20	Forward Region Issues (10') (transparencies)	**T. Tauchi/ P. Bambade**
14:30	Discussion (20')	
15:00	Chair: J. Brau Draft response to ILCSC/ICFA request for a global experimental programme. (10') (transparencies)	**D. Miller**
15:15	Discussion (15')	
15:30	collation	
16:00	Chair: Rolf–Dieter Heuer LC Outreach: to the public and to decision makers (25') (transparencies)	**P. Burrows**
16:25	Draft answers to ITRP questions task force (15') (transparencies)	**JoAnne Hewett**
16:40	Discussion (15')	

17:00–>*18:00* **Colloquium** (Auditorium Gay Lussac) Main conference page

17:00	Energy Flow and Particle Flow (1h00') (transparencies)	**Henri Videau**

19:30–>*22:00* Main conference page

19:30	Social dinner at the Palais du Luxembourg (Senat)

08:30–>*12:00*	**Plenary Session: summary talks** (Auditorium Gay Lussac)	Main conference page
08:30	Higgs and EWSB : Experiments (15') (transparencies)	**Timothy Barklow** *(SLAC)*
08:45	Higgs and EWSB : Theory (15') (transparencies)	**Shinya Kanemura** *(Osaka University)*
09:00	Susy Studies (25') (transparencies)	**Genevieve Belanger** *(LAPTH)*
09:25	New Physics at TeV scale and precision Electroweak (30') (transparencies)	**Atul Gurtu** *(Tata Institute)*
09:55	Top and QCD (12') (transparencies)	**Zenro Hioki** *(University of Tokushima)*
10:10	coffee break	
10:30	Gamma-Gamma e-gamma physics and technology (15') (transparencies)	**Mayda Velasco** *(Northwestern University)*
10:45	Loop calculations (10') (transparencies)	**Sven Heinemeyer** *(CERN)*
10:55	e- e- (08') (transparencies)	**Kingman Cheung** *(National Tsing Hua University)*
11:05	Tracking and Vertexing (30') (transparencies)	**Marco Battaglia** *(UC Berkeley & LBNL)*
11:35	Calorimetry and Muons (30') (transparencies)	**Tohru Takeshita** *(Shinshu University)*

12:05–>*13:30*		Main conference page
12:05	LUNCH	

13:30–>*15:00*	**Plenary Session: summary talks** (Auditorium Gay Lussac)	Main conference page
13:30	Simulation (20') (transparencies)	**Ties Behnke** *(DESY)*
13:50	Machine-Detector interface (15') (transparencies)	**Olivier Napoly** *(CEA/Saclay, DAPNIA/SACM)*
14:05	Test Beams (10') (transparencies)	**Vaclav Vrba** *(Physics Institute, Prague)*
14:15	accelerator Physics (15') (transparencies)	**George Gollin** *(University of Illinois)*
14:30	Polarization (15') (transparencies)	**Achim Stahl** *(DESY Zeuthen)*
14:45	Cosmology (15') (transparencies)	**Howard Baer** *(Florida State University)*
15:00	Collation	
15:30	Summary Talk (30') (transparencies)	**Rolf Heuer** *(Hamburg University)*
16:00	Conference closing	

Technology Choice: Why Downselect Now?

B. Barish

- We have an embarrassment of riches !!!!
  - Two alternate designs -- "warm" and "cold" have come to the stage where the show stoppers have been eliminated and the concepts are well understood.
  - R & D is very expensive (especially D) and to move to the "next step" (being ready to construct such a machine within ~ 5 years) will require lots of money, organization and worldwide effort.
  - It is too expensive and too wasteful to try to do this for both technologies (and governments will not support it).
  - The final decision on construction of such a new machine will be enabled by such a down select and design program consistent with LHC and physics developments.
  - The final decision and funding to build such a machine will be decided at that time.

Report of the Panel

Unanimity in the Panel's recommendation is highly desirable in order to establish the firmest foundation for this challenging global project.
The Panel is urged to report its recommendation as soon as possible, with a firm deadline by the end of 2004.

A full written report with the Panel's evaluation of each of the technologies considered should be available as soon as possible after the Panel's deliberations have been concluded

The making of the technology choice is a key event in the world particle physics program and thus timeliness in the Panel's reporting is of prime importance. The science agencies need to see a demonstration of the particle physics community's determination and ability to collaborate and to unite around the technology chosen by the Panel, as a trigger for their efforts to collaborate in forming a global project.

ITRP

- Six Meetings scheduled
  - RAL (Jan 27,28 2004)
  - DESY (April 5,6 2004)
  - SLAC (April 26,27 2004)
  - KEK (May 25,26 2004)
  - Caltech (June 28,29,30 2004)
  - Korea (August 11,12,13)
  - More meetings as needed

Tutorial and organization

Site Visits

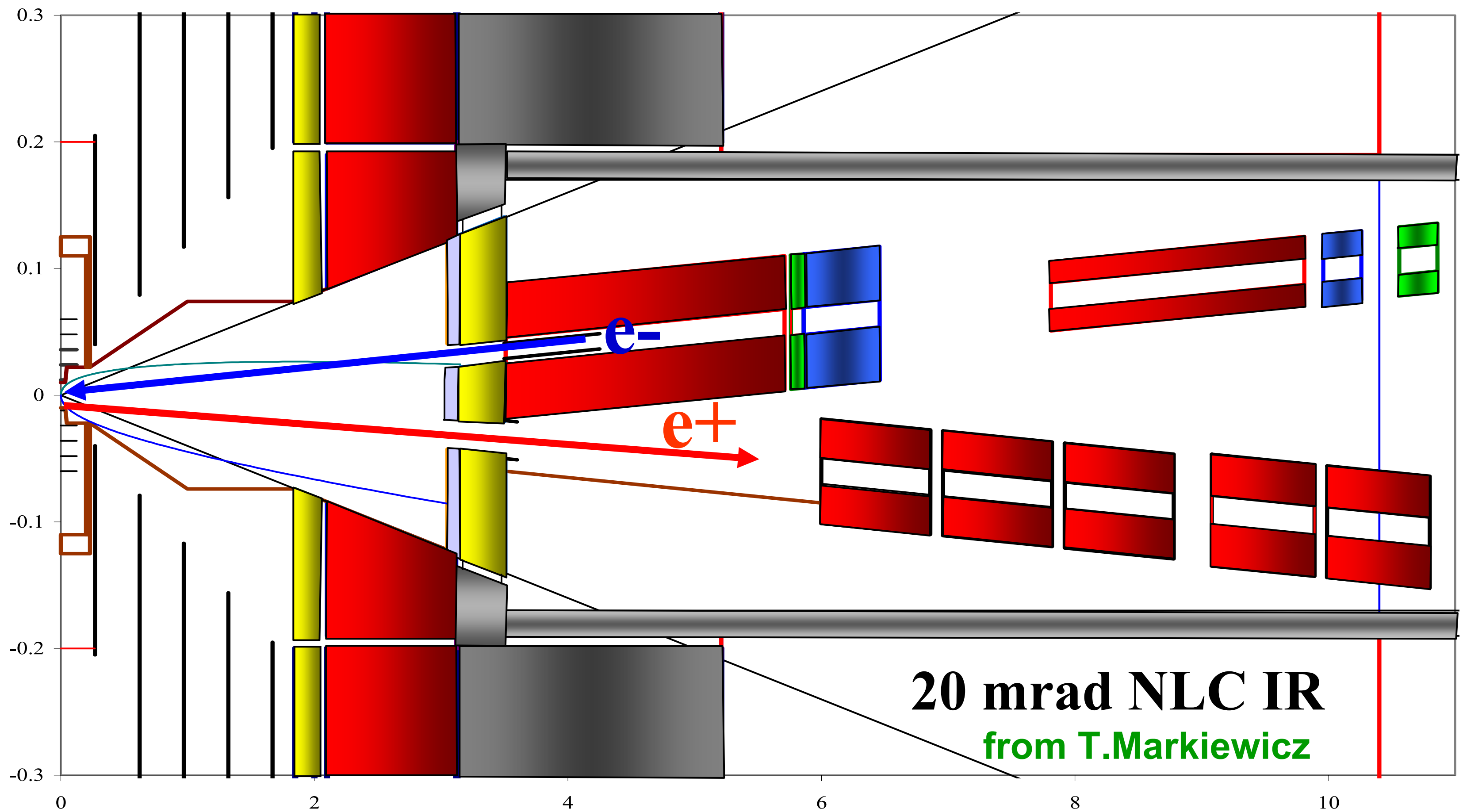
Deliberations Begin

Conclusions

- The ITRP process is underway
- You can follow our progress at http://www.ligo.caltech.edu/~donna/ITRP_Home.htm
- We are analyzing the design choice through studing a matrix having six general categories:
  - the scope and parameters specified by the ILCSC;
  - technical issues;
  - cost issues;
  - schedule issues;
  - physics operation issues;
  - and more general considerations that reflect the impact of the LC on science, technology and society
- We need your input and opinions

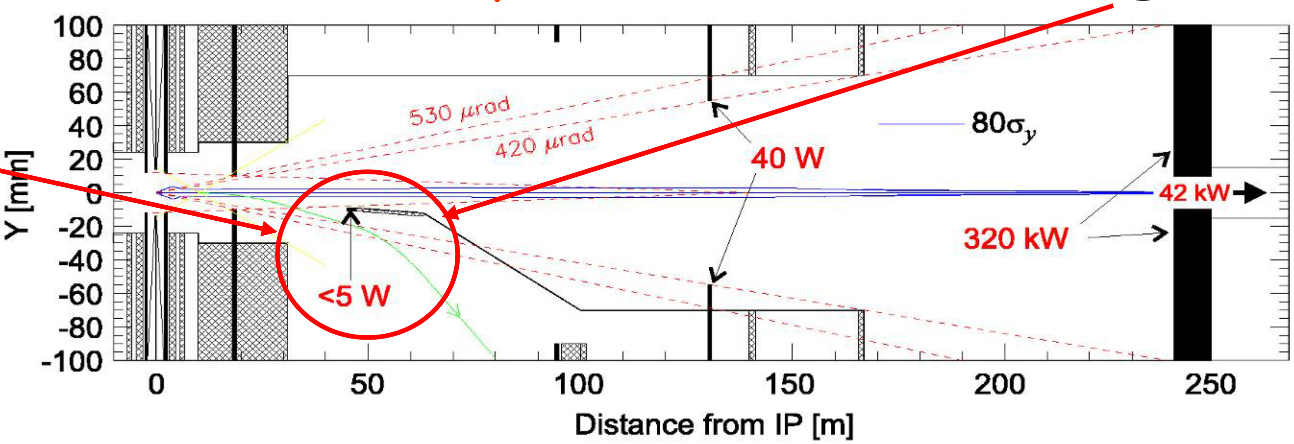
Issues: IR design and X-ing angle

- NLC-GLC : X-ing angle mandatory to avoid parasitic crossings at every 20 cm (1.4 ns) or 40 cm (2.8 cm)



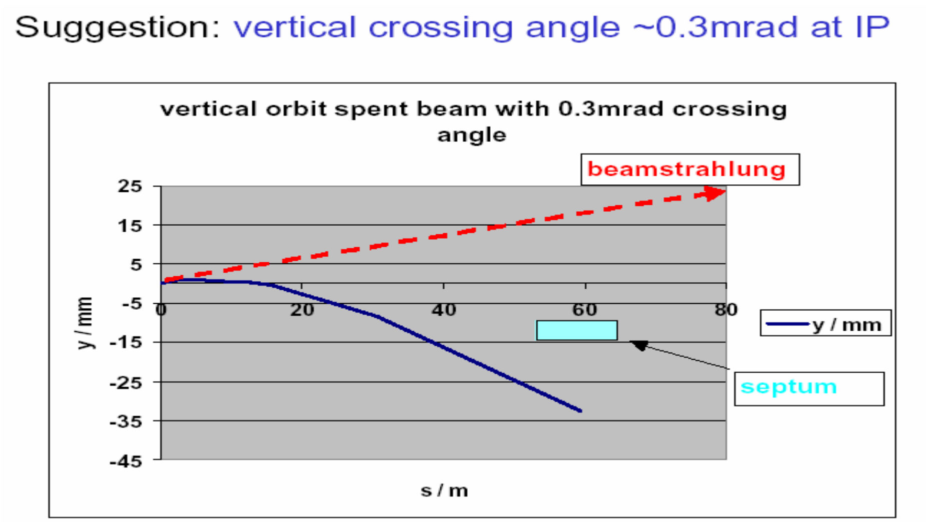
- **TESLA : problem with beam and γ losses in septum region**

