The Status of the International Linear Collider

Brian Foster (Oxford & GDE)

Symposium on *Physics of Elementary Interactions in the LHC Era*

Warsaw, 22/4/08

The future of particle physics

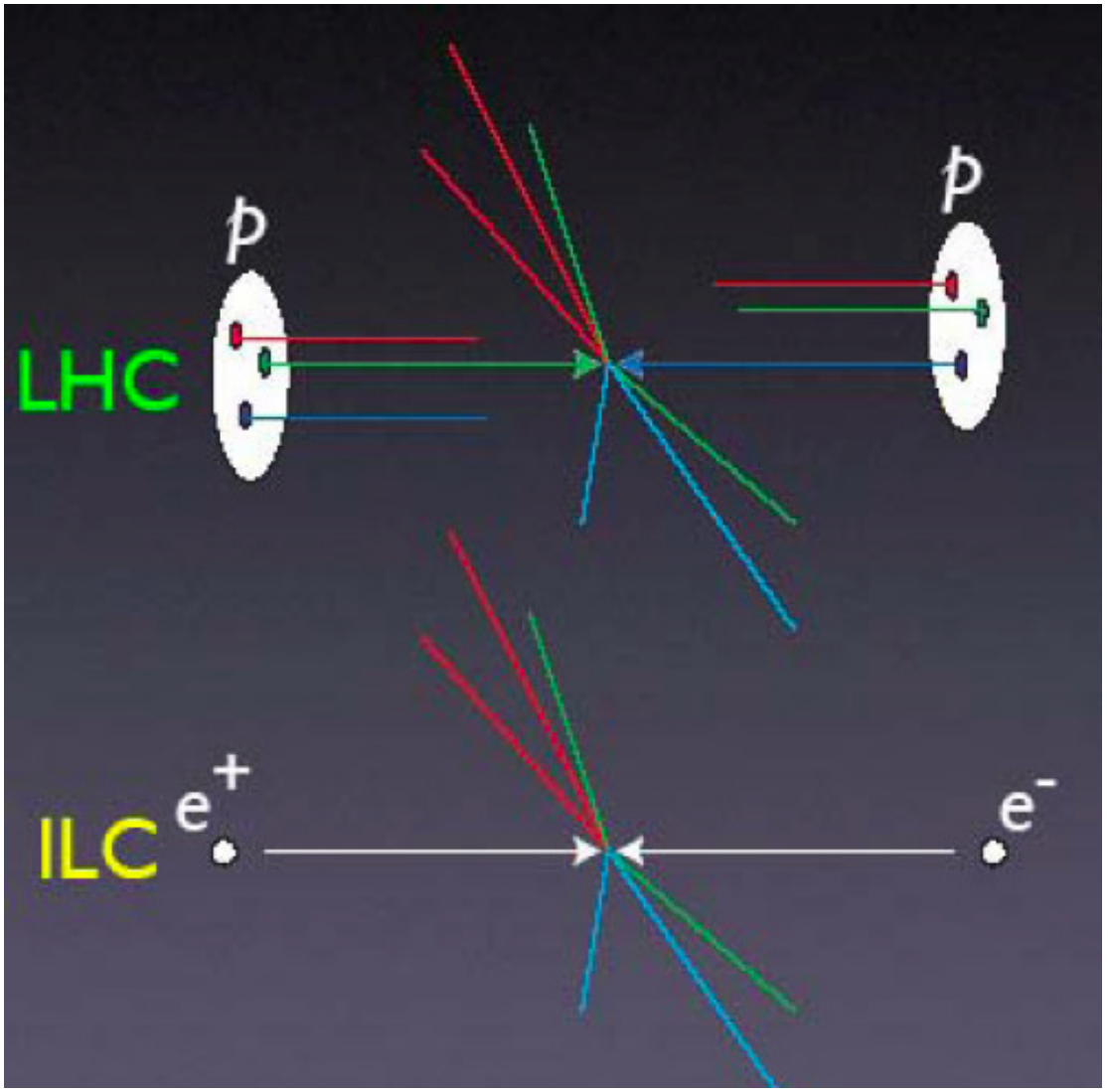
- **The LHC will open up a new world - what it finds will be stranger and more wonderful than any of our theories.**
- **We must exploit its results to ensure the future of particle physics for our lifetime.**
- **The *main* broad thrusts of the future are clear - energy frontier and neutrinos.**
- **The LHC should expose a rich vista - to understand it we need a complementary, precision, affordable e^+e^- machine and we need it as soon as possible.**

Why e^+e^- ?

- **Simple particles**
- **Well defined:**

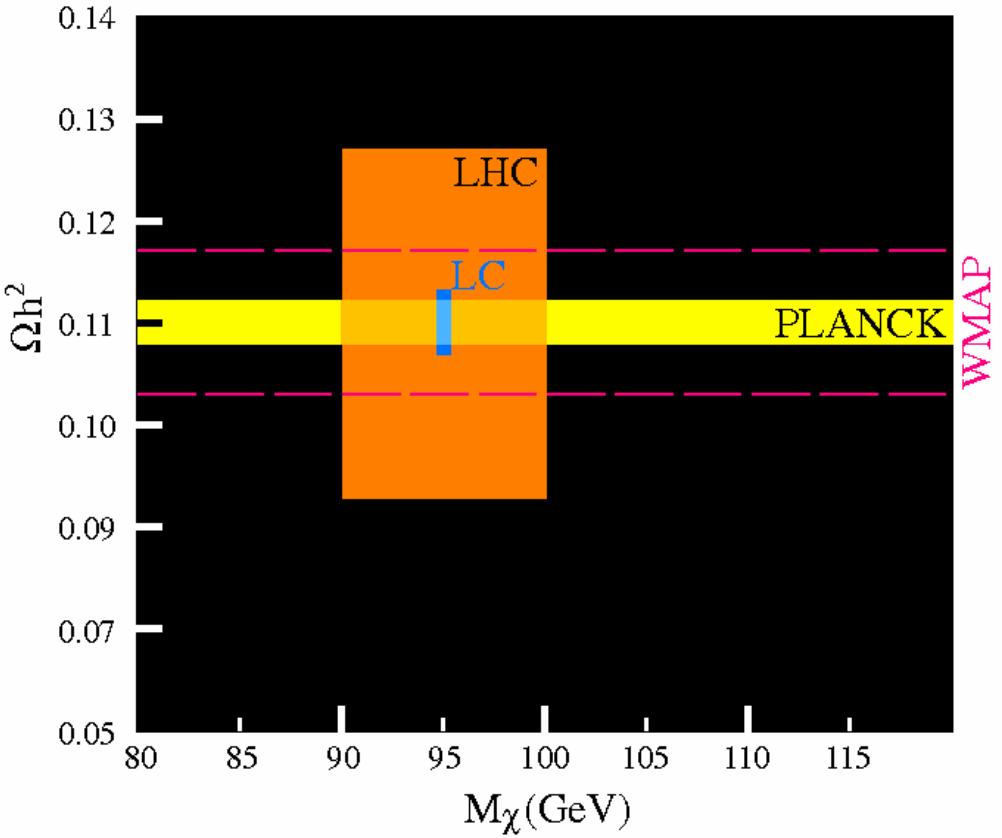
energy
angular momentum

- **E can be scanned precisely**
- **Particles produced democratically**
- **Final states generally fully reconstructable**



