PLUME PROJECT

Pixel Ladder with Ultra-low Material Embedding

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http://iphc.in2p3.fr/-CMOS-ILC-.html

SOCLE meeting 9-10 Novembre 2009

Ladder design

The 2 key elements for design and fabrication :

- the flex on which sensors are connected
- the ladder structure supporting the flex with the sensors

Ladder developped along 2 parallel approaches :

- **classical** : sensors (50 µm) - flex cable - **foam** – flex cable – sensors

- **innovating** : sensors (35 µm) wrapped in polymerised film (<10 µm)
  => adaptable to various mechanical supports (beam pipe)

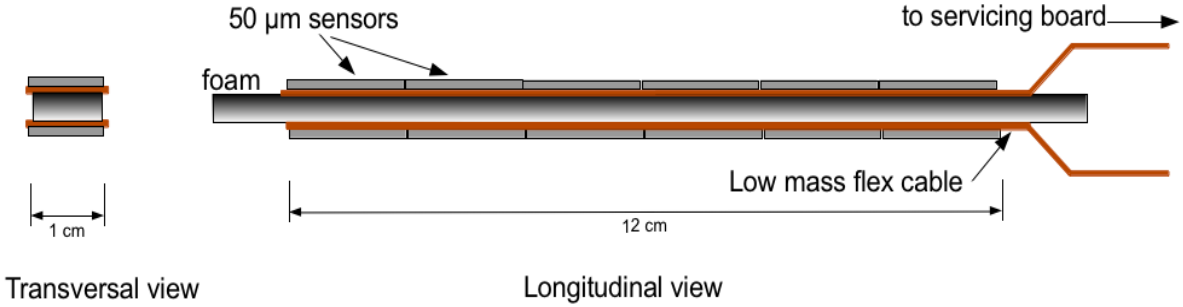
PLUME follows the classical approach

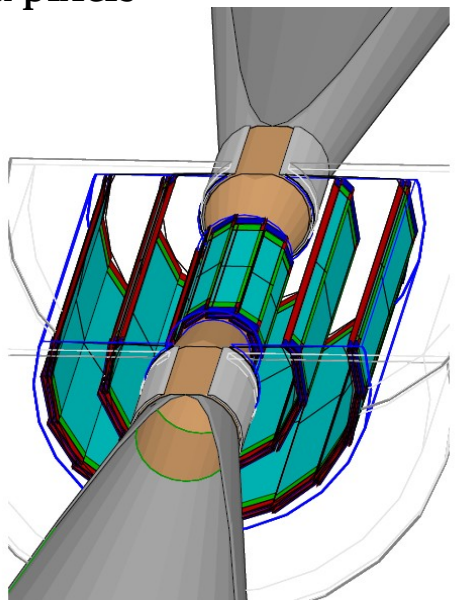
SERWIETE follows the innovating one

The PLUME project

Objectives :

- to achieve a double-sided ladder prototype for an ILC vertex detector by **2012**
  material budget ~ **0.16%X_0** (*LOI Target Value*)
- to quantify power pulsing and air-flow cooling impacts on sensor intrinsic resolution
- to evaluate benefits of double-sided concept (mini-vectors) :
  σ_{ip}, alignment, shallow angle pointing (<15-30°), elongated vs squared pixels





Collaboration :

- Bristol, DESY, Oxford, Strasbourg
- Synergy with vertex Detector of CBM fair

Perspectives :

- to be studied with infrastructure foreseen in AIDA project
- interests for (s)LHC experiments ?
  Ladder and sensors have been proposed within the context of ALICE vertex detector upgrade (2018 shutdown)

