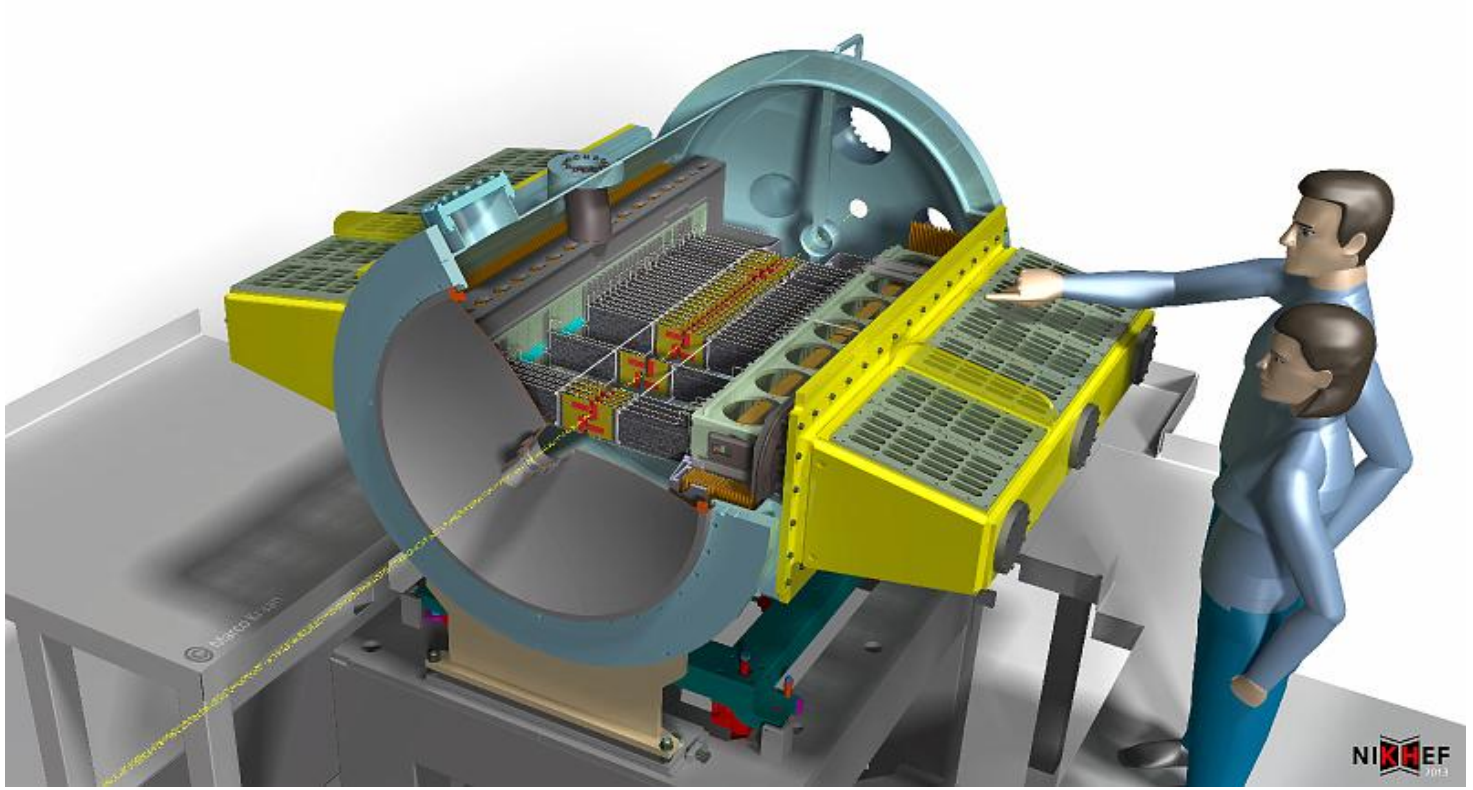
VERTEX LOCATOR UPGRADE

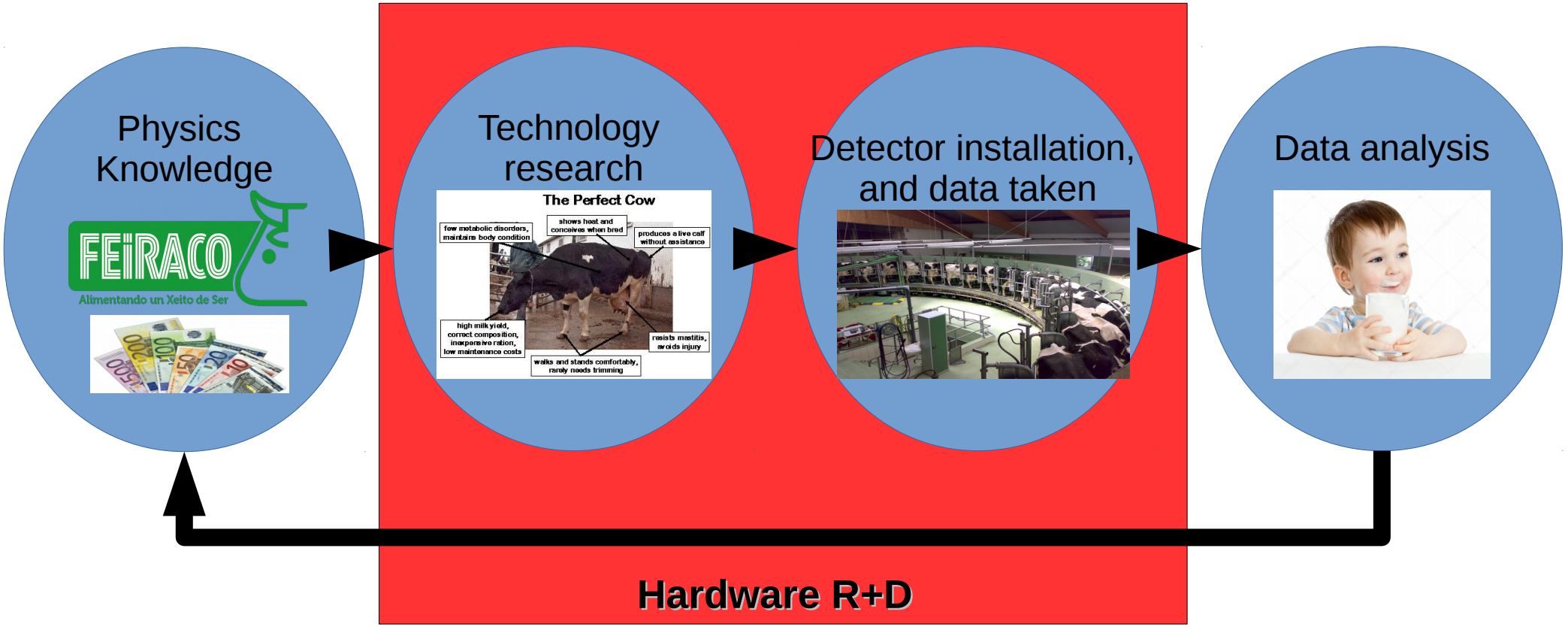


Alvaro Dosil, Daniel Esperante, Antonio Fernandez, Abraham Gallas, Edgar Lemos, Antonio Pazos, Eliseo Perez, Pablo Rodriguez,Carlos Vazquez, Pablo Vazquez

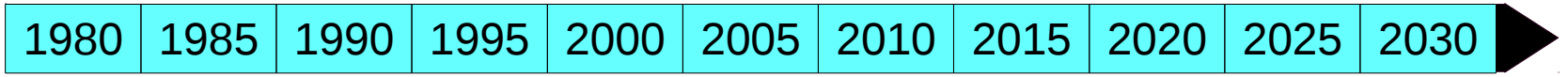
OUTLINE

- Why and when hardware is needed in HEP.
- LHCb upgrade.
- VELO upgrade.
- Contribution of USC.
- Other and future research.
- Conclusions.

WHY HARDWARE IS NEEDED?



WHEN HARDWARE IS NEEDED?



