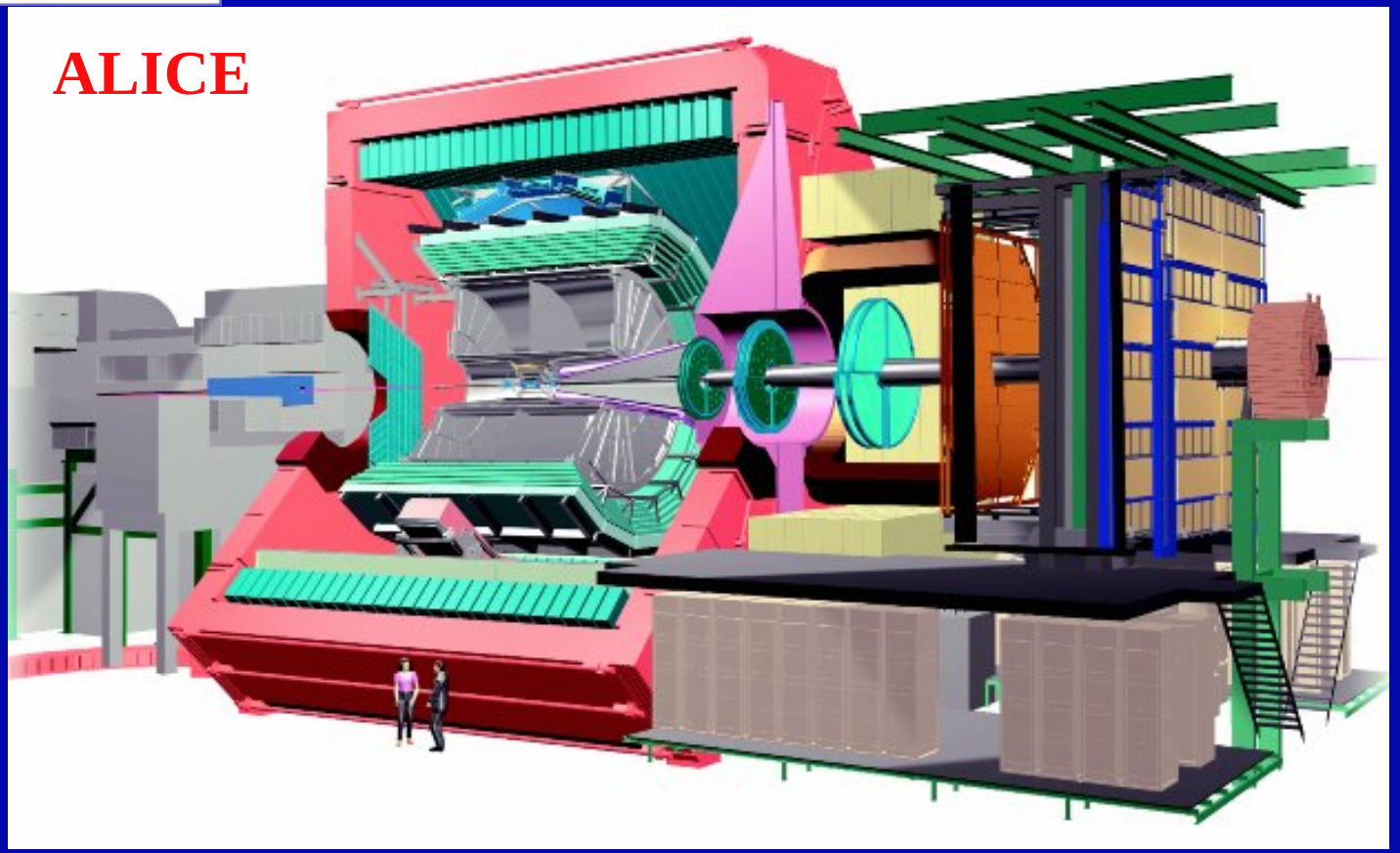
The Silicon Pixel Detector (SPD) for the ALICE Experiment

V. Manzari/INFN Bari, Italy

for the SPD Project in the ALICE Experiment

INFN and Università **Bari**, Comenius University **Bratislava**, INFN and Università **Catania**, CERN **Geneva**, Institute of Experimental Physics **Kosice**, INFN Laboratori Nazionali **Legnaro** (LNL), INFN and Università **Padova**, INFN and Università **Salerno**, INFN and Università **Udine**

ALICE Layout: the ITS and the SPD



- B-field < 0.5 T
- Charged particle multiplicities of up to 8000 per unit of rapidity (head-on Pb-Pb collisions)

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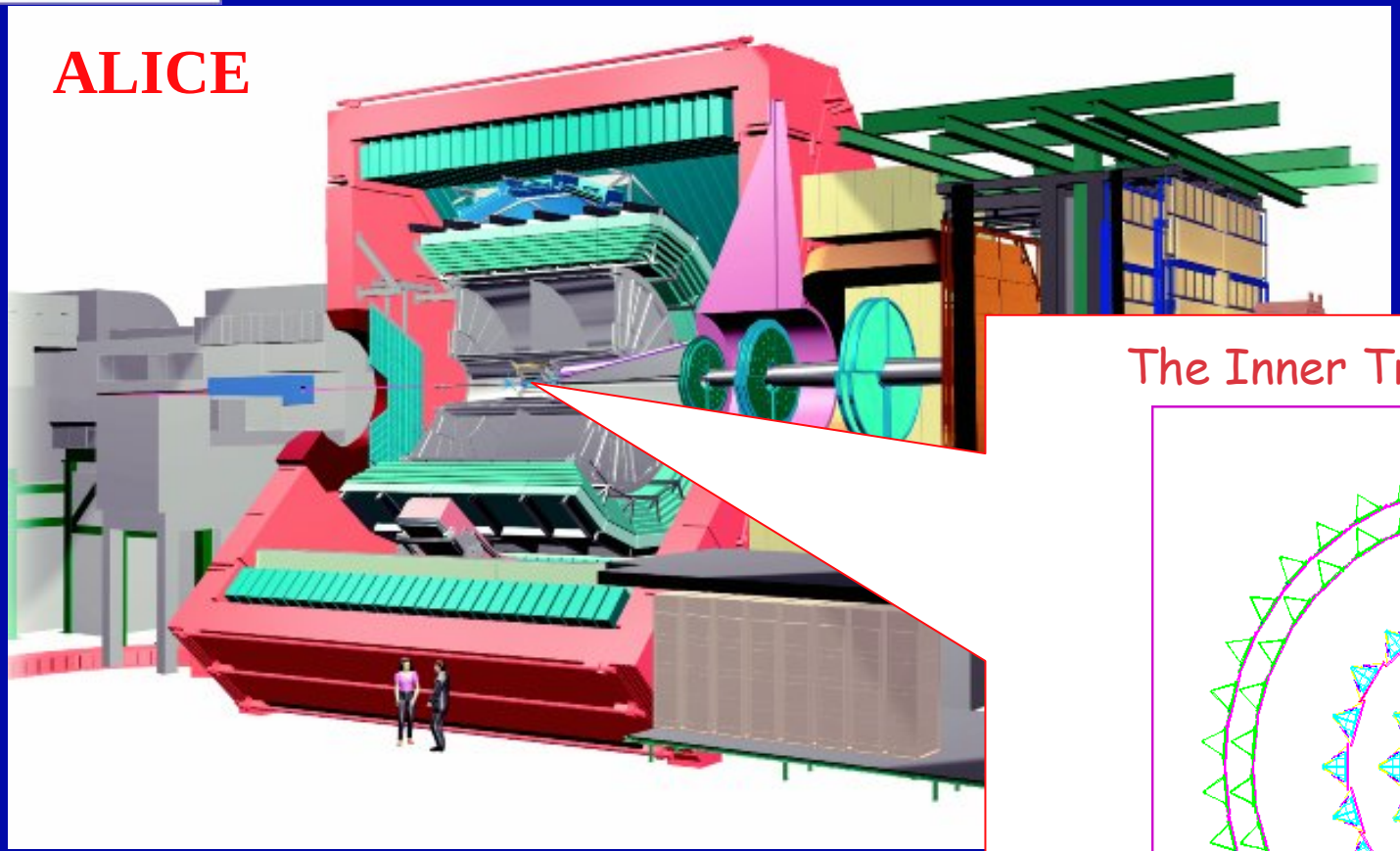

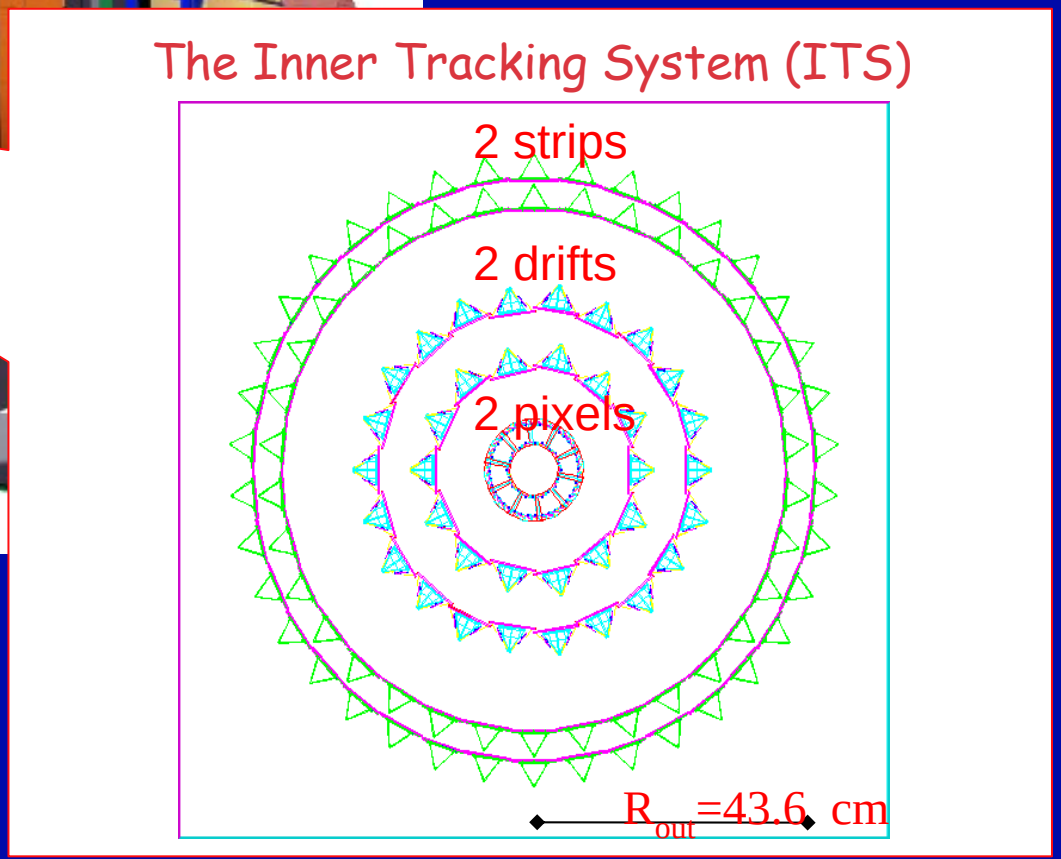

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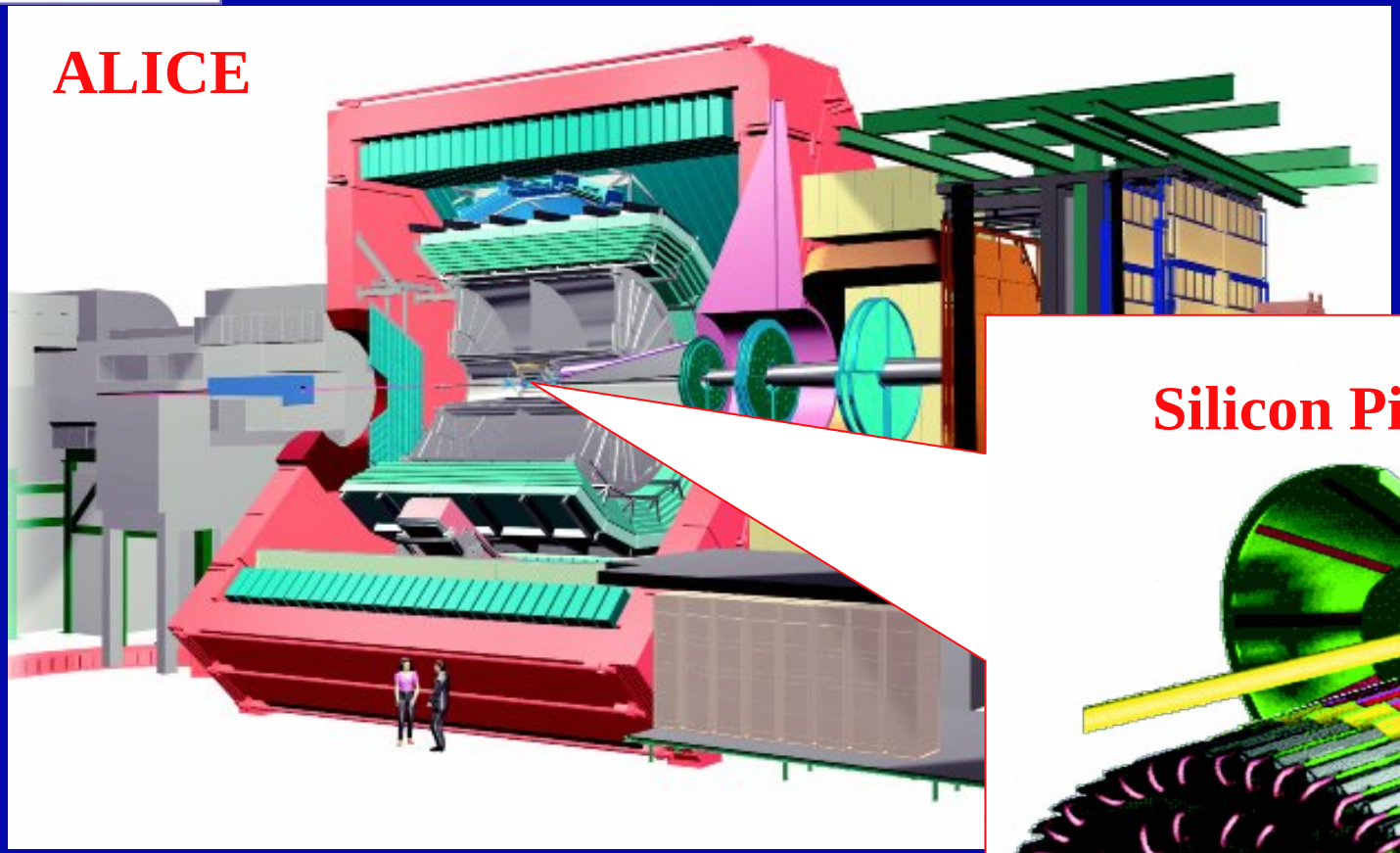
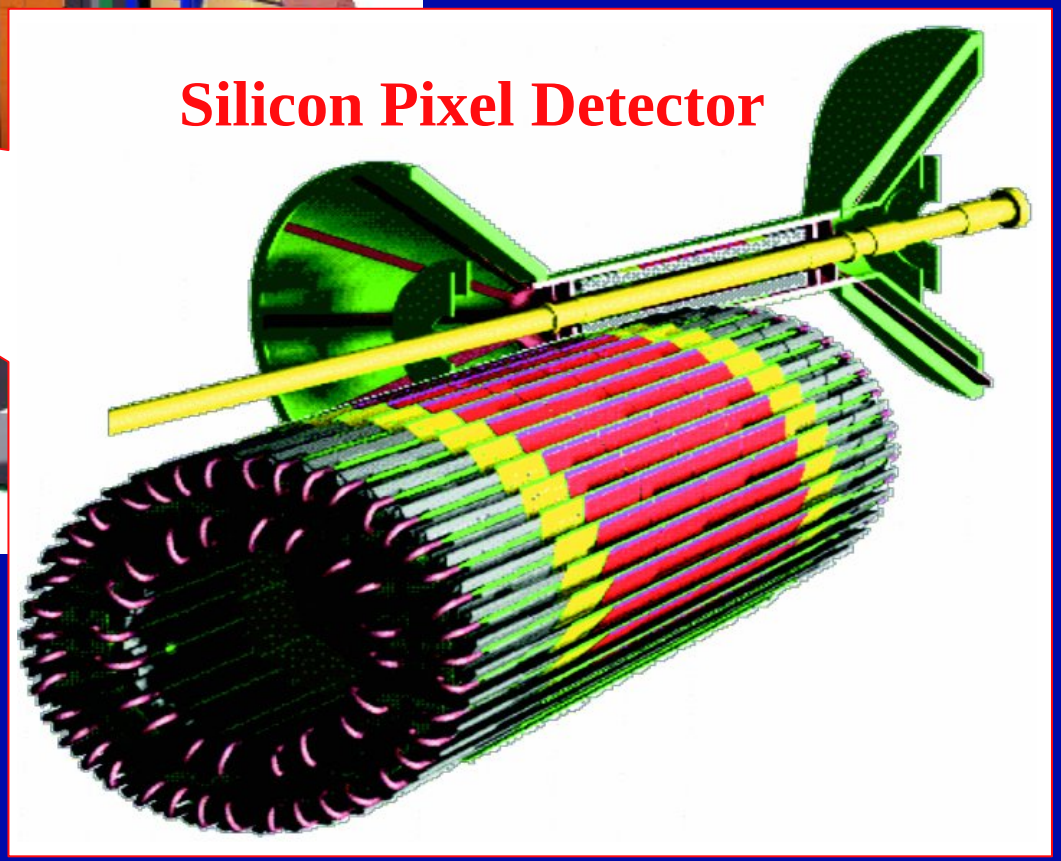
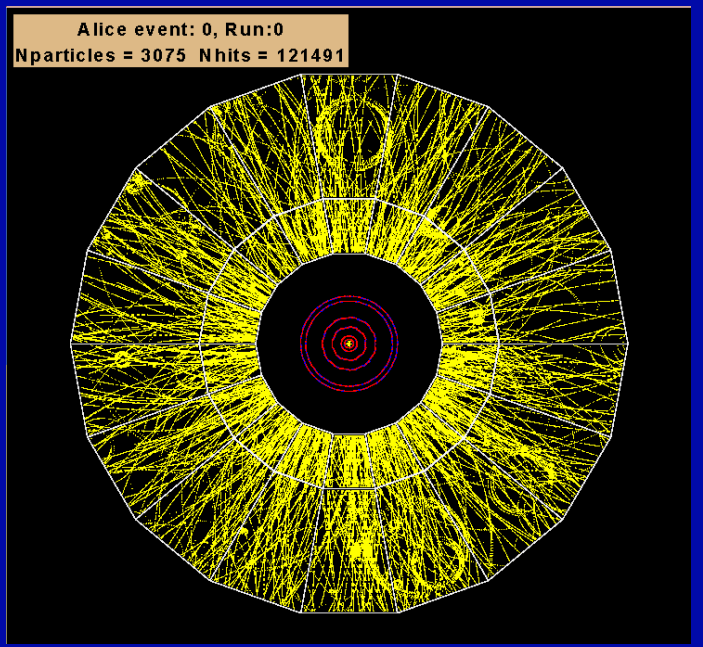




