Overview of Spanish Tracking R&D for FLC

Alberto Ruiz-Jimeno (IFCA, CSIC-Univ. Cantabria)
(on behalf of the Spanish Network for Future Linear Accelerators)

International Linear Collider Workshop 2010
LCWS10 and ILC10

Worldwide Study of
the Physics and Detectors
for Future Linear
e^+e^- Colliders

Coordinated FLC detector- effort in Spain

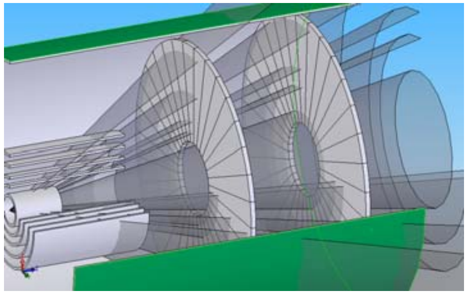
Silicon for Large Colliders

IFIC, IFCA (since 2005), UB, CNM, USC
IFCA→EUDET member, several associates
New EU project: AIDA

Strong Spanish participation in DEPFET
IFIC (since 2005)
USC, UB, URL, CNM (since 2008)
IFCA (mechanical alignment and integration)

CALICE

CIEMAT Madrid

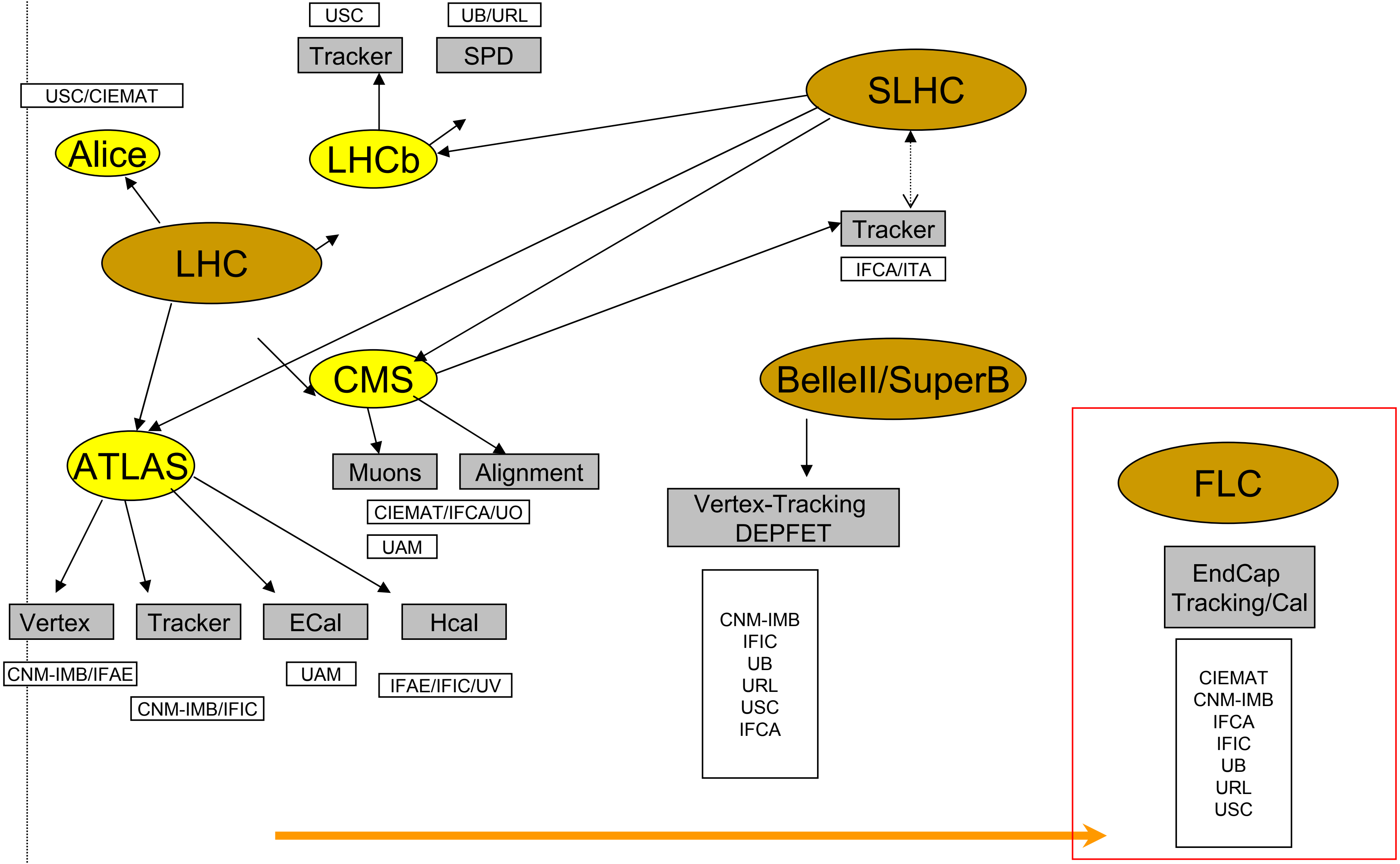


and activities in accelerators R&D

Also some theoreticians involved

Coordinated effort :
- **regular meetings**
- **funding/projects**
- **R&D interests**
- **the forward tracker…**

Spanish interest and evolution



Aims:

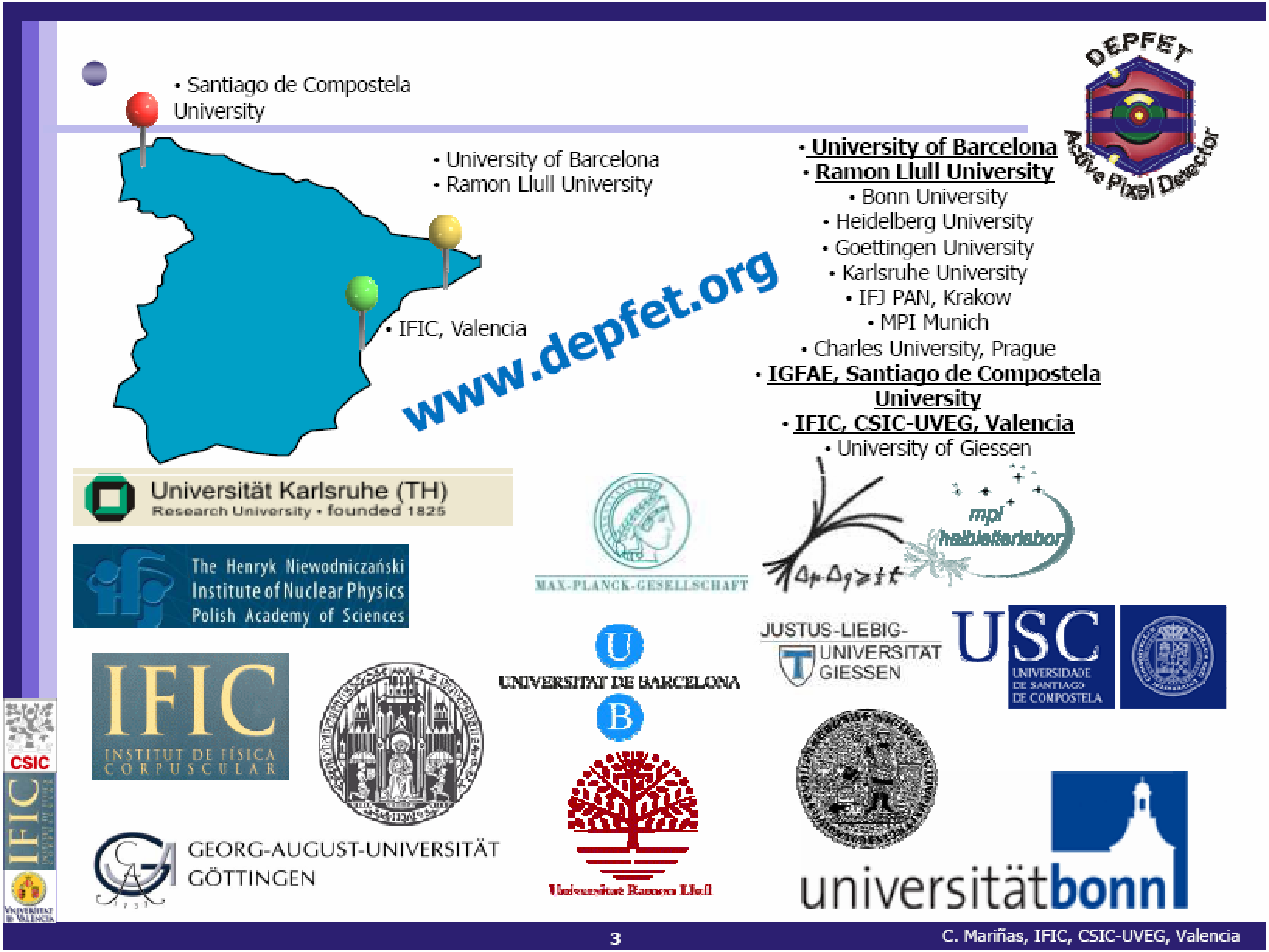
- LongTerm: participate in the design and construction of the forward tracker and vertex detectors of the FLC

→

- Research and development of technologies to reach accurate and efficient reconstruction of charged particle trajectories as well as primary and secondary vertexes
- Alignment and Integration
- Simulation and optimization studies

Studies of technologies for the vertex

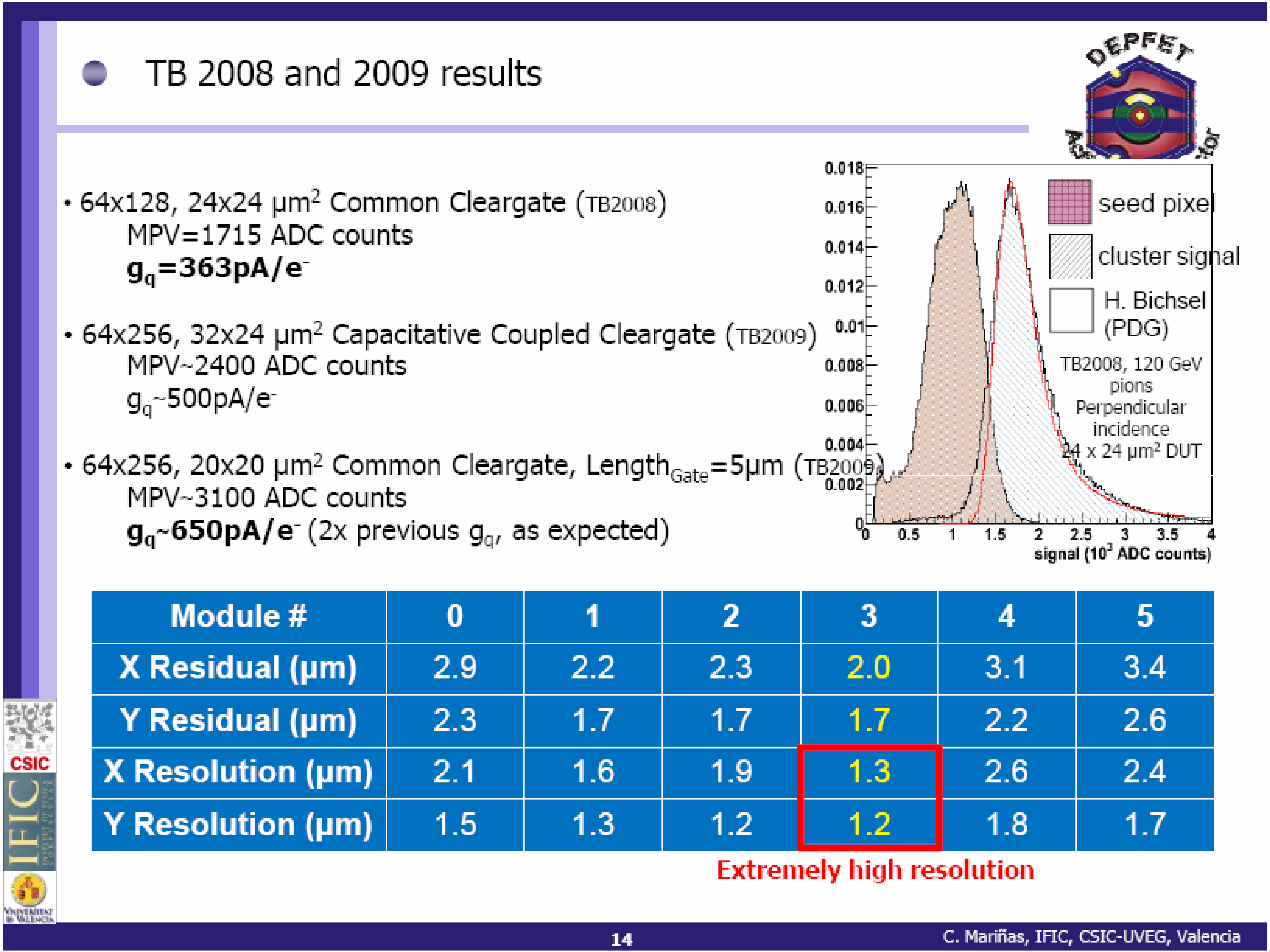
- DEPFET (good resolution and sensitivity, low power consumption, low material budget, good Signal over Noise)
- Thin active pixels, readout by TIMEPIX (time stamping capable, thinning needed on the sensor and the chip, power cycling to be studied)
- CMOS Single Photon APD´s (high gain, simple readout electronics, so low power consumption, extremely fast response)
- Others (contacts with MAPS, FPCCD)



- Santiago de Compostela University
- University of Barcelona
- Ramon Llull University
- IFIC, Valencia

www.depfet.org

- **University of Barcelona**
- **Ramon Llull University**
- Bonn University
- Heidelberg University
- Goettingen University
- Karlsruhe University
- IFJ PAN, Krakow
- MPI Munich
- Charles University, Prague
- **IGFAE, Santiago de Compostela University**
- **IFIC, CSIC-UVEG, Valencia**
- University of Giessen



TB 2008 and 2009 results

- 64x128, 24x24 µm² Common Cleargate (TB2008)
  MPV=1715 ADC counts
  g_q=363pA/e⁻
- 64x256, 32x24 µm² Capacitative Coupled Cleargate (TB2009)
  MPV~2400 ADC counts
  g_q~500pA/e⁻
- 64x256, 20x20 µm² Common Cleargate, Length$_{Gate}$=5µm (TB2009)
  MPV~3100 ADC counts
  g_q~650pA/e⁻ (2x previous g_q, as expected)

Module #	0	1	2	3	4	5
X Residual (µm)	2.9	2.2	2.3	2.0	3.1	3.4
Y Residual (µm)	2.3	1.7	1.7	1.7	2.2	2.6
X Resolution (µm)	2.1	1.6	1.9	1.3	2.6	2.4
Y Resolution (µm)	1.5	1.3	1.2	1.2	1.8	1.7

Extremely high resolution

Studies for the first 3 disks of the FTD:

- Performance evaluation in test beams TimePix assembly last summer and laser/source test stand this year.

  55 um pixel size

  300 um thickness

  Hit resolution ~5 um

  Track resolution ~2.6 um

- Thinning of sensor substrate in collaboration with CNM

- Beside that, in col. With CERN, Nikhef and UK :

Telescope based on Timepix with following characteristics

Active area: 2.8x2.8 cm2
Resolution: 2 um, 1 ns
Readout rate: 75 kHz

(To be used in R&D in detectors for ILC or LHC upgrades)

APDs for the FT region

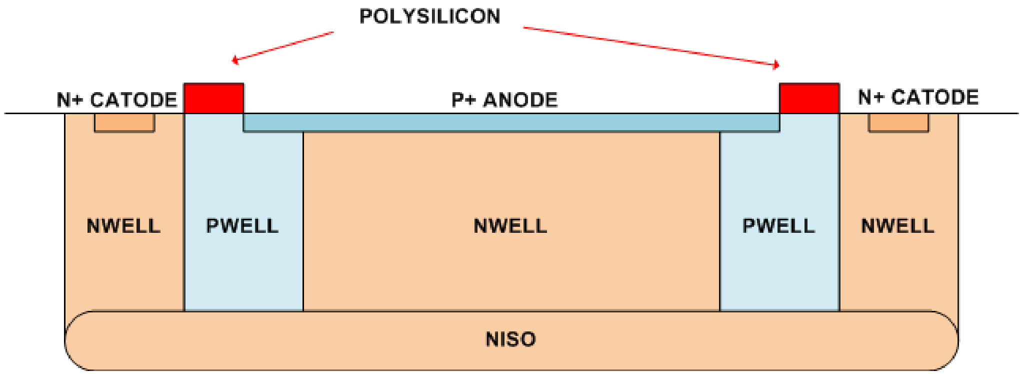
Avalanche photodiodes in standard CMOS technologies

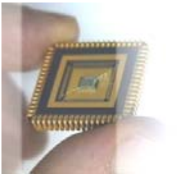
Learning from the fabricated structures: STM 130nm, AMS 0.35um

Detector instabilities (dark counts, afterpulsing, cross-talk) are instabilities contributing to the detector response. Have deep impact on the readout details. It is very important to understand their origin and to reduce their incidence.

Trying to learn also from device simulations

Design of pixels and readout structures: Active quenching and fast readout.





UNIVERSITAT DE BARCELONA

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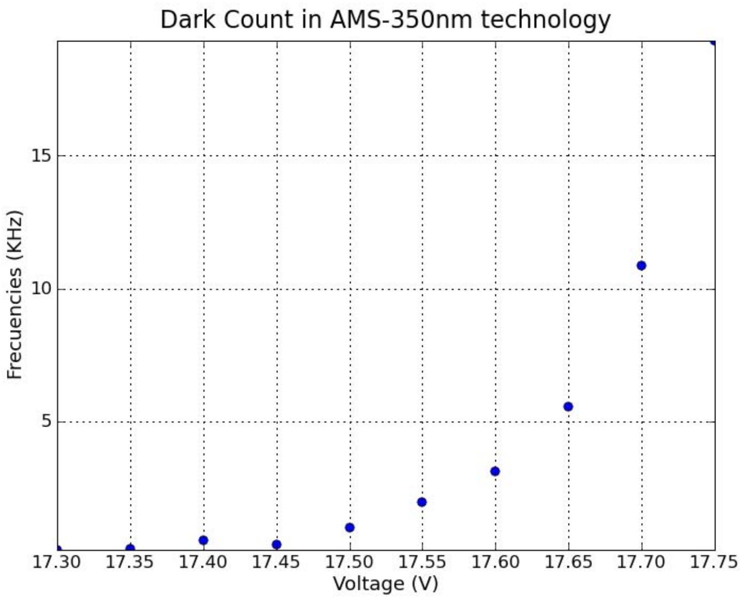
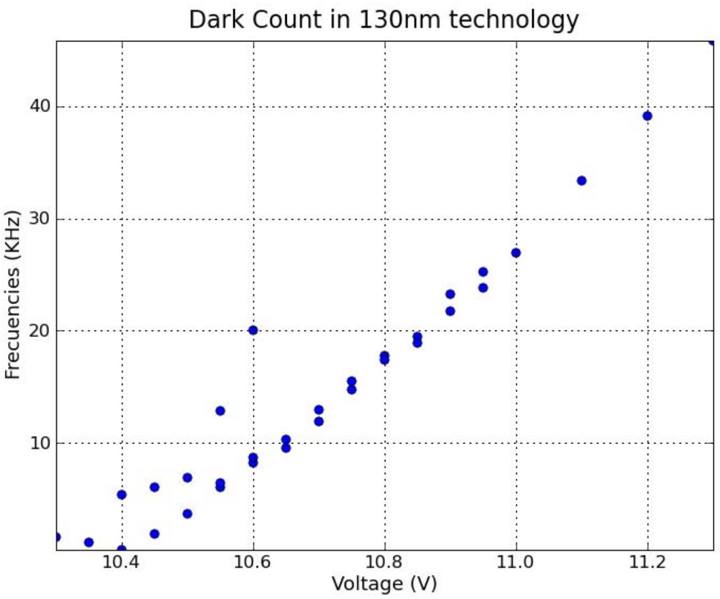
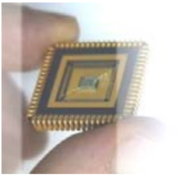


Dark Count in AMS-350nm technology



Dark Count in 130nm technology



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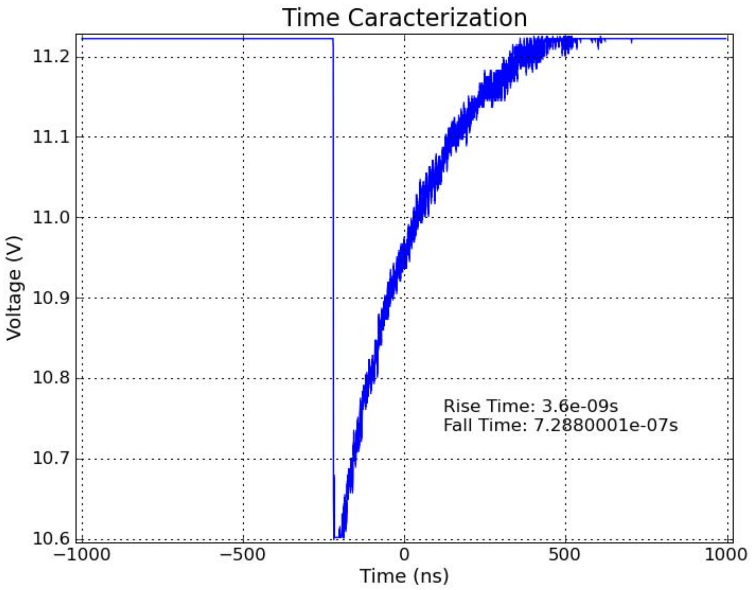

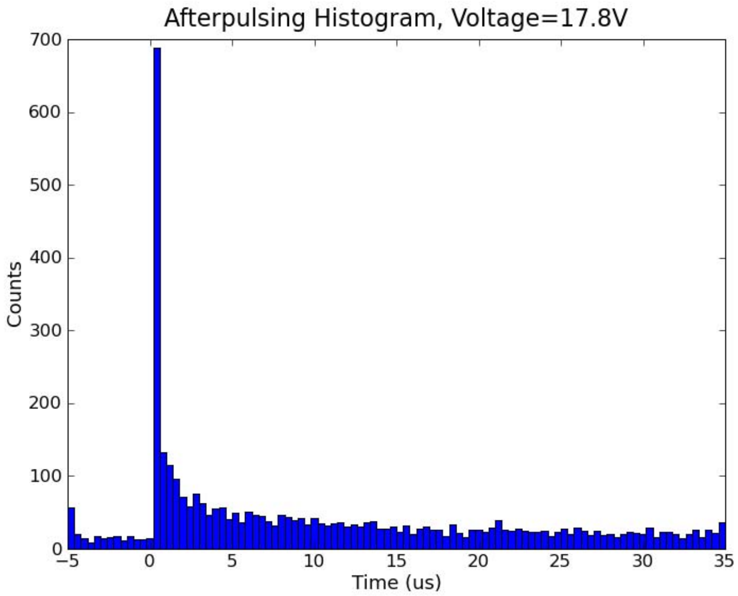

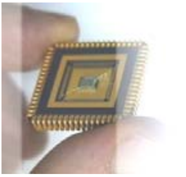

APDs for the FT region

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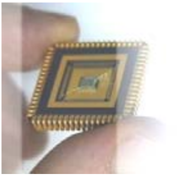
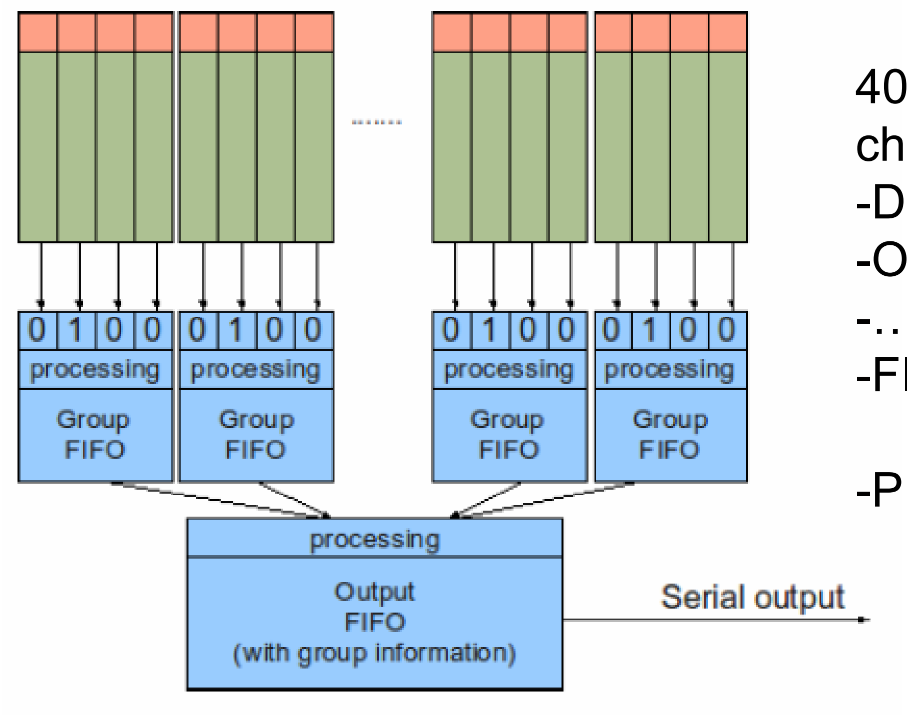
Parameter	AMS HV 350 nm	STM LV 130 nm
Vb	17.2V	10.4 V
Tq	40-70 ns	1.5 – 2 ns
Dark count	5kHz (ΔV~0.3V)	10kHz (ΔV~0.3V)
Afterpulsing	high	Low
Crosstalk	<5%	?



