

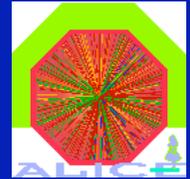
The Silicon Pixel Detector (SPD) for the ALICE Experiment

V. Manzari/INFN Bari, Italy

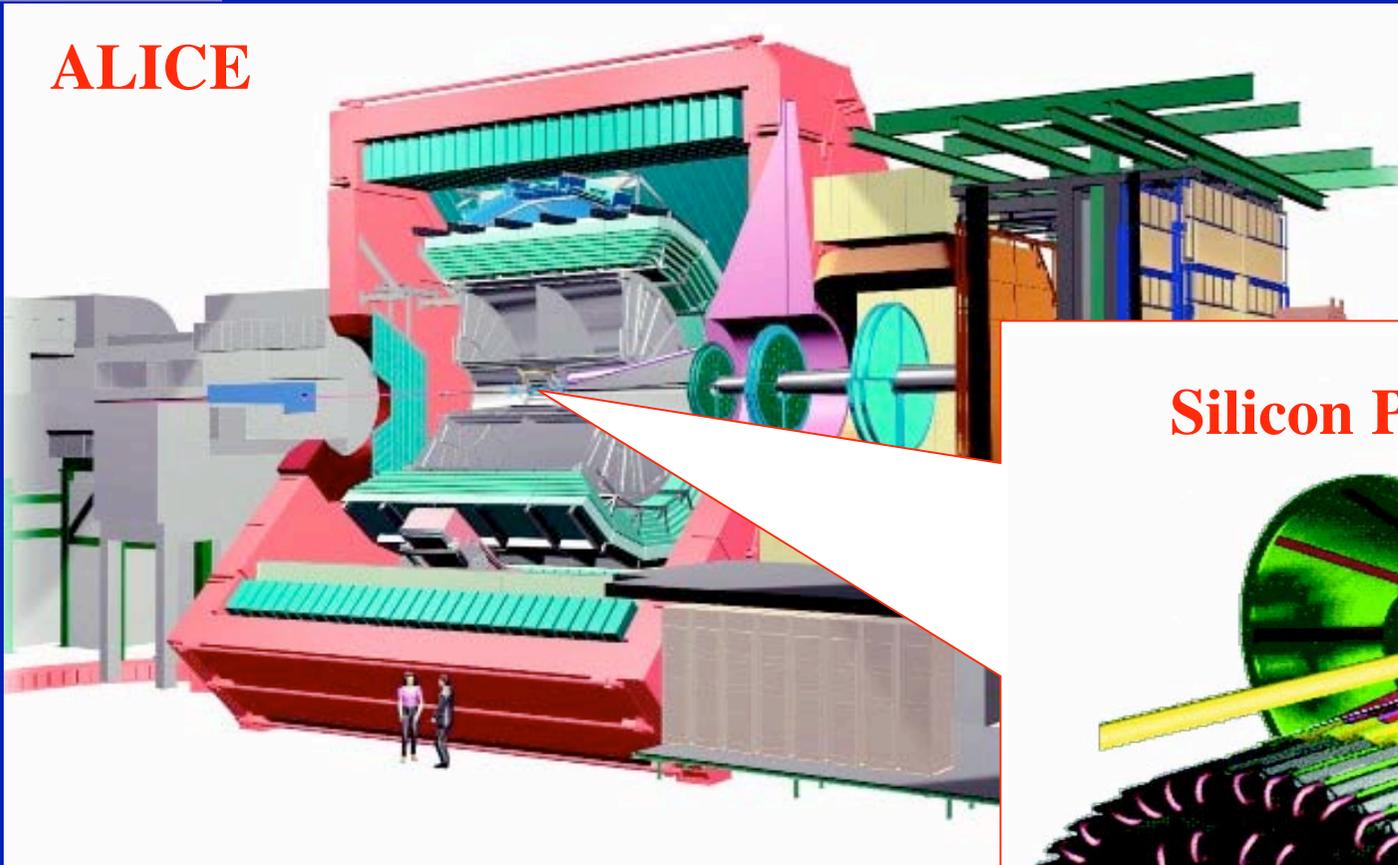
for the SPD Project in the ALICE Experiment

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**

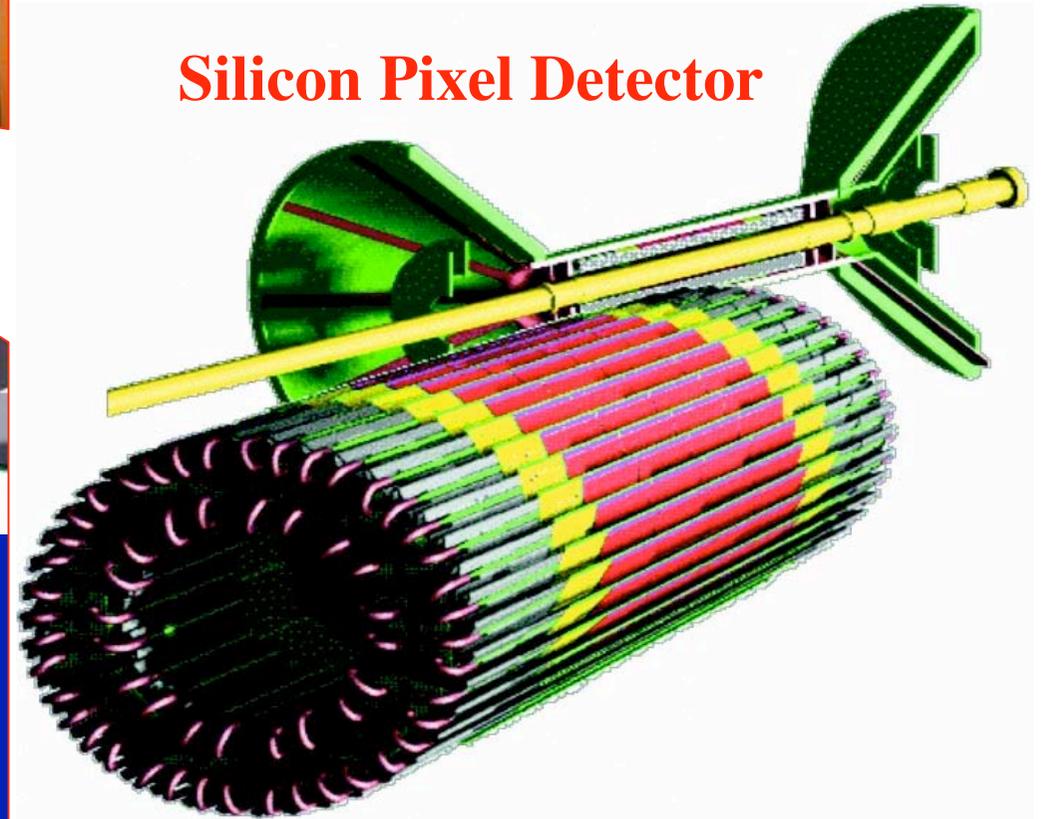
ALICE Layout: the ITS and the SPD



ALICE

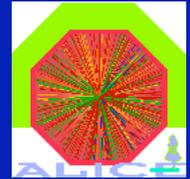


Silicon Pixel Detector

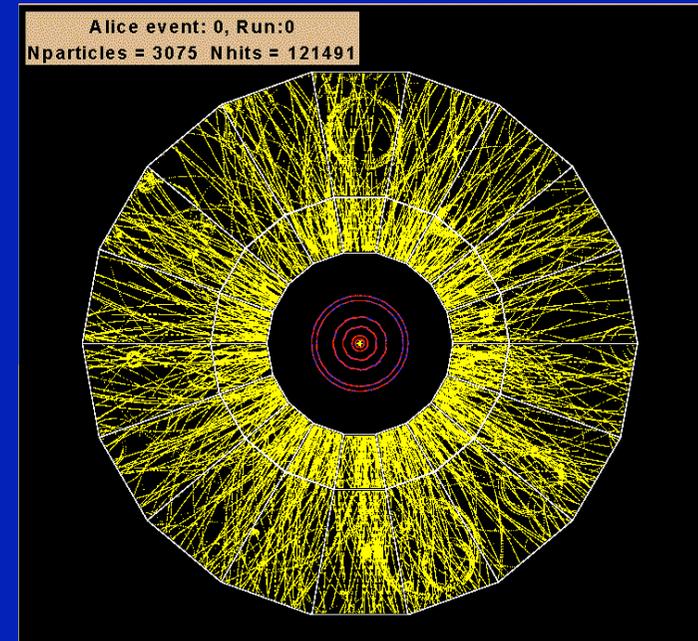


- B -field < 0.5 T
- Charged particle multiplicities of up to 8000 per unit of rapidity (head-on Pb-Pb collisions)

