RD's Report

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Project Advisory Committee

@ Vancouver

May 10, 2009

Contents of the reports on detector activities

Overview

1. Where are we ? Who is doing what ?
2. The submitted LOIs
   general remarks, brief introduction of ILD, SiD, the 4th
3. The status of IDAG and its plan
   IDAG meetings in Chicago, Tsukuba, Paris and its schedule
4. Plans for the next steps
5. Cooperation with CLIC

The activity of each common task group to be made by its convener or deputy convener

MDI (Karsten Buesser)

Engineering Tools (Catherine Clerc)

Detector R&D panel (Marcel Demarteau)

Software Panel (Norman Graf)

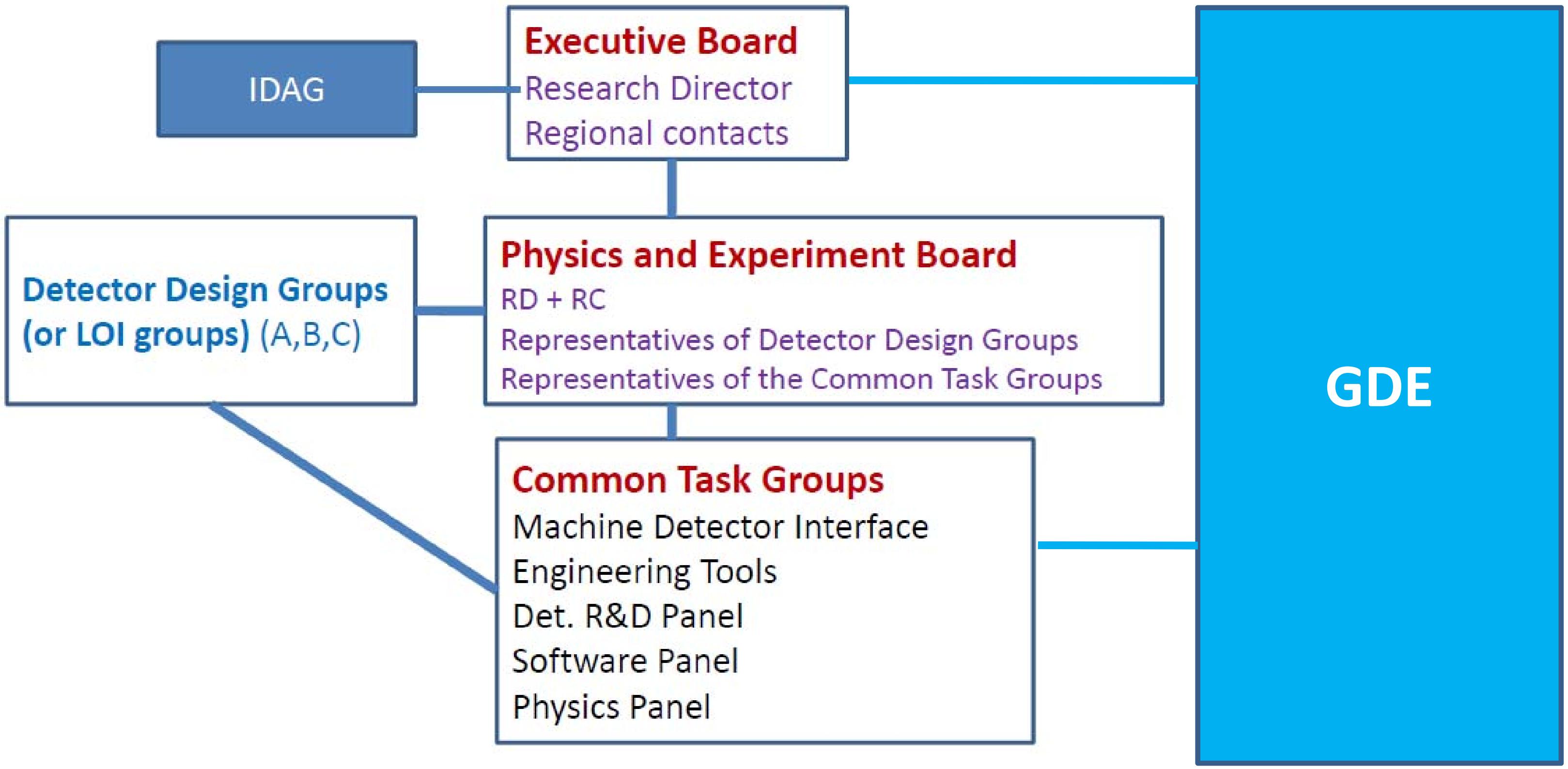
Brief overview of the progress

PAC endorsed the designed management structure and the direction of our activities. (Oct.2008, Paris)
With your support and commend, we could step forward with confidence.

- **The entire management structure for the detector activity was formed by November, 2008, and is in full function now.**
- **LOIs were submitted by the due date.**
- **IDAG had been prepared for the examination of LOIs in advance and began intensive actions immediately.**

Where are we?

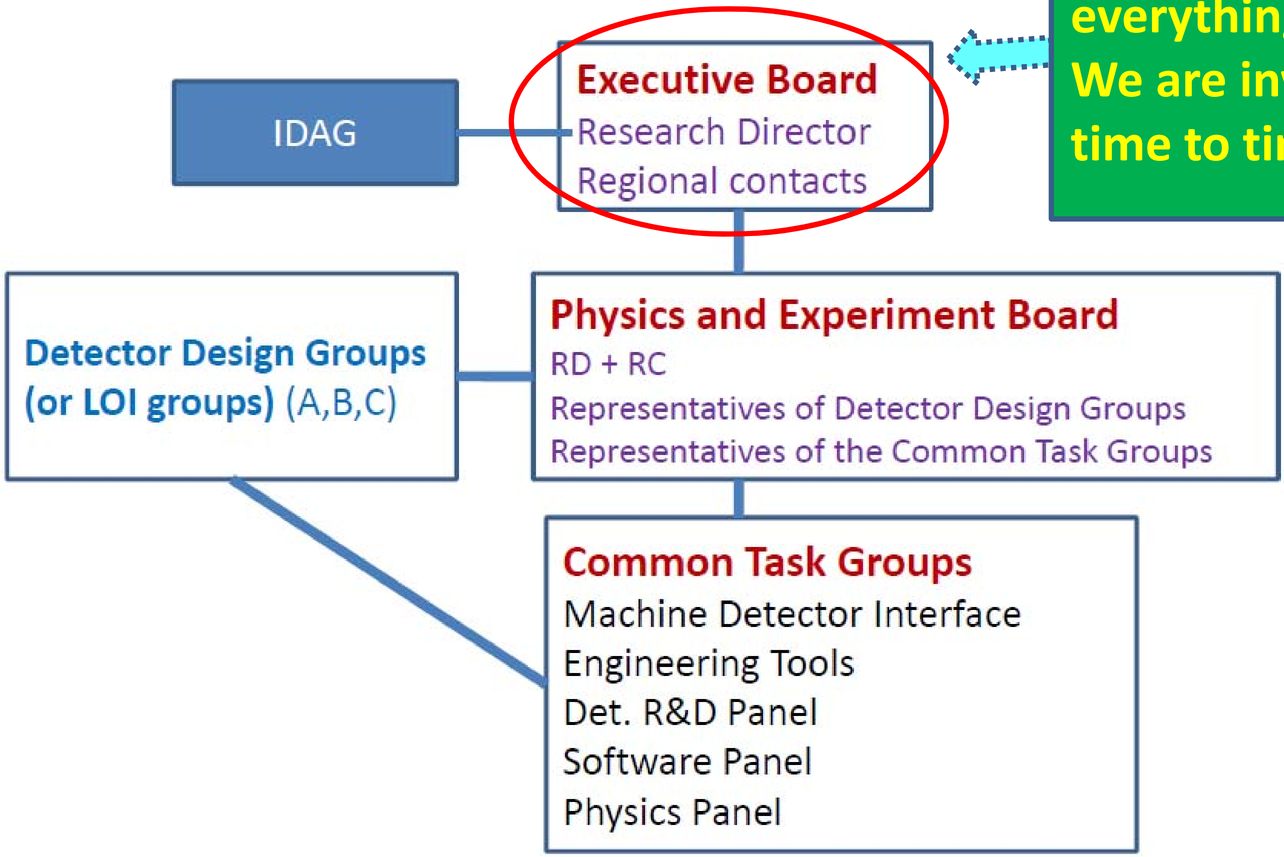
Reminder of the management organization of the detector activity



