

# CHICO2 – A pixelated PPAC

ATLAS Users Meeting 2014

May 15, 2014

Ching-Yen Wu

 Lawrence Livermore  
National Laboratory

LLNL-PRES-654341

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

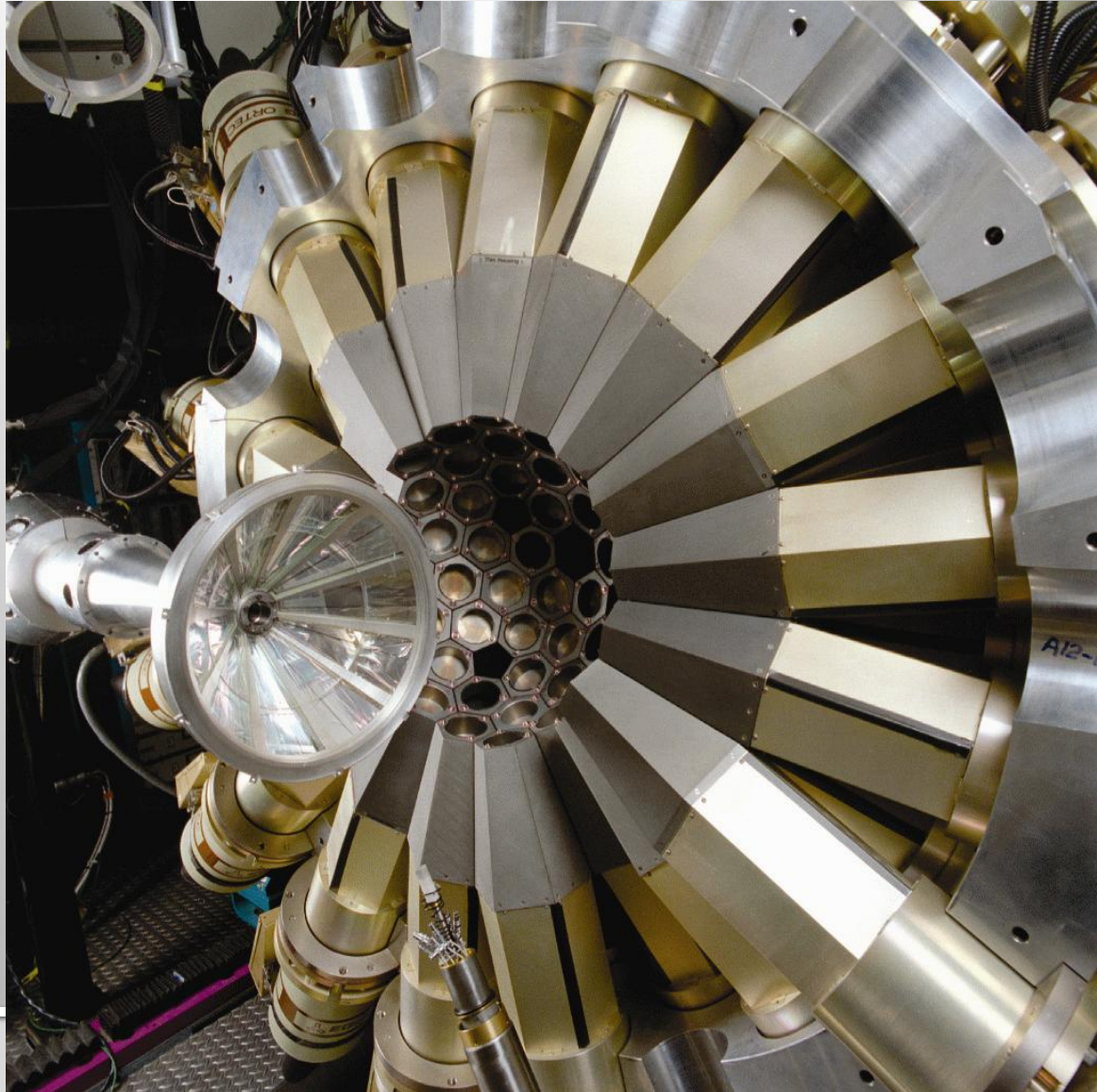


# Acknowledgement

- Upgrade funded by DOE/SC/NP
- Collaboration between U. of Rochester and LLNL
- D. Cline and A. Hayes (U. of Rochester)
- I.Y. Lee (LBNL)
- B. DiGiovine, J. Anderson (ANL)
- D. Swan (Swan Research LLC)
- R. Fox (CAEN)

