

# Schedule/budget scenarios for FCC-ee experiments

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First annual US FCC workshop - BNL

26 April 2023

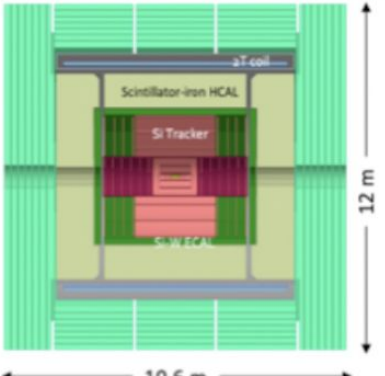


# beautiful detectors

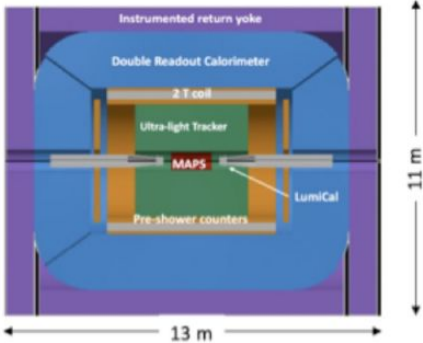
A demanding, precision physics program demands beautiful detectors. Some ideas exist on what to build, but any improvement in resolution translates directly to improved precision. And as we can see from this chart from the ECFA detector report (e.g. solid state detectors), we don't quite have what we need yet.

(2 – 4 detectors planned)

