Technologie du Collisionneur Linéaire

Rapport sur le choix Super-Conducteur par l'ITRP

- **ITRP, ICFA, ILCSC:**
  la coordination internationale de la physique des particules
- **Pourquoi un choix de technologie maintenant?**
- **Les composantes d'un Collisionneur Linéaire**
- **Fonctionnement de l'ITRP et choix de la technologie**

International Technology Recommandation Panel (ITRP)

Mission:

- choisir entre TESLA & JLC-X/NLC

  pour un début de construction <2010

  en se fondant sur des considérations:

  scientifiques, techniques, délais et coûts
- références: **ILC-TRC** (Loew) rapport 2003
- **paramètres LC** : ICFA doc. 9-30-2003
- Recommandation à fournir au plus tôt,

  en tous cas **avant fin 2004**.

Site web:

- **http://www.ligo.caltech.edu/~donna/ITRP_Home.htm**

Les membres sont:

Barry Barish (président)
Jonathan Bagger
Paul Grannis
Norbert Holtkamp
Amérique du Nord

Gyung-Sun Lee
Akira Masaike
Katsunobu Oide
Hirotaka Sugawara
Asie

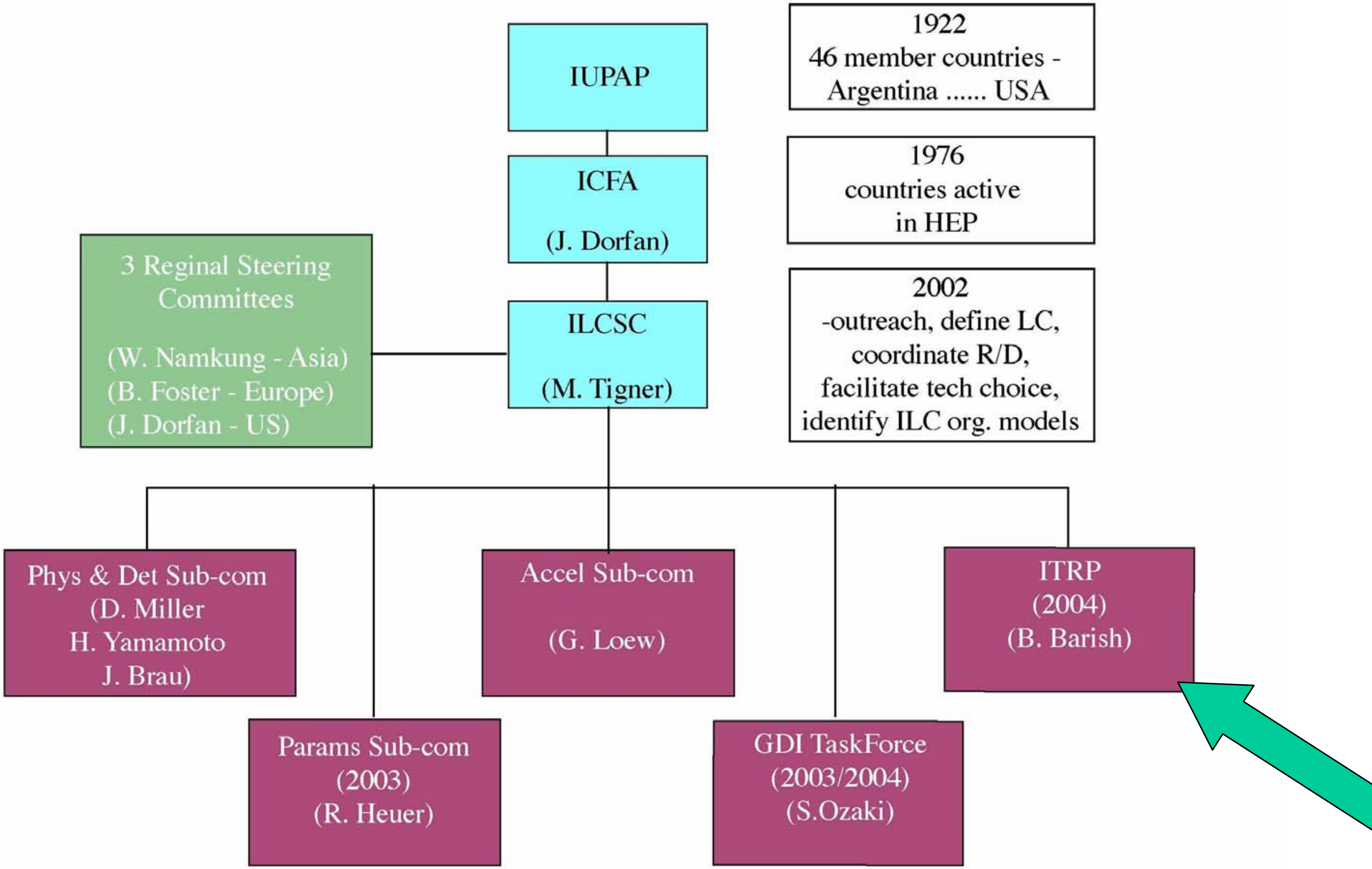
Jean-Eudes Augustin
Giorgio Bellettini
George Kalmus
Volker Soergel
Europe

+David Plane secrétaire

Les coupables

International Technology Recommendation Panel Meeting
August 11 ~ 13, 2004. Republic of Korea

Organisation de la communauté



ICFA

International Committee for Future Accelerators

Sponsored by the Particles and Fields Commission of IUPAP

(2004)

Canada R. Keeler

CERN Member States B. Foster, R. Aymar, A. Wagner

China H. Chen

Japan S. Komamiya, Y. Totsuka

Russia V. Rubakov, Y. Tikhonov

USA J. Dorfan (Chair), M. Witherell, S. Dawson

Other Countries C. Garcia Canal, P. Singer, D. Son

IUPAP C11 V. Lüth

http://www.fnal.gov/directorate/icfa/icfa_membership.html

The Role of ICFA

- Charter and Aegis

  ICFA, the International Committee for Future Accelerators, was created to facilitate international collaboration in the construction and use of accelerators for high energy physics. It was created in 1976 by the International Union of Pure and Applied Physics.

  Its purposes, as stated in 1985, are as follows:

  - To promote international collaboration in all phases of the construction and exploitation of very high energy accelerators
  - To organize regularly world-inclusive meetings for the exchange of information on future plans for regional facilities and for the formulation of advice on joint studies and uses
  - To organize workshops for the study of problems related to super high-energy accelerator complexes and their international exploitation and to foster research and development of necessary technology

For more info see: http://www.fnal.gov/directorate/icfa/

J.Dorfan, ICFA Chair, Beijing 2004

ICFA

International Committee for Future Accelerators

Sponsored by the Particles and Fields Commission of IUPAP

Membres depuis 1977

Chairman:

B. P. Gregory (1977)

J. B. Adams (1978-1982)

V.L. Telegdi (1983-1986)

Y. Yamaguchi (1987-1989)

A.N. Skrinsky(1990-1992)

J. Peoples (1993-1996)

B. Wiik (1997-1999)

H. Sugawara (1999-2002)

J. Dorfan (2003-2005)

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ICFA

(depuis 1977)

International Committee for Future Accelerators

Sponsored by the Particles and Fields Commission of IUPAP

MEMBERS

CERN Member States

J.B. Adams	(1977-1982)
G.H. Stafford	(1978-1980)
J.H. Mulvey	(1981-1983)
W. Hoogland	(1988-1990)
J.-E. Augustin	(1990-1992)
B. Wiik	(1993-1999)
L. Maiani	(1999-2003)
B. Foster	(2002-2005)
W. Paul	(1977)
M. Vivargent	(1978-1980)
H. Schopper	(1983-1988)
V. Soergel	(1987-1992)
G. Flügge	(1992-1995)
C.H. Llewellyn-Smith	(1994-1998)
R. Aymar	(2004-2006)
G. v. Dardel	(1977)
V.L. Telegdi	(1981-1986)
J. Sacton	(1984-1987)
C. Rubbia	(1989-1993)
E. Fernandez	(1995-1998)
A. Wagner	(1999-2005)
L. Foa	(1999-2002)

USA

V.F. Weisskopf	(1977)
B. Richter	(1978-1983)
L. Pondrom	(1984-1989)
J. Peoples	(1990-1996)
F. Sciulli	(1996-1997)
J. Dorfan	(1999-2005)
S. Dawson	(2004-2006)
R.R. Wilson	(1977-1981)
B.D. McDaniel	(1982-1987)
N. Samios	(1984-1989)
R. Schwitters	(1990-1995)
K. Stanfield	(1997-1999)
M. Witherell	(1999-2005)
L. Lederman	(1977-1982)
J.D. Bjorken	(1983)
G.H. Trilling	(1988-1993)
B. Richter	(1994-1999)
E.W. Beier	(1998-2000)
S. Wojcicki	(2001-2003)

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ICFA (depuis 1977)

International Committee for Future Accelerators

Sponsored by the Particles and Fields Commission of IUPAP

Other Countries (1977-1995); Japan (after 1995)

Y. Yamaguchi	(1977-1989)	S. Yamada	(1990-1995)
Y. Nagashima	(1996-1999)	H. Sugawara	(1996-2003)
S. Komamiya	(2000-2005)	Y. Totsuka	(2003-2006)

Canada: R. Hemingway (1996-1998) R. Carnegie (1999-2001) R. Keeler (2002-2004)

Chairman of the IUPAP Commission on Particles and Fields (ex officio)

E.L. Goldwasser	(1977-1981)	L.D. Soloviev	(1982-1984)	I. Mannelli	(1985-1987)
K. Strauch	(1988-1990)	T. Fujii	(1991-1993)	J. Sacton	(1994-1996)
B. Barish	(1996-1999)	P.I.P. Kalmus	(1999-2002)	V. Luth	(2003-2005)

USSR (until 1995); Russia (after 1995)

V.P. Dzelepov	(1977-1982)	K.P. Myznikov	(1977-1983)	V.A. Yarba	(1977-1984)
A.N. Skrinsky	(1983-1992)	E. Myae	(1984-1989)	Yu. Ado	(1986-1991)
V.I. Kryshkin	(1990-1995)	A.A. Vorobyov	(1994-1996)	A.N. Lebedev	(1994-1998)
N.E. Tyurin	(1997-1999	M.V. Danilov	(1998-2003)	N.S. Dikansky	(2000-2002)
Y. Tikhonov	(2003-2005)	V. Rubakov	(2004-2006)		

JINR Member States other than USSR (until 1995)

K. Lanius	(1977-1983)	Nguyen van Hieu	(1984-1986)
A.Ts. Amatuni	(1992-1995)	D. Kiss	(1987-1992)

China

Fang Shouxian	(1985-1992)	Zheng Zhipeng	(1992-1995)	Chen Hesheng	(2000-2005)
Wang Shuhong	(1995-1998)	Li Weiguo	(1999)		

Fourth Region (until 1995); Other Countries (after 1995)

P.K. Malhotra	(1984-1986)	J. Tiomno	(1987-1988)	D.G. Stairs	(1990-1995)
J.S. Kang	(1996-1999)	A. Sissakian	(1996-1997)	C. Escobar	(1996-1998)
A. Zepeda	(1999-2001)	Z. Aydin	(1999-2001)	W. Namkung	(2000-2002)
C. Garcia Canal	(2002-2004)	P. Singer	(2002-2004)	D. Son	(2003-2005)

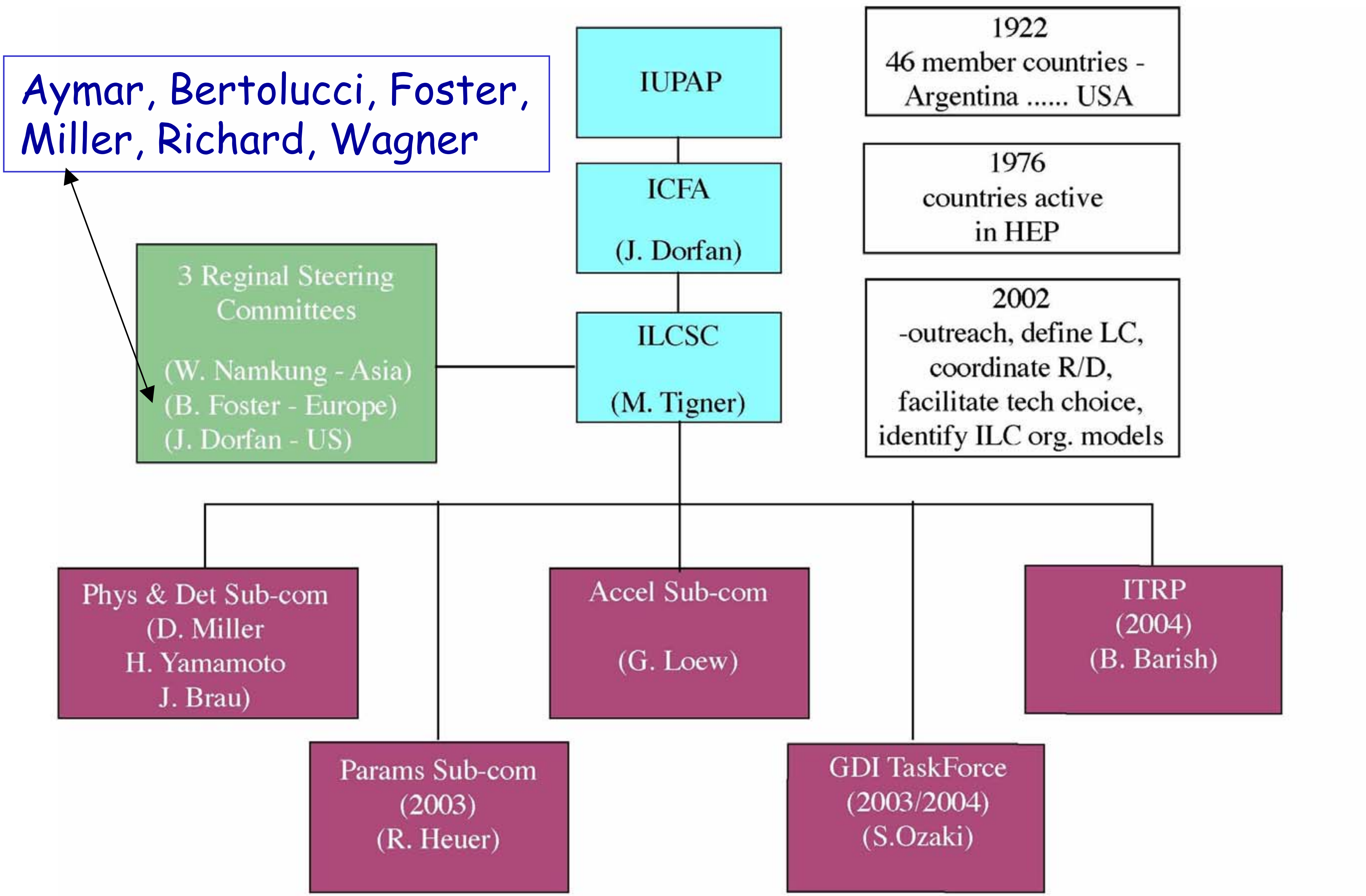
 http://www.fnal.gov/directorate/icfa/icfa_membership.html

