ILD vertex detector powering

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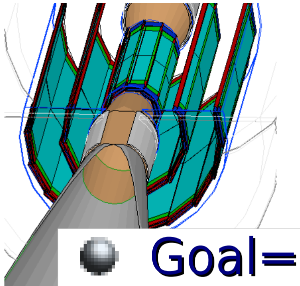
- ✗ Detector specifications
- ✗ CMOS sensor VXD
- ✗ Power integration strategy
- ✗ Details on each area
- ✗ Summary



ILD vertex detector specifications

Goal=impact parameter resolution

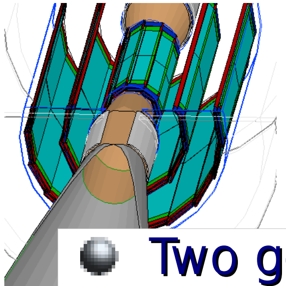
- ✗ Intrinsic sensor spatial resolution
  - ➔ high granularity: single point resolution 3 µm
    - 10^{8}(CMOS) to 10^{10}(FPCCD) pixels
- ✗ Multiple scattering
  - ➔ Low material budget for the whole system
    - few 0.1% X0 range per layer

Require 0-suppression
→ power

Environment

- ✗ Large beam background hits
  - ➔ Dominates the data throughput, whatever the technology
    - *O*(20) Mbits / train
- ✗ Inner region
  - ➔ Not much space
  - ➔ "adiabatic" operation important / thermal budget
  - ➔ Light structure important / material budget

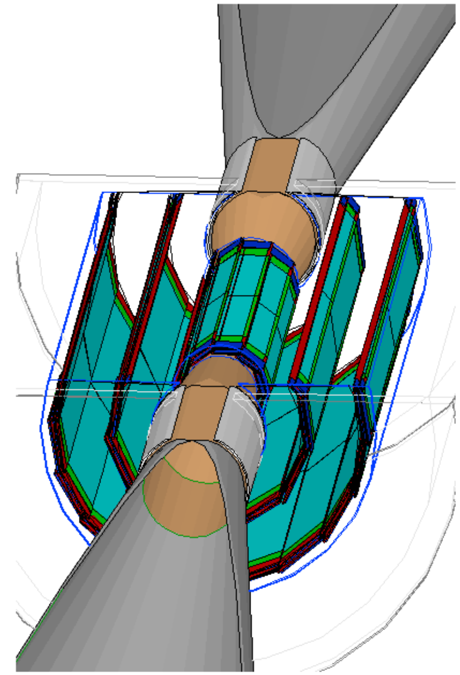
power



The CMOS sensor-based VXD

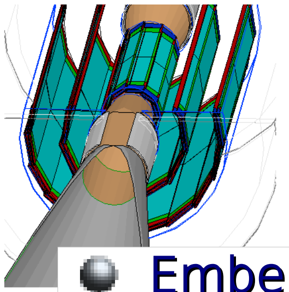
Two geometries

- ✗ 3 double-sided layers = baseline
  - ➔ Double-sided = one support equipped with sensors on both sides
- ✗ 5 single-sided layers
- ✗ Same envelope
  - ➔ Radius coverage
  - ➔ Ladder-end support



layer	radius (mm)	width (mm)	length (mm)	# ladders	# sensors*
1	16/18	11	125	14	168
2	37/39	22	250	26	312
3	58/60	22	250	40	480
total				**80**	**960**

