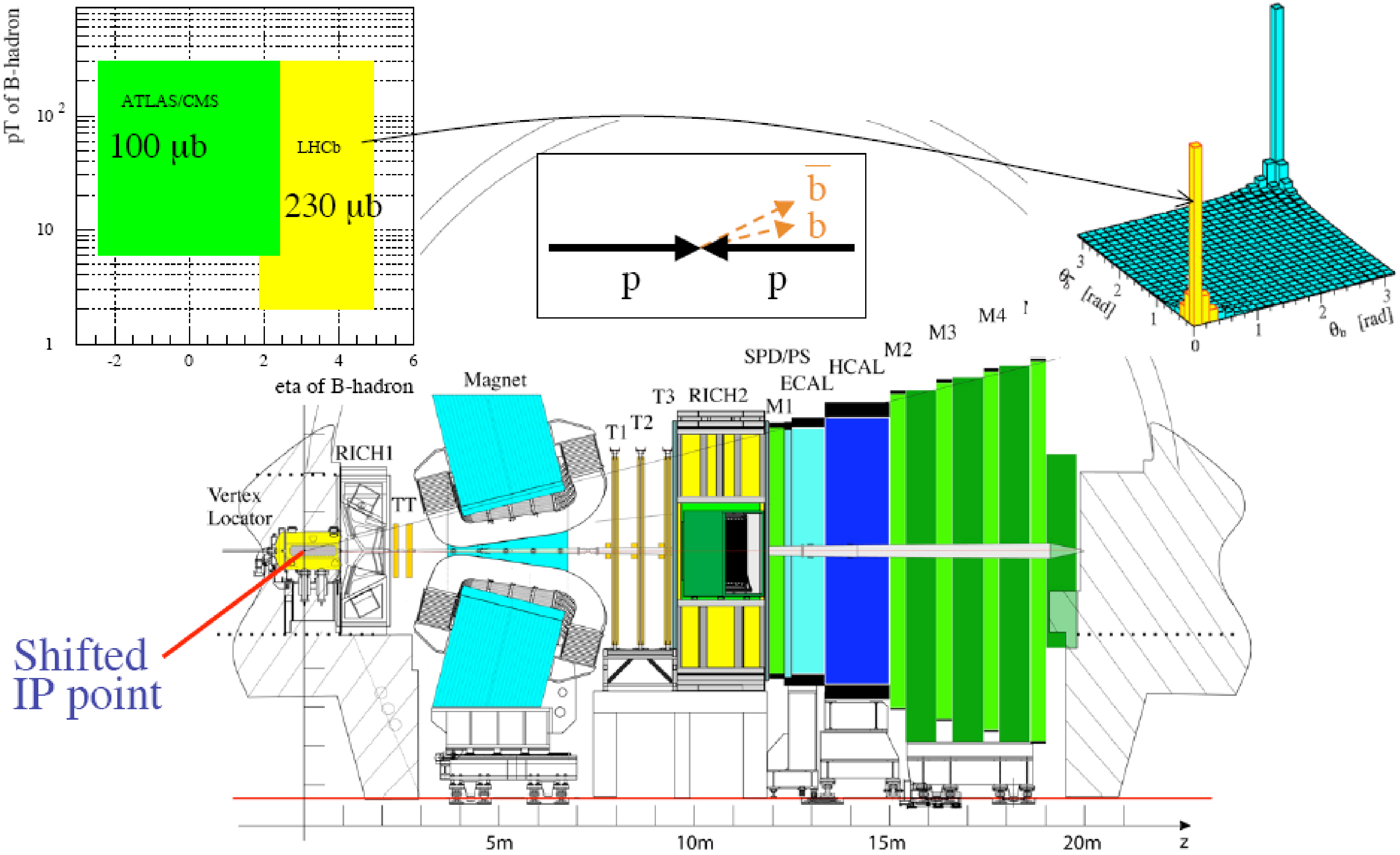
LHCb

Overview

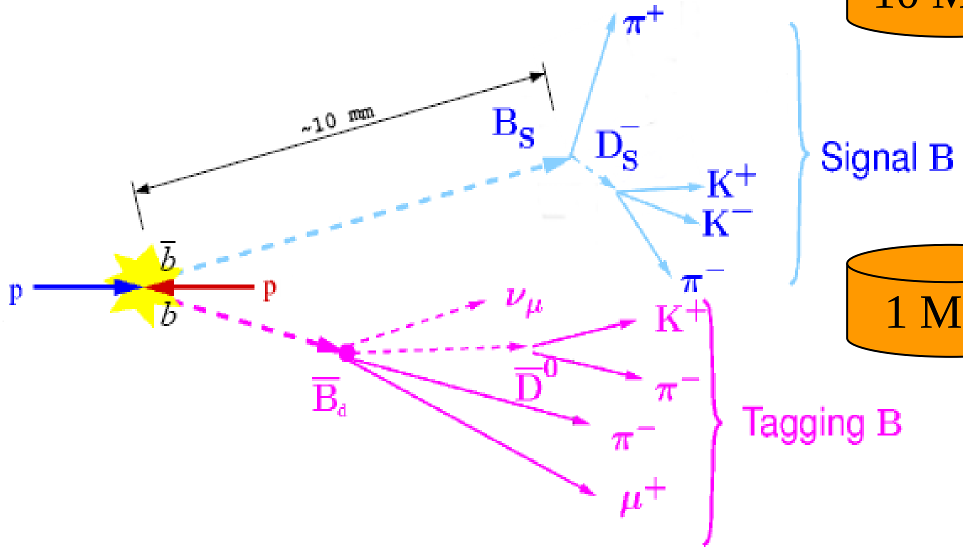
- LHCb
- VELO
- Production
- Testing
- Commissioning
- Summary

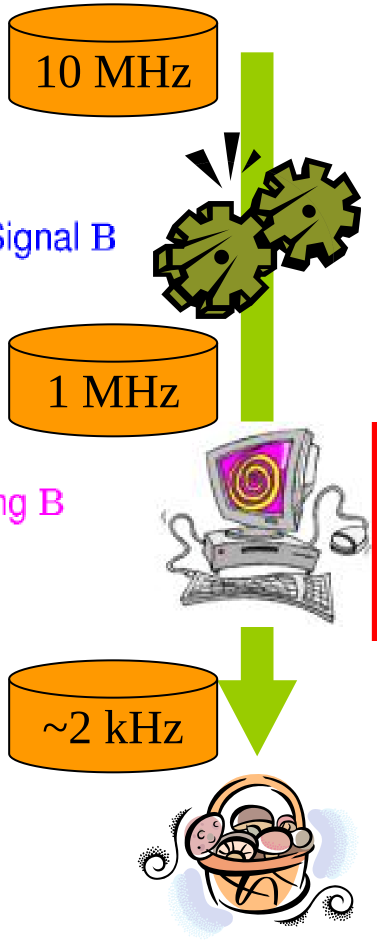
LHCb: Spectrometer



Shifted IP point

LHCb: Triggering on B's





Visible collisions
L = 2 10^{32} cm^{-2} s^{-1}

L0: [hardware]
high Pt particles
calorimeter + muons
4 μs latency

HLT [software]
1 MHz readout
~1800 nodes farm

On tape:
Exclusive selections
Inclusive streams

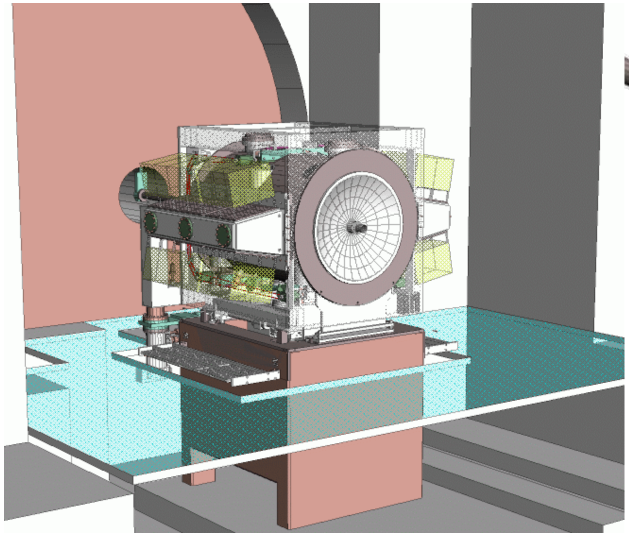
LHCb: VELO Requirements

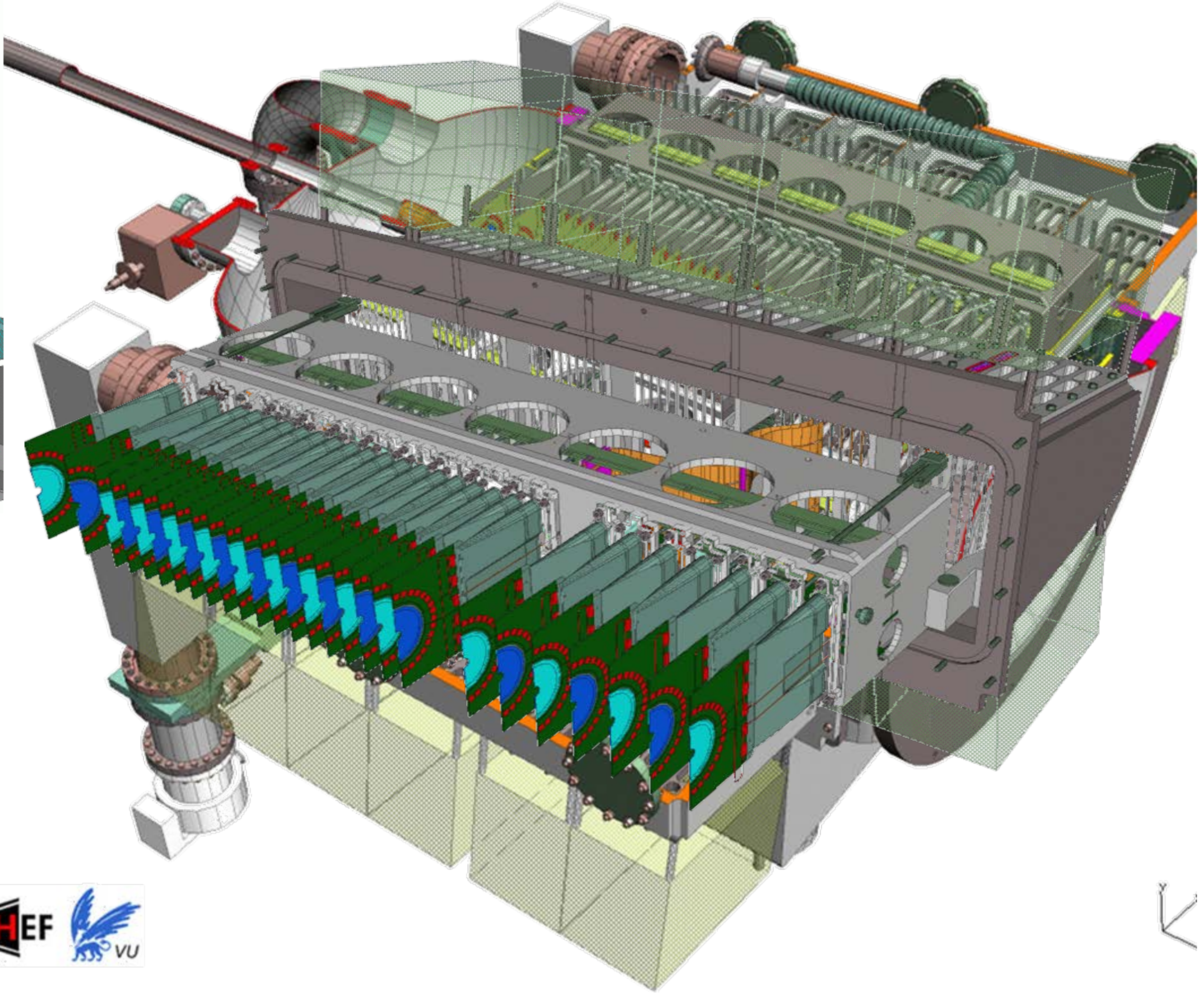
- Good vertexing
  - Primary vertex <10microns
  - IP parameter ~40μm (40fs time resolution)
    - close to LHC beam (vacuum)
    - high radiation levels <10^{15}p/cm^2
  - Close to Beam = moving detectors
- Tracking
- 2D trigger algorithm
  - R-phi geometry
- Low mass ~10% X_0

LHCb: VELO Design

- Tank
- Mechanics and Cooling
- Modules
- FE electronics
- ODE
- Monitoring
- Software

