Overview of FOCUS and a report on charmed mesons in FOCUS

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FOCUS(E831) Collaboration

III International Conference on

Hyperons, Charm and Beauty Hadrons

Palazzina San Lorenzo-Porto Antico, Genova, Italy

June 30th- July 3rd 1998

Outline

- What is FOCUS ?
- Physics Goals
- Overview of the spectrometer
- Online monitor of the experiment using the Web Browser
- PASS1 and SKIM status
- Hadronic decays of charmed mesons: golden modes, singly and doubly Cabibbo suppressed decays
- Conclusions

- FOCUS means
  Photoproduction of Charm with an Upgrade Spectrometer
- $\gamma + N \to c\bar{c} + X$
- top energy $E_\gamma \sim 300$ GeV
- 96-97 Fixed-Target Run at Fermilab
  - Run started on June 96
  - Christmas Shutdown
  - Run Ended on September 97
- More than 6.3 billion triggers collected
- Goal:
  $10\times$ E687 statistics

Physics Goals

1) Lifetimes

   – E687 is the ONLY experiment to have measured ALL the lifetimes of the charm particles

   – charm lifetime hierarchy determined

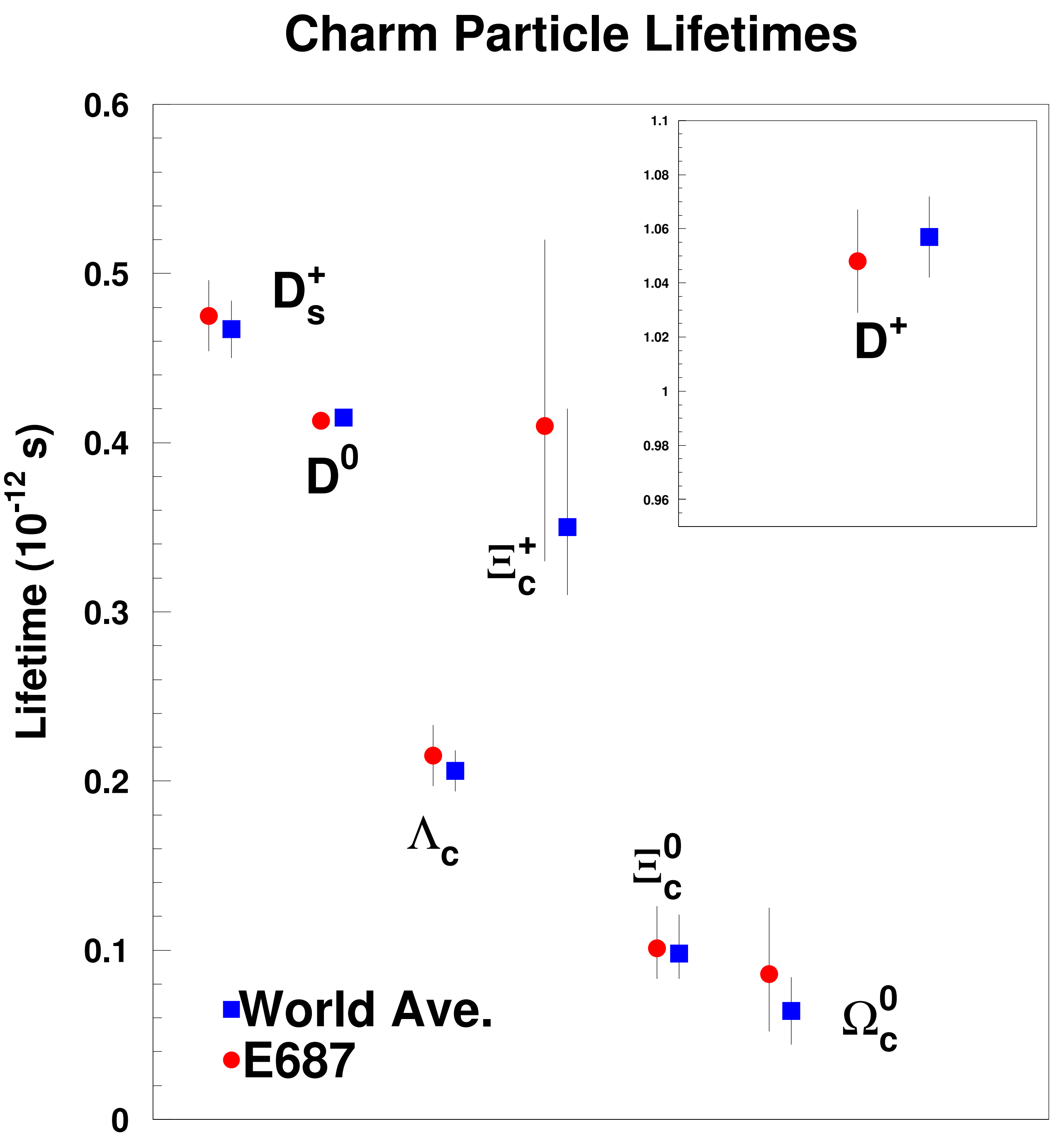
2) High precision studies of the Semileptonic decays

3) Charm production dynamics and comparison with Models

   – Double Charm events particulary useful

4) Systematic study of the Charm Baryons

5) Excited States like $D^{\star\star}$ $\Lambda_c^{\star}$..


Charm Particle Lifetimes
Lifetime (10^{-12} s)
0
0.1
0.2
0.3
0.4
0.5
0.6
D_s^+
D^0
Ξ_c^+
Λ_c
Ξ_c^0
Ω_c^0
D^+
0.96
0.98
1
1.02
1.04
1.06
1.08
1.1
World Ave.
E687

Physics Goals...

6) Hadronic Decays of D mesons

- Dalitz Plot analyses
- Isospin decomposition
- Try to understand FSI

7) Rare and Forbidden decays

8) Double Cabibbo Suppressed Decays

9) Leptonic Decays $\Rightarrow$ f_D pseudoscalar decay constant

10) $D^0 - \overline{D^0}$ Mixing

11) CP violation

Rare and Forbidden Decays

Decay Mode	E687 Limit (10^{-5})	Previous Limit (10^{-5})
$D^+ \to \pi^+ e^+ e^-$	11	6.6 (E791)
$D^+ \to K^+ e^+ e^-$	20	480 (MKII)
$D^+ \to \pi^+ \mu^+ \mu^-$	8.9	1.8 (E791)
$D^+ \to K^+ \mu^+ \mu^-$	9.7	32 (E653)
$D^+ \to \pi^+ \mu^+ e^-$	13	330 (MKII)
$D^+ \to K^+ \mu^+ e^-$	12	340 (MKII)
$D^+ \to \pi^+ \mu^- e^+$	11	330 (MKII)
$D^+ \to K^+ \mu^- e^+$	13	340 (MKII)
$D^+ \to \pi^- e^+ e^+$	11	480 (MKII)
$D^+ \to K^- e^+ e^+$	12	910 (MKII)
$D^+ \to \pi^- \mu^+ \mu^+$	8.7	22 (E653)
$D^+ \to K^- \mu^+ \mu^+$	12	32 (E653)
$D^+ \to \pi^- \mu^+ e^+$	11	370 (MKII)
$D^+ \to K^- \mu^+ e^+$	13	400 (MKII)

