# The Detector R&D Program
# at
# Argonne National Laboratory

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*DOE Laboratory Detector R&D Review*
*Rockville, July 24-26, 2012*

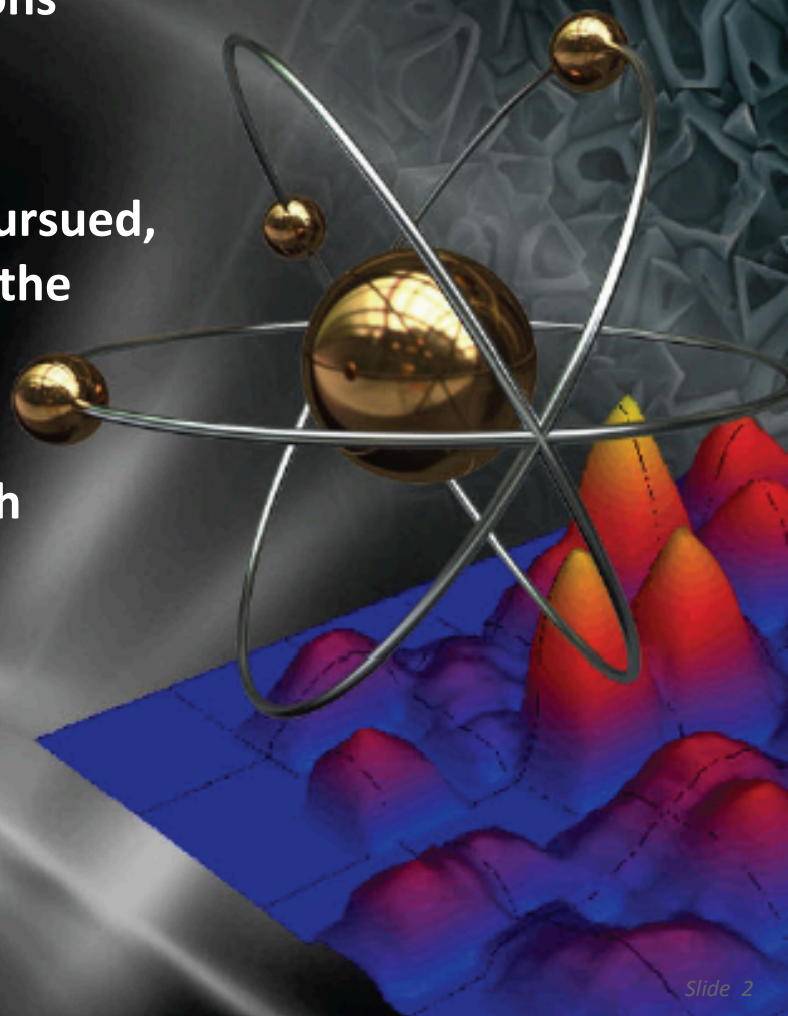
# Our Unifying Goal

**To develop instrumentation that *enables, and is unique***

**Enable answering the fundamental questions in High Energy Physics**

**Unique methodologies and technologies pursued, leveraging the multi-disciplinary nature of the laboratory**

**In the context of a very dynamic world with rapidly changing priorities**



# LDRD Program

| Project Title | PI | FY06 | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 |
|---|---|---|---|---|---|---|---|---|
| Pico-Second Timing | Byrum | 110 | 110 | 70 | | | | |
| Silicon PM | Drake | | 100 | 125 | | | | |
| Dark Energy Survey | Kuhlman | | 330 | 200 | 130 | | | |
| COGENT | DeLurgio | | 66 | 80 | | | | |
| Astrophysics | Byrum | | | 300 | 270 | 408 | | |
| Transition Edge Sensors | Novosad | | 610 | 800 | 600 | | | |
| Computational Cosmology | Kuhlman | | | 130 | | | | |
| Low Mass Technologies | Underwood | | | | | 205 | 186 | 180 |
| Photo-Cathode Growth | Demarteau | | | | | | 200 | 153 |
| Towards the Exascale Sky | Habib | | | | | | 351 | 1,014 |
| Techniques for Large Instrumentation | Djurcic | | | | | | 180 | 180 |

- Successfully used LDRD grants to establish base funding
- Some quite successful and jumped directly from LDRD to project funding

# Last Review's Comments

- C: Digital Hadron Calorimeter for an ILC not well aligned with P5 priorities
  A: Did not want to stop program mid-stream; technical program completed

- C: SiPM is not cutting edge R&D; better done at university
  A: Agreed; phased out

- C: Micro-channel plate photodetector is risky; ANL may not have expertise, but there would be enormous payoff if successful
  A: Looking forward to your evaluation

- C: Wireless/fiberless DAQ are risky, but could have great payoff
  A: Shifted focus to optical modulators which are more promising

- C: TES show great promise
  A: Device complete and taking data on South Pole; would like to move to next generation devices

# Guidelines For This Review

- Relationship of group's activities to overall HEP mission.
- Laboratory's status and plans for collaborative efforts with universities, other divisions and industry.
- Evaluate the impact and promise of the research efforts in detector R&D
  - Quality and impact
  - Scientific significance, merit and feasibility of proposed program
  - Competence and future promise of group
  - Adequacy of resources
  - Quality of support and infrastructure provided by laboratory
- Plans for maintaining or enhancing local facilities
  - Scope and effectiveness
  - Appropriateness of resources
  - Relevance and impact
- Response to the findings and recommendations of the last review.

# Project Alignment

| Project | "Unique" | "Enable" |
|---|---|---|
| TES | Combine superconducting materials science expertise with HEP mission goals | Study of the dawn of time; composition of universe |
| Optical | Alternate robust technology for data readout, work with industry; study new materials for opto-photonics | Full exploitation of energy and intensity frontier data |
| Trigger | Next generation CAM based trigger; build new capability based on 3D technology following industry lead | Full exploitation of energy frontier data; pattern recognition capability |
| LAPPD | Advances in materials science integrated in new methodology; close collaboration with industry from start | $H_2O$ Č-detectors, collider TOF, collider vertexing, rare K-decays, PID, TOF-PET, ... |
| DHCAL | Ultra-fine segmentation with integrated readout using alternate technology; RPC expertise | Improved jet E-resolution, imaging calorimetry |

- All tackle fundamental limitations in current state of instrumentation to advance science

# Partnerships

- In our role as national laboratory we believe partnerships are crucial for a successful program