APDs for the FT region

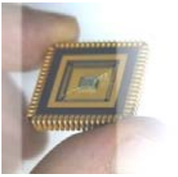
News designs including readout…

Pixel in Geiger mode with active quenching + control of recharge time (adapted to detector/testbeam)
10ns signal and 300ns to send data in ILC (50% / 50% in testbeam)
Occupancy determined by dark count ..0.7avalanches/pixel/ms
3 x 3mm2 translates to a 25 x 152 pixels matrix



400MHz clock is needed in the chip for FIFOs
-DLL on chip
-On chip clock
-…
-FIFOs, control, …

-PIXEL



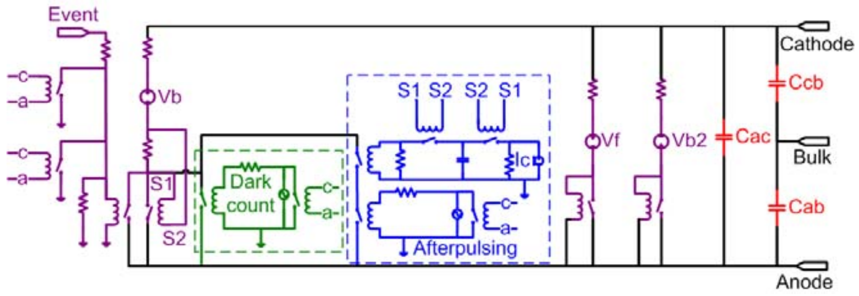
APDs for the FT region

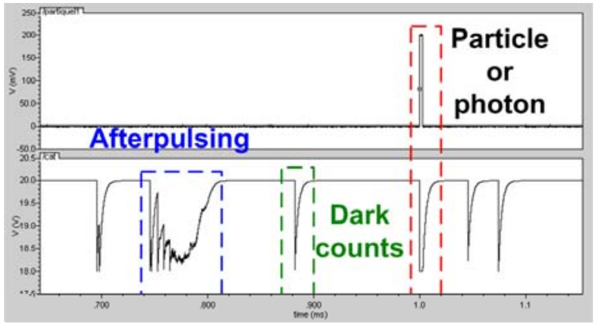
Future designs…

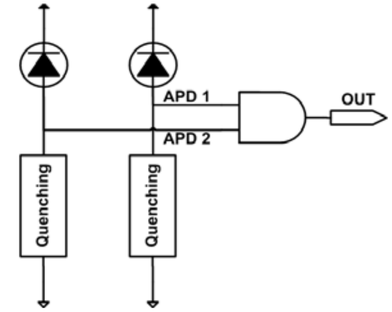
3D interconnection for

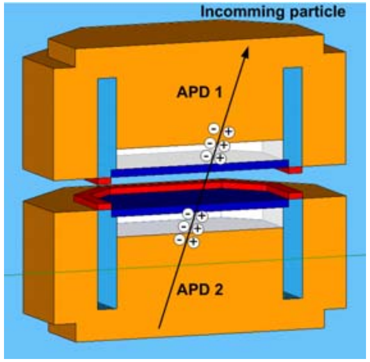
- **1) coincidence filtering , triggering**
- **2) 100% coverage**

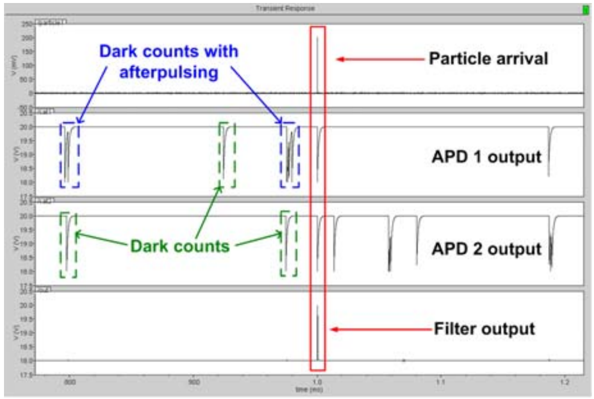
Design for test beam for a developed APD array, radiation tolerance tests, …











Sensor developments for the endcap tracker

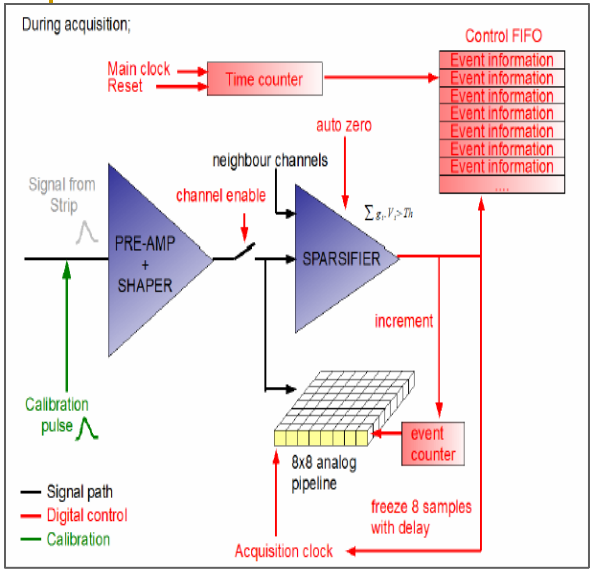
- More relaxed conditions of material budget (~0.25 % X0 first three disks, ~0.65 % X0 last four disks), spatial resolution of 7 µm in Rφ. Very thin (150-200 µm thick) silicon microstrip sensors, pitch of ~ 40 µm. Low power FEE
- Both pixel and micro-strip silicon technologies are being considered
- Characterization of the sensors in the lab
- Edgeless studies to reduce dead zones, removal of pitch adapter to increase signal over noise
- Readout electronics, connectivity
- Integration, mechanical and thermal studies
- Alignment sensors, FOS sensors
- Test beams

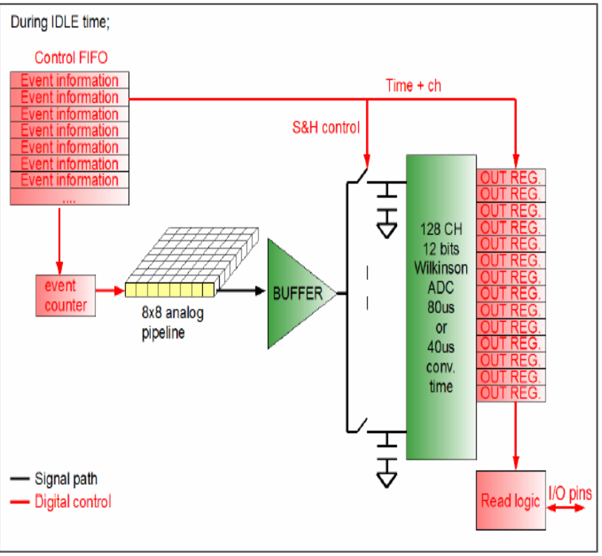
UMC CMOS 130nm
ASIC received first week of October'08

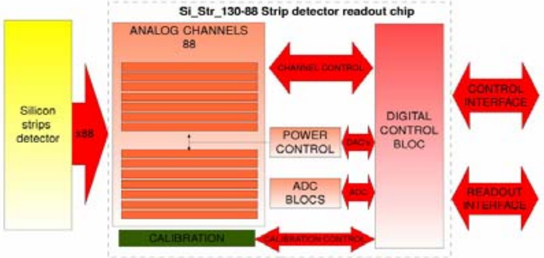
Mixed signal ASIC for readout of Si strip sensors in ILC

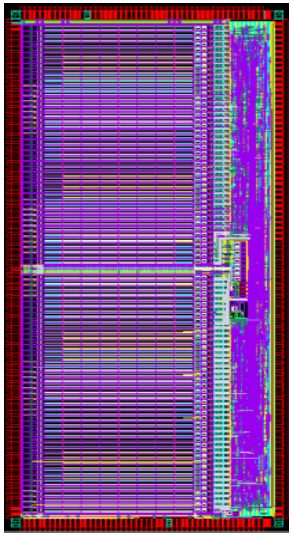
88 channels

Analog part designed by IN2P3
Digital part designed by UB







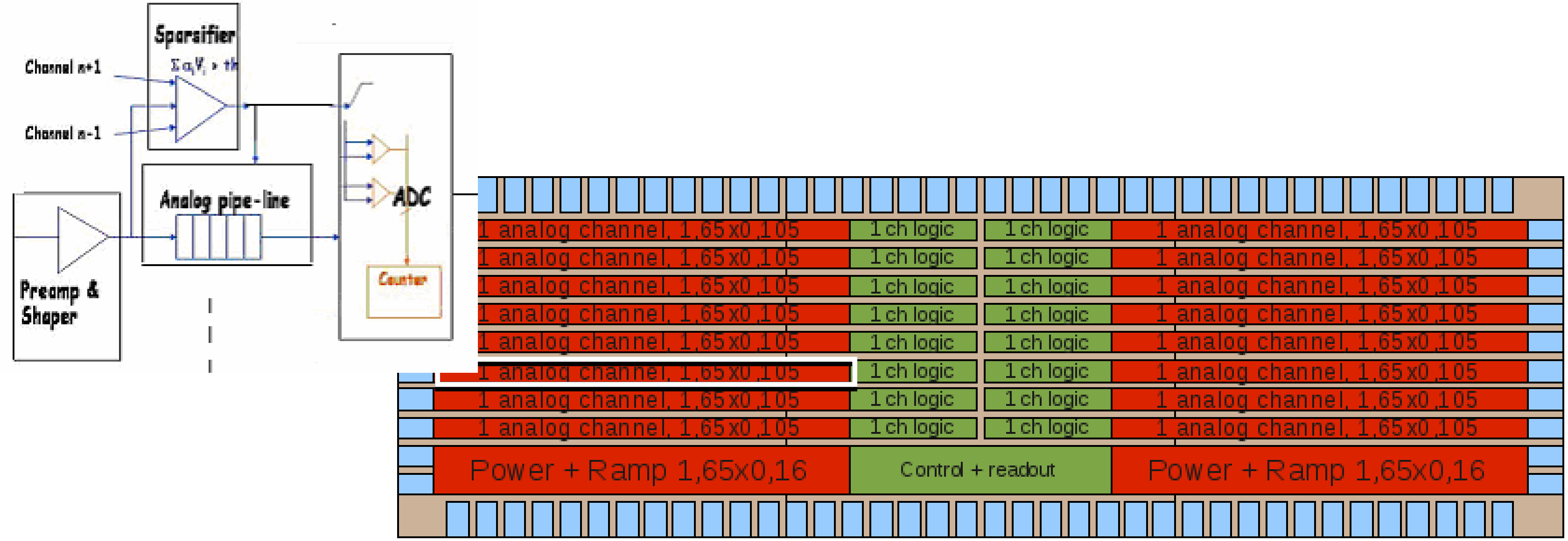


Collaboration with LPNHE-Paris in digital circuitry for Si-strips

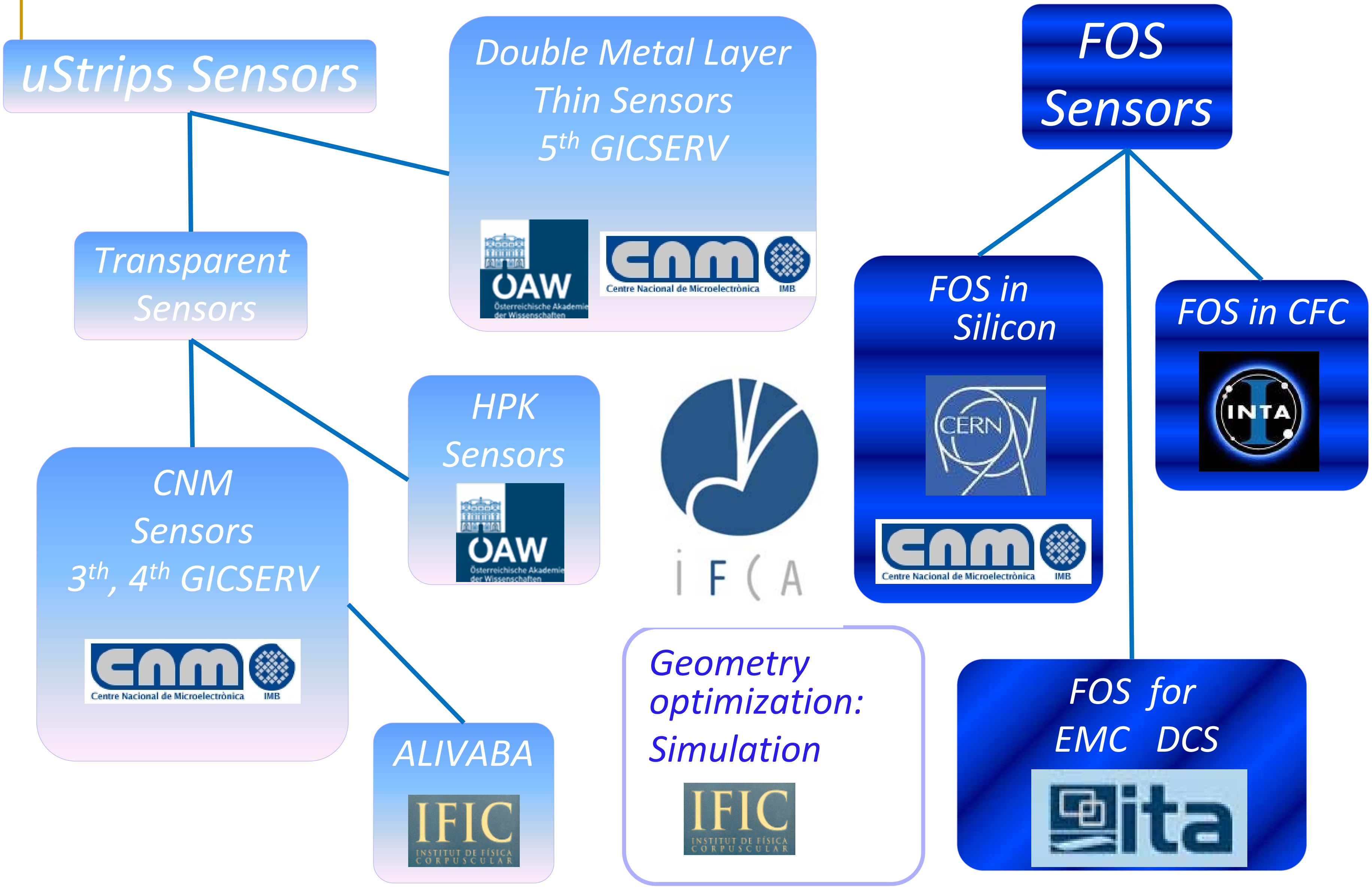
Si strips readout – col. In2P3

Plan for future SiStr chip

Define technology: 130nm IBM, 130nm ST, 90nm IBM
Adapt 1 channel electronics: both Analog and Digital
Build 8-16 channel module: Adapt control electronics to a basic module of 8-16 channels. Build 1st complete module in Si.
…128 channels



1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
1 analog channel, 1,65x0,105	1 ch logic	1 ch logic	1 analog channel, 1,65x0,105
Power + Ramp 1,65x0,16	Control + readout		Power + Ramp 1,65x0,16



uStrips Sensors

Double Metal Layer
Thin Sensors
5th GICSERV

Transparent
Sensors

HPK
Sensors

CNM
Sensors
3th, 4th GICSERV

ALIVABA

FOS
Sensors

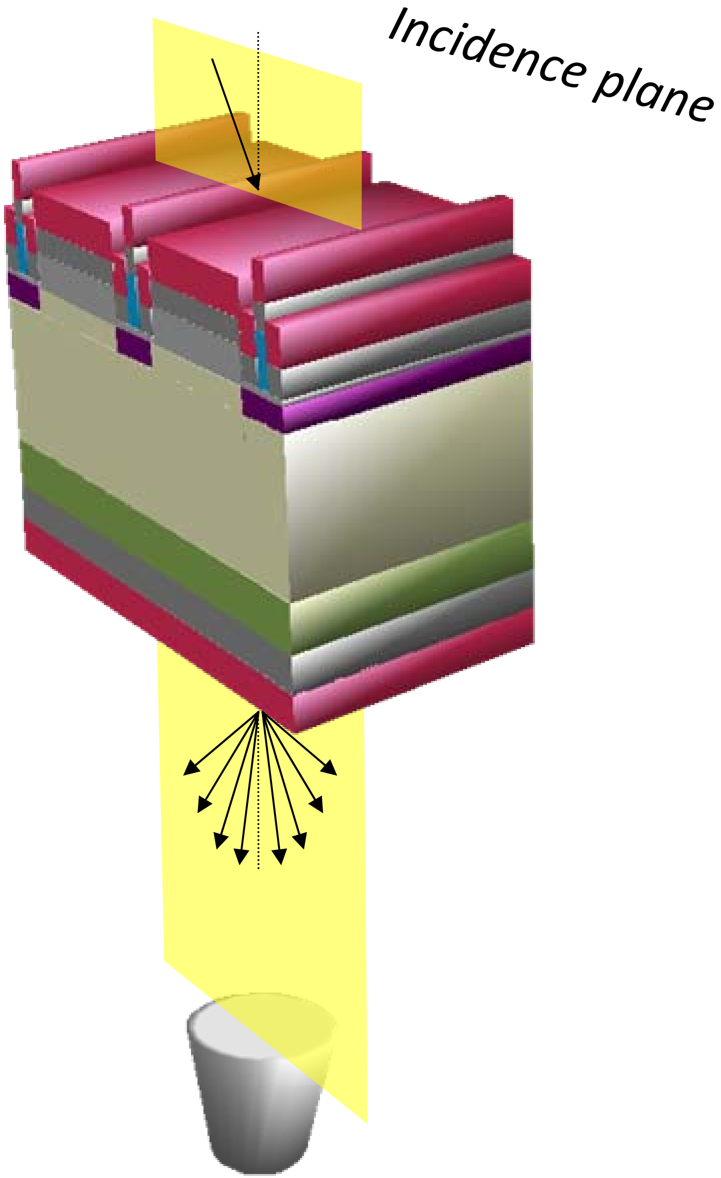
FOS in
Silicon

FOS in CFC

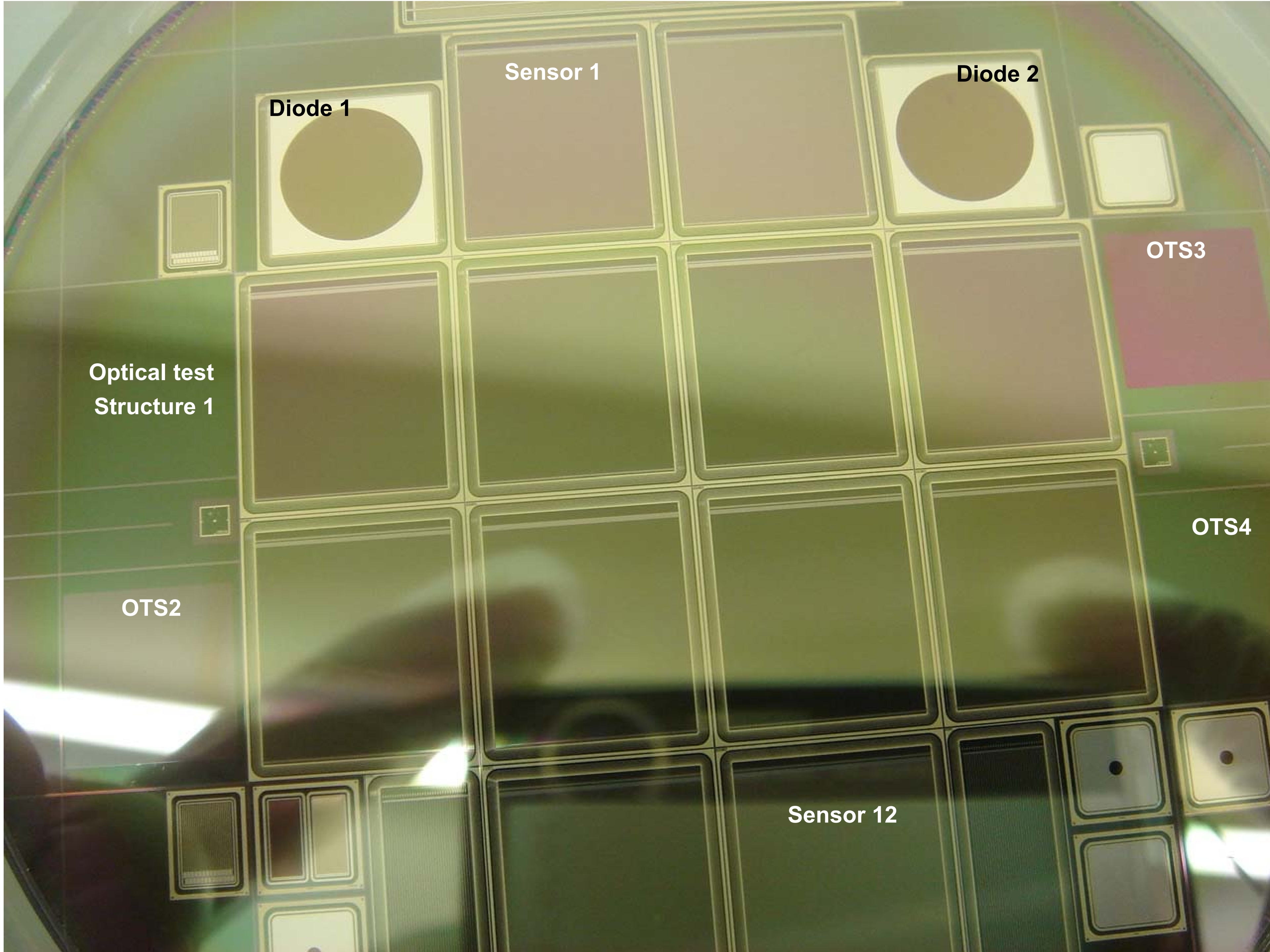
FOS for
EMC DCS

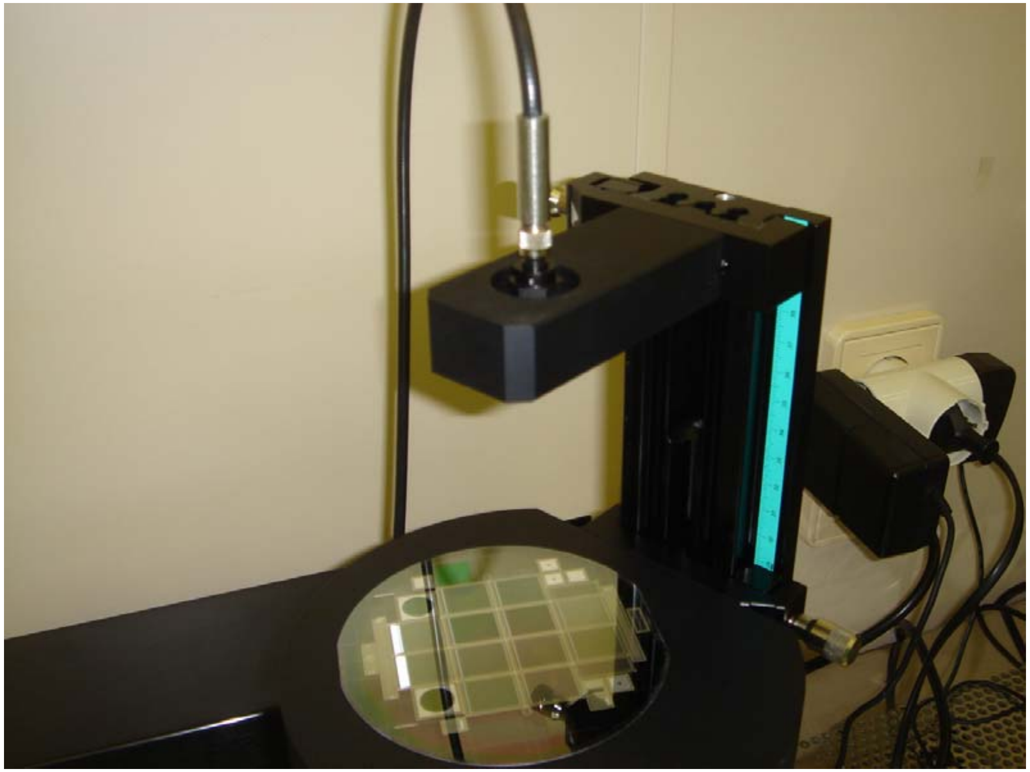
Geometry
optimization:
Simulation

Alignment: Optical computation validation:



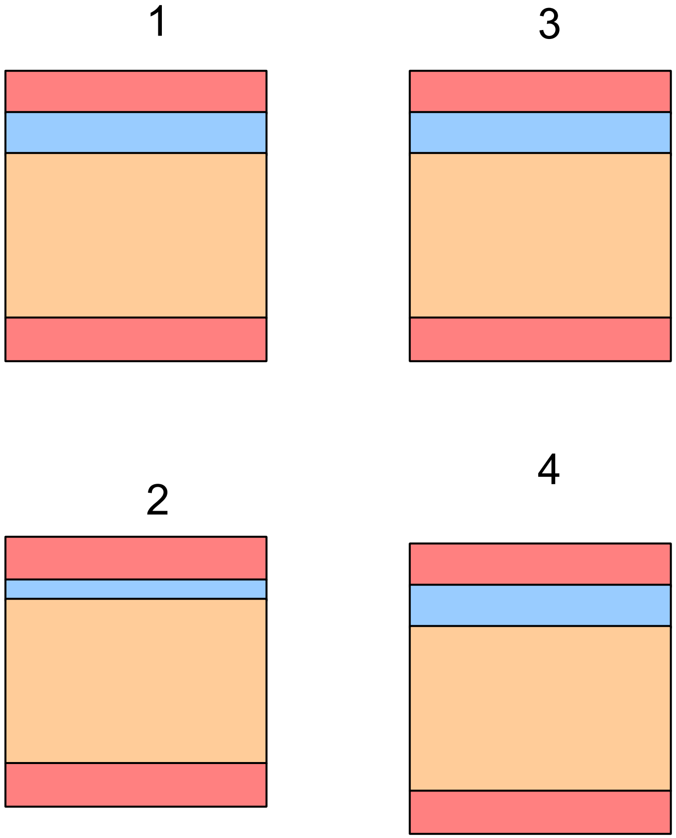
1. Validation of optical simulation software with material samples (planar multilayer samples) Obtain optical parameters
2. Validation of optical simulation for layered diffraction grating.
3. Optical simulation of optical test structures and actual sensors.