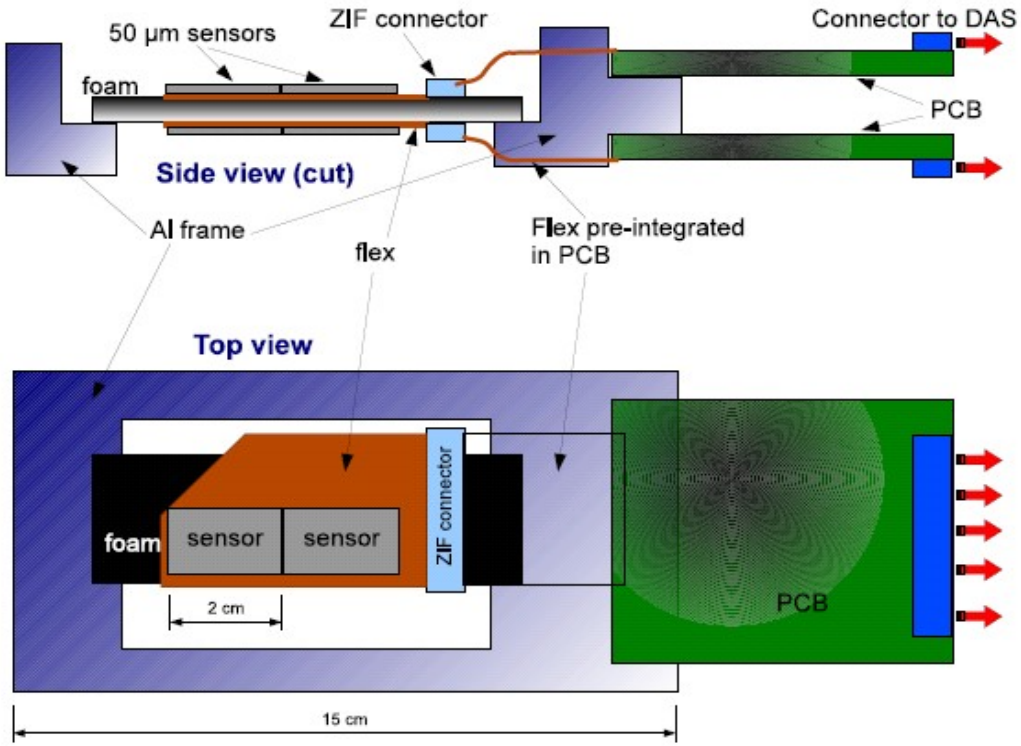
Prototype Ladder – 2009 goal

Objectives :

- to evaluate the ladder mechanical assembly difficulties
- to demonstrate that a low material budget ladder, equipped with CMOS sensors on both sides, can provide the adequate resolution on the track parameters for a particle crossing the two sensors.