~ 15 kW of beam and beamstralung loss in realistic conditions



→ **3 options**

1. 300 μrad collision + quadruplet to reduce beam losses

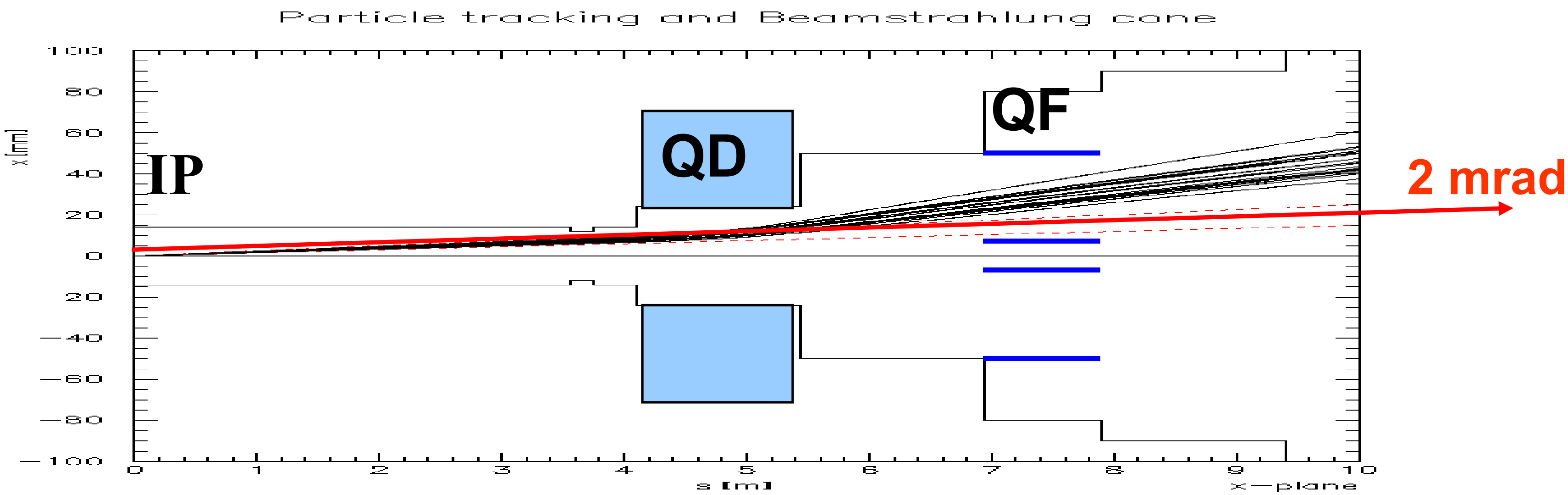


D. Angal-Kalinin, R. Appleby, R. Brinkmann

Not a choice if no progress on 50 kV/cm reliable electro-static separators (20-30 m long)

Crossing Angle Choices for TESLA (cont.ed)

2. 2 mrad Xing angle : no electrostatic separators, 15% Lumi loss compensated by angular dispersion @ IP (~ crab-crossing)



3. 20 mrad Xing angle : NLC like final focus (cf. US-LC study), implies RF cavity crab crossing

⇒ Detector and Physics Implications (later)

Hit density on Vertex Detector from e+e- pairs : contradicting studies ?

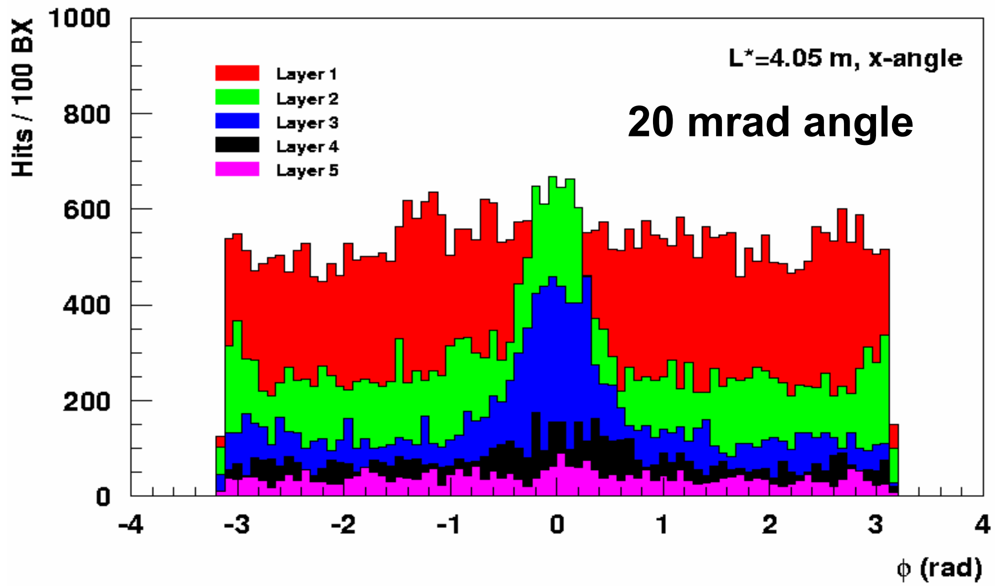
Hit density on 1st Layer
GLC study, from T. Aso

Crossing Angle	VTX Radius	Solenoid Field	Hit density /mm²/train
Head-on	15mm	4Tesla	0.99
7mrad	15mm	4Tesla	1.00
7mrad	24mm	3Tesla	0.38
20mrad	15mm	4Tesla	1.03
20mrad	15mm	3Tesla	1.71

Clear Dependence on VTX radius and B field.
No dependence on crossing angle.

Workshop in Fall 04

Azimuthal dependence
TESLA study, from K. Büsser

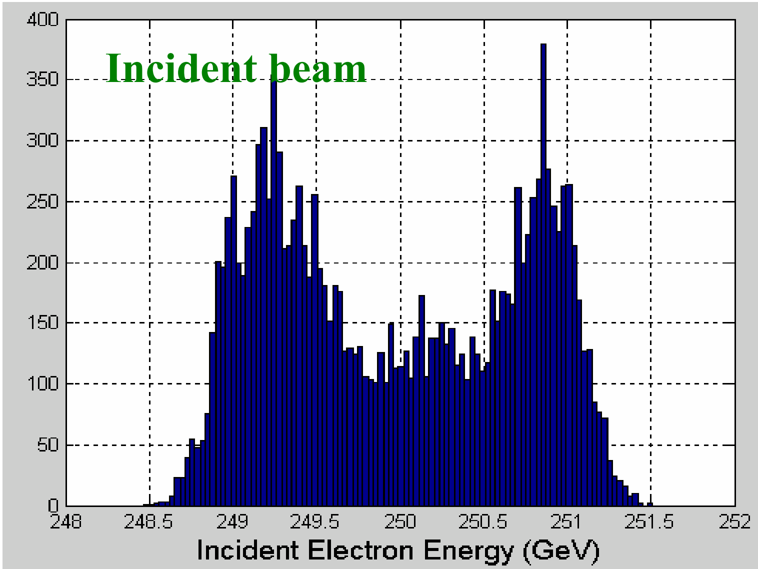


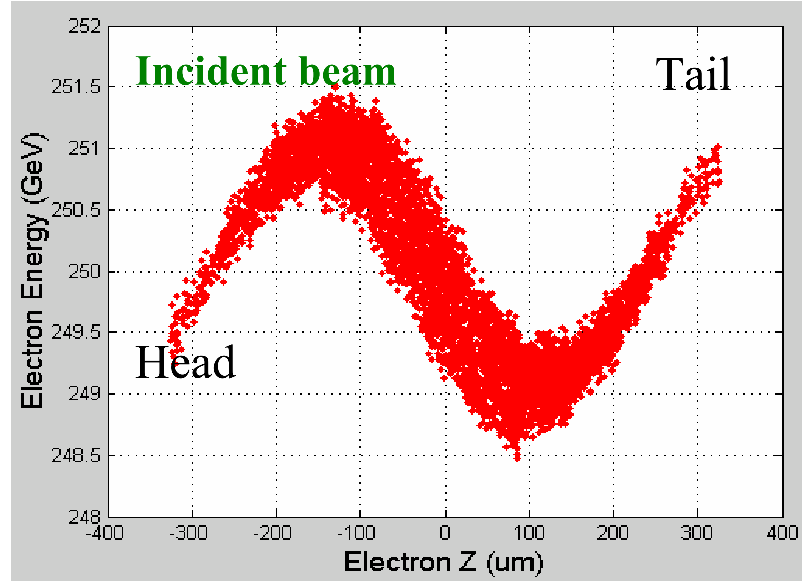
TPC occupancy 2 times larger from 0 to 20 mrad crossing angle but

All backgrounds so far studied are still on tolerable levels

Example of Lumi-weighted Energy Bias related to Beam Energy Spread at NLC-500

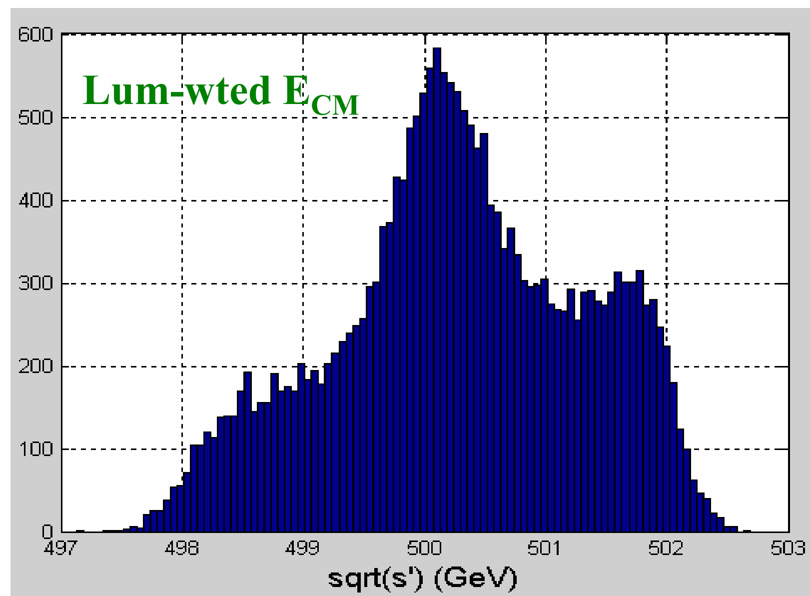
from T. Barklow, M. Woods





For energy bias study, turn off beamstrahlung and only consider beam energy spread.

$$\left\langle E_{CM}^{Bias} \right\rangle = \frac{\left\langle \sqrt{s'} \right\rangle - 500\ \text{GeV}}{500\ \text{GeV}} \approx 500\,\text{ppm}$$



Bhabha acolinearity analysis alone won't help resolve this bias.