CLD



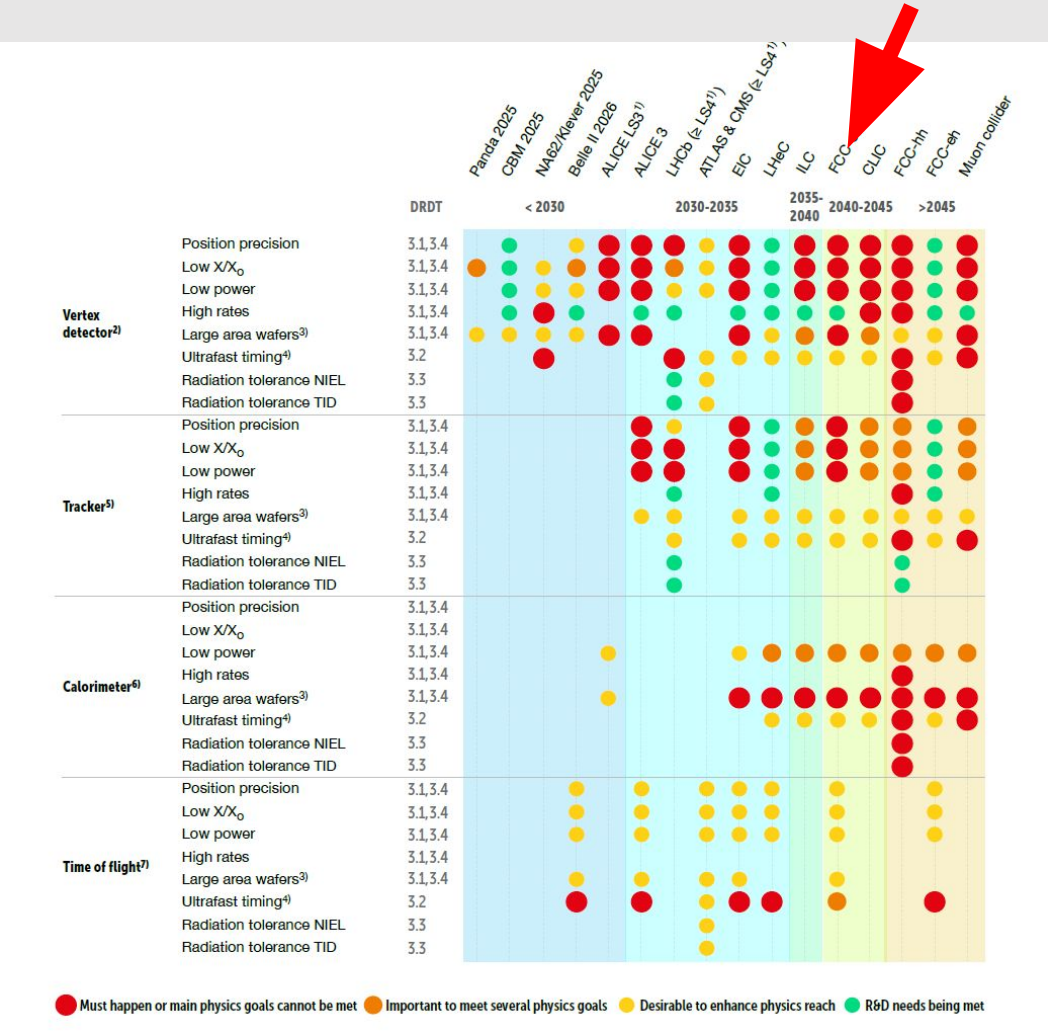
IDEA



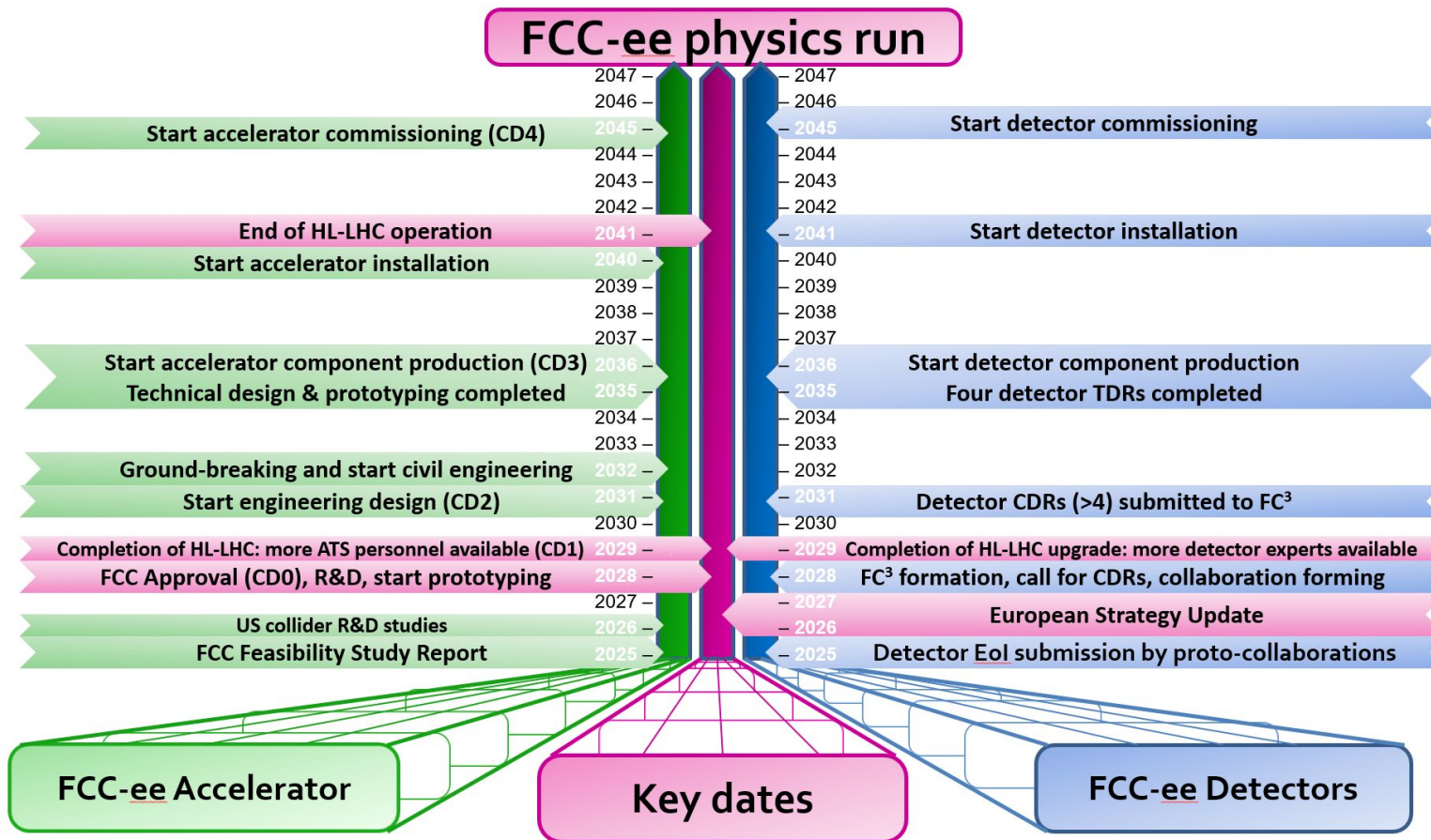
Noble Liquid



And what about a detector optimized for the huge samples of b quarks at Tera-Z???



# Time is short



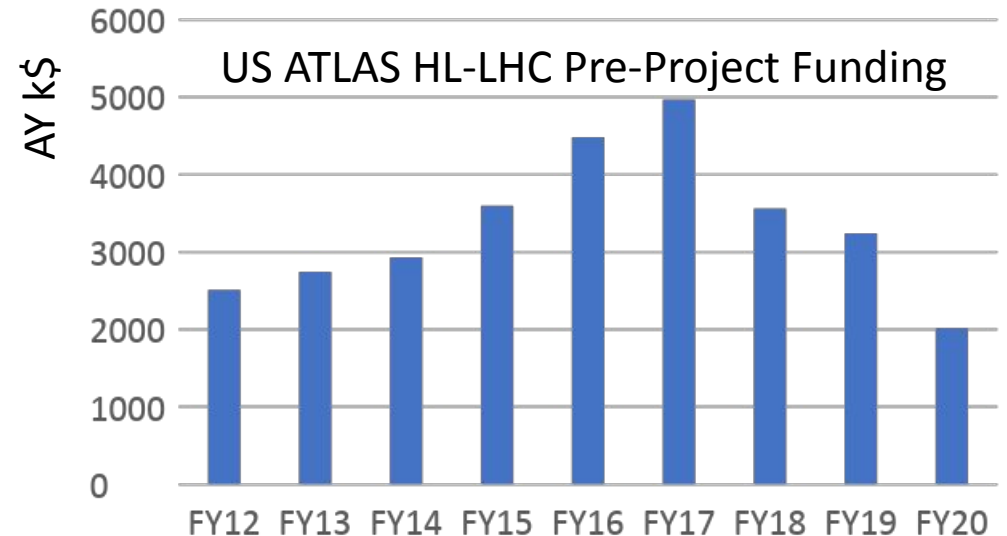
We need a new machine shortly after FCC-ee. But this implies an aggressive (but feasible) timeline. But for this to happen, we need to push!

- 2028 formulation of collaborations. That's five years from now!!
- 2031 detector CDR's (4!) that's eight years from now
- 2041 installation (18 years)
- CD0 in 2028???
- CD1 at time of CDR?

- CD-0 documents that a mission need, such as a scientific goal or a new capability, requiring material investment exists. The mission need does not necessarily specify the facility, technology, or configuration of the project though these things are often described at some level.
- CD-1 serves as a determination that the selected alternative and approach is optimized to meet the mission need defined at CD-0. Key elements of the evaluation are the project's conceptual design, cost and schedule range, and general acquisition approach. The cost range allows for uncertainty in the estimates and scope options such as a range of capabilities.
- CD-2 is an approval of the preliminary design of the project and the baseline scope, cost, and schedule. The baseline is the definitive plan that the project will be measured against using Earned Value metrics for cost and schedule and Key Performance Parameters (KPPs) for technical performance.
- CD-3 is an approval of the project's final design and authorizes release of funds for construction.

