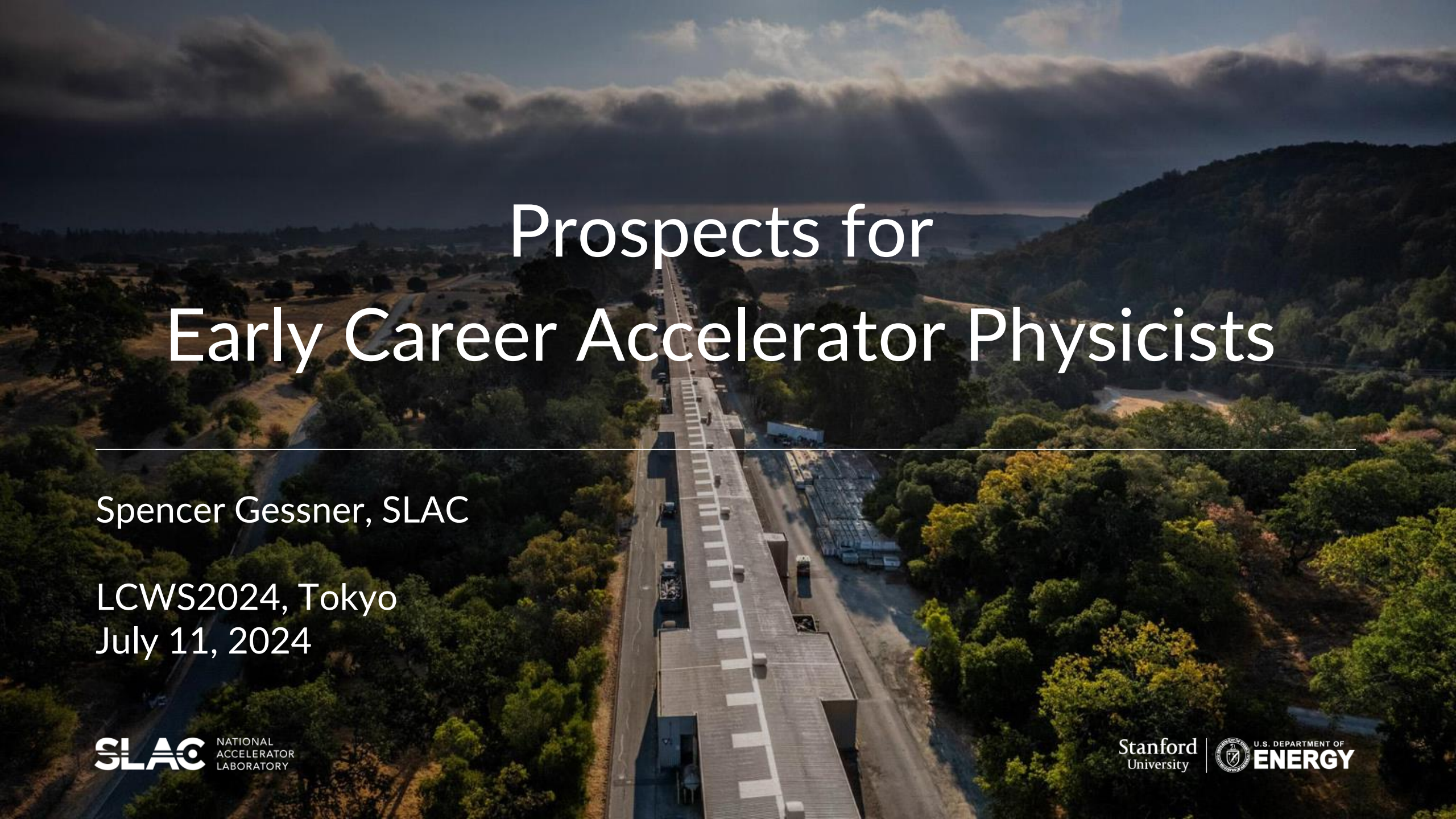


Prospects for Early Career Accelerator Physicists

Spencer Gessner, SLAC

LCWS2024, Tokyo
July 11, 2024

SLAC NATIONAL ACCELERATOR LABORATORY
Stanford University | U.S. DEPARTMENT OF ENERGY