* Numbers corresponding to current CMOS technology (0.35 µm) prototypes



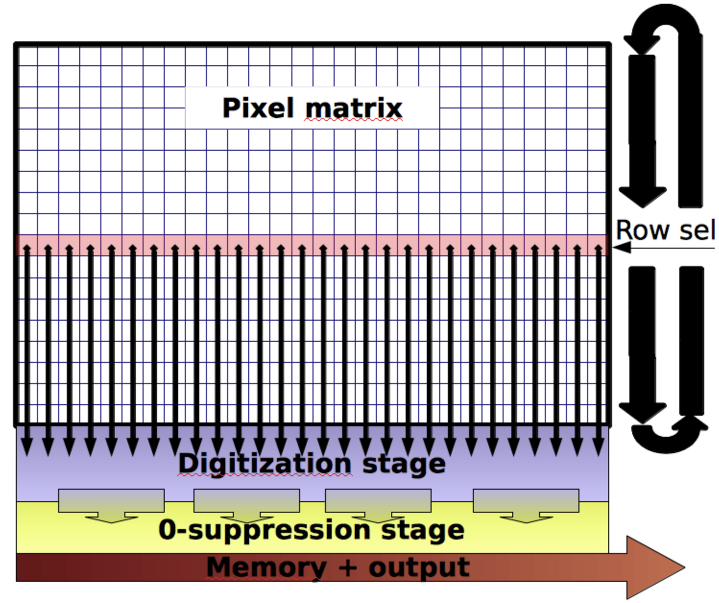
CMOS sensors for the VXD

Embedded functionalities

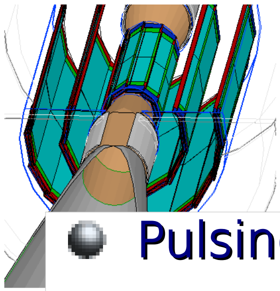
- ✗ In-pixel: pre-amplification pedestal suppression
- ✗ periphery: digitization + zero-suppression
- ✗ Readout strategy = rolling-shutter
  - ➔ Only during train
  - ➔ $t_{integration} = t_{read\text{-}out}$
- ✗ Existing prototype:
  - ➔ 2cm², 0.6Mpixels, t=100µs in CMOS 0.35µm
  - ➔ Development IPHC & IRFU
  - ➔ Evolution toward CMOS 0.18 µm

Optimization / layer

- ✗ Inner layer: face large beam background
  - ➔ shortest readout-time ~ 25 µs
  - ➔ pixel pitch 16x16 µm²
- ✗ Outer layers: optimize power
  - ➔ larger pitch (35 µm)
  - ➔ Keep resolution with 4 bits ADC



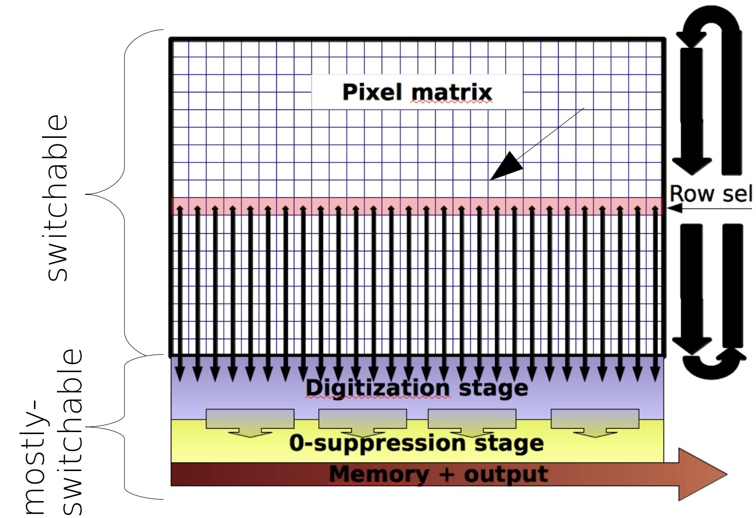
→ Detailed discussion in Marc Winter's talk, tomorrow



Power pulsing sensor

Pulsing strategy

- ✗ Activity period ~ 2 to 4 ms over the 200 ms train
  - ➔ Estimated duty cycle range: 1/50 to 1/100
- ✗ For stability reasons, not all element switchable
  - ➔ Test started for the analog part
  - ➔ To be done for the digital circuitry

