International Workshop on Multi facets of Eos and Clustering
IWM-EC 2014
6th – 9th May 2014 Catania, Italy

Istituto Nazionale di Fisica Nucleare

Status of the FARCOS project

E.V. Pagano[1,2] for EXOCHIM Collaboration

[1]Università di Catania
[2]INFN- Laboratori Nazionali del Sud

Outlines

- Introduction of the Physic cases
- The FARCOS Project status
- First test and characterization
  - Alpha source
  - Beam in INKIISSY experiment
- First test with beam of GET electronic
- Future perspectives

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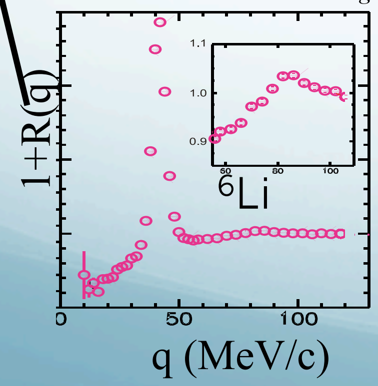
Physics Case

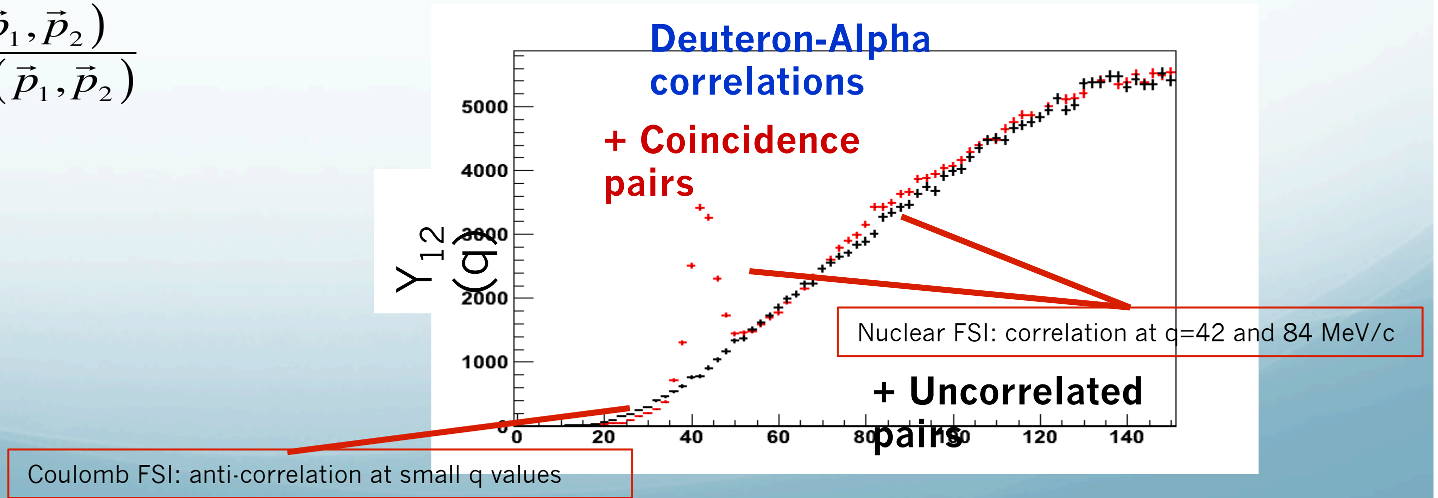
- Nuclear Dynamics Light particle correaltions (p-p) –HBT (Intensity interferometry)

  - Space-Time characterization of emitting source
  - distinction of the different stages of the reaction (from pre-equilibrium to secondary dacays)

  - Study of ASY-EOS
  - Effective in medium n-n interactions σ
  - RIBs

$$1+R(q)=k\cdot\frac{\Sigma Y_{coinc}(\vec{p}_1,\vec{p}_2)}{\Sigma Y_{evt.mixing}(\vec{p}_1,\vec{p}_2)}$$



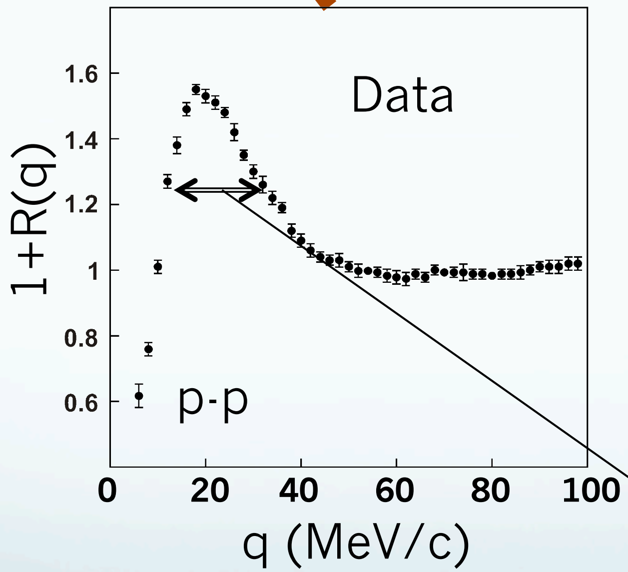


Theoretical correlation functions

P. Danielewicz
D.A. Brown
G. Verde et al., PRC65, 069604 (2002)

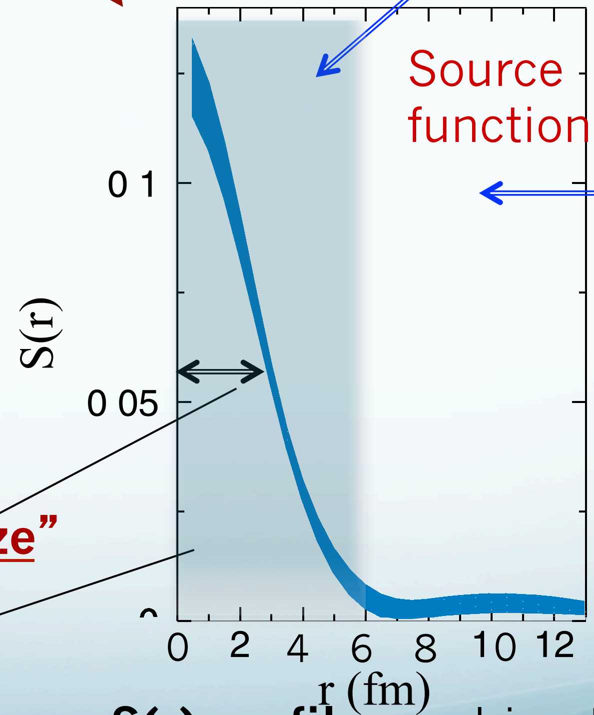
$$R(q) = \int d\vec{r} \cdot S(r) \cdot K(\vec{r},\vec{q})$$

Input (R(q)) — Output (S(r))



"**Size**"

Imaging inversion



Gaussian Fit

Integral of S(r) λ_{fast} = fraction of proton pairs from early dynamical emissions (NN collisions and EoS effects)

S(r) profile: probing transport models: AsyEoS and effective in medium n-n interactions σ

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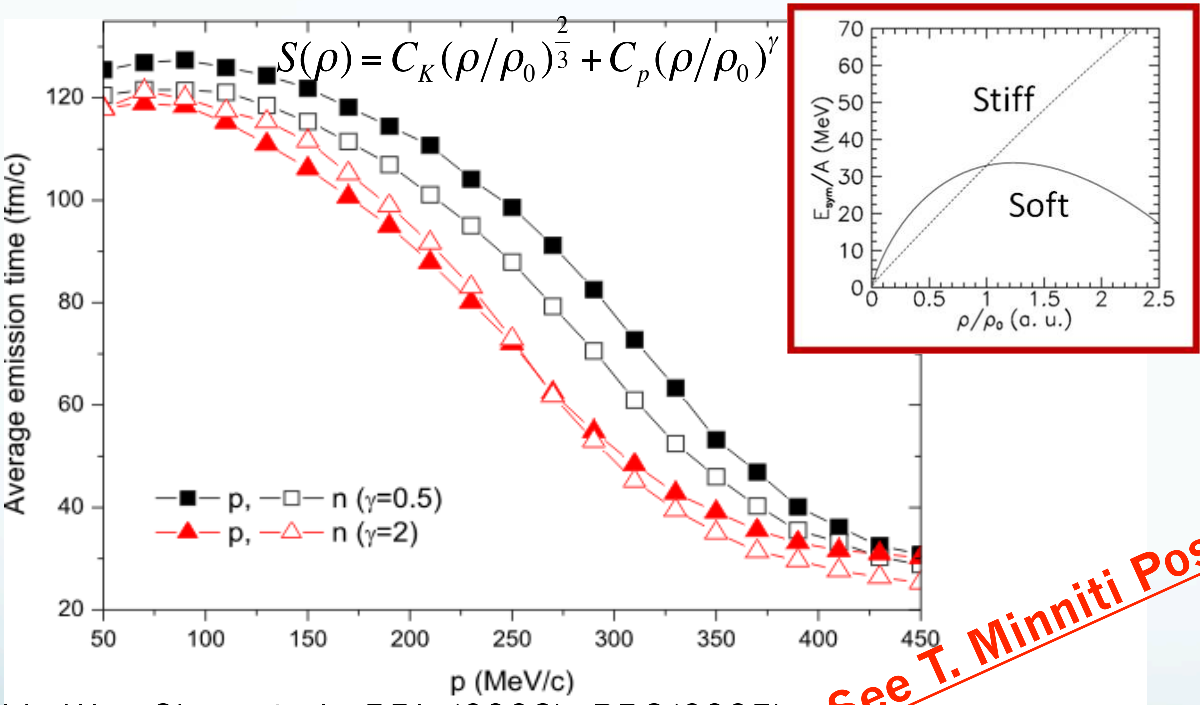
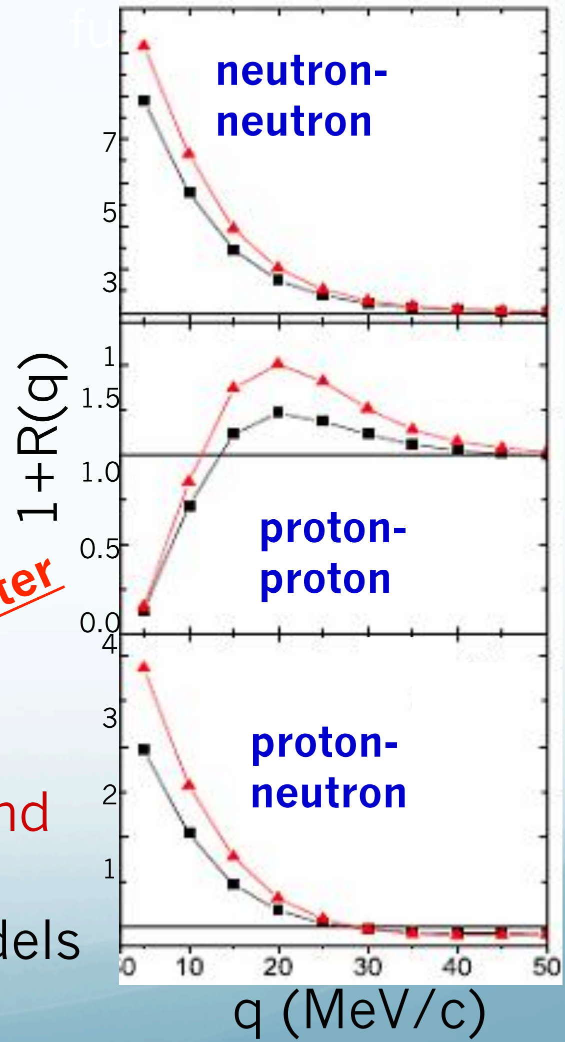
Space-time probes at dynamical stage

IBUU simulations

$^{52}Ca+^{48}Ca$ E/A=80 MeV Central collisions



Correlation



Lie-Wen Chen et al., PRL (2003); PRC(2005)

See T. Minniti Poster

Correlations with dynamically emitted protons and neutrons

→How to perform comparisons to transport models (EoS, Asy-EoS, σ_{NN})

Physics Case

- Nuclear Dynamics
- Nuclear Spectroscopy
    - HIC at Intermediate energy as tools of exotic nuclei
    - Multi-particles correlations (boson condensate)
    - With stable and RIBs

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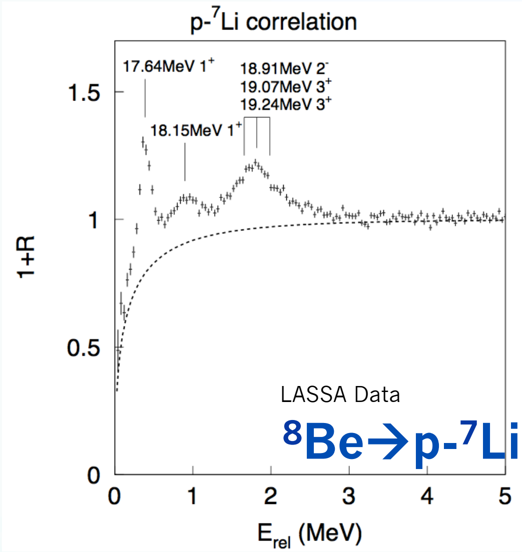
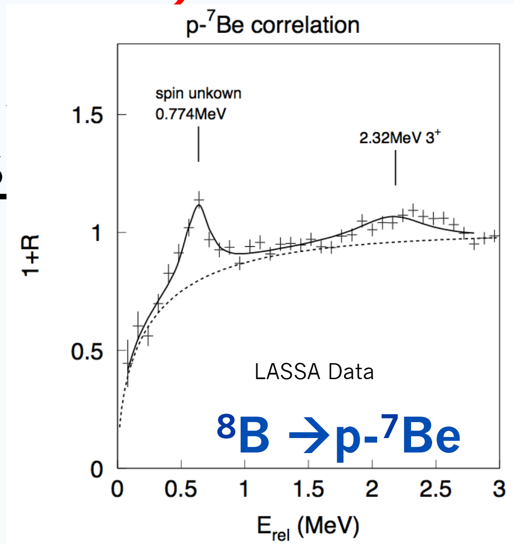
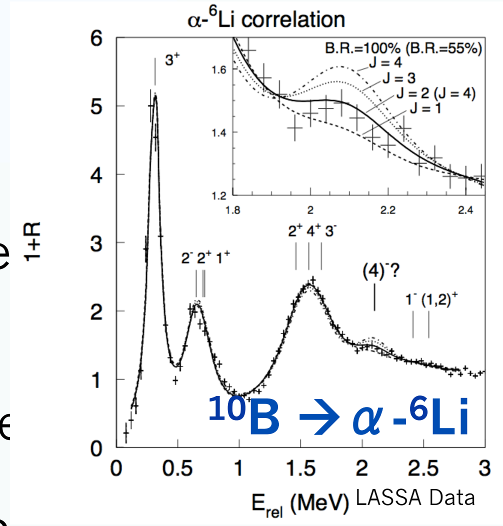
Physics Case







