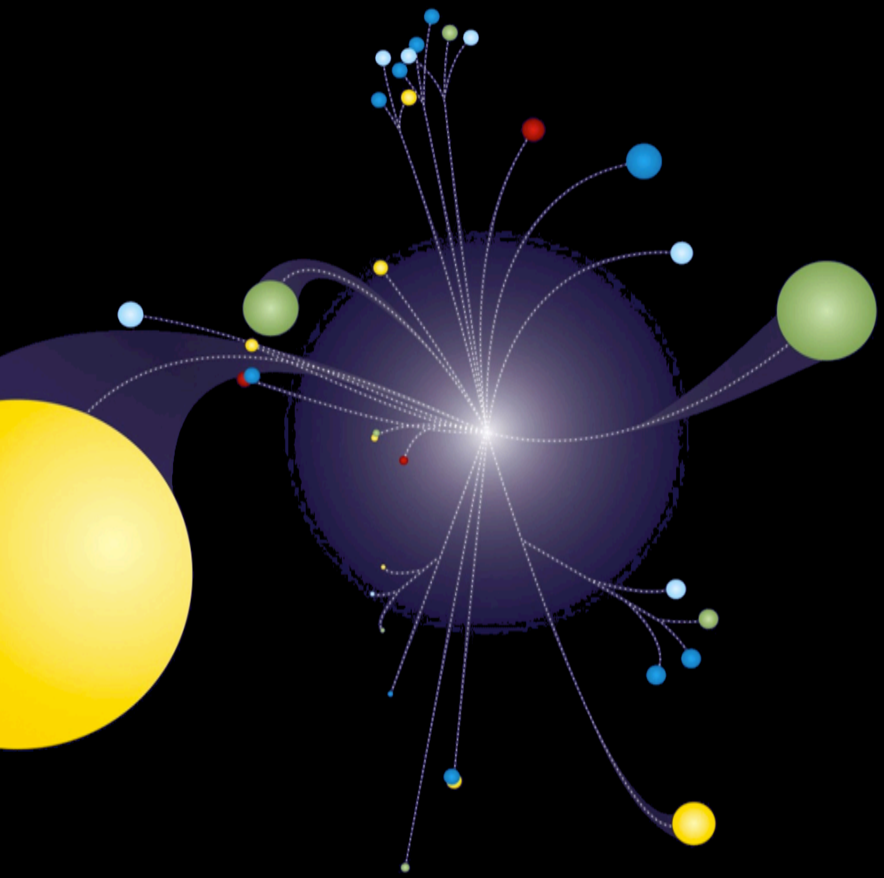
Detector R&D Common Task Group Status Report



Marcel Demarteau

Fermilab

LCWS 2010, Beijing March 26-30, 2010

~ 1963

- What does the time frame of 1963 look like?

