Testing the Standard Model at high energy: the weak mixing angle

Amoroso, Chiesa, Del Pio, Lipka, Piccinini, Vazzoler, Vicini
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$$\sin\theta_w = \frac{e}{g_2} \xrightarrow{\textit{schema } \overline{MS}} \sin\theta_w^{\overline{MS}}(\mu) = \frac{e^{\overline{MS}}(\mu)}{g_2^{\overline{MS}}(\mu)}$$

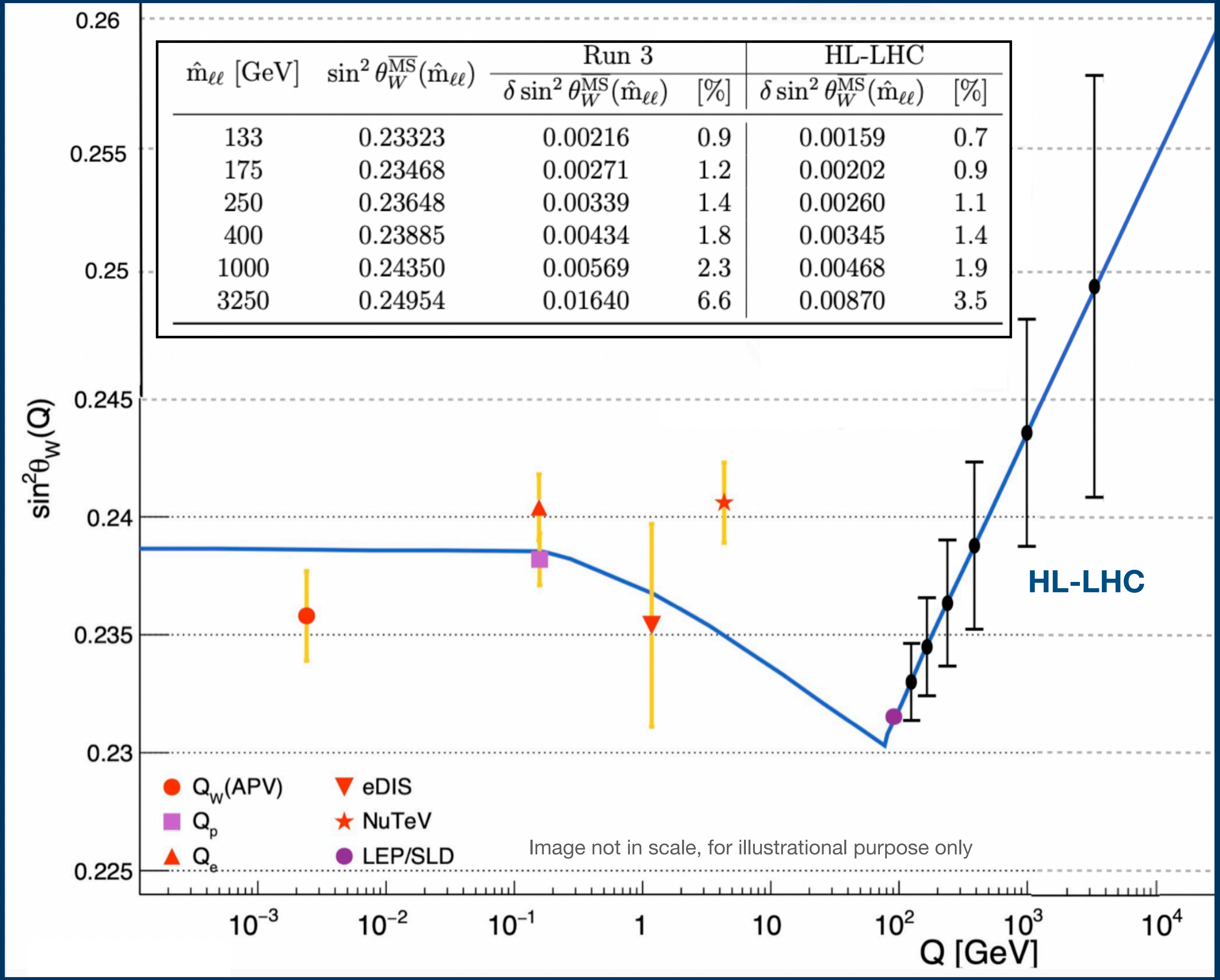
In QFT calculations some input data is necessary to produce numerical predictions → renormalization scheme

Renormalization scheme $\left(\alpha^{\overline{MS}}(\mu),\ \sin^2\theta_w^{\overline{MS}}(\mu), M_Z\right)$ to directly determine the $\overline{MS}$ weak mixing angle

NLO running in Monte Carlo generator POWHEG-BOX for simulation of neutral current Drell Yan

Fit considering Run 3 (300 fb^{-1}) e HL-LHC (3000 fb^{-1})

Templates with SM running for $\alpha^{\overline{MS}}(\mu)$ and $\sin^2\theta_w^{\overline{MS}}(\mu = \hat{m}_{\ell\bar{\ell}}) \pm 0.01$ $\hat{m}_{\ell\bar{\ell}}$ → central point of bin