Messages

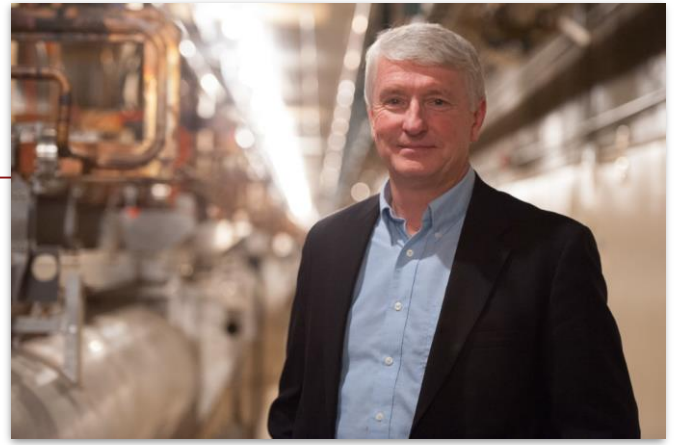
Today's career paths in accelerator physics are different from previous generations.

Fewer colliders today, but accelerator physics is a great choice for a career in science.

The current accelerator work force must expand to meet the needs of future colliders.

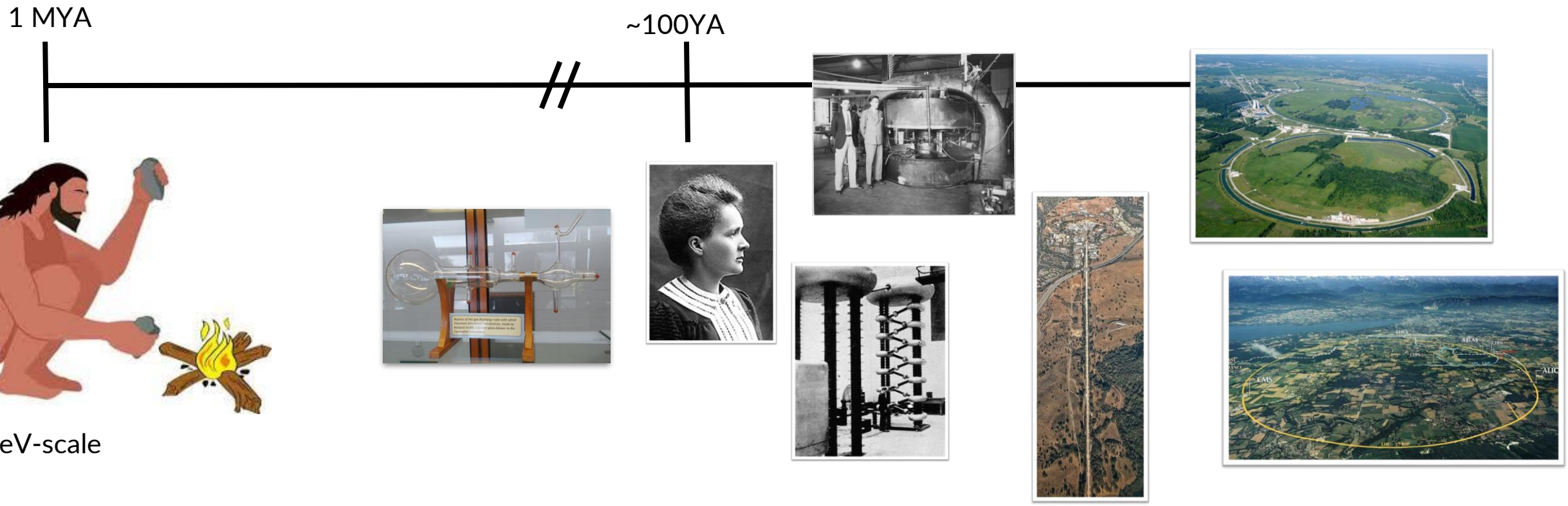
A Career in Colliders

- 1973-1982: Design, construction, and operation of CESR collider at Cornell.
- 1983-1993: Design, construction, and operation of SLC collider at SLAC.
- 1993-2006: Design, construction, and operating of PEP-II collider at SLAC.
- Advisory and collaborative roles on many other colliders including SPEAR, KEKB, Super-KEKB, BEP-II, Tevatron, LHC, and EIC.



