Properties and dynamics

of

hot and compressed baryonic matter

Detailed experimental and theoretical results on formation and expansion dynamics of hot and compressed baryonic matter, information on the equation of state and signals of neutron rich matter populated in relativistic heavy ion collisions are presented.

A brief presentation of a strategy for visible and recognized contributions within large scale international collaborations will argue the perspectives in this field for the Romanian community.

Mihai Petrovici, September 13, 2005, Bucharest

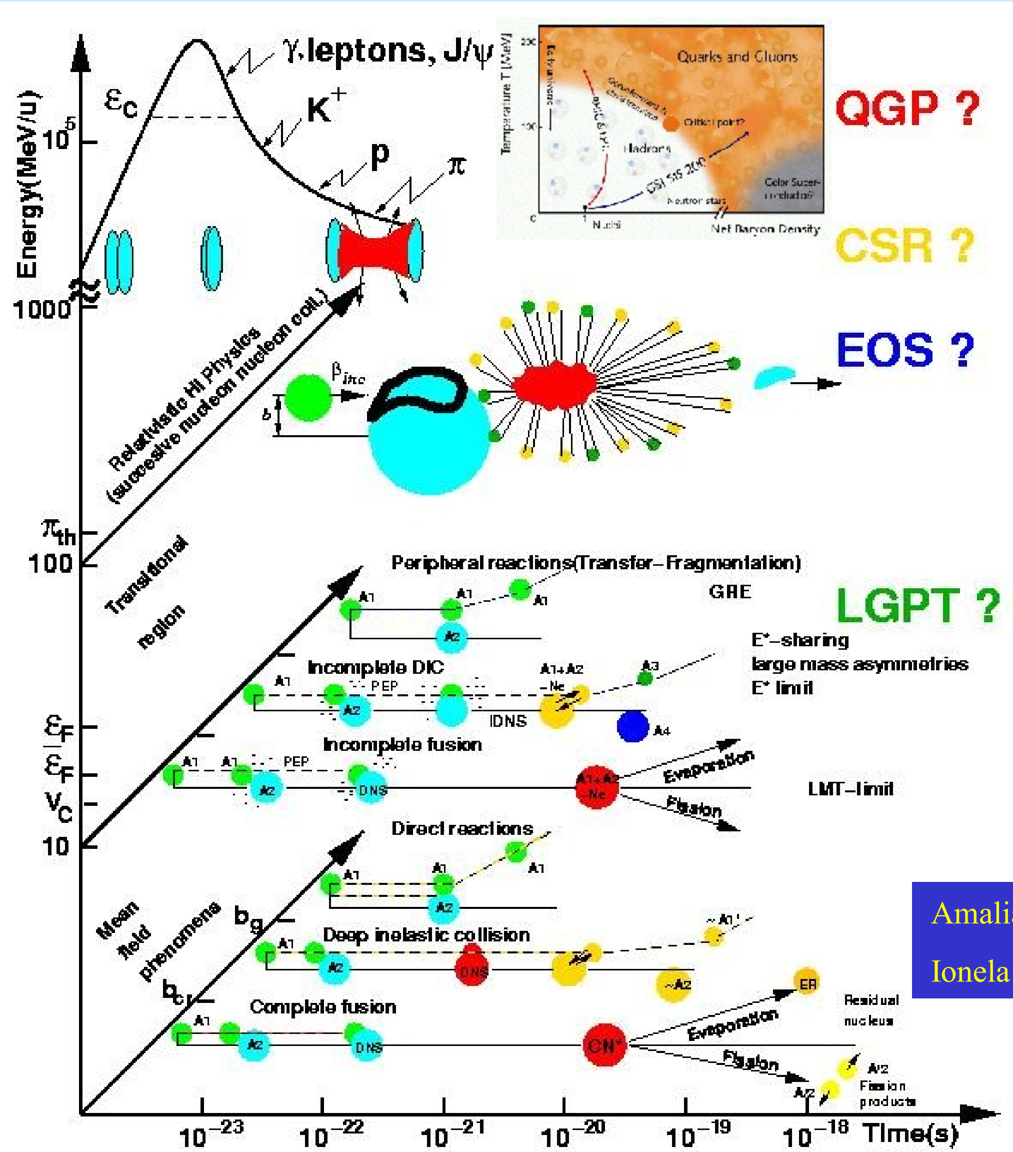

Romania

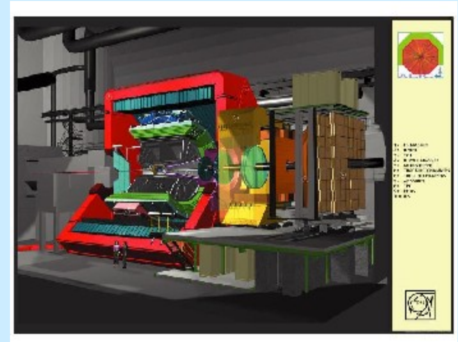
1st invited lecture at the NPC

in 33 years of activity

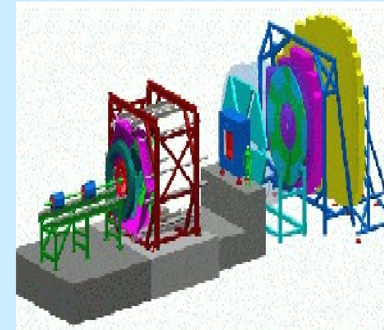
in NIPNE !

Field Overview & Contributions





ALICE



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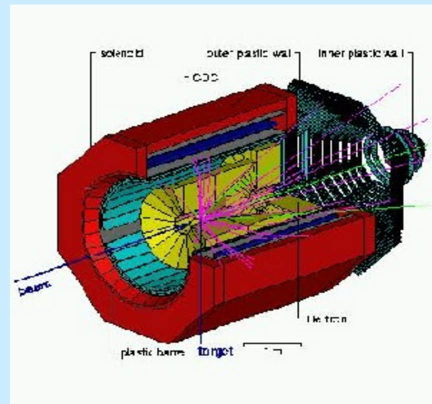
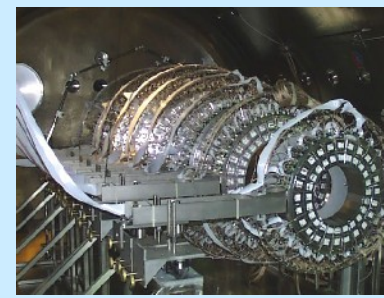


FOPI



CHIMERA

Amalia Pop

Ionela Berceanu

DRACULA

A.

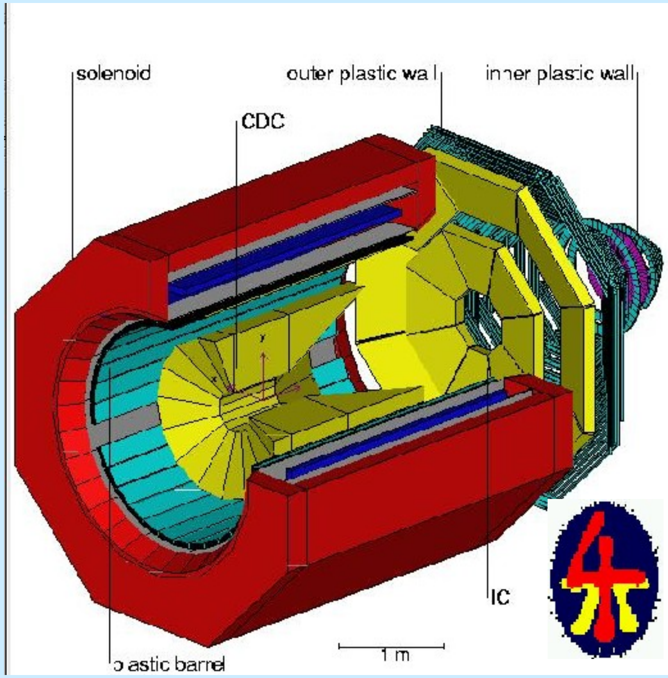
- *Introduction*
- *Collective expansion in highly central collisions*
- *Multidimensional analysis of in-plane to out-of-plane transition of azimuthal distributions*
- *Azimuthal distribtions of $<E_{kin}>$ and E_{coll}*
- *EOS*
- *^{3}H - ^{3}He, $<E_{kin}>$ puzzle*
- *Is the neutron rich matter populated in relativistic heavy ion collisions?*
- *^{3}H - ^{3}He squeeze-out signals*

B.

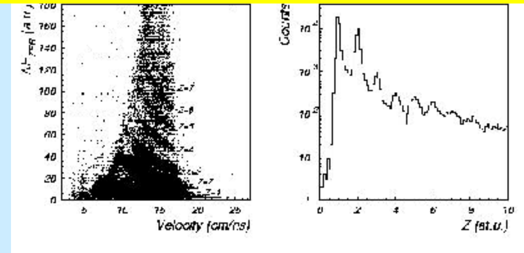
- *Visible & Competitive contributions within Large Scale Collaborations*

- *Conclusions and Outlook*

Particle identification



IPW



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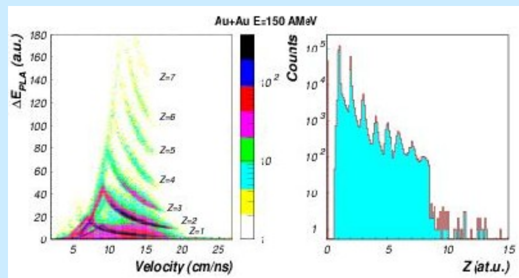
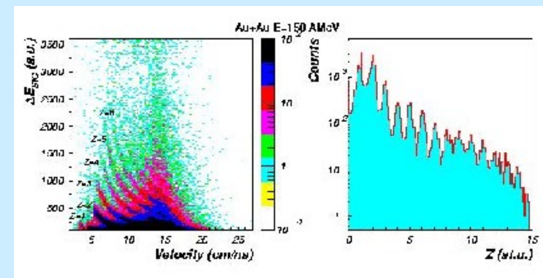
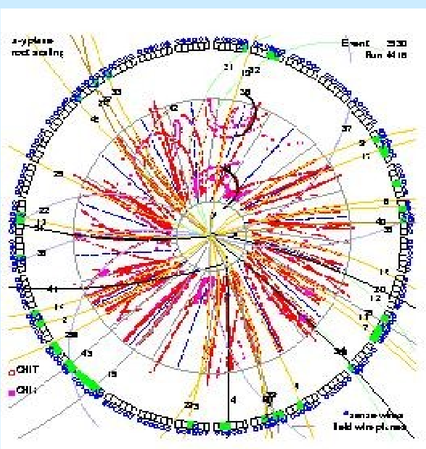
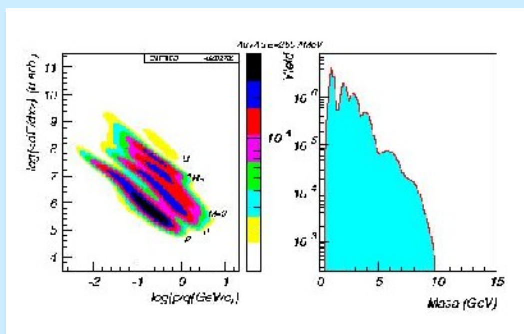


