Deep inelastic @ 0°

French Italian Polish collaboration

I. Stefan for E677 & T14

collaborations

IPN Orsay





How?

Can we use S3 as an In-Flight RIB Facility?







Charges states estimation

⁴⁸Ca+²³⁸U



Charges states estimation

⁴⁸Ca+²³⁸U





What secondary beams?

- \rightarrow neutron rich
- \rightarrow proton rich

What purity (low)

Id of secondary reaction products

Secondary beam production



400

 $\Theta_{\rm CM}$

60°

80°

100°

200

200

100

00

E/B = 1.1

Secondary beam production

Beam energy around the Coulomb barrier	=	Angular distribution mainly peaked around grazing angle
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Deep inelastic measurement @ LISE in 2015



Detection system: dE ionization chamber dE 37 um Silicium detector E 300 um Silicium detector

 $2xTof \rightarrow dE start; RF stop$ $\rightarrow Eres start; RF stop$ Farady cup to measure the beam intensity before the run and TID3 for beam fluctuations during the run Where to look?





Deep inelastic measurement @ LISE in 2015 ¹⁸O 8.5 MeV/A beam

Where to look?









Deep inelastic measurement @ LISE in 2015 ¹⁸O 8.5 MeV/A beam



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Charge state momentum distribution

Measured asymetric charge states distribution



Where we measured







Deep inelastic measurement @ LISE in 2015 ¹⁸O 8.5 MeV/A beam

What we learn

¹⁸O 8.5 MeV/A E/B=1.6

Charge states -> very large (10% dP/P)

Cross s	sections: +1n +2n -2p -2p+2n	~ 1 mb/MeV/st ~ 0.2 mb/MeV/st ~ 0.2 mb/MeV/st ~ 0.003 mb/MeV/st	S3 1 mg/cm ^{2 238} U ±5% dp/p 60 mrad x' y' ~2000 pps/puA ~200000 pps for 100 ~500 pps/puA ~50000 pps ~10 pps/puA <1000 pps
Purity:	+1n +2n -2p -2p+2	~ 0.5% ~ 0.09% ~ 0.09% n ~ 0.001%	min 400000 pps/puA in S3 int focal plane

Deep inelastic measurement @ LISE in 2015 ³⁶S 12 MeV/A beam

Deep inelastic measurement @ LISE in 2015 ³⁶S 12 MeV/A beam

If Low energy for ejectiles after secondary reactions

Fusion – evaporation ? N=Z nuclei ?

Higher energy for ejectiles after secondary reactions

Transfer Coulex Nuclear astrophysics (resonant elastic scattering) Life-time measurements for excited states Fusion evaporation Fusion fission & quasi-fission γ spectroscopy

Higher energy for ejectiles after secondary reactions

Transfer

Possibility for ToF measurement

Coulex Nuclear astrophysics (resonant elastic scattering) Life-time measurements for excited states Fusion evaporation Fusion fission & quasi-fission γ spectroscopy

