

## PRISMA-FIDES 2013-2016

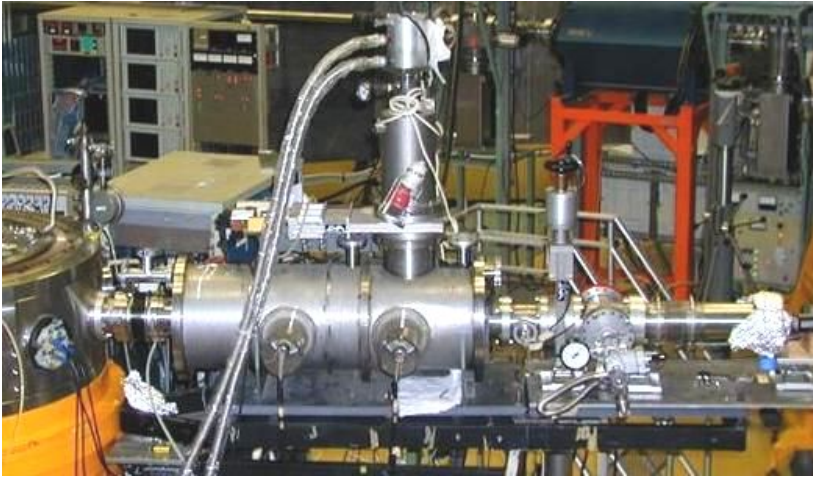
"Heavy-ion reactions from grazing collisions to complete fusion"

<u>G.Montagnoli</u> (100%), E.Strano (80%), <u>F.Scarlassara</u> (50%) (Univ. and INFN - Padova)	2.3 FTE
A.M. Stefanini (100%), L. Corradi (80%), E.Fioretto (100%), (INFN - LNL)	2.8 FTE
G.Pollarolo (50%) (Univ. and INFN - Torino)	0.5 FTE
<b>Total</b>	<b>5.6 FTE</b>

- → Joint work with the **EXOTIC** experiment
- → Collaborations with GSI (D.Ackermann), Zagreb (S.Szilner, T.Mijatovic), Dubna (N.Kondratiev, R.Sagaidak), Strasbourg (F.Haas, S.Courtin, D.Montanari), Cracow (J.Grebosz)

## The PRISMA-FIDES experiment at LNL

Traditionally, our group has always been involved in 2 lines of research:



### HI fusion reactions

around  $V_B$  presently focused at  $E \ll V_B$

using the electrostatic beam separator

**PISOLO**

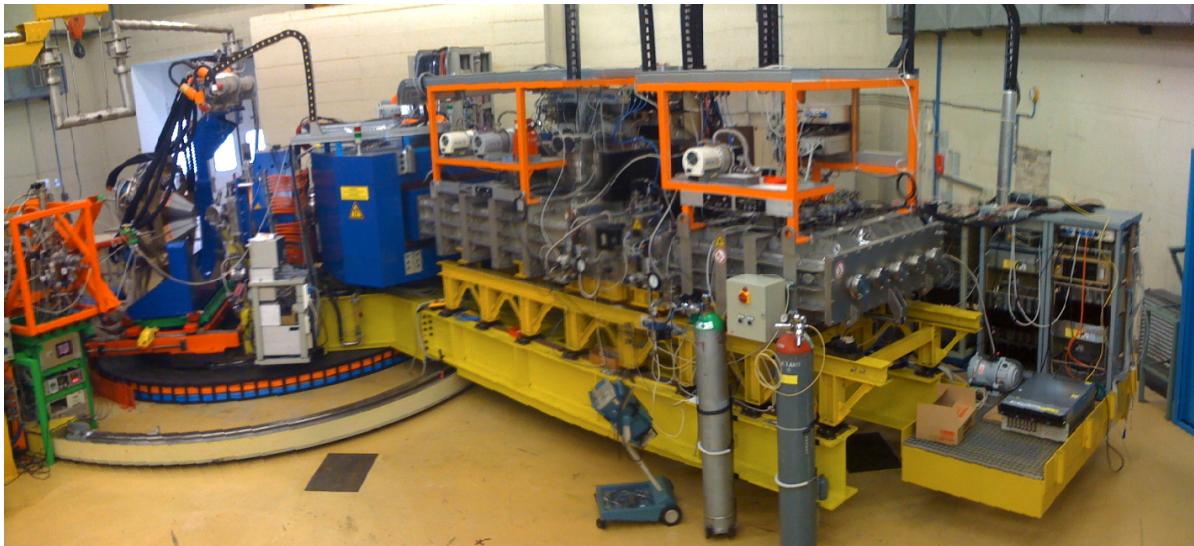
### 2-body reactions

nucleon-nucleon  
correlations, sub-barrier  
transfer, coupling to fusion,  
n-rich isotope production

...

using the magnetic  
spectrometer

**PRISMA**



complementary experiments at other facilities (GANIL, ANL)

