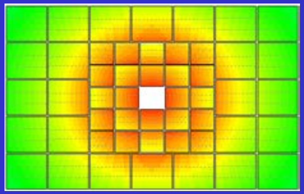
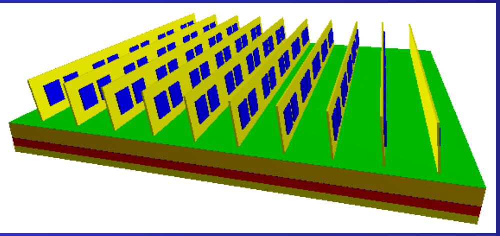


Summary of TRD pad plane, front-end boards and readout chain

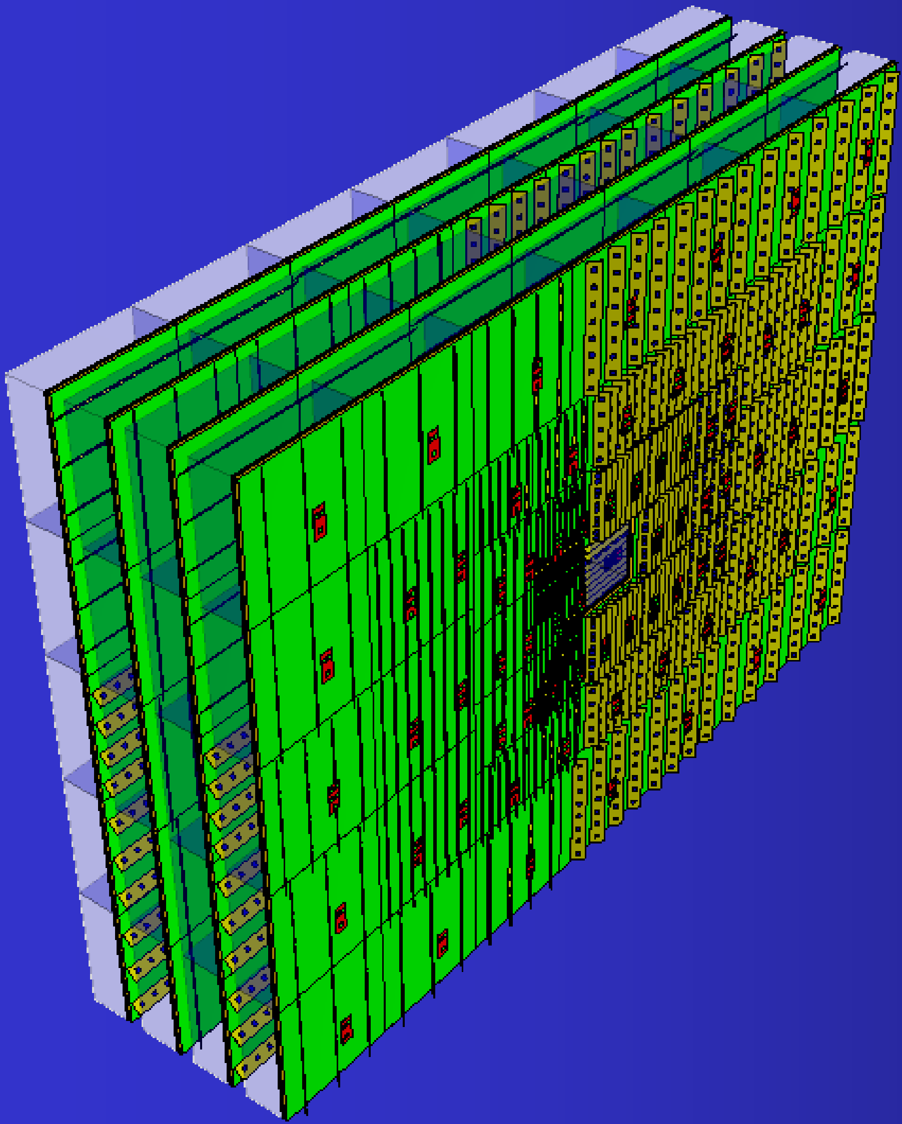
David Emschermann
GSI Darmstadt



Outline

- TRD requirements
- MWPC geometry
- pad plane constraints
- 6 module types
- FEB types
- optimisation beyond TDR
- readout chain

TRD geometry v16b



The TRD geometry v16b described in the TDR:

<u>SIS 100</u>

1	station
4	layers
200	modules
280	ROBs
1384	GBTx
1112	FEBs
8992	32ch ASICs
287744	channels

TRD requirements

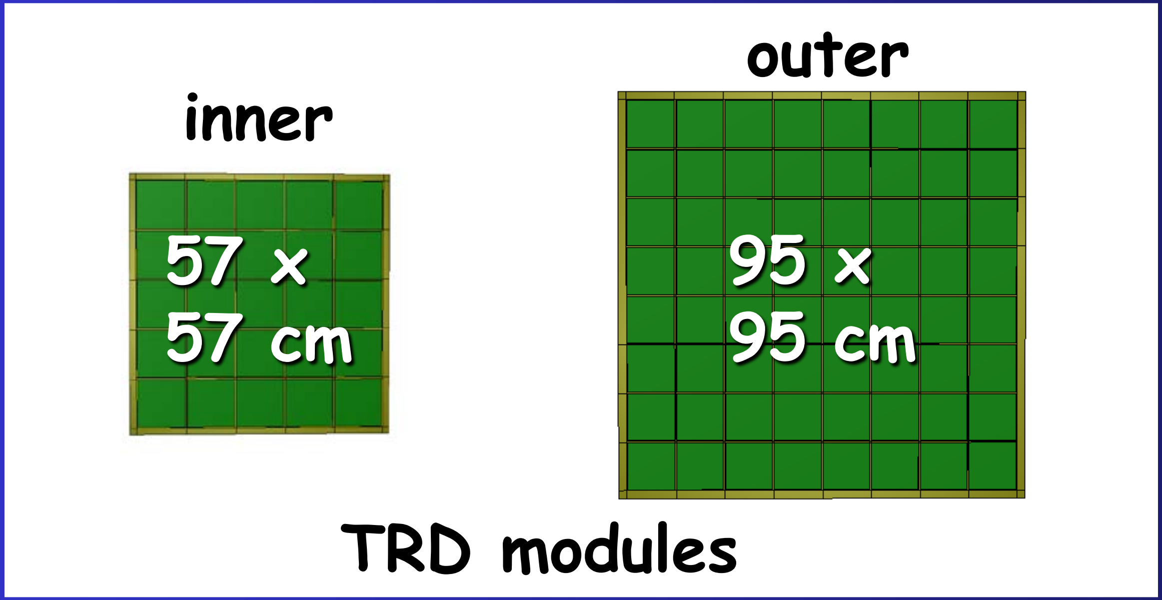
- pion suppression factor 10-20 > 6 GeV/c (@ 90% e-efficiency)
- position resolution of 200 – 300 µm
- rate capability up to 100 kHz/cm²
- capability to deal with high multiplicity

TRD layout

- rectangular pads
- MWPC modules of squared shape
- modules rotated between neighboring layers
- all services connected through the backside
- 2 module sizes, 6 module types
- 4 layers

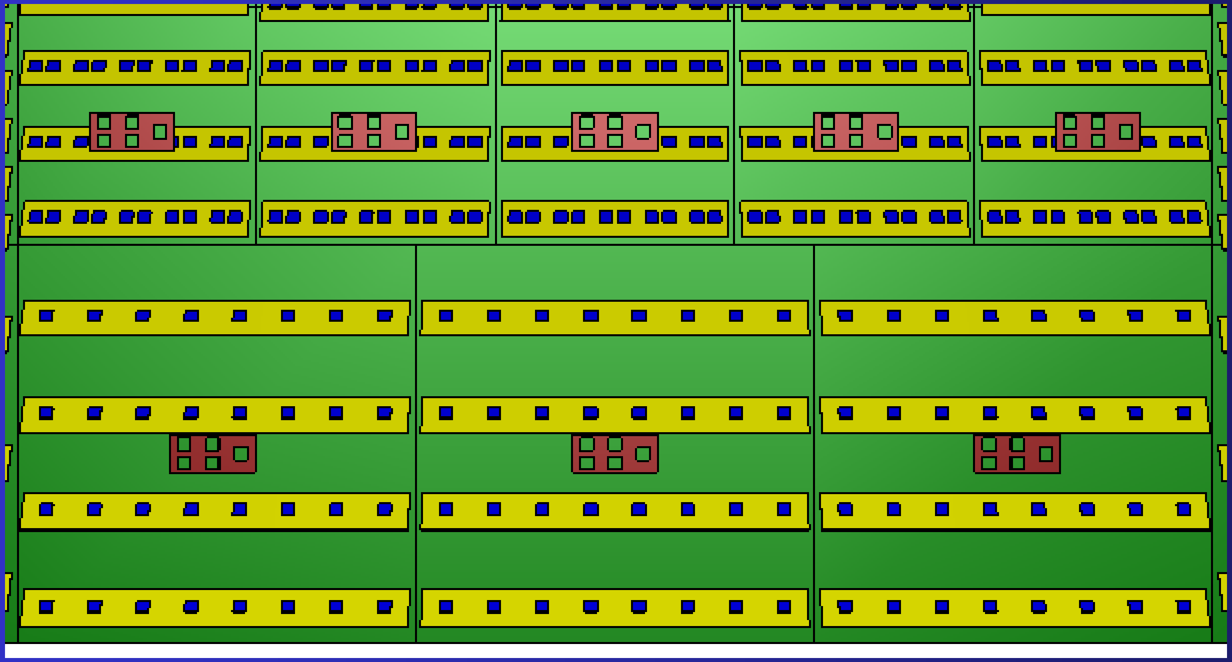
2 TRD module sizes

2 different TRD module sizes



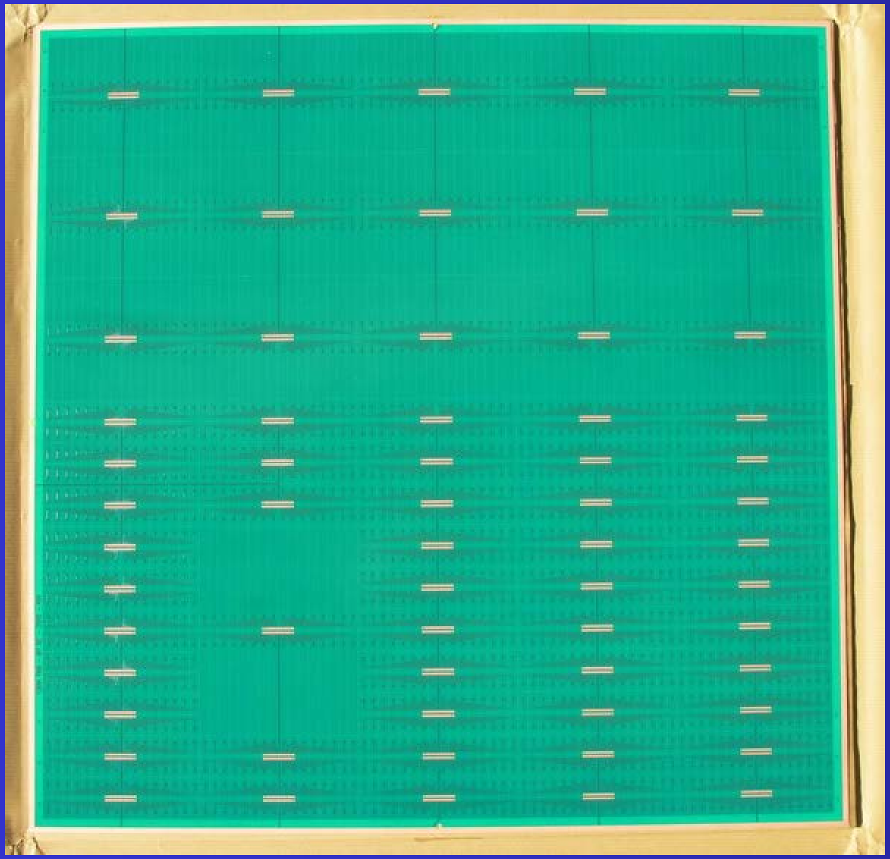
The small module is built from a single pad plane PCB.
The maximum width the PCB manufacturer can handle is: 590 mm.
We build pad planes of 580 mm x 580 mm size.
The resulting small module size is 570 mm x 570 mm.
The large module can be built from 2 PCB pieces.

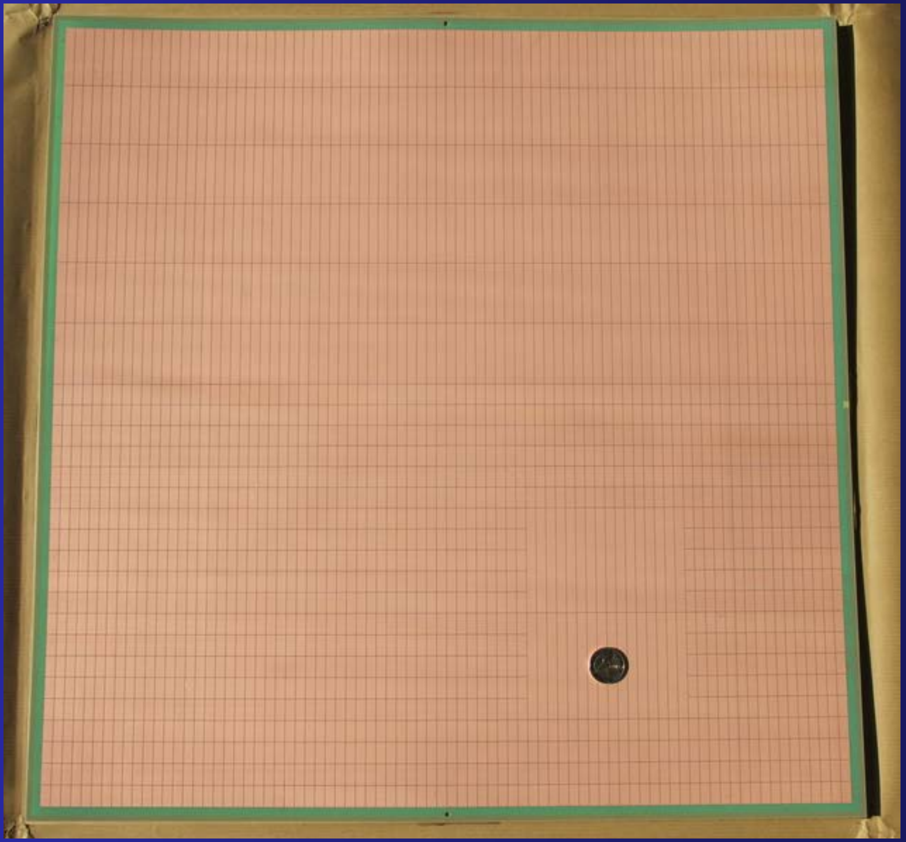
Module size ratio



The large module size is given by the layer design:
5 x small module = 3 x large module
5 x 570 mm = 3 x 950 mm

Pad plane material

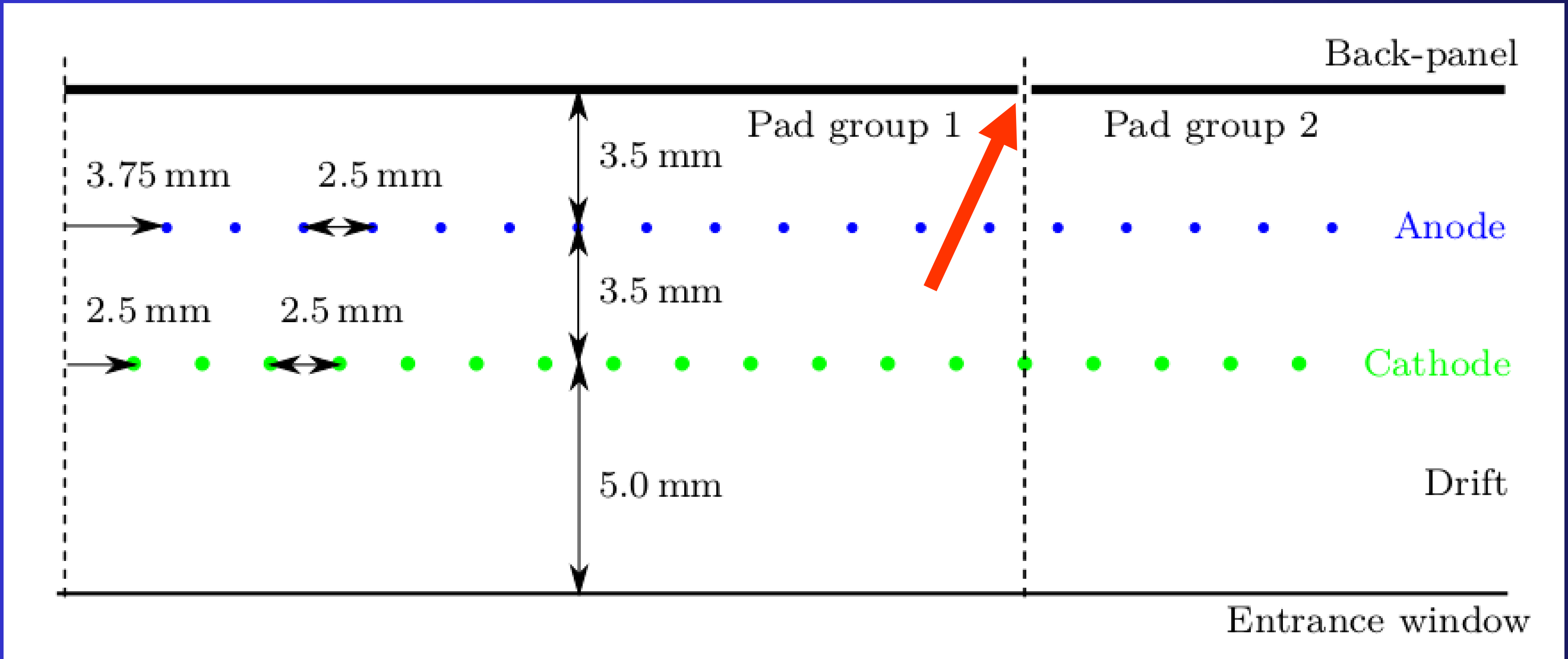




The TRD is a 360 µm thick 2-layer PCB with 25 µm thick Cu layers. PCBs are ordered from the same company as for the ALICE TRD production.

Pad size and orientation

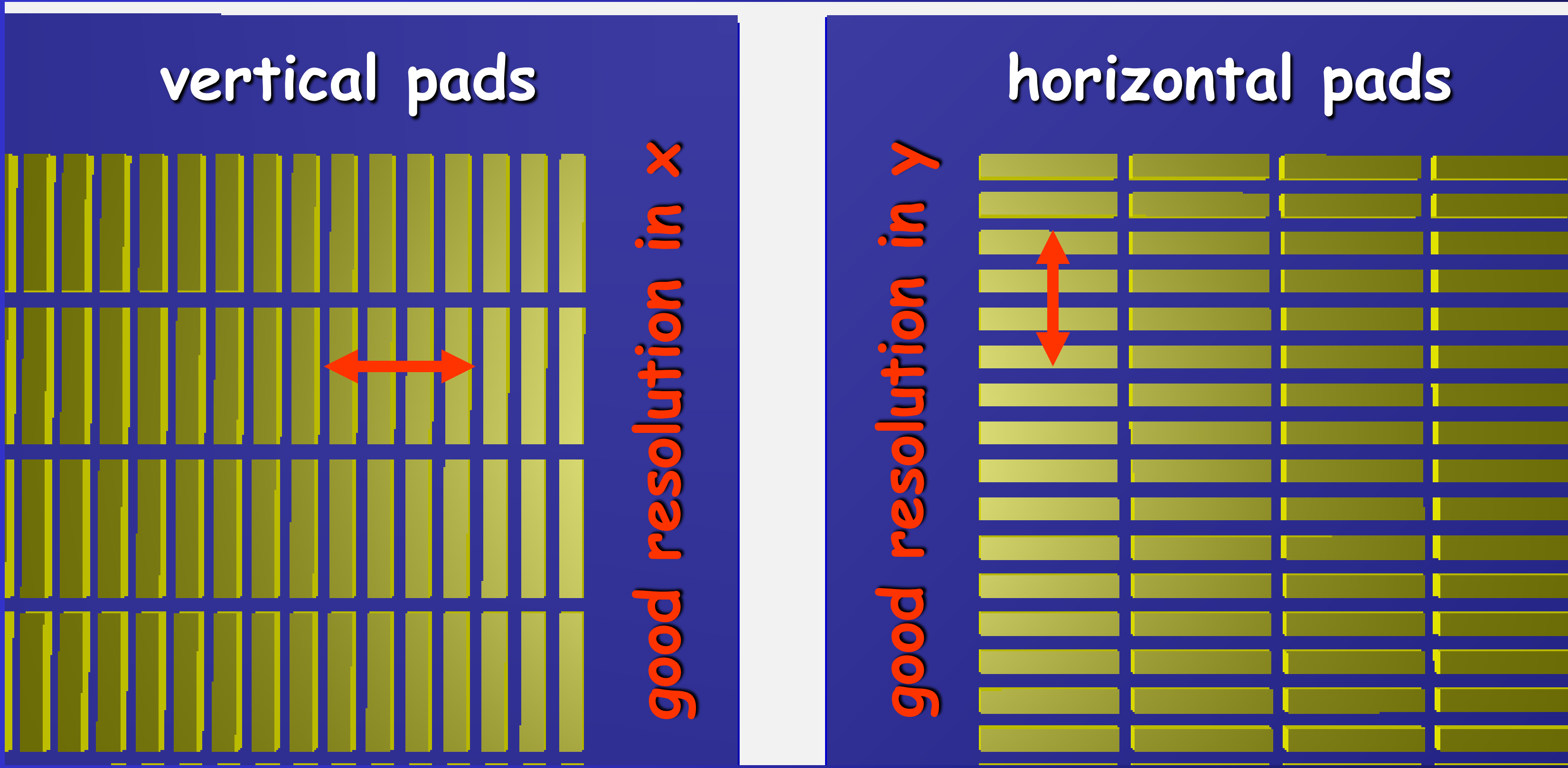
Pad length



The pad length is an integer multiple of the anode wire pitch. The edge of a pad ends between 2 anode wires. This allows for minimal charge sharing between pad rows.

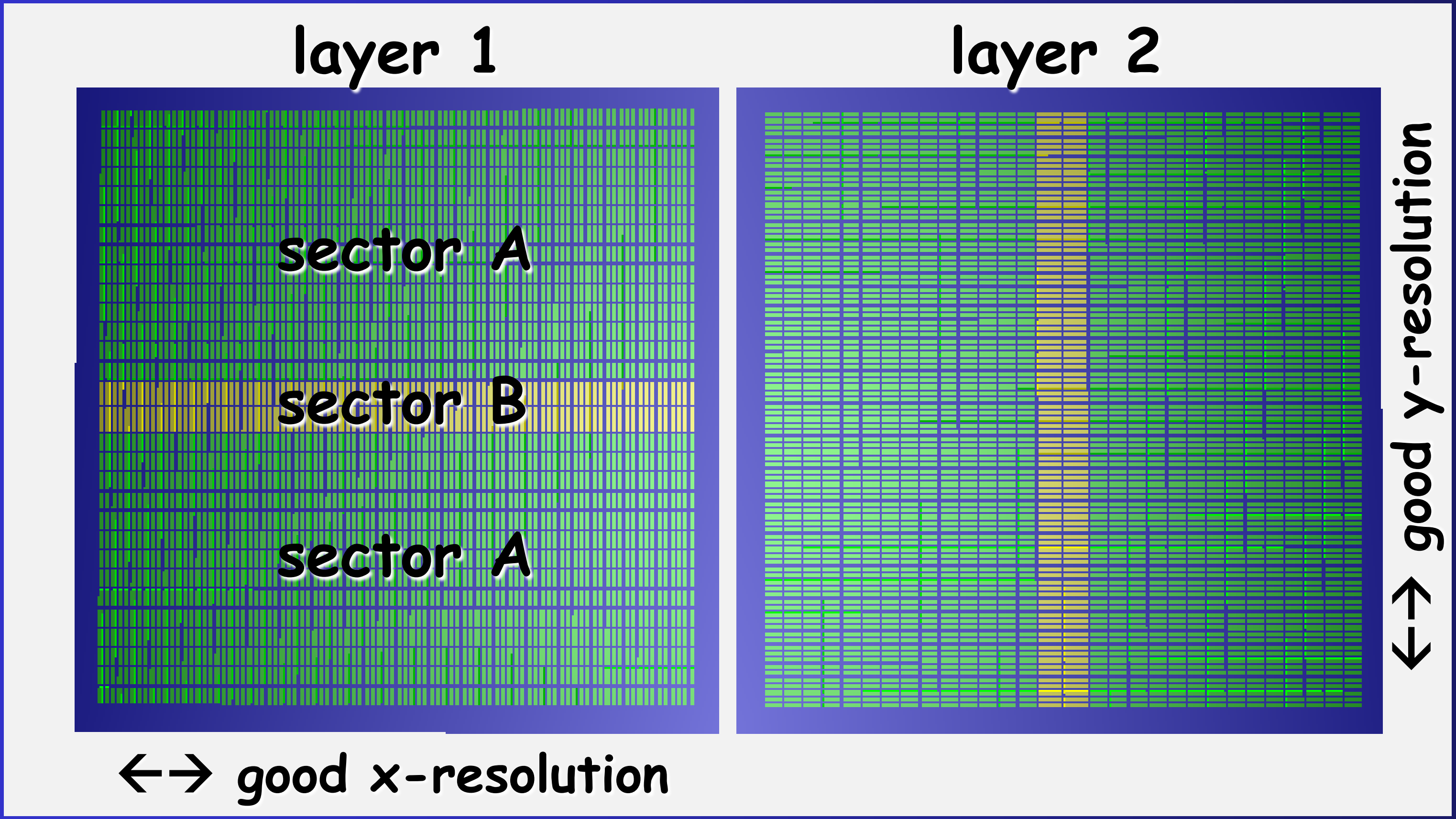
TRD modules - 90° rotated

odd layers (1,3) | even layers (2,4)



here: 7.5mm x 30mm pad size

Pad sectors in TRD modules



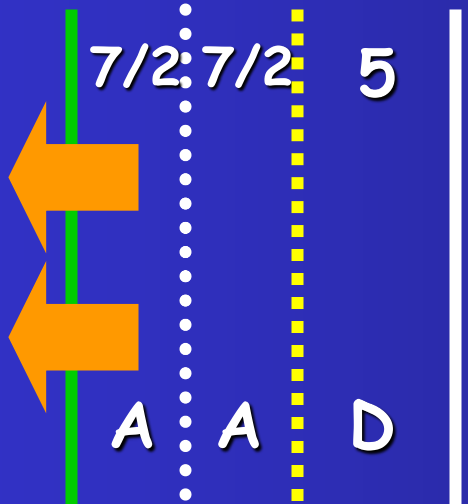
A module can contain pads of different size, they have a fixed width (6.75mm for small modules, 7.12mm for large modules) but may differ in height.

MWPC geometries

TRD wire geometry

TRD 3.5/3.5/5

Data readout



42% drift

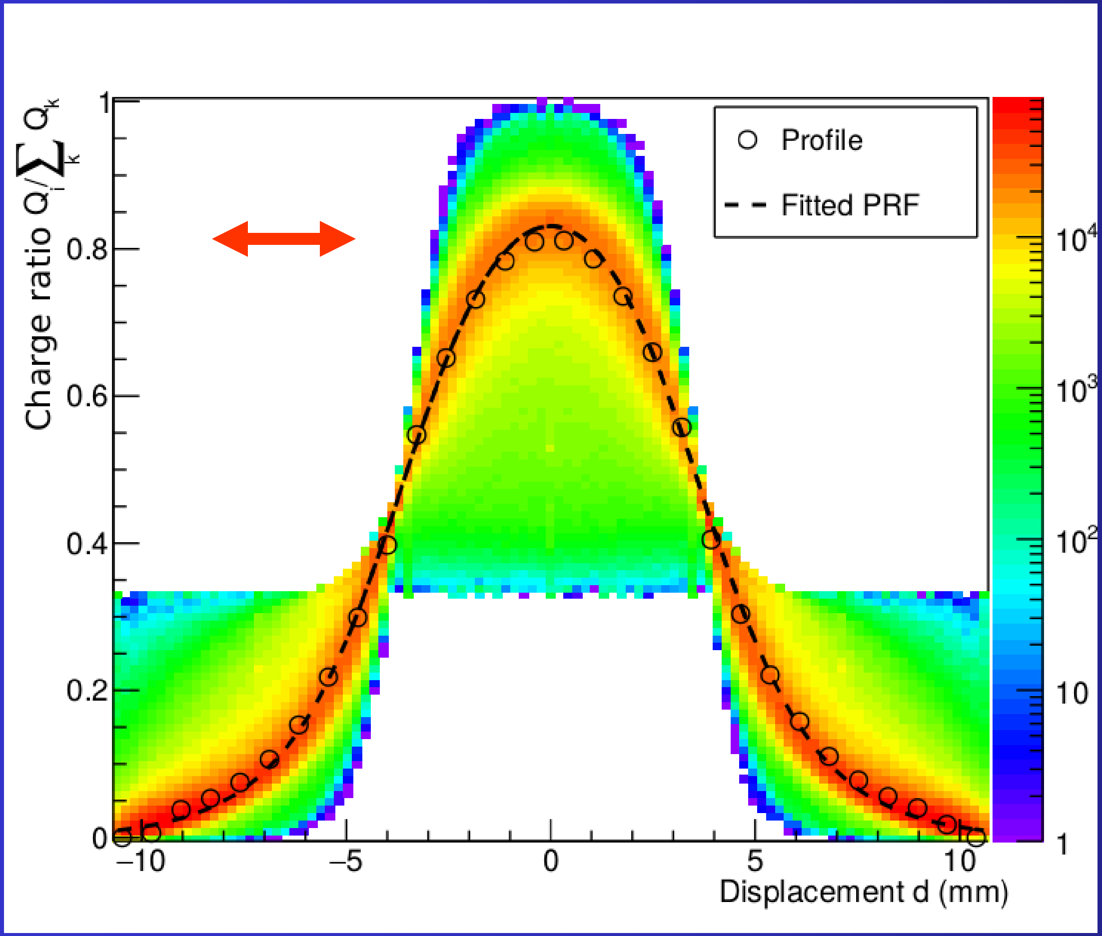
12 mm thickness

signal collection time

255 ns	TRD 3/3/6
230 ns	TRD 3.5/3.5/5
210 ns	TRD 4/4/4

signal collection in Xe/CO_2 (80/20), @ 100V/mm drift

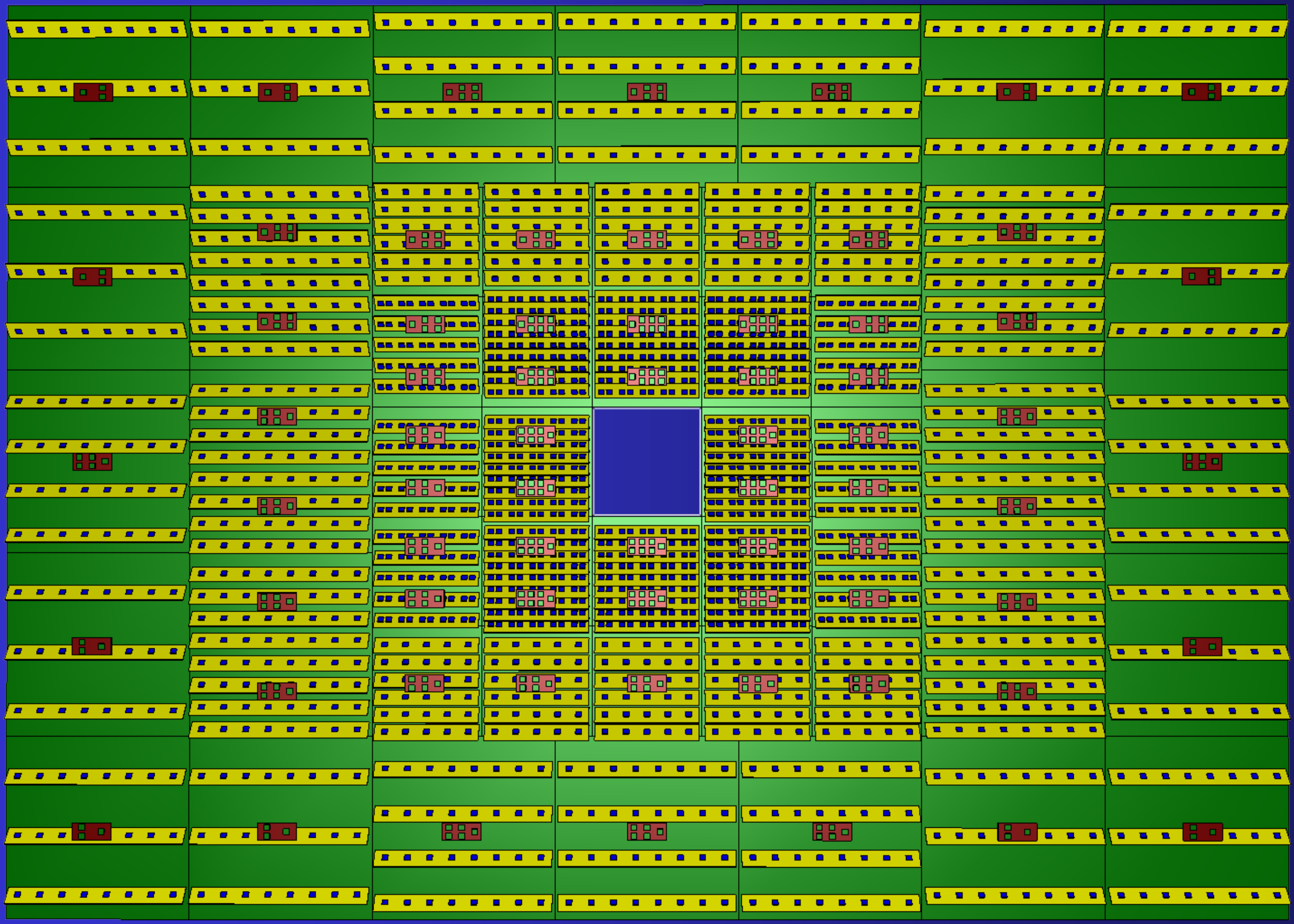
Pad response function



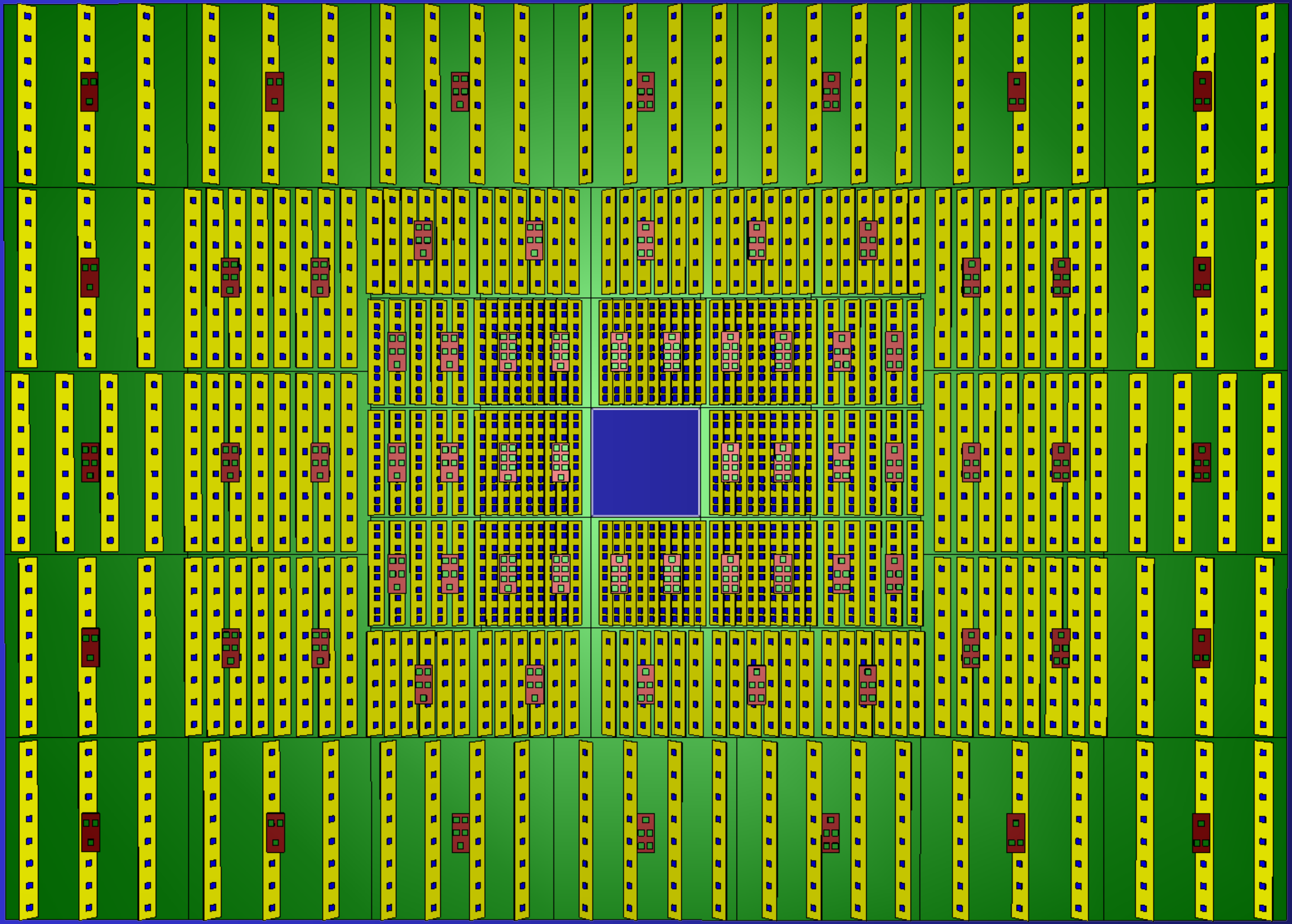
We have aimed at a signal distribution of 10-80-10% between the central and neighboring pads, which is achieved according to beam test data from 2015, see PRF function on the left side.

