LHCb A Coruña Data Challenges (ACDC)

XVI CPAN days
19-21 November 2024
Madrid

Diego Martinez Santos, Veronika Georgieva Chobanova

Current team

UdC (LHCb member since Oct 2023, associated to La Salle)

Research Professor Oportunius: Diego Martinez Santos (Xunta de Galicia)
RyC: Veronika Chobanova
PhD: John Wendel, Sergio Andres Estrada, Axel Iohner
JdC: Claire Prouvé
Postdoc: Jeremy Dalseno

PI's since FPA2015

(RyC Carlos Vázquez Sierra recently moved to UdC but is still at USC project with Xabier Cid)

USC (founding member of LHCb)

Catedráticos (Full Professor): Bernardo Adeva
Technician: Marcos Seco
PhDs: Pablo Baladron, Asier Pereiro, Miguel Fernandez (together w/ Xabier Cid), Angel Morcillo (t. w/ X. Cid)

In the last 8 years had postdoctoral researchers from several nationalities:

Activities

- Flavour Tagging
- Real Time Analysis / High Level Trigger (GPU-based HLT1, HLT2)
- Physics WG's
    - CPV in B decays to charmonia
    - Charmless B decays
    - B decays to open charm
    - Semileptonic hyperon decays
    - Very rare decays
- Other activities: precise fast simulation, HFLAV, phenomenology…

Activities: Technical

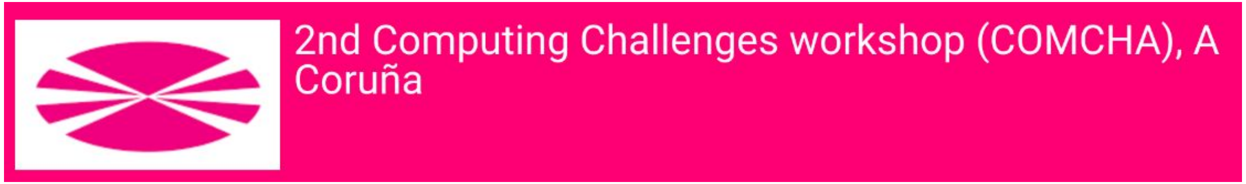
- High Level Trigger (nowadays called Real Time Analysis, RTA)
  - Soft Dimuon trigger for Run2 (lower muon pT thresholds to 80 MeV!)
    - Improved s → X trigger efficiency by ~10 x
  - Proponents of GPU HLT for the upgrade
    - Demonstrator, VELO(UT)-Muon match …
    - Improved s → X trigger efficiency by yet another ~10 x

  → Two main ERC-StG-639068 deliverables, performing above expectations
    - Optimizations of full-sequence throughput gain of up to 14% on GPU (S. Andres TFM)
- Flavour Tagging
  - Inclusive Flavour Tagging (~ 20-35% improvement on effective stats on data) [talks by J. Wendel and C. Prouvé]
  - Full re-implementation of the FT for Run 3 (entire software framework was changed) Persistency of Flavour Tagging in HLT (RTA)

V. Chobanova convener of Flavour Tagging (2020-2022, 2024-2026)
C. Prouve convener of Flavour Tagging (2022-2024)
J. Prisciandaro responsible of LHCb muon trigger (2016-2018)

Activities: Technical

- COMCHA workshop 2-4 October 2024, A Coruña

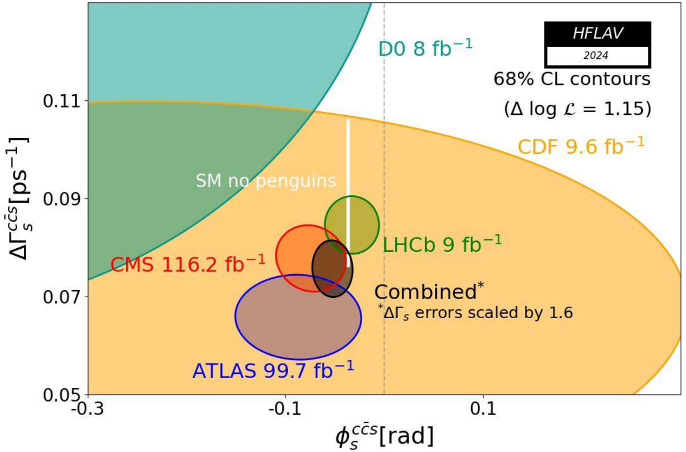


- LHCb Computing workshop and Hackathon 27-31st January 2025, A Coruña

Analyses: B to charmonia (B_s^0 oscillation)