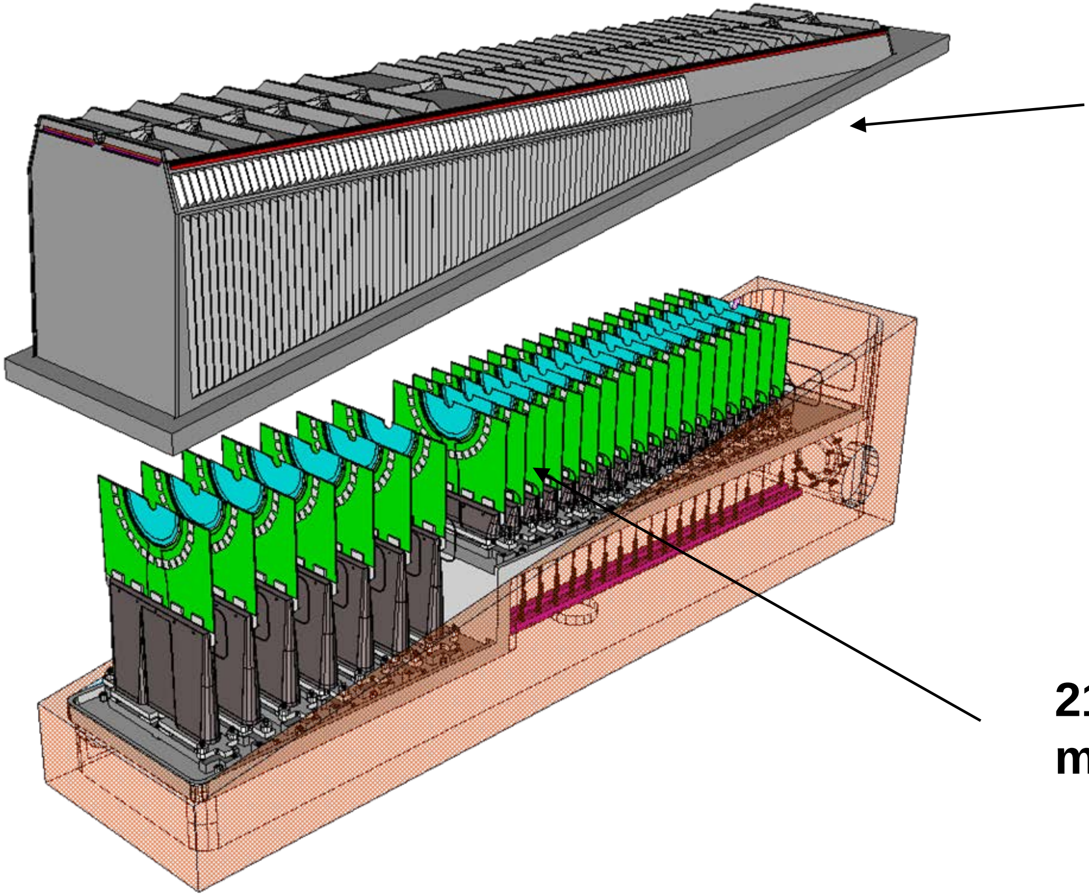
VELO: Tank





NIKHEF VU

VELO: Secondary Vacuum

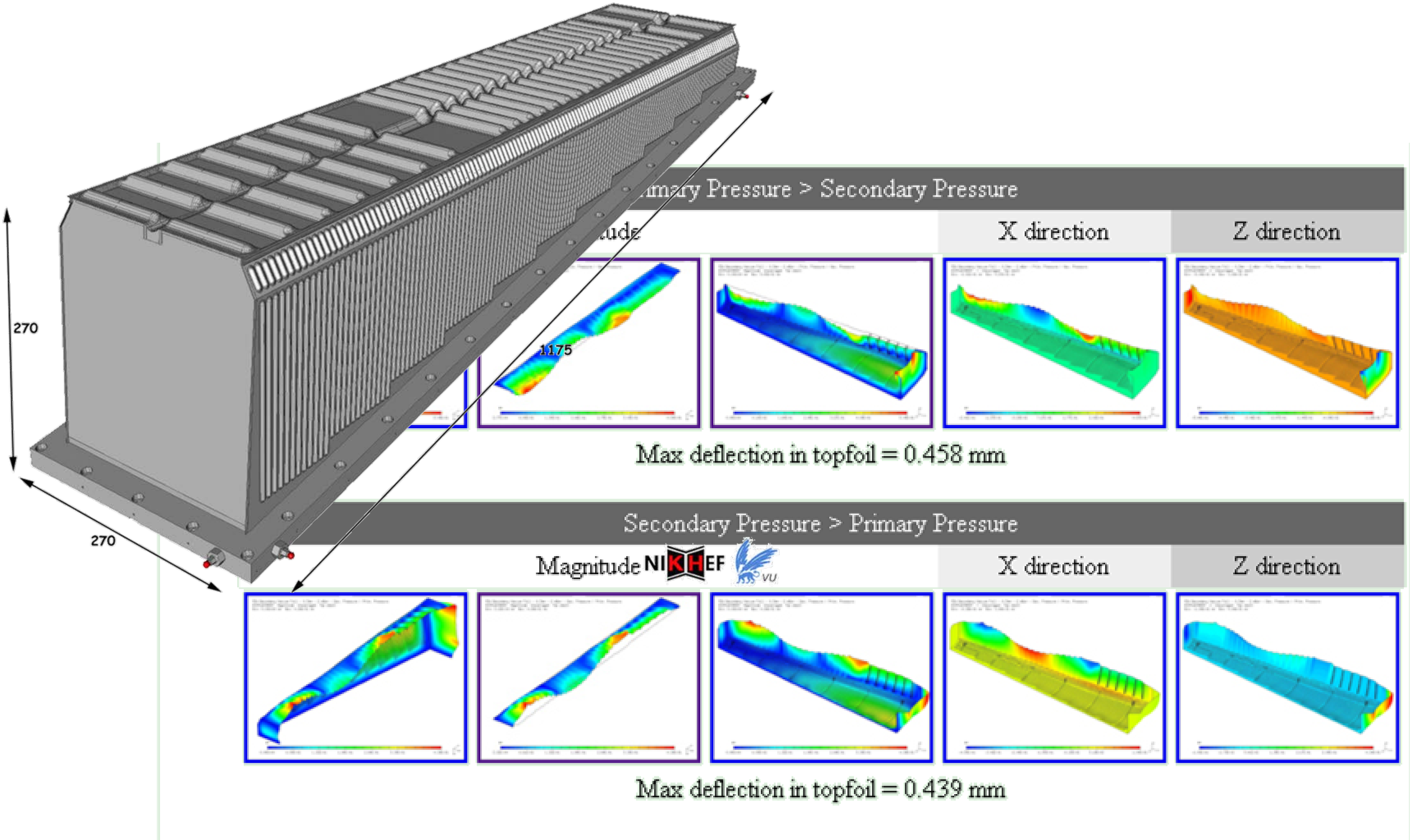


Foil: 5mm from LHC beam

Al 0.3mm thick

21 (originally 25) modules / side

VELO: Secondary Vacuum



…mary Pressure > Secondary Pressure

…tude | X direction | Z direction

Max deflection in topfoil = 0.458 mm

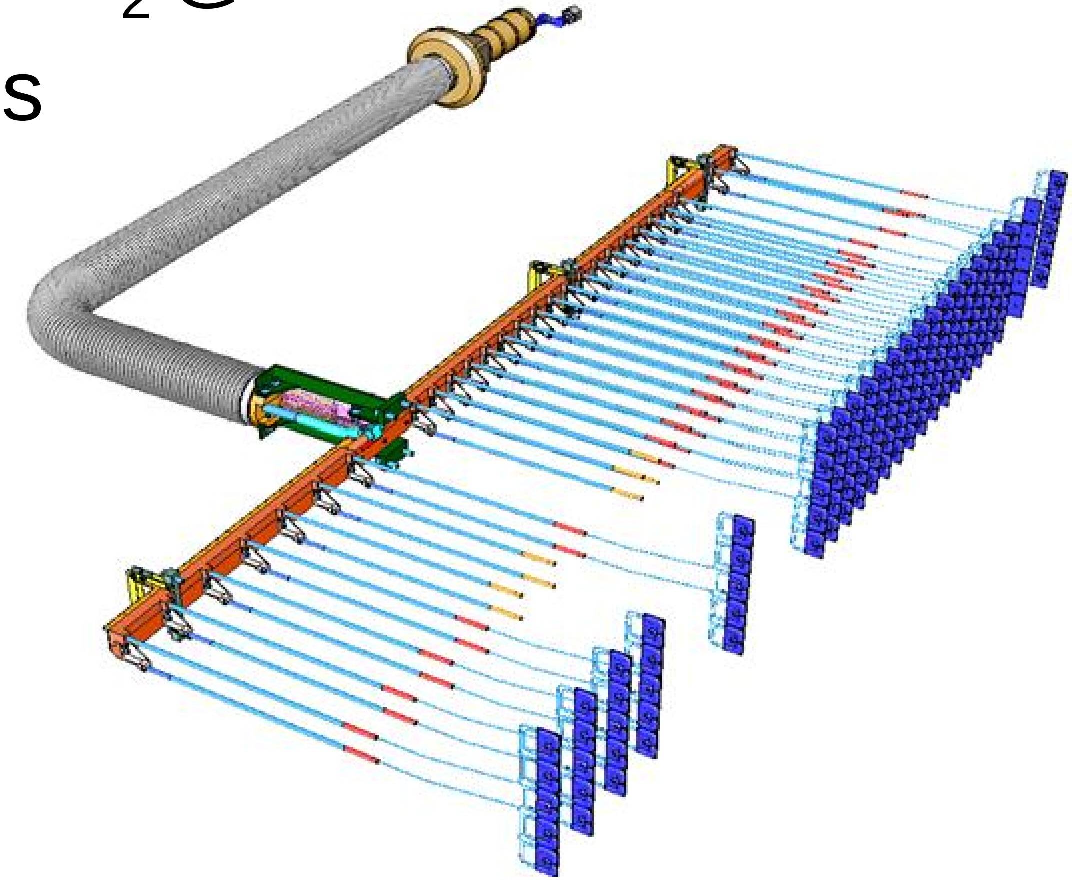
Secondary Pressure > Primary Pressure

Magnitude | X direction | Z direction

Max deflection in topfoil = 0.439 mm

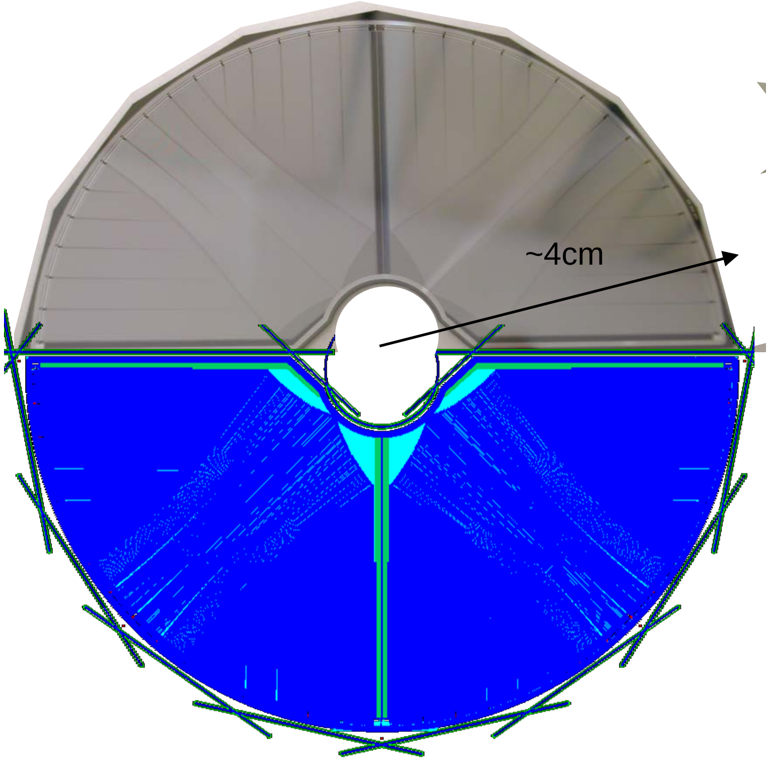
VELO: Cooling

- Biphase CO_2 @ 15bar
- Low mass



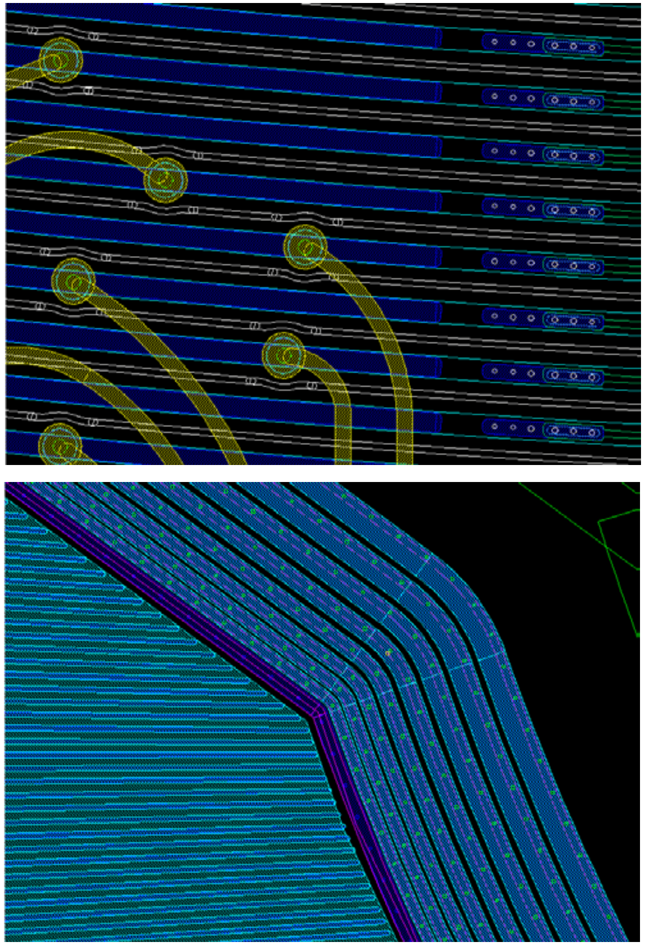
VELO: Sensors

- highly segmented
- n^+n
- double metal layer
- 2048 strips/sensor
- Laser cut
- Two designs
  - – R-measuring
  - – Phi-measuring



LHCb: Sensors Design

- complex
- highly automated
- Simulated ISE-TCAD



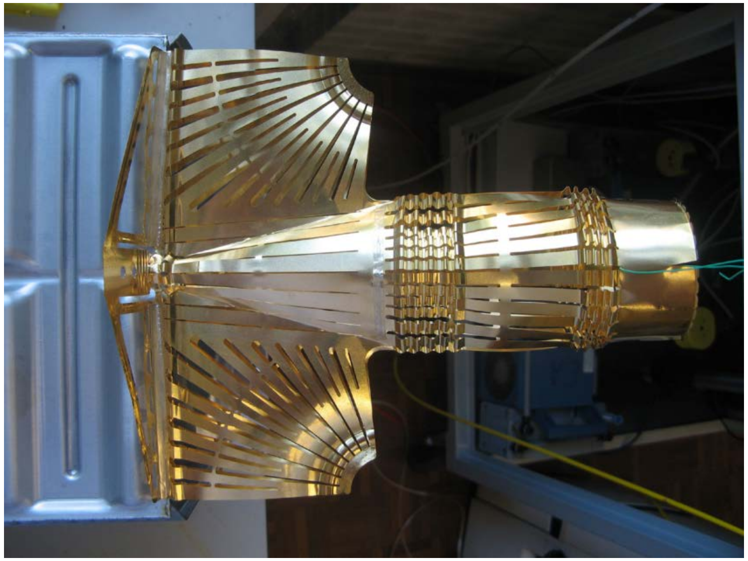
Production and Status

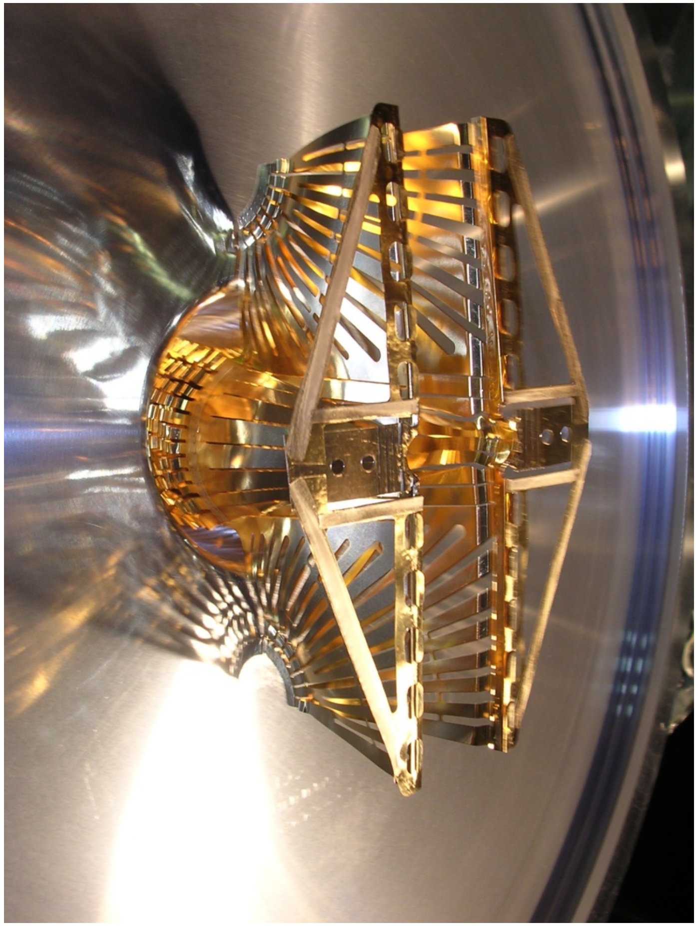
- Selected components
  - Tank
  - Wake Field Suppressor
  - Cooling
  - Hybrids & Bonding
  - Modules
- Many other important parts not mentioned
  - High Voltage, Low Voltage, Cables
  - DAQ