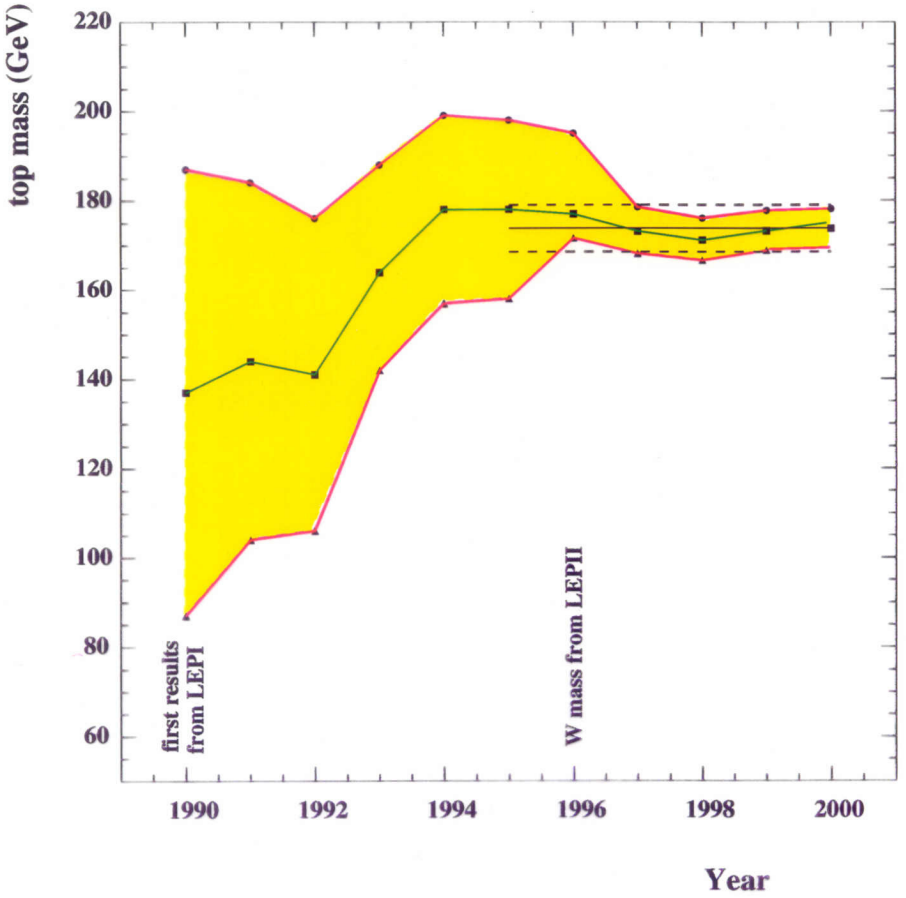
Why/what is ILC?

- Why do we want to build a high-energy e^+e^- collider?
- Physics case rests on three legs:known phenomena that ILC will definitely study-
  - top quark;
  - the Higgs: for which there is very strong indirect evidence and if LHC doesn't find it then ILC will be essential to understand why;
  - new particles for which there is very strong theoretical prejudice



Why/what is ILC?

- **Furthermore the high precision of e^+e^- means that it is sensitive to phenomena far above its CM energy because of quantum corrections – as LEP proved.**



ILC Parameters

- **E_{cm} adjustable from 200 – 500 GeV**
- **Luminosity $\int L dt$ = 500 fb^{-1} in 4 years**

  (corresponds to $2*10^{34}$ cm^{-2} s^{-1})
- **Ability to scan between 200 and 500 GeV**
- **Energy stability and precision below 0.1%**
- **Electron polarization of at least 80%**
- **The machine must be upgradeable to 1 TeV**

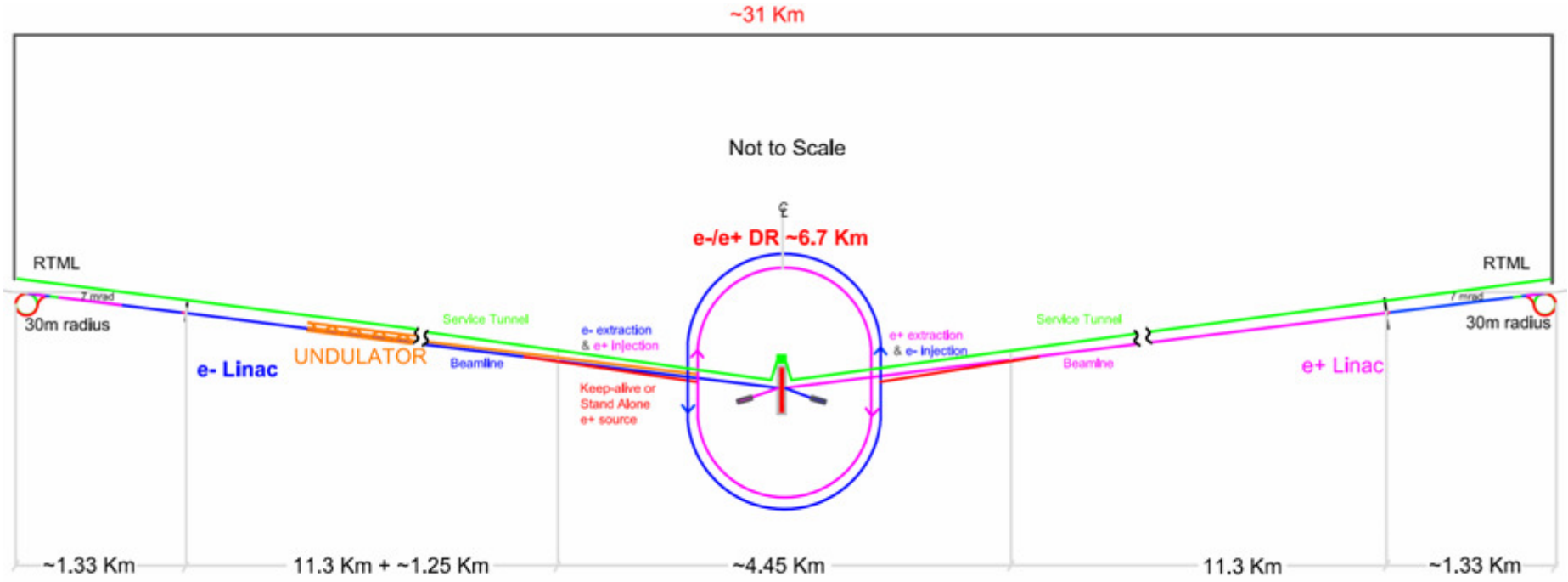
Global Design Effort Mission

- Produce a design for the ILC that includes a detailed design concept, performance assessments, reliable international costing, an industrialization plan, siting analysis, as well as detector concepts and scope.
- Coordinate worldwide prioritized proposal driven R & D efforts (to demonstrate and improve the performance, reduce the costs, attain the required reliability, etc.)
- B. Barish is GDE Director, assisted by 3 regional directors: BF (Europe); M. Nozaki (Asia); M. Harrison (Americas). New GDE (> 30% FTE)- currently 480 GDE members worldwide.