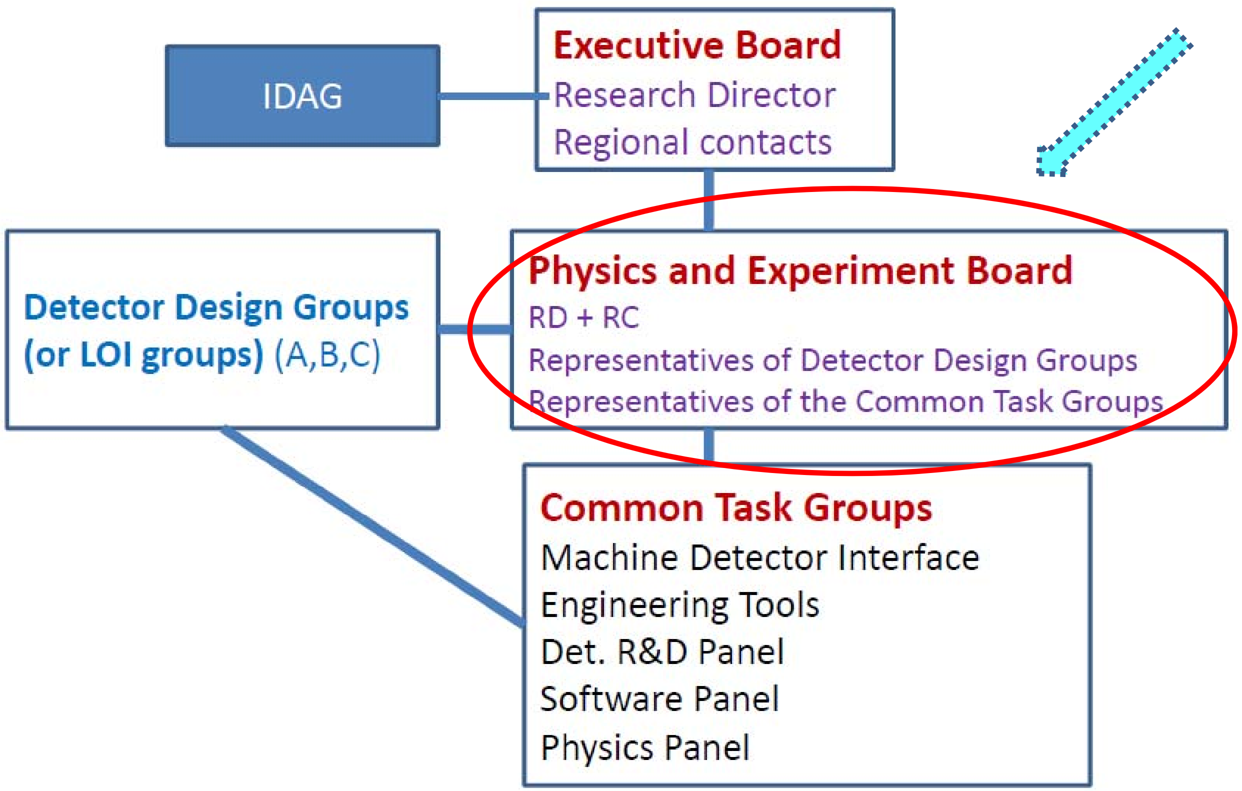
The frames were filled with names and all the functions are working. Each frame will be described..

The executive Board

We meet weekly to discuss everything.
We are invited to the GDE's EC time to time.



Physics and Experiment Board



15 members

EB members 4
LOI reps 6
CTGs 5

The members were known by the time of LCWS08 in Chicago, where it met first.

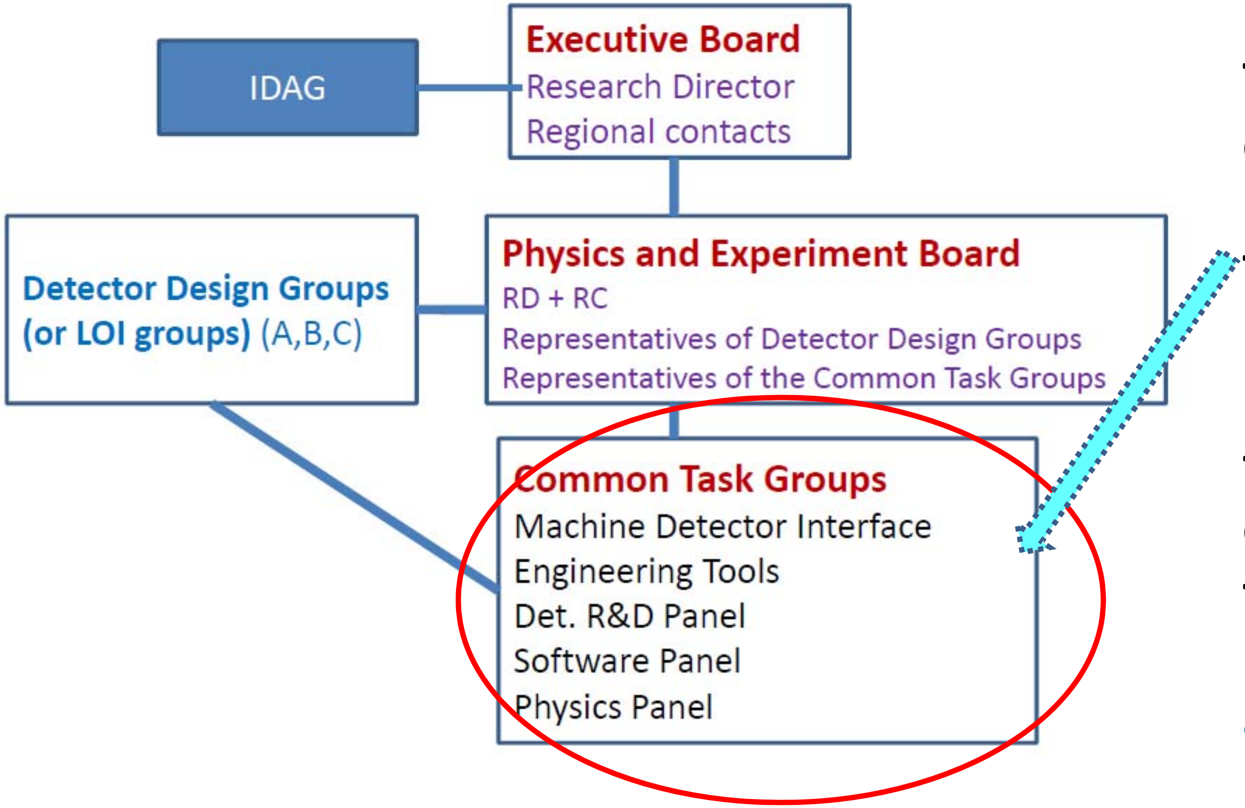
Regular meeting is held monthly (Webex). From the common task groups, either conveners or deputies attend.