MSD
HEP
CNM

Case
CASE WESTERN RESERVE UNIVERSITY

Berkeley
University of California

THE UNIVERSITY OF CHICAGO

KICP

UNIVERSITY OF MICHIGAN

McGill

NIST

***Transition Edge Sensors***

Argonne NATIONAL LABORATORY

CALICE
Calorimeter for ILC

Fermilab

McGill

ILLINOIS INSTITUTE OF TECHNOLOGY

DESY

OREGON

中国科学院高能物理研究所
Institute of High Energy Physics, CAS

THE UNIVERSITY OF IOWA

BOSTON UNIVERSITY

The University of Texas ARLINGTON

Coe College

***Digital Calorimetry***

High Energy Physics Center for Nano-scale Materials

LUXTERA

Stockholm University

CERN

***Optical Readout***

Argonne NATIONAL LABORATORY

Fermilab

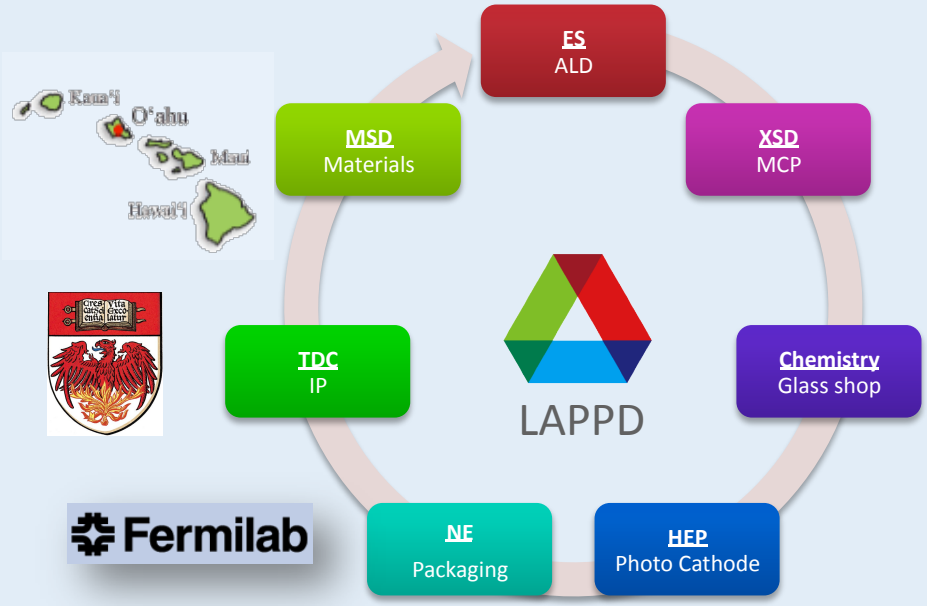
Tezzaron SEMICONDUCTOR

***Fast Track Trigger***

# Partnerships in LAPPD

2012 R&D 100 — The Oscars of Innovation — 50th ANNIVERSARY

| Primary Developer | 2012 R&D 100 Winning Technology | Co-developers / Contributers |
|---|---|---|
| Argonne National Laboratory | Large Area Micro-channel Plates | Incom, Inc.; Berkeley Space Sciences Lab |



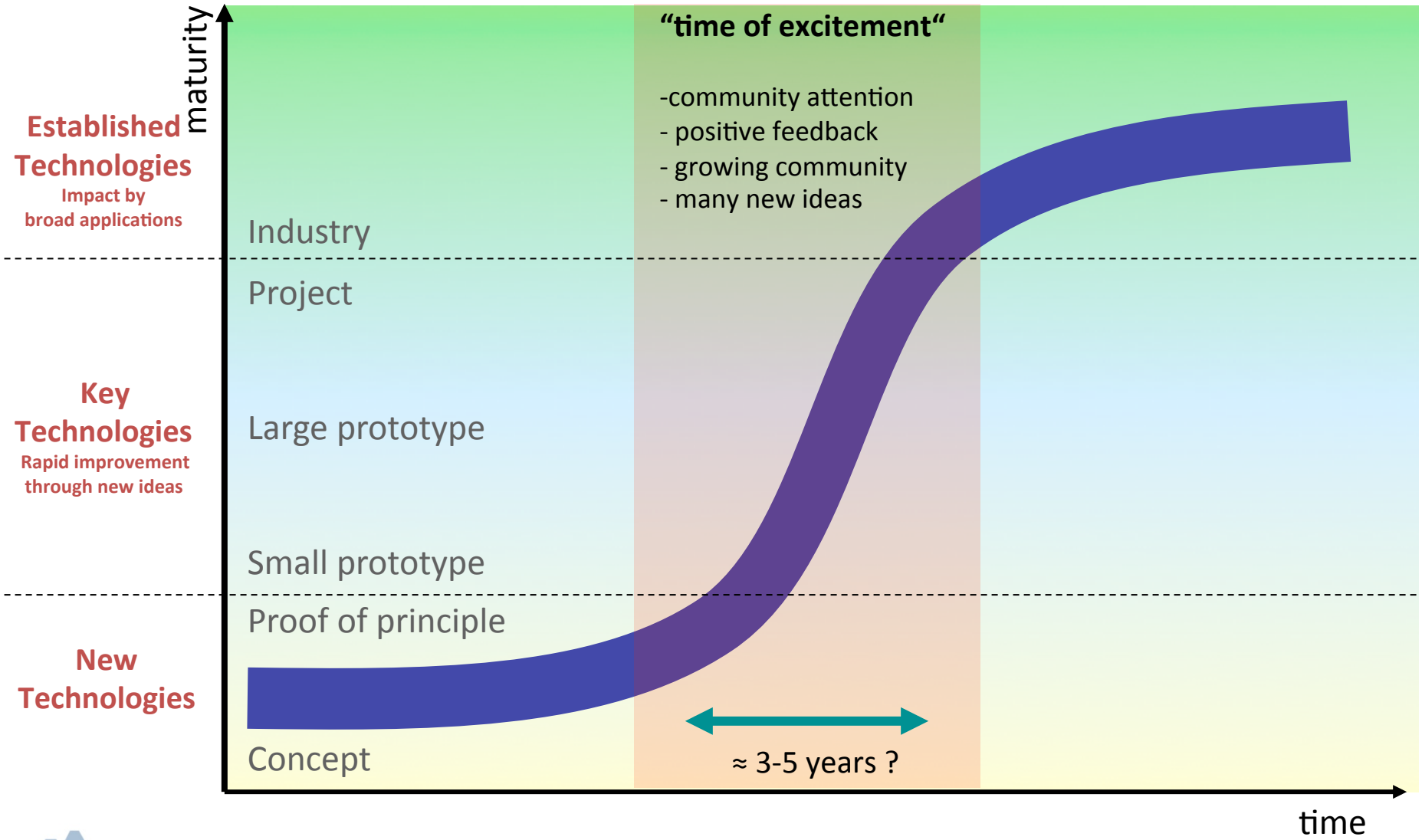

2012 R&D 100 Award made possible through tight collaboration between 7 divisions at Argonne, National Labs, Universities and Industry

Enabled by DOE-HEP

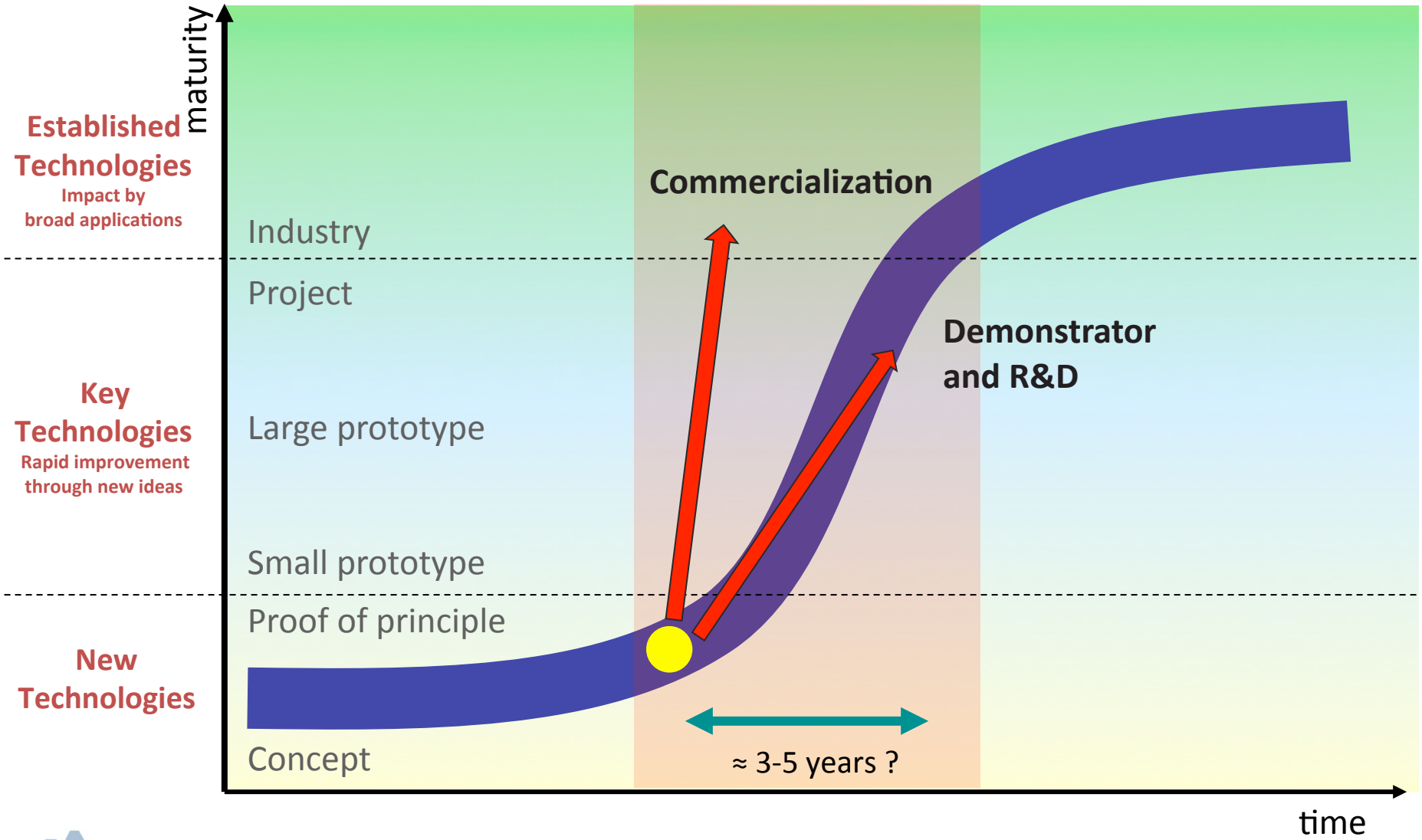
Three patents;
One license for ALD process