# US ATLAS Pre-Project funding for HL-LHC R&D

- DOE Deliverables:
  - CD-0 in 2016 (T-12)
  - 2012–2017: R&D for DOE deliverables supported through Operations Program (pre-project). (T-16)
  - In 2017, HL-LHC upgrades transitioned to DOE Project funds (TPC = 200M)
- NSF Deliverables:
  - MREFC Approved in 2020
  - 2012-2020: R&D for NSF deliverables supported through Operations (pre-project).
  - In 2020, HL-LHC upgrades transition to NSF MREFC funds (Total = 75M)



**HL-LHC experience demonstrates that targeted pre-project R&D funds are critical**

# CMS: Upgrade time scale

## CMS upgrade (finish date 2028)

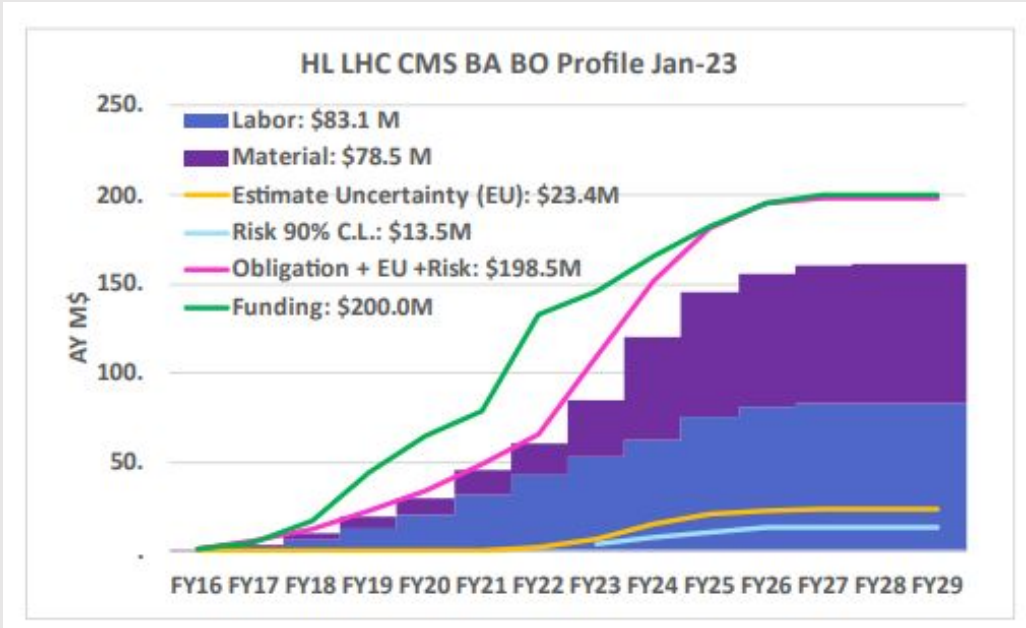
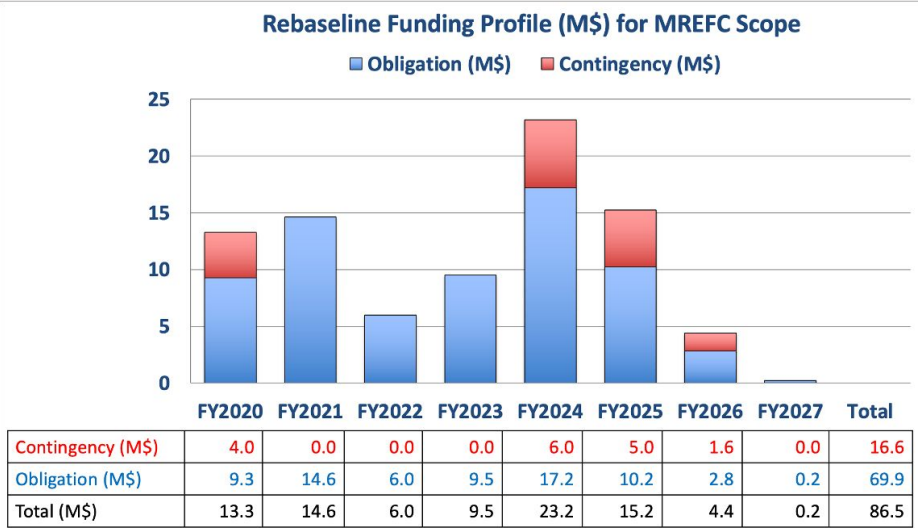
- First HL-LHC upgrade meeting in 2008 (T-20))
- first directed R&D funding 2010 (T-18)
- Serious R&D funding 2014 (T-14)
- Construction start 2023 (T-5)

