New parameter monitoring-protection system of the Dubna Gas-Filled Recoil Separator

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Introduction

PC-based one-crate monitoring and control system of the Dubna Gas Filled Recoil Separator (DGFRS) is considered. It is developed for the long-term experiments at the U400 FLNR cyclotron and is aimed at the synthesis of super heavy nuclei in heavy ion induced complete fusion reactions. Parameters related to beam and cyclotron, separator by itself, detection system, target and entrance window are measured and stored in the protocol file of the experiment. Special attention is paid to generating the "alarm" signals and implementing further the appropriate procedures. One of the main functions of the system is the highly radioactive target protection.

Monitoring system

The In the **Fig. 1** the system schematics is shown.

Design in brief: CAMAC, one (digital) crate, KK012 controller (modified, see Ref. [1,2]), program (Windows XP, Borland's Builder C++)

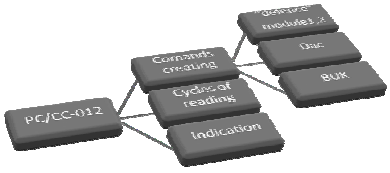

Fig. 1. General **s**chematics of the system

Main CAMAC modules in the digital apparatuses crate:

BUK01 – CAMAC-1M (to create time intervals window to measure parameters, **NF16A0**(3 in parallel, 0.02,02 or 2 s interval) + (three independent outputs) **NF16** (A2/A3, A4/A5, A6/A7)

BZ01 ("alarm" modules (2 mod 2M) each one 8 inputs and 1 output to switch the beam OFF) ; **F24/26(A0-A7)** – off/on "defense" mode, **NF2**(read), **NF10** (to reset alarm's register)

3 16 bit counters KS019

1 ADC PA 01 (8 inp ADC), 2 ADC PA-24K (10 bit, target control, TOF U400(in reserve use) 5 KS022 rate meters (~rotation control, +some others) ,1 KV009 1M - DAC → thresholds setting for low Dipole magnet current and Wobbler current

Gauges(sensors): **MCS** Baratrons (N=4), vacuum gauges "**Pfiefer"** (N=7, long scale!),

Target (entrance window) - el.Motors(N=2) **"Siemens"** asynchronous AC.

- ***Basic dc parameters*** *measurements: voltage-frequency-code conversions*

- Main code **Builder Timers** – 5

(CAMAC, calibration, visualization, imitation of rotation, protocol writing… etc…) In the **Fig. 2** user interface is shown. Picture (*Prt Scr*) corresponds to real SHE experiment with ^{48}Ca on as a projectile.

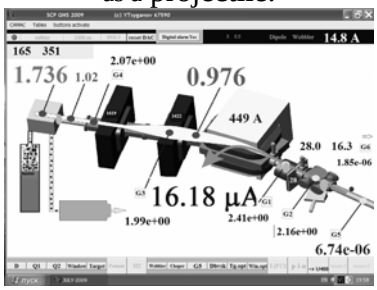

Fig. 2. Schematic of the system interface (three monitors- near the separator, in the control room and near PC).

a) green field means the parameter under control, if alarm will occur-color will red. Action – beam is turned off;

b) **16.18**- value (~ add 10%) of projectile beam at the target;
c) **1.736** (Tor) – pentane pressure;
d) **28.0 and 16.3** – target and entrance window wheel rotation speed (1/s)// double control: rotating itself+ optical pairs light source-photodiode;
e) **0.976** – H_2 pressure in the separator;
f) **6.74-06** - cyclotron vacuum value in the point before the separator window;
g) **449**, 1622, 1619 A – current values in Dipole magnet and in the lenses;
h) **165 351** at yellow field (left-upper corner) – rates of DAS events (focal plane PIPS + side detector) and TOF camera operation; if **165 351** then it means, that rate of events is under control using low limit (dblClick in Edit area, ~5 events in ~ 10 s)
i) 14.8 A (right-upper corner**) –** wobbler current
j) Green button in the left-upper corner: start spectrum measure from additional detector(p-i-n, 8x8 mm^2) located close to rotating target in order to estimate it's state
k) "buster" – pressure of saturated pentane vapor (in progress)

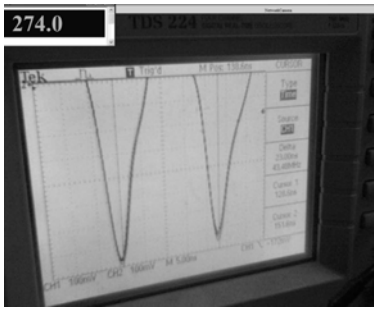

Fig. 3a. A view at the cyclotron operator working place PC. It is shown a beam energy (MeV, $f_{refresh}$ ~ 1 c^{-1}) and "quality" of beam tuning signals from two picUp electrodes located before the separator (oscilloscope picture - via net-camera).

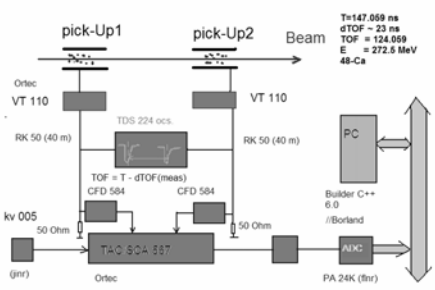

Fig. 3b. TOF U400 system block-diagram

Summary

The experimental parameter monitoring/protection system of the Dubna Gas Filled Recoil separator has been designed and applied in the last three years in the experiments $^{226}Ra+^{48}Ca \rightarrow Hs+4n$ and $^{239}Bk+^{48}Ca->117+3,4n$ experiments. Namely with this system it has become possible to avoid abnormal scenarios. Authors plan to provide an upgrade of the system in the nearest future.

References

[1] A.M.Sukhov et al, Physics Part. And Nuclei Lett., 2010. Vol.7, No.5, pp.370-377
[2] Yu.S.Tsyganov et al. In Proc. of IEEE 2010 Symp., June 2010, Lisbon, Portugal /in print/