Overall Layout @ RDR

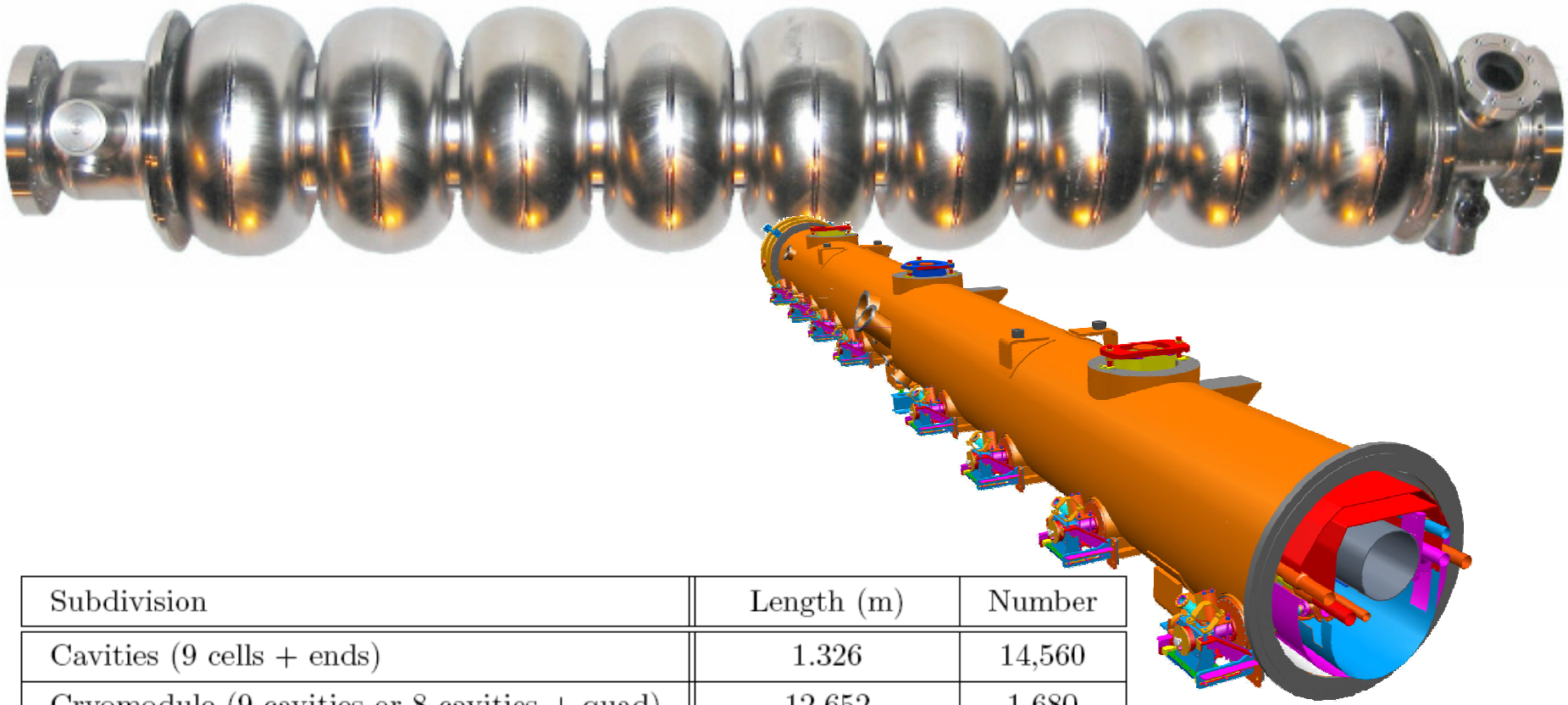
Reference design completed last August.

1st Stage: 500 GeV; central DR et al. campus; 2 “push-pull” detectors in 14 mrad IR.



Schematic Layout of the 500 GeV Machine

ILC's Workhorse - SCRF



Subdivision	Length (m)	Number
Cavities (9 cells + ends)	1.326	14,560
Cryomodule (9 cavities or 8 cavities + quad)	12.652	1,680
RF unit (3 cryomodules)	37.956	560
Cryo-string of 4 RF units (3 RF units)	154.3 (116.4)	71 (6)
Cryogenic unit with 10 to 16 strings	1,546 to 2,472	10
Electron (positron) linac	10,917 (10,770)	1 (1)

RDR cost estimate

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)

Σ Value = 6.62 B ILC Units

The reference design was "frozen" on 1-12-06 for RDR production, including costs.

Important to realise this is a snapshot; design will continue to evolve, due to R&D, accelerator studies & value engineering.

The value costs have already been reviewed many times; all reviews have been very positive and generally consider there is scope for further cost reductions.

EDR phase

- The period between August and December 07 was one of intensive internal reorganisation and preparation for the EDR phase.

- Installation and staffing of the Project Management Office, led by PM 'Troika' :M.Ross (Fermilab) (Chair), N. Walker (DESY) & A. Yamamoto (KEK).

- All positions in project office filled.

EDR phase - technical areas

- The R&D will be divided into 15 technical areas:

	Technical Area		
	1. Superconducting RF Technology	2. Conventional Facilities & Siting and Global Systems	3. Accelerator Systems
Technical Area Groups	1.1 Cavity Processing	2.1 Civil Engineering and Services	3.1 Electron Source
	1.2 Cavity Production and Integration	2.2 Conventional Facilities Process Management	3.2 Positron Source
	1.3 Cryomodules	2.3 Controls	3.3 Damping Ring
	1.4 Cryogenics		3.4 Ring To Main Linac
	1.5 High Level RF		3.5 Beam Delivery Systems
	1.6 Main Linac Integration		3.6 Simulations

Yamamoto Ross Walker

“Black December”

- “Black December” saw UK funding agency, STFC, withdraw from ILC. In unrelated move, US cut funding in FY08 – in principle closing it down for remainder of FY.
- However, enough US money remained unspent to permit GDE Common Fund to be paid and the GDE organisation to remain in being.
- Nevertheless, this has been a major blow to the project.

FALC Meeting

- FALC met 17/18.1.2008 & confirmed that the physics motivation for a linear collider remains unchanged.
- The R&D underway in all three regions is fulfilling an important mission to establish the feasibility and technology necessary for the next large collider.
- FALC recognized that funding stability is the key to any international collaborative effort so none of the partners' investment is jeopardized.

ICFA/ILCSC Meeting

- ICFA Statement on Funding for the Linear Collider

- ICFA expresses its deepest concern about the recent decisions in the United Kingdom and the United States of America on spending for long-term international science projects…..

ICFA/ILCSC Meeting

- …the sudden cuts implemented by two partner countries have devastating effects.
- ICFA feels an obligation to make policy makers aware of the need for stability in the support of major international science efforts.
- It is important for all governments to find ways to maintain the trust needed to move forward international scientific endeavours.

ILC in Europe

- Agreement to continue LC programme in UK @ ~ 25% of previous. Spain signed MoU.
- HiGrade is for “Preparatory Phase” and is intended for projects on the ESFRI Road Map.
- We have now agreed the boundaries of the project, EU starting documents received – started on Feb 1st. “Site selection & governance” is ~ 50% of effort; remainder in SCRF and cavity production on back of XFEL.
- EUCARD - “Son of EuroTeV” - submitted – substantial request joint ILC-CLIC “generic” LC development. Lots of competition.

ILC in US

- The only thing predictable about the US pp budget is that it is unpredictable.
- However, signs seem positive. GDE request for DoE budget line increased from 30M (50% of the level hoped for after Black December) to 31.5M. MH has detailed plan for restoring work in FY09.
- Now working its way through Congressional process
- But election year –may have to survive on continuing resolution until ~ Feb?

ILC in Asia

- Japanese budget still dominated by construction and completion of JPARC. Firm commitment to ILC R&D & TDR phase.

Federation of Diet Members for promotion of the ILC project

- Built in 2006 (June 15th):
- Members: At present more than 60 Diet members.
- Chair: Mr. Kaoru Yosano (former Cabinet Secretary, Minister of MEXT, METI,,,)
- Secretary: Mr. Takeo Kawamura (former Minister of MEXT)

- India has joined MoU for GDE Common Fund.
- Discussions with Chinese political leaders @ GDE Beijing meeting last November

GDE response - the Technical Phase

- The last 4 months have been ones of turmoil and substantial rethinking.
- ALL of the major areas developed by the RDR were led by US or UK scientists.
- It can't be business as usual when such a large fraction of resources lost ~ 30 FTEs in UK – round £3M/year from UK - $60M -> $15M in US.
- New plan for TD phase concentrates and reduces work and lengthens timesales.

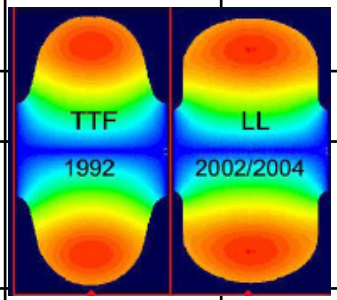
GDE response - the Technical Phase

- Particular concentration in early phase of TP is on cost reduction. Task forces at Sendai met for two days looking at very many ideas – some crazy, some obvious – as to how to reduce the cost of the RDR machine significantly.

