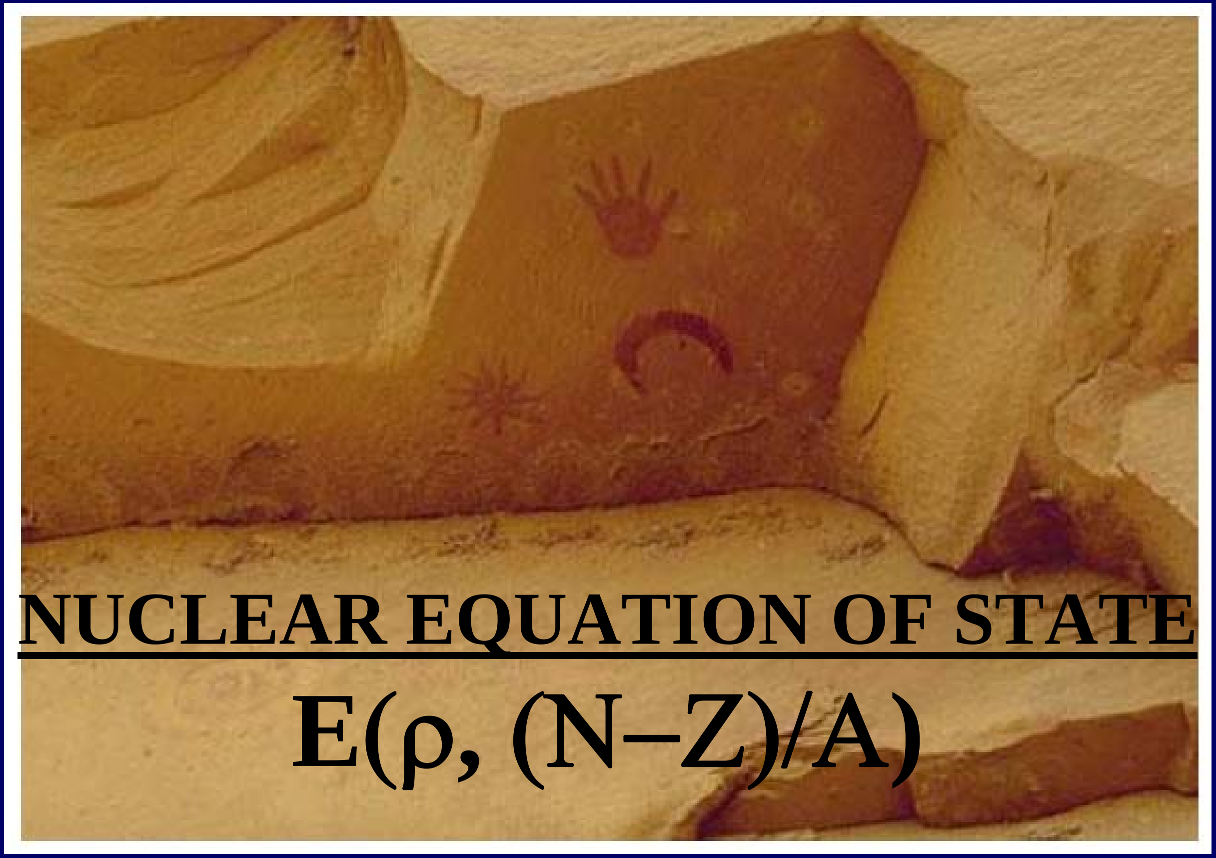
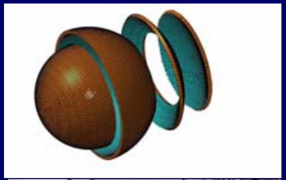


NUCLEAR EQUATION OF STATE

E(ρ, (N–Z)/A)



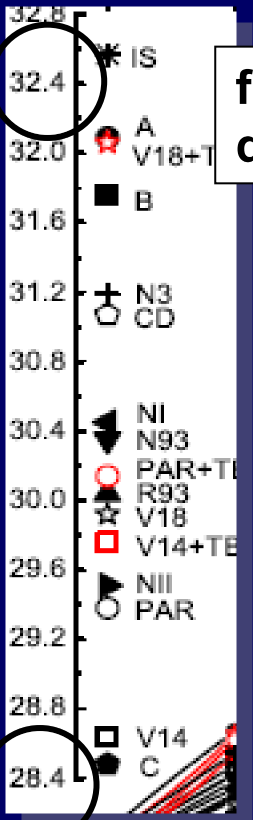
R.BOUGAULT, INDRA/FAZIA COLLABORATION

ENSICAEN
ÉCOLE NATIONALE SUPÉRIEURE D'INGÉNIEURS DE CAEN & CENTRE DE RECHERCHE

LPC

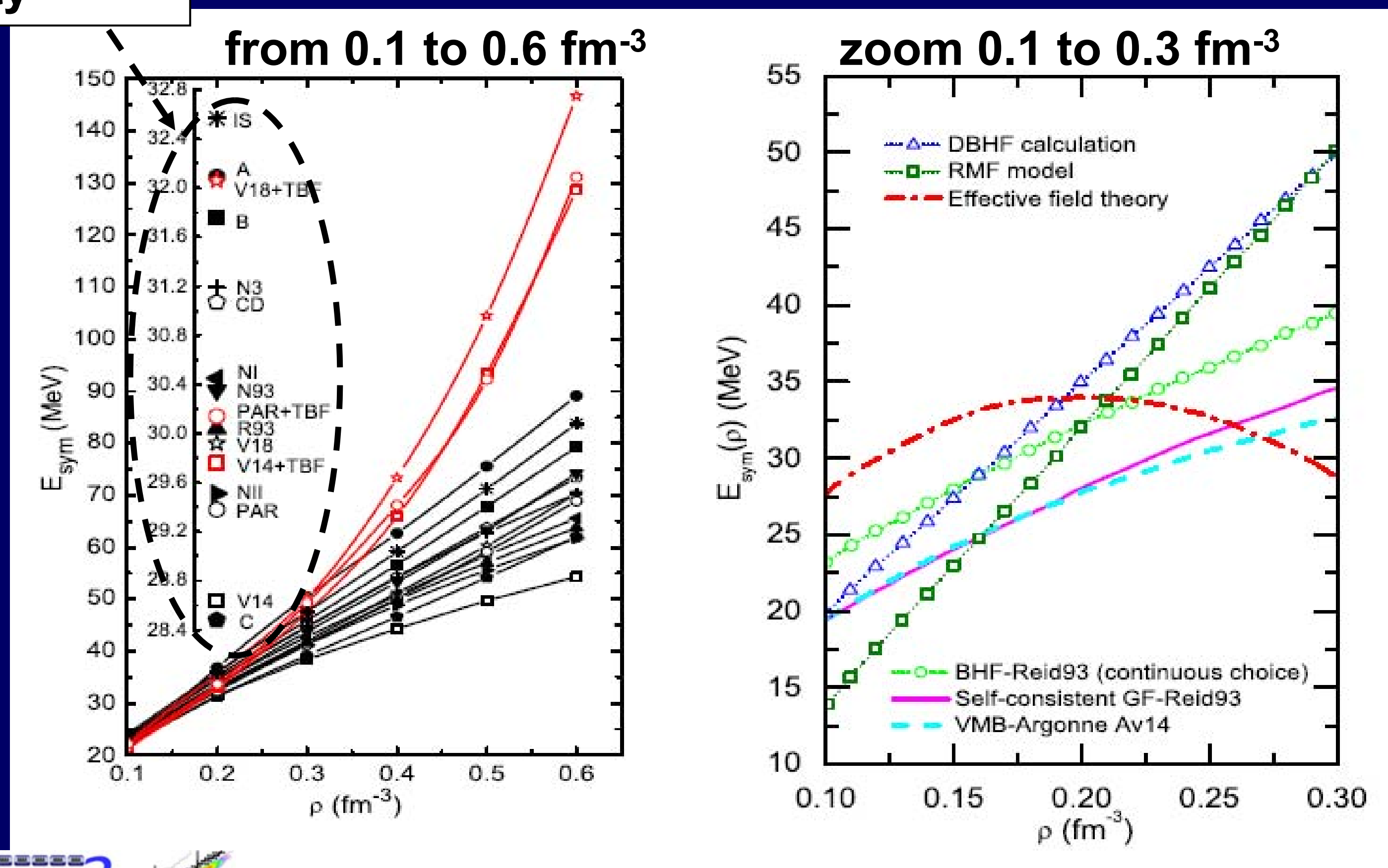
NUCLEAR EQUATION OF STATE

The largest uncertainties on the nuclear energy-density functional concern the SYMMETRY$_{\text{potential}}$ part.



for saturation density

MODEL CALCULATIONS



Even at saturation density!!