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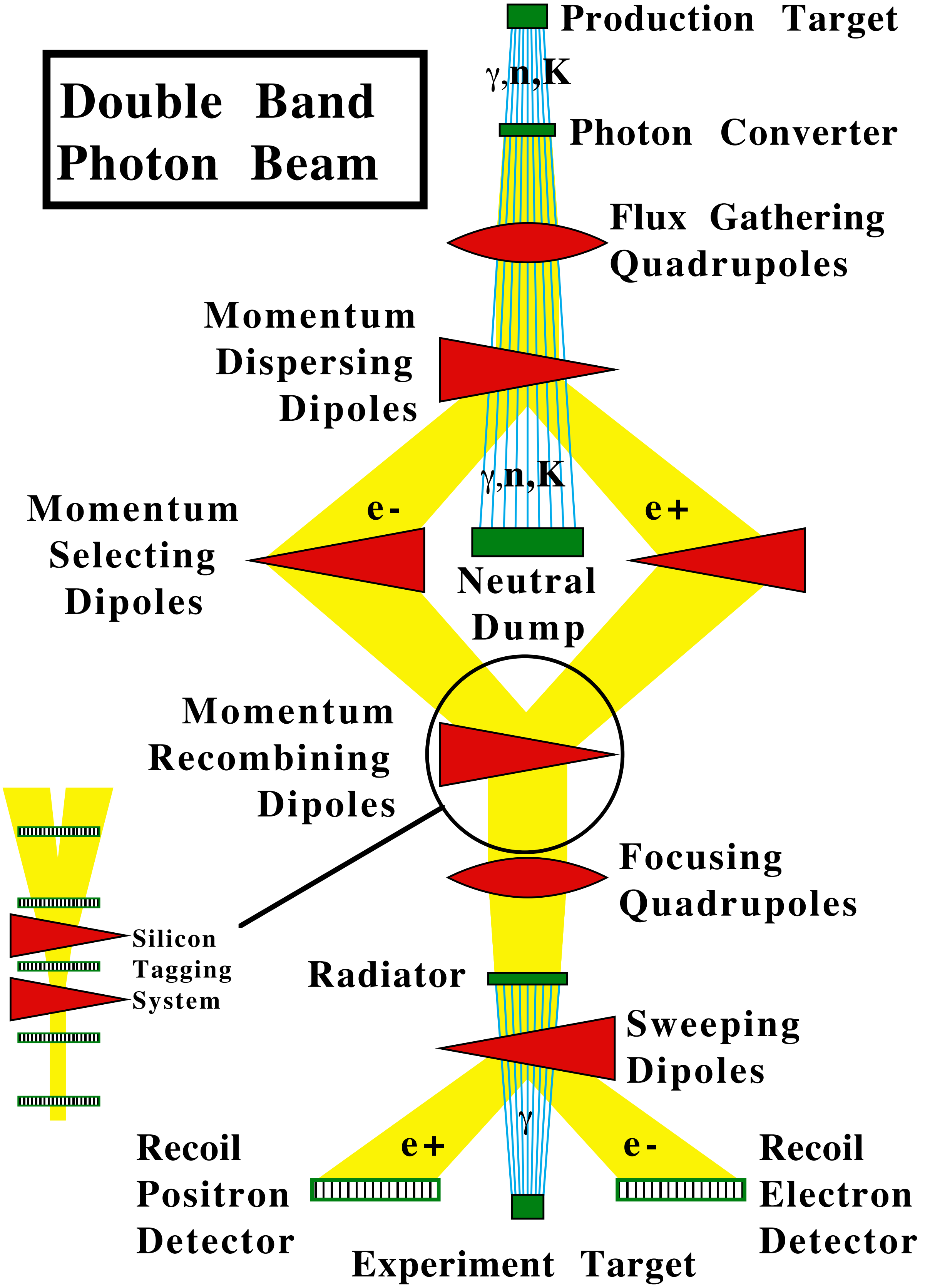
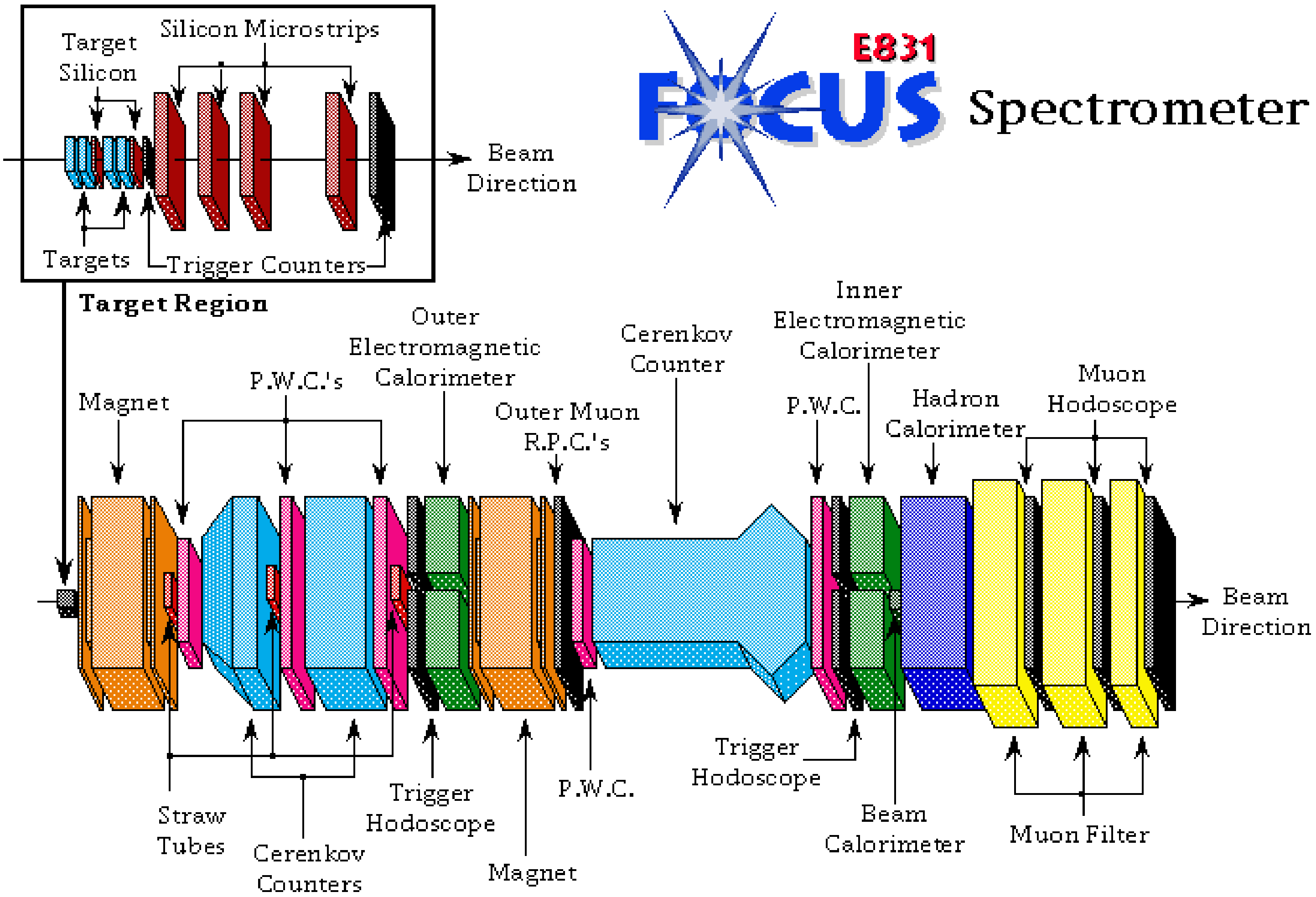
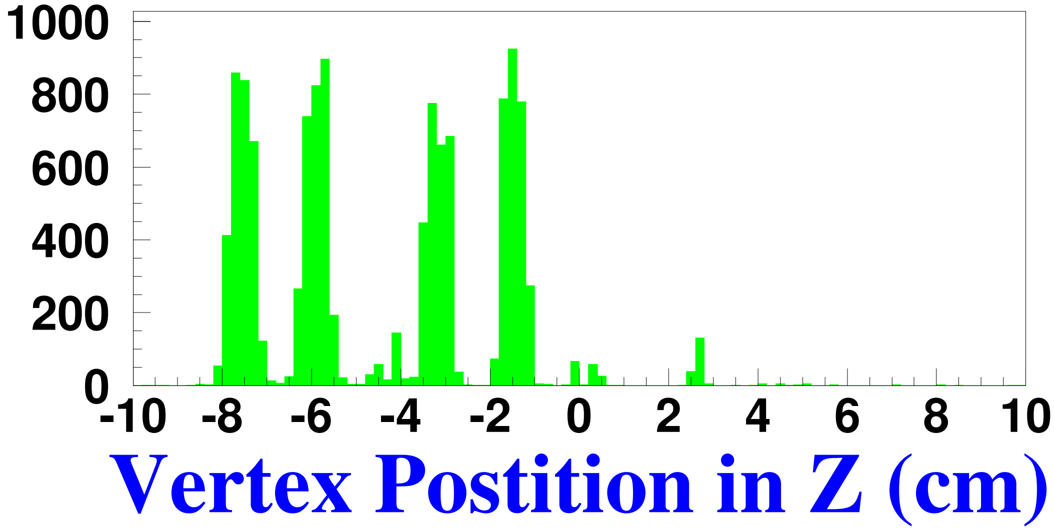

Double Band
Photon Beam
Production Target
γ,n,K
Photon Converter
Flux Gathering
Quadrupoles
Momentum
Dispersing
Dipoles
γ,n,K
Momentum
Selecting
Dipoles
e-
e+
Neutral
Dump
Momentum
Recombining
Dipoles
Focusing
Quadrupoles
Silicon
Tagging
System
Radiator
Sweeping
Dipoles
γ
Recoil
Positron
Detector
e+
e-
Recoil
Electron
Detector
Experiment Target

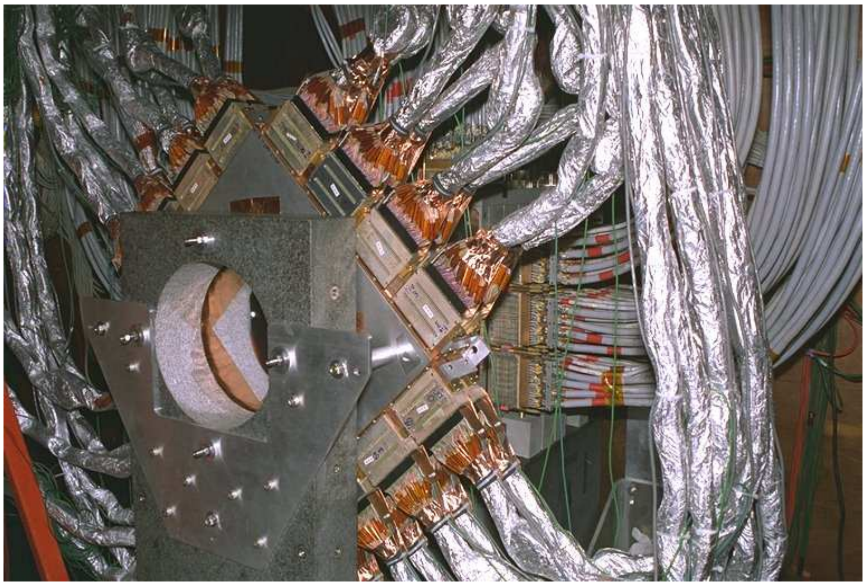
- Detector Upgrades
    - Hadron calorimeter(1st level trigger)
    - Straw tubes (covering "pair region")
    - Segmented target (50% more D°'s outside target)
    - Target silicon planes
    - Lead glass E/M calorimeter ("inner")
    - "Outer" E/M calorimeter upgrade
    - Two new muon systems("inner" and "outer")
    - 2 (of 5) PWC planes rebuilt
- New DAQ (speed)


E831
FOCUS Spectrometer
Target Silicon
Silicon Microstrips
Beam Direction
Targets
Trigger Counters
Target Region
Magnet
P.W.C.'s
Outer Electromagnetic Calorimeter
Outer Muon R.P.C.'s
Cerenkov Counter
Inner Electromagnetic Calorimeter
P.W.C.
Hadron Calorimeter
Muon Hodoscope
Beam Direction
Straw Tubes
Cerenkov Counters
Trigger Hodoscope
Magnet
P.W.C.
Trigger Hodoscope
Beam Calorimeter
Muon Filter