## PRISMA-FIDES

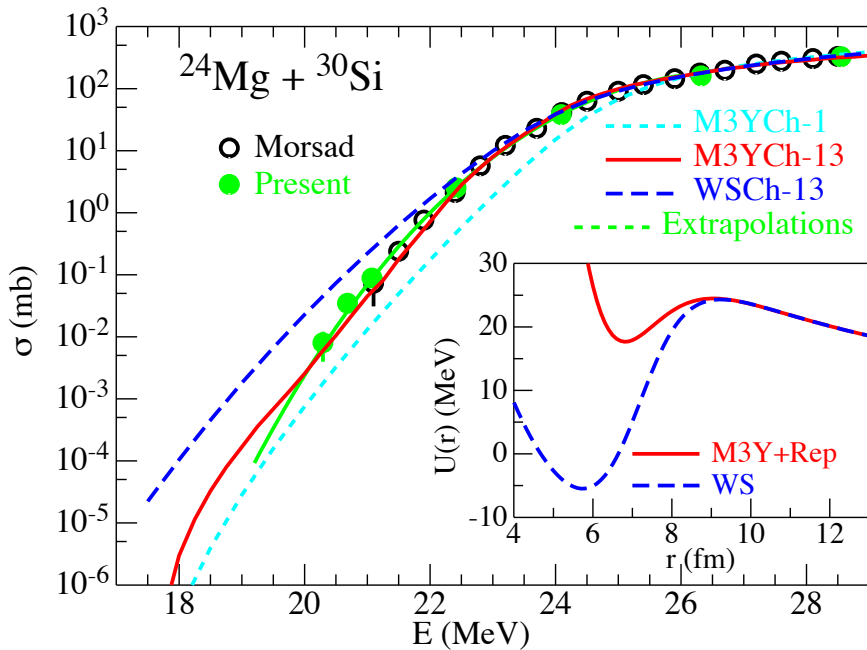
- Study of nucleon-nucleon correlations (particle-vibration couplings, pairing vibrations, sub-barrier transfer) in binary reactions near the barrier
- Couplings effects and hindrance far below the barrier in fusion cross sections of heavy-ion systems
- Test of the EXOTIC set-up for very low fusion x-sects. measurements with stable beams
- The future exotic SPES beams will allow us to take significant steps further in these scientific areas.

## Significant Results and Developments since September 2013

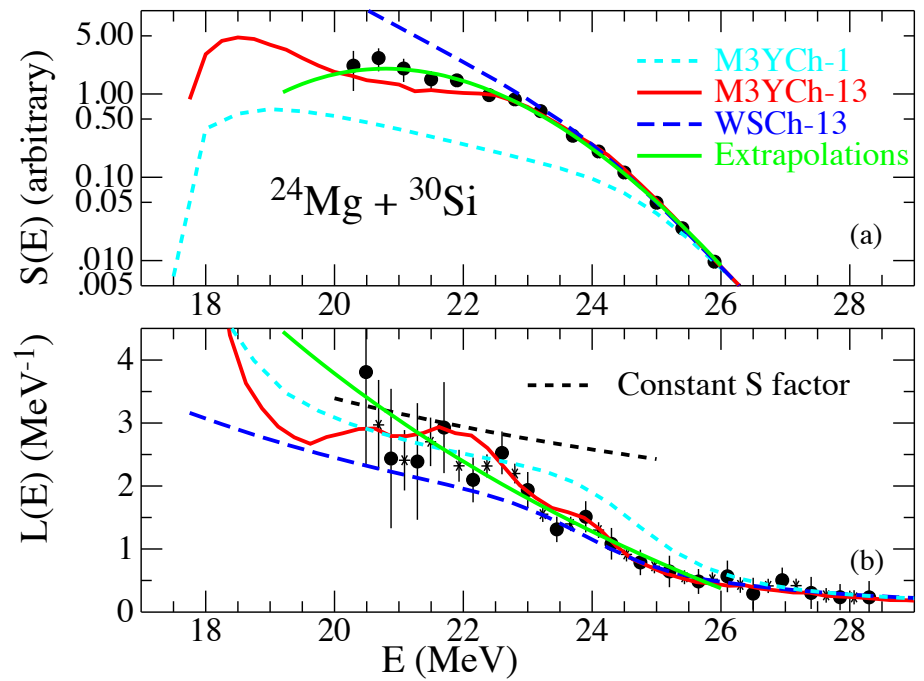
- Study of fusion hindrance for  $^{24}\text{Mg}+^{30}\text{Si}$  at extreme low energies
- Fusion hindrance and quadrupole collectivity in collisions of  $A\sim 50$  nuclei ( $^{48}\text{Ti}+^{58}\text{Fe}$ )
- Study of fusion reactions for  $\text{Ni}+\text{Sn}$  at low energies
- Formation of neutron-rich nuclei in the region of the closed neutron shell  $N=126$ ; the experiment has been performed using the new scattering chamber and the second arm of PRISMA