$\hat{m}_{\ell\ell}$ [GeV]	$\sin^2\theta_W^{\overline{MS}}(\hat{m}_{\ell\ell})$	Run 3 $\delta\sin^2\theta_W^{\overline{MS}}(\hat{m}_{\ell\ell})$	Run 3 [%]	HL-LHC $\delta\sin^2\theta_W^{\overline{MS}}(\hat{m}_{\ell\ell})$	HL-LHC [%]
133	0.23323	0.00216	0.9	0.00159	0.7
175	0.23468	0.00271	1.2	0.00202	0.9
250	0.23648	0.00339	1.4	0.00260	1.1
400	0.23885	0.00434	1.8	0.00345	1.4
1000	0.24350	0.00569	2.3	0.00468	1.9
3250	0.24954	0.01640	6.6	0.00870	3.5

UNIVERSITÀ DEGLI STUDI DI PERUGIA
INFN PERUGIA
DALIAN UNIVERSITY OF TECHNOLOGY
KIT Karlsruher Institut für Technologie
VANDERBILT UNIVERSITY

Phenomenology at the LHC of Composite Boson Leptoquarks from Strongly Interacting SM Fermions via Four-Fermion Operators of NJL type

S. Ajmal, J. T. Gaglione, F. Romeo, A. Gurrola, O.Panella, M. Presilla, H. Sun, and S. S. Xue

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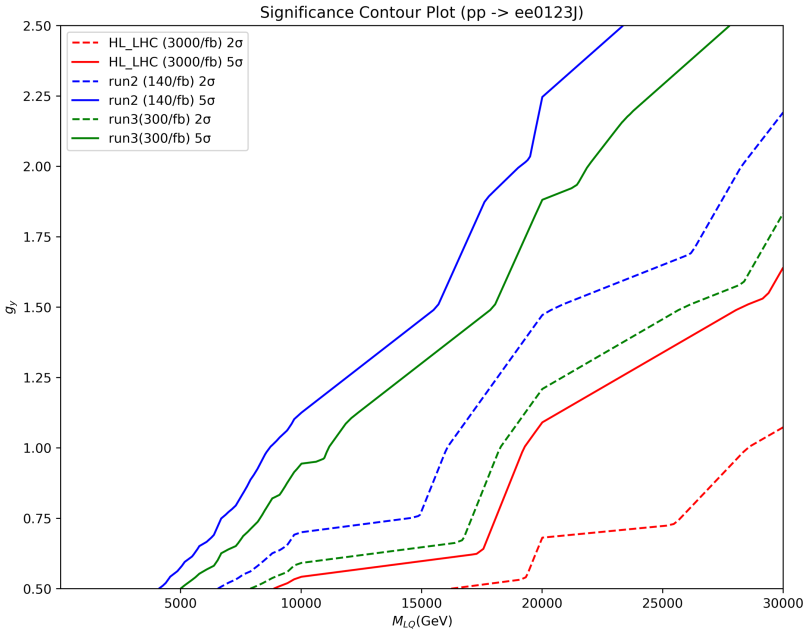
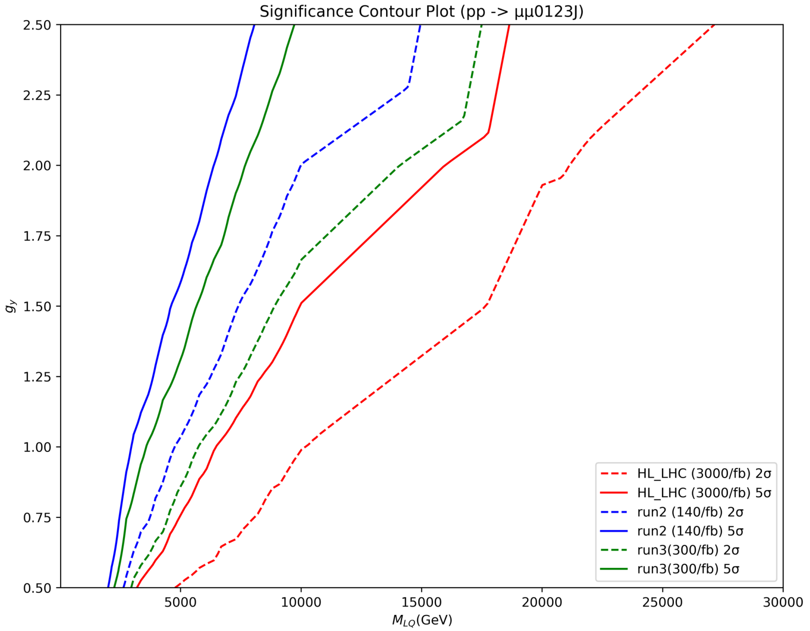
Exploring Composite Leptoquarks at the LHC

- Motivated by significant deviations from the Standard Model in B meson decays and LHC data
- Composite Model → Nambu-Jona-Lasinio (NJL) Four Fermion Interactions at high-energy scaling region, yielding an effective theory of composite particles while preserving SM symmetries.