New Target Silicon Detector

- 4 planes in 2 views in target region
  4 BeO targets

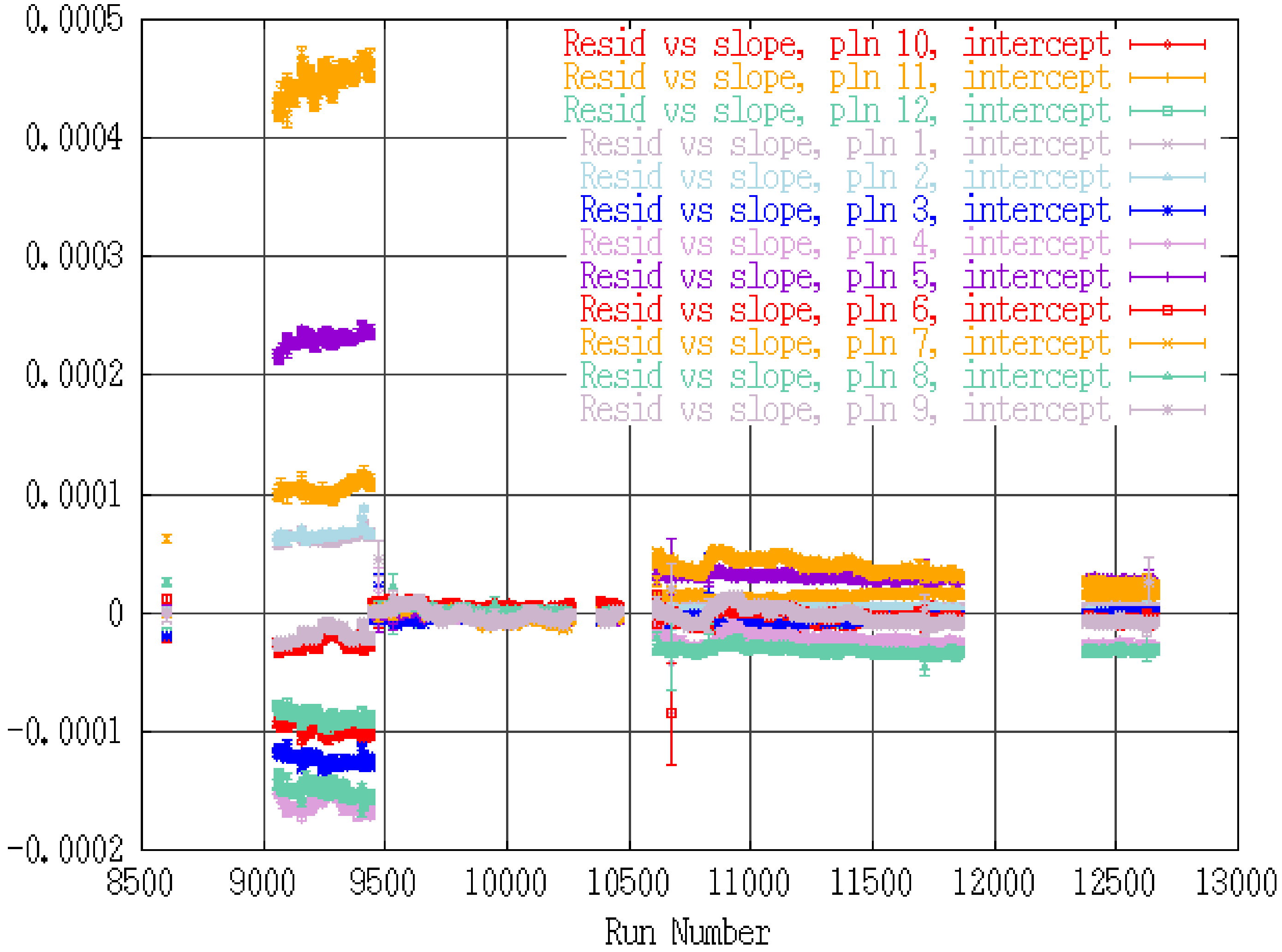




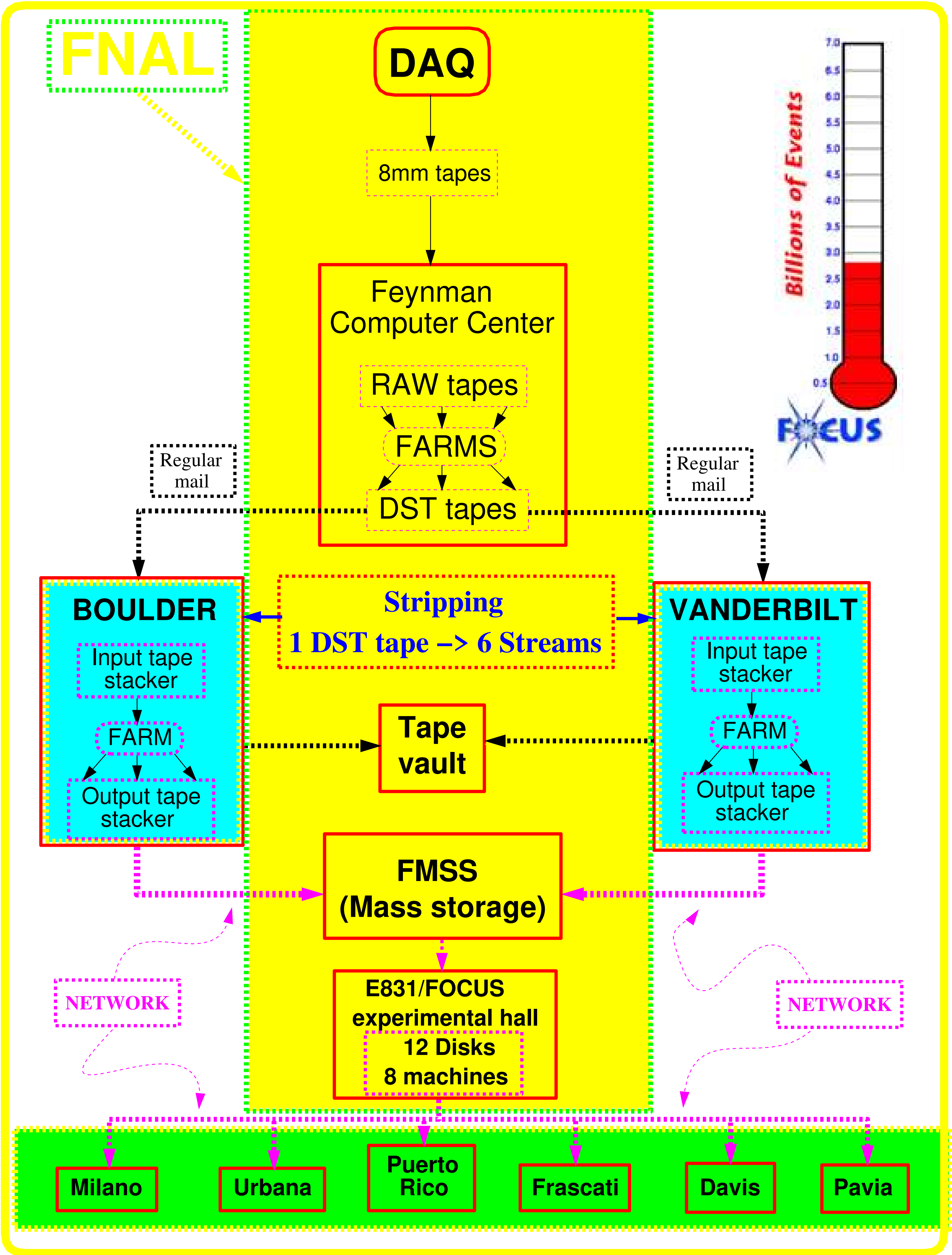
⇒ So far used hits for existing tracks only
Useful for 2/3 of FOCUS data set

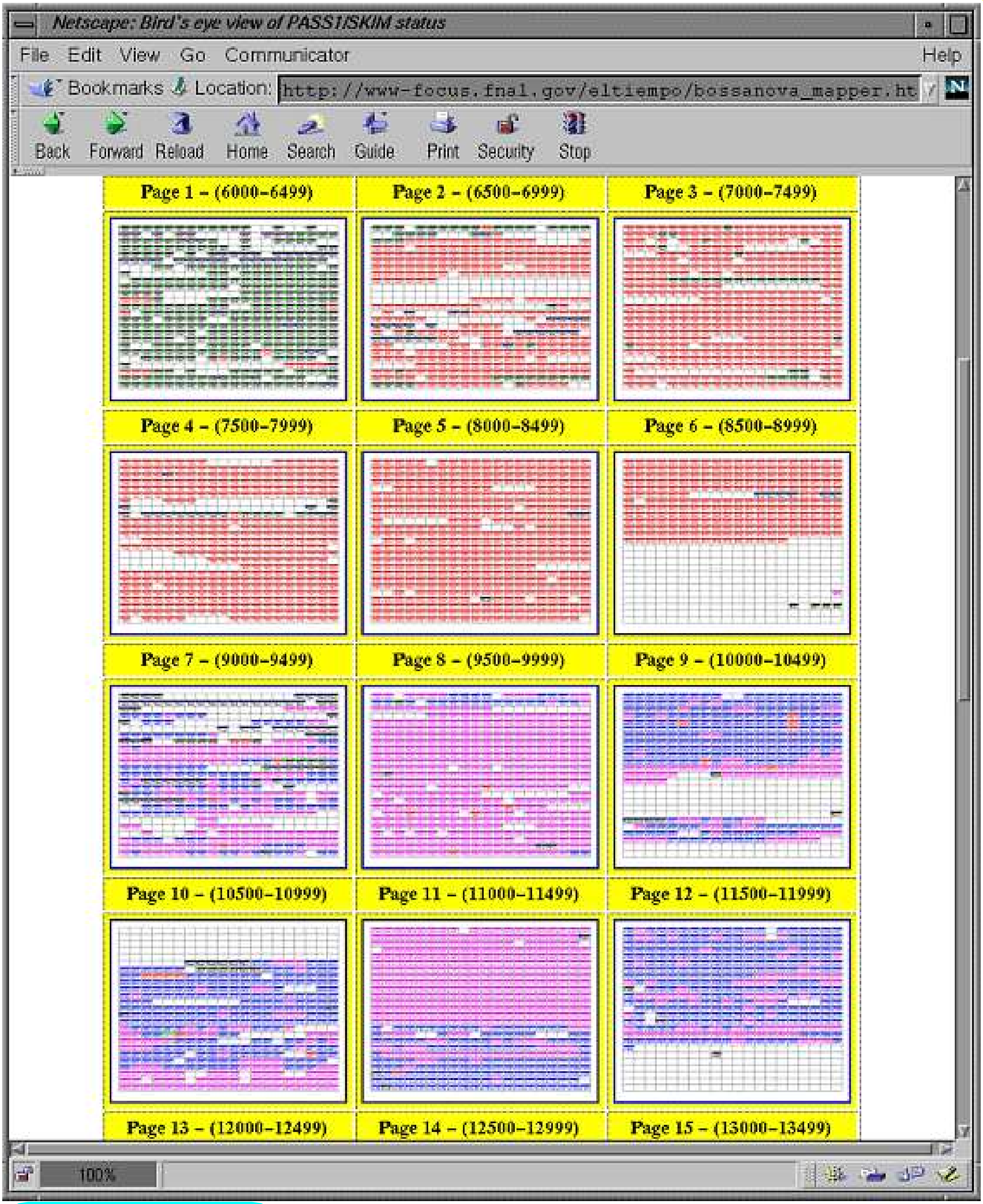
Online monitor of the experiment using the Web Browser

- Great Monitoring of the performances of the spectrometer during the data taking
  - Crucial the use of the Web Browser
  - Monitor online of the Charm Yield for every run
- Monitor and control of the PASS1(event reconstruction) thru the Web Browser
- SKIM in parallel to PASS1
  - Sophisticate feedback by means of physics results (for example looking at the Cabibbo suppressed decay modes)