http://www.rdmag.com/Awards/RD-100-Awards/2012/06/R-D-100-2012-Winners-Overview/

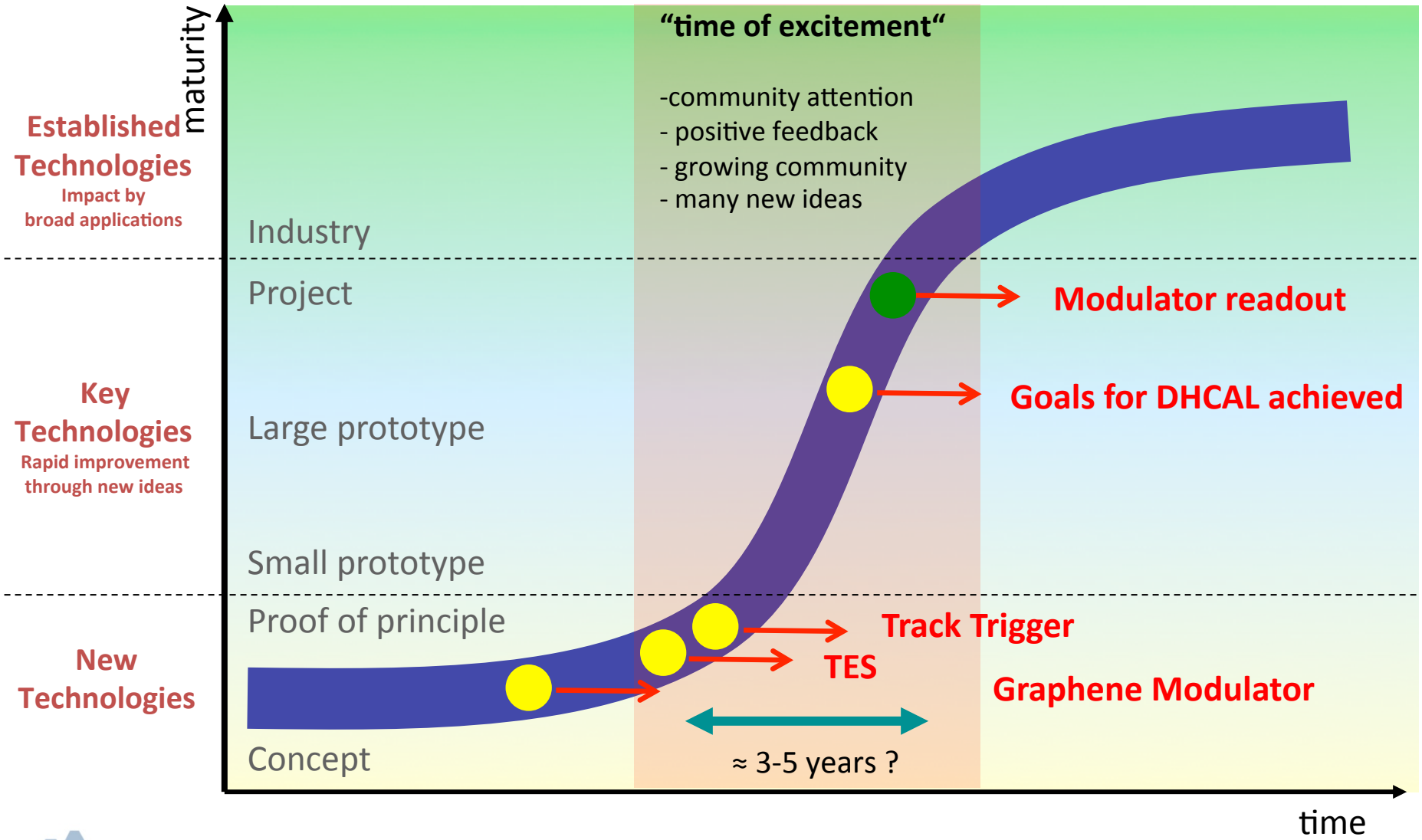
# Technology Development



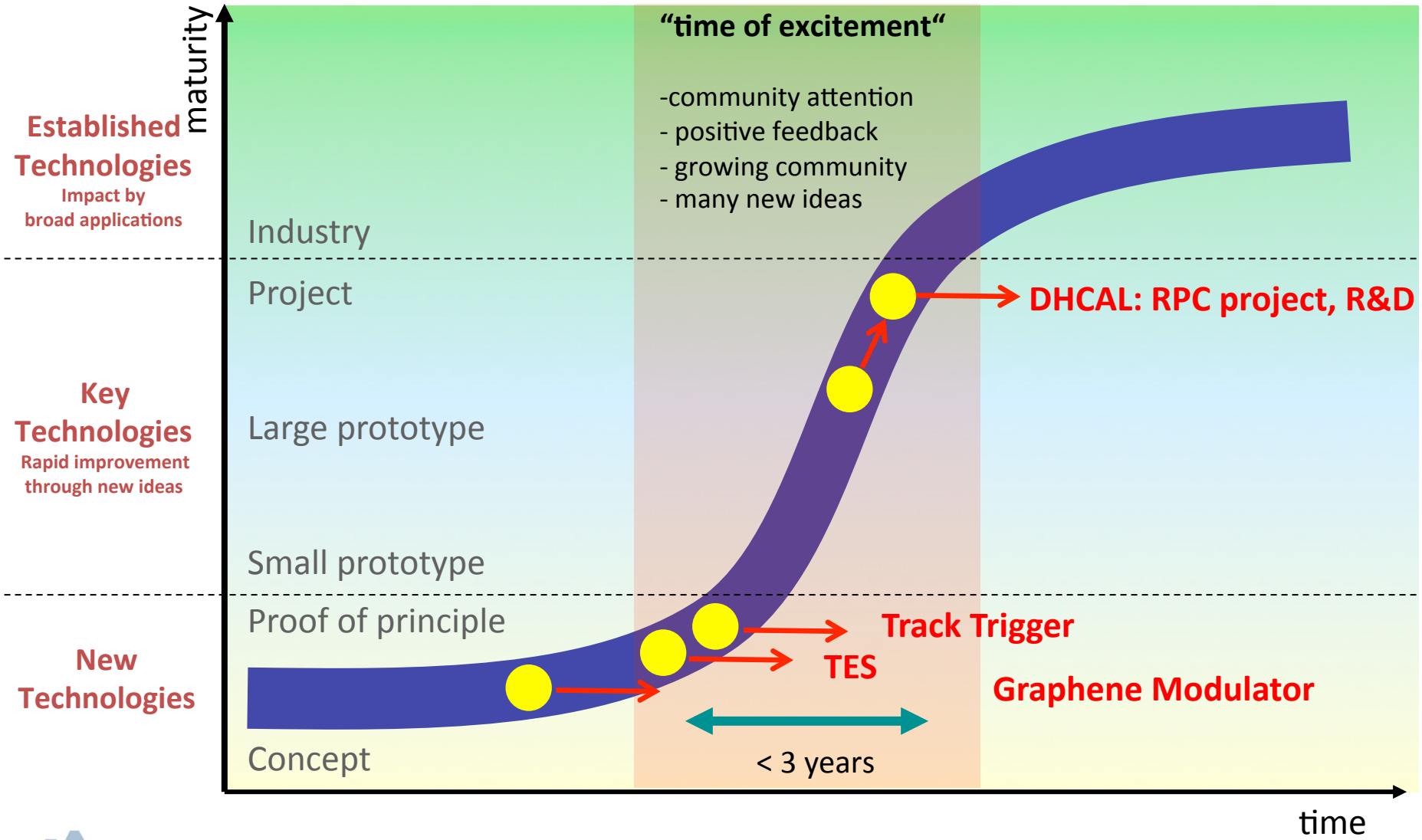
# LAPPD


maturity
Established Technologies
Impact by broad applications
Key Technologies
Rapid improvement through new ideas
New Technologies
Industry
Project
