Comprehensive References:

- The Muon Smasher's Guide
- Towards a Muon Collider

Collider Specifications

Source: Interim report for the International Muon Collider Collaboration (IMCC)

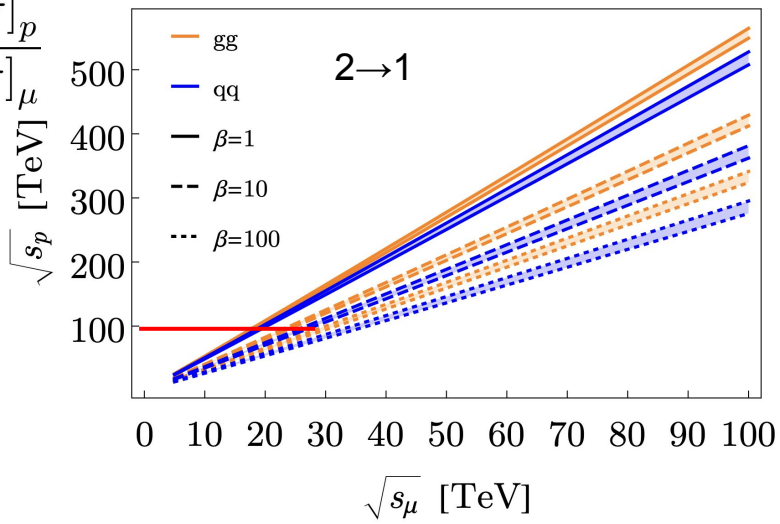
Parameter	Units	Energy Staging		Luminosity Staging	
		Stage 1	Stage 2	Stage 1	Stage 2
Center-of-mass energy	TeV	3	10	10	
Integrated Luminosity	ab^{-1}	1	10	10	
Number of Interaction Points		2		2	
Estimated Year for First Collisions		2049	2056	2049	2058
Time Running at Stage	years	5	5	8	4+
Wall Power	MW				
Accelerator Length*	km	26.5	Stage 1 + 45	72	
Future Upgrade Paths		N/A, upgrade would be far away in 2060+.			

* Sum of all accelerator components. Numbers from WIP Parameters Report.

Event Production

$$\beta = \frac{[\hat{\sigma}]_p}{[\hat{\sigma}]_\mu}$$

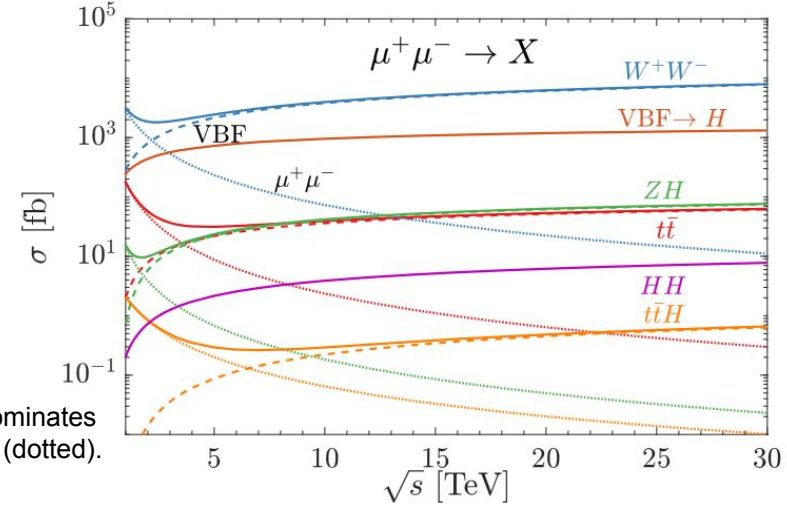
~10 for QCD vs EW production.



- Annihilation: Muon beams use entire energy in collisions (no PDFs).

