Welcome to the TF07 Town Hall!

Collider Phenomenology in the Theory Frontier

December 8, 2020

TF07 Town Hall Outline

- TF07 overview and topics covered
- TF timeline and events planned
- White paper plans
- Letters of interest (LOI)
- Expressions of interest (EOI)
- Open discussion

The goal of this meeting is to:

- update you on activities planned in TF07,
- encourage you to make concrete plans to get involved, and
- get your input if there are areas that haven’t been covered

TF07: Collider phenomenology

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- Slack channel: #tf07-collider

Major Topics

https://snowmass21.org/theory/phenomenology

- Illustrate exciting new directions in collider phenomenology
- Establish key connections between cutting-edge theoretical advances and current and future experimental opportunities
- Identify the most promising avenues where major theory breakthroughs could take place in the coming years, which could lead to transformative concepts and techniques in collider phenomenology.

TF07 Topics (1/3)

TF07 topics https://snowmass21.org/theory/phenomenology

- New collider **data analysis strategies**, including kinematic variables, tagging methods, clustering algorithms (EF06/07), and machine learning approaches (CompF3), for example those that incorporate theoretical developments and experimental requirements

- Novel **collider signatures**, including those that are currently difficult to study or require alternative event reconstruction (EF08/09/10)

- Techniques to maximize the sensitivity and broaden the range of **new physics searches**, including multi-channel combinations and anomaly detection (EF08/09/10), and reinterpretation/archival data (CompF7)

- Advances in **event simulation**, including those that can increase accuracy/precision and overcome speed/storage limitations (CompF2/4)

TF07 Topics (2/3)

TF07 topics https://snowmass21.org/theory/phenomenology

- Theory input on the targets and challenges for **current and next-generation colliders** (AF3/4)
- Top-down: implications of **model building developments** (EF08/TF08) in identifying smoking gun signatures of new physics and developing targeted analysis strategies
- Bottom-up: effective field theories (EF09/EF04/TF02) and simplified models (TF08/EF09/10) for **model-independent characterization** and interpretation of collider data
- Impact of the **precision frontier** (TF06) on event generation and collider measurements (EF01/02/03/04/05)
- Applications of **amplitudes developments** (TF04) for precision predictions and new physics characterization

TF07 Topics (3/3)

TF07 topics https://snowmass21.org/theory/phenomenology

- Impact of **non-perturbative methods** to improve (TF03/05): i) collider inputs (e.g. parton distribution functions, fragmentation functions, strong coupling constant), including lattice field theory and analytic techniques (EF05/06); ii) understanding of non-perturbative BSM scenarios (EF08/09/10)

- Connections to **astrophysics and cosmology** (TF09, CF1/2), including collider probes of dark sectors and baryogenesis (EF10)

- Connections to the **intensity frontier**, including collider probes of neutrino physics (TF11, NF02/03), flavor physics, and CP violation (RF1/2/3), L and B violation (RF4/5)

- Relevance of **quantum information** for collider analyses (TF10/CompF6)

TF Timeline

TF timeline for white paper/reports/summary

- **Now:** Fill out Expression of Interest form to indicate planned contributions or build collaborations.
- **April 15, 2021:** Recommended submission date for contributed papers. Submission of summary paragraphs for papers still in progress.
- **May 1, 2021:** Detailed outlines of Topical Group Reports available for comment.
- **June 1, 2021:** Detailed outline of Frontier Summary available for comment.
- **June 15, 2021:** First drafts of Topical Group Reports available for comment.
- **July 1, 2021:** First draft of Frontier Summary available for comment.
- **July 31, 2021:** Final Snowmass deadline for contributed papers.
- **September 1, 2021:** Second drafts of Topical Group Reports available for comment.
- **September 15, 2021:** Second draft of Frontier Summary available for comment.
- **October 21, 2021:** Topical Group Reports and Frontier Summaries completed & released.

Planned TF Events

Events for the future

- TF (KITP) meeting: March 17-19, 2021
- TF07 focused topic mini-meeting: Spring 2021

N.B.: There is a ongoing discussion about whether the overall Snowmass process should be paused or extended. If you have an opinion, please put it here:

https://docs.google.com/document/d/188oo2u8oce1Oh0f6HBzrcgN5Fpi9wps3kMK_rV673tY/edit

Plans for Contributed Papers

Development of white papers

White papers can be submitted by anyone in the community, on a specific topic, or as a general overview, or anything in between.