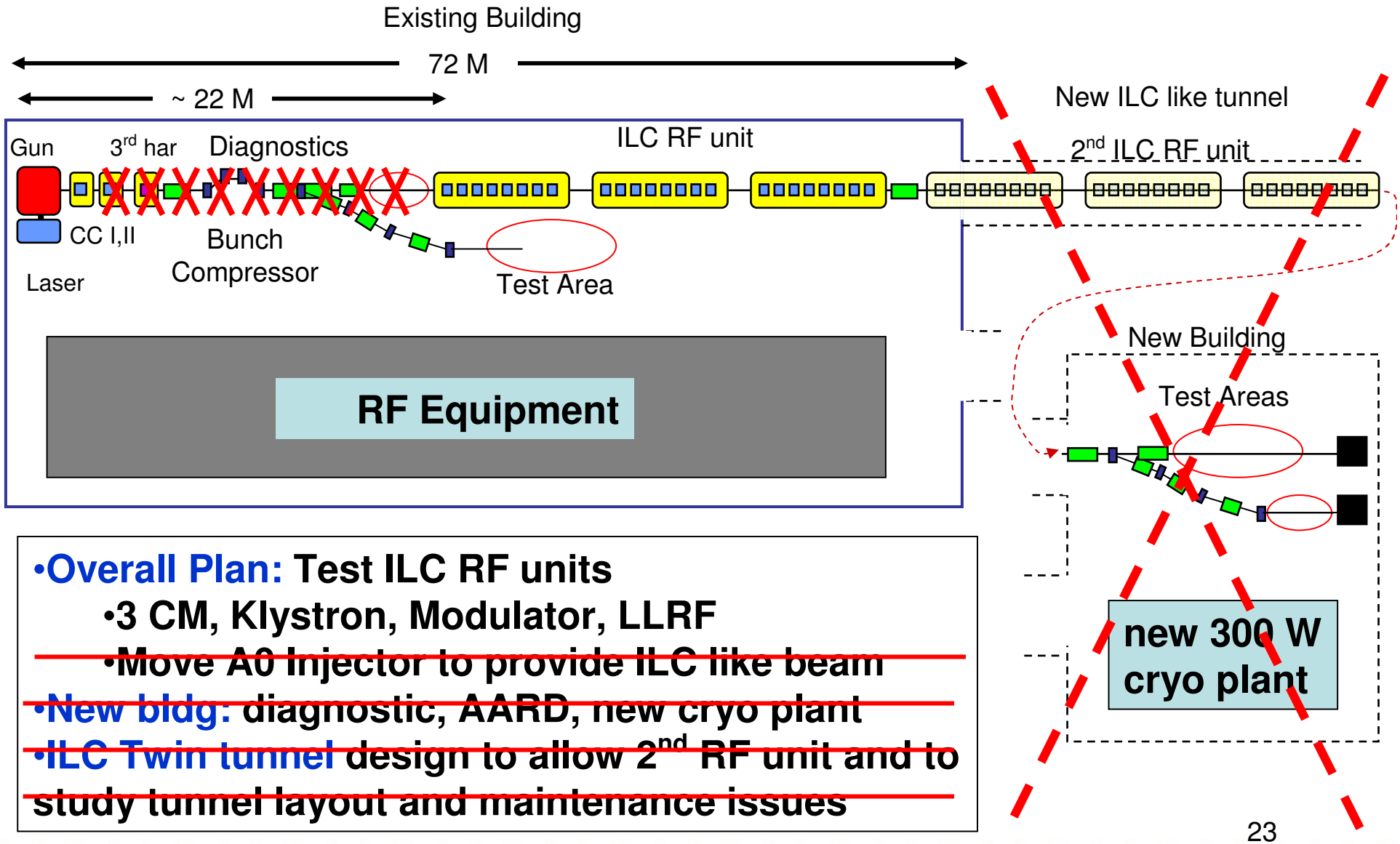
- Will continue to be a priority at future meetings.

TDP R&D - SCRF

Calender Year		2008	2009	2010	2011	2012
EDR	TDP1				TDP-II	
S0: Cavity Gradient (MV/m)	30		35 (> 50%)			35 (>90%)
KEK-STF-0.5a: 1 Tesla-like/LL						
KEK-STF1: 4 cavities						
S1-Global (AS-US-EU) 1 CM (4+2+2 cavities)			CM (4_{AS}+2_{US}+2_{EU}) <31.5 MV/m>			
S1(2) -ILC-NML-Fermilab CM1- 4 with beam			CM2	CM3	CM4	
S2:STF2/KEK: 1 RF-unit with beam			Fabrication in industries		STF2 (3 CMs) Assemble & test	



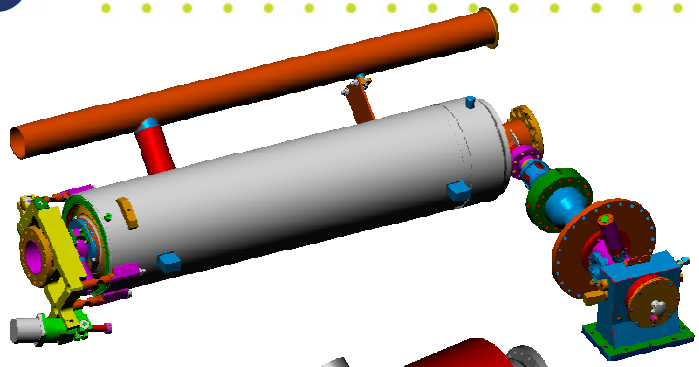
TDP R&D - SCRF

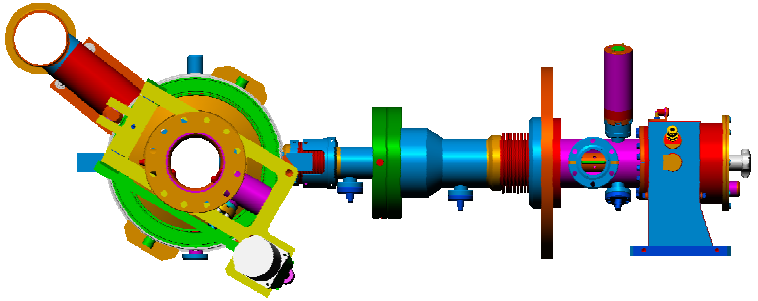


- **Overall Plan: Test ILC RF units**
  - **3 CM, Klystron, Modulator, LLRF**
  - **Move A0 Injector to provide ILC like beam**
- **New bldg: diagnostic, AARD, new cryo plant**
- **ILC Twin tunnel design to allow 2nd RF unit and to study tunnel layout and maintenance issues**