International Linear Collider Steering Cttee (ILCSC)
Chair: Maury Tigner

Membres actuels

Category	Current incumbent
Directors	
KEK	Yoshi Totsuka
SLAC	Jonathan Dorfan
DESY	Albrecht Wagner
CERN	Robert Aymar
FNAL	Michael Witherell
LC Steering Group Chairs	
Asian	Won Namkung
European	Brian Foster
N. American	Jonathan Dorfan
Other	
Chair	Maury Tigner
China (IHEP Director)	Hesheng Chen
Russia (BINP Director)	Alexander Skrinsky
ICFA outside LC regions	Carlos Garcia Canal
Asia Rep.	Sachio Komamiya
Europe Rep.	David Miller
N. American Rep.	Paul Grannis

Organisation de la communauté



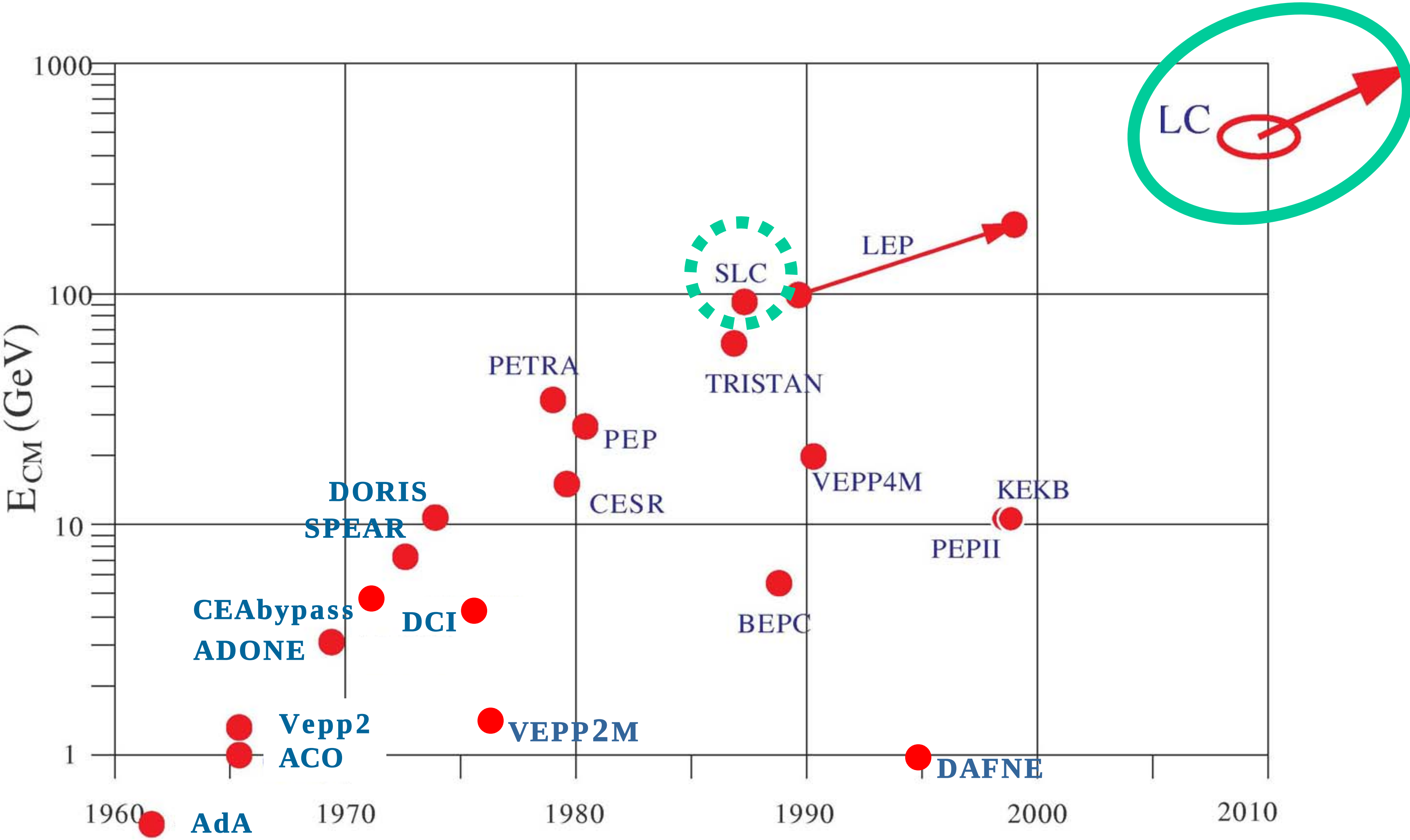
Pourquoi un choix de technologie maintenant?

Il y a eu développment parallèle ces dernières années de la science et de la technologie

- Les mesures de précision au LEP et SLC semblent indiquer un Higgs de basse masse;
- La compréhension de la brisure de la symétrie électrofaible (supersymétrie ou autre) nécessite des mesures de précision
- Les études et prototypes techniques ont abouti à deux approches techniques pour un accélérateur bien adapté à ce besoin actuel de la physique. Il faut réduire les coûts de développement.
- Il y a de très bons arguments en faveur d'une période de recouvrement permettant d'utiliser la complémentarité entre cette machine et le LHC

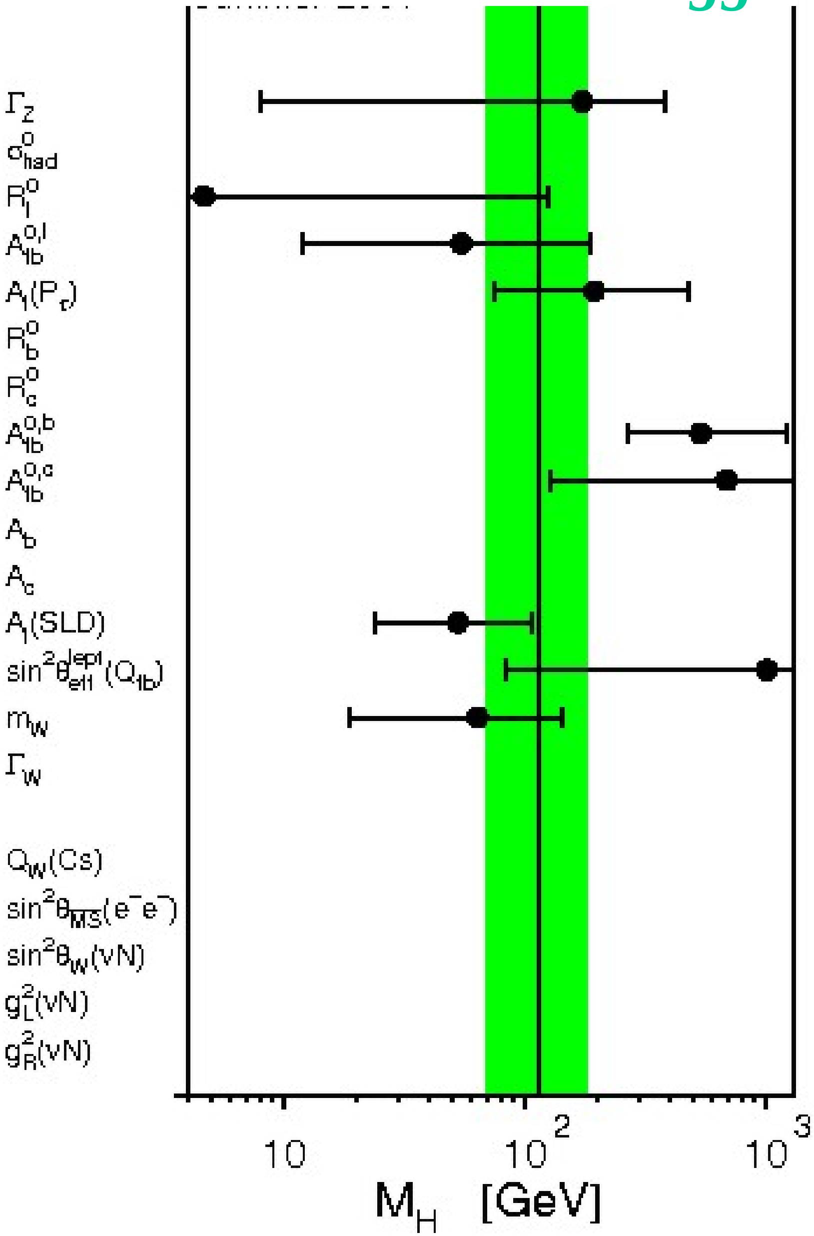
B.Barish,LCWS2004

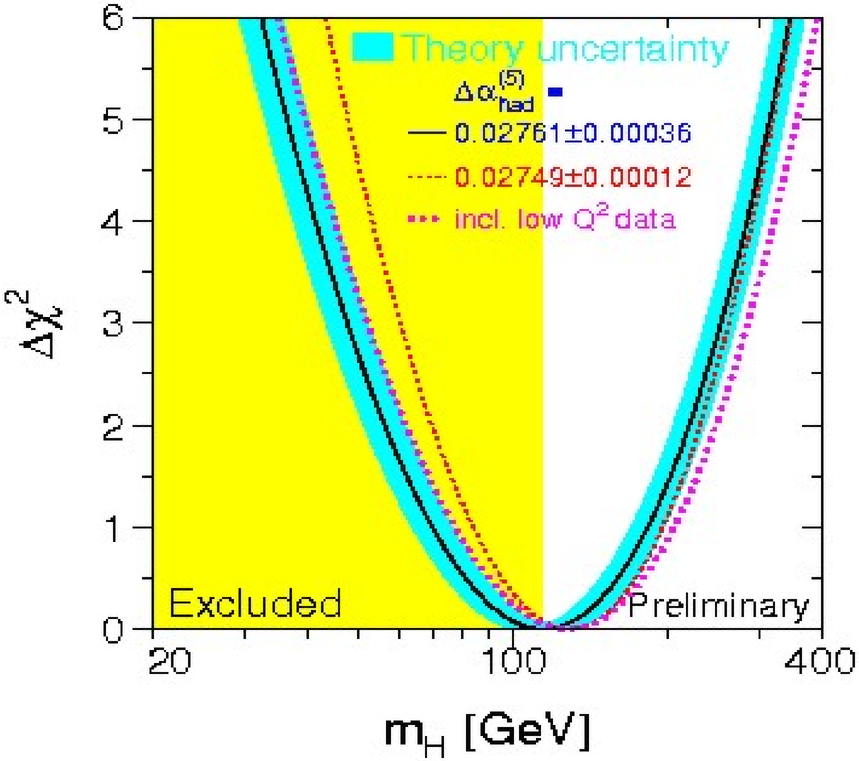
Les Collisionneurs e+e-



Adapté de Kaoru Yokoya

Constraints on m_{Higgs}





$\log(m_{Higgs}) = 2.06 \pm 0.21$

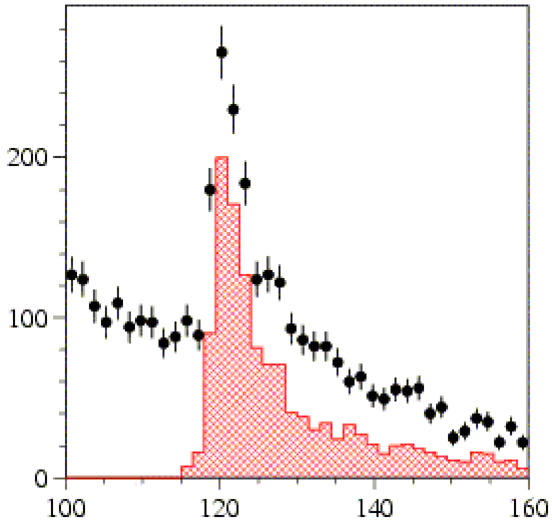
$m_{Higgs} = 114^{+69}_{-45}$ GeV

$m_{Higgs} < 260$ GeV @95% c.l.

