The pixelation technique applied to FARCOS correlator in the CHIFAR experiment

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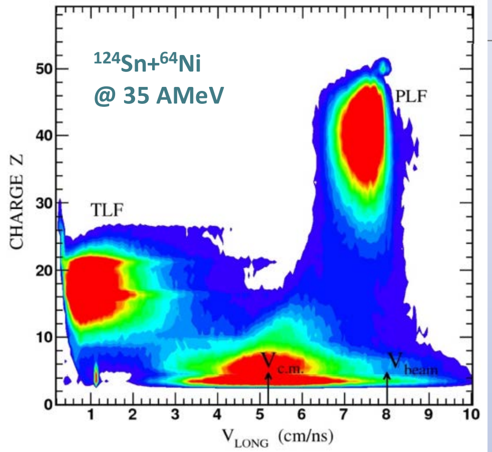
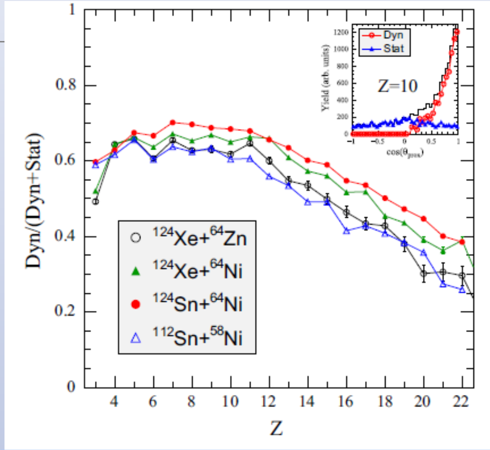
Heavy Ion collisions at Fermi energy regime

$[10\ MeV/A < E/A < 100\ MeV/A]$



E. De Filippo *et al.*, Phys. Rev. C **71**, 044602 (2005).

- Ternary events detected with CHIMERA: PLF + TLF + IMF



P. Russotto *et al.*, Eur. Phys. J. A. **56**, 12 (2020).

Dynamical emission of IMFs:

- Light IMFs ($Z \lesssim 8$) are emitted in fast neck emission process within $100 - 120\ fm/c$ after reseparation between PLF and TLF;
- Heavier IMFs ($Z \gtrsim 9$) are emitted in a fast-dynamical splitting (fission-like) of the PLF in a time ($\lesssim 500\ fm/c$) shorter than the one typical of statistical emission;

Enhancement of dynamical emission probability in neutron rich system:

influence of isospin content (N/Z) on dynamical effects!

CHIFAR experiment @ LNS-INFN

“neutron rich” system:
^{124}Sn+^{64}Ni
@ 20 AMeV

“neutron poor” system:
^{112}Sn+^{58}Ni
@ 20 AMeV

“isobaric” system:
^{124}Xe+^{64}Zn
@ 20 AMeV

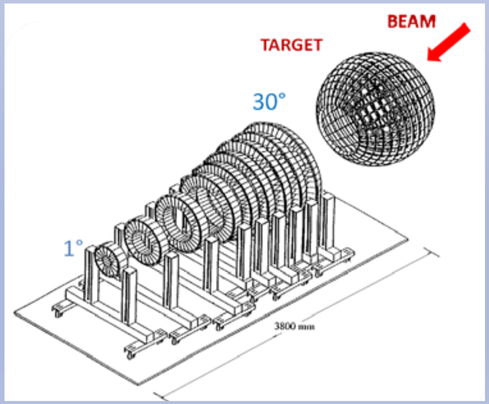
Experimental goals at lower energy to the respect of the Fermi energy regime:

- Study of emission mechanism: dynamical/statistical;
- IMFs production;
- Isospin role in HI collisions;