Possible primary beams for the production of neutron rich secondary beams

												⁴⁰ Sc	41 Sc	42Sc	43Sc	44 Sc	45 Sc	⁴⁶ Sc	4/Sc	⁴⁸ Sc	49 SC	⁵⁰ Sc	⁵¹ Sc	52 Sc
									³⁶ Ca	³⁷ Ca	³⁸ Ca	³⁹ Ca	⁴⁰ Ca	⁴¹ Ca	⁴² Ca	⁴³ Ca	⁴⁴ Ca	⁴⁵ Ca	⁴⁶ Ca	41Ca	⁴⁸ Ca	⁴⁹ Ca	⁵⁰ Ca	⁵¹ Ca
									³⁵ K	³⁶ K	³⁷ K	³⁸ K	³⁹ K	⁴⁰ K	⁴¹ K	⁴² K	⁴³ K	⁴⁴ K	⁴⁵ K	⁴⁶ K	-	⁴⁸ K	⁴⁹ K	⁵⁰ K
						³¹ Ar	³² Ar	³³ Ar	³⁴ Ar	³⁵ Ar	³⁶ Ar	³⁷ Ar	³⁸ Ar	³⁹ Ar	⁴⁰ Ar	⁴¹ Ar	⁴² Ar	⁴³ Ar	44Ar	⁴⁵ Ar	⁴⁶ Ar	⁴⁷ Ar	⁴⁸ Ar	⁴⁹ Ar
							³¹ CI	³² CI	³³ CI	³⁴ CI	³⁵ CI	³⁶ CI	37CI	³⁸ CI	³⁹ CI	⁴⁰ CI	41CI	42CI	⁴³ CI	44CI	⁴⁵ CI	⁴⁶ CI	47CI	⁴⁸ CI
				27 _S	28 S	29 S	³⁰ S	31S	32 S	33 S	34S	³⁵ S	36 S	³⁷ S	³⁸ S	³⁹ S	⁴⁰ S	41S	42 S	43 S	44 S	45 S	⁴⁶ S	47 S
				26p	27p	28p	29p	30p	31р	³² p	33p	34p		36p	37p	³⁸ P	³⁹ P	40p	41p	42p	43p	44p	45p	⁴⁶ P
	²² Si	²³ Si	²⁴ Si	²⁵ Si	²⁶ Si	²⁷ Si	²⁸ Si	²⁹ Si	³⁰ Si	³¹ Si	³² Si	³³ Si	³⁴ Si	³⁵ Si	³⁶ Si	³⁷ Si	³⁸ Si	³⁹ Si	⁴⁰ Si	⁴¹ Si	⁴² Si	⁴³ Si	⁴⁴ Si	
		²² AI	²³ AI	²⁴ AI	²⁵ AI	²⁶ AI	²⁷ AI	²⁸ AI	²⁹ AI	³⁰ AI	³¹ AI	³² AI	³³ AI	³⁴ AI	³⁵ AI	³⁶ AI	³⁷ AI	³⁸ AI	³⁹ AI	⁴⁰ AI	⁴¹ AI	⁴² AI	⁴³ AI	
	²⁰ Mg	²¹ Mg	²² Mg	²³ Mg	²⁴ Mg	²⁵ Mg	²⁶ Mg	²⁷ Mg	²⁸ Mg	²⁹ Mg	³⁰ Mg	³¹ Mg	³² Mg	³³ Mg	³⁴ Mg	³⁵ Mg	³⁶ Mg	³⁷ Mg	³⁸ Mg		⁴⁰ Mg			
		²⁰ Na	²¹ Na	²² Na	²³ Na	²⁴ Na	²⁵ Na	²⁶ Na	27 _{Na}	²⁸ Na	²⁹ Na	³⁰ Na	³¹ Na	³² Na	³³ Na	³⁴ Na	³⁵ Na		³⁷ Na					
¹⁷ Ne	¹⁸ Ne	¹⁹ Ne	²⁰ Ne	²¹ Ne	²² Ne	²³ Ne	²⁴ Ne	²⁵ Ne	²⁶ Ne	²⁷ Ne	²⁸ Ne	²⁹ Ne	³⁰ Ne	³¹ Ne	³² Ne		³⁴ Ne							
	17 _F	18 _F	19F	20F	21F	22F	23F	24F	²⁵ F	²⁶ F	27F		29F		31F									
¹⁵ O	¹⁶ O	170	180	19 ₀	²⁰ O	21 ₀	22 ₀	23 <mark>0</mark>	24 ₀		1	l												
¹⁴ N	¹⁵ N	¹⁶ N	42.	18 _N	19 _N	20 _N	21 _N	22 _N	²³ N															
13C	¹⁴ C	15C	¹⁶ C	17C	18C	19C	20C		22 _C															
12 _B	13 _B	14 _B	15B		17B		19B																	

