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E789 experiment and FAZIA Calibration

2020.7.3 CENuM Workshop

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- Detector and system
- Current status (FAZIA Calibration)
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Experiment E789

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Physical Background : Nuclear Symmetry Energy

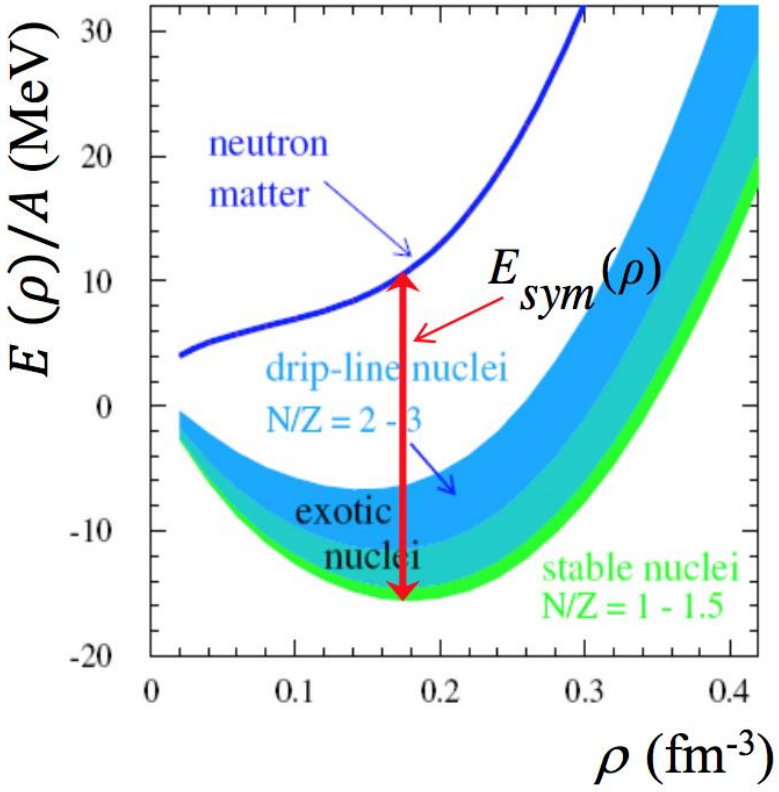
$$E(\rho,\delta)/A = E(\rho_n = \rho_p) + E_{sym}(\rho)\delta^2$$

Isoscalar Isovector

$$with \quad \rho = \rho_n + \rho_p \ , \qquad \delta = (\rho_n - \rho_p)/\rho$$

$$E_{is}(\rho) = E_{sat} + \frac{K_{sat}}{18}\left(\frac{\rho-\rho_0}{\rho_0}\right)^2 ..$$

$$E_{iv}(\rho) = E_{sym} + \frac{L_{sym}}{3}\left(\frac{\rho-\rho_0}{\rho_0}\right) + \frac{K_{sym}}{18}\left(\frac{\rho-\rho_0}{\rho_0}\right)^2 \ \cdots$$



$$E_{sym}(\rho) = \frac{1}{2}\frac{\partial^2 E}{\partial \delta^2} \approx E(\rho)_{nm} - E(\rho)_{sm}$$

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- The isoscalar part of EOS is well established from both experimental and theoretical study.

$$\rho_0 = 0.155 \pm 0.005\ fm^{-3}$$

$$E_0 = -15.8 \pm 0.3\ MeV$$

$$K_0 = 9\rho_0^2 \left(\frac{\partial^2 E_0}{\partial \rho^2}\right)|_{\rho=\rho_0} = 240\ \pm 20\ MeV$$

- The isovector part is less well known.

$$S = E_{sym}(\rho_0) = 32.7\ \pm 1.5\ MeV$$

$$L_{sym} = 3\rho_0 \frac{\partial E_{sym}(\rho)}{\partial \rho}\Big|_{\rho=\rho_0} = 40 \sim 70\ MeV$$

$$K_{sym} = 9\rho_0^2 \left(\frac{\partial^2 E_{sym}}{\partial \rho^2}\right)|_{\rho=\rho_0} = -100 \pm 100 MeV$$

	~1%	~10%		~30%		???				
P_α	E_{sat} MeV	E_{sym} MeV	ρ_0 fm^{-3}	L_{sym} MeV	K_{sat} MeV	K_{sym} MeV	Q_{sat} MeV	Q_{sym} MeV	Z_{sat} MeV	Z_{sym} MeV
$\langle P_\alpha \rangle$	-15.8	32	0.155	60	230	-100	300	0	-500	-500
σ_{P_α}	±0.3	±2	±0.005	±15	±20	±100	±400	±400	±1000	±1000