~ 1963

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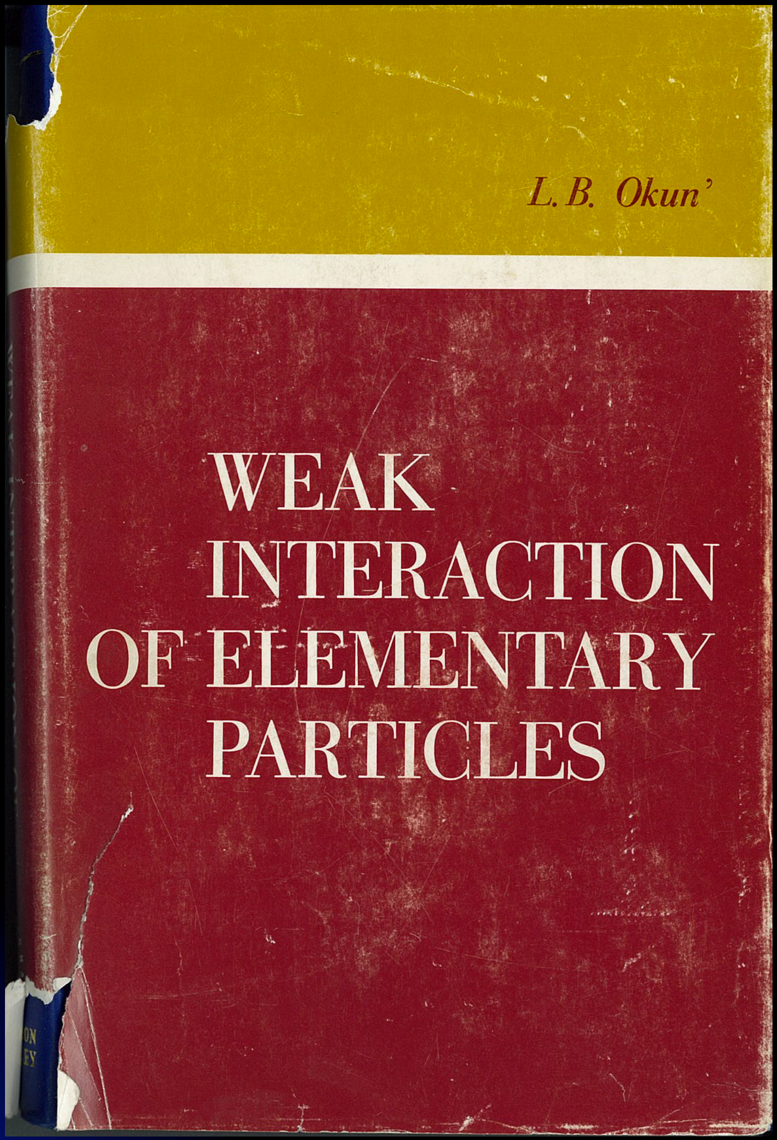
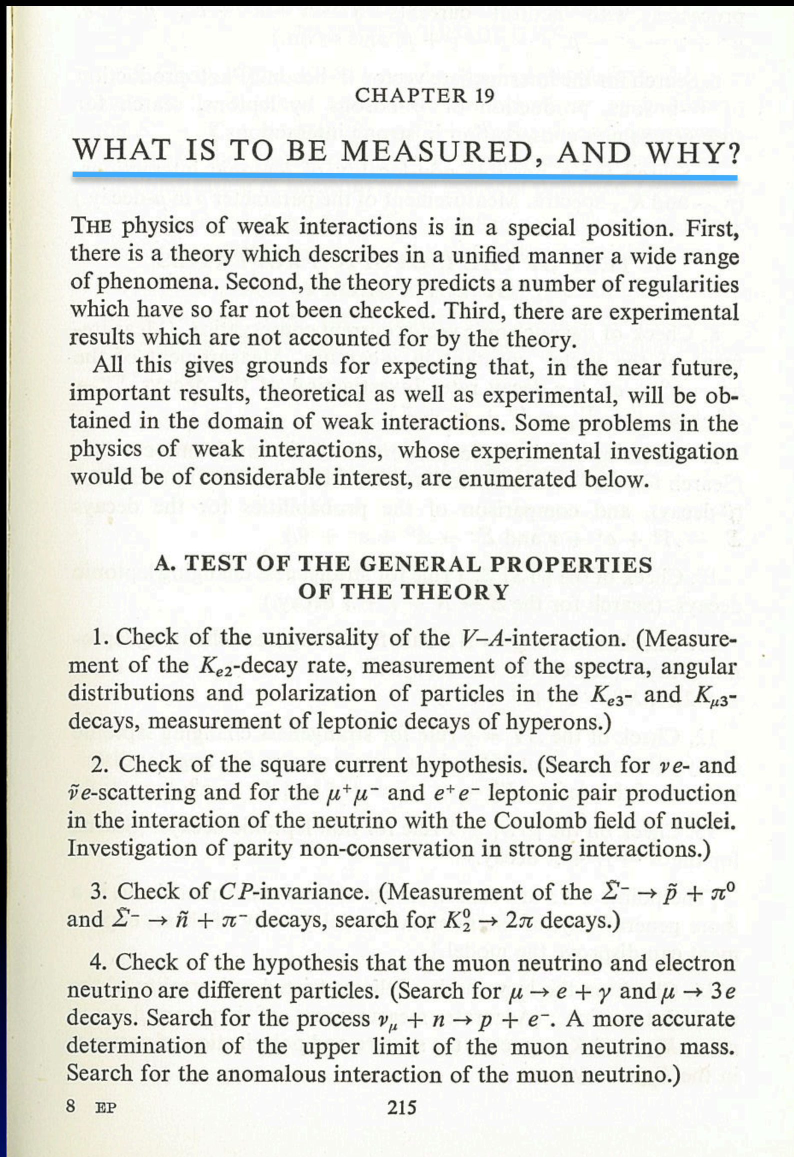
Me

1963



- L. B. Okun, Weak Interaction of Elementary Particles, Reading, Massachusetts; Pergamon Press, 1963
- Based on lectures given in 1960 and 1961 (published first in Russian in 1963)

1963



CHAPTER 19

WHAT IS TO BE MEASURED, AND WHY?

