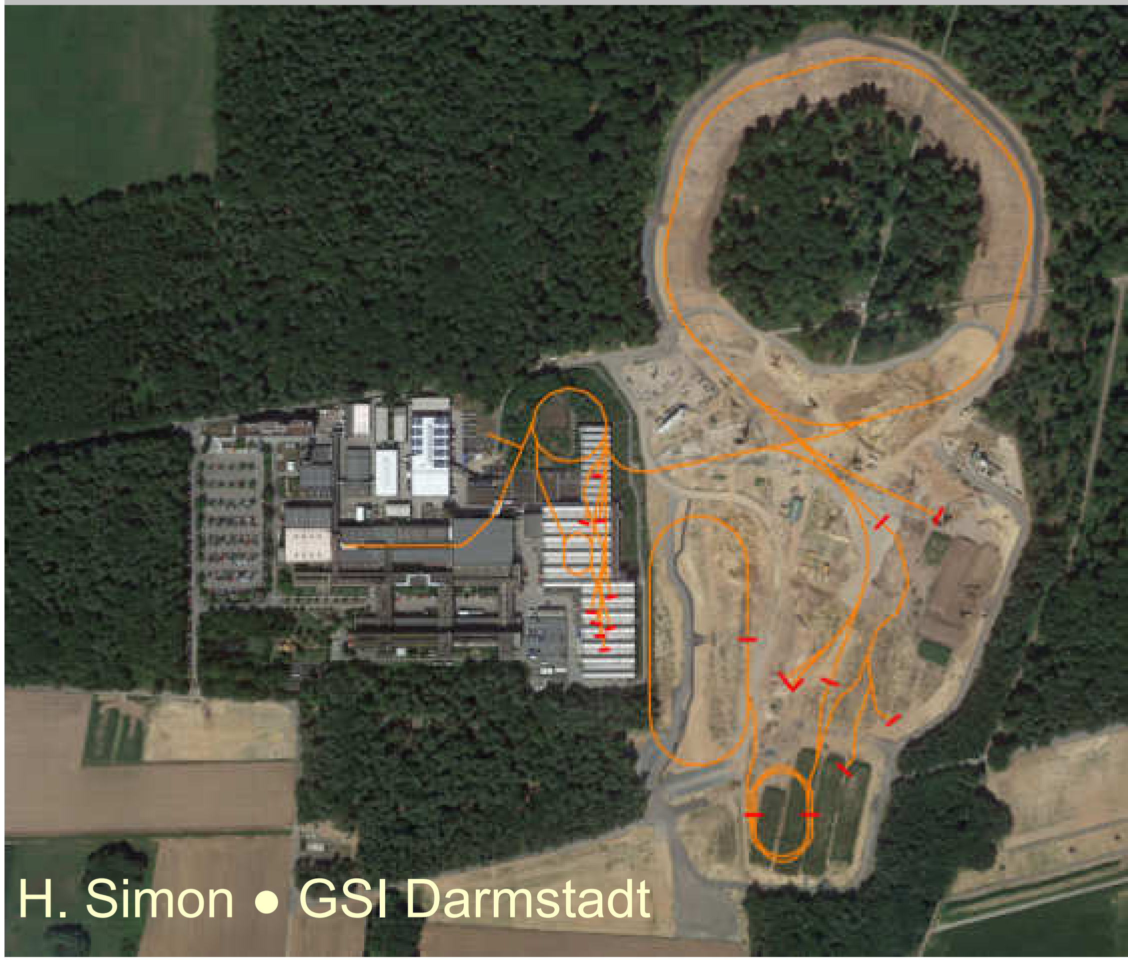
Nuclear reactions with relativistic Nuclei
- Example: Oxygen isotopes

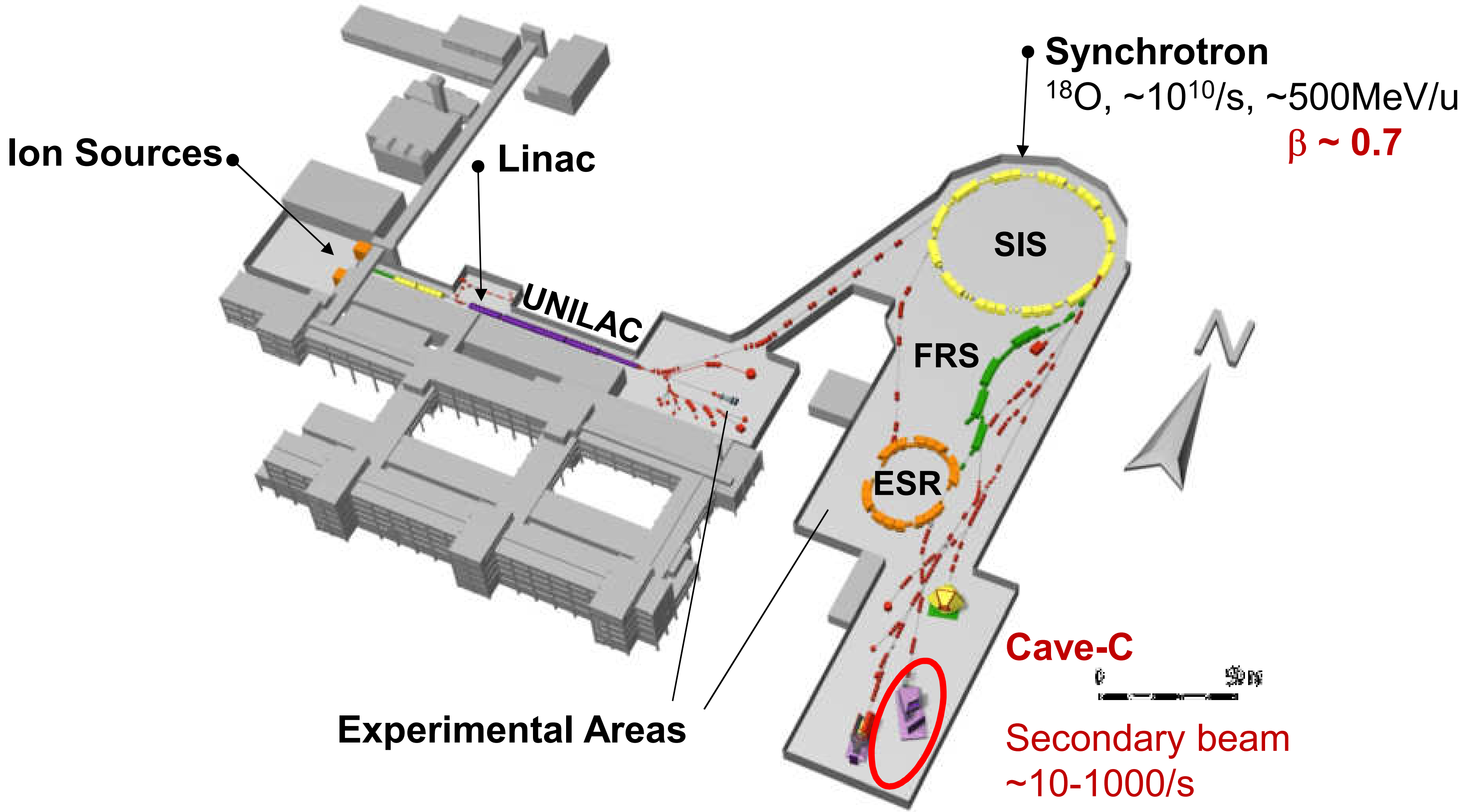
See also: Marios talk



H. Simon ● GSI Darmstadt

Recent advances and challenges in the decription of nuclear reactions at the limit of stability, Trento, ECT* 20180305-09

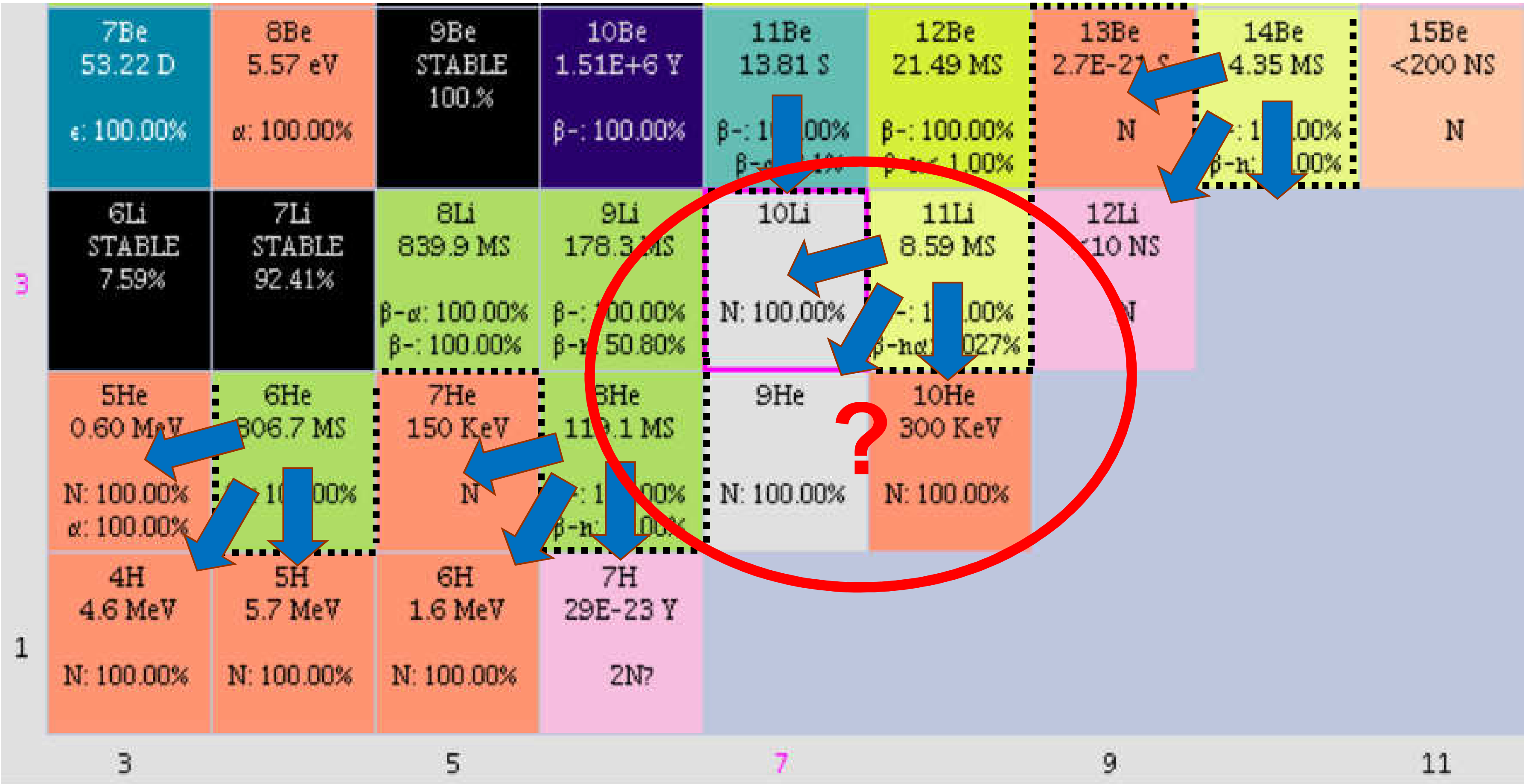
Current GSI accelerator facility …



Secondary beam
~10-1000/s
➔ 0.1 – 10/s after reaction

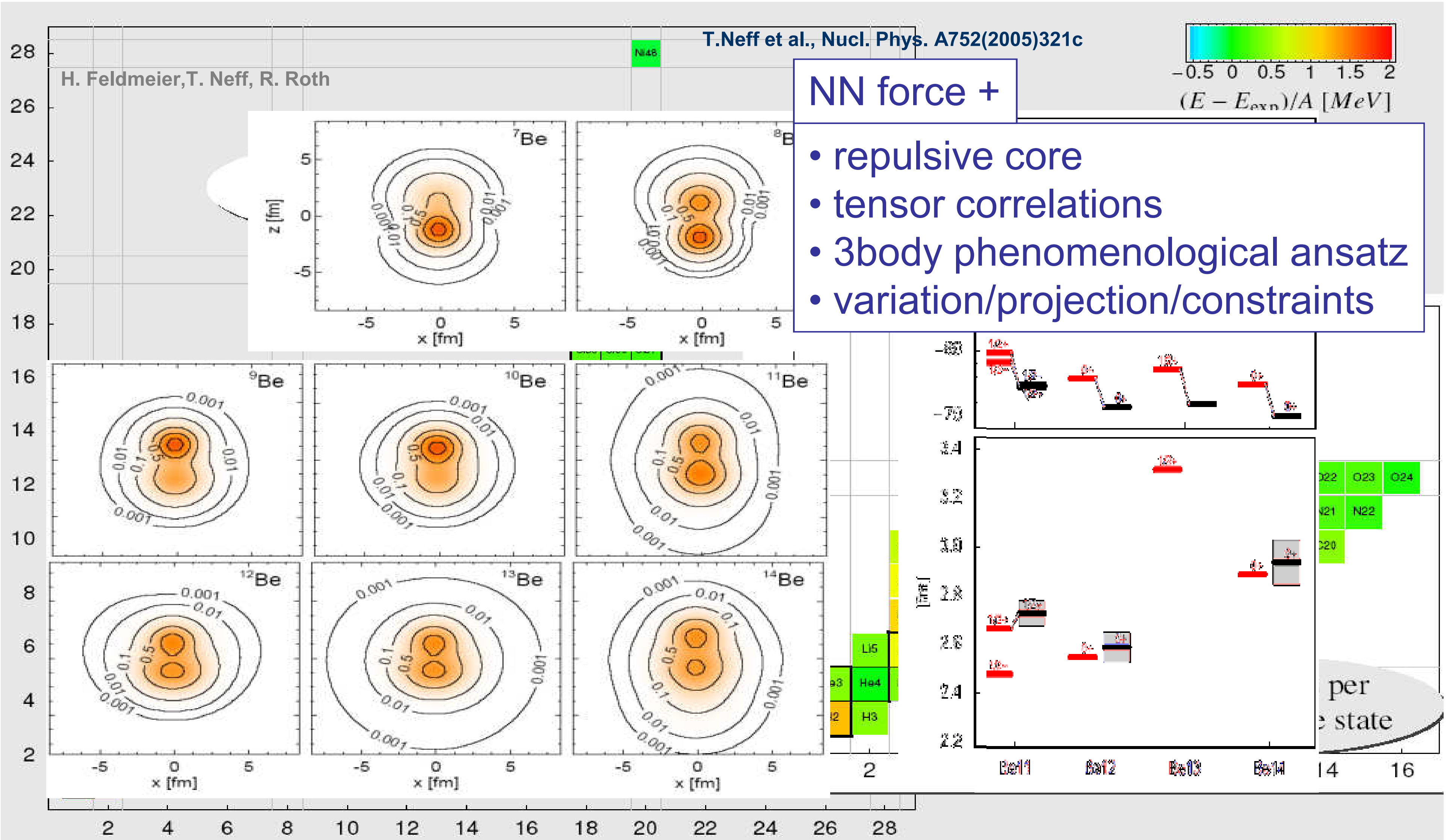
Going Neutron rich …

P.G. Hansen, Nature 328 (1987) 476



^{11}Li with „known“ structure ➔ initial vs. final state
Influence of reaction mechanism ➔ different seed nuclei

