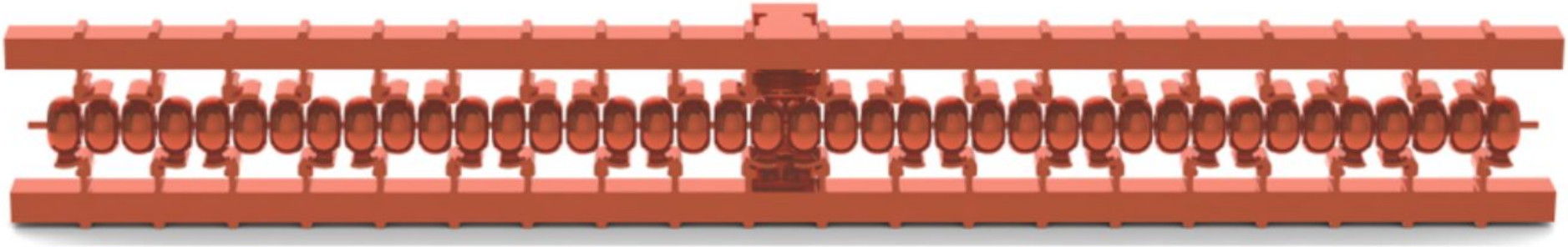
UW Future Colliders Beam Background Studies Summer in Review

Elias Mettner - August 24th, 2023

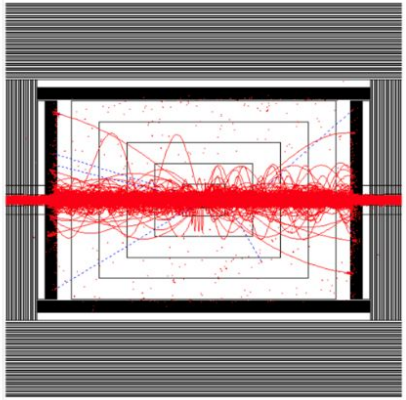
Overview - C3 (The Cool Copper Collider)

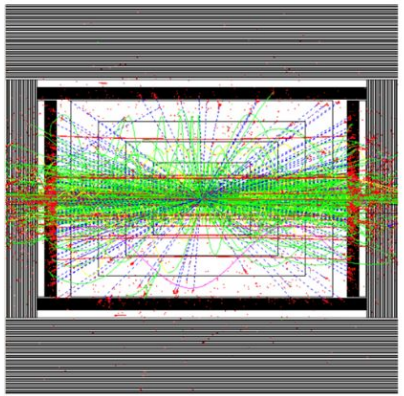
- C3 is a newly proposed electron-positron linear Higgs factory
  - 250 GeV collision energy, with upgrades to 550 GeV and possible extensions to the TeV scale
- Based on new (non-superconducting) rf technology
  - Copper at cryogenic temperatures allows for very high acceleration gradients
  - Thus C3 is able to achieve similar results to other proposed linear e+e- colliders, but much smaller
  - Only a 7-8 km footprint, size allows it to be placed at many different sites
- A compact, upgradable, and sustainable option for the post HL-LHC field



Overview - Beam Background Studies

- The benefits of a clean collision environment that an electron-positron collider offers can only be fully exploited with the use of highly granular & extremely precise detectors.
- Various backgrounds originate in the BDS and IR:
  - Beam-Induced Backgrounds - focus of this research
  - Machine-Induced Background - done in parallel
- Main Beam-Induced Backgrounds to study:
  - Secondary e+e- pair background
  - Gamma-gamma -> Hadron background from beam-beam interactions in the IR
- Understanding how the backgrounds impact the detector will be used in informing the design of the detector and BDS



