Workshop Italiano di Fisica delle Alte Intensità – Seconda Edizione

STATUS AND PERSPECTIVE OF RARE DECAYS AT ATLAS AND CMS

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8 – 10 Nov. 2023, Rome (Italy)

Rare flavour decays

- Rare processes:
  - suppressed in the SM
  - precise theoretical predictions
  - sensitive to New Physics
  - experimentally accessible

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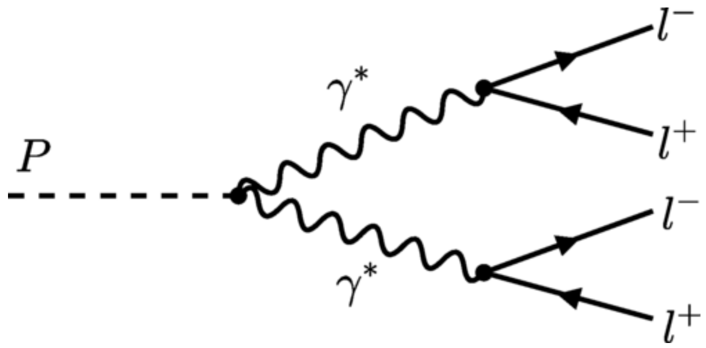
FCNC transitions
e.g. $b \to s\ell^+\ell^-$, also helicity suppressed

Decays forbidden by (accidental) symmetries of the SM:
LUV, LFV and LNV

not covered in this talk

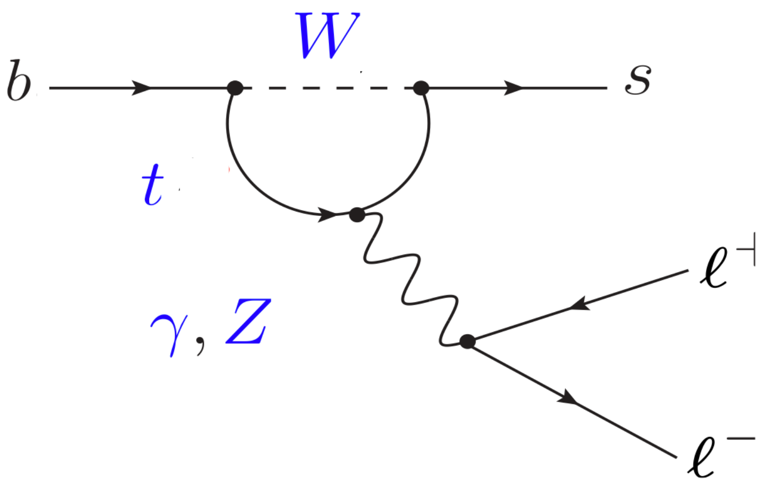
Extra: radiative multilepton decays of neutral mesons
e.g. pseudoscalar decays to 4ℓ

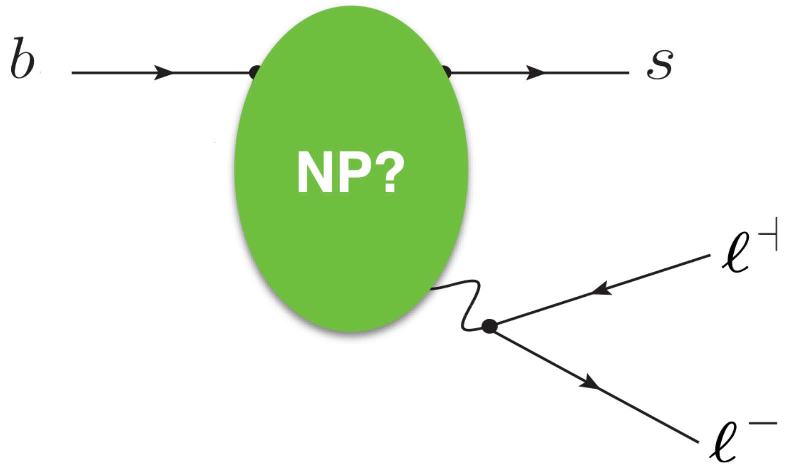


Rare flavour decays

- Rare processes:
  - suppressed in the SM
  - precise theoretical predictions
  - sensitive to New Physics →
  - experimentally accessible

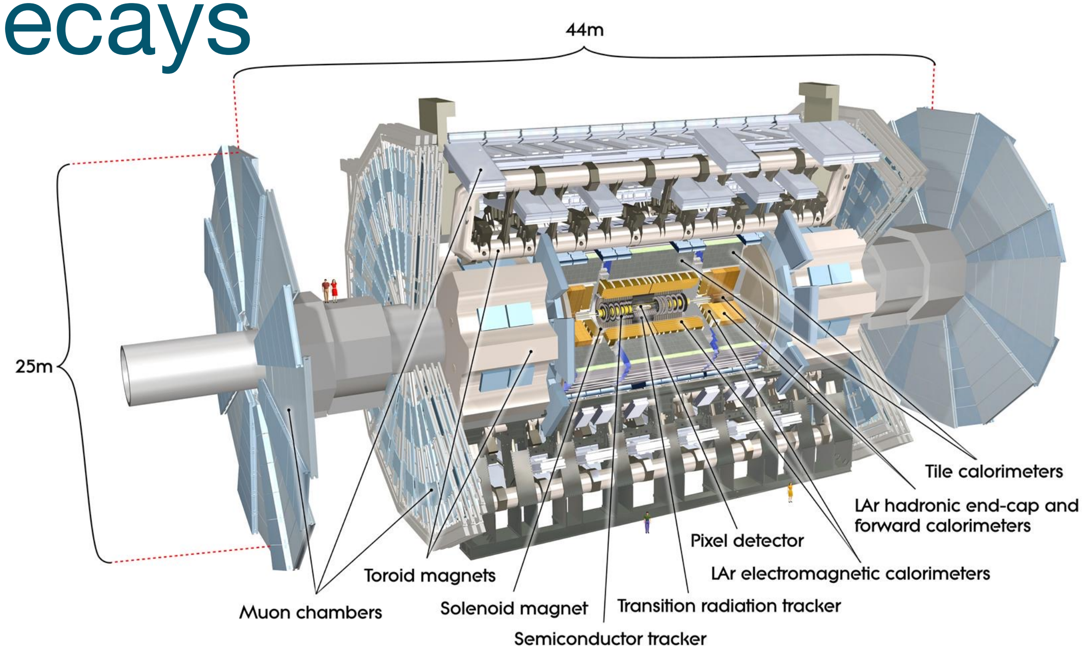
- BR enhanced or suppressed
- New sources of CPV
- Affecting angular distributions

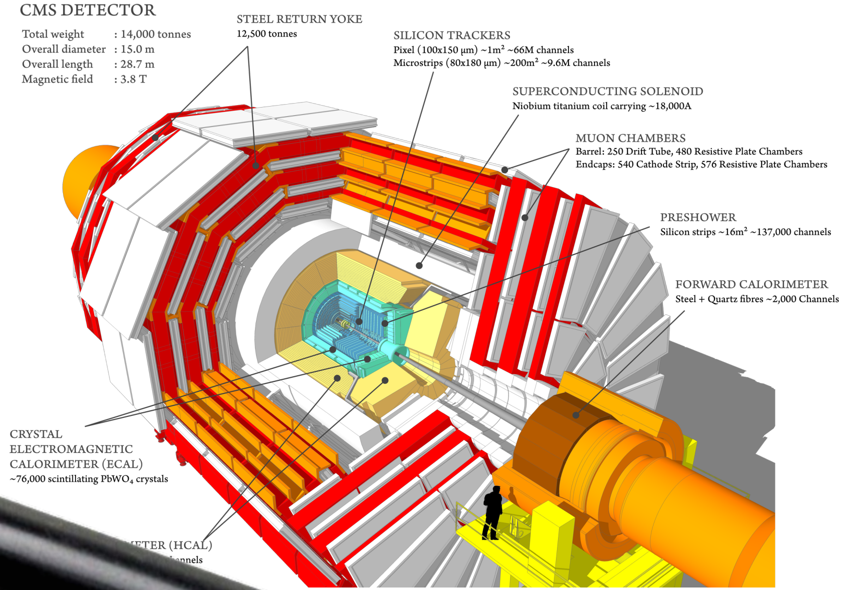




Rare flavour decays

- Rare processes:
  - suppressed in the SM
  - precise theoretical predictions
  - sensitive to New Physics
  - **experimentally accessible**



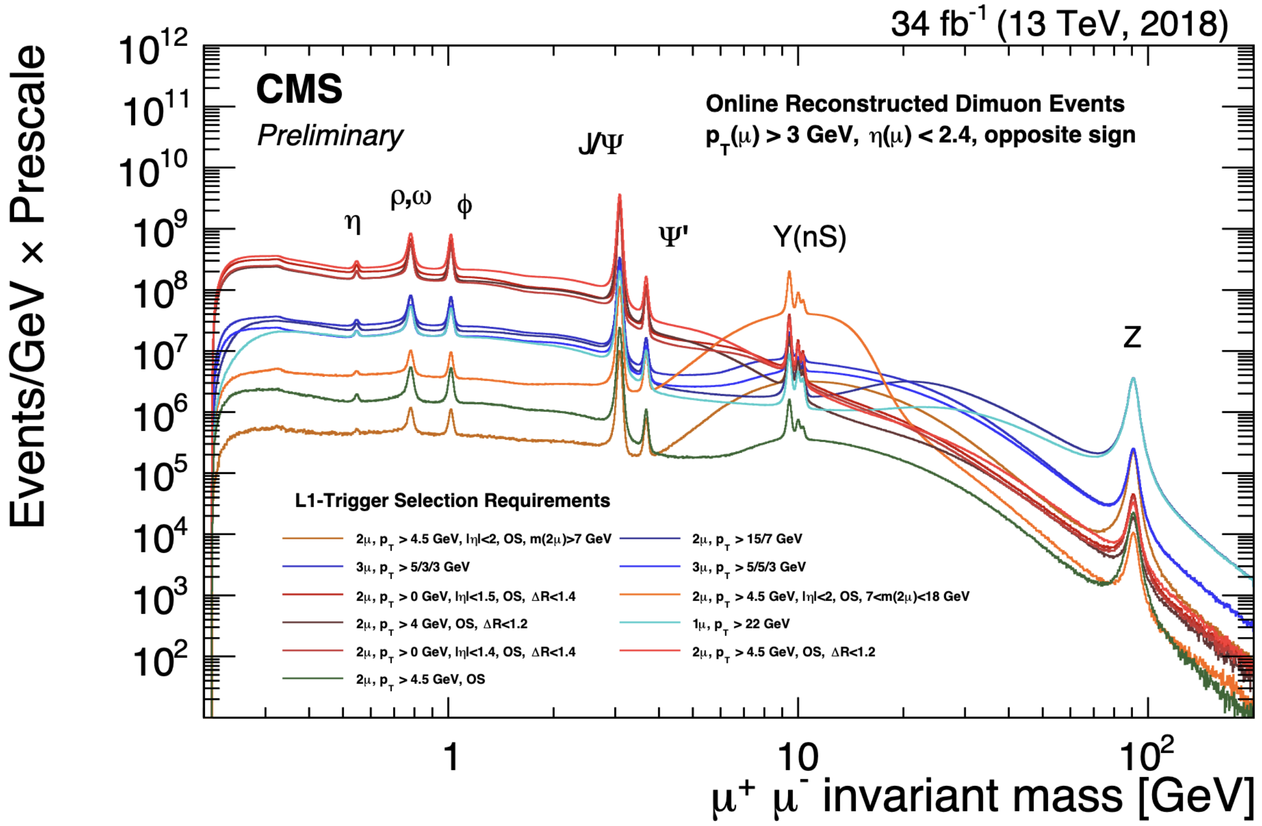


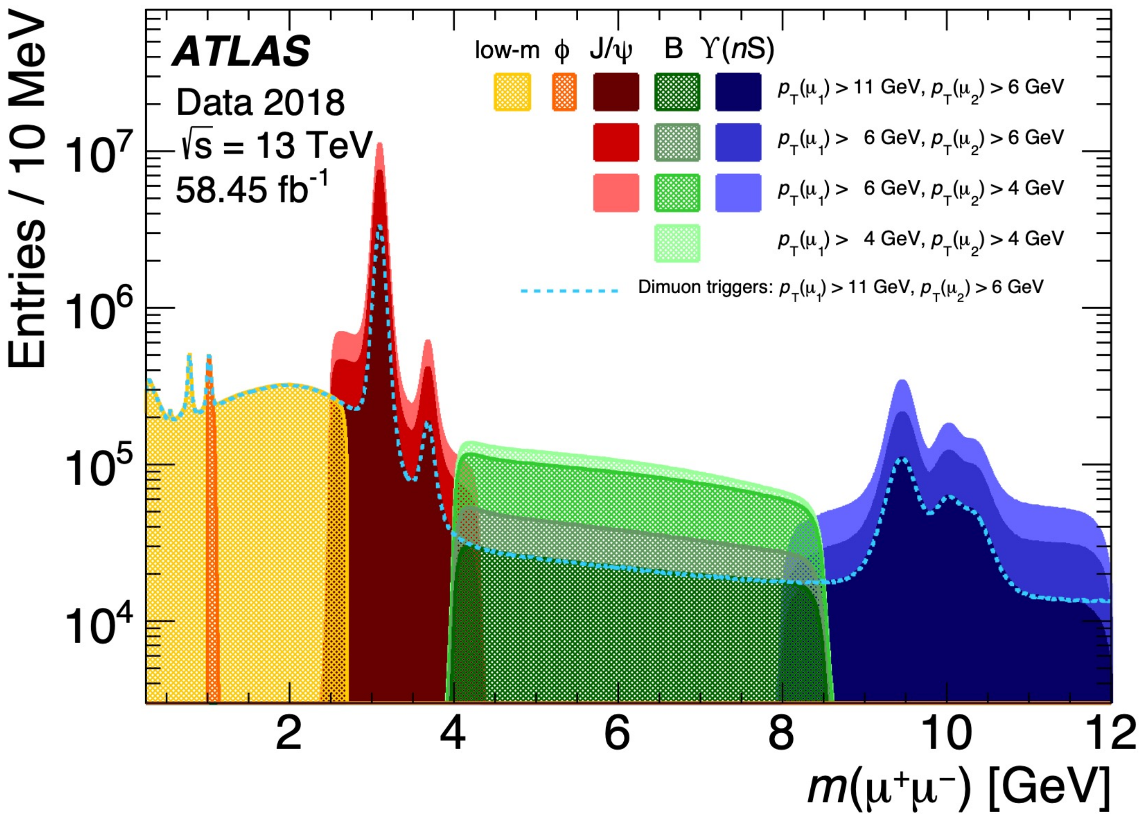
B.R. $\mathcal{O}(10^{-10} \div 10^{-8})$

Experimental signatures accessible @ CMS and ATLAS

pp collisions at 13 TeV: we can probe heavy flavour fields at **high energies**

Excellent LHC performance during Run 2: **high statistics** for searches for rare decays



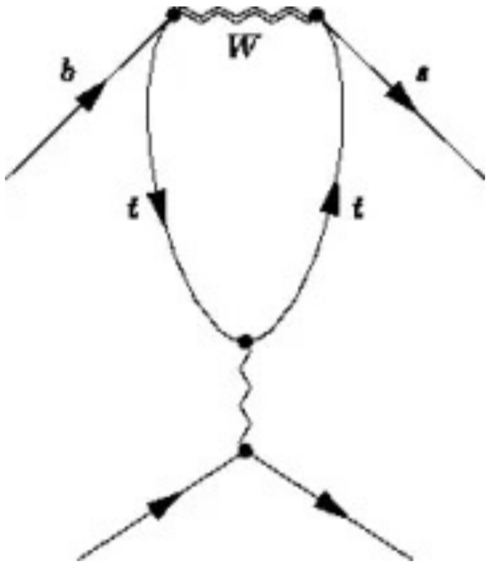


→ Focus on low p_T dimuon B signatures

$B_s^0 \longrightarrow \mu^+\mu^-$ and $B^0 \longrightarrow \mu^+\mu^-$ decays

$B_s^0 \longrightarrow \mu^+\mu^-$ and $B^0 \longrightarrow \mu^+\mu^-$ decays

- Suppressed in the SM (FCNC and helicity)
- Connected to $b \longrightarrow sll$ transitions via the EFT operator O_{10} can help understanding $b \longrightarrow s$ anomalies
- B_s^0 meson effective lifetime sensitive to new physics



CMS: Measurement of the $B_s^0 \longrightarrow \mu^+\mu^-$ decay properties and search for the $B^0 \longrightarrow \mu^+\mu^-$ decay
Phys.Lett.B842(2023)137955

ATLAS: Measurement of the $B_s^0 \longrightarrow \mu^+\mu^-$ effective lifetime
JHEP 2309 (2023) 199

CMS: $B_{(s)} \longrightarrow \mu^+\mu^-$ analysis strategy

full Run 2

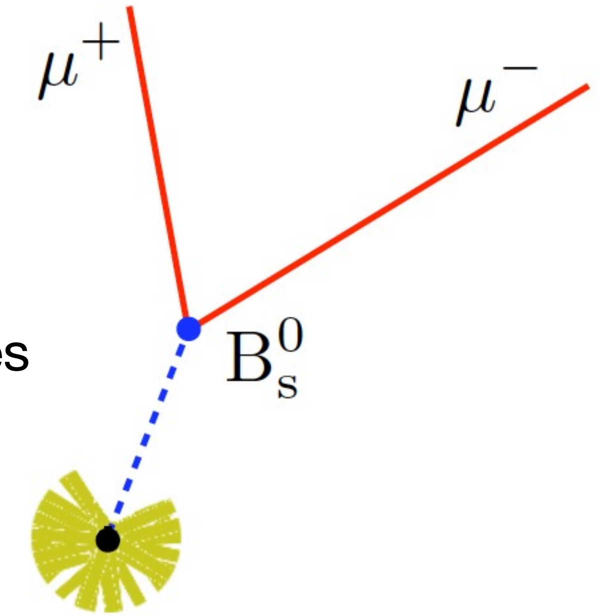
$$\mathcal{B}(\mathrm{B_s^0} \to \mu^+\mu^-) = \mathcal{B}(\mathrm{B^+} \to \mathrm{J}/\psi\mathrm{K^+}) \frac{N_{\mathrm{B_s^0}\to\mu^+\mu^-}}{N_{\mathrm{B^+}\to\mathrm{J}/\psi\mathrm{K^+}}} \frac{\varepsilon_{\mathrm{B^+}\to\mathrm{J}/\psi\mathrm{K^+}}}{\varepsilon_{\mathrm{B_s^0}\to\mu^+\mu^-}} \frac{f_\mathrm{u}}{f_\mathrm{s}},$$

external input

$$\left(\mathcal{B}(\mathrm{B_s^0} \to \mu^+\mu^-) = \mathcal{B}(\mathrm{B_s^0} \to \mathrm{J}/\psi\phi(1020)) \frac{N_{\mathrm{B_s^0}\to\mu^+\mu^-}}{N_{\mathrm{B_s^0}\to\mathrm{J}/\psi\phi(1020)}} \frac{\varepsilon_{\mathrm{B_s^0}\to\mathrm{J}/\psi\phi(1020)}}{\varepsilon_{\mathrm{B_s^0}\to\mu^+\mu^-}},\right)$$

alternative

$$\mathcal{B}(\mathrm{B^0} \to \mu^+\mu^-) = \mathcal{B}(\mathrm{B^+} \to \mathrm{J}/\psi\mathrm{K^+}) \frac{N_{\mathrm{B^0}\to\mu^+\mu^-}}{N_{\mathrm{B^+}\to\mathrm{J}/\psi\mathrm{K^+}}} \frac{\varepsilon_{\mathrm{B^+}\to\mathrm{J}/\psi\mathrm{K^+}}}{\varepsilon_{\mathrm{B^0}\to\mu^+\mu^-}} \frac{f_\mathrm{u}}{f_\mathrm{d}},$$

