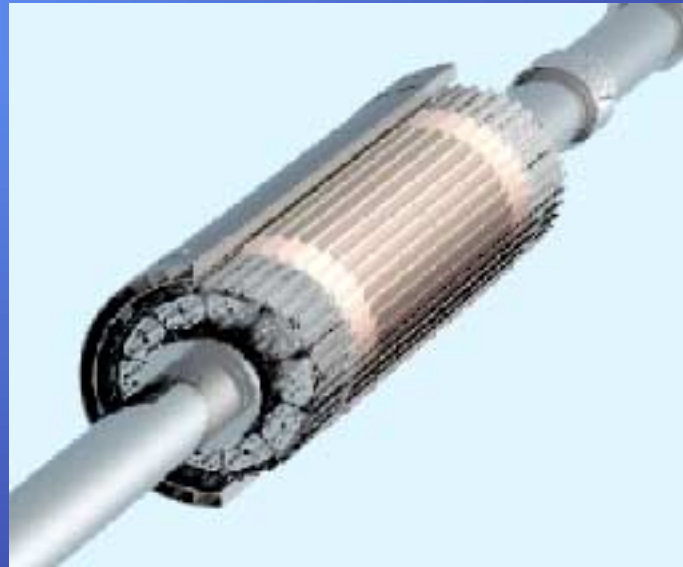




# The Alice Silicon Pixel Detector (SPD)

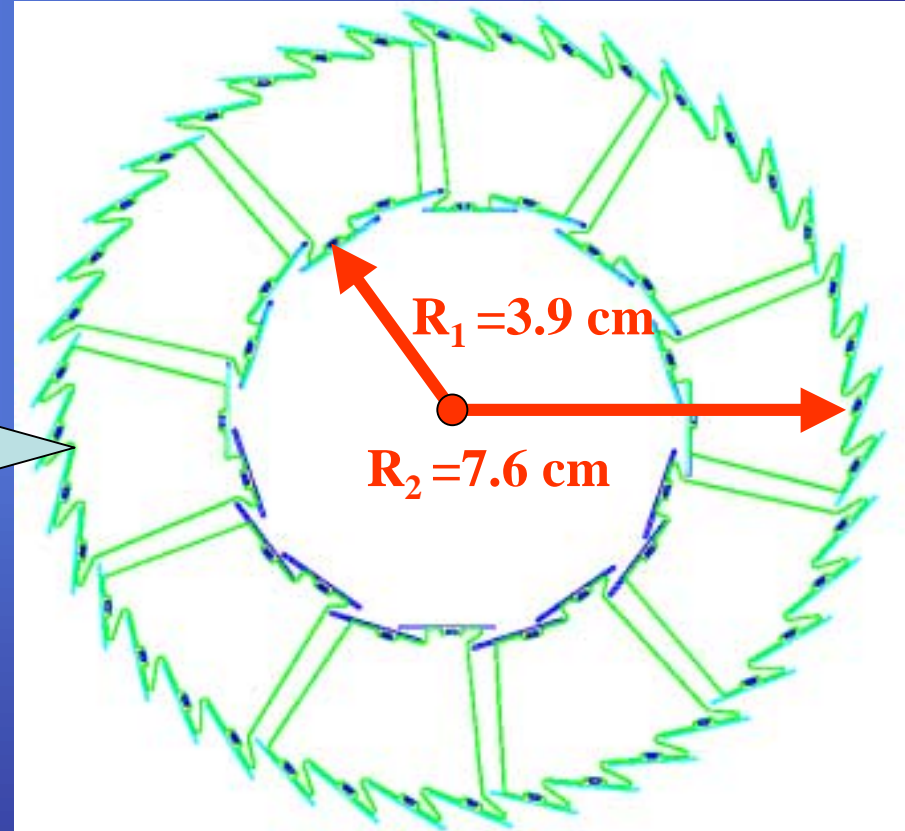
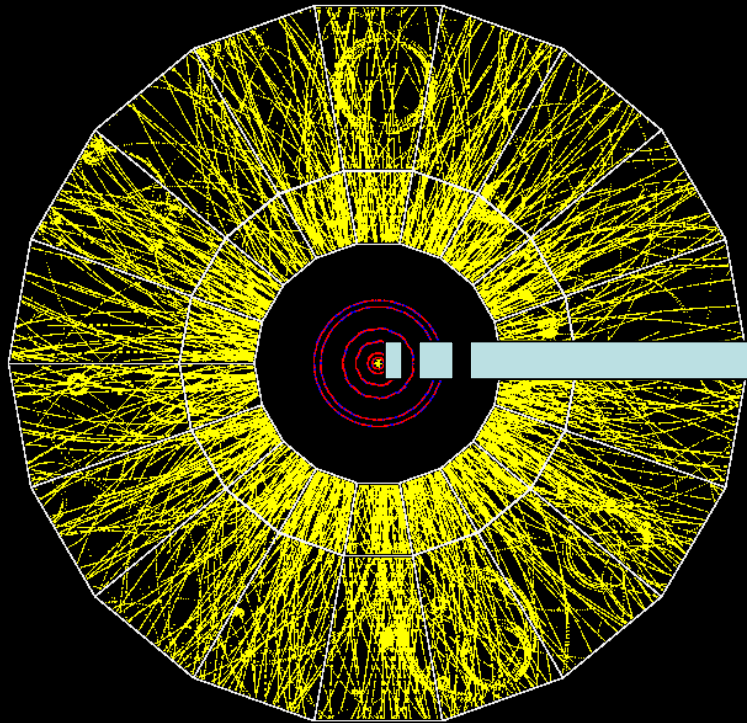


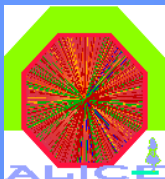
**Peter Chochula**  
for the  
**Alice Pixel Collaboration**



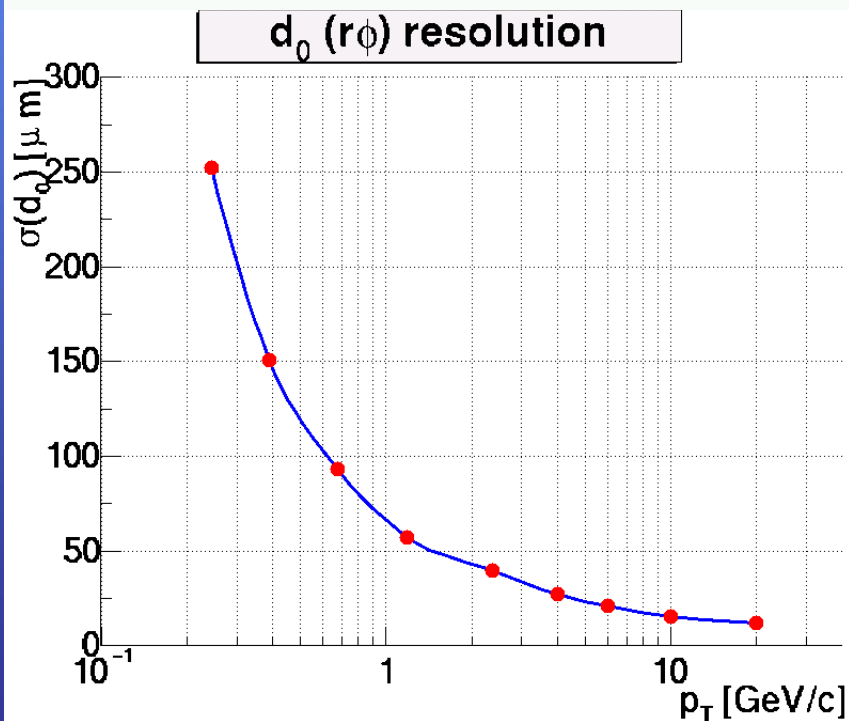
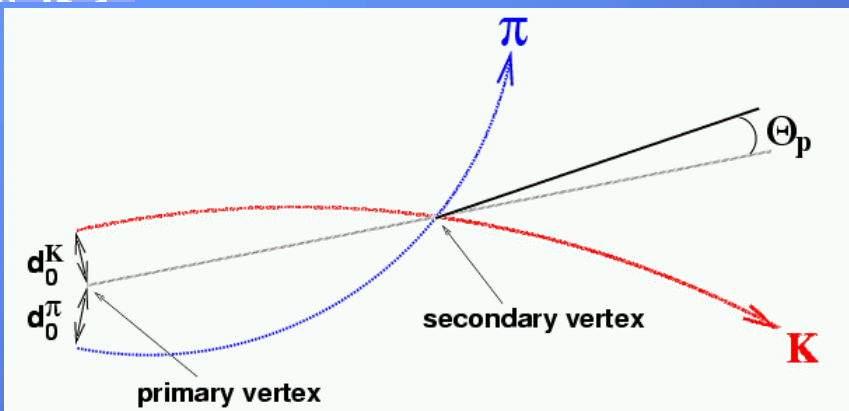
# The Alice Pixel Detector

Alice event: 0, Run:0  
Nparticles = 3075 Nhits = 121491

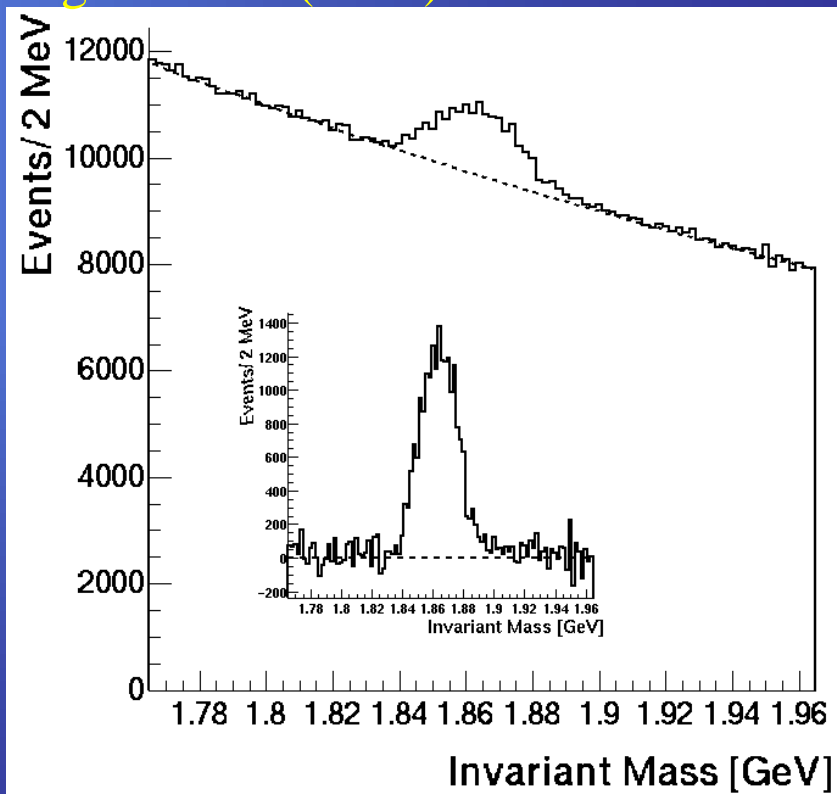




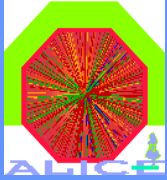
# Main Physics Goal – Heavy Flavour Physics



$D^0 \rightarrow K^-\pi^+$  15 days Pb-Pb data taking  
Significance  $(S/\sqrt{B}) = 35$

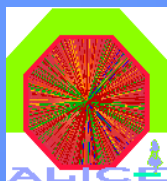


See poster PE 155 by Andrea Dianese

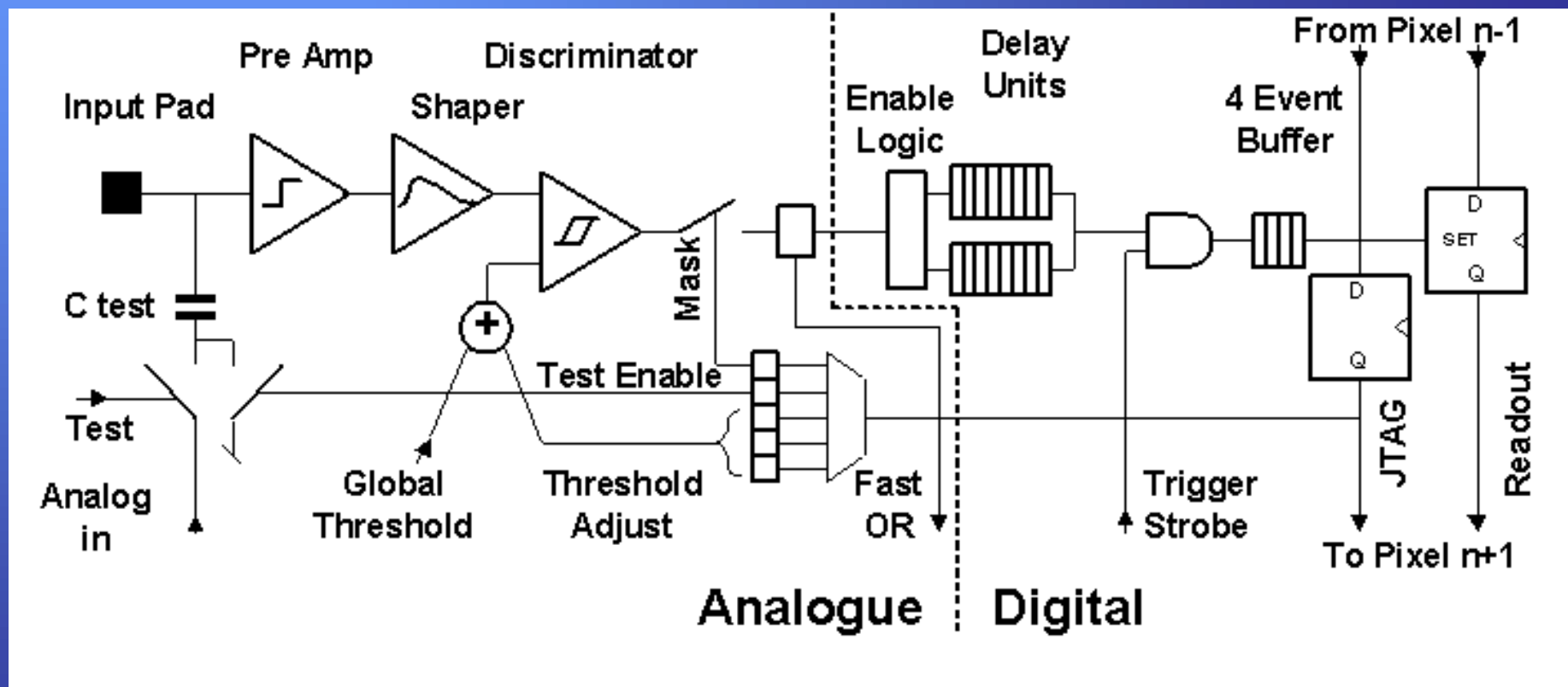


# Main Features of the Readout Chip

- **0.25 $\mu$ m CMOS technology**
- **Radiation-tolerant layout**
- **Mixed analog and digital chip**
- **Low noise : 110 electrons rms**
- **Low threshold: 1000 electrons rms**
- **Power consumption: ~900mW/chip**

