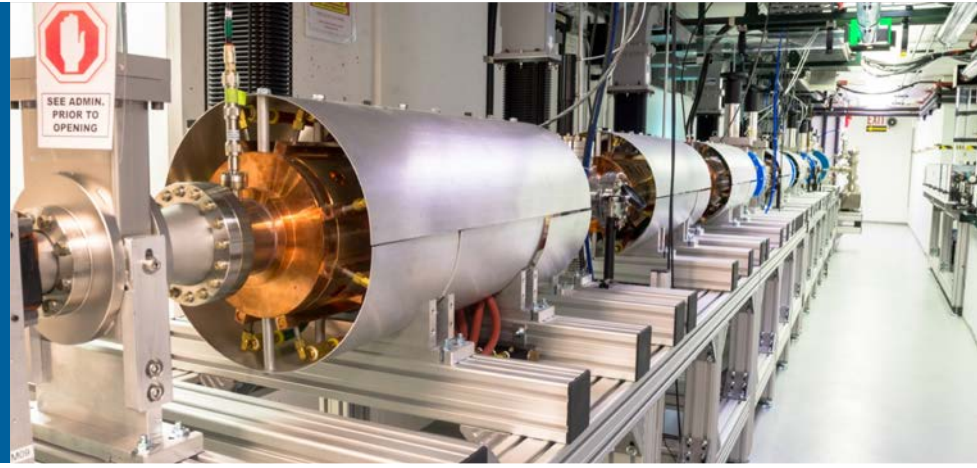
# HEP ROADMAP

# AND AWA

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June 7, 2018

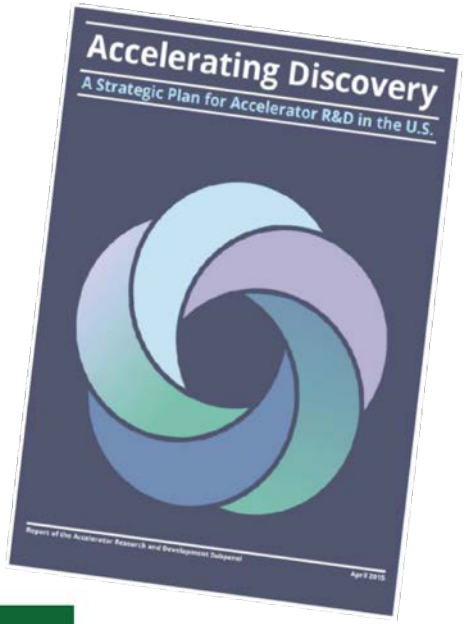
# Building for Discovery

## Strategic Plan for U.S. Particle Physics in the Global Context

- The roadmap for High Energy Physics for the next decade has been articulated in the Particle Physics Project Prioritization Panel (P5) Report “Building for Discovery”, May 22, 2014.
- **The P5 plan is science-driven and identified five science drivers:**
  - ***Use the Higgs boson as a new tool for discovery.***
  - ***Pursue the physics associated with neutrino mass.***
  - ***Identify the new physics of dark matter.***
  - ***Understand cosmic acceleration: dark energy and inflation.***
  - ***Explore the unknown: new particles, interactions, & physical principles.***

# ACCELERATOR R&D

## Subpanel Report on Strategic Plan for Accelerator R&D




- Following P5, an Accelerator R&D Subpanel was charged to identify the most promising accelerator research areas to support the advancement of HEP
  - P5 recommendation: pursue accelerator R&D with a focus on outcomes and capabilities that will dramatically improve cost effectiveness for mid-term and far-term accelerators

| | Intensity Frontier Accelerators | Hadron Colliders | $e^+e^-$ Colliders |
|---|---|---|---|
| Current Efforts | PIP | LHC | |
| | PIP-II | HL-LHC | ILC |
| Next Steps | Multi-MW proton beam | Very high-energy *pp* collider | 1 TeV class energy upgrade of ILC* |
| Further Future Goals | Neutrino factory* | Higher-energy upgrade | Multi-TeV collider* |

* = dependent on how physics unfolds

# ACCELERATOR R&D ROADMAPS

## Subpanel Reports on Strategic Plan for Accelerator R&D

- Following the release of the HEPAP Accelerator R&D Subpanel Report in April 2015, the GARD Program engaged its research community to develop research roadmaps for three thrust areas:
- Superconducting High Field Magnets
  - Produced the U.S. Magnet Development Program Plan
- Advanced Accelerator Concepts
  - **Laser-driven plasma wakefield acceleration (LWFA)**
  - **Particle-beam-driven plasma wakefield acceleration (PWFA)**
  - **Dielectric wakefield acceleration (DWFA)**
- Radiofrequency Acceleration Technology
  - Superconducting RF
  - Normal Conducting RF
  - RF Sources
- Community-developed roadmaps include:
  - Pressing challenges to be addressed to move the field forward
  - Prioritized milestones aligned to the most compelling research

