

Posters Award

Committee: Johannes Albrecht, María Cepeda, Tristan du Pree, Elisabetta Gallo (chair), Stefania Gori, Heather Gray, Yvonne Pachmayer, Marek Schoenherr, José Zurita



Thanks to all the posters presenters!

- 124 posters on a broad range of subjects
- All posters very well prepared and presented
- It was very difficult to choose
- Five best posters to be awarded prizes (sponsored by CERN and IUPAP)



New Small Wheel sTGC Front-End Electronics Integration and Commissioning for ATLAS Phase I Upgrade

Ms. Prachi Atmasiddha
(University of Michigan, Ann Arbor)

- Clear explanation of a technical topic
- Answered questions with great detail and enthusiasm

Integration and Commissioning of the Front-End Electronics of NSW ATLAS small-strip Thin Gap Chambers
Prachi Arvind Atmasiddha, University of Michigan, Ann Arbor, USA
(On Behalf Of The ATLAS Muon Collaboration)

INTRODUCTION

FUNCTIONING OF THE FRONT-END ELECTRONICS

The Large Hadron Collider (LHC) will reach an instantaneous luminosity of $5 - 7.5 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$ (~2027 onward). This necessitates the upgrade of the ATLAS Muon Spectrometer. The innermost station of the muon end-cap system, the Small Wheel, will be replaced by the New Small Wheel (NSW). The NSW is required to improve the trigger selectivity in a high background environment (up to 20 kHz cm^{-2}). The small-strip Thin Gap Chambers (sTGC) sub-system will be the primary trigger detector for the NSW. The sTGC is expected to provide hardware-based online track segment measurements with a pointing accuracy of 1 mrad for the muon Level-1 trigger at the end-cap. The sTGC detector system is equipped with several types of radiation tolerant ASICs, electronics cards and FPGA based Back-End processors. Each sTGC wedge has 3 multilayered modules (quadruplets). Total 64 such wedges need to be commissioned. We present the status and the results from the Front-End electronics integration and commissioning of the sTGC sub-system at CERN.

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STGC INTEGRATION AND COMMISSIONING

FRONT-ENDS AND SERVICE INSTALLATION

Reception Tests of the Front-End Boards:

Reception of FEBs, Reception Tests, Mounting Cooling Plates, Fitting all the services in a tight space (cooling system, Data cables, Front-ends, LV power cables, etc)

After installation of all the services on the sTGC wedge

Board Temperature

The temperature of all the VMs is monitored using the built-in temperature sensors inside the VM.

Temperature should be $< 50^\circ \text{C}$.

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ON-WEDGE ELECTRONICS TESTS

CHALLENGES

ing system, data cables, Front-ends and very tight space on the detector.

and noise control for the large area apacitance.

Front-End connectivity with complex data flow at high speed operated

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ON-WEDGE ELECTRONICS TESTS

CONCLUSION

Data Quality Checks and synchronization:

- The clock-phases of VMM-TDS and ROC-TDS data links are tuned for synchronous trigger.
- Readout parameters which have to be tuned include: Bunch Crossing Offset, Time Trigger and Control (TTC) Phase, Clock phase for VMM to ROC data link, etc.
- Eye-diagrams – for checking the quality of the signal transmission, etc
- All separate data bits are superimposed together and the opening of the eye (area in voltage-time space, where the measurement of the Bit Error Ratio (BER) is lower than a maximum acceptable value which is generally set to $\sim 10^{-8}$ to 10^{-14}) is measured.

Good Eyes

Bad Eyes

Eye-diagrams: for the signal transmission at 4.8 Gbps (Y-axis: voltage, X-axis: time) Smaller opening could be because of more time jitter, signal attenuation, etc.

For a typical sTGC Wedge

Strips	Problems
~ < 2%	
Pads	~ < 1%

NSW Side-A

- The Integration and Commissioning for sTGC detectors is ongoing at CERN for the installation during the LHC Long Shutdown 2 (LS2) period.
- Successful mounting and checking of the Front-ends with trigger and data link tests are being done.
- The fully tested sTGC wedges are being mounted on the New Small Wheel along with the Micromegas detector wedges. All NSW Side-A Wedges have been mounted.

