

PRISMA-FIDES 2017-2019

"Heavy-ion reactions from grazing collisions to complete fusion"

G.Montagnoli (100%), G. Colucci (100%), F.Scarlassara_(100%) (Univ. and INFN - Padova)	3.0 FTE
L. Corradi (100%), A.M. Stefanini (100%), E.Fioretto (100%) F. Galtarossa (20%) (INFN - LNL)	3.2 FTE
G.Pollarolo (100%) (Univ. and INFN - Torino)	1.0 FTE
Total	7.2 FTE

→→ Collaborations with the EXOTIC experiment,
GANIL, IRB Zagreb, ANL, Strasbourg and Cracow

The PRISMA-FIDES experiment at LNL includes 2 lines of research



Heavy-Ion fusion reactions
near V_B and at $E \ll V_B$
using the set-up **PISOLO** based on
an electrostatic beam separator



Quasi-elastic reactions

- nucleon-nucleon correlations,
- sub-barrier transfer
- coupling to fusion,
- n-rich isotope production and
- nuclear structure studies ...

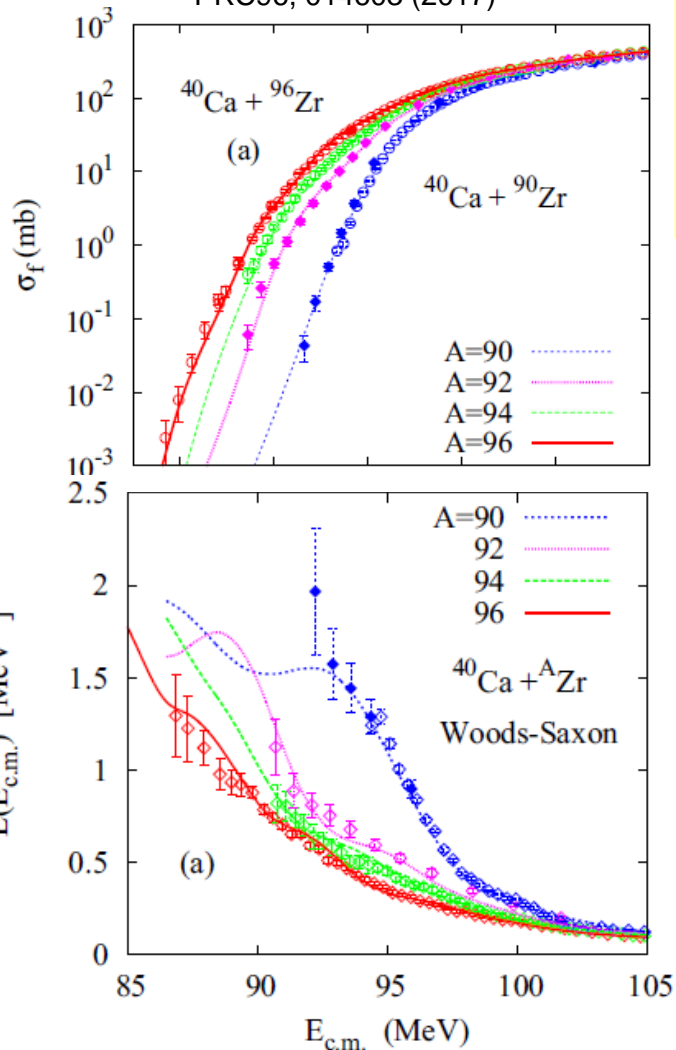
with the magnetic spectrometer **PRISMA**

+ complementary experiments at other facilities (GANIL, ANL, Isolde)

Main scientific results of the PRISMA-FIDES experiment during 2017-18

extending Ca + Zr systematics
completed theoretical analysis

A.M.Stefanini et al.
PRC96, 014603 (2017)