Pad plane layout

TRD v16b layer 1

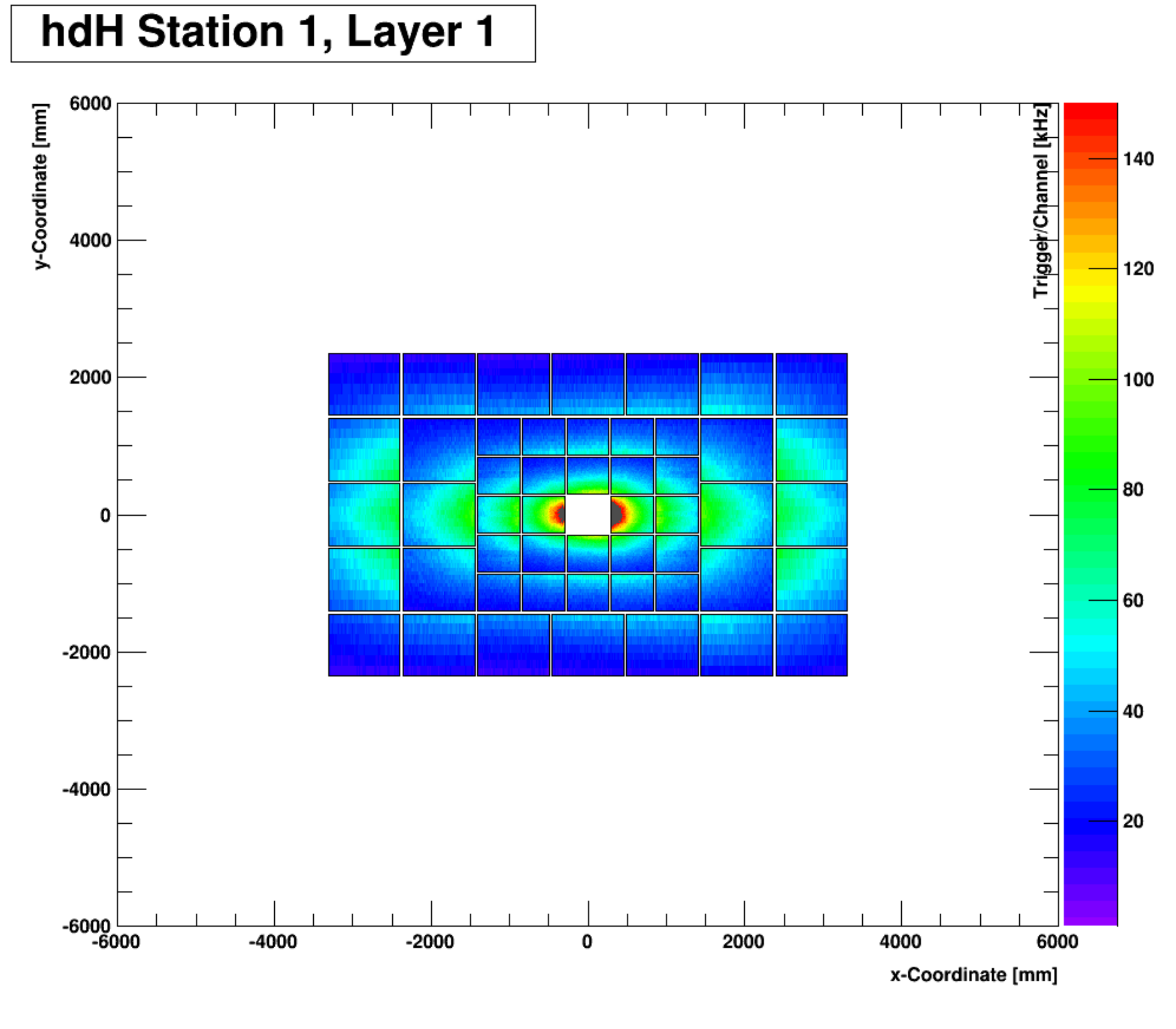


TRD v16b layer 2



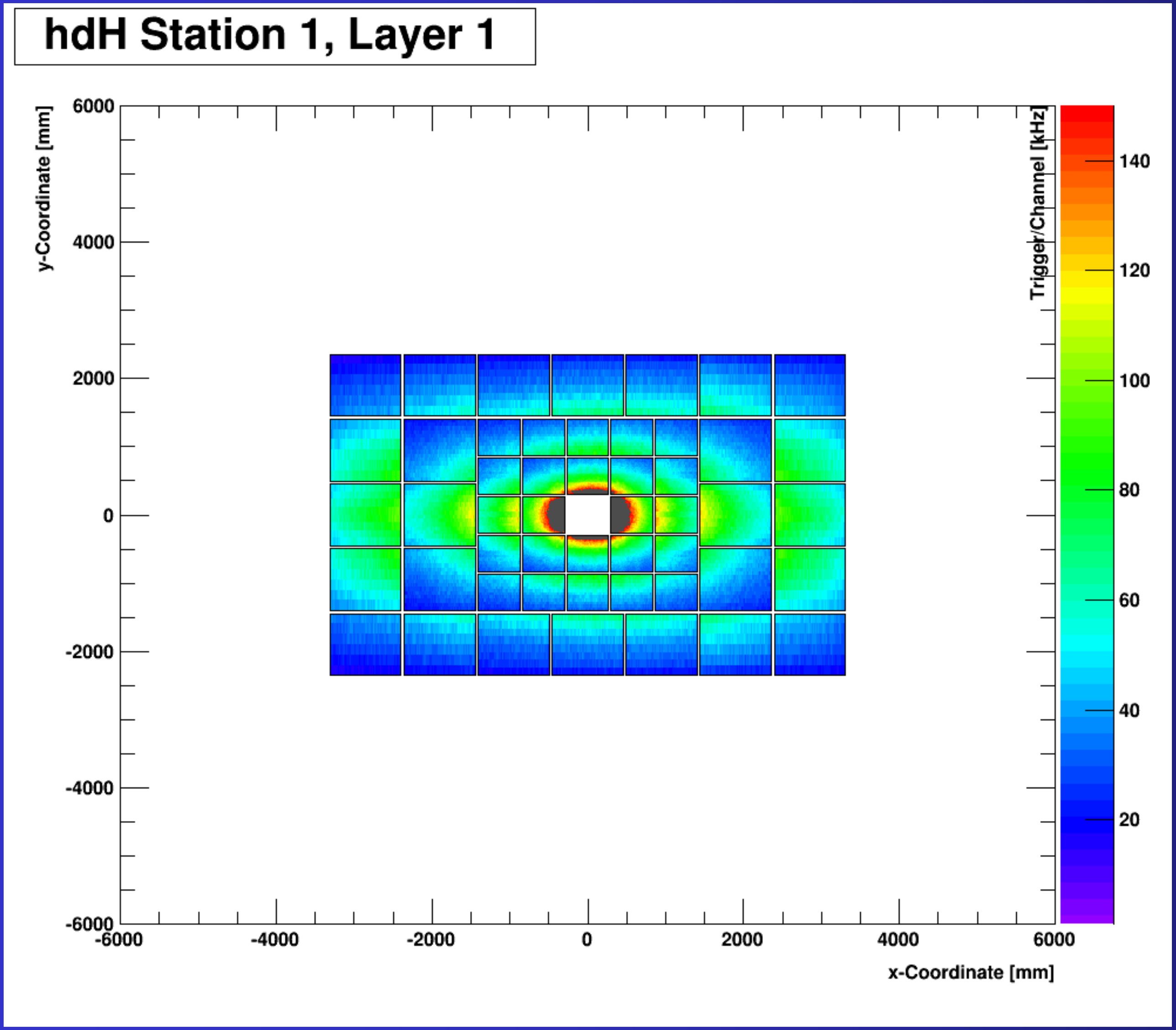
Trigger rate distribution

TRD hit rates RICH v08a



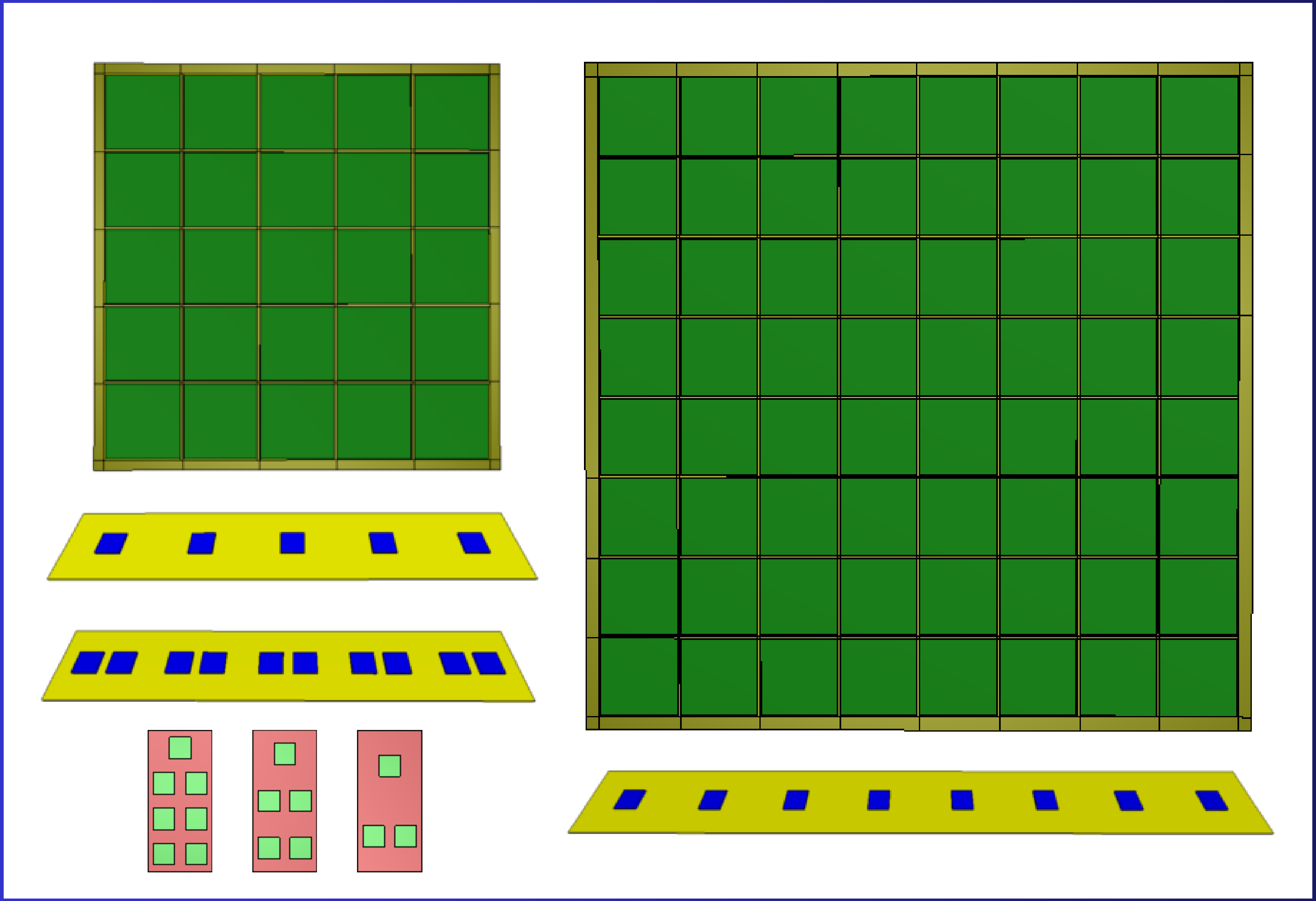
TRD trigger rates with legacy RICH v08a (small amount of material upstream)

TRD hit rates RICH v14a

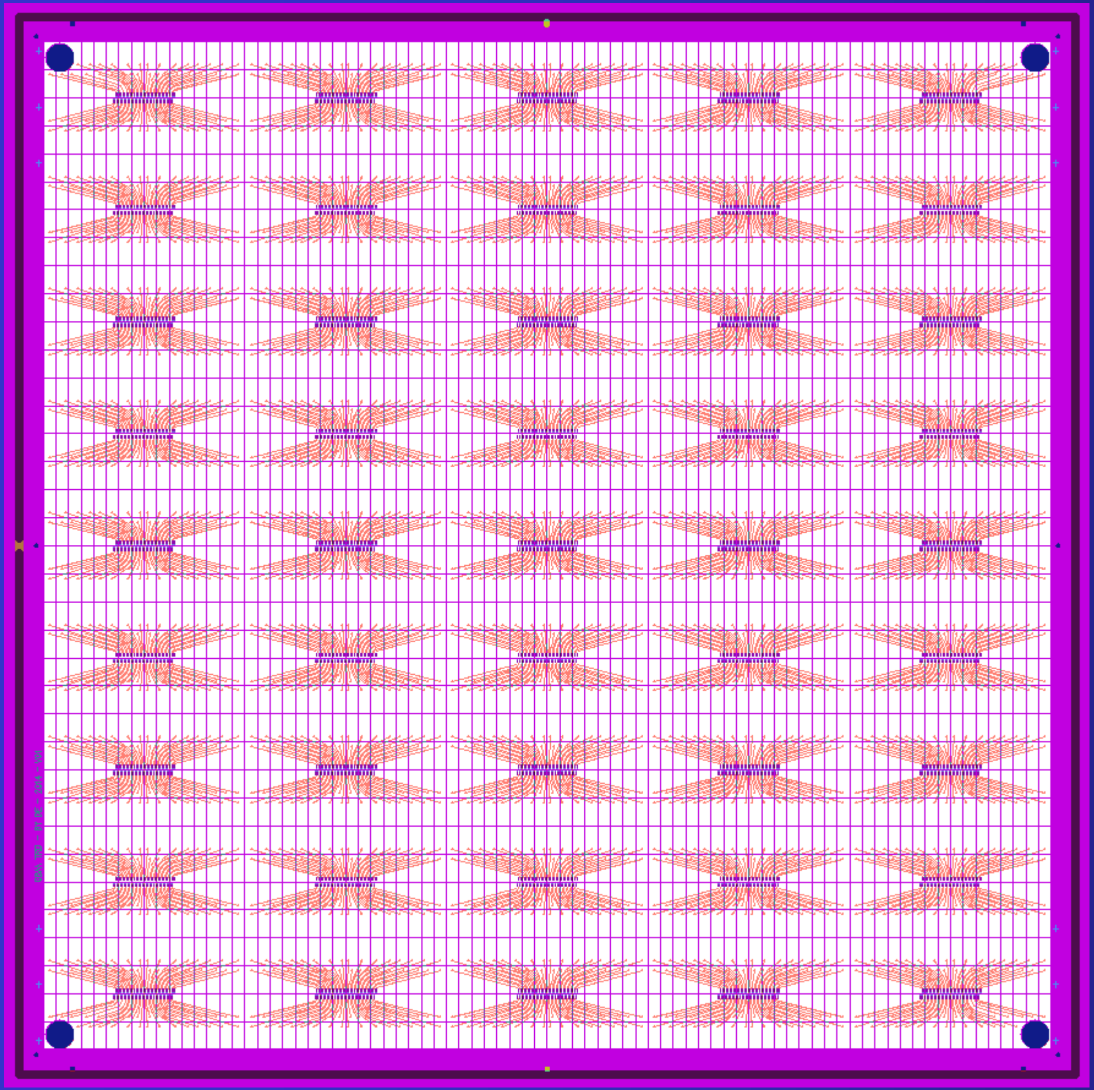


TRD trigger rates with RICH v14a (larger amount of material due to modified support struture)

TRD v16b components

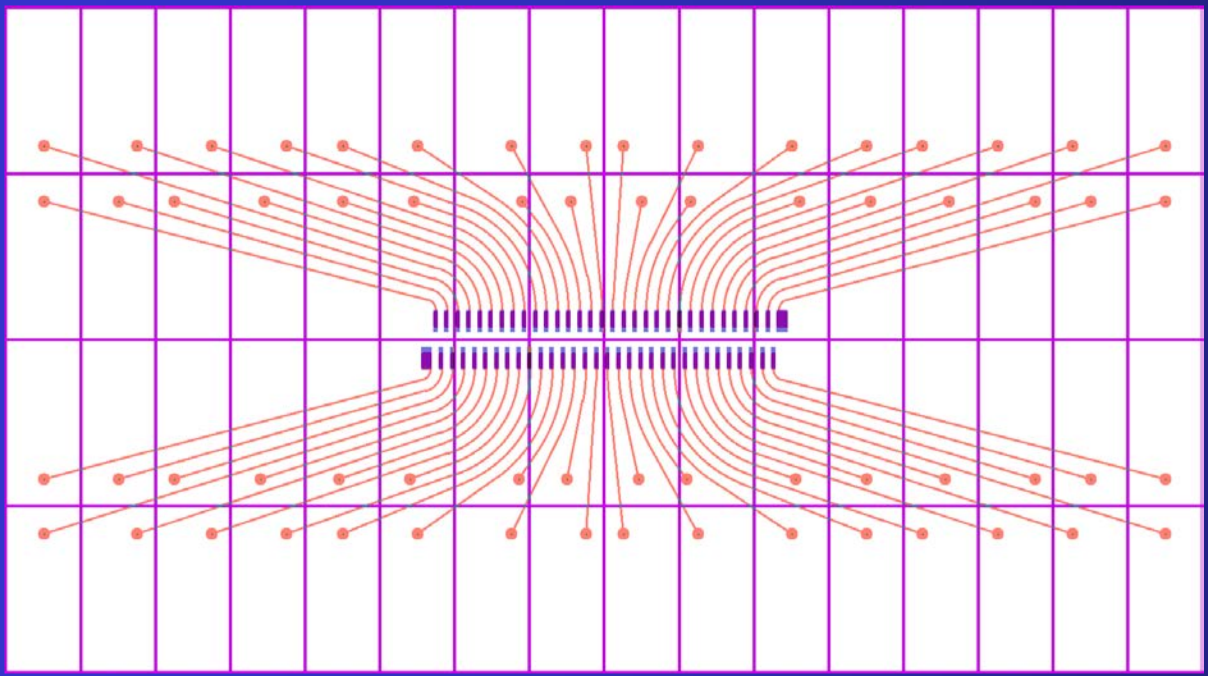


Type 1 pad plane v16b



- 36 rows, 80 columns
- 2880 pads
- 1.01 cm² pad size
- 45x 64-pin connectors
- 5 connectors per row
- 4 rows per connector

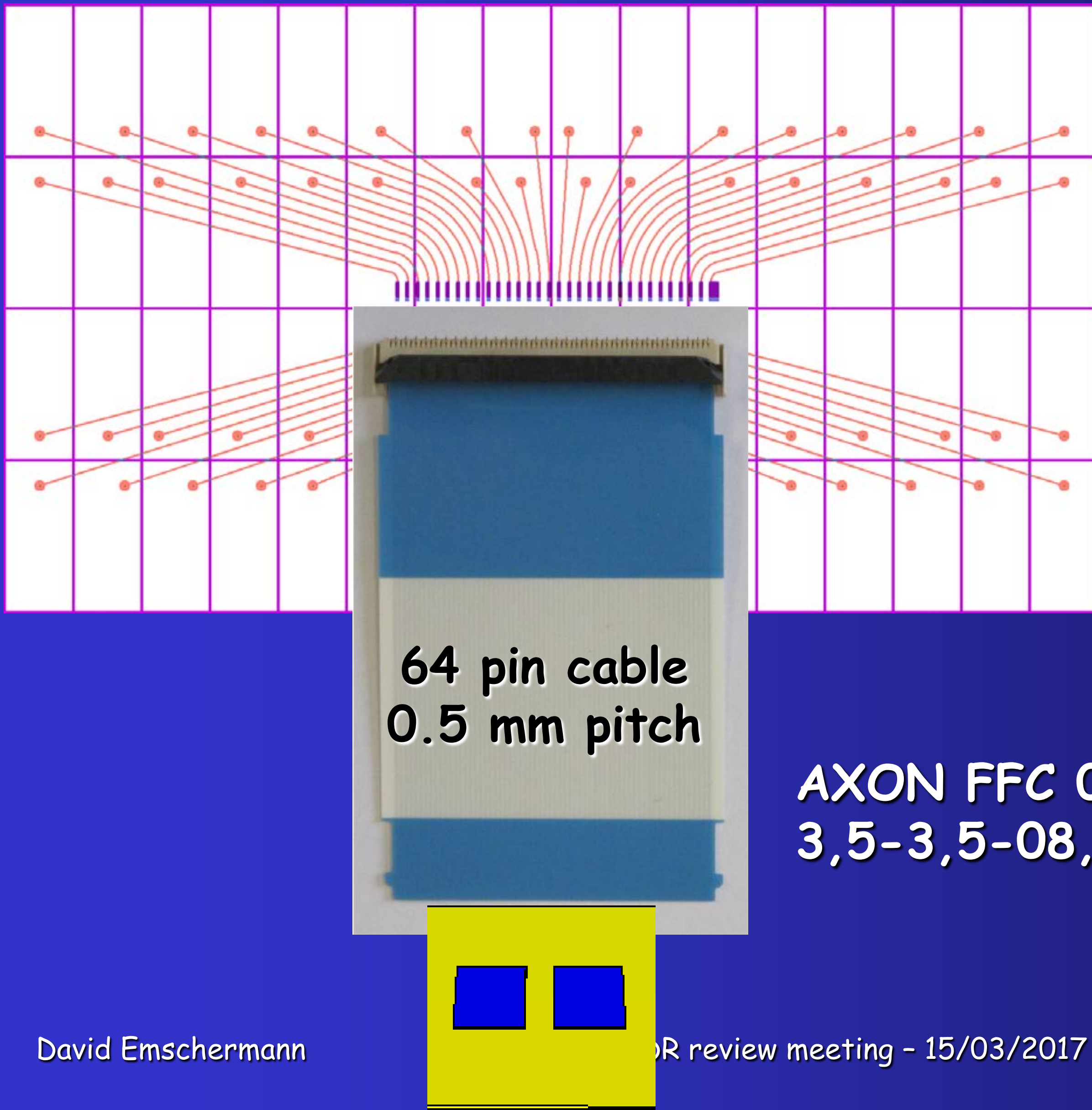
Type 1 pad block v16b



- 16 pads block width
- 4 rows a 16 pads = 64 pads

- channel sequence determined by angular pad order
- identical pattern for all footprints of a given module type
- all vias within a pad row are along a straight line (simpler to seal with glue for gas tightness)

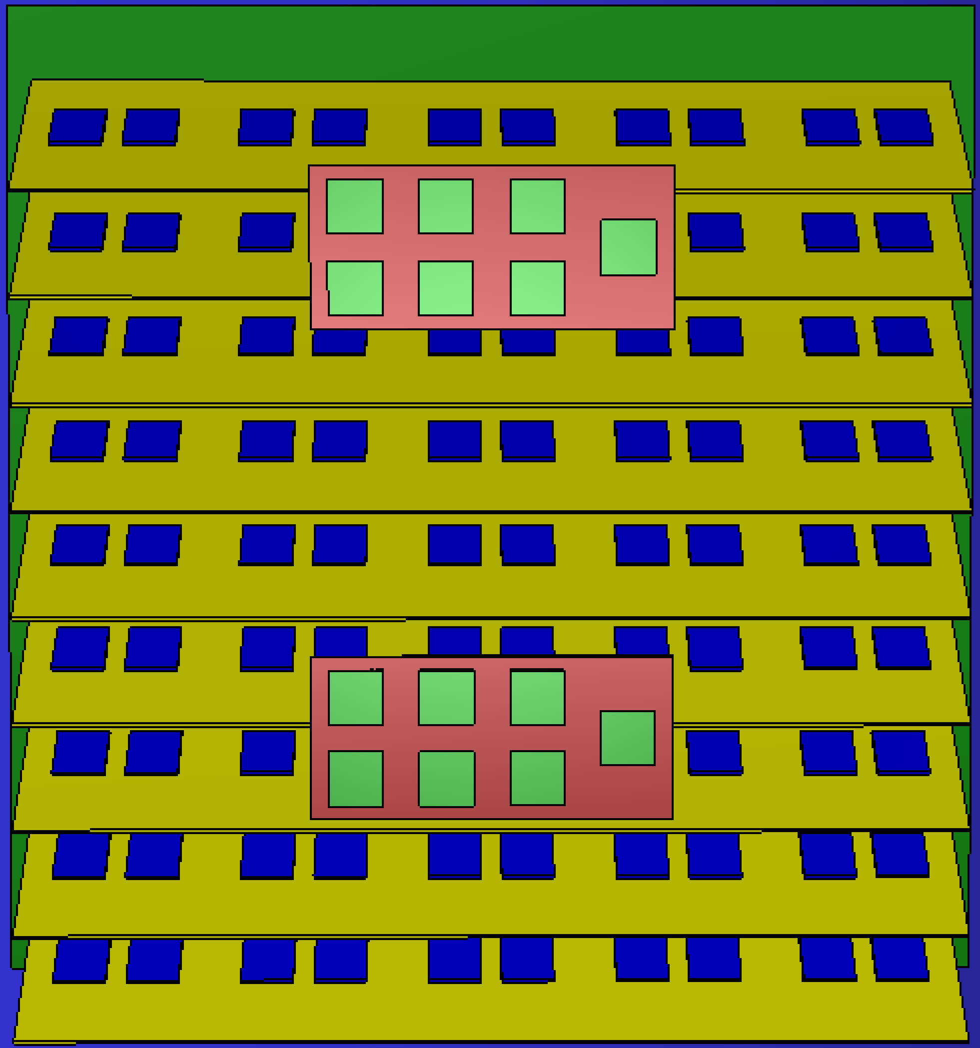
64ch signal cable connection



- 64-pin connectors are solderd to the pad plane
- flat cables are used to connect to the electonics
- 64-pin cables interface to 2x 32ch-SPADICs

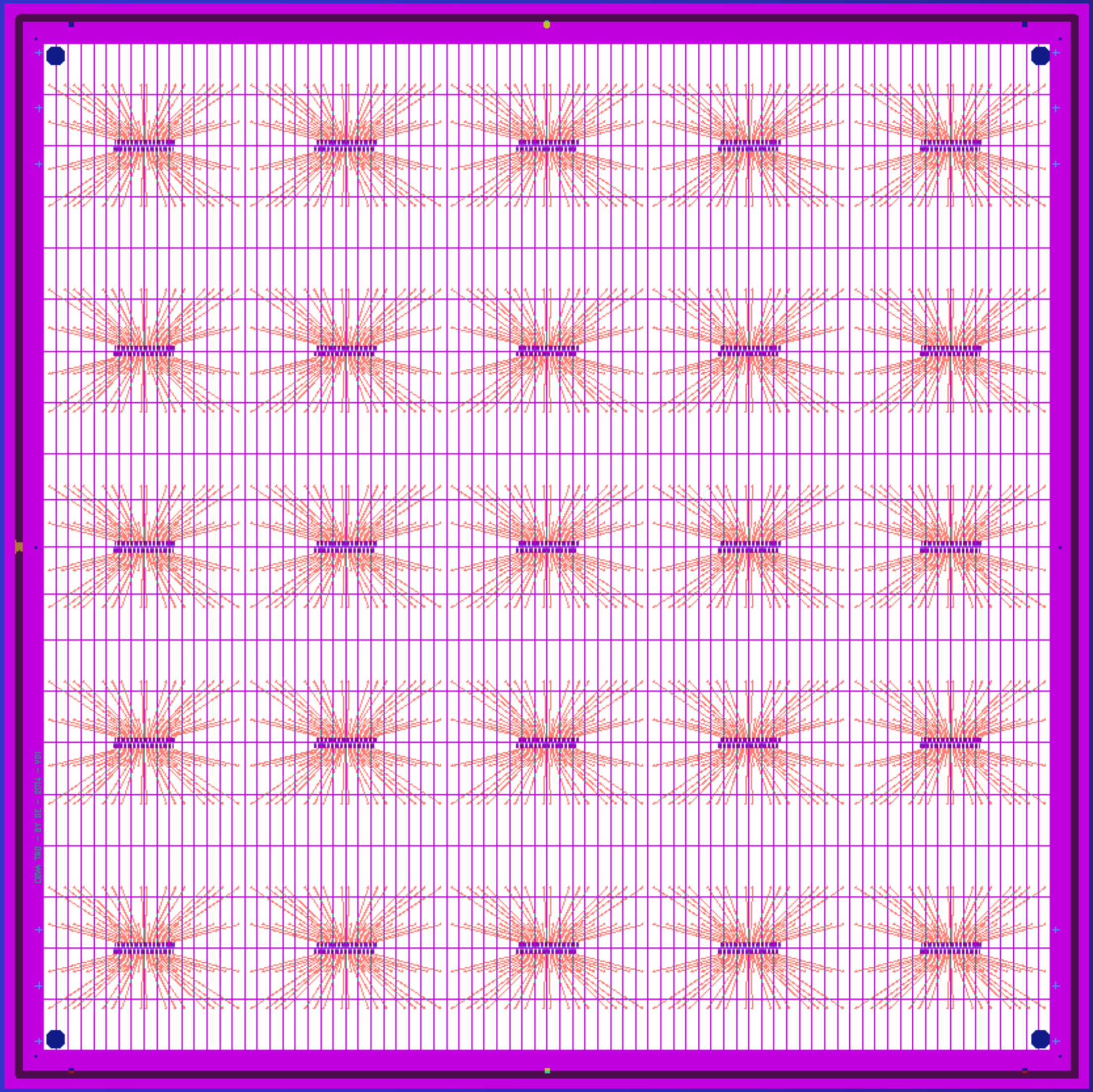
AXON FFC 0.50 A 64 / 0150 S
3,5-3,5-08,0-08,0 F AJJ / N

