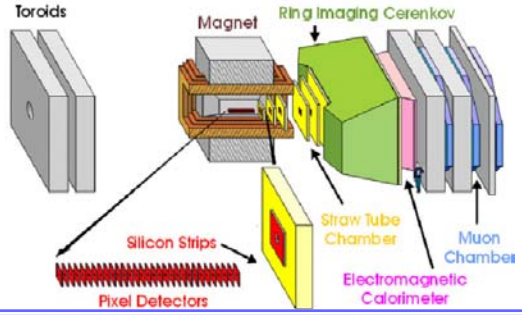


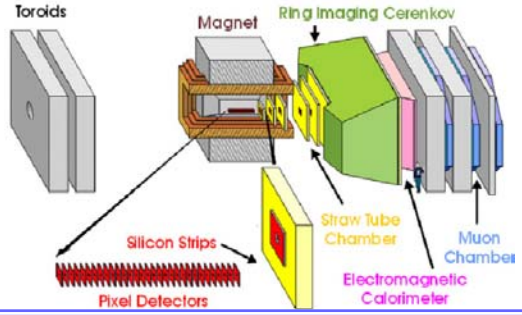
Marina Artuso
July, 2002

BTeV:

The experiment

The physics program

Comparison with other experiments



The BTeV Collaboration

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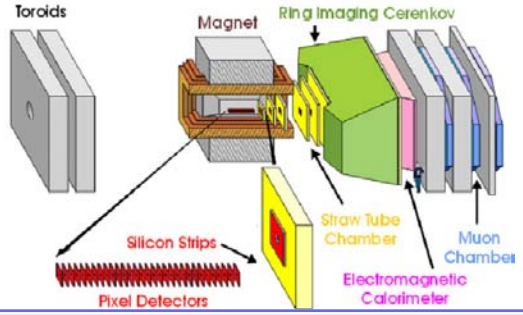
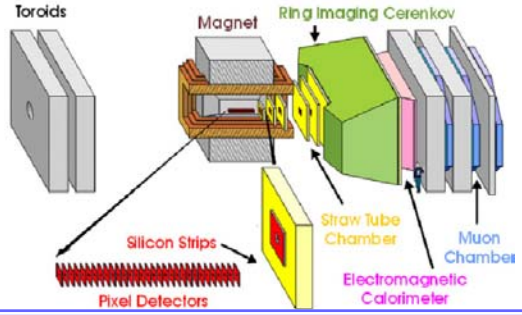


Physics Goals

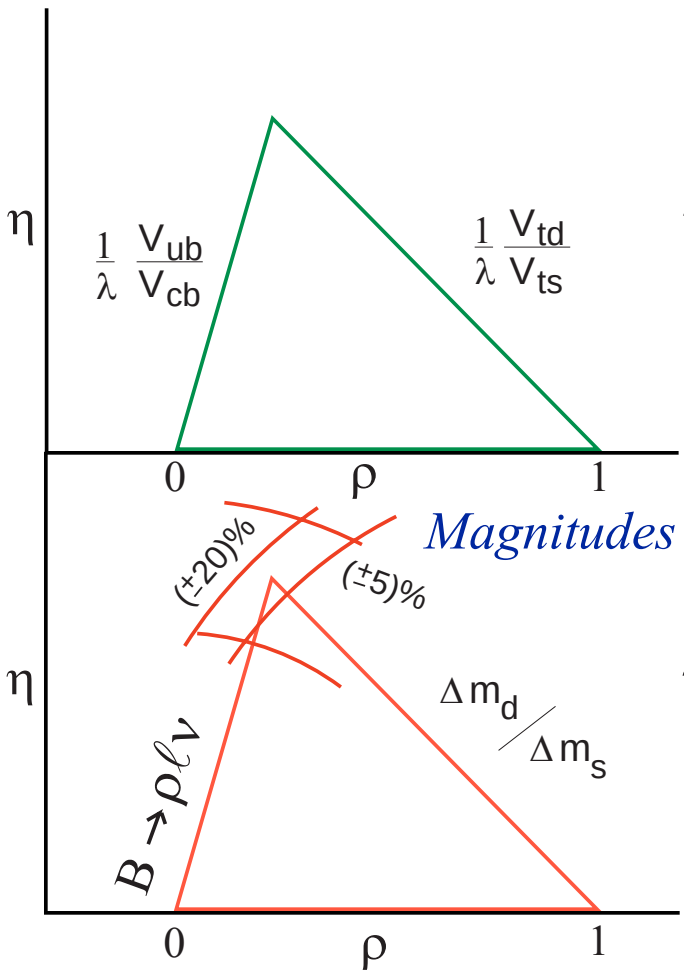
- BTeV is designed to search for physics beyond Standard Model and make precise measurements of SM parameters.
- The important measurements to make involve mixing, CP violation and rare decays of hadrons containing *b* or *c* quarks, especially:
  - CP violation in B^o , B_s and D^o mesons.
  - B_s mixing and $\Delta\Gamma_s$.
  - Rare b decays.

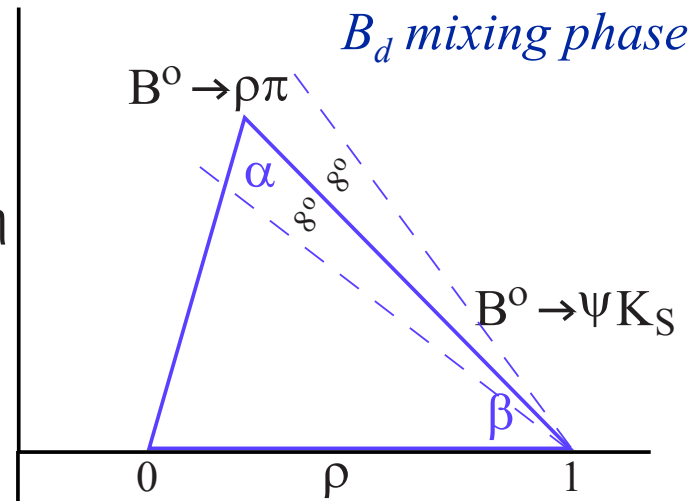
A window to new physics

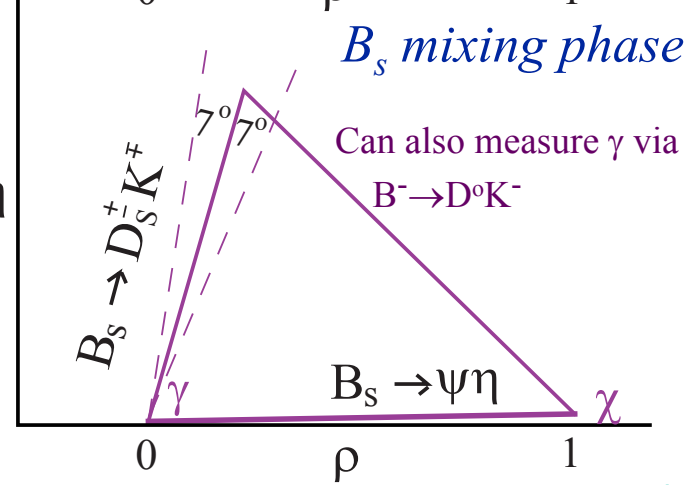


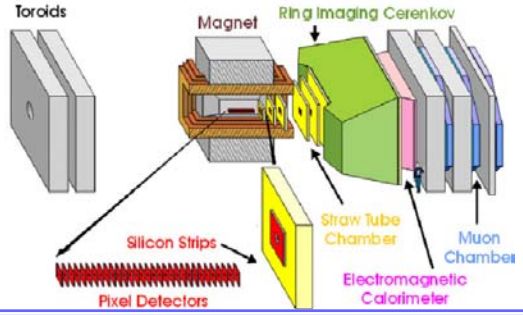
Separate Checks

- Use different sets of measurements to define apex of triangle *(from Peskin)*
- Also have ε_K ($\not{CP}$ in K_L system)



