# Linear Collider Detector R&D

- **Launched new effort in US in 2002**
  - LCRD, UCLC
- **Scope defined in discussion with DOE/NSF**
  - Anticipated annual growth
- **USLCSG commissioned review process and established two review panels**
  - Detector R&D chaired by Howard Gordon
  - Accelerator R&D chaired by Norbert Holtkamp
- **Two years have passed and we enter our third year**
  - Time to assess how we are doing

# Background for LC Detector R&D Program

- **Identified Priorities in 2002**
  - **Summaries at workshops at Fermilab, Cornell, and SLAC**
  - **Developed International Coordination (Int'l R&D Panel and report)**

- **LC Detector were found to pose new challenges that differed from LHC experiments, defined by the very different experimental conditions, requiring coordinated R&D effort**
  - **Precision**
  - **Speed**
  - **Readout**
  - **Granularity**
  - **Hermiticity**
  - **Integration**
  - **Response**
  - **Beam measurements**

# LC Detector R&D Program Challenges

## Precision Frontier

- The linear collider is fundamentally a precision machine, with significant discovery potential
  - Higgs properties
  - Superpartner properties
  - Asymmetries
  - Top quark properties
  - W and Z properties
- Precision measurements require special care in detectors which are not achievable without further R&D
- Unburdened by the high radiation levels of the LHC, the LC offers to opportunity for enhanced physics
- One (important) example: Energy Flow Calorimetry has great potential, but must be developed

## Speed Challenge

- The X-band linear collider delivers events in 1.6 nanosecond bunches - detector response must be fast

## Readout Challenge

- The Superconducting RF linear collider demands handling of data between bunchs, every 337 nseconds.
- RF interference is known to be a problem from SLC experience

  - need to characterize and ameliorate

## Granularity Challenge

- All detector subsystems require high degree of granularity for optimal performance

## Hermiticity Challenge

- Forward detection critical for new physics channels

## Integration Challenge

- How can you build a realistic detector without compromising these important features

# LC Detector R&D Program Challenges

## Beam Measurement Challenges

- **CMS energy Measurement**
  - Smuon mass: 1000 ppm(24 Mev for 220 GeV smuon)
  - Top mass: 200 ppm(35 Mev)
  - Higgs mass: 200 ppm(25 MeV for 120 GeV Higgs)

- **Measure beam polarization**
  **goal 0.2% precision**

- **Luminosity measurement**
  - Total cross sections: absolute $\delta L/L$ to ~0.1%
  - threshold scans : core width to <0.05% $E_{CM}$
    and tail population $\delta L/L$ to <1%

*The optional Giga-Z program requires better precision for luminosity and beam energy measurements,

# LC Detector R&D Program Frontiers

## Some Comparisons to LHC

Vertex Detector layer thickness

| | |
|---|---|
| CMS | 1.7 % $X_0$ |
| ATLAS | 1.7 % $X_0$ |
| LC | 0.06% $X_0$ |

Vertex Detector granularity

| | |
|---|---|
| CMS | 39 Mpixels |
| ATLAS | 100 Mpixels |
| LC | 800 Mpixels |

Tracker thickness:

| | |
|---|---|
| CMS | 0.30 $X_0$ |
| ATLAS | 0.28 $X_0$ |
| LC | 0.05 $X_0$ |

ECAL granularity (detector elements)

| | |
|---|---|
| CMS | $76 \times 10^3$ |
| ATLAS | $120 \times 10^3$ |
| LC | $32 \times 10^6$ |

| 2002 Proposal | Proposed Budget | No. projects |
|---|---|---|
| Accelerator Physics | $1,003,783 | 33 |
| Luminosity, Energy, Polarizatic | $171,541 | 9 |
| Vertex Detector | $119,100 | 3 |
| Tracking | $395,662 | 11 |
| Calorimetry | $514,540 | 12 |
| Muon system and Particle ID | $148,899 | 3 |
| | | |
| **TOTAL** | **$2,353,525** | **71** |