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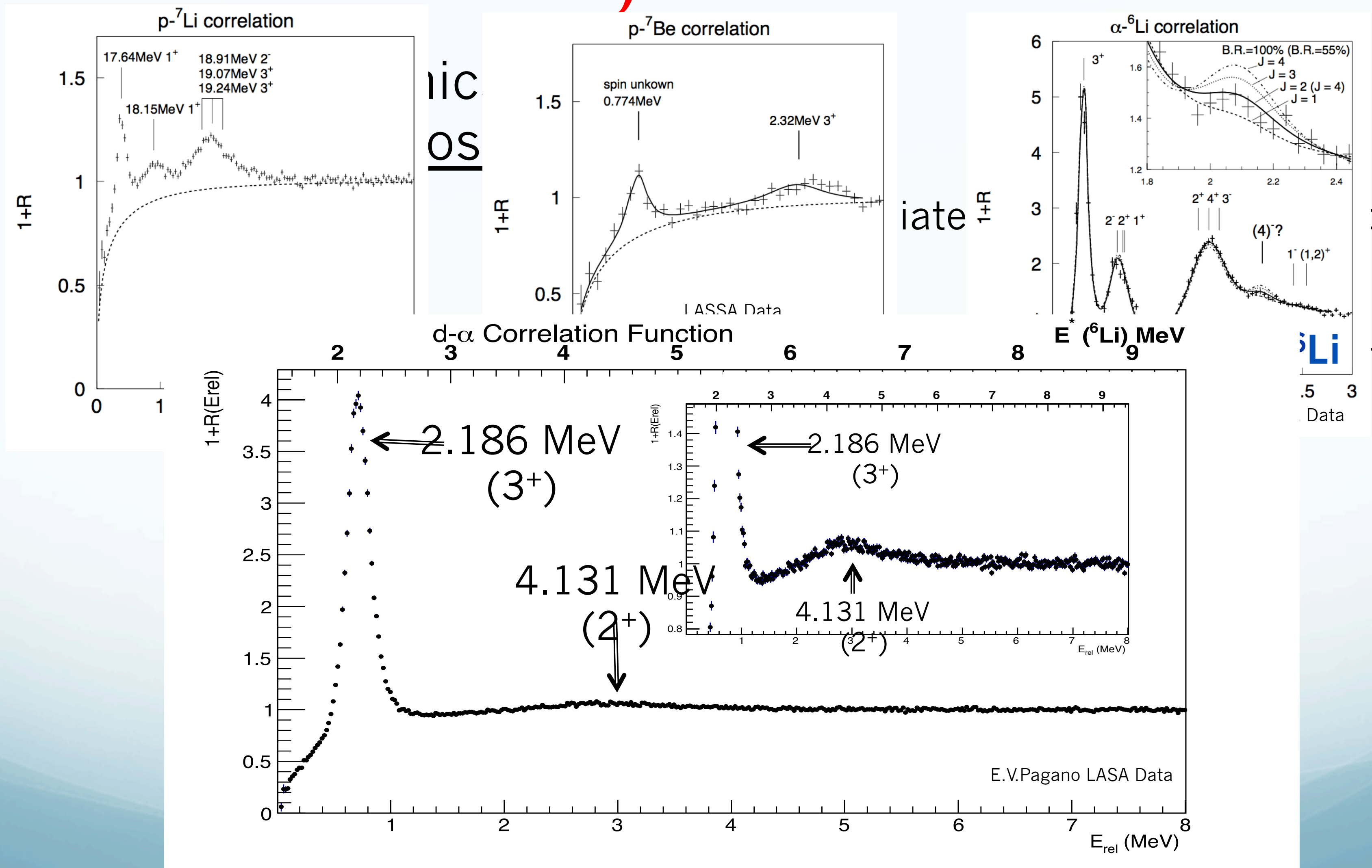
Physics Case



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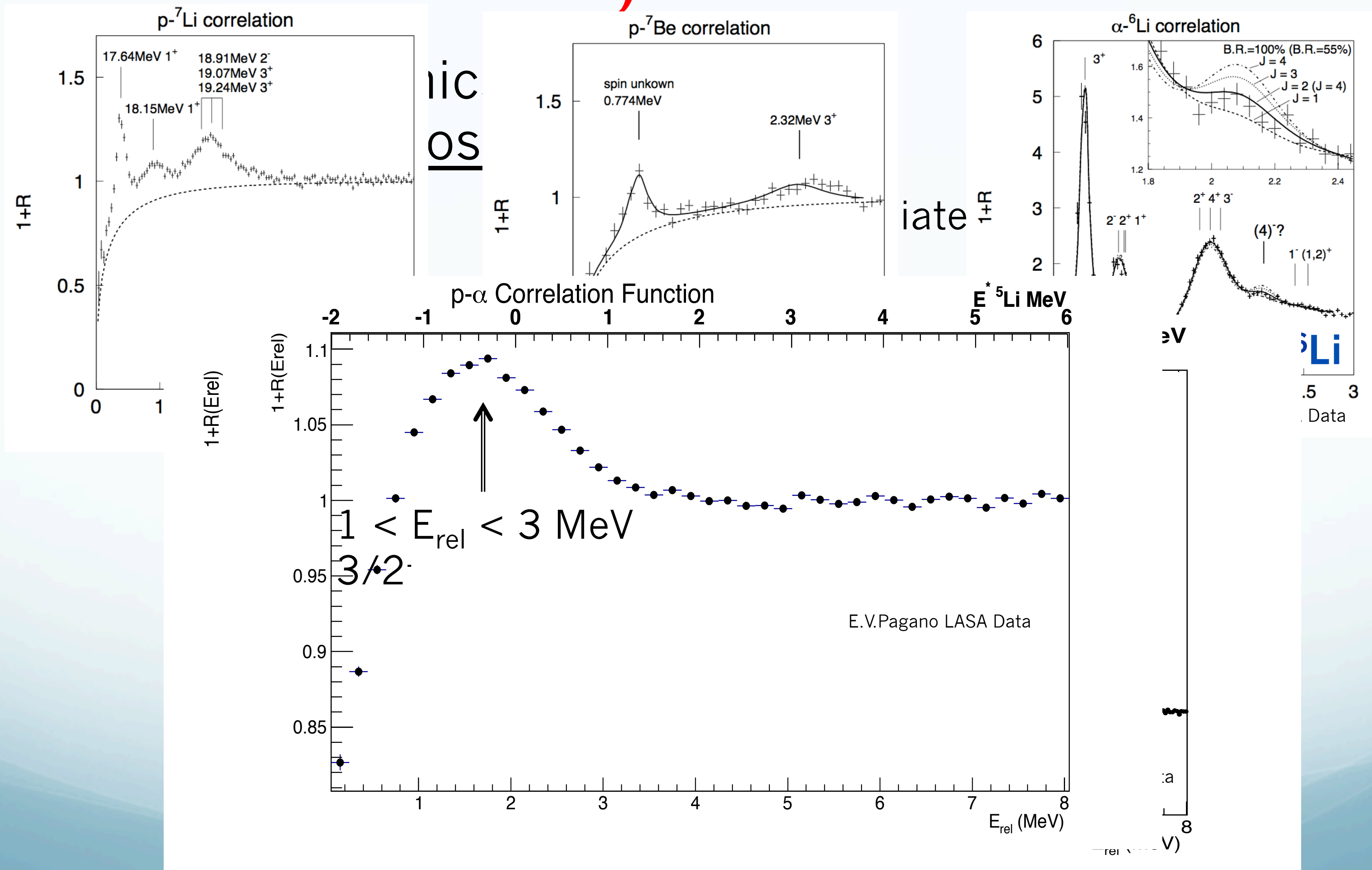
Physics Case



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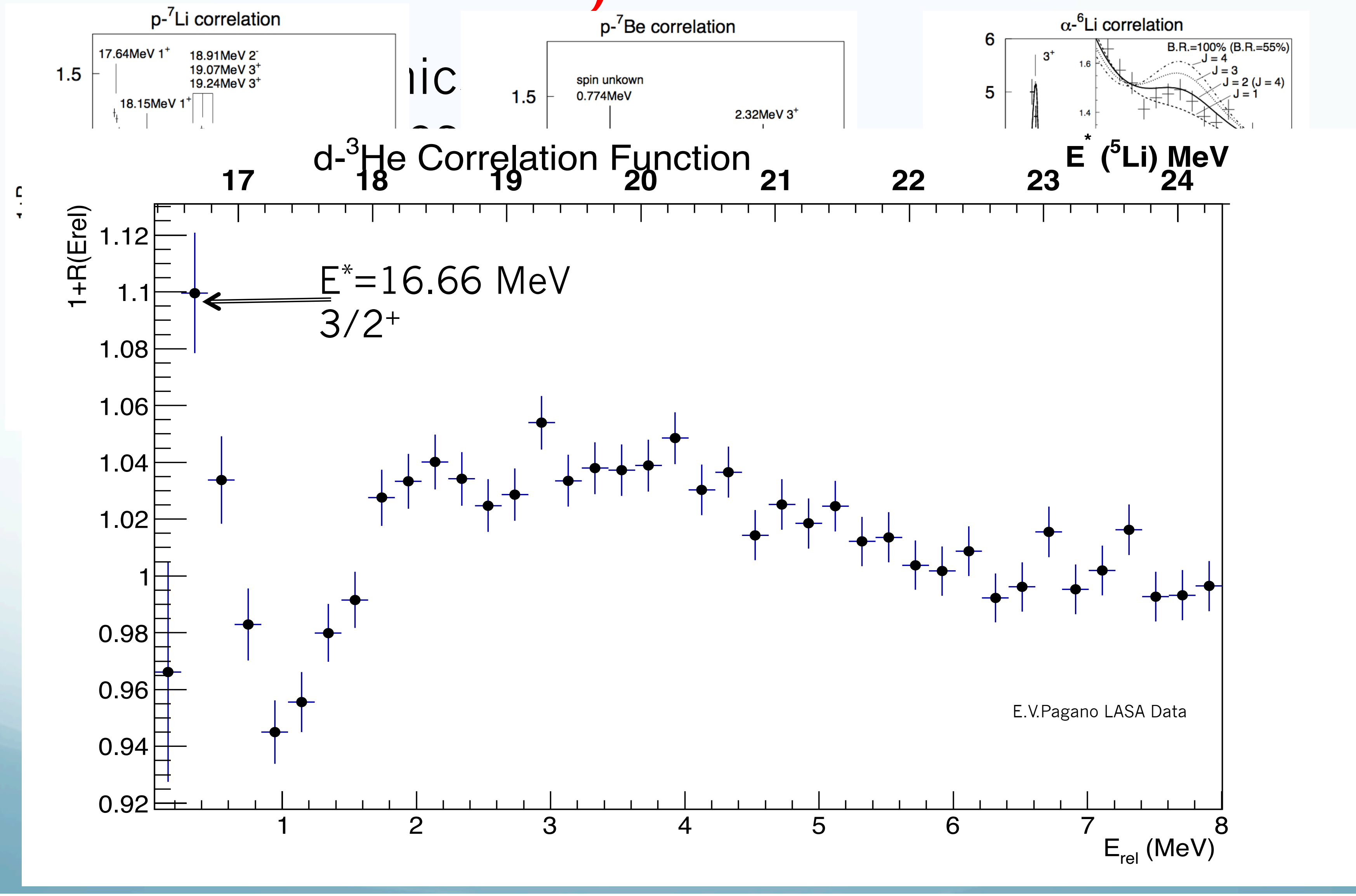
Physics Case