THE physics of weak interactions is in a special position. First, there is a theory which describes in a unified manner a wide range of phenomena. Second, the theory predicts a number of regularities which have so far not been checked. Third, there are experimental results which are not accounted for by the theory.

All this gives grounds for expecting that, in the near future, important results, theoretical as well as experimental, will be obtained in the domain of weak interactions. Some problems in the physics of weak interactions, whose experimental investigation would be of considerable interest, are enumerated below.

A. TEST OF THE GENERAL PROPERTIES OF THE THEORY

1. Check of the universality of the V–A-interaction. (Measurement of the K_{e2}-decay rate, measurement of the spectra, angular distributions and polarization of particles in the K_{e3}- and $K_{\mu 3}$-decays, measurement of leptonic decays of hyperons.)

2. Check of the square current hypothesis. (Search for νe- and $\tilde{\nu} e$-scattering and for the $\mu^+\mu^-$ and e^+e^- leptonic pair production in the interaction of the neutrino with the Coulomb field of nuclei. Investigation of parity non-conservation in strong interactions.)

3. Check of CP-invariance. (Measurement of the $\tilde{\Sigma}^- \to \tilde{p} + \pi^0$ and $\tilde{\Sigma}^- \to \tilde{n} + \pi^-$ decays, search for $K_2^0 \to 2\pi$ decays.)

4. Check of the hypothesis that the muon neutrino and electron neutrino are different particles. (Search for $\mu \to e + \gamma$ and $\mu \to 3e$ decays. Search for the process $\nu_\mu + n \to p + e^-$. A more accurate determination of the upper limit of the muon neutrino mass. Search for the anomalous interaction of the muon neutrino.)

8 EP 215

- Chapter 19: What is to be measured, and why?
  - Enumerates 17 tests of general properties of the ewk theory
    - CP-invariance
    - $\mu \rightarrow e\,\gamma$
    - Two kinds of neutrinos
    - …

1963 – Today

- Many of the fundamental questions, and the specific processes to be studied, have been with us for a long time
- Fundamental breakthroughs have been accomplished through
  - New facilities
  - New, transformational, experimental detection techniques

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  - New facilities
  - New, transformational, experimental detection techniques

- Already recognized in 1963. Premise of Lev Okun is that what is needed is improvements in experimental techniques

In the first square, we encounter at once a process which has not as yet been observed experimentally. This is the … your choice here … The theoretically predicted cross section for this process is so small that it cannot be detected without an essential improvement in experimental techniques.

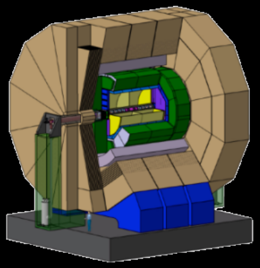
(page 15):

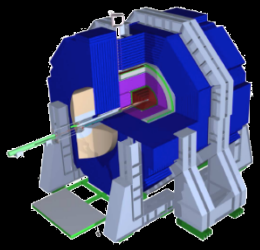
Outline

- The Detector R&D Common Task Group (CTG)
  - Introduction
  - Activities
  - Struggles
- Plans for the near future
- Observations

Common Task Group Membership

- Membership revised after the IDAG validation
  - Three members from the 4th concept stepped down to pursue their other physics interest
  - Two validated concepts each added one member
    - ILD: Dhiman Chakraborty
      Tohru Takeshita
      Marc Winter
    - SiD: Marcel Demarteau (convenor)
      Tim Nelson
      Andy White

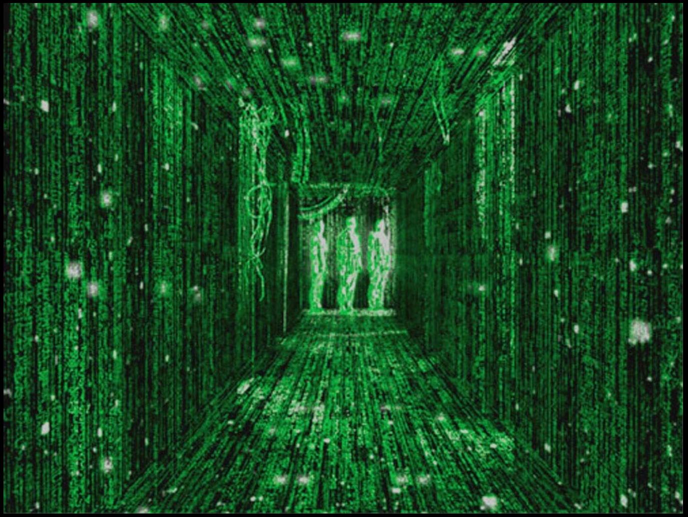




  - Representation of horizontal R&D collaborations:
    - CALICE: Felix Sefkow
    - FCAL: Wolfgang Lohmann
    - LC-TPC: Jan Timmermans
    - SILC: Aurore Savoy-Navarro
    - VERTEX: Ron Lipton
    - Dual Readout: John Hauptman
  - Representation from wider community:
    - CLIC: Burkhard Schmidt