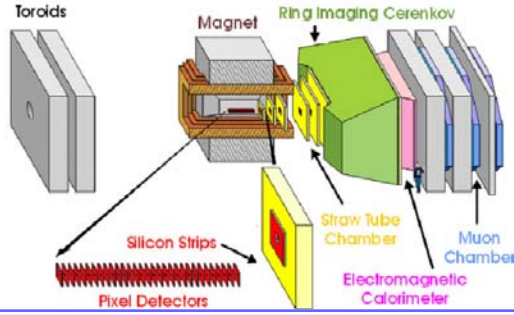






Summary of required measurements to achieve our goals

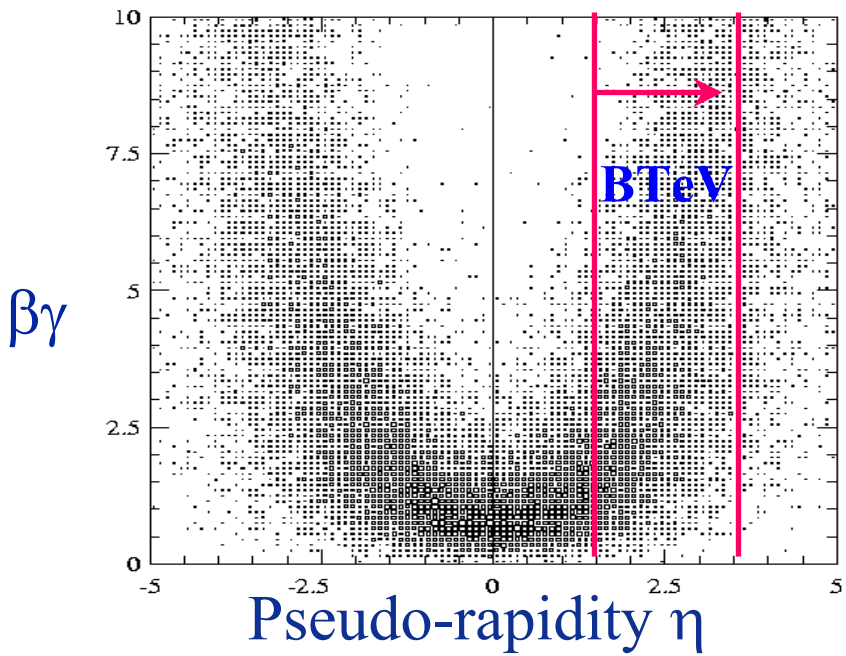
Physics Quantity	Decay Mode	Vertex Trigger	K/π sep	γ det	Decay time σ
sin(2α)	$B^o \to \rho\pi \to \pi^+\pi^-\pi^o$	✓	✓	✓	
sin(2α)	$B^o \to \pi^+\pi^-$ & $B_s \to K^+K^-$	✓	✓		✓
cos(2α)	$B^o \to \rho\pi \to \pi^+\pi^-\pi^o$	✓	✓	✓	
sign(sin(2α))	$B^o \to \rho\pi$ & $B^o \to \pi^+\pi^-$	✓	✓	✓	
sin(γ)	$B_s \to D_s K^-$	✓	✓		✓
sin(γ)	$B^o \to D^o K^-$	✓	✓		
sin(γ)	$B \to K \pi$	✓	✓	✓	
sin(2χ)	$B_s \to J/\psi\eta'$, $J/\psi\eta$		✓	✓	✓
sin(2β)	$B^o \to J/\psi K_s$				
cos(2β)	$B^o \to J/\psi K^*$ & $B_s \to J/\psi\phi$		✓		
x_s	$B_s \to D_s\pi^-$	✓	✓		✓
$\Delta\Gamma$ for B_s	$B_s \to J/\psi\eta'$, K^+K^-, $D_s\pi^-$	✓	✓	✓	✓



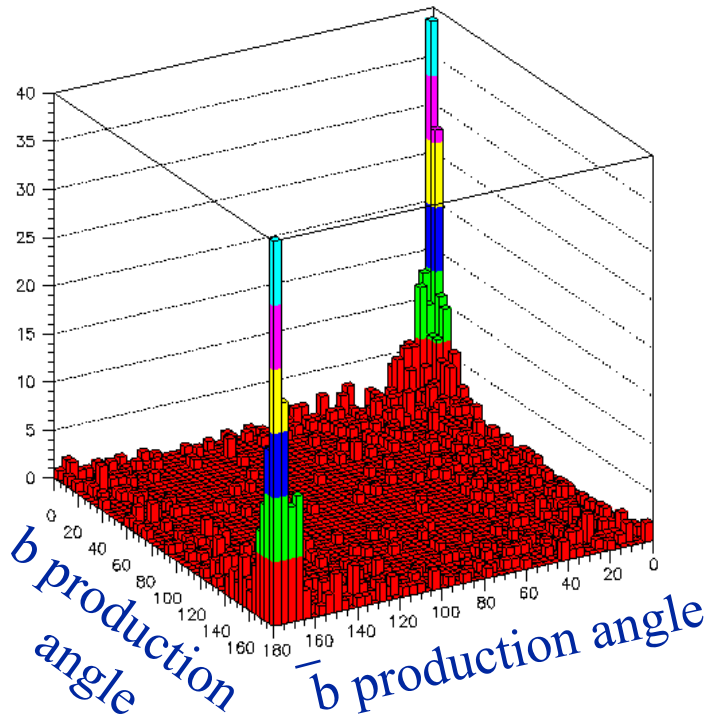
A Forward Detector at $p\bar{p}$ Collider

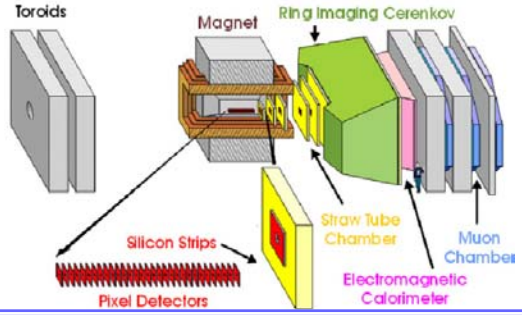
Forward region, 10 – 300 mrad, $1.5 < |\eta| < 3.5$