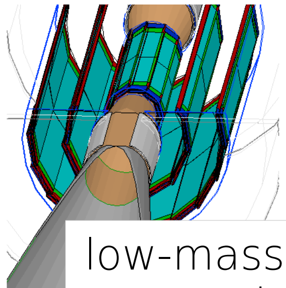


Assuming: 0.18µm techno. & 1.8 V voltage & continuous operation		sensor			2-sided ladder			whole detector		
		switch.	not-swi.	total	switch.	not-swi.	total	switch.	not-swi.	total
inner layer	power (W)	1,575	0,025	1,6	18,9	0,3	19,2	688 W	12 W	700 W
	current (A)	0,875	0,014	0,89	10,5	0,17	10,67			
outer Layers	power (W)	0,490	0,010	0,5	5,88	0,12	6	382 A	7 A	390 A
	current (A)	0,272	0,006	0,28	3,27	0,07	3,33			

Average power (integrating pulsing) 20 to 30 W

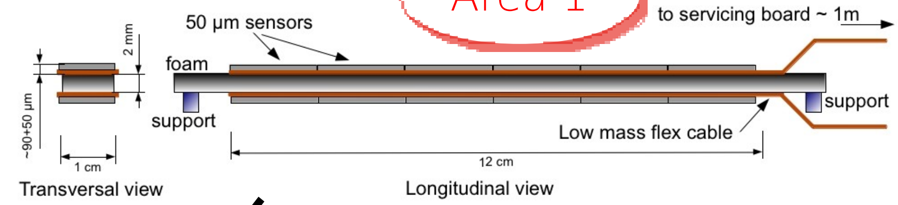
→ Air cooling probably good enough

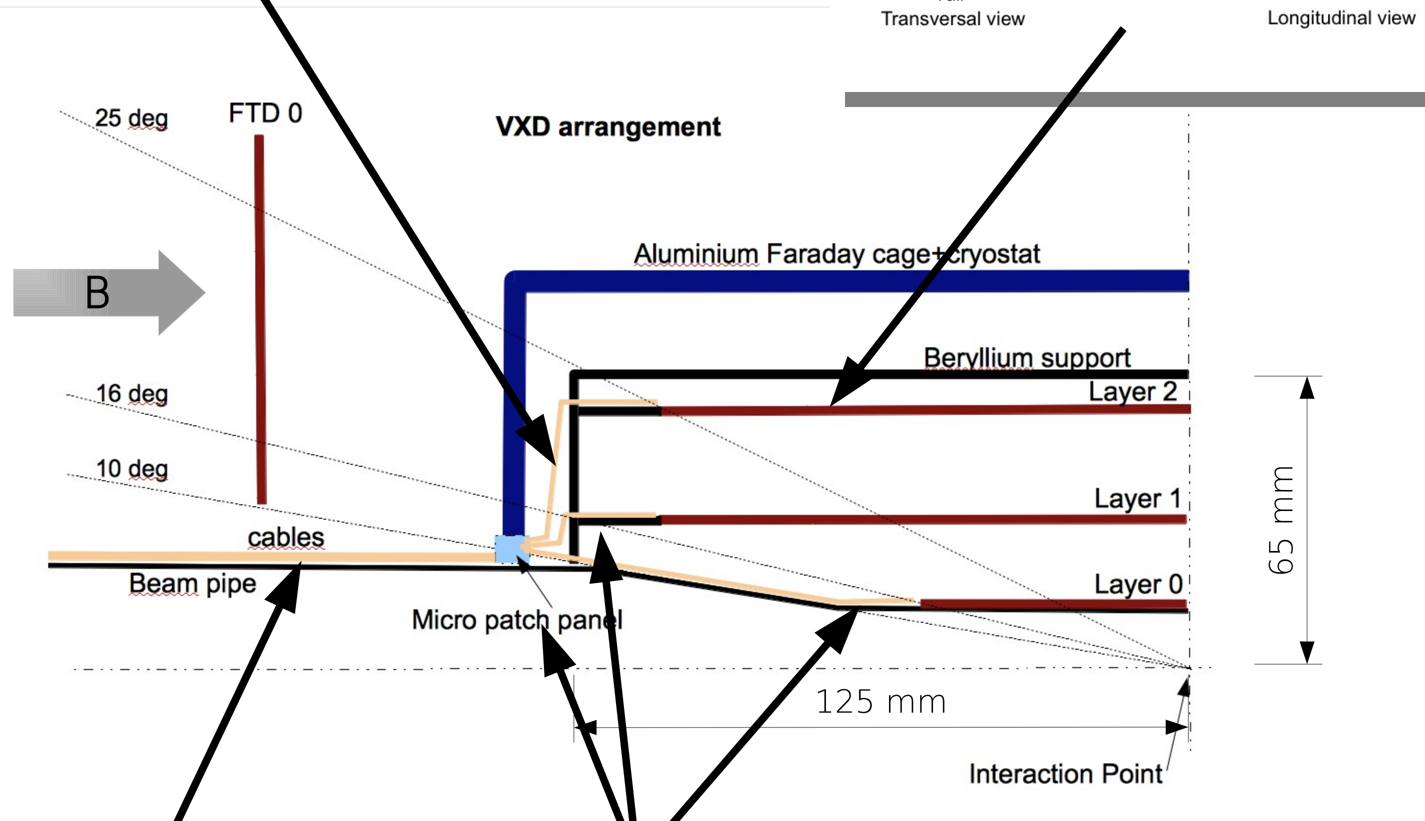
Power integration strategy