Clustering: FMD and AV18/UCOM

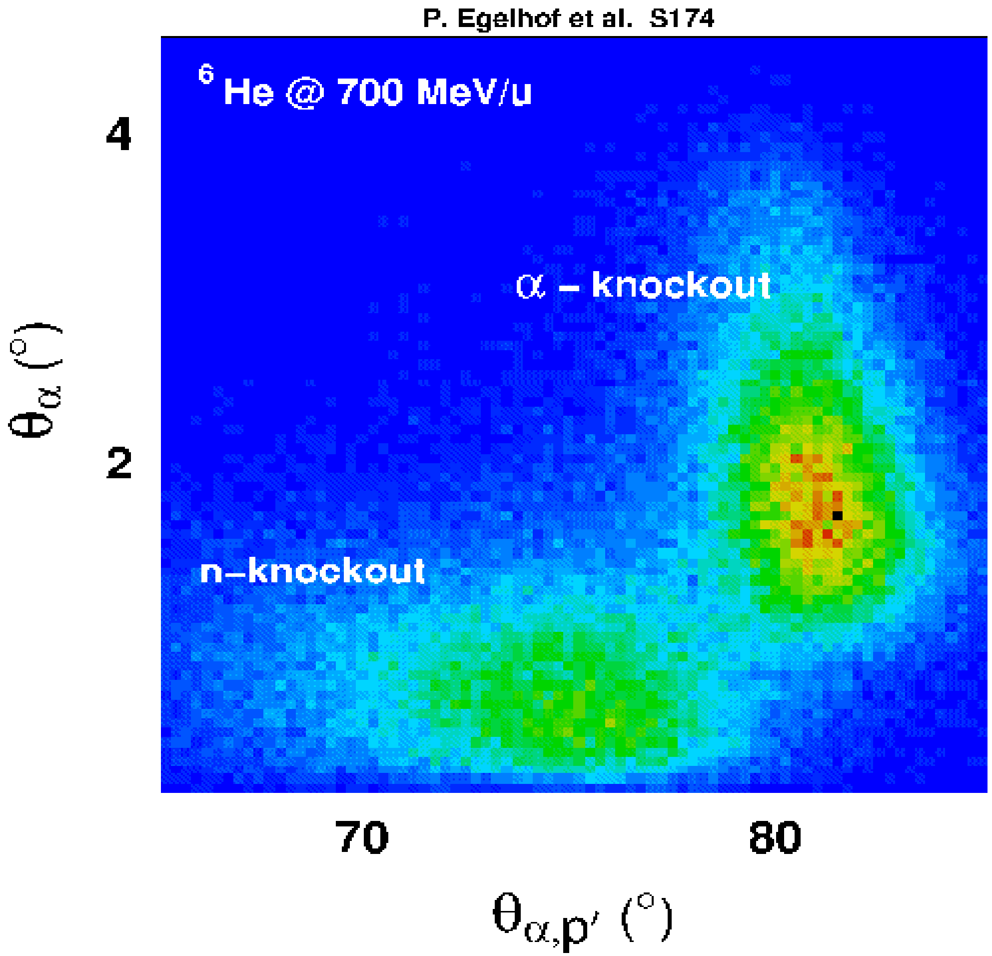


NN force +

- repulsive core
- tensor correlations
- 3body phenomenological ansatz
- variation/projection/constraints

Reactions with target recoil detection

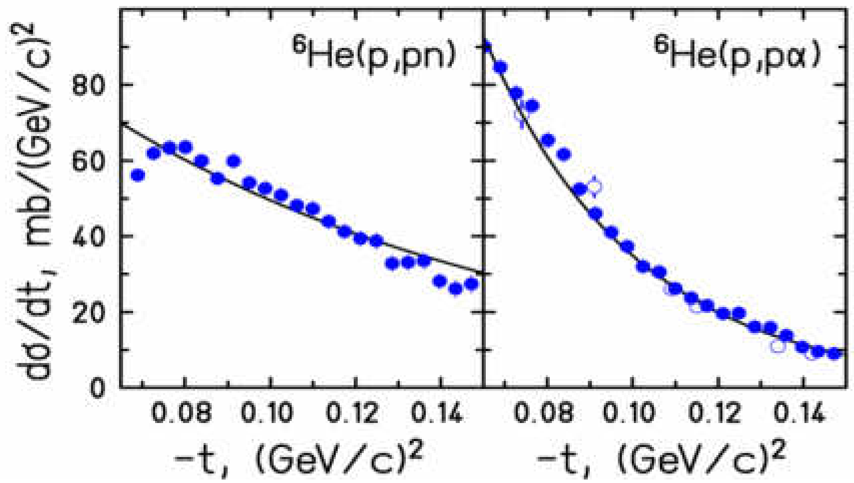
Liquid. hydrogen target:
p(^{6}He,x p')



Very simple system:

Direct observation of
kinematical correlations ➔

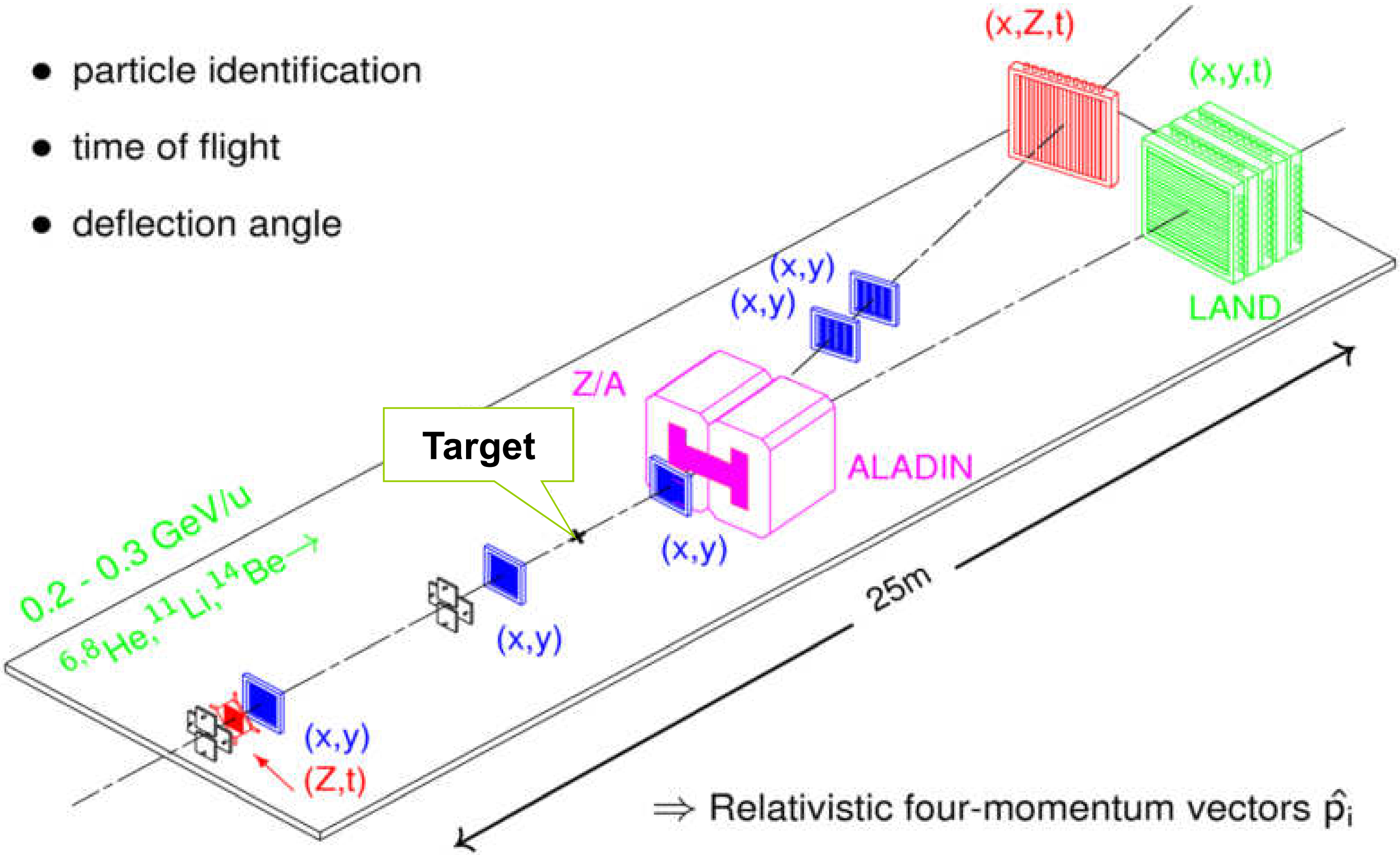
(Cluster) spectroscopic factors ?
Clean production: 4n ,^{7}H, ...



L.V. Chulkov et al., Nucl. Phys. **A759**(2005)43

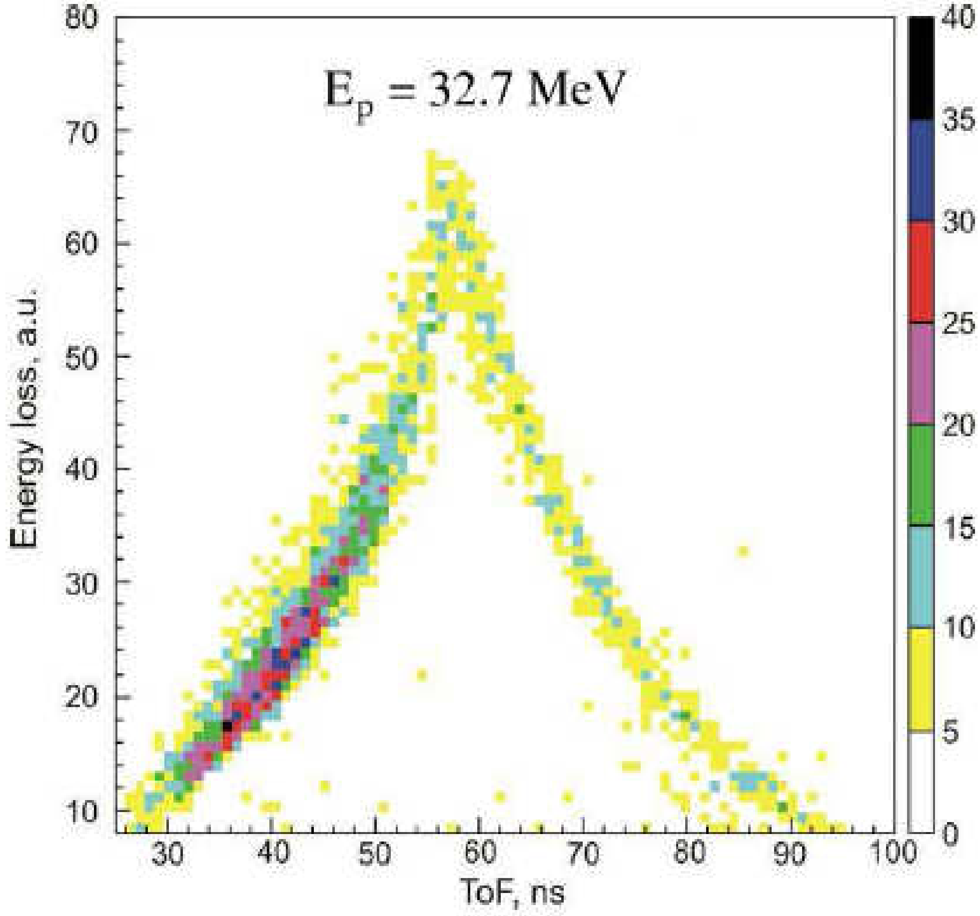
Experimental Setup (kinematically complete, -2005)