0.0005
0.0004
0.0003
0.0002
0.0001
0
-0.0001
-0.0002
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000
Run Number
Resid vs slope, pln 10, intercept
Resid vs slope, pln 11, intercept
Resid vs slope, pln 12, intercept
Resid vs slope, pln 1, intercept
Resid vs slope, pln 2, intercept
Resid vs slope, pln 3, intercept
Resid vs slope, pln 4, intercept
Resid vs slope, pln 5, intercept
Resid vs slope, pln 6, intercept
Resid vs slope, pln 7, intercept
Resid vs slope, pln 8, intercept
Resid vs slope, pln 9, intercept


FNAL
DAQ
8mm tapes
Feynman Computer Center
RAW tapes
FARMS
DST tapes
Regular mail
Regular mail
BOULDER
Input tape stacker
FARM
Output tape stacker
Stripping
1 DST tape –> 6 Streams
VANDERBILT
Input tape stacker
FARM
Output tape stacker
Tape vault
FMSS (Mass storage)
NETWORK
NETWORK
E831/FOCUS experimental hall
12 Disks
8 machines
Milano
Urbana
Puerto Rico
Frascati
Davis
Pavia
Billions of Events
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
FOCUS


Netscape: Bird's eye view of PASS1/SKIM status
File Edit View Go Communicator Help
Bookmarks Location: http://www-focus.fnal.gov/eltiempo/bossanova_mapper.ht
Back Forward Reload Home Search Guide Print Security Stop
Page 1 – (6000–6499)
Page 2 – (6500–6999)
Page 3 – (7000–7499)
Page 4 – (7500–7999)
Page 5 – (8000–8499)
Page 6 – (8500–8999)
Page 7 – (9000–9499)
Page 8 – (9500–9999)
Page 9 – (10000–10499)
Page 10 – (10500–10999)
Page 11 – (11000–11499)
Page 12 – (11500–11999)
Page 13 – (12000–12499)
Page 14 – (12500–12999)
Page 15 – (13000–13499)
100%

PASS1 and SKIM status

- At the end of June

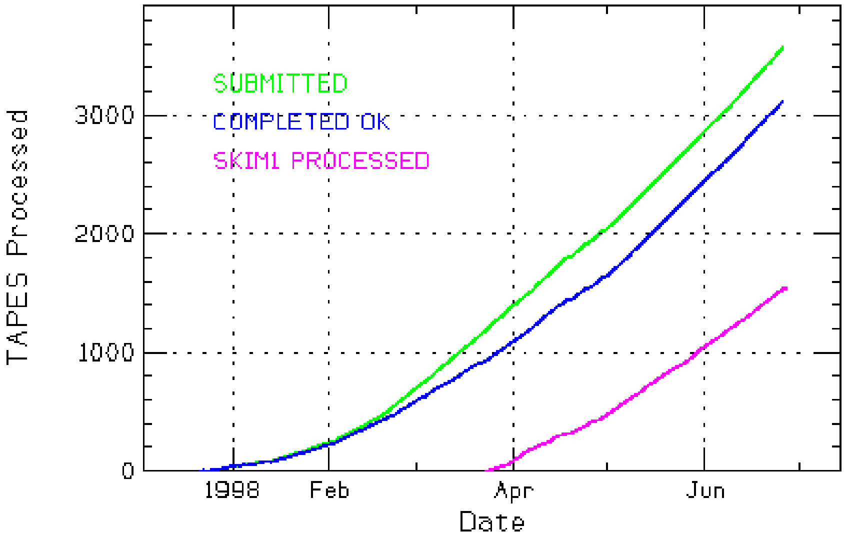
50%

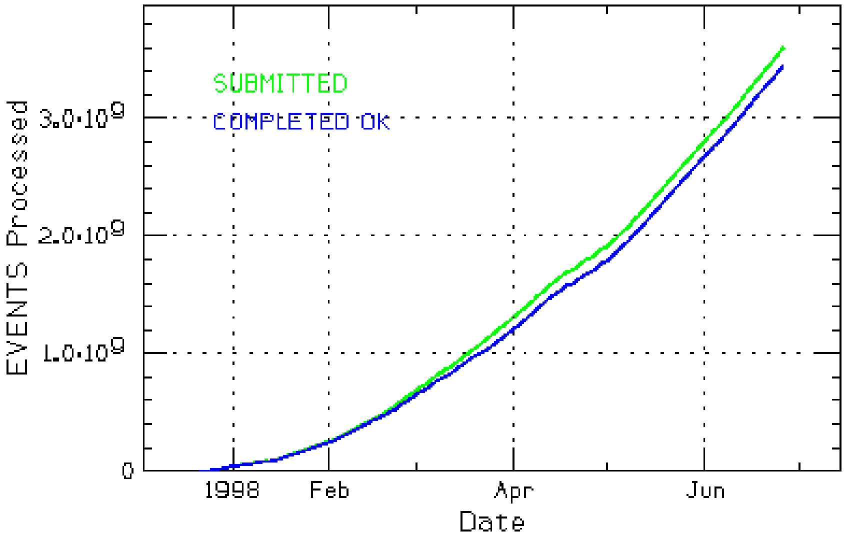
of the total sample (6.3 billions of events) processed

- PASS1 end foreseen for October 98
- SKIM started on April and should end close to PASS1

Tape Timelines

Tape and Event Processing Statistics





- Mecca Access Page: Access to Mecca database, oddpacks, and logfiles for all processed runs

- Oddpack Access to all Pass1 oddpacks
  - Oddpack to Hbook Converter NEW!

- Timelines for PASS1 Oddpacks

- POPSI Page Histogram List and Plots
  - Integrated Charm Summary Page

- Charmometer Page

- Timelines for Tapes and Events processed NEW!

- Multifile Charm Timelines NEW!
  - WhyMe database utilities

Preparation

- PASS1 Shift schedule

- Run Periods

- Pass1 Readiness Checklist

- Data Processing Model When will data be available? NEW!

- Skim ratios for PASS1

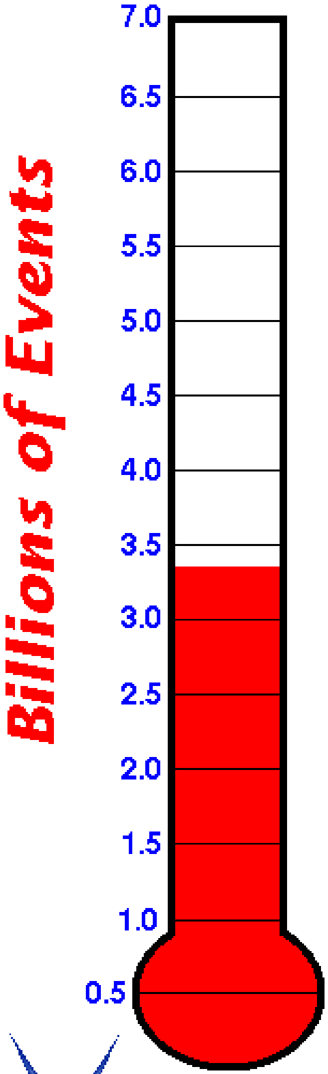
- Calculate and study skim ratios for different skims
  - *Modified version* calculates skim sizes and institution needs

- Pass One Output Blocks and Sizes

- Compression

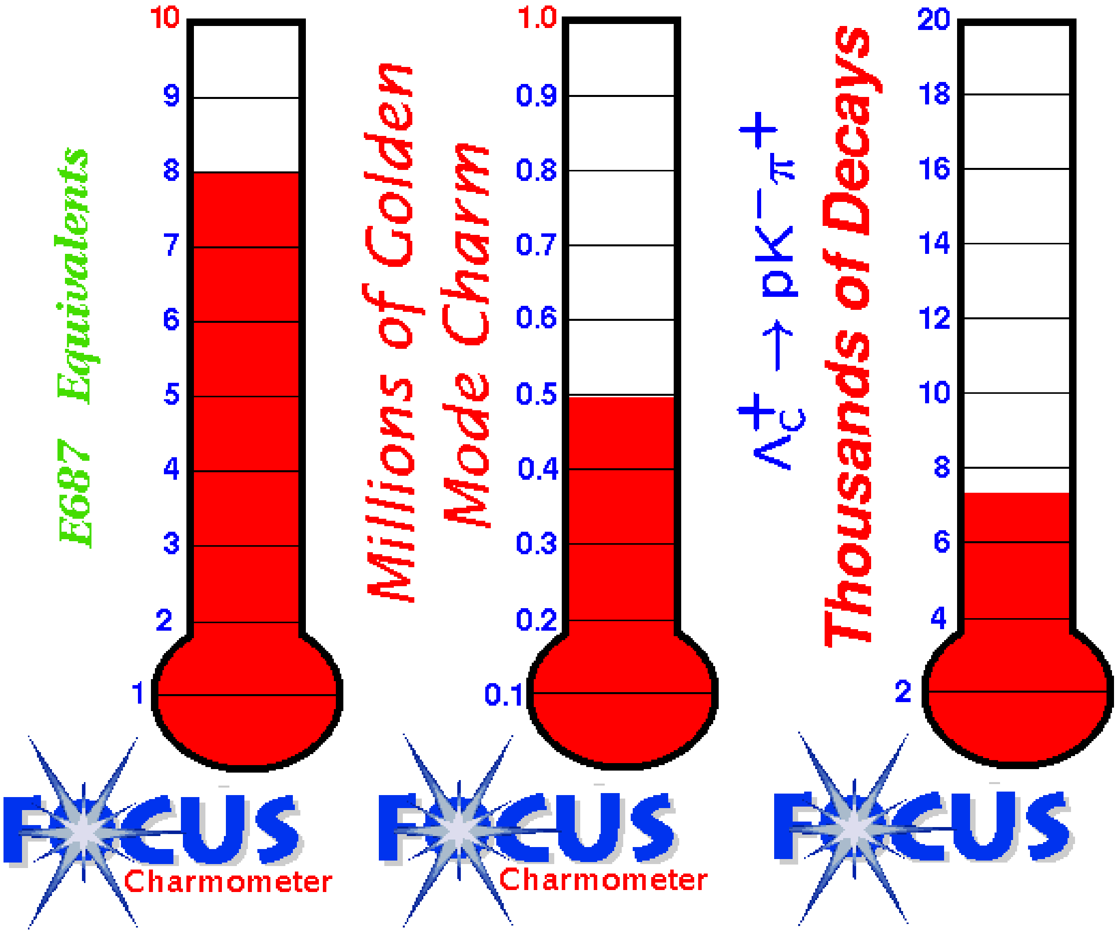
- Code Certification and Optimization

- Mini-Pass One



The graphic on the right shows how many events have been processed through Mecca.

