# University of Hawaii at Manoa Instrumentation Development Lab (IDLAB)

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EEX6SE

# Introduction

- Challenges
- Overview of the STURM2 project
- Amplifier board assembly and testing
- Motherboard Design
- Motherboard schematic
- Fermionics sensor bonding
- Motherboard layout
- Motherboard function
- Conclusion

# Challenges

- Understand the function of the STURM2 device as whole

- Learn the PADS schematic and layout

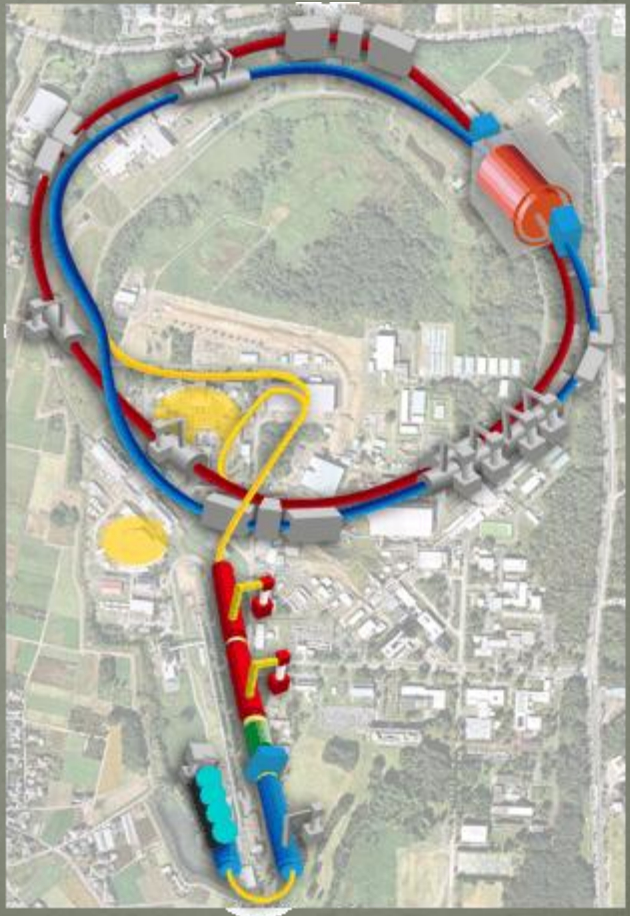
- Learn component selection

- Manage BOM

# Overview of the STURM2 project

- The device is developed as part of the KEKB particle accelerator upgrade to
  Super-KEKB

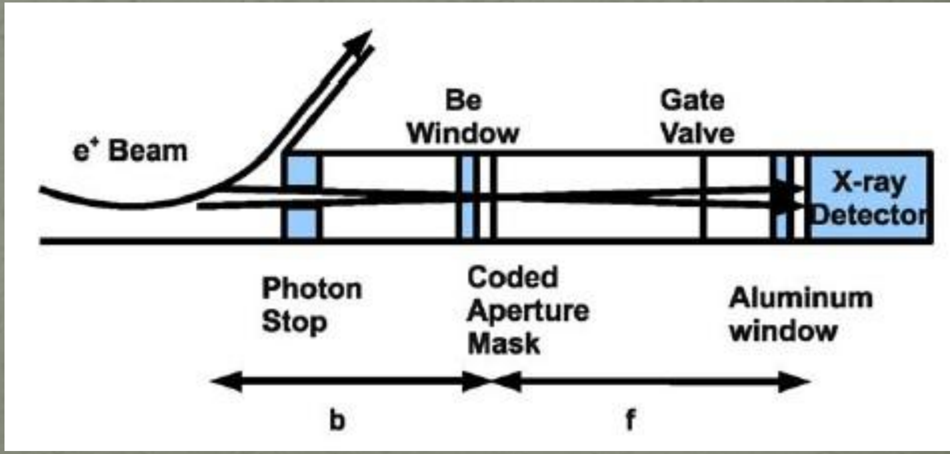
- The device is used to monitor
  electron beam bunches profile



http://accl.kek.jp/eng/acclmap_e.html

# Overview of the STURM2 project

- The Super-KEKB has electron bunch sizes less than one nanometer, which requires a new device to measure the beam profile
- More accurate measurements can be done by using X – ray detector
- When electron beam is bended, it emits an X – ray beam




http://www.phys.hawaii.edu/~idlab/taskAndSchedule/STURM/STURM.html

# Overview of the STURM2 project

- By measuring the profile of this X – ray beam, it is possible to calculate the beam size

- The X – ray beam is focused to fermionics sensor on the motherboard

- The KEKB ring is 3 kilometers long, and the electron beam travels nearly the speed of light

→ Very high speed measurement needed

# Overview of the STURM2 project

- The X –rays hitting the sensor releases electron-hole pairs
- 3.6 KeV releases 1000 electron-hole pairs
- With a sensor low-high response time of 0.25 nanoseconds, 3.6 KeV produces 0.7 microamp current
- The analog transfer line is fitted to 50Ω, so the output voltage from the sensor is 35 microvolts

# Overview of the STURM2 project

- At least 10 mV  output is needed in order to get the signal in to reasonable signal to noise ratio

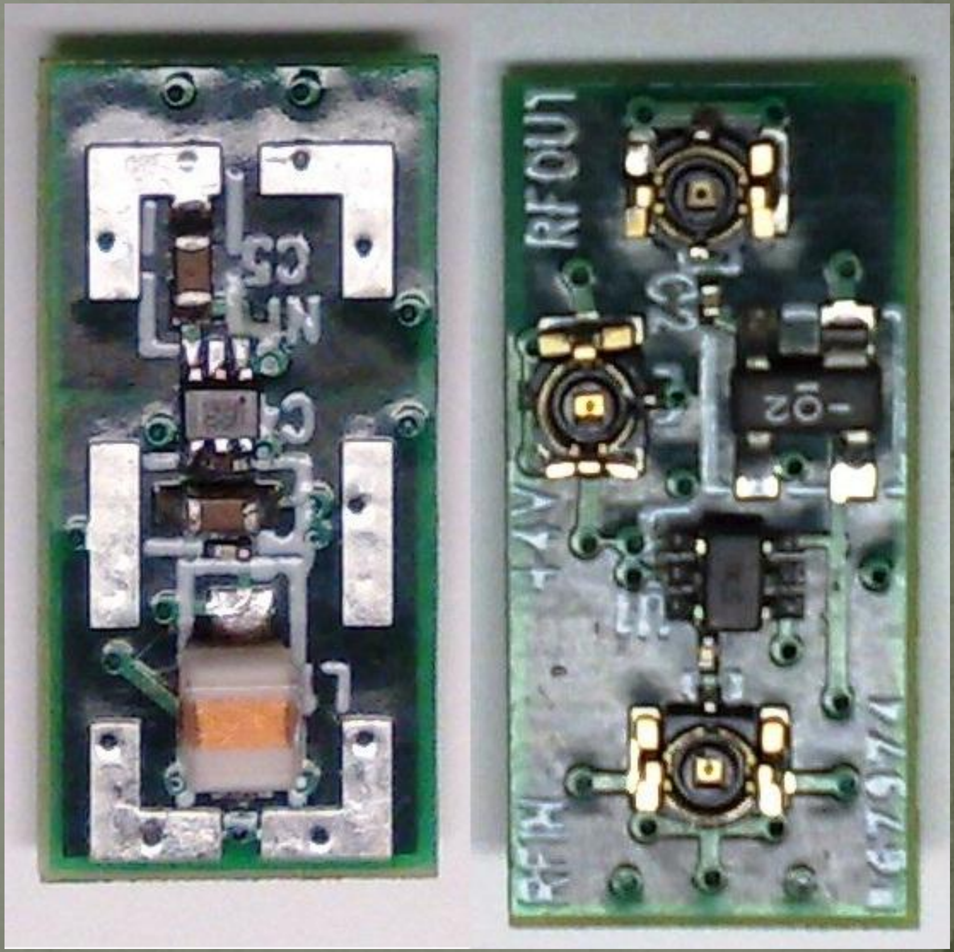
- With 35 μV input signal, the total gain needed is 60 dB