- particle identification
- time of flight
- deflection angle



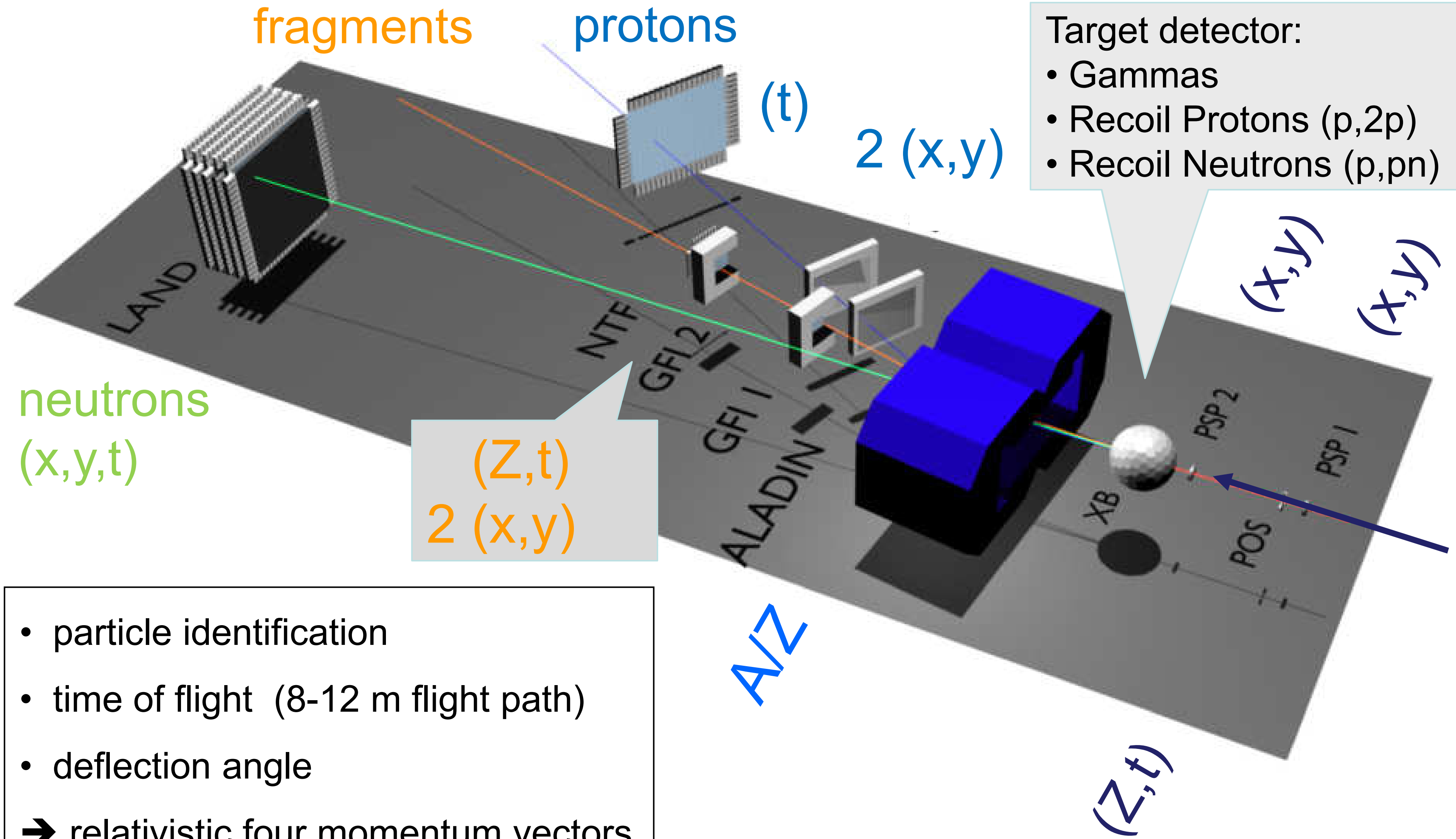
⇒ Relativistic four-momentum vectors $\hat{p}_i$

Experimental Setup
(initial version of proton recoil detection)



First attempt for an ALADiN/LAND experiment 2001…

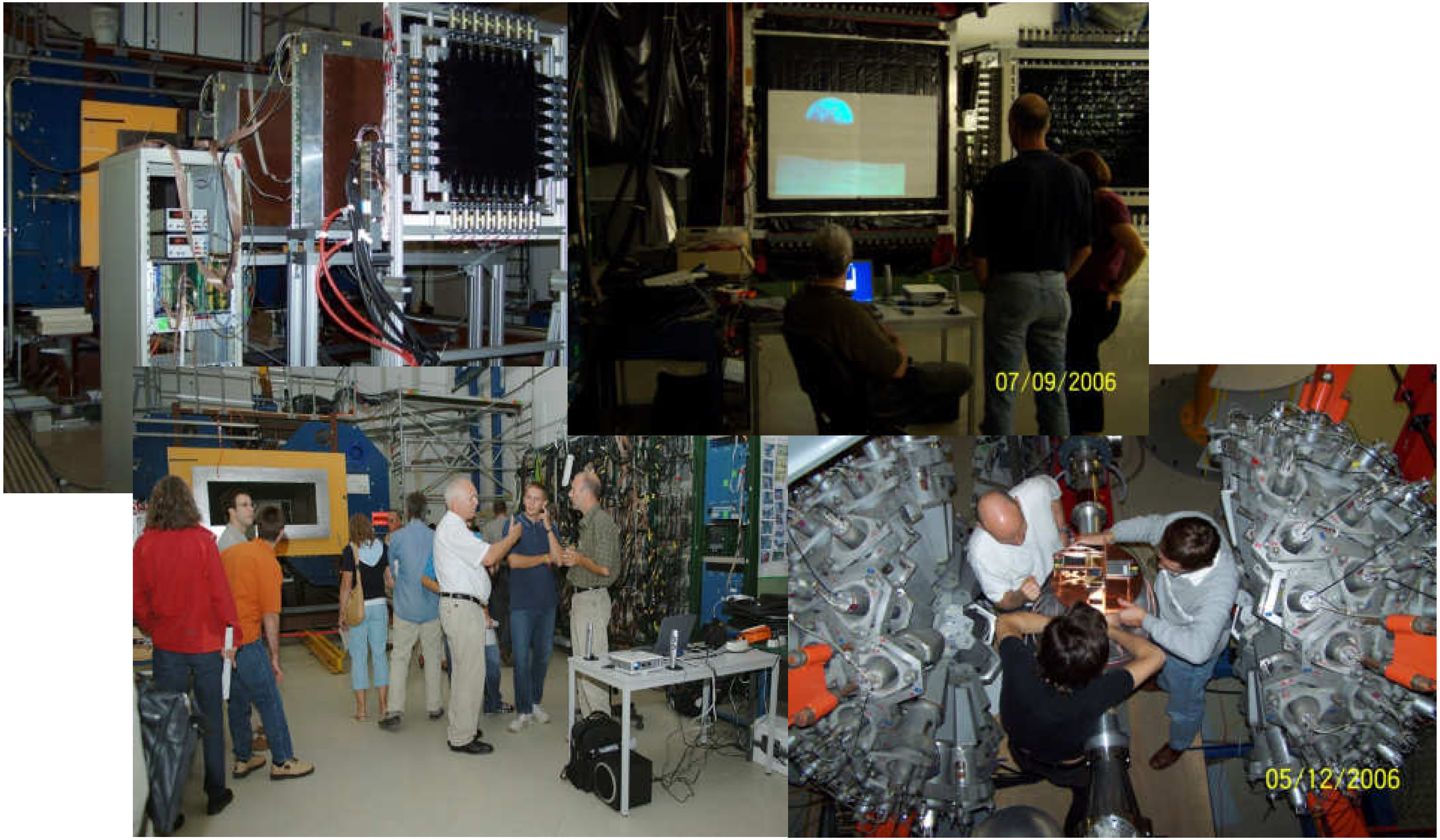
R³B/LAND Setup
(kinematically complete & recoil detection)



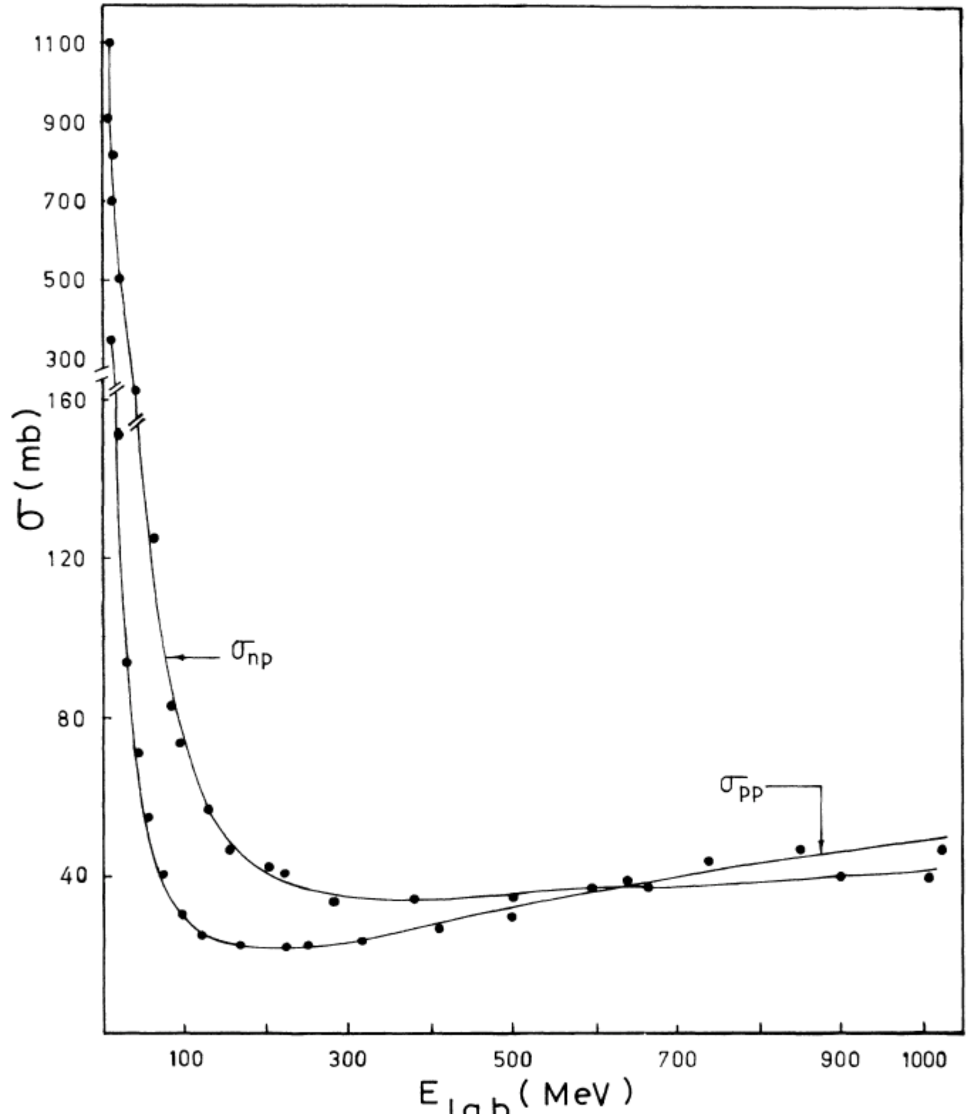
- particle identification
- time of flight (8-12 m flight path)
- deflection angle

➔ relativistic four momentum vectors

Experimental Setup (less schematic)



Nucleon-Nucleon Cross Section vs Beam Energy



S.K. Charagi, S.K. Gupta Phys. Rev. C 41, 4 (1990)

PHYSICAL REVIEW C **88**, 064610 (2013)

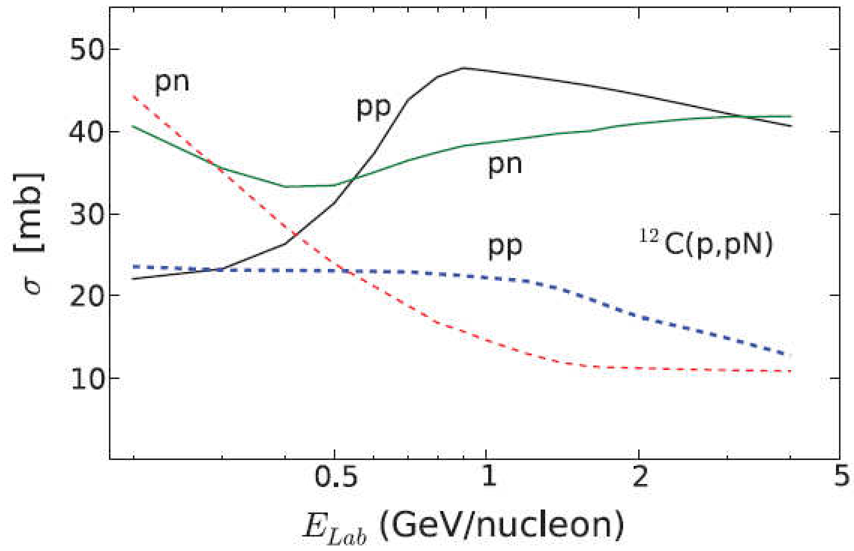


FIG. 4. (Color online) Free *p*-*p* and *p*-*n* *total* cross sections (solid curves) as compared to the constrained angle averaged *elastic* *p*-*p* and *p*-*n* cross sections (dashed curves) according to Eq. (35) and for ^{12}C(p, pN), with $N = p$ or n.