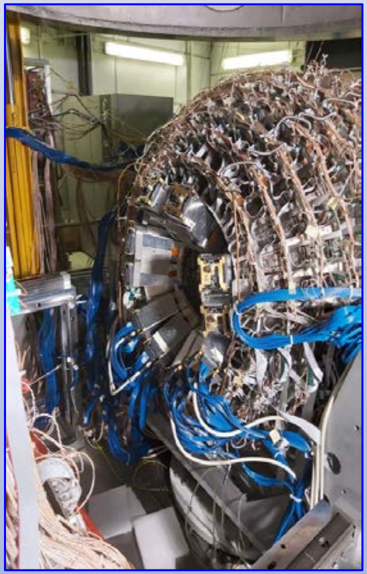
➢ CHIFAR experiment @ LNS-INFN: experimental setup

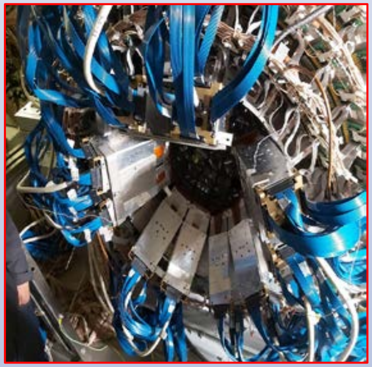
CHIMERA

- **C**harged **H**eavy **I**on **M**ass and **E**nergy **R**esolving **A**rray;
- 4π multi-detector;
- 1192 telescope (35 rings): each one has Si-detector and CsI(Tl) scintillator.



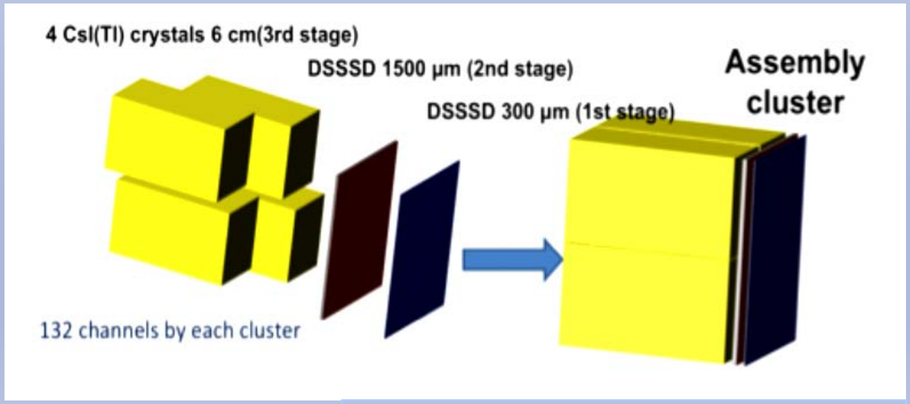
Pagano A. *et al.*, Eur. Phys. J. A 56, 102 (2020)





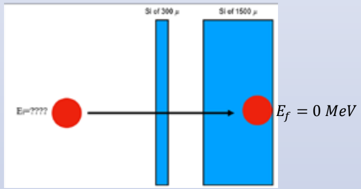
FARCOS

- **F**emtoscope **AR**ray for **CO**rrelation and **S**pectroscopy;
- High energy and angular resolution;
- Modular array of 20 telescopes: each one has 6 detectors: 2 DSSSDs + 4CsI(Tl).
- Angolar range: 13°-30° (lab. system)



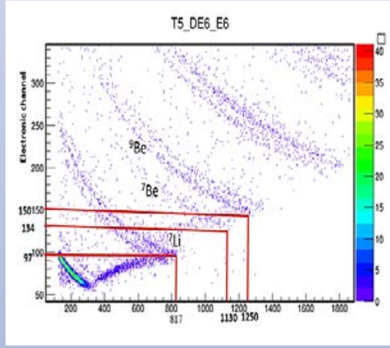
Pagano E. V. *et al.*, EPJ Web of Conferences (2016) 117:10008

