

## Status Report of DIRAC at the SPSC on 16/04/09

# LIFETIME MEASUREMENT OF $\pi^+\pi^-$ AND $\pi^+K^-$ ATOMS TO TEST LOW-ENERGY QCD

The main goals of DIRAC in 2005-2009 and beyond:

- Lifetime measurement of  $A_{2\pi}$  atoms with precision better than 6%, which gives a precision for  $|a_0 - a_2|$  better than 3%.
- Observation of  $A_{\pi K}$  and  $A_{K\pi}$  atoms.
- The measurement of their lifetime and difference of  $\pi K$  scattering lengths  $|a_{1/2} - a_{3/2}|$  with accuracy about 10%.
- Observation of the long-lived states of  $A_{2\pi}$ , with prospect to measure the “Lamb shift” and of determining the value of  $2a_0 + a_2$  in a model-independent way.

What new will be known if  $\pi K$  scattering length will be measured?

The measurement of the  $s$ -wave  $\pi K$  scattering lengths would test our understanding of the chiral  $SU(3)_L \times SU(3)_R$  symmetry breaking of QCD ( $u$ ,  $d$  and  $s$  quarks), while the measurement of  $\pi\pi$  scattering lengths checks only the  $SU(2)_L \times SU(2)_R$  symmetry breaking ( $u$ ,  $d$  quarks).

*This is the principal difference between  $\pi\pi$  and  $\pi K$  scattering!*

Experimental results:

The run 2006 was lost because of the broken magnets in the beam-line, whereas the run 2007 covered:

- Improvement of the proton beam time structure and the beam intensity distribution in the spills
- Beam intensity about  $1.9 \times 10^{11}$  proton/spill and  
1<sup>st</sup> level triggers numbers were  $3200(\pi^+\pi^-) + 2100(K^+\pi^-) + 1000(\pi^+K^-) = 6300/\text{spill}$
- Number of recorded events 2000/spill is near the hardware DAQ limit.  
Full number of  $\pi^+\pi^-$  and  $\pi K$  events recorded during 2 months of data taking is  $1.6 \times 10^9$ .

### Evidence for $\pi K$ -atoms

In the run 2007,  $173 \pm 54$   $\pi K$ -atomic pairs were observed with a significance of  $3.2\sigma$ .

References:

- B. Adeva et al., “Evidence for  $\pi K$ -atoms with DIRAC”, Physics Letters B 674 (2009) 11  
Y. Allkofer, PhD Thesis, Universität Zürich, 2008.

Run 2008:

- The upgraded DIRAC setup with the new front-end electronics, readout system and DAQ was fully tuned.
- Data taking for the lifetime measurement of  $A_{2\pi}$ , observation of  $A_{K\pi}$  and  $A_{\pi K}$  and their lifetime measurement have been performed during 2.5 months and  $1.6 \times 10^9$  events were collected.
- The full set of events collected in 2008 was processed in the so-called preselection mode, which includes the full events reconstruction and some very safe cuts on the relative pair momentum. The background level at the reconstructed events is expected to be by a factor of 4 less in respect to the 2007 data due to the implementation of vertex detectors.

Run 2009:

This run in 2009 will increase the statistics of  $A_{2\pi}$ ,  $A_{\pi K}$  and  $A_{K\pi}$  by a factor of 2.5. To do so, after 3-4 weeks tuning, we need 5-6 spills per supercycle (about 40 seconds) till the end of PS physics this year.

Beam request for 2010:

The observation of long-lived states in  $A_{2\pi}$  (and  $A_{\pi K}$ ) is opening a new possibility to measure atomic energy shifts (Lamb and strong shift) and hence to determine another combination of  $\pi\pi$  scattering lengths:  $2a_0 + a_2$ .

To perform this observation, already mentioned in our addendum, we need to run in 2010 during around 5 months in the same conditions as in 2009.