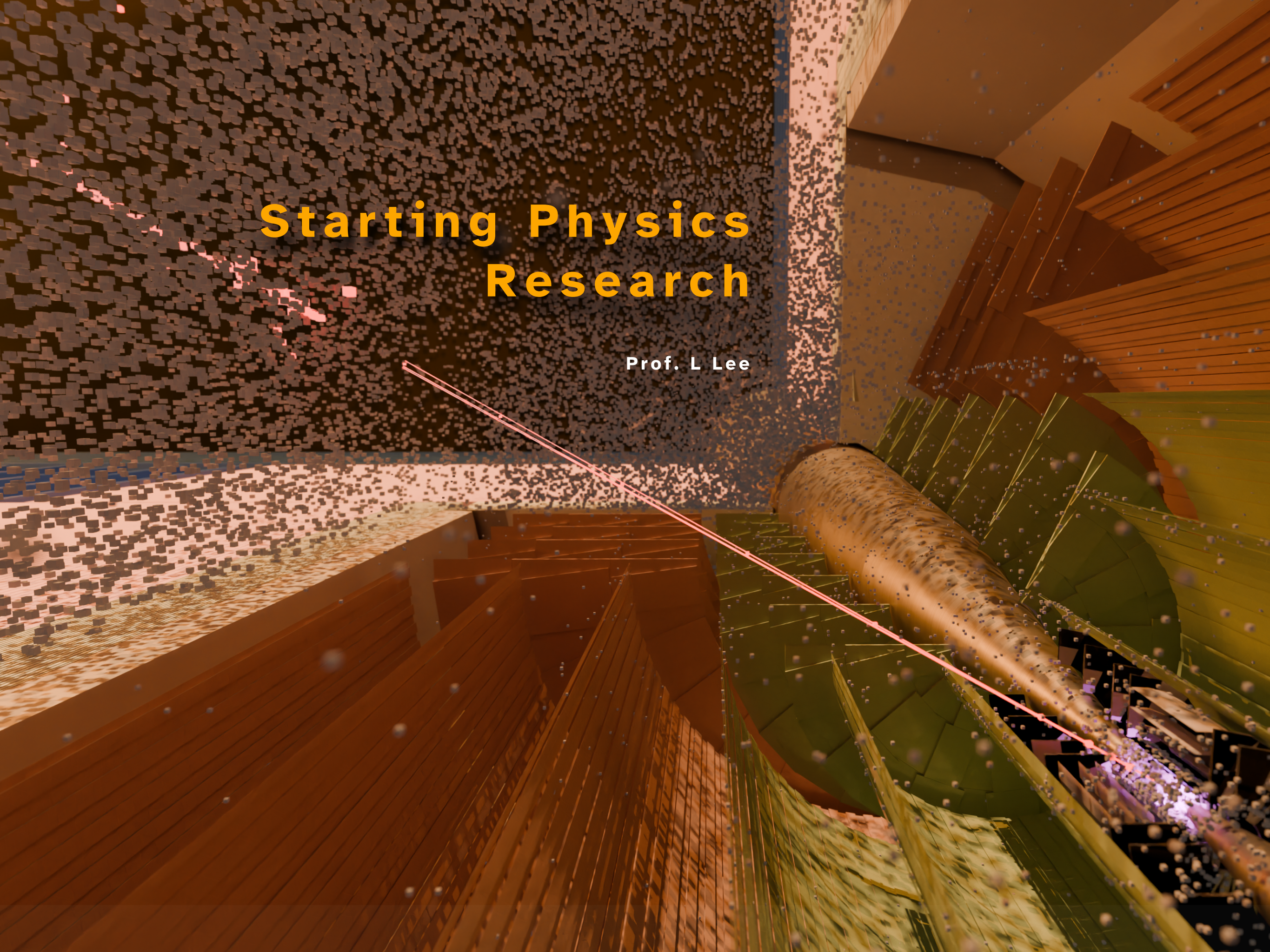


Starting Physics Research

Prof. L Lee

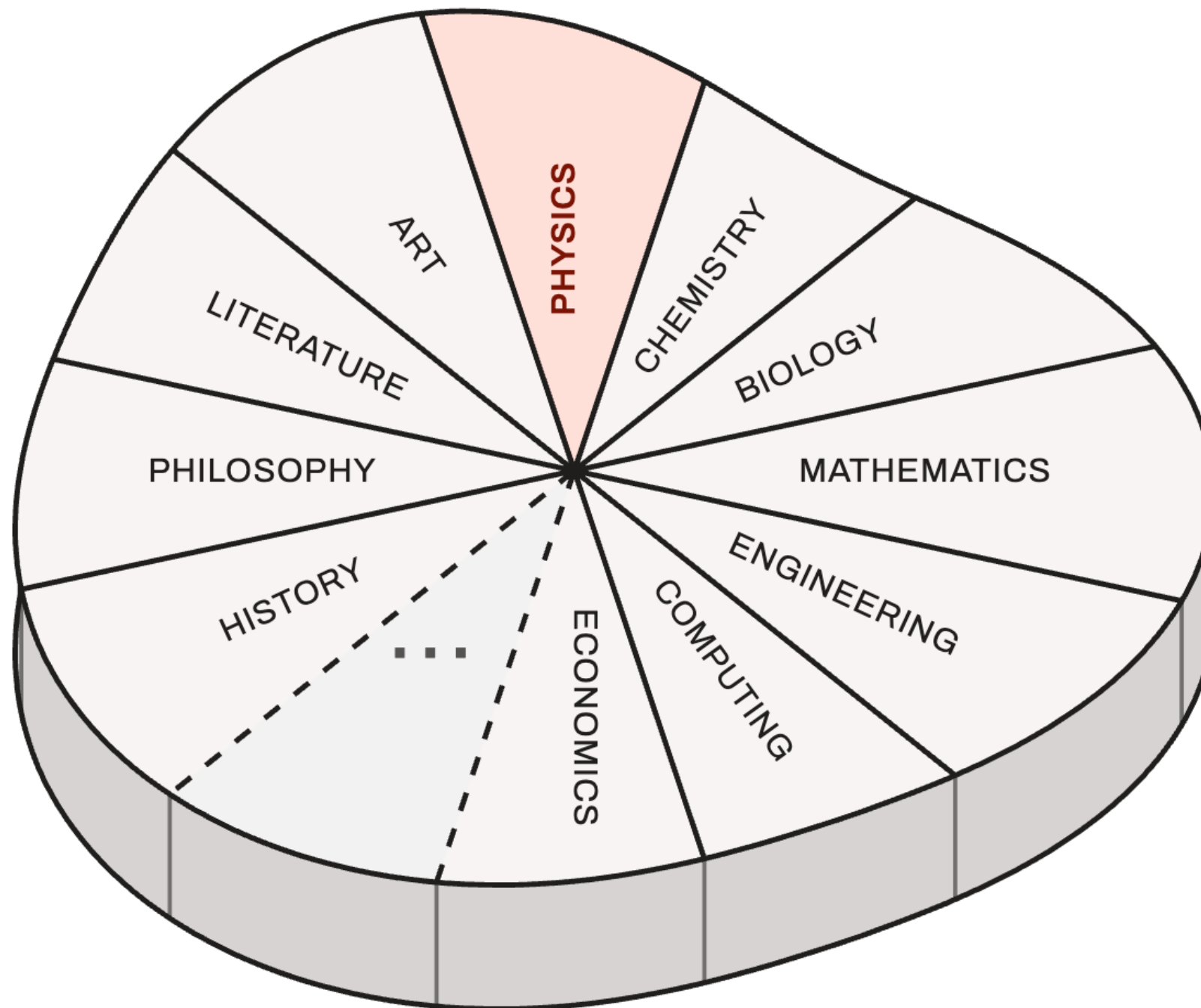


- *Disclaimers:*
 - These slides are **way wordier** than I would normally recommend.
[I want you to be able to go back to these as a reference.]
 - Some views will be biased by me/my research/my philosophy; I'll try to highlight when others might not agree

