

:: HPC-CN1-spoke2-WP1-b2 ::

:: Collider Phenomenology ::

***Flag and Parallel Usecases***

# Usecases :: Advanced Calculus for Precision Physics

1. Models & Diagrams

2. Amplitudes & Integrals

3. Cross Sections & Events

4. Physics at Colliders

5. Physics beyond Colliders

## *Flag Usecase*

Improvement & Interfacing  
available or work-in progress software/strategies  
[high-feasibility confidence-level]

## *Parallel Usecases*

Development of novel software/strategies  
[high-risk/high-gain]

# 1. Models & Diagrams

Tasks	Strategy	Software	Nodes
Automatic Diagram Generation	Model definition + Process selection + Diagrams generation for Elementary Particle Scattering: SM and EFT	Mad-Libraries; FeynRules; FeynCalc; FormCalc; Qgraf; Form; (xTensor); ...	UNINA, UNIBO, UNIPD

Tasks	Strategy	Software	Nodes
Automatic Diagram Generation	Model definition + Process selection + Diagrams generation in EFT-Gravity for Gravitational Wave Physics	EFTforPNG; work-in-progress	UNIPD

## 2. Amplitudes & Integrals

Tasks	Strategy	Software	Nodes
Integral Decomposition	Integration by parts Rational Reconstruction over Finite Fields	Litered; Reduze; Kira; FiniteFlow	UNIBO, UNIPD, UNINA
Integral Evaluation	Numerical evaluation of Feynman Integrals; Numerical solution of Differential Equations;	SecDec; AMFlow; DiffExp;	UNINA, UNIPD

Tasks	Strategy	Software	Nodes
Integral Decomposition	Intersection Theory based methods Rational Reconstruction over Finite Fields	work-in-progress	UNIBO, UNIPD
Integral Evaluation	Numerical evaluation of Feynman Integrals; Numerical solution of Differential Equations and parallel calculus; Advanced MC Integration and Topology-based methods;	work-in-progress	UNINA, UNIPD
Special Functions	High accuracy reconstruction/integer relations	PSLQ algorithm	UNIPD, UNIBO

### 3. Cross Section & Event Generation

Tasks	Strategy	Software	Nodes
Accelerating Event Generation	Improved parallelization and efficiency	Powheg Box, Geneva	UNIMIB
XSections and PDF	Improved numerical evaluation; data fits;	work-in-progress	UNICAL

Tasks	Strategy	Software	Nodes
Accelerating Event Generation	Porting to modern computing infrastructures, GPUs, and heterogeneous architectures	Powheg Box, Geneva	UNIMIB
XSections and PDF	Improved numerical evaluation; data fits;	work-in-progress	UNICAL

## 4. Physics at Colliders

Tasks	Strategy	Software	Nodes
Accurate Predictions for Collider Phenomenology	Parallelization on GPUs; Machine Learning techniques;	Madgraph	UNIBO, UNIPD
New Particles and Couplings	SMEFT effects in existing codes for Higgs and top-physics	work-in-progress	UNIPD

Tasks	Strategy	Software	Nodes
New Particles and Couplings	Codes for SMEFT effects at higher orders; Improved automation for hadronic production and decay of GeV scale particles	work-in-progress	UNIPD

## 5. Physics beyond Colliders

Tasks	Strategy	Software	Nodes
New Physics and Large Scale Structure	New physics effects in existing codes for LSS in standard cosmology; Markov Chain MC integration;	work-in-progress	UNIPD
Amplitudes and Gravitational Waves	Extension of Scattering Amplitudes evaluation from Particle Scattering to Gravitational Wave Forms	work-in-progress	UNIPD

Tasks	Strategy	Software	Nodes
New Physics and Large Scale Structure	New physics effects in existing codes for LSS in standard cosmology; Markov Chain MC integration;	work-in-progress	UNIPD