March 9, 2022
https://muoncollider.web.cern.ch

Muon Collider Physics Summary

Submitted to the Proceedings of the US Community Study
on the Future of Particle Physics (Snowmass 2021)

Authors:
N. Surname[1], *A. Wulzer (corresponding author)*[1]

Signatories:
N. Surname[1]

Thanks to Fabio, Federico, Dario and Rodolfo for writing part of the text.

Thanks to Nathaniel, Maurizio, Lian Tao, Roberto, and those I forgot, for sending me feedback.

Looking forward to more feedback!

Goals:

Be reference document for MuC community:

➡ Concise, and accessible to broad community

➡ To be accompanied by ACC counterpart

Declare physics scope of IMCC:

➡ Desirable to post it on IMCC webpage

Contribute to Snowmass:

➡ Help MuC Forum report writeup

Content:

Mainly 10+TeV:

➡ That is the final aim

But, key findings at 3TeV should appear

Not a shopping list:

➡ Explain basic concepts encourages reading

Status:

Draft complete:

- ➡ Pdf available on indico page for signatures
- ➡ The page should be accessible now. The pdf of some of the reports are being updated now. You will receive an announcement when done
- ➡ You can subscribe already now (barring technical issues …)

Signatures:

Open for signatures:

- ➡ **Author** means that you did contribute to the results documented in the report in any form, including e.g. by participating to the discussions of the community meeting, sending comments on the drafts, etc, or that you plan to contribute to the future work.
- ➡ **Signatory** means that you express support to the Collaboration effort and endorse the Collaboration plans
- ➡ **Same policy applies to all IMCC papers**

International MUON Collider Collaboration

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The physics case of a 3 TeV muon collider stage

(Preliminary Draft)

Submitted to the Proceedings of the US Community Study
on the Future of Particle Physics (Snowmass 2021)

Editors:
J. de Blas[1], *D. Buttazzo*[2], *R. Capdevilla*[3,4], *D. Curtin*[3], *R. Franceschini*[5], *F. Maltoni*[6,7], *P. Meade*[8], *F. Meloni*[9], *S. Su*[10], *E. Vryonidou*[11], *A. Wulzer*[12]

Contributors:
Somebody[12]*;*

Context:

A ~3 TeV stage: (see Daniel's talk)

➡ Cheaper and easier

➡ Faster

➡ More attractive

➡ More funds, more work

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Goals:

Document 3 TeV potential beyond HL-LHC:

➡ Also beyond, and in **synergy**, with ~250 GeV ee

➡ Premature to consider other scenarios? (e.g., ILC)

Make sure that 3 TeV does not spoil 10+ TeV case:

➡ 10+ TeV included. Make sure that clearly separated

➡ True reason: impossible to ask for 3 TeV work w/o getting 10 as well …

Establish proto-working groups:

➡ In preparation for EU strategy update preparation

Contribute to Snowmass:

➡ Better if ready by the end of the month (!)

➡ Maybe premature to talk about staging in US context

➡ New 10+ TeV results/summary still useful

Content:

Higgs and EFT:

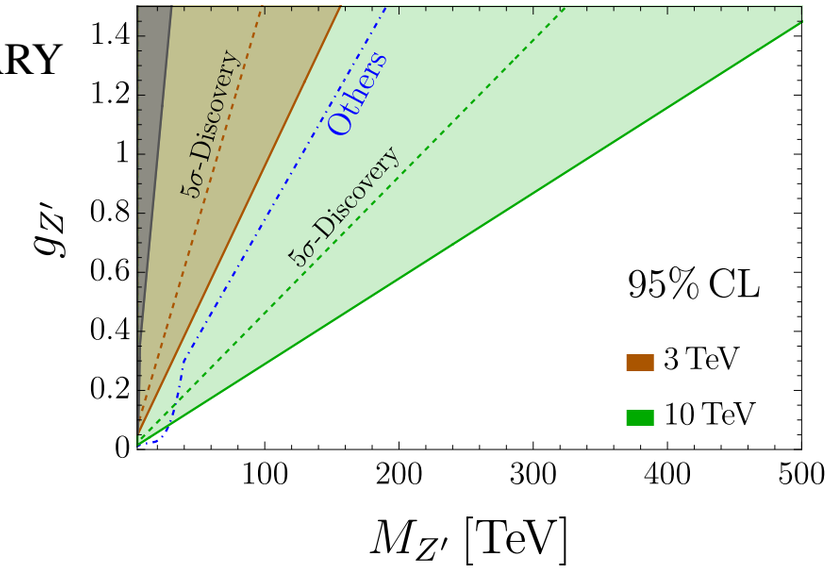
- ➡ Projections in same format and assumptions as EU Strat. input
- ➡ Harmonise results, including full sim ones, for coherent picture
- ➡ Beyond sensitivity tables (reach on models; also in BSM chapter)