- This requires three stages of amplifiers, each with 20 dB amplification

# Amplifier board assembly

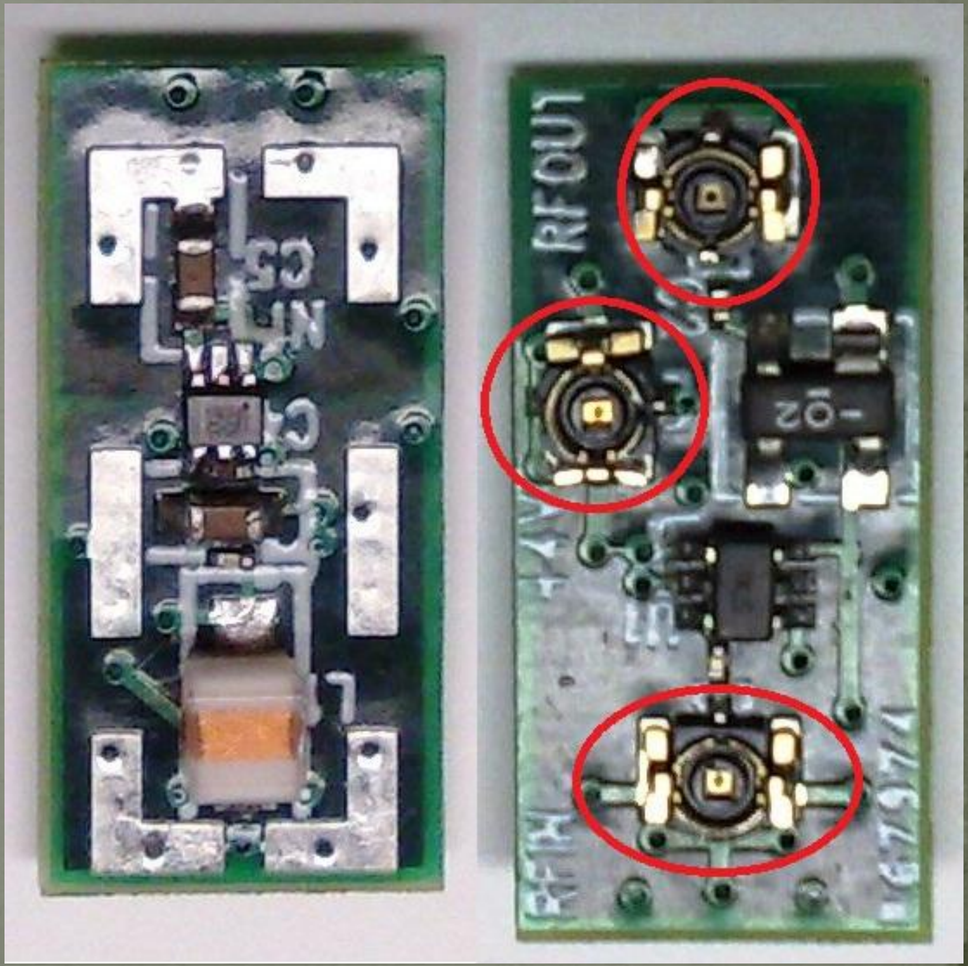
- The first amplifier boards were assembled in the lab by hand

- The assembly was relatively easy, except



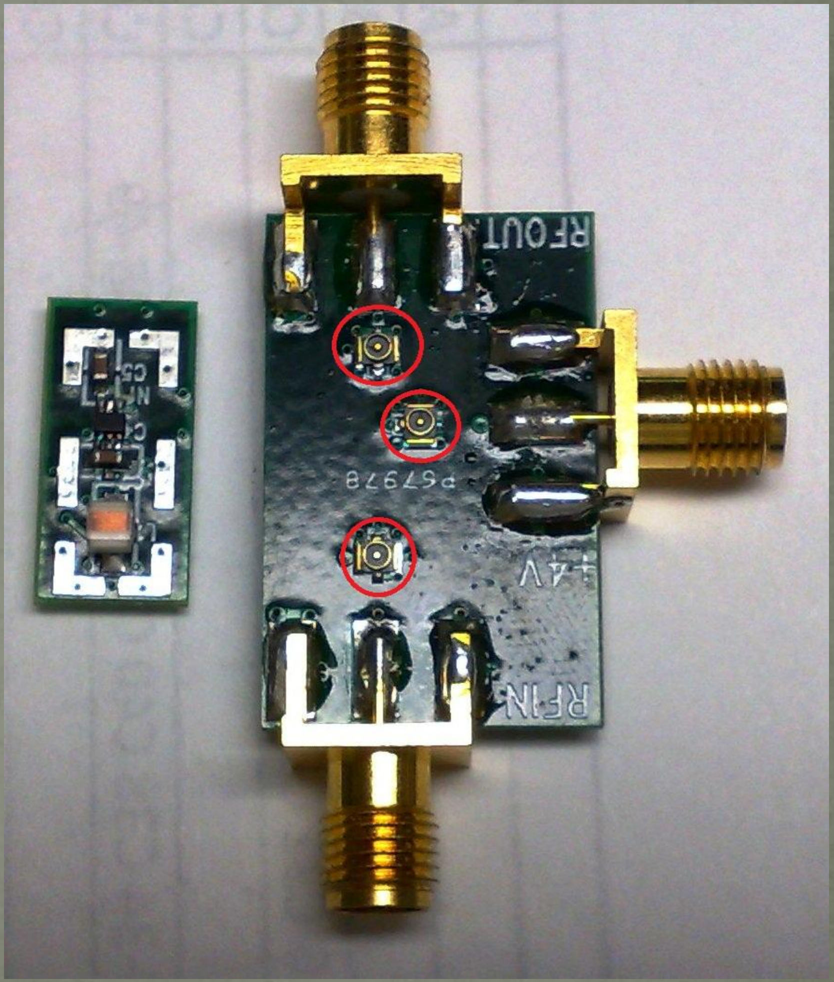
# Amplifier board assembly

- The problem was to align the small RF connectors in the bottom of the board



# Amplifier board testing

- To test the amplifier board, a carrier board was also manufactured
- Same problem with the RF connectors
- The amplifier board revision C reached the desired amplification



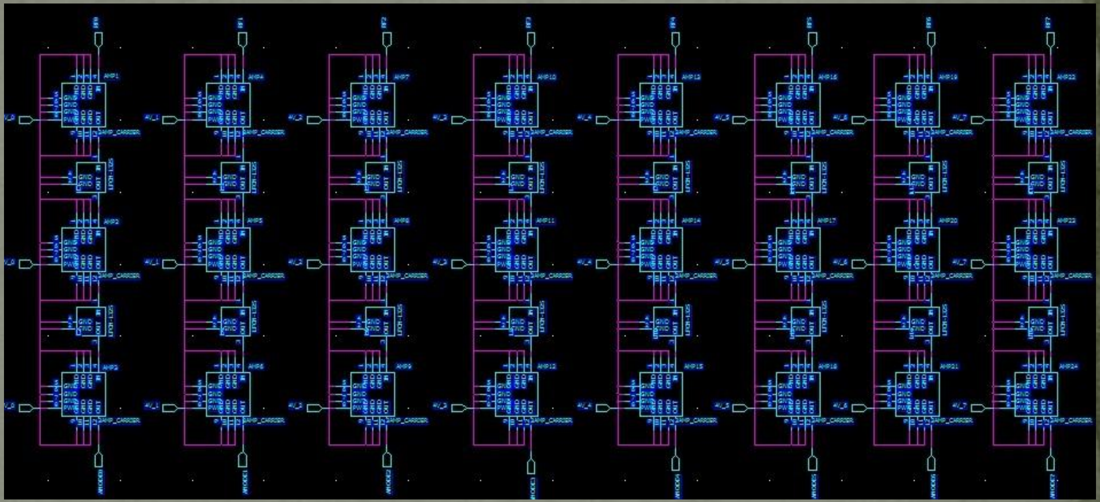
# Motherboard desing

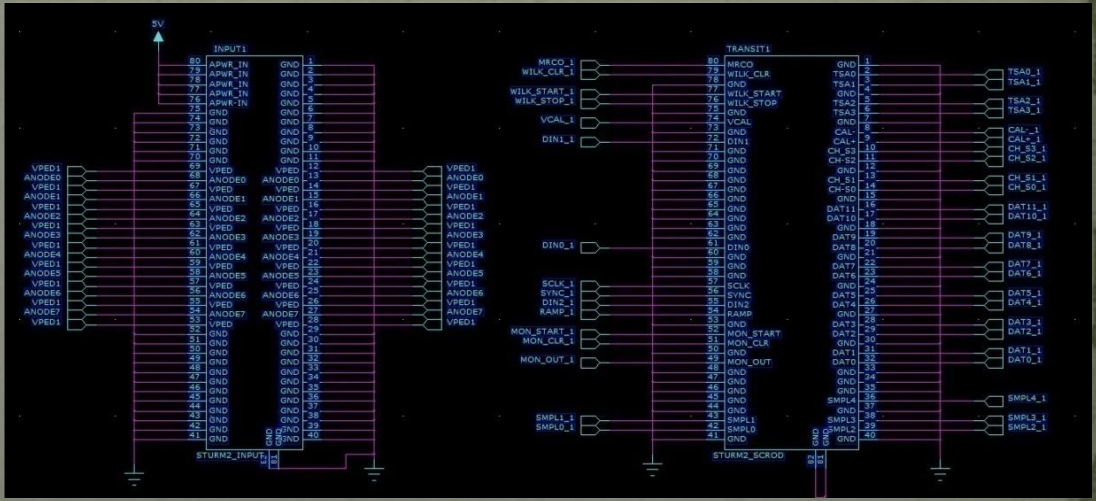
- The motherboard houses
  - 192 amplifier cards
  - 8 ASIC cards
  - Fermionics sensor
  - SCROD
- Fermionics sensor bonding
- Stability
- cooling

# Motherboard schematic

- Several new components had to be made
- The biggest job was naming and connecting all the nets