# Fusion hindrance for the positive Q-value system

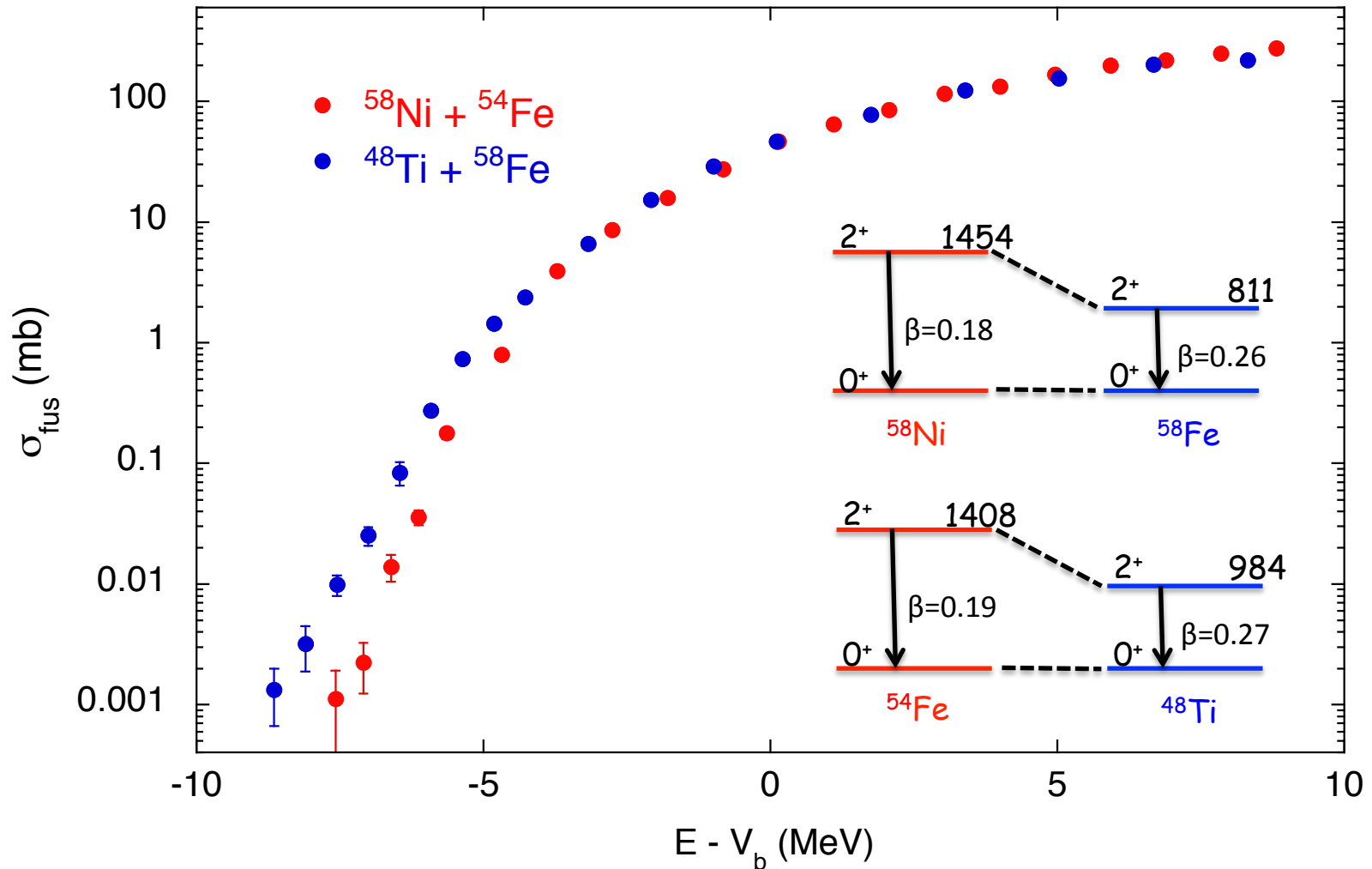
## $^{24}\text{Mg} + ^{30}\text{Si}$



An S-factor maximum has been observed for  $^{24}\text{Mg} + ^{30}\text{Si}$  ( $Q_{\text{fus}} = +17.89$  MeV)