Spiral2

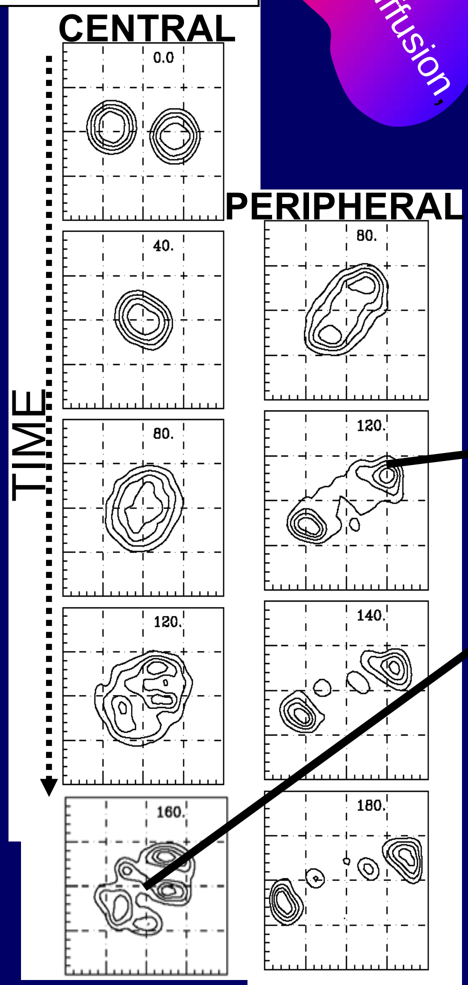
A.Dieperink et al PRC68(2003)064307

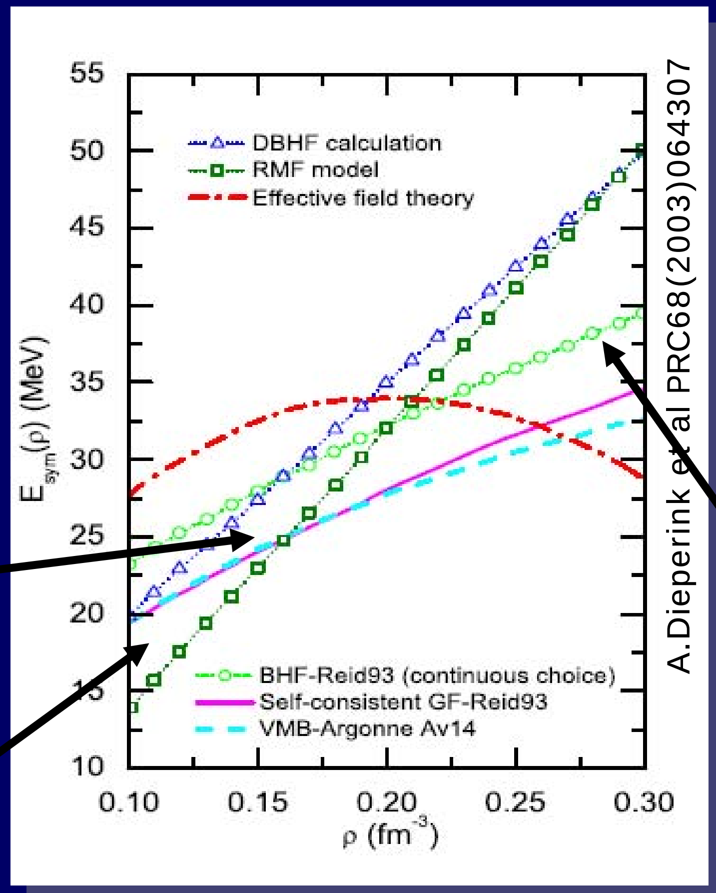
WITH THE HELP OF H.I. COLLISIONS

Measure the Density Dependence of the Symmetry Energy
EXOTIC NUCLEI – Data/Models

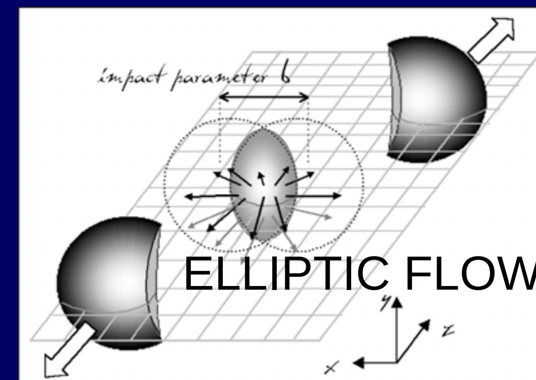
H.I. collisions
Intermediate energies

Isospin diffusion,

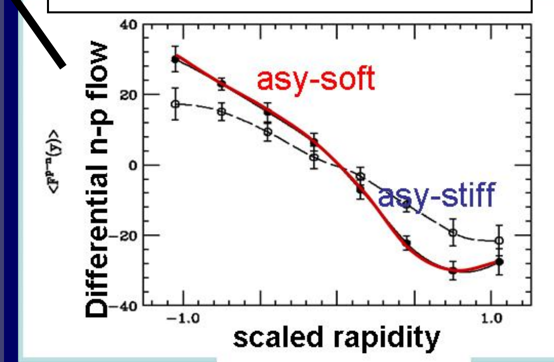




H.I. collisions
High energies



132Sn+132Sn, 1.5 AGeV



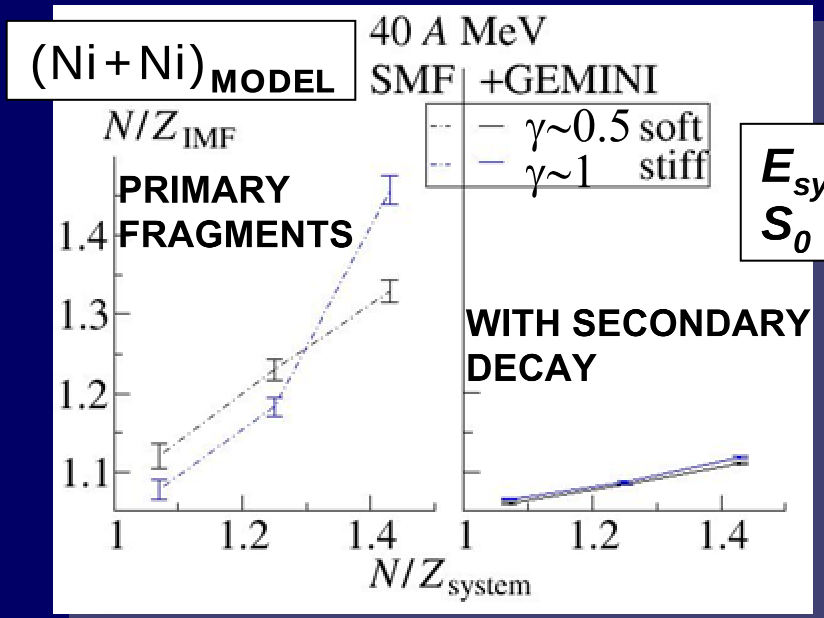
EXAMPLES OF PROBES

Adapted from H.Wolter, IWM2007

WITH THE HELP OF H.I. COLLISIONS

Measure the Density Dependence of the Symmetry Energy

ONE OF A MAJOR PROBLEM IS RELATED TO



SECONDARY DECAY EFFECTS

$E_{sym}(\rho)/A = S_0 \ (\rho/\rho_0)^{\gamma}$

Most isospin observables lose sensitivity to the EOS due to secondary decay

Solutions:

. taking ratios amplifies the signals and (partially) cancels secondary evaporation

. Use very exotic beams

FAZIA simulation group: P.Napolitani et al, in preparation

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV

STUDY OF THE "CHEMISTRY" IN THE FORWARD PART OF c.m
[good detection]
and preliminary results of
STOCHASTIC MEAN FIELD TRANSPORT MODEL (SMF*)

Work in progress, preliminary

***(Phys.Rep. 410 (2005) 335-466)**

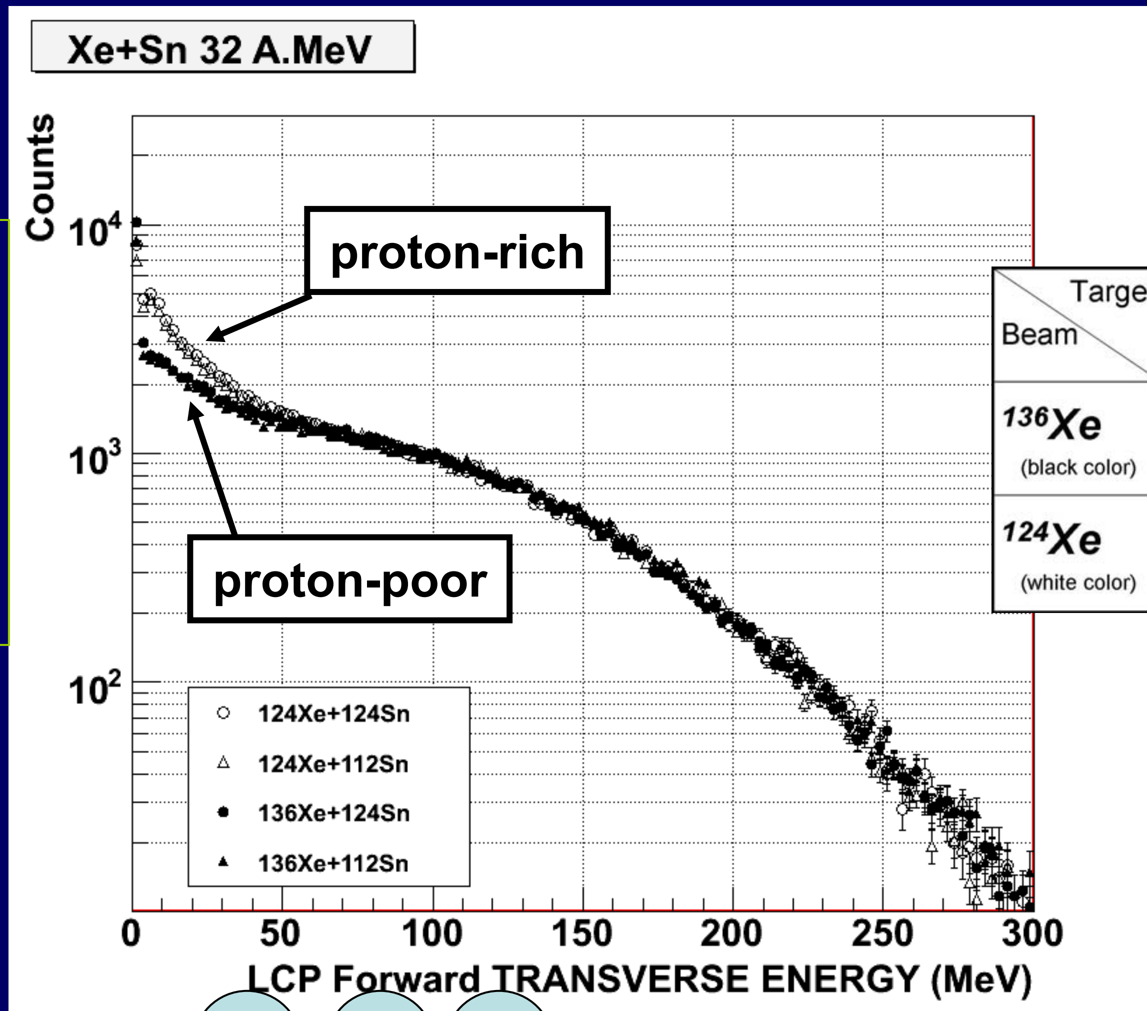
INDRA@GANIL EXPERIMENT

IN THE FORWARD PART OF c.m → "QP-side"

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV

Light Charged Particles: Transverse Energy (Forward part of c.m



Target / Beam	^{124}Sn (circle)	^{112}Sn (triangle)
^{136}Xe (black color)	●	▲
^{124}Xe (white color)	○	△

