# Sun-as-a-star Analysis of Simulated Solar Flares

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We use 1D radiative hydrodynamics flare model and multi-thread flare assumption to obtain the Sun-as-a-star spectrum of a typical flare with an enhancement of chromospheric lines. The flare is modeled with different class and different location. The preflare-subtracted spectrum of H$\alpha$ shows an enhanced and shifted component, highly depending on the flare class and location. The spectrum of a limb flare tends to be wider and shows a dip in the line center. In particular, we propose two quantities to diagnose the class and location of the stellar flares. Besides, caution must be taken when calculating the radiation energy, since the conversion coefficient from observed flux to energy is dependent on the flare location.

**Introduction:** To study the flares by observations with no spatial resolution, the Sun-as-a-star analyses are developed. With the data of the Sun-as-a-star observations, a simulation of solar flares is required to provide a systemic clue to the Sun-as-a-star study. We aim to develop a model of solar flares and study the relationship between the Sun-as-a-star spectrum with the flare magnitude and location.

**Method:** we first simulate the spectrum of a flaring loop using RADYN code, which is regarded as a single thread. Then we calculate the multi-thread spectrum based on the result of the single thread: The foot points of a set of flaring loops start to get heated consecutively with different rate.

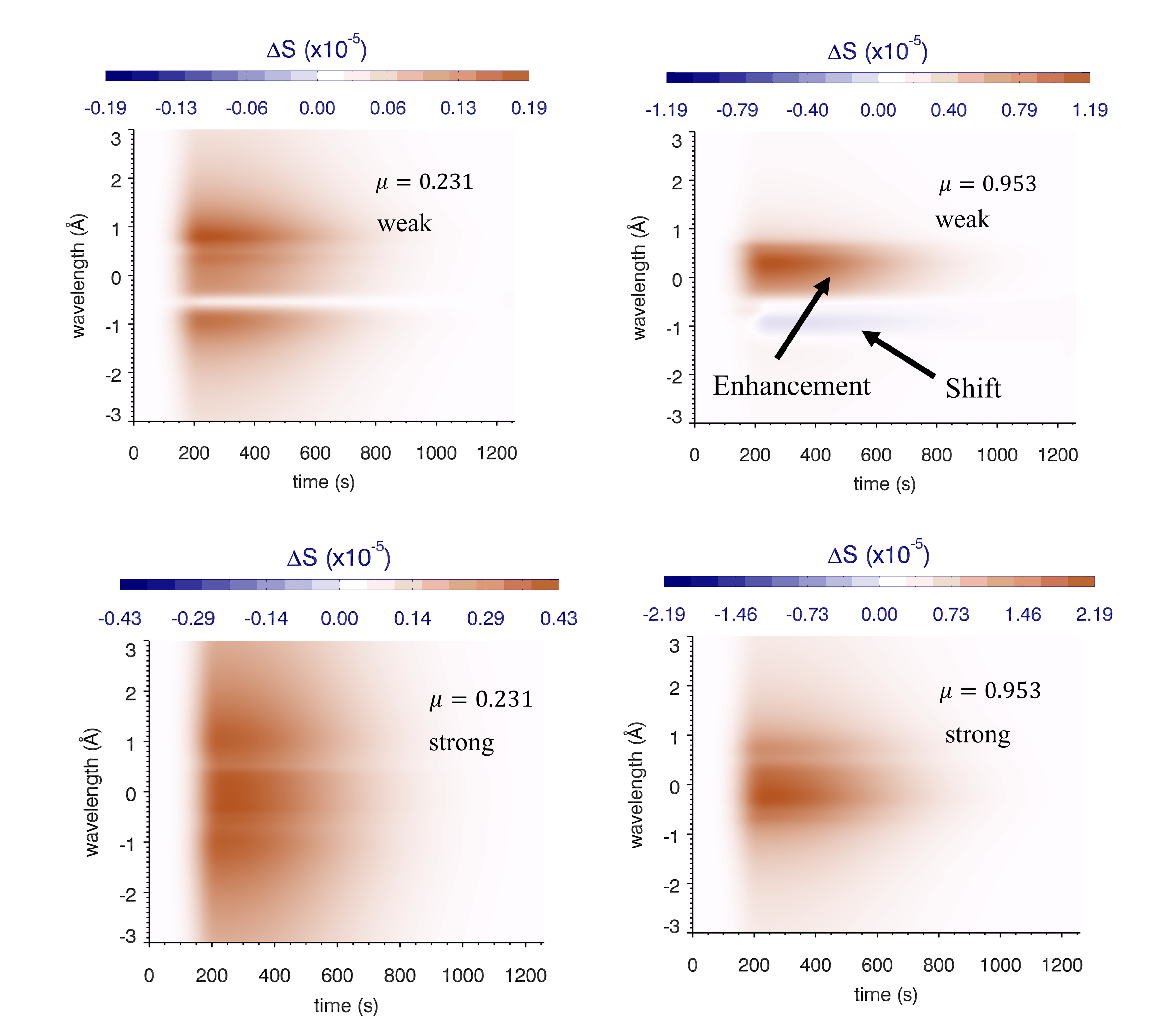
$$I_{\mathrm{F}}(\mu,t) = \int P(t')I(\mu,t-t')\mathrm{d}t'$$

