A Postdoctoral Research Opportunity with University of Virginia on CMS
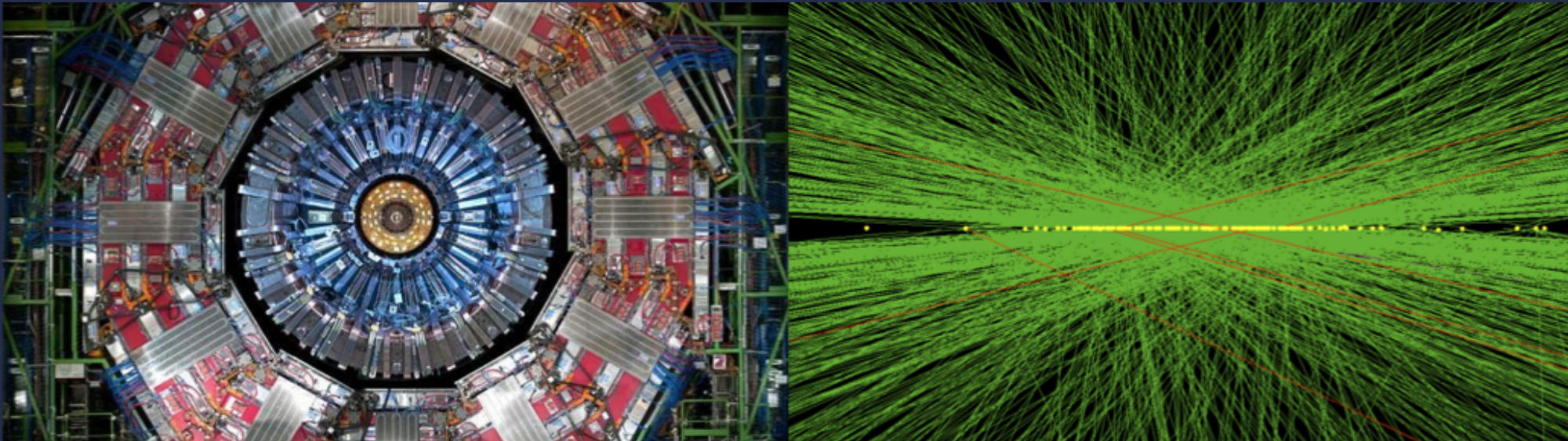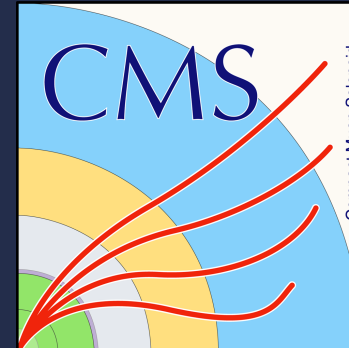
Chris Neu

21 September 2020

About Me

- Chris Neu
  - Associate professor, University of Virginia (UVA)
  - Currently serve as the Director of Diversity, Equity and Inclusion for the Physics Department at UVA and Director of the PhysicsBridge program
  - History:
    - Joined CMS in 2008 as a new assistant professor at UVA
    - Received tenure in 2014
    - Before UVA, I was a postdoc on the CDF experiment at the Tevatron with Penn
    - Before Penn, I was a PhD student on CDF with OSU (Brian Winer)
    - Before OSU, I was an undergrad researcher on CDF with Illinois

  - Personal details:
    - I am 44 years old
    - I grew up outside Chicago, now live in Crozet, VA in the foothills of the Blue Ridge Mountains
    - I have a wife, Laura, two children – Maddy (13) and Charlie (10) – and one dog – Henry (5).
    - I enjoy hiking, woodworking, kayaking, home improvement projects, cooking, fishing and sports
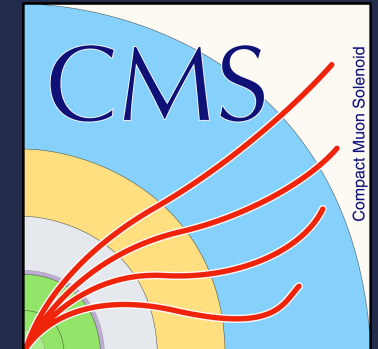
NeuPhysics Group and UVA-CMS