- Mixing parameters
  □ Most interesting: (TH clean, EXP clean, BSM sensitive).
- B_s^0 lifetime
- Fundamental test to any model that predicts new physics in the B_s^0 system
- Full Run-2 analysis published in 2024

CERN Courier
PRL 132 (2024) 051802
V. Chobanova contact author



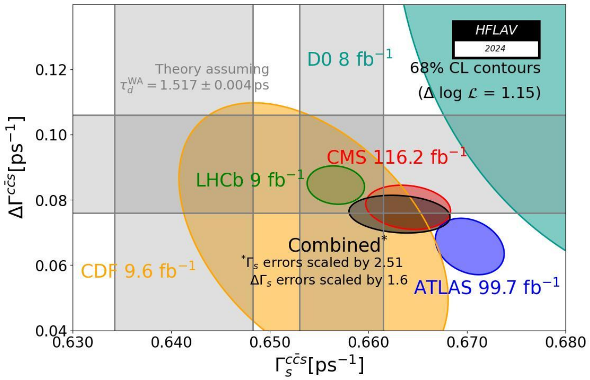
V. Chobanova

B2CC conveners:
D. Martinez (2013-2015)
V. Chobanova (2018-2020)
D. Martinez (2020-2022)

Also co-convener Miriam Lucio (2021) was a former student of the group

Analyses: B to charmonia (B_s^0 oscillation)

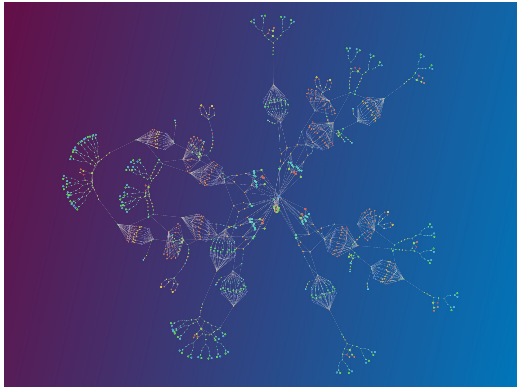
- Main challenge: The lifetime measurement requires per mil systematics (ie. fs precision) → Typically takes several years of work (very different from eg, P→ μμ)
- Full Run 2 analysis in two PhD theses: M. Romero (2023) and R. Ruiz (2024)



V. Chobanova

Example: snakemake pipeline of UDC in 1252 steps (tuple selection, GB weights, BDT, time and angular acceptance, fit...)

Galicia: 3 FTE/year since 2015



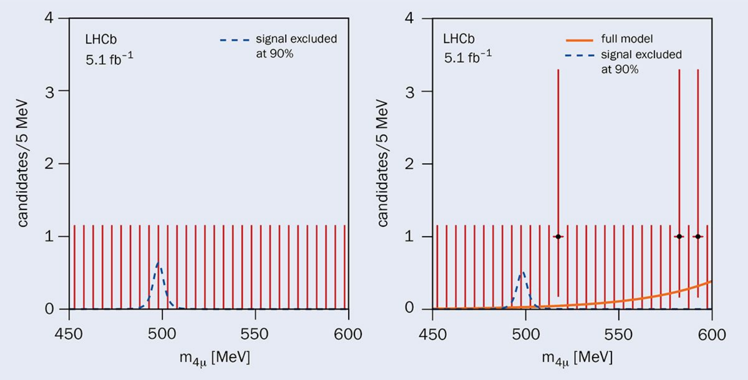
Ramon Ruiz Fernandez (defended Oct 2024), alias "El Moncho"

Analyses: Strange decays, & Rare decays

- Full Run2 $K_S \rightarrow \mu\mu$, $\mu\mu\mu\mu$ analyses
-
    - Final deliverable of ERC-StG-639068, together with Upgrade strange trigger

- Currently doing SL hyperon decays, following suggestion from Camalich et al.