Module type 1 FEBs



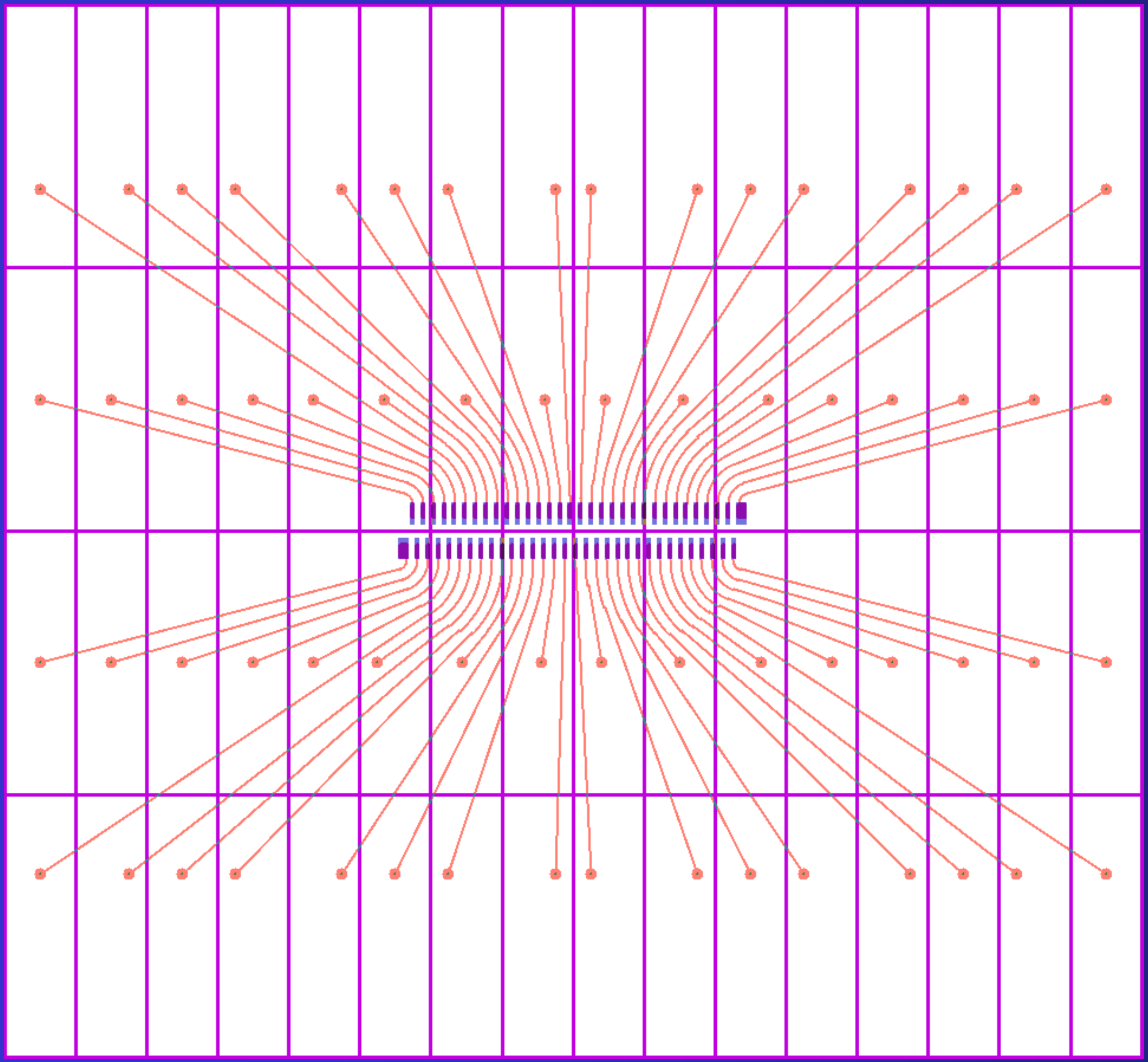
- 2880 channels
- 45x cable connections
- 9 FEBs a 5x2 ASICs
- 2x GBTx ROB-7
- 16 optical links
  2x down- 14x uplink
- 180/196 e-links used
- 92% uplink efficiency

Type 2 pad plane v16b

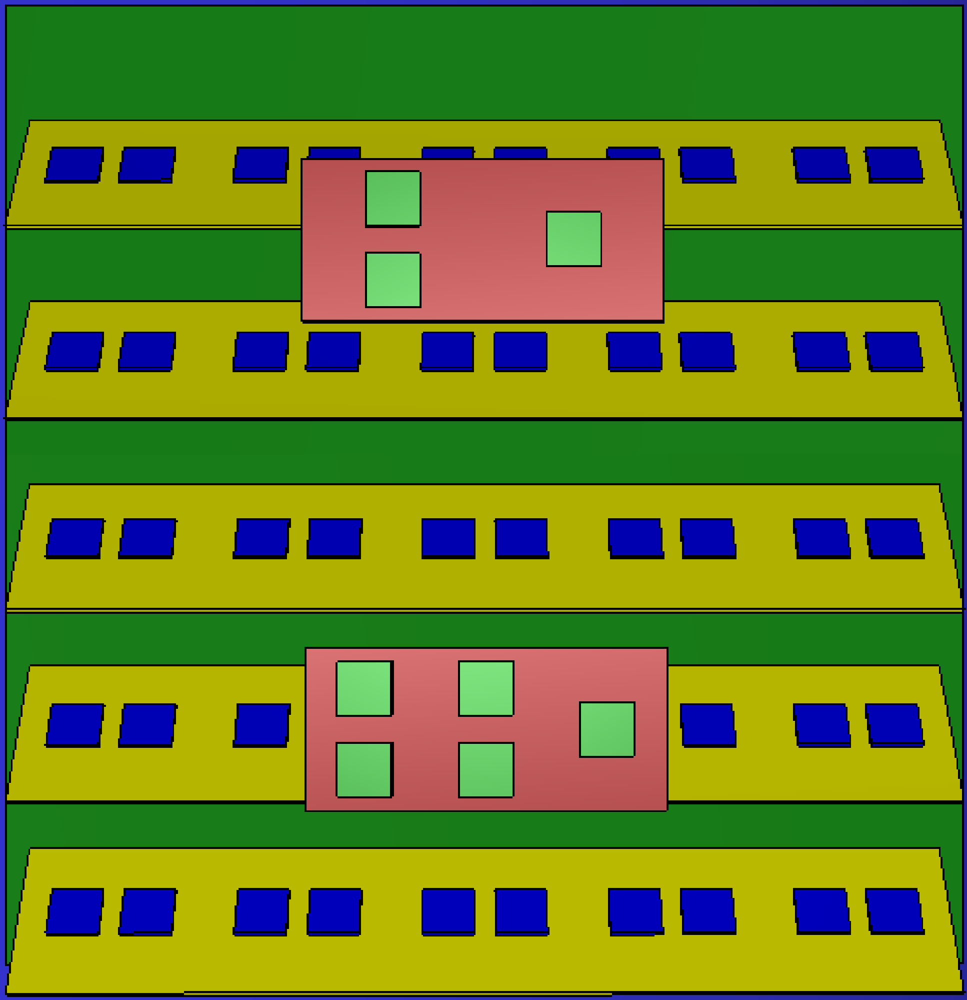


- 20 rows, 80 columns
- 1600 pads
- 1.69 cm² pad size
- 25x 64-pin connectors
- 5 connectors per row
- 4 rows per connector

Type 2 pad block v16b

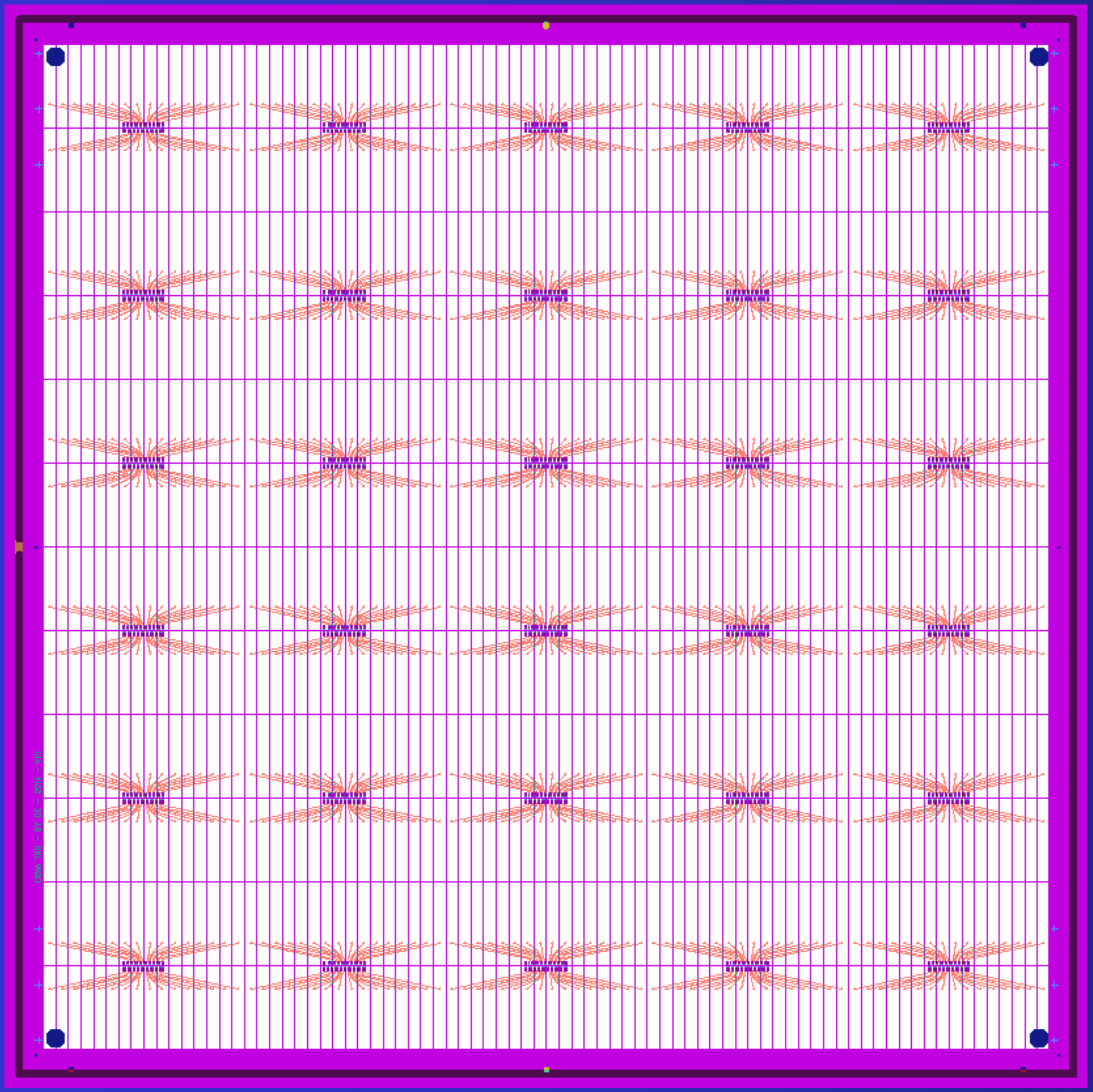


Module type 2 FEBs



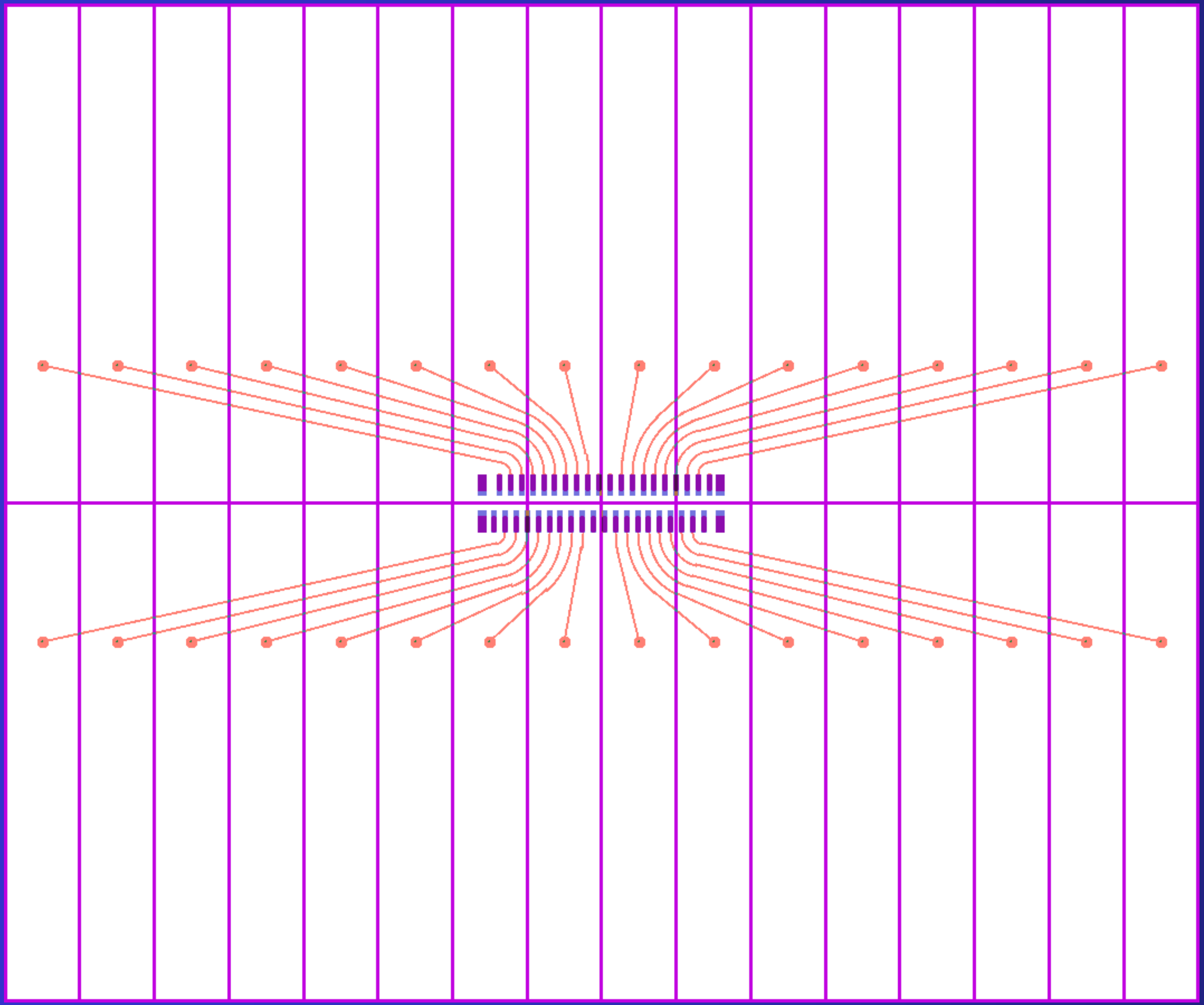
- 1600 channels
- 25x cable connections
- 5 FEBs a 5x2 ASICs
- 1x GBTx ROB-3
- 1x GBTx ROB-5
- 10 optical links
  2x down- 8x uplink
- 100/112 e-links used
- 89% uplink efficiency

Type 3 pad plane v16b



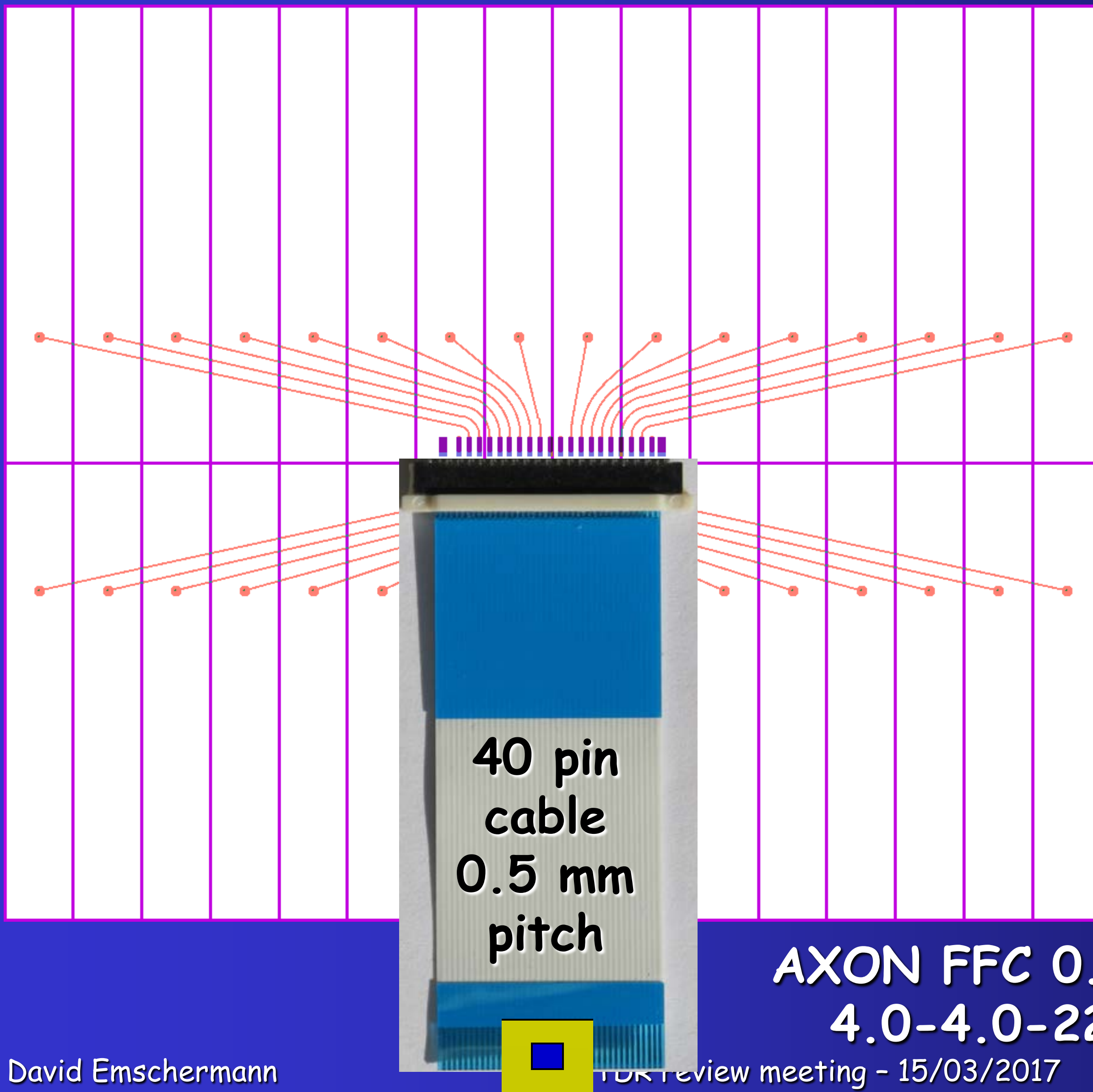
- 12 rows, 80 columns
- 960 pads
- 3.04 cm² pad size
- 30x 32-pin connectors
- 5 connectors per row
- 2 rows per connector

Type 3 pad block v16b



This type of connector layout is also used on all large detectors, module types 6,7,8

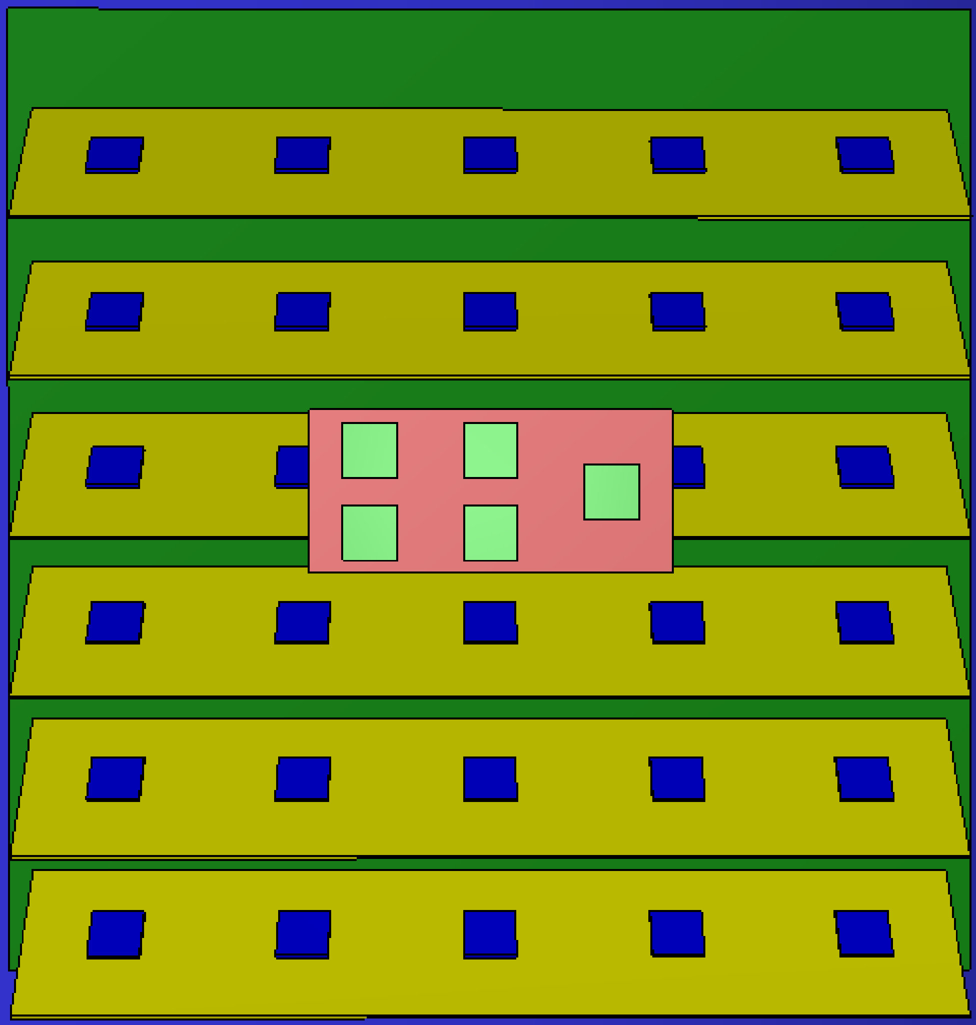
32ch signal cable connection



- 40-pin connectors (for historical reasons) are solderd to the pad plane
- flat cables are used to connect to the electonics
- 40-pin cables interface to 1x 32ch-SPADIC

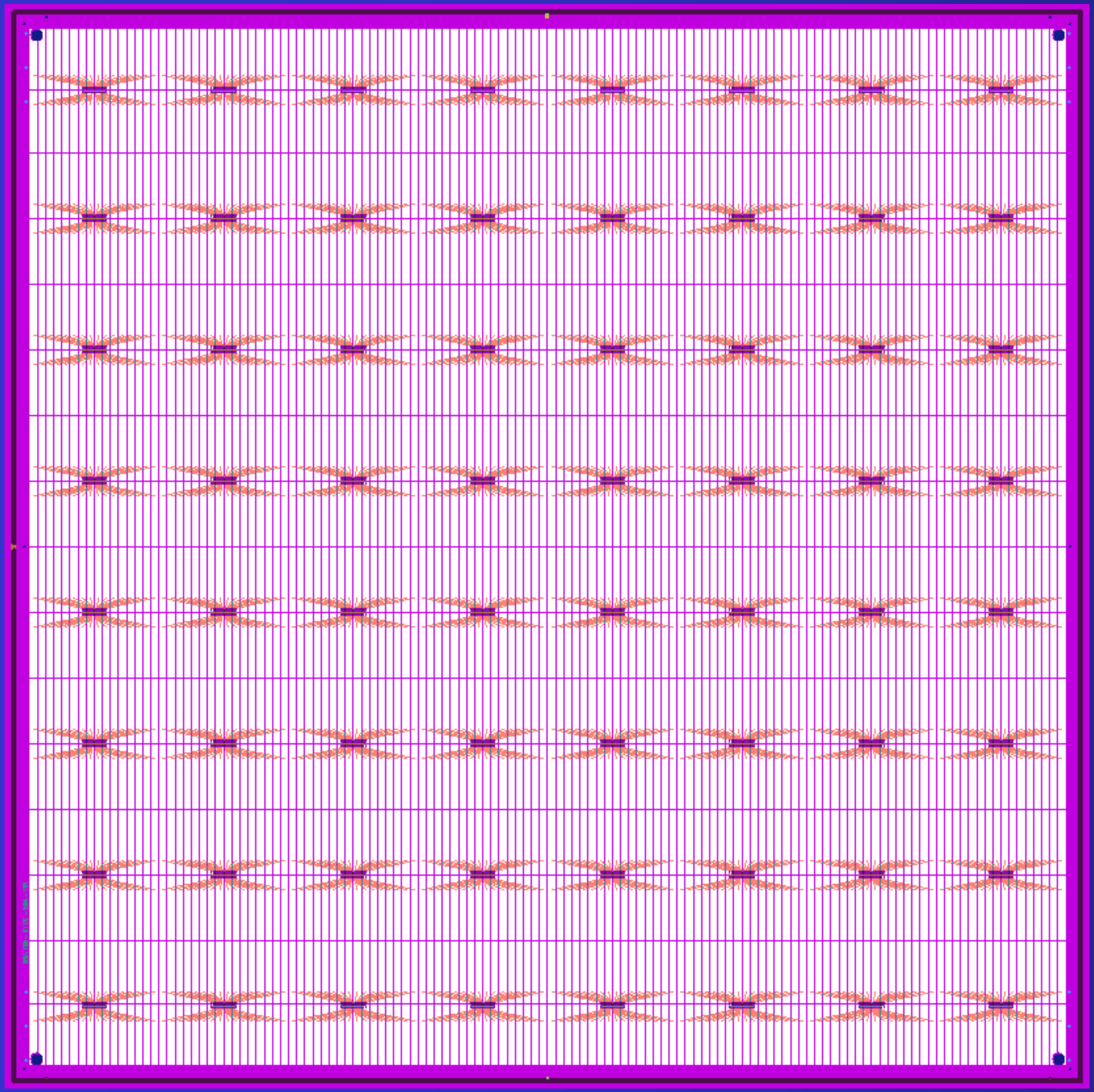
AXON FFC 0.50 A 40 / 0046 L
4.0-4.0-22.0-08.0 S ABB

Module type 3 FEBs



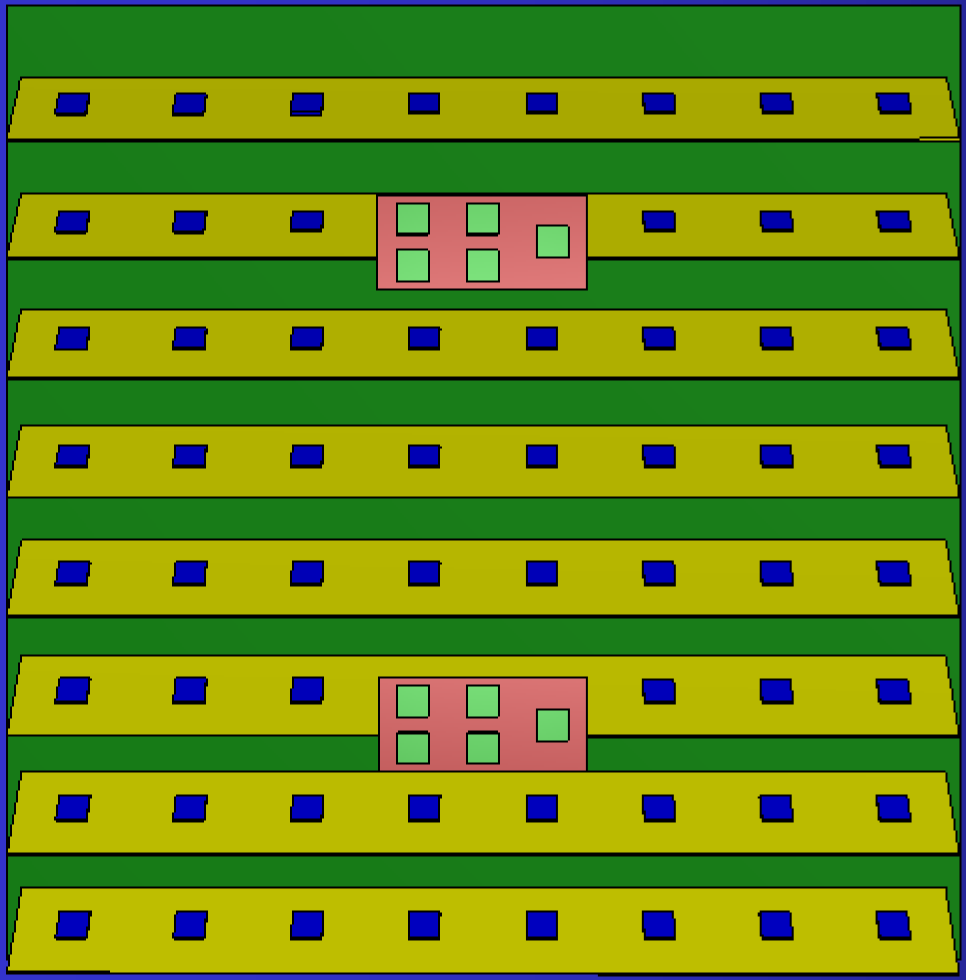
- 960 channels
- 30x cable connections
- 6 FEBs a 5x1 ASICs
- 1x GBTx ROB-5
- 6 optical links
  1x down- 5x uplink
- 60/70 e-links used
- 86% uplink efficiency

Type 6 pad plane v16b



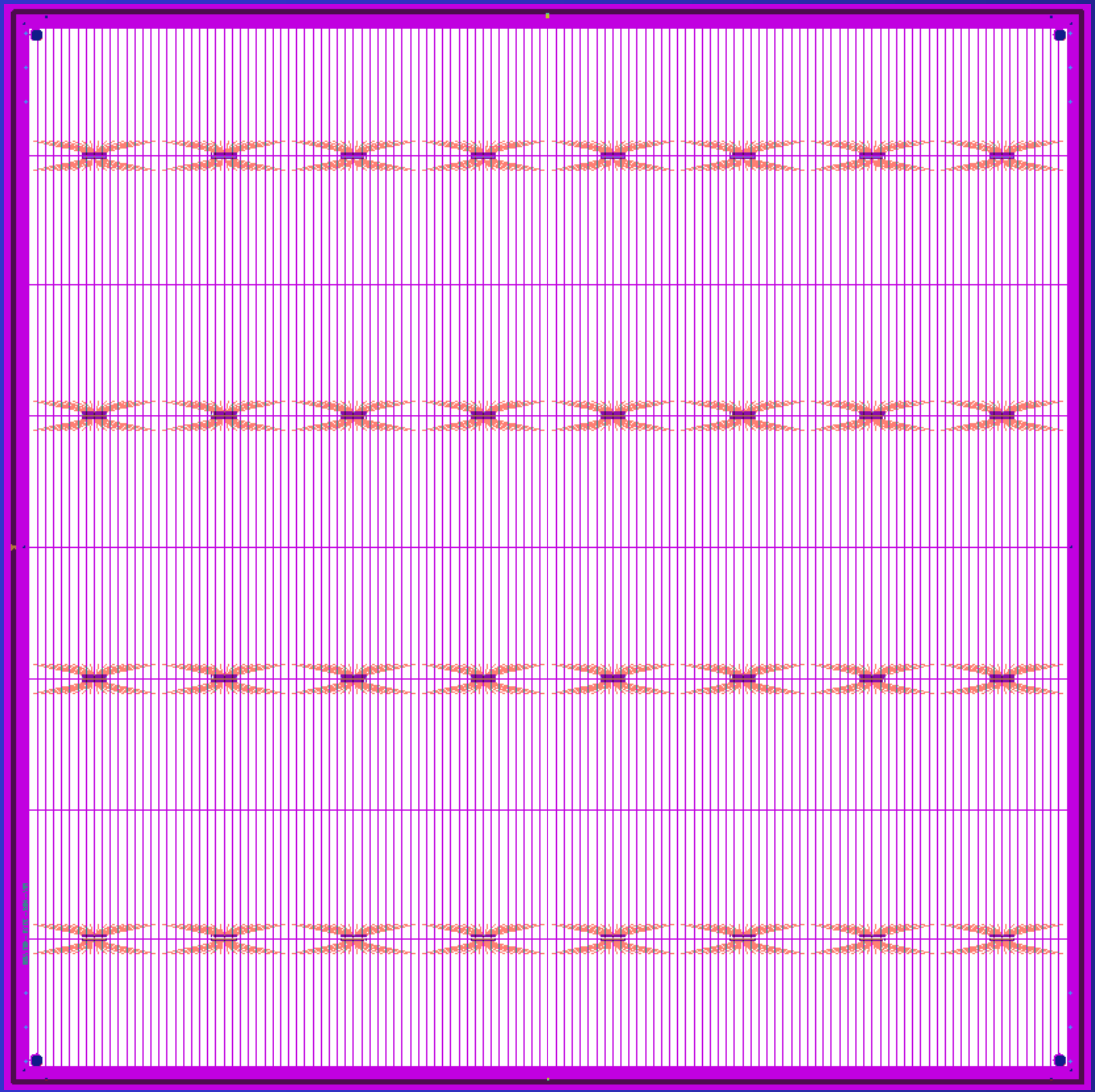
- 16 rows, 128 columns
- 2048 pads
- 4.13 cm² pad size
- 64x 32-pin connectors
- 8 connectors per row
- 2 rows per connector

