Symmetries

CP Violation

NA 48 - CP Violation in K_L Decay

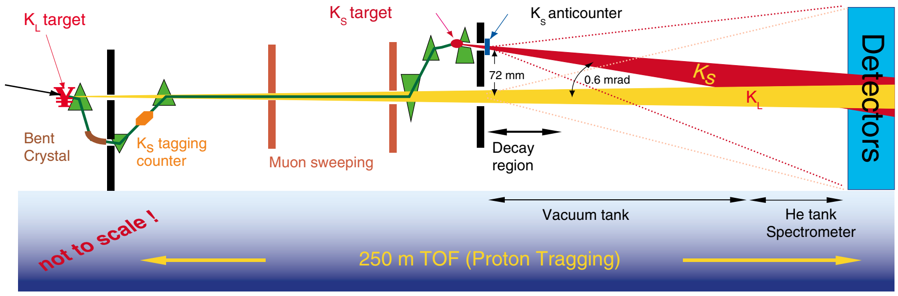
The aim of the NA48 experiment is a measurement of the direct CP-violation parameter ε'/ε by a determination of the double ratio R:

$$R = \frac{\Gamma(K_L \to \pi^0\pi^0)}{\Gamma(K_S \to \pi^0\pi^0)} \Big/ \frac{\Gamma(K_L \to \pi^+\pi^-)}{\Gamma(K_S \to \pi^+\pi^-)} \cong 1 - 6\,\mathrm{Re}\left(\frac{\varepsilon'}{\varepsilon}\right)$$

To achieve an overall accuracy of $2\cdot10^{-4}$ on ε'/ε, an intense double neutral beam is used to produce long-lived and short-lived neutral kaons, K_L and K_S, in the same fiducial volume. Their decays are recorded simultaneously with a magnetic spectrometer and a liquid-Krypton electromagnetic calorimeter. The identification of a decay as originating from K_S or K_L is done by tagging the protons which are directed onto the K_S target.

Since 1997, the experiment has recorded more than two million $K_L \to \pi^0\pi^0$ decays. A preliminary result, based on this data set (roughly 10 % of the total statistics), is $\varepsilon'/\varepsilon = (18.5 \pm 4.5_{stat} \pm 5.8_{syst})\cdot10^{-4}$, favouring a large value for ε'/ε and signalling CP violation in the decay of quarks.

NA48: K_L/K_S simultaneous beams



LHCb - CP Violation in B Decays

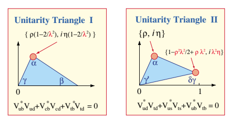
- Magnetic spectrometer (10-300 mrad)
- Vertex in LHC pp interaction point
- Luminosity $L = 2*10^{32}$ cm^{-2} s^{-1}
- Flexible trigger optimized for B physics

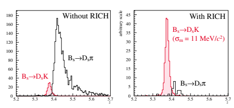
Strong Points

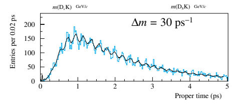
- Particle identification
- Decay time resolution
- Invariant mass resolution

Physics Performance

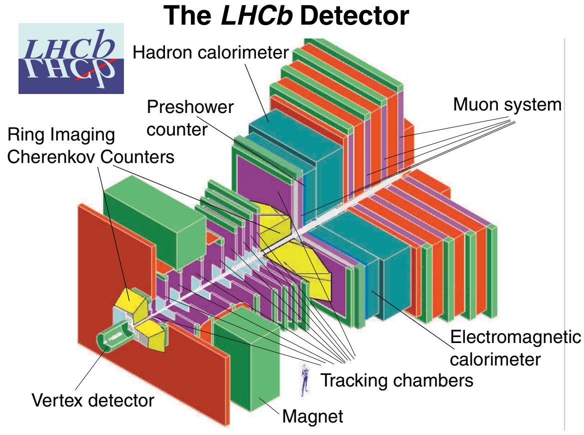
CP parameter	Decay mode	No. of events	Uncertainty (after 10^7 s)	Important detector properties
$\beta+\gamma$	$B_d \to \pi^+\pi^-$	7 k	0.03 ~ 0.16	Particle ID
$= \pi-\alpha$	$B_d \to D\pi$		0.07 ~ 0.38	
β	$B_d \to J/\psi K_S$	55 k	0.01	Trigger
γ	$B_d \to D K^*$	0.4 k	0.07~0.31	Particle ID
$\gamma-2\delta\gamma$	$B_s \to D_s K$	2.4 k	0.05~0.28	Particle ID
$\delta\gamma$	$B_s \to J/\psi\,\Phi$	44 k	0.01	σ (decay time)
B_s Mixing				
x_s	$B_s \to D_s\pi$	120 k	up to x_s = 75	σ (decay time)
Rare Decays				
BR	$B_s \to \mu\mu$		$< 2*10^{-9}$	σ (decay time)
no. evts	$B_d \to K^*\gamma$	26 k		high E_T γ trigger