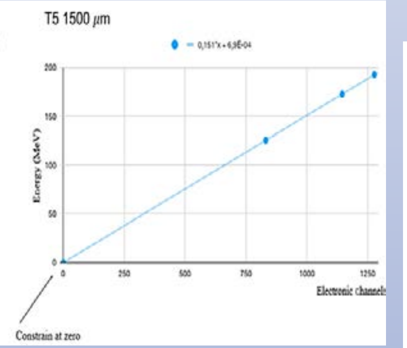
➢ FARCOS correlator in CHIFAR experiment: energy calibration of DSSSDs



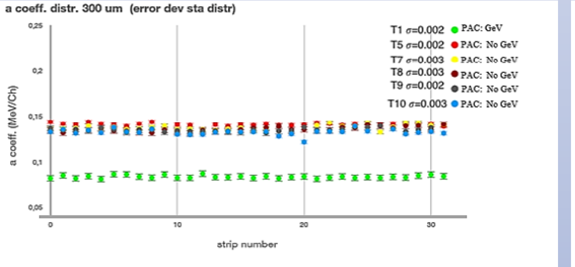
Punching through technique:

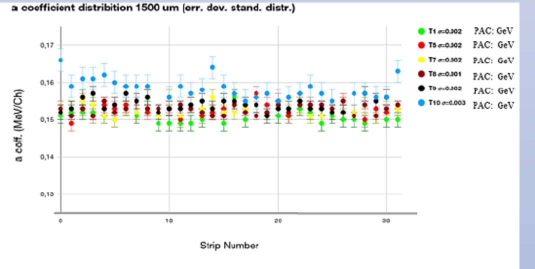
In the ΔE-E identification matrix (Si-Si), the tails at the end of each hyperbolic curve are generated by the particles that are in transmission also in the second Si stage and lose completely their energy in the CsI(Tl) stage. Choosing the very initial point (where we can assume particles arrested in 1800 μm of Si) of the tails of ^{7}Li – ^{7}Be – ^{9}Be and using LISE++ software, the initial energy E_i was reconstructed, by setting $E_f = 0\ MeV$ at the end of 1800 µm; the energy lost in each of the two Si-detectors was obtained by the difference.

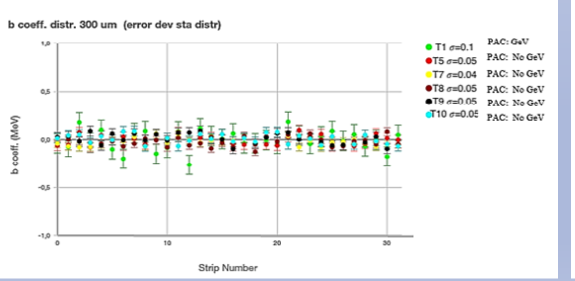


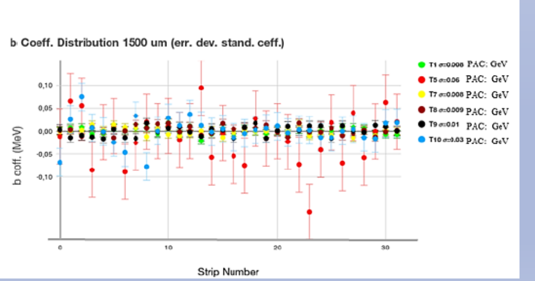


Particle	Energy lost in Si-300 µm	Energy lost in Si-1500 µm	Total kinetic energy released
^{7}Li	13,52 MeV	125,43 MeV	138,95 MeV
^{7}Be	18,45 MeV	172,75 MeV	191,20 MeV
^{9}Be	20,74 MeV	192,76 MeV	213,50 MeV