Module type 6 FEBs



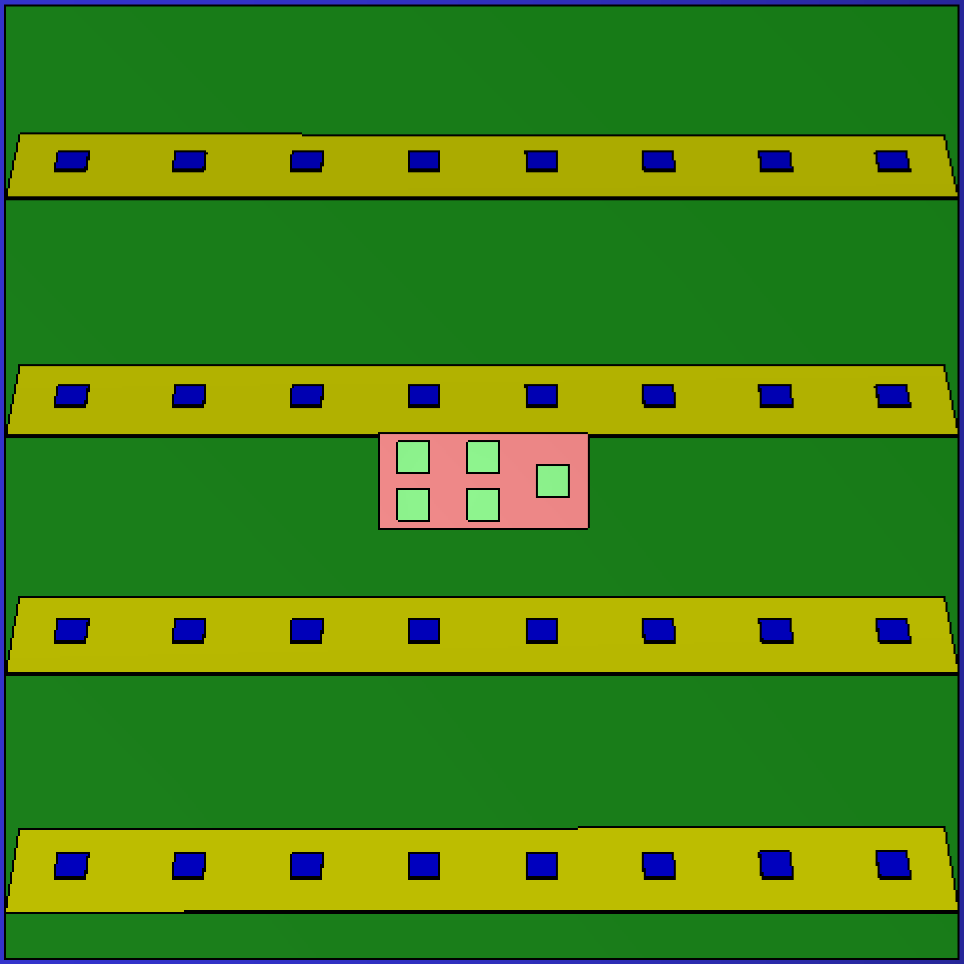
- 2048 channels
- 64x cable connections
- 8 FEBs a 8x1 ASICs
- 2x GBTx ROB-5
- 12 optical links
  2x down- 10x uplink
- 128/140 e-links used
- 91% uplink efficiency

Type 7 pad plane v16b



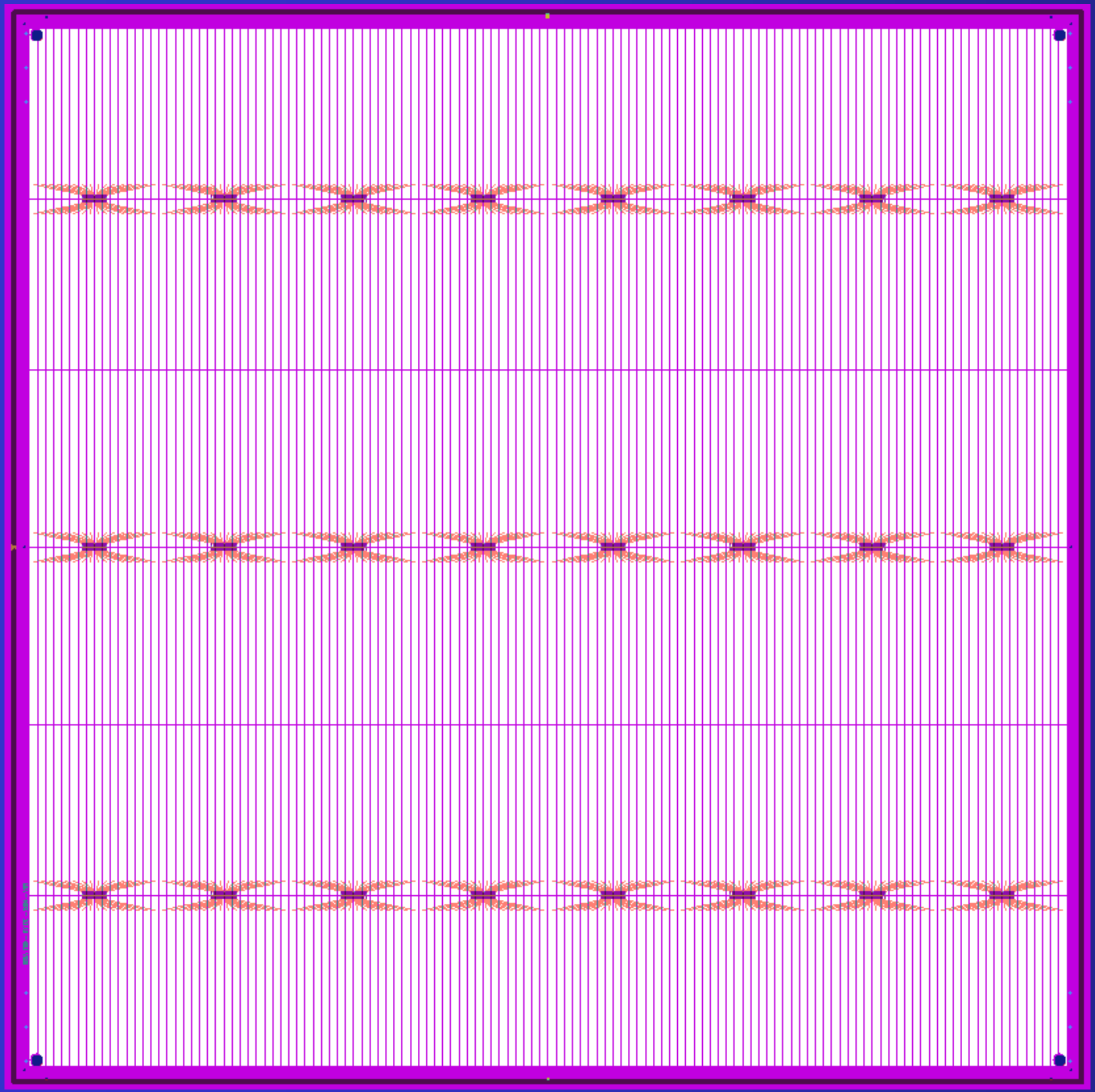
- 8 rows, 128 columns
- 1024 pads
- 8.27 cm^2 pad size
- 32x 32-pin connectors
- 8 connectors per row
- 2 rows per connector

Module type 7 FEBs



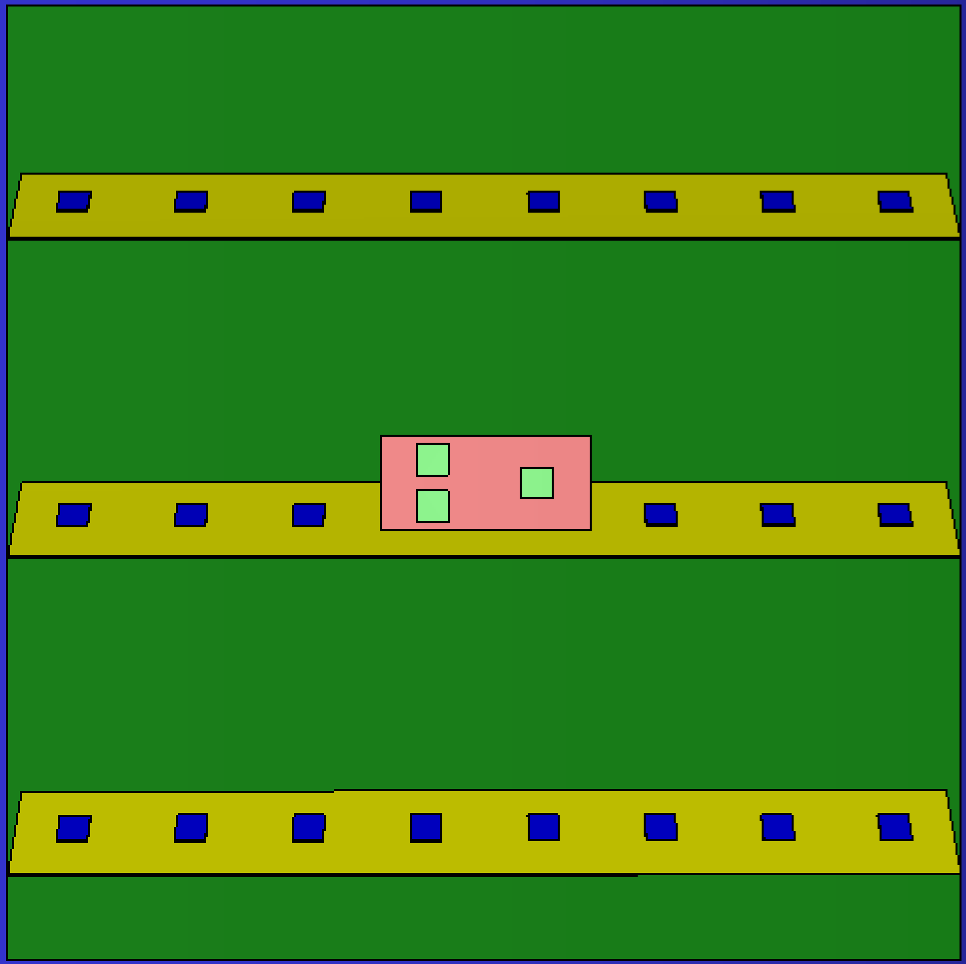
- 1024 channels
- 32x cable connections
- 4 FEBs a 8x1 ASICs
- 1x GBTx ROB-5
- 6 optical links
  1x down- 5x uplink
- 64/70 e-links used
- 91% uplink efficiency

Type 8 pad plane v16b



- 6 rows, 128 columns
- 768 pads
- 10.96 cm² pad size
- 24x 32-pin connectors
- 8 connectors per row
- 2 rows per connector

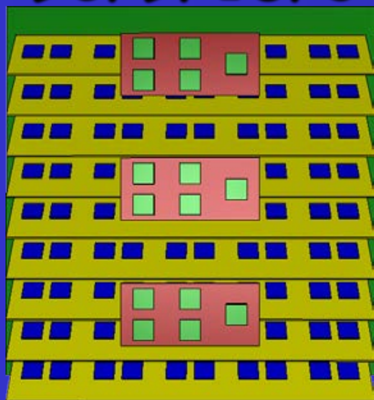
Module type 8 FEBs



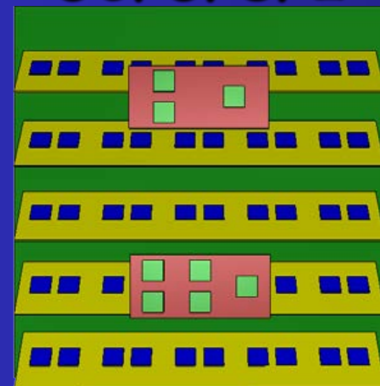
- 768 channels
- 24x cable connections
- 3 FEBs a 8x1 ASICs
- 1x GBTx ROB-3
- 4 optical links
  1x down- 3x uplink
- 24/42 e-links used
  (only 1 e-link per Spadic)
  cannot be done with
  Spadic v2.0
- 57% uplink efficiency

TRD geometry v16b

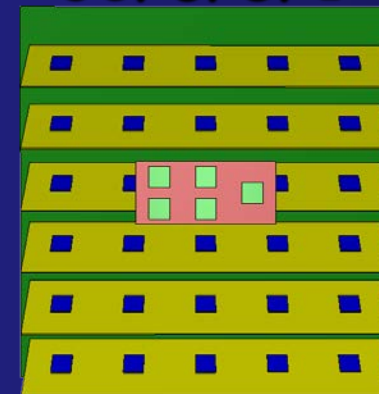
90/9/15/3

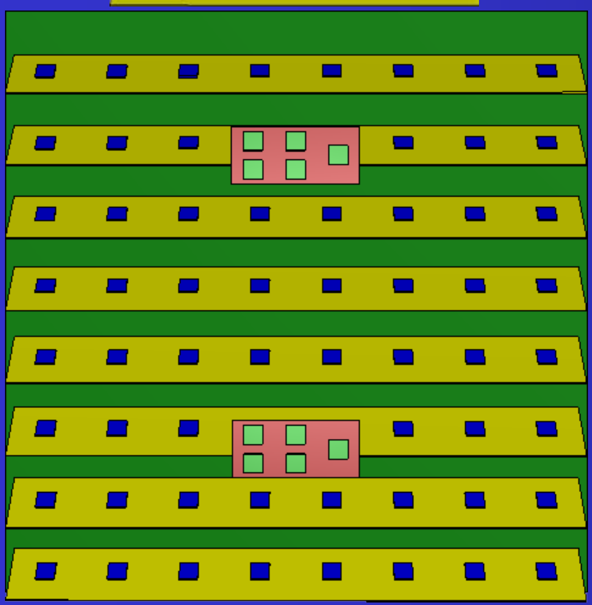


50/5/8/2

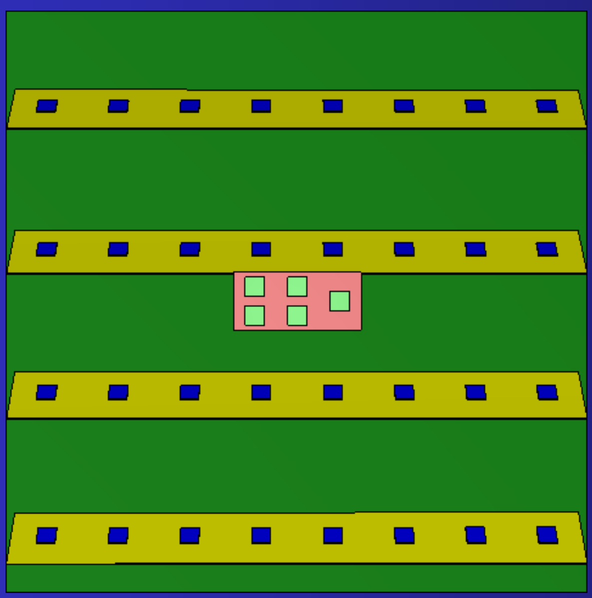


30/6/5/1

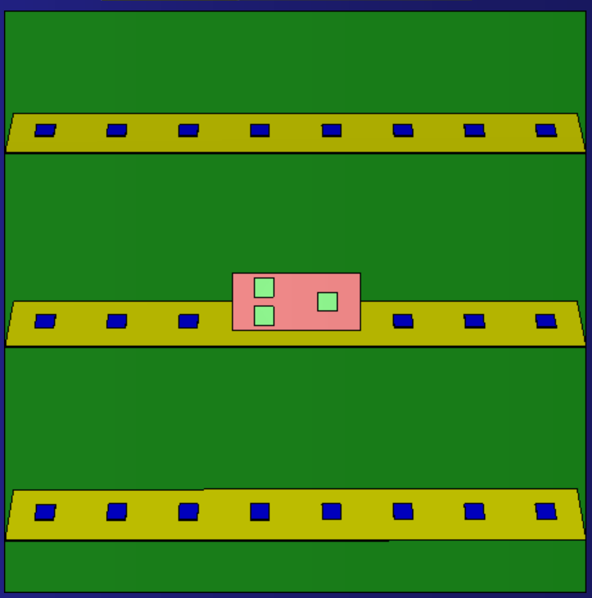




64/8/10/2



32/4/5/1

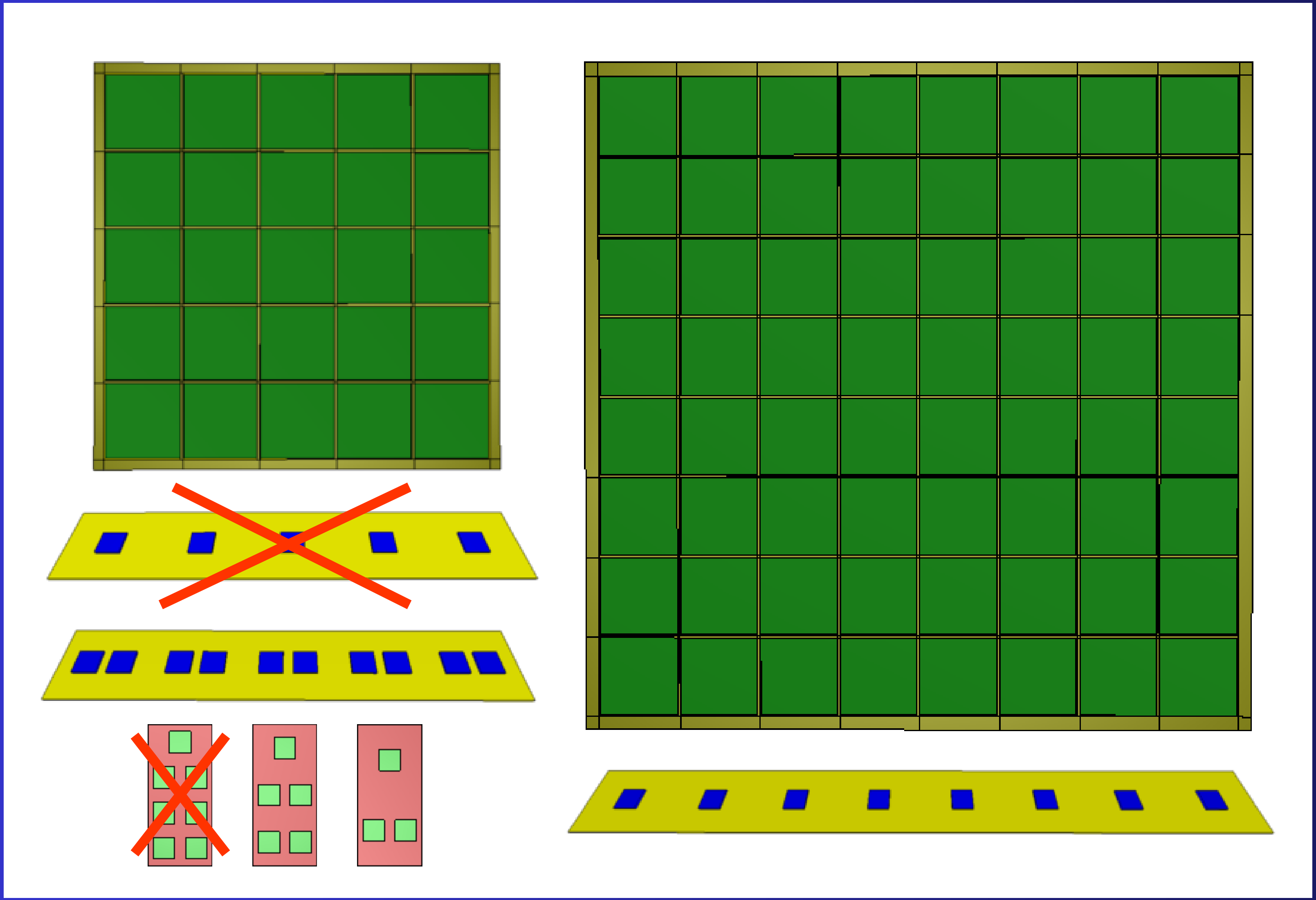


24/3/3/1

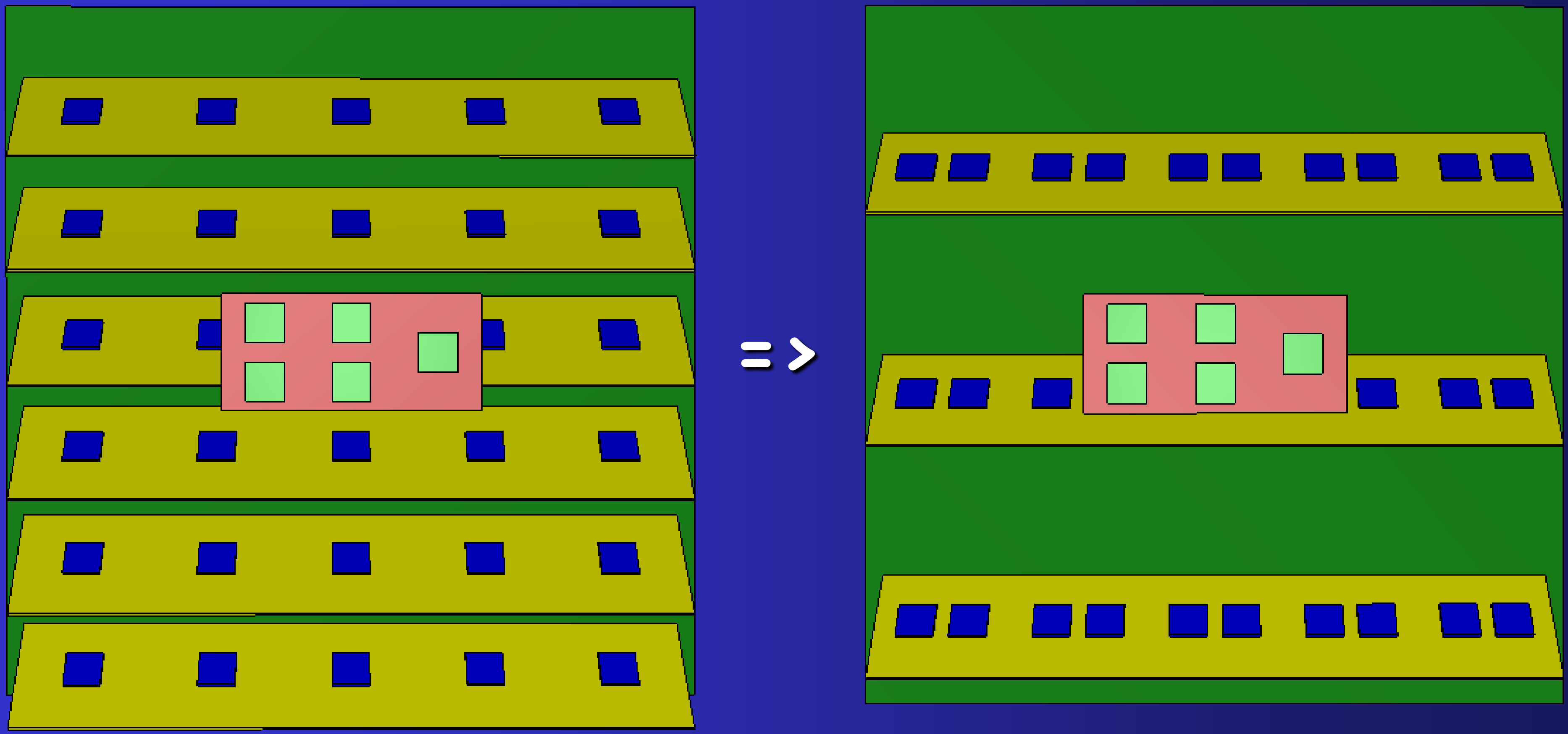
Next steps

TRD v17a
-
Reduction of FEB types

TRD v17a components

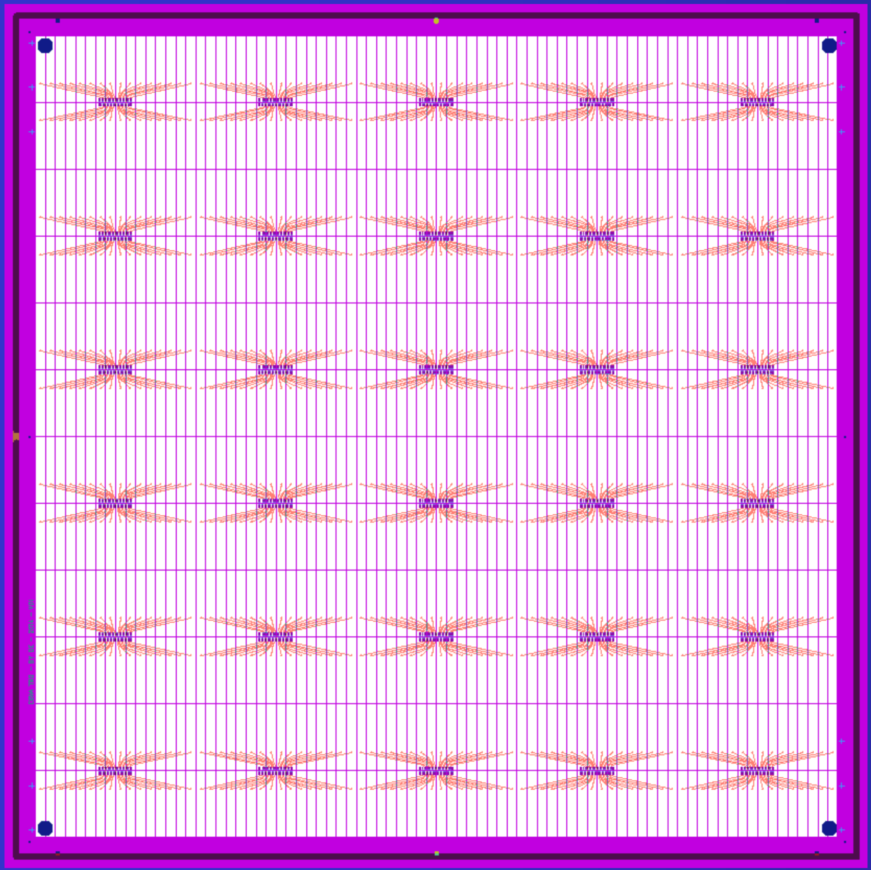


Type 3 v17a modification

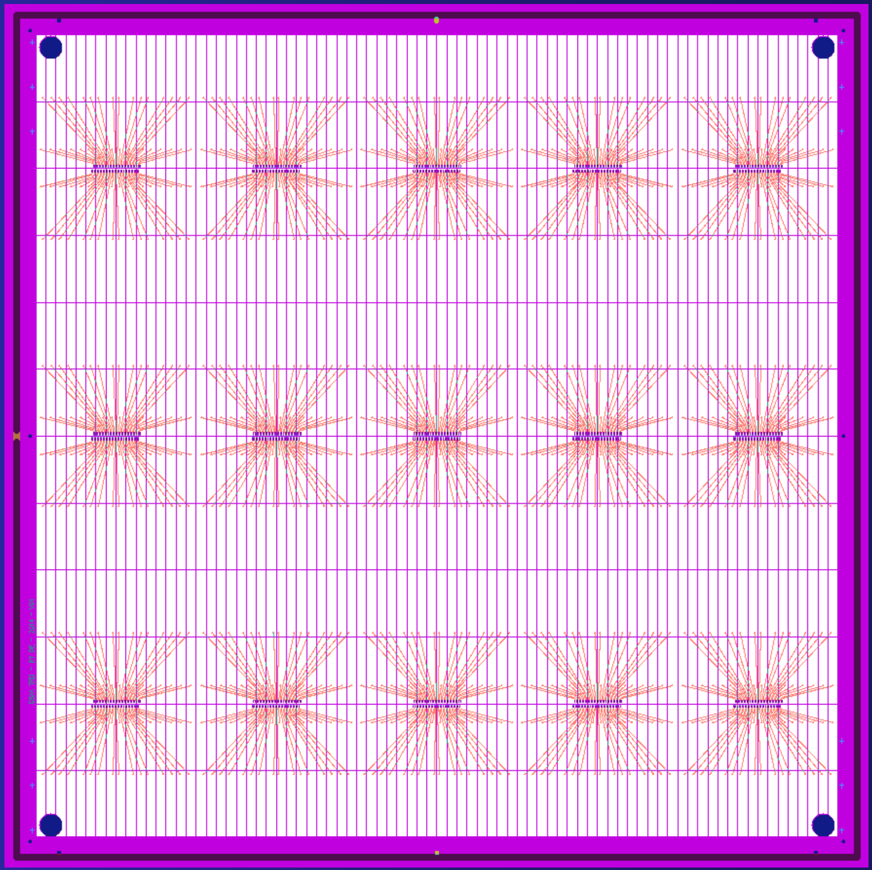


Replace FEB 5x1 which only occurs on module type 3 by FEB 5x2
To reduce FEB diversity.

Pad plane type 3 v17a

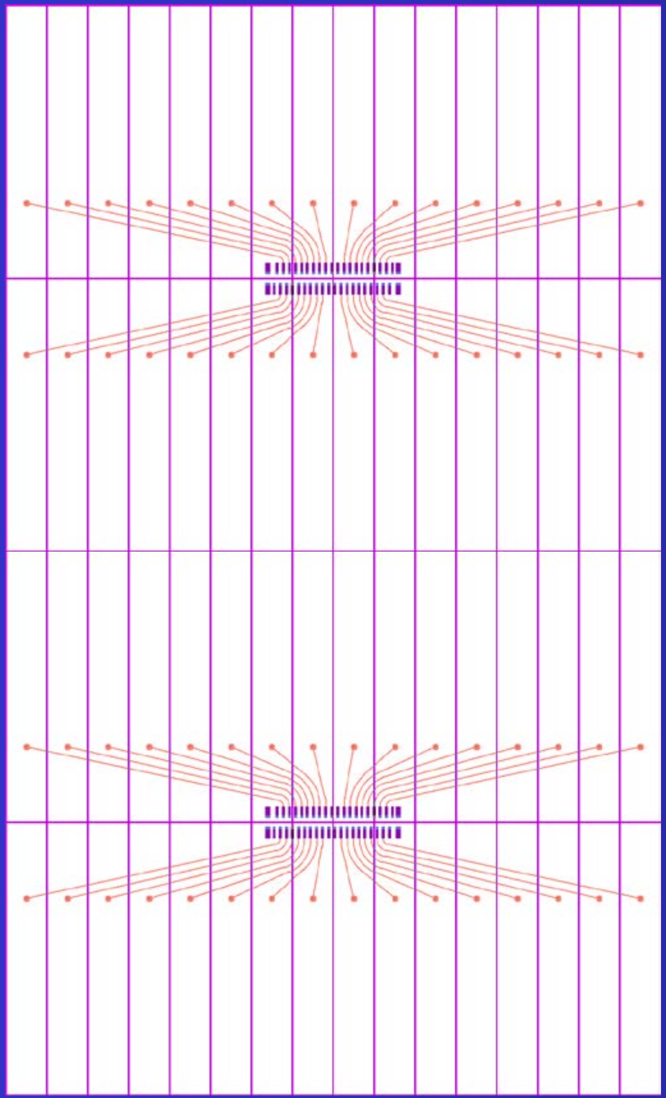


=>



Instead of 2, read 4 rows per connector. This leads to longer wire traces on the pad plane, larger capacity and slight noise increase. It saves 1 FEB type.