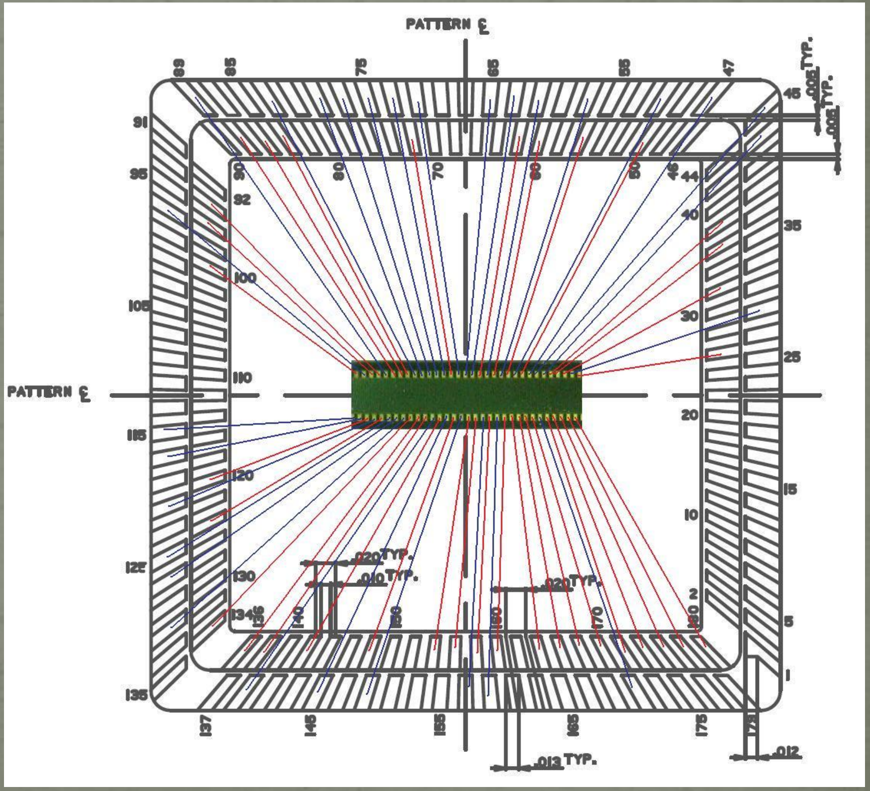
Time consuming





# Fermionics sensor bonding

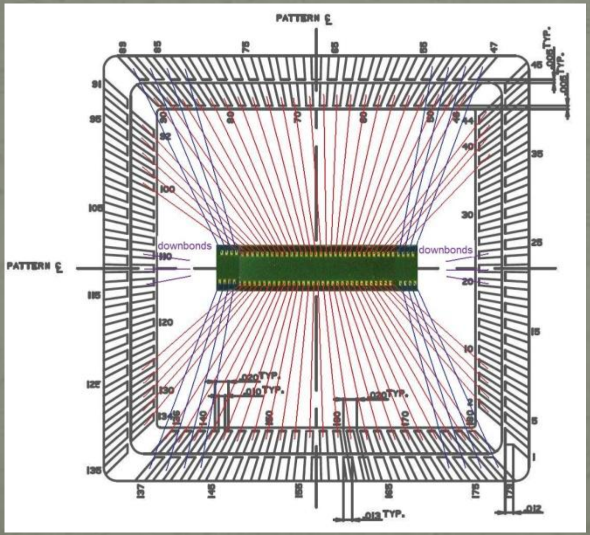
- One of the issues was to figure out the best bonding diagram for the sensor
- The first attempt was to make the bonding so that connecting pins in the bottom would be in numerical order
- Didn't work at all

