Summary: Monte-Carlo Tutorial

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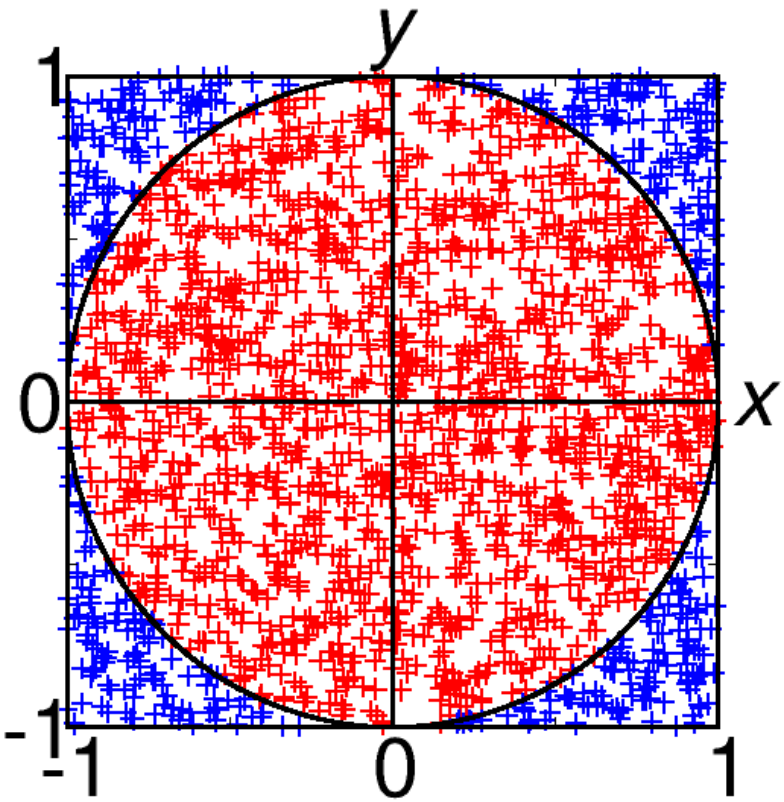
What is Monte-Carlo Simulation?

- Computational algorithm that relies on repeated random sampling to compute its result

Example: Calculate π



- Random sampling of points in box
- Box area: 4
- Circle area: π
- $\curvearrowright$ Probability for hit: $\pi/4$

Herwig++

- Monte-Carlo based tool for computing events at particle colliders
- Great flexibility regarding particle content (even SUSY) and accelerator properties
- What we did:
  - Simulate Drell-Yan events: $q\bar{q} \to (Z, \gamma) \to l\bar{l}$ at LHC and Tevatron

Drell-Yan Eventlog

```
[NEW] | 1 |
 1 -- Colliding particles:
 2   1         p+    2212  (3,8)
 3                                    0.000      0.000  7000.000  7000.000      0.938
 4   2         p+    2212  (4,9)
 5                                    0.000      0.000 -7000.000  7000.000      0.938
 6 ....
 7
 8 Step 1
 9 --- intermediates:
10   3      sbar      -3 [1] (5)   {-1}
11                                   -0.000      0.000    11.700    11.700      0.000
12   4         s       3 [2] (5)   {+1}
13                                    0.000     -0.000   -12.910    12.910      0.000
14   5     gamma      22 [3,4] (6,7)
15                                    0.000      0.000    -1.210    24.611     24.581
16 --- final:
17   6      tau+     -15 [5]
18                                    9.490     -1.653    -8.037    12.671      1.777
19   7      tau-      15 [5]
20                                   -9.490      1.653     6.827    11.940      1.777
21   8    Rem:p+      82 [1]    >9 {+1}
22                                    0.000      0.000  6988.300  6988.300      0.937
23   9    Rem:p+      82 [2]    8> {-1}
24                                   -0.000      0.000 -6987.090  6987.090      0.937
25
                                                                    1,1          Anfang
```

