



**Turnstile Streaming**

- Initialize  $x \leftarrow 0 \in \mathbb{R}^n$

• On update( $i, \Delta$ ):

• Set  $x[i] \leftarrow x[i] + \Delta$

- Answer queries about  $x$  using small space

•  $\max_i |x[i]|$

$$\bullet \sum_i |x[i]|^p \quad (F_p \text{ moments})$$





$x$

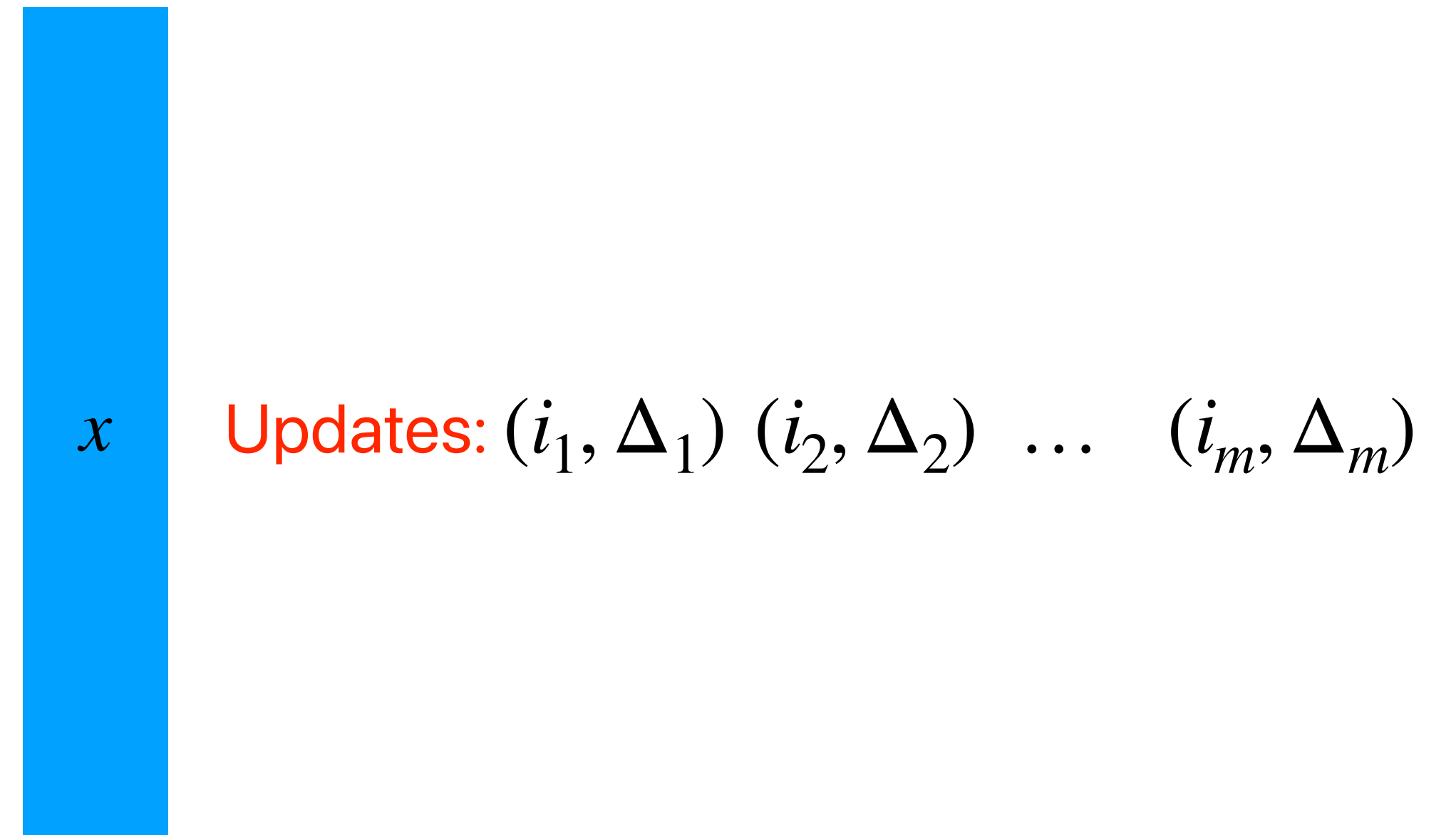
Updates:  $(i_1, \Delta_1)$   $(i_2, \Delta_2)$   $\dots$   $(i_m, \Delta_m)$

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- Answer queries about  $x$  using **small space**
  - $\max_i |x[i]|$
  - $\sum_i |x[i]|^p$  ( $F_p$  moments)



# How is Sketching Useful?

## Turnstile Streaming