GEN Tutorial Part. I

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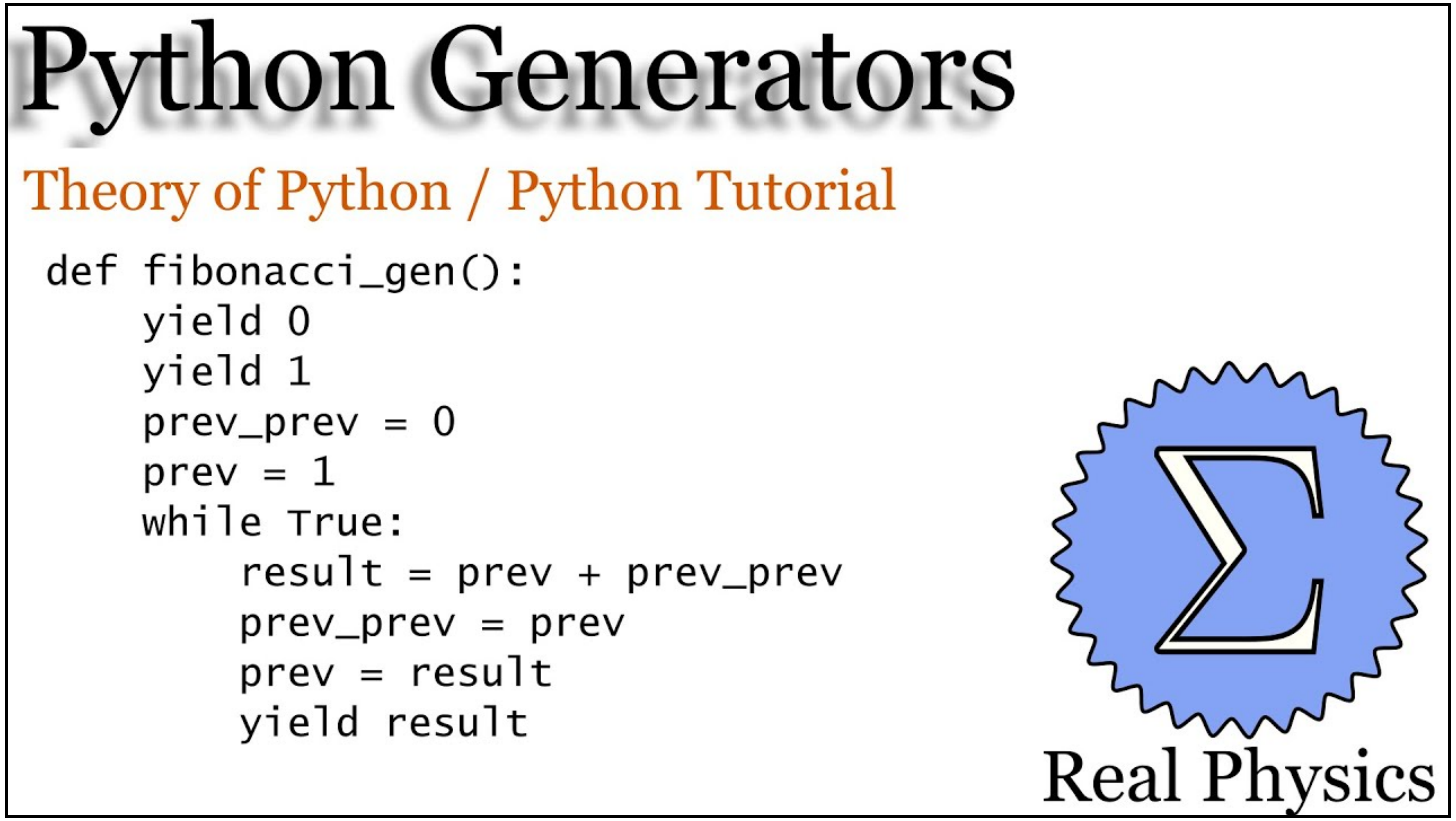
CMS China Winter Camp 2025

2025/01/18

WHAT IS A GENERATOR?

- As a hep-exer, a "generator" that you might hear from your friends could be:
  - A coding concept from your programmer friends



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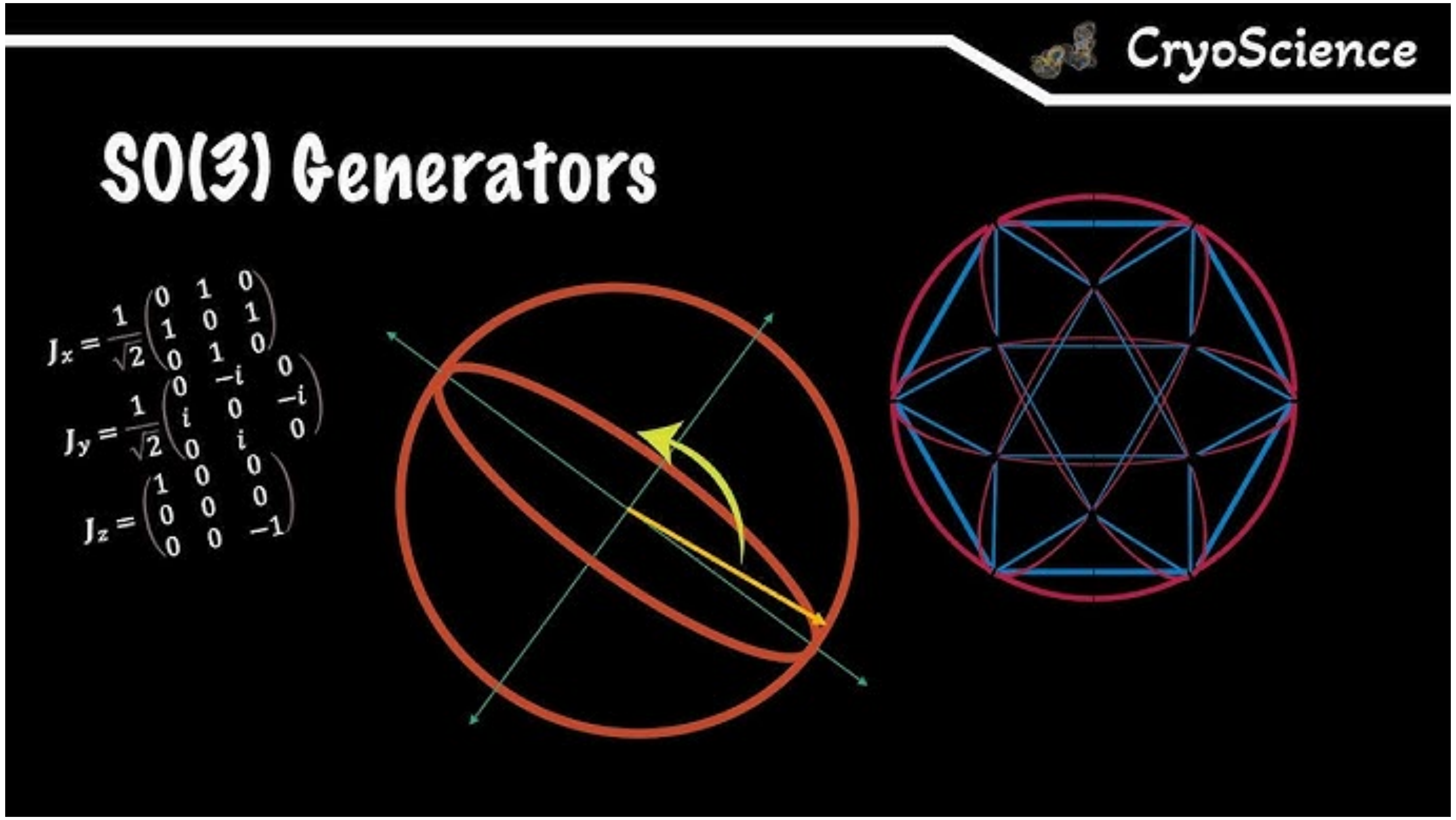

