NUSYM15

5th INTERNATIONAL SYMPOSIUM ON NUCLEAR SYMMETRY ENERGY

INFN Istituto Nazionale di Fisica Nucleare

29 June – 2 July, Krakow -Poland

Status and perspective of the FARCOS detector array

E.V. Pagano[1,2]

for NewChim collaboration

Outlines

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- Introduction of the Physics case

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- The FARCOS Project status

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- Future perspectives

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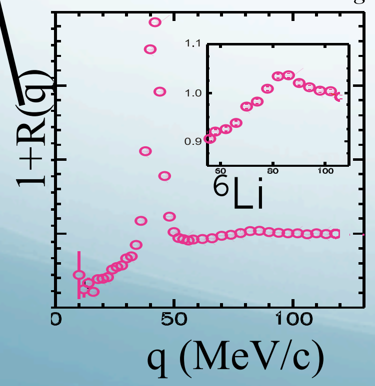

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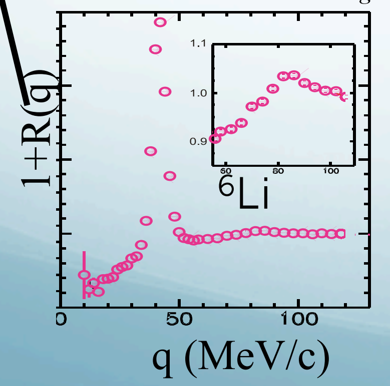

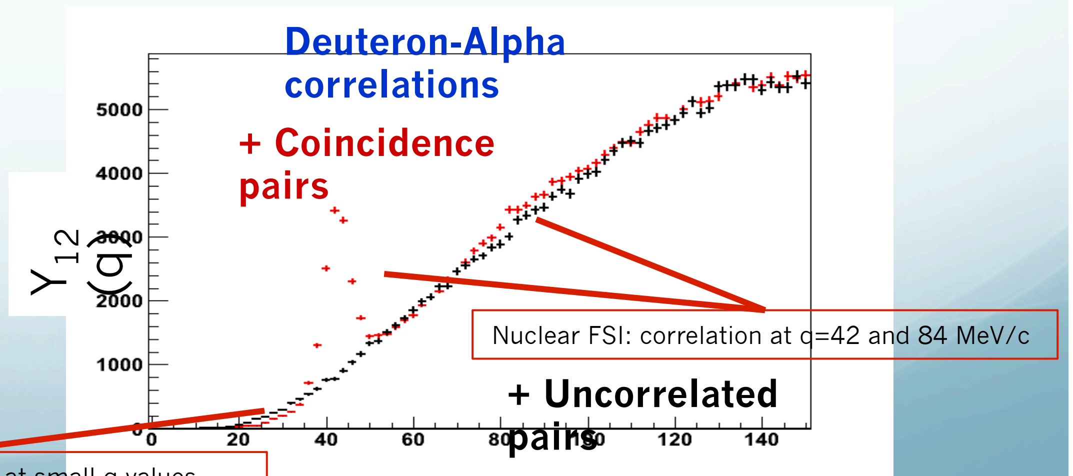

Coulomb FSI: anti-correlation at small q values

Theoretical correlation functions

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

Input Output

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

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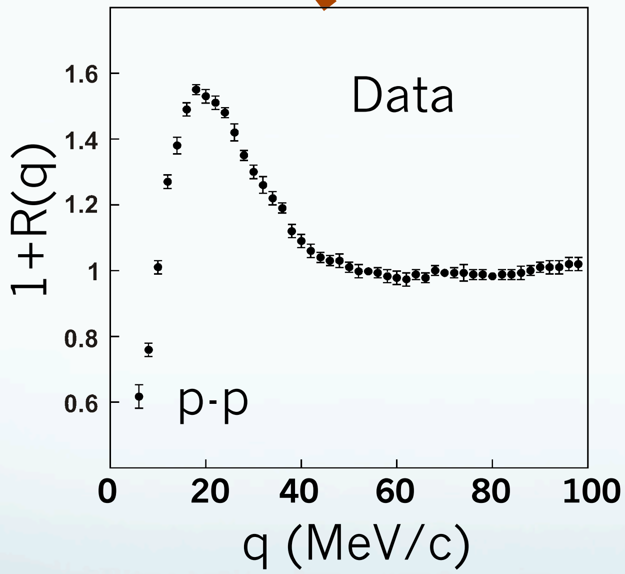

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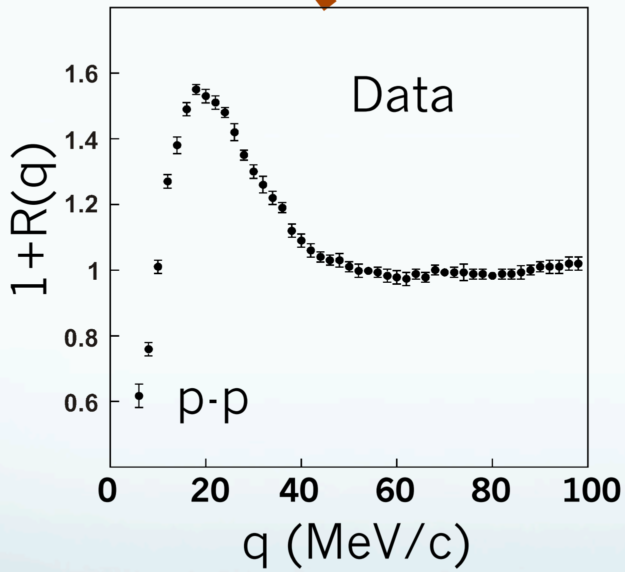

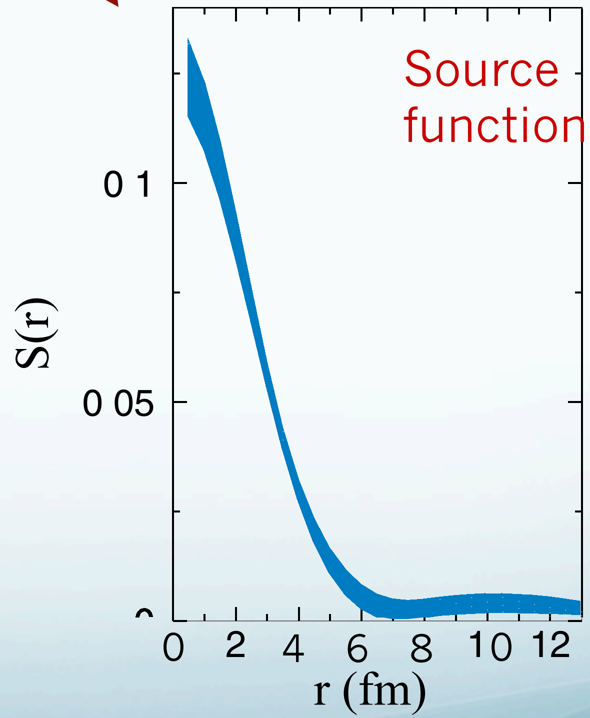

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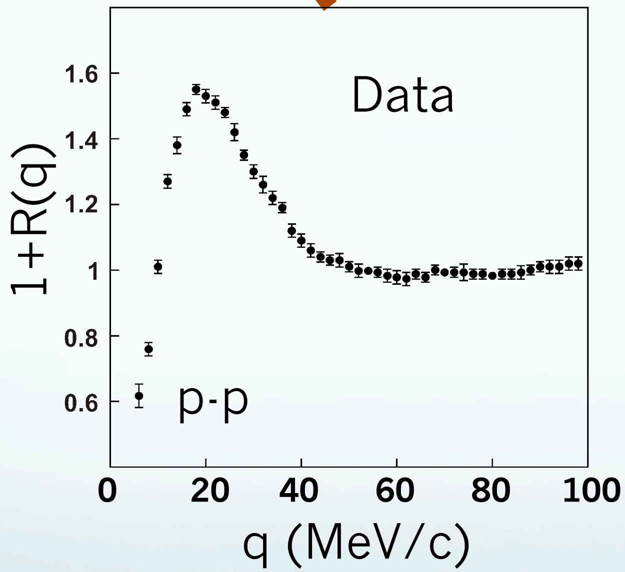
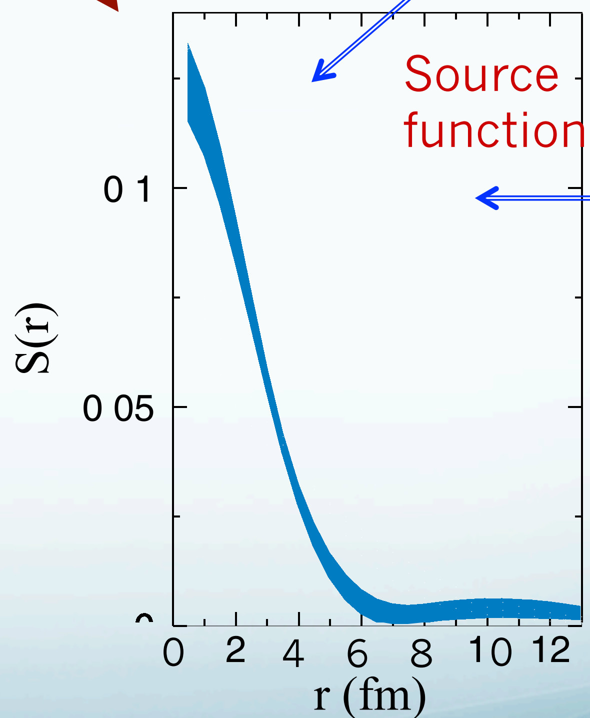


Imaging inversion



Gaussian
Fit

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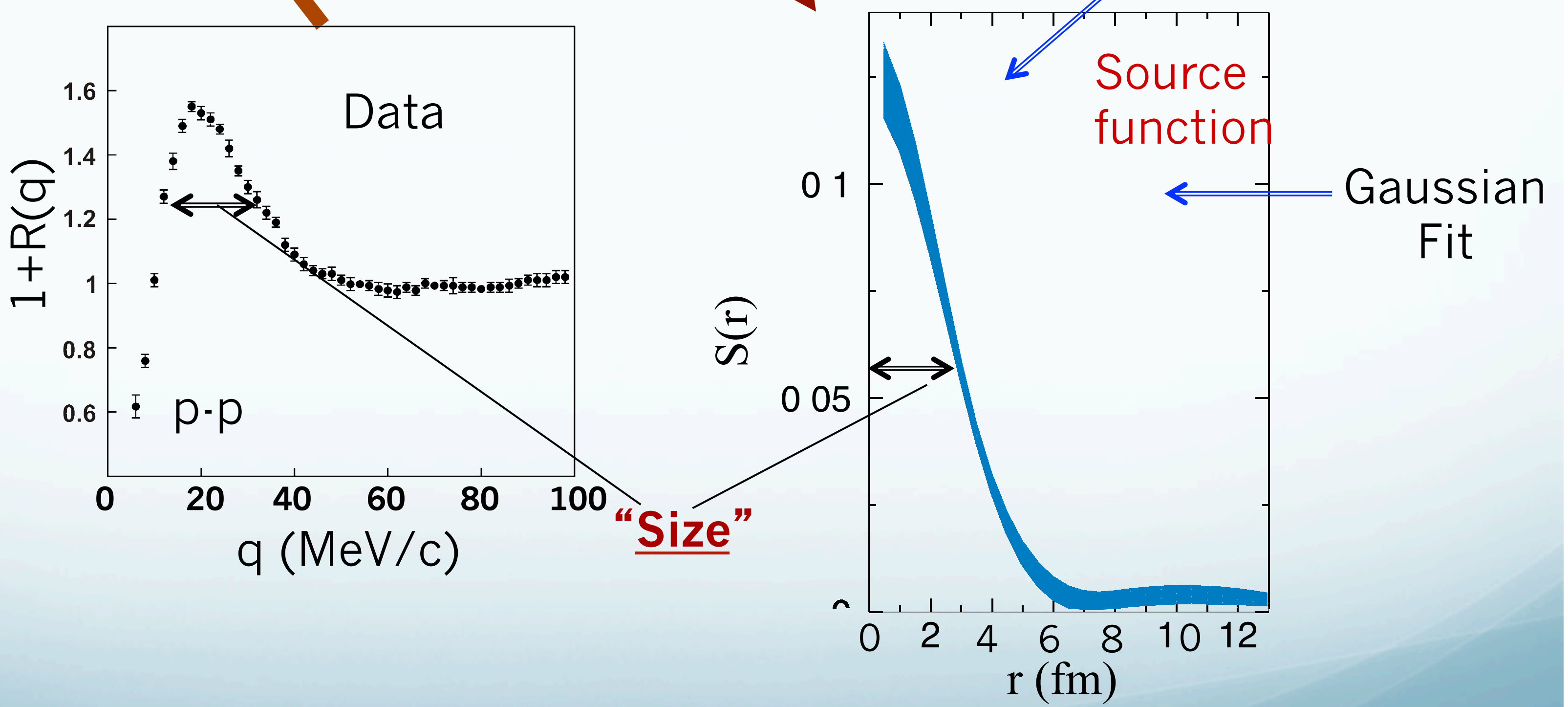

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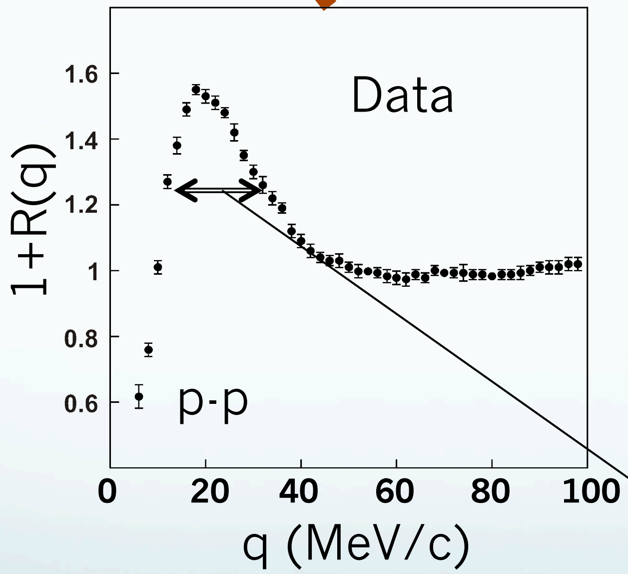
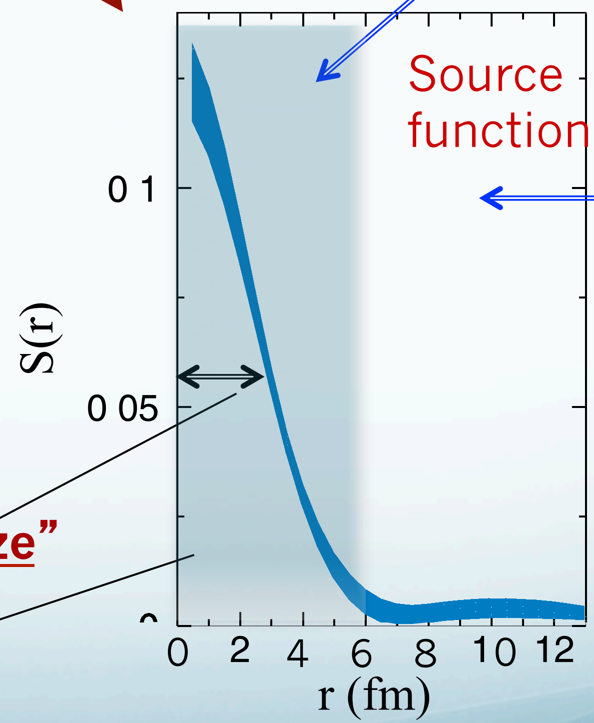


"Size"



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

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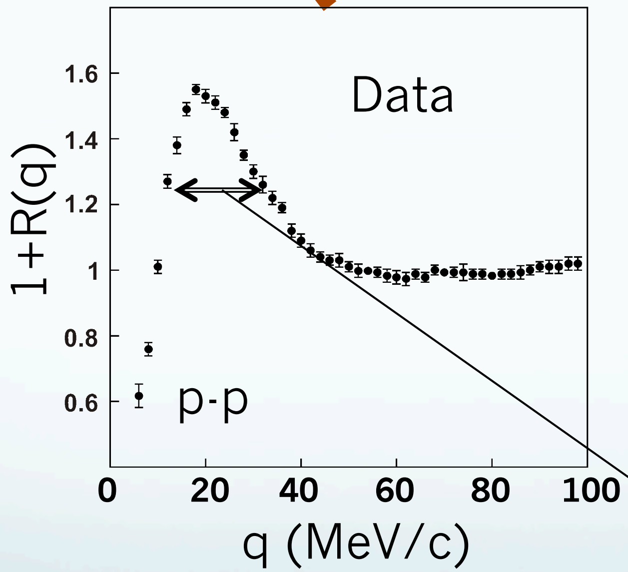

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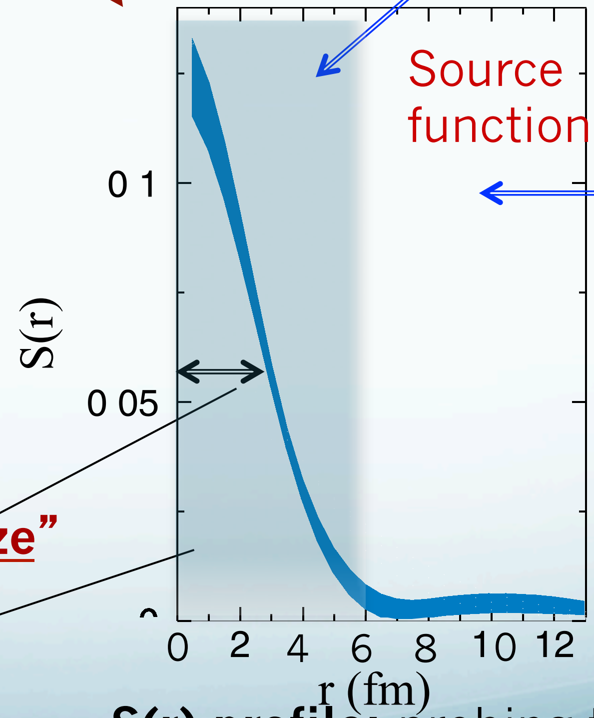


Gaussian Fit

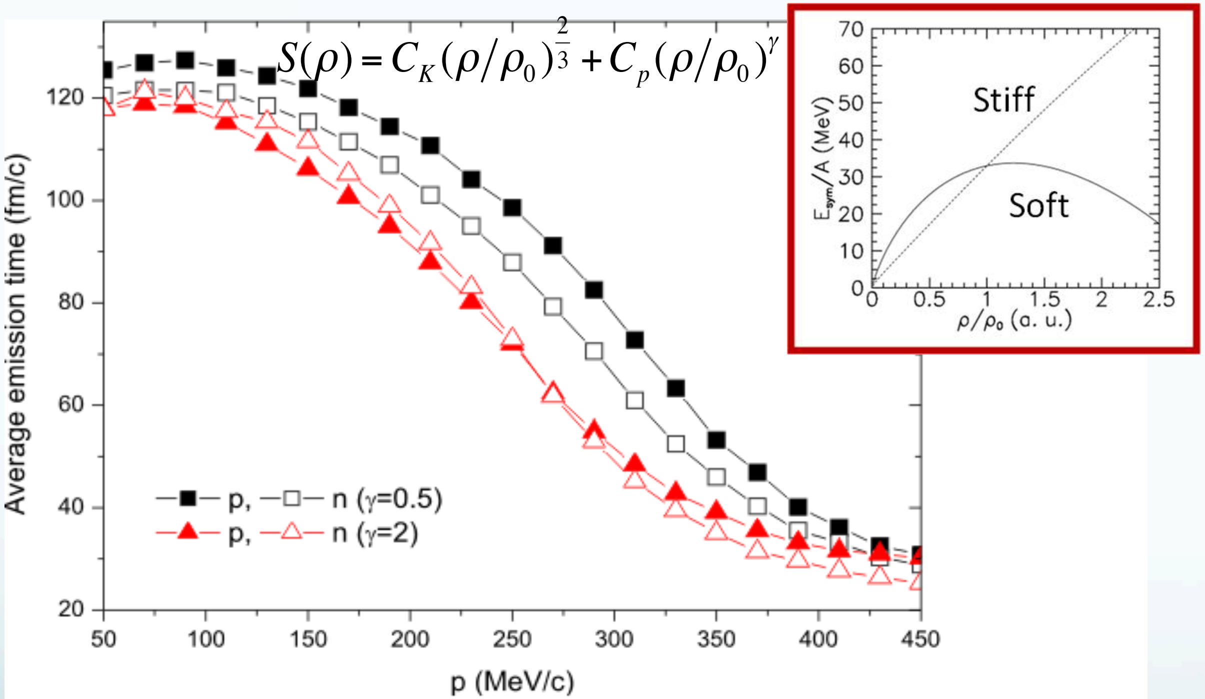
Integral of S(r) λ_{fast} = fraction of proton pairs from early dynamical emissions (NN collisions and EoS effects)

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

Space-time probes at dynamical stage

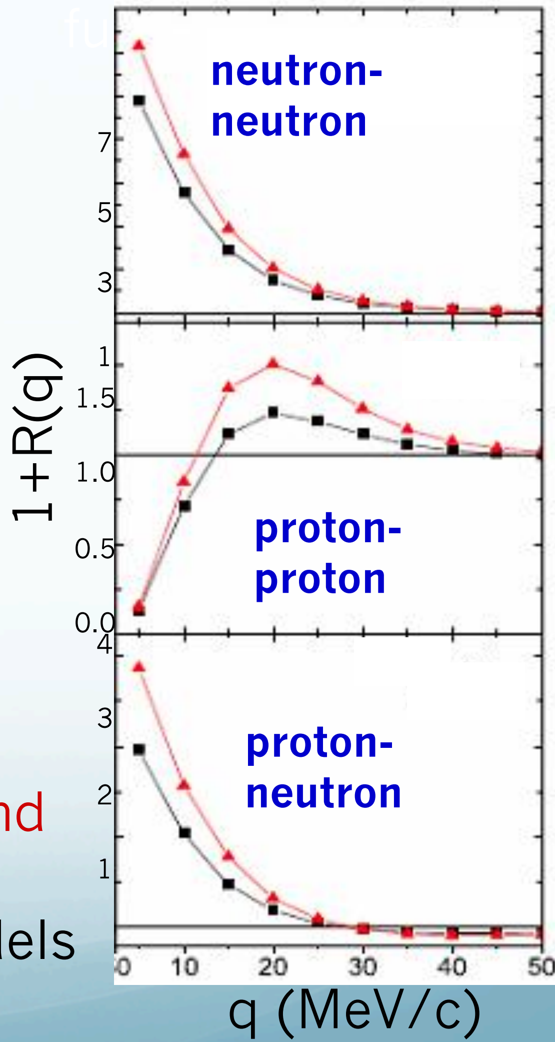
IBUU simulations

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



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

Correlation



Correlations with dynamically emitted protons and neutrons

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

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- Nuclear Spectroscopy

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    - HIC at Intermediate energy as tools of exotic nuclei

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  - Multi-particles correlations (boson condensate)

see L. Quattrocchi talk

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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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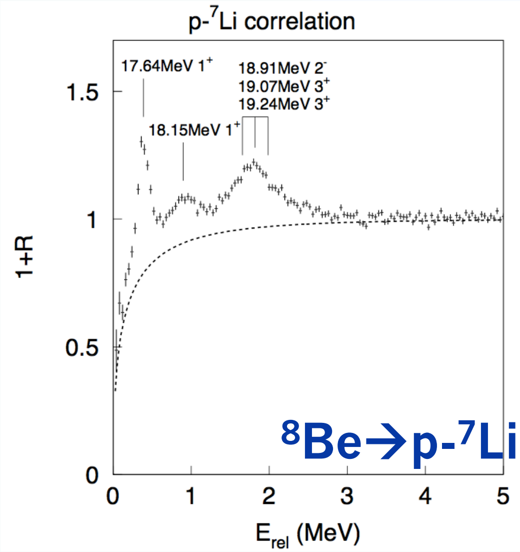

