Brookhaven National Laboratory

Jefferson Lab

U.S. DEPARTMENT OF ENERGY

Barrel Outer Tracker / MPGD (μRWELL)

MPGD Cooling Design Meeting (9/17/2025)

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Electron-Ion Collider

Intro

- Cooling Design for BOT

- Assumption:
- 7 FEB per cooling loop. Total 4 loops per sector (12 sectors)
- Each board has 4 SALSA (ASIC)
- Each FEB requires 8.5 W (including safety margin)
- Total power for each loop = 60 W
- Each sector = 60 x 4 = 240 W
- Total = 12 x 240 = 2880 W

- Water Inlet temperature = 18 °C
- Target ASIC temp = 30 °C

- Q = m x Cp x dT

- Q = 63 W
- m = flow rate (kg/s)
- Cp (water) = 4186 J/kg.K
- dT = ~5 °C
- m = 0.003 kg/s = 3 g/s = 0.18 L/min
- m_safe = 0.6 L/min

- ~~Total = 12 x 4 x m_safe = ~30 L / min~~

Tubing

- Inner diameter: flow rate
- Outer diameter: envelope limit
- 4~8 mm depends on volume, pressure, type of pressure (positive, negative)
- If negative pressure: PVC or PEEK ?
- Pressure drop by connectors: connector inner diameter is smaller than tubing ID
- Pressure drop by 90 degree angle, 4 elbows per FEB

Condensation

- 25 °C and 50% humidity
- Dewpoint = 14 °C
- Minimum water temp = 15 °C
- 16~18 °C will be OK.
- Insulation required from chiller to BOT

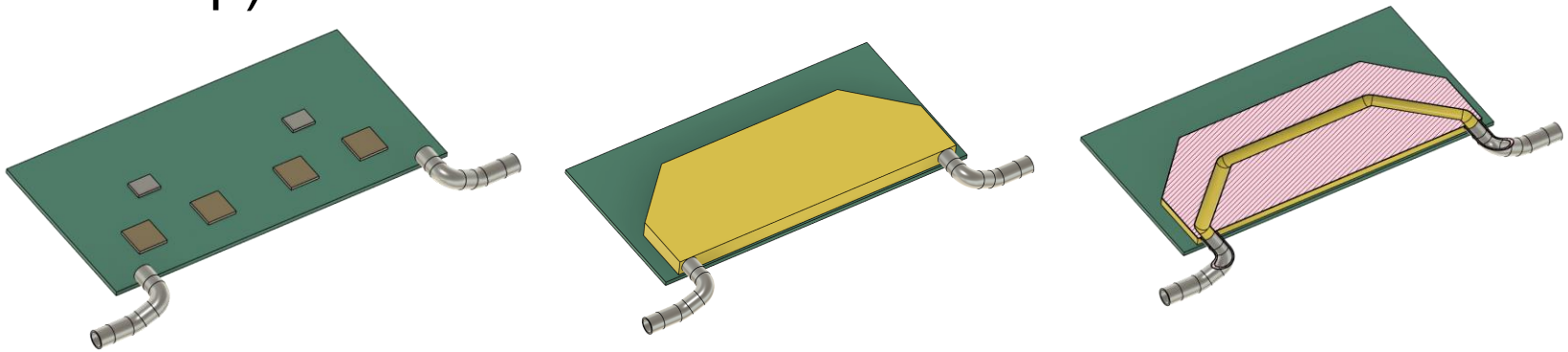
Options for heatsink

- Direct heatsink with stainless steel tubing

- simple, smaller tubing
- less bending (lower pressure drop)
- requires insulation

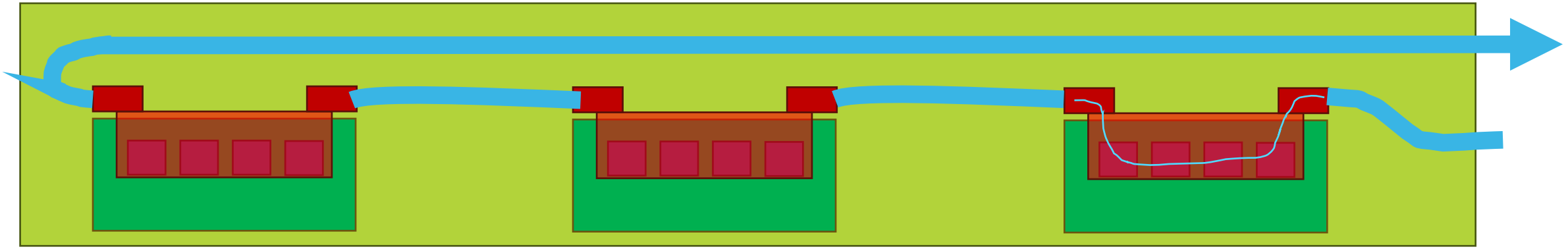
- Custom made heatsink with soft tubing

- complicate heatsink required, larger tubing
- more bending (high pressure drop)