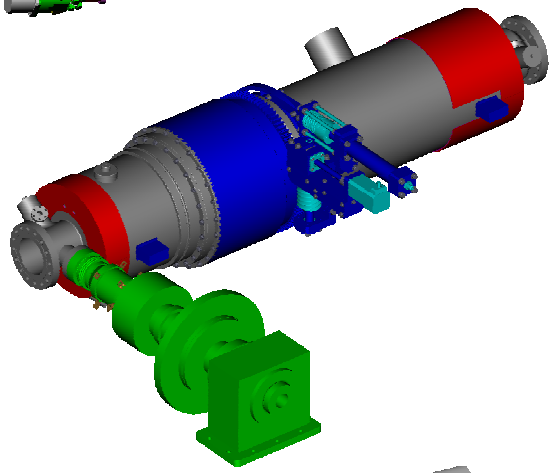
TDP R&D - SCRF

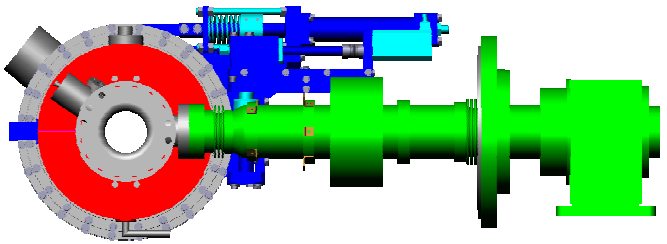
DESY



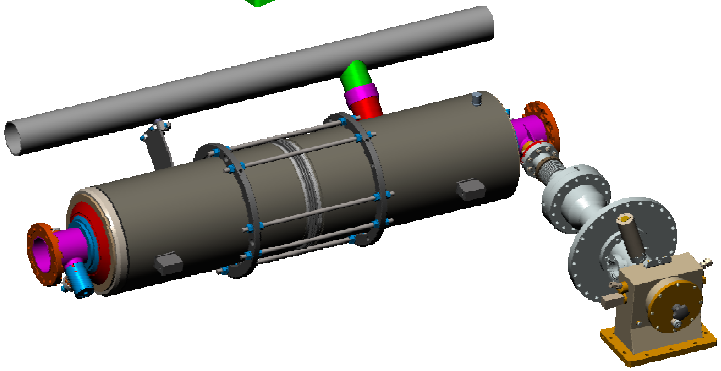


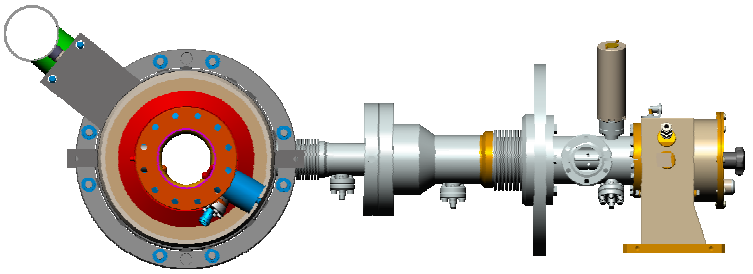
KEK



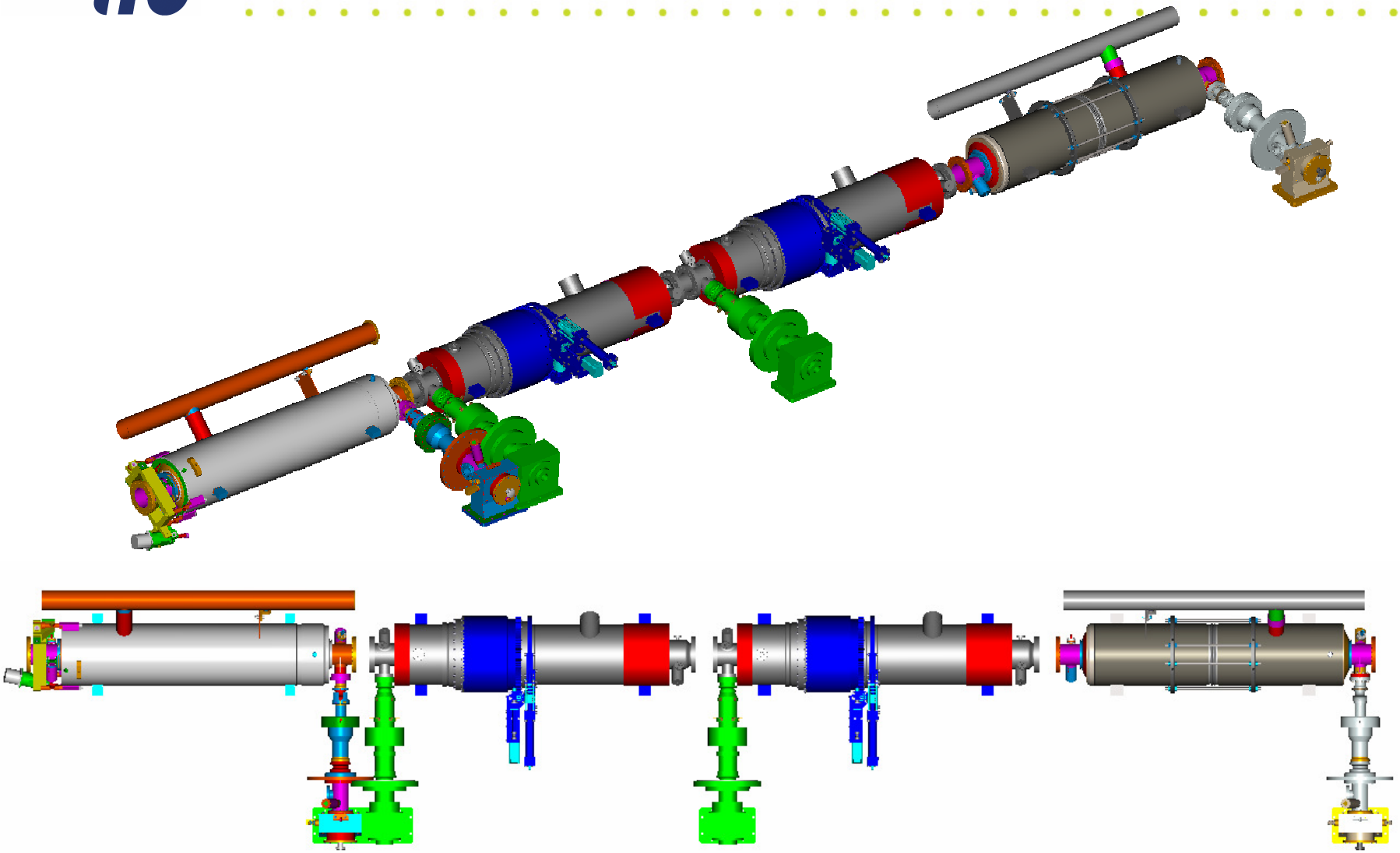


FNAL





TDP R&D - SCRF

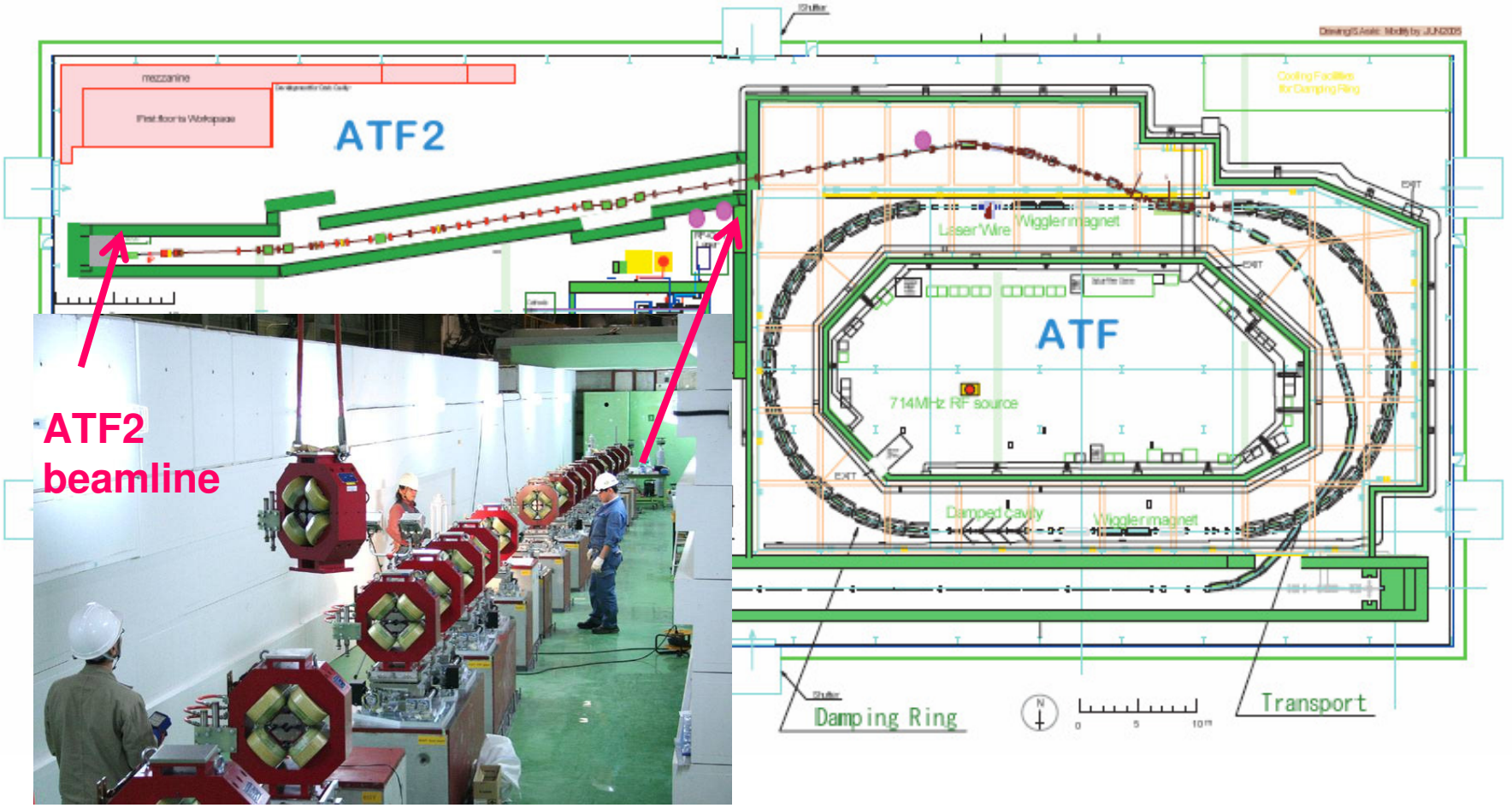


TDP R&D – BDS/MDI

- Perhaps group most strongly affected by “Black December” – dominated by UK/US.
- A great deal will have to be put on hold – but work is continuing on highest priority issues.
- ATF2 in KEK due to come on line in Oct! Will be of major importance for BDS studies and much more!