Type 3 v17a pad block



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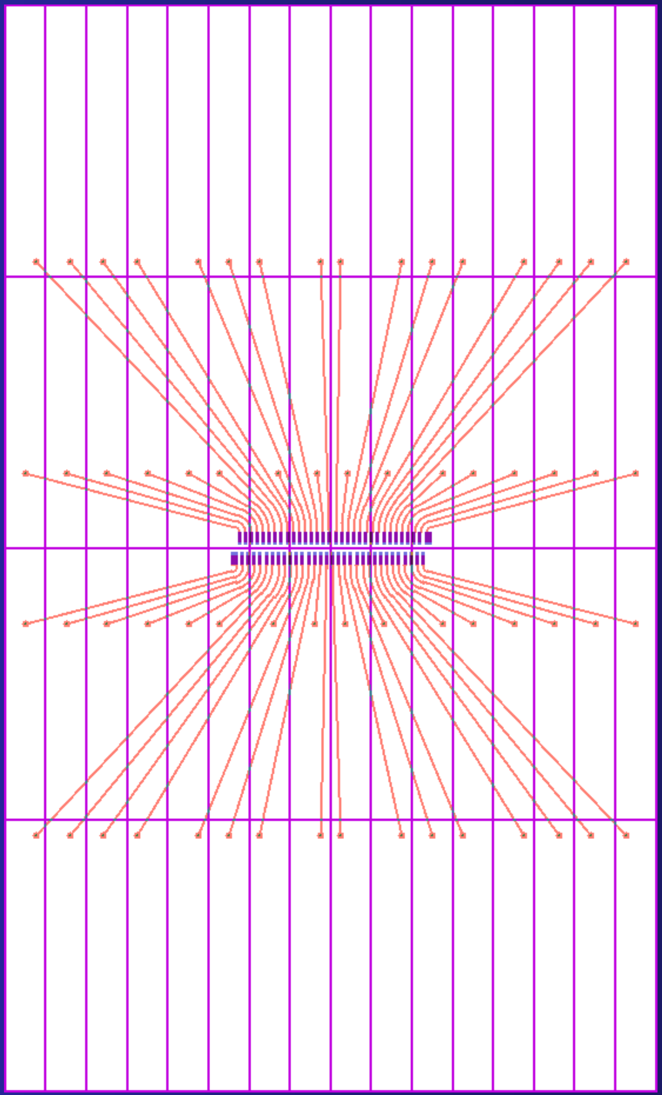
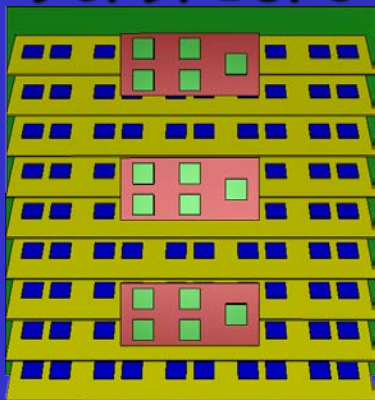
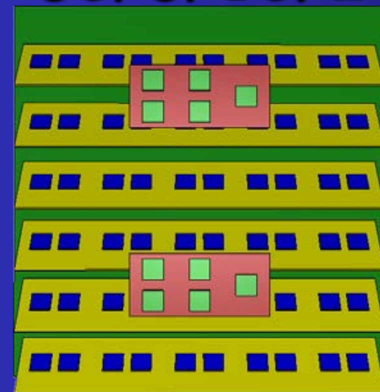


TRD geometry v17a

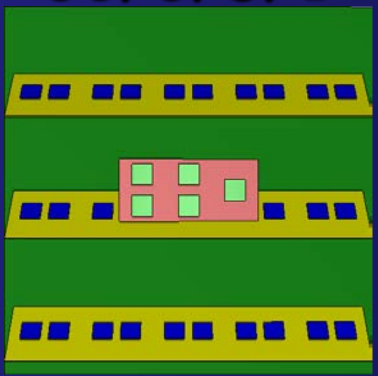
90/9/15/3

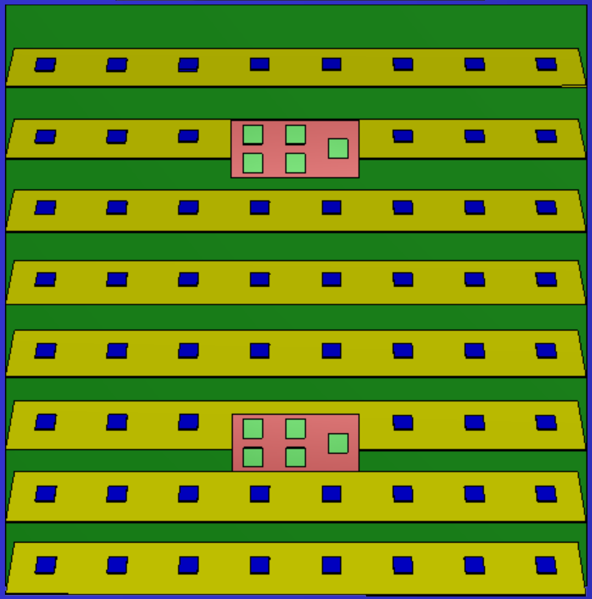


60/6/10/2

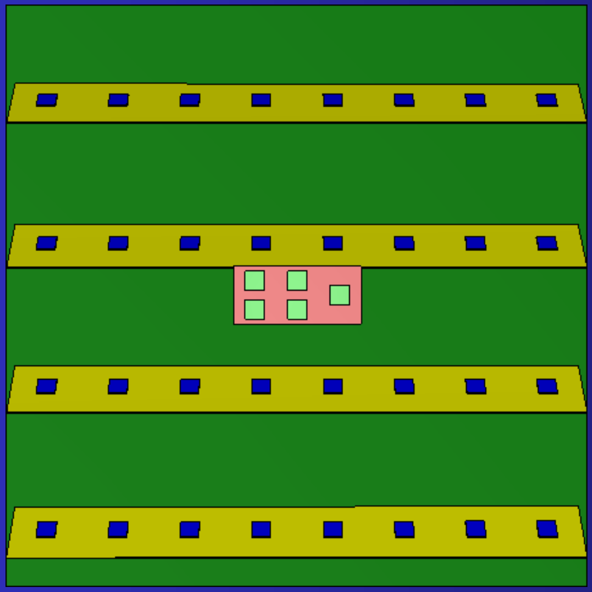


30/3/5/1

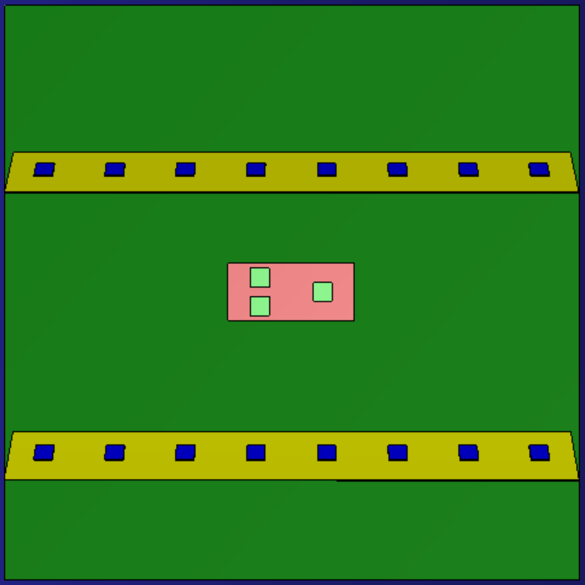




64/8/10/2



32/4/5/1



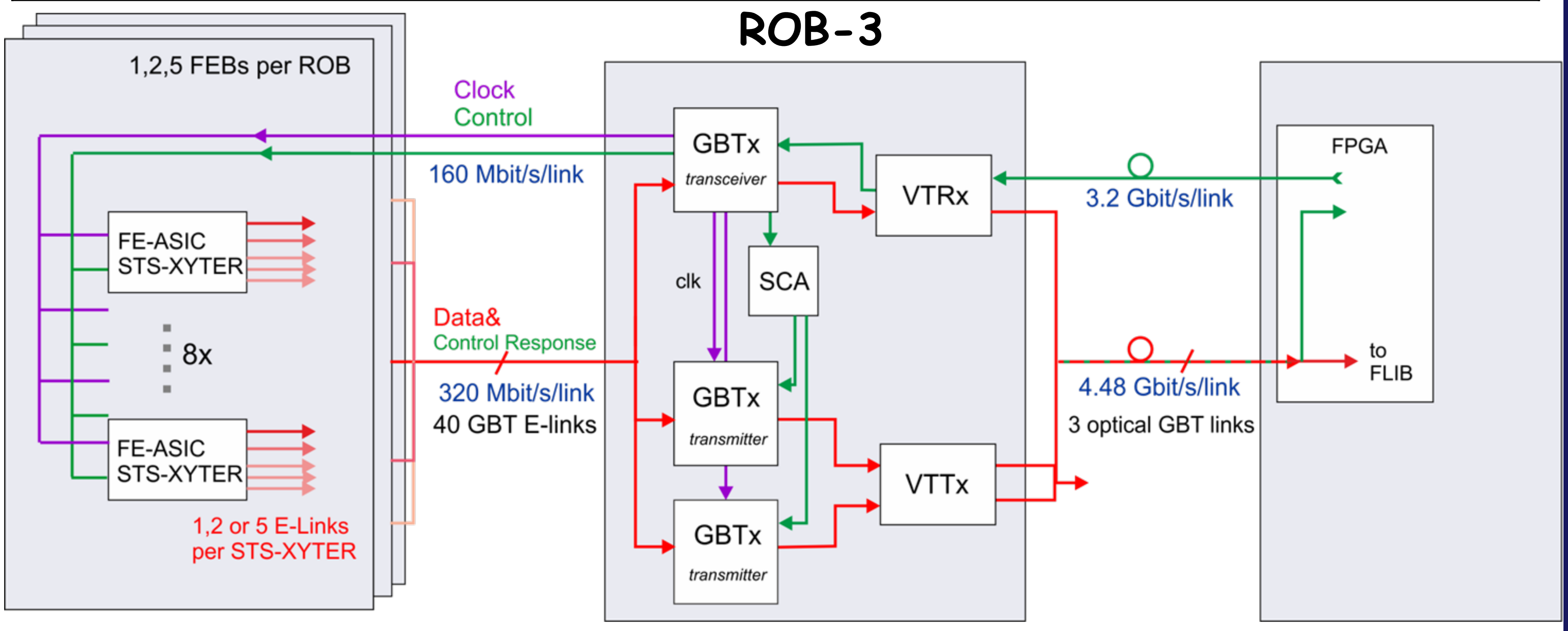
16/2/3/1

GBTx readout

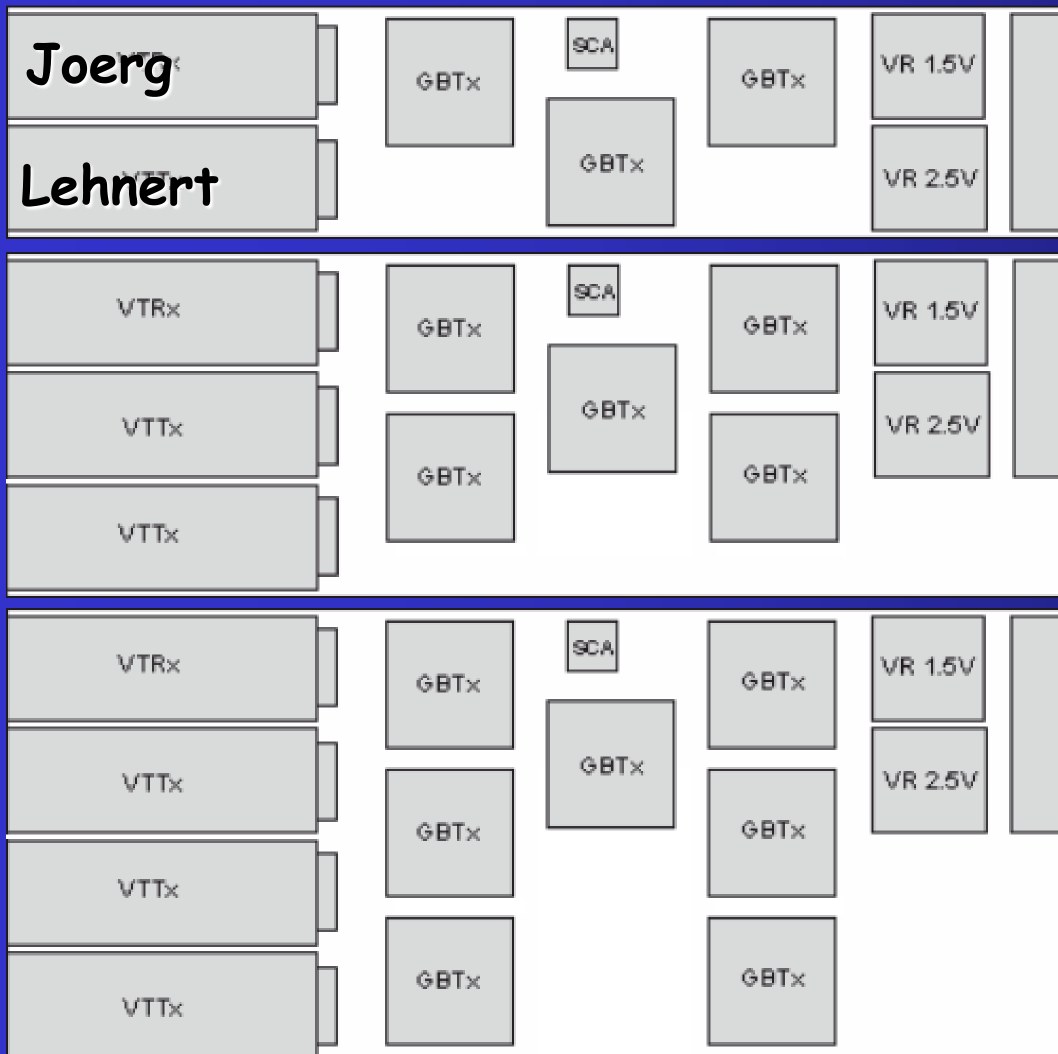
GBTx ROBs for TRD

FrontEnd Board (FEB)	Electrical Interface	ReadOut Board (ROB)	Optical Interface	Data Processing Board (DPB)
8 STS-XYTER ASICs	10-42 SLVS pairs/FEB	CERN GBTx & Versatile Link	4 MM fibers per ROB	

ROB-3



GBTx ROBs for TRD



GBTx ROB-3
42 e-ports

550
CHF
183/ch

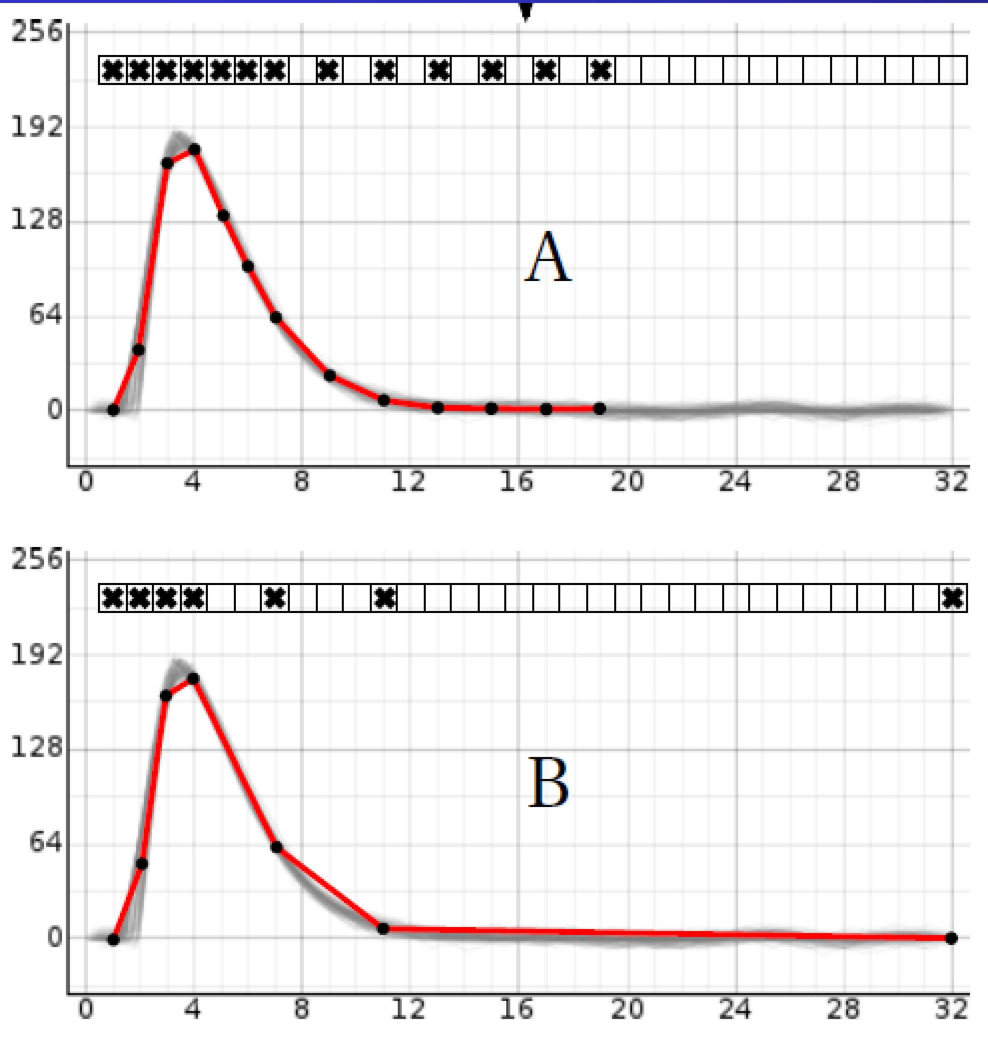
GBTx ROB-5
70 e-ports

840
CHF
168/ch

GBTx ROB-7
98 e-ports

1130
CHF
161/ch

Spadic sample selection



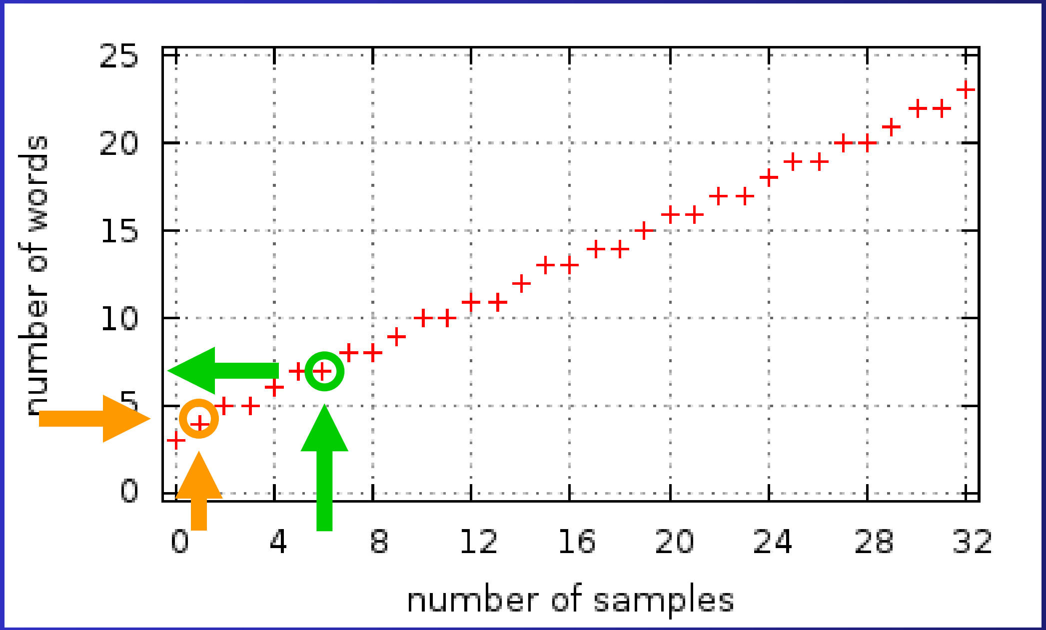
Current baseline:
select 6 samples
per hit:

- 2x pre-samples
- 2x max amplitude
- 2x late baseline

Extreme case:
Select only 1 sample

- 1x max amplitude

Spadic message size

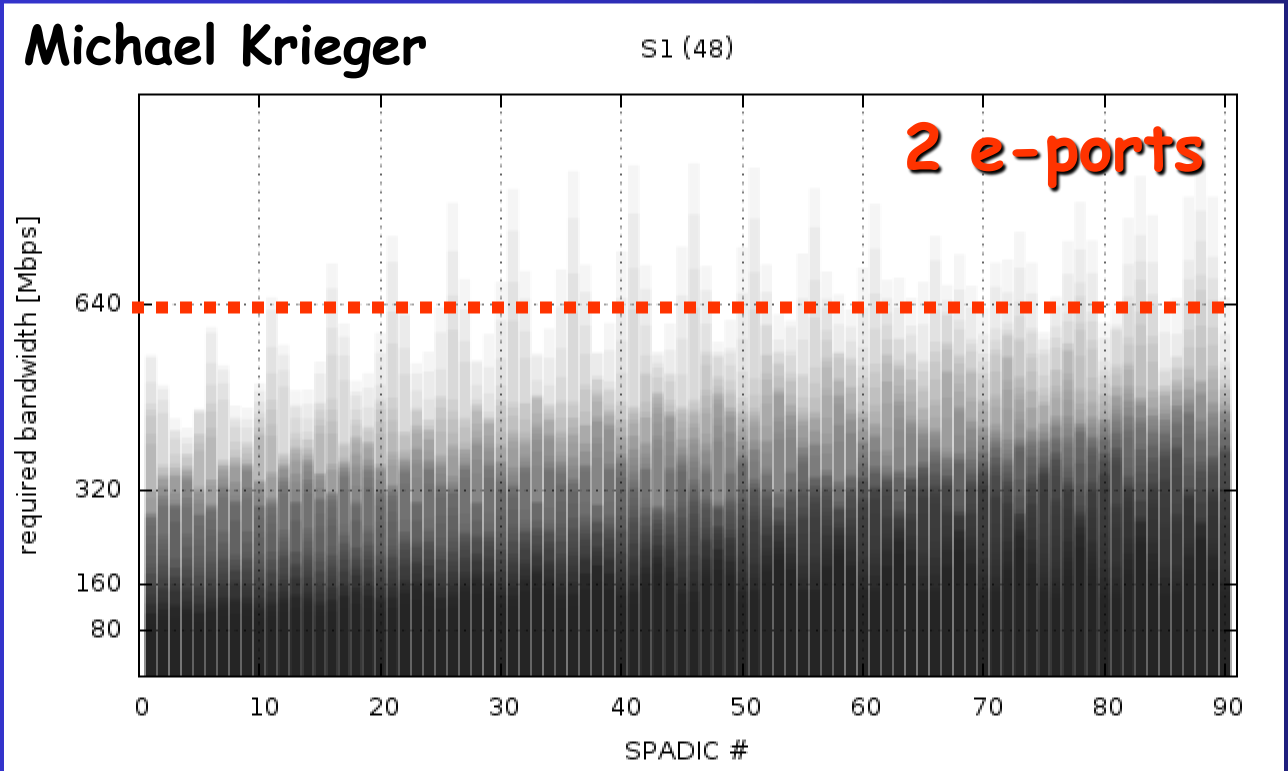


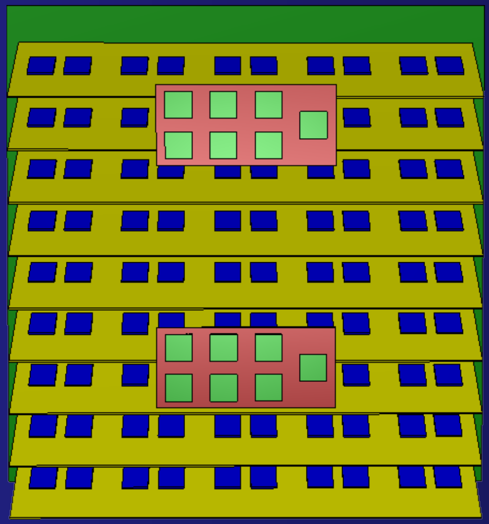
6 time samples per hit
=> 7 words per hit
=> 112 bit per message
@ 100k hits/s/ch
=> 11,2 Mbps/ch
=> 358,4 Mbps/32 ch ASIC

1 time sample per hit
=> 4 words per hit
=> 64 bit per message

ignoring 83% (5/6) of bins
saves 43% (4/7) bandwidth

Module type 1 data rate





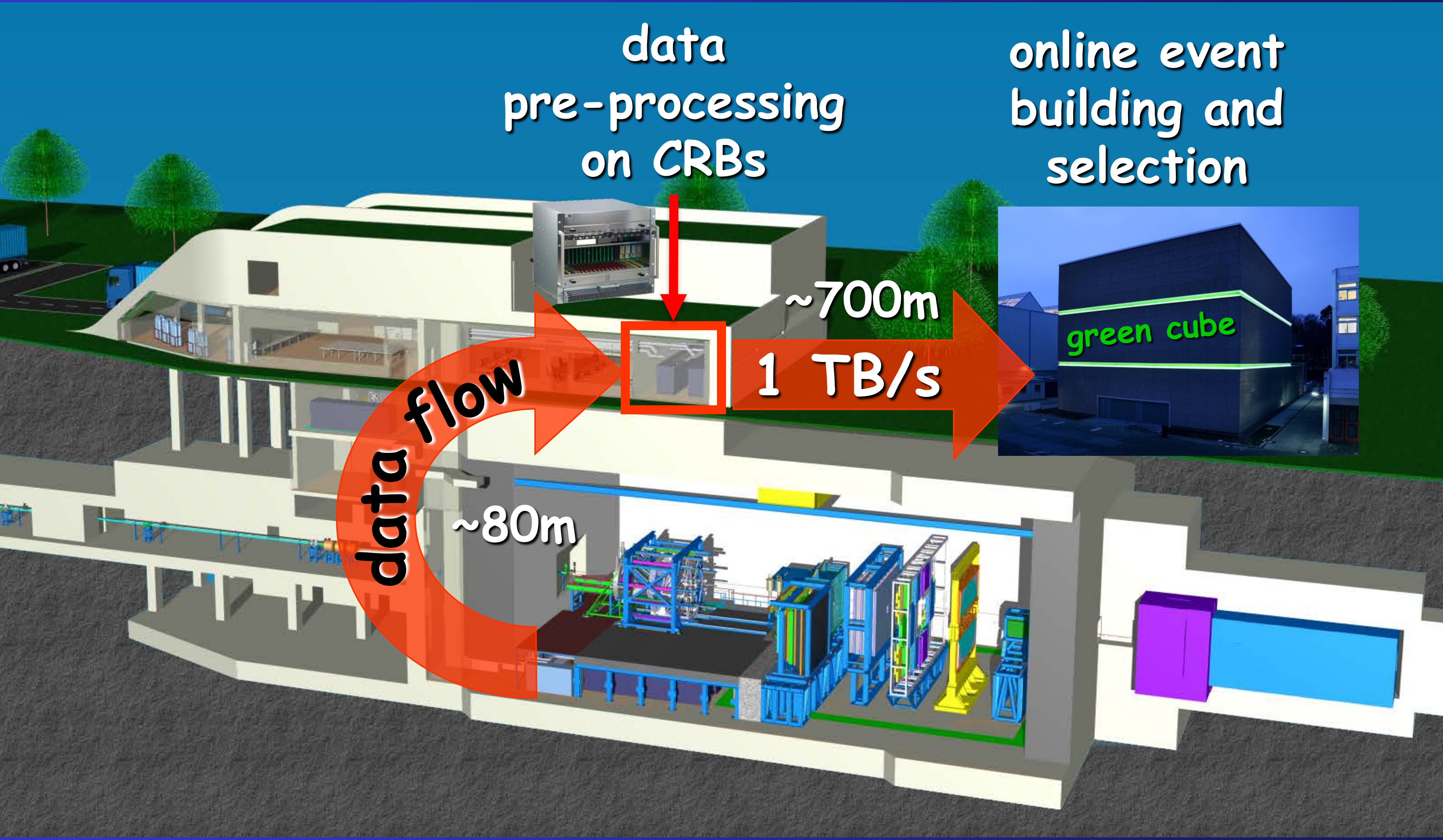
90 Spadics a 2 e-ports = 180 e-ports

2x GBTx ROB 7 = 2x 7x 14 = 196 e-ports

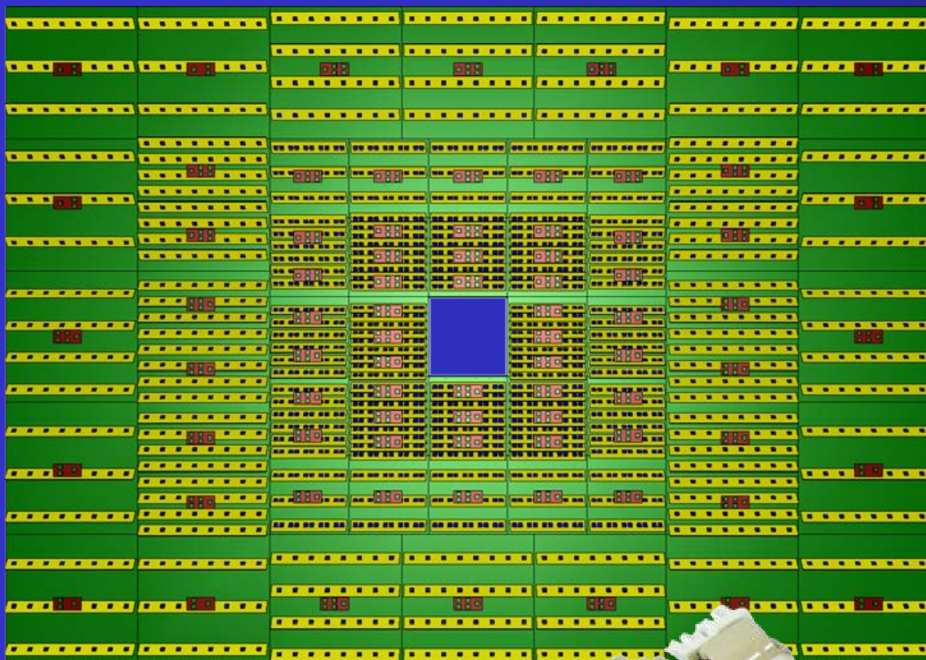
usage 92%

Readout

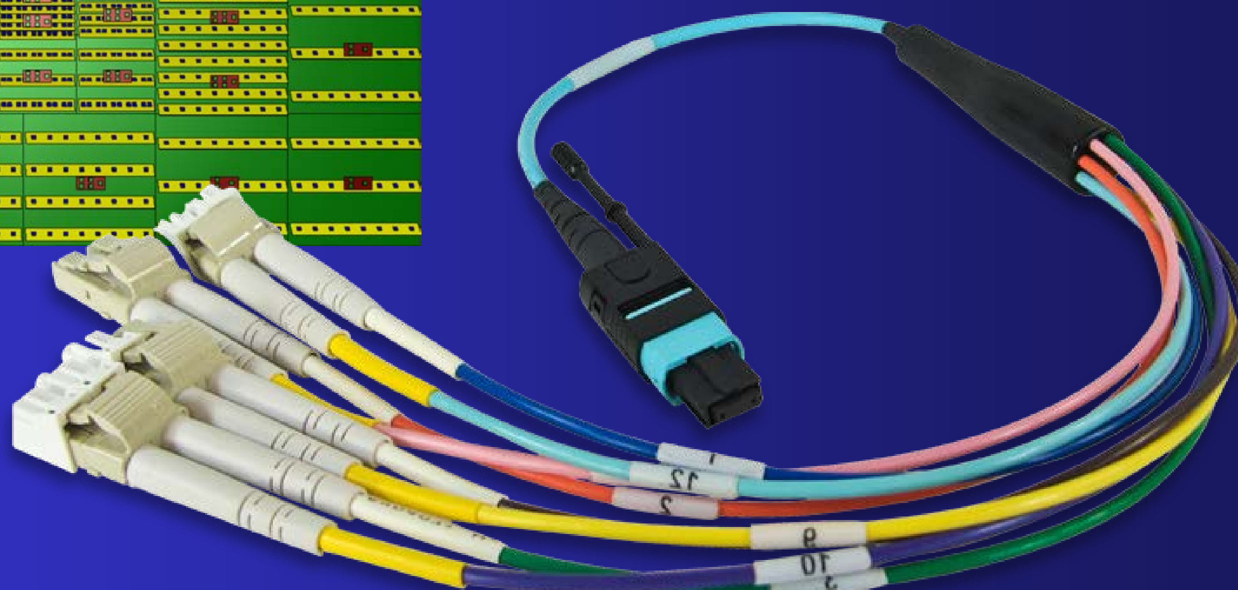
CBM DAQ System



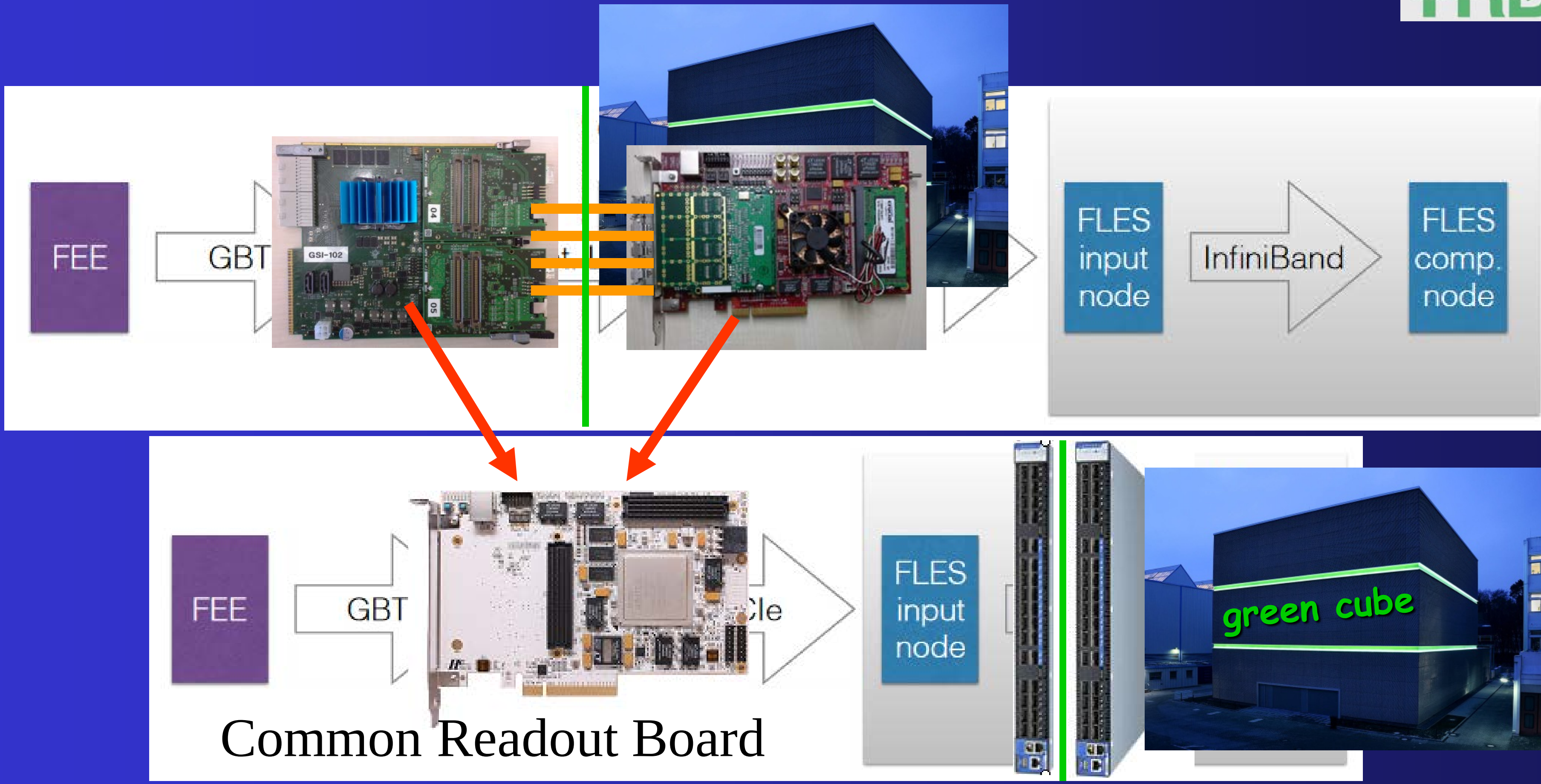
Detector - DAQ interface



For subsystems
with GBTx readout
the DAQ system begins where
the optical readout fibres are
plugged into the ROBs



CRB readout chain



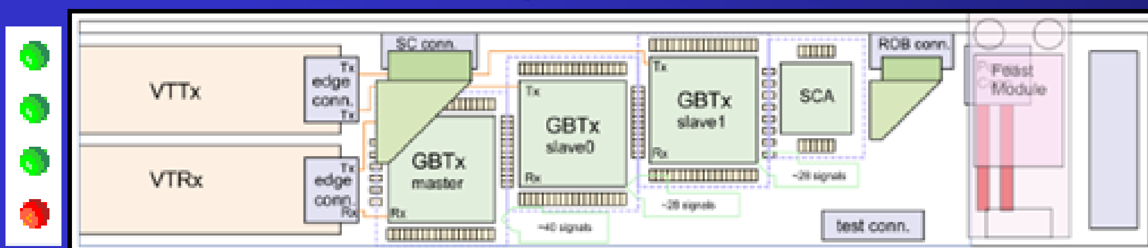
FW blocks developed for the DPB and FLIB layer could end up in a single CRB. This setup would offer extra benefits, e.g. COTS components, local CBM FLES cluster for standalone commissioning

Readout Boards

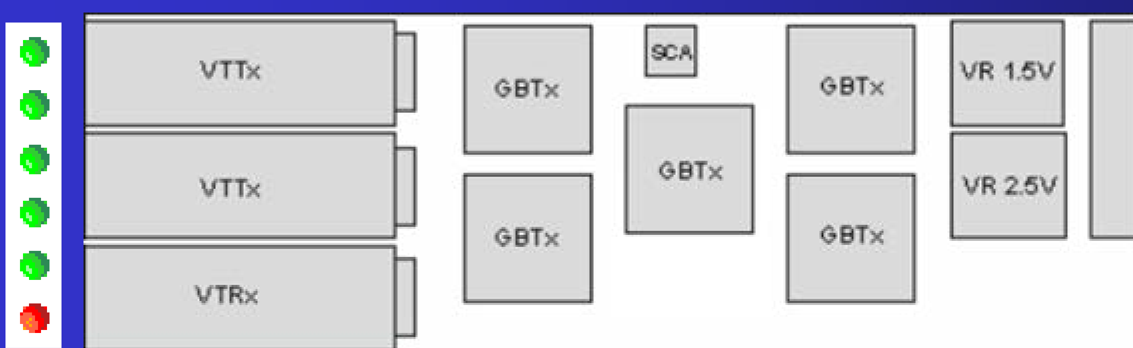
(STS)

(TRD)

A ROB-3 will interface to 3 MGTs on the DPB.