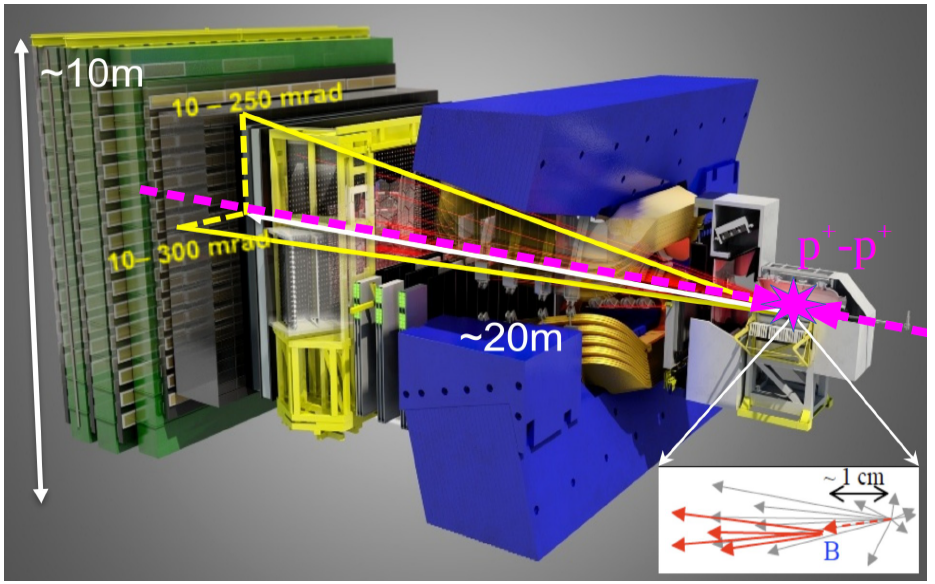
LHCb

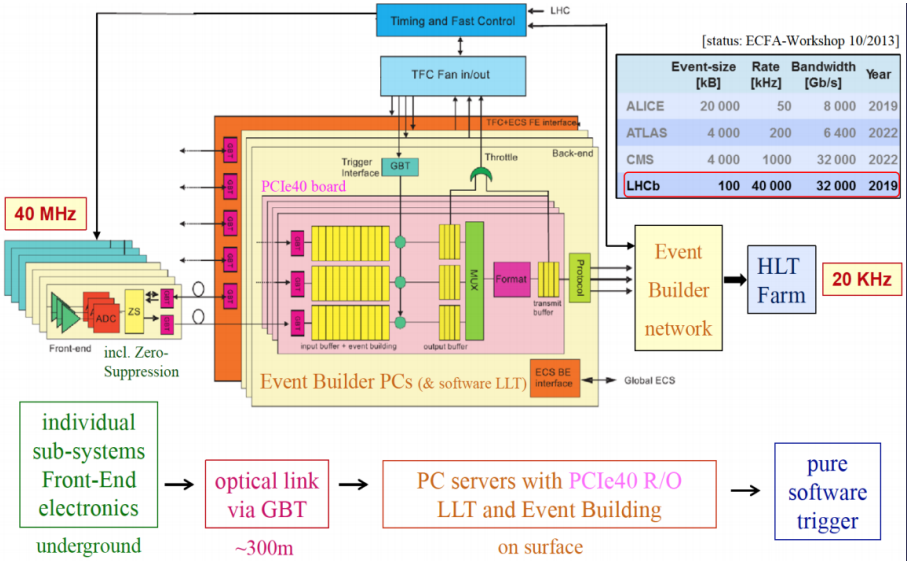
LHCb upgrade I

LHCb upgrade II

LHCb UPGRADE

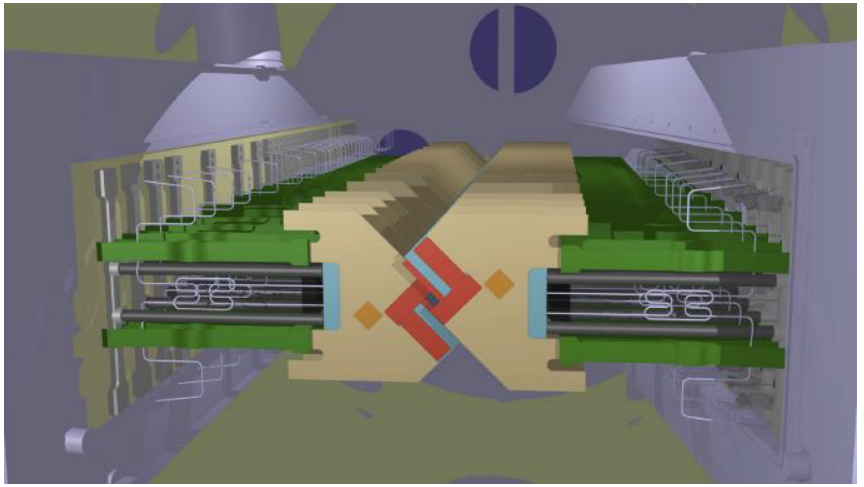
- Run the experiment at a **luminosites 5 times** greater than presently.
- Improve considerably the trigger efficiency on hadronic channels and on rare decays.
- Expand the scope to the lepton flavor sector, electroweak physics, QCD and exotics searches.
- The current **1 MHz L0 trigger** output is a severe **limitation**!
  - Remove the L0 hardware trigger and readout an event at every bunch crossing (40 MHz). Use an efficient fully **software trigger**.
  - **New front-end electronics and New DAQ system**.