# US ROADMAP

## Wakefield Acceleration

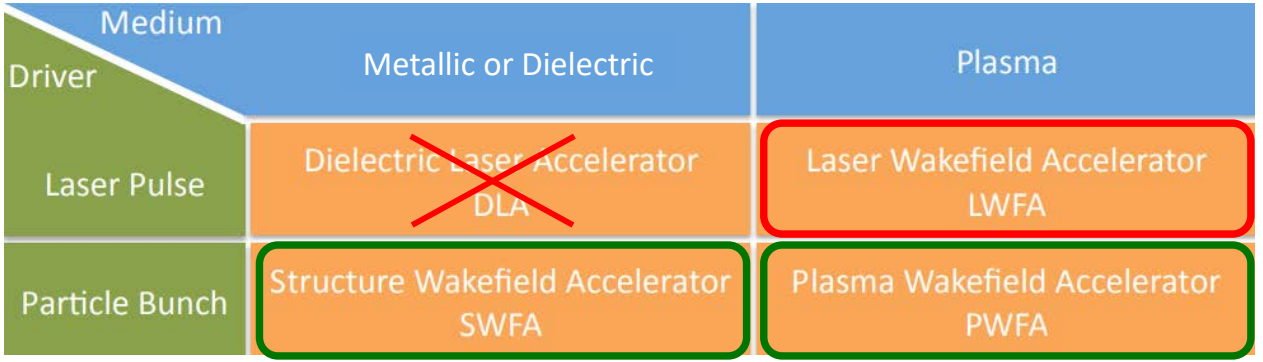
- The US roadmap is fully based on three wakefield acceleration technologies

| Driver \ Medium | Metallic or Dielectric | Plasma |
|---|---|---|
| Laser Pulse | Dielectric Laser Accelerator DLA | Laser Wakefield Accelerator LWFA |
| Particle Bunch | Structure Wakefield Accelerator SWFA | Plasma Wakefield Accelerator PWFA |

# US ROADMAP

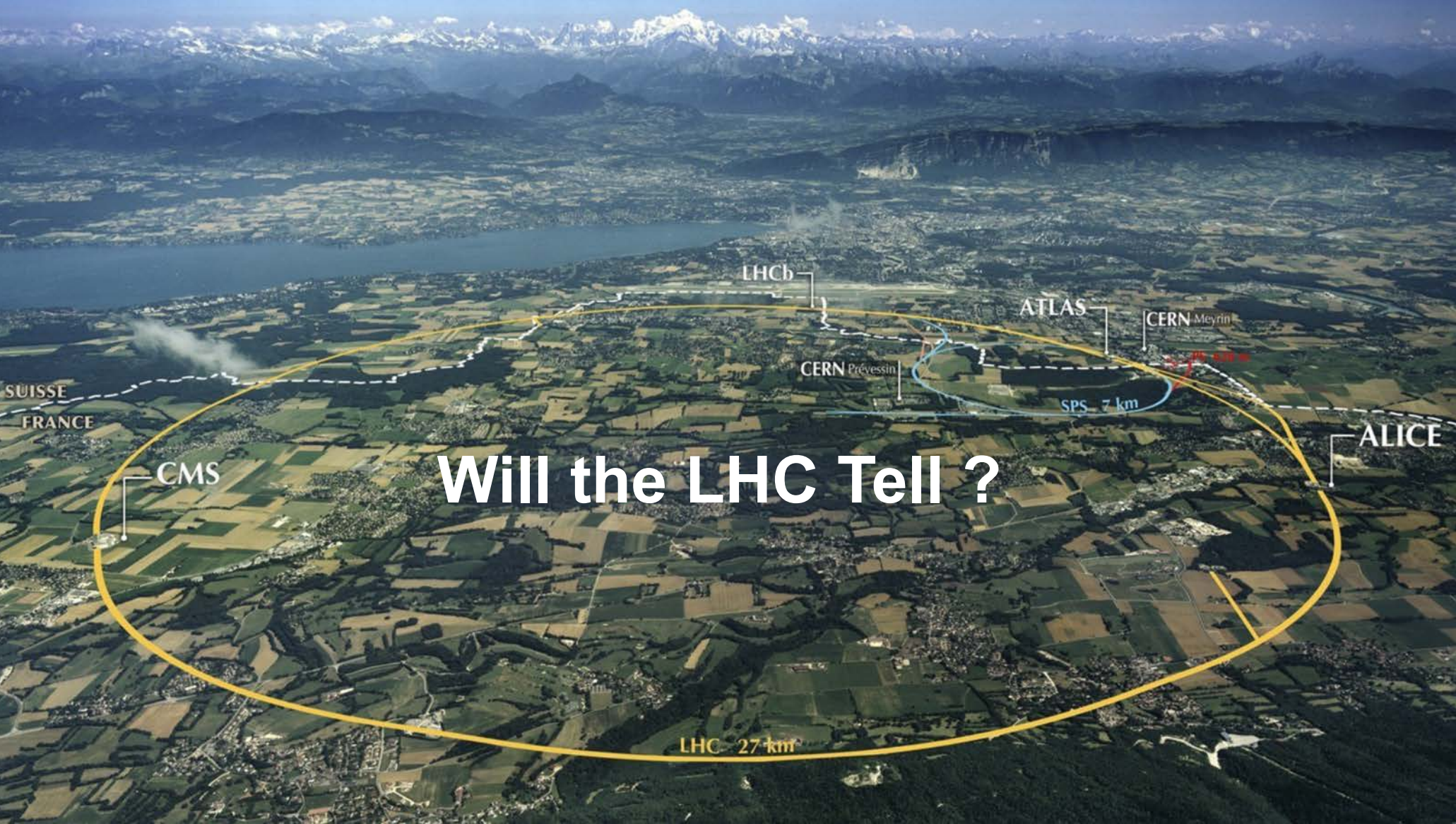
## Wakefield Acceleration

- The US roadmap is fully based on three wakefield acceleration technologies
- AWA supports two out of three




- Where does this lead us?