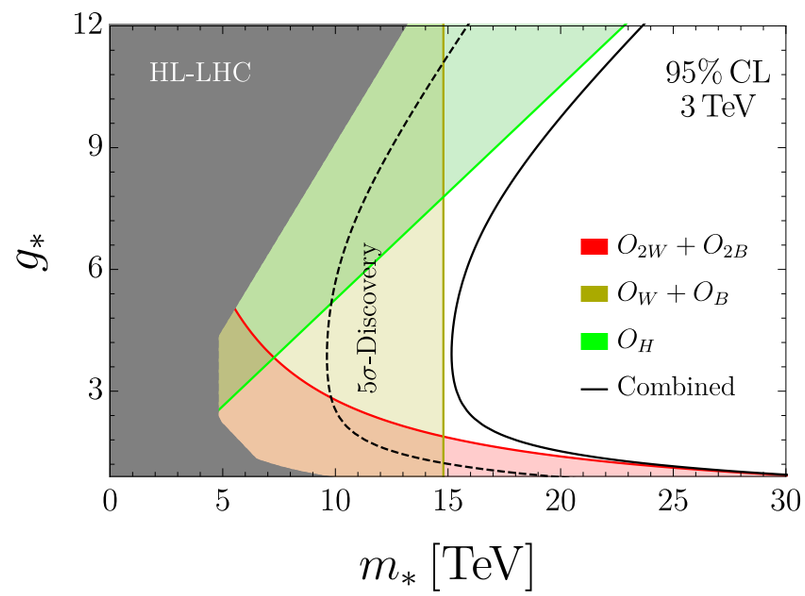
e 2: Results from the κ fit assuming no BSM contributions to the Higgs width. PRELIMINARY

Coupling	HLLHC	HLLHC + 125 GeV μ-coll. 5 / 20 fb^{-1}	HLLHC + 3 TeV μ-coll. 1 ab^{-1}	HLLHC + 10 TeV μ-coll. 10 ab^{-1}	HLLHC + 10 TeV μ-coll. + e^+e^- H fact (240/365 GeV)
κ_W	1.7	1.3 / 0.9	0.4	0.1	0.1 /
κ_Z	1.5	1.3 / 1.0	0.9	0.4	0.1
κ_g	2.3	1.7 / 1.4	1.4	0.7	0.6
κ_γ	1.9	1.6 / 1.5	1.3	0.8	0.8
κ_c	-	12 / 5.9	7.4	2.3	1.1
κ_b	3.6	1.6 / 1.0	0.9	0.4	0.4
κ_μ	4.6	0.6 / 0.3	4.3	3.4	3.2
κ_τ	1.9	1.4 / 1.1	1.3	0.6	0.4 /
$\kappa_t^\dagger$	3.3	3.1 / 3.1	3.1	3.1	3.1
$\kappa_{Z\gamma}^\dagger$	10	10 / 10	10	10	10
$\Gamma_H^\ddagger$	5.3	2.3 /	1.5	0.5	0.4

† No input used for μ collider.

‡ Prediction assuming only SM Higgs decay channels. Not a free parameter in the fits.