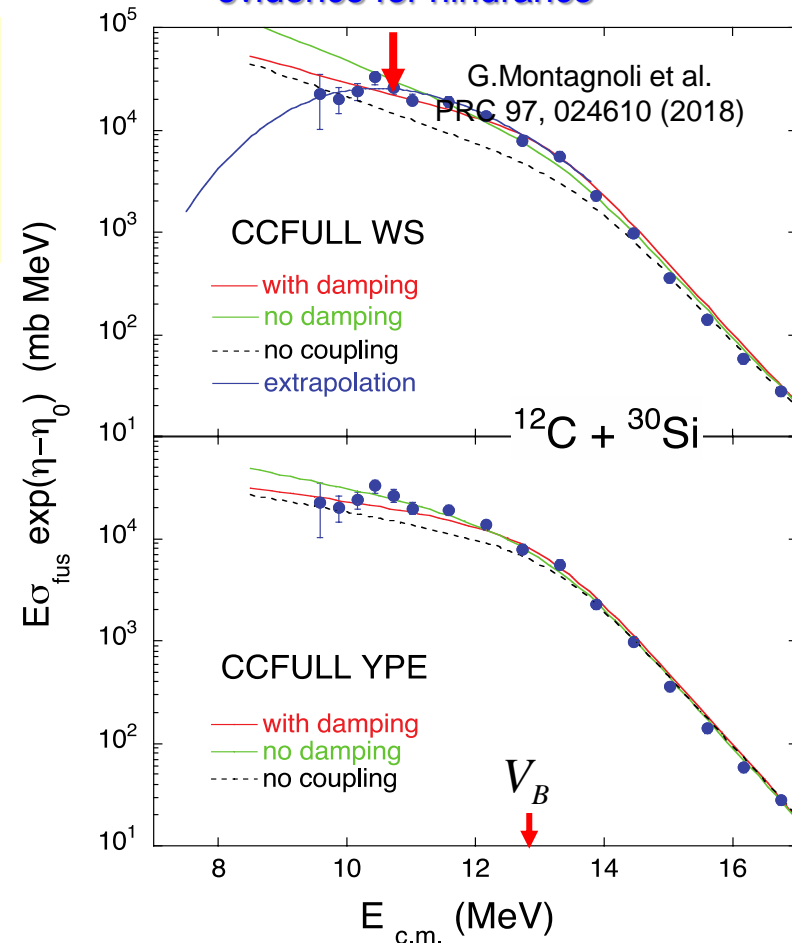
no global fit possible
with Double Folding
potential (M3Y + rep)

Any hindrance?



Fusion of $^{12}\text{C} + ^{30}\text{Si}$, ($Q=+14.1\text{MeV}$)
towards astrophysical systems

evidence for hindrance

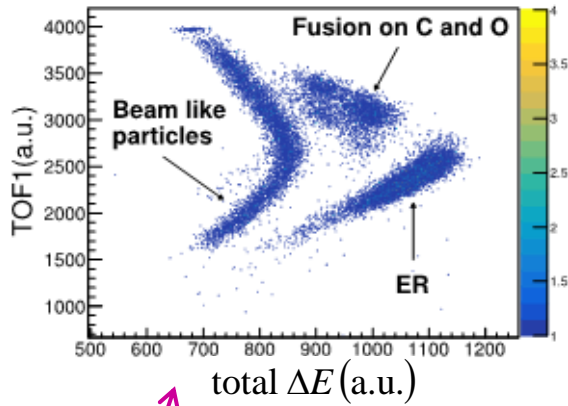
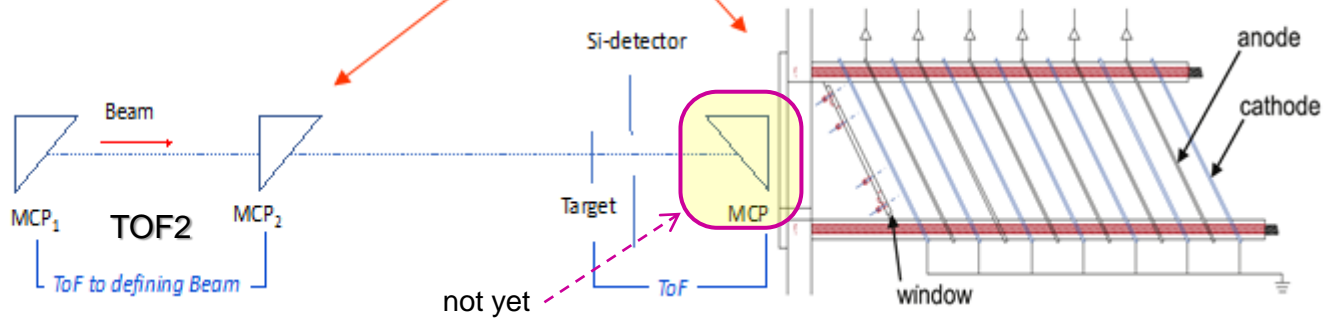


CC calculations fit the overall trend
but fail to reproduce the maximum

New set-up for fusion studies with SPES beams detecting ER at 0°

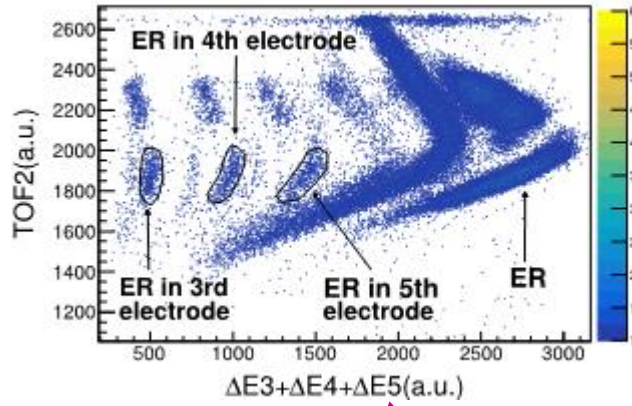
Position sensitive MCP detectors and a fast ionization chamber with tilted electrodes