The higher momentum b are at larger η



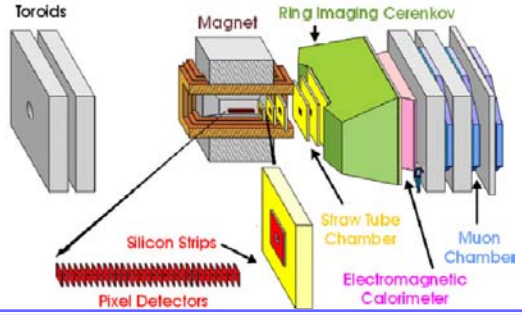
b production peaks at large angles with large $b\bar{b}$ correlation



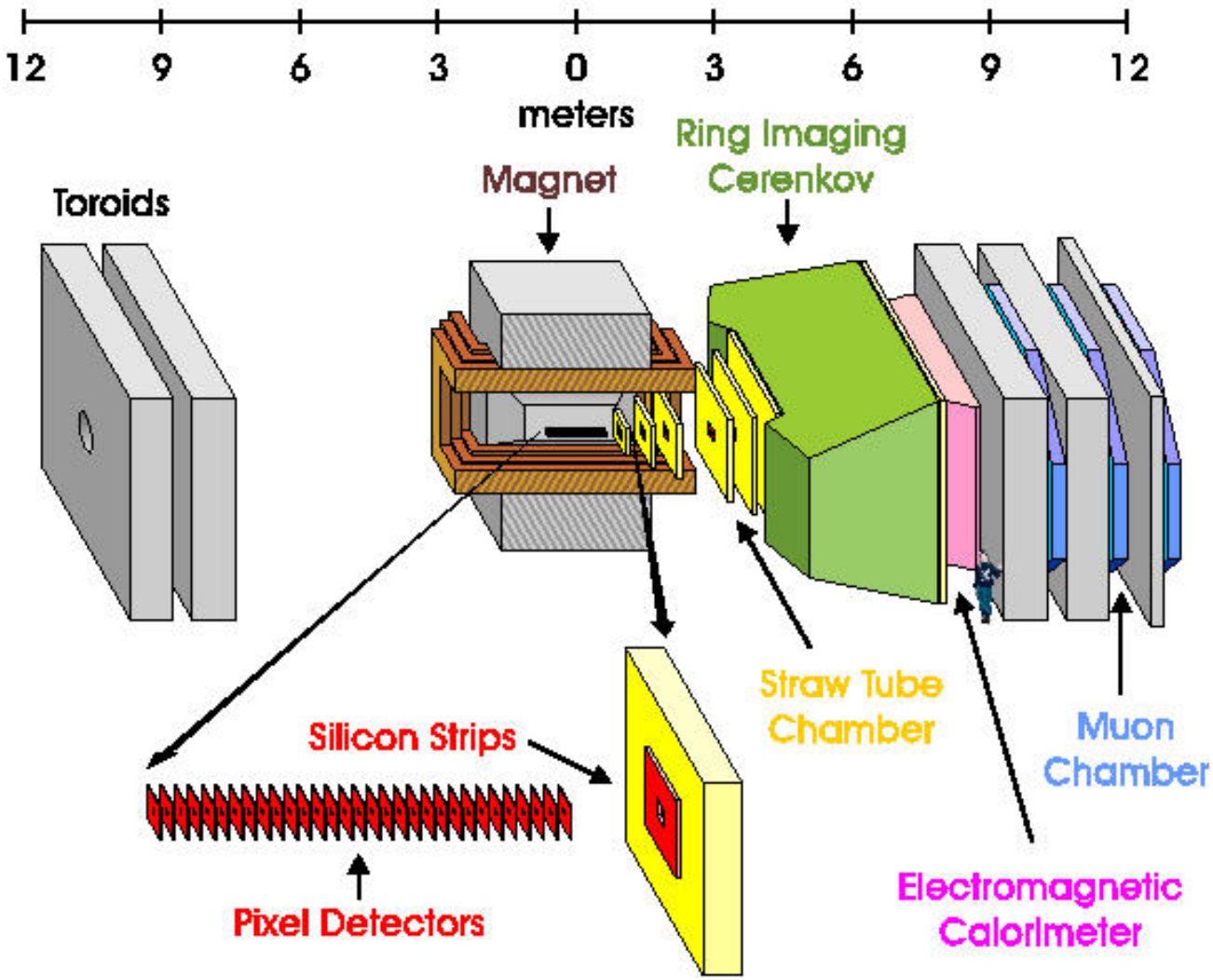


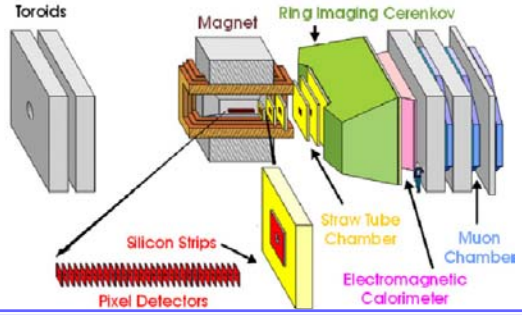
The Tevatron as a b & c Source

Luminosity	$2\times10^{32}\ cm^{-2}s^{-1}$
b cross-section	100 μb
# of b-pairs per 10^7 sec	2×10^{11}
b fraction	1/500
c cross-section	>500 μb
Bunch Spacing	132 ns
Luminous region length	$\sigma_z = 30$ cm
Luminous region width	$\sigma_x \sim \sigma_y \sim 50$ μm
Interactions/crossing	<2>