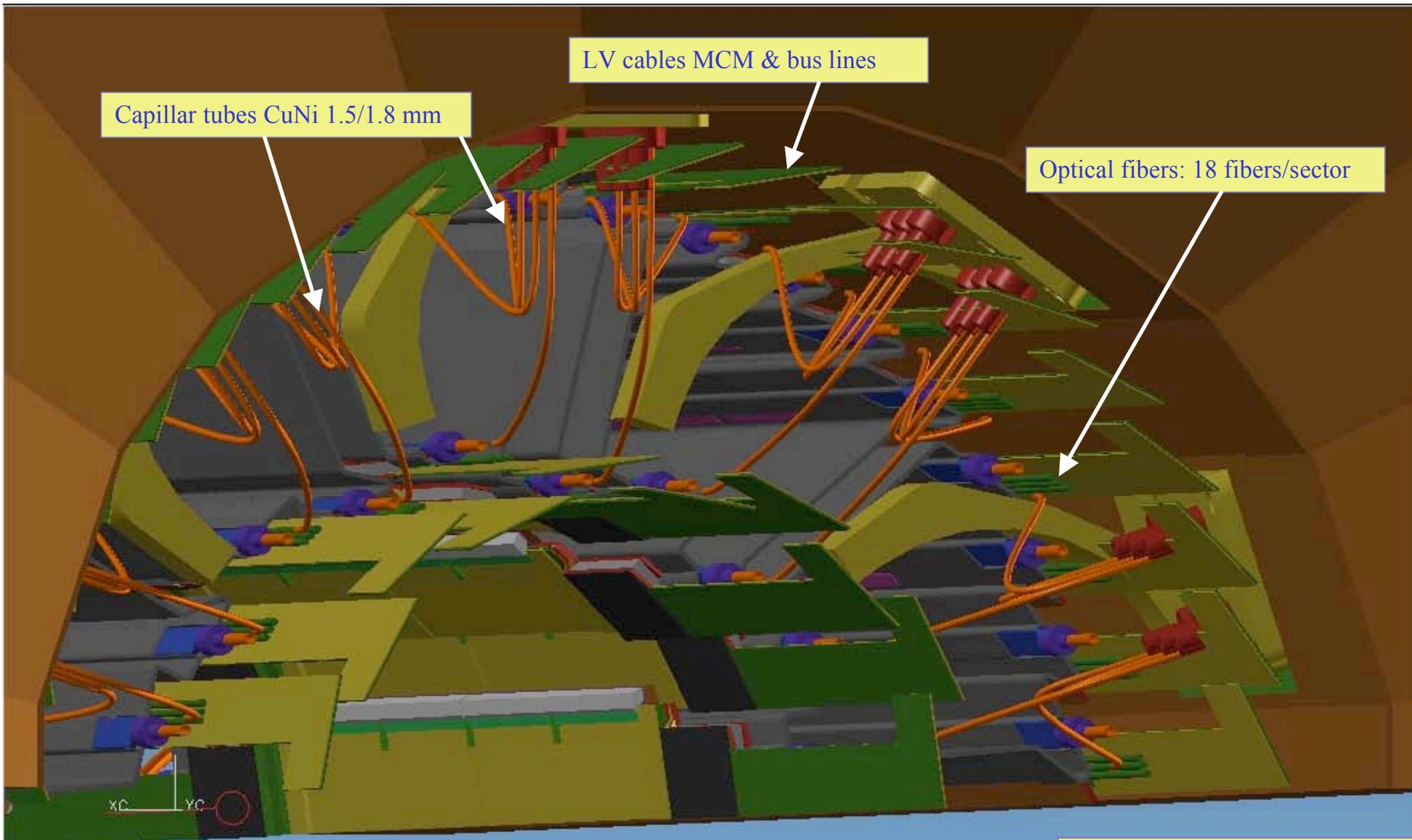
The ALICE SPD



- Secondary vertexing capability (c,b)
- Track impact parameter resolution: $r\phi < 50 \mu\text{m}$ ($p_t > 1.3 \text{ GeV}/c$)
- Two barrel layers: $R_i = 39 \text{ mm}$, $R_o = 76 \text{ mm}$
- Inner layer pseudorapidity coverage: $|\eta| < 1.95$ [ITS coverage $|\eta| \approx 0.8$]
- Total Si surface: $\approx 0.24 \text{ m}^2$
- Individual pixel cell: $50 \mu\text{m}$ ($r\phi$) \times $425 \mu\text{m}$ (z)
- Occupancy (central Pb-Pb): $< 2\%$
- Radiation level at the inner layer for 10 years standard running:
TID $\approx 5 \text{ kGy}$, $F \approx 6 \cdot 10^{12} (1 \text{ MeV } n_{eq})/\text{cm}^2$ (working values!)



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



Capillar tubes CuNi 1.5/1.8 mm

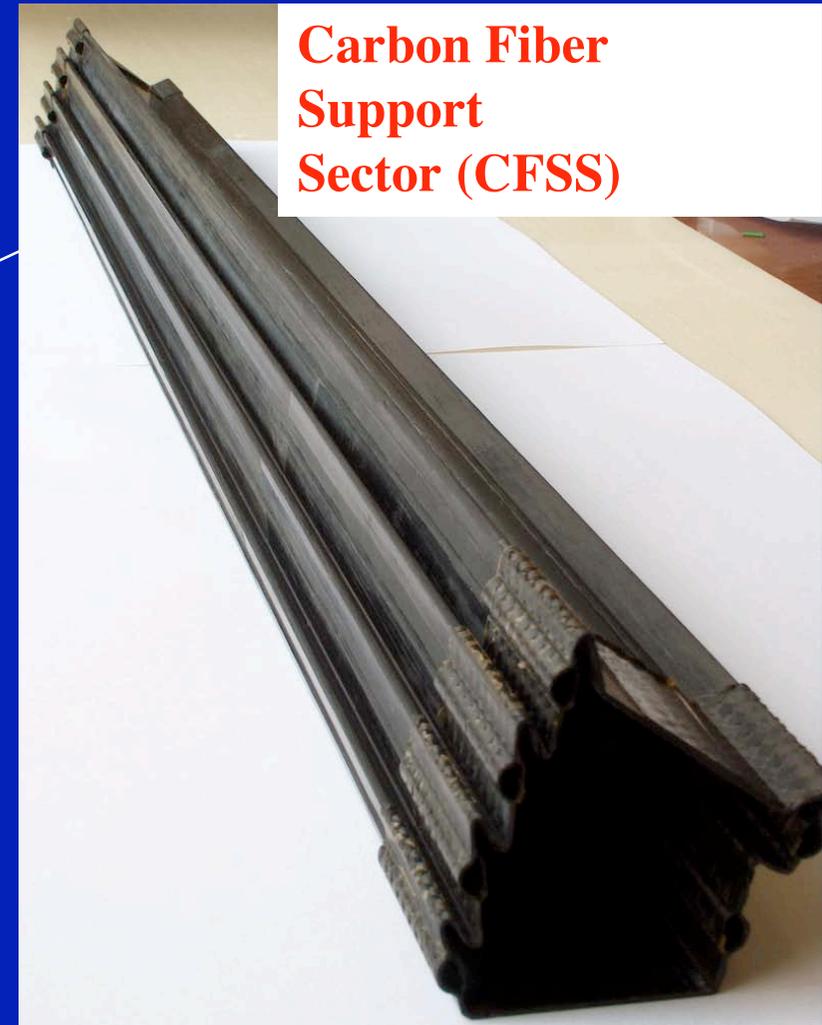
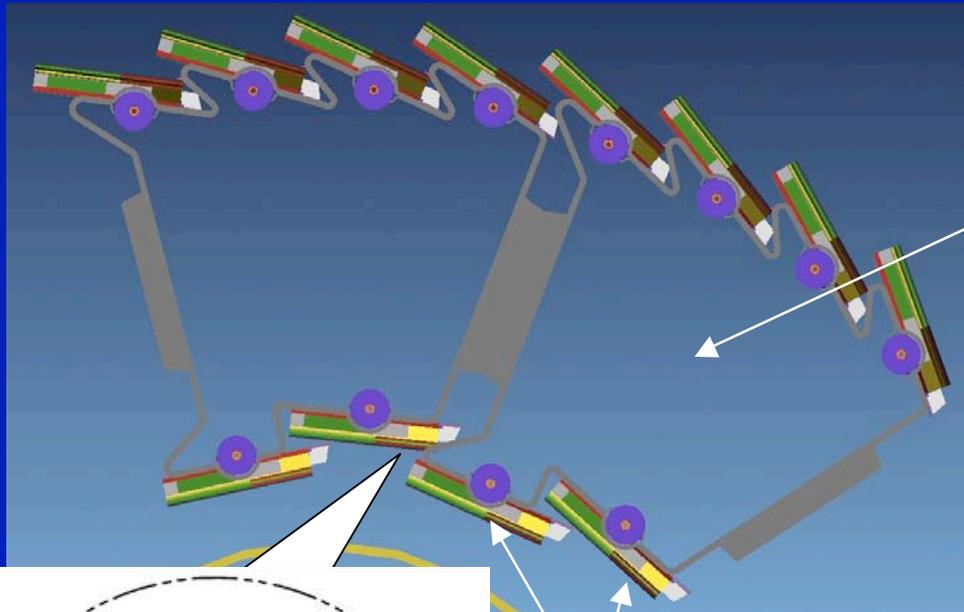
LV cables MCM & bus lines

