

Smith Purcell Effect Emission Determination (SPEED) Presentation

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Cynthia Givens¹

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USA

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HELMHOLTZ

Meet the Team

We are team SPEEDers, a group of 11th and 12th graders who are passionate about physics

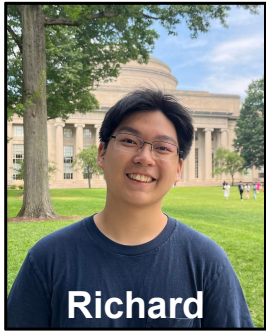
- 7 members and 2 teachers from Andover High School, Andover, MA, USA
- 1 member from Massachusetts Academy of Math and Science, Worcester, MA, USA
- We want to be active in physics research instead of being observers to it

Follow our journey on Instagram [@bl4s_speeders!](https://www.instagram.com/bl4s_speeders/)

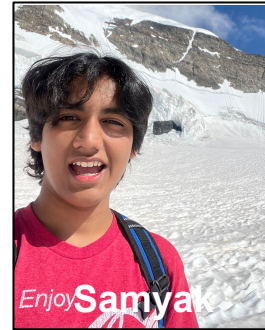
Thank you BL4S, DESY, and CERN!



Meet the Team (ctd.)



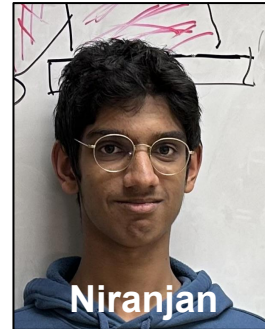
- 12th grader at AHS
- Likes playing piano and trombone, cats, crochet, and cooking
- Interested in space physics, geophysics, and particle physics



- 12th grader at AHS
- Plays cello and has been doing Taekwondo for 14+ years
- Tutors math and physics subjects in free time

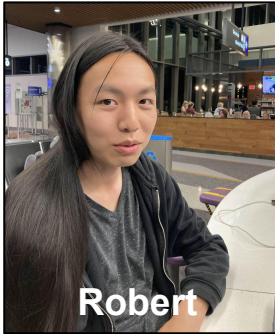


- 12th grader at AHS
- Likes learning languages, writing, and playing piano (favorite German word is Liebestraum!)
- Interested in CS, Linguistics, and astronomy



- 11th grader at MAMS
- Enjoys reading, philosophy, and jazz piano
- Favorite subjects are physics and CS

Meet the Team (ctd.)



Robert

- 11th grader at AHS
- Plays clarinet, piano
- Likes a bunch of things - math, physics, history, economics, linguistics...



Theo

- 11th grader at AHS
- Plays the electric and double bass
- Section leader of pit percussion in the AHS marching band
- Favorite subjects are math and physics



Daniel

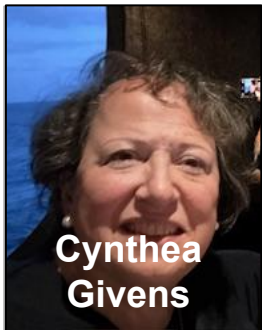
- 11th grader at AHS
- Plays trumpet, learning tuba, currently singing in a hardcore band
- Likes philosophy, reading, computer science, anthropology



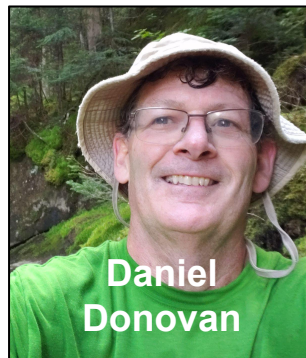
Hari

- 11th grader at AHS
- Plays the guitar and piano
- CEO of Loclo
- Love walking my dog and making stuff

Meet the Team (ctd.)



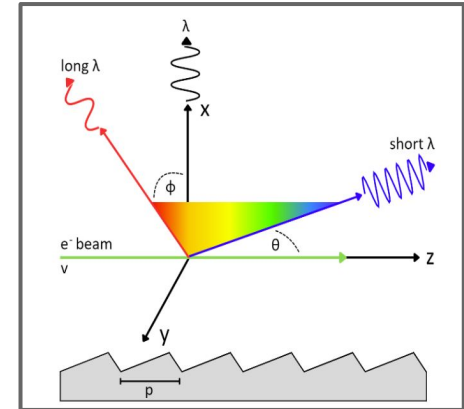
- AHS Physics Teacher
- Plays flute & piano
- Has 12 (+) grandchildren
- Loves to read and knit!



- AHS Physics Teacher
- Former US Navy Nuclear Engineer
- Enjoys hiking, has hiked in Austrian Alps, Colorado Rockies, New Hampshire White Mountains ...