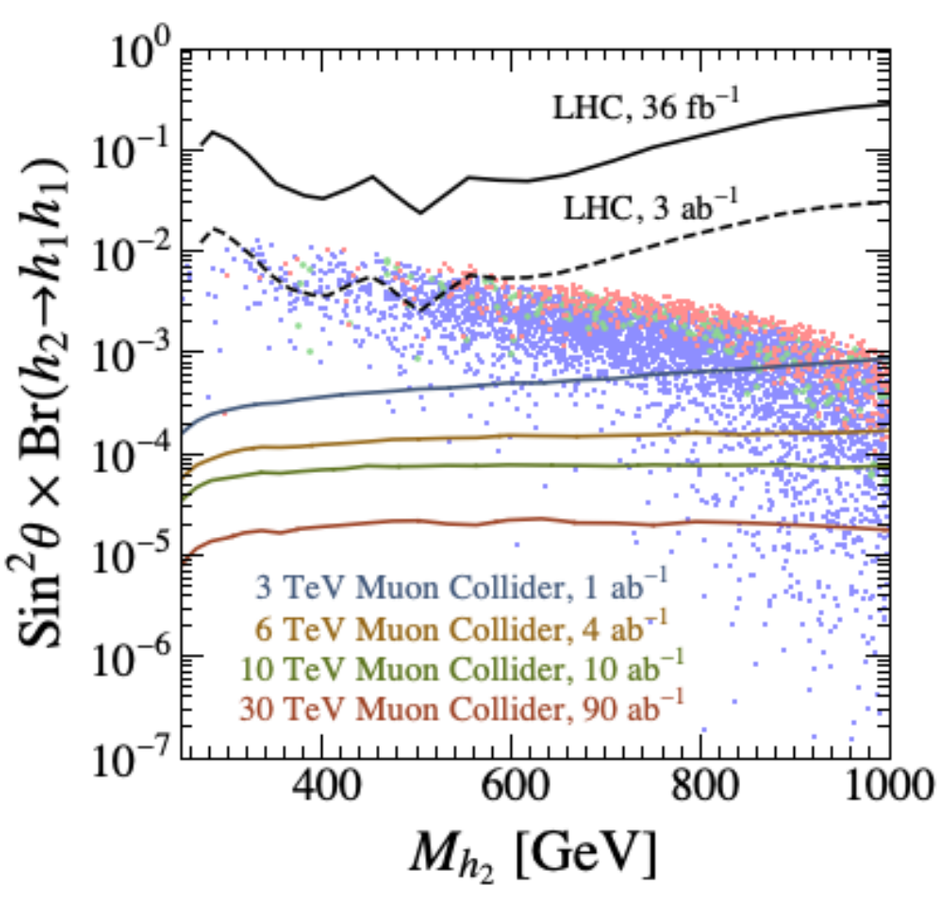


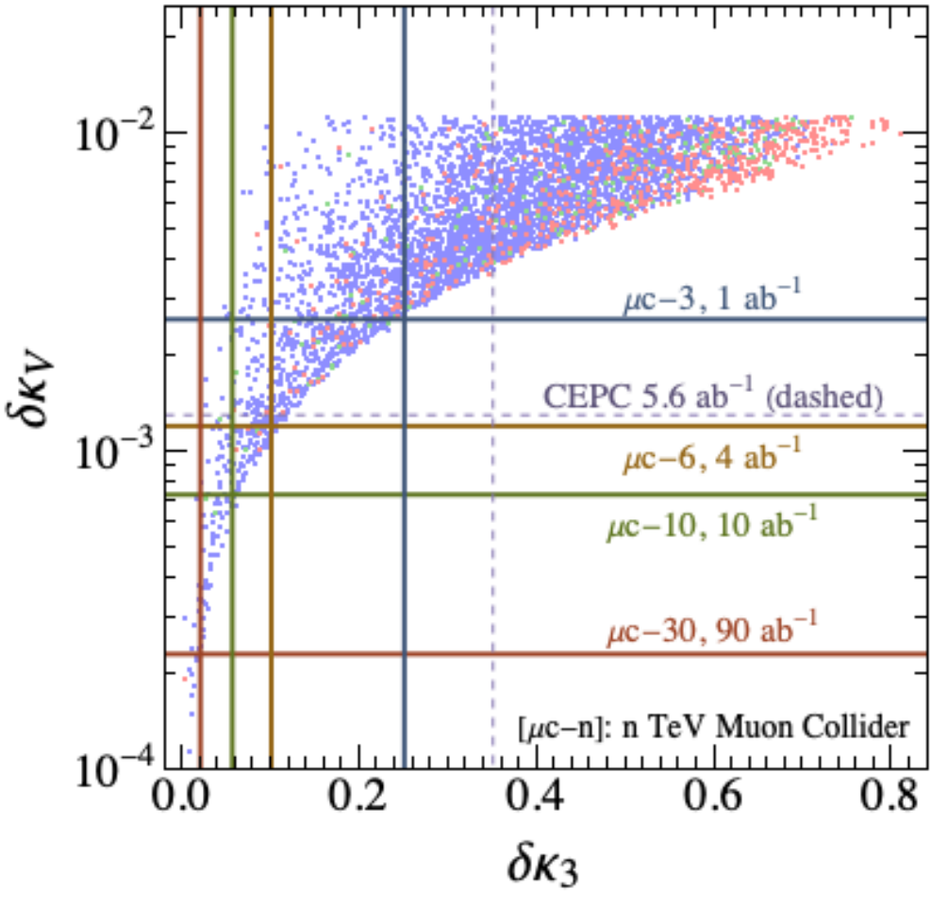


Content:

Beyond the Standard Model:

- ➡ More focus on 3 TeV, as 10+ TeV is obvious
- ➡ Extended Higgs sectors, with implications on EW-Ph.Tr., DM, …
- ➡ Purely Electroweak states
- ➡ Dark Matter
  - ➡ Dedicate chapter on BIB-aware disappearing tracks