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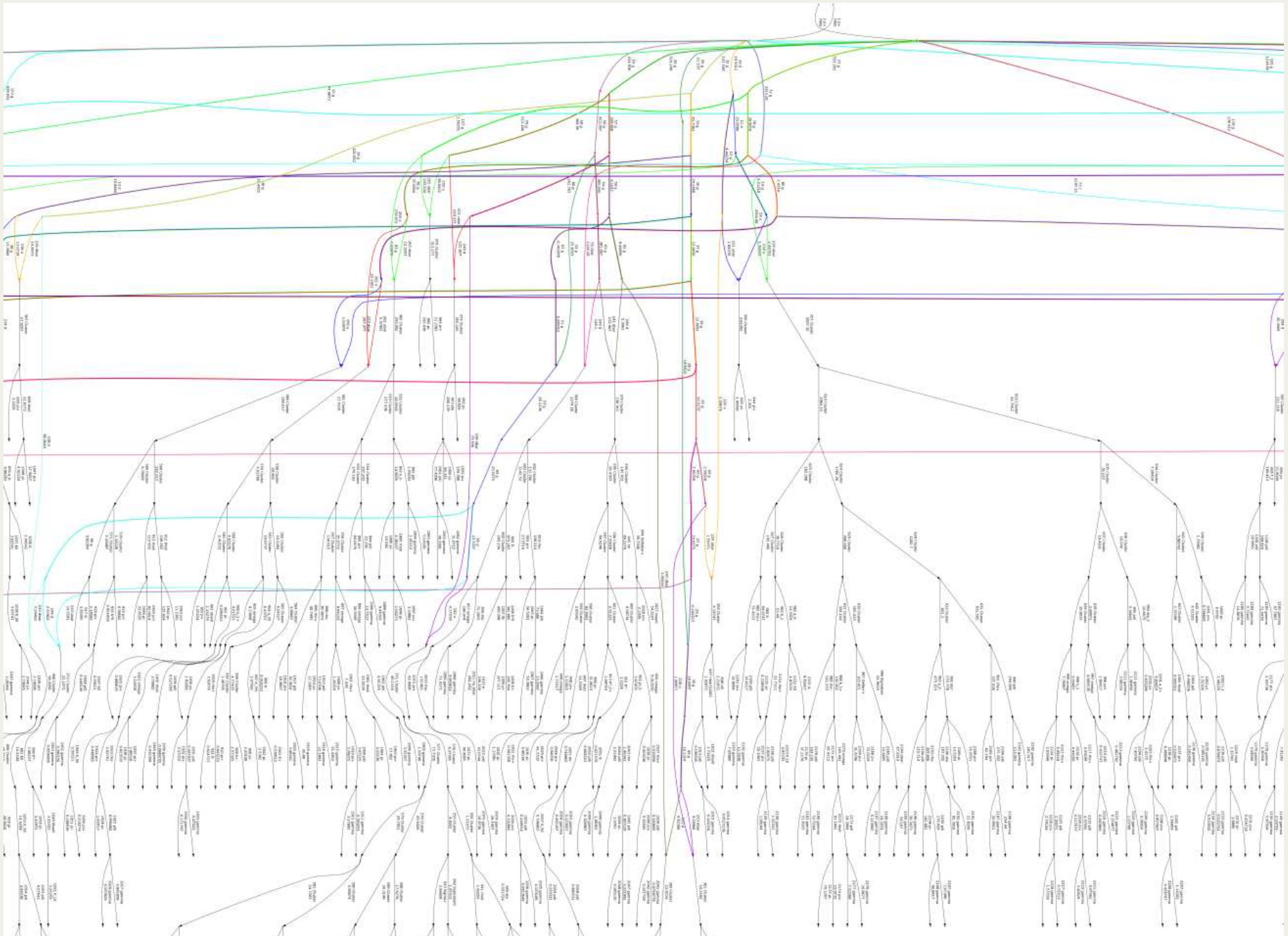
  - Plot results

Too much!