Charge and Organization

- The ctg reports to the Research Director, charged to:
  - Coordinate cooperation of detector R&D
  - Respond to requests from IDAG and PAC on detector R&D
  - Facilitate communication between LOI groups and R&D collaborations
  - Survey R&D efforts and organize reviews when needed
- But, it is a heavily 'matrixed' structure:
  - Two detector concepts
  - Four large horizontal R&D collaborations
  - Independent R&D groups
  - Independent funding agencies
  - Regional interests and priorities
  - Relationship concepts – R&D collaboration
  - …



- No single entity that holds authority

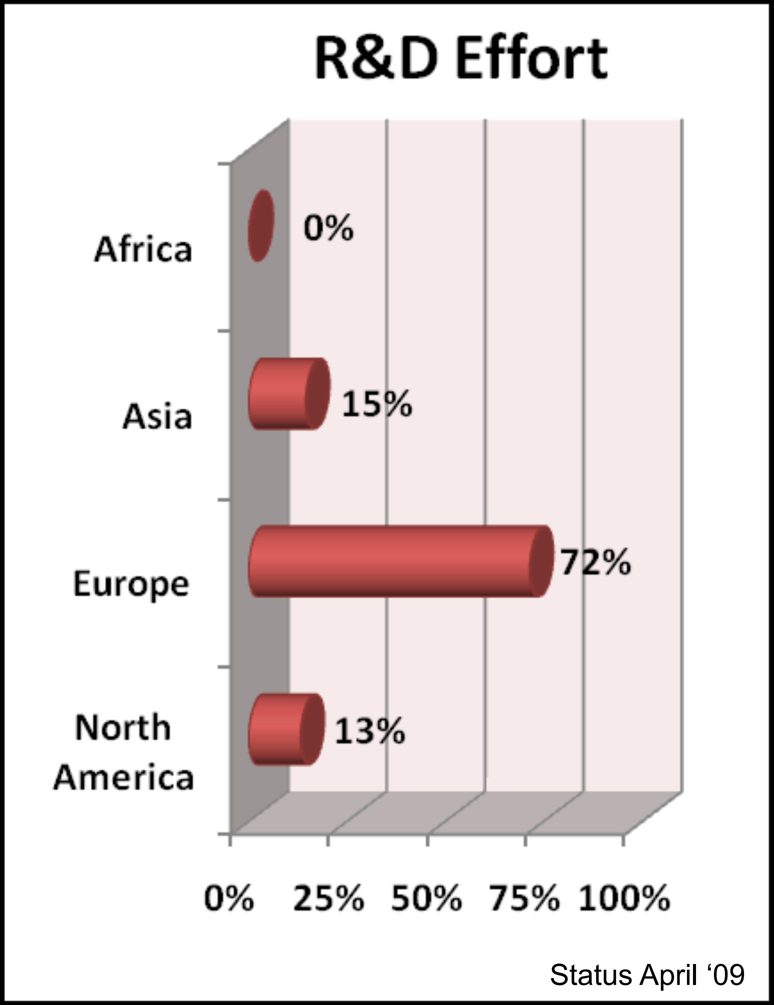
Goals

- At the heart of some critical sub-detectors of the ILC concepts lie unproven technologies
- The goal of the community is to bring these technologies to a level of maturity so that they can justifiably be proposed as the baseline choice for the ILC detectors
- To date, the goals of the ctg have been modest:
  - Highlight the ongoing detector R&D
  - Ensure critical R&D is being addressed in a timely manner and, if not, alert community
  - Plead for more support for an overall balanced R&D program
  - A complete review of all detector R&D à la Damerell was not seen as the most effective way to proceed at that moment

Initial Survey

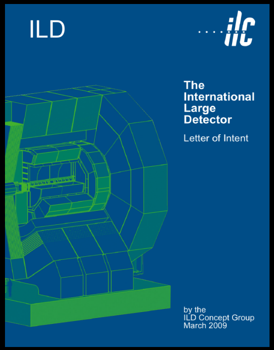
- Initial look at the overall detector R&D effort within the ILC community and R&D identified as critical by concepts