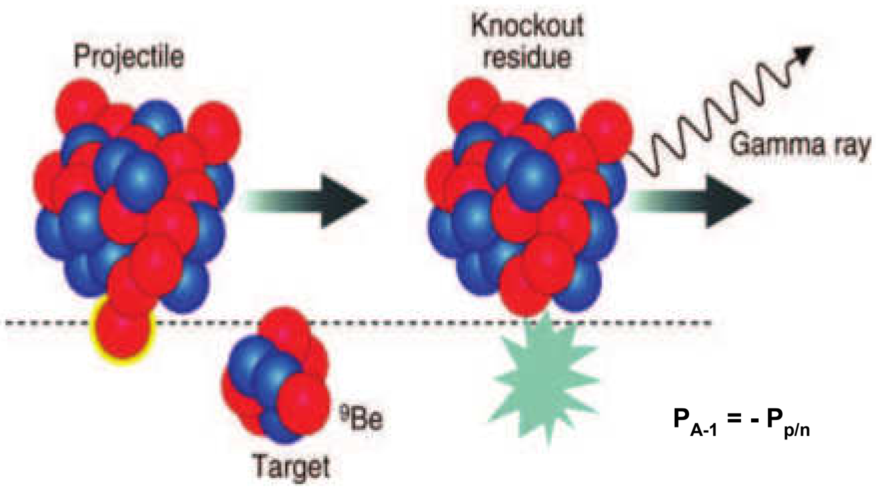
T. Aumann, C.A. Bertulani, J. Ryckebusch

Knockout Reactions vs. Quasi-free Scattering (QFS)

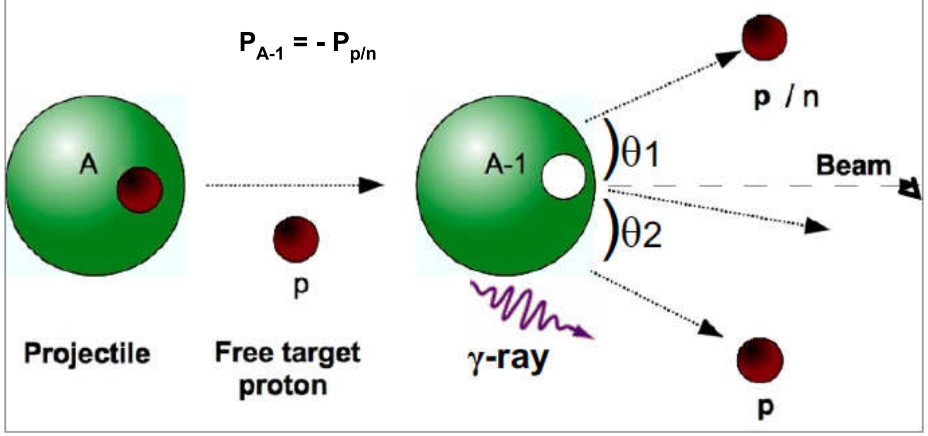
One-nucleon Knockout Reaction

- on light nuclear targets (e.g. Be, C)
- Intermediate beam energy ~ 100MeV/u
- eikonal & sudden approximations
- strong absorption → surface localized

A. Gade et al. PNP 60(1):161-224,2008



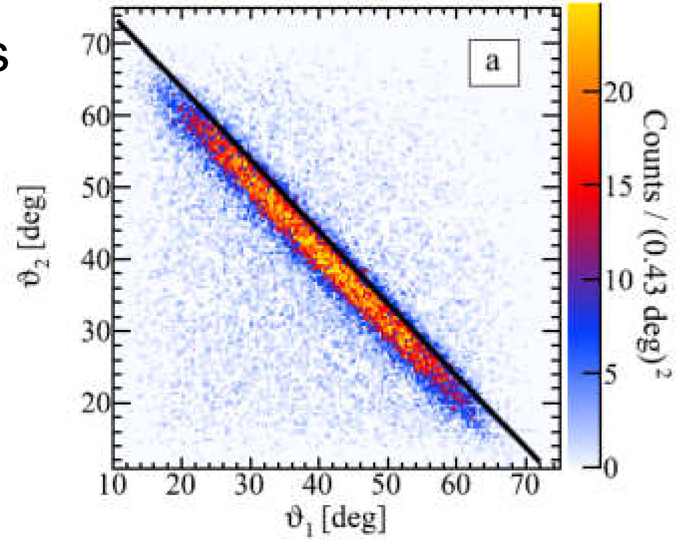
Quasi-free Knockout Reaction

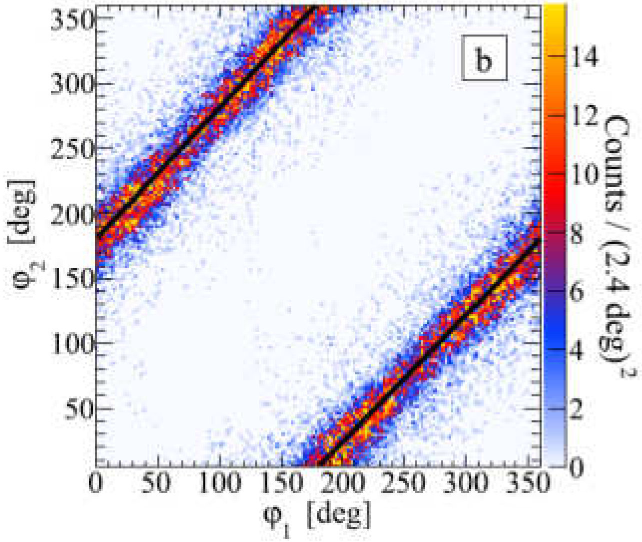


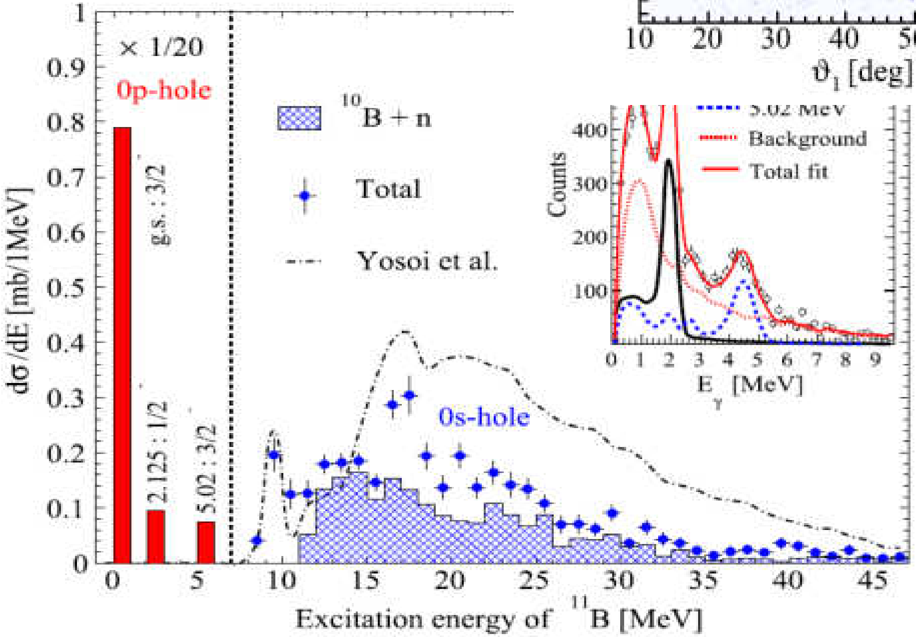
- proton target → quasi-free NN reaction
→ more sensitivity to deeply bound states
- Relativistic energies (0.2-1 GeV/u)
→ sudden approximation:
fast reaction (10^{-23} s) and spectator core
→ weaker absorption in nucleus
→ free NN cross section is min (~300 MeV)
- eikonal approximation
momentum of residue corresponds to momentum of knocked nucleon

First attempt: 12C(p,2p)

QFS kinematics







E* in ^{11}B (bound/unbound)

PLB 753 (2016) 204

Contents lists available at ScienceDirect

Physics Letters B

www.elsevier.com/locate/physletb

Exclusive measurements of quasi-free proton scattering reactions in inverse and complete kinematics

V. Panin[a,*], J.T. Taylor[b], S. Paschalis[a], F. Wamers[a,c], Y. Aksyutina[c], H. Alvarez-Pol[d],

Single-Particle Strength

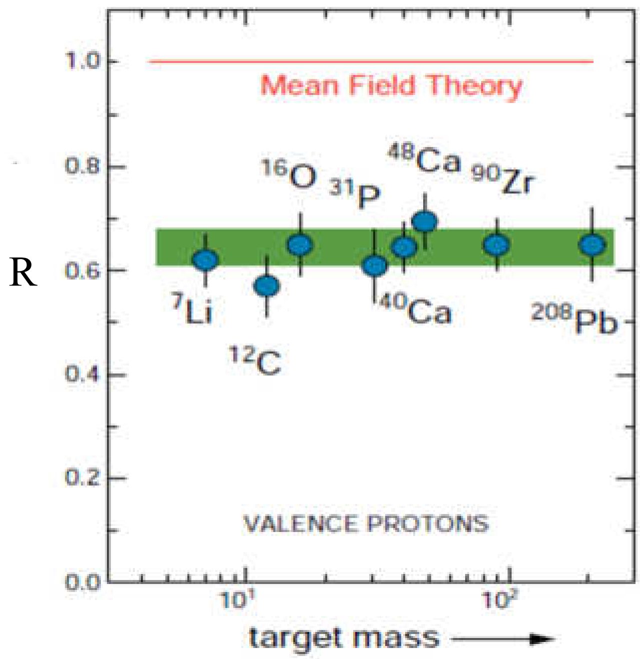
Independent Particle Model (IPM): Nucleons are single particles moving independently in a mean field created by all nucleons.

(e,e'p) reactions at NIKHEF

- **Reduction factor**

  $R = \sigma_{exp}/\sigma_{IPM}$

  relative to the IPM!



- 30-40% deviation of the single-particle strength relative to the IPM

- **Correlations:** not included in the IPM such as short-range and tensor, long-range

→ configuration mixing
→ high momenta

H. Dickhoff, C. Barbieri Prog. Nucl. Phys. 52, 377 (2004)

NIKHEF data: L. Lapikas Nucl. Phys. A553, 297c (1993)

- NIKHEF data is limited to stable nuclei and valence proton states.

Quenching of Single-Particle Strength

- Latest compilation including exotic nuclei from (e,e'p), proton and neutron removal reactions

- Isospin dependency of single-particle strength in asymmetric systems?

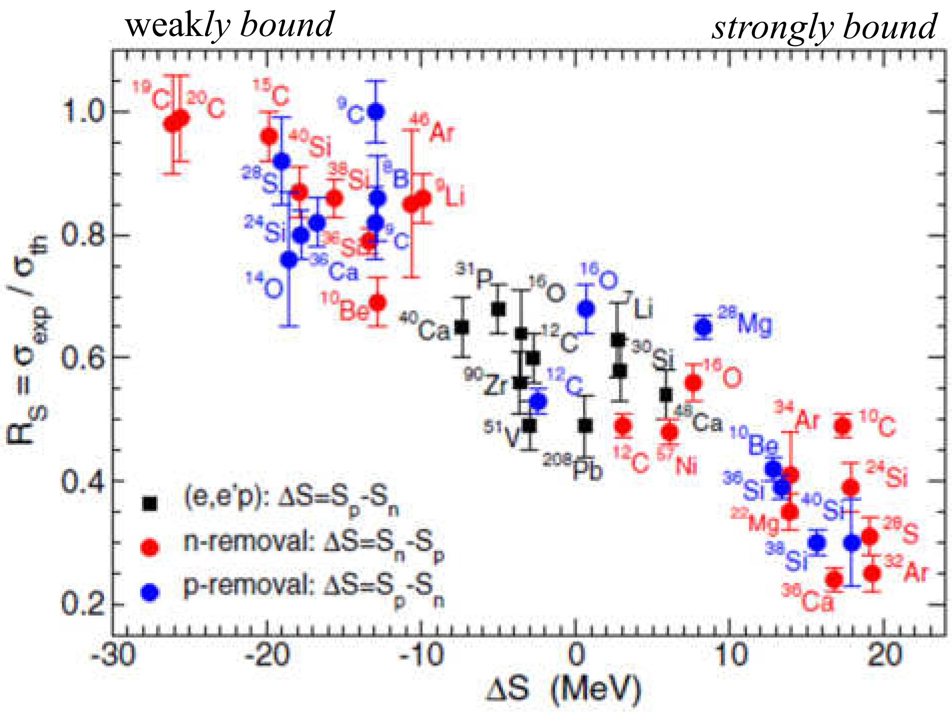
Quenching of single-particle strength in strongly bound states?

→ origin unclear

- Nucleon removal reactions with exotic beams at intermediate energies are limited to surface localized reactions

→ Reaction model?
→ Missing correlations in SM?