Add other channels: γZ, ZZ, WW evts

Kink instability and E_{CM} Bias

from T. Barklow, M. Woods

(larger for NLC) **Wakefields** + (larger for TESLA) **Disruption** → (comparable at NLC, TESLA) **Kink instability**

(larger for NLC) **E-Spread** + (comparable at NLC, TESLA) **E-z correlation** + **Kink instability** → (larger for NLC) **E_{CM} Bias**

$$E_{CM}^{Bias} = \frac{\langle E_1 \rangle + \langle E_2 \rangle - \langle E_{CM}^{lum-wt} \rangle}{\langle E_1 \rangle + \langle E_2 \rangle},$$

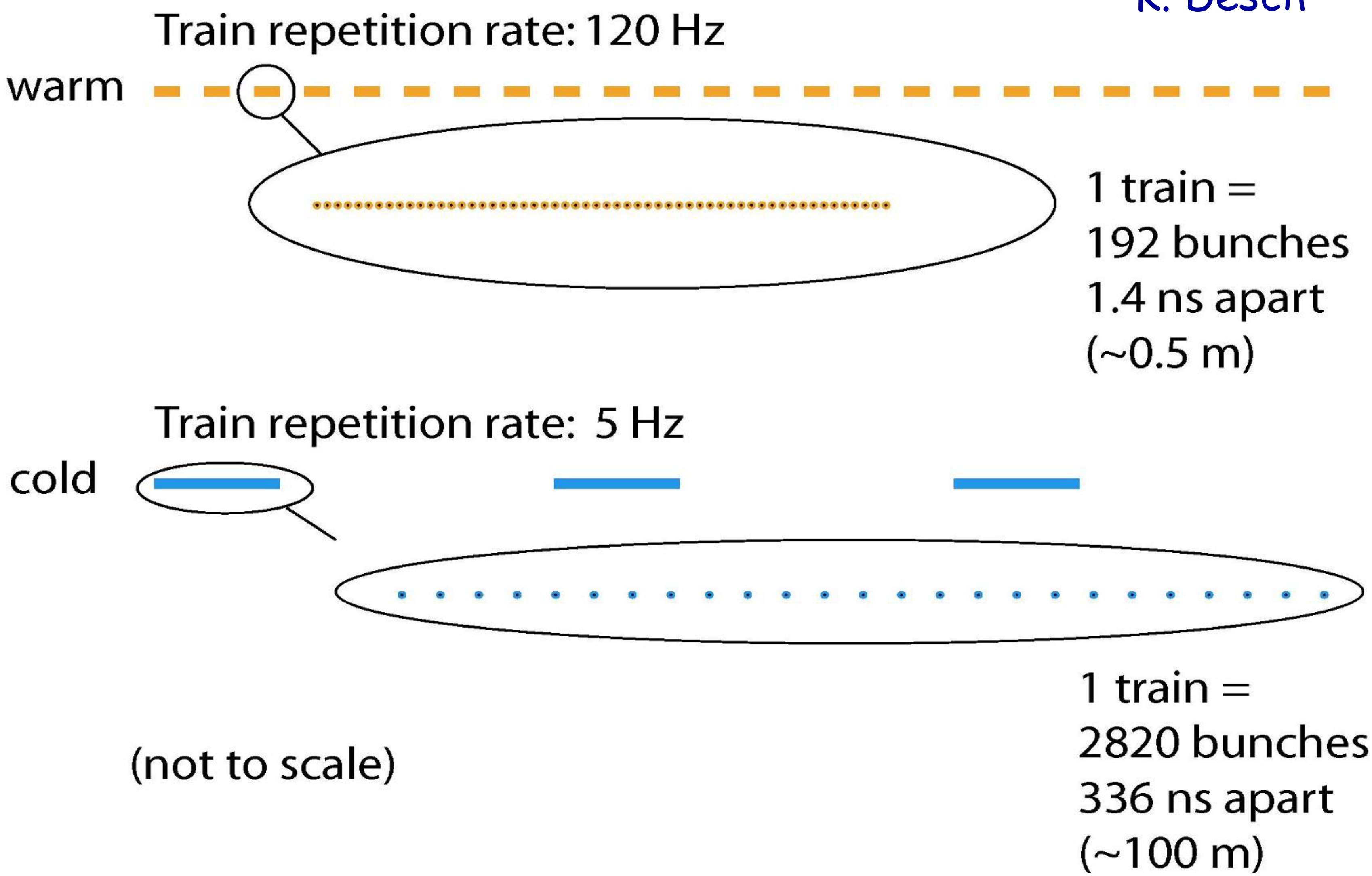
E_1 and E_2 are beam energies measured by the energy spectrometers

Summary of E_{CM}^{bias}

LC Machine Design	Collider Mode	$\langle E_{CM}^{bias} \rangle$ (Δy = 0)	$\sigma(E_{CM}^{bias})$ (Δy = 0)	Max(E_{CM}^{bias}) vary Δy, η_y
NLC-500	e^+e^-	+520 ppm	170 ppm	+1000 ppm
TESLA-500	e^+e^-	+50 ppm	30 ppm	+250 ppm

Time Structure of the Beams

K. Desch



Bunch Distances

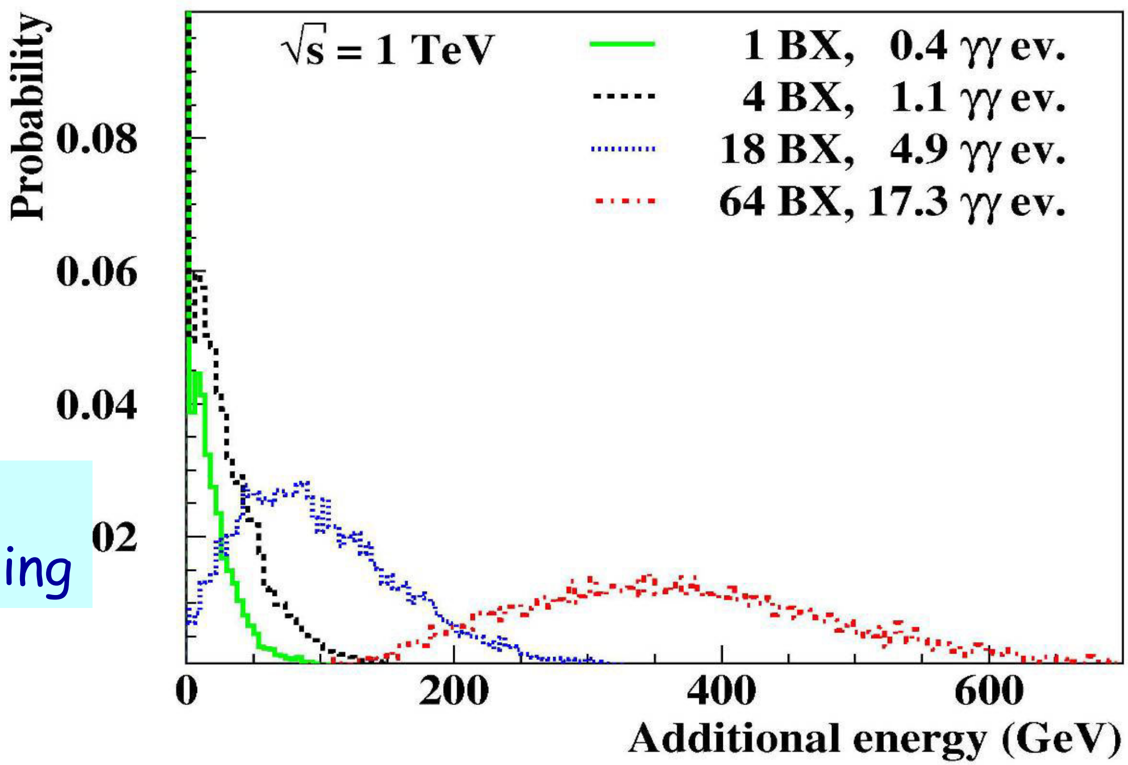
- Short Bunch Distance for warm: pile-up in the detector?
  - → low occupancy in main detector
  - → time-stamping sufficient (rest of this talk)
  - → forward calorimetry has high occupancy
  - → 1BX readout needed (see talk by T.Tauchi)
- Long Bunch trains for cold:
  - → need to readout vertex detector a few times during the train
  - → pick up noise?

Time-Stamping: how much pile-up can we afford?

Physics has to give the answer.

At LCWS04:
physics studies for overlaid background from America, Asia and Europe

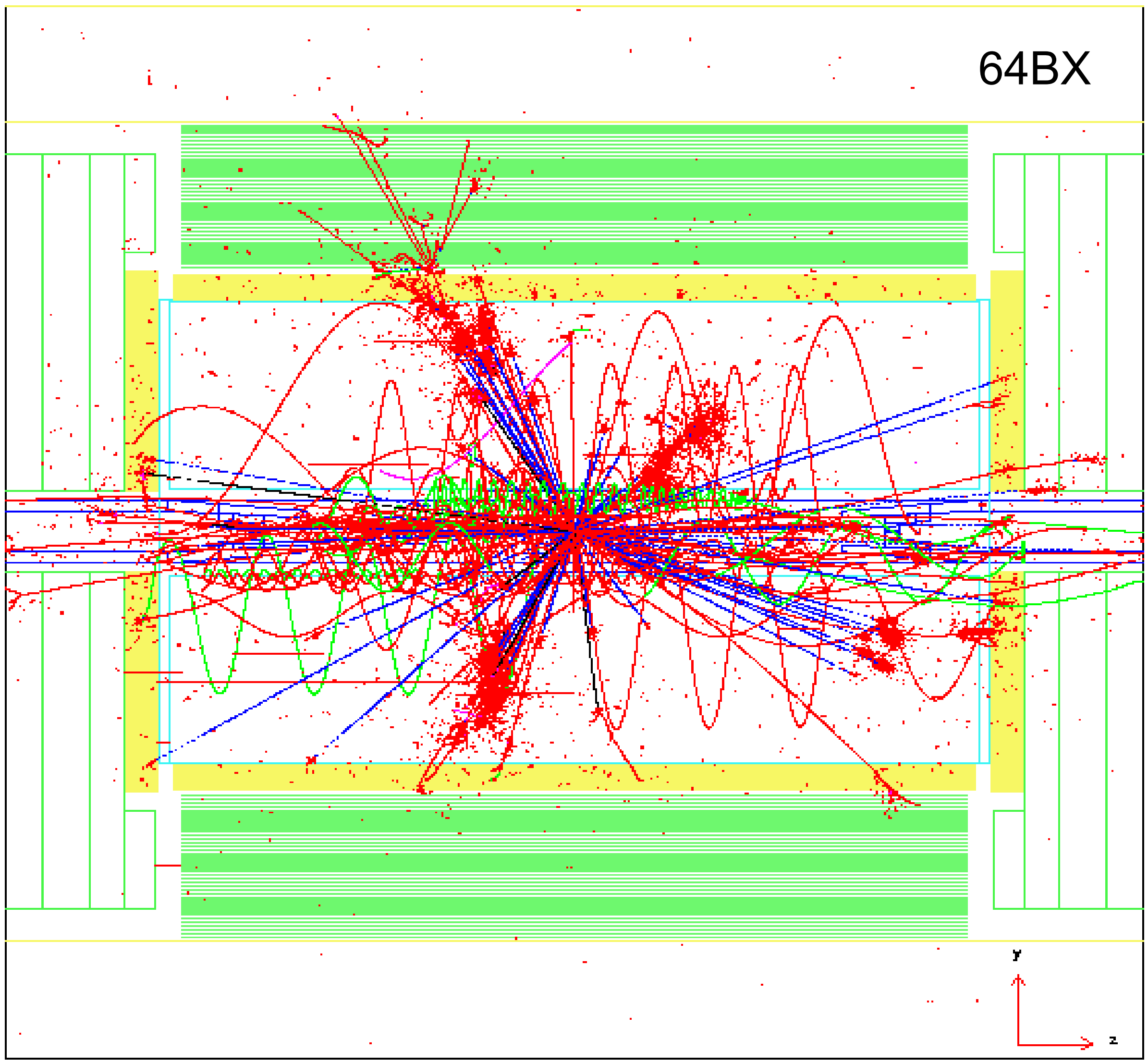
Additional energy in the detector from $\gamma\gamma \rightarrow$ hadrons:



Is being done for the CLIC studies from the begining

Hadronic Background

HZ→bbqq event
(500 GeV,
m_H=120 GeV)



Physics impact: eg. Higgs mass measurement

Higgs mass measurement in hadronic channel bbqq
Kinematic constraints can be applied
Optimization of algorithm partly recuperates effects from background

Comparison of results:

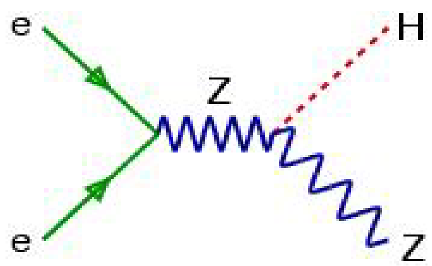
# of BX	US/optimized for <10BX	US/optimized for>=10BX	EU/optimized for 1BX
0	71	74	68
1	74	78	
TESLA	77	79	75
4	79	82	78
5	79	82	
10	91	82	
20	92	81	92
64			110