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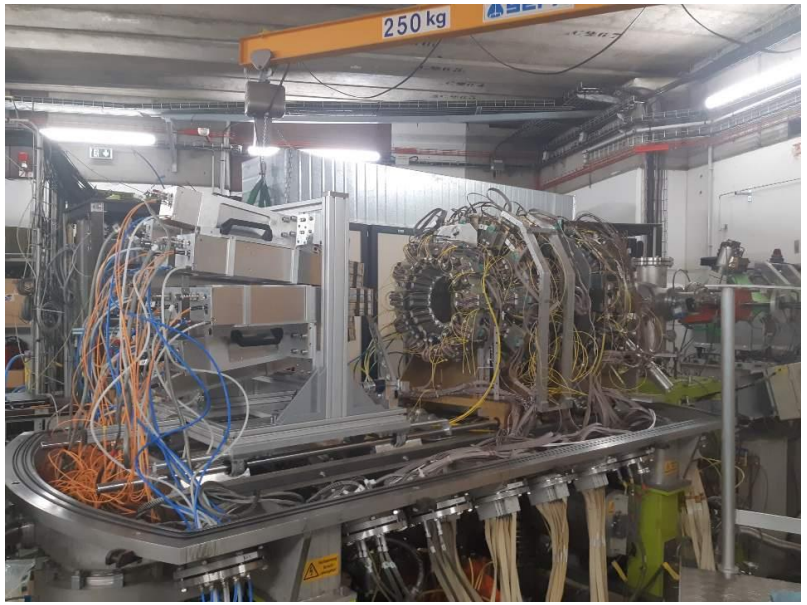
- Last year April to May, experiment E789 was done at GANIL.
- $^{58,64}_{28}Ni + {}^{58,64}_{28}Ni$ target-beam$(32,52AMeV)$ system was used in E789.
- In this experiment, we can study symmetry energy using isospin diffusion, isospin migration and collective flow.
- Direct and elliptic flow are my PhD subject.



Up: E789 detector setting

Down : GANIL

Detector and System

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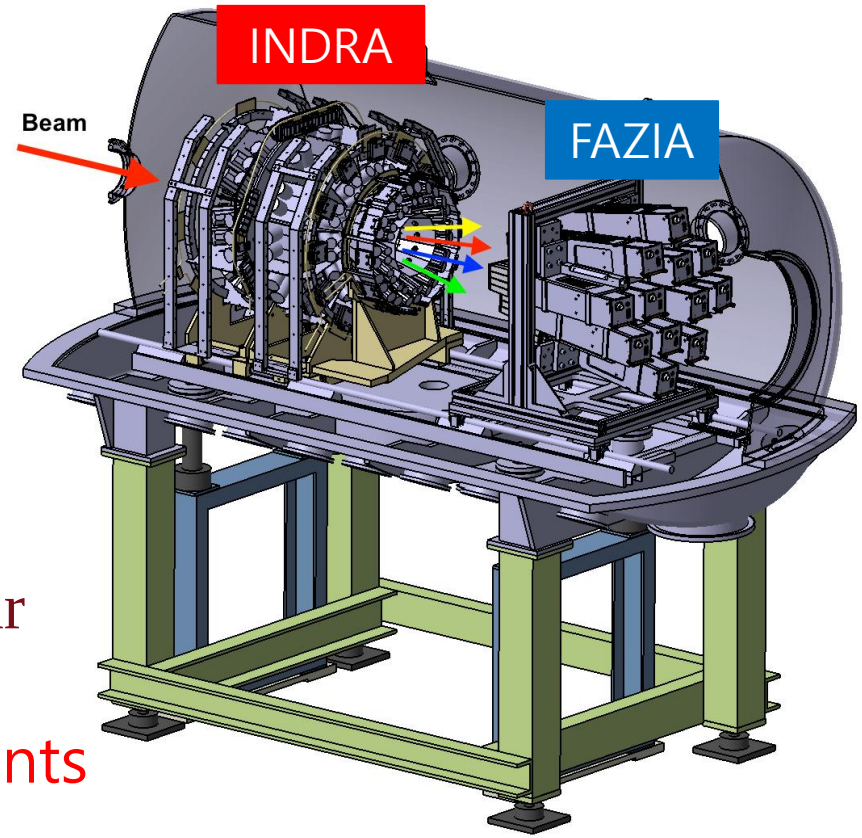
- INDRA-FAZIA system cover 4π sr angle.
- $^{58,64}_{28}Ni + {}^{58,64}_{28}Ni$ beam-target ($32{,}52\ AMeV$)
  -> 8 separated beam time(about 30 hours /system)
- Beam intensity : 1.9*10^8 pps
- Pressure inside of chamber : 1.2*10^-5 mbar
- Each collision system statistics ~ $30*10^6$events
  ->Total ~$240*10^6$events