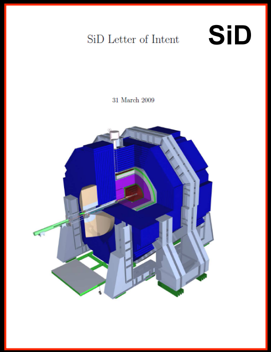
- Findings:
  - Based on the composition of the horizontal R&D collaborations, large imbalance between the regions
    - Effort in the Americas is the smallest
  - Overall effort has shrunk over the last few ears (funding issues)
  - The US effort is becoming subcritical
  - The balance between funding for machine and detector may need to be revisited
- Observation:
  - The situation seemed unsustainable for a long-term healthy community



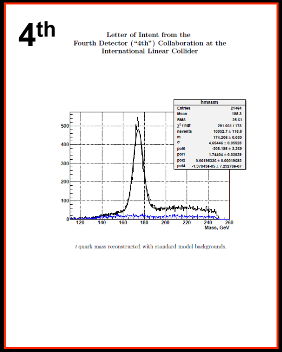
Reaction

- The detector R&D ctg then formulated a reaction to strengthen the detector R&D, based upon
  - LOIs as submitted
  - Lists of critical R&D from concepts
  - R&D plans of the horizontal R&D coll.
  - Validation review process
  - Needs of user community
  - PE Board discussions, …





- At various venues:
  - Emphasized the necessity of continued base support for all ongoing detector R&D efforts to avoid falling below a critical mass
  - Identified a few key R&D areas that need additional support to be able to reach the goal to put forward a defensible DBD by 2012



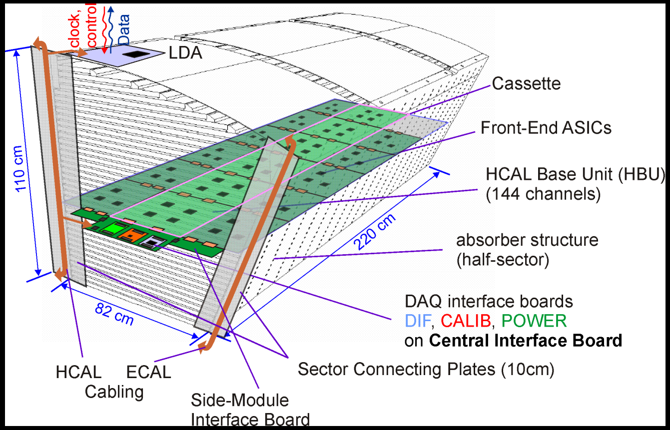
Criteria for Key R&D Support

- The physics and detector goals addressed by the R&D are critical to the linear collider detector and physics program
  - R&D addresses detector performance that lies at the very heart of the ILC physics repertoire
- With adequate support, compelling results of at least one technology, or a preponderance of solid, important results, will be available by 2012.
  - Verification that the fundamental underlying premise of the technology is correct and achievable in real systems
- Detector technology should mainly be under the purview of the ILC detector community
  - Technologies that are vigorously being pursued by other projects, such as the LHC upgrades, are not considered unless it is believed that such R&D is not progressing at adequate pace
- Programmatic issues
  - Emphasis on cooperation vs. duplication/competition

Five Key Areas

- Five areas have been identified in need of additional support to be able to put the DBDs on a firm scientific basis

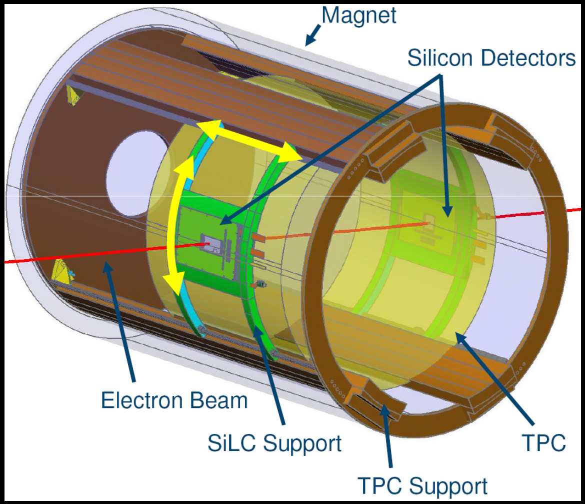
1. Areas of Particle Flow Calorimetry within CALICE



2. Further development and understanding of PFA

3. Areas of LC-TPC studies

4. Development of 1k-channel ASIC for tracking, calorimetry and forward calorimetry



5. Test Beams and Infrastructure

Presentations

- The ctg reported on their progress at the last PAC meeting with a very explicit plea to the PAC:

  - To avoid a (further) contraction of the community, we ask
    1. The PAC to recognize the dire situation of the detector community, especially in the US
    2. The PAC and ILCSC to support our recommendation for additional support
    3. Address the balance in allocation of resources between the accelerator and detector, especially for those regions where the balance is precarious.