G. Colucci LNL Annual Report 2017, p. 77

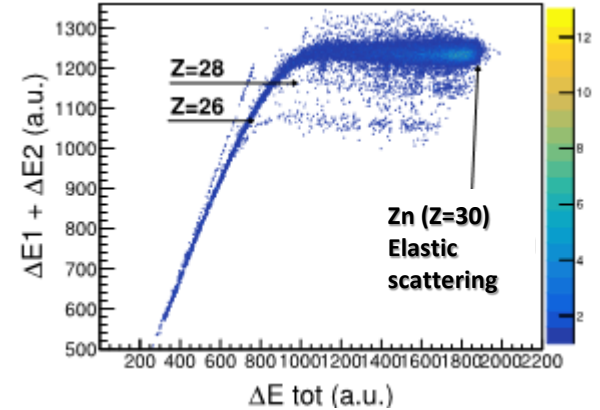


back trigger

$^{58}\text{Ni} + ^{28}\text{Si}$ @ 190 MeV



front trigger

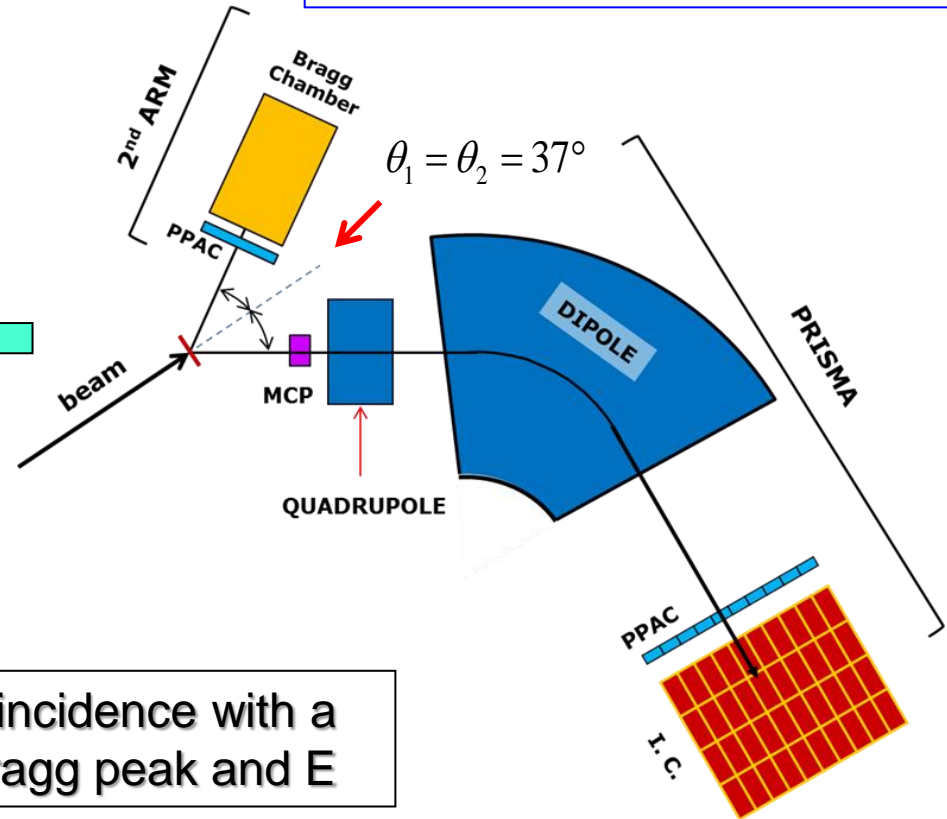
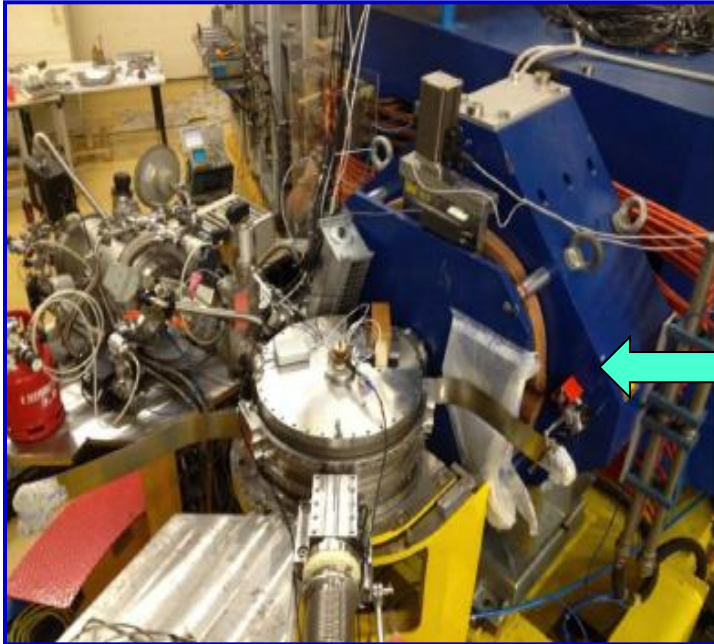