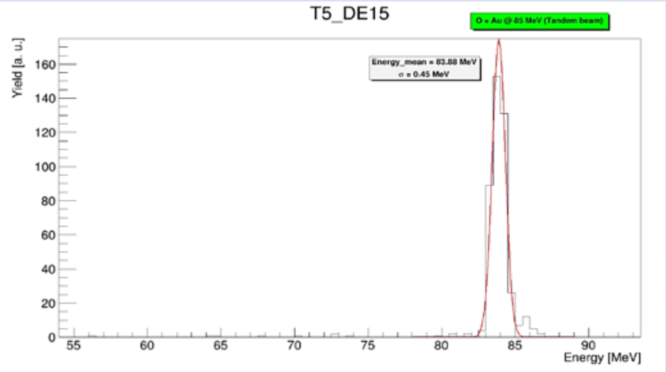
➢ FARCOS correlator in CHIFAR experiment: energy resolution of DSSSDs (front side)

For each DSSSD (300 μm) was taken into account all 32 strips front, except the first one (n° 0) and the last one (n°31), and not working strips, in coincidence with four sets of 8 back strips.

T1: 300μm all working
T5: 300μm all working
T7: 300μm 3 strips not work (n°18, n°19, n°20)
T8: 300μm all working
T9: 300μm all working
T10: 300μm 2 strips not work (n°9, n°26)

Evaluation through elastic scattering:

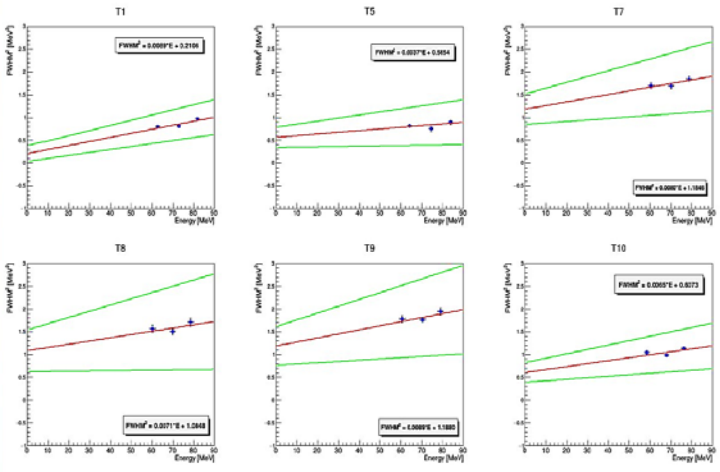
1. O + Au @ 85 MeV (Tandem beam)
2. C + Au @ 75 MeV (Tandem beam)
3. C + Au @ 65 MeV (Tandem beam)



$$FWHM^2 = a \cdot E + b$$

with:

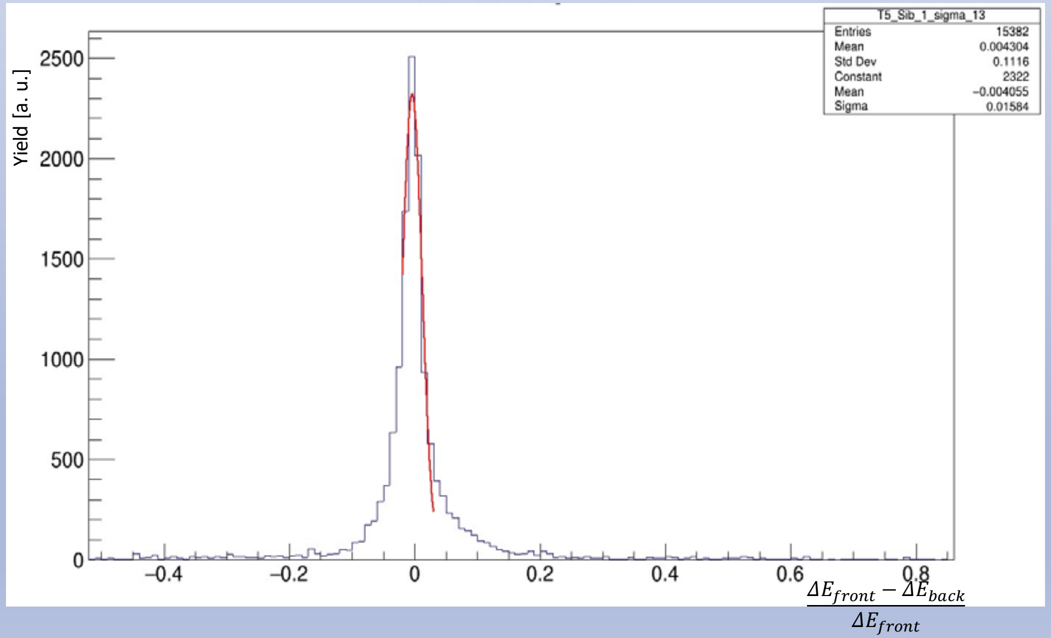
- E = mean value for each telescope
- a = differential increasing of $FMWH$ as function of E
- b = square of electronic error for each telescope