Imhof,Meyer,
Raspereza,KD

Abe,Barklow,Jaros

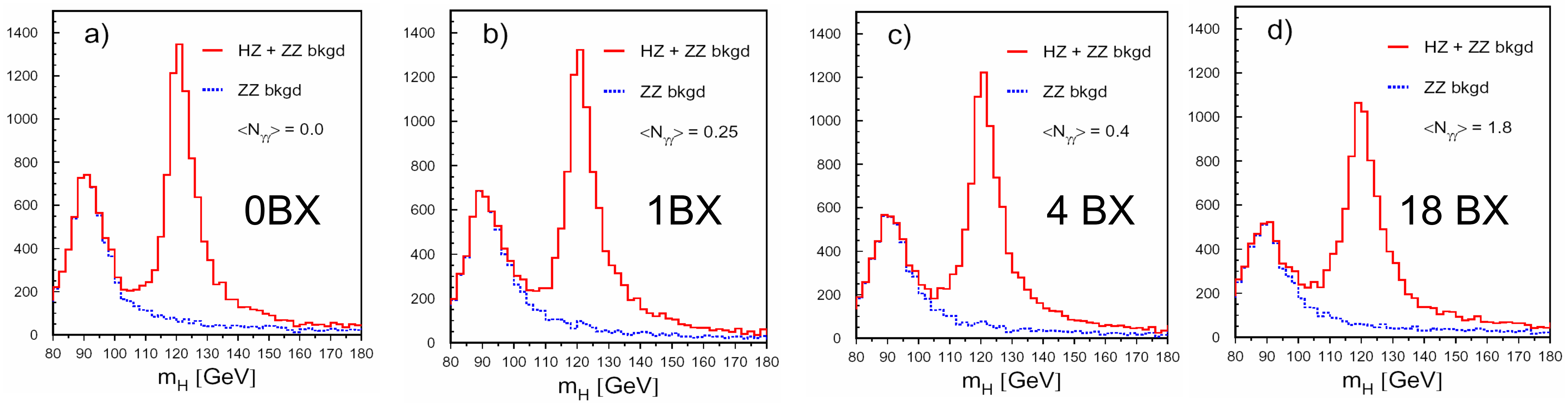
Bunch Crossing : $\gamma\gamma \rightarrow$ hadrons background

from K. Desch



Mass measurement of light Higgs boson (m_H=120 GeV)

$H \rightarrow bb$, $Z \rightarrow qq$ $\Rightarrow$ 4 jets reconstruction



NLC, GLC and TESLA have about the same L / BX

Integrating over several BX hadronic backgrounds reduces the resolution on Δm_H from 75 MeV (1BX) to 92 MeV (18 BX)

What can be achieved?

Tracking:

Studies indicate 2-5 ns track timing possible in principle for TPC and Si
Detailed time-dependent simulation needed – non-trivial

Calorimetry (most important in central detector, many neutrals):

With electronics inside Si-W calorimeter 5ns for single cells achievable in SLAC design
Averaging over 30 hits: 5 ns / sqrt(30) = 1 ns   (Jaros, Frey)

Concerns:

- Distribute o(GHz) clock over a large detector
- Timing calibration for o(10^8) cells (o(10^5) r/o chips) to ns precision
- Cluster finding to do the averaging – need detailed time-dependent simulation
- Charged particles in endcap: time-of-flight correction (loopers!)

Multi-BX : Preliminary Summary

Integrating the hadronic background from more than a few bunch-crossings has a sizeable impact on the physics performance

America, Asian, and European studies agree

At NLC, a bunch tagging of few ns is needed to become comparable to the TESLA situation

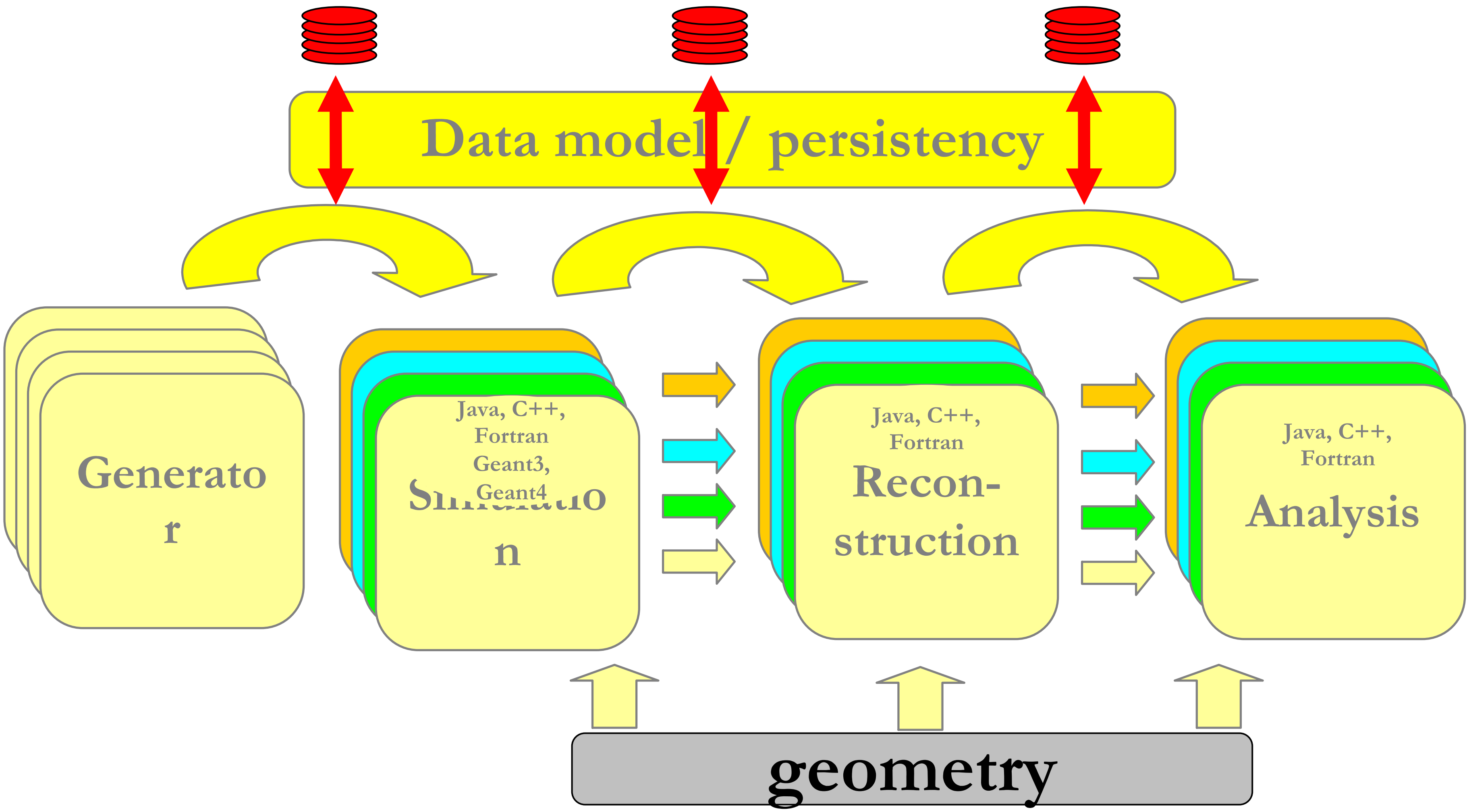
→ R&D on detector timing is vital for warm technology

→ Timing capability adds complexity – how much?

Software: Architecture

CLIC study can join here

proposed architecture of a simulation / reconstruction system



US Technology comparison

http://www.slac.stanford.edu/xorg/accelops/

USLCSG

L-band Reference Design

- The L-band reference design follows, for the most part, the design outlined in the TESLA TDR. Major changes made to the TESLA design are:
  - An increase in the upgrade energy to 1 TeV (c.m.), with a tunnel of sufficient length to accommodate this in the initial reference design, assuming a gradient of 35 MV/m.
  - Improvements to the wigglers and vacuum systems of the damping rings,
  - The choice of 28 MV/m as the main linac design gradient for the 500 GeV (c.m.) machine.
  - The use of a two-parallel-tunnel architecture for the linac facilities.
  - NLC-style beam delivery system and IP configuration.
  - Vertical emittance at the IP = 40 nm-rad, vs. 30 nm-rad in the TESLA TDR. This change reflects recent simulations both in the U.S. and Europe, which indicate larger emittance growth in the cold main linacs than originally anticipated.

US Technology comparison

USLCSG

Comparison of reference design key parameters

Warm option upgrade energy reach is 30% higher than warm

500 GeV cold linacs are x2 longer than warm linacs

Cold option $\mathcal{L}$ is 25% higher than warm

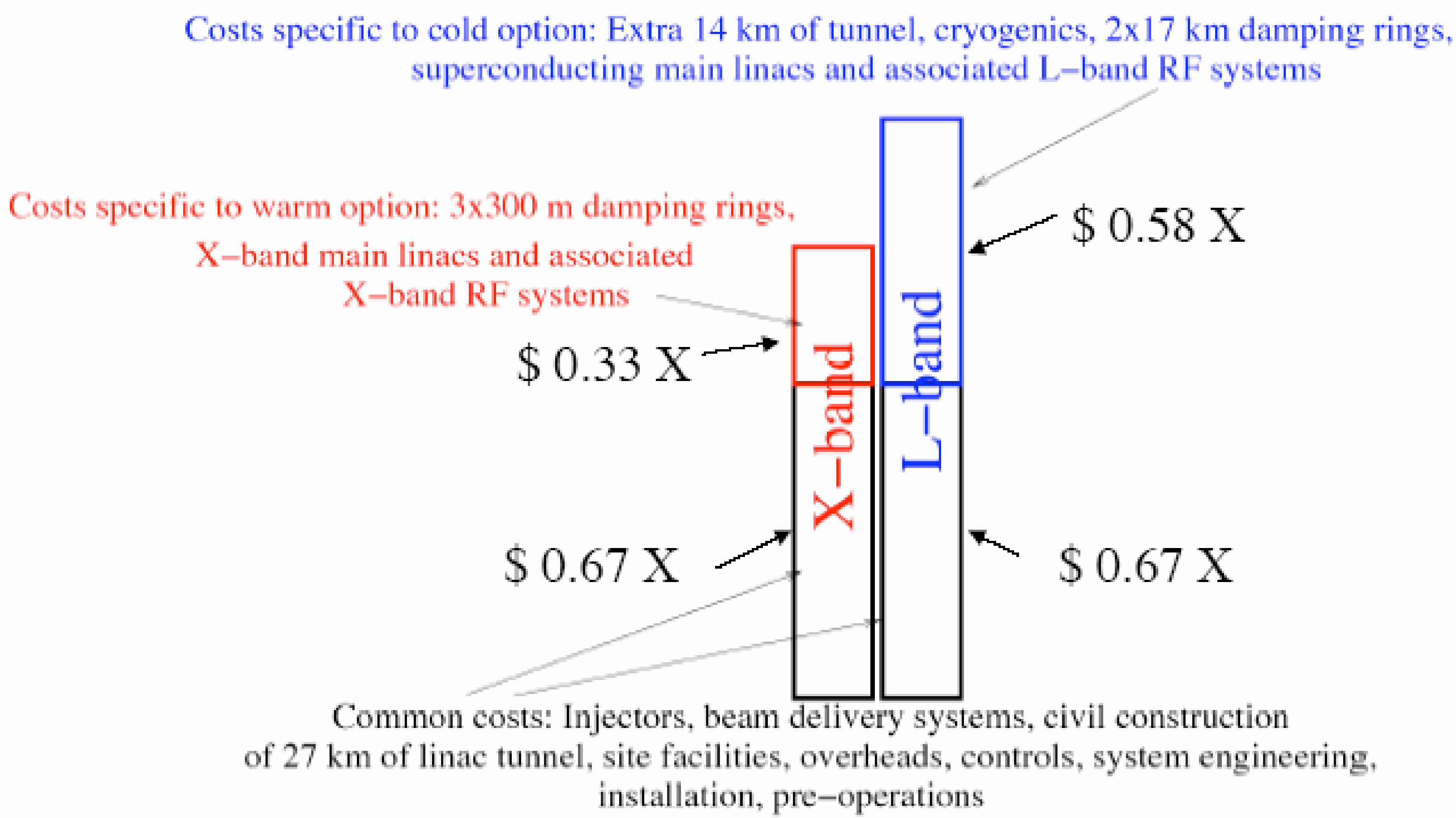
Baseline cold option AC power is 30% less than warm

Parameter	X	L	X	L
C. M. Energy/Energy Reach [TeV]	0.5/0.625	0.5/0.625	1/1.3	1/1
Loaded rf gradient [MV/m]	52	28	52	35
2-linac total length [km]	13.4	27.0	26.8	42.5
$\gamma\varepsilon_x$(IP) [μm-rad]	3.6	9.6	3.6	9.6
$\gamma\varepsilon_y$(IP) [μm-rad]	0.04	0.04	0.04	0.04
$\mathcal{L}_g$ [10^{33}cm^{-2}s^{-1}]	14.2	14.5	22.2	22.7
D_y	12.9	22.0	10.1	17.3
H_D	1.46	1.77	1.41	1.68
$\mathcal{L}$[10^{33}cm^{-2}s^{-1}]	20.8	25.6	31.3	38.1
Number of main linac klystrons	4520	603	8984	1211
Number of main linac RF structures	18080	18096	35936	29064
Peak RF power per structure [MW]	56	0.28	56	0.35
Average power per beam [MW]	6.9	11.3	13.8	22.6
Linac AC to beam efficiency [%]	6.6	17.0	7.1	15.3
Site Operating AC power [MW]	260	179	454	356

US Technology comparison

USLCSG

Cost and schedule estimates-Cost comparisons



US Technology comparison

USLCSG

Conclusions

- The two technology options examined in this study have different challenges, advantages, and disadvantages, and differ in many details.