Next, calculate the Sun-as-a-star spectrum by assuming that the remainder of the disk is still well represented by the quiet-Sun model.

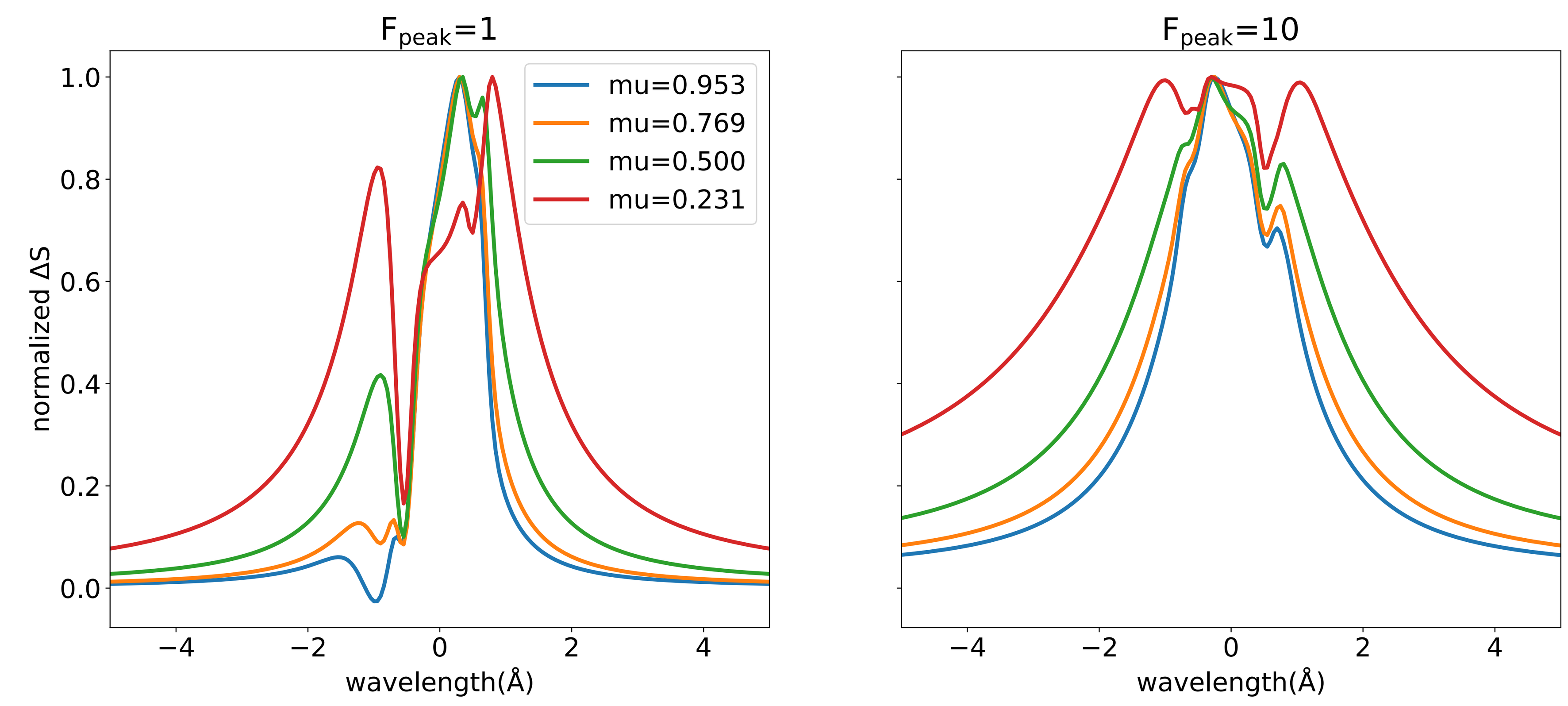
After that, we have constructed a grid of 50 flare models with 10 different flare magnitudes and 5 different flare locations.