С

Possible primary beams for the production of neutron rich secondary beams

												40 Sc	41Sc	42Sc	⁴³ Sc	⁴⁴Sc	⁴⁵Sc	46 Sc	4/Sc	48 Sc	49 Sc	50 Sc	51 Sc	52Sc
									³⁶ Ca	³⁷ Ca	³⁸ Ca	³⁹ Ca	⁴⁰ Ca	⁴¹ Ca	⁴² Ca	⁴³ Ca	⁴⁴ Ca	⁴⁵ Ca	⁴⁶ Ca	⁴⁷ Ca	⁴⁸ Ca	49C	^J ℃a	51 a
									³⁵ K	³⁶ K	³⁷ K	³⁸ K	³⁹ K	⁴⁰ K	⁴¹ K	⁴² K	⁴³ K	⁴⁴ K	⁴⁵ K	⁴⁶ K	47-	⊀	⁴⁹ K	чк
						³¹ Ar	³² Ar	³³ Ar	³⁴ Ar	³⁵ Ar	³⁶ Ar	³⁷ Ar	³⁸ Ar	³⁹ Ar	⁴⁰ Ar	⁴¹ Ar	⁴² Ar	⁴³ Ar	44.24	⁴⁵ Ar	⁴⁶ Ar	⁴⁷ Ar	48A	⁴⁹ Ar
							³¹ CI	³² CI	³³ CI	³⁴ CI	³⁵ CI	³⁶ CI	³⁷ CI	³⁸ CI	³⁹ CI	•ªCI	⁴¹ CI	42CI	⁴³ CI	⁴⁴ CI	⁴⁵ CI	46.7	47CI	⁴⁸ CI
				27 S	28 S	29 S	³⁰ S	³¹ S	32 S	33 S	34 S	³⁵ S	36 S	³⁷ S	38 S	³⁹ S	⁴⁰ S		42 S	43 S	44S	⁴⁵ S	⁴⁶ S	47 S
				26p	27p	28p	29p	30p	31p	32p	33p	34p		30				⁴⁰ P	41p	42p	43p	44p	45p	46p
	²² Si	²³ Si	²⁴ Si	²⁵ Si	²⁶ Si	27 Si	²⁸ Si	²⁹ Si	³⁰ Si	³¹ Si	³² Si	³³ Si	³⁴ Si	³⁵ Si	³⁶ Si	³⁷ Si	³⁸ Si	JUSI	⁴⁰ Si	⁴¹ Si	⁴² Si	⁴³ Si	⁴⁴ Si	
		²² AI	²³ AI	²⁴ AI	²⁵ AI	²⁶ AI	27AI	²⁸ AI	²⁹ AI	³⁰ AI	³¹ AI	³² AI	³³ AI	³⁴ AI	³⁵ AI	36.1	³⁷ AI	³⁸ AI	³⁹ AI	⁴⁰ AI	⁴¹ AI	⁴² AI	⁴³ AI	
	²⁰ Mg	²¹ Mg	²² Mg	²³ Mg	²⁴ Mg	²⁵ Mg	²⁶ Mg	27Mg	²⁸ M	²⁹ Mg	³⁰ Mg	³¹ Mg	³² Mg	³³ Mg	³⁴ Mg	³⁵ Mg	³⁶ Mg	³⁷ Mg	³⁸ Mg		⁴⁰ Mg			
		²⁰ Na	²¹ Na	22 _{Na}	²³ Na	²⁴ Na	²⁵ Na	26) a	²⁷ Na	²⁸ Na	²⁹ Na	³⁰ Na	³¹ Na	³² Na	³³ Na	³⁴ Na	³⁵ Na		³⁷ Na					
¹⁷ Ne	¹⁸ Ne	¹⁹ Ne	²⁰ Ne	²¹ Ne	²² Ne	²³ Ne	2411-2	²⁵ Ne		²⁷ Ne	²⁸ Ne	291-8	³⁰ Ne	³¹ Ne	³² Ne		³⁴ Ne							
	17 _E	18F	¹⁹ F	20F	21 _F	22-	23F			26F	27F		29F		³¹ F									
¹⁵ O	¹⁶ O	170	180	¹⁹ 0	-0	²¹ 0	22 ₀	²³ O	-0															
¹⁴ N	¹⁵ N	¹⁶ N	47	18 _N	¹⁹ N		21 _N	²² N	²³ N															
¹³ C	14 _C	¹⁵ C		17C			²⁰ C		²² C															
12 _B	13B	14B	¹⁵ B		17B		19B																	