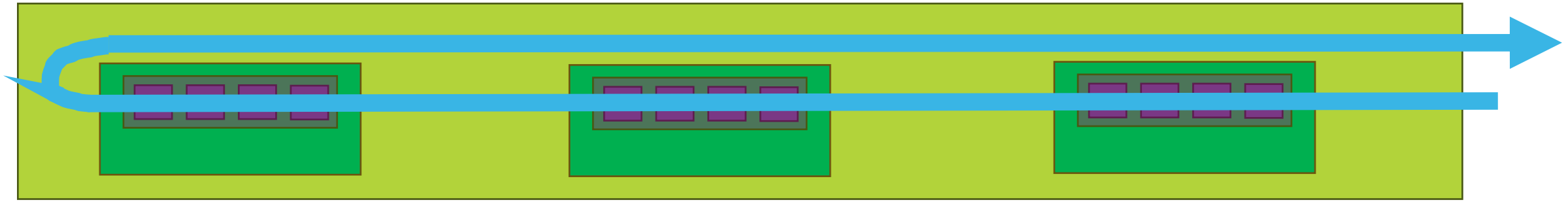


Comparison

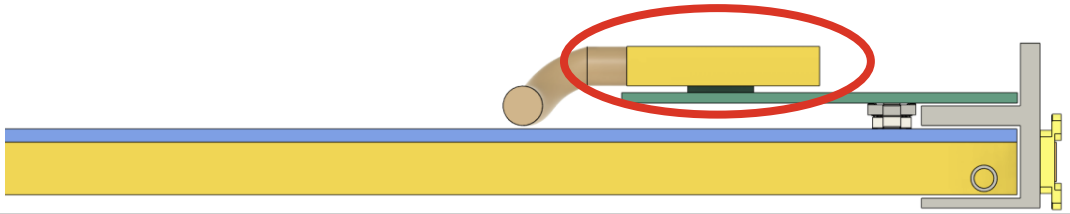
Heat sink and water tubing by connectors



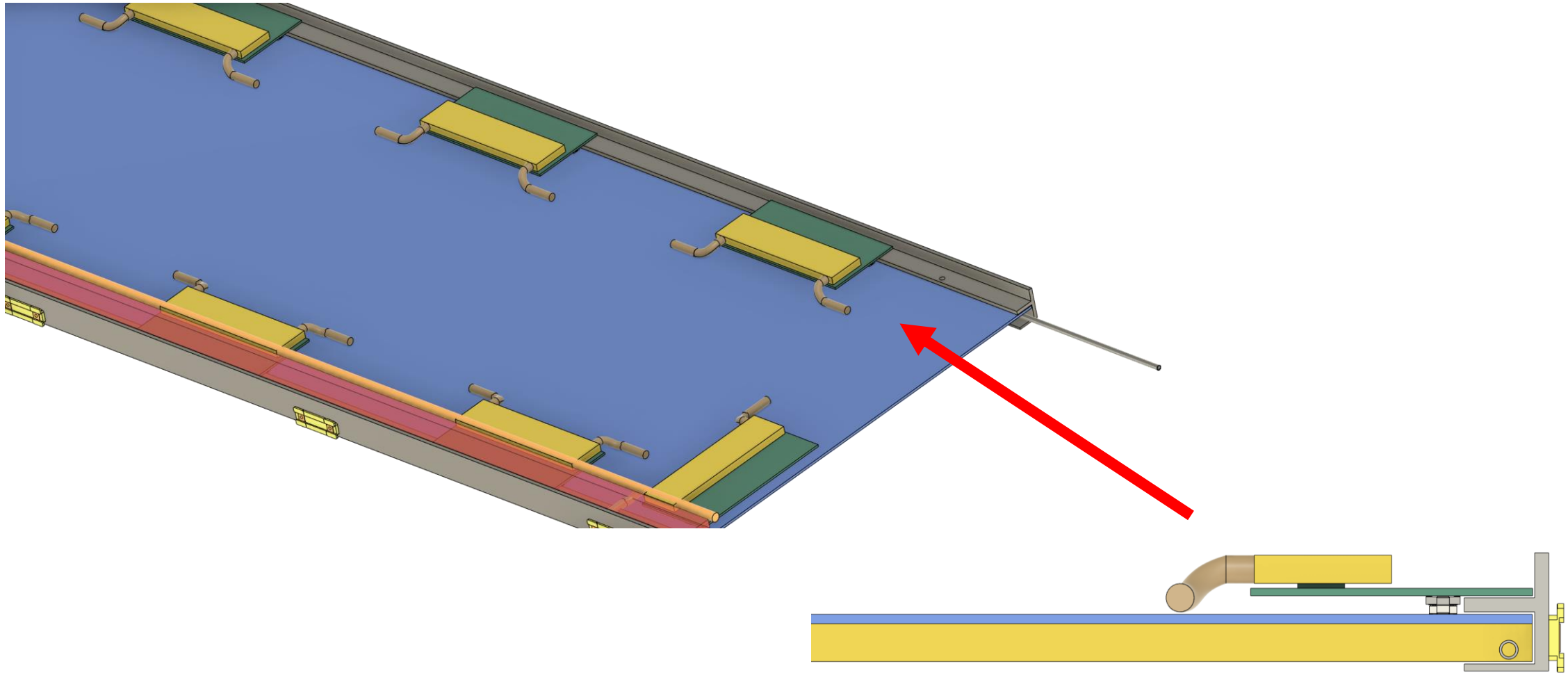
Heat sink welded with water tubing without connectors



