CESR and CLEO

Lepton Photon 99
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Where to "B"

To measure a key ~~CP~~ parameter (sin(2β)) to ~ 10 % requires:

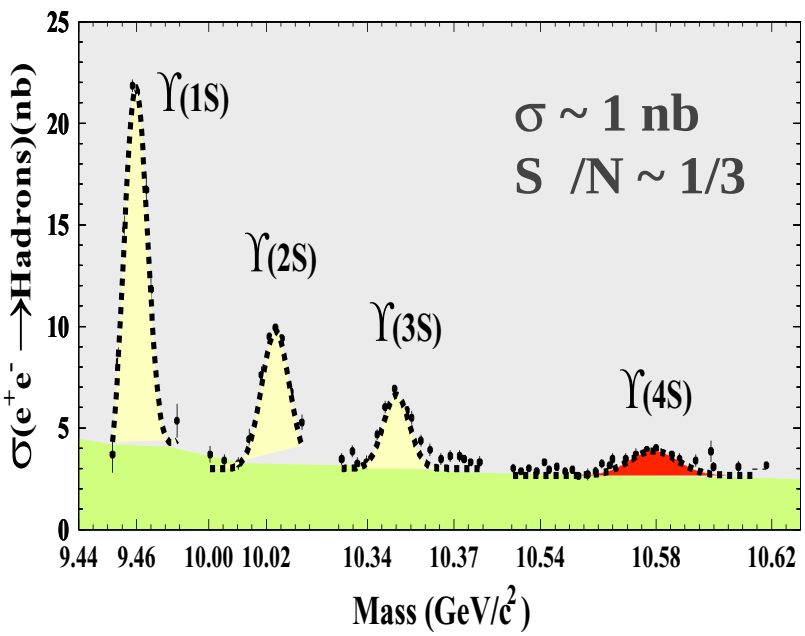
a few hundred $B^0 \rightarrow J/\psi K_s$ events

+ fully reconstructed, flavor tagged

+ BR's, efficiency, tagging…

⇨ 3 0x 10 BB events (Y (4 S))

e^+e^- Annihilation

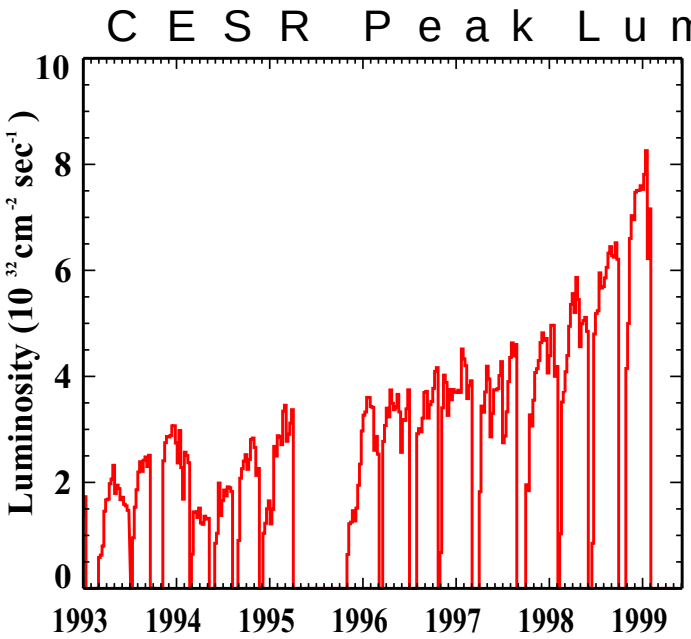


Hadro-Production

σ ~ 100 μb (Tevatron)

S /N ~ 1/500

CESR Performance

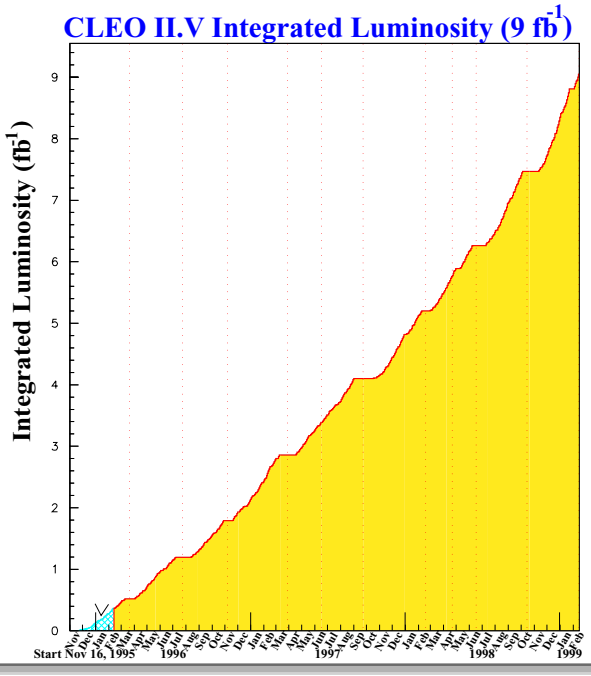


Peak Luminosity: 8.5 x 10^{32} cm^{-2} s^{-1}

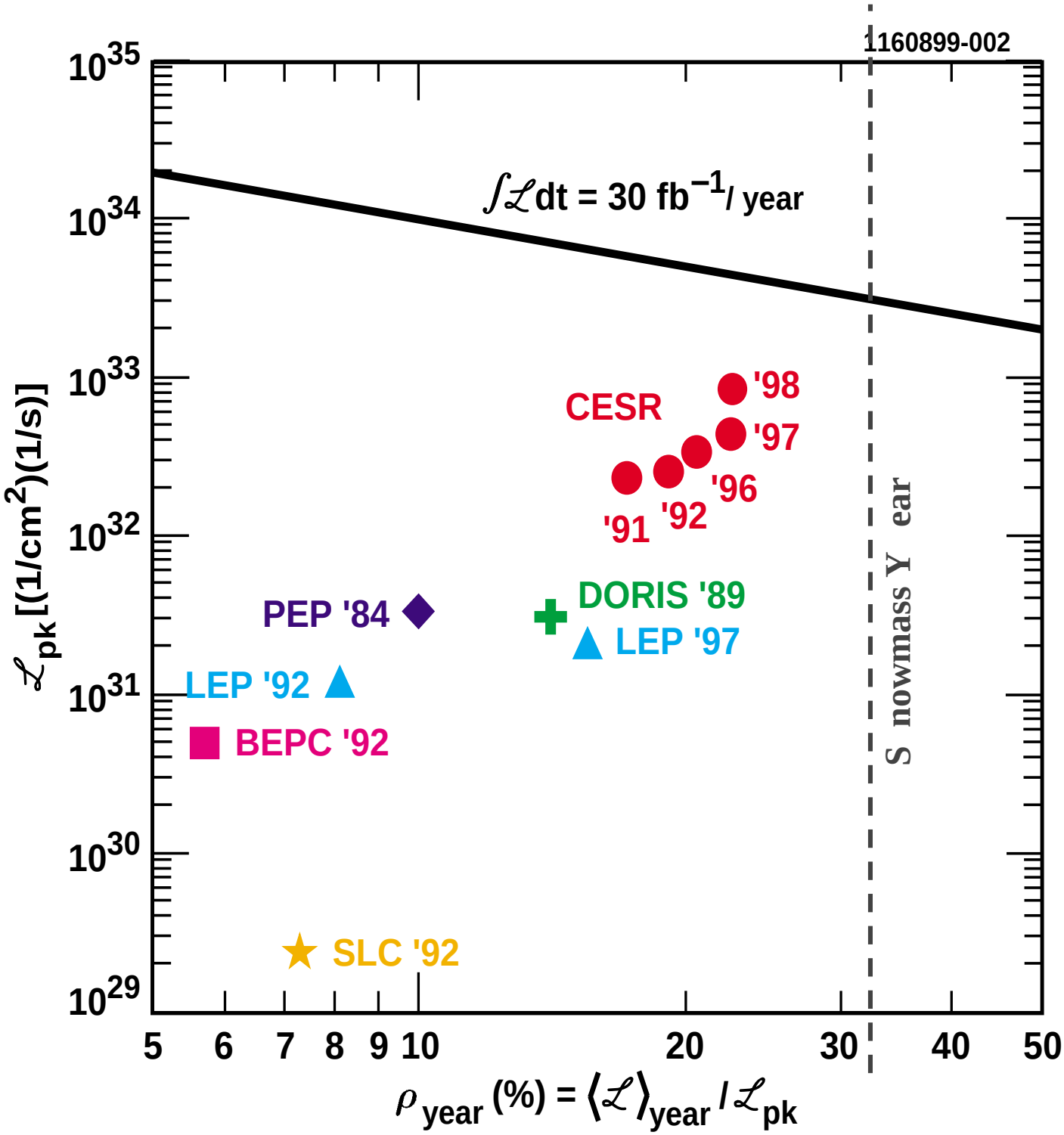
Integrated	40 pb^{-1}	(Day)
Luminosity	750 pb^{-1}	(Month)
	4400 pb^{-1}	(Year)

