ILC Detector R&D

Tracking Review 5-8 February 2007

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RAL

On behalf of the ILC Detector R&D Panel
(a Panel of the World-Wide Study Organising Committee)

(Jean-Claude Brient, Chris Damerell, Ray Frey, Dean Karlen, Wolfgang Lohmann, Hwanbae Park, Yasuhiro Sugimoto, Tohru Takeshita, Harry Weerts)

Committee membership

- **Panel members: Chris Damerell, Dean Karlen, Wolfgang Lohmann, Hwanbae Park, Harry Weerts**
- **External consultants: Peter Braun-Munzinger, Ioanis Giomataris, Hideki Hamagaki, Hartmut Sadrozinski, Fabio Sauli, Helmuth Spieler, Mike Tyndel, Yoshinobu Unno**
- **Regional representatives: Jim Brau, Junji Haba, Bing Zhou**
- **RDB chair: Bill Willis**
- **Local tracking experts: Chen Yuanbo, Ouyang Chun**
- **Admin support: Naomi Nagahashi, Maura Barone, Maxine Hronek, Xu Tongzhou**

Overview of these reviews

- **To be included in every regional workshop from now on:**
  - **Beijing (Feb ’07) Tracking**
  - **DESY (LCWS June ’07) Calorimetry**
  - **Fermilab (Oct ’07) Vertexing**
  - **Asia (Feb ‘08) PID, muon trkg, solenoid, beam diagnostics, DAQ**
- **Our responsibility is to work with the R&D collaborations to ensure that the feasibility of the critical goals can be demonstrated by 2010-2012**
- **This means (for tracking) that the community can be confident that the option they choose will satisfy the challenging physics needs**
- **We are currently far from this position, for all tracking options**

What is at stake

Tracking technology	Detector A	Detector B
Gaseous + Silicon	?	?
All Silicon	?	?

It could be that both detector tracking systems will work well, or one well and one badly, or both badly. How to achieve the first outcome? (maybe *not* by following the easy compromise of 'one of each technology')

- **Caution! Past glittering track record of established technologies may not be the best guide …**
- **SLC Experiments Workshop 1982, only 7 years before SLC turn-on**
- **A premature technology choice could have ruined the physics programme**
- **Fortunately, Marty B and others supported R&D on the Si pixel 'alternative', which (just in time) proved to be viable**