- ## NeuPhysics group members:
  - Outgoing postdoc: Ben Tannenwald
  - PhD students
    - Evan Wolfe (expected defense 2020)
    - Ang Li (defense expected 2023)
  - Undergraduate students:
    - Gracemarie Buehlmann
    - Anna Cuddeback
    - Leigh Hatfield
    - Colby Thompson
  - Technical staff:
    - Thomas Anderson
    - Eric Fernandez

- ## Two other faculty on CMS at UVA:
  - Bob Hirosky
  - Brad Cox

In my research group, people from diverse backgrounds are welcomed and every member is treated with respect regardless of rank, race, ethnicity, color, gender, orientation, or faith.
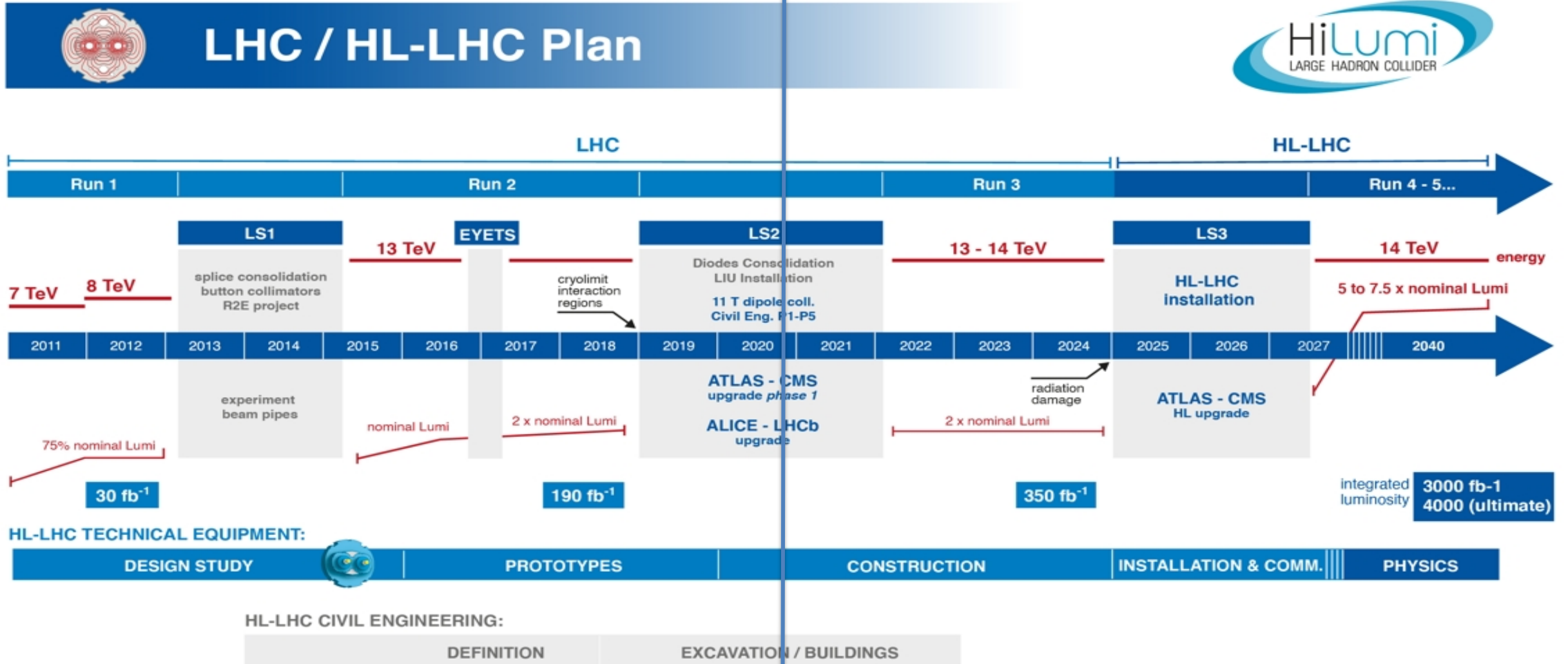
Strong mentoring is an important component in this research group. I seek to develop a community where each person has the support they need as they pursue their learning and research missions.