DOE

HL LHC CMS Detector Upgrade  
Coarse Estimates of costs to CD-2, and final BAC  
Does not include any Management, Installation and Integration Activities, or Contingency Estimates  
All costs Actual Year \$M

Subsystem	Budget to CD-2			Total BAC
	EDIA	M&S	Total	
Outer Tracker	12.3	12.3	24.6	49.1
Calorimeter Endcap	12.6	4.1	16.7	54.4
Trigger/DAQ	3.0	1.0	4.0	10.5
Timing Layer	5.5	2.5	8.0	20.5
<b>Grand Total</b>	<b>33.3</b>	<b>19.9</b>	<b>53.2</b>	<b>134.5</b>

NSF



13 year time scale



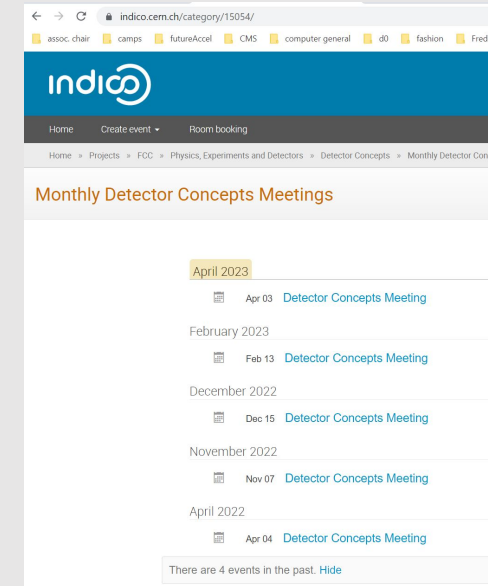
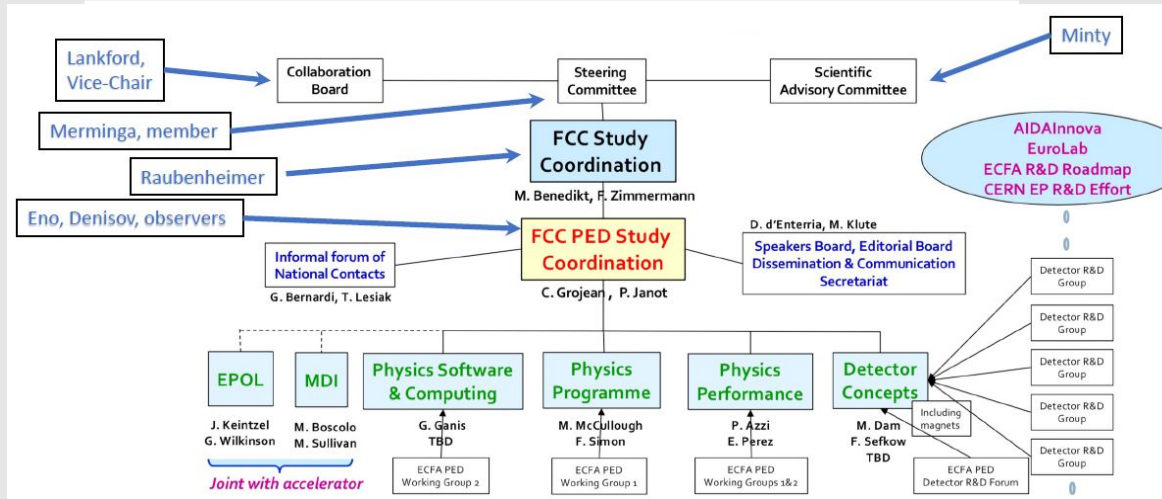
# EIC experience