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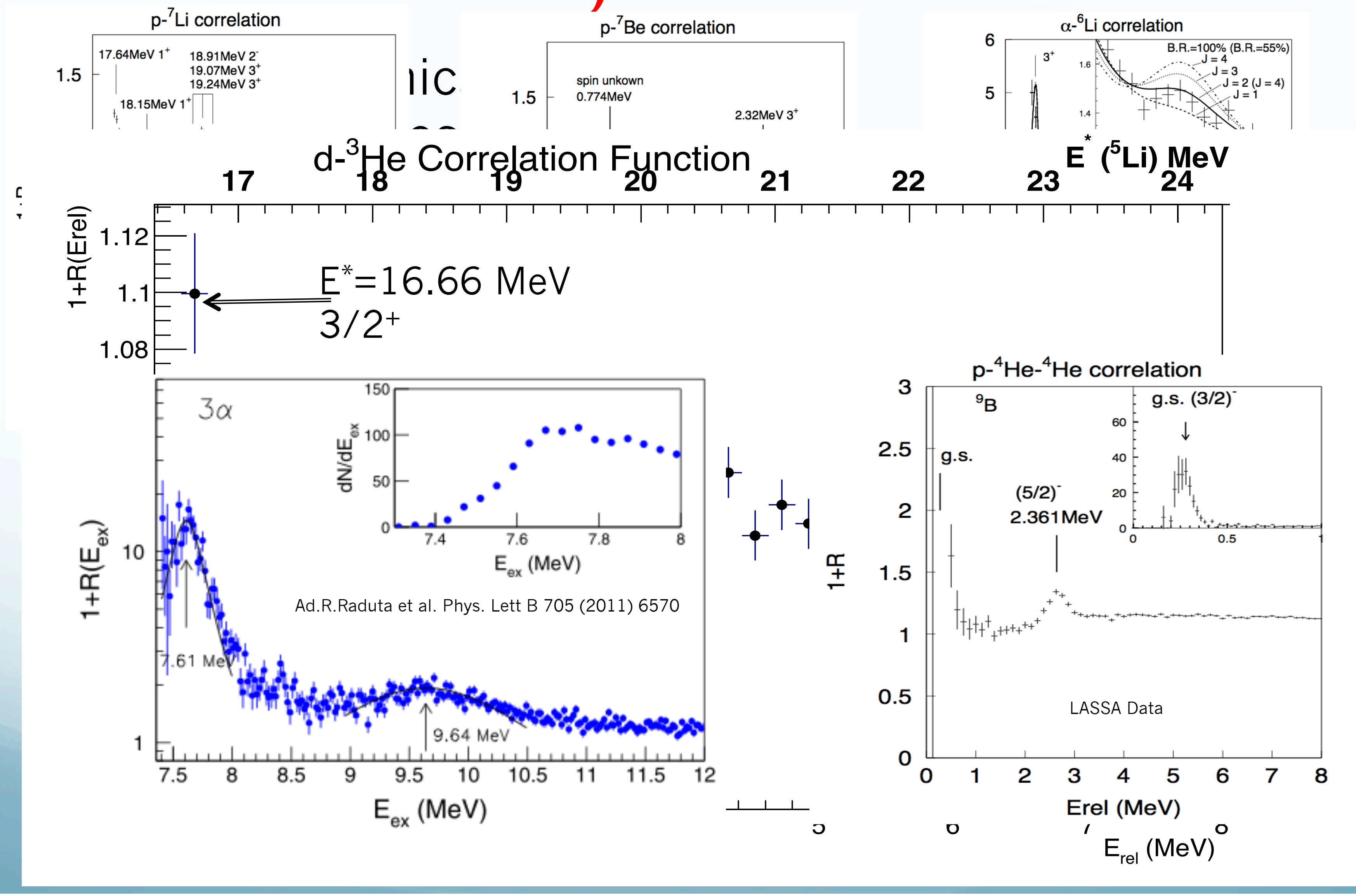
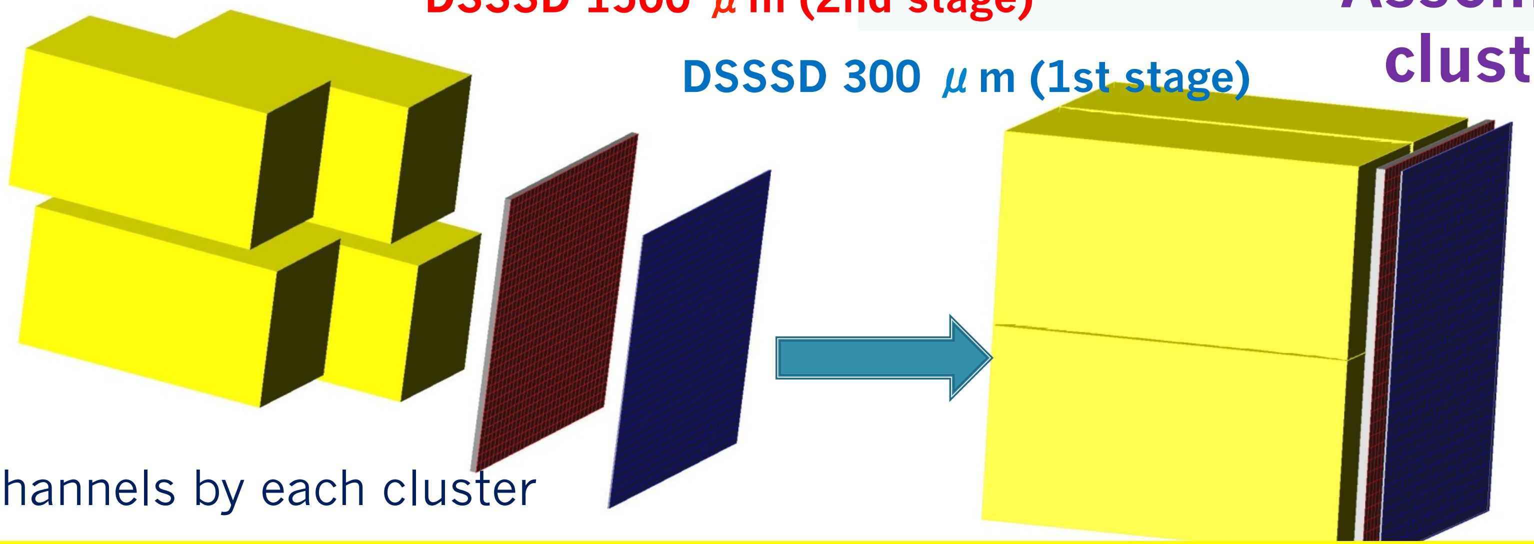
Physics Case



FARCOS

(Femtoscope ARray for COrrelations and Spectroscope)

- Based on (62x64x64 mm^3) clusters
- 1 square (0.3x64x64 mm^3) DSSSD 32+32 strips
- 1 square (1.5x64x64 mm^3) DSSSD 32+32 strips
- 4 60x32x32 mm^3 CsI(Tl) crystals



Fully reconfigurable (more Si layers, neutron detection,…)

FARCOS Features

- **FARCOS (Fentoscope ARray for Correlations and Spectroscopy)**
- **Modular array of telescopes**
- **High energy and angular resolution**
- **ΔE/E discrimination, pulse-shape discrimination and TOF discrimination (4pi CHIMERA)**
- **Digitization**
- **DSSSD(Double-Sided Silicon Strip Detector) each with 32 strips, both in vertical and in a horizontal and 4 crystals of CsI(TI).**
- **Portability and modularity to be coupled to 4π detectors as CHIMERA or magnetic spectrometers**
- **Integrated and reconfigurable electronics**
- **Possibility of updating and upgrades (neutrons)** *See L.Auditore Poster*

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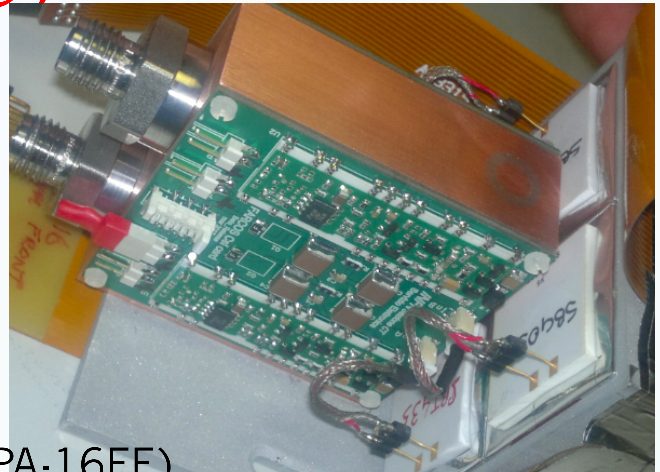
Electronic (PAC)

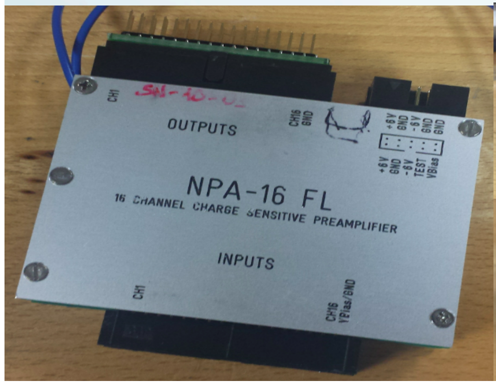


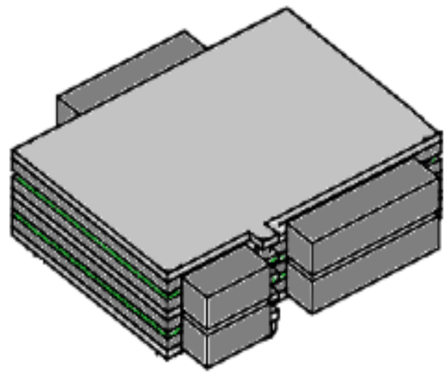
- CsI Crystals: Standard PAC “CHIMERALIKE”
- DSSSD: 32 Ch PAC (INFN-MI)

Features:

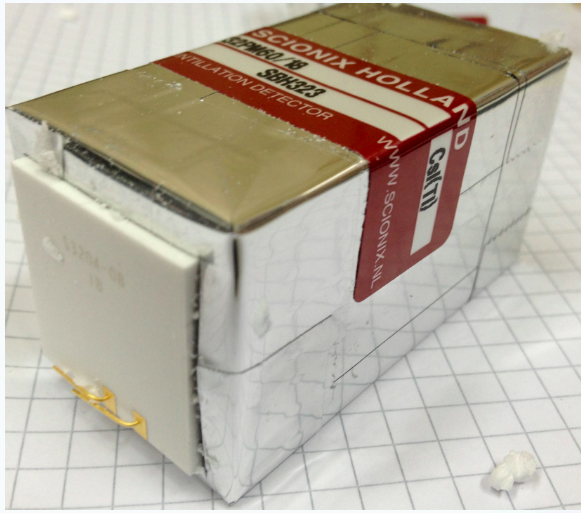
- Channel: 32
- Sensitivity: 5, 10, 20 or 45 mV/MeV
- Dimension: 86x80x10 mm (NPA-16FL), 98x80x15 mm(NPA-16FE)
- Input Bias voltage: ± 300 V (Max)
- ESD Input Protection
- TEST pulse input
- Low power consumption (<900 mW) for vacuum use
- Pseudo-differential or single ended output (with 100 or 50 Ω back termination)
- Max output voltage: ± 4.5 V

Comparison with Mesytech PAC was made





Test and Characterizations of CsI(Tl) light response



- Surface response

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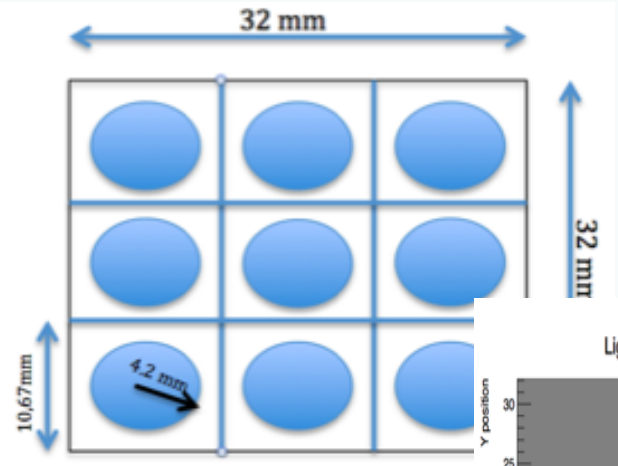
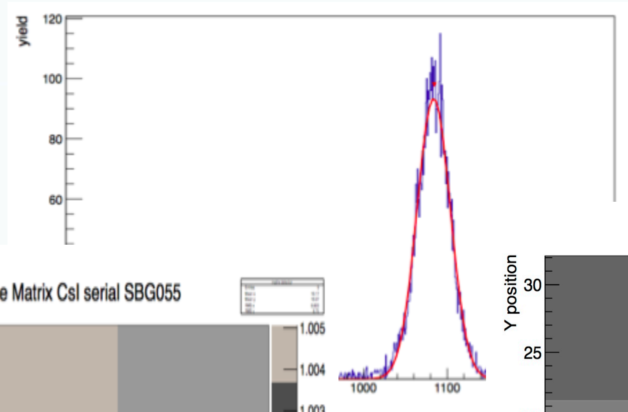
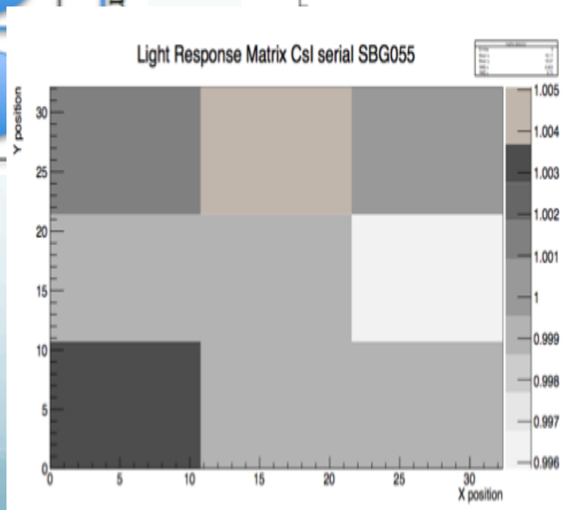
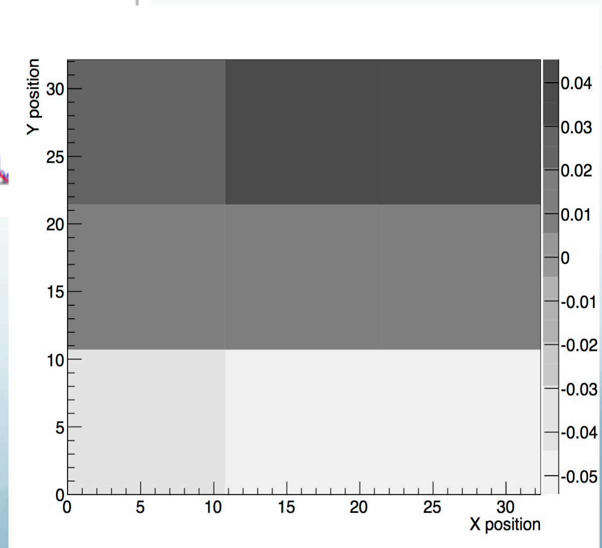
✓ vacuum conditions (≈ 10^{-2} $mbar$)
✓ ^{241}Am source of 150 nCu of intensity, E_α = 5.485 MeV
✓ Doping of CsI(Tl) crystals 1200-1500 ppm









Good Uniformity:
<0.5% in the best case
<2% in the worst case

See E.V.Pagano undergraduate Thesis work

- depth response

≈1.5 cm

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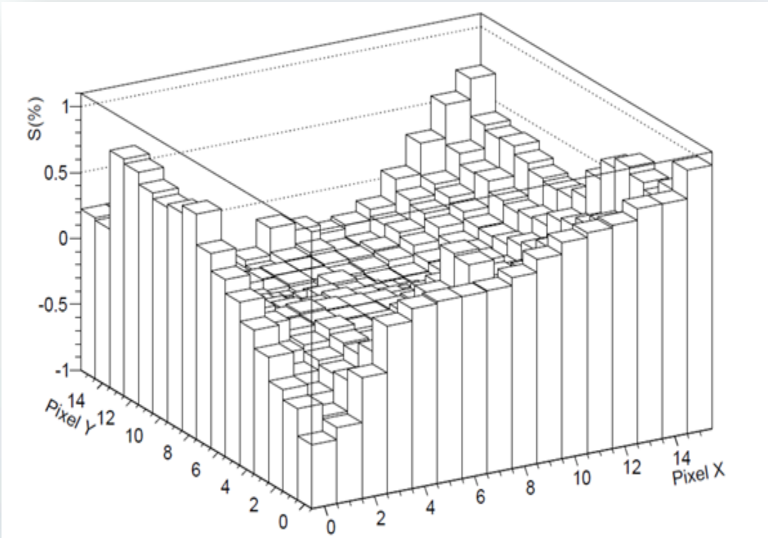
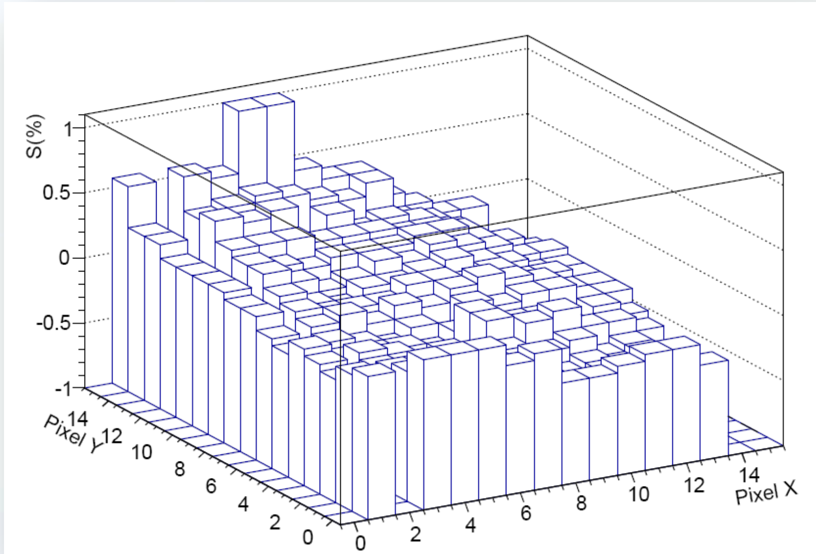
α+Pb at E/A=62 MeV