8fm 6fm 4fm

MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

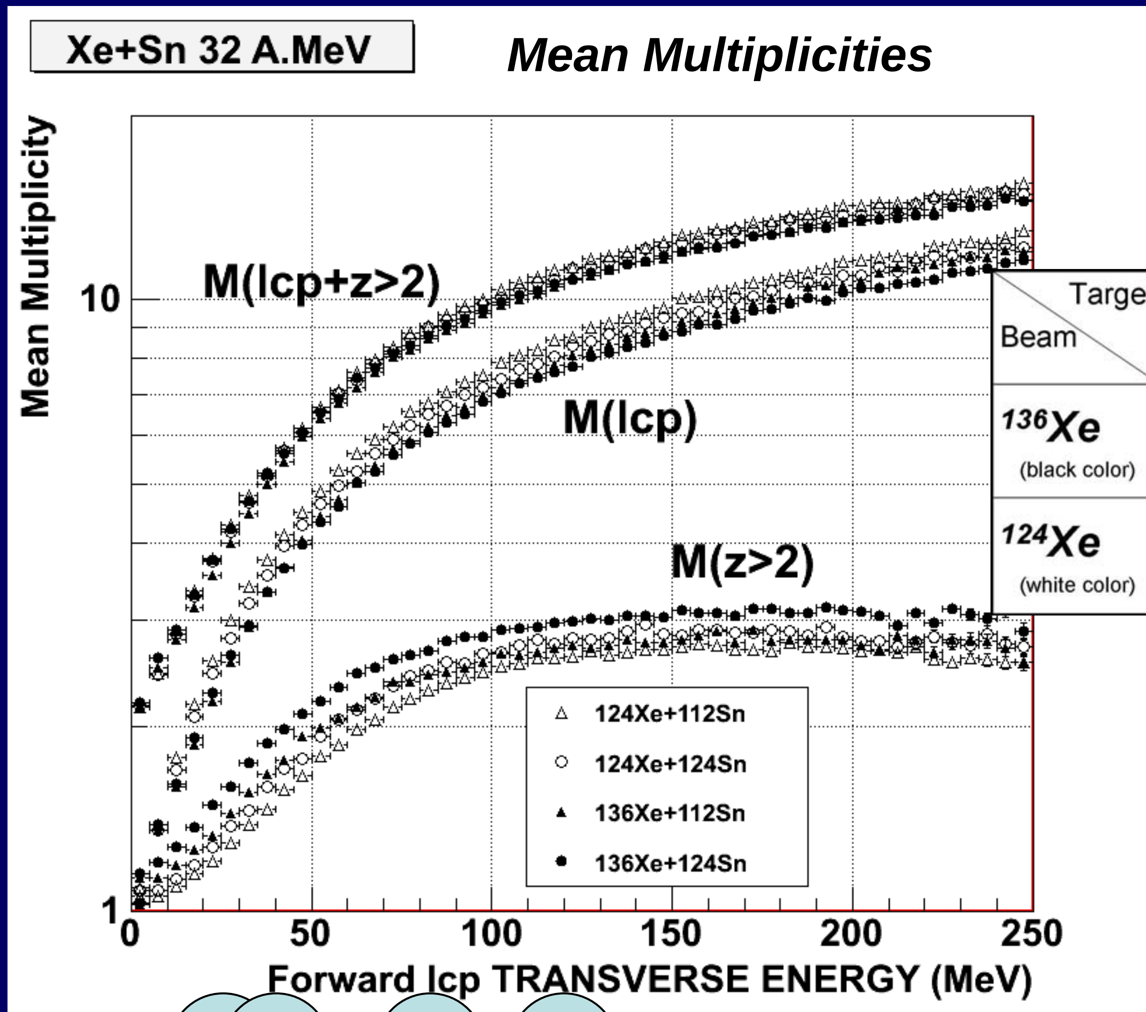
$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV

Total Mcharged id.

$Mlcp_{p\text{-rich}} > Mlcp_{p\text{-poor}}$

$Mfrag_{p\text{-rich}} < Mfrag_{p\text{-poor}}$

see MSU. results



Beam \ Target	*124Sn* (circle)	*112Sn* (triangle)
136Xe (black color)	●	▲
124Xe (white color)	○	△

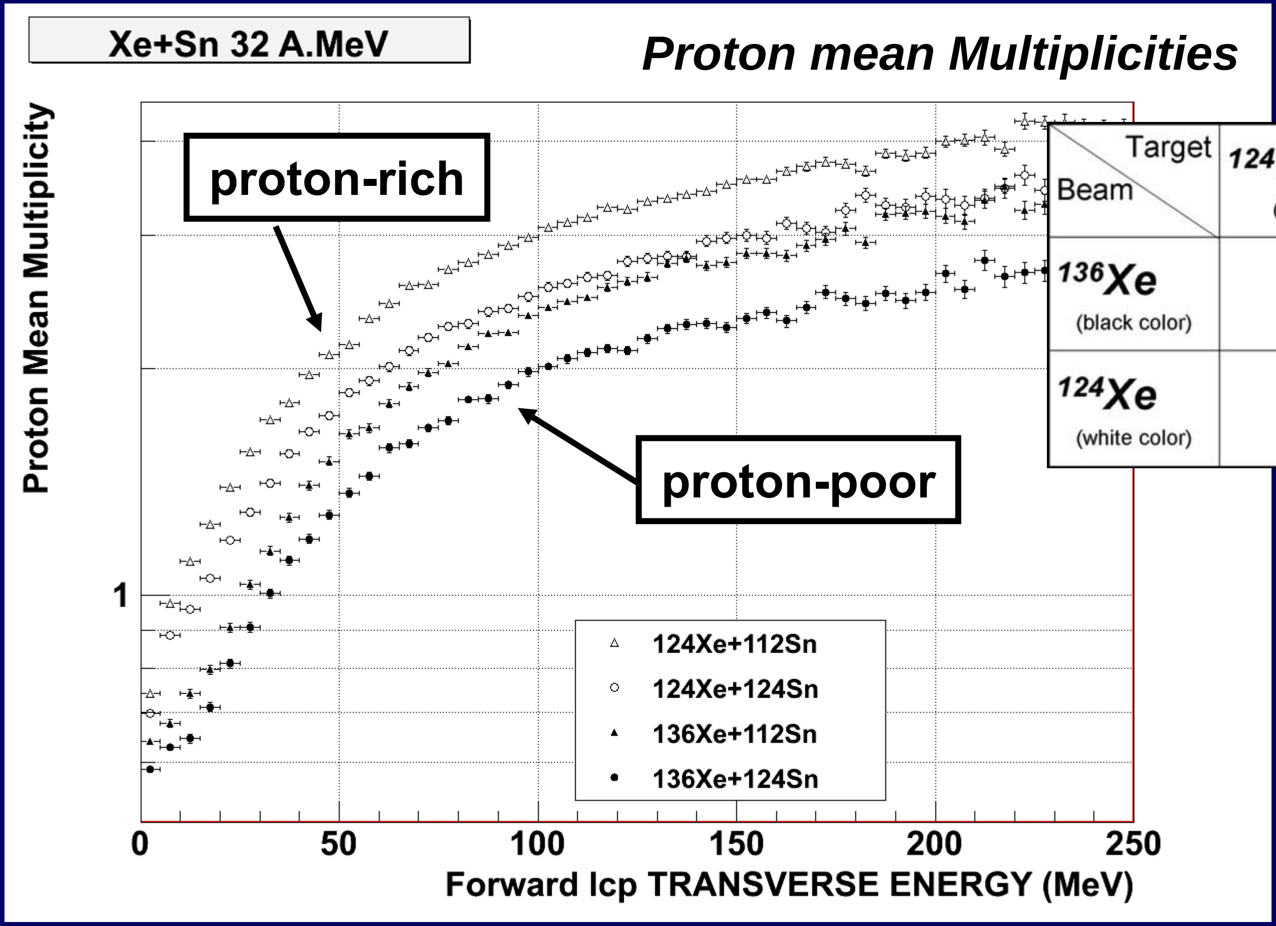
10 8fm 6fm 4fm

MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV

$MIcp_{p\text{-}rich} > MIcp_{p\text{-}poor}$ largely due to Mproton



Beam \ Target	^{124}Sn (circle)	^{112}Sn (triangle)
^{136}Xe (black color)	●	▲
^{124}Xe (white color)	○	△

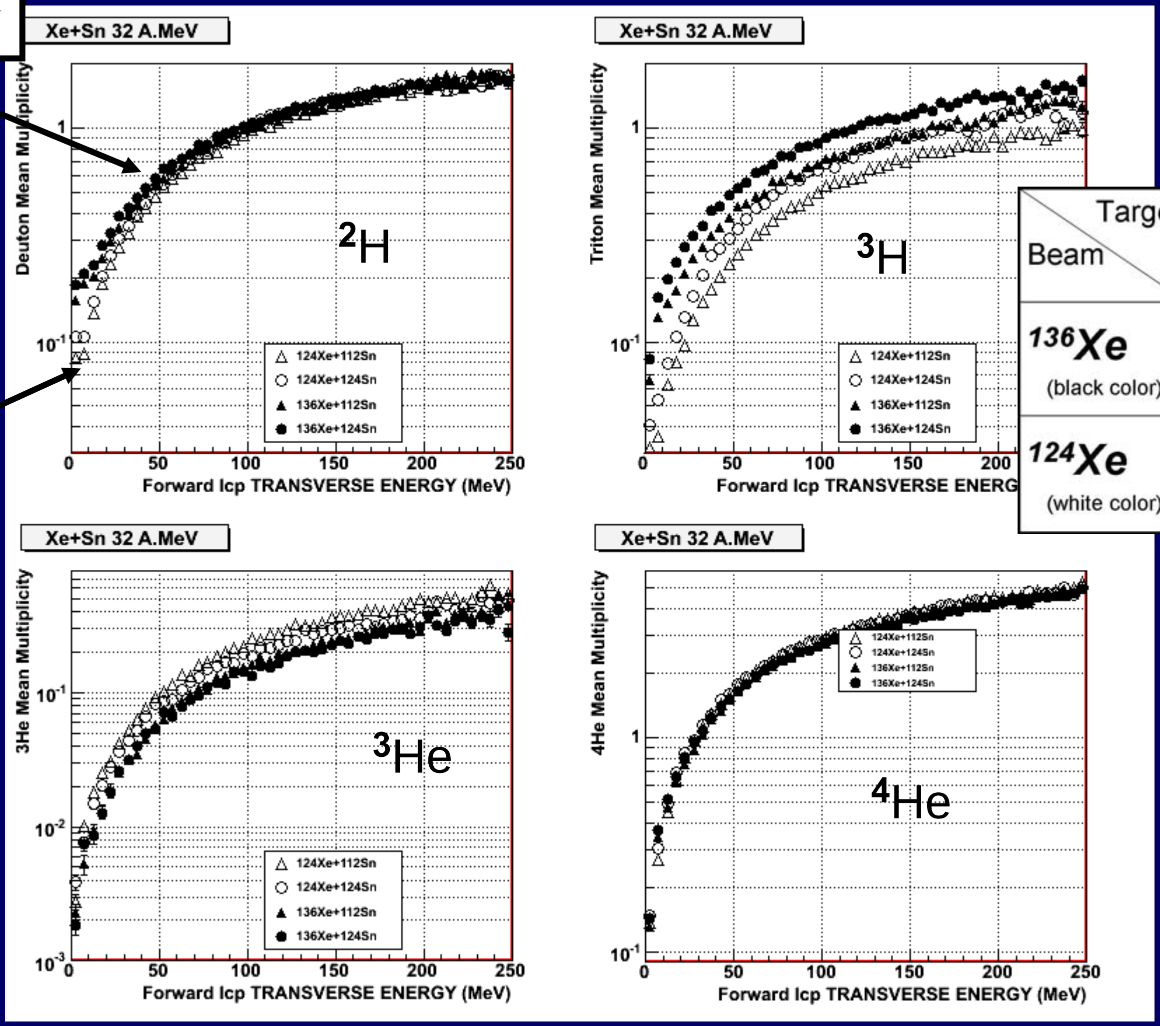
MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV

proton-poor

proton-rich



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MEASURE OF THE IMPACT PARAMETER