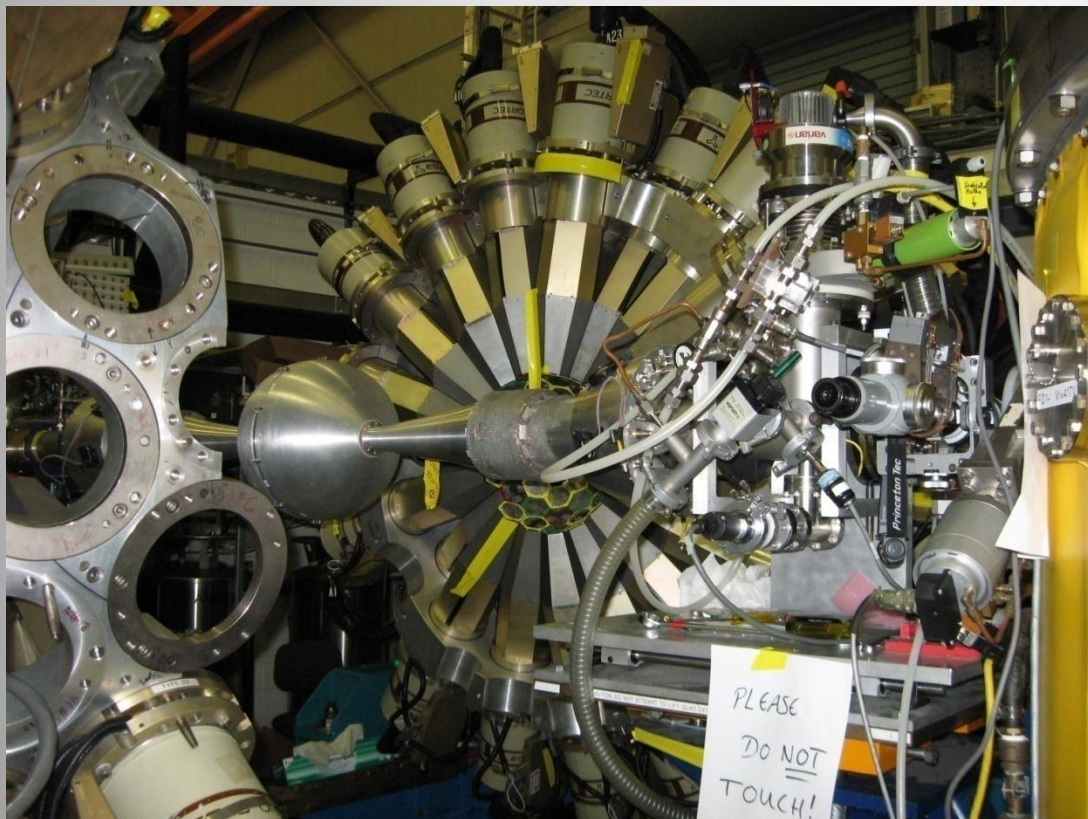
# CHICO and Gammasphere

- 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

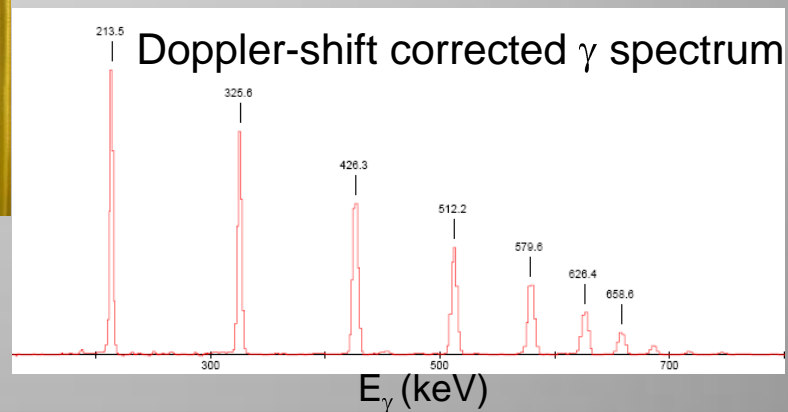
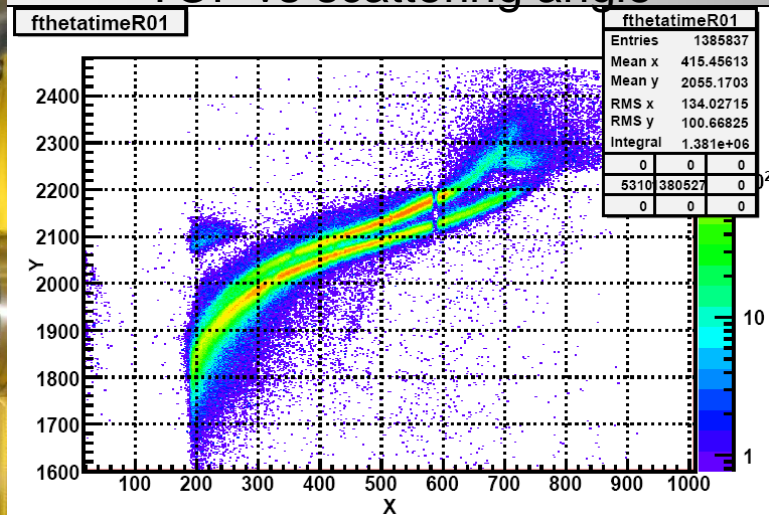


# GammaSphere/CHICO at ANL, 2008

GammaSphere/CHICO setup

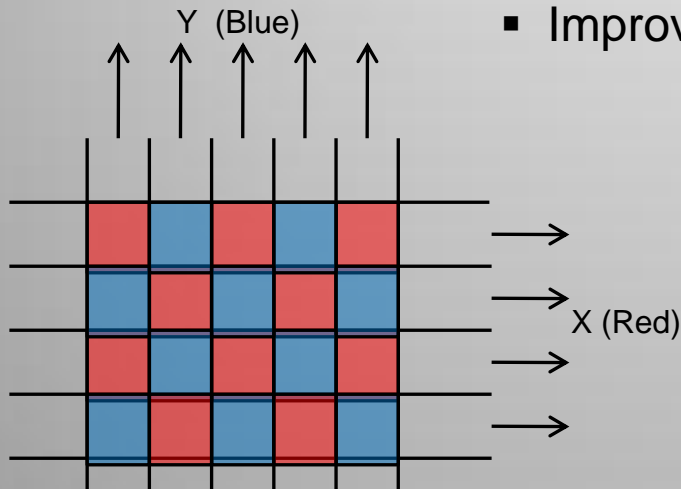


$^{178}\text{Hf}$  on  $^{208}\text{Pb}$  at  $E_{\text{lab}}=984$  MeV  
TOF vs scattering angle

