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FÜR PHYSIK

ATLAS
EXPERIMENT

Signal MC Generation

Chi2 Extension

Tobias Heintz, B2F Theory Chat, 14/10/2025

Signal Generation

- 4 masses + 1 lifetime, parametrised as

$$m_S,\ \beta_1^* = \frac{\sqrt{\left[m_S^2 - (m_1 + m_2)^2\right] \times \left[m_S^2 - (m_2 - m_1)^2\right]}}{m_S^2 - m_2^2 + m_1^2},\ \Delta_{21} = m_2 - m_1,\ \Delta_{10} = m_1 - m_0,\ c\tau_{\chi_1}$$

- Compared signal efficiencies of 33 samples with $\varepsilon_S > 0.001 \Rightarrow$ Solid agreement:
  - 22/33 samples agree within one standard deviation
  - The remaining samples within 2 sigma
  - That is what we expect from statistical fluctuations
- We can slightly widen the active timing windows
  - Previously, we used rather conservative cuts at $(0,10)\,\mathrm{ns}$ and $(25,35)\,\mathrm{ns}$ for $N-1$ and N, respectively
  - Based on the CalRatio timing cuts $(-3,15)\,\mathrm{ns}$, we could use $(-3,15)\,\mathrm{ns}$ and $(22,40)\,\mathrm{ns}$ for $N-1$ and N, respectively
  - Still need to propagate this info to André!
- The lifetime reweighting scheme is slightly modified (since it depends on the number of LLPs):
  - A reference sample with lifetime τ_{gen} can be reweighted to a toy sample using event-level weights: for each LLP i with decay time t_i, we get a weight

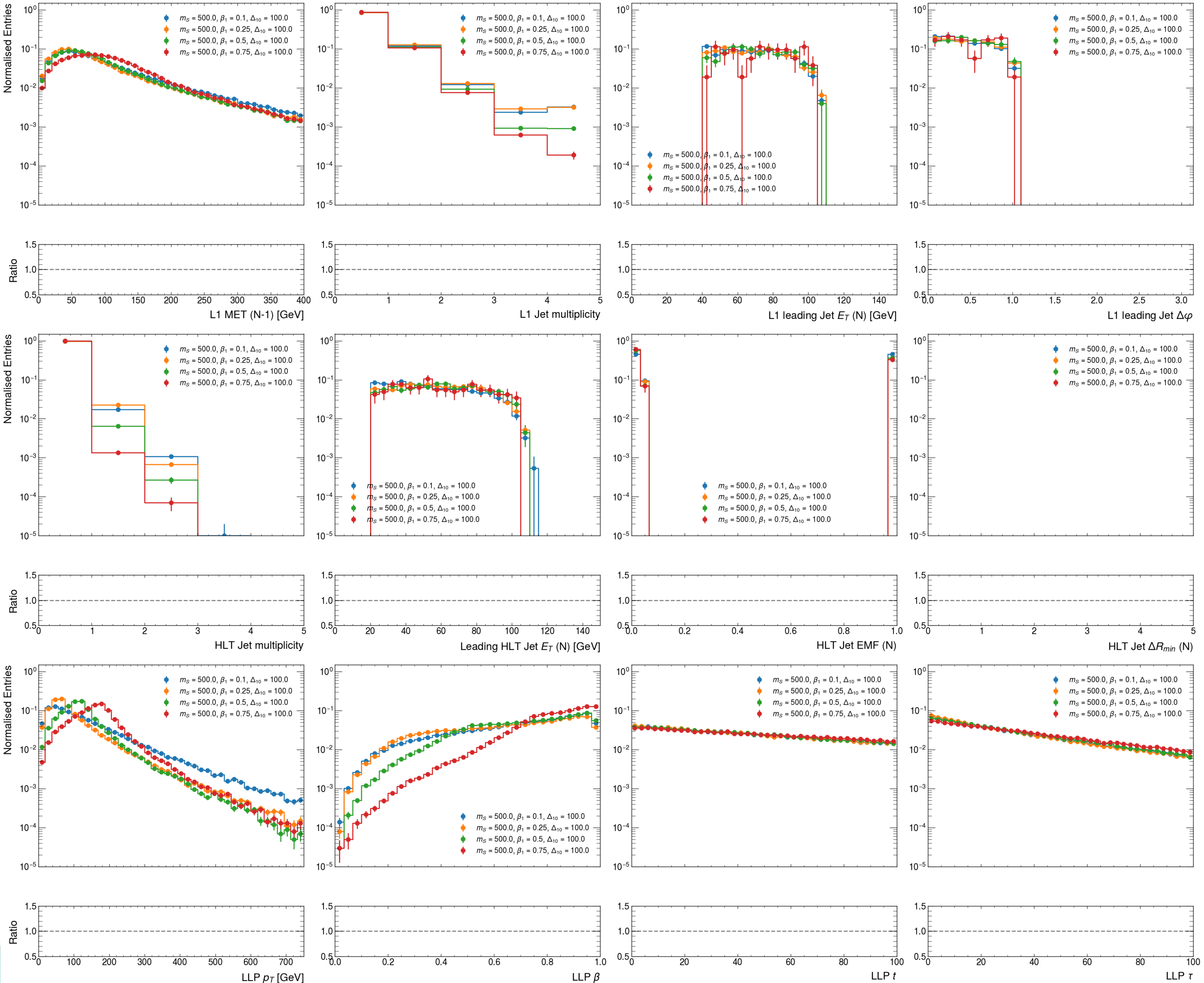
$$w_i = \frac{\tau_{\mathrm{gen}}}{\tau_{\mathrm{toy}}} \times \exp\left\{-\left(\frac{1}{\tau_{\mathrm{toy}}} - \frac{1}{\tau_{\mathrm{gen}}}\right) \times t_i\right\},\ \Rightarrow w_{\mathrm{tot}} = \prod w_i$$

