

# B-Physics with CMS

Chiara Rovelli,

for the CMS-Roma group

(F. Cavallari, M. Cipriani M. Diemoz, D. del Re, E. Di Marco,  
E. Longo, P. Meridiani, G. Organtini, F. Pandolfi, R. Paramatti,  
C. Quaranta, S. Rahatlou, C.R., F. Santanastasio, L. Soffi, R. Tramontano)

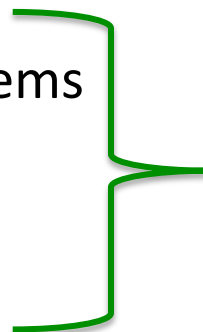
Heavy Flavor Physics Workshop, Roma, Feb 17<sup>th</sup> 2020

# CMS and flavor physics

CMS was NOT designed with flavor physics in mind

BUT:

- large redundancy of the detector systems
- excellent solid angle coverage
- state-of-the-art all-silicon tracker
- strong magnetic field



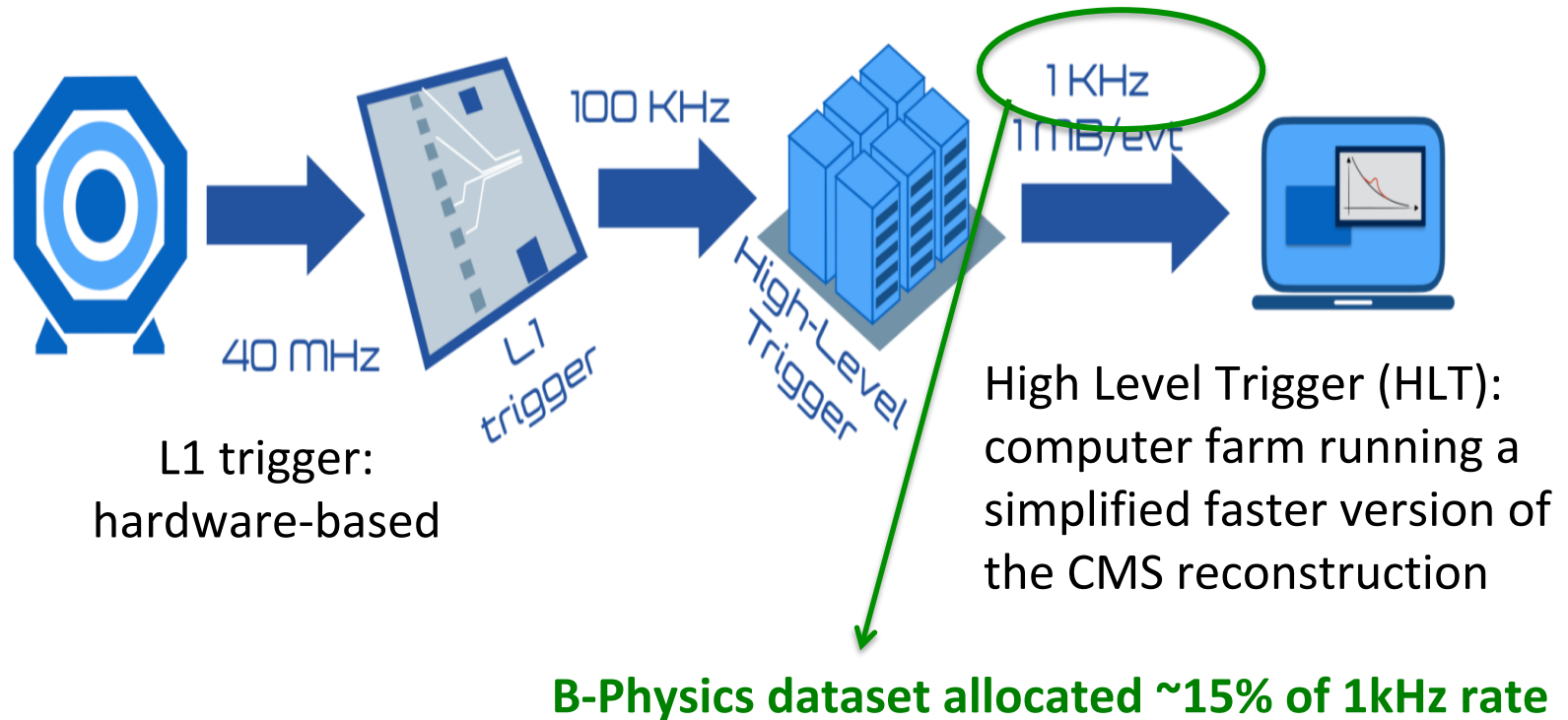
**Ok for a number of Heavy Flavor (HF) measurements (mainly with central muons)**