low-mass cables:
~ one / ladder

Area 2



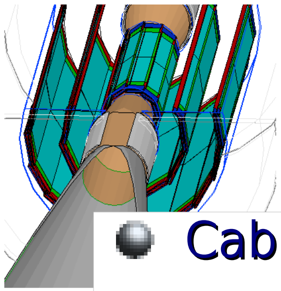


copper cables for power:
a few per side

Area 3

Power re-distribution
& potential conversion

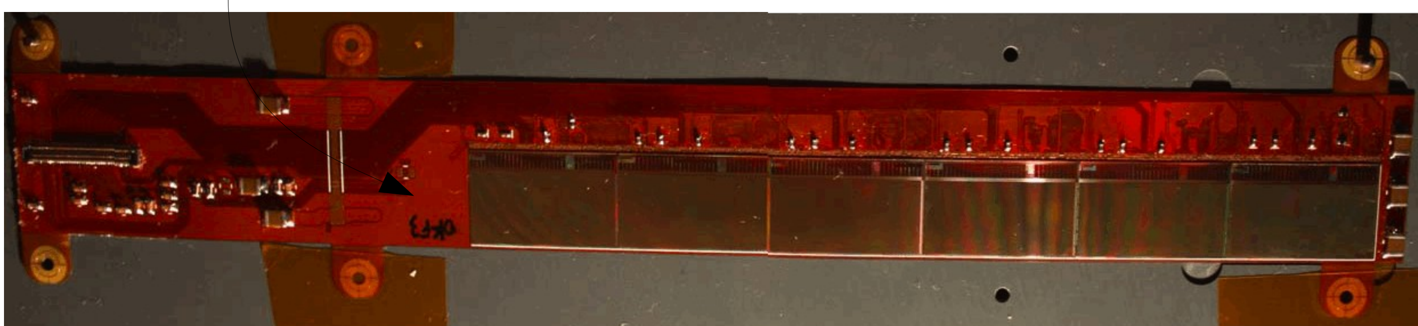
Cooling:
Air flow @ few m/s



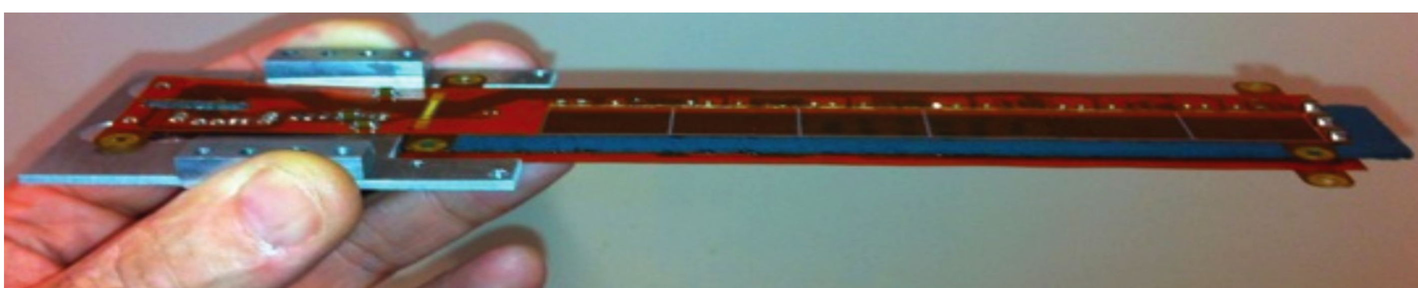
Area 1: sensor integration

Cable structure

- ✗ 2 metal layers in polyimide (1 to 2 x15 cm^2) + 6 sensors → weight ≤ 5 g
- ✗ Current ≤ 5 A / cable → typical section for each aluminum power trace: 10 µm x ≥ 2 mm
  - ➔ limit the voltage drop to about 0.1 V over 15 cm
  - ➔ ~ 5 % additional power dissipated
- ✗ Parallel powering assumed so far