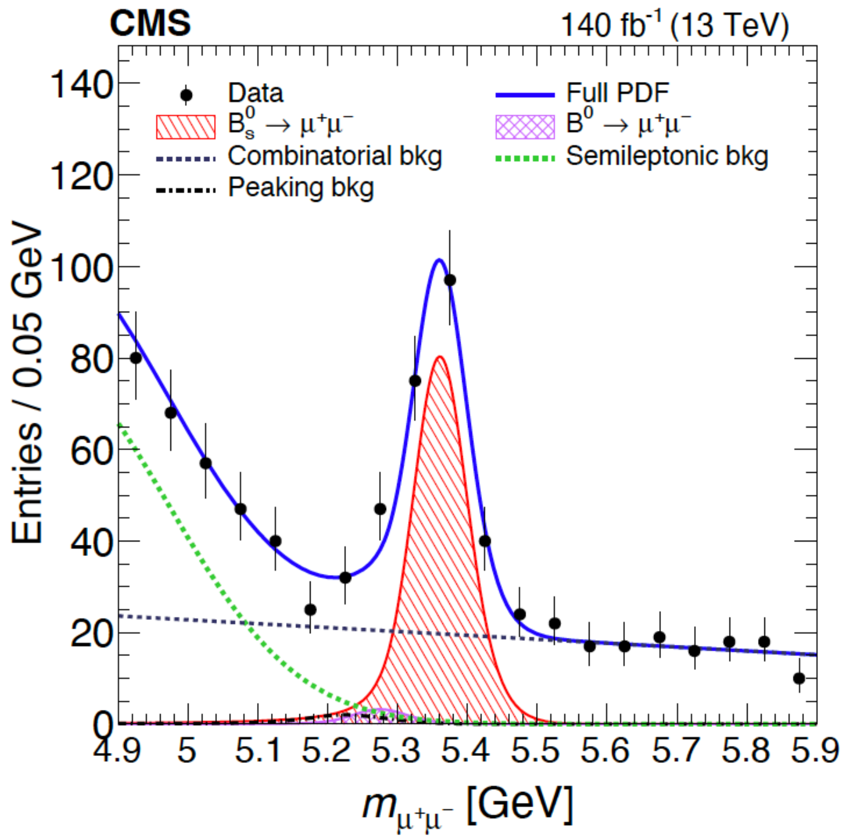


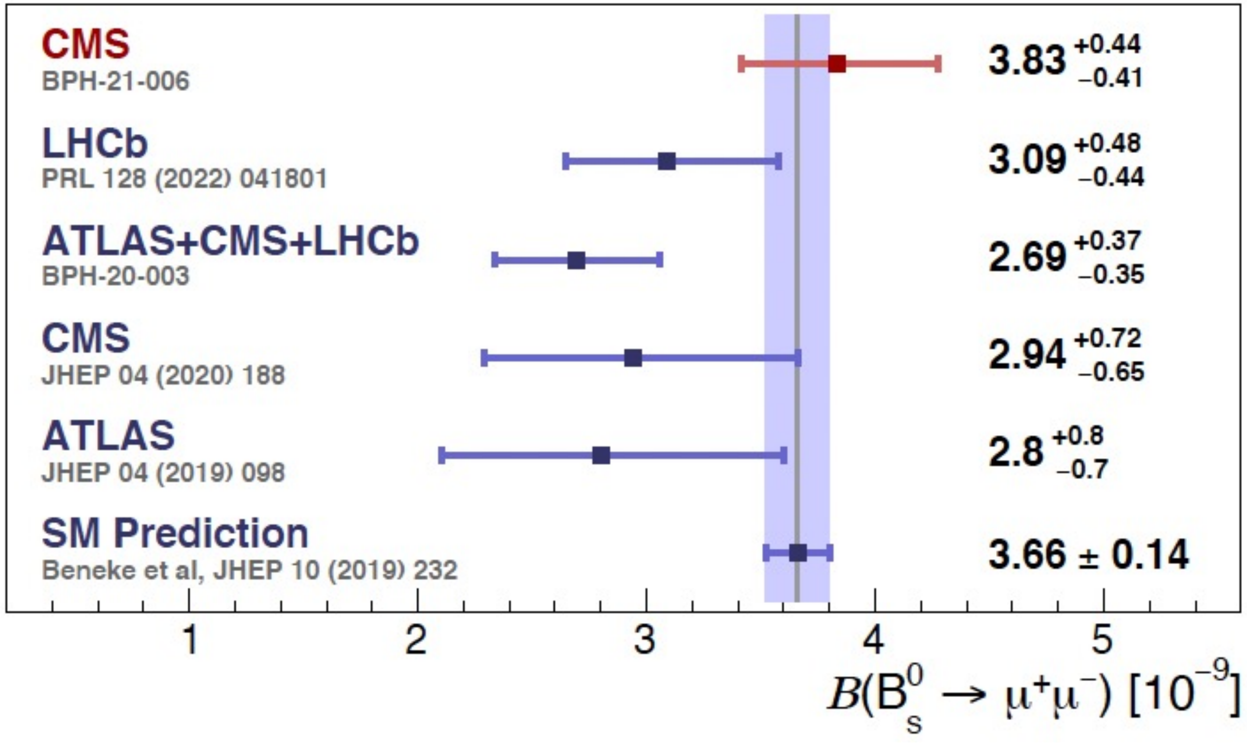
- BR normalized using $B^+ \longrightarrow J/\psi\, K^+$ or $B_s^0 \longrightarrow J/\psi\phi$ to reduce uncertainties
- Measurement extracted from simultaneous unbinned ML fits:
  - signal yield: 2D fit in mass and its uncertainty
  - effective lifetime: 3D fit in mass, decay time and its uncertainty
- Dimuon triggers, loose selections applied (SV requirements, invariant mass)
- MVA for background suppression

CMS: $B_s^0 \longrightarrow \mu^+\mu^-$ branching fraction

$$\mathcal{B}(\mathrm{B_s^0} \to \mu^+\mu^-) = \left[3.83^{+0.38}_{-0.36}\ (\mathrm{stat})\ ^{+0.19}_{-0.16}\,(\mathrm{syst})\ ^{+0.14}_{-0.13}\,(f_s/f_u)\right] \times 10^{-9}$$

Alternative using $B_s^0 \longrightarrow J/\psi\phi$: $\mathcal{B}(\mathrm{B_s^0} \to \mu^+\mu^-) = \left[4.02^{+0.40}_{-0.38}\,(\mathrm{stat})\ ^{+0.28}_{-0.23}\,(\mathrm{syst})\ ^{+0.18}_{-0.15}\,(\mathcal{B})\right] \times 10^{-9}$

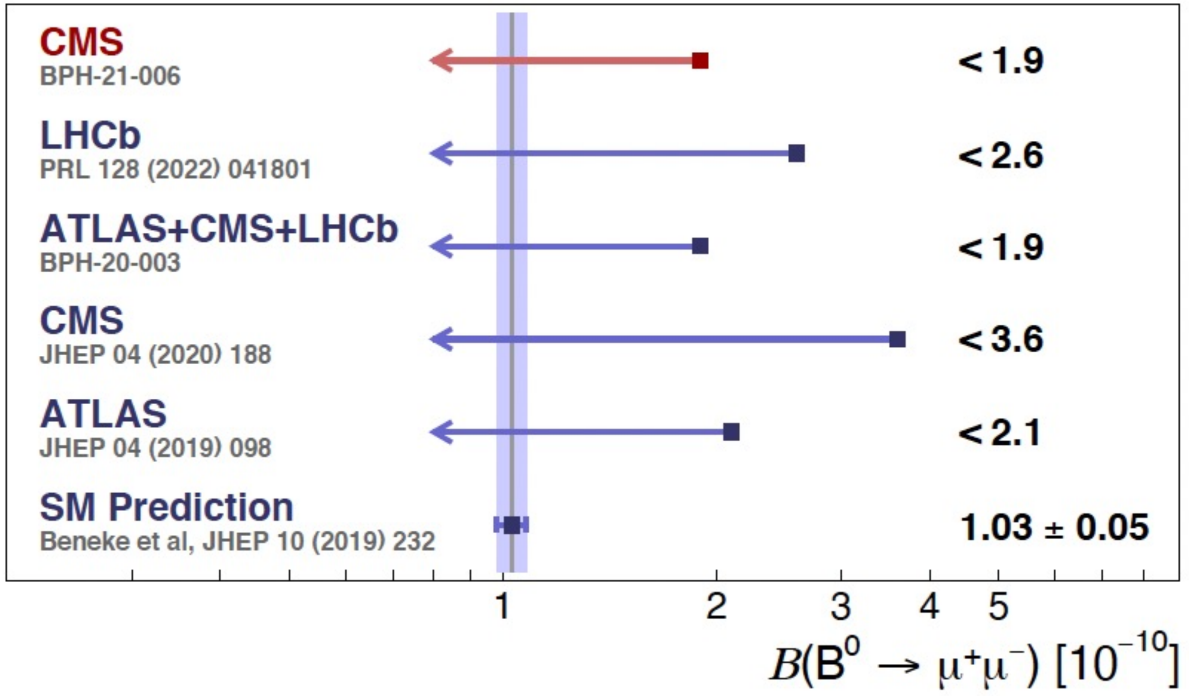


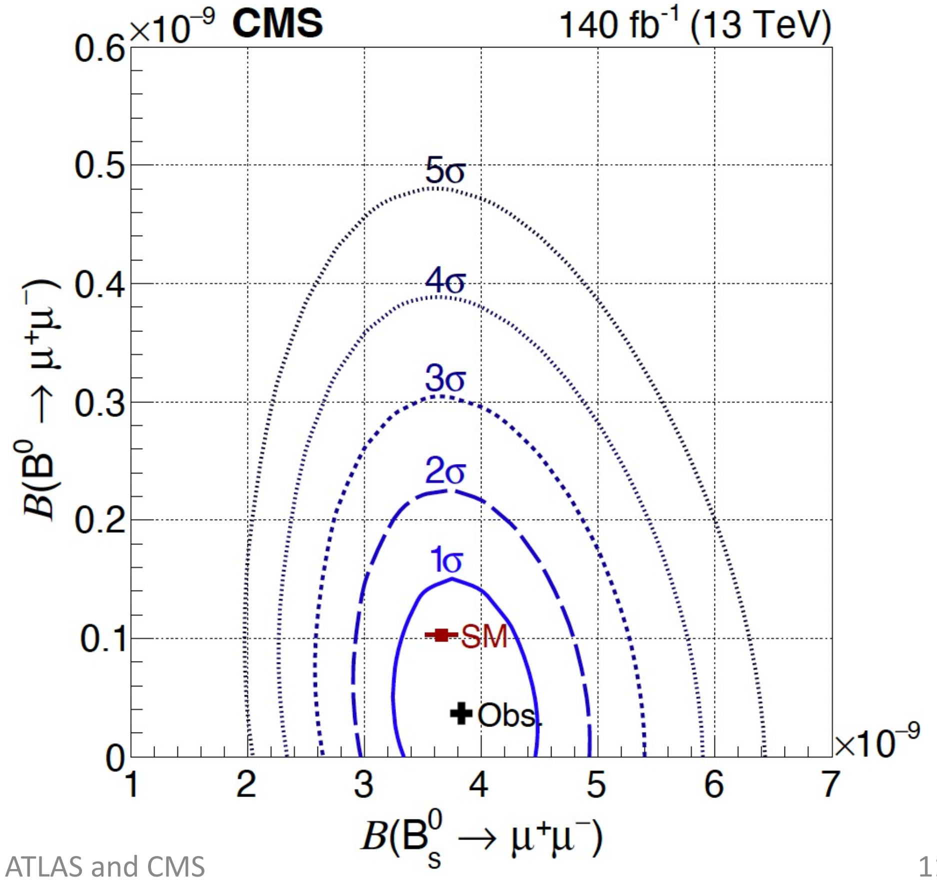


CMS: $B^0 \longrightarrow \mu^+\mu^-$ branching fraction upper limit

$$\mathcal{B}(\mathrm{B}^0 \to \mu^+\mu^-) < 1.5 \times 10^{-10} \text{ at } 90\% \text{ CL}$$

$$\mathcal{B}(\mathrm{B}^0 \to \mu^+\mu^-) < 1.9 \times 10^{-10} \text{ at } 95\% \text{ CL}$$





$B_s^0 \longrightarrow \mu^+\mu^-$ effective lifetime

$B_s^0 \longrightarrow \mu^+\mu^-$ effective lifetime: motivations

- B_s^0 mass eigenstates are combination of flavor eigenstates

- Their SM lifetimes are different and precisely known:
  τ_H = 1.624 ± 0.009 ps, τ_L = 1.429 ± 0.007 ps

- [In absence of CP violation] Only the heavy eigenstate can decay to $\mu^+\mu^-$

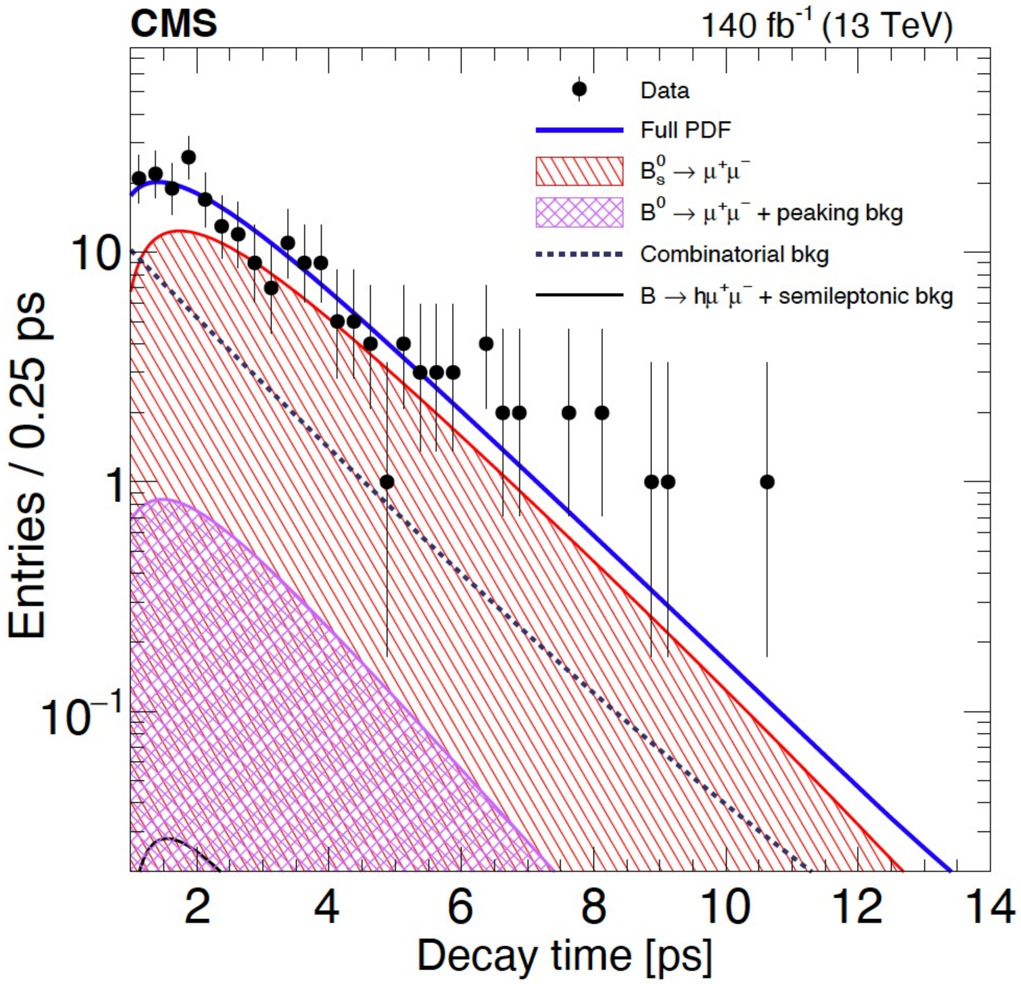
→ New physics introducing CPV would affect the B_s^0 lifetime!