Optical fibers: 18 fibers/sector

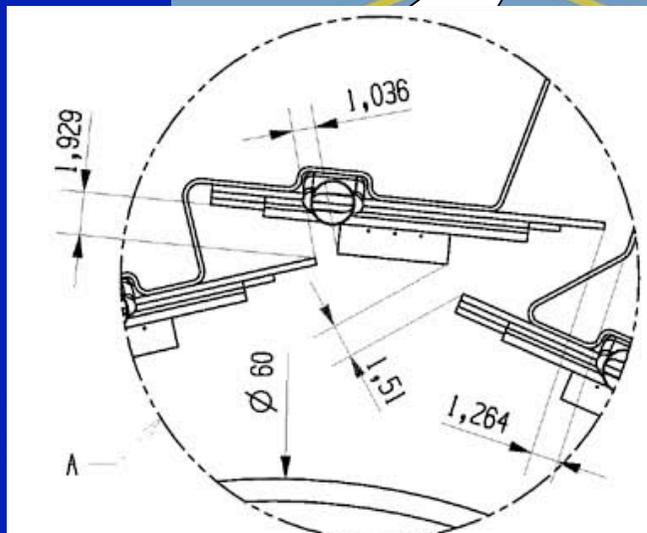
Service harness @ RB24

BOTTOM WORK

SPD Mounting



**Carbon Fiber
Support
Sector (CFSS)**

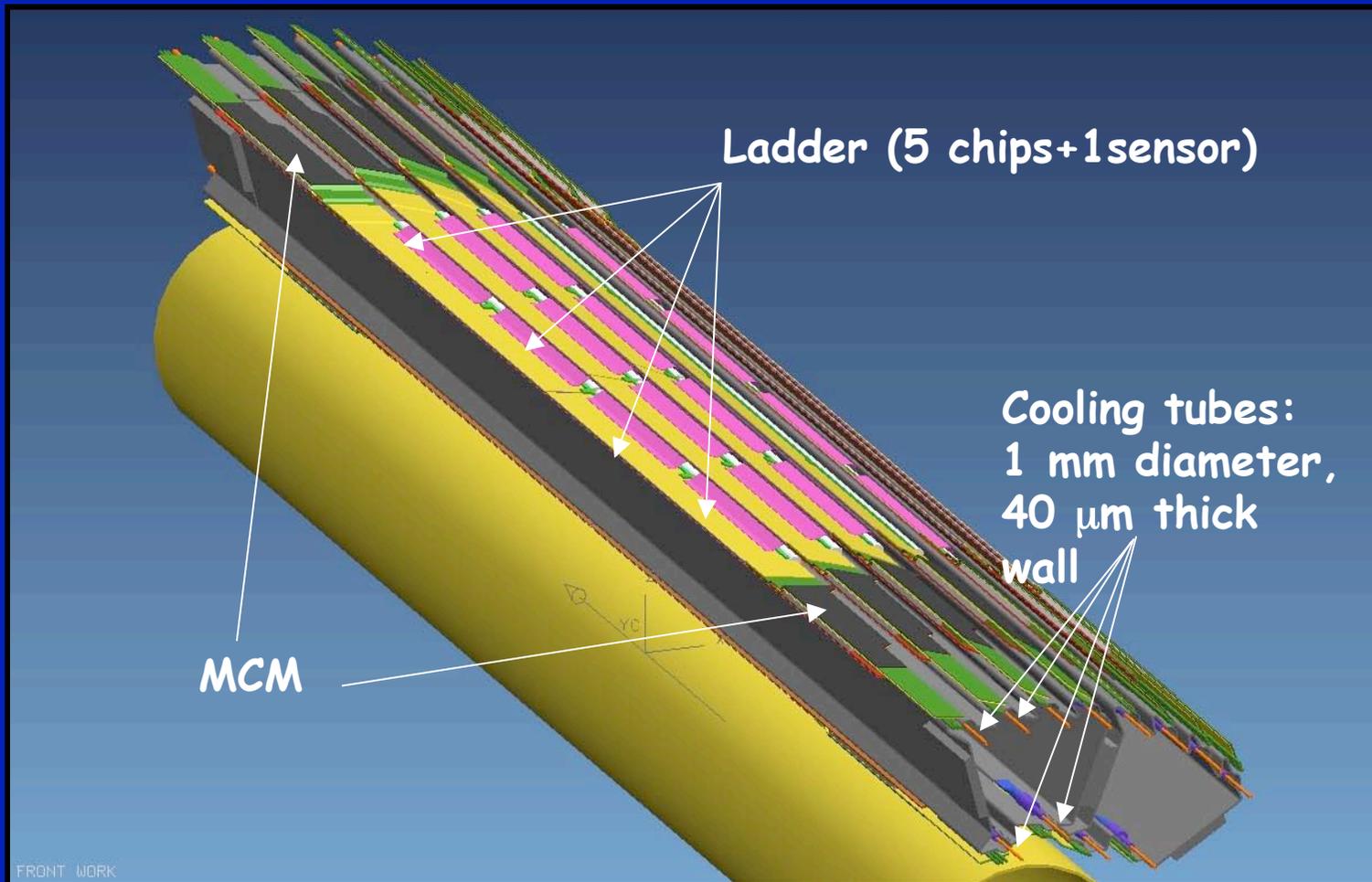
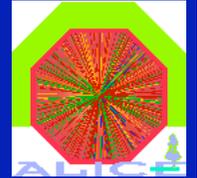


6 staves/sector

(2 from inner layer and
4 from outer layer)

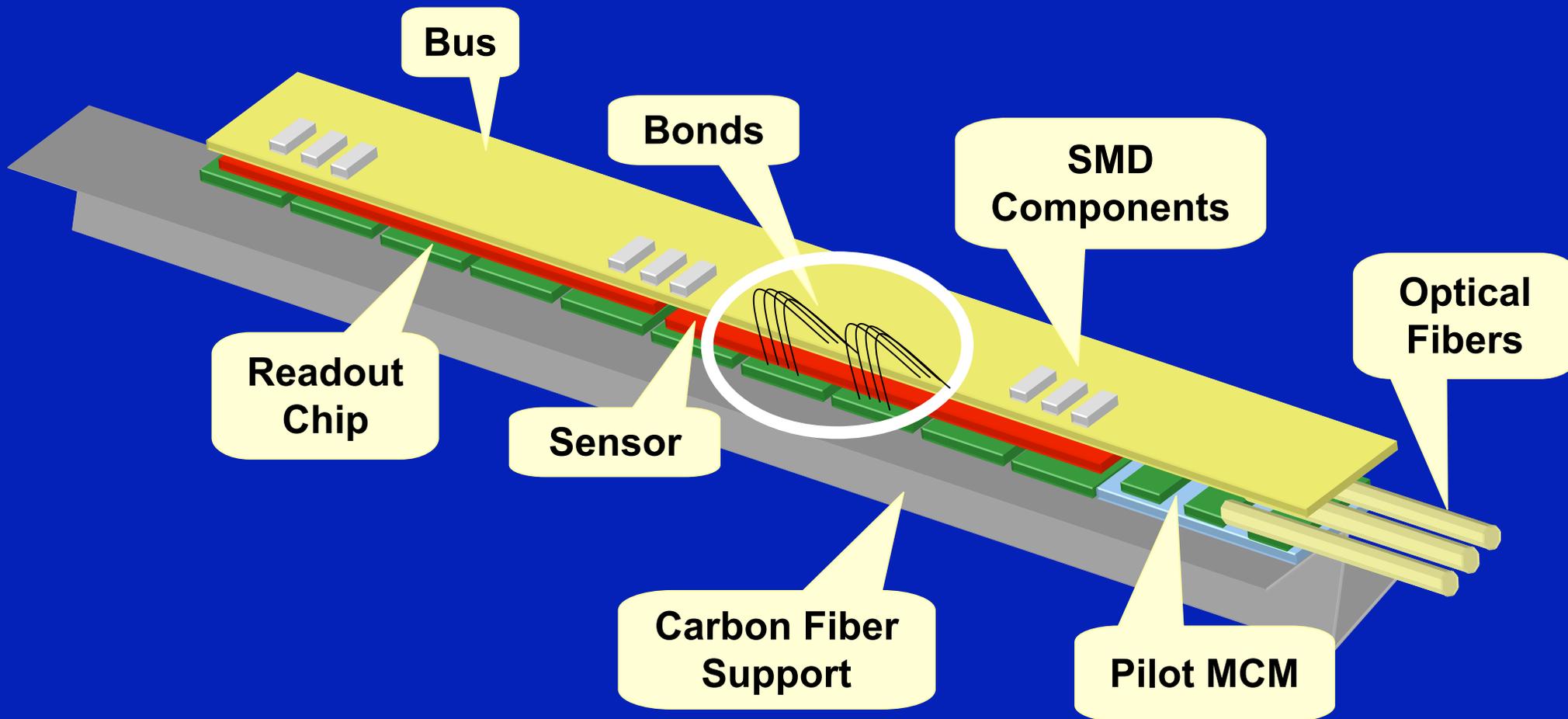
Material budget (each layer): $\approx 0.9\% X_0$
(Si ≈ 0.37 , cooling ≈ 0.3 , bus ≈ 0.17 , CFSS ≈ 0.1)

SPD Sector

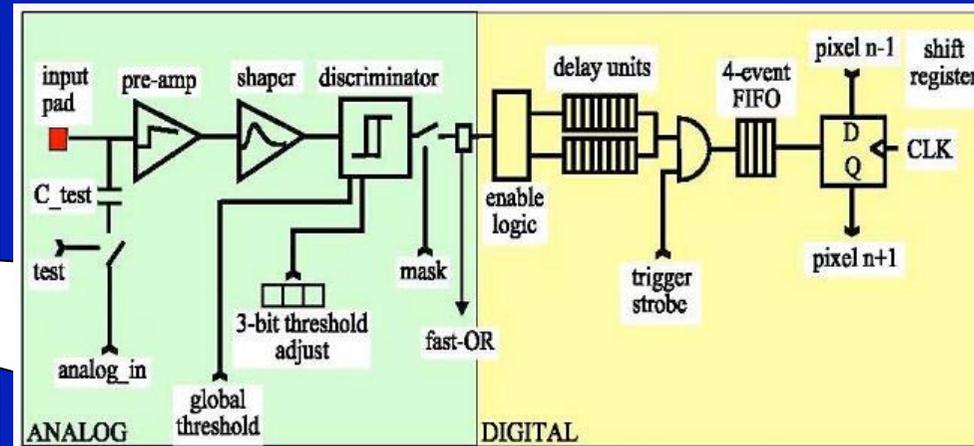
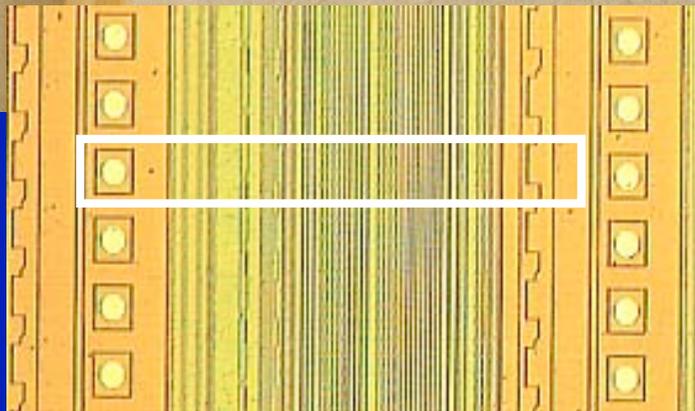
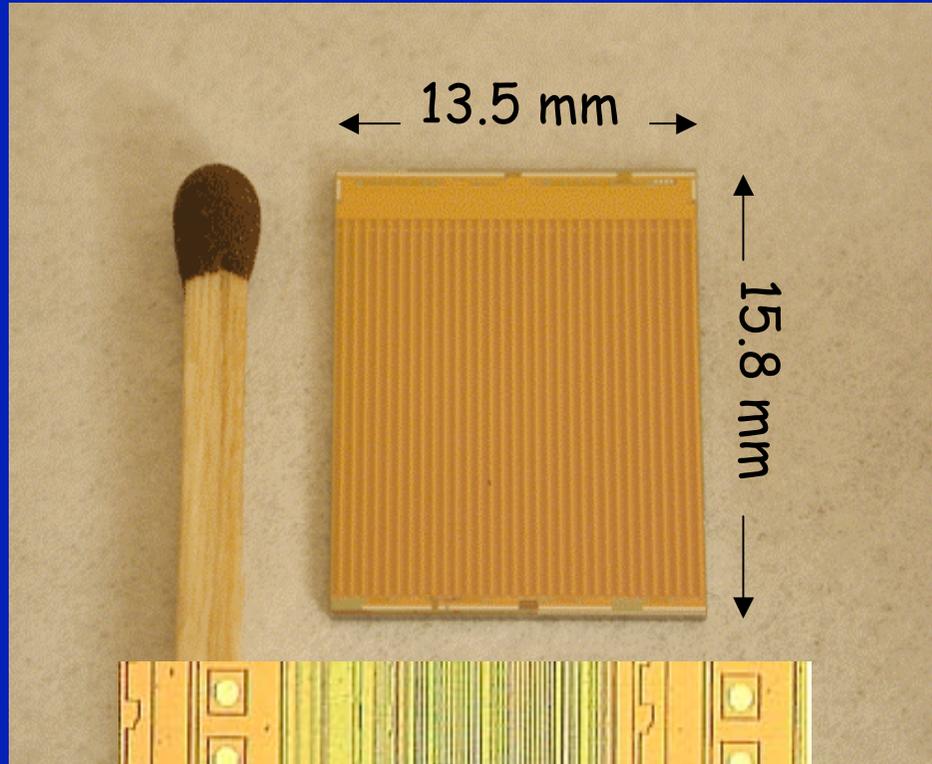
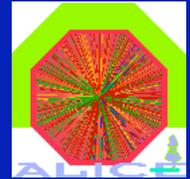