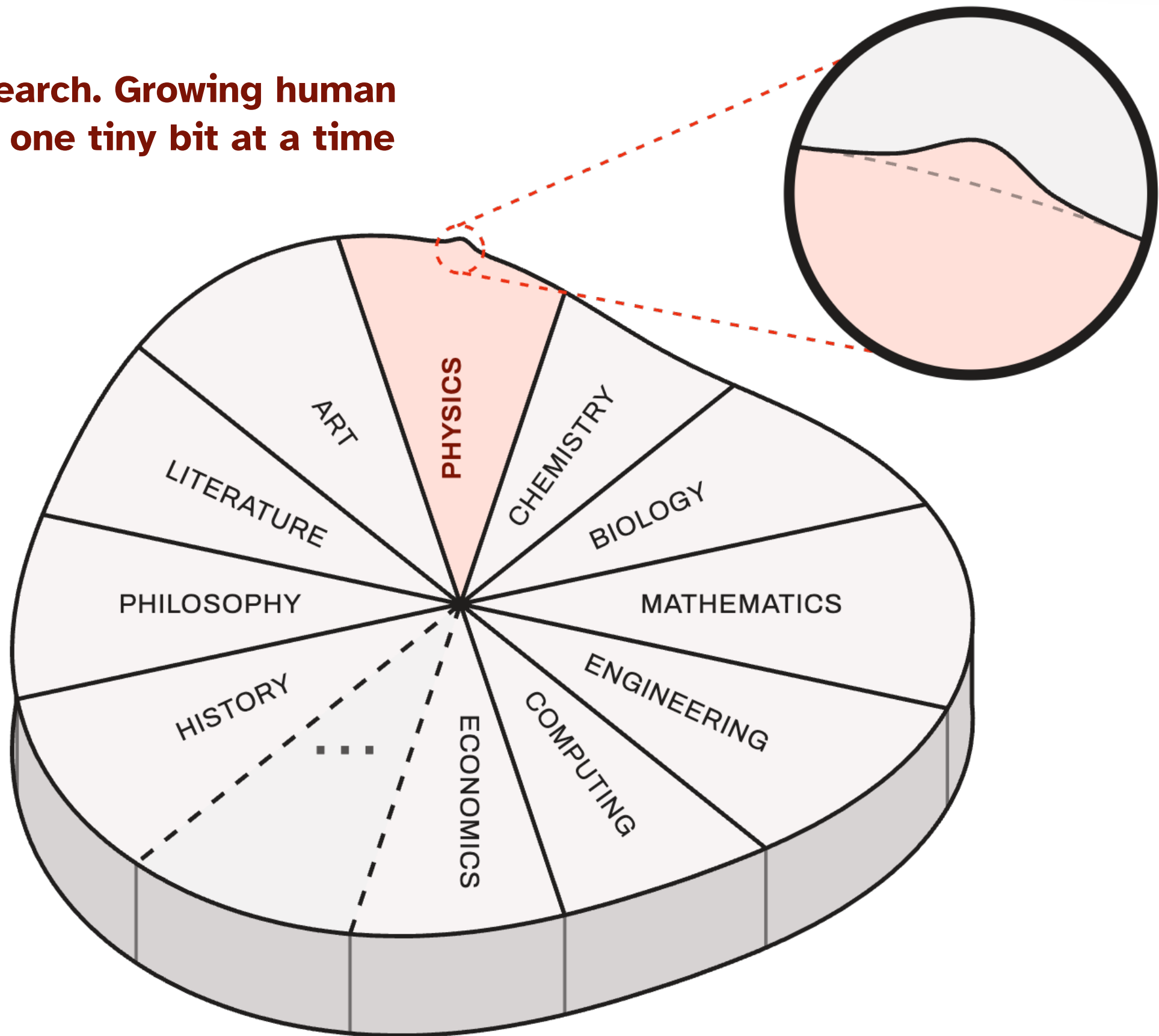
WHAT IS RESEARCH?



**ALL OF HUMAN
KNOWLEDGE**



This is research. Growing human knowledge one tiny bit at a time



WHY SHOULD YOU DO RESEARCH...