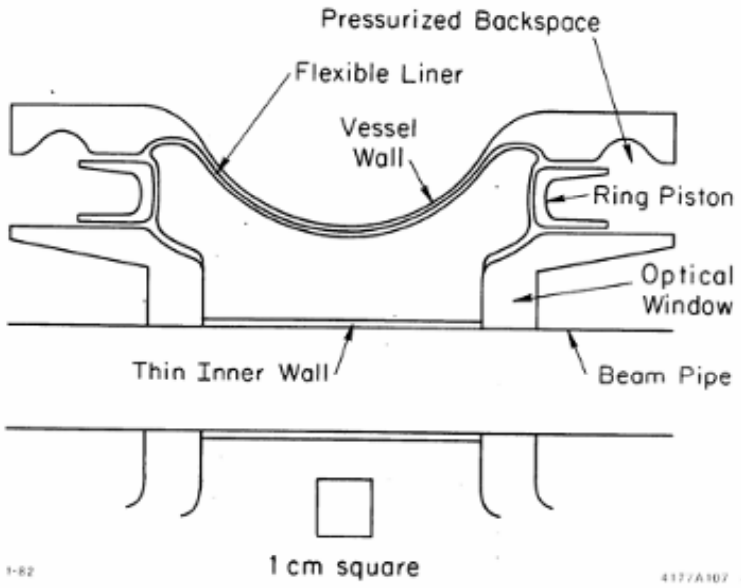
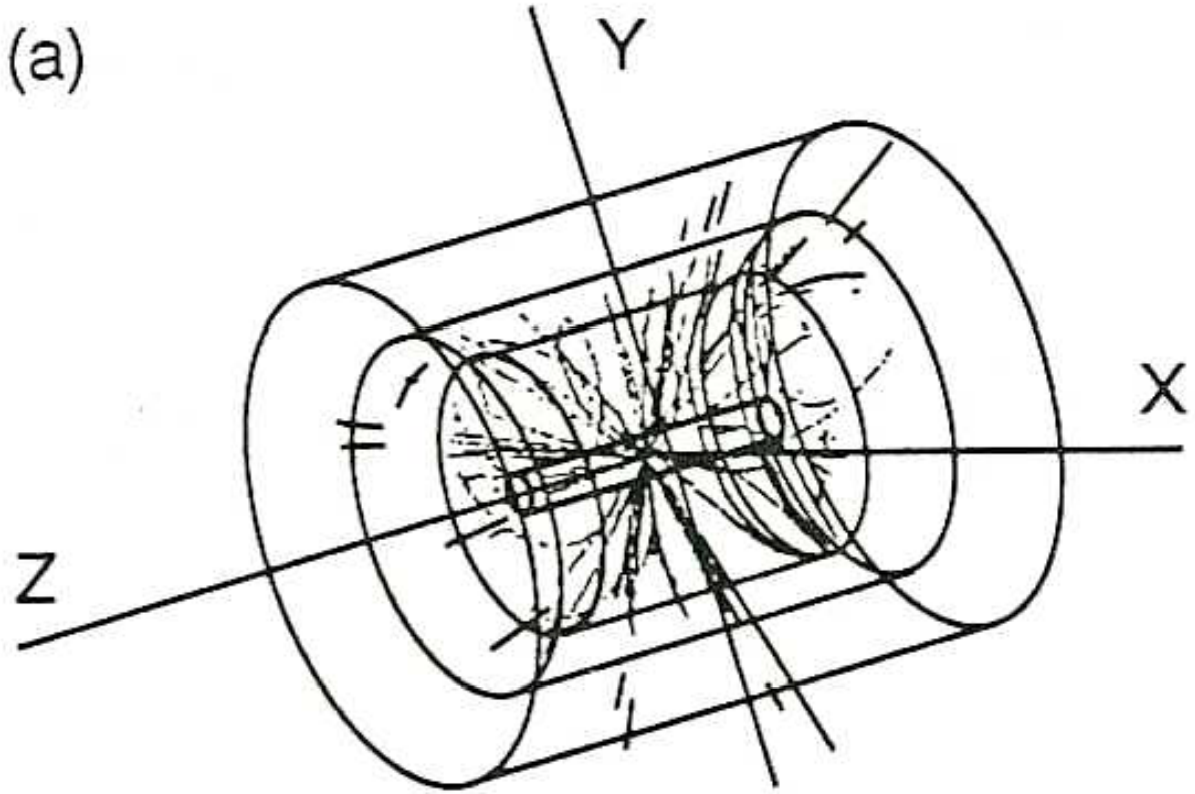
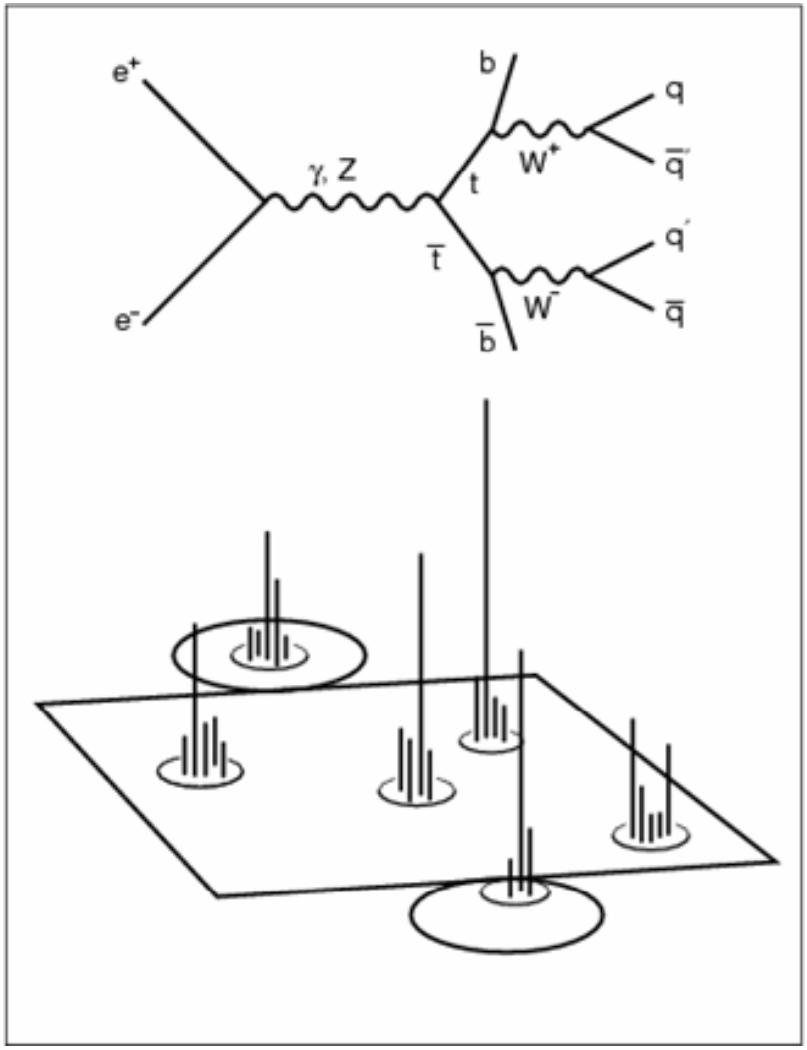


