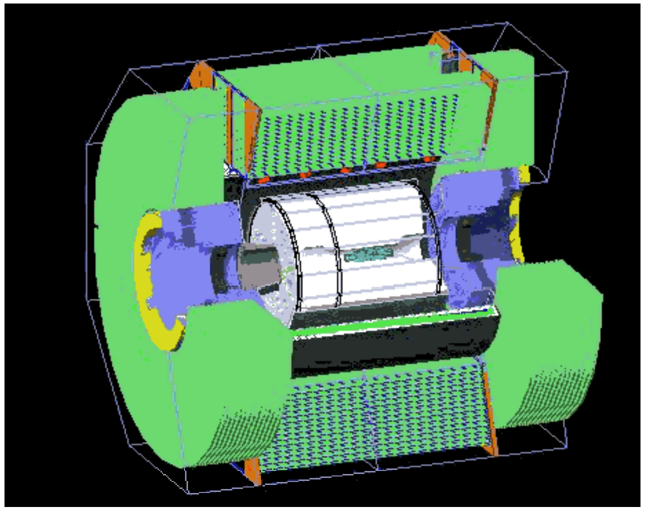
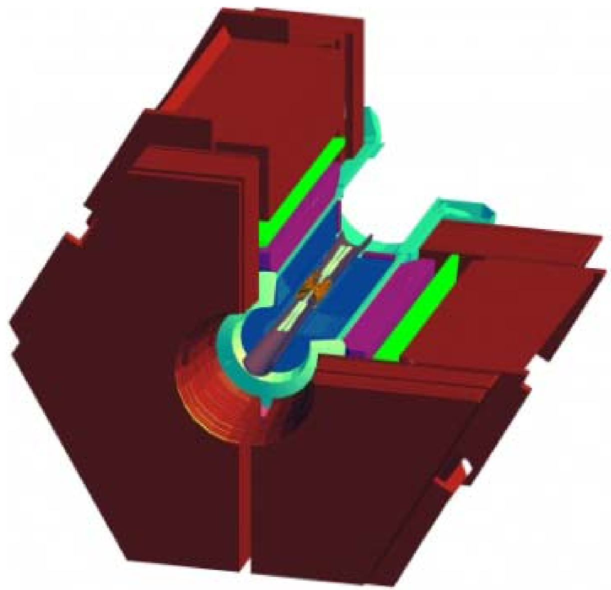
Super B activities at IFIC

A. Oyanguren

2nd Workshop on Flavour Physics in the LHC era





Outline

- Detector activities (silicon vertex detectors)
  - Belle II (PXD: Layers 1-2):
    - PXD support: termo-mechanics
    - Testbeam
    - Electronics: test and reparation
  - SuperB (VTX:Layers 1-5)
    - Electronics (FEE)
    - Microstrips sensors: tests and characterization
- Physics
  - Charm threshold studies at SuperB
  - Defining common Spanish interests

Detector activities: present and plans

Detector activities: The IFIC's lab

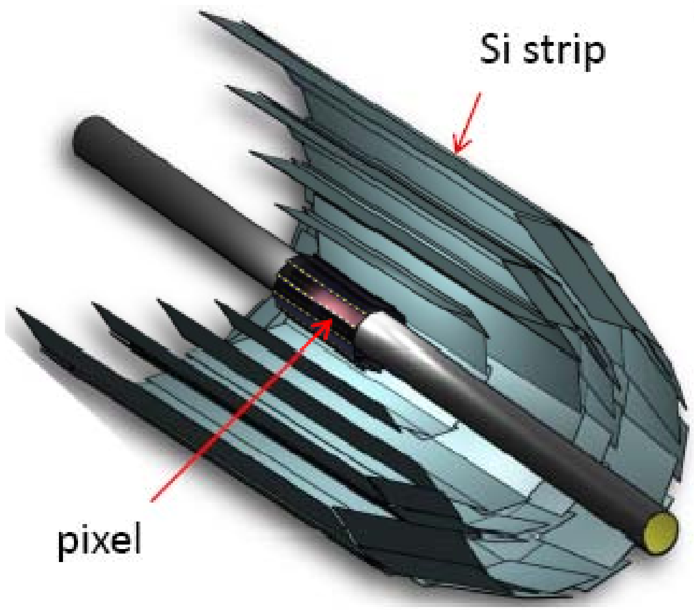
Two automatic wafer probe stations
Wire-bonders: one fully automatic, the other 2 manual
Laser interferometer system, Glue dispenser, sensor test cage

80m^2 clean room *class 10000* (ISO7), with 1^{o}C controlled temperature and ±5% humidity:
detector characterization, module assembly, bonding, metrology, and electrical QA test
+ dedicated laboratory room with a CO_2 cooling open system, N_2 dewar, climatic chamber and thermal camera: thermal tests

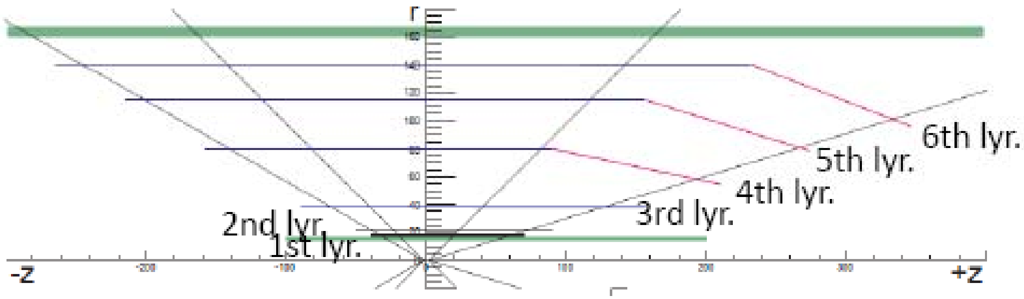
CNC lathers and grinders with ~5µm precision
MIG and TIG soldering machines, 3D CAD design
Visual and contact CMM with ~ 1µm prec.

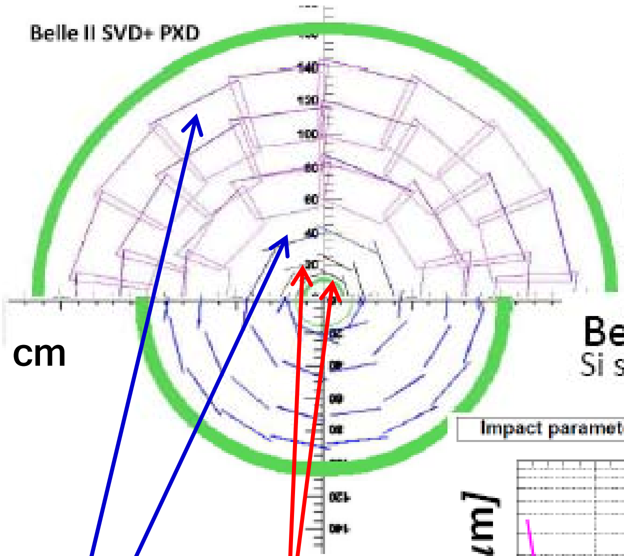
PCB design and fabrication (up 7 layers)

Belle II vertex detector: PXD + SVD



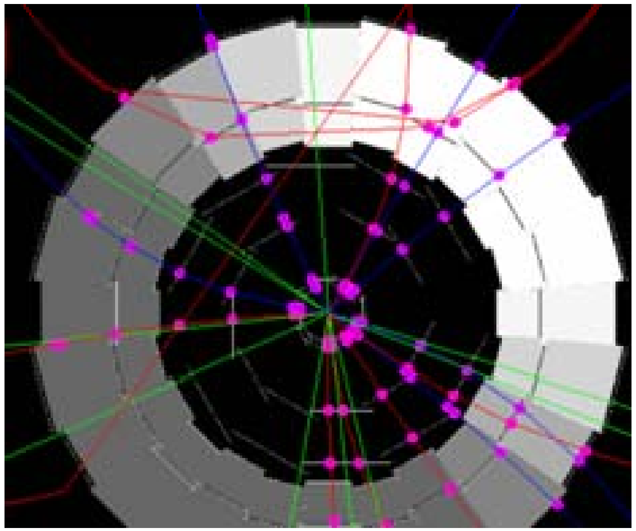
- 6 layers at radii from 1.3 cm to 14 cm





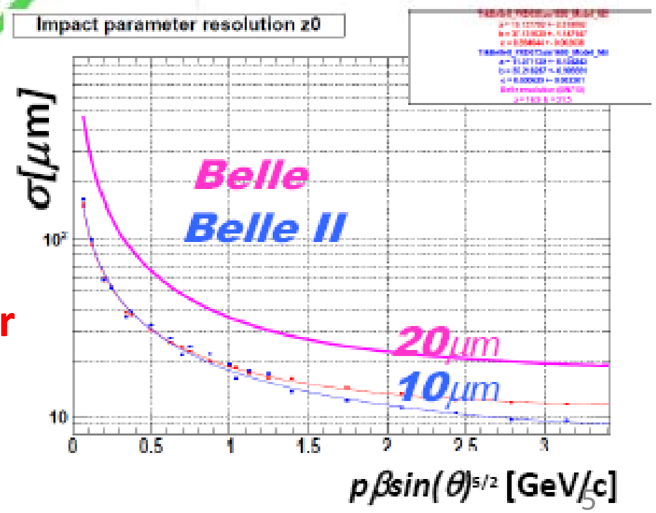
Belle-II
Pixel: r=14/22mm
Si strip: r=38/80/115/140mm

Belle
Si strip: r=20/43.5/70/88mm



4 layers with Strip detectors

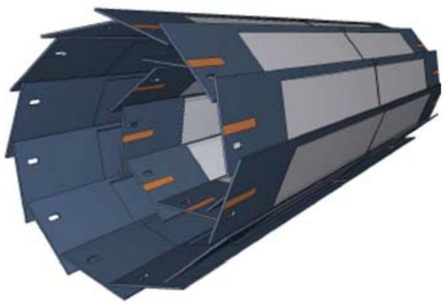
2 layers with Pixel detector (DEPFET)