CLEO Datasample

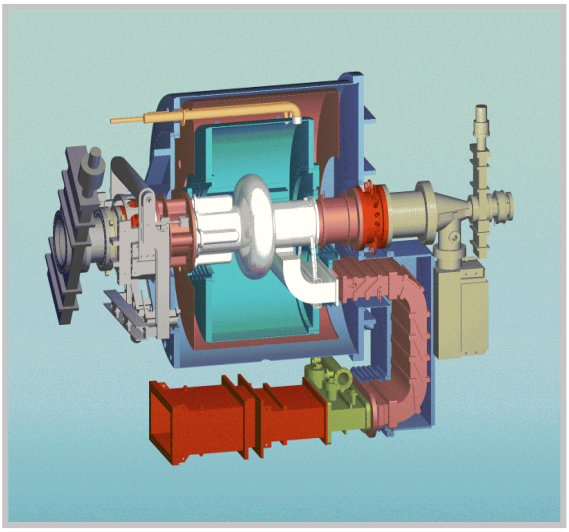
	on 4S	Cont. [fb^{-1}]
CLEO II	3.1	1.6
CLEO II.5	6.2	2.8
Total	9.3	4.4



CESR Performance

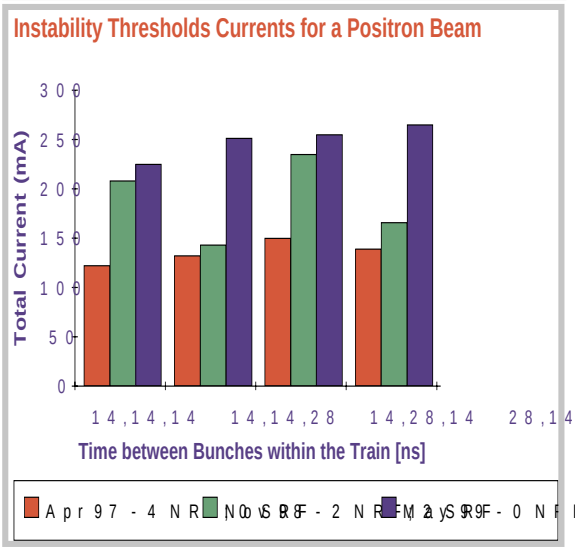


CES R Upgrades



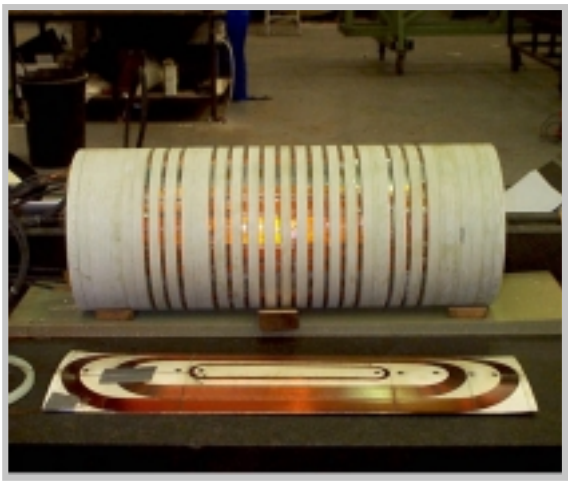
S uperconducting R F

- More Power
  - ⇨ 1 A beam current
- Less Impedance
  - ⇨ 4 R F cells vs. 20
  - ⇨ R educed Instabilities
- Higher Gradient
  - ⇨S horter Bunches
- Installed

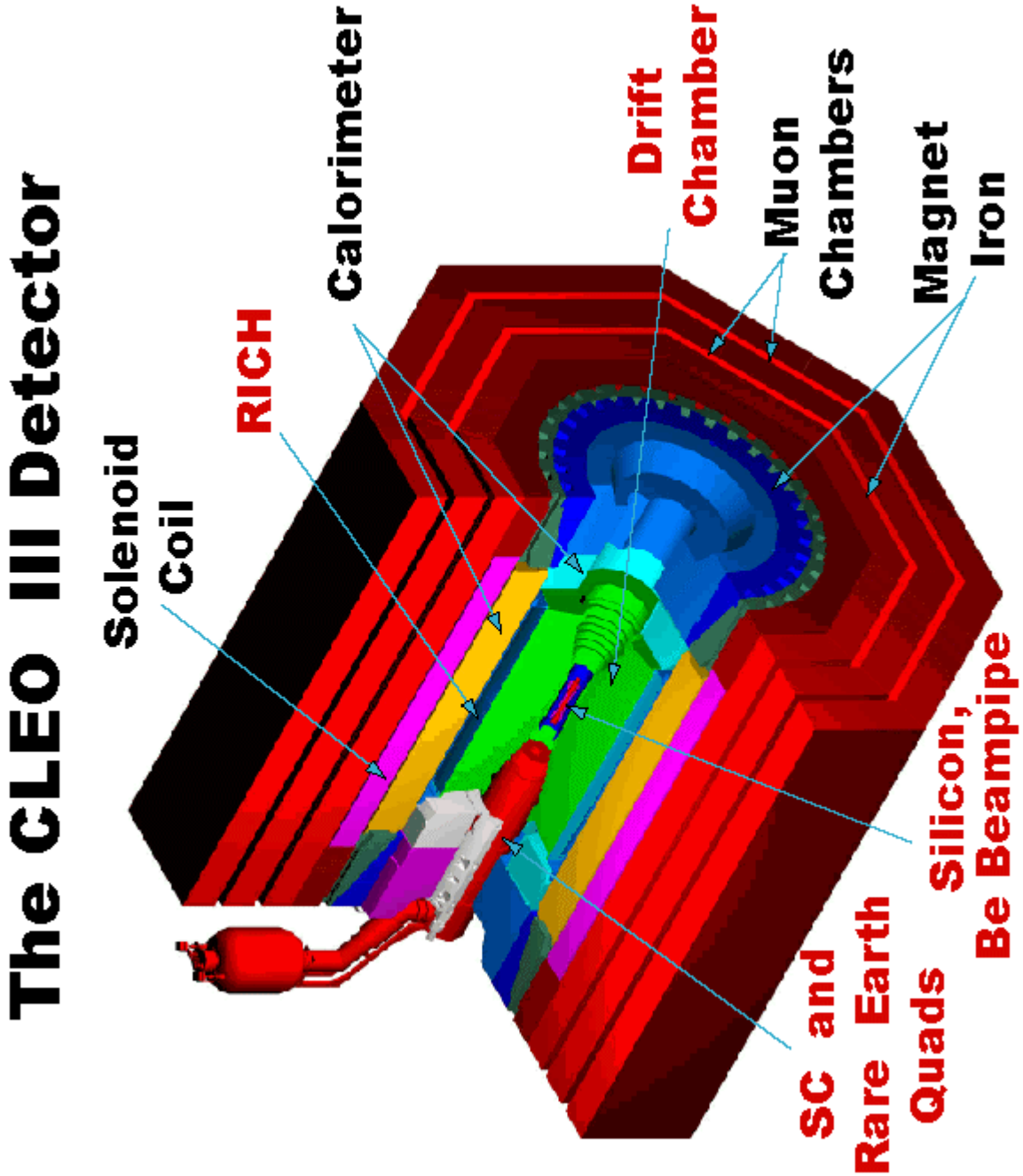


S uperconducting Quads

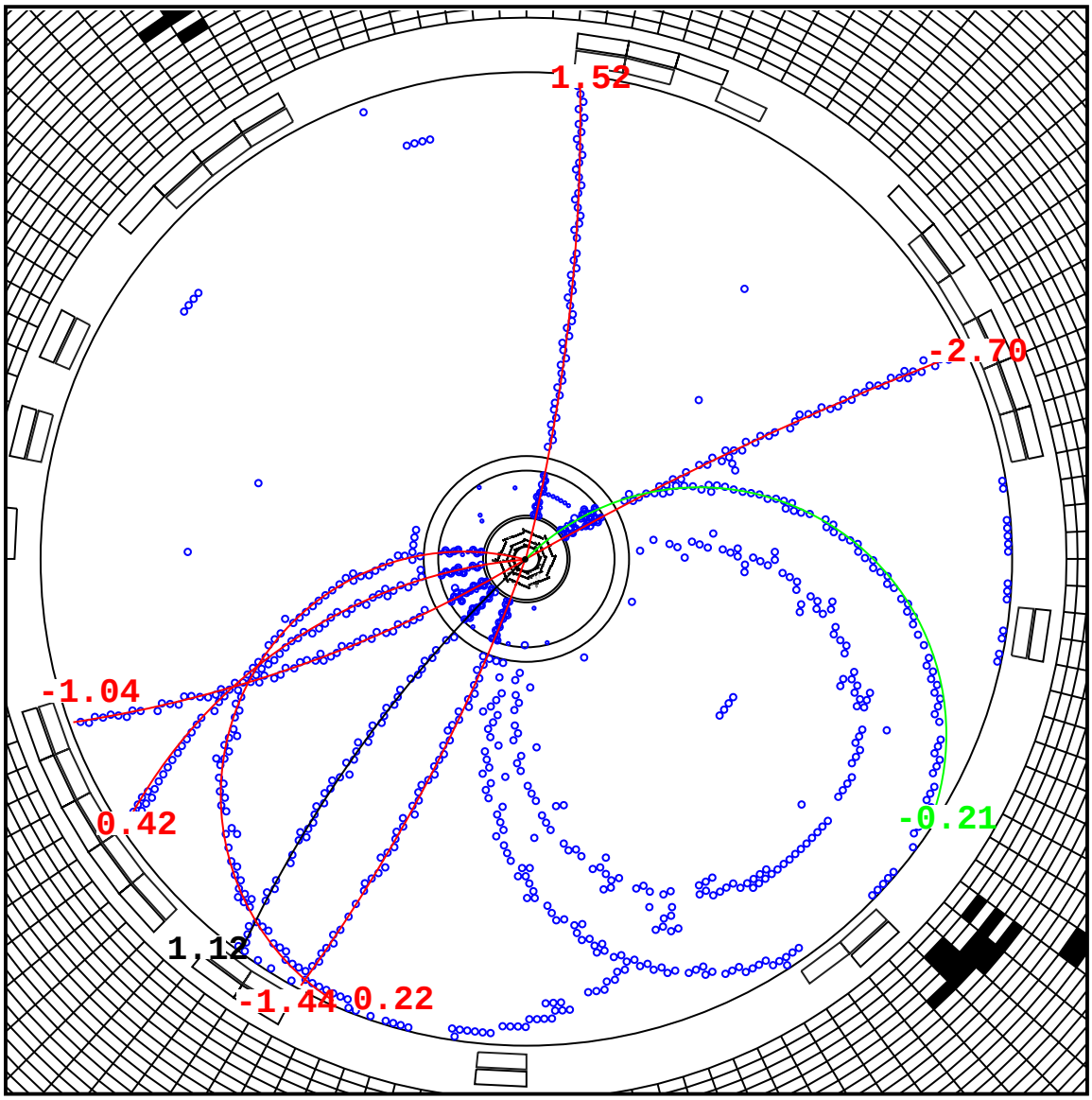
- Better focus
  - ⇨ β* from 18 to 13 mm
- S pring 2000