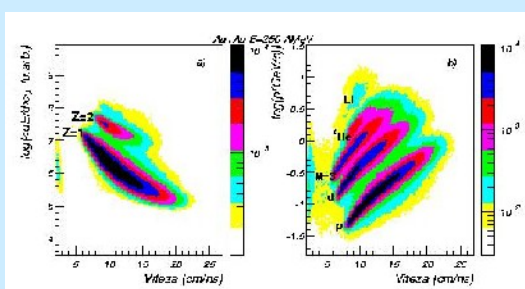
IC

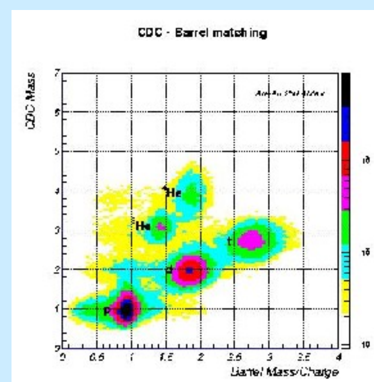


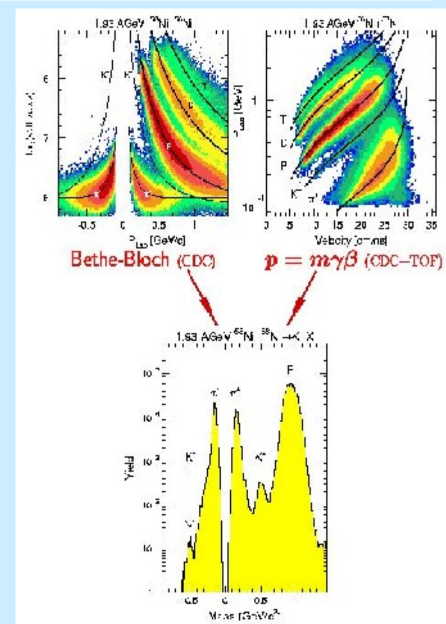
CDC + PB

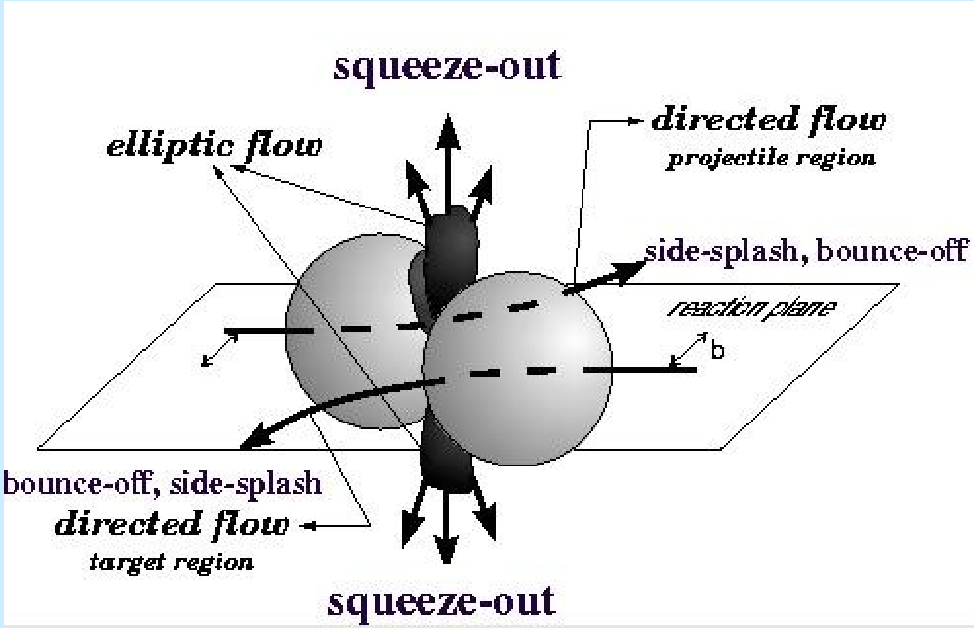






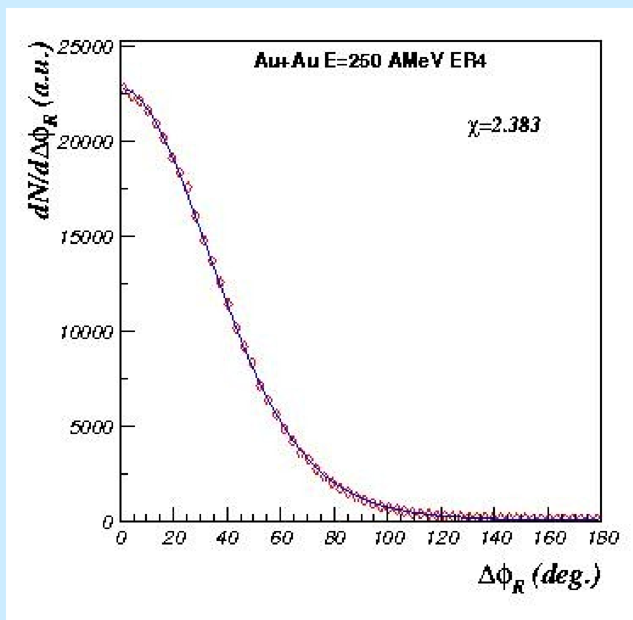


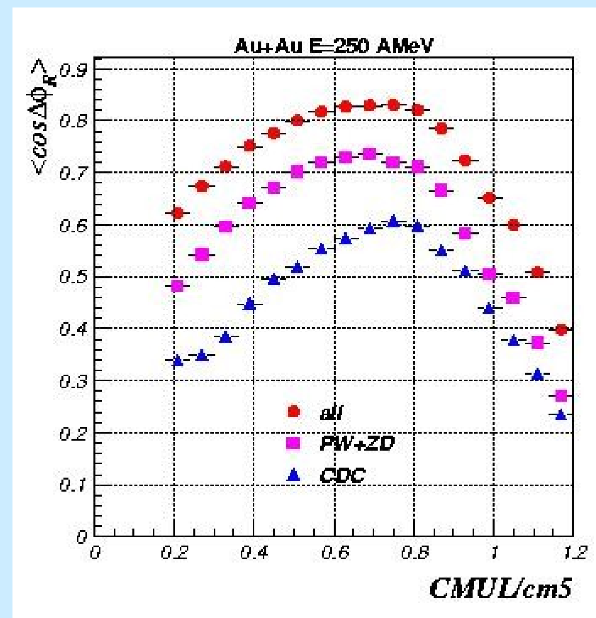




Reaction Plane

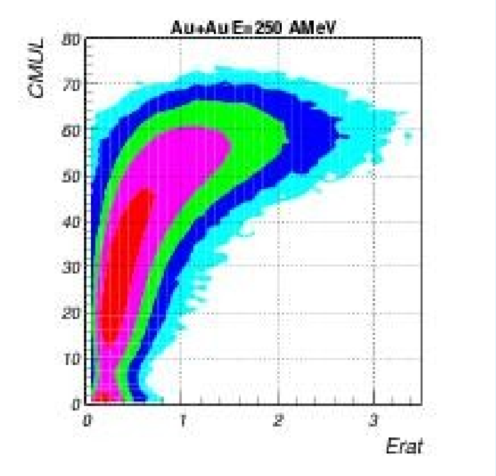
$$\vec{Q} = \sum_{i=1}^{M} w_i \vec{p}_i^{\perp}$$

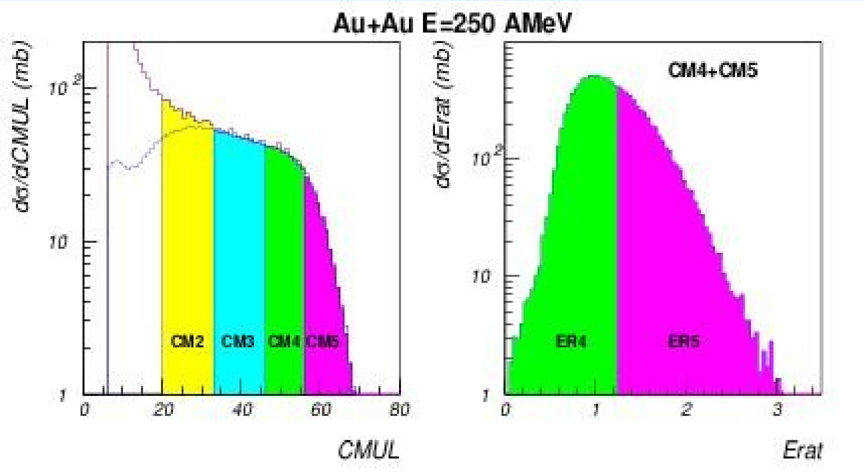




$y=1/2 \cdot \ln[(E+p_z)/(E-p_z)]$

Collision Geometry

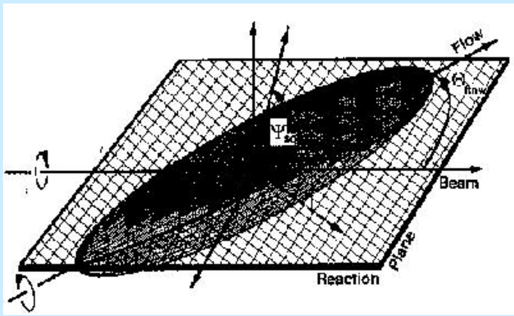


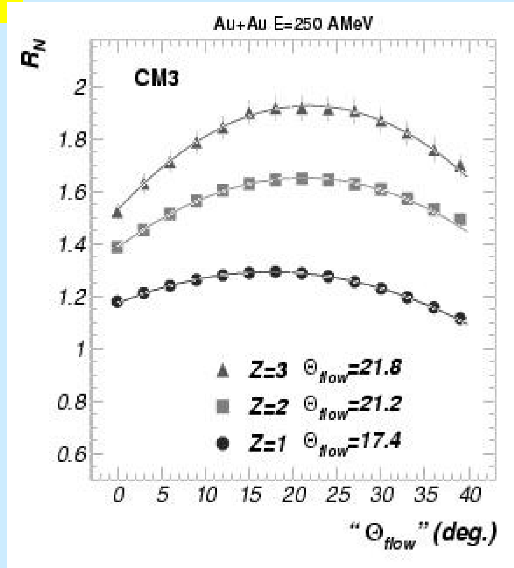


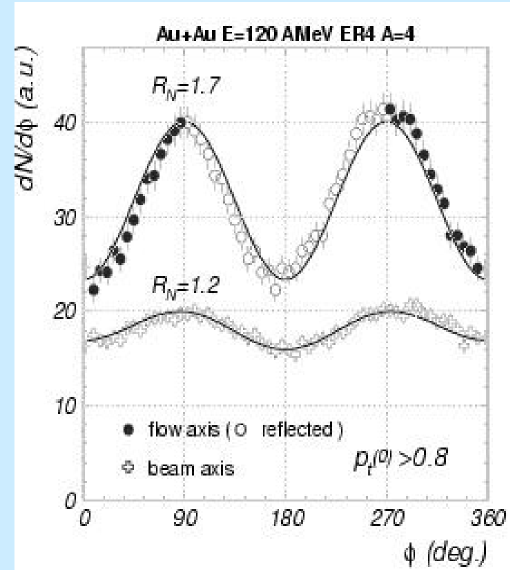
$$Erat = \sum_i \frac{E_{\perp,i}}{E_{||,i}}$$

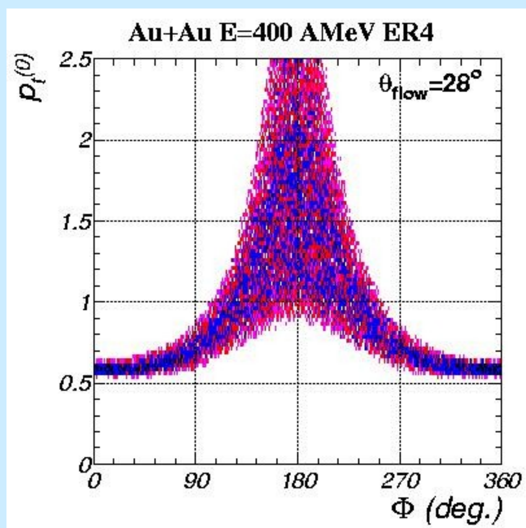
Reference System

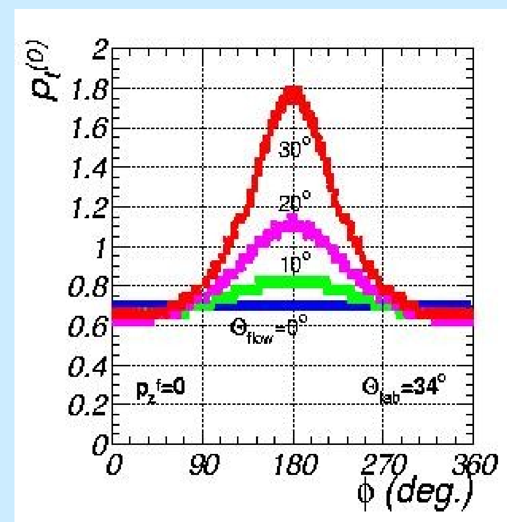
$$dN/d\varphi = a_0(1 + a_1 \cos\varphi + a_2 \cos 2\varphi)$$