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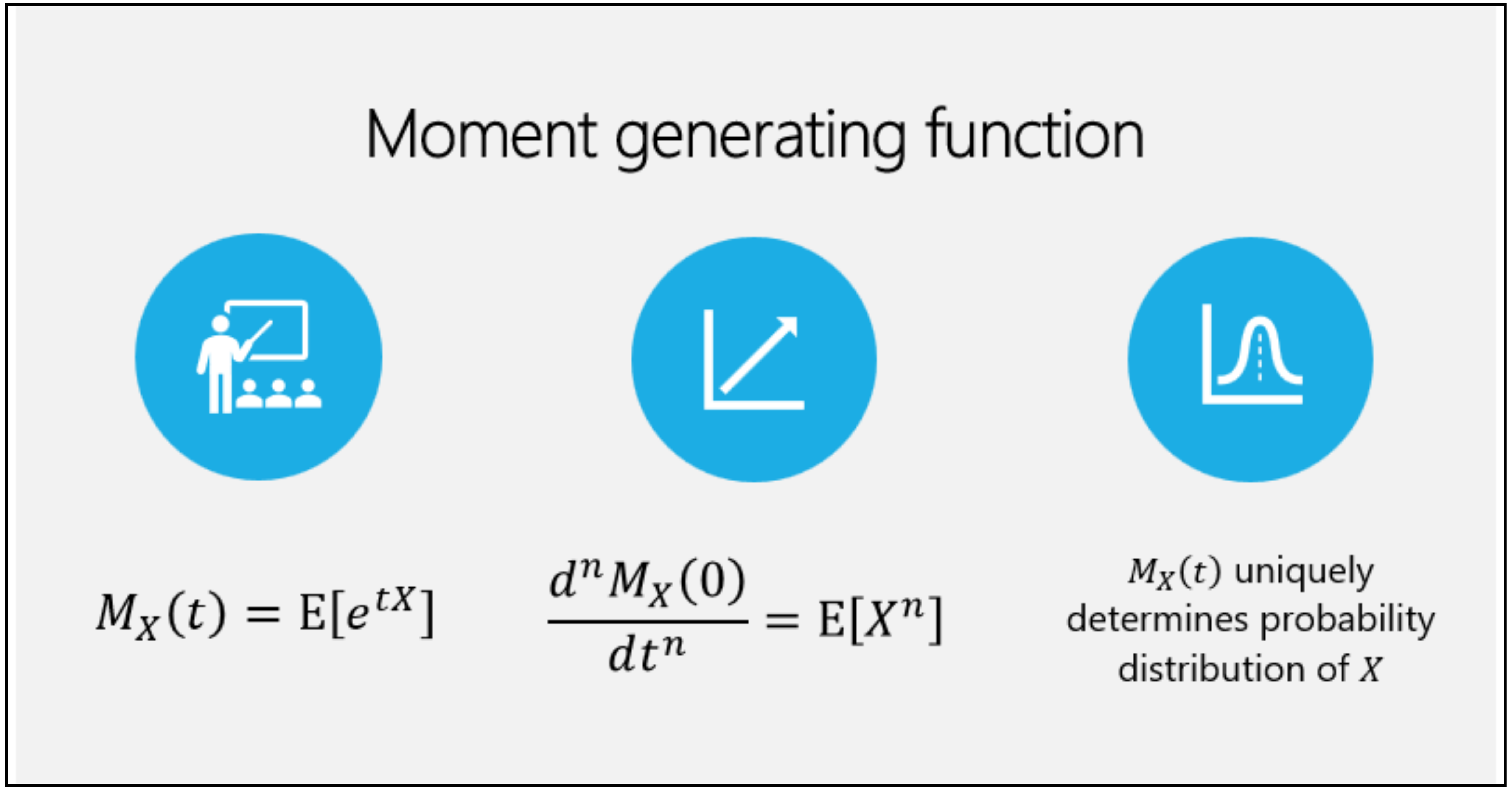