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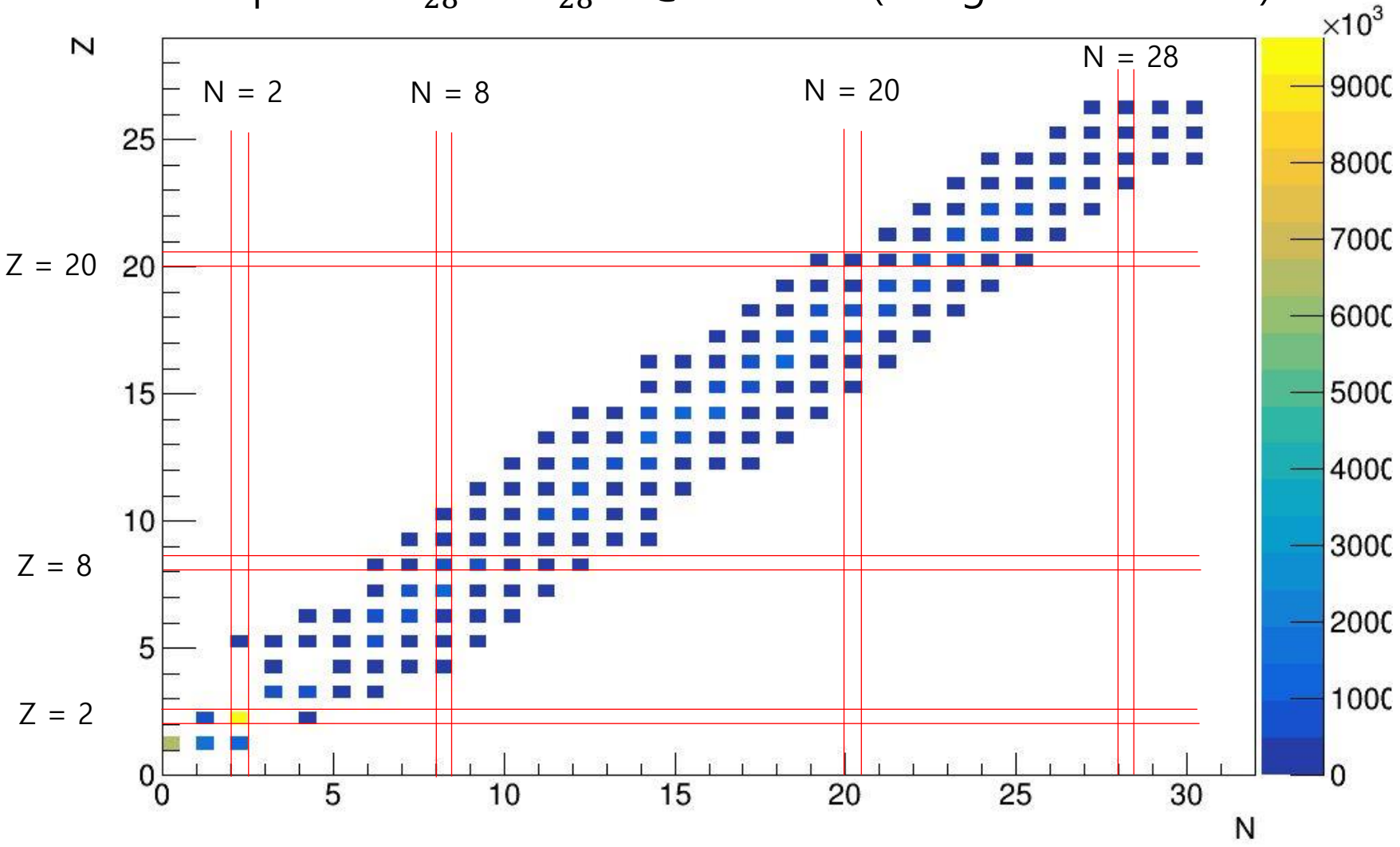
Isotope from $^{58}_{28}Ni + ^{58}_{28}Ni$ @ $32AMeV$ (using FAZIA Si1-Si2)



Isotope separation ability of two detectors

FAZIA : Z=92
A=Z~20-25

INDRA : Z=92
A=8($\theta < 45^{\circ}$)
A=5($\theta > 45^{\circ}$)

Current status (FAZIA Calibration)

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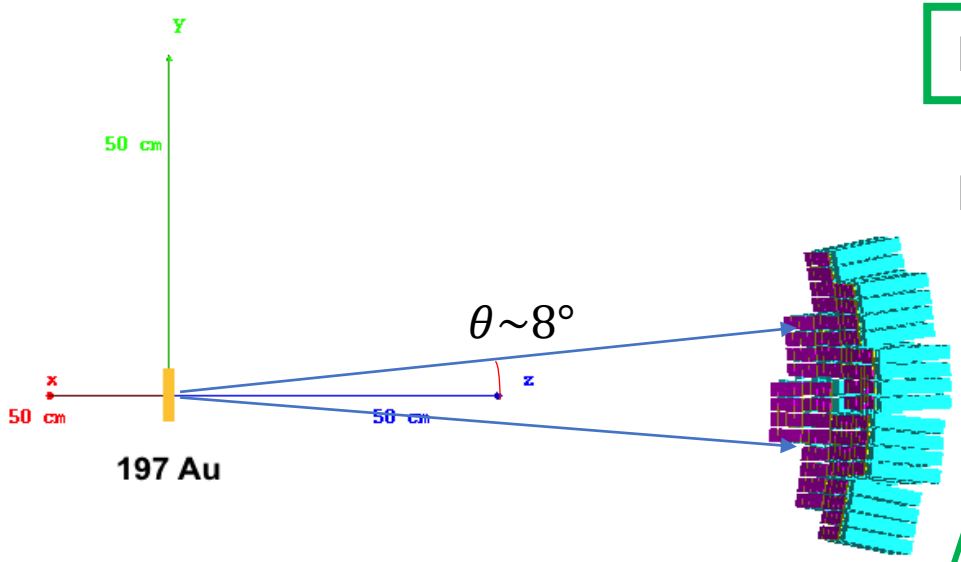
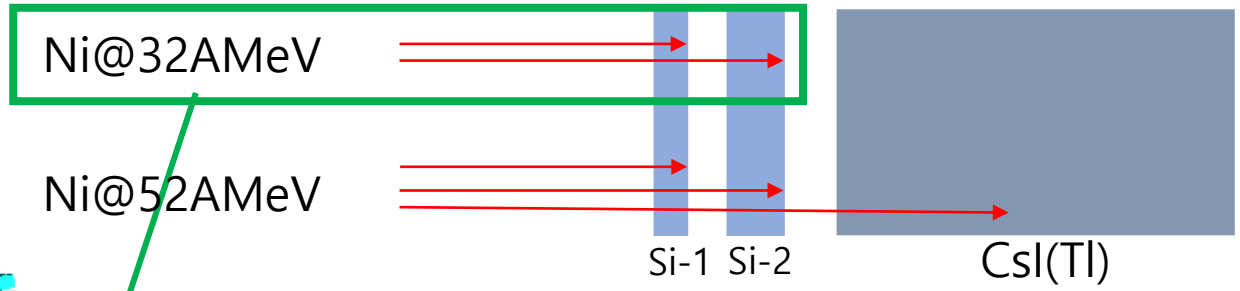
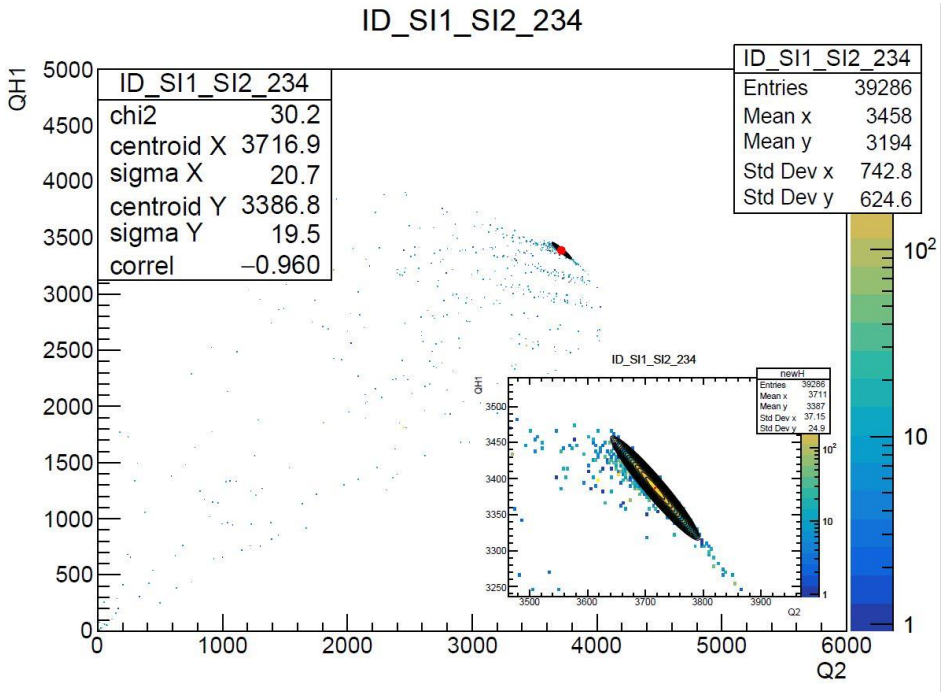
Blocks at core position (0,1,2,3)