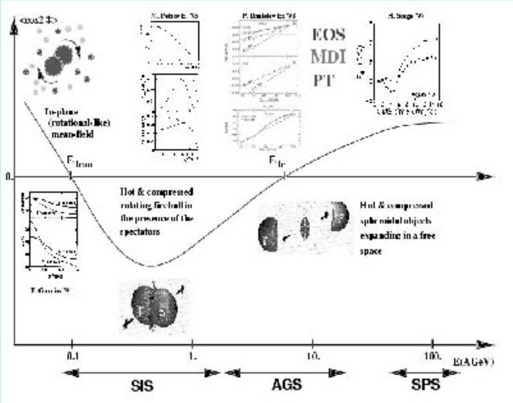




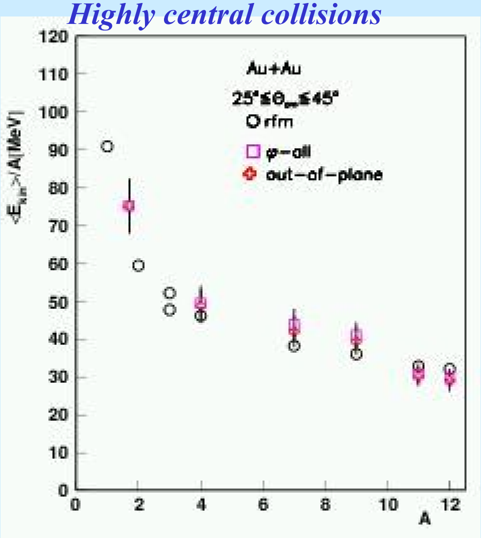


Physics topics proposed and followed by our group

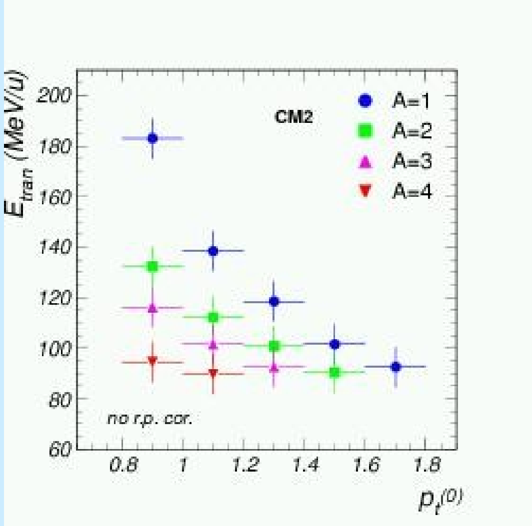
Peripheral collisions

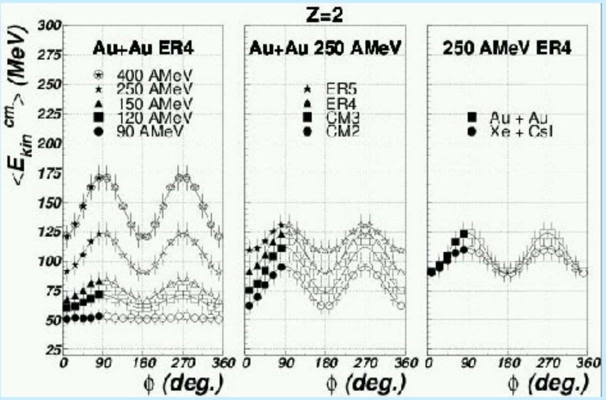


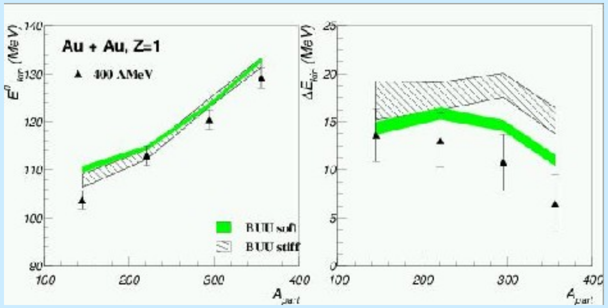
Highly central collisions



M. Petrovici , I. Legrand& FOPI
Phys.Rev.Lett.25(1995)5001





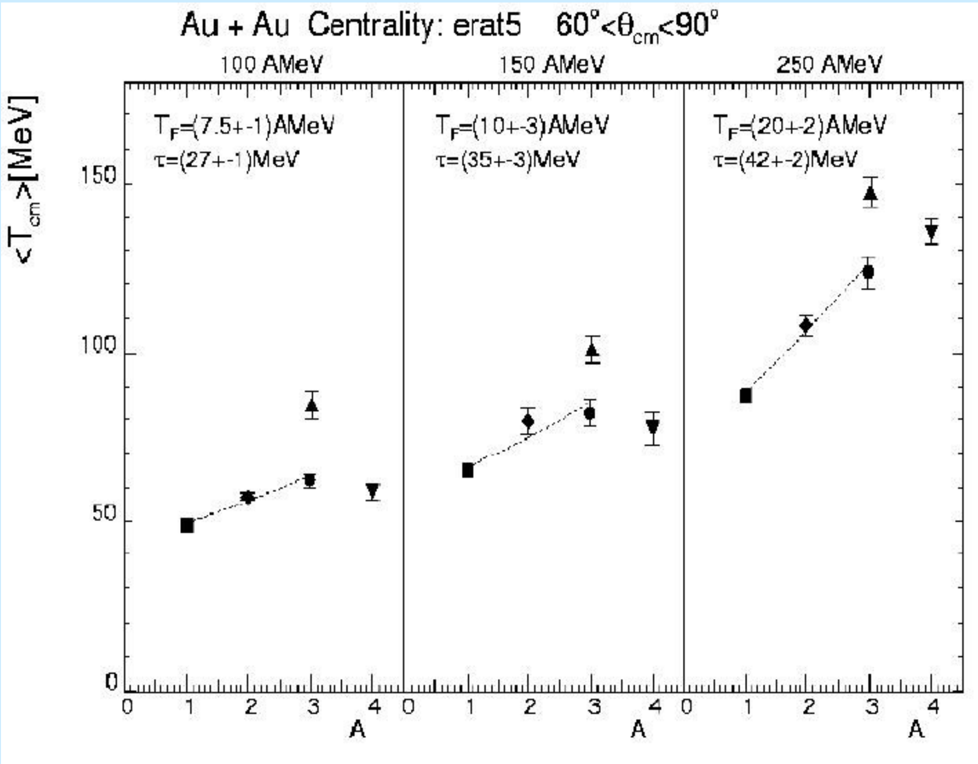


A. Andronic, G. Stoicea, M. Petrovici & FOPI
Nucl.Phys.A679(2001)765

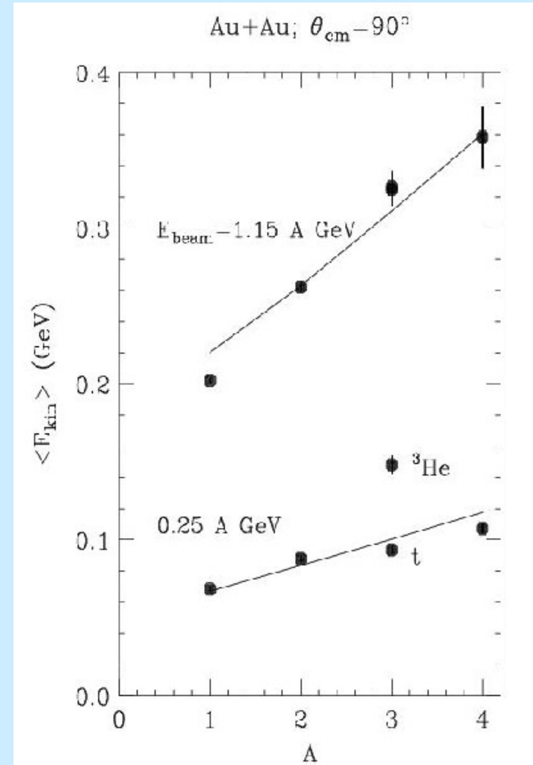
G. Stoicea, M. Petrovici & FOPI
Phys.Rev.Lett.92(2004)072303

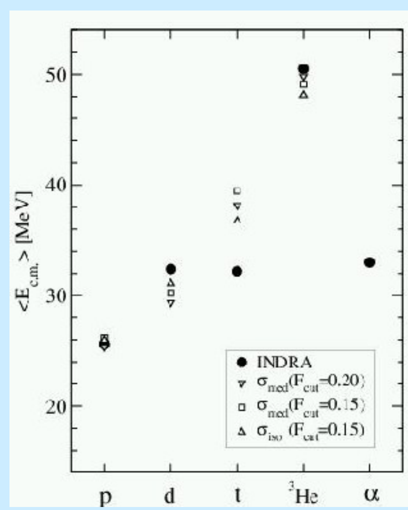
Experimental Facts

FOPI



EOS





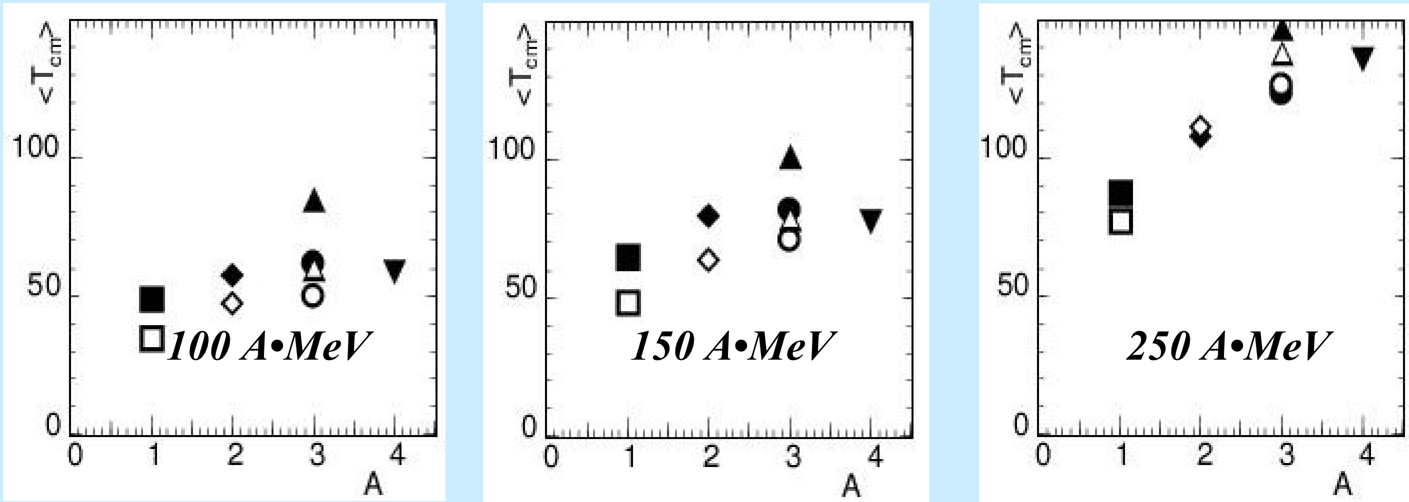
INDRA: $^{129}Xe + {}^{119}Sn$

50 A·MeV

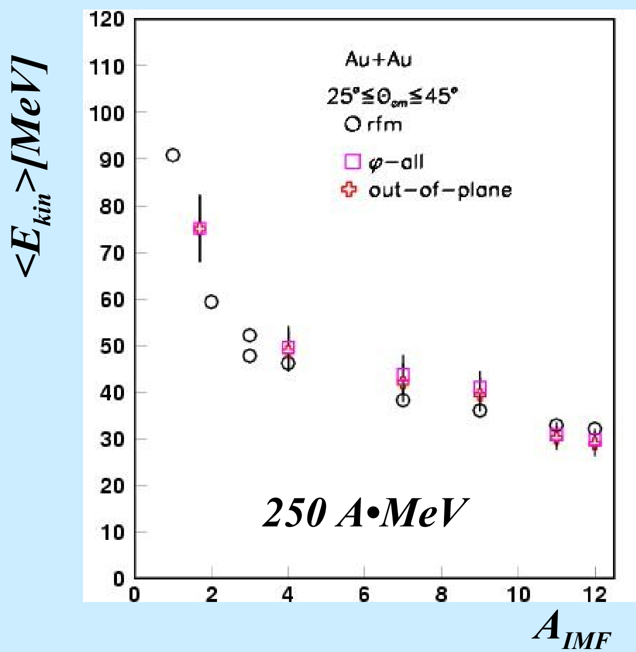
$-0.5 \leq \cos(\vartheta_{cm}) \leq 0.5$

Theoretical Predictions

Au + Au 60° ≤ ϑ_{cm} ≤ 90°



BUU



RFM

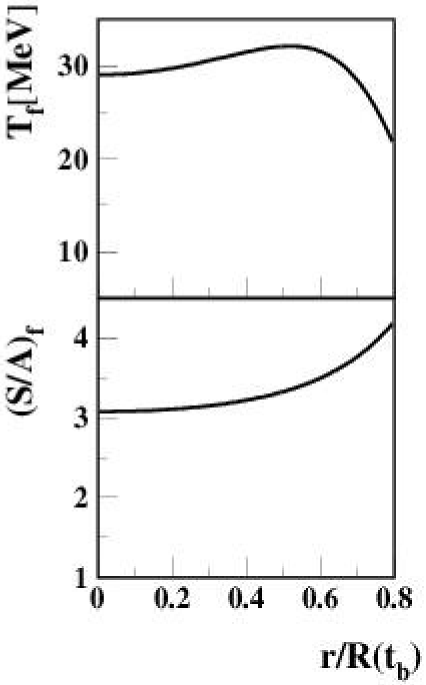


Figure 9: The final temperature and entropy distributions in the fireball at the breakup moment

studies. The results depend on the specific type of species used in these analysis. As far as concerns the breakup parameter, its value (b_t^0=0.3) indicates that, in contrast to an ideal gas, the breakup when the clusterization takes place accurs earlier. This result agrees with estimations based on new procedures used for cluster recognition in the microscopic models for nuclear collisions[48,49]. One could observe also the difference in the average kinetic energy of ^{3}He and t. This is a pure Coulombeffect and simlar to the results of a more sofisticated model calculations[37] can explain only part of the experimental difference[10,7,17]. Very well could be that the isospin effects, not taken into account in our model up to the breakup moment, could produce different proton relative to the neutron distribution at the breakup moment which influences the final yield distribution of ^{3}He and t and concequently different contribution to their final kinetic energies from the dynamical expansion itself.

An other test of this model could be to use it in order to predict the influence of the barionic content of the fireball on the expansion process. This was one of the objectives of measuring three symmetric systems Au + Au, Xe + CsI and Ni + Ni. Fig.10 shows the kinetic energy distribution for Z=3 products for the three measured systems at 250 A·MeV in two different polar angular ranges 25°-45° and 80°-100° with a selection in centrality of 1% of the total cross section using E_{rat} value. If for Au+Au the two distributions are almost identical, confirming the conclusion of a spherical symmetry based on Fig.6, a difference is evidenced for Xe+CsI which becoms larger for Ni+Ni. They confirm the conclusion of a less stopping for lighter systems based on

M.Petrovici

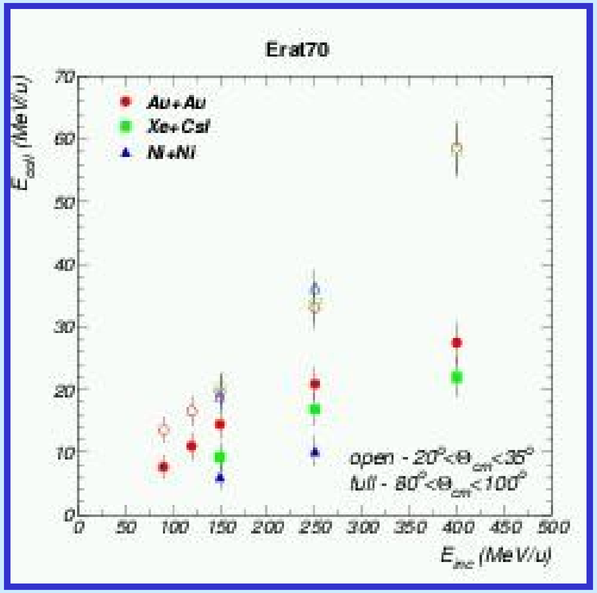
Heavy Ion Physics Workshop

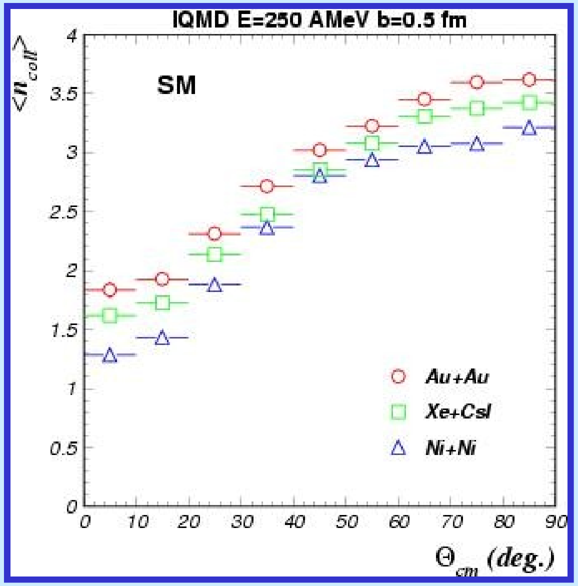
Poiana Brasov 1996

World Scientific, p.228

Where and which observables one should look ?

Where?