- There is more to the Standard Model than we know ….




# Will the LHC Tell ?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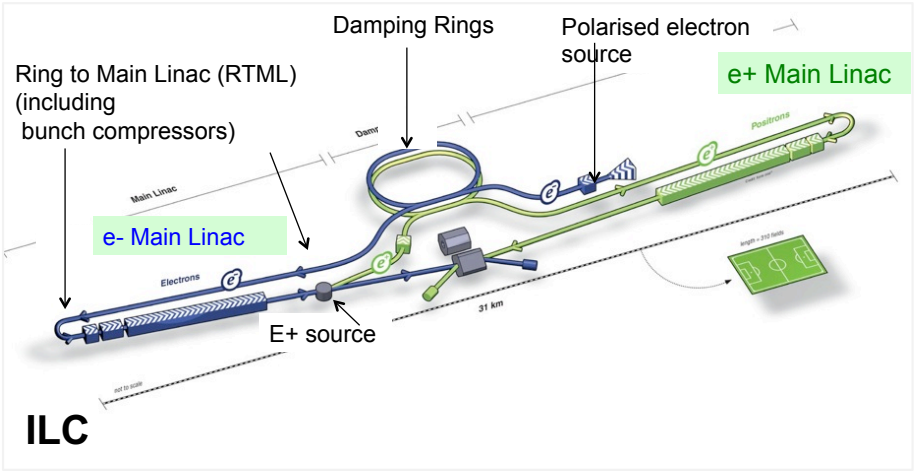
**A: Yes → need precision studies!**

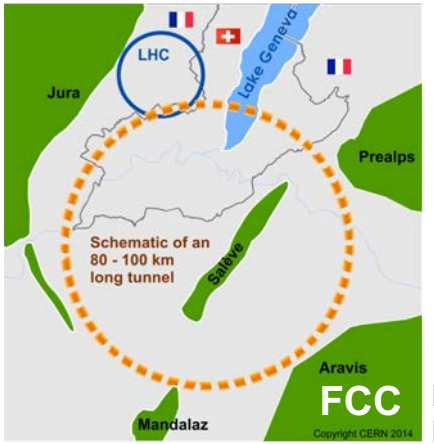

# Will the LHC Tell ?

**A: Yes → need precision studies!**

**A: No → need new tool!**

# OPTIONS




Phase I: $e^+e^-$
Phase II: pp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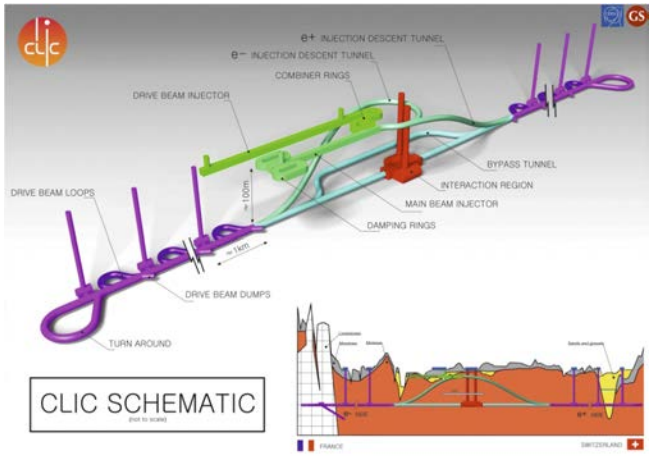
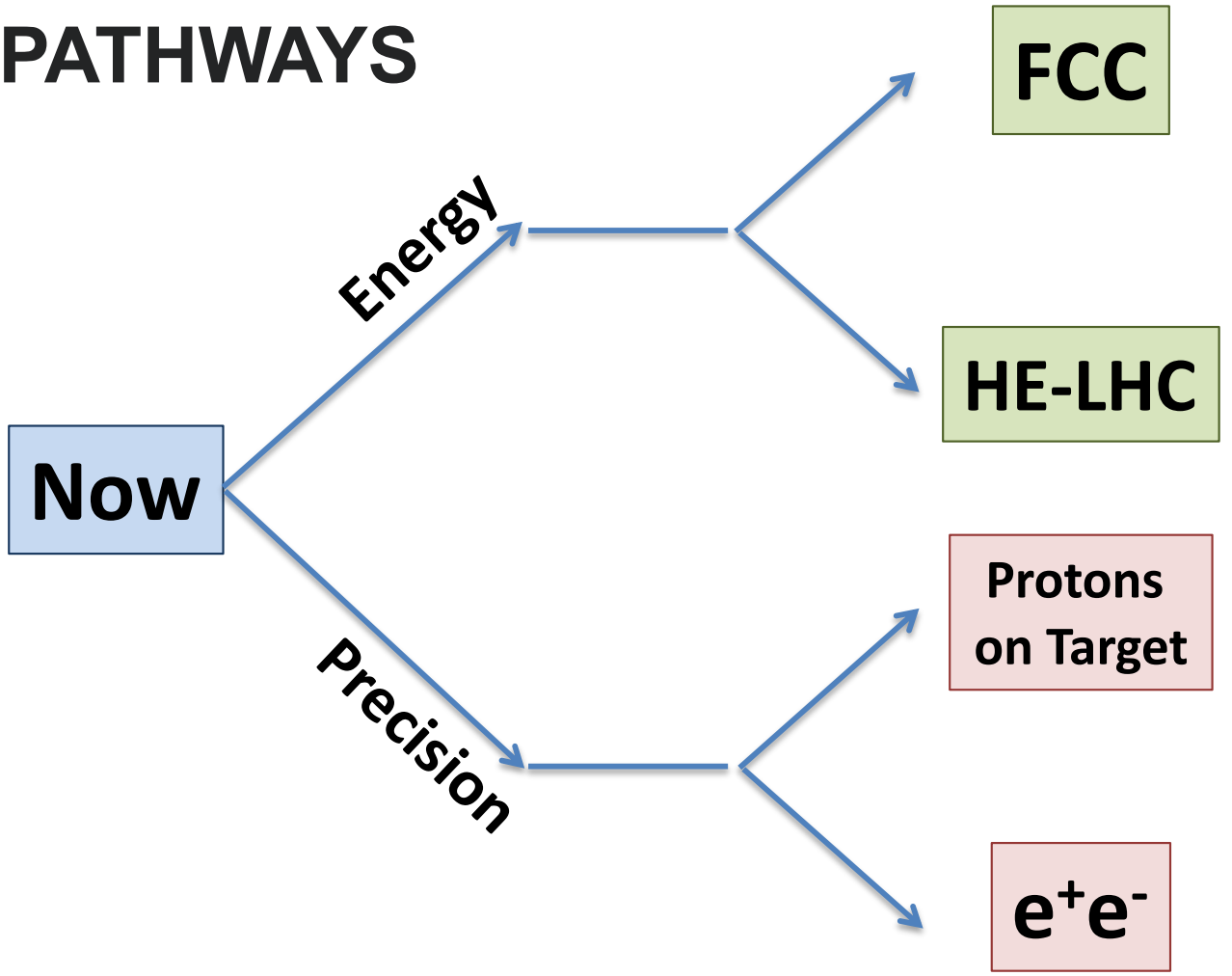
Phase II: pp