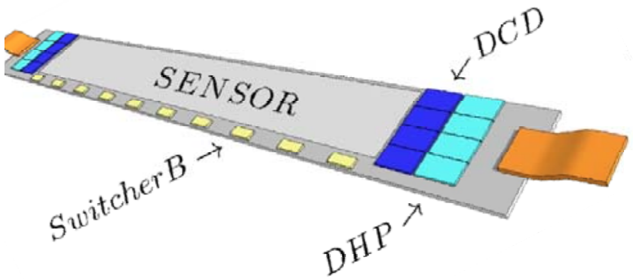


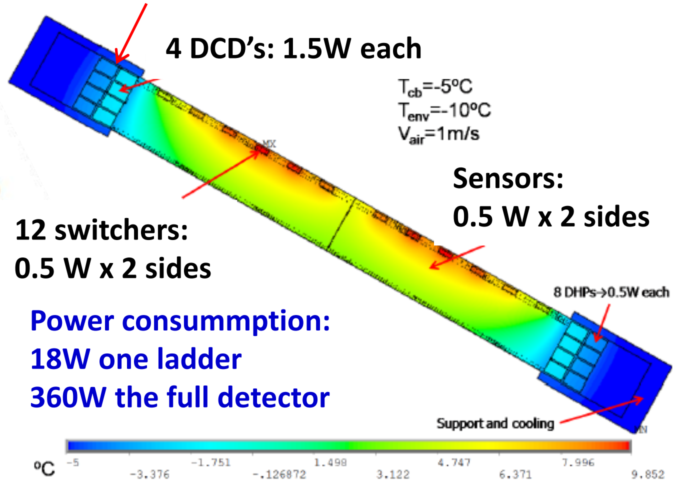
Belle II PXD

C. Mariñas simulation
CERN-THESIS-2011-101

2 layers with 8 (inner)+ 12 (outer) ladders (r=14,22mm)

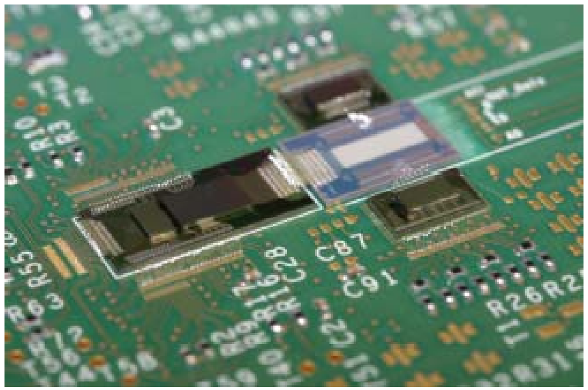






	Belle-II PXD
Point resolution	10 µm
Material budget	~ 0.1% X_0
Radiation tolerance	>1 MRad/year
Frame time	10 µs
Occupancy	0.4 hits/µm²/s
Power consumption	18 W/ladder (360W entire detector)

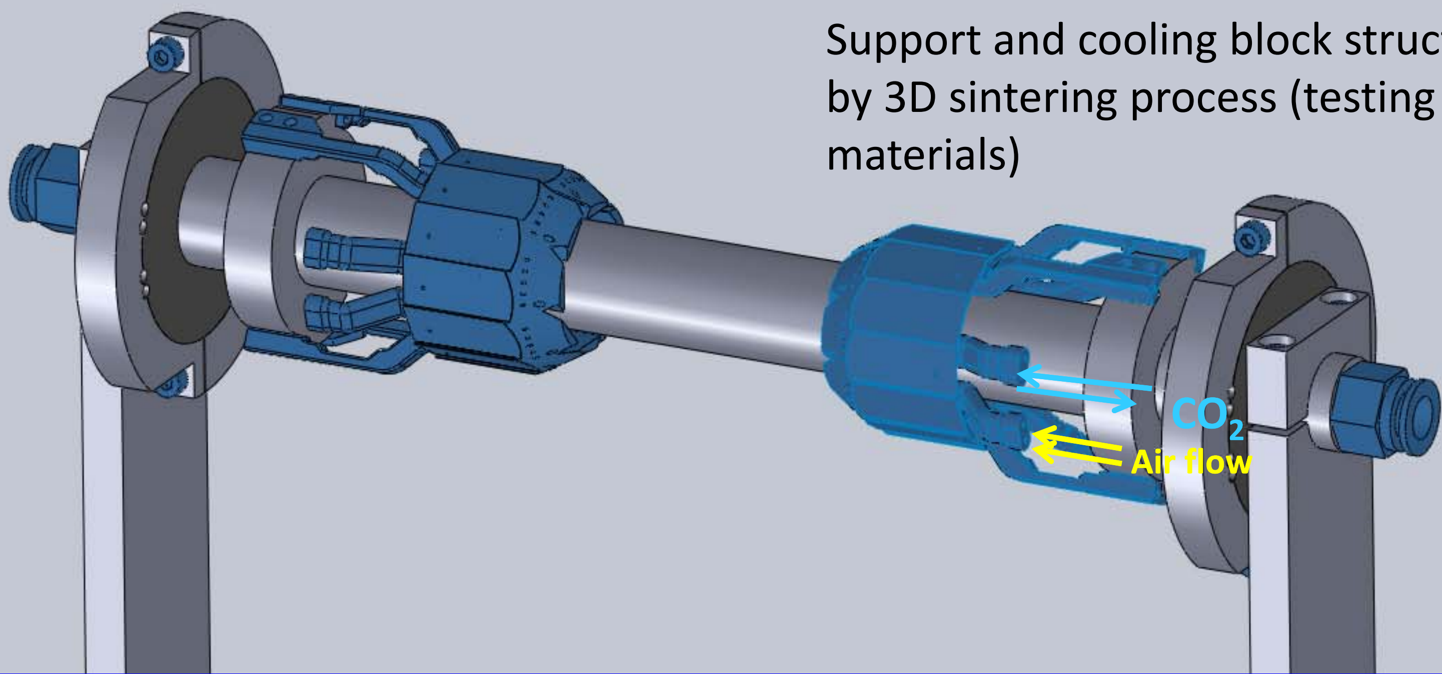
Prototype DEPFET pixel sensor and readout

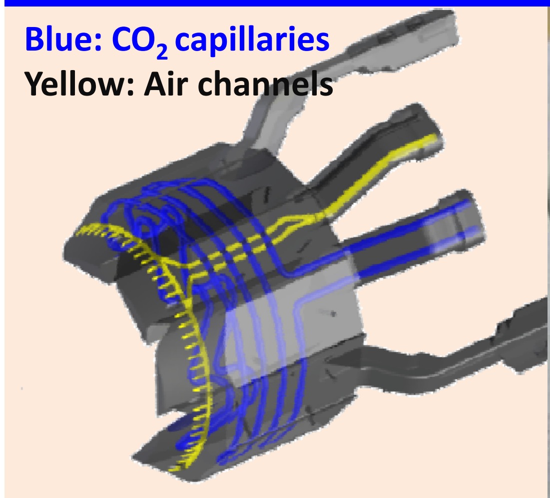


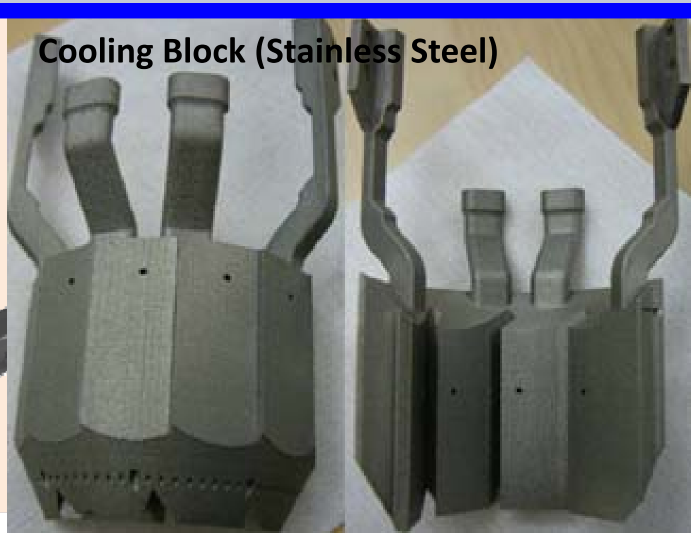
→ At IFIC test the mechanical design and cooling system for the PXD detector

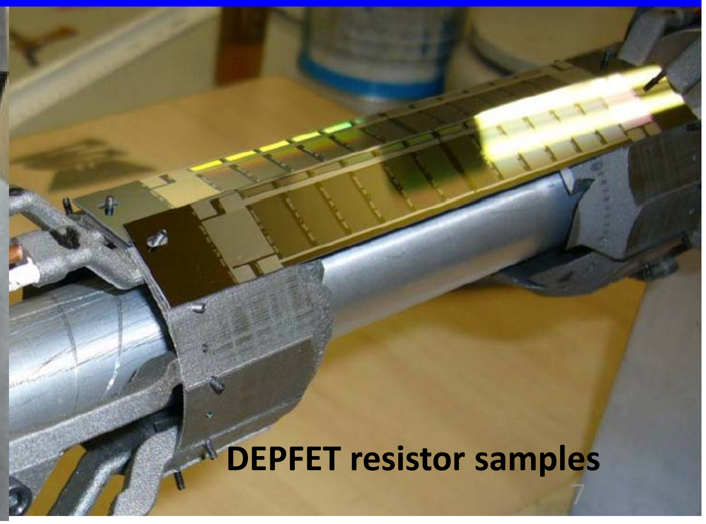
PXD thermal Mock-up

Support and cooling block structures made by 3D sintering process (testing several materials)







