Experimental study of the BETA ASICs performance for the High Energy cosmic-Radiation Detection (HERD)

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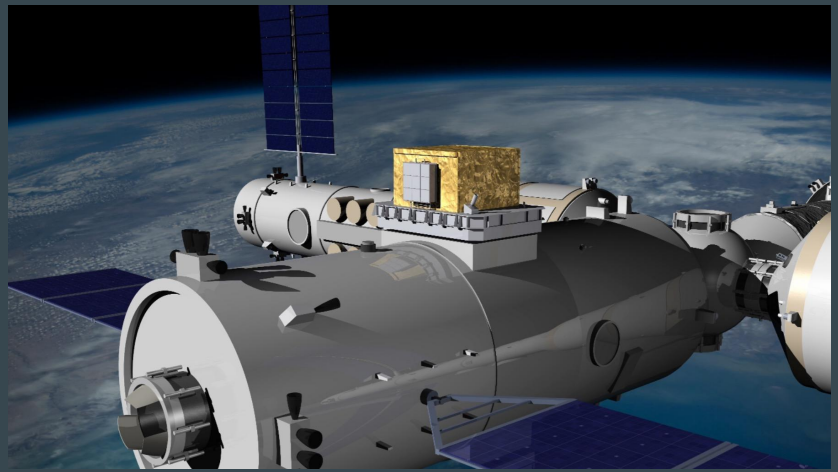
Introduction to the project

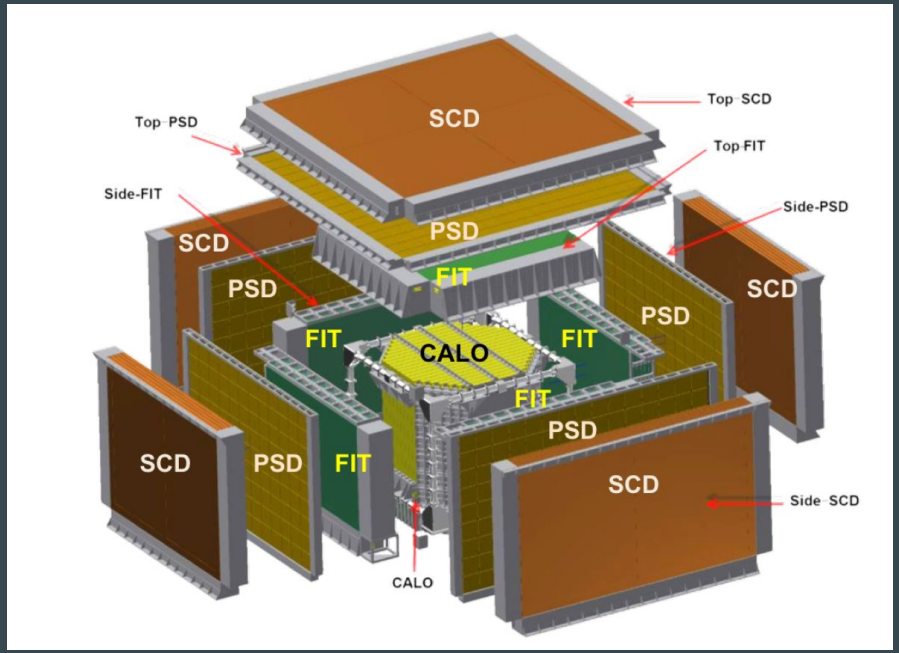


- Energy measures of primary cosmic rays up to PeV range
- High energy gamma-rays above 100MeV
- Dark Matter

"Gamma-ray performance of the High Energy cosmic-Radiation Detection (HERD) space mission", G. Lucchetta, J.Rico et al., 38th International Cosmic Ray Conference , 2023