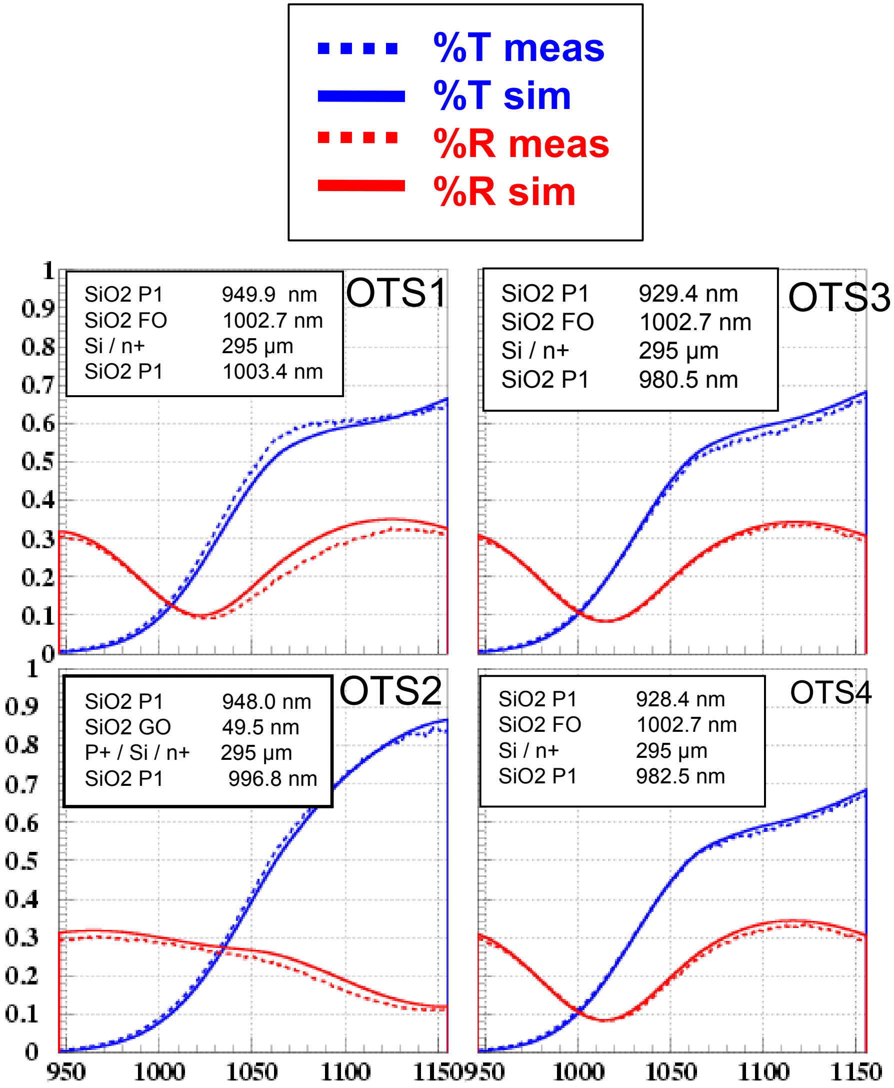

Sensor 1
Diode 1
Diode 2
OTS3
Optical test
Structure 1
OTS4
OTS2
Sensor 12



Comparing measurement with simulated nominal (only SiO2 passivation)

Optical Test Structure stacks with only SiO2 on top





OTS1

SiO2 P1	949.9 nm
SiO2 FO	1002.7 nm
Si / n+	295 µm
SiO2 P1	1003.4 nm

OTS3

SiO2 P1	929.4 nm
SiO2 FO	1002.7 nm
Si / n+	295 µm
SiO2 P1	980.5 nm

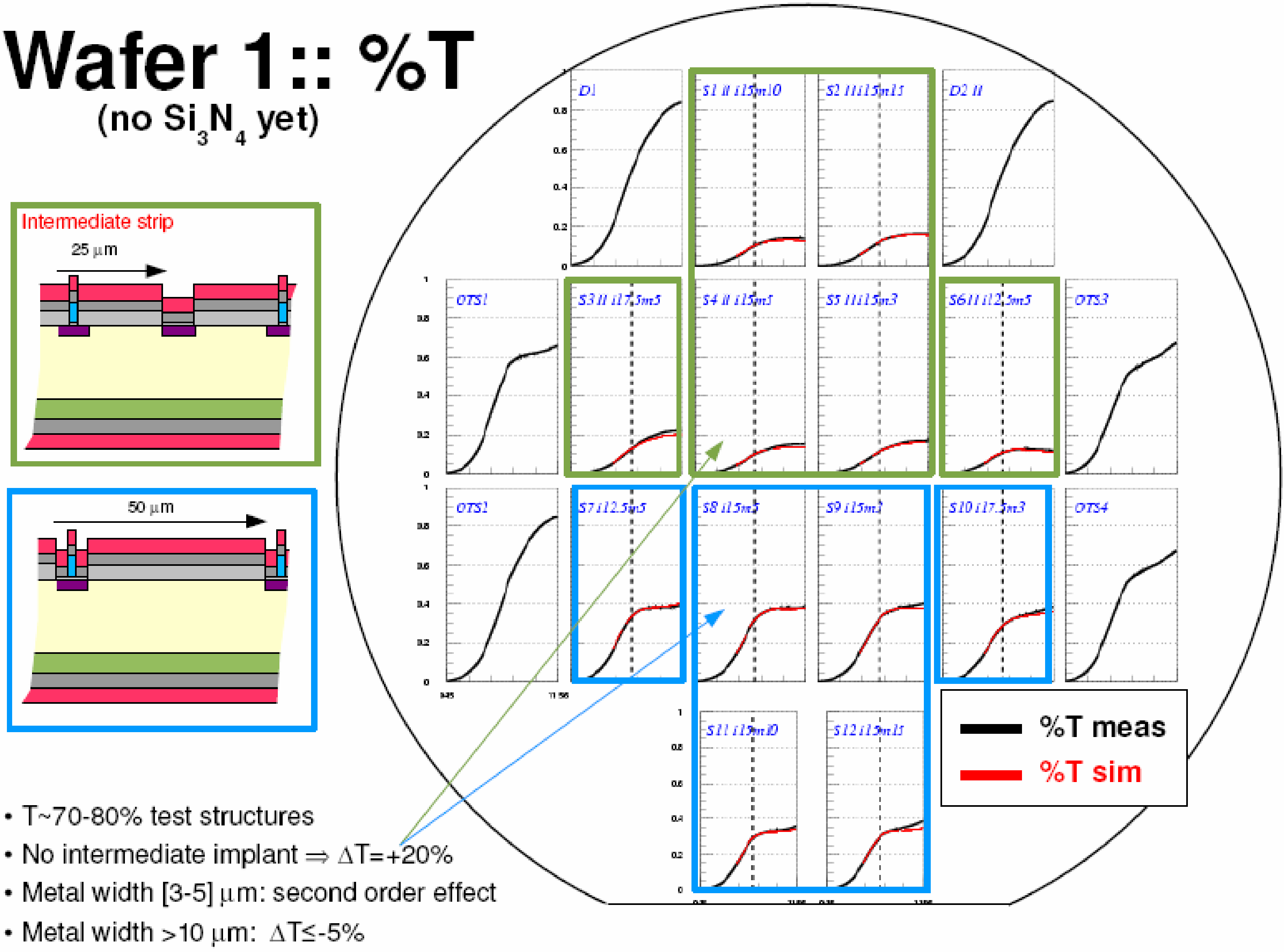
OTS2

SiO2 P1	948.0 nm
SiO2 GO	49.5 nm
P+ / Si / n+	295 µm
SiO2 P1	996.8 nm

OTS4

SiO2 P1	928.4 nm
SiO2 FO	1002.7 nm
Si / n+	295 µm
SiO2 P1	982.5 nm

Sensor measurement vs. calculations.



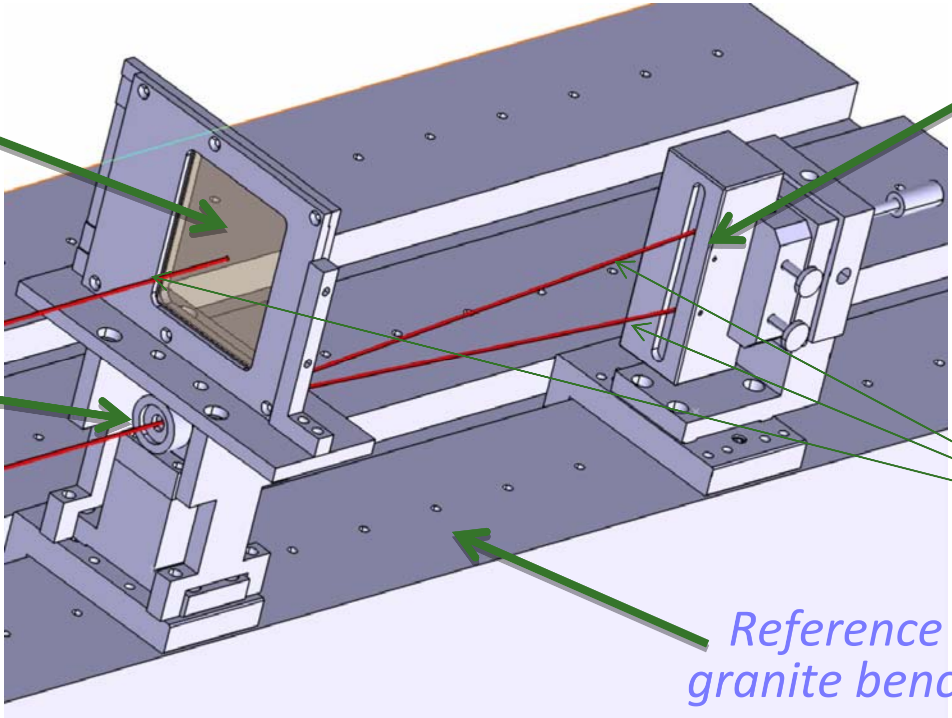
Wafer 1:: %T

(no Si_3N_4 yet)

- T~70-80% test structures
- No intermediate implant ⇒ ΔT=+20%
- Metal width [3-5] µm: second order effect
- Metal width >10 µm: ΔT≤-5%

Absolute accuracy Determination

- Direct comparison with interferometric measurement (accuracy better than 1 um).



Sensor to be calibrated

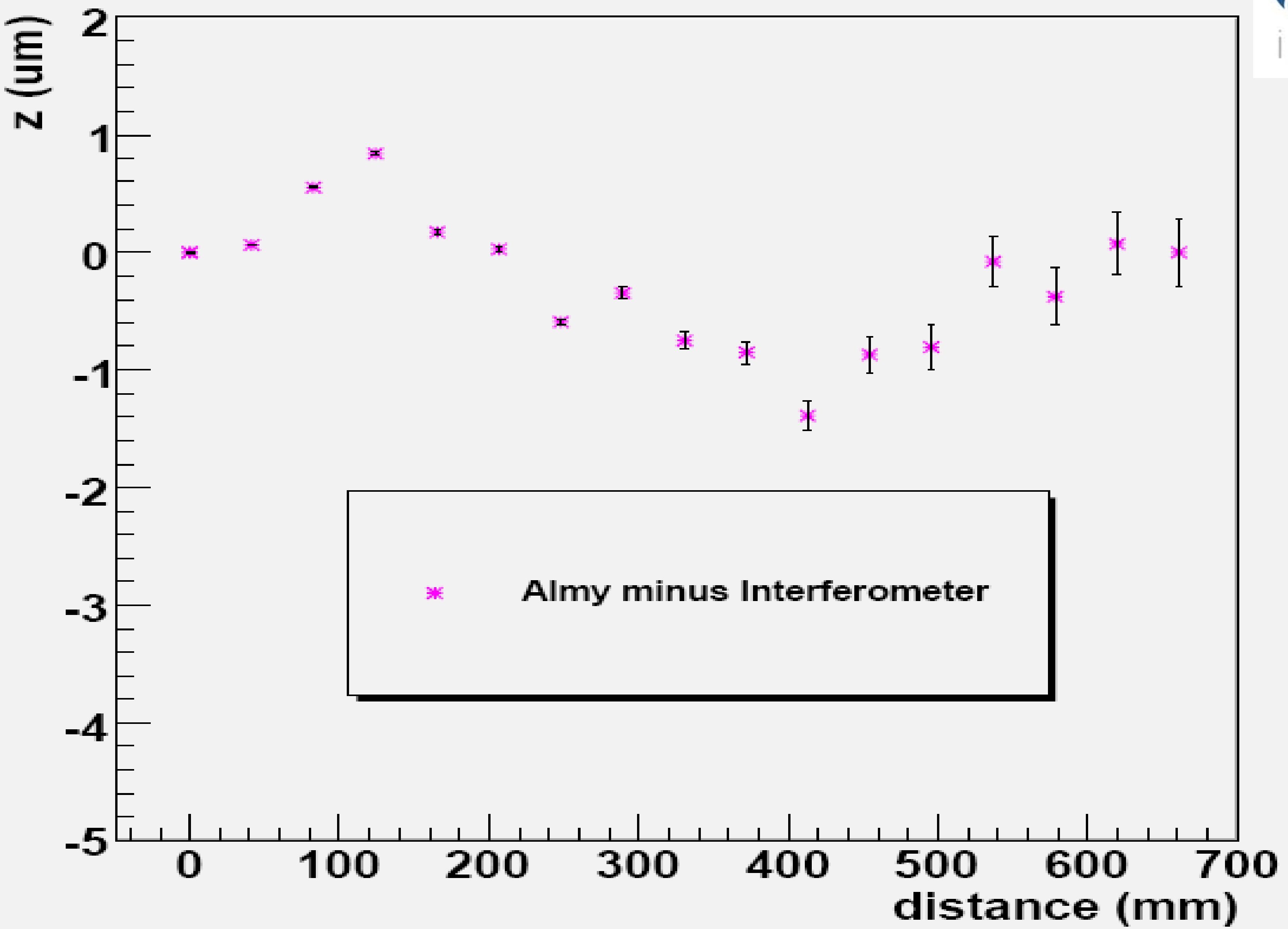
Interferometer reflector

Wollaston prism

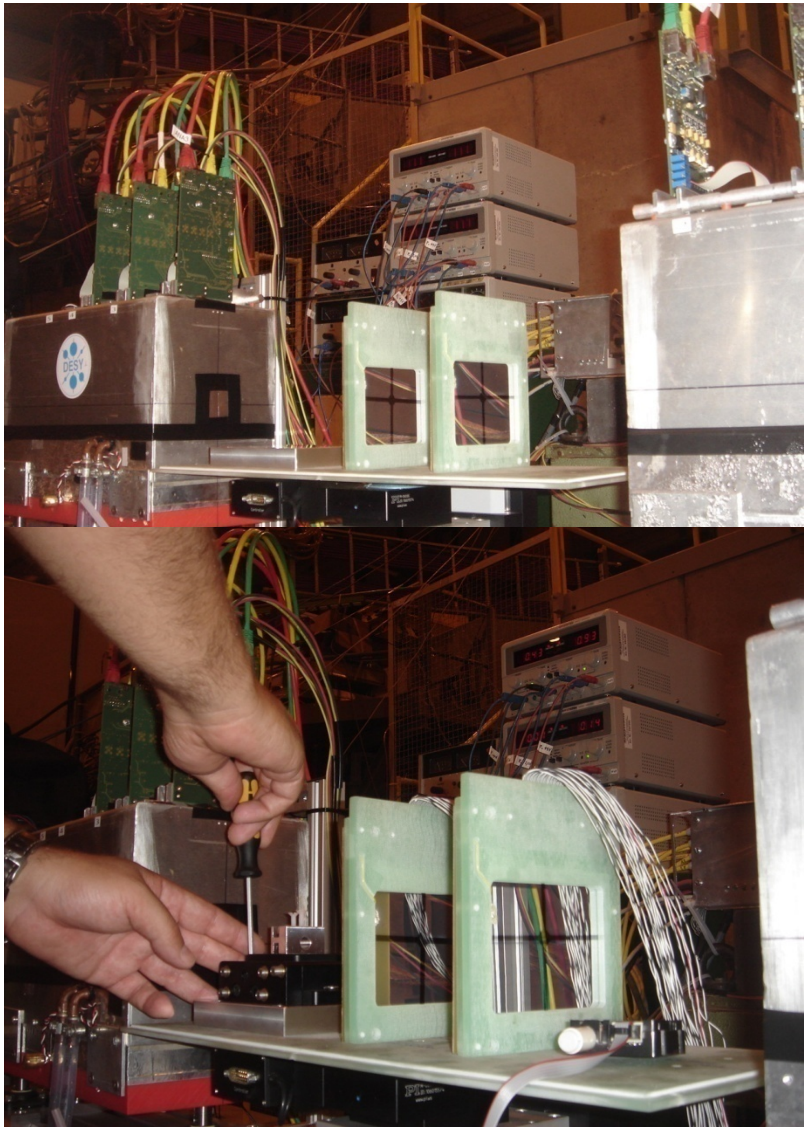
Laser Paths

Reference granite bench

Straightness ALMY



SiTRA Alignment – SPS Test beam



AIM:

Assessment of SNR for backside removed metallization.

Comparison between track-based and laser alignment.

Testbeam at CERNs SPS

(19. to 26. August 2009)

- CERN SPS North Area: H6B
- We used the *EUDET* Beam Telescope to get triggers and tracks

Results

- About beam 100Kevents + laser 100Kevents.
- Analysis still in progress

R&D on sensors: Thinned ustrips

- GICSERV09 access on ustrip thin sensors.
- Direct wafer bonding and deep anisotropic etching.
- Aim: frame layout design, FEA analysis, mechanical characterization of dummies, bonding tests, bench & test beam testing.

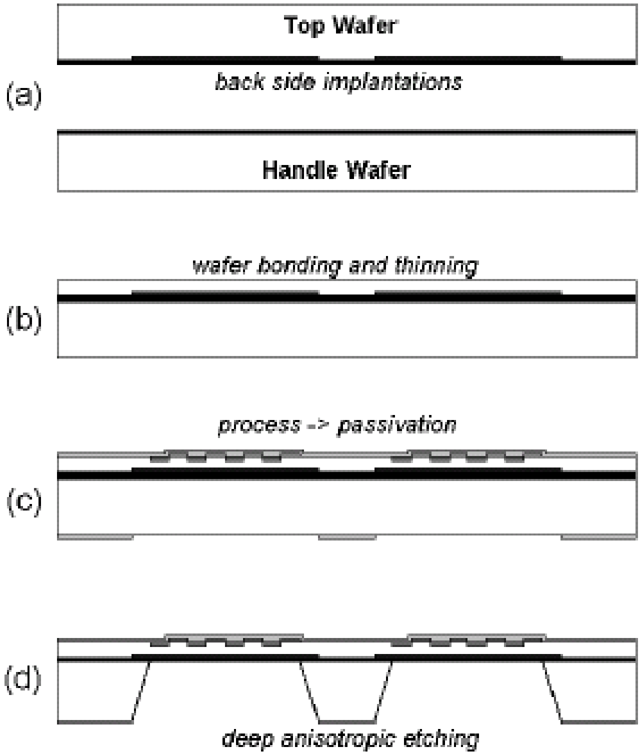
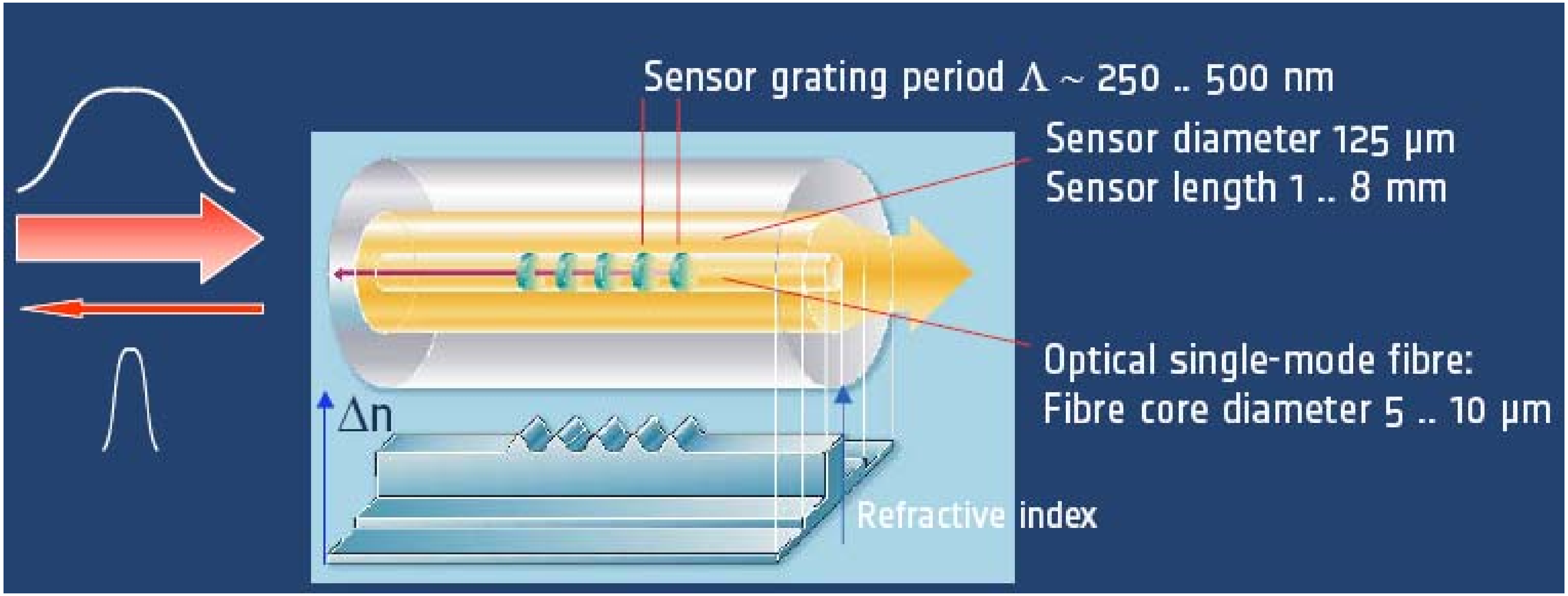
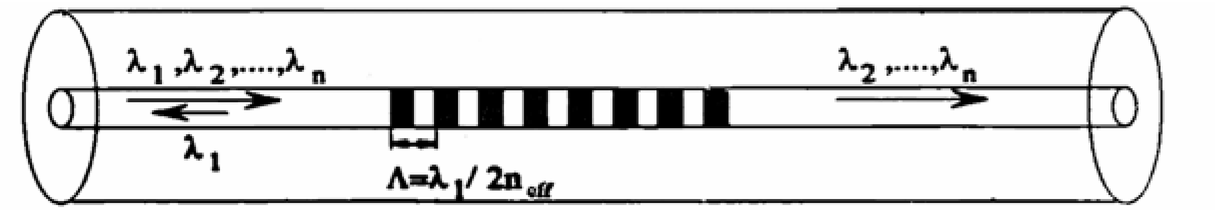


Figure 2: Thinning of double-sided processed detectors. See text and ref. [6] for further details.

R&D on mechanics: Bragg grating

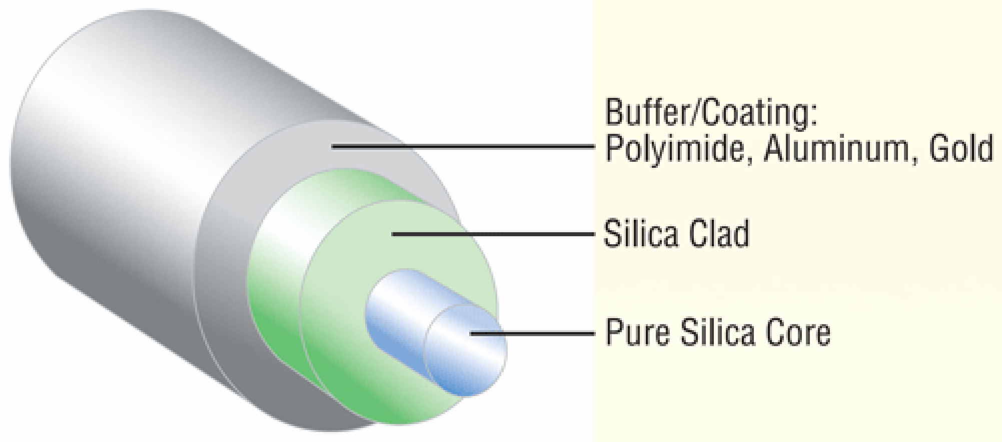
- Fiber Bragg Grating optical transducer very common to measure strain and temperature





R&D targets: Sensor reliability

“Bare” Optical Fibers are quite inhomogeneous



Many coating available:

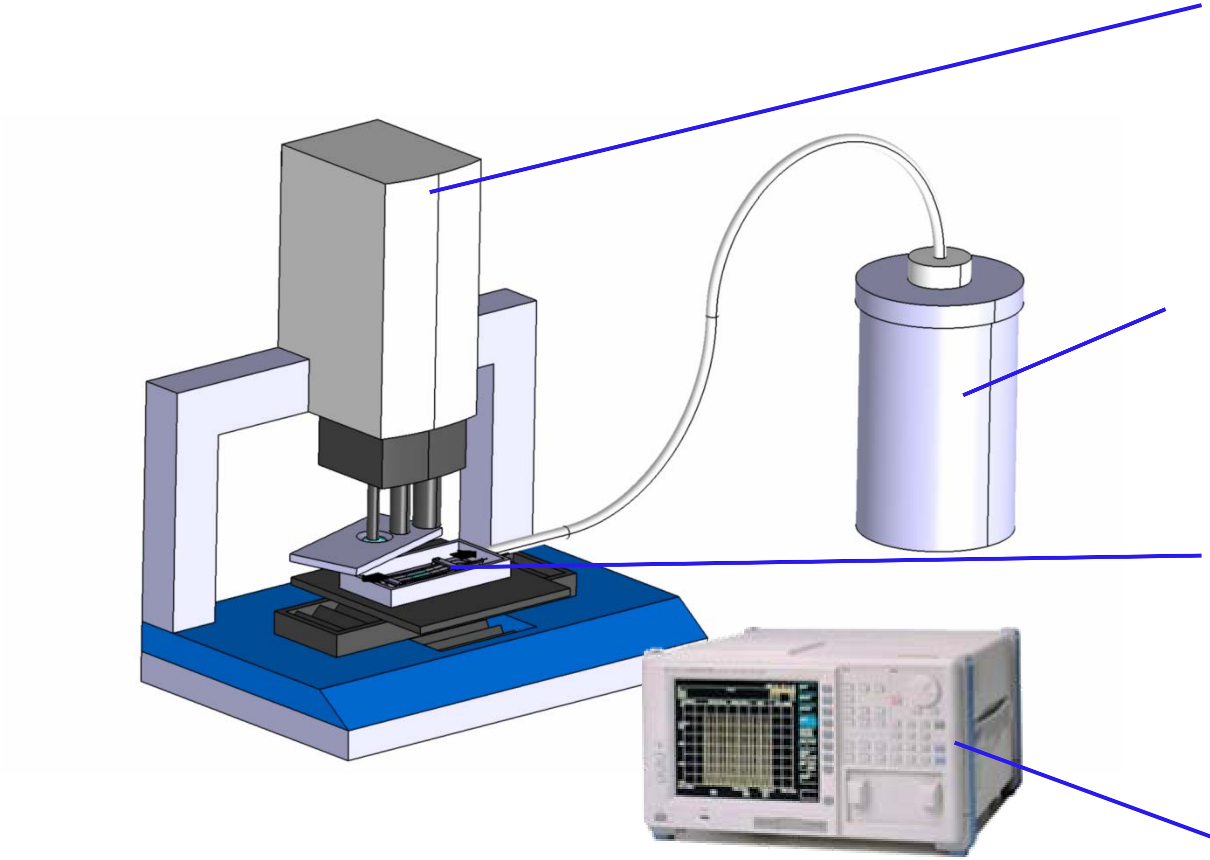
Acriyate, polyimide, ormocer, metalic, …

External agents can induce changes of the mechanical properties of the fiber materials (young, poisson parameters) $\Rightarrow \Lambda$ changes

Others (radiation) can also induce changes in n

R&D Targets: Test Setup (1)

Calibration of bare fibers with different coattings (acrylate, polyimide, ormocer) and without coattings.