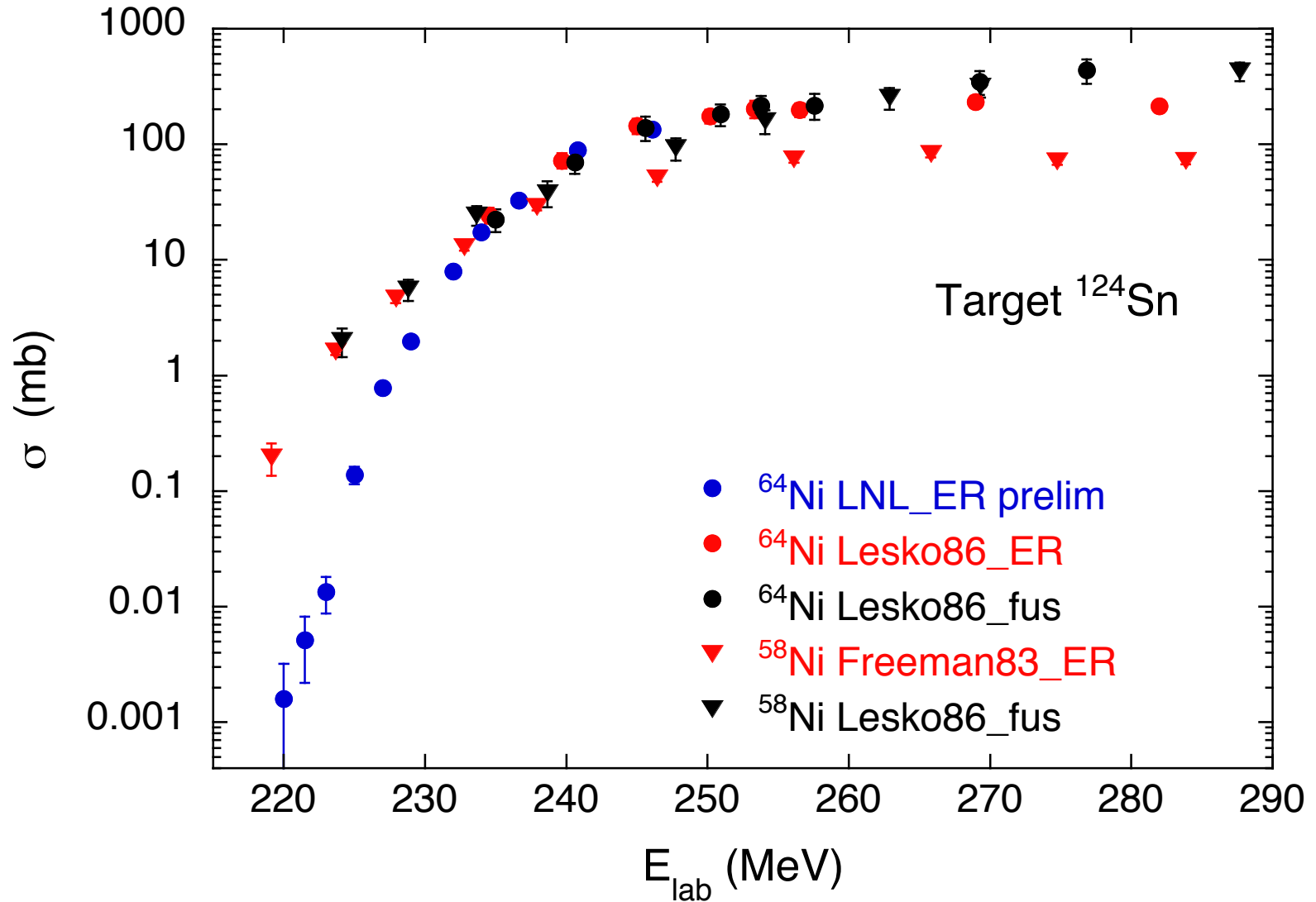


# Fusion excitation functions of $^{58}\text{Ni} + ^{54}\text{Fe}$ and $^{48}\text{Ti} + ^{58}\text{Fe}$ vs. the energy difference from the barrier $V_b$

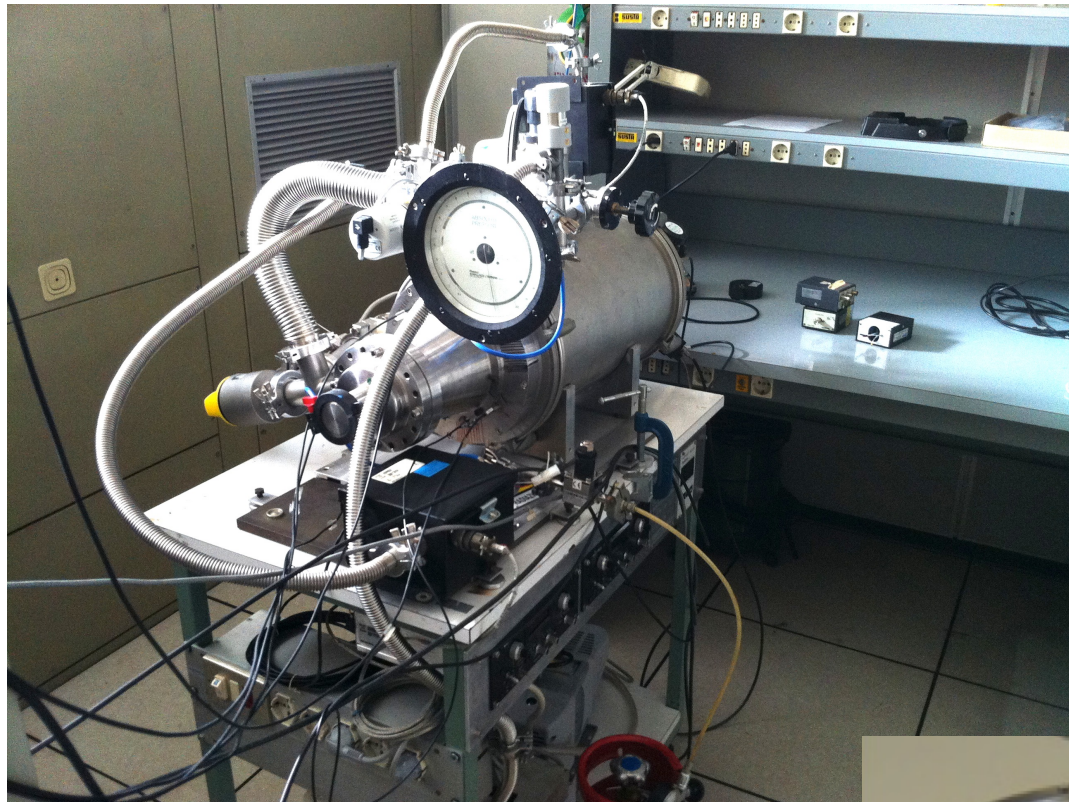


$V_b$  is the barrier of the Akyüz-Winther potential.