[1] <https://project-hi-hc-industry.web.cern.ch/content/project-schedule> [2] Kawamoto, T. ATLAS Collaboration (ATLAS-TDR-020). [3] P. Gkoutounis, JINST12, no. 01, C01088(2017) [4] W. Wu, IEEE Transactions on Nuclear Science, vol. 66, no. 7, no. 986-992, Jul. 2019. [5] Lefebvre, benoit, JINST 15 (2020) C07013

Playing cards as a tool to create public interest in physics

Jason Robert Veatch (Georg August Universitaet Goettingen)

- Imaginative and original way to engage the public and create interest in particle physics

Communicating physics with playing cards

Jason Veatch
Yuko Veatch
University of Göttingen

- Playing cards are common around the world
- They are a common medium to communicate
- QUANTUM playing cards are a physics and inspire an interest
- First in a series of decks planned
- [Performance and review](#)

Jason Veatch

Double beta decay

Two-photon absorption

Nuclear magic numbers

SI unit for two-photon absorption cross section

Uranium hexafluoride

Georg-August Universität

Benzene

Manhattan Project

Jason Veatch

LHCP 2021

Experiment card

- Includes a card that discusses and gives instructions to perform Thomas Young's double-slit experiment at home
- Works reasonably well using a commercial laser pointer

Accompanying booklet

- An accompanying booklet provides an introduction to quantum mechanics, a brief biography of each physicist, and suggested further reading
- Available online for free [here](#)
- Can be purchased as a printed booklet

Jason Veatch

LHCP 2021

Logistics

- Cards will be printed in Belgium
- Raising production funds with a [Kickstarter campaign](#)
- Campaign will run until July 1st (nearly 300% funded)
- A single deck costs €10 (plus shipping)
- Can be provided at cost for outreach/education uses
- Searching for grant options to provide decks for free
- Expected delivery by November 2021

Outreach

- A conversation starter and an inspiration to learn
- Can be used at outreach events (e.g., activity table)
- Already planned for an upcoming event this fall
- Other material such as coloring pages, posters, t-shirts and temporary tattoos will also be available
- The project has already provided me with unique outreach opportunities
- Engaging with card collectors directly about physics
- Public outreach talks through contacts I've made
- Kickstarter as a means of offering public outreach talks

- Instagram: [@qedplayingcards](#)
- Twitter: [@CardsQcd](#)
- Facebook: [QEDPlayingCards](#)
- Website: [www.qedplayingcards.com](#)

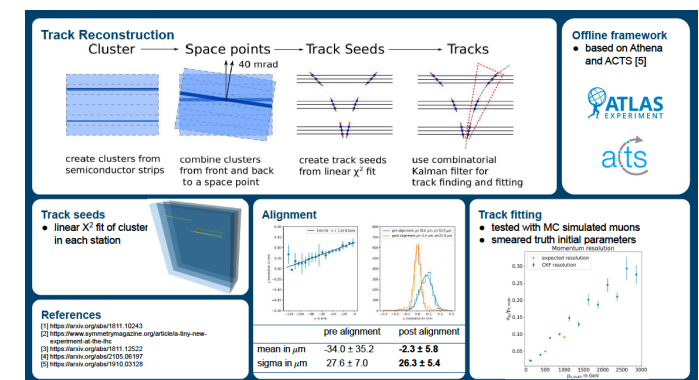
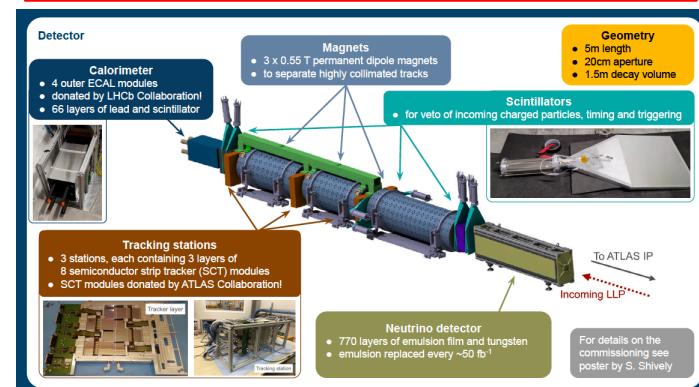
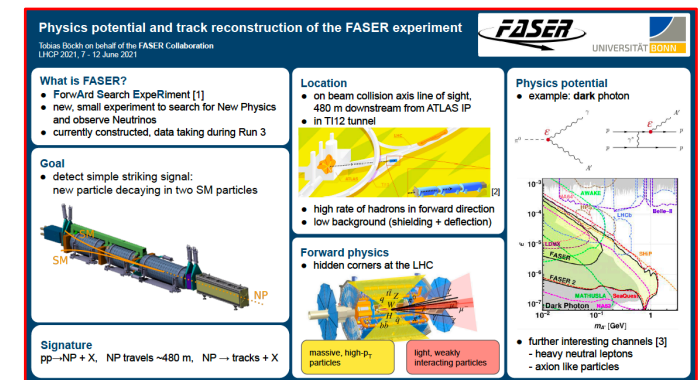
Jason Veatch