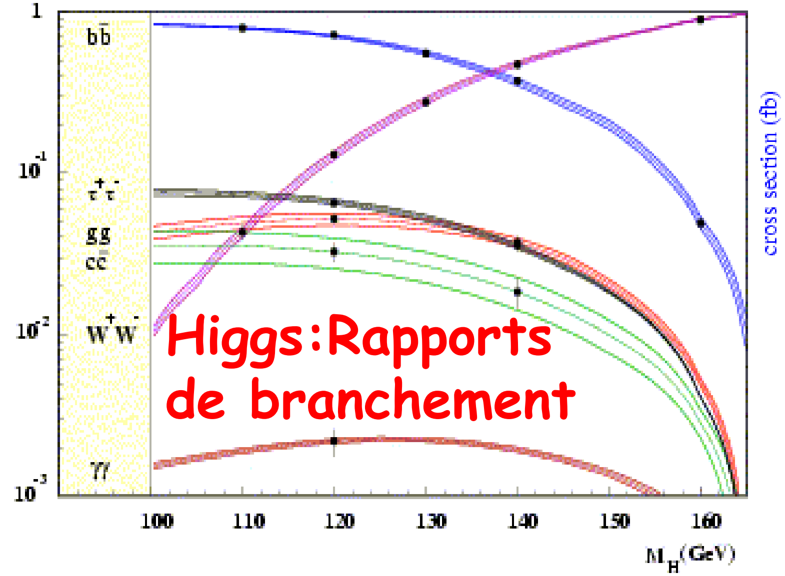
$m_{Higgs} > 114$ GeV @95% c.l.

Teubert, IHEP 2004 Beijing

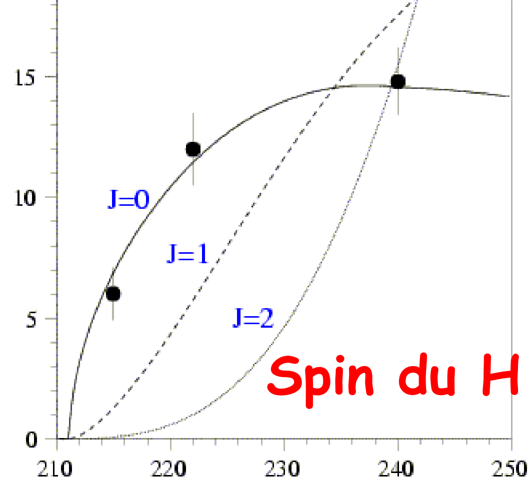
Physique du Collisionneur Linéaire: Mesures de Précision



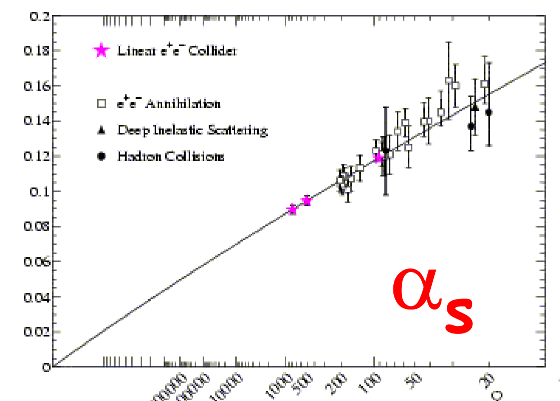
Higgs Inclusif:
masse de recul au Z



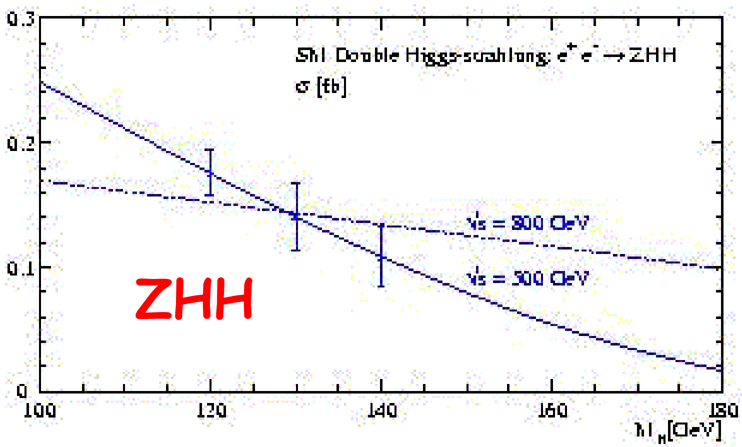
Higgs:Rapports de branchement



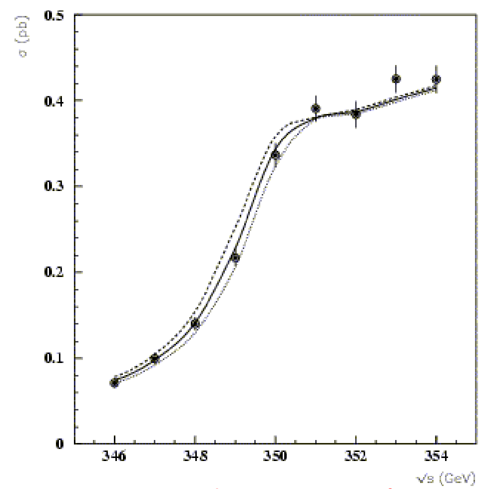
Spin du H



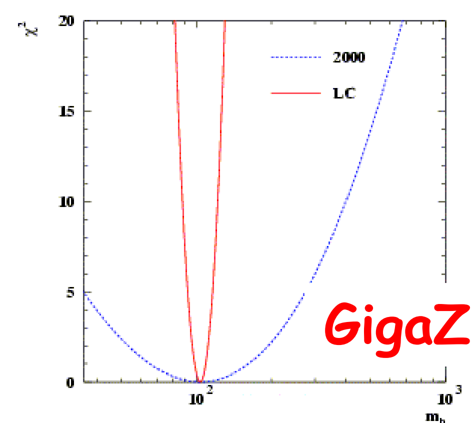
α_s



ZHH



mass du quark Top



GigaZ

... et bien plus au-delà du MS

Rappel:

Stanford Linear Collider (1988-1998)

A fourni de l'excellente physique au Z

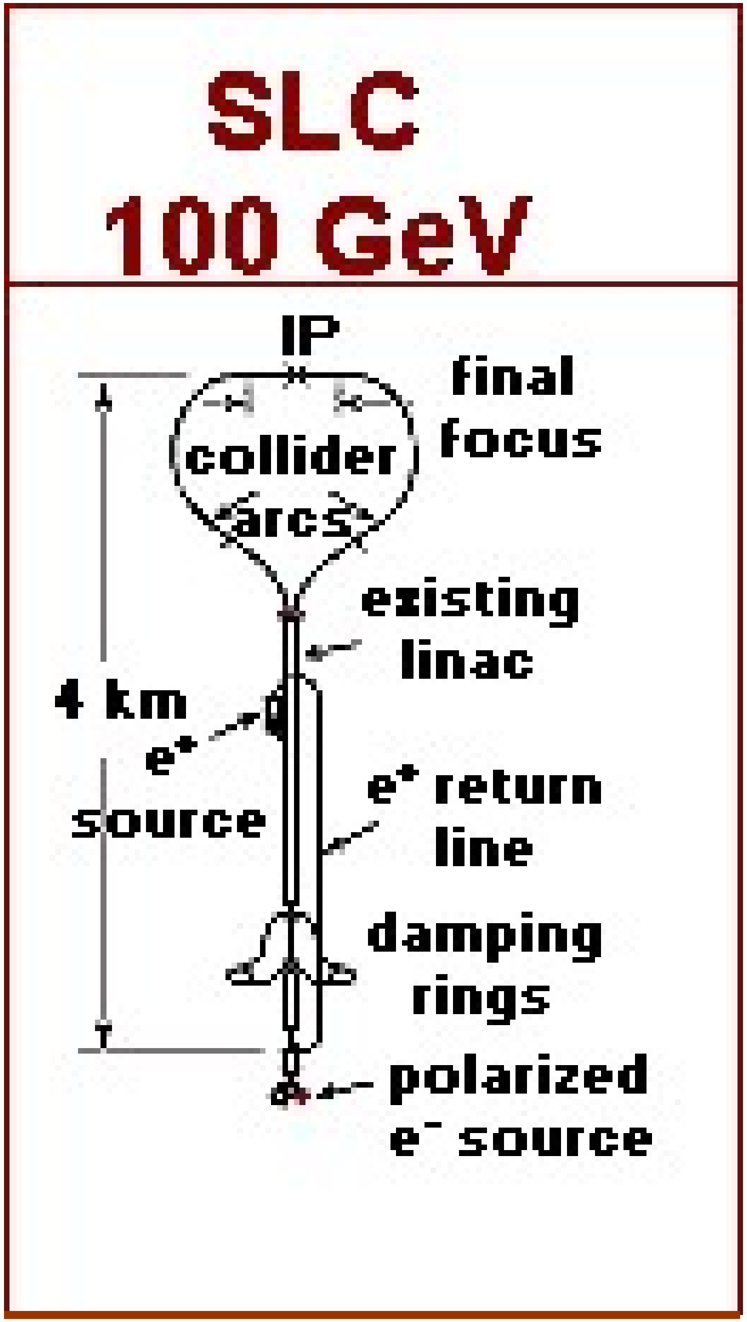
A prouvé la faisabilité d'un collisionneur linéaire… (et formé les spécialistes actuels.)

Il a atteint finalement en 1998

$\mathcal{L}=3.10^{30}$ cm^{-2} s^{-1}

(~50% de la valeur prévue)

[SLAC, S-band, 2.84GHZ]



Pourquoi le Collisionneur Linéaire?

Dans un anneau, les électrons perdent leur énergie par rayonnement synchrotron ~E^4/R:

2,8 GeV/tour à LEP200…

Il faut une machine linéaire pour monter en énergie.

*M. Tigner, Nuovo Cimento **37** (1965) 1228*

Mais…

- **Il faut une RF très puissante (100% par passage)**
- **Il faut des faisceaux extrêmement petits et une intensité maximale (fréquence des croisements beaucoup plus faible)**

A la suite du SLC, dès le début des années 1990

Plusieurs développements en parallèle, théorie et expérience pour un « vrai » collisionneur linéaire:

- S-Band (2.84 GHz) à DESY (A.Voss),et à SLAC

- C-band (5.7 GHz) au Japon et en Corée

- X-band (11,4 GHz) NLC-X à SLAC (B.Richter,G.Loew)
  et JLC à KEK
  et en Russie au BINP (Balakin,14 GHz)

(Amortissement BNS (Balaikin Novokhatski Smirnov) vital pour le SLC)

- L-band (1,3 GHz) Supraconducteur
  TESLA à DESY (Bjorn WIIK)

-30 GHz génération RF par faisceau:
  CLIC au CERN (W.Schnell)

INTERNATIONAL LINEAR COLLIDER

TECHNICAL REVIEW COMMITTEE

"Greg Loew Committee"

SECOND REPORT

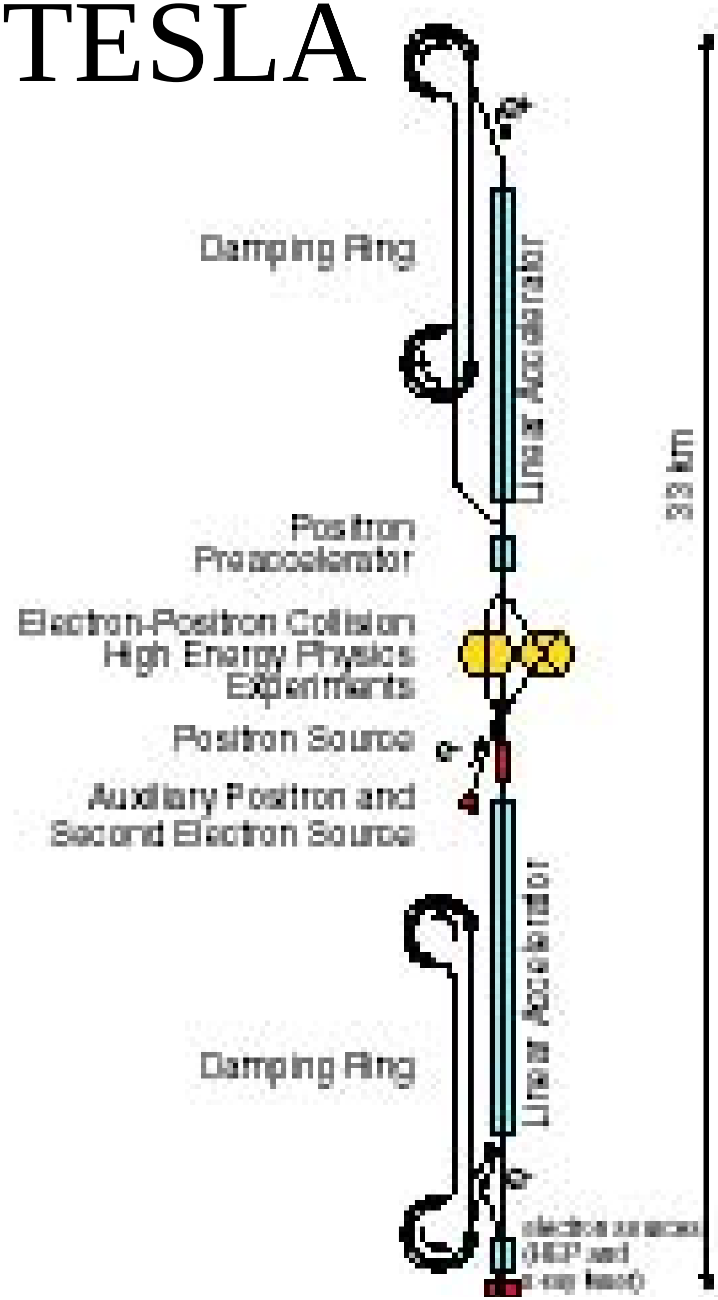
2003

480pp

Chair: G.Loew,
Steering Cttee: R.Brinkman, K.Yokoya, T.Raubenheimer, G.Guignard
WG chairs: D.Boussard, G.Dugan, N.Phinney, R.Pasquinelli