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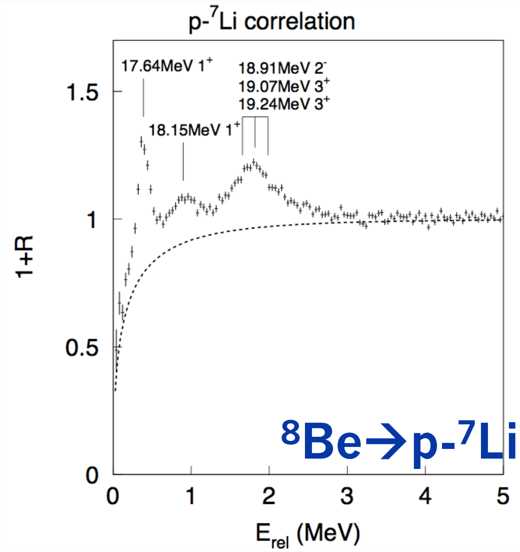

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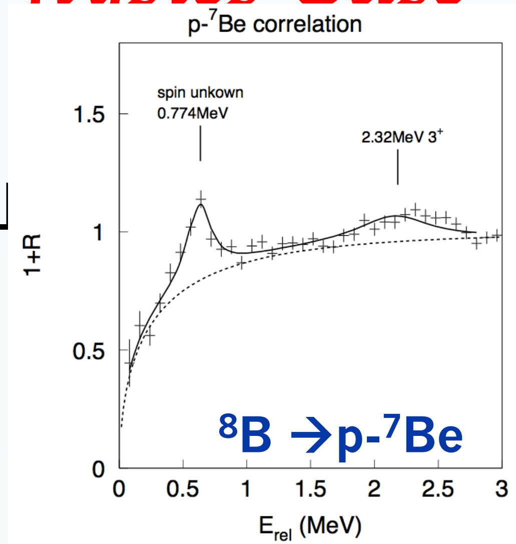

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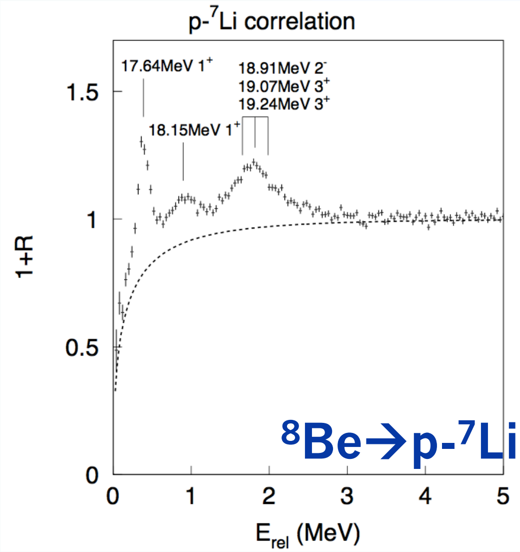

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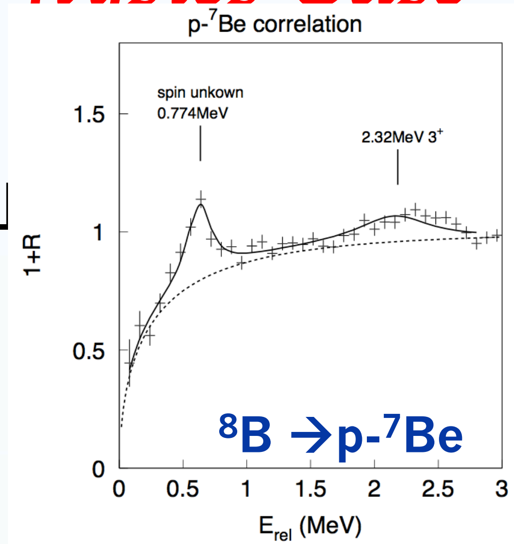

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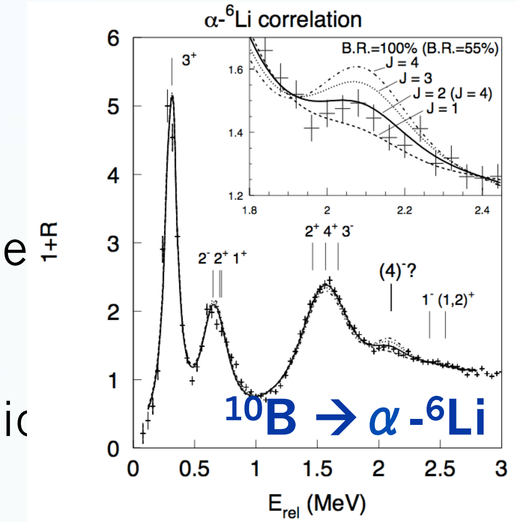

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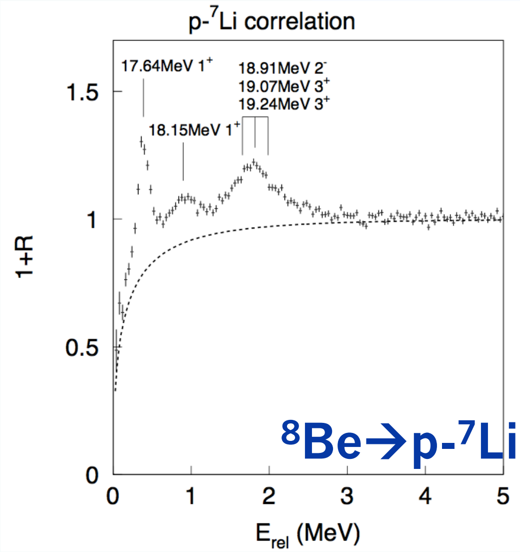

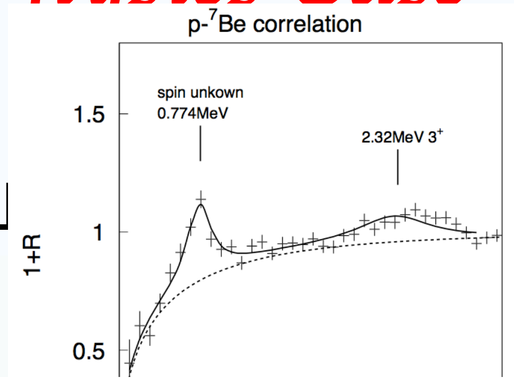

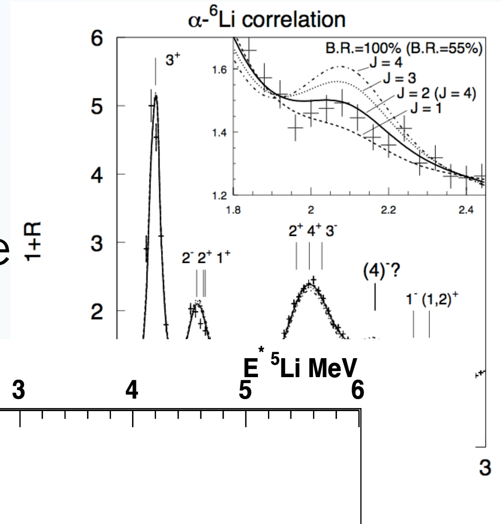

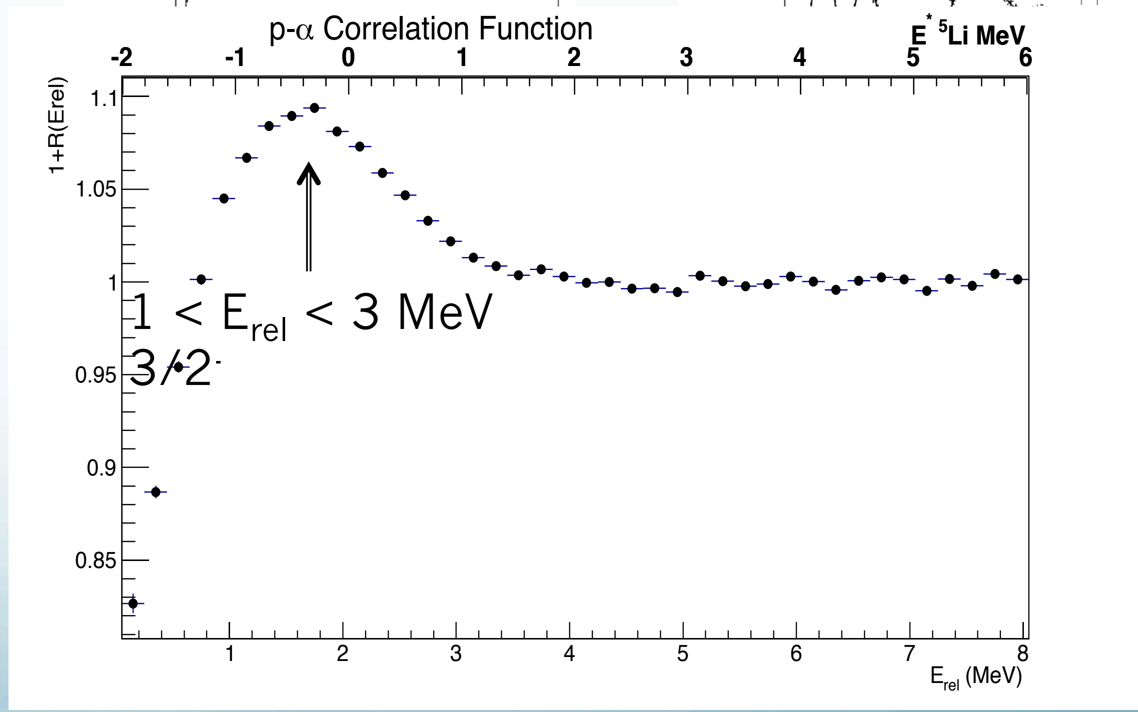

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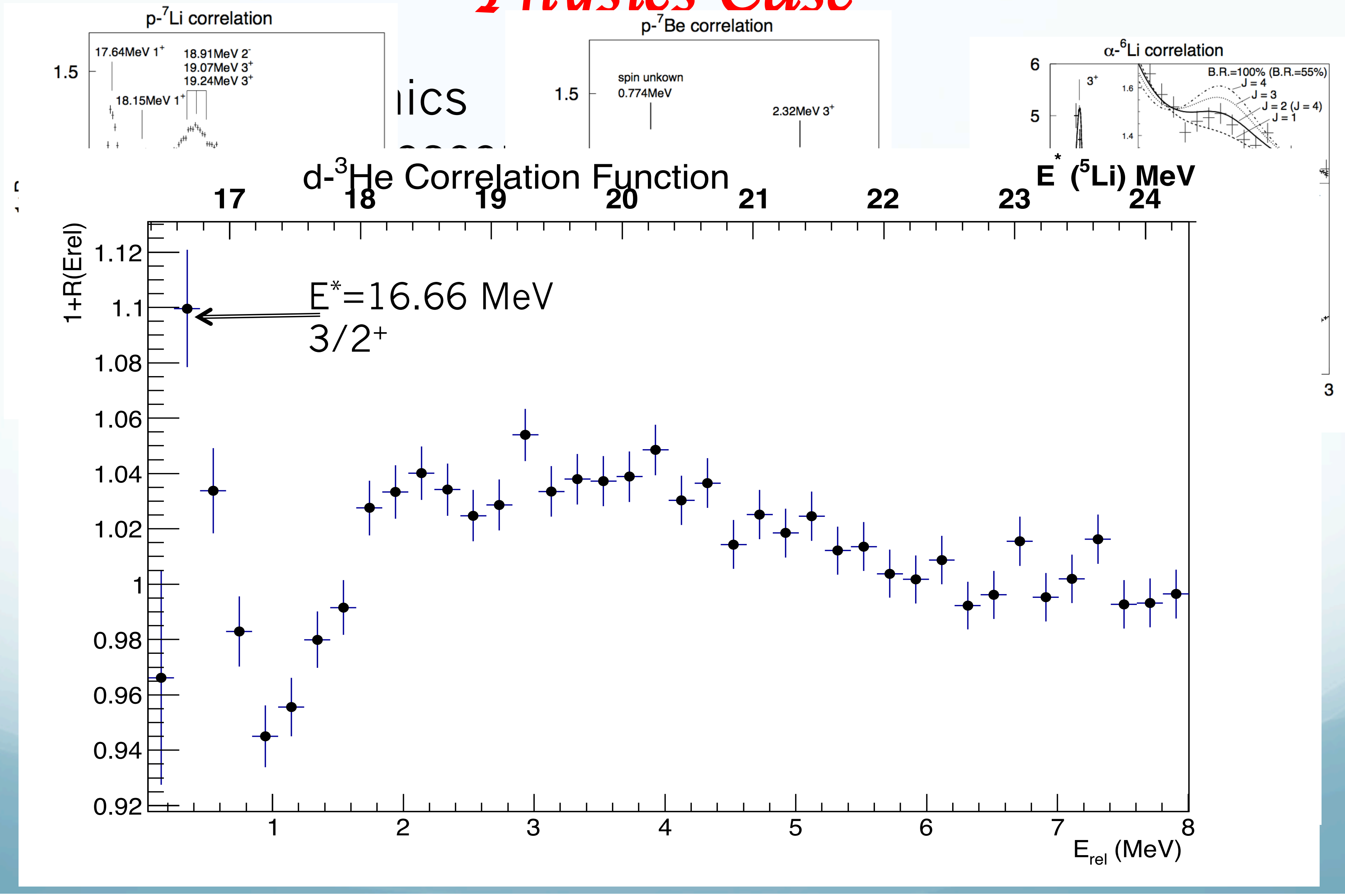

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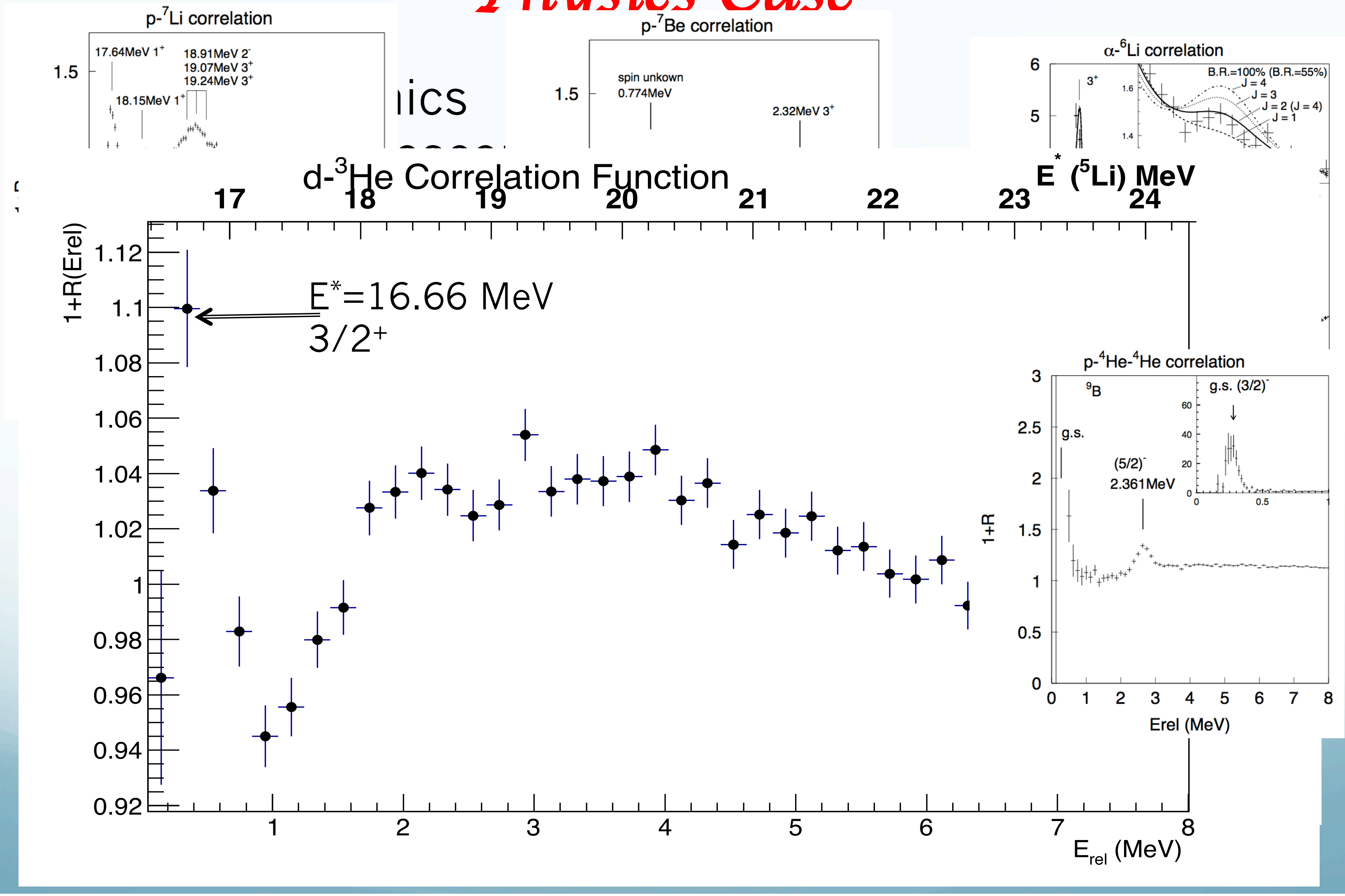

Krakow, Poland
2 July, 2015

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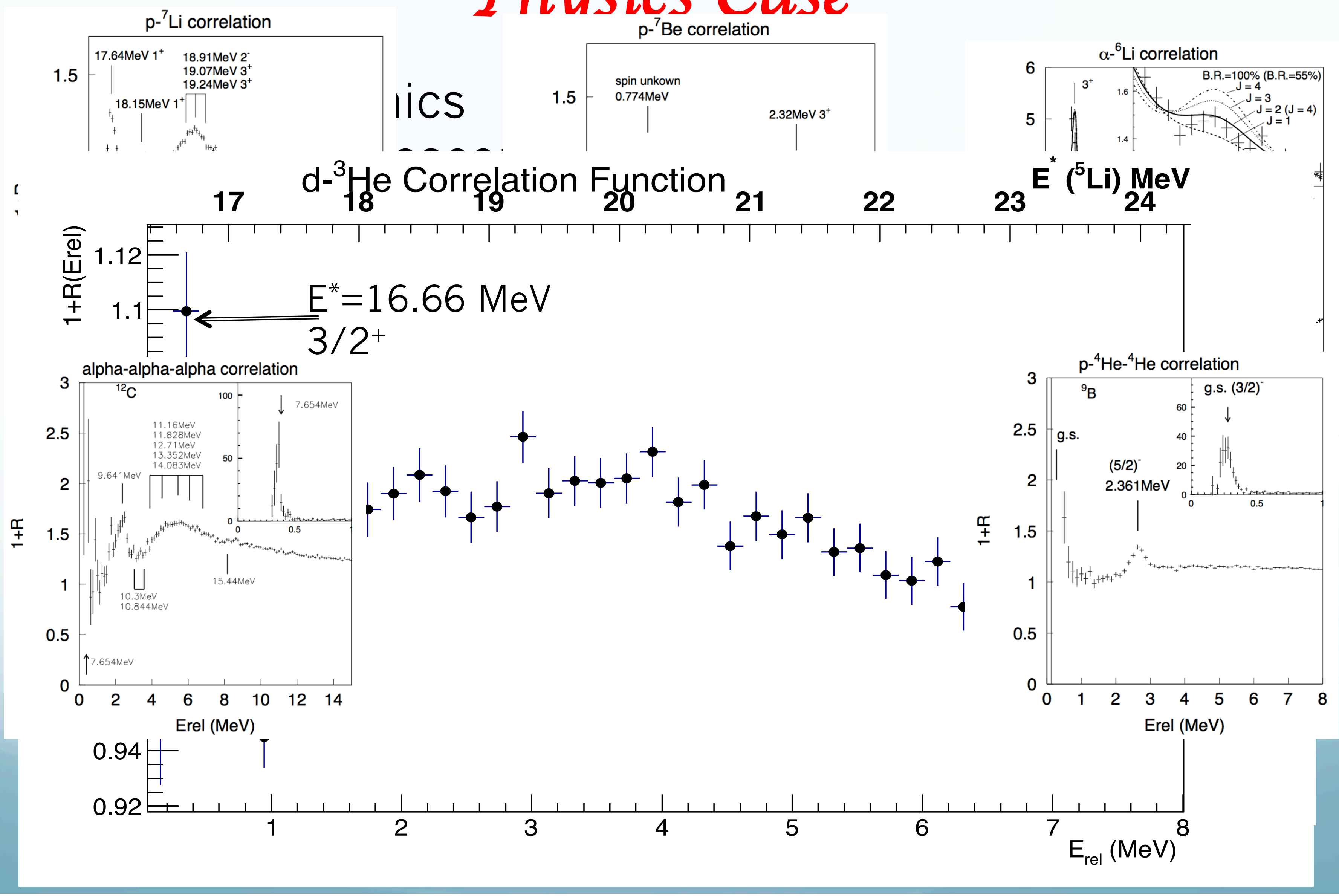

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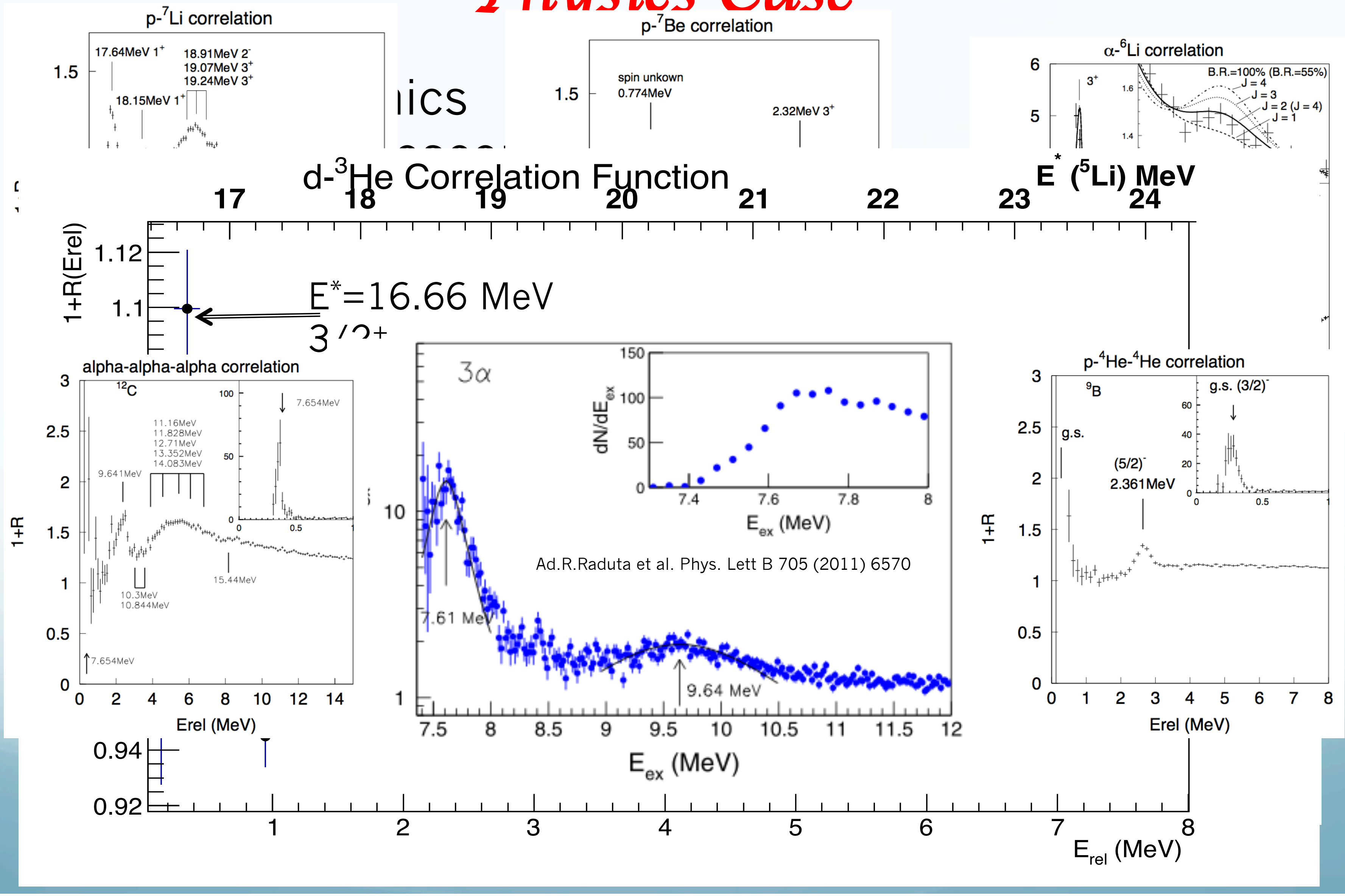
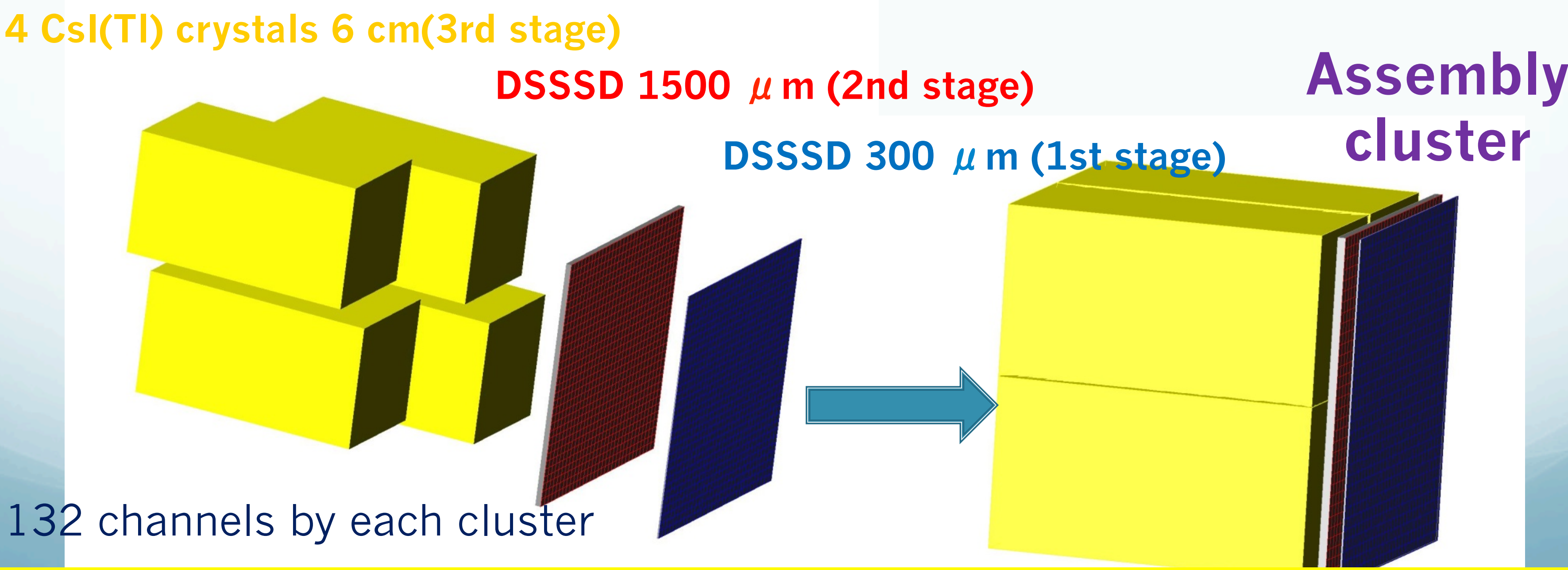


