

DIRAC collaboration status report.

1. Long-lived atoms.

1. Paper on observation of Long-lived atoms:

- a) The expected number of atomic pairs has been recalculated using a more conservative theoretical approach.
- b) The second draft of this paper with the new calculations will be sent to the collaboration before the end of June.

2. Paper on the measurement of the atom life-time:

- a) The number of produced atoms on the Be target has been evaluated.
- b) The atom distribution for different n, l and m after the Be target has been obtained.
- c) A first version of the analysis of the atoms that decay between the Be and the Pt target have been done.
- d) It is planned to obtain the preliminary result and the corresponding first draft of the paper in October 2015.

3. Measurement of the minimum value of Lamb shift:

- a) The atom distribution for different m after the Be target on the magnetic field direction will be calculated.
- b) After having obtained the preliminary result of this analysis we take the decision on the feasibility of the measurement of the minimum value of the Lamb shift.

4. Analysis of data from the 2011 run. Decide if to process the data taken with the Be target to extract on the number of produced atoms.

2. Status of the $K^+ \pi^-$, $K^- \pi^+$ and $\pi^+ \pi^-$ data process.

1. The Monte-Carlo ntuples with the improved SFD response for the runs of 2007, 2008, 2009, 2010 and 2012 are ready.
2. The improved procedure for identifying K^+ , π^+ and protons using the time of flight is ready and will be applied to the runs 2007, 2008, 2009, 2010 and 2012 data.
3. The SFD region where the particle hit is expected will be defined taking into account the particle momentum. The main aim of this procedure is to improve the quality of the statistics with the low and medium background and to use a part of the statistics with high background.
4. The analysis of the Lambda width using M.C. with the improved SFD response has been performed. There is no change in the result obtained with the previous version response.
5. The preliminary results on $K^+ \pi^-$ and $K^- \pi^+$ atoms investigations using all the data available from 2007, 2008, 2009 and 2010 runs and with the improved analysis will be ready in October 2015.
6. The $\pi^+ \pi^-$ atom lifetime measurement will be finished in 2016.

3. K^+K^- pair analysis.

1. The search for K^+K^- Coulomb pairs in the existing data will be performed, and the number of K^+K^- atoms, produced in parallel with the Coulomb pairs, will be extracted. During the first part of the work, we will analyse K^+K^- pairs with a total momentum in the laboratory system (l.s.) between 2.8 GeV/c and 6.0 GeV/c. Should we see a signal, Coulomb pairs will also be searched for in the higher momentum region between 6.0 GeV/c and 9.6 GeV/c.

2. The yield calculation of K^+K^- pairs and of K^+K^- atoms at proton momentum 24 GeV/c and 450 GeV/c is under study using CERN version of FRITIOF generator.

3. The theoretical investigation of the K^+K^- atom wave function square in coordinate space in S and P states and the K^+K^- atom lifetime calculation in S and P states need to be performed.

4. Proton-antiproton pair analysis

DIRAC will perform a search for proton-antiproton Coulomb pairs and thus proton-antiproton atoms with the same strategy as in the K^+K^- case (see section 3). The search for the proton-antiproton Coulomb pairs in the lower momentum region will be finished before May 2016.

5. Investigation of $K^+\pi^-$, $K^-\pi^+$, $\pi^+\pi^-$, K^+K^- atom production in p-nucleus interaction at proton momentum 24 GeV/c and 450 GeV/c

A DIRAC note on the simulation of the inclusive production of K^+ , K^- , π^+ and π^- in p-nucleus interactions at 24 GeV/c and 450 GeV/c is ready. The yields of $K^+\pi^-$, $K^-\pi^+$ and $\pi^+\pi^-$ atoms in p-nucleus interactions at proton momenta of 24 and 450 GeV/c are given in the table.

Table 1: The yield of $\pi^+\pi^-$, π^+K^- and $K^+\pi^-$ atoms W_A into the aperture of 10^{-3} sr taking into account the setup acceptance and pion and kaon decays per one p-Ni interaction at the proton momenta $P_p = 24$ and 450 GeV/c versus emission angle θ_{lab} . Correction factors are used and the correlation function $R_{24\text{GeV}/c}$ were set to be equal to $R_{450\text{GeV}/c}$. We have fix the yields of DIRAC at the PS at 24 GeV/c as reference, and for the other energies we indicate the yields as ratio to this reference.

θ_{lab}	5.7°	4°	2°	0°
E_p	24 GeV/c	450 GeV/c	450 GeV/c	450 GeV
yield of $\pi^+\pi^-$ atoms				
W_A	$(1.73 \pm 0.09)10^{-9}$	$(1.7 \pm 0.2) \cdot 10^{-8}$	$(3.0 \pm 0.5) \cdot 10^{-8}$	$(3.9 \pm 0.6) \cdot 10^{-8}$
	1	9.7 ± 1.5	17.5 ± 2.8	22.7 ± 3.6
yield of π^+K^- atoms				
W_A	$(1.46 \pm 0.09)10^{-11}$	$(6.6 \pm 1.1) \cdot 10^{-10}$	$(1.31 \pm 0.21) \cdot 10^{-9}$	$(1.52 \pm 0.24) \cdot 10^{-9}$
	1	45 ± 8	87 ± 15	104 ± 18
yield of $K^+\pi^-$ atoms				
W_A	$(4.2 \pm 0.3) \cdot 10^{-11}$	$(7.9 \pm 1.6) \cdot 10^{-10}$	$(1.8 \pm 0.4) \cdot 10^{-9}$	$(2.2 \pm 0.5) \cdot 10^{-9}$
	1	18.6 ± 4.1	41 ± 9	52 ± 11

6. Preparation of a Letter of Intent about the investigation of dimesonic atoms at SPS energy.

7. Instrumental publication

The paper "Updated DIRAC spectrometer at CERN PS for the investigation of $\pi\pi$ and $K\pi$ atoms" has been registered at CERN. This paper covers all the details of the detectors and discusses the overall performance of the spectrometer.

8. $\pi^+\mu^-$ and $\pi^-\mu^+$ pair analysis

The 2010 experimental data has been searched for $\pi^+\mu^-$ and $\pi^-\mu^+$ Coulomb pairs with the aim of extracting the number of $\pi\mu$ atoms produced simultaneously with the Coulomb pairs. The preliminary analysis was finished in January 2015. An upper limit on the atom production will be calculated and published in a DIRAC note before the end of 2015.

9. Use of experimental data 2007–2012 to measure production cross sections for $K^+\pi^-$, $K^-\pi^+$ and $\pi^+\pi^-$ atoms in proton interaction with Be, Ni and Pt nuclei, to be done in 2016

In order to evaluate the atom production cross section we can use two independent methods :

1. measure the proton flux for every run and evaluate the statistics of lost events from the dead time of electronics and of DAQ, then measure the statistics of lost events during data process.

2. extrapolate the precise inclusive cross sections of π^+ and π^- production at proton momentum of 32 GeV/c to the proton momentum of 24 GeV/c using Fritiof. This relation allows to evaluate the atom production cross section.