Fig. 7. Conceptual design of a propane bubble chamber vertex detector.

Forward tracking: a major challenge



$e^+ e^-$ → t tbar, LCWS 1991. At first sight, a confusing spray of particles …



The miracle of PFA (or equivalent) reveals the flow of energy from the quarks of the primary process

But 2 out of 6 jets depend entirely on forward tracking. How good is this?

Furthermore, for vertex charge determination, *any* of other jets may have essential low-Pt tracks curled into the forward tracking system

Previously, tracking performance has deteriorated badly in the forward region

A chain is as strong as its weakest link

Structure of this review

- **Collaboration reports provided an overview of the projects through to 'completion' of R&D, meaning 'ready for engineering design and construction'**
- **Open session presentations provided summaries of status and plans**
- **Closed session was used to clarify technical and strategic issues**
- **Closeout session: Committee informed collaborations of our draft recommendations, and obtained their verbal agreement (sort of)**
- **Report (after 6 drafts) was accepted by the WWS-OC chairs on 15th April, who will publish it along with appendices from the R&D collaborations, in which they will each be able to discuss areas of disagreement**
- **We (the committee) are hoping that our primary recommendations will be accepted by the WWS-OC and the collaborations**

Main conclusions and recommendations

- **Building a tracking system with excellent performance for θ_p >7 degrees will be challenging. *Feasibility is not yet demonstrated***

- **The committee is convinced of the need to construct large prototypes (~1 m diameter), and operate them in 3-5 T field, under ILC-like beam conditions, to establish the performance that will be achievable for central and forward tracking [We feel that ~20 cm prototypes in ~1 T would not suffice. This may be one of the main points of disagreement with R&D groups*]**

- **Until such tests are completed satisfactorily, we do not consider that any of the three options proposed (all-silicon, TPC-plus-silicon, or drift-chamber-plus-silicon) could be considered ready for selection as an ILC tracking system**

- **We see an opportunity (and a necessity) for enhanced coordination between the groups working towards these goals, and we suggest the formation of a Tracking Coordination Group to drive this forward**

- *** But, is it possible that recent experience with LHC inner triplet quads could encourage more extensive prototype testing?**