Large prototype
Small prototype
Proof of principle
Concept
Commercialization
Demonstrator and R&D
≈ 3-5 years ?
time

# Status Other Projects



# Future Development: 2015



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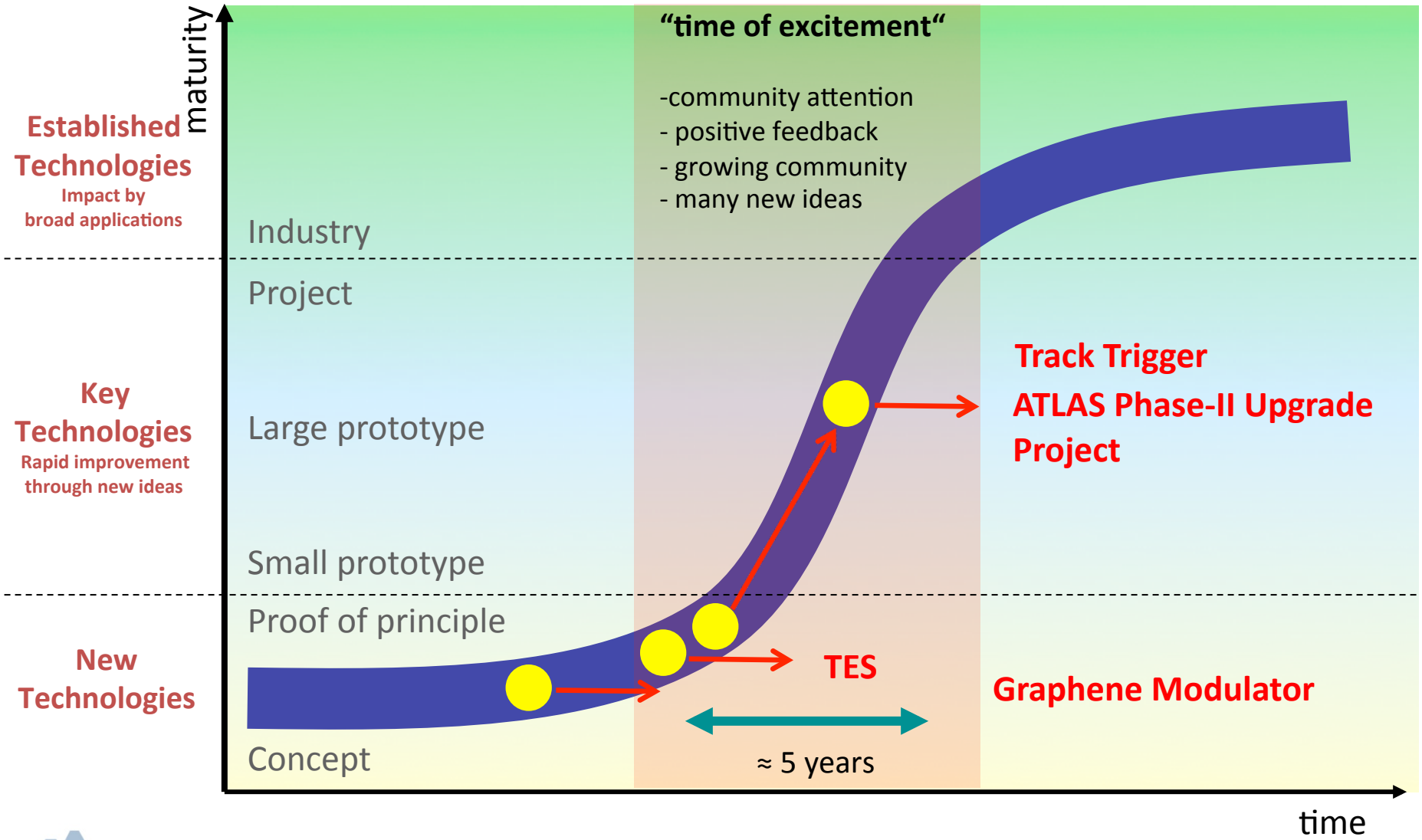

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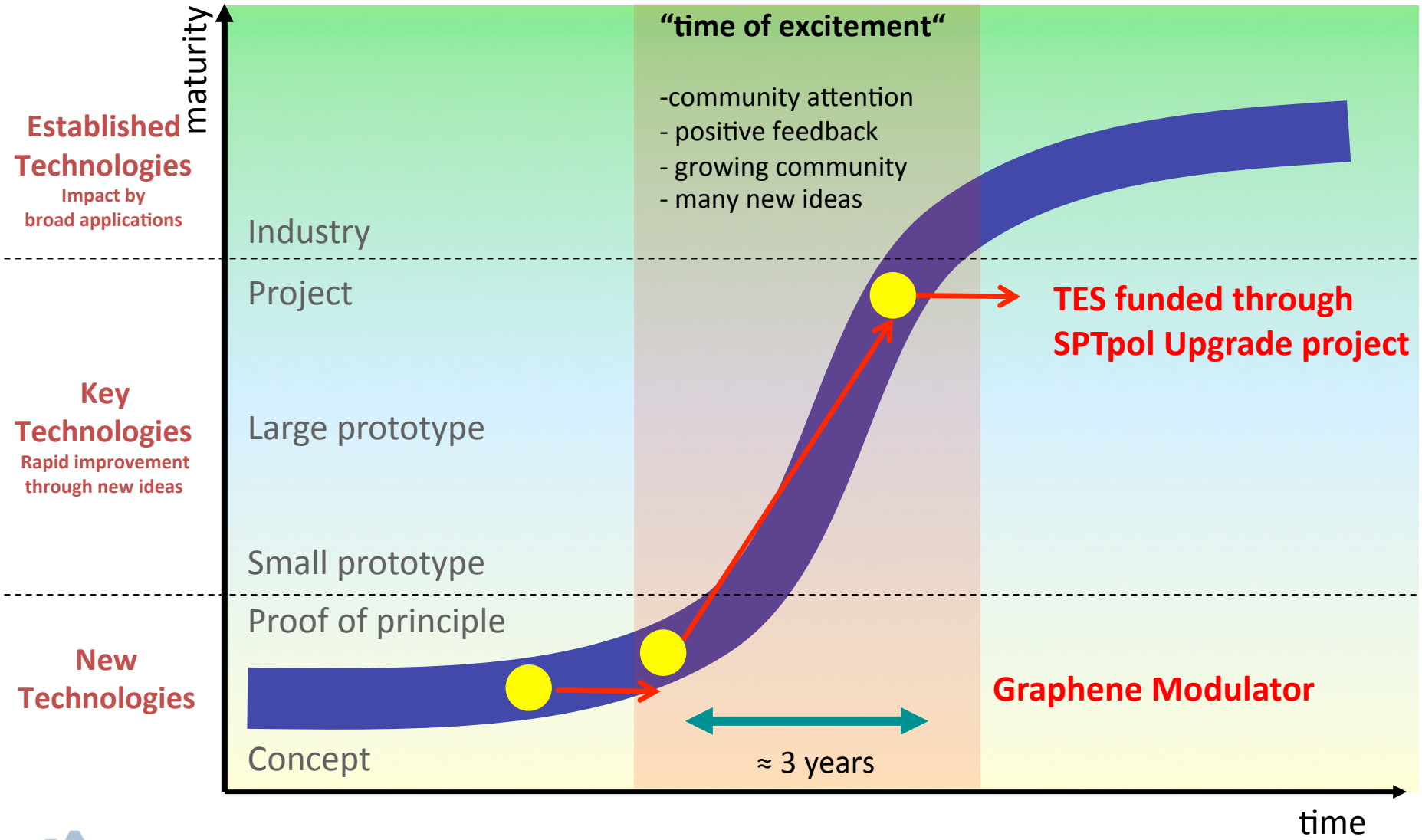