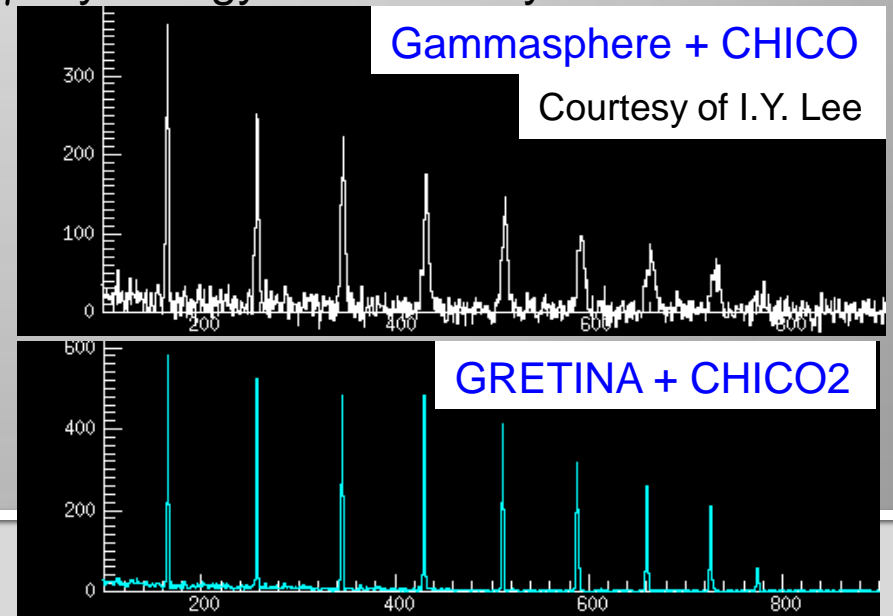


# CHICO2

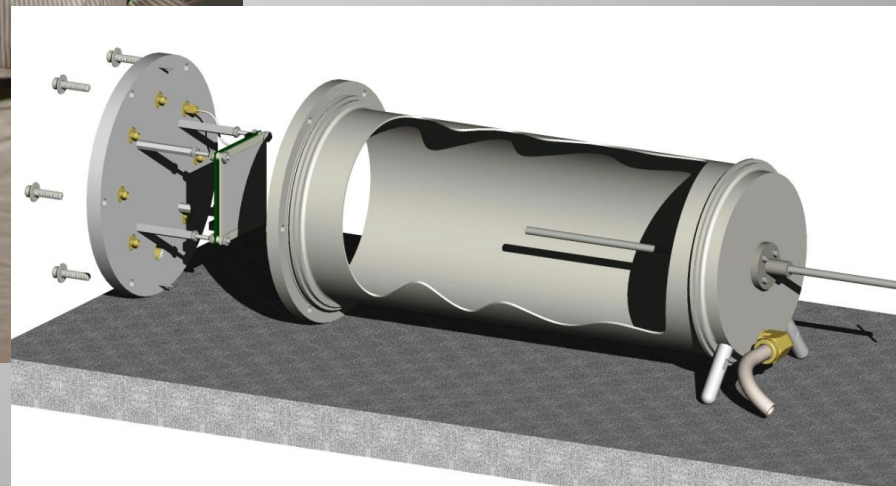
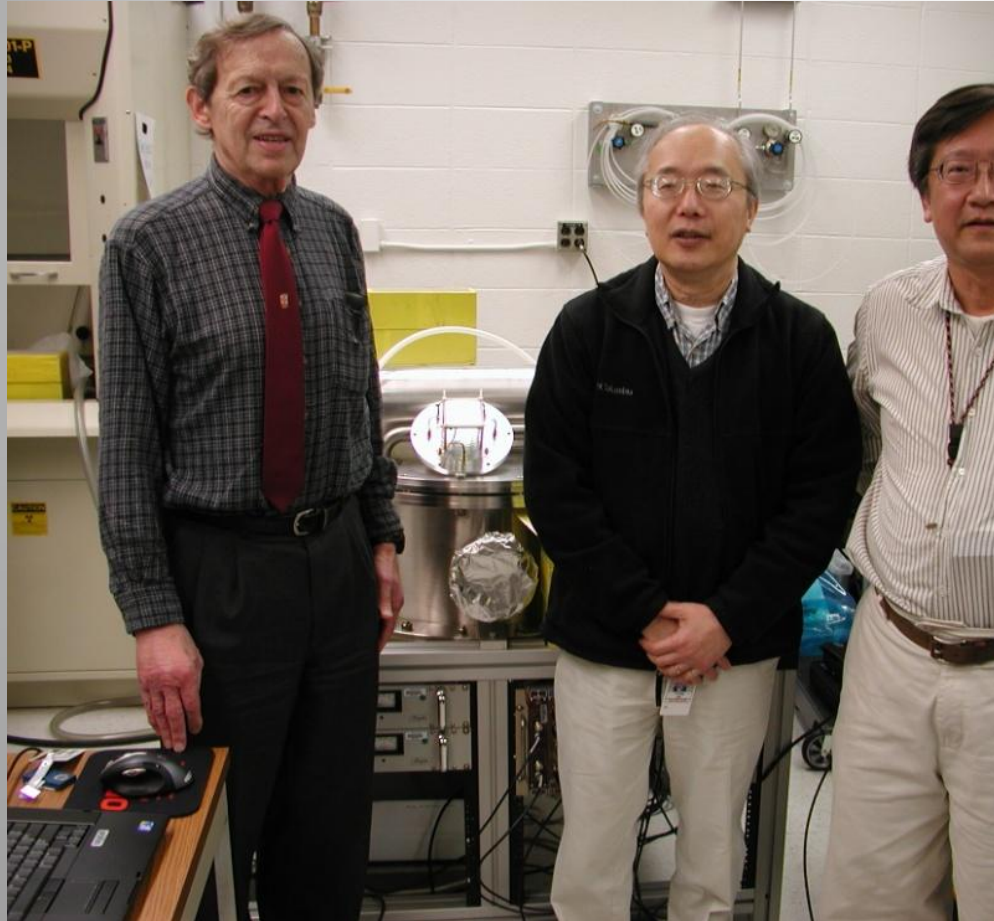
- Angular resolution of CHICO improved to  $\sim 1^\circ$  in both  $\theta$  and  $\phi$  coordinates, matching those of GRETINA by pixelating the position-sensing plate
- Position determination not by the location of pixel but by the delay-line readout technique, which reduces the readout to 100 instead 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