$$\sum_{f=1,2,3} G[\overline{\psi_L}^f \psi_R{}^f \overline{\psi_R}^f \psi_L{}^f]_{Q_i=0,-1,\frac{2}{3},-\frac{1}{3}}. \quad \textit{where} \quad G \propto \Lambda^{-2}$$

- Under investigation leptoquarks are Scalars with charge 5/3e and coupling $(ue, \mu c)$
- Signal Processes $p\,p > l^+l^-(0-3\ jets)$ & $p\,p > l^+l^-j, p = \gamma, g, q$ **(InElastic case)**
- **Search Strategy**
  - Signal: Two leptons (e or μ) + 0, 1, 2, or ≥3 jets and used Jet merging Technique
  - Backgrounds: Top, WJ, VV, Drell-Yan
  - Selection: Leptons (pT > 20 GeV, |η| < 2.5, invariant lepton pair mass > 120 GeV, MET < 50 GeV)
  - Jets: pT > 20 GeV, |η| < 5, ΔR > 0.4 separation from leptons, no b-jets.
  - S_T and χ as discriminating variable.
- Examined the coupling g_y(0.5 to 2.5) on outcomes, illustrated the mass-coupling relationship in 2D at 13 TeV COM energy and projected 2 (dashed) and 5(plain)σ contours for different luminosities. Red→ 3000 fb^{-1},Green→ 300 fb^{-1} and blue→ 140 fb^{-1}





Thank you for your attention

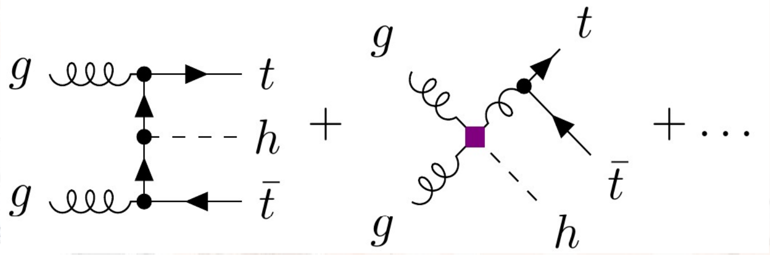
RG effects in pp→tth in the SMEFT

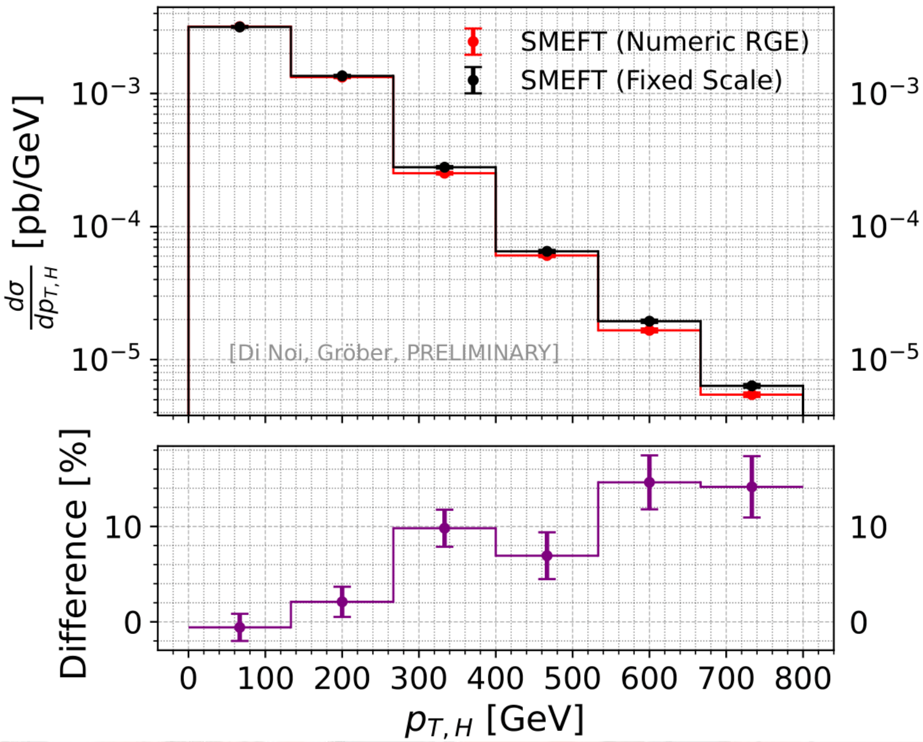
S. Di Noi, R. Gröber
(UNIPD & I.N.F.N.)

- Define the SMEFT 4t coefficients @ Λ=O(1 TeV) [Ethier et.al.,'21]
- Test their impact on distributions using a dynamical renormalization scale:

$$\mu_R = (m_{T,t}\, m_{T,\bar{t}}\, m_{T,H})^{1/3}, \quad m_{T,i} = \sqrt{p_{T,i}^2 + m_i^2}$$

- Test several implementations of running effects (leading-log, numeric) vs fixed scale.
- **Running effects up to O(10%)!**





An high-efficiency tool is needed: RGESolver [SDN, Silvestrini,'22]

This plot: 100000 events, ~15 min (parallelized).