Larger integrated luminosity wrt LHCb

compensates for mainly central coverage and higher trigger thresholds

- **Competitive in *selected* HF measurements** with LHCb and B-Factories

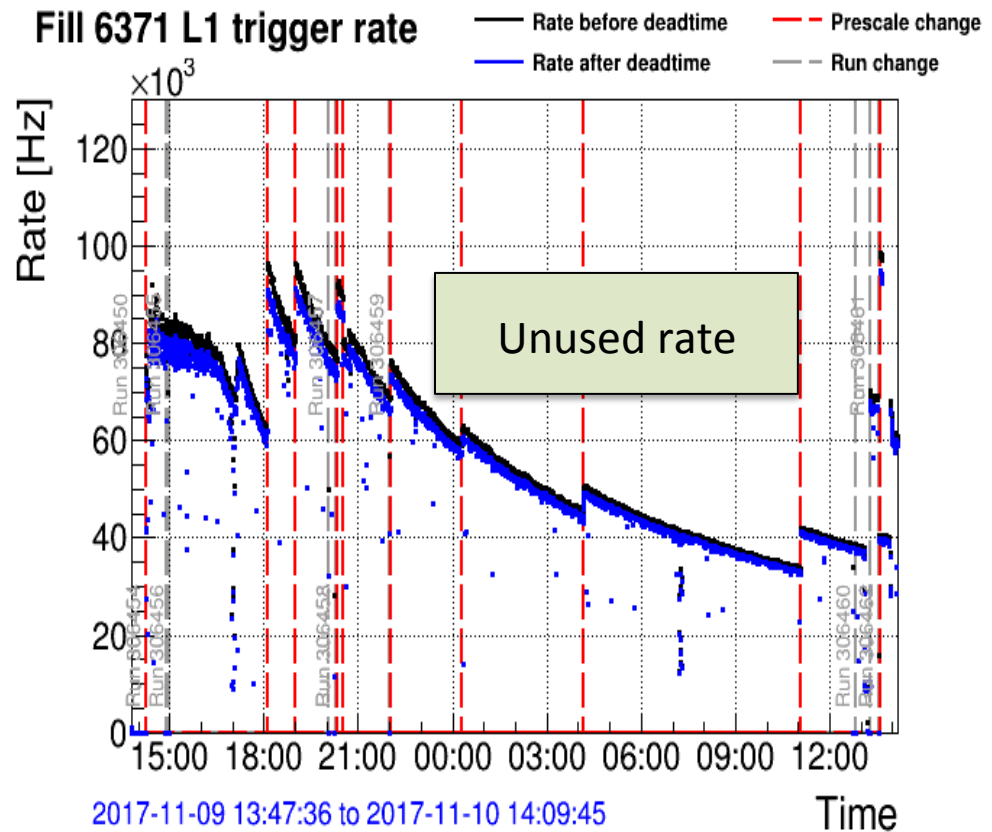
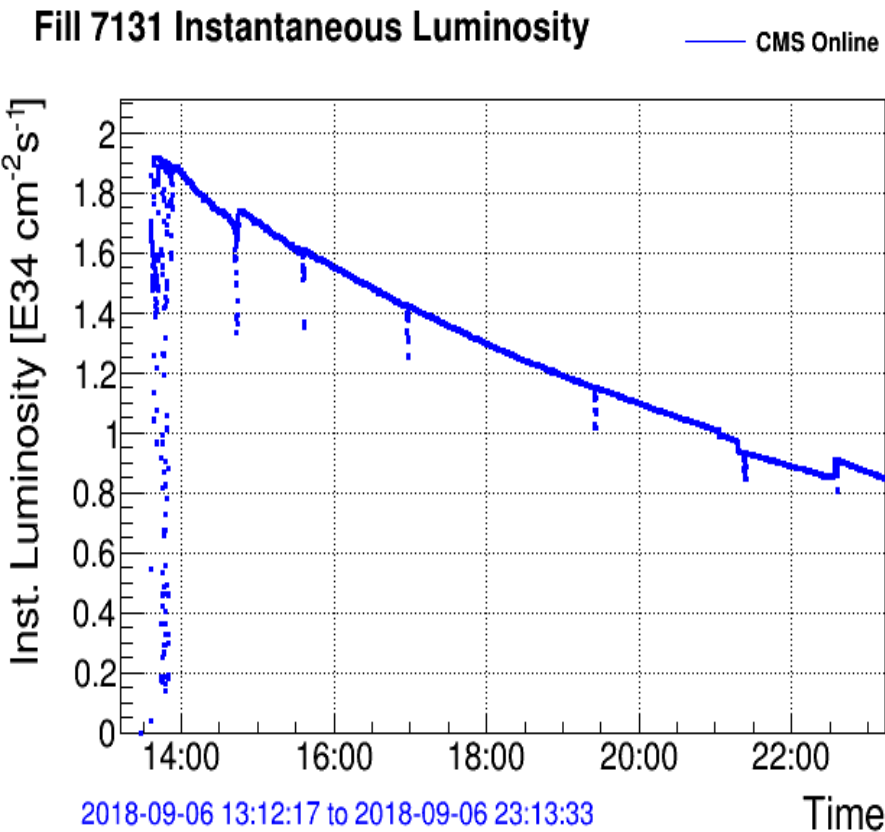
# The main issue: trigger