С

Possible primary beams for the production of neutron rich secondary beams

												40 Sc	⁴¹ Sc	⁴² Sc	⁴³ Sc	44 Sc	45 Sc	46 Sc	4′Sc	48 Sc	49 Sc	⁵⁰ Sc	51 SC	⁵² Sc	
									³⁶ Ca	³⁷ Ca	³⁸ Ca	³⁹ Ca	⁴⁰ Ca	⁴¹ Ca	⁴² Ca	⁴³ Ca	⁴⁴ Ca	⁴⁵ Ca	⁴⁶ Ca	47Ca	⁴⁸ Ca	⁴⁹ C7	∾Ca	51 a	
									³⁵ K	³⁶ K	³⁷ K	³⁸ K	³⁹ K	⁴⁰ K	⁴¹ K	⁴² K	⁴³ K	⁴⁴ K	⁴⁵ K	⁴⁶ K		К	⁴⁹ K	чк	
						³¹ Ar	³² Ar	³³ Ar	³⁴ Ar	³⁵ Ar	³⁶ Ar	³⁷ Ar	³⁸ Ar	³⁹ Ar	⁴⁰ Ar	⁴¹ Ar	⁴² Ar	⁴³ Ar	44.2	⁴⁵ Ar	⁴⁶ Ar	⁴⁷ Ar	48 _A	⁴⁹ Ar	
							³¹ CI	32CI	³³ CI	³⁴ CI	³⁵ CI	³⁶ CI	³⁷ CI	³⁸ CI	³⁹ CI	۳CI	⁴¹ CI	⁴² CI	⁴³ CI	⁴⁴ CI	⁴⁵ CI	460	47CI	⁴⁸ CI	
				27 S	²⁸ S	29 S	³⁰ S	31S	32 S	33 S	34S	³⁵ S	36 S	³⁷ S	38 S	³⁹ S	⁴⁰ S		42 S	43 S	44 S	⁴⁵ S	46 S	47 S	
				26p	27p	28p	²⁹ P	30p	31p	³² P	33p	34p		30				⁴⁰ P	41p	42p	43p	44p	45p	⁴⁶ P	
	²² Si	²³ Si	²⁴ Si	²⁵ Si	²⁶ Si	²⁷ Si	²⁸ Si	²⁹ Si	³⁰ Si	³¹ Si	³² Si	³³ Si	³⁴ Si	³⁵ Si	³⁶ Si	³⁷ Si	³⁸ Si	^{JU} Si	⁴⁰ Si	⁴¹ Si	⁴² Si	⁴³ Si	⁴⁴ Si		
		²² AI	²³ AI	²⁴ AI	²⁵ AI	²⁶ AI	27AI	²⁸ AI	²⁹ AI	³⁰ AI	31 _{AI}	³² AI	³³ AI	³⁴ AI	³⁵ AI	36	³⁷ AI	³⁸ AI	³⁹ AI	⁴⁰ AI	⁴¹ AI	⁴² AI	⁴³ AI		
	²⁰ Mg	²¹ Mg	²² Mg	²³ Mg	²⁴ Mg	²⁵ Mg	²⁶ Mg	²⁷ Mg	28M	²⁹ Mg	³⁰ Mg	³¹ Mg	³² Mg	³³ Mg	³⁴ Mg	³⁵ Mg	³⁶ Mg	³⁷ Mg	³⁸ Mg		⁴⁰ Mg				
		²⁰ Na	21 _{Na}	²² Na	²³ Na	²⁴ Na	²⁵ Na	26) a	²⁷ Na	²⁸ Na	²⁹ Na	³⁰ Na	³¹ Na	³² Na		LISE @0°									
¹⁷ Ne	¹⁸ Ne	¹⁹ Ne	²⁰ Ne	²¹ Ne	²² Ne	²³ Ne	24N'e	²⁵ Ne		²⁷ Ne	²⁸ Ne	2911-2	³⁰ Ne	³¹ Ne		³⁰ S & ¹⁸ O primary beams									
	17F	18F	¹⁹ F	20F	21F	22-	23F			26F	27F		29F			→ Production cross-section									
¹⁵ O	¹⁶ O	170	180	¹⁹ 0	-0	21 ₀	22 ₀	²³ 0	0							→ (iye:	Slalt		stribt	ποι	I		
¹⁴ N	¹⁵ N	¹⁶ N	-11-	¹⁸ N			21 _N	22 _N	²³ N																
13C	14C	15C		17 _C	¹⁸ C	/	20C		22 _C																
12 _B	¹³ B	14B	¹⁵ B	/	17B		¹⁹ B			_															

С

В

Deep inelastic measurement @ LISE in 2015 ¹⁸O 8.5 MeV/A beam

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