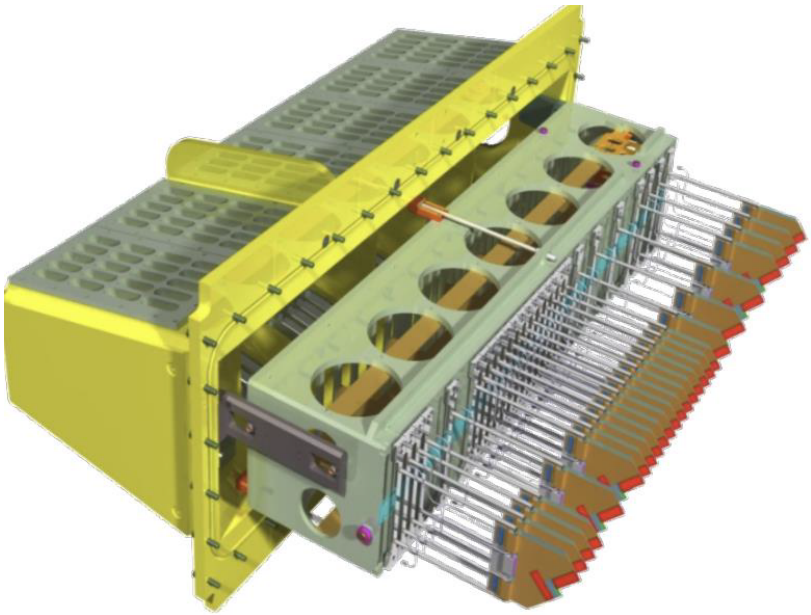




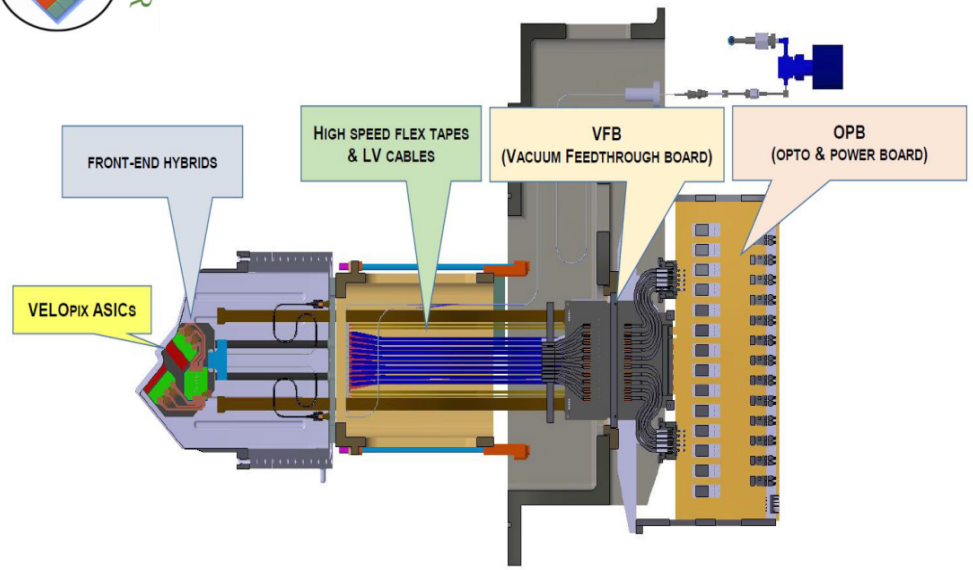
VELO UPGRADE

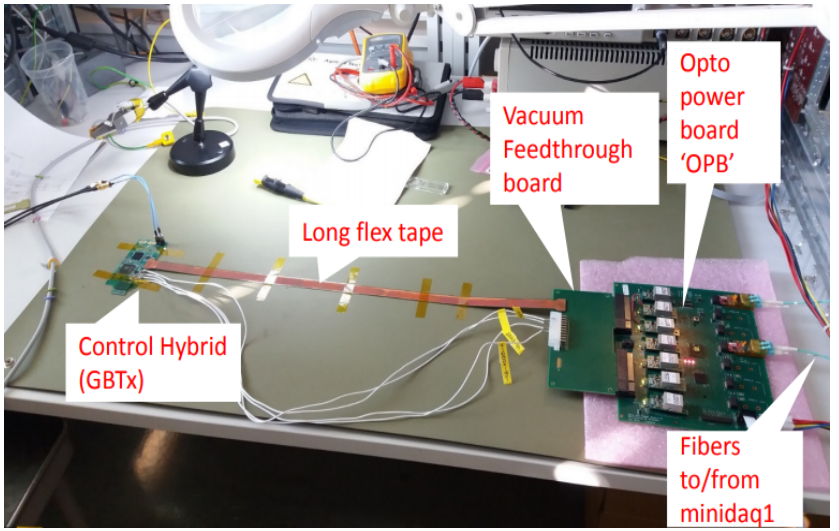
- **Better Technology**: Strips => Pixels.
- **More cells**: 172k => 41M
- **Thinner Sensor and Asic**: 300 µm => 200 µm.
- **Higher readout rate**, 1 MHz => 40 MHz.
  - Up to **20 Gbit/s per Asic**. ~3 Tbit/s in total.
- **Closer to beam**: 8.2mm => 5.1mm.
- **More rad hard**: 400 Mrads.
- New **cooling**: pipes => **silicon microchannel**.