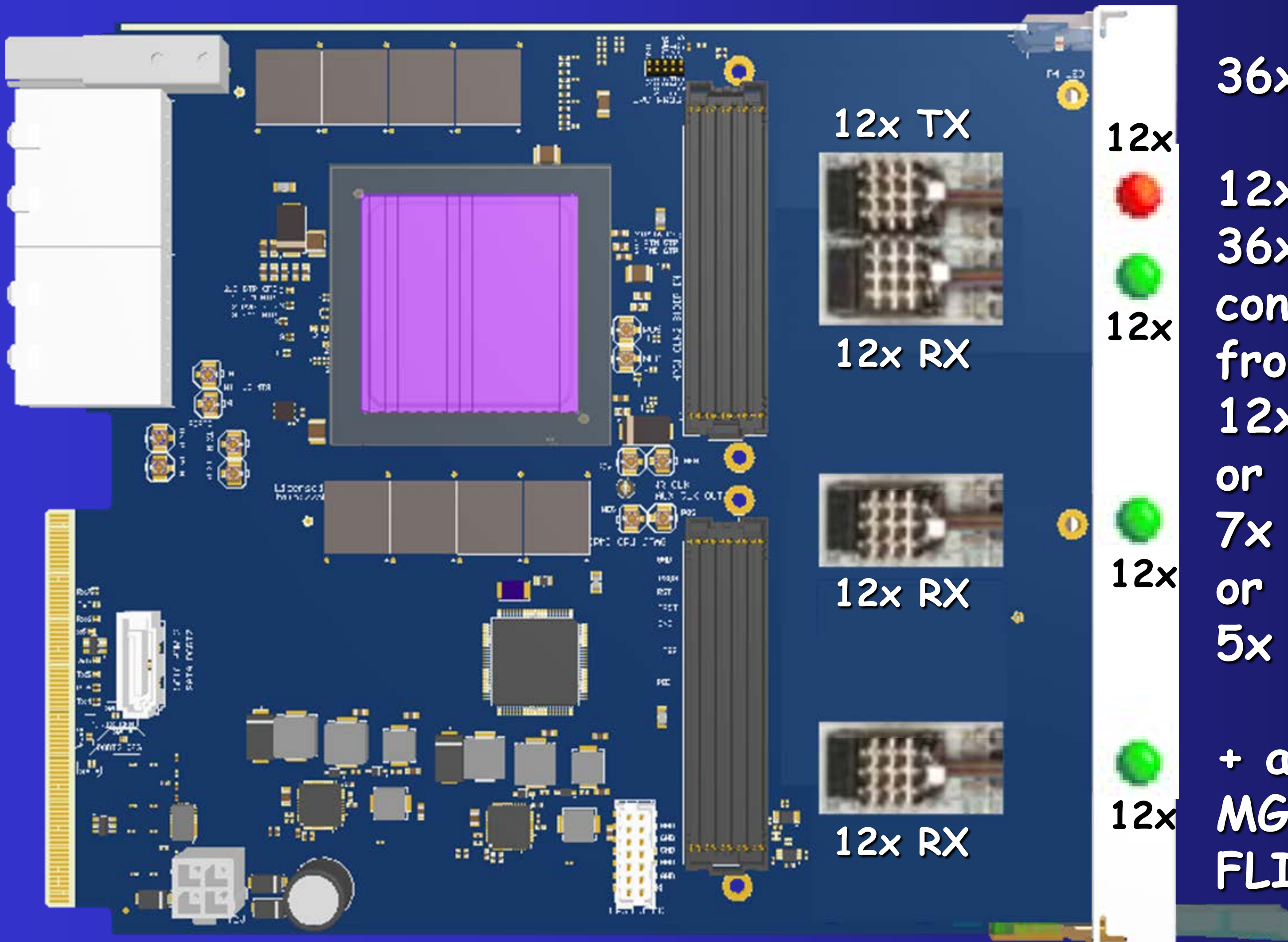


GBTx ROB-3
42 e-ports



GBTx ROB-5
70 e-ports

A possible DPB successor



prototype DPB successor

36x MGTs:

12x TX and 36x RX for connections from up to 12x ROB-3 or 7x ROB-5 or 5x ROB-7

+ additional MGTs for the FLIB link

A possible DPB successor PCIe

12x TX

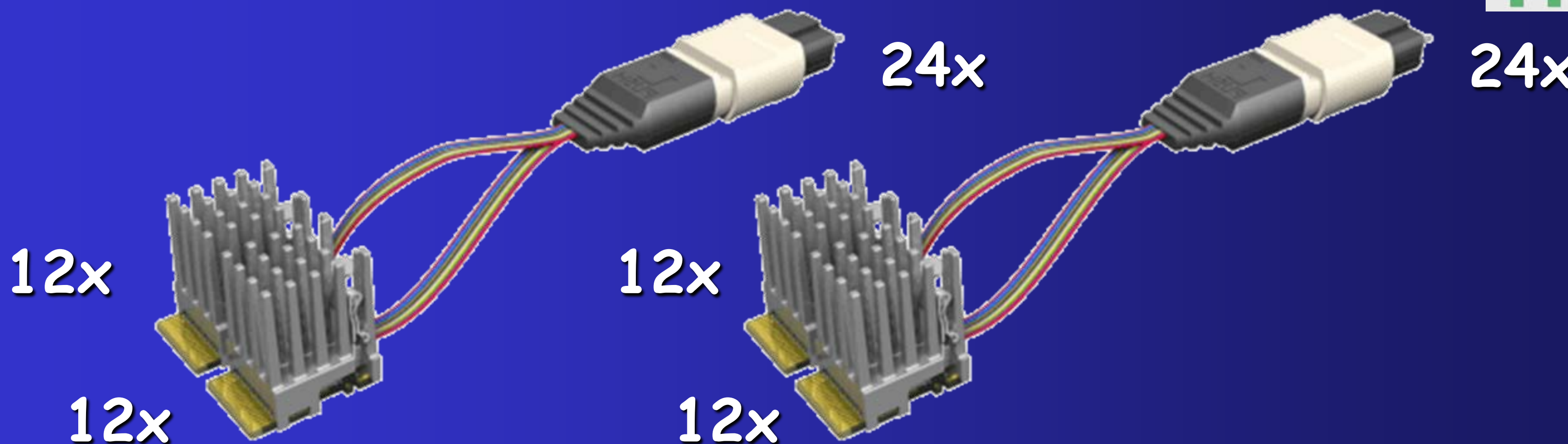
12x RX

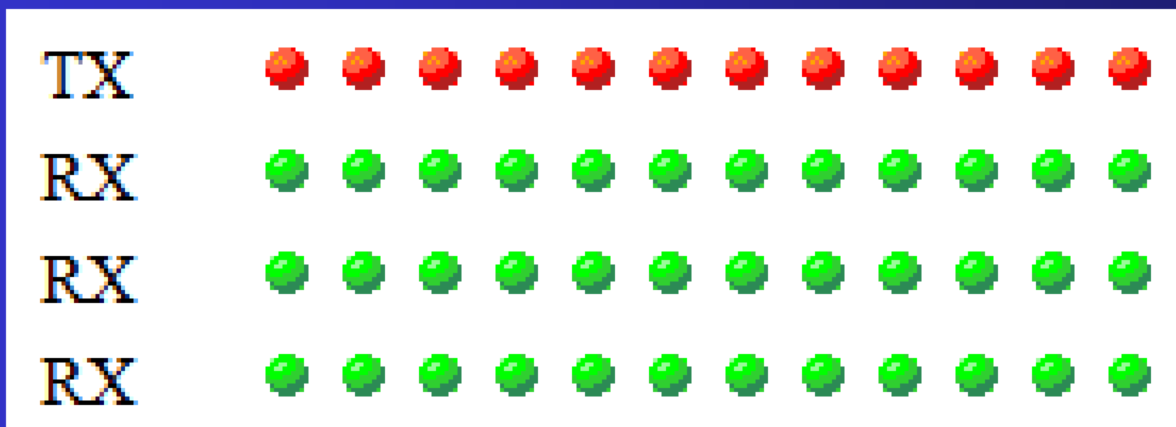
12x RX

12x RX

HTG K816 with ZRAY FireFly adapter
And Kintex Ultrascale FPGA
commercially available

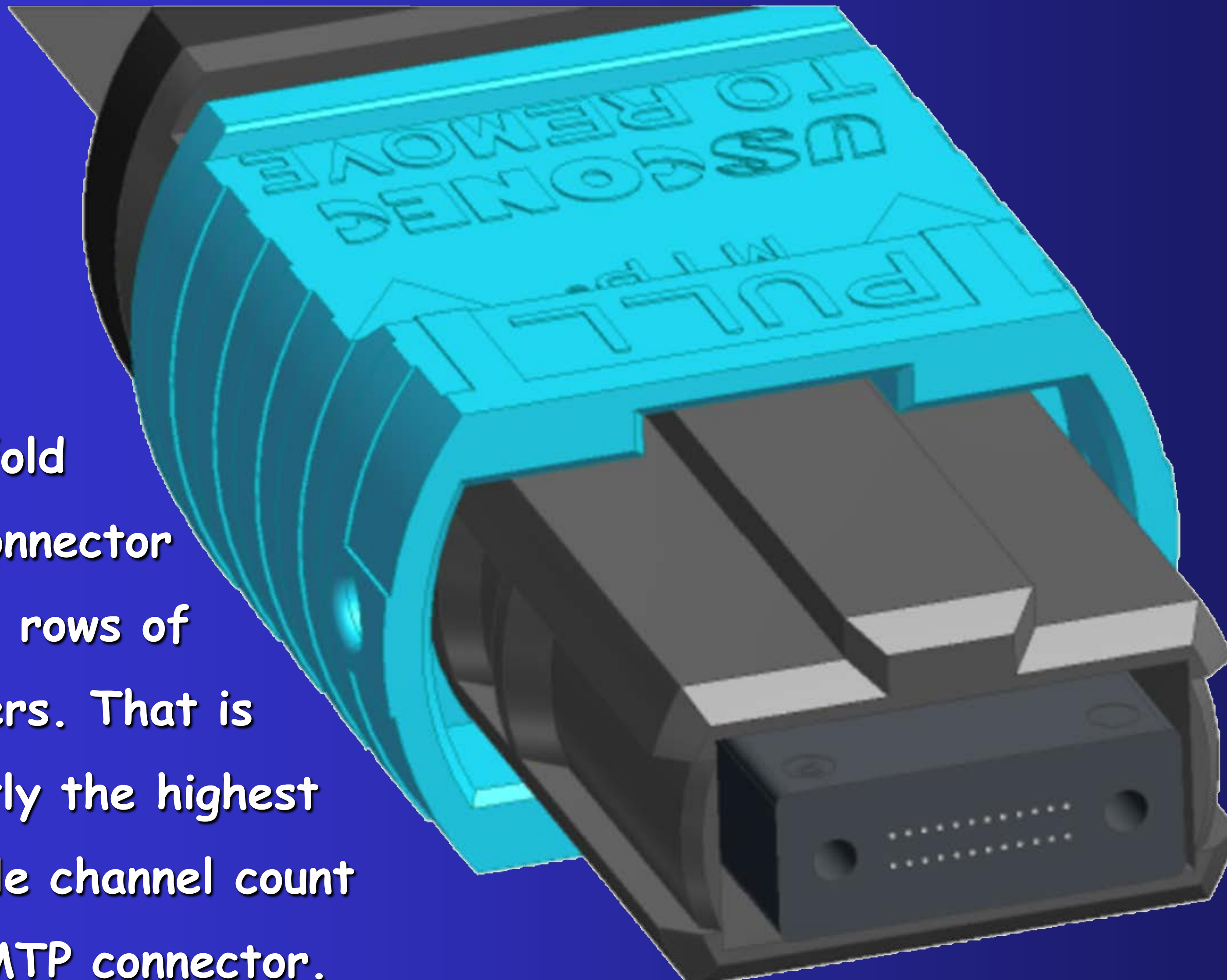
Distribution of links to DPB





On the AFCK+ the optical connections will be grouped in 12x down- and 3x 12x uplinks.

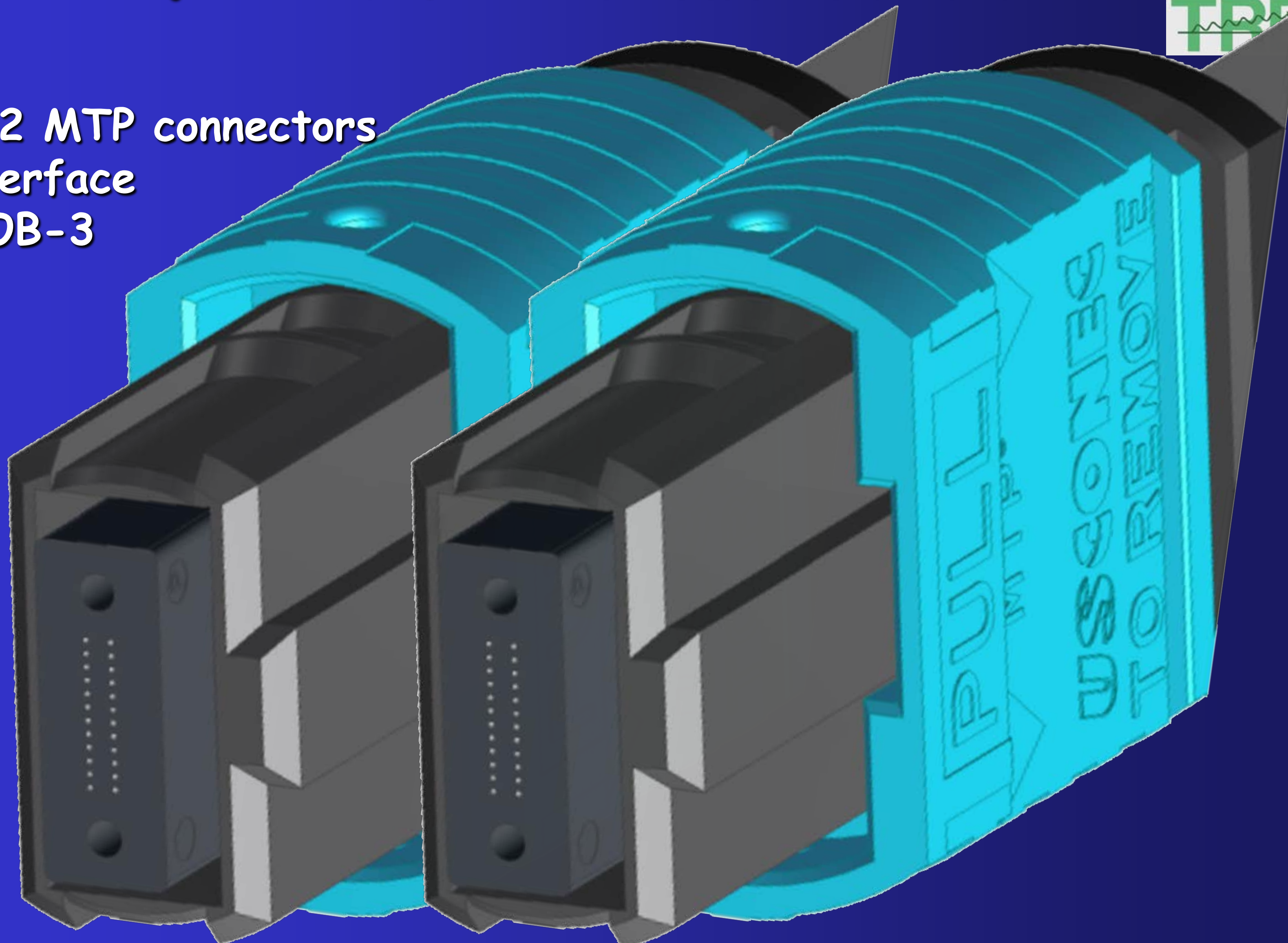
MTP connector



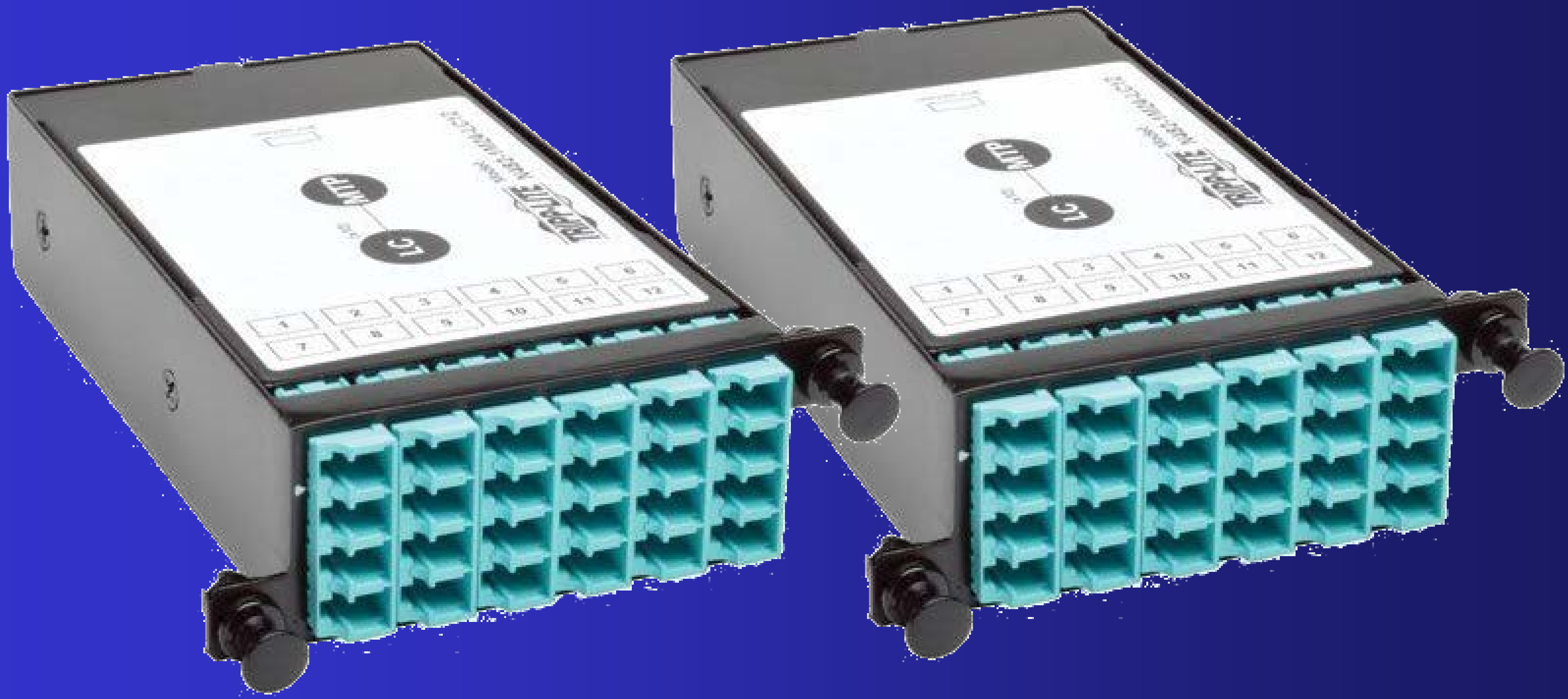
A 24-fold MTP connector holds 2 rows of 12 fibers. That is currently the highest available channel count for a MTP connector.

2x 24-fold MTP connectors

These 2 MTP connectors
can interface
12x ROB-3

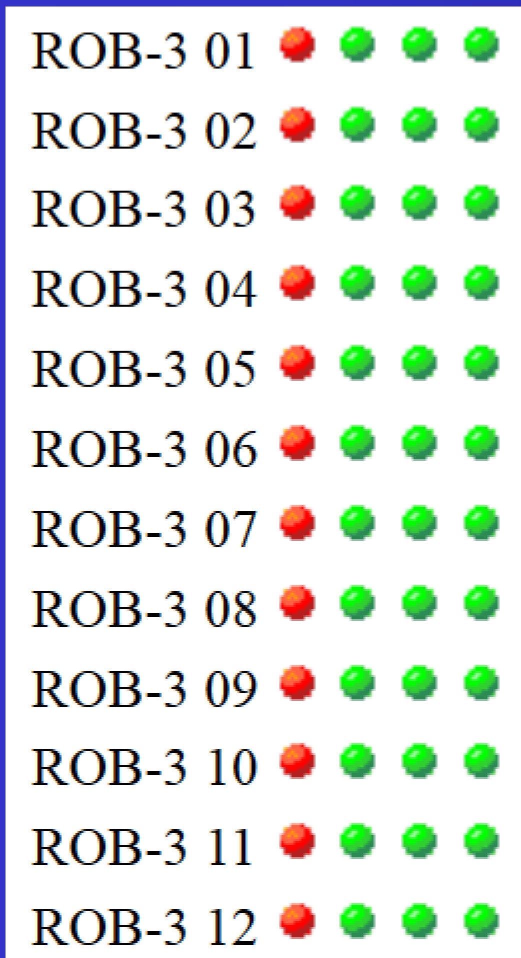


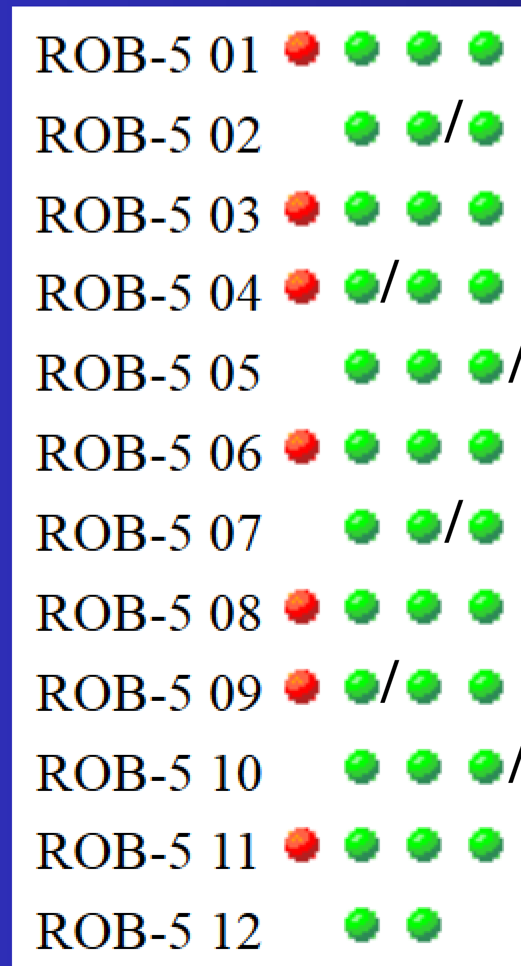
48x LC – 2x MTP Patchboxes

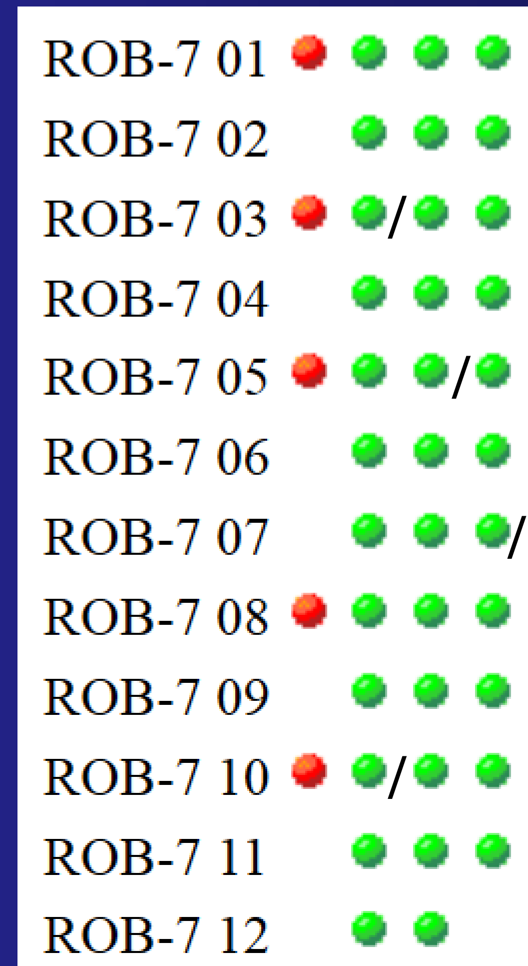


Patch boxes with 12x LC quad connectors can serve as DAQ interface for the TRD. They interface the LC-LC patch fibers from several modules to the 24-fold MTP fibers to the DPB.

Grouping of ROBs on the PP



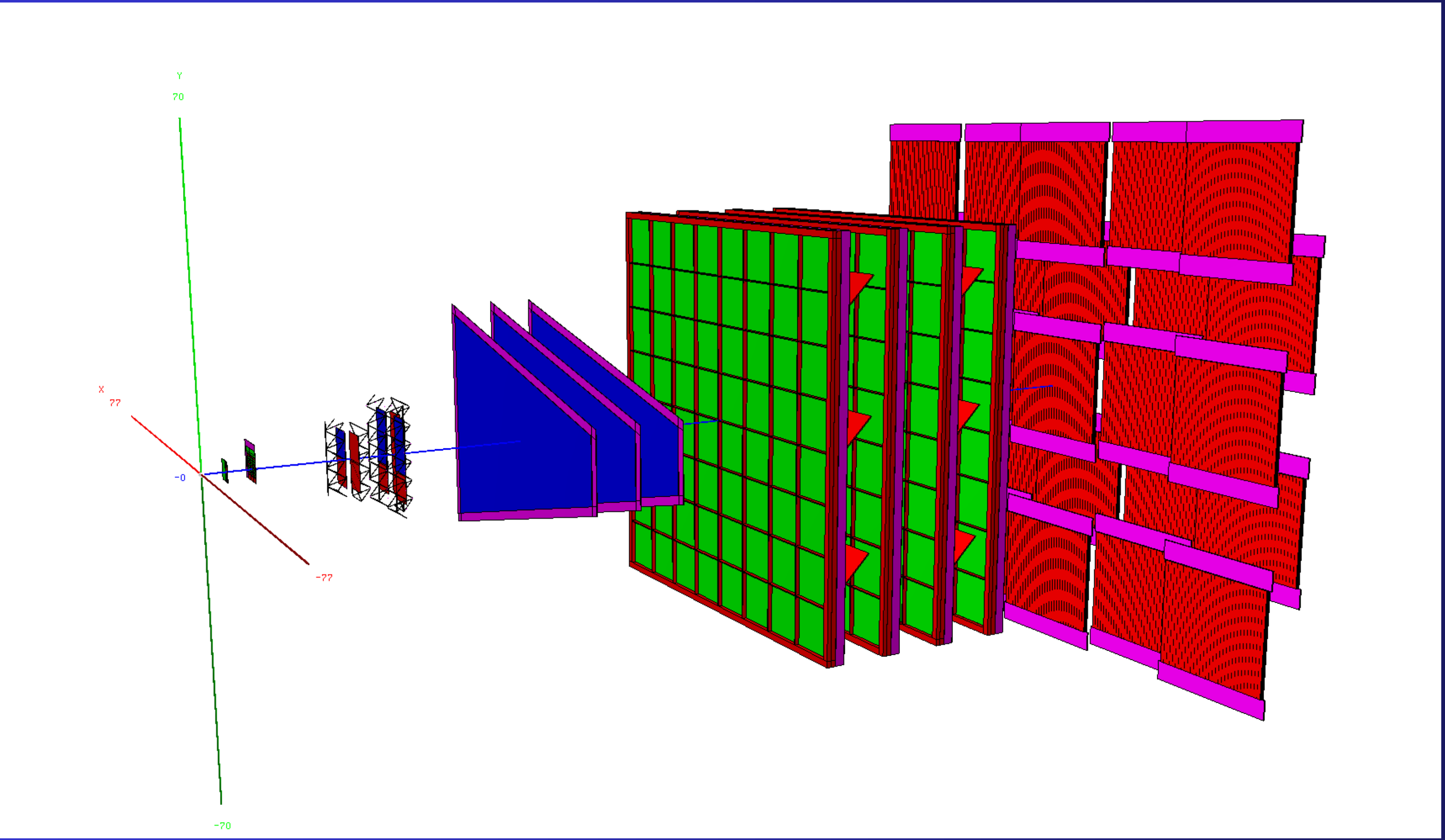




97% uplink efficiency for ROB-5 and ROB-7 topology.

miniCBM

miniCBM@SIS18



97% uplink efficiency for ROB-5 and ROB-7 topology.

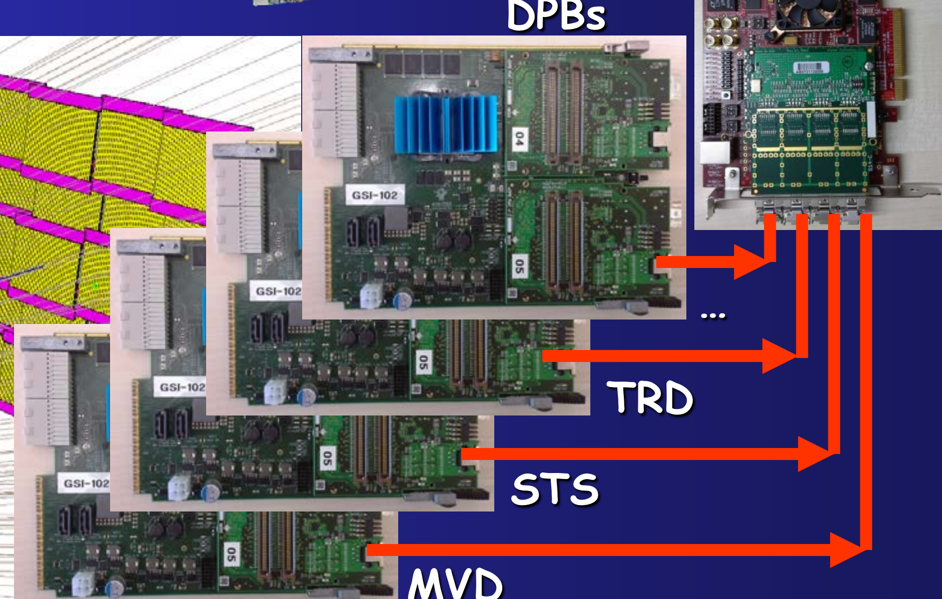
mCBM DAQ chain

Build mCBM at GSI/SIS18 for a full system integration and commissioning test with high-rate A-A collisions 2018-21

Set-up with full size detector modules and read-out chain
Test and optimization of:

- performance of the detectors under experiment conditions
- free streaming data transport to FLES
- online reconstruction
- data analysis (offline)

Goals:
- Reduction of CBM commissioning time at SIS100
- Enforcement of CBM DAQ and SW development!