John Seeman
Distinguished Staff Scientist
SLAC National Accelerator Lab

Alignment Between Technology and Nature



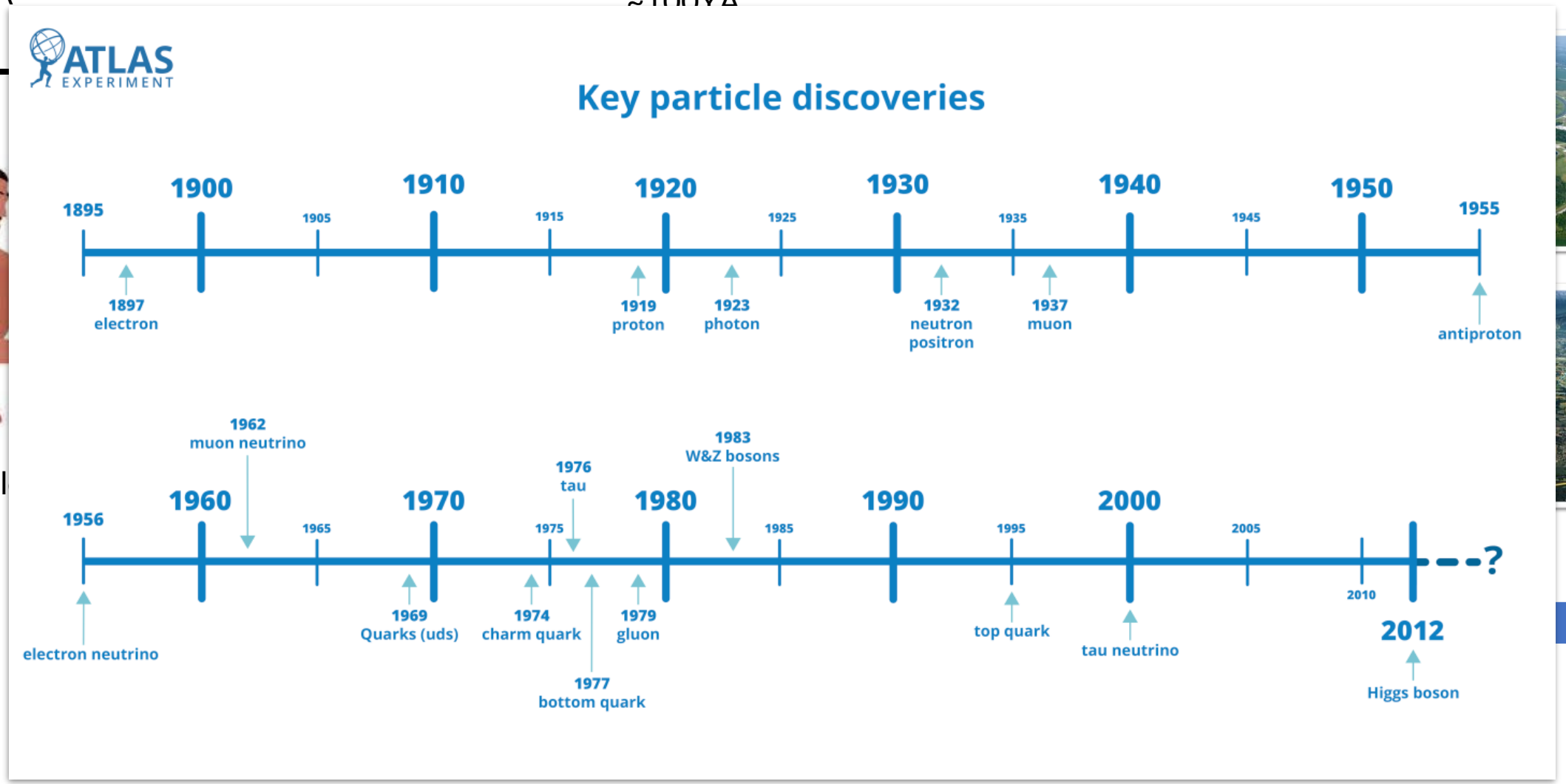
keV to 10 TeV in 120 years
10 orders of magnitude!