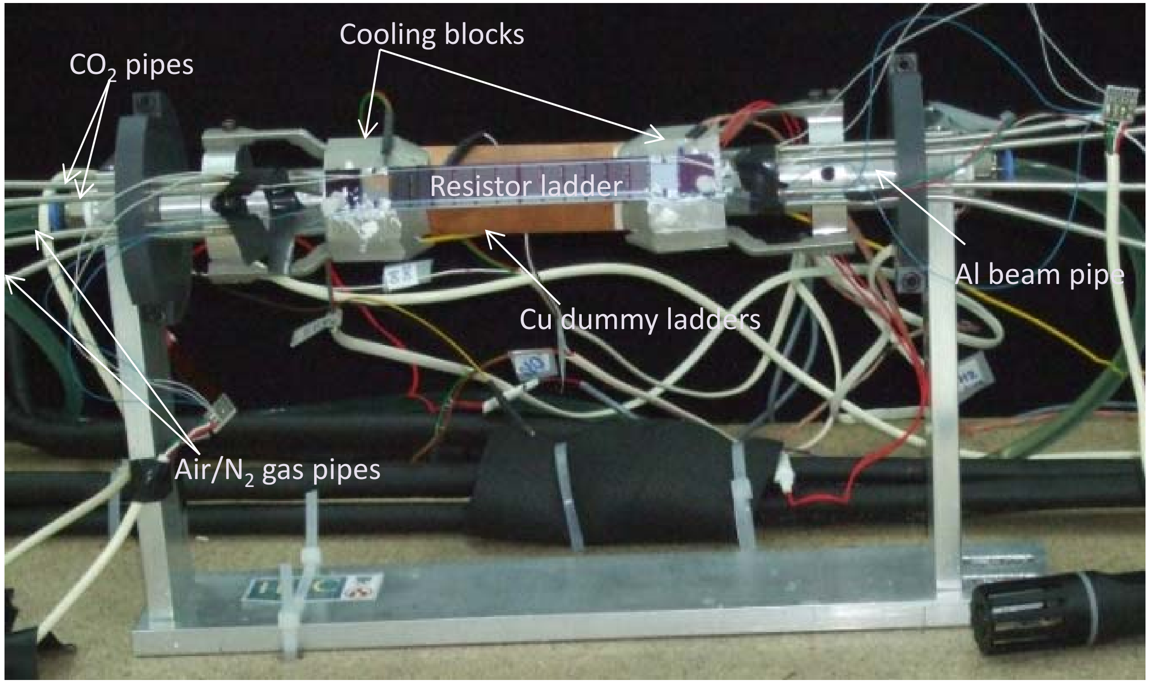


PXD thermal Mock-up

- Mock-up setup:

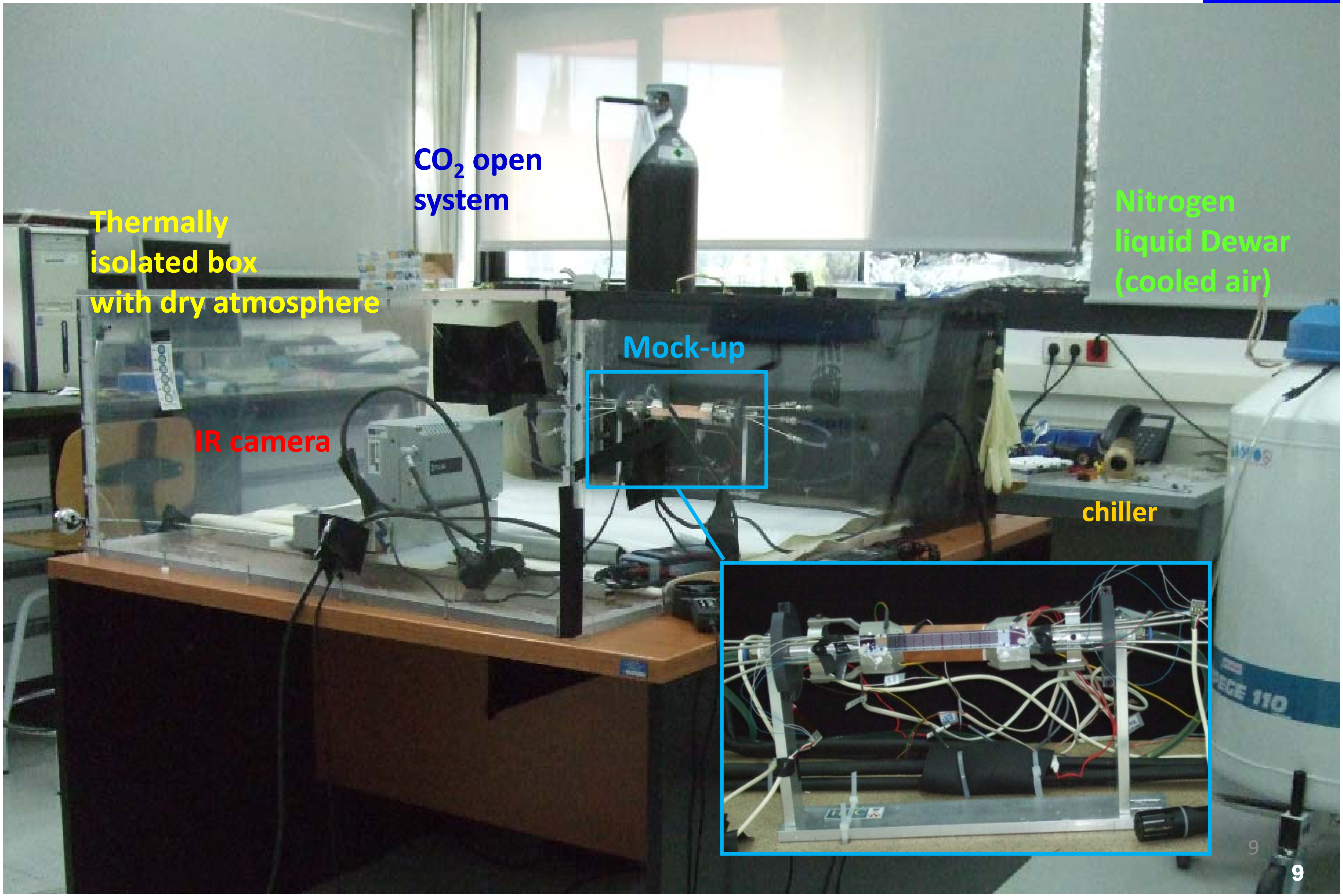
- Cooling blocks, cooled down with CO_2 (~12bar→ T~-30°C)
- Dry air/N_2 gas flow (v =2 m/s, T= -15 – 25°C *) (cooled down with N_2 liquid atmosphere)
- Dummy ladders: → Cu and Al ladders with heaters (inner and outer ladders).
  - Power dissipated along ladder: 1-4 W → T ~ 30°C-60°C

  → Resistor Si samples
  - Power dissipation: Sensor: P ~ 0.5 - 1 W
    Switchers: P ~ 0.25 - 0.5 W
    DCDs/DHPs: P ~2.5 - 8 W



(*before entering the pipes)

PXD thermal Mock-up



PXD thermal Mock-up

- Method:

- Measure temperature along inner and outer ladders and in the cooling blocks with an IR camera (properly calibrated) and PT’100 probes

- Studies:

CO_2 cooling:

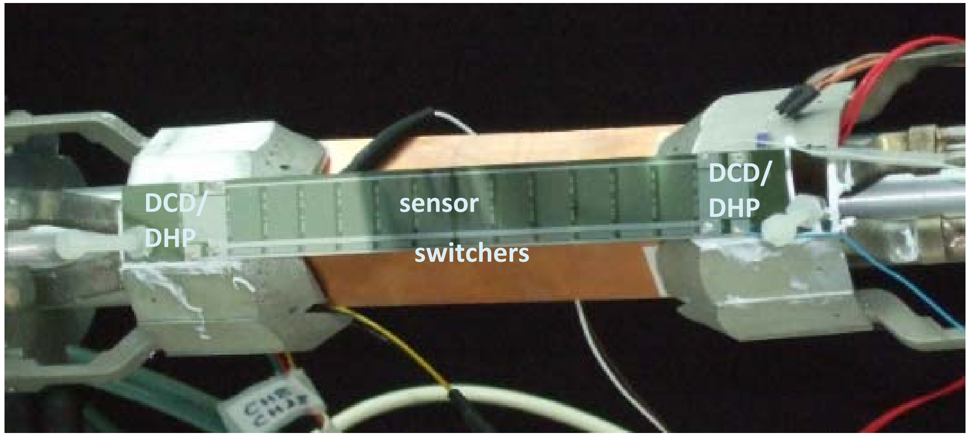
→ Cooling Block temperature

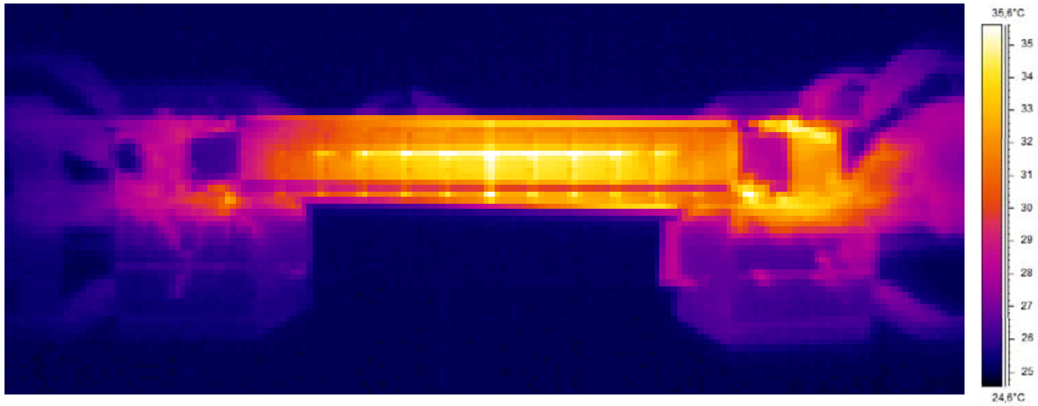
→ Power dissipation (DCDs/DHPs)