Production: Tank

precision 0.2/0.3 mm

Production: Wake Field Suppressor

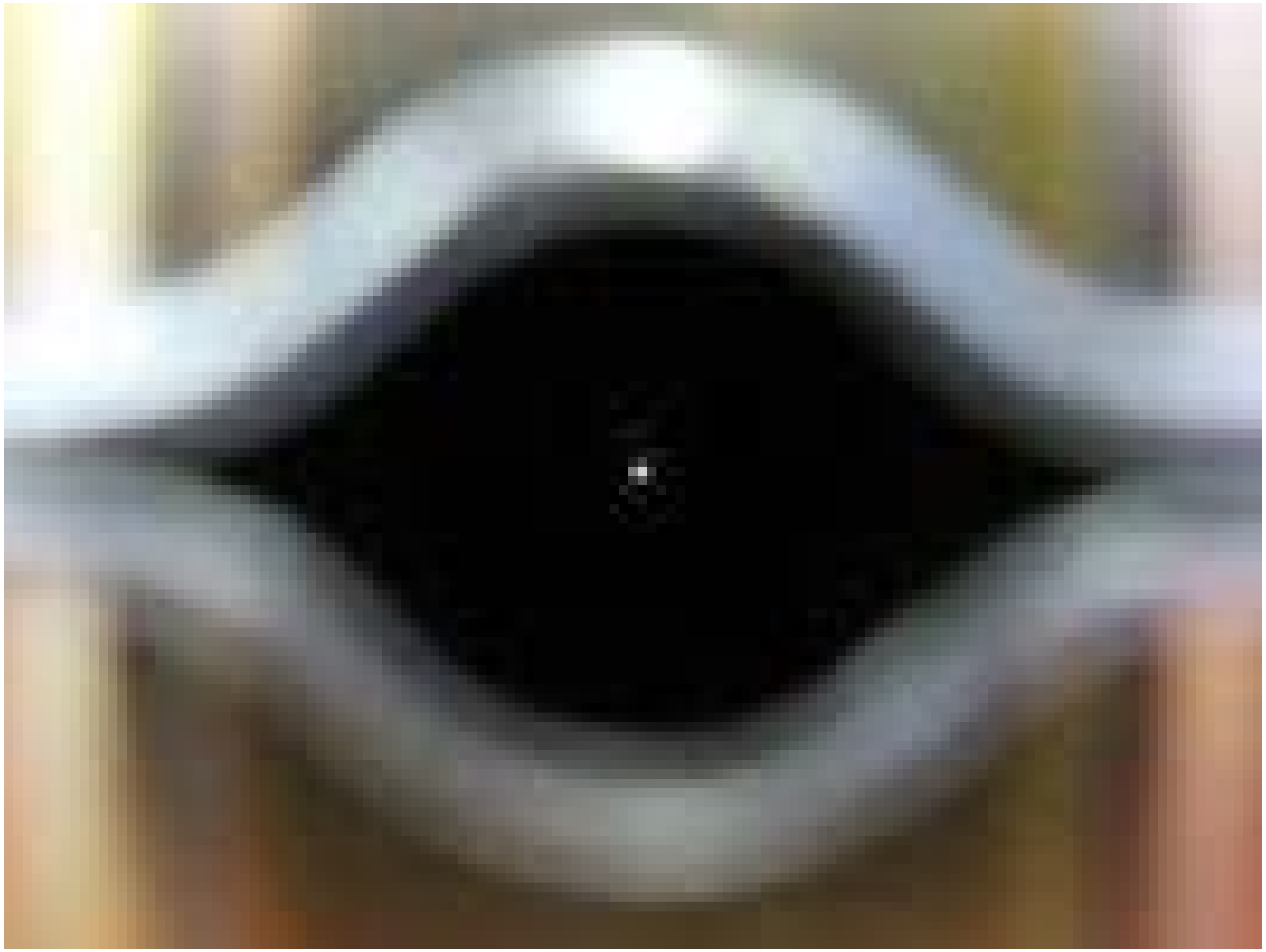




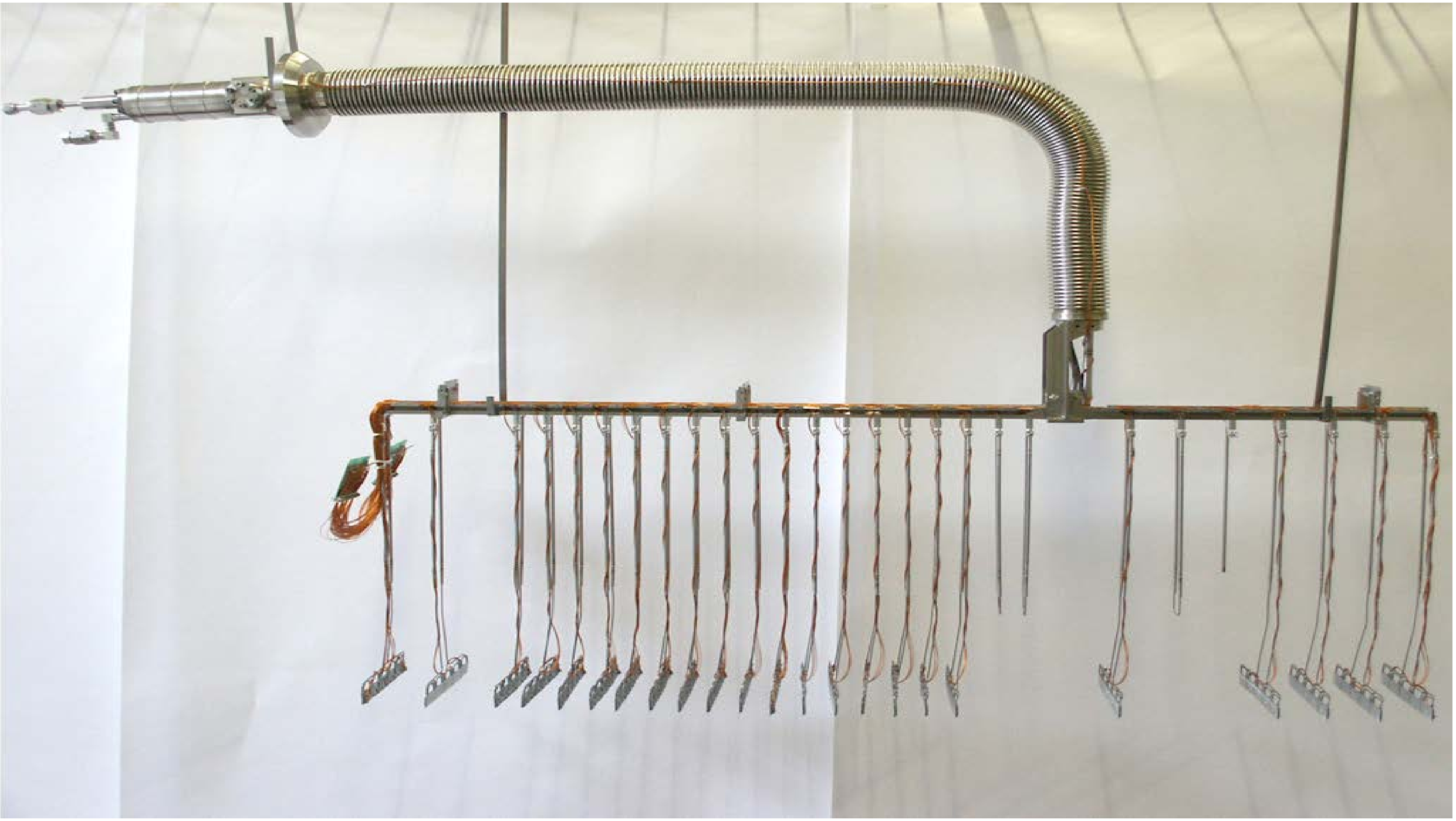
Production: Foils

Production: Foils

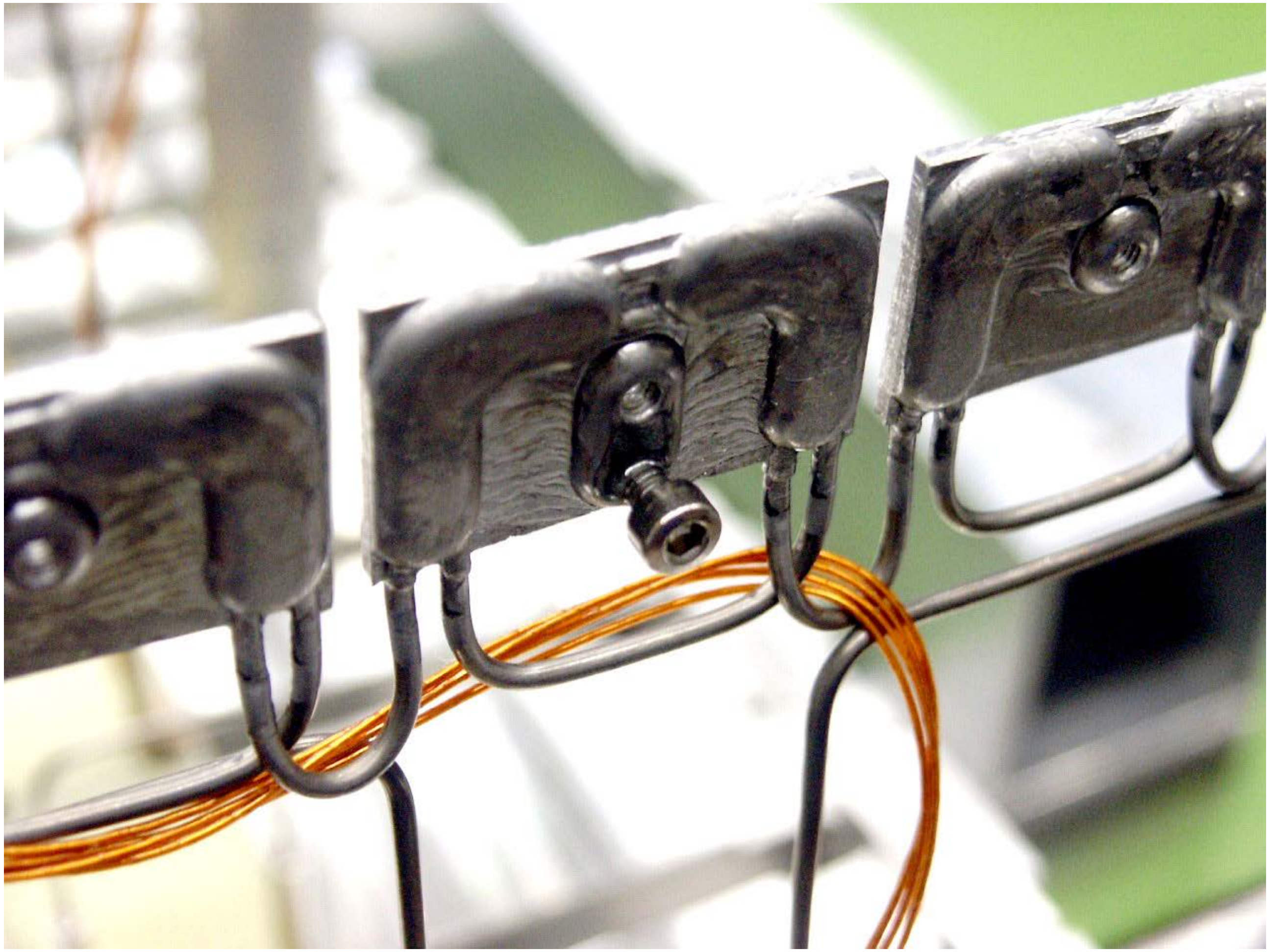
Production: Foils



Production: Cooling

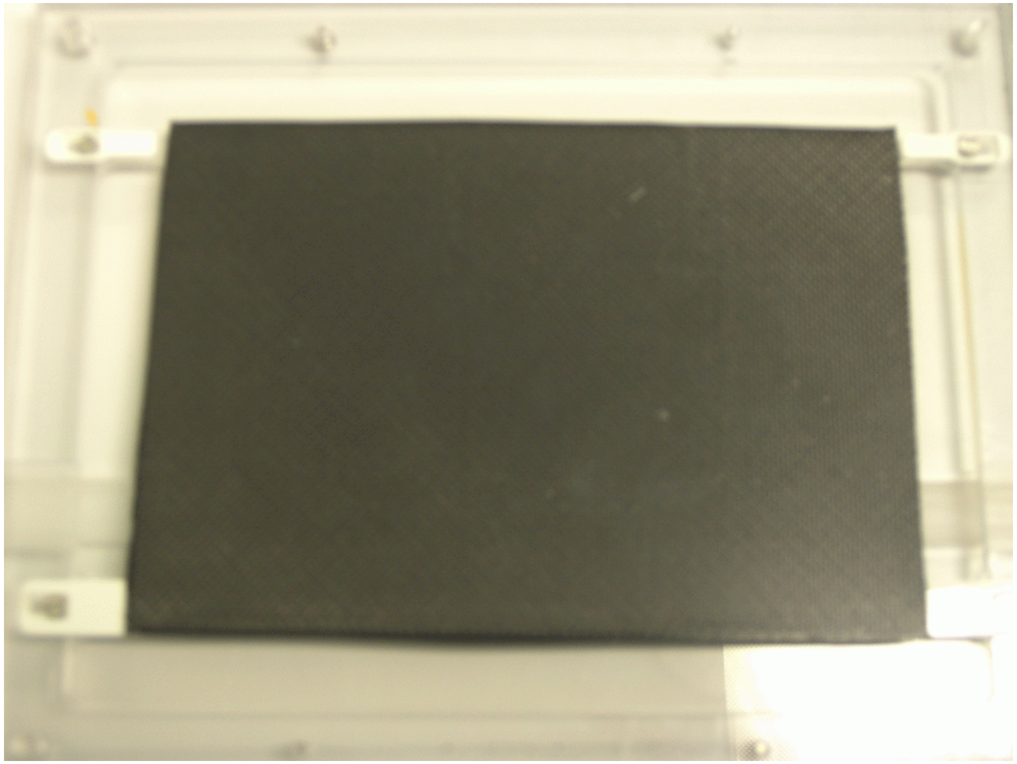


Production: Cooling

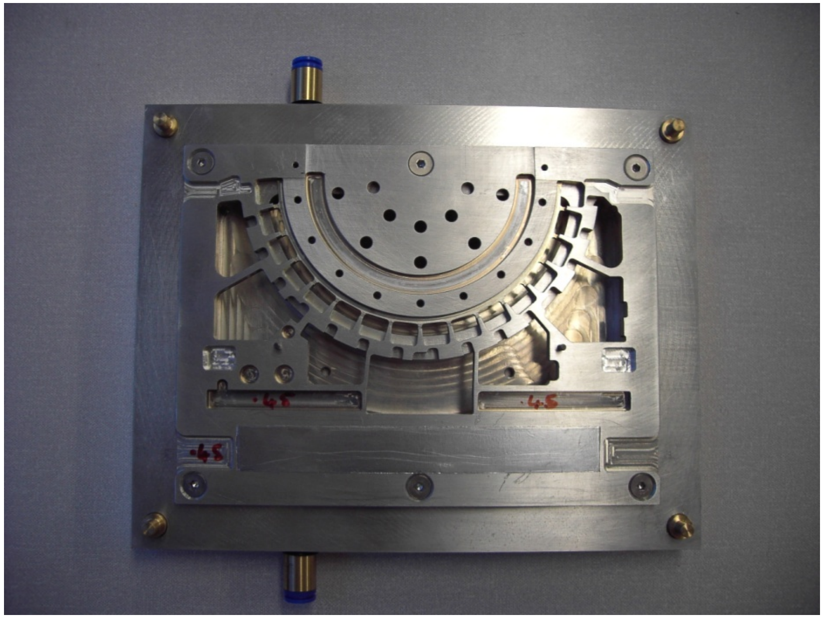


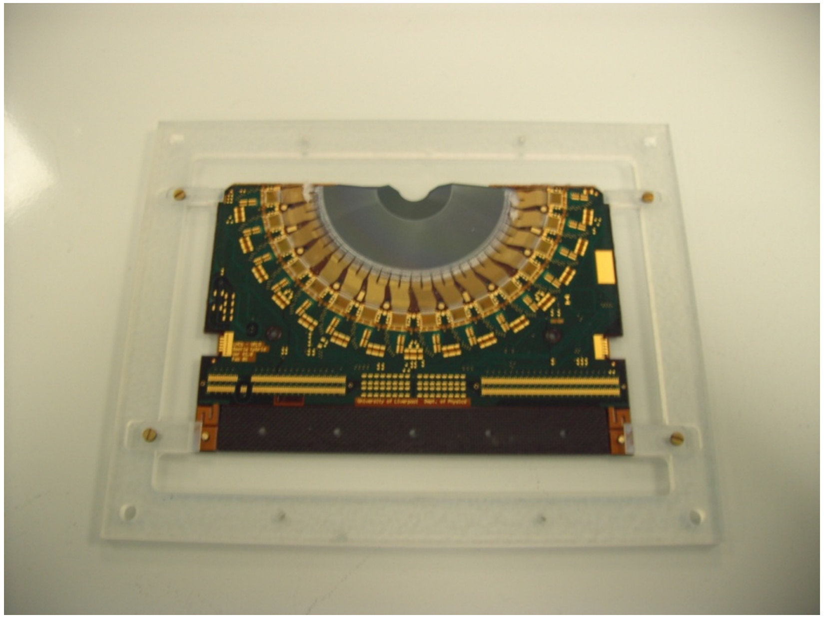
Production: Hybrid

- TPG/CF core
- Double sided
- Populated
- Pitch adaptors
  - Chips
- Bonding
- Sensors
- More bonding



Production Bonding

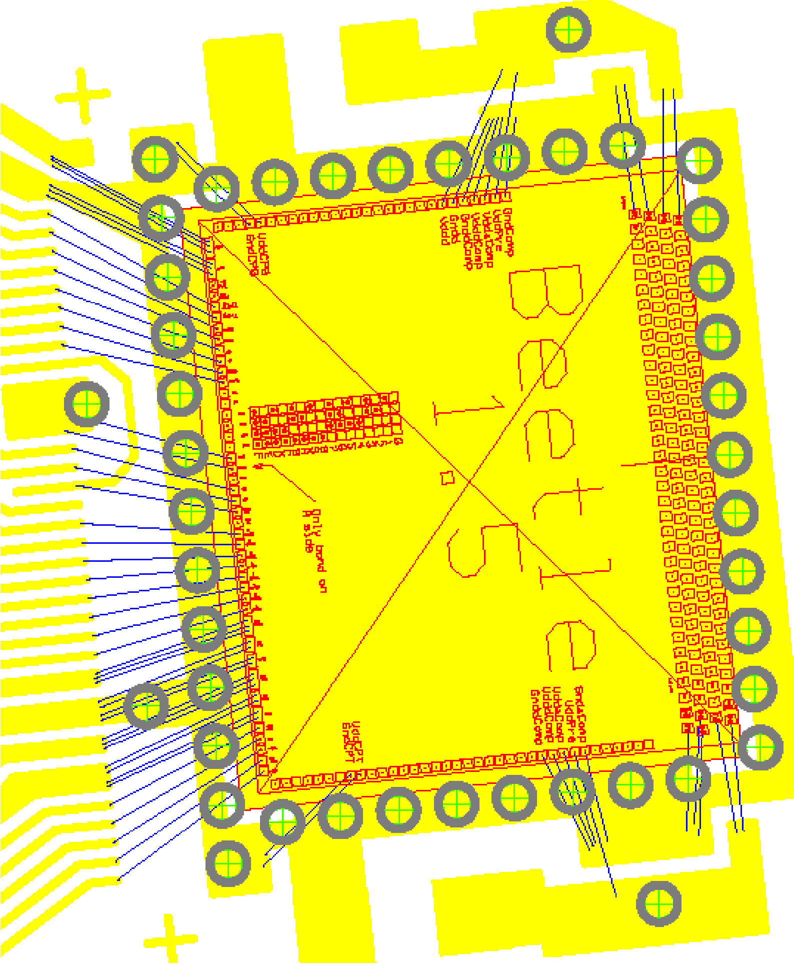


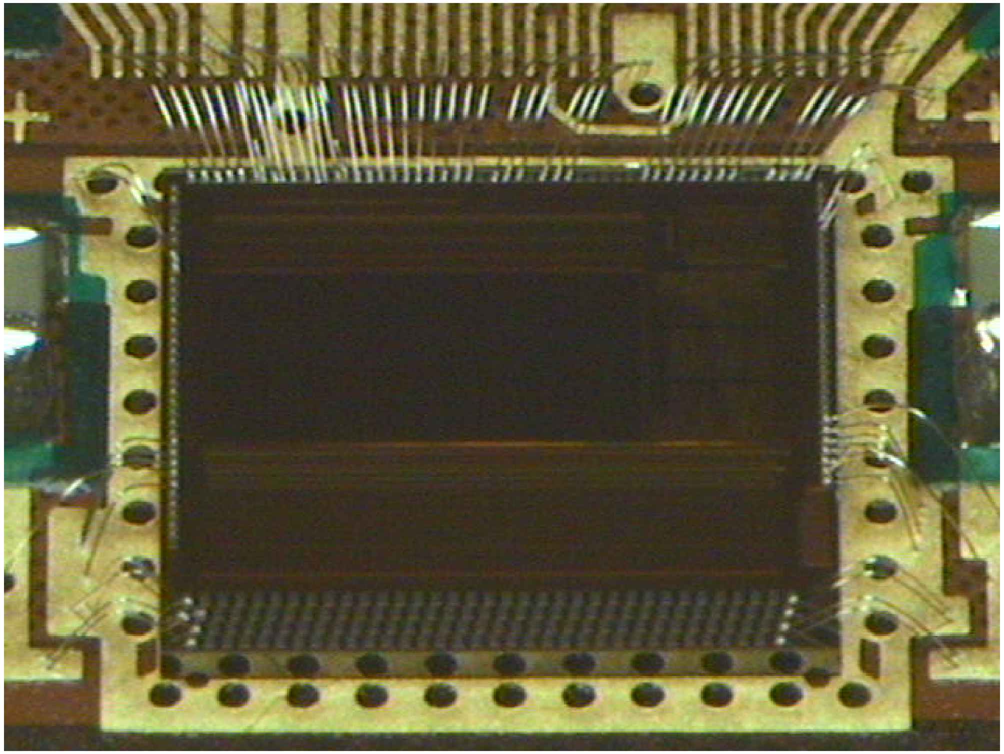


- Vacuum jig to hold Hybrid during bonding

- Handling frame to protect hybrids during transfer

Production: Backend Bonding

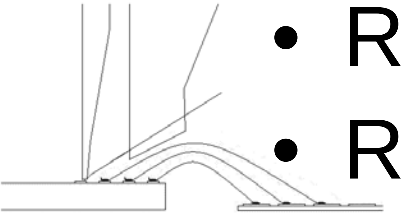




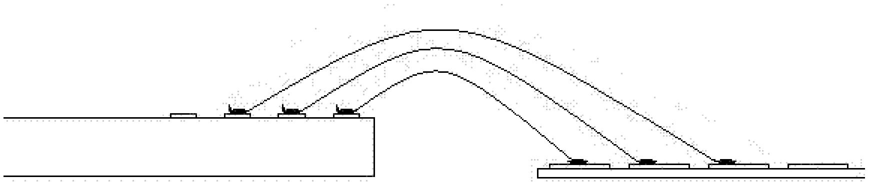
There are approximately 72 Back end wires per chip (each chip is different because of the addressing).
16 chips at 72 wires Rad side=1,152
16 chips at 73 wires Phi side=1,168