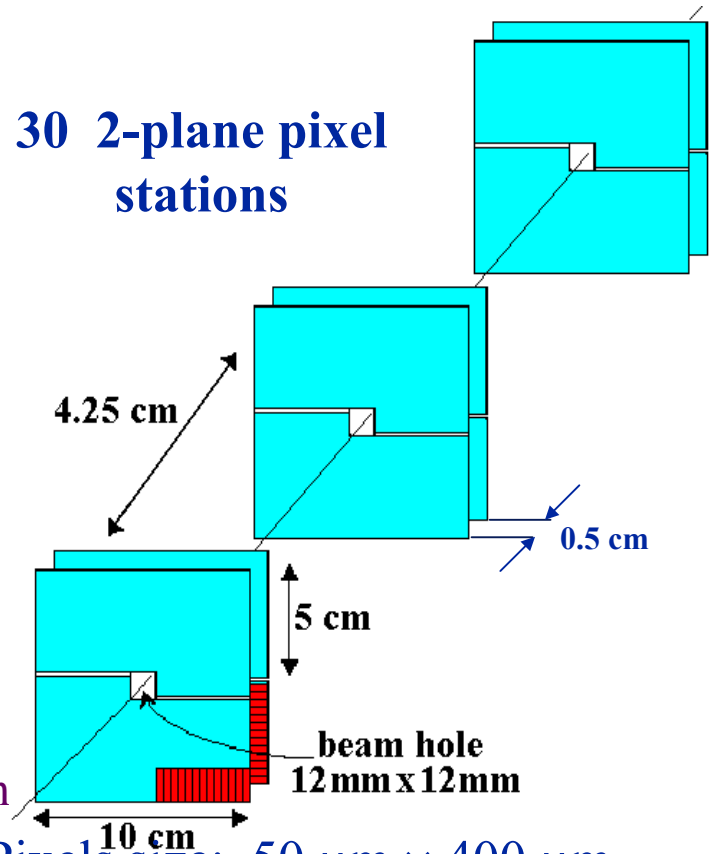
The BTeV Spectrometer



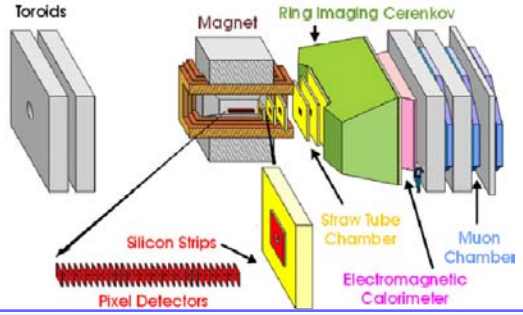


The BTeV Pixel Detector

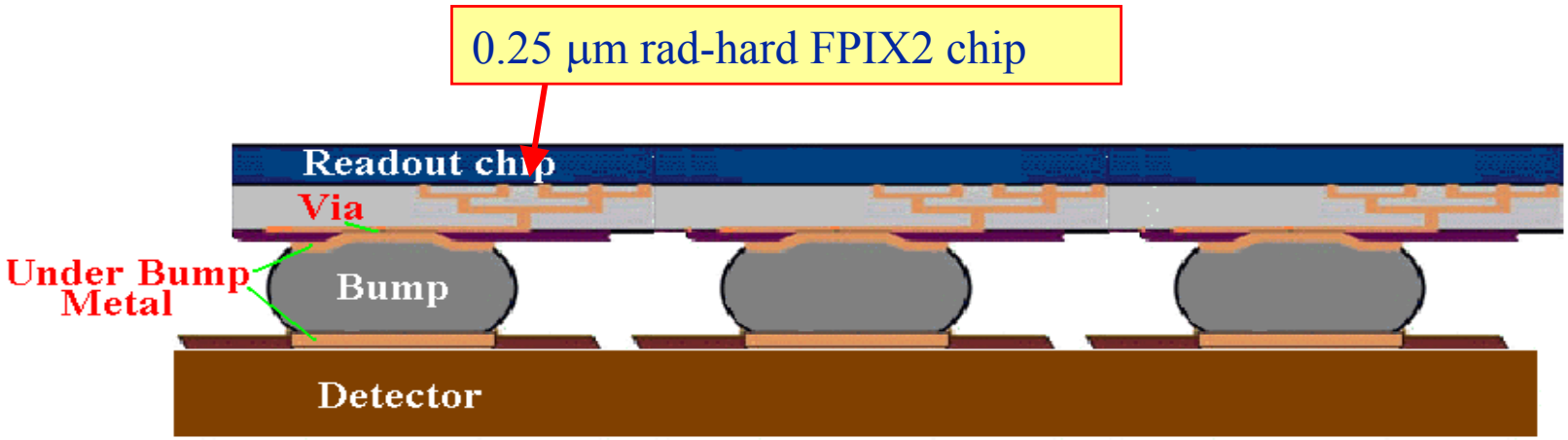
- Provides extremely high quality precision space points for vertex reconstruction, which are also used in the detached vertex trigger.
- Reasons for pixel detector:
  - Superior signal to noise.
  - Excellent spatial resolution (5-10 μm).
  - Very low occupancy.
  - Radiation hard.
  - Very fast.
- Special features:
  - Directly used in the level 1 trigger.
  - Pulse height is measured on every channel with a 3-bit FADC.
  - It is inside a dipole and gives a standalone momentum.



