Study of Opto-Box

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Outline

- Reliability of Opto-Links
- Use of Electrical Repeater?
- Radiation Level at ID Endplate
- Opto-Box with High-Speed Downlinks
- Opto-Box with Low-Speed Downlinks

Reliability of Opto-Links

- Best data on reliability of opto-links are from the pixel detector
  - 1st generation on-detector opto-links built by OSU had failure rate of ~0.1%
  - no failure so far for 2nd generation on-detector opto-links
    - ⇨ accumulated 4×10^6 device-hours
      - each device contains about 20 channels
  - proposed ITK-Pixel links are similar to 2nd generation links
    - ⇨ expect similar reliability
    - opto-links will be installed at a location that can be accessed for the first few years
- opto-links of ITK-Stripe will be installed at inaccessible locations
  - no need to build ITK-Pixel if opto-links are unreliable

Repeater Box vs Opto-Box

Repeater Box	Opto-Box	Comment
ASIC	ASIC	Non trivial to develop high-speed repeater ASIC. Need programmable pre-emphasis.
	VCSELs + PINs	No opto failure
Messy input cables	Messy input cables	Same mess
Messy output cables	Messy output cables	Need dimensions of opto vs elec. cables
Services: +V, NTC	Services: +V, -V, VPIN, NTC	Opto needs more services. Need dimensions

- Repeater box is as messy as opto-box
- Development of repeater ASIC is non trivial

⇨ No clear gain in replacing opto-box by repeater box

Radiation Level at ID Endplates

- Radiation level at ID endplate (Z = 335 cm) is acceptable for opto-link operation
  - safety factor not included in table below
  - radiation tolerance of opto-links needs to be verified

R (cm)	1 MeV neq (10^{14}/cm^2)	TID (MGy)
35	10.41	0.464
50	7.73	0.231
75	5.24	0.102

Radiation Level at End of Staves

- GBT is rated to 1 MGy
  - radiation level in layers 1-3 too high for GBT
  - safety factor not included in table below
  - GBT can be mounted at end of staves for layers 4 + 5

Layer	1 MeV neq (10^{14}/cm^2)	TID (MGy)
1	137.4	10.34
2	62.7	5.00
3	16.0	0.88
4	10.6	0.53
5	7.8	0.36