Confocal profile meter
15nm resolution with
3mm range
(Installed Dec '09)

Nitrogen Dewar (Feb '10)

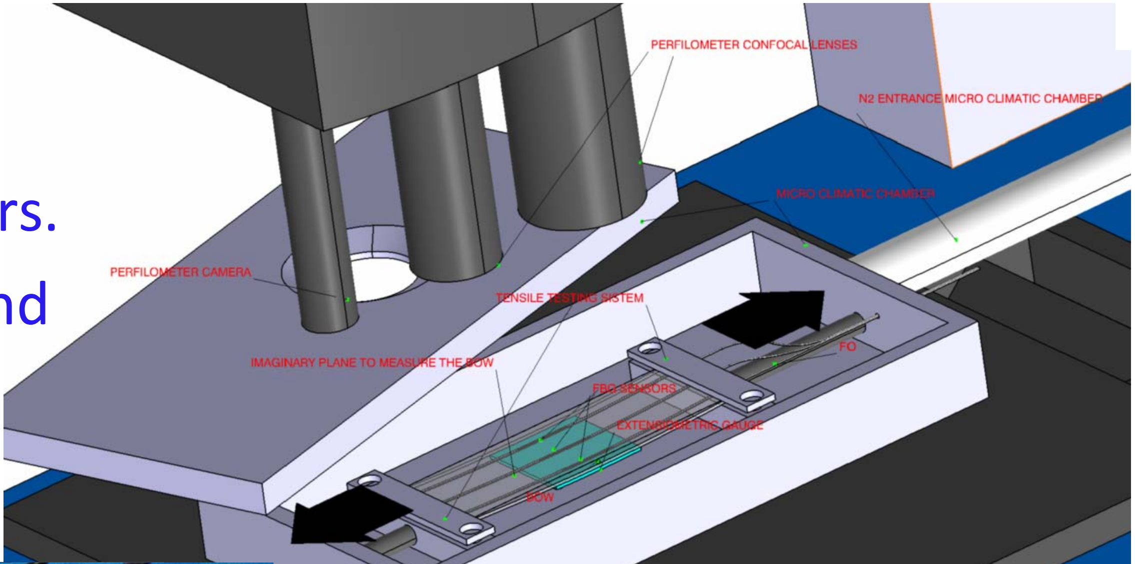
Miniclimatic chamber
Temp range (-196 to 350 deg) +-0.2 deg.
with optical window
Contains the FBG FOS
(Feb '10)

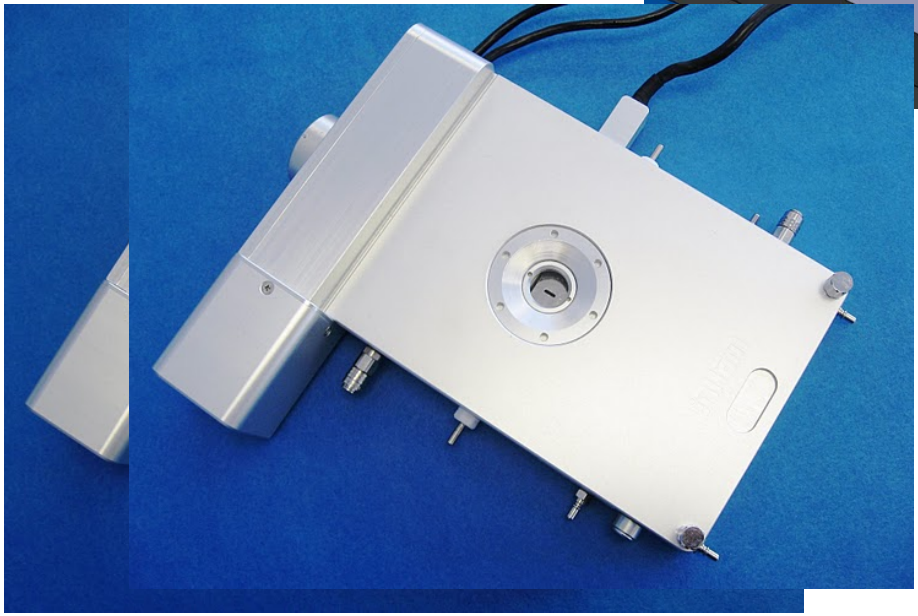
Interrogating unit (March '10)

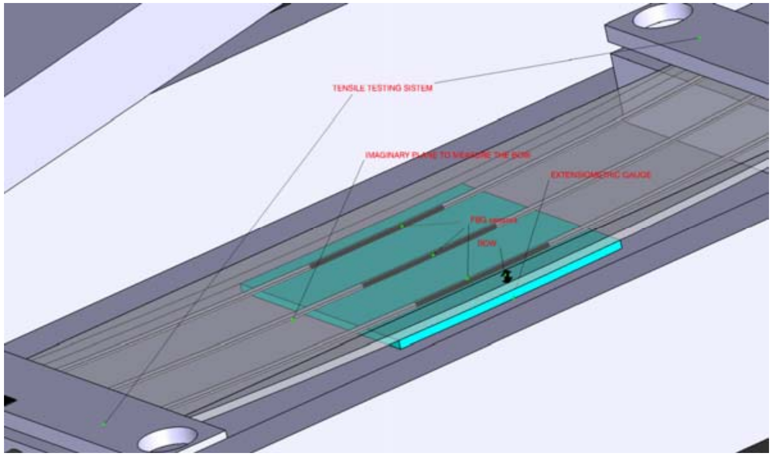
R&D Targets: test setup (2)

Redundant calibration:

- Reference T and ε sensors.
- Tensile testing system and confocal profile meter

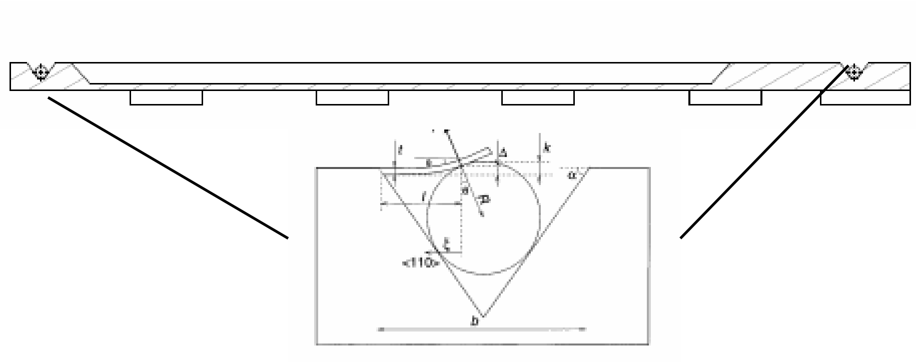


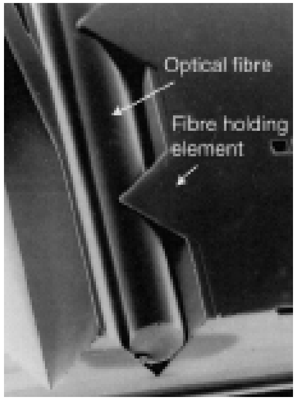


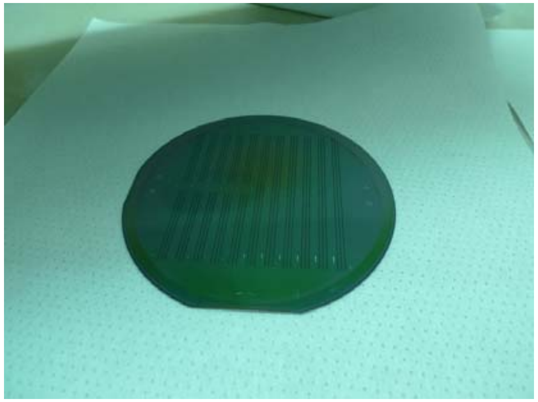


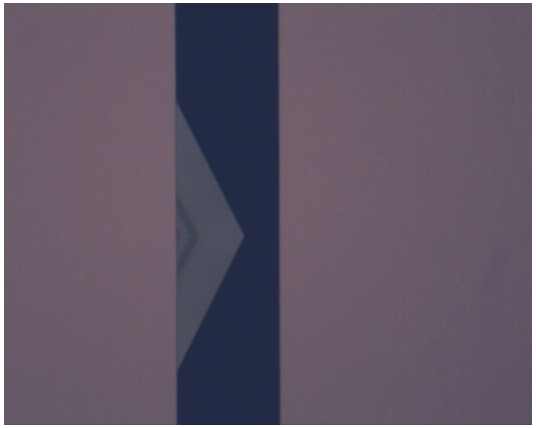
Sensors attachment to Silicon

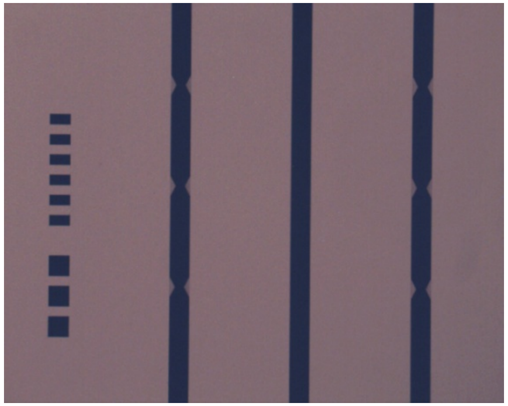
- Which fixation is the best ?
- Multi-groove wafer produced (CNM, HEPHY)











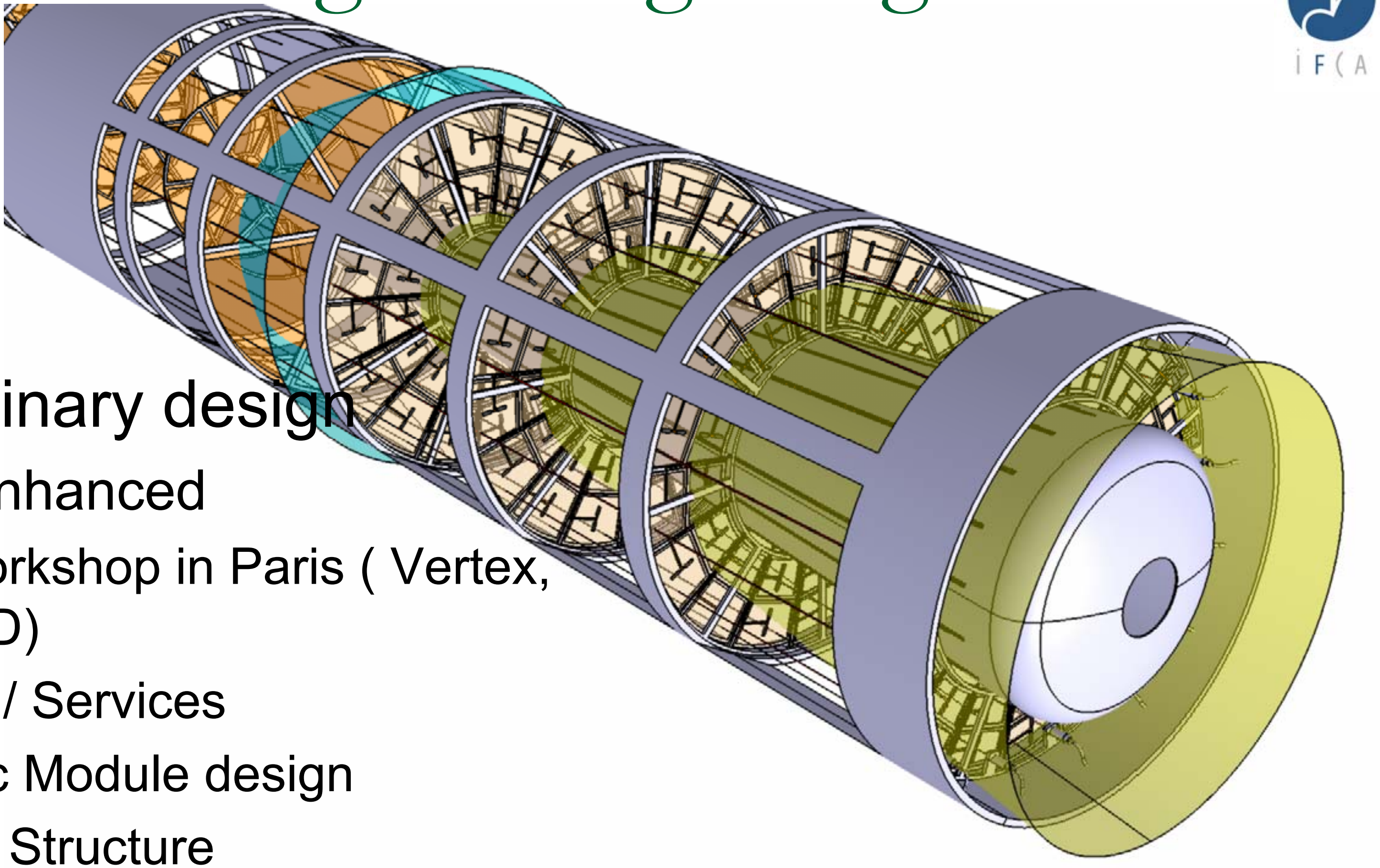
Embedding on CF composites

- Joint project with Spanish Aerospace Agency (INTA)
- Initial step: irradiation of embedded fibers with different coatings (required to increase the mechanical resistance of the non-coated bare fiber)
- Small samples 15x3x3 mm^3 of composite laminates with different stack configurations with and without optical fiber embedded in preparation
- Nano-indentation characterization of the different components of the samples (coating, cladding) and composite matrix for extracting the mechanical parameters: poisson, young, …

Short term plans

- Working together with the thermo-mechanical group on a strawman design for a temperature and position monitor for the PXD
- Use FBG in the Valencia thermal test stand.
- Expect first results concerning the FBG sensors calibrations (reliability studies) in the 3QT of 2010.
- By the end of the year characterization of the fiber materials and embedded fibers in Carbon Fiber composites.
- Design of displacement FBG sensors by the end of the year.

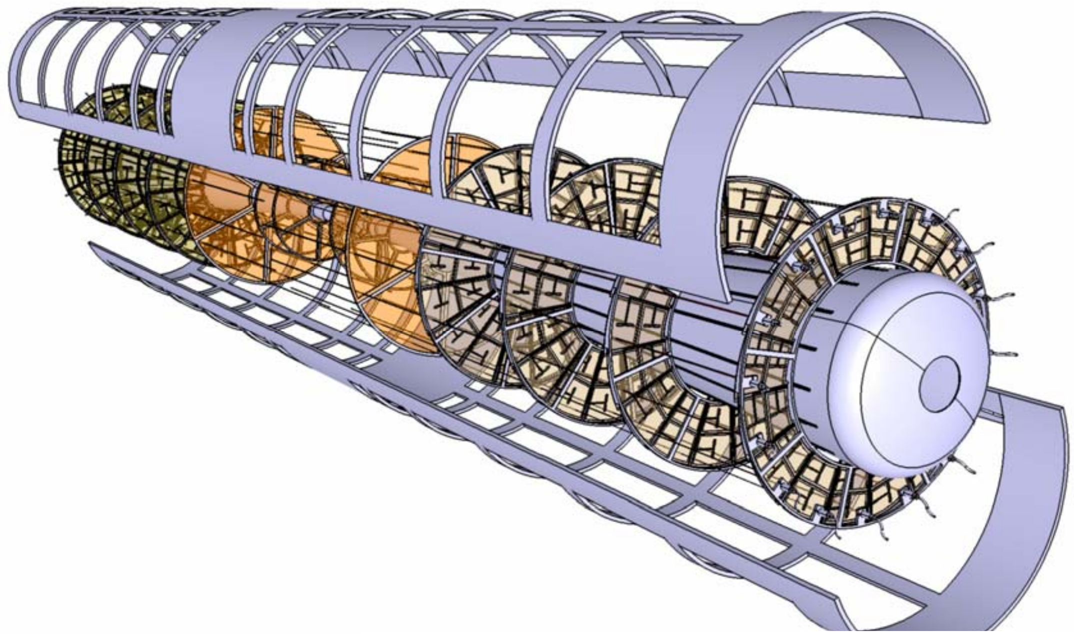
Towards an engineering design



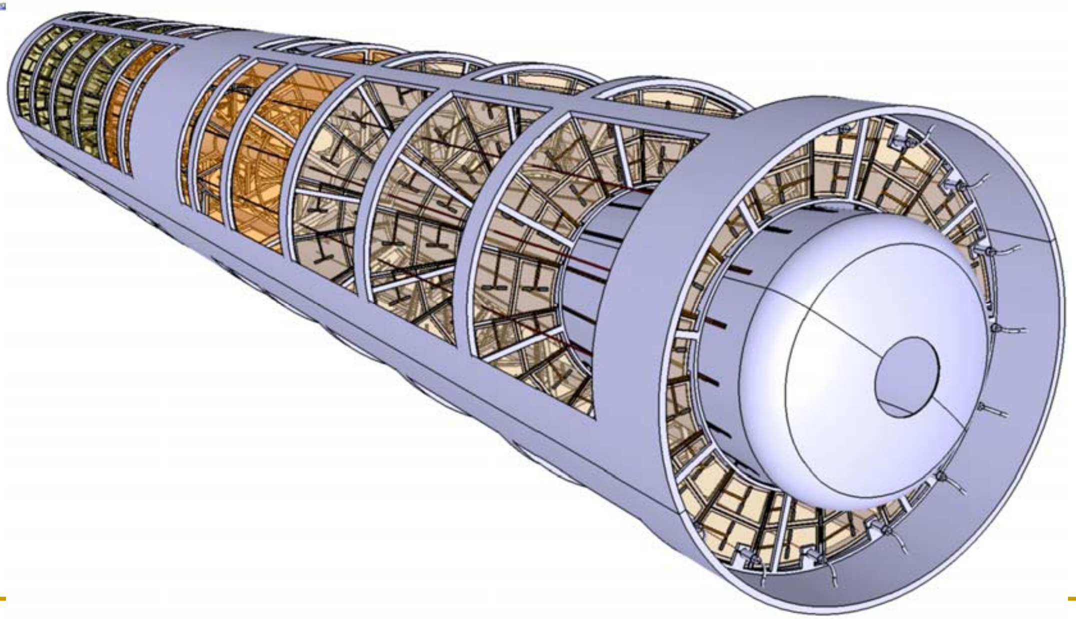
- Naïf preliminary design
  - Must be enhanced
    - April Workshop in Paris (Vertex, MDI,FTD)
    - Cabling / Services
    - Realistic Module design
    - Support Structure
      - Beam Pipe / Vertex / FTD as a part (IMP)
      - IMP with TPC

(Plots:David Moya (IFCA))

Towards an engineering design



Snapshot of C:\Documents and Setting



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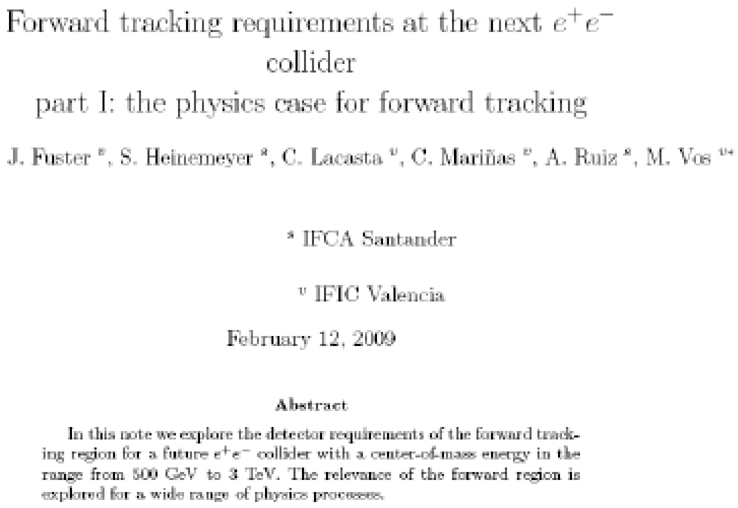
Forward tracking physics case



Forward tracking requirements at the next e^+e^- collider
part I: the physics case for forward tracking

J. Fuster [v], S. Heinemeyer [s], C. Lacasta [v], C. Mariñas [v], A. Ruiz [s], M. Vos [v*]

[s] IFCA Santander

[v] IFIC Valencia

February 12, 2009

Abstract

In this note we explore the detector requirements of the forward tracking region for a future e^+e^- collider with a center-of-mass energy in the range from 500 GeV to 3 TeV. The relevance of the forward region is explored for a wide range of physics processes.

Little guidance for forward detector design from standard benchmark reactions ($\cos\theta < 0.95$)

Together with many other analyses and channels that we didn't discuss:

- A_{FB} in the bb and cc system
- Degenerate staus and neutralino
- center-of-mass energy determination using $\mu\mu\gamma$ events

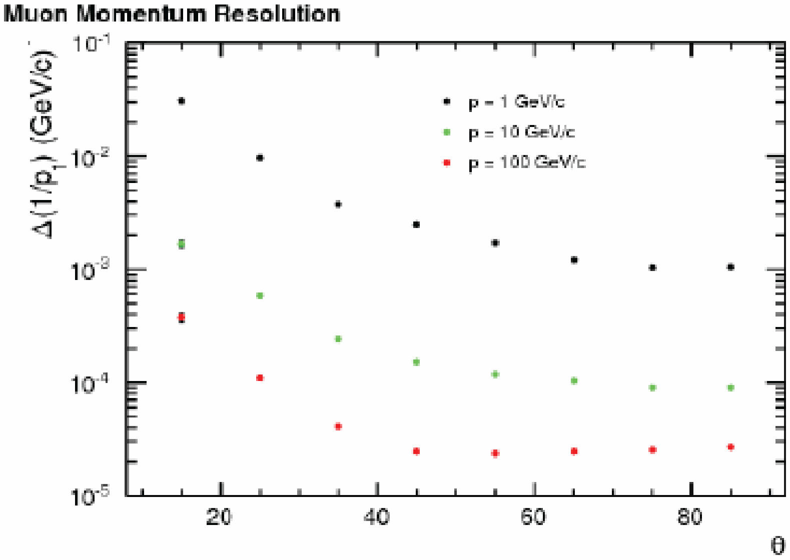
These examples make the physics case for orward tracking:

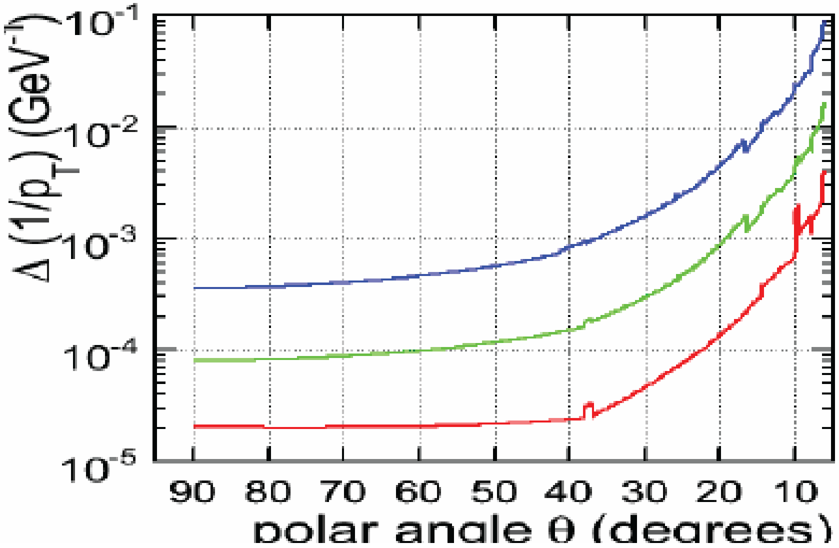
At a high-energy e^+e^- collider several potentially very interesting physics analyses require excellent tracking and vertexing performance. These arguments become more urgent as the center-of-mass energy increases. Precise electron reconstruction is of particular importance.

Challenges for the Forward Tracking

Momentum Resolution: Single Electrons

- Generated Single electron samples (private but available)
- Simulated with ILD_00 model and Reconstructed following the standard processors availables in the framework (Marlin, ..)
- Compared with LOI results for muons

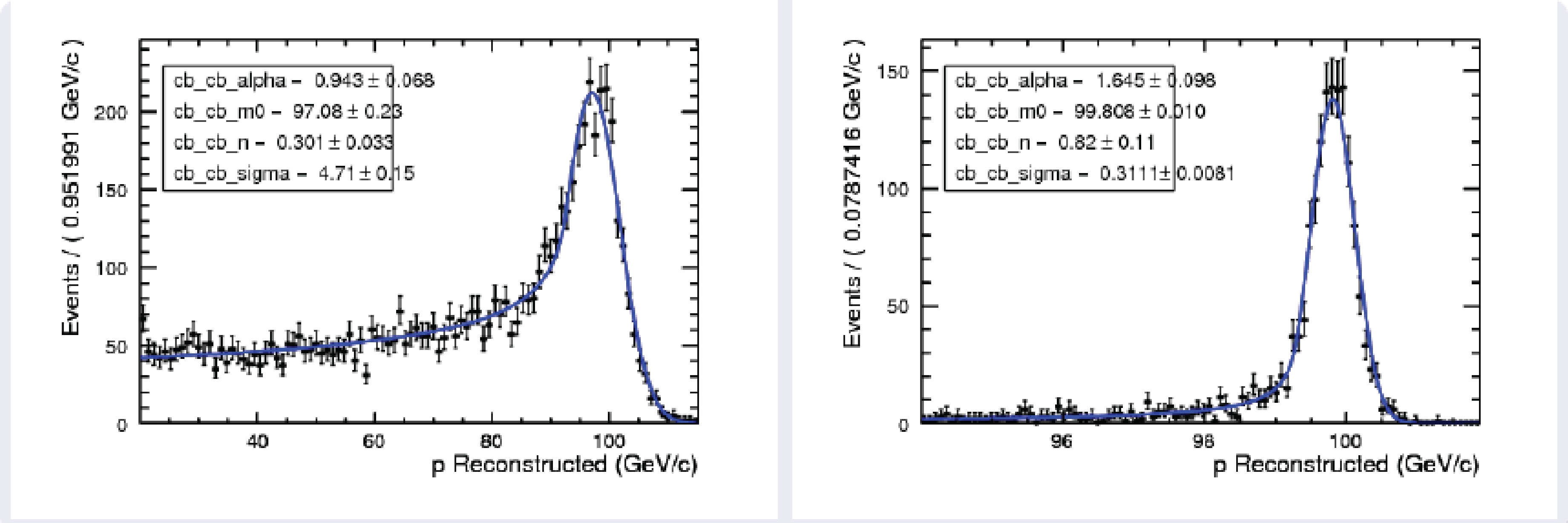

Muon Momentum Resolution



Challenges for the Forward Tracking

Momentum Resolution: Single Electrons

$5^o < \theta < 10^o$ $\qquad$ $85^o < \theta < 90^o$



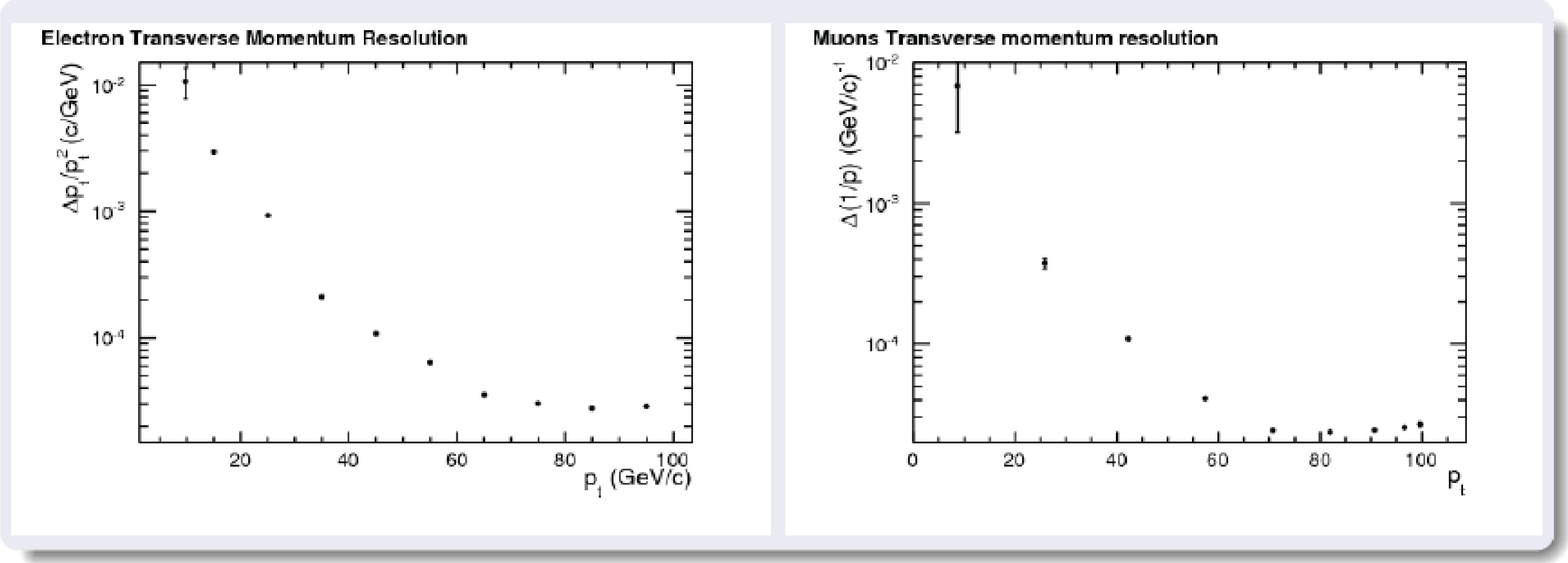
Energy Loss:

- 3 GeV/c in average (forward)
- 150-200 MeV/c in average (central)

Challenges for the Forward Tracking

Momentum Resolution: Single Electrons

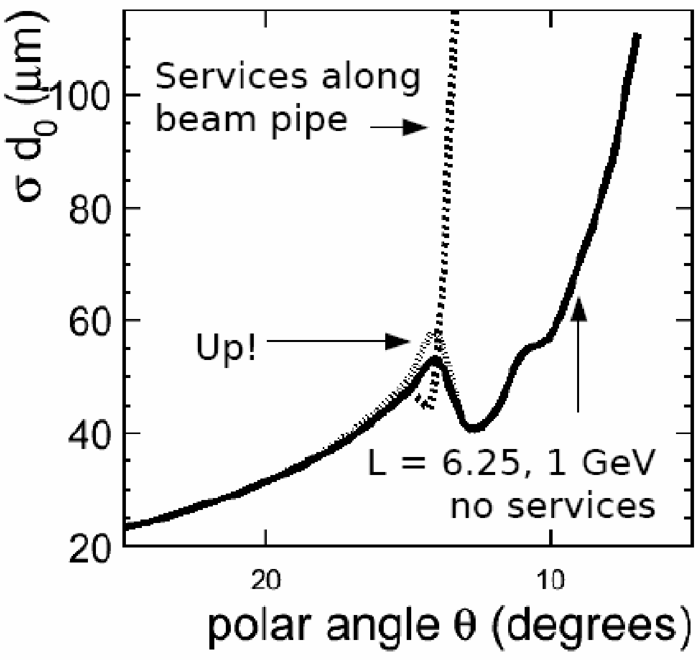
Fixed p=100 GeV/c (ongoing study for differents shoots, p=1GeV/c, p=10GeV/c,...)

