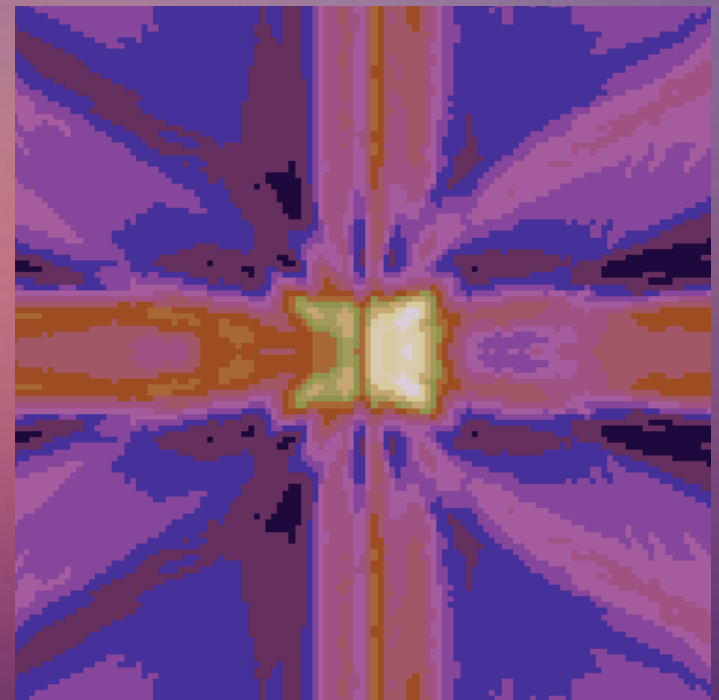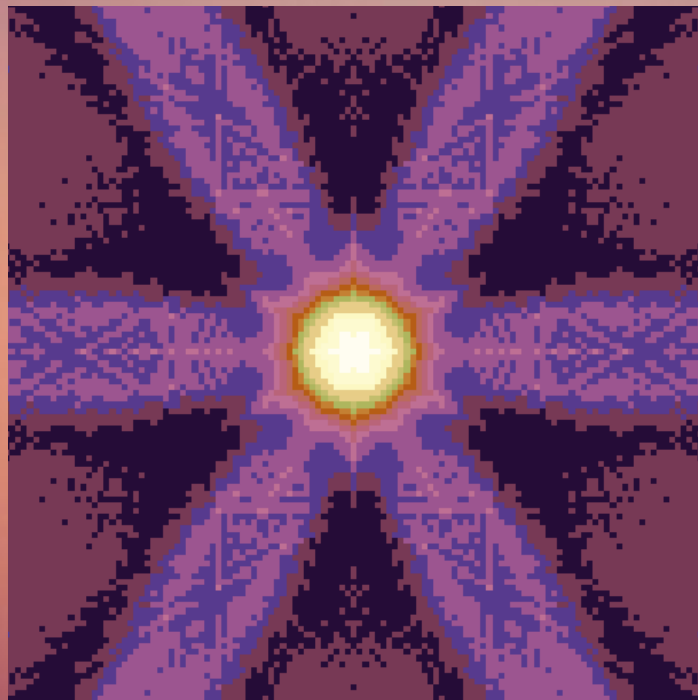