$^{64}\text{Ni}+^{124}\text{Sn}$  preliminary results compared  
with previous data and with  $^{58}\text{Ni}+^{124}\text{Sn}$



# The Bragg chamber for the 2<sup>nd</sup> arm of Prisma



Frisch grid



Cathode

Inner side of the axial chamber with the guard rings

Position sensitive PPAC mounted  
in front of the axial ionization chamber

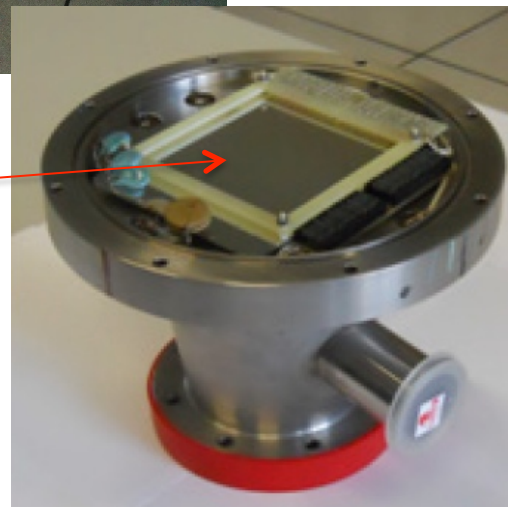
X and Y anode wire planes

10  $\mu\text{m}$  diameter - 1 mm spacing

delay-line readout  $\rightarrow$  1ns

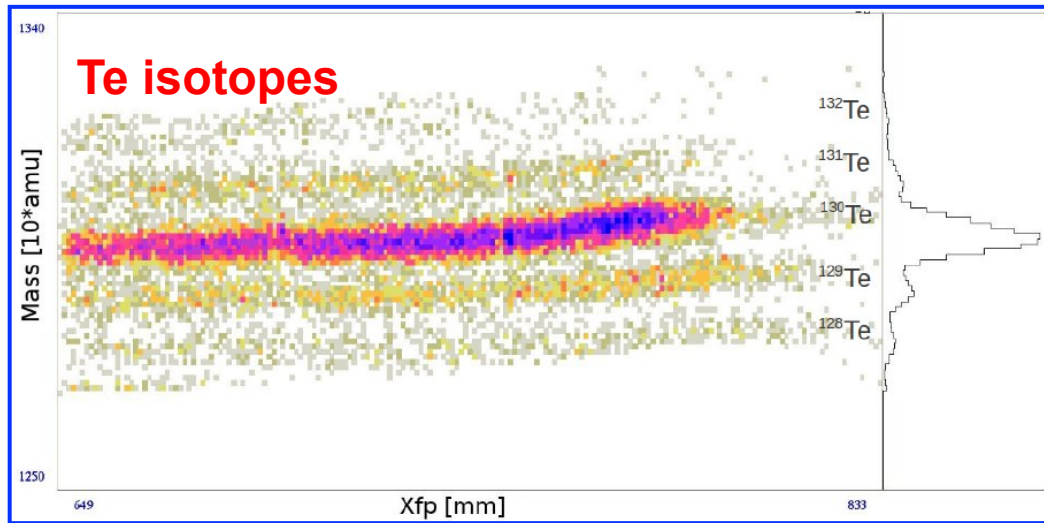
Cathode  $\rightarrow$  1.5  $\mu\text{m}$  thick mylar foil + Al

$d_{\text{cathode-anodes}} = 2 \text{ mm}$



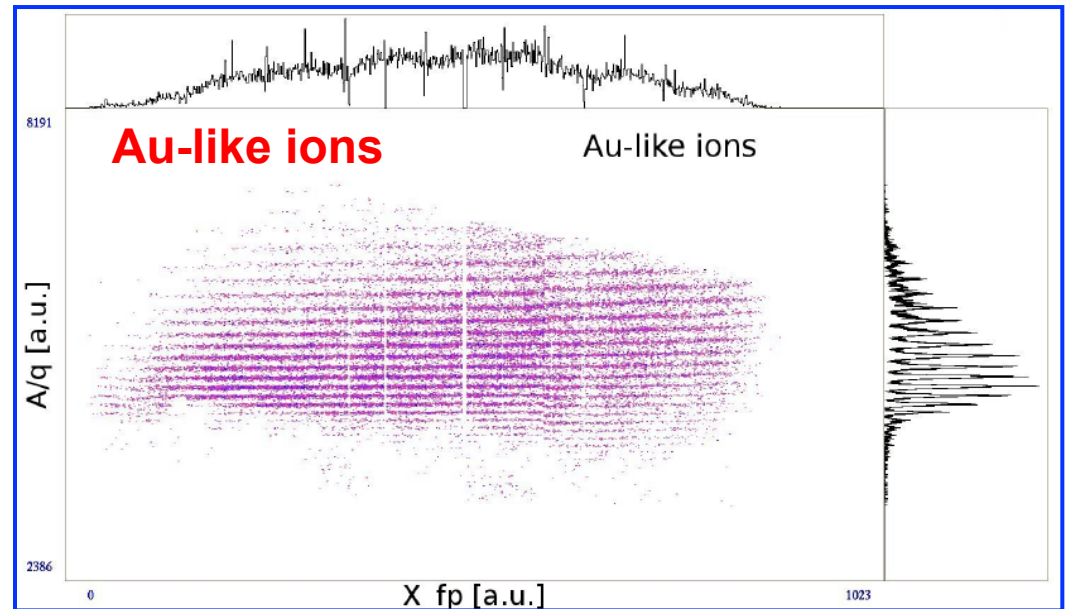


$^{197}\text{Au}+^{130}\text{Te}$  in inverse kinematics at  $E_{\text{lab}}=1070$  MeV and  $\theta_{\text{lab}}=37^\circ$

