CHICO2 – A pixelated PPAC

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CHICO and Gammasphere

- CHICO (Compact Heavy Ion COunter) developed at U. of Rochester in 1994 – 1996, under NSF funding. [M. Simon et al, NIM A452, 205 (2000)]

- Designed as an auxiliary charged-particle detector for Gammasphere with a solid-angle coverage of 69% of $4\pi$.

- 26 experiments fielded over a decade, involving 58 experimentalists from 17 institutions, which results in 37 publications and 5 Ph.D.’s
Gammasphere/CHICO at ANL, 2008

Gammasphere/CHICO setup

$^{178}$Hf on $^{208}$Pb at $E_{\text{lab}} = 984$ MeV

TOF vs scattering angle

Doppler-shift corrected $\gamma$ spectrum
CHICO2

- Angular resolution of CHICO improved to $\sim 1^\circ$ in both $\theta$ and $\phi$ coordinates, matching those of GRETINA by pixelating the position-sensing plate.
- Position determination not by the location of pixel but by the delay-line readout technique, which reduces the readout to 100 instead of 14,780 channels.
- Funded in FY10 and completed by the end of 2012.
- Excellent uniformity and linearity is achieved during the testing phase.
  - Improving the $\gamma$-ray energy resolution by a factor of 2 - 3.
CHICO2 – Early planning
VME based electronics design

**GRETINA**
- Anode (20)
  - 500 MHz Bandwidth
  - Gain of 200

**CHICO2**
- Cathode (80)
  - 500 MHz Bandwidth
  - Gain of 800

**QDC (CAEN V792)**
- 32-channel; 400 pC

**TDC (CAEN V1190A)**
- 128-channel; 100 ps res

**Logic/Trig (CAEN V1495)**
- Customisable FPGA

**Scaler (CAEN FW1495SC)**
- 128-channel; 270 MHz

**TDC (CAEN V1190A)**
- 128-channel; 100 ps res
Firmware diagram
Experimental results

- Octupole collectivity in $^{144}$Ba
  - $\sim 500$ pps $^{144}$Ba on 2 mg/cm$^2$ $^{208}$Pb target for 36 hrs
  - Excited states with spin up to $8^+$ was observed

Courtesy of S.F. Zhu
GRETINA/CHICO2 at ANL, 2014
GRETINA/CHICO2 at ANL, 2014
CHICO2 test with a $^{252}$Cf source

ToF difference vs scattering angle (uncalibrated)

Derived mass spectrum

Courtesy of S.F. Zhu
76Ge; first GRETINA/CHICO2 experiment

- 318 MeV 76Ge on 0.5 mg/cm² 208Pb
- Particle single rate up to 500 k/s for the scattering angle between 20° and 80°
- ~ 100 M p-γ events collected in ~ 36 hrs
- γ-ray energy resolution < 0.78%; work still in progress

Courtesy of M. Albers
\(^{144}\text{Ba}; \text{CARIBU/GRETINA/CHICO2}\)

- 650 MeV \(^{144}\text{Ba}\) on 1.0 mg/cm\(^2\) \(^{208}\text{Pb}\)
- Particle single rate up to > 1000 s for the scattering angle between 20\(^\circ\) and 80\(^\circ\)

**TOF Difference**

**Scattering angle (degree)**

**Counts**

**E\(_\gamma\) (keV)**

**Courtesy of M. Albers**
Summary

- CHICO2 has been successfully integrated into (Digital)Gammasphere and GRETINA.
  - It has reached the position resolution as designed;
  - $0.7^\circ (\sigma)$ for $\theta$ and $1.4^\circ$ for $\phi$

- Current status of GRETINA/CHICO2
  - Coulomb excitation of $^{72}$Ge and $^{76}$Ge was complete
  - Coulomb excitation of $^{144}$Ba is ongoing
  - Coulomb excitation of $^{146}$Ba is scheduled