LOI @

Isospin dependence of compound nuclear formation and decay

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SPES 2010 Workshop & IV LEA-COLLIGA Meeting

15-19 November 2010 INFN Laboratori Nazionali di Legnaro

ISODEC - Scientific Program

Stable Beams

-E475S@GANIL , with INDRA (2007)

-ISODEC@LNS , with CHIMERA (2010)

Next Exotic Beams

-Loi for SPES@LNL

-Next proposal for SPIRAL2@GANIL

LEA COLLIGA agreement

- **J.P. Wieleczko et al., LOI for Lea GANIL-LNL 2007**
- **E.Bonnet , Lea Colliga Meeting, LNS 2008**
- **S.Pirrone, Lea Colliga Meeting, Paris 2009**

- **Physics Case and Context**
- **Experiment INDRA@GANIL**
- **Experiment CHIMERA@LNS** **PRELIMINARY**
- **LOI@SPES**

Physics Case and Context

• Heavy ion collisions with stable and exotic beam

•Low energy regime E/A ≤ 15 MeV/A

•Fusion reaction mechanism

• the isospin dependence (N/Z) of the emission mechanism of complex fragments (Z≥3) from CN, to extract information on:

- level density parameter, (thermal properties, E*, $m_{effective}$)
- fission barrier, (Esym, congruence energy term)
- viscosity, (coupling collective – intrinsic modes, Fermi level)

• the interplay between nuclear structure and reaction mechanism in the emission process, at different excitation energy for medium mass region

E475S INDRA @GANIL E = 5.5 AMeV

$^{78,82}Kr + ^{40}Ca \longrightarrow ^{118,122}Ba^{*}$ (~ 100 MeV)

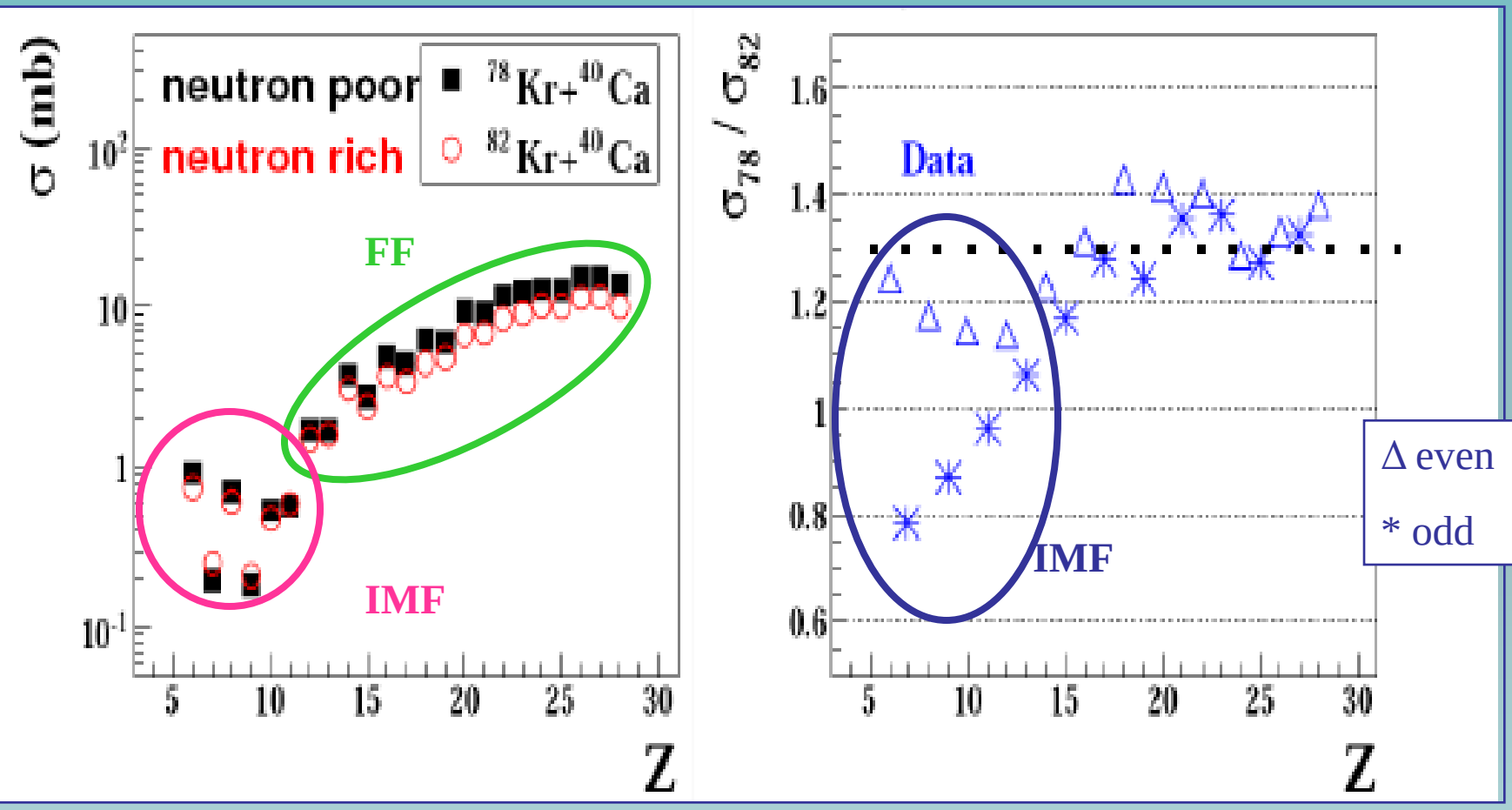
$3° \leq \theta \leq 44°$ IC-Si-CsI
forward part