A validé TESLA et NLC-X/JLC

TESLA



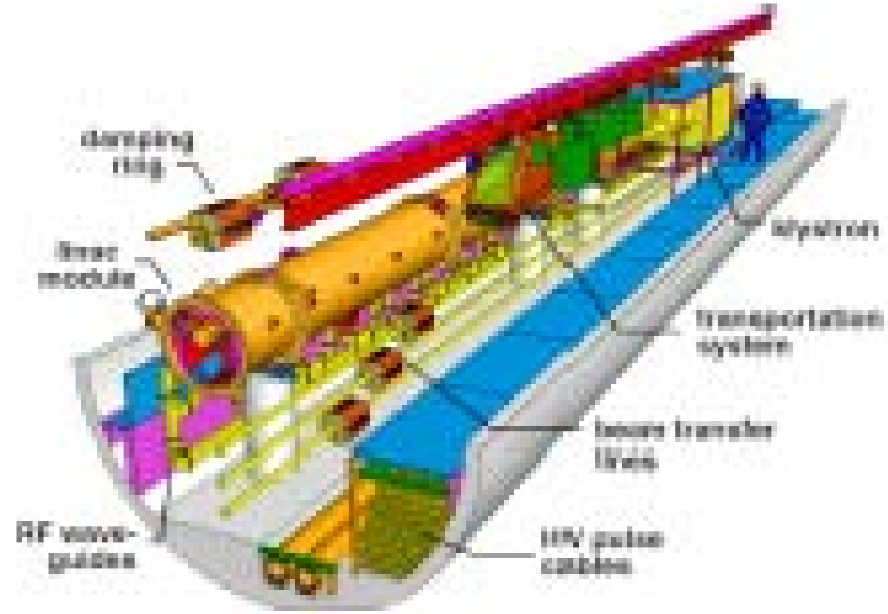
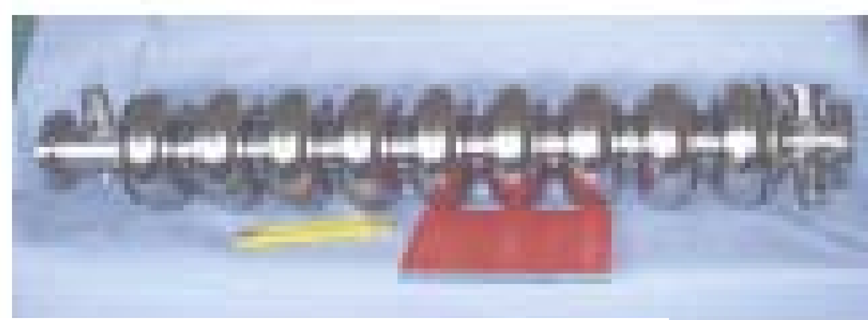
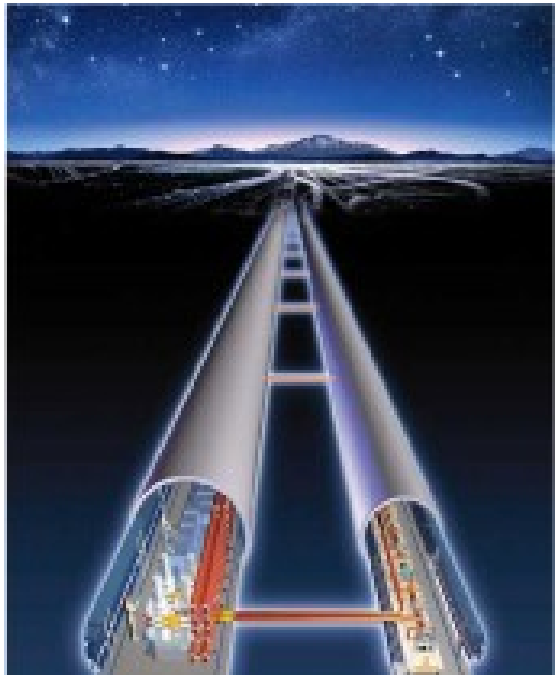


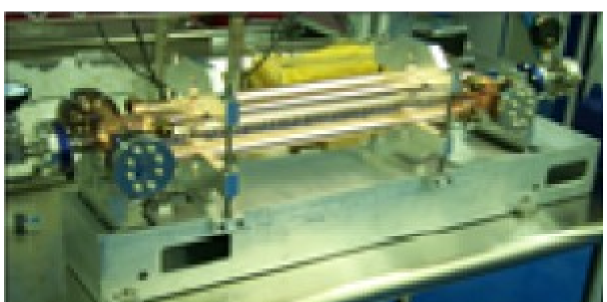
FIGURE 2: Sketch of the 5 m diameter TESLA linac tunnel

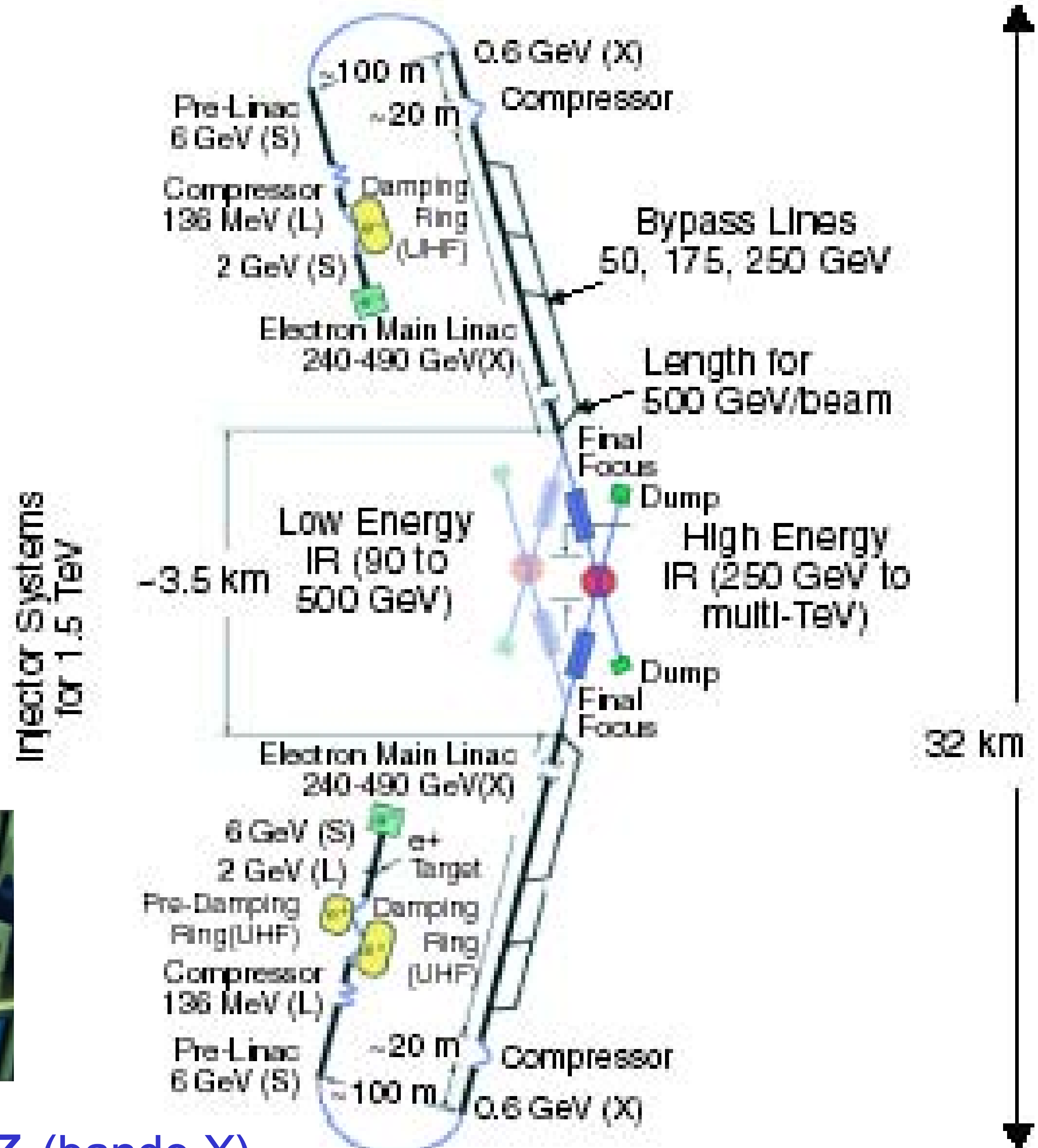


RF Supraconductrice, 1,3 GHz   Cavités en Niobium

NLC-X







Cuivre, 11,4 GHz (bande X)

Principaux Paramètres

	TESLA		NLC/JLX(X)	
énergie c.m. ***GeV***	500	800	500	1000
fréquence RF ***GHz***	1.3		11.4	
Luminosité 10^**34**/cm2/s	3.4	5.8	2.5	
nb paquetss/pulse	2820	4500	192	
N± /paquet (*10*^10)	2	4	0.75	
Séparation paquets ***ns***	337	176	1.4	
Taux de Répétition ***Hz***	5	4	150	100
σ_y au point croisem. **nm**	5	2.8	3	2.1
ΔE/E beamstrahlung	3.2%	4.3%	4.6%	7.5%
Gradient Accél. **MV/m**	23.4	35	65/52*	
Puissance totale **MW**	140	200	243	292
Longueur du Site **km**	33		32	

* en charge par le faisceau

Pourquoi choisir maintenant?

– Il y a deux projets -- “chaud” et “froid” -- arrivés au point où les difficultés majeures ont été éliminées et les difficultés sont bien comprises.

– La R&D coûte cher (spécialement D), l’étape suivante (pour être prêt à construire une telle machine dans ~ 5 ans) va demander beaucoup d’argent, d’organisation et un effort mondial.

– Il est trop cher, et inutile, d’essayer de le faire pour les deux technologies (et les gouvernements ne le soutiendront pas).

– La décision finale de construire cette nouvelle machine sera rendue possible par ce choix, et avec un calendrier en accord avec le LHC et les développements de la physique.

– La décision finale et le financement pour construire cette machine seront alors décidés.

B.Barish,LCWS2004

Paramètres pour le Collisionneur Linéaire

Parameters for the Linear Collider

September 30, 2003

Parameter Sub-committee (2003)

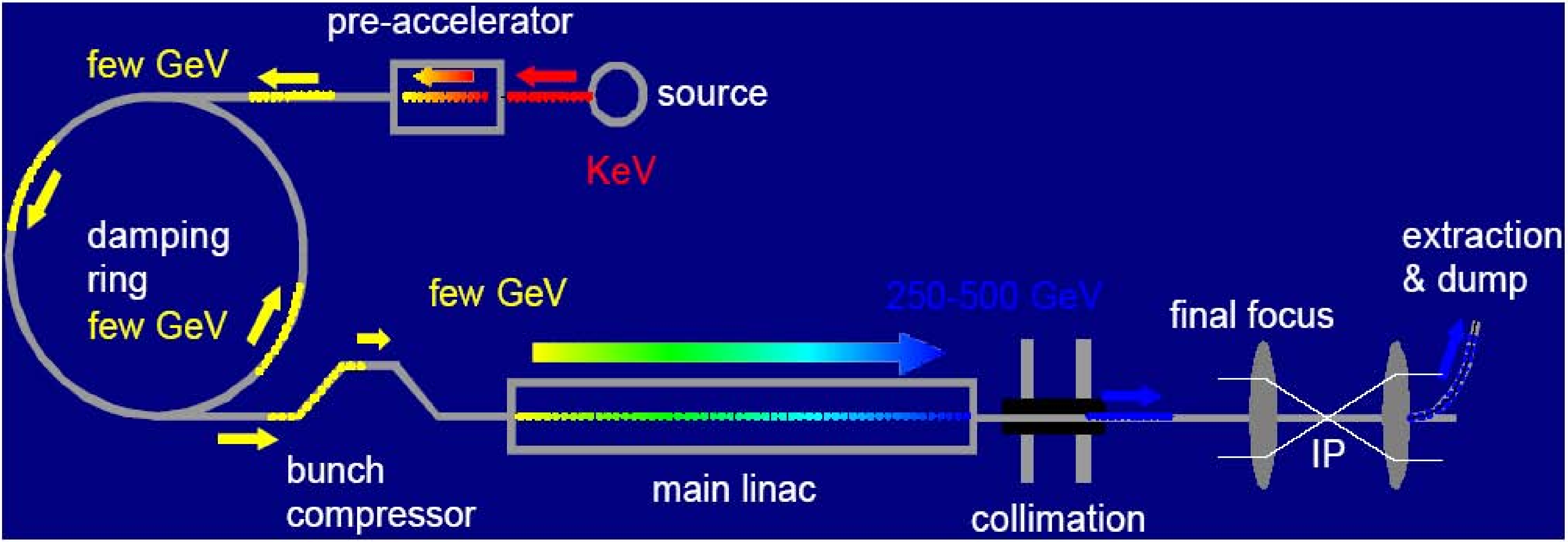
(S.Komamiya, Dongsul Son, R.Heuer(Chair), F.Richard, P.Grannis, M.Oreglia)
(aussi ITRP)

- Machine de base : $\sqrt{s}$ = 500 GeV, 500 fb^{-1} (en 4 ans)
  - Scans 200 à 500 GeV, - E stable à 0.1%,
  - Deux zones expérimentales, une avec croisement ($\gamma\gamma$)
  - Calibn à 91 GeV (Z0), - e^- Polarisés à 80%
- Possibilité d'augmenter l'énergie: ~1 TeV, 1 at^{-1} en 3-4 ans
- 6 Options:
  - 1 at^{-1} les 2 ans suivants,
  - collisions e^-e^-,
  - positron polarisés à 50%,
  - "Giga Z": $\mathcal{L}$ plusieurs 10^{33} cm^{-2} sec^{-1}, E à 0.1%,
  - WW au seuil, $\mathcal{L}$ plusieurs 10^{33} cm^{-2} sec^{-1}, **E à 10^{-5}**,
  - et $\gamma\gamma$ par faisceau laser rétro-Compton dans une ZE.