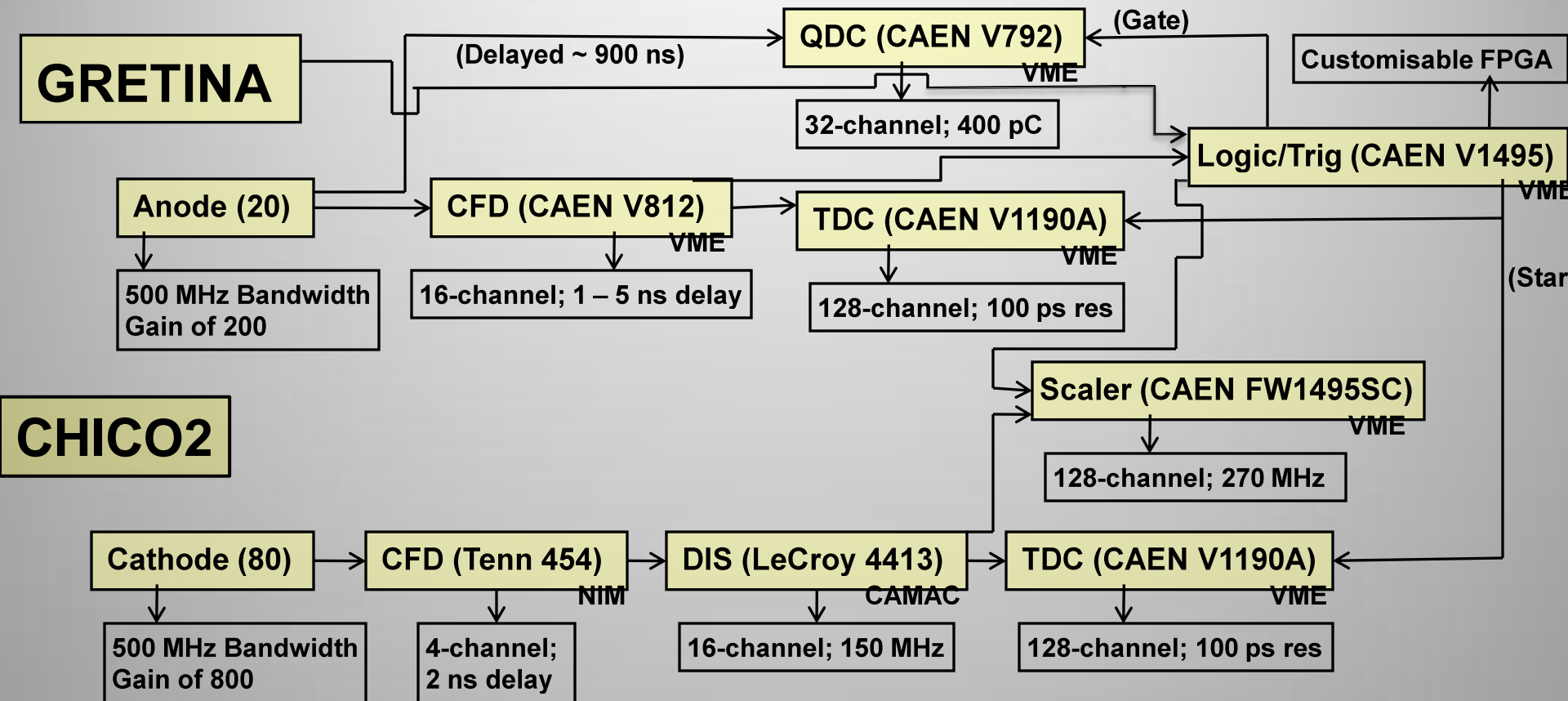
Pattern of interconnected pixels



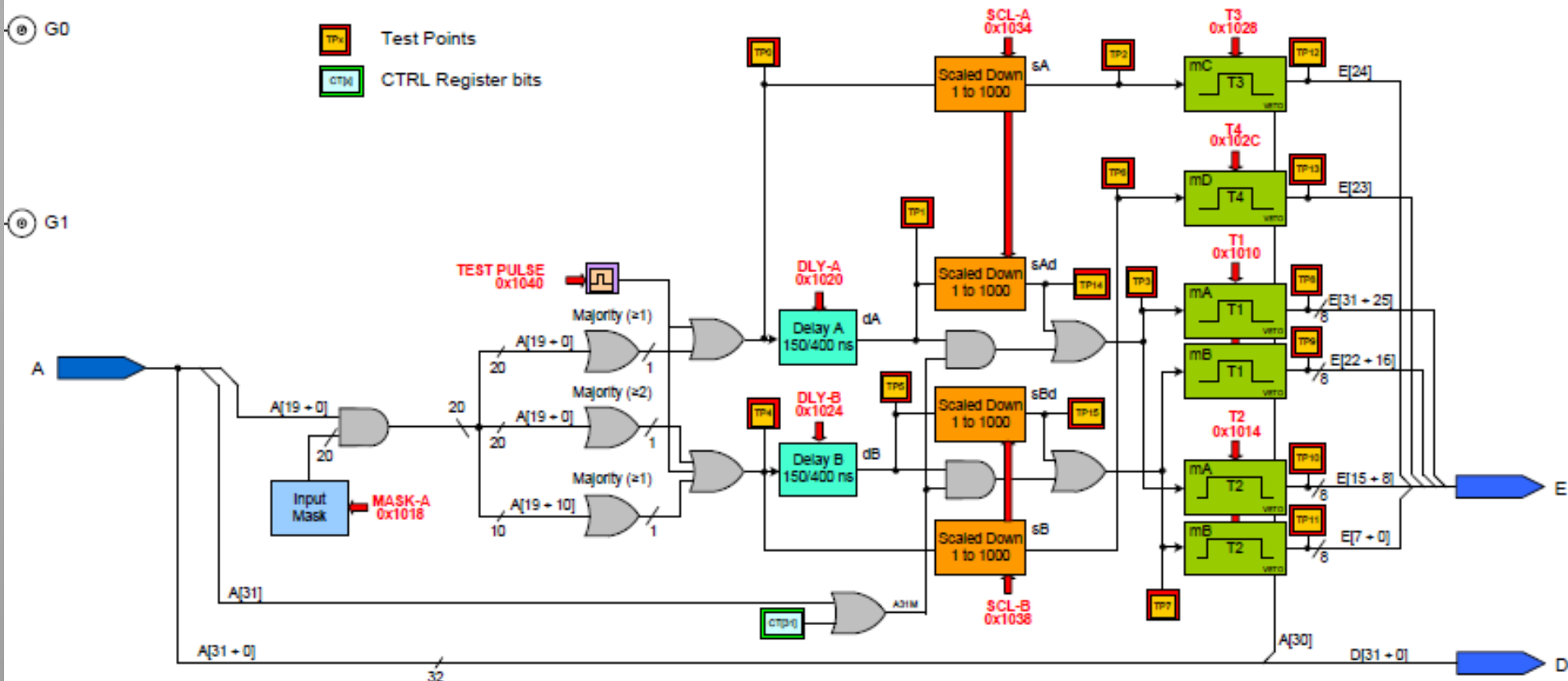
# CHICO2 – Early planning



# VME based