Total Back end bonds per hybrid = 2,320 wires

Production: Front end Bonding

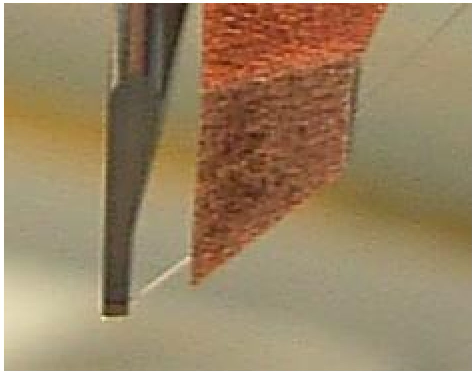
Loop heights



- Row 1 = 250 µm
- Row 2 = 450 µm
- Row 3 = 750 µm
- Row 4 = 900 µm



8090 clamps



710 clamps

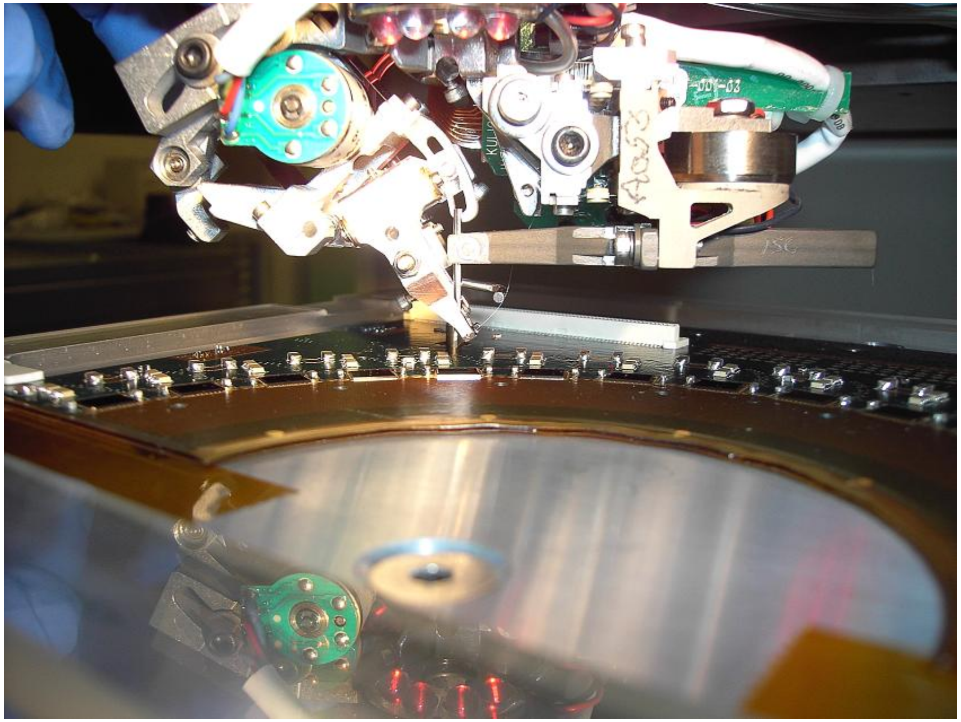
Production: Front end Bonding

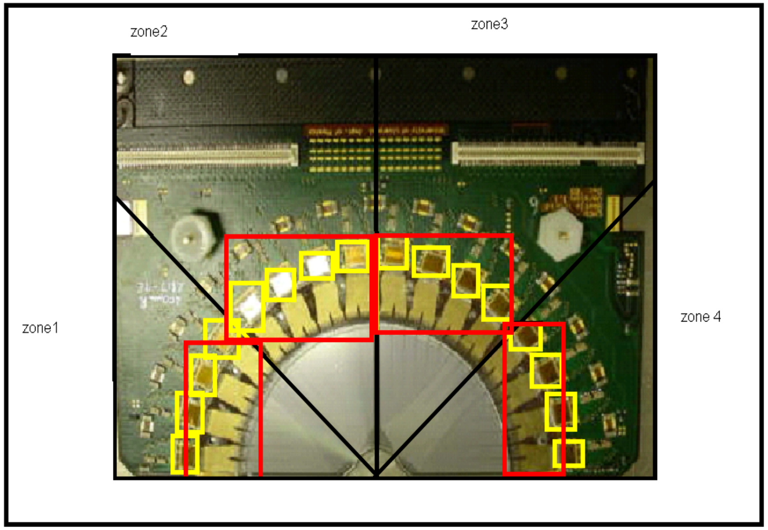
Kulicke & Soffa 8090

- *The 8090 has the industry's largest **bonding area**, at 16" x 14" (406mm x 335mm).*
- *This is obtained using SAW'S (small area windows set at 50mm square)*
- *120 kHz Ultrasonic Transducer*
- *The 8090 bonds at a lightning-fast 5 wires per second*
- *Pad finder and lead locator to help with programming*
  - *Because of the pad sizes and angles of the pads on our pitch adaptors this mode has to be switched off.*

Production: Front end Bonding

Bonding on the Kulicke & Soffa 8090





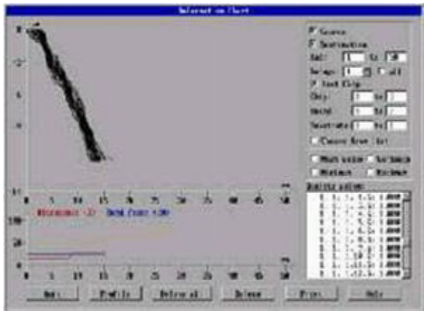
The above slide shows we can only bond in quadrants because of the small area Windows (SAW)

This is one program but has to aligned each time it accesses a new SAW.