Composantes des Collisionneurs Linéaires

et comparaison entre les technologies

Composantes du C.L.



Nick Walker, DESY http://www.desy.de/~njwalker/uspas/

Outre -le Linac principal et les sources RF

il y a - les sources d'électron et de positrons

- les anneaux d'amortissement

- la compression longitudinale des paquets

- la focalisation finale (commune aux deux projets)

puis - l'extraction des faisceaux utilisés.

CL: Composantes

Luminosité: faible émittance (Faisceaux plats: $\sigma_y \gg \sigma_x$)

anneaux d'amortissement, compression des paquets

Déviation & focalisation finale σ_y = 5 à 3 nm

$$\mathcal{L} = \frac{f_{rep}\, n_b\, N_+ N_-}{4\pi\sigma_x\sigma_y} H_D$$

(H_D facteur de pincement)

Extraction & Dump

- préservation de l'émittance : Source, Damping Ring, Linac, BDS
- $\mathcal{L} = \eta\, P_{AC} \left(\frac{1}{E_{cm}}\right) \left(\frac{N_\pm}{\sigma_x}\right) \left(\frac{1}{\sigma_y}\right) H_D \propto \frac{\eta_{RF} P_{RF}}{E_{cm}} \sqrt{\frac{\delta_{BS}}{\varepsilon_{n,y}}} H_D$ ($\beta_y \approx \sigma_z$)

Efficicacité Puissance

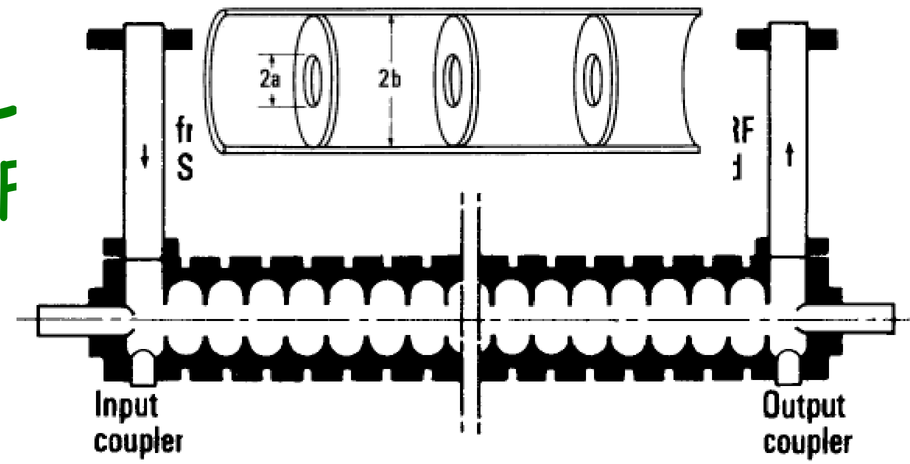
et $\mathcal{L}$uminosité intégrée: **fiabilité**

Energie: cavités RF, klystrons, modulateurs, compresseurs

Intensité: source e+, ondulateur ou conventionnelle

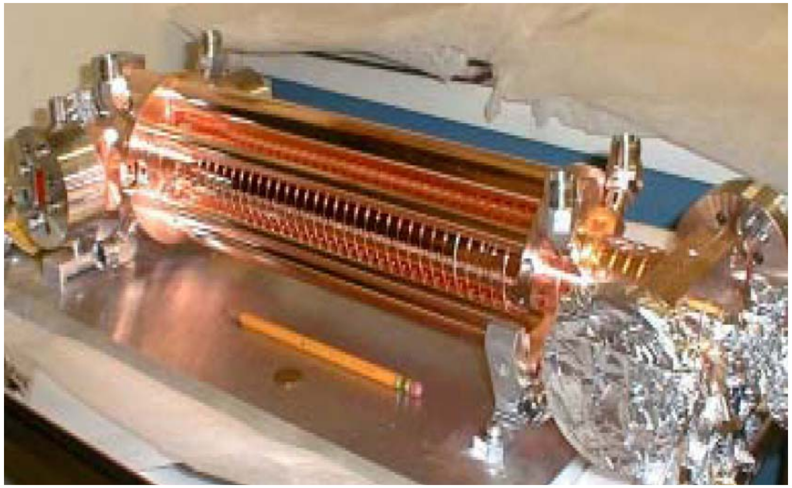
Composantes du C.L

Energie: cavités RF



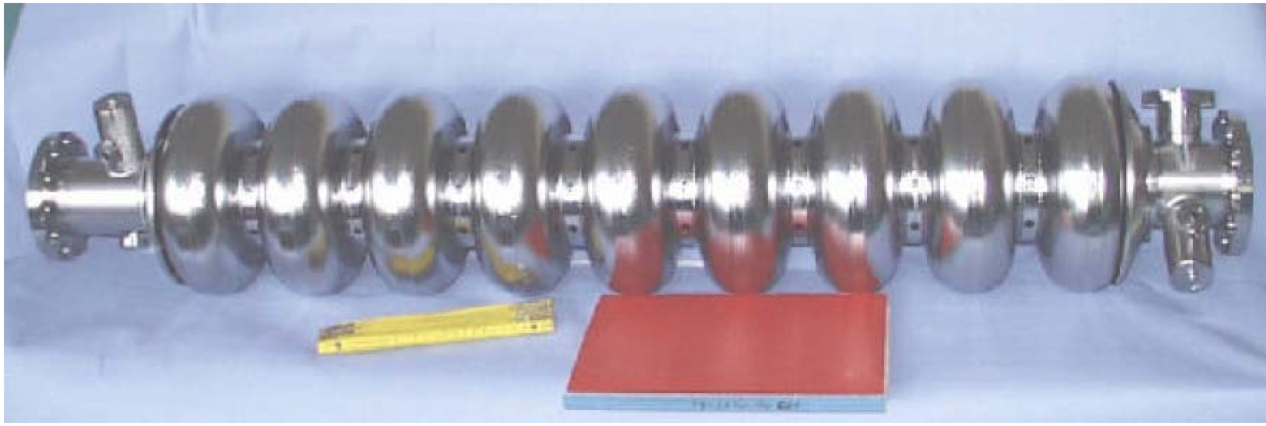
X-band

Cuivre, 60cm,
65MV/m non chargé,
52MV/m à l'intensité nominale
Réduction de 1,8m à 0,6m
dûe aux claquages: <0,1/heure/section
soit un/2sec ce qui est tolérable (?)
Précision d'usinage au micron



TESLA

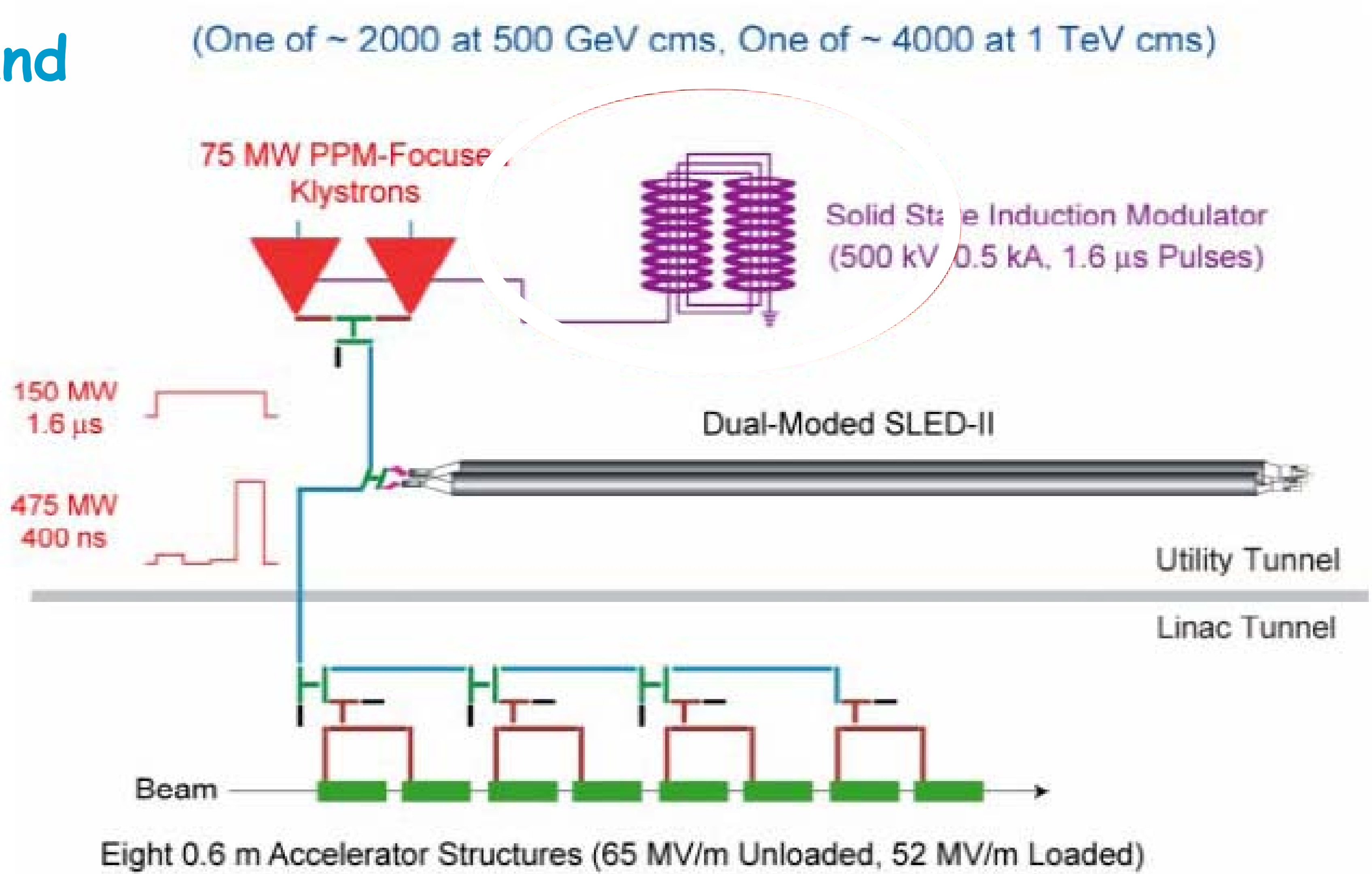
Niobium, 35MV/m
Coupleur RF complexe
Courant d'obscurité
sous contrôle (?)
Salles blanches,
Contrôle de qualité
critique



Composantes du C.L.

Energie: cavités RF, klystrons, modulateurs, compresseurs

X-band

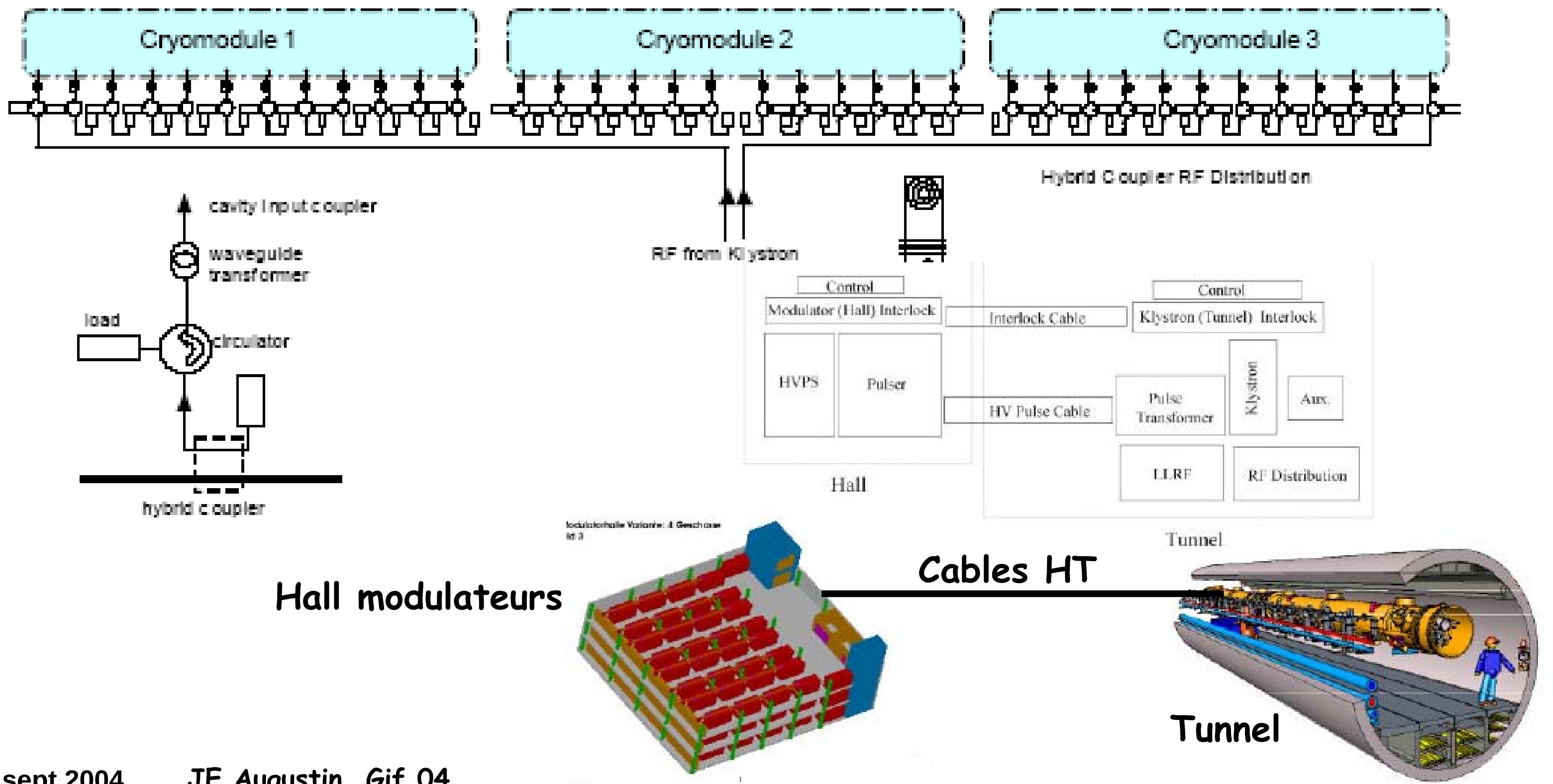


Composantes du C.L.