Suggested composition and responsibilities of TCG

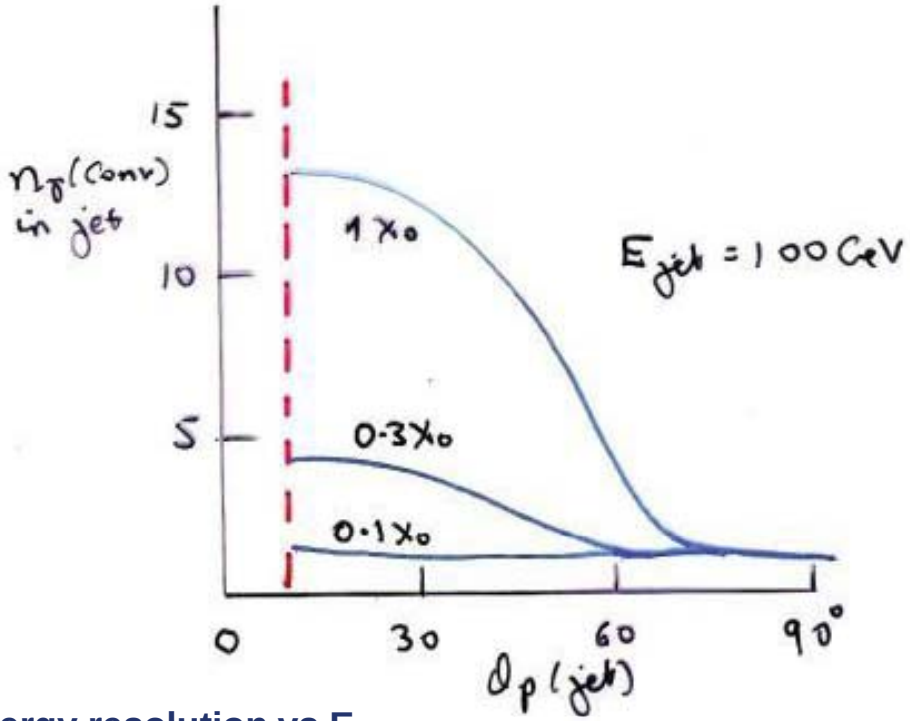
- NOT some external body (like the Review Committee) but representative 'insiders', possibly those on the R&D Panel (Weerts, Karlen, Park) plus two from each R&D group, plus leaders of VCG and Test-Beam CG … (it would be for R&D groups to decide) [Was this a point of confusion in our report?]

- Their responsibilities would include negotiating for suitable funding for infrastructure (comprising a custom-designed test beam, solenoid, etc,), coordinating the use of these facilities, and ensuring objective evaluation and presentation of the test results

- Decisive R&D results could be established by ~2012. Even on the most optimistic ILC schedule, this will be in time to choose the tracking technologies