## High trigger thresholds

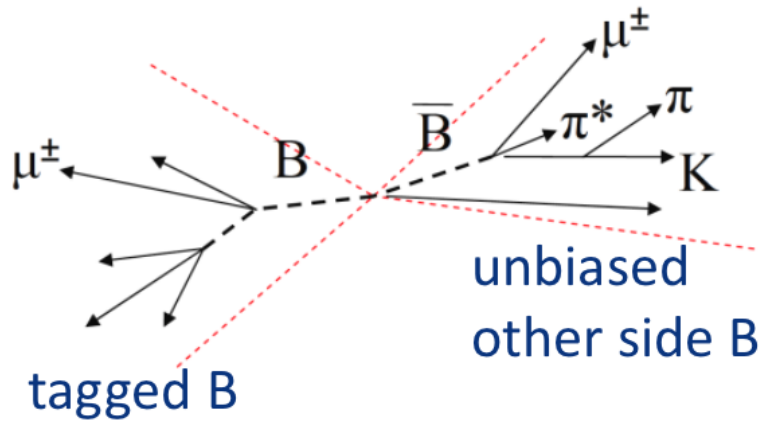
- Some B-Phys analyses still use Run1 data
  - Lower thresholds than sustainable in Run2
- CMS can not directly trigger on electrons from B

# A typical LHC fill in 2017



Instantaneous luminosity drop  $\implies$  L1 Trigger rate drop during fill

# The idea of parking



Trigger on tag-side  $\mu$  from  $b \rightarrow \mu X$  decays  
Use other side to access unbiased B decays