# PATHWAYS



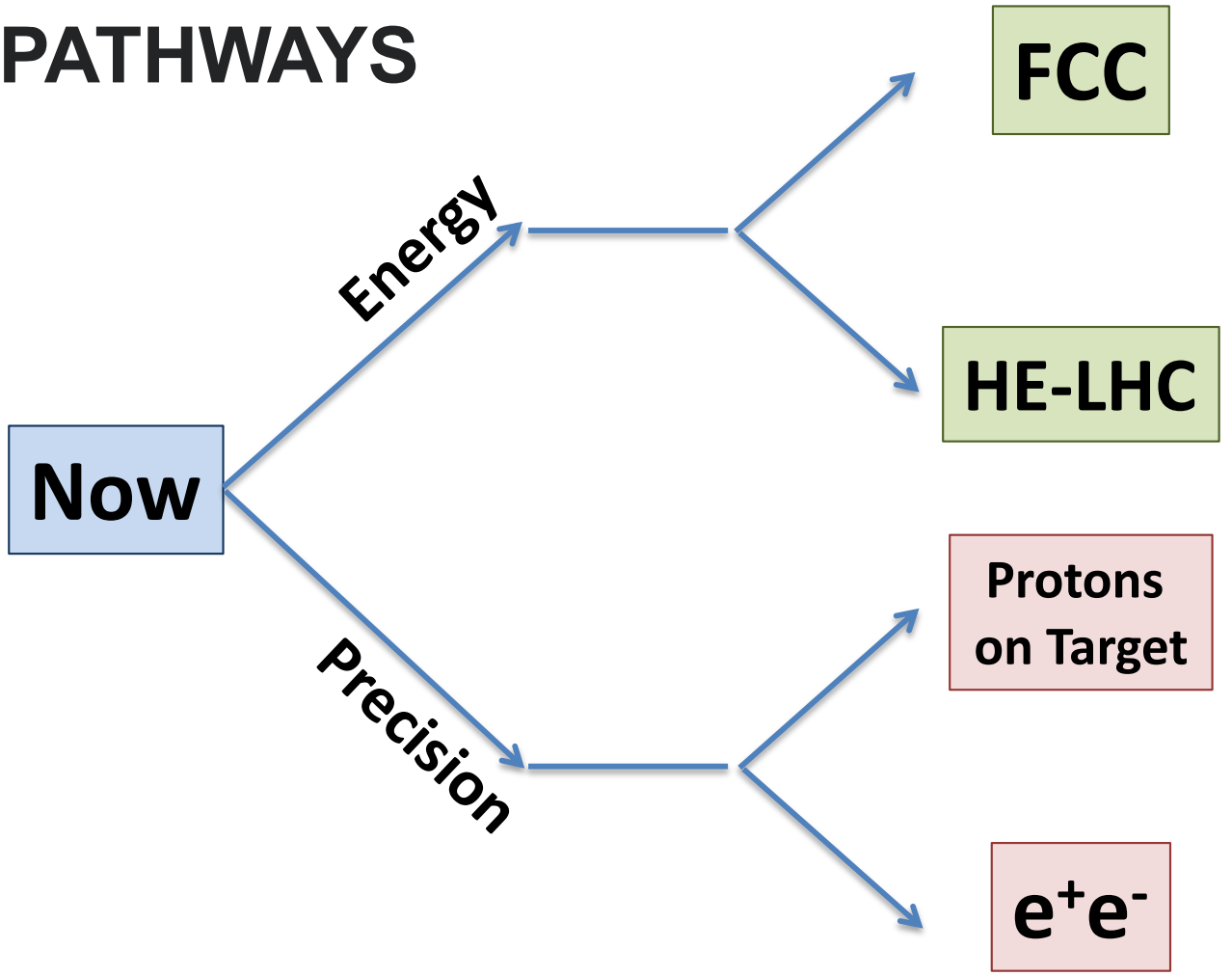

Future Circular Collider
CepC ($e^+e^-$/pp)

Energy upgrade
of the LHC

Many MW Proton flux to
create muons/neutrinos

$e^+e^-$ gives precision:
Luminosity, Energy,
Polarization

# PATHWAYS




Future C[illegible]ollider Ce[illegible], pp)

Too Costly ?

Ener[illegible]ade o[illegible]HC

E-Scale ?

Many MW[illegible] flux to crea[illegible]s/neutrinos

Path Forward ?

$e^+e^-$ gives precision: Luminosity, Energy, Polarization

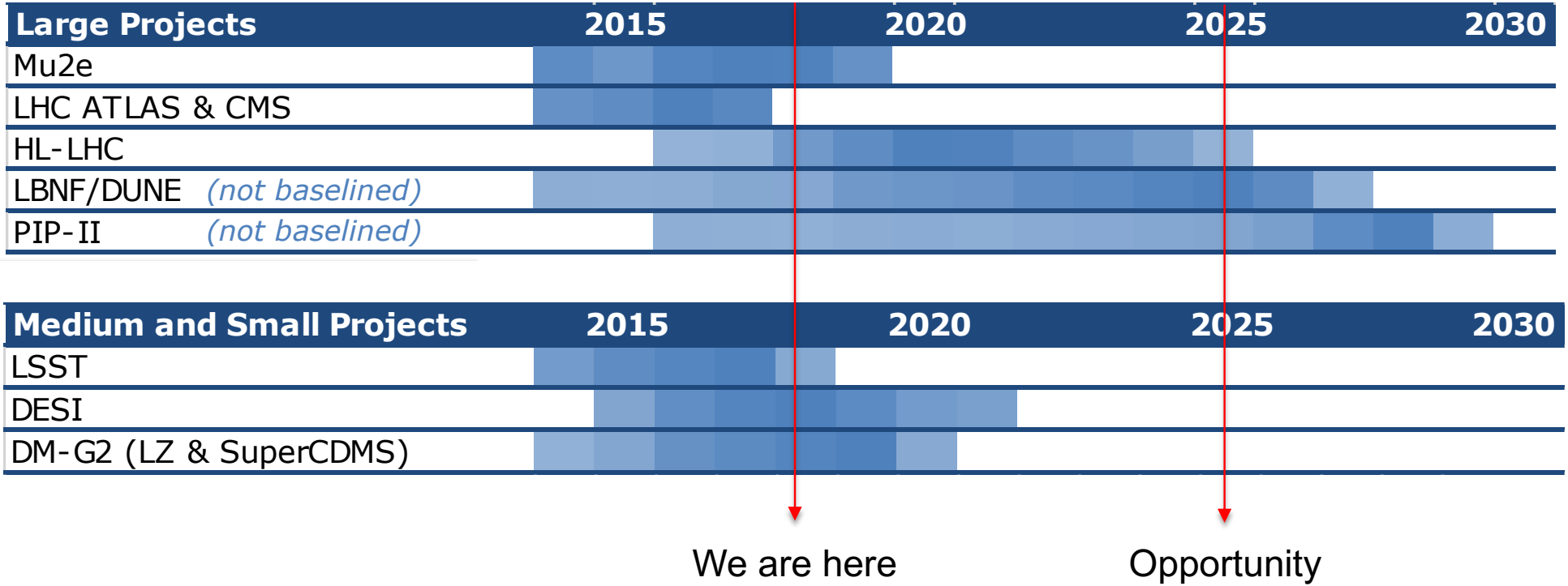
# OBSERVATIONS

## Personal Point of View

- There are no no-lose theorems anymore in particle physics
- The future, i.e. beyond HL-LHC, points towards:
  - Higher Energy: need high-field magnets, long development path, not cheap.
  - $e^+e^-$ machines for precision studies: Energy, Luminosity, Polarization.
  - High power proton drivers for low rate experiments: many MW proton drivers.
- The value of $e^+e^-$ colliders is well recognized.
- The world is evaluating its options:
  - **Japan**: bid to host the ILC or not known by the end of the year (250 GeV).
  - **European strategy**: HE-LHC, CLIC? (final decision at next strategy update?).
  - **China**: CepC (needs to wait until next 5-year plan).
  - **USA**: LBNF/DUNE.