One-nucleon knockout reactions at intermediate energies



J.A.Tostevin, A. Gade Phys. Rev. C 90, 057602 (2014)

Reduction factor relative to a certain Shell Model (SM):

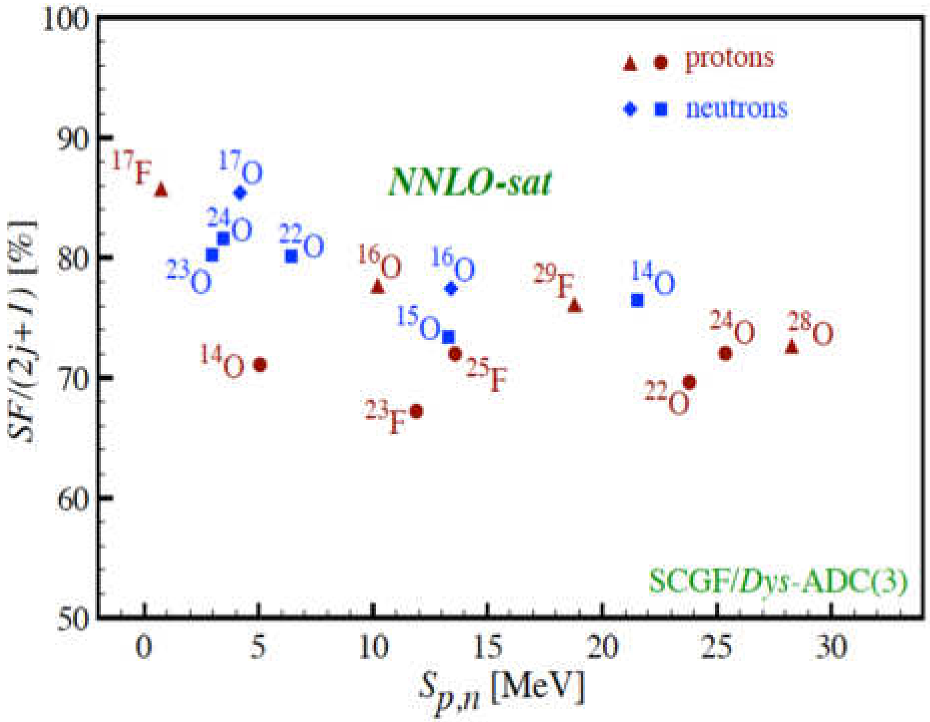
$R_s = \sigma_{exp} / \sigma_{SM}$

correlations are partially included!

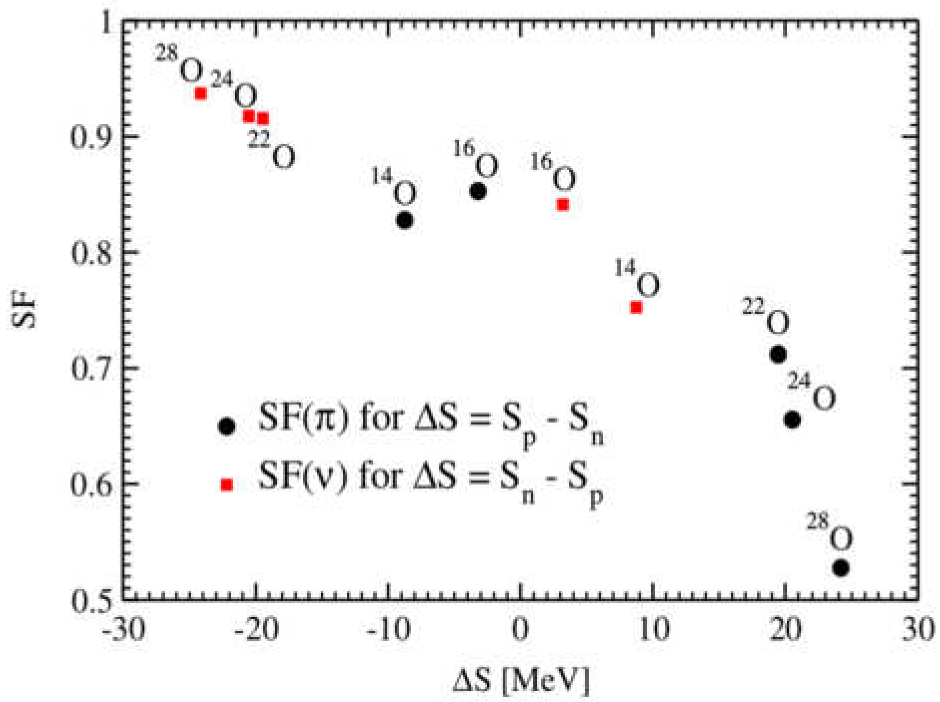
Ab-initio Theory: Weak Dependence

- Self Consistent Green Function (SCGF) with chiral NNLO-sat interactions
- weak ΔS dependence from 0.6 to 0.9

- Coupled-cluster calculations with N2LO NN
- weak ΔS dependence with further decrease at the dripline due to coupling to continuum



C. Barbieri, private communication (July/2016).

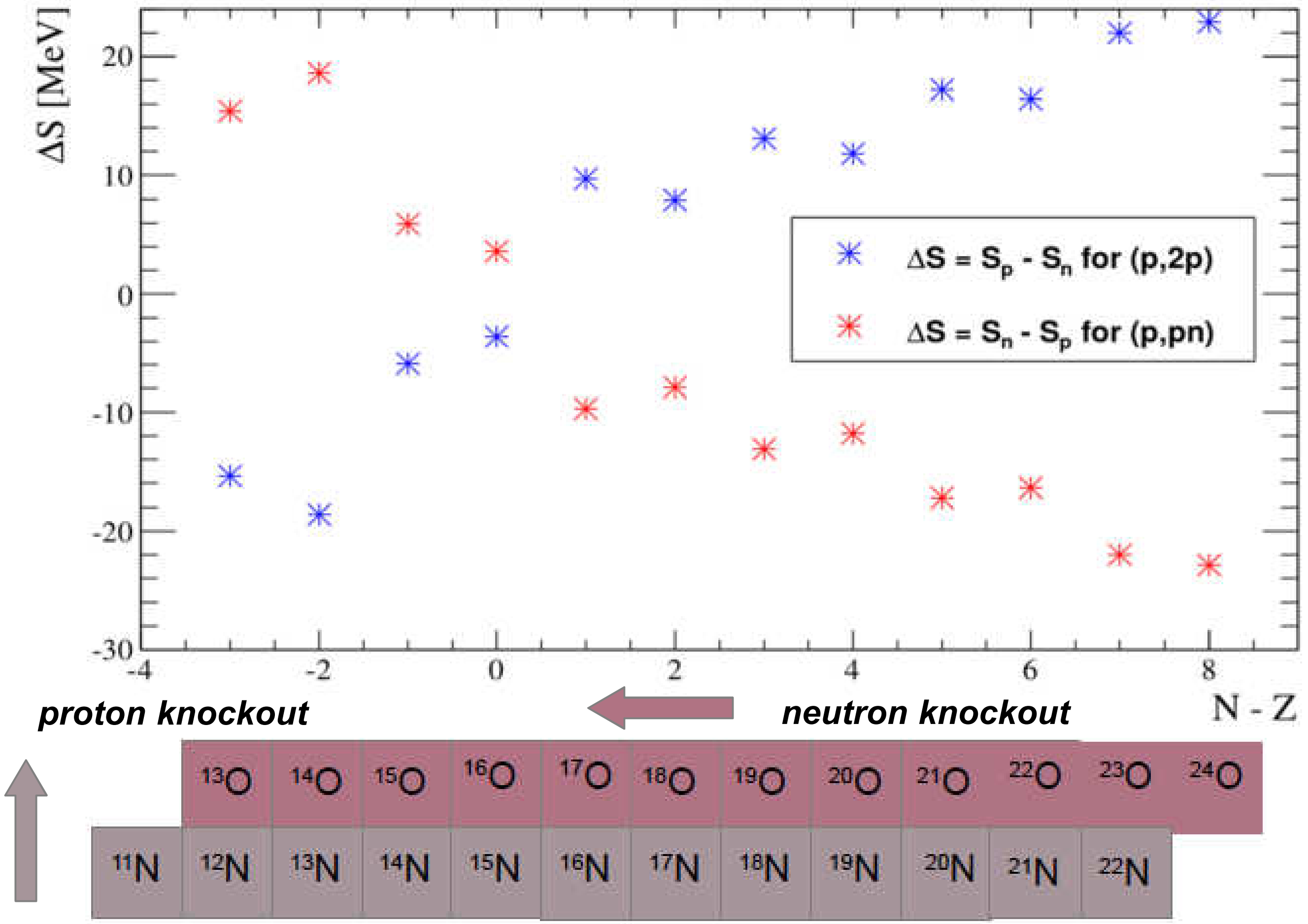


Jensen et al. Phys. Rev. Lett. 107, 032501 (2011)

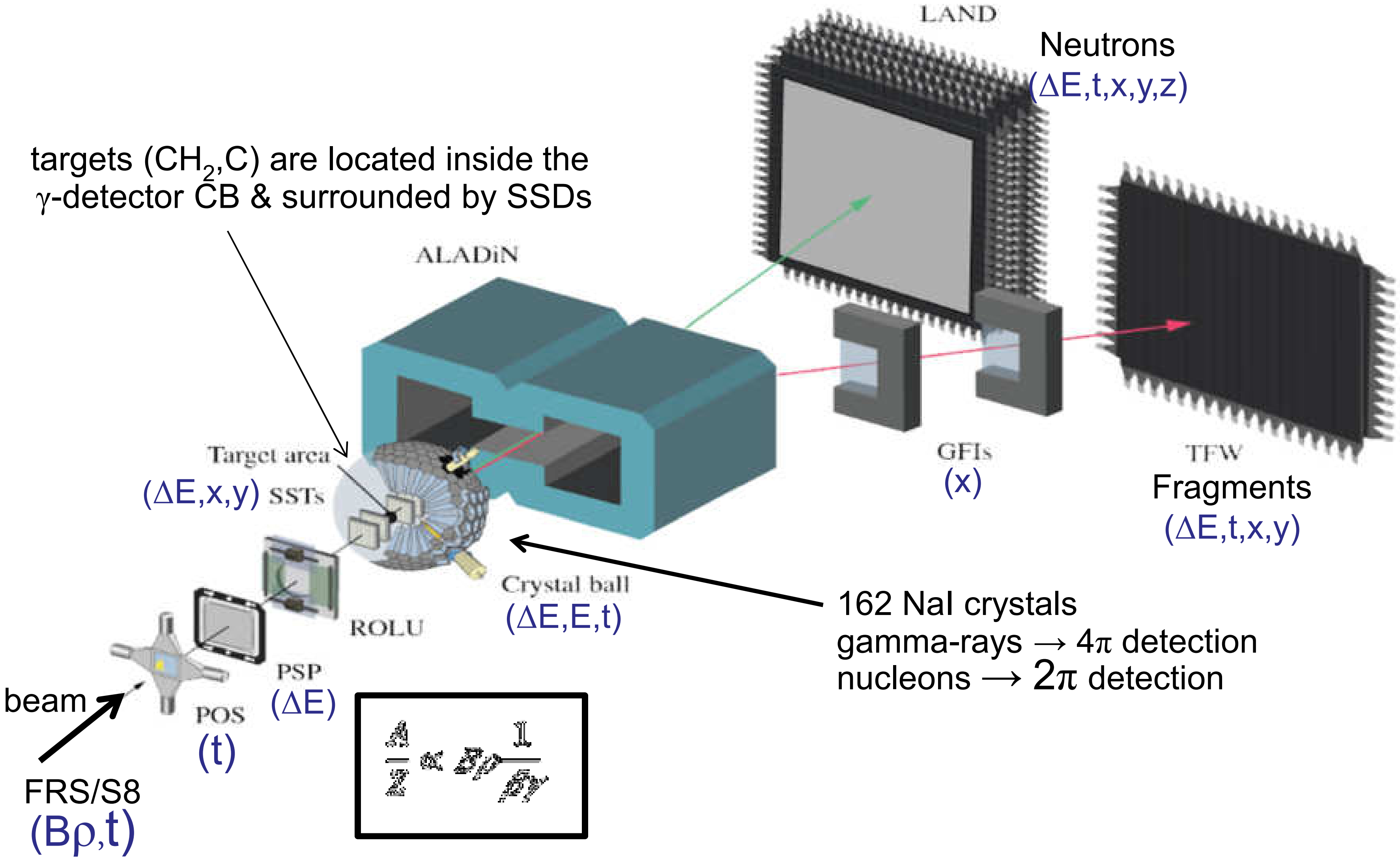
Disagreement with knockout experiments at intermediate energies analyzed with eikonal theory!