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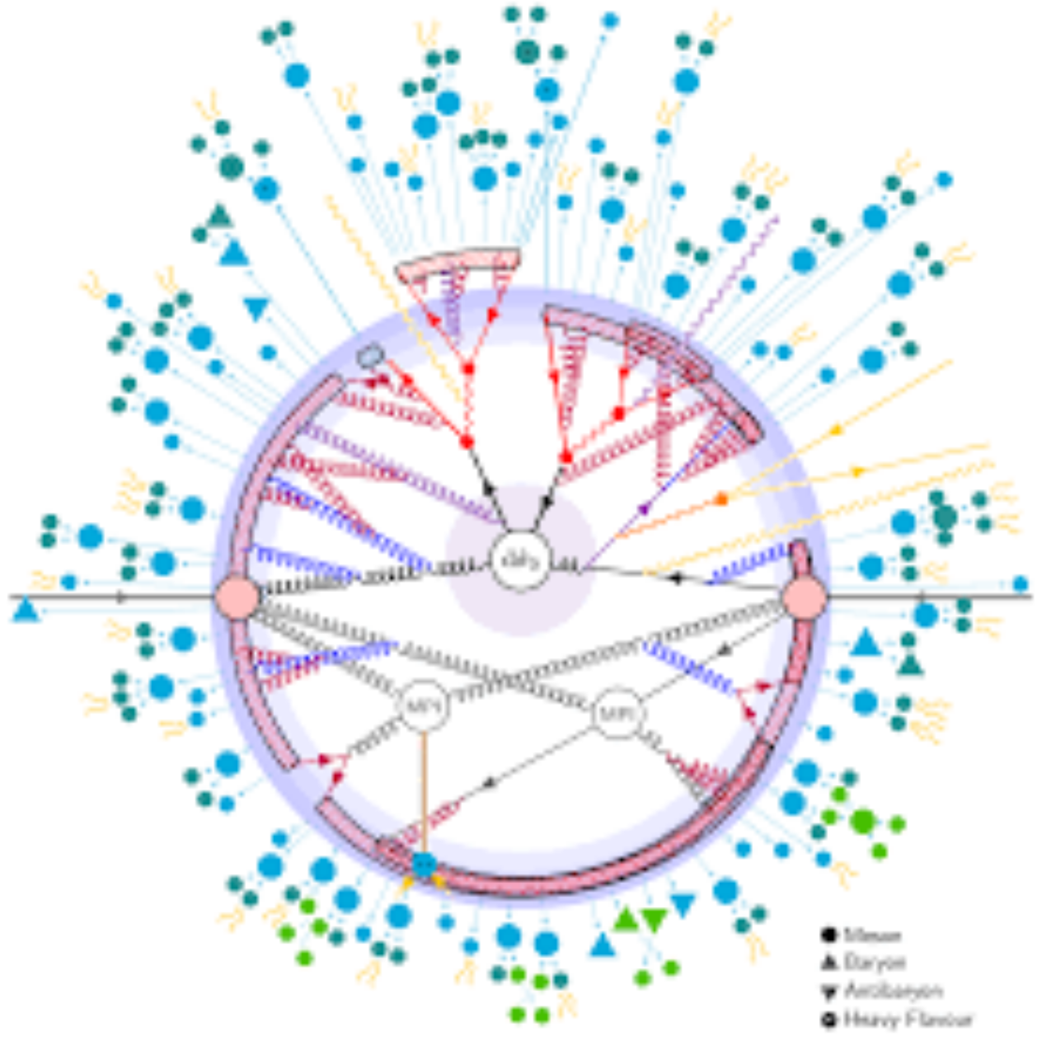
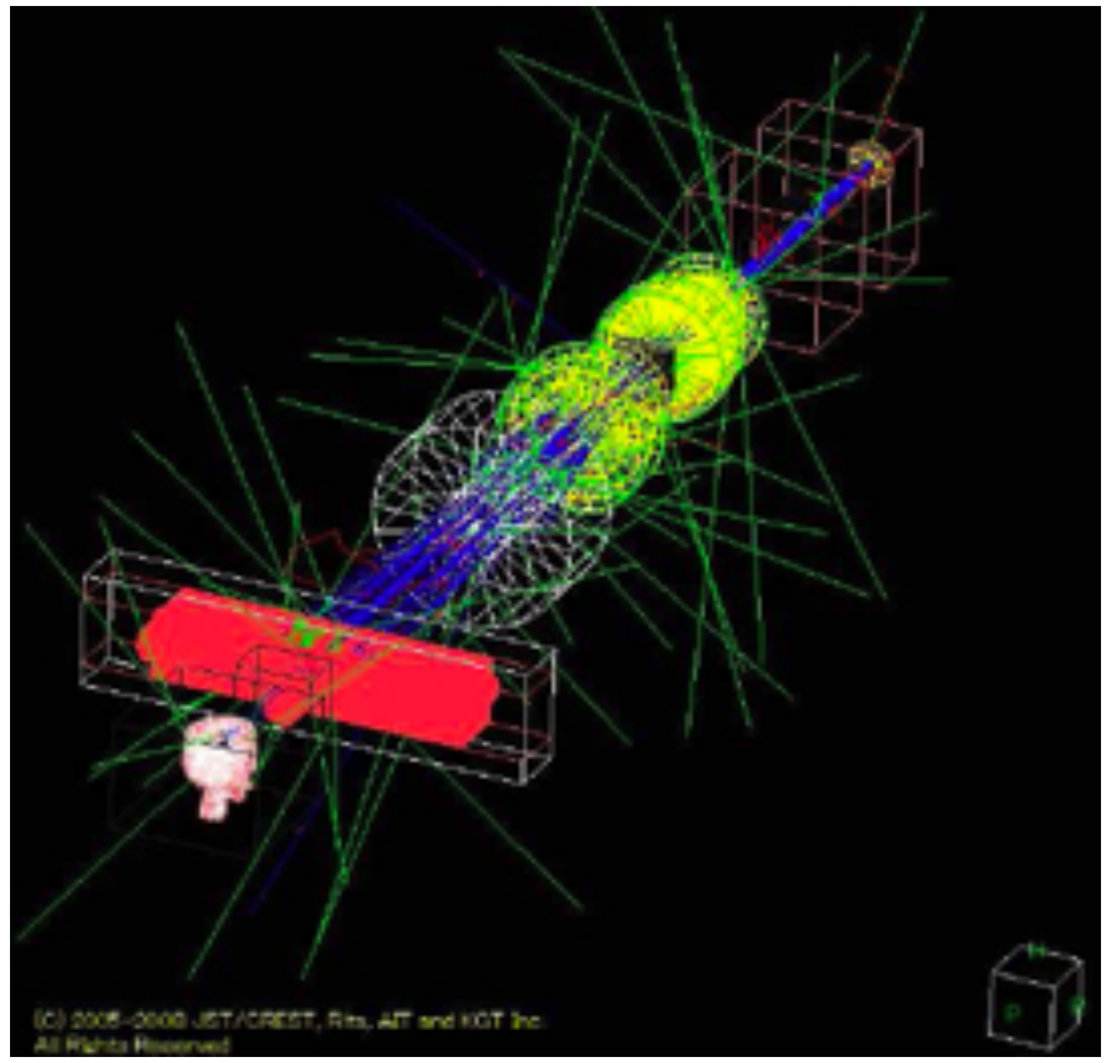
  - ~~A coding concept from your programmer friends~~
  - ~~A Lie group theory concept from your hep-th / hep-ph friends~~
  - ~~A statistics concept from your statistician friends~~
- Today, the “generator” you are going to play with is:
  - A tool (program) to generate events from certain (collision) physics events



N.B.