$^{64}\text{Zn} + ^{54}\text{Fe}$

channels -2p and -4p (including ^{54}Fe recoils) are well separated

The $^{197}\text{Au} + ^{130}\text{Te}$ experiment with the PRISMA spectrometer

$^{197}\text{Au} + ^{130}\text{Te}$ @ $E_{\text{lab}} = 1.07$ GeV
inverse kinematics

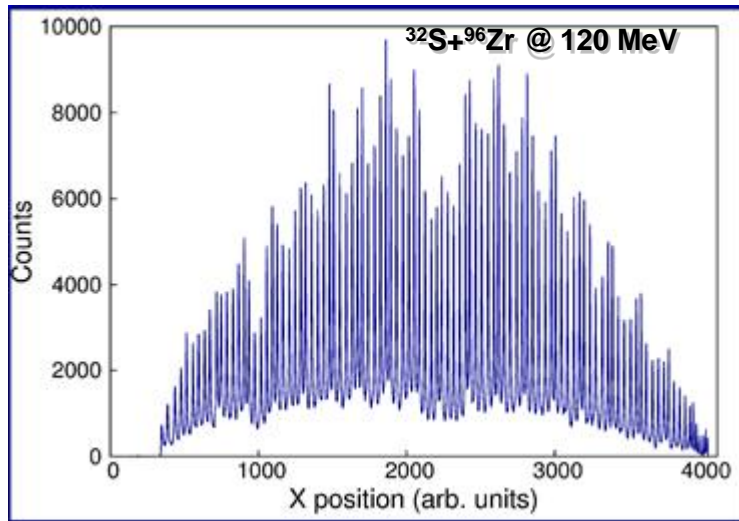


PRISMA spectrometer in kinematic coincidence with a 2nd Arm yielding XY position, ΔToF , Bragg peak and E

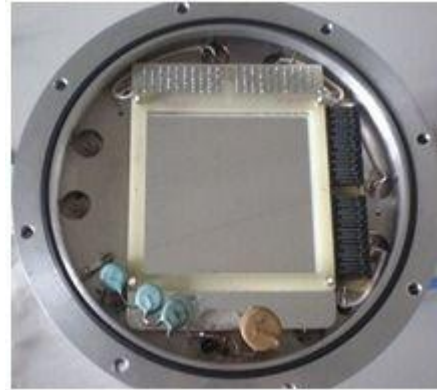
PRISMA \rightarrow A, Z of light Te-recoils - $\Delta A/A \sim 1/240$

2nd ARM \rightarrow A, Z of heavy Au-proj. - $\Delta A/A \sim 1/40$

The second arm of the PRISMA spectrometer (aka NOSE)



PPAC



$d_{\text{cathode-anodes}} = 2 \text{ mm}$
Gas : C_4H_{10}



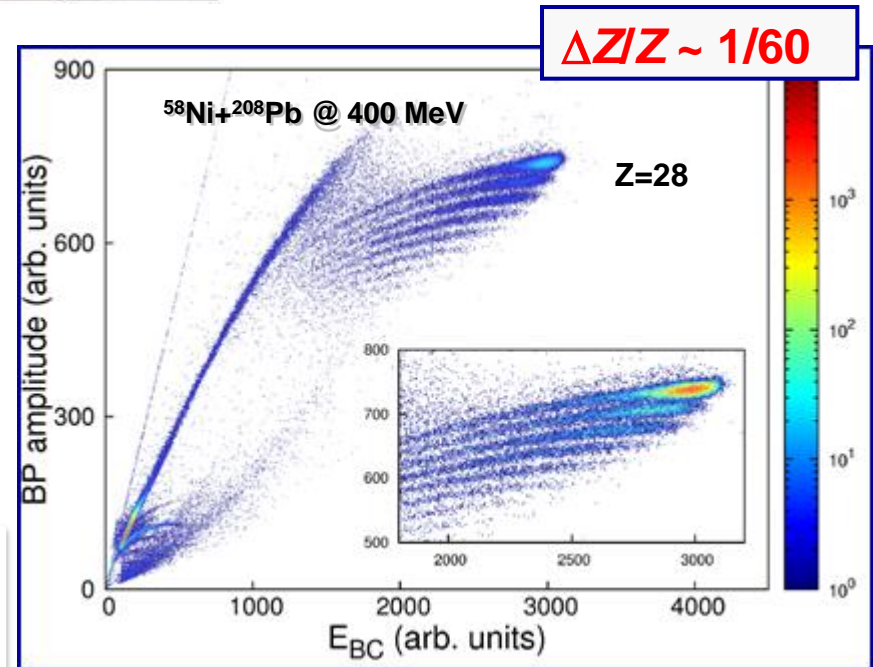
X and Y anode wires
10 μm diameter - 1 mm
delay-line readout $\rightarrow 1\text{ns}$