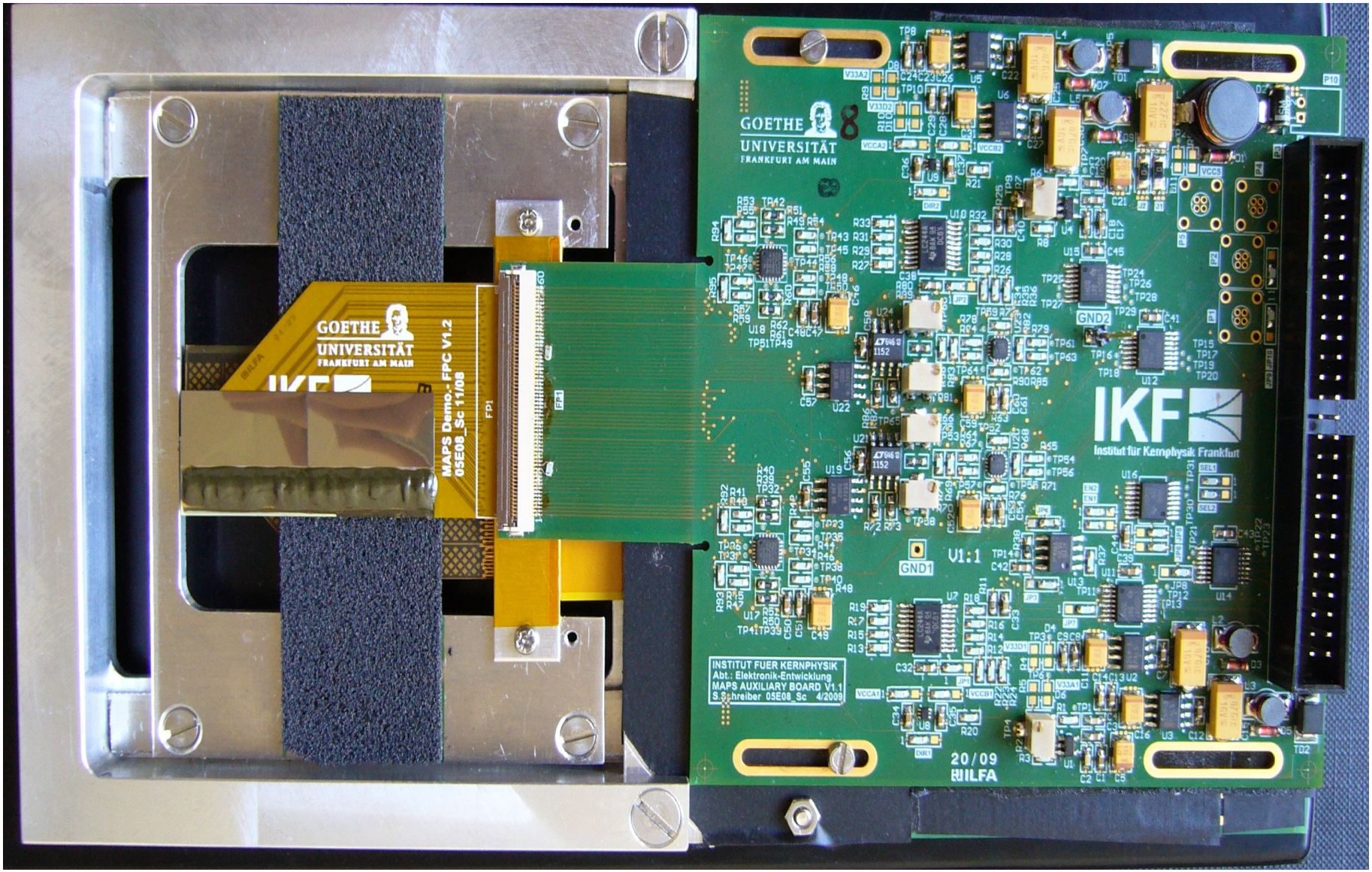
Initial concept :

- based on an existing large size sensor : **MIMOSA-20** (analog output, ~ 2ms @ 50 MHz)
  area of **1 × 2 cm²**, thinned down to **50 µm**
- use of **flex cables** developed for the CBM ladder demonstrator by **IK-Frankfurt/CBM**
  300 µm thick **polyimide** slab
- use of **silicon carbide (SiC) foam** (8% density) as a mechanical structure which supports the two flex
- material budget **~ 0.6% X_0**