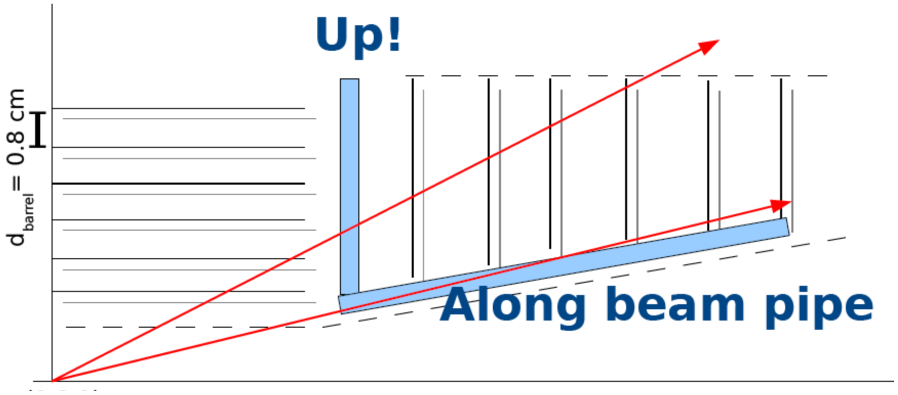


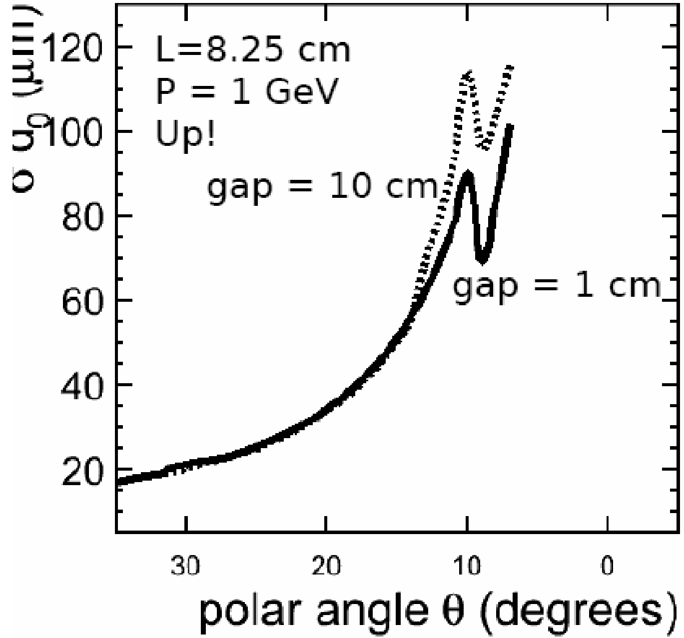
Worse resolution than muons in the forward region, but in the same order.

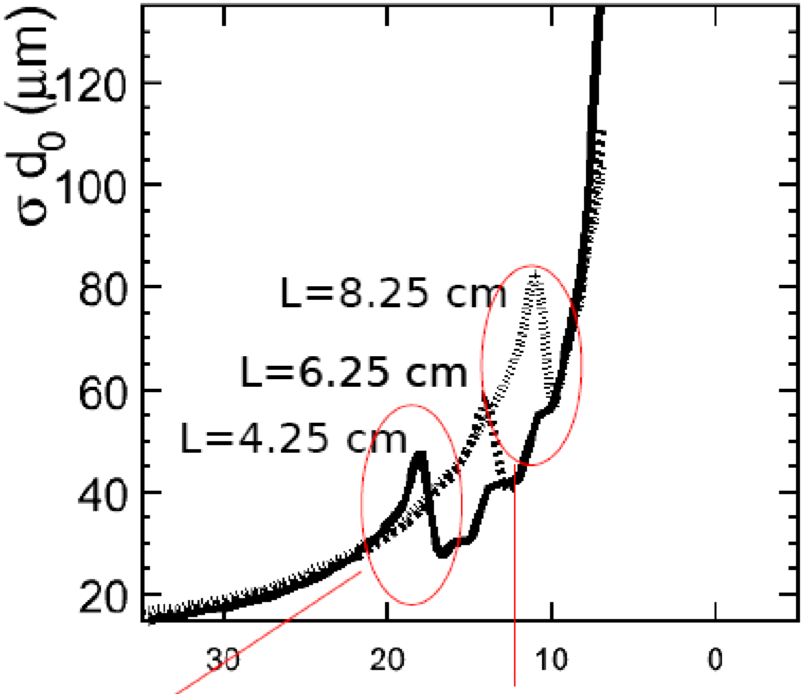
ILC specifications are yield in the central region $\theta \gtrsim 50^o - 60^o$

Choosing a toy geometry









Large distance, shallow angle

Save a little here….

Choosing a toy geometry

There is significant physics to be gained (or lost) in the forward region (6-30°)

If the central vertexing performance is somewhat of a challenge, maintaining good performance at small polar angle is close to impossible

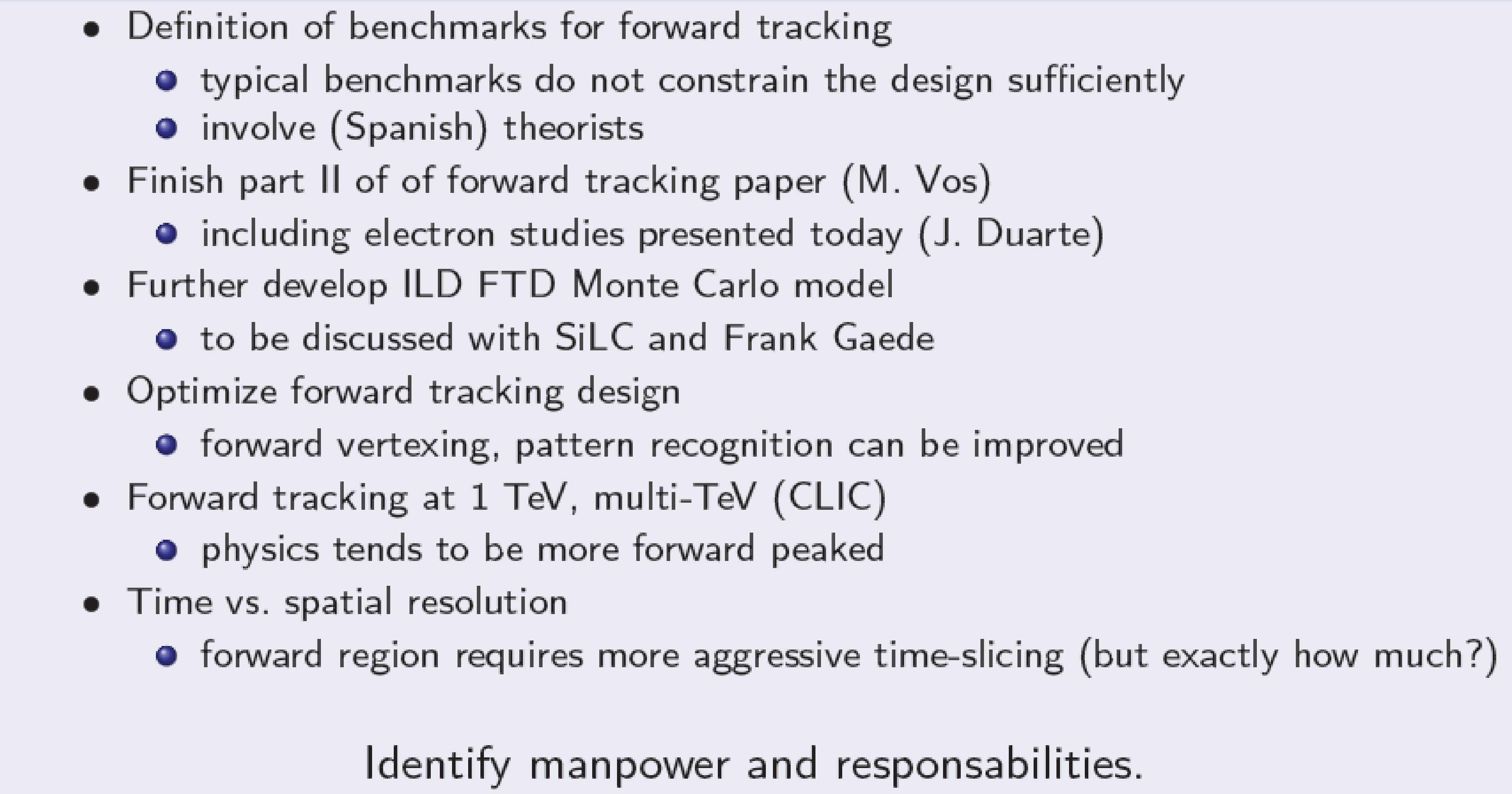
A simple-minded layout optimization (see caveats) of the VXD-FTD layout for forward vertexing performance yields:

- Minimize z_{gap}

Service routing/material is essential in choosing optimal geometry:

- Upward ⇔ very short barrel + closely packed end-cap:
  + works well even at low angle
  - any material (beam pipe) in front of the disks will destroy the performance
- Along beam pipe ⇔ very long barrel
  + no "material bump" due to services down to ~15°
  - limited vertexing beyond first barrel layer coverage

Ongoing optimizations activities for FLC-Spain



- Definition of benchmarks for forward tracking
  - typical benchmarks do not constrain the design sufficiently
  - involve (Spanish) theorists
- Finish part II of of forward tracking paper (M. Vos)
  - including electron studies presented today (J. Duarte)
- Further develop ILD FTD Monte Carlo model
  - to be discussed with SiLC and Frank Gaede
- Optimize forward tracking design
  - forward vertexing, pattern recognition can be improved
- Forward tracking at 1 TeV, multi-TeV (CLIC)
  - physics tends to be more forward peaked
- Time vs. spatial resolution
  - forward region requires more aggressive time-slicing (but exactly how much?)

Identify manpower and responsabilities.

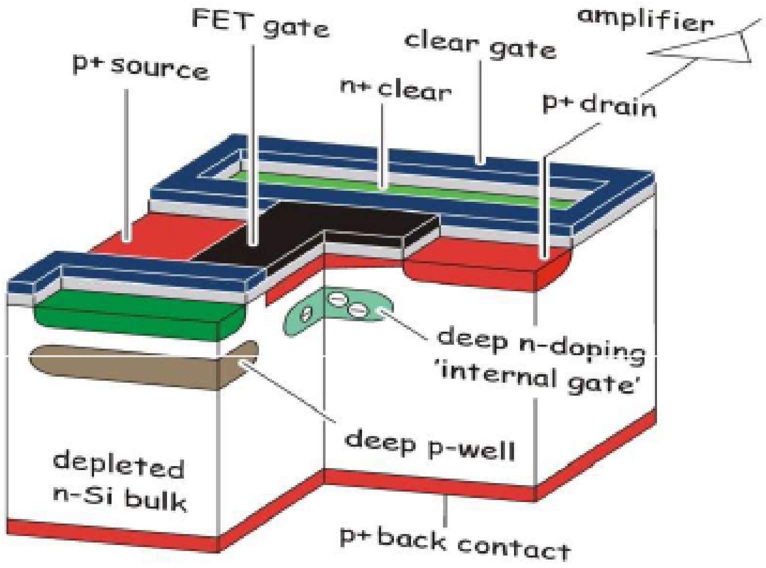
Backup

DEPFET – DEpleted P-channel Field Effect Transistor

- Each pixel is a p-channel FET integrated on a completely depleted bulk.
- A deep n-implant creates a potential minimum for electrons under the gate (internal gate)

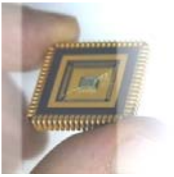
- Signal electrons created in the substrate are accumulated in the internal gate and modulate the transistor current ($g_q \approx 600$pA/e$^-$)
- Accumulated charge can be removed by a clear contact placed in the periphery of each pixel

- Internal amplification
- Low power consumption: Readout on demand (Sensitive all the time, even in OFF state)



GOAL (ILC)

- Small pixel size ~25µm
- r/o per row ~50ns (20MHz) (drain)→Fully depleted bulk
- Noise≈40e$^-$ at high bandwith→Small capacitance and first in-pixel amplification
- Thin Detectors≈50µm

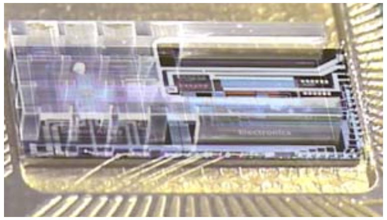


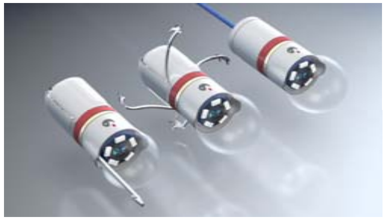
UNIVERSITAT DE BARCELONA

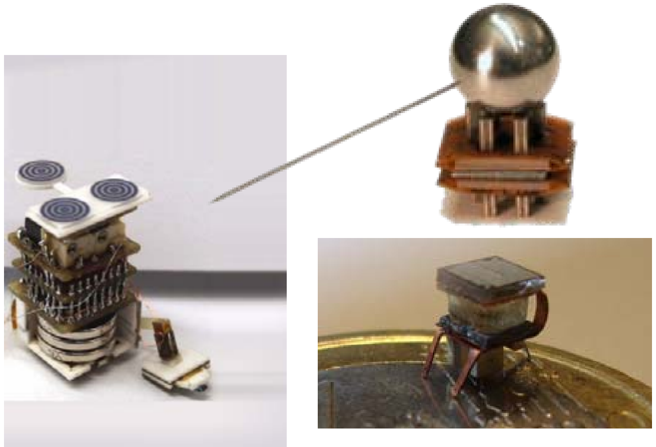
ASIC Design

RESEARCH LINES

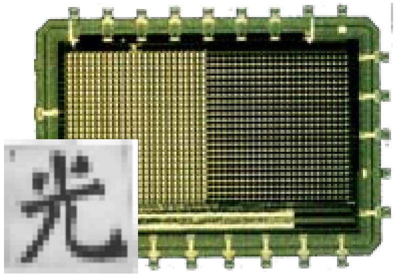
- **Design and Test of Analogue and Mixed-signal Systems**
  - Sensor interfaces
  - Low cost vision systems
  - Measurement/Control in high energy physics
- **Design and Test of Digital ICs**
  - Smart-power digital control systems
  - HW/SW embedded systems
  - SoC plattforms for embedded aplications
  - Low power high performance CMOS circuits
  - Microarchitecture design
  - Reconfigurable HW and retargetable architectures
- **Smart Power Integrated Circuits**
  - DC-DC converters
  - LDO regulators
  - Inductorless DC-DC Converters
- **Formation of Engineers in Design and Test of VLSI systems**

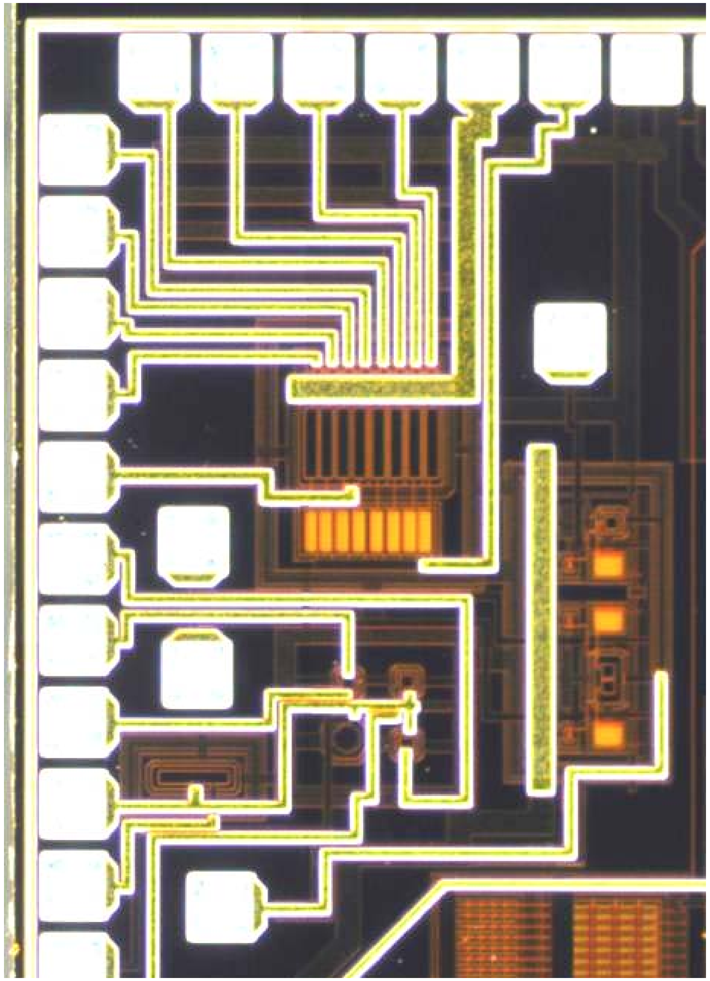




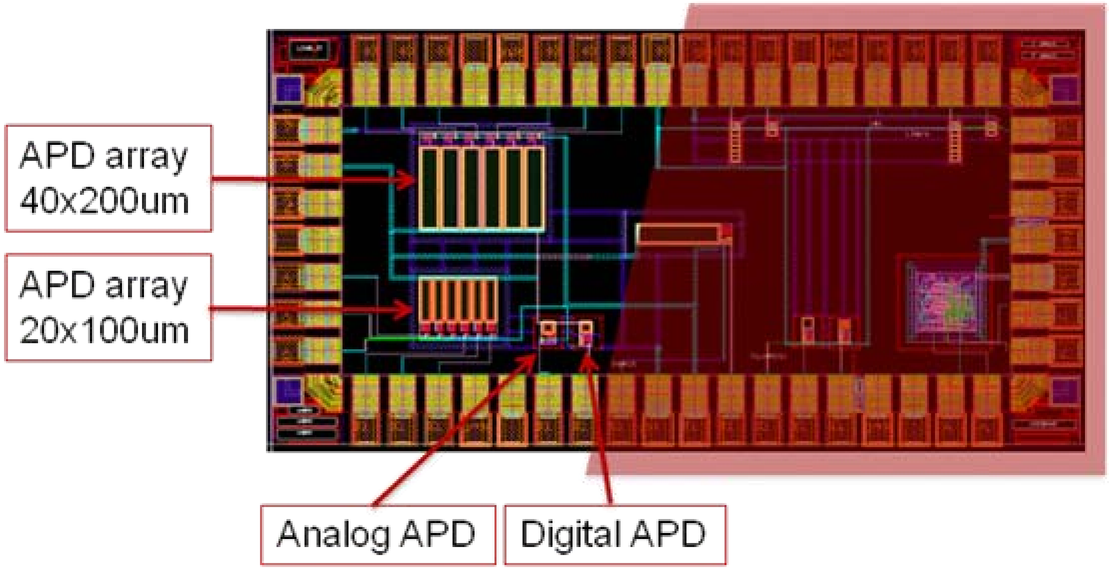


- cadence SYNOPSYS COVENTOR ALTERA
- Full custom, semicustom and FPGA designs can be implemented
- Design is possible at the behavioral, RTL, logic and transistor levels
- Fabrication through EUROPRACTICE or CMP at low cost
- Expertise in different CMOS and BiCMOS technologies: AMS, ST, AMI, …





AustriaMicrosystems CMOS 0.35um



APD array 40x200um

APD array 20x100um

Analog APD

Digital APD

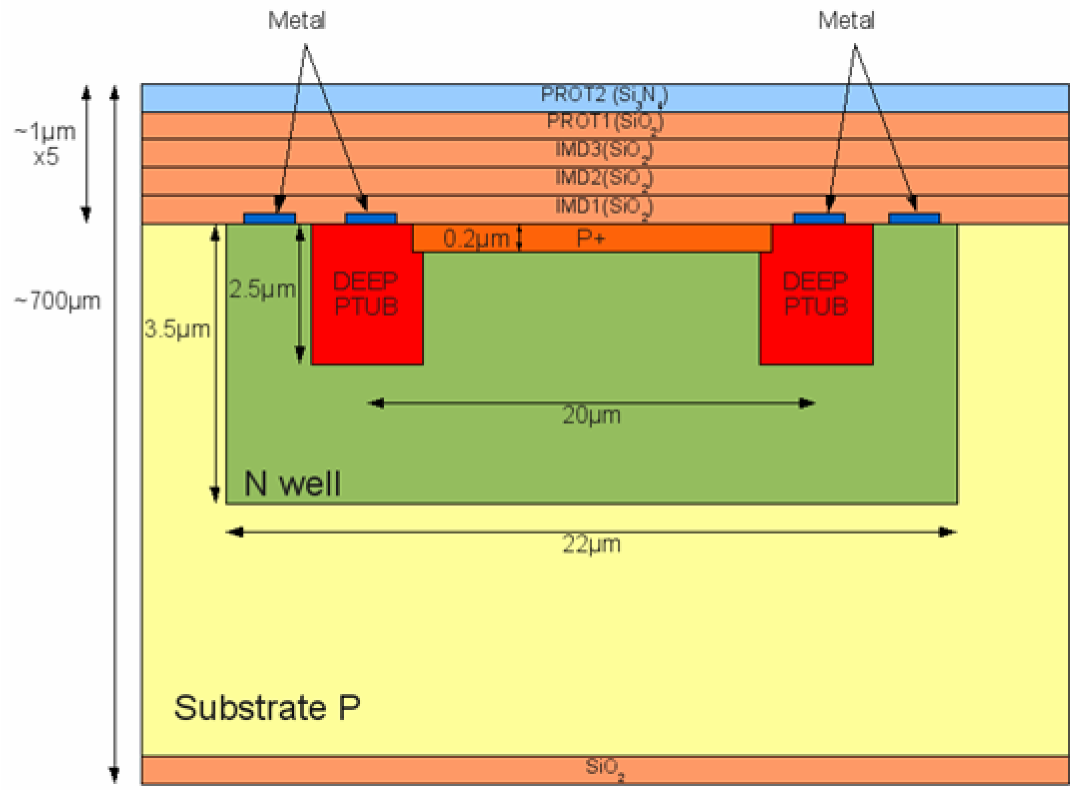
STMicroelectronics CMOS 130nm

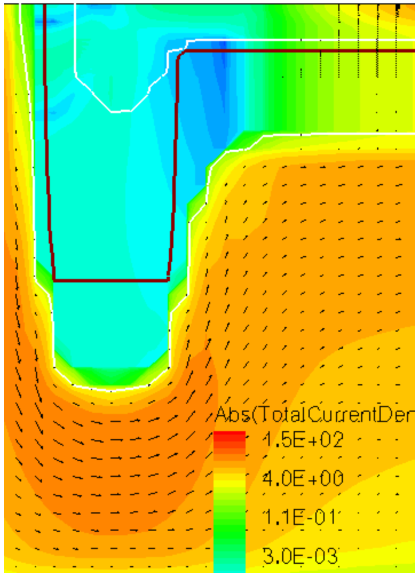
Avalanche photodiodes in standard CMOS technologies

Learning from the fabricated structures

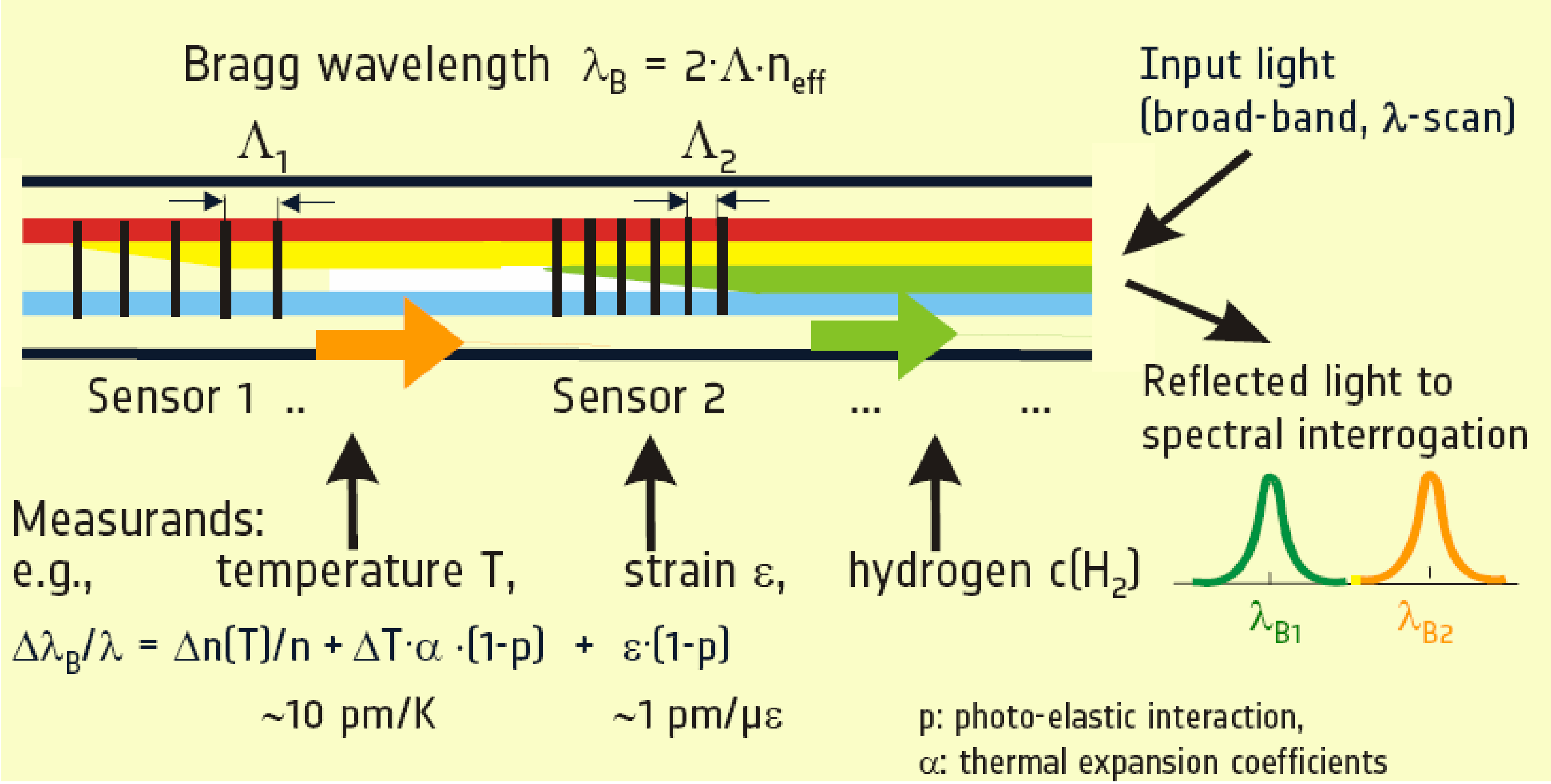
Trying to learn also from device simulations

Design of pixels and readout structures: Active quenching and fast readout.