- Energy, angular distribution RP
- Charge distribution
- Cross section decay mode

- J.-P. Wieleczko et al., LOI for Lea GANIL-LNL 2007
- J.-P. Wieleczko *et al*, proceedings of the FUSION08 international conference on New Aspects of Heavy Ion Collisions Near the Coulomb Barrier, sept. 2008, Chicago, USA
- E.Bonnet, Lea Colliga Meeting, LNS 2008
- G.Ademard et al, IWM2009, Catania

N/Z effects on σ measurement

Inclusive data

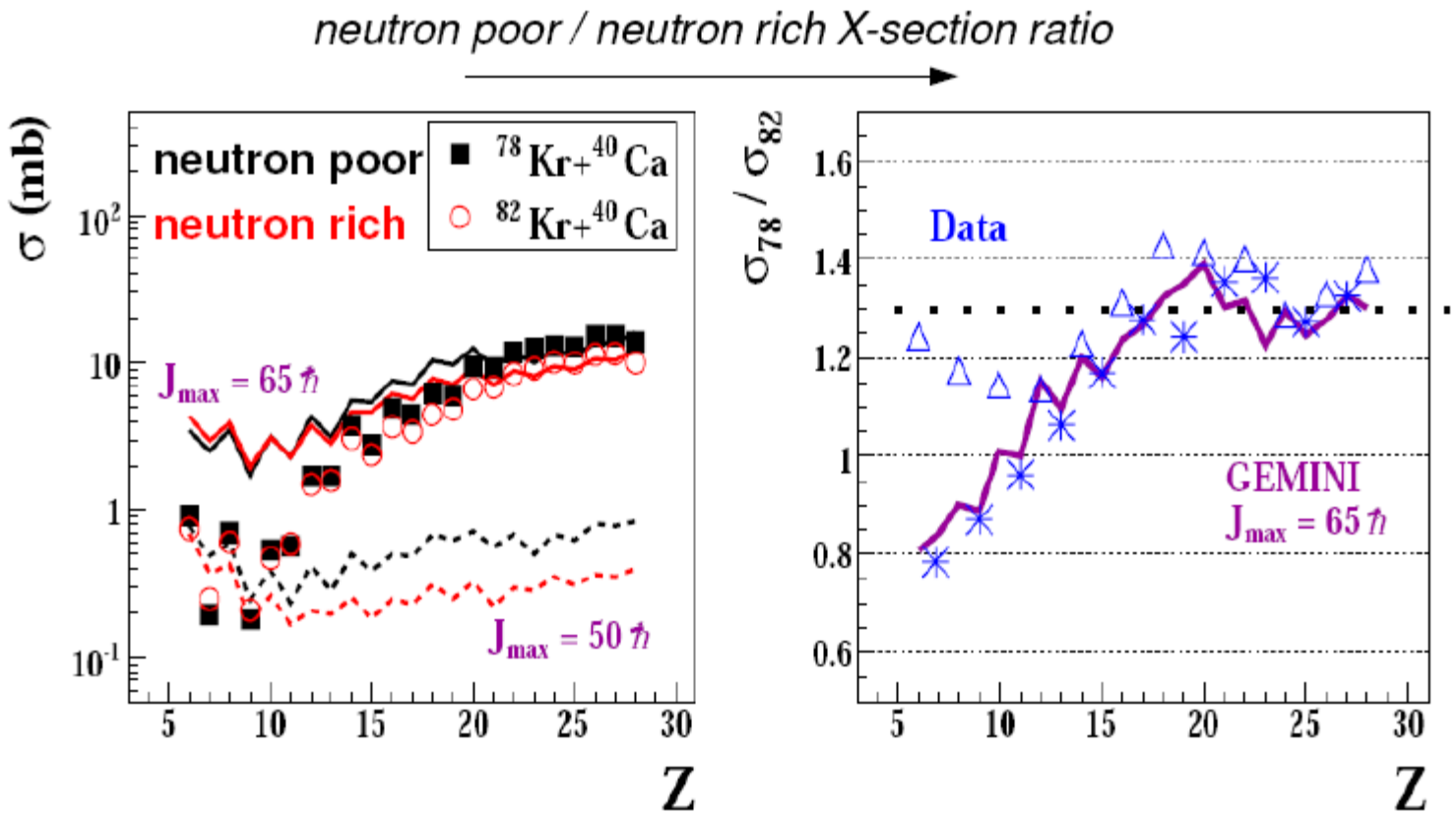


CN neutron rich (o)

- **30% less fission ($Z \geq 14$)**
- **Less even-odd staggering of IMF ($6 \leq Z \leq 12$)**
- **Even (odd) IMF are less (more) produced**