Energie: cavités RF, klystrons, modulateurs, compresseurs

TESLA RF organisation

21024 cavités, 36 par klystron soit 584 stations de 10KW à 500 GeV
le double à 1 TeV



USLC report:

Etats Unis seuls

…nouvelle information après le début d'ITRP
disponibilité, coût, planning, site, évaluation des risques

U.S. Linear Collider
Technology Options Study
U.S. Linear Collider Steering Group
Accelerator Sub-committee
Linear Collider Option Task Forces
March 4, 2004

Table 3.2.0.1: US Linear Collider: overall parameters

Parameter	X-band *(warm)* Reference design	*(cold)* L-band Reference design	X-band **upgrade**	L-band **upgrade**
Beam Energy [GeV]	250	250	500	500
Loaded RF gradient[MV/m]	52	28	52	35
Two-Linac total length[km]	15.94	27.00	29.36	42.54
Bunches/pulse	192	2820	192	2820
Electrons/bunch[10^{10}]	0.75	2	0.75	2
Pulse/s[Hz]	120	5	120	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
βx(IP)[mm]	8	15	13	24.4
βy(IP)[mm]	0.11	0.4	0.11	0.4
σx(IP)[nm]	243	543	219	489
σy(IP)[nm]	3.0	5.7	2.1	4.0
σz(IP)[mm]	0.11	0.3	0.11	0.3
Dy	12.9	22.0	10.1	17.3
H_D	1.46	1.77	1.41	1.68

Parameter	X-band *(warm)* Reference design	*(cold)* L-band Reference design	X-band **upgrade**	L-band **upgrade**
$\mathcal{L}_{geom}[10^{33}cm^{-2}\ s^{-1}]$	14.2	14.5	22.2	22.7
$\mathcal{L}[10^{33}cm^{-2}\ s^{-1}]$	20.8	25.6	31.3	38.1
N γ/e	1.19	1.48	1.24	1.58
δE_b[%]	4.6	3.0	8.2	5.9
Average power/beam [MW]	6.9	11.3	13.8	22.6
Peak beam current in pulse [mA]	855	9.51	855	9.51
Beam pulse length [μs]	0.270	950	0.270	950
Total number of klystrons →	4520	603	8984	1211
Peak RF power per klystron [MW]	75	10.0	75	9.7
Total number of structures →	18080	18096	35936	29064
Peak RF power per structure [MW]	56	0.276	56	0.345
Linac AC power [MW] →	207.6	132.7	389.9	295.9
Linac AC to beam efficiency [%]	6.6	17.0	7.1	15.3

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

Effets de fréquence RF: 1.3 vs 11.4 GHz

Iris des cavités $a \sim \lambda$,

Instabilité transverse tête-queue $\sim a^{-3} = f^3$: rapport $\sim 10^3$

maîtrisée dans NLC par la dispersion en énergie

et une focalisation puissante (amortissement BNS)

la dispersion en énergie est réduite au minimum

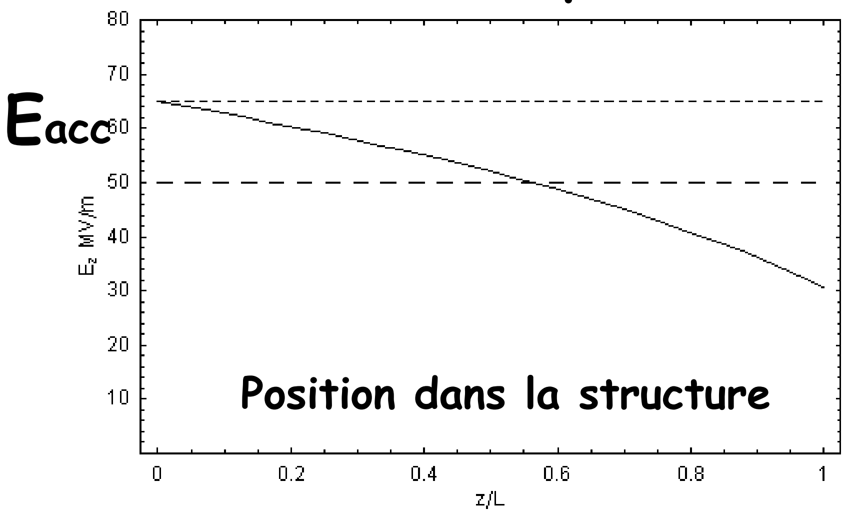
à la fin de l'accélération.

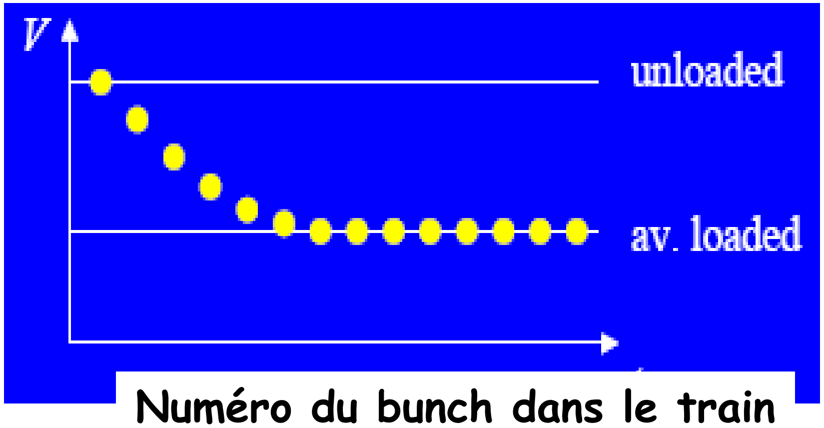
Dans TESLA la focalisation est bien plus faible, et la sensibilité ($\sim f^3$) aux désalignements et mouvements du sol est moins grande.

Dans le projet NLC/JLC les difficultés sont résolues au prix d'un plus grand nombre d'éléments de focalisation, de mesure de position (modes dipolaires des cavités), et de moyens d'alignement.

Effets de la supraconductivité

Il n'y a pas de charge par le faisceau dans Tesla.
Dans NLC, cela réduit fortement le gradient à haute intensité.
L'effet transitoire en début de train doit être compensé par une mise en forme de l'impulsion RF



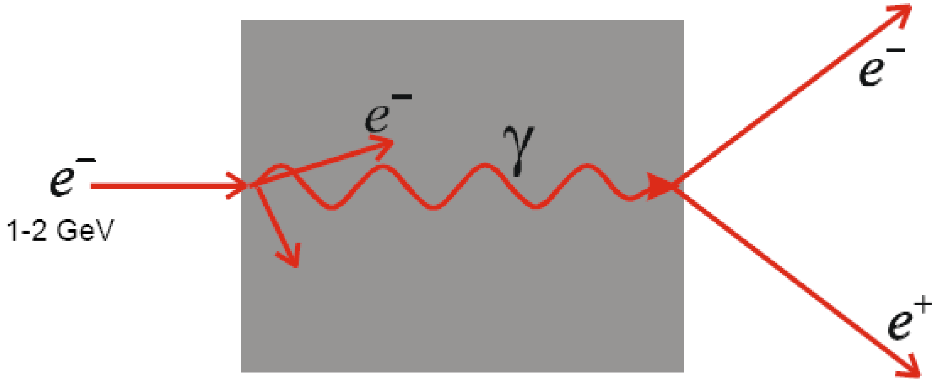


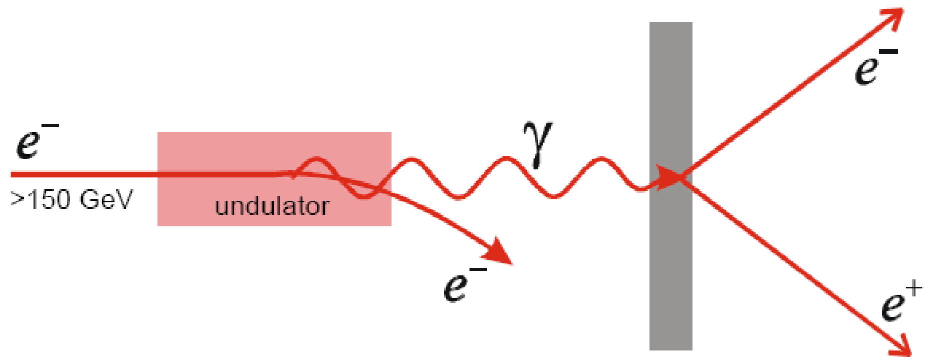
Plus généralement la techno supra a une grande stabilité et des temps de décroissance de plusieurs microsecondes qui permettent de prendre des mesures appropriées en cas d'incident.

Toutes ces difficultés sont résolues une à une dans le projet chaud, grâce à un travail, très approfondi, et au prix d'une plus grande complexité de fonctionnement.

Composantes du C.L.

Intensité: source e+, conventionnelle ou ondulateur





Conventionnelle: Basse énergie
Plusieurs cibles épaisses
Bien connu

Ondulateur: Haute énergie (150GeV)
Cible mince, émittance réduite
non testé (énergie!)
attendre e- pour travailler e+

X-band - source positron conventionelle 3 cibles
- prévoir pour un ondulateur pour e+ polarisés (R&D)

TESLA: - ondulateur, développement nouveau
- peut avoir une source conventionnelle mais 6 cibles
- ondulateur hélicoidal pour e+ polarisés possible (R&D)

Composantes du C.L.

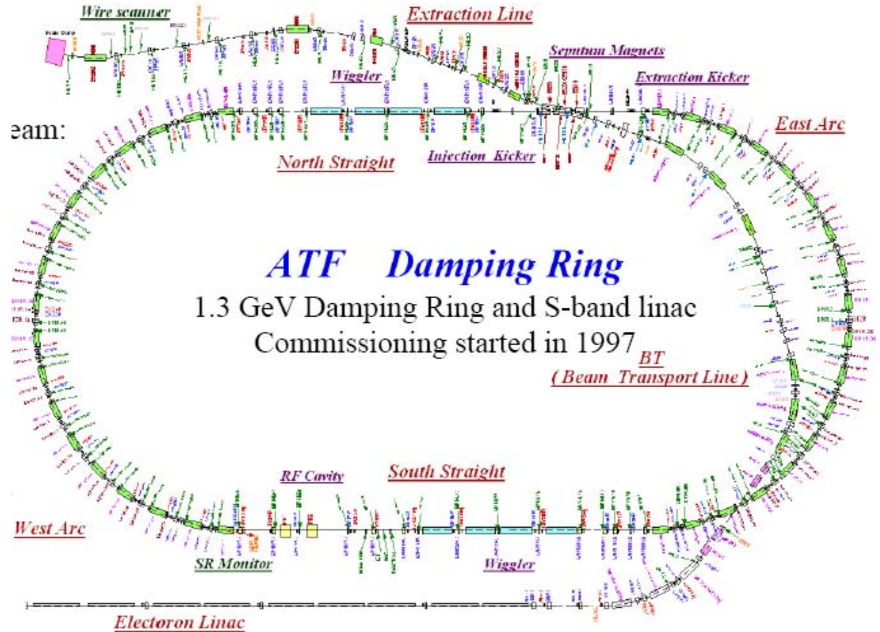
anneaux d'amortissement

X-band

anneaux d'amortissement 2GeV, L=300m

prototype: l'ATF du KEK

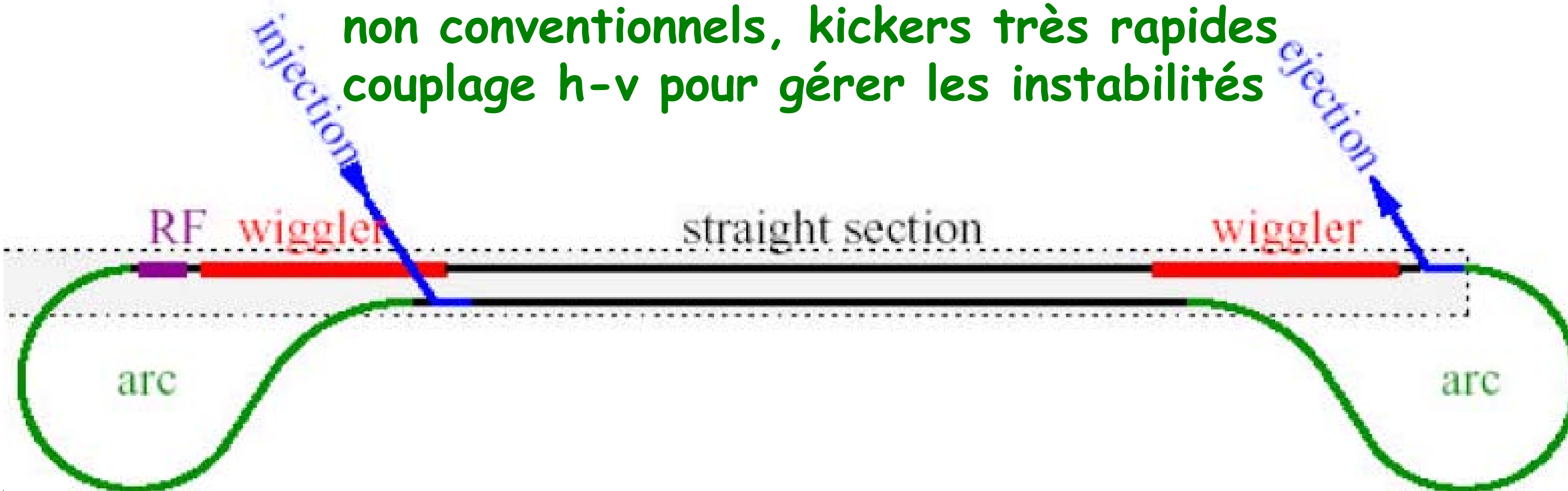
Anneau de pré-amortissement e+



TESLA: anneaux d'amortissement 5GeV, L=17 km « dog-bone »

non conventionnels, kickers très rapides

couplage h-v pour gérer les instabilités



Fonctionnement de l'ITRP

The Charge to the International Technology Recommendation Panel

General Considerations

The International Technology Recommendation Panel (the Panel) should recommend a Linear Collider (LC) technology to the International Linear Collider Steering Committee (ILCSC).

