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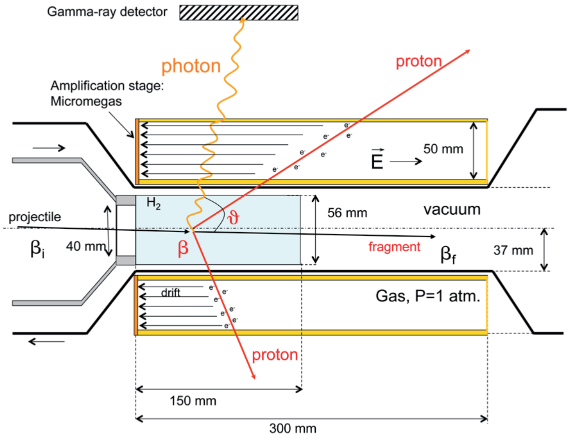
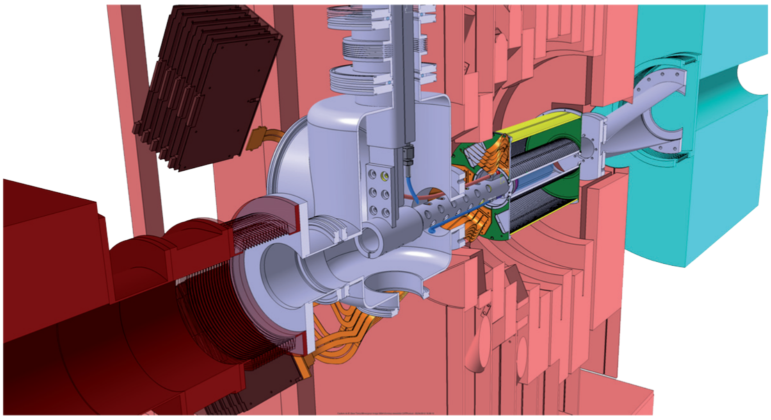
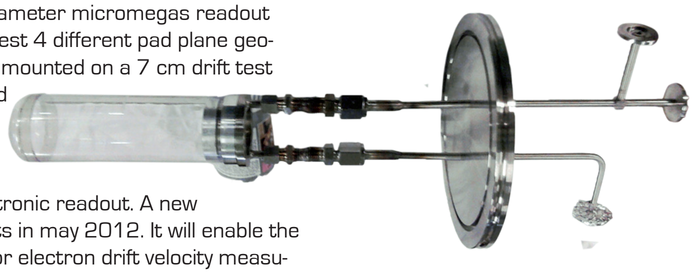
MINOS, acronym for MagIc Numbers Off Stability, represents both a physics program and a device. The physics program aims at investigating the properties of the in-medium NN interaction through the spectroscopy of the most exotic nuclei produced at fragmentation facilities. The device is composed of a thick cryogenic liquid hydrogen target surrounded by a cylindrical time projection chamber devoted to determine the reaction vertex by tracking charged particles produced in knockout reactions. MINOS is being built at IRFU, CEA Saclay. The project has been funded by the European Research Council for the period 2010-2015, period during which the device should be coupled with the DALI2 gamma spectrometer and the Zero Degree or Samurai spectrometers at the RIBF and operated in collaboration with teams from RIKEN. The ongoing development of the system is scheduled up to June 2013. The detector should be then shipped to RIKEN.
The physics program is based on experiments where light charged particles are emitted at high energy such as (p,2p) or (p,pn) knockout reactions. The TPC surrounding the target allows the tracking of the vertex location with a resolution better than 3 mm FWHM. The gains compared to traditional knockout-measurement setups are threefold: (i) an exclusive measurement, (ii) a thick target and therefore a larger luminosity, (iii) a non-degraded (even improved) energy resolution for gammas.