Ex pect to reach 2 x 10^{33} cm^{-2} s^{-1} sometime nex t Y ear.


The CLEO III Detector
Solenoid Coil
RICH
Calorimeter
Drift Chamber
Muon Chambers
Magnet Iron
SC and Rare Earth Quads
Silicon, Be Beampipe

Charged Particle Tracking



Charged Multiplicity ~ 10
Typical Momentum ~ 700 MeV/c down to 100 MeV/c

Momentum R esolution = f(Length, Multiple S cattering)

CLEO II ⇒ CLEO III: 20 cm smaller radius (R ICH)
Final focus quads

R educed Multiple S cattering

Inner Gas S eal

2.5 mm R ohacell with 20 μm Al skins
X_o < 0.15%
No support function

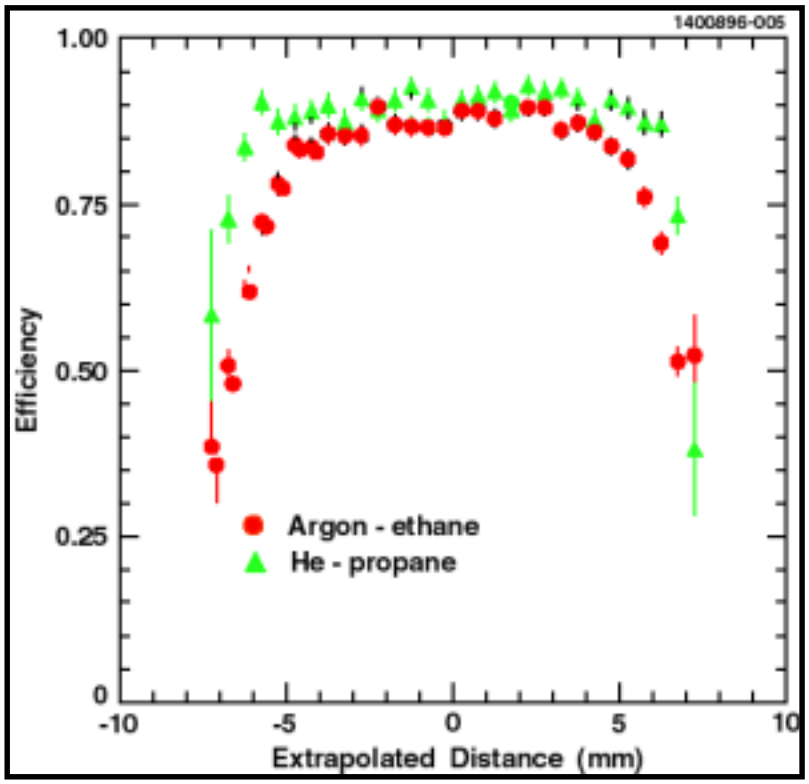
He based Gas Mix tures

R esolution
Efficiency

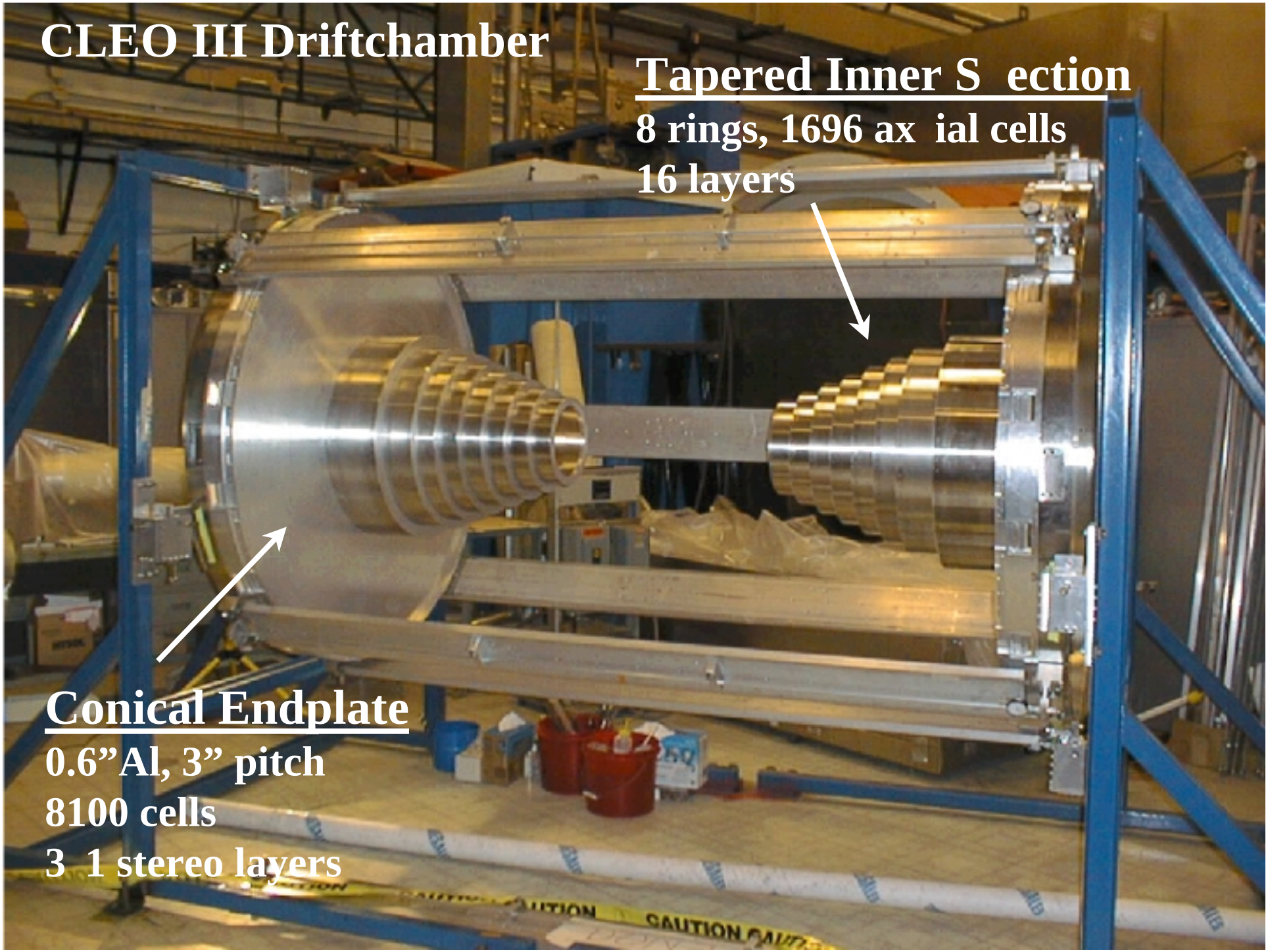
He:Propane	X_o > 580 m
60:4 0	Lorentz Angle (@ 1.5 T) < 3°5
Ar:Ethane	X_o = 165 m
50:50	Lorentz Angle (@ 1.5 T) < 69°

Test Beam R esults (CLEO II.5)