Physics Interests and Activities

- My historical expertise is in signatures using high p_T isolated leptons, jets and b-tags
  - Most recently:
    - A focus on ttH production in the H→bb channel (2012-2018)
    - Developing optimized search strategies for HH → bbbb (see arxiv:2009.06754)
  - Previously:
    - H → WW → lvqq on CMS (2012-2015)
    - ttbar production measurement at CMS (2009-2011)
    - W+b-jets production measurement at CDF (2006-2008)
    - Z → bb at CDF (2004-2005)
    - WH → lvbb search at CDF (2001-2003) – first Higgs search at the Tevatron to use a neural network

- Service to CMS physics program:
  - LHC Higgs Cross Sections Working Group, ttH/tH subgroup co-convener (2010-2017)
  - Top PAG's Cross Sections subgroup co-convener (2010-2013)
  - Member of the CMS Publications Committee (2012-present)

- Focus throughout my career:
  - The search for the Higgs
    - Driven by a curiosity to understand the mystery surrounding mass of the fundamental particles
  - Top-quark studies
    - Optimized signal extraction
    - More complete background evaluations
  - Machine learning techniques

- Recently started working on exotica searches using displaced vertices
  - LHC has blind spots in the lifetime domain
  - Long-lived particles (LLPs) are hallmarks of several BSM theories that seek to explain things like DM, the matter/antimatter asymmetry, feebleness of gravity, etc.
  - Can capitalize on existing ML expertise to build optimized analyses