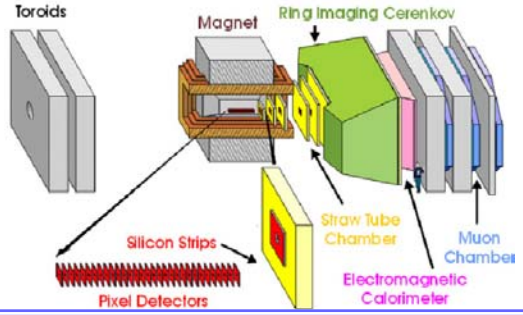
Pixels size: 50 μm × 400 μm



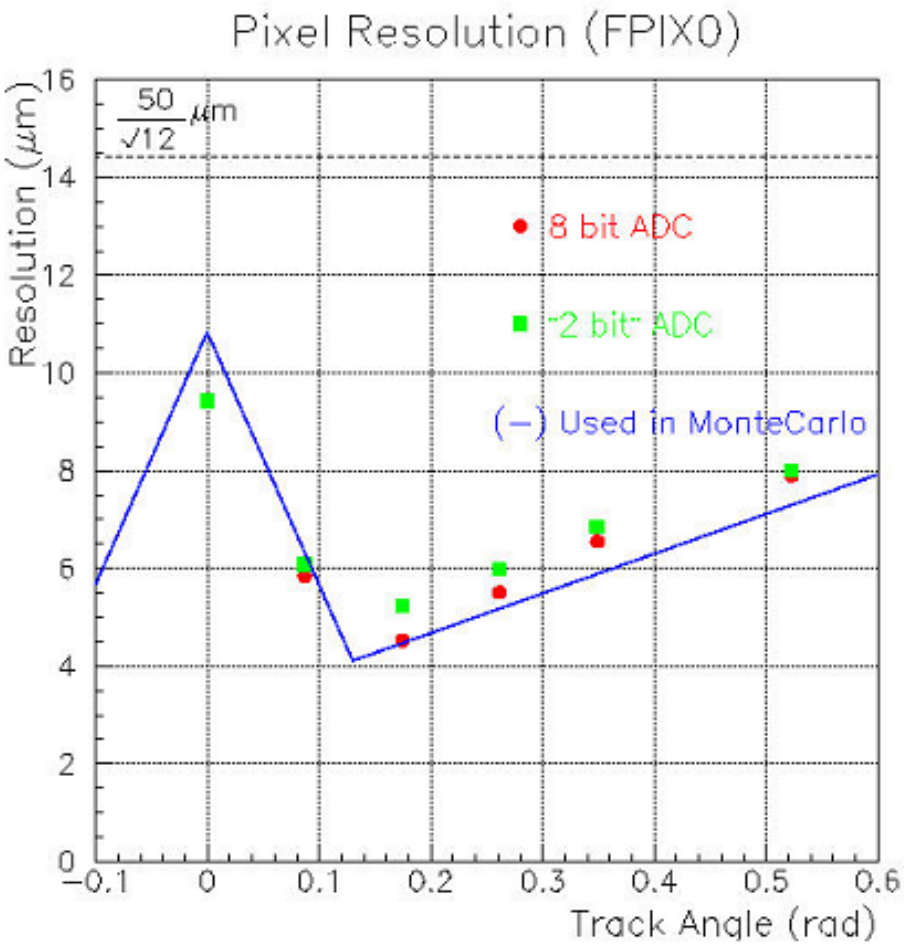
Hybrid Silicon pixel devices



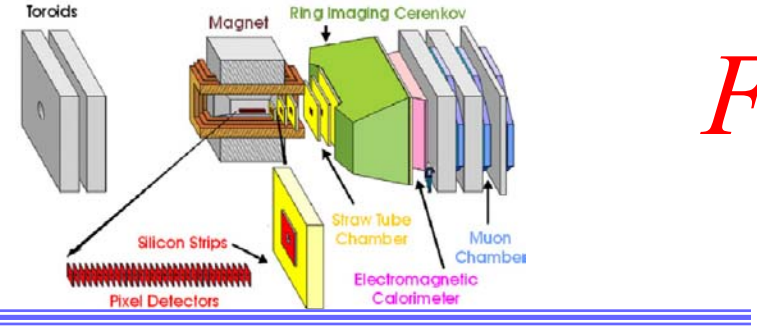
- Independent development and optimizations of readout chip and sensor
- n^+ pixels on n-type substrates: inter-pixel insulation technology under investigation
- Bump-bonding of flipped chip: 2 technologies being considered: Indium (In) and solder (SnPb)



Pixel Test Beam Results



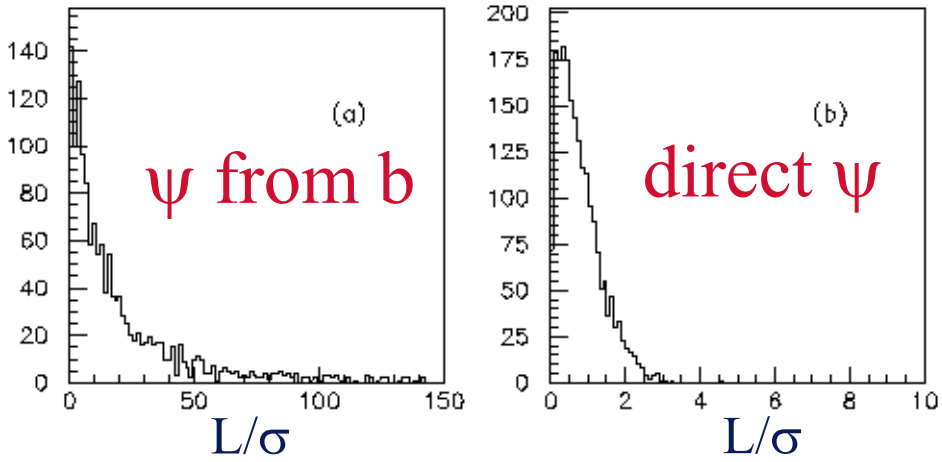
- **Solid curve** is a piece wise linear fit to a simulation based on a detailed Monte Carlo
- We will use a 3 bit ADC

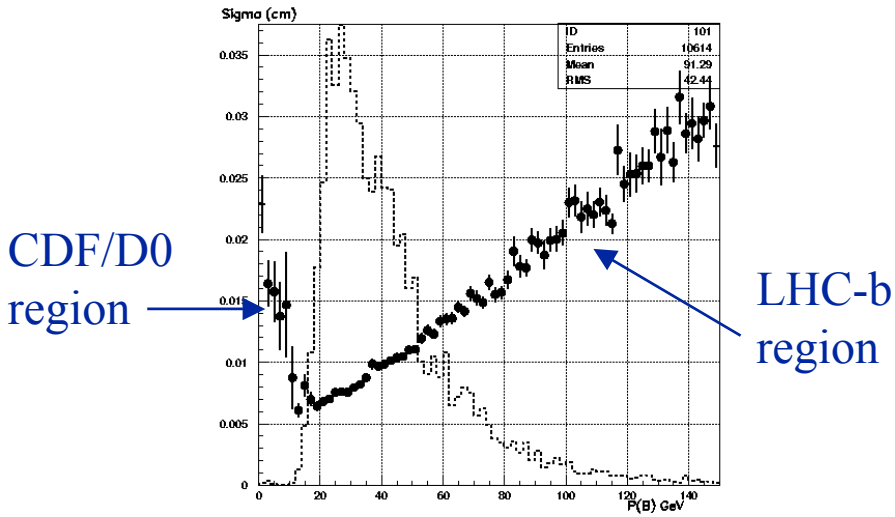


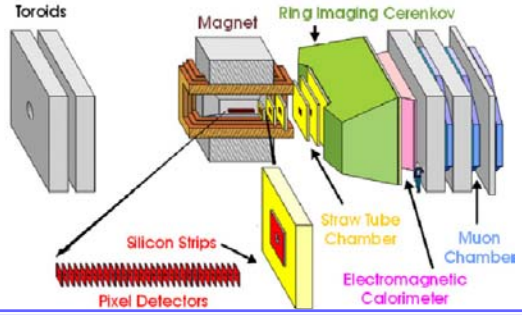
Fundamentals: Decay Time Resolution

- Excellent decay time resolution
  - Reduces background
  - Allows detached vertex trigger
- The average decay distance and the uncertainty in the average decay distance are functions of B momentum:

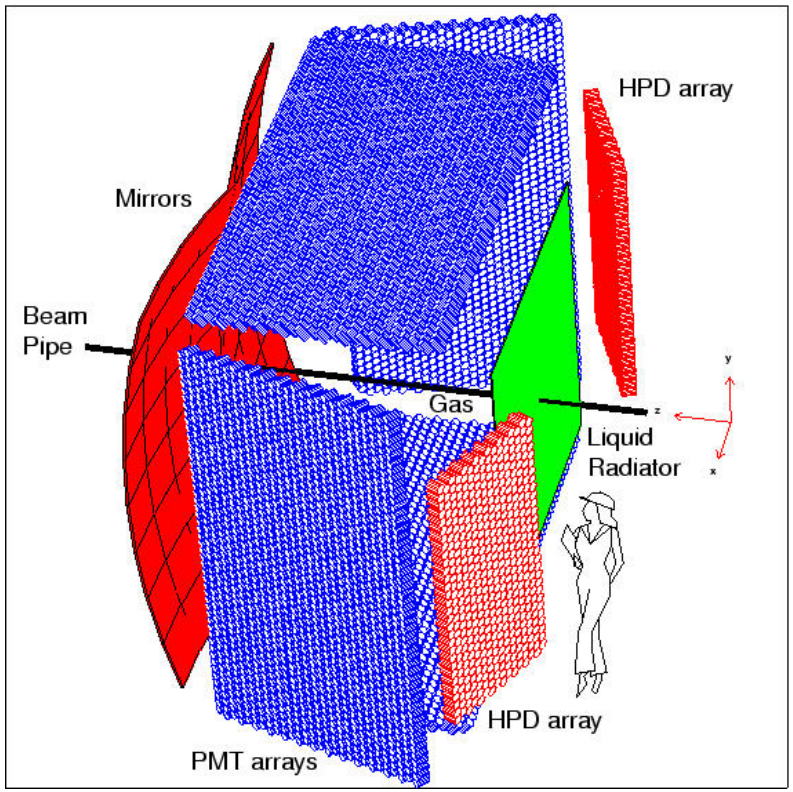
$$\langle L \rangle = \gamma\beta c\tau_B$$
$$= 480\ \mu m \times p_B/m_B$$