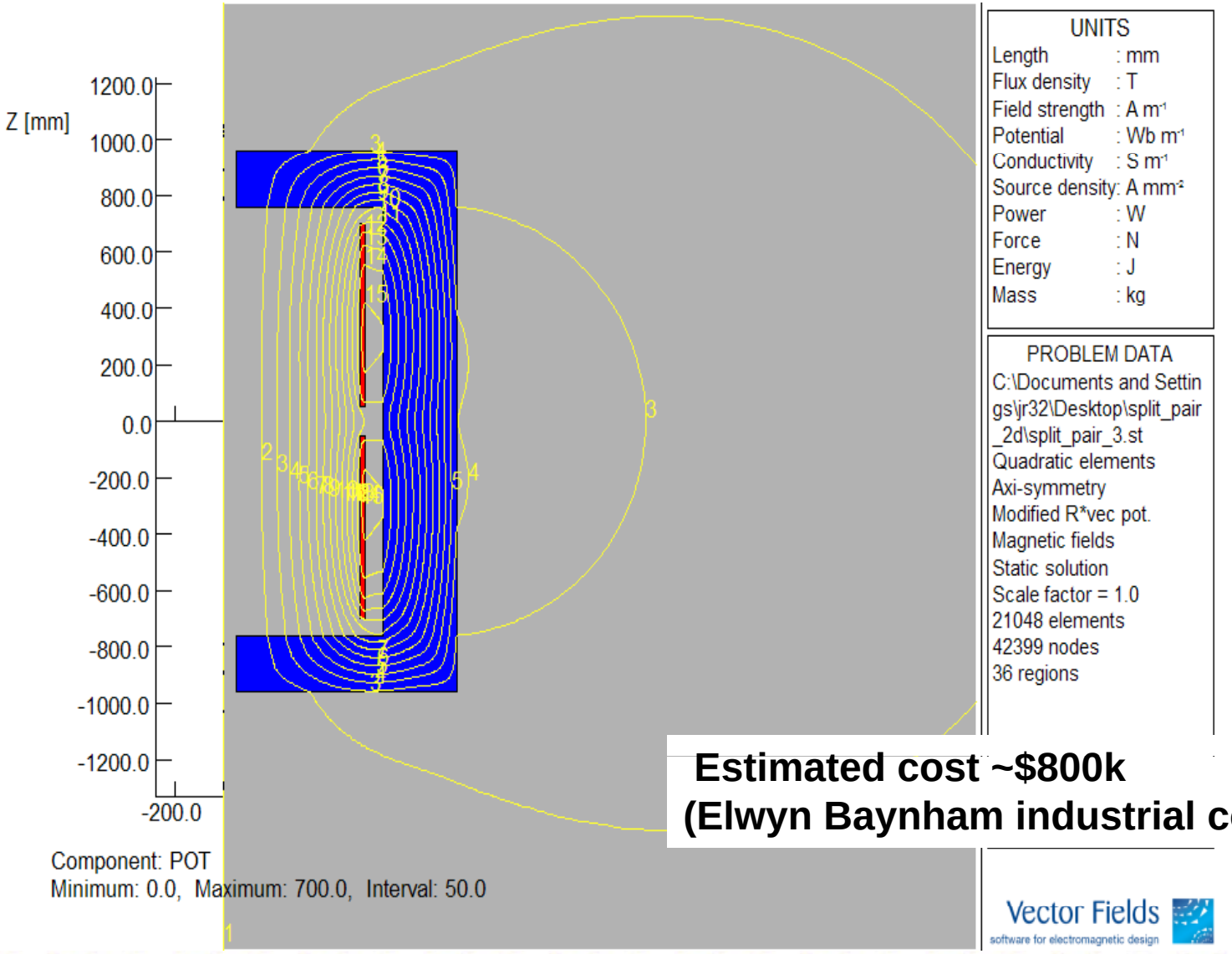
- The choice of technologies will as usual be taken by experiment collaborations in conjunction with the official detector review committee of ILC lab, but the TCG would aim to *inform* those decisions in the most objective way possible

What is $\sigma(E_{jet})$ vs θ_{jet}?