As a postdoc in my group you will be encouraged to pursue physics analysis topics that interest you – even ones that go beyond this historical expertise.
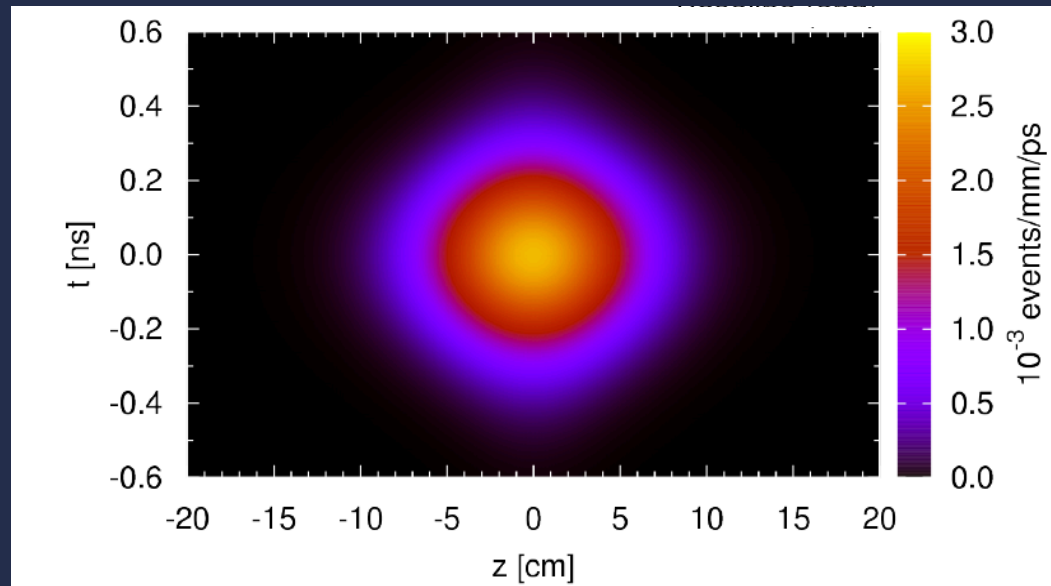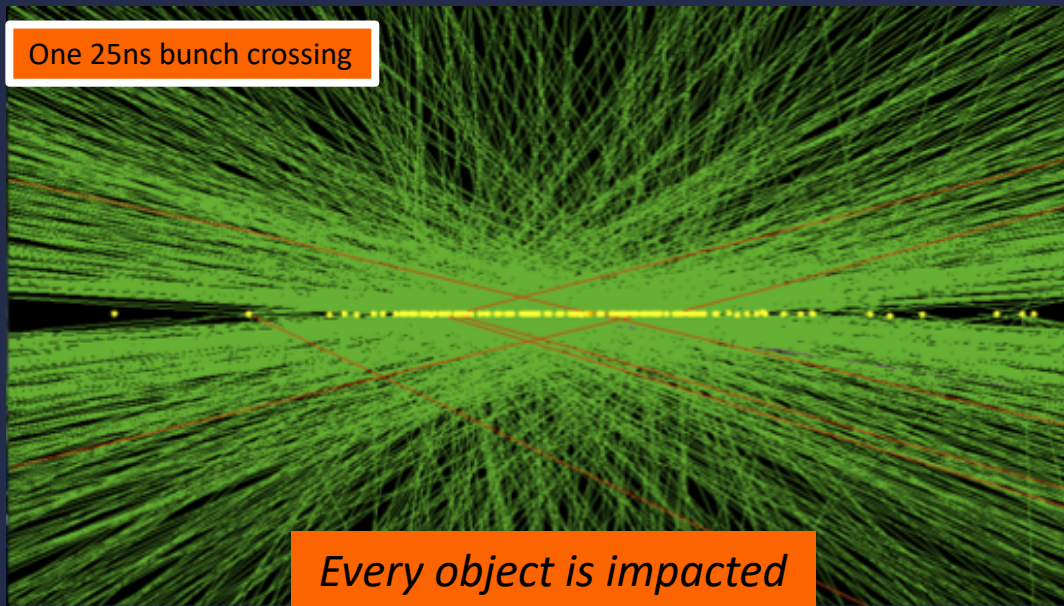
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Schedule

https://project-hl-lhc-industry.web.cern.ch/content/project-schedule

The Challenge of the HL-LHC era

One 25ns bunch crossing

Every object is impacted

- Dealing with the effects of pileup interactions will be a major challenge of the HL-LHC era
- Although PU interactions significantly overlap in space, they are **more separable in space + time.**
- Imagine separating the 25ns beam crossing into consecutive time slices
  - **Each exposure has far fewer vertices** than when integrating over an event's complete time profile.
- Per-particle timing provided by the **MIP Timing Detector (MTD)** allows 4D track and vertex reconstruction
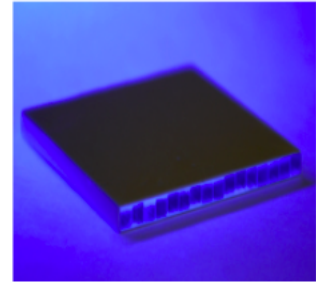 - PU reduced in each time slice
  - Every object is improved

Significant benefit to CMS HL-LHC physics program

MTD Conceptual Design
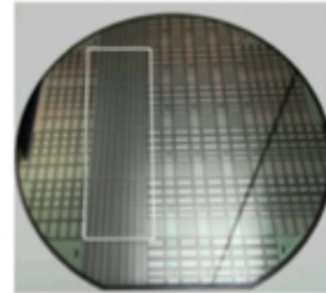
Barrel Timing Layer (BTL)

LYSO bars + SiPM readout
- TK/ECAL interface: $|\eta| < 1.45$
- Inner radius: 1148 mm
- Thickness: 40 mm
- Length: ±2.6 m along z
- Area: 38 m^2
- 332k channels