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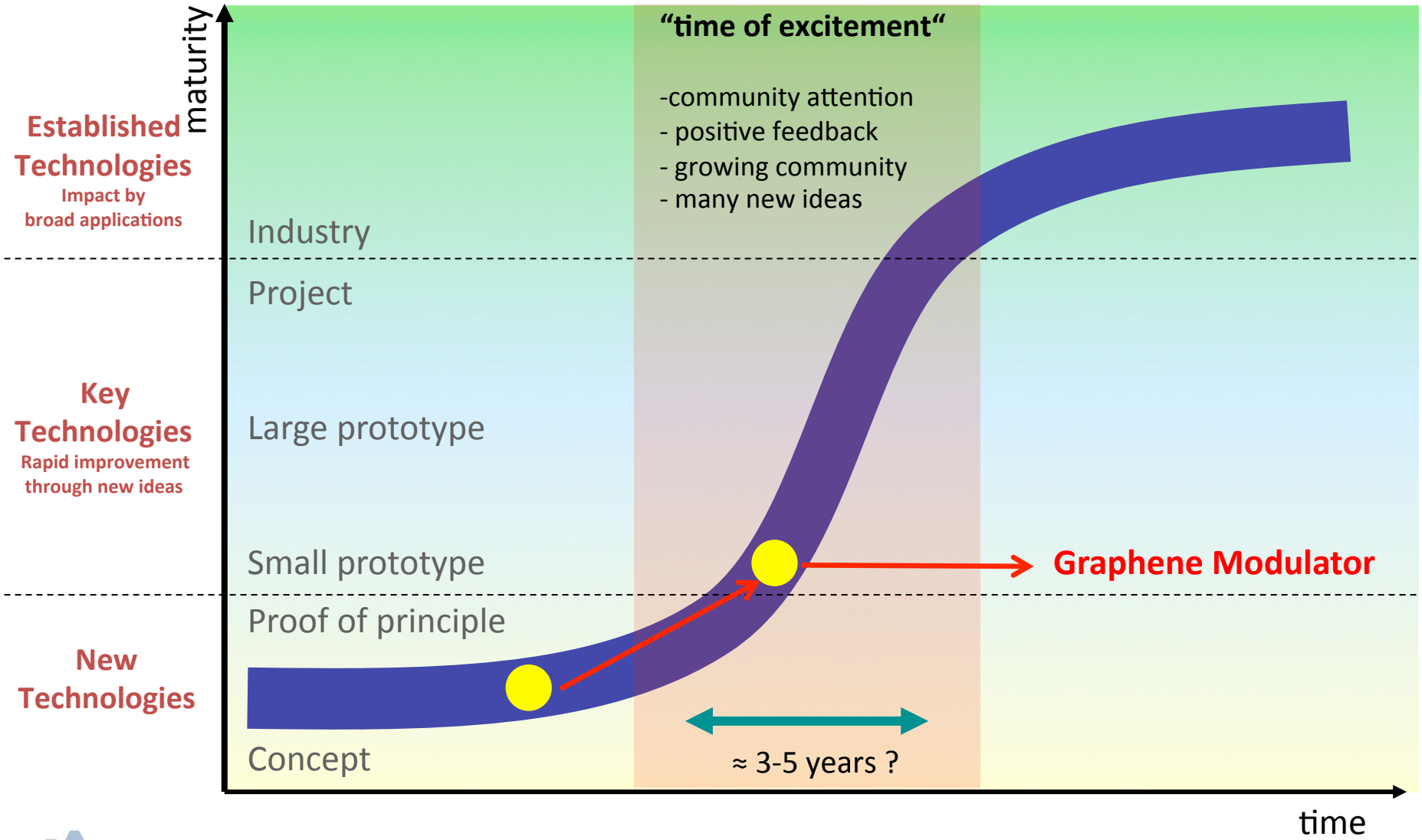
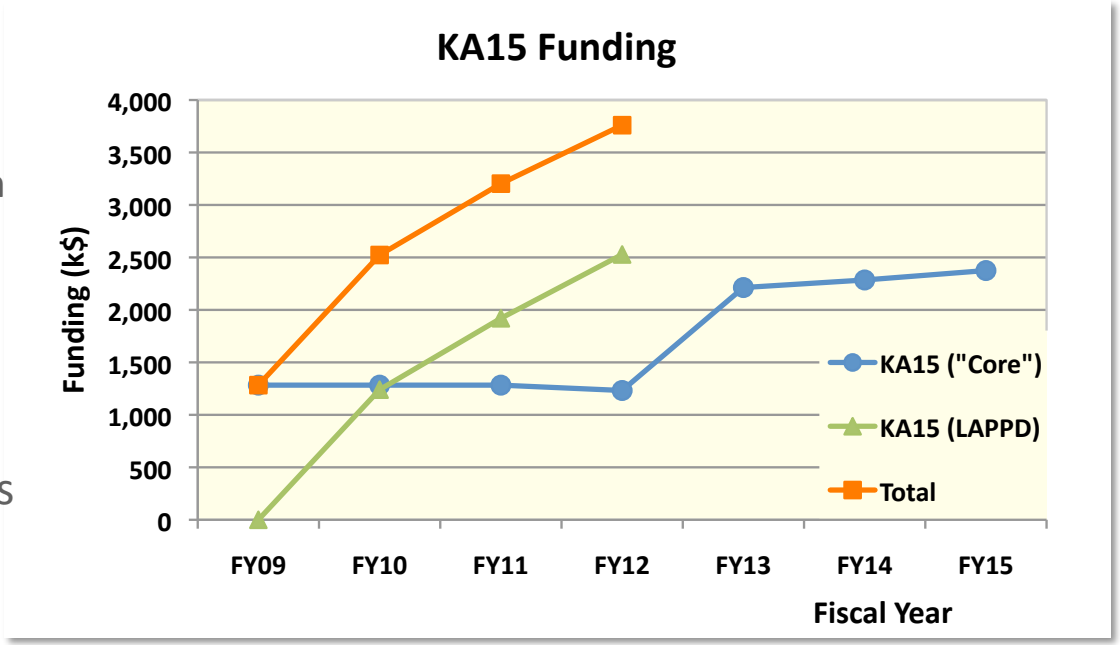


# KA15 Program with Flat-Flat / -3% Budget

- The Argonne KA15 funding is a relatively modest $1.3M with additional funding for the LAPPD project
- Most of the $1.3M has been allocated to the DHCAL; request continued support for completion of the data analysis and future R&D.
- This leaves very little to no room for initiation of any of the projects that were presented today.
- We would like to properly structure our “core” program