- B-field < 0.5 T
- Charged particle multiplicities of up to 8000 per unit of rapidity (head-on Pb-Pb collisions)

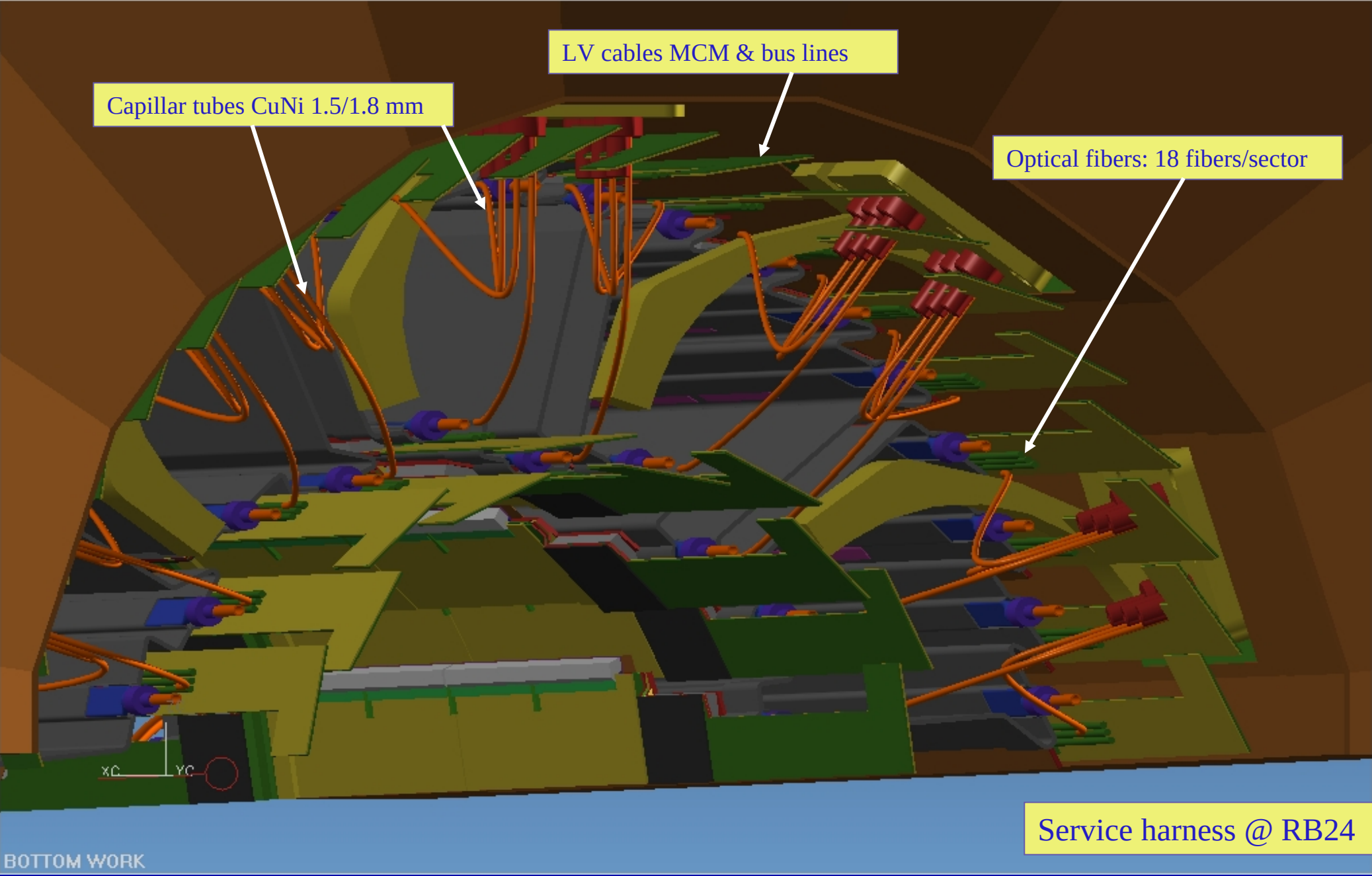
The ALICE SPD

- Secondary vertexing capability (c,b)
- Track impact parameter resolution: $r\phi < 50\ \mu m$ (pt >1.3 GeV/c)
- Two barrel layers: $R_i = 39$ mm, $R_o = 76$ mm
- Inner layer pseudorapidity coverage: $|\eta| < 1.95$ [ITS coverage $|\eta| \approx 0.8$]
- Total Si surface: $\approx 0.24\ m^2$
- Individual pixel cell: 50 μm ($r\phi$) x 425 μm (z)
- Occupancy (central Pb-Pb): < 2%



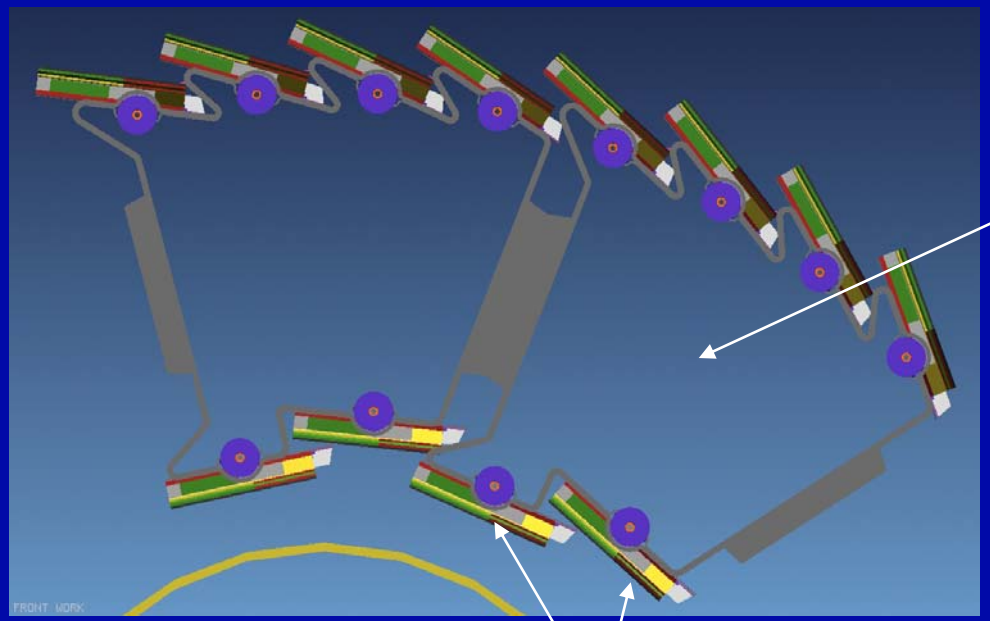
Track densities at r = 4 cm (1^{st} pixel layer): up to $100/cm^2$

- Radiation level at the inner layer for 10 years standard running: TID $\approx$ 5kGy, F $\approx 6 \cdot 10^{12}$ (1MeV n_{eq})/cm^2 (working values!)



Service harness @ RB24

SPD Mounting



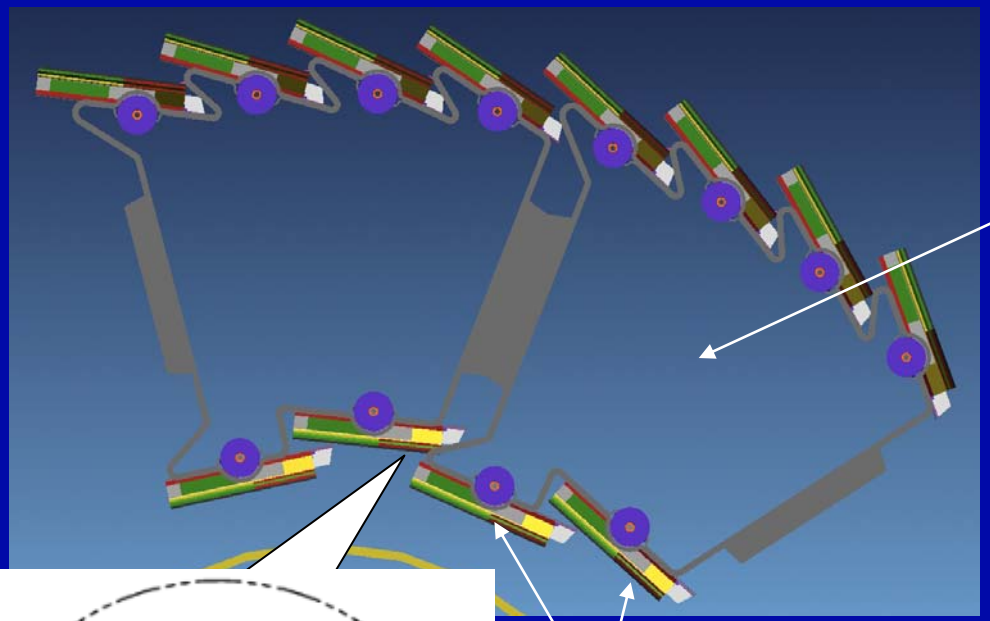
The 2 barrels will be built of 10 sectors

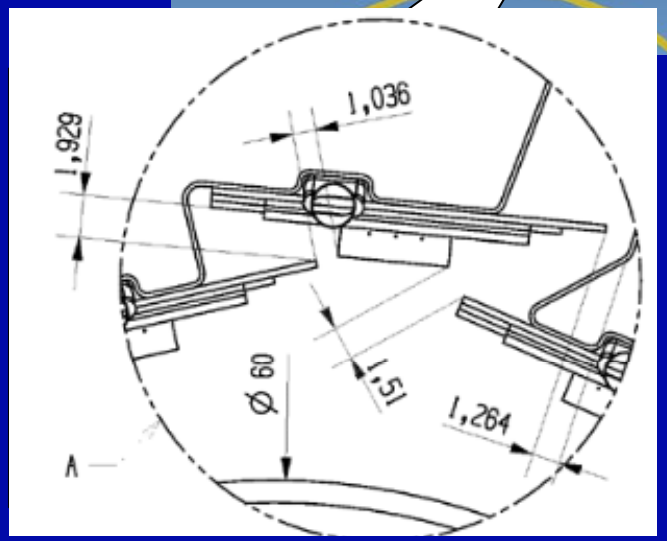
6 staves/sector

(2 from inner layer and
4 from outer layer)

Material budget (each layer): ≈ 0.9% X_0
(Si ≈ 0.37, cooling ≈ 0.3, bus ≈ 0.17, CFSS ≈ 0.1)