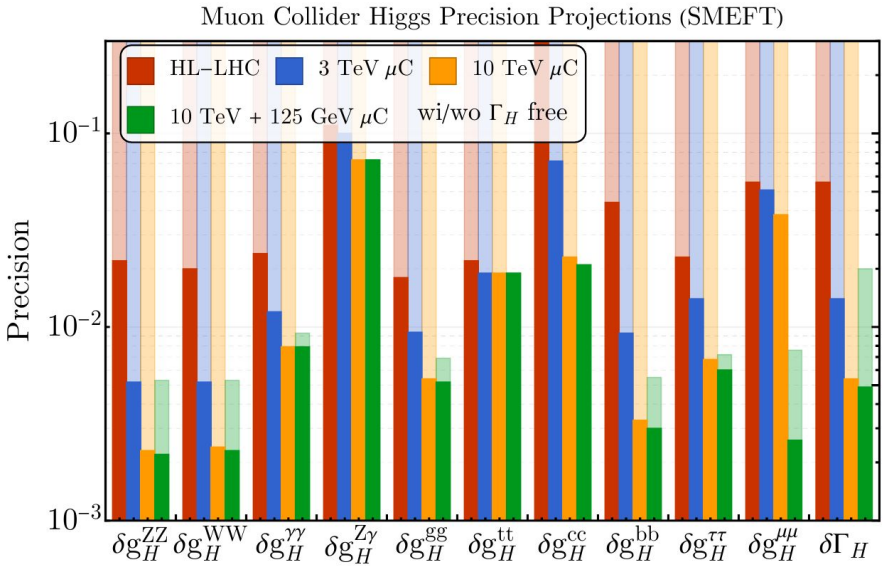
  100 TeV pp ≈ 10-30 TeV μμ

- VBF: primary production mechanism for most processes.
  - Allows to “scan” CM energies.
  - High cross-section for most processes.
  - Is a WW or γγ collider.
- Very low QCD backgrounds.
  - Clean *physics* environment.



VBF (dashed) dominates over annihilation (dotted).

Higgs Physics

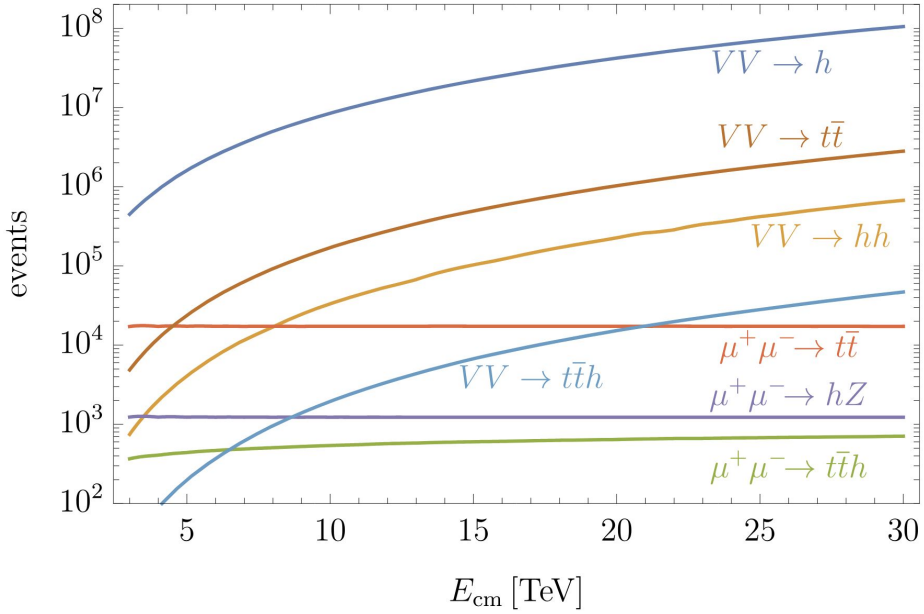


Orange is the proposed 10 TeV CoM μC.

Order of magnitude improvements to most couplings over HL-LHC.

Running at 125 GeV is not planned due to very high BIB (muons have very low Γ).

Main production mechanism is VBF.



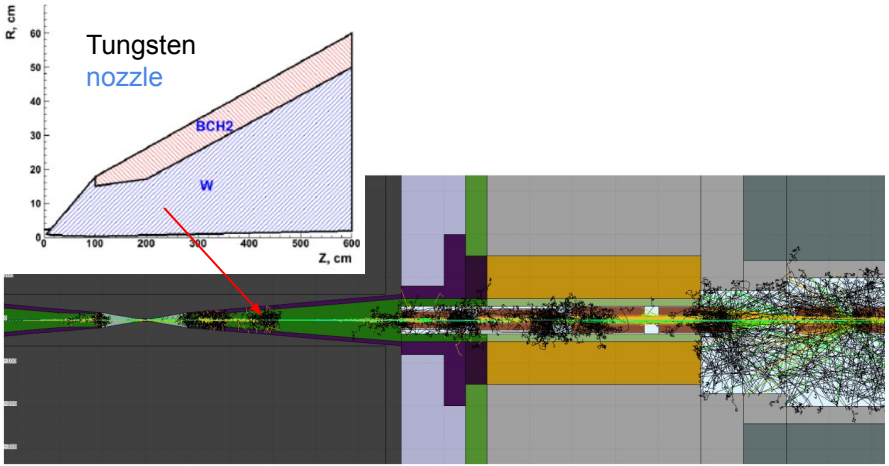
4% precision on Higgs Self-coupling sensitive to *SM Higgs potential shape*.