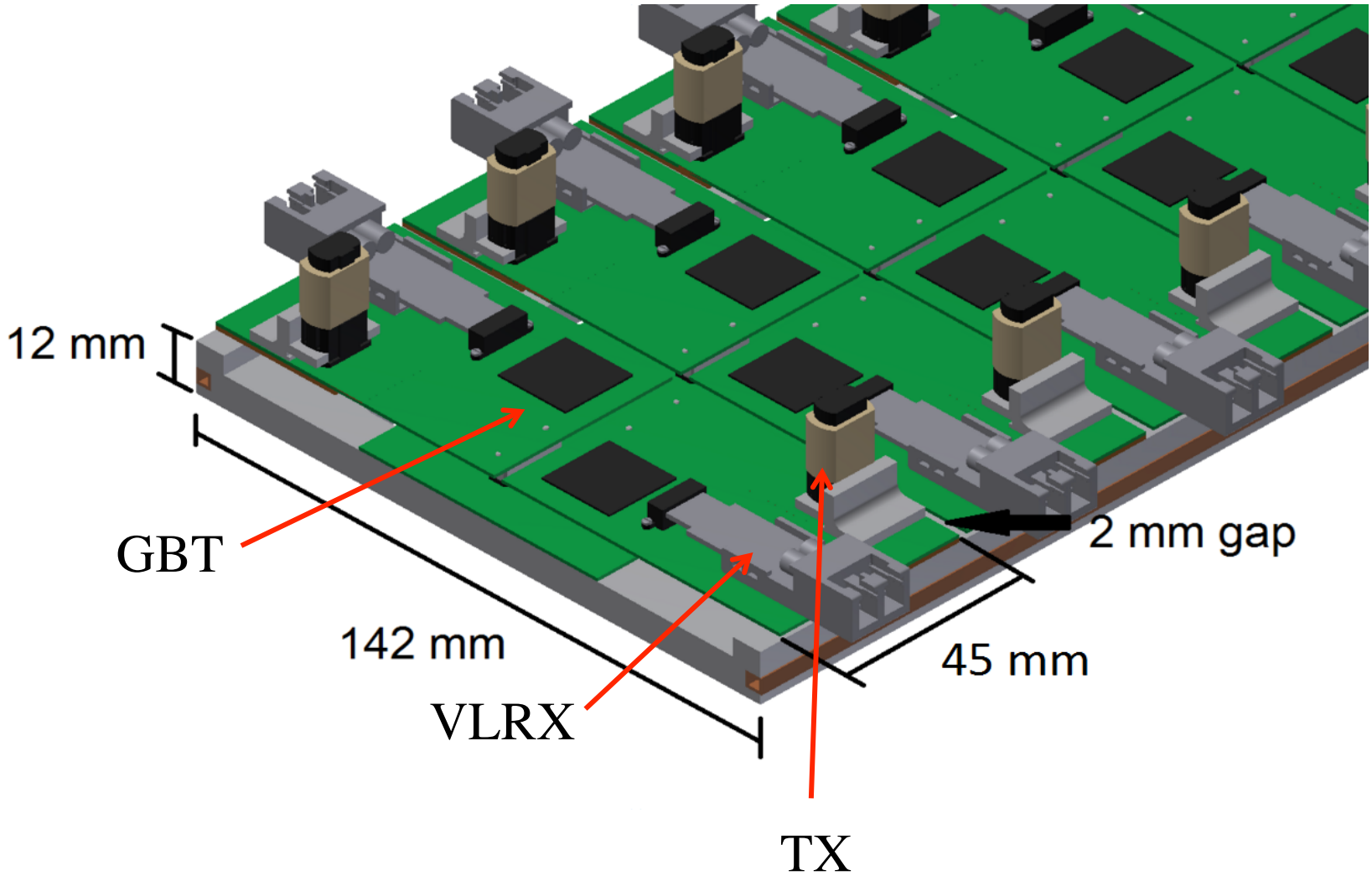
GBT at End of Staves

- GBT can be mounted at end of staves for layers 4 + 5
  - account for only 24% of the links
  - ☺ smaller wires bundles
    - GBT on stave: 19 TwinAx + 2 supply wires+ 2 sense wires
    - GBT on opto-boards: 18 TwinAx + 9 or 18 skinny wires
  - ☹ introduce an additional favor of opto-board
  - ☹ loss half stave if GBT link is broken
  - ☹ introduce significant material in central region of detector:
    - target lpGBT packaged dice: 9 mm x 9 mm x 2 mm
      - ASE minimum: 15 mm x 15 mm
    - need heat sink under the dice

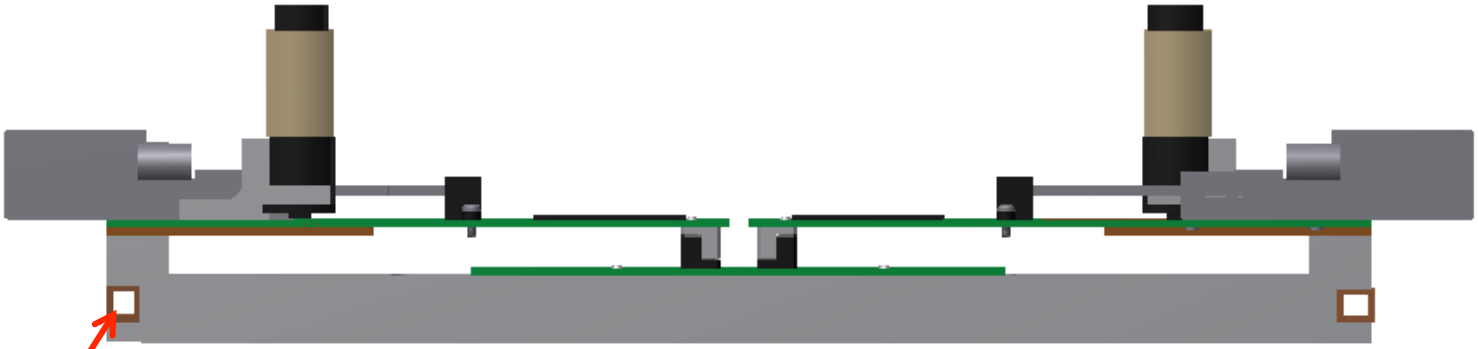
Opto-Box with High-Speed Downlinks

- Basic assumptions:
  - up-links: use 12-channel VCSEL array operating at 5 Gb/s
  - down-links: use one GBT
    - would need two GBTs for redundancy to prevent lost of half stave with a broken down-link
      - ☹ need to develop redundancy ASIC
    - send 160 Mb/s signal to 1 or 2 modules