SPD Mounting





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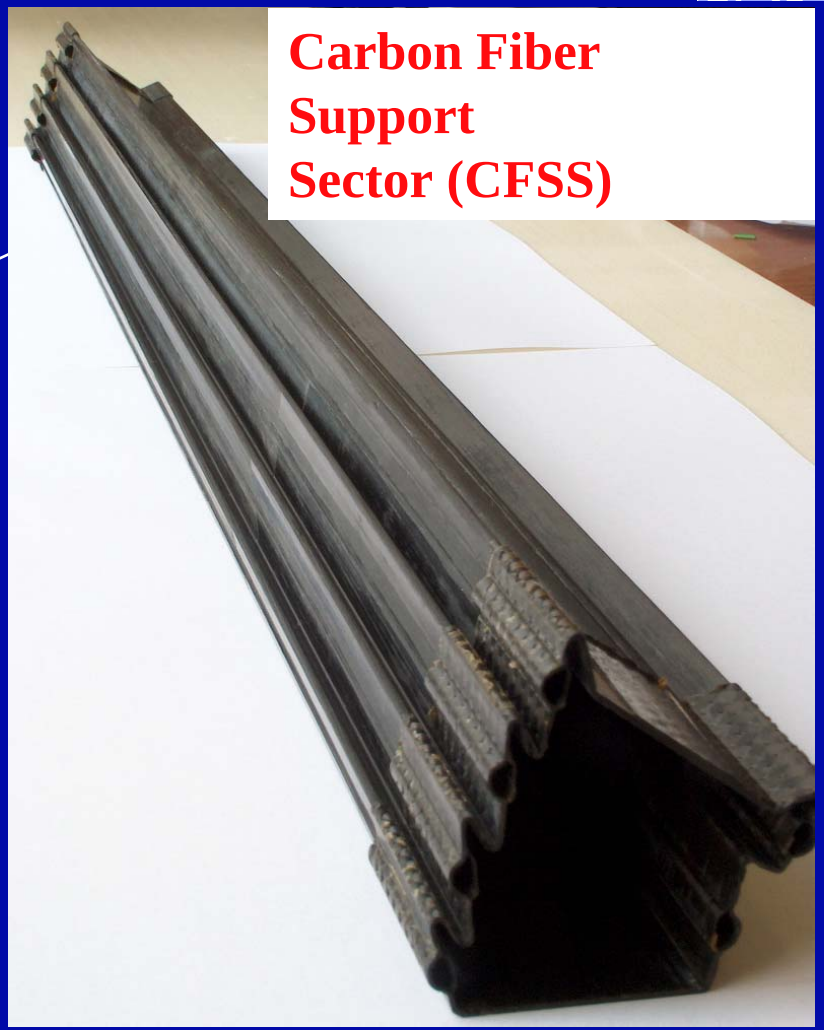
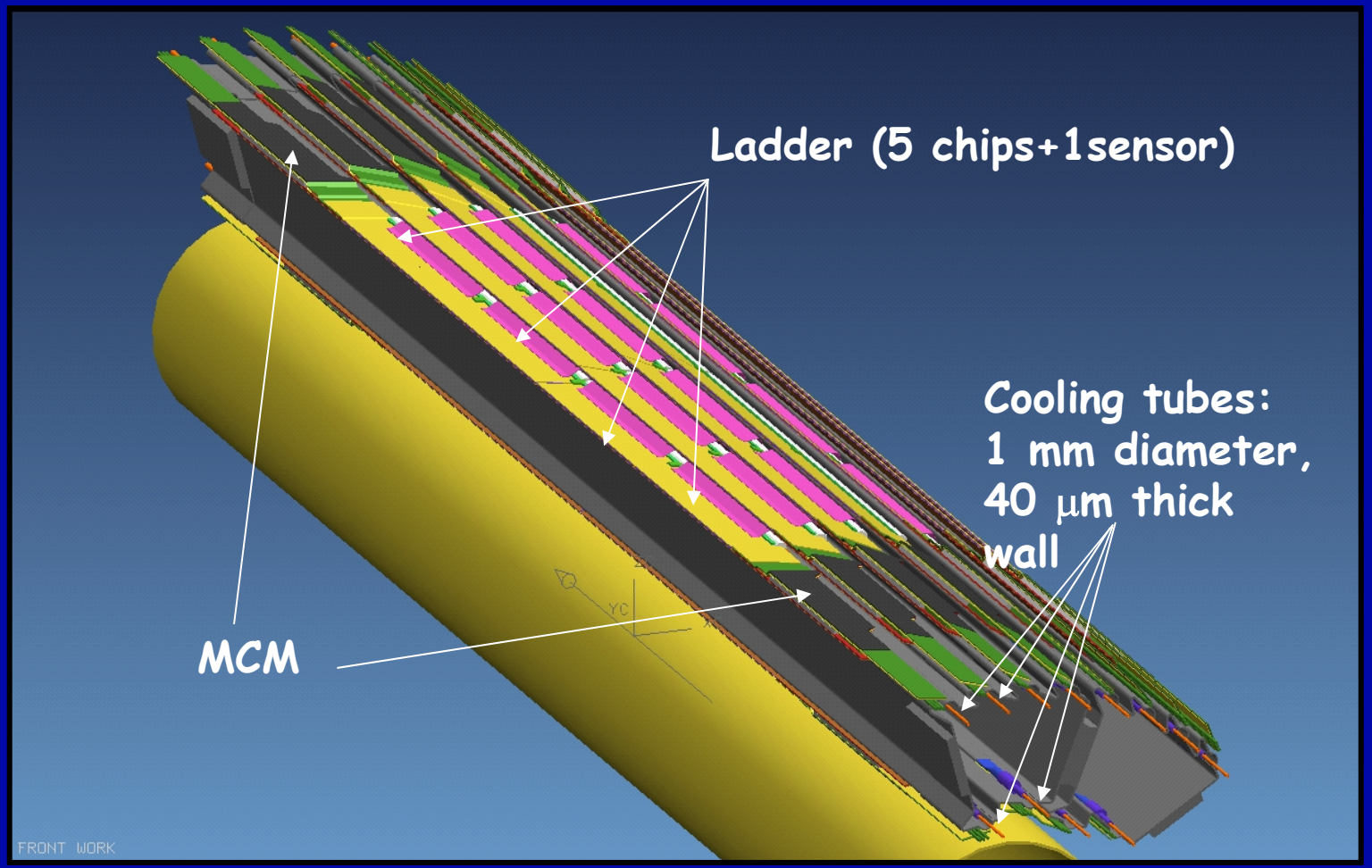


Carbon Fiber Support Sector (CFSS)

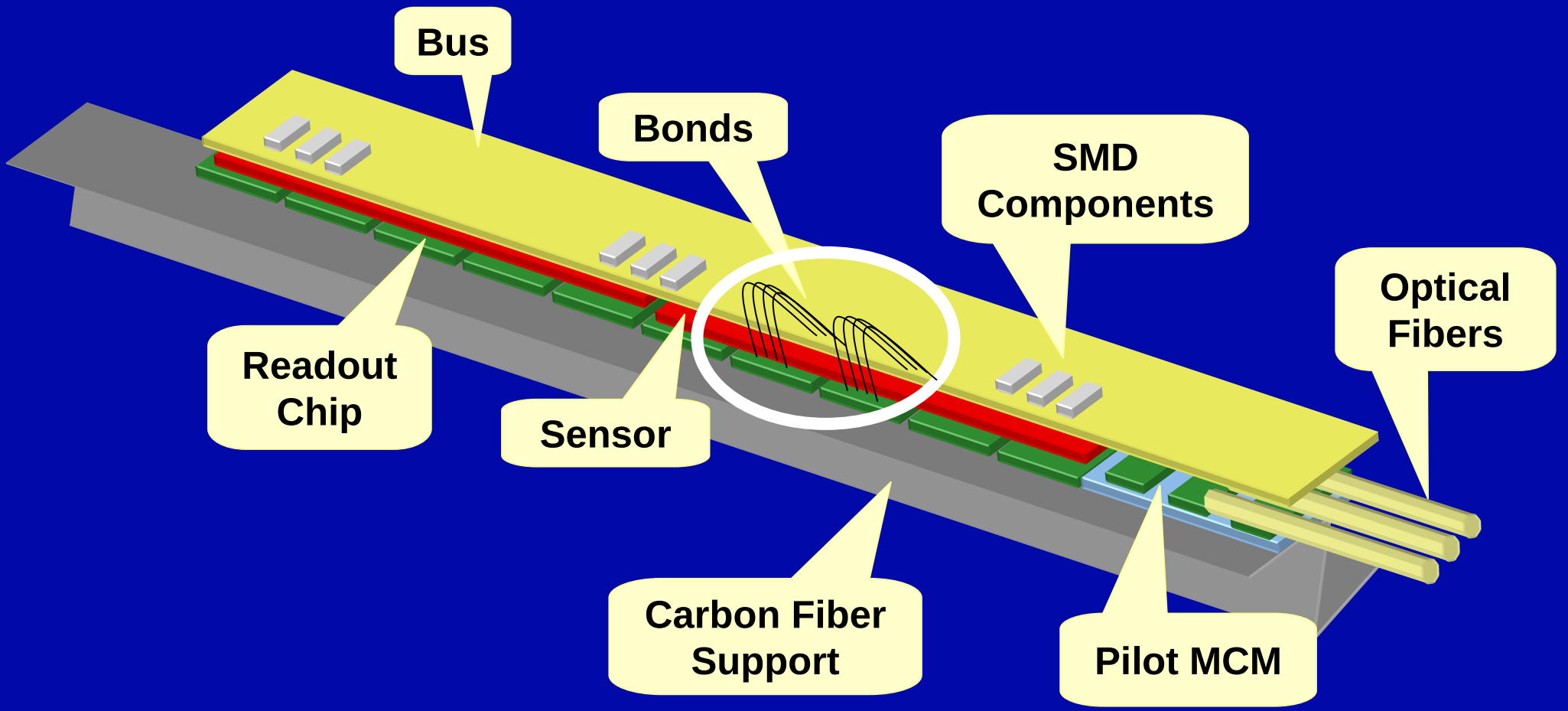
Material budget (each layer): ≈ 0.9% X_0
(Si ≈ 0.37, cooling ≈ 0.3, bus ≈ 0.17, CFSS ≈ 0.1)

SPD Sector

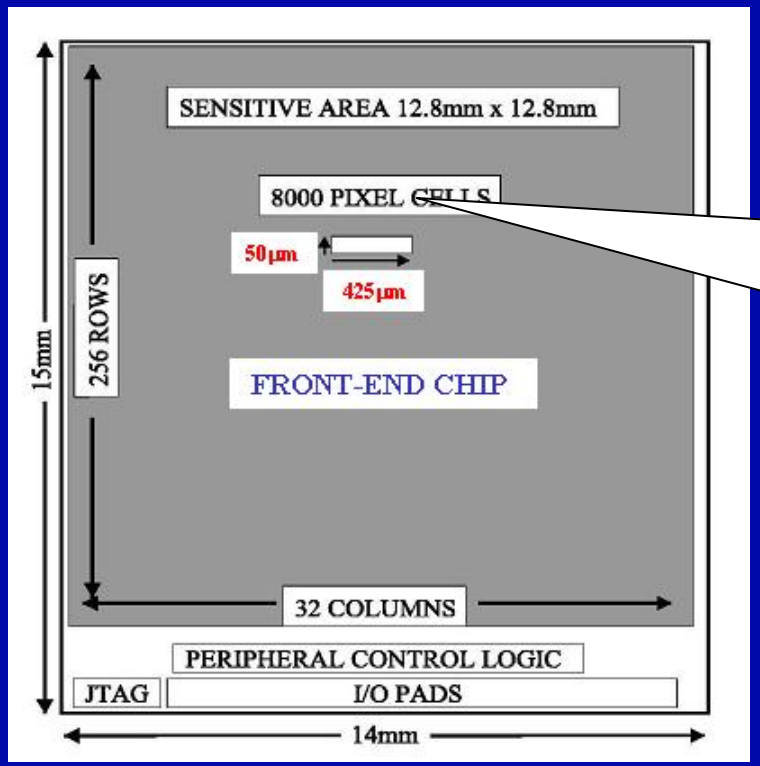


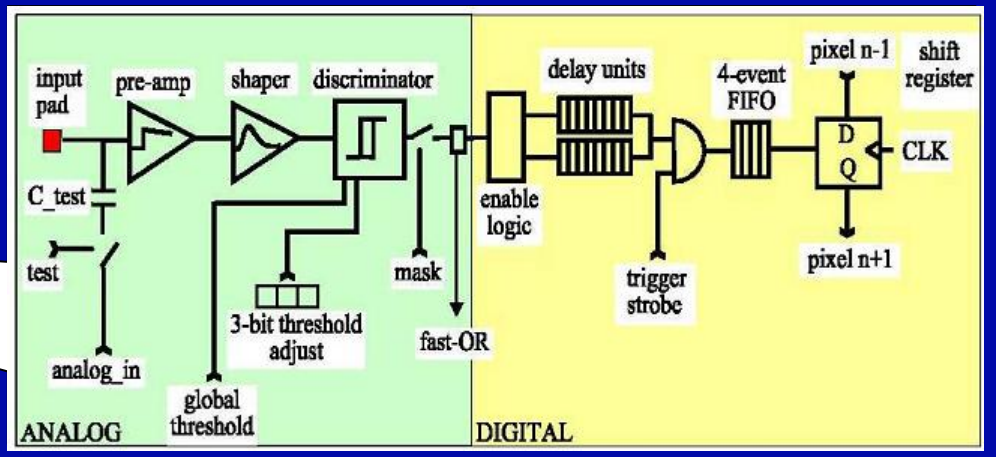
- FE power dissipation/sector: ≈ 150 W
- Cooling: C_4F_{10} (evaporative), operating temperature ≈ 25°C
- Cooling test with a prototype module is currently under way

SPD Half-Stave



ALICELHCb1 Pixel ASIC





- Mixed signal (analogue, digital)
- Produced in a commercial 0.25μm CMOS process (8" wafers)
- Radiation tolerant design (enclosed gates, guard rings)
- 8192 pixel cells
- 50 μm (rϕ) x 425 μm (z) pixel cell
- ~100 μW/channel
- ~1000 e^- mean threshold (~200 e^- RMS)
- ~120 e^- mean noise

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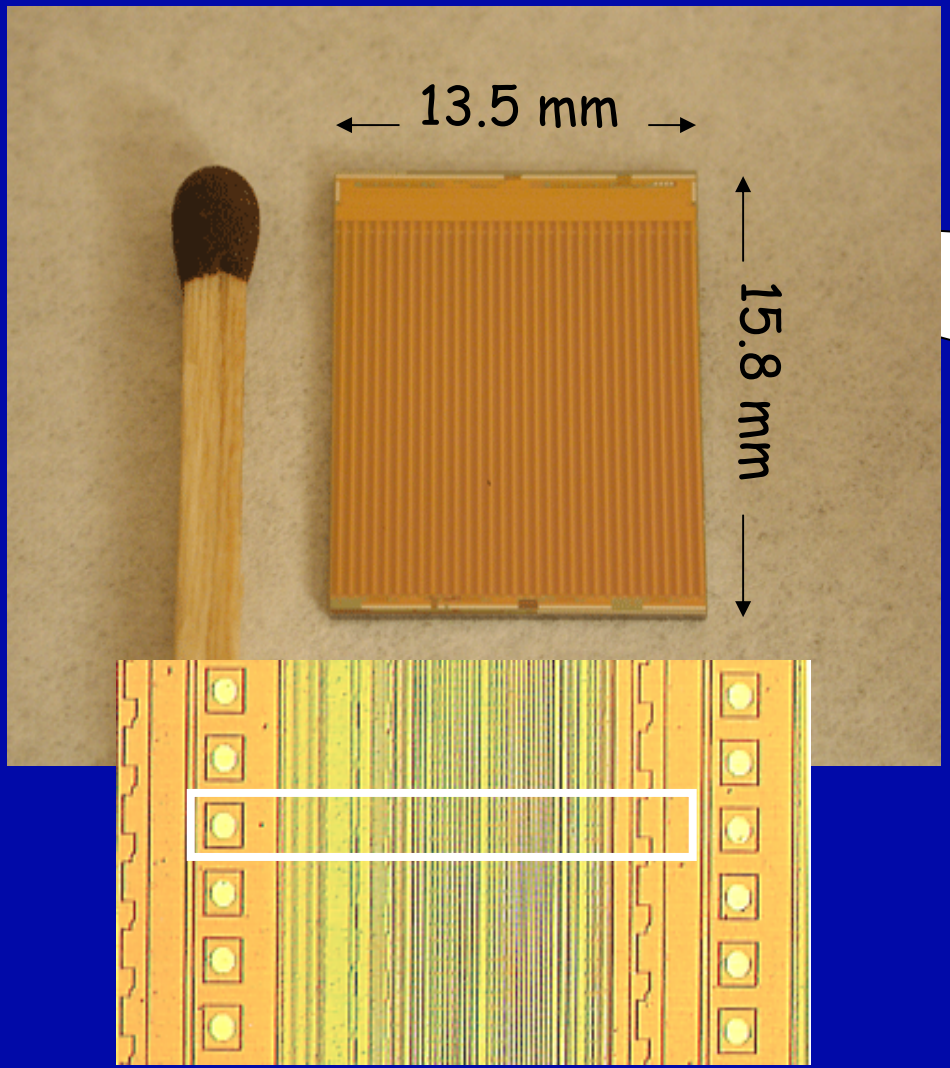