FARCOS
(Femtoscope ARray for COrrelations and Spectroscopy)

- 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 (Femtoscope ARray for Correlations and Spectroscopy)
- Modular array of telescopes
- High energy and angular resolution
- ΔE/E discrimination, pulse-shape discrimination and possible TOF discrimination like in 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(Tl).
- Portability and modularity to be coupled to 4π detectors as CHIMERA or magnetic spectrometers
- Integrated and reconfigurable electronics
- Possibility of updating and upgrades

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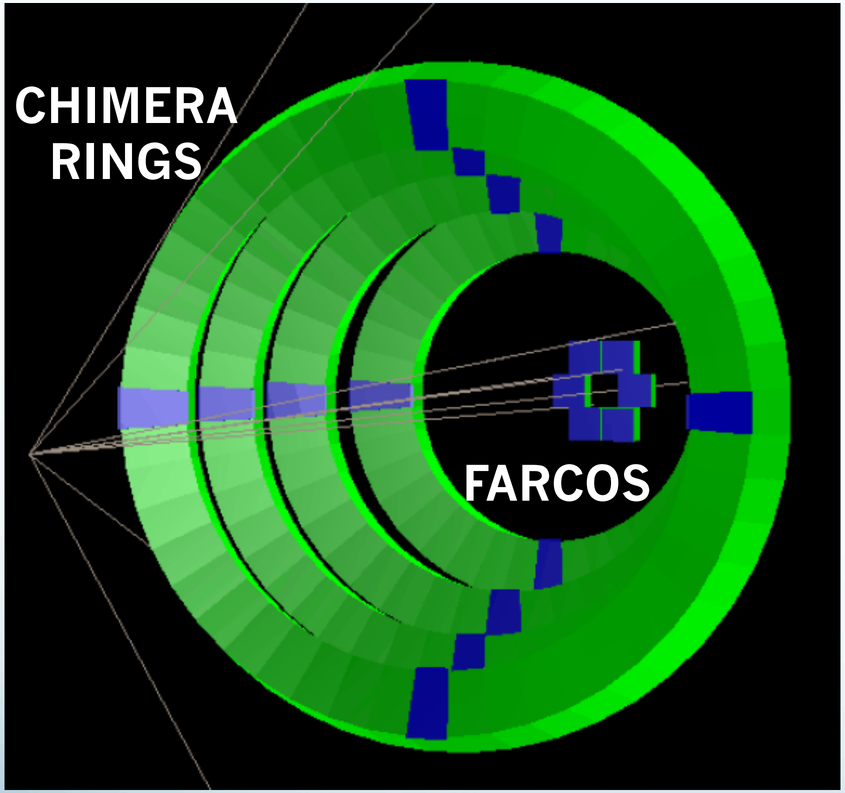
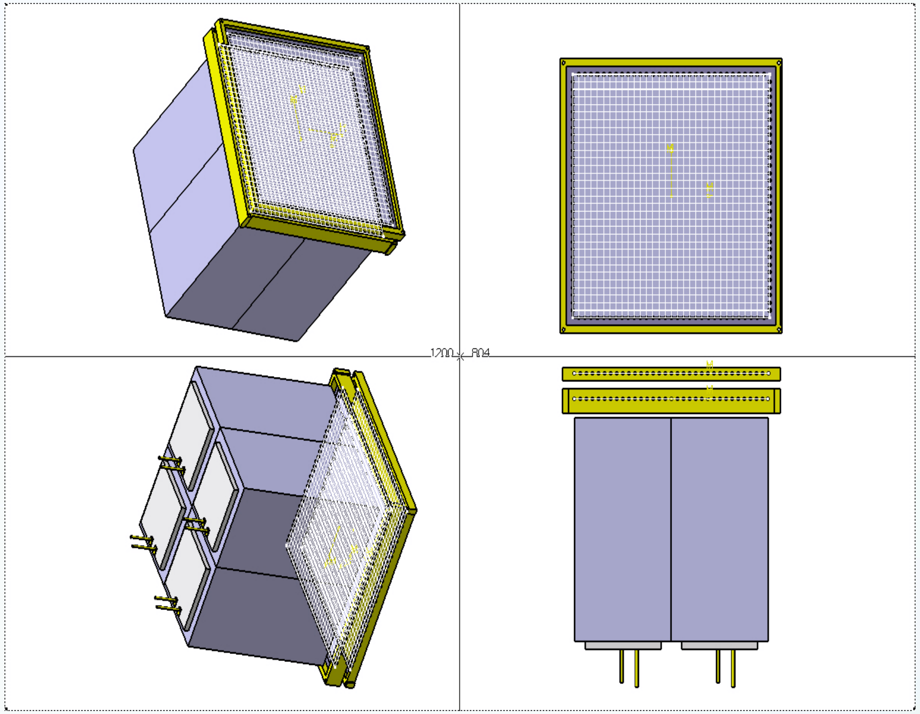
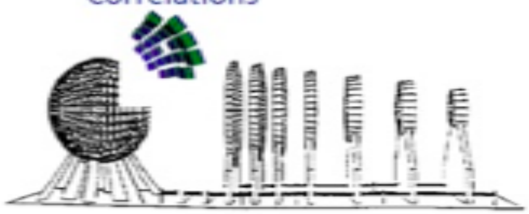
Coupling FARCOS with CHIMERA





Operations with 4π detectors

Farcos + 4π array



Heavy-ion collisions
Direct reactions

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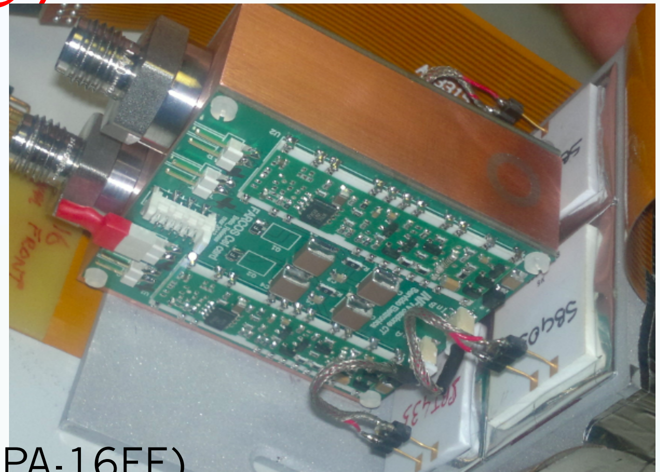
Electronic (PAC)

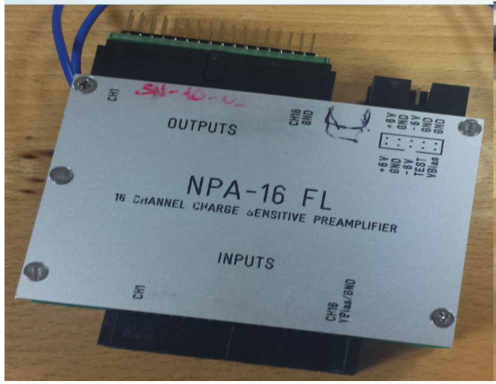


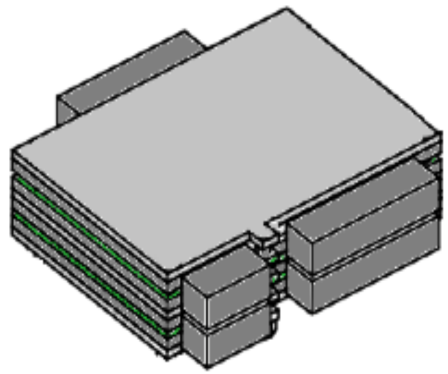
- CsI Crystals: Standard PAC "CHIMERALIKE"
- DSSSD: 32 Ch PAC (INFN-MI)

Features: *Ref From Net.Instruments*

- 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





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Test of FARCOS with beam @ LNS-INFN (April 2013)

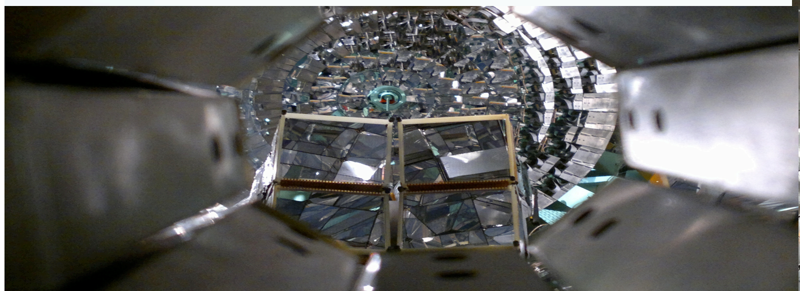
Chimera+FARCOS prototype

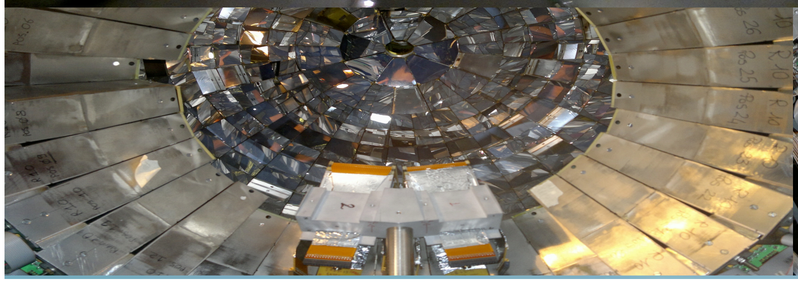
Test with beam was made during the InKiIsSY experiment (INverse KInematic ISobaric SYstem)

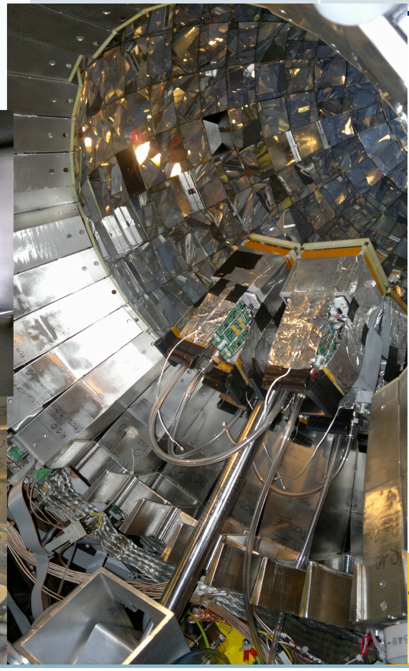
The idea of the this experiment is to use projectile/target combination having the same mass of the neutron rich $^{124}Sn+^{64}Ni$ system a N/Z similar to the neutron poor $^{112}Sn+^{58}Ni$ one, that is $^{124}Xe+^{64}Zn$, at the same bombarding energy of 35 MeV/u using the 4π detector CHIMERA and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

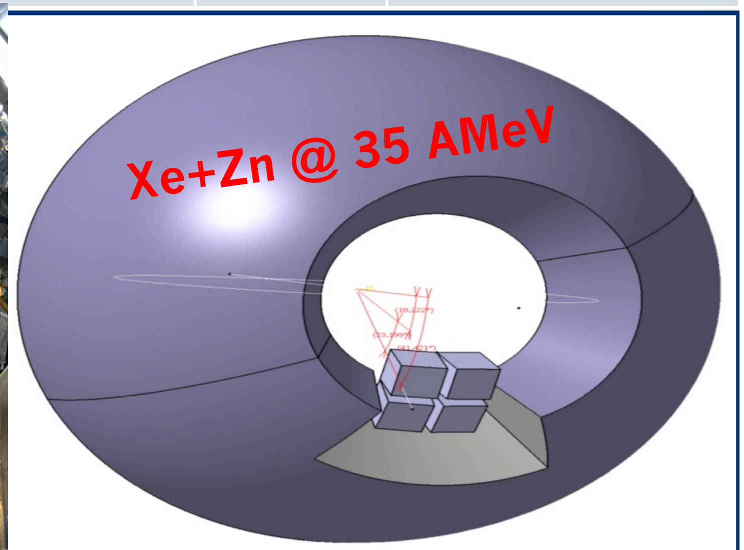
P. Russotto *et al.*, Phys. Rev. C 81, 064605 (2010).

System	N/Z Projectile	N/Z target	N/Z Coumpound
$^{124}Sn+^{64}Ni$	1.48	1.29	1.41
$^{112}Sn+^{58}Ni$	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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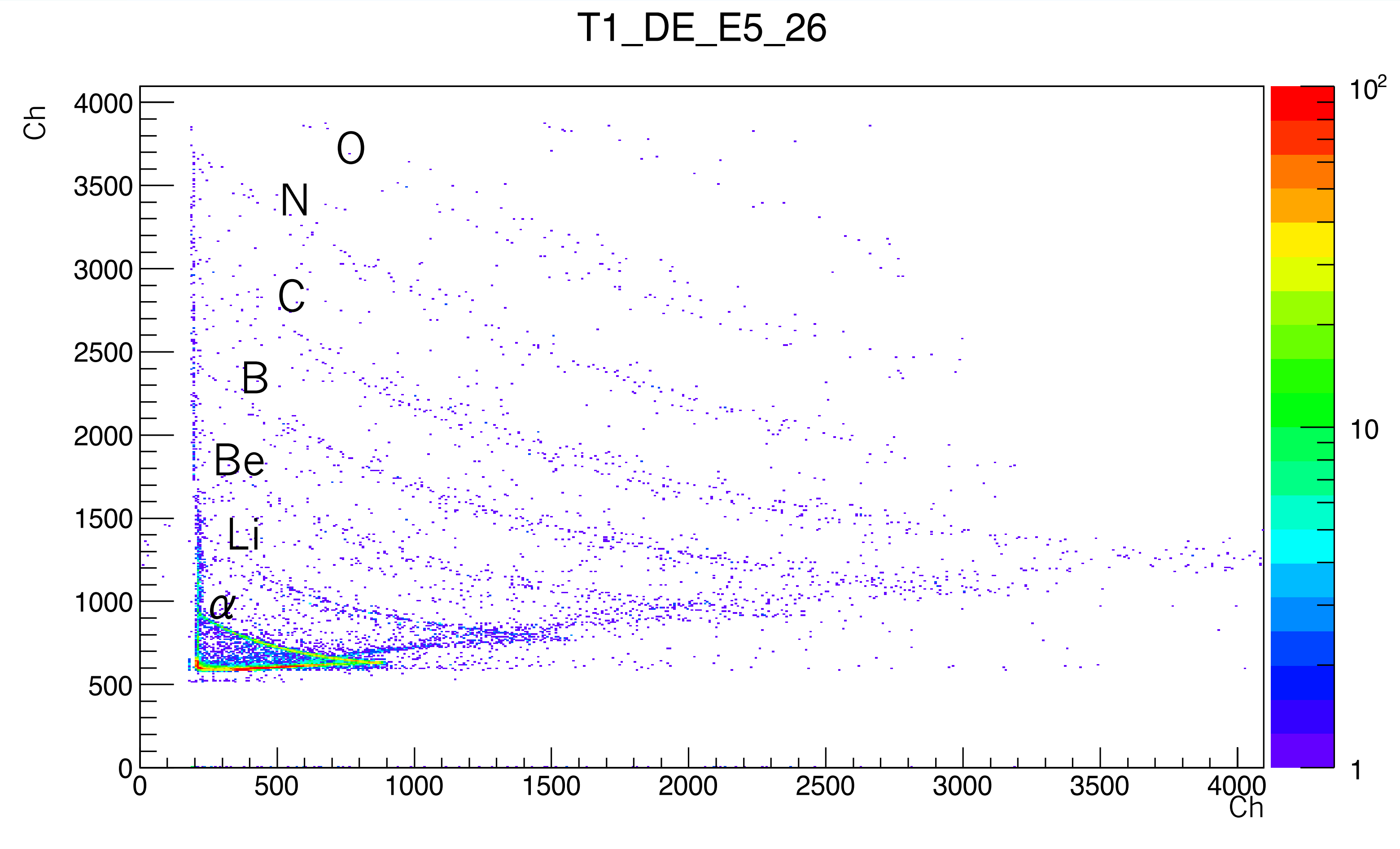

Identifications and calibrations

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- Strips by strips it means about 100 identification matrices 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)

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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 among the strips is negligible. But the electronic channels are completely independent and for this reason it is possible to use a pulse signal to homogenize all the strips.

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  - 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 among the strips is negligible. But the electronic channels are completely 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?

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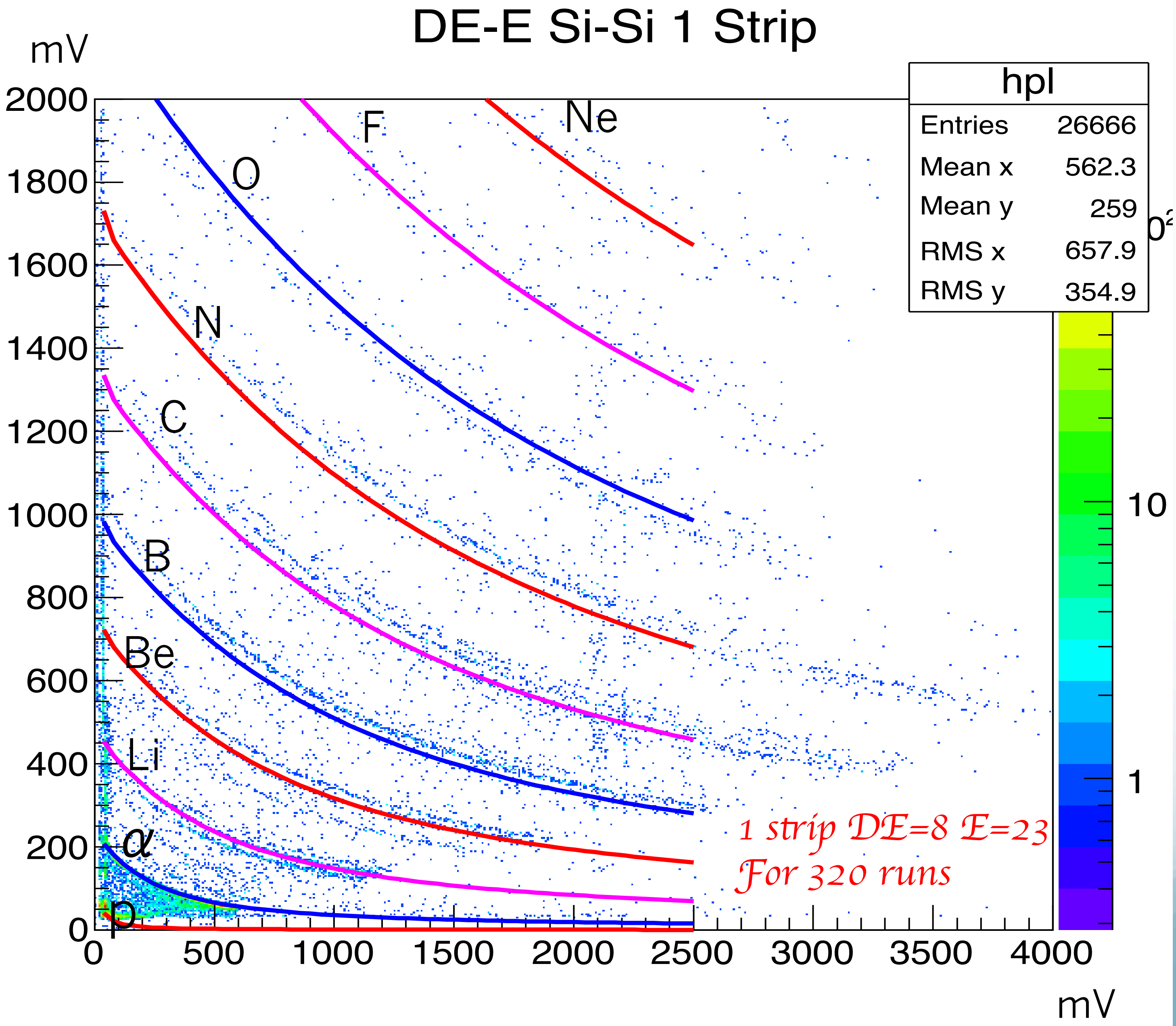