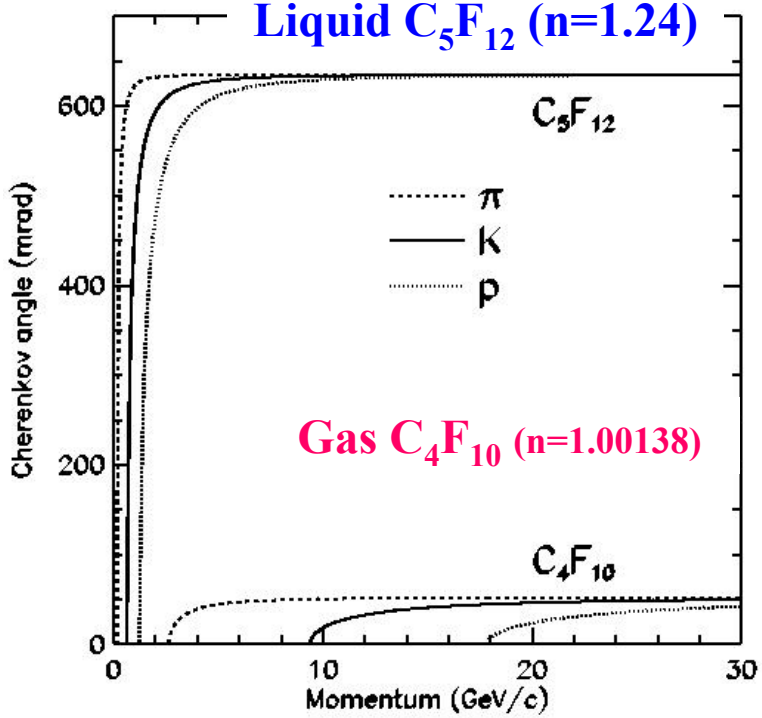




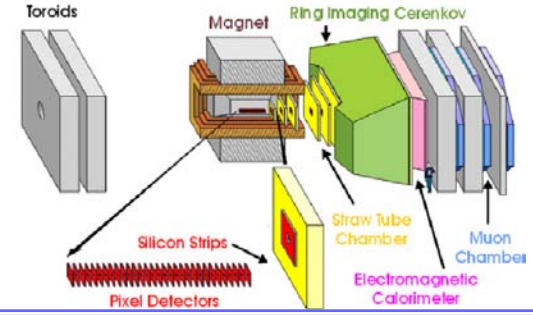
Ring Imaging Cherenkov Detector



Cherenkov angle vs P

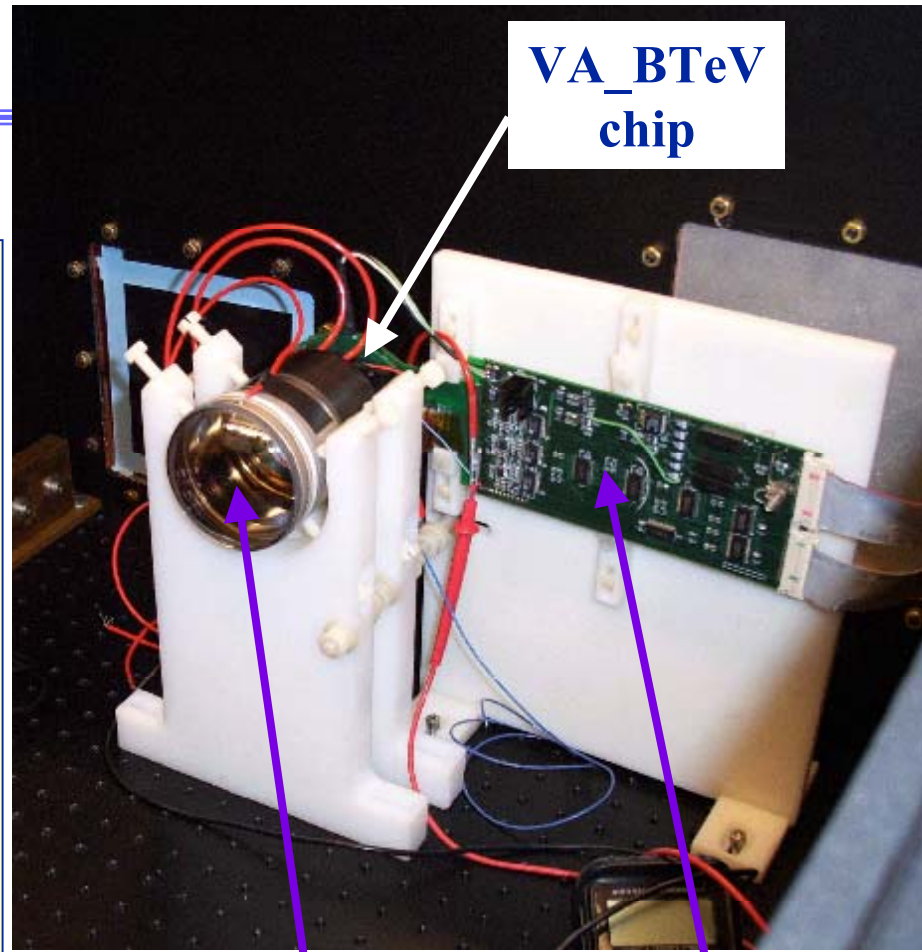


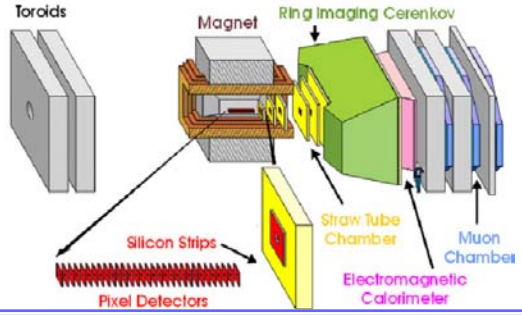
The RICH provides identification of kaons and pions from 3-70 GeV/c. It is essential to CP violation studies