N/Z effects on X-section

Comparison with transition state model
GEMINI code



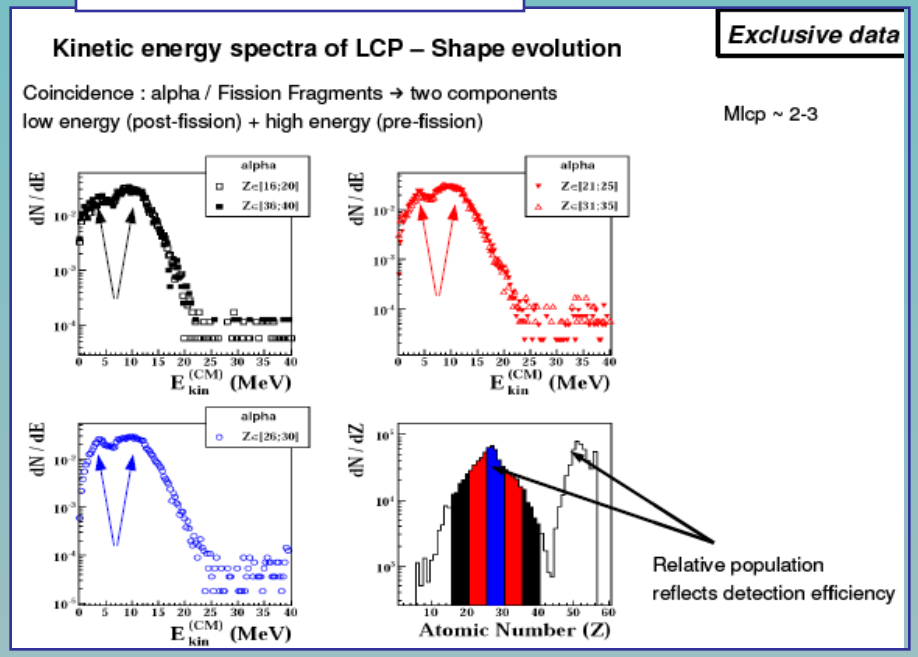
Δ even
* odd

- Multistep Hauser-Feshbach model (code including emission up to Ca)
- Extended Hauser-Feshbach scission point model
- Transition State model
- Dynamical Cluster Decay model

The discrepancies with theoretical previsions show the need to include the N/Z dependence on the emission mechanism from CN and to get new constraining data

Coincidence α-FF

INDRA@GANIL



Location peaks and slopes give us information on the shape and on the temperature of the emitting system

Deconvolution gives information on

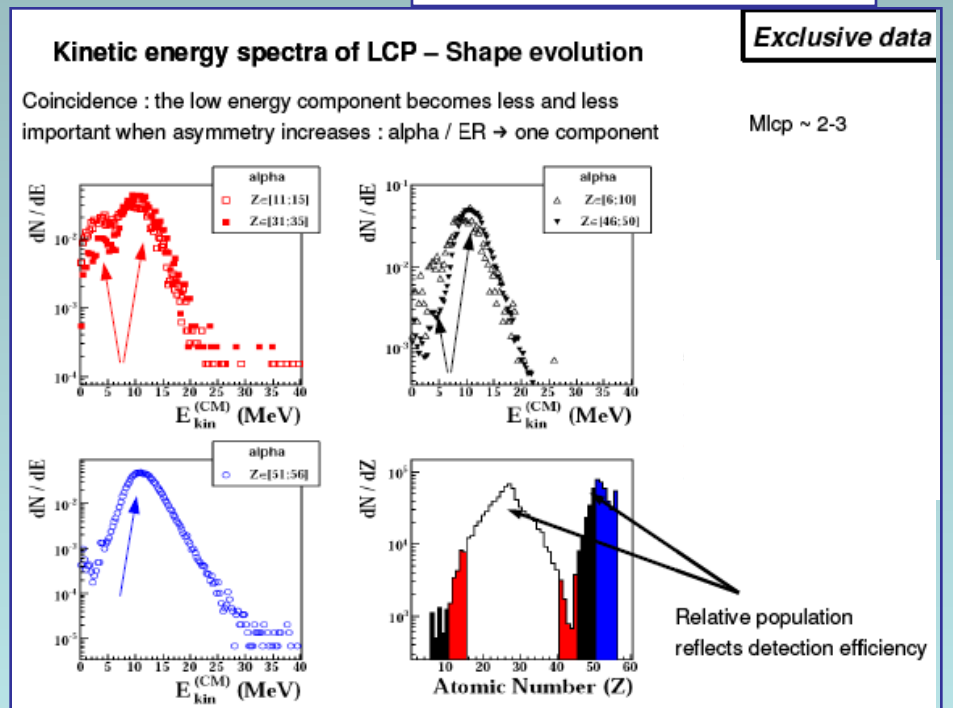
E* sharing

Level densitity

Viscosity

Dynamics of the process

Coincidence α-ER



Improving and Complementary Experiment :

- **Higher energy**

  Influence on the amplitude of the staggering.

  Influence on the temperature of the emitting system.

- **Isotopic separation of IMF**

  to investigate the staggering effects looking at the isotopic distribution of IMF.