Air flow cooling:

→ Air velocity

→ Power dissipation (sensor and switchers)



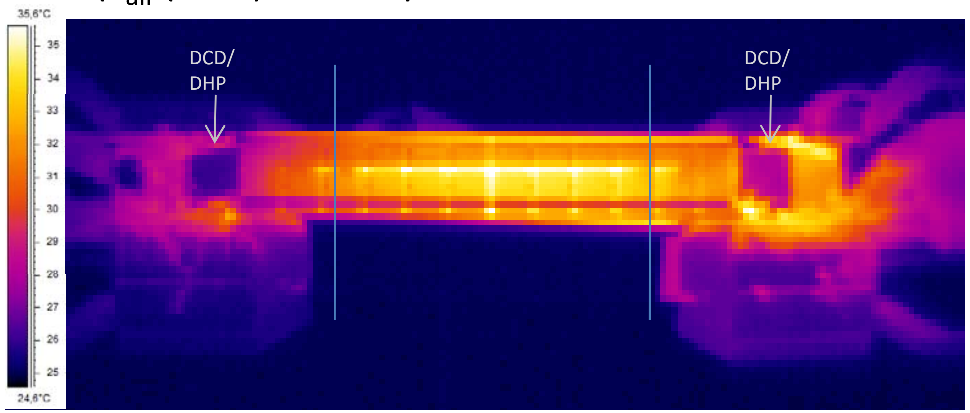


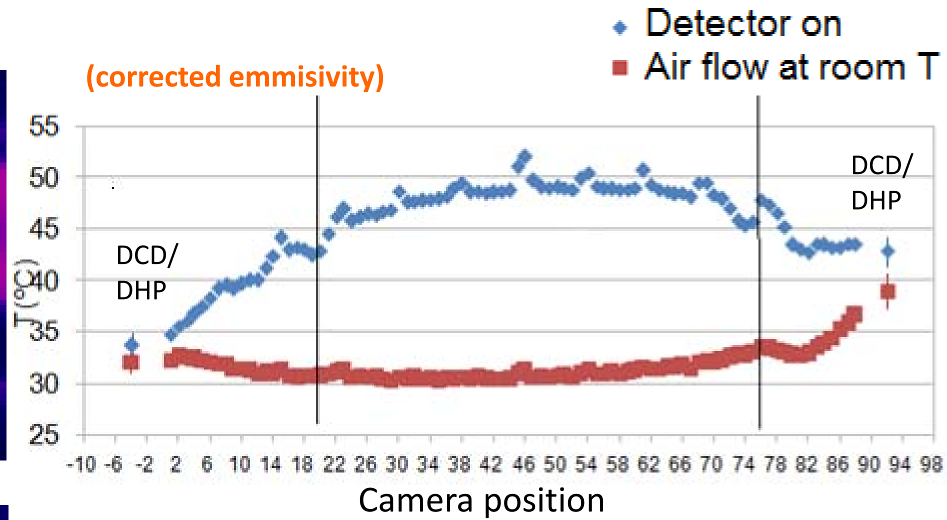
PXD thermal Mock-up

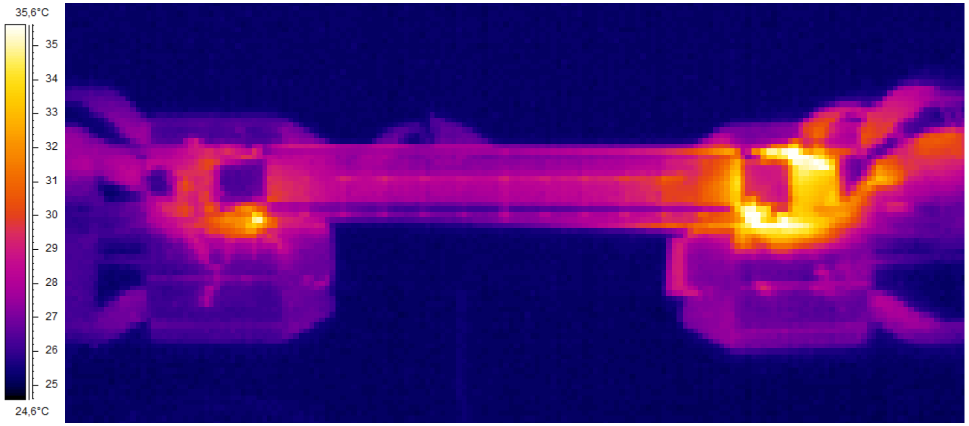
- Results:

- Effect of blowing dry air at room temperature (25°C):
  (v_{air} (inlet) ~ 2 m/s)

Sensor: P ~ 1 W x 2
Switchers: P ~ 0.25 W (left switcher off)
DCDs/DHPs: P ~2.5 W x 2







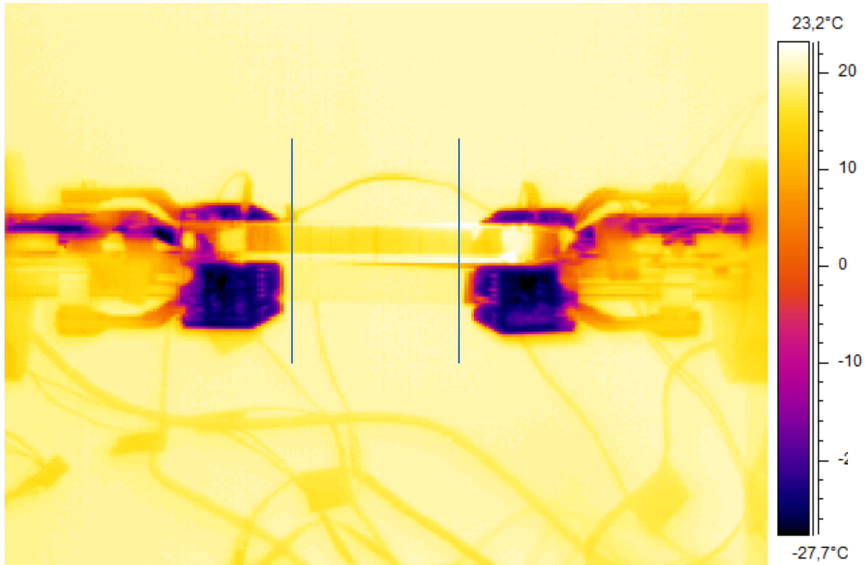
-The air flow (at room T) decreases and homogenizes the temperature along the detector.
→ Decreases T ~ 15° C
→ Max ΔT along the ladder 18°C→ 8°C

PXD thermal Mock-up

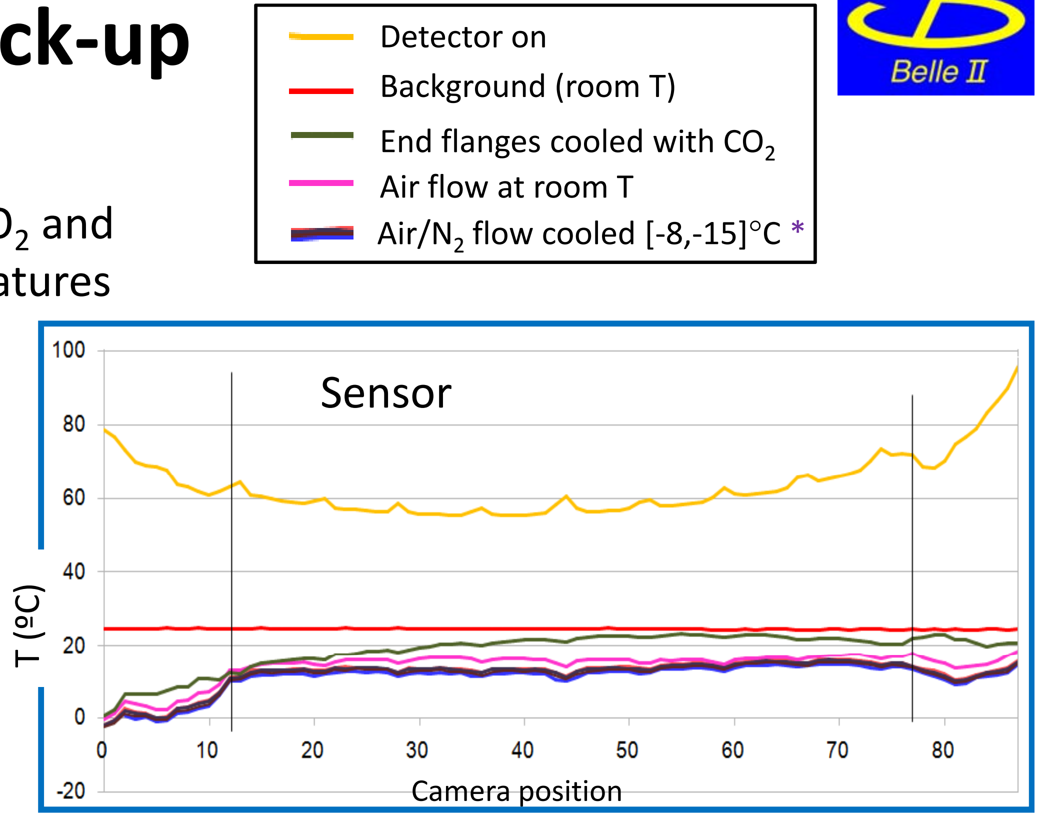
- Results:

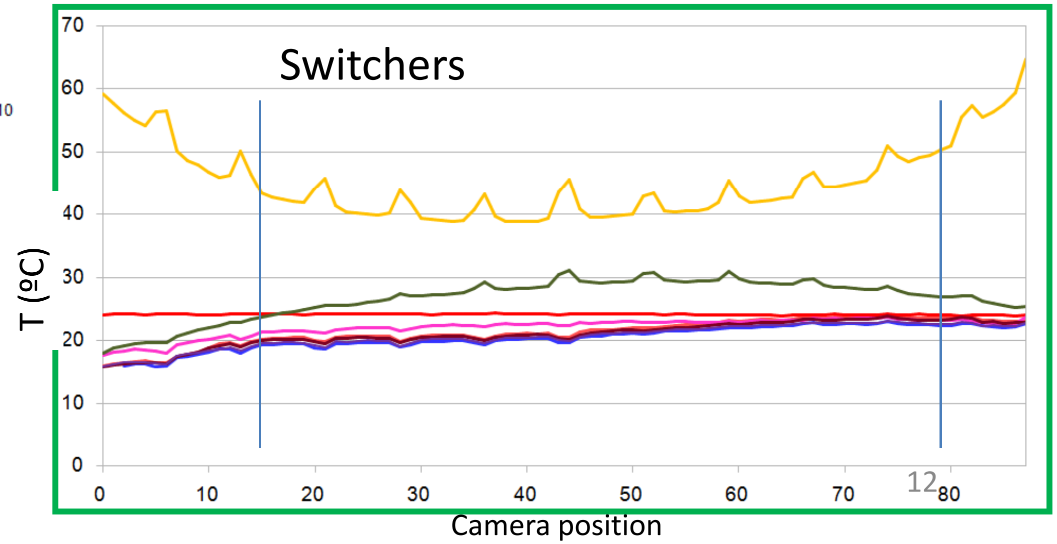
- Cooling down the cooling blocks with CO_2 and blowing dry air/ N_2 gas at several temperatures

Sensor: → P ~ 0.5 W x 2
Switchers: → P ~ 0.5 W
DCDs/DHPs: → P ~ 8 W x 2



(corrected emmisivity)





(* T measured before entering the pipes)

PXD thermal Mock-up

Summary:

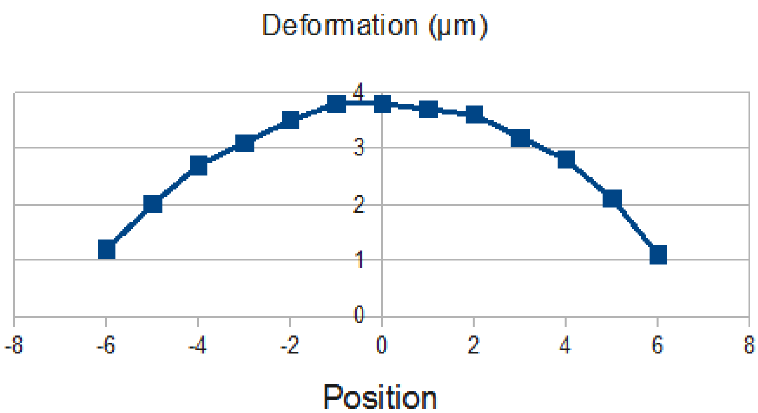
- **At present, all tests of air cooling show:**
  - **Significant effect of air cooling even at room T (ΔT=15°C for P ~2.5W)**
  - **Cooled air flow decreases the ladder temperature below ~20°C**
  - **ΔT_{max} along the ladder less or around 10°C (with cooled endflanges)**

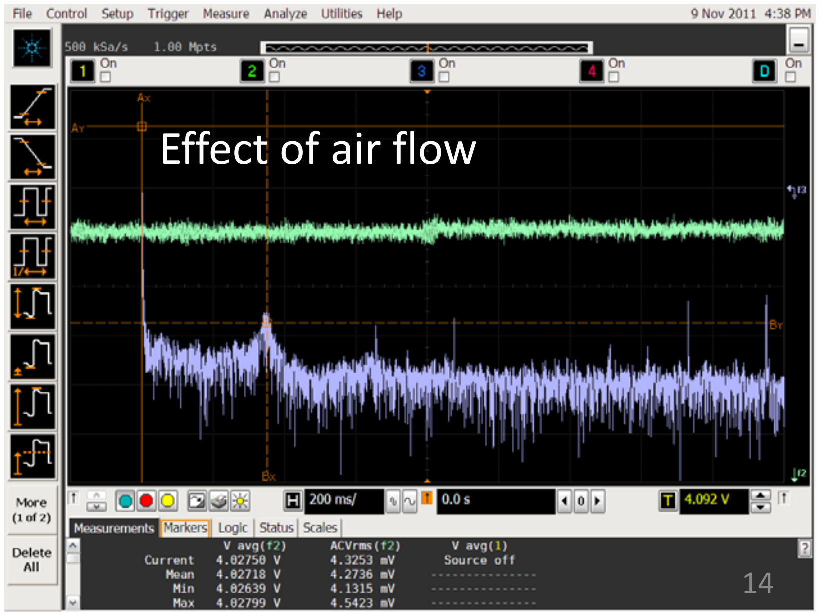
→ Next tests with closed volume, endflanges fully covered with heaters, air flow through carbon fibers

PXD thermal Mock-up

Detector vibrations/deformations:

Capacitive movement sensors





→ **Max deformation along the ladder~ 4µm**

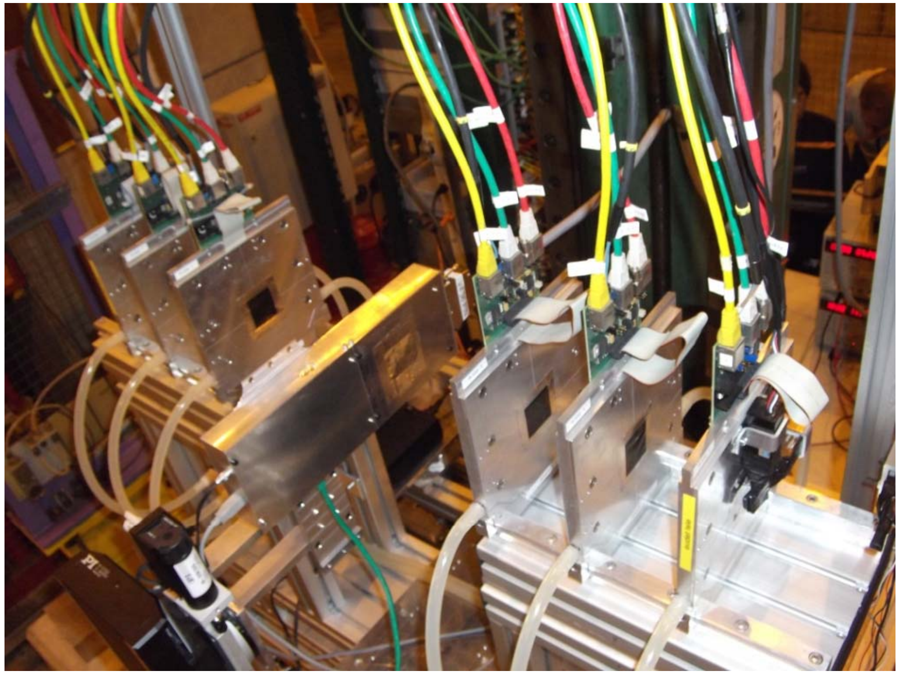
→**Vibration peak at 350Hz (very low amplitude)**

→ **RMS with air flow is 0.4 µm (0.2 µm w/o)**

(M. Vos)

DEPFET Testbeam ('11)

Belle II



•Telescope: use EUDET at CERN
•(3-5 mm pointing precision)

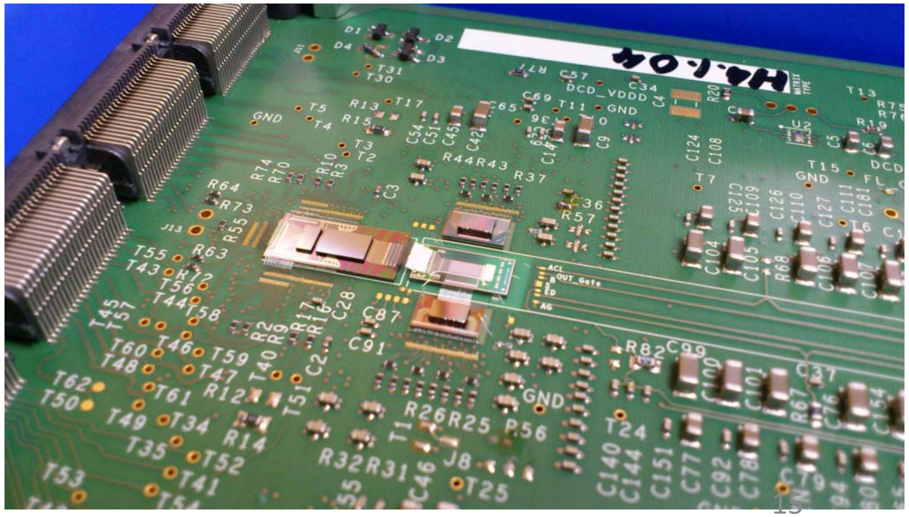
3-19 October 2011:
Running together with Belle-II SVD.

Sustained 800 Hz data taking.
Data taking efficiency ~ 30%.