# KA15 Program

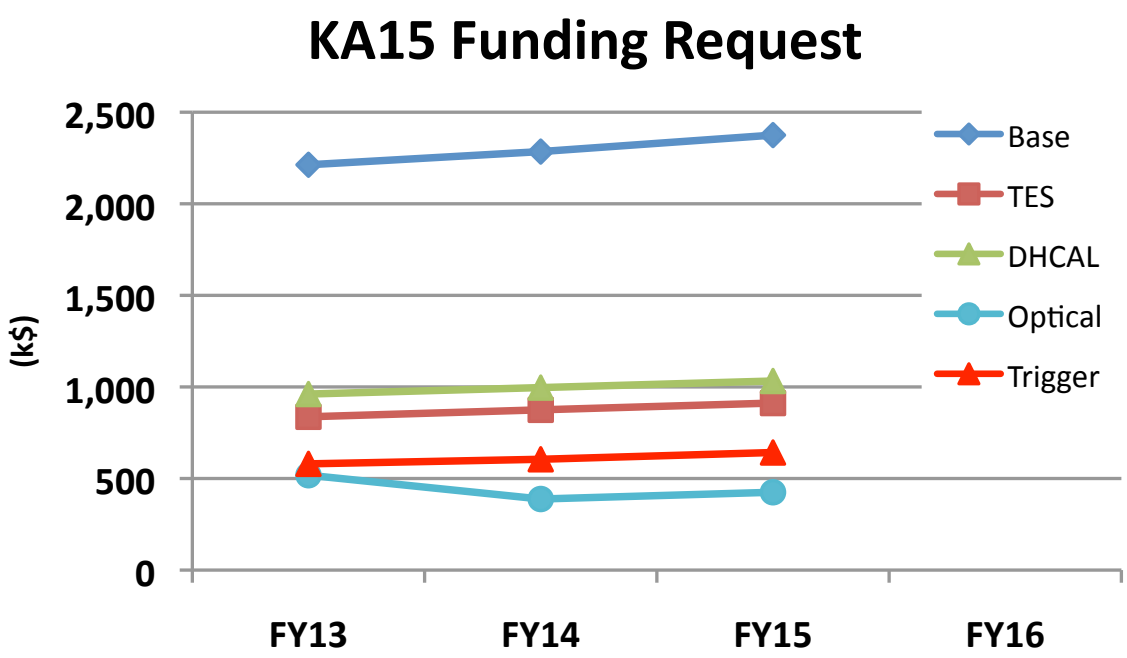
- KA15 funding currently has two key components:
  - Base program ("core"), which has been mainly DHCAL
  - LAPPD




- Implement a budget structure aligned with other laboratories and the guidance of the office

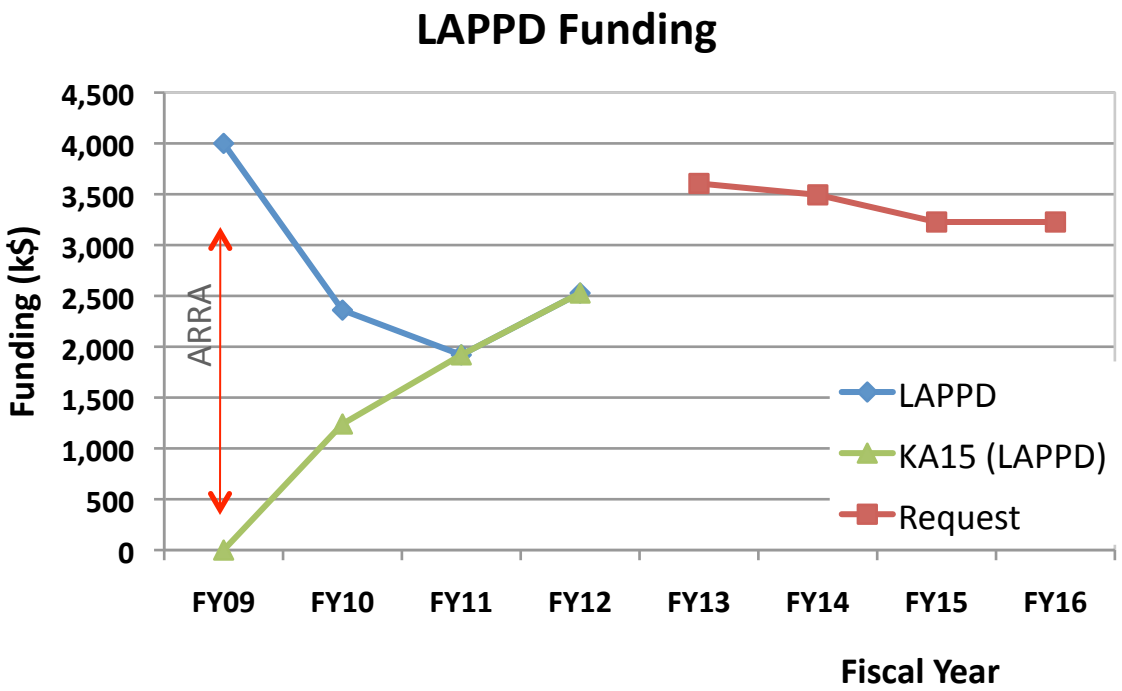
- Realign core program with well-defined expertise:
  - Superconducting device fabrication
  - Support for photo-detector device fabrication
  - Front-end readout and trigger support
  - Technical and engineering support
  - MOU with Fermilab for ASIC support
  - Program development and management

# KA15 Program if More Resources Were Available




- Base: establish core program
- TES: multi-chroic and multiplexed readout (about equal share each)
- DHCAL: complete analysis; research on low-resistivity glass; project identification
- Optical: modulator development for use in all of LHC; graphene based modulation
- Trigger: laying the foundation to address any pattern recognition problem

# LAPPD Budget Request



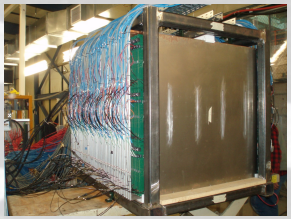

- Budget estimate for project total
- Good prospects for outside funding sources: SBIR/STT
  - $450k Phase I / $3M Phase II. Working with office to maximize opportunity and minimize the lappd budget request
  - ANL maturization program
  - http://science.energy.gov/~/media/sbir/pdf/docs/DOEFY13PhaseIRelease1Topics071612.pdf

# Delivery and Impact

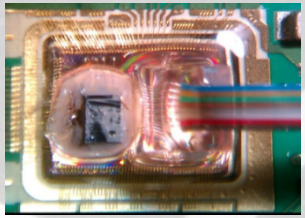
**Supported projects are brought to fruition to enable the science:**

- Topological trigger, funded by LDRD, now taking data on VERITAS telescope

- Transition Edge Sensor development, initiated by LDRD, now taking data on the South Pole



- Digital Hadron Calorimeter, initiated for ILC, now completed (and used by CLIC project)