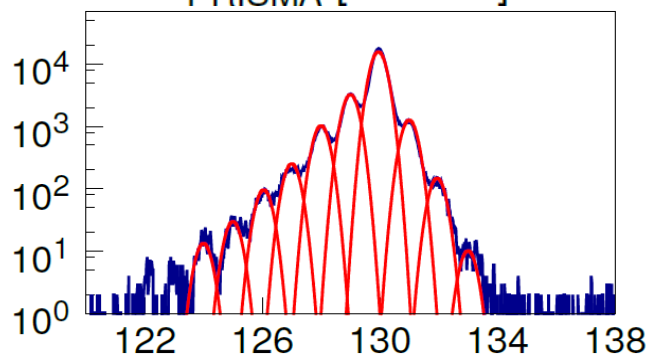
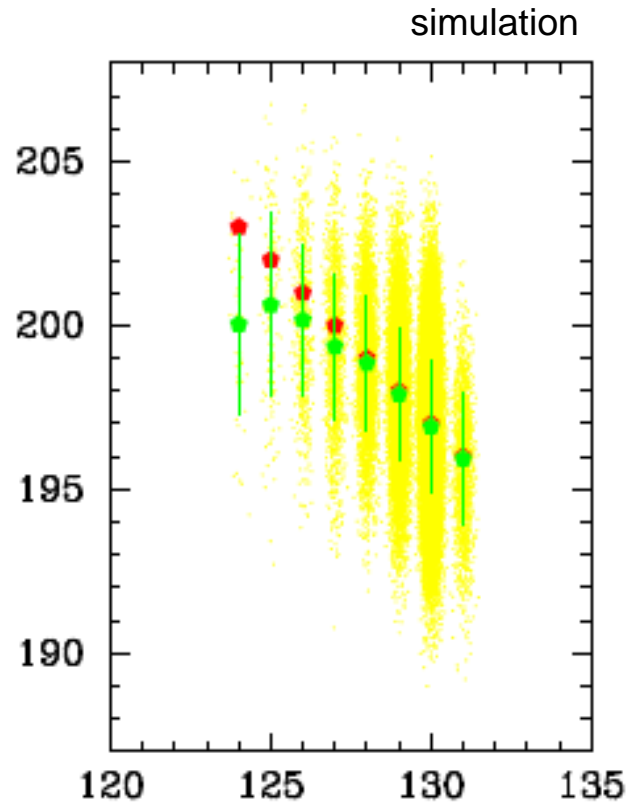
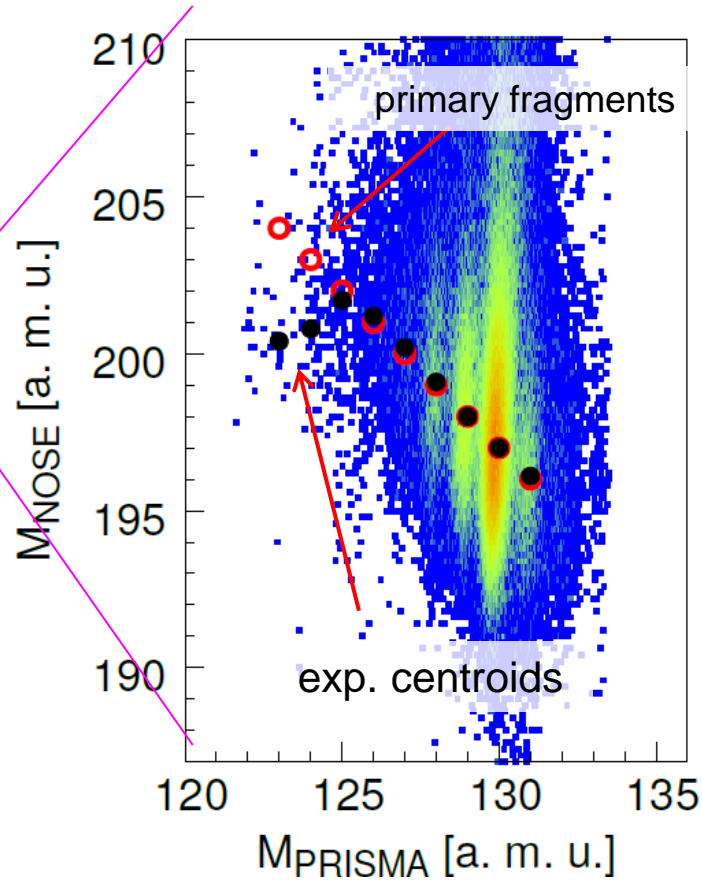
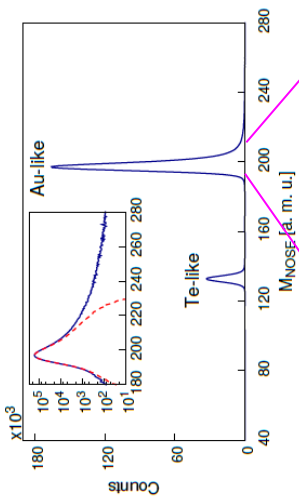
Axial field IC
"Bragg chamber"