(Data: 120 GeV pions under perpendicular incidence)

Three Devices Under Test:

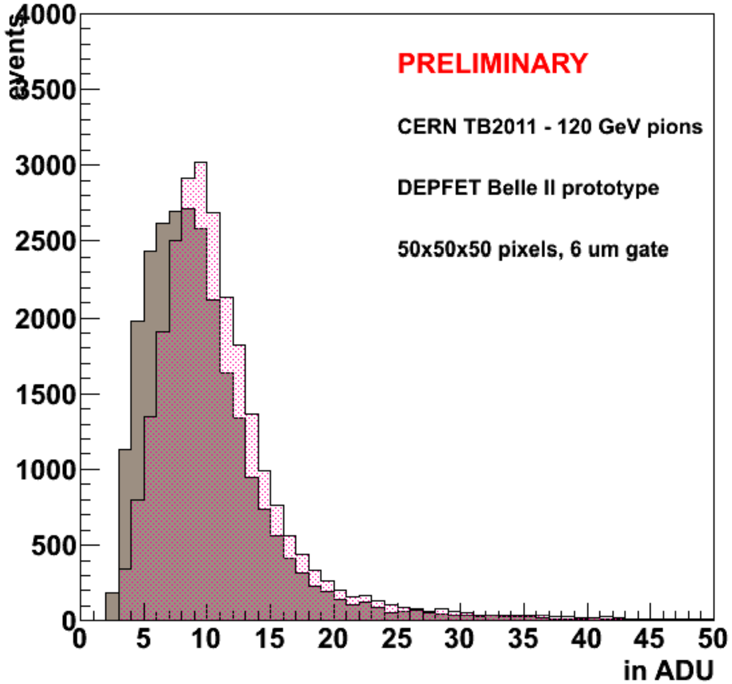
- **Old system:** 450 μm ILC design sensor
- **Two new devices:**
  - Built on new hybrid 4.1
  - PXD6 with Belle-II design
  - Sensors thinned to 50 μm (Belle-II → 75 μm)
  - DCD read-out chip operated at 100 MHz
    (nominal 320 MHz is possible on one)



DEPFET Testbeam

Noise performance:

Common mode noise < 1 ADU
Intrinsic noise, after CM subtraction: 0.5 ADU
Noise measurement agrees with lab. tests



Preliminary result for most probable signal on H4.1.04:
MPV ~ 10 ADU

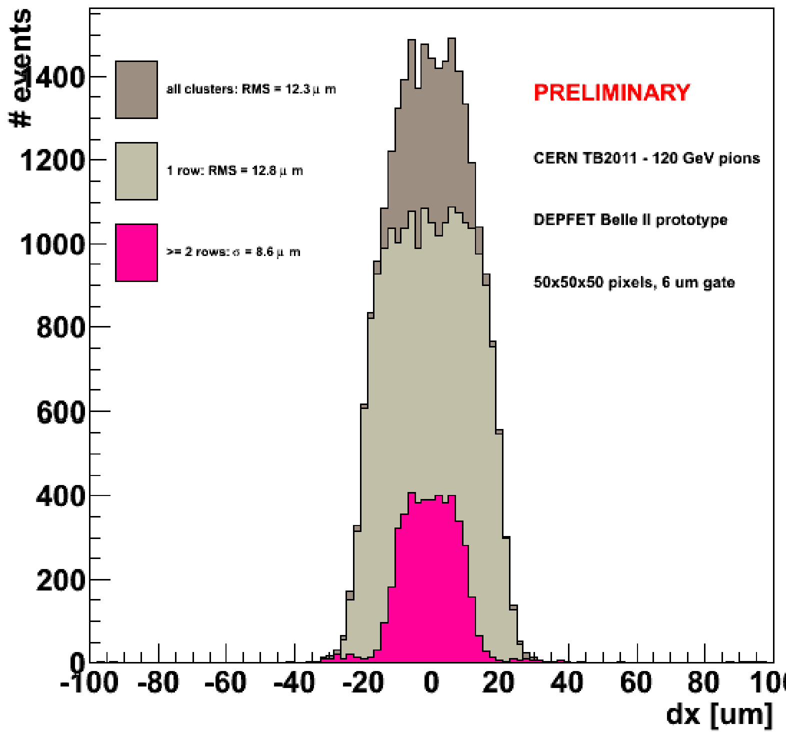
S/N ratio ~ 20
(i.e. 40 in Belle-II)

Spatial resolution:

Single-pixel cluster show expected "box" distribution from -25 to +25 µm,

- smearing by telescope resolution ~ 2-3 µm
- binary RMS = 50 µm / √12 = 14.4 µm

Multiple-pixel clusters are relatively rare under perpendicular incidence



SuperB SVT

Based on BaBar SVT: 5 layers silicon strip modules **+ Layer0 at small radius** to improve vertex resolution

Requeriments for **Layer0:**

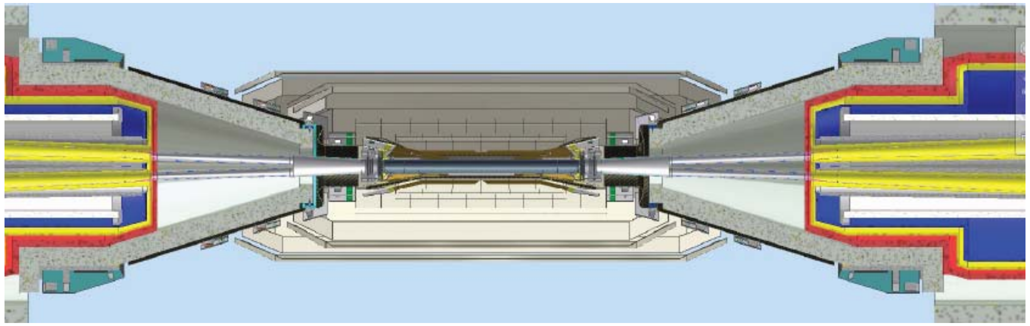
→ R~1.5 cm, material budget < 1% X0,

→ hit resolution 10-15 μm in both coordinates

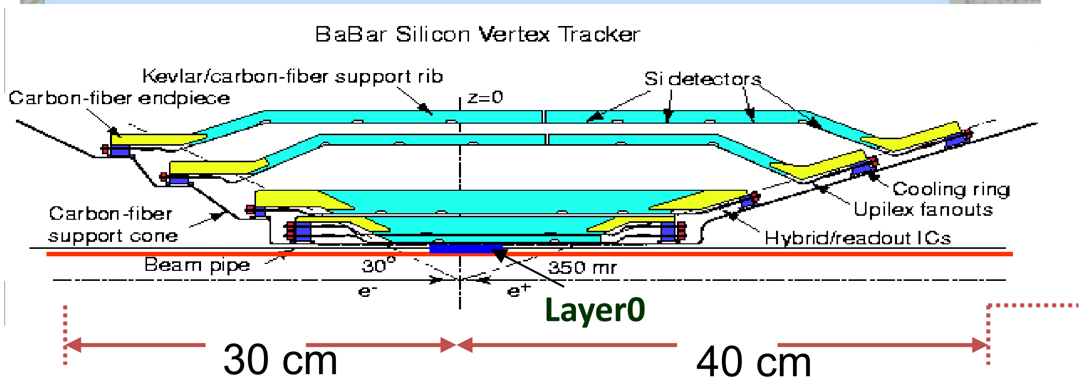
→ Track rate > 5MHz/cm^2 (Total Dose > 3MRad/yr)

Technologies: Striplets, Hibrid Pixels, MAPS, VIPIX)

Layer 1-5: Strips, new readout schemes L1-3, L4-5



Layer	Radius
0	1.5 cm
1	3.3 cm
2	4.0 cm
3	5.9 cm
4	9.1 to 12.7 cm
5	11.4 to 14.6 cm



SVT baseline: L0 + L1-L5 (300 μm) strip detectors, ±300 mrad angular coverage in Lab frame;

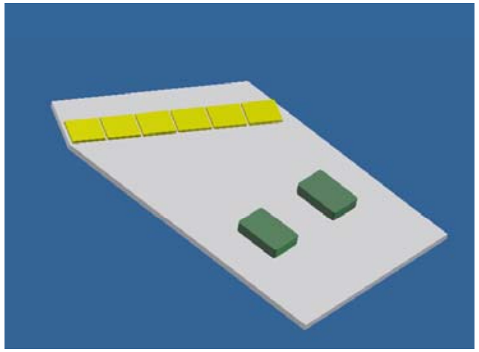
SuperB SVT

IFIC's aim:

-**Join Trieste and Milano efforts on sensor design, test and characterization for SVT layers 1-5** (L. Bosisio)

- electrical test and characterization

→ Waiting BABAR spares to setup electrical tests



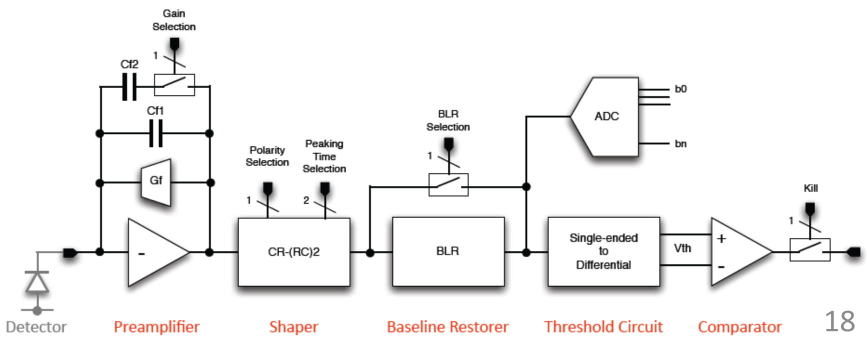
-**Join Pavia in the readout design** (M. Manghisoni)

- Inner layer (L1-3) analog readout circuit
- electrical tests and characterization
- HDI (High Denisity Interconnect) circuit design (?)

→ In contact with Pavia designers, negotiating CADENCE Spectre Lisence with EUROPRACTICE

→ Want to contribute in the tests of first prototypes at the end of the year

- **Mechanics / thermal test?**



Physics:
present and plans

Physics:

Sensitivity studies on mixing and CP violation in charm at Ψ(3770) and Υ(4S) at SuperB

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[1] Università and INFN Pisa, [2] IFIC Valencia, [3] INFN Milano, [4] INFN Laboratori Nazionali di Frascati

Goal:

- Estimate and compare the experimental sensitivity on charm mixing and CP violating parameters at SuperB:
  - Υ(4S)
  - Ψ(3770) as a function of CM boost and detector configuration
- First step: study the 2-body decays ✓
- Second step: include the 3-body decays

Considerations:

- At Υ(4S)
  - Flavor tagged D^0 through $D^{*+} \to D^0\pi^+$ decay. We denote the D* flavor tag with the label *l*X
  - D^0 can be reconstructed in flavor *l*X, CP, Kπ and multibody (e.g. Ksππ) final states. Relatively high purity due to $m(D^0)$ and $\Delta m = m(D^{*+}) - m(D^0)$
  - Flavor mistag ~0.2%
  - Proper time resolution is about $\tau(D^0)/4 \approx 0.1$ ps
- At Ψ(3770)
  - Coherent $D^0 \bar{D}^0$ production
  - Both D mesons can be reconstructed in *l*X, CP, Kπ and Ksππ final states, with very low background
  - Flavor mistag ~0.2% with eX,
  - Time-dependent measurements require larger CM boost compared to the Υ(4S) case to achieve similar time resolution, but reconstruction efficiency decreases with large CM boost. Need to determine the optimal boost range.