All the important issues are discussed. Communication among the 3 frames.

(Minutes in the ILC web page)

E.g. during preparation of LOIs, we could monitor the status of LOI preparation and make their formats more uniform.

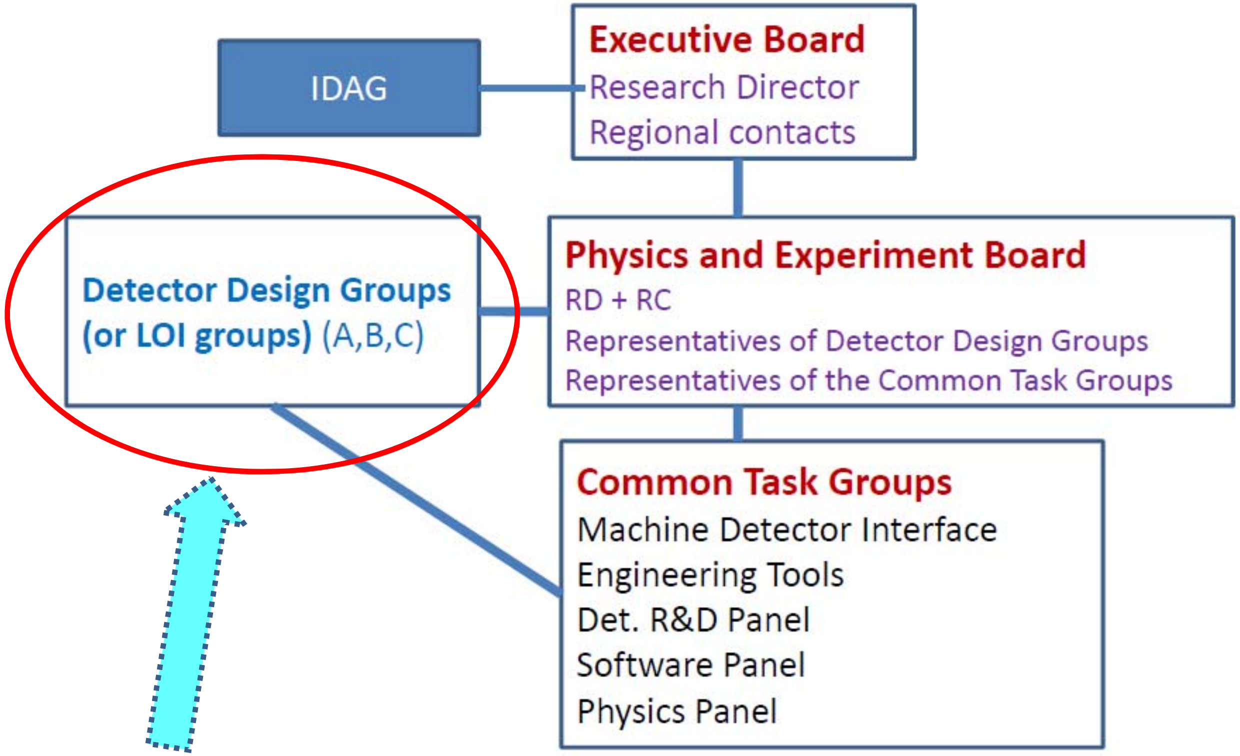
Common Task Groups



There are five groups on common subjects for all LOIs.
The members were named before LCWS08.
Many C.T. groups made face-to-face meeting during LCWS08 to start the activity of the groups.
(MDI group has been active about a year by now.)

Most groups report their activities in detail in the following presentations.

LOI Groups



The 3 Detector Design Groups (ILD, SiD, the 4th), which submitted EOIs March 2008, completed their LOIs successfully by the due date of March 31, 2009.

Each group presented its LOI during the ACFA plenary session during TILC09 workshop in Tsukuba in April.

LOIs in general

- **They contain much information for IDAG to study for validation.**
- **The groups provided more detailed information with support documents.**

  They reflect tremendous amount of work of the groups.
- **These are available from their web pages.**

http://www.linearcollider.org/cms/?pid=1000472

- **Many authors signed the LOIs.**
- **They included many university people.**
- ***It is encouraging and important in the view that ILC will be a research facility for yet-young generations.***
- **Also there will be many topics for universities to study regarding R&D for detector technologies and physics simulations. They provide ideal opportunities for training.**

LOIs continued

- The 3 LOI groups are all international.
- But there are some unbalance in the weight of participating regions for a historical reason.

ILD: more European and Asian institutions

SiD: more American institutions

the 4th: mainly American and European

It is desirable to have global-widely mixed groups.

Each group made good effort to invite more members with some success.

Brief introduction of LOIs

- These are *overviews* of some keywords and only very limited fraction of the entire documents.
- Detailed examination is under way by IDAG.
- A few slides are shown from their LOIs or presentations.
- The slides are public in the TILC09 agenda.

The ILD group

http://www.ilcild.org/documents/ild-letter-of-intent

695 authors
148 institutions
32 counties

Introduction
Detector Optimization
Physics performance
Sub-detector system
DAQ and computing
Detector integration and MDI
Costing
The group
R&D plan
Conclusion

ILD Philosophy

International Large Detector

- Based on high granularity particle flow calorimetry
  - confident this will provide necessary jet energy resolution
- "Large" central Time Projection Chamber (TPC)
  - proven technology; provides excellent pattern recognition in a dense track environment
- Tracking augmented by Si strip/pixels
  - extend tracking coverage + improves precision
- A high precision Vertex detector close to IP
  - for best possible heavy flavour tagging
- Close to 4π tracking/calorimetric acceptance

Optimization referring to LDC and GLD detectors.

ILD Optimisation: Summary

	B/T	r_{ECAL}/m
LDC	4.0	1.6
Prime	3.5	1.8
GLD	3.0	2.0

What did we learn ? (much more detail in LoI)

★ LDC, "Prime", GLD give similar performance
- almost by "construction"
- all reasonable detector concepts for ILC

★ For PFlow, radius is more important than B

★ Arguments for high B are not strong

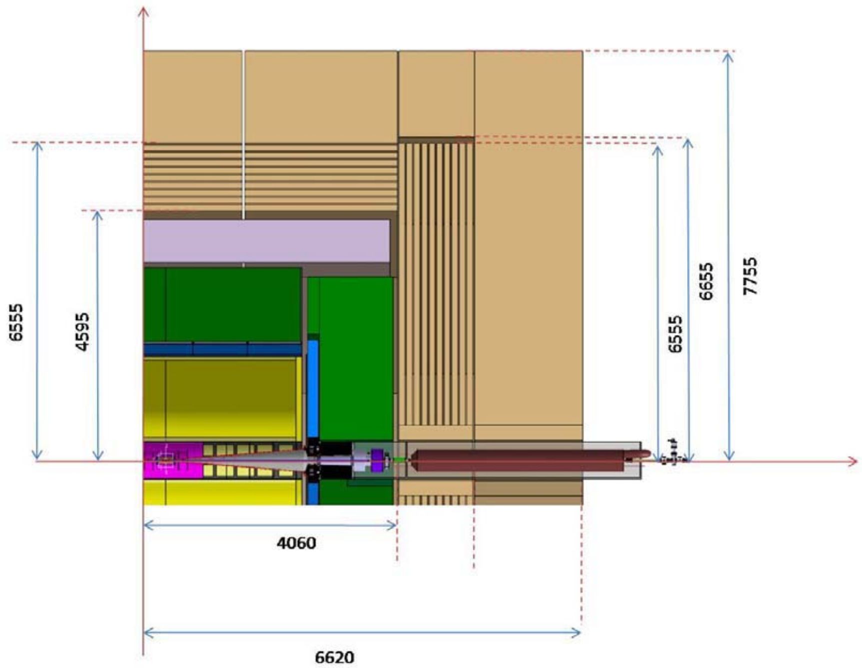
★ For current PFlow algorithm want segmentation
- ECAL $\leq 10\times10\ mm^2$ ($5\times5\ mm^2$ preferred)
- HCAL ~$3\times3\ cm^2$ (no obvious advantage in higher granular for analogue HCAL)