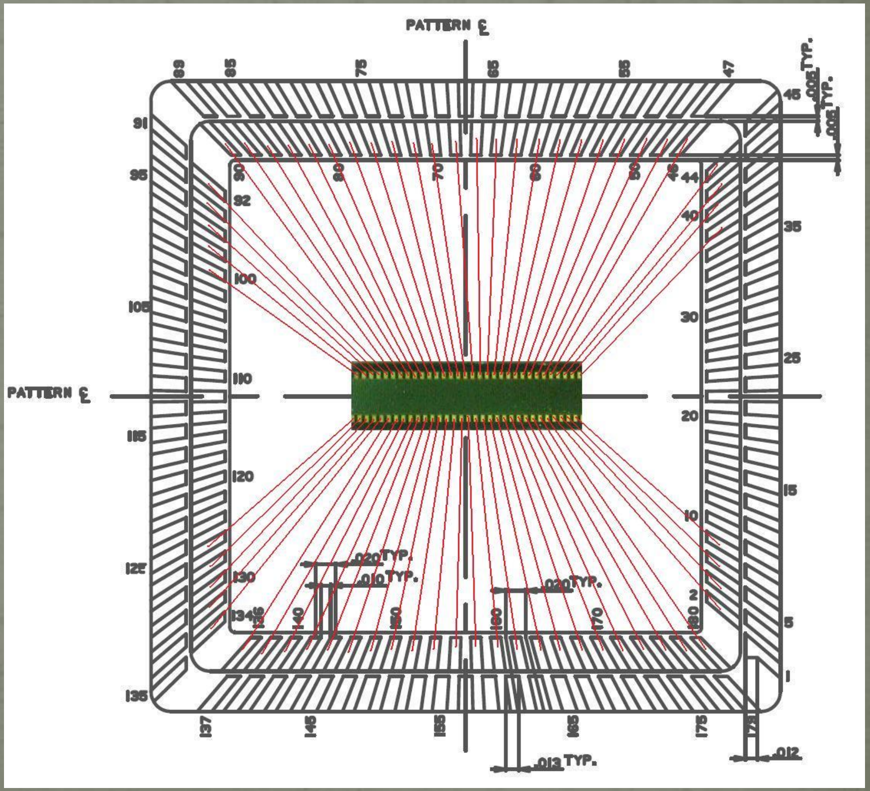


# Fermionics sensor bonding

- Several other diagrams were tried, three in total

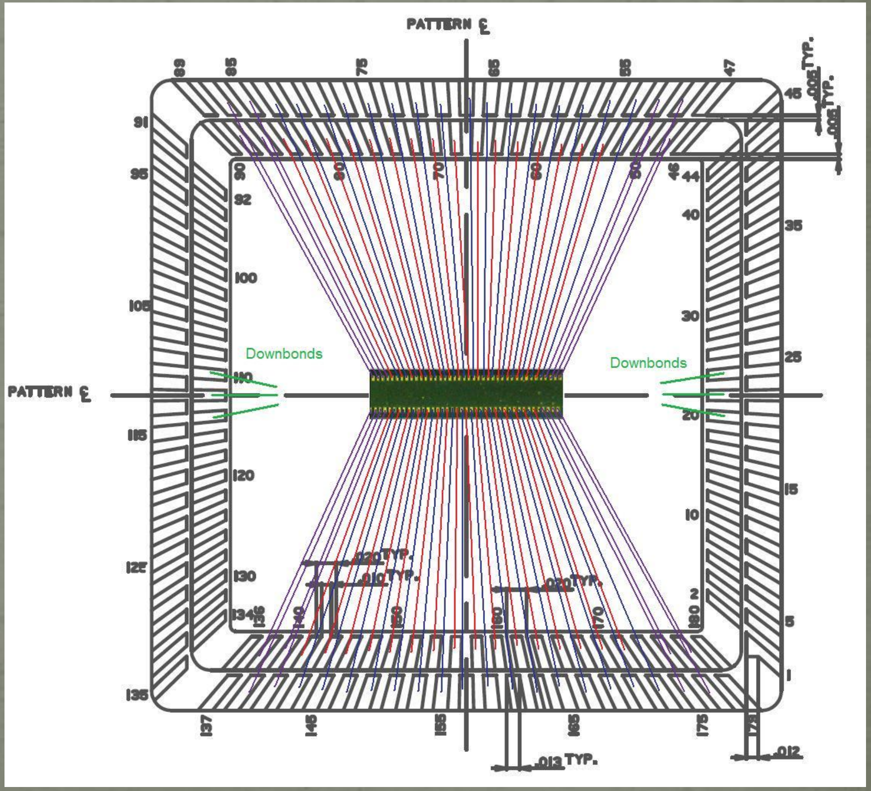
- None of those were good either





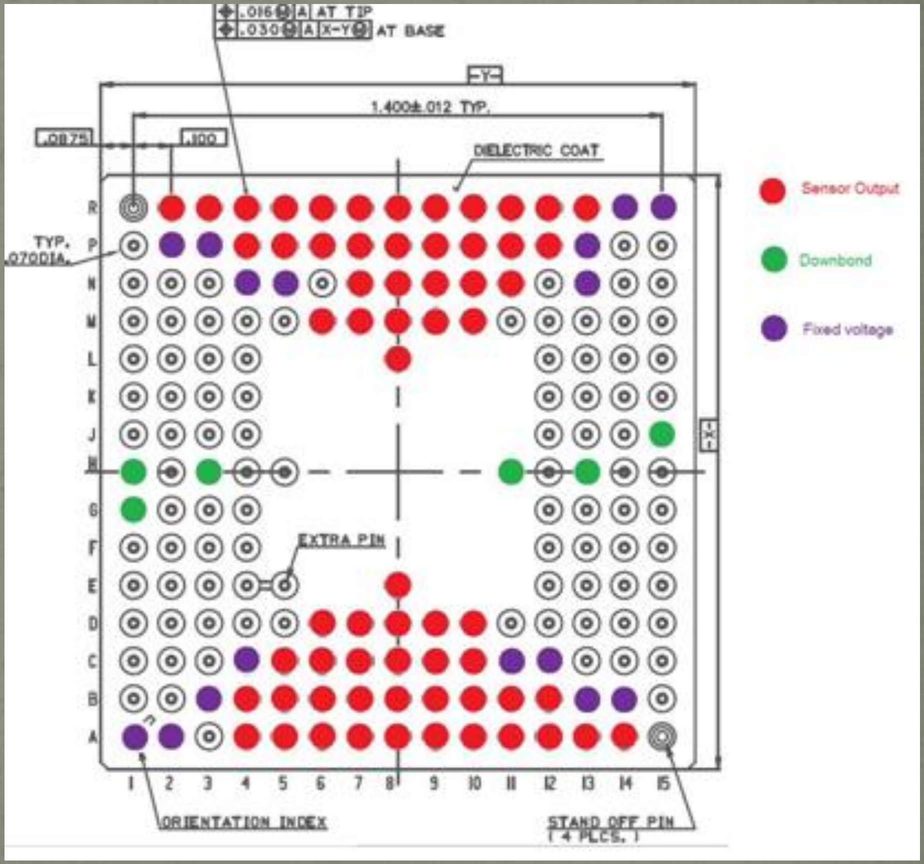
# Fermionics sensor bonding

- After a few discussions with the manufacturing company, a final diagram was made
- Additional wires were added to keep the bottom plane and the sensor pads at both ends at a constant voltage level



# Fermionics sensor bonding

- This made routing more complex, since the pins on the CPG18020 socket were now  on completely random order