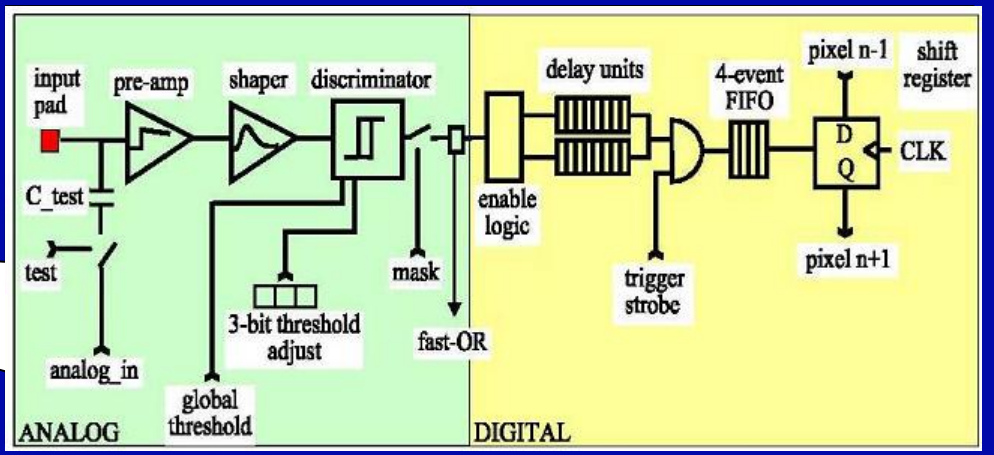

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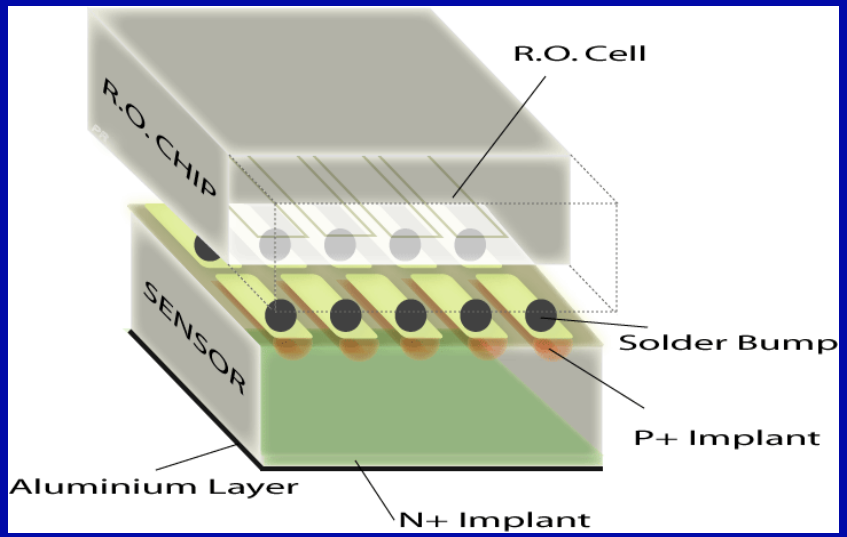
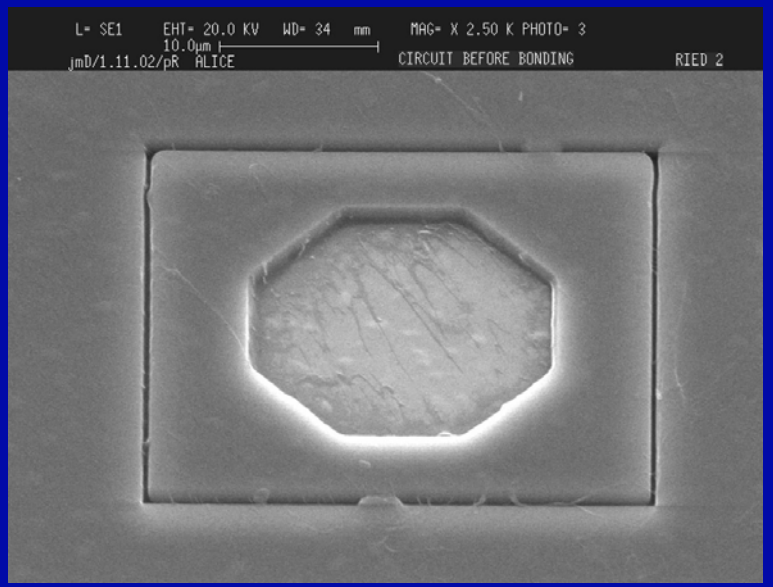
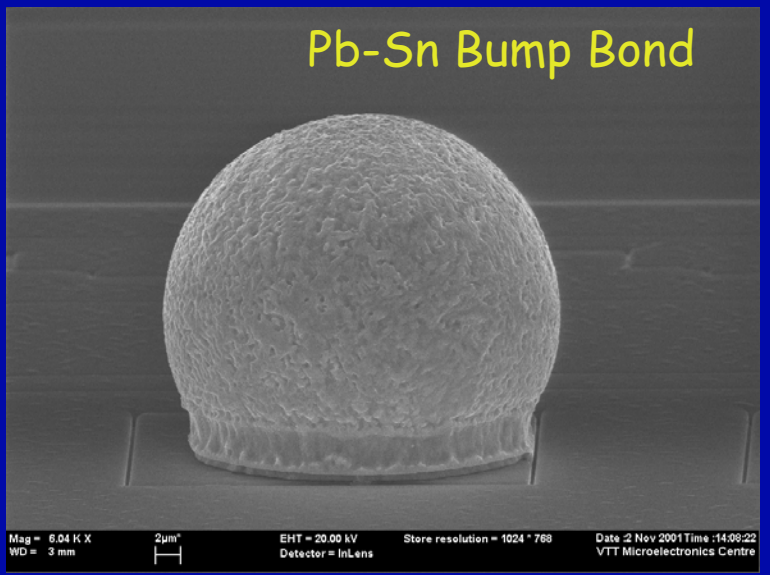
VTT Bump-Bonding



- VTT/Finland
- Pb-Sn solder bumps: ~25μm diameter
- p-in-n silicon sensor: 200μm thick (Canberra)
- IBM readout chips: 750μm native thickness thinned to 150μm after bump deposition
- stand-off: ~20μm (Pb-Sn)



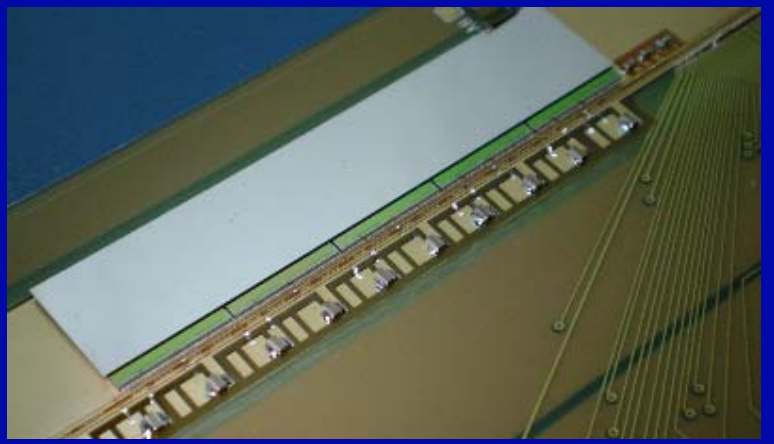
SEM Pictures



SPD Ladder

- 1 p-in-n sensor (200μm thick)
- 5 readout chips (150μm thick)
- 4960 bump bonds

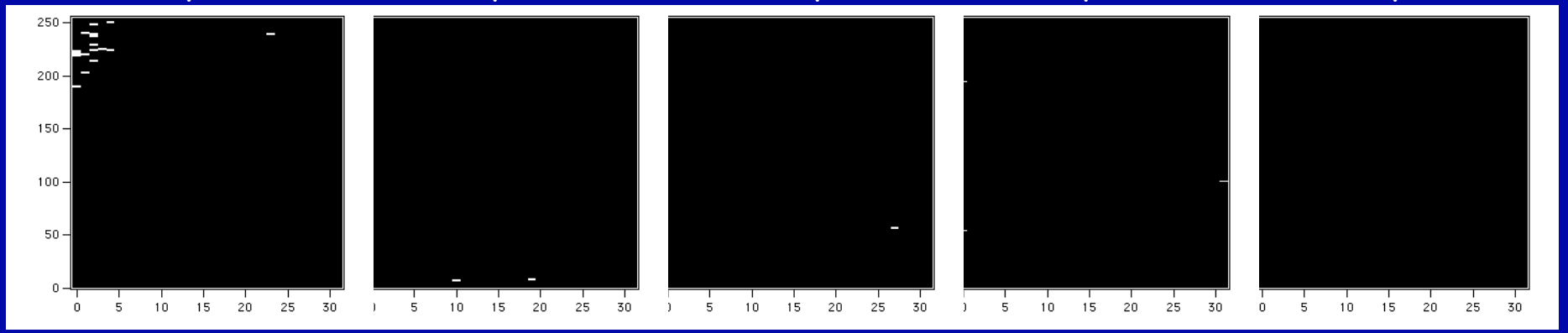
- I_{det} @50V=120-200nA, V_{fd}=15V



Sr-Measurements :

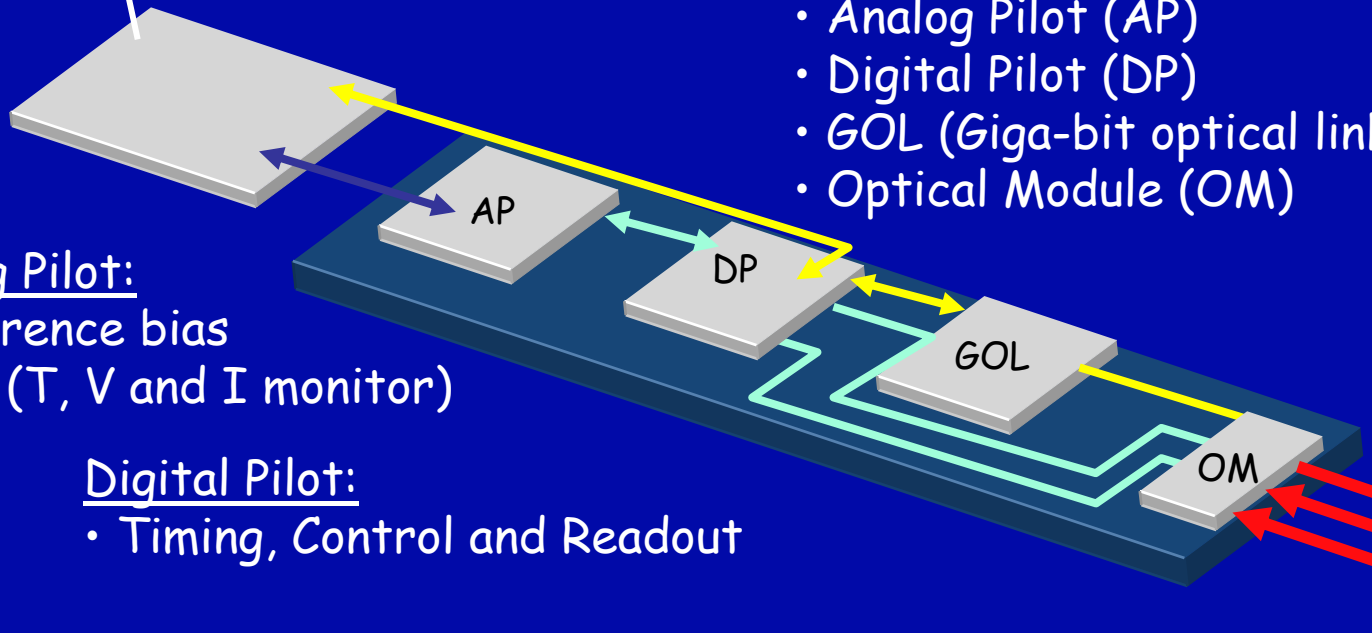
	Chip43	Chip46	Chip42	Chip32	Chip30
Working pixels	99.7%	99.95%	99.98%	99.98%	100%
Missing pixels	28	4	2	2	0

Chip 43 Chip 46 Chip 42 Chip 32 Chip 30



Multi Chip Module (MCM)

ALICE1LHCb chip



Multi Chip Module (MCM)

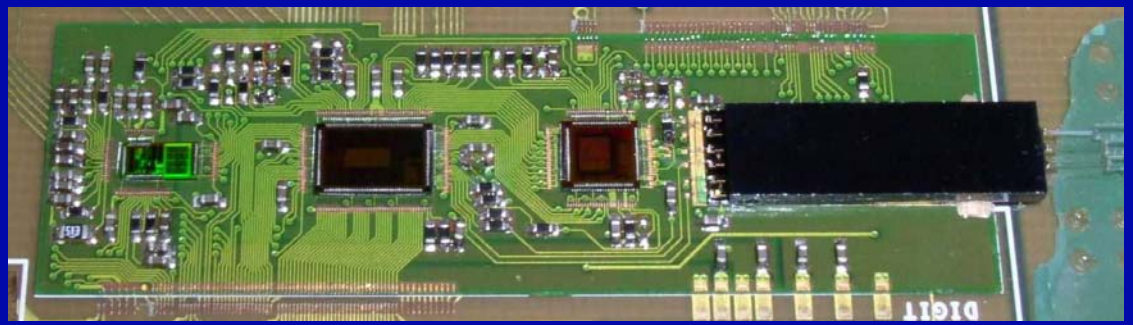
- Analog Pilot (AP)
- Digital Pilot (DP)
- GOL (Giga-bit optical link)
- Optical Module (OM)

Optical Module
- Laser and pin diode
- In Si-case
- 1.2 x 17 x 5.5 mm^3

Analog Pilot:
- Reference bias
- ADC (T, V and I monitor)

Digital Pilot:
- Timing, Control and Readout

- Outogoing Data Stream
- Trigger and JTAG configuration data
- LHC 40 MHz clock



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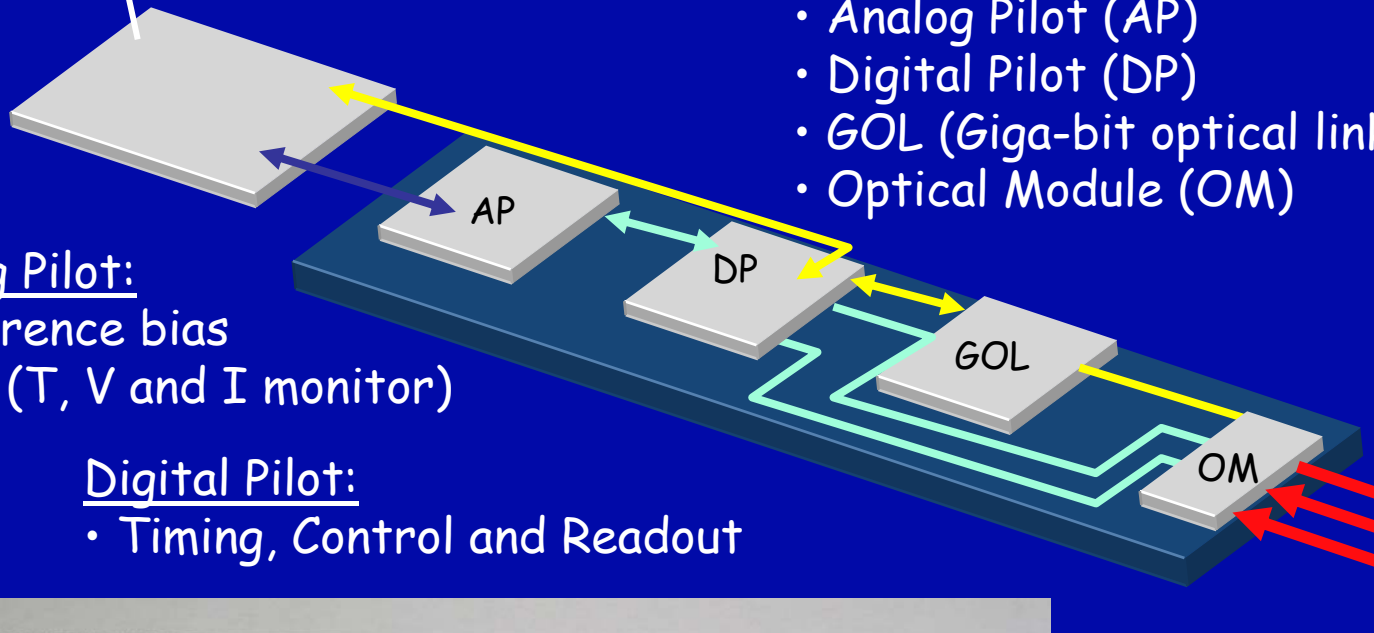