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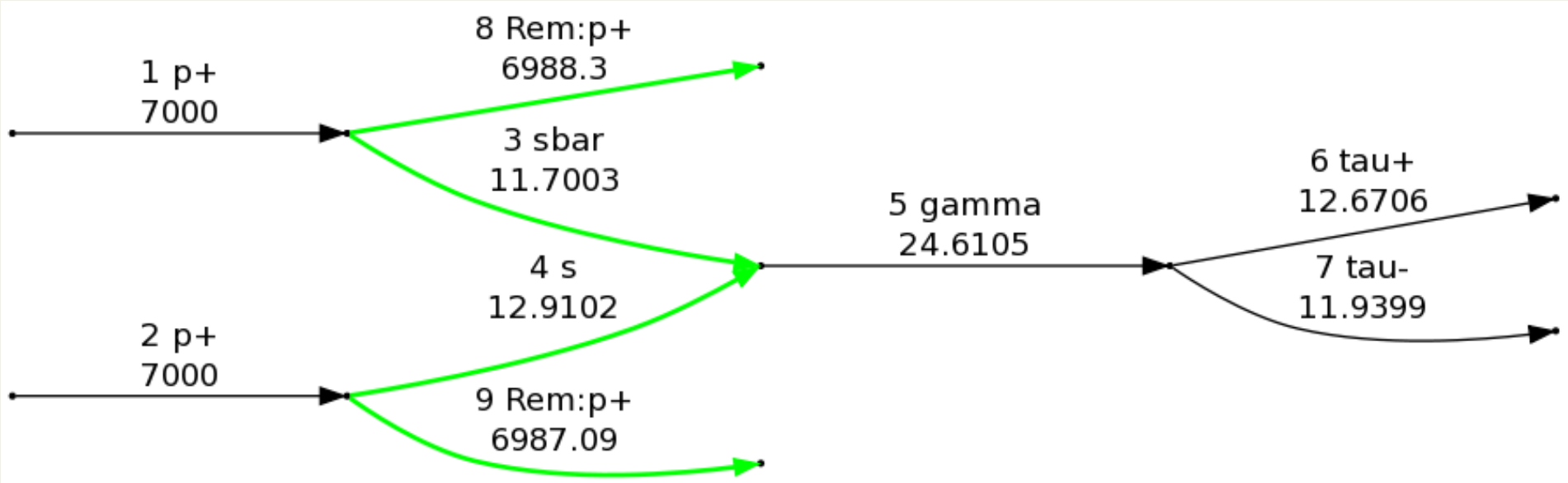
  - Reduce simulation complexity

Human readable!



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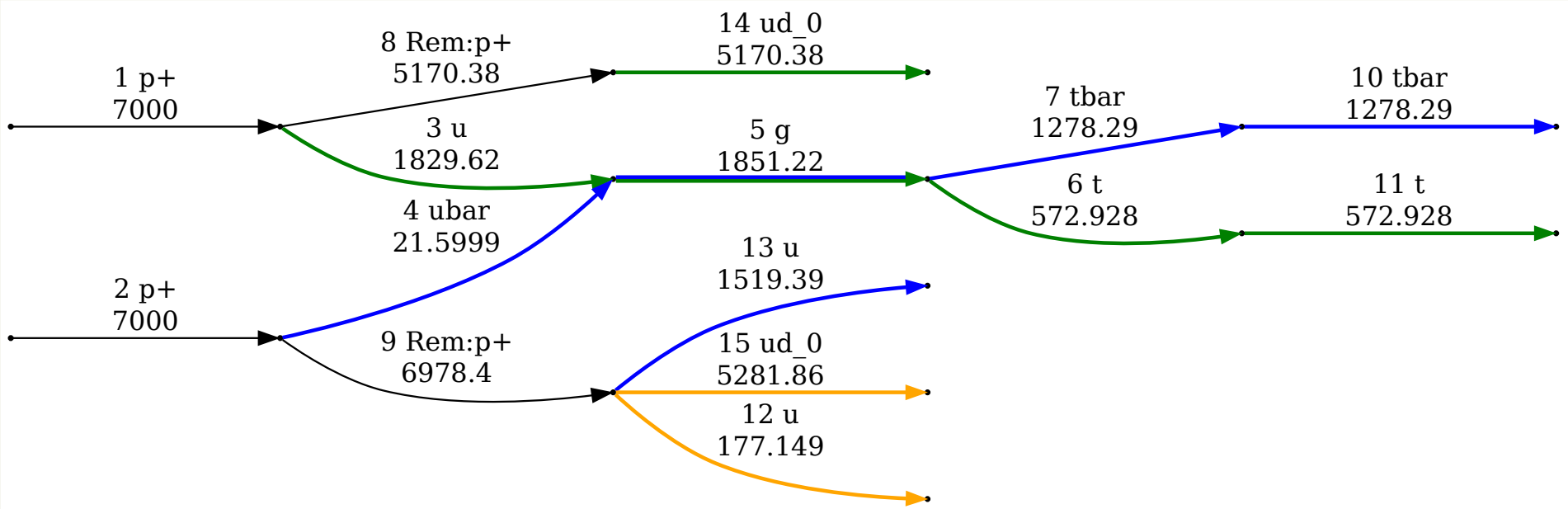
  - Plot results ..
  - Reduce simulation complexity ..
  - Change particle properties..