- From Yamada's plenary talk on Friday:
  - "… at the last PAC stressed the crucial importance and serious necessity of R&D resources. It triggered a positive climate for improvement, while such efforts need to be continued."

Evaluation

- Our recommendations have been summarized in a draft report
- Received with mixed feelings; some of the (valid) objections
  - Unbalanced, incomplete
  - Inappropriate emphasis
  - …
- Our attempt to quantify the need for resources was a miserable failure
- None of the proposed target audiences holds any real authority, the situation is heavily matrixed and each region has a different metric
- At this workshop reached an agreement on how to finish and release document

ILC Research and Development Plan for the Concept Detectors

Version 0.1

October 2009

ILC Research Directorate

Director: Sakue Yamada

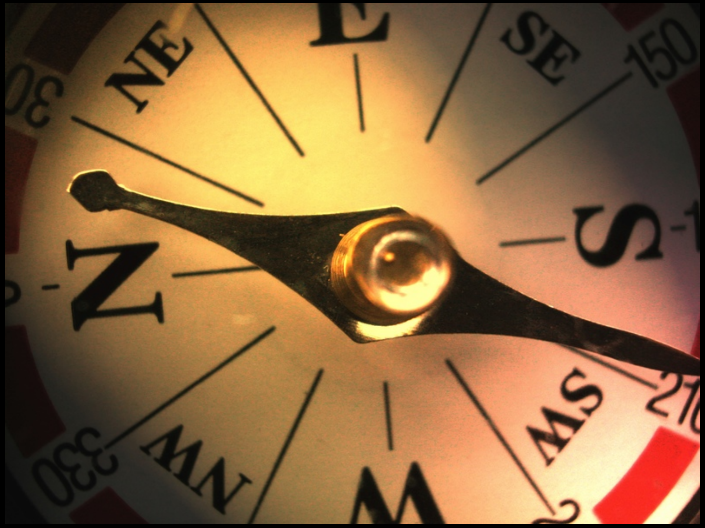
Prepared by the Common Task Group for Detector R&D:

Roberto Carosi, Dhiman Chakraborty, Marcel Demarteau (convenor), Franco Grancagnolo (deputy convenor), John Hauptman, Ron Lipton, Wolfgang Lohmann, Aurore Savoy-Navarro, Felix Sefkow, Tohru Takeshita, Yuri Tikhonov, Jan Timmermans, Andy White