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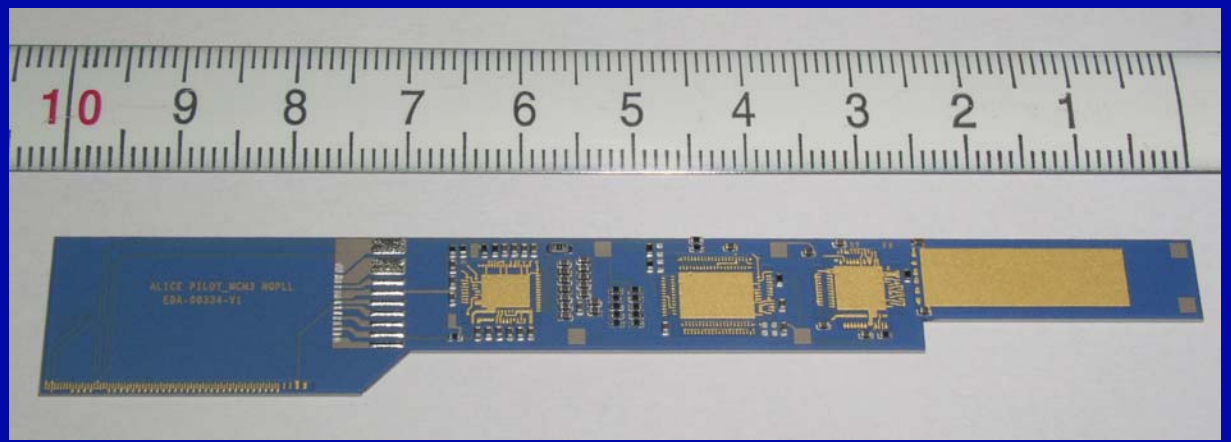
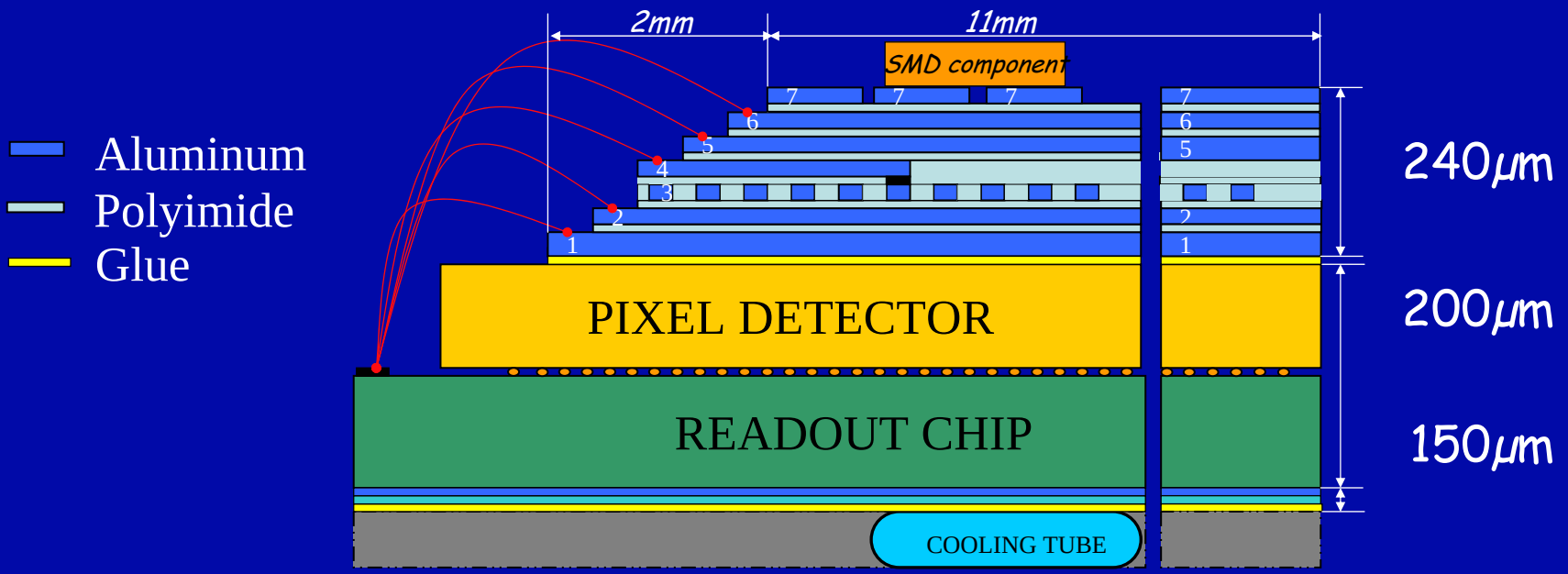
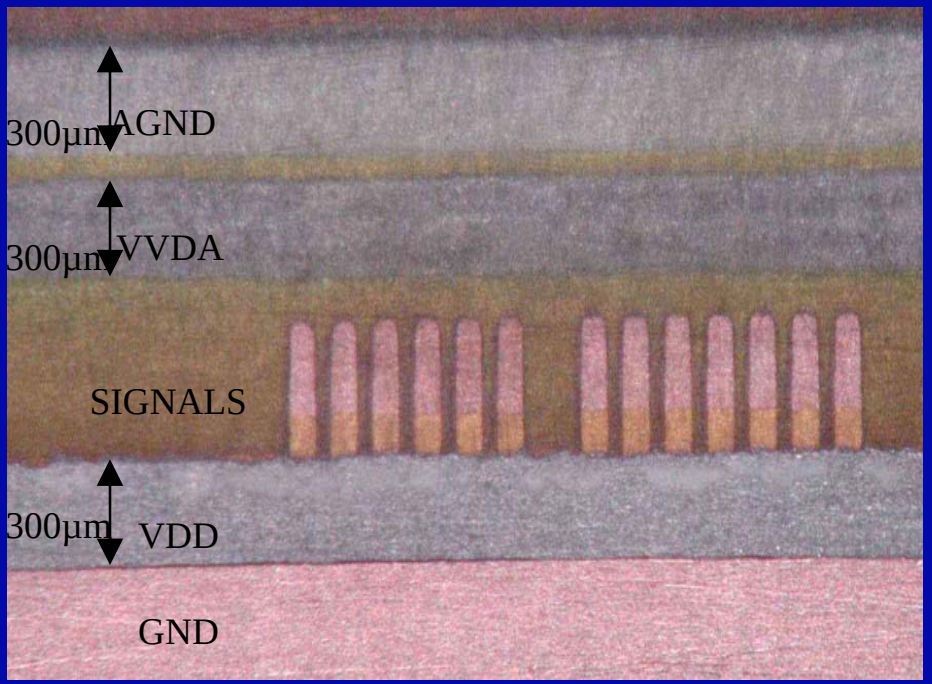


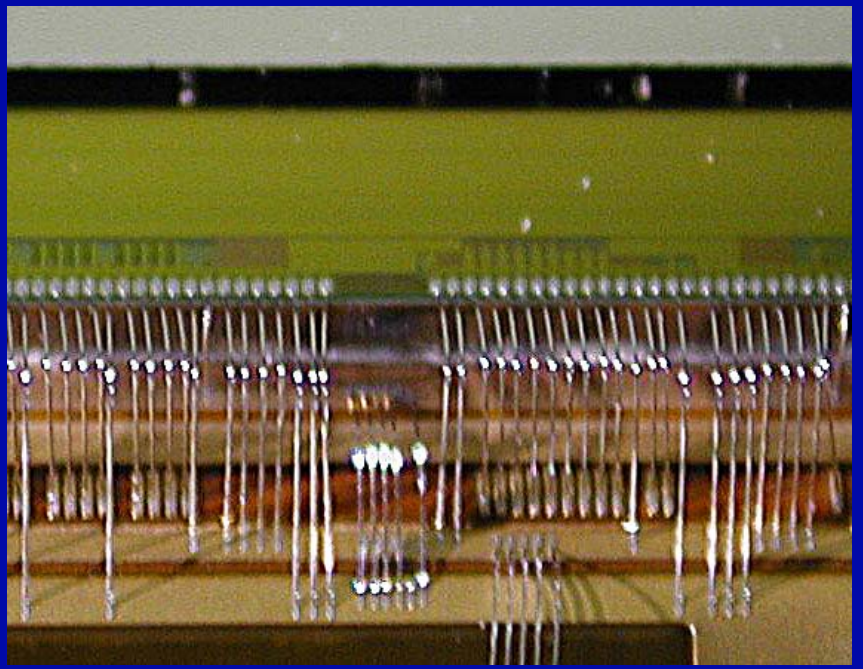
SPD Multilayer Bus

- 5 layer Al-Kapton flex 240 μm thick
- wire bonds to the readout chips and MCM
- provides data -, control- and power-lines between readout chips and MCM



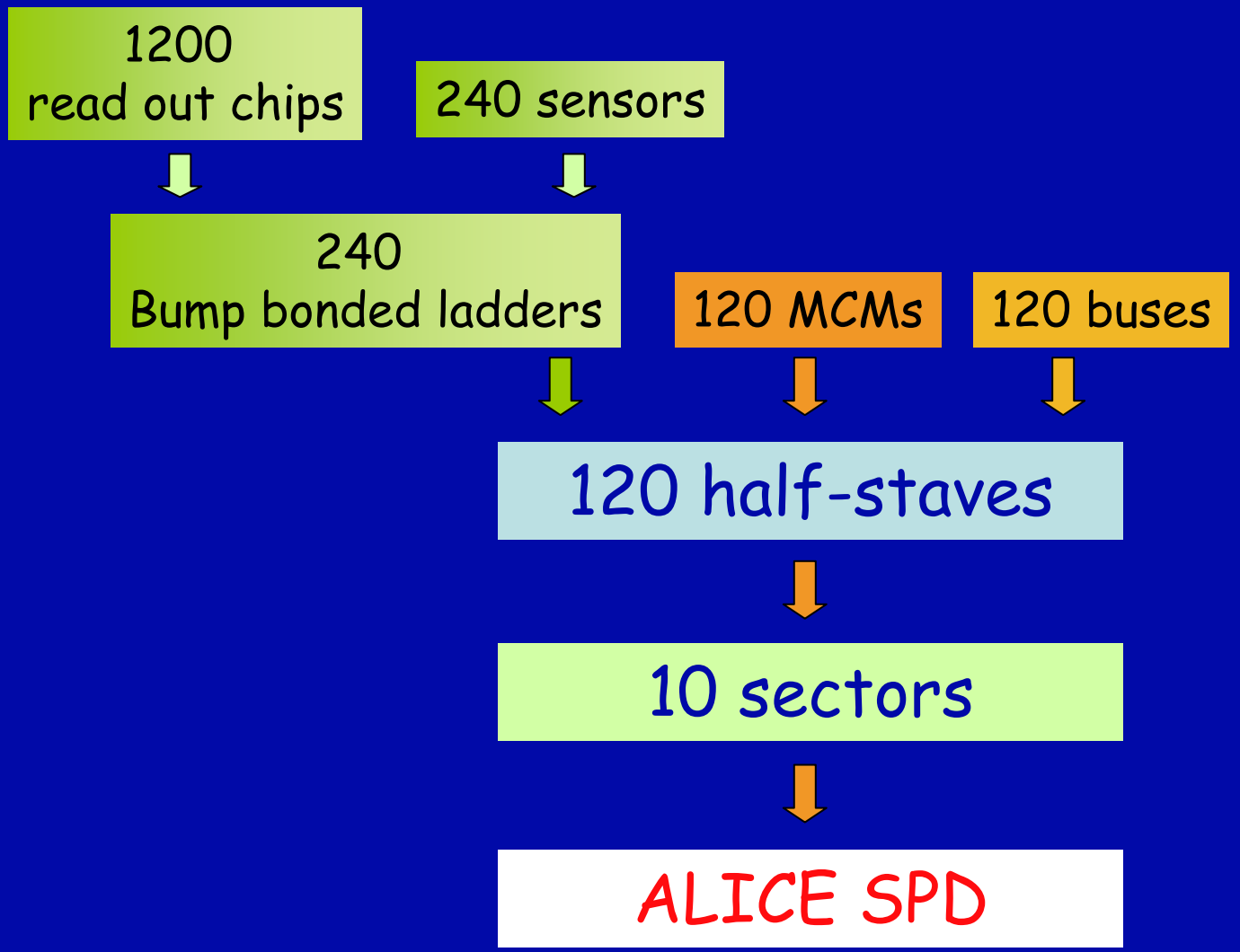
Wire Bonding on Bus and Ladder





- ~1100 Wire bonds/half-stave
- 25µm diameter wire
- Bonding pads on the bus: 80 x 300µm^2
- Step height: 40-60µm

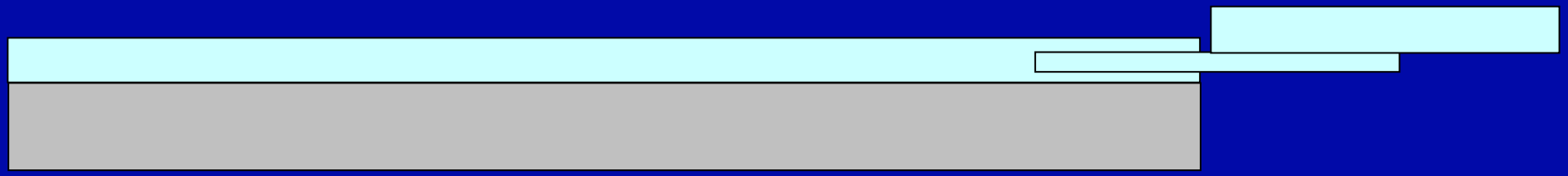
SPD Components



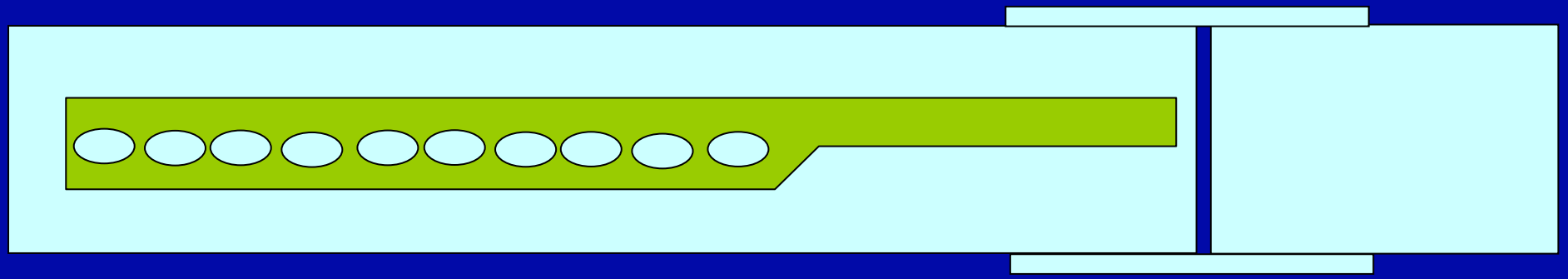
2 spare sectors + 1 pre-production sector

Half-stave Assembly (I)

Side view



Top view



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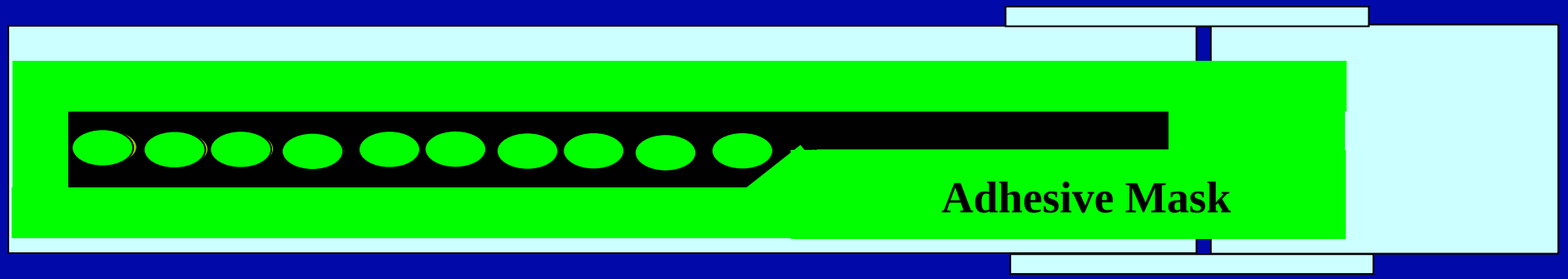

