

# Form Factors: Overview and Challenges

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# Overview

b to c:  $V_{cb}$ ,  $R(D)$ ..

Updated  $B \rightarrow D^*$  [FNAL/MILC 2021];  $B \rightarrow D$  [FNAL/MILC, HPQCD 2015];  $B_s \rightarrow D_s^{(*)}$  [HPQCD 2018, 2020, 2021, Blossier et al 2021] and LCSR results [Gubernari et al 2019]  $\Lambda_b \rightarrow \Lambda_c$ : LQCD [Detmold et al 2015] and ZRSR [Mannel et al 2015]

Form factors

b to u:  $V_{ub}$ , ..

B decays: LQCD [FNAL/MILC 2015 RBCQCD 2015, FNAL/MILC 2019, JLQCD 2022] FNAL/MILC  $B \rightarrow \pi$  to be updated soon. LCSR [Bharucha 2012, Khodjamirian et al 2017], Bayesian approach [Leljak 2021]  $B \rightarrow \pi\pi$  [Cheng et al 2017, Feldmann et al 2018] Baryon decays in LQCD [Detmold et al 2015] and LCSR [Khodjamirian et al 2011, Mannel et al 2011]

b to s: BR,  $P(S)'$ ,  $R(K)$  ..

B decays: State-of-the art  $B \rightarrow K^{(*)}$  from LQCD [HPQCD 2013, FNAL/MILC 2016] and LCSR [Khodjamirian et al 2017, Bharucha et al 2015]. Recent interest in  $B \rightarrow K \pi$  in [Descotes-Genon et al 2019]  $\Lambda_b$  decays in LQCD [Meinel et al 2021] and LCSR [Khodjamirian et al 2011, Mannel et al 2011]

c to u, c to s

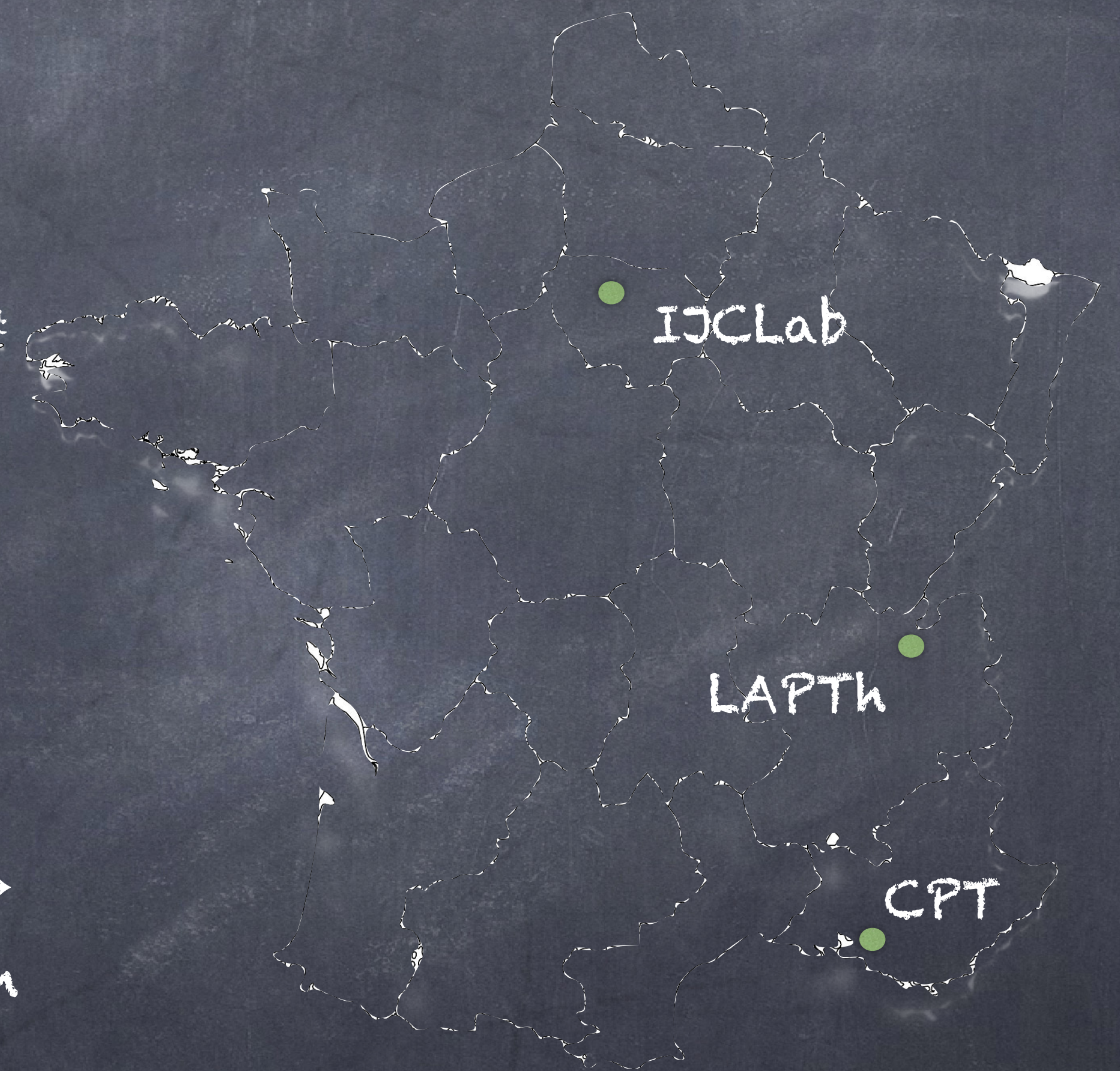
$D \rightarrow \pi$  [ETM 2018] and  $D \rightarrow K$  form factors [HPQCD 2021] Charm Baryon decays in LQCD for  $\Lambda_c \rightarrow \Lambda$  and  $\Lambda_c \rightarrow N$  [Meinel 2017, 2018]

See also B LCDA LCSR results for B to P and B to V [Gubernari et al 2019] Form factors for  $B_c$  to  $D(s)^{(*)}/J'\Psi/B(s)$  [HPQCD 2020, 2021]



# Ongoing work in France

- IJCLab (B. Blossier) : LQCD:  $B_s$  and  $B_s^*$  decay constants and  $B_s \rightarrow D^{(*)}_s$  form factors. [Balasubramanian et al 2020, Blossier et al 2022]. Aim to obtain discretisation errors under satisfactory control. The issue remains: how to deal with B physics on simulations at the physical point with volumes  $\sim 100^3 \times 200$  points (Exascale era)? There are algorithmic problems (critical slowing down at fine lattice spacing), software adaptation (use of GPUs), besides theoretical questions, to address along the way. Future:  $B \rightarrow D^{**}$ , study internal structure of B meson to obtain heavy meson  $\chi$ PT couplings, strong decay of radial excited  $\psi(3770)$  state, distribution amplitude of charmonia
- CPT (AB, A. Gerardin, S. Zafeiropoulos) :  $B \rightarrow \pi$ ,  $B_s \rightarrow K$ ,  $B \rightarrow D$ ,  $B_s \rightarrow D_s$  with HQET in Lattice QCD (in collaboration with DESY + Madrid).  $B \rightarrow \pi$  and  $B_s \rightarrow K$  form factors in LCSR



See also talks by Meril Reboud and Ludovico Vittorio (LAPTH Annecy) !!