HW8: Answer 1

Luminosity - collision number

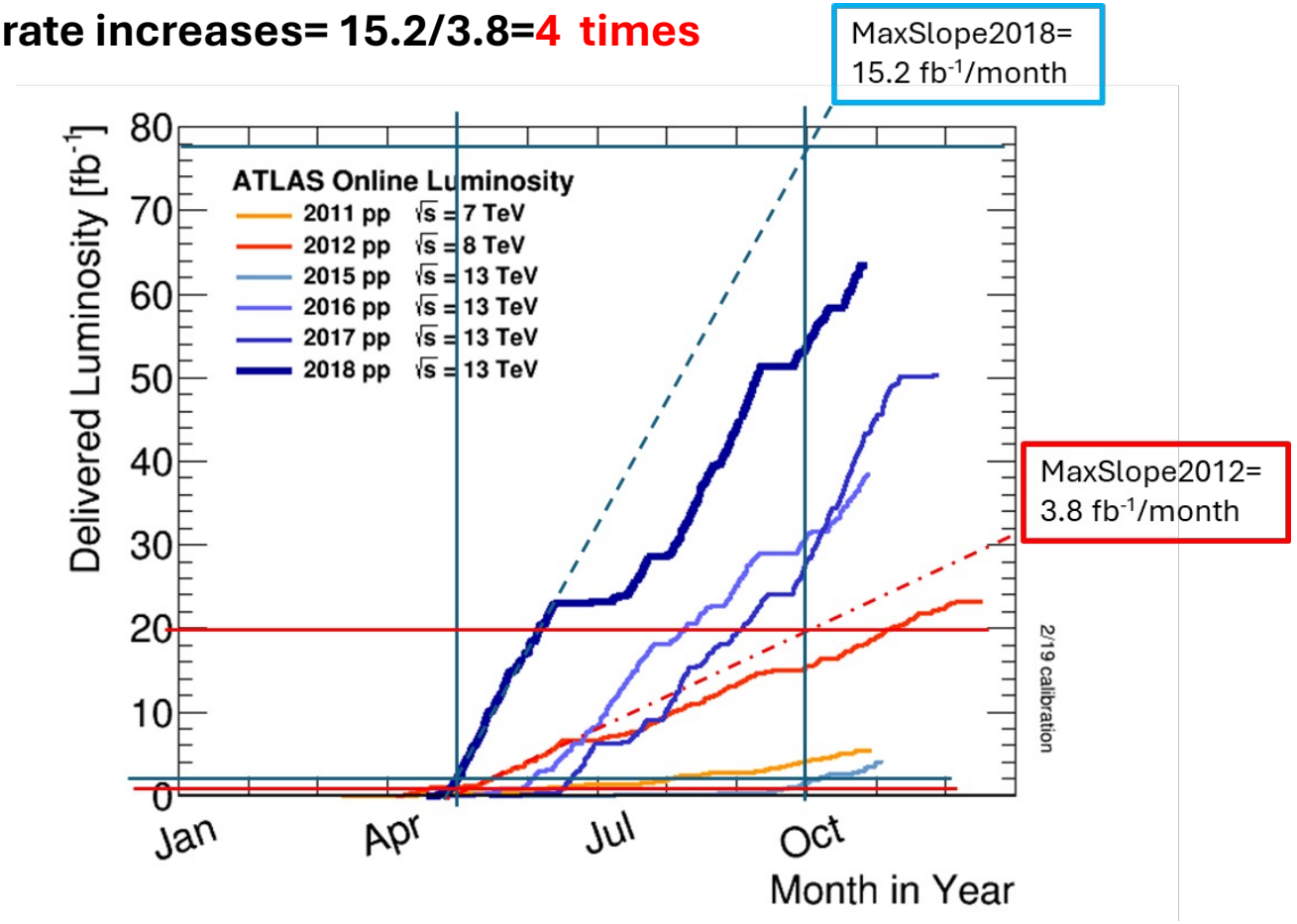
A1(2 points): Run 2 LHC luminosity **increased to 4** times in comparison with Run 1.