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proton-poor

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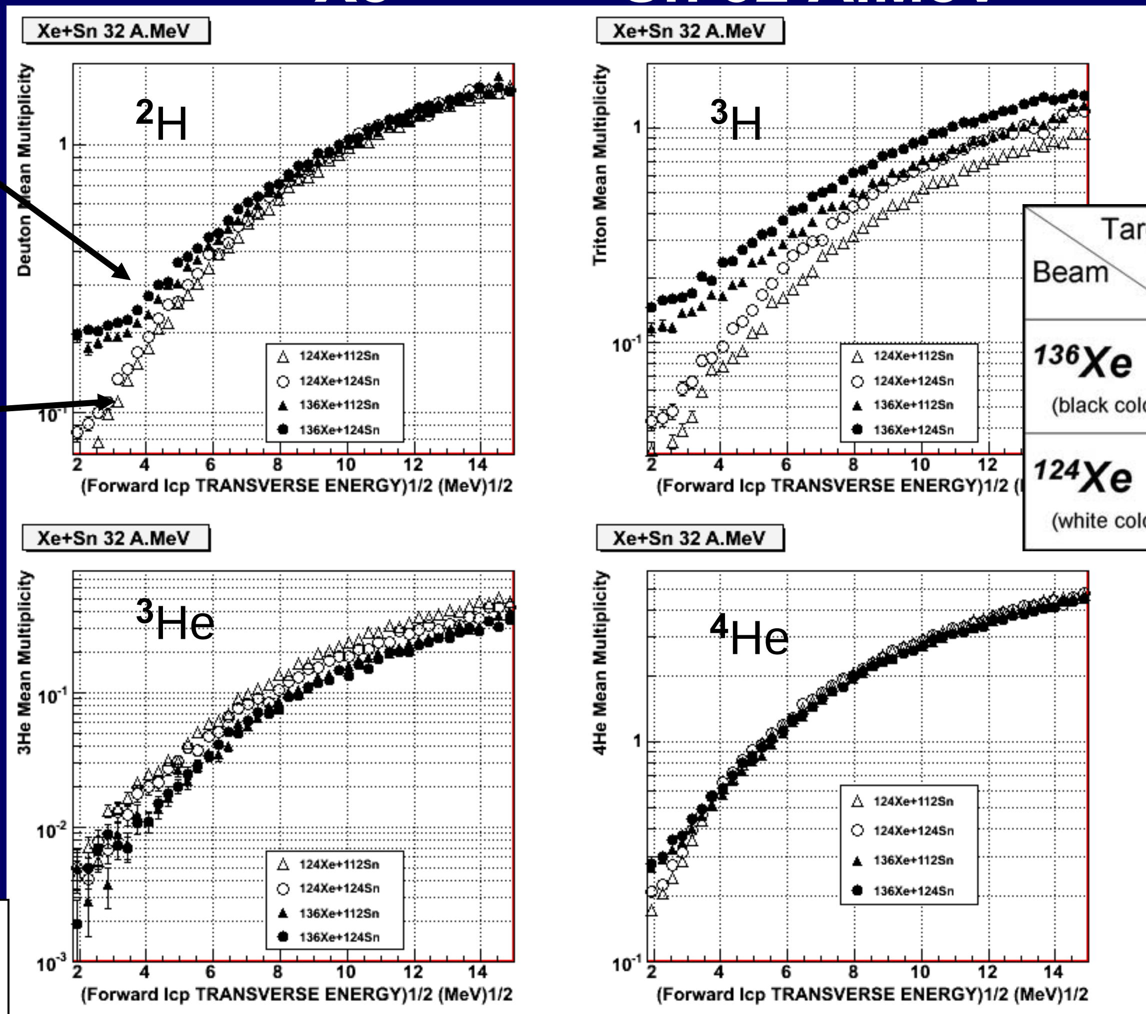


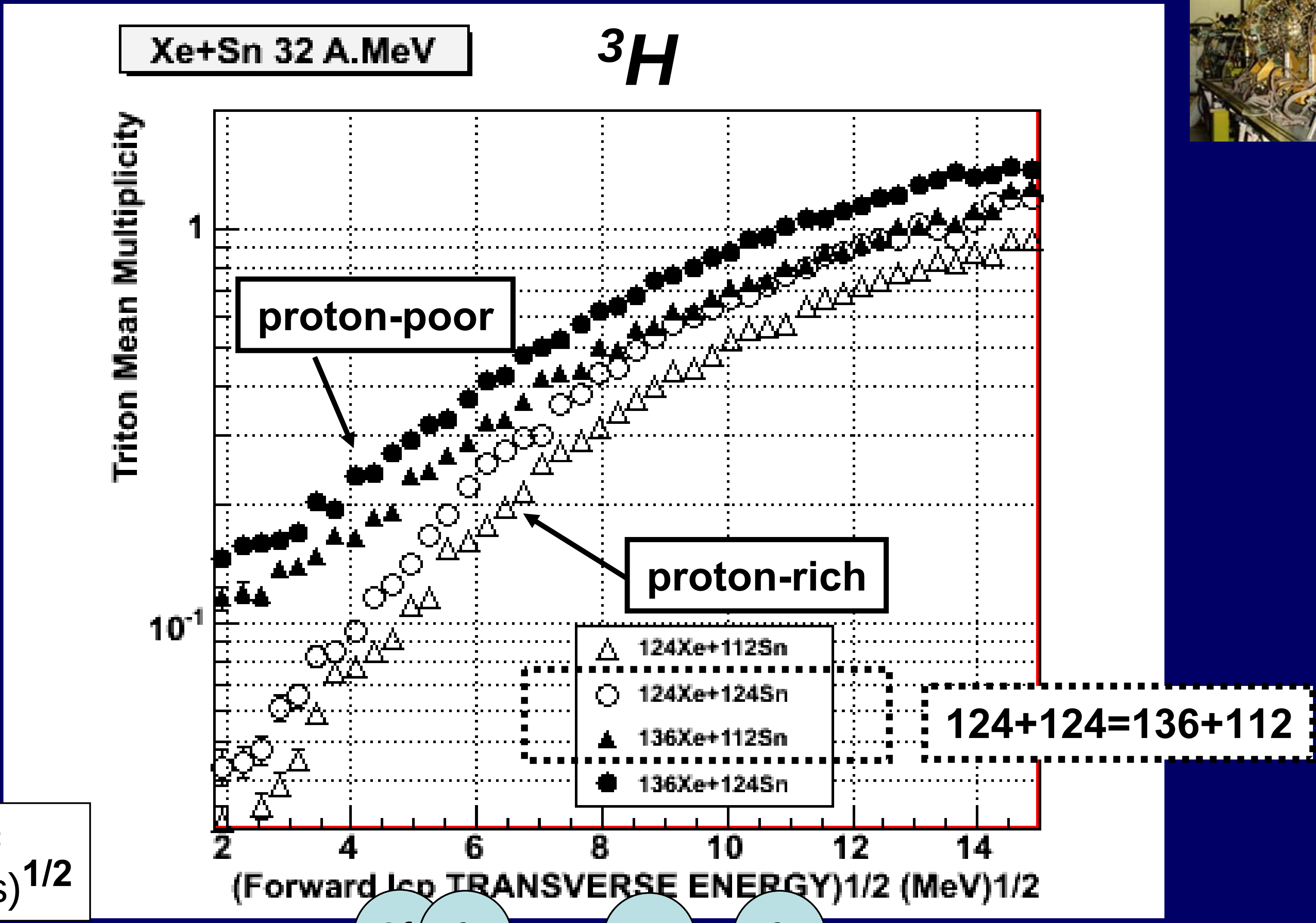
Target / Beam	^{124}Sn (circle)	^{112}Sn (triangle)
^{136}Xe (black color)	●	▲
^{124}Xe (white color)	○	△