Choice of ILD parameters

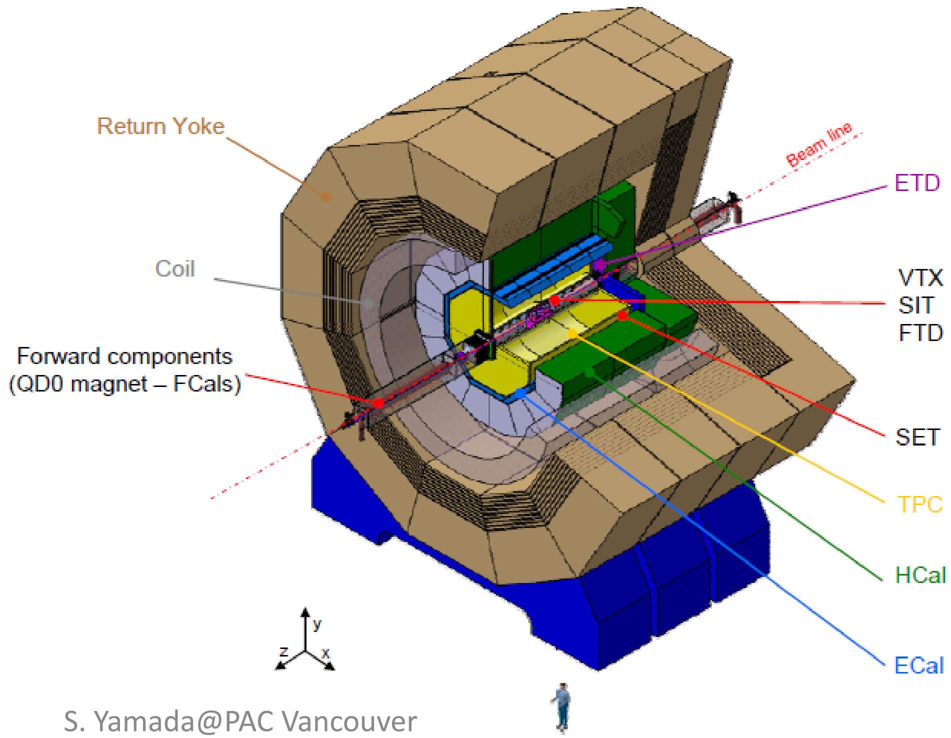
★ B = 3.5 T
- not a big extrapolation from CMS solenoid (larger)
- only weak arguments for higher field
- 3.0 T viable, but would like to better understand backgrounds

★ r_{ECAL} = 1.85 m
- for B = 3.5 T need ~1.55 m to reach jet E goal
- then allow for uncertainties in shower simulation
- larger radius brings performance advantages (~16 % for 1.85 c.f. 1.55)

★ Technology
- no selection at this stage



The ILD Sub-detector Systems



TPC for tracking,
Tile/strip-W ECAl
Tile-Fe HCAL
P. Flow Algorithm for CAL.

Chargino and Neutralino Production at √s = 500 GeV

★ Chargino and neutralino production in the **SUSY "point 5" scenario** provides a benchmark for jet energy resolution

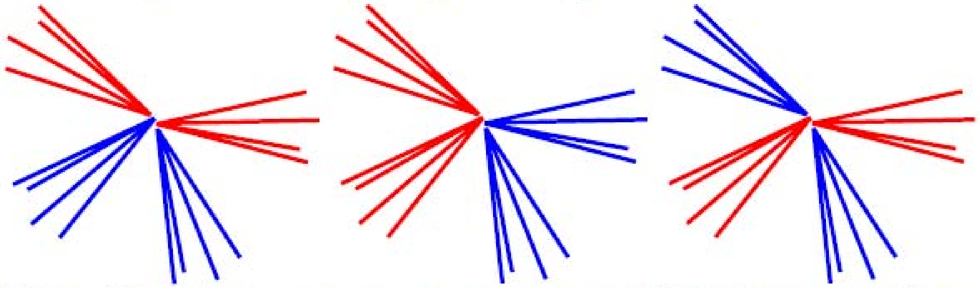
★ $e^+e^- \rightarrow \tilde{\chi}_1^+\tilde{\chi}_1^- \rightarrow W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ and $e^+e^- \rightarrow \tilde{\chi}_2^0\tilde{\chi}_2^0 \rightarrow ZZ\tilde{\chi}_1^0\tilde{\chi}_1^0$ result in final states with **four jets and missing energy**

★ Neutralino process is challenging: cross section ~10% chargino

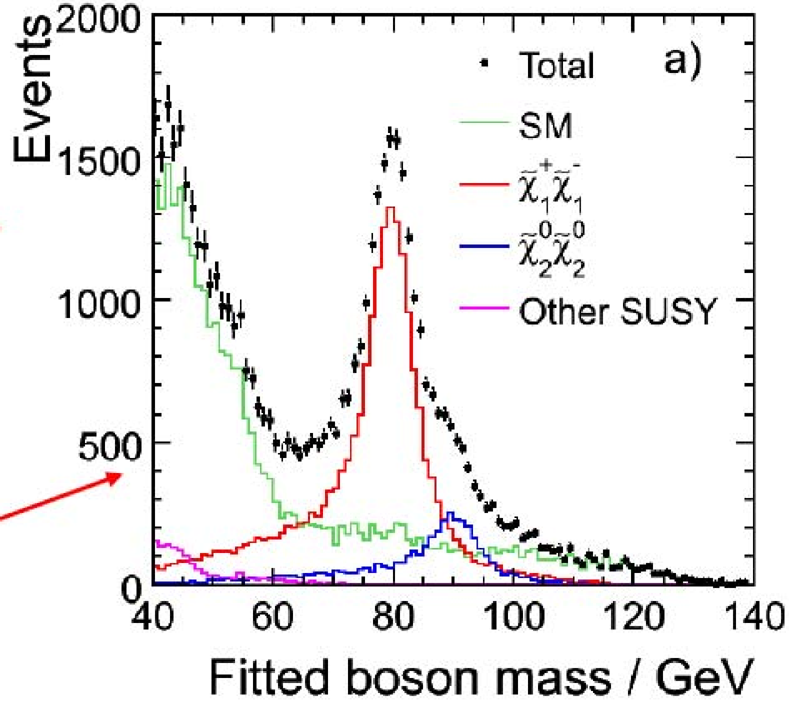
Analysis:

Only time to describe one of two analyses in LoI: method i)