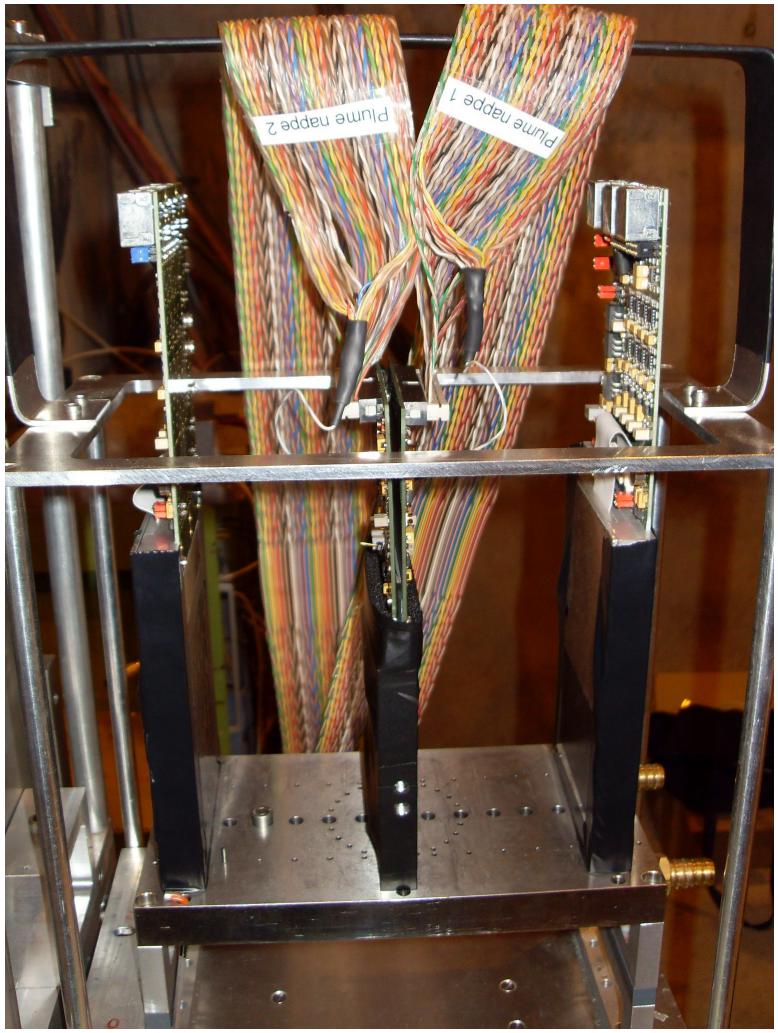
Prototype Ladder – 2009 goal

Experimental design



PLUME : the mechanical prototype

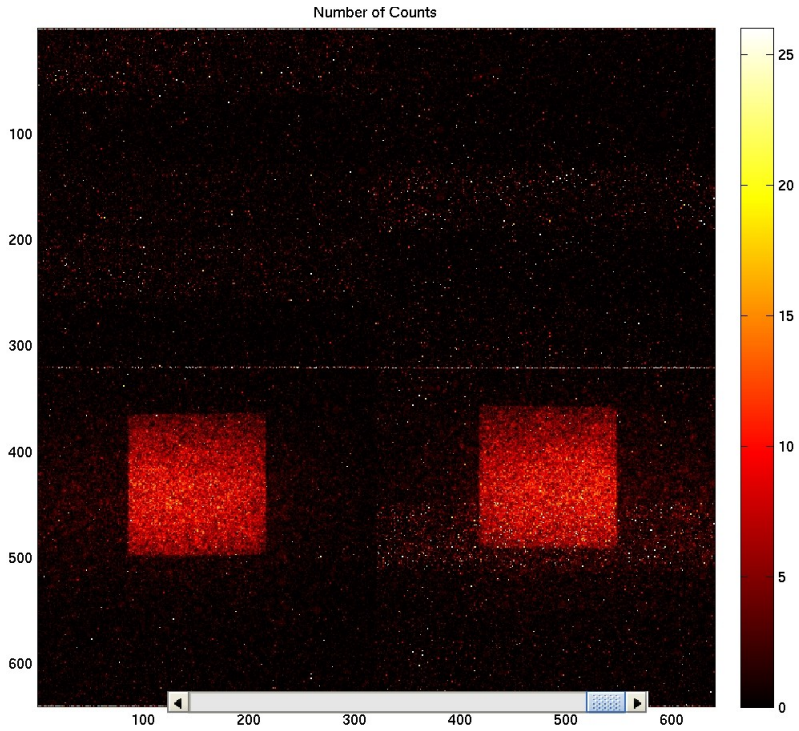
Prototype Ladder – 2009 Status



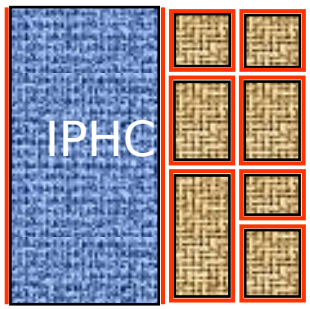
Status :

- Two ladders have been assembled : a mechanical one and a prototype ladder

- The prototype ladder is currently being tested @ CERN-SPS (~120 GeV π-)

