# Prospects of Vector boson scattering at future colliders

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# Introduction

- Which future collider option maximizes the BSM physics potential for the VBS processes?
  - In LOI we proposed to try to answer this question
    - Collider options depending on manpower/interest  (high energy mu-collider, e-collider, p-collider)

1. Adopt the collider/detector scenarios endorsed by Snowmass community.

2. Agree on model parameter benchmarks (EFT dimension-6, dimension-8, GM model).

3. Explore the space of generator and collider process scenarios for model parameter sensitivity.

4. Introduce increasing experimental realism in detector performance and backgrounds.

5. Introduce increasing theoretical realism in signal and irreducible background estimation.

6. Provide comparative analysis of model parameter sensitivity.

# VBS at muon collider

- VBS at high energy muon colliders
  - mu-collider at few ~TeV is a high luminosity boson collider!
  - Production cross sections grow as logs while the corresponding s-channel decrease as 1/s
- Generated SM signal samples with WHIZARD (EFT samples will come next)
  - With and without beam ISR
- Will generate background samples and asses the sensitivity
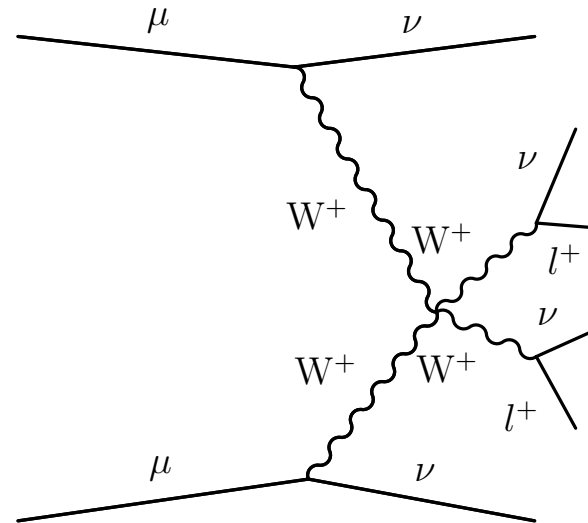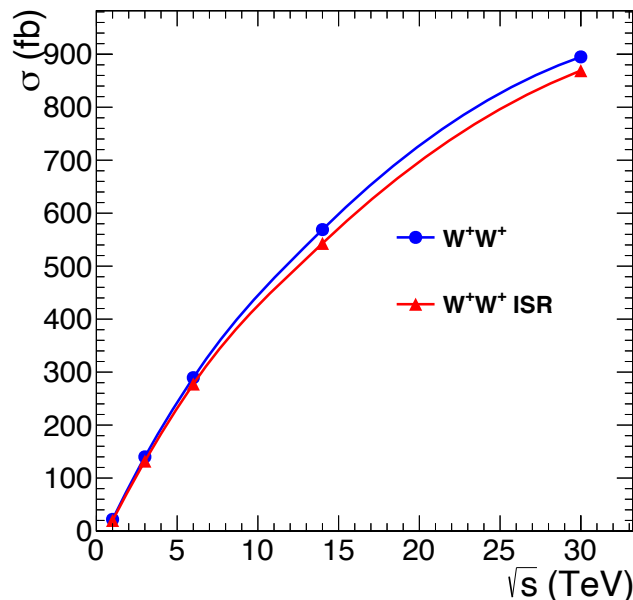
# Beam induced backgrounds

- Large amount of beam induced backgrounds from muon decays
  - Depends on beam energy and on the design of interaction region
  - High occupancy in the first layers of detector tracking system->need to asses the detector performance
    - Dedicated LOI #234 to study the performance of reconstructed objects in the presence of beam induced backgrounds