For white papers submitted to other frontiers (or other topical groups within the Theory Frontier), we will happily take them into account in the TF07 topical group report

We expect a number of the LOIs to be extended into white papers.

In areas where we thought overview-style reports would be helpful, we have identified coordinators to lead the development of those white papers

Please let us know if you have additional suggestions for overview-style contributions or if you want to participate in one of the planned efforts!

Overview-style Contributions (1/5)

Development of white papers

Observables

- **Geometric strategies for collider data analysis**. Coordinator: Jesse Thaler (MIT)
- **Theoretical perspective on machine learning for data analysis**. Coordinator: Andrew Larkoski (Reed)
- **New developments in kinematic observables**. Coordinator: Doojin Kim (Texas A&M)
- **New kinematic representations of jets and events**. Coordinator: Tao Liu (HKUST)
- …

Overview-style Contributions (2/5)

Development of white papers

Calculations

- **Interface of theory calculations with experimental methods**. Coordinator: Simone Marzani (Genova)
- **Electroweak at very high energy and EW parton showers**. Coordinator: Tao Han (Pittsburg)
- **Needs and trends in QED resummation**. Coordinators: Stefano Frixione (Genova) and Eric Laenen (NIKHEF)
- **Higher order QCD calculations inspired by aspects of collider pheno** – This is a topic being explored but *no coordinator identified yet*
- …

Overview-style Contributions (3/5)

Development of white papers

Generators

- **NNLO+NNLL event generators**. Coordinator: Giulia Zanderighi (Munich)
- **First-principles simulations with machine learning**. Coordinator: Tilman Plehn (Heidelberg)
- …

Overview-style Contributions (4/5)

Development of white papers

Interpretation

- **Anomaly detection with machine learning**. Contact: David Shih (Rutgers) – To be developed under this LOI: https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF9_EF10-CompF3-028.pdf

- **Opportunities for theory studies with public collider data**. Coordinator: Matt Bellis (Siena)

- **Data preservation, recasting, and reinterpretation** — to be developed with CompF7

- **Fully differential likelihood techniques**. Coordinators: Kyle Cranmer (NYU), Felix Kling (SLAC)

- …

Overview-style Contributions (5/5)

Development of white papers

BSM Signatures

- **Ultra-exotics and forgotten signatures at colliders** – This is a topic being explored but *no coordinator identified yet*
- **Model dependent vs. model independent approaches** – This is a topic being explored but *no coordinator identified yet*
- …

Letters of Interest

Letters of Interest

Thanks to everyone who submitted an LOI! We hope many of these turn into white papers. They were also helpful in identifying areas where overview-style reports would be valuable.

Whether or not you submitted an LOI, we welcome additional contributions! Just let us know what you want to do so we know to anticipate your contribution.

For completeness, we provide the list of LOIs below (apologies for formatting and incomplete information), both ones where primary submission were to TF07 and where TF07 was secondary.

During the open discussion, you are welcome to expand on your planned contribution(s).

Letters of Interest (1/4)

LOIs (primary submission to TF07)

SNOWMASS21-TF7_TF0-CompF3_CompF0-086.pdf	Detecting New Physics as Novelty
SNOWMASS21-TF7_TF0-EF1_EF2-033.pdf	Portraying Double Higgs at the HL-LHC and Future Colliders
SNOWMASS21-TF7_TF0-EF1_EF4-CompF3_CompF0-048.pdf	CMB-Like Observable Scheme for Collider Searches
SNOWMASS21-TF7_TF0-EF1_EF4-CompF3_CompF0-049.pdf	Topological Aspects of Jets and Events at Colliders
SNOWMASS21-TF7_TF0-EF4_EF0-026.pdf	EW effects in very high-energy phenomena
SNOWMASS21-TF7_TF0-EF4_EF0-034.pdf	Electroweak parton distributions and fragmentations at ultrahigh
SNOWMASS21-TF7_TF0-EF4_EF0-AF4_AF0-046.pdf	Muon Collider Study of methods for the luminosity measurement
SNOWMASS21-TF7_TF0-EF9_EF0-039.pdf	Unexplored Landscape of Top-partner decays
SNOWMASS21-TF7_TF10-EF4_EF6_Quantum_tomography-062.pdf	Quantum tomography at the energy frontier
SNOWMASS21-TF7_TF11_Rojalin_Padhan-023.pdf	Low Mass Right Handed Neutrino at LHC and HL-LHC