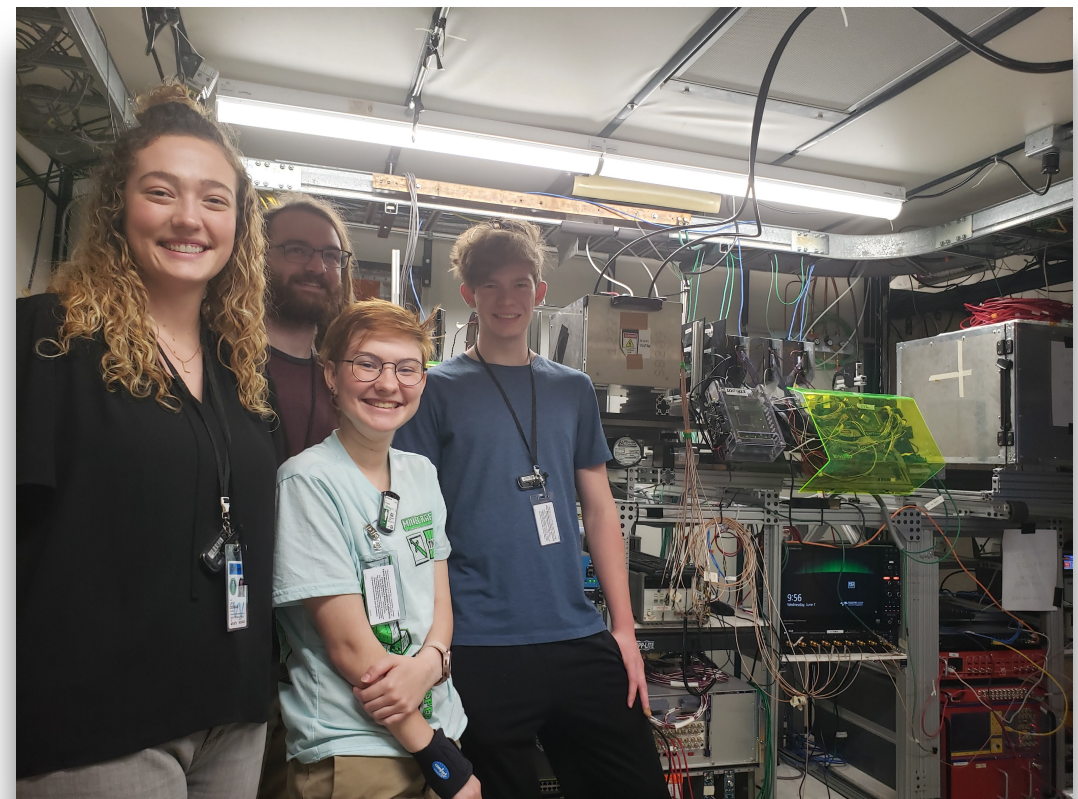
- For the degree, it's *optional*. But...
- **This is what physics is really all about:** learning how the universe works until you reach the point where no one knows the answer — and then figuring it out.
- It's a great way to **build practical skills** for the workforce after graduation.
- It's a great way to get a small taste of what a career in research could be like, if that interests you.
- *For me:* It's fun. I like problem solving, relying on technical/physics intuition, and discovering new things.



UTK undergrad (in UTK SPS t-shirt)
+ Rutgers Professor in 2T magnet at CERN

WHAT TO EXPECT ONCE IN A GROUP...

- Day-to-day physics research takes lots of forms!
 - Programming; Building/testing electronics; Building instruments; Operating large expensive machines; Data analysis; Running large scale simulations; Paper and pencil work; CAD modeling; Test tube work; Writing talks/papers/proposals
- Most faculty will offer a **hourly pay** for research work.
 - If you have a **Federal Work Study** award, we can actually apply that to research! You'd be **free** to a group!
 - There are also other funding sources *[more later]*
 - You can also do research for **credit** instead — useful if it helps with your graduation requirements.
- Talk with your research advisor about how much time per week you can reasonably spend on a project. Be honest with yourself and them.
 - Time expectations for an undergrad during term time are low and depend on your course load. **We don't want to compromise your classes!**