Introduction & Background

- **Smith-Purcell radiation (SPR)** is the radiation emitted by a charged particle traveling closely parallel to a blazed, metallic grating
- Discovered by Edward Purcell and Steve Smith in 1953 (Purcell & Smith, 1953)
- Has been used as a form of **beam diagnostic** (Blackmore et al., 2009)
- Inspired by previous BL4S winners who studied Cherenkov (2020) and Transition radiation (2021)
- Builds upon previous research of SPR at DESY (Kube, 2004)
 - Problems with gratings, longer wavelengths



Why SPR?

- SPR holds potential for beam diagnostics and has been previously studied in GeV energies (Blackmore et al., 2009, Kube et al., 2003, Sergeeva et al., 2017)
 - Coherent vs. incoherent SPR: Bunch length $>$ wavelength of radiation at DESY, expected to produce incoherent SPR
- Advantages of SPR:
 - Non-invasive technique to measure longitudinal beam profile
 - Can create radiation from soft x-rays to far IR spectrum
- Difficulties of SPR:
 - Less investigated than other forms of diffraction radiation
 - Low expected photon count at ultra relativistic velocities

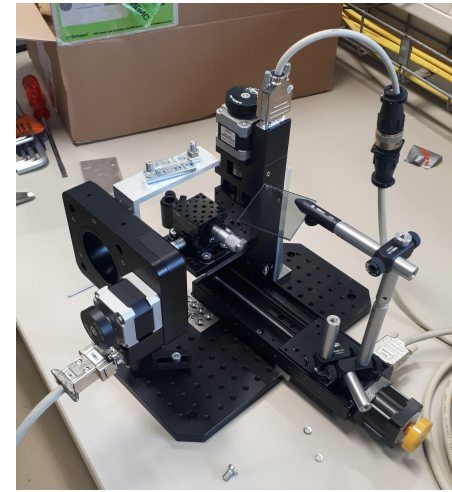
Experimental Overview

Experimental goals:

- Characterize SPR using DESY II electron beam for non-invasive beam diagnostics
- Evaluate intensity of radiation using different blazed grating periods

Project specifications:

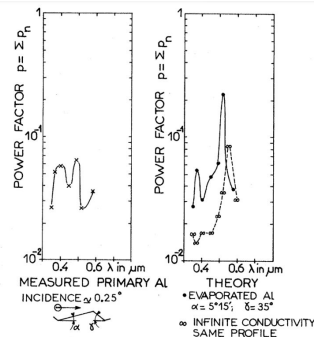
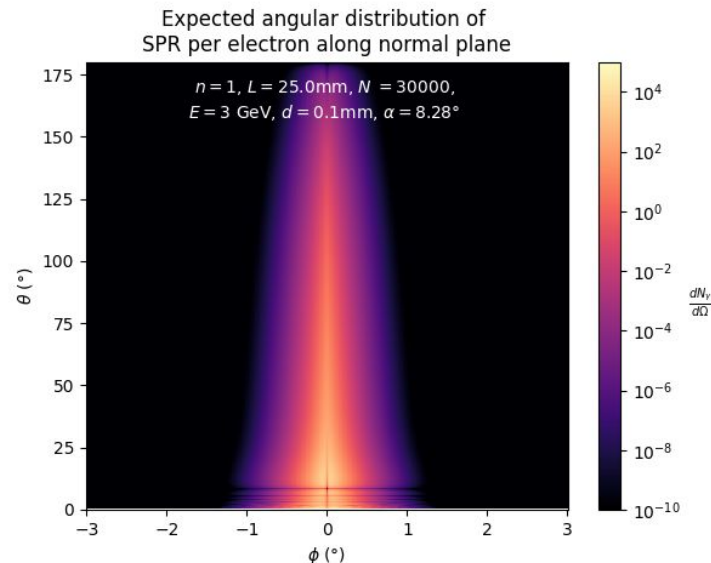
- Four 25x25x6mm **blazed gratings** with periods of 278-833nm positioned ~ 0.1 mm from center of beam
- Primary/secondary **collimators** to narrow beam width
- Six **beam telescopes** to measure beam positioning/path
- Five **silicon photomultipliers** (SiPMs) to measure SPR intensity at multiple angles, angles measured via **goniometer**
- **Color filters** to measure wavelengths of emitted radiation



Grating ID#	n (grooves/mm)	p (nm)
1	1200	833
2	1800	556
3	2400	417
4	3600	278

Expected Challenges

- Not currently simulated in GEANT4
 - Conflicting theories (surface current vs Van Den Berg) for photon production rate relative to grating
- Experimental Setup
 - Detection efficiency of SiPMs and PMTs
 - Precision of relative height of beam
- Low expected photon production
 - Wide beam (~5mm vs. ~0.1mm)
 - Low particle rate (~40 kHz)
 - Effects from relativistic e^- velocities
- Effect of conductivity unknown
 - Many papers assume infinite conductivity; not realistic



J.P. Bachheimer,
 Phys. Rev. B 6 (1972)
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