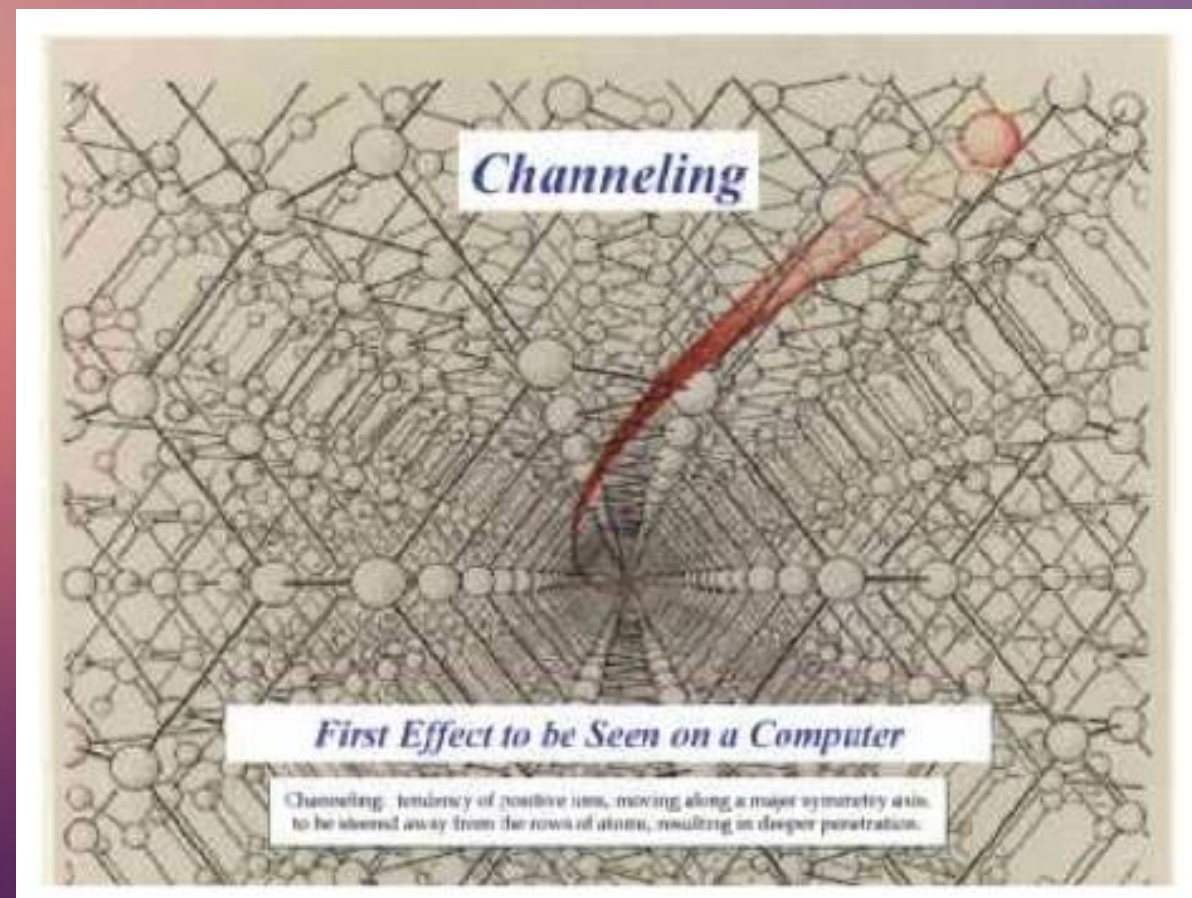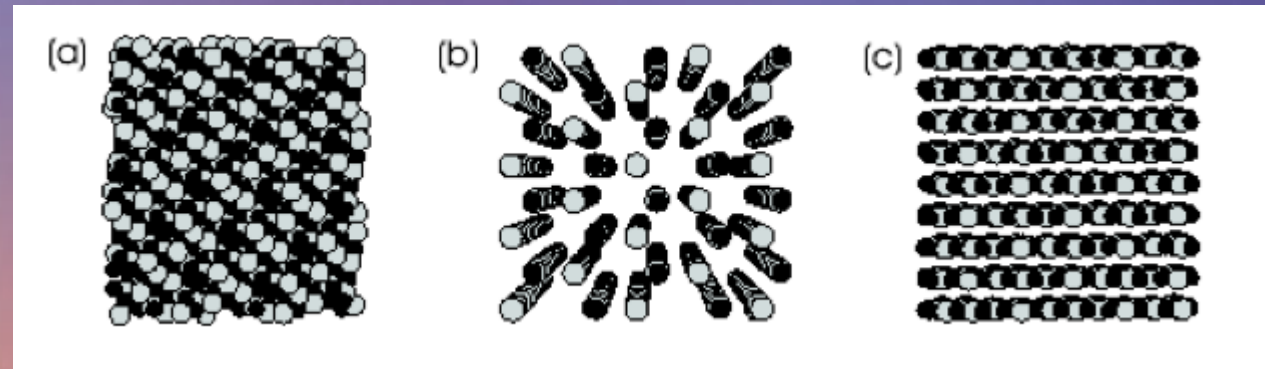