- ✗ Could include DC-DC converter chip at cable end & regulators inside sensor
  - ➔ Material budget and heat cost?

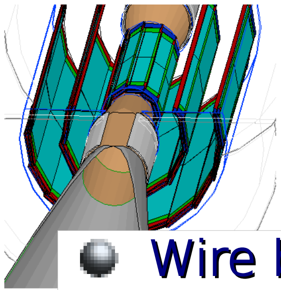


→ Under development within the PLUME project: DESY + IPHC + U.Bristol + U.Oxford



This structure weight 0.6 % of X0 (2010)

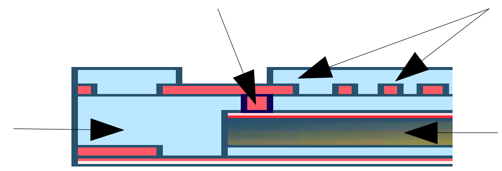
Target for 2011: 0.3%



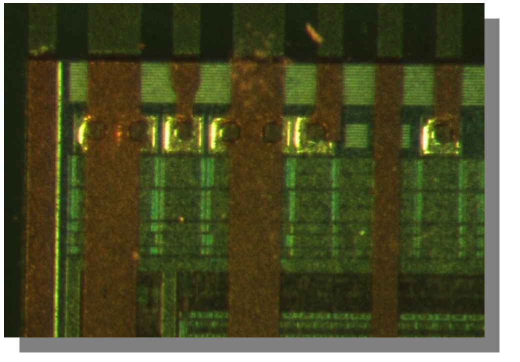
Area 1: power pulsing

Wire bonds

- ✗ Average current through powering wires ~10 mA
  - ➔ Small residual force in B=4T but vibrations possible
- ✗ Monolithic sensors are easy to handle
  - ➔ Possibility to embed in polyimide & connect through metallization
  - ➔ IMEC+CMST & CERN projects