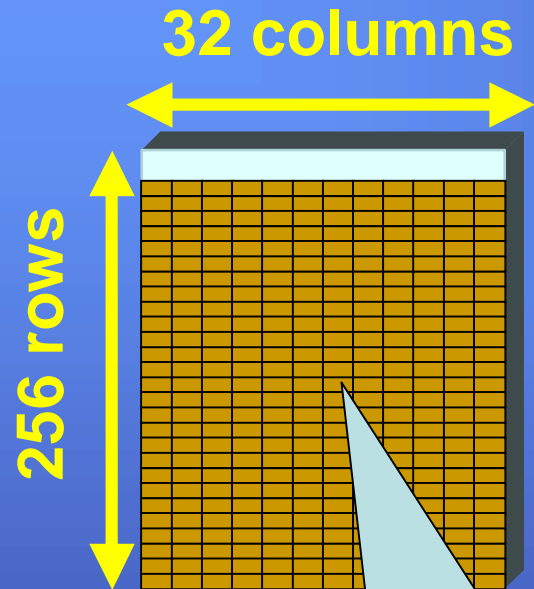


# The Alice1 Pixel Cell



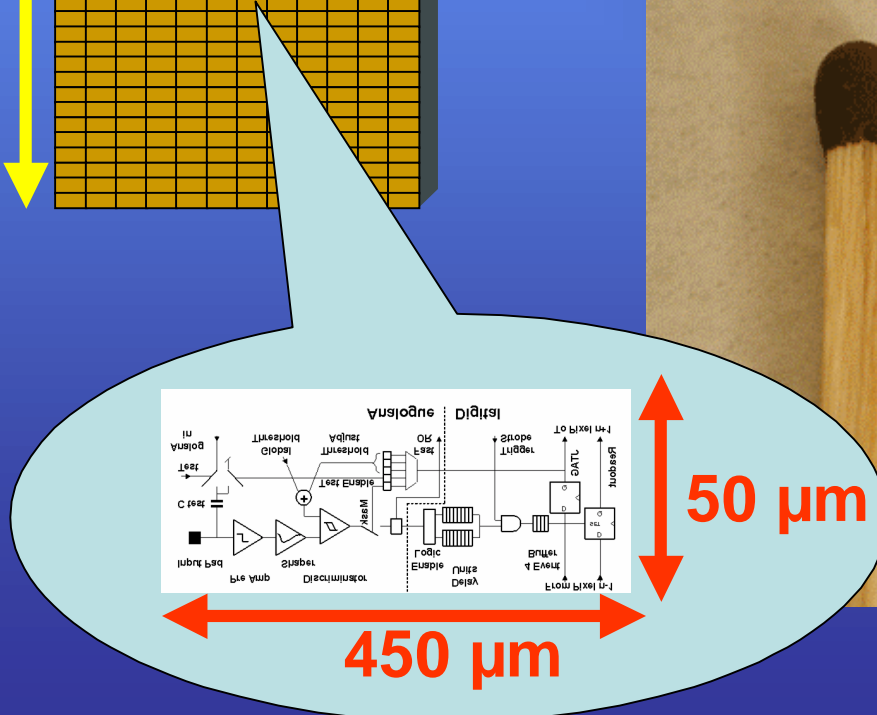
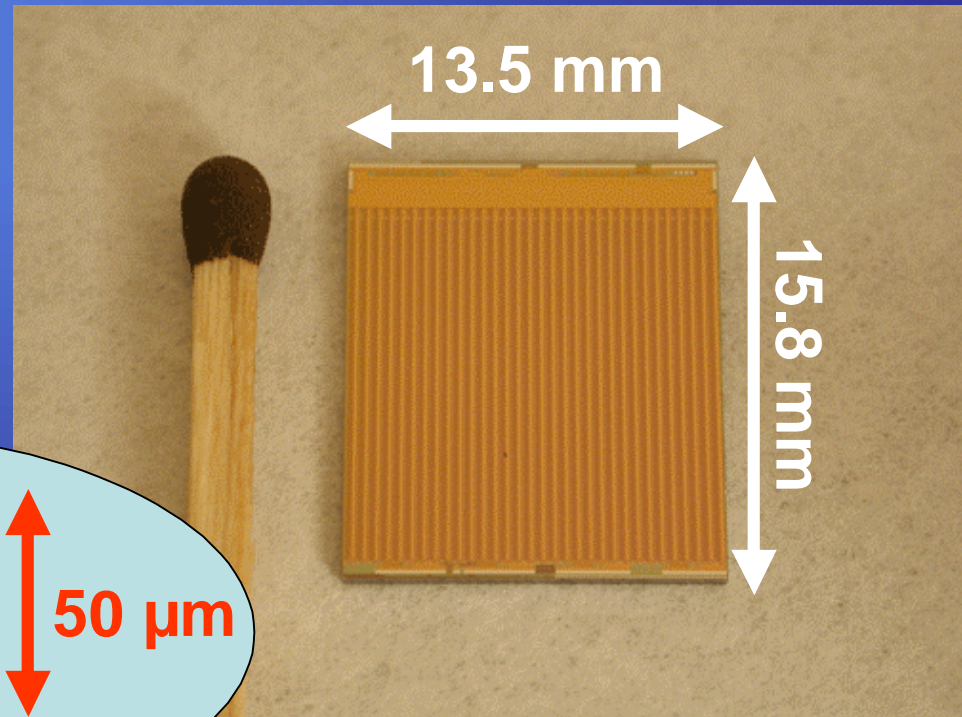