Endcap Timing Layer (ETL)

Si with internal gain (LGAD):
- On the CE nose: $1.6 < |\eta| < 3.0$
- Radius: 315 < R < 1200 mm
- Position: z = ±3.0 m (45mm thick)
- Surface ~14 m^2; 8.5M channels
- Fluence: up to 2E15 n_{eq}/cm^2 at 4000/fb

The MTD provides precision time measurement for MIPs with σ_t=30-40ps and has sufficient radiation tolerance to maintain σ_t<60ps up to 3000/fb.
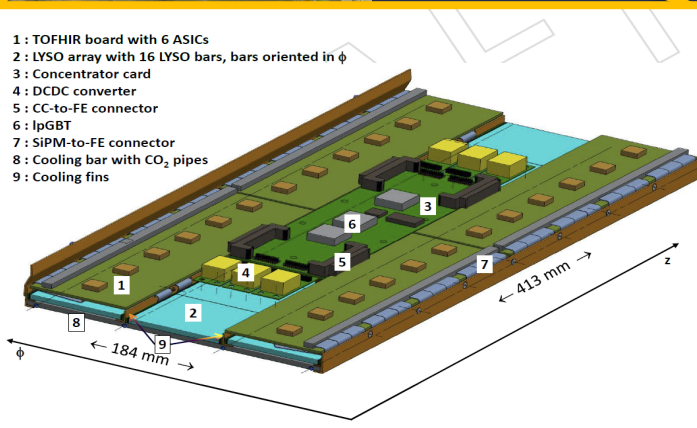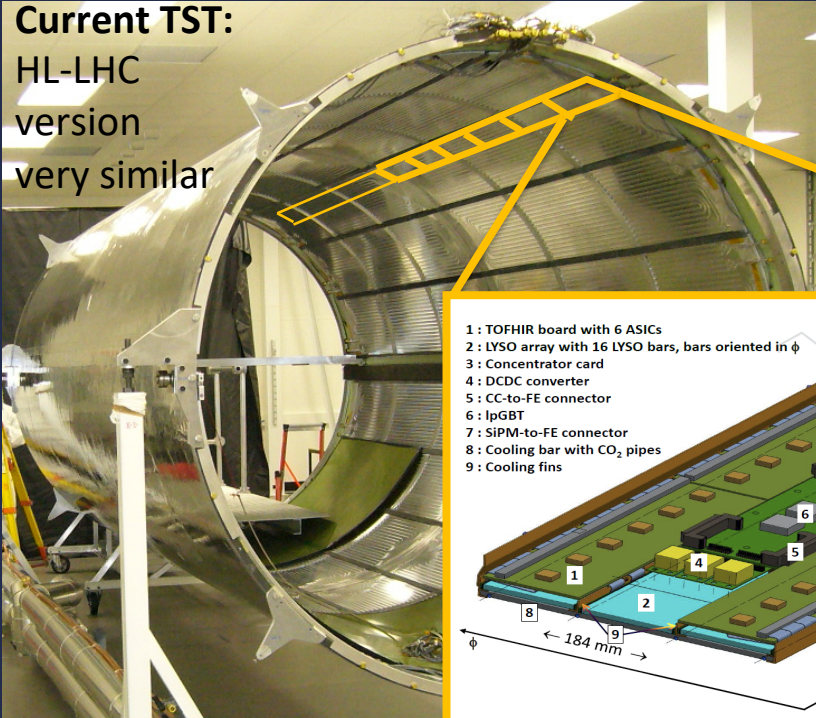
Visualization of MTD geometry implemented in GEANT and relationship to CMS.