DOE Nuclear

19 year schedule

dedicated proto-protoproject R&D funds  
\$1M starting 2012, managed by “small  
grants” to various groups via an “advisory  
committee”. Construction starts about now  
for a 2031 turnon.

Efforts well underway in Europe to deliver detectors for FCC-ee for installation in 2041



Felix Sefkow, Morgen  
Dams current detector  
coordinators.

Experiment formation  
expect in 20XX

While the US has some participation, e.g. proposing the addition of dual-readout crystals to the IDEA detector and a new initiative (LDRD) at BNL for Noble Liquids, the impact is not right now commensurate with our proposed scale of participation. There are many reasons for this.

Do you want to change this? What would we need to change this?

# upcoming important milestones

Today DRD6 (Calorimeter) 2nd community Meeting: actually ongoing, with US participation, and worthwhile to check the slides:

<https://indico.cern.ch/event/1246381/>

May 16-17 DRD4 (PD/PID) Community Meeting <https://indico.cern.ch/event/1263731/>

May 3-4 ECFA Higgs w/s calorimetry & PID <https://indico.cern.ch/event/1256374/>

May 30-31 ECFA Higgs w/s tracking & vertexing <https://indico.cern.ch/event/1264807/>

Jun 5-9 FCC Week London <https://indico.cern.ch/event/1202105/>

FCC physics and detector workshop at Annecy, proposed date April 8-12, 2024

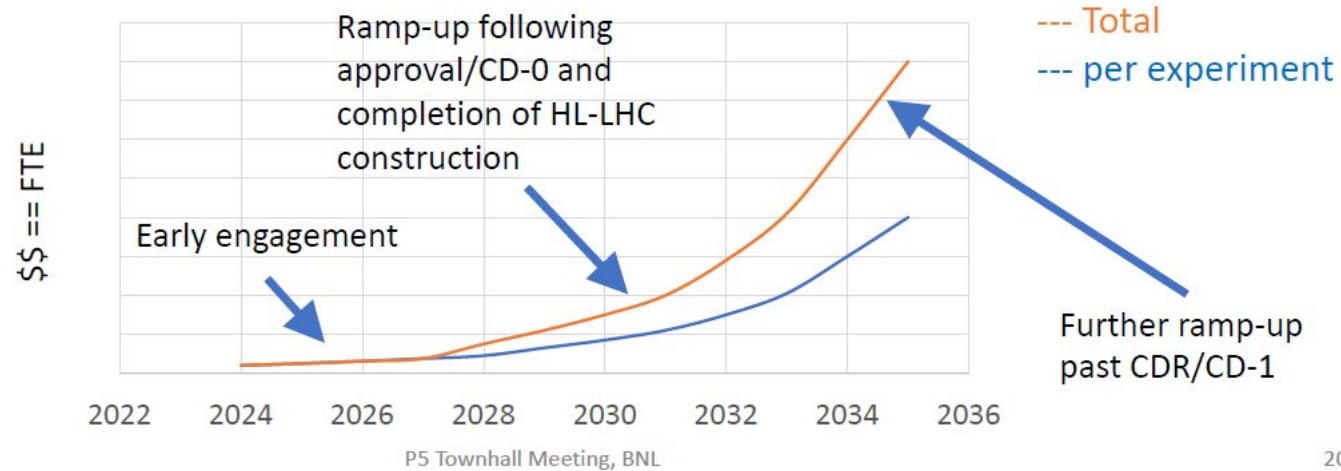


# US funding

USFCC-ee is in the process of developing a bottoms-up funding needs for strong US participation in FCC-ee, building on our experiences with LHC upgrades. Goal is to be able to submit to P5 and funding agencies before summer and allow the US to come in strong.. Srimi Rajagopalan lead.