# The Alice1 Chip Layout



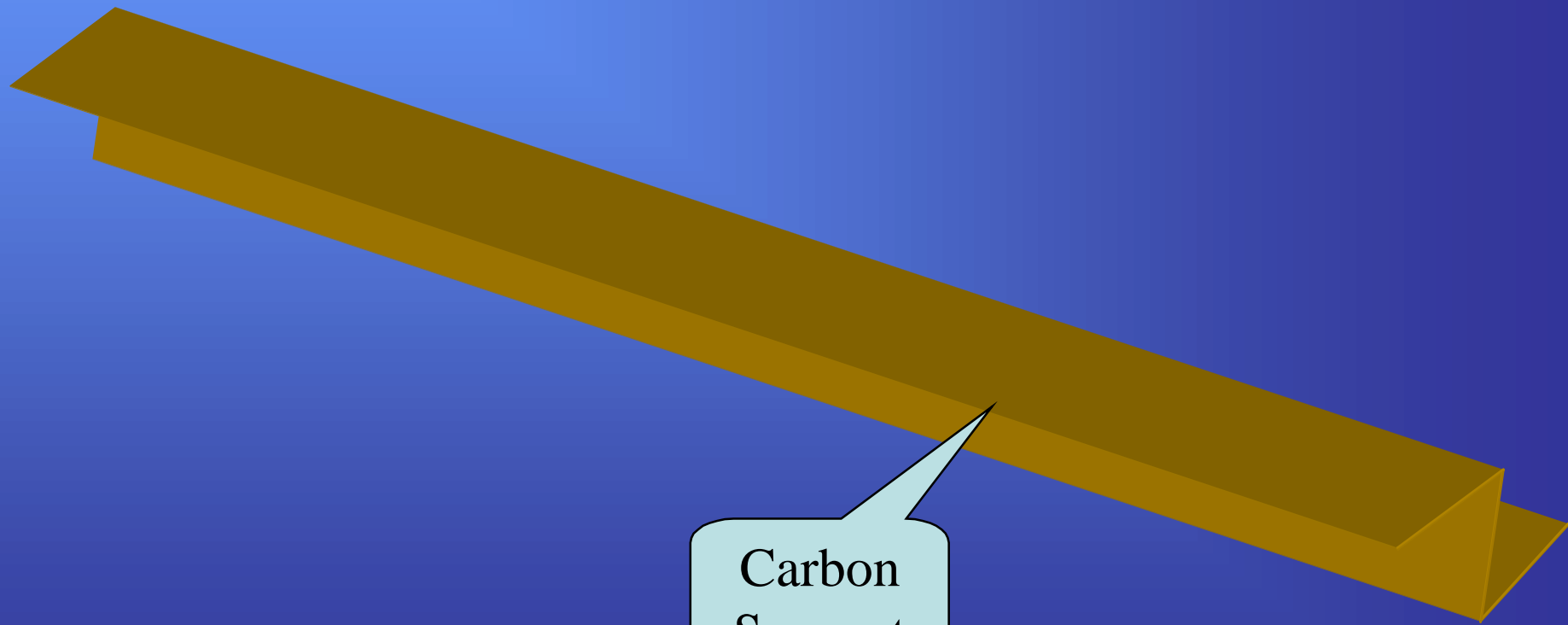
8 192 pixels/chip

~13 000 000 transistors/chip

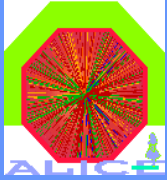




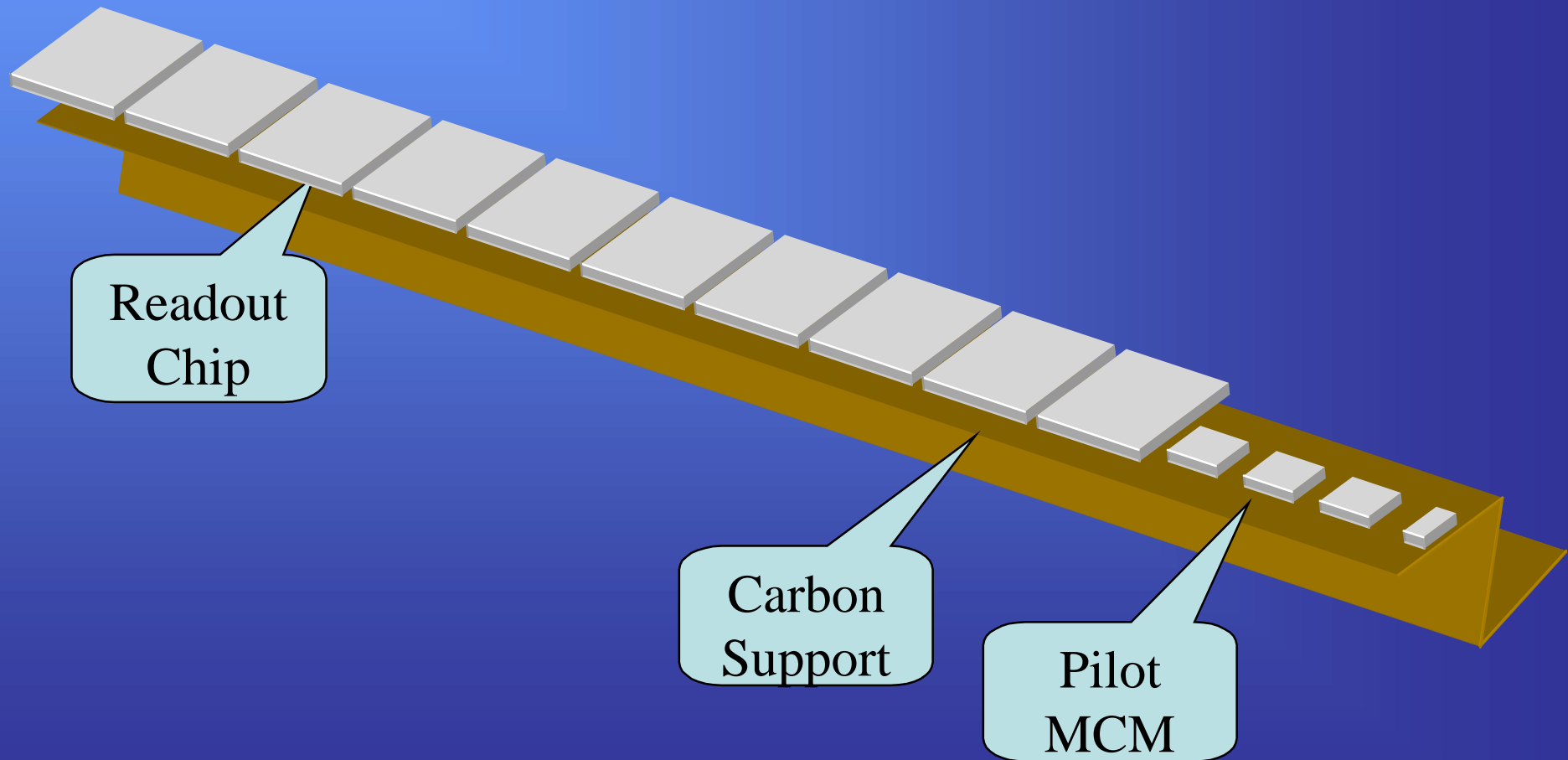
# SPD Components



Carbon  
Support



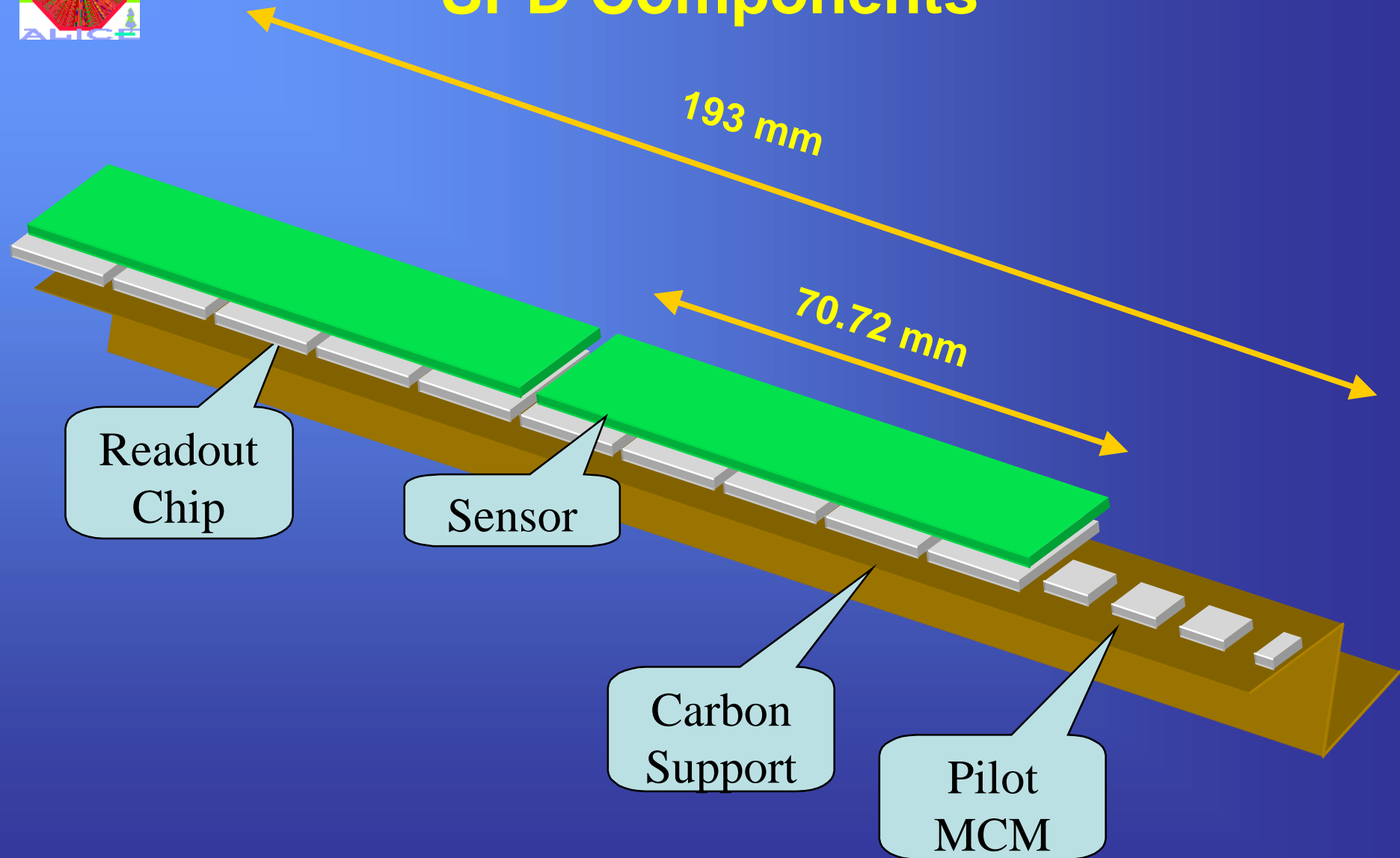
# SPD Components







# SPD Components





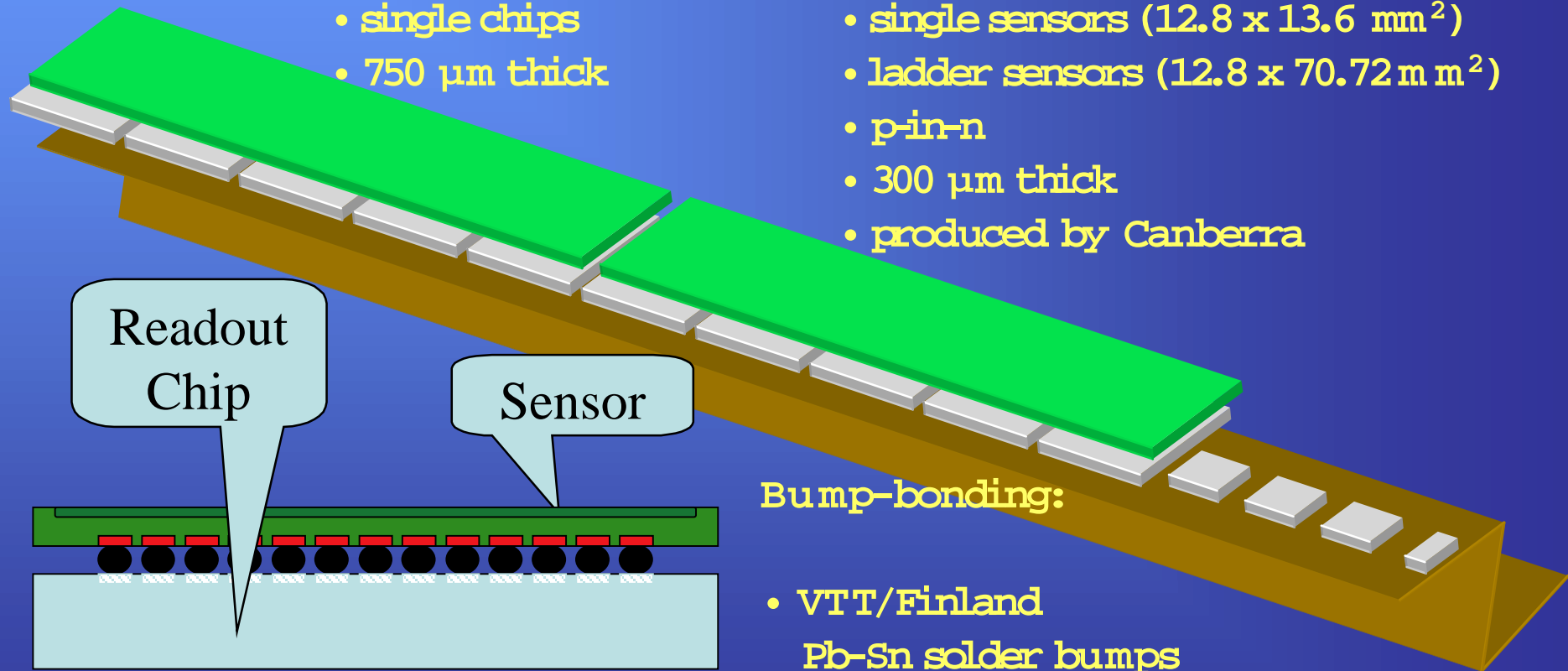
# SPD Components

## Chips:

- single chips
- 750  $\mu\text{m}$  thick

## Sensors:

- single sensors (12.8 x 13.6  $\text{mm}^2$ )
- ladder sensors (12.8 x 70.72  $\text{mm}^2$ )
- p-in-n
- 300  $\mu\text{m}$  thick
- produced by Canberra

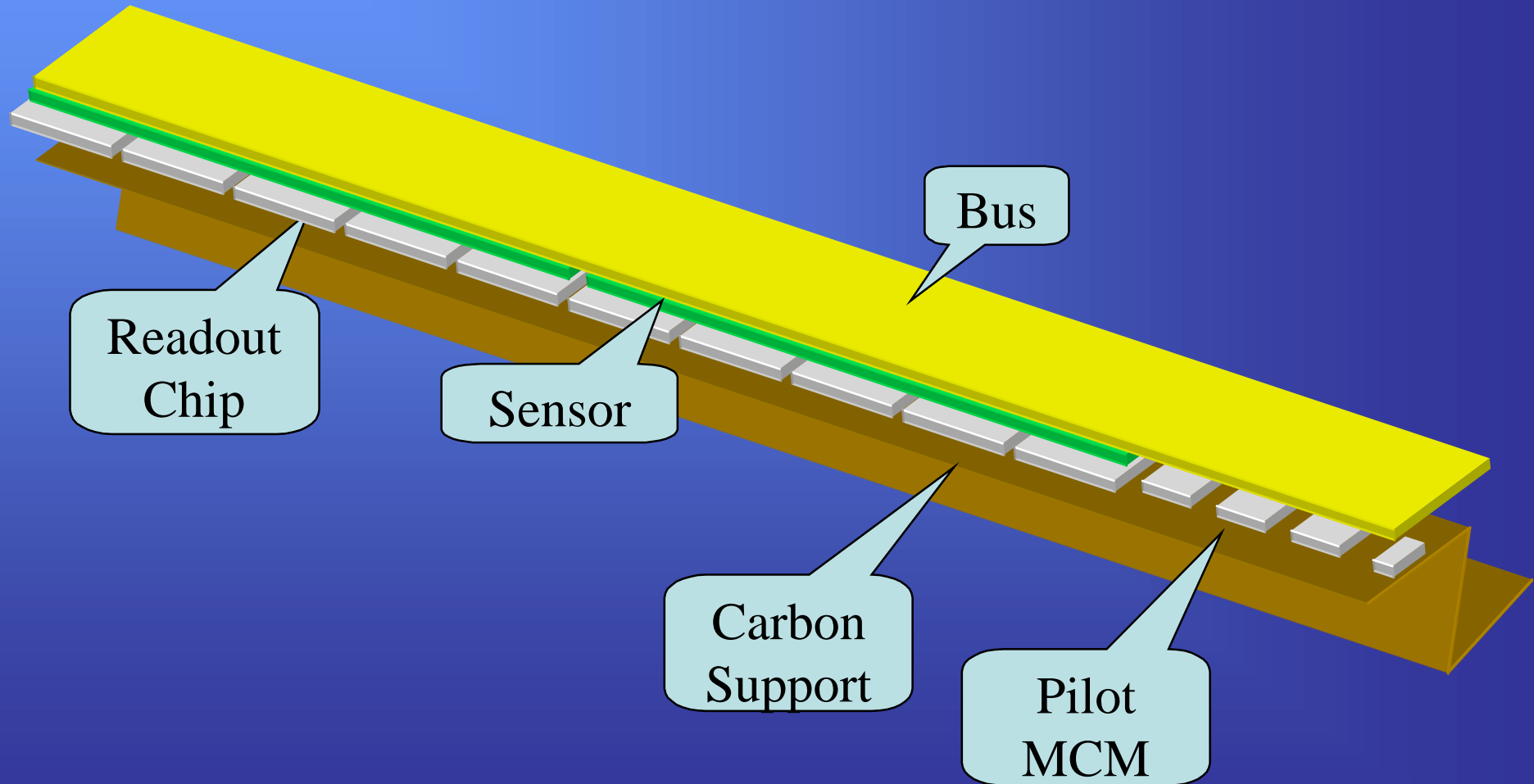


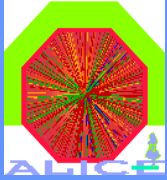
## Bump-bonding:

- VTT/Finland  
Pb-Sn solder bumps
- AMS/Italy  
In bumps

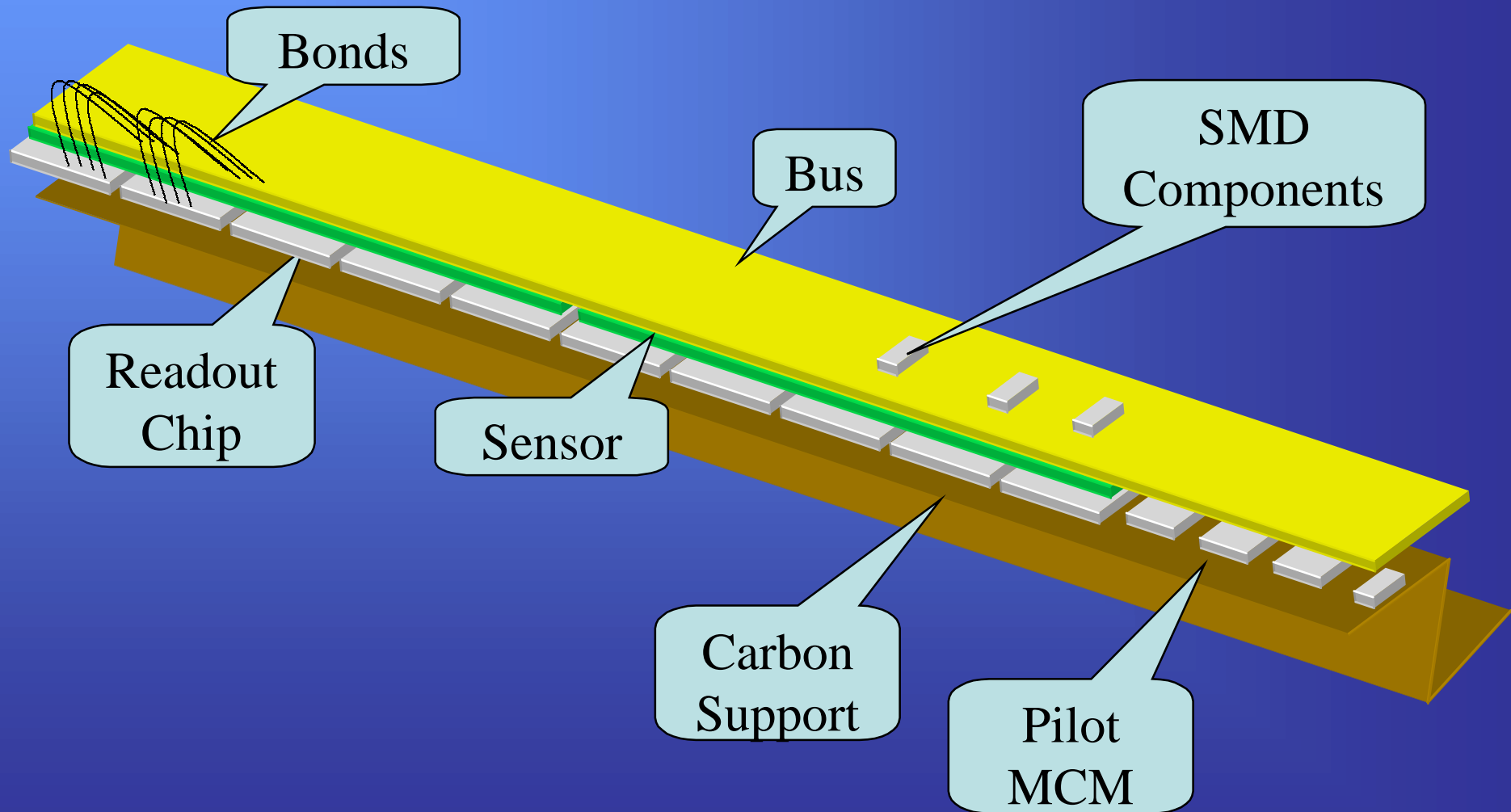


# SPD Components



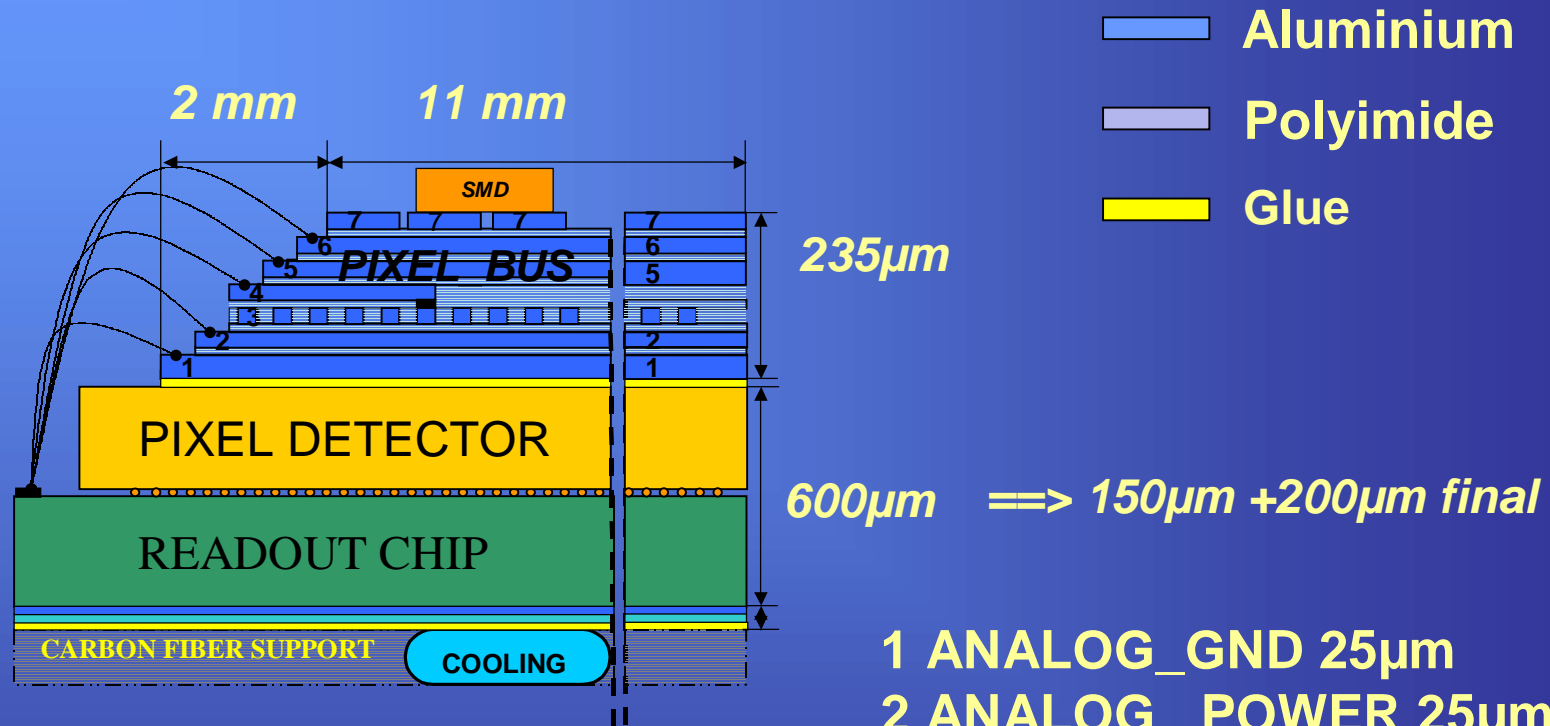


# SPD Components





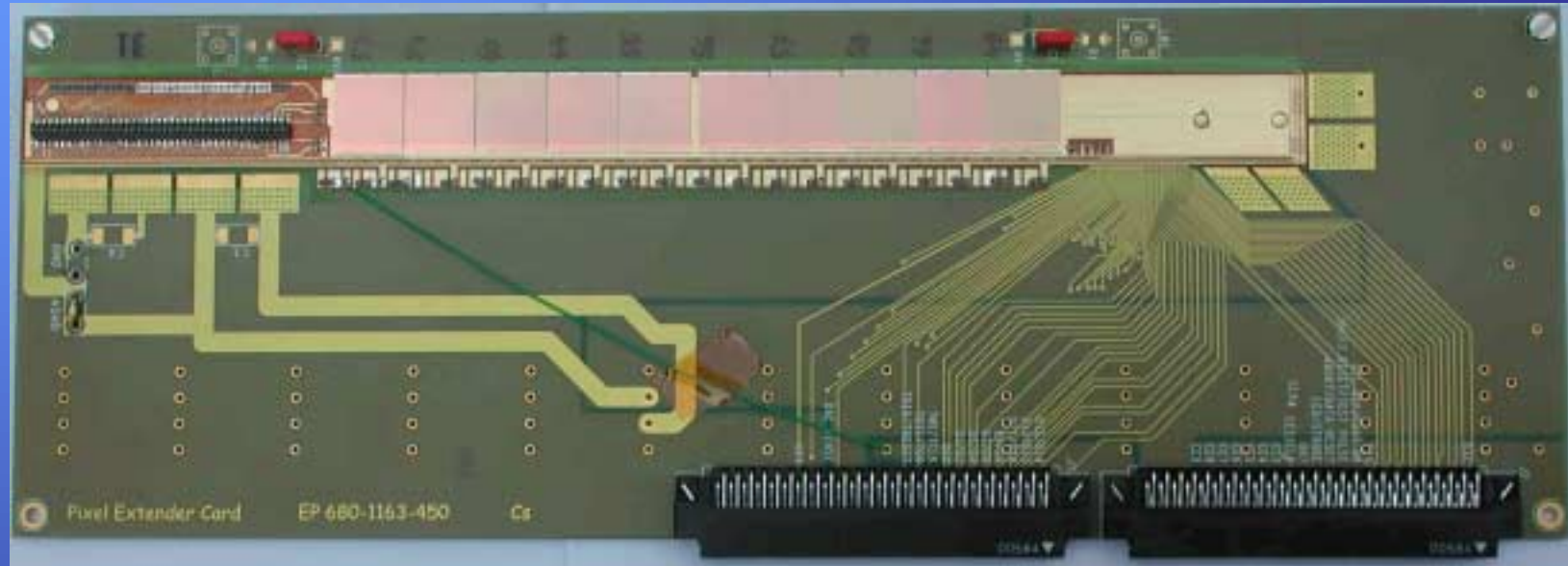
# SPD Bus



- 1 ANALOG\_GND 25µm
- 2 ANALOG\_POWER 25µm
- 3 HORIZONTAL LINES 10µm
- 4 VERTICAL LINES 5µm
- 5 DIGITAL\_POWER 25µm
- 6 DIGITAL\_GND 25µm
- 7 RES + CAPA PADS 15µm



# SPD Bus Tests

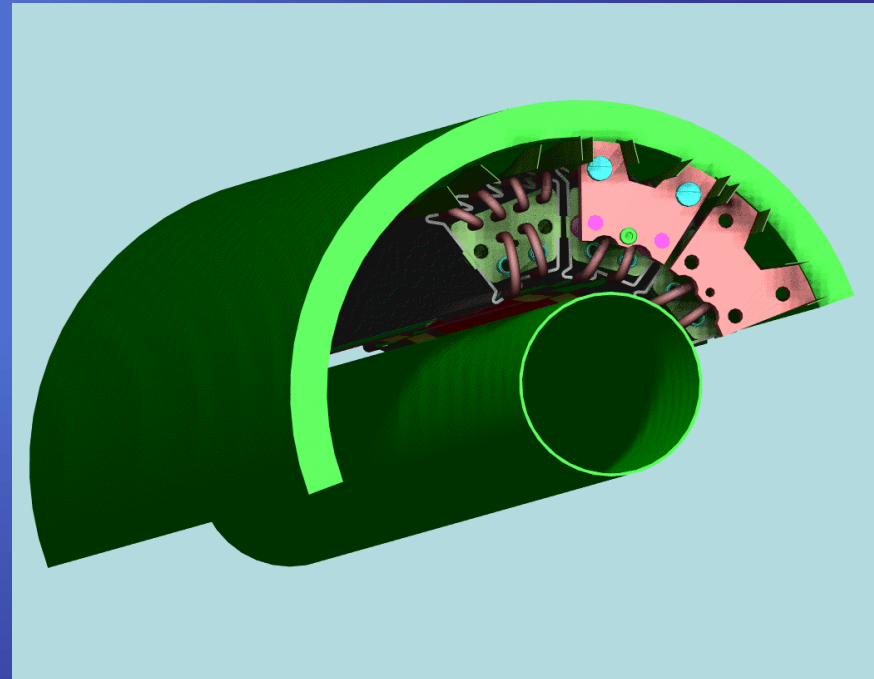
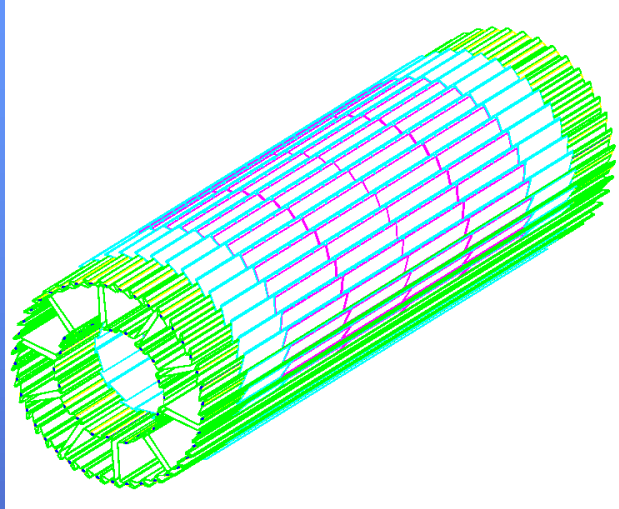


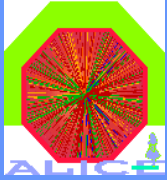
**As of today, we successfully tested:**

- **First Bus prototype with 10 mounted chips**
- **Ladder with 5 chips mounted on bus (with beam)**

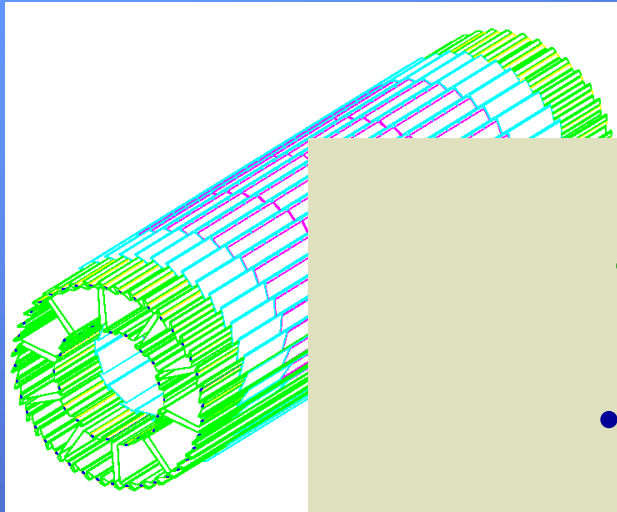


# SPD segmentation

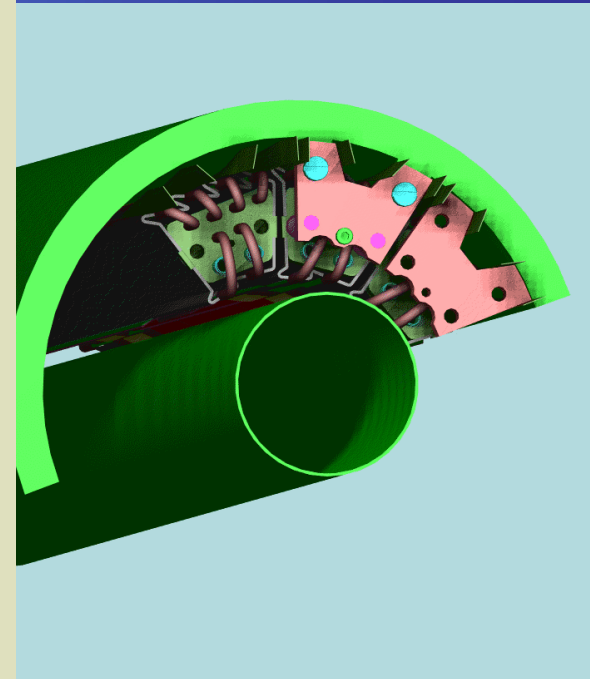




# SPD segmentation



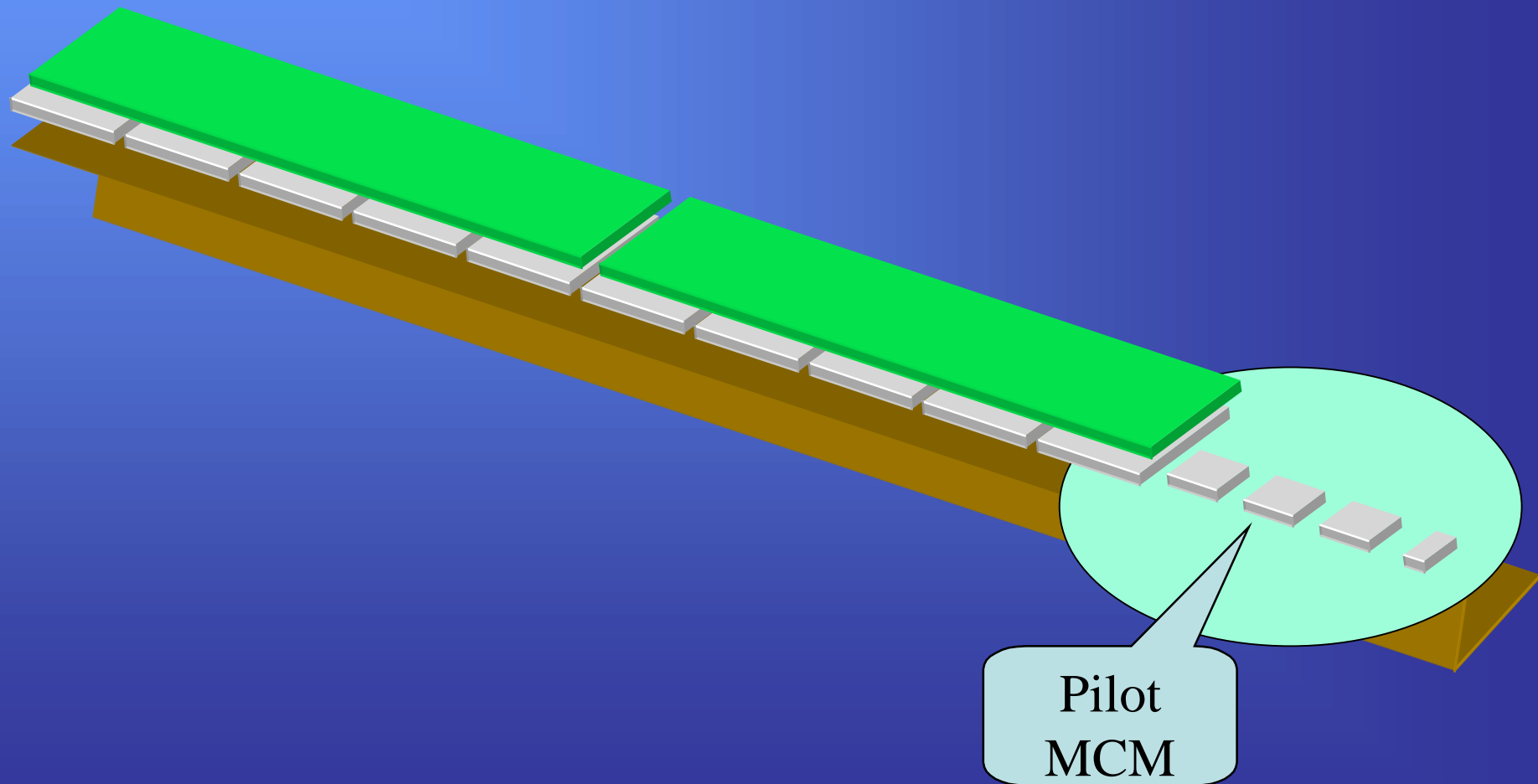
- 2 layers
- 60 staves
- 240 ladders
- 1200 chips
- 9.83 E6 active channels