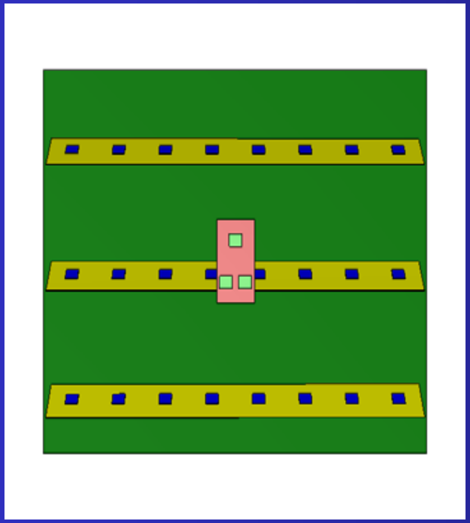


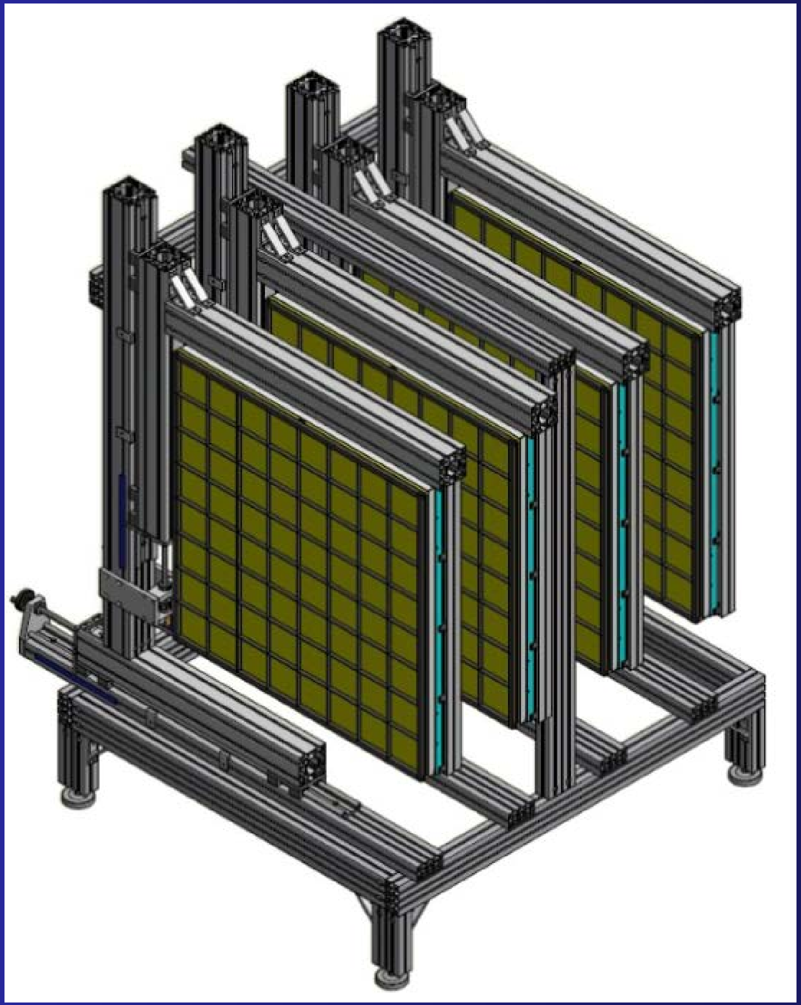
TRD contribution to mCBM

Needed by end of 2017

Configuration:

- 4x TRD module type 8
- detectors are available now, need FEE
- each module equipped with 24x SPADIC v2.0 (96 in total)





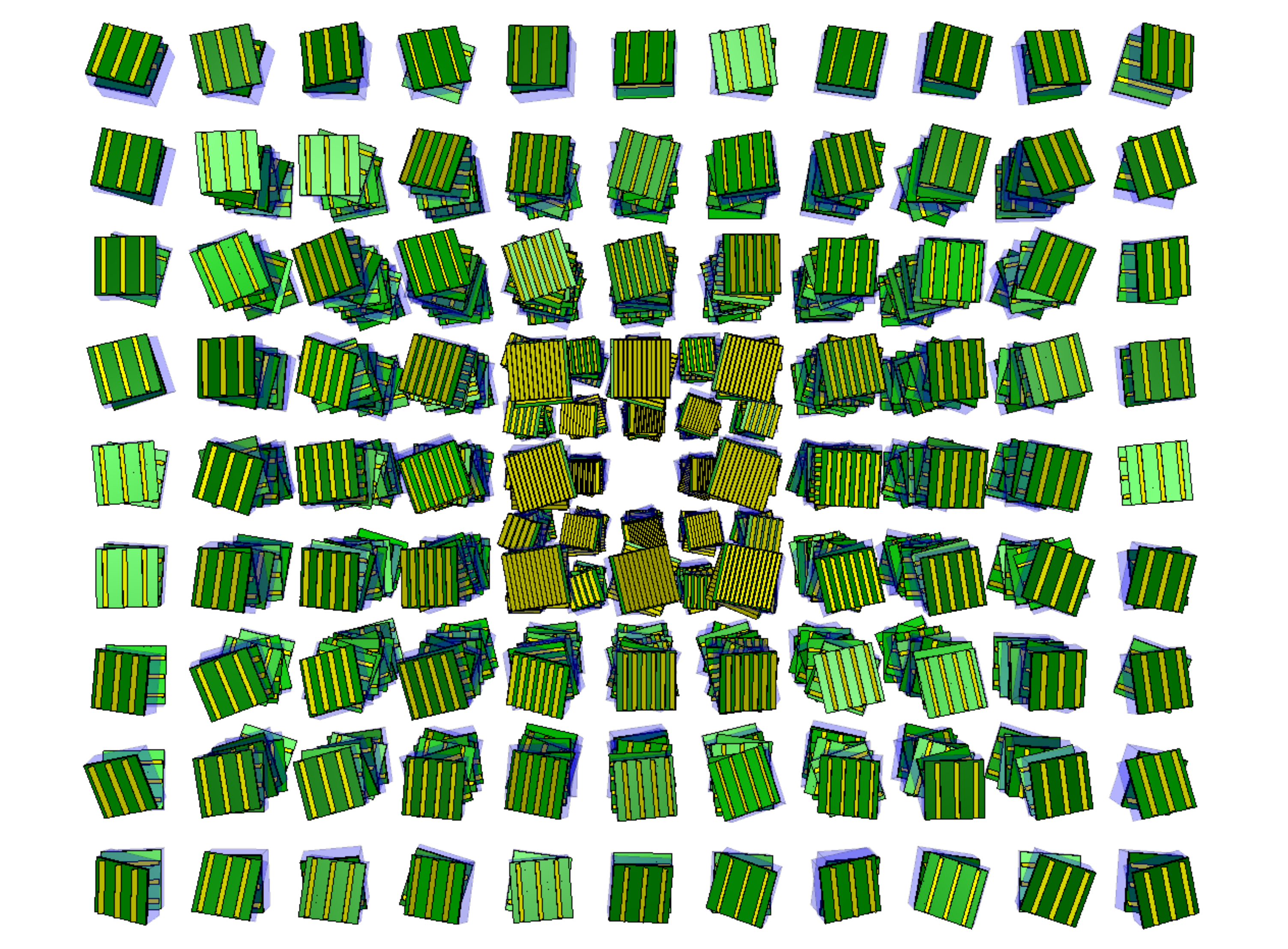
Same DAQ requirements as STS.

Can simply leave TRD equipment at GSI upon return from SPS Xe-beamtest in Nov 2017.

Summary

- we have an industrial PCB manufaturer for the production of large size TRD pad planes
- the pad plane layout of the TRD was optimised to a minimum number of 6 module types
- the connection of FEBs to ROBs needs to be finalised
- there is a concept for the optical network from the detector to the DPB stage
- GBTX uplinks need to be used efficiently to save cost in the DPB stage
- TRD will be part of the miniCBM commissioning test setup at GSI

Thank you



Thank you

Thank you

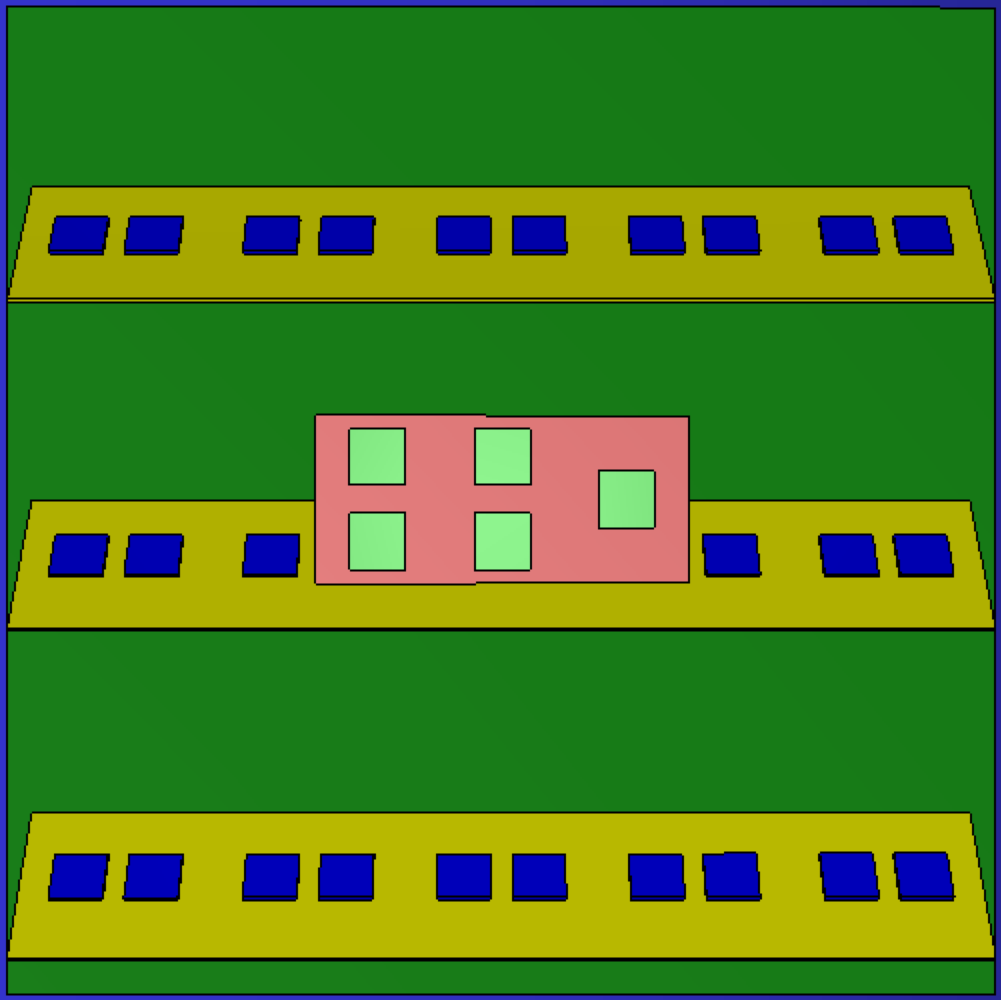
Backup

Material to show at the Collaboration Meeting

Reduction of ROB types

Data rate distribution

ROB-5 small module readout

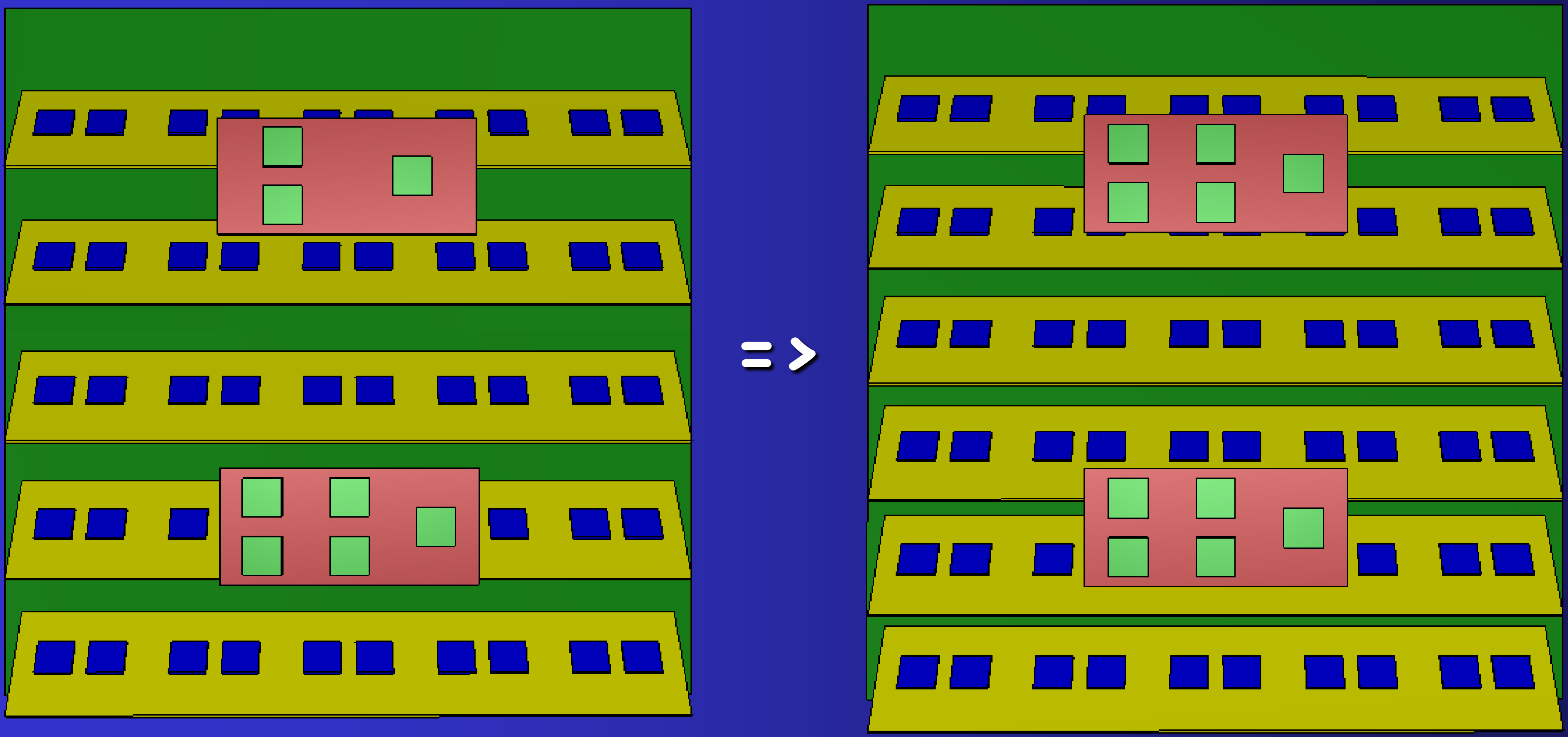


Use 3x FEB-5x2
and 1x ROB-5
as default element
of small TRD readout.

Identical FEB-ROB
interface
on all small modules.

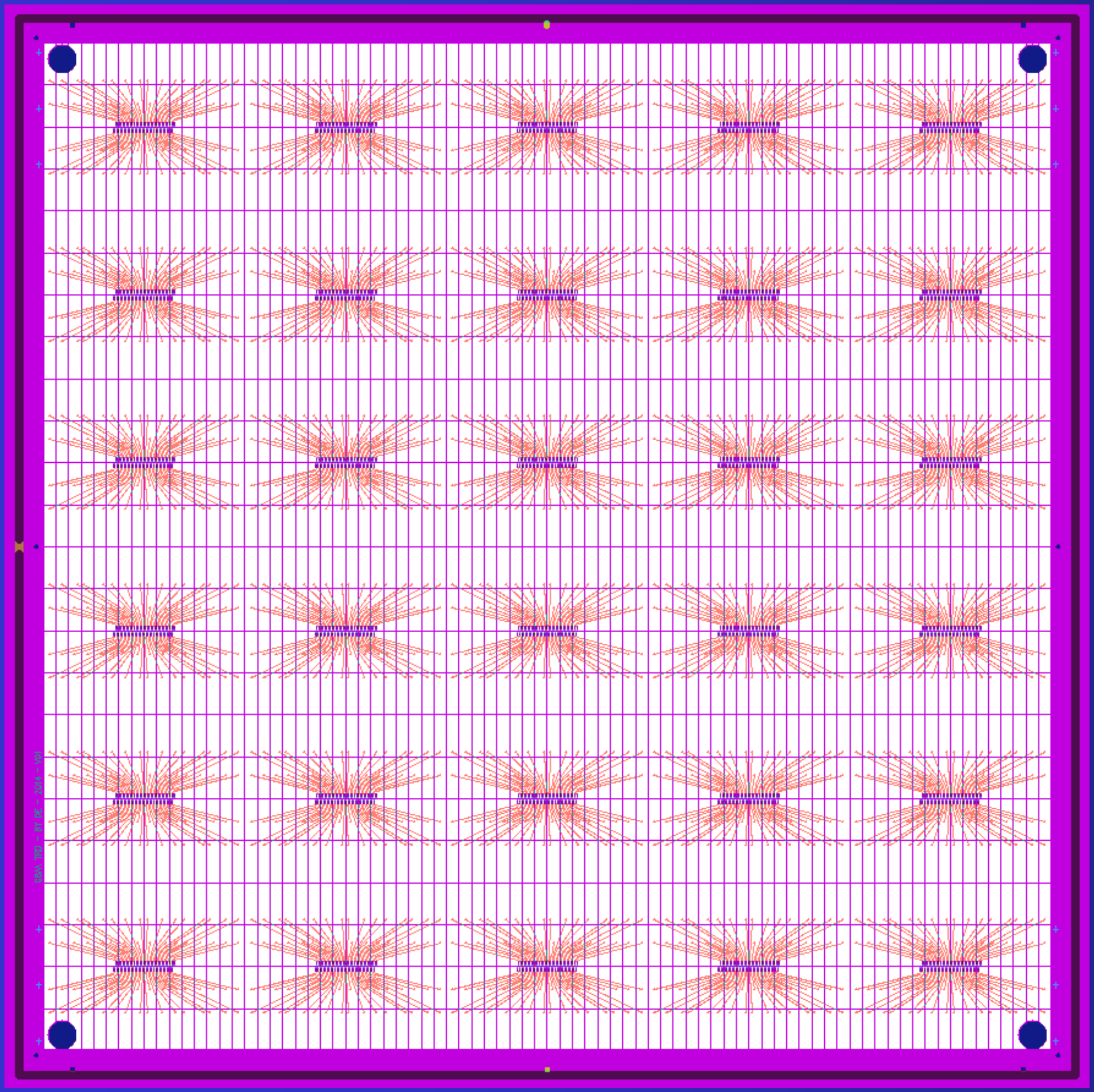
To get rid of
complicated ROB-7
on module type 1
and ROB-5 / ROB-3
mix on module type 2.

Type 2 v17a modification



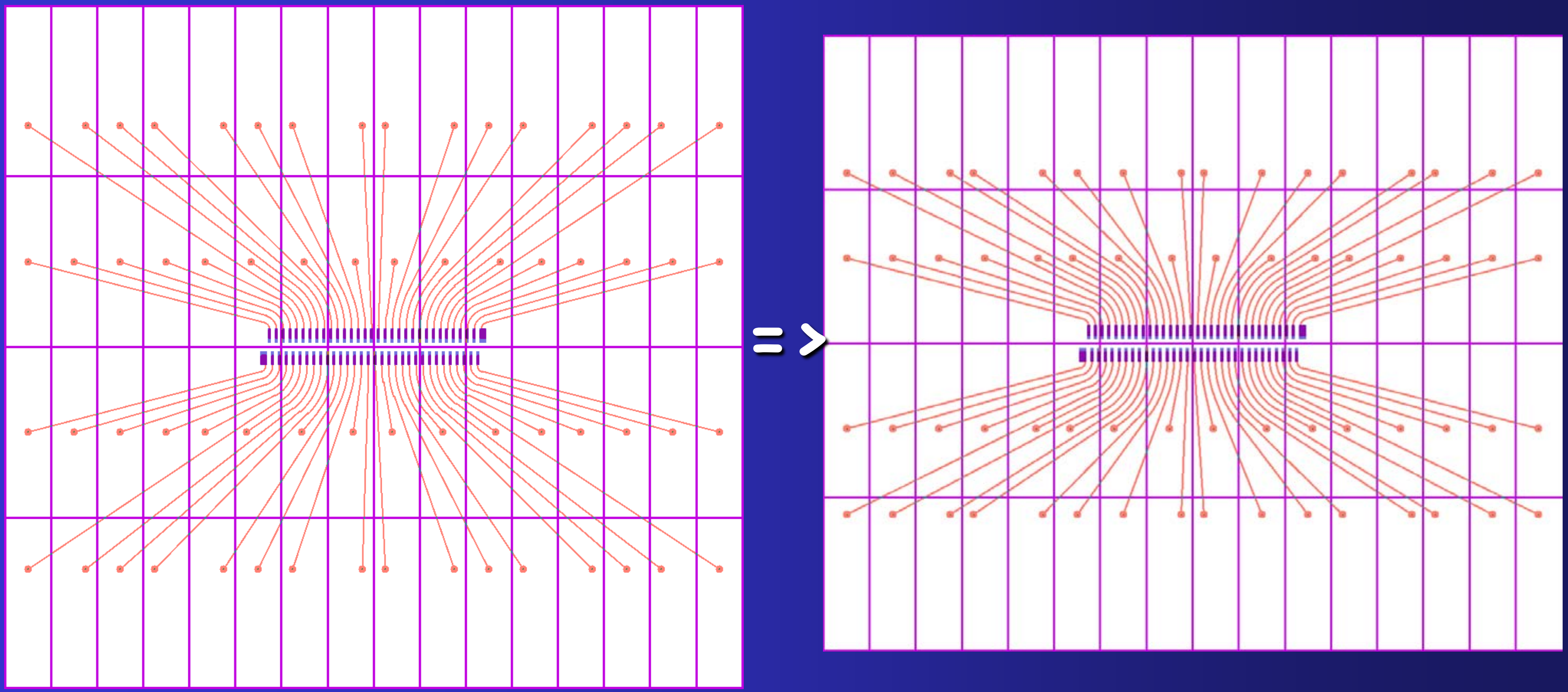
Switching ROB-3 with a ROB-5 gives the opportunity to add one additional FEB 5x2 for free. 89% -> 86% uplink efficiency.

Module type 2 v17a



- 24 rows, 80 columns
- 1920 pads
- 1.52 cm^2 pad size
- 30x 64-pin connectors
- 5 connectors per row
- 4 rows per connector

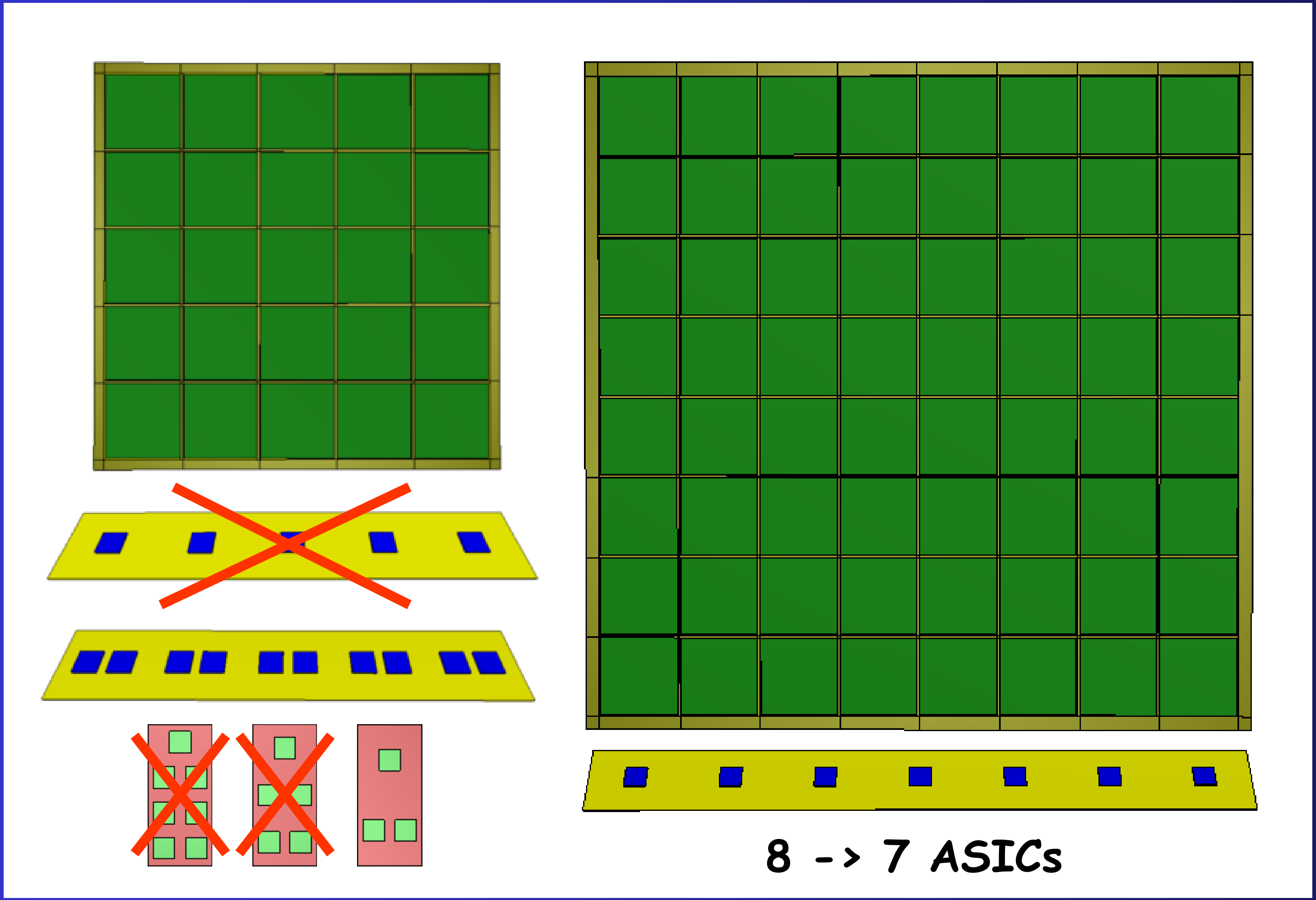
Type 2 pad block v17a



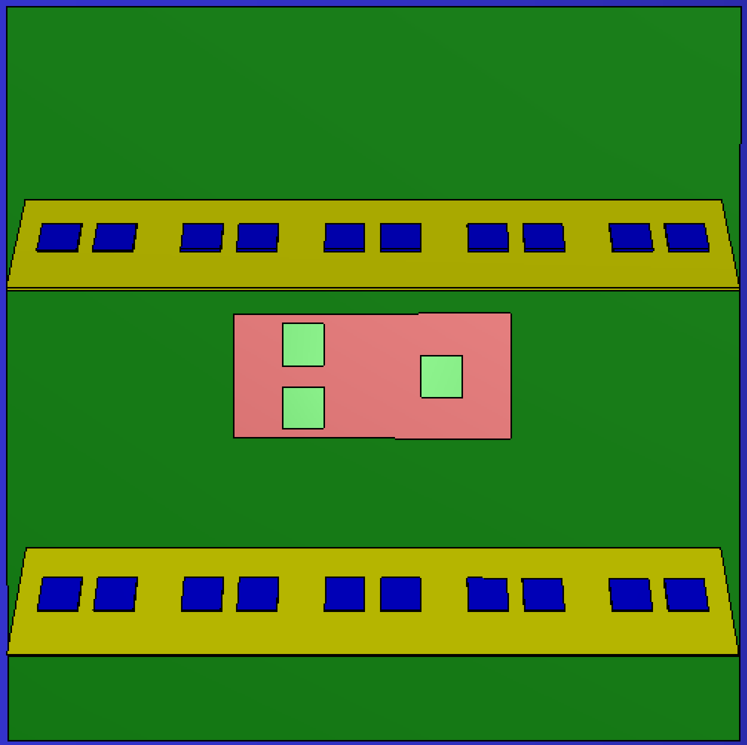
Pad length drops from 16x 2.75 cm + 4x 2.50 cm to 24x 2.25 cm.

TRD v17b
-
Optimise readout efficiency

TRD v17b components



Small module readout

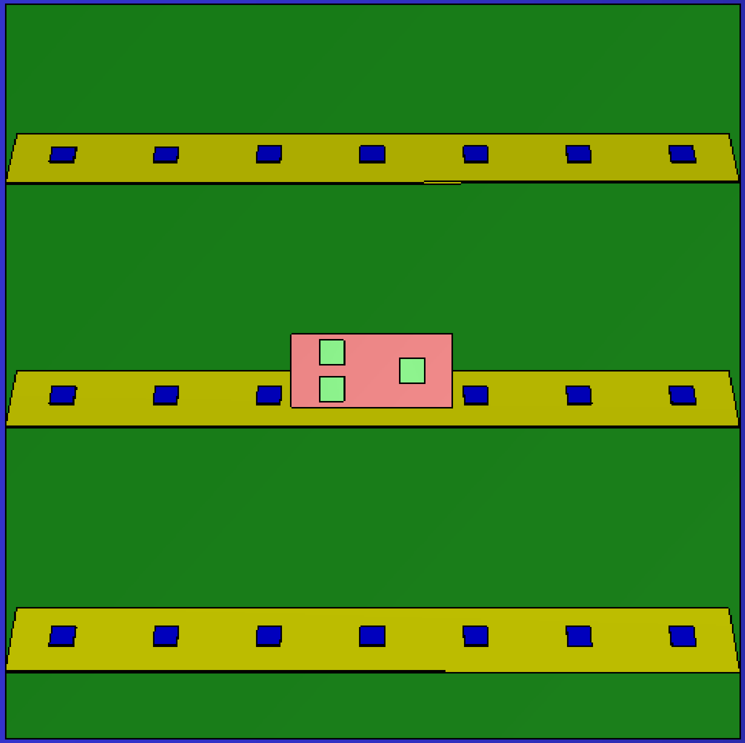


update

Pitch

super
9 FEBs x 4 rows

Large module readout



update

Pitch

super
9 FEBs x 4 rows

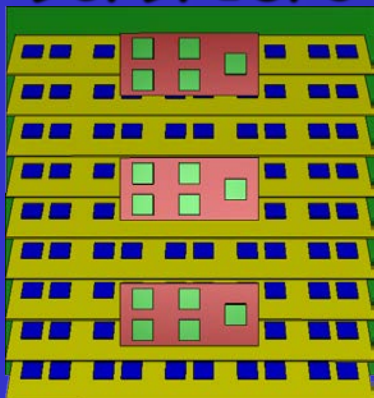
Geometry summary

Geometry summary

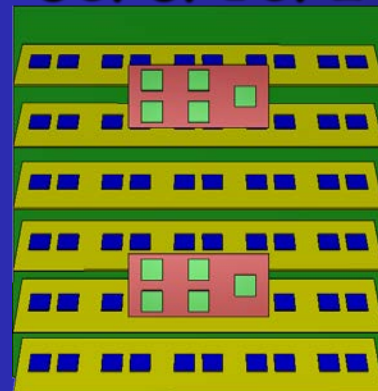
geometry –	module types	FEB types	ROB types	uplink efficiency
TDR v16b	6	3	3	
v17a	6	2	2	update
v17b	6	2	1	