Oxygen Isotopic Chain

- Changing of single-particle strength with proton-neutron asymmetry
- Oxygen isotopic chain offers a large variation in isospin
- Systematic study of Oxygen isotopes via quasi-free (p,pn) & (p,2p) reactions



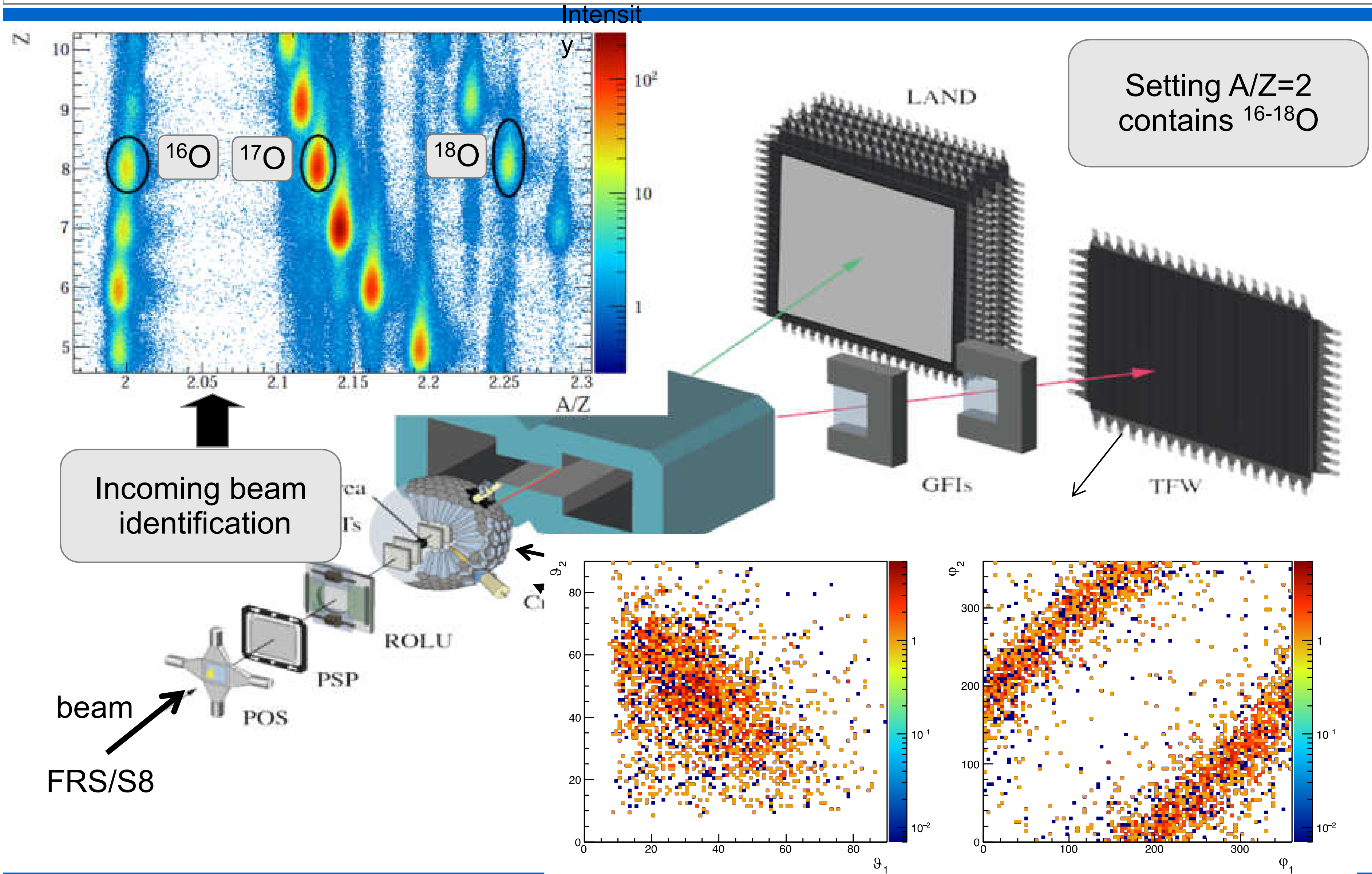
S393 Experiment at R³B/LAND Setup @ GSI



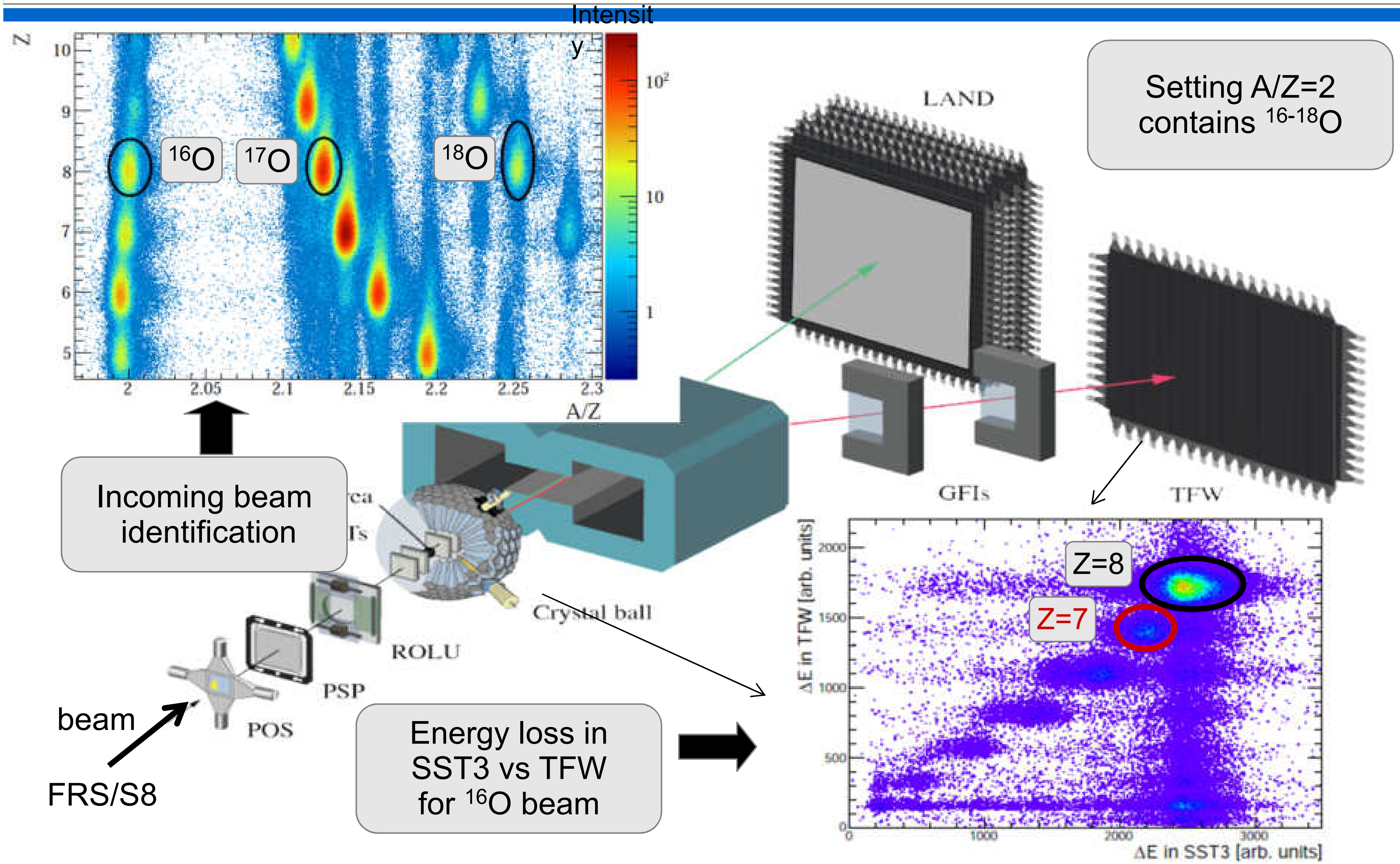
$$\frac{A}{Z} \propto B\rho \frac{1}{\beta\gamma}$$

Picture taken from S. Altstadt

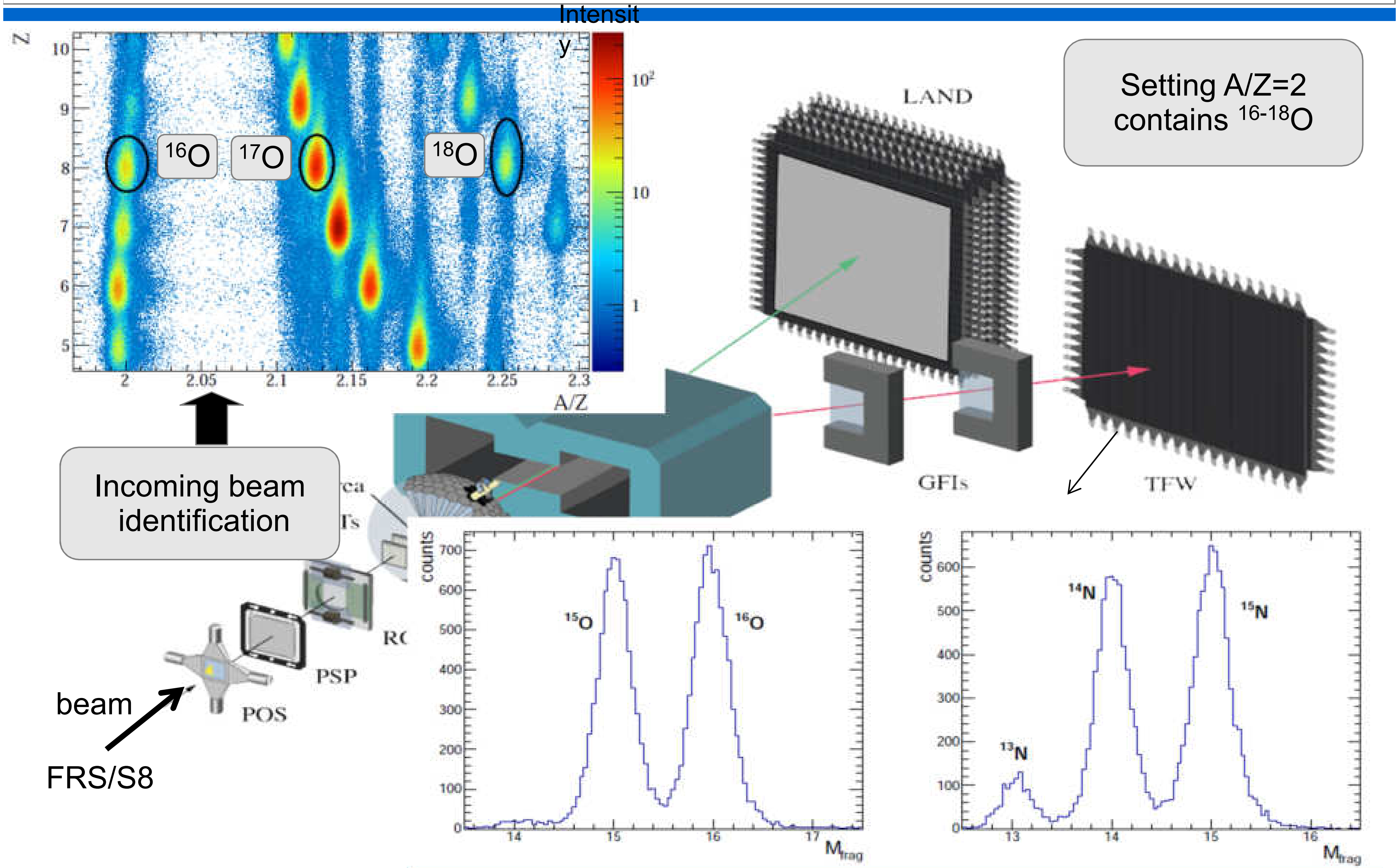
Incoming Beam & Outgoing Fragment Identification

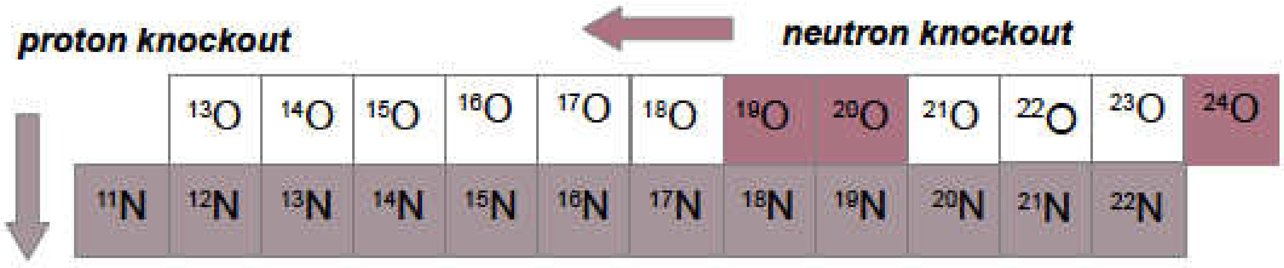


Incoming Beam & Outgoing Fragment Identification



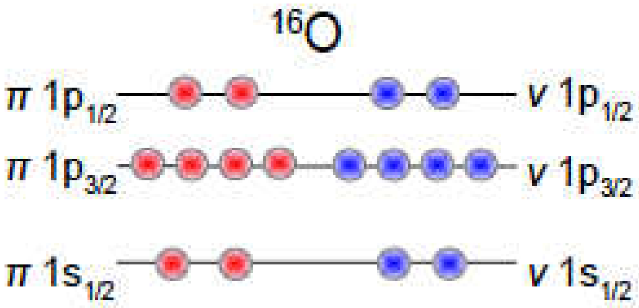
Incoming Beam & Outgoing Fragment Identification





proton knockout
neutron knockout
13O
14O
15O
16O
17O
18O
19O
20O
21O
22O
23O
24O
11N
12N
13N
14N
15N
16N
17N
18N
19N
20N
21N
22N

Inclusive Cross Section & Transverse Momentum: $^{16}O(p,2p)^{15}N$



- Reaction theory: C. Bertulani, eikonal theory

T. Aumann, C. Bertulani, J. Ryckebusch Phys. Rev. C88, 064610 (2013)

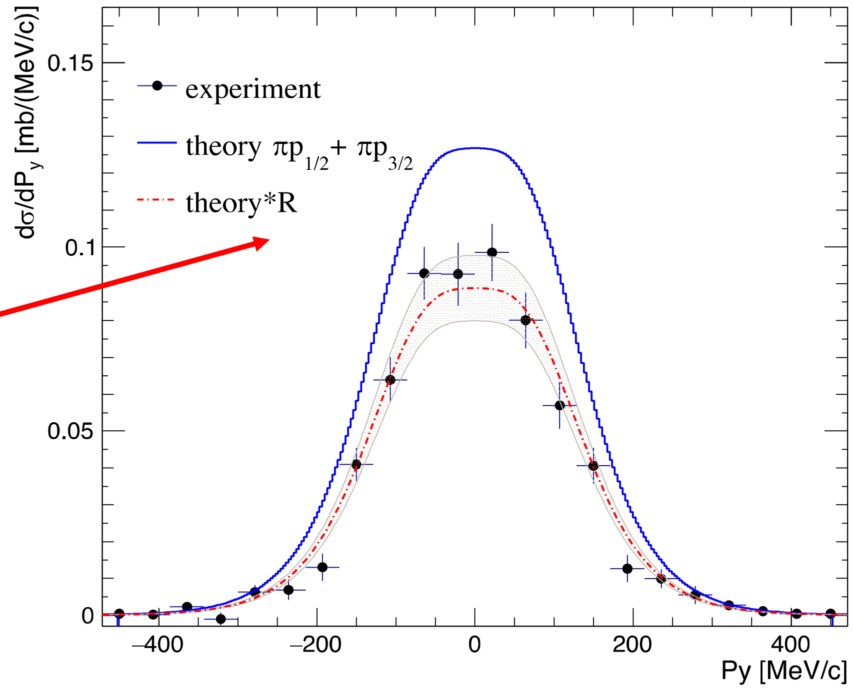
- Multiple scattering → Glauber model
- Absorption → complex optical potential
- Only bound core excited states considered