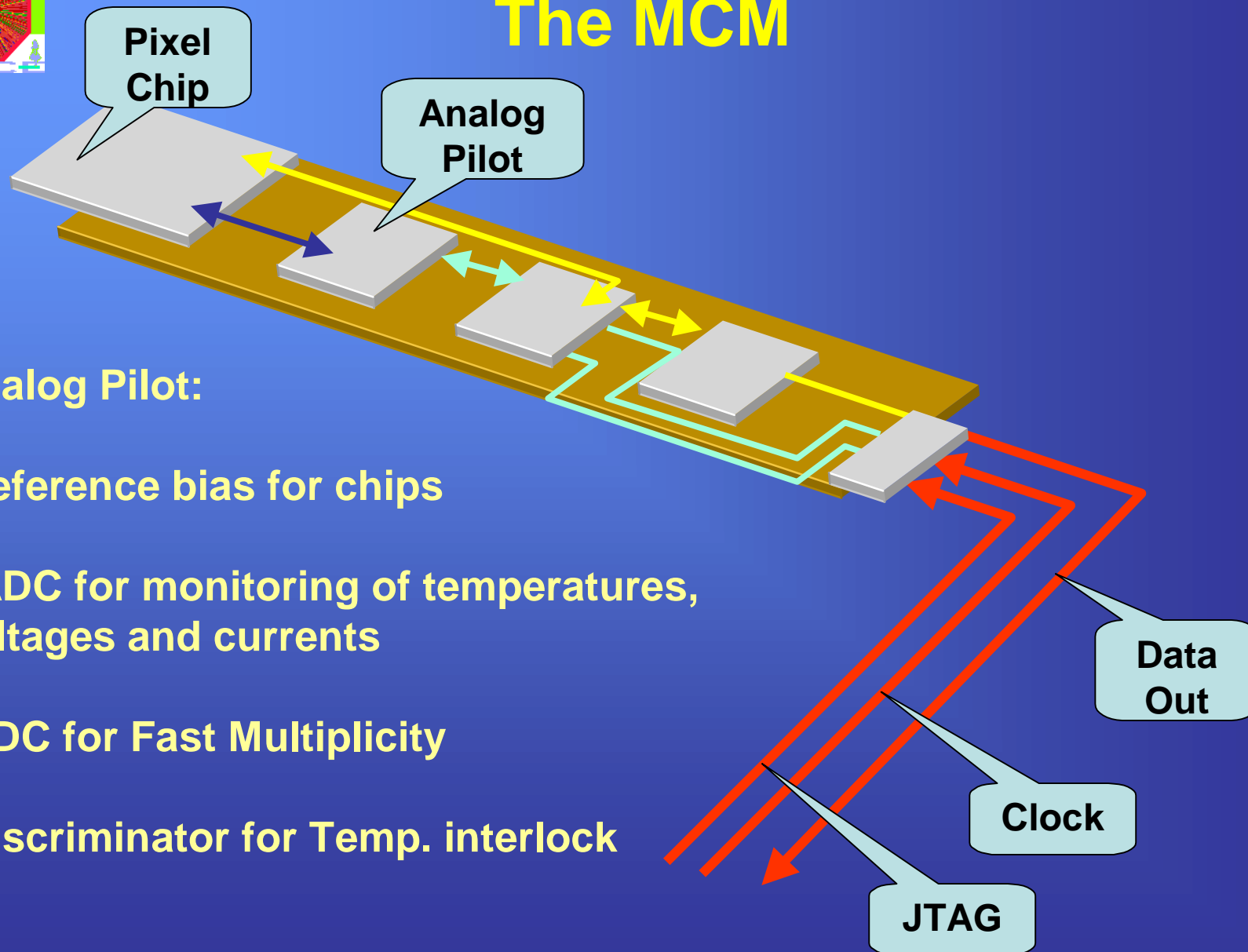


# The Pilot Multichip Module (MCM)





# The MCM

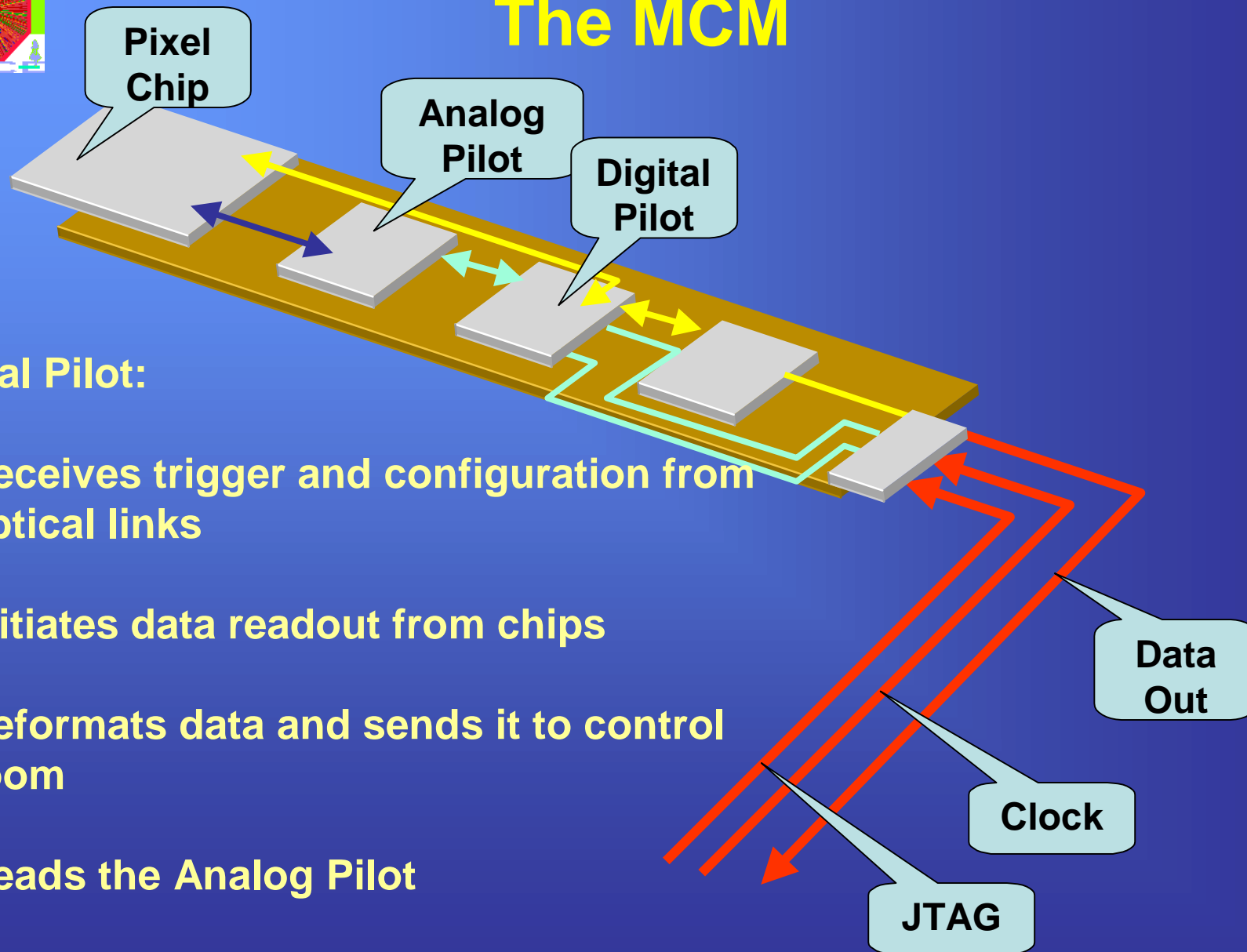


## Analog Pilot:

- reference bias for chips
- ADC for monitoring of temperatures, voltages and currents
- ADC for Fast Multiplicity
- Discriminator for Temp. interlock

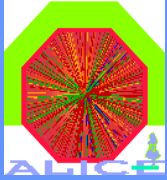


# The MCM

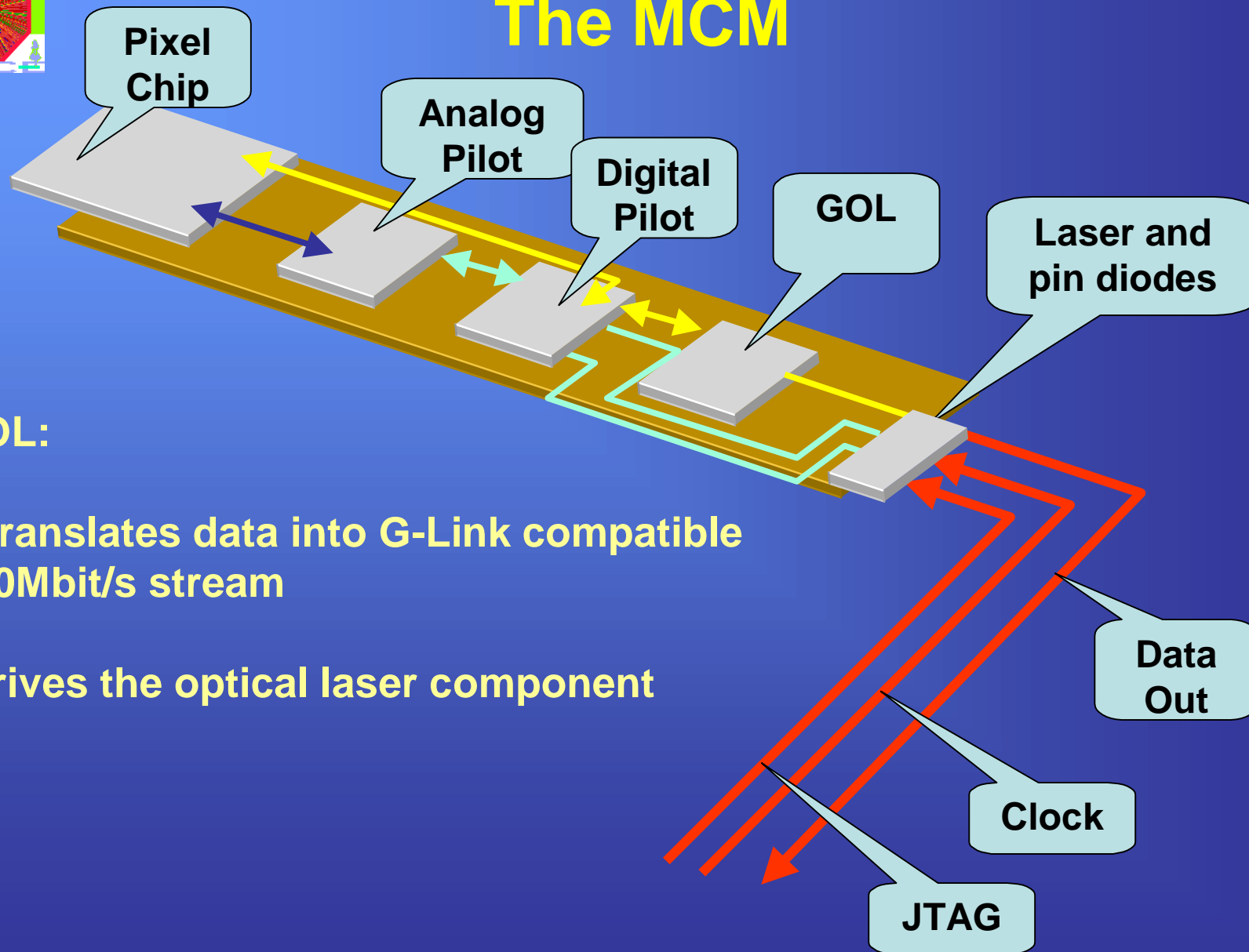


## Digital Pilot:

- Receives trigger and configuration from optical links
- Initiates data readout from chips
- Reformats data and sends it to control room
- Reads the Analog Pilot



# The MCM

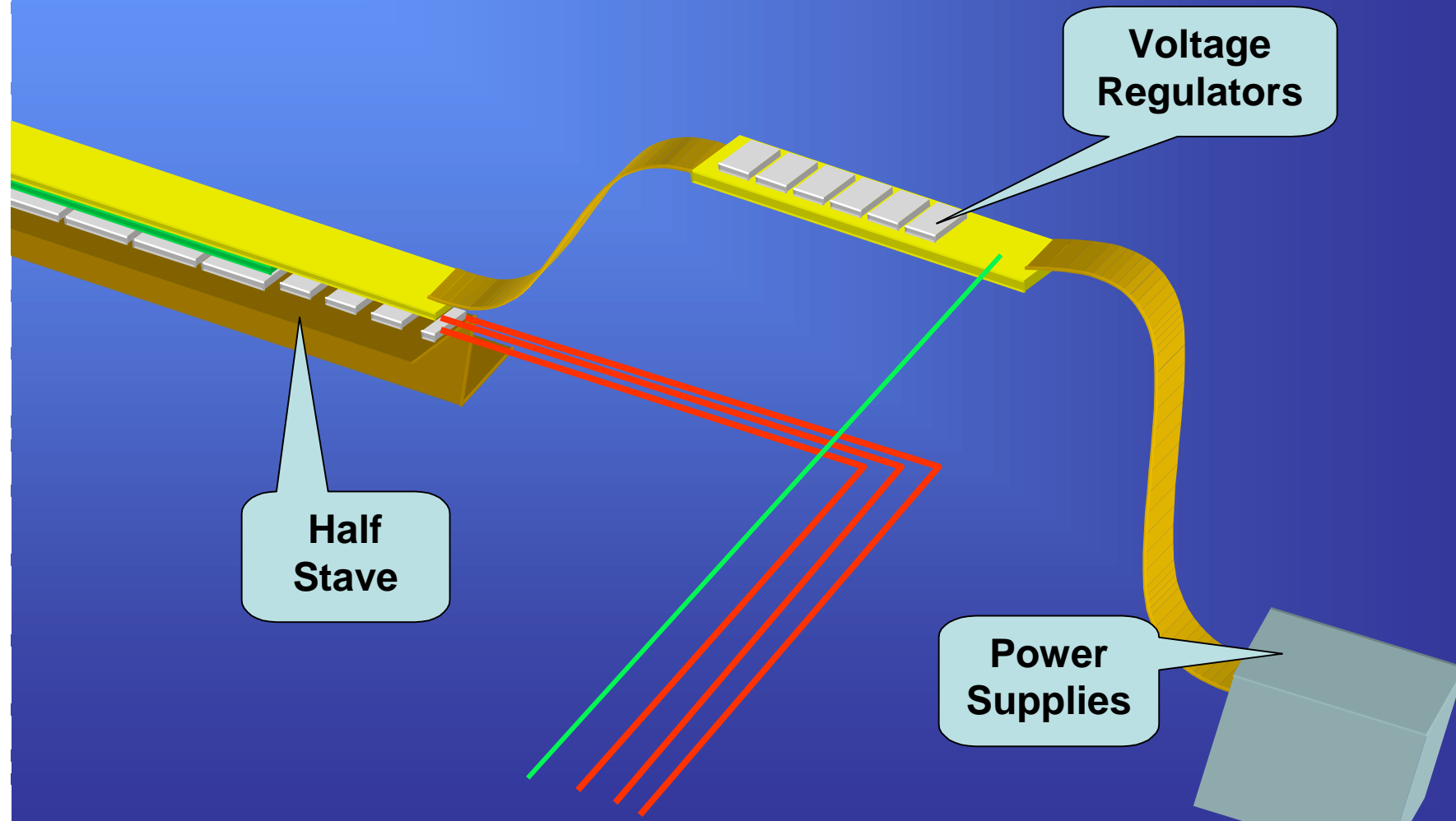


## GOL:

- Translates data into G-Link compatible 800Mbit/s stream
- Drives the optical laser component