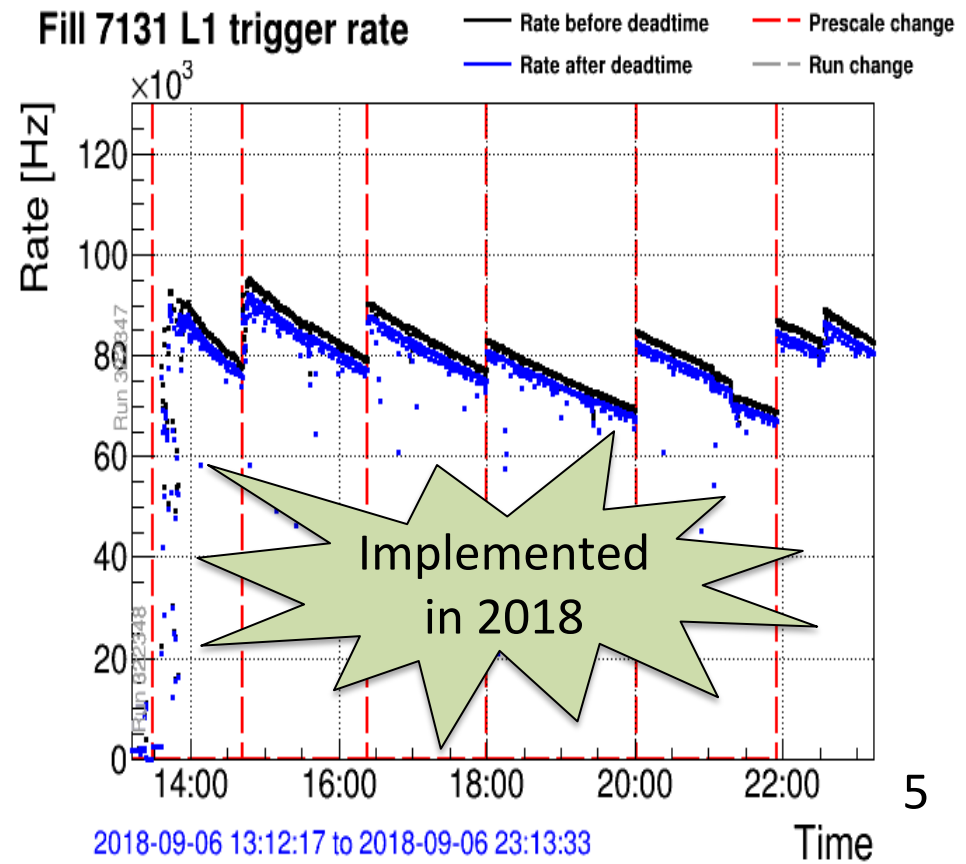
## Lumi-dependent trigger thresholds

L1:

- more stable rate lowering  $p_T$  thresholds when  $\mathcal{L}_{inst}$  drops

HLT:

- Displaced  $\mu$ , to improve purity
- Saturate bandwidth with Bs when standard physics stream rate drops



# B parking data sample

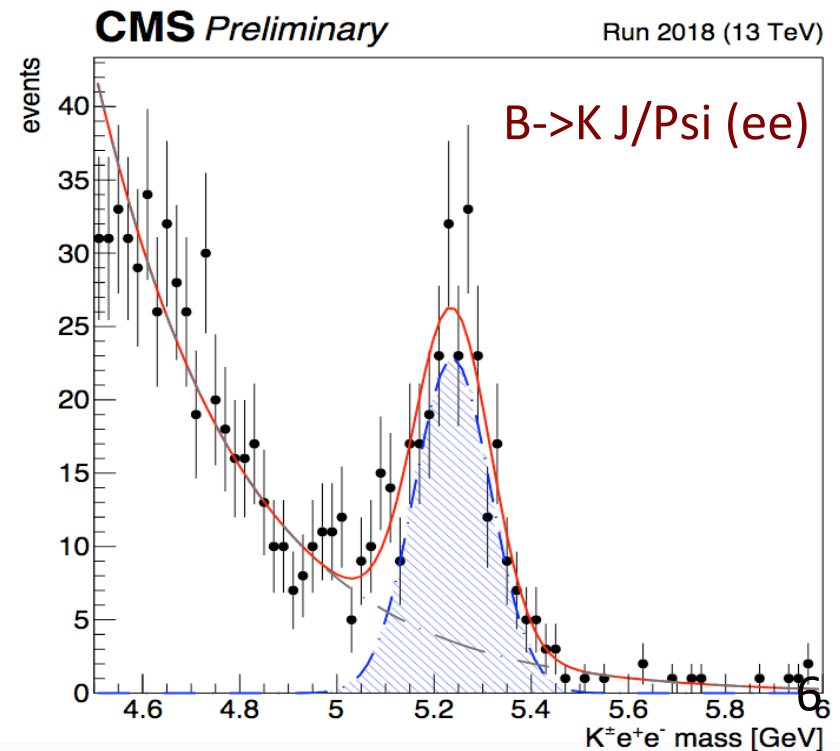
~1.2\*10<sup>10</sup> events recorded during June–Nov 2018 with high purity triggers

Average pile-up lower than typical CMS events (typically 20 PU).