- To make routing more easier, two layers were added to existing six

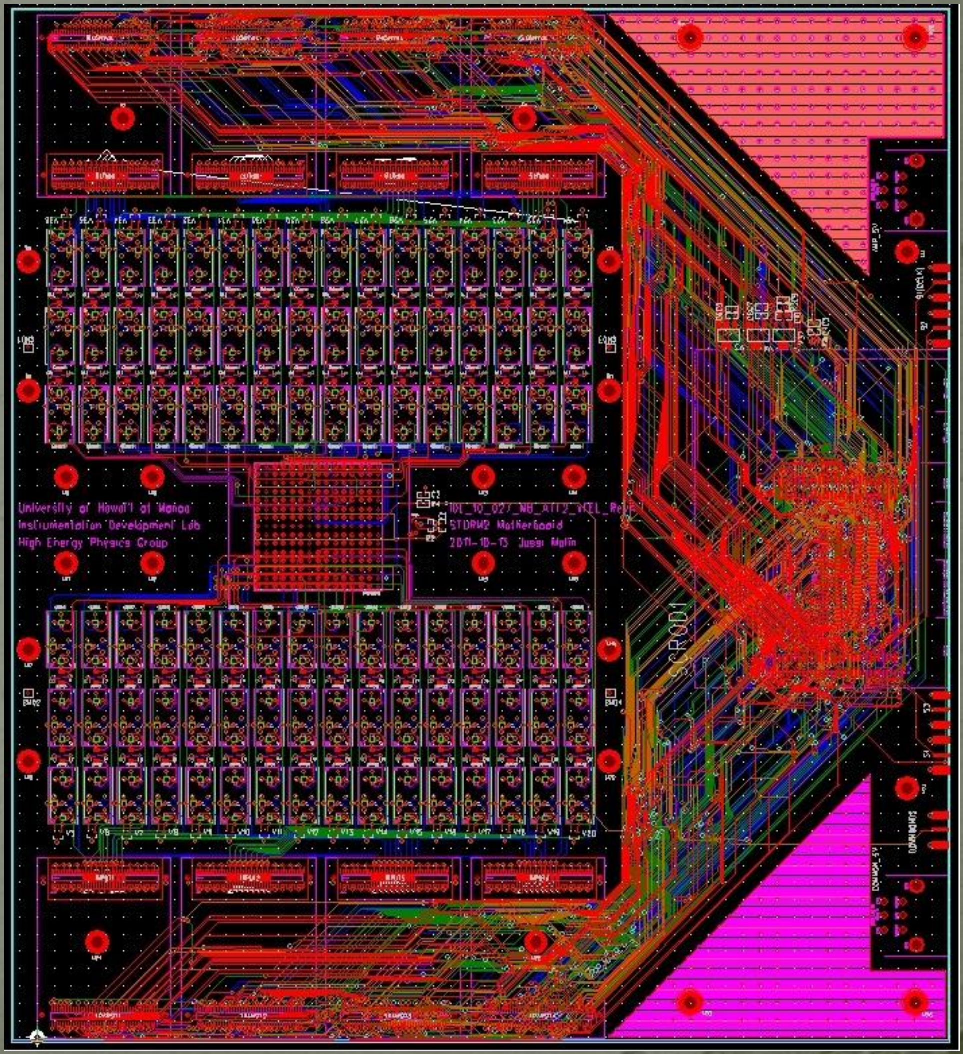


# Motherboard layout

- Board dimensions 10,9 X 12 inches
- 8 electrical layers
- 7 different operating voltages from 1.2 volts to 5 volts
    - 1,2 volts for SCROD
    - 1,8 volts for SCROD
    - 2,5 volts for SCROD and VPED
    - 3,3 volts for SCROD
    - 4 volts for amplifiers
    - 5 volts for daughter cards
    - Adjustable voltage for downbonds

# Motherboard layout

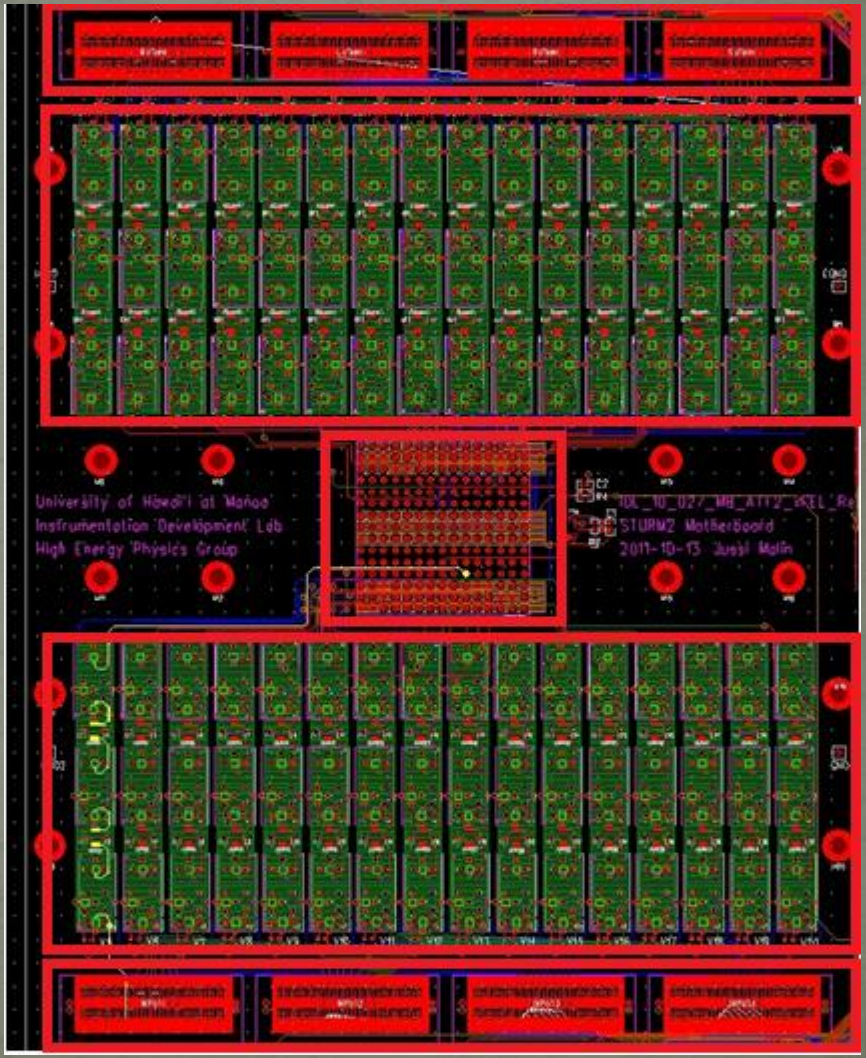
- First thing to do is the component placing
- The board has over 400 components that need to be placed and routed by hand