1. The plot shows the delivered (integrated) luminosity month by month.
2. We can take the best year from RUN 1 (2012) and the best year from RUN2 (2018) (see plot)

MaxSlope2018=15.2 fb^{-1}/month

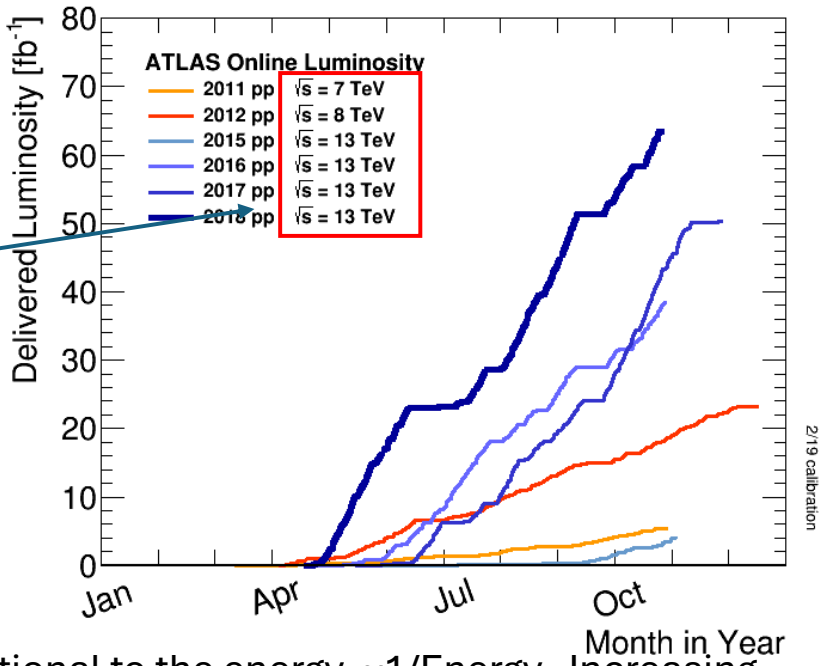
MaxSlope2012=3.8 fb^{-1}/month

The delivered luminosity rate increases= 15.2/3.8=4 times



HW8: Answers 2-3

A2 (2 points): As shown on the plot, the operation energy from RUN1 to RUN2 has been increased
from $\sqrt{s}$ =7 TeV to $\sqrt{s}$ =13 TeV.



Luminosity - collision numbers

$$L = f_c \frac{N_1 N_2}{A} \cong f_c \frac{N_1 N_2}{2\pi\sqrt{\beta_{x1}\varepsilon_{x1} + \beta_{x2}\varepsilon_{x2}}\sqrt{\beta_{y1}\varepsilon_{y1} + \beta_{y2}\varepsilon_{y2}}}$$

1) Emittance in hadron machines is inversely proportional to the energy ~1/Energy. Increasing energy reduces emittance two-fold.

2) Operation at smaller emittance allows to propagate beam with larger β function through the final focusing quadrupoles and reduce β* at the collision point in another factor of two increase of the luminosity.

Higher energy gives smaller emittance and smaller β* as a result **significantly increases luminosity.**

3) Other possible explanations: such as injectors upgrades, or better matching and operation efficiency would require some additional research

A3 (1 point): Delivered luminosity for three years (2016,2017,2018): $L_{delivered}$=152 fb^{-1} (38 fb^{-1} +50 fb^{-1} +64 fb^{-1}).

σ_{higgs}= 10^{-35} cm^2, 1fb = 10^{-39} cm^2.

N_{higgs}= σ_{higgs}*$L_{delivered}$= 10^{-35}*152/ 10^{-39}=**1.52x10^6**

About 1.5 millions basons were generated at LHC during 206-2018 operation years.