Alignment Between Technology and Nature

1 MYA

~100YA

eV-scal



Fewer Colliders but MANY Accelerators

Priorities for Accelerator R&D – US Facility Construction / Preparation

Contemporary accelerator facility construction activity in the US from DOE Science Programmes:

Basic Energy Sciences Advisory Committee – 2023 Facilities Charge:

- Linac Coherent Light Source II – High Energy Upgrade: $710M CD3B
- Spallation Neutron Source – Second Target Station: $1800M CD1
- National Synchrotron Light Source II – Experimental Tools III: $350M CD0
- Linac Coherent Light Source II – Low Emittance Injector: $210M
- National Synchrotron Light Source II – Upgrade: $1000M
- Linac Coherent Light Source X: $1500M

High Energy Physics Advisory Panel – 2023 Facilities Charge:

- LBNF/DUNE: $350M CD3A (furthest advanced sub-project)
- Fermilab Accelerator Complex Enhancement – Main Injector & Target: $?
- Advanced Accelerator Test Facilities (LWFA / PWFA): $?
- Future Energy Frontier Colliders (FCC / ILC / ?): $?
- Fermilab Accelerator Complex Enhancement – Booster Replacement: $?

Nuclear Science Advisory Committee – 2023 Facilities Charge:

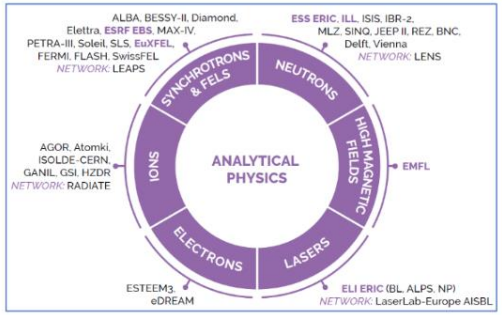
- Electron-Ion Collider: $2000M CD1
- Facility for Radioactive Ion Beams – Energy Upgrade: $?

Priorities for Accelerator R&D – European Facility Construction / Preparation

Main body for pan-European research coordination = ESFRI – representation from: European Commission, Each of the 27 EU Member States, Each Associated Country (= a further 15 States e.g. UK)

The latest strategy report on Research Infrastructures (2021) enumerates the live priority projects and their "investment costs". Accelerators fall under "Analytical Physics" (light & neutron sources) and "Particle & Nuclear Physics" categories:

ESFRI European Strategy Forum on Research Infrastructures

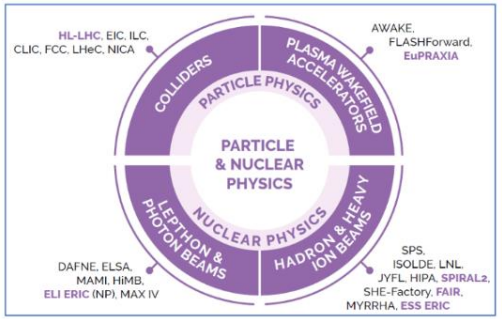


ESFRI Projects (Early stage, construction start expected within 5 years):

- **EuPRAXIA** – Plasma & novel acceleration R&D facility (569 M€)

ESFRI Landmarks (Finalising construction or operational):

- **ESRF-EBS** – Upgrade of 8 GeV synchrotron light source to near-diffraction limit (128 M€)
- **ELI** – Extreme Light Infrastructure = high power laser multi-site facility (850 M€)
- **European Spallation Source** – SC linac driven neutron source (3009 M€)
- **European XFEL** – SC linac driven free-electron laser (1540 M€)
- **FAIR** – Heavy ion synchrotron, storage rings & antiproton production (? M€)
- **High-Luminosity LHC** (1408 M€)
- **SPIRAL-2** - light ion SC linac upgrade of cyclotron based ion facility (307 M€)



Funding models are bespoke to each. **The list matters as it guides EU research funding** – notably "Framework programmes" – current one is **Horizon Europe** (2021 – 2027) = 95 Bn€

~20 new and ongoing accelerator construction and upgrade projects in US and Europe.