The *LHCb* Detector



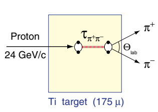
Chiral QCD

DIRAC

DI-meson Relativistic Atomic Complexes

The aim of the DIRAC experiment is the measurement of the difference of the pion scattering lengths $|a_0 - a_2|$, from the lifetime of the ($\pi^+\pi^-$) Atom. The $\pi\pi$ scattering lengths can be predicted from Chiral Perturbation Theory to 2 loops approximation:

$|a_0 - a_2| = 0.258 \pm < 5\ \%$ (Gasser et al., Stern et al.)



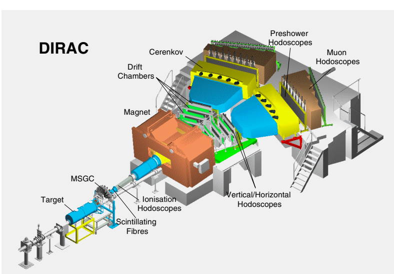
Signature of $\pi^+\pi^-$ atoms:

Low relative c.m.s. momentum:
- $q_\pi^{cms} < 3$ MeV/c

Low opening angle in lab:
- $\Theta_{lab} \leq 0.35$ mrad

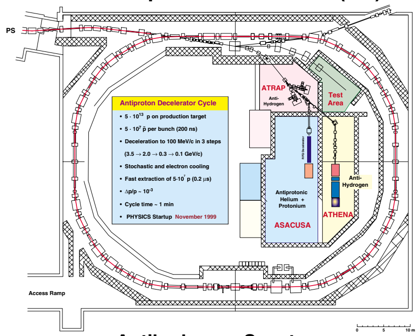
Nearly equal energies:
- $E_{\pi^+} \approx E_{\pi^-}$ ($\pm$ 0.3 %)

30,000 events expected in DIRAC (272±49 obs. at Serpukhov)
Data taking: Autumn 1998 - 2001



CPT Tests

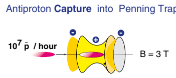
Antiproton Decelerator (AD)



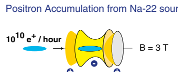
Antihydrogen Spectroscopy

ATHENA - ATRAP

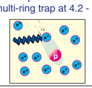
1. Antiproton **Capture** into Penning Trap



2. Positron Accumulation from Na-22 source



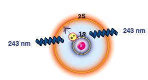
3. Positron-Antiproton Recombination in multi-ring trap at 4.2 - 0.1 K



4. Antihydrogen **Storage** in Magnetic Bottle
Magnetic well depth ~ 0.35 K (35 meV)

5. Antihydrogen **Detection**
- Annihilation products: Si Pad Detectors
- 511 keV Gammas: CsI or BGO + Photodiodes

6. 2-Photon Laser **Spectroscopy**: ΔE (1S-2S)



Comparison $\bar{H}$: H with precision 10^{-12} ...10^{-15}

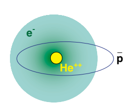
Data taking: 1999 - 2004

Exotic Atoms

Antiprotonic Helium and Hydrogen Atoms

ASACUSA

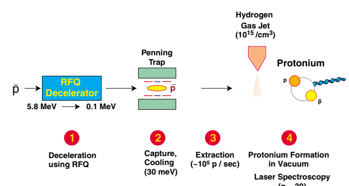
This experiment will capture and cool antiprotons from the AD in a Penning trap. The cold antiprotons will then be extracted and brought in contact with either Helium or Hydrogen Gas Cells at very low pressures to produce antiprotonic Helium or antiprotonic Hydrogen Atoms in vacuum.
The aim of this experiment is the study of the structure and formation process of antiprotonic atoms. Laser and microwave spectroscopy of $\bar{p}$-He^+ and $\bar{p}$-p will allow the precise determination of basic properties of the antiproton like its mass, charge and magnetic moment, as has been shown by the last results of the PS205 experiment at LEAR.



$\bar{p}$-e^-He^{++} ' Atomcule '

Lifetime ~ few µs
n_p, L_p ~ 33 ... 39

In a second stage, the atomic structure of protonium atoms in high-n (n~30) states will be explored by laser spectroscopy.



AD - PS - SPS - LHC