Stable Top-Quark



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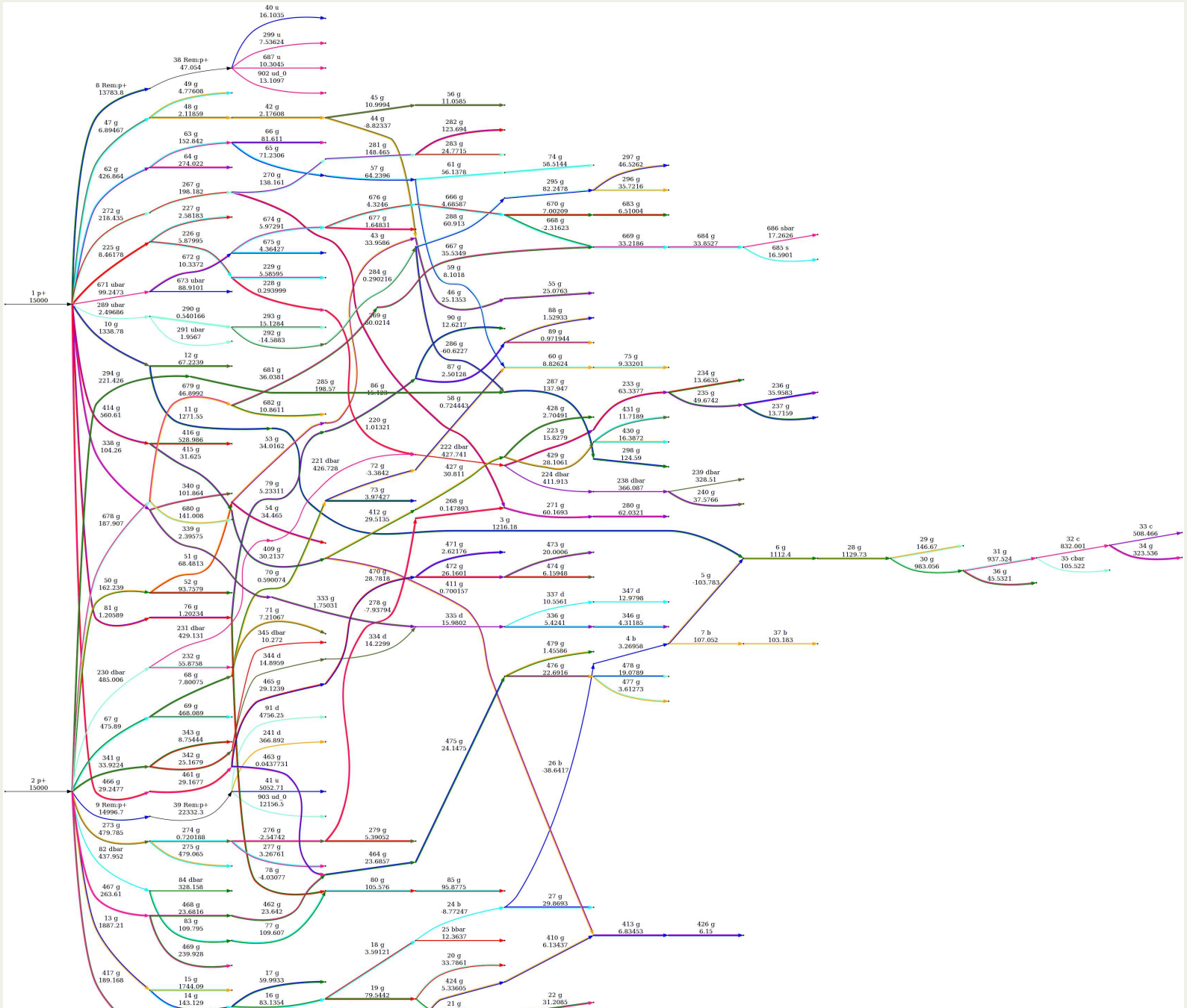
  - Plot results ..
  - Reduce simulation complexity ..
  - Change particle properties ..
  - Add matrix elements ..

LHC II at 30 TeV - All Matrix Elements



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  - Plot results ..
  - Reduce simulation complexity ..
  - Change particle properties ..
  - Add matrix elements ..
  - Play around

Real World

- Complicated Theory
- Single event plots out of interest
- Interest in large number of runs for in-depth statistical analysis; used for comparison to experimental results and fitting
- Other Frameworks: PYTHIA, Sherpa, Alpgen, etc.
- Detector geometry not included in simulation