CMS: B_s^0 lifetime measurement

Measurement extracted from simultaneous unbinned ML fits:

- effective lifetime: 3D fit in mass, decay time and its uncertainty

Effect	2016a	2016b	2017	2018
Lifetime fit bias	0.04	0.04	0.05	0.04
Decay time distribution mismodeling	0.10	0.06	0.02	0.02
Efficiency modeling		0.01		
Lifetime dependence		0.01		
Total	0.11	0.07	0.05	0.04



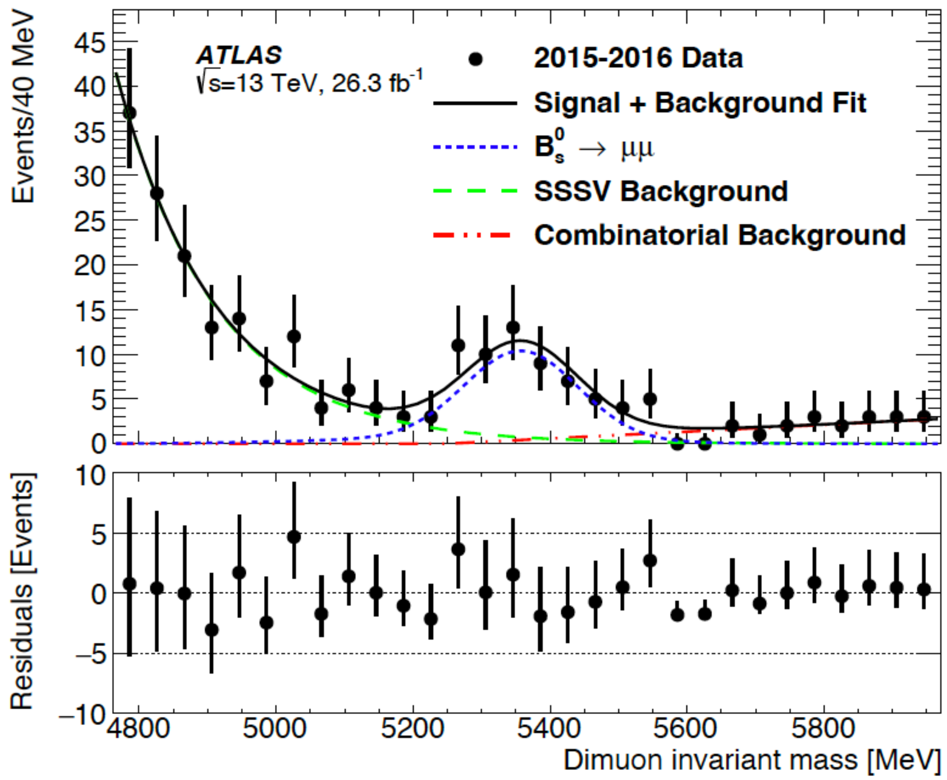
$$\tau = 1.83\,^{+0.23}_{-0.20}\,(\text{stat})\,^{+0.04}_{-0.04}\,(\text{syst})\text{ ps}$$

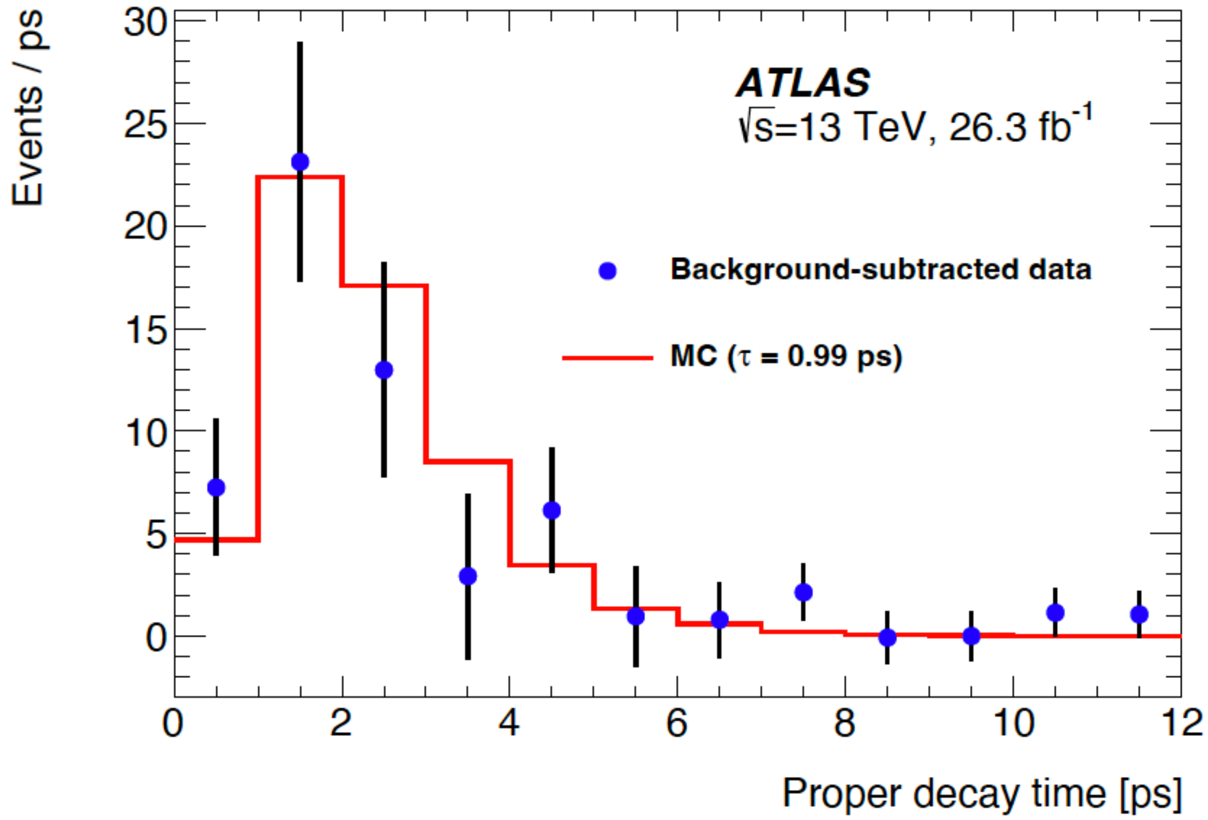
ATLAS: B_s^0 lifetime measurement

Data collected in 2015-2016

Proper decay-time distribution of 58 ± 13 (stat) signal candidates.

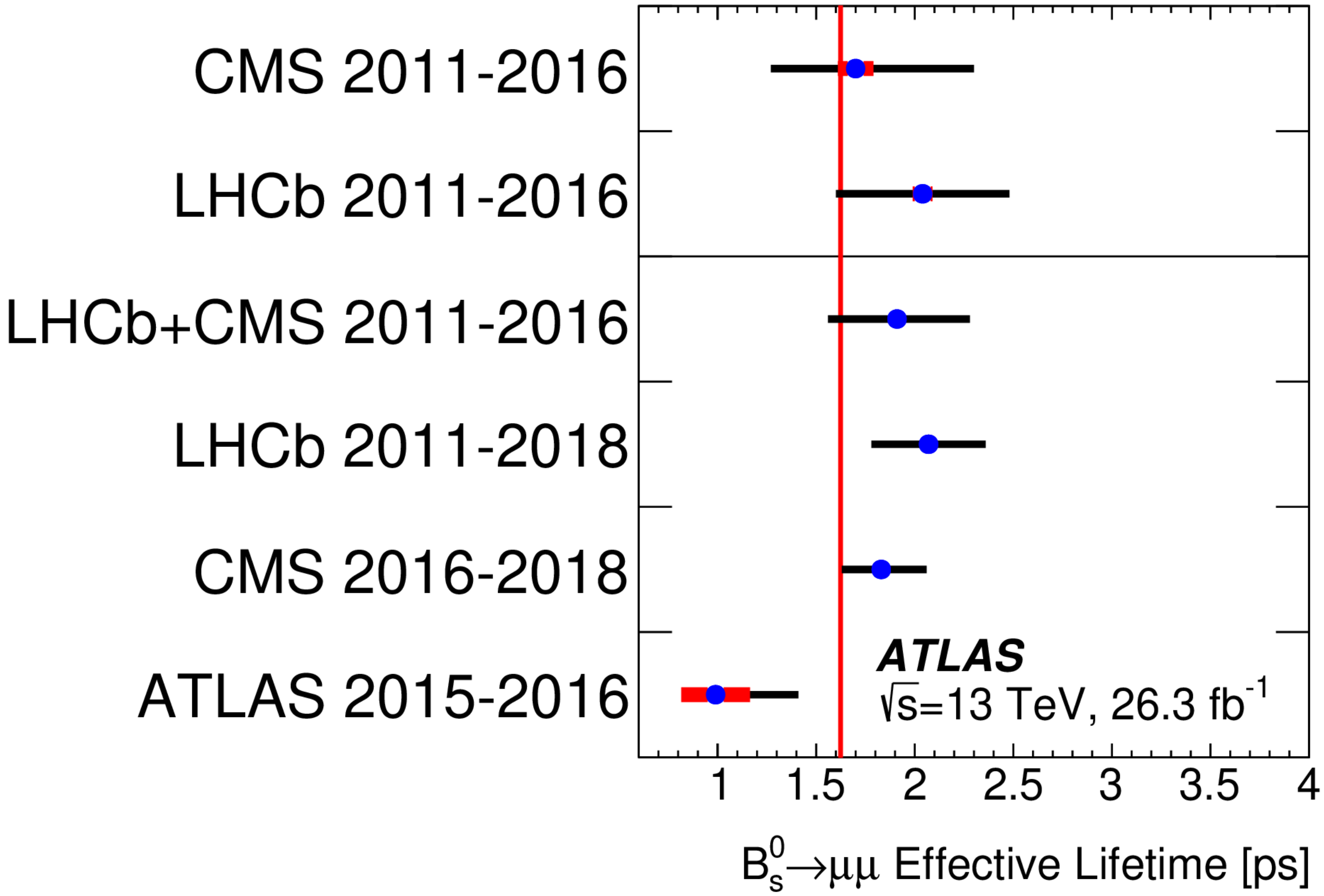
Fit with simulated signal templates parametrized a function of the B effective lifetime



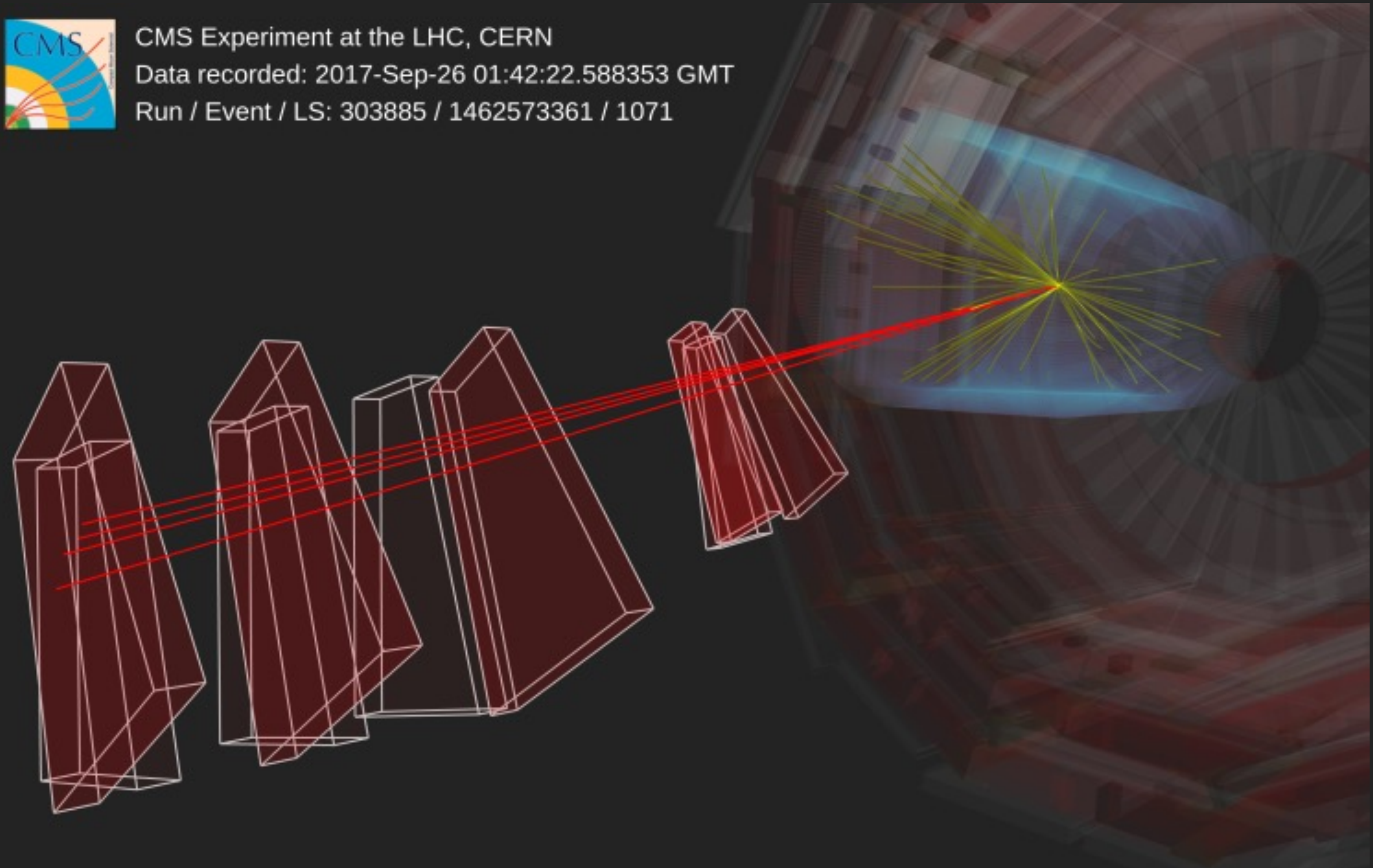


$$\tau_{\mu\mu}^{\mathrm{Obs}} = 0.99^{+0.42}_{-0.07}\ (\mathrm{stat.}) \pm 0.17\ (\mathrm{syst.})\ \mathrm{ps}$$

Summary: B_s^0 lifetime measurement

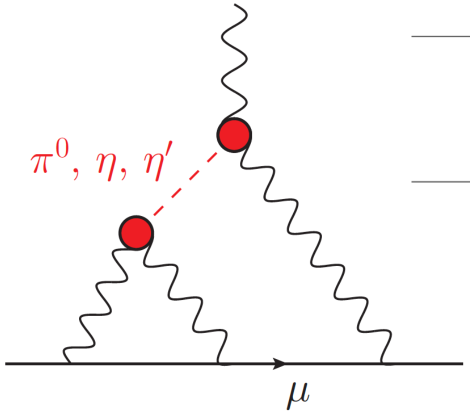


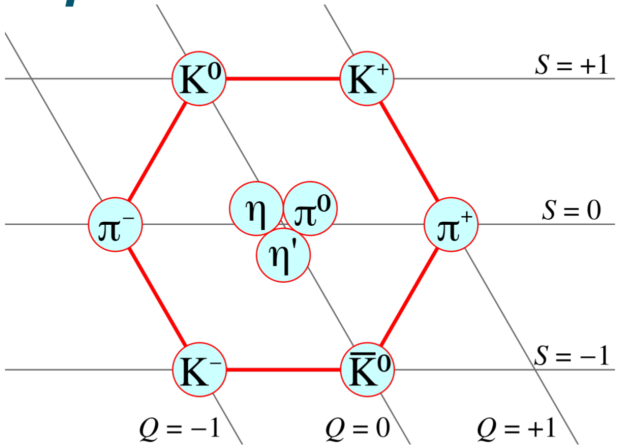
CMS: First observation of the rare 4μ decay of the η meson



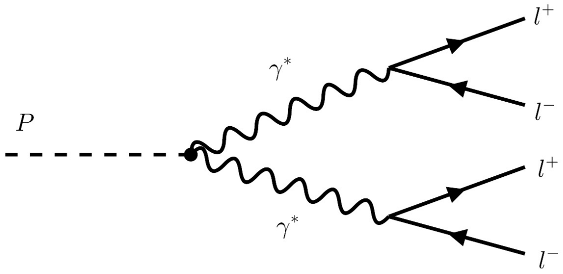
Leptonic radiative decays of the neutral pseudoscalars η and η'

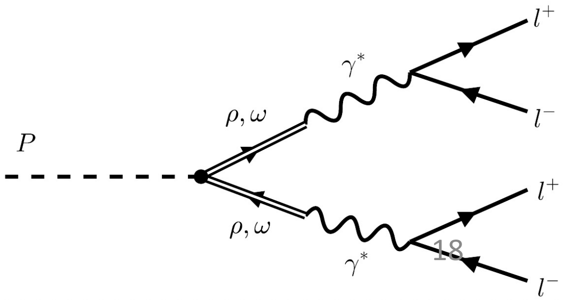
- **Important tests of the SM** (*Phys.Rept.* 945 (2022) 1)
  - light quark mass ratios,
  - $\eta\ -\eta'$ mixing parameters,
  - hadronic contributions to the anomalous magnetic moment of the muon (*Phys.Lett.B* 787 (2018) 111)





- **Sensitive to BSM** theories (*Rept.Prog.Phys.* 86 (2023) 1)
  - searches for hidden photons, light Higgs scalars, and axion-like particles
    - complementary to worldwide efforts to detect new light particles below the GeV mass scale



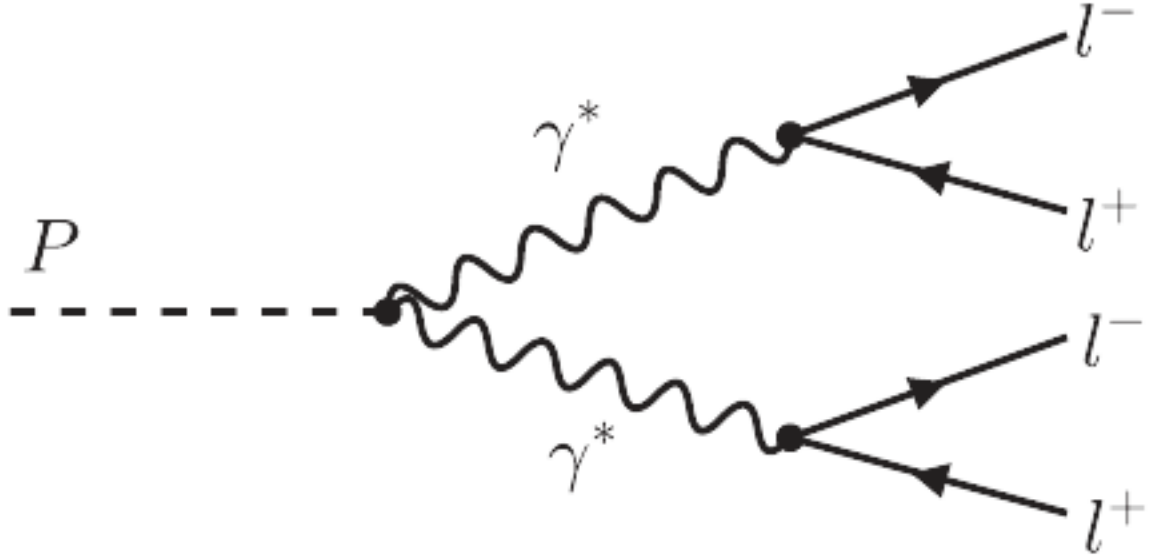


Leptonic radiative decays of the neutral pseudoscalars η and η'

$\eta \longrightarrow 4\mu$ double Dalitz decays **predicted** with

BR $\mathcal{B}(\eta \longrightarrow 4\mu) = (3.98 \pm 0.15)\times10^{-9}$

(*Chi.Phys. C* **42** (2018) 023109)



First observation at CMS:

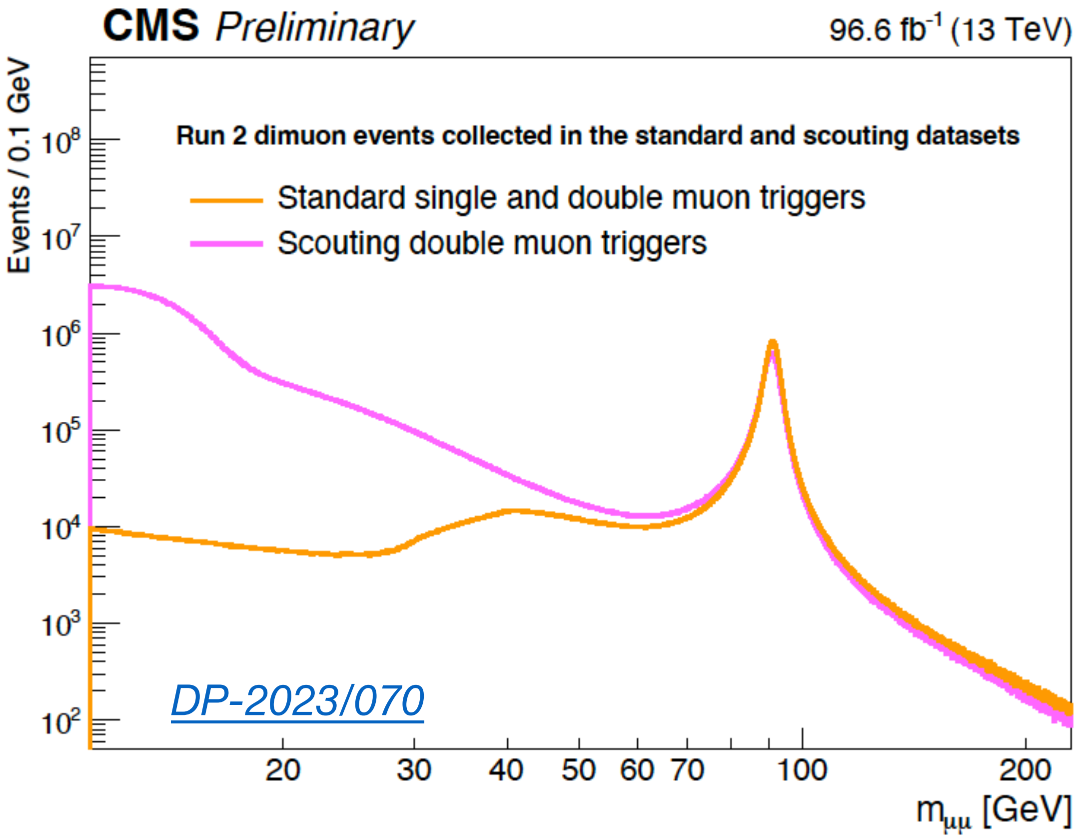
Phys. Rev. Lett. **131**, 091903

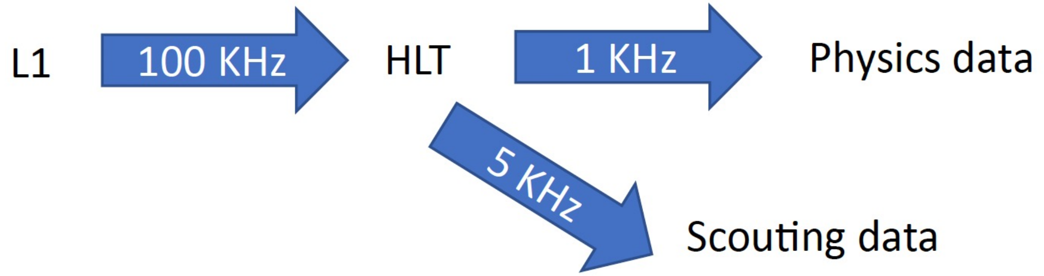
$\eta \longrightarrow 4\mu$: trigger strategy

Trigger – the Muon Scouting stream:

- Loose-selection, high-rate triggers
- Store only a limited amount of information per event
    - keep same total data transfer bandwidth wrt standard stream
- in 2017 and 2018, collected ~100 fb^{-1}

L1 path	p_T [GeV]	$\|\eta\|$	ΔR	$m_{2\mu}$ [GeV]	Charge	Fraction
#1	> 4.0 (4.5)	...	< 1.2	...	OS	90%
#2	...	< 1.5	< 1.4	...	OS	48%
#3	> 15, > 7	...	...	...	...	46%
#4	> 4.5	< 2.0	...	7–18	OS	9%





$\eta \longrightarrow 4\mu$: analysis strategy

- $\eta \longrightarrow 4\mu$ BF determined relative to $\eta \longrightarrow 2\mu$
- Offline selections: total charge, common vertex
- Acceptance and efficiencies from MC simulation

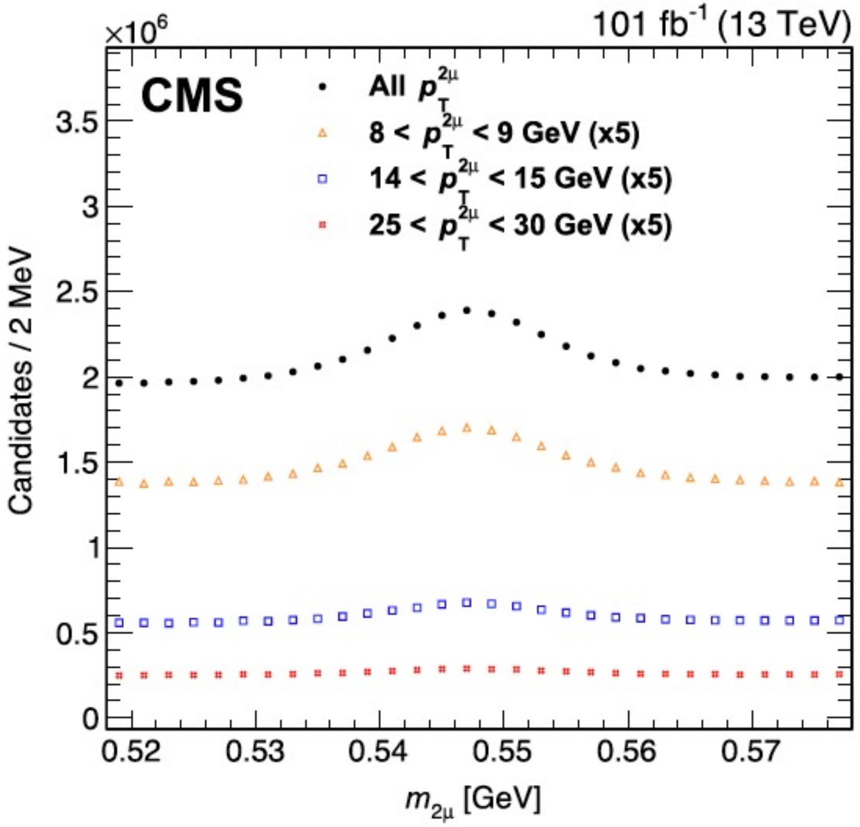
$$\frac{\mathcal{B}_{4\mu}}{\mathcal{B}_{2\mu}} = \frac{N_{4\mu}}{\sum_{i,j} N_{2\mu}^{i,j} \frac{A_{4\mu}^{i,j}}{A_{2\mu}^{i,j}}},$$

measured $\eta \longrightarrow 4\mu$ yield

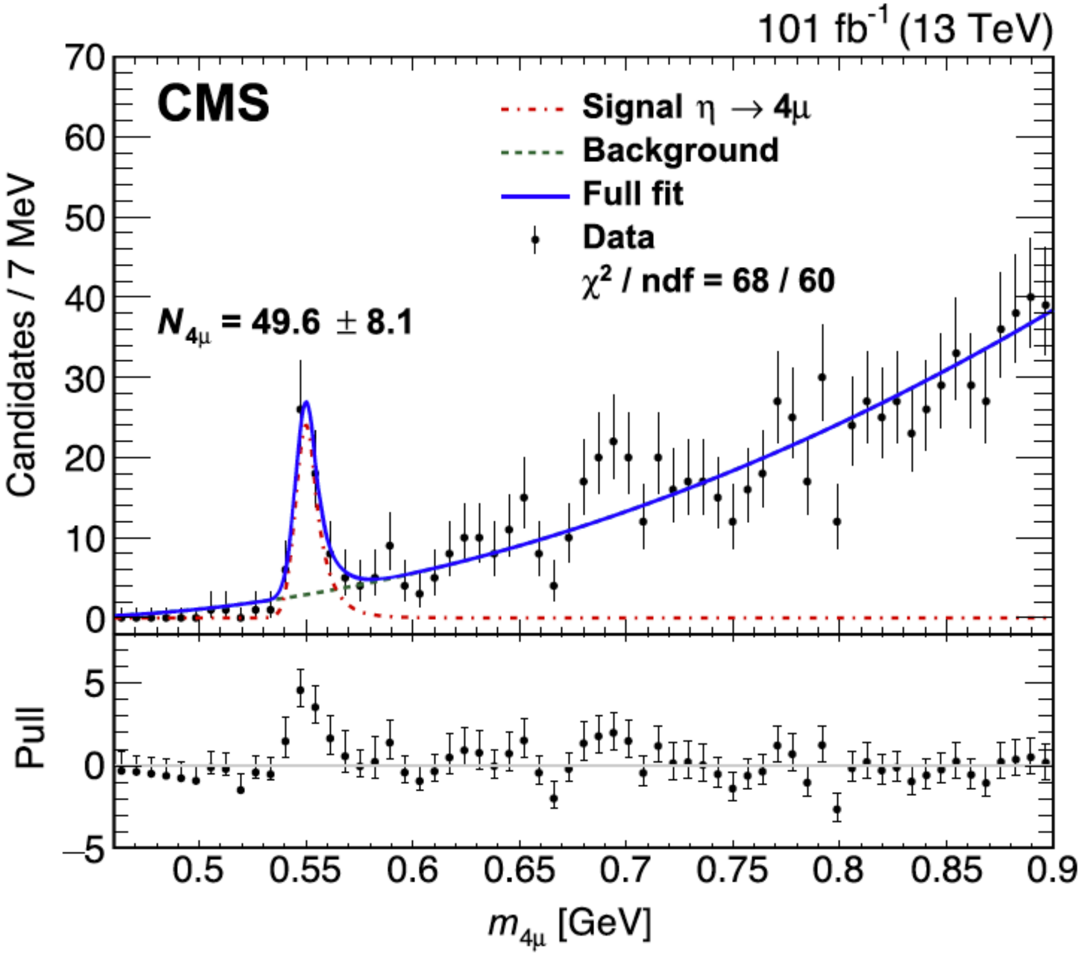
$\mathcal{B}(\eta \longrightarrow 2\mu) = (5.8 \pm 0.8)\times 10^{-6}$ (PDG)

measured $\eta \longrightarrow 2\mu$ yield

CMS acceptance and efficiencies for $\eta \longrightarrow 4\mu$ and $\eta \longrightarrow 2\mu$ from simulation, in bins of p_T and pseudorapidity



$\eta \longrightarrow 4\mu$: observation and BR result



- Clear peak in the 4μ spectrum
- Statistical significance > 5 standard deviations

- Possible background contaminations studied from simulation
  - Found that contamination of misidentified hadrons is negligible in the signal region

$$\frac{\mathcal{B}_{4\mu}}{\mathcal{B}_{2\mu}} = [0.86 \pm 0.14(\text{stat}) \pm 0.12(\text{syst})] \times 10^{-3}.$$

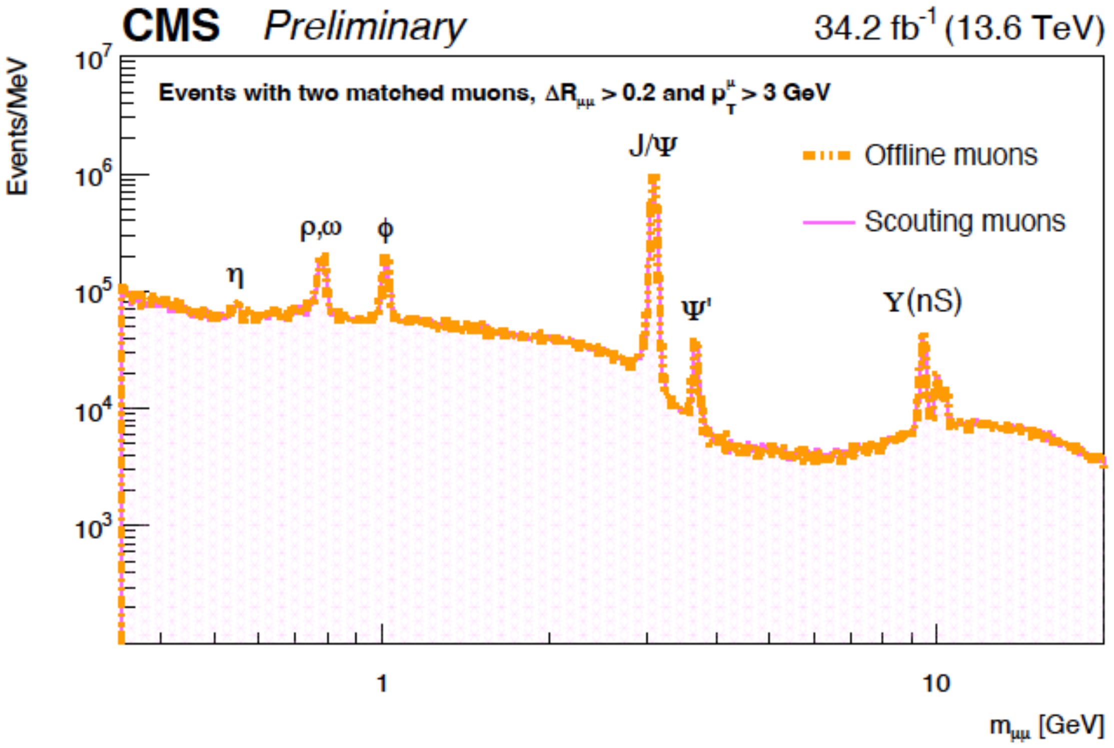
$$\mathcal{B}(\eta \to 4\mu) = [5.0 \pm 0.8(\text{stat}) \pm 0.7(\text{syst}) \pm 0.7(\mathcal{B}_{2\mu})] \times 10^{-9}$$

in agreement with SM expectation

Perspectives

Both for **ATLAS** and **CMS**, the Run2 dataset still has a large potential.

In **Run3**, dedicated trigger strategies can further expand our physics programme



CMS:

- scouting strategy continues in Run3 [1]
- so-called "parking" strategy with soft dimuon triggers allows for searches, as well as angular analyses
- inclusion of soft di-electron triggers [2]

[1] *DP-2023/070*
[2] *PoS* ICHEP2022 (2022) 681

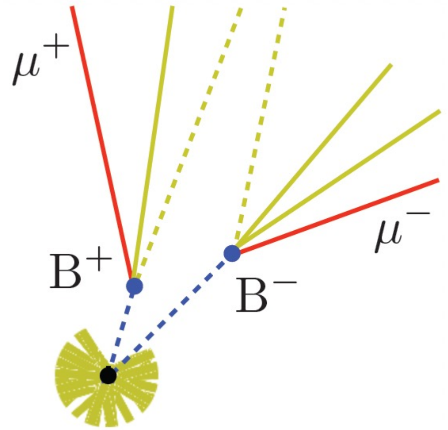
Backup

CMS: $B_{(s)} \longrightarrow \mu^+\mu^-$ selections

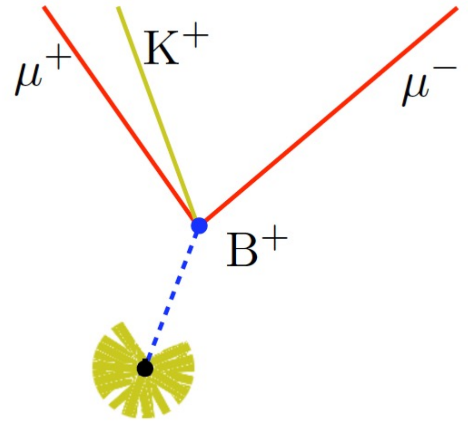
Selection	$B_s^0 \to \mu^+\mu^-$	$B^+ \to J/\psi K^+$	$B_s^0 \to J/\psi\phi$
B candidate mass [GeV]	[4.90,5.90]	[4.90,5.90]	[4.90,5.90]
Blinding window [GeV]	[5.15,5.50]		
$p_{T\mu}$ [GeV]	> 4	> 4	> 4
$\lvert\eta_\mu\rvert$	< 1.4	< 1.4	< 1.4
3D SV displacement significance	> 6	> 4	> 4
$p_{T\mu\mu}$ [GeV]	> 5	> 7	> 7
$\mu\mu$ SV probability	> 0.025	> 0.1	> 0.1
J/ψ candidate mass [GeV]		[2.9,3.3]	[2.9,3.3]
Kaon p_T [GeV]		> 1	> 1
Mass-constrained fit probability		> 0.025	> 0.025
2D $\mu\mu$ pointing angle [rad]		< 0.4	< 0.4
ϕ candidate mass [GeV]			[1.01, 1.03]

CMS: $B_{(s)} \longrightarrow \mu^+\mu^-$ background contamination

- combinatorial background (two muons from two different heavy quarks

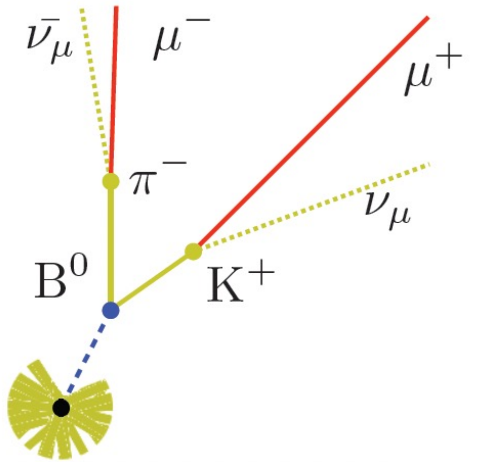


- the partially reconstructed semileptonic decays (both muons from the same B meson

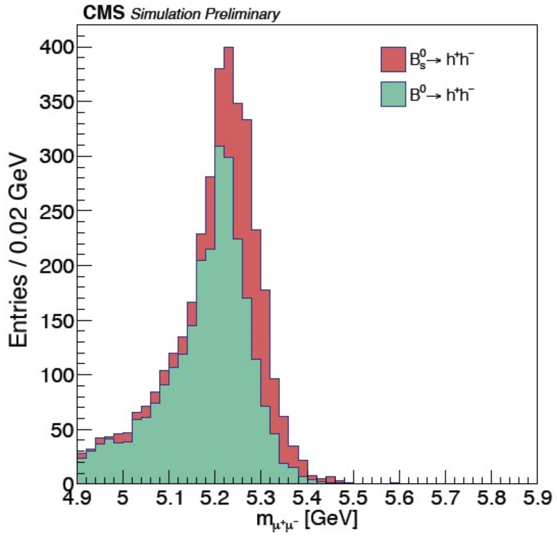


MVA to suppress dominant backgrounds

- the peaking background from misidentification ($B^0 \longrightarrow K^+\pi^-$, $B_s^0 \longrightarrow K^+K^-$)



- mostly decays in flight $\mathrm{K}/\pi \longrightarrow \mu\nu_\mu$
- fake rates measured in $K_s \longrightarrow \pi\pi$ and $\phi \longrightarrow KK$ control samples
- used MVA-based muon identification