- FE power dissipation/sector: ≈ 150 W
- Cooling: C_4F_{10} (evaporative), operating temperature $\approx 25^\circ C$
- Cooling test with a prototype module is currently under way

SPD Half-Stage

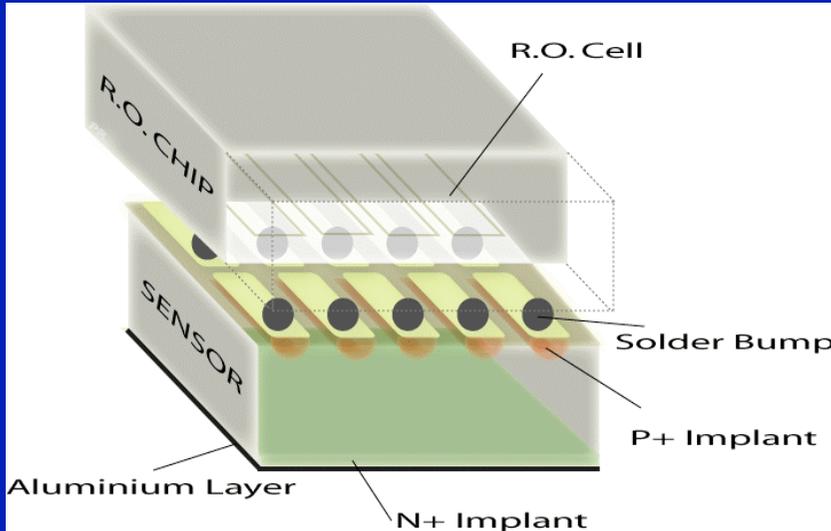
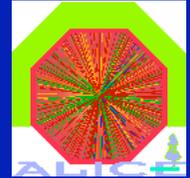


ALICE LHCb1 Pixel ASIC

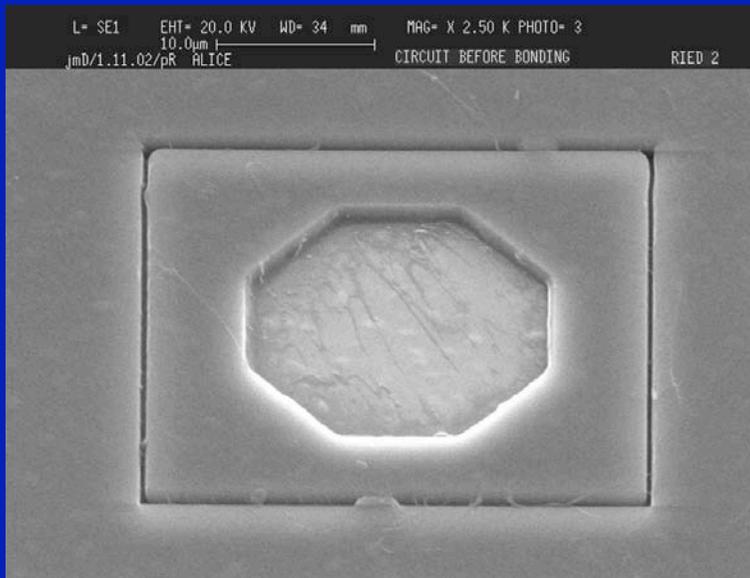


- Mixed signal (analogue, digital)
- Produced in a commercial $0.25\mu\text{m}$ CMOS process (8" wafers)
- Radiation tolerant design (enclosed gates, guard rings)
- 8192 pixel cells
- $50\mu\text{m}$ ($r\phi$) \times $425\mu\text{m}$ (z) pixel cell
- $\sim 100\mu\text{W}/\text{channel}$
- $\sim 1000 e^-$ mean threshold ($\sim 200 e^-$ RMS)
- $\sim 120 e^-$ mean noise

VTT Bump-Bonding

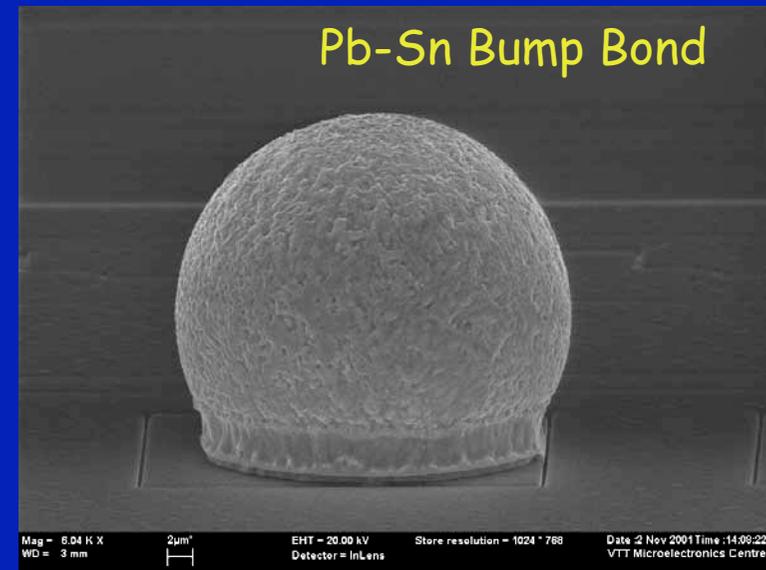


- VTT/Finland
- Pb-Sn solder bumps: $\sim 25\mu\text{m}$ diameter
- p-in-n silicon sensor: $200\mu\text{m}$ thick (Canberra)
- IBM readout chips: $750\mu\text{m}$ native thickness thinned to $150\mu\text{m}$ after bump deposition
- stand-off: $\sim 20\mu\text{m}$ (Pb-Sn)



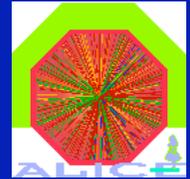
13 January 2004

SEM Pictures



V. Manzari - Quark Matter 2004 - Oakland

SPD Ladder



- 1 p-in-n sensor (200 μ m thick)
- 5 readout chips (150 μ m thick)
- 4960 bump bonds
- $I_{det} @50V=120-200nA$, $V_{fd}=15V$



Sr-Measurements :

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

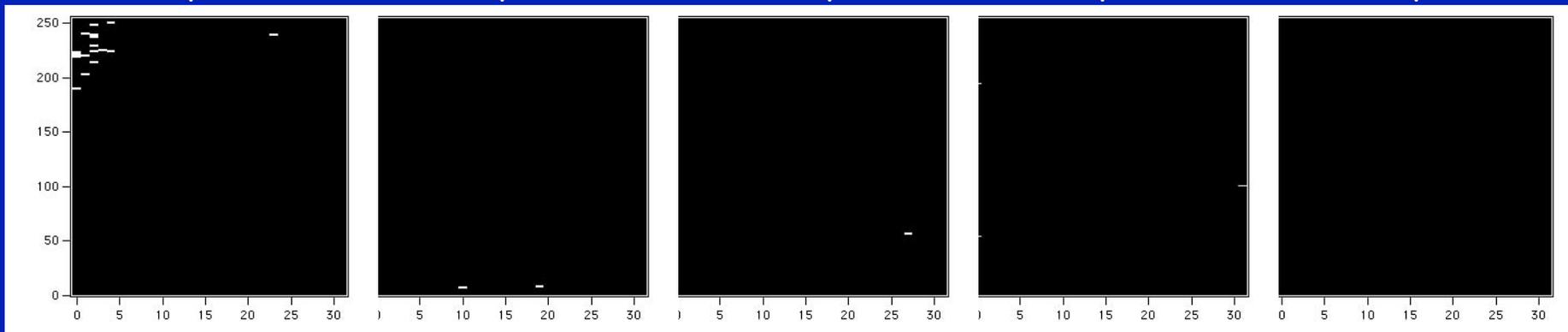
Chip 43

Chip 46

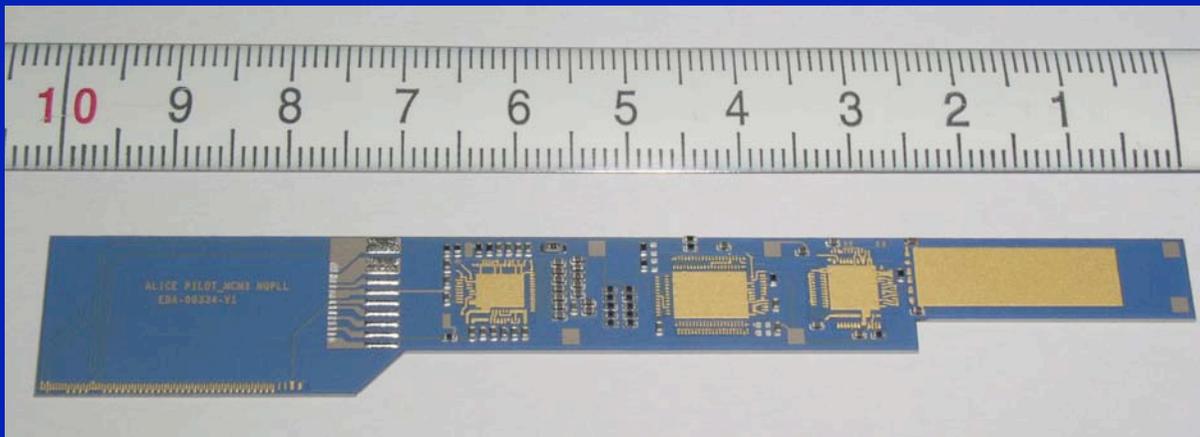
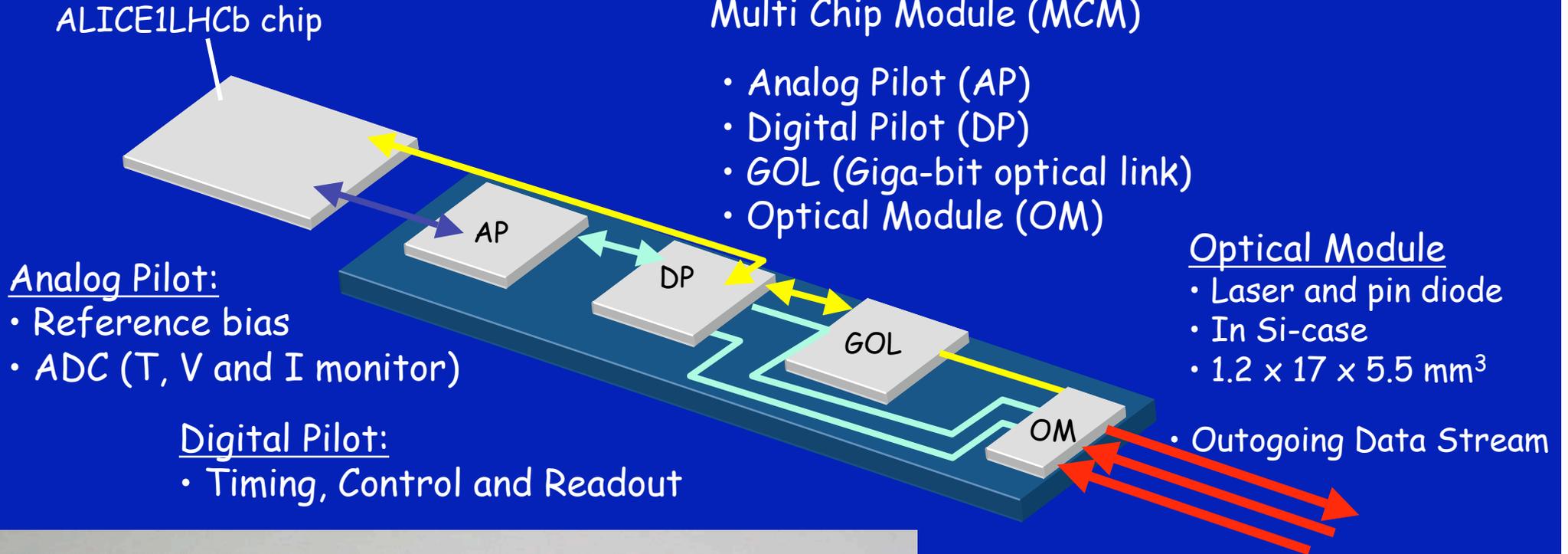
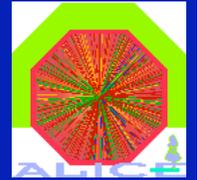
Chip 42