- **Exploration of a larger domain in N/Z of the system (stable beam!)**

  to compare with theoretical model and to study the dependence from the N/Z on the mechanism of complex fragment emission from CN

- **Exclusive measurements in a large angular range**

ISODEC CHIMERA@LNS E = 10 AMeV

$^{78,86}Kr + ^{40,48}Ca \rightarrow ^{118,134}Ba^*$ (~ 250 MeV)

Spokepersons:

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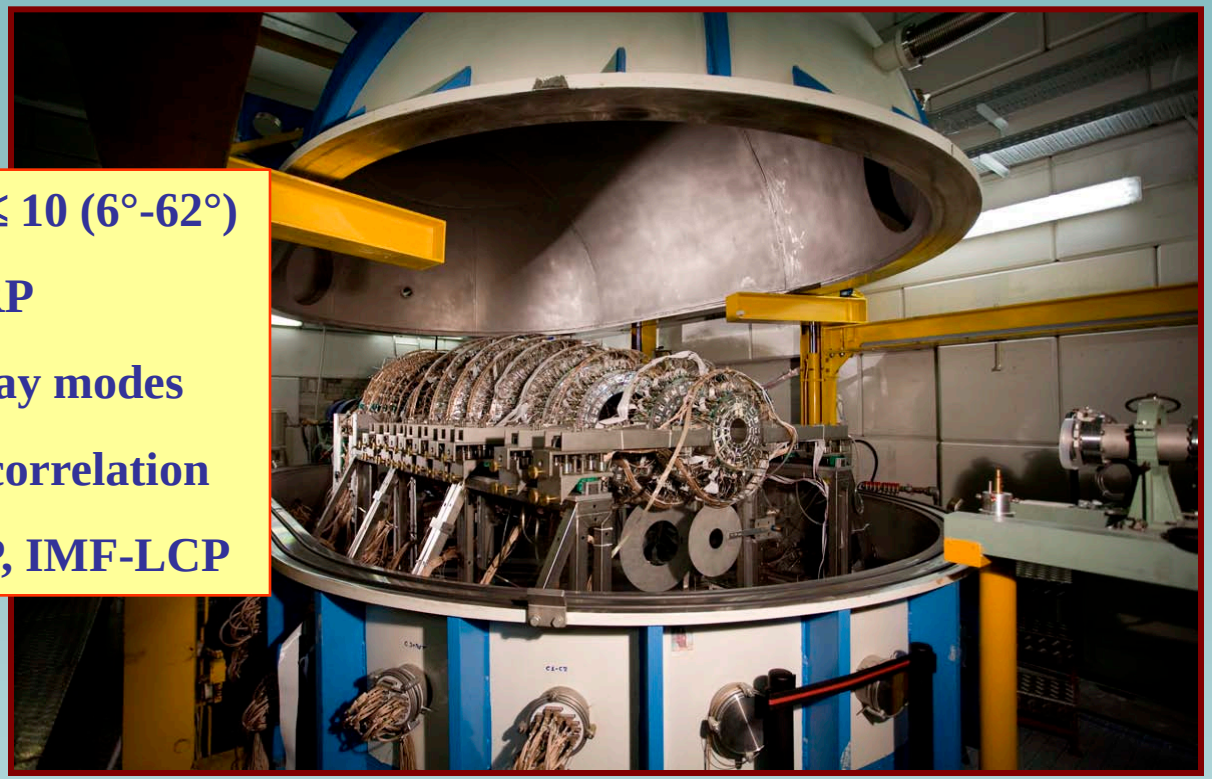


- Isotopic distribution for $3 \leq Z \leq 10$ (6°-62°)
- Energy, angular distribution RP
- Absolute cross sections for decay modes
- Relative velocity and angular correlation
- Coincidence ER-LCP, FF-LCP, IMF-LCP