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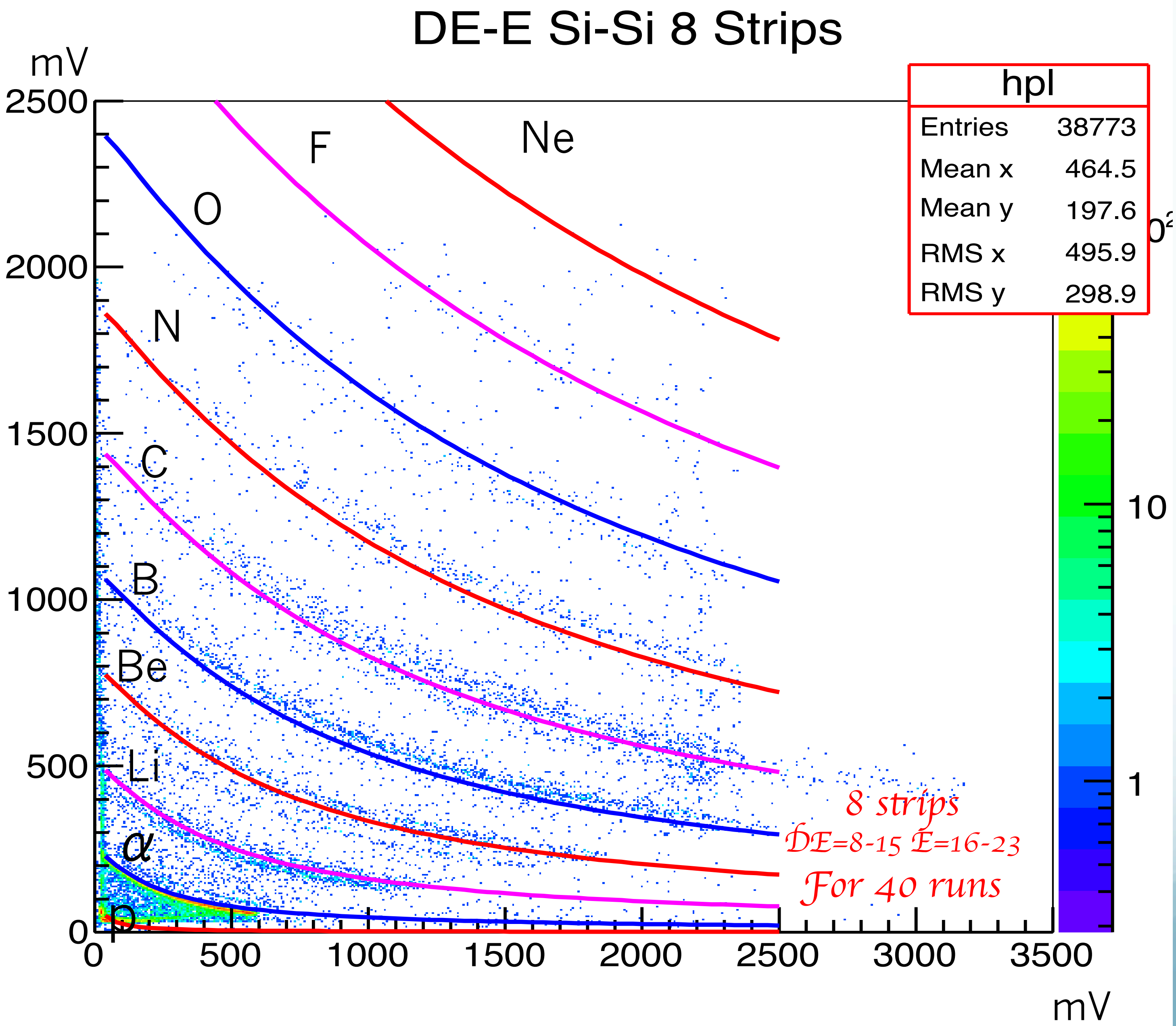

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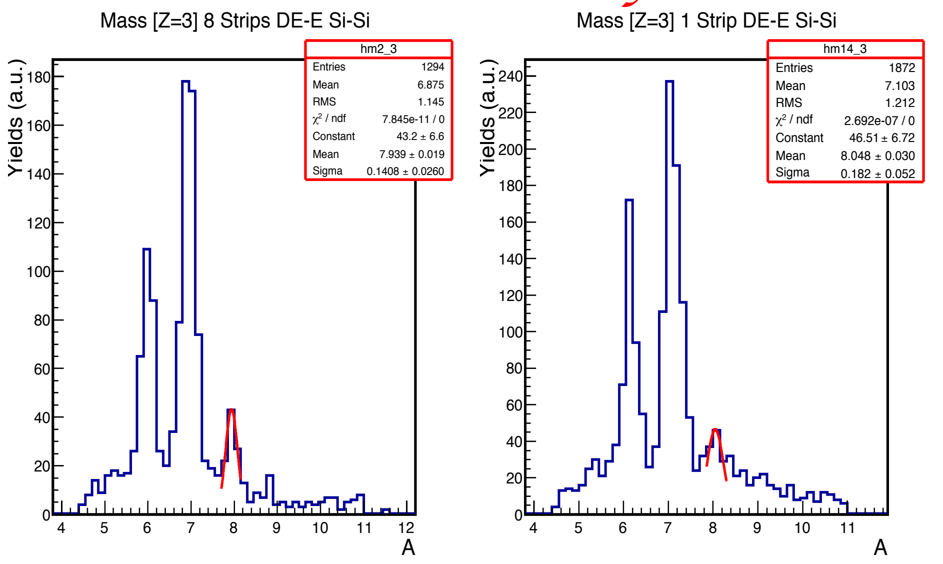
Comparison between the two ways



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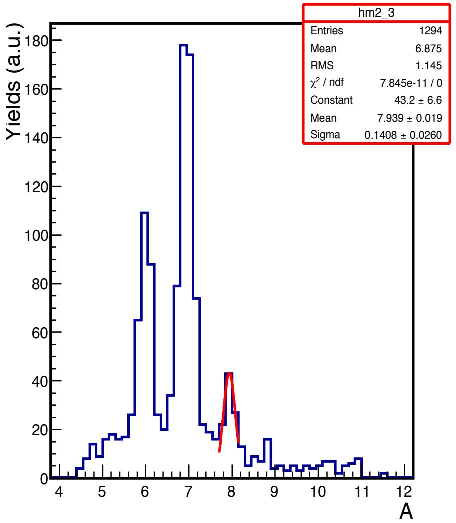
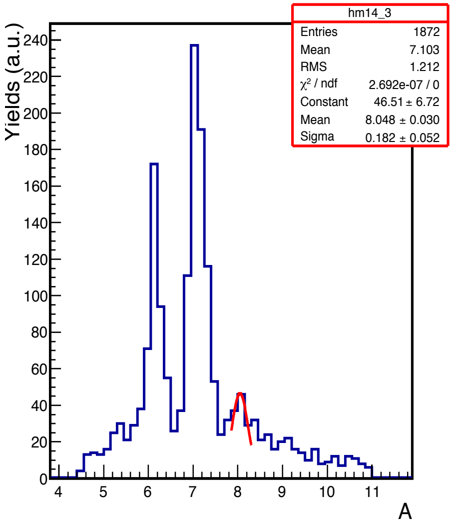
Comparison between the two ways

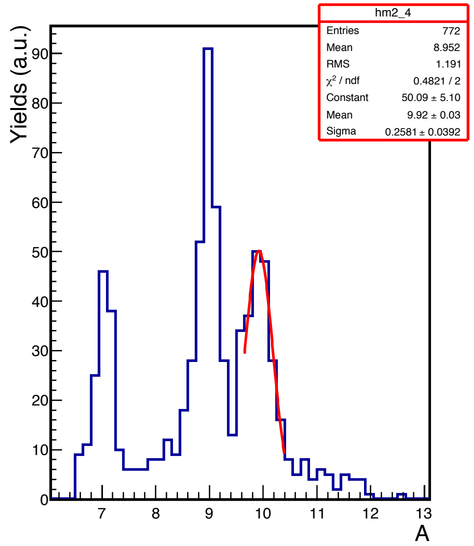
Mass [Z=3] 8 Strips DE-E Si-Si



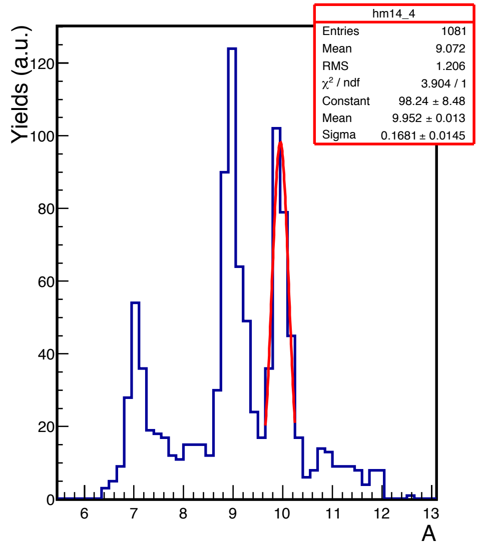
Mass [Z=3] 1 Strip DE-E Si-Si



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



Mass [Z=4]



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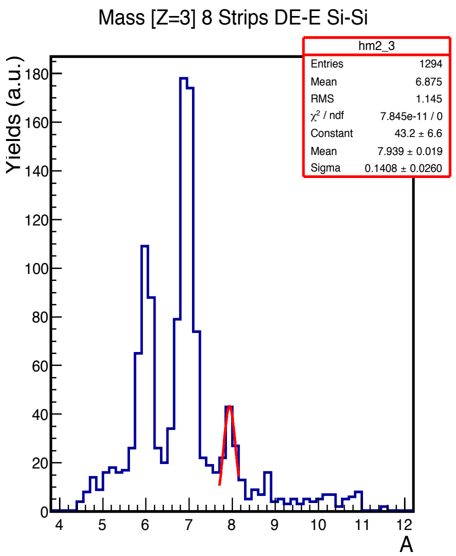

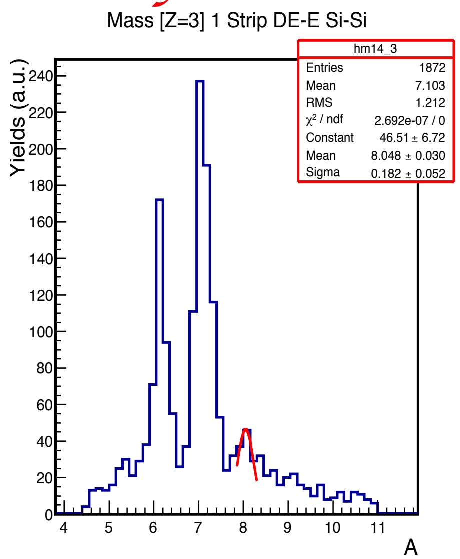

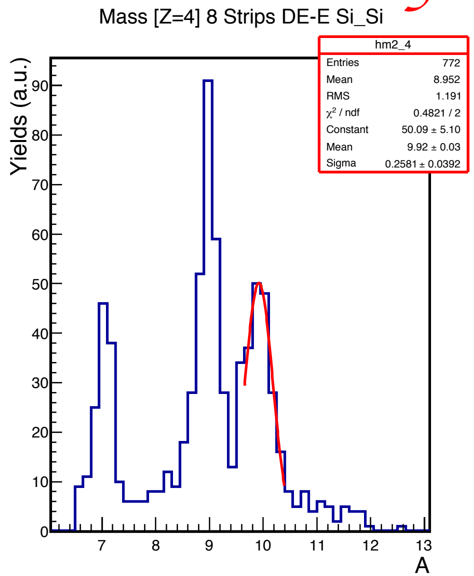

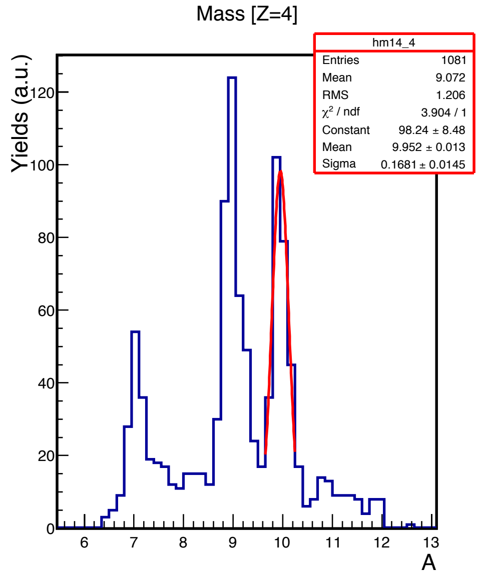

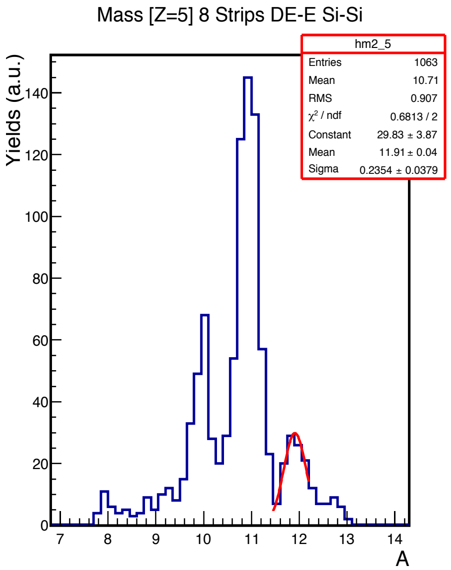

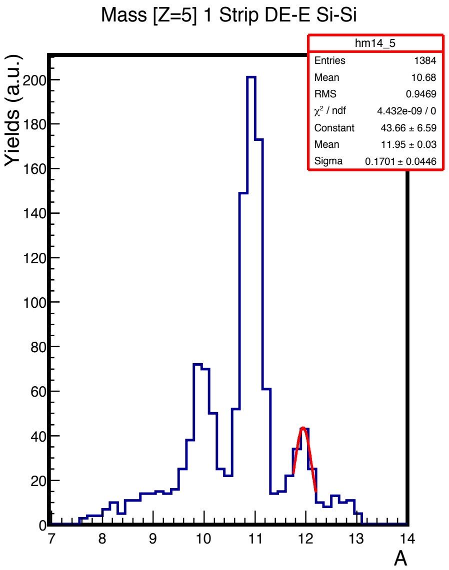

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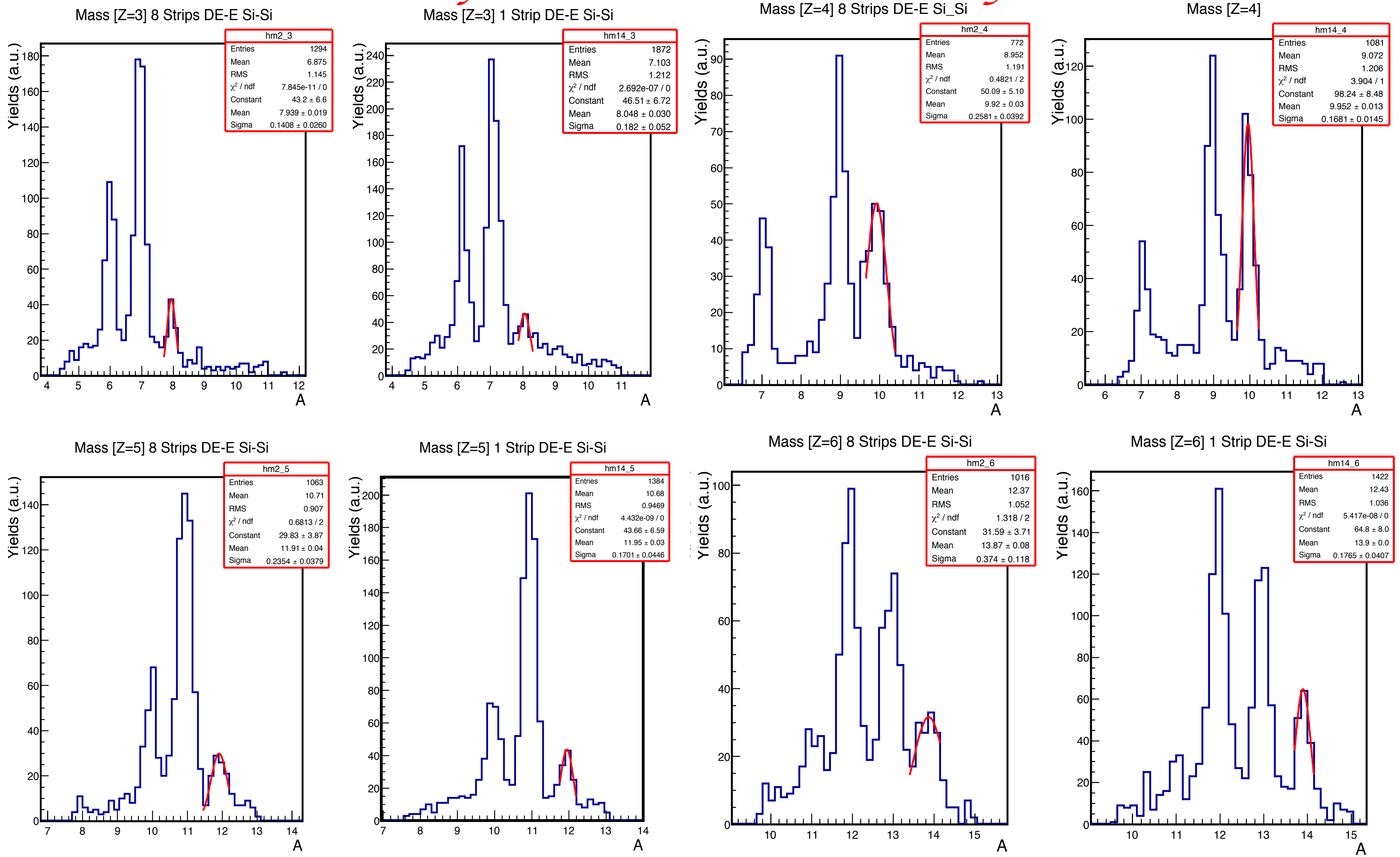
Comparison between the two ways



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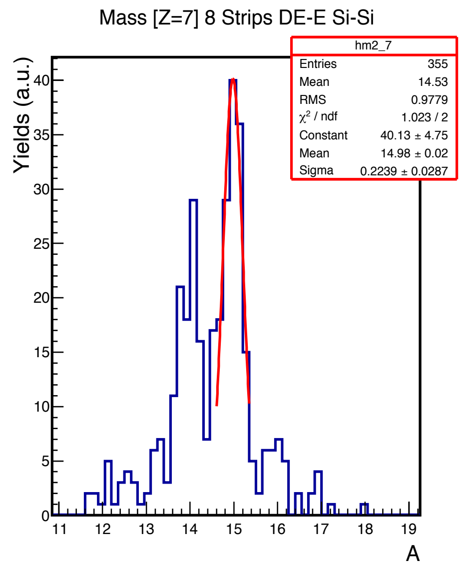
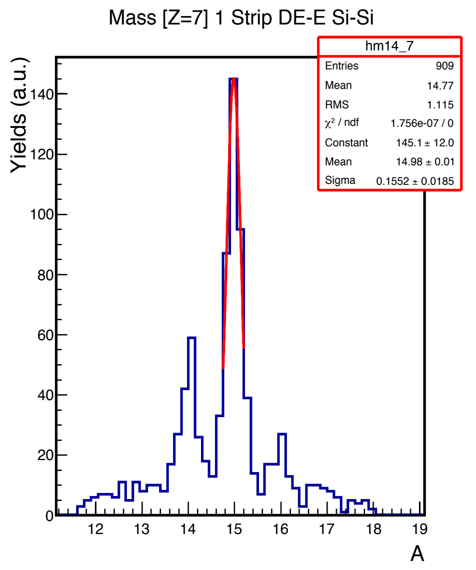
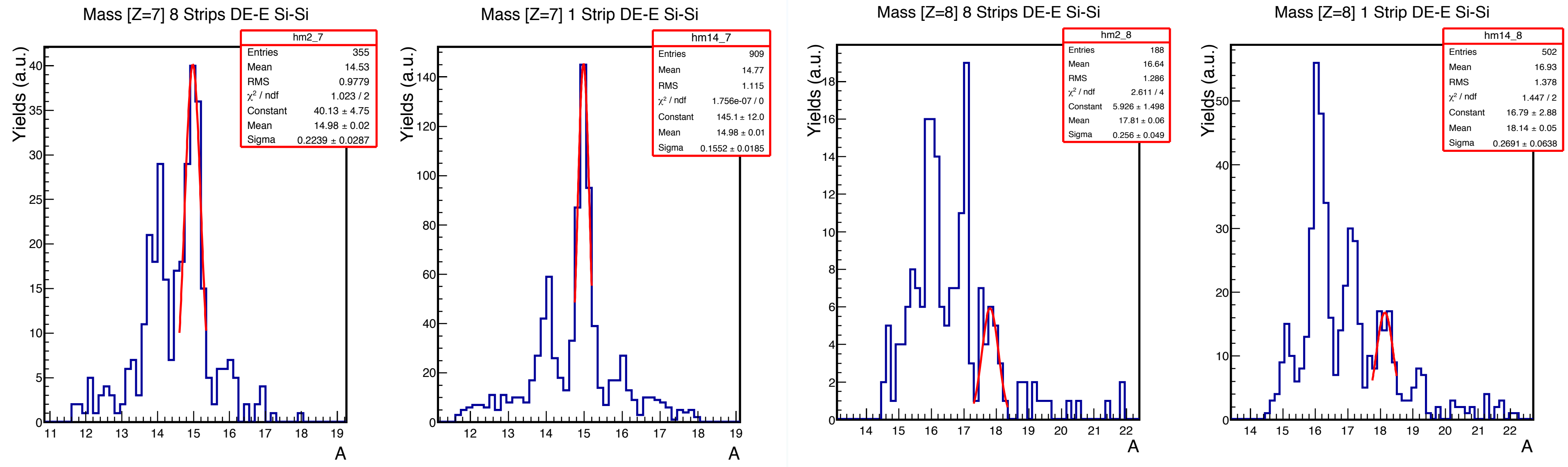




Comparison between the two ways



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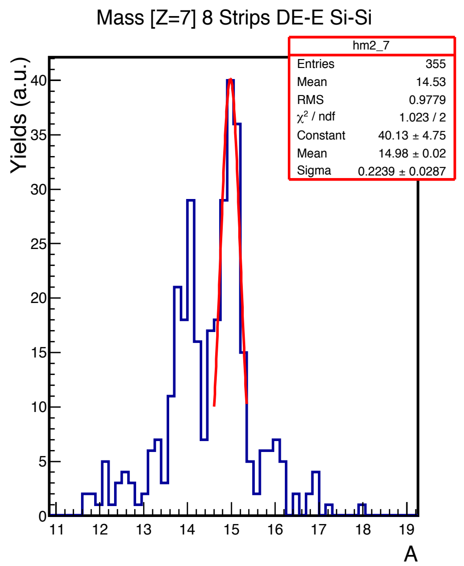