$d_{\text{cathode-FG}} = 33 \text{ cm}$
Gas : CF_4

Digital electronics
 $\tau_{\text{BP}} = 0.25 \mu\text{s}$
 $\tau_{\text{E}} = 4 \mu\text{s}$

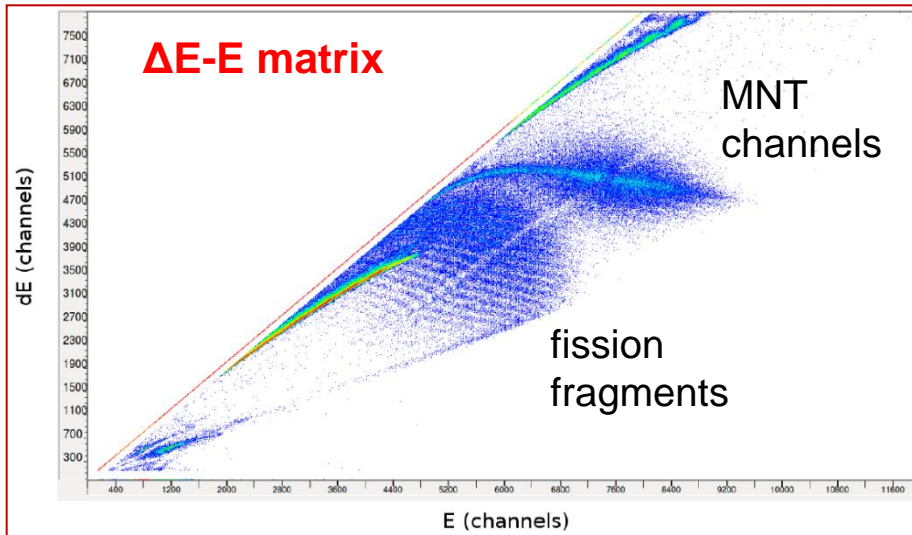


$^{197}\text{Au}+^{130}\text{Te}$: mass-mass correlation matrix



one can thus evidence the effect of secondary processes

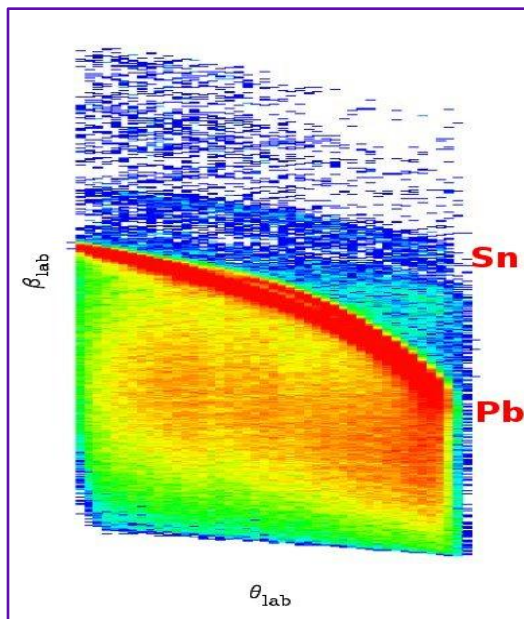
Pairing correlations probed in $^{206}\text{Pb}+^{118}\text{Sn}$ - PRISMA



^{206}Pb (1.2 GeV) + ^{118}Sn
($Q_{g.s.}(2n) \sim 0.8$ MeV)