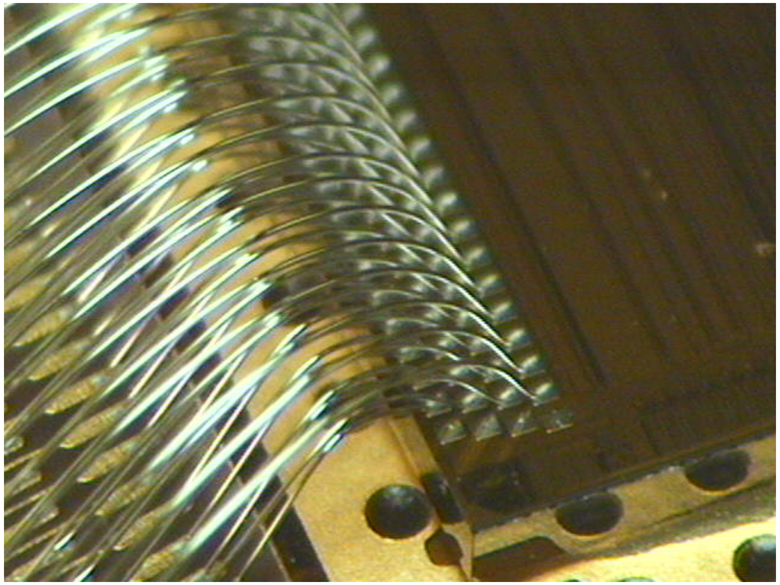
You can't bond from one saw to another, all wires must be in the same SAW.

Production: Front end Bonding

- *The* bondjet 710 has the largest **working area** with all axis in the bondhead 10,0" x 7,0“(255 mm 180mm) This allows us to access the whole hybrid.
- *100 kHz Ultrasonic Transducer*
- *The 710 bonds at a speed of 2 wires per second*
- ***Bond quality control** Continuous monitoring of wire deformation and transducer current within programmable upper and lower control limits*



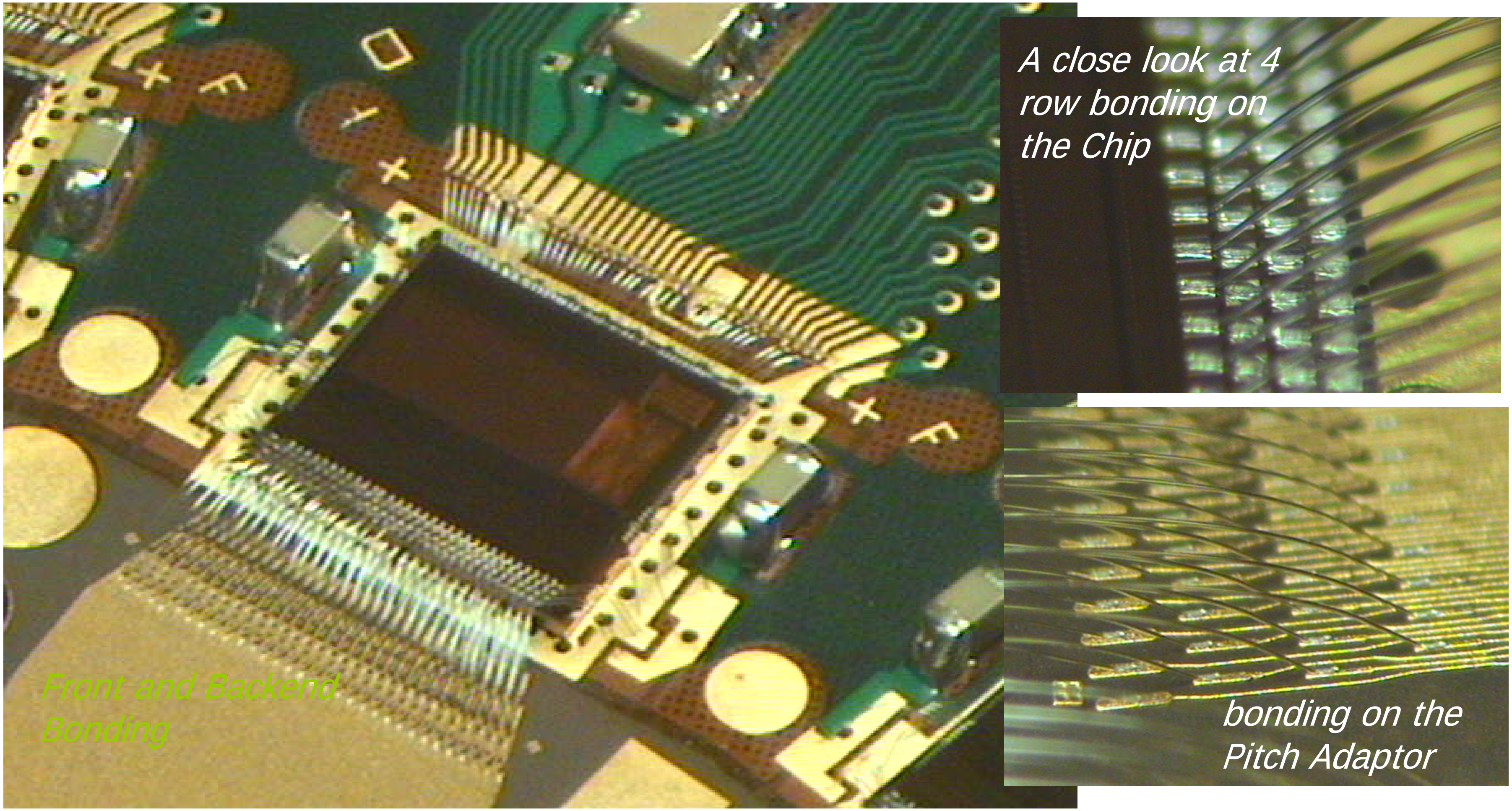
Production: Front end Bonding



Chip to pitch adaptor bonds

- **Use two H&K 710’s**
- There are two problems with the front end bonds.
- The chip pads are four row bonding with small pads, making it difficult but not impossible to do repair work.
- Pads on pitch adaptor rows three and four are only 50µm and 40µm wide making it very difficult to bond in an auto state without spending a lot of time checking the positioning of the bond placement
- *There are 16 chips per side each with 128 wires a total of 4096 wires*

Production: Front end Bonding

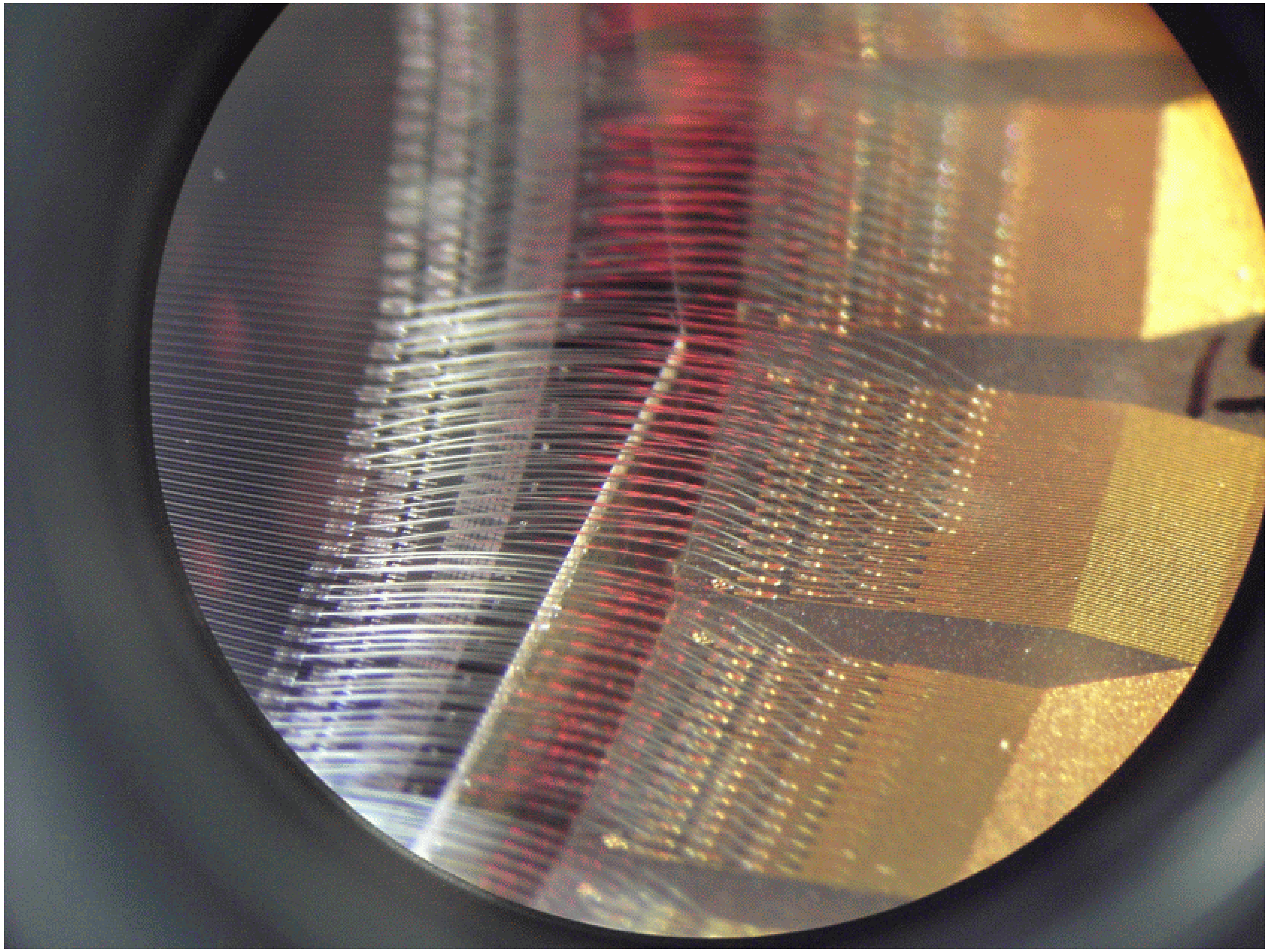


A close look at 4 row bonding on the Chip

bonding on the Pitch Adaptor

Front and Backend Bonding

Production: Sensor Bonding

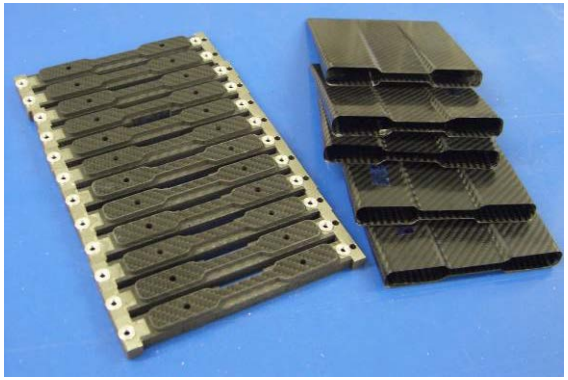


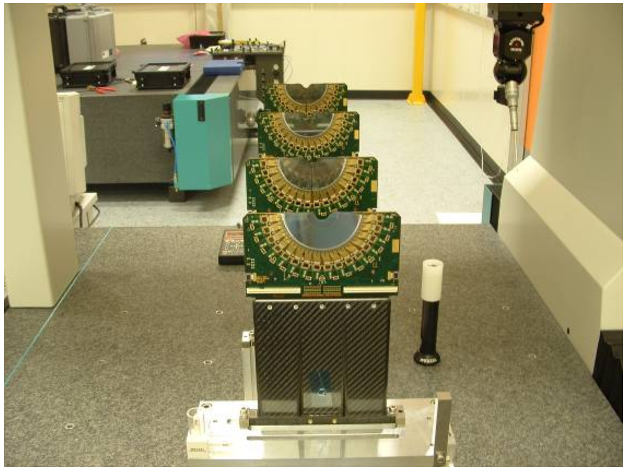
Production: Bonding Problems

- 8090 not as reliable or as flexible as we would like
- Lack of pattern recognition hurts with differing dimension kapton pitch adaptor
- Double sided bonding
  - VERY specialized jigging
  - Bounce (1 year to remove)
  - Danger of damaged bond wires (e.g. bias bonds!). Repairs VERY difficult