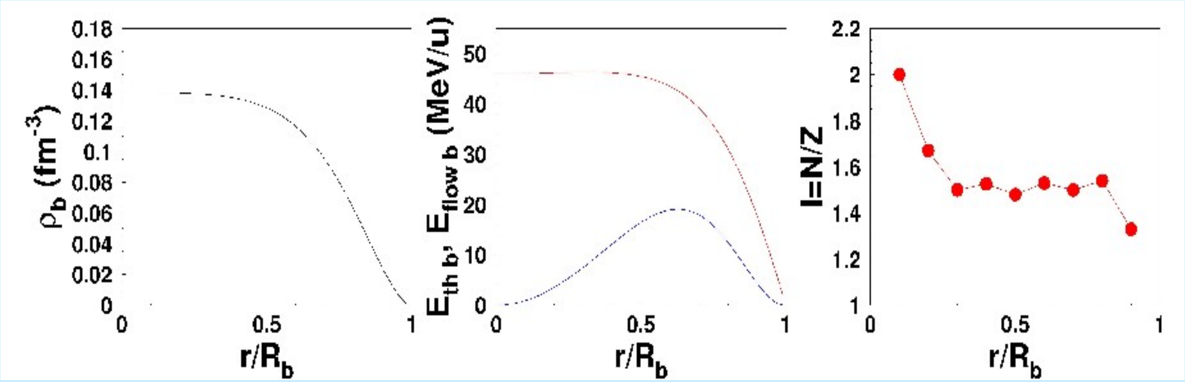


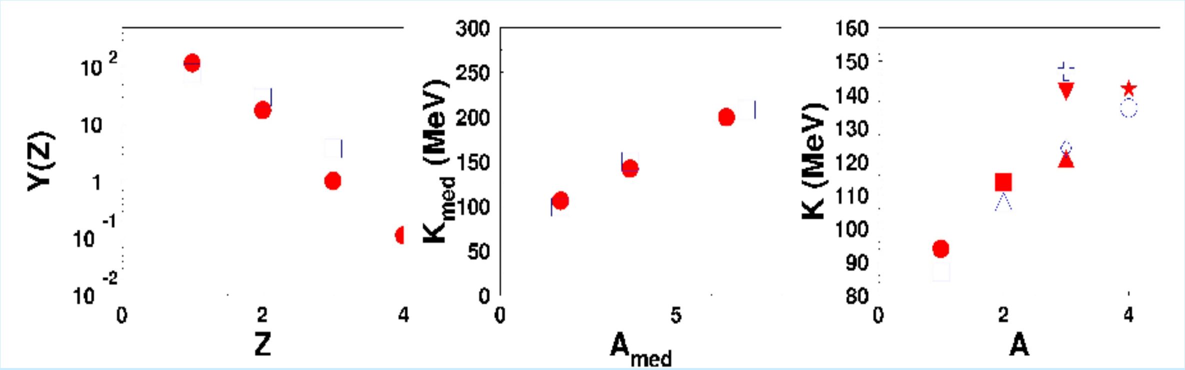


RFM predictions

Au + Au @ 250 A·MeV

Adriana Raduta

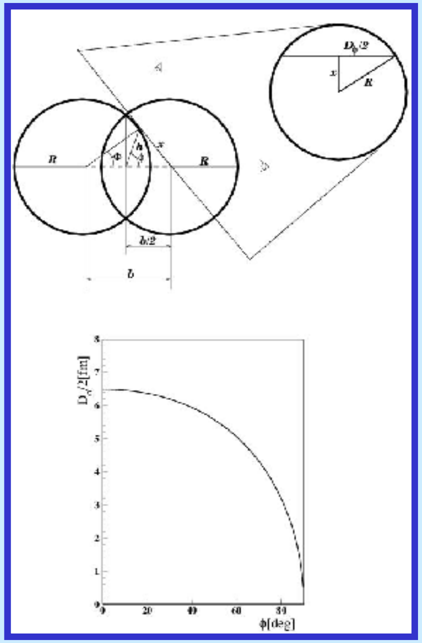


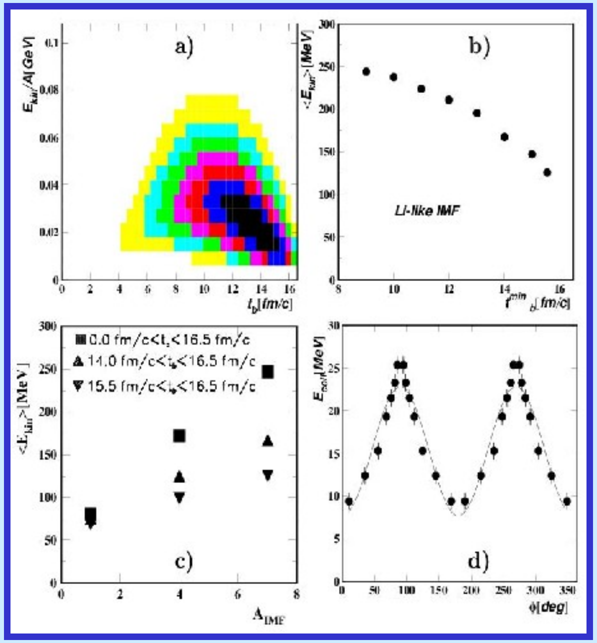


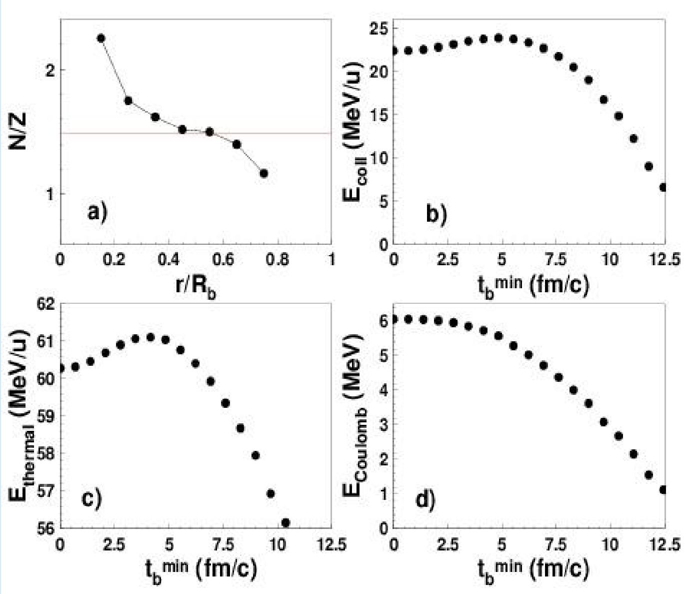
Particle	$<E_{kin}^{th}>$[MeV]	$<E_{kin}^{exp}>$[MeV]
p	84.8	87±2
d	107.4	108±3
t	120.0	124±4
^{3}He	141.5	147±4
^{4}He	142.1	136±3

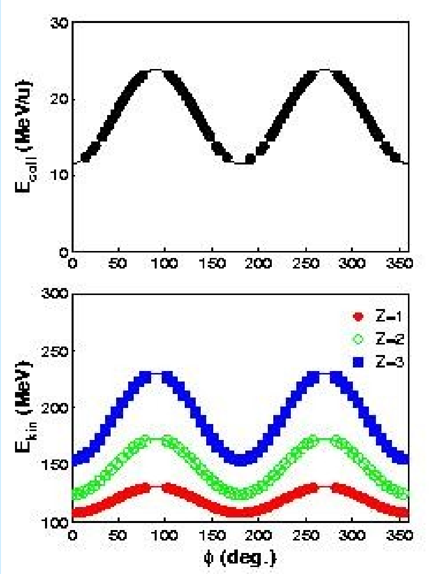
Do we have a clock?

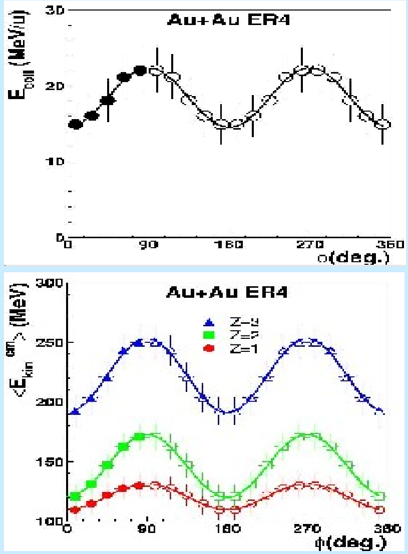
M.Petrovici, Fizika 12B(2003)2,165







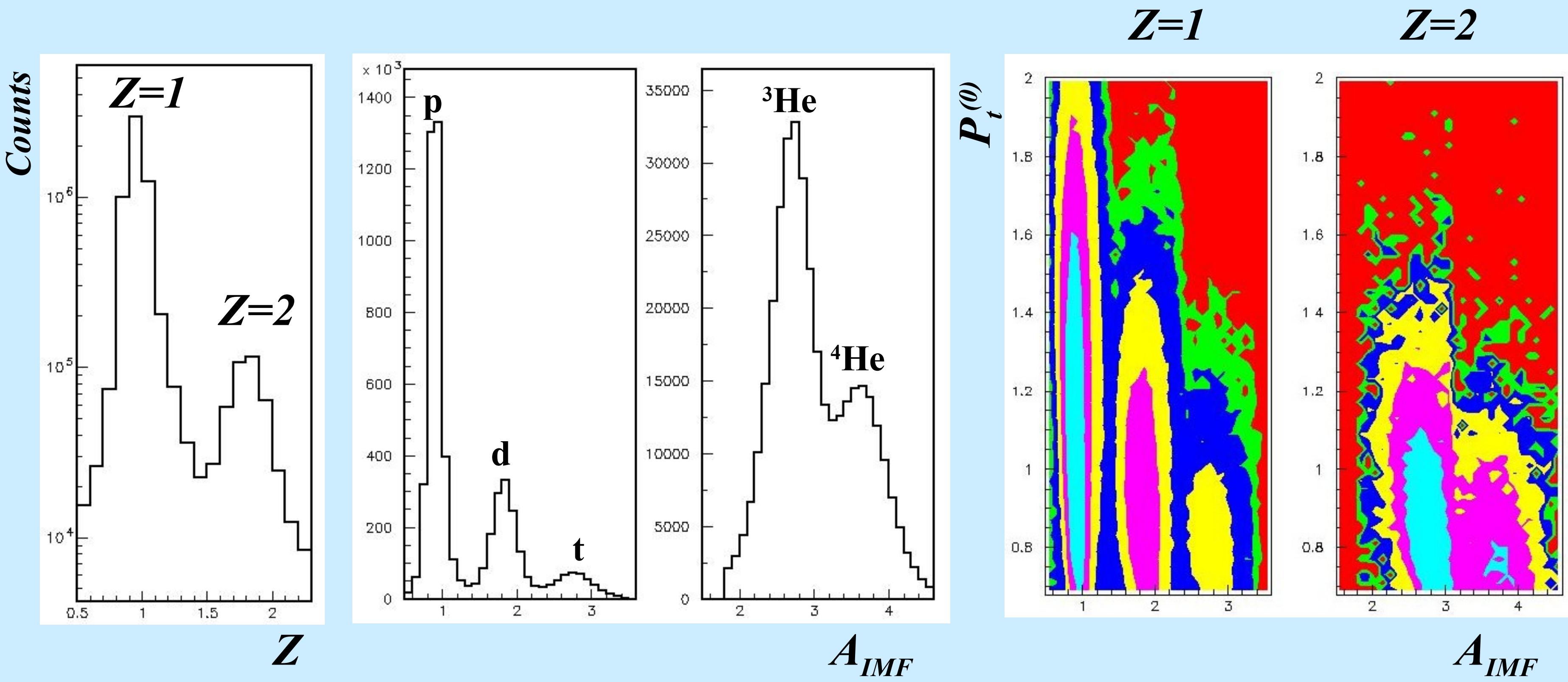




⇒ ***Let's look for the squeeze-out signal of***

^{3}H & ^{3}He fragments

PID - RuRu - 400 A•MeV



Collision geometry selection: ***CDC multiplicity-CMUL, CM3 4fm<b<6fm***

$$Erat = \sum_i \frac{E_{\perp,i}}{E_{\parallel,i}}$$

CDC { ***ER3 2fm<b<4fm*** / ***ER4 0fm<b<2fm*** }

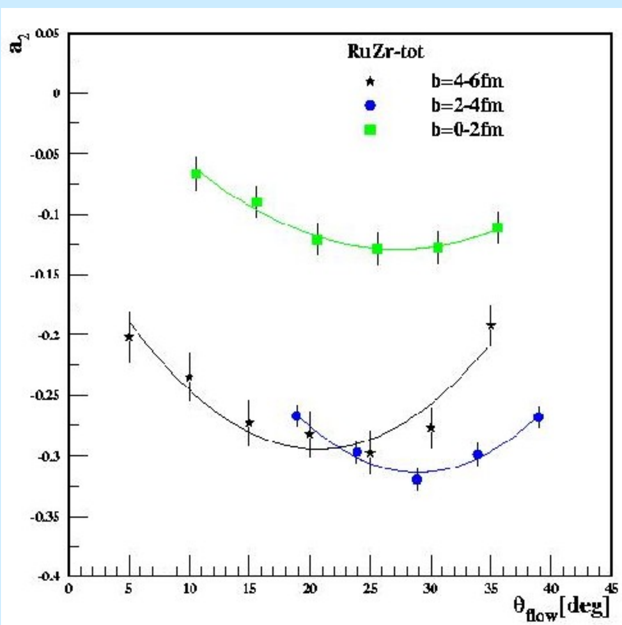
Reaction plane:

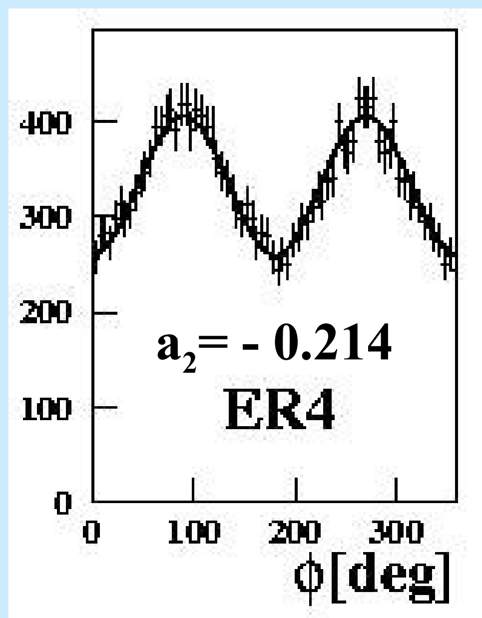
$$\vec{Q} = \sum_{i=1}^{M} w_i \vec{p}_i^{\perp}$$

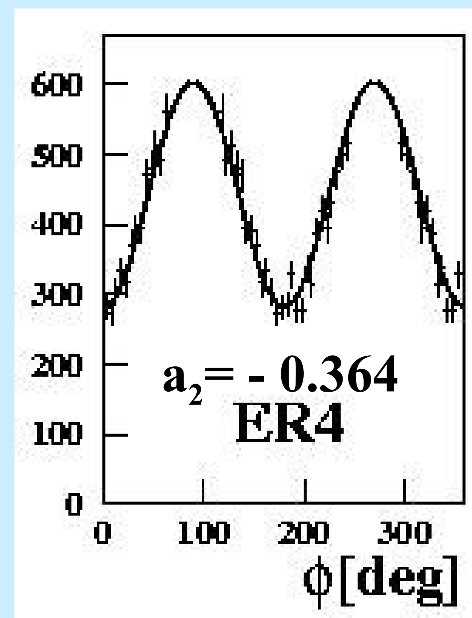
CDC

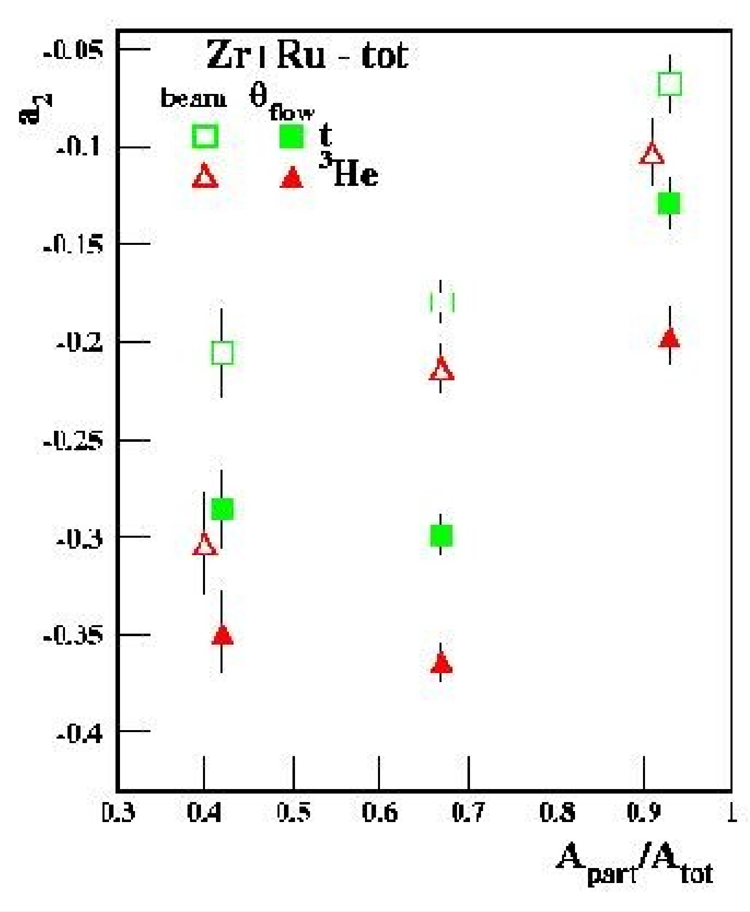
Reference system:

^{3}He

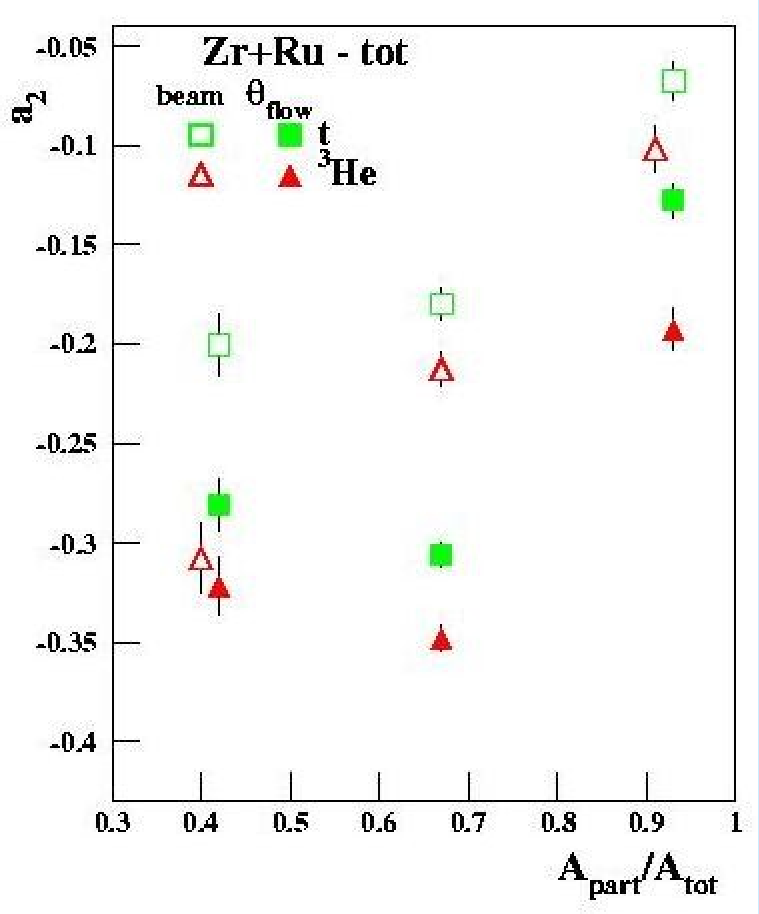




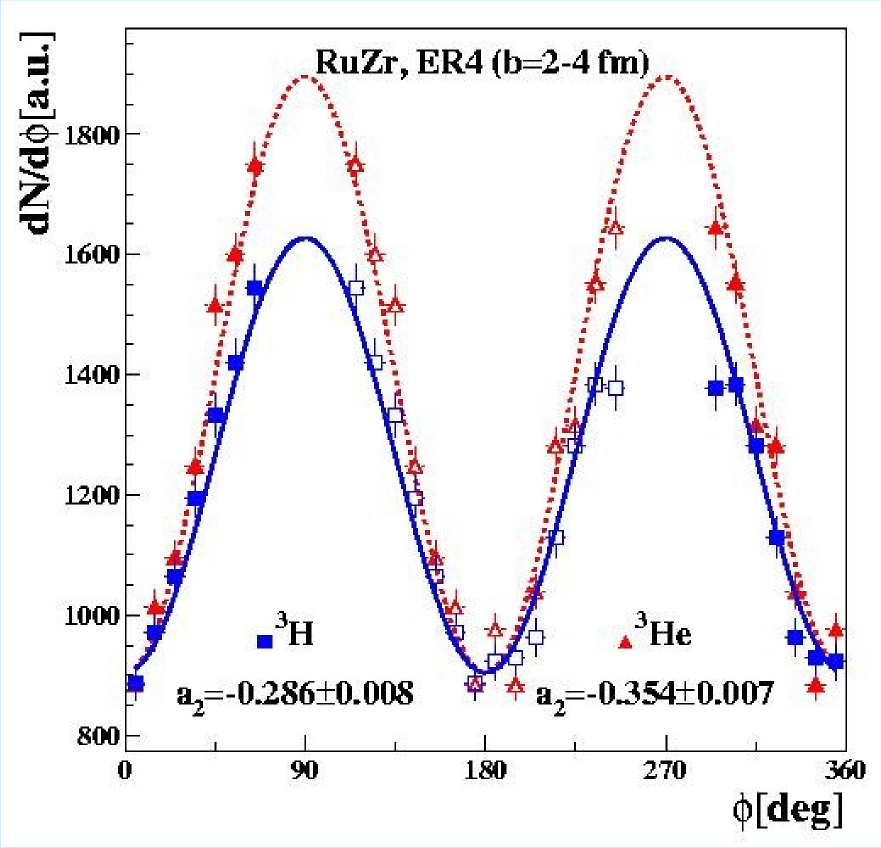


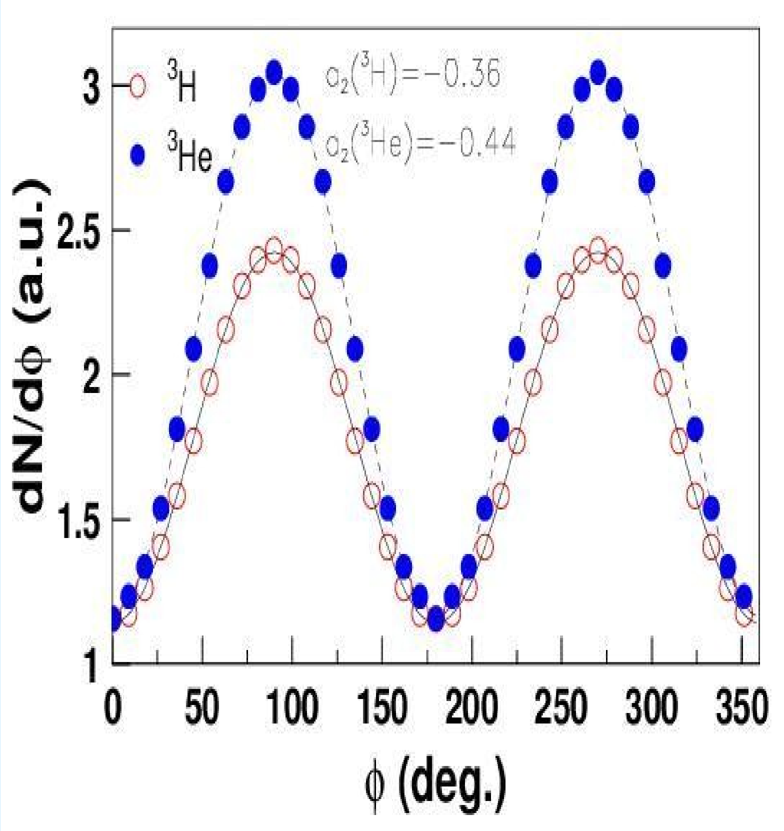


Zr+Ru - tot
a_2
beam θ_flow
t
³He
A_part/A_tot



Zr+Ru - tot
a_2
beam θ_flow
t
³He
A_part/A_tot


RuZr, ER4 (b=2-4 fm)
dN/dϕ[a.u.]
ϕ[deg]
^{3}H
^{3}He
a_2=-0.286±0.008
a_2=-0.354±0.007


^{3}H
^{3}He
$a_2(^3H)=-0.36$
$a_2(^3He)=-0.44$
dN/dϕ (a.u.)
ϕ (deg.)

Isospin dependent hadronic transport model

$$\partial_t f_1 + \frac{\vec{p}}{E}\vec{\nabla} f_1 - \vec{\nabla} U \vec{\nabla}_p f_r = \int \frac{d^3p_{1'} d^3p_2 d^3p_{2'}}{(2\pi)^9} \sigma_{12} v_{12} (2\pi)^3$$
$$\cdot \delta^3(\vec{p}_1 + \vec{p}_2 - \vec{p}_{1'} - \vec{p}_{2'}) \cdot \{f_{1'} f_{2'} (1 - f_1)(1 - f_2) - f_1 f_2 (1 - f_{1'})(1 - f_{2'})\}$$

Nuclear mean field

$$U(\rho,\tau) = a(\rho/\rho_o) + b(\rho/\rho_o)^{\sigma} + (1-\tau_z)V_c + C(\rho_n - \rho_p)/\rho_o \cdot \tau_z$$

$$U(\rho,\tau) = a(\rho/\rho_o) + b(\rho/\rho_o)^{\sigma} + V_{asy}^{q}(\rho,\delta) \quad (q = n \text{ or } p)$$

$$V_{asy}^{q}(\rho,\delta) = \partial\, w_a(\rho,\delta) / \partial \rho_q$$

$$w_a(\rho,\delta) = e_a \cdot \rho \cdot F(u)\, \delta^2$$

$$\delta = (\rho_n - \rho_p)/(\rho_n + \rho_p)$$

$$e(\rho,\delta) = e(\rho,0) + E_{sym}(\rho)\delta^2$$

$e(\rho,0)$ - is the energy per nucleon in symm. nuclear matter

$\delta \equiv (\rho_n - \rho_p)/(\rho_n + \rho_p)$ - is the isospin asymmetry

$$e(\rho,0) = a/2 \cdot u + b/(1+\sigma) \cdot u^\sigma + 3/5 \cdot e_F^0 \cdot u^{2/3}$$

(the simplest momentum-independent parametrization)

$u = \rho/\rho_0$ - is the reduced density

$e_F^0 = 36$ MeV - is the Fermi energy

a=-358.1 MeV, b=304.8 MeV, $\sigma = 7/6$

(determined by saturation properties)

$K_\infty = 201$ MeV

$K = 9\rho_0^2 \bullet d^2/d\rho^2 \, (E/A)$

$$E_{sym}(\rho) \equiv \mathrm{e}(\rho,1)\text{-}\mathrm{e}(\rho,0) = 5/9 \cdot E_{kin}(\rho, 0) + V_2(\rho)$$

$E_{kin}(\rho, 0)$- is the kinetic energy per nucleon in the symm. nuclear matter

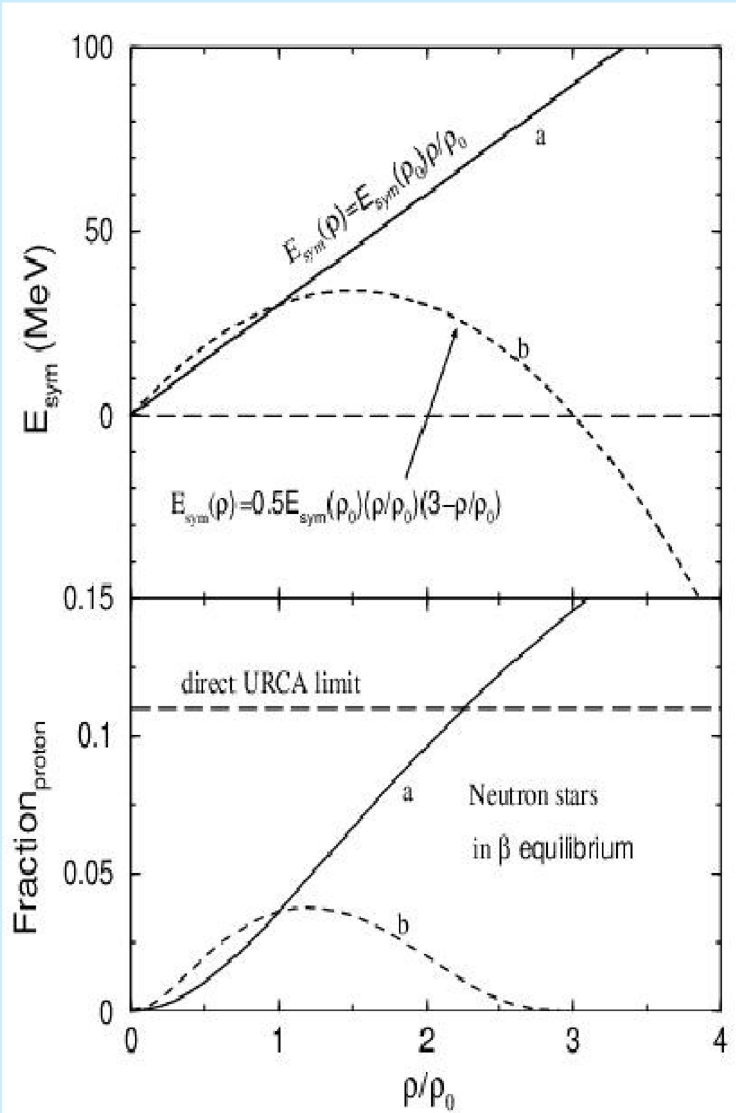
$V_2(\rho)$- is the deviation of the inter. energy of pure neutron matter

from that of symm. nuclear matter

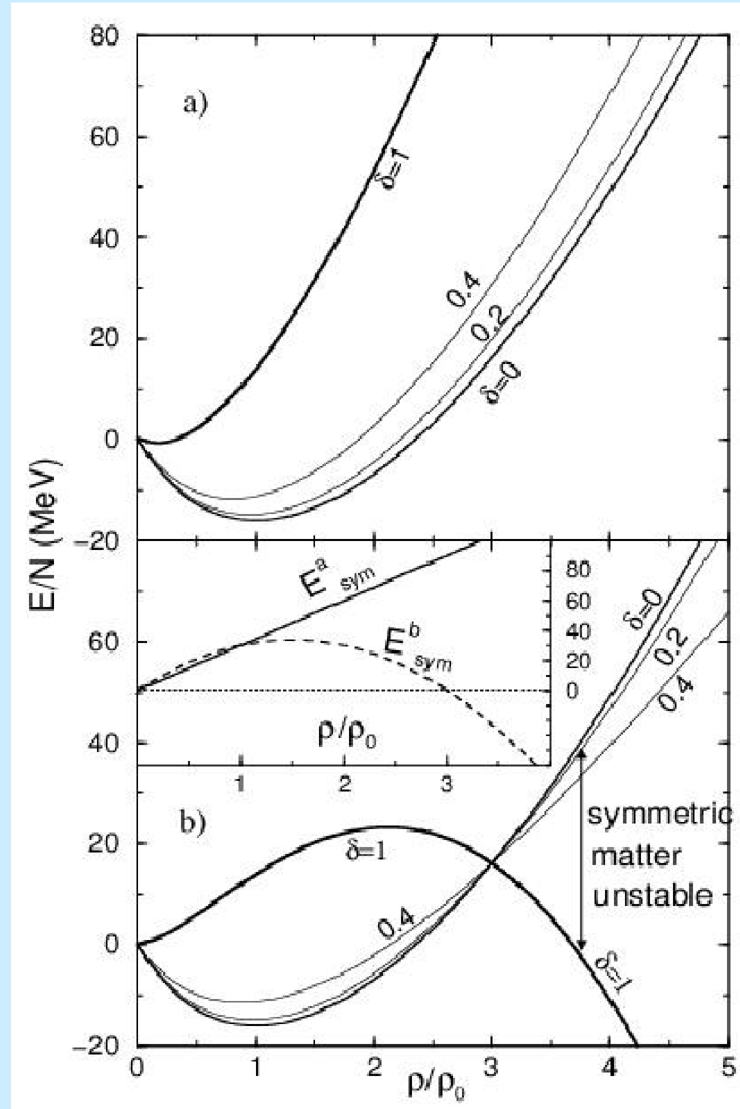
$E_{sym}(\rho)$ becomes negative if $V_2(\rho) \leq -5/9 E_{kin}(\rho, 0)$ at high densities