Huge rates => cannot reconstruct promptly @ Tier0

*Parked* in RAW format and reconstruction done during LS2 (now ready!)

$B_d^0$	$4.99 \times 10^9$
$B^\pm$	$4.99 \times 10^9$
$B_s$	$1.56 \times 10^9$
$b$ baryons	$1.56 \times 10^9$
$B_c$	$1.25 \times 10^7$
$B$ hadrons total	$1.25 \times 10^{10}$



# B parking data sample

~1.2\*10<sup>10</sup> events recorded during June–Nov 2018 with high purity triggers

Average pile-up lower than typical CMS event (typically 20 PU).

Huge rates => can't reconstruct completely

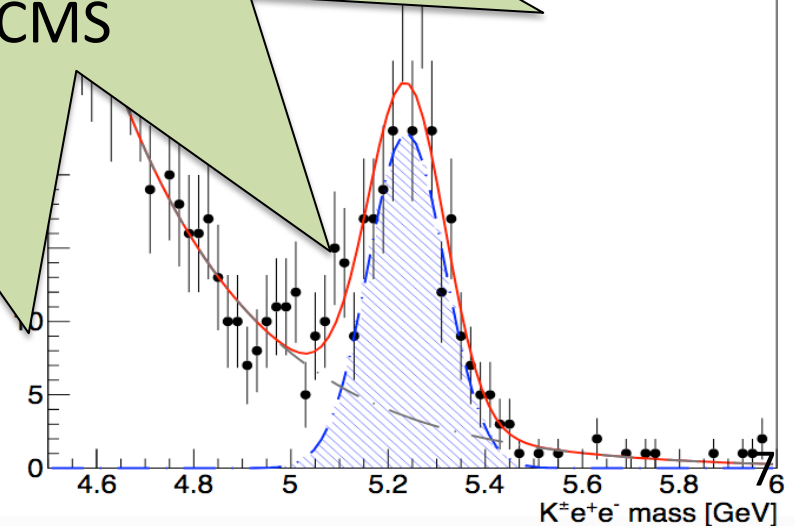
*Parked* in RAW format (now ready!)

Unprecedented dataset:  
 LOTs of opportunities!  
 E.g. R(K) analysis would  
 have been impossible  
 otherwise for CMS

$B_d^0$	
$B^\pm$	
$B_s$	
$b$ baryons	1.56 × 10 <sup>9</sup>
$B_c$	1.25 × 10 <sup>7</sup>
$B$ hadrons total	1.25 × 10 <sup>10</sup>

Run 2018 (13 TeV)

B->K J/Psi (ee)



# Our group and B-Physics

**The Rome CMS group has a large expertise basically in all the CMS-analysis sectors**

- Important contributions given in Higgs, Standard Model, EXO and SUSY...

*... Except in B-Physics*

But:

- **The parking dataset is an unprecedented opportunity to do B-Phys in CMS**
- **Good moment to try: the only tensions in Standard Model are in this sector**

Not really new:

- Members of the group coming from Babar ( D. del Re, E. Di Marco, S. Rahatlou)
- Parking dataset = basically 1<sup>st</sup> experience with B-electrons in CMS
  - We have large expertise (**leading group**) in ECAL and electron reconstruction