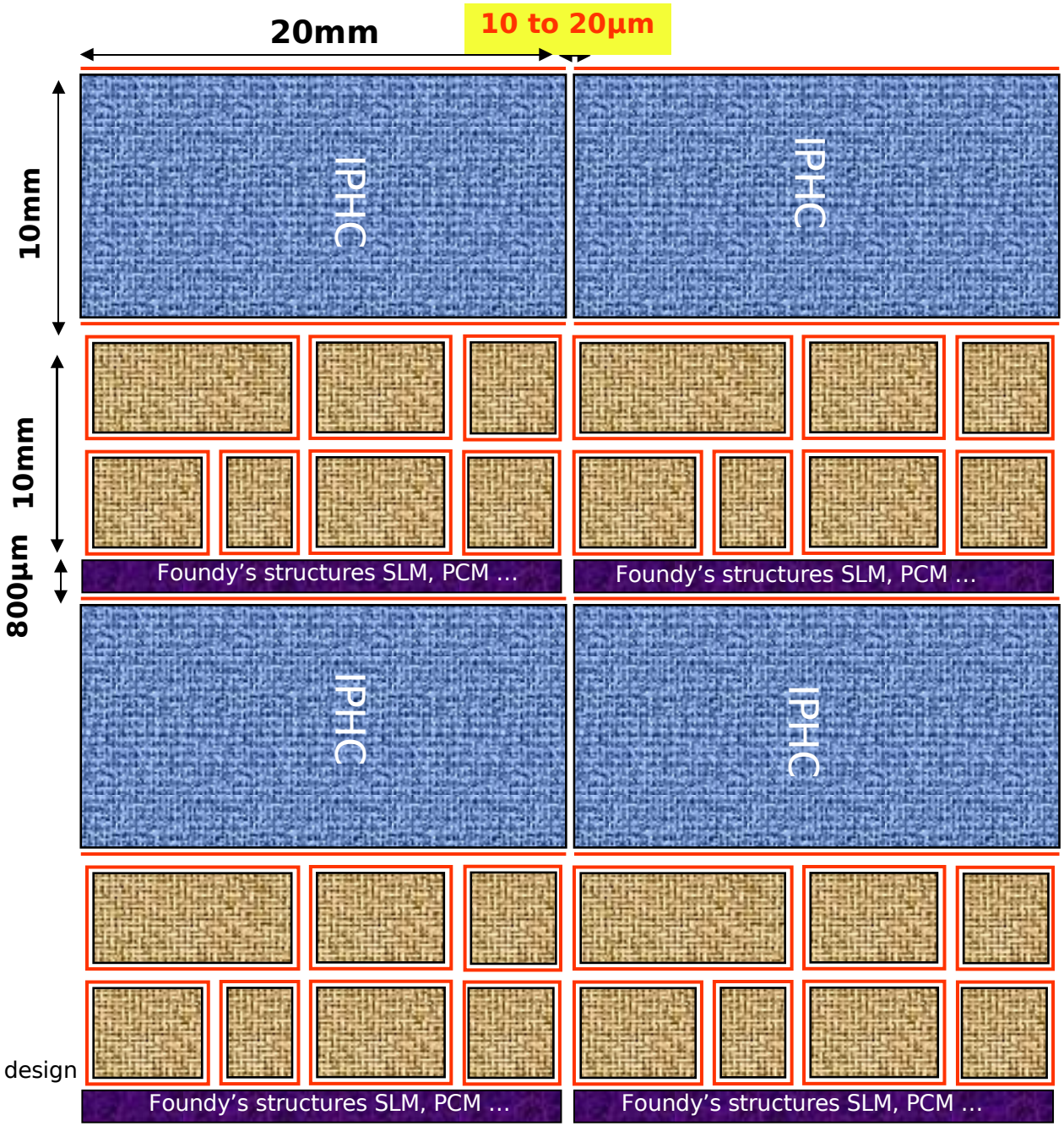


Partial Abutment for a MPW reticle in one Direction



MPW run Reticle

MIMOSA-20



SLM and PCM foundry structures

IPHC large array of photodiodes

MPW designs from other customers

Sealring around the circuits

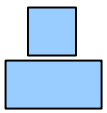
Vertical only Sealring around the IPHC design