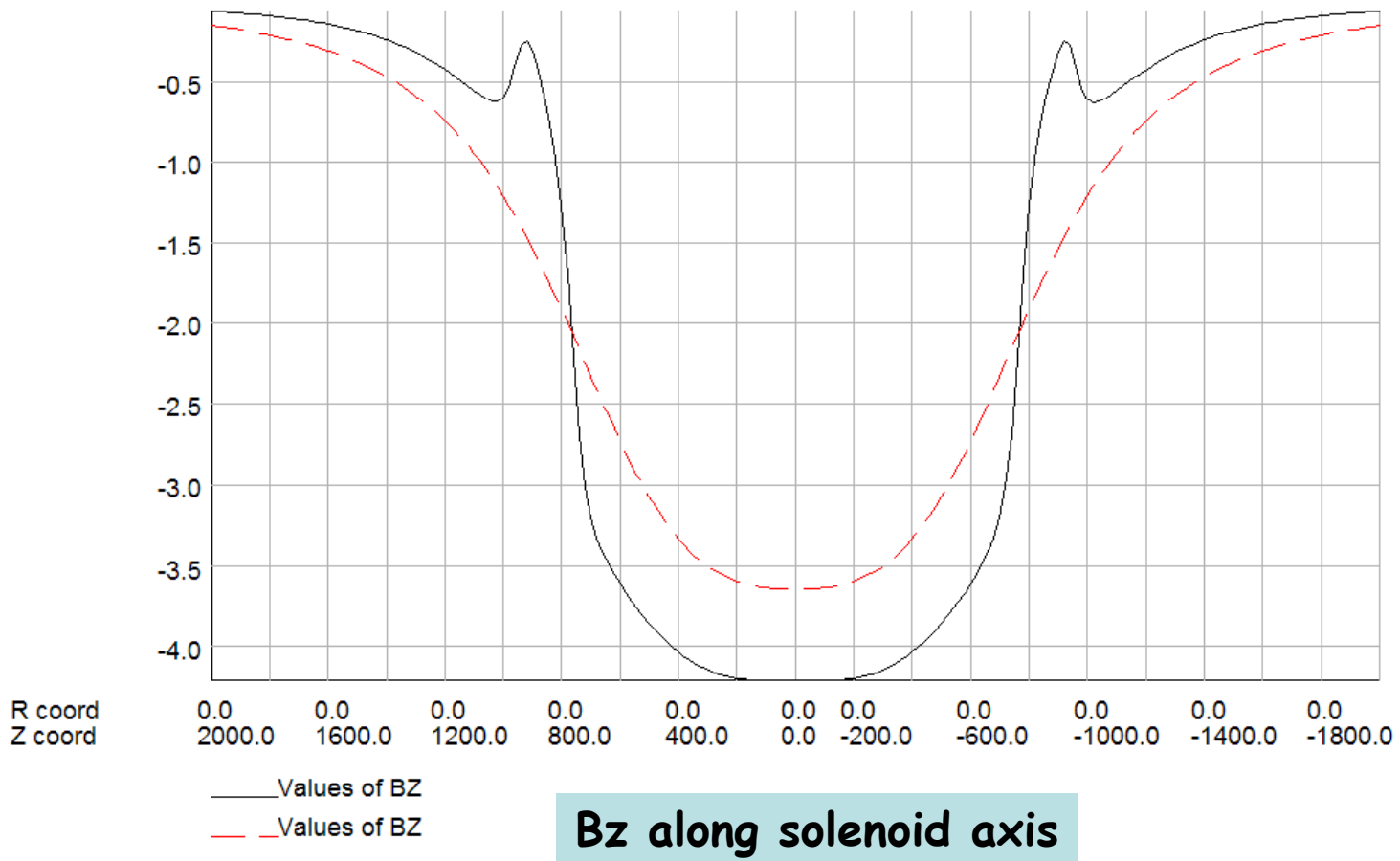


- We hear a lot about jet energy resolution vs E_{jet}
- How about resolution versus jet direction?
- **Photon conversions and secondary interactions** of charged and neutral hadrons will degrade jet energy measurements
- Depending on the amount and location of the material (vertex detector services, tracking system barrels, end-disks, services) effects will be quite different
- Forthcoming detector EDRs will permit the evaluation of such effects, for those few technologies which are **sufficiently mature** to realistically estimate their material budgets
- Note the experience of the H1 tracking system …

A possible split-coil solenoid



Estimated cost ~$800k
(Elwyn Baynham industrial contacts)



UNITS

Length	: mm
Flux density	: T
Field strength	: A m^{-1}
Potential	: Wb m^{-1}
Conductivity	: S m^{-1}
Source density	: A mm^{-2}
Power	: W
Force	: N
Energy	: J
Mass	: kg

PROBLEM DATA

C:\Documents and Settings\jr32\Desktop\split_pair_2d\split_pair_4.st
Quadratic elements
Axi-symmetry
Modified R*vec pot.
Magnetic fields
Static solution
Scale factor = 1.0
21048 elements
42399 nodes
36 regions

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Vector Fields
software for electromagnetic design

Bz along solenoid axis

Blue – with iron

Red without iron

Lessons from the ILC accelerator task forces

- Formed by the RDB over 5 months (January-May 2006) for all R&D areas of the machine
- Nominally 7 of them, but 1 is still dormant
- To learn about their achievements, look at the slides from the MAC review of ILC R&D, held in Fermilab 26-27 April, http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=1388
- Without the TFs, it is difficult to imagine that the ILC R&D today would be anything but disorganised and disconnected – all TF leaders are doing a marvellous job
- The TFs have (not surprisingly) contrasting styles of working
- Judging from their example, the TCG should not be given a detailed charge – that is something for them to work out!