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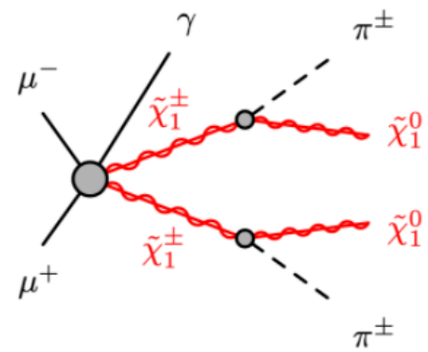
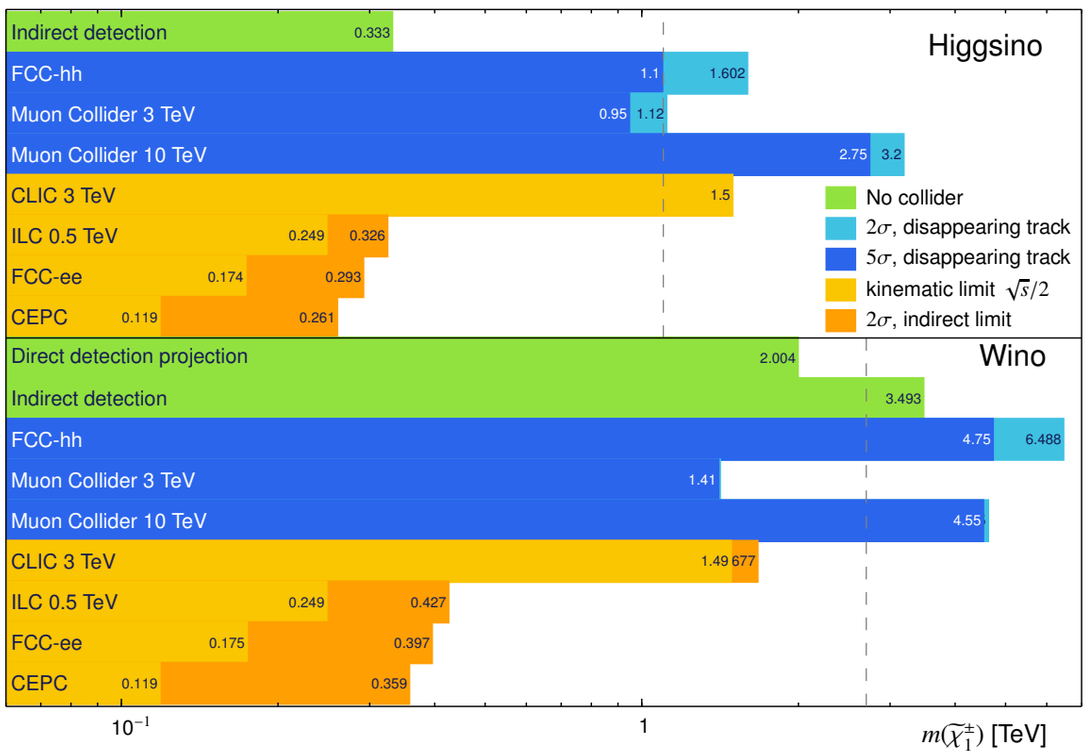
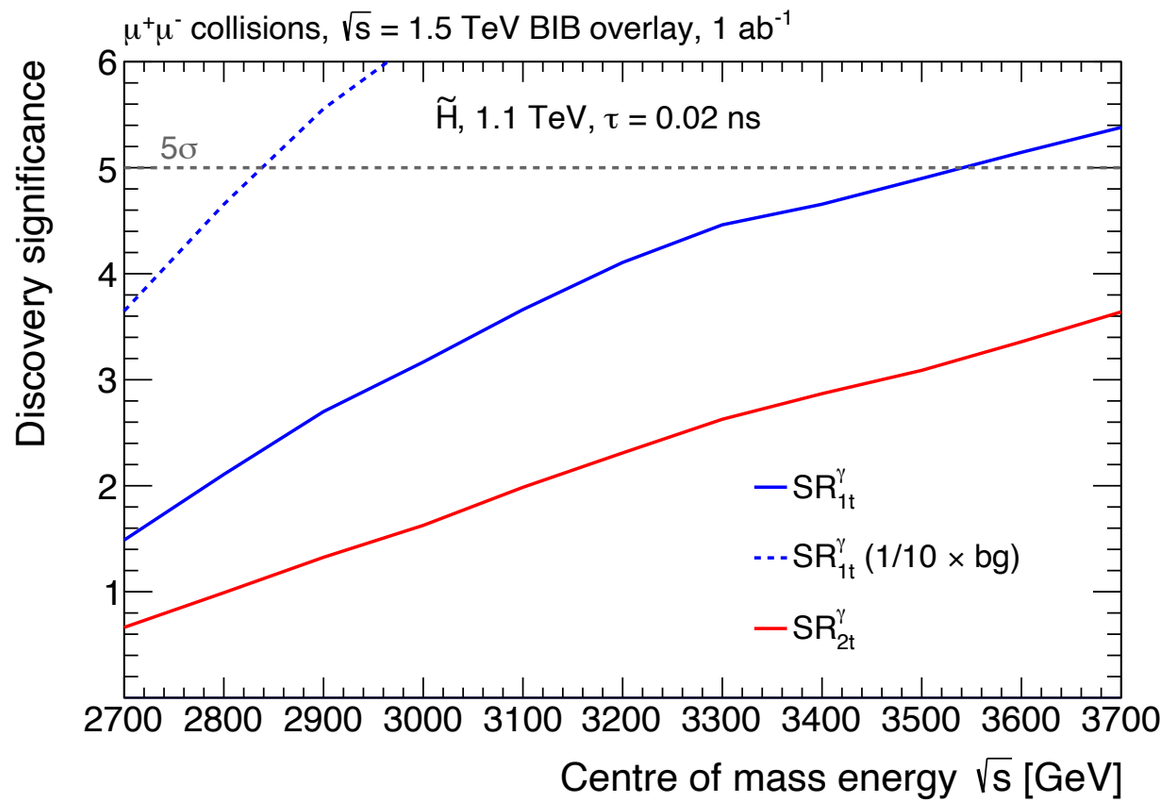






Content:

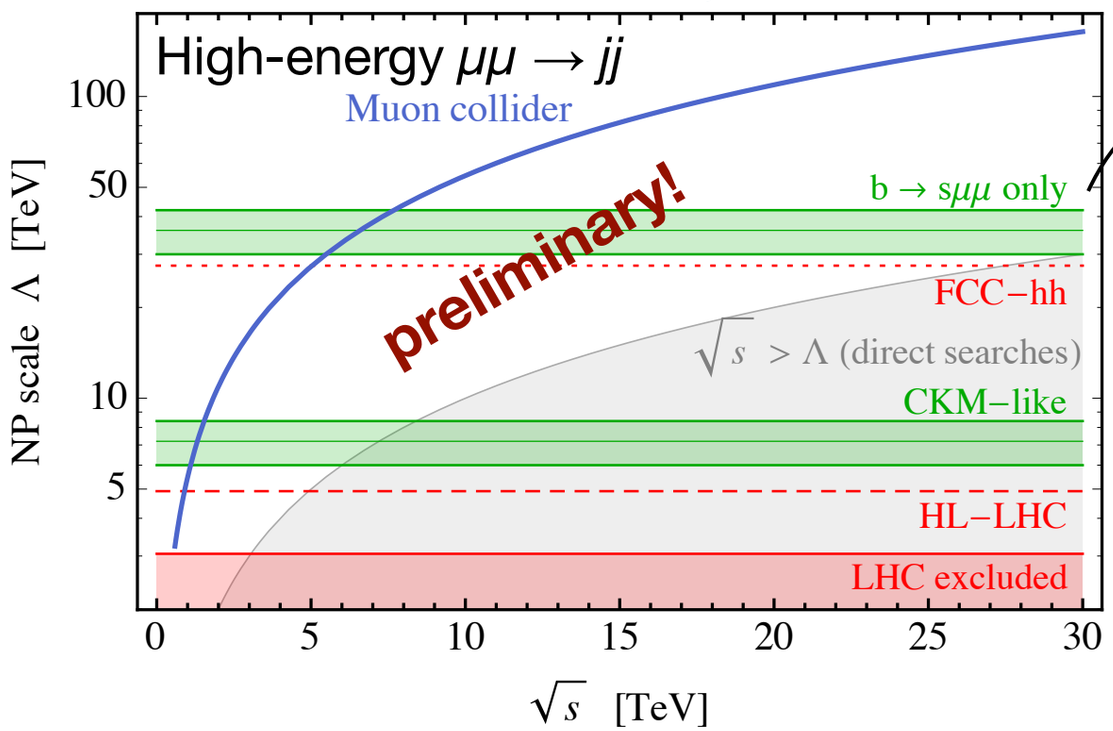
Muon-specific opportunities:

- ➡ From colliding μ, rather than e or p
- ➡ Anomalies in g-2, RK* et. al., play major role
- ➡ Big question to be posed or (partly) answered:

  Which collider if anomalies confirmed?

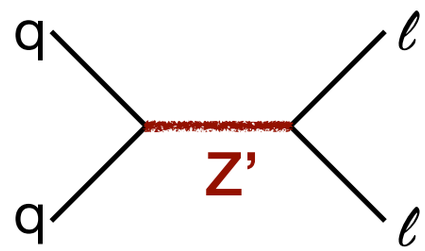
thanks to D. Marzocca, et al. for results!

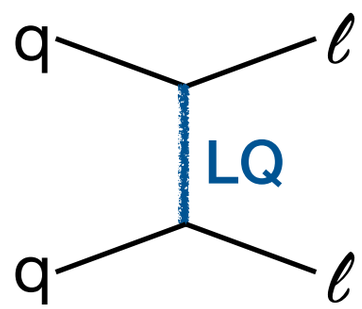
see also Asadi et al.; Huang et al.



nightmare scenario! only *bsμμ* coupling
(not realistic: excluded by other flavor bounds)

No-lose theorem for ~ 5 TeV μ-collider?





Realistic models much easier to test,
but still not necessarily in reach of HL-LHC