Scale=
$(Etrans)^{1/2}$

MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV



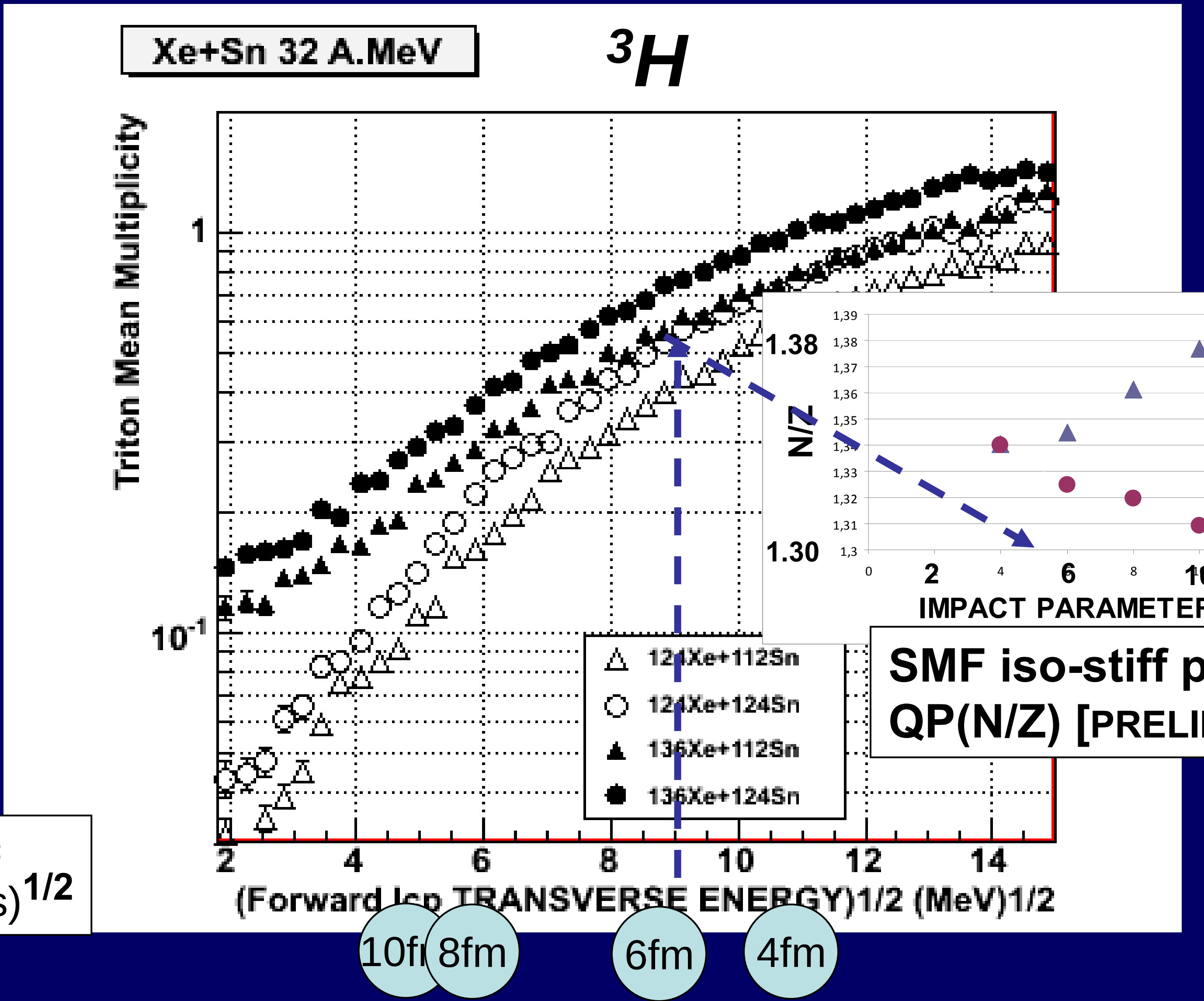
Scale= (Etrans)$^{1/2}$

10fm 8fm 6fm 4fm

MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV



SMF iso-stiff primary QP(N/Z) [PRELIMINARY]

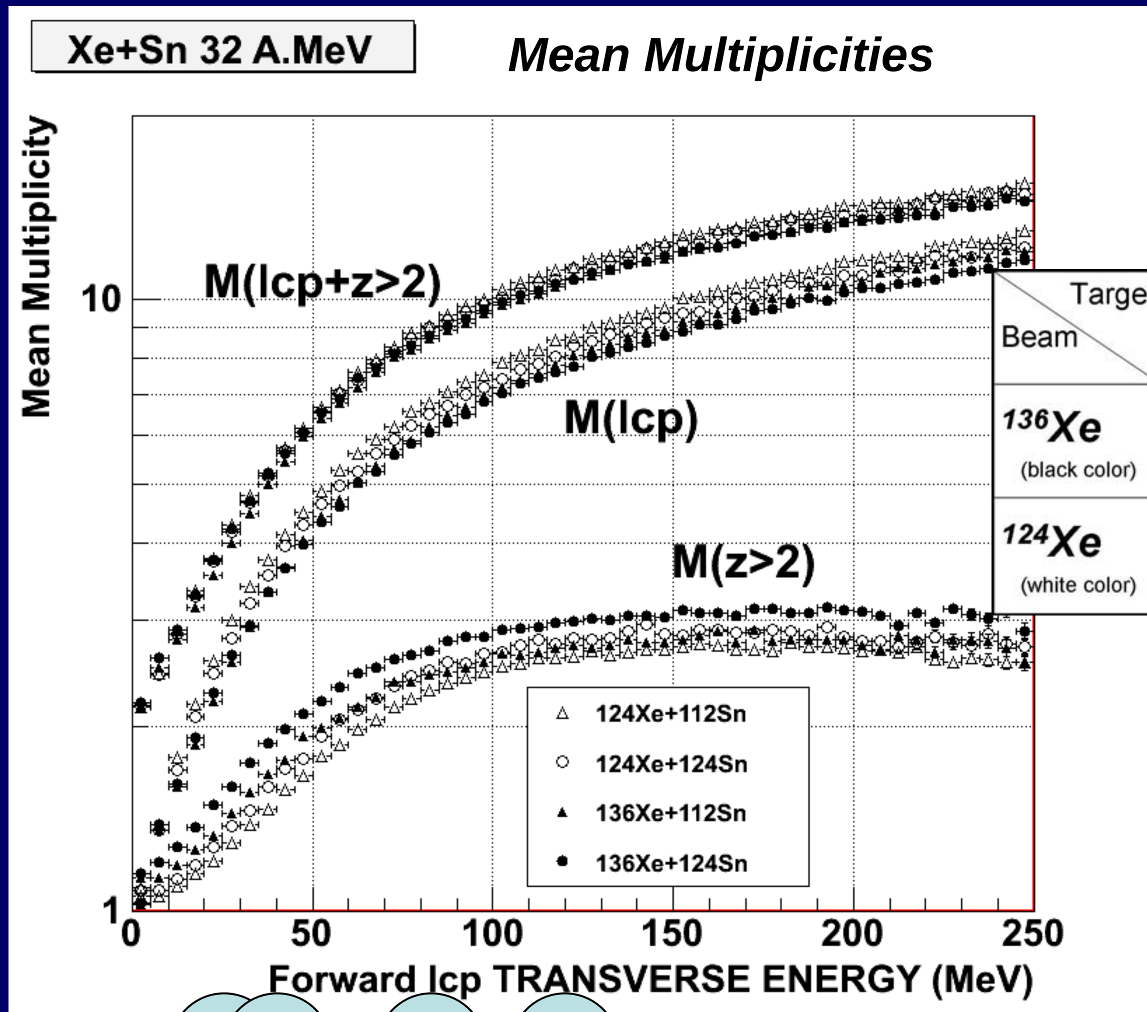
Scale= $(E_{trans})^{1/2}$

with E.Galichet and M.Colonna

MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV



Target / Beam	^{124}Sn (circle)	^{112}Sn (triangle)
^{136}Xe (black color)	●	▲
^{124}Xe (white color)	○	△

Total Mcharged id.