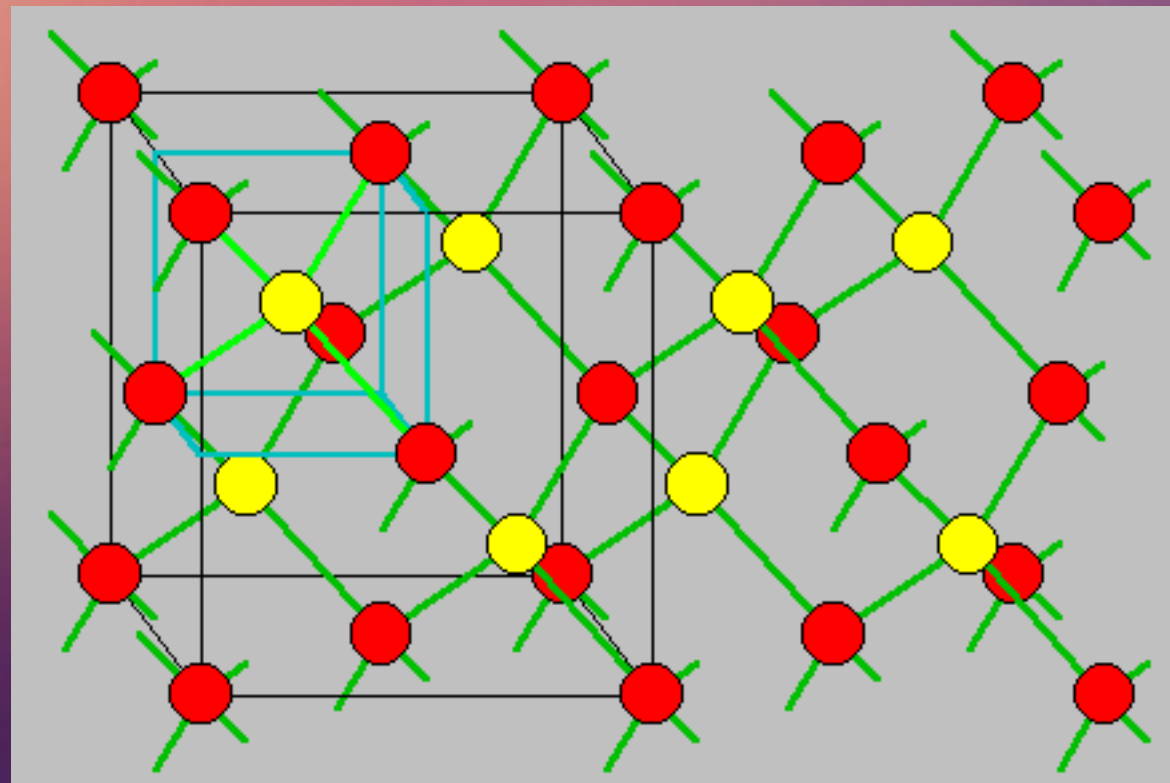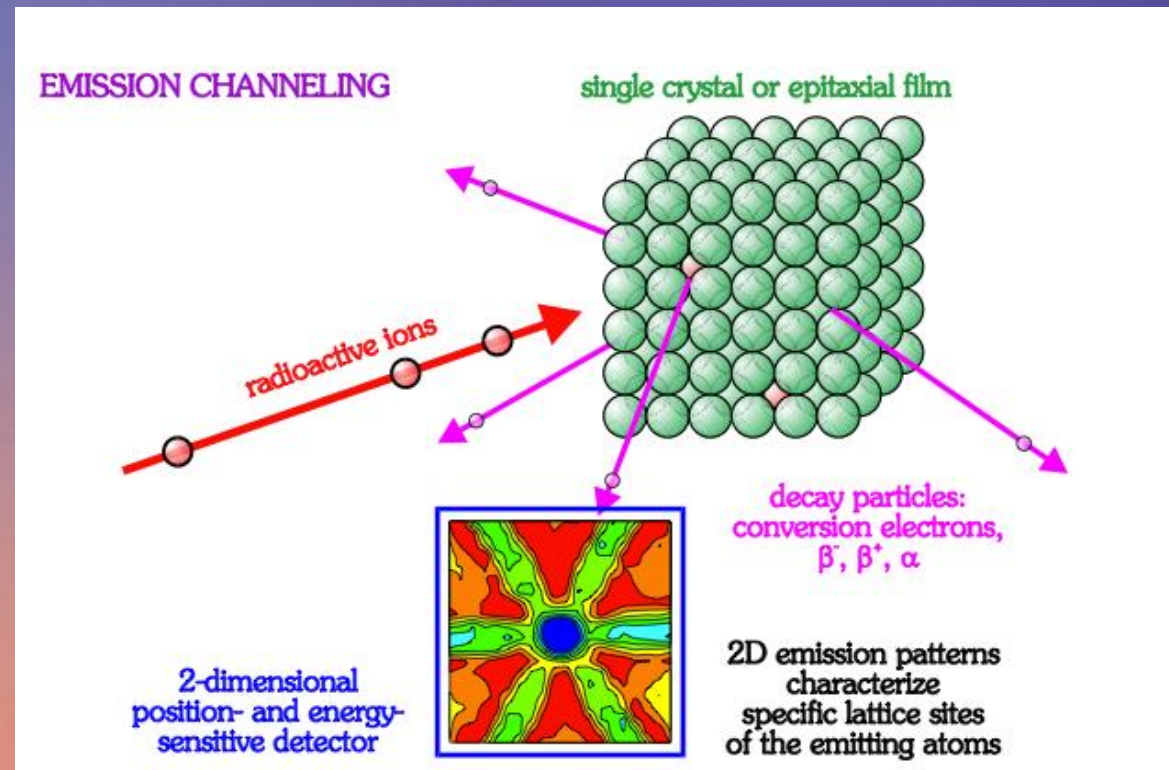# Emission Channeling