- We found that, within relative factors of 30% or less, the two approaches would provide similar technical performance at roughly equivalent cost.

- The two options can have similar levels of availability, with comparable overall levels of risk, and can be realized on roughly the same schedule.

- These two options are at comparable levels of development, and both have the potential to provide a viable route to a linear collider which meets the requirements of the USLCSG.

Comments concerning the US Cold Warm Comparison

Good effort but…

A. Wagner

In view of existing international efforts, it would have been preferable had the study been done internationally, under the guidance of the ILCSC. This view is shared by the Asian colleagues.

There are at least two reasons for this:

- It is extremely important to build and strengthen the spirit of international co-operation and collaboration, and not to have unilateral and polarizing activities.
- The second reason is technical. The members of the study with cold expertise were limited to 4 out of a total of 28. One of these four had not been part of the TESLA effort, but rather had independent experience with the cold technology cost. A more balanced working group would have reduced the potential for a bias in the study.

Cost Comparison - Cold

The US study has used for the cold design directly the cost figures provided by the TESLA collaboration.

For the cold option, the areas that received further scrutiny were: linac components, refrigerator and damping rings.

In this effort the cost task force representatives made 3 separate visits to DESY, of 2- 3 days each to examine the methodology and look in detail at the industrial studies.

The cold damping ring was extensively re-evaluated by LBNL.

The refrigeration system was completely re-costed by Fermilab.

Cost Comparison - Warm

The Warm costing is base on scaling assumptions from one of a kind prototypes which lead to cost reductions in mass production of some factors. These extrapolation factors are assumed to be very large (up to 6) with a correspondingly large uncertainty.

There was no external review of the warm cost.

Therefore the warm costs deserve a much closer look than we understand was performed during the study.

Conclusion on US Study

Important work, will be useful in future optimisation

The quoted cost differential of 1.25 is a product of many few % differences and depends on many detailed assumptions, on large cost extrapolations for the warm machine and has an error which is probably larger than the quoted 10%

The luminosity is > 1.3 times higher in a cold machine

The TESLA collaboration is impressed by the amount of effort that this study has put into trying to understand the TESLA design. However, a more equal and wider participation of cold experts would have led to a more balanced report

The operating cost is definitely lower in the cold machine

Again, as in previous studies, no major errors/cost discrepancies have been found in the TESLA case

If cost were to play an important role in the technology choice, a fully co-ordinated international cost estimate must be made

500 GeV Variants
and their Energy Reach at Reduced Luminosity

Baseline design in European accounting. In addition: 7000 py

operatingGrad for 500 GeV (MeV/m)	Max Energy reach * (GeV)	Cost or % change wrt Baseline	Comment
24	~ 700	3.14 B€	Baseline
18	~ 900	+ 15%	2. tun'l + 350M
24	~ 700	+ 5%	
28	~ 630	+ 5%	
35	500	+ 5%	
35	500	- 5%	

With additional funds these options can be expanded to high luminosity operation at 800- 1000 GeV (see below)

* Assuming an installed gradient of 35 MV/m, High energy reach comes from trading energy against luminosity, no mod's of accelerator needed

TESLA NEWS

TESLA | Cavity Program for TESLA & X-FEL

- **Industry is being producing 30 new cavities** for extensive tests
- Cavity delivery will start end of May
- **Cavities will follow the standard preparation procedure** at DESY to further define protocols for industry. This includes:
  - 800 °C annealing, no 1400 °C firing is foreseen
  - ElectroPolishing (EP)
  - High Pressure Rinsing (HPR)
  - Clean Room handling and assembling
- Because of conflict with TTF II operation as VUV-FEL test Facility a Module test stand has been designed and will be in operation by 2005. **The 35 MV/m module test is expected by end 2005**.
- Meanwhile **tests of fully equipped cavities will continue into the horizontal cryostat "Chechia".**
- **The worst of the 35 MV/m cavities has been scarified for a test in module *ACC 1***, which will be operated in the VUV-FEL Test Facility with an accelerating voltage below 20 MV/m (Injector issues)

⇒ April 1st: cavity at 35Mv/m with beam

X-band

- The technology is demonstrated
  - TRC R1s and R2s for RF have been met (or due soon)
- It is a complete project – all systems are prototyped
  - test facilities verify the designs for subsystems
  - ATF, ASSET, E-158, FFTB, GLCTA, NLCTA + more
  - SLC verified the integrated system
- There is a strong US-Japan collaboration
  - large pool with expertise in X-band ready to build an LC
- It is the path to higher energies
  - 1.3 TeV in phase II and a stepping stone to multi-TeV
  - CLIC only viable option - chance to learn necessary techniques
  - upstream systems ~ identical to CLIC, could be reused

Interlaboratory Collaboration for R&D Towards TeV-scale Electron-Positron Linear Colliders

International Linear Collider Technical Review Committee

ILC-TRC

2003 GLC/NLC RF R&D Requirements R1 & R2

- R1 Demonstration of SLED-II pulse compression system at design power level ✓
- R1 Test of complete accelerator structure at design gradient with detuning and damping ✓
- R2 Test of PPM Klystron at full repetition rate ✓
- R2 Full system test of an RF sub-unit — In progress

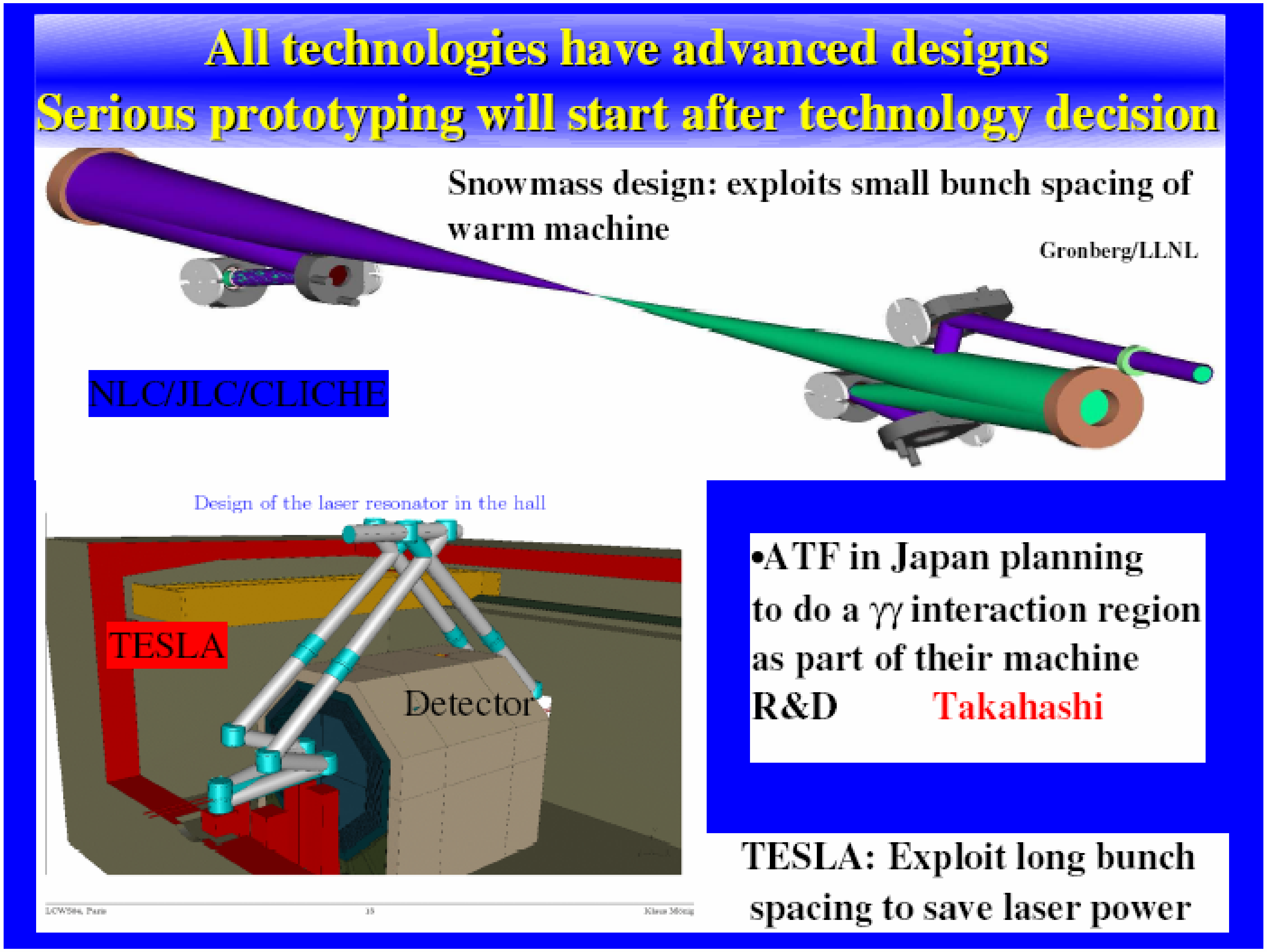
•R1: R&D needed for feasibility demonstration of the machine

•R2: R&D needed to finalize design choices and ensure reliability

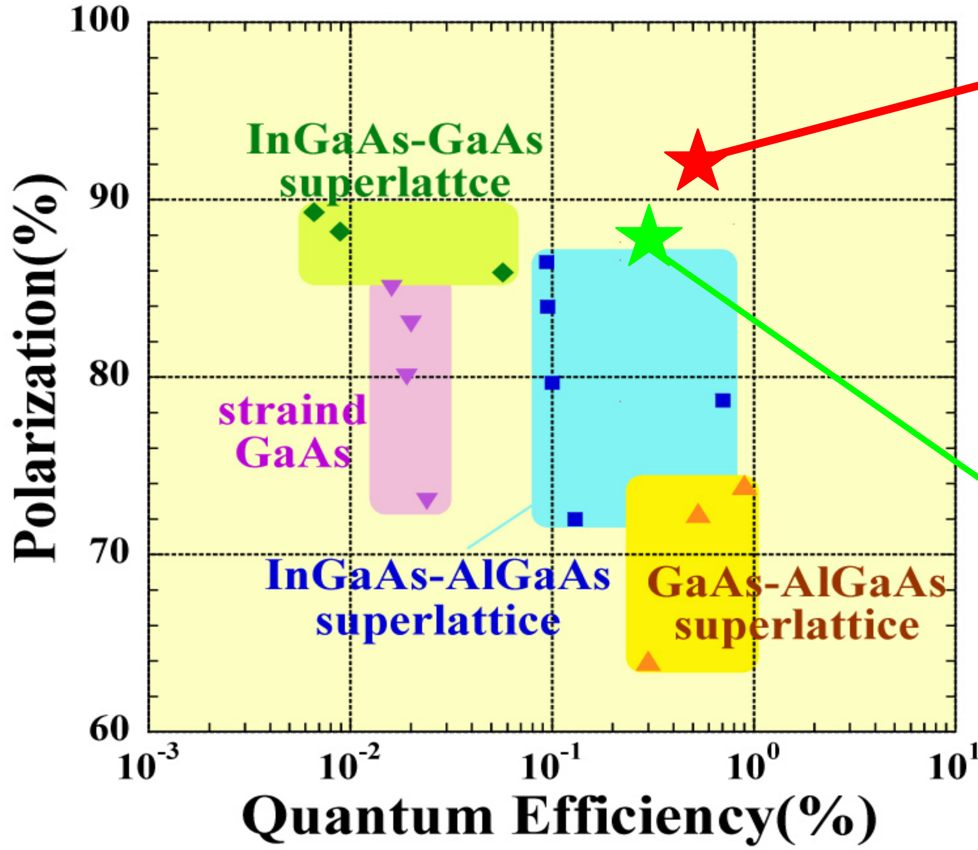
•R3: R&D needed before starting production of systems and components

•R4: R&D desirable for technical or cost optimization

Photon Collider



polarization



new cathode
Pol: 92 %
QE: 0.5 %

SLAC: E158
Pol: 85-90 %
QE: 0.3 %
routine operation

Masahiro Yamamoto

University Based LC Accelerator R&D

G. Gollin

Of course university groups can do accelerator physics!