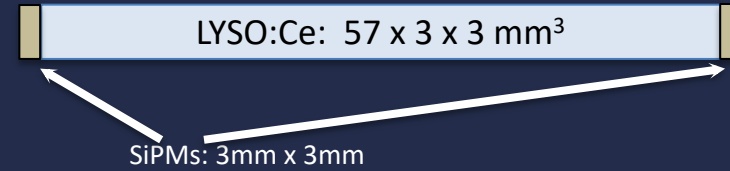Detailed description available in MTD TDR: CERN-LHCC-2019-003
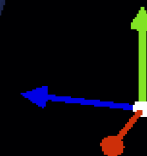
BTL Design Overview

- Overall BTL design :
  - **Cooling tray**: mechanical support & CO_2
    - 72 total trays: 36 in azimuth split in $\pm\eta$ regions
    - Each tray is 18cm x 2.5cm x 250cm
  - Sensor layer, segmented into **modules:**
    - 16 crystals = 32 SiPM channels per module
  - FE electronics, grouped in **Readout Unit**s:
   - 24 modules = 768 channels per RU
    - 6 RUs/tray

Current TST:
HL-LHC
version
very similar

1 : TOFHIR board with 6 ASICs
2 : LYSO array with 16 LYSO bars, bars oriented in ϕ
3 : Concentrator card
4 : DCDC converter
5 : CC-to-FE connector
6 : lpGBT
7 : SiPM-to-FE connector
8 : Cooling bar with CO_2 pipes
9 : Cooling fins

Active elements:

LYSO:Ce: 57 x 3 x 3 mm^3

SiPMs: 3mm x 3mm

- LYSO:Ce bar glued to SiPMs on each end
  - Fast and bright crystal
  - Radiation tolerant
  - Well-understood commodities

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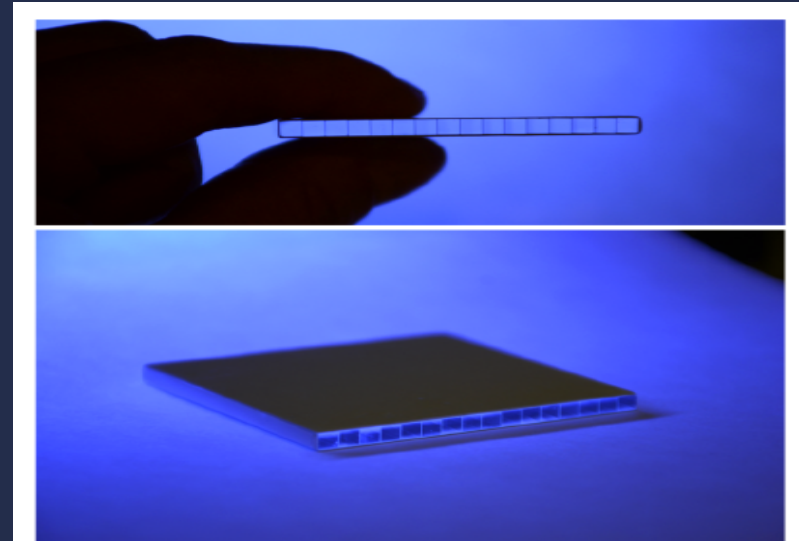
US-MTD Schedule: pre-COVID

- UVA will serve as one of three global BTL Assembly Centers
  - Assemble modules
  - Construct trays
  - Perform QC testing, warm and cold
  - Send qualified trays to CERN

- This UVA postdoc will get the chance to be a leader on MTD
  - Assembly: Main activities at UVA during 2021-early 2024
  - Commissioning: early 2024