Production:Module

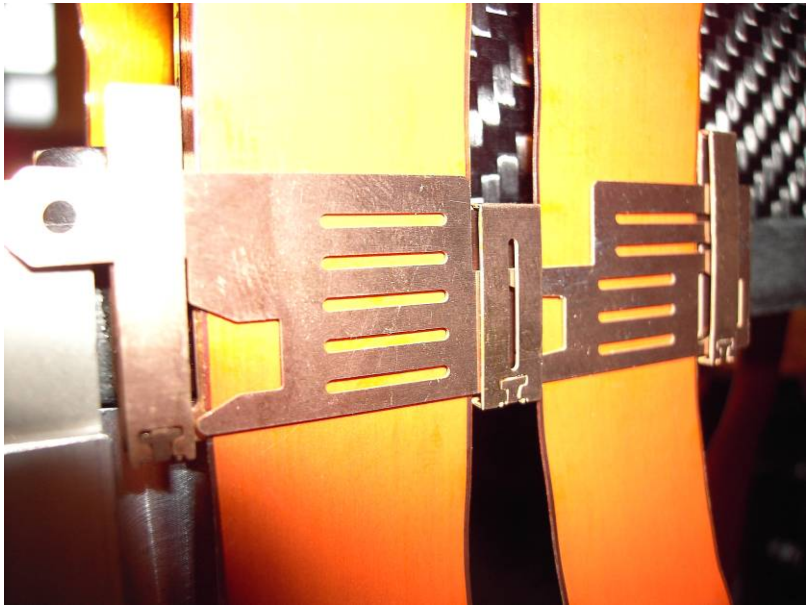
- 0 CTE module
- Metrology
- Si-Si < 5 μm
- Si to removeable base < 20 μm (~15 μm) (will reduce)
- Hybrid and Si needs to be in right place
  - Trigger
  - Foil

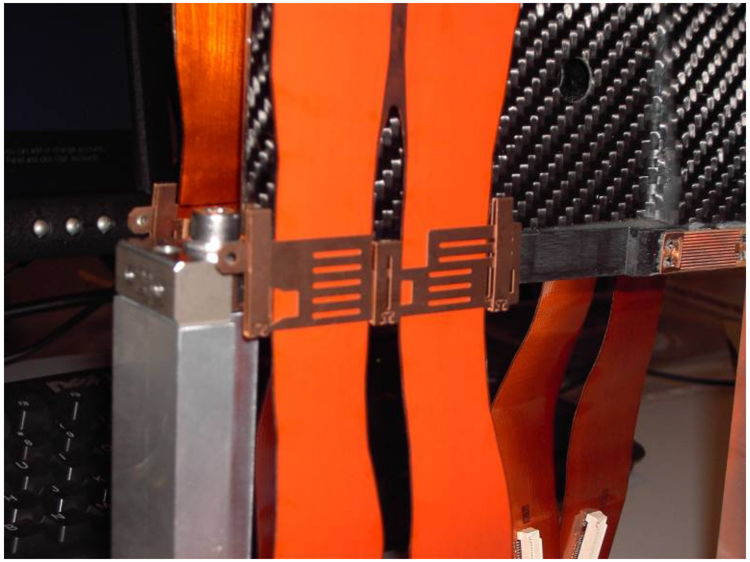




Production:Cable Clamps

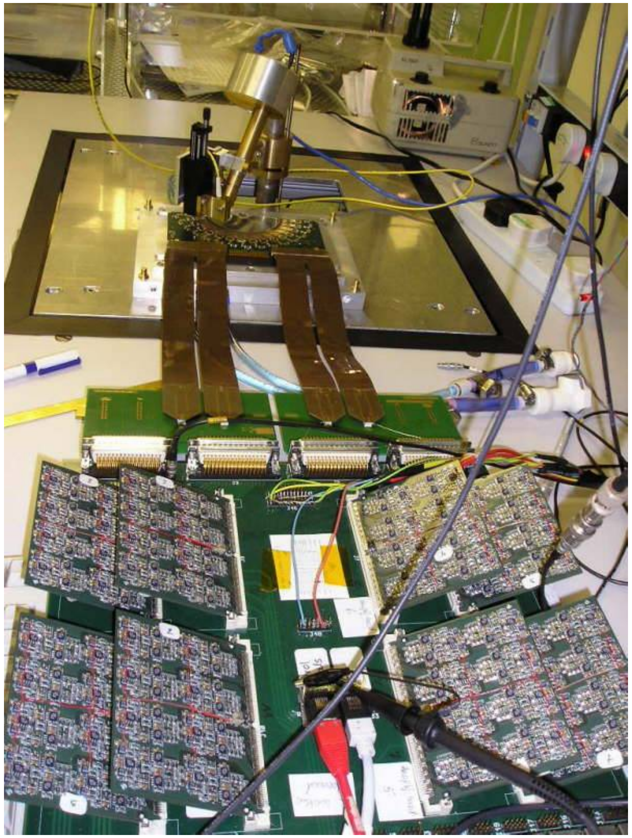
Clamps are used to relieve any stress on the modules caused by the cables, they are manufactured by Photofabrication.

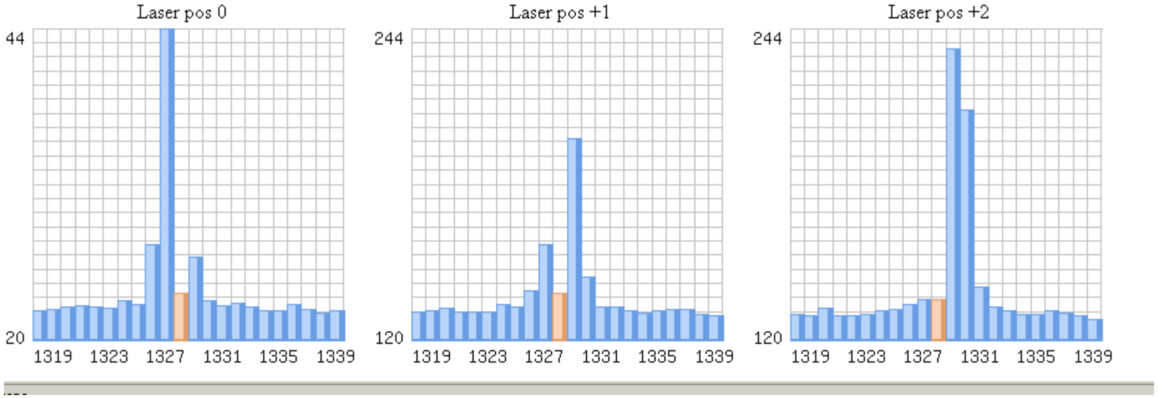




Cable and clamp assembly in position and ready to be locked to the module base.

Testing: IR Laser

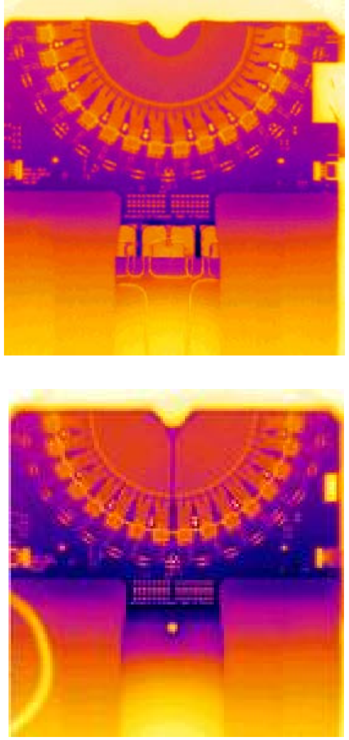




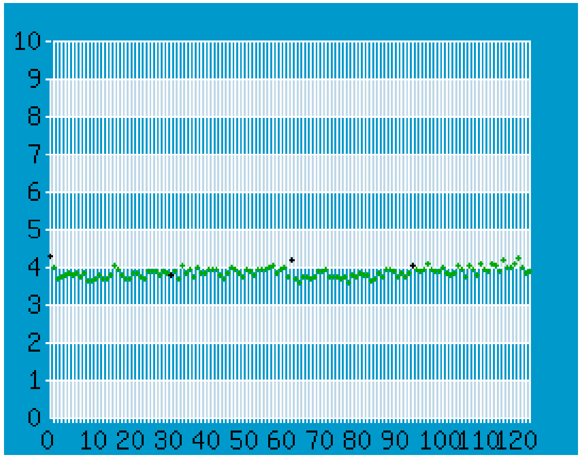
- •Programmed & aligned
- •Noise plots
- •Laser scan every strip of every detector

Production: Laboratory

- Final testing complicated
  - Cooling in vac
  - CO_2 system safety
  - Pump down
- Noise Plots
- Achieve >99% good strips

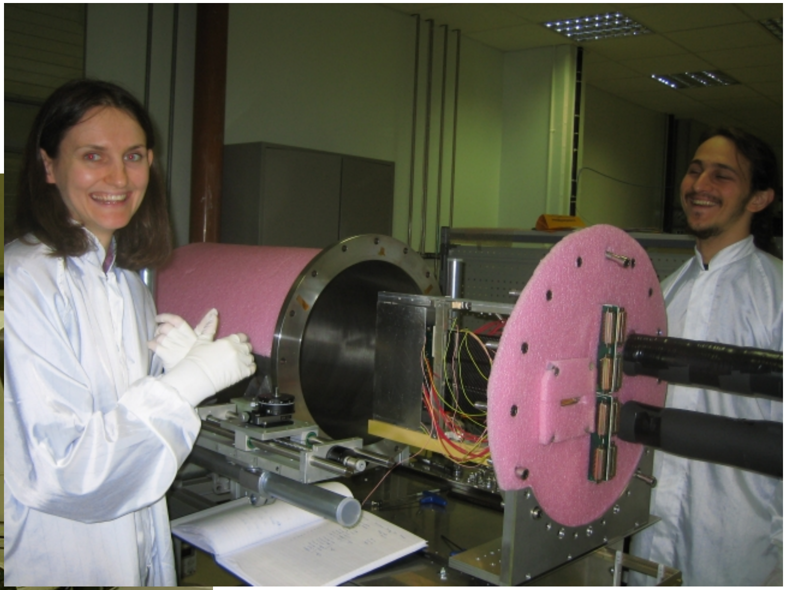


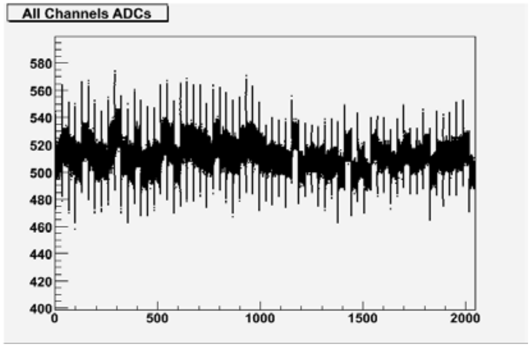
Module 24



Testing: Reception

- Visual inspection
  - Low Resolution
  - High Resolution
- Vacuum Burnin
  - Thermal cycling
  - Noise

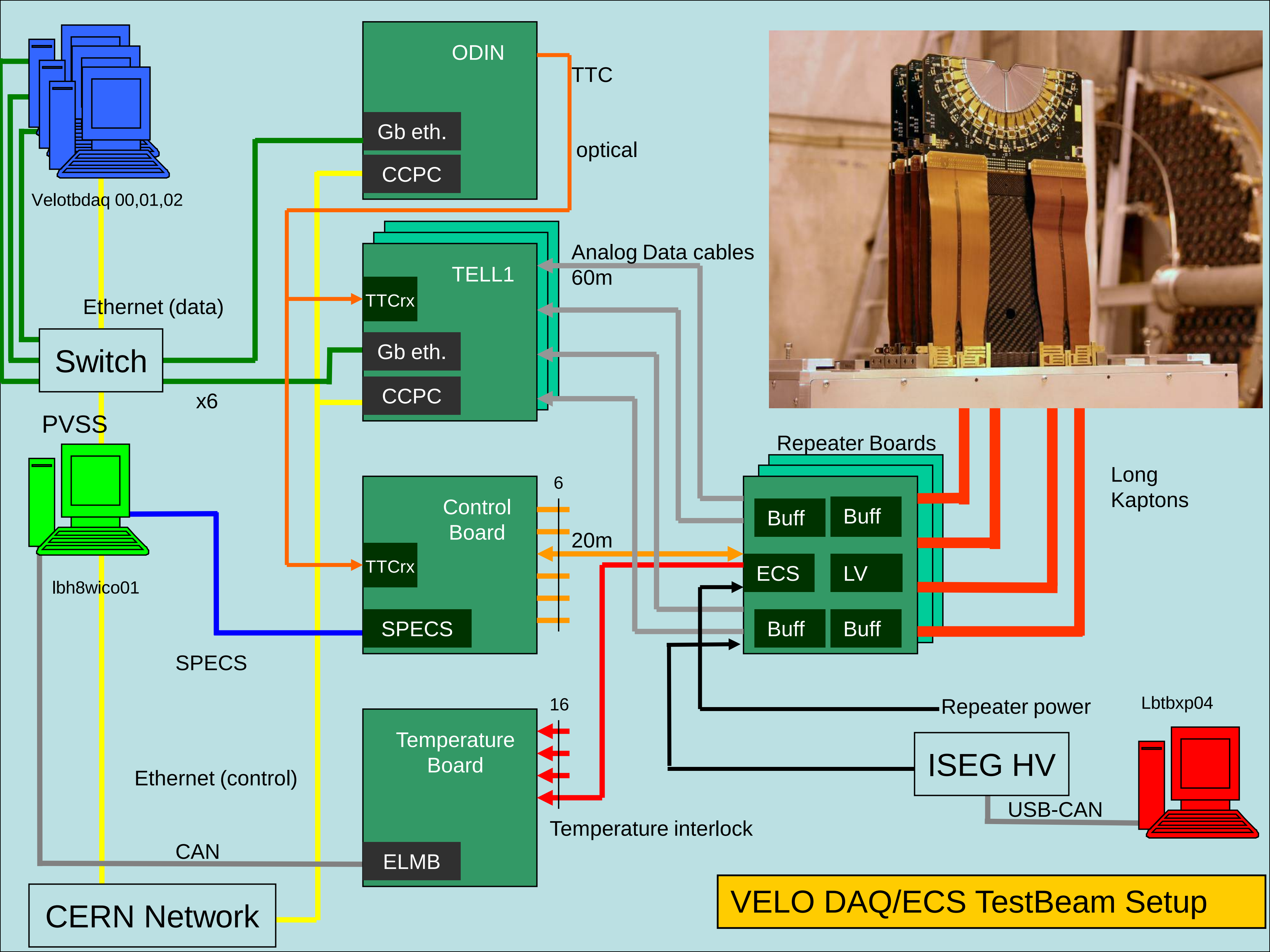




Commissioning:

- Alignment Commissing and Data Challenges
  - Testbeam
  - Detector half (system test)
  - Alreay using full DAQ and software chain
    - Real Control System, Analogue links etc…

VELO DAQ/ECS TestBeam Setup



Velotbdaq 00,01,02

ODIN

Gb eth.