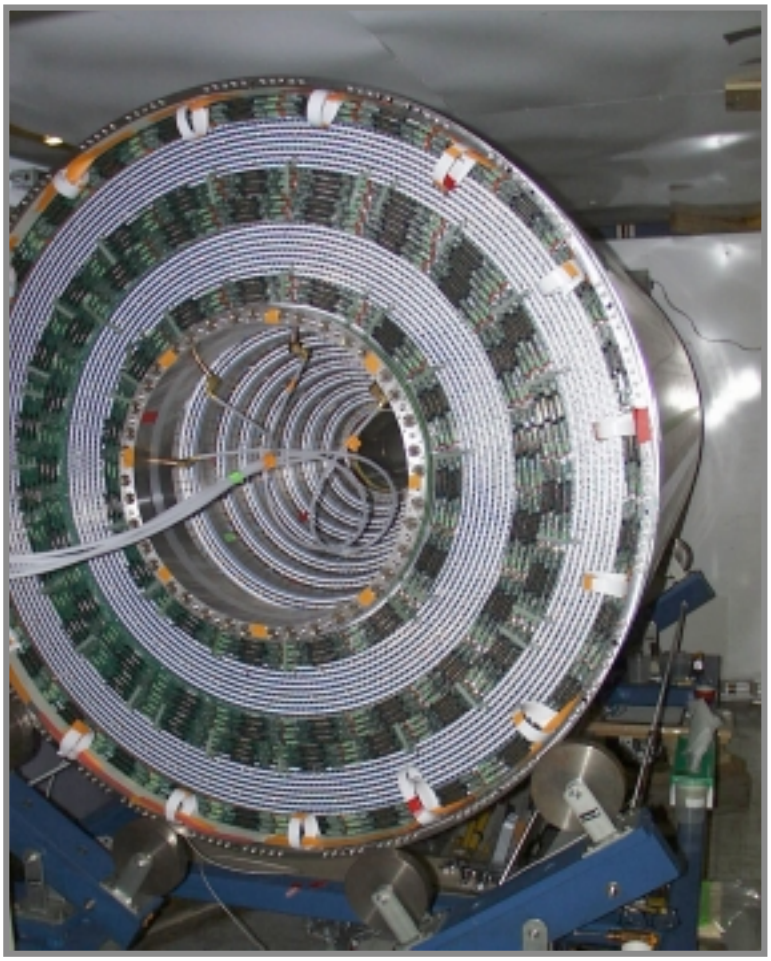
Improved efficiency
Improved resolution
122 μm -> 112 μm
Improved dE/dx



All B-Factories use He-based drift chamber gases

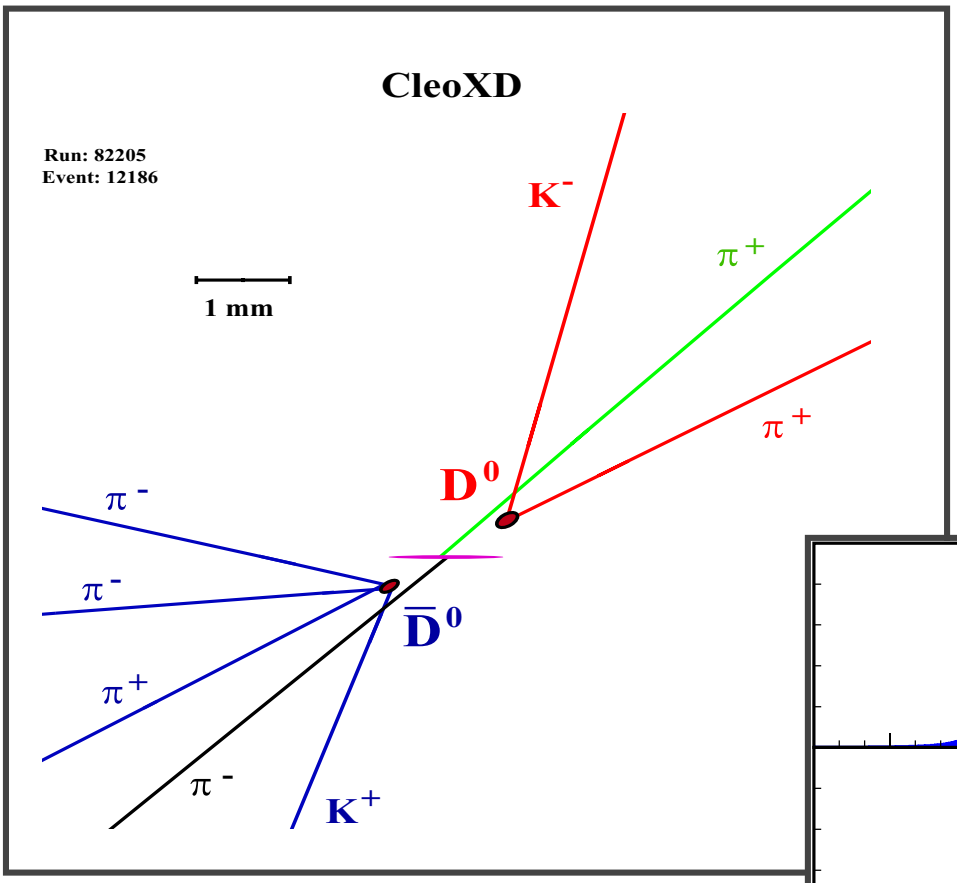

CLEO III Driftchamber
Tapered Inner S ection
8 rings, 1696 ax ial cells
16 layers
Conical Endplate
0.6”Al, 3” pitch
8100 cells
3 1 stereo layers