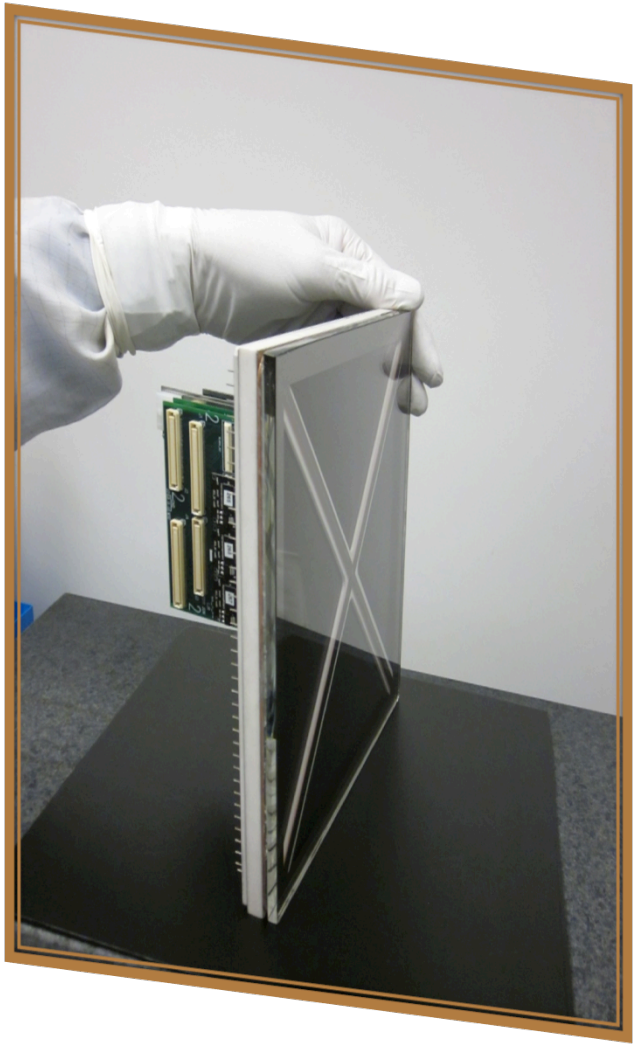
- Optical Modulators, funded by LDRD, being incorporated in ATLAS TileCal

- Micro-Channel Plate functionalized through Atomic Layer Deposition: RD100 award

# Delivery and Impact

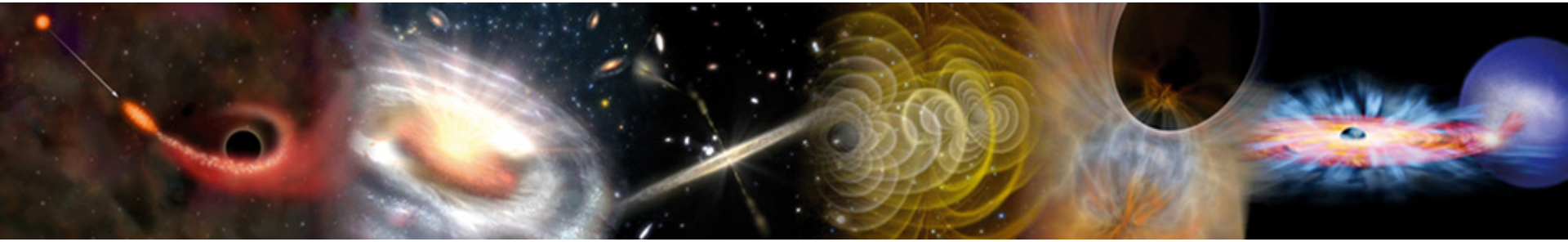
- **LAPPD: from a bold idea three years ago to ....**

... and deliver



# Summary

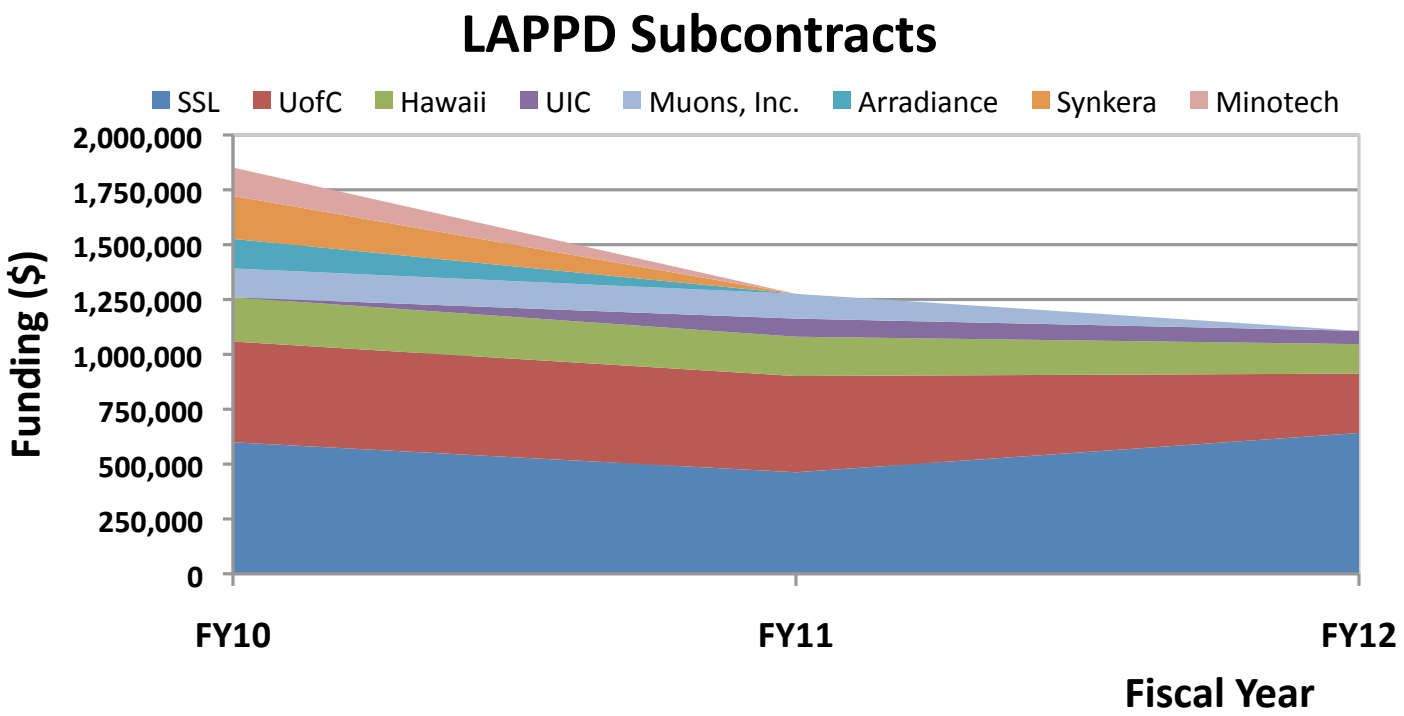
- Targeted multi-disciplinary detector development program
- Program is focused, science driven, internally reviewed, to advance experimental capabilities using unique methodologies and technologies
- A key to current and future success is to embrace advances in other sciences and collaborate with other science disciplines through a bi-directionally process
- This set of presentations was not aimed at staying within the budget guidance but we proposed a future program for comparative review



# LAPPD

| Industrialization | Demonstrator | R&D |
|---|---|---|
| **Year 1:**<br>Through SBIR/STTR program develop full maturization process with shared ANL responsibilities<br><br>**Year 2:**<br>Initiate commercial production<br><br>**Year 3:**<br>Complete transfer of technology to industrial partner<br><br>**Note:**<br>Dialogue with three companies on technoloy transfer; Facilitation through ANL maturization program | **Year 1:**<br>- Deliver first device before end of FY. Deliver all-glass device within 6 months<br>- Senior hire<br>- Construct Single Tile Production Facility<br><br>**Year 2:**<br>- Produce all glass detectors with goal of 10/yr for use by community<br><br>**Year 3:**<br>- Device production (goal of 50/yr) with various configurations leading to project implementation | **Year 1:**<br>- Further development of 8" MCP substrates (L/D, OAR, bias, plating, ... )<br>- Exploration of new readout ASIC with higher BW<br>-Study fundamental process of photocathode growth<br><br>**Year 2:**<br>-Produce photocathodes with QE substantially greater than 20%<br><br>**Year 3:**<br>- Review future development |

# LAPPD Subcontracts




- Because of the front-loaded budget, broad-based exploration in the beginning
- Many initial projects phased-out quickly when promise was not apparent