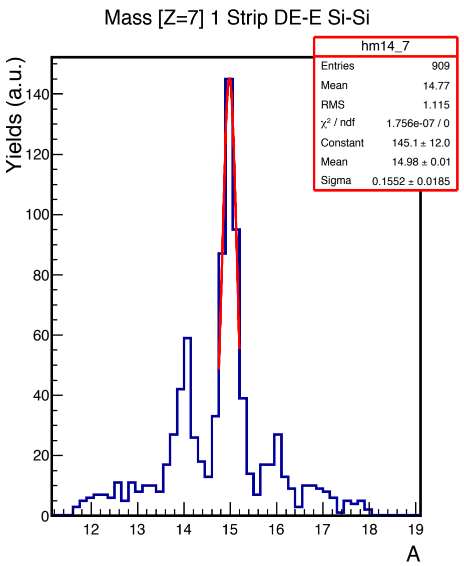

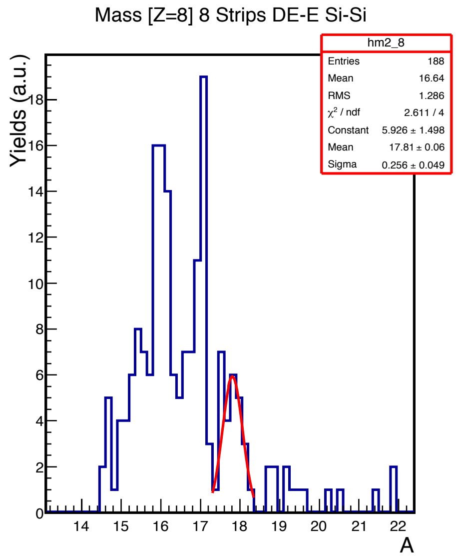

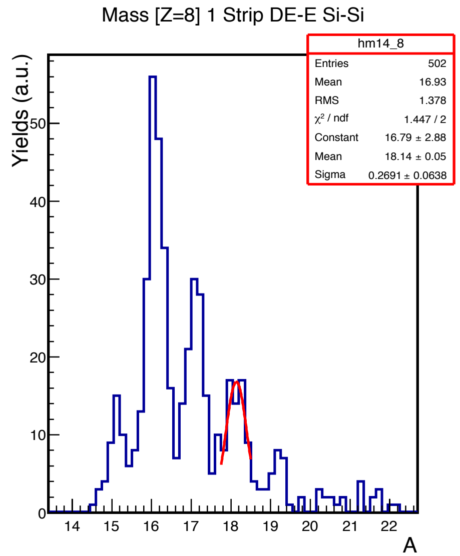

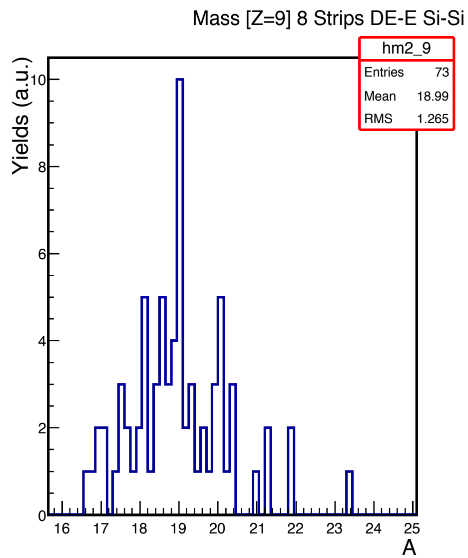

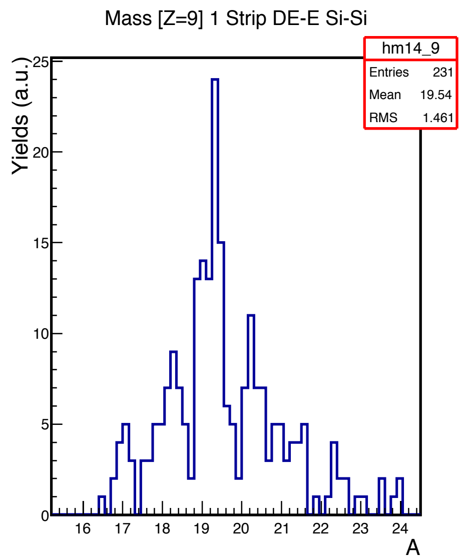

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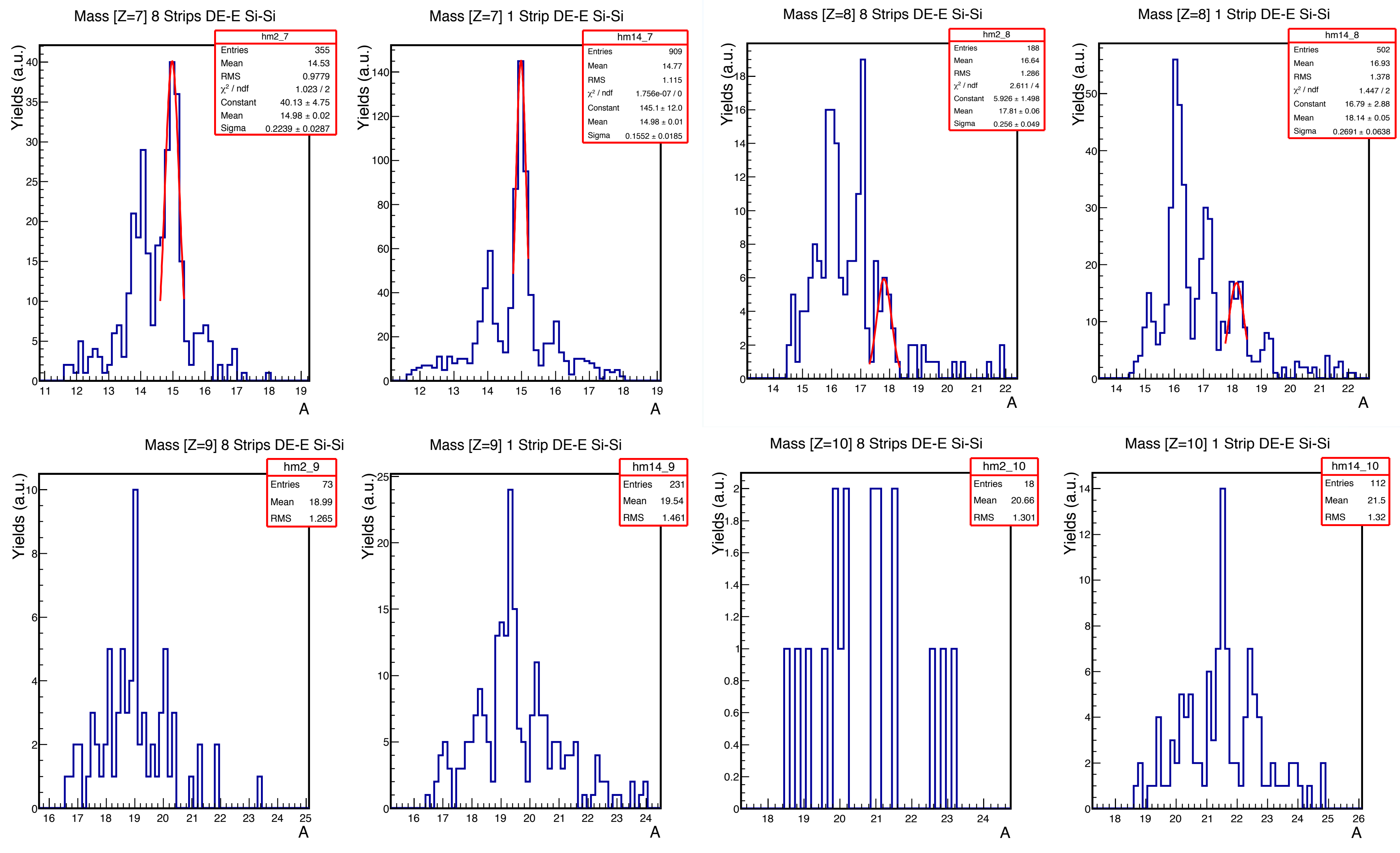
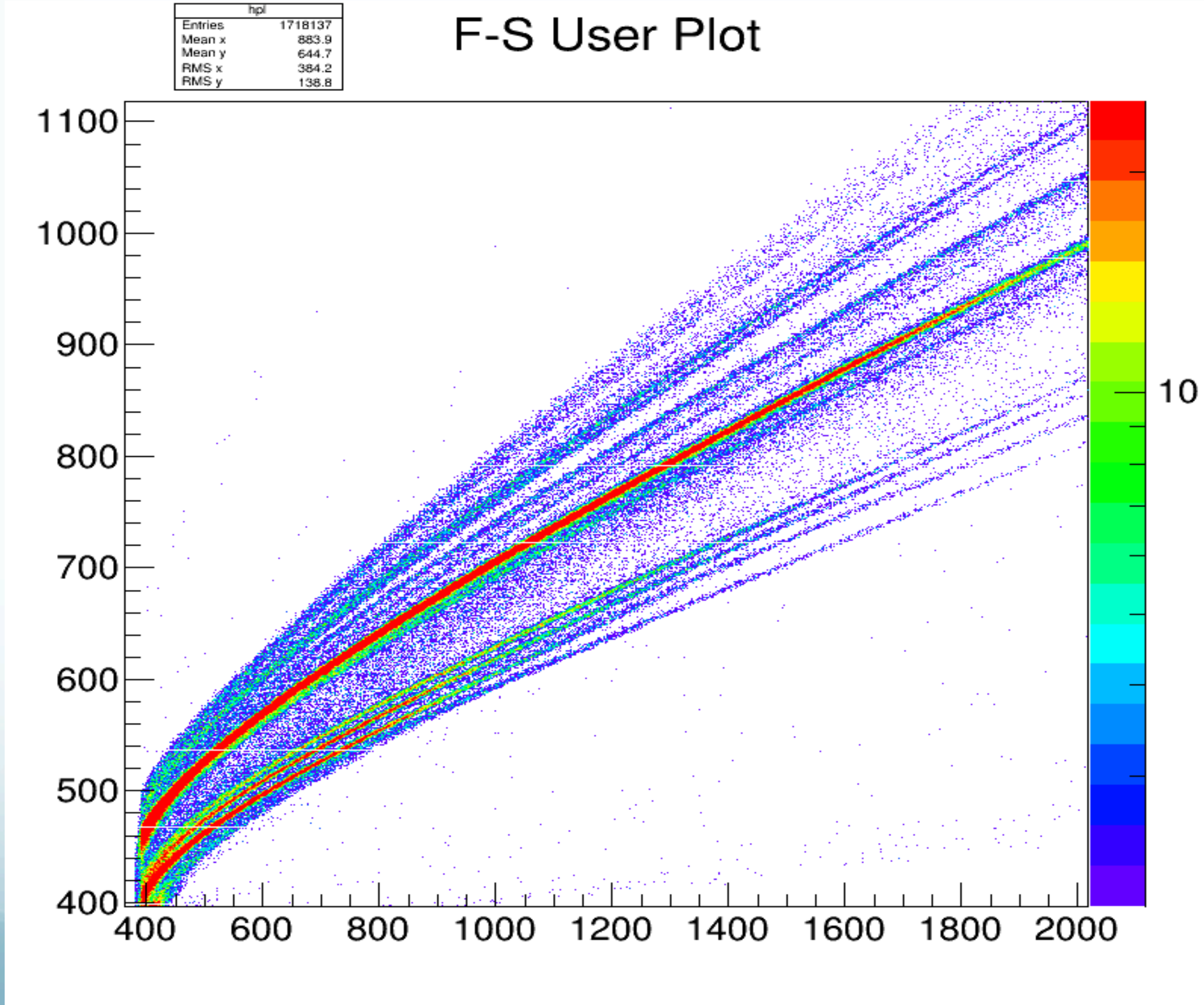


FAST - SLOW Identification (PSD) in CsI(Tl)



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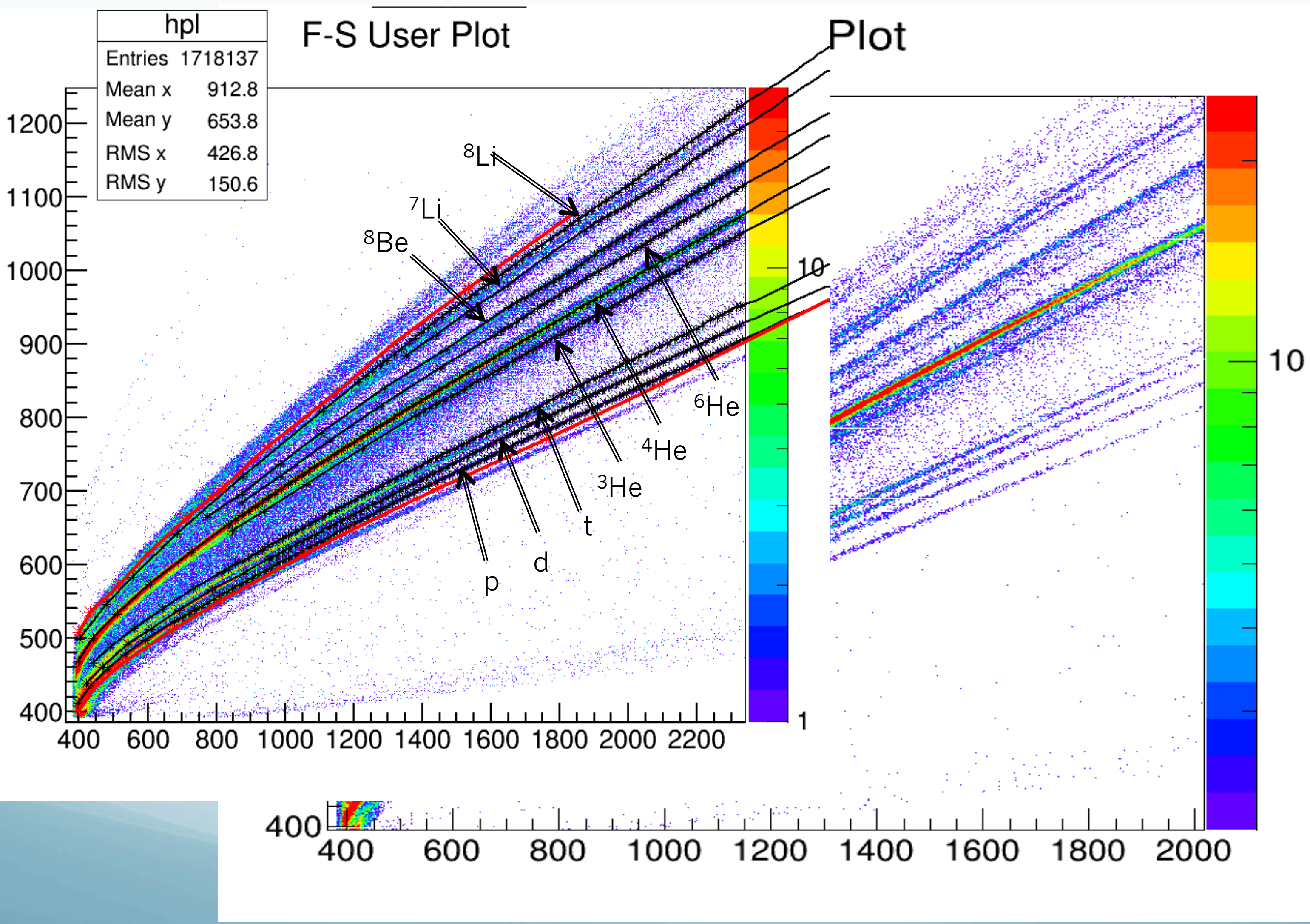

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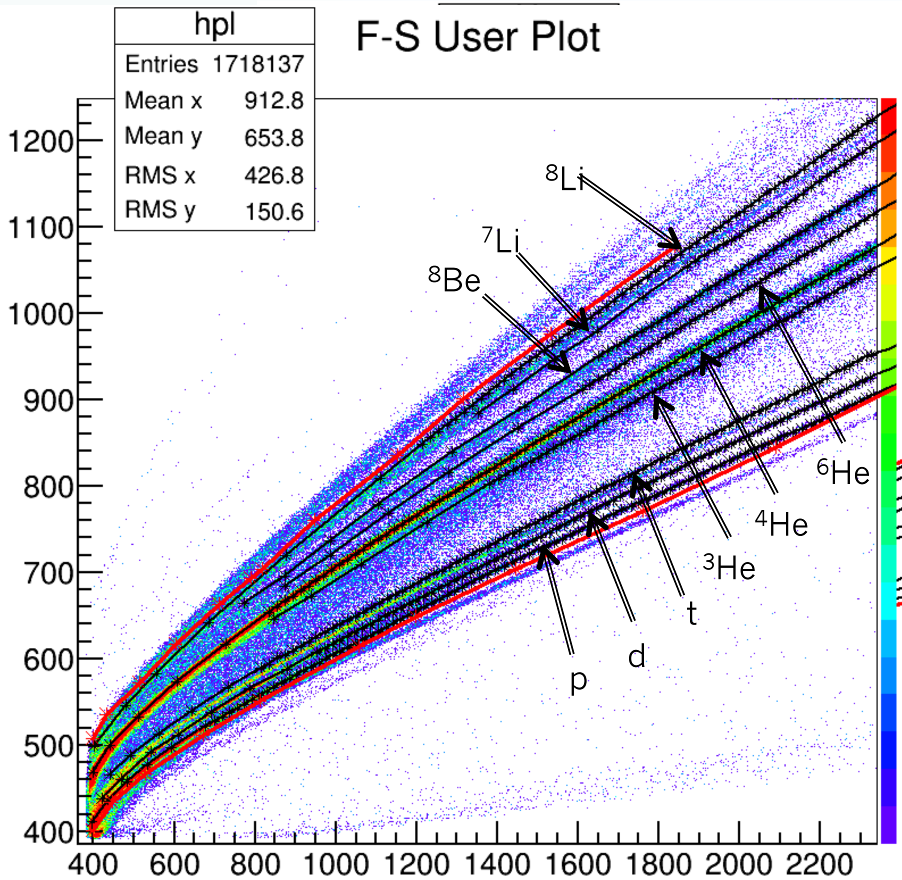

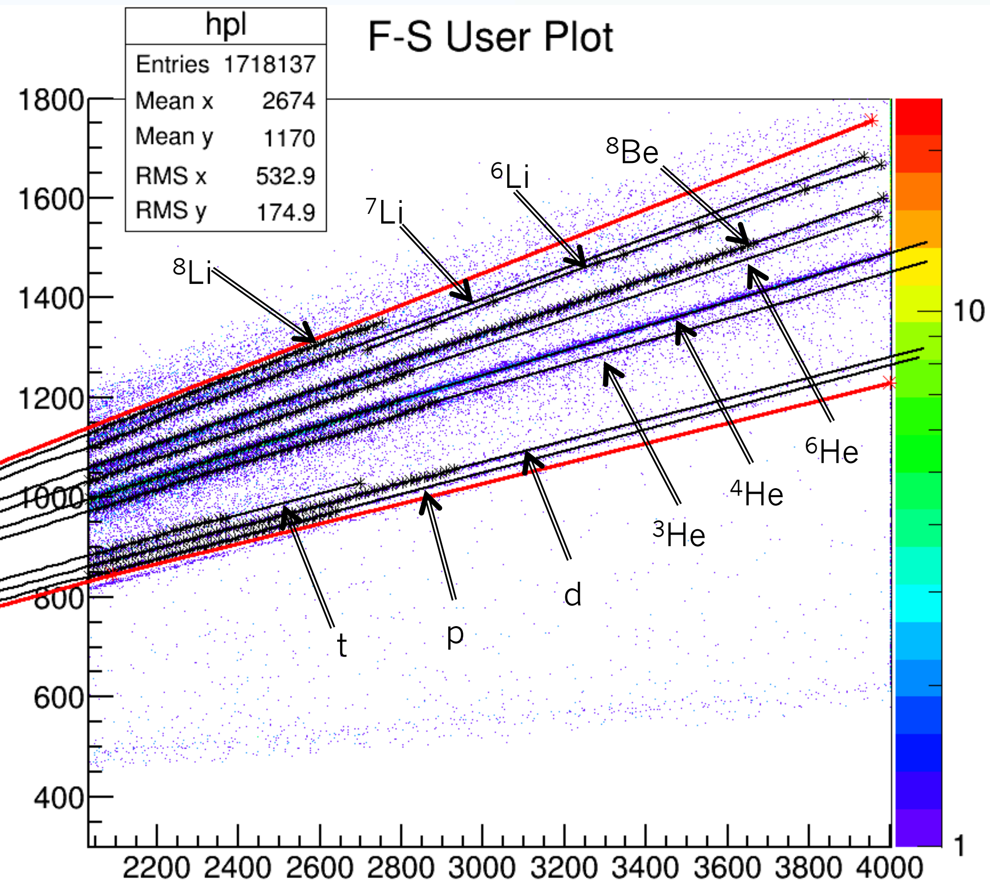

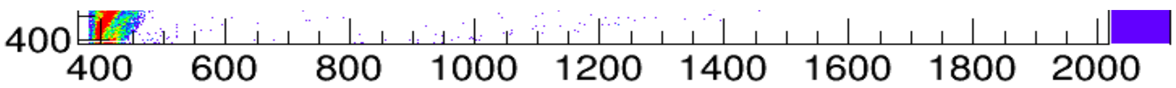

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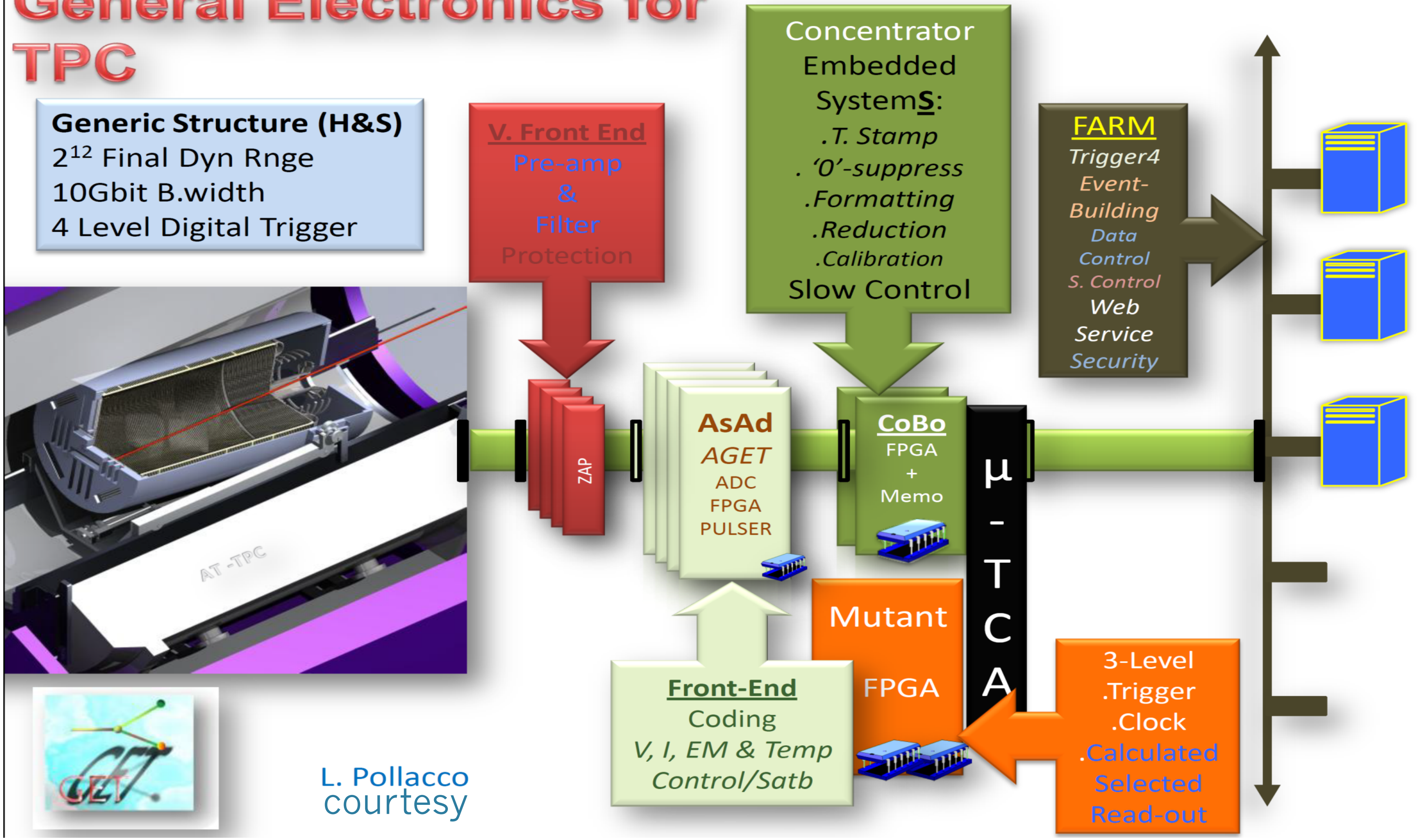
Test with GET Electronic

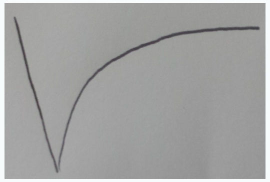
General Electronics for TPC



Test with GET Electronic

GET (General Electronics for TPC)

Si – detector
and
CsI(Tl)



→ PAC (Standard) → GET →

- High pass filter
- Amplifier
- 100 MHz sampling
- Storing 100point/50ns
- Digitizing

CLIR experiment performed @ LNS (March 2015)