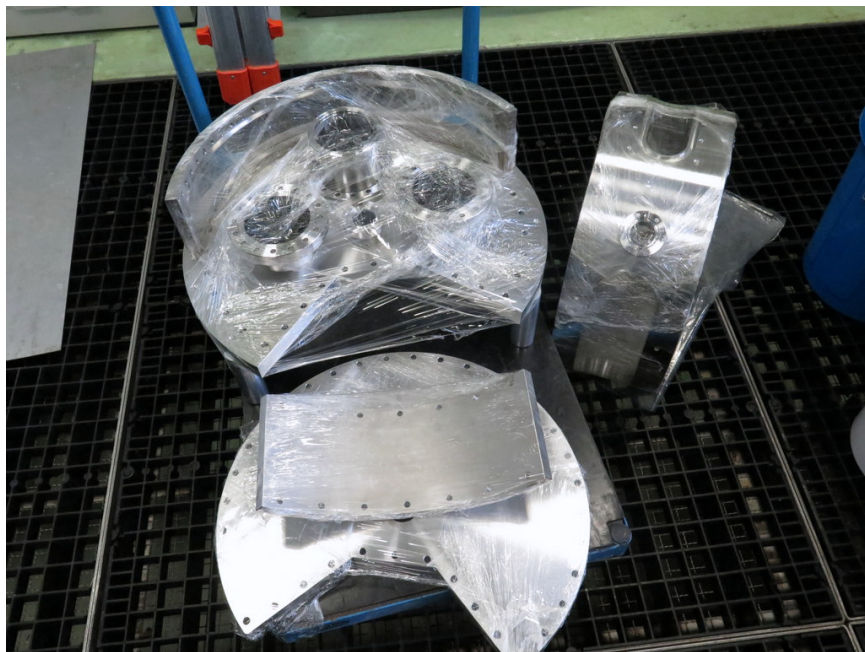


Mass vs position at the focal plane for Te isotopes

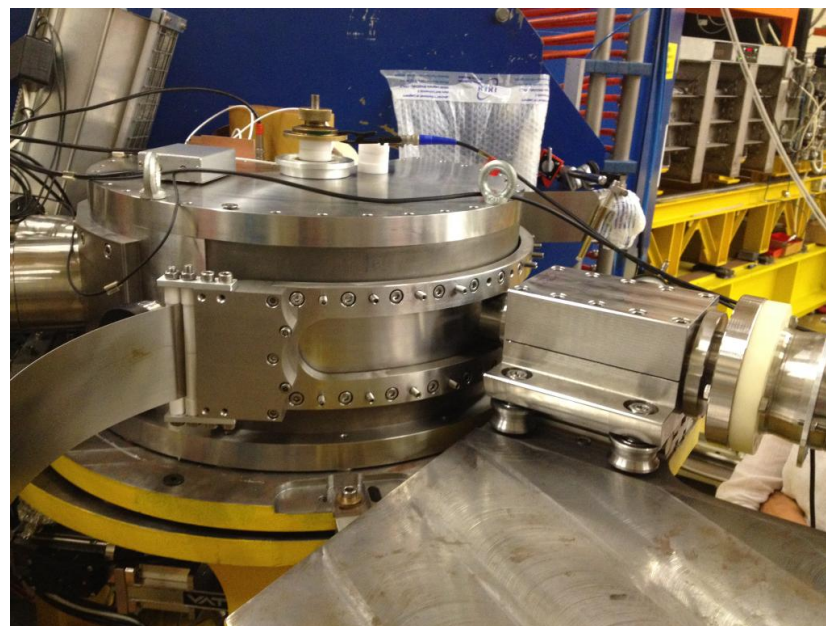
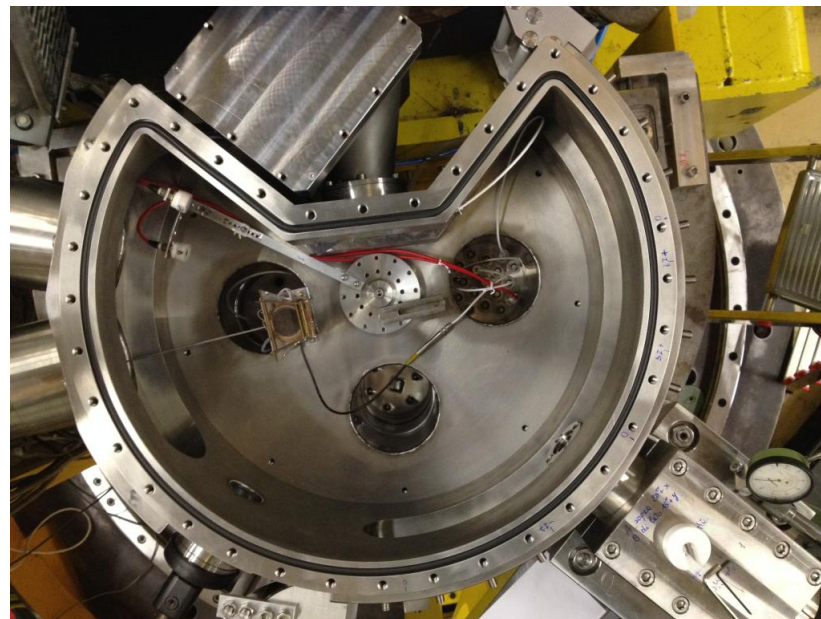
Mass over atomic charge state  $q$   
( $A/q$ ) for Au-like ions