Takes a long time

# Motherboard layout

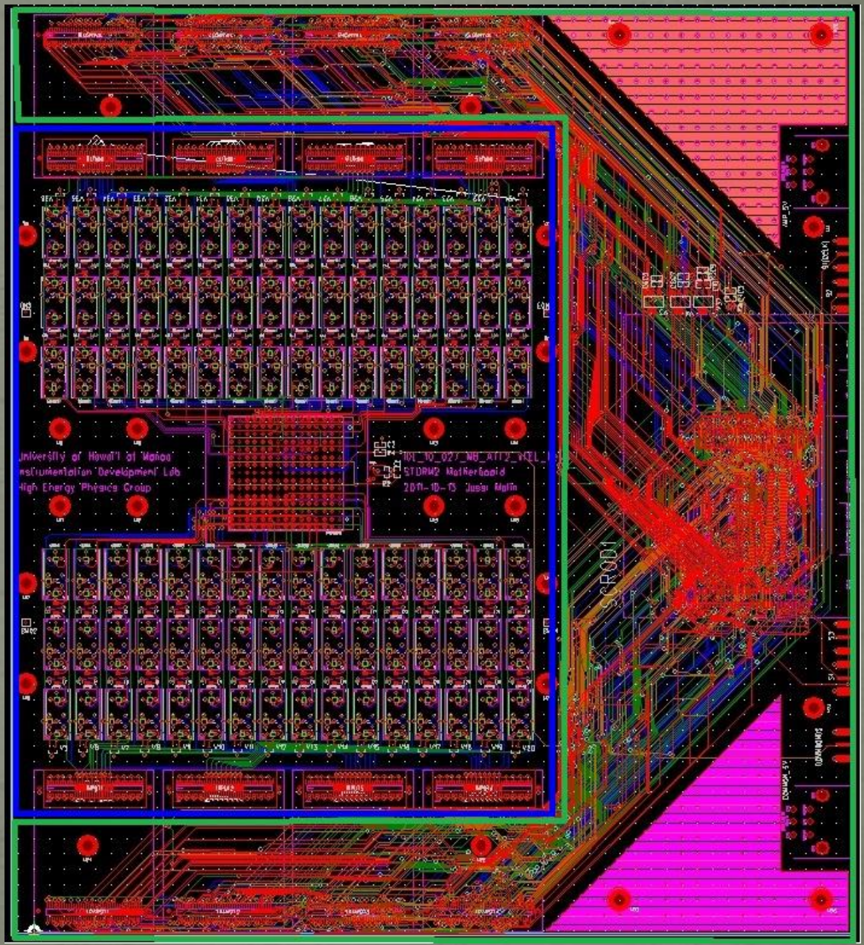
- To ease the routing, several different plane areas were created




- VPED
- Amp power
- Downbonds
- Two ground planes
- Two power planes

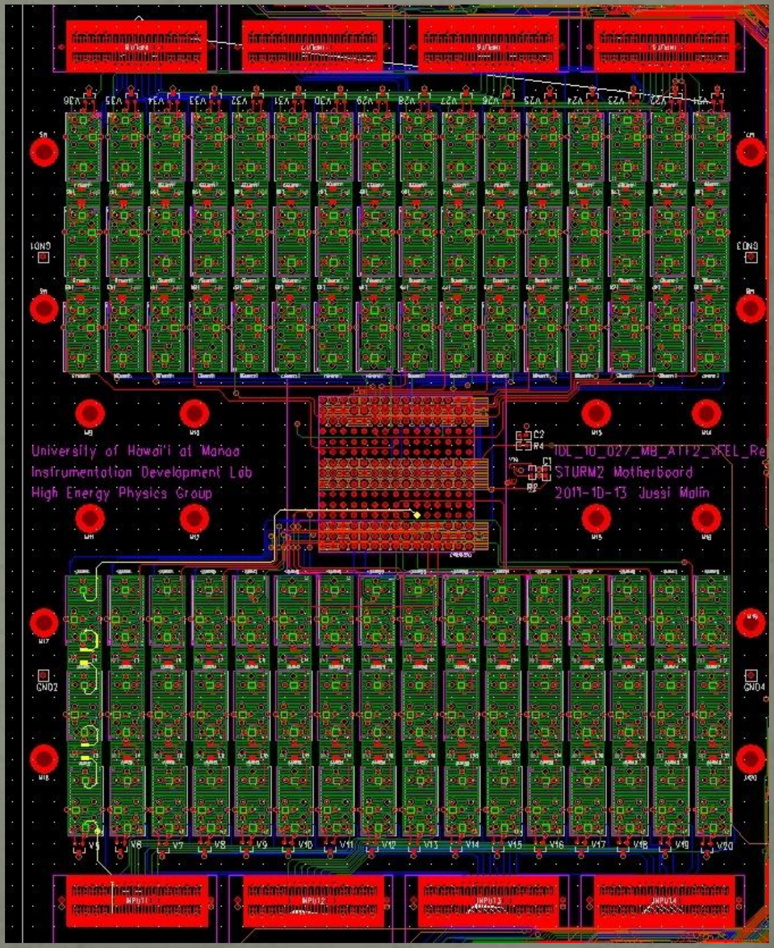
# Motherboard layout

- All the analog signals were routed by hand
  - Transfer line impedance
- The digital signals were done by PADS auto router
  - Crashes, bugs
  - Needed to force the auto router by using keepouts



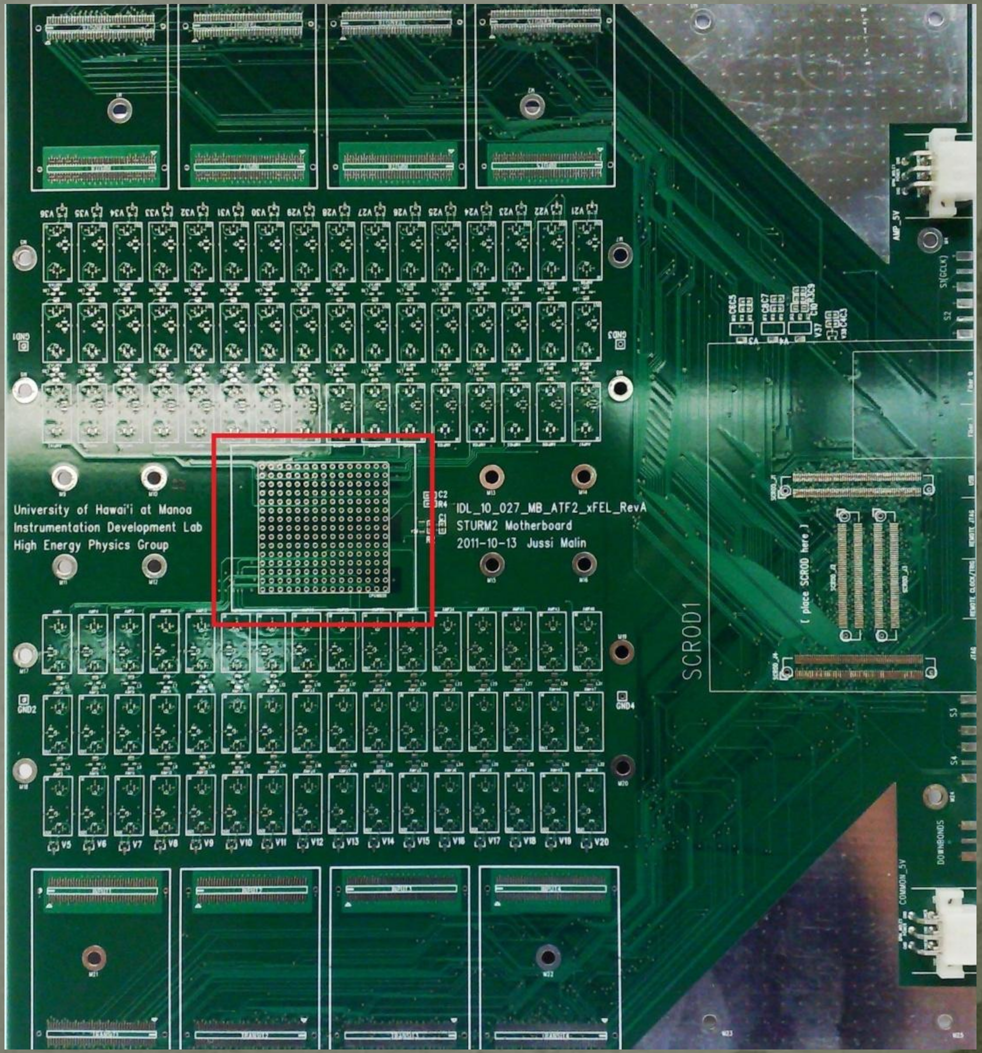
# Motherboard layout

- The amplifiers draw most of the current, 31 milliamps each
- ≈ 6 amps in total
- Another power connector was added