# LAPPD Funding Request

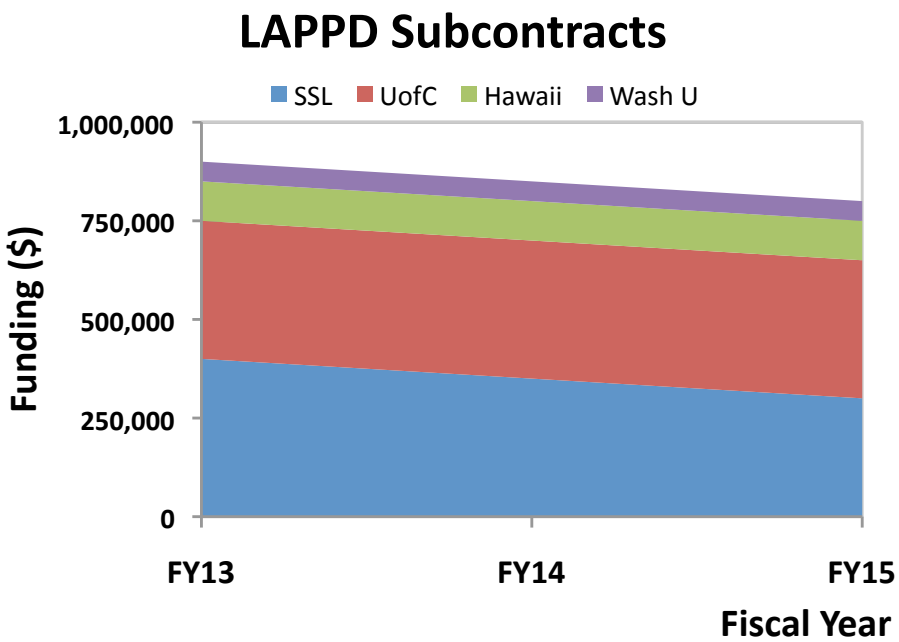
| (k$) | FY13 | FY14 | FY15 |
|---|---|---|---|
| Field Deployment | 655 | 702 | 708 |
| R&D | 901 | 992 | 966 |
| Tile Facility | 2,050 | 1,800 | 1,553 |
| Total | 3,606 | 3,494 | 3,227 |

- Field Deployment
  - Full-time staff and M&S for producing ceramic and glass devices and getting them into the community
  - Collaborate with other communities (NP, BES) who have expressed interest
  - Work with industry on maturization and industrialization
- R&D
  - Continued R&D on 8” substrates, exploration of new ASIC, R&D on photocathode growth in stand-alone UHV system, seal and hermetic package, ...
  - Devices with different form factors
- Tile Facility
  - Setup of tile production facility in first year followed by commissioning and production of devices. In FY15 routine production of devices (50/yr) for demonstrator project

# LAPPD Projected Subcontracts

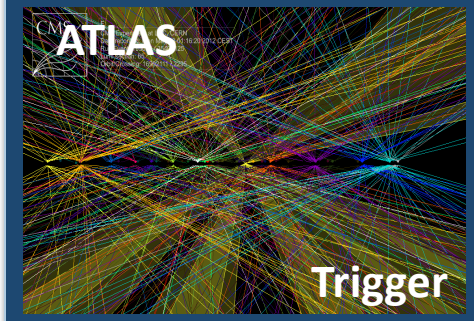
| ($) | FY13 | FY14 | FY15 |
|---|---|---|---|
| SSL | 400,000 | 350,000 | 300,000 |
| UofC | 350,000 | 350,000 | 350,000 |
| Hawaii | 100,000 | 100,000 | 100,000 |
| Wash U | 50,000 | 50,000 | 50,000 |
| UIC | 26,000 | | |

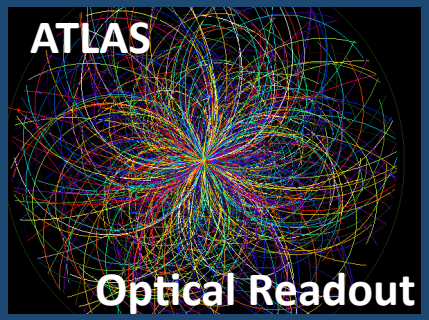
- SSL: development of ceramic tile
- UofC: readout, seal, super-module, physics
- Hawaii: readout
- WashU: photocathode
- UIC: graduate student support for seal

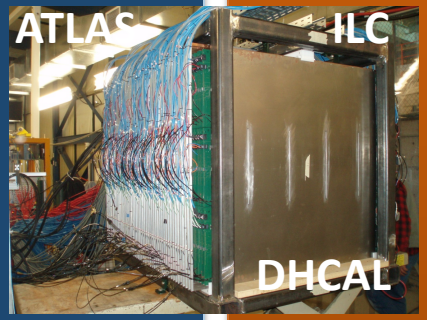


# Science and Frontier Alignment

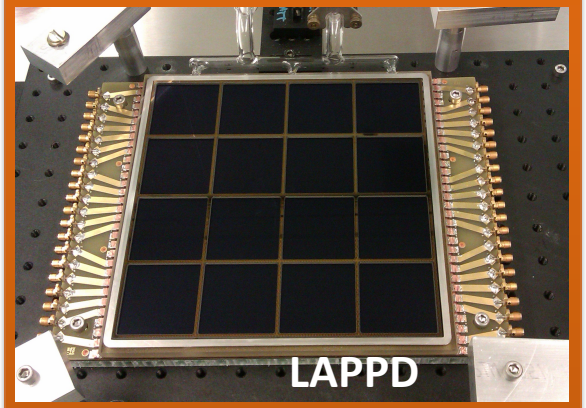
## Energy Frontier



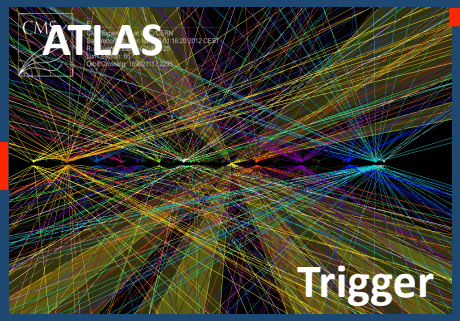

## Intensity Frontier

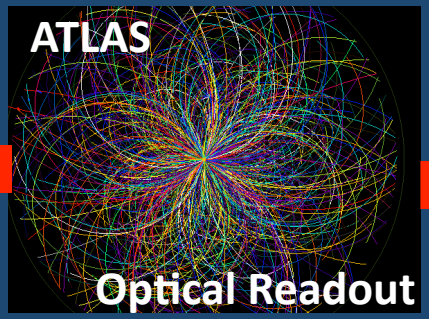


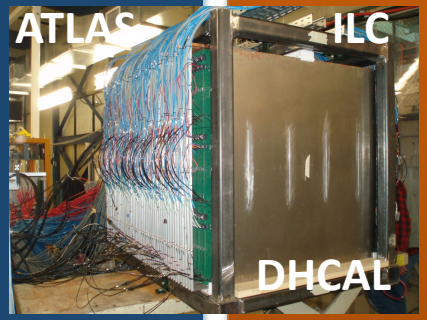

## Cosmic Frontier

# Science and Frontier Alignment

## Energy Frontier

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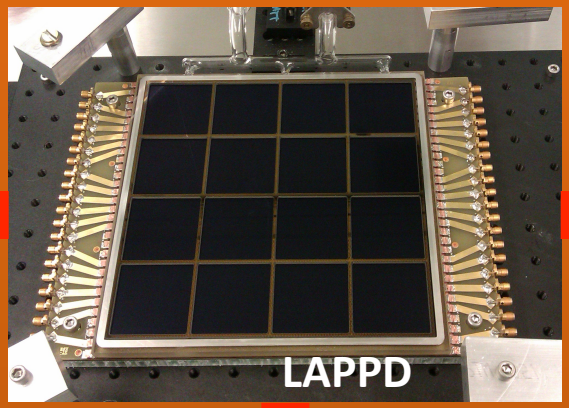


## Cosmic Frontier