Letters of Interest (2/4)

LOIs (secondary submission to TF07)

SNOWMASS21-EF10_EF0-CF1_CF0-TF7_TF0_Marietti-070.pdf	Feebly interacting Dark Matter at colliders and Early
SNOWMASS21-EF10_EF8-TF7_TF0-Comp52_Comp50_Kulkarni_Suchita-139.pdf	Long-lived charginos in the MSSM and beyond Thematic Areas (cid4) (EF08) BSM Model specific explora
SNOWMASS21-EF1_EF2-TF7_TF0_Ian_Lewis-222.pdf	Singlet Scalar Model Benchmarks for Di-Scalar Production
SNOWMASS21-EF1_EF2-TF7_TF0_Lucien_Heurtier-156.pdf	EF01, EF02 and TF07
SNOWMASS21-EF1_EF4-TF7_TF0-221.pdf	Electroweak Restoration at the LHC and Beyond Li Huang,1, ∗ Samuel D. Lane,1, 2, † Ian M.
SNOWMASS21-EF1_EF5-TF6_TF7-027.pdf	Precise predictions for Higgs pair hadroproduction
SNOWMASS21-EF2_EF0-TF7_TF0_Hidaka-063.pdf	Probing the quark flavour structure of New Physics by measuring the branching ratio of the decay h(
SNOWMASS21-EF2_EF1-TF7_TF0-058.pdf	New Physics in double-Higgs production at future
SNOWMASS21-EF2_EF1-TF7_TF0_Hanglei_Li-072.pdf	MSSM Under Higgs Factories
SNOWMASS21-EF2_EF1-TF7_TF0_ShuailongLi-082.pdf	2HDM under the Higgs and Electroweak Precision
SNOWMASS21-EF2_EF1-TF7_TF6-139.pdf	Muon Collider Study of Higgs couplings and self-couplings precision
SNOWMASS21-EF2_EF8-TF7_TF0-090.pdf	Exotic Higgs Decays in Type-II 2HDMs at Future 100
SNOWMASS21-EF2_EF8-TF7_TF8-138.pdf	Combined signatures of heavy Higgses and vectorlike fermions
SNOWMASS21-EF2_EF9-RF6_RF0-TF7_TF8_Claudius_Krause-226.pdf	Electroweak Symmetry non-Restoration and Delayed

Letters of Interest (3/4)

LOIs (secondary submission to TF07)

SNOWMASS21-EF3_EF1-	A detailed comparison of QCD modelling in pp → t¯tW ± production∗
SNOWMASS21-EF3_EF9-	Energy Peak and Its Implications on Collider Phenomenology Top Quark Mass
SNOWMASS21-EF4_EF1-	The Higgs Inverse Problem
SNOWMASS21-EF4_EF5-	EFT Analysis of the VVV process a for
SNOWMASS21-	Impact of the Electron Ion Collider on particle physics at the Energy Frontier
SNOWMASS21-EF5_EF7-	Generative, Explainable Artificial
SNOWMASS21-EF5_EF7-	Jets and Jet Substructure at Future Colliders
SNOWMASS21-EF6_EF3-	Constraining heavy flavor PDFs at hadron colliders
SNOWMASS21-EF6_EF5-	
SNOWMASS21-EF6_EF5-	The Femtography Project
SNOWMASS21-EF6_EF6-	New opportunities at the photon energy frontier
SNOWMASS21-EF6_EF7-	Heavy Flavors at the EIC
SNOWMASS21-EF6_EF7-	Hadronic Tomography at the EIC and the Energy Frontier
SNOWMASS21-EF8_EF0-	Composite Higgs Collider Signals and Electroweak Phase Transition

Letters of Interest (4/4)

LOIs (secondary submission to TF07)