- This is an **excellent opportunity** – position yourself to be the leader of the MTD into the operations era
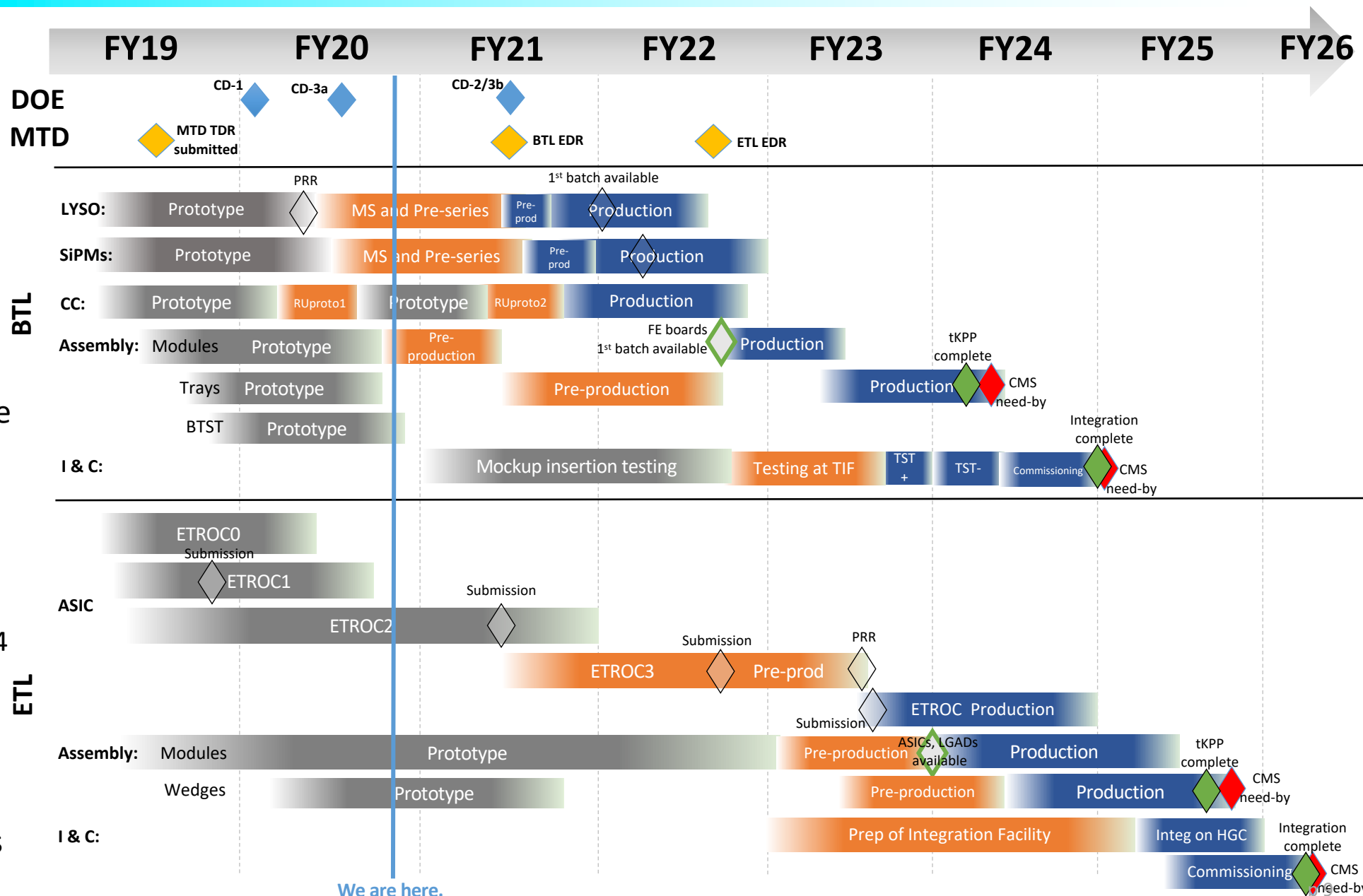
Summary

- This position offers one to join a supportive research group with the chance to pursue exciting physics opportunities, mentor talented diverse students and make leadership contributions to a new detector system at CMS.

- See https://uva.wd1.myworkdayjobs.com/en-US/UVAJobs/job/Charlottesville-VA/Research-Associate-in-Physics_R0017597
….for complete application details

- Review of applications will begin next week. If you plan to apply but you need more time, please reach out and we can work something out.

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