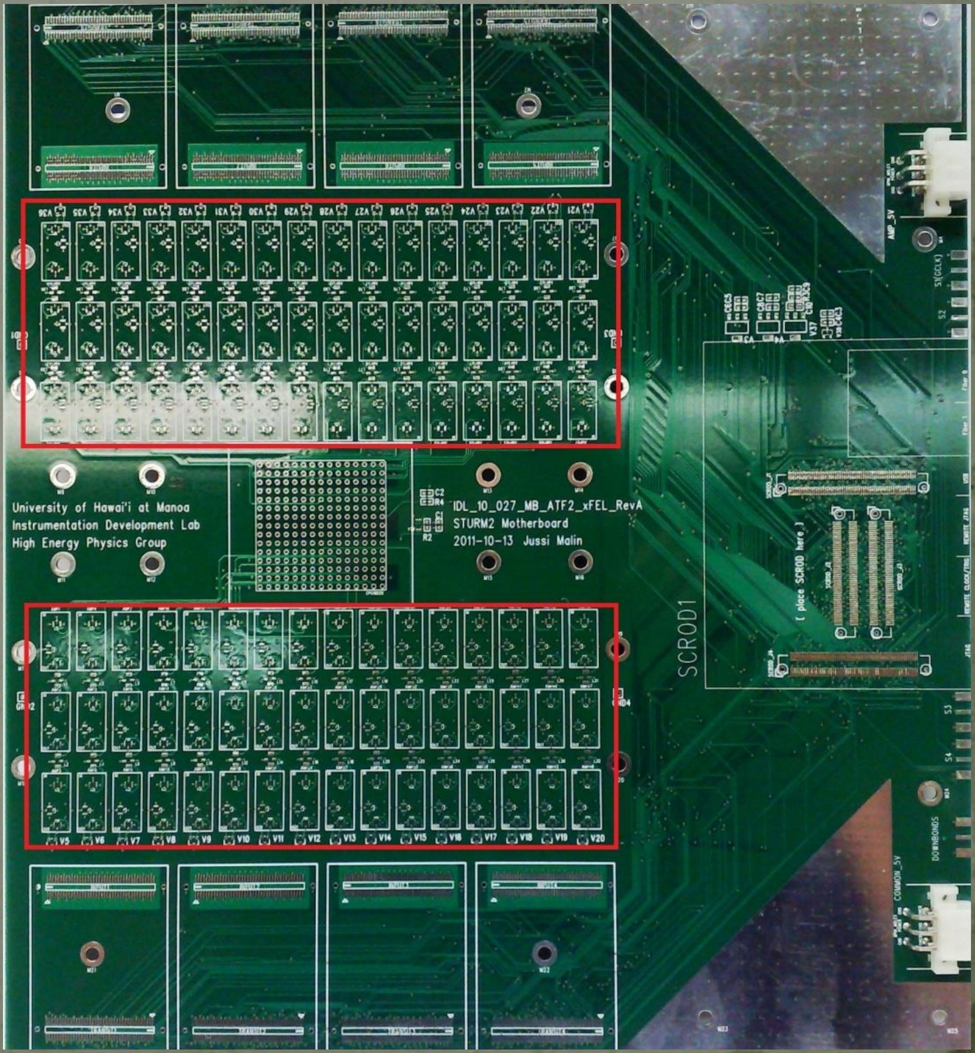
# Motherboard layout

- Fermionics sensor sits in the CPG18020 socket



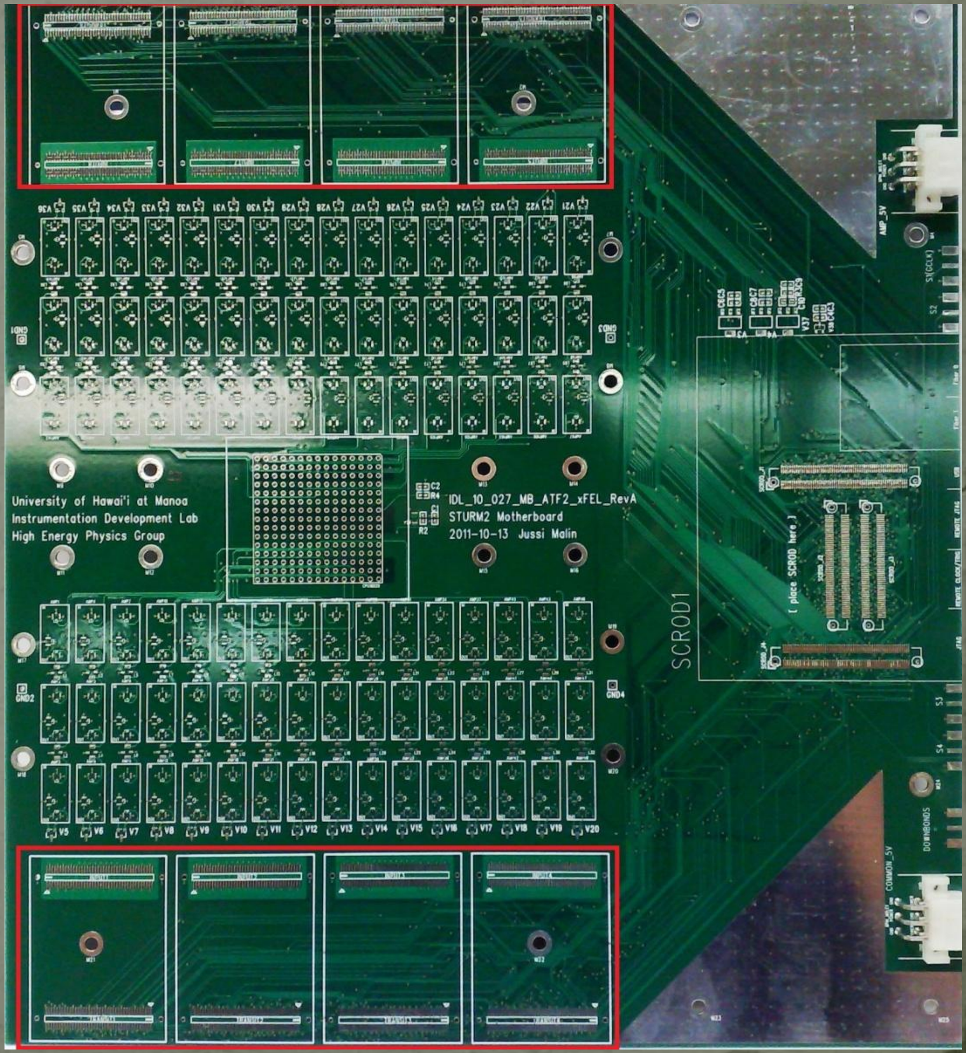
# Motherboard layout

- 192 amplifiers, 96 on top and 96 on the bottom side



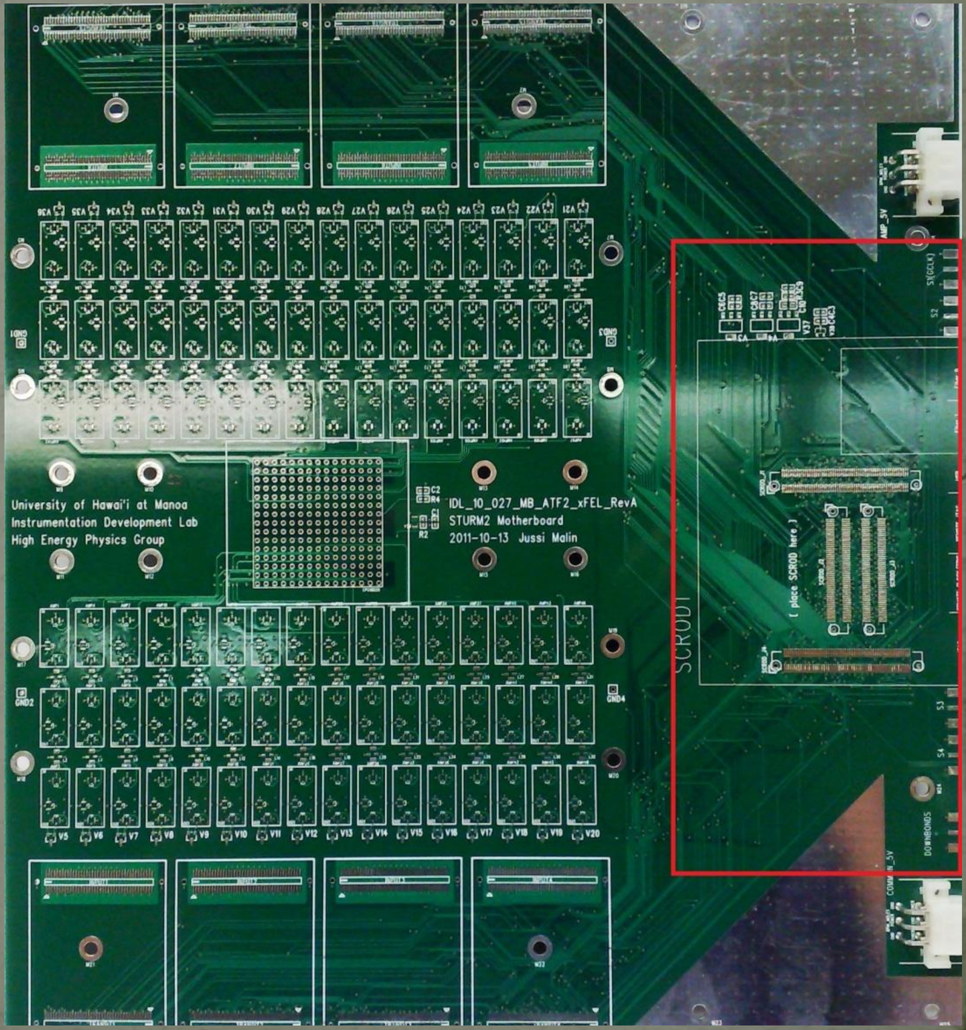
# Motherboard layout

- 8 ASIC cards
- Each card handles 8 channels



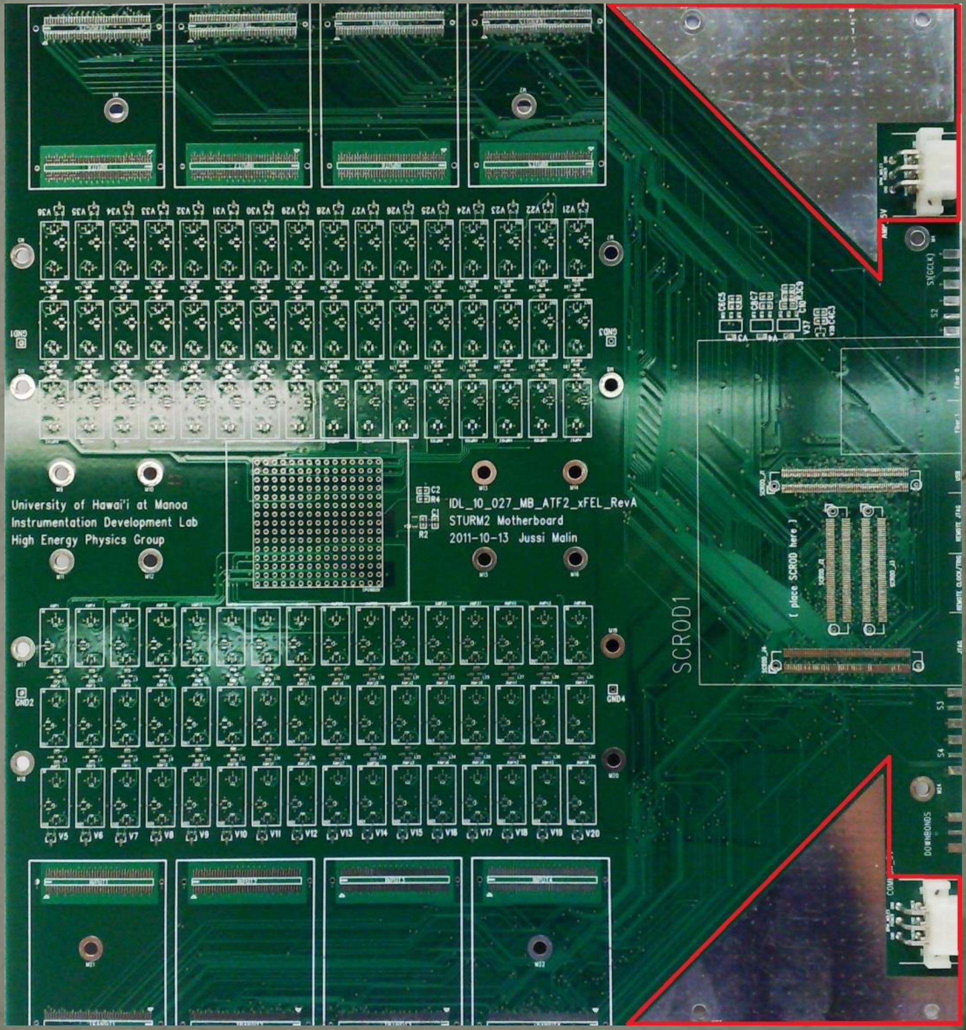
# Motherboard layout

- SCROD
- 5 SMA connectors
    - Debugging ( 3 )
    - Real time clock ( 1 )
    - Downbonds ( 1)