S0/S1: Gradient Task Force Charge

- **The RDB is asked to set up a Task Force to carry out a closely coordinated global execution of the work leading to the achievement of the accelerating gradient specified in the ILC Baseline.**

- **A definition of the goals for the cavity performance in terms of gradient and yield and a plan for achieving them should be proposed by this group, which should take account of the global resources available and how they may be used most rapidly and efficiently.**

- **The accelerating gradient performance and yield should be specified both for an individual 9-cell cavity and for an individual cryomodule, and the plan should cover the demonstration of this performance in both cases.**

- **The GDE will facilitate the coordination at the global level to achieve this vital goal as soon as possible.**

Accelerator TF responsibilities

S0/1 RF cavities Lutz Lilje
S2 Cryomodules/string tests Tom Himel, Hasan Padamsee
S3 Damping rings Andy Wolski
S4 Beam delivery system Andreij Seryi
S5 Positron source John Sheppard
S6 Controls
S7 Main linac RF Chris Adolphsen

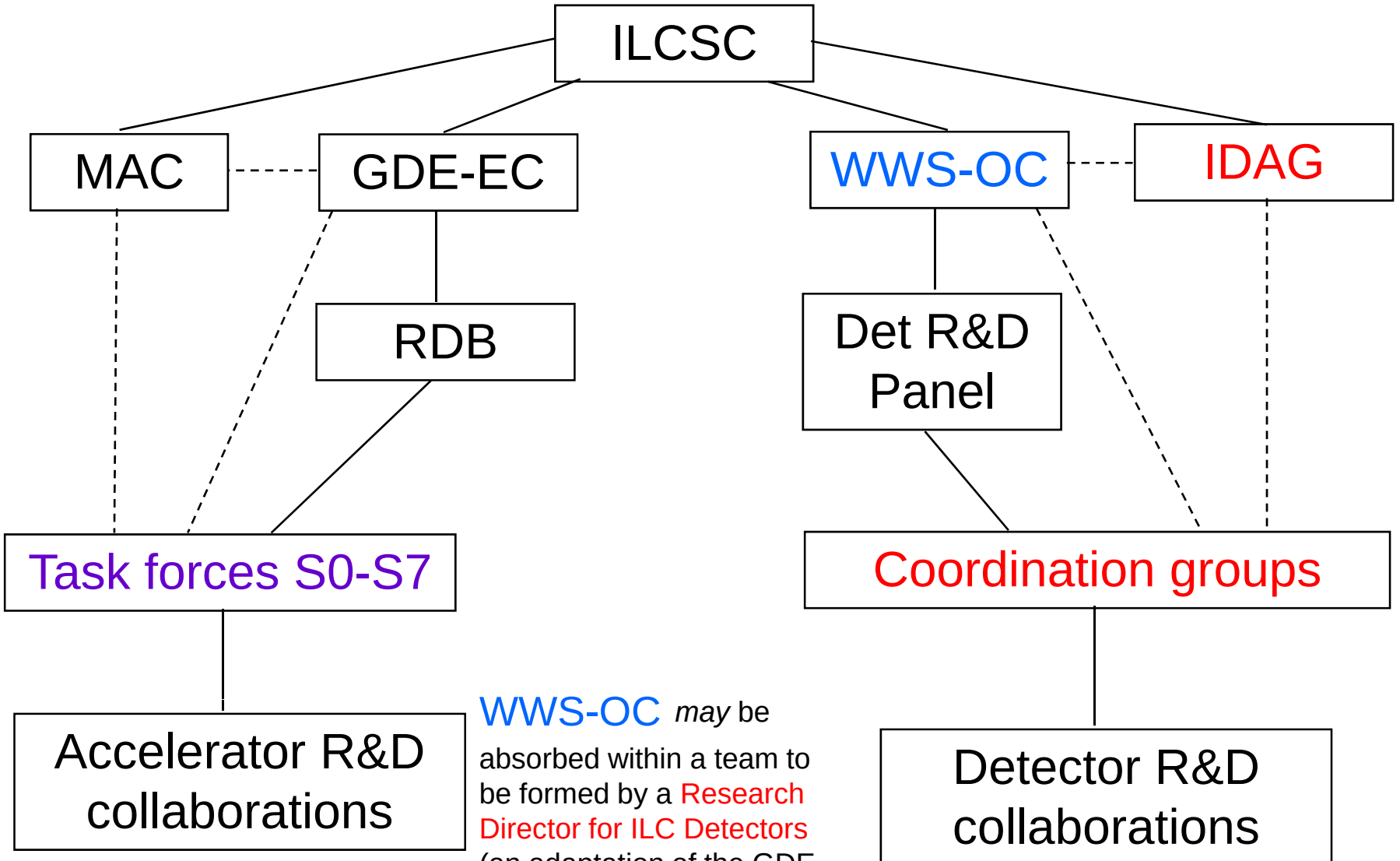
These TFs typically organise the R&D into WPs, hold phone meetings at 1-2 week intervals, hold occasional workshops, review progress on baseline and alternatives, aim to ensure that all important R&D is adequately covered, encourage groups to avoid unnecessary duplication, alert RDB and GDE to major technical and funding problems …