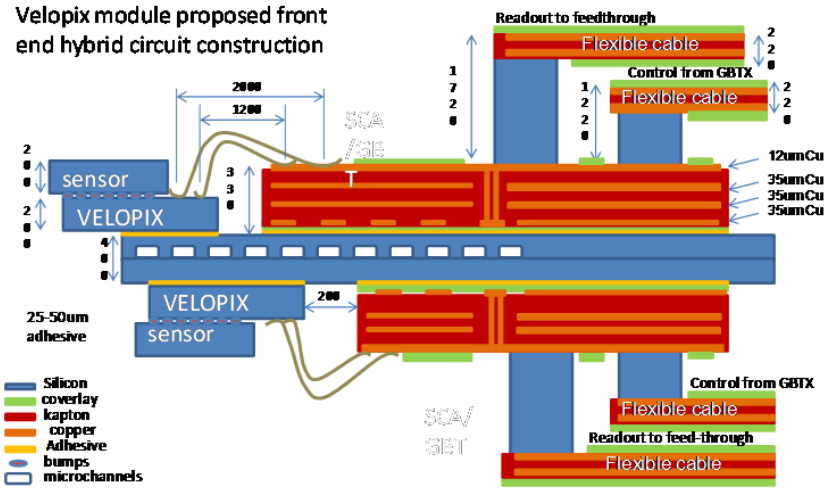


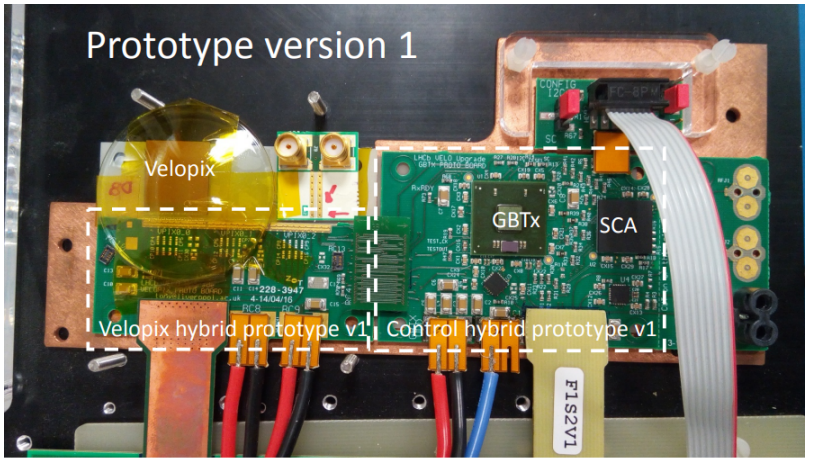


VELO UPGRADE





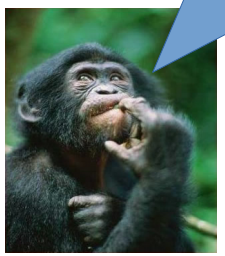


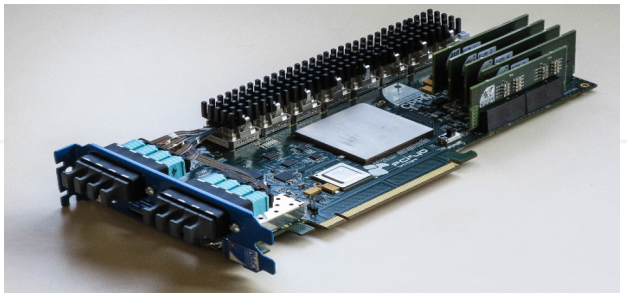


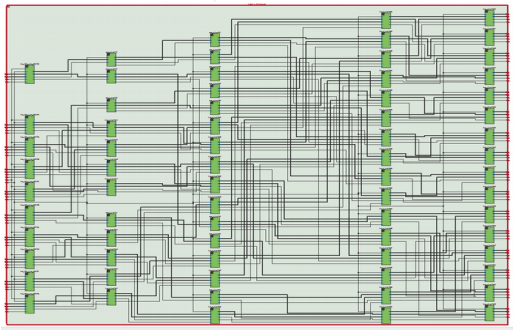
Contribution of Santiago. Firmware.

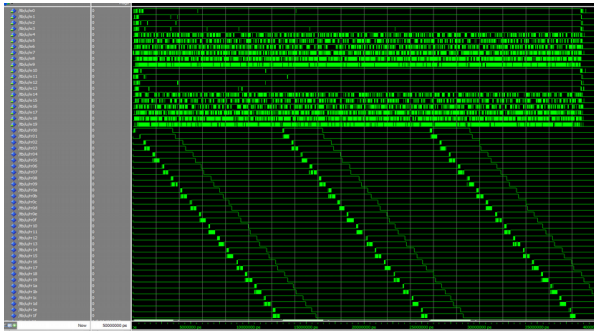
- MiniDAQ firmware development in the LHCb framework.
  - Real time data processing (100Gbps).
  - Trigger and slow control.
  - Hardware validation.

Why Intel bought Altera? (Speed of processor reach the end → improve using hardware).