Double tags @ Ψ(3770)

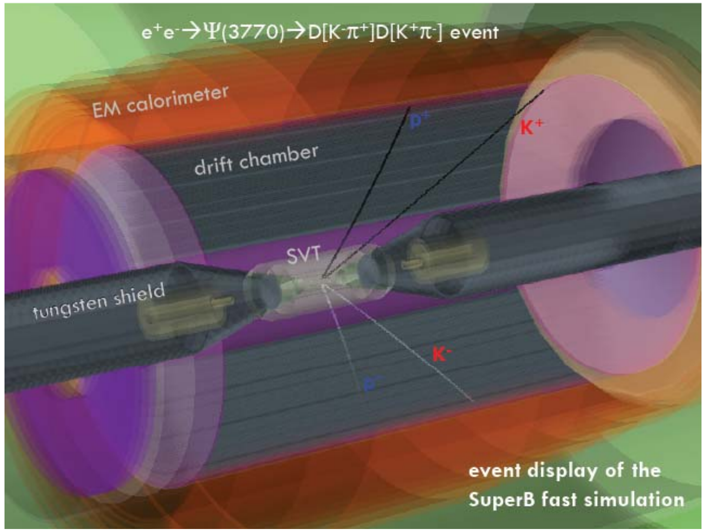
Modes with D* tag @ Υ (4S)

	CP−	Kπ	*l*X	Ksππ
CP+	X	X	XX	X
CP−		X	XX	X
Kπ		X	XX	X
*l*X			XX	XX
Ksππ				X

→ Complete expressions for time dependent rates

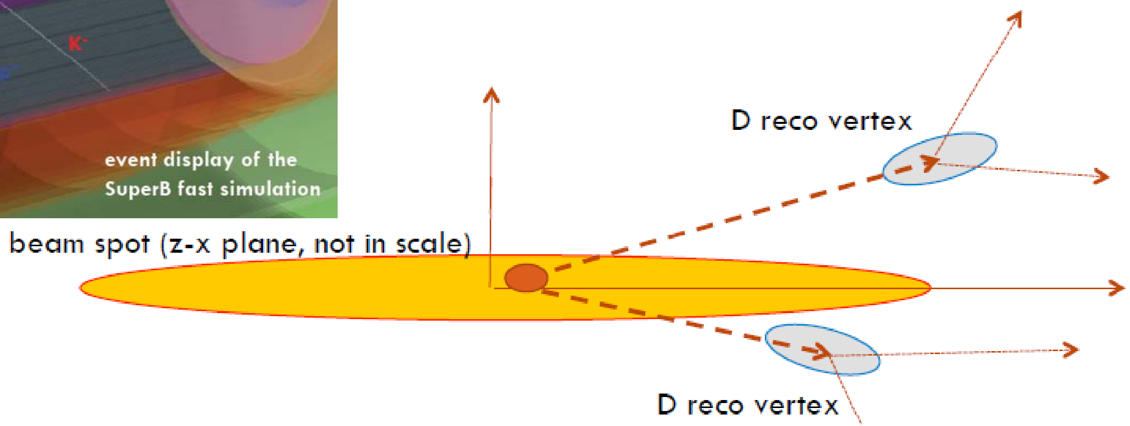
→ Simplified expressions with CPT invariance, CP conserved in decay, and 2nd order in x, y

SuperB fast simulation (FastSim):

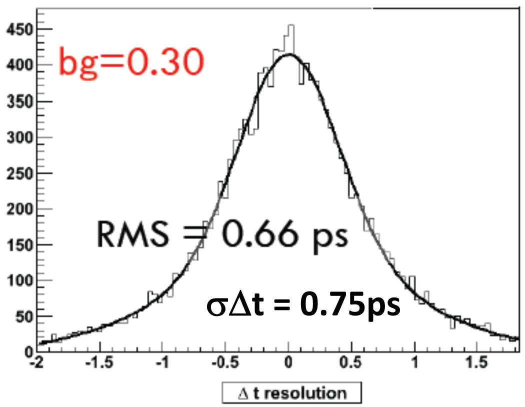


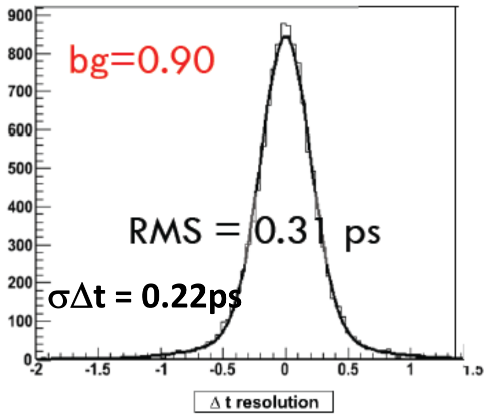
D reconstruction:

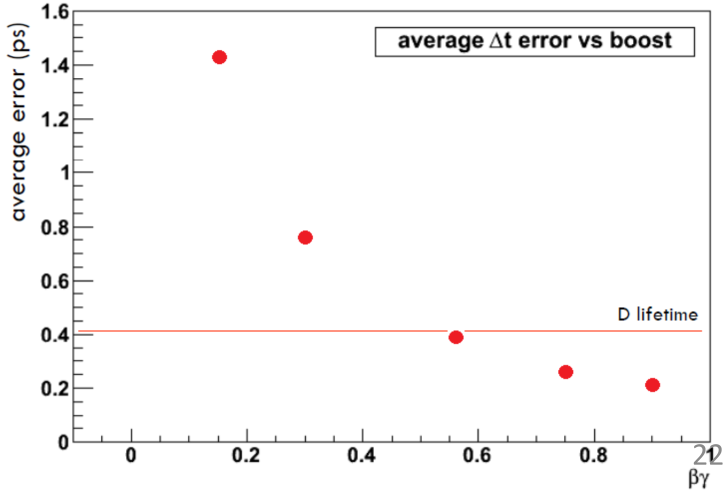
- The flight lengths of the two Ds are reconstructed through a combined beam spot constrained vertex fit
- Proper times are computed from the flight lengths and the D momenta



Δt resolution:

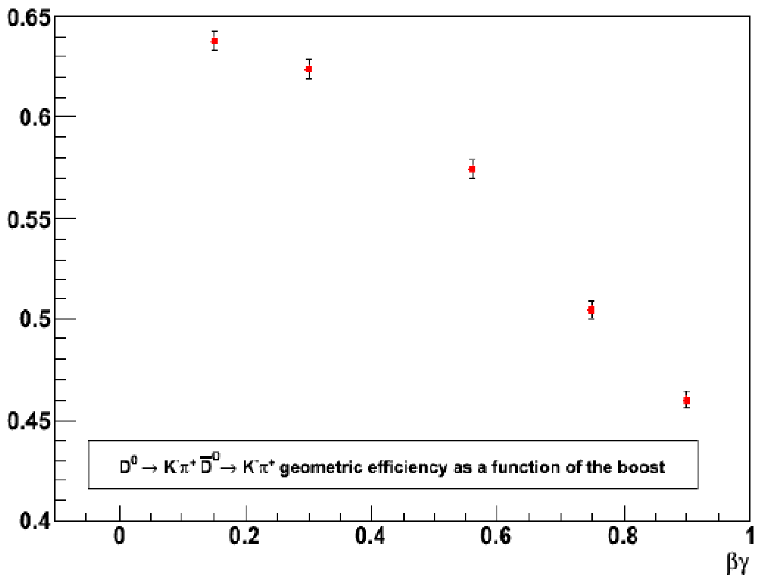






Sensitivity studies:

- For Ψ(3770) modes 0.5 ab^{-1}
  - Extrapolate CLEOc yields (includes cross-sections and selection efficiencies)
  - Correct by SuperB geometrical efficiency vs CM boost
  - Evaluate triple Gaussian (TG) resolution function from FastSim vs CM boost
- For Υ(4S) modes, extrapolate BaBar yields 75 ab^{-1}
  - TG proper time resolution of ~0.15 ps (0.1 ps core)
- Toy MC generator and fitter developed
  - For now focus on 2-body decays
  - the next step will be 3-body decays



Double tags @ Ψ(3770)
Modes with D* tag @ Υ(4S)
used in this study

	CP−	Kπ	*l*X
CP+	X	X	XX
CP−		X	XX
Kπ		X	XX
*l*X			XX

Sensitivity studies:

- Strategy:
  - Generate $O(100)$ experiments for each double tag
  - Perform combined UML fit of given ensemble of 2-body double tags, fitting simultaneously for the mixing and CPV parameters: x, y, arg(q/p), |q/p|
  - Assumed CP conservation in decay
  - D(Kπ) strong phase kept fixed
  - Generated values are current HFAG averages

