# Upgrade and Design of the Pluto Event Generator

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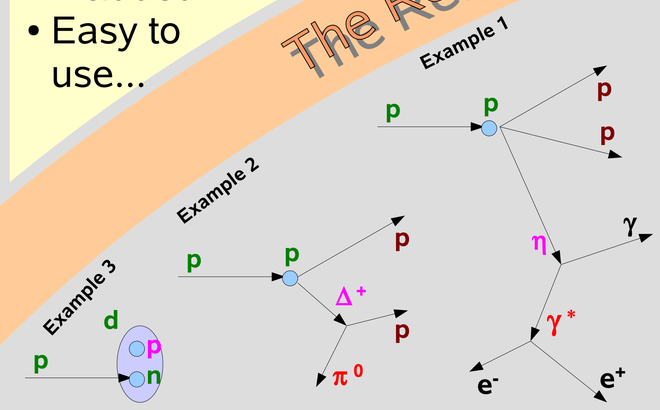
## Motivation & Purpose

- Fast tool for simulation of hadronic interactions
- For experimental setup design & beam time proposals
- Detector performance & sensitivity studies
- Comparison of results with different models
- Model-dependent acceptance corrections

## Design Features

- Object-oriented, modular, flexible, extensible
- Only based on ROOT, various models included
- Easy to use...

## The Reaction




## User Macro

- Single macro for configuration & production
- User-friendly syntax and interface

```
Example 1:
PReaction my_reaction(3.13,"p","p","p p eta [dilepton [e+ e-] g]", "eta_dalitz");
my_reaction.Print();
my_reaction.Loop(10000);

Example 2:
PReaction my_reaction(3.13,"p","p","p D+ [pi0 p]", "delta");

Example 3:
PReaction my_reaction(3.13,"p","d","p n p", "quasi_elastic");
```

Beam momentum · Beam (proton) · Target (proton) · Decay cascade · Filename · Information about the decay steps & models · Number of events · Spectator

More detailed definitions can be done in the macro if needed

## Distribution Manager

- User interface to select (alternative) models or disable build-in physics

```
Example: Print included "eta_physics"
makeDistributionManager()->Print("eta_physics")

Group name
eta_physics
...
[X] pp_eta_prod_angle      Eta polar angle in pp reactions
...
makeDistributionManager()->Disable("pp_eta_prod_angle");
```

Unique identifier · Description

**Enable/Disable**

```
Re-usability of distributions
(with different parameters):

Example: new angular
distribution in
a (dummy) decay "x->y1+y2":

PAngularDistribution xx("xx");
xx->Add("y1,daugther,primary");
xx->Add("y2,daughter");
xx->Add("x,parent");
makeDistributionManager->Add(xx);
```

**Add**

```
gSystem->CompileMacro("MyModel.C");
```

**Compile** · **Link**

```
MyModel("xx@x_to_y1_y2/tcross","My model");
```

Identifier · Decay string · Model ID · Description

### Distributions

- Sample generated particles:
- Angular distributions
- Masses
- Correlations
- Different reference frames

### User Models

- Added inside macro
- No recompilation of framework needed
- Parser for data base link

## Data Base & Interface Classes

The hidden kernel

- Keep models
- Particle & decay data base
- Flexible and extendable
- Models work like "lego" pieces

### Example

- Recursive calculation of Breit-Wigner resonances

**Mass sampling** → **Breit-Wigner model**

**Mass dependent decay widths** → **Breit-Wigner model**, **Decay widths models**

$$g(M) \sim \frac{M^2\,\Gamma^{tot}(M)}{(M^2_R - M^2)^2 + M^2\,(\Gamma^{tot}(M))^2}$$

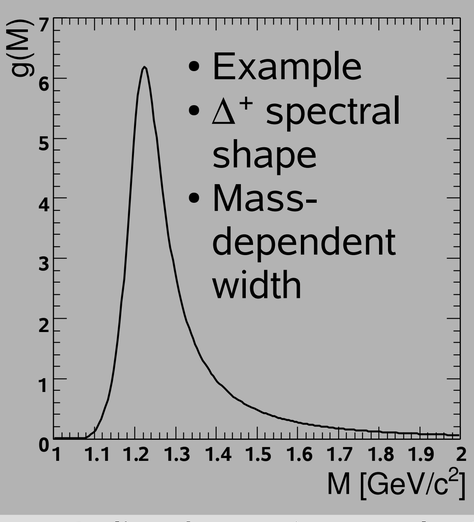
$$\Gamma^{tot}(M) = \Sigma\ \Gamma^k(M)$$

**Decay widths models**
**e.g., 1/2 unstable hadrons, $e^+e^-$ direct & Dalitz decays**

**„Secondary“ models**
**Cross sections, Form factors, Generators, ...**

- All values and models are created in background and the data base is filled.
- Predefined models may be exchanged/supplemented by user defined models.