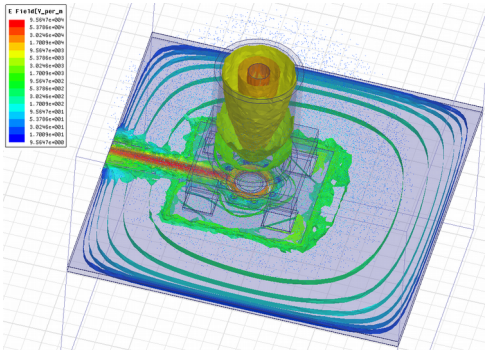


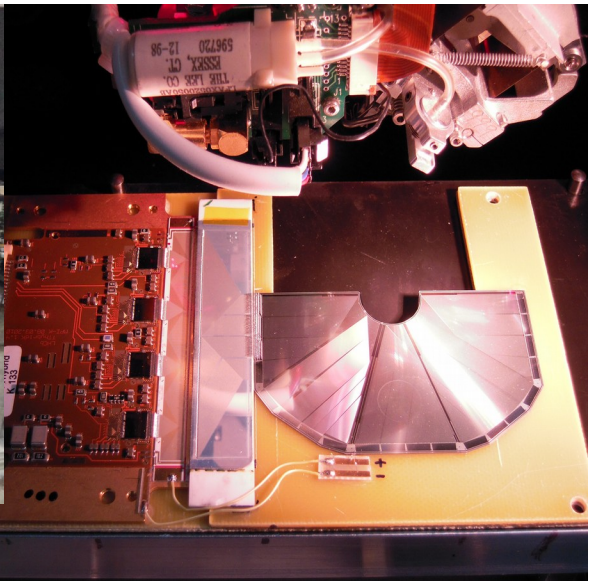


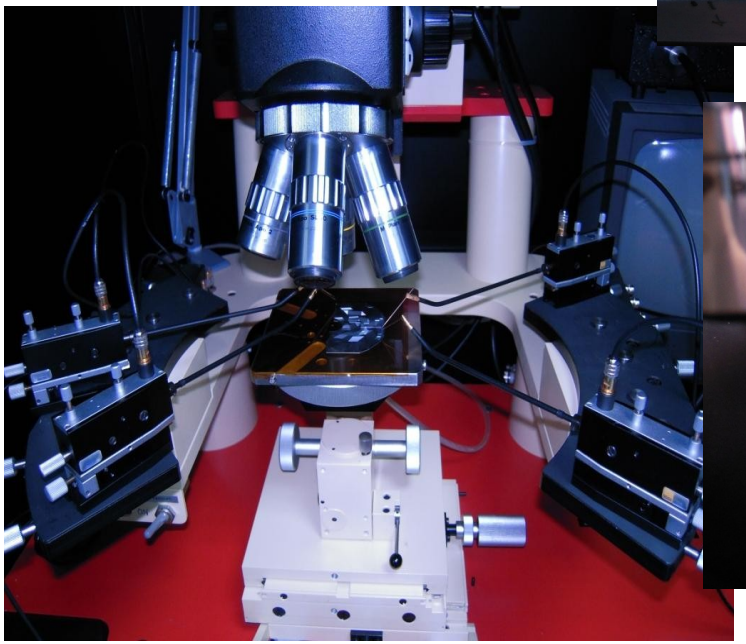


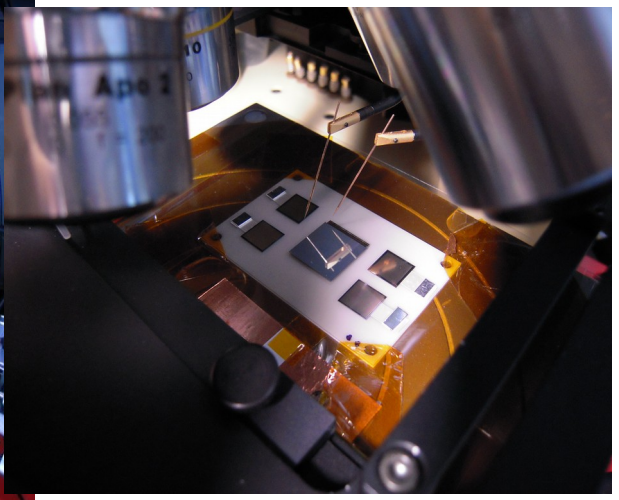
Contribution of Santiago. Testing.

- Decision between strips and pixels.
- VeloPix Asic testing.
  - 60 carrier boards designed and populated.
  - Wire-bonding.
  - Lab test: X-ray, laser, source, I-V...
  - Beam test: ion, n, p+, e-.