$$E^a_{sym}(\rho) = E^a_{sym}(\rho_0) \cdot \mathrm{u}$$

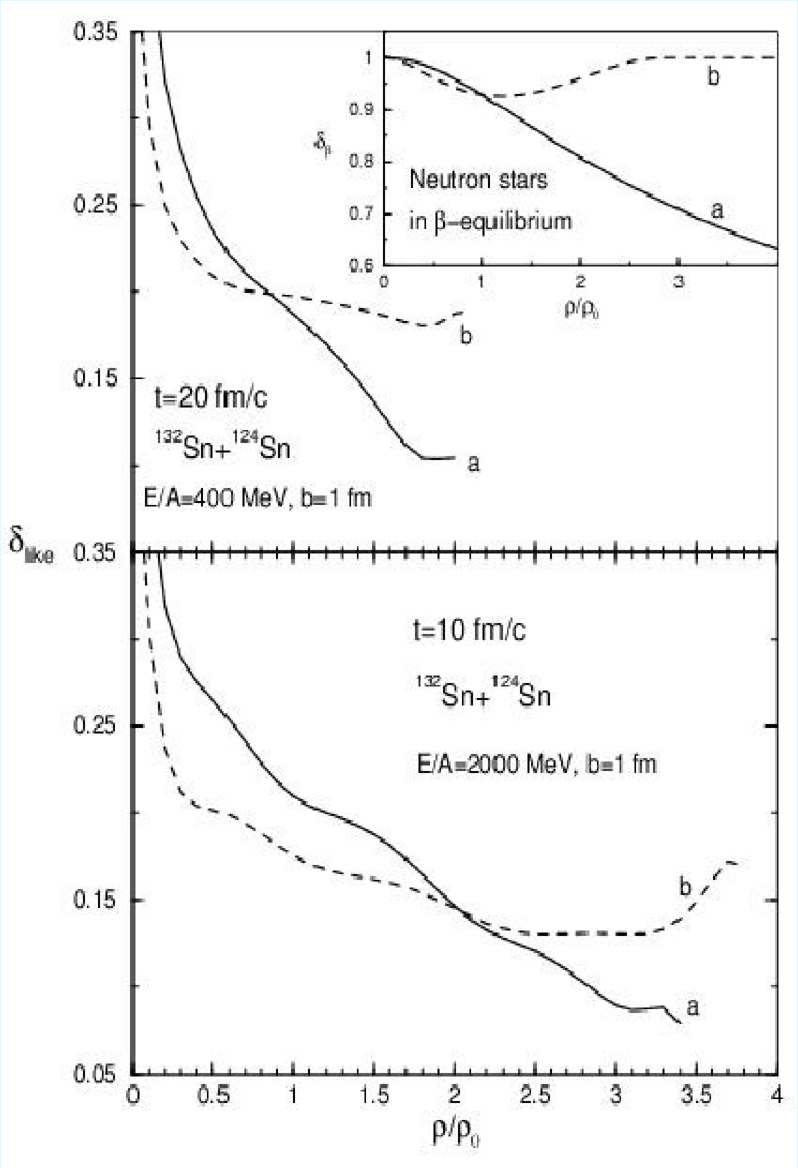
$$E^b_{sym}(\rho) = E^a_{sym}(\rho_0) \cdot \mathrm{u} \cdot (u_c - u)/(u_c - 1)$$



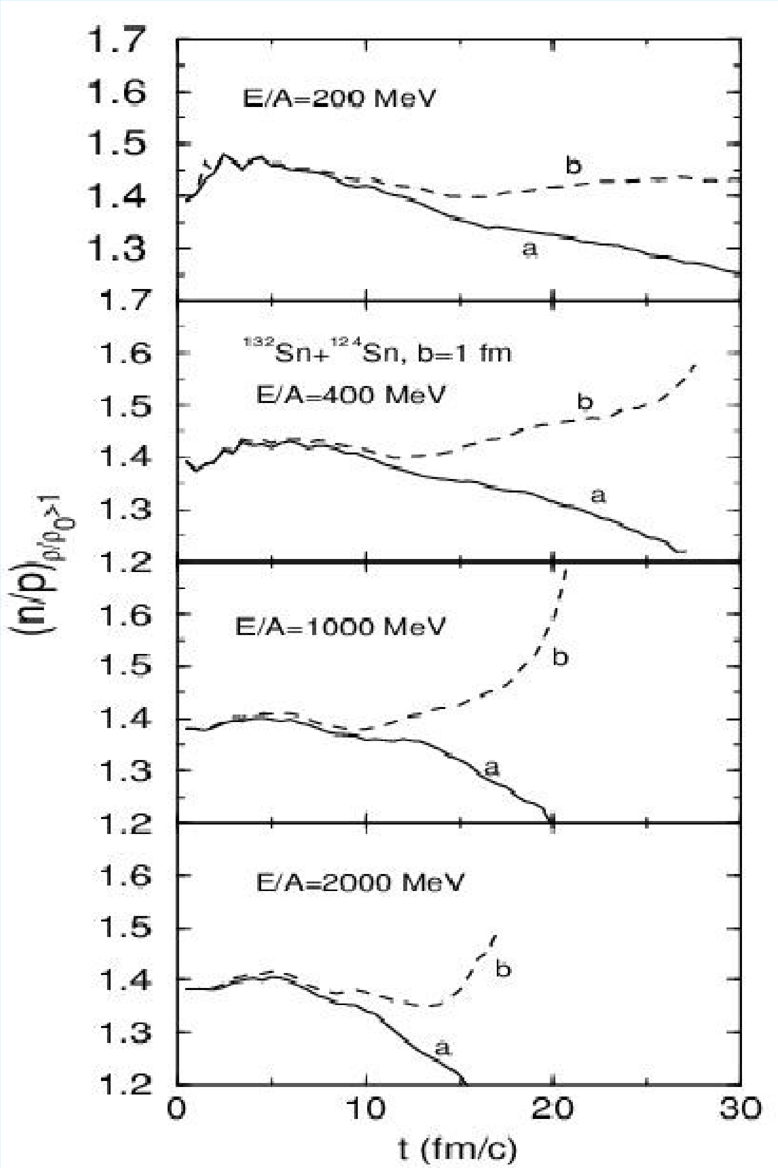
E_{sym} (MeV)
$E_{sym}(\rho)=E_{sym}(\rho_0)\rho/\rho_0$
a
b
$E_{sym}(\rho)=0.5E_{sym}(\rho_0)(\rho/\rho_0)(3-\rho/\rho_0)$
direct URCA limit
$Fraction_{proton}$
Neutron stars
in β equilibrium
ρ/ρ_0



a)
E/N (MeV)
δ=1
0.4
0.2
δ=0
E^a_{sym}
E^b_{sym}
ρ/ρ_0
b)
δ=1
0.4
δ=0
0.2
0.4
symmetric
matter
unstable
δ=1
ρ/ρ_0

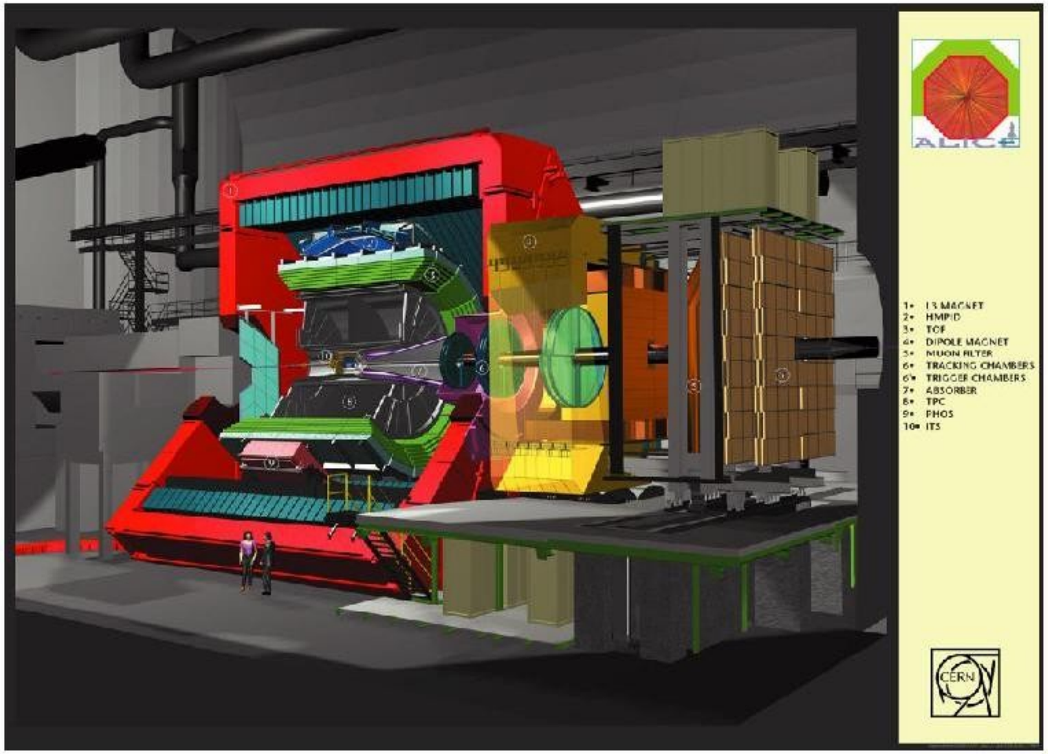


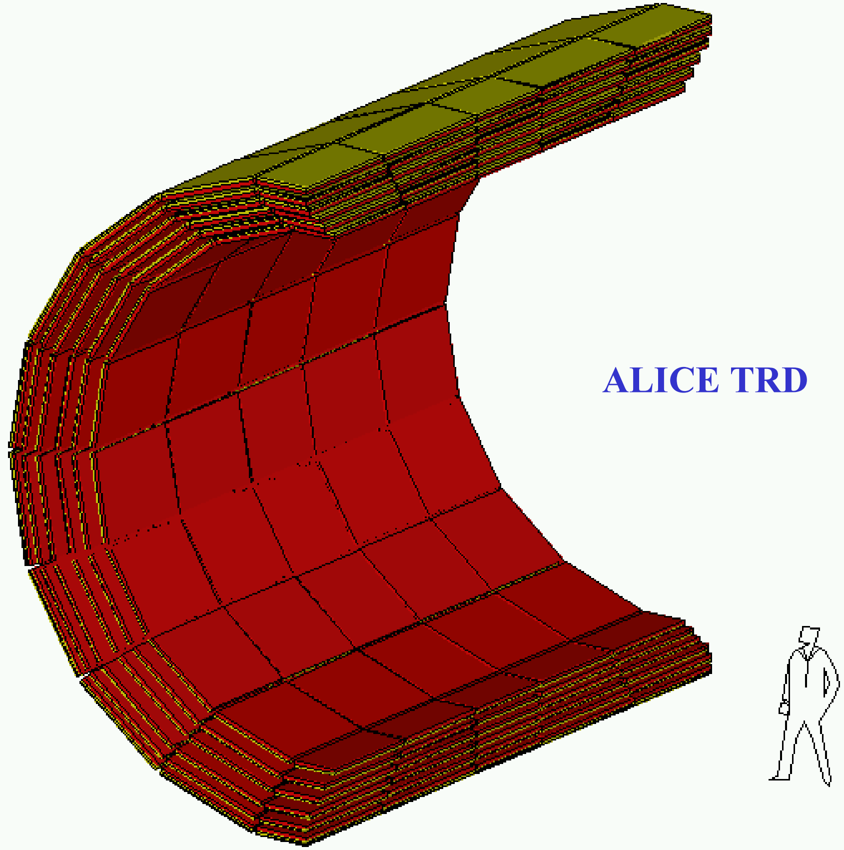
Neutron stars
in β−equilibrium
δ_β
ρ/ρ_0
t=20 fm/c
$^{132}Sn+^{124}Sn$
E/A=400 MeV, b=1 fm
δ_{like}
t=10 fm/c
$^{132}Sn+^{124}Sn$
E/A=2000 MeV, b=1 fm
ρ/ρ_0



E/A=200 MeV
$^{132}Sn+^{124}Sn$, b=1 fm
E/A=400 MeV
E/A=1000 MeV
E/A=2000 MeV
$(n/p)_{\rho/\rho_0>1}$
t (fm/c)


Romania


ALICE
1• L3 MAGNET
2• HMPID
3• TOF
4• DIPOLE MAGNET
5• MUON FILTER
6• TRACKING CHAMBERS
6'• TRIGGER CHAMBERS
7• ABSORBER
8• TPC
9• PHOS
10• ITS
CERN



ALICE TRD

ALICE TRD

Table 1: Synopsis of TRD parameters.