  - Tbc if I implemented the “new” reweighting scheme correctly

Trigger Efficiencies -- Chi2 Extension

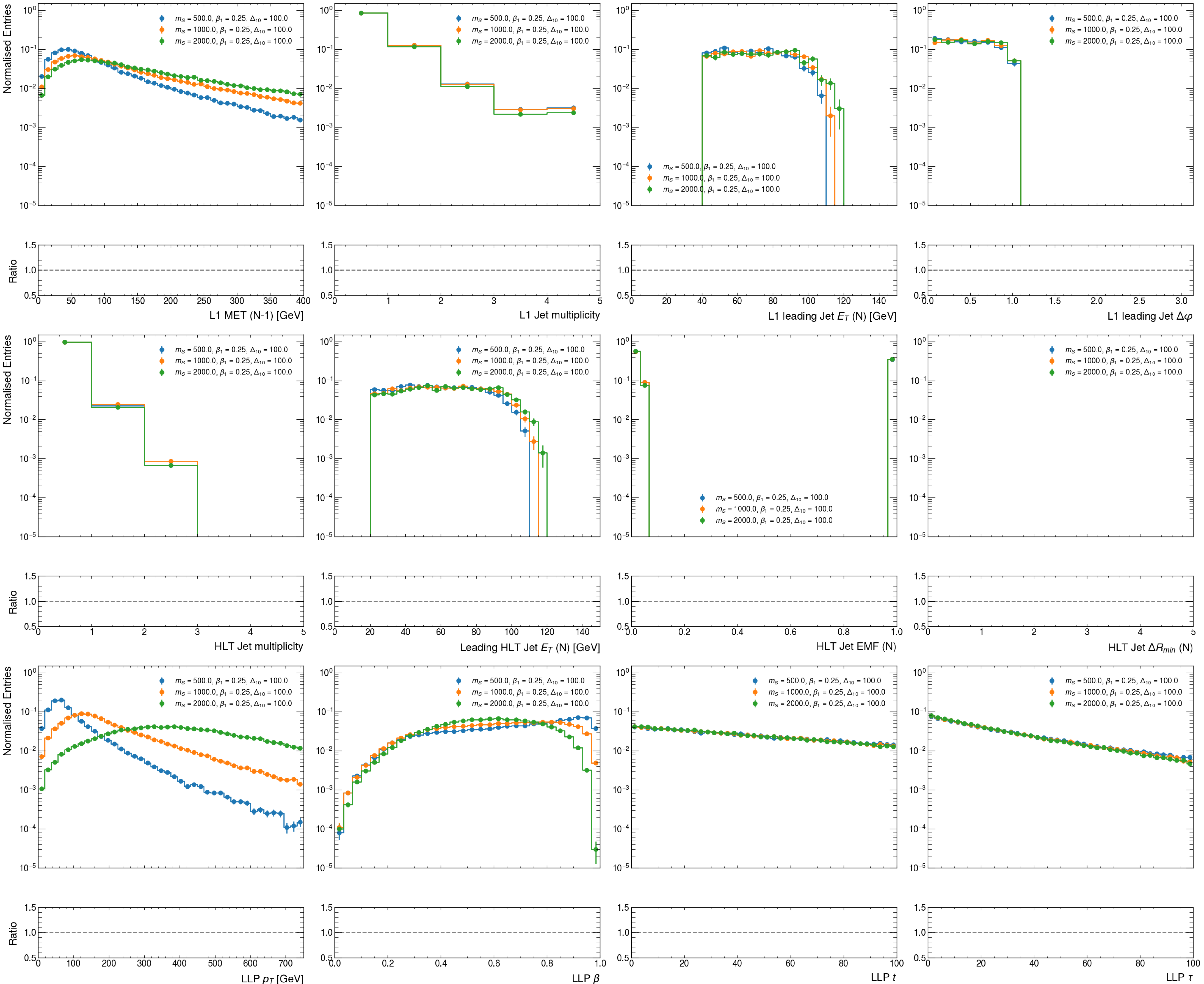
- For $m_S = 500\,\mathrm{GeV}$, $\Delta_{21} = 7\,\mathrm{GeV}$, the β_1^* values correspond to the following masses
  - $\beta_1^* = 0.1 \Rightarrow m_2 = 252.3\,\mathrm{GeV}, m_1 = 245.3\,\mathrm{GeV}$
  - $\beta_1^* = 0.25 \Rightarrow m_2 = 245.8\,\mathrm{GeV}, m_1 = 238.8\,\mathrm{GeV}$
  - $\beta_1^* = 0.5 \Rightarrow m_2 = 220.9\,\mathrm{GeV}, m_1 = 213.9\,\mathrm{GeV}$
  - $\beta_1^* = 0.75 \Rightarrow m_2 = 170.8\,\mathrm{GeV}, m_1 = 163.8\,\mathrm{GeV}$