L.Quattrocchi et al.

$$S_{ij} = \frac{L_{ij} - \langle L \rangle}{\langle L \rangle}$$

Light response: less than 0.5% non-uniformity

More energie and reactions are available to study the depth response of CsI(Tl) at different section.
R.Andolina undergraduate thesis (work in progress)

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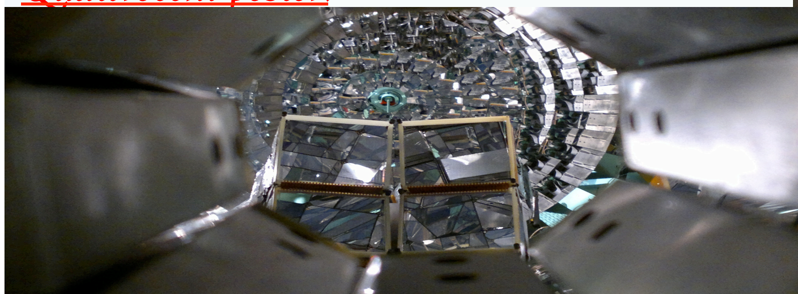
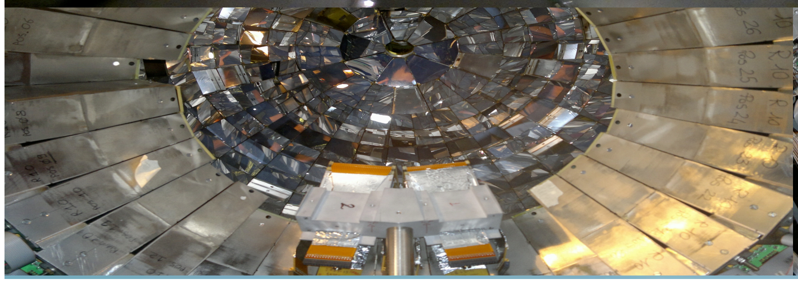
Test of FARCOS with beam @ LNS-INFN

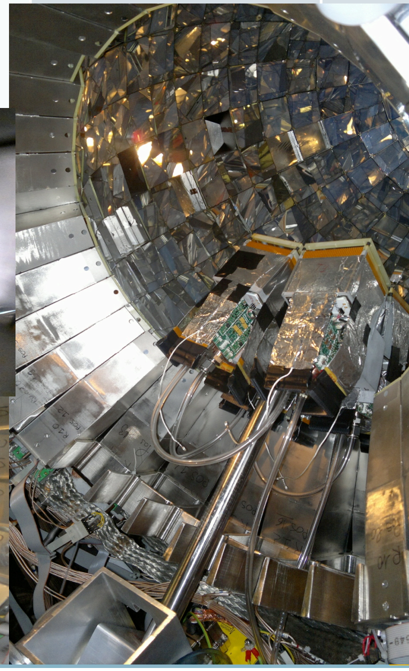
Test with beam was made during the InKiIsSY experiment (INverse KInematic ISobaric SYstem)

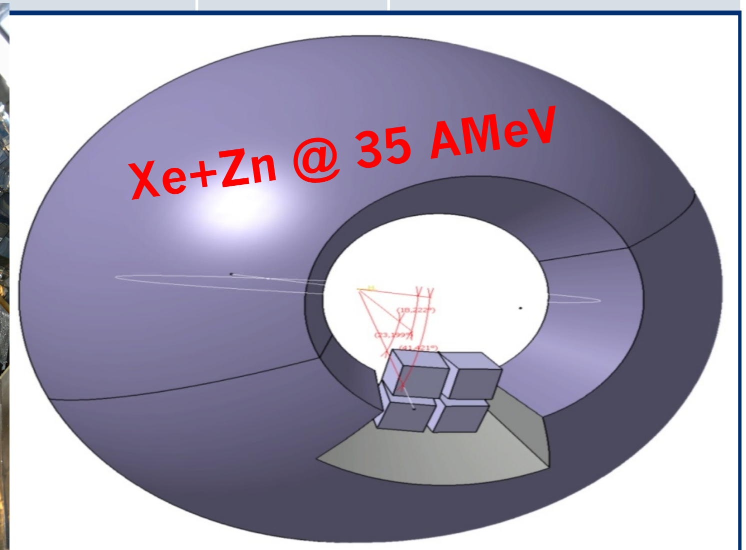
The idea of this experiment is to use projectile/target combination having the same mass of the neutron rich $^{124}Sn+^{64}Ni$ system a N/Z similar to the neutron poor $^{112}Sn+^{58}Ni$ one, that is $^{124}Xe+^{64}Zn$, at the same bombarding energy of 35 MeV/u using the 4π detector CHIMERA and 4 modules of FARCOS prototype. *For more details see L. Quattrocchi poster.*

System	N/Z Projectile	N/Z target	N/Z Coumpound
$^{124}Sn+^{64}Ni$	1.48	1.29	1.41 P. Russotto *et al.*, Phys. Rev. C **81**, 064605 (2010).
$^{112}Sn+^{58}Ni$	1.30	1.13	1.24
$^{124}Xe+^{64}Zn$	1.24	1.07	1.18









4 telescopes at 25 cm from the target
$\theta_{lab} \sim 16°–44°$ $\Delta\phi \sim 60°$

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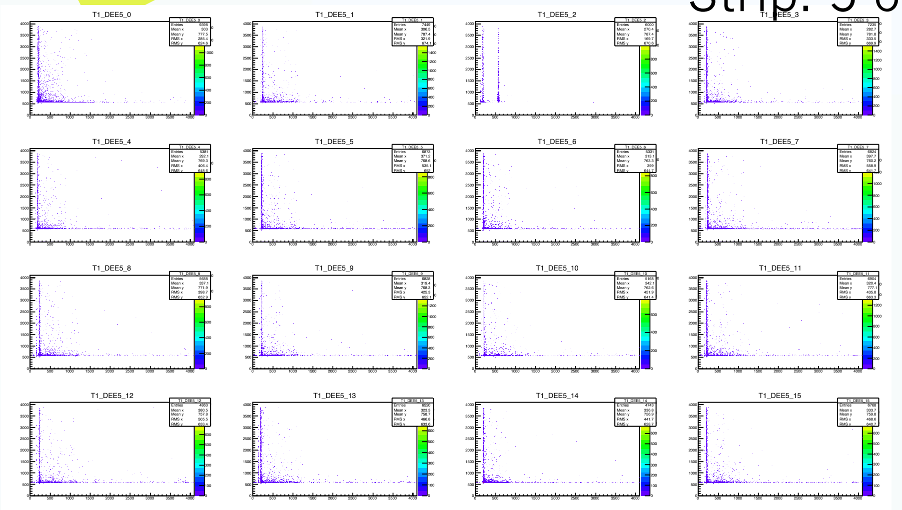
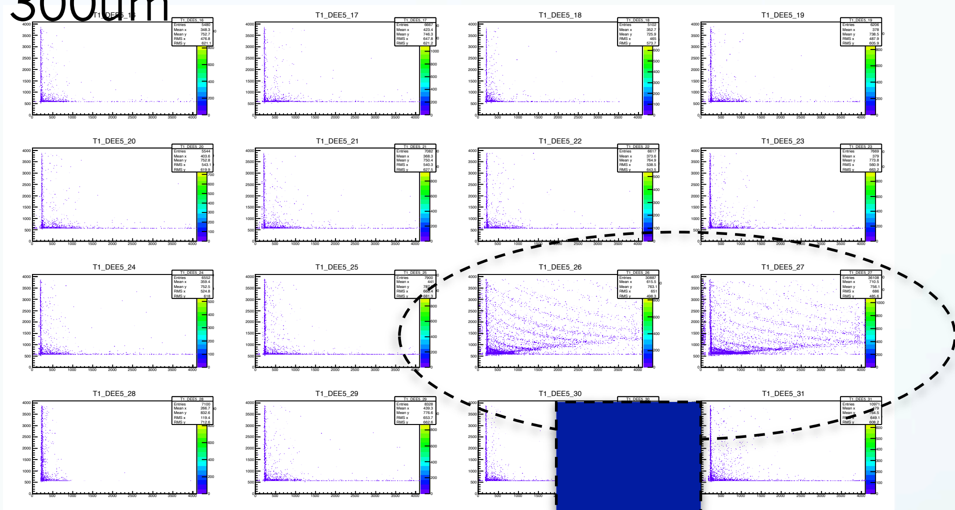
Preliminary

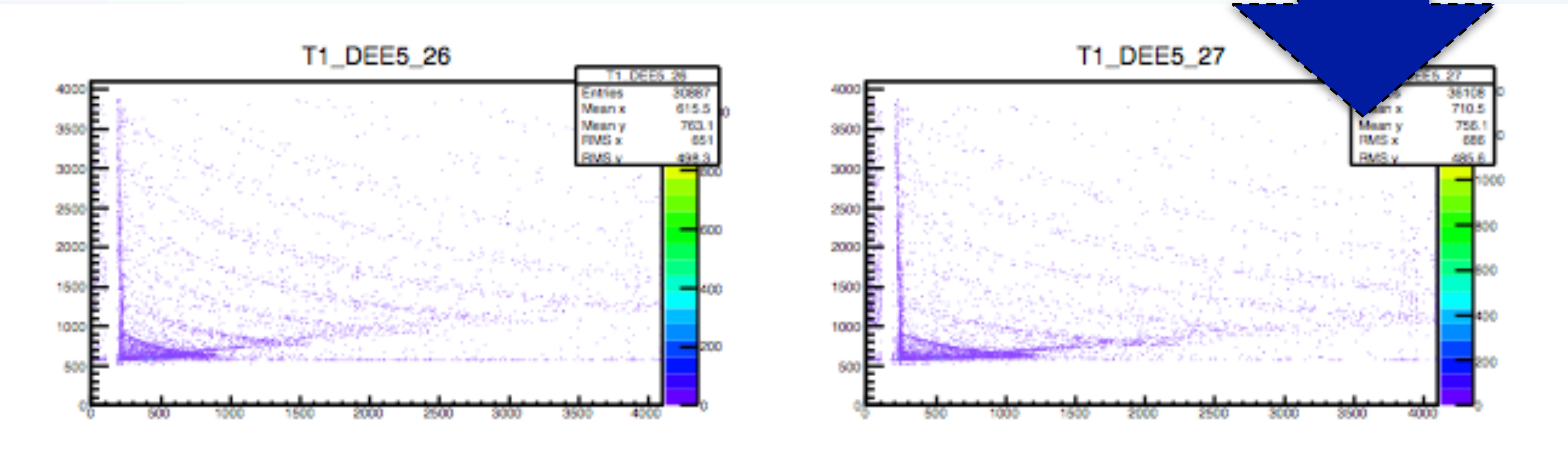
Test work:
only 40 runs
Out of about 800

