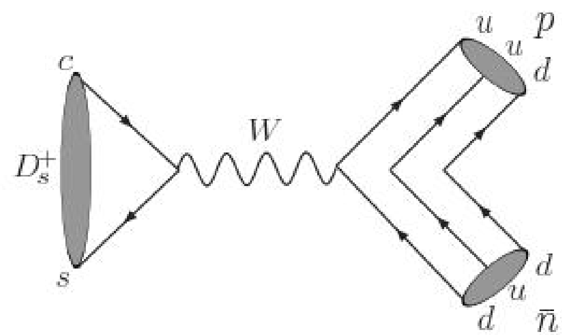
First Observation of the Decay $D_s^+ \to p\bar{n}$

CLEO-c Collaboration

Motivation

- Three ground-states in charmed meson family: Ds+, D0, D+
  - only Ds+ is massive enough to decay to a baryon-antibaryon pair.



- Good enviroment to test the contributions of W-annialation and other processes, which depen our understanding of the charmed meson decay mechanism

Event Selection strategy

- **Signal process is e+e- --> DsDs* --> Ds- Ds+ Gamma**
- **Partial reconstruction method:**
  - **to tag a Ds**
  - **to find another Gamma**
  - **to detect a proton candidate in the left charged tracks**
  - **find (anti-)neutron in the missing mass spectrum.**

Ds- tag

- Ds- candidates were reconstructed in 8 modes:

$K^+K^-\pi^-$	$\phi\rho^-$
$K^0_S K^-$	$\pi^+\pi^-\pi^-$
$\eta\pi^-$	$K^{*-}K^{*0}$
$\eta'\pi^-$	$\eta\rho^-$

- These modes have different resolutions in the Ds- mass spectrum
- They fit and select Ds- candidates in a *resolution reduced* *mass spectrum*.

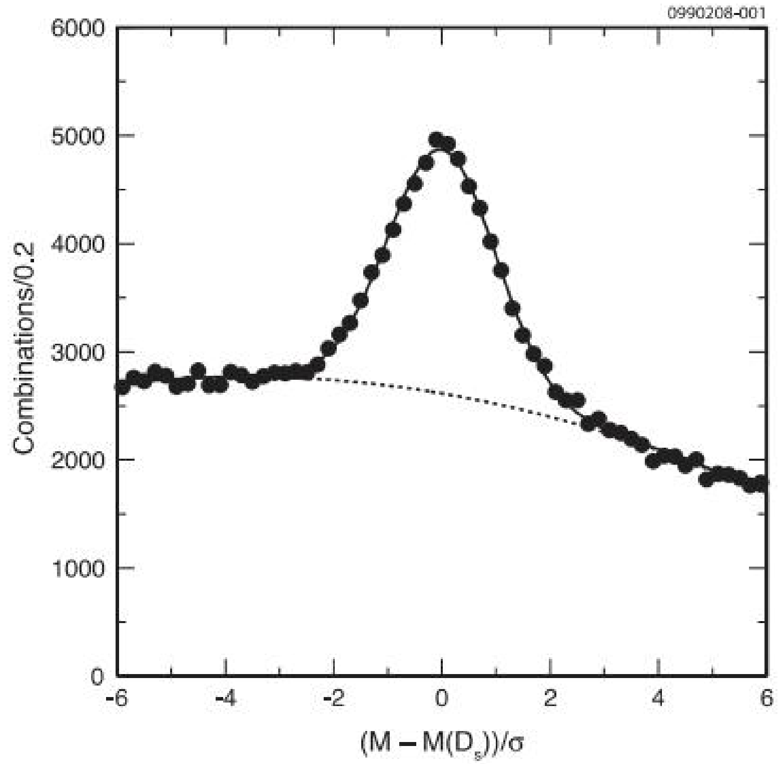


FIG. 1. The reconstructed mass minus the known D_s mass, divided by the detector resolution, for all eight modes of D_s tags reconstructed. The fit shown is a unit Gaussian centered at zero, together with a second order polynomial background function.

Detect *DsDs Gamma* signals

- **Reconstructed:**
  - Ds-
  - Gamma

- Four momentum of the missing Ds+

$$p(D_s^+) = \quad p_{\text{beam}} - p(D_s^-) - p(\gamma)$$

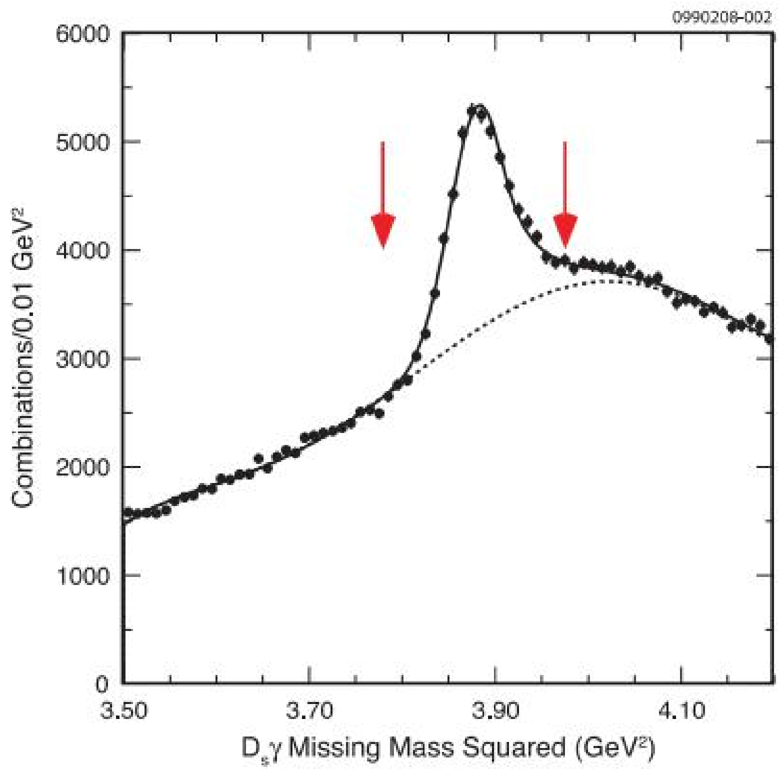


FIG. 2 (color online). The missing-mass squared from events with a reconstructed γ and D_s(tag). The fit is to a signal shape of a Crystal Ball function [6] with fixed tail parameters, together with a fifth order polynomial background function.