On the assumption that a linear collider construction commences before 2010 and given the assessment by the ITRC that both TESLA and JLC-X/NLC have rather mature conceptual designs, the choice should be between these two designs. If necessary, a solution incorporating C-band technology should be evaluated.

Note -- We have interpreted our charge as being to recommend a technology, rather than choose a design

The recommendation should be based on all relevant scientific, technical, schedule and cost considerations. Major references for the Panel will be the recently issued "International Linear Collider Technical Review Committee Second Report 2003" (http://www.slac.stanford.edu/xorg/ilc-trc/2002/2002/report/03rep.htm) and the document outlining the case for the electron-positron linear collider "Understanding Matter, Energy, Space and Time" (http://sbhep1.physics.sunysb.edu/~grannis/lc_consensus.html)

To reach its recommendation the Panel will hear presentations from the design proponents addressing the above issues.

The agendas of the presentations will be approved by the Panel in advance to assure uniformity of coverage of the technologies put forward. The Panel may ask for expert advice on any of the considerations listed above, drawing first on the ILCSC and its expert subcommittees, then moving beyond the ILCSC as necessary and appropriate. Relevant input from the world particle physics community will be solicited.

Scientific Criteria

The technology recommended shall be capable of meeting the scope and parameters set forth by the ILCSC, in the document "Parameters for the Linear Collider", as accepted by the ILCSC on 19 November 2003.

Technical Criteria

Using the ICFA Technical Review Committee report and materials supplied by technical experts that may be called, the Panel will make its recommendation based on its judgment of the potential capabilities of each conceptual design for achieving the energies and the peak and integrated luminosities needed to carry out the currently understood scientific program, as envisioned in the ILC Parameters Document.

Schedule Criteria

Aiming for timely completion of the project, the Panel should compare milestones relating to design, engineering and industrialization for each of the two technologies being considered.

Cost Criteria

The Panel will need to know if there is a significant cost differential between the two designs being examined for completing the 500 GeV project and possibly any upgrades set forth in the ILC Parameters Document. The cost information should be based on available estimates as well as on the Panel's judgments as to the reliability or completeness of the cost estimates. The Panel needs to decide what items are to be included in the cost estimates in arriving at its own comparative analyses.

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.

Operation of the Panel

The ILCSC would like to make some suggestions regarding procedure. The Accelerator Sub-committee of the ILCSC is prepared to give an extensive tutorial on the LC. This would inform the Panel about LC issues and acquaint it with the experts from whom they can solicit advice.

Following that, visits to the major LC technology sites, in as close a sequence as possible, would help to solidify understanding of the status and issues while allowing the Panel to receive input on each technology.

To afford the Panel access to expert advice when needed, the ILCSC Accelerator Sub-committee should be in session on site at the Panel meeting place during their meetings.

It is expected that the presentation sessions will be open to the scientific and funding agency communities.

ITRP

- Six réunions
  - RAL (Jan 27,28 2004) → **Organisation, information**
  - DESY (5,6 Avril 2004)
  - SLAC (26,27 Avril 2004)
  - KEK (25,26 Mai 2004)

    → **Visite des Sites** (DESY, SLAC, KEK)
  - Caltech (28,29,30 Juin 2004) → **Début des délibérations**
  - Pohang (Corée) (11,12,13 Août 2004) → **Choix SC**

Agenda – Meeting 1
Rutherford Laboratory
January 27-28, 2004

Mise en jambes

Tuesday 27 January
Morning (9:00 – 12:30) – Meeting of the Panel, including :
•Discussion on how to organize the panel's work.
•Presentation of the ITRP charge – **Maury Tigner**.
•Telephone inputs from the **Laboratory Directors & ICFA Chair**.
•Round table – panellists present issues which they think are key to the ITRP recommendation.

Afternoon (13:30 – 18:00) - Tutorials
13:30 – 14:30 : Detector related issues – **David Miller**.
14:30 - 17:45 : X-band linear collider – **Kaoru Yokoya, Tor Raubenheimer**.
15:30 – 15:45 : Tea break

Wednesday 28 January
Morning (9:00 – 13:00) – Tutorials
9:00 – 12:15 : L-band linear collider – **Reinhard Brinkmann, Nick Walker**.
10:30 – 10:45 : coffee break.
12:15 – 13:15 : conclusions of the Technical Review Committee report – **Gerald Dugan**.

Afternoon (14:00 – 18:00) – panel discussions
Development of a plan to meet the charge.
Future meetings (places, dates).

Agenda – Meeting 2
DESY Laboratory
Monday 5 April 2004

La technologie FROIDE

1. Closed session 9:00-10:30
1.1 Introduction to the visit (15 min, **A.Wagner**) 10:30-10:45
Hall 3 (building 28,a,b)
2. **Visit** to the overall TESLA installations, **poster exhibition** 11:00-13:00
Lunch in the EXPO/FEL Hall (building 28c) 13:00-14:00
Hall 3 (building 28,a,b)
2.1 Presentations on the spot by experts 14:00-15:45
3. Presentations - part 1 16:30-18:00
Status of SC Technology **L.Lilje** (25'+5')
Operational experience with TTF **H.Weise** (25'+5')
Status of SC RF accelerators world wide experience etc, including TTF **H.Padamsee** (25'+5')

Tuesday 6 April 2004
5. Presentations - part 2 9:00-10:20
Damping Rings **W.Decking** (25'+5')
Status of RF Systems **S.Choroba** (15'+5')
Interplay between XFEL and LC **R.Brinkmann** (15'+5')
Tea/Coffee (in 1b, Foyer)
6. Restricted Session: 10:40-13:00
Industrial Fabrication of SC Cavities **D.Proch**
Overall Cost Studies **D.Trines**

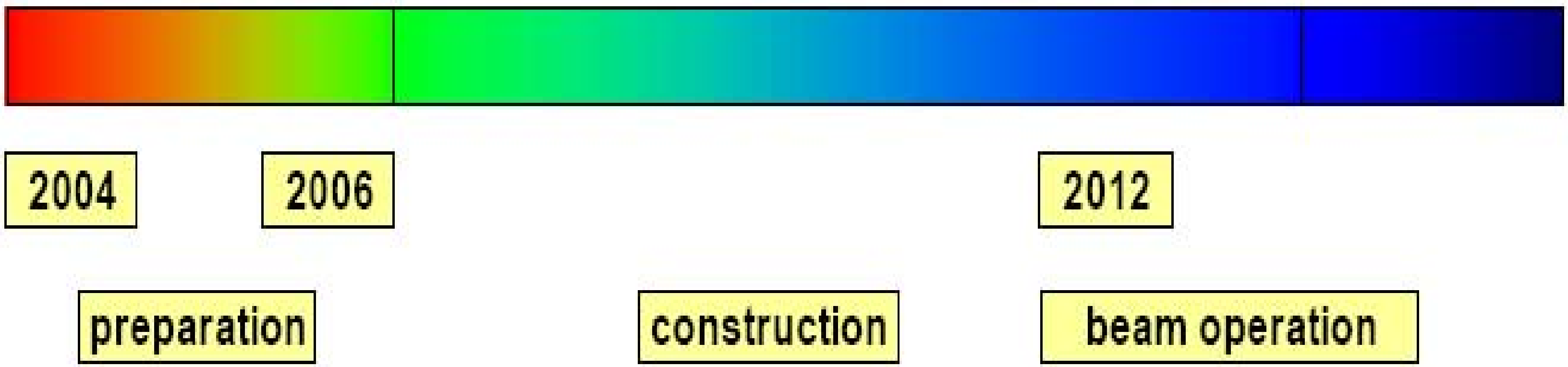
Tesla Test Facility

(à DESY)

Montage d'un module de 8 Cavités SC dans leur cryostat

XFEL à DESY

Linac de 1,5 km en technologie TESLA,
17,5 GeV @ 23Mv/m et jusqu'à 28 MV/m pour 25 GeV



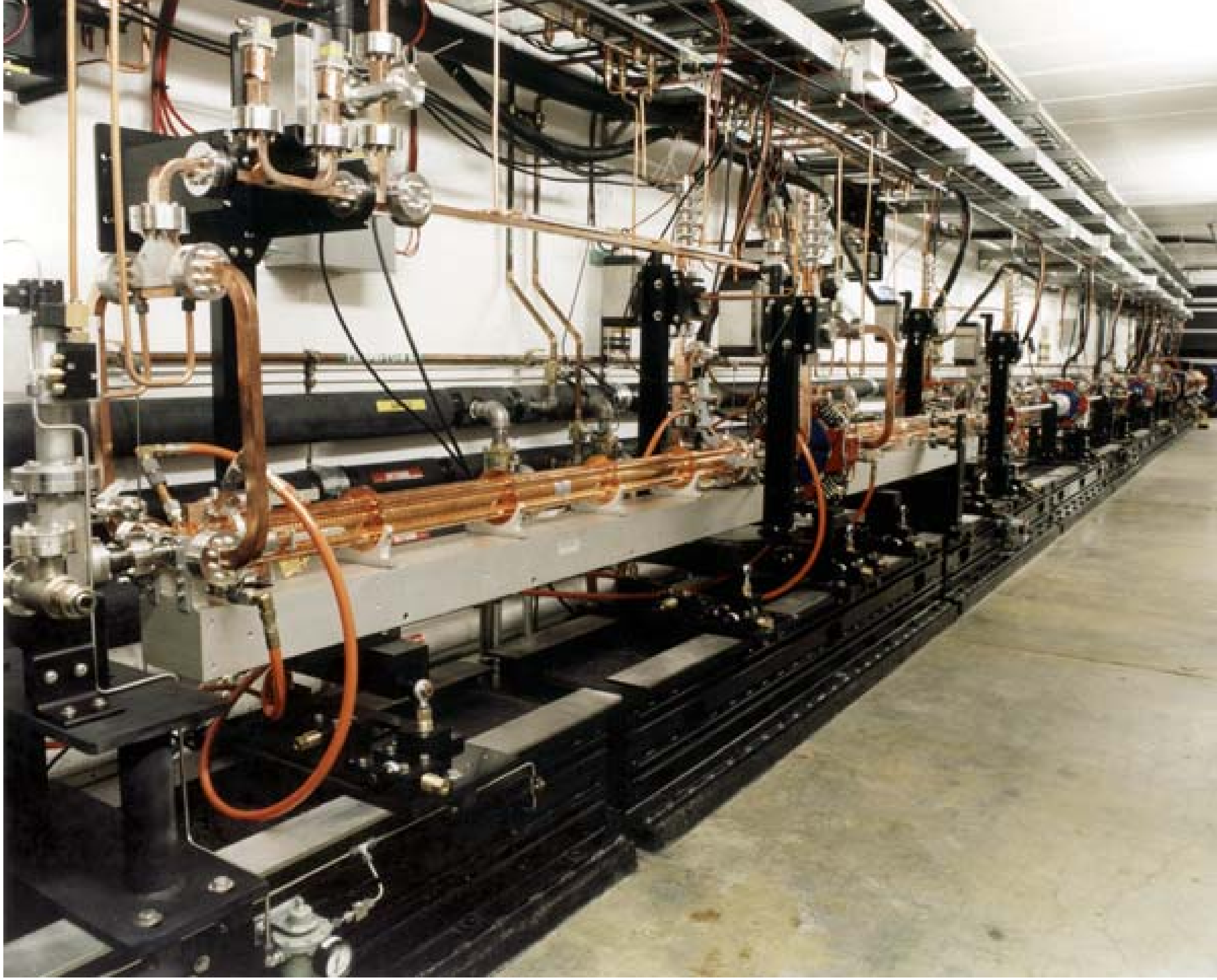
Construction dans l'industrie de 120 modules accélérateurs (~100 cavités) et 32 stations RF, ce qui requiers pratiquement **TOUT** ce qui est nécessaire pour le Collisionneur.
L'installation cryogénique est l'une des six de TESLA500.