**User Models**




- Example
- $\Delta^+$ spectral shape
- Mass-dependent width

## Bulk Interface

- Change/add particles before/after decay
- *Examples:*
  - Bulk decays: 3rd party event generators, Pluto: mass-dependent resonance decay
  - Embedded particles: detector studies
  - Histogram projector: fast batch language

```
Analyze the Example 2:
AddHistogram("_x=([p,1]+[pi0])->M2();
              _y=([p,2]+[pi0])->M2()");
```

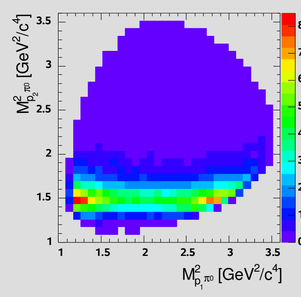
Composite · Axis values · PID & order · Method (here: mass squared) · Dalitz plot

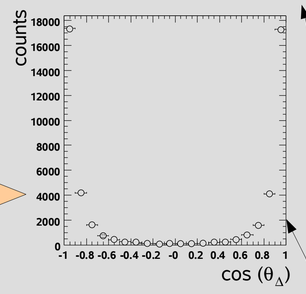
```
AddHistogram("delta=[D+];
              delta->Boost([p + p]);
              _x=cos(delta->Theta())";
```

Boost (here: into reaction c.m. framw) · Δ+ polar angle

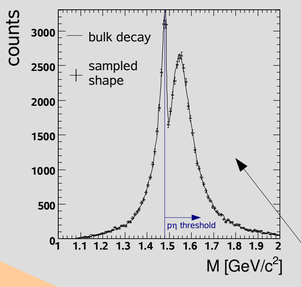
More complicated rotations, boostings etc. are possible

- Decay manager for cocktails




N*(1535) ⟶ Nπ



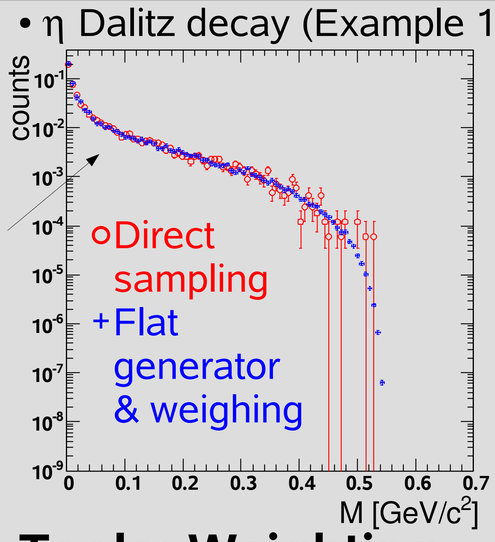

## Selected cases

- η physics
  - η Dalitz decay: VMD form factor[1] & helicity angle[2]
  - $\eta \to \pi^+\pi^-\pi^0$: matrix element[3]
  - ppη reaction plane alignment[4]
- Δ physics
  - Partial wave in boson exchange frame[5]
  - Mass-dependent width[6]
  - Strong forward/backward peaking[7]
- Mass sampling
  - Sampled shape with partial decay width

  *vs*
  - Bulk decay

  ➔ Consistent

- η Dalitz decay (Example 1)




### Tools: Weighting

- Separation of generator & physics model
- better statistics in low population regions

### Tools: Sampling

- Fast sampling method based on adaptive meshs
- Multi-dimensional sampling (e.g. folding of fermi motion with NN cross section)

## File Output

- Interface class
- Adaption to user format

## Digitizer

- ...but allows for a lot of customizations:
- User-defined models
- New particles & decays
- Distribution Manager
- Interface to particle data stream
- Embedded particles
- Histogram projector


## Outlook

- Keep/extend user friendly interface
- Collect different standard sets of models
- Container for model parameterizations
- Plugins for different detector groups
- Interface to transport code files
- Extend weighting support
- *A simulation framework for hadronic interactions and detector studies*

work supported by the Hessian LOEWE initiative through HIC for FAIR

References:
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