N° of Events ≈ 8 x 10^6

Strip: 5 of 300um







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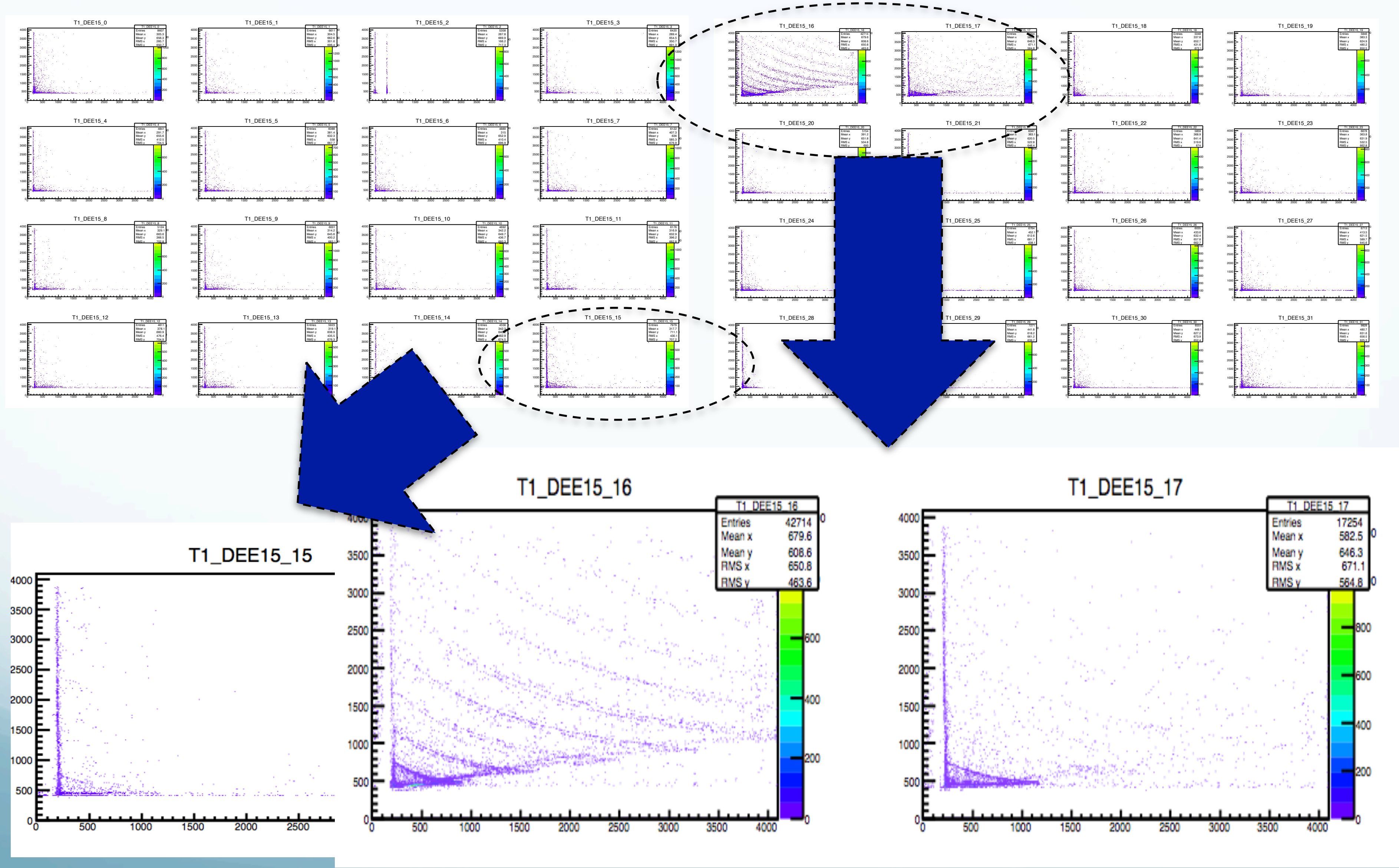
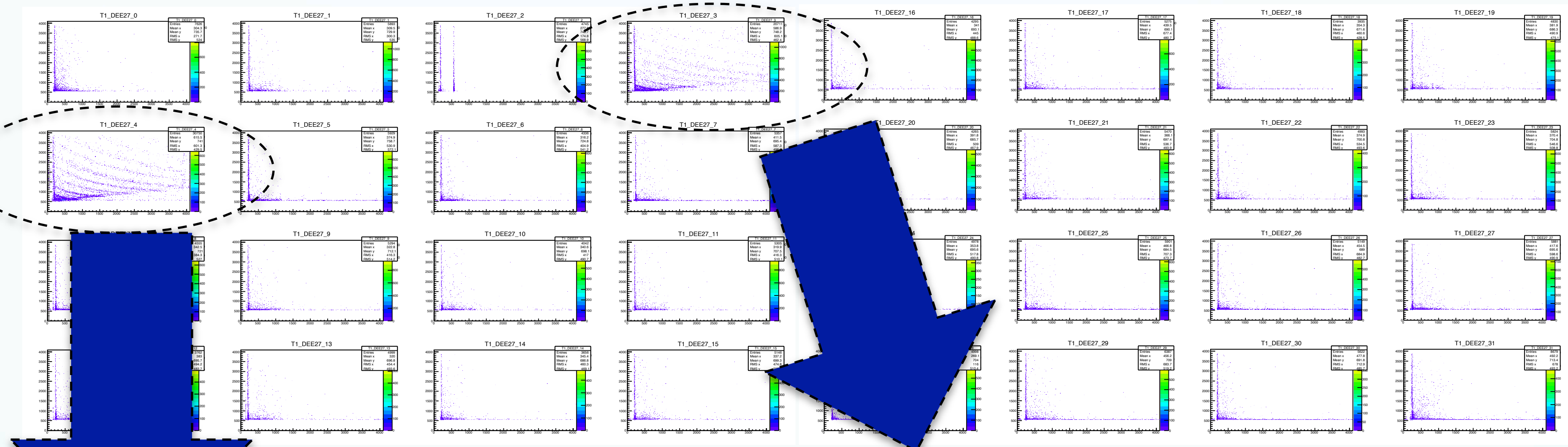
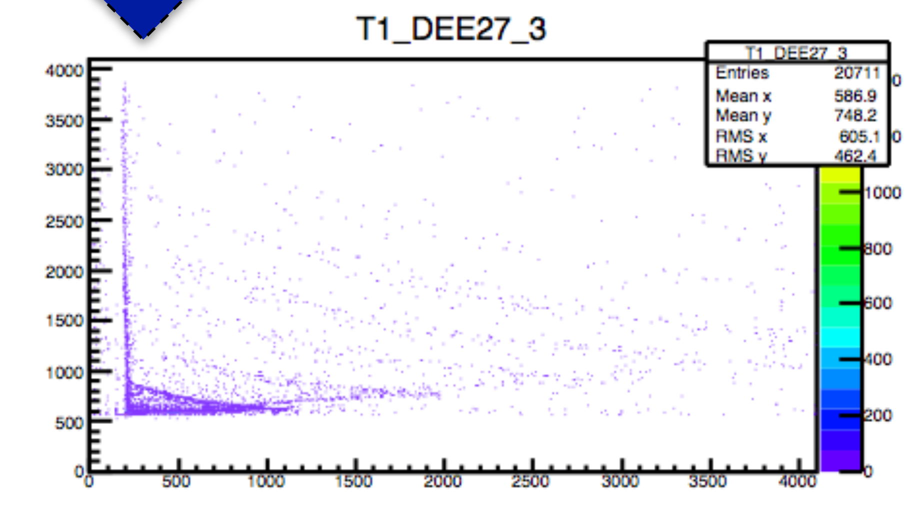
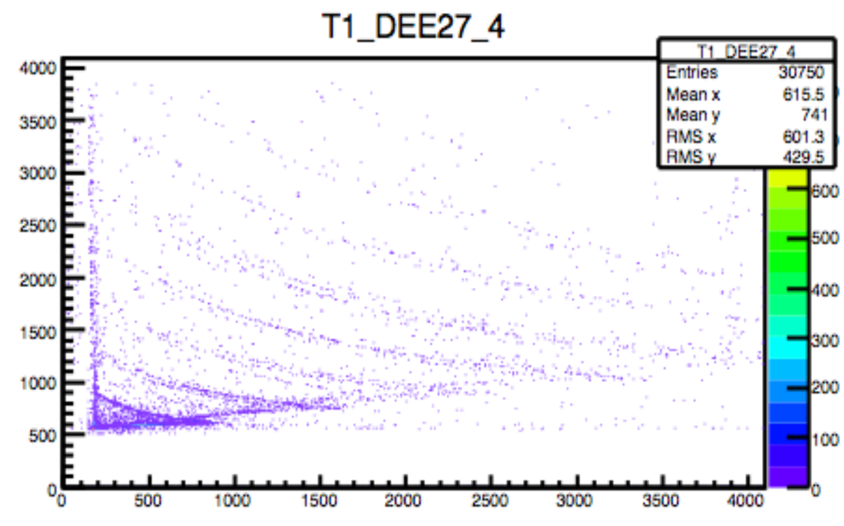
Strip: 15 of 300um



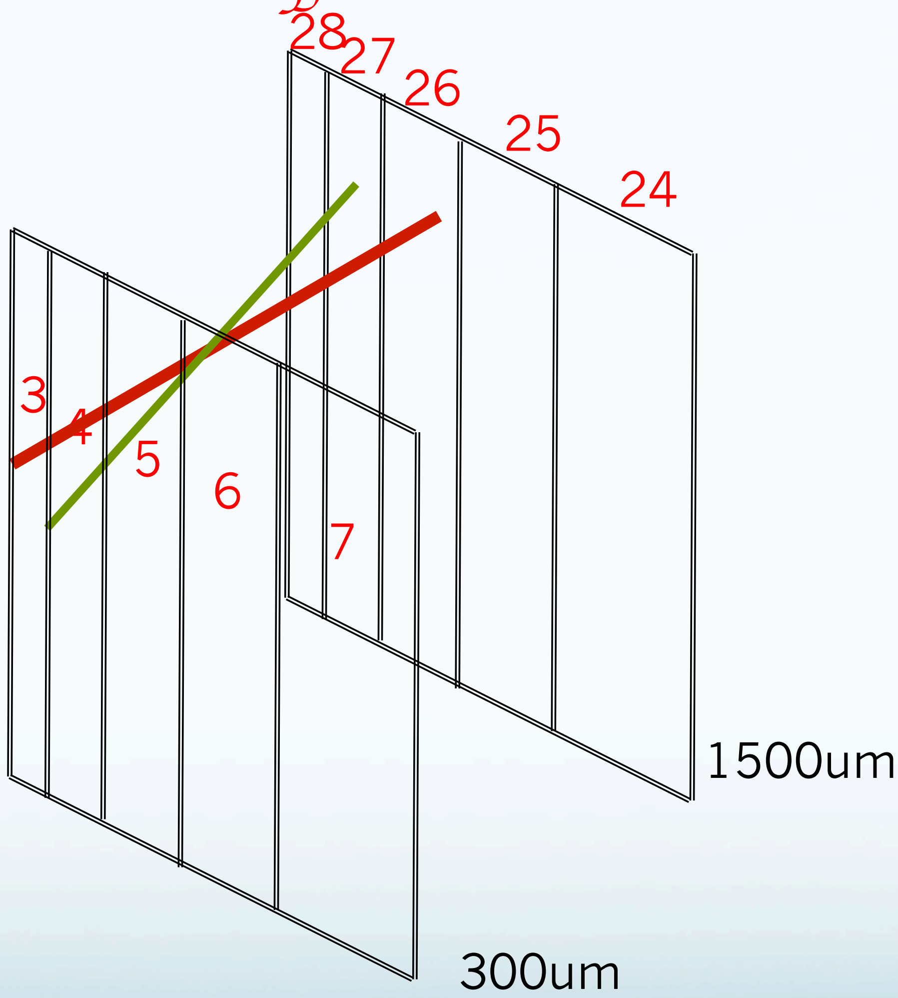
Strip: 27 of 300um



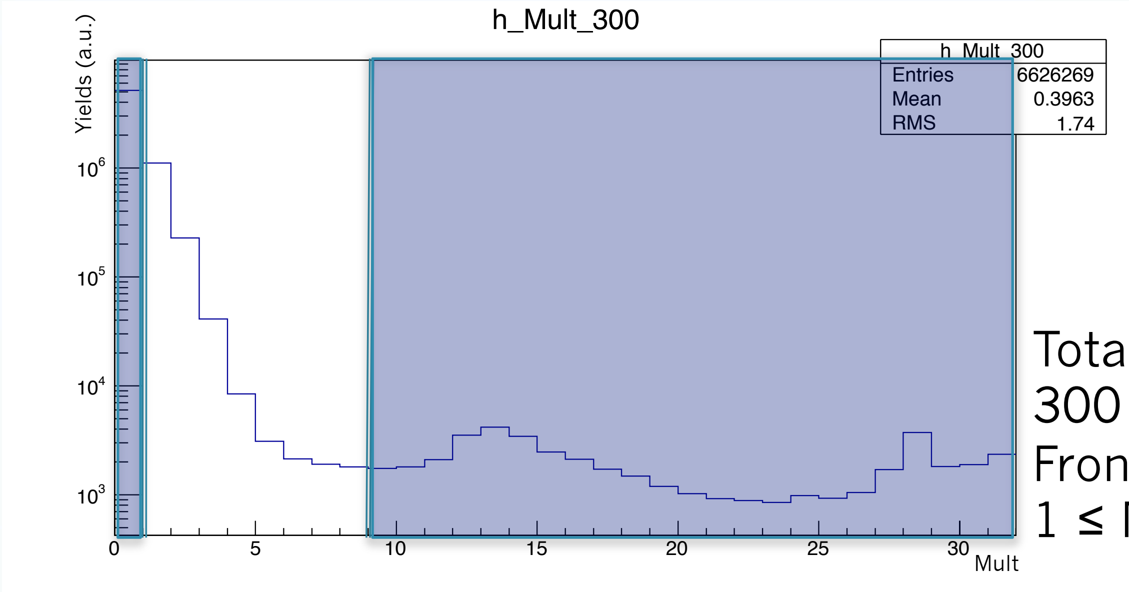




"Effetto Calotta"

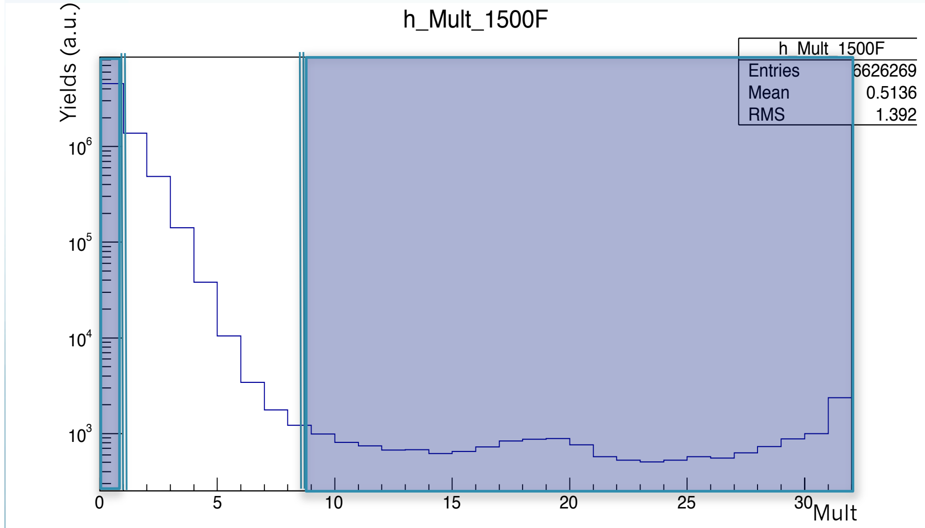


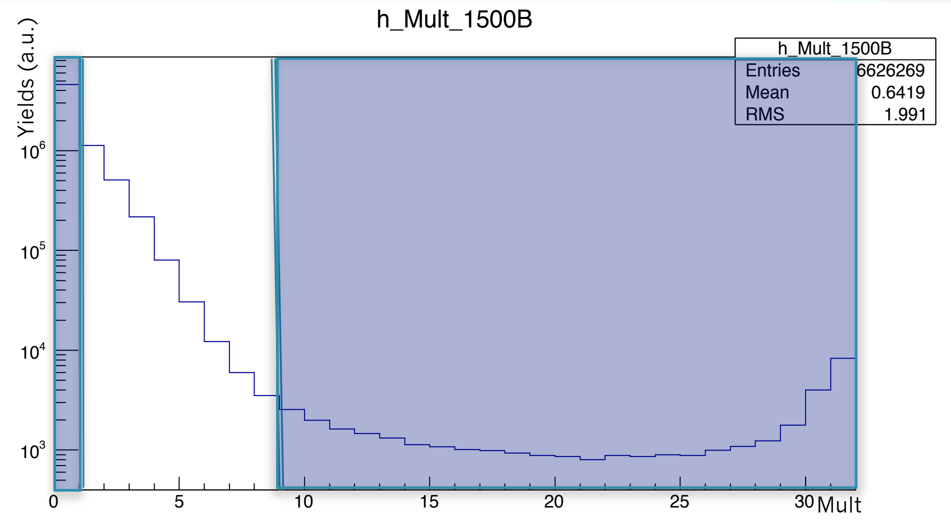
This Cap Effect is due to the fact that the detector obviously have a flat surface and it is too near to the target (25 cm). Maybe it is avoided with a distance of about 80 cm form the target