There are interesting, important projects whose scope is ideal for a university group.

The (inter)national labs welcome our participation and will help us get started, as well as loaning us instrumentation.

Many projects involve applications of classical mechanics and classical electrodynamics. These are perfect for bright, but inexperienced undergraduate students.

The projects are REALLY INTERESTING. (Also, it's fun to learn something new.)

University Based LC Accelerator R&D

An example from Himel's list…

ID 61 project size Medium skill type physicist

short project description Acoustic sensors for structure and DLDS breakdown

Detailed project description understand the acoustic emissions from breakdowns and how the sounds propogate so that the use of acoustic sensors can improved in diagnosing breakdowns.

Needed by whom NLC and TESLA

present status In progress, help needed

Needed by date 6/1/2003

Contact Person Marc Ross, (650)926-3526, mcrec@slac.stanford.edu

www-conf.slac.stanford.edu/lcprojectlist/asp/projectlistbyanything.asp

University Based LC Accelerator R&D

We organized ourselves.

A University Program of Accelerator and Detector Research for the Linear Collider

University Consortium for Linear Collider R&D

and

Linear Collider Research and Development Working Group

October 22, 2002

…renewal submitted November, 2003

The result:

- 71 new projects
- 47 U.S. universities
- 6 labs
- 22 states
- 11 foreign institutions
- 297 authors
- 2 funding agencies
- two review panels
- two drafts
- 546 pages
- 8 months from t_0

Funded by NSF* and DOE

*planning grant only

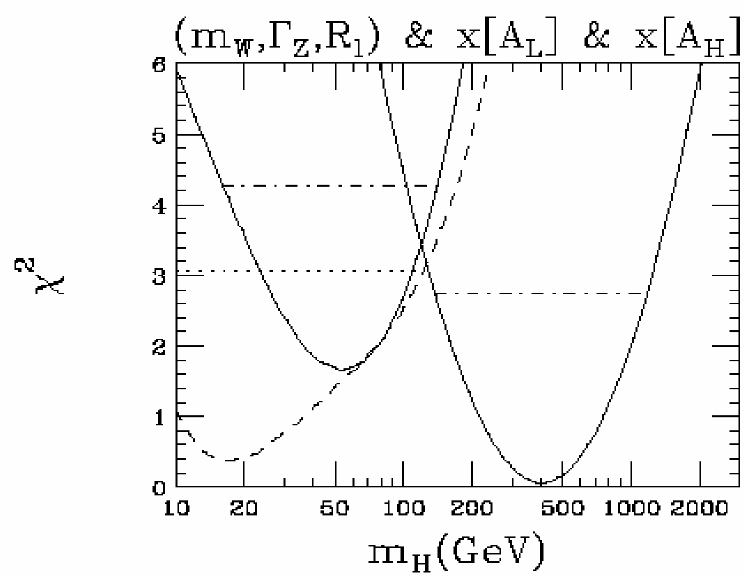
J. Ellis

Does the Higgs exist?
Theorists getting Cold Feet

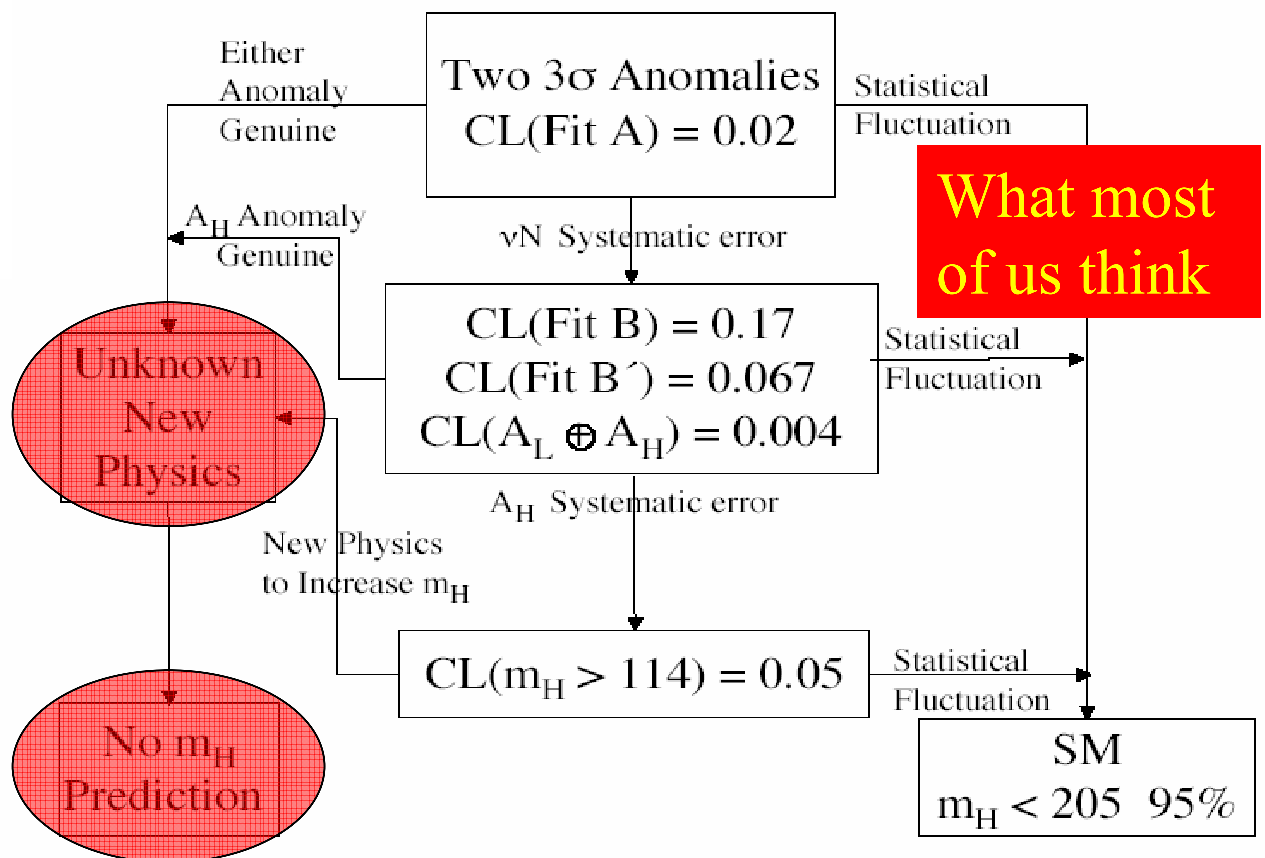
- Interpretation of EW data?
  consistency of measurements? Discard some?
- Higgs + higher-dimensional operators?
  corridors to higher Higgs masses?
- Little Higgs models
  extra \`Top', gauge bosons, \`Higgses'
- Higgsless models
  strong WW scattering, extra D?

Heretical Interpretation of EW Data

Do all the data
tell the same story?
e.g., A_L vs A_H



What attitude towards LEP, NuTeV?



Higgsless Models

- Four-dimensional versions:

  Strong WW scattering @ TeV, incompatible with precision data?
- Break EW symmetry by boundary conditions in extra dimension:

  delay strong WW scattering to ~ 10 TeV?

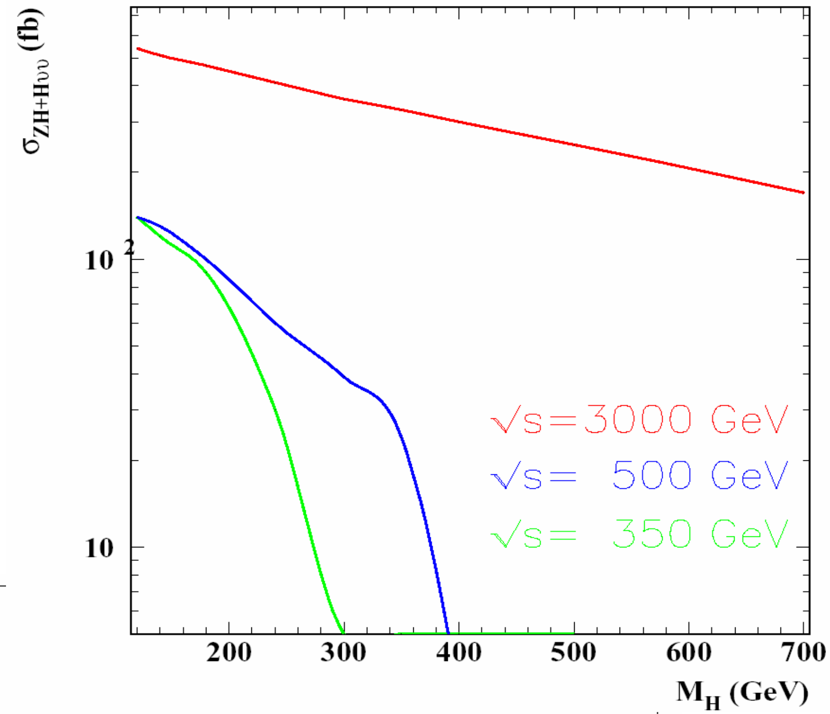
  Kaluza-Klein modes: m_{KK} > 300 GeV?

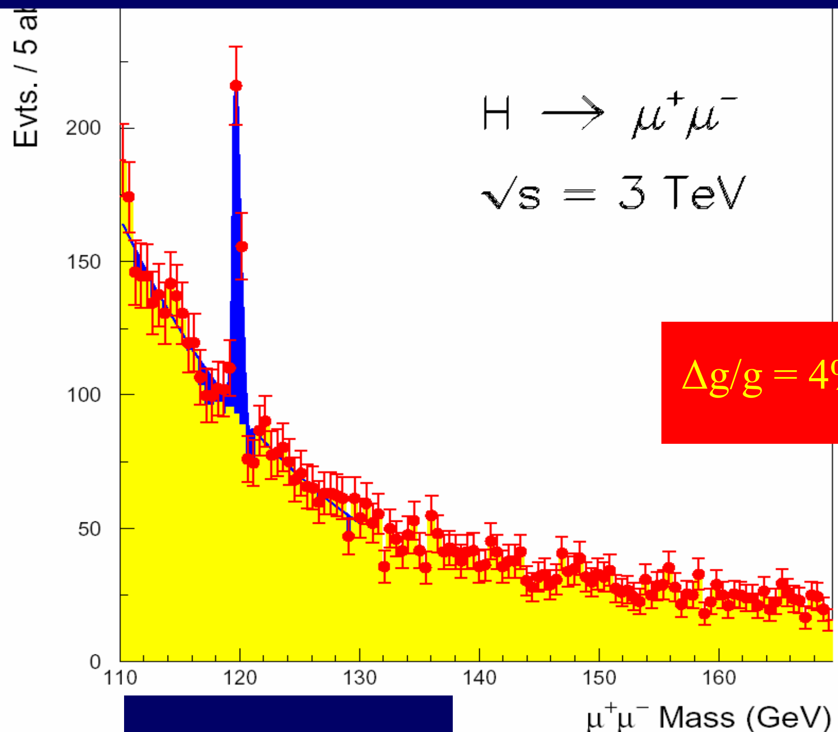
  compatibility with precision data?
- Warped extra dimension + brane kinetic terms?