- Select 4 jet + missing E events
- Three possible jet-pairings

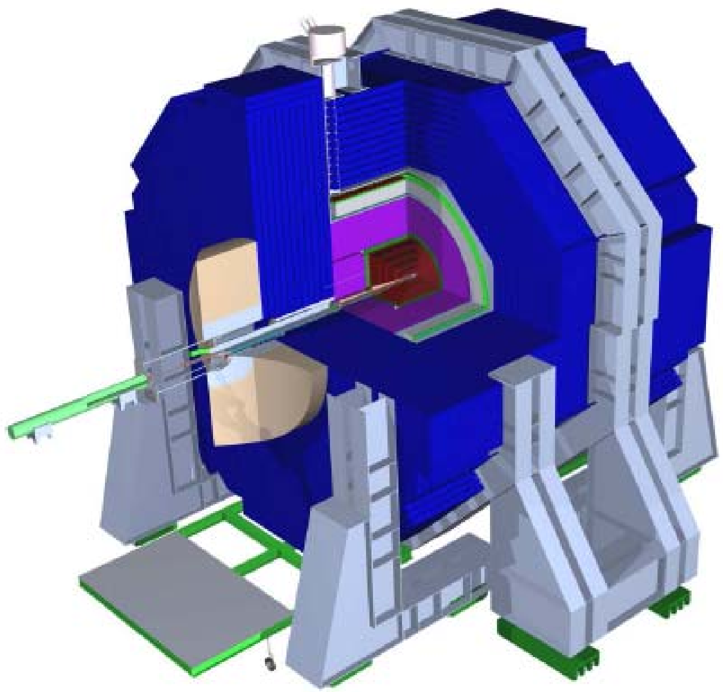


- Kin. fit assuming common di-jet mass for two bosons applied to each jet-pairing
- Jet-pairing giving highest fit prob used
- Fit mass distribution to i) SM, ii) chargino and iii) neutralino components to get cross sections



SiD Letter of Intent

31 March 2009



The SiD group

http://silicondetector.org/display/SiD/LOI

234 authors
77 institutions
18 countries

- **Introduction**
- **Subsystem**
- **MDI and global issues**
- **Physics performance and Benchmarking**
- **Cost estimate**
- **SiD R&D**

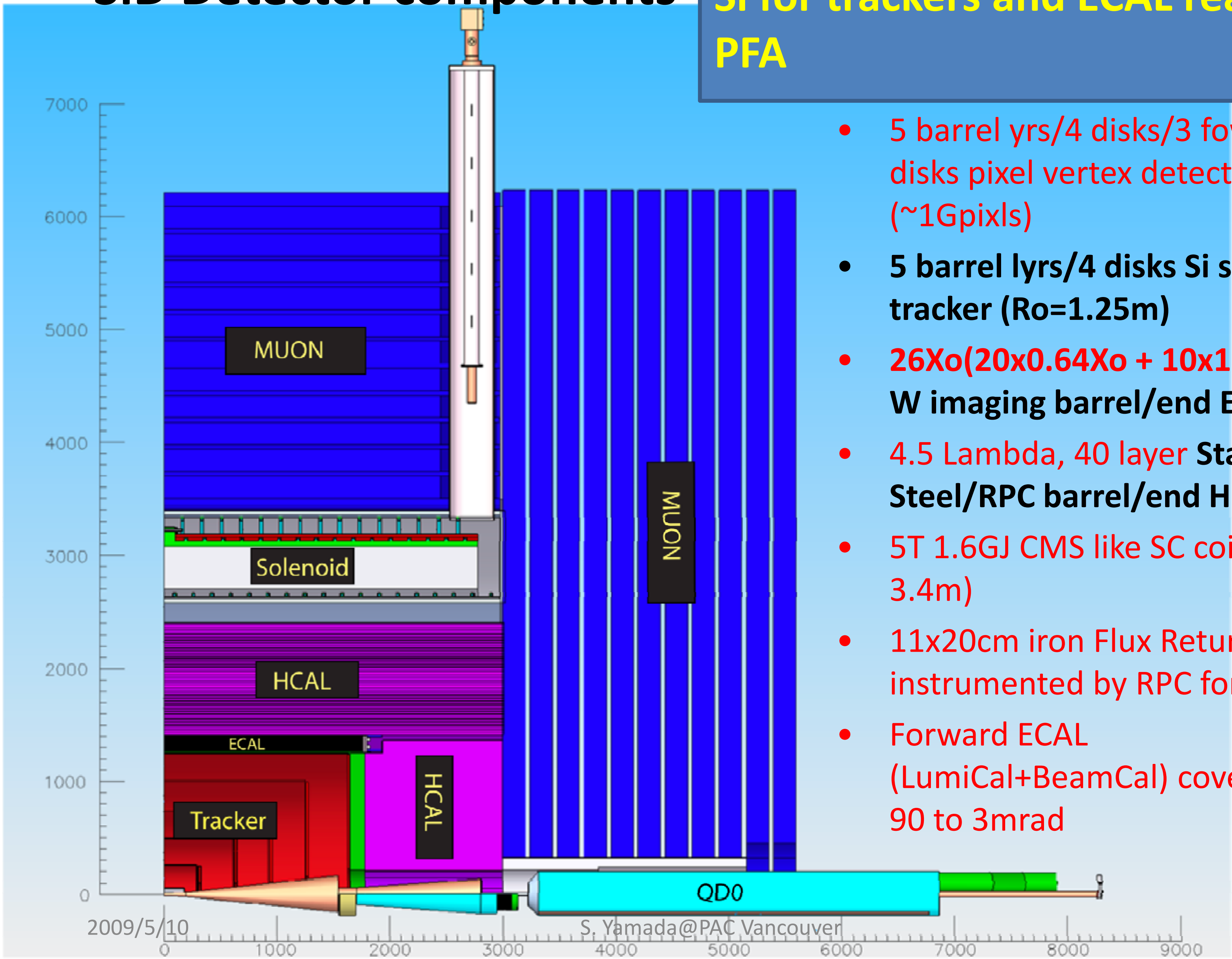
SiD project definition

- Design an ILC general purpose detector that enables precision measurements on
  - Higgs boson properties,
  - Gauge boson scattering,
  - Effects resulting form extra dimensions,
  - Supersymmetric particles, and
  - Top quark properties.
- Challenges
  - Excellent mass resolution to measure recoil masses, kinematic edges and spectra
  - Flavor tagging capability based on a precision vertexing
  - Excellent hadronic (or jet) energy resolution capable of separating W(jj) from Z(jj)
  - Excellent hermeticity for missing-energy final states
  - Works in the ILC environment
- Who are we ?   234 authors, 77 institutes, 18 countries and up.