Use Rutherford scattering of Ni isotope

Deposit energy inside each Silicon crystal is calculated by GANIL data analysis tool called KaliVeda.



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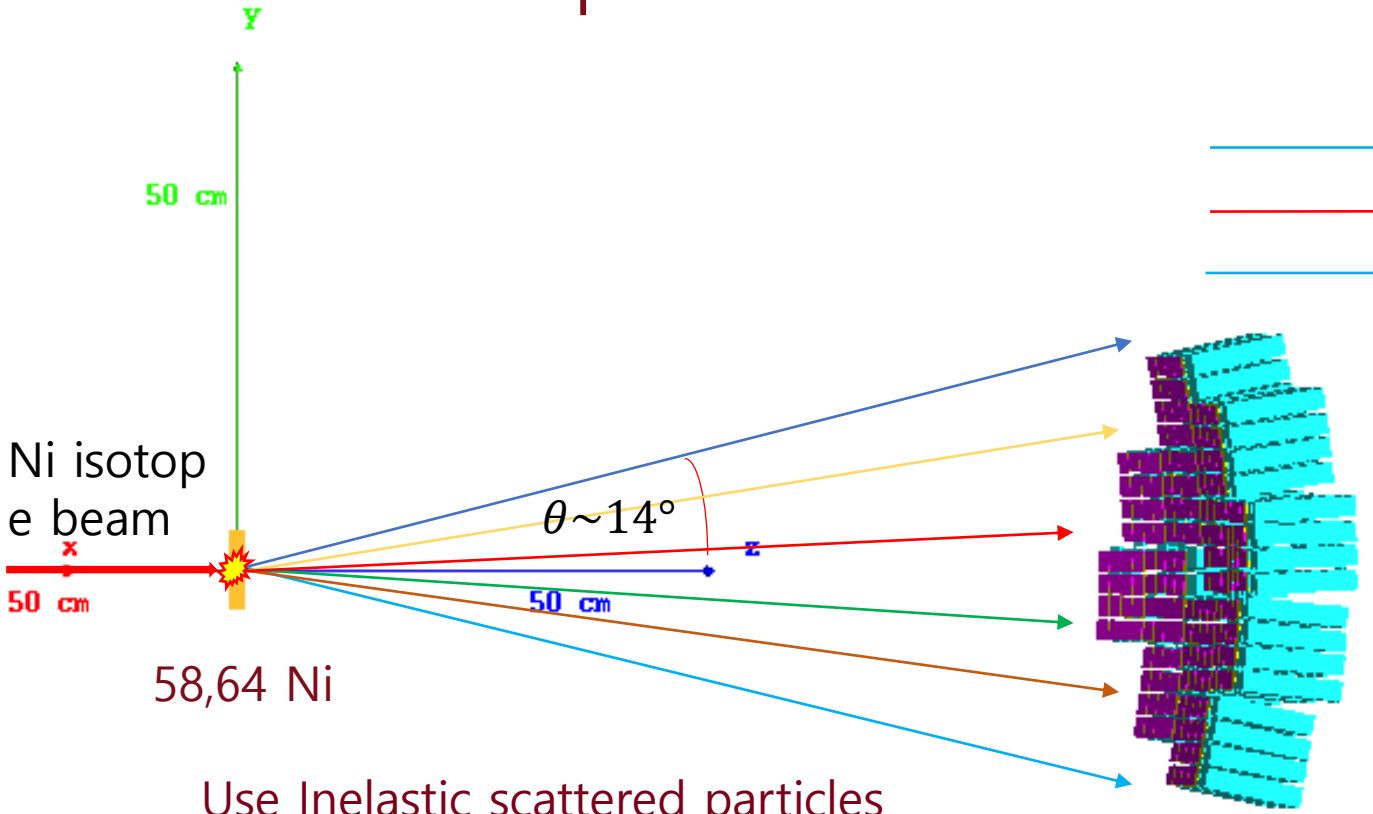
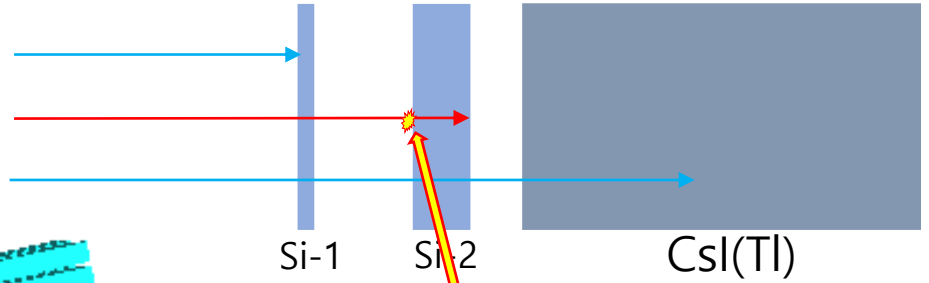
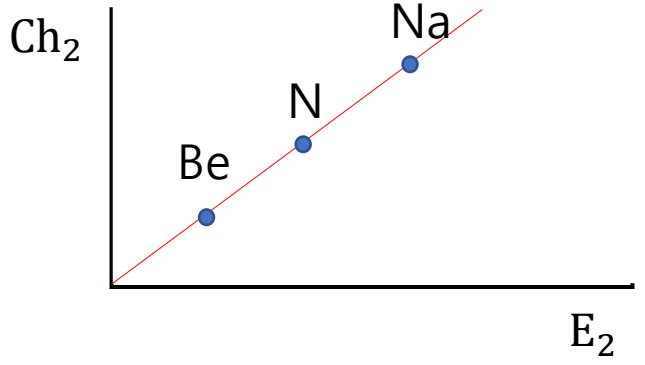
Blocks of all position