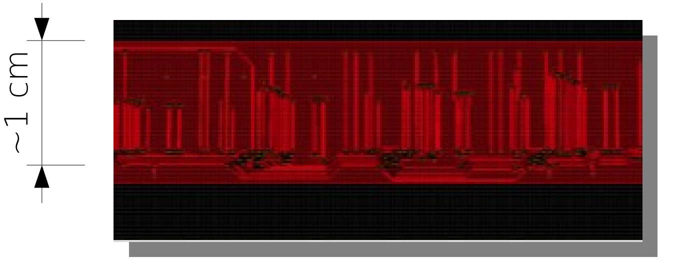
profile view

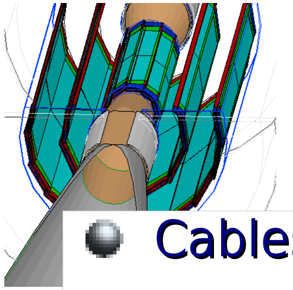


Top view
1st trial of a MIMOSA embedded by IMEC

Lorentz force on low mass cable

- ✗ Many "small" transverse traces
  - ➔ Residual force could reach few g ≈ cable mass!
- ✗ Double-sided structure could be used to counter-balance the effect
  - ➔ Cable design with reverse current path on each side
- ✗ Switching sensors with some delay and not simultaneously → reduce current
  - ➔ Require specific sensor functionalities





Area 2: intermediate cables

Cables

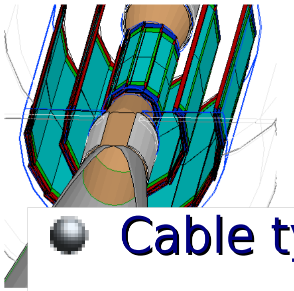
- ✗ Length ≤ 10 cm
- ✗ Low mass still required to preserve forward region
  - ➔ Metal = aluminum
  - ➔ Metal thickness limited
- ✗ Current @ 1.8 V: 5 to 10 A / ladder
  - ➔ One cable may serve several ladder, current >10 A ?
  - ➔ ≤ 40 such cables on each side of the VXD
- ✗ <u>Higher voltage transport highly desirable</u>
  - ➔ Require DC-DC converters at ladder end

Lorentz force

- ✗ Several Amps at switching on, transverse to B
  - ➔ Lateral forces
- ✗ Run along beryllium disk support structure
  - ➔ Cables could be fixed

Optimization to be done for conductor sizing

- ✗ Material budget
- ✗ Power dissipated in cable
- ✗ Voltage drop



Area 3: power transport cables

Cable type

- ✗ Still inside the detector but not in fiducial volume → copper allowed
- ✗ Weighting against & heating the beam pipe

Nominal voltage power transport

- ✗ At 1.8 V : current to transport in activity is ~400 A (otherwise ≤ 10 A)
- ✗ Requiring a voltage drop < 0.1 V → section of conductor ~ 0.8 cm^2
- ✗ Total weight ~ 7 kg
- ✗ Power dissipated in conductors 40 W (with duty cycle 1/100 to 1/50)
  - ➔ Small compared to 700 W

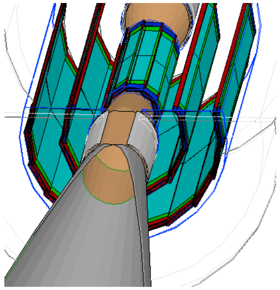
Higher voltage power transport

- ✗ Both weight and power dissipated decrease linearly with voltage

Pulsing

- ✗ Longitudinal cable / B field → no Lorentz force
- ✗ How fast can we switch on/off many Amps on 4 meters?

Technical solutions
still to investigate:
- power supplies
- cables with high rise time
if no DC-DC converters



Summary

- **The CMOS sensor based ILD vertex detector**
  - is a 1000 sensors detector
  - dissipates ~ 700 W (~400 A) during train
  - dissipates 20 to 30 W in average with power pulsing
- **Power distribution**
  - studied on the ladder through dedicated R&D (PLUME project)
  - will benefit from DC-DC converters but not quantitatively estimated yet
  - No safety/failure analysis yet
- **Power pulsing**
  - Absolutely necessary for material budget (through cooling)
  - Largely not yet experimented with prototypes
    - Starting with sensors
    - Some material ready for low mass cabels
  - Potential mechanical issues need setup with large B field