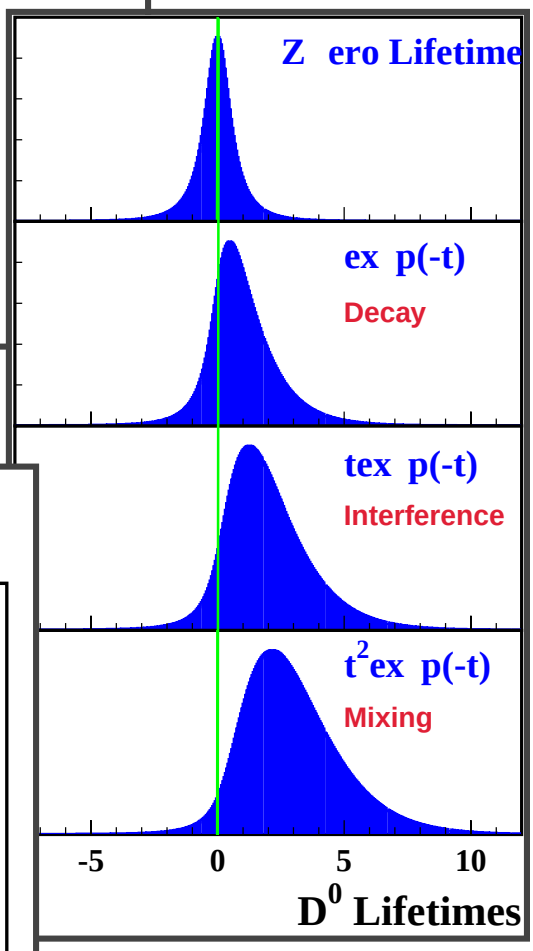
Moving Day

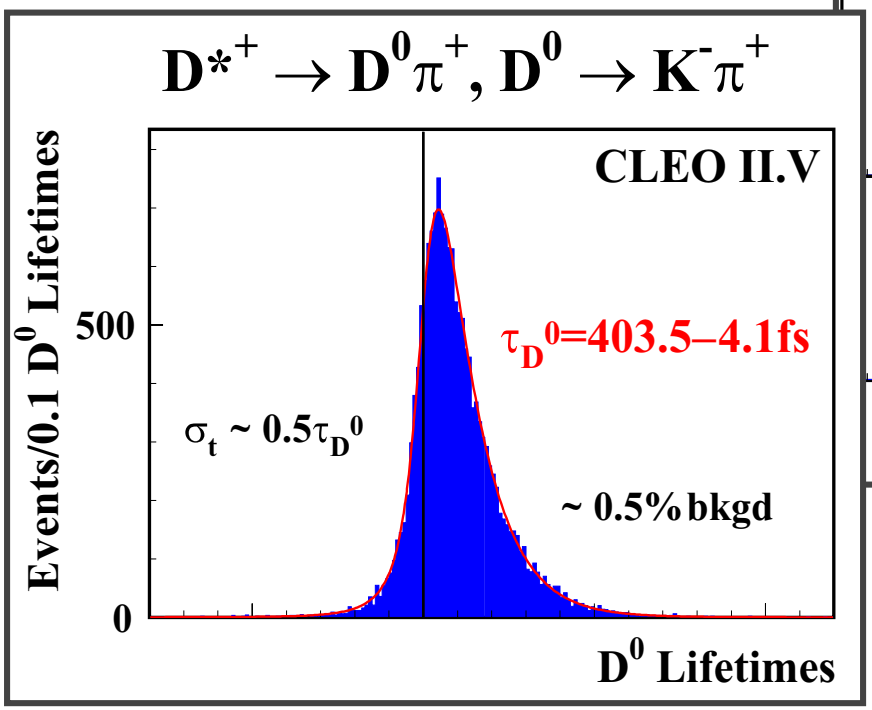


Endplate View

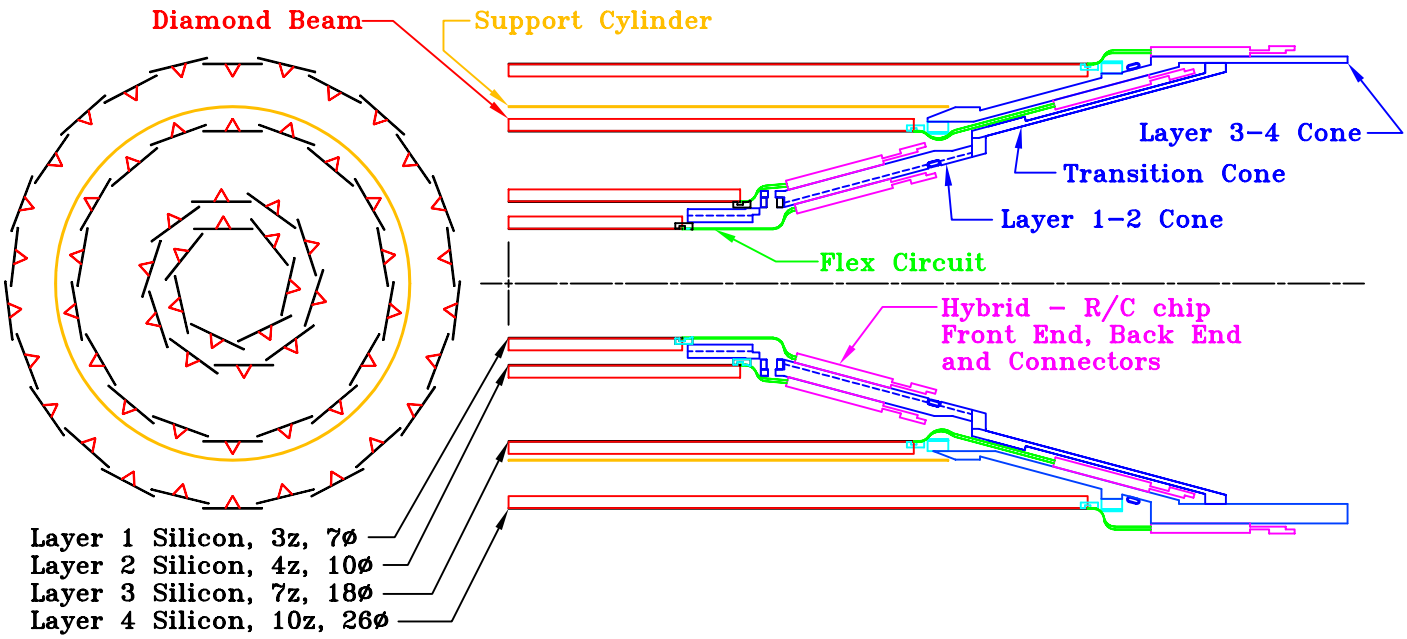
Charged Particle Tracking





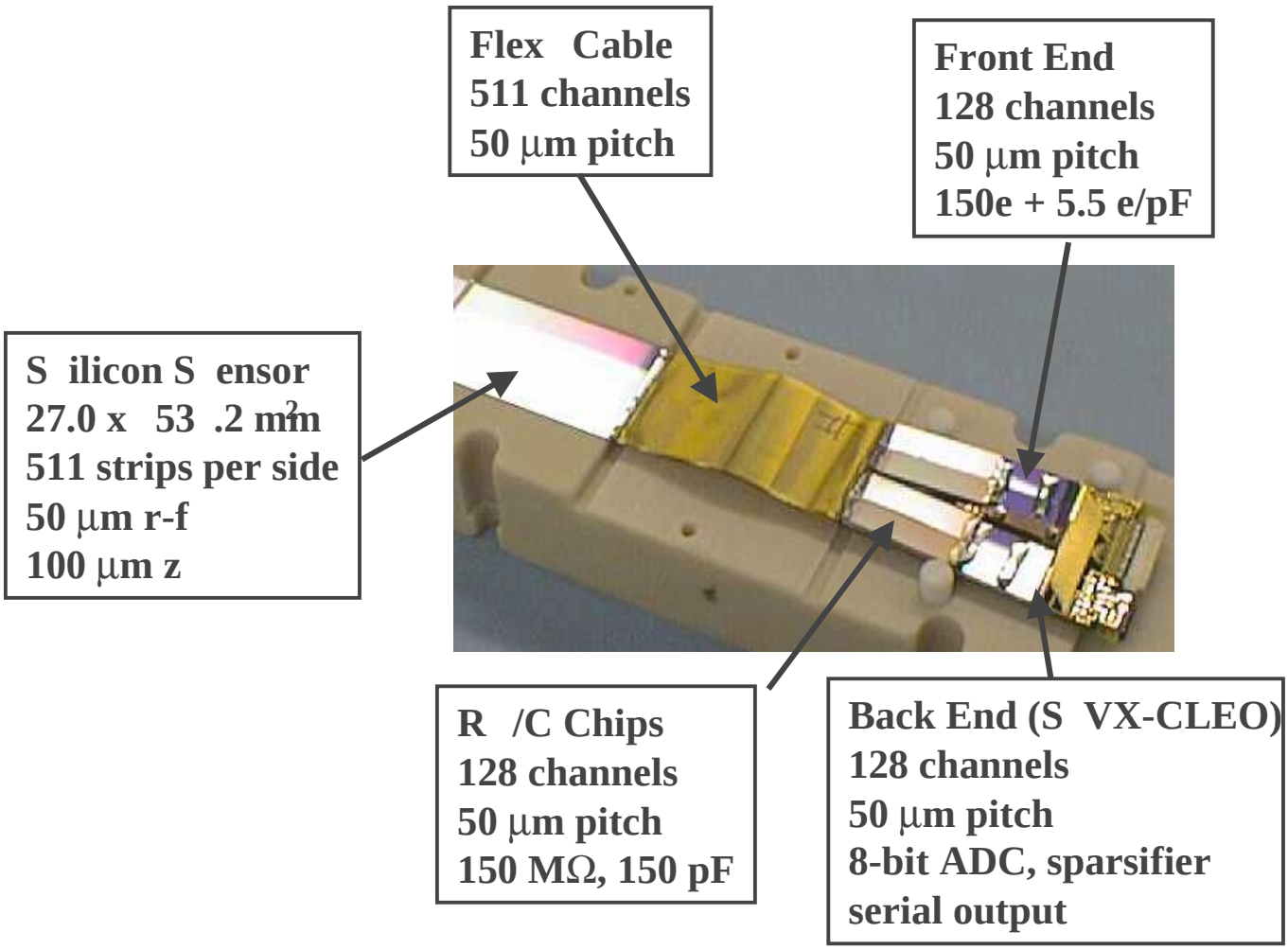


S ilicon Vertex Detector



4 Layers of double sided silicon detectors, 3 00μm thick.
Only active elements and minimal support material in detector fiducial region
No support structure outside outermost silicon layer.
Conical support structure to max imize acceptance.

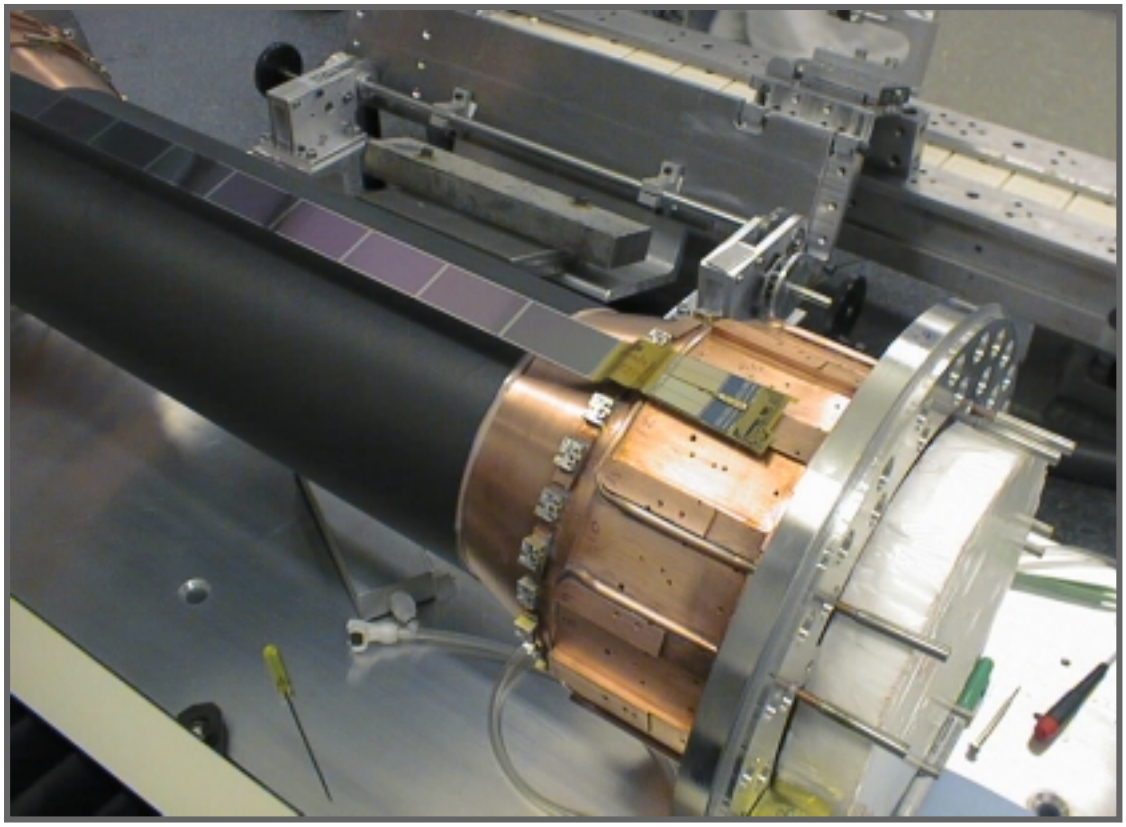
R ead Out Electronics



- Up to 5 silicon sensors daisy-chained to one readout.
- R adiation hard (100 kR ad)
- Very low noise, Viking based Front-End chip.
- Back-End chip based on S VX II
- BeO Hybrids mounted on copper cones (cooling)
- S /N > 15:1 (worst case)