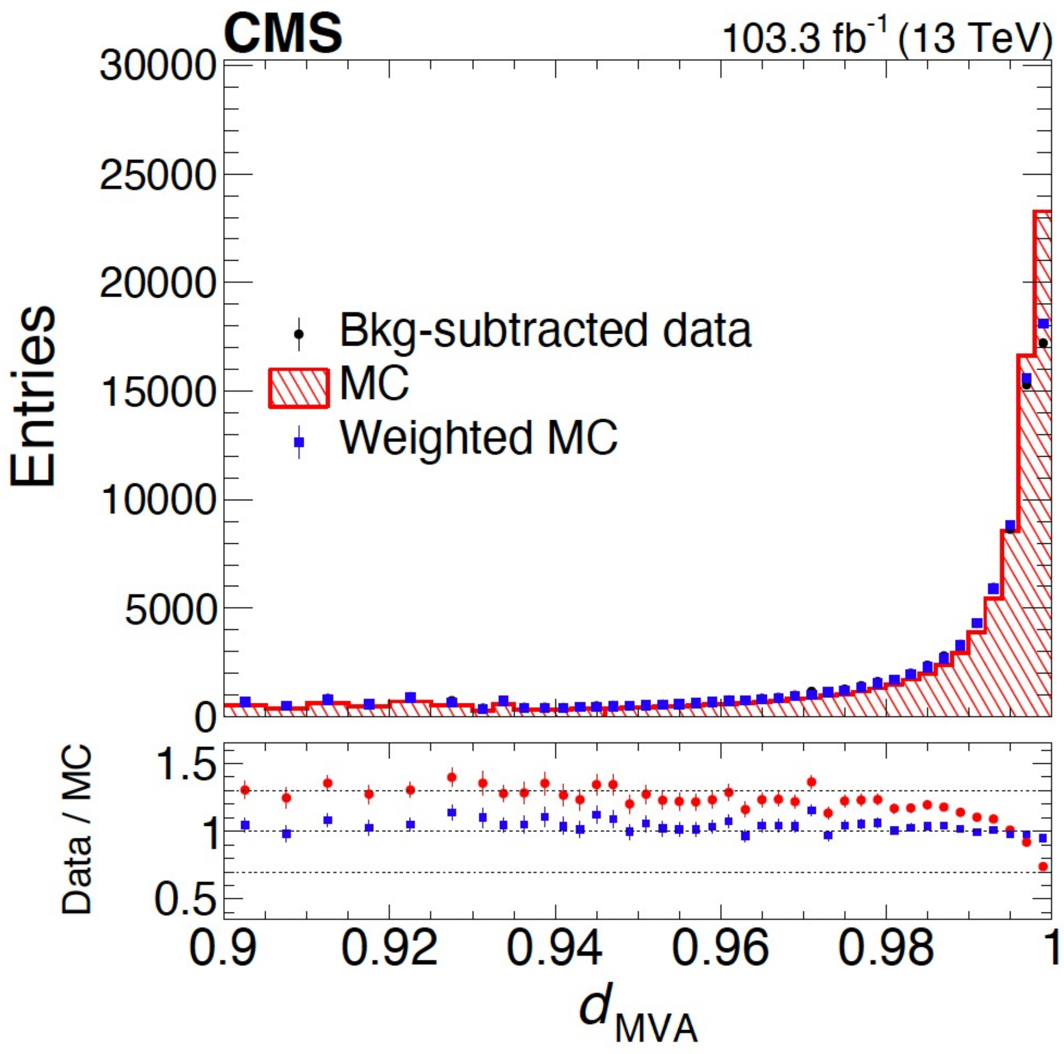
CMS: $B_{(s)} \longrightarrow \mu^+\mu^-$: multivariate analysis

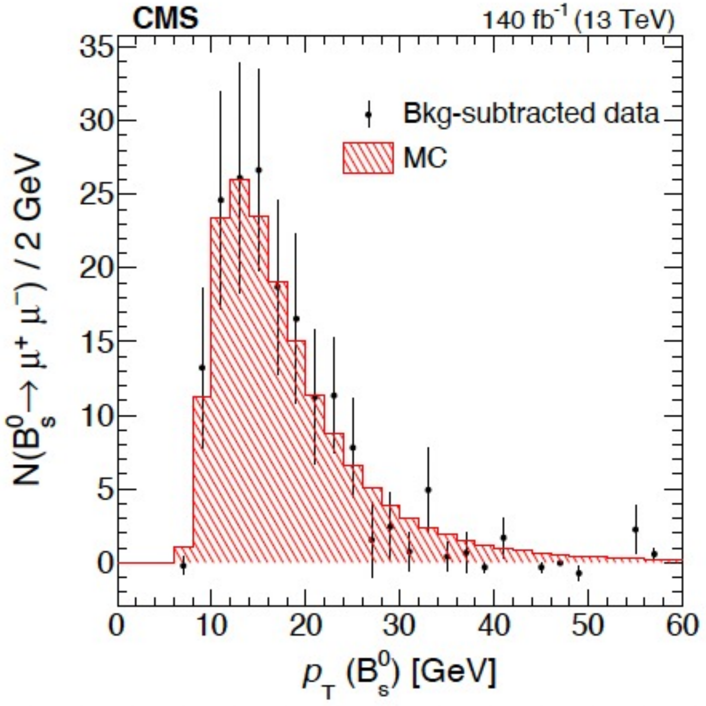
- exploit several weak discrimination variables with a BDT (XGBoost)

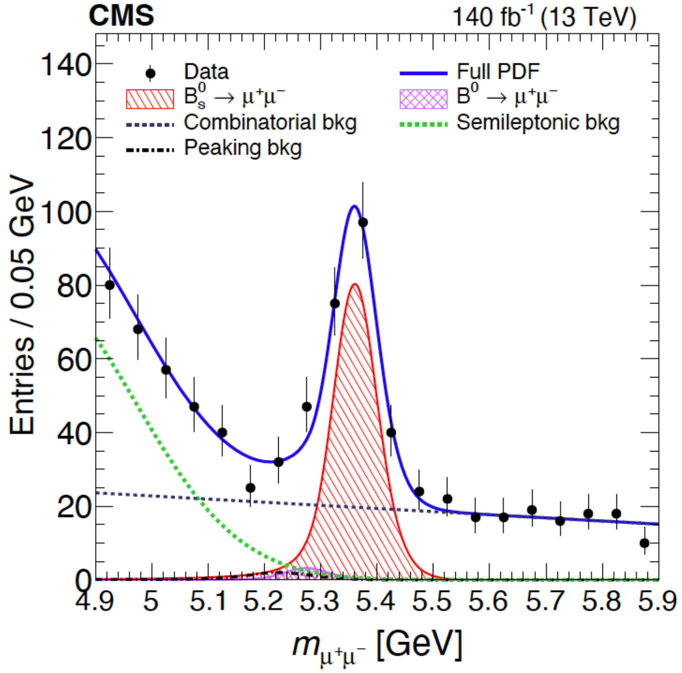
- features:
  - **pointing angles** (2D and 3D)
    → all non-two-body backgrounds
  - **SV** (quality and displacement)
    → combinatorial
  - **isolation** (sum of p_T surrounding the signal)
    → semi-leptonic decays

- training: MC signal sample, data from mass sidebands

- BDT score validated on $B^+ \longrightarrow J/\psi\, K^+$







CMS: BR systematics and fit

Effect	$B_s^0 \to \mu^+\mu^-$	$B^0 \to \mu^+\mu^-$
f_s/f_u ratio of the B meson production fractions	3.5%	–
d_{MVA} correction	2–3%	
Tracking efficiency (per kaon)	2.3%	
Trigger efficiency	2.4–3.7%	
Fit bias	2.2%	4.5%
Pileup	1%	
Vertex quality requirement	1%	
$B^+ \to J/\psi K^+$ shape uncertainty	1%	
$B^+ \to J/\psi K^+$ branching fraction	1.9%	

External inputs in the BF measurement:

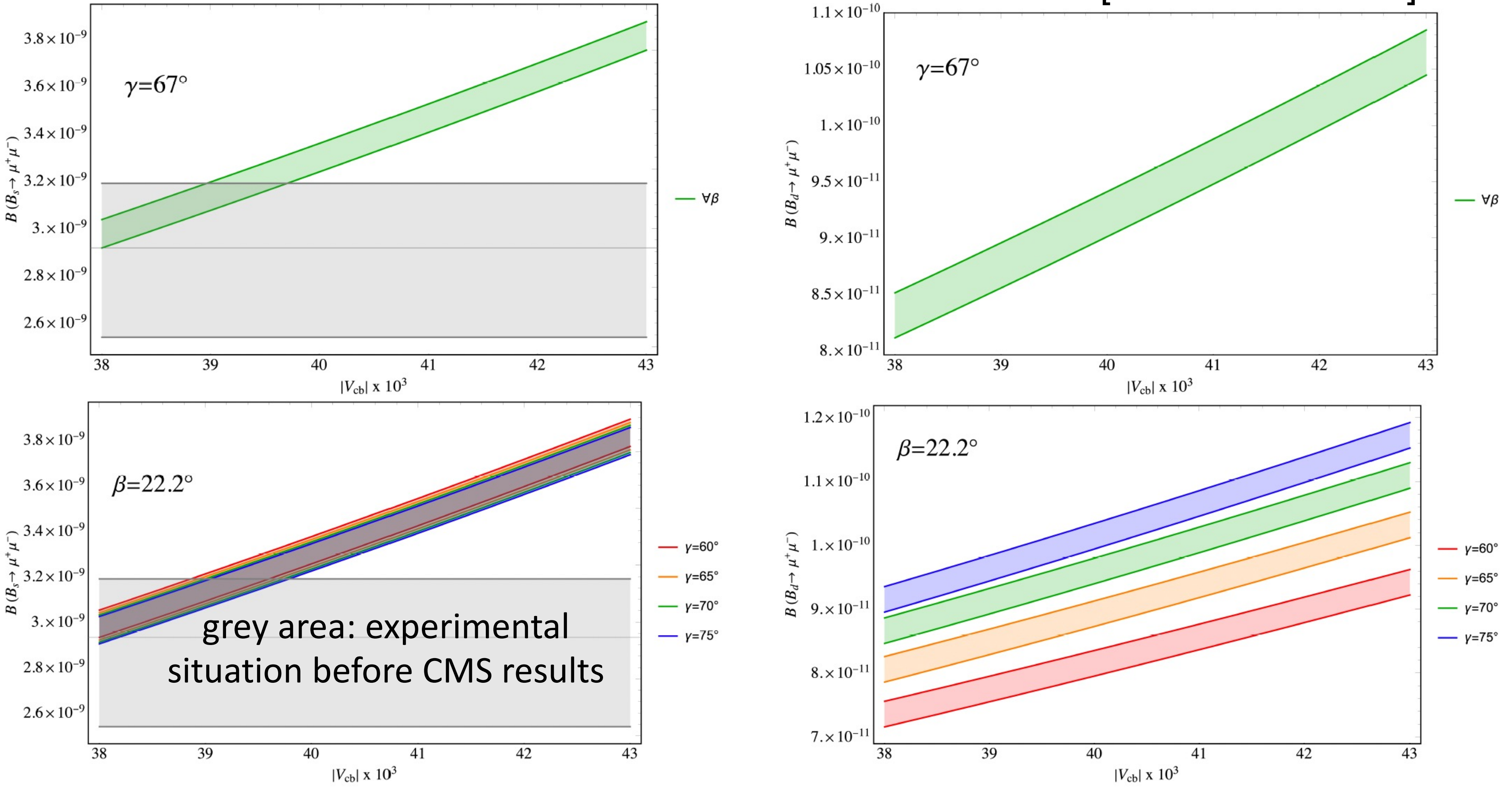
- $\mathcal{B}(B^+ \to J/\psi K^+) = (1.020 \pm 0.019) \times 10^{-3}$,
- $\mathcal{B}(J/\psi \to \mu^+\mu^-) = (5.961 \pm 0.033) \times 10^{-2}$,
- $f_s/f_u = 0.231 \pm 0.008.$

from LHCb: PRD 104 (2021) 032005

fs/fu measured by CMS is in agreement: Phys. Rev. Lett. 131, 121901

Results interpretation: $B_{(s)} \rightarrow \mu\mu$ dependency on CKM and UT

[arXiv:2109.11032]



Results interpretation: correlations btw B and K sectots

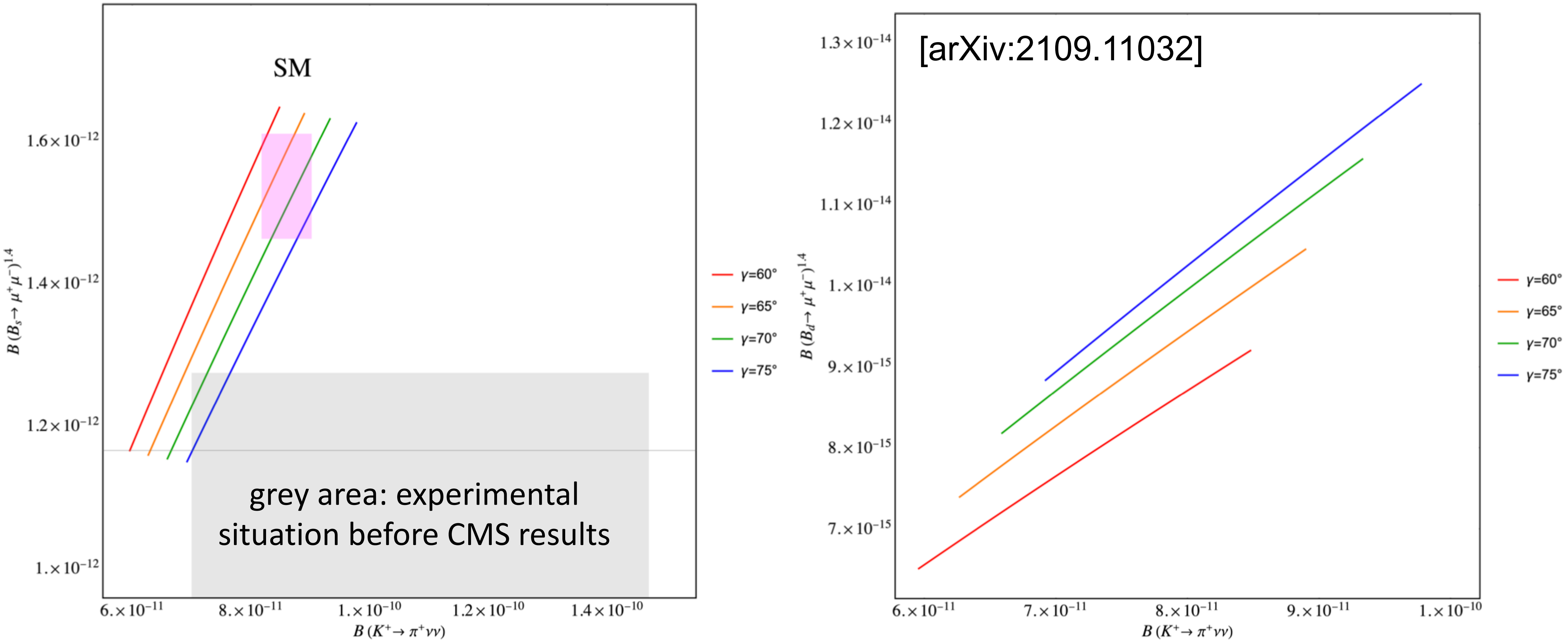
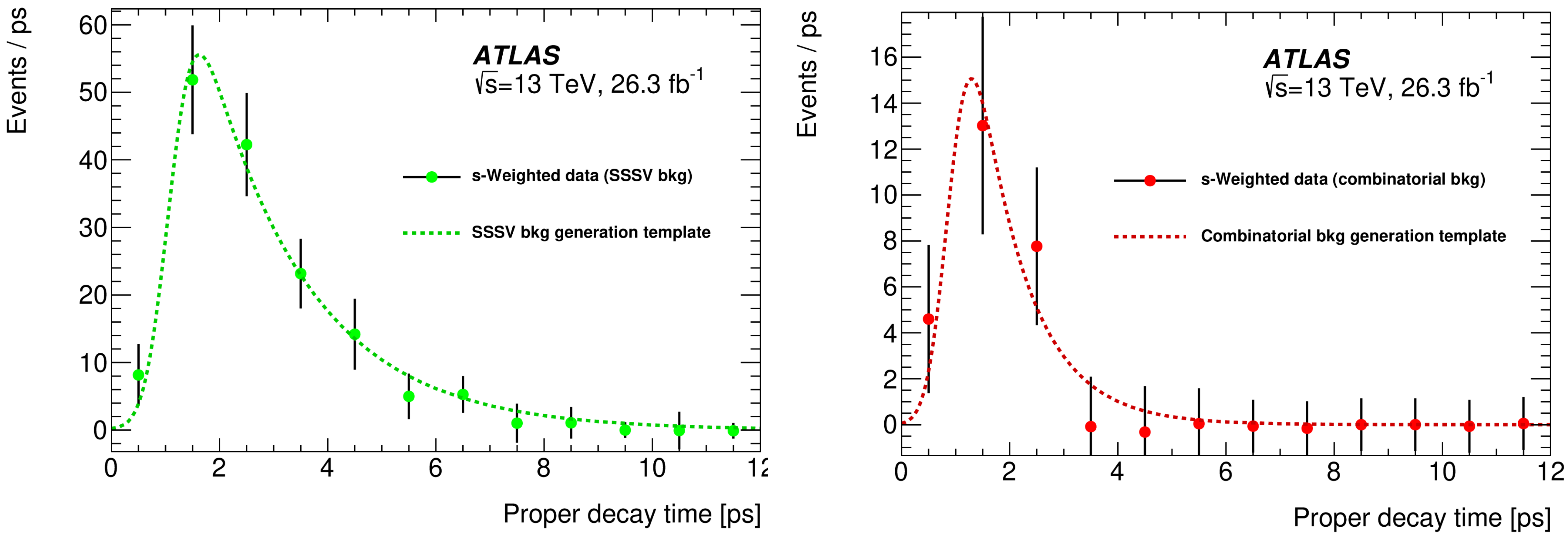


Figure 7: *The correlations of* $\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$ *with* $\overline{\mathcal{B}}(B_s \to \mu^+\mu^-)^{1.4}$ *(left panel) and with* $\mathcal{B}(B_d \to \mu^+\mu^-)^{1.4}$ *(right panel) as given in (40) and (43), for different values of* γ *within the SM. The ranges of branching ratios correspond to* $38 \leq |V_{cb}| \times 10^3 \leq 43$ *and* $20° \leq \beta \leq 24°$. *The gray area represents the present experimental situation.*