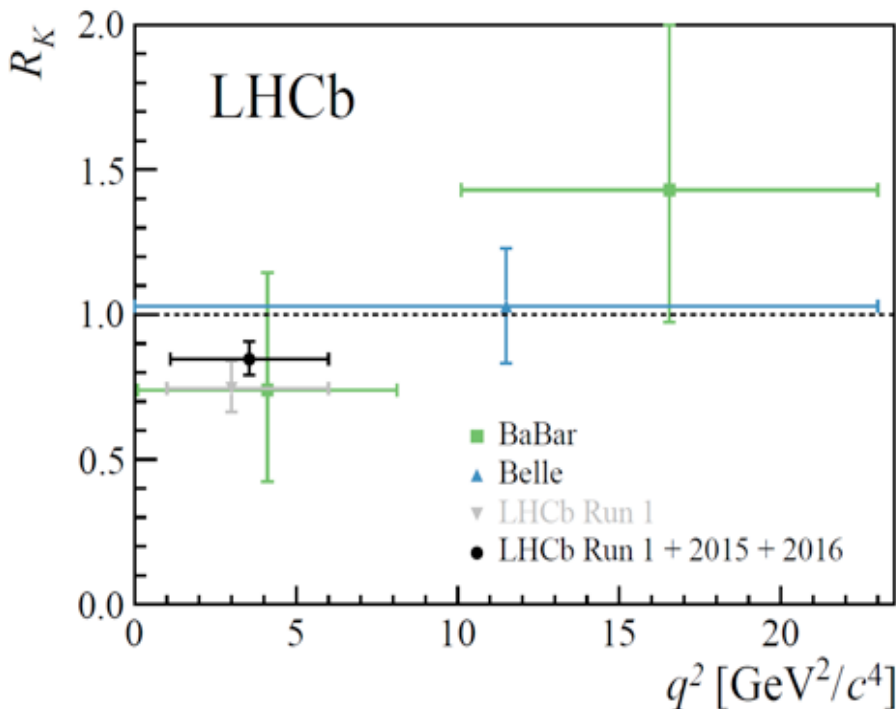


# Opportunities

We joined the B-Physics activities since a few months

Ongoing activity:

$$R_{K^{(*)}} = \frac{\mathcal{B}(B \rightarrow K^{(*)} \mu\mu)}{\mathcal{B}(B \rightarrow K^{(*)} ee)}$$



High-profile analysis:

Tensions with SM reported by LHCb

Opportunity for interested students to work on all the different analysis aspects:

- selection
- background control
- fitting strategy
- control samples
- ...

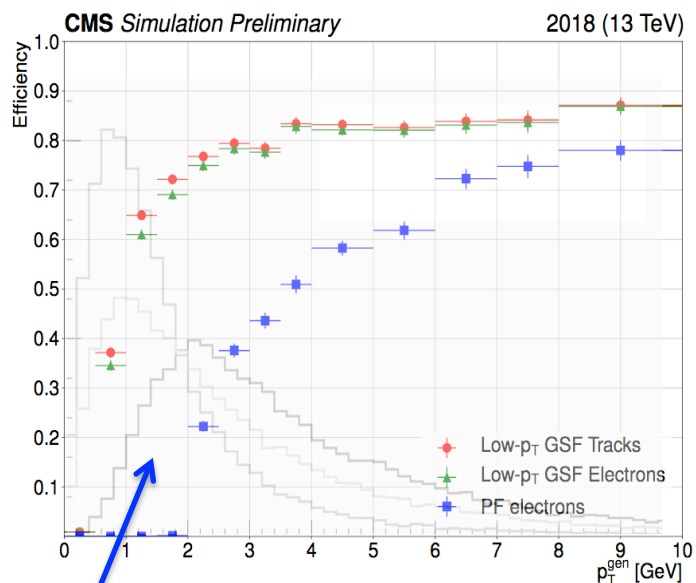
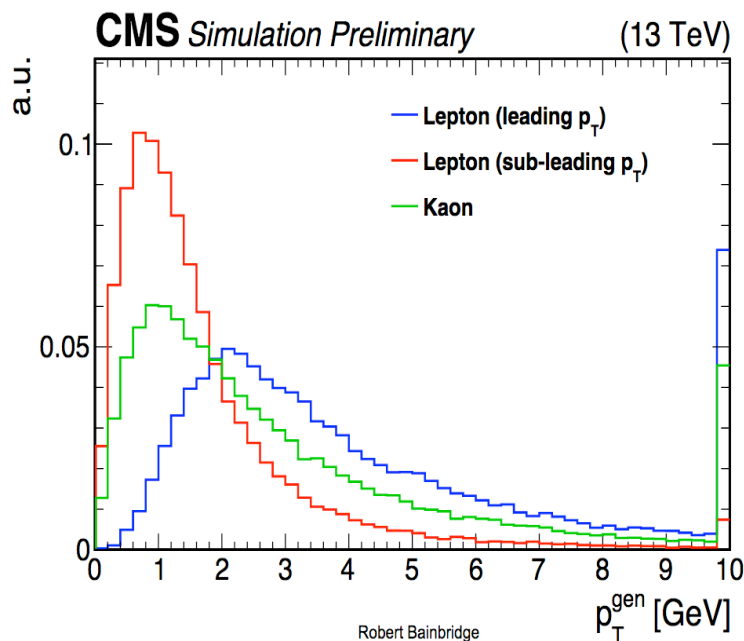
Active people:  
F. Cavallari,  
F. Pandolfi,  
C. Rovelli,  
R. Tramontano (PhD)