Lightest KK mode @ 300 GeV, strong WW @ 6-7 TeV

Advantages of Higher Energy LC

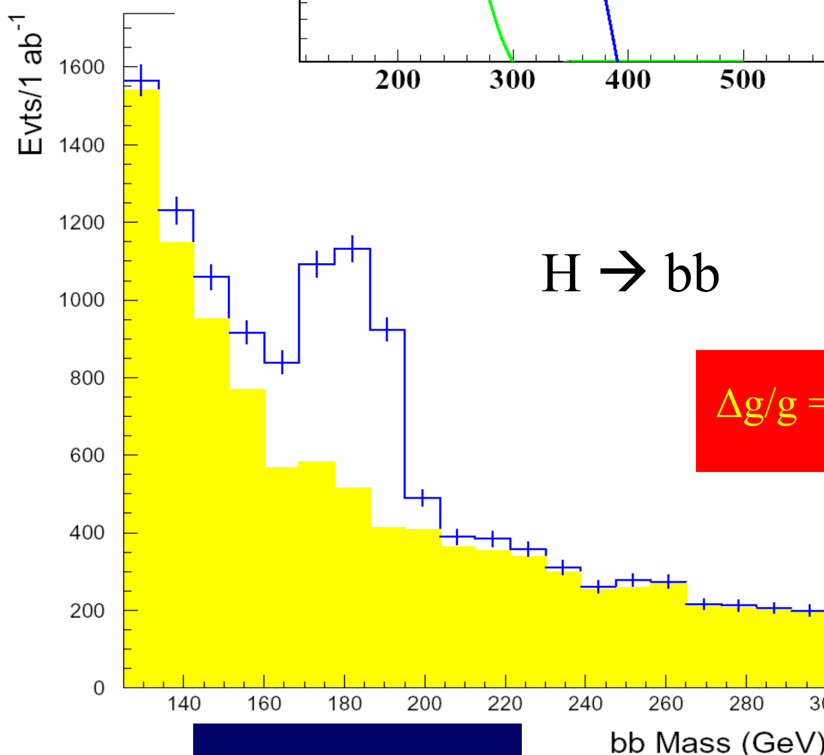
Larger cross section @ 3 TeV
can measure rare decay modes