CCPC

TTC

optical

TELL1

TTCrx

Gb eth.

CCPC

Analog Data cables 60m

Ethernet (data)

Switch

x6

PVSS

lbh8wico01

Control Board

TTCrx

SPECS

6

20m

SPECS

Repeater Boards

Buff

Buff

ECS

LV

Buff

Buff

Long Kaptons

Repeater power

Lbtbxp04

ISEG HV

USB-CAN

Temperature Board

16

ELMB

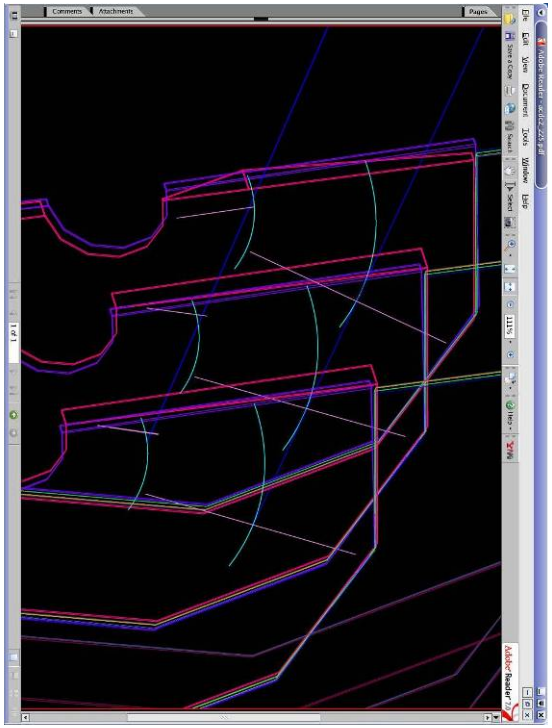
Temperature interlock

Ethernet (control)

CAN

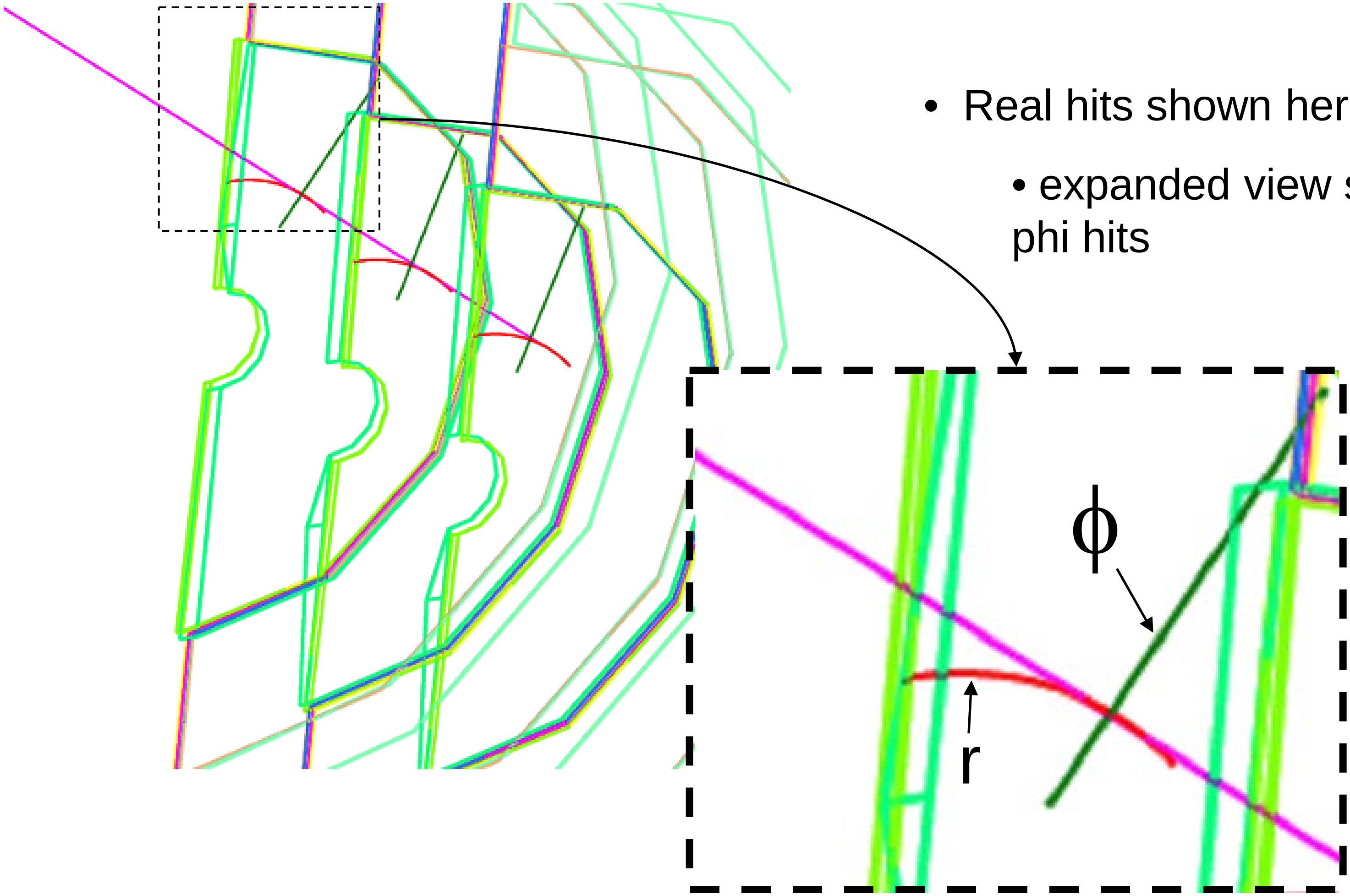
CERN Network

Testing: With Beam



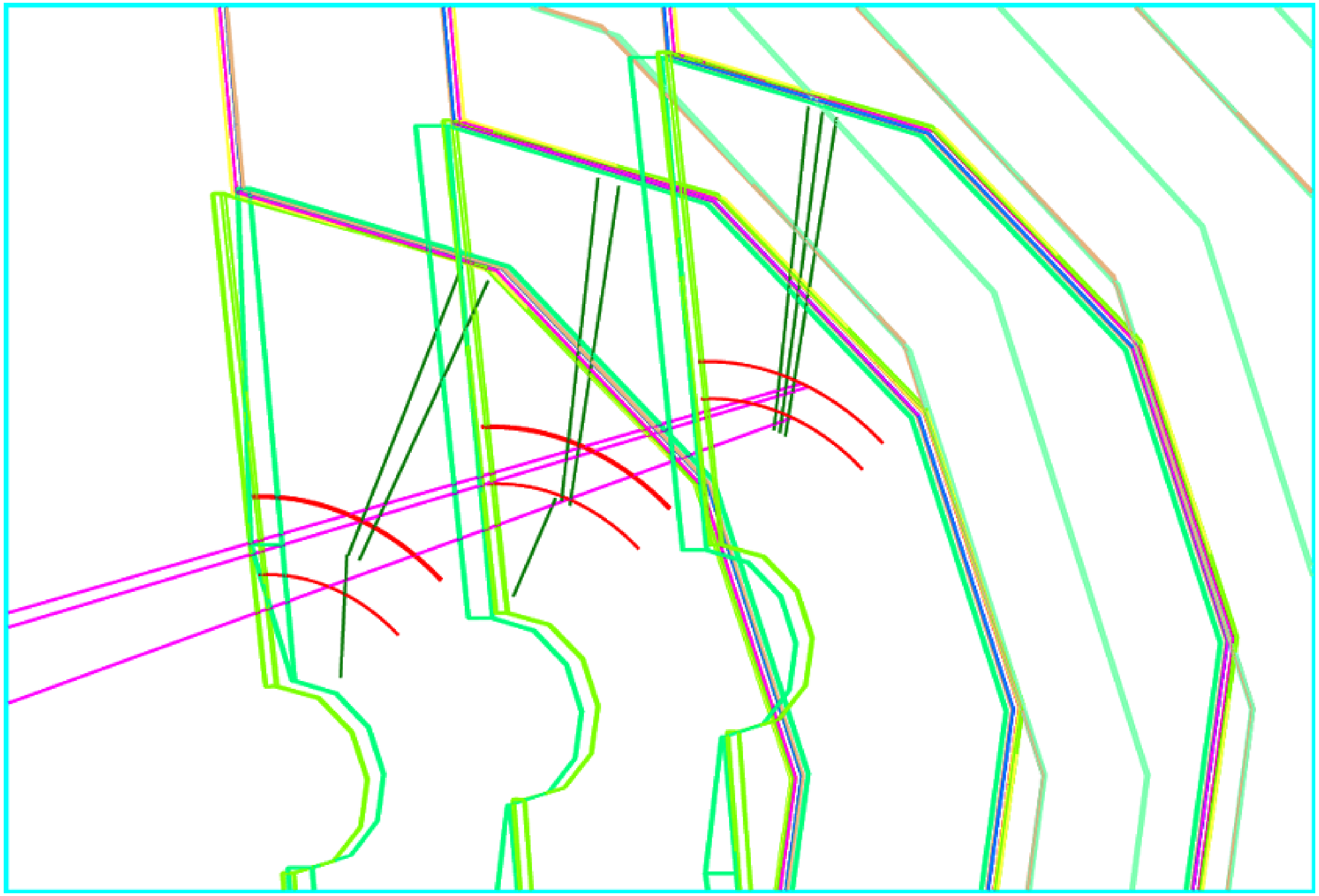
All software ran smoothly: Real alignment software etc

Testing: With Beam

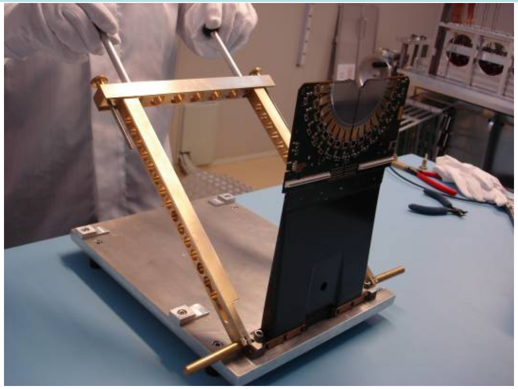


- Real hits shown here
  - expanded view shows r and phi hits

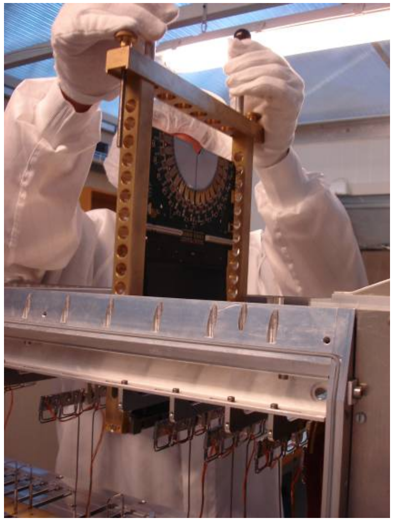
Testing: With Beam



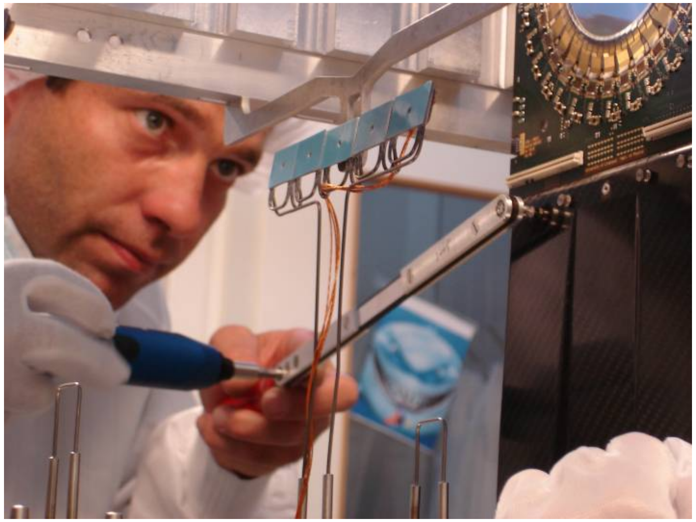
Assembly: Mounting



module bridge rotated into position

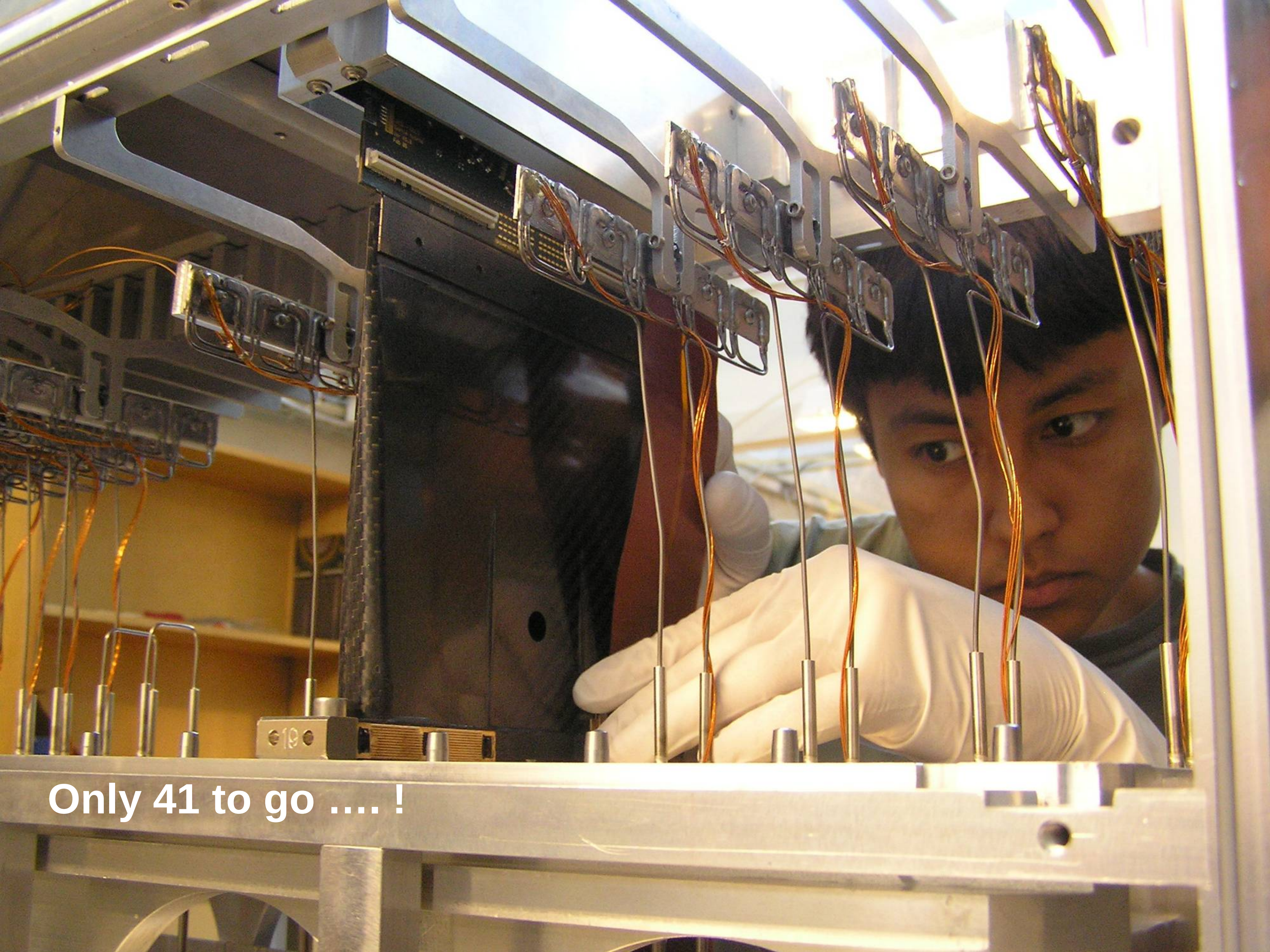


module inserted onto support



cooling cookies attached

experts brought in for kapton attachments



Only 41 to go …. !