PassOne Progress



Send comments to: Jonathan Link

Hadronic decays of charmed mesons

- Golden Modes:
  - $D^+ \to K^-\pi^+\pi^+$
  - $D^0 \to K^-\pi^+$
  - $D^0 \to K^-\pi^-\pi^+\pi^+$
  - $D_s^+ \to K^-K^+\pi^+$
  - $\Lambda_c^+ \to pK^-\pi^+$

  out of 3374602924 events ($\sim$ 50%)
- Singly Cabibbo Suppressed Decay (SCSD)
  - $D^0 \to K^-K^+$
  - $D^0 \to \pi^-\pi^+$

  out of $\sim$ 16%

Hadronic decays of charmed mesons...

- $D^+(D_s^+) \rightarrow \pi^-\pi^+\pi^+$
  out of $\sim 16\%$
- Doubly Cabibbo Suppressed Decay (DCSD)
  - $D^+ \rightarrow K^+\pi^-\pi^+$

  out of $\sim 16\%$

Integrated Charm Signals

from PassOne

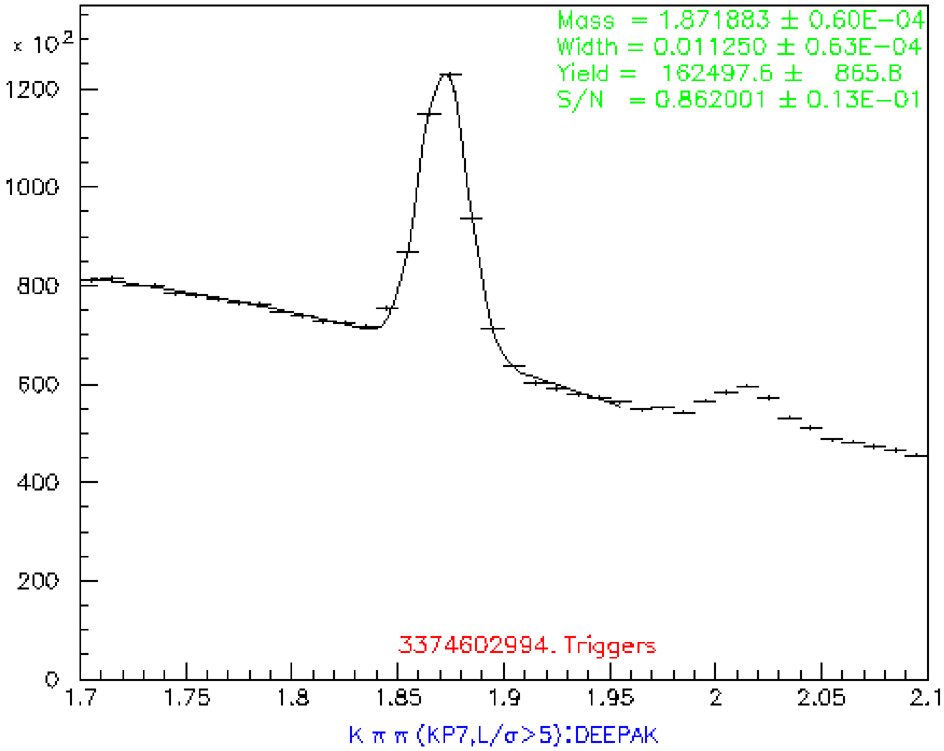
Golden Mode Charm Signals   Cabbibo Suppressed D and D_s Lambda C   Popsi Home Page

Golden Modes

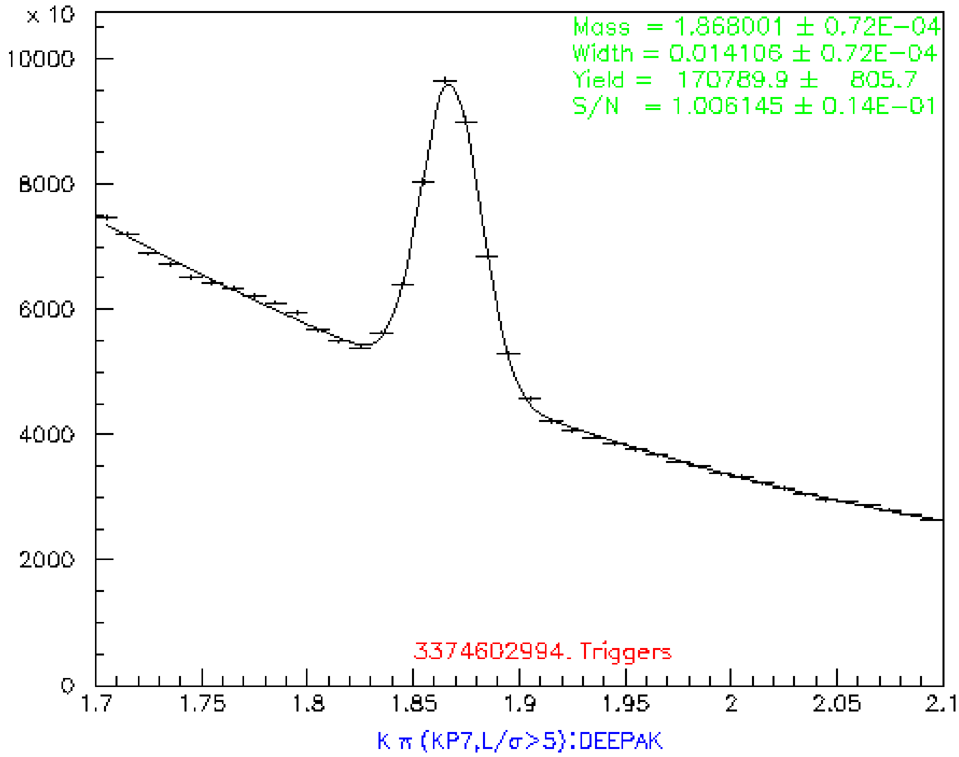
(D^+--> K^- pi^+ pi^+, D^0--> K^- pi^+, D^0--> K^- pi^+ pi^- pi^+)

The signals were found using SuperEZDEE, which uses SuperDVERT for vertexing. The cuts are very basic:

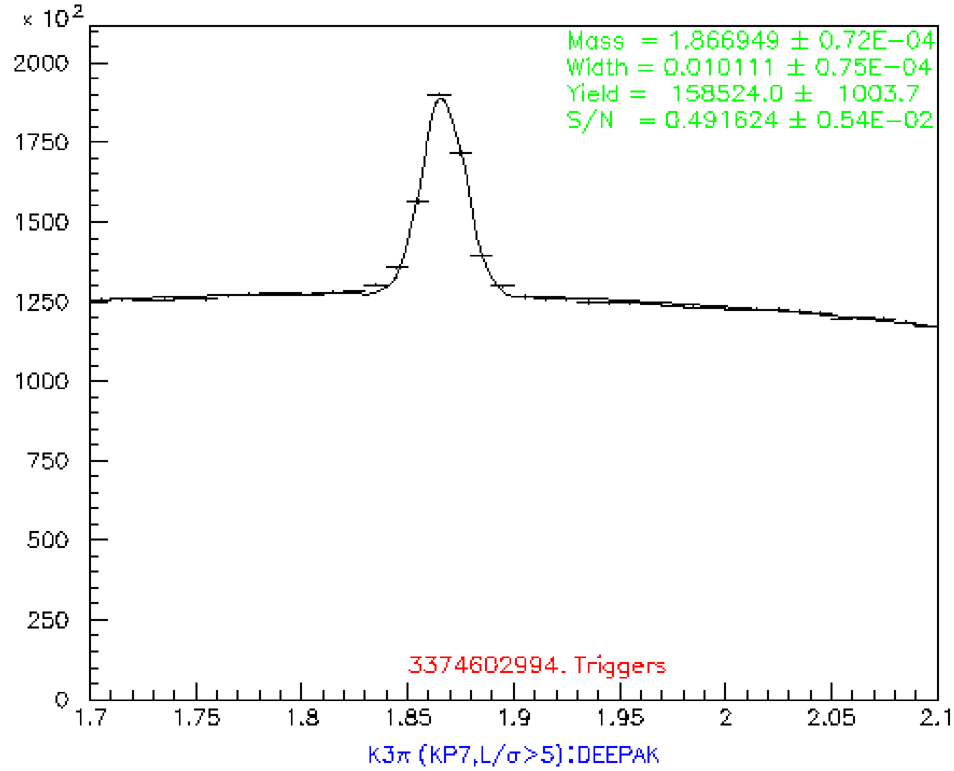
- KP7 Cerenkov ID cut on Kaons
- no Cerenkov ID cuts on pions
- DCL > 1% (DCL = confidence level of the fit to the charm decay vertex)
- L/sig > 5