Plans for Immediate Future

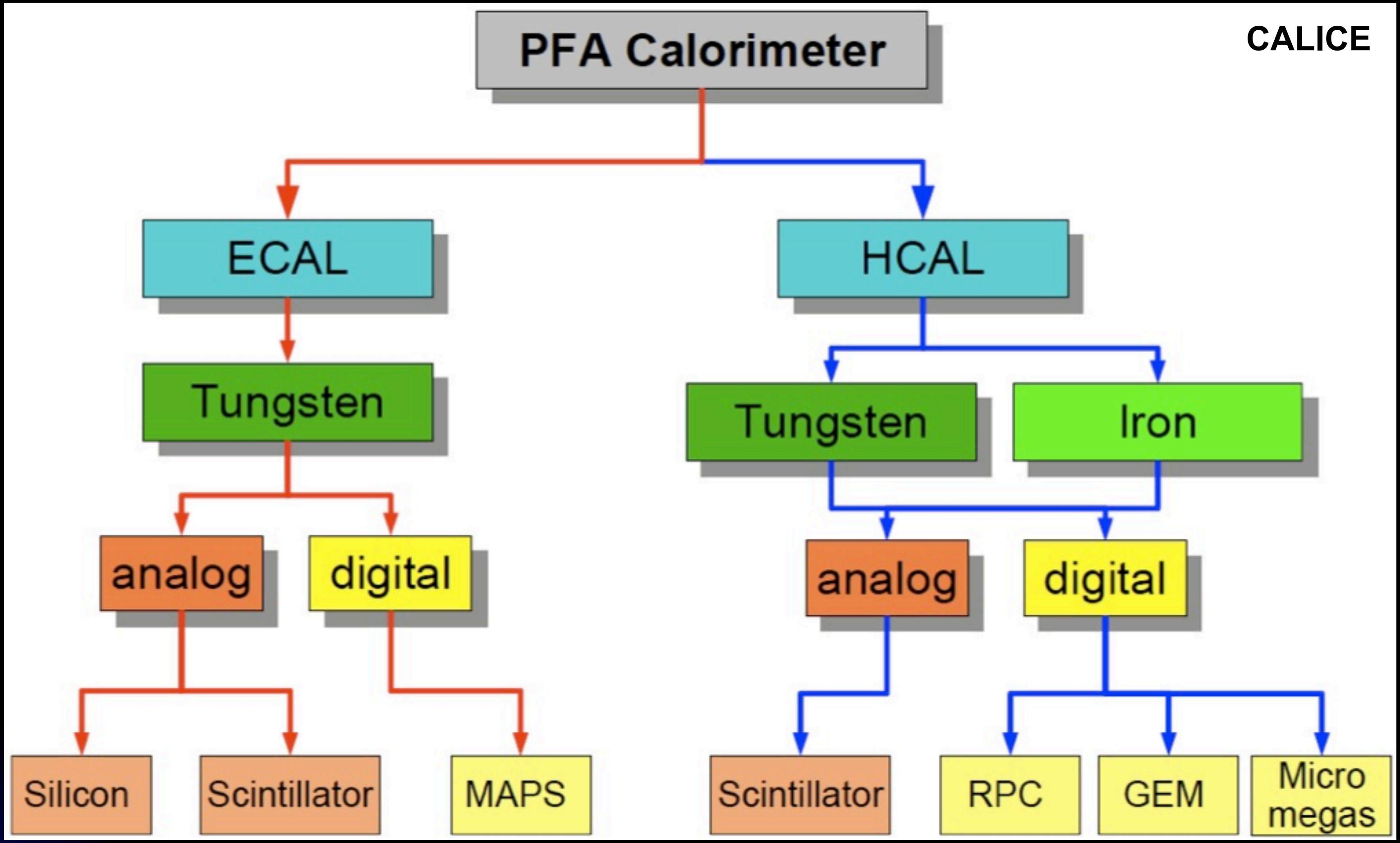
- The RD has called for 'monitoring' of the common task groups by the IDAG
- Our group will be 'interviewed' at the next meeting in October

- Our plan is to build on our current work to summarize the current effort and make recommendations to device a strategy – with the help of IDAG – to reverse the contraction of the detector community and to develop a viable long-term plan that extends beyond 2012
  - Support for program
  - Evaluation of program
  - Test beam support
  - …



Long-Term Plan

- Groups are contemplating a contraction of their original goals:
  - For example, 'growing the PFA technology tree with physics and technical prototypes by 2012'



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- Every effort will be given, within the resources available, to bring as many technologies as possible to a level of maturity so that they can justifiably be proposed by the concepts
- As far as detector development is concerned, the DBD will be a road marker
- For a healthy, sustained, long term effort, collaboration with other initiatives, notably CLIC, will be very important

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The LHC

- Often heard:
  - We need to wait for results from the LHC
  - What is a good enough discovery for start of ILC ?
  - Many other variants of the same question
- This may be true for approval of the overall project

- However, I believe this does not apply to detector development
- Our justification is to nail the expected.
- Our dream is to find the really unexpected !!
- For that, you need to be prepared with the best possible precision instruments you can obtain.

Discoveries in Physics

Facility	Original purpose, Expert Opinion	Discovery with Precision Instrument
P.S. CERN (1960)	π N interactions	Neutral Currents -> Z, W
AGS Brookhaven (1960)	π N interactions	2 kinds of neutrinos, Time reversal non-symmetry, New form of matter (4th Quark)
FNAL Batavia (1970)	Neutrino physics	*5th Quark, 6th Quark*
SLAC Spear (1970)	ep, QED	Partons, 4th Quark, 3rd electron
ISR CERN (1980)	PP	*Increasing PP Cross section*
PETRA Hamburg (1980)	6th Quark	*Gluon*
Super Kamiokande (2000)	Proton decay	Neutrinos have mass
Hubble Space Telescope	Galactic survey	*Curvature of the universe, dark energy*

Exploring a new territory with a precision instrument is the key to discovery.