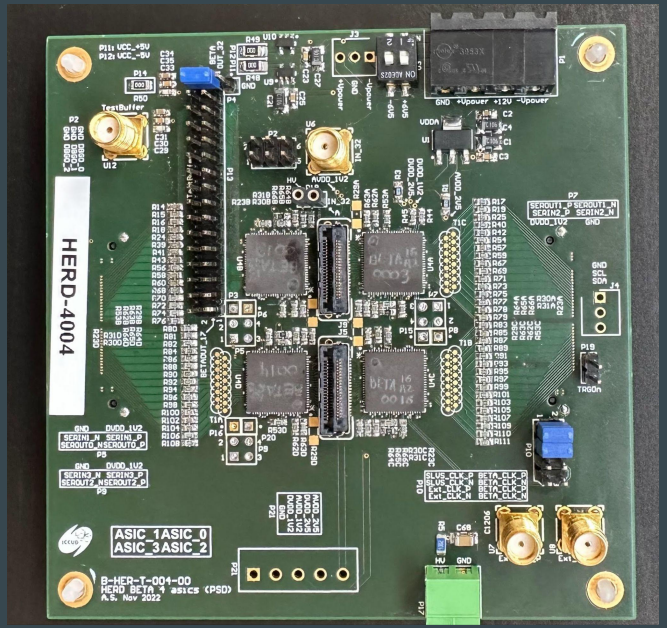
"The High Energy cosmic-Radiation Detection (HERD) facility on board the Chinese Space Station: hunting for high-energy cosmic rays", F. Gargano et al., 37th International Cosmic Ray Conference , 2021

Technical features



"The High Energy cosmic-Radiation Detection (HERD) facility on board the Chinese Space Station: hunting for high-energy cosmic rays", F. Gargano et al., 37th International Cosmic Ray Conference , 2021

BETAs and SiPMs



- Silicon PhotoMultipliers (SiPMs) for the readouts
- These send a signal to the BETA (fiBer trackEr readouT Asic), with 16 channels for PSD.
- Logic of majority: 3 out of 4 SiPMs to generate the triggers for PSD

"fiBre trackEr readouT Asic (BETA) - Specifications document", A. Cormena et al., 2021
"BETA IC for the High Energy cosmic Radiation Detection (HERD) facility", Data Sheet

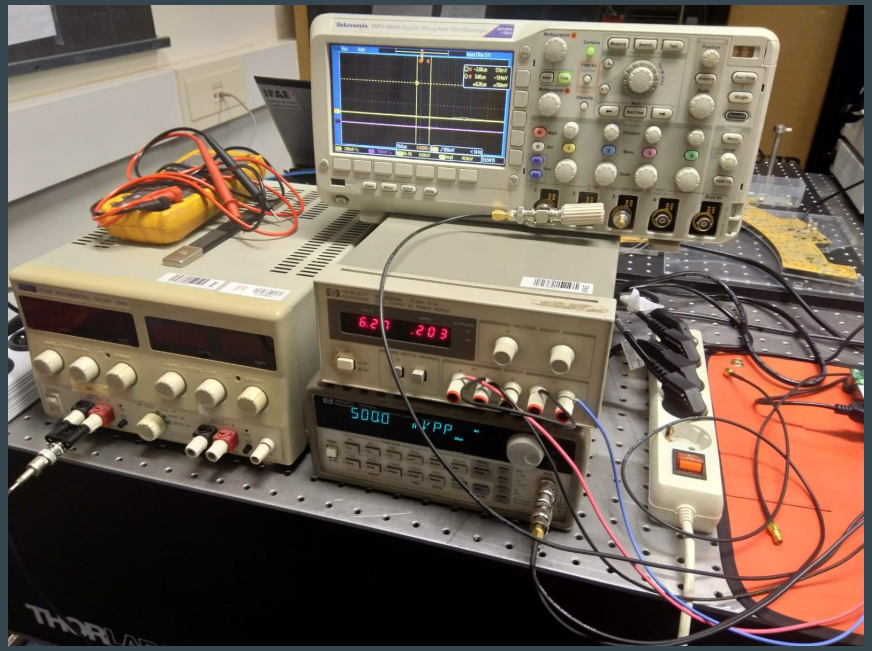
How do the BETAs work?

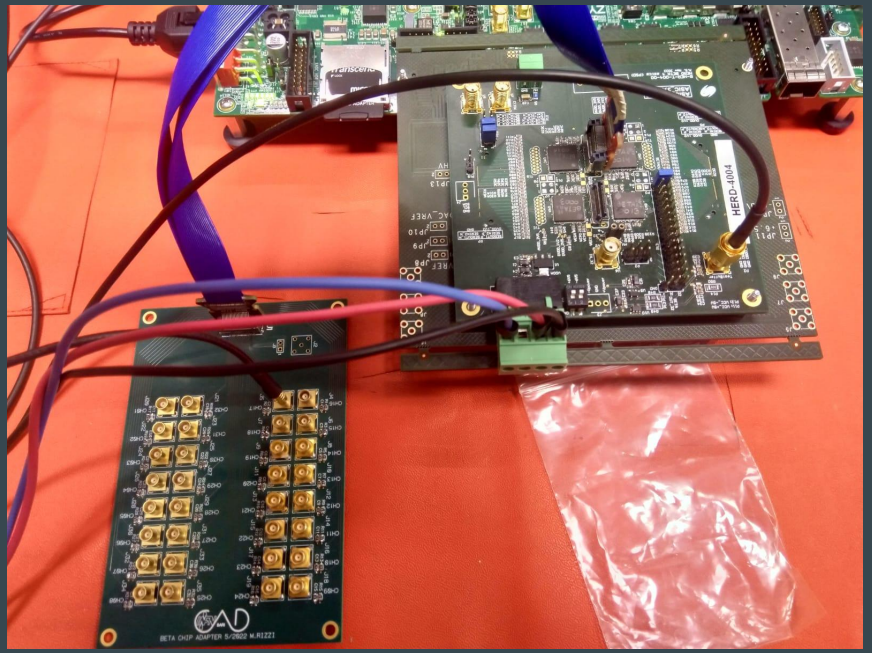
- Trigger signal -> String of data in binary representation