# Opportunities

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Ongoing activity: low  $p_T$  reconstruction and selection

Active people:  
F. Cavallari,  
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Precise electron selection crucial for  $R(K)$  measurement

**Default** reconstruction efficiency very low in the relevant phase-space

*For interested students:*

*lot of challenging work, using on-the-edge techniques (deep learning...)*

# Opportunities

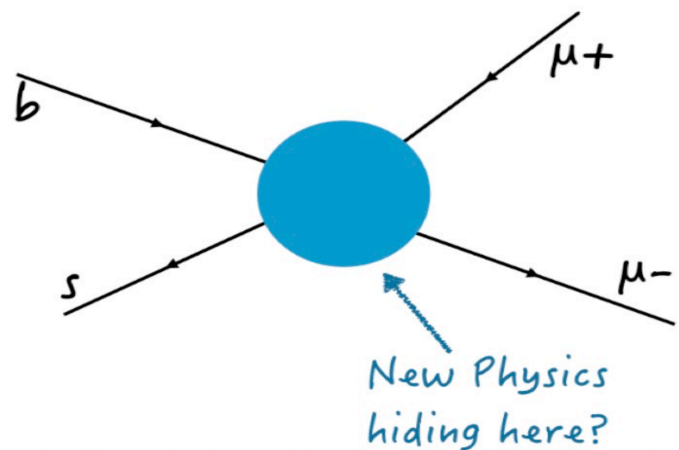
We joined the B-Physics activities since a few months

## Ongoing activity:

- R(K) analysis
- Low pT reconstruction and selection

## Other possible interests:

- Rare processes in general, as a probe for NP
- E.g. Majorana- $\nu$  in B decays (starting)
- Spectroscopy and search for exotic hadrons (see A. Polosa's talk)
- ... (here today to collect ideas)