R&D on mechanics: Bragg grating



Bragg wavelength $\lambda_B = 2 \cdot \Lambda \cdot n_{eff}$

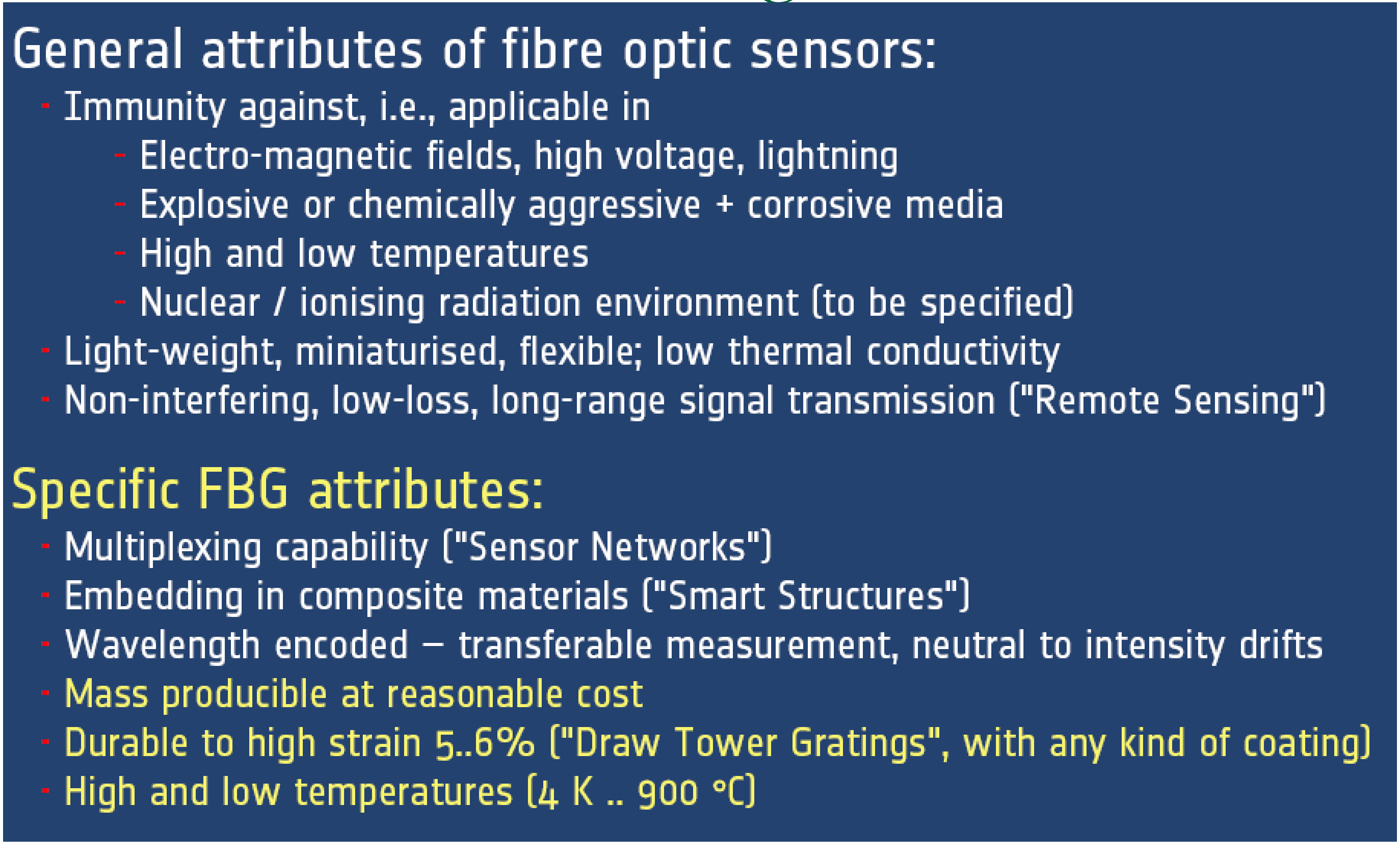
Measurands:
e.g., temperature T, strain ε, hydrogen $c(H_2)$

$\Delta\lambda_B/\lambda = \Delta n(T)/n + \Delta T \cdot \alpha \cdot (1-p) + \varepsilon \cdot (1-p)$

~10 pm/K ~1 pm/με

p: photo-elastic interaction,
α: thermal expansion coefficients

OFS & FBG advantages



General attributes of fibre optic sensors:

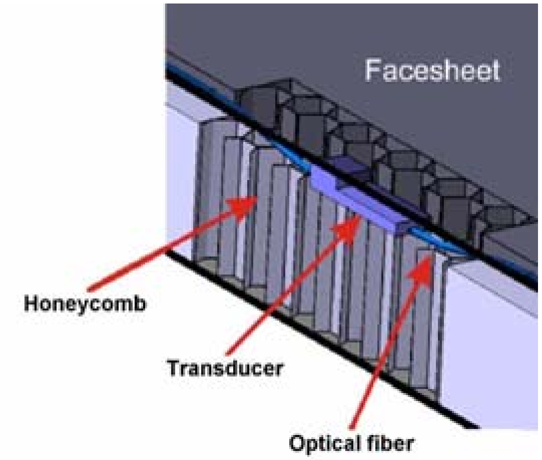
- Immunity against, i.e., applicable in
  - Electro-magnetic fields, high voltage, lightning
  - Explosive or chemically aggressive + corrosive media
  - High and low temperatures
  - Nuclear / ionising radiation environment (to be specified)
- Light-weight, miniaturised, flexible; low thermal conductivity
- Non-interfering, low-loss, long-range signal transmission ("Remote Sensing")

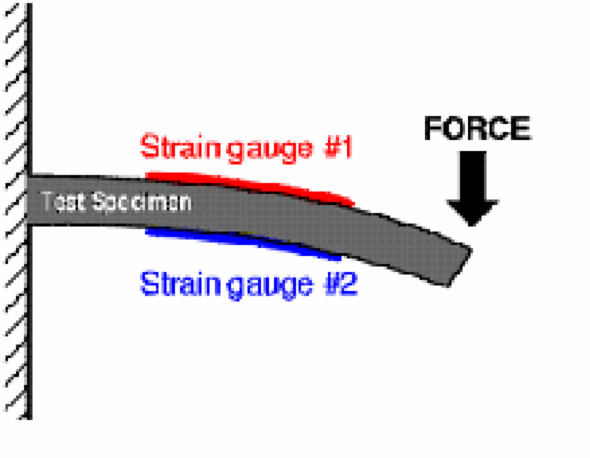
Specific FBG attributes:

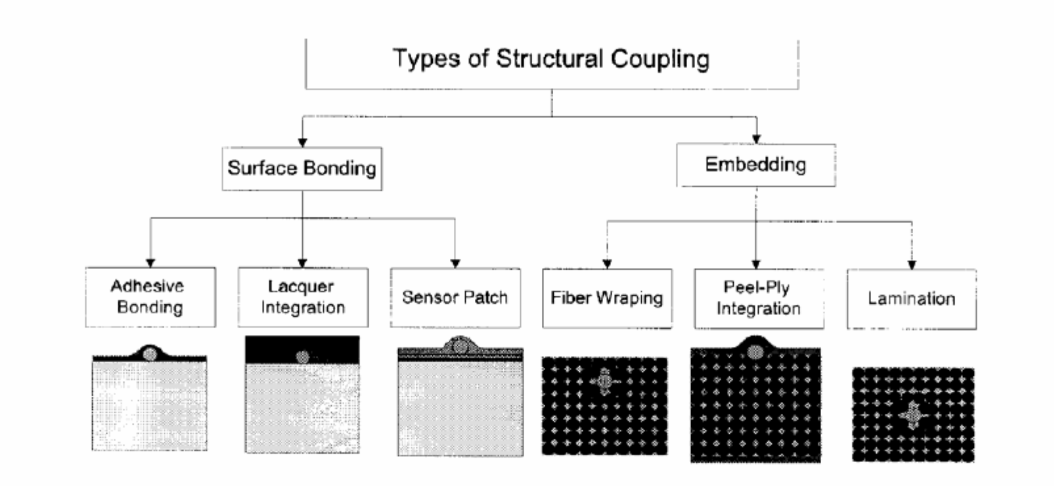
- Multiplexing capability ("Sensor Networks")
- Embedding in composite materials ("Smart Structures")
- Wavelength encoded – transferable measurement, neutral to intensity drifts
- Mass producible at reasonable cost
- Durable to high strain 5..6% ("Draw Tower Gratings", with any kind of coating)
- High and low temperatures (4 K .. 900 °C)

Integrating OFS & carbon fiber composites

- For the Track structure would be interesting to use a embedded fiber optic sensor.
  - more precise and reliable data
- It could be use 2 side solution
  - Better understanding of the results
  - Useful to quantify the thermal strain

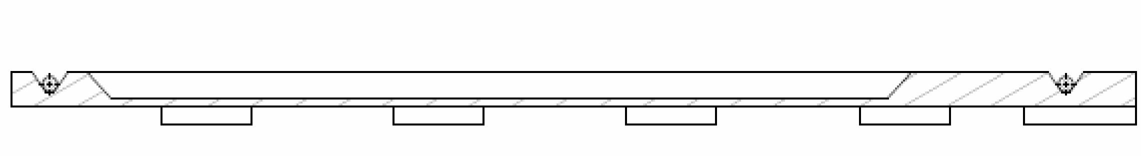




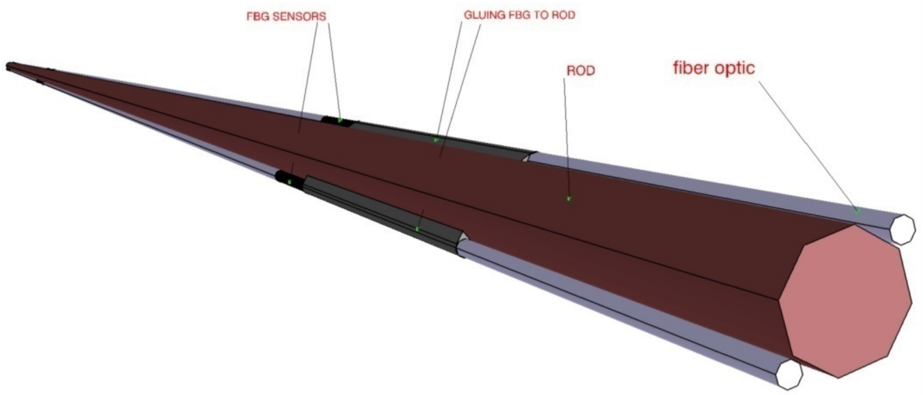


What about DEPFETS?

- During the thinning process V-groove could be also etched.



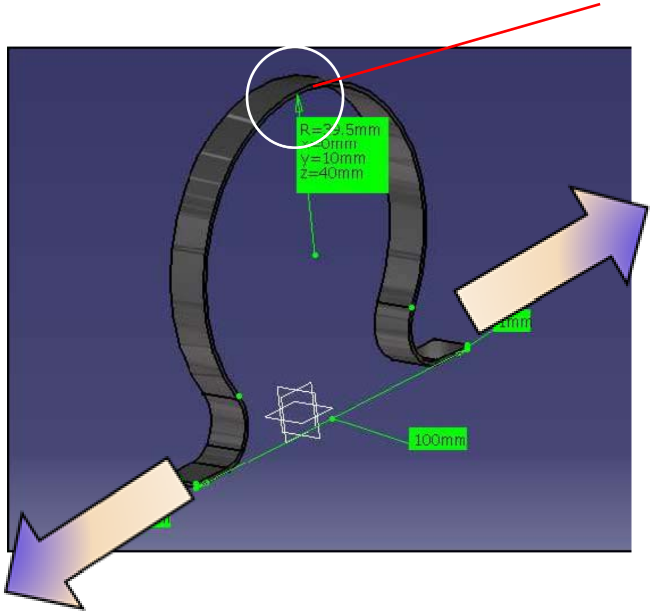
Integration on other Vertex supporting structures very doable

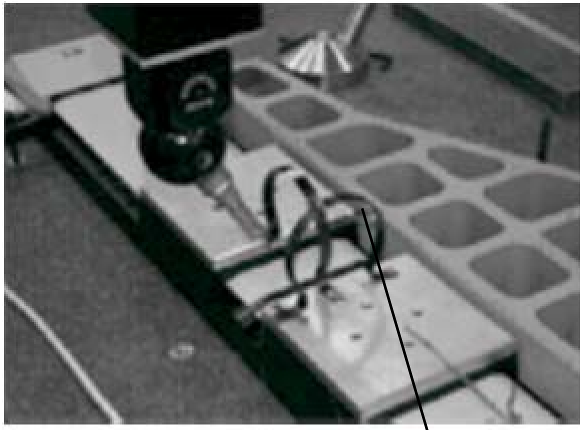


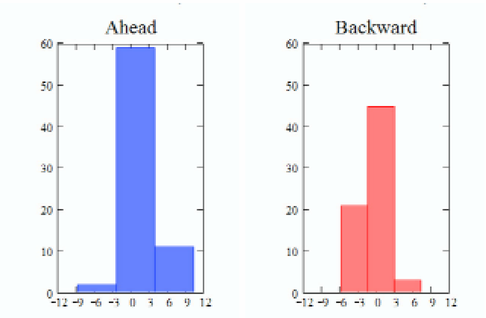
Displacement sensors based on strain FBG

- Original idea from the late BTeV vertex detector: “ The omega-like gauge”
- Mechanical displacement range adapter.

STRAIN FBG SENSOR ON THE TIP





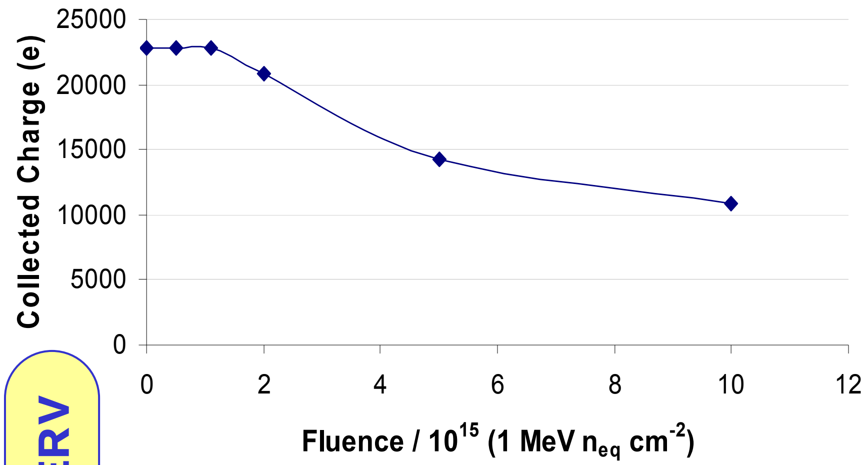


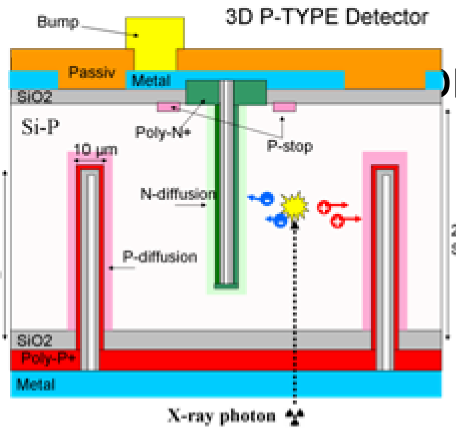
Temperature Compensating “omega”

3D detector technology

- Second institute in the world (after Stanford) in developing a 3D detector technology
- Success with Medipix type pixel sensors
- Now we are designing of a new mask set for ATLAS pixel sensors

Electron collecting strip detectors





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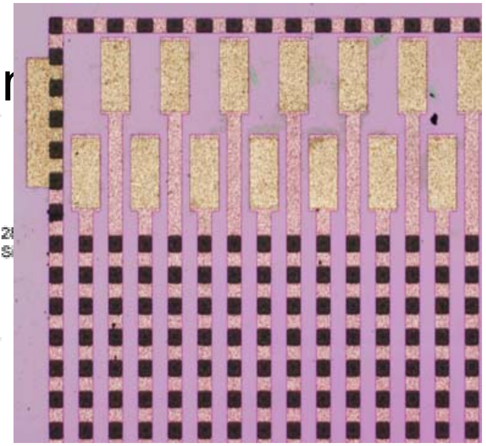


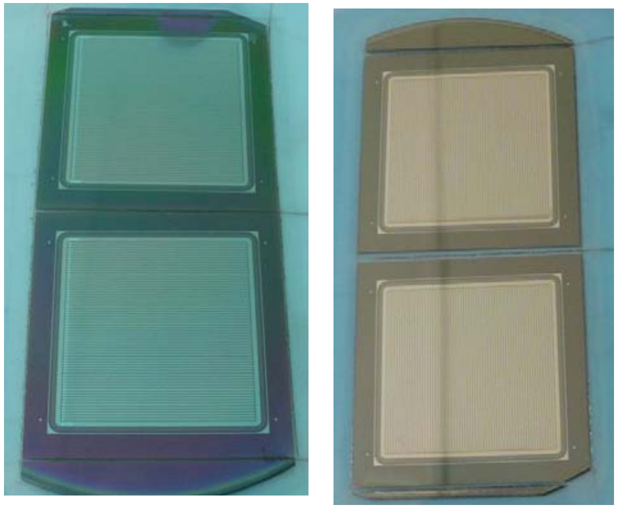
- **Bias Voltage fixed at 150V for all irradiated samples**
- **Non-irradiated sample biased at 18V**
- **Detector's ceramic based board temperature between -10°C to -15°C**

Partially funded GICSERV

GICSERV

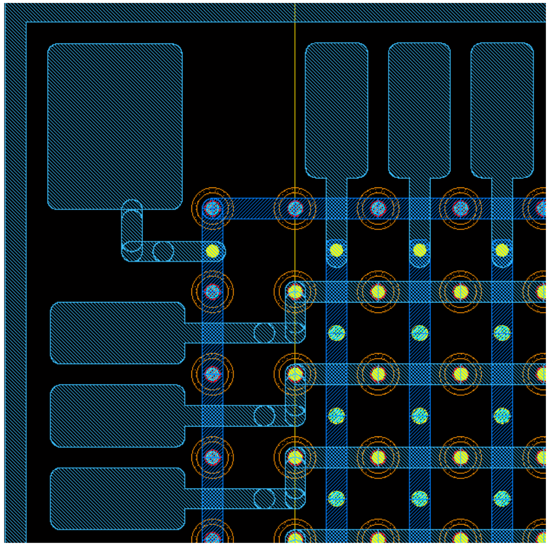
Double side strip detectors

- Double side strip detectors developed for Monash University (Australia)
- Also developing double side packaging and wire bonding
- Future collaboration with Universidad de Huelva for nuclear physics



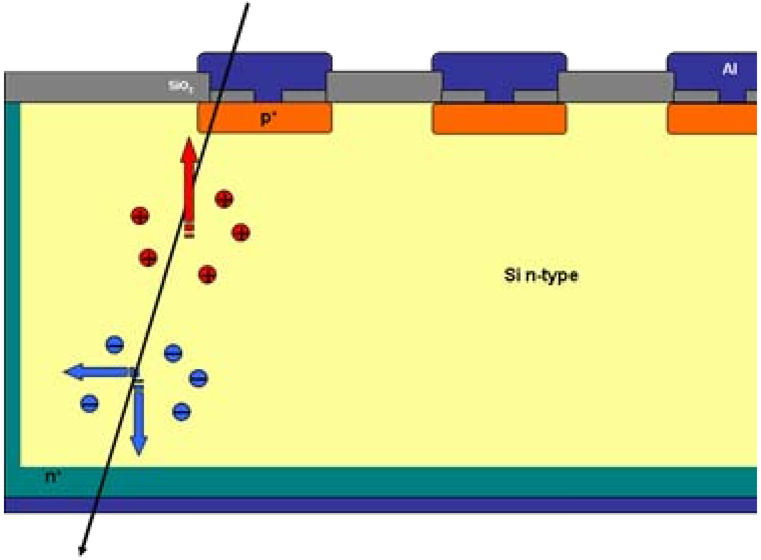
Stripixels

- Combination of the concept of double side reading with 3D contacts
  - Better performace than classic stripixels
  - Single side processing
  - 2D position sensitivity
  - 2N readout channels (instead of N^2)
- Simulations and mask design ready
- Wafers to be processed



Active edge and trenched detectors

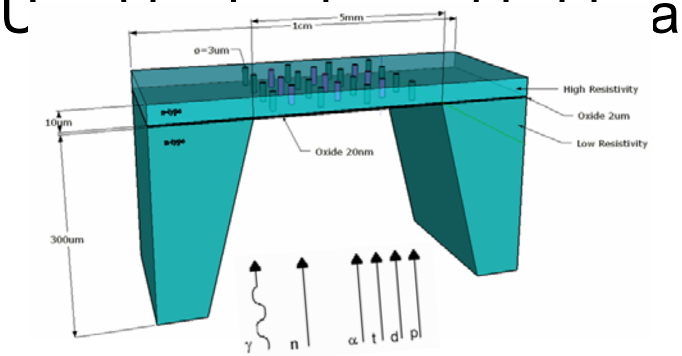
- Trenches used to reduce the dead area at the edge of the sensor
    - (also named edgeless, slim-edge, ...)
- Work started in collaboration with IFAE (Cristobal Padilla)
- Features:
    - Implanted edge side
    - Backplane and edge in the same electrode
- Designed detectors:
    - PAD
    - Microstrips
    - MediPix2

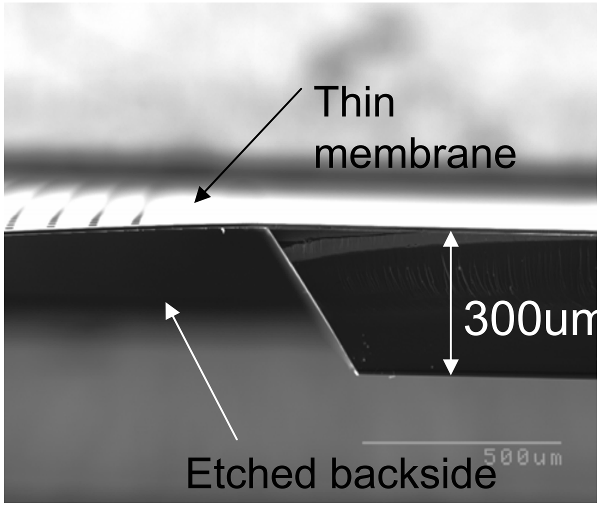


GICSERV

Ultrathin 3D detector

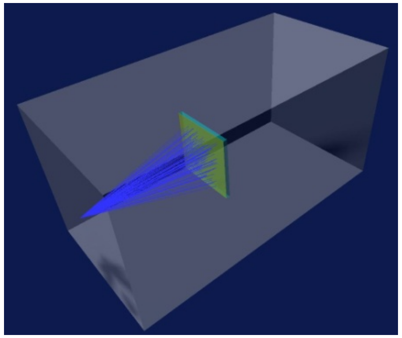
- 10 µm thick detector
- Virtually no entry window
- U articles



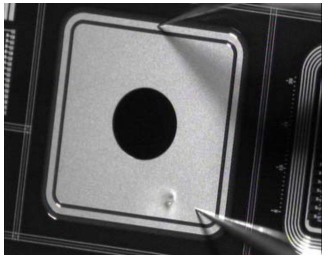


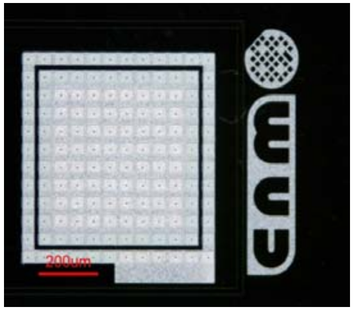
Neutron detectors

- Geant4 simulation
- Detector design and manufacturing
- Conversion layer deposition
- Used for dosimetry



Planar detector

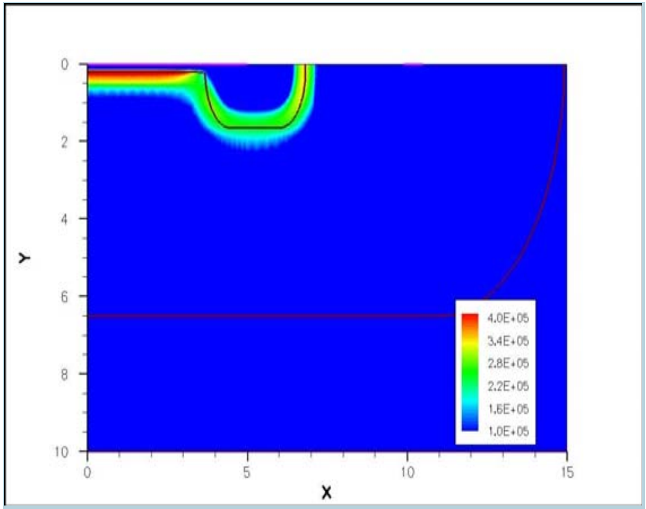




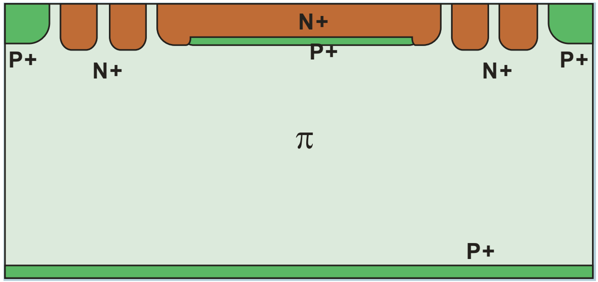
Perforated detector

Avalanche Photodiodes (APDs)

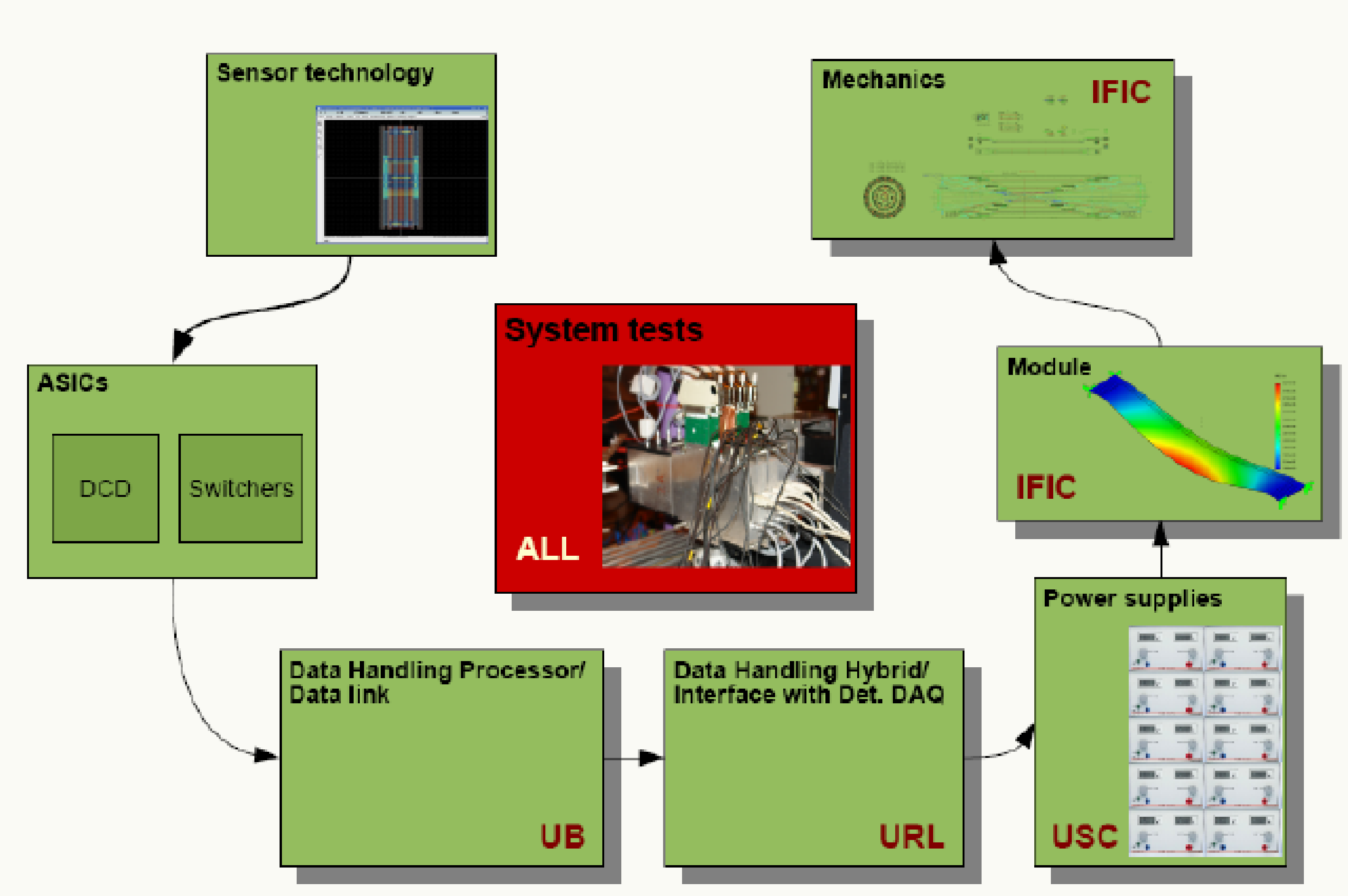
- Power Devices and Radiation Detectors Groups at IMB-CNM have started a new research line in optoelectronic silicon detectors.
- Cover the needs of the scientific community with custom made devices designed for specific applications
- We have finished electrical and technological simulations
- We are now designing the masks
- Next year we will process the devices.
- We plan to develop
  - Linear mode APDs (to use with scintillators)
  - Geiger mode APDs high energy tracking
  - In the future, also SiPMs



