Contribution ID : **60** Type : **plenary talk**

# Measurement of the pion mass from X-ray spectroscopy of exotic atoms

*Tuesday, 7 June 2016 09:00 (0:30)*

## Collaboration

Pion mass

## Abstract content

X-ray spectroscopy of exotic atoms allows the determination of the mass of short-lived negatively charged unstable particle like muons, pions, or kaons from the energies of characteristic X-ray radiation. Pions are captured by the target atoms in a highly excited state and a de-excitation cascade takes place accompanied by Auger and radiative emission. Auger emission is dominant at the beginning of the cascade process, with the shell by shell ejection of the electrons, when the X-ray emission take place mainly for lower level de-excitation. The mass of the pion is extracted by the accurate measurement of X-ray photons corresponding to transitions between levels neither affected by strong-interaction effects nor by remaining electrons. The best conditions are found in the medium part of medium Z atoms which corresponds to the few keV range for X-ray transitions. The actual reference value of the pion mass from the Particle Data Group has an accuracy of 2.5 parts per million (ppm) and is based on two high-accuracy crystal spectroscopy of pionic magnesium and pionic nitrogen. In the case the $\pi$Mg, the use of a solid target induces a continuous electron refilling during the de-excitation cascade and an assumption on the number of remaining electrons has to be done to extract the pion mass value from the $(4f - 3d)$ transition energy measurement. This is not the case when a gaseous target is used as in the measurement of $\pi$N atoms where the $(5g - 4f)$ energy transition was measured with respect to Cu˜K$\alpha$ fluorescence radiation. In this case, the accuracy was limited by the complex structure of the broad copper calibration line.

Here we present a new experiment performed at the Paul Scherrer Institut that resumes the strategy of the gas target measuring the $\pi$N $(5g-4f)$ transition but exploiting the almost coinciding narrower $\mu$O $(5g - 4f)$ transition as reference. With an uncertainty of 0.033ppm, the mass of the muon provides a very high accuracy of the reference energy (1 meV). The $\pi$N and $\mu$O transitions are measured simultaneously with a Johann-type spectrometer equipped with a spherically bent Si(220) crystal and a dedicated array of 6 x-ray CCDs. The simultaneous measurement minimizes possible systematic shifts during the unavoidably long measuring periods.

**Primary author(s) :** TRASSINELLI, Martino (Institut des NanoSciences de Paris, CNRS, Sorbonne Universités UPMC Univ Paris 06, Paris, France)

**Co-author(s) :** ANAGNOSTOPOULOS, Dimitrios F. (Dept. of Materials Science and Engineering, University of Ioannina, Ioannina, Greece); BORCHERT, Gunther (Institut für Kernphysik, Forschungszentrum Jülich GmbH, Jülich, Germany); DAX, Andreas (Laboratory for Particle Physics, Paul Scherrer Institut, Villigen PSI, Switzerland); EGGER, Jean-Pierre (Institut de Physique de l' Université de Neuchâtel, Neuchâtel, Switzerland); GOTTA, Detlev (Institut für Kernphysik, Forschungszentrum Jülich GmbH, Jülich, Germany); HENNEBACH, Maik (Institut für Kernphysik, Forschungszentrum Jülich GmbH, Jülich, Germany); MANIL, Bruno (Laboratoire Kastler Brossel, CNRS, Sorbonne Universités UPMC Univ. Paris 06, ENS, Paris, France); NELMS, Nick (Dept. of Physics and Astronomy, University of Leicester, Leicester, England); LIU, Yi-Wei (Laboratory for Particle Physics, Paul Scherrer Institut, Villigen PSI, Switzerland); INDELICATO, Paul (Laboratoire Kastler Brossel, CNRS, Sorbonne Universités UPMC Univ. Paris 06, ENS, Paris, France); WELLS, Alan (Dept. of Physics and Astronomy, University of Leicester, Leicester, England); SIMONS, Leopold M. (Laboratory for Particle Physics, Paul Scherrer Institut, Villigen)

**Presenter(s) :** TRASSINELLI, Martino (Institut des NanoSciences de Paris, CNRS, Sorbonne Universités UPMC Univ Paris 06, Paris, France)

**Session Classification :** Plenary Session