# P5 PROJECTS

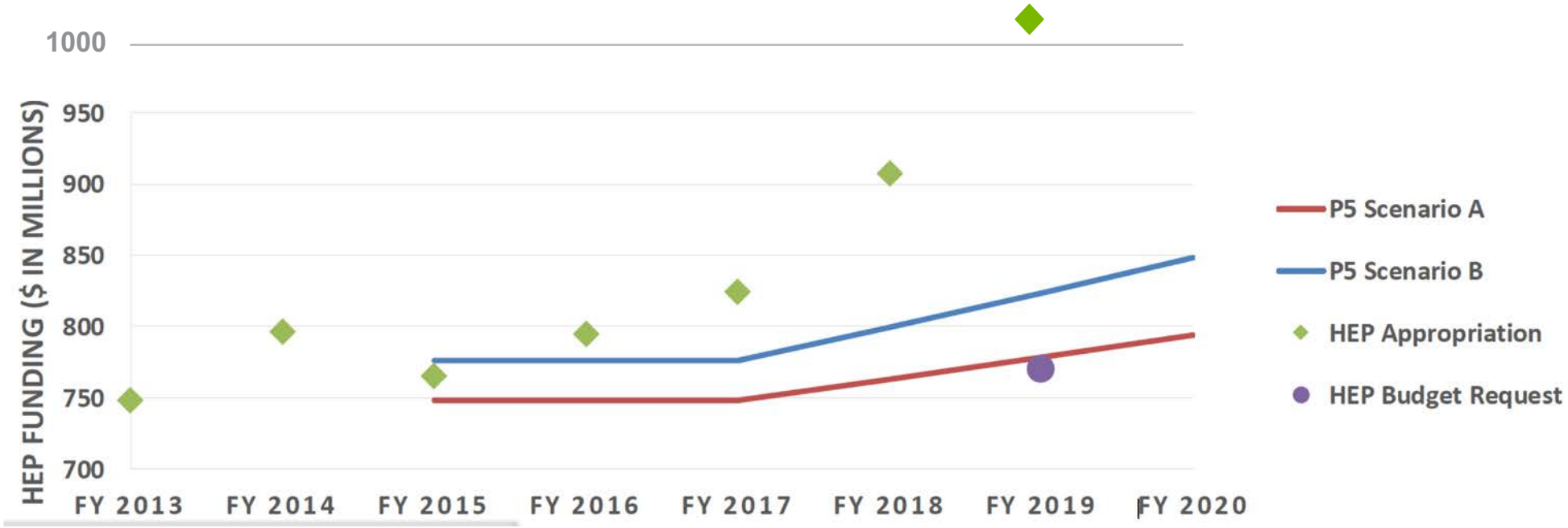
## Funding Profile



# HEP BUDGET PROFILE

## Major Projects

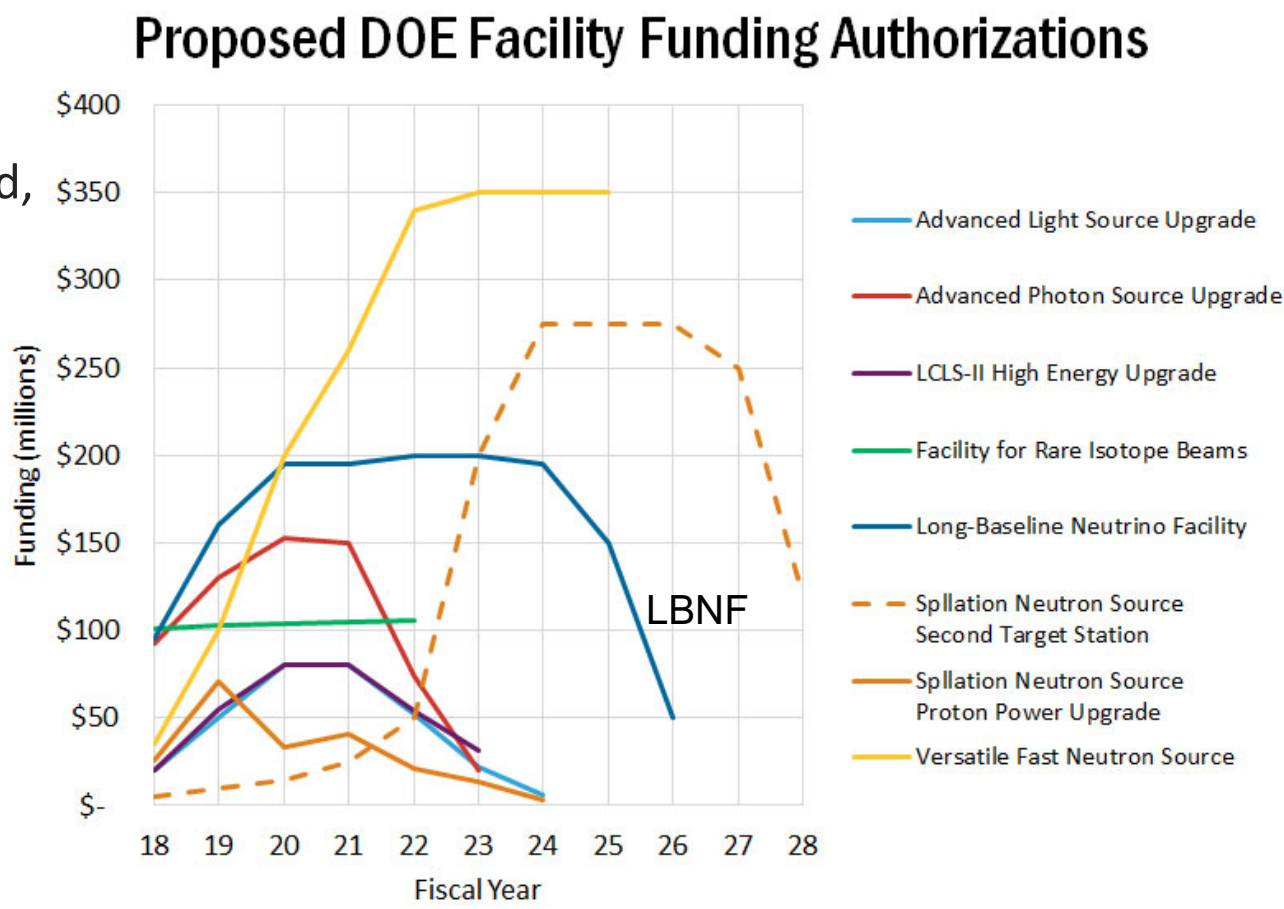
- Prospects for funding beyond scenario B are looking very good