January 24<sup>th</sup>

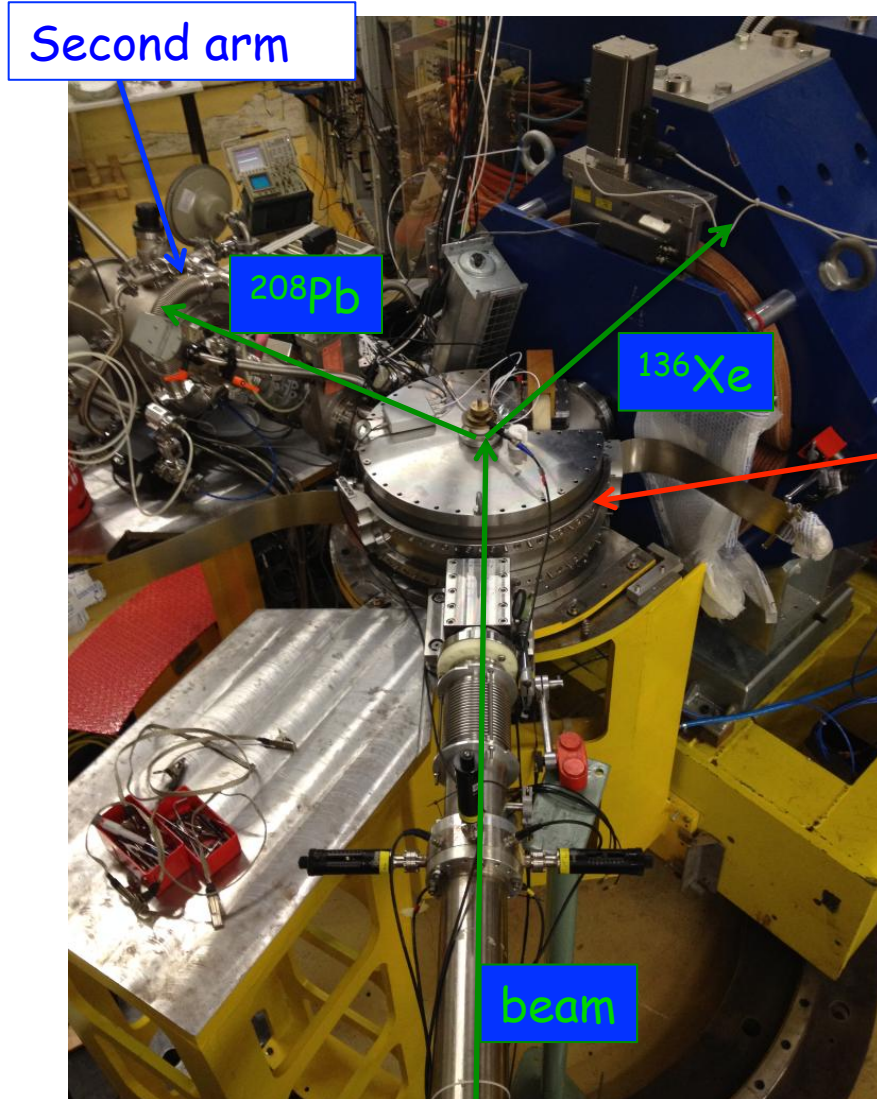


June 24<sup>th</sup>



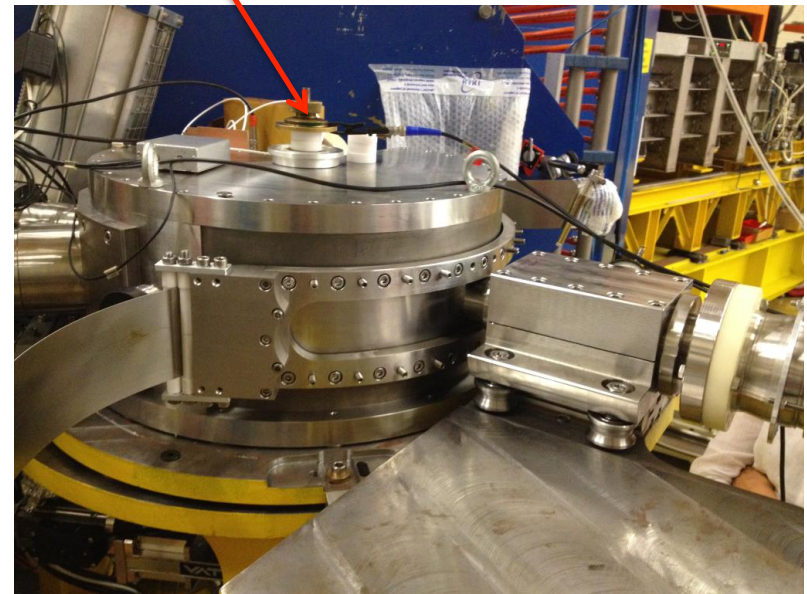
Camera di reazione a tenuta strisciante progettata a Padova e costruita nelle officine di PD e LNL

# $^{136}\text{Xe}$ (Piave-ALPI beam) + $^{208}\text{Pb}$



We have very recently measured the formation cross sections for the isotopes of Pt, Ir and Os, obtained in the multi-nucleon transfer reactions in low-energy collisions of  $^{136}\text{Xe}$  with  $^{208}\text{Pb}$  at  $E_{\text{lab}} = 870 \text{ MeV}$

Scattering chamber



## Pubblicazioni su rivista luglio 2013 - giugno 2014

*- Fusion hindrance for a positive Q-value system-  $^{24}\text{Mg}+^{30}\text{Si}$*

CL Jiang, AM Stefanini, H Esbensen, KE Rehm, S Almaraz-Calderon, BB Back, L Corradi, E Fioretto, G Montagnoli et al.  
Physical Review Letters, 113, 022701 (2014)