TRD geometry v17a -3

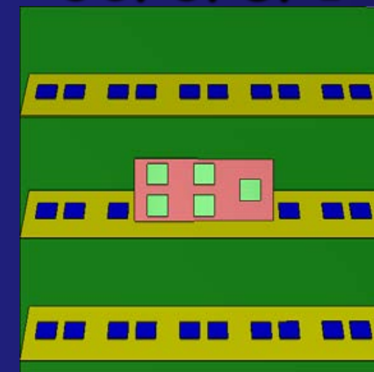
90/9/15/3

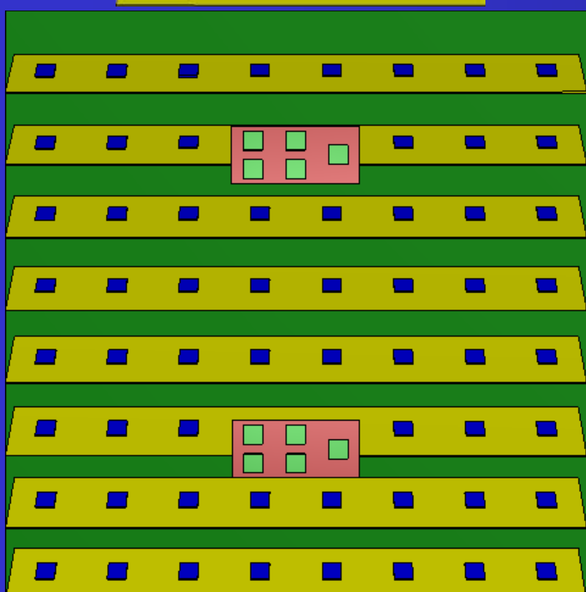


60/6/10/2

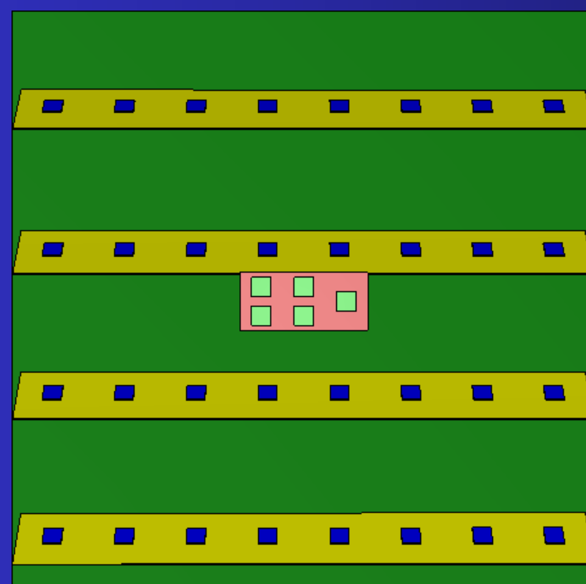


30/3/5/1

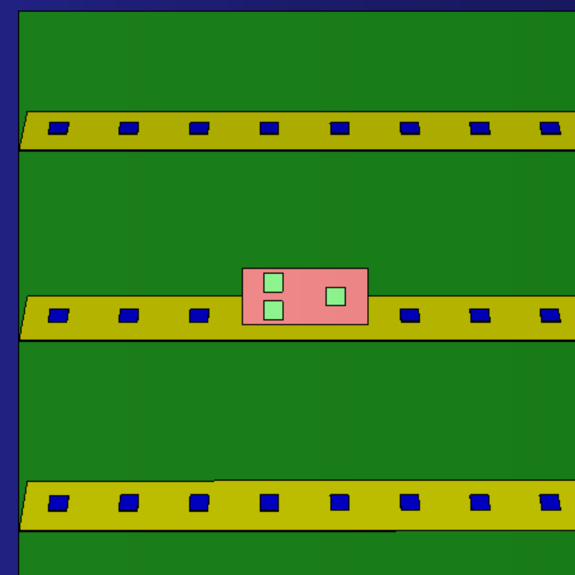




64/8/10/2



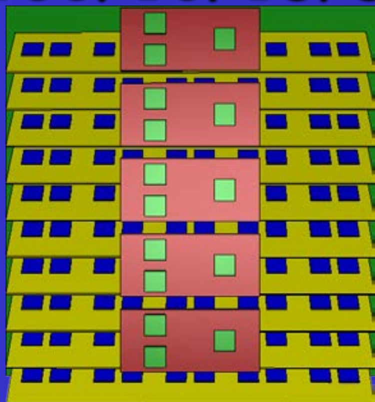
32/4/5/1



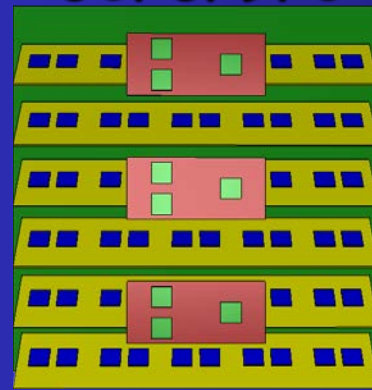
24/3/3/1

TRD geometry v17b

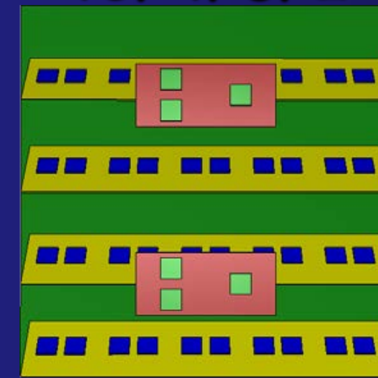
100/10/15/5

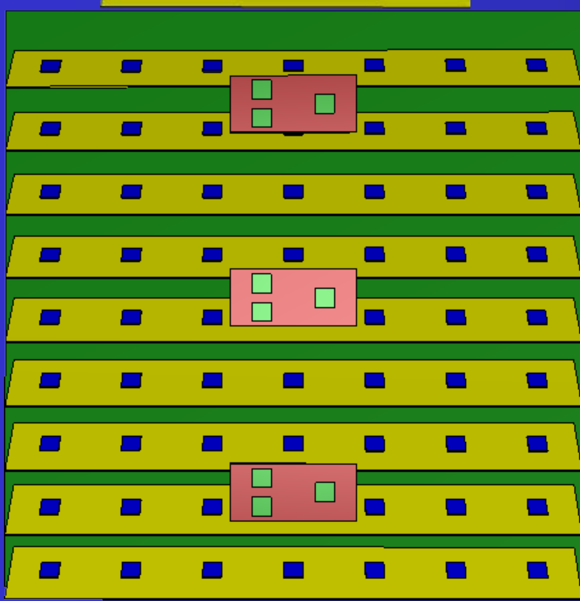


60/6/9/3

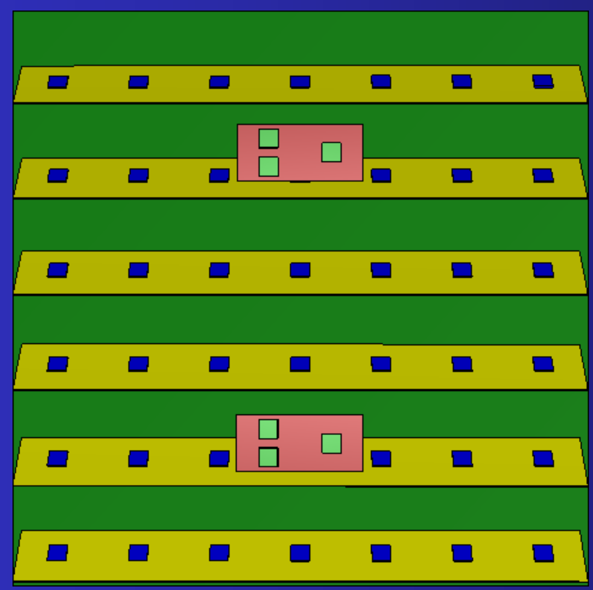


40/4/6/2

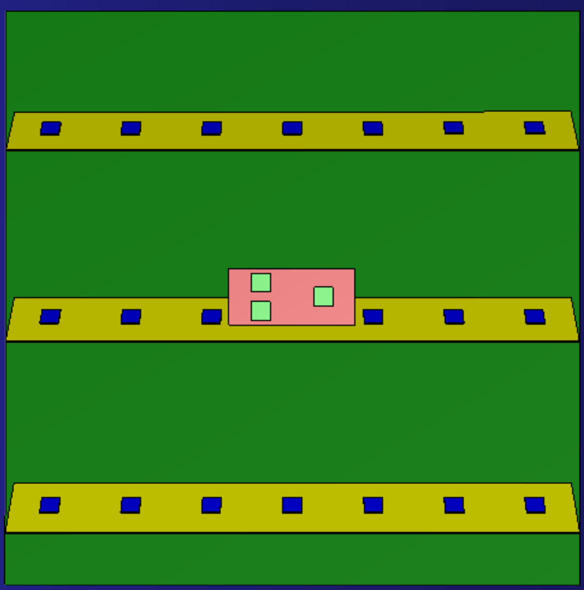




63/9/9/3

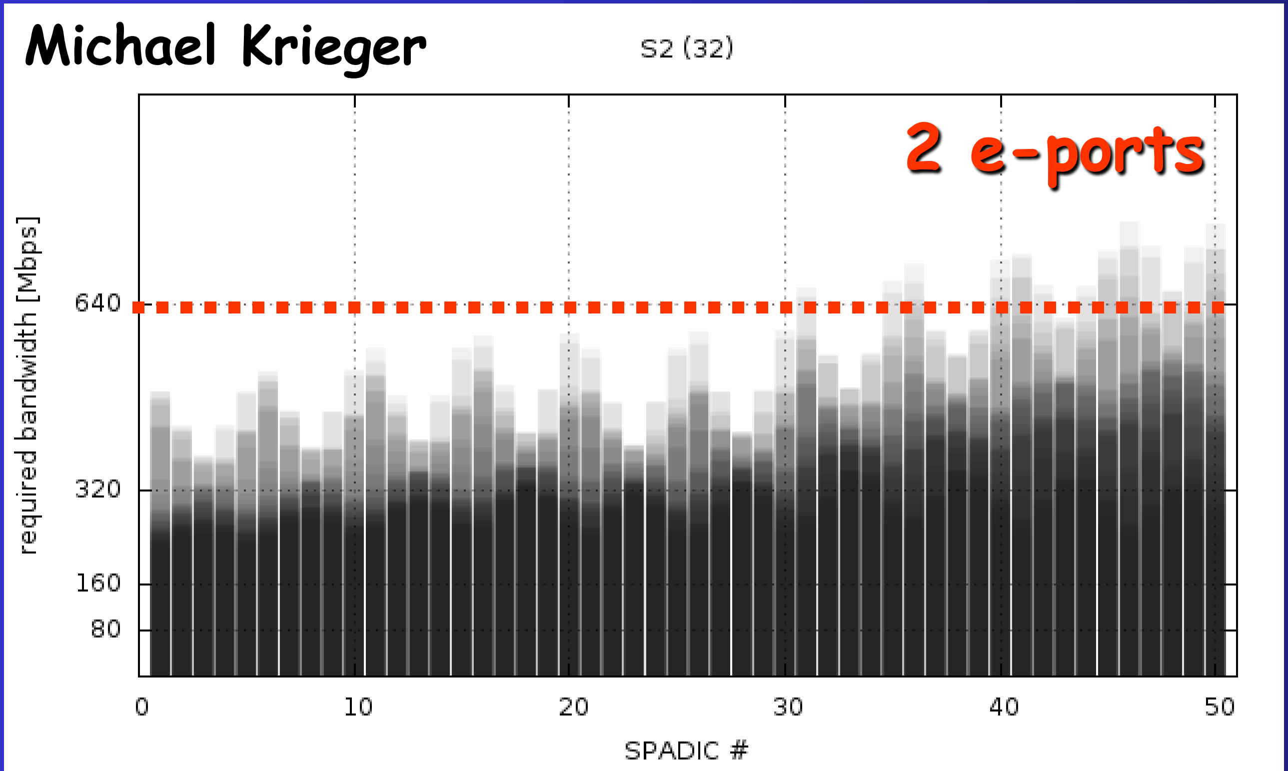


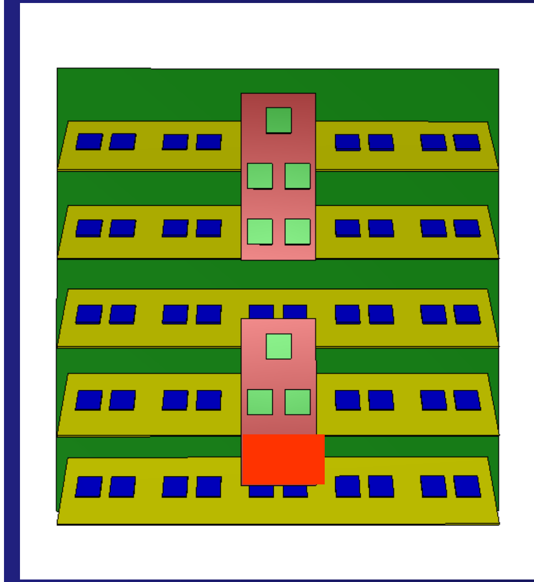
42/6/6/2



21/3/3/1

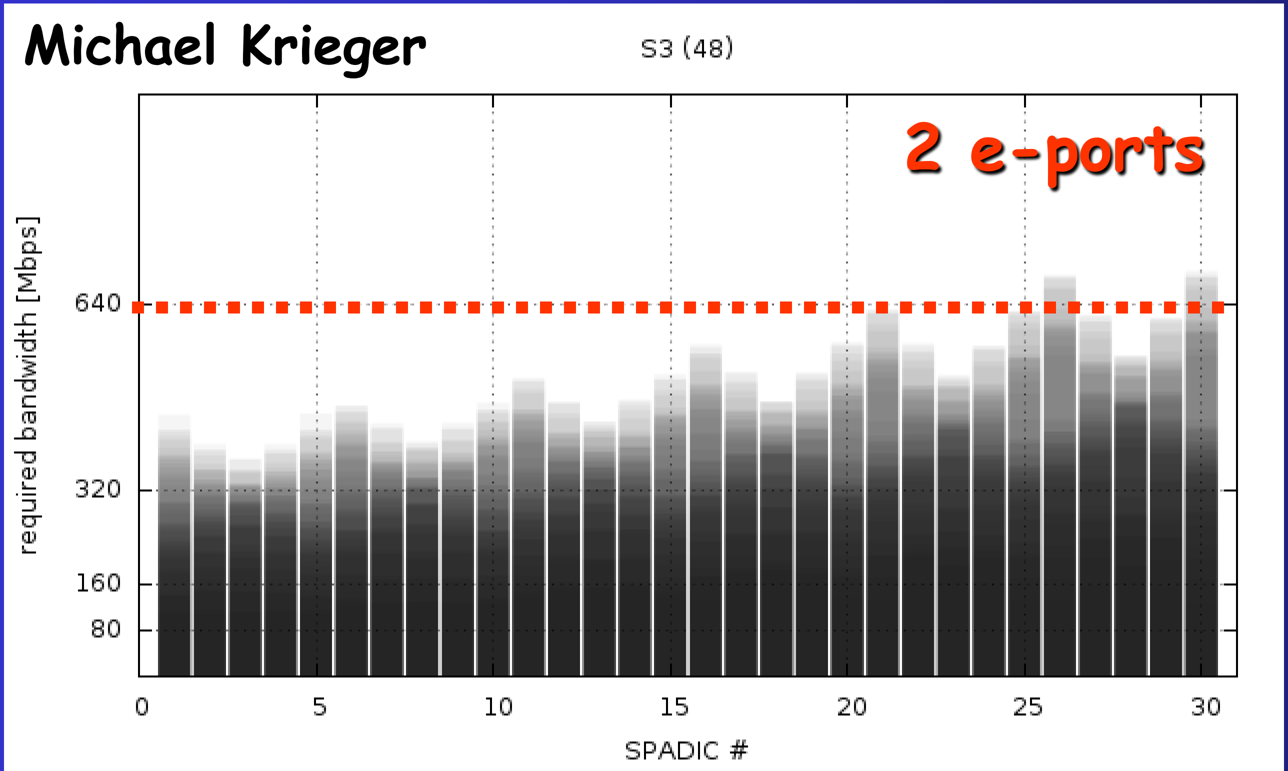
Module type 2 data rate

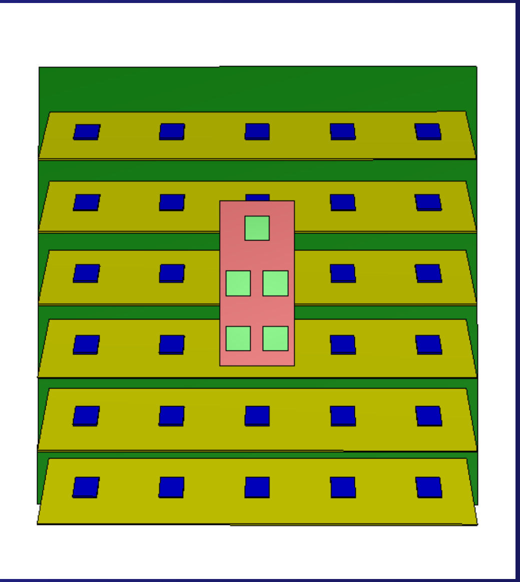




50 Spadics a 2 e-ports	= 100 e-ports		usage
2x GBTx ROB 5 = 2x 5x 14	= 140 e-ports	or	57%
GBTx ROB 3+5 = (3 + 5)x 14	= 112 e-ports		85%

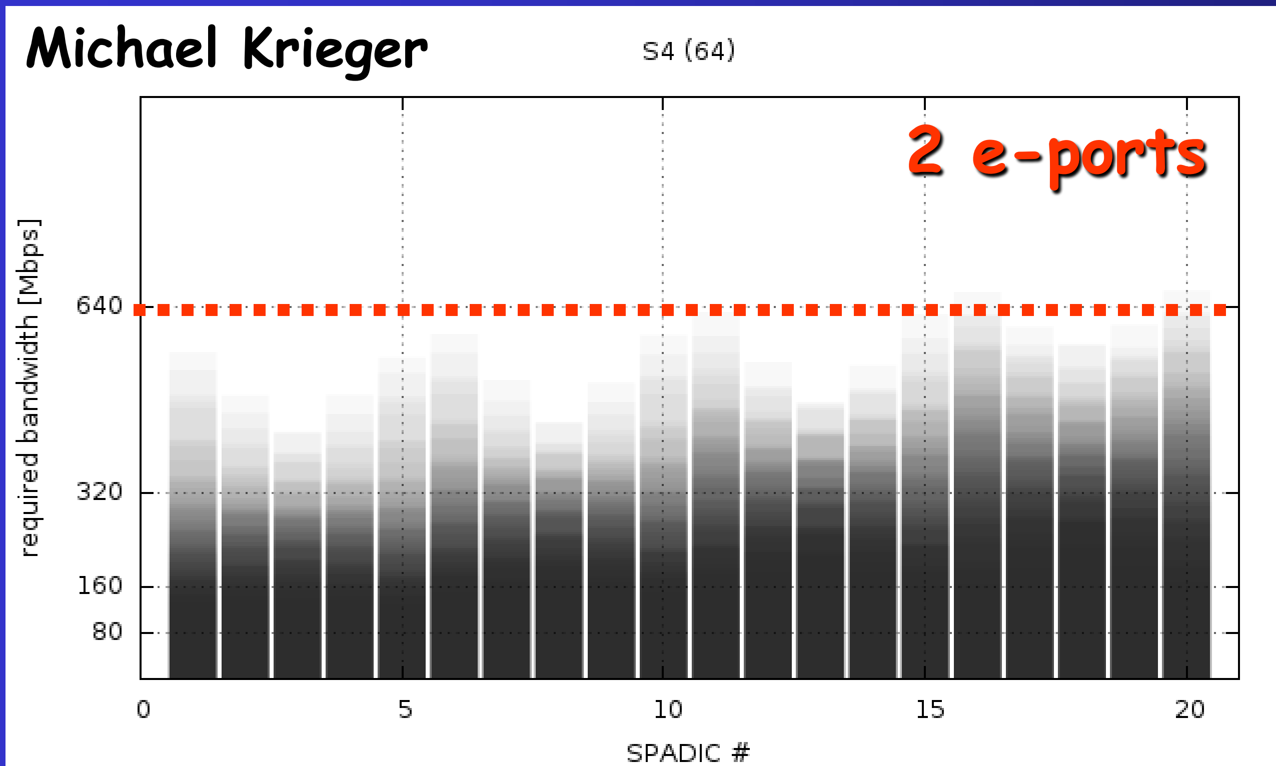
Module type 3 data rate

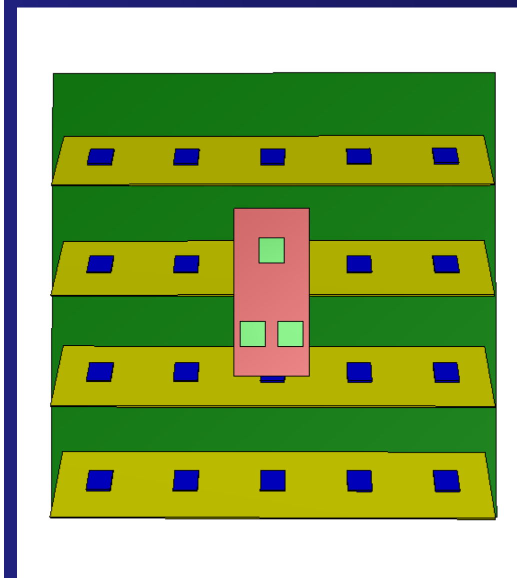




30 Spadics a 2 e-ports = 60 e-ports usage
1x GBTx ROB 5 = 1x 5x 14 = 70 e-ports 86%

Module type 4 data rate

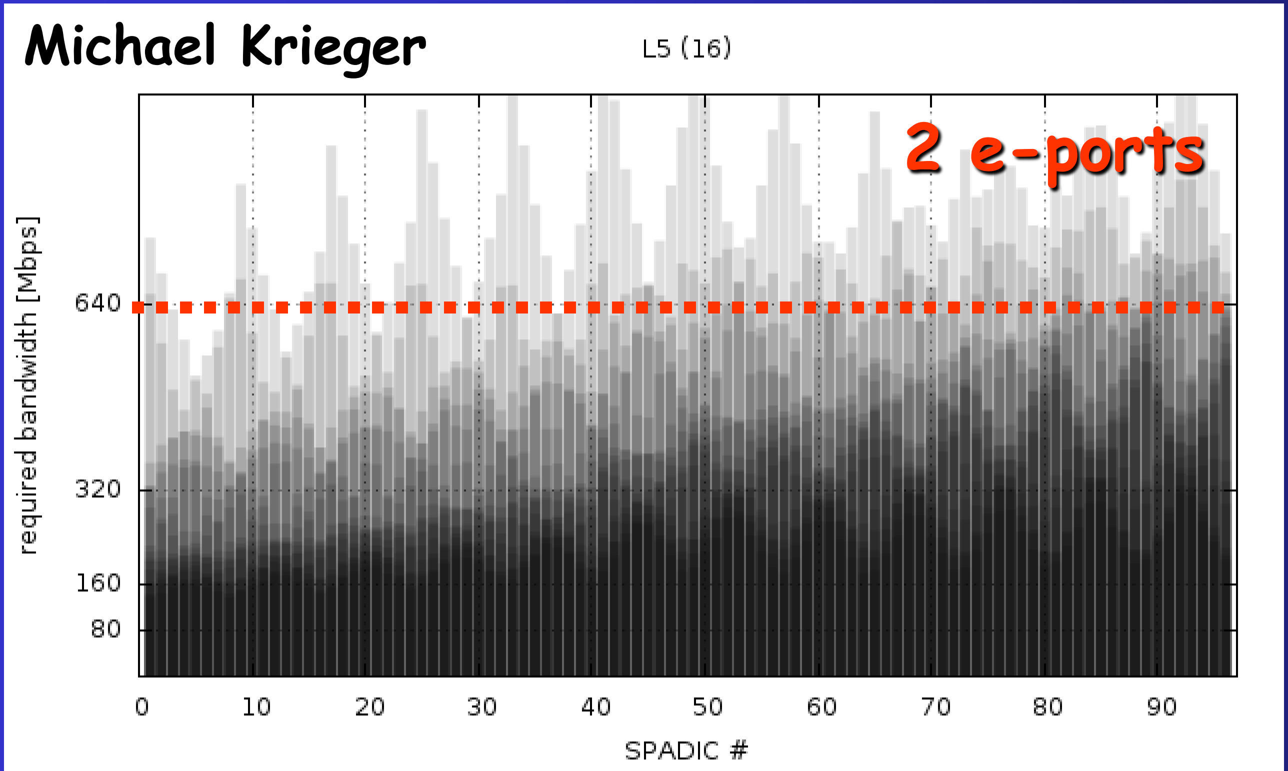


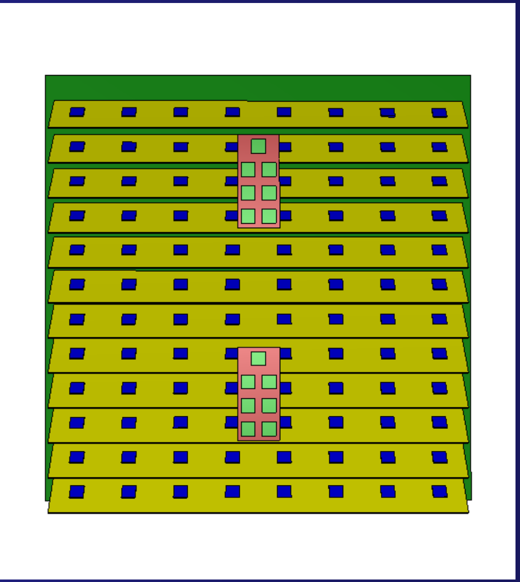


20 Spadics a 2 e-ports = 40 e-ports
1x GBTx ROB 3 = 1x 3x 14 = 42 e-ports

usage
95%

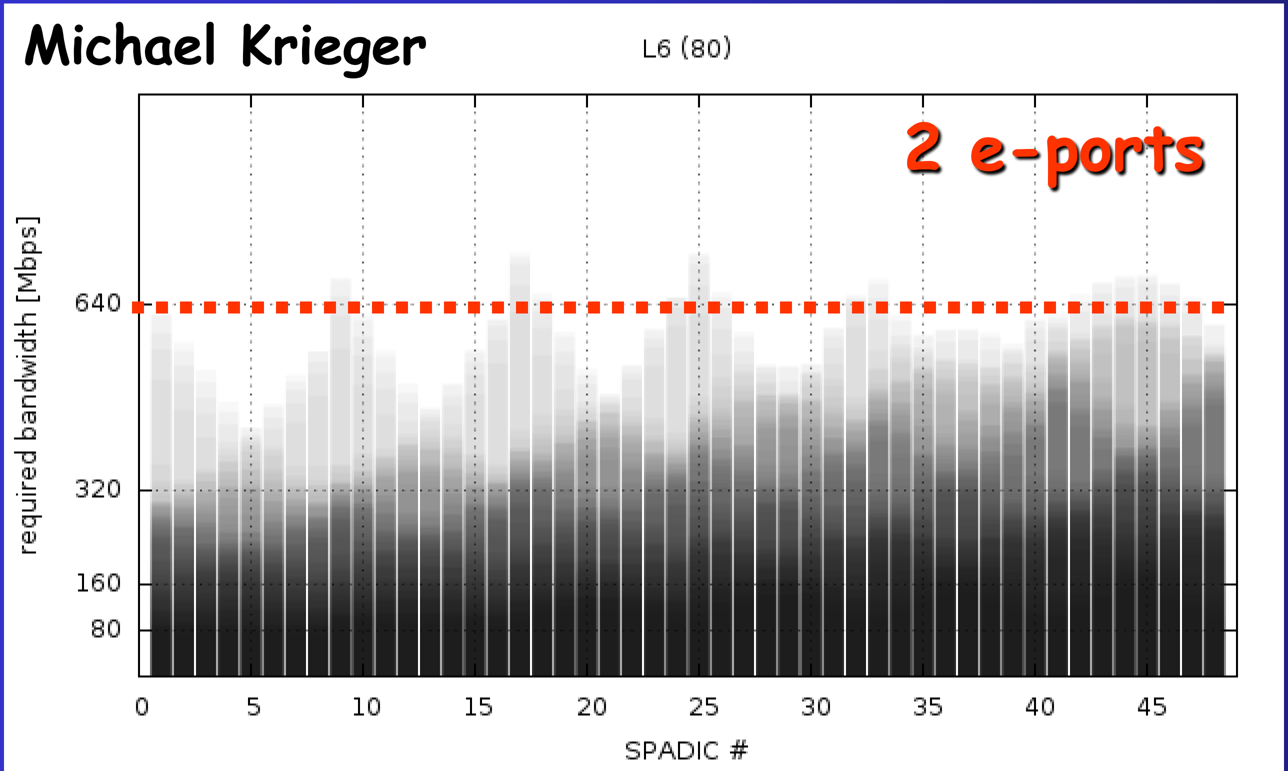
Module type 5 data rate

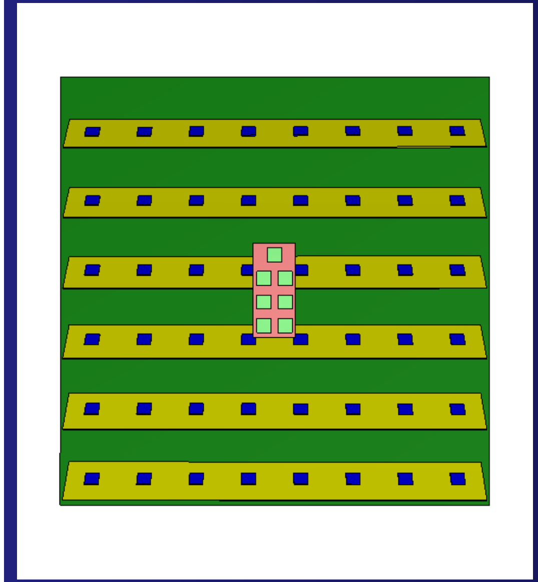




96 Spadics a 2 e-ports = 192 e-ports usage
2x GBTx ROB 7 = 2x 7x 14 = 196 e-ports 98%

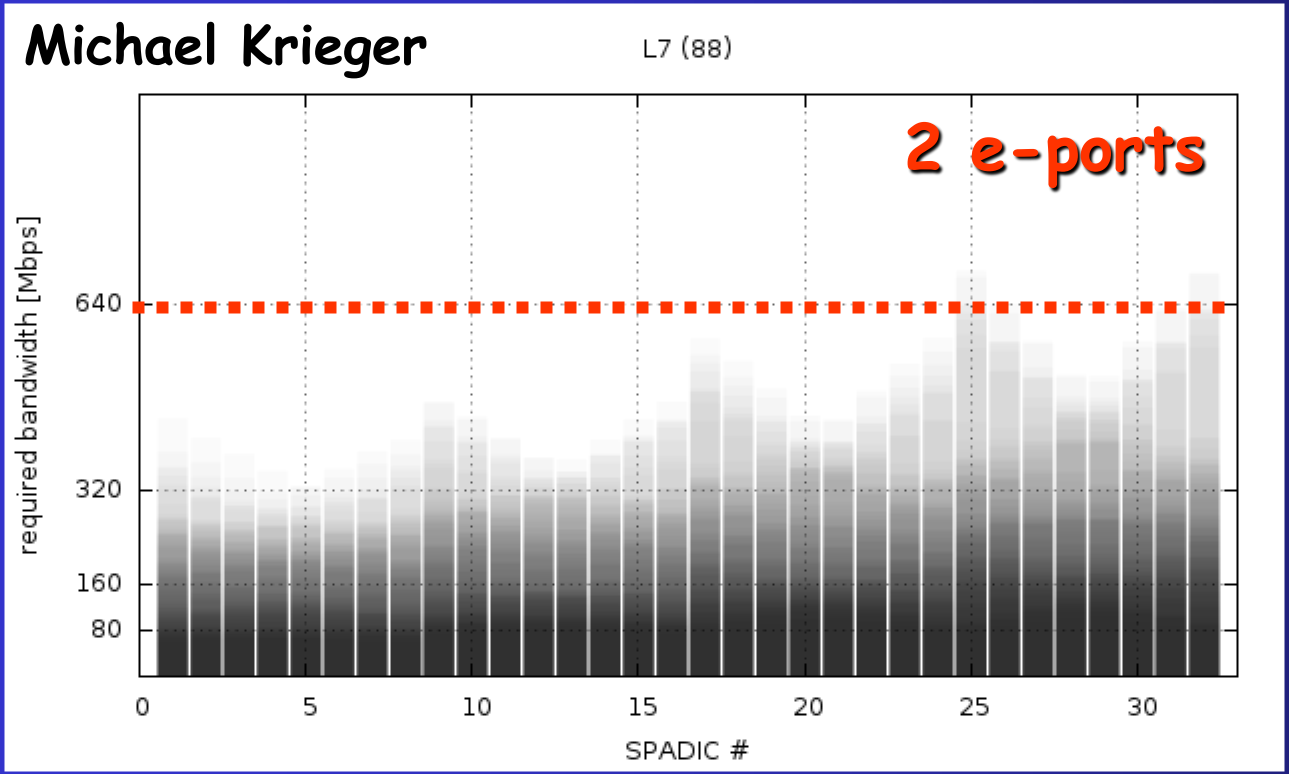
Module type 6 data rate

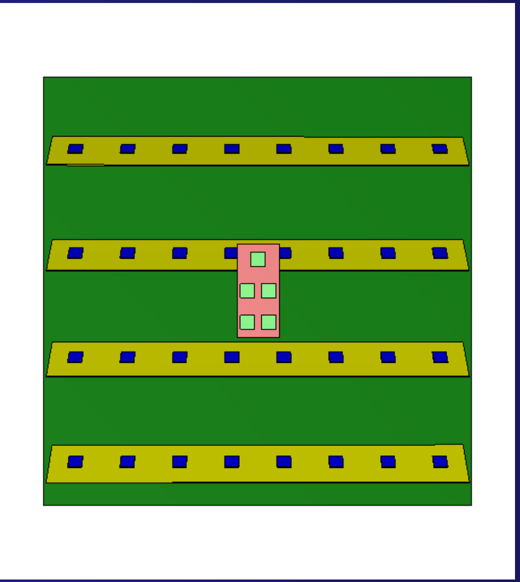




48 Spadics a 2 e-ports	=	96 e-ports	usage
1x GBTx ROB 7 = 1x 7x 14	=	98 e-ports	98%

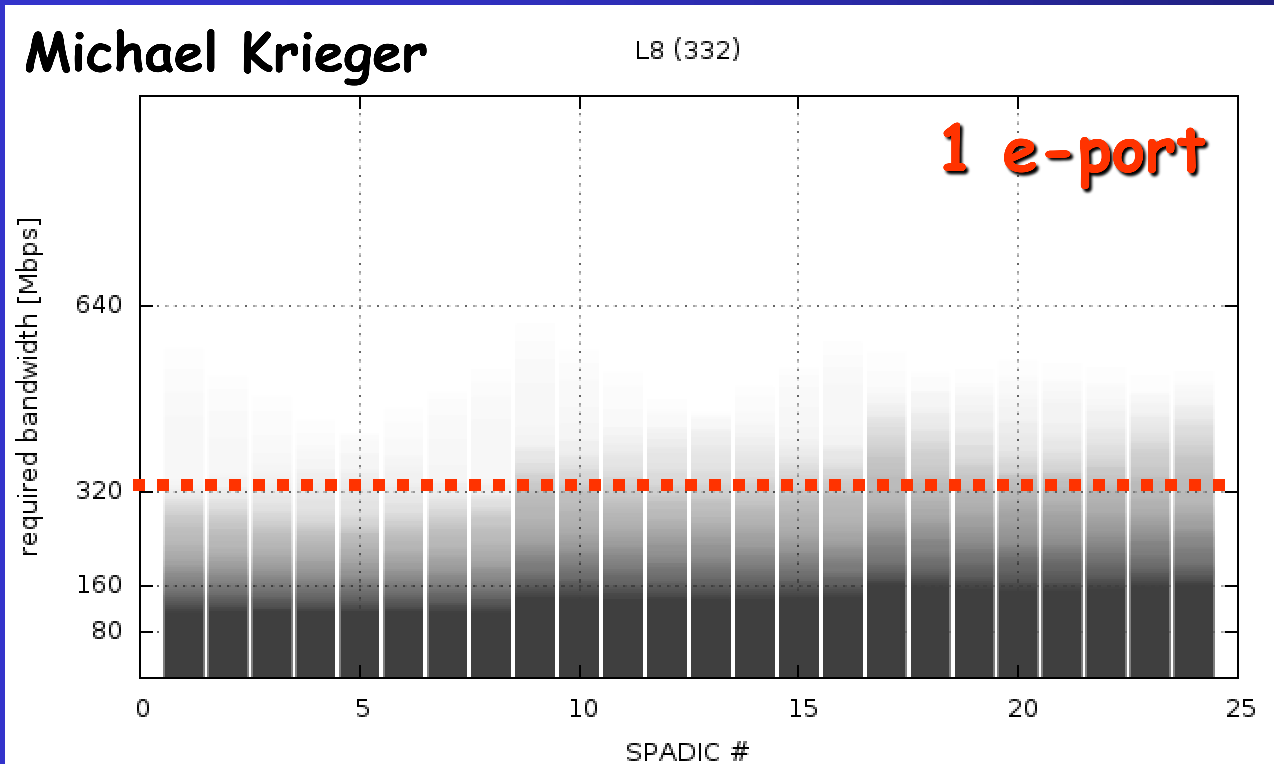
Module type 7 data rate

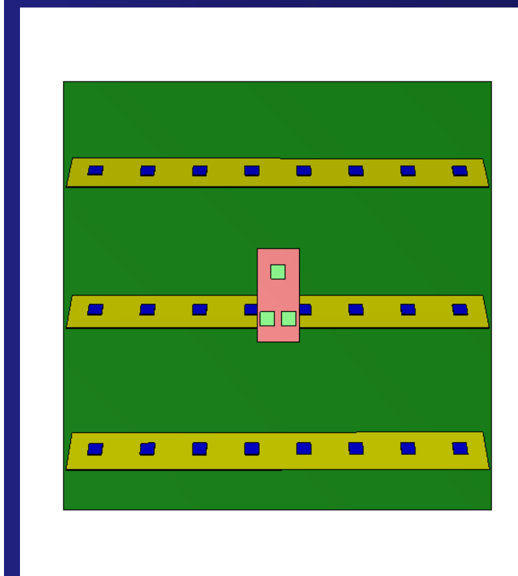




32 Spadics a 2 e-ports = 64 e-ports usage
1x GBTx ROB 5 = 1x 5x 14 = 70 e-ports 91%

Module type 8 data rate





24 Spadics a 1 e-port = 24 e-ports usage
1x GBTx ROB 3 = 1x 3x 14 = 42 e-ports or 57%
2x GBTx ROB 1 = 2x 1x 14 = 28 e-ports 85%
almost the same price for both options