Very often generators (physics process provider) are discussed together with detector simulators as they both contributes to the Monte Carlo (MC) Modeling



What if a world without Generators?

- Higgs mass measurement is of course an import input to understand our universe
  - Vacuum stability, mass origin…

Code	Name	Status	PAS	PAPER	ARC	IRC
HIG-24-007 » I ▲show	H->gamma gamma mass measurement (full Run2)	PRE-APP			Philippe Gras (SACLAY)	NO IRC

HIG-24-007 (*Sat, 18 Jan 2025 00:38:52*)

Name	H->gamma gamma mass measurement (full Run2)	**Description**	Measurement of H mass with gamma gamma channel with full Run2 data, and combination with other channels
Status	**PRE-APP**	**Contact Person**	Fabio Iemmi (BEIJING-IHEP)
Twiki	HIG-24-007	**Forum**	PubTalk HIG-24-007
Data,Samples	DataSet: Run2 Samples: not set	**Conference**	
Target Date PreApp	28/06/2024	**Target Date PhysApp**	
Talks	Pre-Approval Talk » I No Approval Talk	**Actions**	Not in Edit Mode
Related Analyses	HIG-19-004	**Related CMS Notes**	AN-2020/217 I AN-2021/025
Physics Analysis Summary (PAS)			
ARC Chair	Philippe Gras (SACLAY)	**ARC**	**Accepted** I show *4 members*
PAS Actions		**PAS CDS id**	
PAPER			
Target Journal		**Target Date Pub**	
AuthorList	No AL available yet	**IRC**	No IRC yet
PAPER Actions		**PAPER CDS id**	
arXiv		**DOI**	
HepData		**Rivet Plugin tar file**	

- Now, Imagine yourself measuring higgs boson mass without event generators in its diphoton decay channel

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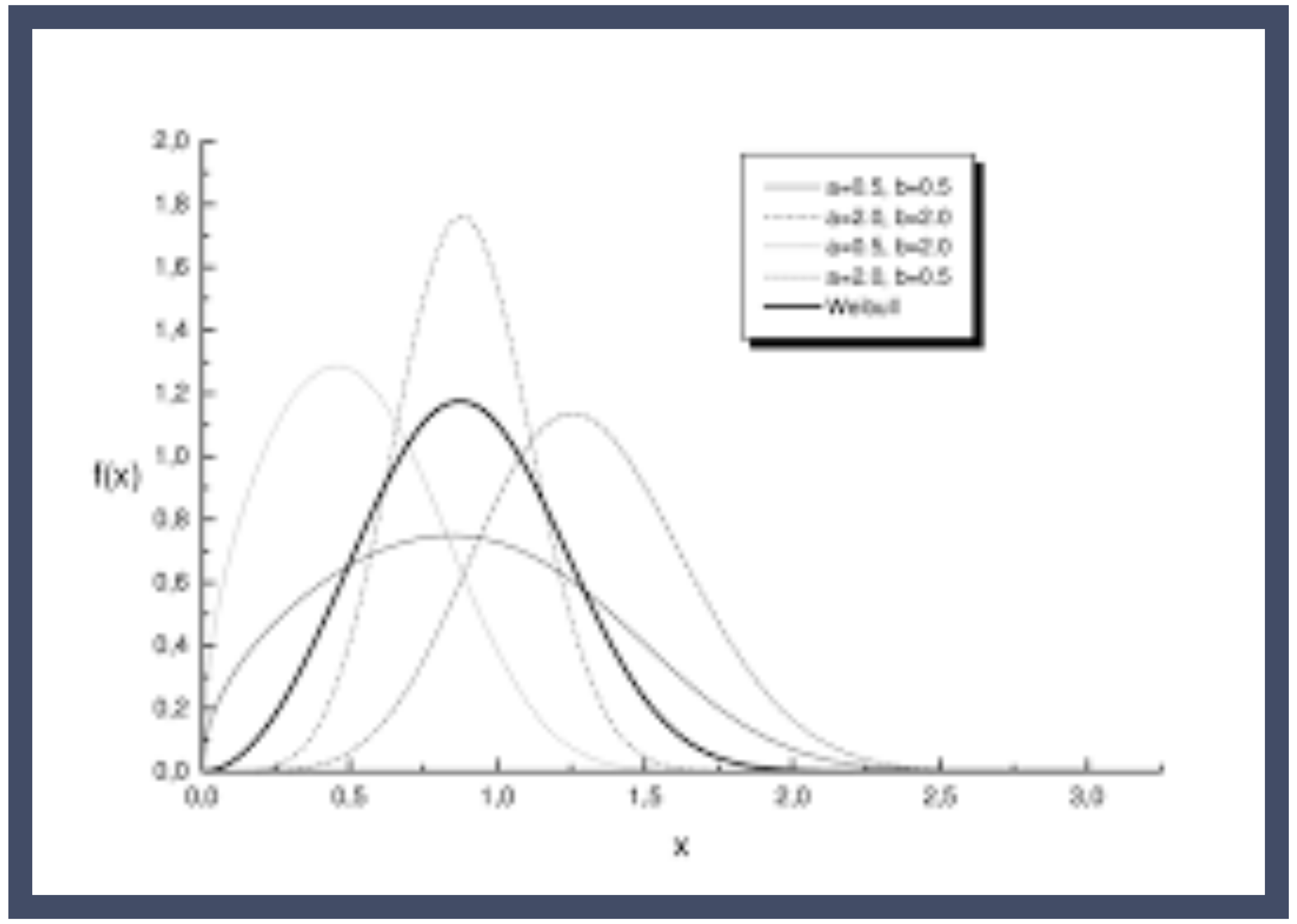