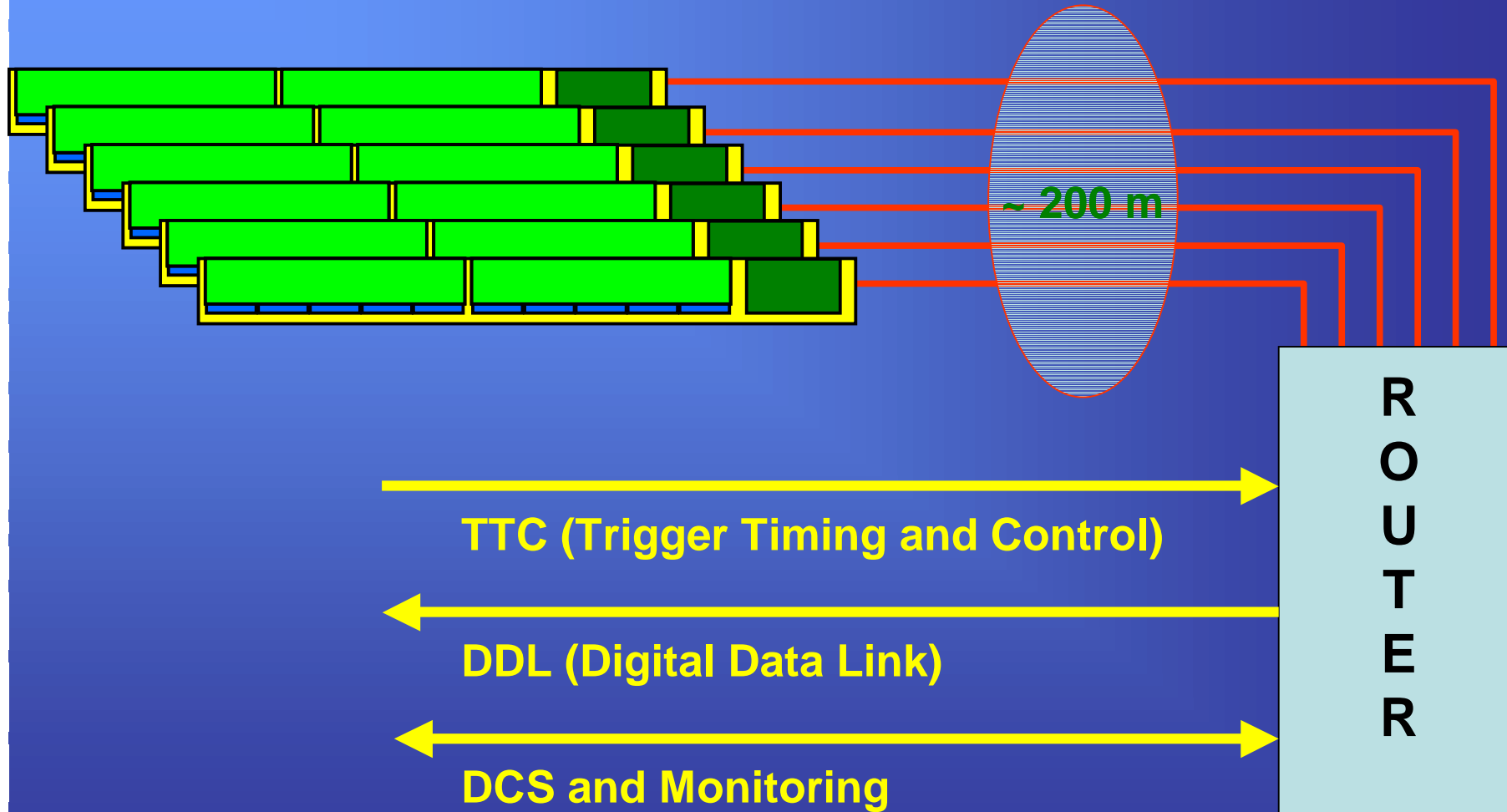


# SPD Power Distribution



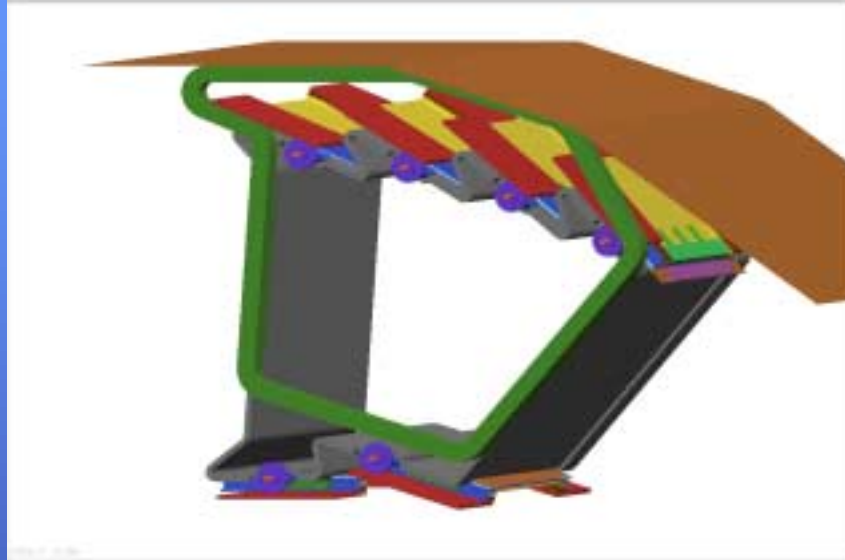


# SPD Readout Structure



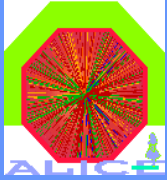


# SPD Cooling

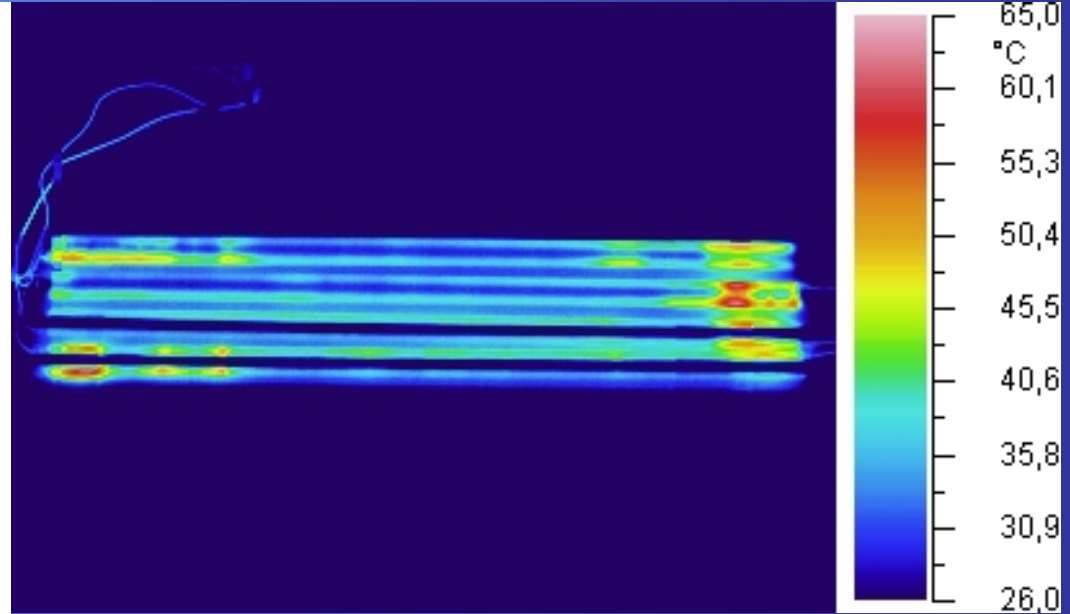
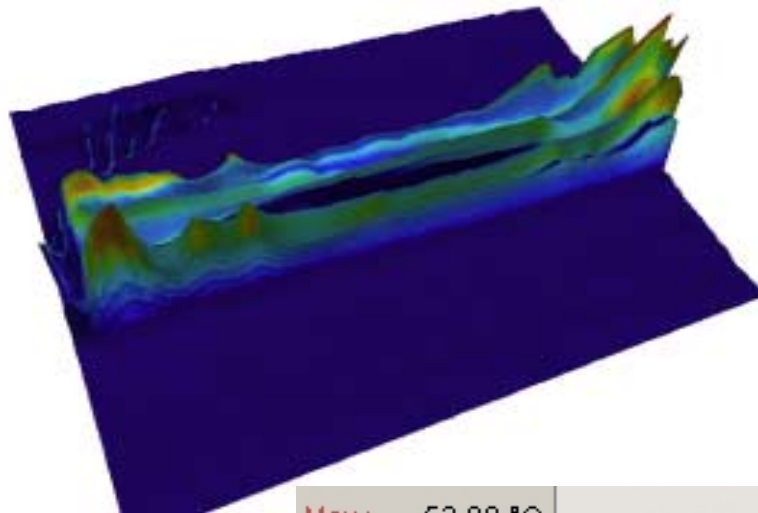


**~1.5 kW of dissipated power will be removed by a two phase evaporative cooling system**

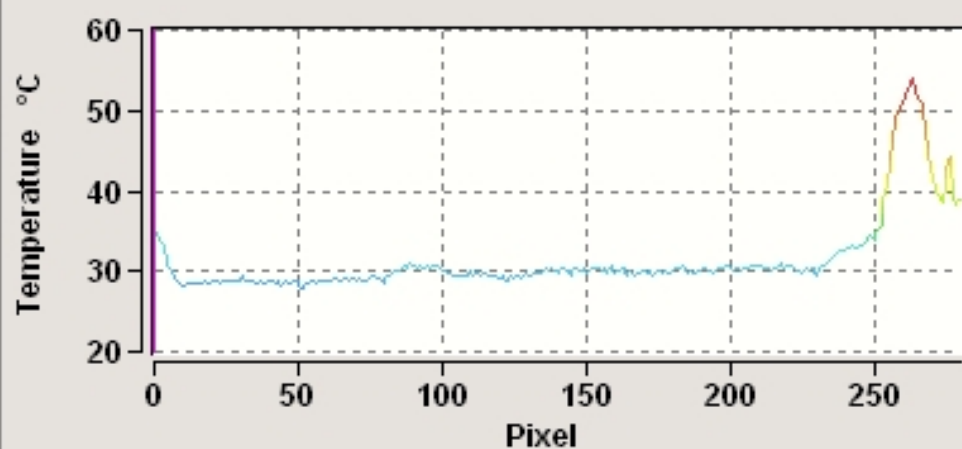




# SPD Cooling Tests



Max : 53,80 °C  
Avr : 31,42 °C  
Min : 27,95 °C  
Temp: 34,36 °C  
FstP (x/y): 18/108  
LstP (x/y): 298/113  
Points : 281





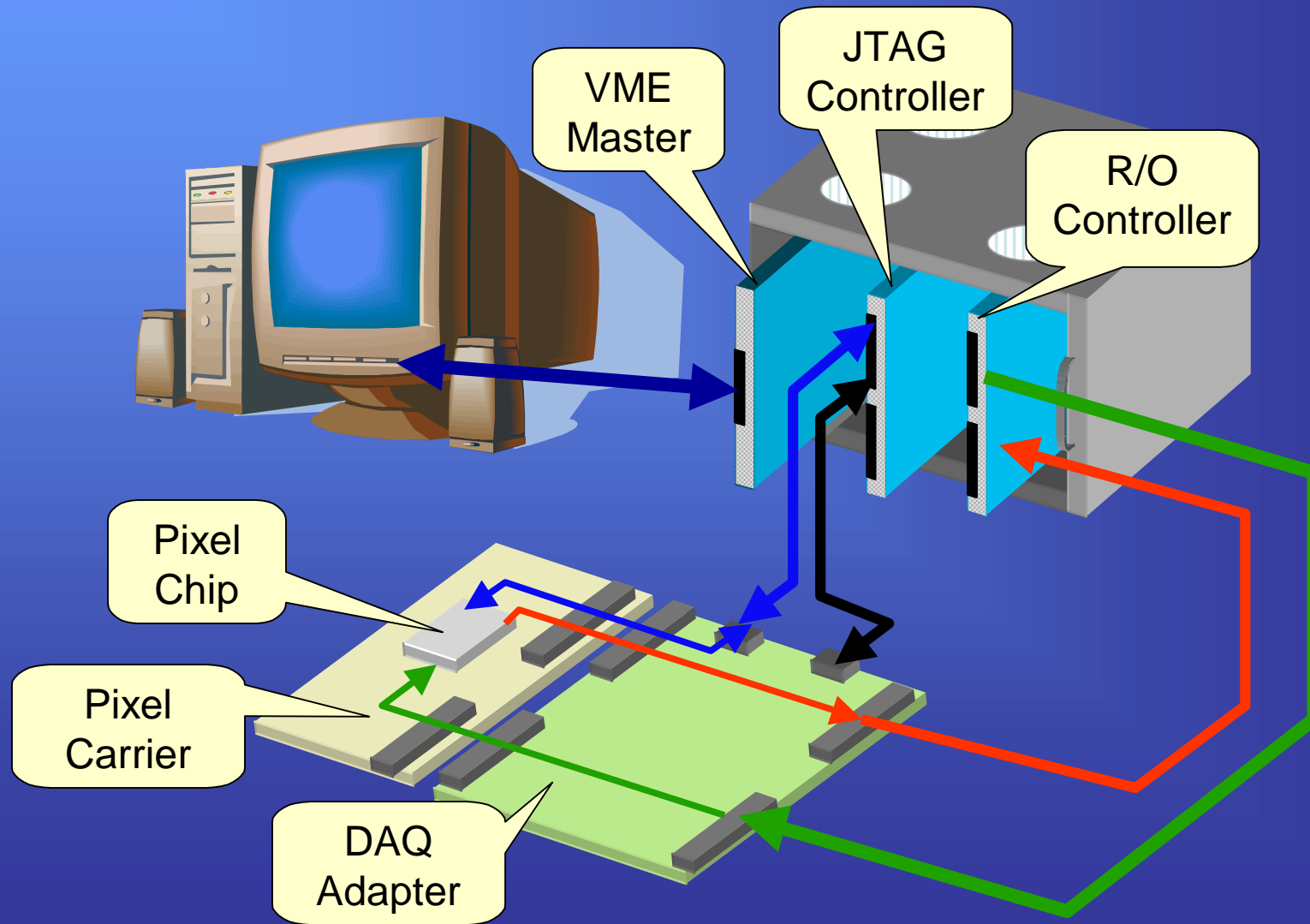


# Alice Pixel Test Systems

- **Modular System based on VME**
- **Designed for wafer probing, chip studies and testbeams**
- **Control software based on Windows, LabView and open standards (VISA, ADO, MySQL, root)**