Chip 32

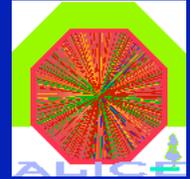
Chip 30



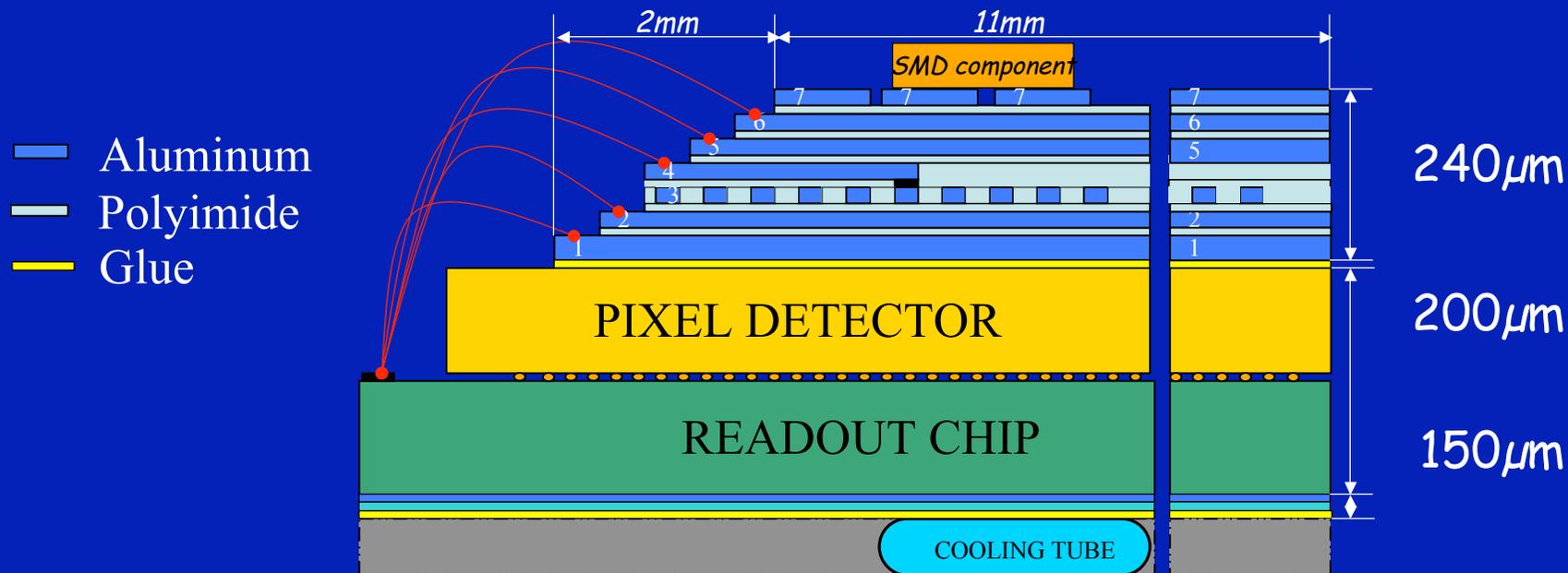
Multi Chip Module (MCM)



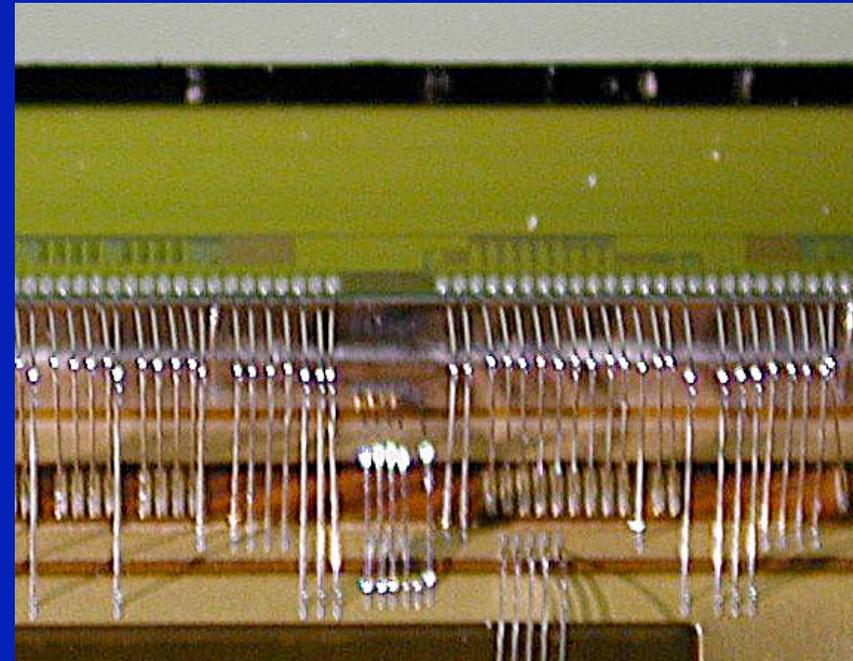
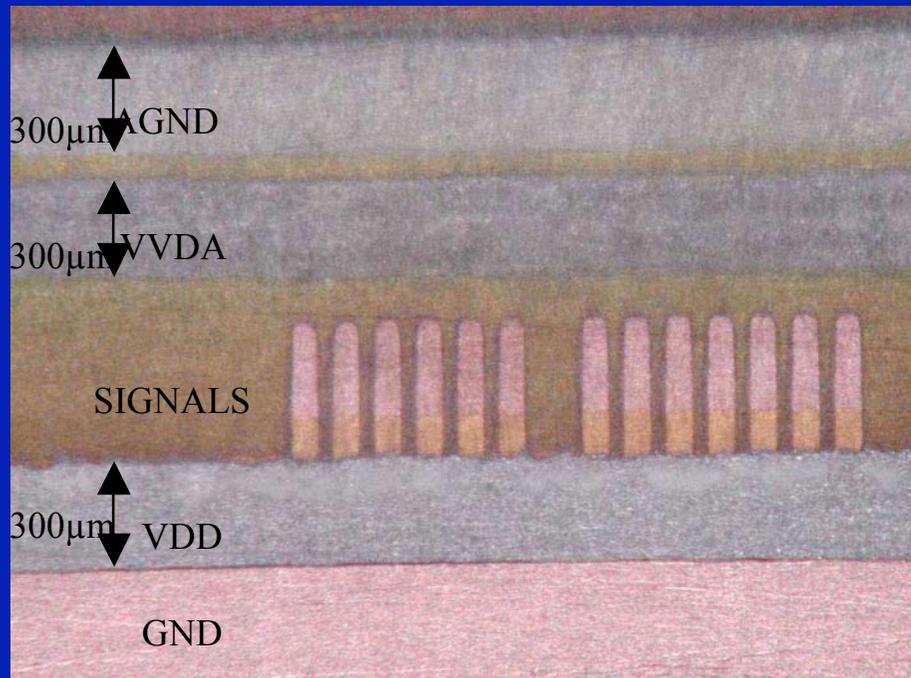
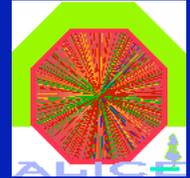
SPD Multilayer Bus