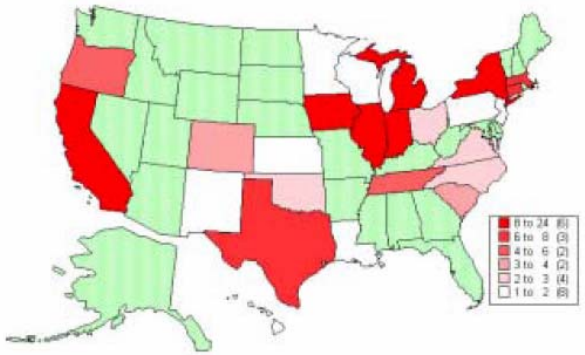
**2003 Proposal**

| $ year 1 | $ year 2 | $ year 3 | proposals |
|---|---|---|---|
| $1,126,162 | $1,575,474 | $1,554,058 | 29 |
| $237,733 | $462,277 | $435,995 | 9 |
| $172,716 | $319,140 | $325,190 | 3 |
| $596,660 | $915,936 | $932,386 | 11 |
| $855,212 | $1,903,475 | $1,334,401 | 13 |
| $194,188 | $224,444 | $230,991 | 3 |
| $3,207,732 | $5,452,641 | $4,861,065 | 68 |

http://www.hep.uiuc.edu/LCRD/html_files/proposal.html

http://www.hep.uiuc.edu/LCRD/pdf_docs/LCRD_UCLC_Big_Doc/

participation, incl. labs



# DOE Grants

**DOE responded to the proposals in FY03 and FY04 by funding 14 university LC detector R&D efforts**

| | FY03 | FY04 |
|---|---|---|
| Lum/Energy/Pol | 4 | 4 (1) |
| Calorimetry | 3 | 6 (2) |
| Muons | 2 | 3 |
| Particle ID | 1 | |
| Tracking | 2 | 5 (1) |
| Vertex | 2 | 2 |

» NOTE : Parenthesis refers to UCLC projects

**and 12 university LC accelerator R&D projects in FY03**

**4 supplements and 8 new grants**

**about $500k for detector R&D and about $400k for accelerator R&D in FY03**
**and about $700k for detector R&D and about $400k for accelerator R&D in FY04**