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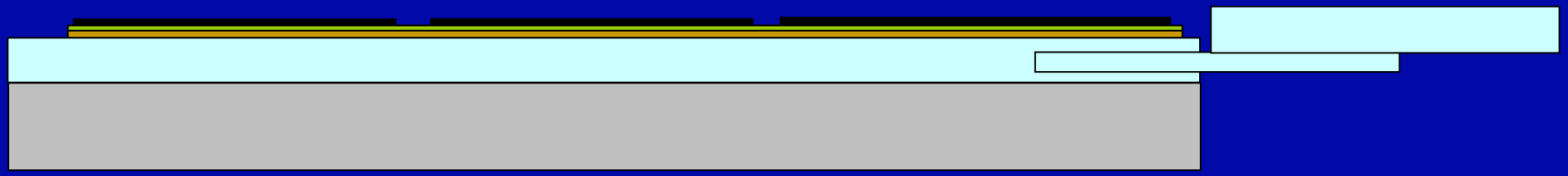

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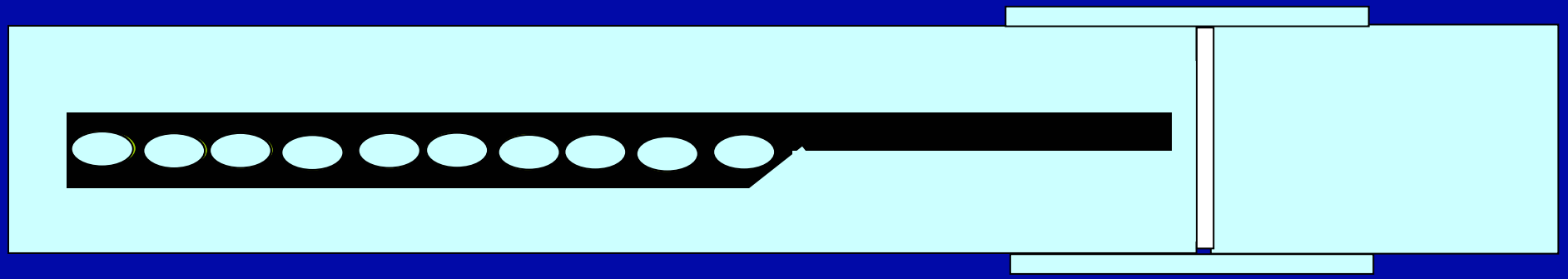

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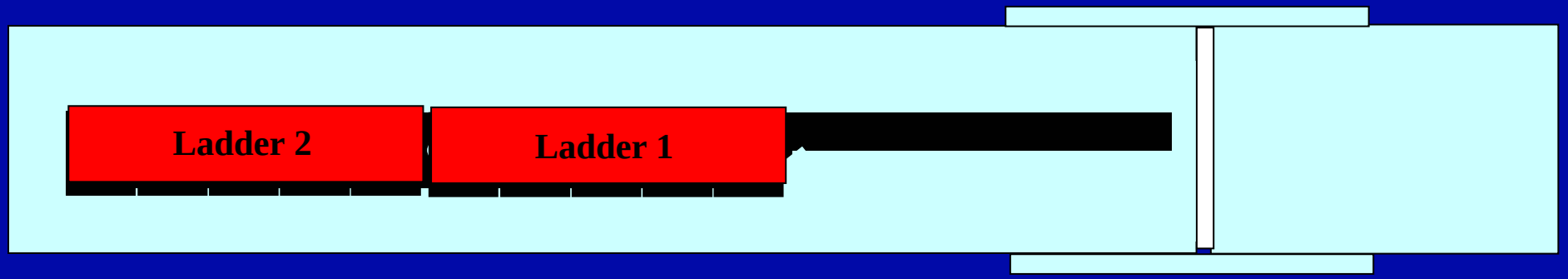

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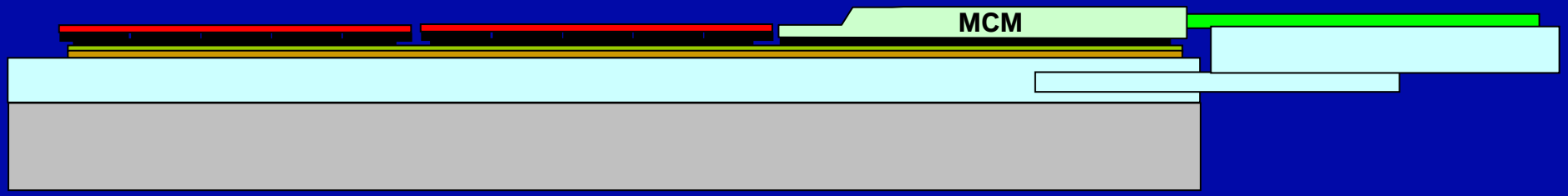
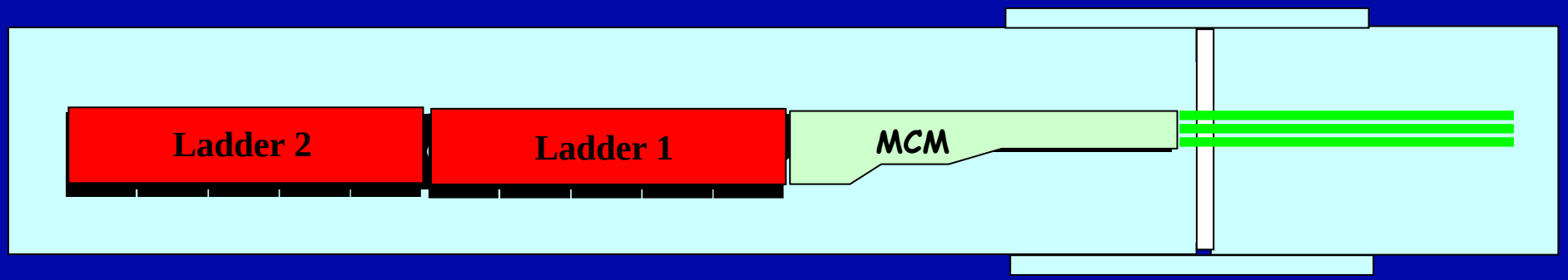


Top view



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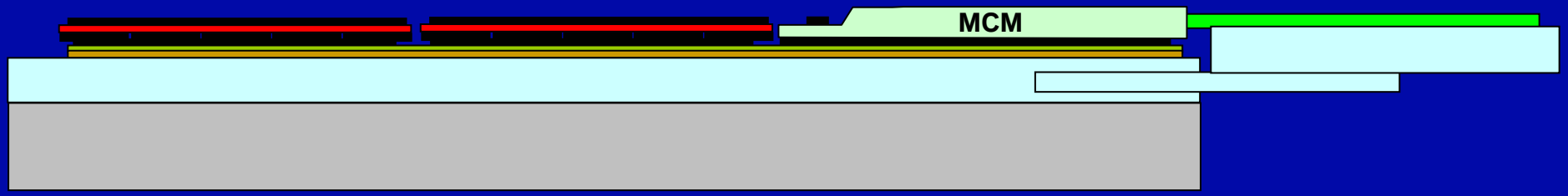

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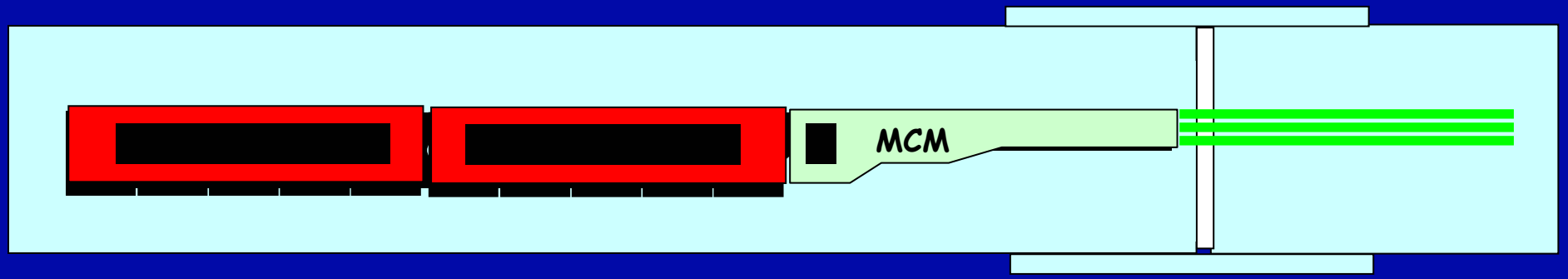

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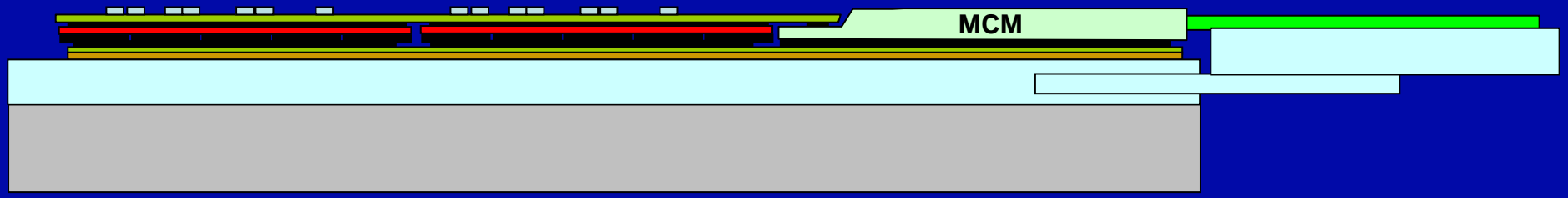

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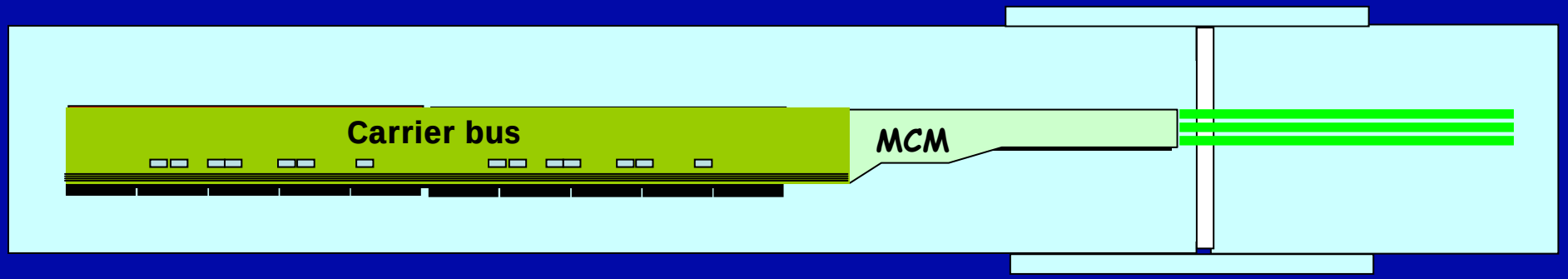

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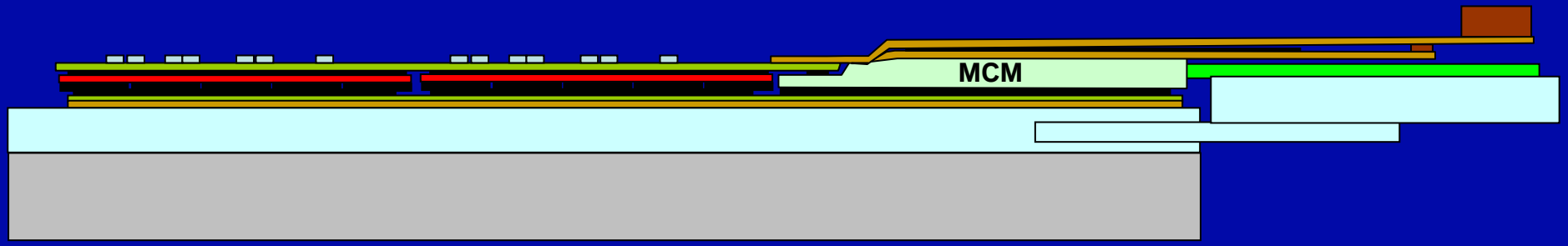
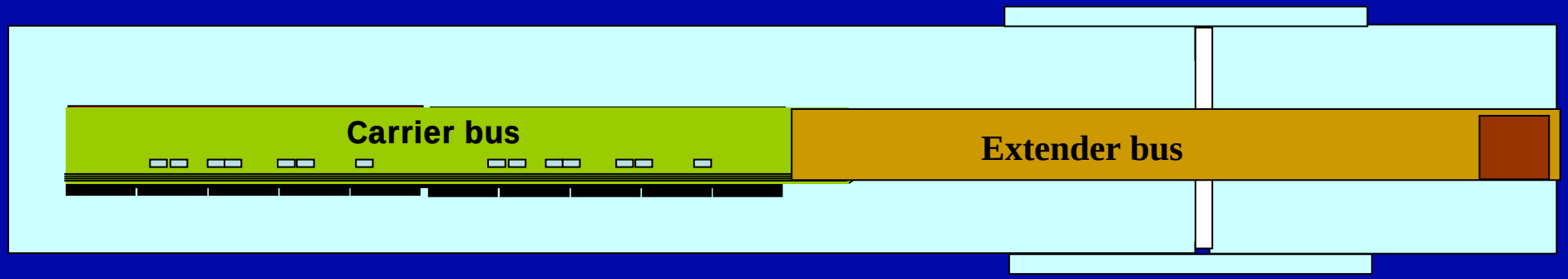
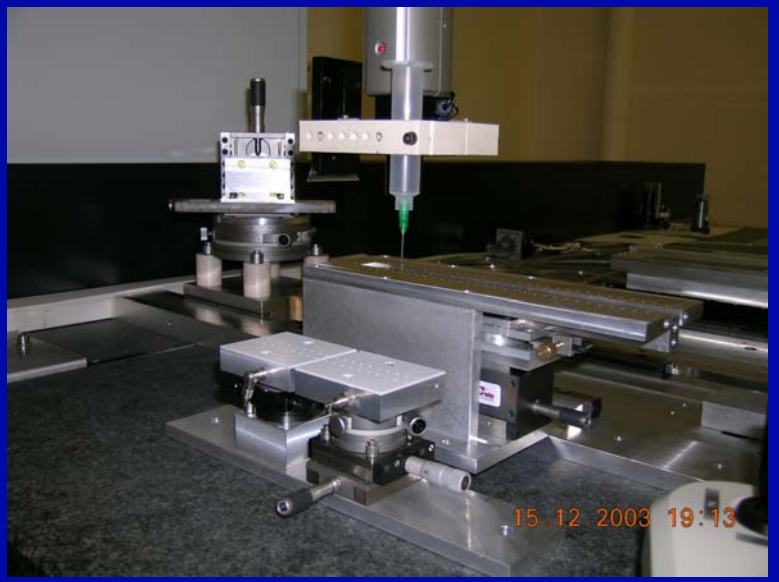


Top view



Half-stave Assembly (II)