HPD Readout

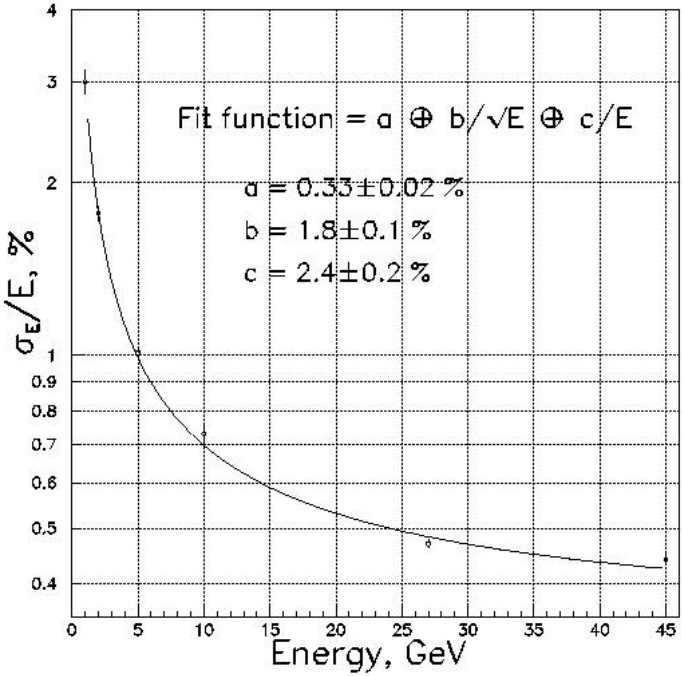
- VA_BTeV ASIC being developed in collaboration with IDE AS Norway (independent from HPD development)
- Initial tests indicate that ~500 e^- noise level be achieved.
- Threshold for each channel is adjustable.
- Readout is binary (ON or OFF)
- Testing of first prototypes is underway at Syracuse.

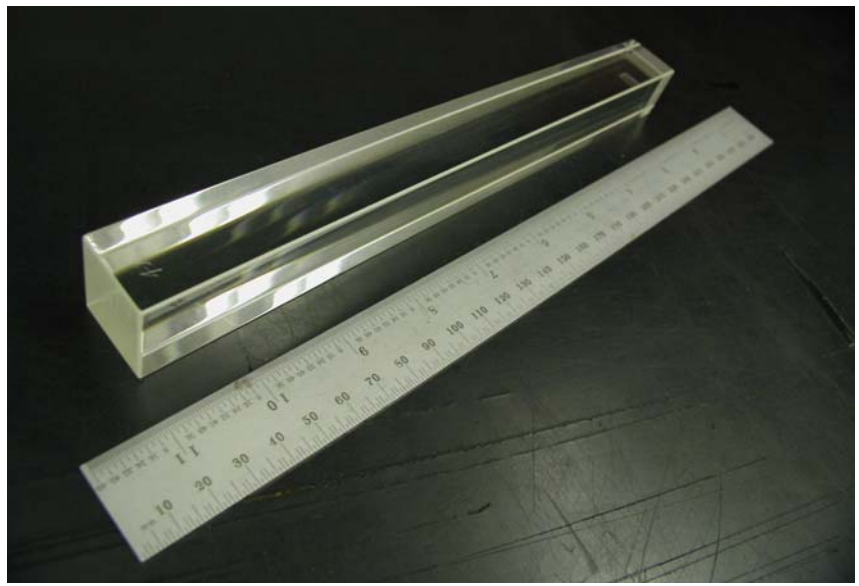


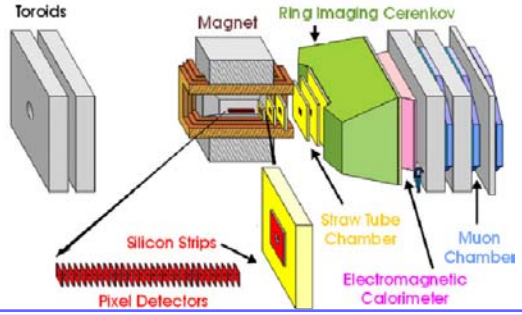


Electromagnetic Calorimeter

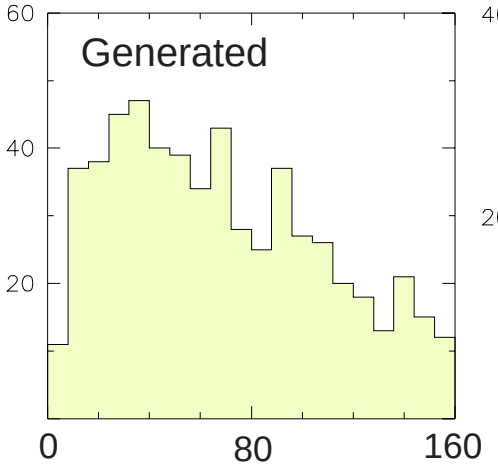
- EM calorimeter for γ/π^0 reconstruction and electron ID.
- 10,000 $PbWO_4$ crystal (rad hard) with PMT readout
- Lateral size: $27.2\times27.2mm^2$ (front), $28\times28mm^2$ (back), Length 22cm (25 X_0)
- Resolution: $\sigma_E/E = 0.8\%$ for γ in $B\rightarrow K^*\gamma$, $\sigma_M = 2.6$ MeV for 10 GeV π^0.
- Sample crystals tested in a beam at Protvino.