ATLAS: $B_s^0 \longrightarrow \mu^+\mu^-$ lifetime

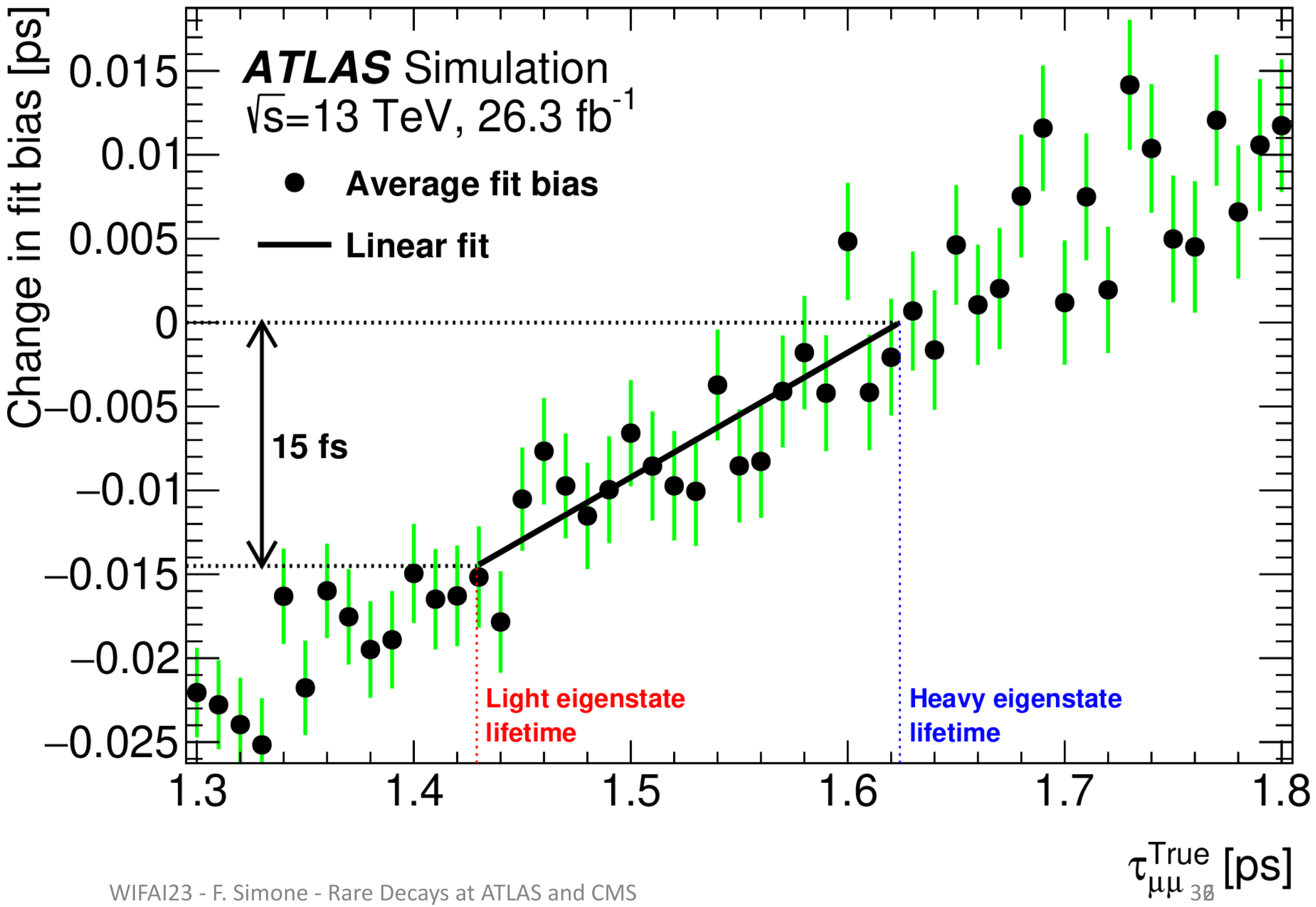


Comparison between data (dots) and the MC pseudo-experiment proper decay time templates (dotted line) for the SSSV (a) and Combinatorial (b) backgrounds. The data distributions are extracted using the sPlot technique.

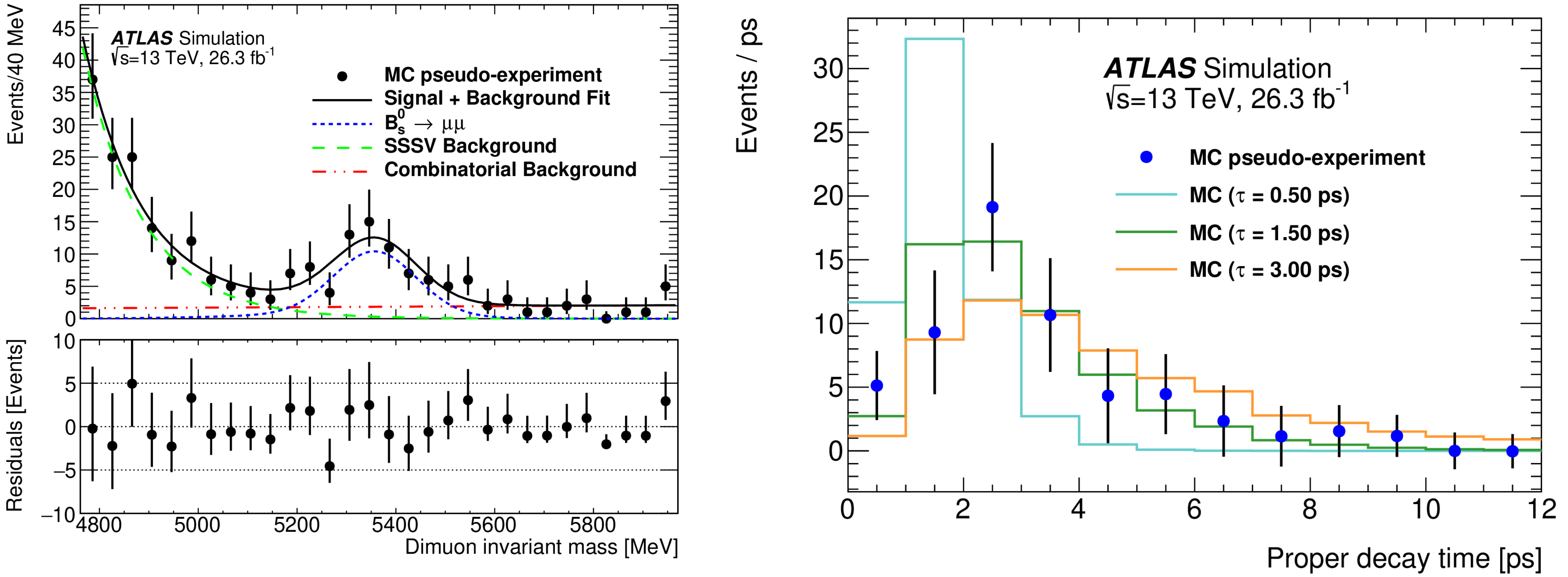
ATLAS: $B_s^0 \longrightarrow \mu^+\mu^-$ lifetime

Variation of the lifetime fit bias as a function of the lifetime used in the generation of the MC pseudo-experiments.

The linear fit is performed in the interval between the lifetime of the light (red) and heavy (blue) B_s^0 mass eigenstates.



ATLAS: $B_s^0 \longrightarrow \mu^+\mu^-$ lifetime



Example of random MC pseudo-experiment sample lifetime extraction. (a) Invariant mass fit (top panel) and residuals (bottom panel). (b) sPlot extraction of the signal proper decay time distribution (blue dots). This specific MC pseudo-experiment sample is generated with $\tau_{\mu\mu}^{True}$ = 1.47 ps. Three proper decay time MC templates are superimposed on the right histogram, corresponding to $\tau_{\mu\mu}$= 0.5 ps (cyan), 1.5 ps (green) and 3 ps (orange).

ATLAS: $B_s^0 \longrightarrow \mu^+\mu^-$ lifetime

Uncertainty source	$\Delta\tau_{\mu\mu}^{\mathbf{Obs}}$ [fs]
Data - MC discrepancies	134
SSSV lifetime model	60
Combinatorial lifetime model	56
B kinematic reweighting	55
B isolation reweighting	32
SSSV mass model	22
B_d background	16
Fit bias lifetime dependency and B_s^0 eigenstates admixture	15
Combinatorial mass model	14
Pileup reweighting	13
B_c background	10
Muon Δ_η correction	6
$B \rightarrow hh'$ background	3
Muon reconstruction SF reweighting	2
Semileptonic background	2
Trigger reweighting	1
Total	174

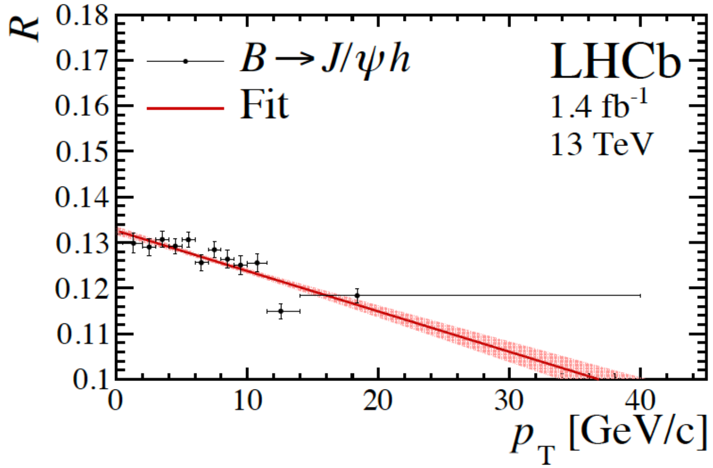
fs/fd ratio, LHCb measurement

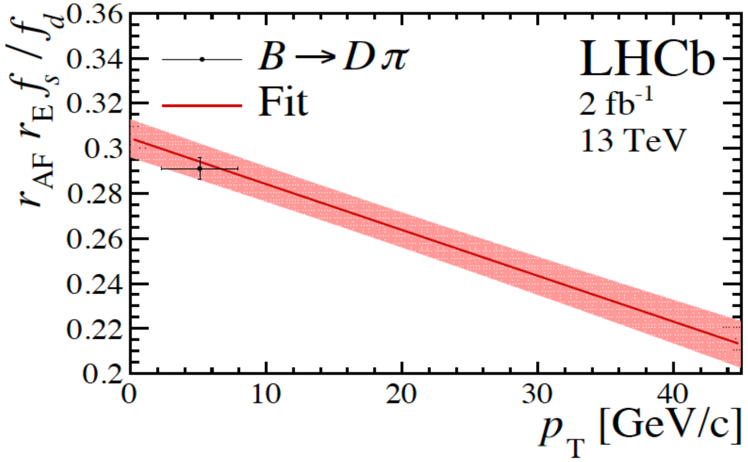
B^0 and B_S^0 production cross section ratio (fragmentation fraction) extrapolated from LHCb result [Phys. Rev. D 104, 032005 (2021)]

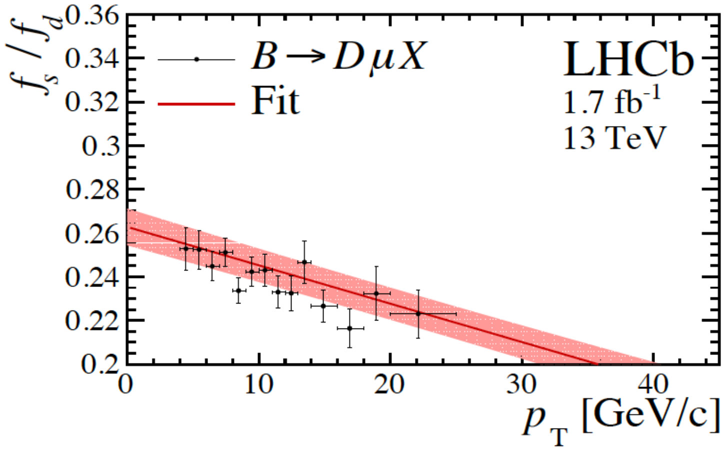
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \mathcal{B}(B^+ \to J/\psi K^+) \frac{N_{B_s^0 \to \mu^+\mu^-}}{N_{B^+ \to J/\psi K^+}} \frac{\varepsilon_{B^+ \to J/\psi K^+}}{\varepsilon_{B_s^0 \to \mu^+\mu^-}} \boxed{\frac{f_u}{f_s}},$$

fs/fd is the ratio of the B_S^0 and B^0 production cross sections.
LHCb has shown several times that this ratio depends on the B meson pT, the most recent measurement combines several previous results. Some channels allow direct extraction of fs/fd but are limited by statistics, other channels have branching fractions tied to fs/fd but allow to estimate pT and η dependence of fs/fd.
All the information was combined in simultaneous global fit:

$$\boxed{f_s/f_d \quad (p_T, 13\,\text{TeV}) \quad = (0.263 \pm 0.008) + ((-17.6 \pm 2.1) \times 10^{-4}) \cdot p_T \ ,}$$

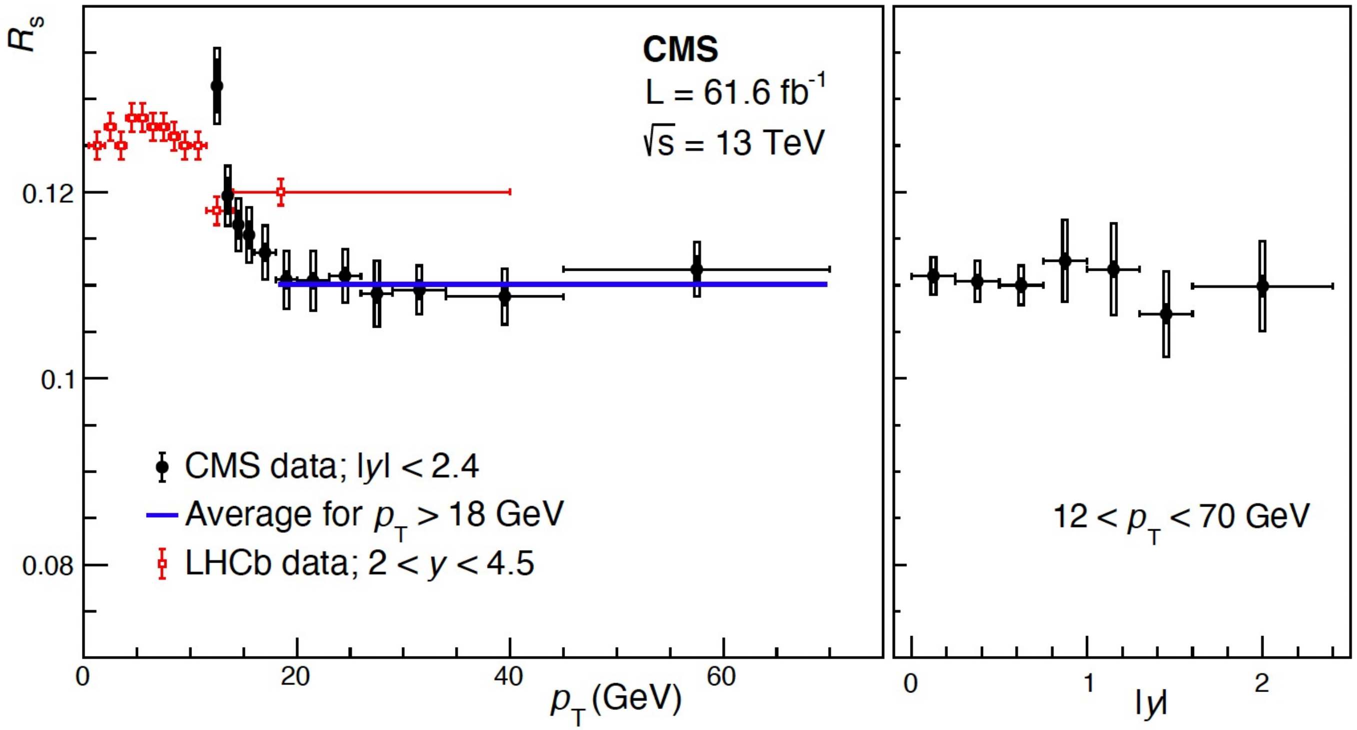




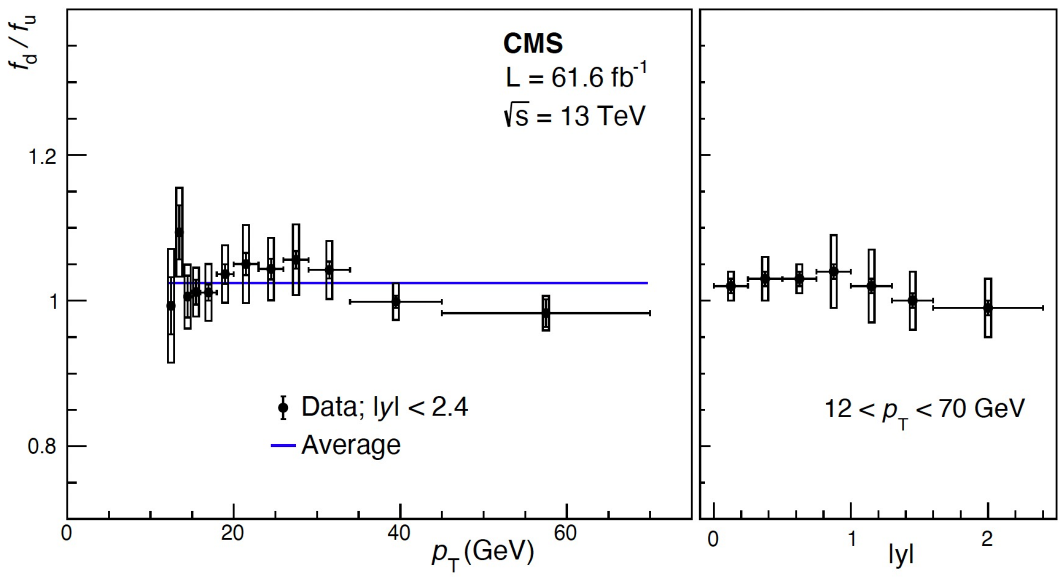


fs/fd ratio, CMS measurement

$$\mathcal{R}_s = f_s / f_u \frac{\mathcal{B}(B_s^0 \to J/\psi\, \phi)\mathcal{B}(\phi \to K^+K^-)}{\mathcal{B}(B^+ \to J/\psi\, K^+)}$$



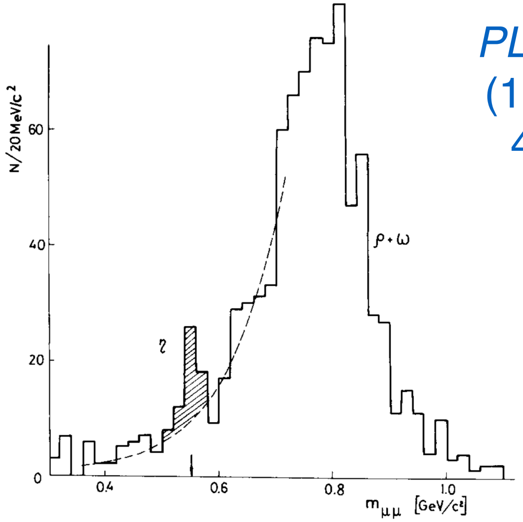
$$\mathcal{R}_d = \frac{N_{B^0}}{\epsilon_{B^0}} \Big/ \frac{N_{B^+}}{\epsilon_{B^+}} = f_d / f_u \frac{\mathcal{B}(B^0 \to J/\psi\, K^{*0})\mathcal{B}(K^{*0} \to \pi^- K^+)}{\mathcal{B}(B^+ \to J/\psi\, K^+)}.$$