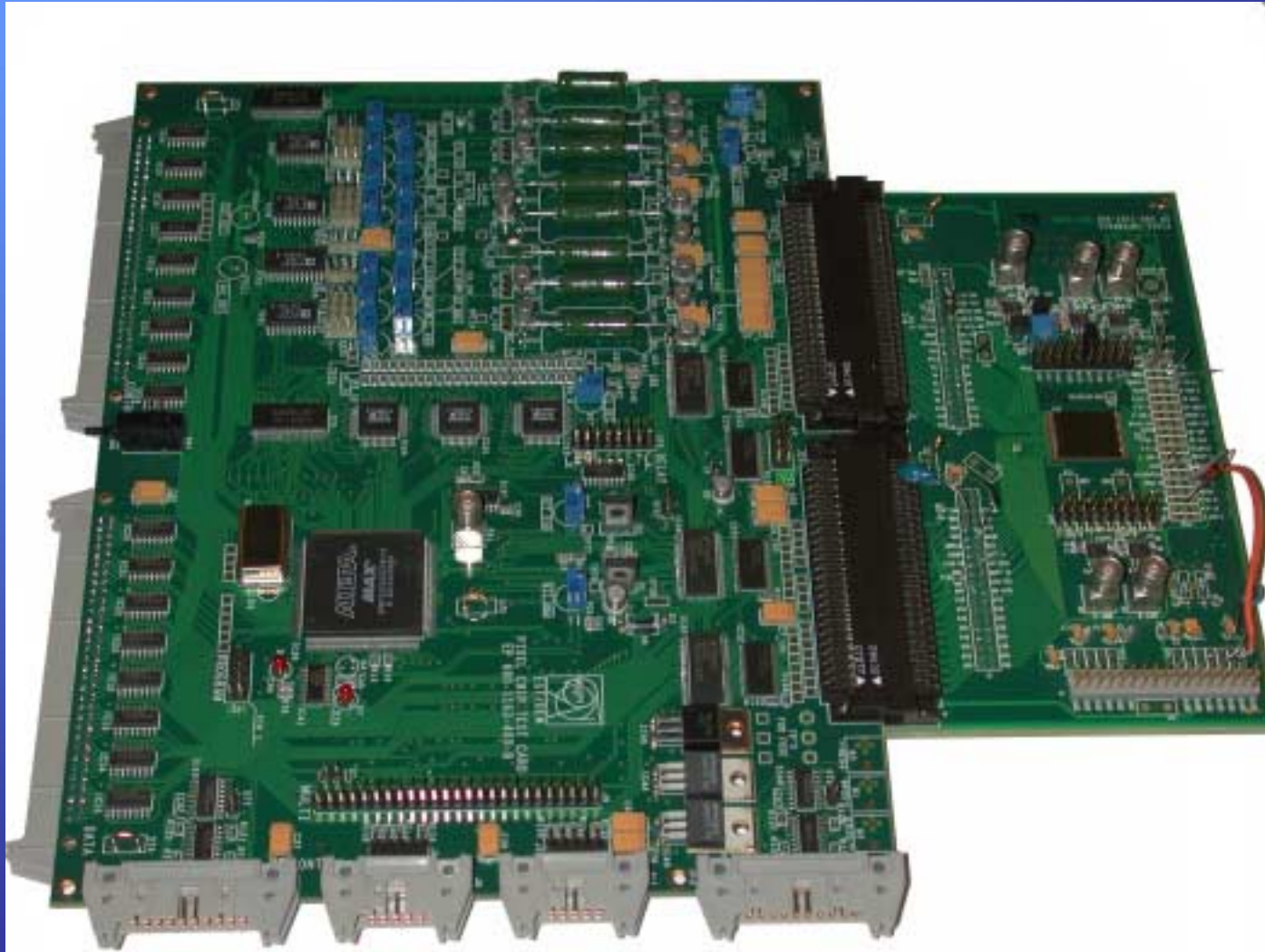


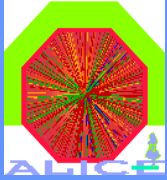
# Pixel Test System Components





# Test System Components



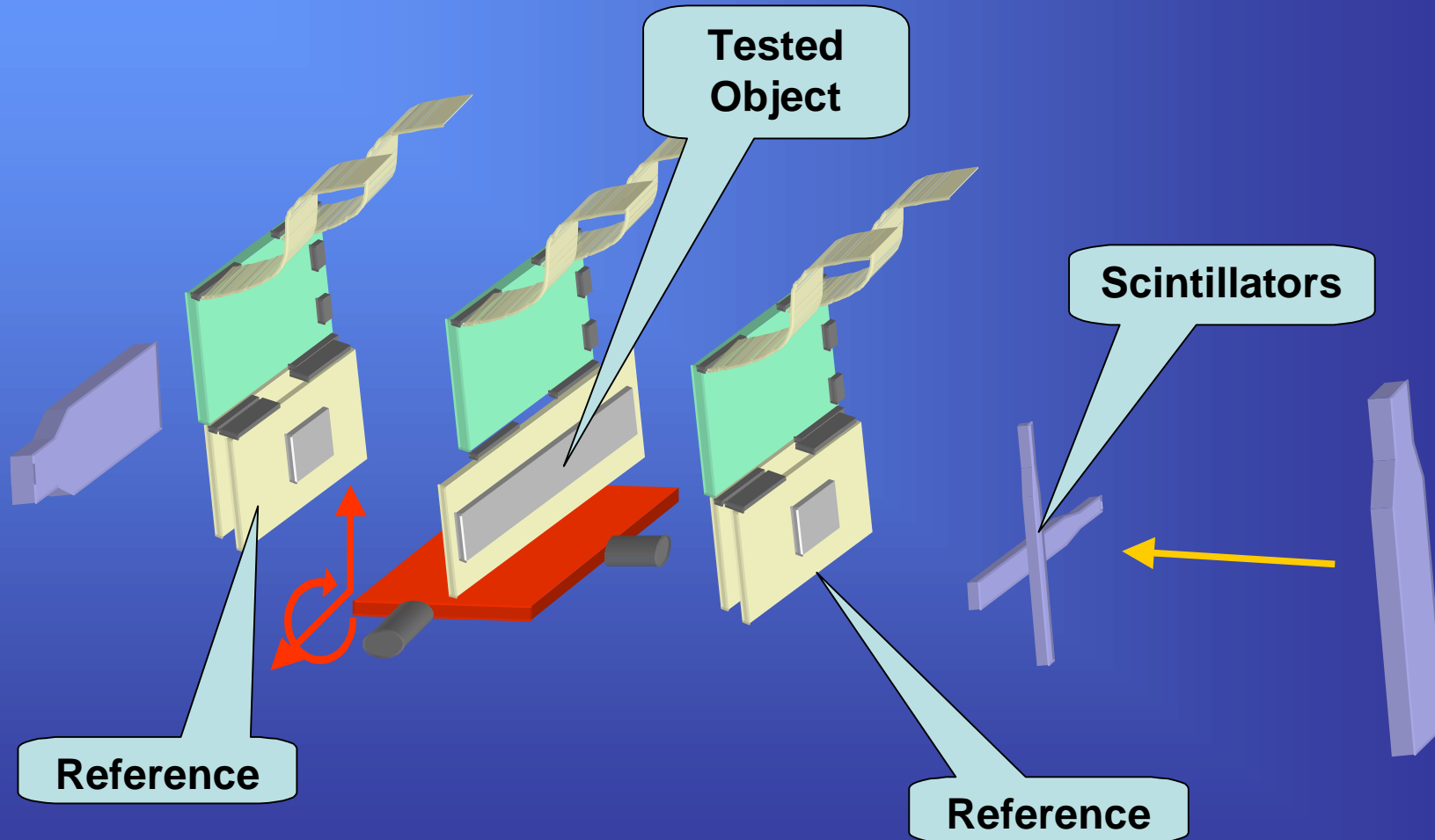


# Test System Components





# The Testbeam Setup







# The Testbeam Setup



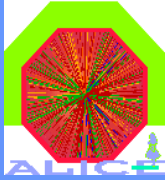


# Pixel Chip Tests

- **Laboratory test protocol includes:**
  - **Power consumption tests**
  - **Tests of configuration registers**
  - **Scan of all DACs**
  - **Threshold scan**

**Full production assumes tests of ~3000 chips**

**Test System will acquire ~5.2 TB of data from chips**



# Radiation Tolerance

## Single Event Effects:

- Studied at Louvain-la-Neuve
- No SEGR nor SEL observed
- Measure SEU rate indicates that in Alice environment it will not exceed 1bit/10hours of operation (calculated for all DACs in SPD)

## Total Ionizing Dose:

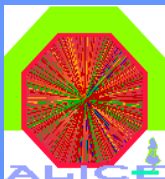
- Studied at CERN-MIC irradiation facility
- Total expected dose:
  - 130 (40) krad
- Design tolerance:
  - 500 krad
- Tested tolerance:
  - >12 Mrad



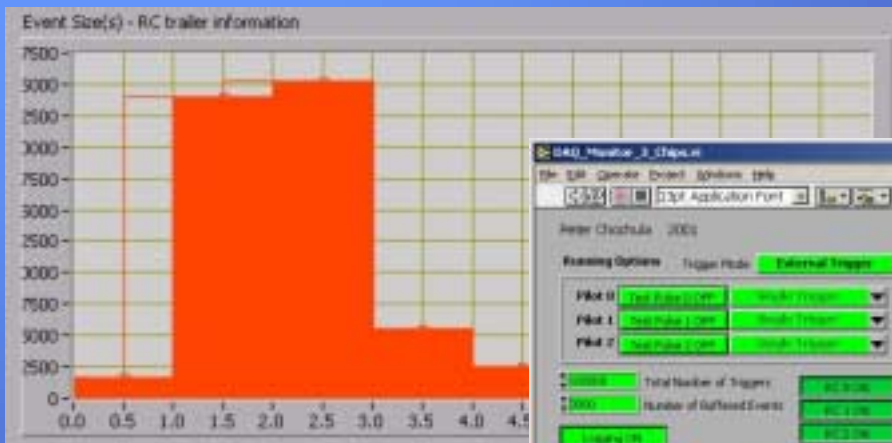


# Pixel Testbeams

- **July and September 2001**
  - 3 detector planes with single chip assemblies
  - Studies of chip efficiency, thresholds and timings
- **July 2002**
  - 5 detector planes in the beam
  - Tests of thinned assembly
  - Tests of a ladder with 5 chips
  - Collection of data for simulation tuning



# Testbeam Software



Control interface for the Testbeam Software. The window title is "DAQ\_Master\_3\_Chapec". It displays various configuration options and real-time monitoring data.

**Running Options:** Trigger Mode: External Trigger, Run Rate: 100, Run Mode: Run.

**File Settings:** File 0: Test Beam Data, File 1: Test Beam Data, File 2: Test Beam Data. Buffer sizes are set to 10000, 10000, and 10000 respectively.

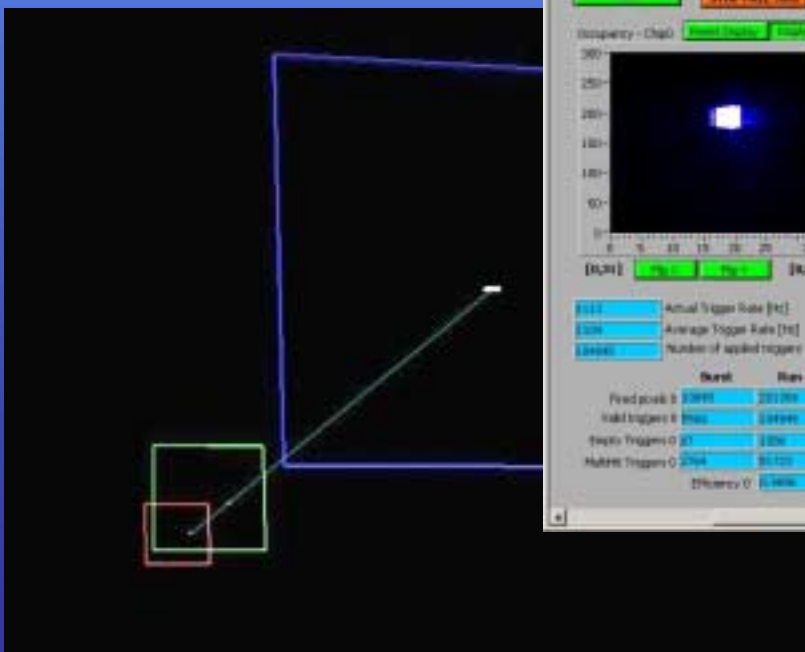
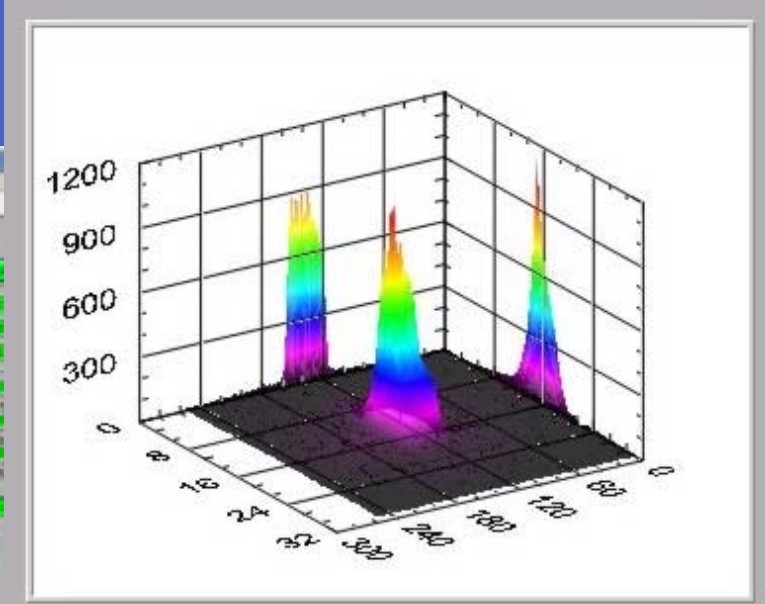
**Occupancy - Ch0 and Ch1:** Two occupancy charts showing event distribution. The left chart (Ch0) has a color scale from -17 to 170. The right chart (Ch1) has a color scale from -17 to 170.