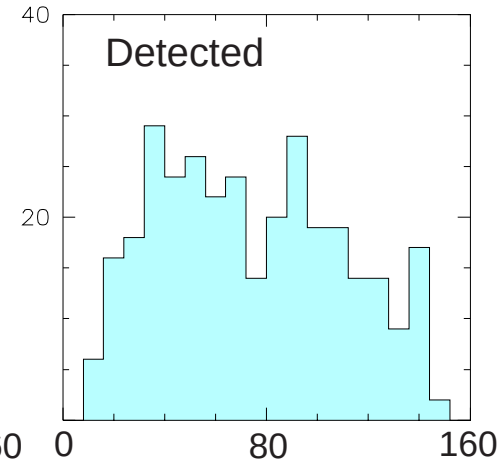


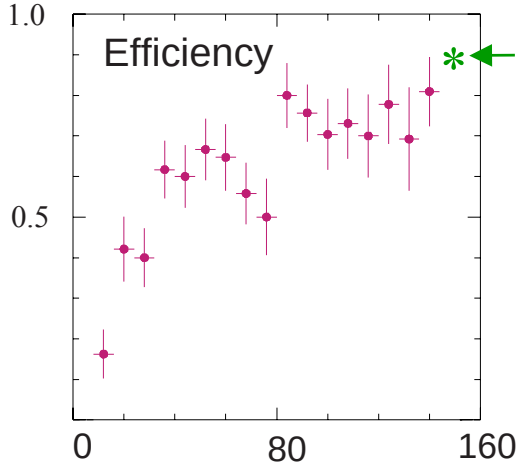




EM calorimetry

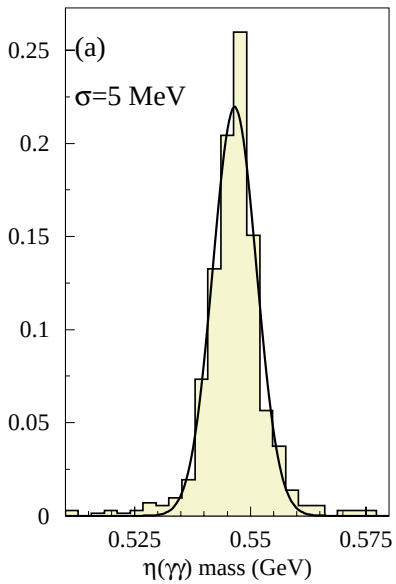


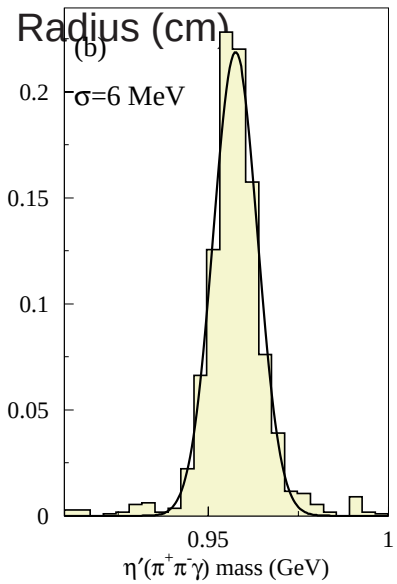


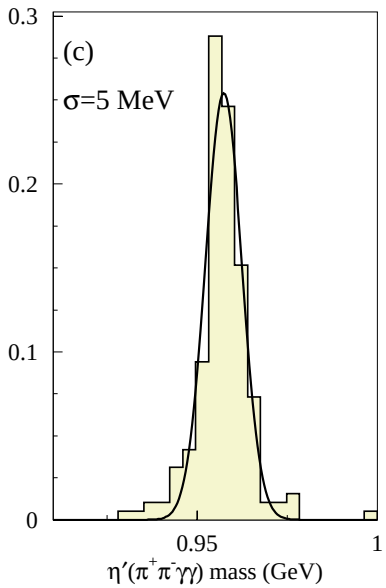


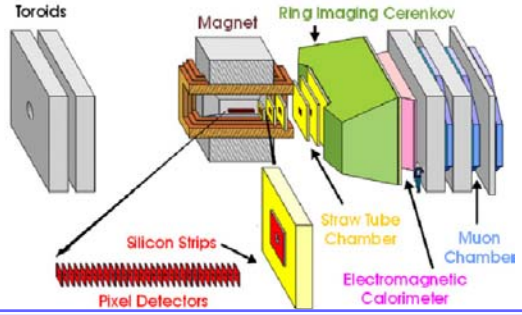
CLEO barrel
ε=89%

Radius (cm)

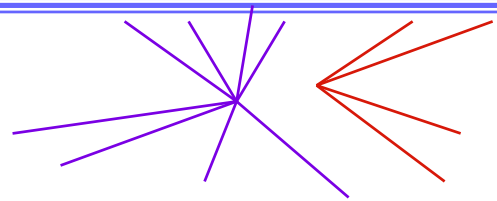






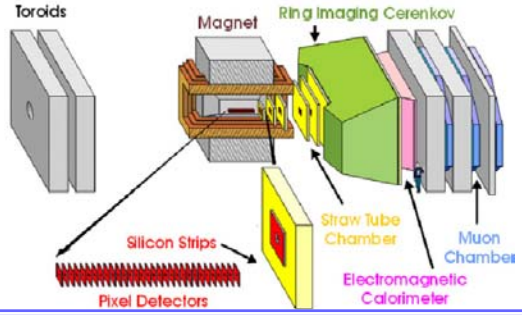


Detached Vertex Trigger



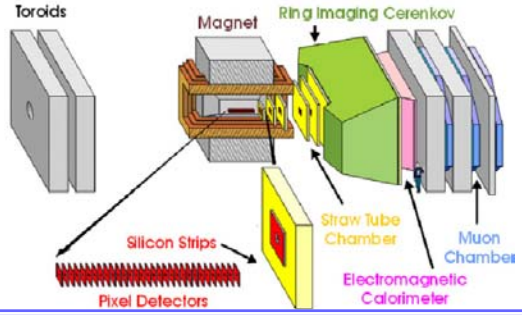
- Idea: finds the primary vertex, selects events that have additional tracks miss it
- Requirement: at least 2 tracks detached by more than 6σ $\Rightarrow$ 1% minimum bias at level 1 trigger.
- Refined reconstruction at level 2 and 3. 7.6 MHz $\Rightarrow$ 3 kHz
- With 3-level trigger scheme, the event rate:
- Efficiency: (after the other analyses cuts)

State	efficiency(%)	State	efficiency(%)
$B \rightarrow \pi^+\pi^-$	63	$B^o \rightarrow K^+\pi^-$	63
$B_s \rightarrow D_sK$	71	$B^o \rightarrow J/\psi\ K_s$	50
$B^- \rightarrow D^oK^-$	70	$B_s \rightarrow J/\psi K^*$	68
$B^- \rightarrow K_s\pi^-$	27	$B^o \rightarrow \rho^o\pi^o$	56



Reconstructed Events in New Physics Modes: Comparison of BTeV with B-factories

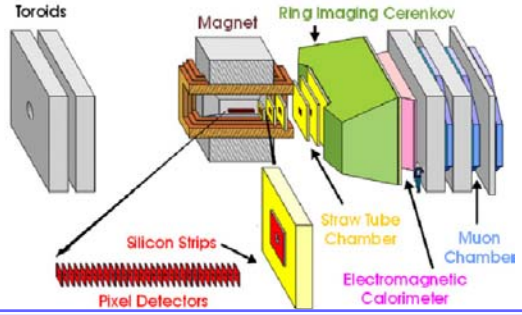
Mode	BTeV (10^7s)			B-fact (500 fb^{-1})		
	Yield	Tagged	S/B	Yield	Tagged	S/B
$B_s \to J/\psi\eta^{(\prime)}$	12650	1645	>15	-	-	
$B^- \to \phi K^-$	6325	6325	>10	700	700	4
$B^o \to \phi K_s$	1150	115	5.2	250	75	4
$B^o \to K^* \mu^+ \mu^-$	2530	2530	11	~50	~50	3
$B_s \to \mu^+ \mu^-$	6	0.7	>15	0		
$B^o \to \mu^+ \mu^-$	1	0.1	>10	0		
$D^{*+} \to \pi^+ D^o$, $D^o \to K\pi^+$	~10^8	~10^8	large	8x10^5	8x10^5	large



Specific Comparisons with LHC-b

Yields in two final states

Mode	BR	BTeV		LHC-b	
		Yield	S/B	Yield	S/B
$B_s \rightarrow D_s K^-$	3.0×10^{-4}	7530	7	7660	7
$B^o \rightarrow \rho^+ \pi^-$	2.8×10^{-5}	5400	4.1	2140	0.8
$B^o \rightarrow \rho^o \pi^o$	0.5×10^{-5}	776	0.3	880	not known



Status

- BTeV received a second unanimous approval by the Fermilab PAC (4/2002).

PAC Recommendation

" ... BTeV has designed and prototyped an ambitious trigger that will use B decay displaced vertices as its primary criterion. This capability, together with BTeV's excellent electromagnetic calorimetry and particle ID and enormous yields, will allow this experiment to study a broad array of B and B_s decays. BTeV has a broader physics reach than LHCb and should provide definitive measurements of CKM parameters and the most sensitive tests for new physics in the flavor sector."

- Detector costs have been reduced from ~180 M$ to ~110 M$ (includes G&A and 30% contingency). Full "Temple" review in 9/2002.
- P5 or equivalent review for DOE in Fall 2002.