Detector R&D

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HEP PI Meeting

June 17 2014

Take Away Messages

- **The U.S. HEP program is unlikely to be able to outspend our international competition**
- **Our only hope to maintain leadership in the long-term is to out-innovate the competition, and/or exploit unique capabilities**
  - Focus on areas where US can have leadership
  - "High-risk, high-impact" as opposed to incremental advances
  - See e.g. Instrumentation summary talk at Snowmass
- **P5 recommended specific project priorities**
  - These need to be supported by the technology R&D programs
- **Still several issues to work through**
  - R&D efforts split across "silos"
  - Long-term support of infrastructure
  - Lab/university balance and collaboration

HEP Detector R&D Program

- **Detector R&D Research program supports:**
  - Core R&D groups at several universities and 6 national labs
  - (Past) Special solicitations for short-term projects
    - Advanced Detector Research and Collider Detector R&D
    - Now combined into Comparative Review FOA detector topic
  - Total funding about $25M/yr (FY2014). Approx. 85-90% of funding to labs, including Ops for test beams and detector facilities
- **Major Activities:**
  - Liquid Argon and water Cerenkov detectors
  - Large area photodetectors
  - CCD development
  - 3D pixel sensors
  - Particle flow and compensated calorimetry
  - Radiation hard detectors and electronics

Energy Frontier Plan

- **P5 Recommends LHC Phase II as "highest-priority near-term large project" [Recommendation #10]**
- **Discussions with CERN about follow-on to LHC Agreement proceeding**
  - Necessary precursor to planning for "Phase-II" upgrades
- **Energy Frontier science implementation plan is to fully exploit high-energy LHC running**
  - Phase I upgrades starting ~now, in FY15 Request
  - Initial discussion of Phase II (HL-LHC) upgrades underway
  - Need to determine R&D profile needed for US participation
  - Expect the bulk of R&D effort to be supported by LHC Ops program for near-term, transitioning to project later in the decade
- **We expect ILC Detector R&D is further off in the future, depending on Japanese approach and HEP budgets**
  - Any near-term efforts will need to be focused on "generic" R&D

Intensity Frontier Plan

Current program: Minerva, NOvA, T2K, MicroBoone, Daya Bay, EXO-200

- **NOvA** and **MicroBoone** will complete construction in 2014
- Others taking data

Planned program: P5 recommended "a coherent program" of short- and long-baseline neutrino experiments at FNAL [Recommendations 12-15]

Several Projects are in design/R&D phase; fabrication not approved yet.

- **Mu2e, Muon g-2** recommended in all scenarios, close to CD-2/3
- **LBNE(F)** at CD-1, and working on "internationalization"
- **Short Baseline Program** in definition phase (no CD-0 yet)
- Several small experiments under consideration (see Alan's breakout talk)

To make a coherent program will require careful consideration of which experiments to do, and their time-phasing

- There are several areas of related technology R&D that will require refocusing or redirection of effort from Ops and Detector R&D programs:
  - Liquid Argon TPCs (fundamentals, scaling, purity, HV,…)
  - Other detector technologies (near detector, far detector alternatives(?))
  - Beam monitoring

Cosmic Frontier Plan

Current program: **Fermi/GLAST, Veritas, Auger, AMS, G1DM, DES**

- Plus several smaller experiments

Planned program: P5 recommended a program based on the drivers:

- Dark matter, dark energy, and CMB [Recommendations 16-20]

(Near) Future Projects have a well defined plan and are well advanced technically:

- **G2DM** downselection by end of June, expanded program if possible
- **LSST** in all funding scenarios
- **DESI** if budgets permit
- **CTA** if and only if NSF Astronomy supports it
- Several small experiments under consideration (see Cosmic breakout talk)