# FUNDING PROFILE

## Major Projects

- If the FY19 proposed funding for HEP is passed and sustained, there is a real opportunity for a large project on the timescale of 2025
- The US could retake its leader-ship position in colliders

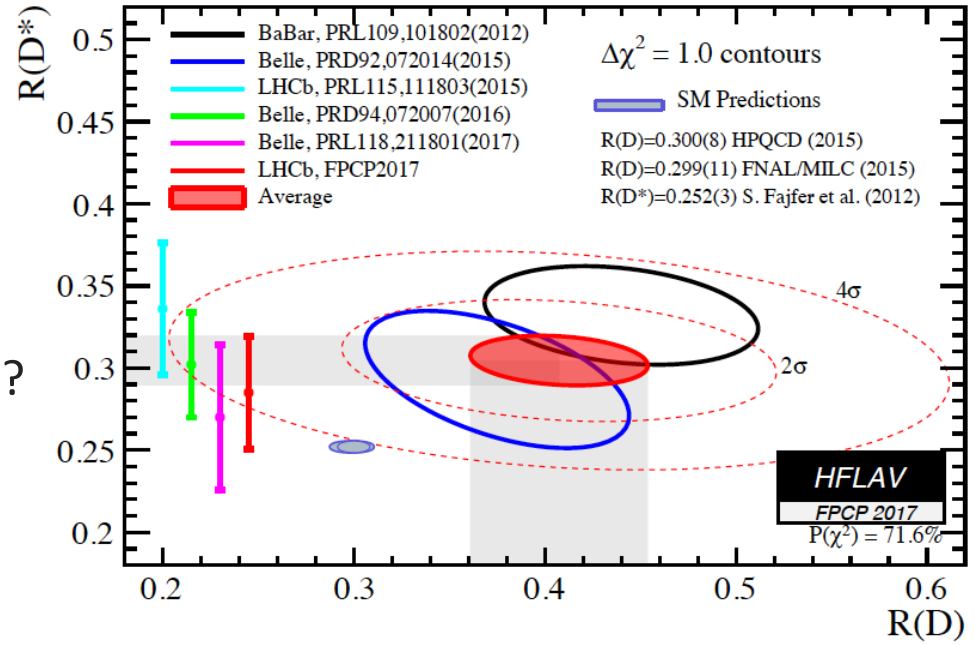


# PRECISION

## Most Significant Deviations at Low Energy

Belle II: hadronic uncertainty in semi-leptonic B decays with tau, B to Kll decays, etc.

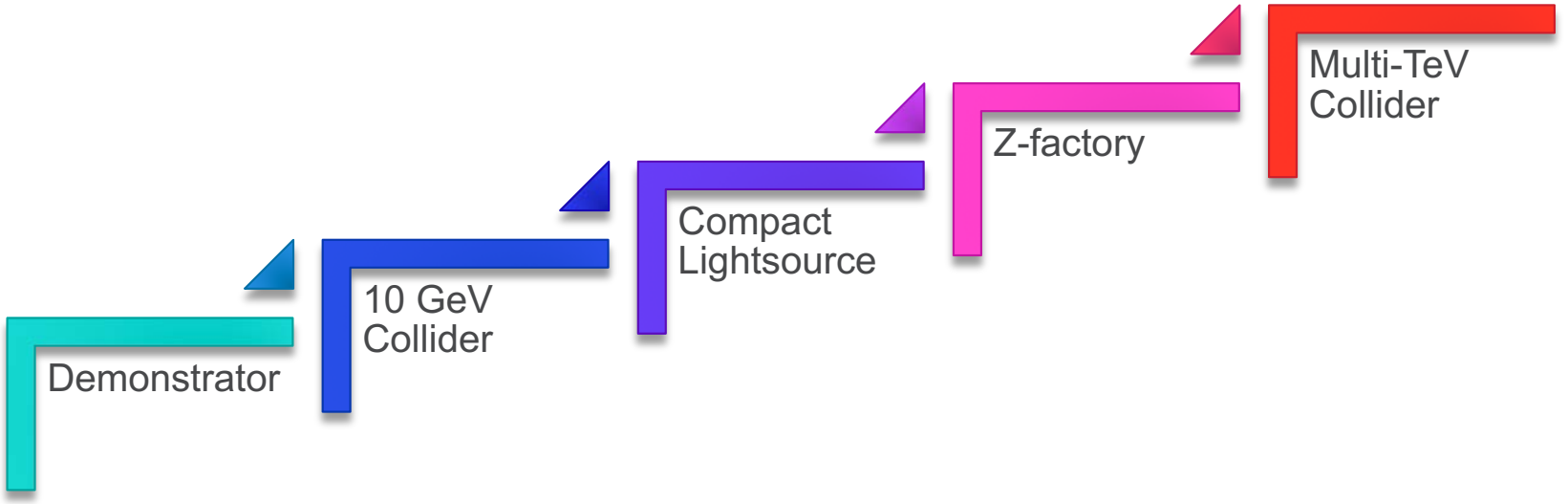
$R(D^{(*)}) = Br\,(B \to D^{(*)} \tau \nu_\tau) \,/\, Br\,(B \to D^{(*)}\, \ell \nu_\ell)$