LHCP 2021

Physics Potential and Track Reconstruction of the FASER Experiment

Tobias Boeckh (University of Bonn)

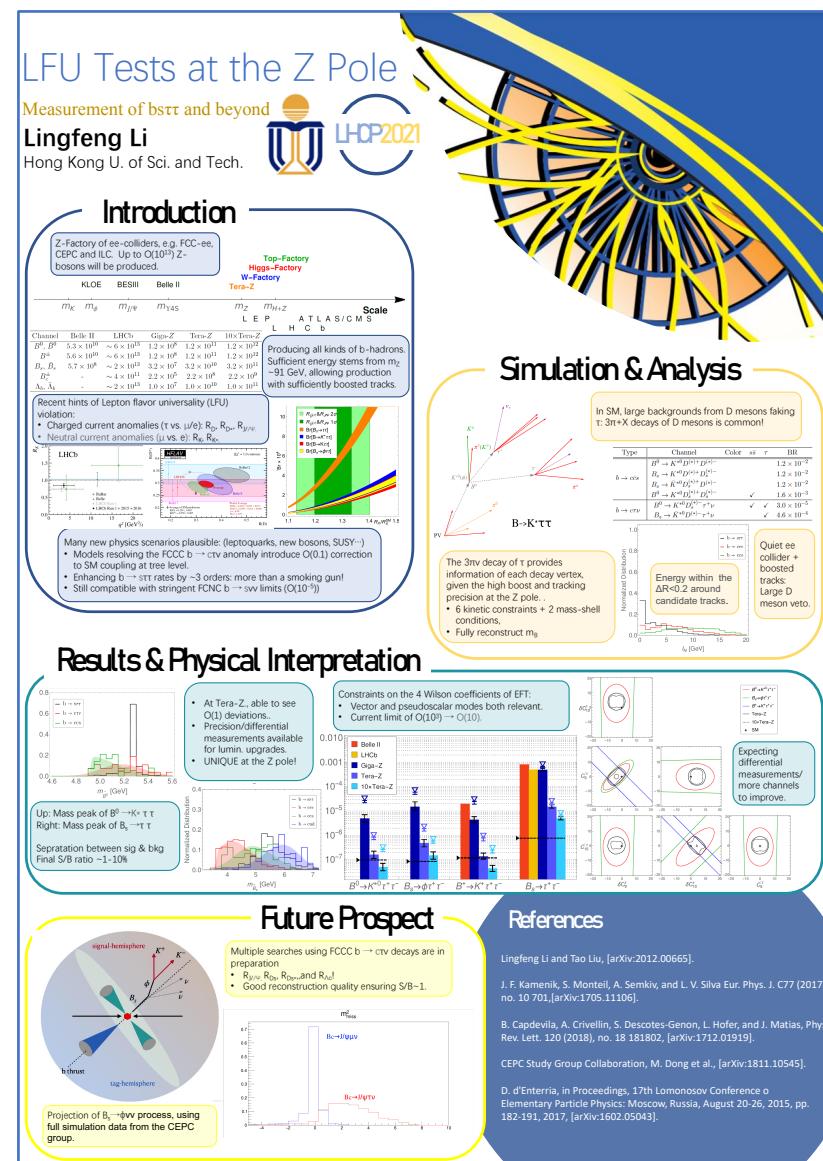
- Very good overview of a small, but high-potential experiment in the shadow of the LHC
- Clear explanations in the videos
- Nice plots, well explained, complete