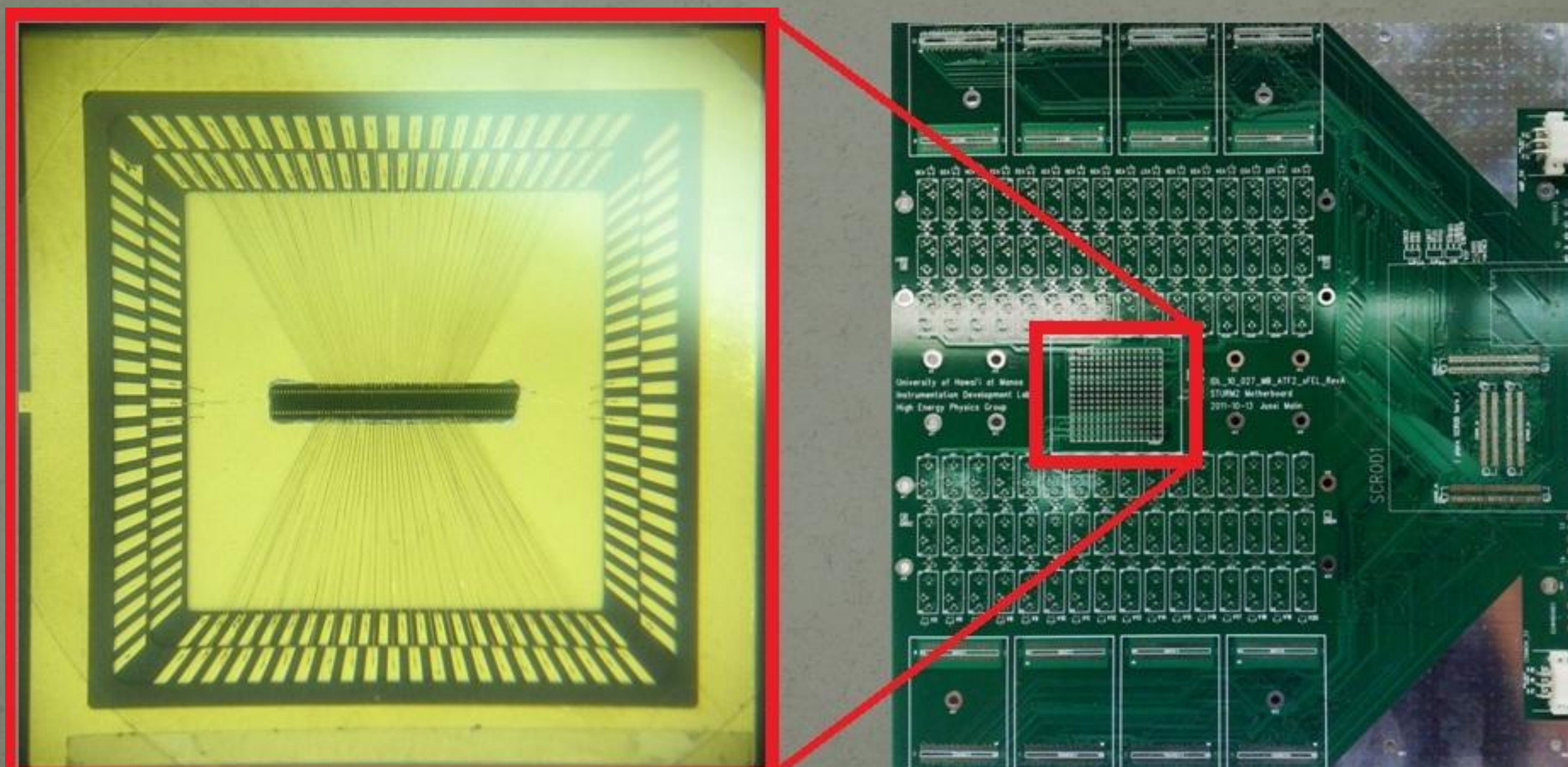
# Motherboard layout

- Power connectors
- Cooling areas on top and bottom



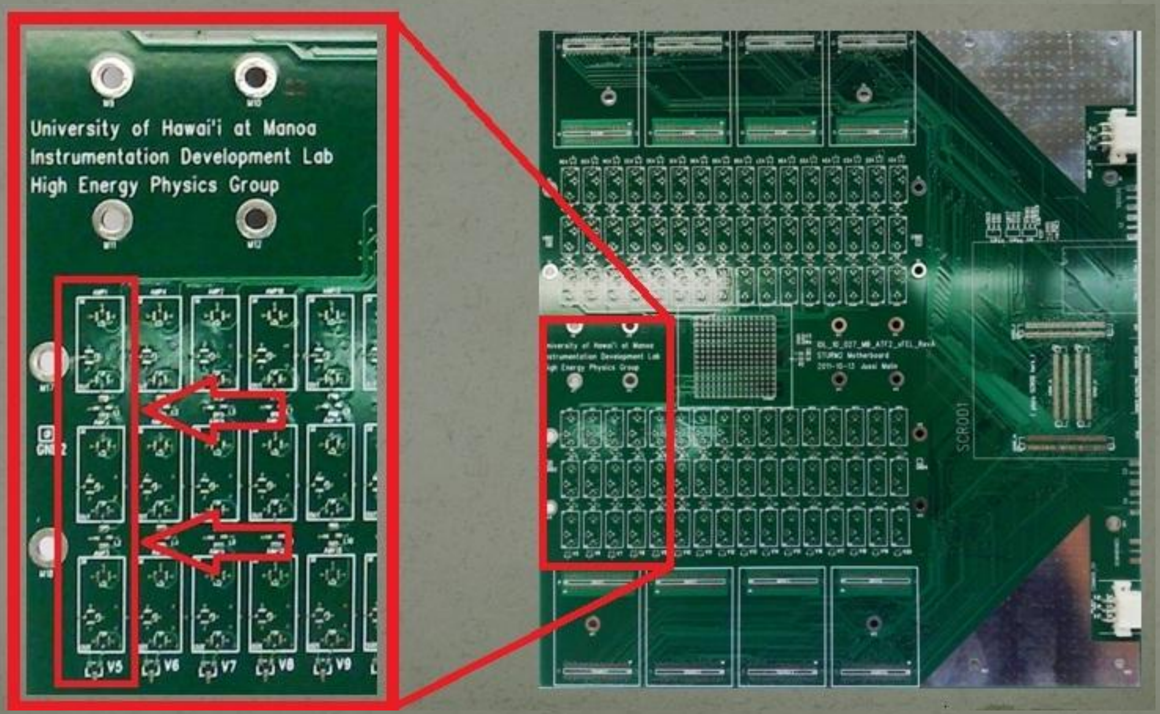
# Function  of the board

- The fermionics sensor produces the weak analog signal



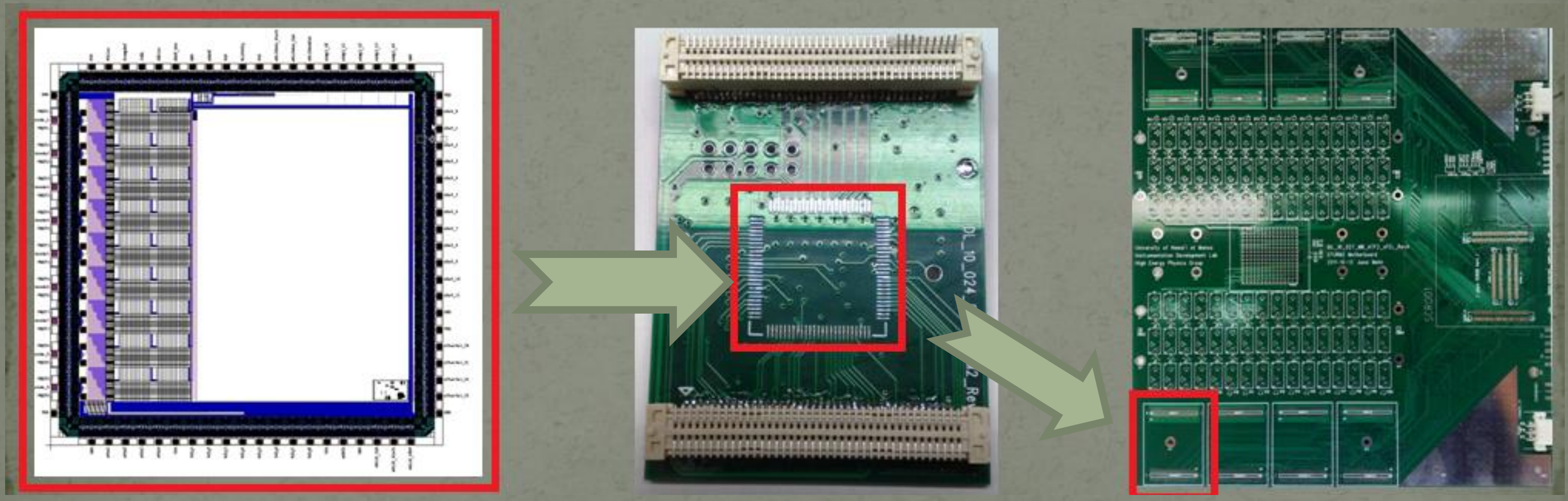
# Function of the board

- Analog signal is amplified by 60 dB to 10 millivolts
- Fixed low pass filter between amplifiers removes the spike found in testing



# Function of the board

- Signal is then fed to the ASIC card, which holds the STURM2 ASIC chip



- http://www.phys.hawaii.edu/~idlab/taskAndSchedule/STURM/STURM.html

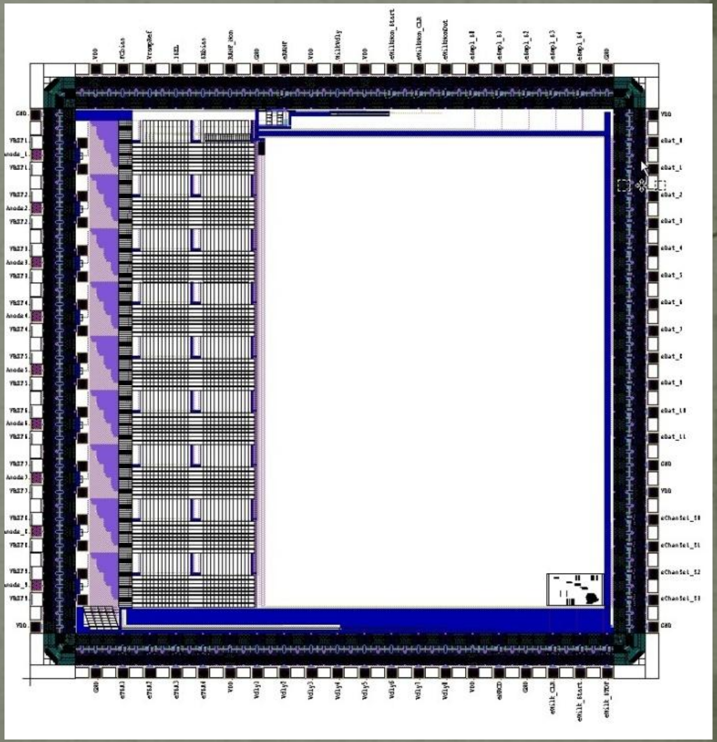
# STURM2 ASIC

- 8 Channels, each has 4 storages, which each hold 8 samples

- Adjustable sample delay

- Makes an 12 bit analog / digital conversion

- http://www.phys.hawaii.edu/~idlab/taskAndSchedule/STURM/STURM.html

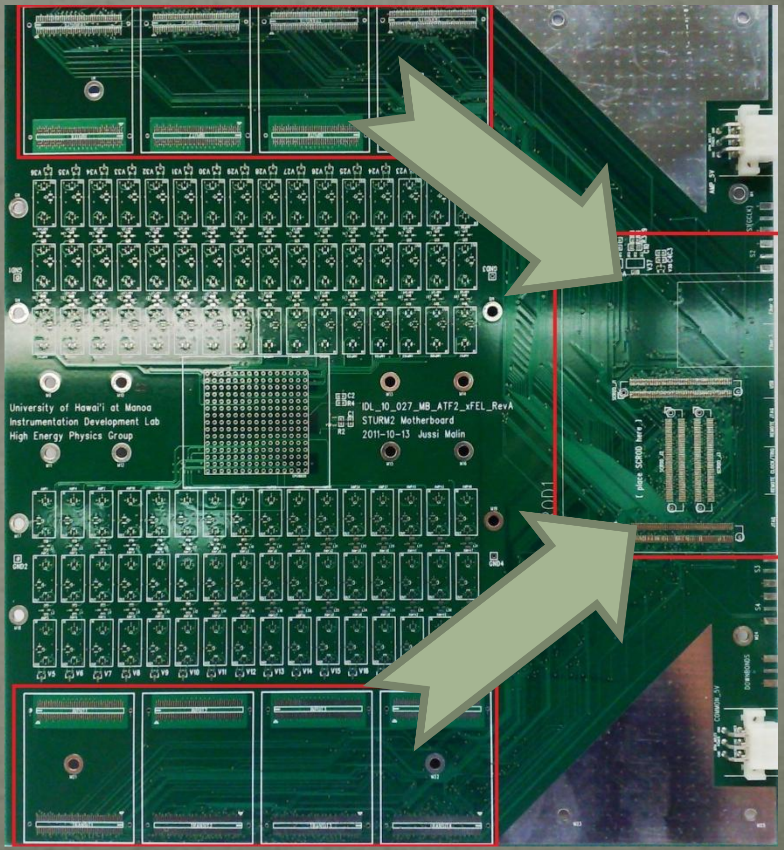


# Function of the board

- The sampling speed of the device is 10 giga samples per second
- This produces a large amount of analog data
- The STURM ASIC chip makes an analog / digital conversion
- This reduces the amount of data to be processed

# Function of the board

- By changing the data signal to digital form allows longer connecting distances
- From the ASIC card the Signal is fed to the SCROD
- The SCROD connects to computer were the data can be analysed



# Conclusion

- Learned a lot about schematic and layout design
- Component selection
- Problem solving
- Improved my English a lot

# Questions / comments


Thanks for attending
Kiitos osallistumisesta