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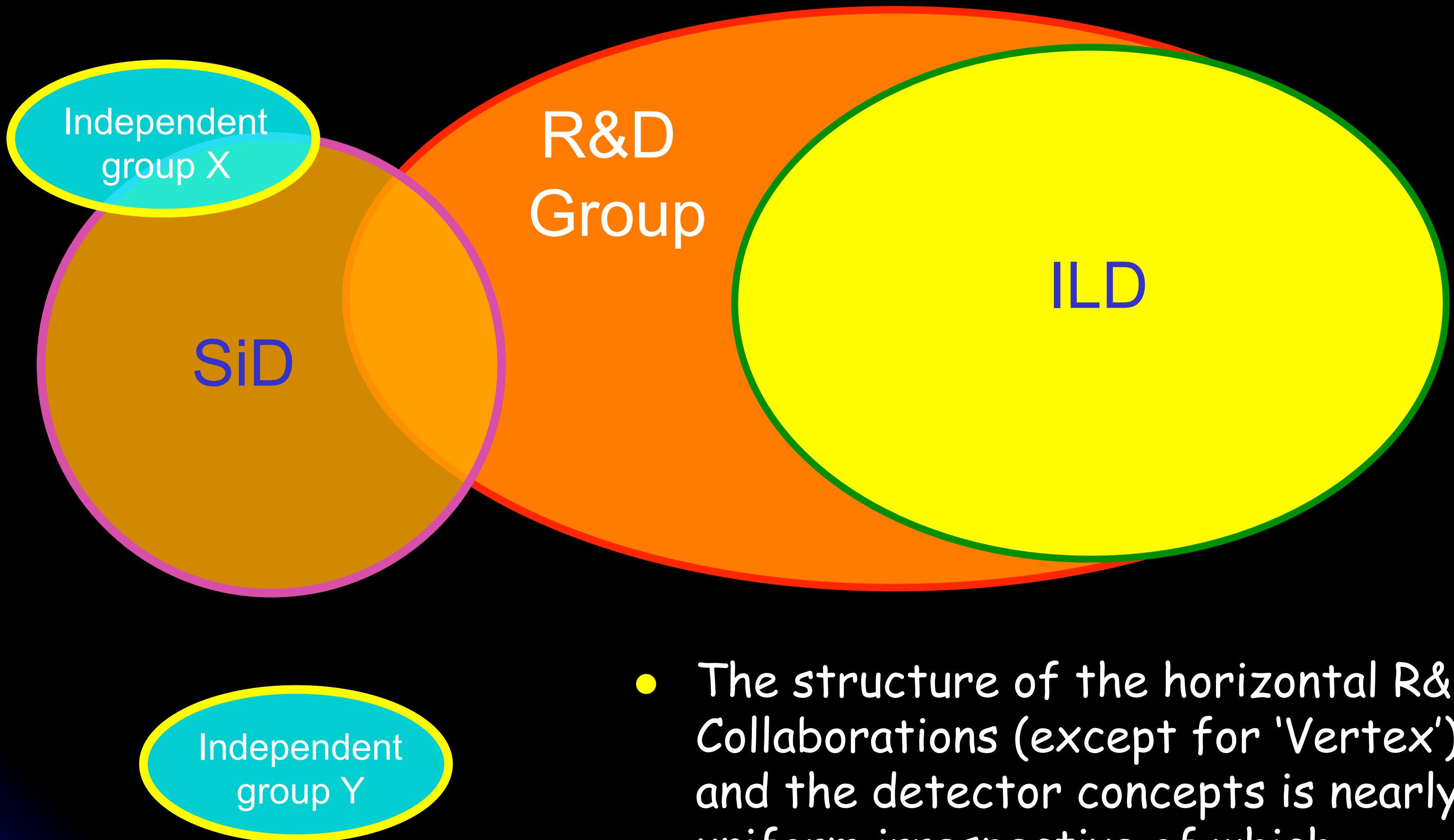
Samuel Ting, La Thuile 2006

Final Remarks

- The first year of the detector R&D ctg has been very valuable in understanding the complexity of the community
- Transformational new detector technologies are being pursued within the ILC community, but the support is steadily eroding
- The key to discoveries are precision detectors
  - Independent of an external timetable
  - Independent of our theoretical prejudice
- We will continue to explore ways – in collaboration with the community – to build the case for strong support for detector development extending beyond the DBD
- We welcome suggestions from the community!

Horizontal R&D Collaborations and LOIs



- The structure of the horizontal R&D Collaborations (except for 'Vertex') and the detector concepts is nearly uniform irrespective of which horizontal R&D collaboration
  - ILD is completely embedded in the horizontal R&D collaboration