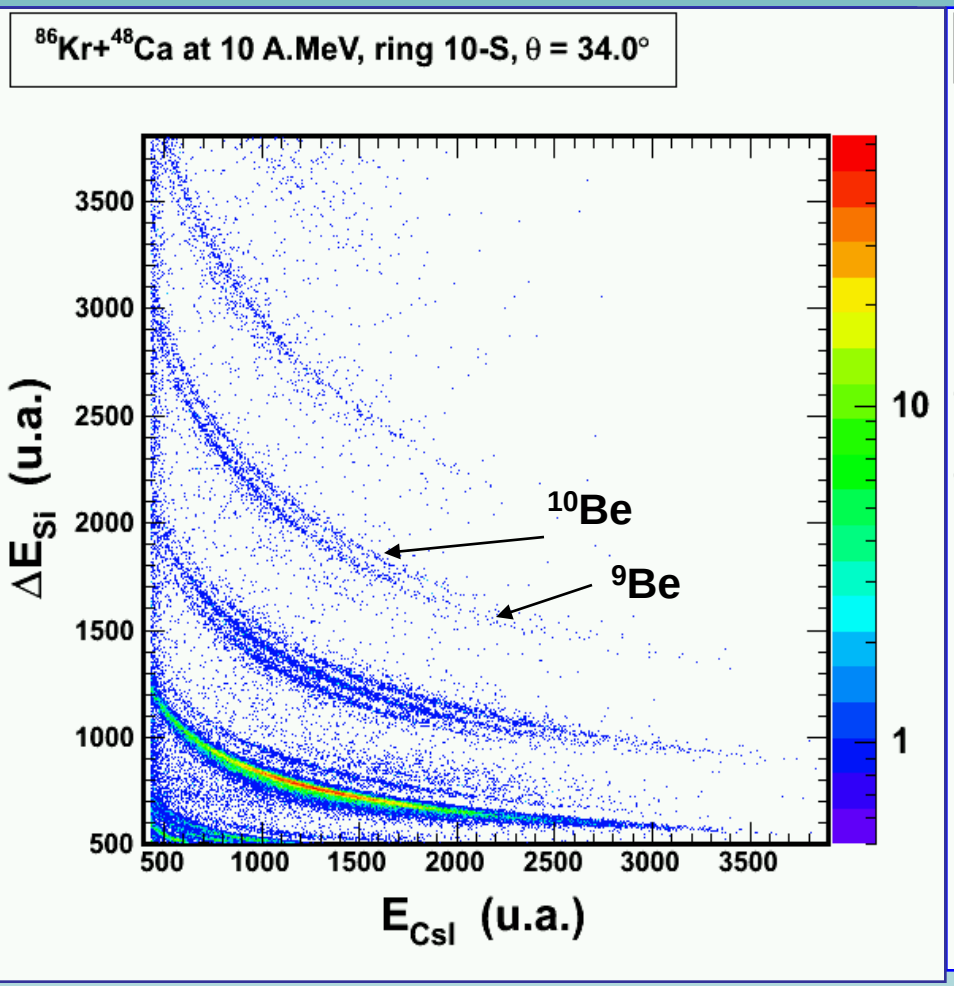
January 2010

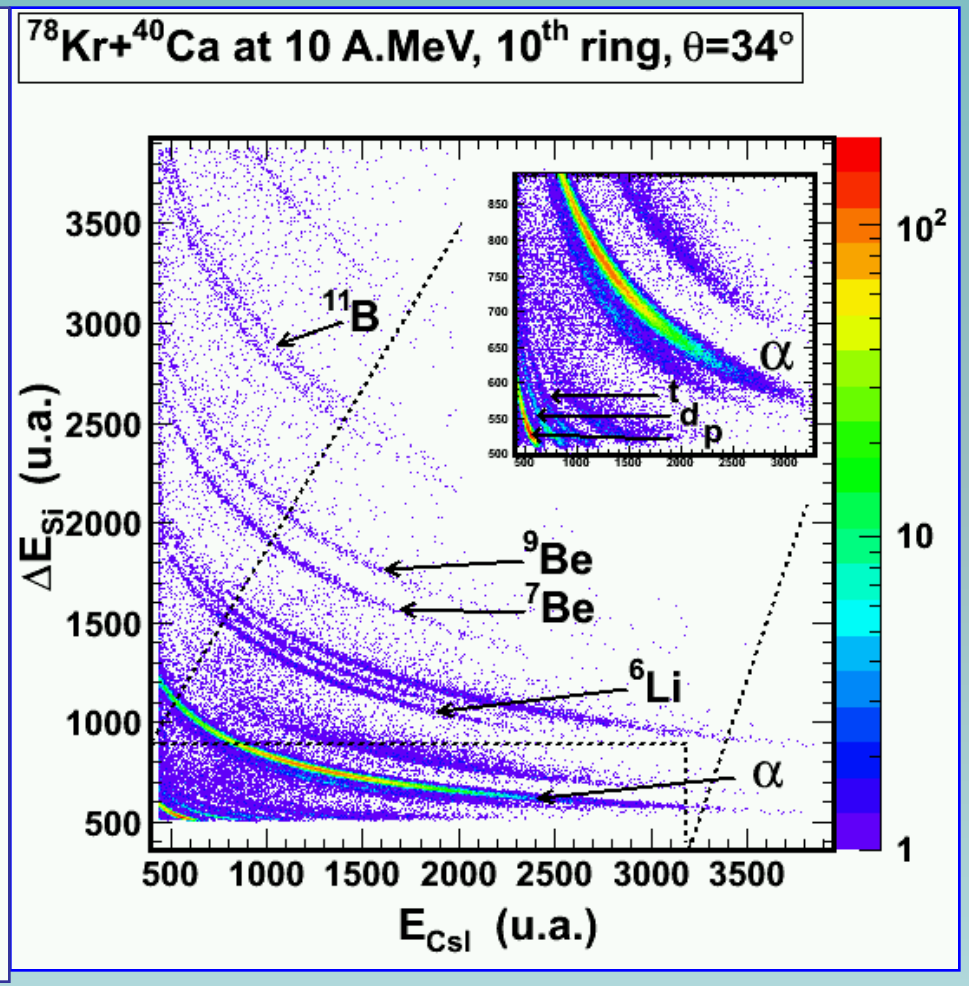
- **S.Pirrone, Lea Colliga Meeting, Paris 2009**

IMF Isotopic Identification

PSD in Silicon

ΔE-E , Si-CsI(Tl)





n-rich

n-poor

PRELIMINARY

LOI@SPES E =10 AMeV