Pseudorapidity coverage	$-0.9 < \eta < 0.9$
Azimuthal coverage	2π
Radial position	$2.9 < r < 3.7$ m
Length	maximal 7.0 m
Segmentation in φ	18–fold
Segmentation in radius	6 layers
Segmentation in z	5–fold
Total number of modules	540
Largest module	120×159 cm^2
Detector active area	736 m^2
Detector thickness radially	$X/X_0 = 14.3\%$
Radiator	fibres/foam sandwich, 4.8 cm per layer
Module segmentation in φ	144
Module segmentation in z	12–16
Typical pad geometry	$0.725 \times 8.75 = 6.34$ cm^2
Time samples in r (drift)	15
Number of readout channels	$1.16 \cdot 10^6$
Number of readout pixels	$1.74 \cdot 10^7$
Detector gas	Xe,CO_2 (15%)
Gas volume	27.2 m^3
Depth of drift region	3 cm
Depth of amplification region	0.7 cm
Nominal magnetic field	0.4 T
Drift field	0.7 kV/cm
Drift velocity	1.5 cm/μs
Diffusion, longitudinal	$D_L = 250\ \mu m/\sqrt{cm}$
Diffusion, transversal	$D_T = 180\ \mu m/\sqrt{cm}$
Lorentz angle	8°
Occupancy (for full multiplicity)	34%
Typical space point resolution at 1 GeV/c	
in $r\varphi$	400(600) μm for low (high) multiplicity
in z	2.3 cm (without tilt)
Momentum resolution	$\delta p/p = 2.5\% \oplus 0.5\%(0.8\%)p$ for low (high) multiplicity
Pion suppression at 90% electron efficiency and $p_t \geq 3$ GeV/c	better than 100

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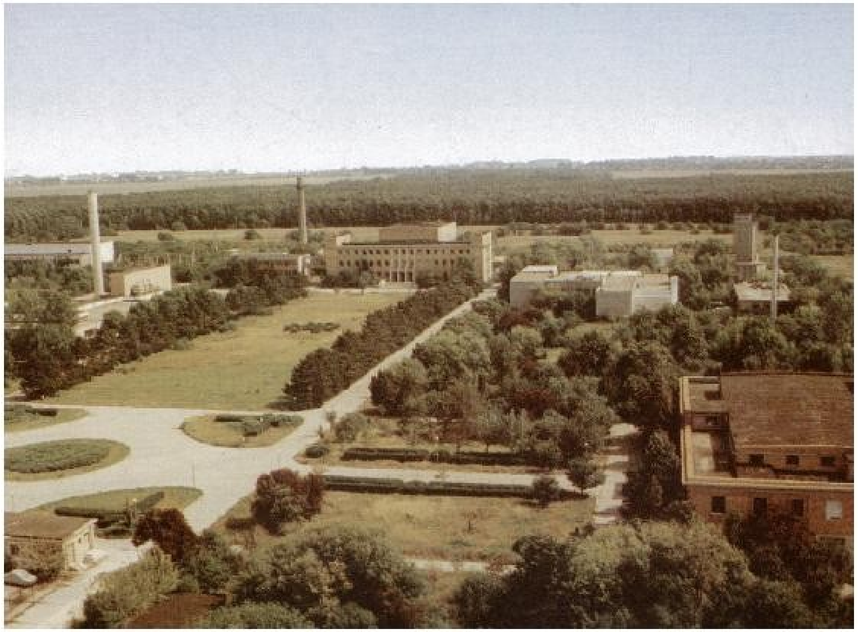
Centre of Excellence

LOCATION



NIPNE

DETLAB

2 pairs of Glueing & Vacuum Tables installed

TRD Frame glueing

Preparation for Radiator glueing

Radiator alignement on the frame profile

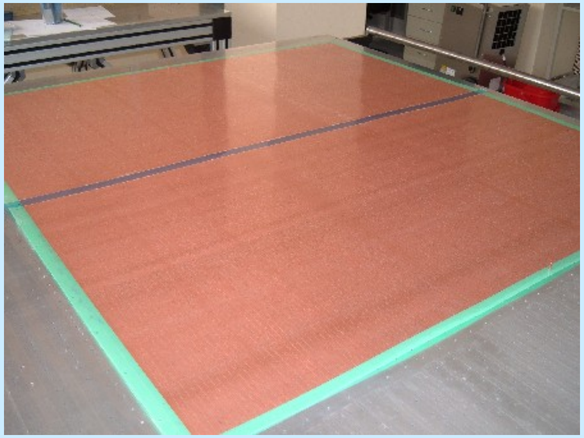
Ready for polimerisation

Filling the gap between Radiator & Frame

Valerica Aprodu
Elena Ionescu
Lucica Prodan
Petre Zaharia

Dispersing the glue between Frame and Radiator

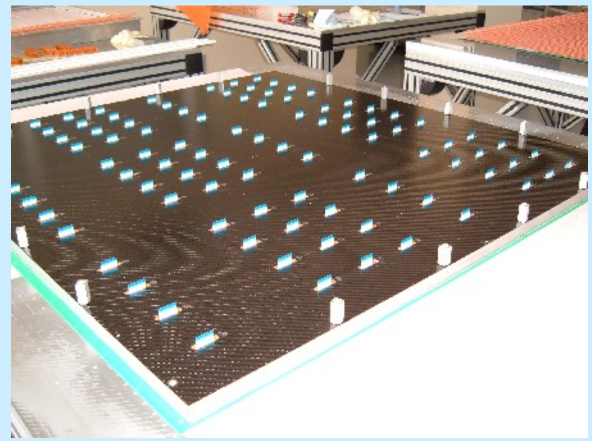
Frame & Radiator Ready



Taping together two adjoining planes

Distributed weigt on the Honeycomb Panel during polimerisation

Final check of the Honeycomb Panel



Pad Plane ready after filling cut outs

Valerica Aprodu
Elena Ionescu
Lucica Prodan
Victor Simion

Honeycomb Panel above the Pad Plane before lowering

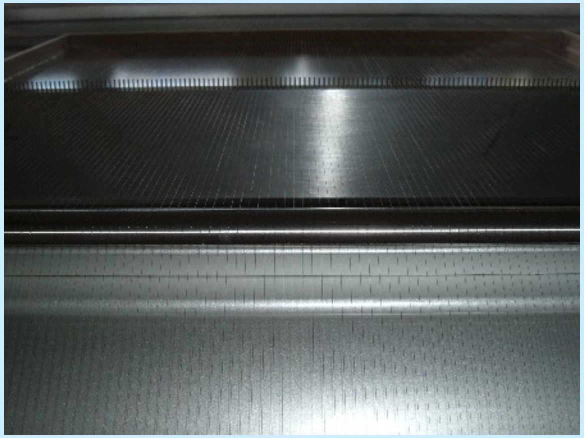
Pad Plane's flatness check

Drilling the hole for the Drift HV cable

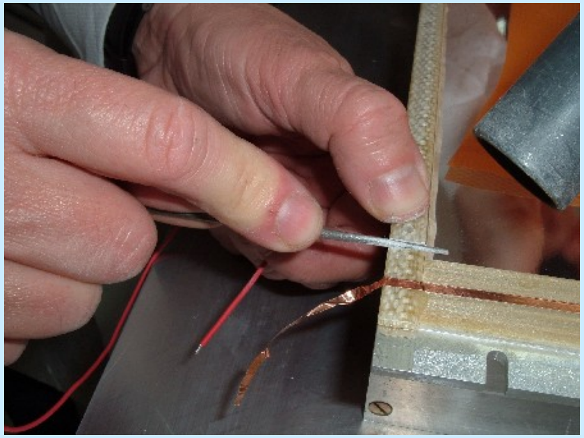
MW Electrode on the Winding Machine

Cristian Andrei
Andrei Herghelegiu
Alexandru Dobrin
Andrei Radu

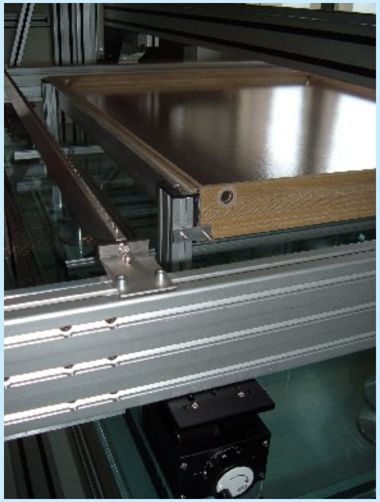
Drift HV connection on the Radiator



MW Electrode with the combs mounted

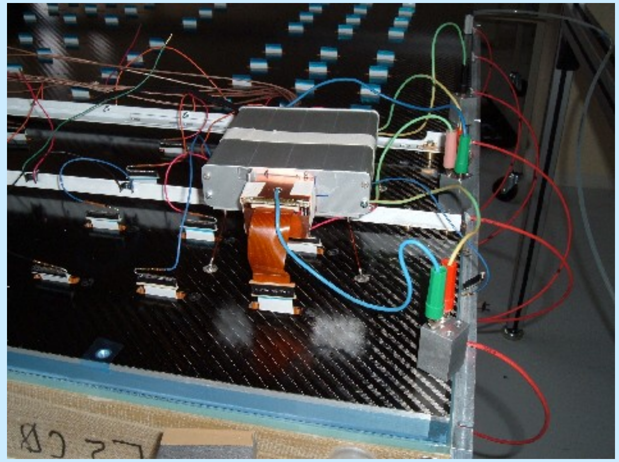


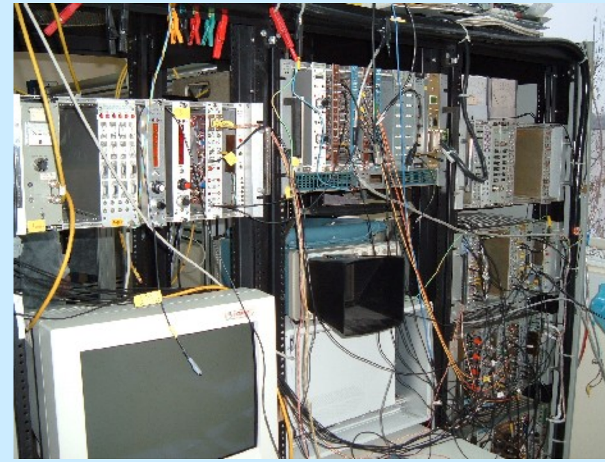
Preparing the access for the Drift HV end point

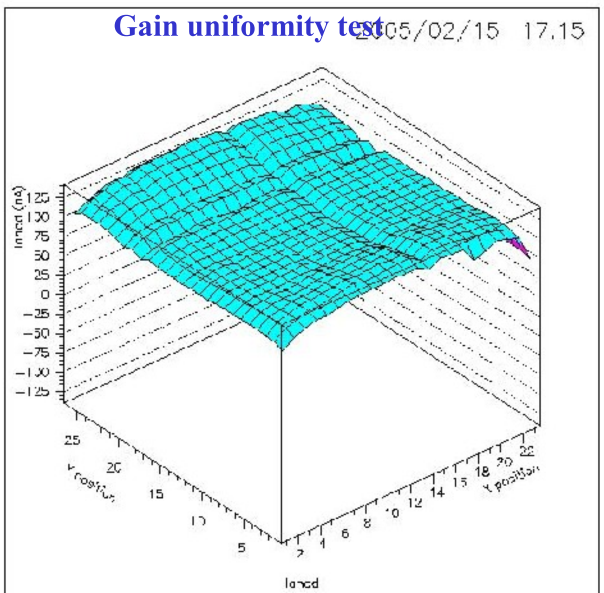


The configuration used for alignment & glueing the MW Electrodes

Viorel Duta
Gheorghe Giolu
Gheorghe Mateescu



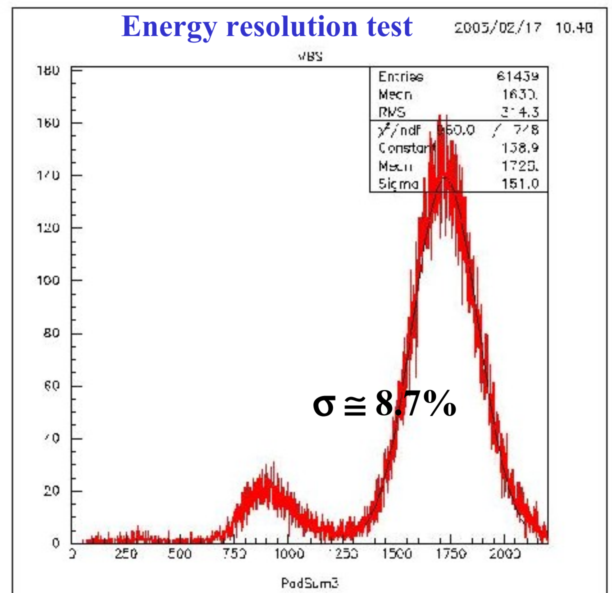




Constantin Magureanu

Daniel Bartos

Gheorghe Caragheorgheopol

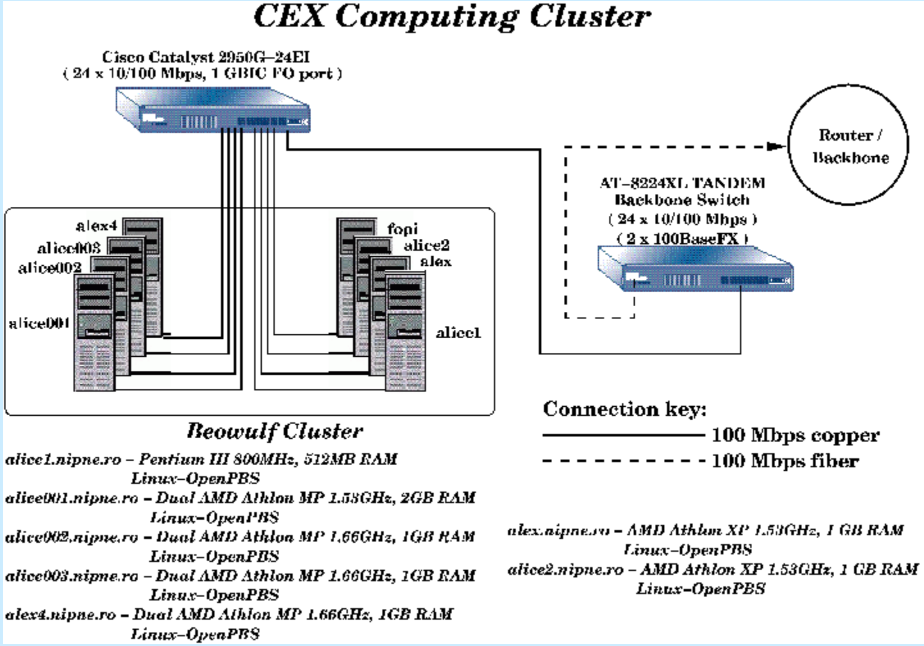


Mariana Petris

Ionela Berceanu

Amalia Pop

Towards a Tier 2 Centre



Claudiu Schiaua
Gabriel Stoicea
Cristina Aiftimiei
Duma Marin
Cristian Andrei
Amalia Pop
Alexandra Petrovici
Adriana Raduta
Oana Radu