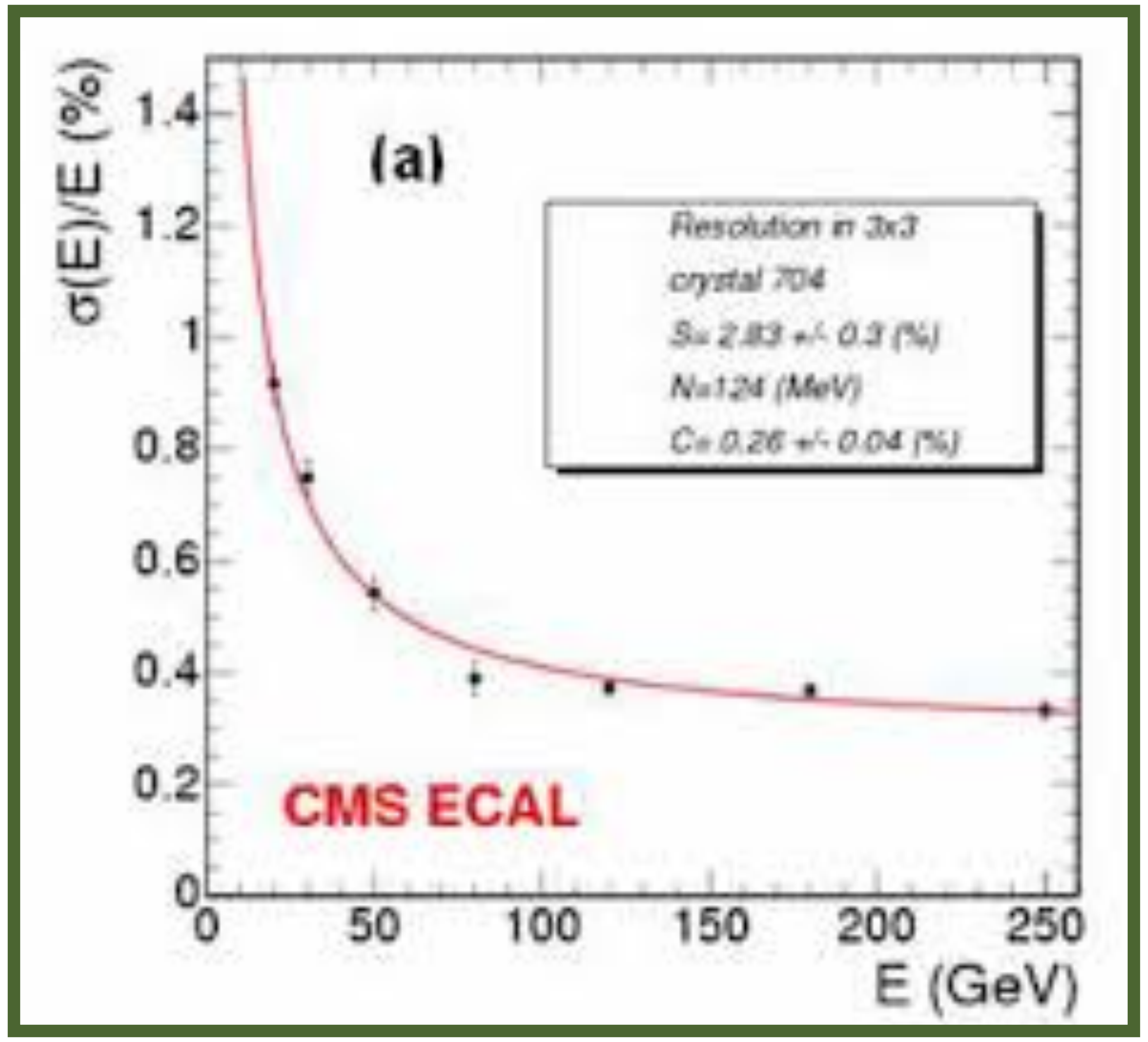

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  - ??All needs: Higgs BW shape + Detector photon resolution + pure higgs phase space??

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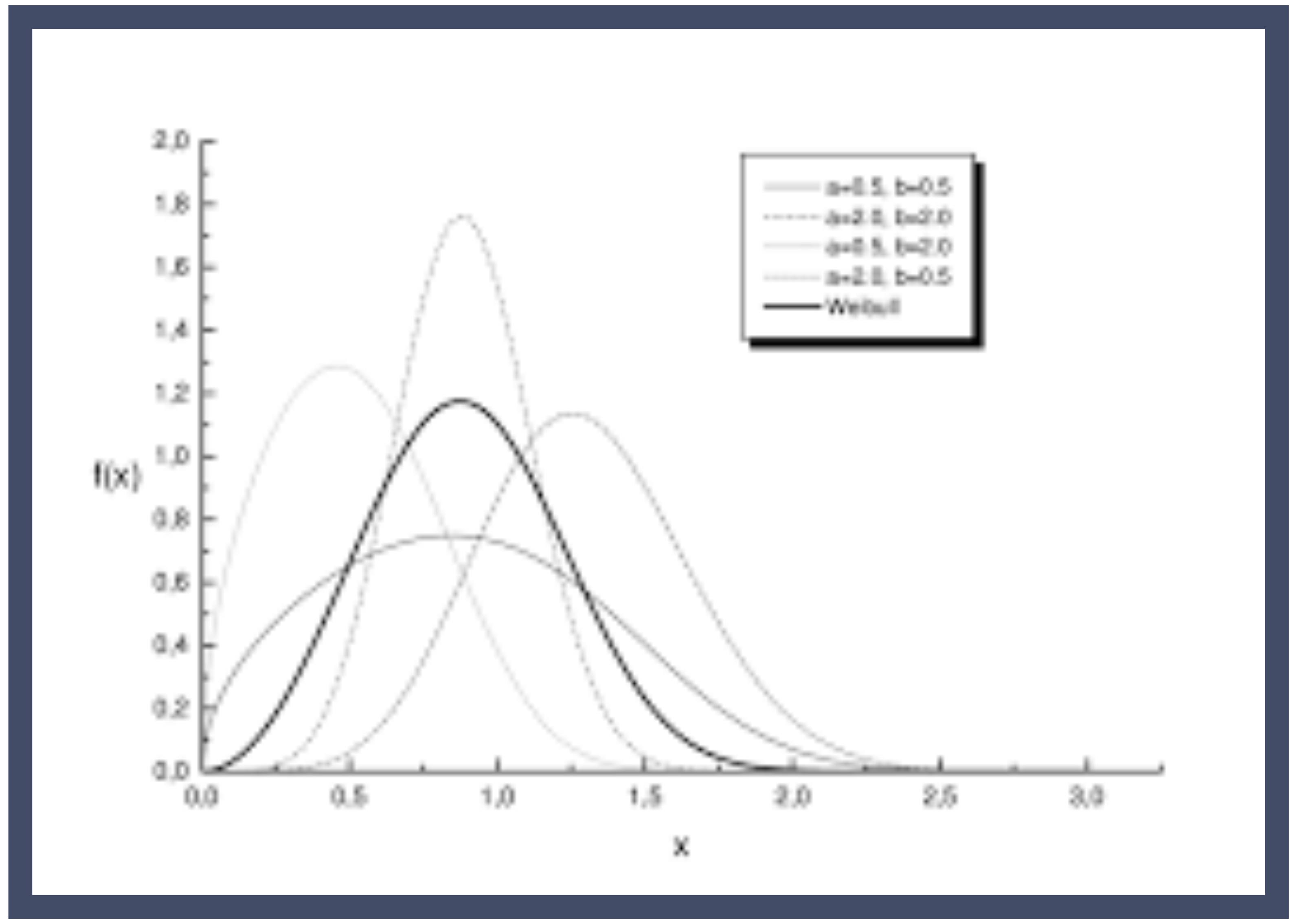