Elastic scattering: O + Au @ 85 MeV							
Telescope	Energy mean [MeV]	FWHM (total error) [MeV]	Resolution (FWHM) [%]	Electronic error [keV]	Electronic error [%]	Detector error [keV]	Detector error [%]
T1	81,8 ± 0,99	0,99 ± 0,02	1,2	459 ± 187	47	528 ± 202	53
T5	83,8 ± 0,95	0,95 ± 0,02	1,1	752 ± 149	79	196 ± 171	21
T7	78,8 ± 1,36	1,36 ± 0,02	1,7	1088 ± 154	80	271 ± 176	20
T8	78,4 ± 1,31	1,31 ± 0,03	1,7	1042 ± 220	80	266 ± 253	20
T9	78,9 ± 1,40	1,40 ± 0,03	1,8	1090 ± 195	78	306 ± 224	22
T10	76,1 ± 1,07	1,07 ± 0,02	1,4	779 ± 140	73	286 ± 156	27

➢ FARCOS correlator in CHIFAR experiment: energy resolution of DSSSDs (back side)

For each DSSSD (300 μm), the ratio $\frac{\Delta E_{front} - \Delta E_{back}}{\Delta E_{front}}$ was evaluated, for each front strip in coincidence with all 32 back strips

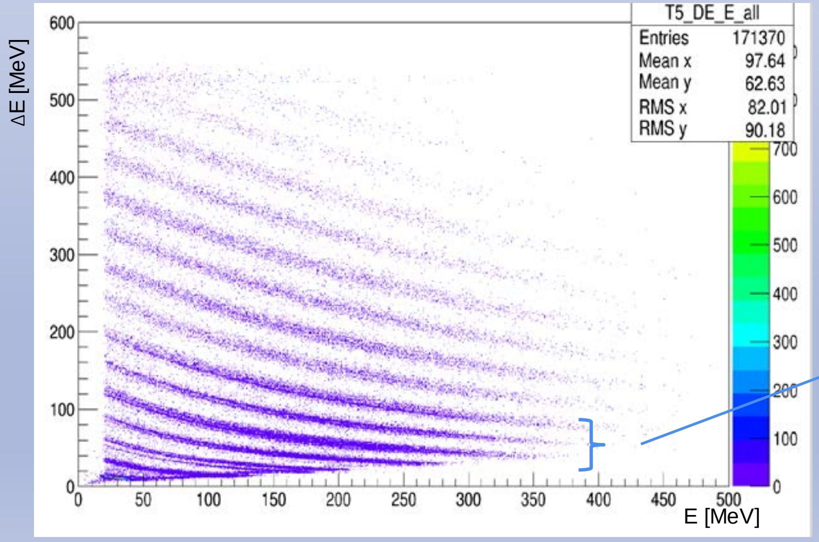


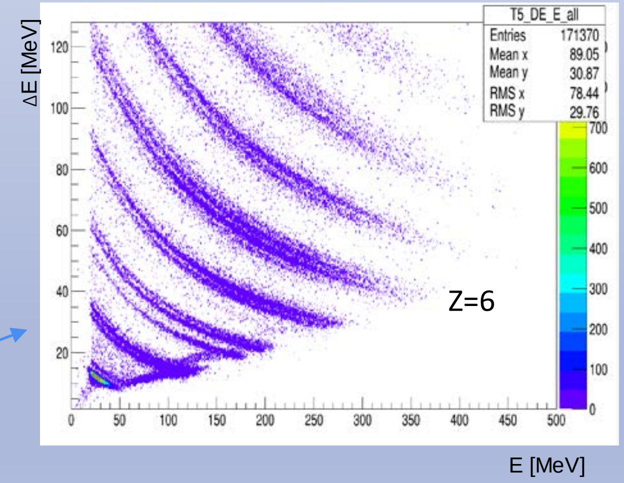
$\boldsymbol{\sigma = 0,01584 \rightarrow \approx 1,6\%}$

➢ FARCOS correlator in CHIFAR experiment: particle identification

Experimental constraints to select only “true particles”:

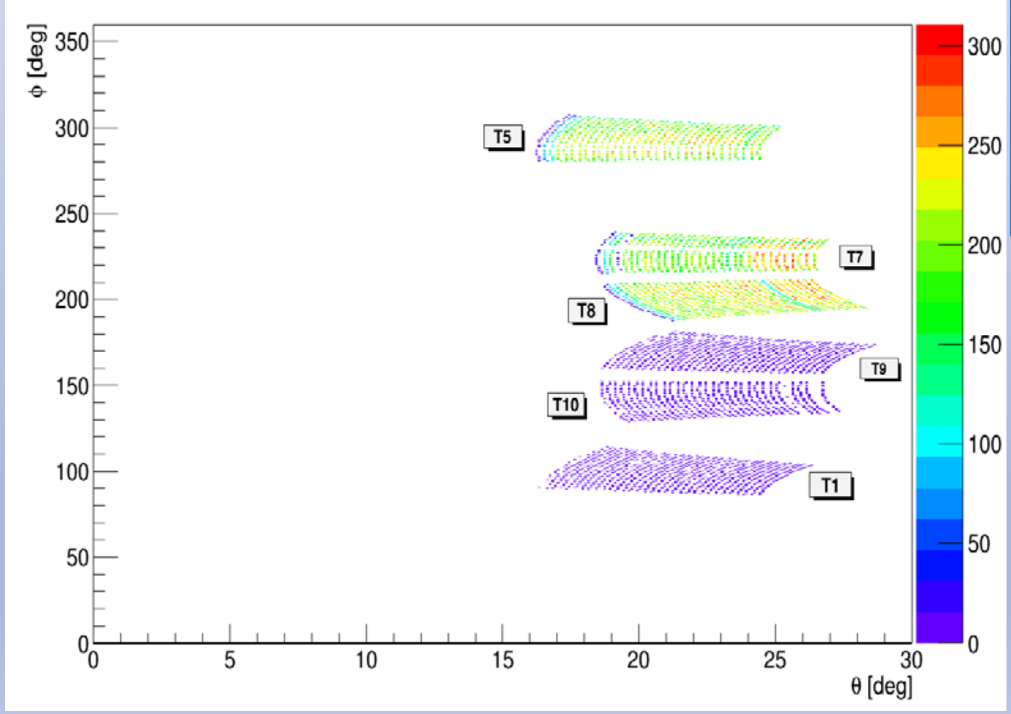
- particle multiplicity
  - = 1 for Si−300 µm, front and back;
  - = 1 for Si−1500 µm, front;
  - < 4 for Si−1500 µm, back;
  - = 0 for CsI(Tl)
- 85% $\Delta E_{back} < \Delta E_{front} <$ 115% ΔE_{back} (7σ)
- N_{strip} (300 µm) = N_{strip} (1500 µm) || N_{strip} (300 µm) = N_{strip} (1500 µm) ±1