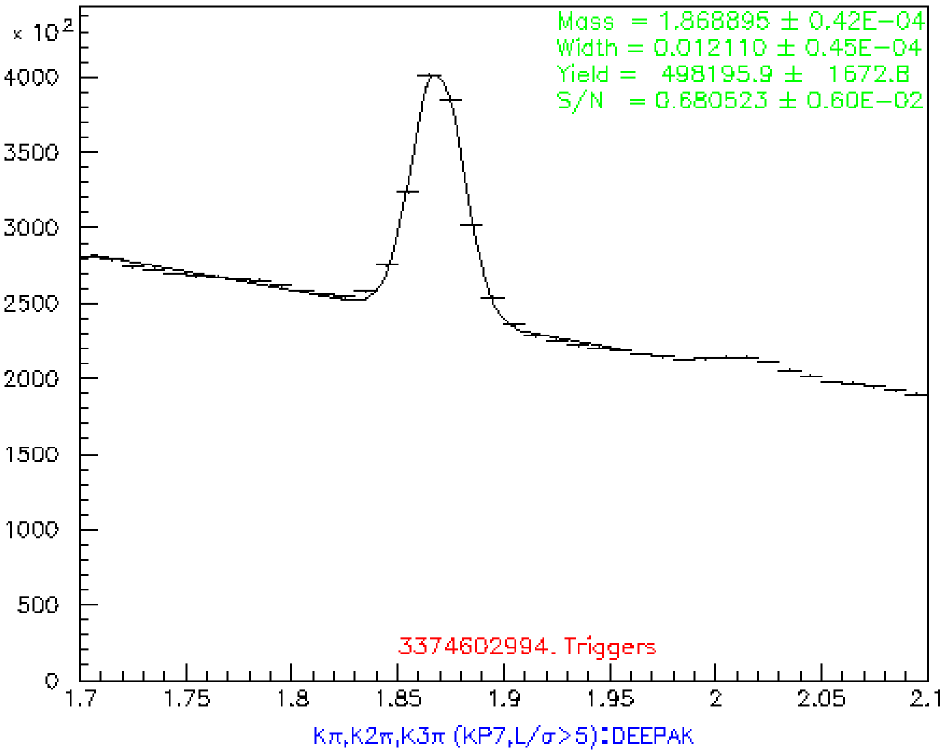
Full Plot Set



Full Plot Set

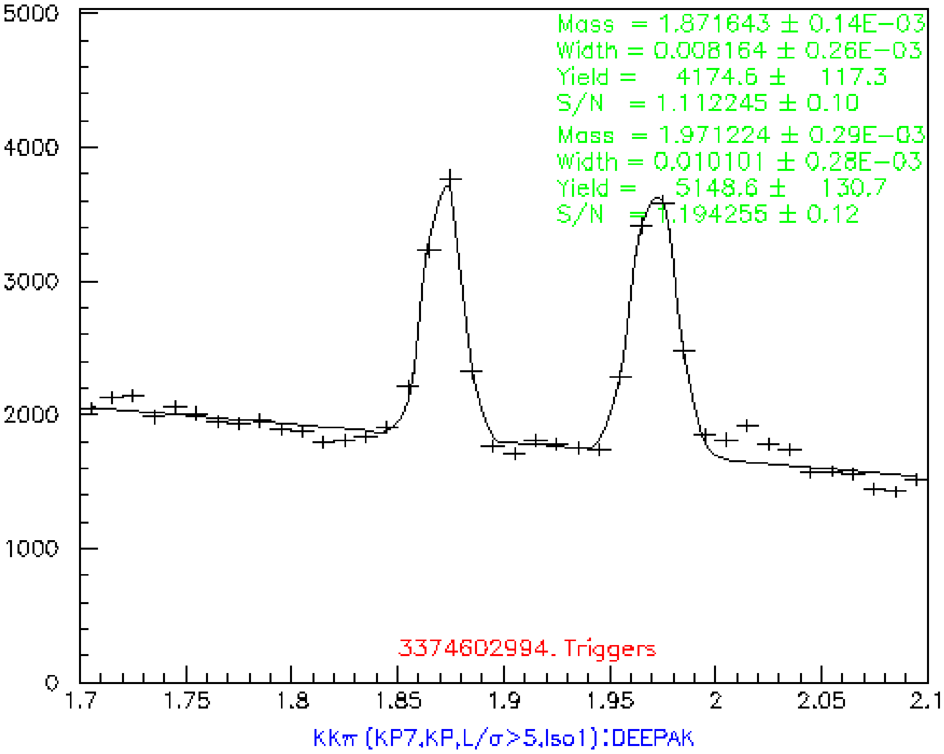


Full Plot Set



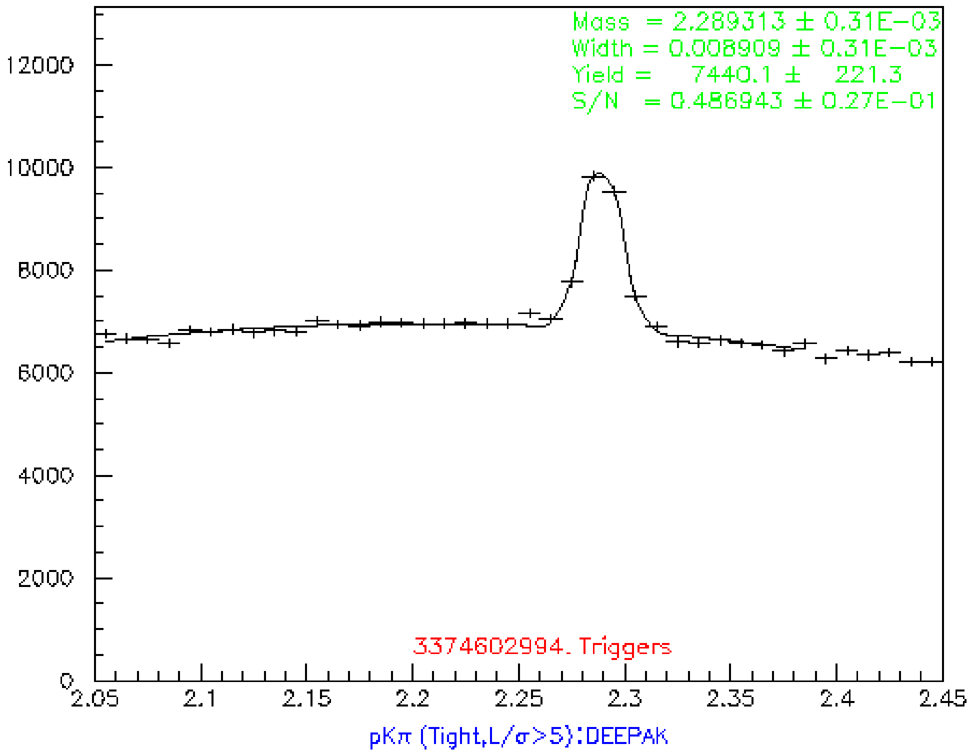
Full Plot Set

Cabbibo Suppressed D and D_s



Full Plot Set

Lambda C



Full Plot Set

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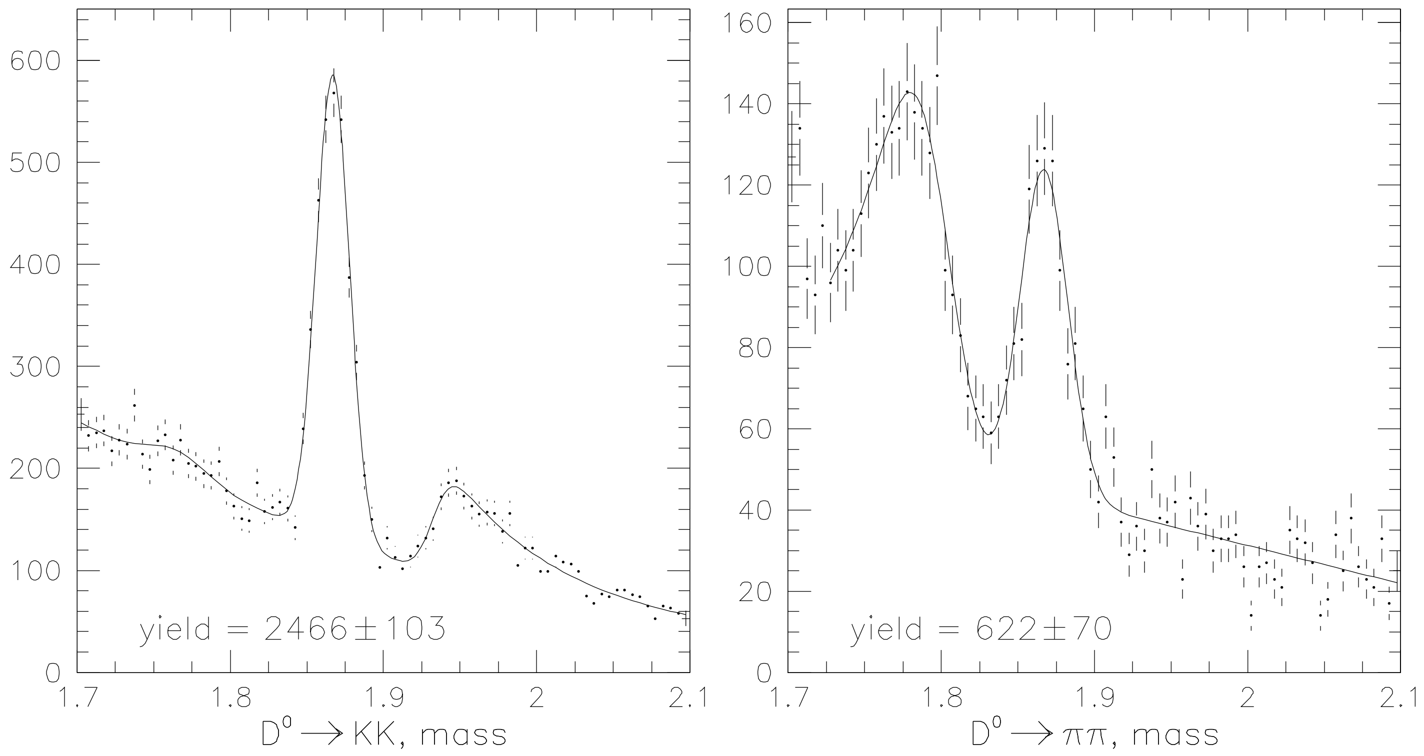
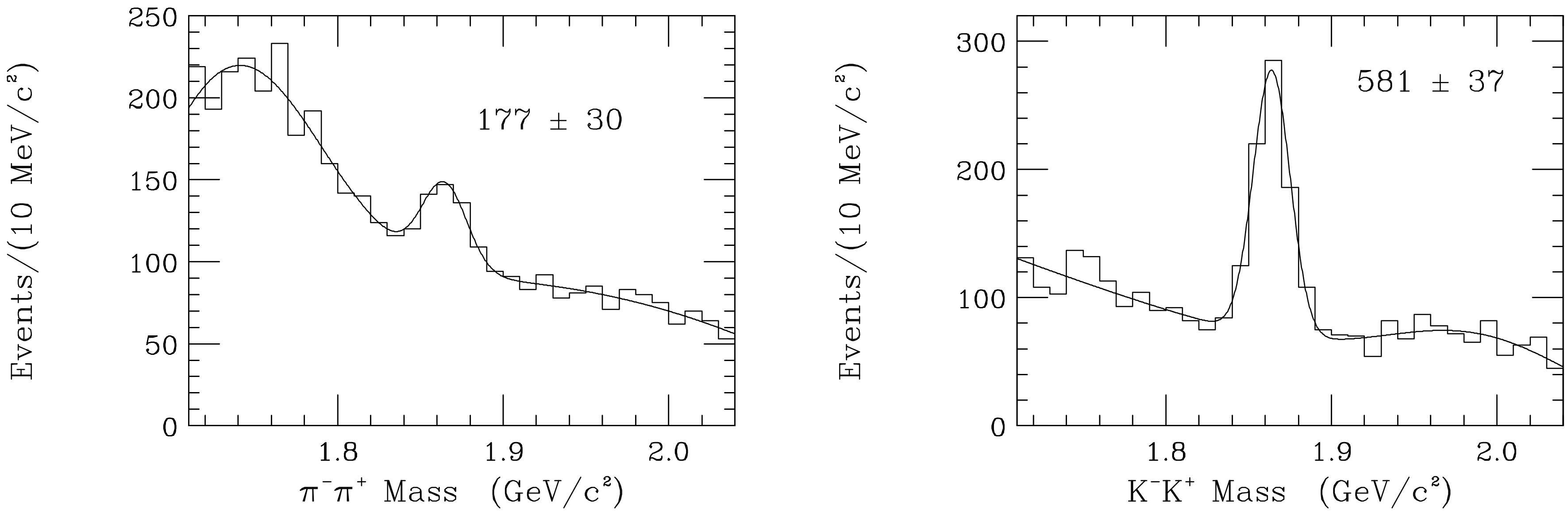
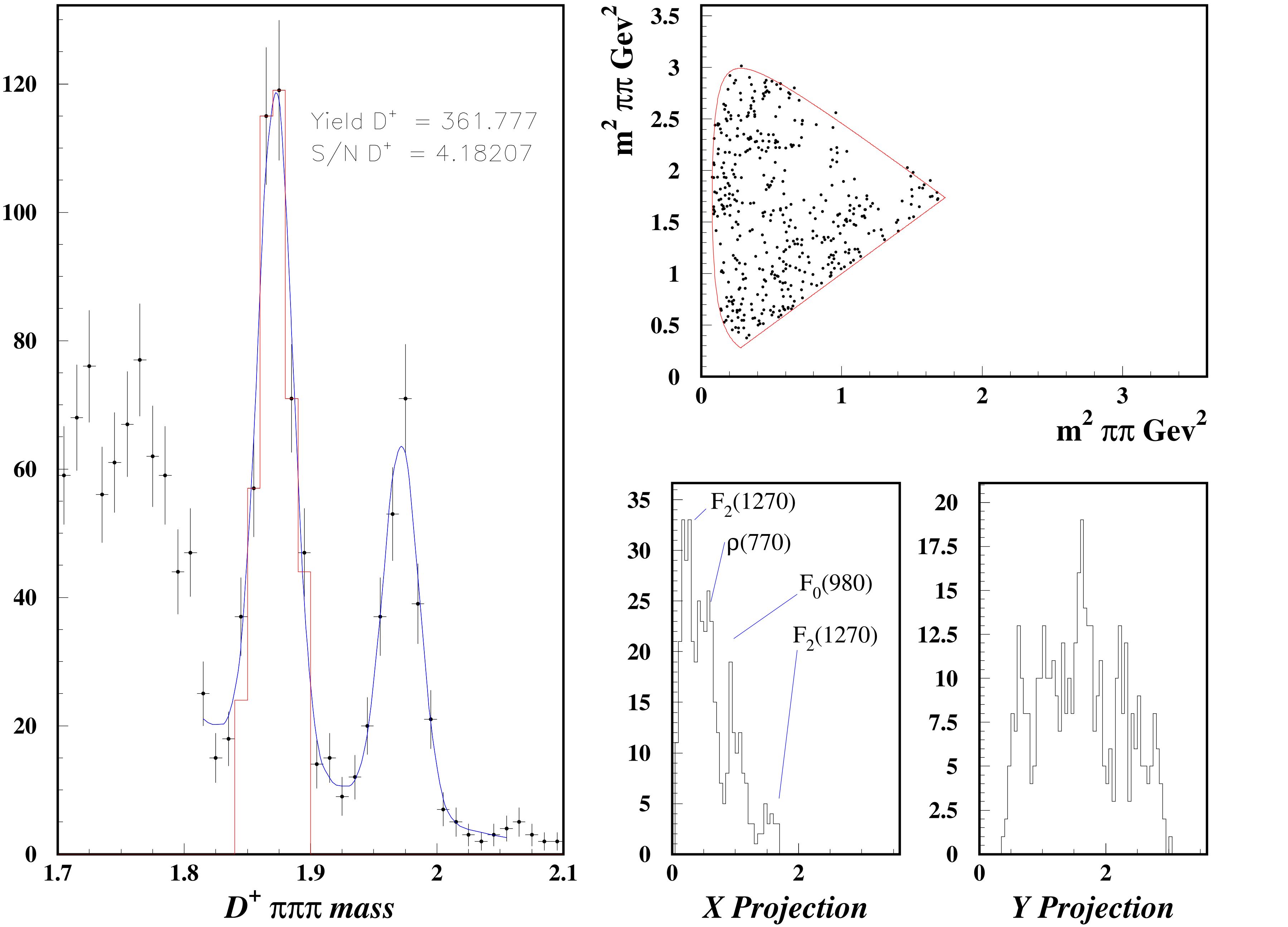