electronics design

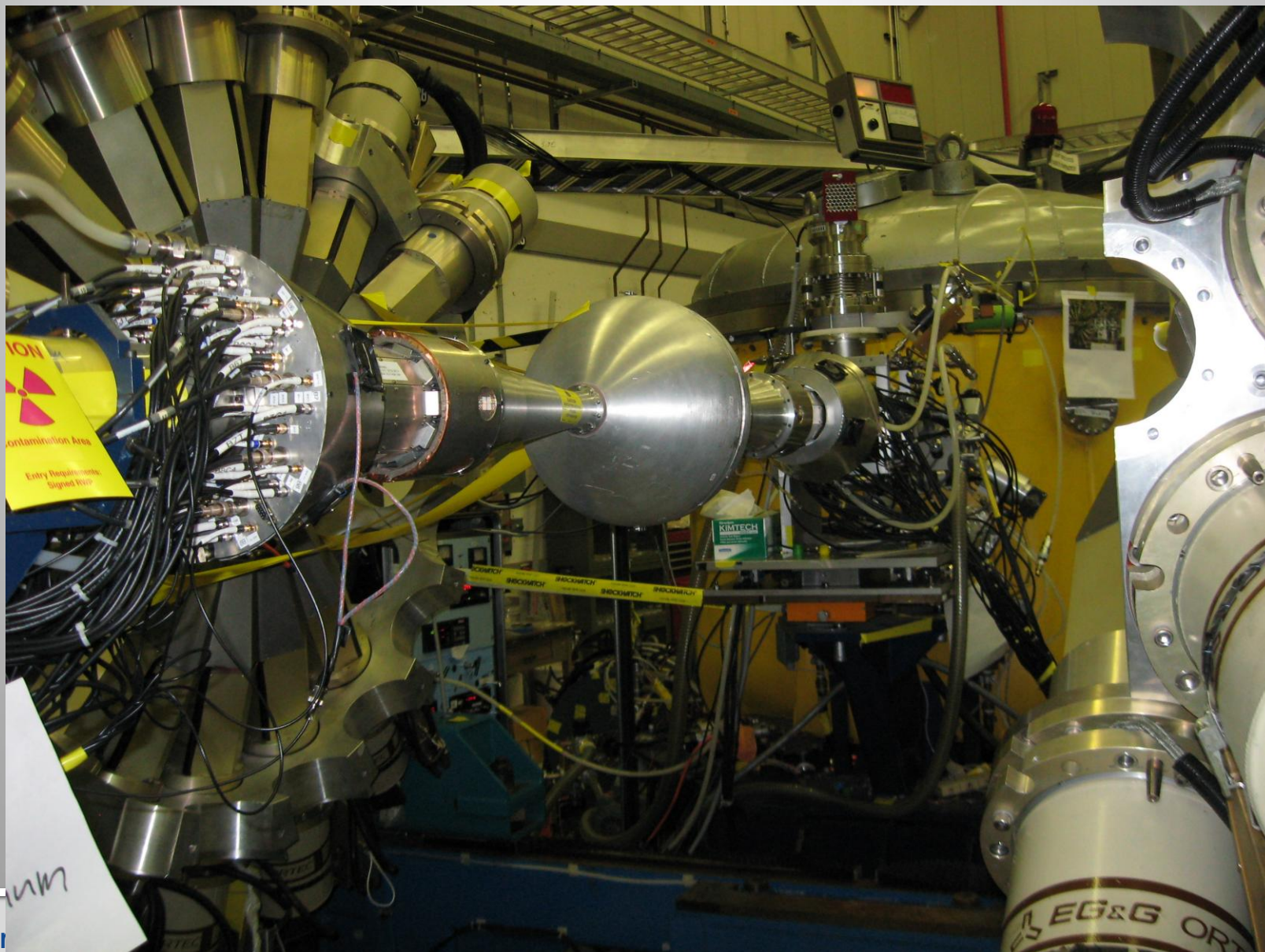


# Firmware diagram



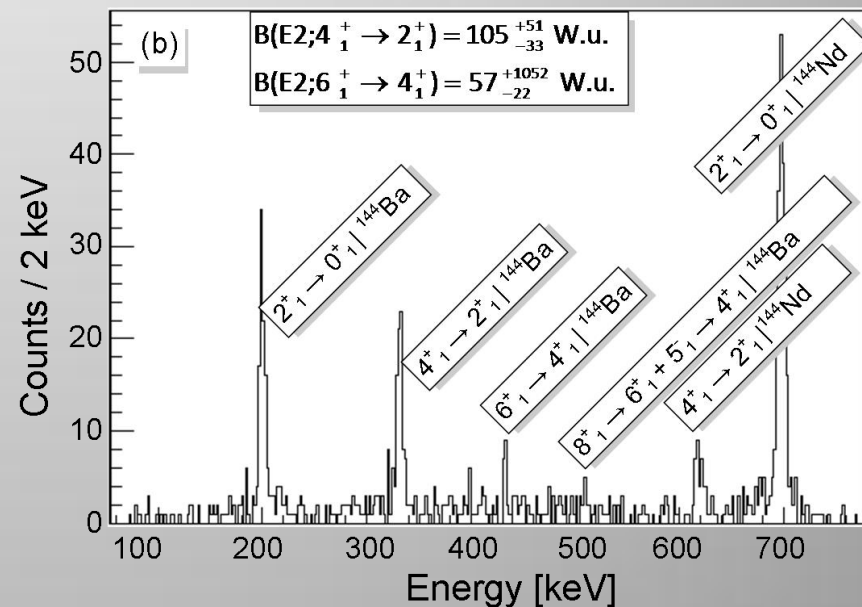
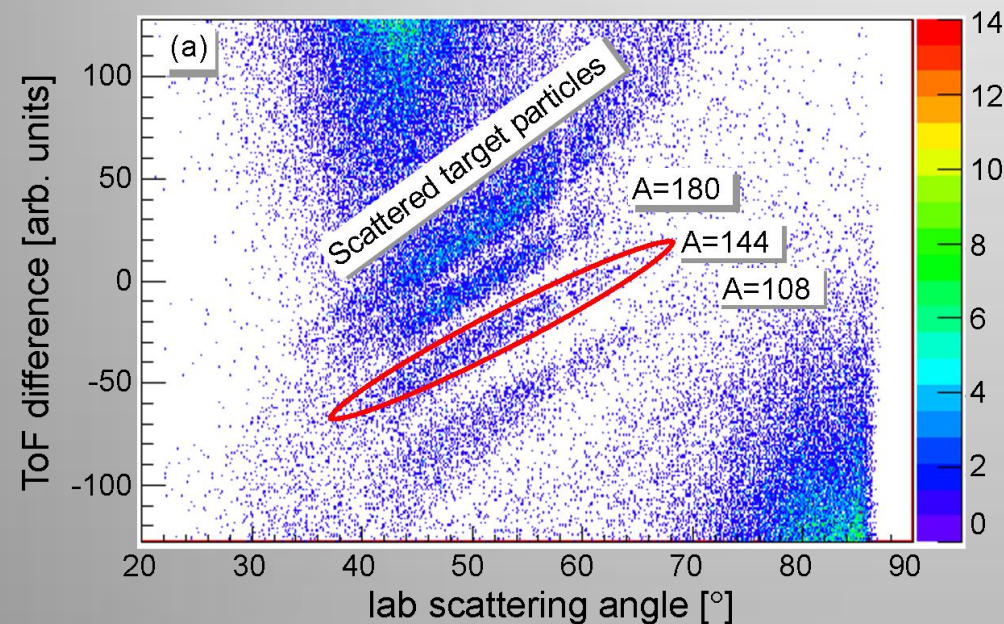