σ_{exp} [mb]	27(2)
$\sigma_{theo}(1p_{1/2})$	13
$\sigma_{theo}(1p_{3/2})$	25
R	0.70(5)
$S_{p/n}$ [MeV]	12/16

Reduction factor $R = \sigma_{exp}/\sigma_{theo(IPM)}$

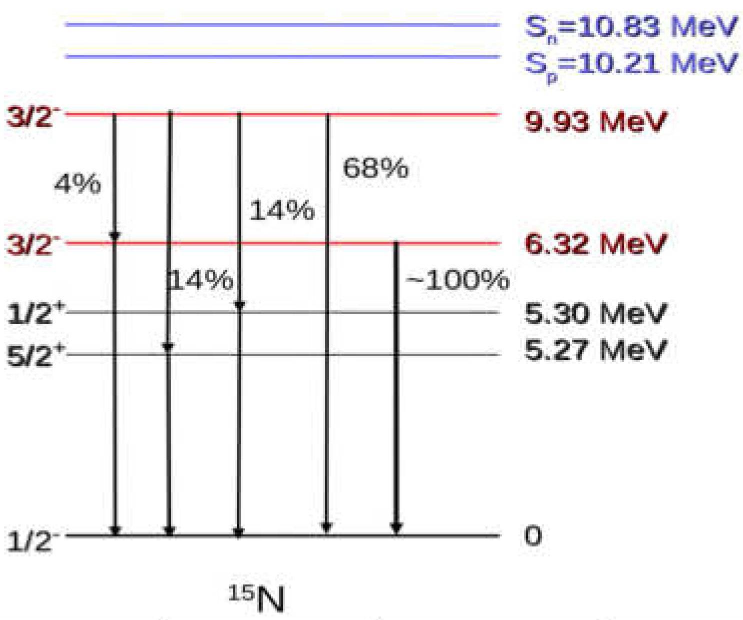
R = 0.65(5)
from
(e,e'p) @ NIKHEF
→ agreement!

L. Lapikas Nucl. Phys. A 553, 297c (1993)



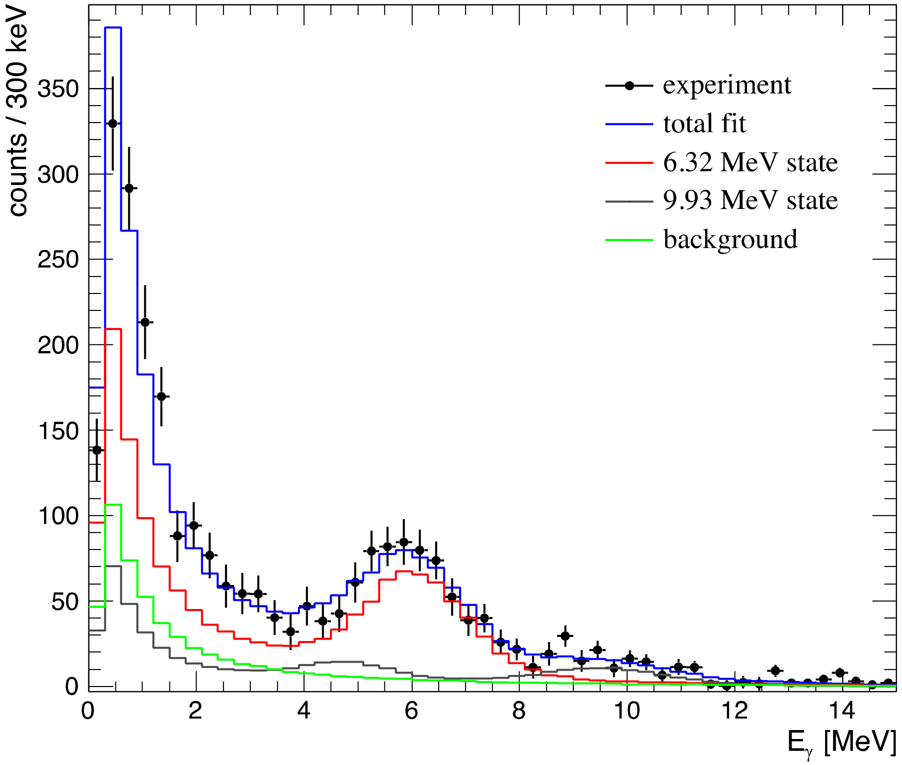
Inclusive P_y distribution for $1p_{1/2}$ and $1p_{3/2}$ proton knockout

Partial Cross Sections and Spectroscopic Factors: $^{16}O(p,2p)^{15}N$



J^π	1/2⁻ 0.0 MeV	3/2⁻ 6.3 MeV	3/2⁻ 9.9 MeV
b (%)	39(5)	47(4)	13(3)
σ_{exp} [mb]	10.6(25)	12.6(15)	3.6(8)
C^2S	1.6(4)	2.0(2)	0.6(1)
C^2S (e,e'p)	1.3(1)	2.4(2)	0.1(2)

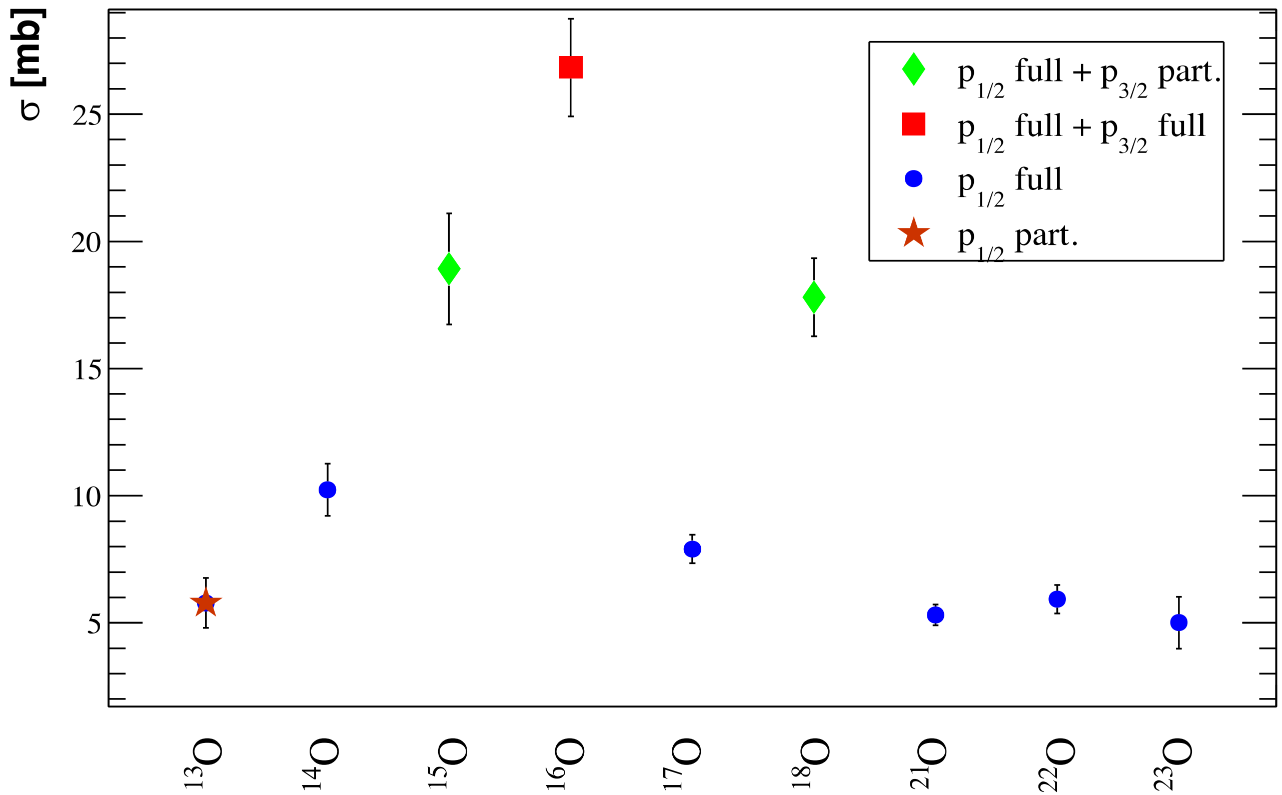
Doppler corrected γ-spectrum measured in coincidence with $^{16}O(p,2p)^{15}N$

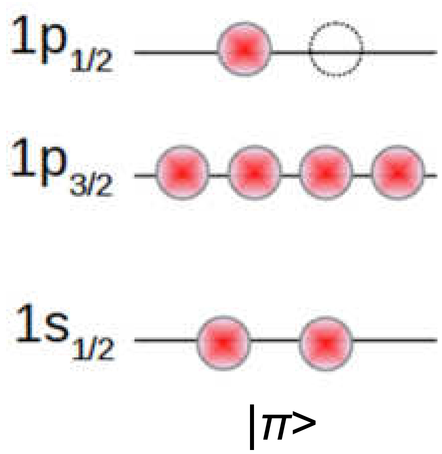


Spectroscopic factors deduced from the theoretical predictions and partial cross sections obtained from the fit of the γ-spectrum.

← (e,e'p) @ NIKHEF

Inclusive Cross Sections for Projectiles $^{13-18}O$ and $^{21-23}O$

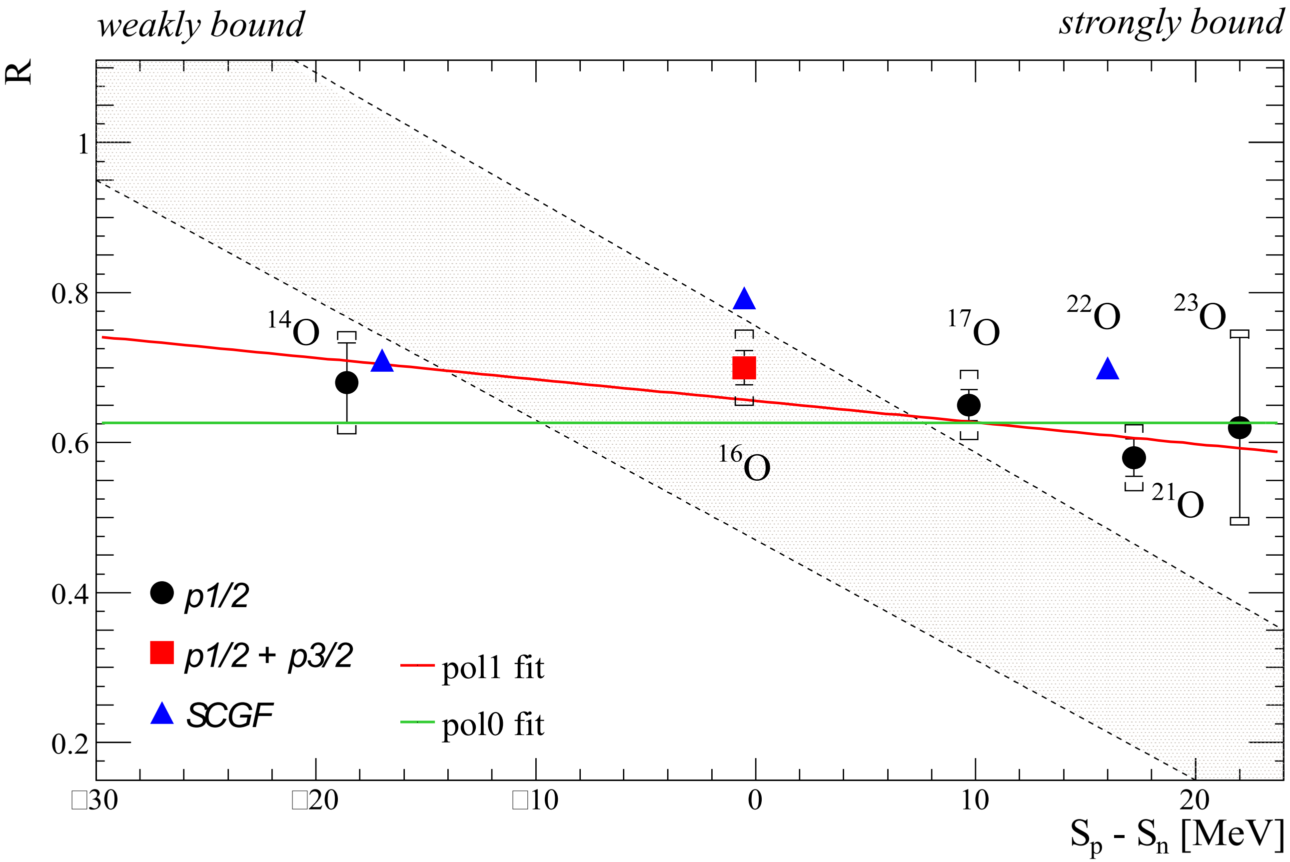




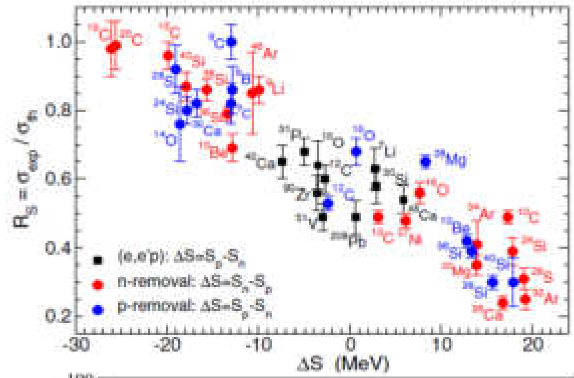
(p,2p) reaction channel

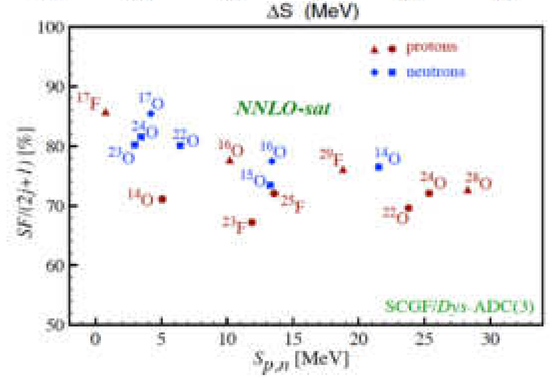
- $^{15-16}O$ and ^{18}O → larger S_n →knockout of $1p_{1/2}$ and $1p_{3/2}$ protons
- $^{13-14-17}O$ and $^{21-23}O$ → lower $S_{n/p}$ →knockout of only $1p_{1/2}$ protons
- fragmentation of $1p_{3/2}$ proton strengths!