➢ FARCOS correlator in CHIFAR experiment: the pixelation technique

the assignment for each detected particle of its pixel, determined from the crossing of a strip of the front side to another of the back side, its angle in the laboratory frame, the polar angle θ and the azimuthal angle ϕ



Experimental constraints to select only "true particles":

- particle multiplicity
  - = 1 for Si–300 μm, front and back;
  - = 1 for Si–1500 μm, front;
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  - = 0 for CsI(Tl)
- $85\% \, \Delta E_{back} < \Delta E_{front} < 115\% \, \Delta E_{back}$ (7σ)
- N_{strip} (300 μm) = N_{strip} (1500 μm) || N_{strip} (300 μm) = N_{strip} (1500 μm) ±1

FARCOS telescopes covered polar angles between 16° and 29°

There is no ambiguity in the assignment of the position!

➢ FARCOS correlator in CHIFAR experiment: the pixelation technique

the assignment for each detected particle of its pixel, determined from the crossing of a strip of the front side to another of the back side, its angle in the laboratory frame, the polar angle θ and the azimuthal angle ϕ

Experimental constraints to select only "true particles":

- particle multiplicity
  - = 2 for Si–300 μm, front and back;
  - = 2 for Si–1500 μm, front;
  - < 4 for Si–1500 μm, back;
  - = 0 for CsI(Tl)
- 85% $\Delta E_{back} < \Delta E_{front} <$ 115% ΔE_{back} (7σ)
- N_{strip} (300 μm) = N_{strip} (1500 μm) || N_{strip} (300 μm) = N_{strip} (1500 μm) ±1

There are some **ambiguities** regarding the assignment of the position of the detected particle…

WORK IN PROGRESS…

	ΔE_front [MeV]	ΔE_back [MeV]	E_front [MeV]	Nstrip_300_front	Nstrip_300_back	Nstrip_1500_front
#1	51,6344	51,8097	79,8859	29 [1]	13 [1]	29 [0]
			148,723			30 [1]
			228,6089	**Solved ambiguity in position: it is an Interstrip event in DSSSD_1500μm, (ambiguity only in energy)**		
#2	12,9576	12,9558	22,1211	4 [0]	0 [0]	4 [0]
	118,896	120,412	180,113	13 [1]	25 [1]	13 [1]
	Unsolved ambiguity: are they 2 different particles?? Could we assign the position using the TIME VARIABLE??					
#3	12,0703	12,3186	24,9049	29 [0]	29 [1]	30 [1]
	114,905	116,925		30 [1]	18 [0]	
	126,9753			**Unsolved ambiguity:** it is an Interstrip event in DSSSD_300μm; **Could we assign the position using the TIME VARIABLE?? -> next step…**		

see G. Cardella's talk

Current results and perspectives

From (only) FARCOS data analysis

- DSSSDs' electronic error contribute: $\sim(0.5 - 1)\ MeV \pm 0.2\ MeV$;
- DSSSDs' total error: $< 1.5\ MeV$;
- DSSSDs' energy resolution of the front side (FWHM): $1.2\% - 2.2\%$; (≈0.5% in σ)
- DSSSDs' energy resolution of the back side (FWHM): 4%; (≈1.6% in σ)
- Particle identification: in charge up to $Z \approx 16$, isotopic identification of IMFs up to $Z \approx 9$ and $\mathrm{A} \approx 20$;
- **Pixelation technique** (assignment for each detected particle of its pixel)
  1. FARCOS telescopes covered polar angles between 16° and 29°;
  2. Some unsolved ambiguities in the assignment of the position: i.e. distinction among the case of 2 different particles and other cases like interstrip or induction; The time variable is important to eliminate the spurious event ...let's see Dr. Cardella's talk!

WPCF - Resonance Workshop 2023

Thank you
for your attention!

Catania (Italy), November 6-10, 2023