Opto-Box with High-Speed Downlinks

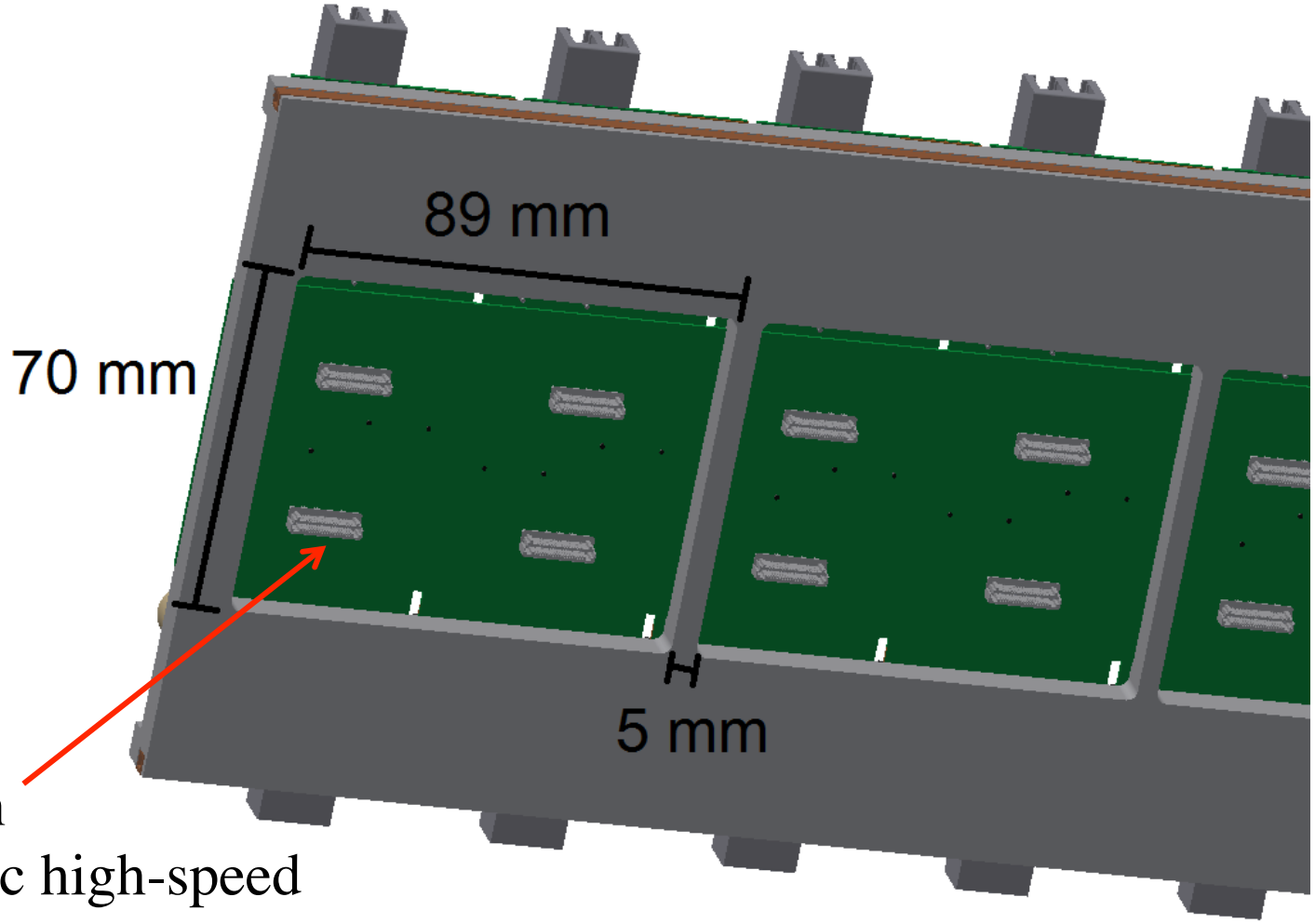


Side View



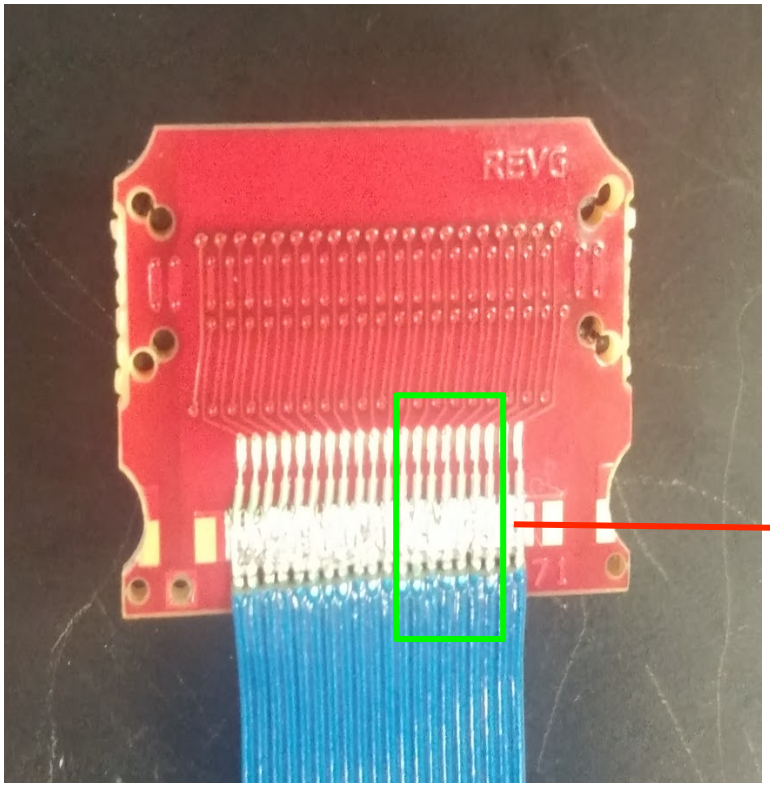
Cooling pipe

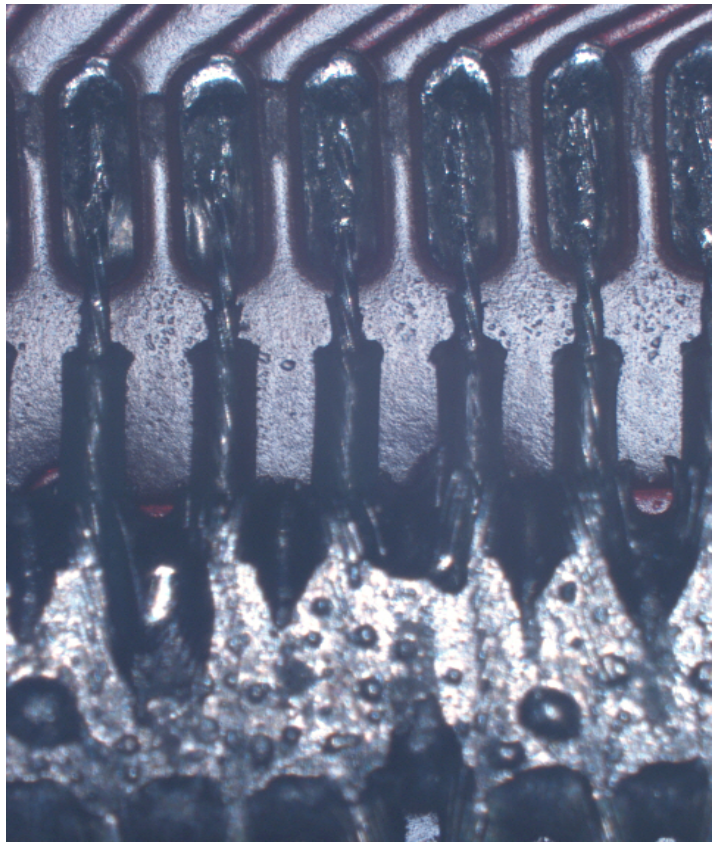
Bottom View



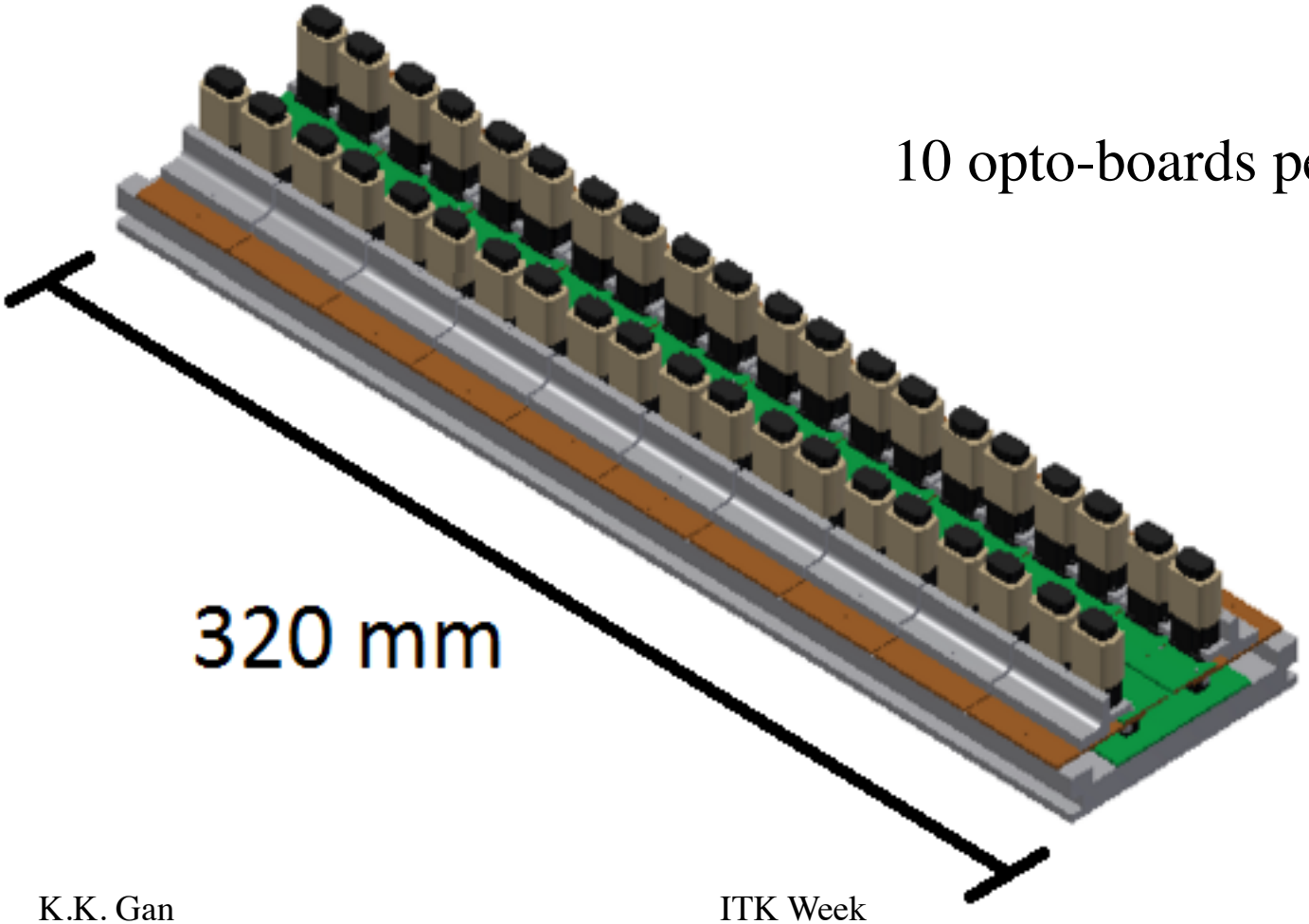
60-pin
Samtec high-speed
coax connector

Samtec High-Speed Coax Connector



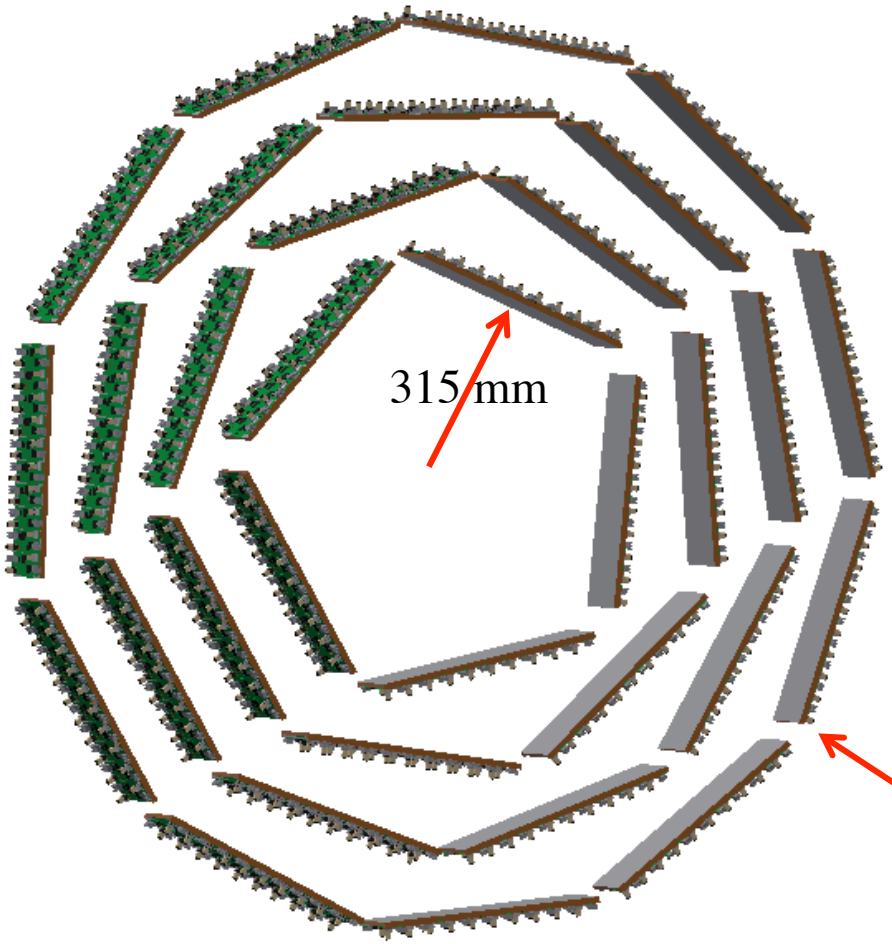