$^{92}Kr + ^{40,48}Ca \longrightarrow ^{132,140}Ba^*$ (~320 MeV)

Key Observables

- **Isotopic distribution for IMF**

  $3 \leq Z \leq 12$ E = 8÷20 MeV/A $4° < \theta < 30°$

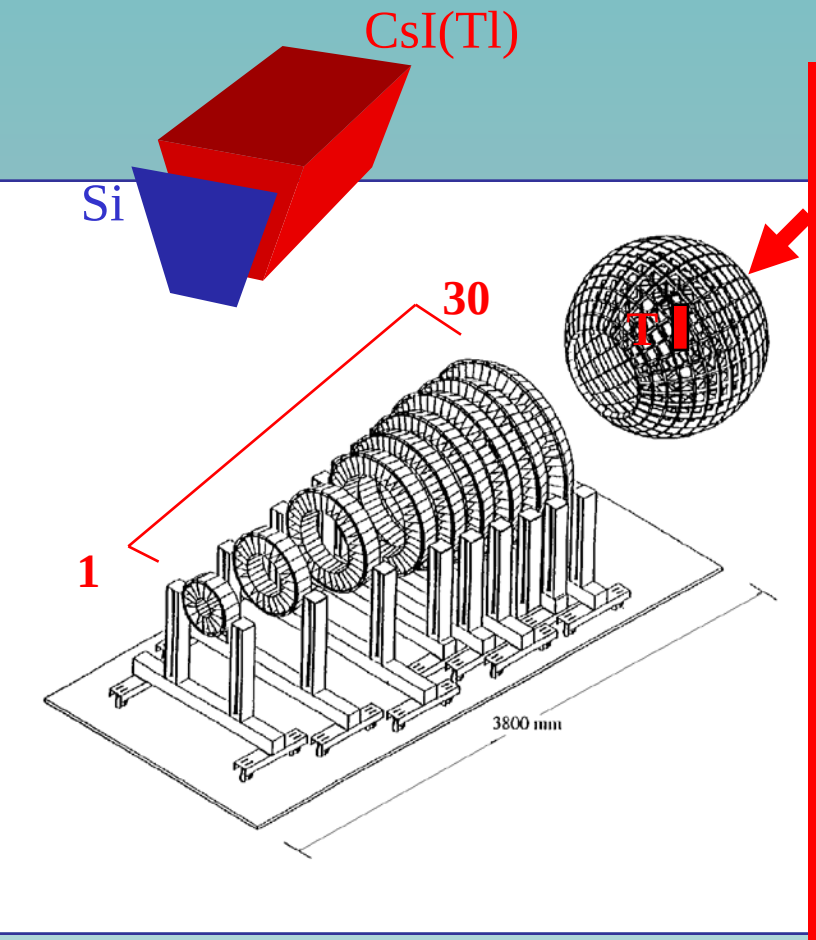
- **Energy, angular distribution RP (FF-ER-IMF-LCP)**