## The US FCC Coordination Team

Solid State	Artur Apresyan (Fermilab), Carl Haber (LBNL)
Gaseous Detectors	Marcus Hohlmann (FIT), Bing Zhou (Michigan)
Calorimeter	Hucheng Chen (BNL), Chris Tully (Princeton)
Particle ID	Marina Artuso (Syracuse), Sarah Eno (Maryland)
Readout/ASICs	Julia Gonski (Columbia), Jim Hirschauer (Fermilab)
Trigger/DAQ	Zeynep Demiragli (Boston), Jinlong Zhang (ANL)
Software/Computing	Heather Gray (Berkeley), Oliver Gutsche (Fermilab)
Quantum	Marcel Demarteau (ORNL), Cristian Pena (Fermilab), Si Xie (CalTech)
Advisers	Karl Jakobs (ECFA), Andy Lankford (ILC)
ex-officio	Abid Patwa (DOE), Helmut Marsiske (DOE), Jonathan Asaadi (CPAD)
Chair	Srimi Rajagopalan (BNL)

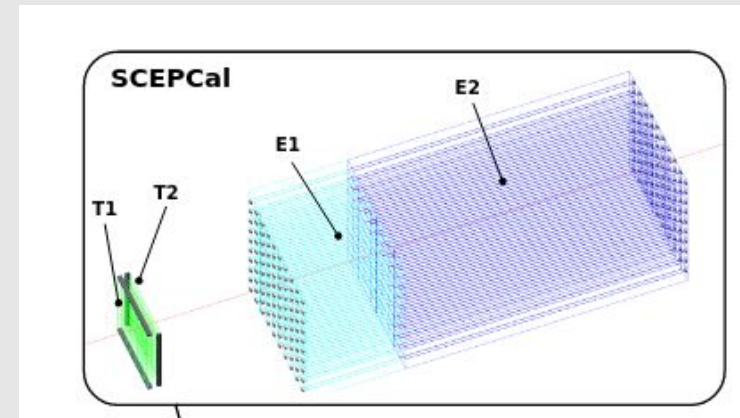


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# think bold

For CMS, I do radiation damage in plastic scintillators. There is no need for that at FCCee. So working with colleagues at a variety of institutions, I've pivoted to dual readout calorimetry.

You have a year or so before work gets serious. Think about trying something new. That's why we got into physics, right?



# Conclusions

- If we want turn-on in 2040's, we need to act now
- If we want the US to be an intellectual as well as a financial contributor, we need to act now
- If we want the FCCee detectors to incorporate new ideas, instead of just rebuilding ALICE, we need to act now.
- In fact, we still need to act now even if we want to recycle old detectors.
- Can you work with us to make sure the US will have a big impact on this exciting physics facility? Let's discuss this with our panel!



# experiments

## Some literature

- Main FCC website: <https://fcc-ped.web.cern.ch/>
- FCCee CDR with detectors: <https://cds.cern.ch/record/2651299?ln=en>
- CLD: <https://arxiv.org/pdf/1911.12230.pdf>
- IDEA: <https://inspirehep.net/files/49ec726758c422bc454e270a71f6e59f>
- Noble liquid: <https://arxiv.org/pdf/2109.00391.pdf>
- Detector Challenges at FCC-ee  
<https://fcc-ee-conference.web.cern.ch/database/conference/960/presentation/1036/>
- BRN: <https://www.osti.gov/biblio/1659761>
- ECFA: <https://cds.cern.ch/record/2784893>
- Particle identification at FCC-ee <https://link.springer.com/article/10.1140/epjp/s13360-021-01810-4>