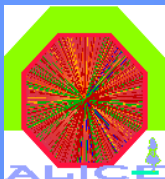
**Statistics:**

Category	Value
Actual Trigger Rate [Hz]	1.0
Average Trigger Rate [Hz]	1.0
Number of applied triggers	10000
Actual Rate	1.0
Rate Readout Cycle	1.0

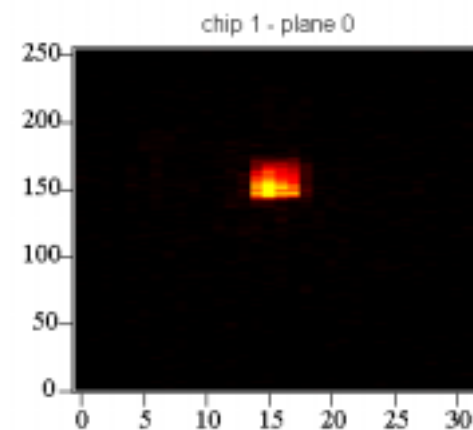
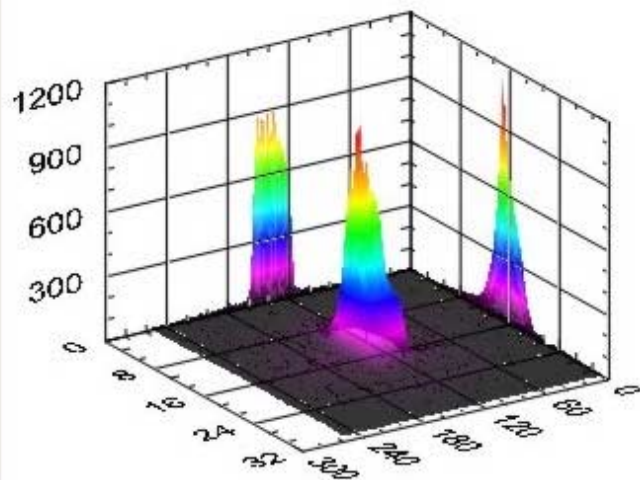
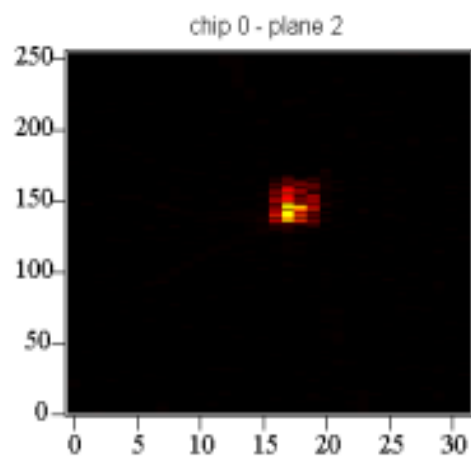
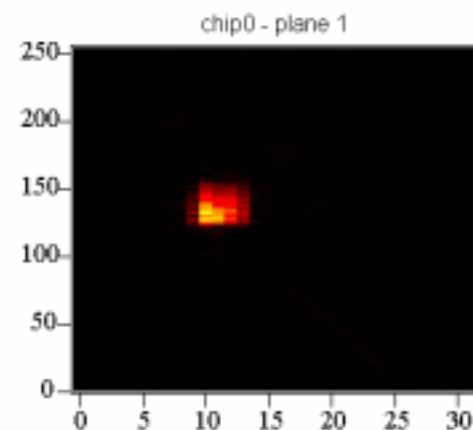
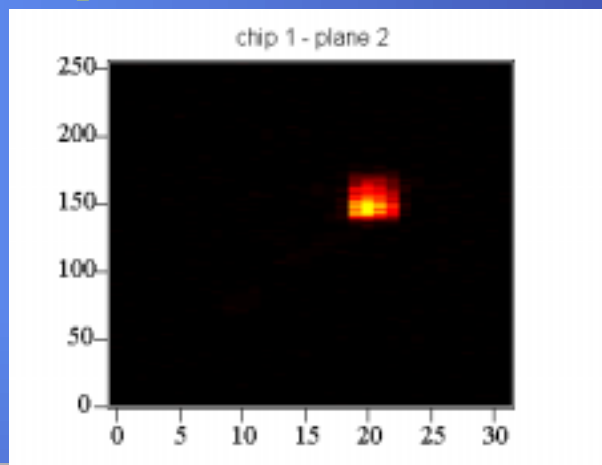
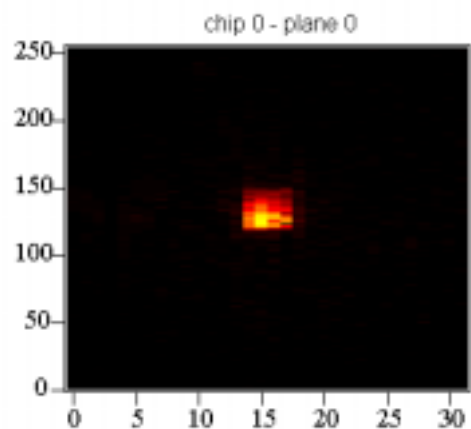
**Trigger Status:**

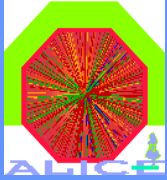
Trigger	Count	Rate
Fixed peak 0	10000	1.0000
Valid triggers 0	10000	1.0000
Empty Triggers 0	0	0.0000
Invalid Triggers 0	0	0.0000
Fixed peak 1	10000	1.0000
Valid triggers 1	10000	1.0000
Empty Triggers 1	0	0.0000
Invalid Triggers 1	0	0.0000
Fixed peak 2	10000	1.0000
Valid triggers 2	10000	1.0000
Empty Triggers 2	0	0.0000
Invalid Triggers 2	0	0.0000



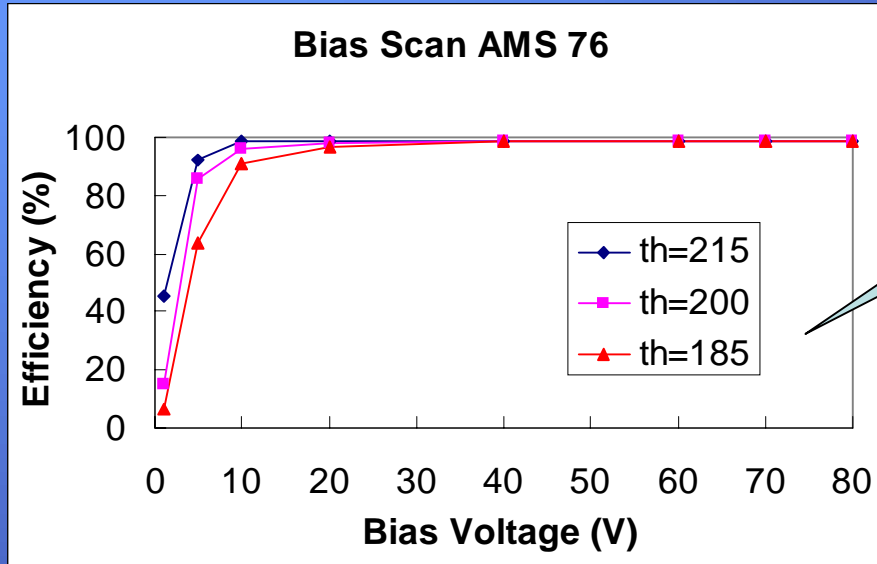


# Beamspot measurements



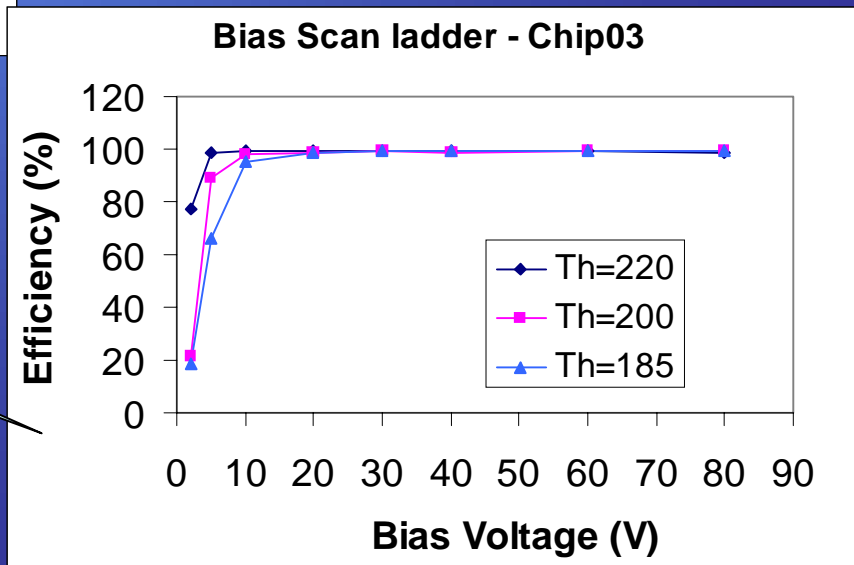


# First Results of the Testbeam 2002



Single Assembly

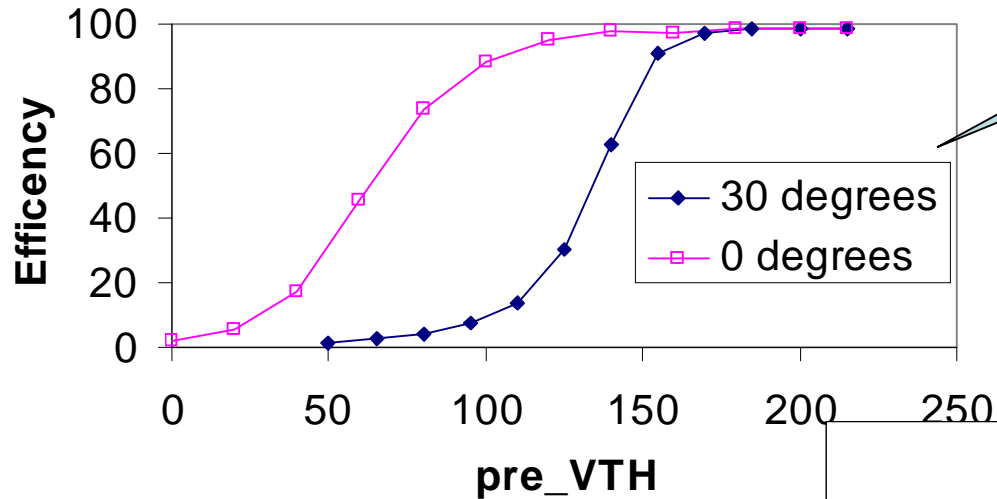
Ladder





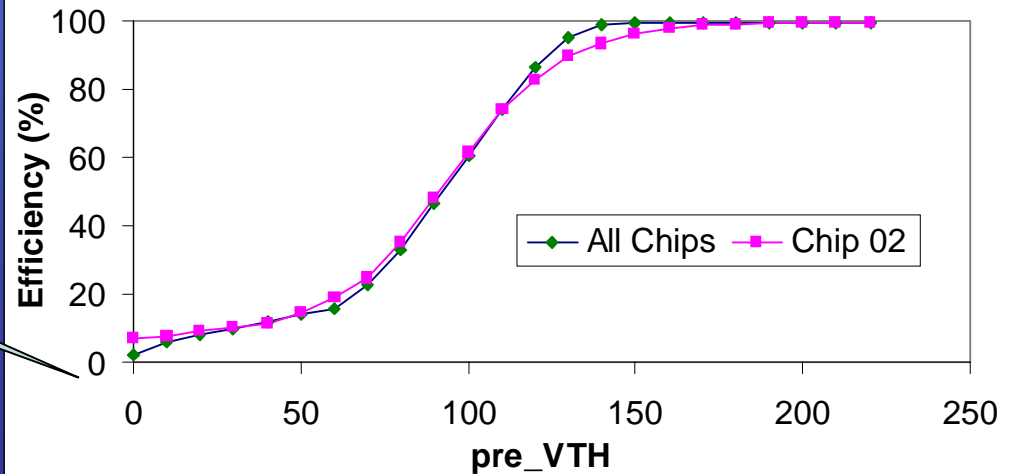
# First Results of the Testbeam 2002

### Threshold scan AMS76

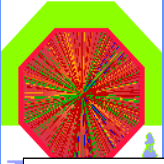


Single Assembly

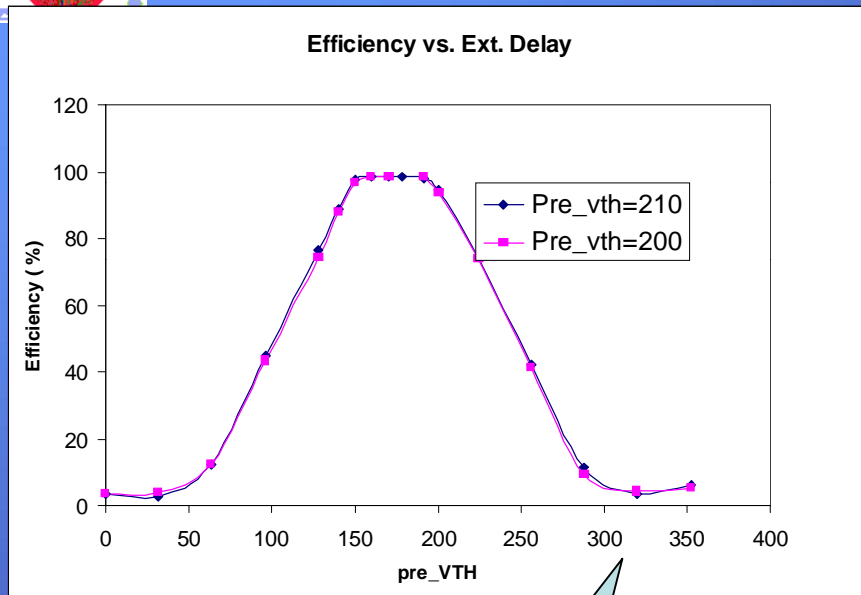
### Threshold scan (LADDER-Chip02)



Ladder

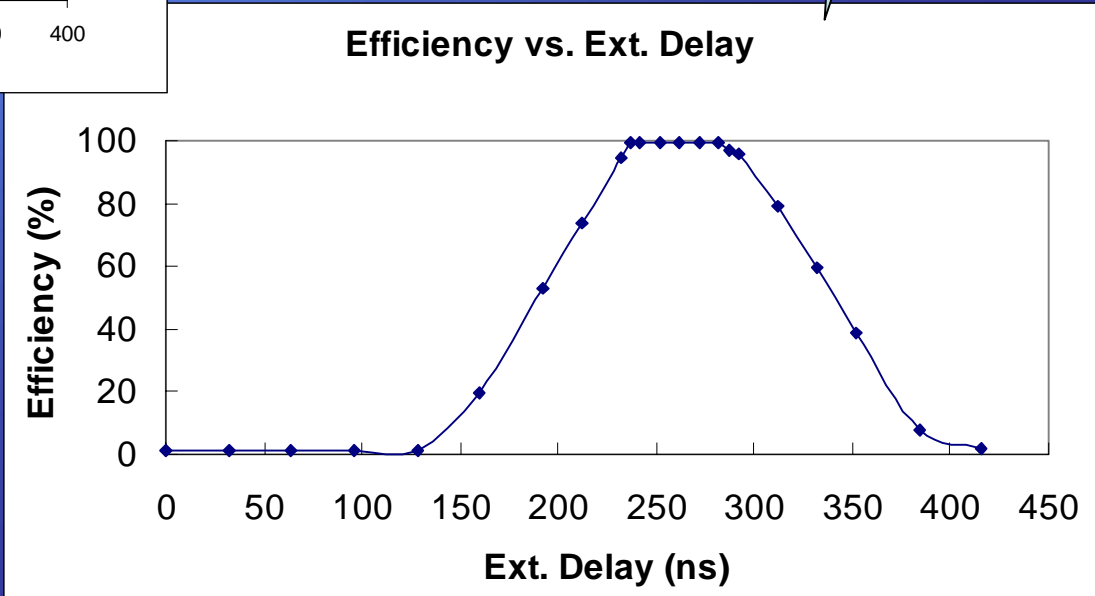


# First Results of the Testbeam 2002



Thin Assembly

Ladder





# Conclusions

- **The Alice SPD made a big progress**
- **The Alice1 chip has been qualified for use in the Alice Experiment**
- **Procedures of sector assembly are under development**
- **Next challenge – system integration**