Detector optimization

- Calorimeters (and a solenoid) is costly and their design determines the global parameter of the detector.
- The cal performance/cost critically depend on how far they are placed from the IP and how thick they must be.
- Therefore, to a large degree, the system optimization reduces to optimization of the parameters of the calorimeters (and a solenoid).
- SiD uses a parametric model for cost vs global parameters and a model to estimate the jet energy/momentum/impact parameter resolutions as a function of global parameters (derived from a full simulation). Based on these tools, for each jet resolution, we find the global parameters that give the lowest cost.
- Using a fast MC simulation we physics performance vs jet energy resolution, and therefore, **we find physics performance vs minimum cost.**

SiD Detector components

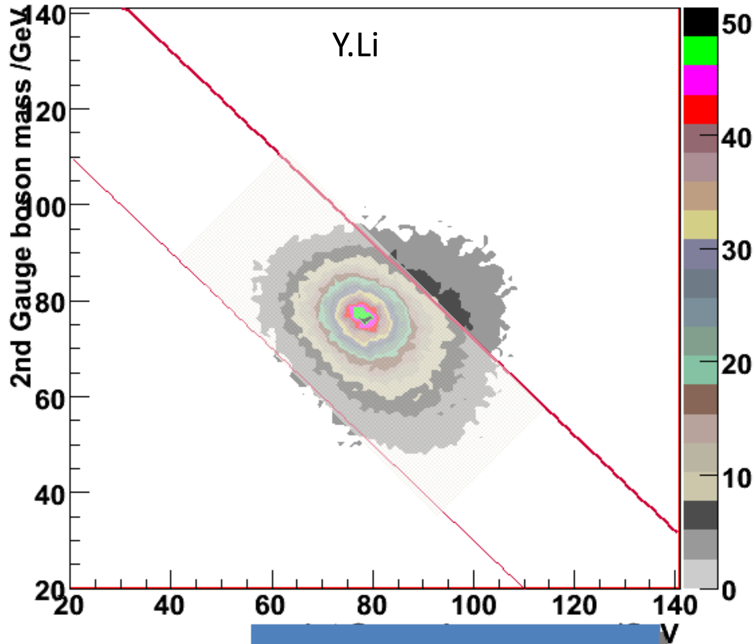


Si for trackers and ECAL readout PFA

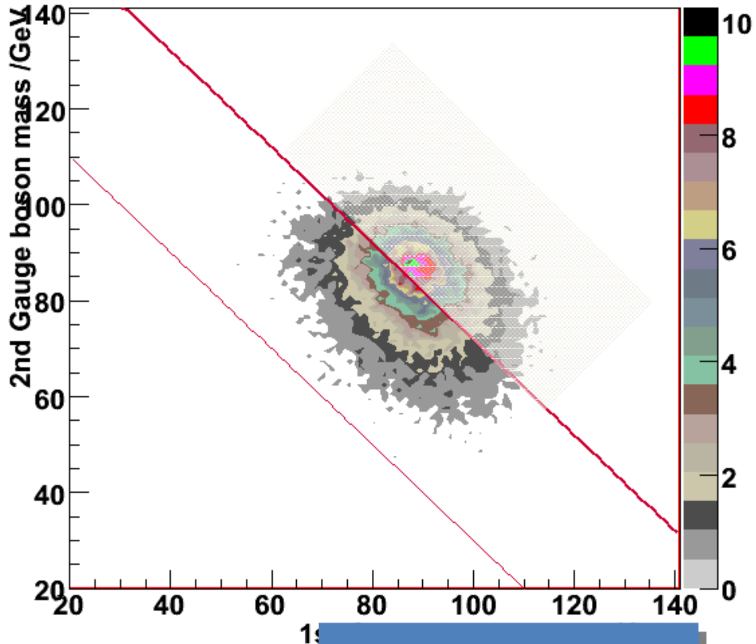
- 5 barrel yrs/4 disks/3 foward disks pixel vertex detector (~1Gpixls)
- **5 barrel lyrs/4 disks Si strip tracker (Ro=1.25m)**
- **26Xo(20x0.64Xo + 10x1.3Xo) Si-W imaging barrel/end ECAL**
- 4.5 Lambda, 40 layer **Stainless Steel/RPC barrel/end HCAL**
- 5T 1.6GJ CMS like SC coil (R=2.6-3.4m)
- 11x20cm iron Flux Return instrumented by RPC for muons
- Forward ECAL (LumiCal+BeamCal) covers from 90 to 3mrad

Chargino/Neutralino Separation

- Kinematic fitting to improve energy and mass resolution
- Correlation of two m_V is a powerful selection criteria
  - C1 xsection is x10 N2 xsection



m_{W1} vs m_{W2}



m_{Z1} vs m_{Z2}

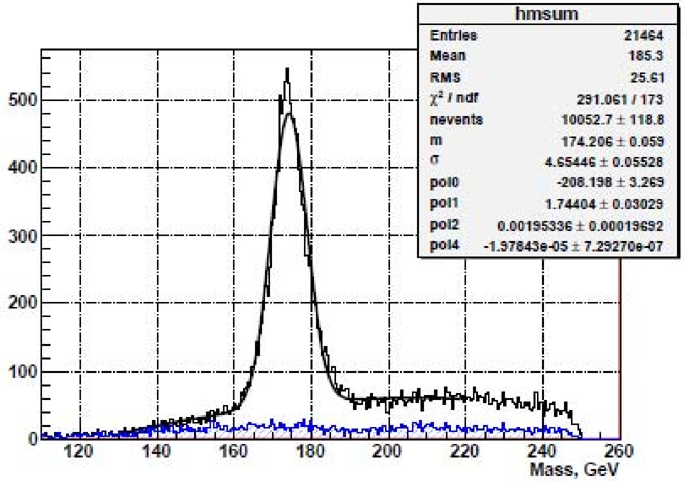
Chargino events signal

130 GeV < M(W1) + M (W2) < 172 GeV

Neutralino events signal

M(Z1) + M (Z2) > 172 GeV

Letter of Intent from the
Fourth Detector ("4th") Collaboration at the
International Linear Collider



t quark mass reconstructed with standard model backgrounds.

The 4th group

http://www.4thconcept.org

140 authors
33 institutions
15 countries

Introduction
Description of the detector
The performance of the detector
Physics Studies of the
Benchmark processes
MDI
Status of realistic detector
model and R&D
Structure and capability

Detector overall philosophy

- **Detector Complementariness**

  To minimize the risk of bias for new discoveries and to reduce the systematic error contribution to precise combined measurements.
  The choice of one IR and two push-pull detectors makes sense only if the two detectors are complementary in technologies and use different methodologies:

  PFA calorimetry - multiple read-out compensating calorimetry
  solid state tracker - gas tracking device
  gas TPC - cluster timing drift chamber

- **Particle identification**
- **Subsystems Orthogonality**
- **Subsystems Self-sufficiency**
- **Subsystems Hermeticity**
- **Detector Lightness**

No flux return iron

Detector Optimization

At this stage, the uncertainties on the costs of the various subsystems are much larger than any possible cost optimization, unless of drastic changes in technologies.