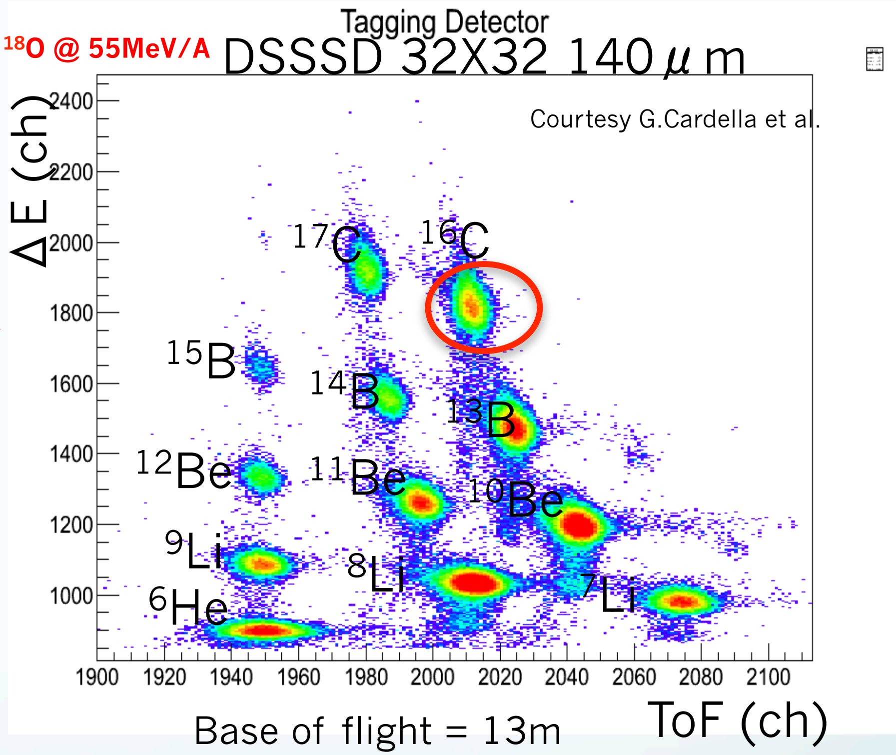
CLIR: Clustering in Light Ion Reactions.
As an example:
16C + 12C→16C*+12C*→10Be + 6He + 12C*
→ 12Be + 4He

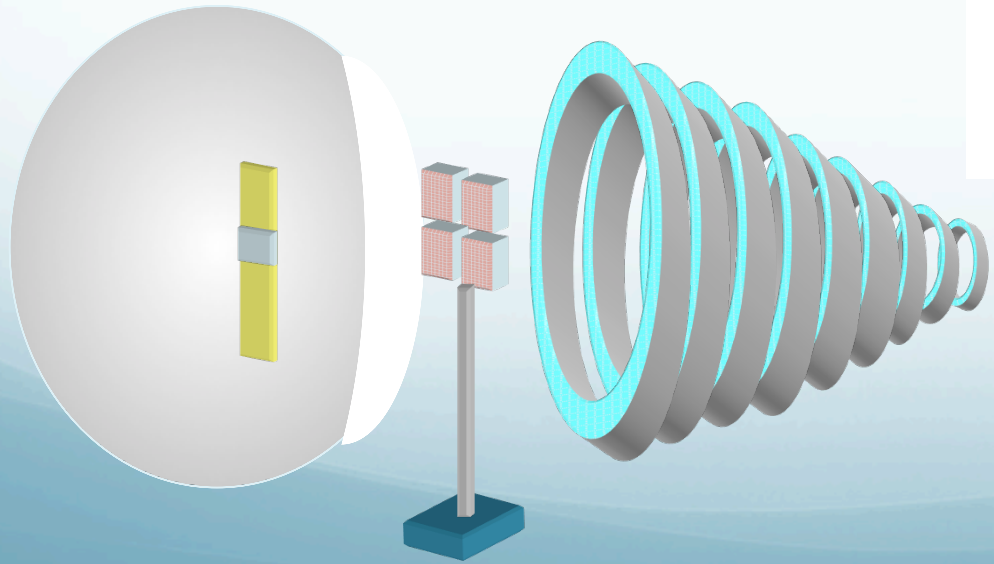
16C from tagged FRIBS projectile fragmentation @ 40MeV/A→ 15 kHz

I. Lombardo, G. Verde

Preliminary

Primary beam ^{18}O @ 55MeV/A





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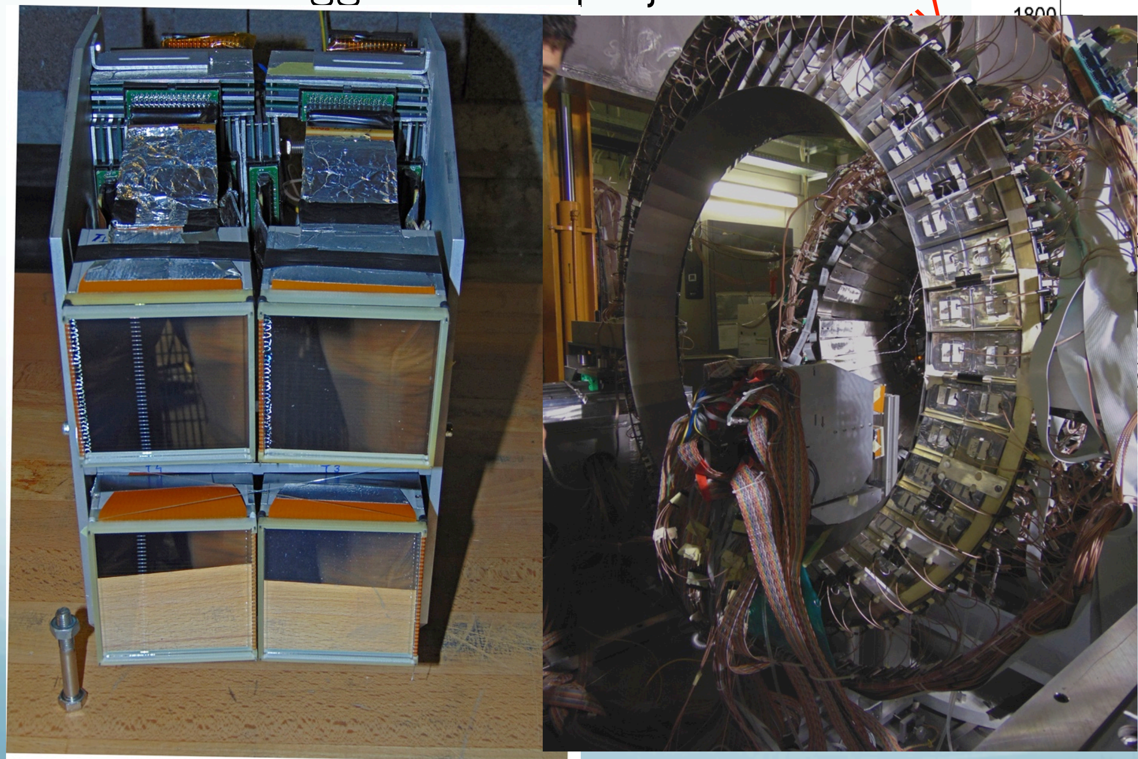

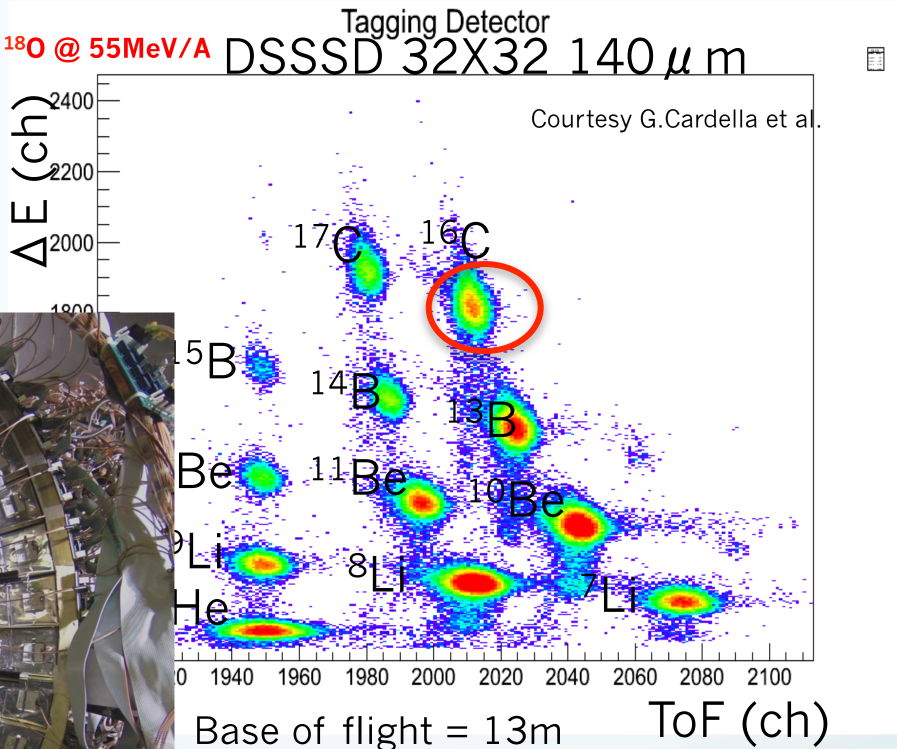

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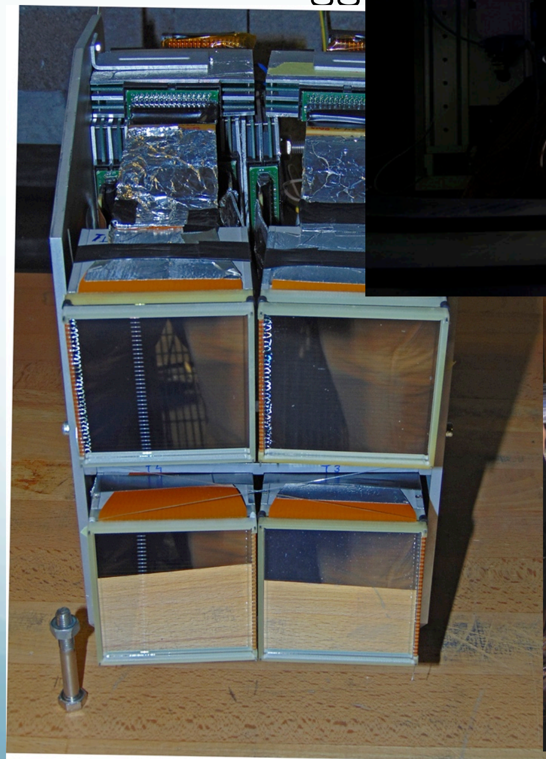
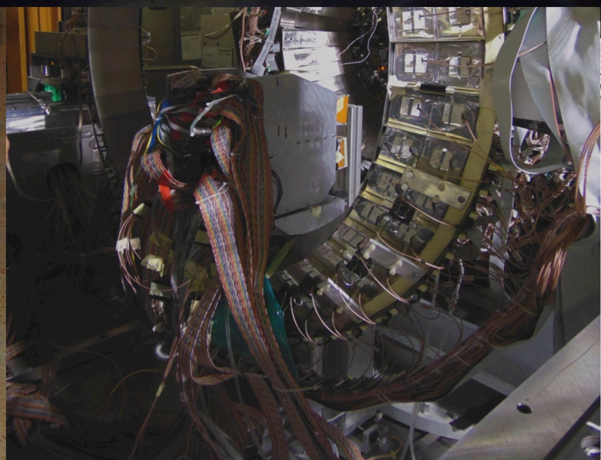
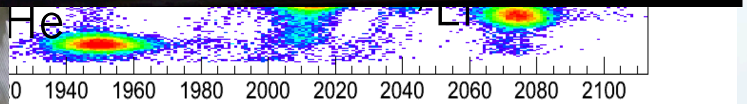
CLI

CLIR: Clusterin
Reactions.
As an example:
16C + 12C→16C*

16C from tagg







ToF (ch)

Base of flight = 13m

TEST OF GET ELECTRONICS WITH BEAM

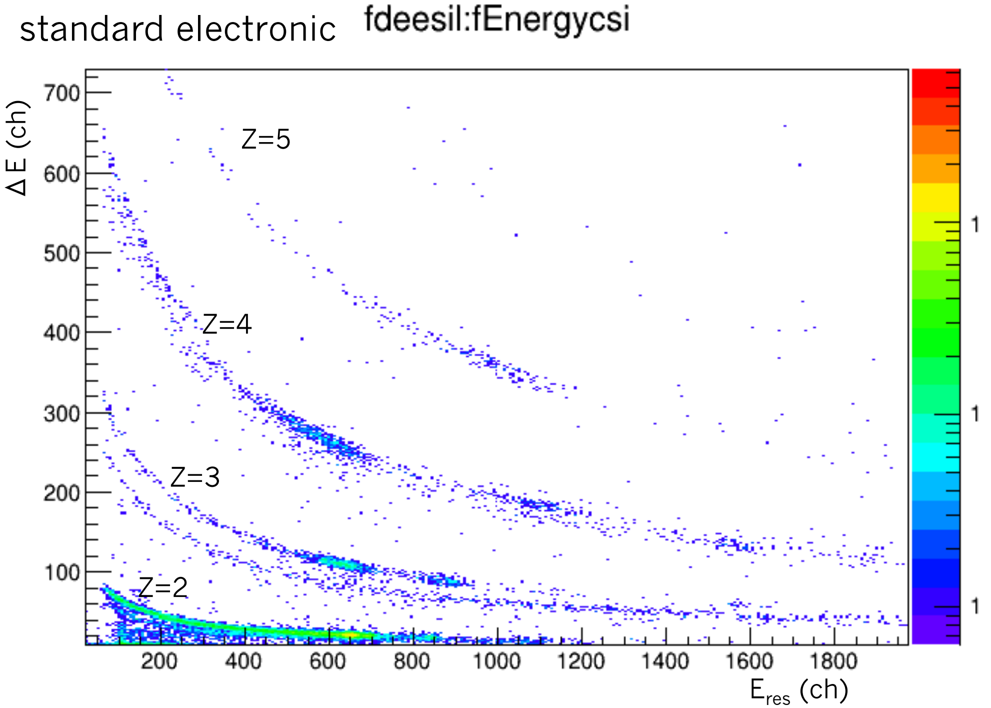
Exotic beam of ^{16}C @ 40MeV/A

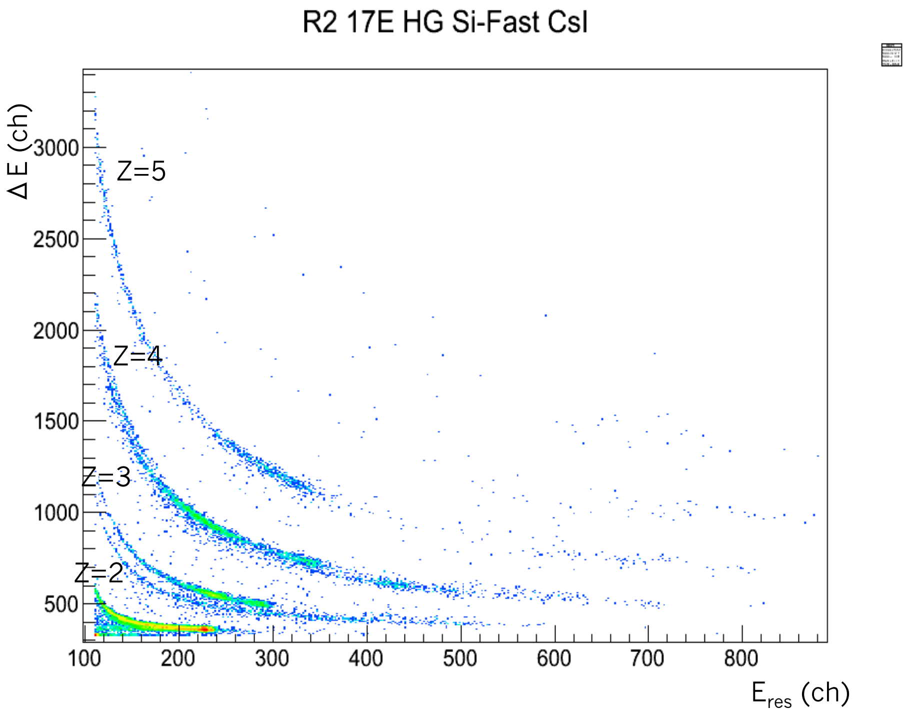
For the test of GET was connected to a telescope of CHIMERA from the Ring 2, 300 μm of Si – 12 cm of CsI(Tl), in order to compare with a telescope of the same ring connected with the standard electronic

GET Electronic

CHIMERA STANDARD

Preliminary





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FARCOS: perspectives

Milestones of FARCOS construction:

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

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- 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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FARCOS: perspective II

2 Letter of Intent Presented in SPESS - LNL

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SPES exotic beams for science

Isospin dynamics and thermodynamics in n-rich heavy-ion induced reactions

G. Casini[a], S. Barlini[a], M.Bini[a], M. Bruno[c], M. Cinausero[f], M. D'Agostino[c], D. Fabris[pd], N. Gelli[a], F. Gramegna[f], T. Marchi[f], L. Morelli[c], A. Olmi[a], G. Pasquali[a], G. Pastore[a], S. Piantelli[a], G. Poggi[a], A. Stefanini[a], S. Valdré[a], R. Alba[i], E. Bonnet[i], R. Bougault[d], A. Brondi [na], M. Chartier[g], M. Degerlier[m], J.D. Frankland[e], S. Grimes[oh], D. Gruyer[e], T.Kozik[ju], M. La Commara,[na], G. La Rana,[na], R. Lemmon[g], N. Le Neindre[d], I. Lombardo[na], C. Maiolino[i], A. Ordine[na], E. Rosato[na], D.Santonocito[i], G. Spadaccini[na], T. Twarog[ju], E. Vardaci,[na], G. Verde[b], E. Vient[d], M. Vigilante[na], A. Voinov[oh], and
M. Colonna[i], M. Di Toro[i], C. Rizzo[i], A. Botvina[mo]

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M. Colonna[i], M. Di Toro[i], C. Rizzo[i], A. Botvina[mo]

SPES Letter Of Intent – March 2014

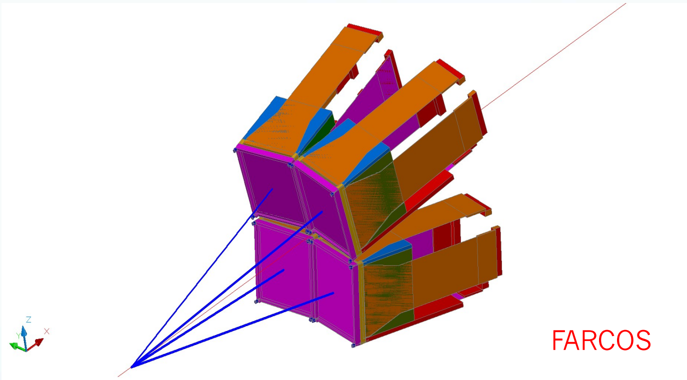
Isospin dependence of compound nucleus formation and decay

E.DeFilippo (INFN - Catania), J.D.Frankland (GANIL Caen), S.Pirrone (INFN - Catania),
G.Politi (Univ. and INFN – Catania), Russotto (INFN-Catania)

E. V. Pagano
Univ. of Catania & LNS-INFN

FARCOS: perspective II

New sperimental campain coupling FARCOS and MUST II
Using
The 4pi Detector CHIMERA @ LNS (CATANIA-ITALY)
The 4pi Detector INDRA @ GANIL (CAEN-FRANCE)



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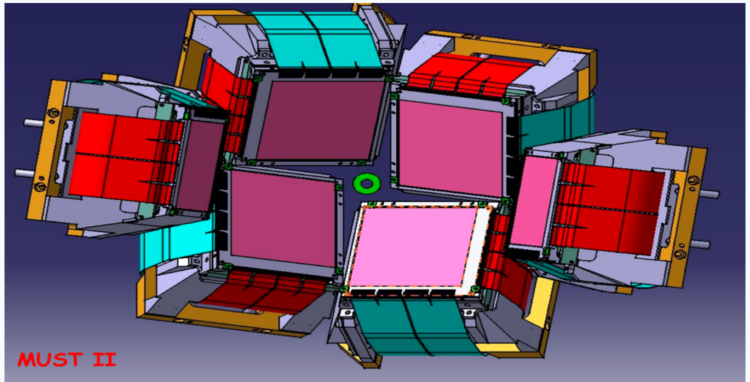

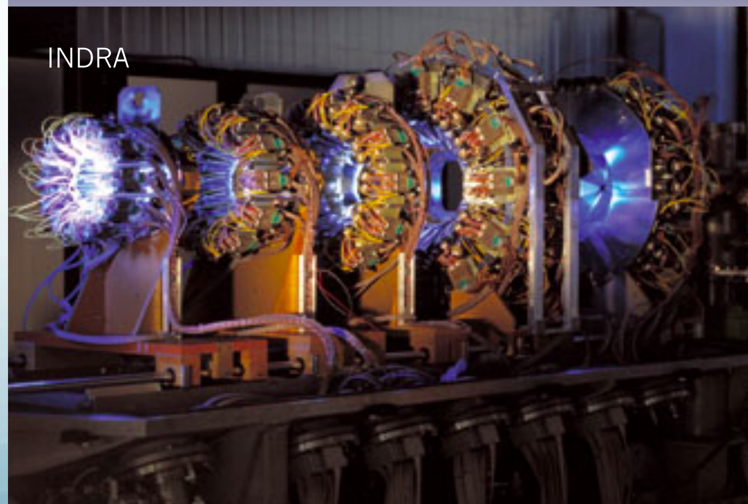

Conclusions

The prototype of FARCOS, made by 4 telescopes, is under testing.
Preliminary analysis suggest that FARCOS performances are very good with good in isotopic identification resolution and in energy and angular resolution.
For the future the goal is to develop some automatic procedures in order to make easier 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 plan to assemble 20 telescopes in order to perform experiments coupling FARCOS with 4π detectors in order to progress in our understanding in heavy ion physics of both stable and exotic beams

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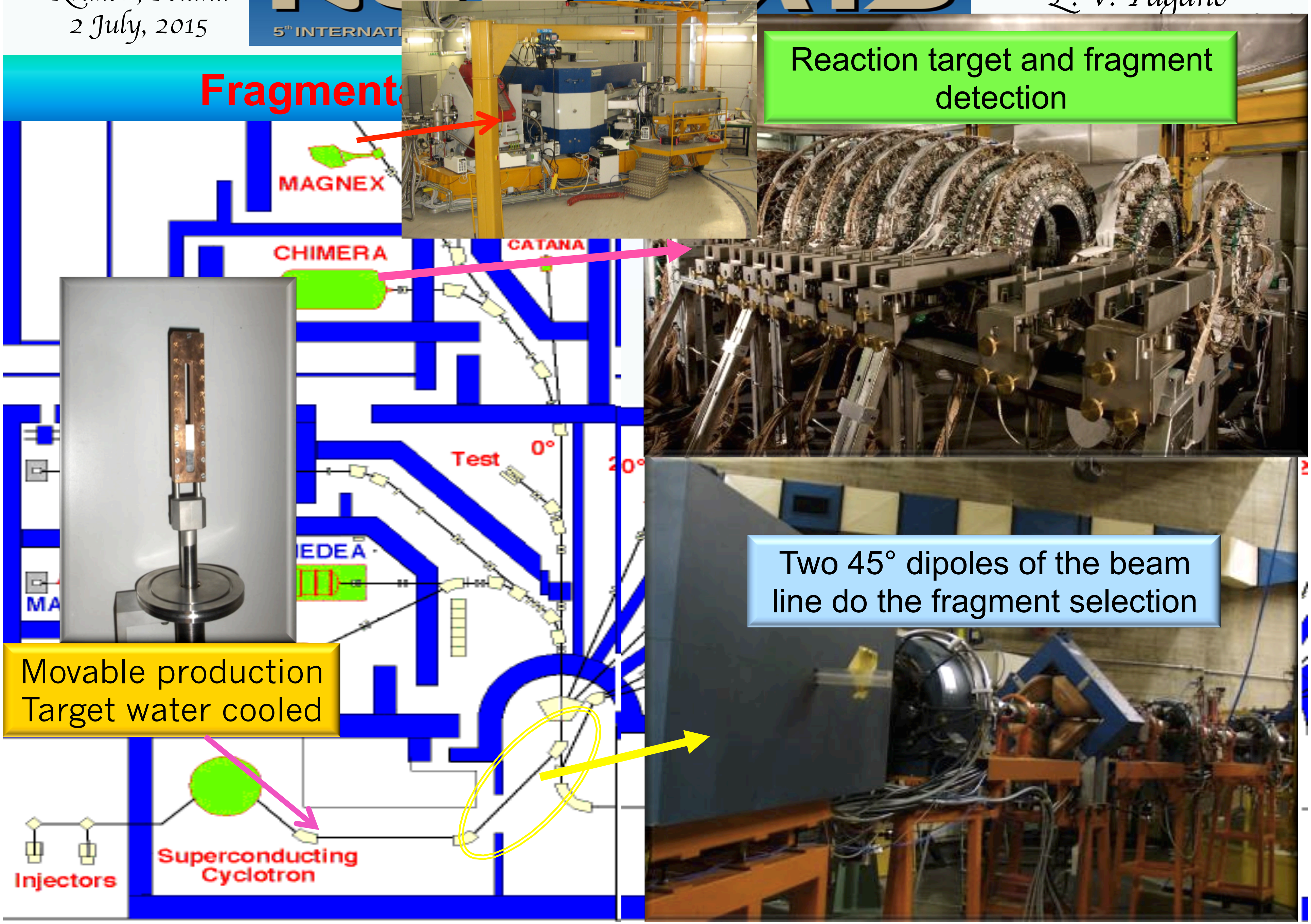
Thanks for the attention