- 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

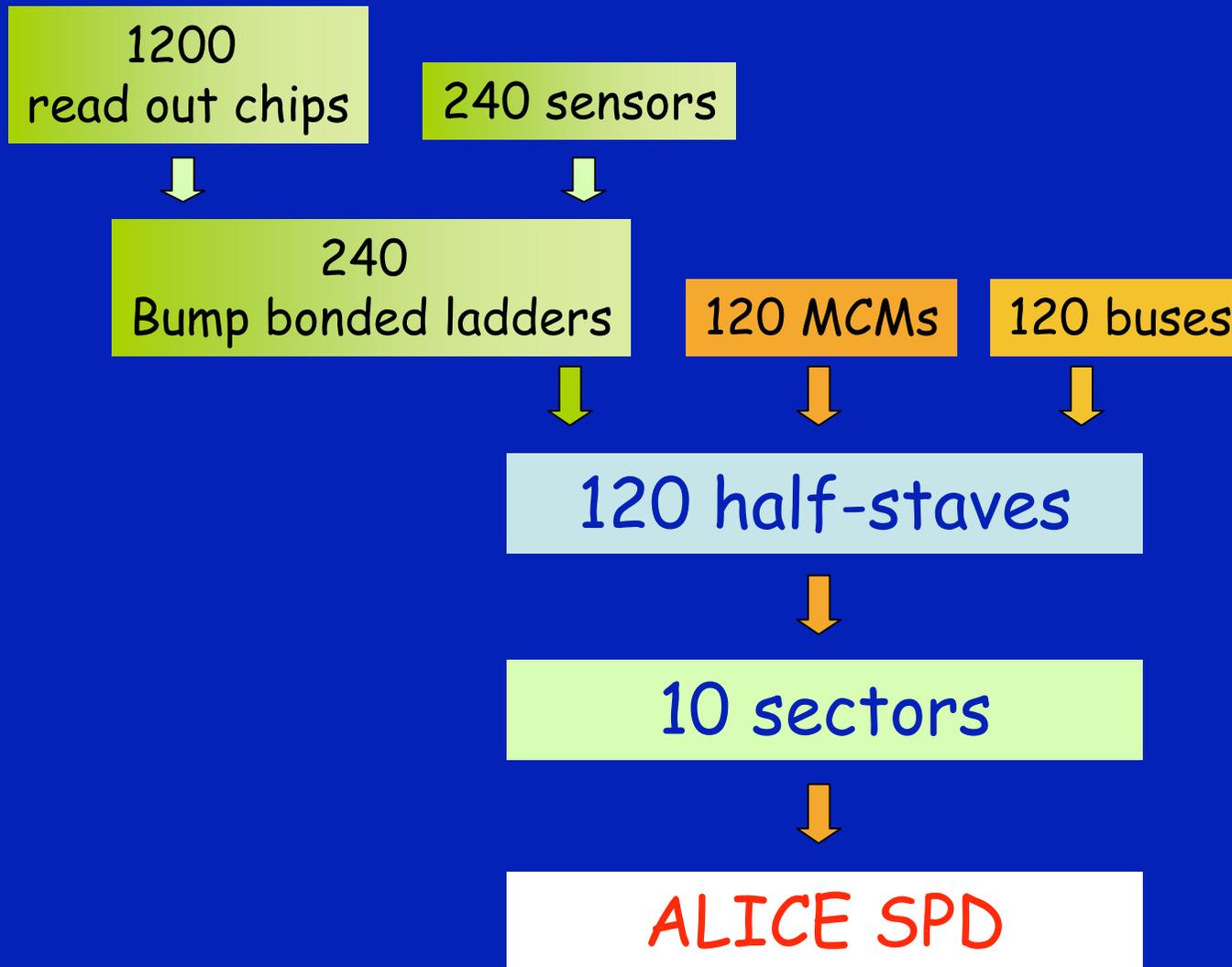
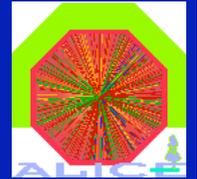


Wire Bonding on Bus and Ladder



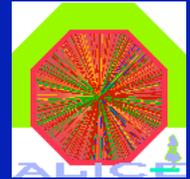
- ~1100 Wire bonds/half-stave
- 25 μm diameter wire
- Bonding pads on the bus: $80 \times 300 \mu\text{m}^2$
- Step height: 40-60 μm

SPD Components

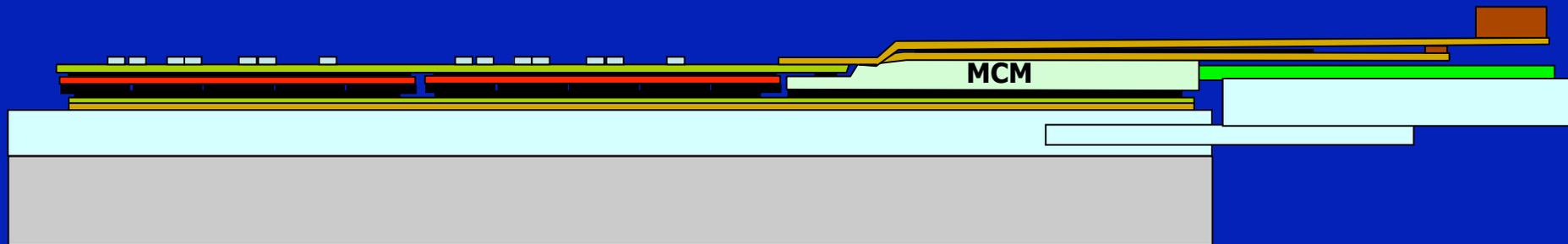


2 spare sectors + 1 pre-production sector

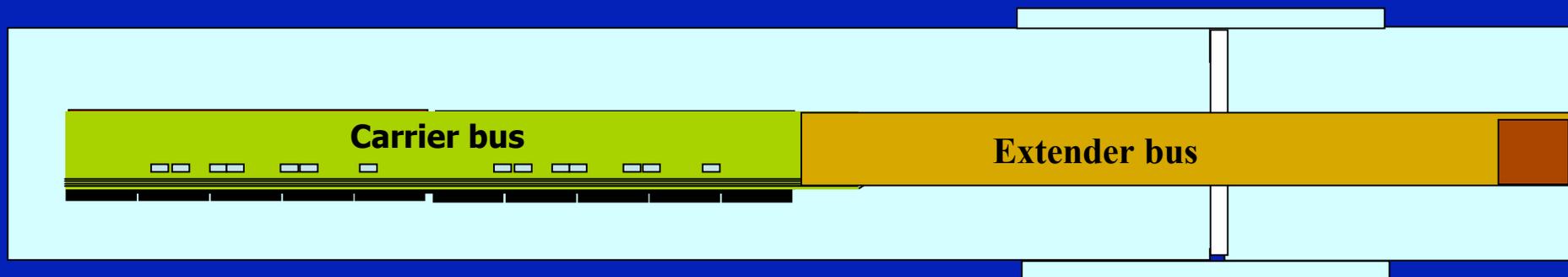
Half-stave Assembly (I)



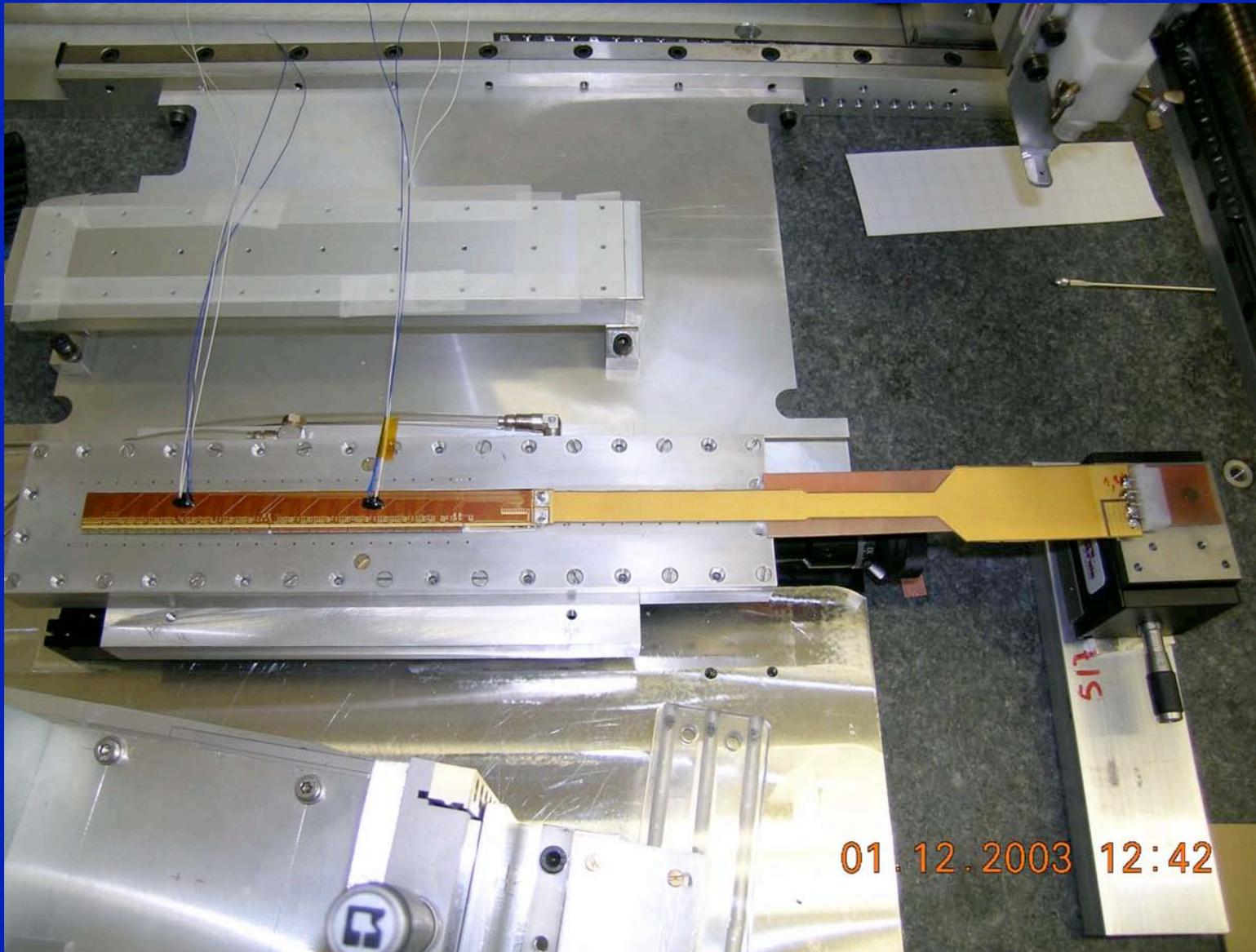
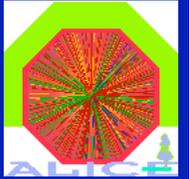
Side view