ISOLDE

Nick Charron

What is Channeling?

- "The extended propagation of the particles we know and love (electrons, positrons - even some molecules and atoms) through a crystal lattice along certain preferred directions".
- Initially discovered by Johannes Stark in1912, the classical theory of channeling was somewhat abandoned for the newly popular quantum wave mechanics which came with the discovery of Bragg diffraction.
- 1962 - "The Year of Channeling"

Channeling

First Effect to be Seen on a Computer

Channeling: tendency of positive ions, moving along a major symmetry axis, to be steered away from the rows of atoms, resulting in deeper penetration.
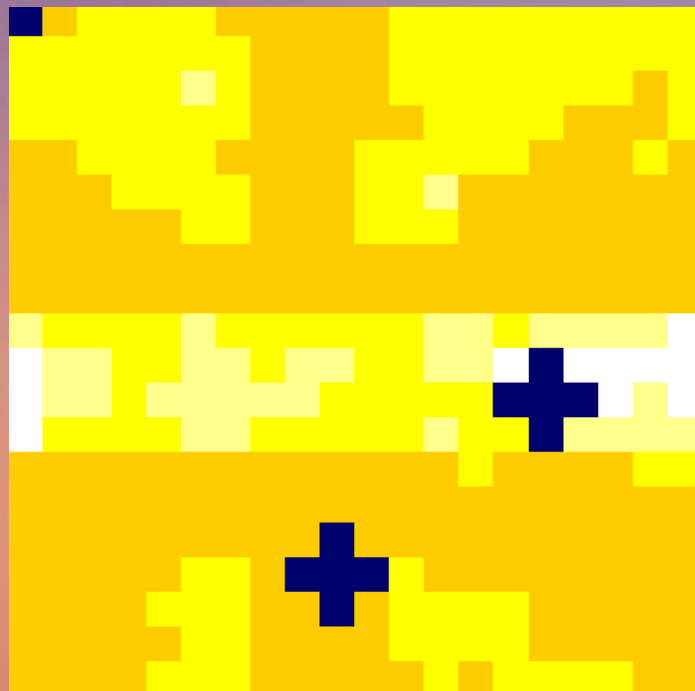
Studying SiC - Emission Channeling

- Emission Channeling - We *implant* into the SiC sample radioactive 59Fe (half-life of 44.5 days, beta minus decay). *The location of the impurity is initially not known!*
- The iron decays and a detector chip registers electrons that escape the lattice. The sample is rotated through many orientations for these measurements.
- The sample is *annealed* several times, up to 900 C for repeated measurements.
- (The picture to the right shows the structure of SiC. Note the FCC pattern and the tetrahedral formation of the silicon).


EMISSION CHANNELING

single crystal or epitaxial film

radioactive ions

decay particles: conversion electrons, β^-, β^+, α

2-dimensional position- and energy-sensitive detector

2D emission patterns characterize specific lattice sites of the emitting atoms

What Happens Next?