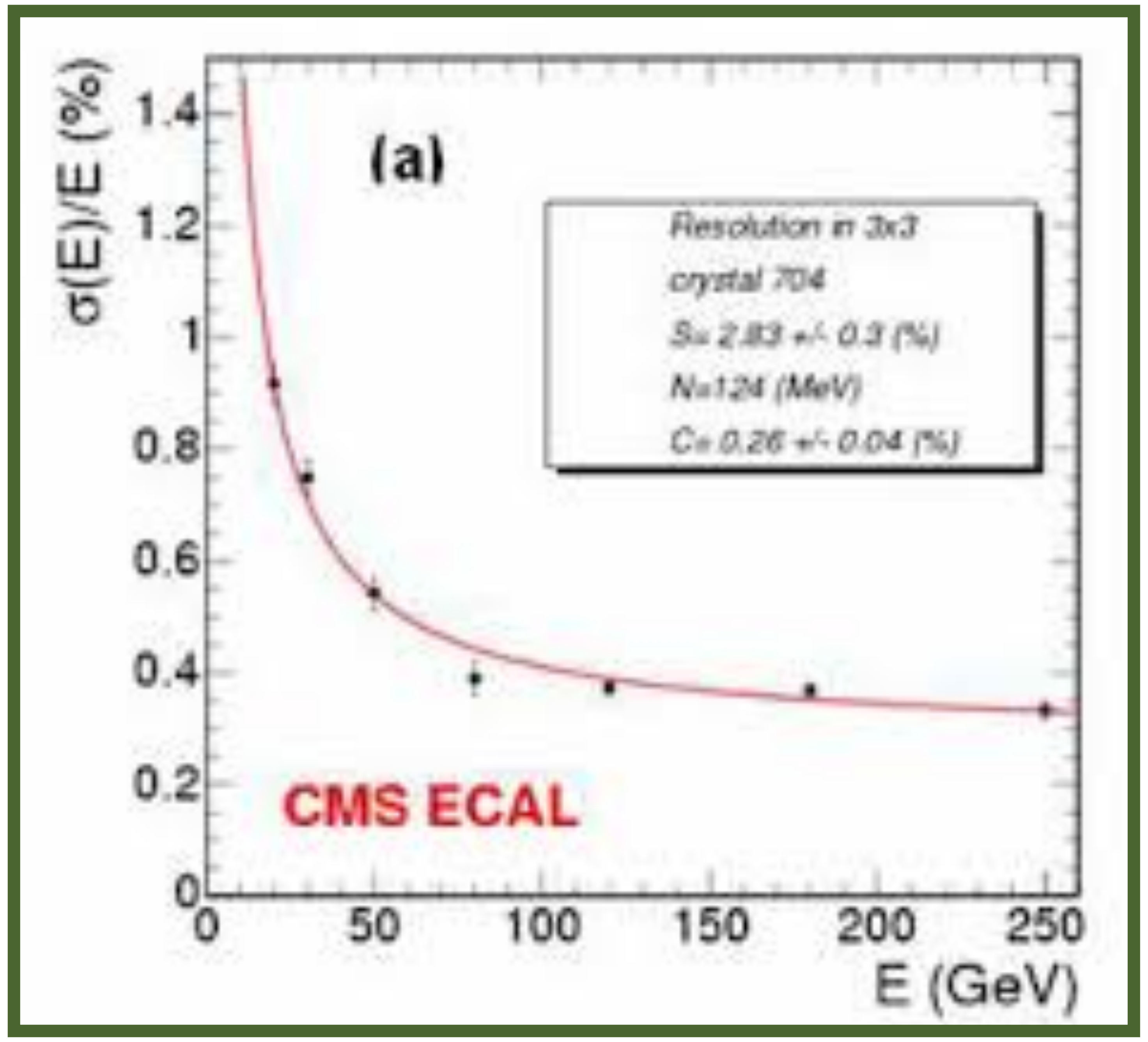

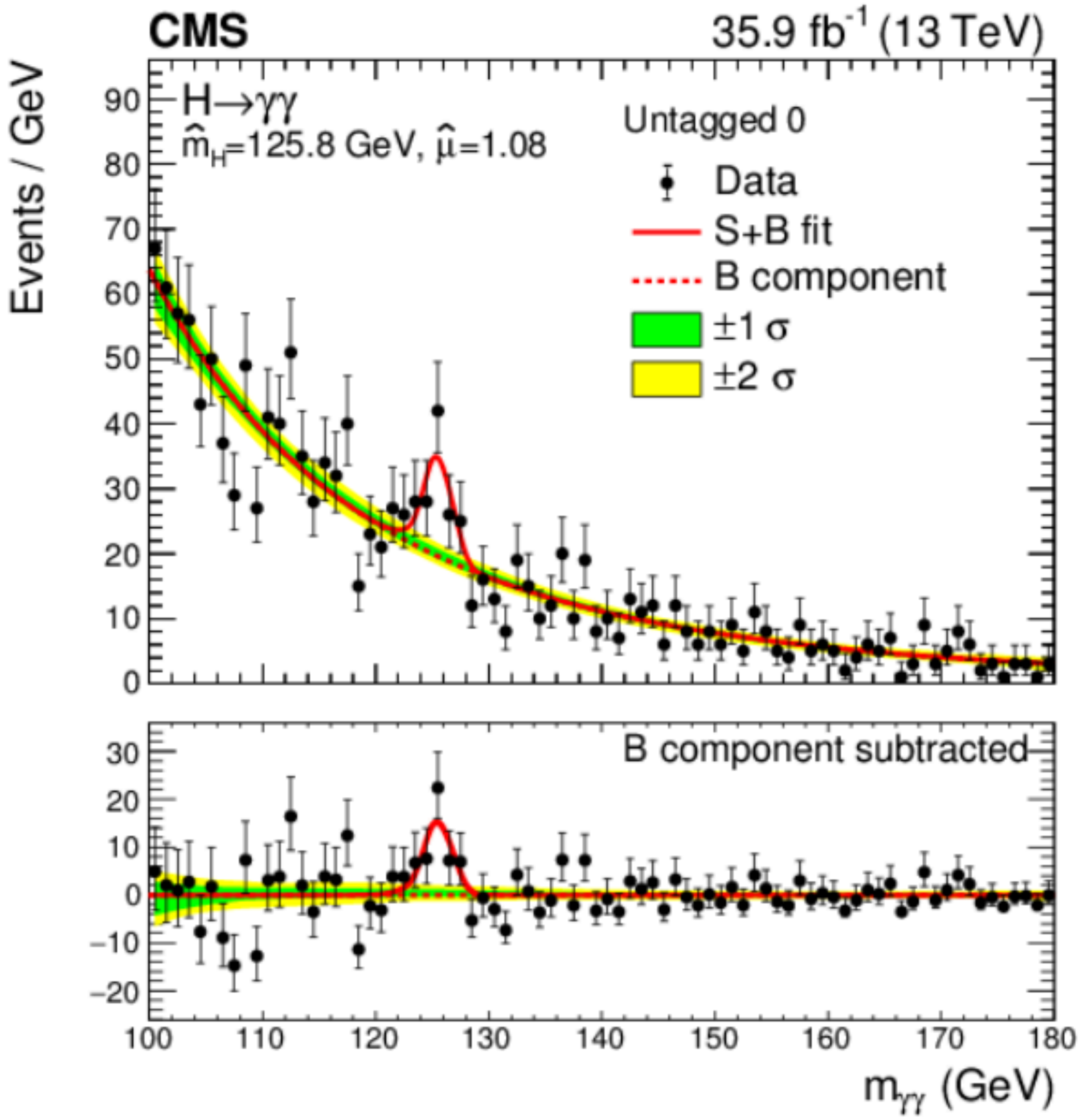

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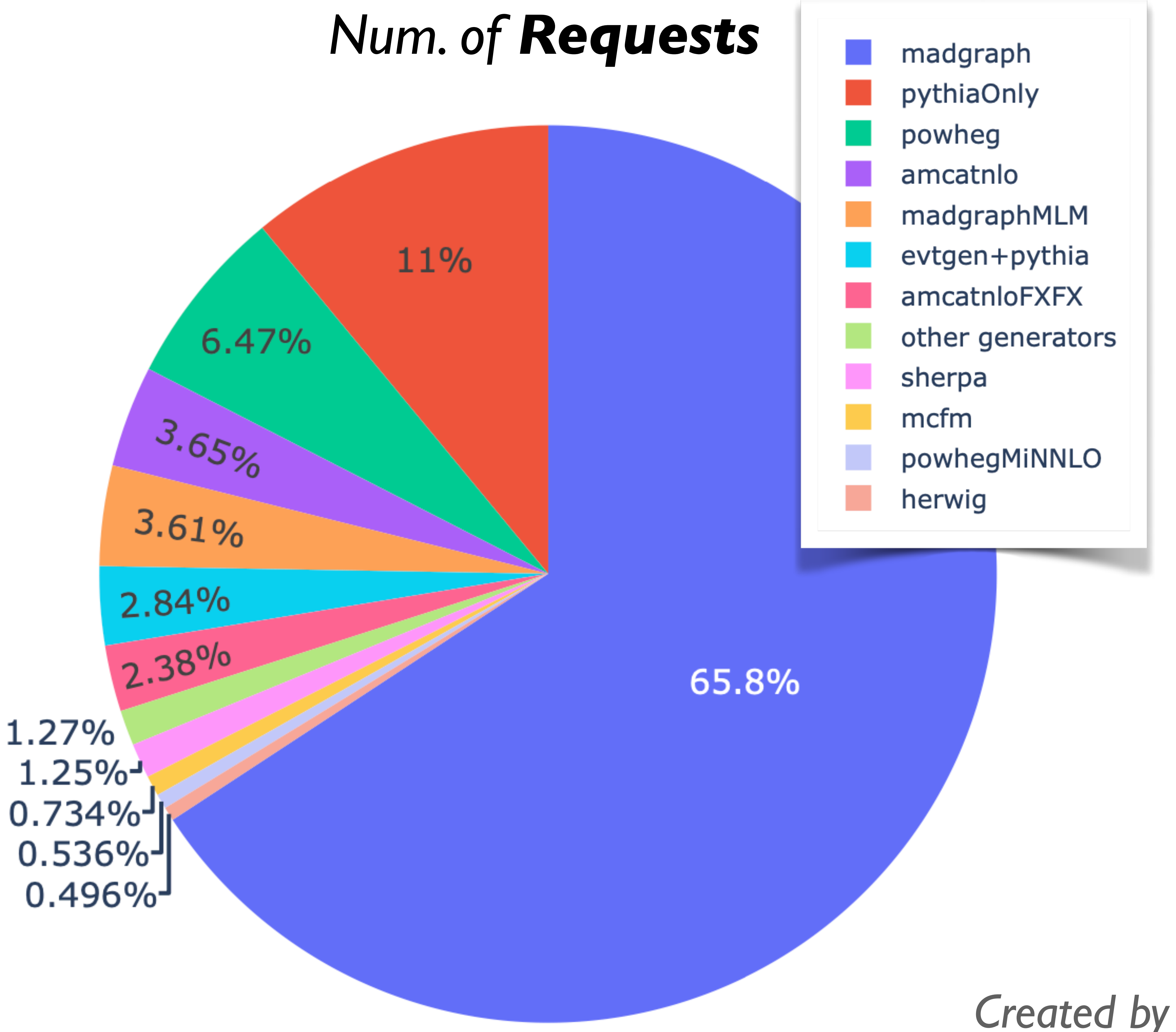
  - ??All needs: Higgs BW shape + Detector photon resolution + pure higgs phase space??
  - Yes, though it is not BW shape, detector res. Is complicated, and no perfect purity!