Opto-Box



10 opto-boards per side

Opto-Box at End of Stave

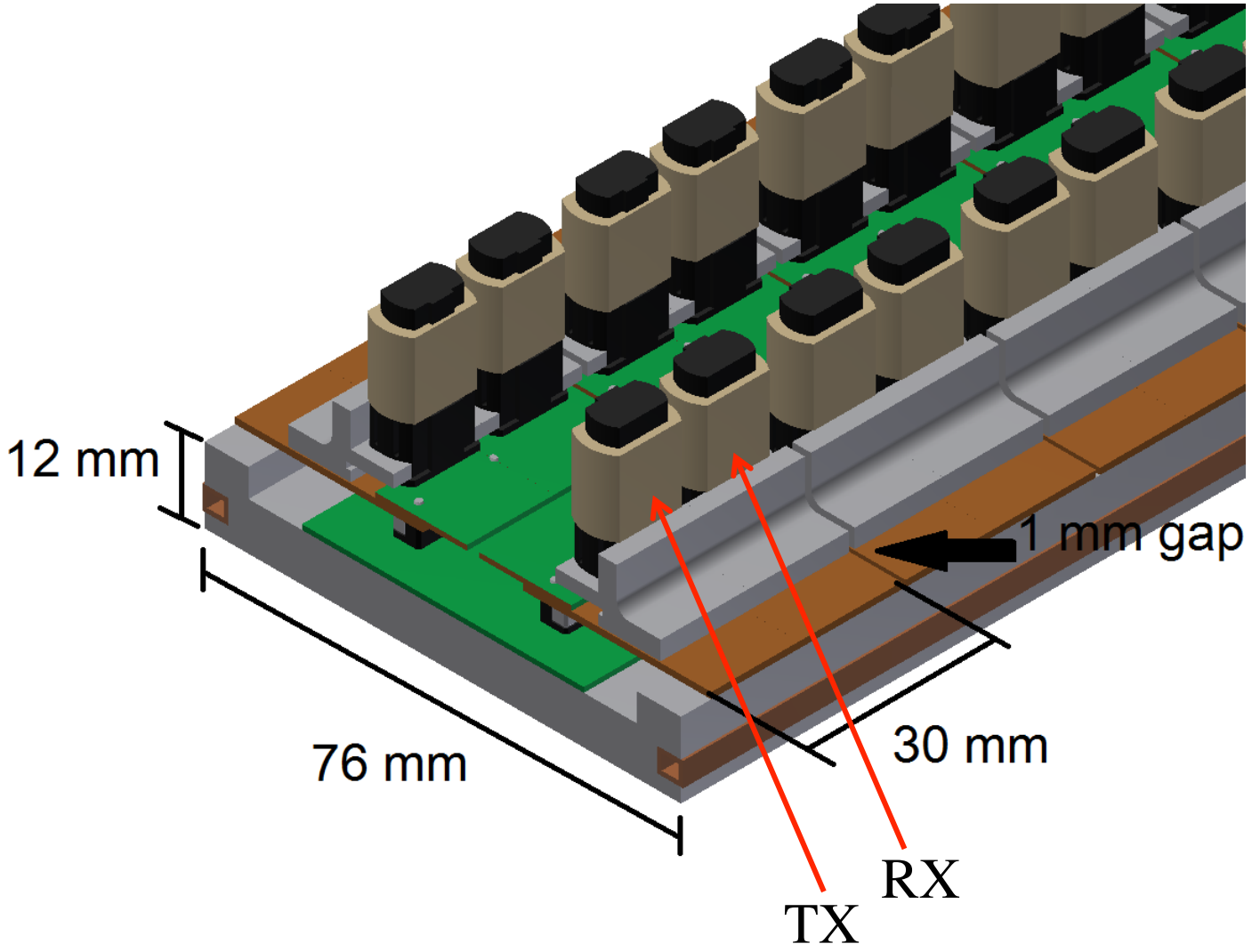


32 opto-boxes
2 x 10 opto-boards/box
640 opto-boards

Opto-Box with Low-Speed Downlinks

- Basic assumptions:
  - up-links: use 12-channel VCSEL array operating at 5 Gb/s
  - down-links: send 12 channels of 8b/10b signals at 160 Mb/s from counting room to opto-box
    - not a technical challenge to program FPGA in counting room and to develop low-speed ASIC for the opto-board
    - send 160 Mb/s signal to 1 or 2 modules
    - ☺ one opto-board flavor with up- and down-links using MTP connectors as in current opto-board
    - ☺ use relative old/proven technology