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Fewer Colliders but MANY Accelerators

Jie Gao, IHEP

CEPC in Synergy with other Accelerator Projects in China

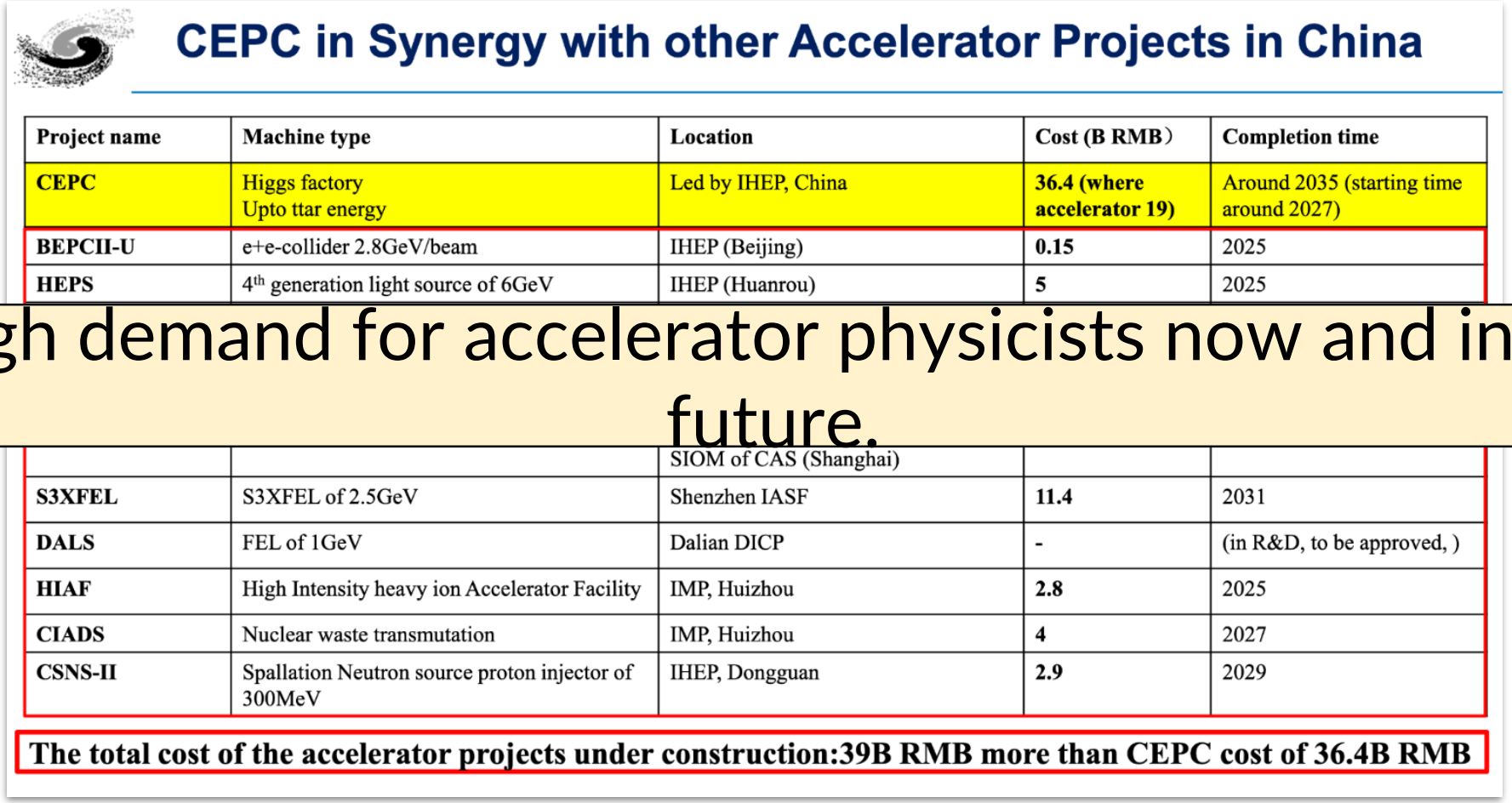
Project name	Machine type	Location	Cost (B RMB)	Completion time
CEPC	Higgs factory Upto ttar energy	Led by IHEP, China	**36.4 (where accelerator 19)**	Around 2035 (starting time around 2027)
BEPCII-U	e+e-collider 2.8GeV/beam	IHEP (Beijing)	**0.15**	2025
HEPS	4th generation light source of 6GeV	IHEP (Huanrou)	**5**	2025
SAPS	4th generation light source of 3.5GeV	IHEP (Dongguan)	**3**	2031 (in R&D, to be approved)
HALF	4th generation light source of 2.2GeV	USTC (Hefei)	**2.8**	2028
SHINE	Hard XFEL of 8GeV	Shanghai-Tech Univ., SARI and SIOM of CAS (Shanghai)	**10**	2027
S3XFEL	S3XFEL of 2.5GeV	Shenzhen IASF	**11.4**	2031
DALS	FEL of 1GeV	Dalian DICP	-	(in R&D, to be approved,)
HIAF	High Intensity heavy ion Accelerator Facility	IMP, Huizhou	**2.8**	2025
CIADS	Nuclear waste transmutation	IMP, Huizhou	**4**	2027
CSNS-II	Spallation Neutron source proton injector of 300MeV	IHEP, Dongguan	**2.9**	2029