Fragment


Reaction target and fragment detection
Two 45° dipoles of the beam line do the fragment selection
Movable production Target water cooled
MAGNEX
CHIMERA
CATANA
Test
0°
20°
MEDEA
Superconducting Cyclotron
Injectors

TEST OF GET ELECTRONICS WITH BEAM

Stable beam

$^{16}O+^{11}B$ @ 40 MeV/A (calibration beam)

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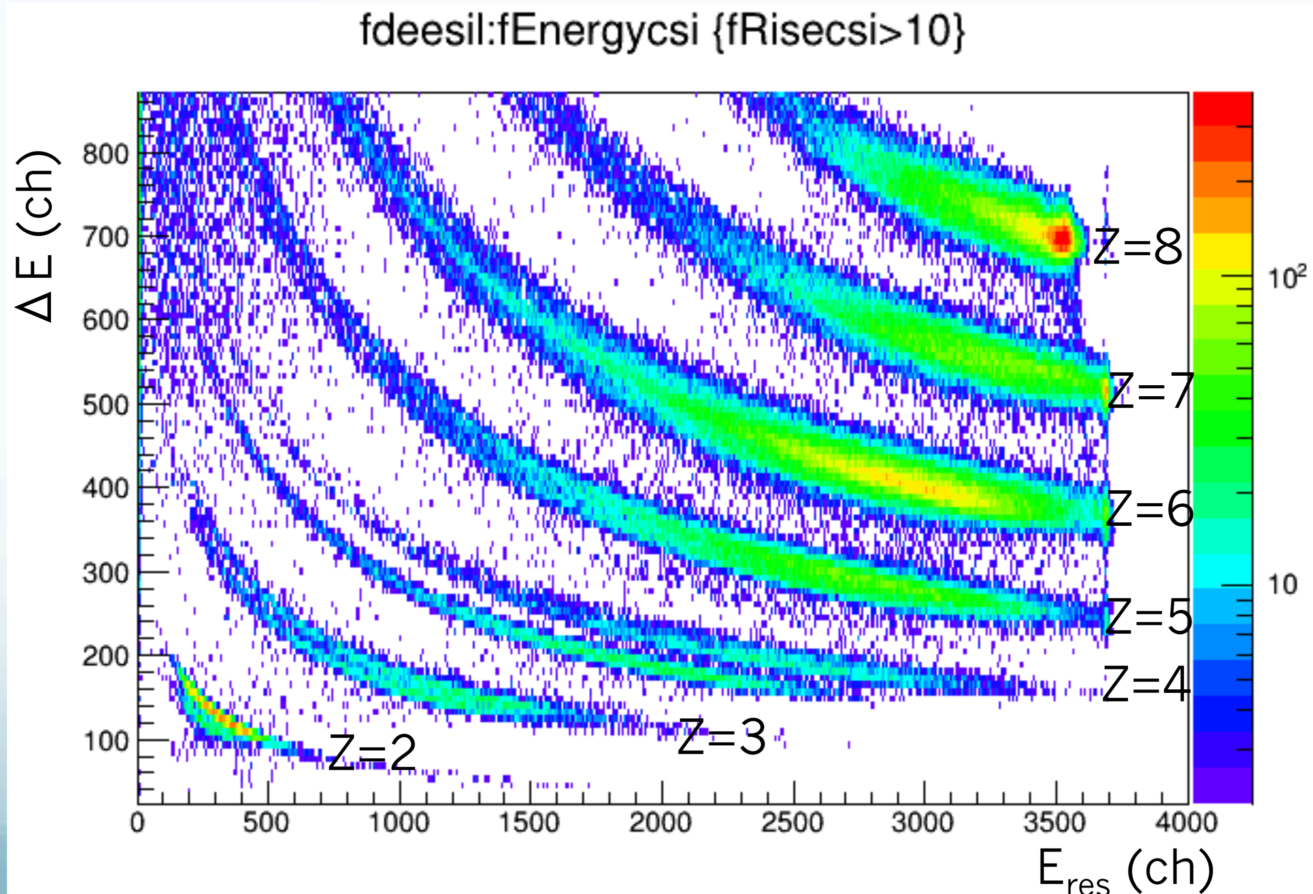
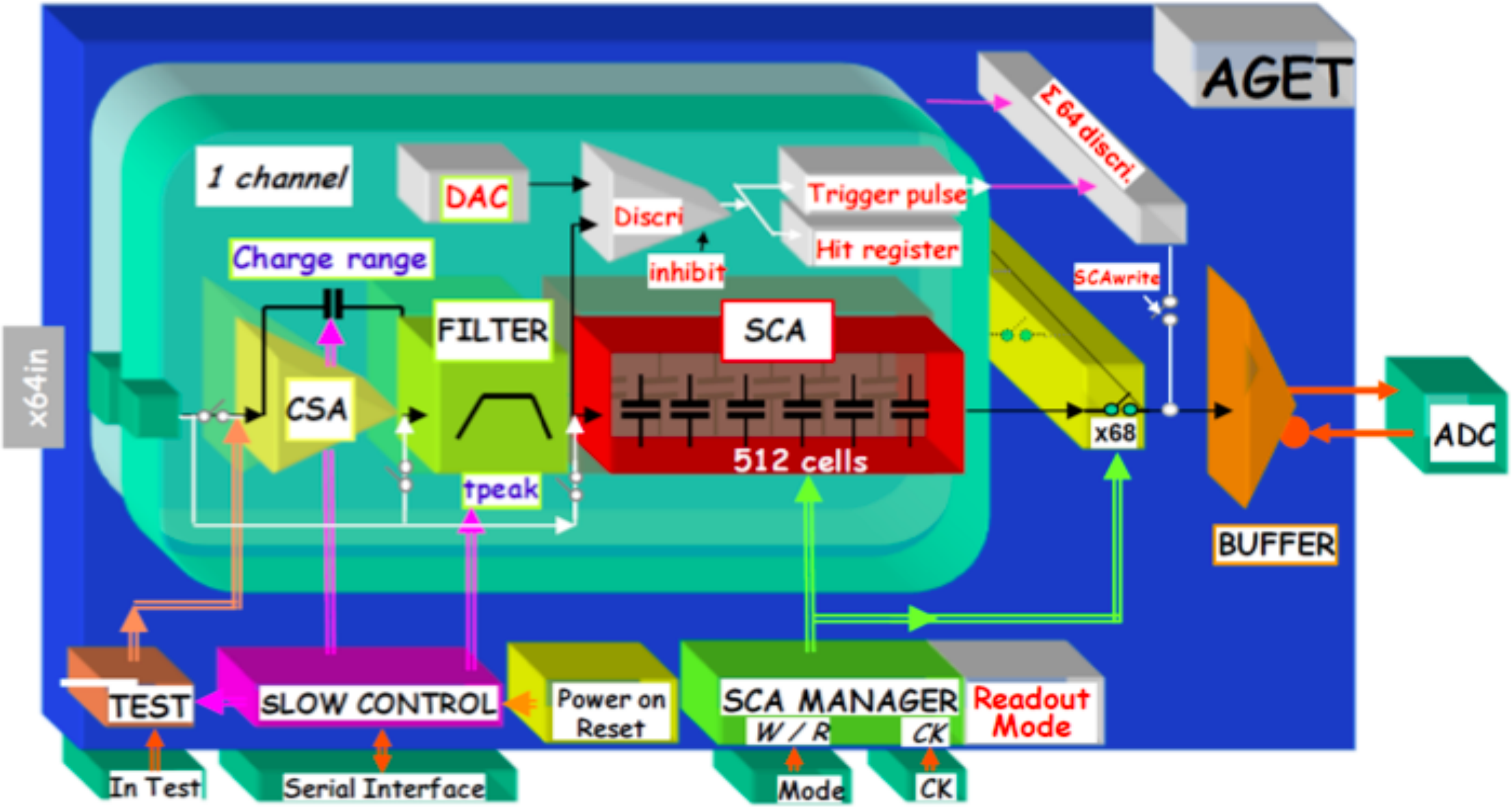


Hardware Architecture for AGET



Block diagram of the AGET chip.

E. V. Pagano
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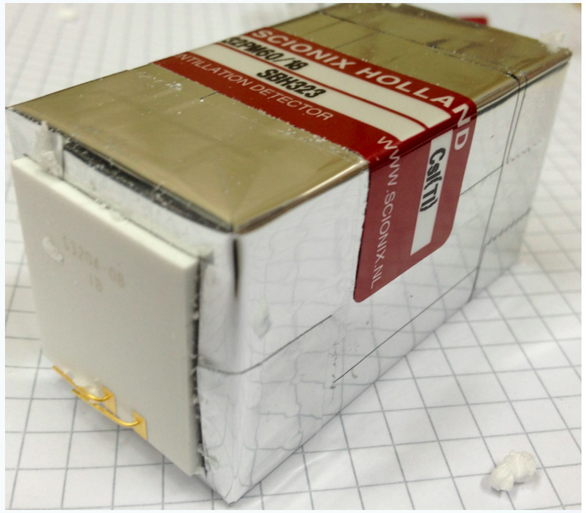
Test and Characterizations of CsI(Tl) light response



- Surface response

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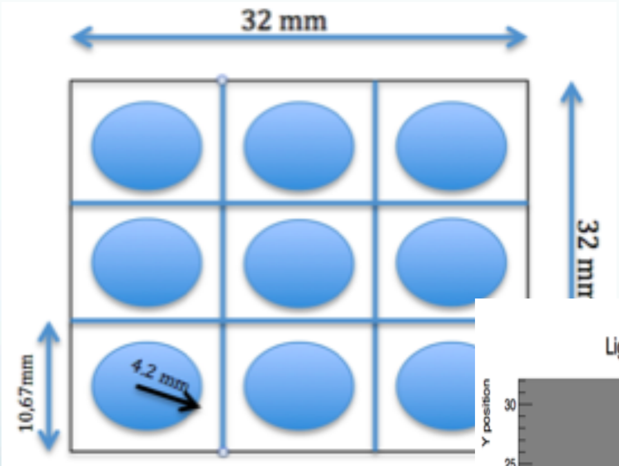
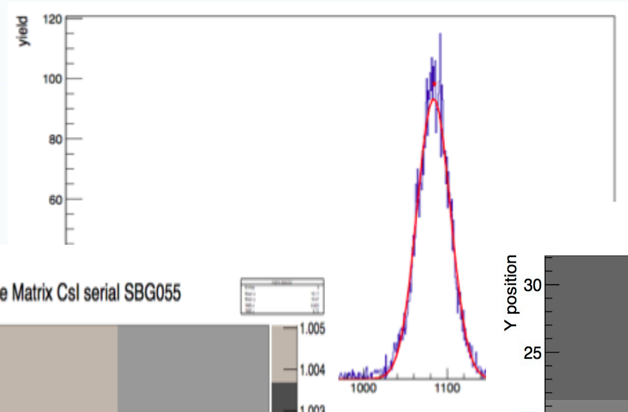
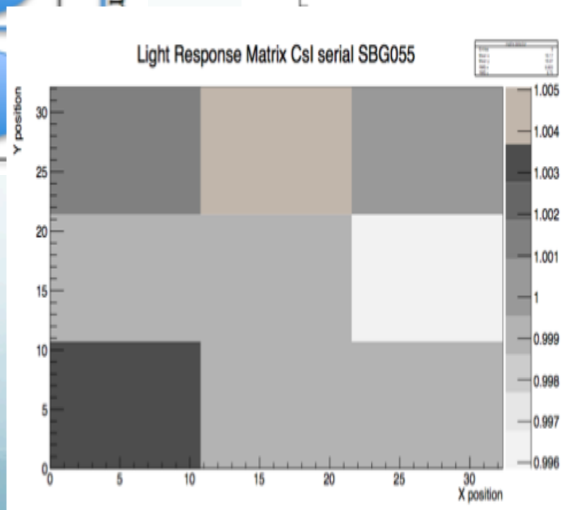
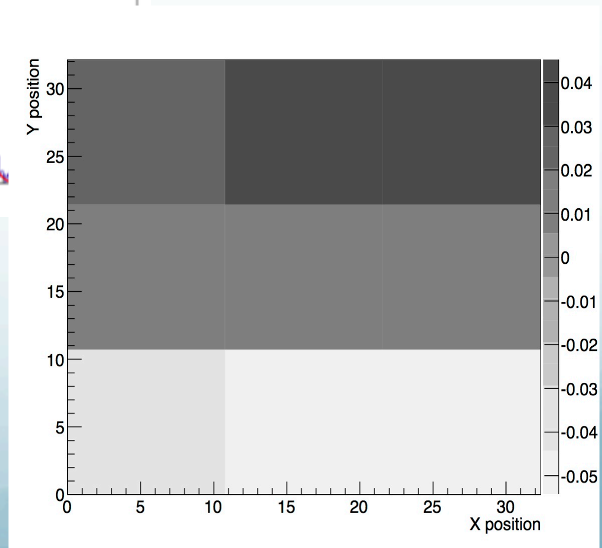
- ✓ vacuum conditions (≈ 10^{-2} $mbar$)
- ✓ ^{241}Am source of 150 nCu of intensity, E_{α} = 5.485 MeV
- ✓ Doping of CsI(Tl) crystals 1200-1500 ppm









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

E.V.Pagano undergraduate Thesis work

- depth response

≈1.5 cm

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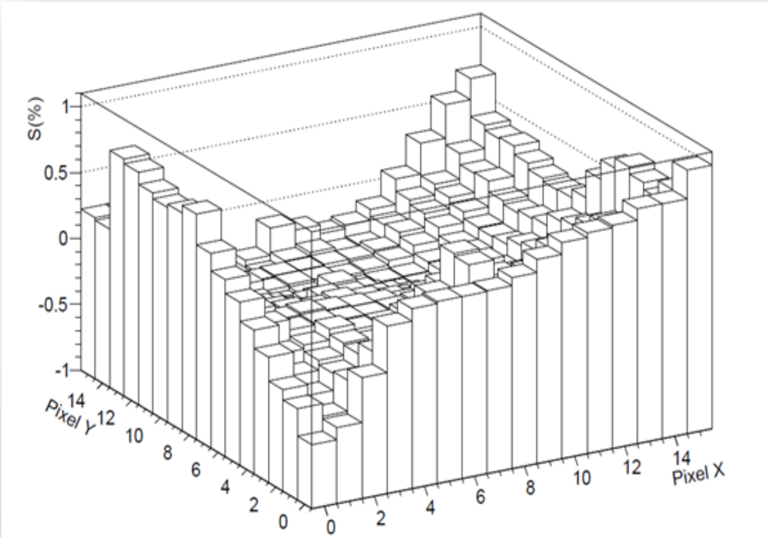
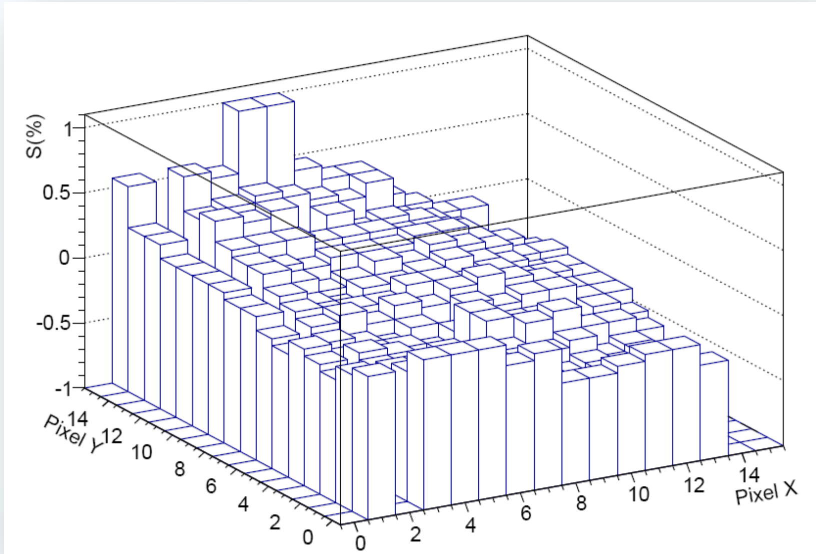
α+Pb at E/A=62 MeV





L.Quattrocchi

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

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

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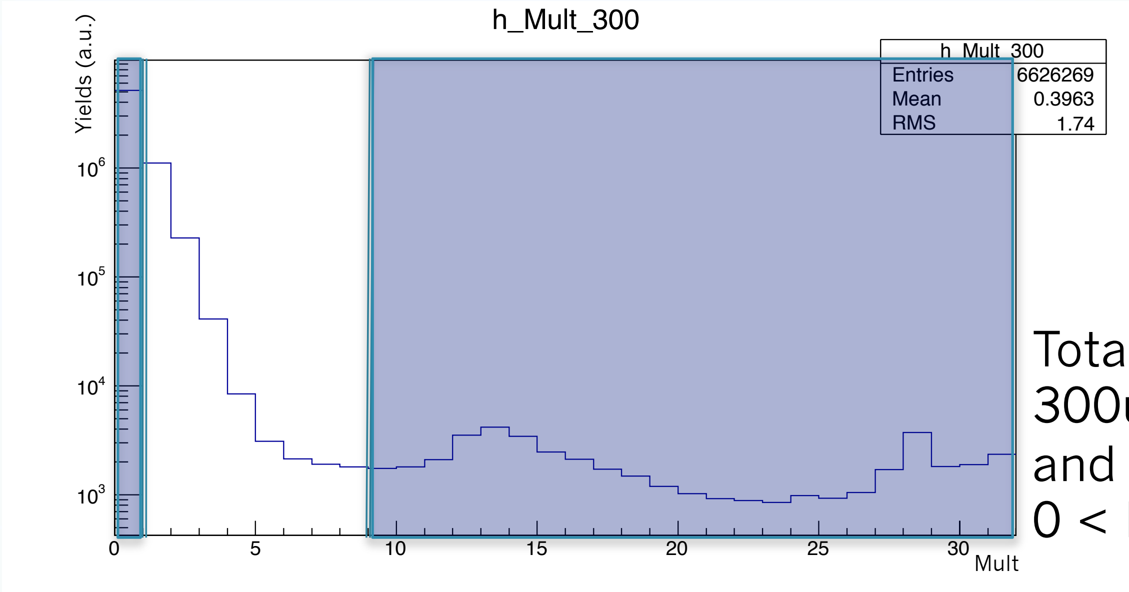
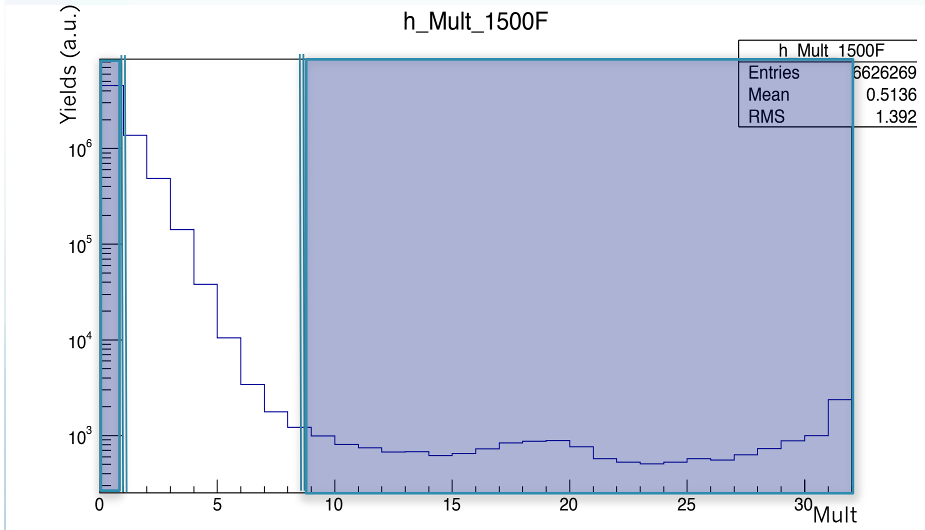
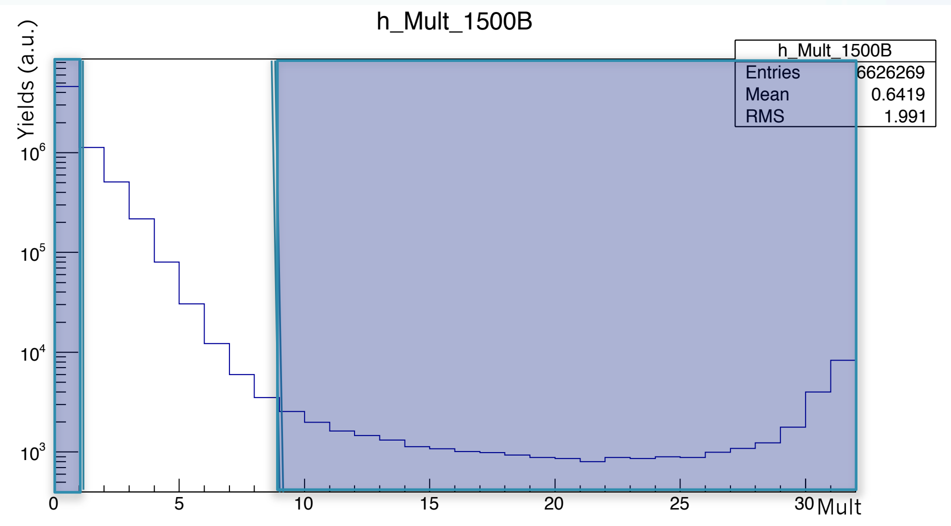


A multiplicity cut is necessary in order to eliminate bad events for physcal reasons