$Mlcp_{p\text{-}rich} > Mlcp_{p\text{-}poor}$

$Mfrag_{p\text{-}rich} < Mfrag_{p\text{-}poor}$

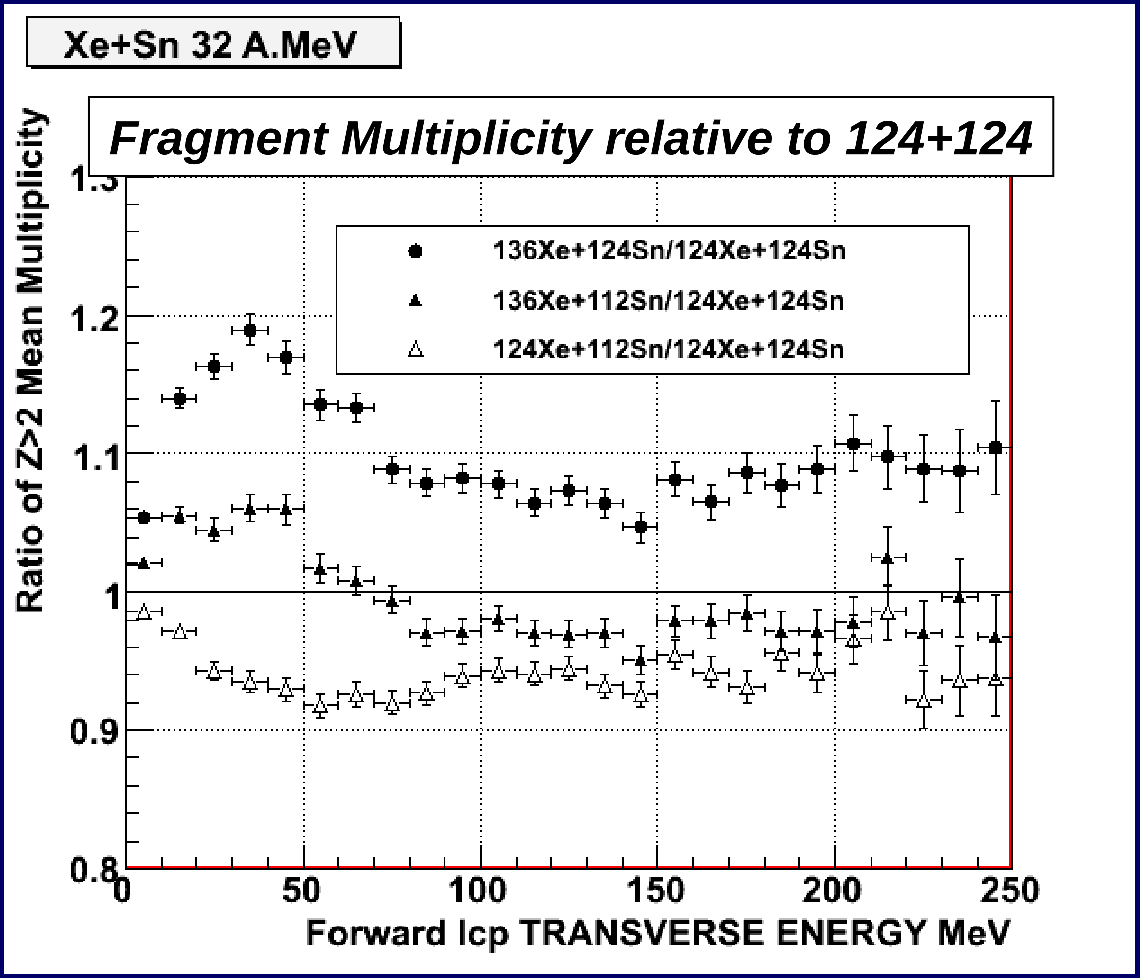
see MSU. results

10 8fm 6fm 4fm

MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

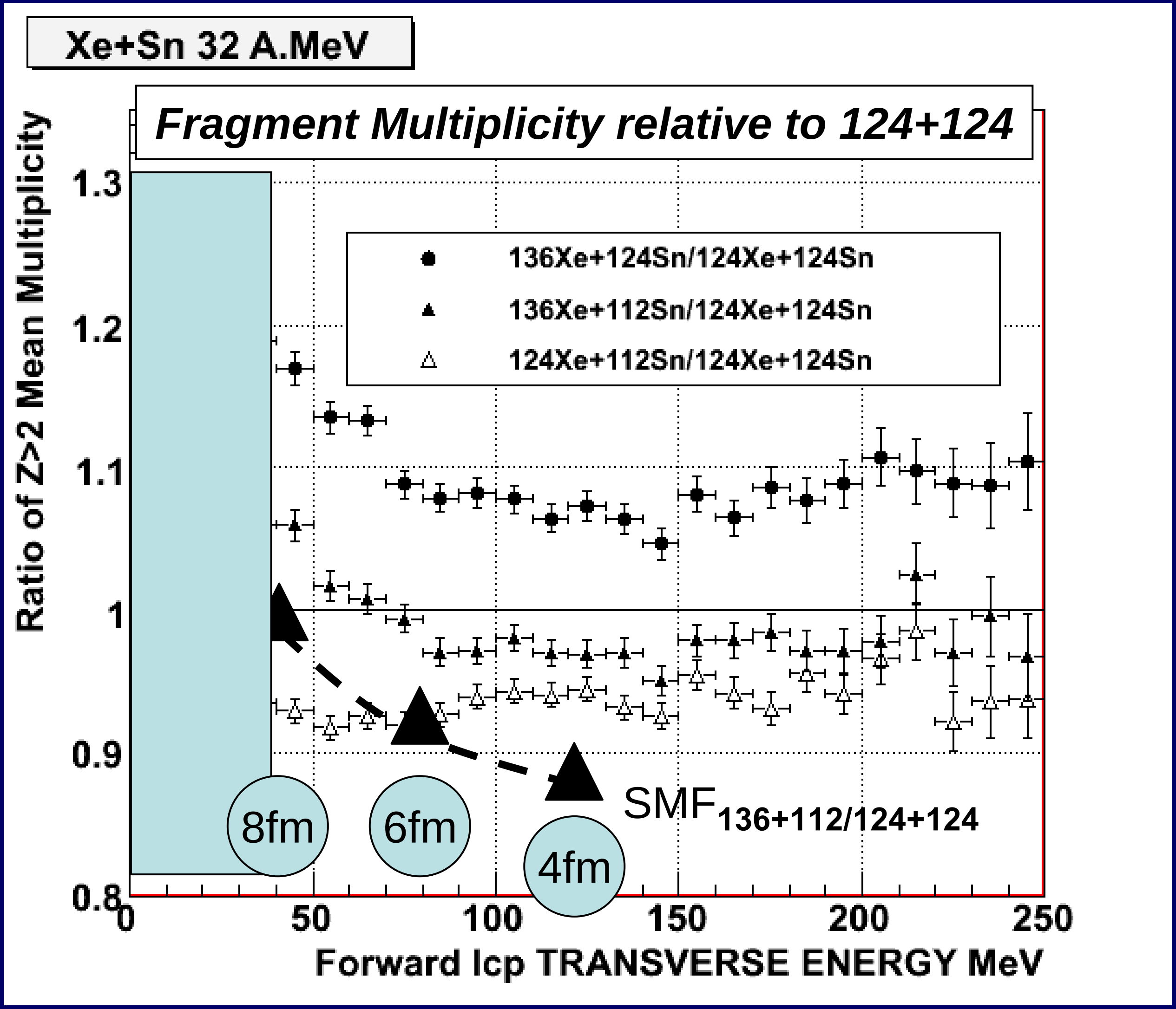
$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV