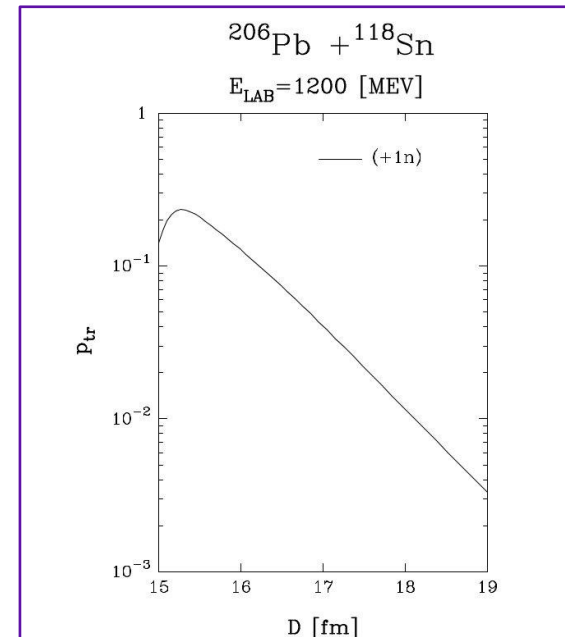
inverse kinematics
PIAVE+ALPI complex

evolution of neutron-neutron correlations
in the presence of high Coulomb fields



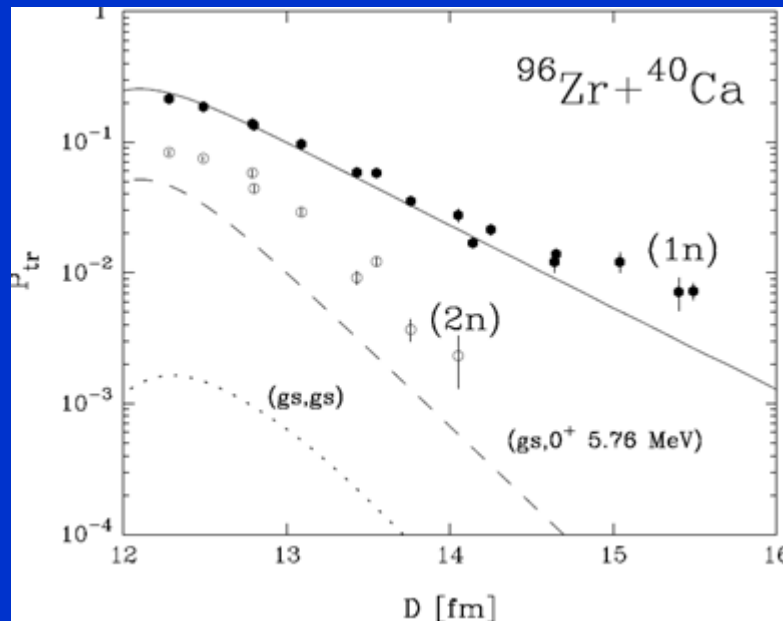
$\theta_{\text{lab}}=35^\circ$ is close to
the limiting angle for
Pb-like ions, so one
can safely control
the correct geometry
of the experiment

GRAZING predictions



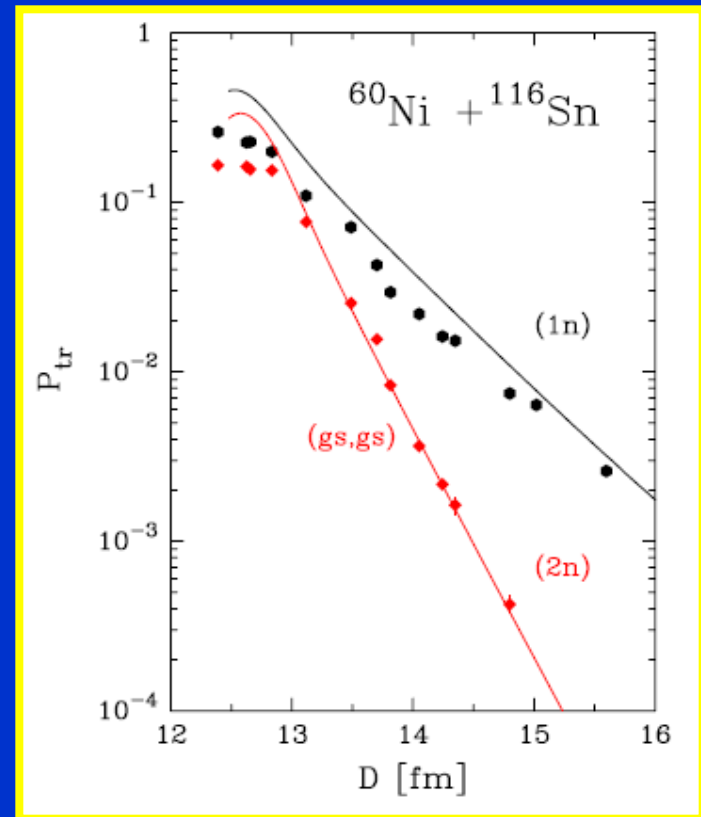
Transfer probabilities : comparison between exp and microscopic theory

$Q_{g.s.}$ for +2n **+5.5 MeV**,
far from Q_{opt} (~ 0 MeV)



L.Corradi, S.Szilner, G.Pollarolo et al,
PRC84(2011)034603

$Q_{g.s.}$ for +2n **+1.3 MeV**
close to Q_{opt} (~ 0 MeV)