# DGS/CHICO2 setup at ANL, 2013



# Experimental results

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

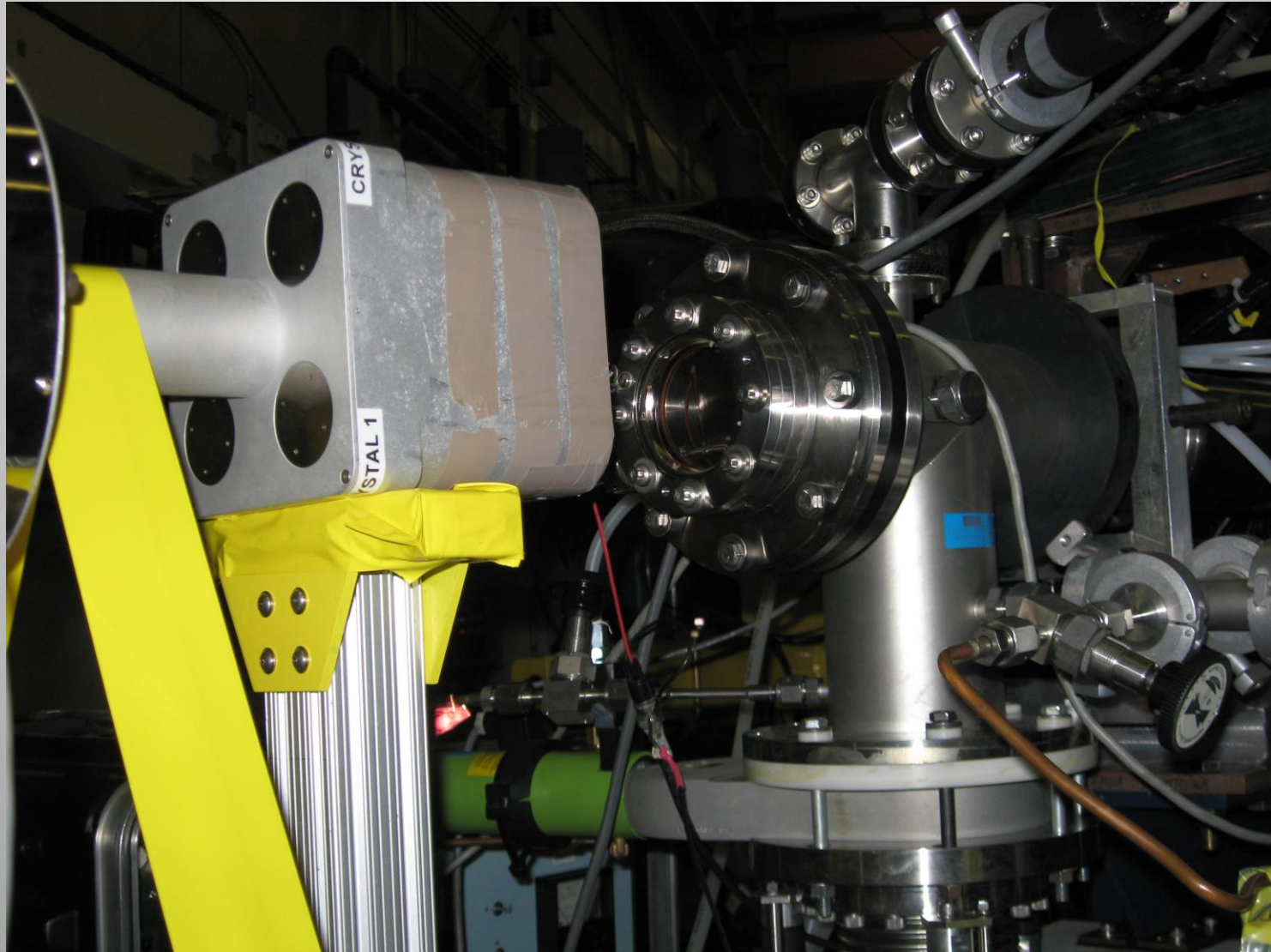


Courtesy of S.F. Zhu

# GRETINA/CHICO2 at ANL, 2014