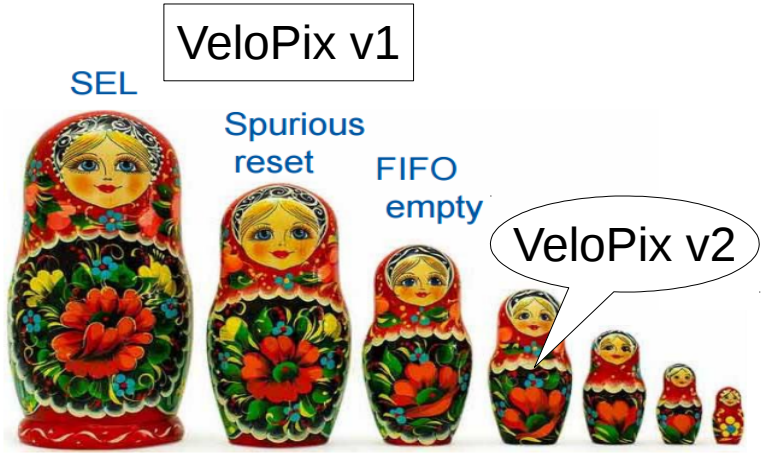


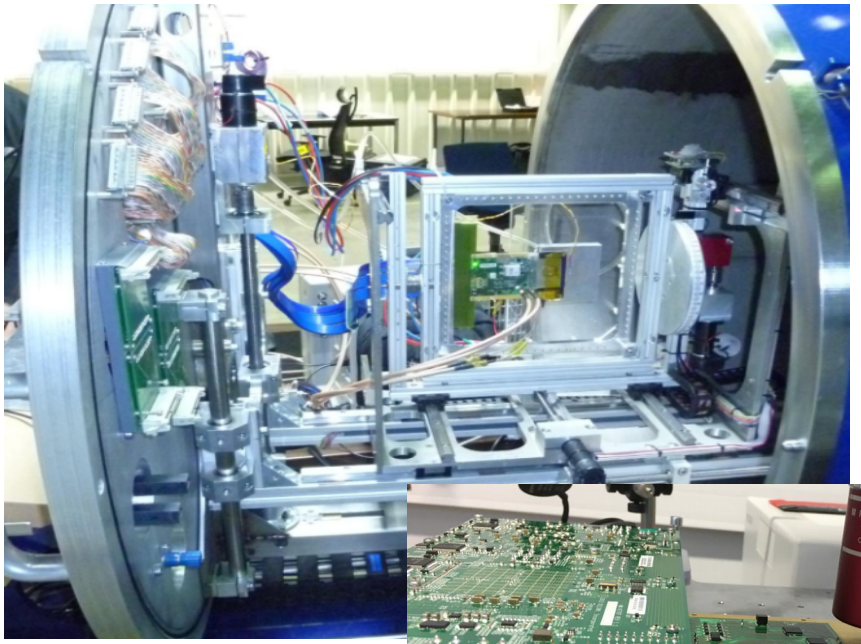


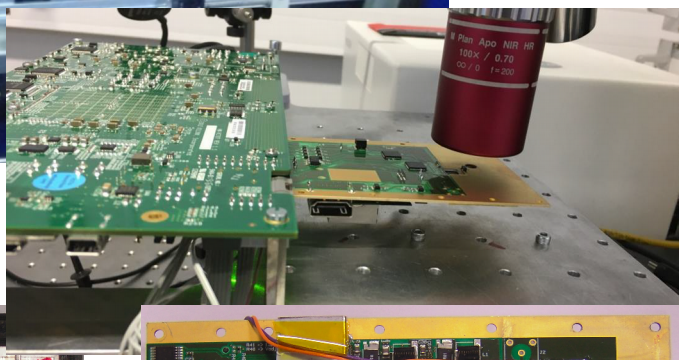


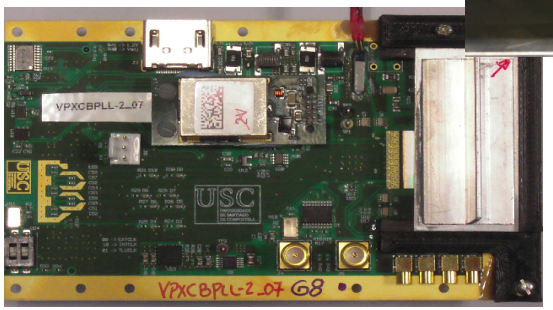
Contribution of Santiago. Single Event Effects.

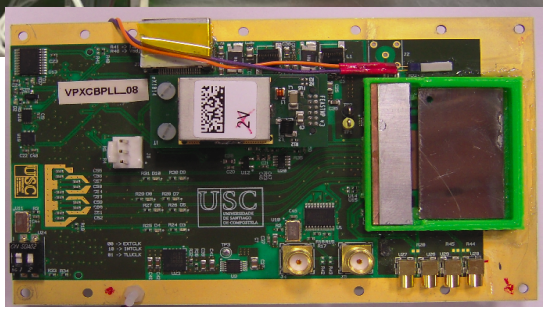
- Rusian dolls:
  - Testing in Belgium.
  - 5 radiation campaigns
  - Vacuum feed through, frame, Asic covering...