The total cost of the accelerator projects under construction:39B RMB more than CEPC cost of 36.4B RMB

~10 projects in China plus accelerator upgrades in Japan and Korea.

Fewer Colliders but MANY Accelerators

Jie Gao, IHEP



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The total cost of the accelerator projects under construction:39B RMB more than CEPC cost of 36.4B RMB

High demand for accelerator physicists now and in the future.

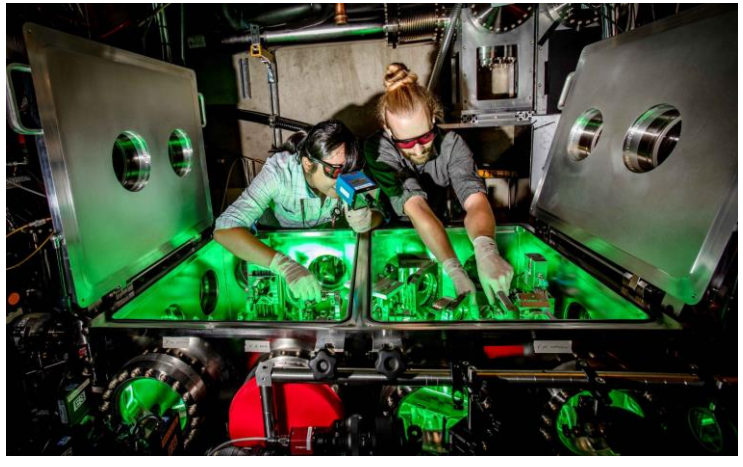
~10 projects in China plus accelerator upgrades in Japan and Korea.

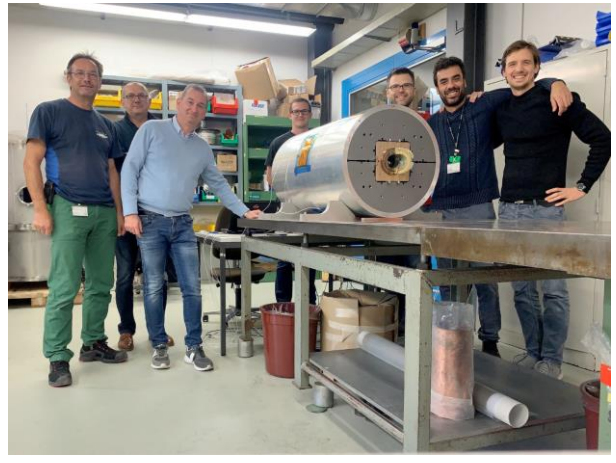
R&D is critical for training young accelerator physicists

Today's accelerator physicists come from High Energy Physics backgrounds, but also:

- Materials science
- Plasma physics
- Photon science
- Computer science
- Electrical engineering
- Mechanical engineering
- Many other disciplines

R&D converts generic scientific skills into accelerator knowledge.





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Conclusion: Accelerator Workforce

Good news!

- The P5 Report specifies $10M increase in GARD funding plus $35M in accelerator collider R&D.
- That's a 50% increase over current US accelerator R&D.

Where will new accelerator physicists come from?

- Continued and expanded support of funding agencies for university programs.
- Support for USPAS, CAS, JUAS. Bring back LC school?