  FF - ER E > 2 MeV/A $4° < \theta < 30°$
  LCP E > 2 MeV/A $4° < \theta < 170°$

- **Charge identification FF (Z < 30) ER (Z < 50)**
- **Cross sections for decay modes**
- **Multiplicity**
- **Relative velocity and angular correlation**
- **Coincidence ER-LCP, FF-LCP, IMF-LCP**

CHIMERA

Charge Heavy Ion Mass and Energy Resolving Array



- **CHIMERA@LNL**
- **Part of CHIMERA + existing detectors @LNL**
- **New detector**

Estimated beam intensities with BEST Cyclotron@SPES
Protons on direct target: E_p=40MeV, Current on target 200 μA
UCx target; other targets shown in "Comments"
September 2010 – Ref.: F. Gramegna

Element	A	Z	N	T1/2 s	RIBs at 260KeV 1+	Re-accelerated RIBs C.B. eff=3- 4 % Linac tr.=50% particles/s	q+	Max E/A	Comments * target different from UCx. To be developed @SPES SIS= surface ion source LIS= laser ion source FEBIAD= plasma source x = easy, xxxx= difficult
Kr	81	36	45	7.23E+12	4,44E+05	8,88E+03	15	11,8	FEBIAD source xxx
Kr	85	36	49	3.39E+08	5,93E+08	1,19E+07	15	11,8	
Kr	87	36	51	4.58E+03	2,97E+09	5,94E+07	15	11,6	
Kr	88	36	52	1.02E+04	4,04E+09	8,08E+07	15	11,4	
Kr	89	36	53	1.89E+02	3,99E+09	7,98E+07	15	11,2	
Kr	90	36	54	3.23E+01	4,37E+09	8,74E+07	15	11,2	
Kr	91	36	55	8.57E+00	2,12E+09	4,24E+07	15	11	
Kr	92	36	56	1.84E+00	6,89E+08	1,38E+07	15	11	
Kr	93	36	57	1.28E+00	2,28E+08	4,57E+06	15	10,8	
Kr	94	36	58	2.00E-01	2,49E+07	4,99E+05	15	10,8	
Kr	95	36	59	7.80E-01	1,14E+07	2,29E+05	15	10,6	
Kr	96	36	60	3.20E-01	1,47E+06	2,94E+04	15	10,6	
Kr	97	36	61	3.17E-01	4,84E+04	9,69E+02			

time resolution $\Delta t \leq 1$ns

Conclusion

• ISODEC Scientific Program proposes to study the isospin dependence on CN formation and decay modes and the N/Z influence on some properties of nuclei :

fission barriers, level density parameter, viscosity

• Obtained results by using stable beams @GANIL and @LNS suggest to extend and improve the measurements with exotic beams, to study nuclear fundamental properties in an exotic domain of the nuclear chart.

•CHIMERA@LNL – CHIMERA + other detectors - New Arrays are proposed to realize the experiment.

•SPES@LNL will be a very suitable facility for this program

Participants

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