La synergie est évidente

Agenda – Meeting 3
SLAC
April 26-27, 2004
April 26

La technologie CHAUDE

8:30	Executive session
9:00	Welcome – **Jonathan Dorfan** (15 min)
9:15	Project Introduction – **David Burke** (40 + 20 min)
10:15	Coffee Break
10:45	Collider Design and Accelerator Physics – **Tor Raubenheimer** (40 + 20 min)
11:45	RF System Overview – **Chris Adolphsen** (30 + 15 min)
12:30	Lunch in ROB
1:00	**Tour** through End Station B/**NLCTA**
3:30	Return to ROB/coffee break
3:45	Cost Evaluations and Project Engineering – **John Cornuelle** (30 +15 min)
4:30	Commissioning, Operations, and Availability – **Tom Himel** (20 +10 min)
5:00	Close out – **Jonathan Dorfan** (20 +10 min)
April 27	Closed sessions



Next
Linear
Collider
Test
Accelerator (à SLAC)

Système RF complet

Agenda – Meeting 4

KEK May 25-26, 2004

La technologie CHAUDE (suite)

Scientific Program, Day 1, May 25, 2004

8:30 - 9:00 Closed session

9:00 - 9:15 Welcome Address - **Yoji Totsuka**

9:15 - 10:00 X-band Linear Collider Overview - **Nobu Toge**

Break

10:30 - 11:15 Status and Prospects for RF Technologies - **Yong Ho Chin**

11:15 - 12:00 Status and Prospects for Test Facilities - **Hitoshi Hayano**

Lunch

13:00 - 13:45

Facilities, Manufacturing Industrialization and Cost - **Atsushi Enomoto**

14:00 - 17:30 **Posters and Tour**

Building 3 -- RF development, Site studies, Industry contributions

Assembly Hall -- ATF and GLCTA

AR-South Hall -- RF power source testing

17:30 - 18:00

Prospects of Accelerator-based Science and Technology in Asia – **Won Namkung**

18:00 - 18:15 Closing Address - Yoji Totsuka

Scientific Program, Day 2, May 26, 2004

13:30 - 14:30

Presentation on C-band collider developments - **Hiroshi Matsumoto**

Accelerator
Test
Facility
Anneau d'amortissement
(à KEK)

Obtention de l'émittance requise
Effets multibunch,
nuage d'électrons,
piégeage d'ions
Instrumentation et mesures

Caltech ITRP Meeting Agenda
Monday, June 28

CLIC

8:30 - 10:30 CLIC Presentation (**J-P Delahaye and I. Wilson**).
10:30 - 11:00 break
11:00 - 13:00 Meeting with the U.S. cold technology proponents.
Presentations by : **Steve Holmes** (FNAL),
Christoph Leemann (JLab),
Hermann Grunder (Argonne).

La technologie FROIDE (suite)

Lunch break

14:00 – 16:00 TESLA update :
- TESLA: Status and Perspectives (**Nick Walker**)
- Dark Current (**Carlo Pagani**)
- Synergy XFEL/LC (**Reinhard Brinkmann**)
- Comments concerning DESY and TESLA : (**Albrecht Wagner**)

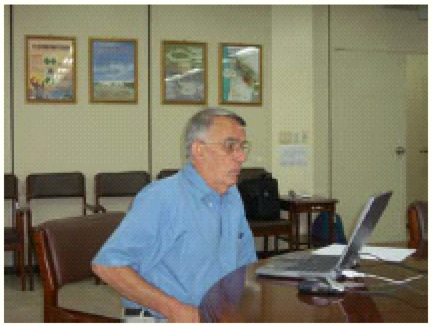
16:00 – 16:30 break

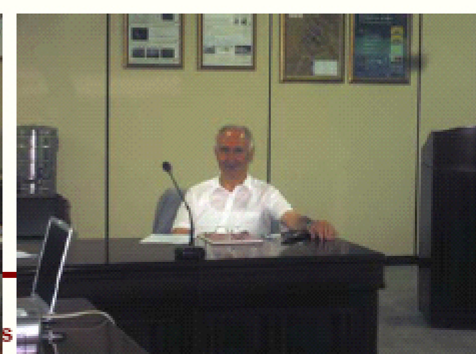
Technologie vs. Détecteurs et Physique

16:30 – 18:30 Detector and Physics Issues :
Energy Spread Issues : **Tim Barklow**
Crossing Angle : **Philip Bambade**
Bunch Timing from the Cold Perspective : **Klaus Moenig**
Bunch Timing from the Warm Perspective : **Hitoshi Yamamoto**

Deliberating in Korea

6th meeting
3 jours
session fermée





Nous avons analysé les projets au moyen d'une matrice, selon six catégories de sujets:

- Les buts et paramètres spécifiés par l'ILCSC;
- Les questions techniques;
- Les questions de coût;
- Les questions de plannings;
- Le fonctionnement pour la physique;
- Et des considérations plus générales reflétant l'impact du CL sur la science, la technique et la société

Plus spécifiquement:

-ITRP a examiné en commun et dans le détail les **réponses au questionnaire** distribué aux directeurs des trois labos.
→32 questions analysées en détail

-ITRP a ensuite discuté sa **matrice de comparaison des techniques** en traitant les points d'accord et en discutant en détail sur les points de désaccord.

- Finalement les **poids relatifs** des différentes composantes de la matrice ont été attribués par chacun, pour aboutir à une opinion individuelle.

- Les désaccords ont été résolus en votant. A un membre près, un **consensus final** a pu se dégager.

EXECUTIVE SUMMARY

Executive Summary

International Technology Recommendation Panel

Jean-Eudes Augustin, Jonathan Bagger, Barry Barish (chair),
Giorgio Bellettini, Paul Grannis, Norbert Holtkamp,
George Kalmus, G. S. Lee, Akira Masaike,
Katsunobu Oide, Volker Soergel, Hirotaka Sugawara

David Plane (scientific secretary)

19 August, 2004

1. Introduction

Particle physics stands at the threshold of discovery. The standard model gives a precise and quantitative description of the interactions of quarks and leptons. Its predictions have been confirmed by hundreds of experimental measurements. Nevertheless, experiments at accelerators and observations of the cosmos point to phenomena that cannot be explained by the standard model. Dark matter, dark energy and neutrino masses all require new physics beyond present understanding. Exploring this new frontier will be the task of twenty-first century particle physics.

The essential first step is to find the Higgs boson, or whatever mechanism takes its place. The Higgs is a revolutionary new form of matter whose interactions give mass to the elementary particles. If it exists, the Higgs should be discovered at the CERN LHC, but measuring its properties with precision will require a TeV-scale electron-positron linear collider.

1 Beyond the Higgs, strong arguments suggest that the TeV scale will be fertile ground for discovery. The LHC will open this new territory, and a TeV-scale linear collider will be necessary to explore it in detail. Higher precision leads to greater understanding and discovery. For these reasons, the global particle physics community has endorsed such a linear collider as the next major step in the field. The case for its construction is firm.

During the past decade, dedicated and successful work by several research groups has demonstrated that a linear collider can be built and reliably operated. There are two competing designs. One, developed by the TESLA collaboration, accelerates beams in 1.3 GHz (L-band) super-conducting cavities. The other, a result of joint research by the NLC and GLC collaborations, accelerates beams using 11.4 GHz (X-band) room temperature copper structures. Both R&D programs have verified the proofs of principle for the accelerating structures and the systems that drive them.

1 The critical R&D steps were reviewed in the Technical Review Committee (TRC) charged by the International Committee for Future Accelerators (ICFA) to assess the technical readiness of these designs. The essential R&D milestones identified by the TRC in its 2003 report have now been met.

In 2004, ICFA formed the International Technology Recommendation Panel (ITRP) to evaluate the two technologies and to recommend a single choice on which to base the linear collider. Our panel met six times from January to August 2004 to hear presentations by the proponents of the two projects, gather input from the wider community, evaluate the information and prepare our recommendation. We requested responses from the proponents to an extensive set of questions. We based our decision on a set of criteria that addressed scientific, technical, cost, schedule, operability issues for each technology, as well as their wider impacts on the field and beyond.

2. Recommendation and rationale

The ITRP charge specified a set of design goals for the linear collider. We found that both technologies can achieve the goals presented in the charge. Both have been pursued by dedicated and talented collaborations of physicists and engineers from around the world. Each collaboration has made important contributions that will prove essential to the successful realization of the linear collider.

The details of our assessment are presented in the body of this report. On the basis of that assessment, we recommend that the linear collider be based on superconducting rf technology. This recommendation is made with the understanding that we are recommending a technology, not a design. We expect the final design to be developed by a team drawn from the combined warm and cold linear collider communities, taking full advantage of the experience and expertise of both.

Our evaluation process focused on the major acceleration and beam transfer elements of each design. We also examined other critical components, including the damping rings and the positron source. We found that both technologies can achieve the goals presented in the charge. Each had considerable strengths.

The warm technology allows a greater energy reach for a fixed length, and the damping rings and positron source are simpler. The panel acknowledged that these are strong arguments in favor of the warm technology. One member (Sugawara) felt that they were decisive.

The superconducting technology has features, some of which follow from the low rf frequency, that the Panel considered attractive and that will facilitate the future design.

2

•The large cavity aperture and long bunch interval simplify operations, reduce the sensitivity to ground motion, permit inter-bunch feedback, and may enable increased beam current.

• The main linac and rf systems, the single largest technical cost elements, are of comparatively lower risk.

• The construction of the superconducting XFEL free electron laser will provide prototypes and test many aspects of the linac.

• The industrialization of most major components of the linac is underway.

• The use of superconducting cavities significantly reduces power consumption.

Both technologies have wider impact beyond particle physics. The superconducting rf technology has applications in other fields of accelerator-based research, while the X-band rf technology has applications in medicine and other areas.

3. The next steps

The choice of the technology should enable the project to move forward rapidly. This will require the engagement of both cold and warm proponents, augmented by new teams from laboratories and universities in all regions. The experience gained from the Stanford Linear Collider and Final Focus Test Beam at SLAC, the Accelerator Test Facility at KEK, and the TESLA Test Facility at DESY will be crucial in the design, construction and operation of the machine. The range of systems from sources to beam delivery is so extensive that an optimized design can only emerge by **pooling the expertise of all participants.**

The machine will be designed to begin operation at 500 GeV, with a capability for an upgrade to about 1 TeV, as the physics requires. This capability is an essential feature of the design. Therefore we urge that part of the global R&D and design effort be focused **on increasing the ultimate collider energy to the maximum extent feasible**.

We endorse the effort now underway **to establish an international model for the design, engineering, industrialization and construction of the linear collider.** Formulating that model in consultation with governments is an immediate priority. **Strong central management will be critical from the beginning.**
A TeV scale electron-positron linear collider is an essential part of a grand adventure that will provide new insights into the structure of space, time, matter and energy. We believe that the technology for achieving this goal is now in hand, and that the prospects for its success are extraordinarily bright.

***

- **In Beijing, the ILCSC and ICFA met to review the ITRP recommendation.**

ITRP Chair made a presentation accompanied by a 2.5 page Executive Summary that encapsulates the recommendation

ICFA/ILCSC
unanimously
endorsed the recommendation

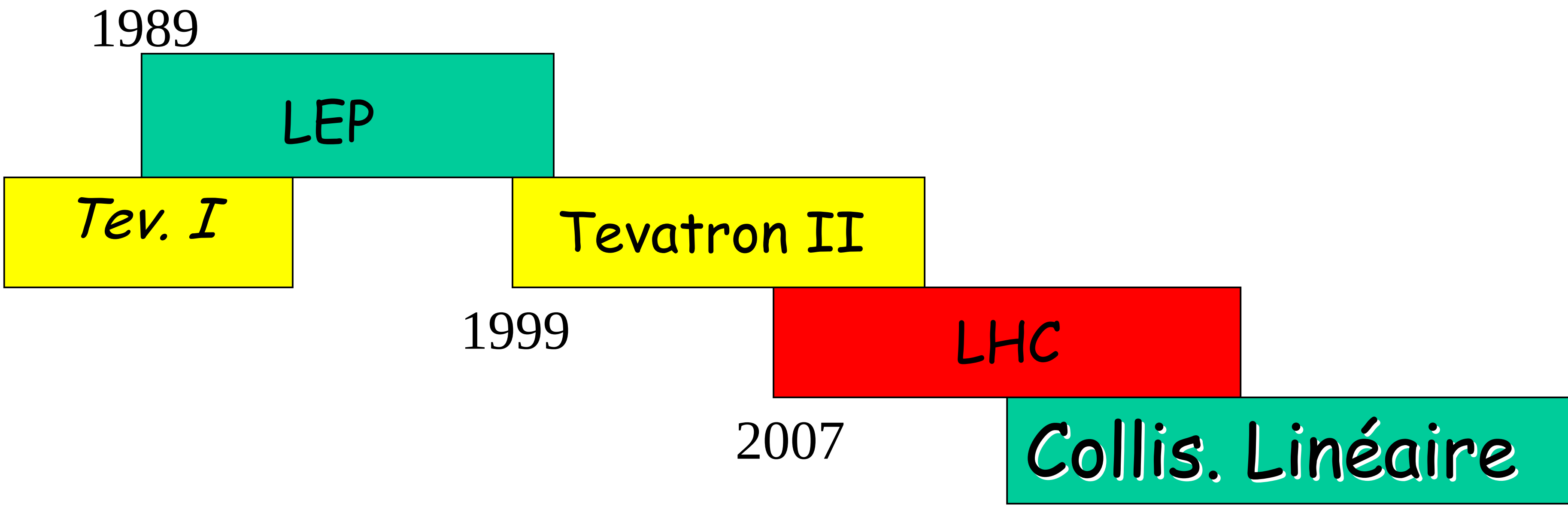
J.Dorfan, ICFA Chair, Beijing 2004

We Live in Extraordinary Times

- Just as it did with the LHC in the 1990's, ICFA has a very strong focus on facilitating the wishes of the worldwide HEP community – in this era of the 2000's it is to establish a fully international TeV Linear Collider
- At no time in the history of particle physics has the scientific landscape presented us with such an exciting spectrum of unanswered questions! The LHC will make major discoveries that challenge that agenda, but to engage the fullness of the scientific quest will take discoveries from a companion TeV Linear Collider
- The stage is now set to proceed forward to realize expeditiously an international design for a TeV linear collider…………

…..ICFA encourages the international HEP community to unify enthusiastically in support of this exciting mission

Conclusion



~2015 *L'avenir de la physique des particules*