?? Particle of ?? AMeV
right this position!!



Use Inelastic scattered particles
Calculate penetration threshold energy using KaliVeda.

$$E_2 = \alpha\, Ch_2 + (\beta \to 0)$$

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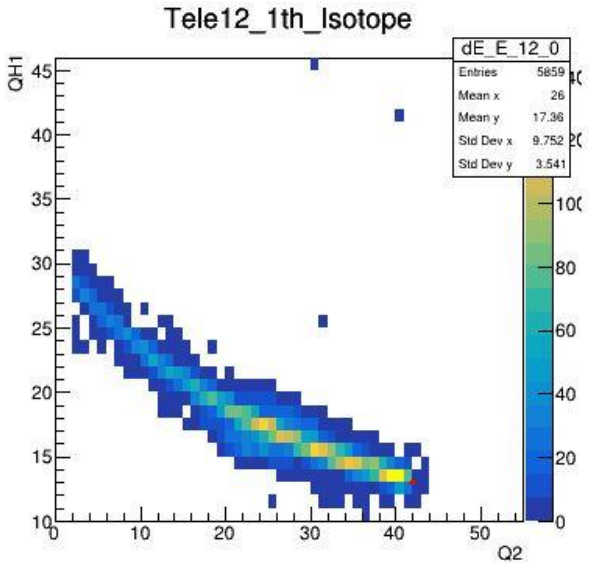