$$V(\phi) = \mu^2 \phi^\dagger \phi + \lambda (\phi^\dagger \phi)^2$$

Credit: R. Petrossian-Byrne, N. Craig

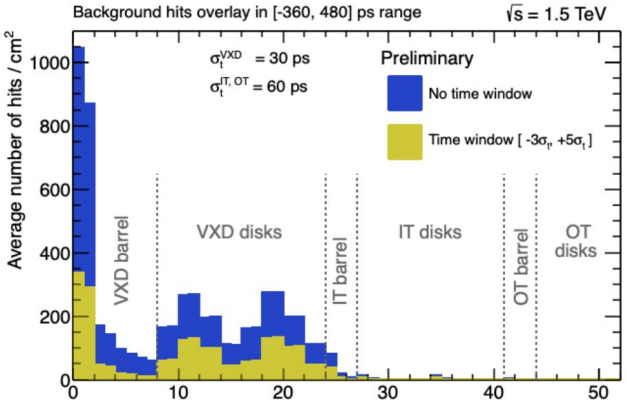
Beam Induced Background

- BIB = muon beam decays and strike the detector
- Main challenge for reconstruction and readout
- Two key mitigations
  - **10°** tungsten nozzle to shield from beam decay products
  - Precision timing information from detectors

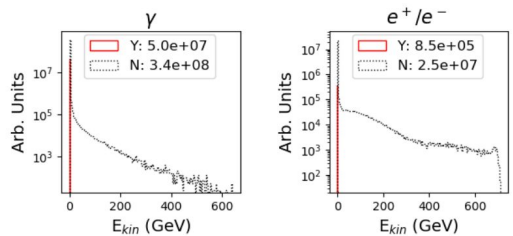


FLUKA simulation of BIB before reaching the detector.

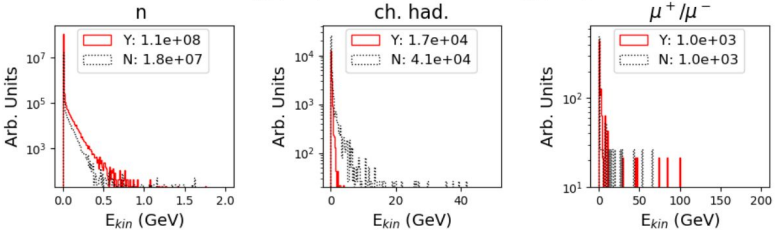
Tracker occupancy after timing cuts.



Tracker occupancy 10x that of HL-LHC!

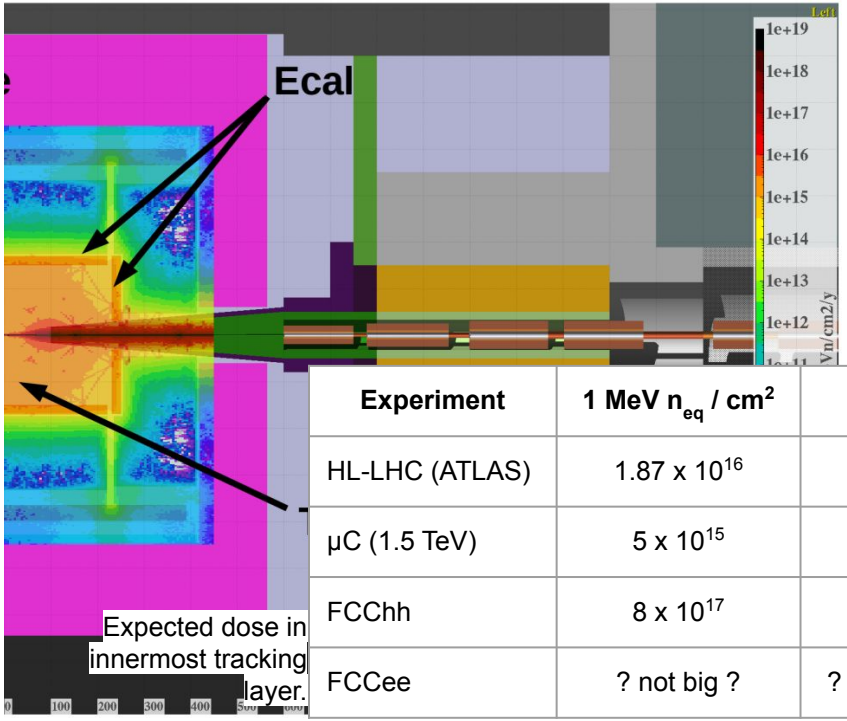


Particle energy spectra with (Y) and without (N) nozzle.



Detector Requirements

- High occupancy (10x HL-LHC), but low rad damage (1x HL-LHC) due to BIB.



Expected dose in innermost tracking layer.

Experiment	1 MeV n_{eq} / cm^2	GRad
HL-LHC (ATLAS)	1.87 x 10^{16}	1.268
μC (1.5 TeV)	5 x 10^{15}	0.05
FCChh	8 x 10^{17}	27
FCCee	? not big ?	? not big ?

ITk Layer Position at equivalent radii	ITk Hit Density [mm^{-2}]	MCC Equiv Hit Density [mm^{-2}]
Pix Lay 0	0.643	3.68
Pix Lay 1	0.022	0.51
Str Lay 1	0.003	0.03

Tracking detector comparison between μC and ATLAS ITk