Planning (High Profile)

2009 : Flex design and fabrication (not fully optimized) for 6 binary readout sensors

2010 : Better flex design and fabrication

Q1 (=first quarter of) => mounting and assembly of ladder with 2×6 MIMOSA-26
Q2+Q3 => electrical, mechanical and thermal test of ladder

	Sensors	Material Budget	tr.o	Concept
2010	2×6 MIMOSA-26	~0.6 % X0	110µs	Inner Layer
2011	2×6 MIMOSA-26 TB	≤ 0.4 % X0	~50µs	Inner Layer
2012	a) 1×6 MIMOSA-26 TB 1×6 MIMOSA-26 TB 	≤ 0.3 % X0	~50µs ~10µs	Inner Layer
	b) 2×6 MIMOSA-26 with ADC (pitch 35µm)	≤ 0.3 % X0	~100µs	Outer Layer

SERWIETE

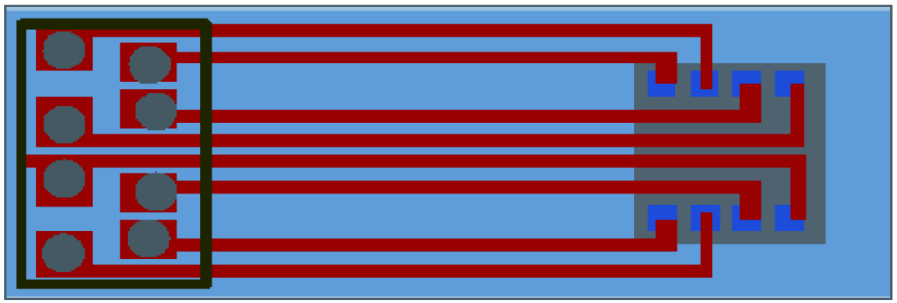
Hadron Physics-2 project (FP7) :
SEnsor Row Wrapped In Extra-Thin Enveloppe

Objectives :
- to achieve a sensor assembly mounted on flex and wrapped in polymerised film with **< 0.1 % X_0** for **1 unsupported layer** (sensors – flex - film)
- to evaluate the possibility of mounting supportless ladder on cylindrical surface (used as mechanical support)
  => proof of principle expected in 2012

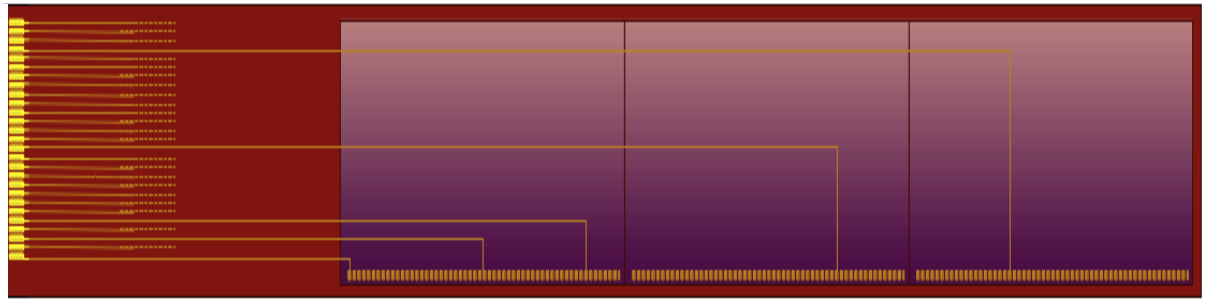
Working program :
- prototype Nr. 1 (2010) made of 1 sensor :
  MIMOSA-18 (analog output, ~4 ms @16MHz)
- prototype Nr. 2 (2011) made of 3 sensors :
  MIMOSA-26 (binary output, ~ 110 μs @80MHz)

Context of development :
- Collaboration with IKF-Frankfurt and GSI/Darmstadt (CBM coll.)
- Synergy with Vertex Detector R&D for CBM, ILC, ALICE (?) etc.