Through participation in national reviews (so far in USA, UK, Japan) they have some influence over funding, but don't have direct control. Their role will be strengthened by MoUs in the ED phase

If the TCG is formed, I would suggest that they consider talking to any or all of the above, as well as reading the recent slides for the MAC review of R&D. We can learn some things from our accelerator colleagues

- **What matters is not so much the charge, but the motivation and dedication of the members of the TF/coordination group**
- **Bill Willis attributes the great success of these TFs to the fact that the accelerator people ‘want to be organised’**
- **However, it isn’t only a question of internal leadership. The TFs could not have flourished without being embedded in a supportive structure …**

Possible structure for coordination of detector R&D



WWS-OC *may* be absorbed within a team to be formed by a Research Director for ILC Detectors (an adaptation of the GDE for the different scale and character of the detectors)

XXX not yet formed

Connections with Detector Roadmap

- **The Roadmap Group: WWS-OC chairs, 2 physicists per concept, plus R&D Panel chair, has been meeting since 20th March**
- **Jim Brau, Francois Richard, Hitoshi Yamamoto, Ties Behnke, Henri Videau, Yasuhiro Sugimoto, Mark Thomson, Harry Weerts, John Jaros, John Hauptman, Sorina Popescu, Chris Damerell**
- **How to merge from 4 concepts to two *contrasting* detector designs, to be developed into EDRs by 2010?**
- **LOIs may be invited. The result may be '20% EDRs', but in this case it should be the most critical 20%**
- **A Research Director for ILC Detectors, and team ('GDE-equivalent for detectors') may be formed to organise the process. They may receive advice from an IDAG (International Detector Advisory Group), and will of course report to ILCSC (like the GDE and MAC)**
- **When they have formed, EDR groups should NOT be seen as proto-collaborations**
- **The subdetectors chosen for the EDRs will need to be safe 'baseline' options, which may be replaced by 'alternatives' after 2010, if their superiority is demonstrated**
- **These EDRs, along with that for the accelerator, will be used to establish 'construction-readiness' of the ILC project in 2010. This does NOT mean frozen! (quote B Barish)**

Balance between support for accelerator and detector R&D, and overall resources

- For the accelerator, priorities for R&D through the EDR phase are driven mostly by considerations of reducing technical risk
- The risk to ILC physics of an underperforming tracking system would be a good fraction of the *total construction and operating cost* of ILC. We should not get locked in to any technology before their R&D is successfully completed. It would be irresponsible to suggest otherwise *(at least, this is how the tracking review committee sees it)*
- Support for the *most critical* detector R&D, both for the baseline and for promising alternatives, should be given high priority, as is done for the accelerator work
- Detector R&D can be considered along with accelerator R&D in terms of reducing risk to the ILC performance
- Example: underperforming damping rings or underperforming tracking systems have quantifiable consequences in terms of diminished physics potential

- **Both for accelerator and detector, we need to establish the most cost-effective means of reducing the main technical risks**

- **Spend on ILC detector R&D is considered by the community to be seriously inadequate (see R&D Panel Report of January 2006). The first of the R&D reviews (on tracking) confirms this conclusion**

- **Our committee echoed the comment of one of the collaborations: 'Ultimately, the greatest R&D risk is that insufficient resources will be directed towards achieving the goals of this plan'**

- **We depend on the proposed ILC Detector Directorate, working with the funding agencies and lab directors, to help secure the needed resources, just as the GDE is doing for the machine (for example, in working out how best to deal with the current threat to CESR-TA)**

- *Optimal relationship between GDE and this Detector Directorate? (a hot topic, not for this talk)*