- Pipeline: $K_S \rightarrow \pi\pi\mu\mu$, $K_S \rightarrow \pi^0\mu\mu$, $\Sigma \rightarrow p\mu\mu$ (in LHCb internal review)…



[CERN Courier]

Phys. Rev. D108 (2023) L031102
M. Fernandez, D. Martinez Santos
contact authors

VRD subconveners: J.Prisciandaro (2016-2017), T. Mombacher (2021-2022)

(former RD convener Paula Alvarez was former student of the group)

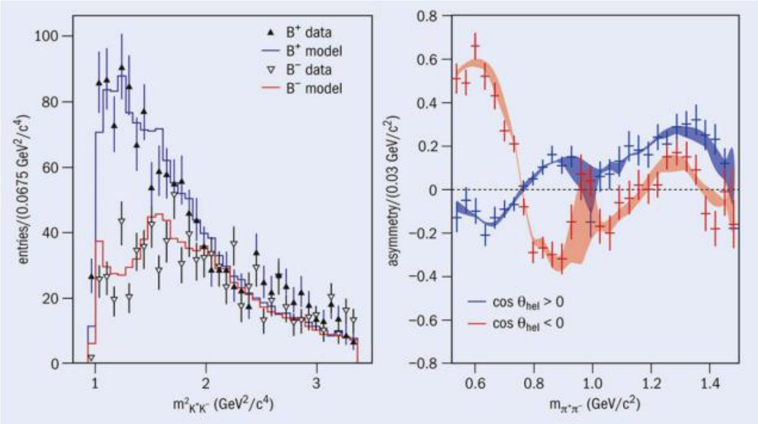
Analyses: charmless, open charm

- Charmless and open charm decays: sophisticated analyses of differential decay rates to obtain CPV information
- Strong involvement in several charmless B decays
  - $B \to 3h$ (eg, maximal CPV)
  - $B \to 4h$ (K^*K^*, $K_1\pi$, $\rho^0\rho^0$)
    - Polarization fractions, CPV parameters
    - Measurement of α_{CKM}

Pablo Baladron (defended Nov 2024) and PhD Asier Pereiro (defense expected 2025)

- CKM angle γ in $B \to D(\to 4\pi) K$

BnoC convener: J. Dalseno (2019-2021)



[CERN Courier]

Phys. Rev. Lett. 124, 031801 (2020)
J. Dalseno contact author

J. Dalseno also
LHCb editorial board member (2024-2026)
Amplitude analysis convener (2022-2024)

Beyond LHCb activities

- Pan-LHC (pan-experiment)
    - HFLAV (V. Chobanova) → averages for PDG, convenes Oscillations subgroup
    - LPCC LHC convener: HF WG (V. Chobanova), LLP WG (C. Vázquez)
    - SMARTHEP MSCA-ITN (D. Martinez Santos, V. Chobanova)

- Methodology
    - New magnetic field calibration techniques
    - Accelerating neutrino oscillations calculations for HyperK

- Phenomenology
    - MasterCode collaboration (SUSY global fits)
    - Global fits for b→sll anomalies (first group to calculate the global significance - i.e., no LEE)
    - Devising CKM angle α program for LHCb
    - Direct searches prospects
    - Convener roles at Yellow reports…

- Conference series organization:
    - D. Martinez IAC of FPCP & KAON
    - V. Chobanova chair of CKM 2023 (Santiago de Compostela) and now SAC

Ongoing funds

LHCb	Total (Euro)	Period
Plan Nacional (Veronika, Diego)	353k	2023-2026
PCI	109k	2023-2026
Xunta (Veronika)	115k	2020-2023
INTALENT Inditex (Veronika)	40k	2023-2027
Individual fellowships	2 RyC 1 JdC 5 PhD students from Xunta	2023-2027, 2025-2029

2024 →

Main <u>technical</u> challenges in the coming years

Real Time Analysis

- Commissioning of GPU trigger (in particular Velo-UT-Muon match)
- R&D for Upgrade Ib, Upgrade 2
- Strangeness to dielectron

Flavour Tagging

- Run Flavour Tagging in real time (save bandwidth/disk space)
- Inclusive Flavour Tagging shows 20-35% improvement on data
- Run 3 algorithm implementation and optimization

Main analysis challenges in the coming years

- Increased data volume → higher computing performance to analyse data and simulation
- Even more precise understanding of systematics
  - New methodology
  - Even more precise treatment of data/simulation differences
- New trigger in strange decays
  - Completely redesign analysis
  - Access to new decay modes

Summary

- Intercontinental group with a broad set of scientific activities which often use very different methodologies

    - Complex differential decay rates to access CPV
    - Address tiny experimental effects in high precision , high statistics measurements
    - Searches for small signals (rare decays, new particles)
    - Technical work: High Level Trigger, GPU programming, Flavour Tagging
    - Theory interpretations, prospects.