Raw data from the chip is normalized and calibrated…

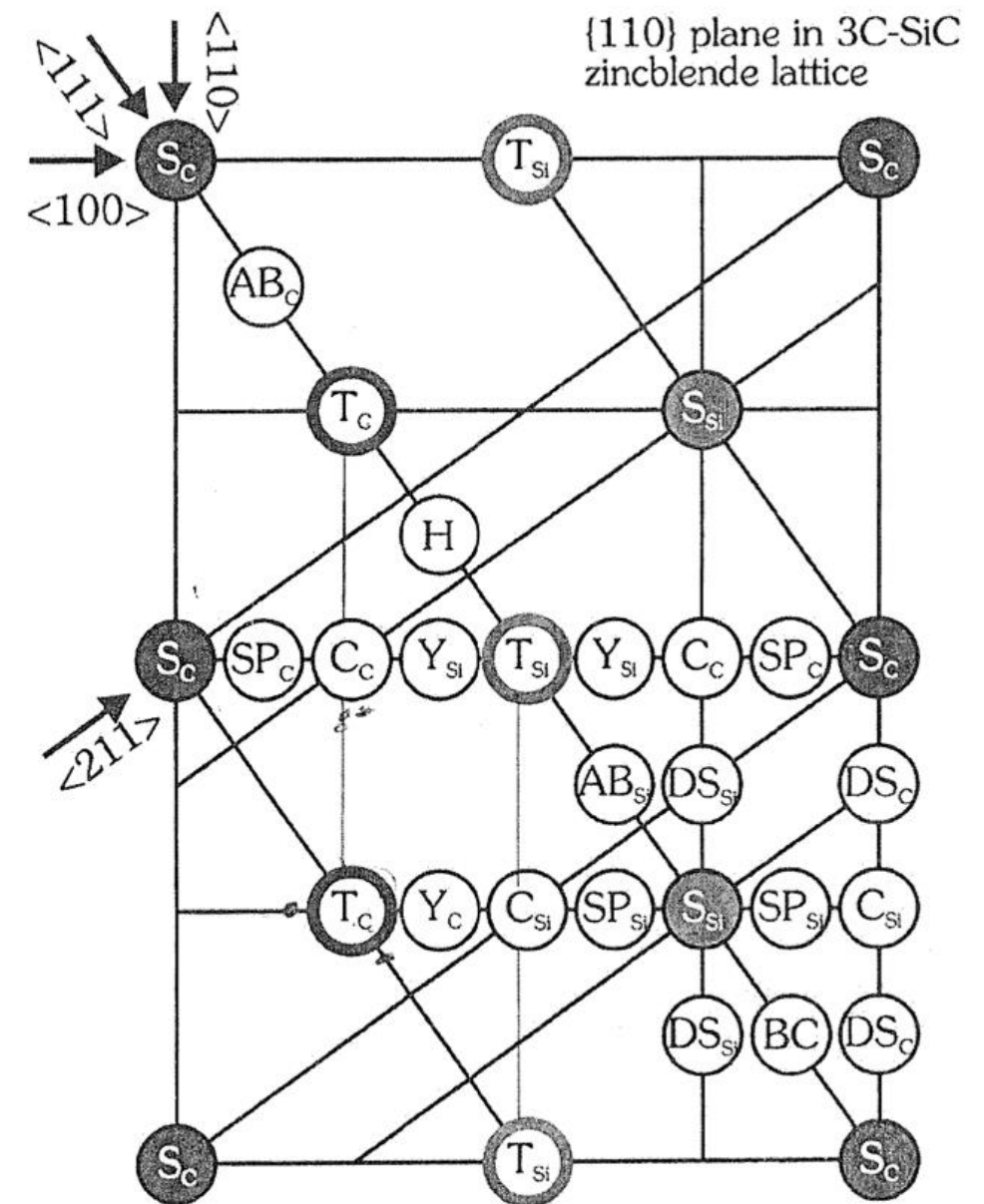…Then we compare it to emission patterns based on theory…
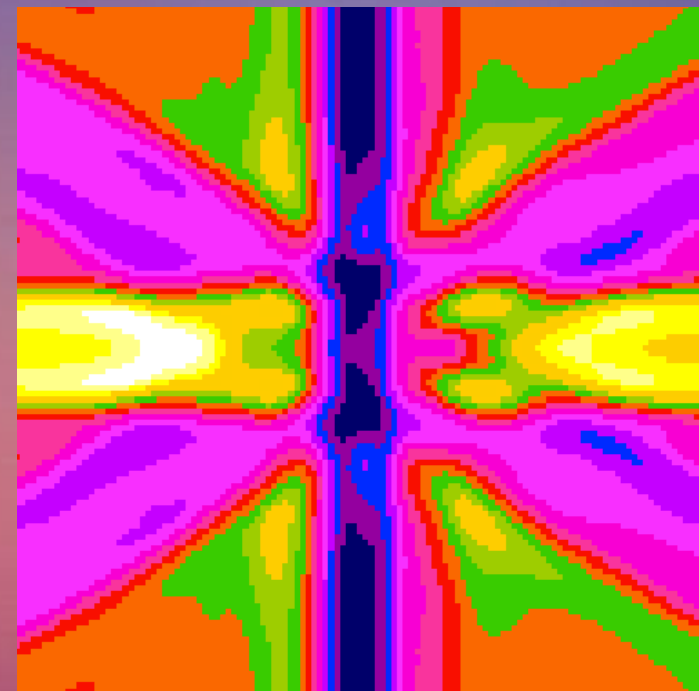
…Then we run a fitting loop to generate a library of data for manual analysis in Excel.

Possible Impurity Sites

Lattice sites in 3C-SiC

{110} plane in 3C-SiC zincblende lattice

| S_{Si}, S_C | substitutional (lattice sites) |
T_{Si}, T_C	tetrahedral interstitial
BC	bond center
AB_{Si}, AB_C	anti-bonding
H	hexagonal
SP_{Si}, SP_C	split-<100>
C_{Si}, C_C	"C"-site (C_{2v} symmetry)
Y_{Si}, Y_C	"Y" or "Yb"-sites
DS_{Si}, DS_C	<110>-displaced from S

Applications:

- Impurity site location
- Investigating properties of the lattice, and the effects of impurities (such as doping)