Opto-Box with Low-Speed Downlinks



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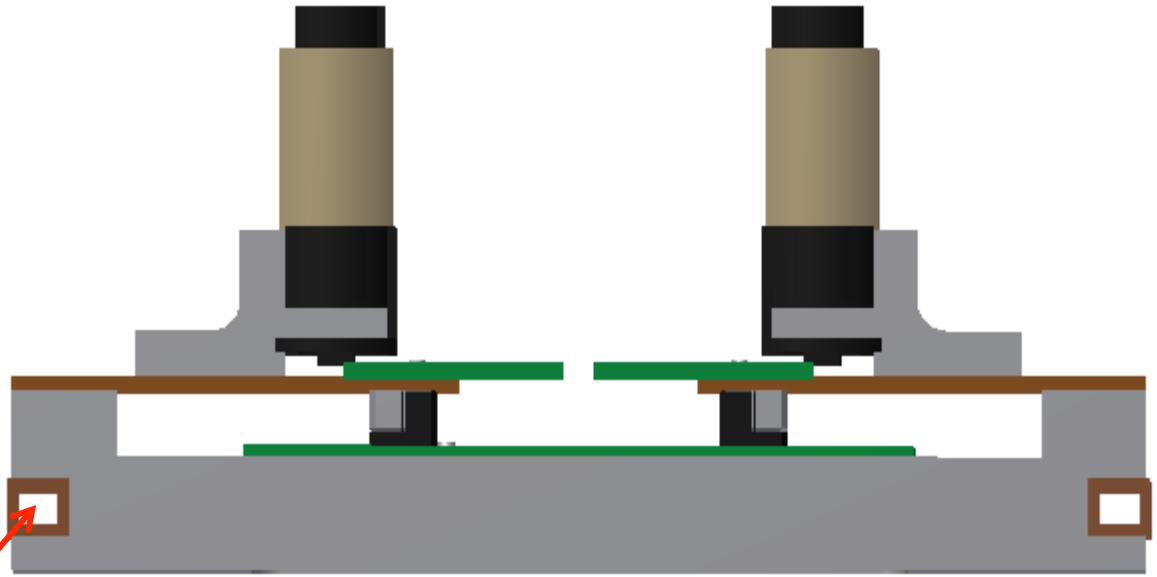
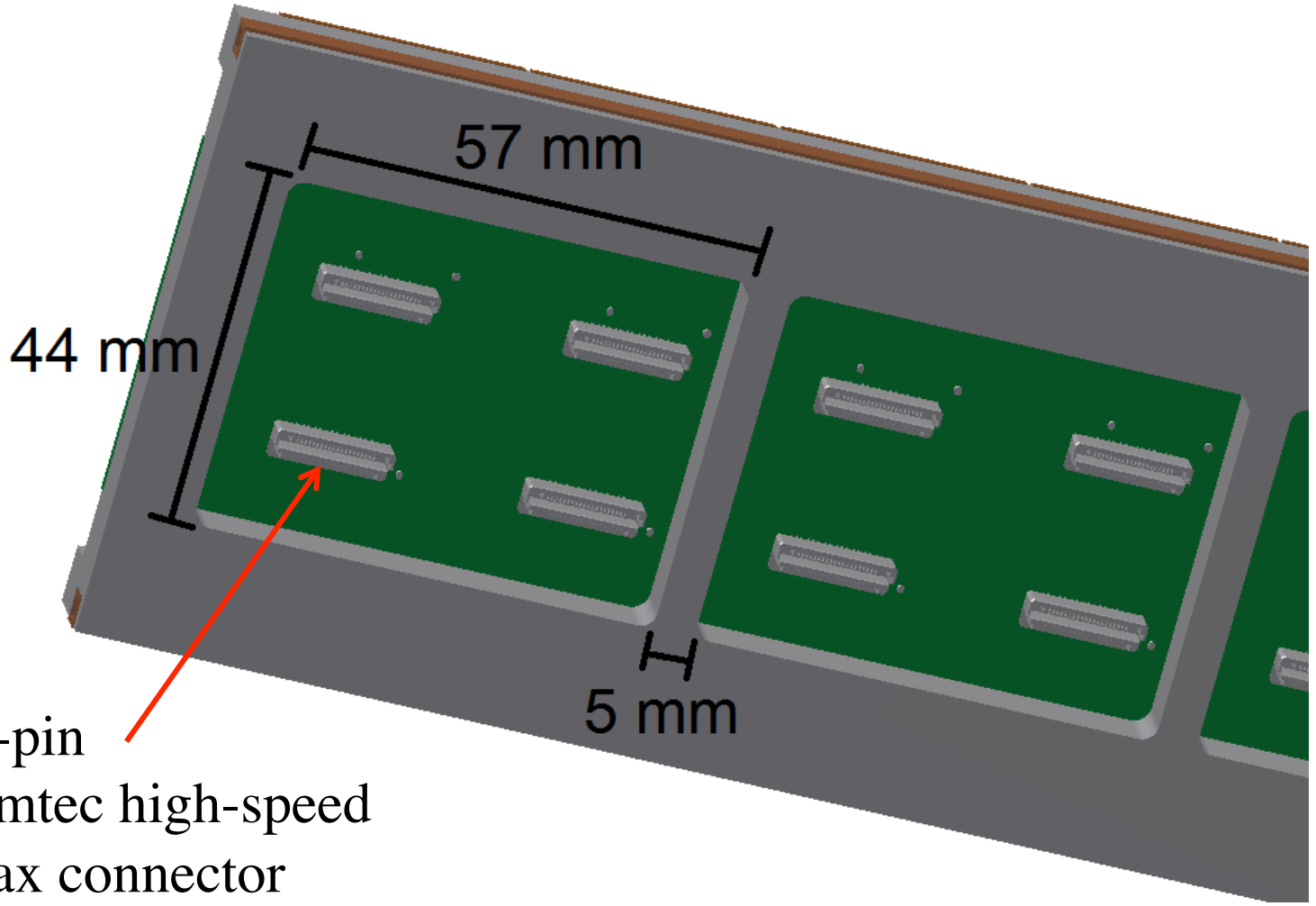
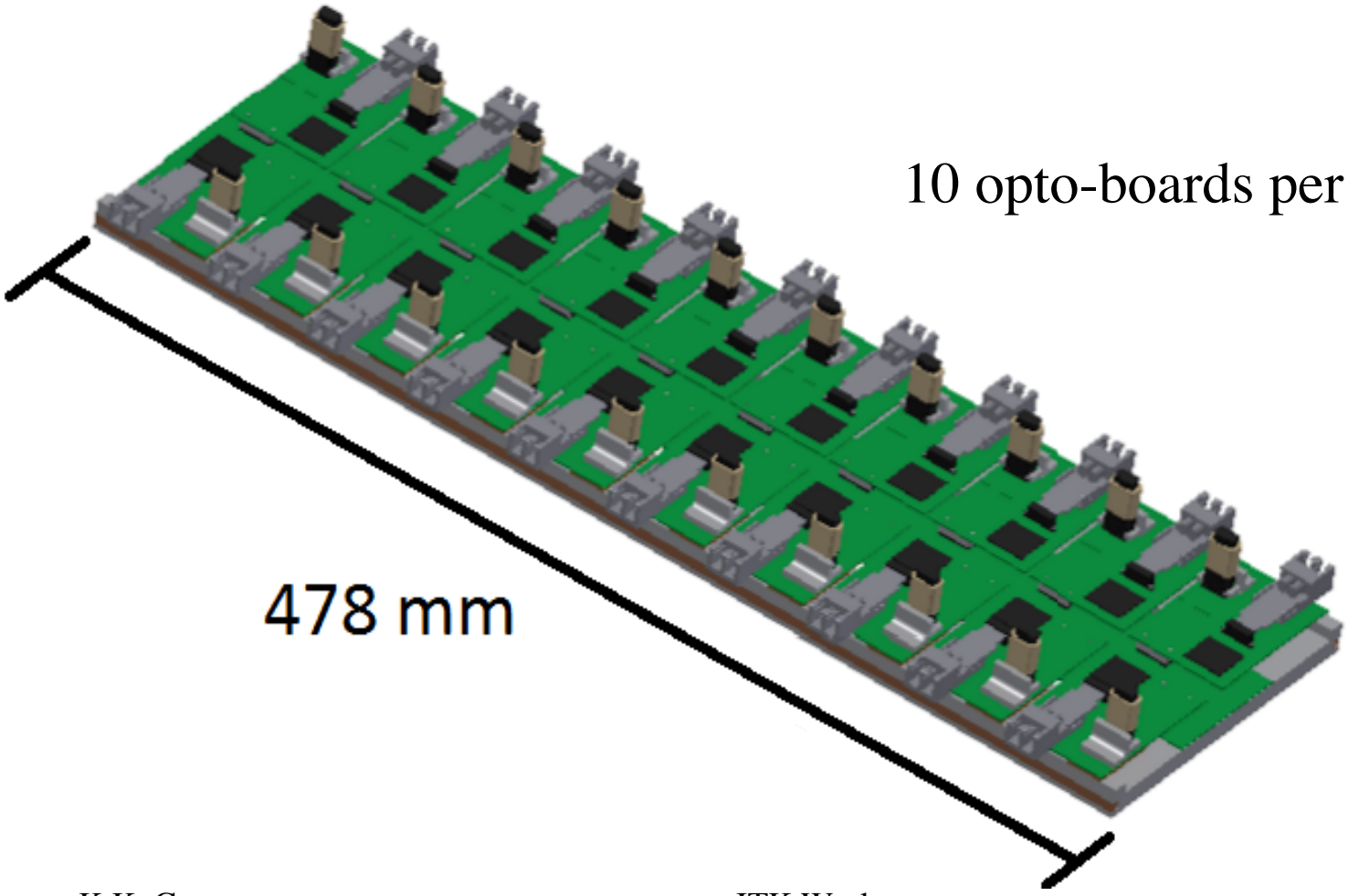