TDP R&D – BDS/MDI

- ATF collaboration > 200 scientists, 20 institutions. ATF2 designed for ILC.



TDP R&D – DR

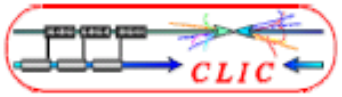
- One of areas where significant critical R&D remains to be done – if particular in properties and defences against electron-cloud effect.

- CESR-TA project

(funding ~agreed from NSF with some matching funds from DoE)

ILC-CLIC synergy

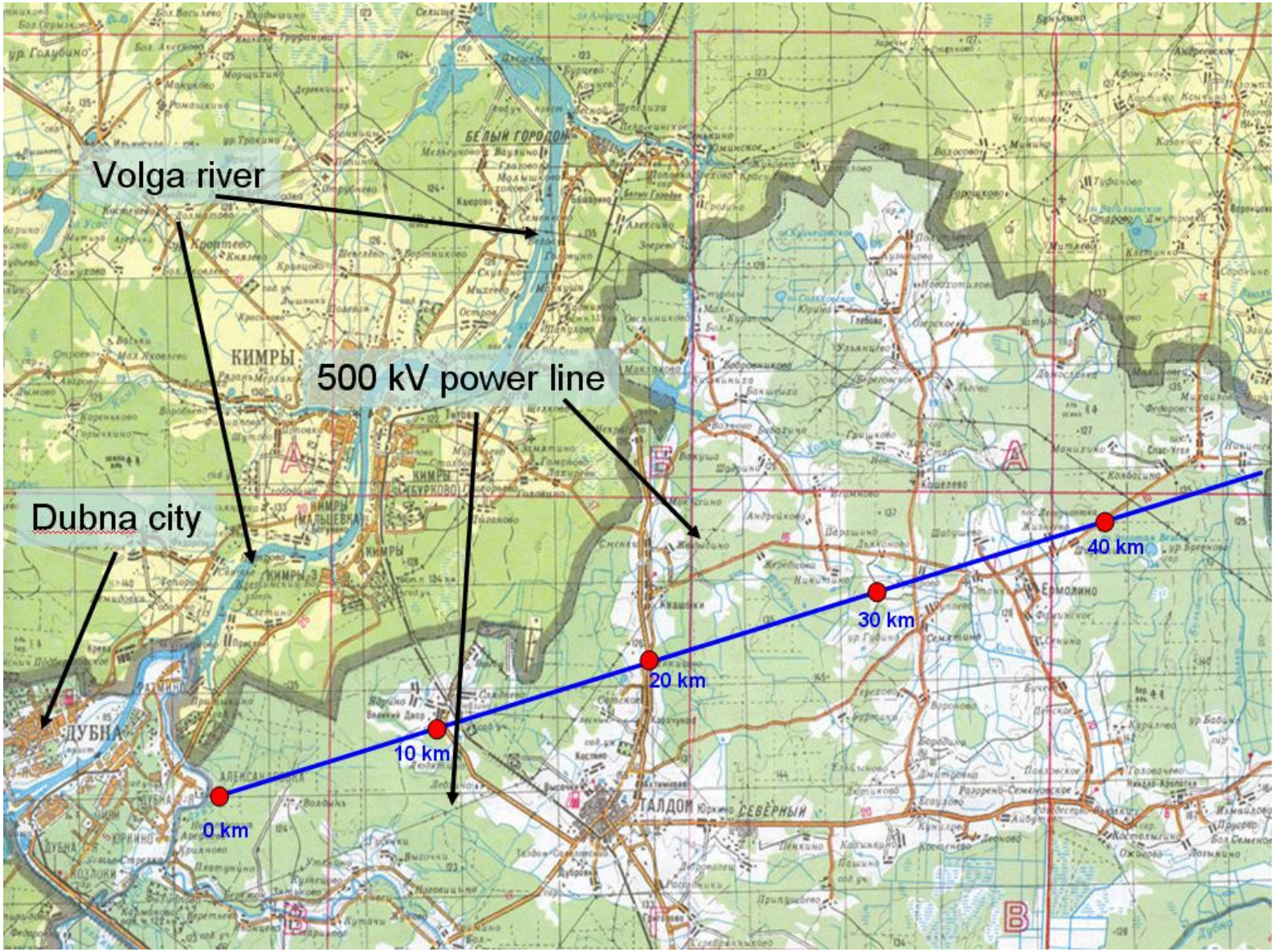
- Meetings going on and planned before "Black December". Latest @ CERN in Feb.