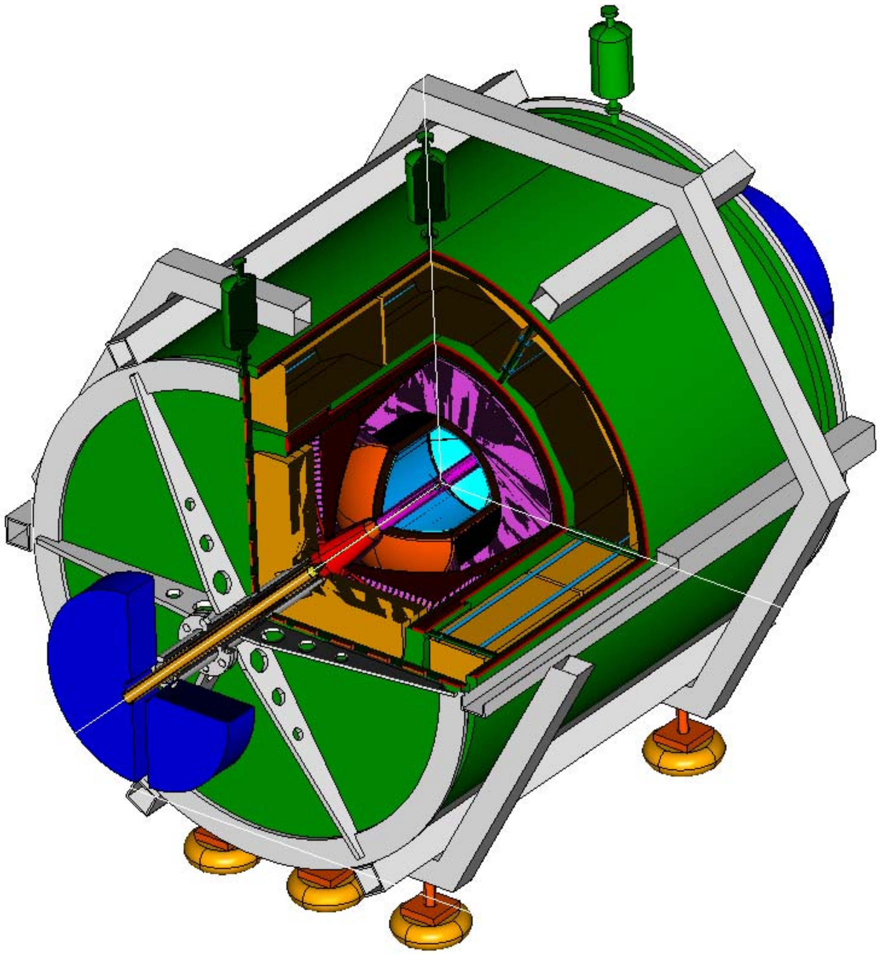
In general, the size of a detector is determined by its resolutions. We think we have achieved a good balance of resolutions in this detector design.

Electrons, muons, hadrons and jets at around 100 GeV are all measured with comparable resolutions both by the tracking systems and by the crystal and fiber calorimeters.

Any, even moderate, increment in the dimensions of one sub-detector to increase its performance will be made at the expenses of the other sub-detectors with a resulting imbalance in the resolutions on these fundamental partons.

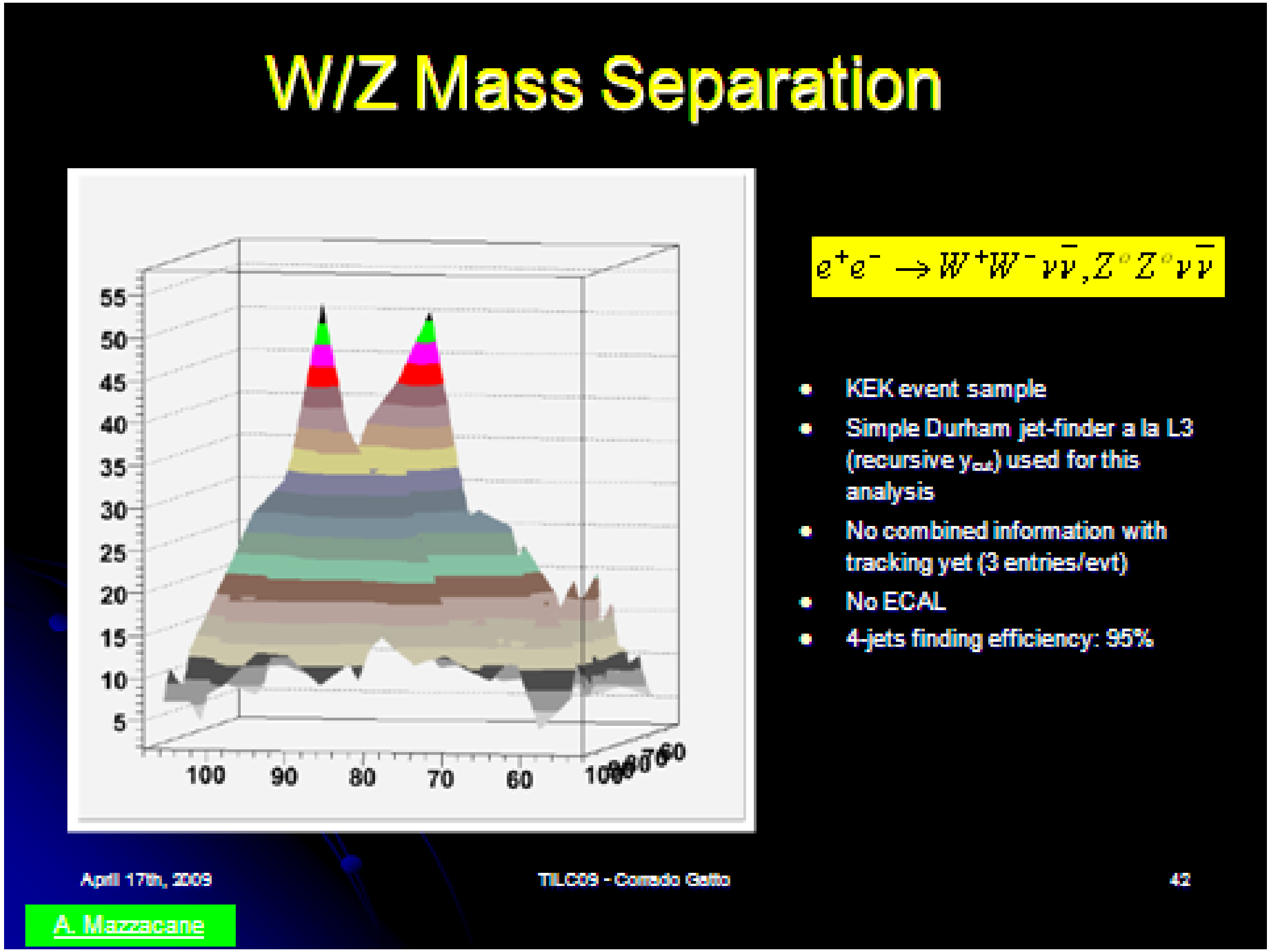
The 4th detector

Dual Solenoids without flux return iron



Question of shielding.

They think additional light shielding wall will be used to stop neutrons.