Vertex Detector Assembly

Layer 4



Layer 3

Detecting Neutral Particles

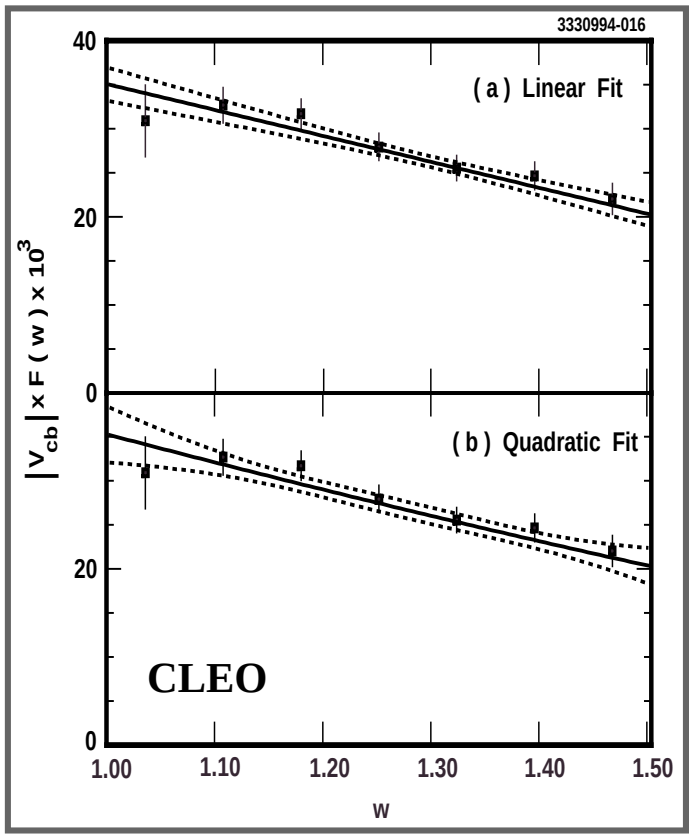
How to measure V_{cb}?

HQET: use $B \to D^* l \nu$ at q^2_{max}

D* at rest (in B frame)

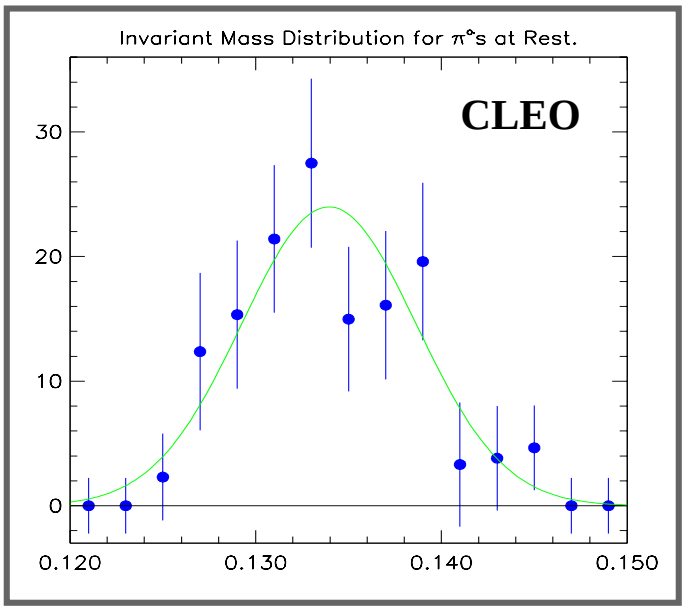
with $D^* \to D\pi$ and almost no phasespace the π is as rest as well.

How to find a π at rest?



With good resolution (at low energies) and high granularity try:

π^0's

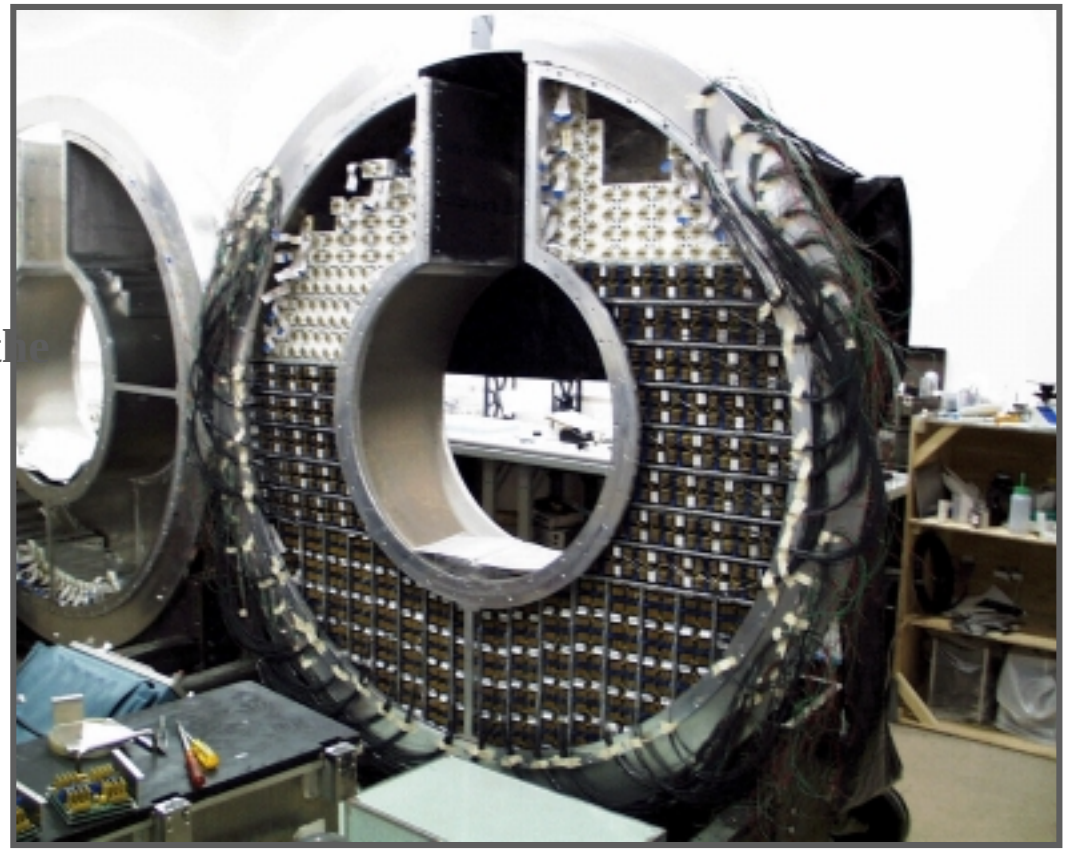


Electromagnetic Calorimeter

- CLEO pioneered use of CsI calorimeter
- 7800 crystals.
- 2% energy resolution at 1 GeV.
- 4 mr angular resolution at 1 GeV.
- no radiation damage observed.
- reduced material in front of endcaps.