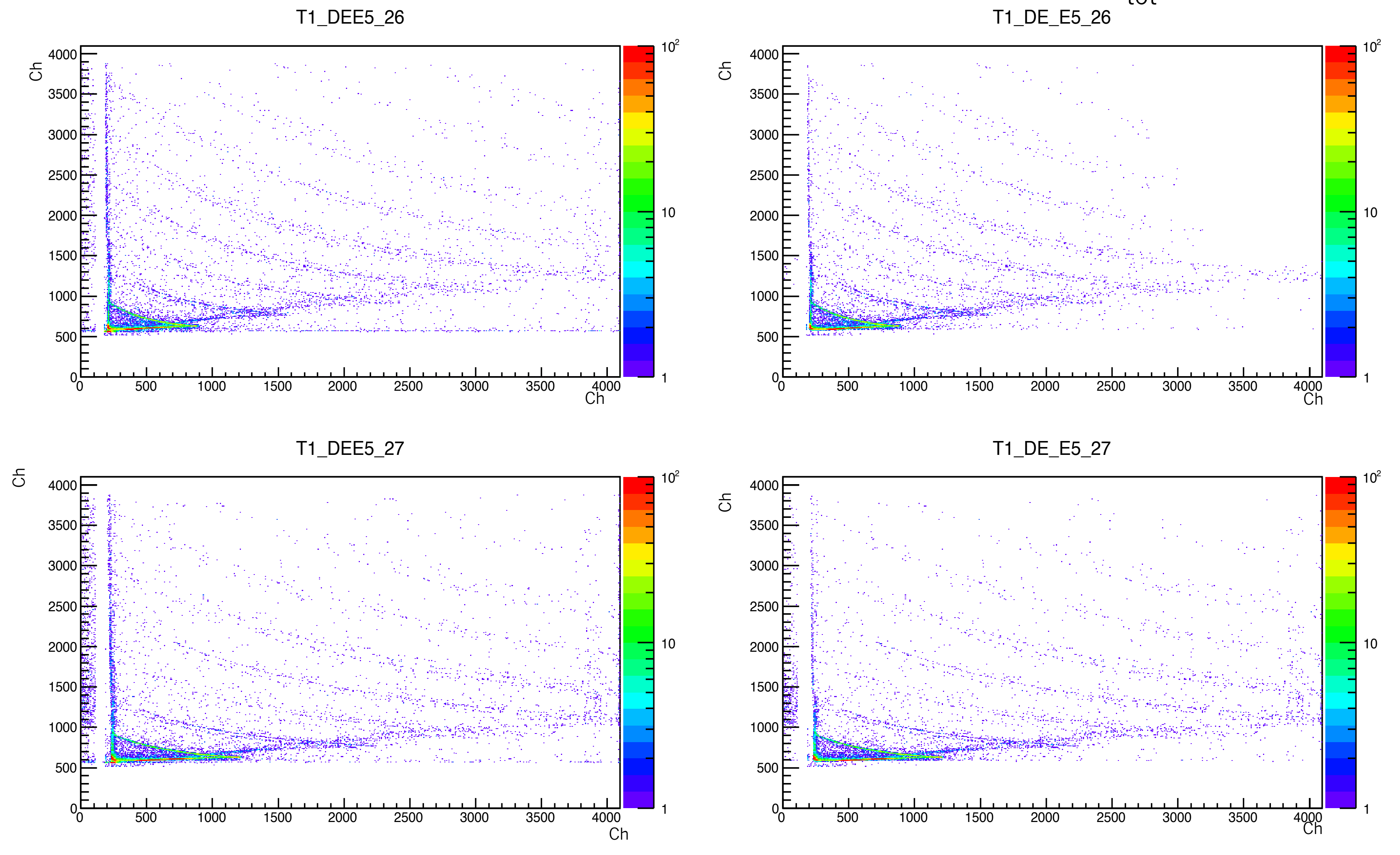
A multiplicity cut is necessary in order to eliminate bad events for physical reasons

Total Multiplicity of 300 μm, 1500 μm Front and back is:
$1 \leq Mult_{tot} \leq 8$





No Cut T1_DE_E Strip 5 $1 \leq Mult_{tot} \leq 8$



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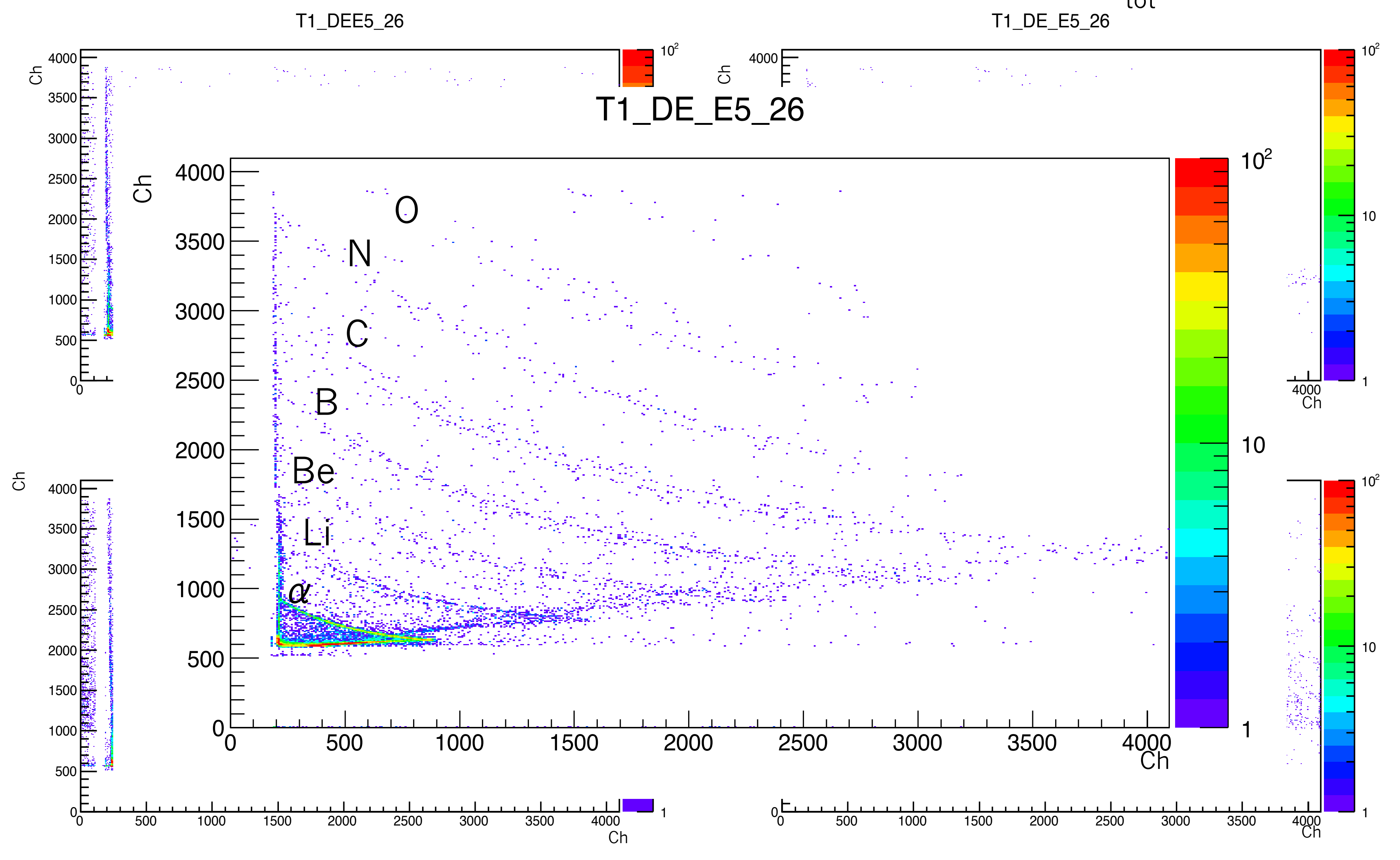
No Cut | T1_DE_E Strip 5 | $1 \leq Mult_{tot} \leq 8$



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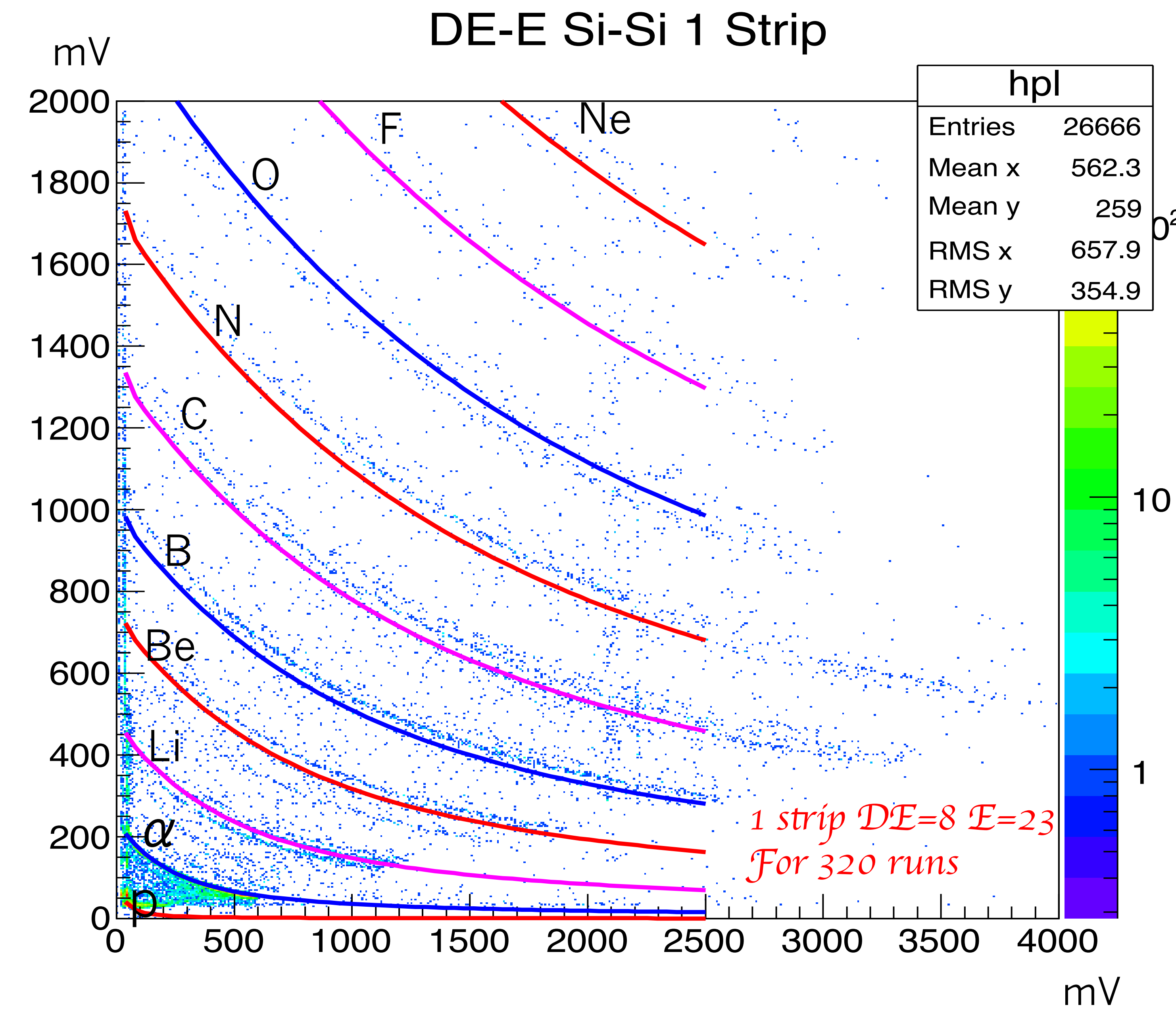
Identifications and calibrations

For isotopic identification (Si-Si, Si-CsI(Tl), fast-slow) should be two ways:

- Strips by strips it means about 100 identifications matrix for each telescope:
  - 32 + 32 DE-E (Si-Si) (the second 32 are due to the "effetto Calotta")
  - 32 DE-E (Si-CsI)
  - 4 fast-slow (CsI)
- Summing the strips, 8 for example, should be reduce the job 16 identifications matrix for each telescope:
  - 4+4 DE-E (Si-Si)
  - 4 DE-E (Si-CsI)
  - 4 fast-slow (CsI)

In principle should be possible to sum the strips one over ones, in fact the detector DSSSD is one. The hypothesis is that the thickness difference among the strips is negligible. But the electronic channels are independent and for this reason it is possible to use a pulse signal to homogenize all the strips.

What are the difference in the isotopic identification in the two way?


DE-E Si-Si 1 Strip
mV
mV
hpl
Entries 26666
Mean x 562.3
Mean y 259
RMS x 657.9
RMS y 354.9
p
α
Li
Be
B
C
N
O
F
Ne
10
1
1 strip DE=8 E=23
For 320 runs

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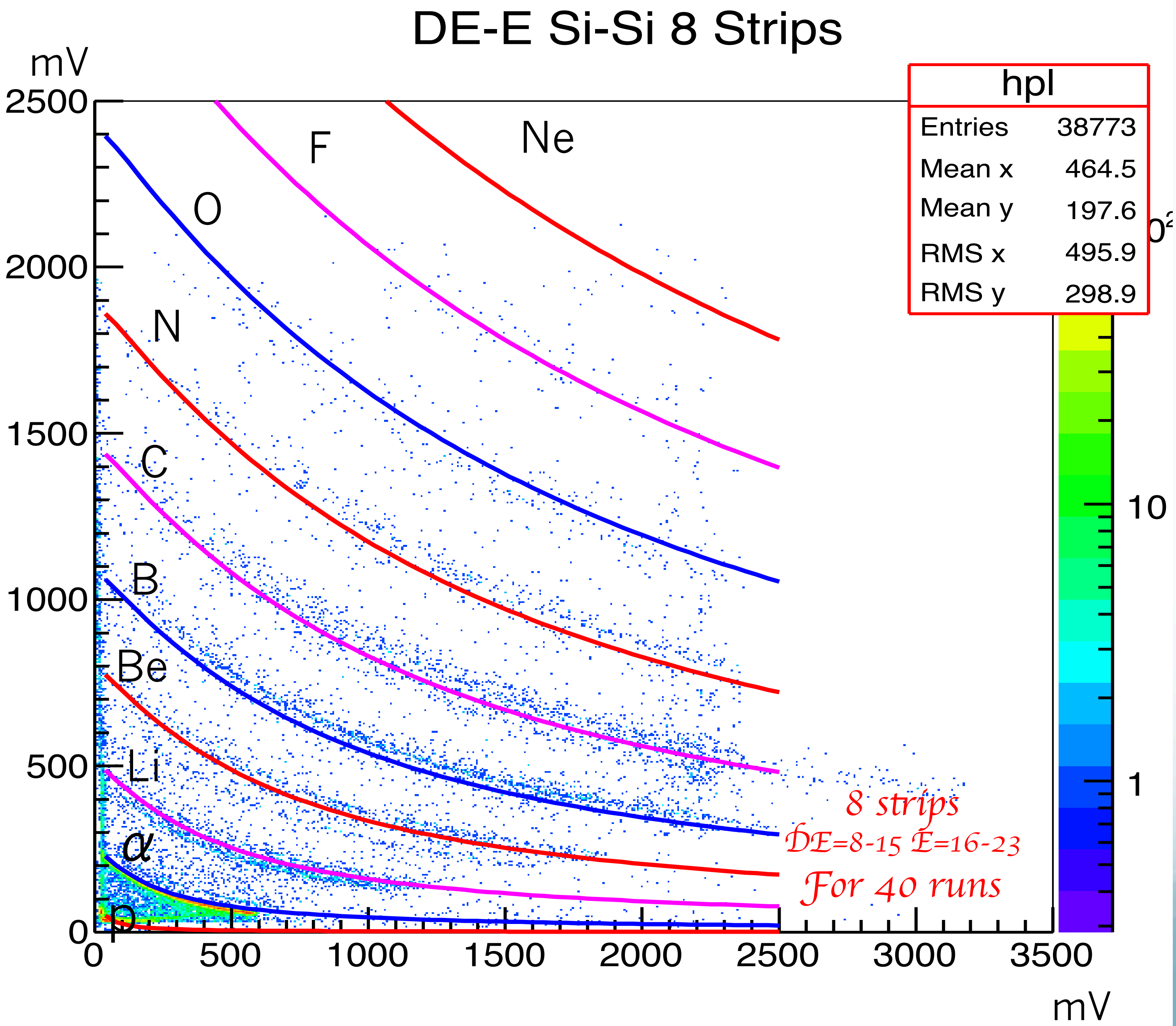