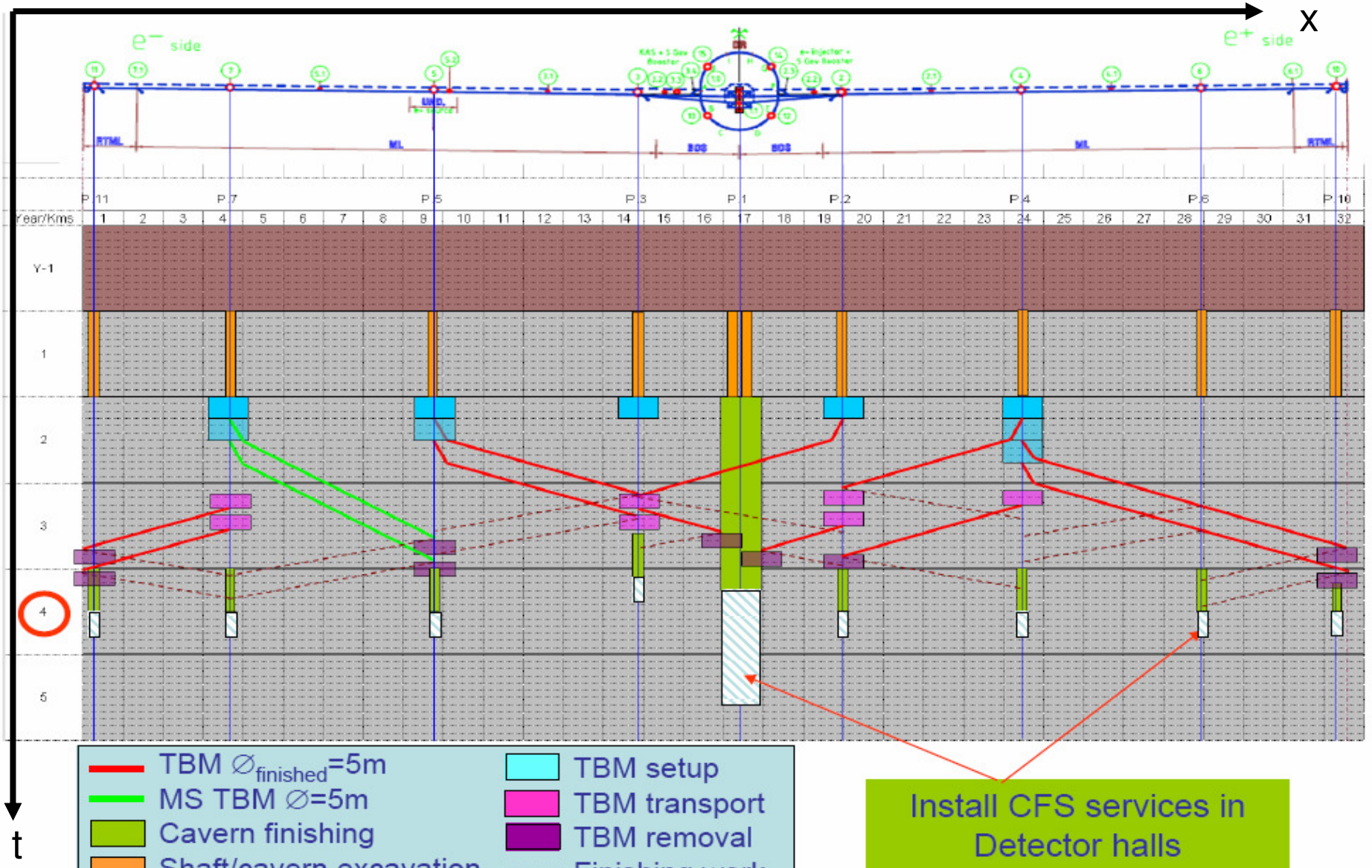
Conclusions - CFS

- Interaction Area is obvious area where resources can be shared
- Civil Engineering models can be worked on 'in parallel' for ILC & CLIC.
- Other possible areas of collaboration in the TS area : Ventilation, Electricity, Handling….
- Resources to be defined, if limited, then perhaps Joint 'Value Engineering' exercises could be the way forward, rather than full blown studies…..
- First milestone : At Sendai meeting develop deliverables for 2008 for ILC Value Engineering and ILC/CLIC common efforts
- Identify link persons for highlighted areas
- CFS Video meetings will continue with possible CLIC input on specific subjects

Next GDE plenary – Dubna 6/08



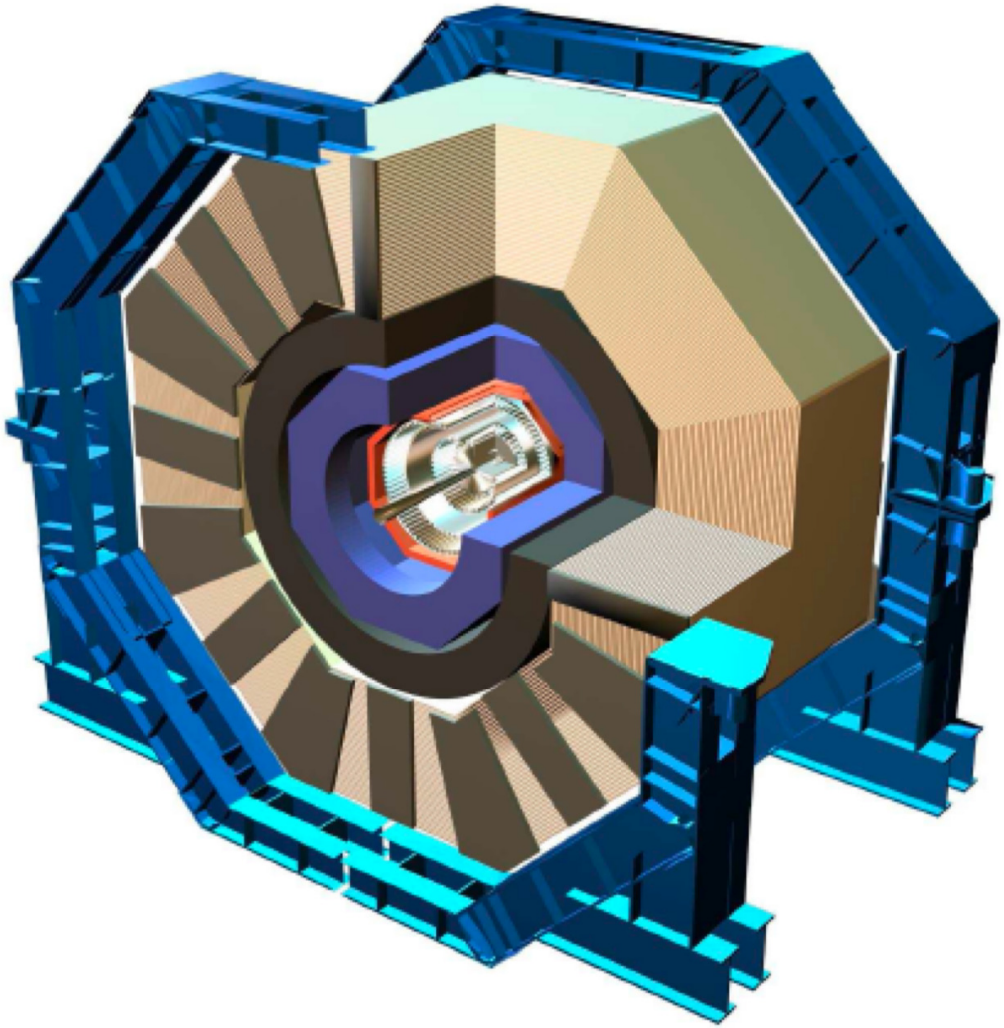
Civil Construction Timeline



Detectors - SiD

Design philosophy

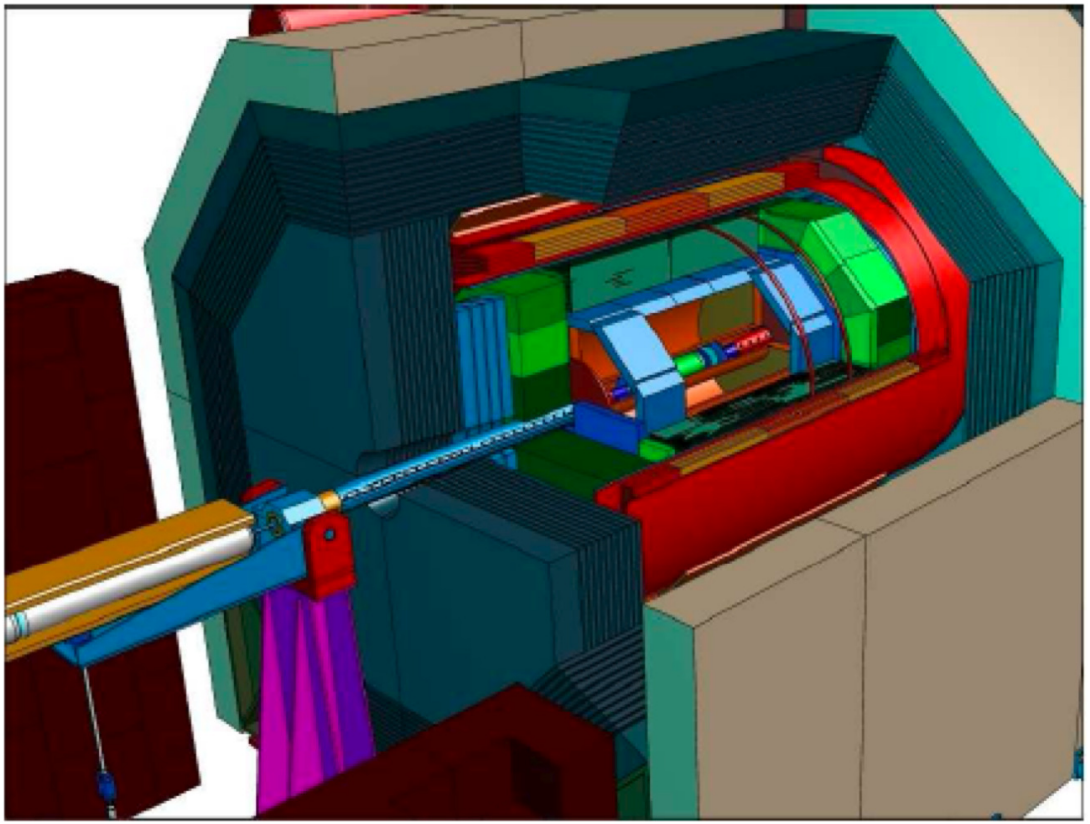
- Aim for SiW calorimeter with best possible resolution
- Keep radius small to make this affordable
- Compensate by high B-field (5 T) and very precise tracking (Si)
- Fast timing of Silicon to suppress background