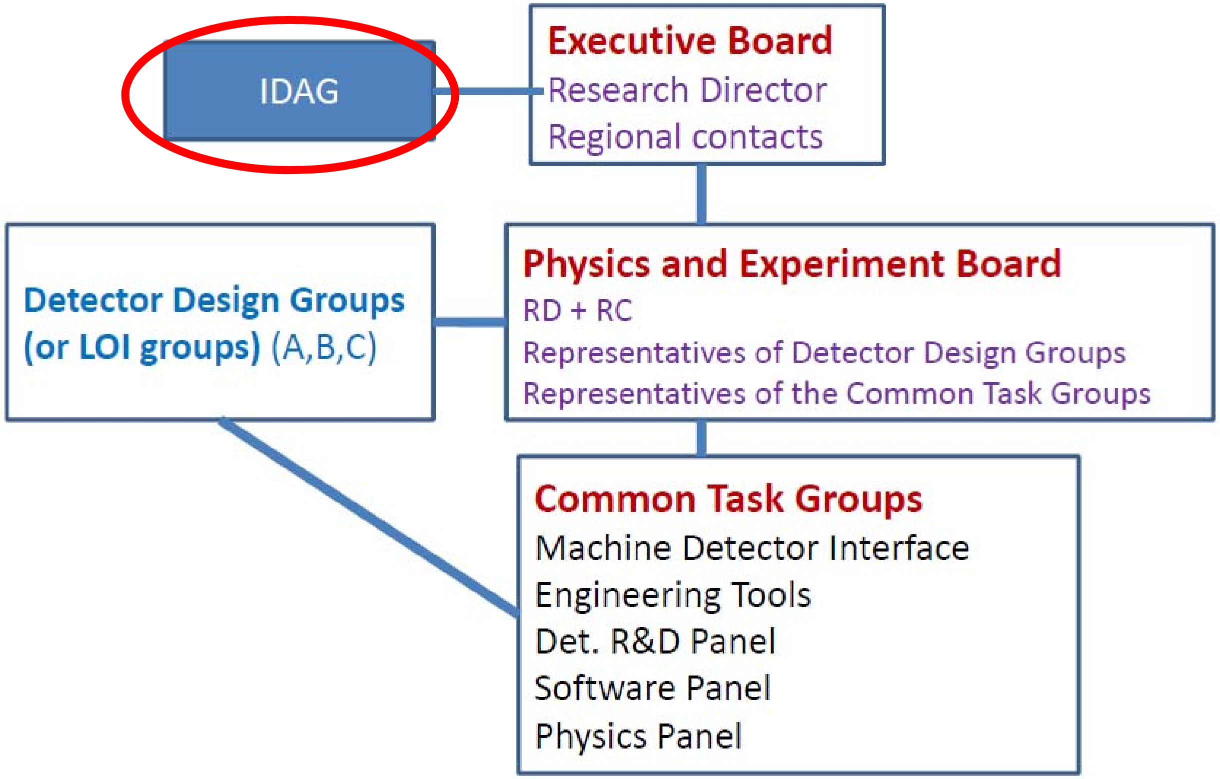


This study is not chargino/neutralino production.

IDAG

Advices the RD on experimental program issues and recommends on the validation of LOIs

Following the recommendation by PAC, ILCSC clarified the mandate of IDAG to be through the end of the TDP-ll, 2012.



The activity of IDAG for validation

- IDAG got organized itself at its second meeting during LCWS08 in Chicago, November 2008,

  in order to be ready for scrutinizing LOIs.

1. **Distribution of tasks among the members**
2. **Listing additional questions to the concept groups**
3. **Preparatory meetings on critical items before the due date**

(One theory member stepped down and was replaced by another theory member in the same region right after this.)

IDAG members (updated Dec.2008)

Experiment & Detector

Michael Danilov	ITEP
Michel Davier (Chair)	Orsay
Paul Grannis	Stony Brook
Dan Green	FNAL
Dean Karlen	Victoria
Sun-Kee Kim	SNU
Tomio Kobayashi	ICEPP/Tokyo
Weiguo Li	IHEP
Richard Nickerson	Oxford ATLAS
Sandro Palestini	CERN

Phenomenology

Christophe Grojean	Saclay/CERN
Rohini Godbole	IIS
JoAnne Hewett	SLAC

Accelerator

Tom Himel	SLAC
Nobukazu Toge	KEK
Eckhard Elsen	DESY

Task Sharing among IDAG members

Each member examines one of the four categories of all the LOIs.

Benchmarking	Tracking	Calorimetry	MDI
Hewett, Li	*Nickerson*	*Green*	*Himel*
Grojean, Palestini	*Danilov*	*Karlen*	*Toge*
Godbole, Grannis	*Elsen*	*Kobayashi*	*Kim*

Every member looks into one of the three LOIs, too.

IDAG Meetings during TILC09

- IDAG read LOIs and heard LOI presentations
- IDAG interviewed each group separately.

  The groups came with experts of relevant topics.
- There was a specific interview on benchmarks with all the groups together. ***This was useful to distinguish differences among the groups.***
- **IDAG discussed in closed meetings in detail and compiled additional questions to the groups both common and specific to each.**

The meetings lasted almost the entire days of TILC09

and made a big progress.

The Plan of IDAG

- **The 4–th IDAG meeting is scheduled in Paris on June 19-21 at LAL, Orsay.**

  This is an IDAG proper meeting and attending members will be available full time.
- All LOI groups will be interviewed separately. They are expected to bring answers to the given additional questions.
- IDAG will continue closed meetings to deepen discussions wishing to approach close to their conclusion.
- **IDAG will make validation report in ALCPG workshop in Albuquerque, New Mexico, 29.Sep.- 3. Oct., 2009.**
- ***If IDAG reaches a conclusion earlier,*** I might receive its recommendation in summer and be able to make an interim report at the next ILCSC meeting, scheduled during LP09, August 2009.

Time Plan after validation

- **Validated LOI groups will proceed with R&Ds according to their priorities, make choices of critical detector** components, and **complete advanced conceptual designs by 2012**.
- IDAG keep watching the entire process.
- Interim report is planned in 2010.
- It will be a written report by the RD with contributions from the LOI groups on their progress.
- In 2012 the groups will complete their reports.
- **In order to realize this plan, financial support will be crucial for the LOI groups to complete the required R&Ds, i.e. for the participating groups, particularly university groups, to accomplish their roles.**
- **Efforts are being made in each region. But the outcome is not clear.**

Common Task groups

- The common task groups are also doing real work.
- It will be important that competing groups cooperate.
- Each group, except Physics Panel, will report individually.

Some remarks about Physics Panel

- Physics Panel has members from out of ILC communities.
- **They met during LCWS08 in Chicago and made a plan to study possible physics cases, assuming early LHC results obtained within a year or two.**
- Six such topics are listed and distributed among the members for investigation of existing works. The report will become available this summer. At the next PAC meeting, they can make a presentation of the activities.

Cooperation with CLIC detector

- **Detector activity is one of the working groups of the CLIC-ILC collaboration.**
- There were attempts to apply ILC detector concept at higher energies by ILD and SiD.
- It was shown that even at some CLIC energies the PFA idea worked reasonably. *(This indicates that ILC detector concepts may be valid also beyond ILC energy scale. But the study needs further work.)*
- CLIC detector people participated ILC workshops, in Chicago and Tsukuba and presented. **They signed LOIs, too.**
- ILD group learned from the experience of LHC detector assembly in preparing LOI.
- **The channels are not very thick but beneficial to the both sides.**
- These cooperation will continue and can be strengthened.

Summary

- **The detector management is in full operation since November, 2008.**

  The entire common task groups became active, too.
- **The LOI process is advancing on schedule.**

  Three LOIs (ILD, SiD, the 4th) were submitted in time.

  IDAG is examining the LOIs and communicate with the LOI groups intensively. IDAG will work through this summer.
- After the validation, expected by autumn this year, **validated groups will continue R&D of detectors and physics studies to complete advanced conceptual designs,**

  being synchronized GDE's T.D. phase II till 2012.
- **For the detector groups to carry out these works, financial support is crucial.**
- **Cooperation with CLIC is going in a productive way.**

Back up

validation

- Are the **physics aims** of the detector convincing for an experiment at ILC?
- Is the detector concept suited and **powerful enough for the desired physics aims and the expected accelerator environment**?
  Namely, is the arrangement of the employed detector components adequate?
- Do the mechanism for the push-pull operation, related alignment and calibration methods enable the desired switching process?
- Is the detector feasible?
  Namely, is the required R&D for the selected technologies advancing fast enough so that they can be completed during the design phase?
- Are the estimated cost and the way to obtain it reasonable when examined at the time of LOI?
- Is the group powerful enough to accomplish the required design work through the technical design phase?

	Current Common Task Members	10/03/2009
	From LOI groups	memebrs from out of LOI groups
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Deputy: Georg Weiglein

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