$$\Delta S(t) = \frac{A_{\mathrm{flare}}[I_{\mathrm{F}}(\mu,t) - I_{\mathrm{F}}(\mu,0)]}{I(\mathrm{full\ disk},0)_{\mathrm{cont}}}$$

**Result1:**



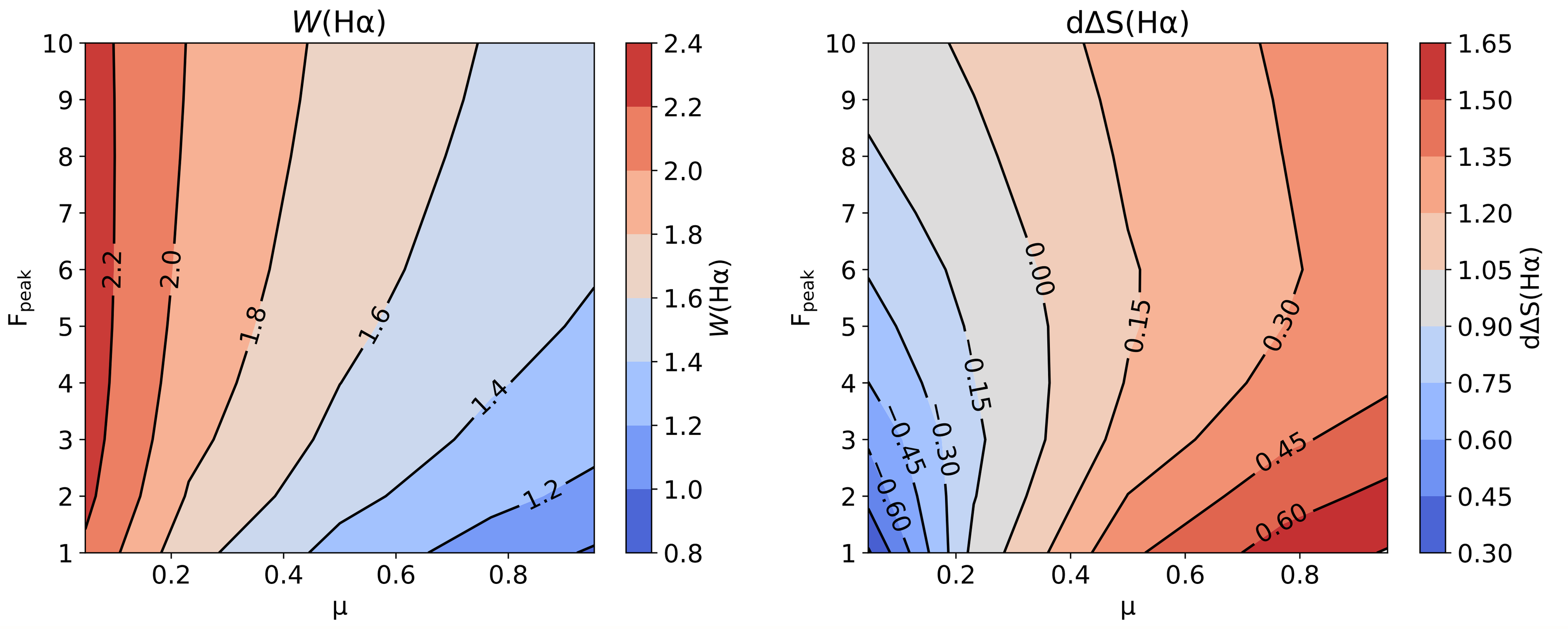

$\Delta S$(H$\alpha$) can be characterized by line enhancement and shift, weak flare on the disk center shows more apparent shift signal.




When flare occurs towards the solar limb:

1) The enhancement of normalized $\Delta S$ has a larger spread.
2) The dip around the line center is more pronounced.

Two quantities are proposed to extract two information above: $W$ for 1 and $\mathrm{d}\Delta S$ for 2.