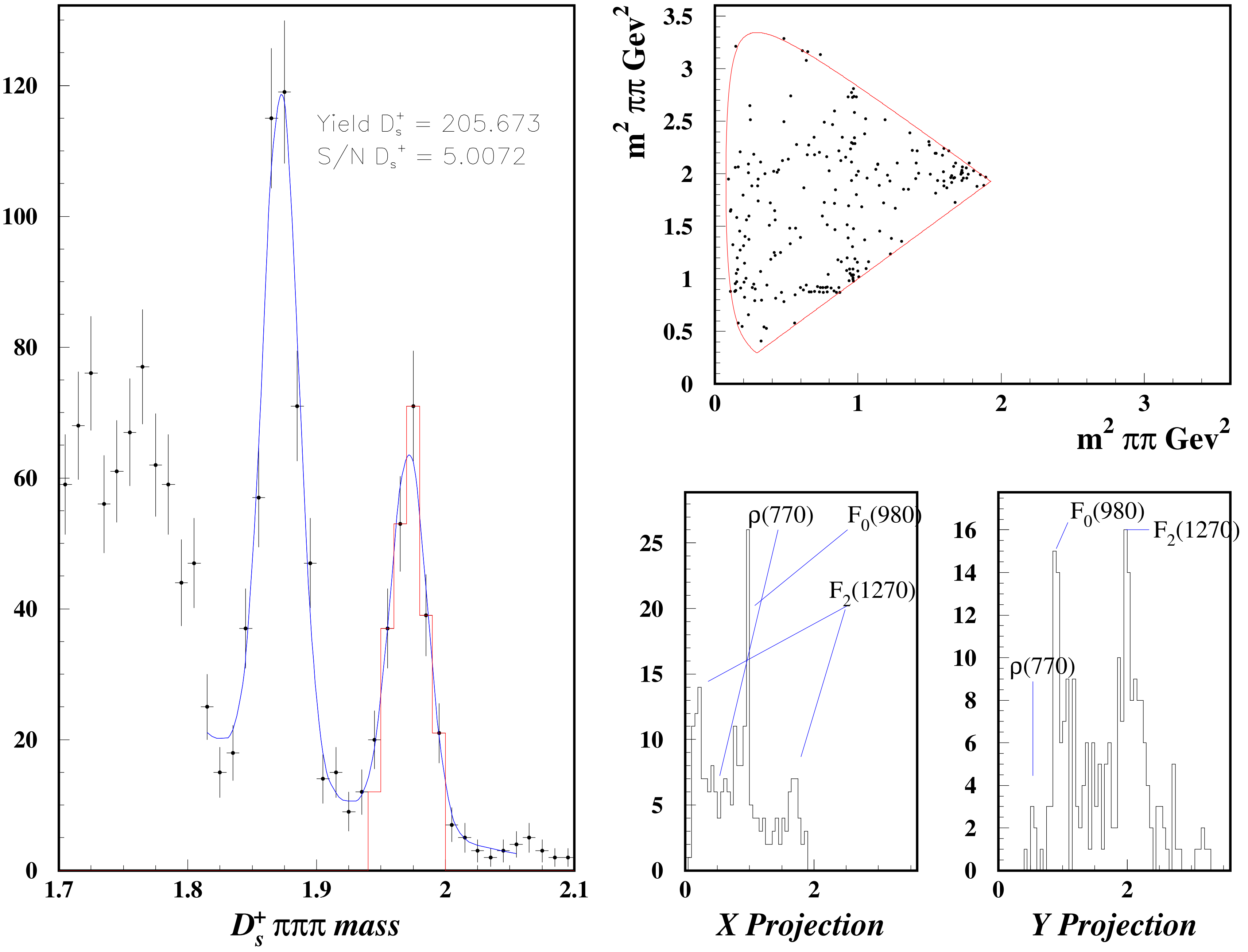
600
500
400
300
200
100
0
1.7
1.8
1.9
2
2.1
yield = 2466±103
$D^0 \rightarrow KK$, mass
160
140
120
100
80
60
40
20
0
1.7
1.8
1.9
2
2.1
yield = 622±70
$D^0 \rightarrow \pi\pi$, mass


Events/(10 MeV/c²)
250
200
150
100
50
0
1.8
1.9
2.0
π⁻π⁺ Mass (GeV/c²)
177 ± 30
Events/(10 MeV/c²)
300
200
100
0
1.8
1.9
2.0
K⁻K⁺ Mass (GeV/c²)
581 ± 37