# Summary

CMS collected in 2018 a sample of  $\sim 10^{10}$  unbiased B-decays

- Wonderful opportunity for many new analyses

Our group joined the CMS experiment B-Physics effort

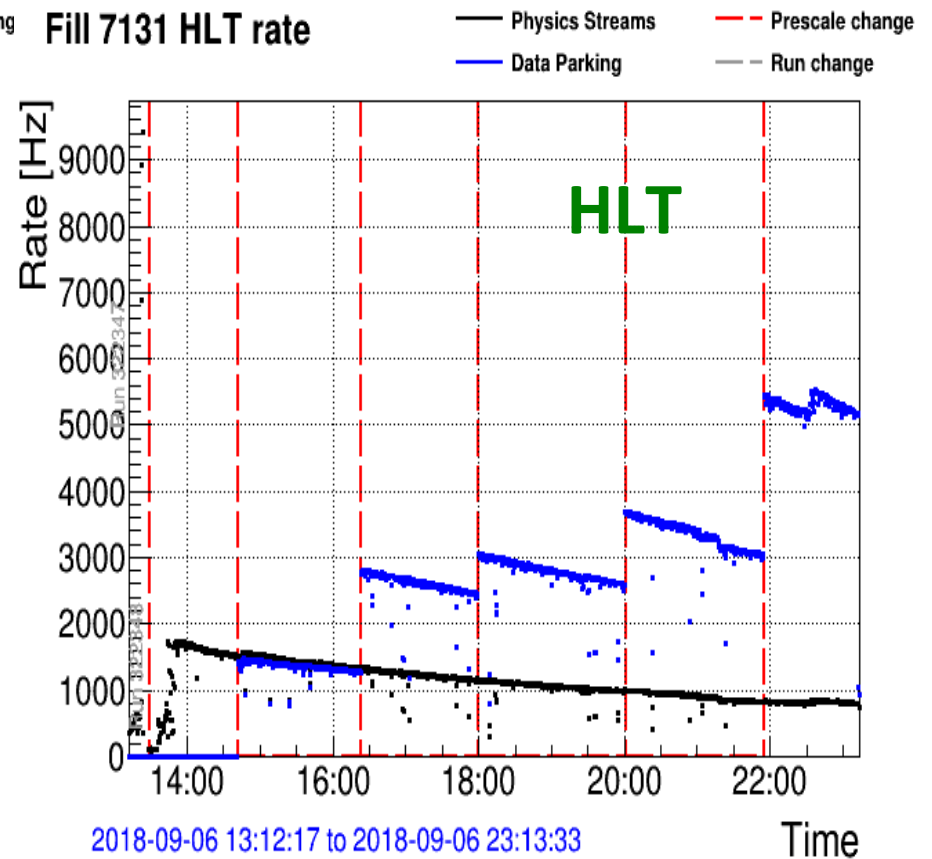
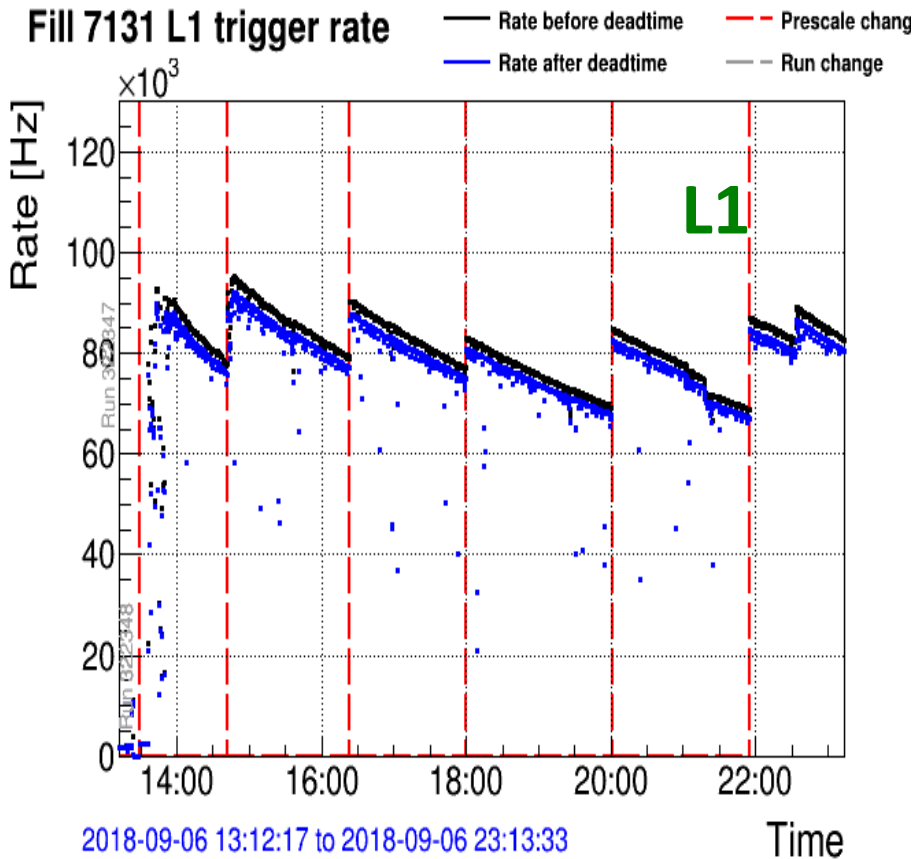
- A few activities already ongoing, other to be started

Excellent opportunity for students willing to join

- Analysis or object-related work possible
- Get in touch with high profile analysis and machine learning techniques



# Typical trigger rate in 2018



Single- $\mu$  rate peaks at 50 kHz (90 total)

Peak rate up to 5 kHz