LFU Tests at the Z Pole

Lingfeng Li (Hong Kong UST)

- Hot topic
- Original design
with LHCP2021 logo
- Attracts attention



Combined Constraints on First Generation Leptoquarks

Luc Schnell (LPTHE Paris,
ETH Zurich,
École Polytechnique de Paris)

- Thorough work
- Includes colliders and low energy experiments, also HERA data
- Nice design!

Combined Constraints on First Generation Leptoquarks

Andreas Crivellin^{a,b,c}, Dario Müller^{a,b,c}, Luc Schnell^{d,e,f}

^aCERN Theory Division; ^bUniversität Zürich; ^cPaul Scherrer Institut; ^dLPTHE Paris; ^eETH Zürich; ^fÉcole Polytechnique;

1 Introduction

Leptoquarks (LQs) are hypothetical beyond the Standard Model (BSM) particles that feature quark-lepton couplings. They have attracted particular attention in recent years, since they can explain the „flavor anomalies“, deviations from SM predictions that test at Lepton Flavor Universality Violation (LFUV).

$$\begin{aligned} R(D^{(*)}) &= \frac{\text{Br}(B \rightarrow D^{(*)} \tau^+ \nu_\tau)}{\text{Br}(B \rightarrow D^{(*)} \mu^+ \nu_\mu)} \text{ with } \tau = e, \mu &> 3\sigma \text{ R} \\ b \rightarrow s \ell^+ \ell^- \text{ transitions} &&- 6\sigma \text{ R} \\ R_K &= \frac{\text{Br}(B^+ \rightarrow K^+ \mu^+ \nu_\mu)}{\text{Br}(B^+ \rightarrow K^+ e^+ \nu_e)} \text{ with } \tau = e, \mu &> 3\sigma \text{ R} \\ R_{K^*} &= \frac{\text{Br}(B^0 \rightarrow K^{*0} \mu^+ \nu_\mu)}{\text{Br}(B^0 \rightarrow K^{*0} e^+ \nu_e)} \text{ with } \tau = e, \mu &> 3\sigma \text{ R} \\ \mu \text{on anomalous magnetic moment (AMM): } a_\mu &= \frac{a_\mu - 2}{2} &4.2\sigma \text{ R} \end{aligned}$$

2 Setup

- We consider the complete set of LQ interactions with first generation quarks and leptons.

$$\begin{aligned} Q &\rightarrow \bar{q} \ell^+ \ell^- + \bar{q} \nu_\ell \ell^- + \bar{q} \ell^+ \nu_\ell \\ \bar{Q} &\rightarrow q \ell^+ \ell^- + q \nu_\ell \ell^- + q \ell^+ \nu_\ell \\ \bar{Q} &\rightarrow q \ell^+ \ell^- + q \nu_\ell \ell^- + q \ell^+ \nu_\ell \\ \bar{Q} &\rightarrow q \ell^+ \ell^- + q \nu_\ell \ell^- + q \ell^+ \nu_\ell \end{aligned}$$

Table 1: Interaction terms for the first generation SM quarks ($Q = u, d$) and leptons ($\ell = e, \mu$).

3 Observables

Low Energy Precision Observables

- Cabibbo Angle Anomaly (CAA): deficit in 1st row CKM unitarity, can be explained with 1st generation LQs.

$$\begin{aligned} V_{ud}^2 + V_{us}^2 + V_{ub}^2 &= 1 \\ V_{ud}^2 &= 0.998(1) \\ V_{us}^2 &= 0.224(4) \\ V_{ub}^2 &= 0.002(4) \end{aligned}$$

- Tree-level neutral current: constraints from parity violation experiments (QWEAK and APV).

$$K \rightarrow \pi \pi^0 \nu \bar{\nu} \text{ and } K \rightarrow \pi \pi^0 \nu \bar{\nu} \text{ and } K \rightarrow \pi \pi^0 \nu \bar{\nu}$$

- D^0 – D^0 and E^0 – E^0 mixing: constraints on one-loop LQ contributions.