SNOWMASS21-EF8_EF2-	Global fit of 2HDM with future collider results
SNOWMASS21-EF8_EF9-	Muon collider A window to new physics
SNOWMASS21-EF8_EF9-	Extended Warped Extra-Dimensional Models and Their Physics Opportunities at
SNOWMASS21-EF8_EF9-	
SNOWMASS21-EF9-	Model-independent searches for new physics in multi-body
SNOWMASS21-EF9_EF10-	Long-lived particle signatures at the energy frontier
SNOWMASS21-EF9_EF10-	A New Strategy for Unmasking Non-Minimal Dark Sectors at Colliders
SNOWMASS21-EF9_EF10-	Searching for the Stop-Bino Coannihilation Using CMS
SNOWMASS21-	
SNOWMASS21-RF5_RF0-	(NF2) Sterile neutrinos
SNOWMASS21-TF6_TF7-	QCD and PRECISION PHYSICS
SNOWMASS21-TF8_TF7-	The Strong Multi-Pole Interaction Scenario

Expression of Interest

EOI form https://docs.google.com/forms/d/e/1FAIpQLScs4QfrIyAcymVWE6CSnYp6QKA6xgpSrAR4rWLc9Ub1dBY1Vw/viewform

To further lower the barrier to getting involved, there is an “expression of interest” form where you can write just a few sentences about topics of interest, and whether you are already working on white papers

To give you a sense of the things people are thinking about, here are the current submissions that mention TF07

Expression of Interest (1/3)

EOI form (mentions TF07, could be primarily in other area)

Topic(s) of interest	If you are already working on one or more white papers, what are their topics? If they have working titles, please include them.
Extended scalar sectors at current and future colliders	EF/SNOWMASS21-EF9 EF2 Filip Zarnecki-158
neutrinos, lepton number violation, double beta decay, effective field theories, gravitational waves, baryon asymmetry, GUTs, left-right symmetric models	
axion physics: development of new models and phenomenology in recent years; particle production: application of particle production to particle physics model building, new cosmological models and observational signals (this may be incorporated in a broad white paper, e.g., TF09 early universe model building); gravitational probe of dark matter (e.g., Gaia) and implications for dark matter models and detection; future collider physics cases.	Prateek Agrawal, Anson Hook, Junwu Huang, Gustavo Marques-Tavares and I are planning to write a theory / model building oriented review of axion physics, perhaps including some discussion on phenomenological aspects which are relatively new and are hard to find in existing reviews.
Naturalness, Higgsino DM	
SMEFT, search design	Vision article for SMEFT, SMEFT fits including theory uncertainties
dark matter models and detection strategies	I've been in touch with Michael Peskin about adding something to the ILC motivation paper on sensitivity to scalar lepton partners.

Expression of Interest (2/3)

EOI form (mentions TF07, could be primarily in other area)

Topic(s) of interest	If you are already working on one or more white papers, what are their topics? If they have working titles, please include them.
I've mainly been working on dark matter physics, but my interests are broad.	
BSM cosmology, gravitational wave, collider physics relating to long-lived particles	(preliminary) Cosmological Constraints on Naturalness Models
Hierarchy problem, intensity frontier physics, AdS/CFT in the context of model building	
Leptoquark	
SMEFT LHC analyses, formal SMEFT development, composite dark matter, inelastic dark matter	Theoretical developments in the SMEFT at dimension-8 and beyond (TF06)
Axions, Phase Transitions, Gravitational Waves, Inflationary Cosmology, Primordial Non-Gaussianity	

Expression of Interest (3/3)

EOI form (mentions TF07, could be primarily in other area)

Topic(s) of interest	If you are already working on one or more white papers, what are their topics? If they have working titles, please include them.
Warped extra-dimensional/strongly-coupled BSM models. Generic Machine Learning methods relevant for new physics signals. Cosmological phase transitions in BSM models and their experimental implications. Model-independent classification of dark sectors, present experimental bounds, and ways to increase experimental sensitivity.	
	We are currently working on hhh final states at future colliders in BSM scenarios and their discovery prospects; paper should be out ~ end of the year. If possible we can briefly discuss this at the town hall meeting [but final results are pending].
All areas related to Standard Model (collider) precision phenomenology	
Nucleon matrix elements from lattice QCD	Nucleon matrix elements from lattice QCD

Open Discussion

Input on any topic is welcome! Raise your blue zoom hand and we'll call on you in order. You can alternatively use the chat.

E.g.:

- Do you have a white paper in the works that we aren't aware of?
- Are there topics you are working on that haven't been mentioned (or mentioned enough) thus far in the Snowmass process?
- Do you have ideas for overview-style contributed papers? Are you interested to lead an overview-style contribution?
- What themes do you want to make sure we highlight in our topical group report?
- Do you have blue sky ideas that you want to discuss today? (We blocked off time until 3pm Boston time)