MEASURE OF THE IMPACT PARAMETER

INDRA@GANIL EXPERIMENT

$^{136,124}Xe + ^{124,112}Sn$ 32 A.MeV



with E.Galichet and M.Colonna

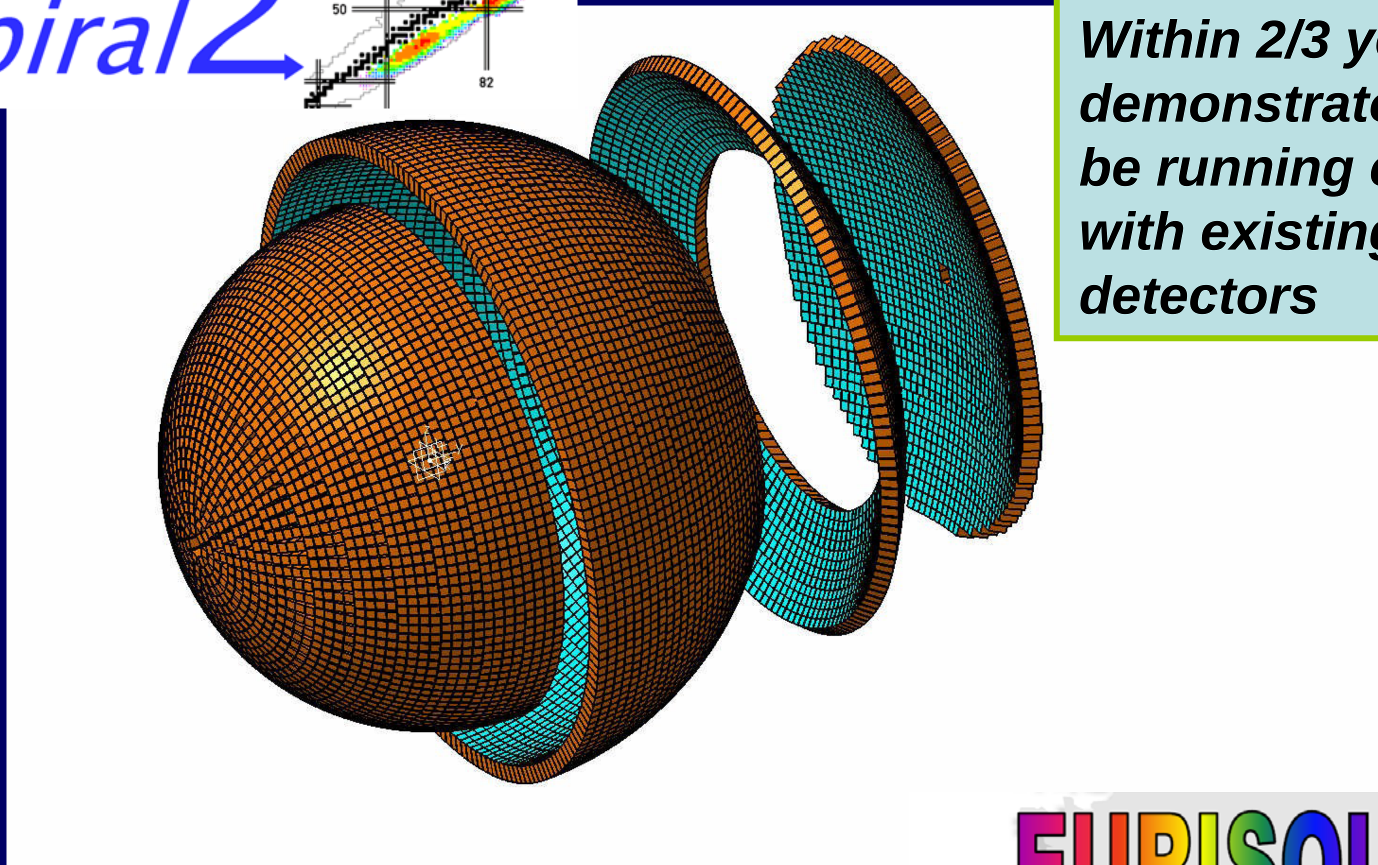
To be continued ………

This part is impossible to compare with SMF (neutron) “Et of lcp” for b

▲ SMF iso-Stiff primary fragments *PRELIMINARY*

FAZIA collaboration

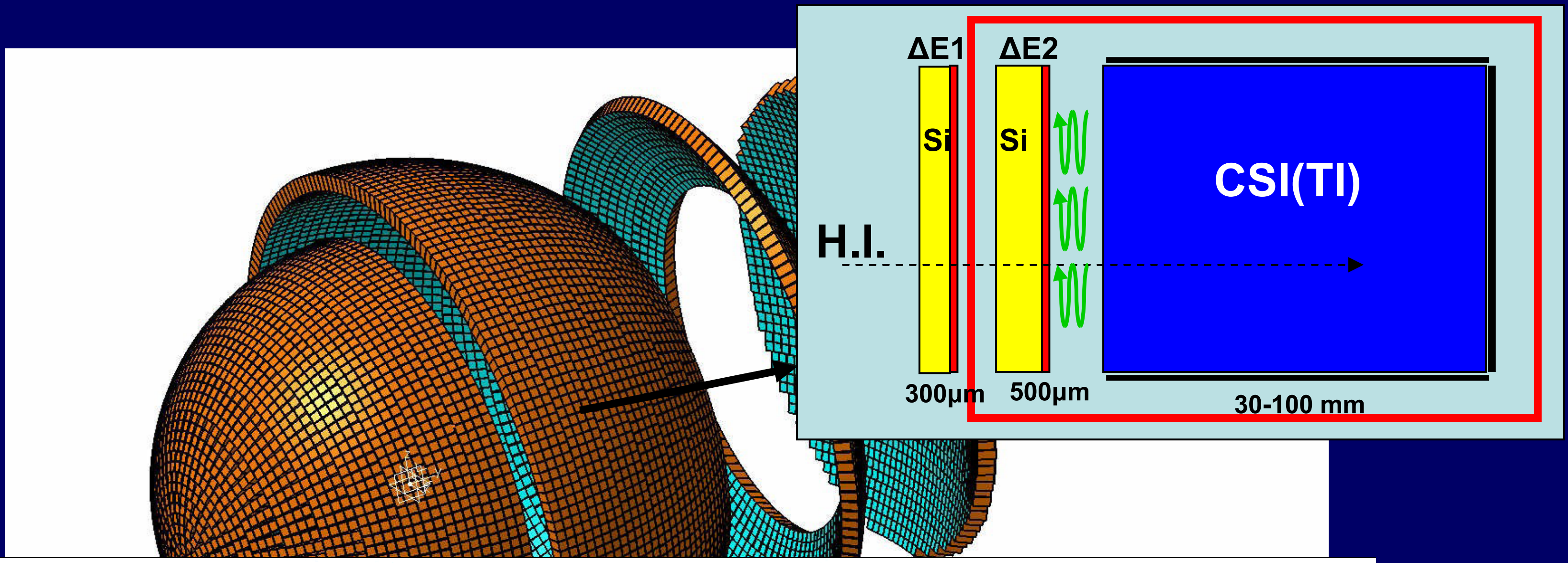
Spiral2

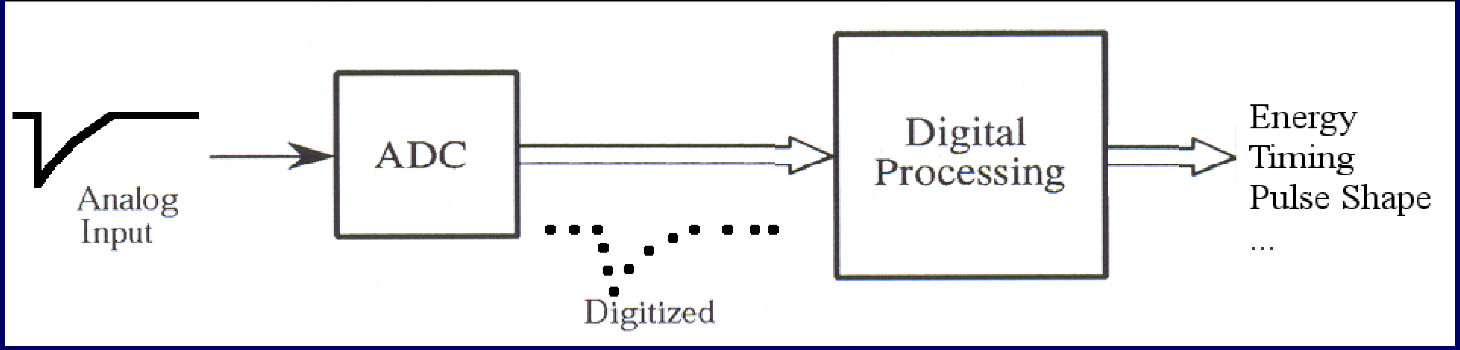


Within 2/3 years a demonstrator will be running coupled with existing multi-detectors