Electric field in the avalanche zone



Pixels - DEPFET IFIC, UB, URL, USC



Sensor technology

Mechanics IFIC

ASICs
- DCD
- Switchers

System tests ALL

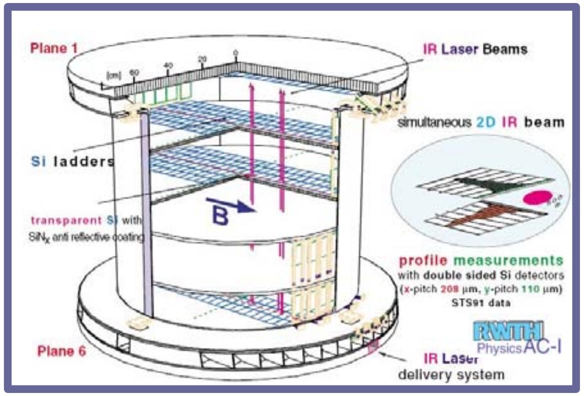
Module IFIC

Power supplies USC

Data Handling Processor/ Data link UB

Data Handling Hybrid/ Interface with Det. DAQ URL

Microstrips - IR Transparent CNM, IFCA



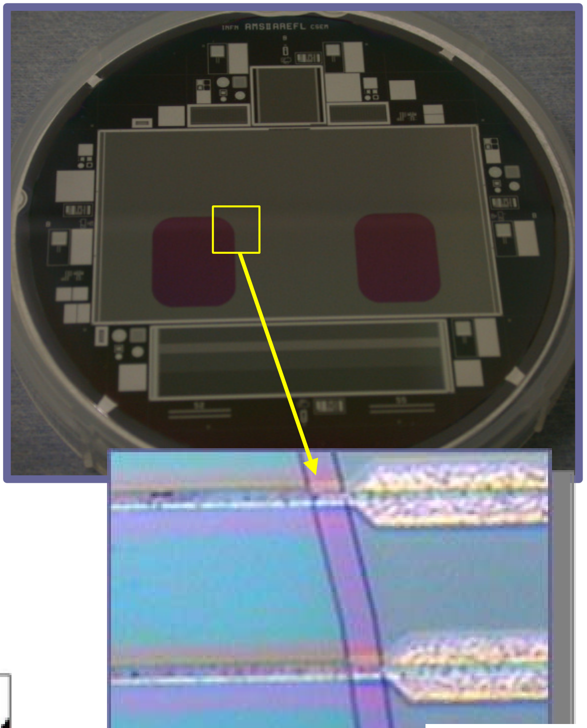
AMS-01 innovation (W. Wallraff)

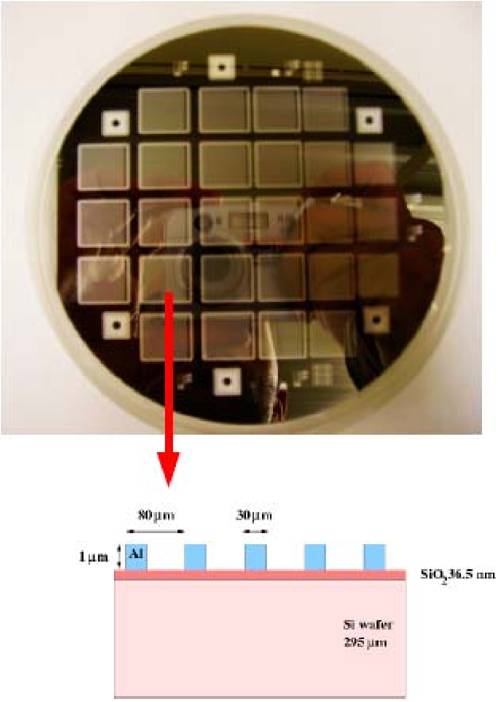
λ = 1082 nm

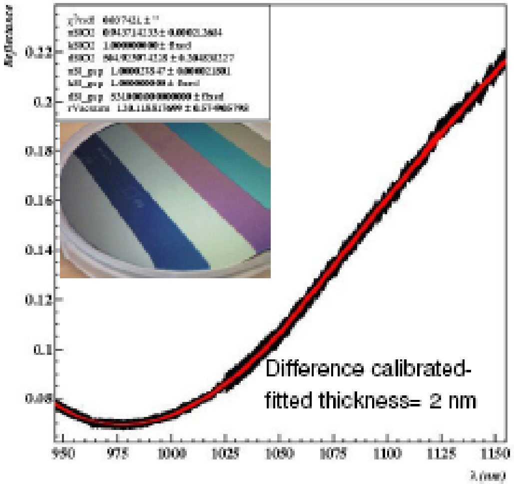
IR “pseudotracks”

1-2 µm accuracy obtained

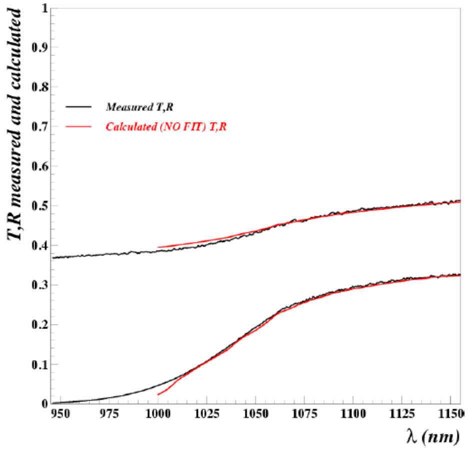
Transmittance~ 50%







Difference calibrated-fitted thickness= 2 nm



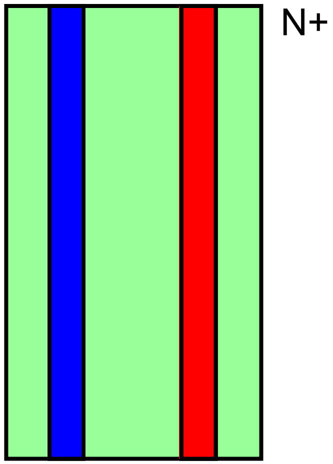
Reflectance and transmittance of wafer 5 matched. No fits involved!!

Compatible with 45 nm roughness of Al surface

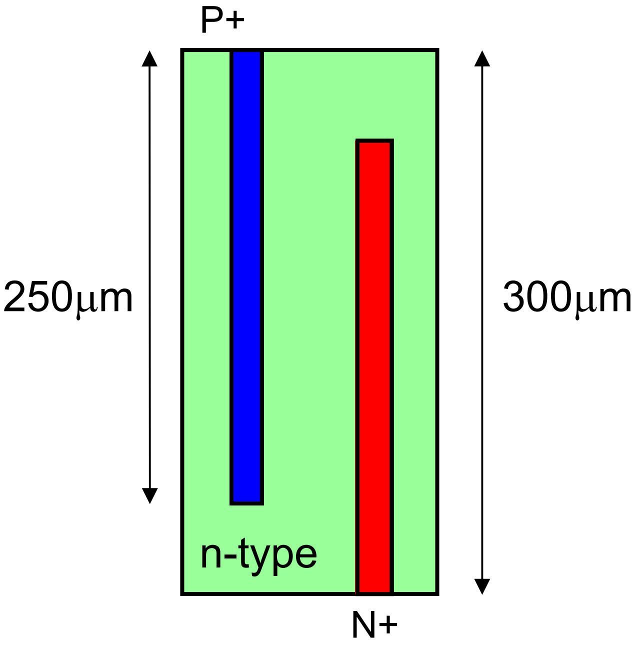
Is this real? We need to measure the wafer roughness. I think it is possible to be done at CERN.

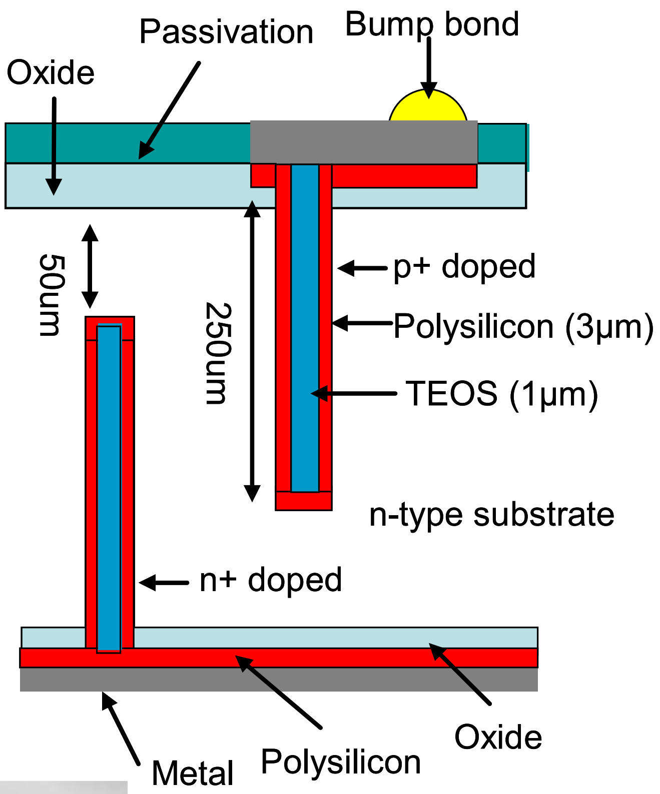
3D sensors – CNM, UB

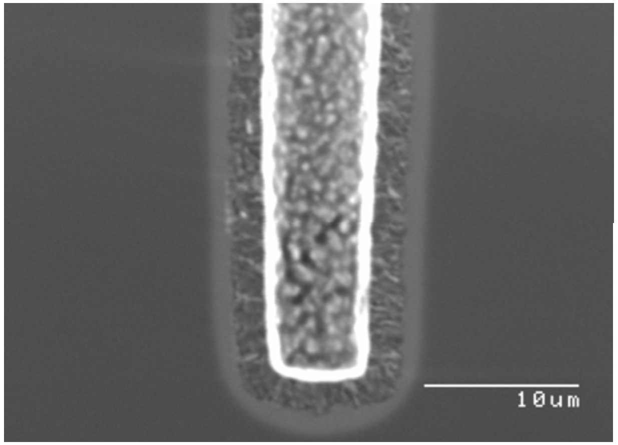
Full 3D

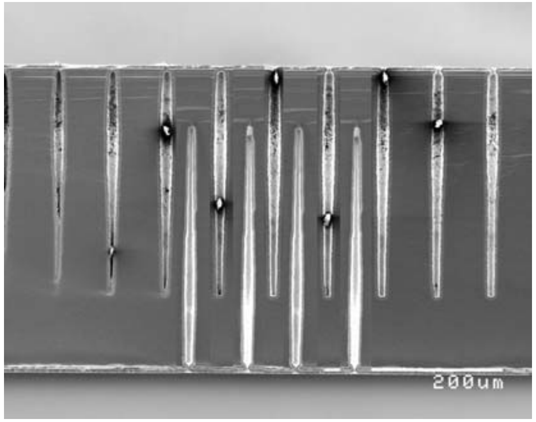


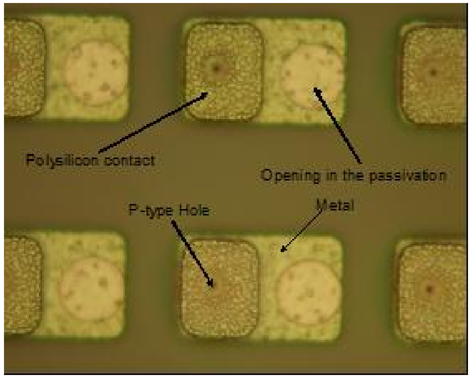
Double–sided 3D









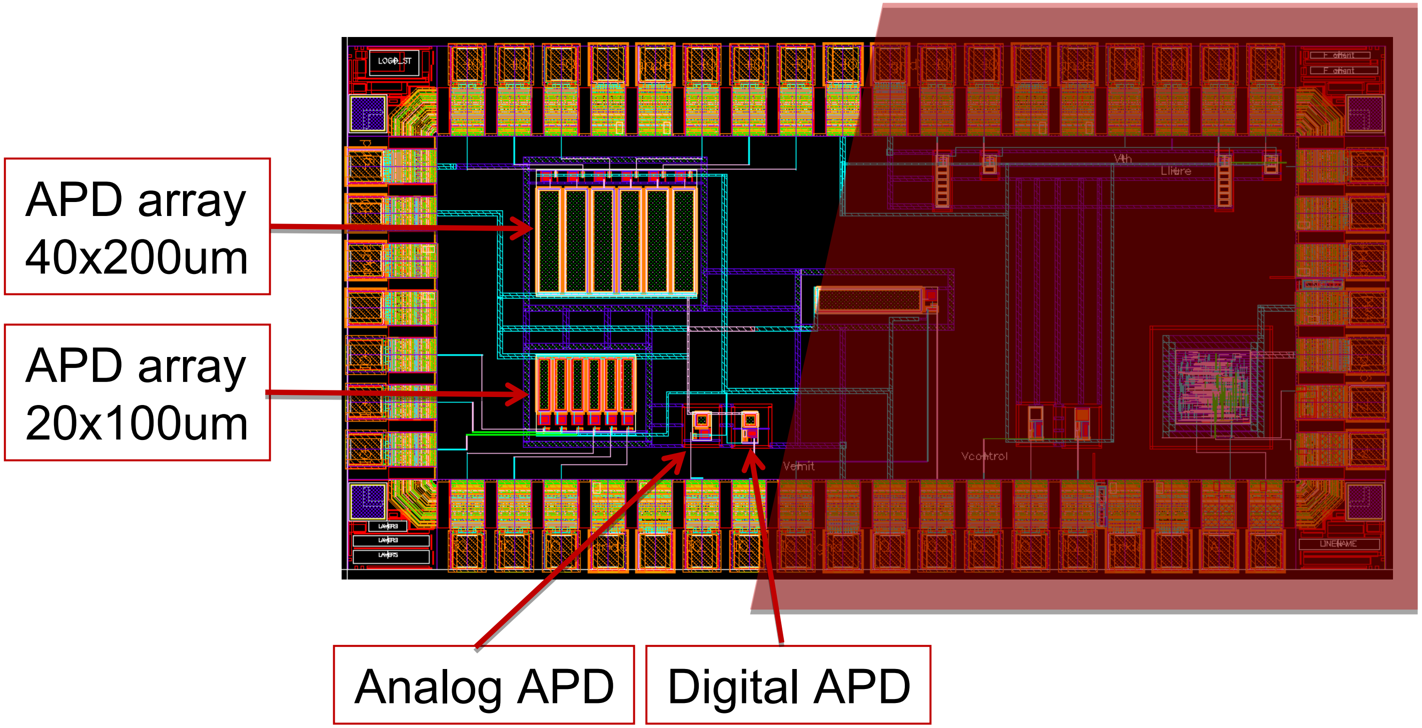


Digital GAPD– CNM, UB, URL

…on design of sensors for future trackers

Integrate electronics and sensors using industrial CMOS processes
Reduce analog readout electronics by using high sensitivity devices

STMicroelectronics CMOS 130nm



APD array
40x200um

APD array
20x100um

Analog APD

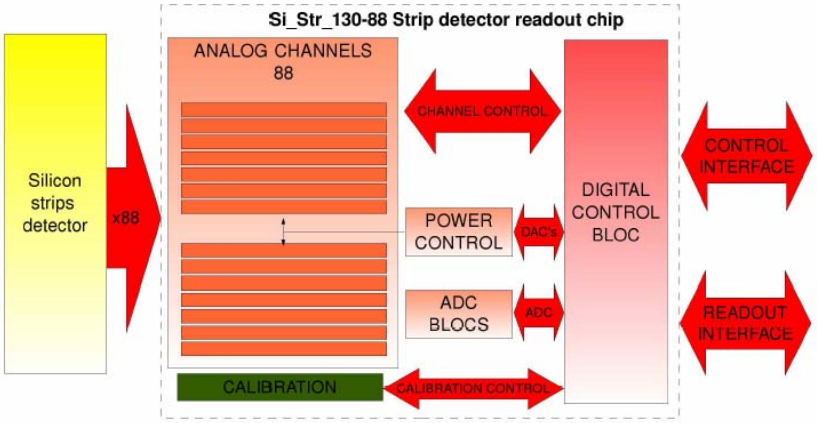
Digital APD

R/O Electronics – CNM, UB, URL

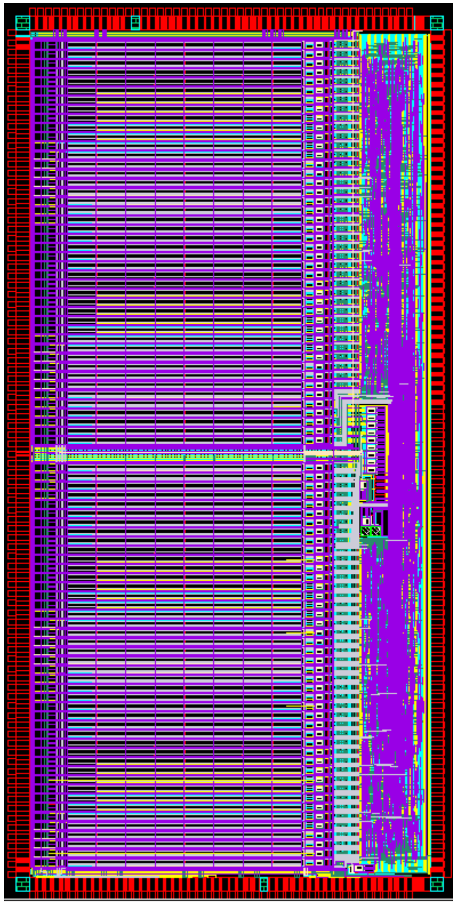
UMC CMOS 130nm
ASIC received first week of October'08

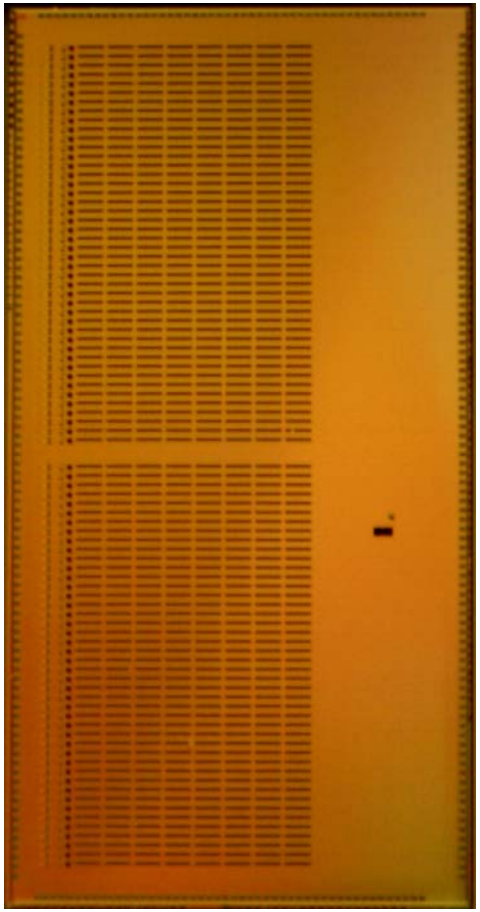
Mixed signal ASIC for readout of Si strip sensors in ILC

Analog part designed by IN2P3
Digital part designed by UB



88 channels

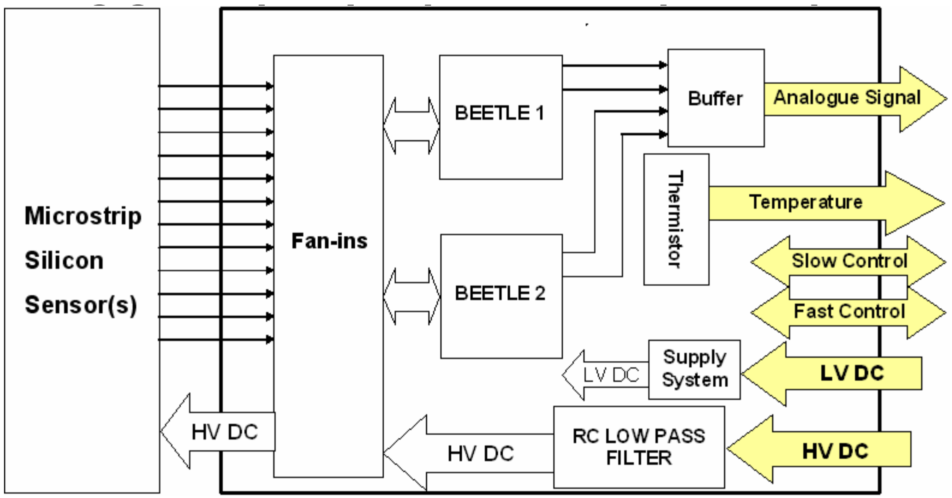




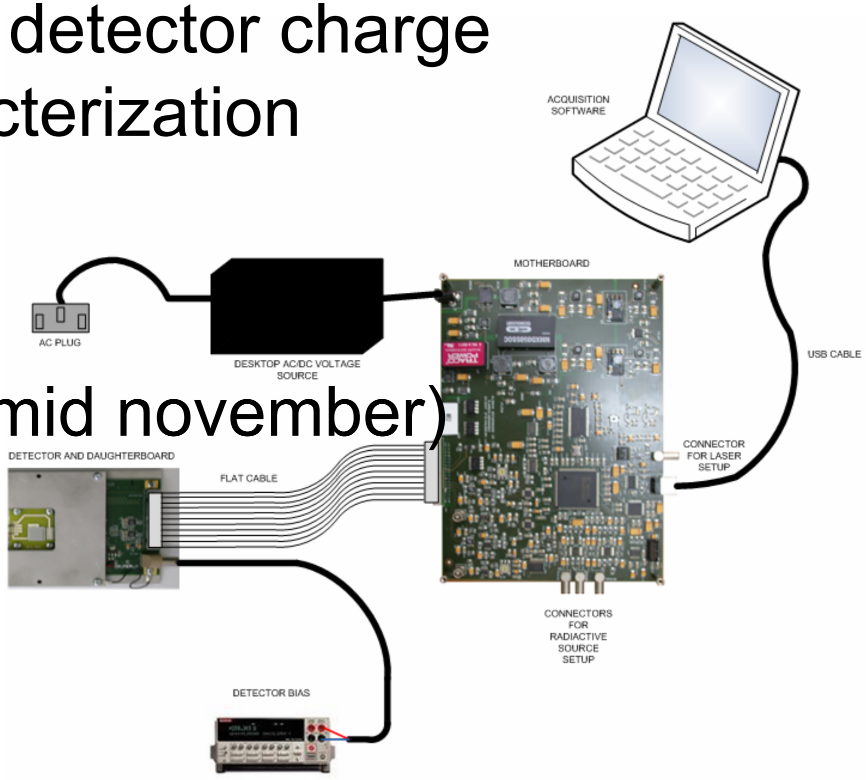
Electronics (2) - CNM, UB, URL

ALIBAVA: A readout system for microstrip silicon sensors

- Joint development of Liverpool Univ., IFIC-Valencia and CNM-Barcelona
- Simple and cheap system for detector charge collection performance characterization



(mid november)



CNM sensors (GICSERV08)

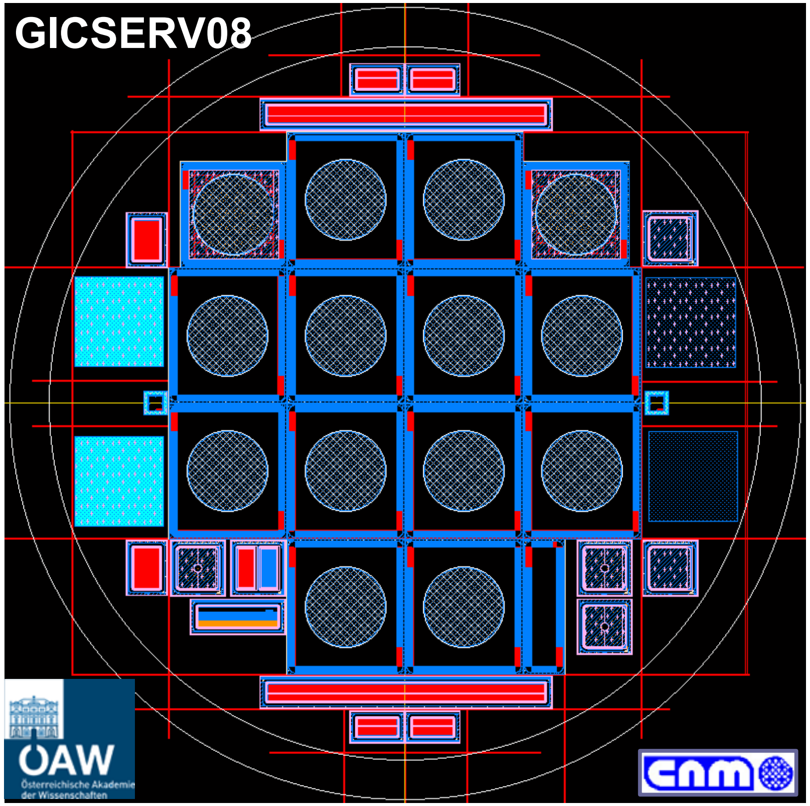
- Prototypes built by CNM-Barcelona (Spain)

- Aims:

— Test %T vs multigeometry

— Use optical test structures (continuous layers) to extract refraction index and control deposition

— Test of electrical test structures



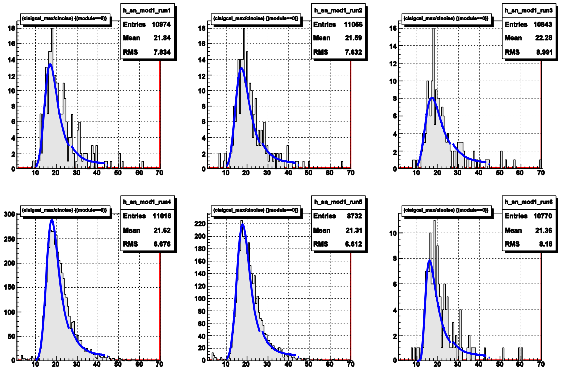
- 5+1 wafers
- 12 μstrip detectors per wafer (6 with intermediate strips, without metal contacts)
- 50 μm RO pitch (25 μm interm. strip)
- 256 RO strips
- 1.5 cm length varying strip width (3,5,10,15 μm)