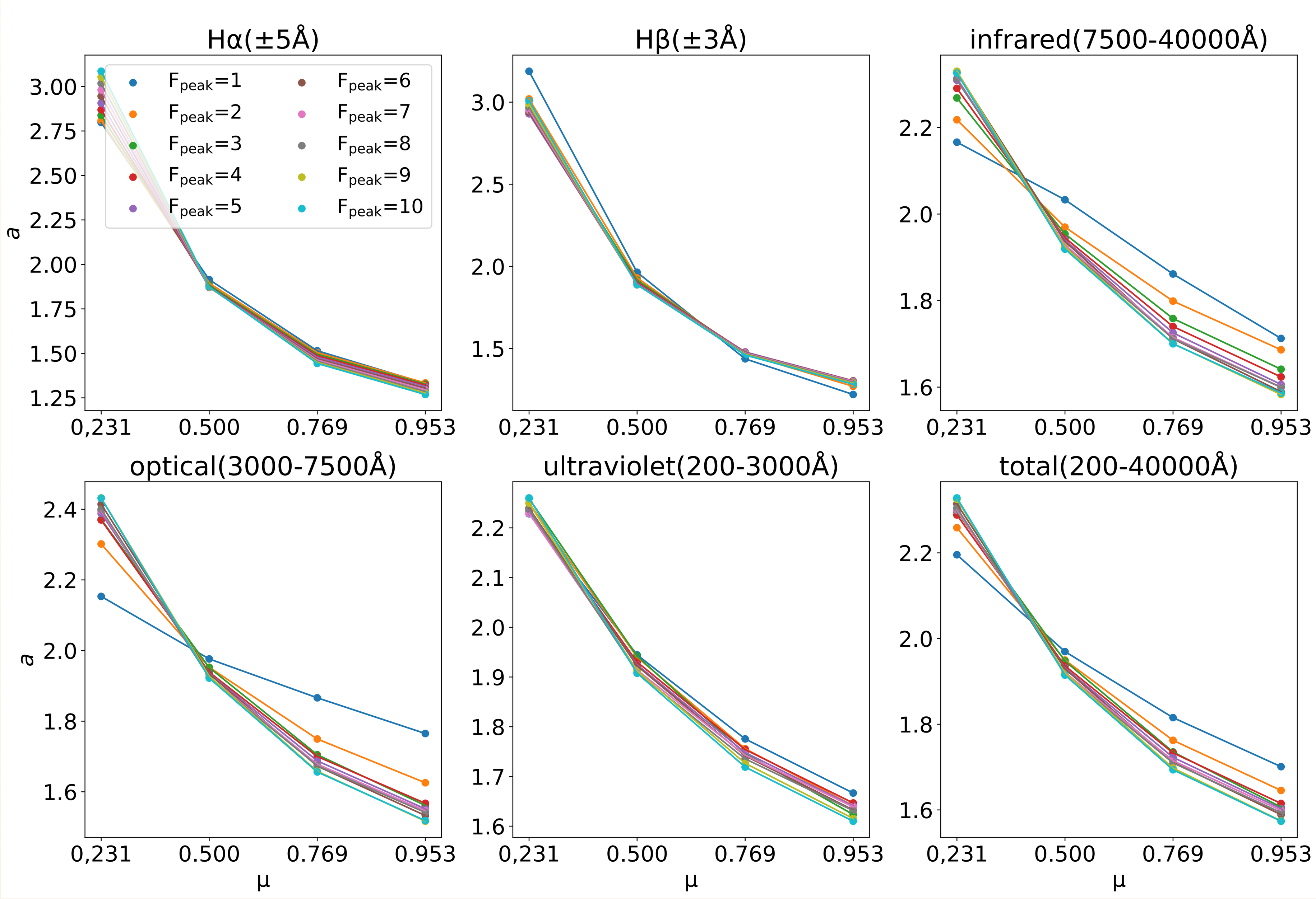



We could use $W$ and $\mathrm{d}\Delta S$ to diagnose the class and location of the stellar flare with no spatial resolution.

**Result2:** One needs a conversion coefficient $a\pi D^2$ (not $4\pi D^2$!) to calculate the radiation energy $E$ from the observed flux $F$,

$$E = a(\mu)\pi D^2 \int F\mathrm{d}\lambda\mathrm{d}t\,.$$

We prove that $a$ depends on the flare location:

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