Both cooling scheme requires space on top of FEB.
Not much space!

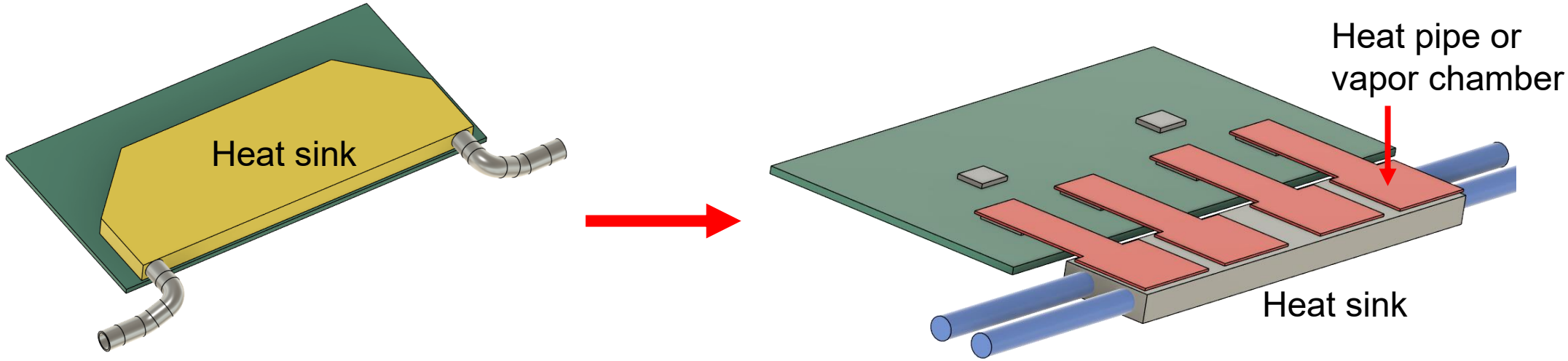


Heat sink on top

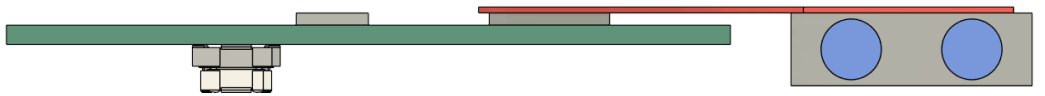


Heat sink on side

- Place heatsink on the side of FEB and deliver heat by heat pipe or vapor chamber



Heat sink: ~ 3 mm thick
Vapor chamber: ~ 0.5 mm thick



It will add more mass but also save mass by shortening tubing and connectors.
Also easy to make heat sink. Much less pressure drop. Safer negative pressure system (no connectors)

Summary

- Current design with heat sink on top of FEB requires space which may not be feasible.
- Heat sink on side using heat pipe or vapor chamber is considered.

Question & Comments

Heat pipe vs Vapor chamber

- Both are working by the same principle. Evaporation – Condensation cycle.
- Heat pipe – 1D while Vapor chamber – 2D (faster, efficient)
- High-end cell phones are using vapor chamber to spread out heat quickly through the back wall of phone.
- Heat pipe can deliver heat long distance. Very cheap.
- Vapor chamber can be use for heat delivery in short distance. Price vary.