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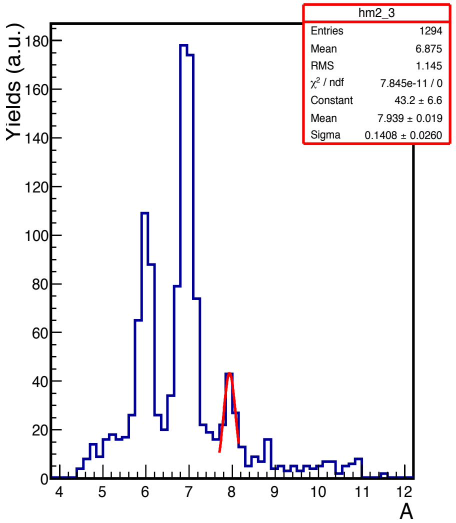
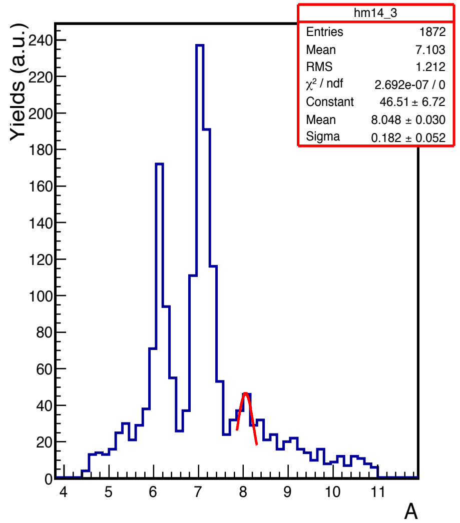
Comparison between the two ways

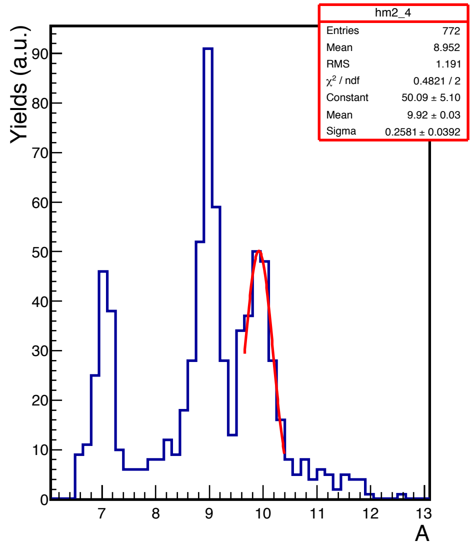
Mass [Z=3] 8 Strips DE-E Si-Si



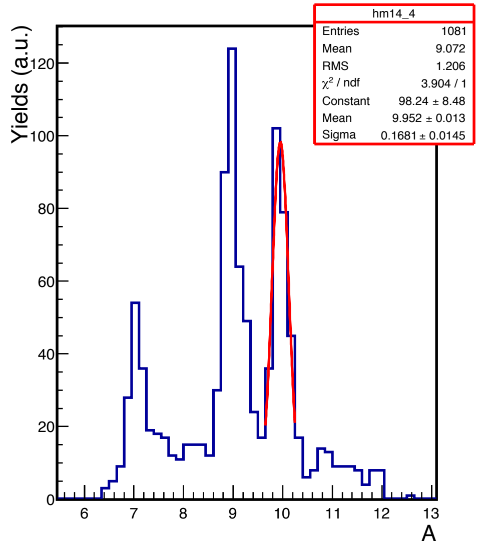
Mass [Z=3] 1 Strip DE-E Si-Si



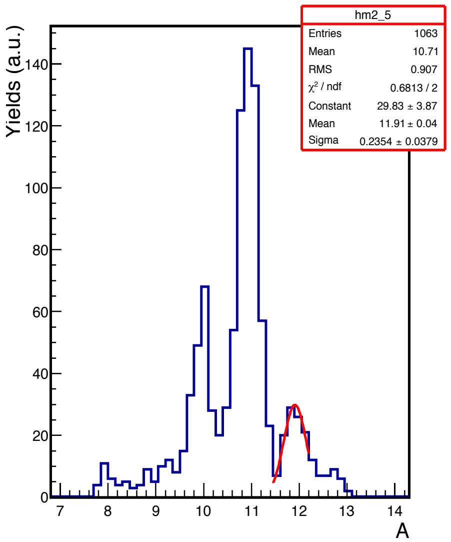
Mass [Z=4] 8 Strips DE-E Si_Si



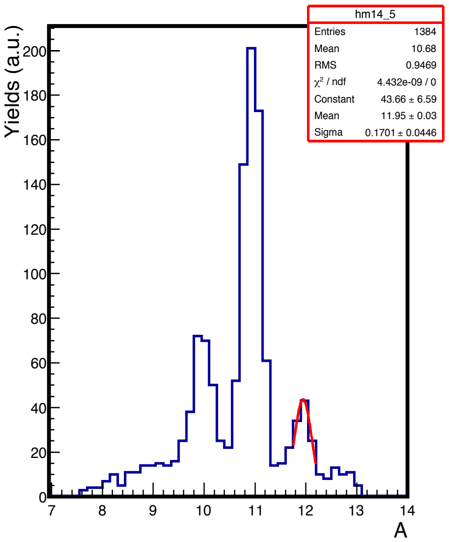
Mass [Z=4]



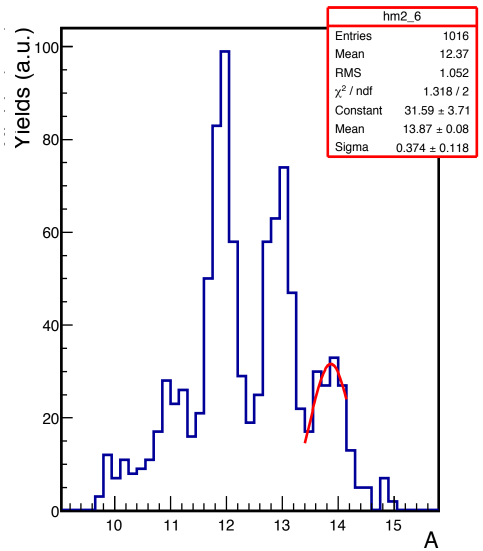
Mass [Z=5] 8 Strips DE-E Si-Si



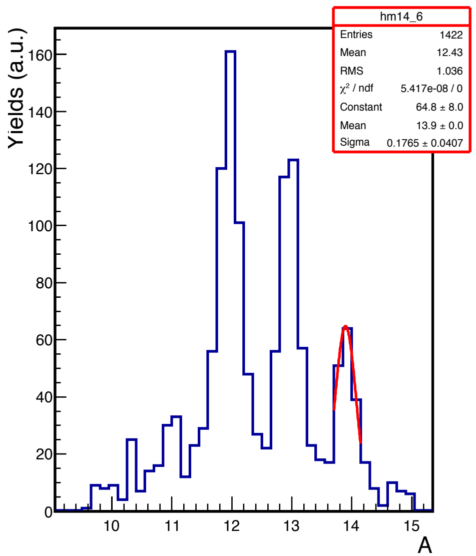
Mass [Z=5] 1 Strip DE-E Si-Si



Mass [Z=6] 8 Strips DE-E Si-Si



Mass [Z=6] 1 Strip DE-E Si-Si



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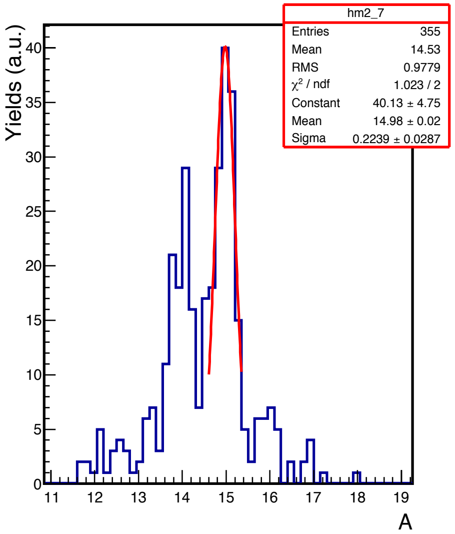
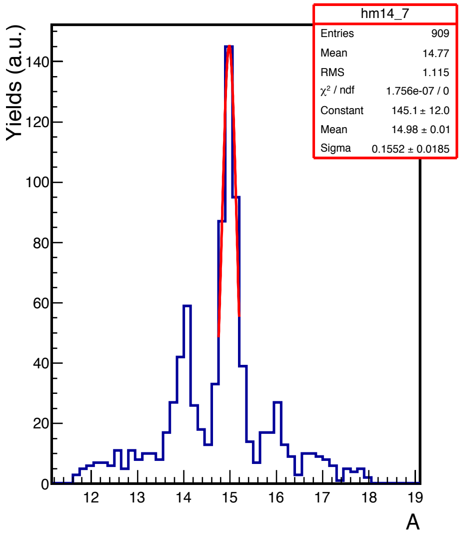
Comparison between the two ways