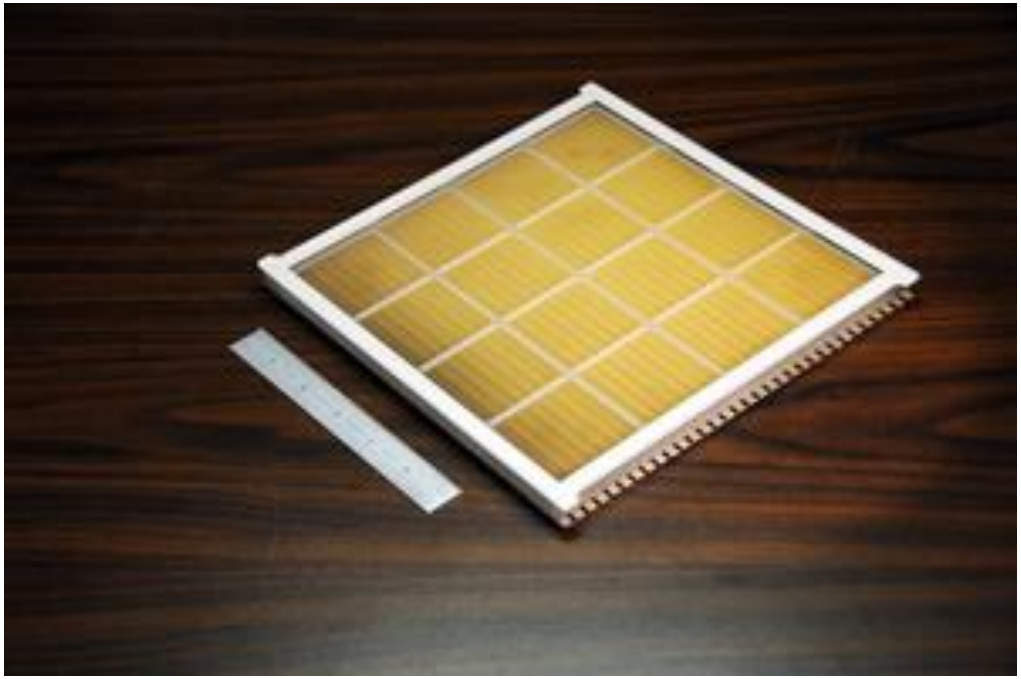
The main areas in need of additional R&D are the ones farther in the future:

- G3DM
- CMB-S4
- New concepts?

We will work to develop a coherent research/operations/R&D plan for these areas, working with the community.

Advanced Detector Technology

- **Large Area Picosecond PhotoDetecor project (LAPPD) was launched in 2008 to develop new photodetectors for HEP (using ALD coated glass) and other applications that can provide**
  - Large area (sq. meters)
  - Flat panel geometry
  - Picosecond timing
  - Low cost
- **Lab/university consortium**
- **Multi-disciplinary team**
- **Industry partners, SBIR/STTR**
- **Reviewed in May 2014**
- **Next steps:**
  - Fabricate small number of working samples for testing
- **Need to develop other (new) candidates for this kind of "demonstration" R&D**



Recent Lessons Learned

- **"Generic" detector R&D that has (in principle) multiple customers reviews well in comparative peer review. Project-specific R&D does not.**
- **Small-scale, proof-of-principle R&D typically reviews well. Large demonstration projects usually do not.**
- **There is support (community, DOE) for maintaining what's left of university R&D infrastructure if it is a recognized resource for the national program**
  - We would like to grow this if we can
- **Trying to re-diagonalize project-related R&D onto specific technology axes (a la CDRD) does not work well**
  - Even with a generic label reviewers interpret as project R&D
  - Integration of R&D activities is lost in cut-and-paste approach
- **LAPPD seems to be a good (if expensive) model for demonstrating new technology bridging the product development "valley of death"**
  - This is similar to Accelerator Stewardship model
  - Note other partners may have different goals and priorities

HEP Model for Detector R&D

Type of R&D	Project-specific	Near-term, "incremental"	Mid-term, "demonstration"	Long-term, "generic" or Infrastructure
Typical Funding Source(s)	Project funds (post-CD0) Program Directed R&D (pre-CD0)	Facility Ops	Detector R&D Program	Det R&D Core Special FOAs
Review mechanism	Lehman/CD Program review	Ops Review	Ad-hoc	Comparative Review
Recent Examples	LHC Detector upgrades DM G2 R&D ILDRD	BaBar IFR upgrade	LAPPD	ADR CDRD

What We Need

- **Ideas on how to revitalize the existing program (that don't require large infusions of cash):**
  - How best to assess/prioritize lab + univ infrastructure
  - How best to enhance sharing of univ + lab resources
  - Better ways to support young people with detector interests
- **Ideas on how to work within the HEP funding model to preserve university technical infrastructure & training**
  - Current model works ok (?) if core detector R&D funding is "reliable"
- **What are the best areas to make strategic/directed R&D investments, evaluated by:**
  - Potential for science impact (not necessarily just HEP)
  - Technological readiness and clear milestones
  - US leadership or unique capability
  - Could develop specific targeted FOAs for identified "grand challenges"

Summary

- **Innovation in accelerator and particle detector technology has been a historic strength of HEP**
  - We need to preserve and reinvigorate this core competency for the future
- **Near-term priority is to support P5 plan as part of a coherent program:**
  - LHC Phase II R&D
  - Neutrino detector R&D
  - Dark matter and CMB detectors
- **In the past the stewardship of these efforts has rested largely with the HEP labs and some university groups as part of their institutional heritage**
  - Today the institutional model has largely eroded
  - We must forge new collaborative models that cross-cut labs, universities, disciplines
    - The community has a key role in identifying the science opportunities and technology challenges (and executing!). CPAD would be a natural mechanism for this.
    - The agencies have a key role in providing national stewardship and enabling success for good new ideas and people
- **Be alert and nimble for paradigm shifts**

Technology R&D , circa 1948