Selected decays	$\Upsilon(4S)$ $75\,\mathrm{ab}^{-1}$	LB $\Psi(3770)$ $\Psi(3770)$ $0.5\,\mathrm{ab}^{-1}$, $\beta\gamma = 0.238$	IB $\Psi(3770)$ $\Psi(3770)$ $0.5\,\mathrm{ab}^{-1}$, $\beta\gamma = 0.56$	HB $\Psi(3770)$ $\Psi(3770)$ $0.5\,\mathrm{ab}^{-1}$, $\beta\gamma = 0.91$
$l^{\pm}X^{\mp}$, $CP+$	19600000	569395	525890	418331
$l^{\pm}X^{\mp}$, $CP-$	30900000	685053	612430	491599
$l^{\pm}X^{\mp}$, $K^{\pm}\pi^{\mp}$	222900000	4181494	3862011	3072118
	(790000)	(13798)	(12744)	(10137)
$l^{\pm}X^{\mp}$, $K^0_S\pi^+\pi^-$	86600000	828850	689557	498370
$l^{\pm}X^{\mp}$, $l^{\mp}X^{\pm}$	85300000	1067615	986045	784370
	(50)	(51)	(47)	(38)
$K^{\mp}\pi^{\pm}$, $K^{\pm}\pi^{\mp}$	N/A	1067615	986045	784370
	(N/A)	(51)	(47)	(38)
$CP+$, $K^{\mp}\pi^{\pm}$	N/A	309608	285953	227467
$CP-$, $K^{\mp}\pi^{\pm}$	N/A	291814	260879	209408
$CP+$, $CP-$	N/A	92526	82717	66397
$CP+$, $K^0_S\pi^+\pi^-$	N/A	113691	91553	66770
$CP-$, $K^0_S\pi^+\pi^-$	N/A	115525	93030	67847
$K^0_S\pi^+\pi^-$, $K^0_S\pi^+\pi^-$	N/A	290342	217578	142875

Favored # of events

Suppressed # of events

Υ (4S) Ψ(3770)

Sensitivity studies:

Considered scenarios:

$\Psi(3770)$, 500 fb^{-1}

CM boost (bg)	time resolution	mistag
0.24	realistic	0
0.56	realistic	0
0.90	realistic	0
0.24	perfect	0
0.24	the one at bg=0.15	0
0.24	the one at bg=0.56	0
0.24	the one at bg=0.90	0
0.24 [large x,y]	perfect	0
0.24 [no CPV]	perfect	0

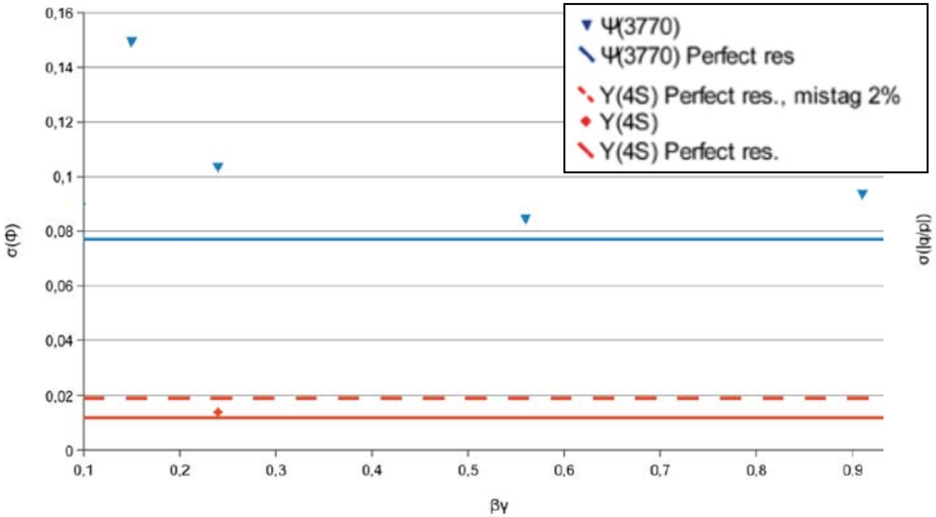
effect of ~0.2% mistag under evaluation

$\Upsilon(4S)$, 75 ab^{-1}, bg=0.24

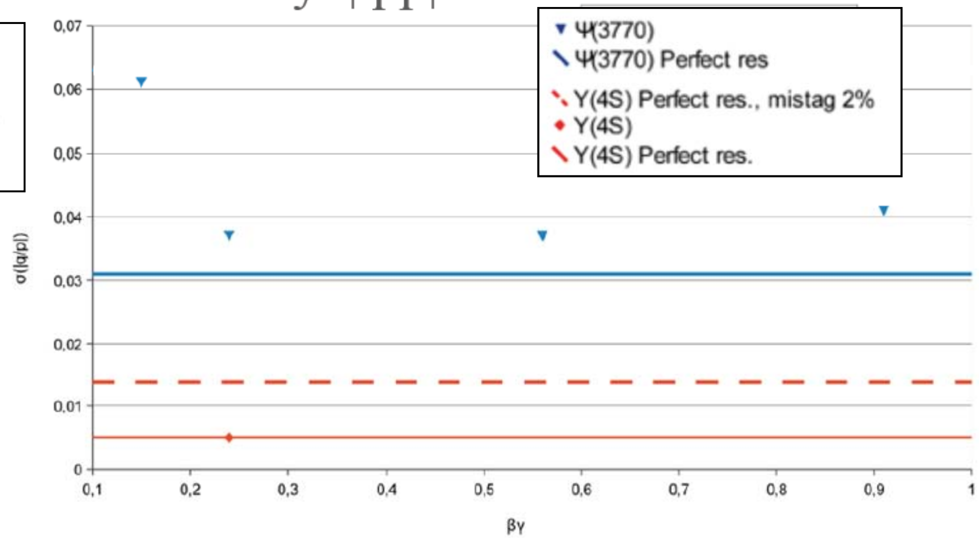
time resolution	mistag	notes
realistic	0	
perfect	0	
perfect	2%	
perfect	0	large x,y
perfect	0	no CPV

Results:

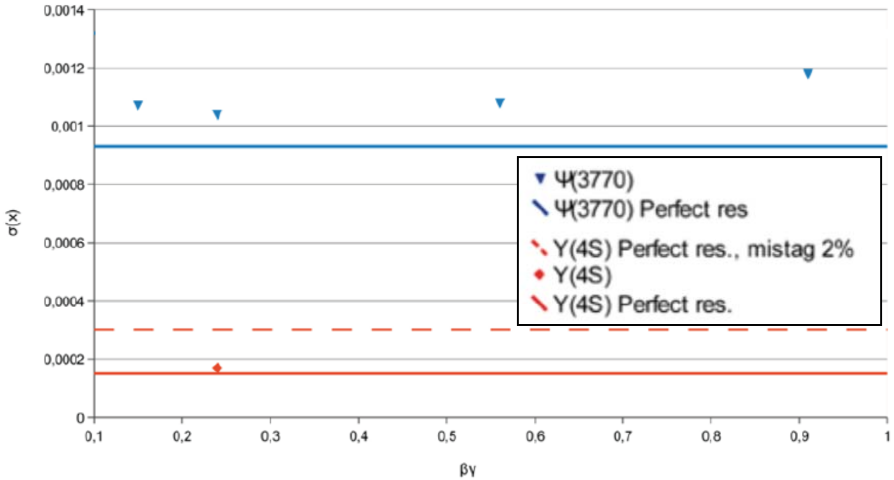
Sensitivity: Φ=arg(q/p)



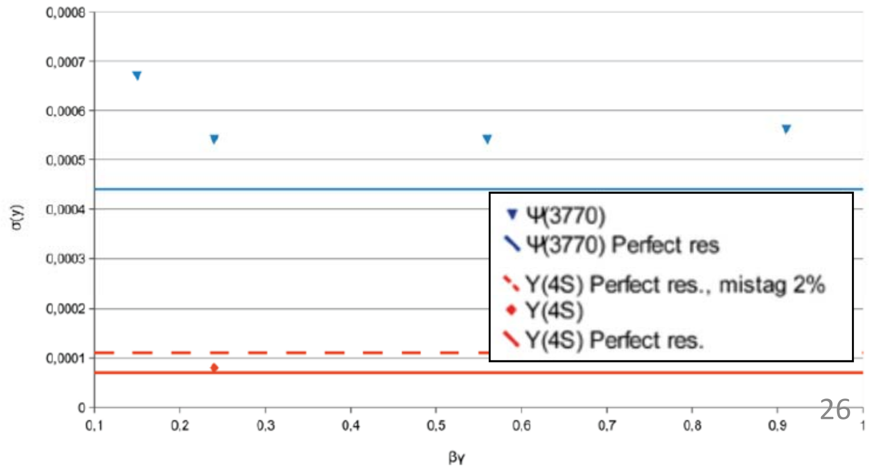
Sensitivity: |q/p|



Sensitivity: x



Sensitivity: y



Conclusions:

- Flavor tag at $D\bar{D}$ threshold provides identical time-dependence than at Υ(4S) using D* tagging, and less events, although in a different environment
- $D\bar{D}$ threshold is unique to provide CP, $K\pi$ and $Ks\pi\pi$ tags
- Variation of Δt resolution and geometrical acceptance vs CM boost was evaluated
- Estimated the impact on physics with 2-body decays
  - Combined fit to all 2-body double-tags allows determination of x, y, arg(q/p), |q/p|
  - Best sensitivity at Ψ(3770) for intermediate boost, bg ~ 0.3-0.6

Parameter	Sensitivity @ Υ (4S) with time resolution, no mistag. 75 ab^{-1}	Best sensitivity @ Ψ(3770) with time resolution (bg=0.56), no mistag. 0.5 ab^{-1}
x	0.017%	0.11%
y	0.008%	0.05%
Arg(q/p)	0.8 deg	4.8 deg
|q/p|	0.5%	3.7%

Relative effect of flavor mistag similar at Ψ(3770) and Υ(4S)

  - error per ab^{-1} at Ψ(3770) ~ ½ error per ab^{-1} at Υ(4S) (2-body only, no mistag)
  - error at Ψ(3770) [0.5ab^{-1}] ~ 6x error at Υ(4S) [75ab^{-1}] (2-body only, no mistag)

Physics (future plans):

→ Finish sensitivity studies at charm threshold

→ **Define common interest with Spanish theorists** to start analyses setup

- tau physics
- rare B decays
- charm CPV
- .... ?

→Join efforts from experimental and theory sides