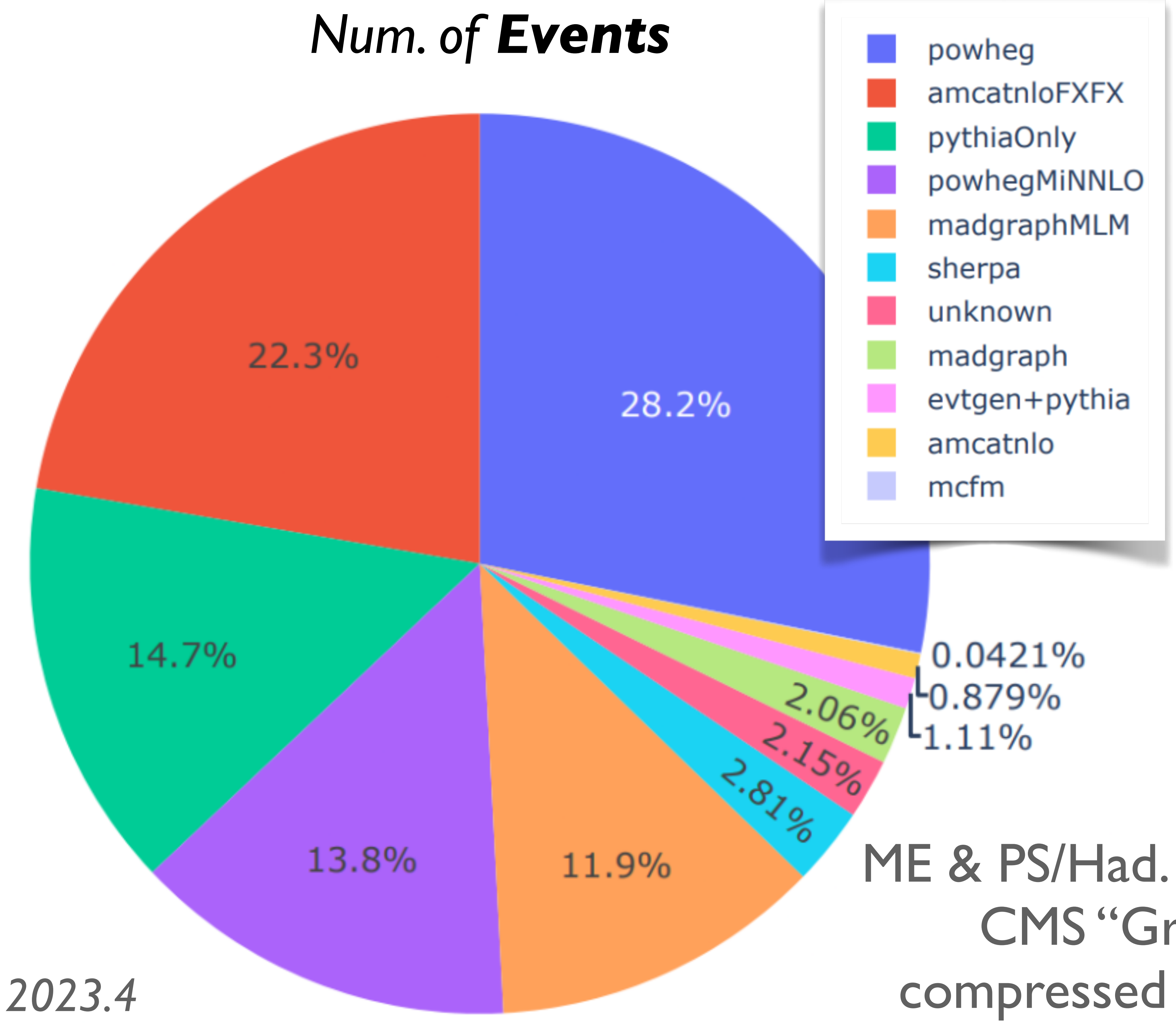
Luckily we have generators

- Higgs mass measurement is of course an import input to understand our universe
  - Vacuum stability, mass origin…
- Now, Imagine yourself measuring higgs boson mass without event generators in its diphoton decay channel
  - ??All needs: Higgs BW shape + Detector photon resolution + pure higgs phase space??
  - Yes, though it is not BW shape, detector res. Is complicated, and no perfect purity!
- Since we have generator:
  - We could model every time phase space related cuts/acceptance/efficiencies to model higgs shape
  - We could have properly modeled detector response modeled event by event
  - And we just need to simulate additional background processes :)

CMS Generator Usage: A glance from Legacy Run2 dataset

Generator (***Matrix Element*** modeling) usage breakdown based on legacy Run2 dataset
Pythia8 mostly chosen for ***parton shower*** and ***hadronization***





Created by 2023.4

ME & PS/Had. factorization:
CMS "Gridpack":
compressed tarball with
precompiled ME grids

Benefit a lot from the convenience of MadGraph!
More events calls for more sophisticated modeling (high order, jet merging…)!

So:

- This tutorial will be focused on MG
  - For its wide usage
  - For its user friendly design
  - For me as CMS MG5 contact :)
- Please check out this gitlab repo, and login into lxlogin server!

MadGraph5_aMC@NLO

Overview | Code | Bugs | Blueprints | Translations | Answers

Registered 2009-09-15 by Michel Herquet

MadGraph5_aMC@NLO is a framework that aims at providing all the elements necessary for SM and BSM phenomenology, such as the computations of cross sections, the generation of hard events and their matching with event generators, and the use of a variety of tools relevant to event manipulation and analysis. Processes can be simulated to LO accuracy for any user-defined Lagrangian, an the NLO accuracy in the case of models that support this kind of calculations -- prominent among these are QCD and EW corrections to SM processes. Matrix elements at the tree- and one-loop-level can also be obtained.

MadGraph5_aMC@NLO is the new version of both MadGraph5 and aMC@NLO that unifies the LO and NLO lines of development of automated tools within the MadGraph family. It therefore supersedes all the MadGraph5 1.5.x versions and all the beta versions of aMC@NLO. As such, the code allows one to simulate processes in virtually all configurations of interest, in particular for hadronic and e+e- colliders; starting from version 3.2.0, the latter include Initial State Radiation and beamstrahlung effects.

The standard reference for the use of the code is: J. Alwall et al, "The automated computation of tree-level and next-to-leading order differential cross sections, and their matching to parton shower simulations", arXiv:1405.0301 [hep-ph]. In addition to that, computations in mixed-coupling expansions and/or of NLO corrections in theories other than QCD (eg NLO EW) require the citation of: R. Frederix et al, "The automation of next-to-leading order electroweak calculations", arXiv:1804.10017 [hep-ph]. A more complete list of references can be found here: http://amcatnlo.web.cern.ch/amcatnlo/list_refs.htm

THANKS!