$\Delta g/g = 4\%$

$m_H = 120$ GeV

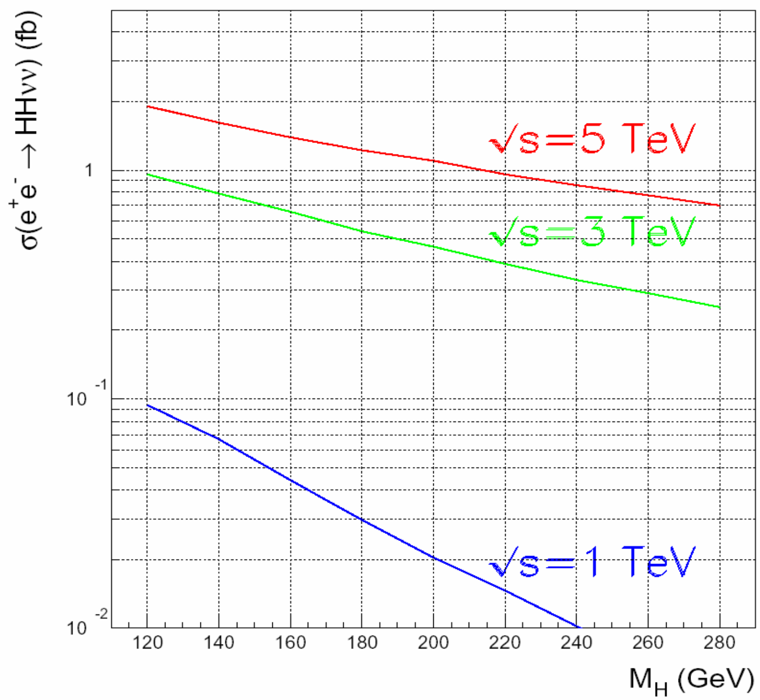


$\Delta g/g = 2\%$

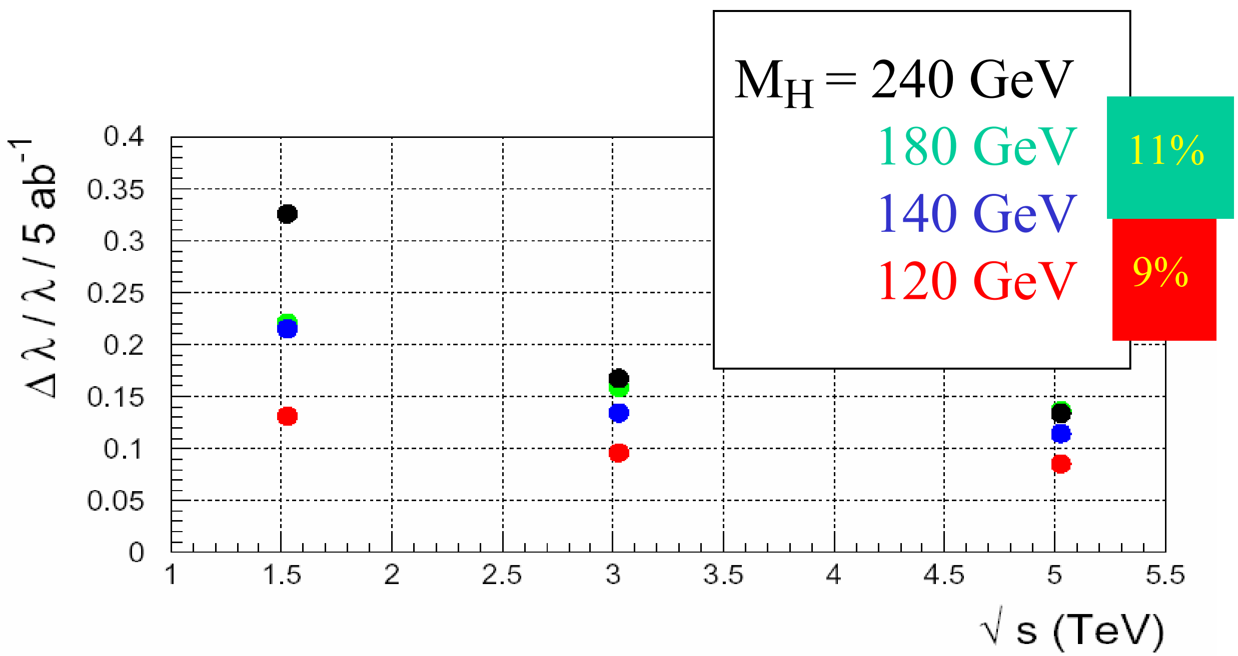
$m_H = 180$ GeV

Measuring Effective Higgs Potential @ 3 TeV

Large cross section
for HH pair production



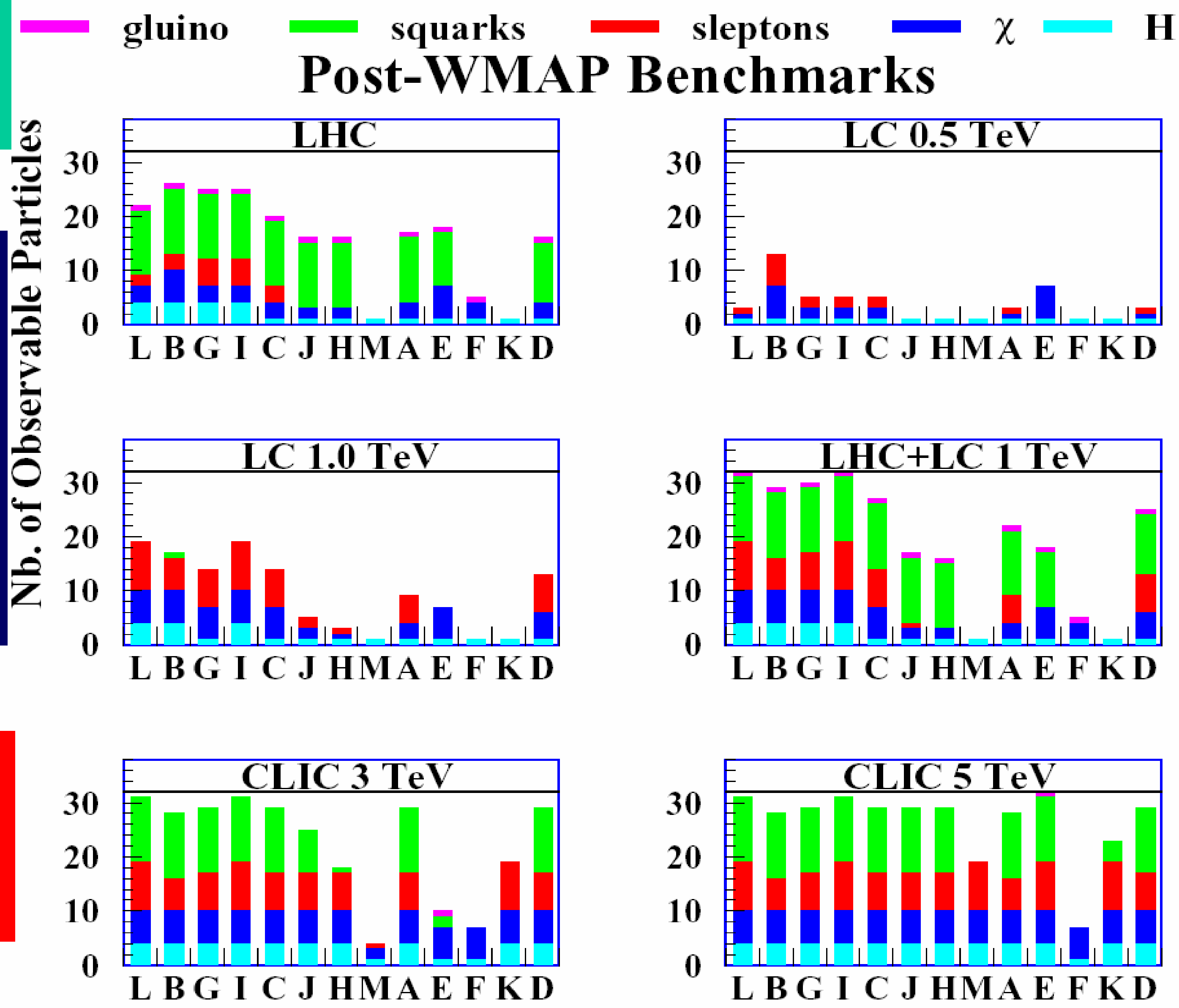
Accuracy in measurement of HHH coupling



LHC and LC Scapabilities

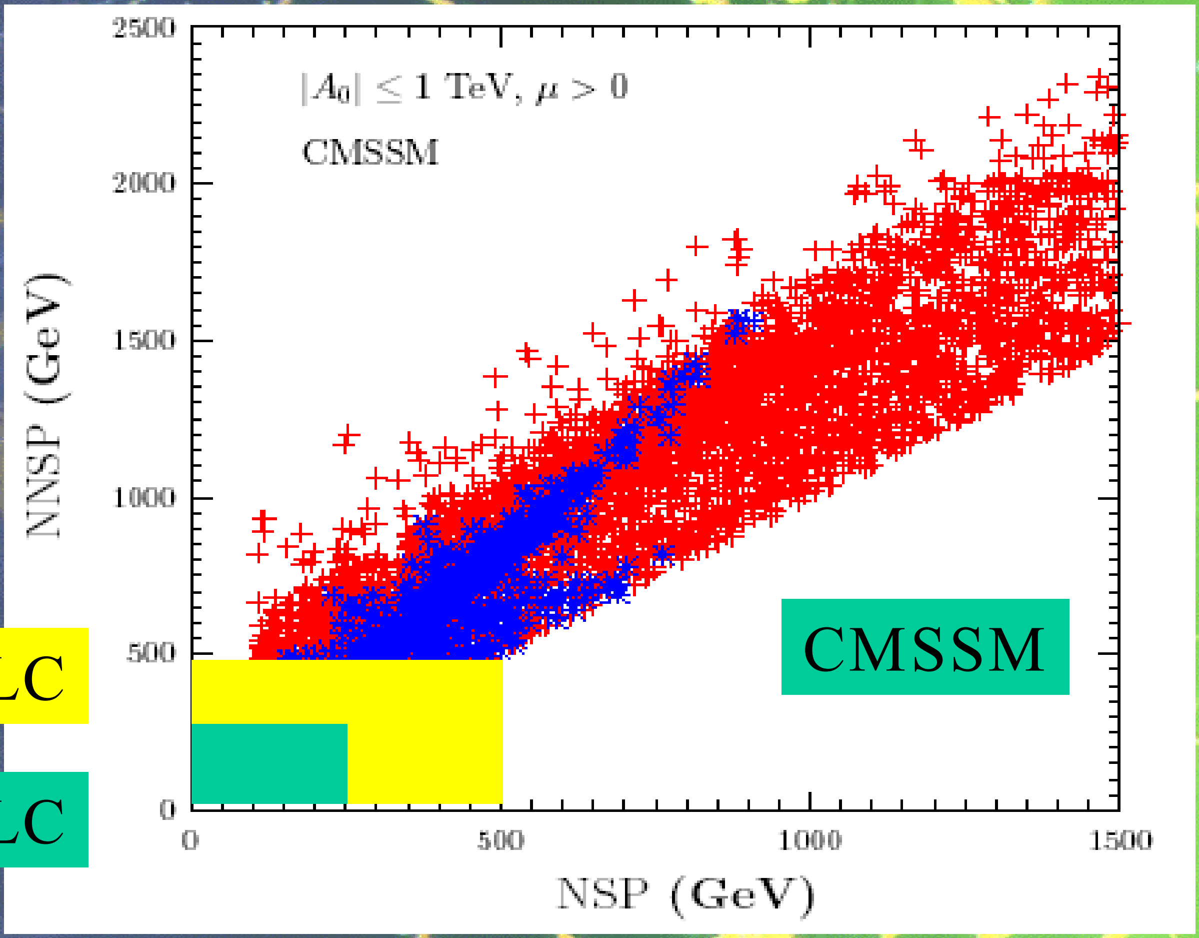
LHC almost
`guaranteed'
to discover
supersymmetry
if it is relevant
to the mass problem

LC oberves
complementary
sparticles



How much of Susy Parameter Space Covered by LC?

Scatter plot of two lightest observable sparticles: NSP, NNSP



Reach of 1000 GeV LC

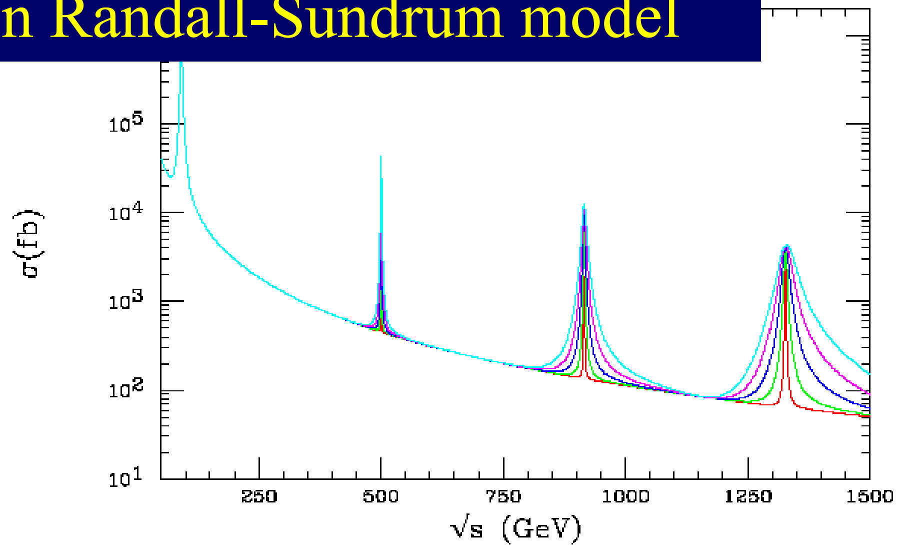
Reach of 500 GeV LC

LHC/LC complementarity

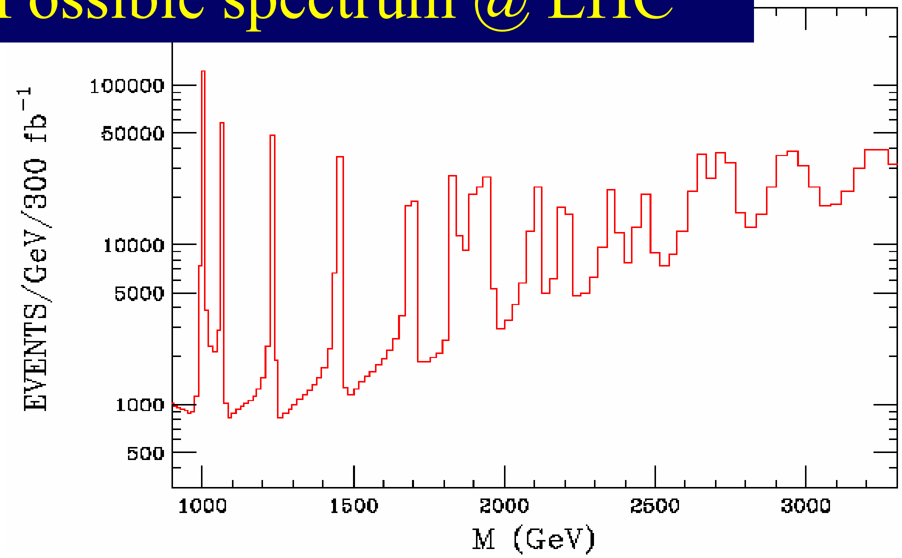
	Mass, ideal	"LHC"	"LC"	"LHC+LC"	Δ_{th}(GeV)
$\tilde{\chi}_1^{\pm}$	179.7		0.55	0.55	1.2
$\tilde{\chi}_1^0$	97.2	4.8	0.05	0.05	.34
$\tilde{\chi}_2^0$	180.7	4.7	1.2	0.08	1.1
$\tilde{\chi}_4^0$	381.9	5.1	3-5	2.23	0.3
$\tilde{e}_R$	143.9	4.8	0.05	0.05	0.82
$\tilde{e}_L$	207.1	5.0	0.2	0.2	0.31
$\tilde{\nu}_e$	191.3	–	1.2	1.2	0.24
$\tilde{\tau}_1$	134.8	5-8	0.3	0.3	0.59
$\tilde{\tau}_2$	210.7	–	1.1	1.1	0.30
$\tilde{\nu}_\tau$	190.4	–	–	–	0.25
$\tilde{q}_R$	547.6	7-12	–	5-11	8.4
$\tilde{q}_L$	570.6	8.7	–	4.9	9.1
$\tilde{t}_1$	399.5		2.0	2.0	4.4
$\tilde{b}_1$	515.1	7.5	–	5.7	7.4
$\tilde{b}_2$	547.1	7.9	–	6.2	8.2
$\tilde{g}$	604.0	8.0	–	6.5	1.2
h^0	110.8	0.25	0.05	0.05	1.2
H^0	399.8		1.5	1.5	0.7

Sequence of KK Resonances?

In Randall-Sundrum model



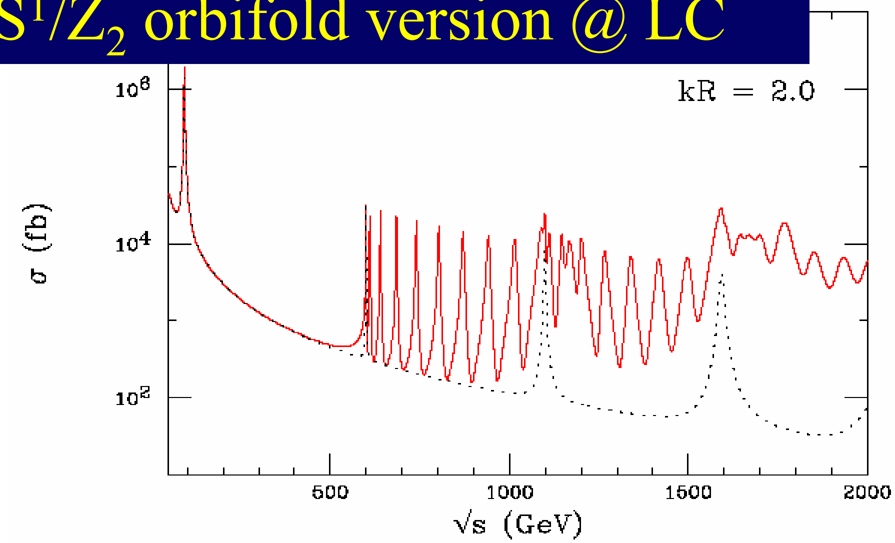
Possible spectrum @ LHC



Sensitivity in contact-interaction regime

	$k/\overline{M}_{Pl}$		
	0.01	0.1	1.0
LC $\sqrt{s} = 0.5$ TeV	20.0	5.0	1.5
LC $\sqrt{s} = 1.0$ TeV	40.0	10.0	3.0
LHC	20.0	7.0	3.0

S^1/Z_2 orbifold version @ LC



Conclusion on the physics

- There are (still) good reasons to expect new physics in the TeV range
- We shall not know what and where before the LHC starts providing results
- Any LC above a threshold for new physics will provide tremendous added value
- **Energy flexibility is desirable**

- **Several new processes studied (Eg. Little Higgs models, UEDs)**
- **Studies get more 'complete' (adding of background, lumi smearing etc., as done for CLIC)**

World's Physicists Endorse Linear Collider

Paris, April 23 2004

Over 2600 physicists from around the world have signed a document supporting a high-energy electron-positron linear collider as the next major experimental facility for frontier particle physics research, members of the World Wide Study of Physics and Detectors for a Linear Collider announced today:

Understanding Matter, Space and Time

http://sbhep1.physics.sunysb.edu/~grannis/lc_consensus.html

The press release contains quotes from
Masatoshi Koshiba, Jim Brau, Francois Le Diberder, Maury Tigner

For the full text see www.interactions.org

Technology II

R. Heuer

ICFA and ILCSC established

- procedure to arrive at a technology recommendation
- time scale for collider design and construction

agreed to by all parties involved

ITRP (see presentation by B.Barish)

- we are in good hands
- important for all of us to:

accept the recommendation of the panel

and

unite behind the recommendation of the panel

only then the project will become reality

Physics II

- Continue to work out the physics capabilities
    - sharpen the physics case
    - provide input to detector design
- LHC / LC
    - draft of first report circulating
    - important to continue this effort
- Cosmology / LC
    - increasingly important topic
    - fascinating topic
    - create working groups in ACFA and ECFA studies as already done in NA and WW studies
- Q: LC notes on world wide repository?

contact: Behnke, Graf, Miayamoto

Time scale

ILCSC (see presentation by M.Tigner) :

2004 technology recommendation (confirmed by ITRP)

Establish Global Design Initiative / Effort (GDI/E)

2005 CDR for Collider (incl. first cost estimate)

2007 TDR for Collider

2008 site selection

2009 construction could start (need approval of funding but not yet major spending !)

→ **keep this momentum**

≥2010?? (Spiro)

Global LC Experimental Programme

Necessity to work out detector concepts on a time scale matching the accelerator (GDI/E) time scale

→ **keep this momentum**

Need to work out a procedure now (i.e. on the time scale of ICHEP04) for detector concepts up to LoIs and experiment proposals (see presentation by D.Miller)

- w/o damaging the international R&D collaborations

-open for newcomers and new ideas

-- as much as possible within international context

-- avoid shoot out between regional concepts !

how are we going to do this ?