All B-Factories use CsI calorimeter

R e-S tacking the
Calorimeter
Endcap



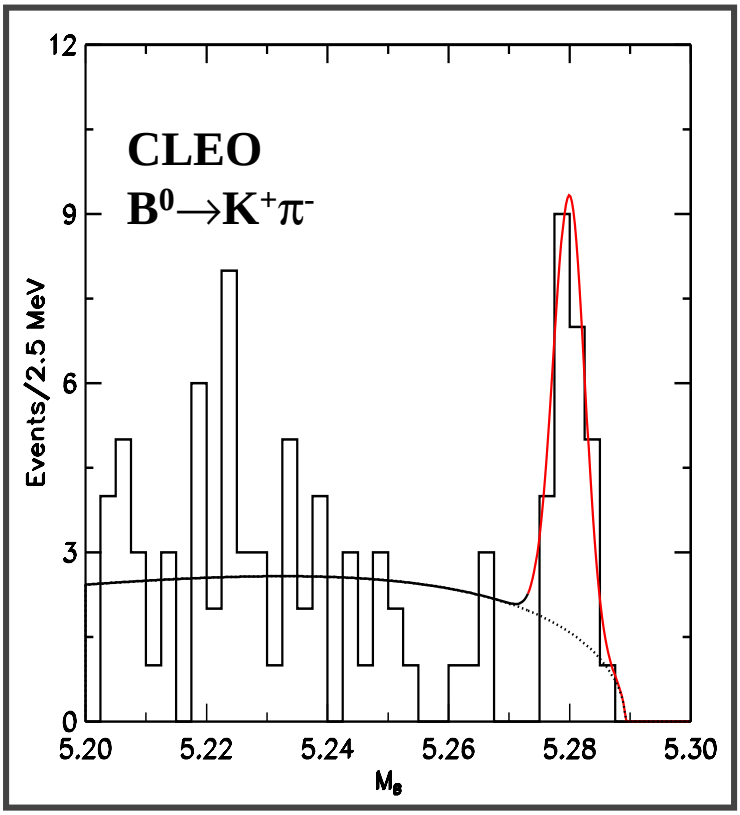
Particle Identification

S earch for $B \to \pi\pi$ and $B \to K\pi$

- important for CP
- very rare

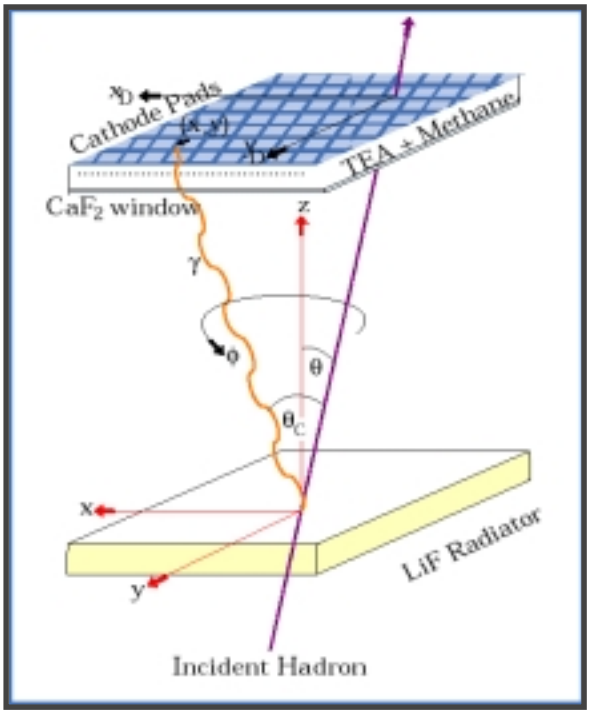
  $B^0 \to K^+\pi^- = 1.8 \times 10^{-5}$

  $B \to \pi\pi = ?$

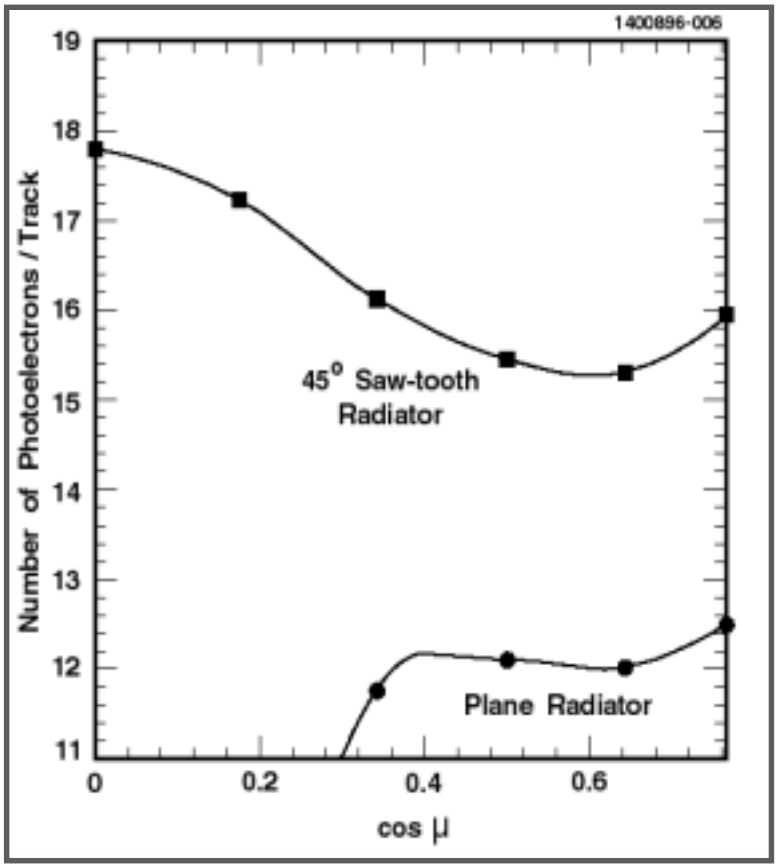


CLEO gets R ICH

- 4σ K/π separation at 3 GeV
- LiF radiator, saw tooth + plane
- N_2 ex pansion volume (16 cm)
- TEA/CH_4 based photo detector
- ~250,000 electronic channels