D.Montanari, L.Corradi, S.Szilner,
G.Pollarolo et al, PRL113(2014)052501

Programma scientifico per il 2019

Nel 2019 è prevista la seguente attività scientifica:

- **Completamento dell'upgrade del set-up PISOLO** con l'uso della **camera a ionizzazione (IC) veloce** per il futuro utilizzo a 0° in esperimenti di fusione con i fasci di SPES.
- **Misura delle sezioni d'urto di fusione** a bassa energia per la reazione $^{24}\text{Mg} + ^{12}\text{C}$ in cinematica inversa e $^{58}\text{Ni} + ^{64}\text{Ni}$, con l'uso della **nuova IC**.
- **Completamento della interpretazione teorica** dei risultati relativi alla fusione dei sistemi $^{36}\text{S} + ^{50}\text{Ti}, ^{51}\text{V}$
- **Analisi dati dell'esperimento PRISMA** in cinematica inversa $^{206}\text{Pb} + ^{118}\text{Sn}$
- **Analisi dati dell'esperimento PRISMA** con coincidenze γ -particella $^{54}\text{Fe} + ^{92}\text{Mo}$
- **Misure di trasferimento a molti nucleoni** mediante l'utilizzo dei fasci pesanti disponibili da PIAVE+ALPI, es. $^{208}\text{Pb} + ^{48}\text{Ca}$, per lo studio degli effetti di correlazione protone-protone (energie sotto la barriera Coulombiana) e per lo studio di effetti secondari (sopra barriera) da effettuarsi mediante coincidenze cinematiche
- **Continuazione dello sviluppo del secondo braccio** riguardante l'uso del Flash-ADC

Richieste ai servizi Padova per il 2019

Servizio	Lavoro richiesto	Tempo (mesi uomo)
Ufficio Tecnico	Progetto per controllo remoto del bersaglio camera di Prisma	1
Officina Meccanica	Alloggiamento del 3° rivelatore MCP per upgrade PISOLO in vista di SPES Manutenzione e interventi PISOLO e PRISMA	3 1
Laboratorio Elettronica	Manutenzione elettronica per rivelatori PRISMA e PISOLO	1

Bilancio preliminare PRISMA-FIDES 2019 Padova in k€

Missioni	Interne + Estere	8
Consumo	Rivelatori al silicio per monitor (2 da 50 mm ²) e per PISOLO (1 da 600 mm ²)	6
	consumo e ricambi ordinari	5
	Set-up terzo rivelatore MCP con accessori per upgrade PISOLO in vista di SPES	5
Inventario	controllo del sistema da vuoto	3
	scaler counter	5
	logica per veto beam-like	8
	Sistema di acquisizione dati multiparametrico da laboratorio con PC dedicato	2
Totale		42

Publications July 2017- June 2018 on Fusion and Multi nucleon transfer

- **Charge distributions of Ra recoil ions produced in $^{12}\text{C} + \text{Pb}$ fusion-evaporation reactions**
R.N. Sagaidak, N.A. Kondratiev, L. Corradi, E. Fioretto, T. Mijatović, G. Montagnoli, F. Scarlassara, A.M. Stefanini and S. Szilner
Physical Review C 97, 054622 (2018)
- **Mass correlation between light and heavy reaction products in multinucleon transfer $^{197}\text{Au} + ^{130}\text{Te}$ collisions**
F. Galtarossa et al.,
Physical Review C 97, 054606 (2018)
- **Isotopic effects in sub-barrier fusion of Si plus Si systems**
G. Colucci et al.,
Physical Review C 97, 044613 (2018)
- **Fusion hindrance for the positive Q-value system $^{12}\text{C} + ^{30}\text{Si}$**
G. Montagnoli et al.,
Physical Review C 97, 024610 (2018)
- **Use of the facility EXOTIC for fusion-evaporation studies**
E. Strano et al.,
Nucl. Instr. And Meth. A 877, 293 (2018)
- **A gas detection system for fragment identification in low-energy heavy-ion collisions**
E. Fioretto et al.,
Nucl. Instr. And Meth. A 899, 73 (2018)
- **Recent experimental results in sub- and near-barrier heavy-ion fusion reactions**
G. Montagnoli and A. M. Stefanini
European Physical Journal A 53, 169 (2017)
- **New results in low-energy fusion of $^{40}\text{Ca} + ^{90,92}\text{Zr}$**
A. M. Stefanini, G. Montagnoli, H. Esbensen, P. Colović, L. Corradi....
Physical Review C 96, 014603 (2017)
- **Transition probabilities in neutron-rich $^{80,82}\text{Se}$ and the role of the $\nu g_{9/2}$ orbital**
J. Litzinger et al.,
Physical Review C 97, 044323 (2018)