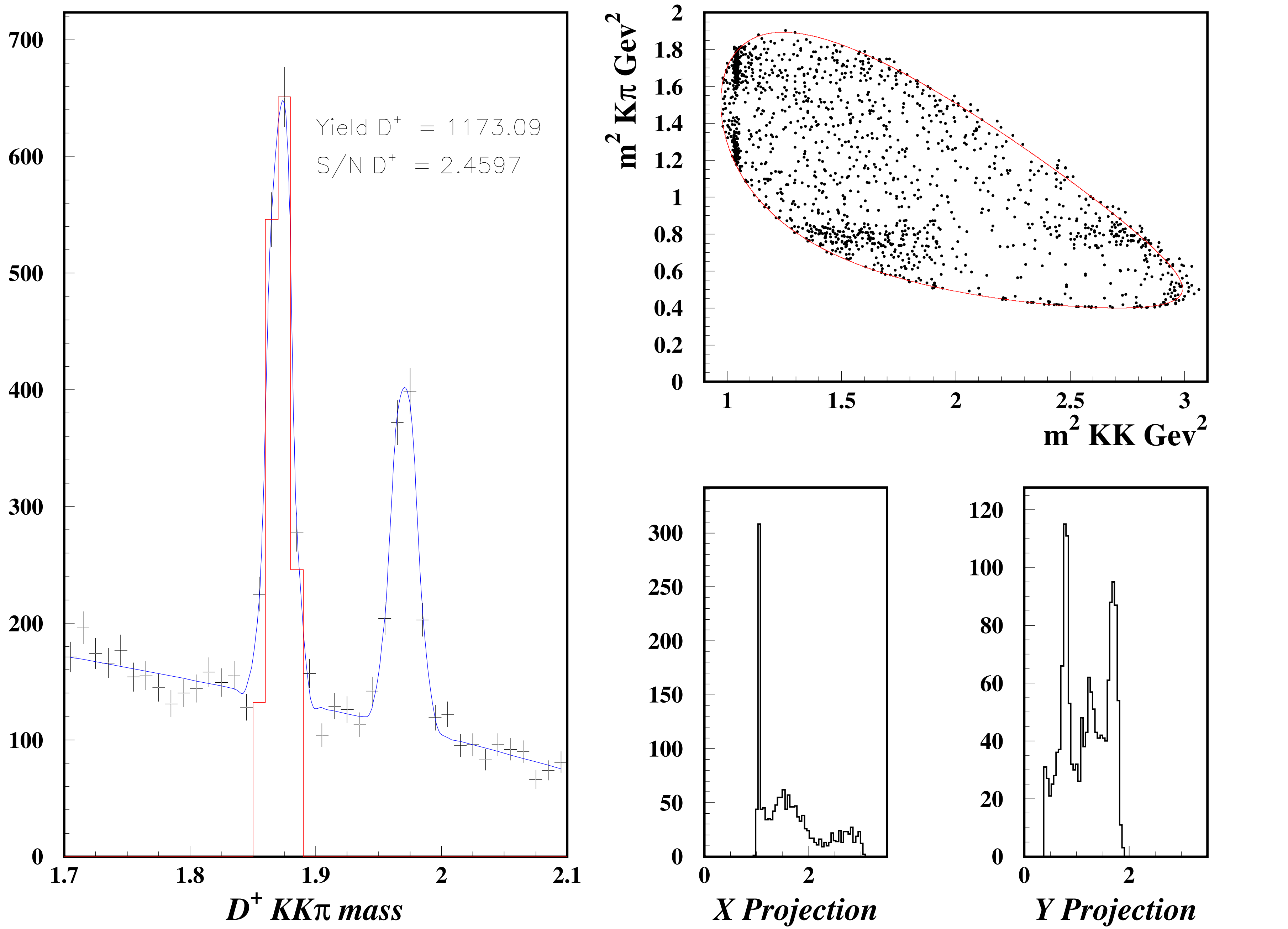
$D^+ \to \pi\pi\pi$ dalitz plot and projections



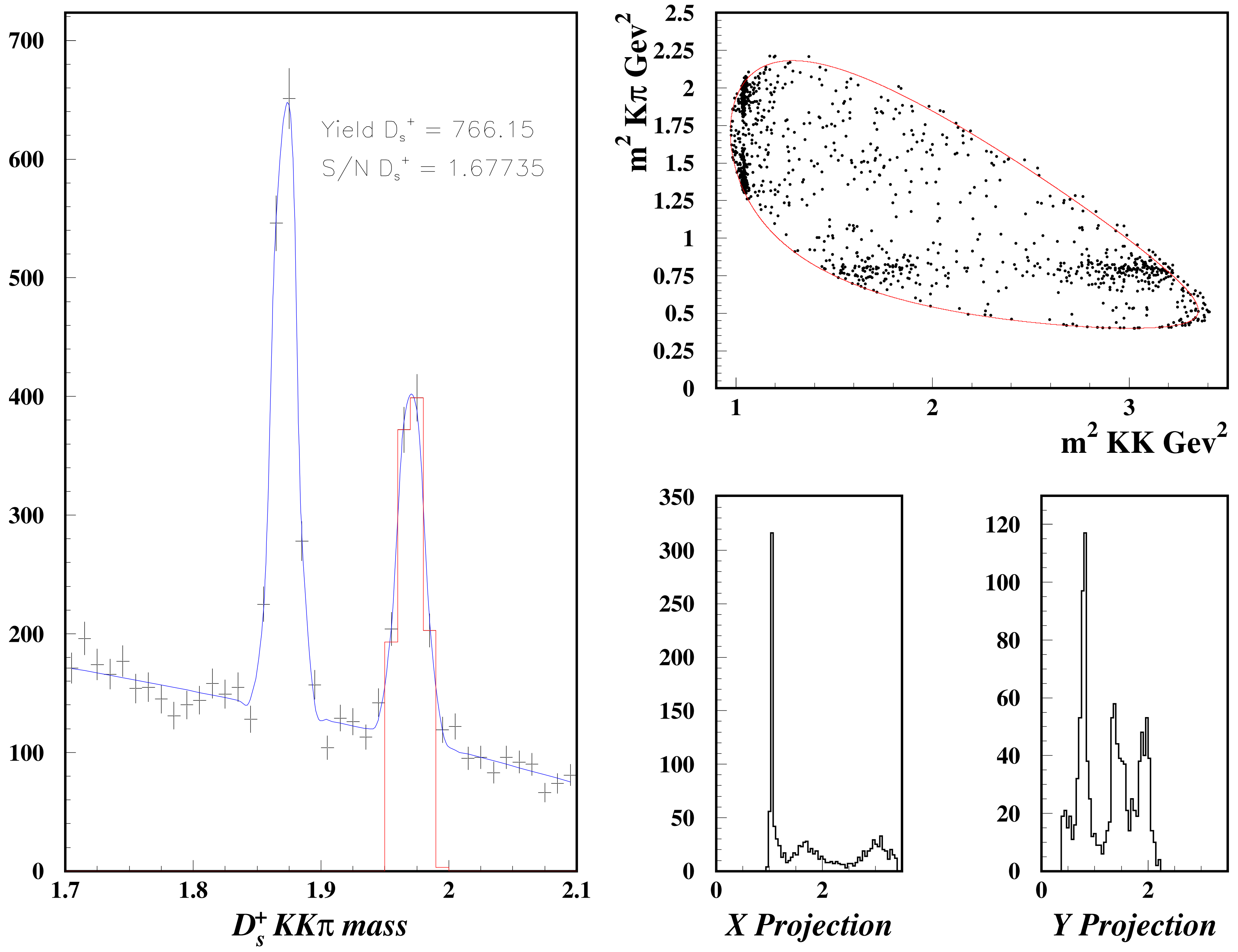
$D_s^+ \to \pi\pi\pi$ dalitz plot and projections



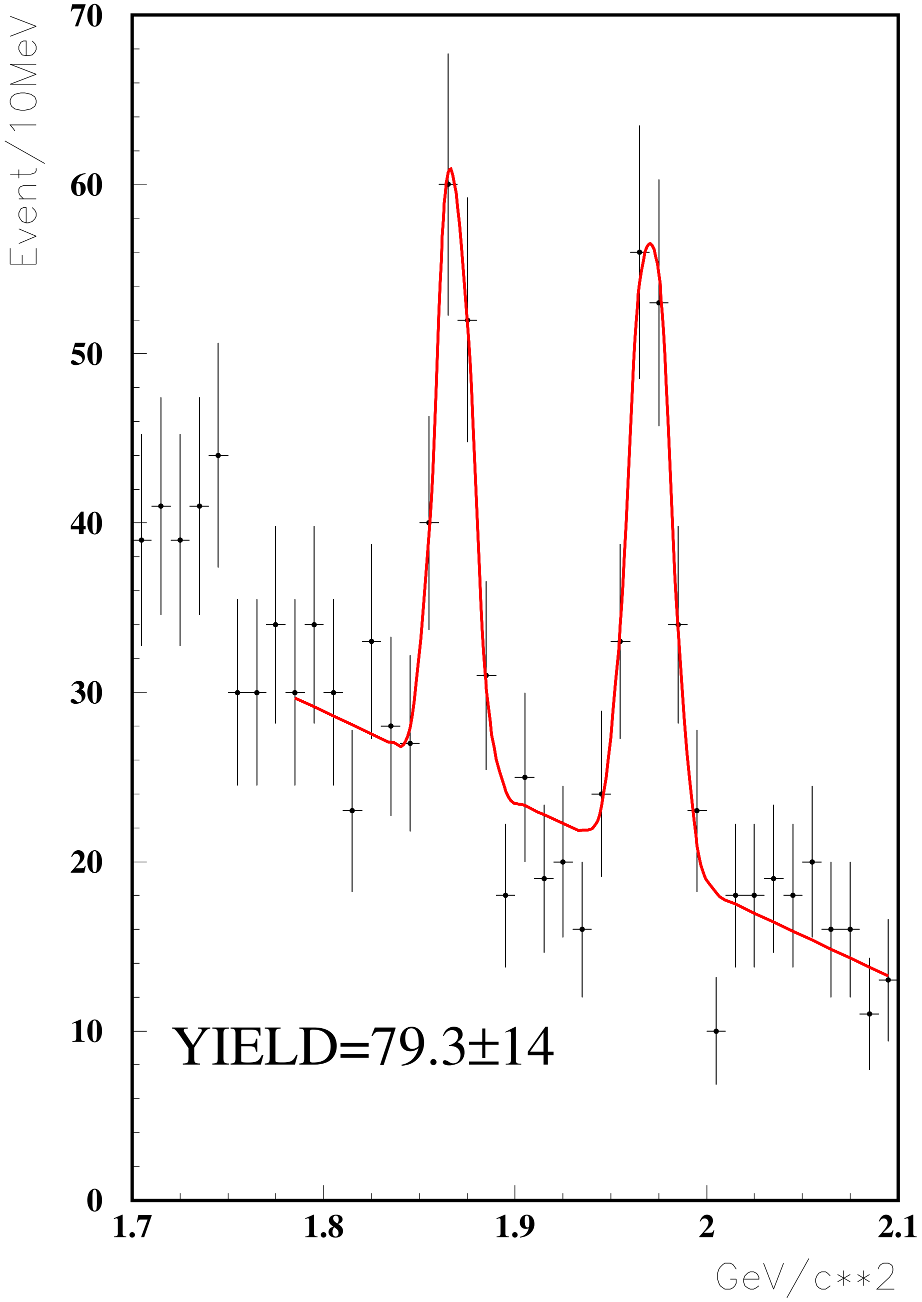
Dalitz $D^+ \rightarrow KK\pi$



Dalitz $D_s^+ \to KK\pi$



DOUBLY CABIBBO SUPPRESSED $K\pi\pi$



Conclusions

- Initial goal of the experiment, $10\times$ E687 statistics, achieved
- Reasonable estimate is $16\times$ E687 statistics
  1 Million Charm particles RECONSTRUCTED
- Comprehensive study of the Charm Physics
- First physics results expected for the end of the year (1998)

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