Particle Identification

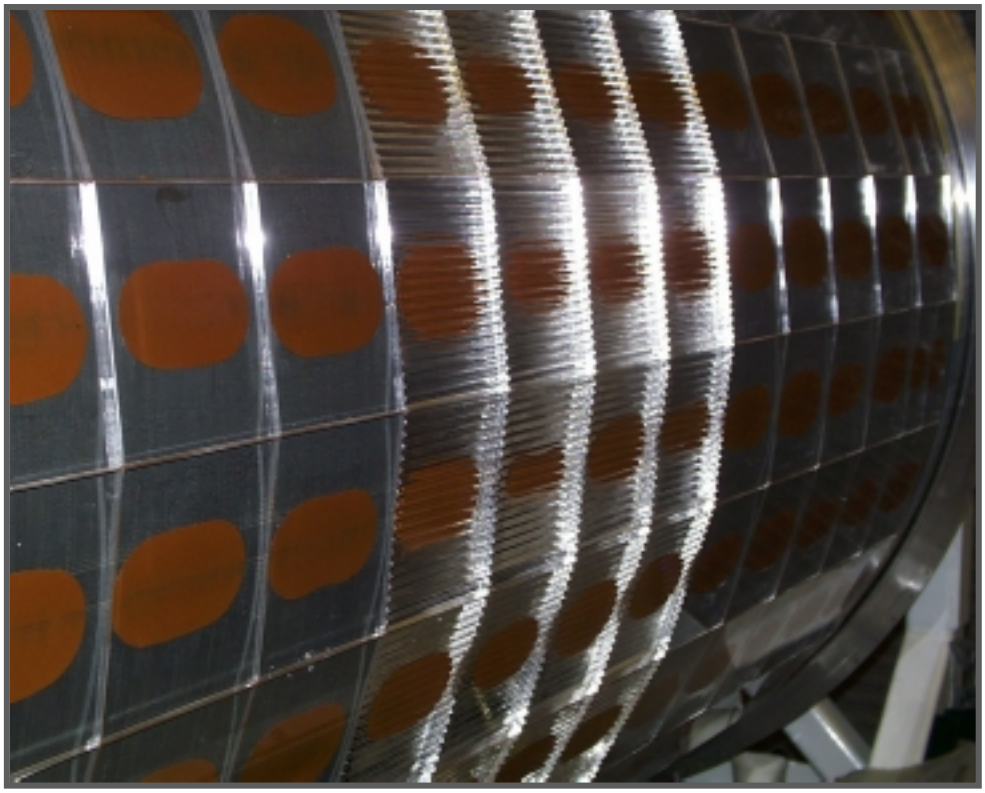


4 20 LiF radiators

- **3 00 Plane**
- **120 S aw-tooth**
- **17.5 x 17 x 1 cm³**

UV transparent

- **13 5-165 nm**

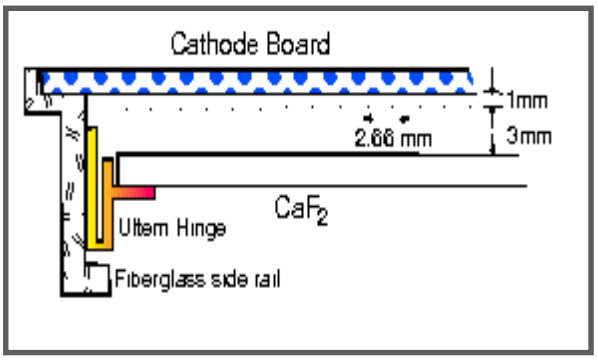


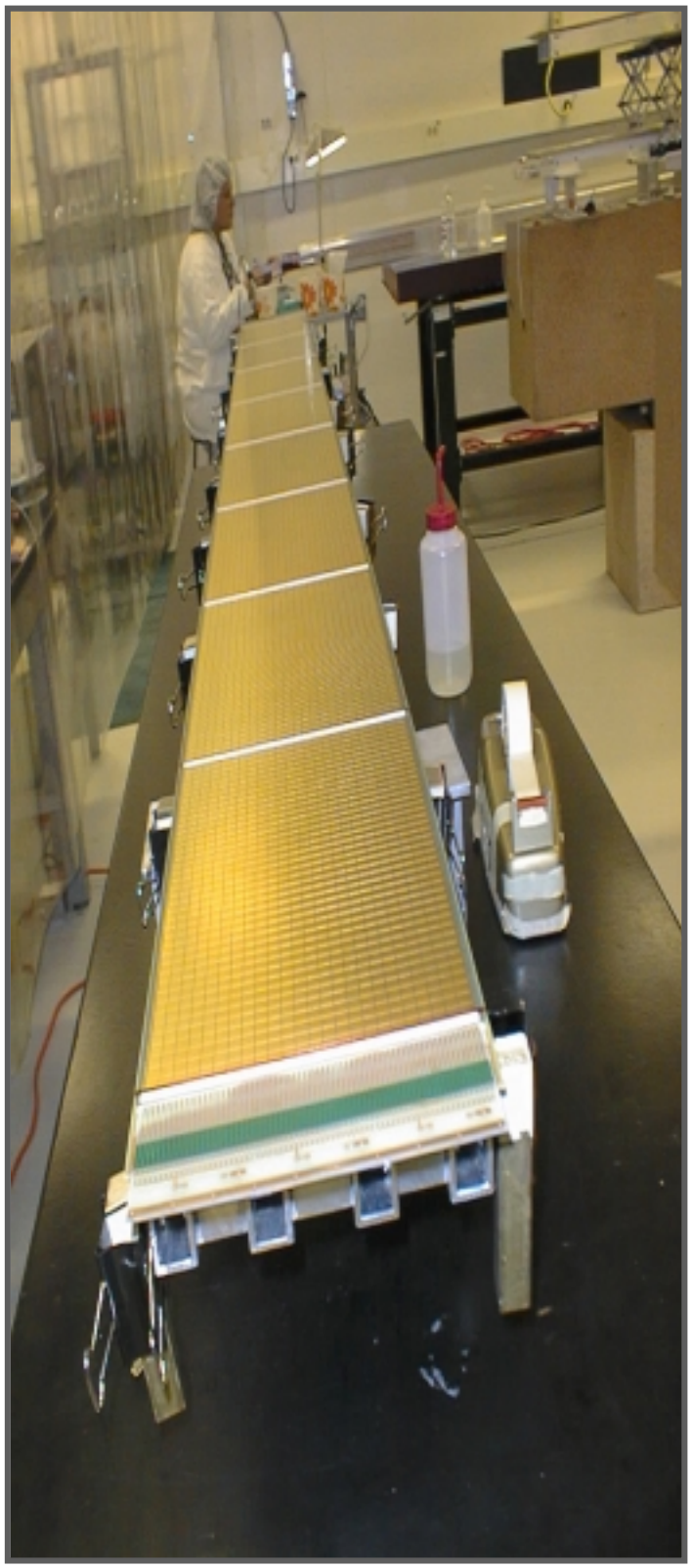
Photon Detection

MWPC + Pad R eadout
~23 0,000 pads
(8 mm x 7.5 mm)
TEA/CH_4
Gas gain ~25,000

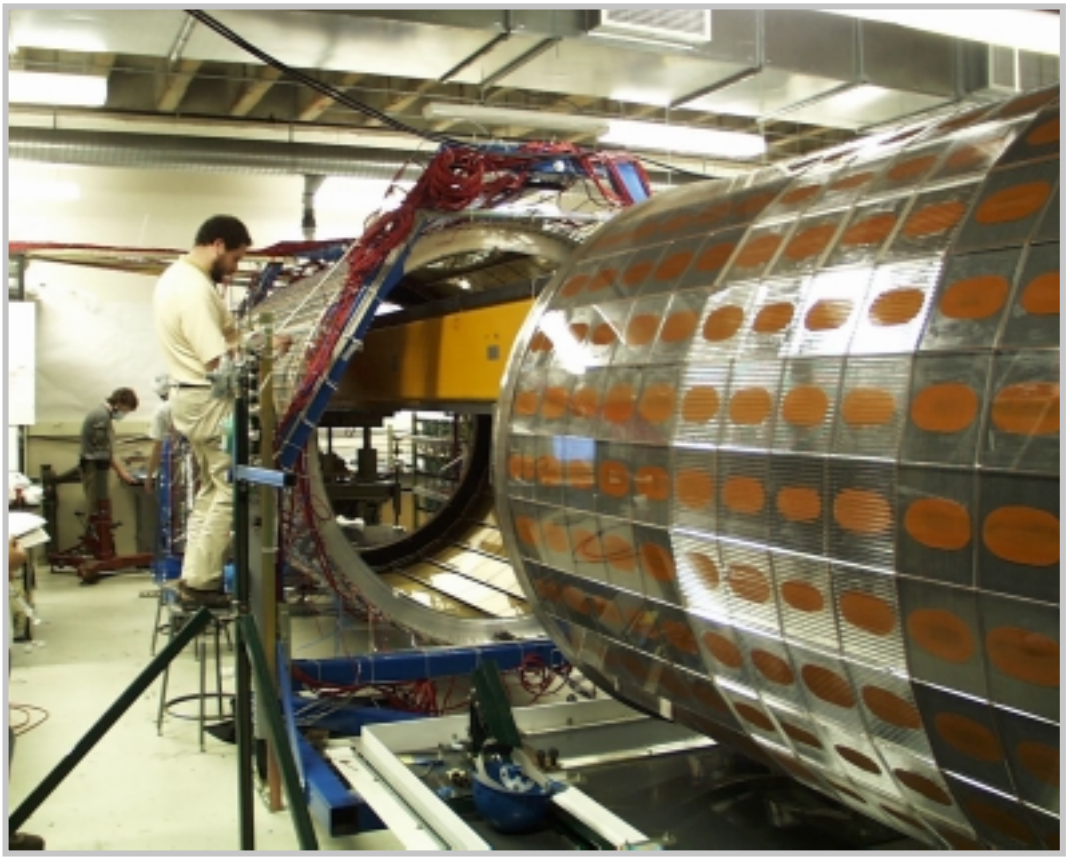
8 CaF windows
100 μm strips, every 2.5 mm
(field shaping)
G10 frame
(and ribs for flatness)

CaF, LiF Transmission ~ 90%

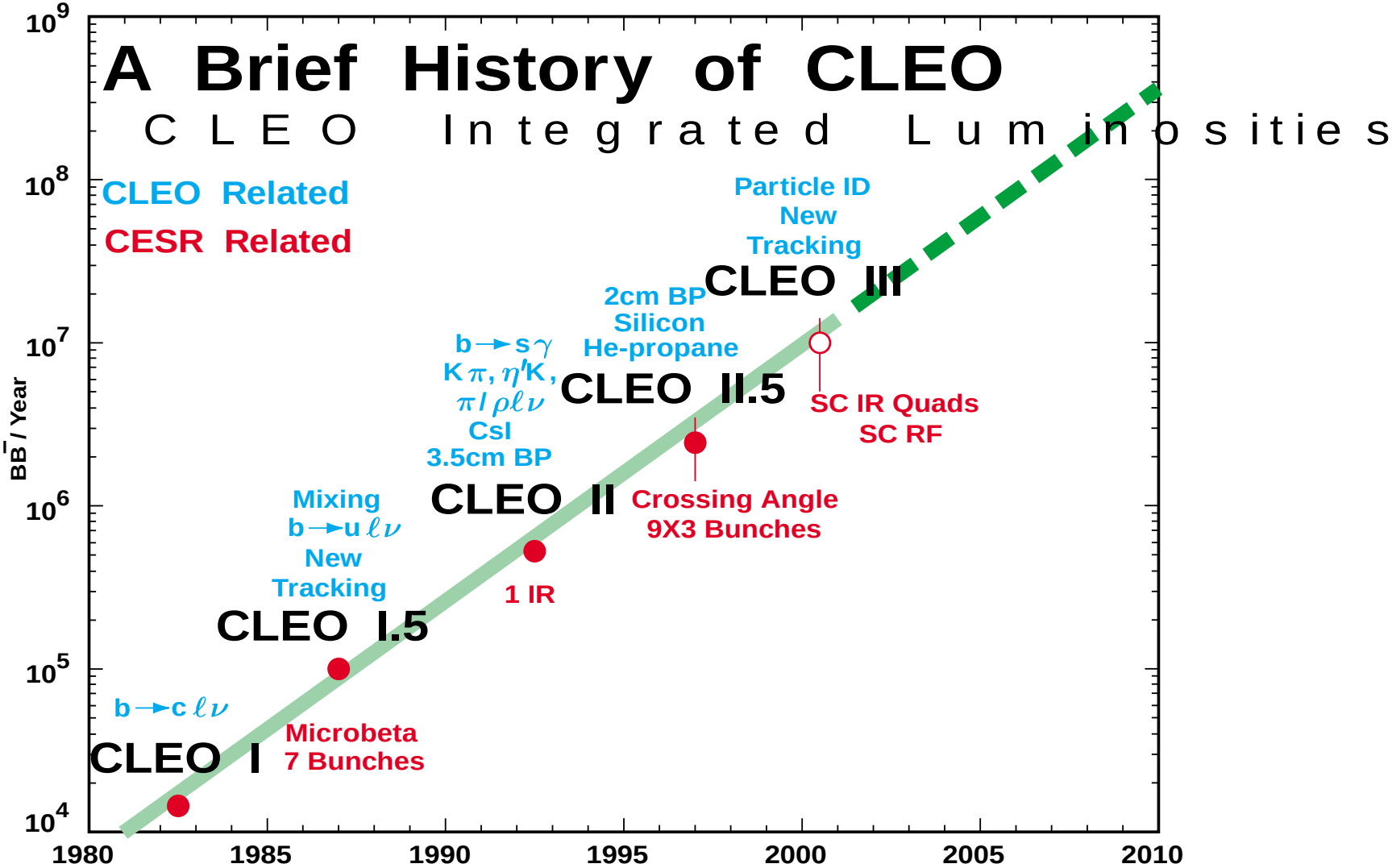




R ICH Assembly



Arrival at Wilson Lab


A Brief History of CLEO
C L E O Integrated Lum in o s itie s
CLEO Related
CESR Related
Particle ID
New
Tracking
CLEO III
2cm BP
Silicon
He-propane
b→s γ
K π, η′K,
π / ρ ℓ ν
CLEO II.5
SC IR Quads
SC RF
CsI
3.5cm BP
CLEO II
Crossing Angle
9X3 Bunches
Mixing
b→u ℓ ν
New
Tracking
1 IR
CLEO I.5
b→c ℓ ν
CLEO I
Microbeta
7 Bunches
BB̄ / Year
10^9
10^8
10^7
10^6
10^5
10^4
1980
1985
1990
1995
2000
2005
2010