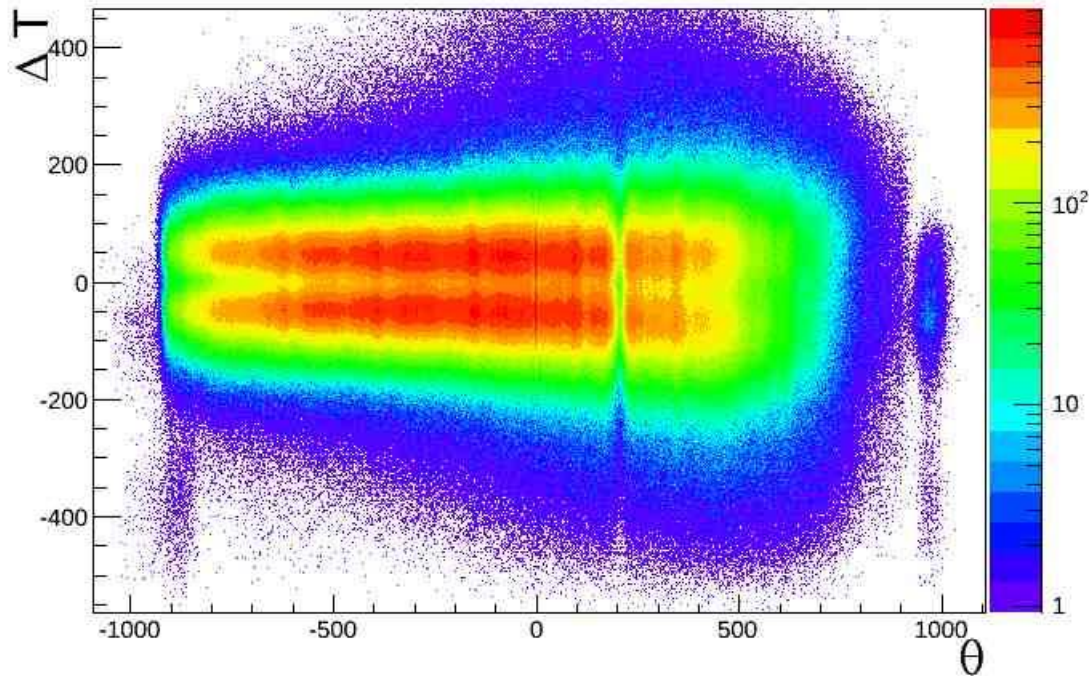


# GRETINA/CHICO2 at ANL, 2014

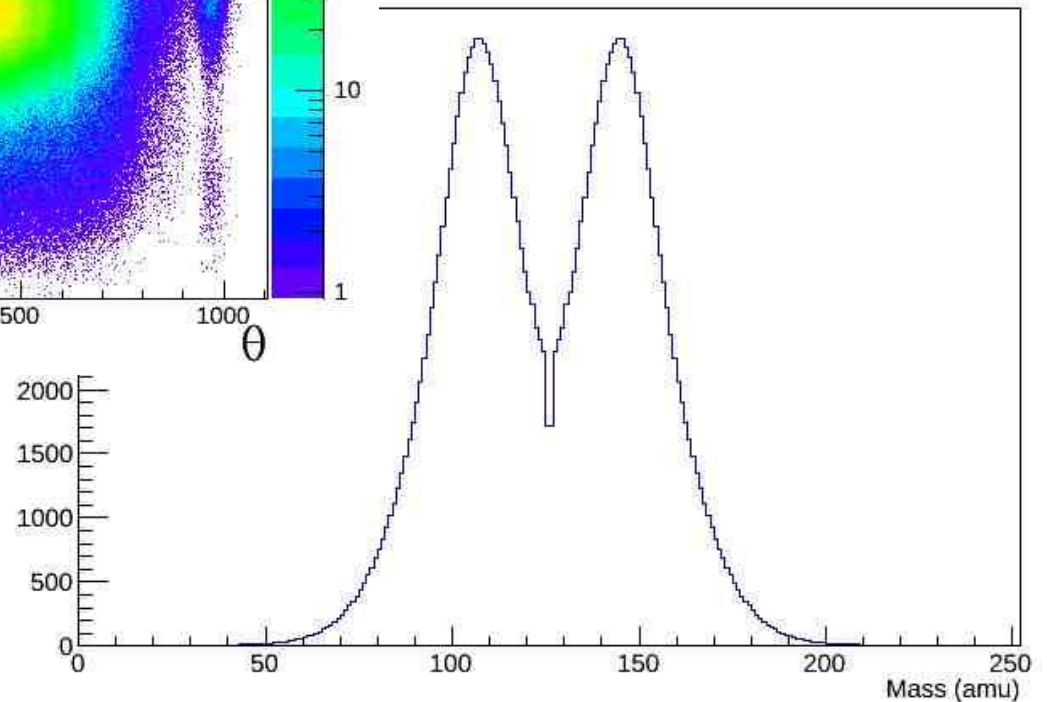


# CHICO2 test with a $^{252}\text{Cf}$ source

ToF difference vs scattering angle (uncalibrated)