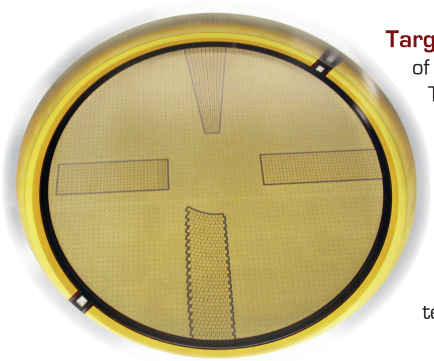




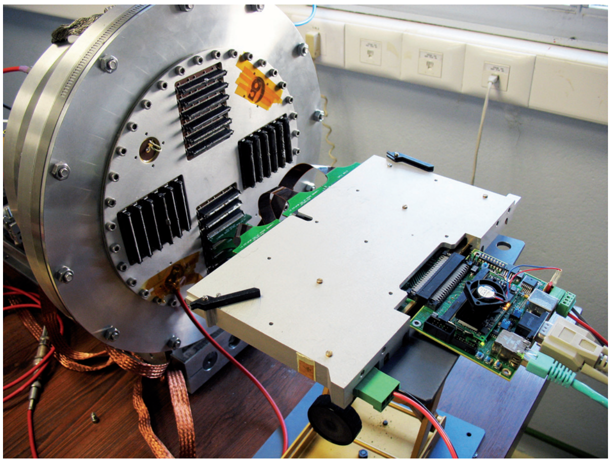
Mechanics The mechanical activity of MINOS can be divided into four parts: the design of the TPC, the LH2 target, the cryostat and then its implantation in the beamline. The integration, disassembly, assembly and maintenance are at full charge of the engineering system laboratory (SIS).
After a first step, during the end of 2011, centered on the feasibility of MINOS implantation at RIKEN and the definitions of the TPC and the LH2 target, the beginning of 2012 was devoted to the design/drawing of the cryostat. Its drawing will be external contracted to ensure its manufacturing launch in early July.
The MINOS integration in the environment of the beamline will continue until the visit to RIKEN in early June: definition of the support components, fixing electronic boxes, completion of installation scenarios. On this occasion the establishment of MINOS at GSI, for a period beyond 2015 to be defined, will be reviewed.

TPC micromegas readout plane The TPC readout plane will be made of a bulk-micromegas amplification stage. In order to fix the anode pad plane segmentation, a 210 mm diameter micromegas readout plane prototype was designed and produced in october 2011 in order to test 4 different pad plane geometries and distributions with 1 to 4 mm^2 pad sizes. This readout plane is mounted on a 7 cm drift test chamber equipped with an electric field cage composed of six 1 cm spaced copper rings which permits to set a 50 to 400 V/cm drift electric field.
This setup is used to measure the micromegas gas gain with a ^{55}Fe X-ray source and to test the reconstruction of alpha tracks emitted by a ^{241}Am source located on the cathode plane with a 288 channels T2K-based electronic readout. A new 30 cm drift test chamber is under production and should be ready for tests in may 2012. It will enable the use of a UV laser beam to either extract electrons from a metallic mesh for electron drift velocity measurements or to directly ionize the gas along the laser beam tracks and reconstruct them with the TPC.

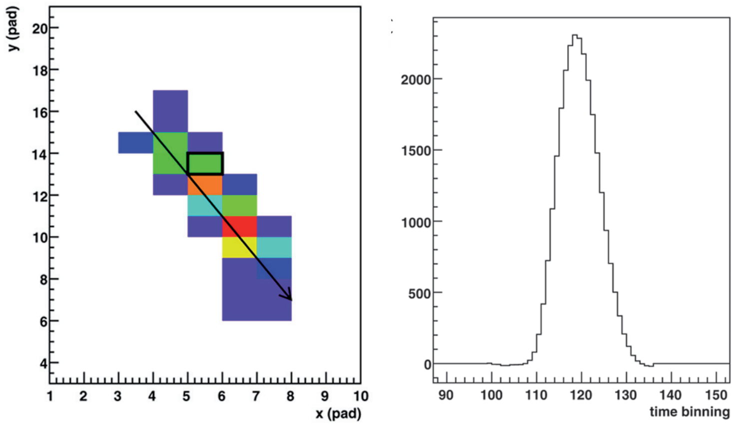




Target The liquid hydrogen product in the cryostat in the upper part (the condenser) at the temperature of 20.4 K and a pressure of 1050mbar (ABS) flows by gravity in a circuit (2 m) connected to the target. The liquid hydrogen target is composed of a stainless steel support (connected to the supply circuit) on which two windows of Mylar are glued. It is a cylindrical target; the main dimensions are 150 mm long and 52 mm in diameter. These envelopes are performed using dedicated tooling to obtain the desired geometry. Currently the parts are made of Mylar multiple copies. Several assemblies have been made since November 2011.
A test campaign of pressure resistance is underway. The goal of these tests is to check the measurement of the thickness of the envelope and obtain a safety factor of 3 between the operating pressure (1050 mbar ABS) and the burst pressure. All these destructive tests are performed at liquid nitrogen temperature (77 K).

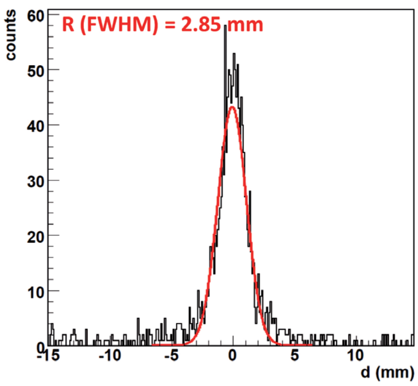


Prototype detector coupled to a 288-channel AFTER front- end card and Feminos.