3 UTK undergrads at Fermilab Test Beam Facility

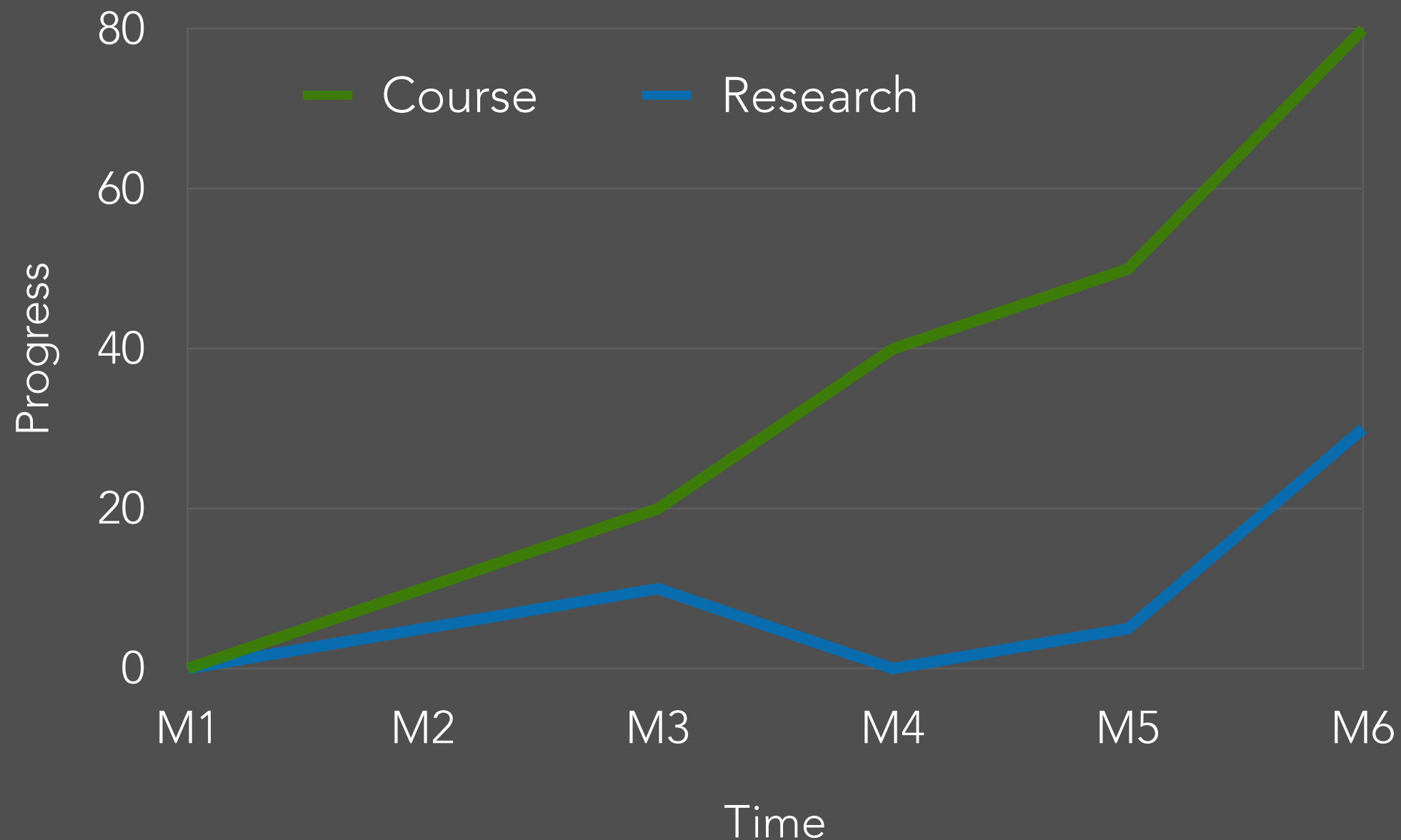
HOW TO SUCCEED...

- **Throw yourself at the problem.** Crucial to dive in and try things out. Be fearless. *[more later]*
- But also **ask for help.** Don't bang your head on the table for two days on a single problem. Spend ~30 min trying to fix, then ask for help. The group has probably seen that problem a million times.
- This is not a class. It's an **apprenticeship.**
- Pay attention in meetings, **ask clarifying questions.** Scary at first — lots of jargon. Learning doesn't happen overnight. Takes effort+time.
- **Be organized. Take notes.** Build a note-taking system. If you're doing software, use GitHub issues and project management tools.