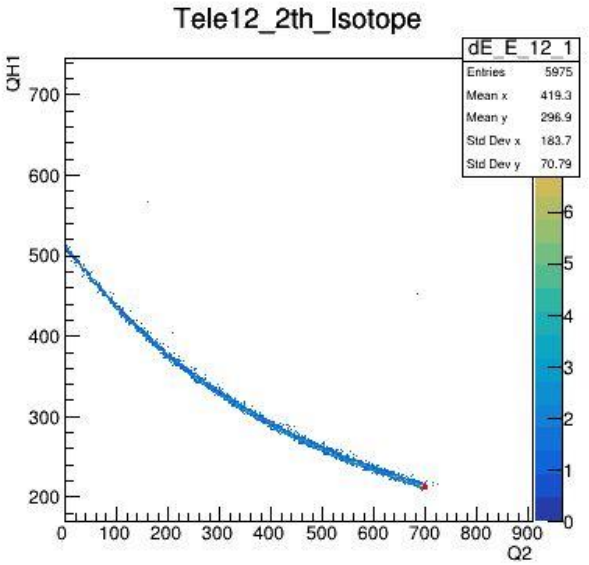

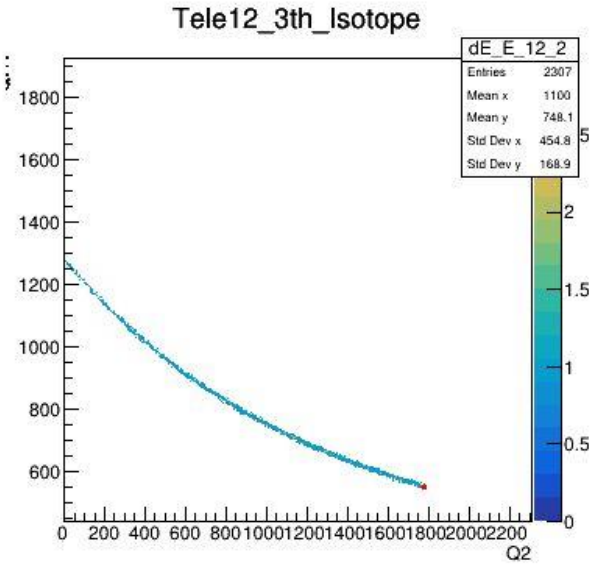

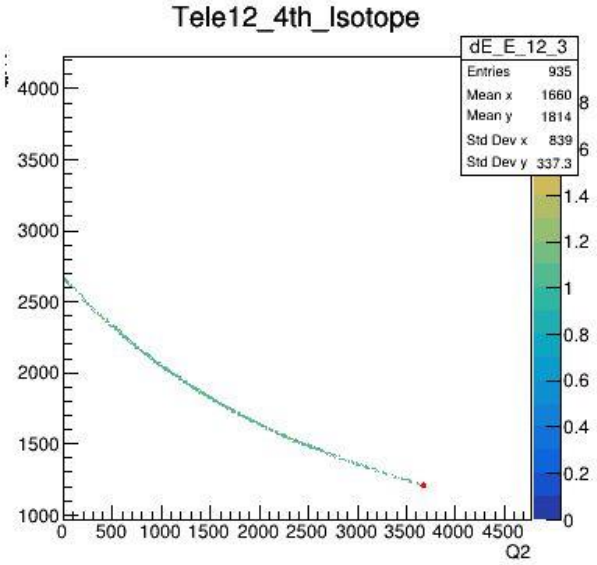

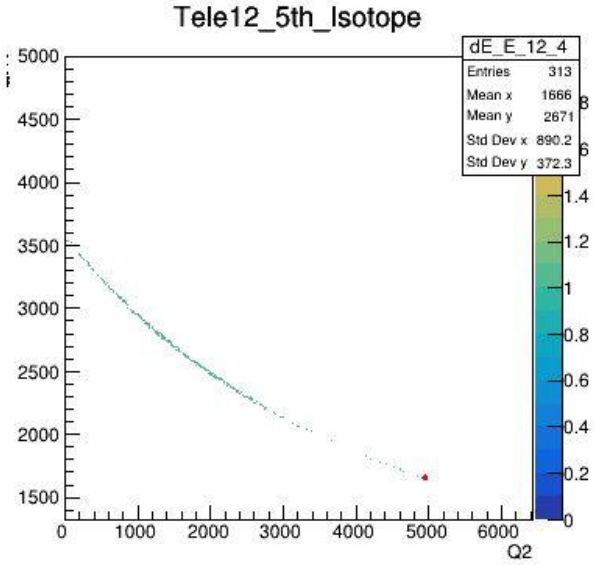

I got Maximum Q2 and Minimum QH1 values of 5 different isotopes from almost of all telescopes

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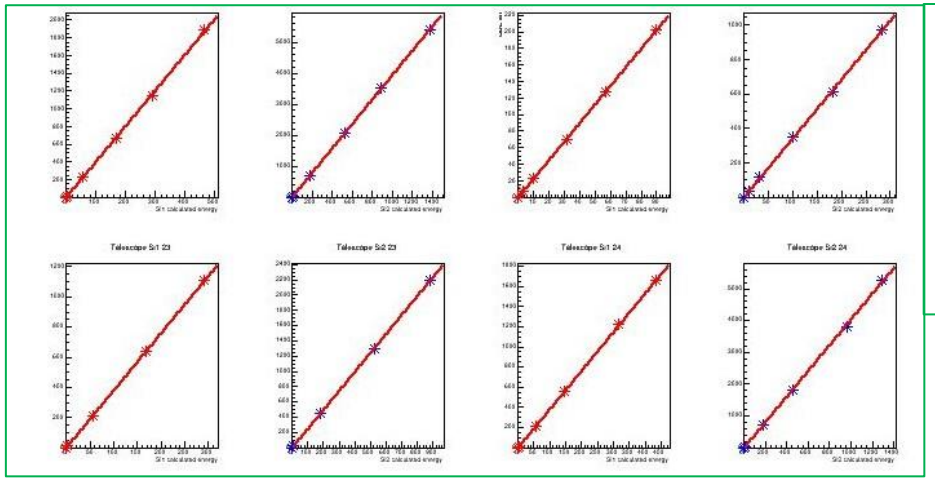
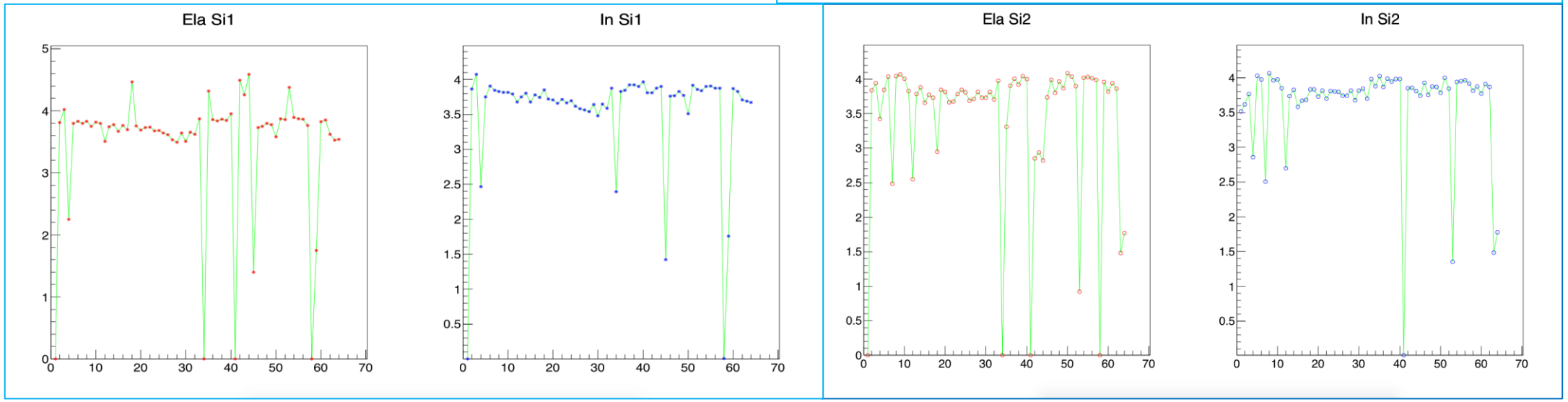
Si1 Si2