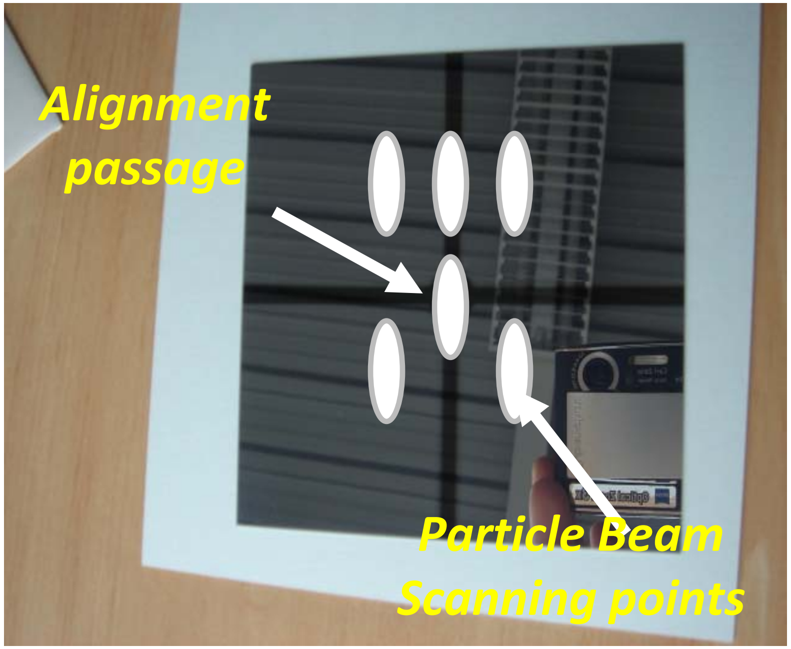
- Mask designed by **D. Bassignana** (CNM)
- Electronic test structures designed by **M. Dragicevic** (Vienna) including:

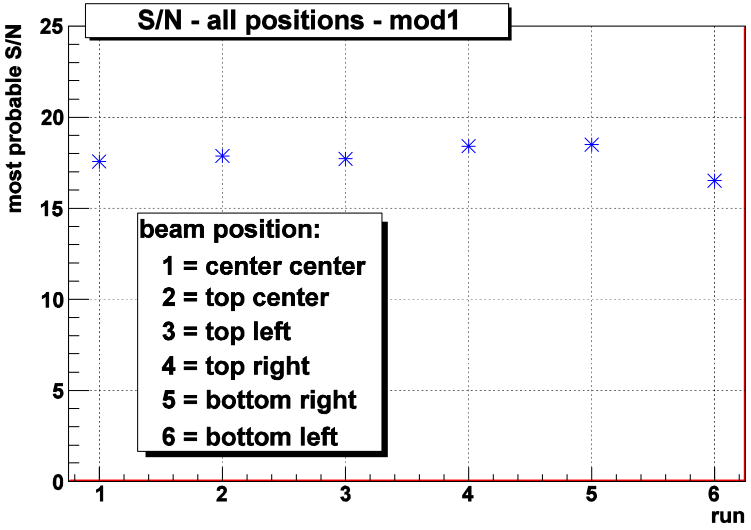
  CAP TS AC, CAP TS DC, CMS Diode, MOS, GCD, Sheet
- Optical test structures available (Si, Si+p^+,SiO_2, SiO_2+passivation)

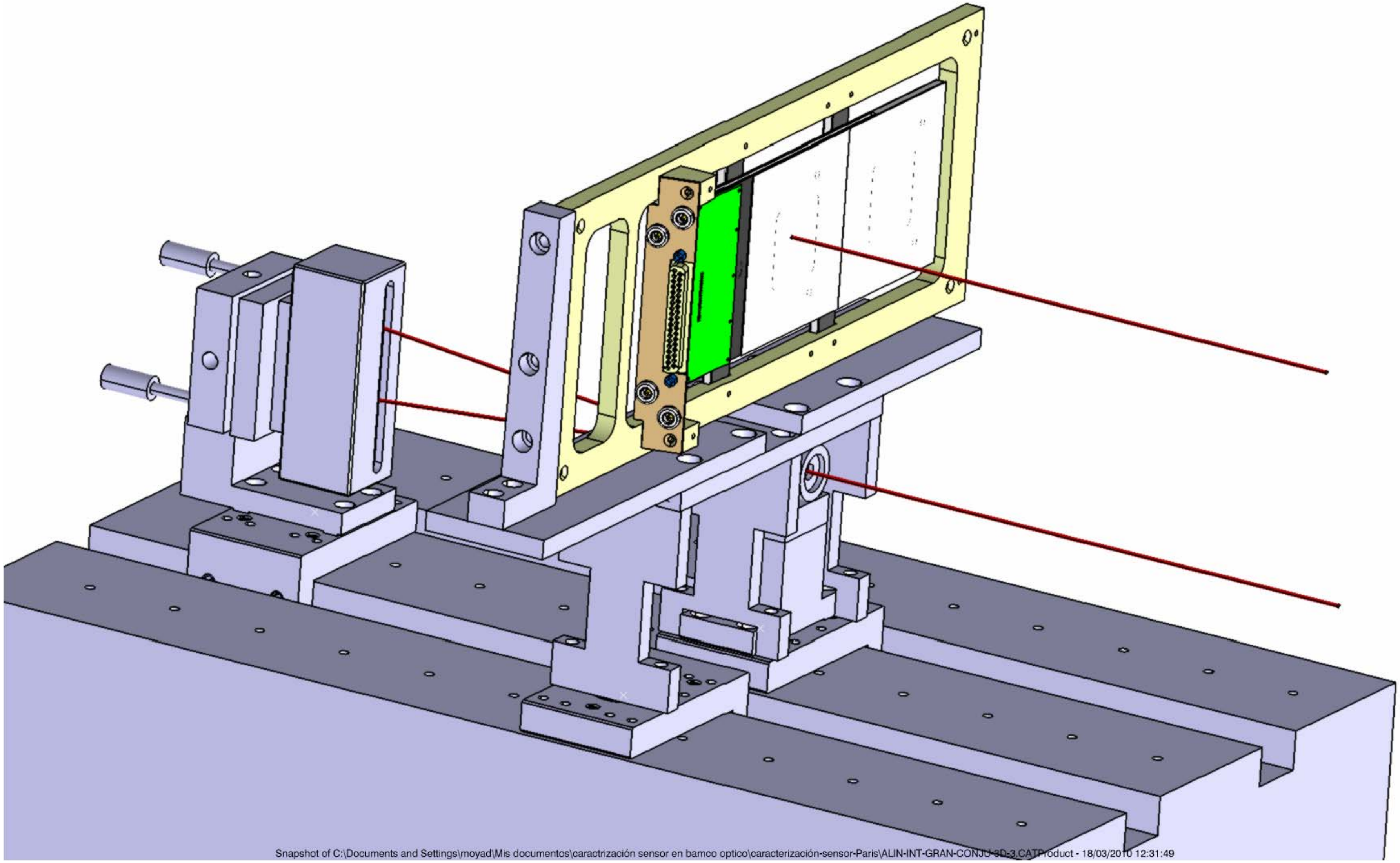
Preliminary TB results

- SNR sensor scanning comparing Back side with Al vs. n Back side with Al metallization







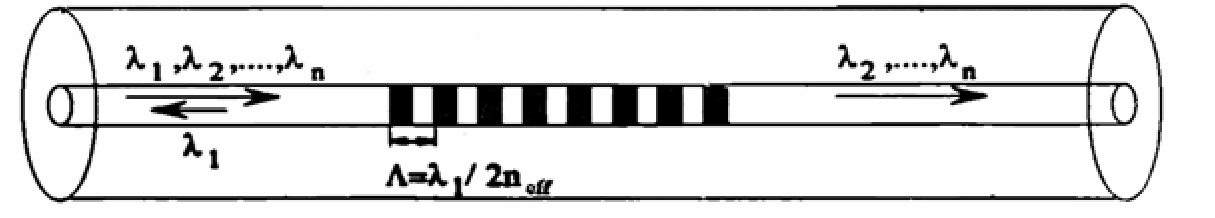


Snapshot of C:\Documents and Settings\moyad\Mis documentos\caractrización sensor en bamco optico\caracterización-sensor-Paris\ALIN-INT-GRAN-CONJU-3D-3.CATProduct - 18/03/2010 12:31:49

R&D FOS targets: Sensor reliability

Stability of the FBG FOS response write in a bare fiber (same response under same conditions T, ε)

Bragg Grating



Selective narrow band mirror

TEMPERATURE CHANGE

Thermal expansion for Λ
Termo-optic effect for n_{eff}

STRESS

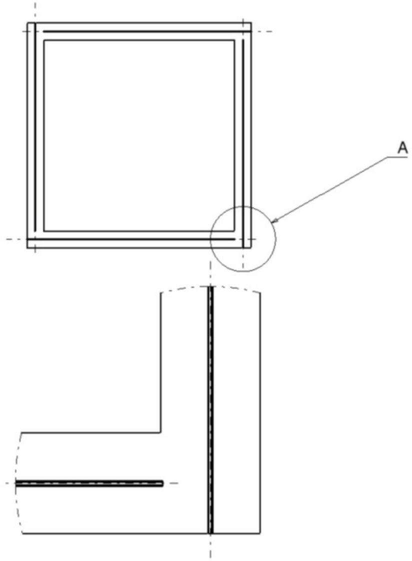
Elasto-optic effect for n_{eff}
Direct Strain for Λ

$$\lambda_B = 2n_{eff} \cdot \Lambda$$

Depends on refraction Index and geometry stability

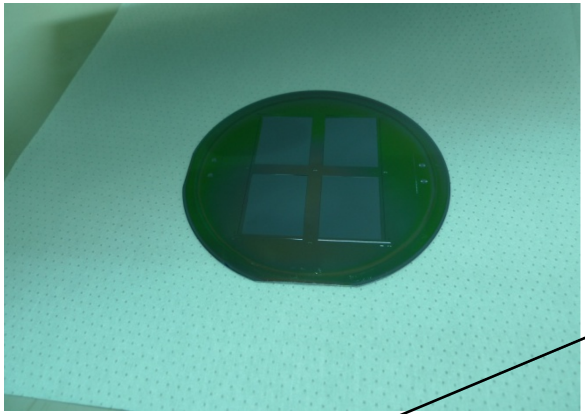
Thin Sensor mechanical dummies

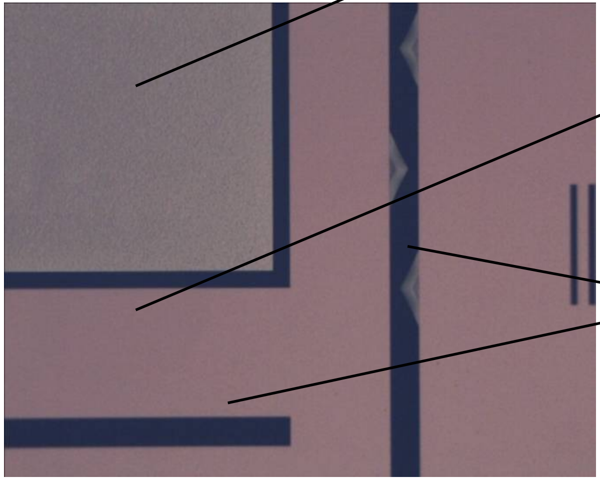
- Thinned (100, 150, 200 um) sensor mechanical dummies.



Exp. validation of FEA simulations.

Conventional KOH anisotropic etching on SOI wafer.





Thin area

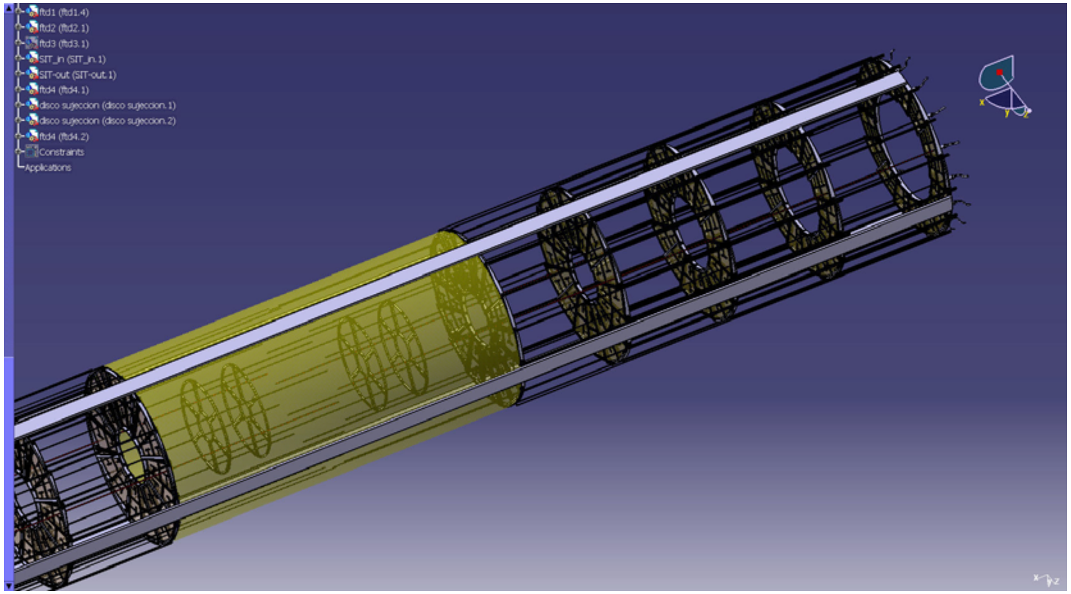
Frame

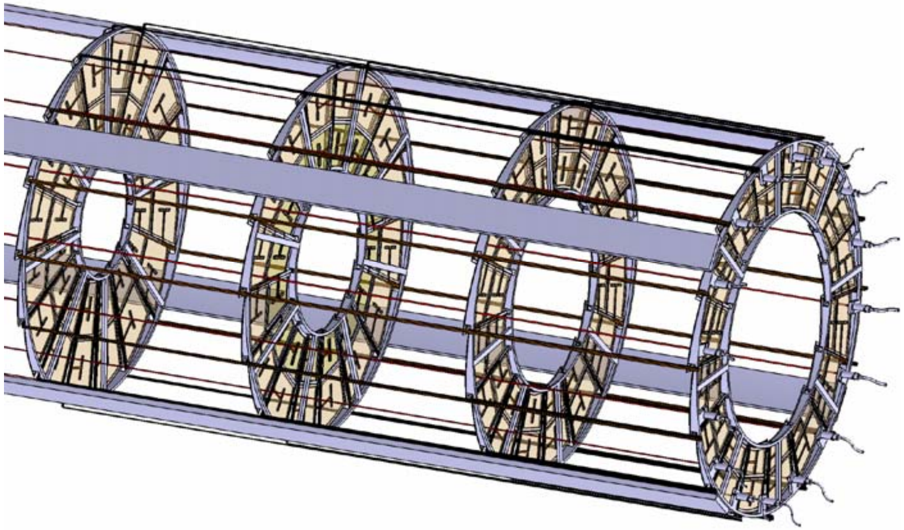
Microgroove

Displacement sensors based on strain FBG

- Improvement paths:
  - Adjust the mechanical design to our displacement range.
  - Embedding of the fiber, avoid glues.
  - Integrate the temperature composition FBG
  - Now first toy montecarlos.

ILD Forward Tracking Disks IFCA, IFIC

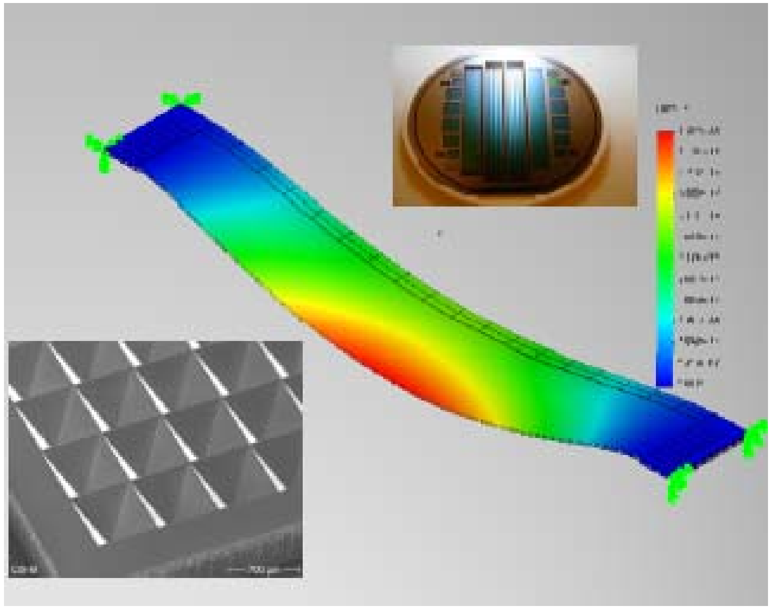


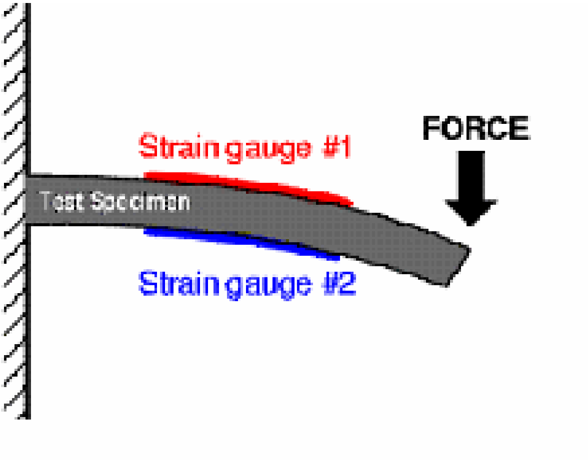


Three inermost disks pixels

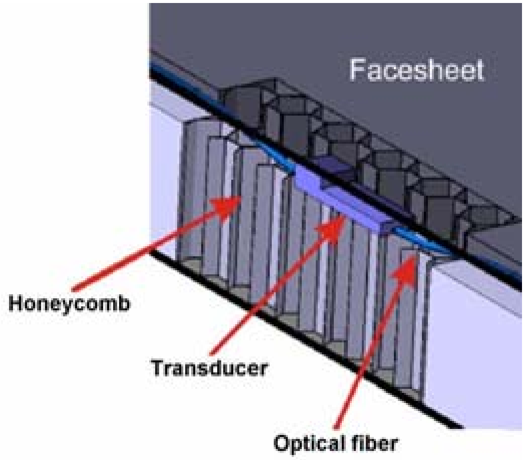
Four outermost disks microstrips

Mechanics – IFIC, IFCA



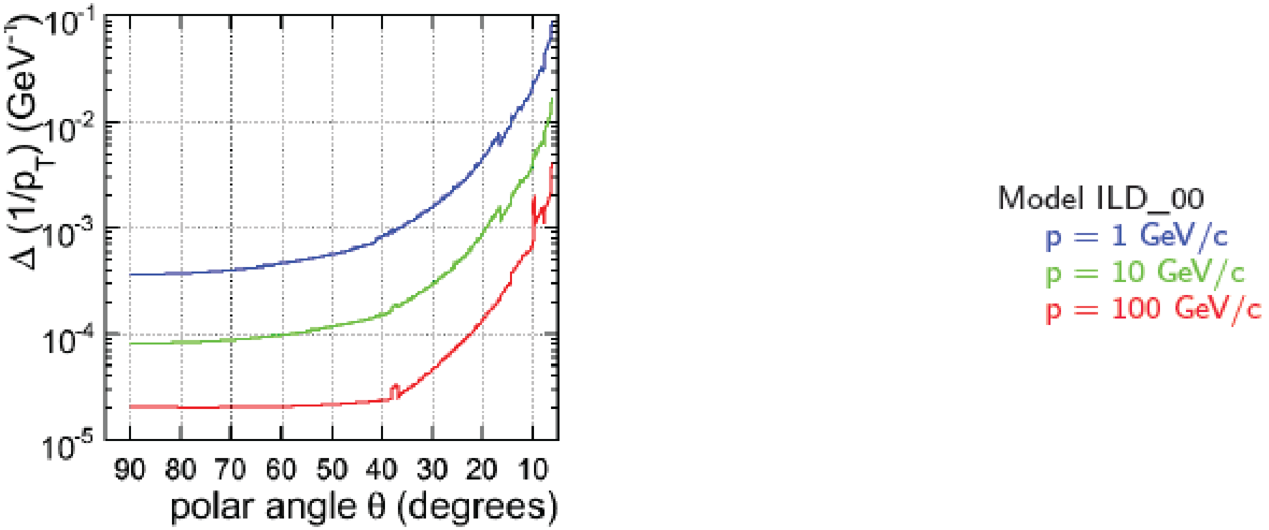


- For the Track structure would be interesting to use a embedded fiber optic sensor.
  - more precise and reliable data
- It could be use 2 side solution
  - Better understanding of the results
  - Useful to quantify the termical strain



ILC tracking specification: $\Delta(1/p_t) < 5 \cdot 10^{-5}\,(GeV/c)^{-1}$

Precision required to reconstruct the Higgs boson using the recoil method, and to reconstruct SUSY end-points



Momentum resolution Single Muons

- Performance ∼ stable down to 36^o
- Sudden loss between $6^0 - 36^o$.
  - Magnetic field orientation (inevitable within 4π detector geometry)
  - loss of number of measurements in TPC

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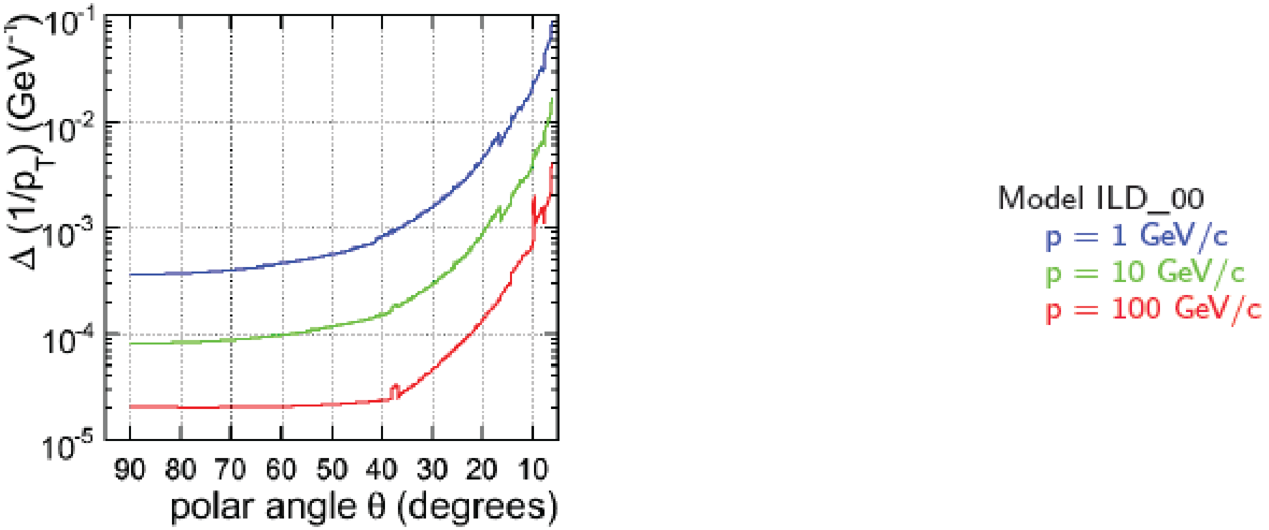

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Challenges for the Forward Tracking

Impact Parameter Resolution

VXD: impact parameter resolution 5 - 10 μm.

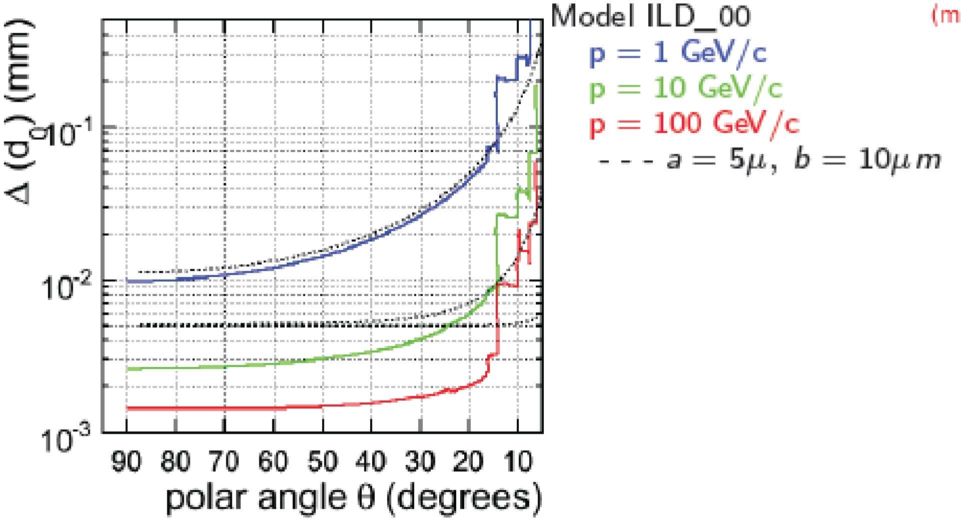
This precision is required to achieve excellent heavy flavour tagging, particularly for couplings of the Higgs boson to charm ($c\tau \sim 150\mu m$) and bottom ($c\tau \sim 450\mu m$)

$$\sigma_{IP} = a \oplus \frac{b}{p\sin^{3/2}\theta}$$

	a (µm)	b (µm GeV)
LEP	25	70
SLD	8	33
LHC	12	70
ILC	5	10

Unprecedented precision
(small pixels, 20x20 µm²)

Strongly reduce the multiple Coulomb scattering term
(material: 0.1 % X_0 / layer ~ 100 µm Si)

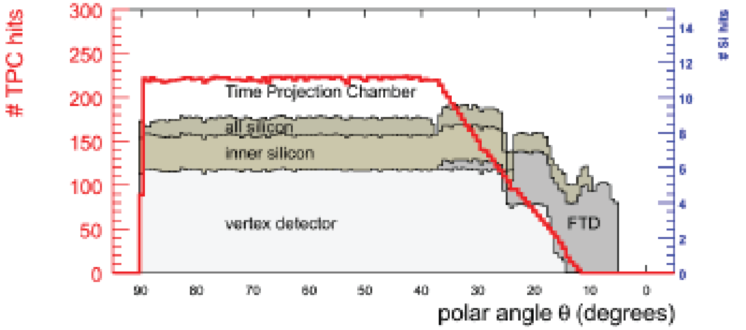


- Barrel: $a \simeq 1.7\mu m$
- forward: performance down

Challenges for the Forward Tracking

Pattern Recognition

- Clearly, 6-15 degrees is weakest region in ILD in terms of number of measurement
    - Ongoing study (C. Iglesias) evaluate hit densities in $t\bar{t}$ events per disk and per petal, subdividing disks in several single-wafers segments.
- The combinatorial algorithm on stand-alone FTD i able to efficiently and cleanly reconstruct tracks down to a p_t of 100 MeV/c (see M.Vos talk, ILC meeting Sendai)
    - R-segmentation: in innermost disks 500μm required, in outermost disks O (1cm)
    - Read-out speed: beyond several 10 sec of integrated bunch crossings the density of low momentum tracks prevents algorithm convergence
    - Material: an increase of the material beyond 1 %/disk has dramatic consequences on pattern recognition



Challenges for the Forward Tracking

Impact Parameter Resolution

To improve performance in the forward region: routing the barrel VXD services

See talk A.Ruiz, M.Vos ALCPG Alburquerque of the Toy model for barrel+end-cap vertex detector

- The forward region clearly does NOT like the services routed along the beam pipe
- If anything close to a few radiation lengths comes in the way between endcap and interaction point we can forget about forward vertexing