Detectors - ILD

Design philosophy

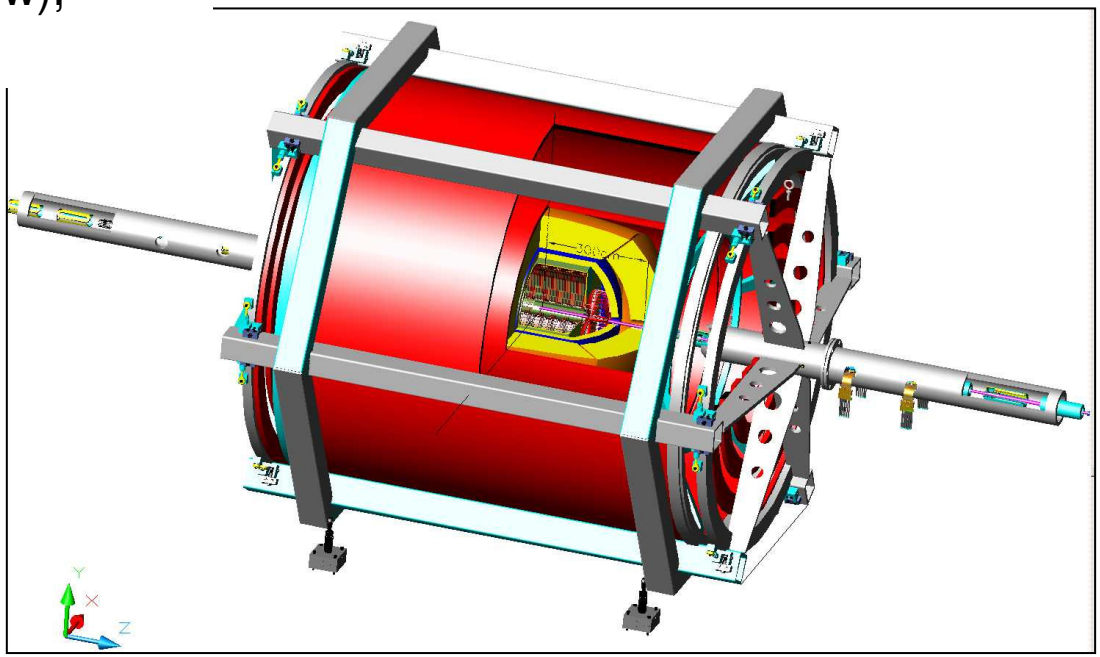
- Fine resolution calorimeter for particle flow
- Gaseous tracking for high tracking efficiency and redundancy
- Large enough radius and high enough B-field (B=4 T) to get required momentum resolution



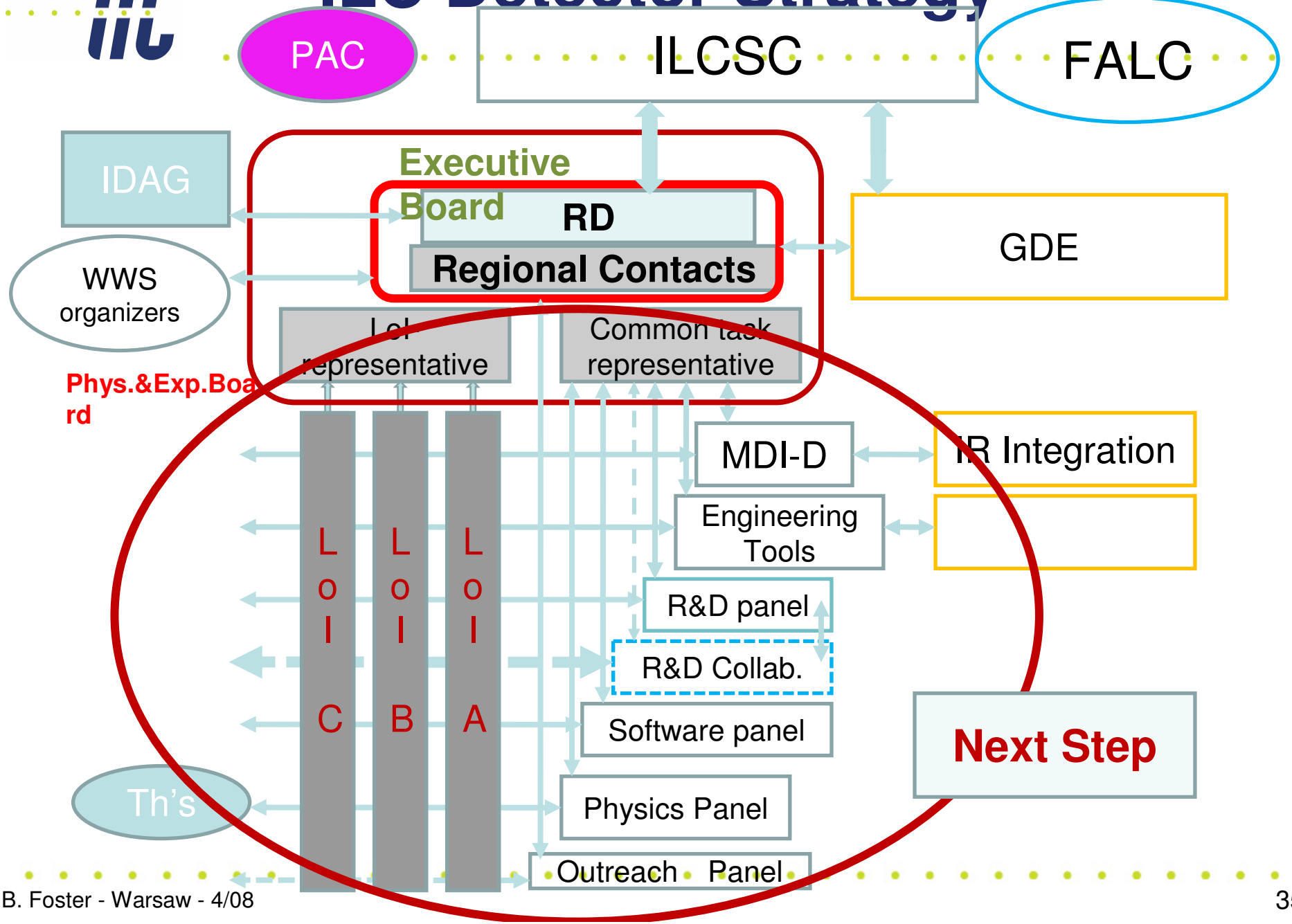
(NB – above is actually LDC detector!)

Detectors - 4th concept

- Pixel Vertex (PX) 5-micron pixels
- Drift chamber based on CHLOE design
- Crystal dual-readout ECAL
- Triple-readout fiber HCAL:
  scintillation/Cerenkov/neutron (new)
- Muon dual-solenoid geometry (new),
  with ATLAS drift tubes.



ILC Detector Strategy



Summary

- "Black December" a major setback to the prospects of the ILC particularly in UK & US
- It has precipitated a major rethink of the way forward and we now have a new plan.
- Many details need to be resolved to get all the R&D back on the road in a coherent way.
- No sign of any "domino" effect; promising efforts to restore significant efforts in UK & US and new countires committing to MoUs. Strong determination among all to stay the course and produce design for this machine.