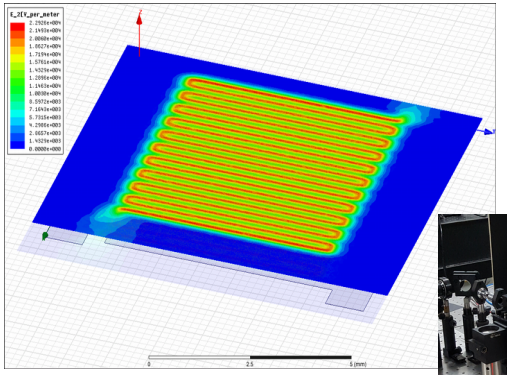


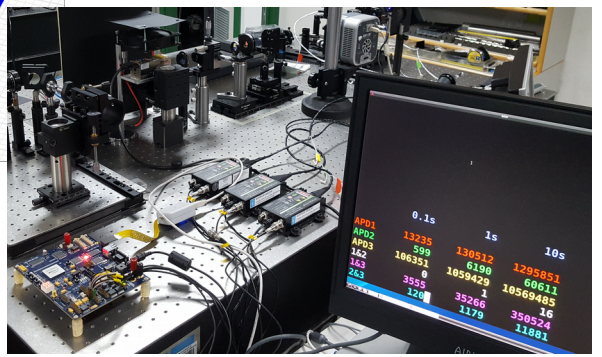


Other and future research

- Future research:
  - Continue development of the **firmware and control software**.
  - **Wafer test boards**.
  - **TID** testing of the **VeloPix v2** in the **USC X-ray**.
  - **Production, testing and installation of the detector**.

  - New **LGAD sensor testing for LS4.**





- Other research:
  - **Bifoton project**.
  - **Cardiac Cells Electro-stimulator.**

Conclusions

- Santiago group is expert in the Firmware development of the VELO upgrade.
- Santiago group take part in the decision between strip or pixel detector.
- Santiago group test the first VeloPix Asic and give most of the proposals for version 2.
- **We test and improve the VeloPix, but we could be an institute that built the Asic?**
- **All the Physics experiments have similarities (like houses, apartment or skyscraper). But it need experts in electronics, optics, vacuum, mechanics... (like a construction company have architect, engineer, mason, plumber, electrician...).**

NEXT STEP

Conclusions

	Scientific Staff	PhD students	Post-Docs	Administrative	Technical / engineering
Nikhef	**71**	**100**	**29**	**25**	**70**
USC now	**31**	**31**	**12**	**2**	**6**
Comparison (Nikhef/USC)	**24% / 37%**	**33% / 37%**	**10% / 14%**	**8% / 2%**	**23% / 7%**

https://www.nikhef.nl/JV/JV16/JV2016.pdf

Thanks. Questions?

Type	Observable	Current precision	LHCb ($5\ \text{fb}^{-1}$)	Upgrade ($50\ \text{fb}^{-1}$)	Theory uncertainty
Gluonic penguin	$S(B_s \to \phi\phi)$	-	0.08	0.02	0.02
	$S(B_s \to K^{*0}\bar{K}^{*0})$	-	0.07	0.02	< 0.02
	$S(B^0 \to \phi K^0_S)$	0.17	0.15	0.03	0.02
B_s mixing	$2\beta_s\ (B_s \to J/\psi\phi)$	0.35	0.019	0.006	~ 0.003
Right-handed currents	$S(B_s \to \phi\gamma)$	-	0.07	0.02	< 0.01
	$\mathcal{A}^{\Delta\Gamma_s}(B_s \to \phi\gamma)$	-	0.14	0.03	0.02
E/W penguin	$A_T^{(2)}(B^0 \to K^{*0}\mu^+\mu^-)$	-	0.14	0.04	0.05
	$s_0\, A_{\text{FB}}(B^0 \to K^{*0}\mu^+\mu^-)$	-	4%	1%	7%
Higgs penguin	$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	30%	8%	$< 10\%$
	$\frac{\mathcal{B}(B^0\to\mu^+\mu^-)}{\mathcal{B}(B_s\to\mu^+\mu^-)}$	-	-	$\sim 35\%$	$\sim 5\%$
Unitarity triangle angles	$\gamma\ (B \to D^{(*)}K^{(*)})$	$\sim 20°$	$\sim 4°$	$0.9°$	negligible
	$\gamma\ (B_s \to D_s K)$	-	$\sim 7°$	$1.5°$	negligible
	$\beta\ (B^0 \to J/\psi\, K^0)$	$1°$	$0.5°$	$0.2°$	negligible
Charm CPV	A_Γ	2.5×10^{-3}	2×10^{-4}	4×10^{-5}	-
	$A_{CP}^{dir}(KK) - A_{CP}^{dir}(\pi\pi)$	4.3×10^{-3}	4×10^{-4}	8×10^{-5}	-