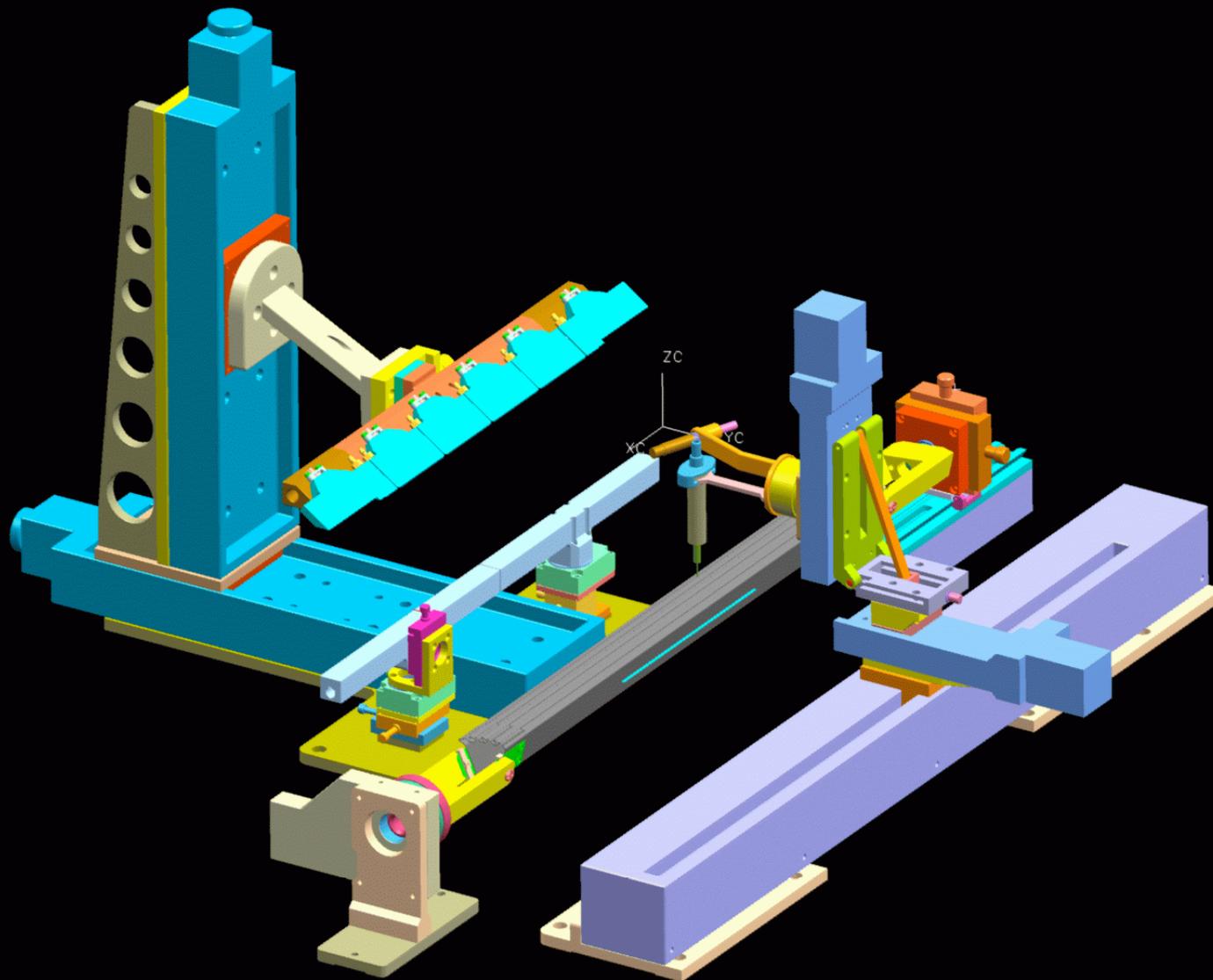
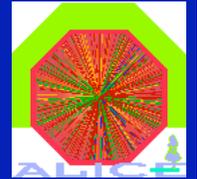
Top view



Half-stave Assembly (II)

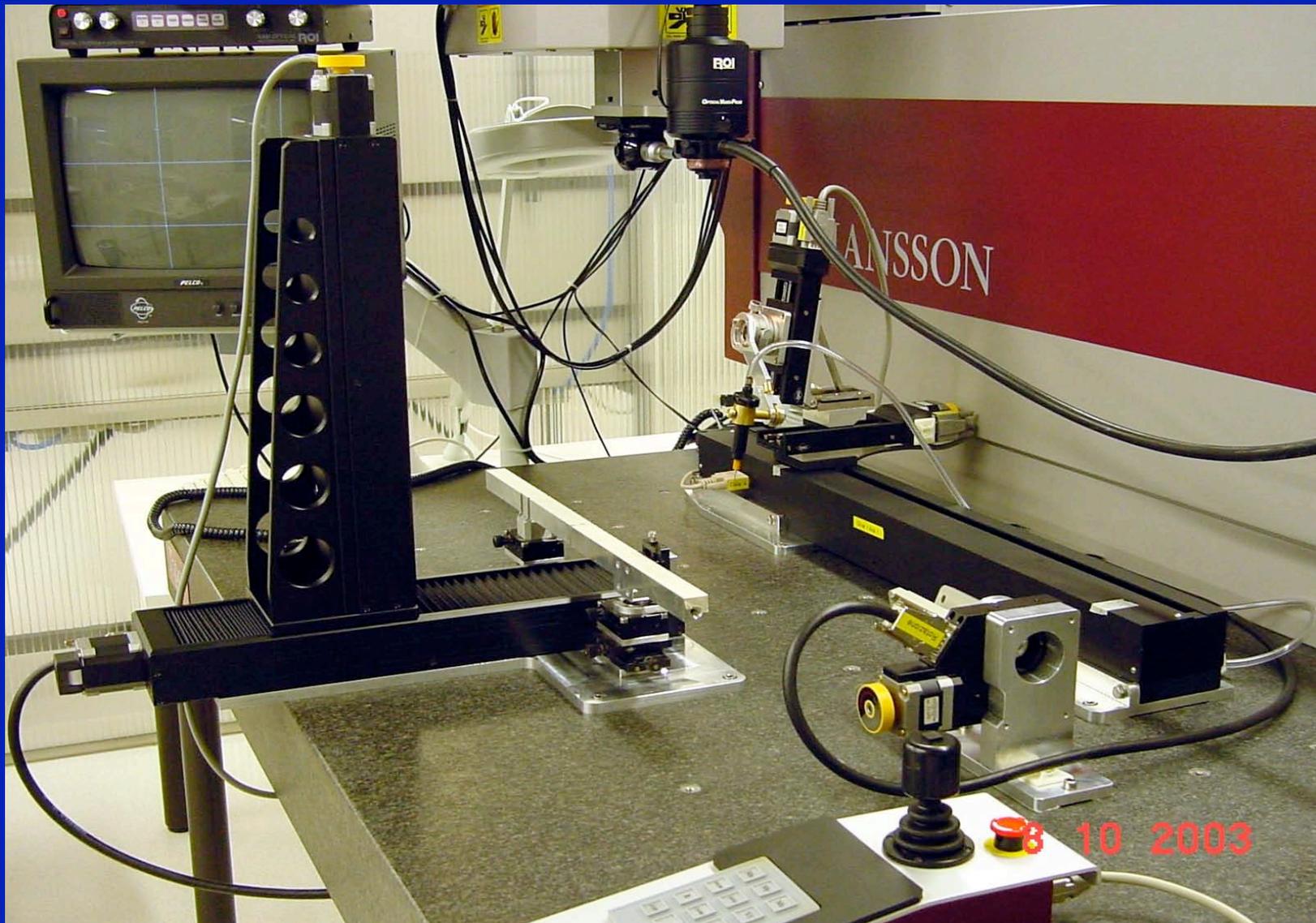
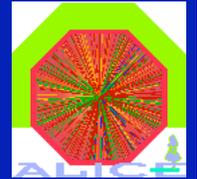


Barrel Sector Assembly System (I)

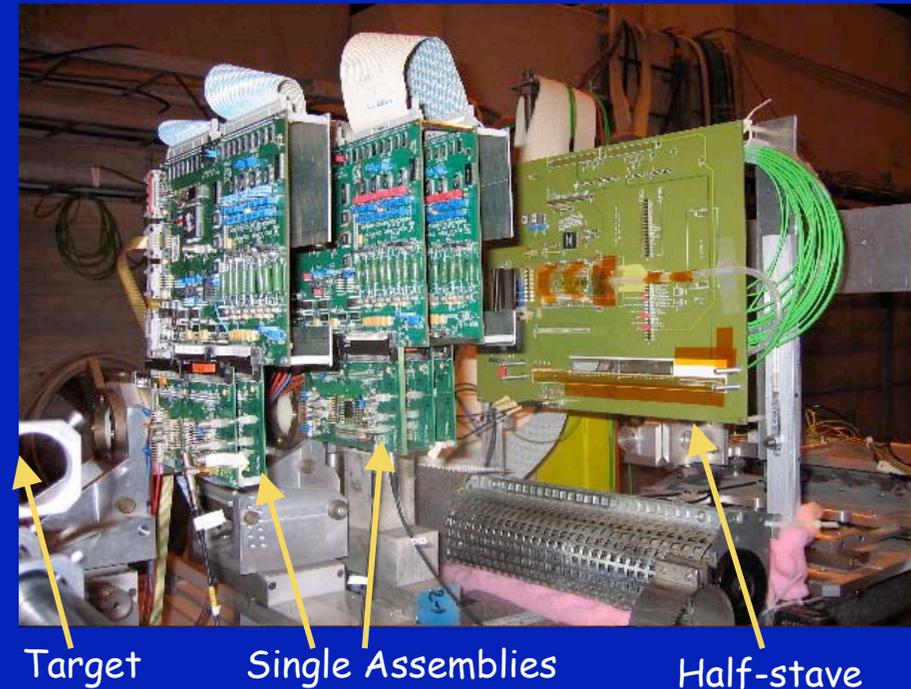
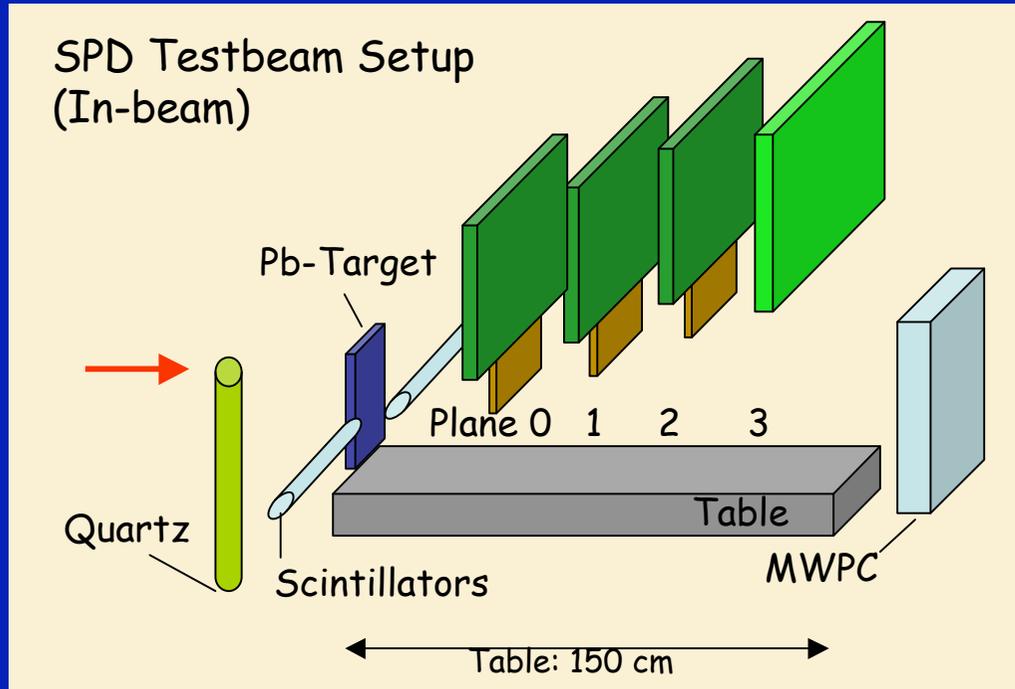
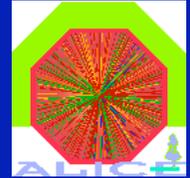