Left: alpha track as observed with the prototype detector. Right: signal as a function of time for a selected pad along the track (black rectangle).

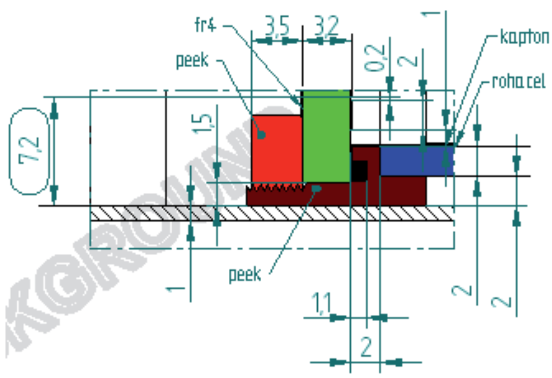
Electronics Tests of the prototype detector have started with front-end electronics based on the AFTER chip, a 72-channel ASIC developed for the T2K experiment. While present measurements are done with a digital readout card based on a mature FPGA device, an upgraded version, the Feminos, based on a newer device, is being introduced. A Feminos reads out a 288-channel front-end card based on the AFTER chip and is also compatible with the successor device, the AGET chip, a 64-channel ASIC developed by the GET collaboration. The final readout for the ~5000-channel TPC of Minos is thought to be the GET system which comprises three main custom hardware components: 256-channel (4 AGET per board) front-end cards (AsAd's), digital concentrator boards (CoBo's), and a synchronization board (Mutant). Alternatively, a scaled-up system based on Feminos and AFTER front-end cards could be used as an interim solution before it is eventually upgraded to AGET or the complete GET system is deployed. At present, R&D on detector, flexible and micro-coaxial cables, and tests of the various options of readout electronics are being pursued to demonstrate concepts and evaluate performance before final decisions are made.



Vertex-reconstruction resolution

Realistic simulations of the MINOS device in GEANT4 were performed in the case of a 53K beam interacting with the liquid-H2 target. The characteristics of the beam at RIKEN (Japan) simulated with LISE++ are considered. Events of (p,2p) reactions were selected to measure the resolution over the reaction vertex. Geant4 coupled with INCL/ABLA is used to simulate the reaction processes and get the energy loss by the two protons in the TPC. The energy loss by the protons creates ionization electrons in the TPC. The drift of the electrons is performed individually towards the Micromegas detector by a Monte-Carlo method. The characteristics of the gas (drift velocity, diffusions), the amplification stage of the Micromegas and the AGET electronics are considered. A spatial reconstruction of the proton tracks in three dimensions is achieved. Combining with the beam line reconstruction, a resolution at FWHM of 2.9 mm over the vertex position is reached with a time resolution over the arrival time of the electrons on pads of about 10 ns.
Simulations of the DALI2 response by considering these realistic events have also been performed. A 1 MeV transition emitted at 250 MeV/nucleon is calculated with a 34% photopeak efficiency.

TPC field cage The MINOS-TPC electric field cage is a key component of the TPC since it defines the path the electrons released along the proton tracks will follow towards the micromegas readout plane. The precision of the proton track 3D reconstruction and hence the precision of the vertex localization strongly depend on the uniformity, stability, and knowledge of the electric field lines in the TPC volume. Full MINOS GEANT4 simulations also show that the sooner the proton track is reconstructed at the exit of the liquid Hydrogen target, the better is the precision on the vertex reconstruction, leading to the need of a light and compact design of the TPC. The on-going design of the TPC walls is thus based on 2 mm rohacell cylinders and the first active pad of the micromegas readout plane is foreseen to be located 7.2 mm from the exit of the vacuum beam pipe. The electric field lines will be defined by two hundreds 1mm large strips printed with a 1.5 mm pitch on both side of a 100 µm thick kapton foil glued on the rohacell cylinders. Two 0805 CMS 1% resistors will be soldered in parallel between strips for a total of 800 resistors for a cylinder. A compact design can also only be reached by use of a cathode high voltage as low as possible. This is the case with the current baseline TPC gas mixture which was defined after Magbolz simulations and micromegas gas gain measurements : a non-flammable gas mixture of Argon, 3% of iC4H10 and 15% of CF4. This gas mixture is, for a 250 V/cm drift electric field (7.5 kV cathode high voltage), a good trade-off between low electron diffusion (less than 200 µm/sqrt(cm)), high enough electron drift velocity (higher than 5 cm/µs) and high enough micromegas gas gain (up to 5000).



Current design of the mechanical interface between the micromegas readout plane and the TPC field cage (micromegas readout plane is in red, the rohacell electric field cage wall in blue).

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