- What are the opportunities for a (colliding) beam facility with energy around 10 GeV (<50 meters at 300MV/m) ?

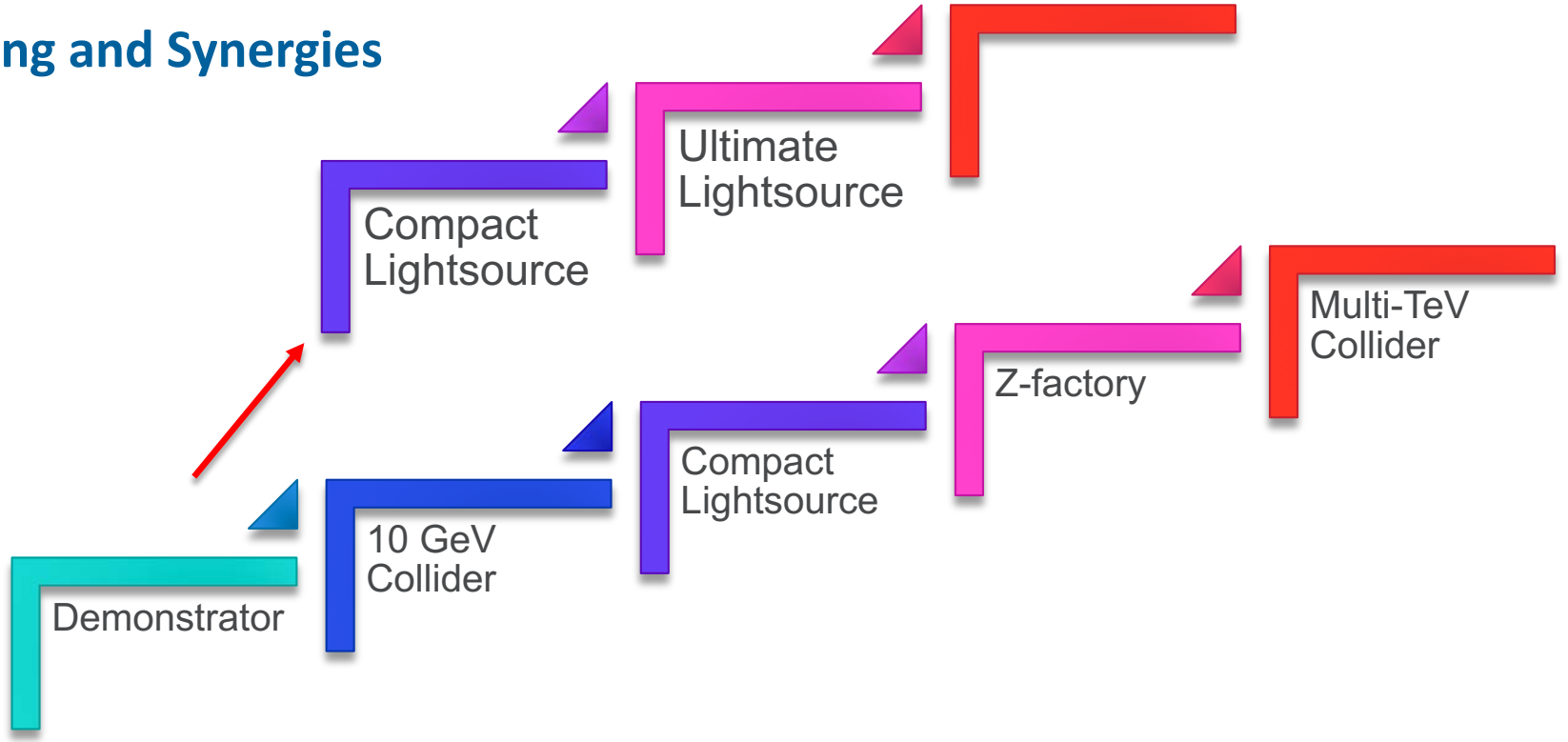
# OPTIONS

## Staging



# OPTIONS

## Staging and Synergies



# AWA STRATEGY

## AWA's broad capabilities

**Advanced Accelerator R&D**

**Facility for Users**

**Non-HEP applications**

## Can enable transformational initiatives