Phys. Rev. Lett. 131 (2023) 121901

η leptonic decays: state of the art

SEPR $\eta \to 2\mu$ observation (1980)
$\sim 2\times10^7$ η's produced

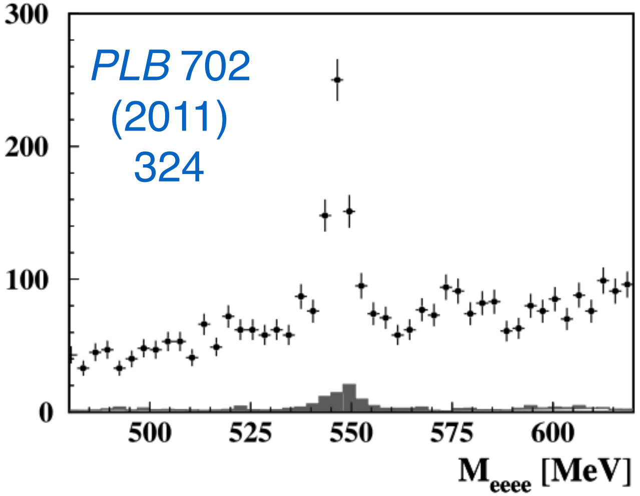


PLB 97 (1980) 471

Charged modes PDG 2022

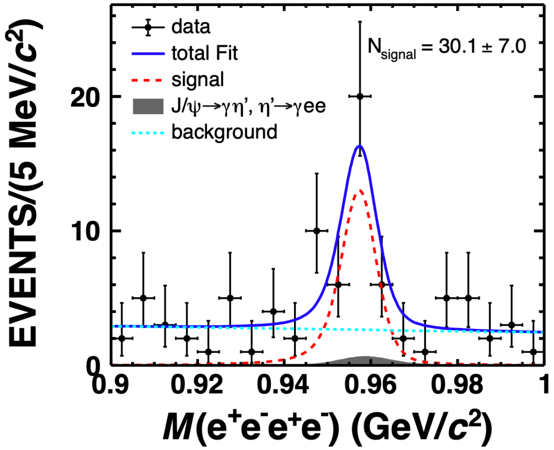
Γ_8	charged modes		(27.89 ± 0.29) %	S=1.2
Γ_9	$\pi^+\pi^-\pi^0$		(22.92 ± 0.28) %	S=1.2
Γ_{10}	$\pi^+\pi^-\gamma$		$(\ 4.22\pm0.08)$ %	S=1.1
Γ_{11}	$e^+e^-\gamma$		$(\ 6.9\ \pm0.4\ )\times10^{-3}$	S=1.3
Γ_{12}	$\mu^+\mu^-\gamma$		$(\ 3.1\ \pm0.4\ )\times10^{-4}$	
Γ_{13}	e^+e^-	$<$	7×10^{-7}	CL=90%
Γ_{14}	$\mu^+\mu^-$		$(\ 5.8\ \pm0.8\ )\times10^{-6}$	
Γ_{15}	$2e^+2e^-$		$(\ 2.40\pm0.22)\times10^{-5}$	
Γ_{16}	$\pi^+\pi^-e^+e^-(\gamma)$		$(\ 2.68\pm0.11)\times10^{-4}$	
Γ_{17}	$e^+e^-\mu^+\mu^-$	$<$	1.6×10^{-4}	CL=90%
Γ_{18}	$2\mu^+2\mu^-$	$<$	3.6×10^{-4}	CL=90%

$\eta \to 4e$ (KLOE 2011, BESIII 2022)
$\sim 5\times10^7$ η's produced



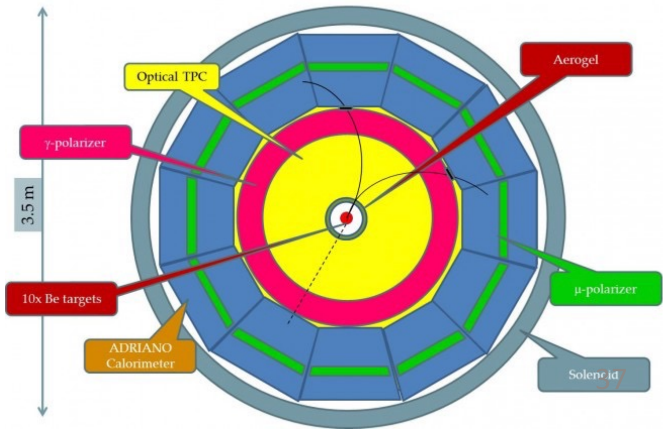
PLB 702 (2011) 324

Phys.Rev.D 105 (2022) 11



proposed experiment
2022 Snowmass Summer Study

REDTOP at Fermilab
Rare Eta Decays To Observe new Physics
$\sim 10^{13}$ η's/year



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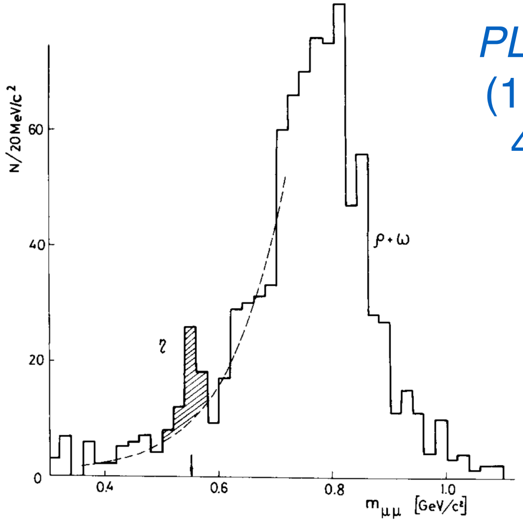

PLB 97 (1980) 471

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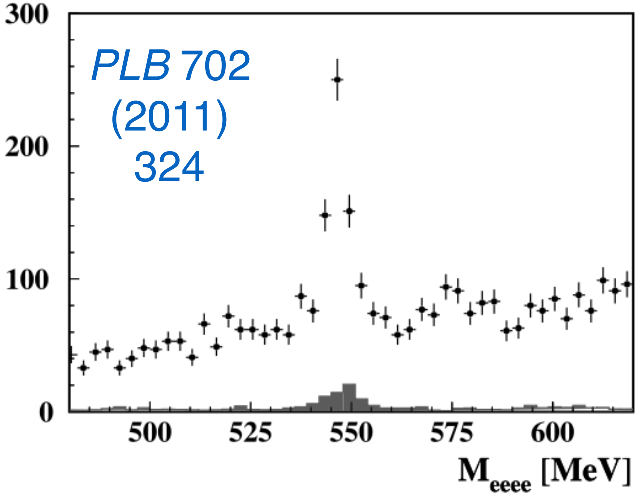
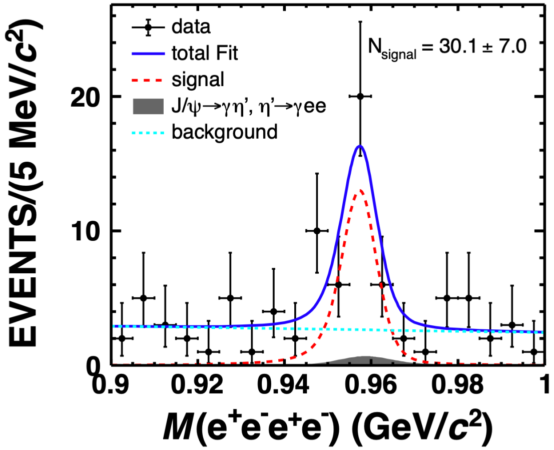
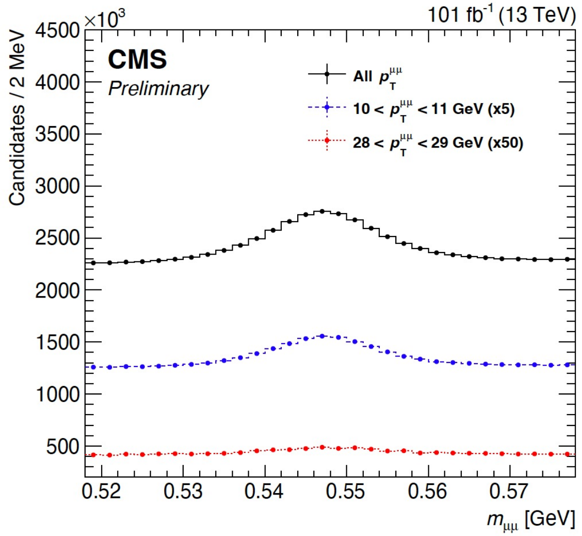


Phys.Rev.D 105 (2022) 11



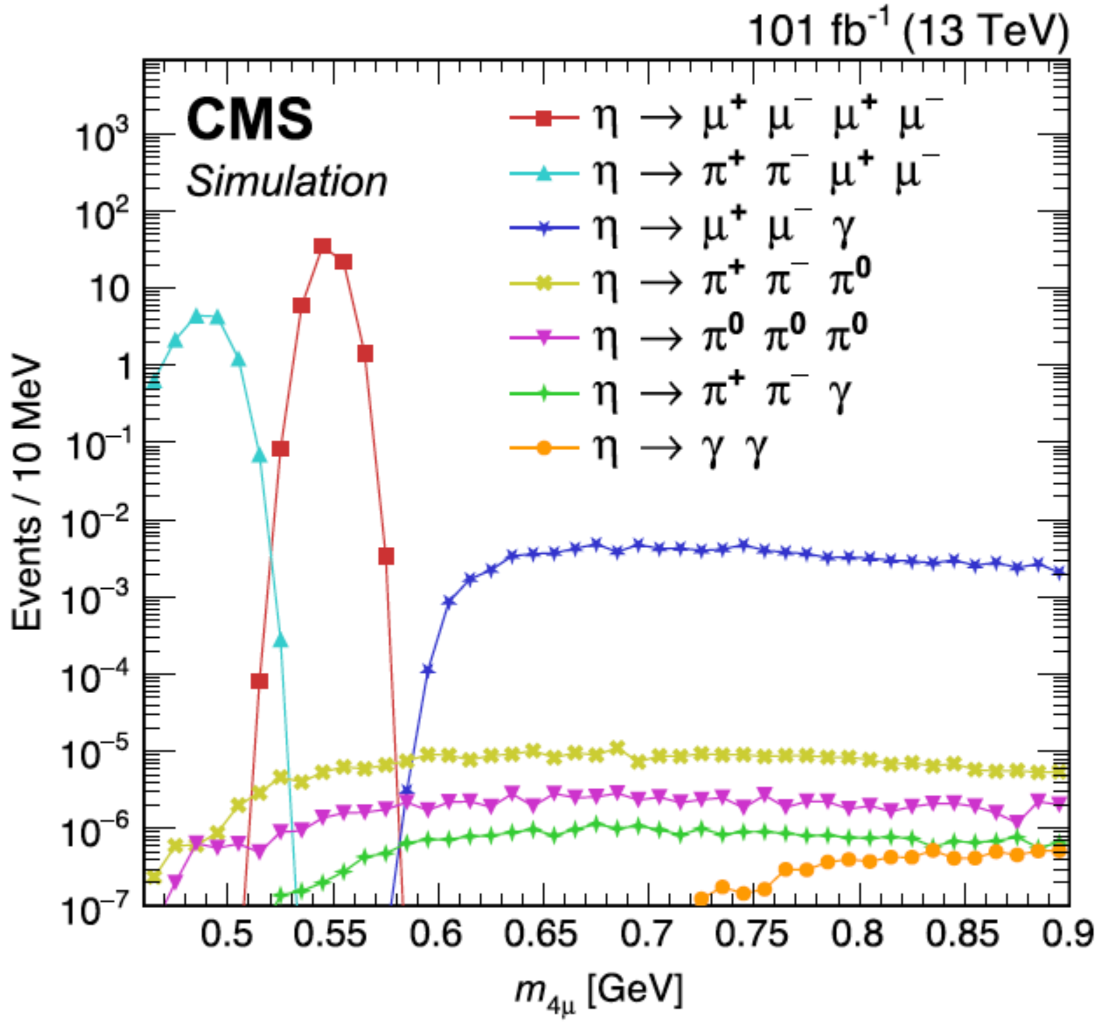
CMS: 4.5 M $\eta \to 2\mu$ events / 101 fb^{-1}
$\sim 10^{12}$ η's recorded!



$\eta \longrightarrow 4\mu$: background studies

Cross check performed to check for possibility of rare η decay backgrounds using simulated samples

- η→μ+μ- γ with γ conversion in material non-peaking and shifted to higher m(4μ)
- η→π+π-μ+μ- with π→μ fake shifted to lower mass due to wrong mass hypothesis
  - Rate shown is for current experimental limit
    - B(η→π+π-μ+μ-)<1.6x10-4
    - SM Prediction 6.5x10-9



No possibility of significant peaking background component

$\eta \longrightarrow 4\mu$: uncertainties

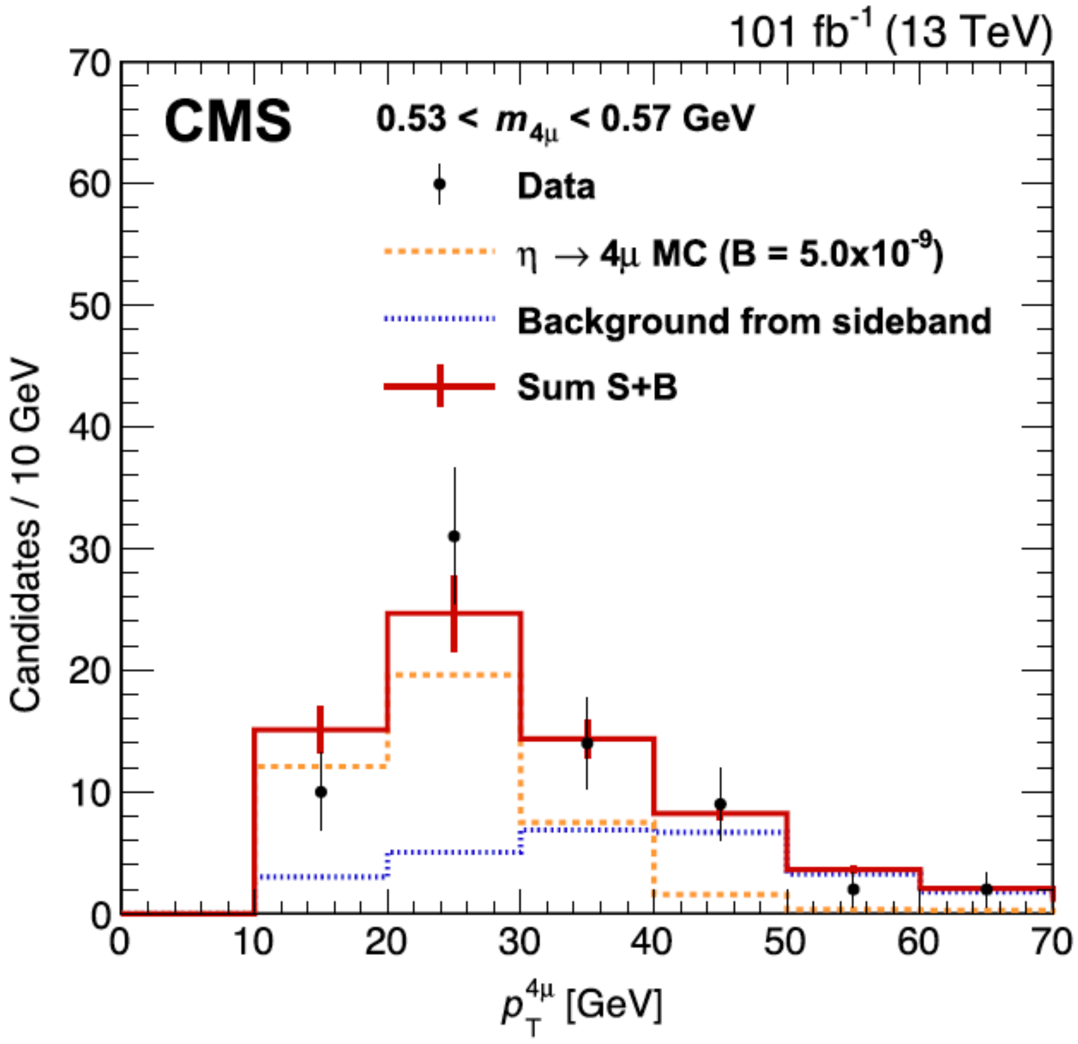
η→4μ differential event rate as a function of pT in excellent agreement with the simulation

Residual uncertainty due to the imperfect knowledge of Axε for η→2μ and η→4μ

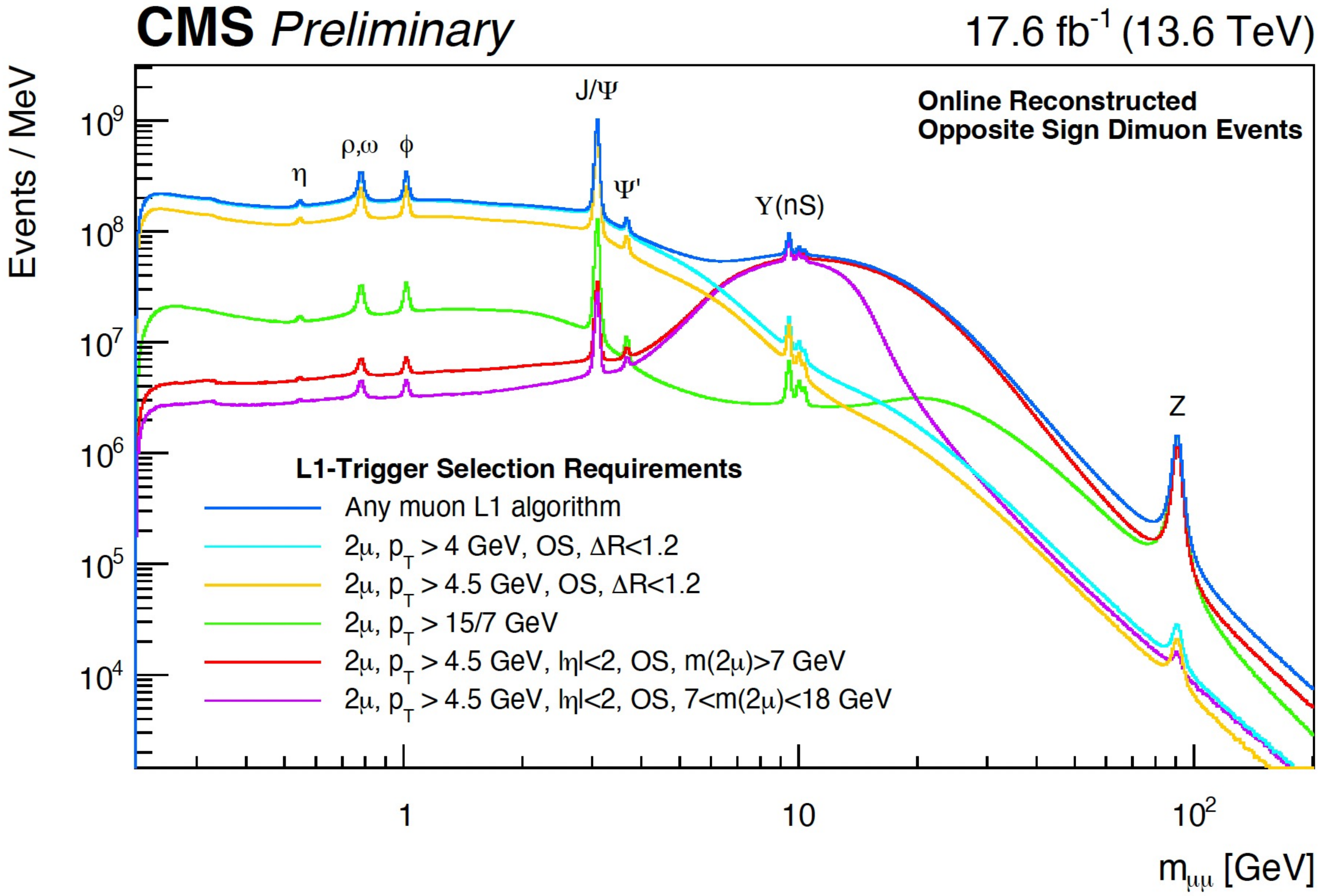
- Accounts for threshold effects determined η→2μ efficiency differences between data and MC (in total ~13%)