2 UTK undergrads in cleanroom at Fermilab

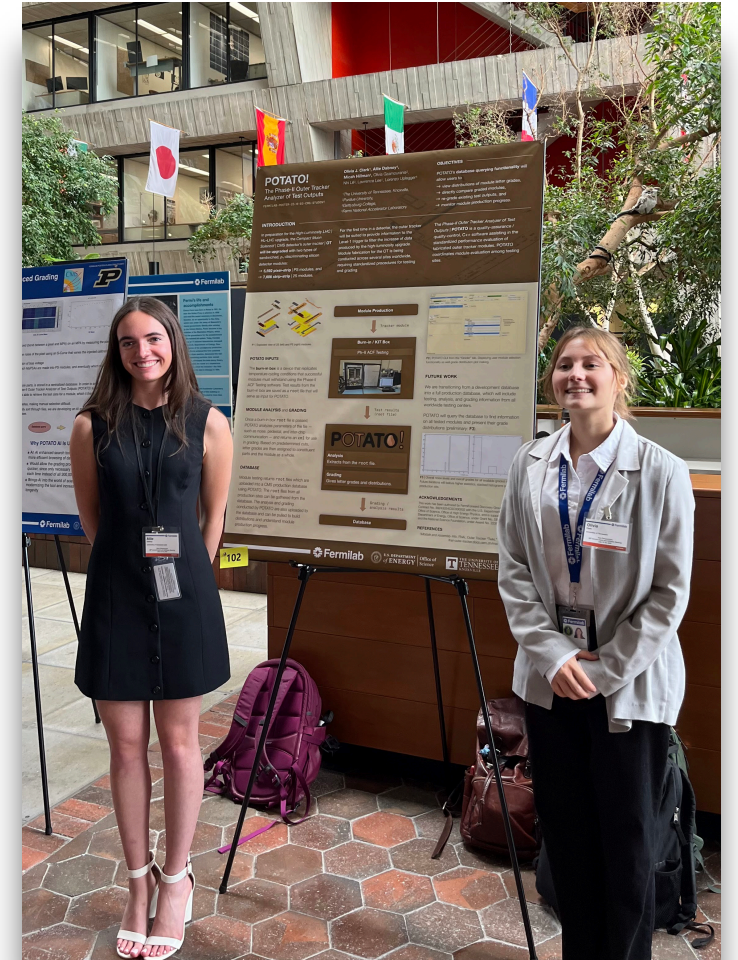
THIS IS DIFFERENT...



Research is chaotic; no monotonic improvement. There are major setbacks, and you learn to improvise and lean on a growing library of experience for what to do next.

WHEN SHOULD I START...

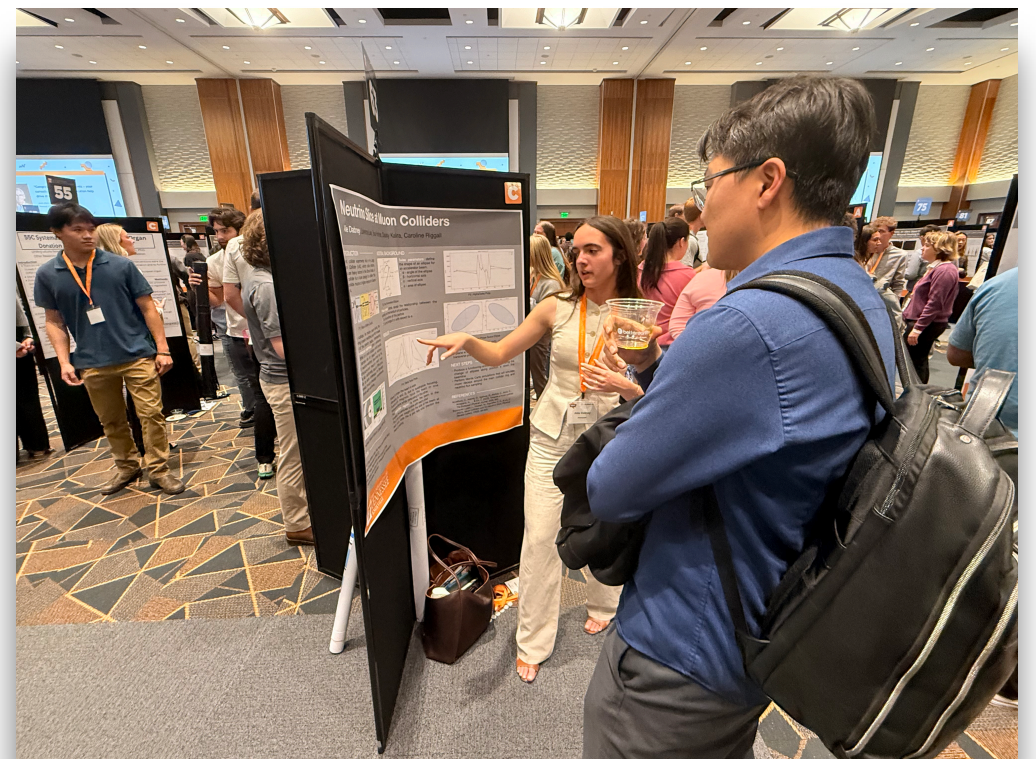
- **Start early.** The sooner you join a group, the sooner learn if it's a good fit, and the more time you have to try another group after.
 - Multiple good research experiences mean multiple good letters for grad school, jobs, or whatever comes next.
- Your main term-time goal is to learn/do enough to **earn a summer research position** where you can really focus without classes and learn deeply. *[more later]*



2 UTK undergrads
presenting a poster at Fermilab

HOW TO PREPARE...