EURISOL

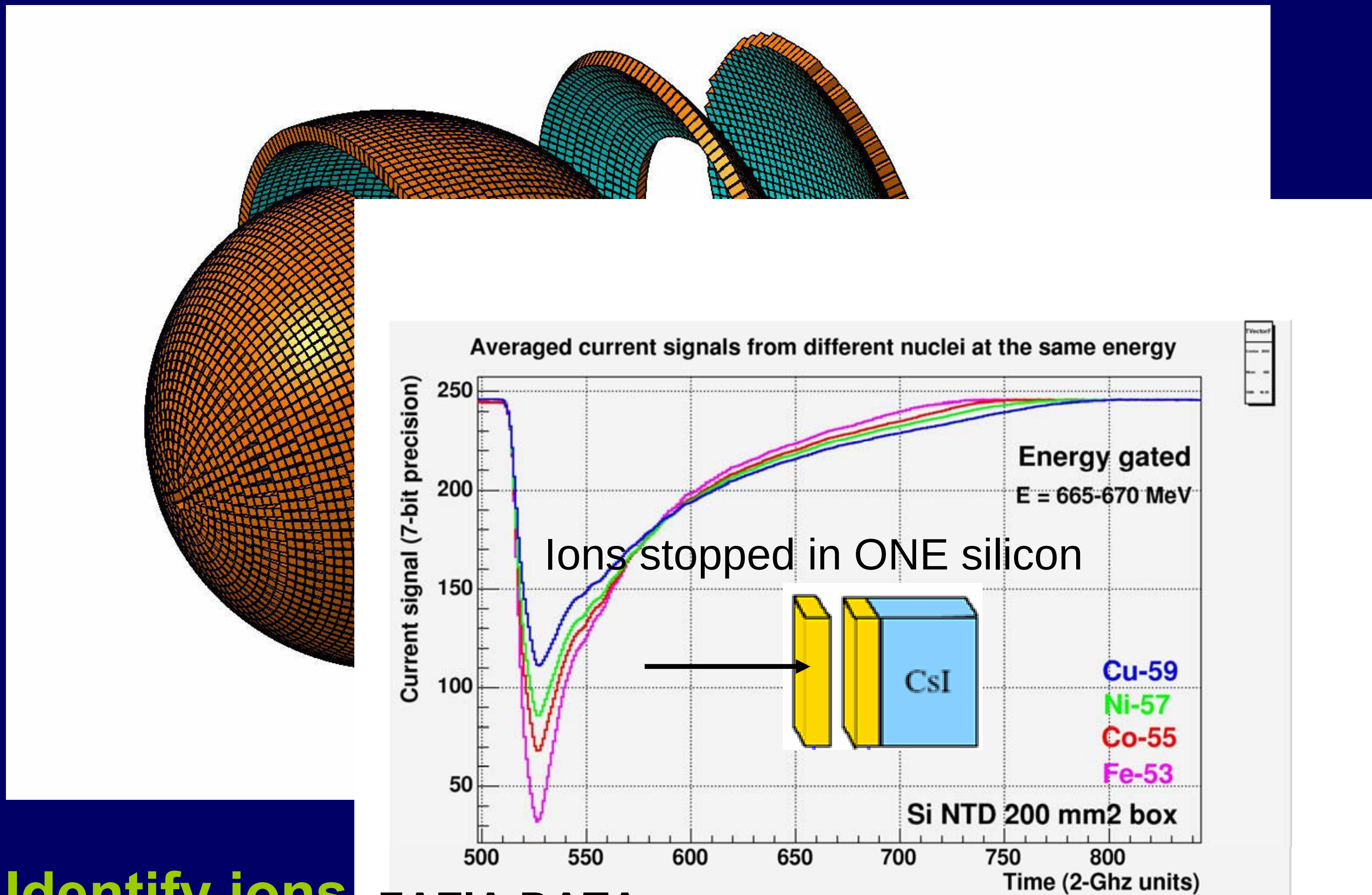
FAZIA collaboration





Identify ions stopped in one silicon detector
low id. thresholds

FAZIA collaboration



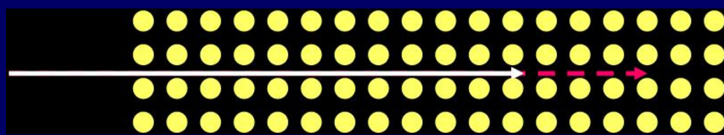
Identify ions

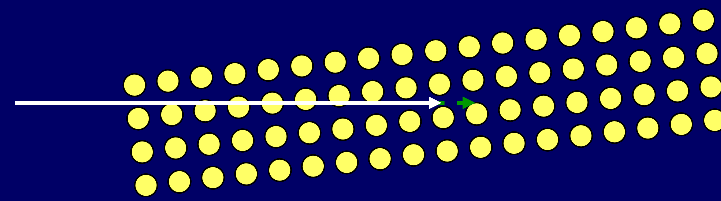
FAZIA DATA

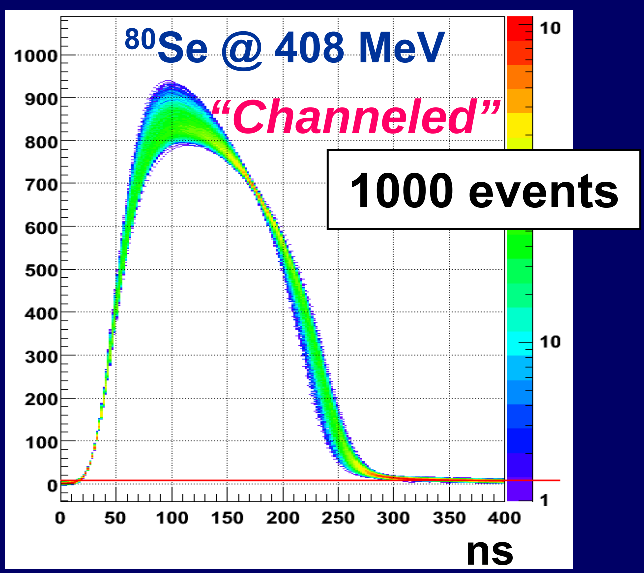
low id. thresholds

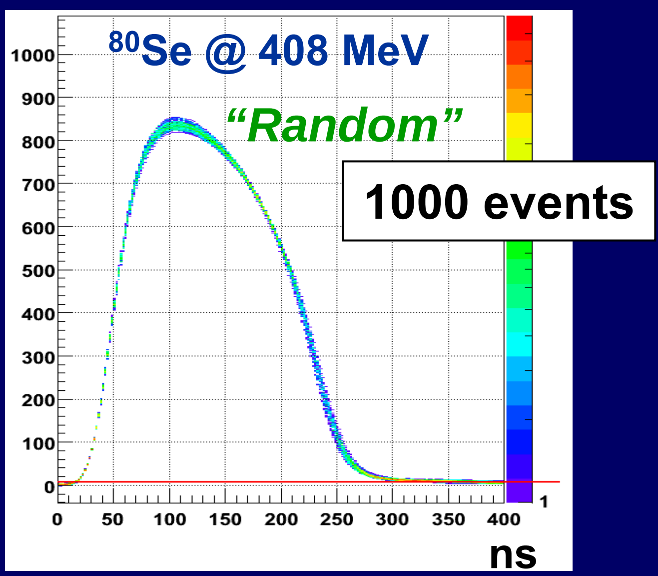
FAZIA collaboration

“Channeled” **“Random”**







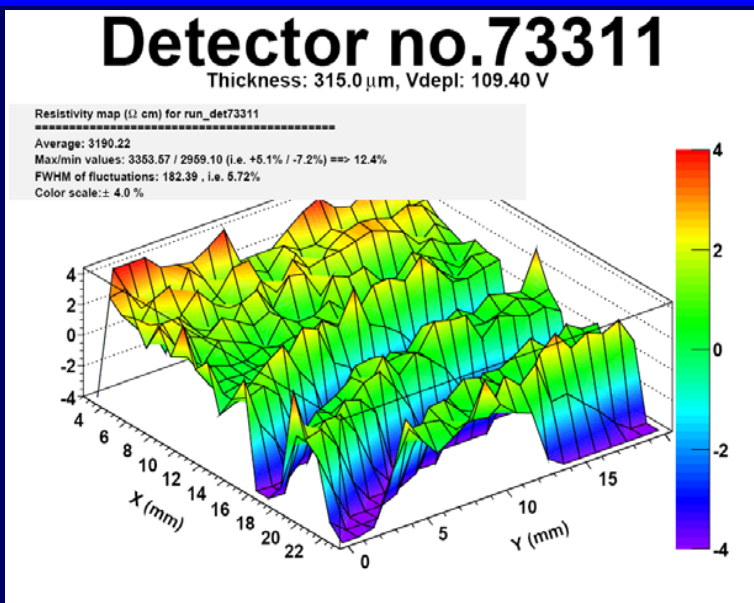


IMPROVEMENT IN SIGNAL DISPERSION

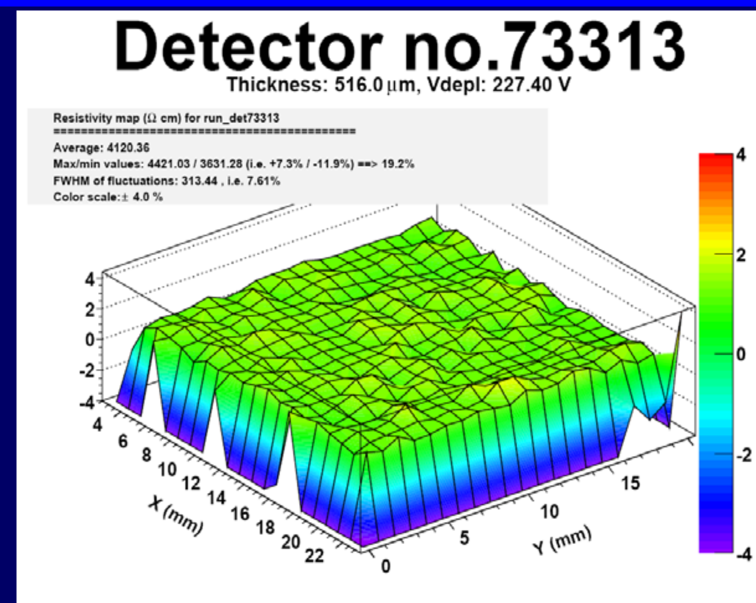
FAZIA collaboration

non-homogeneity in the electric field inside the detector (doping) may have a severe impact over the Pulse Shape Discrimination capabilities:

A typical detector: ~9% non-uniformity



A <u>very good</u> detector: ~1% non-uniformity



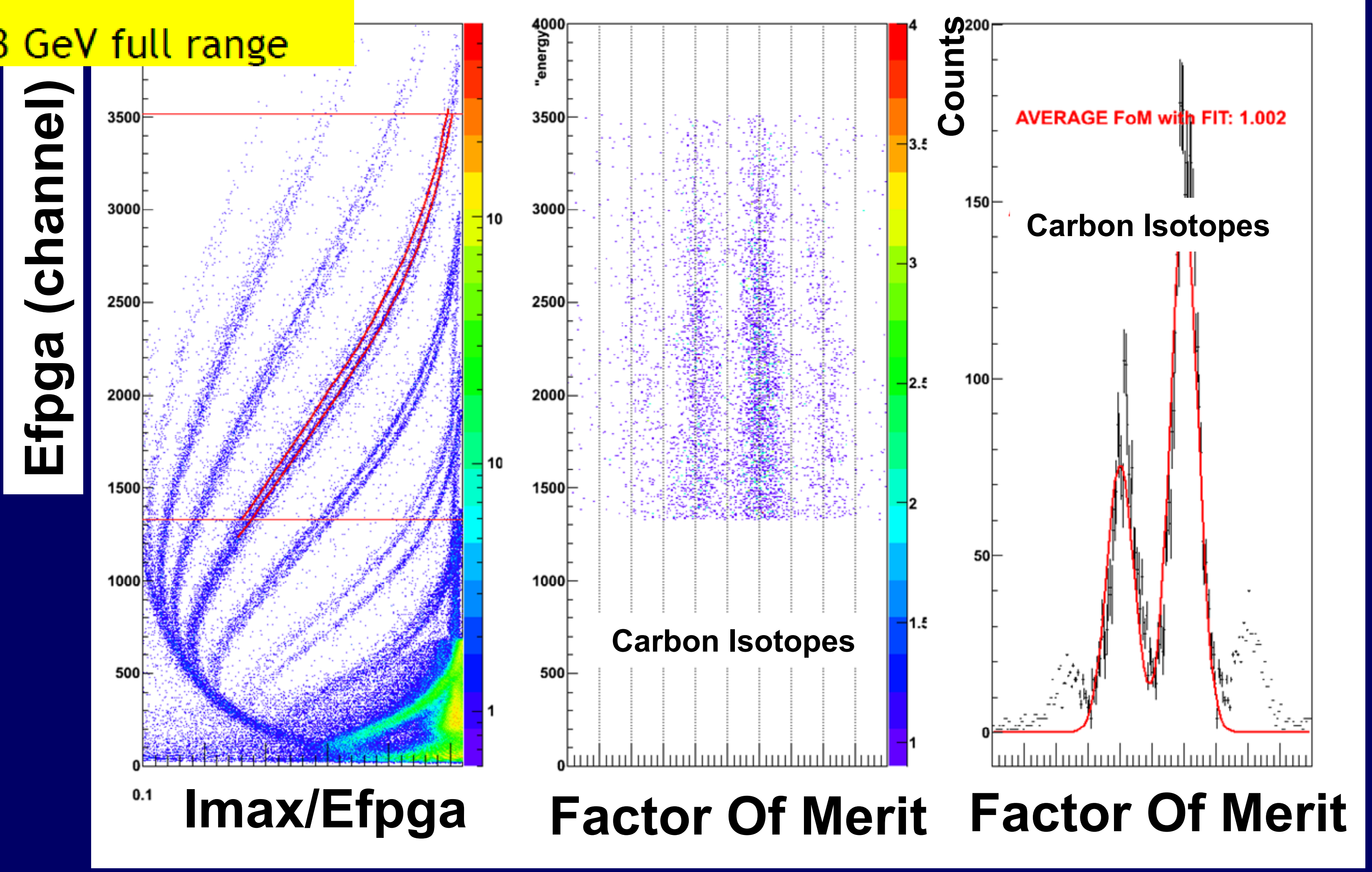
IMPROVEMENT IN DOPING UNIFORMITY

FAZIA collaboration

14 bit, 100 MS/s digitizer

1.3 GeV full range

IONS STOPPED IN ONE DETECTOR

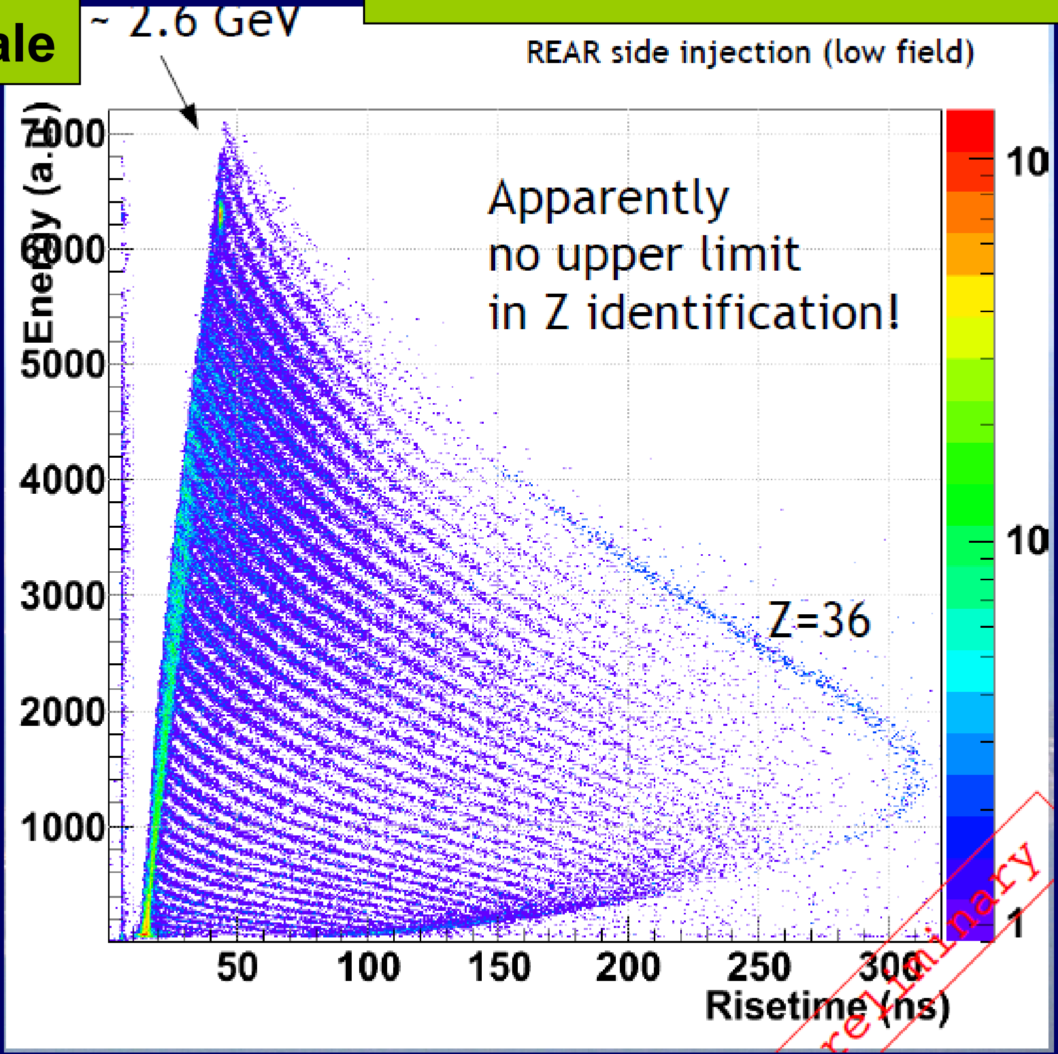


leneindre@lpccaen.in2p3.fr

FAZIA collaboration

14 bits 100MS/s
6 GeV full scale

IONS STOPPED IN ONE DETECTOR



FAZIA collaboration