Telescope 13,23,14,24

Red Point : Si1, BluePoint : Si2
X-axis : calculated energy
Y-axis : QDC values

Calibration values of core block
Si1(below right), Si2(below left)



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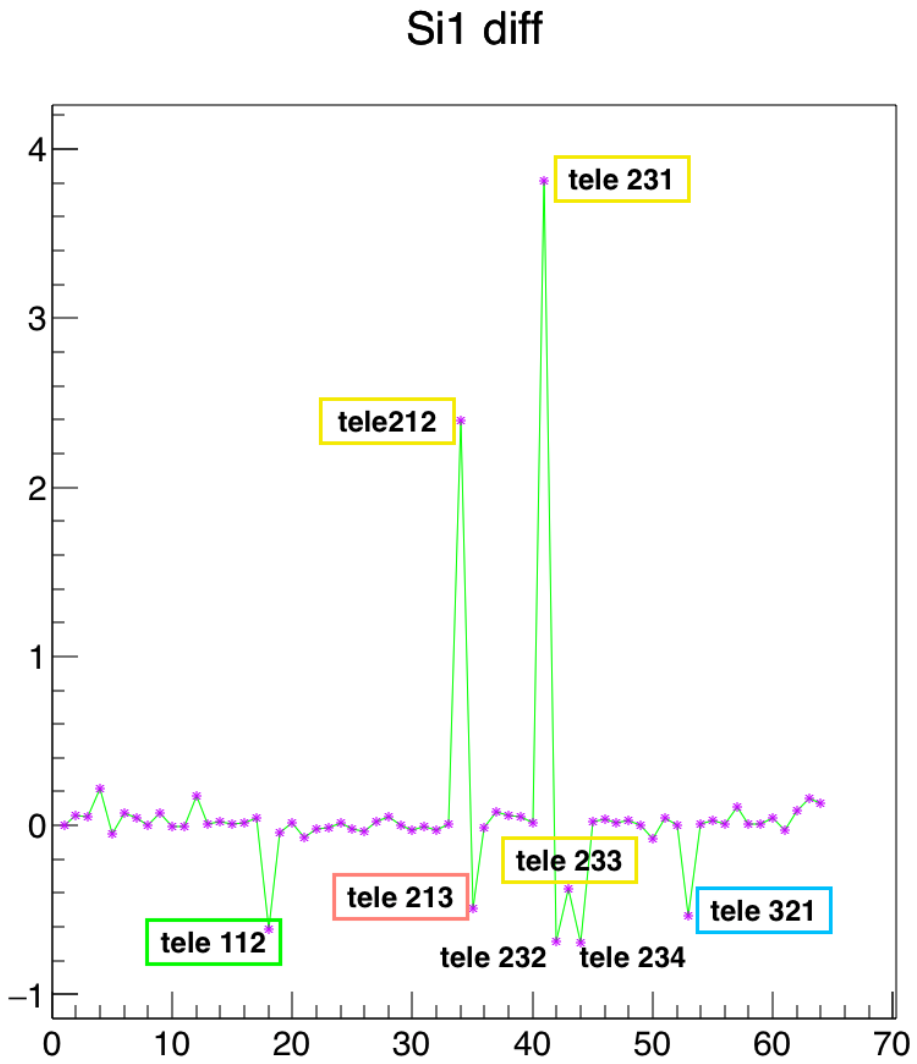