- Each channel gives an integer between 0 and 4095 (12-bits):
  - If <2048/ First bit 0: High Gain
  - If >2048/ First bit 1: Low Gain

"fiBre trackEr readouT Asic (BETA) - Specifications document", A. Cormena et al., 2021
"BETA IC for the High Energy cosmic Radiation Detection (HERD) facility", Data Sheet

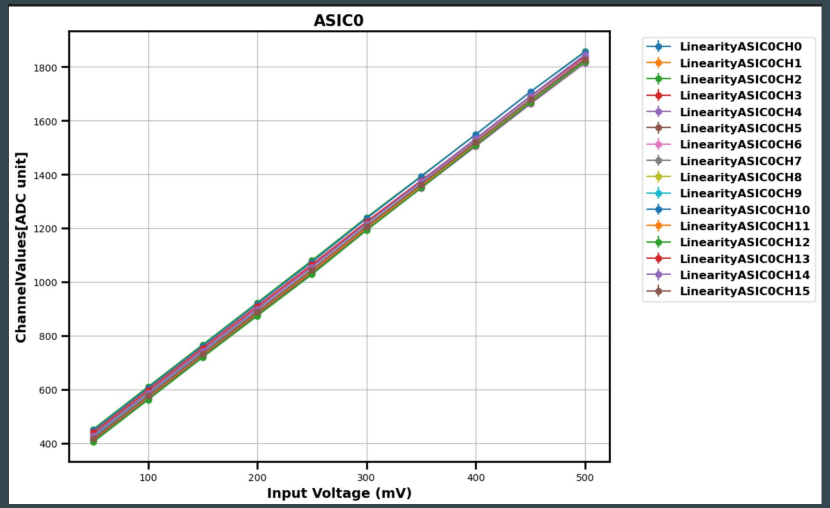
Experiments and Results

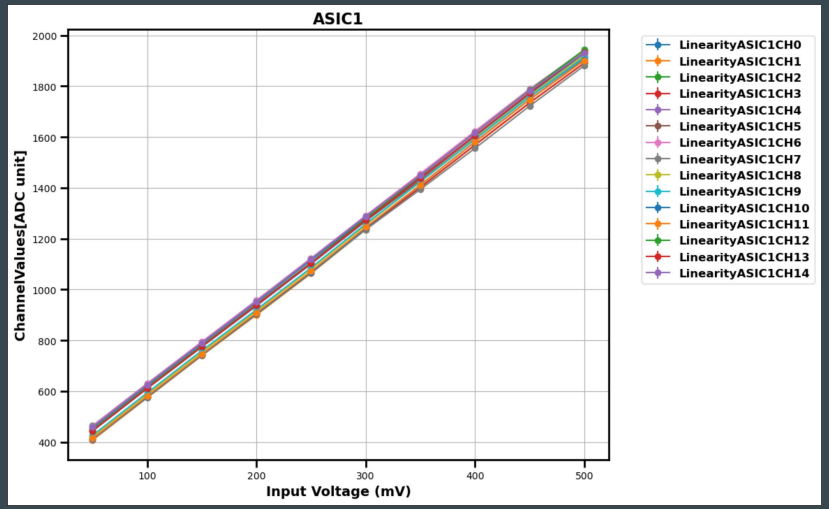




Pictures taken in the Optical Room of the IFAE's workshop

Experiments and Results

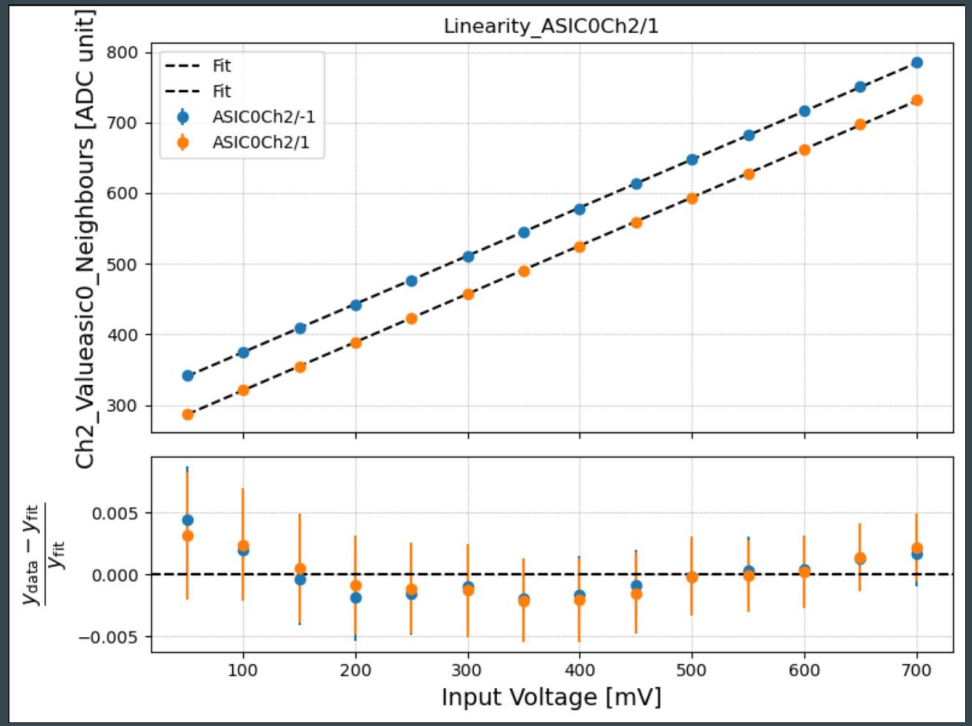




Linearity of the returned values by the BETAs for each channel

=> Satisfactory results.

Experiments and Results



Cross-talk between nearest neighbours: study of the values returned by the nearest channels

Picture: for the channel 2 ASIC 0, we analyse the data given by the channels 1 and 3.

Experiments and Results

VFS[0] Temp[0] Ch14[0] Ch15[0] Ch12[0] Ch13[0] Ch10[0] Ch11[0] Ch08[0] Ch09[0] Ch06[0] Ch07[0] Ch04[0] Ch05[0] Ch02[0] Ch03[0] Ch00[0] Ch01[0]