Commissioning:

- Final Testbeam/System Test in October/November
- 1st ½ installed in pit by February 2007
- April – May installation of second half
- Ready to take data for pilot run

Summary: Significant Problems

- K&S 8090 not the ideal bonder for front-ends on VELO
- Kapton pitch adaptors VERY difficult to make …
- Clamps → unique cables
- Very cramped space

Summary: Status

- Mechanics almost complete
  - Tank in pit
  - One half ready other very close
  - Cooling well underway
  - Foils ready (being measured)
- Modules
  - 25% at CERN
  - 50% by mid October (currently 4/week)
  - Remainder (~2/week) until Jan 2007.
- Software
  - Close to being fully ready

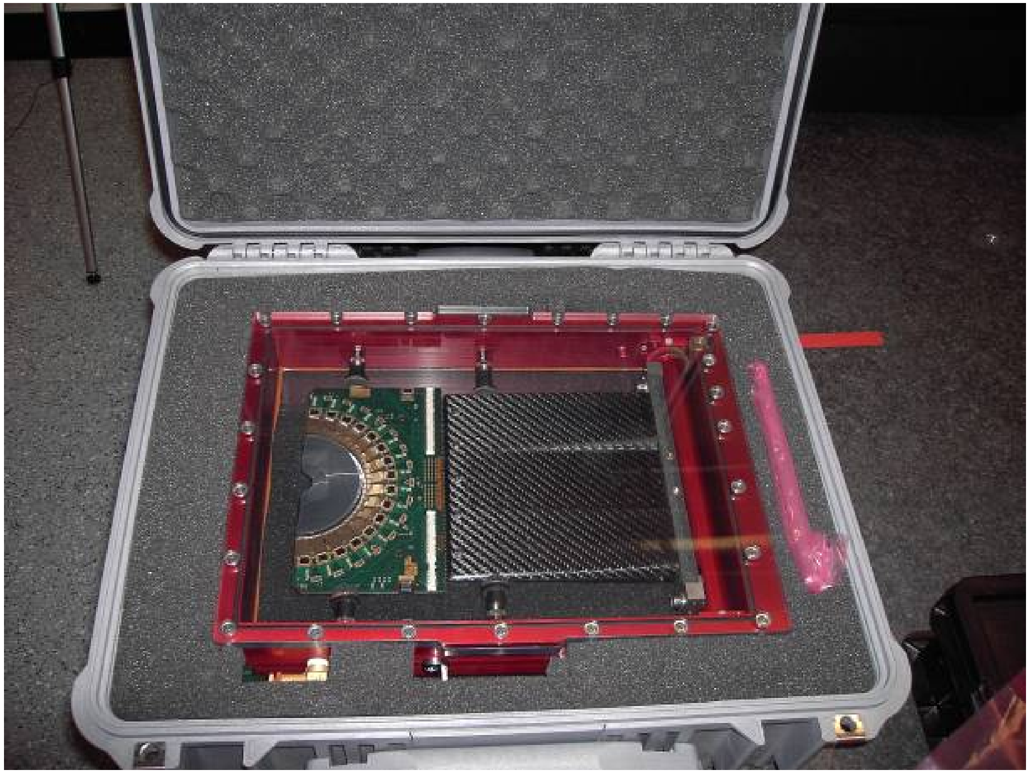
Conclusion

- VELO a small but complex detector
- LEP scale vertex detector moving in a vacuum
- Well underway for completion in time for 450GeV pilot runs next year

Backup Transparancies

- Shipping
- Frontend bonding
- Assembly/Alignment
- Testbeam results
- Assman/Nakada slides

Production: Shipping Modules



Modules are placed into transportation box with associated Cables ready for shipping to Cern.

Production module delivery

- mid August, production modules available. Coincided with new UK flight regulations

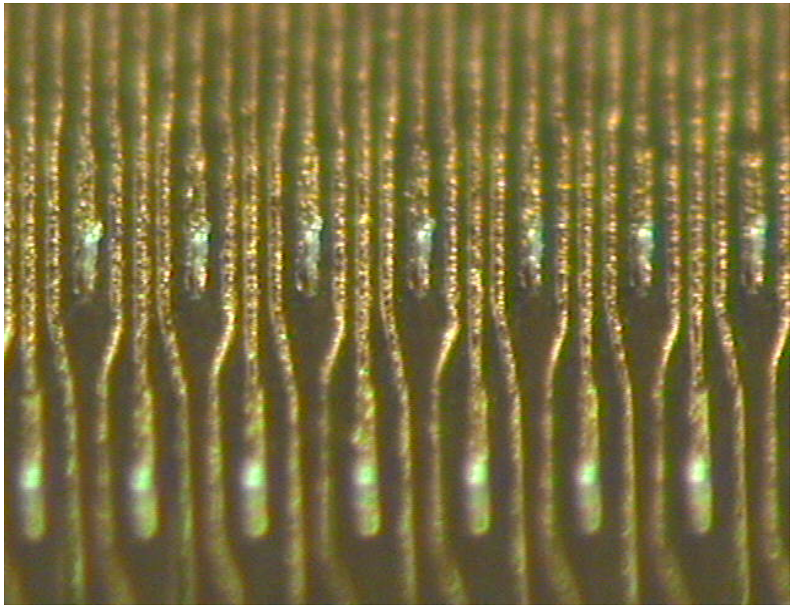
items forbidden in cabin baggage

- Explosives, ammunition, weapons, fireworks
- Corrosive products
- Compressed gases
- Radioactive materials
- Inflammable liquids and solids
- Magnetic materials
- Poisons and infectious substances
- Alarm devices
- Liquids and drinks
- VELO modules

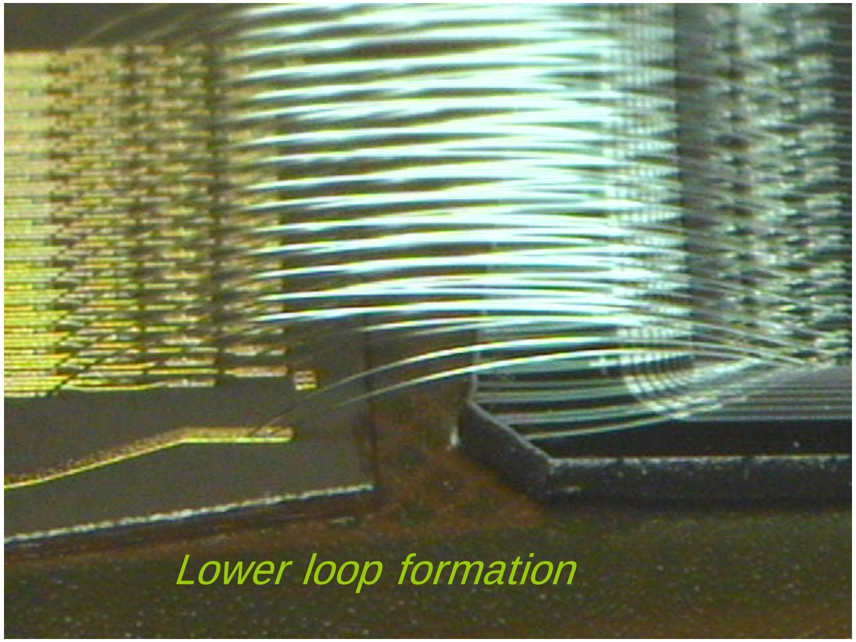
So switched to chauffeur delivery

- 25th August: M24 and M26 delivered to CERN
- 5th September, further 4 production modules

Production: Bonding



Bond footprint is the same size as track width on 4 row

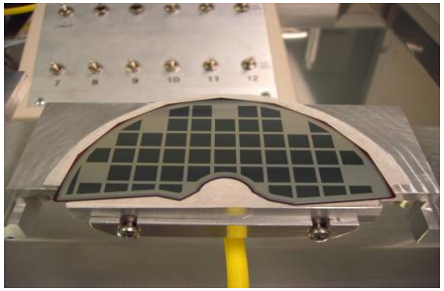


Lower loop formation

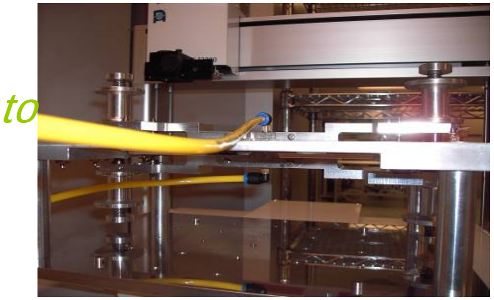
THERE ARE A TOTAL OF 10,528 WIRES BONDED PER HYBRID

Sensor being prepared for gluing. Sensor alignment ≤ 5 μm

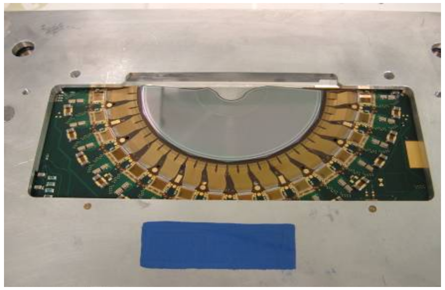
Position the Sensor on to the Transfer jig and apply vacuum.



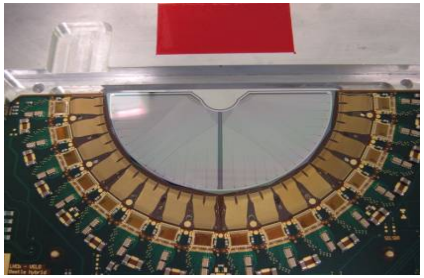
Place transfer plates to the hybrid which is held in a glue jig.



Both Radial and Phi sides are glued at the same time.

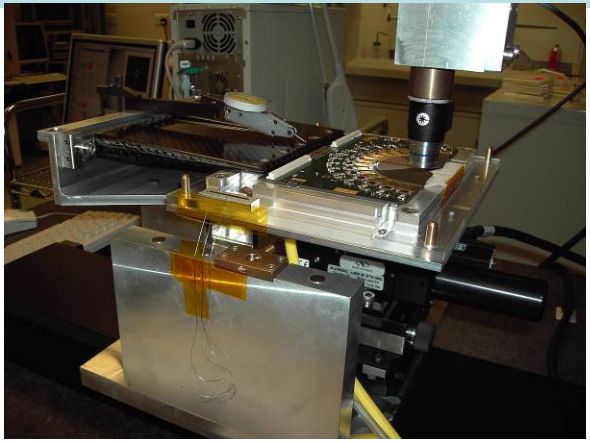


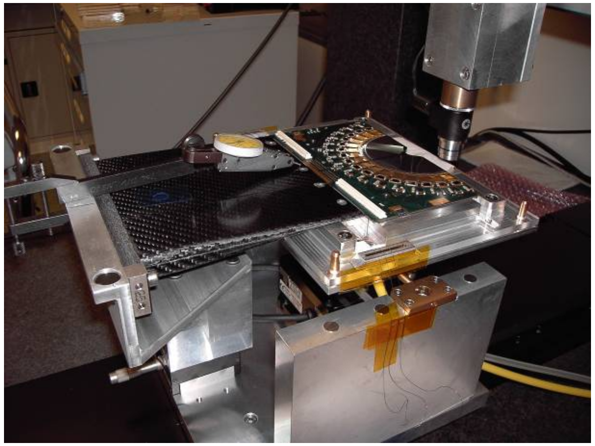
Remove transfer jigs, then the hybrid/sensor can be taken out of the glue jig, ready for metrology.

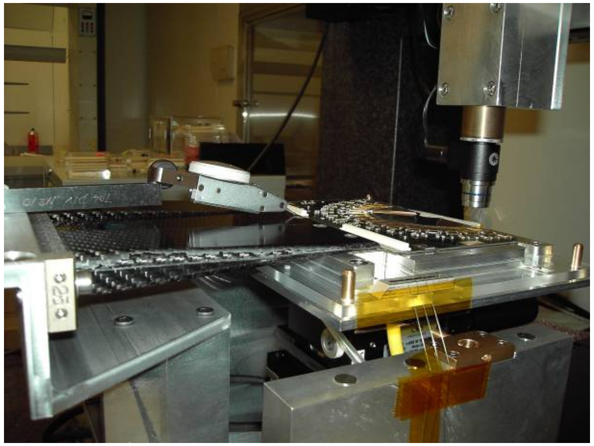


Module

- *Now we have a hybrid and paddle, these need to be glued together.*
- *We apply the glue to the hybrid.*
- *We place the hybrid on a vacuum jig, this jig can be manipulated in X, Y and Θ axis*
- *The paddle is bolted to an independent jig. which has movement in Z axis*
- *The paddle is lowered to within 0.5mm and aligned optically.*
- *When happy the paddle is lowered to the correct height glue to adhere to both sides.*
- *Then when the glue has been correctly spread it is aligned to its final position.*
- *Final alignment ≤ 20 μm.*







Assman & Nakada from Plenary

- Risk at 450Gev
- Magnetic field (off on)
- 7 sigma from beam