# What Now?

**While we have had some success, let's face it, it is still disappointing.**

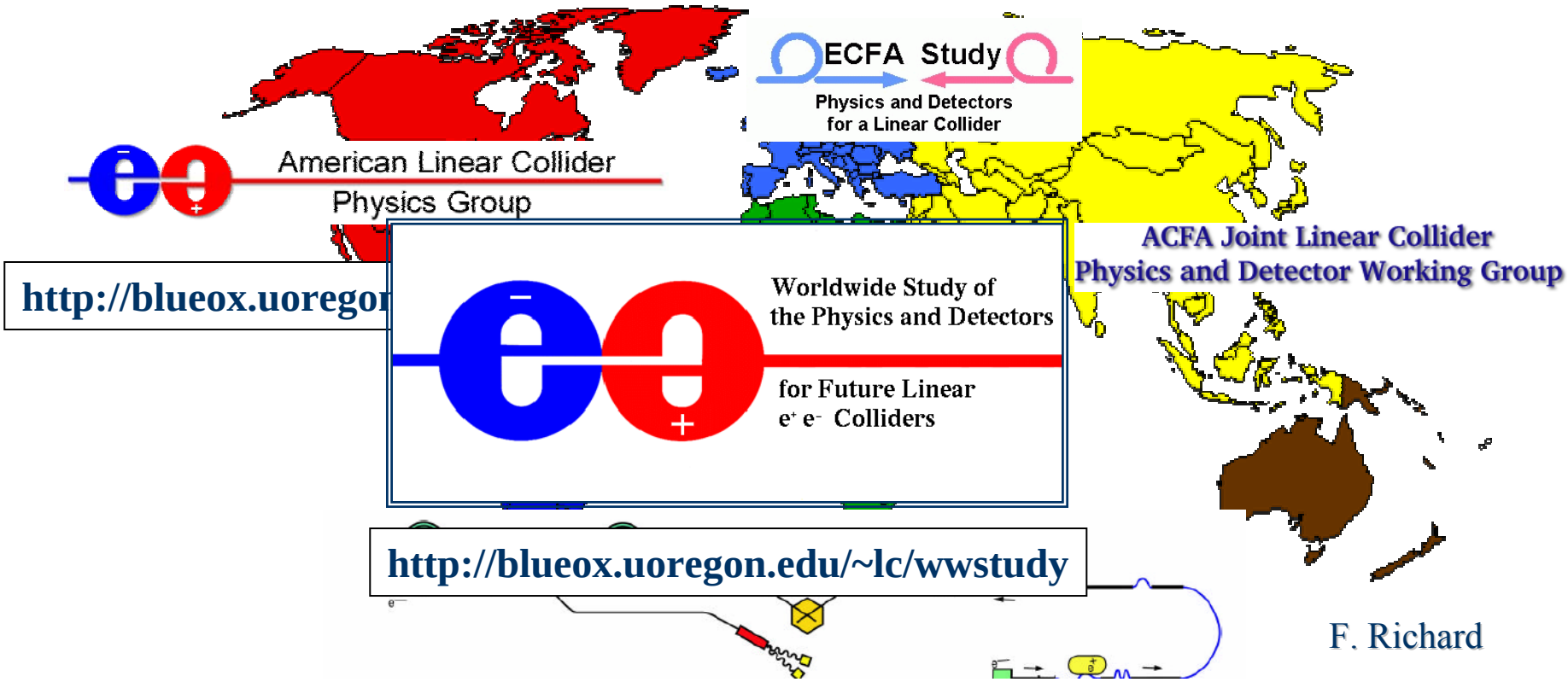
**We must do better!**

**What can we do to improve our funding levels? We need to prepare a better strategy**

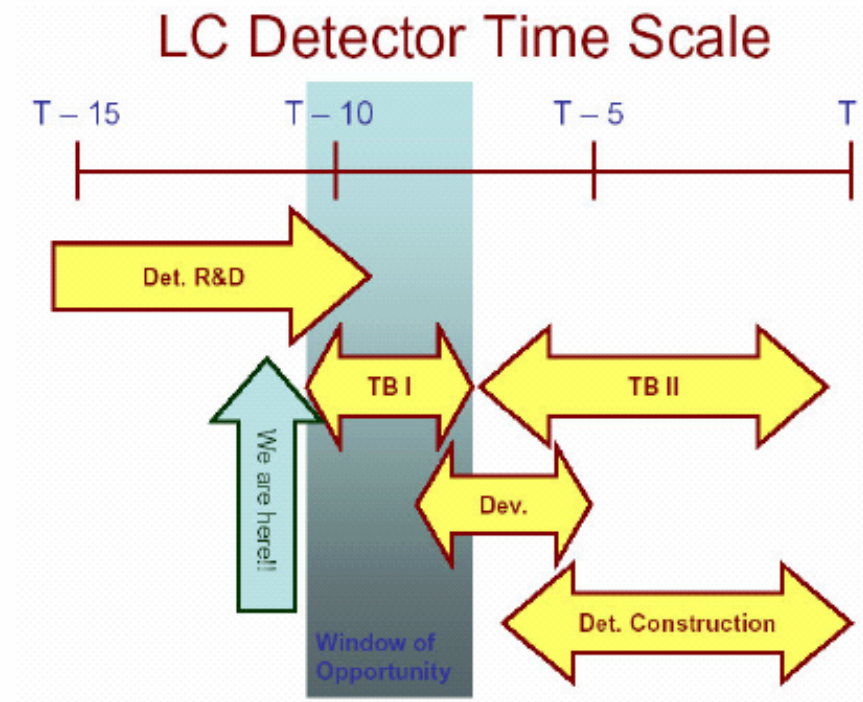
- **Organize the R&D more explicitly around whole-detector designs**
  - **Detector Design Studies are critical to this**
- **Strengthen our arguments**
- **Listen to the agencies and react**

# Detector Development and Planning

- **Physics and Detector Studies and R&D are being conducted, coordinated, and merged to the extent possible through the World-wide Study**



# Detector R&D is Critical




| Time | T=2015 | Tasks |
|---|---|---|
| T – >10~11 | Before 2005 | Detector R&D |
| T – 10~11 | 2005~6 | Test Beam I |
| T – 8~9 | 2006~7 | •Detector Technology chosen.<br>•Detector Development and design begins |
| T – 6 | 2009 | Detector Construction begins<br>Test Beam II (Calibration) |
| T | 2015 | LC and Detector ready |

Graphically summarized
by Jae Yu

# Moving Forward

- **We have started a very good Detector R&D program.**
- **Now is the time to ramp it up and deal with the critical issues.**
- **What are the critial R&D needs for the detector design studies**
  - **Silicon Detector** **John Jaros**
  - **Tesla TDR Detector/Large Detectors** **Rolf Heuer**