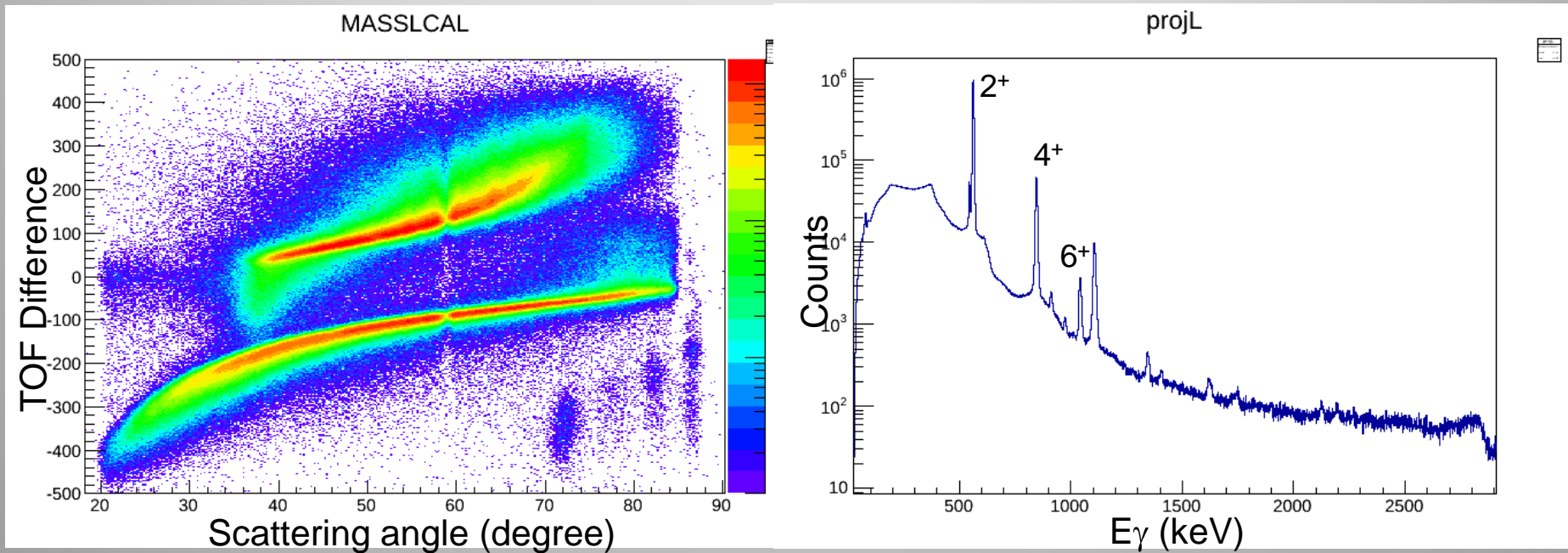
Derived mass spectrum



Courtesy of S.F. Zhu

# $^{76}\text{Ge}$ ; first GRETINA/CHICO2 experiment

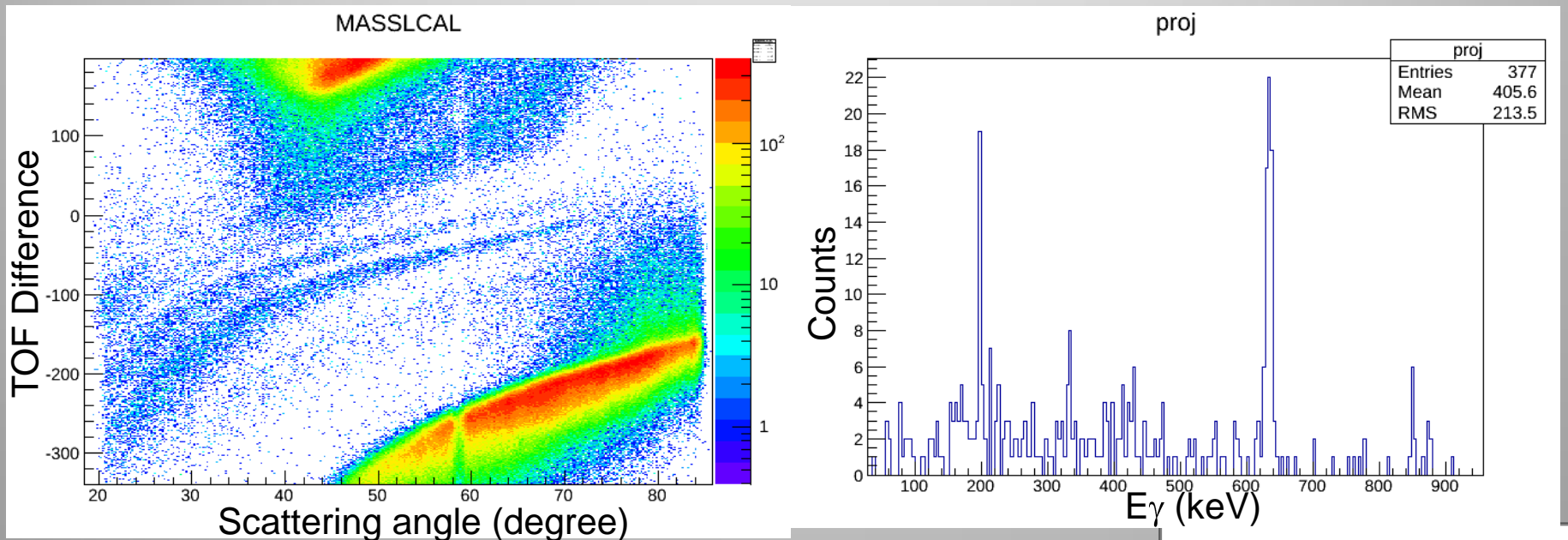
- 318 MeV  $^{76}\text{Ge}$  on 0.5 mg/cm<sup>2</sup>  $^{208}\text{Pb}$
- Particle single rate up to 500 k/s for the scattering angle between 20° and 80°
- ~ 100 M p- $\gamma$  events collected in ~ 36 hrs
- $\gamma$ -ray energy resolution < 0.78%; work still in progress



Courtesy of M. Albers

# $^{144}\text{Ba}$ ; CARIBU/GRETINA/CHICO2

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



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  $^{72}\text{Ge}$  and  $^{76}\text{Ge}$  was complete
  - Coulomb excitation of  $^{144}\text{Ba}$  is ongoing
  - Coulomb excitation of  $^{146}\text{Ba}$  is scheduled