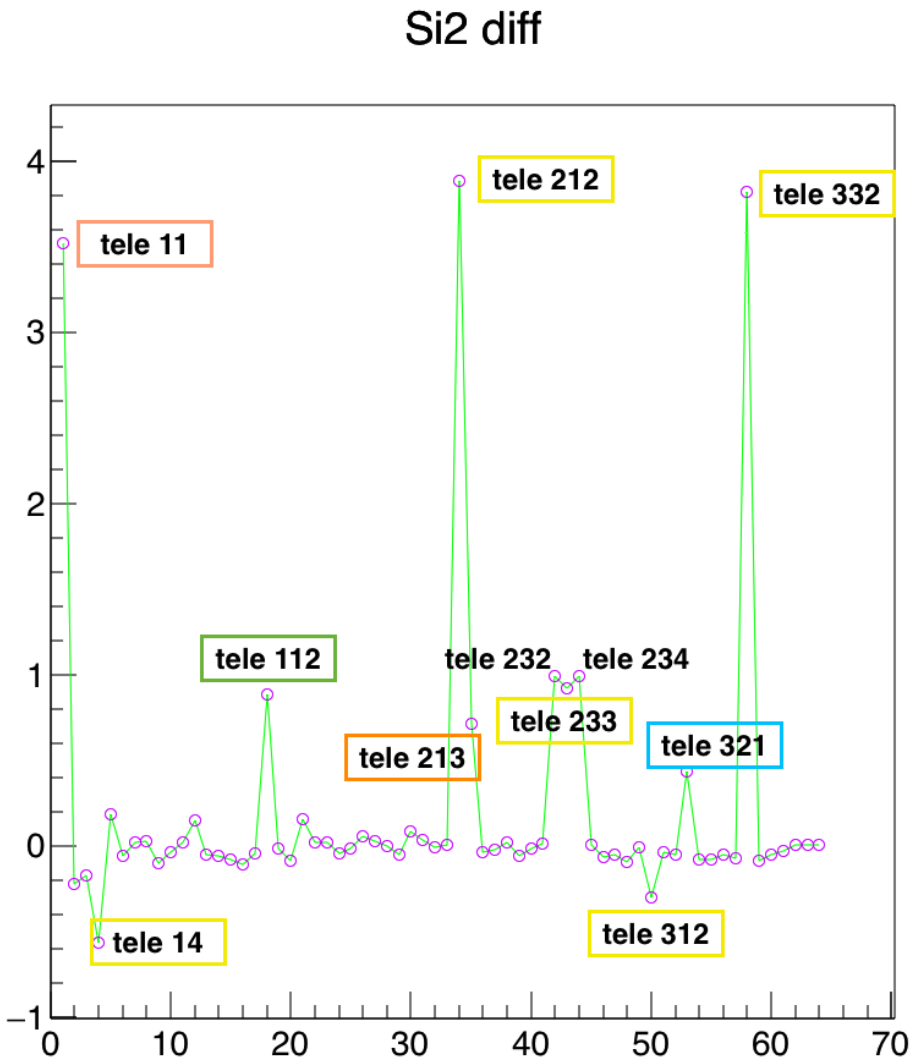

Future Plans

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- Crosscheck of all FAZIA Block Si1, Si2 calibration values.
- CsI(Tl) data PId task assist.
- CsI(Tl) Crystal calibration.
- Start analysis after data organization finished

Summary

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- For study symmetry energy at few ten MeV/u region,
  last year FAZIA collaborator did e789(Ni isotope collision)
  experiment.

- Data organization job (Calibration and PId) is currently doing and
  PId is done by analysis tool and calibration is done by two
  different mechanisms.

- Some telescopes has problem in PId task, So these are must be re
  organized before calibration.

- Assist CsI(Tl) PId task will be started after collabo meeting.

Problems in telescopes

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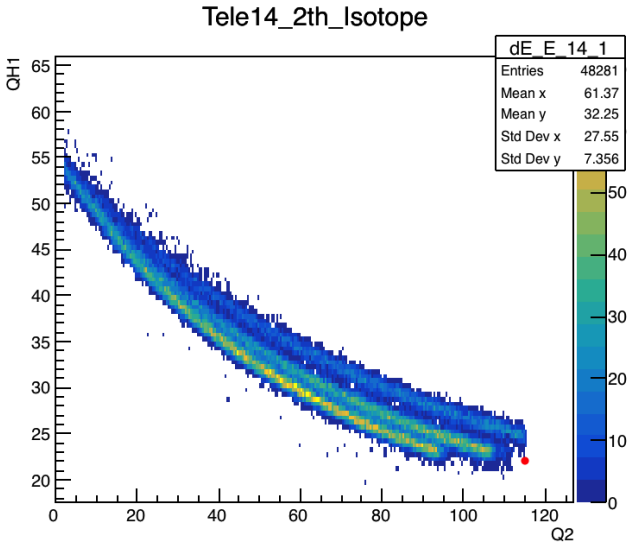
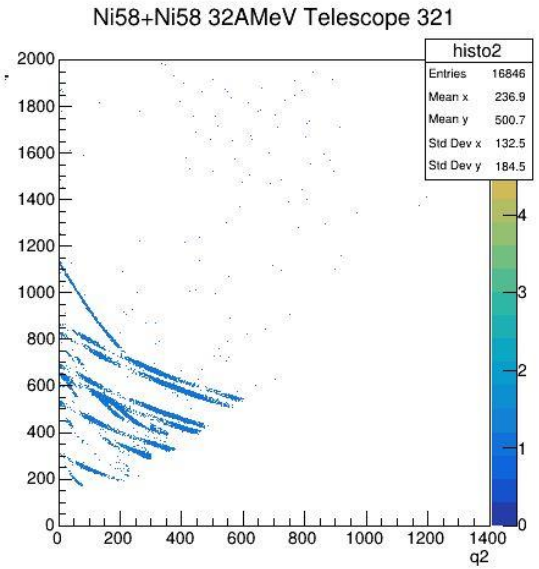
grids not made Because of bad detection quality	33	11
	34	231
	112	332 (Si1 dead ?)
	213	421
	231	--512 (grid finally made, not always working)
	342	-513
	421	521
	423	--542 (grid finally made, not always working)
	513	723
	532	731 (doesn't exist)
	533	732 (doesn't exist)
	543	912
	622	923 (si2 almost dead, id en Z possible ?)
	634	1024 (si2 almost dead, id en Z possible ?)
	723 (doesn't exist)	1033 (si2 almost dead, id en Z possible ?)
	731	1143 (si1 almost dead, no id possible)
	831	
	923	
	931	
	1014	
	1024	
	1033	
grids not made Because of 2 working modes	233	14
	332	22
	534	212
	612	231
	732	233
	811 (done for the working mode)	241
	924	312
	943	342 (one mode could be used)
		344 (one mode could be used)
		--533 (2 barely different modes, look at bore and carbon, both can be used)
		624
		-913
		--932 (one mode could be used)
grids with huge punch through		112
		612
		622
		634
		641
		642
		643
		+1014 (but grid made however)
grids not made Because of bad id quality or Z only		233
		321
		343
		423
		623
		831 (bad Si2 resolution ?)
		912 (bad quality AND 2 modes)





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