Uncertainty in normalization mode branching ratio (~14%)

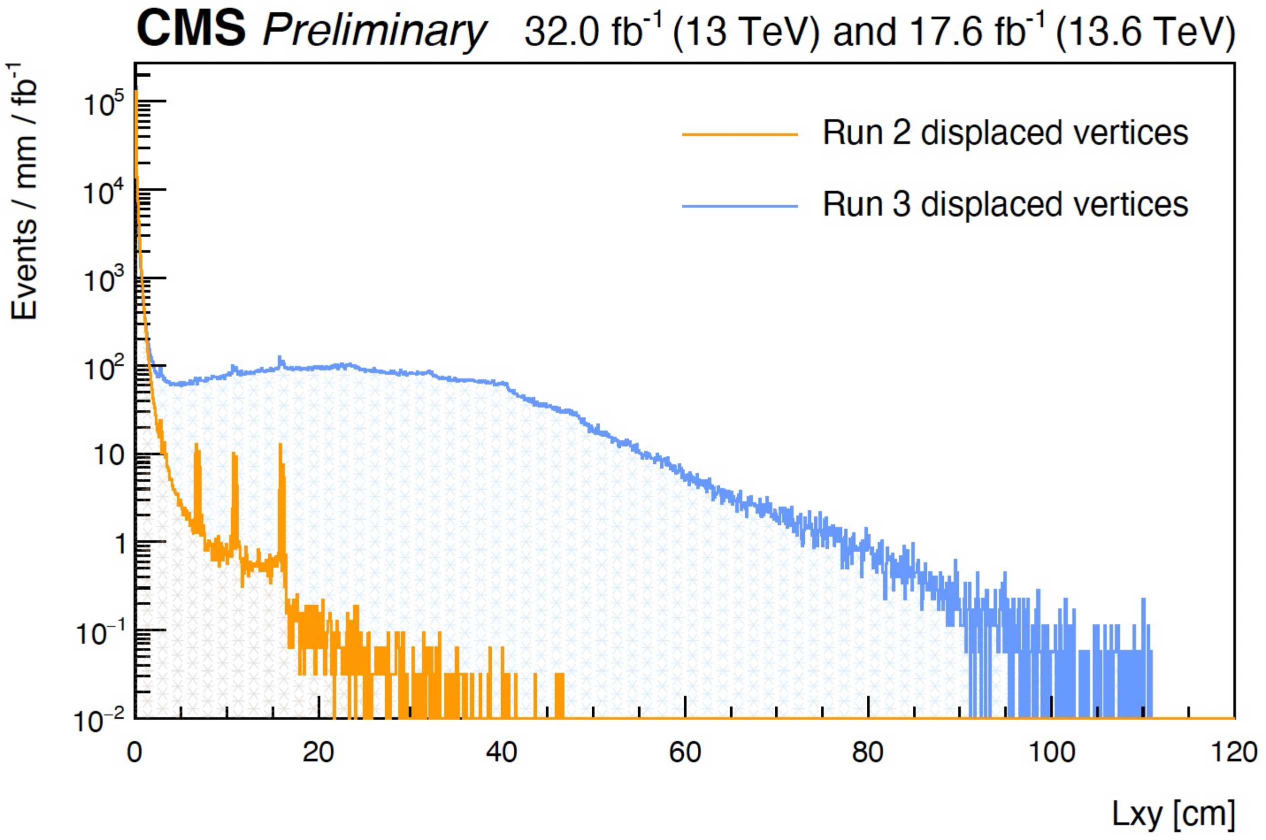
$$\mathcal{B}(\eta \to 2\mu) = (5.8 \pm 0.8) \times 10^{-6}$$

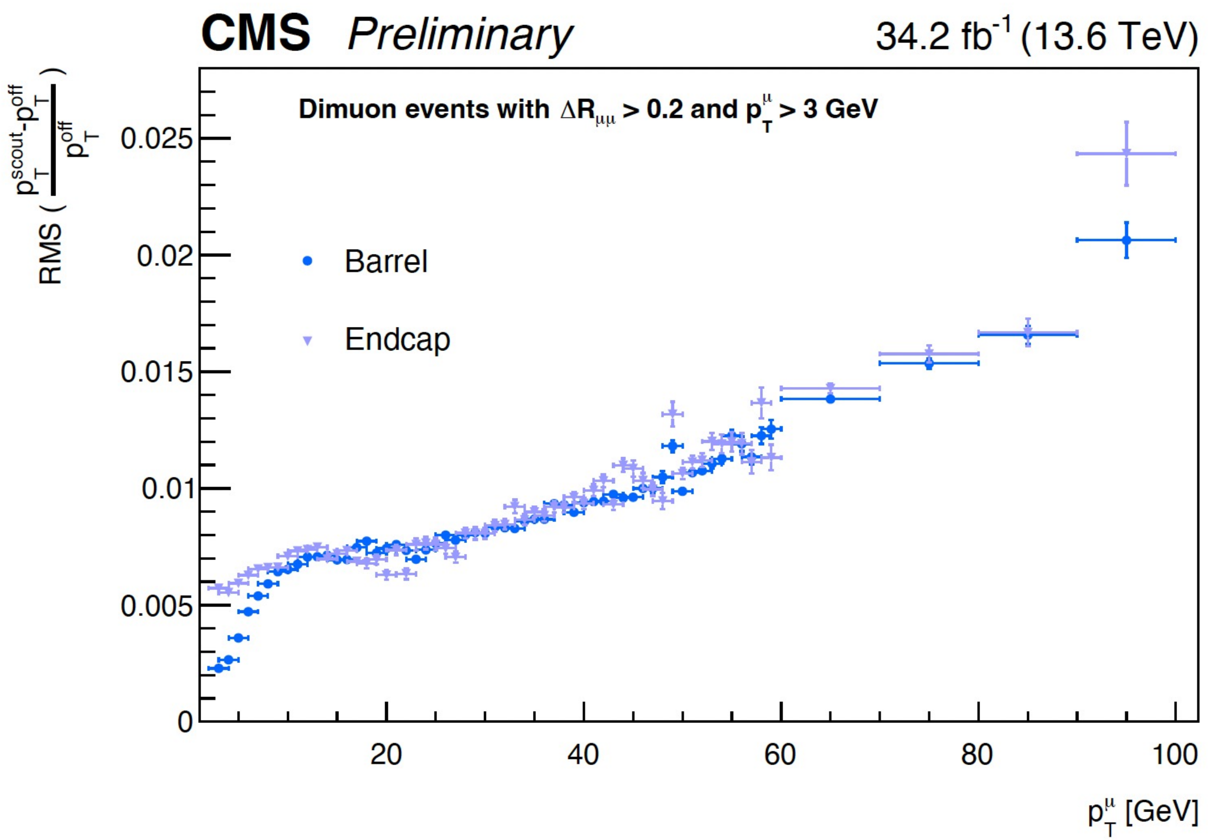


Dimuon triggers in Run3

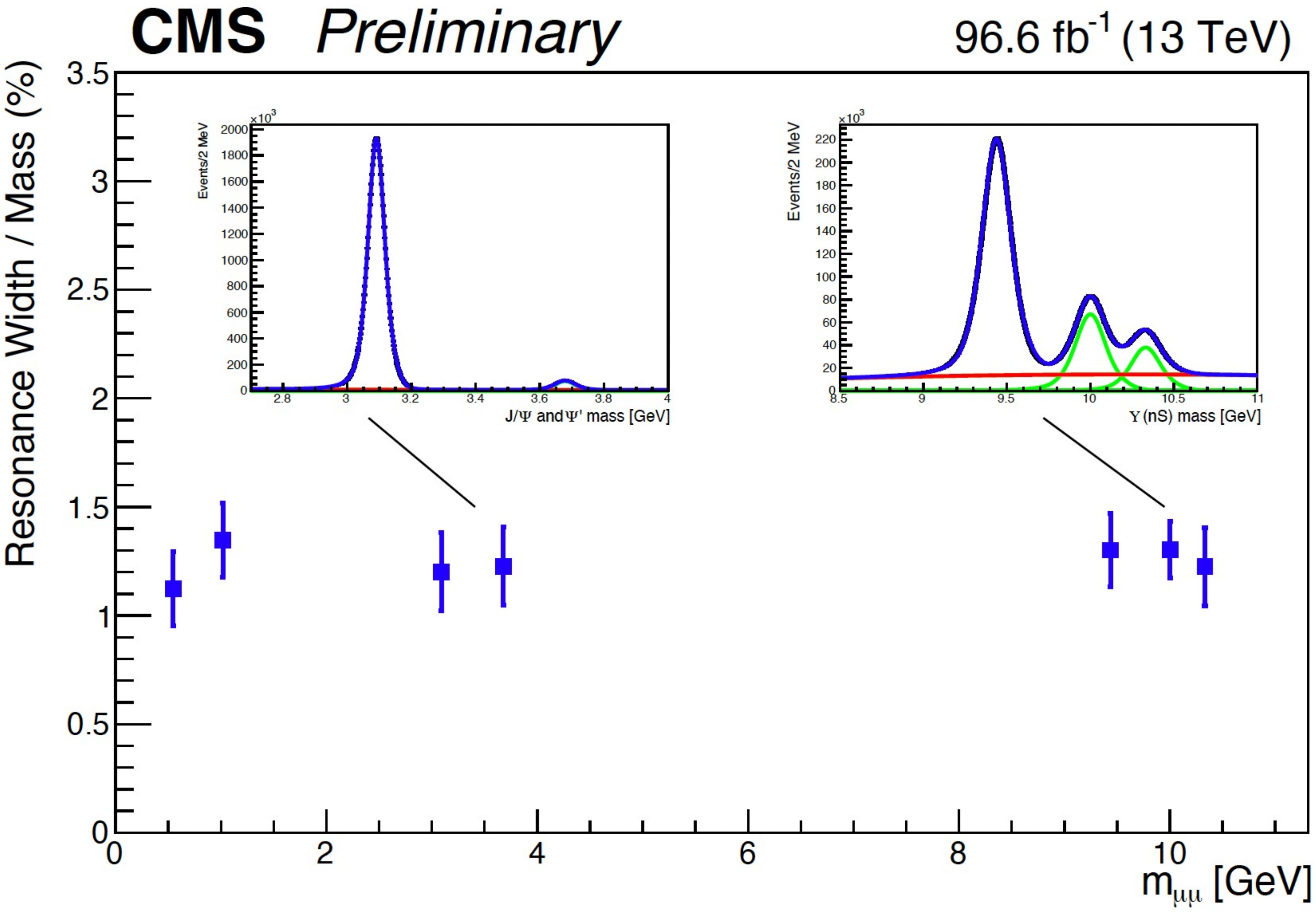


Dimuon scounting in Run3

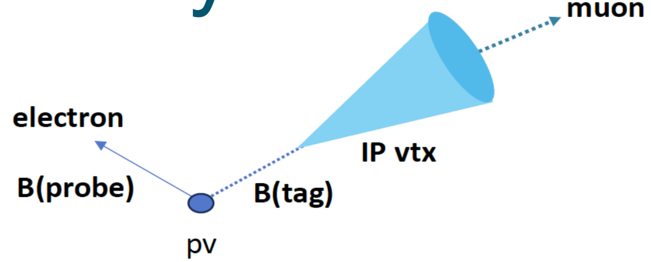




Dimuon scounting performance in Run2



R(K): test of LFU in $B^{\pm} \to K^{\pm}\ell^{+}\ell^{-}$ decays

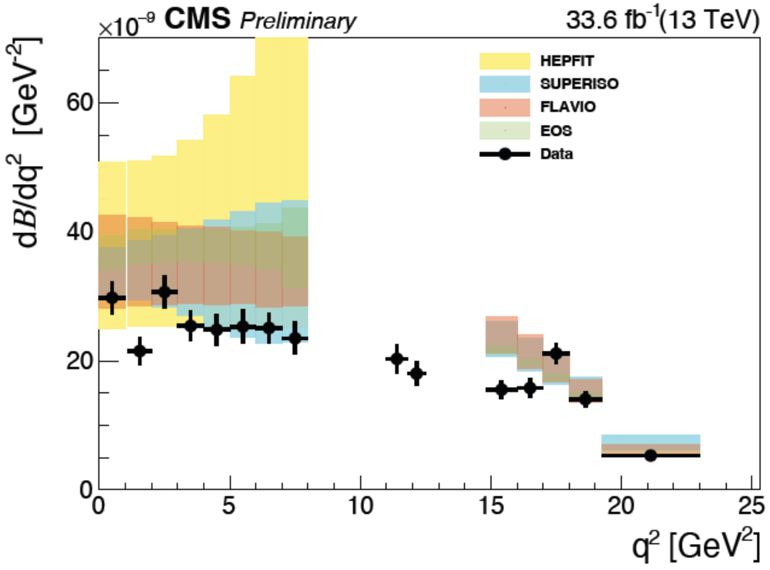


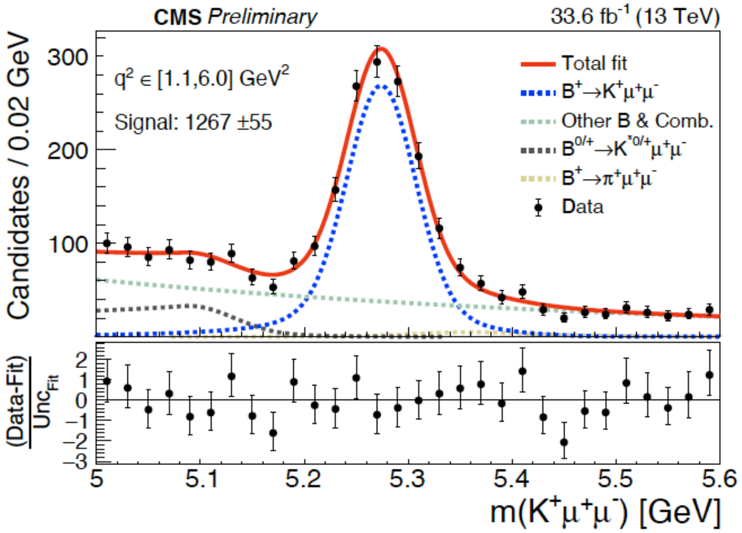
- **First R(K) measurement by CMS** presented at EPS-HEP2023
- Uses **B-parking** data collected in 2018

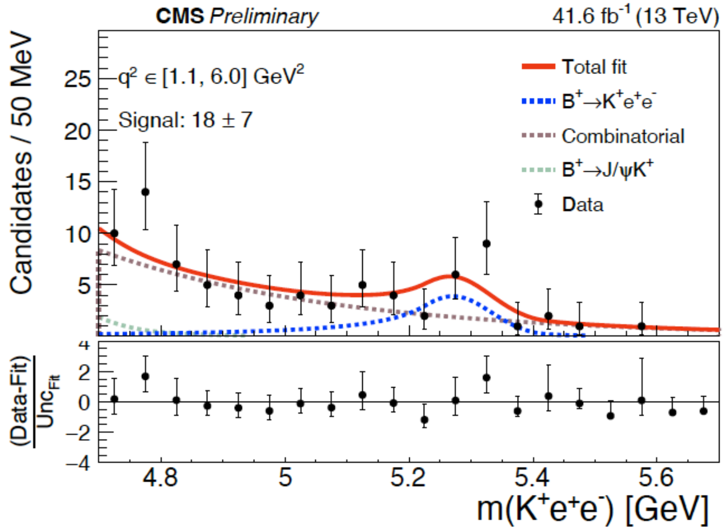
Results:

- **Differential measurement of $BR(B^{\pm} \to K^{\pm}\mu^{+}\mu^{-})$** in a wide q^2 range
- Measurement in the low-q^2 bin in agreement with the world-average, with **unc. reduced by 40%**
- **R(K)** in $q^2 \in [1.1; 6.0]$ GeV^2 $= 0.78^{+0.46}_{-0.23}\,(stat)^{+0.09}_{-0.05}(syst)$

$$R(K)(q^2) = \frac{\mathcal{B}(B^+ \to K^+\mu^+\mu^-)(q^2)}{\mathcal{B}(B^+ \to J/\psi(\mu^+\mu^-)K^+)} \Big/ \frac{\mathcal{B}(B^+ \to K^+e^+e^-)(q^2)}{\mathcal{B}(B^+ \to J/\psi(e^+e^-)K^+)}$$







BPH-22-005

R(J/Psi): LFU test in semileptonic decays $B_c^{\pm} \to J/\psi \ell^{+} \nu$

BPH-22-012

- **First R(J/Psi) measurement at CMS** using 2018 data (B-Parking dataset)
- Leptonic decay $\tau^{+} \to \mu^{+} \nu_{\mu} \bar{\nu}_{\tau}$, 3μ trigger designed for the $J/\psi + \mu$ final state
- R(J/Psi) extracted from sim. max. likelihood fit of q^2 and $L_{xy}/\sigma_{L_{xy}}$
- Results in agreement with SM (0.3 σ) and LHCb (1.3 σ), limited by **statistics** and **theoretical uncertainties** related to the Bc form factors

$$R(J/\psi) = \frac{\mathcal{B}(B_c^{+} \to J/\psi\, \tau^{+} \nu_{\tau})}{\mathcal{B}(B_c^{+} \to J/\psi\, \mu^{+} \nu_{\mu})} = 0.17^{+0.18}_{-0.17}\,(\text{stat.})^{+0.21}_{-0.22}\,(\text{syst.})^{+0.19}_{-0.18}\,(\text{theo.}) = 0.17 \pm 0.33,$$