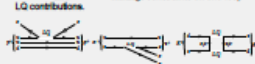
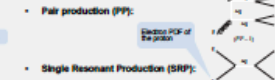


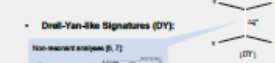
Figure 1: Feynman diagrams depicting the LQ contributions to the low energy processes D^0 – D^0 and E^0 – E^0 mixing.

Direct LHC Searches

- Pair production (PP):



- Single Resonant Production (SRP):



- Drell-Yan-like Signatures (DY):



Figure 2: Feynman diagrams depicting the LQ contributions to the low energy processes D^0 – D^0 and E^0 – E^0 mixing.

4 Phenomenological Analysis

Low Energy Precision Observables

- The CAA could be explained by contributions from Φ_1, V_2 . However, DY searches as well as the meson mixing constraints exclude sizeable contributions C_{11}^{LL} (black line in Figure 4).
- The neutral current and meson mixing limits (blue, open and orange lines in Figure 4) depend on the angle θ relating left-handed down-type quark flavor and mass eigenstates.

Direct LHC Searches

- PP (gray region in Figure 4) sets coupling-independent limits on the LQ masses.
- The excess in electron pairs found in CMS' non-resonant DY analysis (yellow region in Figure 4) prefers the LQ representations Φ_1, Φ_2, V_1, V_2 ($\theta = 0$) and V_2 interfering constructively with the SM.



Figure 3: Ratio of cross sections $\sigma_{\text{LQ}}/\sigma_{\text{SM}}$ for $e^+e^- \rightarrow \ell^+\ell^-$ as a function of the invariant dilepton mass $m_{\ell\ell}$. The LQs are assumed to be produced via $q\bar{q} \rightarrow \ell^+\ell^-$ (second line) over the SM contribution (black line at 1.0).

- ATLAS' non-resonant DY bounds (green region in Figure 4) are more constraining than the resonant DY searches.

Exclusion Plots

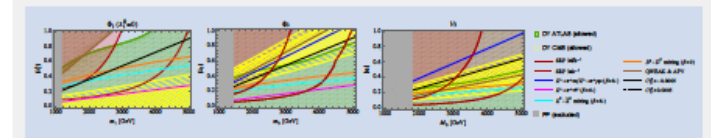


Figure 4: Limits on the parameter space for scalar and vector LQs. The region above the colored lines is excluded. The plots for the remaining LQ representations are given in Ref. [2].

5 Conclusions

- We performed a combined analysis of constraints on first generation LQs, including both low energy precision observables and direct searches.
- The CAA could be explained by first generation Φ_1, V_2 , but the size of this effect is too constrained by DY and the meson mixing.
- The non-resonant DY analysis of ATLAS gives stringent constraints on first generation LQs. The representations Φ_1, Φ_2, V_1, V_2 ($\theta = 0$) and V_2 can account for the di-electron excess found in the CMS non-resonant DY analysis without violating other bounds.

References

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2. Abdurrahman, A., et al. "Measurement of $R(D)$ and $R(D^*)$ with a semileptonic tagging method." *arXiv:1904.03263* [hep-ex] (2019).
3. Wüster, David. "Anomalous $b \rightarrow s \ell^+ \ell^-$ Transitions and Global Fits." *arXiv:2101.01008* [hep-th] (2021).
4. Ali, B., et al. "Measurement of the positive muon anomalous magnetic moment to 0.46 ppm." *Physical Review Letters* 126.14 (2021): 141801. [arXiv:2104.03134](#) [hep-ex] (2021).
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7. CMS Collaboration. "Search for resonant and non-resonant new phenomena in high-mass dilepton final states at $\sqrt{s} = 13$ TeV." *arXiv:2103.13178* [hep-ex] (2021).