VFS[1] Temp[1] Ch14[1] Ch15[1] Ch12[1] Ch13[1] Ch10[1] Ch11[1] Ch08[1] Ch09[1] Ch06[1] Ch07[1] Ch04[1] Ch05[1] Ch02[1] Ch03[1] Ch00[1] Ch01[1]
VFS[2] Temp[2] Ch14[2] Ch15[2] Ch12[2] Ch13[2] Ch10[2] Ch11[2] Ch08[2] Ch09[2] Ch06[2] Ch07[2] Ch04[2] Ch05[2] Ch02[2] Ch03[2] Ch00[2] Ch01[2]
VFS[3] Temp[3] Ch14[3] Ch15[3] Ch12[3] Ch13[3] Ch10[3] Ch11[3] Ch08[3] Ch09[3] Ch06[3] Ch07[3] Ch04[3] Ch05[3] Ch02[3] Ch03[3] Ch00[3] Ch01[3]

303 311 272 286 291 293 311 261 287 314 **1994** 397 287 277 786 319 767 4029
282 275 350 283 348 334 292 304 288 266 **2041** 438 307 295 288 268 280 261
303 299 246 253 314 295 278 310 265 247 **1996** 385 255 273 276 288 281 238
298 313 299 314 307 330 303 320 293 315 **2035** 398 314 329 318 333 277 283

1994 397 287 277 786 319 767 4029 282 275 350 283 348 334 292 304 288 266
2041 438 307 295 288 268 280 261 303 299 246 253 314 295 278 310 265 247
1996 385 255 273 276 288 281 238 298 313 299 314 307 330 303 320 293 315
2035 398 314 329 318 333 277 283 314 303 311 272 286 291 293 311 261 287

Right: Correct data
Left: Data presents mixed values in all the rows.