- Skills and knowledge are mostly built on the job, but knowing some background helps.
 - Do I expect you to know how the top quark decays? No. Do I expect you to run a Python script from the command line? Kind of. *Different groups may expect different levels of coursework material command.*
- **Computing helps everyone.** Have at least some familiarity with Python. C++ is a big plus-plus.
- **LinkedIn Learning** is a great way to pick up new skills; **free** with UTK login: <https://oit.utk.edu/training/online-training/lil/students/>



UTK undergrad
presenting a poster at EURECA

HOW TO PREPARE...

- **Computing-heavy groups:** Crucial basic **Linux** command line knowledge. Really know **git**. Know VSCode **and** emacs/vim. *[All of this is muscle memory, so it's a matter of practice.]*
 - Highly recommended: **The Missing Semester of Your CS Education** — do the exercises to get the commands into your finger memory. <https://missing.csail.mit.edu/>
- **Electronics-heavy labs:** know some basic analog+digital electronics; find a crash course; will come up in most experimental labs
 - If you're serious, The Art of Electronics is the bible; there's a **free, more student-friendly derivative** here: <https://atomoptics.uoregon.edu/~dsteck/teaching/electronics/electronics-notes.pdf>
- Know the basics of **LaTeX**. Overleaf's “Learn LaTeX in 30 minutes” is enough to get going. https://www.overleaf.com/learn/latex/Learn_LaTeX_in_30_minutes



UTK undergrad
presenting a poster at Chicago

FINDING RESEARCH THAT INTERESTS YOU...

- Go to the departmental **seminars and colloquia**.
- **Talk** to undergrads and graduate students to learn about the different kinds of work being done.
- Read through the department web pages to understand the range of research in the department and groups that have a history of taking undergraduates.
 - UTK P&A Undergrad Research Opportunities (not exhaustive)
- **Your hobbies may guide you:** Do you like electronics? Programming? Building computers? Solving math puzzles? Operating complex equipment? Visualization? These all point to different kinds of physics.

FOUND AN INTERESTING GROUP? HOW TO REACH OUT...

- **Don't be annoying**, and don't spam the department. One at a time.
- Find work that **genuinely interests** you.
- **Email** professors directly. Keep it short, cut to the chase, and be polite. Ask if they have possible research opportunities, and ask to schedule a meeting.
- **Don't oversell yourself.** We know you're all beginners. I'm more interested in real technical experience/interests.



UTK undergrad at a summer school on muon colliders

AVAILABLE PROGRAMS

- *On campus:*

- Office of Undergraduate Research & Fellowships — pays salary.
<https://studentsuccess.utk.edu/urf/scholarly-development-grants-sdgs/>
- P&A Department summer fellowship — pays summer stipend.
<http://electron4.phys.utk.edu/summerfellows/>

- *National:*

- DOE National Labs SULI program — apply to any DOE national lab; they cover travel, housing, and stipend.
<https://science.osti.gov/wdts/suli>
- NSF Research Experiences for Undergraduates (REU) — same deal.
<https://www.nsf.gov/funding/initiatives/reu>

Apply early. Deadlines for summer research opportunities start as early as December or January.

TIPS: MOST IMPORTANT QUALITIES

- Reliability, grit, and deep curiosity — ability to make progress and finish projects.
- You speak up when you're stuck.
- **Be fearless.** You can understand anything if you put in the work. Every piece of code comes down to a tiny thing you can understand; it just takes digging fearlessly.
- **Initiative.** Don't twiddle your thumbs waiting to be told what to do next. Go dig, go explore, poke the thing until you understand it better.

TIPS (IMO):

- I don't care if you have a flawless transcript or not
 - Again, research and coursework require different skills
- I don't care if you think you know a lot about my research. Honestly, you don't — and that's okay. You're new to this. **Our job in the dept is to train you!**
- **Do not pretend to understand when you don't.**
Be honest; ask questions!

Questions?