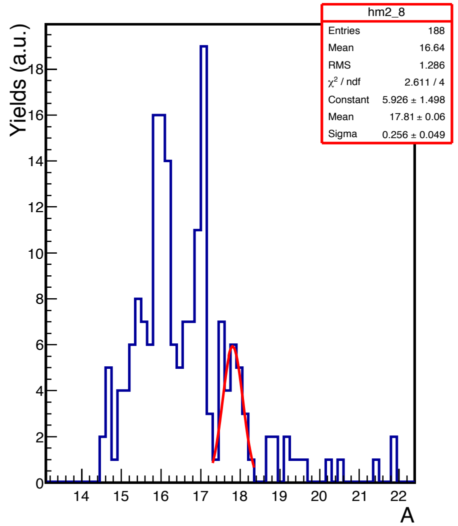
Mass [Z=7] 8 Strips DE-E Si-Si



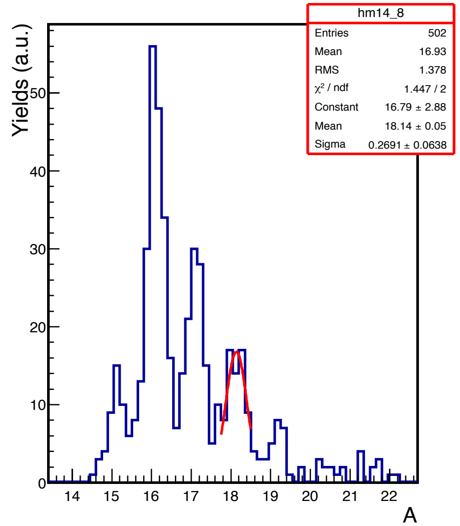
Mass [Z=7] 1 Strip DE-E Si-Si



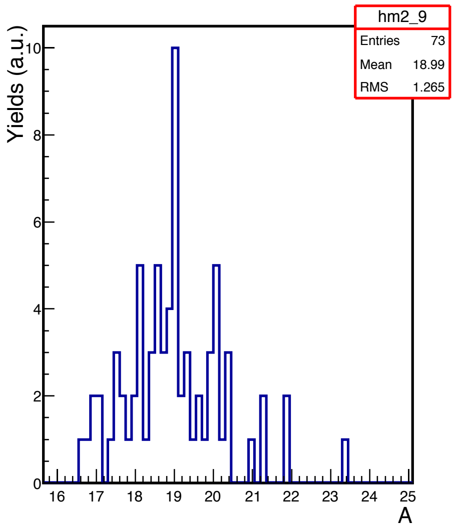
Mass [Z=8] 8 Strips DE-E Si-Si



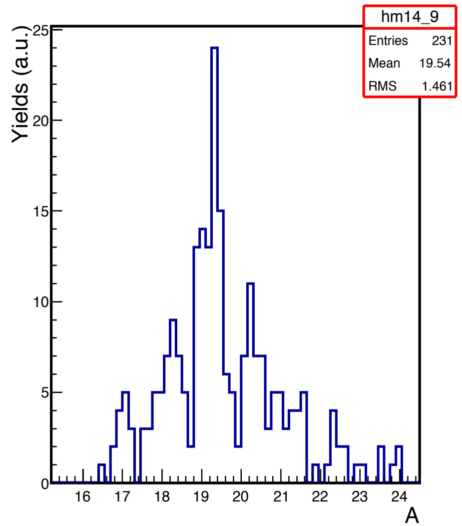
Mass [Z=8] 1 Strip DE-E Si-Si



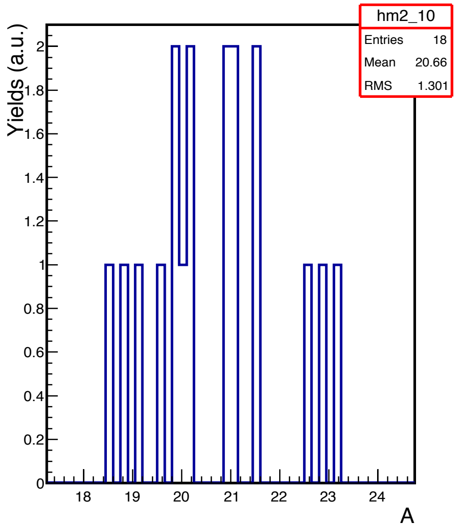
Mass [Z=9] 8 Strips DE-E Si-Si



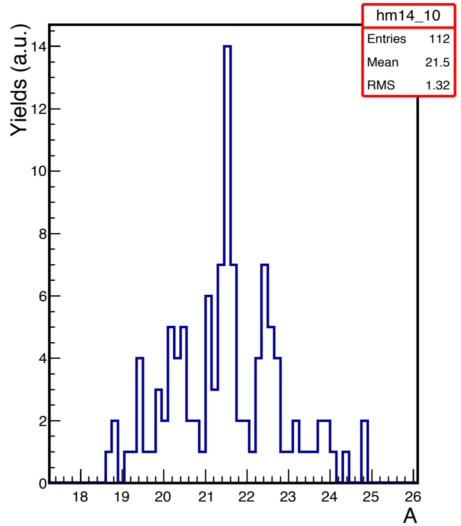
Mass [Z=9] 1 Strip DE-E Si-Si



Mass [Z=10] 8 Strips DE-E Si-Si



Mass [Z=10] 1 Strip DE-E Si-Si



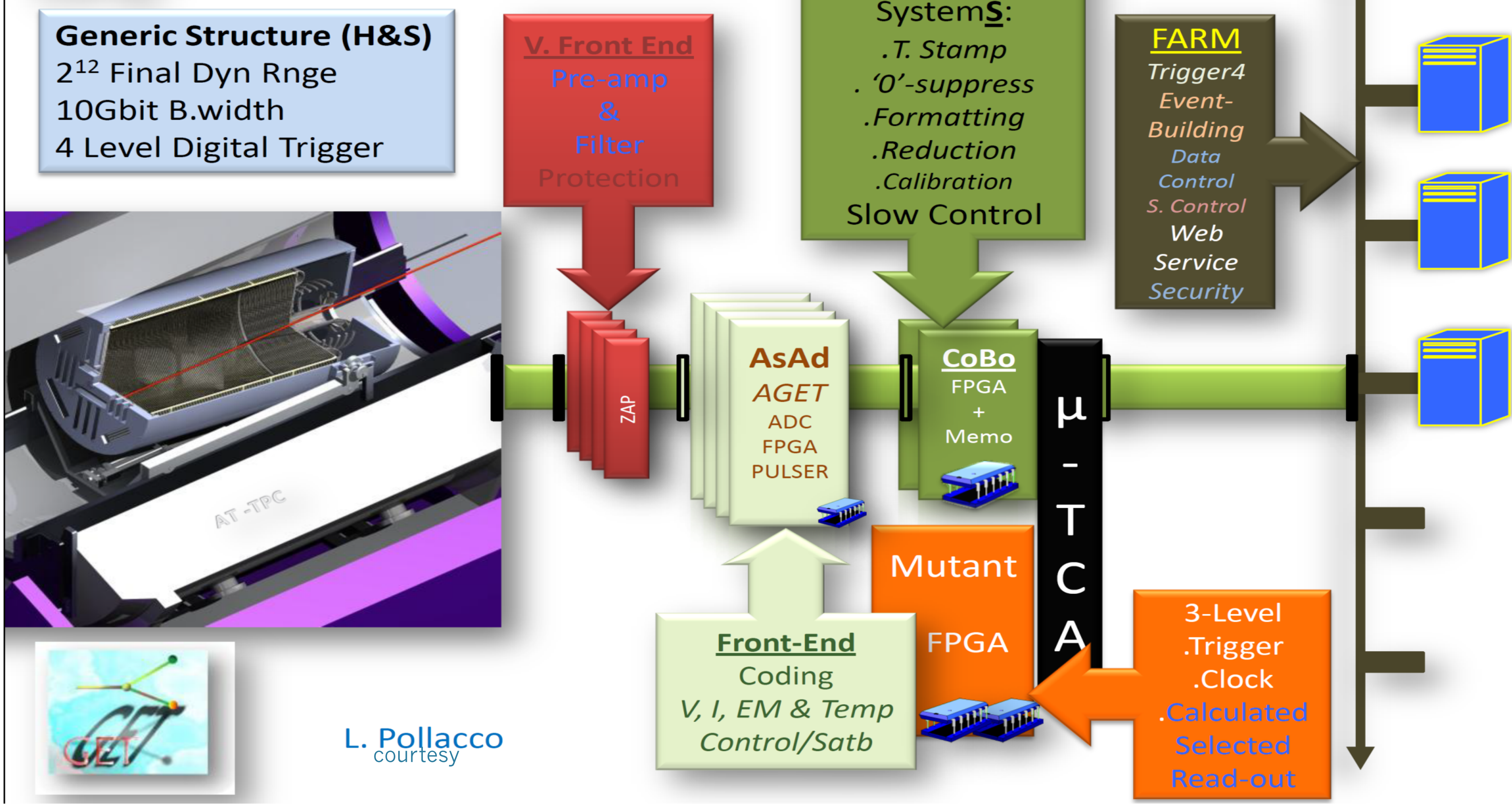
Comparison between the two ways

"Single-strip way"		"sum-strips way"	
✓	✗	✓	✗
Good Isotopic Resolution Not necessary energy calibration	Long identification work (100 Matrix for each telescope, possible if we have only 4 telescopes)	Fast identification work (16 matrix for each telescope, good for 20 telescopes) Good if not have large statistic	Worse isotopic identification resolution (at least for now!)
Wide identification range: 1≤Z≤10	Need a large statistic in each strip (0.2x6.4 cm)	Good if it is not necessary a wide identification range: 1≤Z≤2(3)	Necessary energy calibration (mV or better MeV
Good if the detector in near to the target (25cm)		Far to the target(0.8-1.0 m)	

In the case of the InKiIsSy experiment (only 4 telescopes) the "Single-Strip Way" is better and feasable

Test with GET Electronic

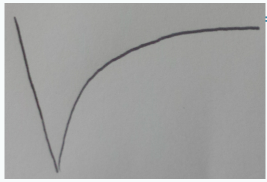
General Electronics for TPC



Test with GET Electronic

GET (General Electronics for TPC)

DSSSD or CsI(Tl) → PAC (Standard)



→ GET →

- High pass filter
- Amplifier
- 100 MHz sampling
- Storing 512point/5 μs
- Digitizing

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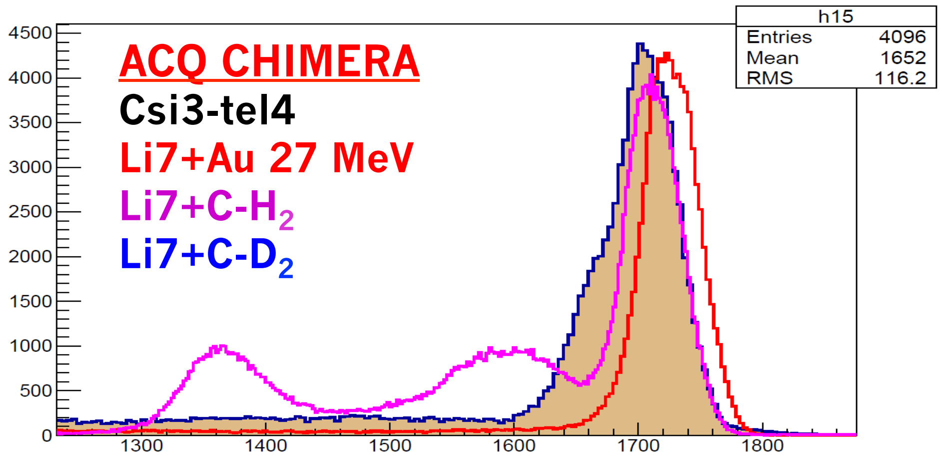
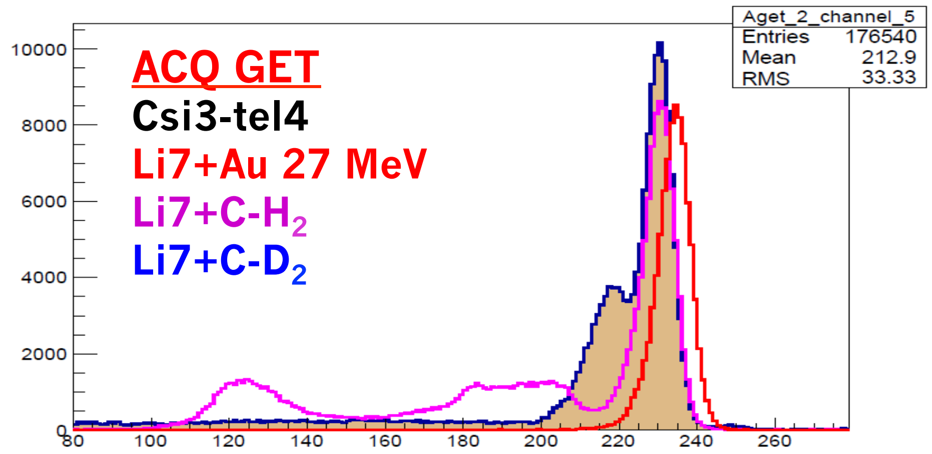
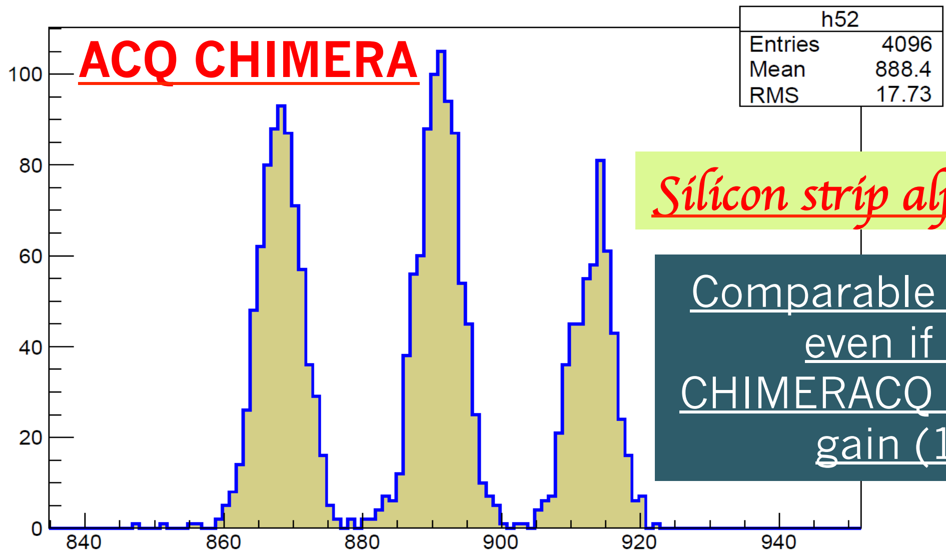
Test with GET Electronic: first results

Very Preliminary (March 2014)

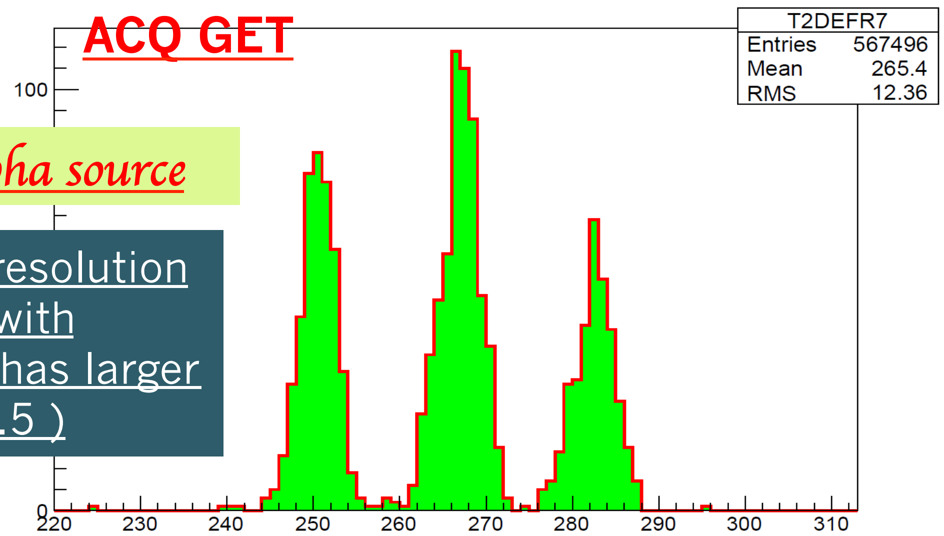






Silicon strip alpha source

Comparable resolution even if with CHIMERACQ has larger gain (1.5)



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FARCOS: perspectives

Milestones of FARCOS construction:

- 2015 (I semester): end of the GET tests and assembling 2 new telescopes (PRIN funds).
- 2015 (II semester): purchase electronics for 20 telescopes and beginning of the ASIC preamplifier tests.
- 2016: assembling of 6 new telescopes and submission batch for ASIC preamplifier.
- 2017: assembling of 4 new telescopes and submission batch for ASIC preamplifier.
- 2018: assembling of 4 new telescopes.
- 2019: available 20 telescopes completely of FARCOS

Estimation of FARCOS completion cost

- Si (300 μm + 1500 μm) + CsI(Tl): 316.5 K€
- GET Electronic for Si (5120 ch) and CsI(Tl) (80 ch) in double dynamic: 208.5 K€
- Spare parts 20%: 40 K€
- Power boards: 20 K€
- Mechanics (interface, flanges, etc.): 60 K€
- PAC (Different types): 80 K€
- Farm disk server and online analysis: 70 K€
- Unexpected (6%): 54.5 K€
- Total amount: ≈850 K€

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Conclusions

FARCOS at the moment has 4 telescopes under testing.
Preliminary analysis suggests that FARCOS is working well with good isotopic identification resolution and good energy and angular resolution.
For the future the goal is to develop same automatic procedures in order to make easer and faster the identification and calibration analysis.
GET electronic should represent a great opportunity to have a large number of channels (≈ 5000) compact and portable!
In the next years we should have more telescopes (20) in order to plane experiment coupling FARCOS with 4π detectors or magnetic spectrometer or other correlator arrays in order to give our contributions to the nuclear phenomena

Thanks for the attention

L. Acosta[10] , L. Auditore[4,5] , R. Bassini[7], C. Boiano[7], G. Cardella[3], A. Castoldi[6,7], M. Colonna[2], M. D'Andrea[3], F. Fichera[3], E. De Filippo[3], L. Francalanza[1,2], E. Geraci[1,3], N. Giudice[3], B. Gnoffo[1], A. Grimaldi[3], C. Guazzoni[6,7], G. Lanzalone[2,8], I. Lombardo[9], G. Marquínez-Durán[10], T. Minniti[1],E. Morgana, S. Norella[4,5], A. Pagano[3], E.V. Pagano[1,2], M. Papa[3], G. Passaro[2], S. Pirrone[3], G. Politi[1,3], F. Porto[1,2], L. Quattrocchi[4,5], F. Riccio, F. Rizzo[1,2], E. Rosato[9], P. Russotto[3], G. Saccà[3], A. Trifiro[4,5], M. Trimarchi[4,5] , G. Verde[3],M. Vigilante[9], P. Zambon[6]

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[10]University of Huelva