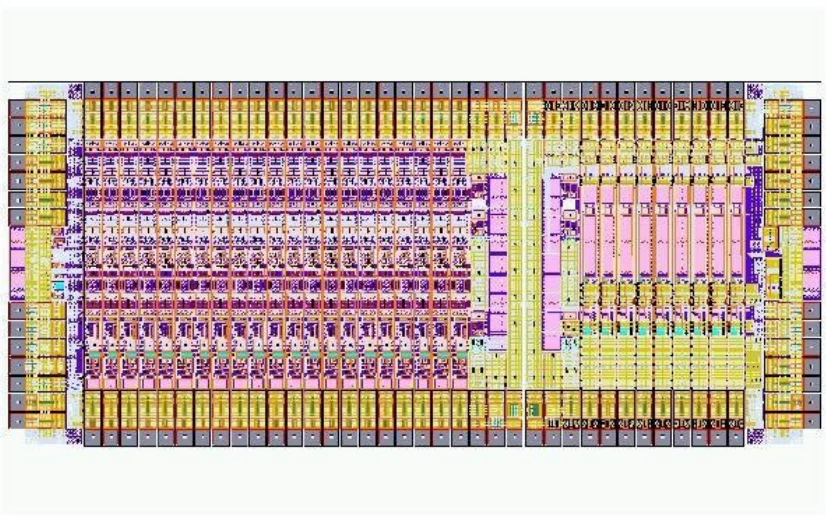
Nov. 2002

Present

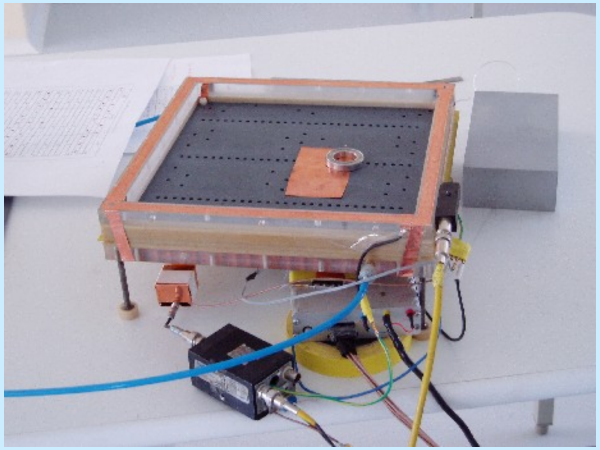
CADENCE @ NIHAM

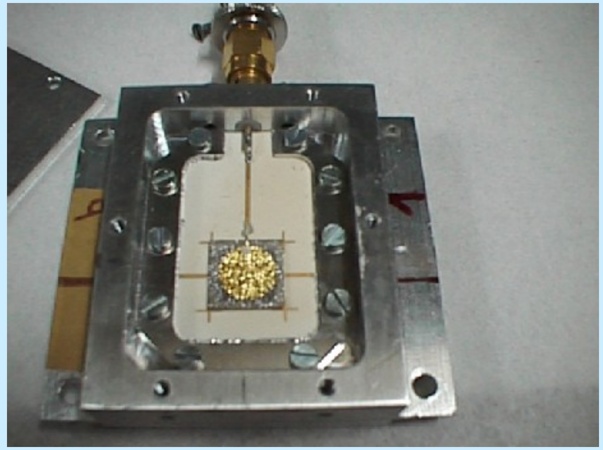
Vasile Catanescu

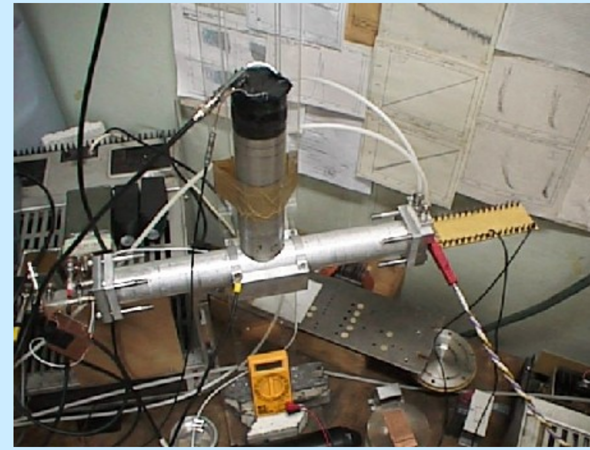
Claudiu Schiaua

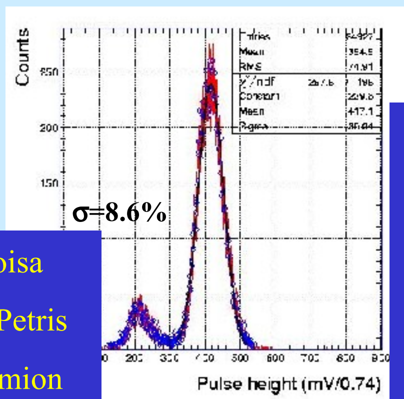


R&D Activities









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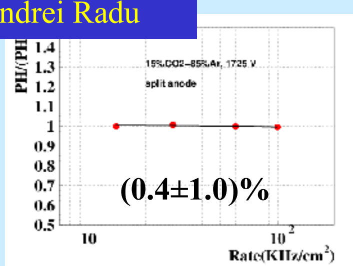
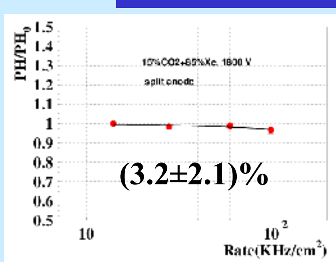
Mariana Petris

Victor Simion

Andrei Radu





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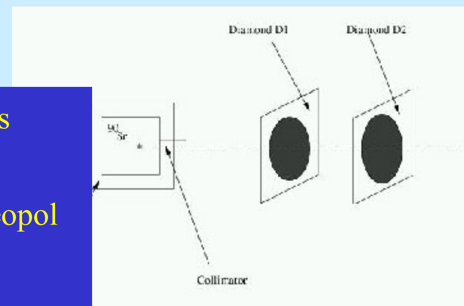
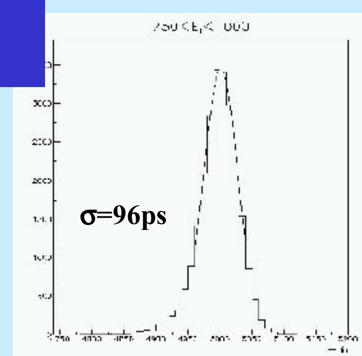
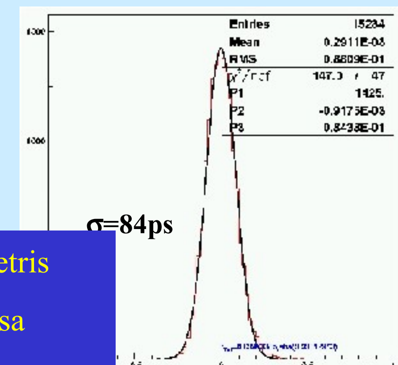






Mariana Petris

Dorin Moisa

Victor Simion

Ilie Cruceru

Andrei Radu

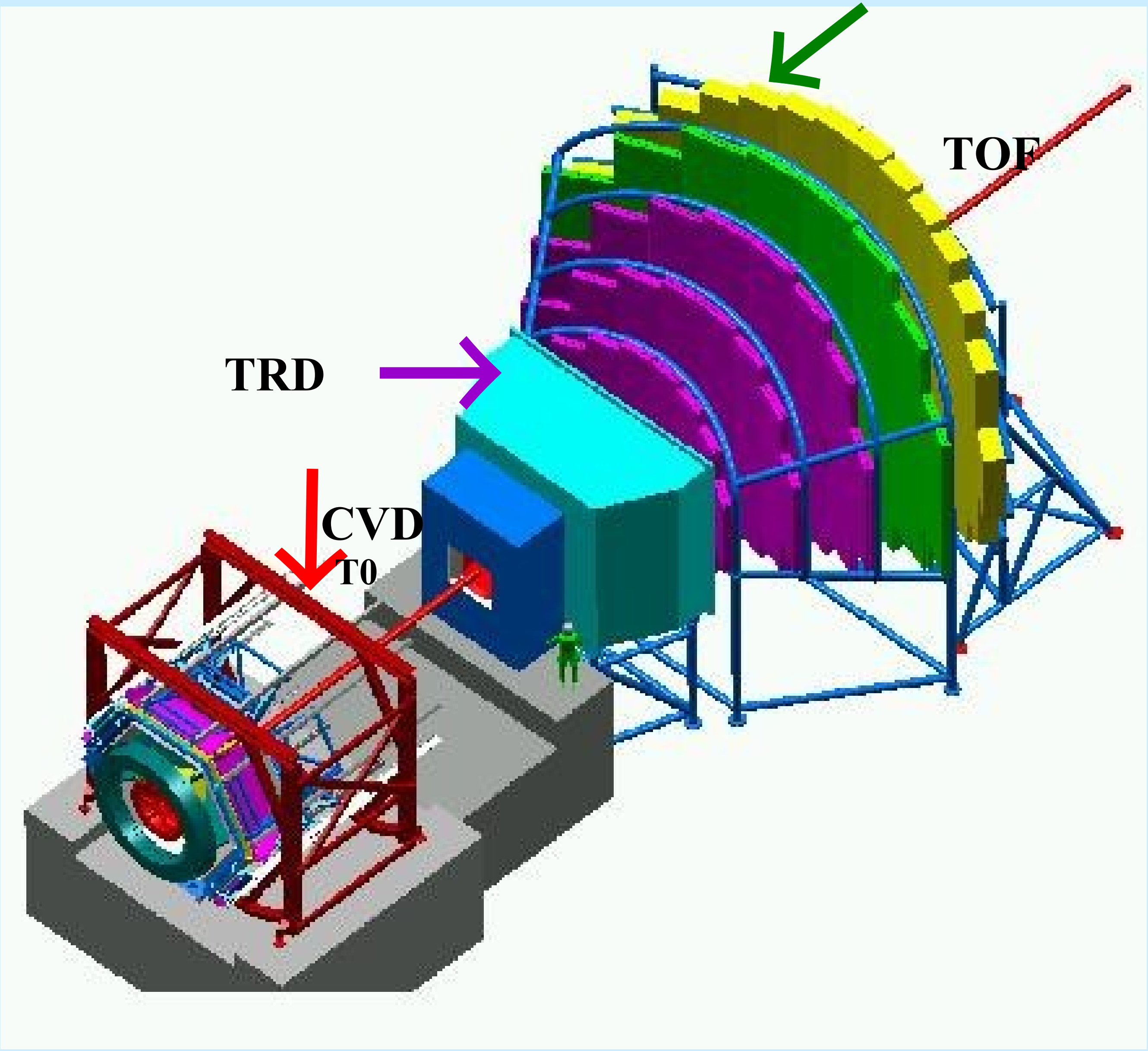
HCR - TRD
JRA4

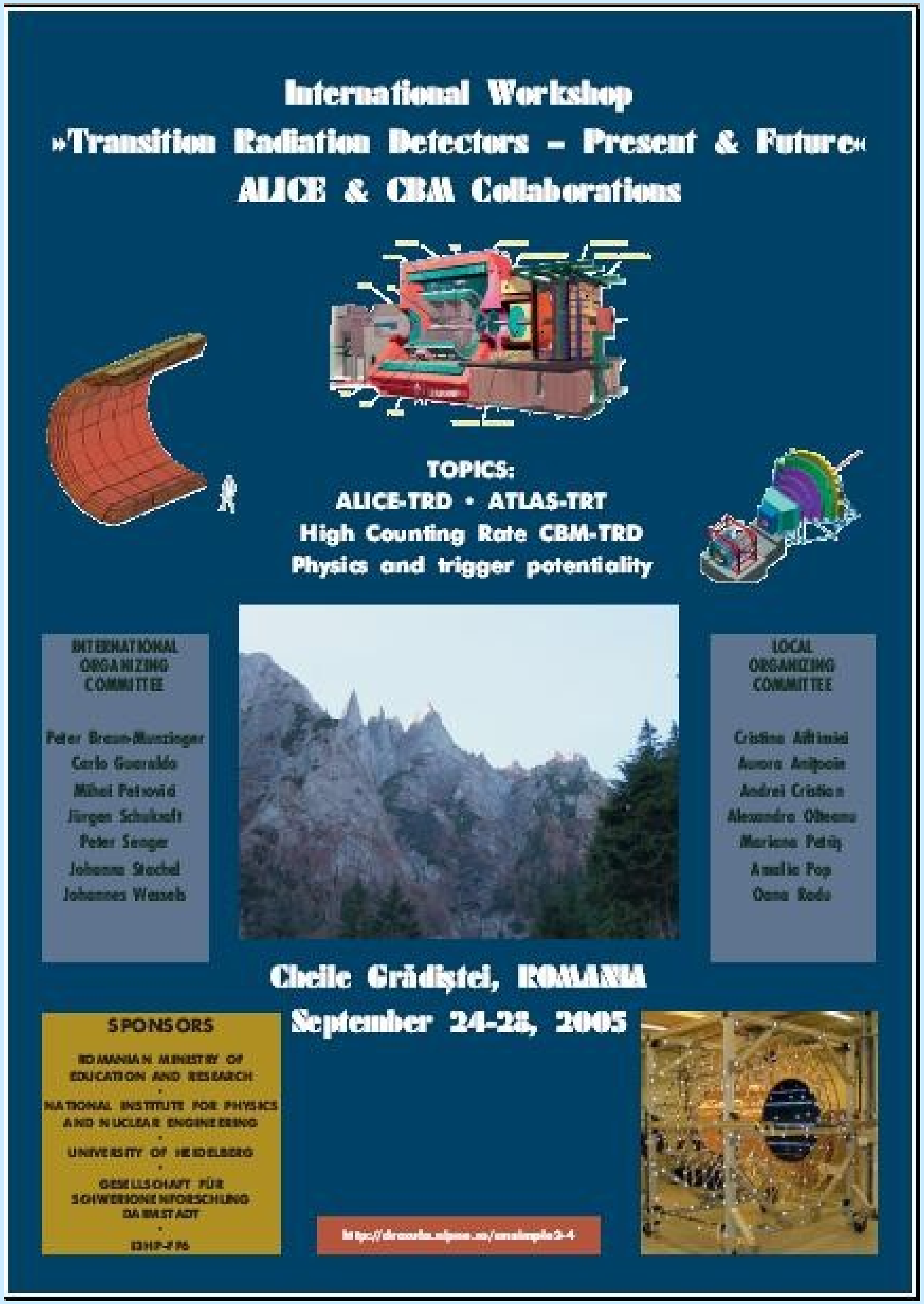
CVD - DD
JRA11

HCR - RPC
JRA12

I3HP - FP6

CBM @ FAIR

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»Transition Radiation Detectors – Present & Future«
ALICE & CBM Collaborations
TOPICS:
ALICE-TRD • ATLAS-TRT
High Counting Rate CBM-TRD
Physics and trigger potentiality
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Carlo Guaraldo
Mihai Petrovici
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I3HP-FP6











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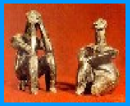
Conclusion:

YES!



Outlook:

“Lumea
nu e a cui o strabate cu piciorul,
ci a cui o intelege cu gandul”

Nicolae Iorga