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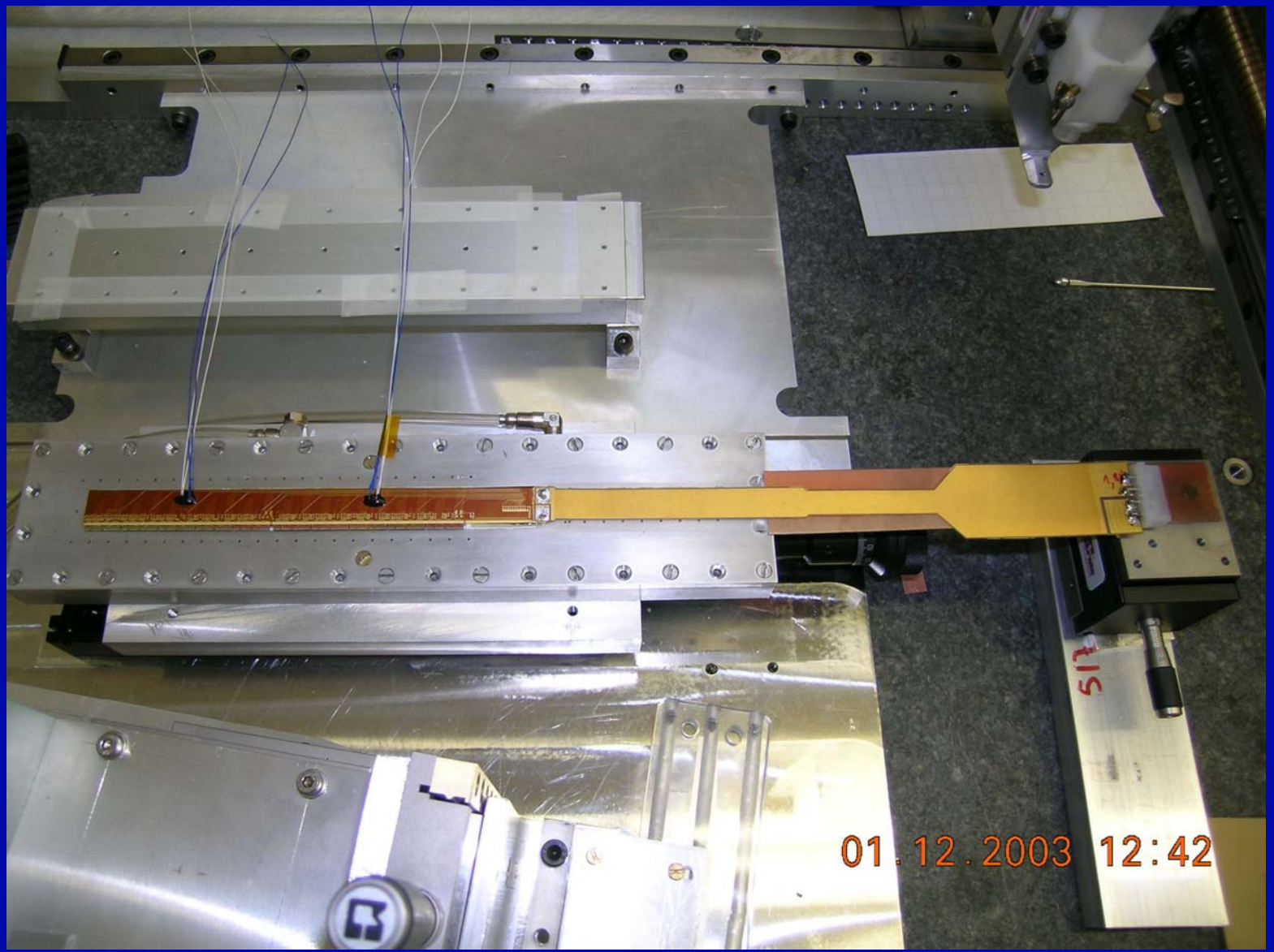
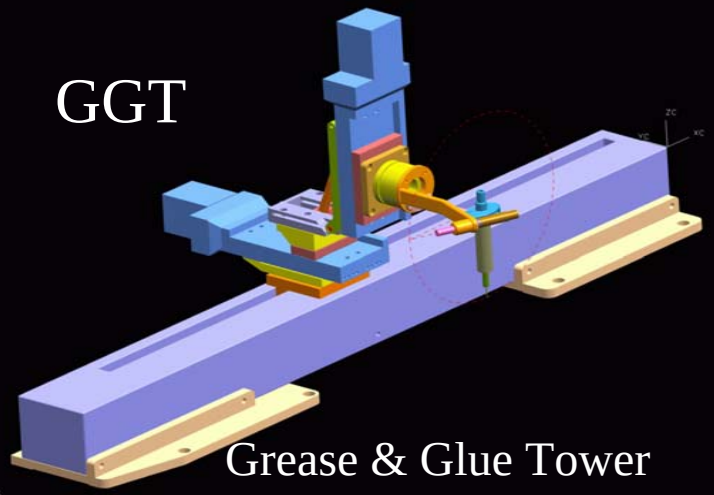


Barrel Sector Assembly System (I)

SJT

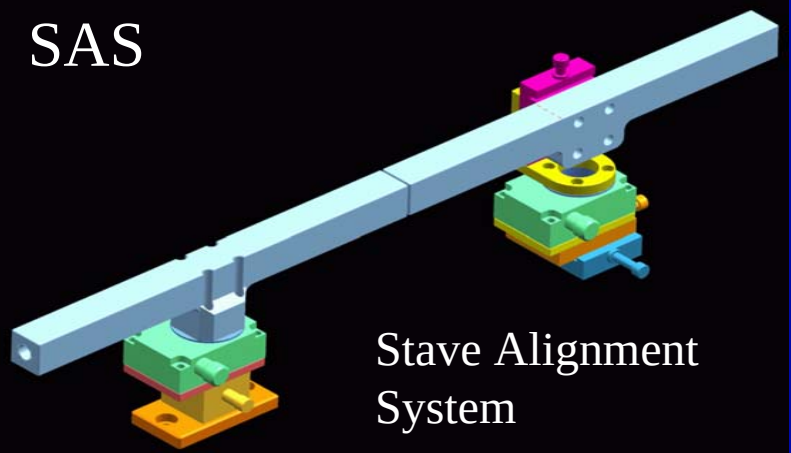
Stave Jig Tower

GGT



Grease & Glue Tower

SAS

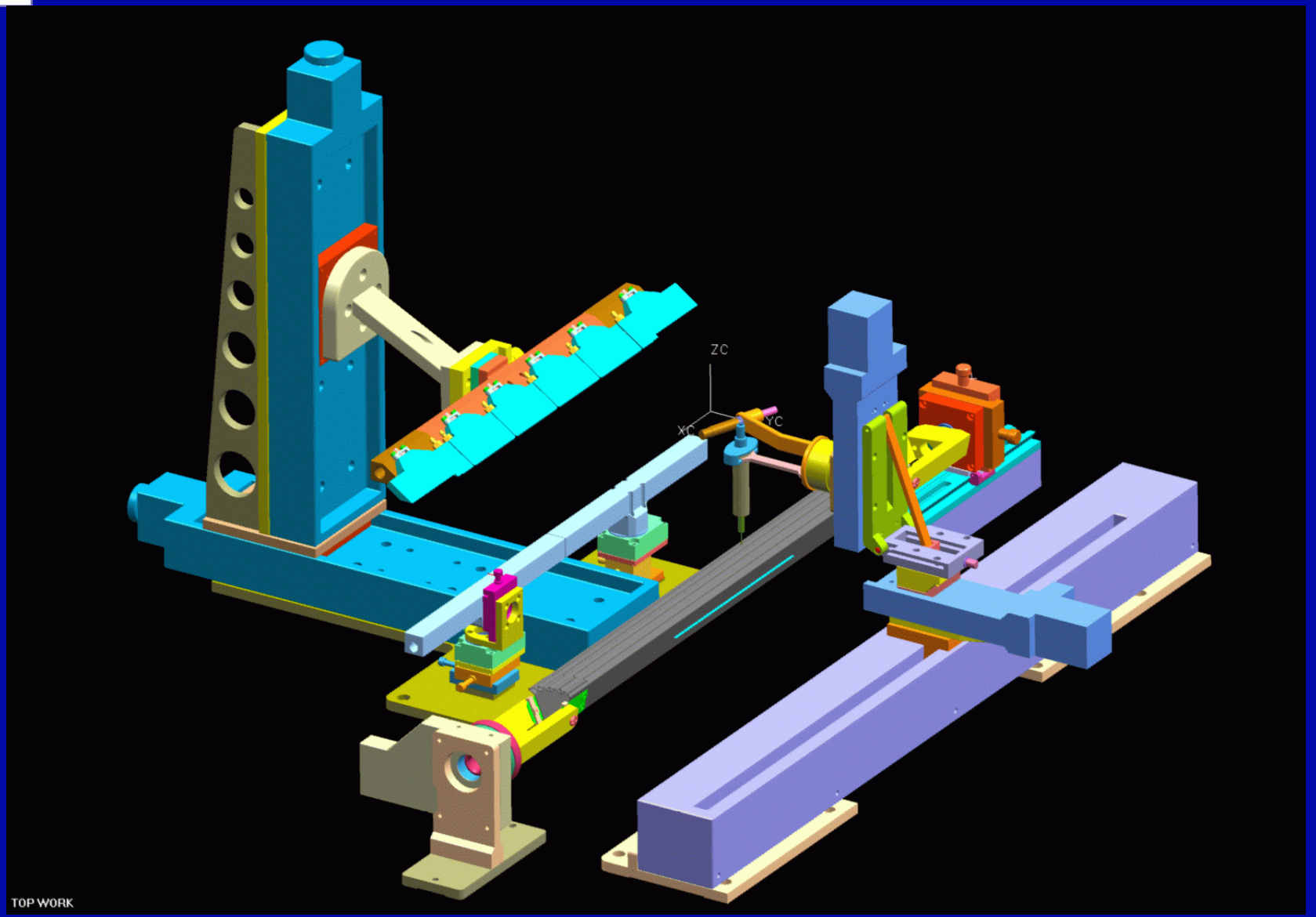


Stave Alignment System

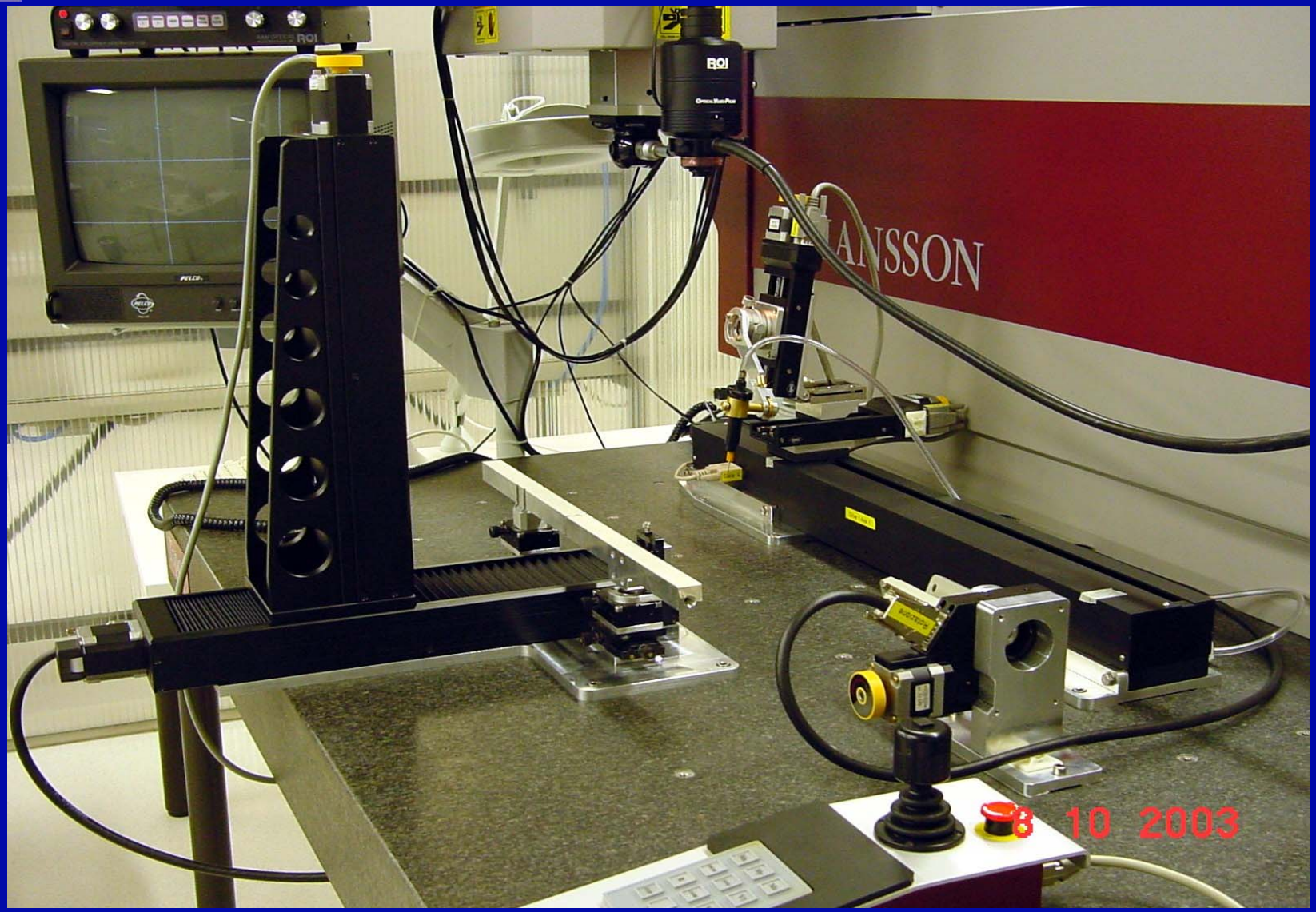
RSS

Rotating Sector Support

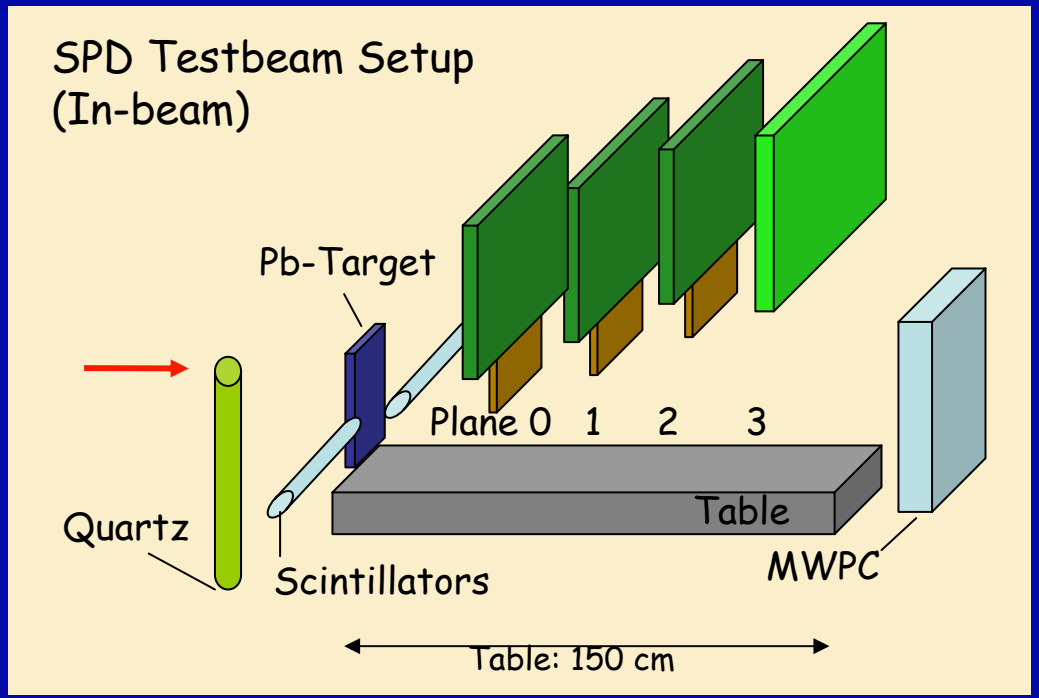
Barrel Sector Assembly System (I)



Barrel Sector Assembly System (II)