*-Neutron pair transfer in  $^{60}\text{Ni}+^{116}\text{Sn}$  far below the Coulomb barrier*

D. Montanari, L. Corradi, S. Szilner, G. Pollarolo, E. Fioretto, G. Montagnoli, F. Scarlassara, A. M. Stefanini, S. Courtin, A. Goasdu, F. Haas, D. Jelavic Malenica, C. Michelagnoli, T. Mijatovic, N. Soic, C. A. Ur, and M. Varga Pajtler  
Physical Review Letters, accepted for publication

*- Influence of heavy-ion transfer on fusion reactions*

CL Jiang, KE Rehm, BB Back, H Esbensen, RVF Janssens, AM Stefanini, G. Montagnoli  
Physical Review C **89**, 051603 (2014)

*- Influence of multiphonon excitations and transfer on the fusion of  $\text{Ca}+ \text{Zr}$*

H Esbensen, AM Stefanini  
Physical Review C **89**, 044616 (2014)





*- Fusion of  $^{40}\text{Ca}+^{96}\text{Zr}$  revisited: Transfer couplings and hindrance far below the barrier*

AM Stefanini, G Montagnoli, H Esbensen, L Corradi, S Courtin, E Fioretto, F. Scarlassara  
Physics Letters B **728**, 639-644 (2014)

*- Lifetime measurements in neutron-rich  $^{63}, ^{65}\text{Co}$  isotopes using the AGATA demonstrator*

V Modamio, JJ Valiente-Dobón, S Lunardi, SM Lenzi, A Gadea, ...G Montagnoli, F Scarlassara et al.  
Physical Review C **88**, 044326 (2013)

## Milestones PRISMA-FIDES 2014

- 1) **July 30, 2014** to complete the installation and the in-beam commissioning of the 2nd arm of PRISMA, including the Flash ADC for the read-out of the Bragg chamber  80 %
- 2) **July 30, 2014** to complete the in-beam tests for the use of Exotic for measuring sub-barrier fusion with stable beams  50%
- 3) **July 30, 2014** to perform the approved experiments on deep sub-barrier fusion with medium-mass and light systems  100 %
- 4) **Nov. 30, 2014** to perform a sub-barrier transfer experiment with a Piave-Alpi beam of  $A \approx 200$  in inverse kinematics using Prisma and its 2nd arm  in July

## Milestones PRISMA-FIDES 2015

1. **March 31, 2015** to complete the experimental study of sub-barrier fusion for the two systems  $^{58,64}\text{Ni} + ^{124}\text{Sn}$
2. **July 31, 2015** to publish two more papers on deep sub-barrier fusion with medium-mass and light systems
3. **October 31, 2015** to complete the in-beam tests for the use of Exotic for measuring sub-barrier fusion with stable beams
4. **Nov. 30, 2015** to complete the data analysis, and submit a paper, for the multi-nucleon transfer experiment with a Piave-Alpi beam of  $A \approx 200$  in inverse kinematics using Prisma and its 2nd arm

## Bilancio complessivo PRISMA-FIDES 2015

	<b>Padova</b>		<b>LNL</b>		<b>Torino</b>
<b>Missioni</b>	Interne + Estere	8	Interne + Estere	10	3
<b>Consumo</b>	Si e monitor x Pisolo e Prisma	6	Isotopi ( $^{40}\text{Ca}$ , $^{30}\text{Si}$ , $^{124}\text{Sn}$ , $^{90}\text{Zr}$ )	10	
	Coppia MCP Prisma 80x100 mm <sup>2</sup> con lavorazioni	8	Cons. vario, gas, cavi, manutenzioni	4	
	Consumo vario, attrezz. lab.	3	Automatizzazione movimenti camera Prisma	6	
<b>Inventario</b>	2 Preamp Canberra 2003BT (Si)	4	Gruppo turbo da lab.	5	
	1 Quad FastAmp 9309-4 Ortec	3	Elettronica logica 2° braccio/Prisma	7	
	Fast amp Ortec 9306, 9326 (MCP)	3	Misuratore vuoto lab. con Penning	2	
<b>Totali</b>		<b>35</b>		<b>44</b>	<b>3</b>

## Richieste ai servizi Padova per il 2015

Servizio	Lavoro richiesto	Tempo (mesi uomo)
Ufficio Tecnico	Alloggiamento rivelatori $\text{LaBr}_3$ su coperchio cam. sliding seal. Progetto per controllo remoto del bersaglio	1
Officina Meccanica	Sostituzione e manutenzione di parti meccaniche dei rivelatori di start e di piano focale di Prisma. Meccanica per controllo remoto del bersaglio	6
Laboratorio Elettronica	Completamento fast ampl. + HV per i due PPAC	1

## Richieste ai servizi LNL per il 2015

Servizio	Lavoro richiesto	Tempo (mesi uomo)
Officina Meccanica	Costruzione alloggiamento rivelatori $\text{LaBr}_3$ su coperchio cam. sliding seal. Accessori interni camera di scattering	4
Servizio Utenti (Supporto App. Sperim.)	Controllo PLC del vuoto Pisolo Integrazione sistema da vuoto del II braccio nel controllo di Prisma	3
STIE (Servizio Tecnologie Informatiche ed Elettroniche)	Integrazione di un Flash ADC nel DAQ di Prisma. Assistenza durante gli esperimenti Prisma e Pisolo.	4