- At higher energies, enhanced production of gamma rays, and the use of channeling as a means of removing desired/undesired particles from a particle accelerator.
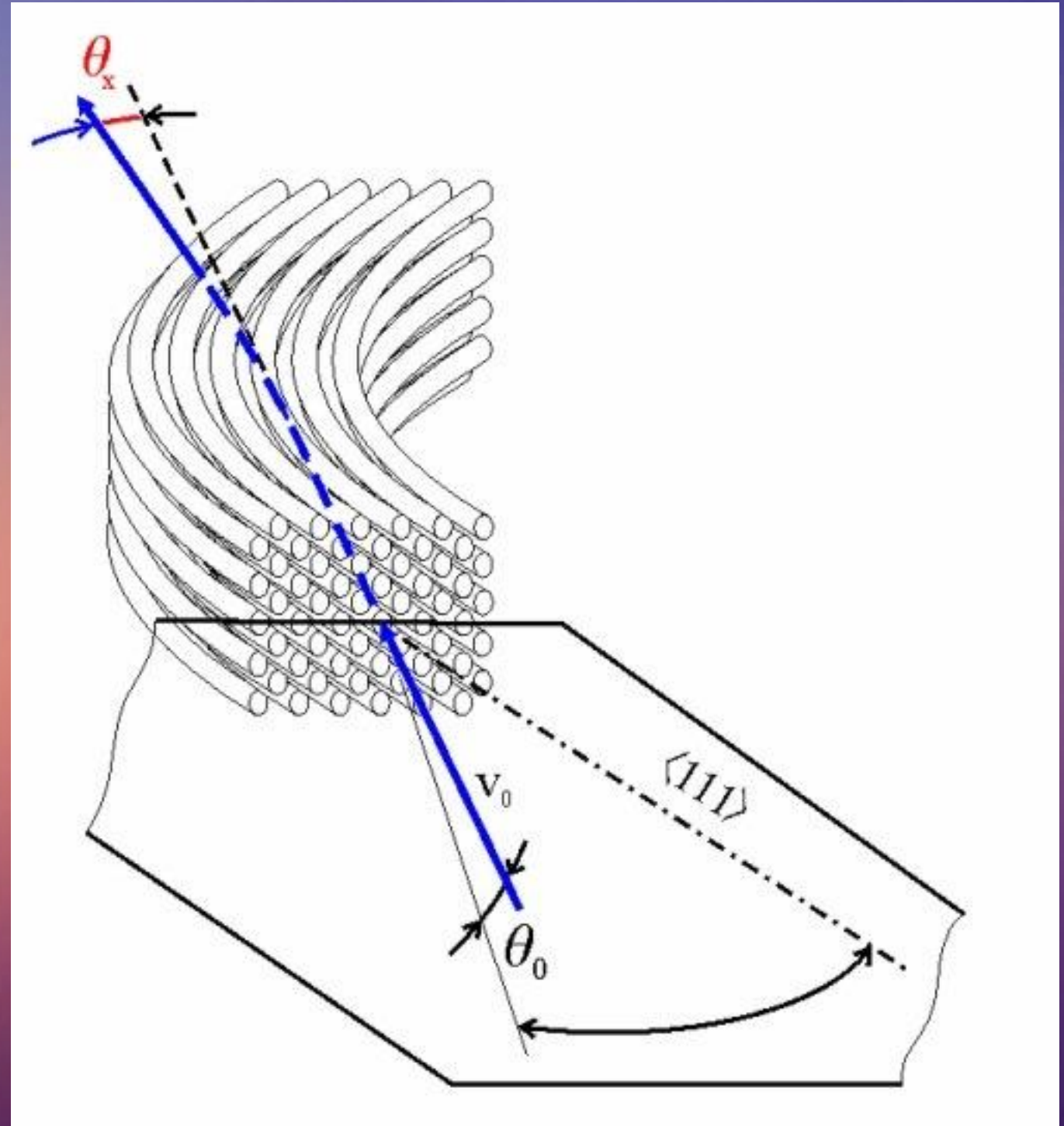
What I do:

- Normally, I run fitting loops using a program with a java interface, and then analyze the data in excel to determine the most likely positions of our impurities and observe any site changes that occur with the annealing.
- The fitting loop can feed incorrect error measurements to excel (such as negative error) in its attempt to make sense of the raw data. This happens when inverse patterns try to "shake hands" so to speak - In the end human eyes are better than robot eyes, and it is up to us to manually find the actual error.
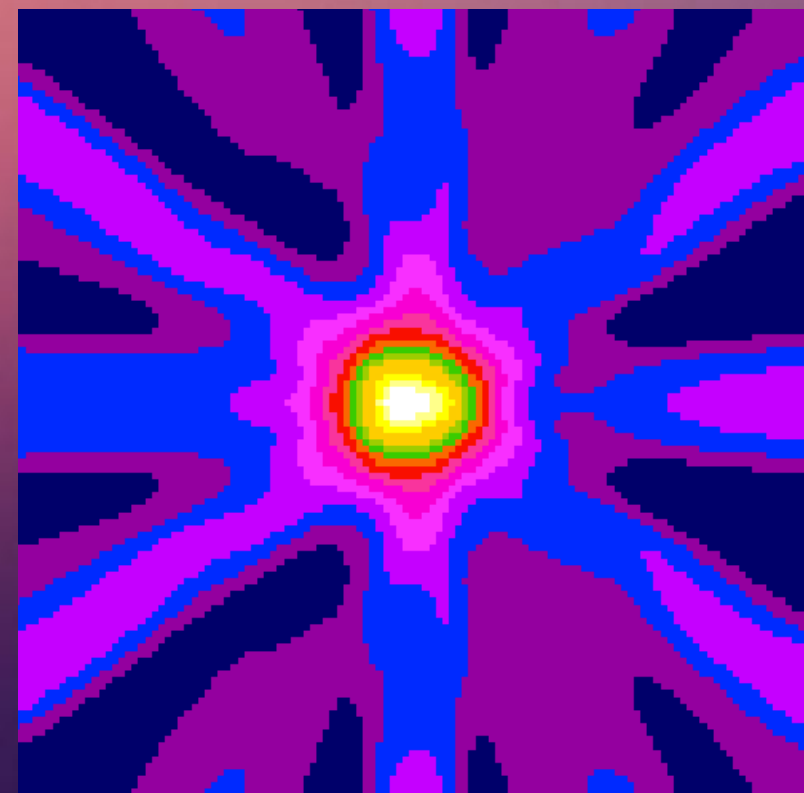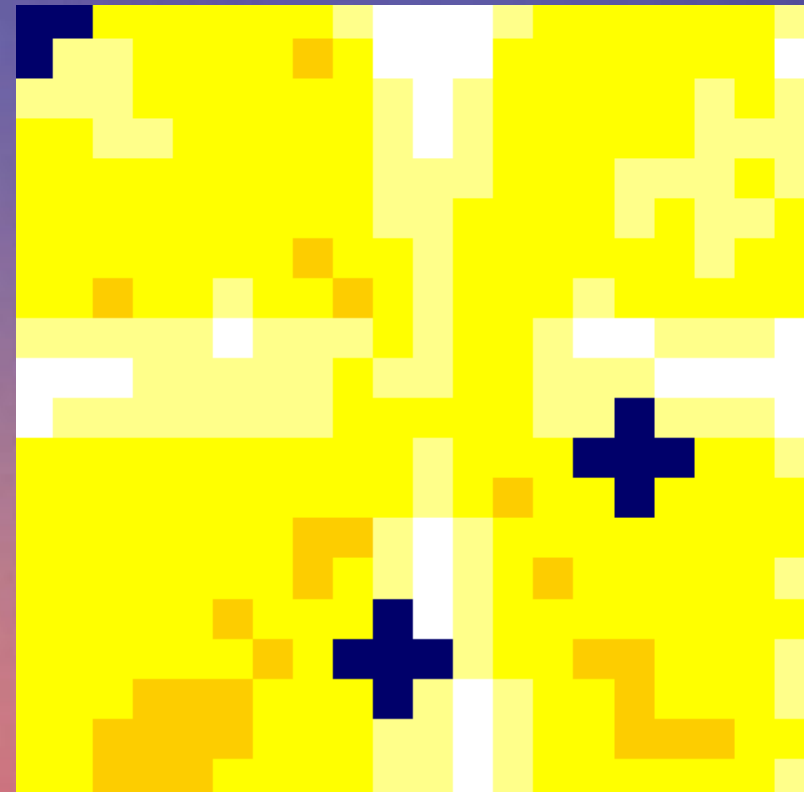
Other Things That I Do:

- When not at my desk, I help with preparations for upcoming experiments in the new ISOLDE laboratory. For instance, I recently helped design an external cooling system for a prototype detector chip to be used in upcoming measurements.
- Other than that, I help catalogue and move materials from the old lab site to the new lab site.
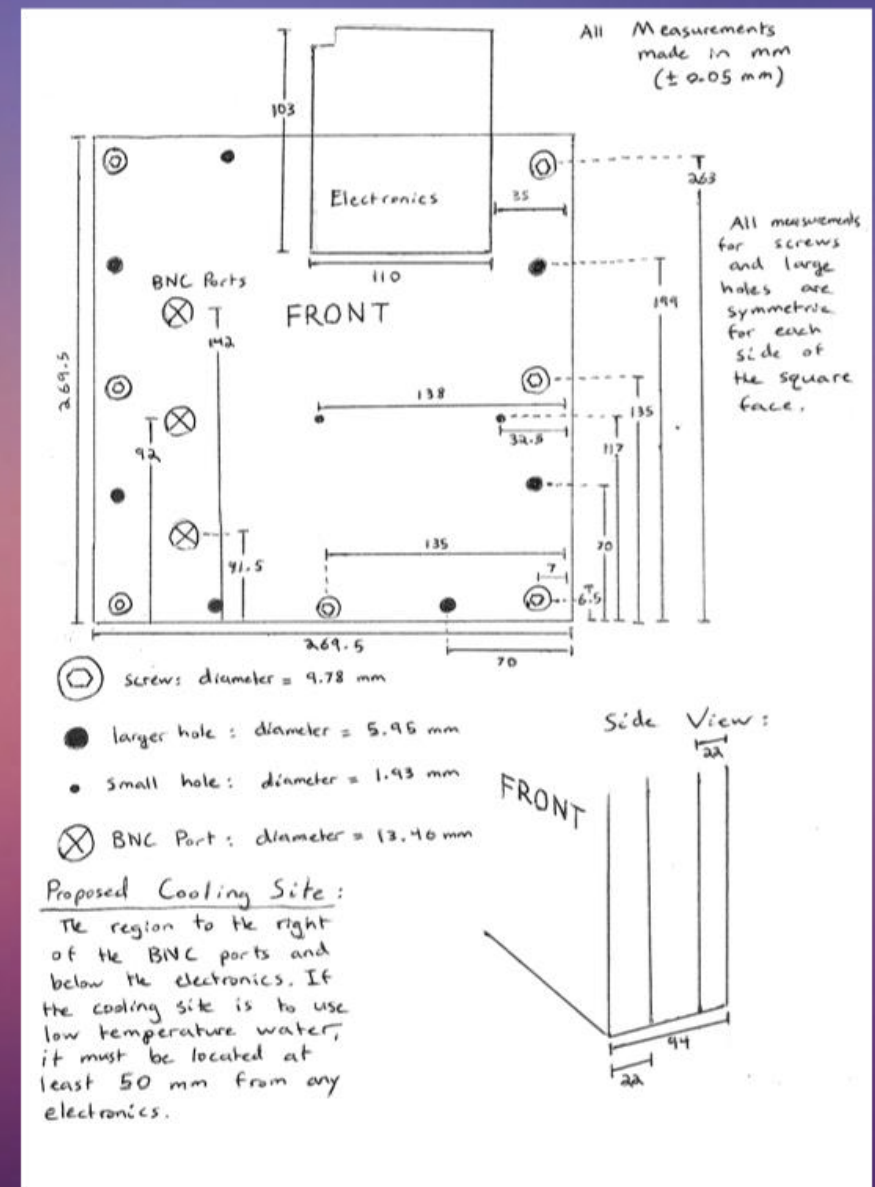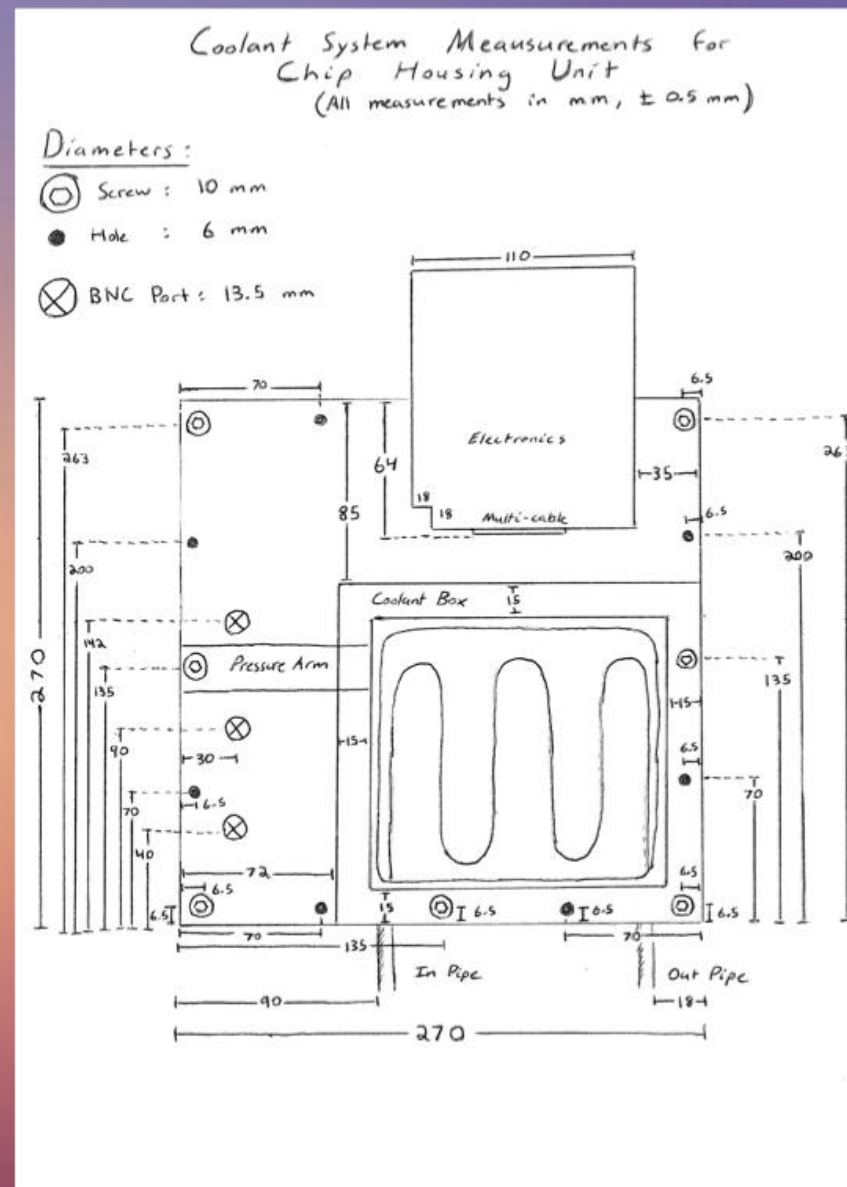
Goals:

- Right now, we are trying to precisely locate the impurities in our SiC samples from the raw data. This is a long and important process, so it is first on the list.
- Secondly, we are trying to get all equipment prepared for the on-line beam in July/August for the next measurements.
- Personally, I want to continue with my interest in solid state physics and learn more skills for experimental research.

Thank You!

(And also questions).