TOP WORK

Barrel Sector Assembly System (II)

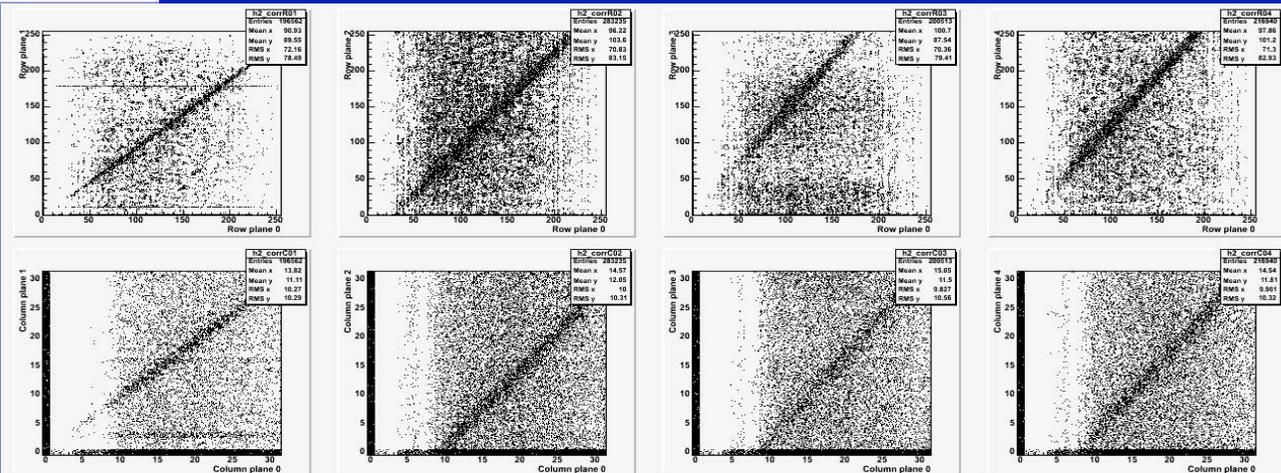
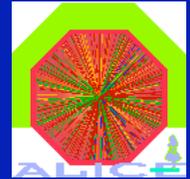


2003 Beam Test Setup

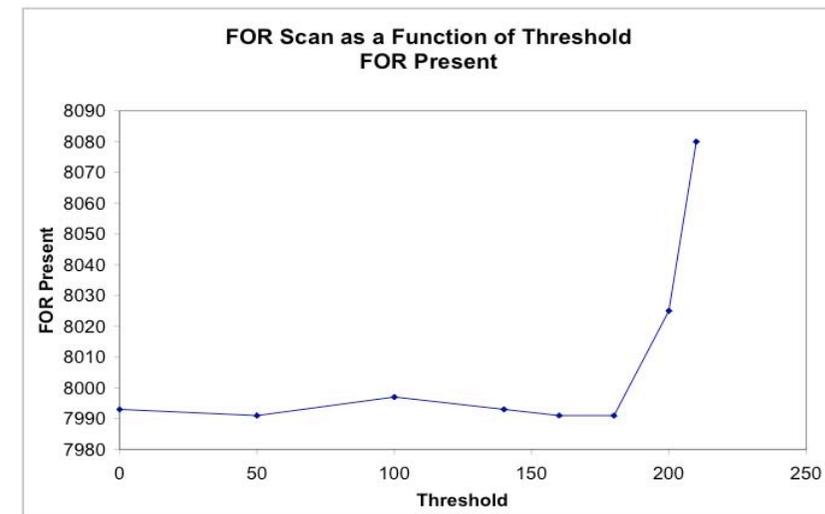
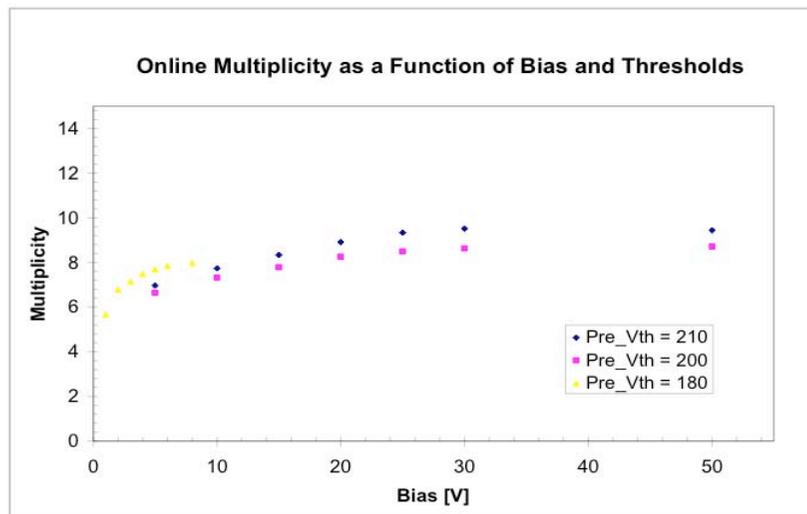


- Up to 6 planes (= 5 singles + half stave) in the beam (up to 122 880 active pixels)
- Plane 0 - Plane 3 distance \approx 80 cm, vertically adjusted for tracking
- Target: 4 mm Pb
- Trigger: quartz counter (beam) + 2 cm x 2 cm scintillator (interactions)
- Half-stave read out through MCM including optical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

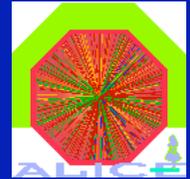
First Results (very preliminary)



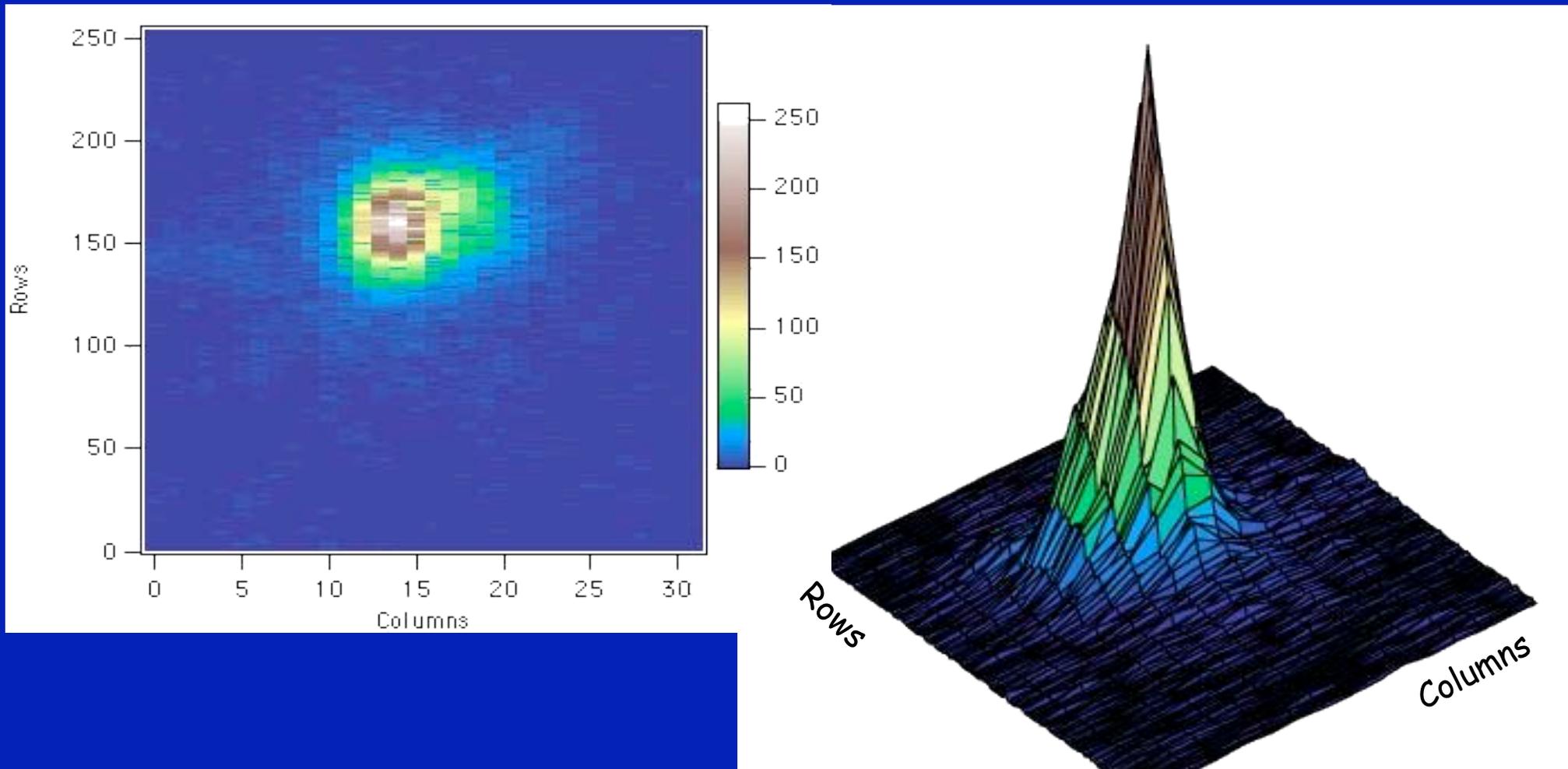
Hit correlations
between the planes
(stripped In ion beam)



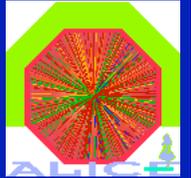
Indium Ion Beam on Single Assembly



Beamsport (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.