Credit: N V Mokhov
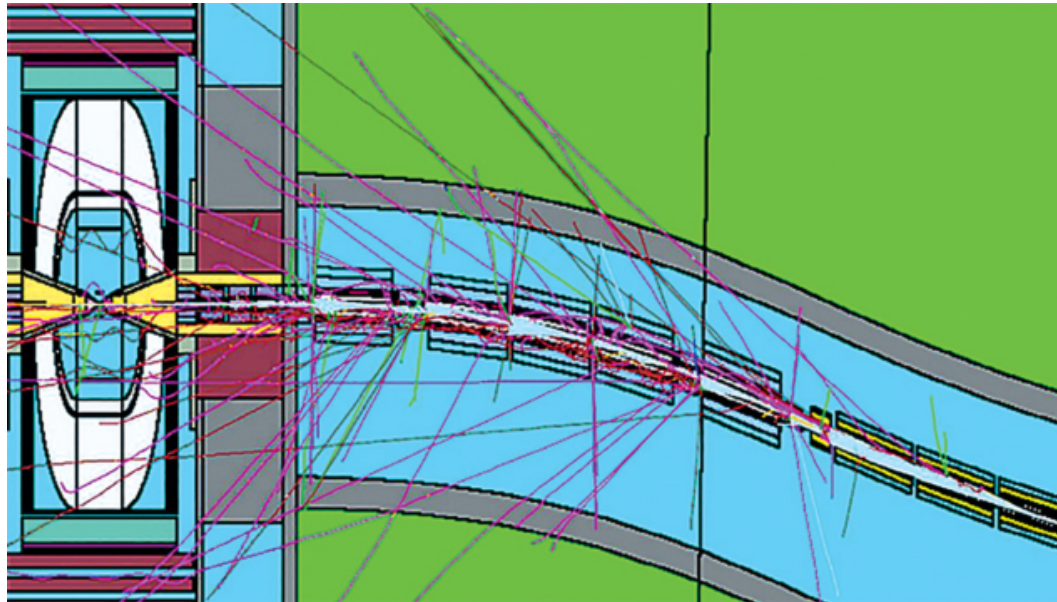
# Detector performance

- Plan to study the physics reach considering sqrt{s} = 6, 14, and 30 TeV

- Start with recent Delphes cards:
    - https://github.com/delphes/delphes/tree/master/cards/MuonCollider
    - https://indico.cern.ch/event/957299/contributions/4023467/attachments/2106044/3541874/delphes_card_mucol_mdi_.pdf
        - Hybrid of FCC-hh and CLIC cards
        - Includes target detector performance without BIB background effects
        - Impact of BIB background can be assessed by varying the parameterized performances around the target performance without BIB

# ADDITIONAL MATERIAL

# Georgi-Machacek model

- An example of BSM model that can be used as a benchmark
  - Production of singly and doubly charged Higgs bosons

$$\Phi = \begin{pmatrix} \phi_2^* & \phi_1 \\ -\phi_1^* & \phi_2 \end{pmatrix}, \qquad \Xi = \begin{pmatrix} \chi_3^* & \xi_1 & \chi_1 \\ -\chi_2^* & \xi_2 & \chi_2 \\ \chi_1^* & -\xi_1^* & \chi_3 \end{pmatrix}.$$

$$\sin\theta_H =: s_H = \frac{2\sqrt{2}\, v_\Xi}{v_{SM}}$$

- arXiv:1905.07445

- arXiv:2005.10289

CMS      35.9 fb$^{-1}$ (13 TeV)

- Observed
- Expected
- 68% expected
- 95% expected
- $\Gamma(H)/m(H) > 0.1$

$s_H$

$m(H_5)$ (GeV)

$\sigma$ [fb]

$\sqrt{s}$ [TeV]

$M_{H^{\pm\pm}} = 0.4$ TeV
$M_{H^{\pm\pm}} = 0.6$ TeV
$M_{H^{\pm\pm}} = 0.8$ TeV
$M_{H^{\pm\pm}} = 2$ TeV
$M_{H^{\pm\pm}} = 3$ TeV
$M_{H^{\pm\pm}} = 4$ TeV
H

11/06/20