Validation of Kinematics -- β_1^* Dependence



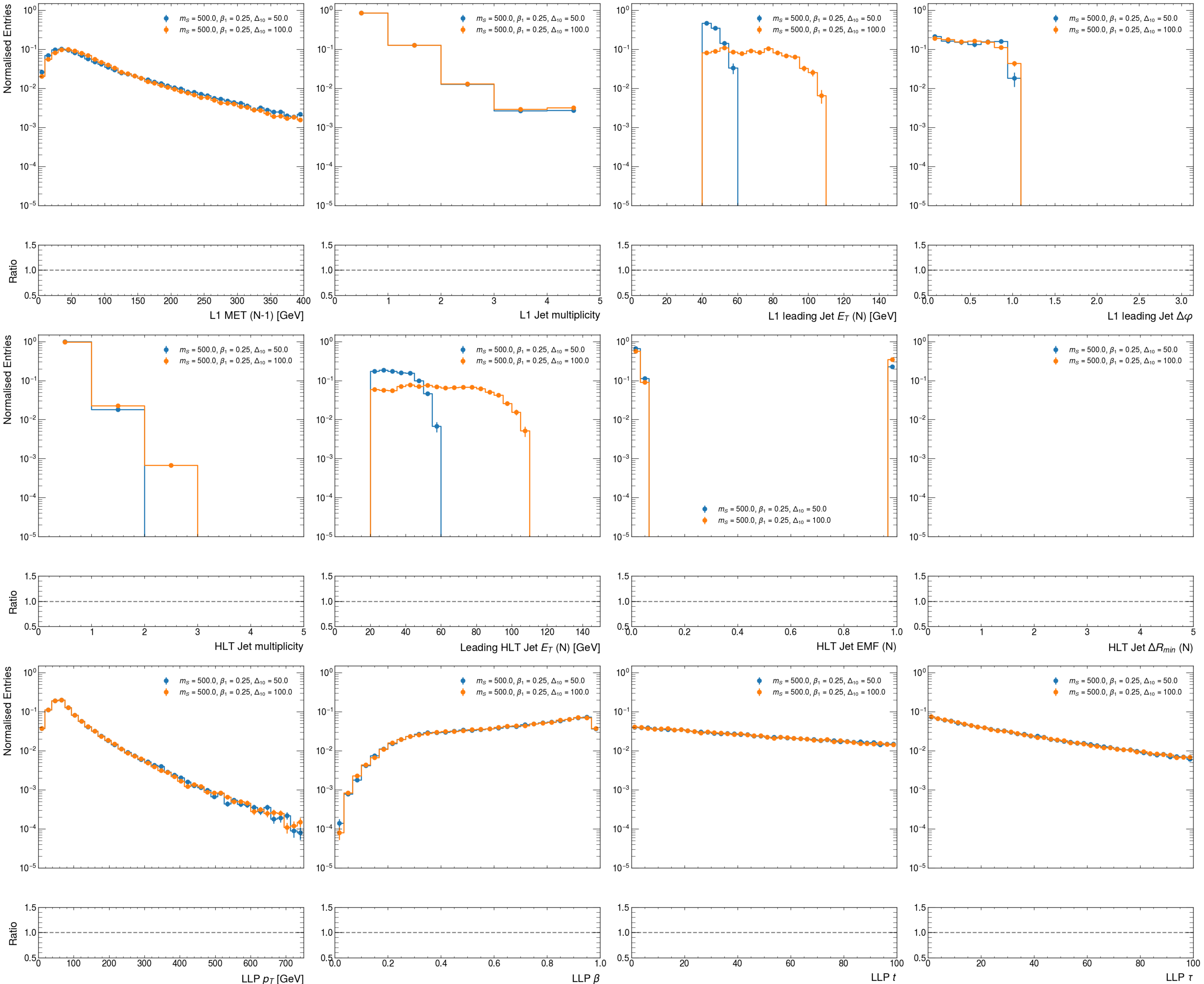
- β_1^* Dependence
  - L1 Variables (1st row)
  - HLT Variables (2nd row)
  - LLP Variables (3rd row)
- Using the following samples
  - m_S = 500.0, β_1 = 0.1, Δ_{10} = 100.0
  - m_S = 500.0, β_1 = 0.25, Δ_{10} = 100.0
  - m_S = 500.0, β_1 = 0.5, Δ_{10} = 100.0
  - m_S = 500.0, β_1 = 0.75, Δ_{10} = 100.0

Validation of Kinematics -- m_S Dependence



- m_S Dependence
  - L1 Variables (1st row)
  - HLT Variables (2nd row)
  - LLP Variables (3rd row)
- Using the following samples
  - m_S = 500.0, β_1 = 0.25, Δ_{10} = 100.0
  - m_S = 1000.0, β_1 = 0.25, Δ_{10} = 100.0
  - m_S = 2000.0, β_1 = 0.25, Δ_{10} = 100.0

Validation of Kinematics -- Δ_{10} Dependence



- Δ_{10} Dependence
  - L1 Variables (1st row)
  - HLT Variables (2nd row)
  - LLP Variables (3rd row)
- Using the following samples
  - m_S = 500.0, β_1 = 0.25, Δ_{10} = 50.0
  - m_S = 500.0, β_1 = 0.25, Δ_{10} = 100.0