Cooling pipe

Bottom View



Opto-Box



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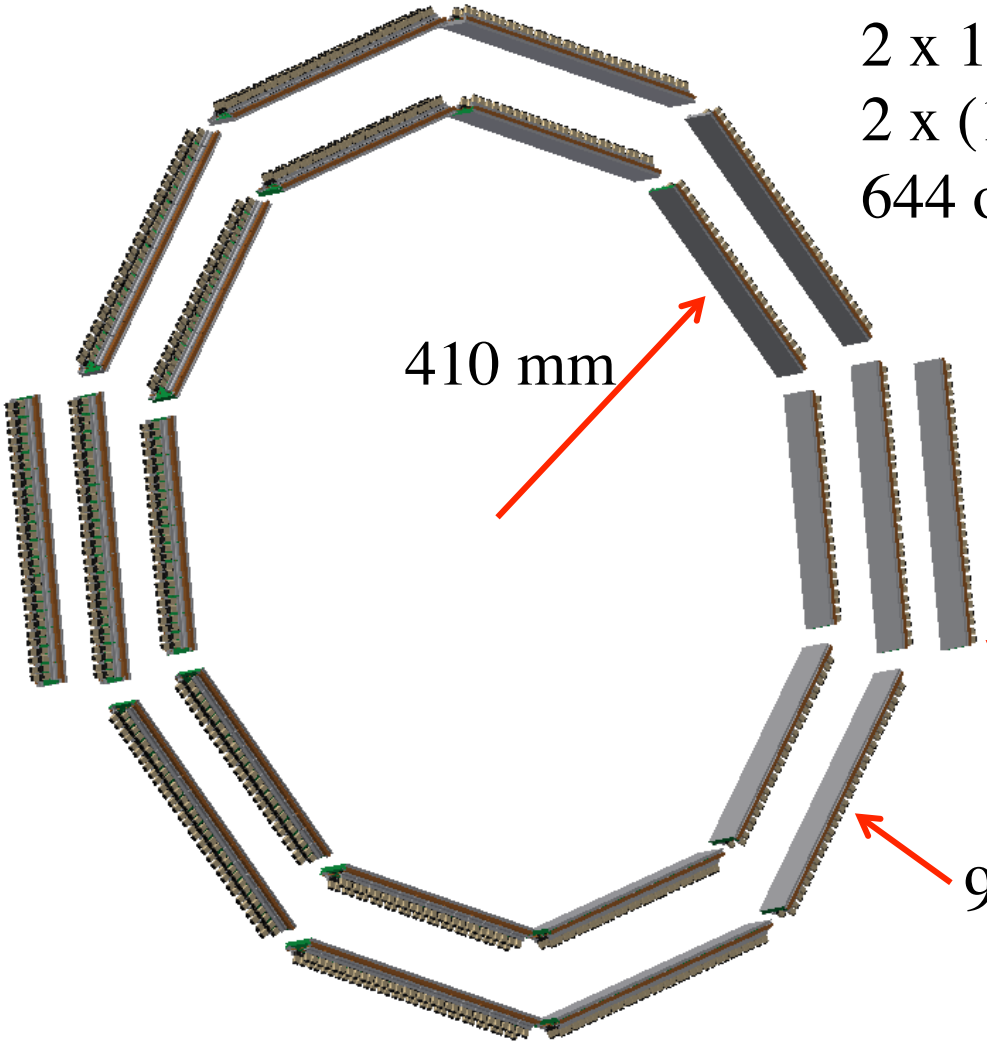
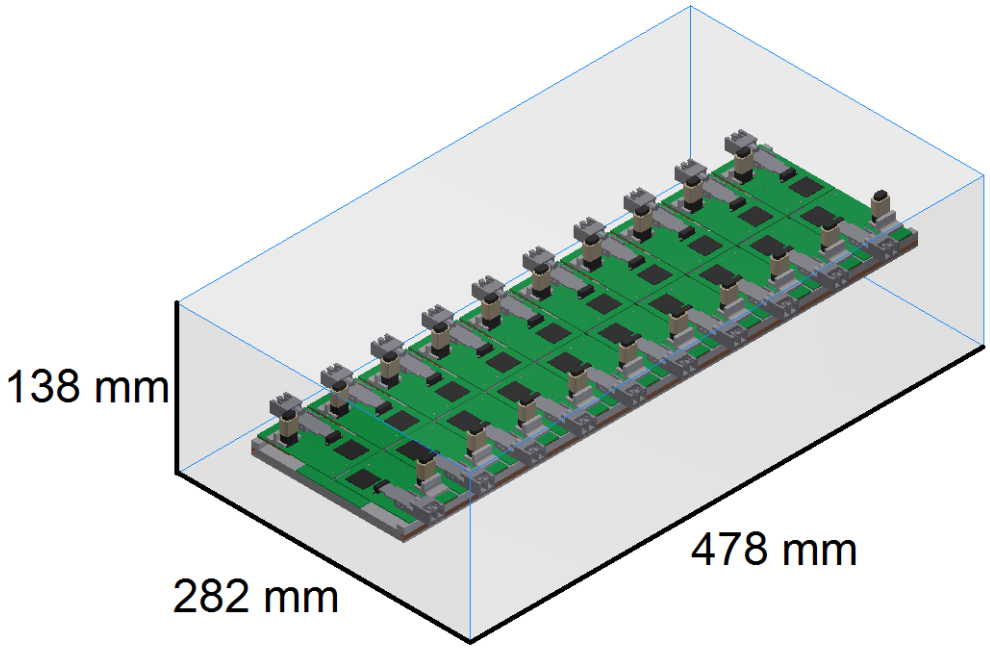
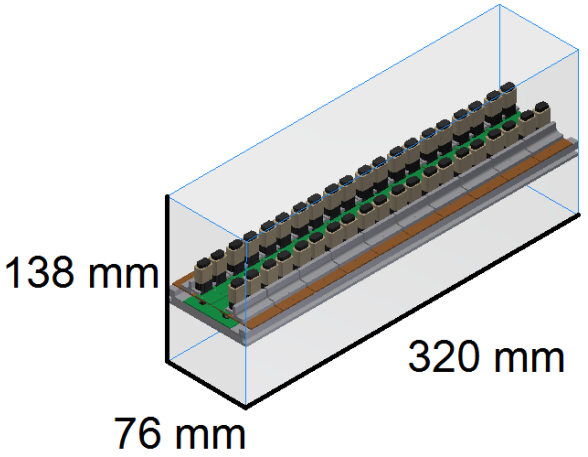


2 x 10 + 2 opto-boxes
2 x (13 or 16) opto-boards/box
644 opto-boards

Opto-Box at End of Stave





- 2 x 10 opto-boards/box for comparison
- 5 to 7 cm of clearance on the sides for cable/fiber routing & access
- opto-box with low-speed optical down links is 5.5 x smaller

Summary

- preliminary estimate of the physical size of opto-boxes
- opto-board with low-speed optical down links is more reliable
  - a broken link results in loss of 1-2 modules instead of half stave
  - opto-box is 5.5 x smaller