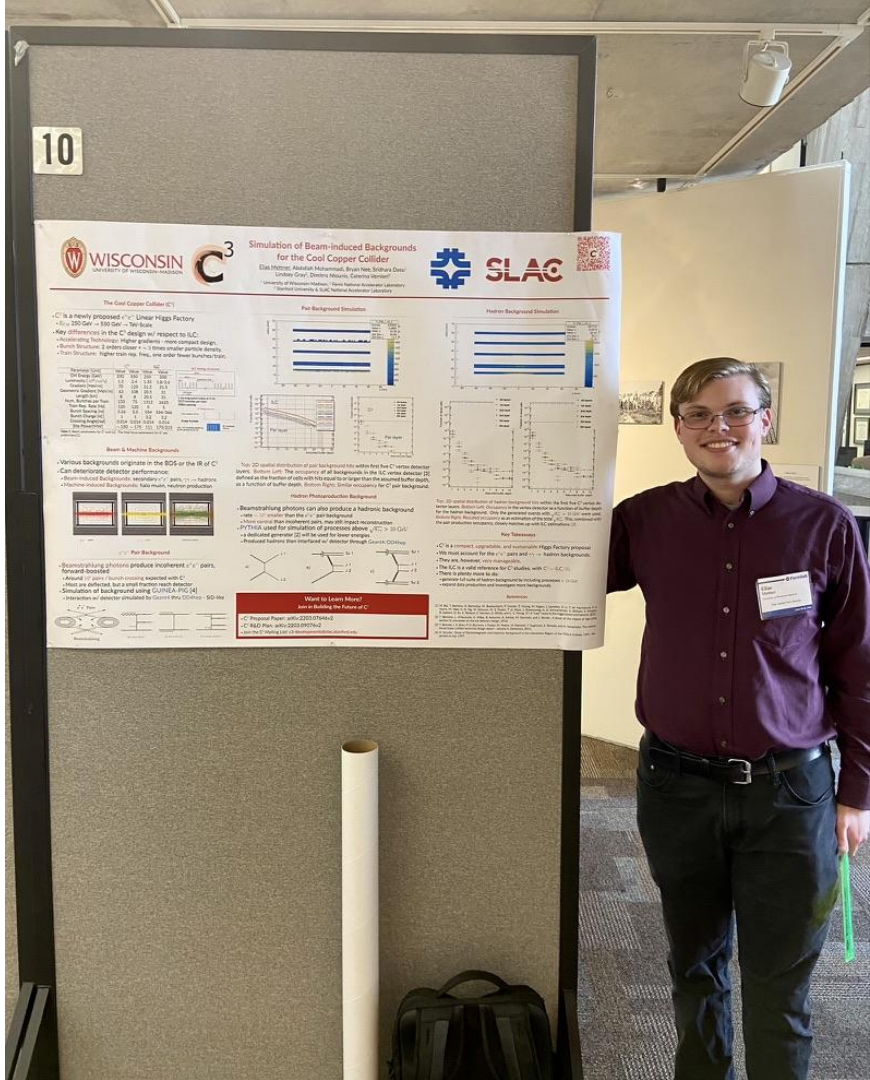


State of Project at the End of Spring

- By the end of spring, we had simulated a full bunch train of background for the secondary e+e- pairs, and as well the hadronic background (but only those > 10 GeV)
- We found that these backgrounds did have an impact on the detector, especially the first layer of the pixel tracker, they appeared to be completely manageable from a design and development perspective
    - There have been some discussion about moving the tracker layers closer to the beam, even
- The next step at the end of the spring was to simulate the hadronic background that was < 10 GeV - easier said than done

LCWS and FNAL Users Meeting

- Right at the start of summer in May, I was given chance to present our research at the International Workshop on Future Colliders (LCWS 2023)
- I then took that presentation and translated it into poster form for presentation at the 2023 FNAL Users Meeting
- This period of summer was sort of a waiting/transitional period for the project, so it was very useful to take this time to go over everything I had worked on over the past year



WHIZARD and CIRCE

- The next step in simulating the beam background was to simulate hadron photoproduction between .511-2 GeV.
- We had used Pythia for the >10 GeV range, but it is too inaccurate below that
- Instead, we need to use CIRCE (WHIZARD's lepton collider beam spectrum generator) to create our beam spectra, and feed that into WHIZARD
- A few issues with this: need the most up-to-date versions of both CIRCE and WHIZARD
- Around mid-July I received access to the version of CIRCE we needed

Working Through CIRCE

- The CIRCE program is used for inclusion of realistic energy spectra in physics calculations and event generators for Linear Colliders and is supported by the multi-purpose event generator WHIZARD
- CIRCE has documentation but it doesn't really go into nontechnical details about actually configuring and running it
- This means we have had to sort of feel our way through each step of the CIRCE simulation process
- I have my CIRCE Run Guide created here
- All things told it took about a month for us to reach output from CIRCE, and to understand what everything meant

Current Results and Plans

- CIRCE appears to successfully simulate and output data that we need to thread into WHIZARD
- Once we feed this into (a correctly figured version of) WHIZARD, we can take the WHIZARD output and repeat the previous simulation process steps by feeding that into GEANT
- However, current releases of WHIZARD do not correctly account for the hadron photoproduction sim we need (just like Pythia)
    - This is being worked on the next large release by T. Barklow, as mentioned previously
- We fortunately have been given instructions by him to implement all the configurations we need to an earlier version - so we can get started now
- We need simulate at least enough data for a full bunch train to see if this new background significantly impacts the detector occupancy

Conclusion and Next Steps

- This summer has been a transitional period for this project and our C3 group
  - After presenting our results at LCWS, more people are joining the group and we're expanding to new projects
- My side of the project is just starting to pick up steam again
- Our success with CIRCE and steps forward with WHIZARD make me confident we can have the full suite of backgrounds generated in due time
- Once we have successfully generated the background, there are many things to do:
  - Simulate on a larger scale
  - Go back and fix many questionable bugs/issues we've glazed over
  - Thread all of these different programs and steps together in an easier interface for future use/collab
  - Continue to push for more members and people to work on this project in the future