a peak at $M^2(D_s^+)$ corresponding to $D_s^* D_s$ production

To detect *Ds+ --> p nbar* signals in the selected *Ds Ds Gamma* sample

- To reconstruct a proton
  - From simulation, the momenta of protons from signal process falls in (150, 550) MeV
  - below the momentum range for RICH detector to identify protons.
  - use dE/dx information to identify proton candidates

Further constraints

- To improve the missing-mass resolution and reject combinatorial background.

- Two assumptions based on where the Gamma come from.

$$D_s^{*-} \to D_s^-(\text{tag})\gamma, \text{ or } D_s^{*+} \to D_s^+(\text{signal})\gamma$$

left

- add Gamma to tagged Ds- to get a Ds*- candidate
- constrain Ds*- momentum to the value in ee --> Ds*- Ds+
- constrain its mass difference to the nominal value

right

- constrain Ds- to the momentum value in ee-> Ds- Ds*+ process
- combine the Gamma with the missing Ds+, constrain the mass difference $M(D_s^{*+} - D_s^+)$

choose the scheme with the lowest total chisqure value
select Gamma produces lowest combined chisqure in the kinematic fit

Fit to Ds --> p nbar signal spectrum

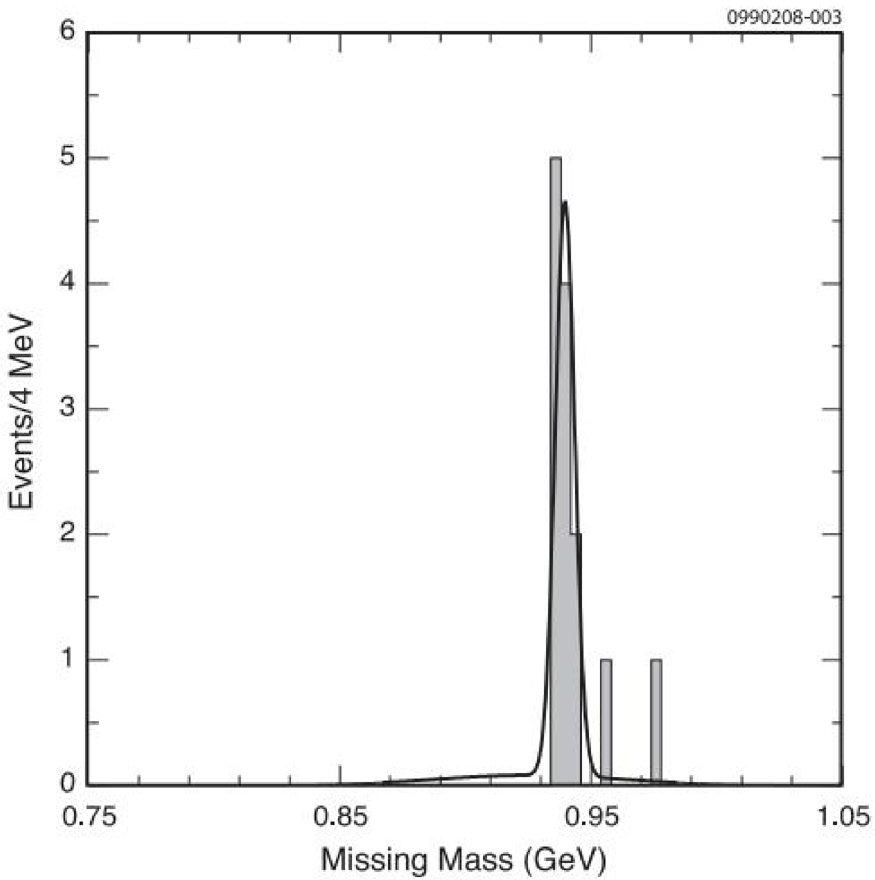


FIG. 3. The missing mass in the event after all requirements and kinematic fitting has been performed. The fit is described in the text.

13.0 ± 3.6 events

$$\mathcal{B}(D_s^+ \to p\bar{n}) = (1.30 \pm 0.36^{+0.12}_{-0.16}) \times 10^{-3}$$

BESIII preliminary result

- Using about 3.19fb^{-1} DsDs* data, we observe the baryon decay in Ds, the branching fraction of Ds→pnbar is:
  - **Br = (1.25+-0.10+-0.06)×10^{-3}**

CLEO-c: 325 pb^-1
$(1.36\pm 0.36^{+0.12}_{-0.16})*10^{-3}$

- This result is consistent with CLEO-c's. The precision is improved

Summary

- the Ds -> p nbar was first observed by CLEO-c Collaboration, and braching fraction is given
- this is the first observation of a charm meson decaying into baryon-antibaryon pair
- Highlights in this analysis:
  - use resolution reduced mass spectrum to select the tagged Ds-
  - kinematic constraints were introduced to improve the missing-mass resolution and reduce background.

THANK YOU