2003 Beam Test Setup

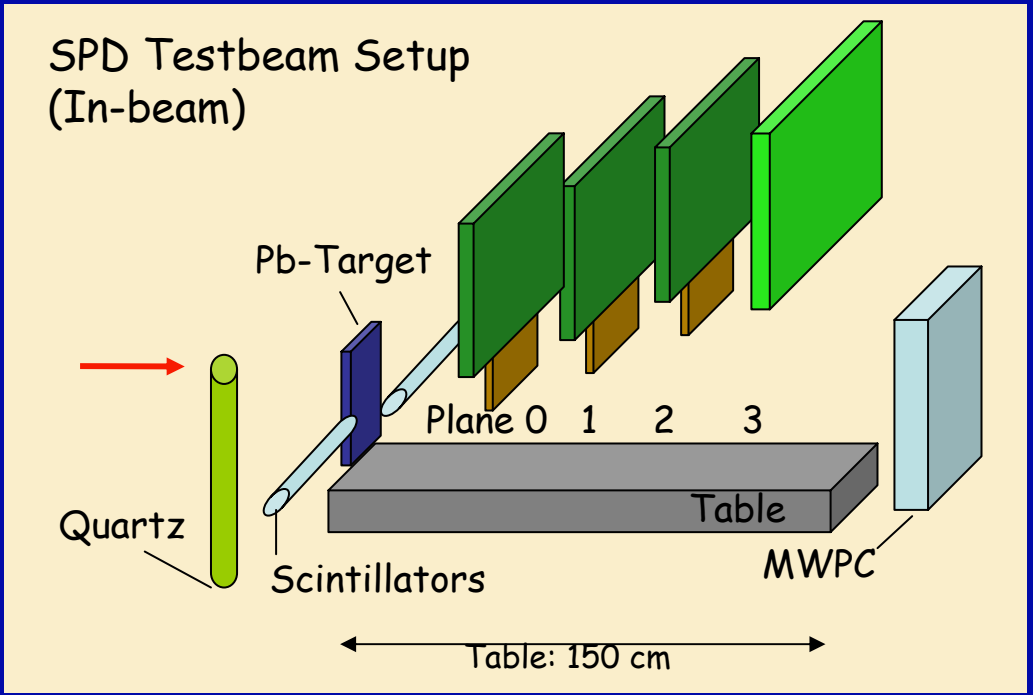


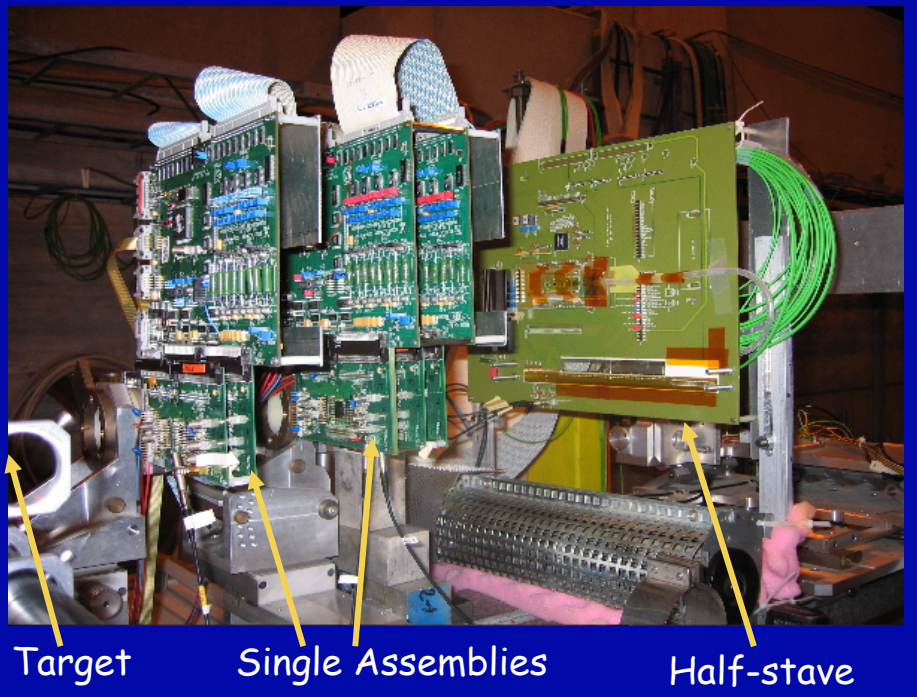
158 GeV/A In ion beam
- ≈ 10^4 ions/spill
- 15 days
- Pb target 4mm thick

120 GeV protons
- 3 days

- Up to 6 planes (= 5 singles + half stave) in the beam (up to 122 880 active pixels)
- Plane 0 - Plane 3 distance ≈ 80 cm, vertically adjusted for tracking
- Target: 4 mm Pb
- Trigger: quartz counter (beam) + 2 cm x 2 cm scintillator (interactions)
- Half-stave read out through MCM including optical module
- 2.8 GB of data collected
- DCS (PVSS) system for HV

2003 Beam Test Setup





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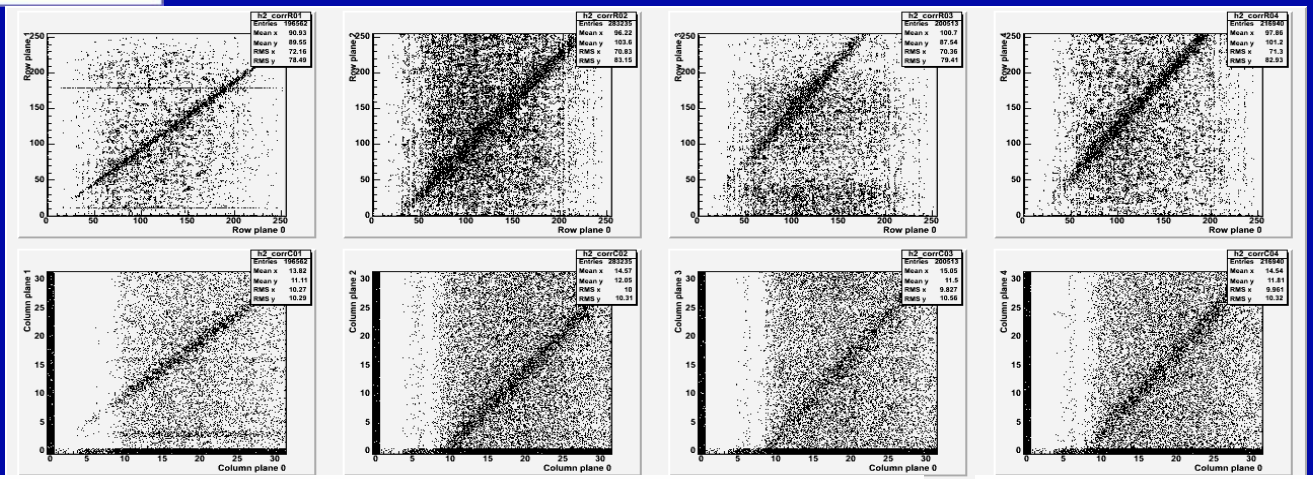
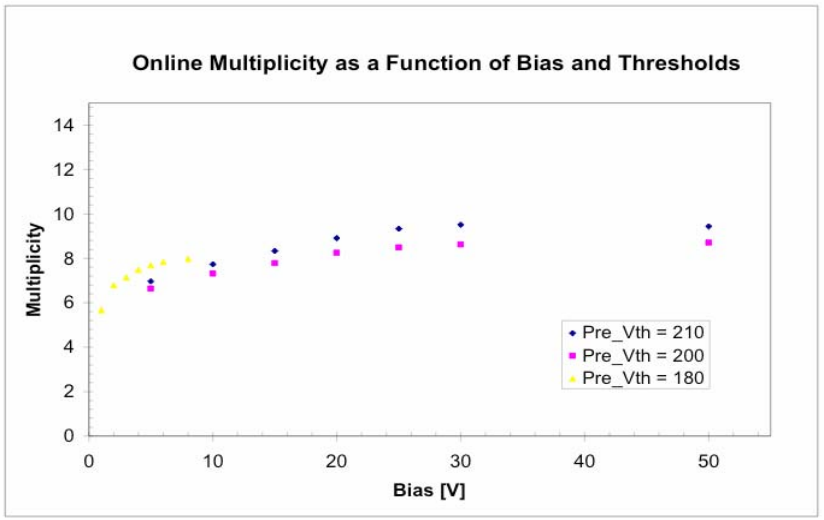
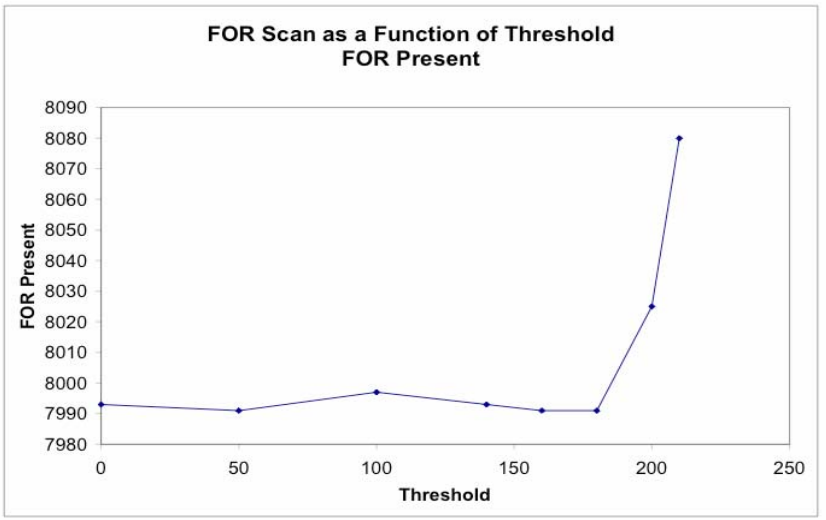
First Results (very preliminary)



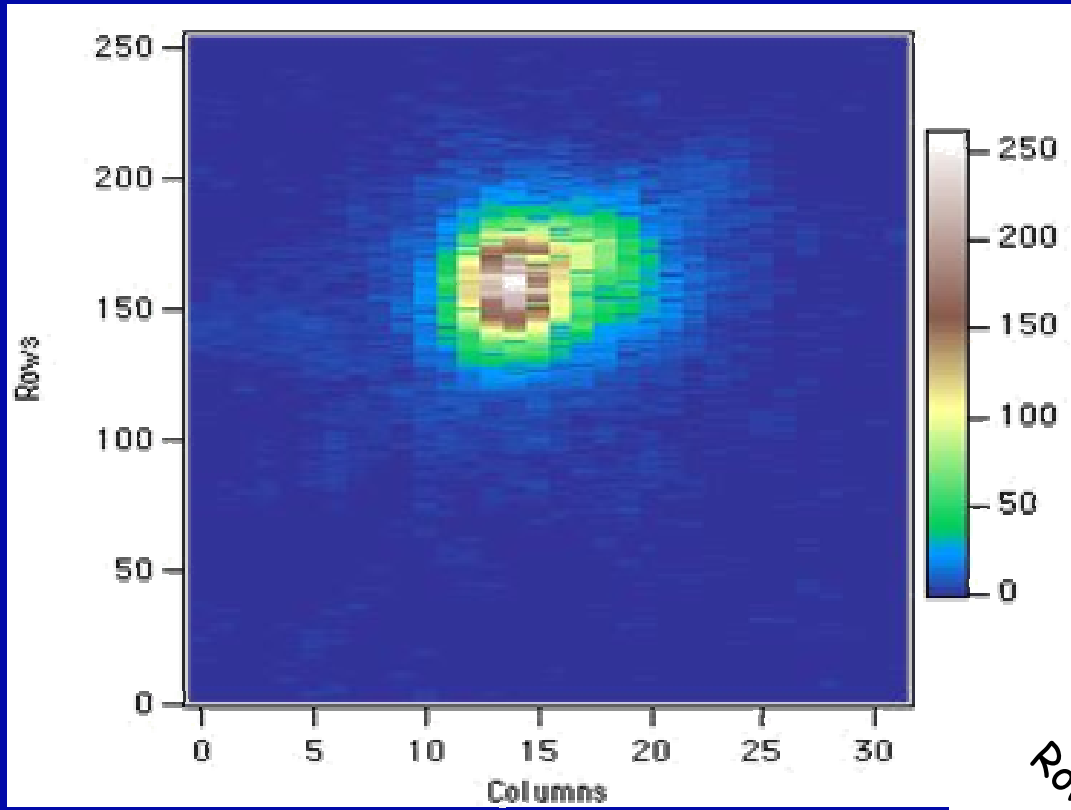
Hit correlations between the planes (stripped In ion beam)

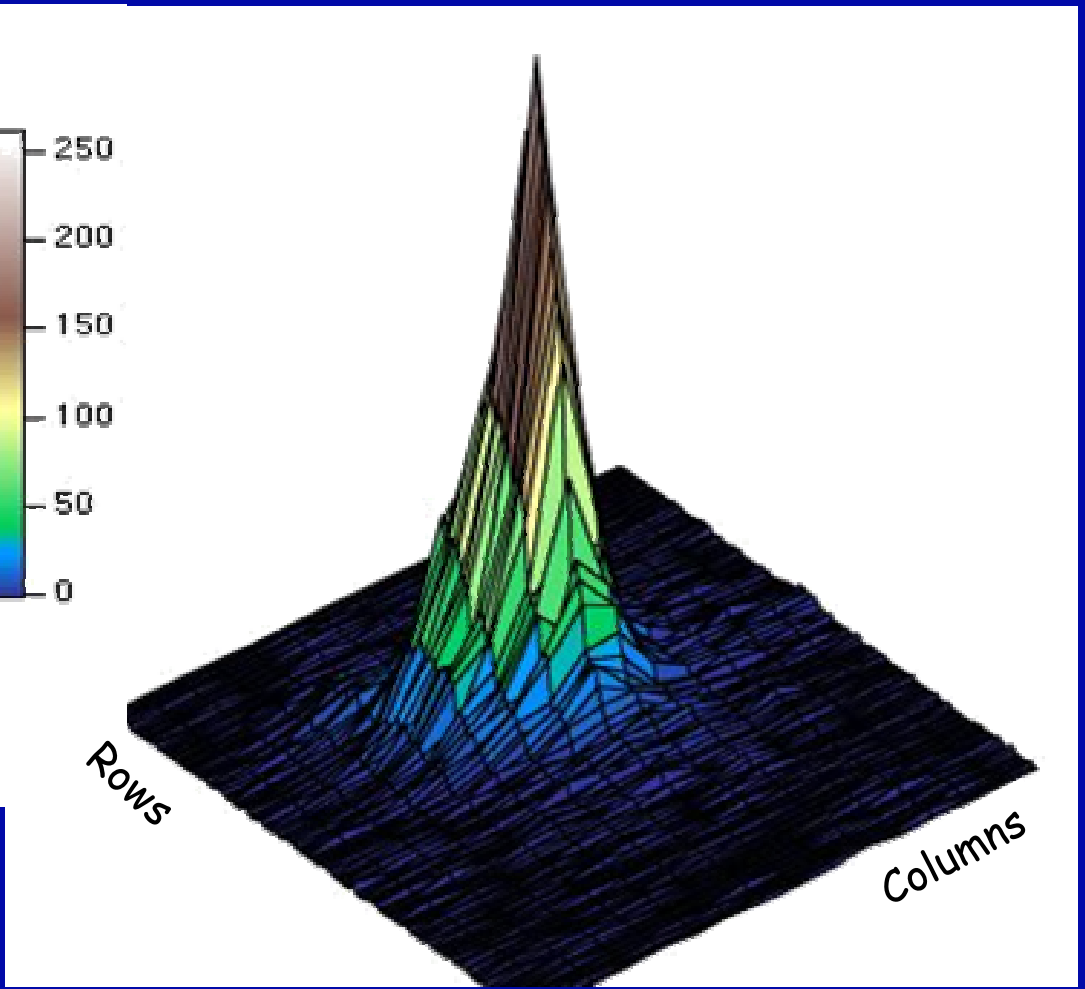




Indium Ion Beam on Single Assembly

Beamspot (32V sensor bias) 10^4 ions/spill





Summary

- Challenging constraints on geometry and material budget.

- Specific technology developments and extensive tests of the SPD components have been carried out.

- Half-stave and Sector assembly procedures have been developed and tests with dummy components are currently being completed.

- Construction of prototypes with real components has been started: a half-stave with real ladders has been delivered for cooling test, a half-stave for the validation of the multilayer bus with working ladders is under construction.

- SPD components have been tested in a heavy-ion beam (October 2003): offline analysis of collected data ongoing.