Total Multiplicity of 300um, 1500 Front and back is:
$0 < Mult_{tot} < 9$

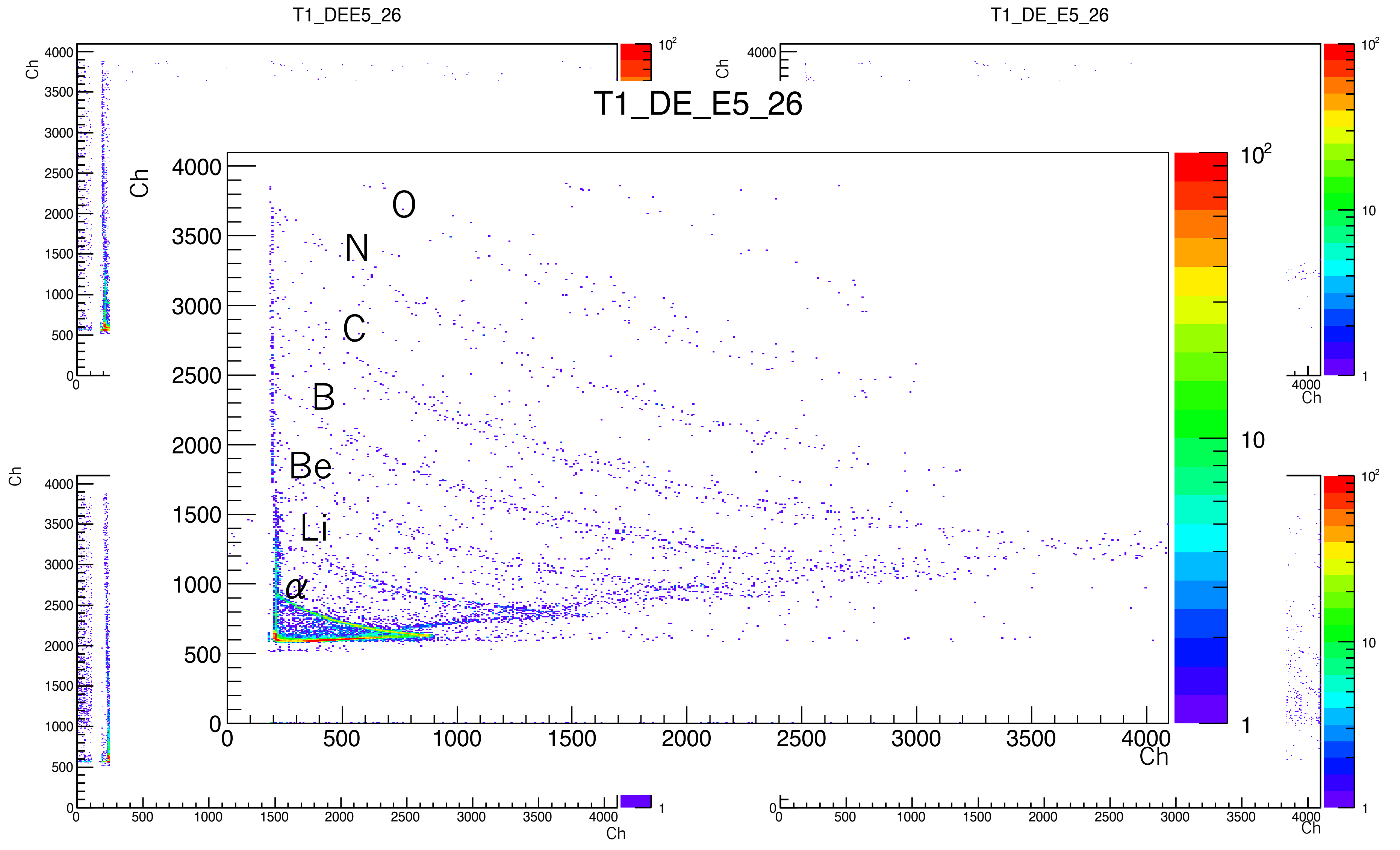




No Cut

T1_DE_E Strip 5

0 < Mult < 9



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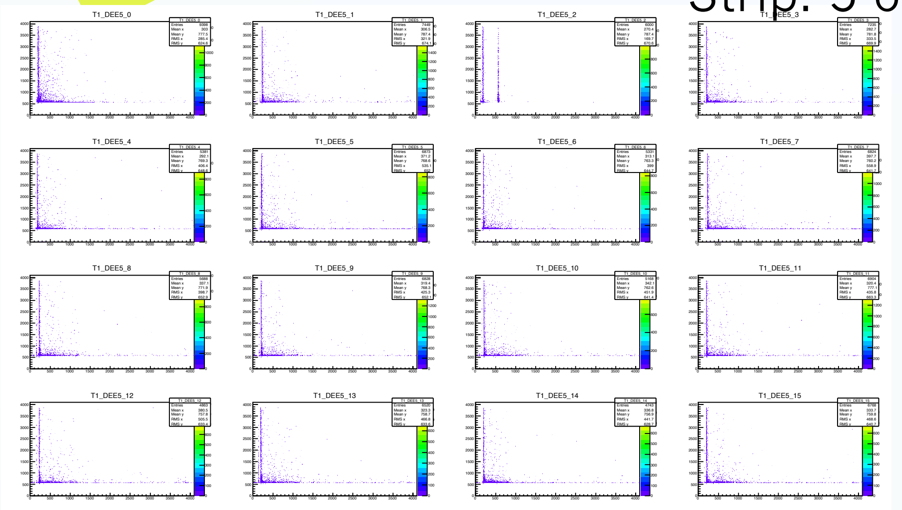
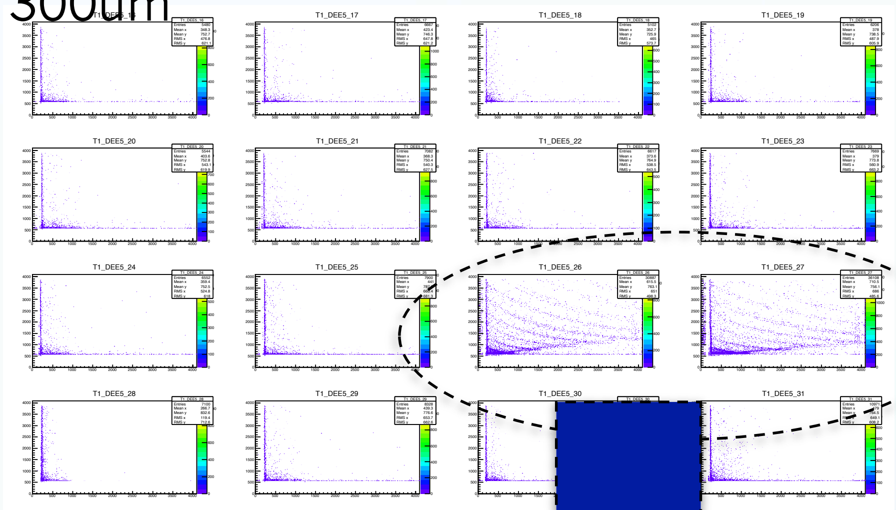
Preliminary

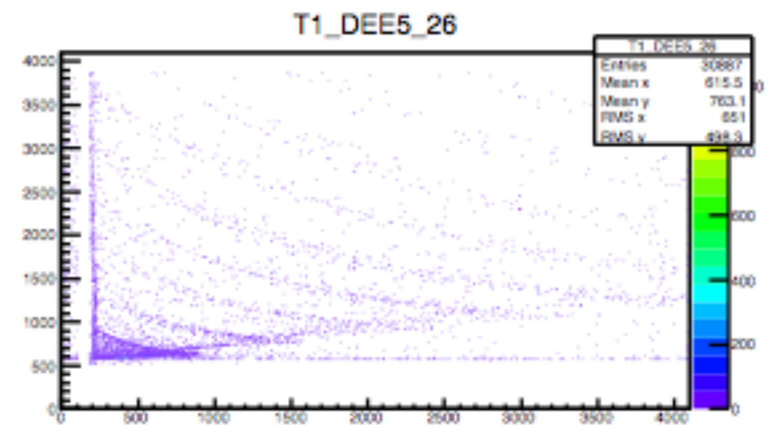
Test work:
only 40 runs
over about 800

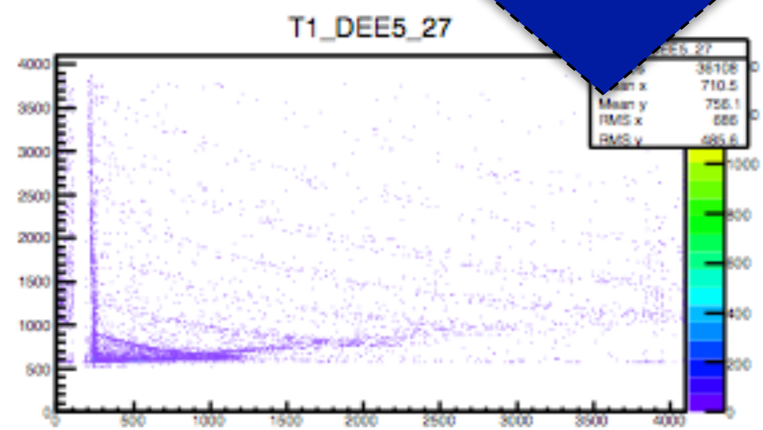
N° of Events ≈ 8 Millinos

Strip: 5 of 300um









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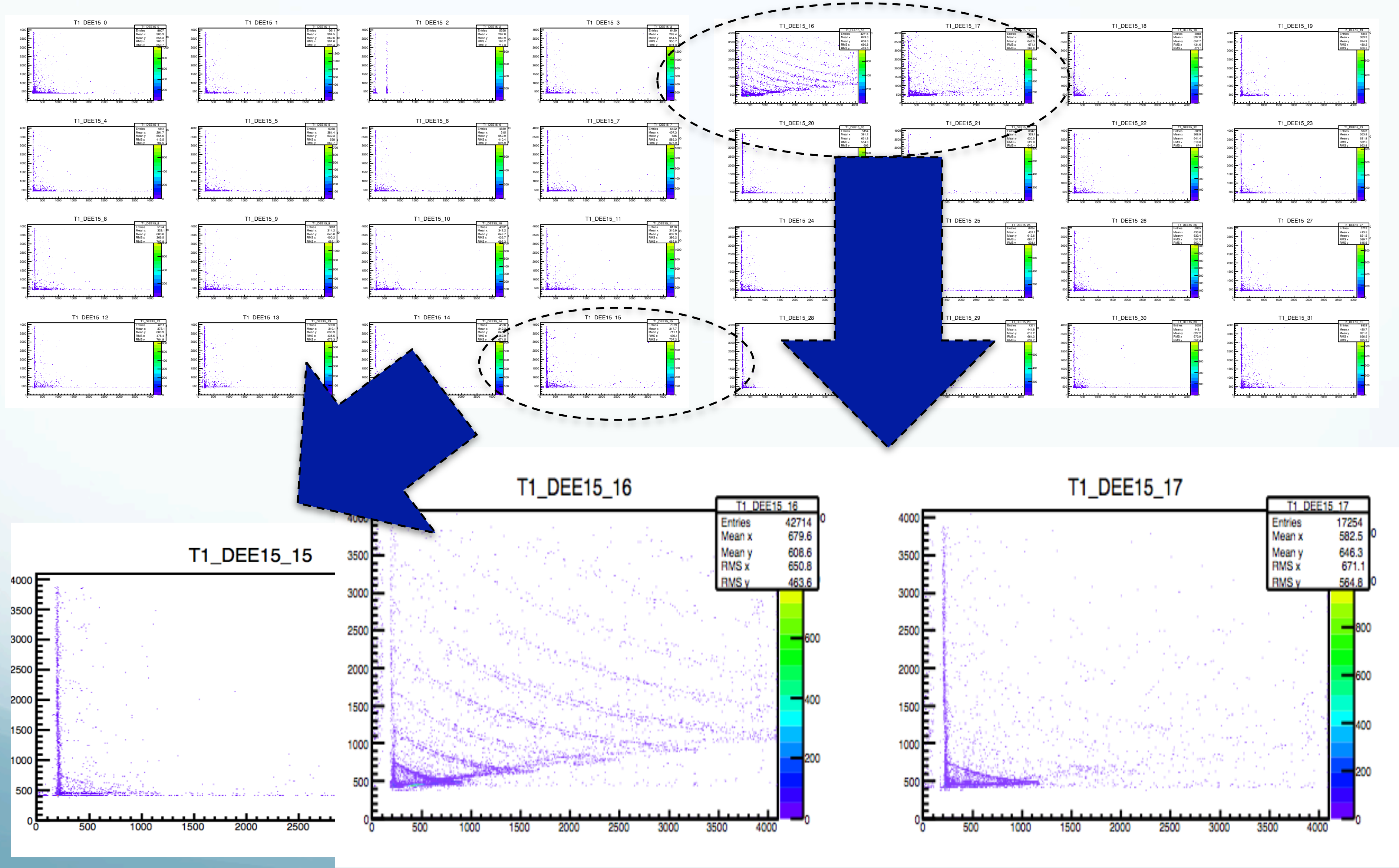
Strip: 15 of 300um



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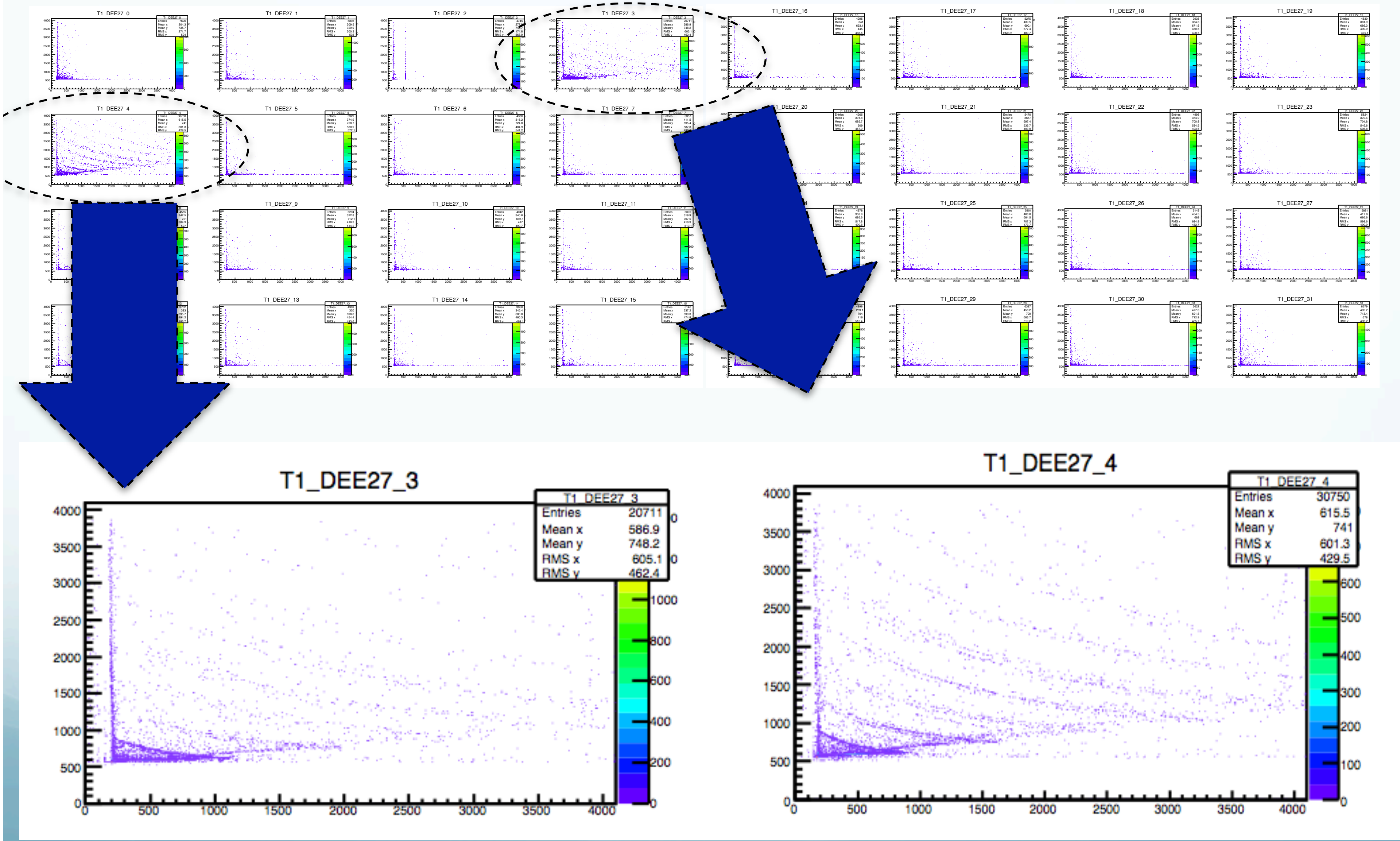
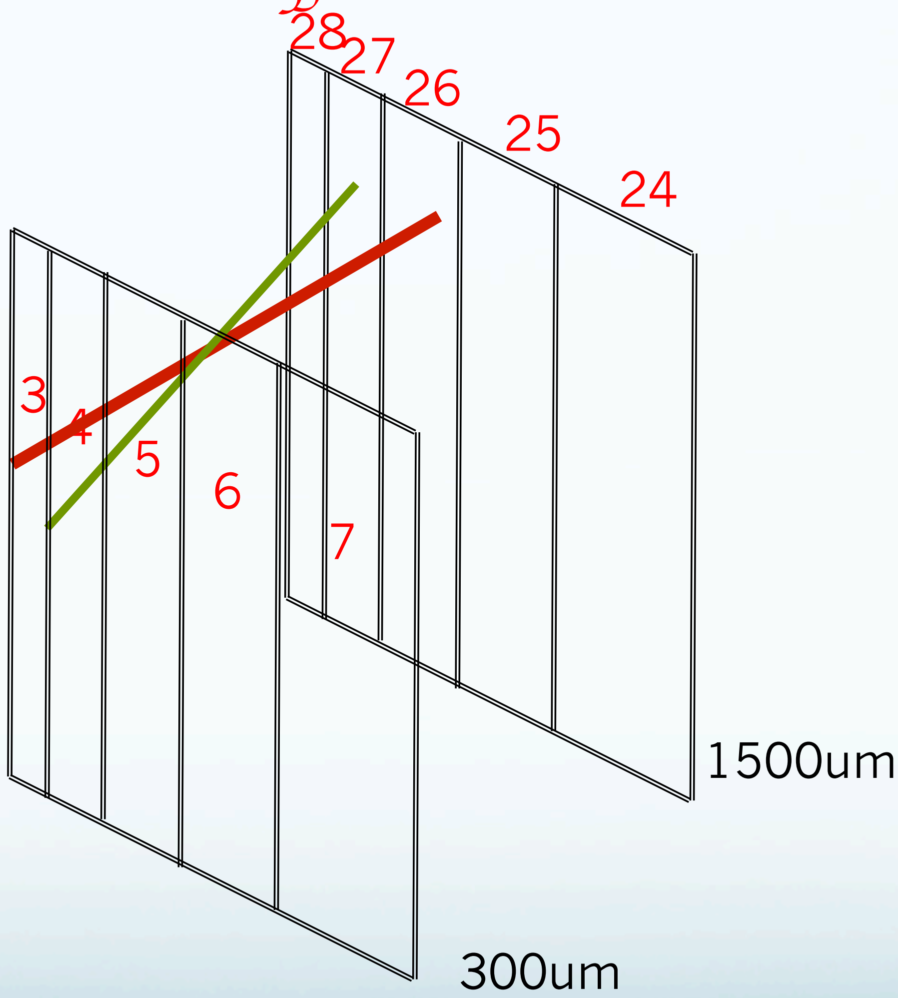
Strip: 27 of 300um



"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

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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)	Worse isotopic identification resolution (at least for now!)
Wide identification range: 1<Z<10	Need a large statistic in each strip (0.2x4.6 cm)	Good if not is 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)	Good if not have large statistic

In the case of the InKiIsSy experiment configuration my idea is that is better the "Single-Strip Way"

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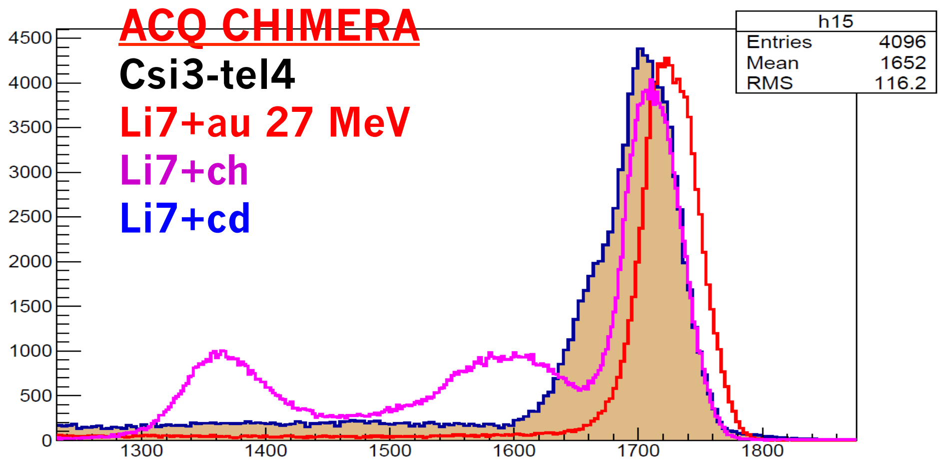
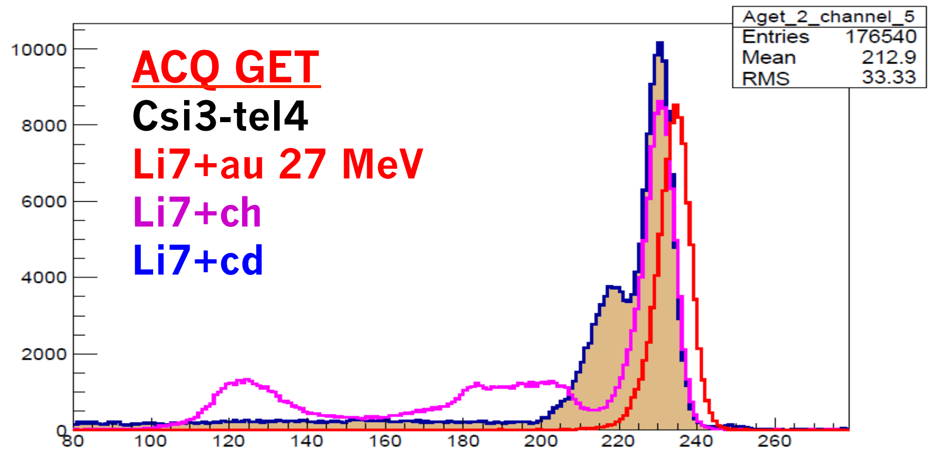
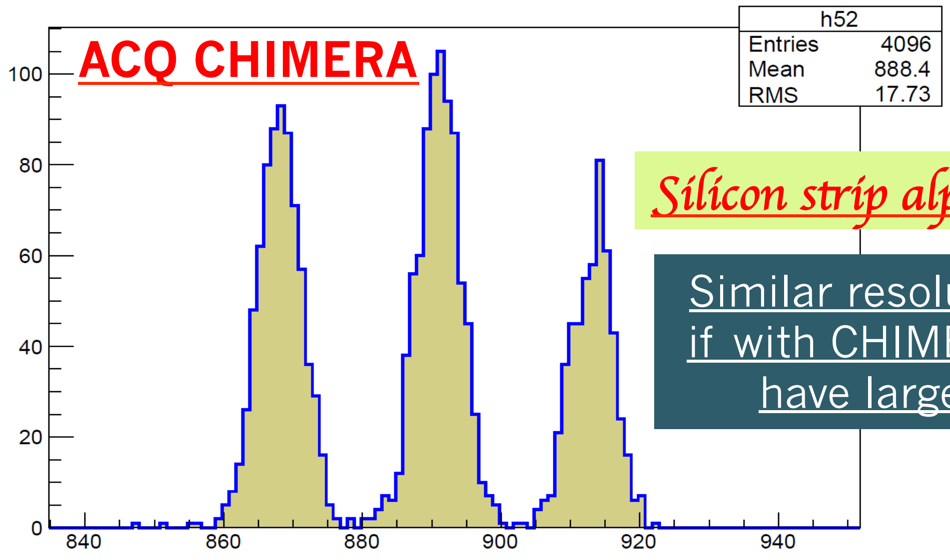
Test with GET Electronic: first results

Very Preliminary (March 2014)

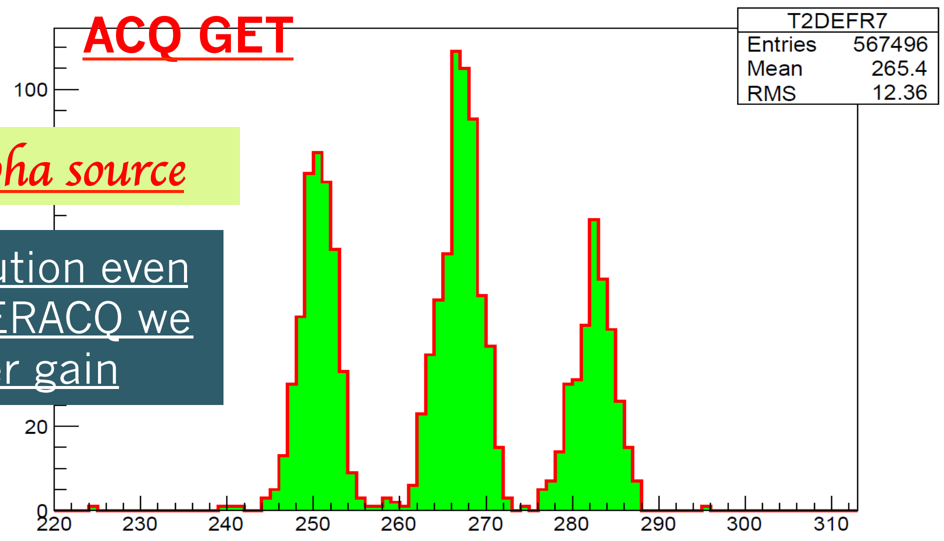






Silicon strip alpha source

Similar resolution even if with CHIMERACQ we have larger gain



Physics Case