Fully functional microprocessor chip
in flexible plastic envelope.
*Courtesy of Piet De Moor, IMEC, Belgium



prototype Nr. 1 : spring 2010

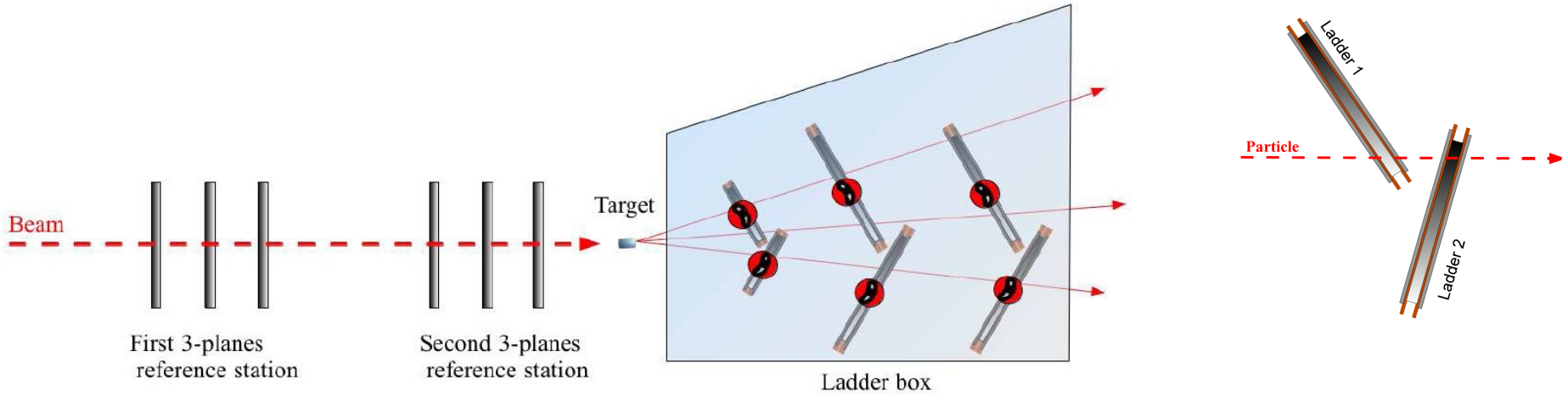


prototype Nr. 2 : summer 2011

VTX Oriented Infrastructures Proposed for AIDA WP-9.2

On-beam test infrastructure:

- Large Area beam Telescope (LAT)
- Alignment Investigation Devices (AID): mini-telescope and/or ladder box
- Very thin removable target



Off-beam test infrastructure:

- thermo-mechanical studies, including effect of air-flow based power extracting system
- power cycling effect in strong magnetic field, e.g. Lorentz forces, on ultra-light ladders

Summary

Problem :

How to preserve the intrinsic good resolution of CMOS sensors once they've been integrated in a vertex detector system ?

The 2009 integration study of a ladder satisfying the ILD requirements (double-sided ladder, 3 µm resolution with less that 0.3 % X_0 material budget) has started !

We intend to show that the goals defined in the LOI are reachable

In parallel the sensors conditioning is being developped.

Tests that will be implemented :

- power-pulsing mode
- air-flow cooling (temperature distribution, mechanical displacement, vibration)
- operation in magnetic field

Material budget estimate

Material budget along a path crossing the 2 sensors.

Flex material budget :

sum of three component thicknesses weighted by their respective radiation length, taking into account a conservative fill factor for the copper lines of 25%.

layer	thickness (μm)	X_0 (cm)
polyimide	150	28
adhesive	100	35
copper	36 × 0.25	14.3
AVERAGE	**300**	**20.5**

Ladder material budget :

sensors are glued to flex and both flex to foam => an adhesive layer appears 4 times.
Its thickness of 20 μm and X0 = 35cm (acrylat adhesive) are first very preliminary hypothesis.

material	X0(cm)	thickness (μm)	budget (%X_0)
SiC foam	8.7×8%	2000	0.18
sensor	9.36	50×2	0.11
adhesive	35	20×4	0.02
flex average	20.5	300×2	0.29
TOTAL			**0.60**