-> In addition to this mixing, there is a repetition of the rows for every file.

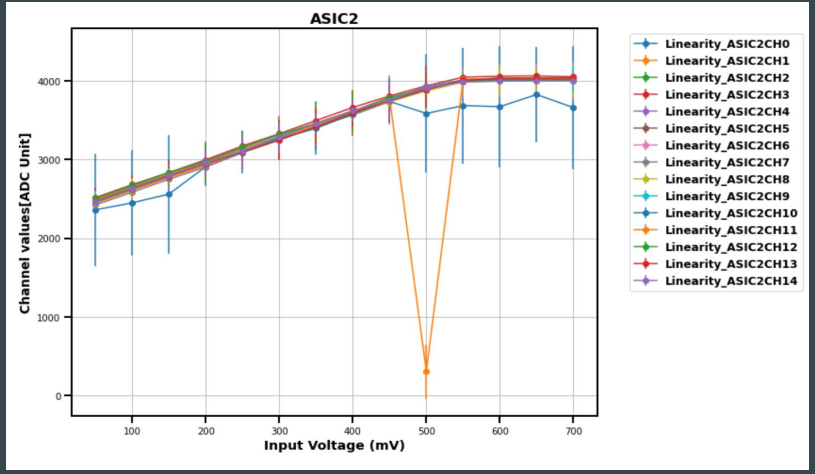
Experiments and Results

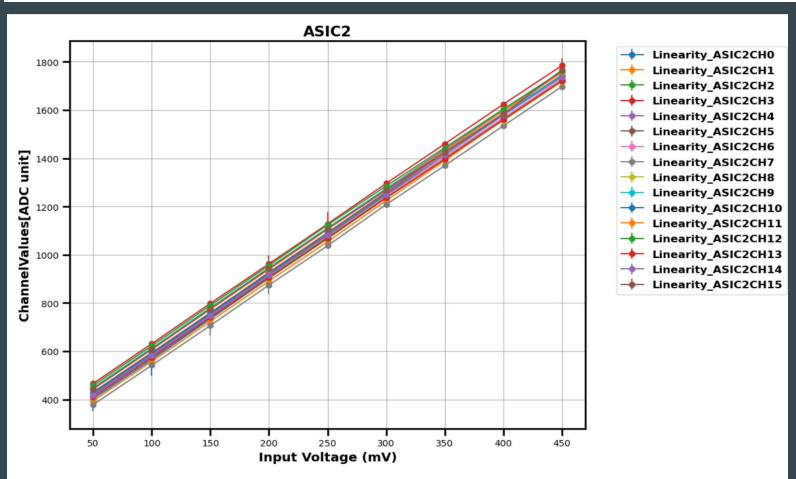
1995 391 275 275 301 278 285 273 290 271 272 284 294 290 311 262 291 312
2036 432 305 295 284 267 279 259 281 275 341 282 298 307 282 277 287 263
2000 380 256 275 275 285 280 240 306 297 249 256 320 311 279 313 265 247
2033 393 314 331 331 337 3011 424 313 451 301 318 307 332 305 322 295 315

1997 392 277 277 305 279 285 273 290 270 272 285 292 294 312 264 290 313
2039 433 309 295 289 270 281 261 280 277 343 282 301 307 287 278 287 263
1998 379 259 275 275 287 281 239 303 300 252 257 321 315 279 315 268 248
2035 392 316 328 328 337 3016 428 312 454 301 318 308 329 304 323 294 316

1995 391 275 275 301 278 285 273 290 271 272 284 294 290 311 262 291 312
2036 432 305 295 284 267 279 259 281 275 341 282 298 307 282 277 287 263
2000 380 256 275 275 285 280 240 306 297 249 256 320 311 279 313 265 247
2033 393 314 331 331 337 3011 424 313 451 301 318 307 332 305 322 295 315

- Above: Repetition
- Right: Proves the bit shift





Conclusions

- Aim: Understand, prepare and debug the BETA's for the PSD setup
- At the end of my fellowship: Repetition solved, but others appeared:
  - Some channels always presented a trigger even though there was not an input signal
  - Drops in some columns
  - Fall to 0 of the TimeStamp values
  - Lost of a gaussian profile in some situations
- Principal contributions:
  - Running data acquisitions all along the internship
  - Create some algorithms to analyse the data acquired (e.g.: Python script that generates a PDF with a quick analysis of the data)
  - Help discuss the different problems
  - Help determining the Trigger Map for the PSD's acquisition

Thank you for your attention and time!