Reduction Factors from (p,2p) Cross Sections



Reduction factor
$R = \sigma_{exp}/\sigma_{theo(IPM)}$





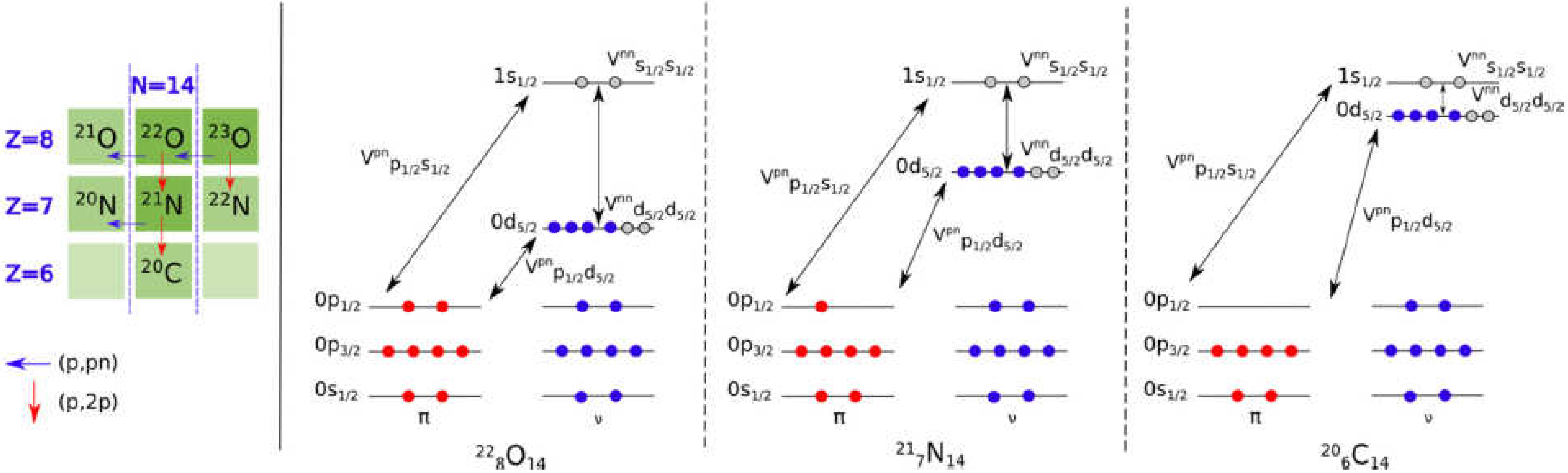
- *W*eak or no dependence of single-particle strength on the isospin asymmetry
- Discrepancy to composite target results at intermediate energies
- In agreement to ab-initio GF and coupled cluster calculations as well as (e,e'p) data

S393 Experiment (p,pN) N=p,n

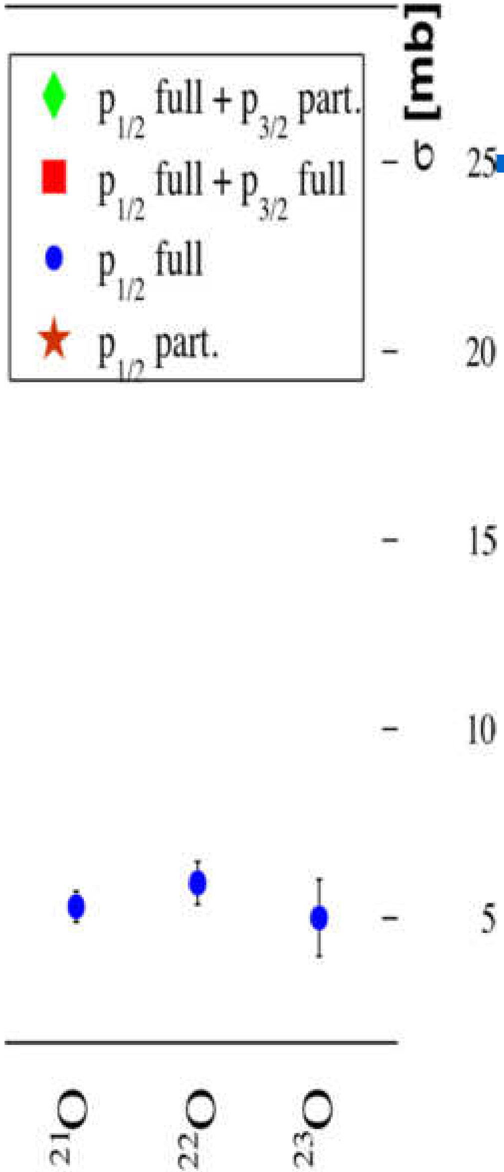
PHYSICAL REVIEW C 97, 024311 (2018)

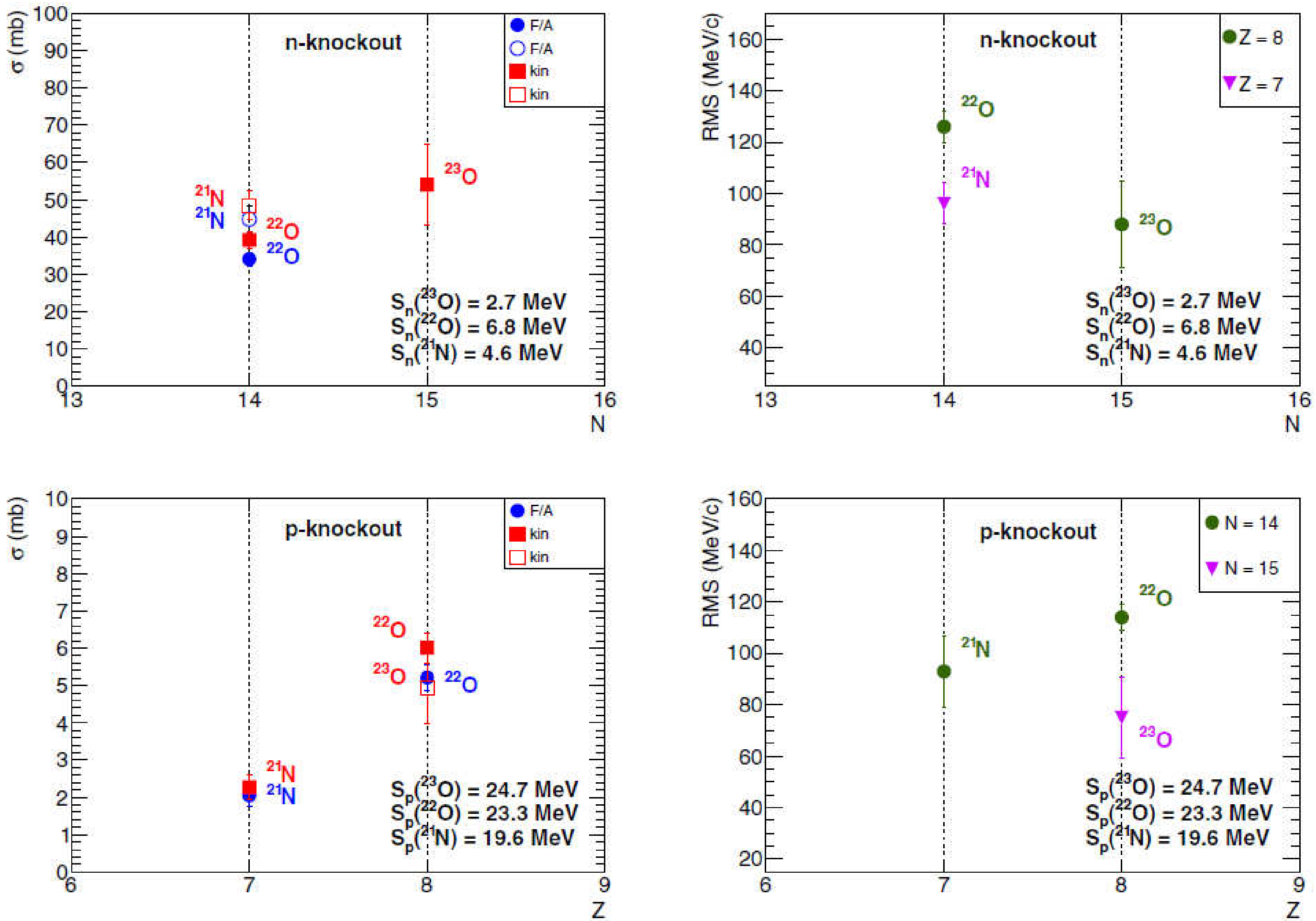
Quasifree (*p*, *pN*) scattering of light neutron-rich nuclei near *N* = 14

P. Díaz Fernández,[1,2,3] H. Alvarez-Pol,[2,3] R. Crespo,[4,5] E. Cravo,[6] L. Atar,[7] A. Deltuva,[8] T. Aumann,[7,9] V. Avdeichikov,[10]



Similar results for independent analysis





Interpretation still ongoing:
Fadeev/AGS calculations (
Agreement with momentum distribution
smaller R (0.4) for (p,2p) $^{23,22}O$, ^{21}N
(p,pn) similar

Work in progress: understand differences in description

^{A}X	$^{A-1}$X	E_c (MeV)	I_c^{π}	$n\ell j$	C^2S	σ_{sp}(mb)	σ_{th}(mb)	$\sigma_{exp,F/A}$(mb)	$\sigma_{exp,F/A}/\sigma_{th}$	$\sigma_{exp,Kin}$(mb)	$\sigma_{exp,Kin}/\sigma_{th}$
						(p,pn)					
		0.0	0_1^+	$1s_{1/2}$	0.87	15.4					
		3.4	2_1^+	$0d_{5/2}$	2.27	12.1					
		4.6	0_2^+	$1s_{1/2}$	0.13	15.4*					
^{23}O	^{22}O	4.8	3^+	$0d_{5/2}$	3.37	12.1*	98.8	–	–	54.0 ± 10.8	0.55 ± 0.11
		5.8	1^-	$0p_{1/2}$	0.82	10.5					
		6.1	0^-	$0p_{1/2}$	0.33	10.4					
		6.5	2_2^+	$0d_{5/2}$	0.26	12.1*					
^{22}O	^{21}O	0.0	$5/2^+$	$0d_{5/2}$	5.73	11.5	69.0	34.1 ± 2.0	0.49 ± 0.03	39.2 ± 2.3	0.57 ± 0.03
		1.5	$1/2^+$	$1s_{1/2}$	0.25	12.6					
		0.0	2^-	$0d_{5/2}$	1.97	12.7					
^{21}N	^{20}N	0.6	0^-	$1s_{1/2}$	0.16	14.8	72.5	44.8 ± 3.7	0.62 ± 0.05	48.5 ± 4.0	0.67 ± 0.06
		0.9	3^-	$0d_{5/2}$	2.98	12.7*					
		1.1	1^-	$1s_{1/2}$	0.49	14.8*					
						$(p,2p)$					
^{23}O	^{22}N	0.0	0^-	$0p_{1/2}$	0.50	6.3	12.5	–	–	4.93 ± 0.96	0.39 ± 0.08
		0.8	1^-	$0p_{1/2}$	1.48	6.3*					
^{22}O	^{21}N	0.0	$1/2^-$	$0p_{1/2}$	1.87	6.23	15.8	5.21 ± 0.36	0.32 ± 0.02	6.01 ± 0.41	0.38 ± 0.03
		1.9	$3/2^-$	$0p_{3/2}$	0.73	6.0					
^{21}N	^{20}C	0.0	0^+	$0p_{1/2}$	0.72	6.8	7.0	2.05 ± 0.31	0.29 ± 0.04	2.27 ± 0.34	0.32 ± 0.05
		2.2	2^+	$0p_{3/2}$	0.33	6.5					

PHYSICAL REVIEW C **97**, 024311 (2018)

All data (p,2p) & (p,pn)

Slope differs from knockout data

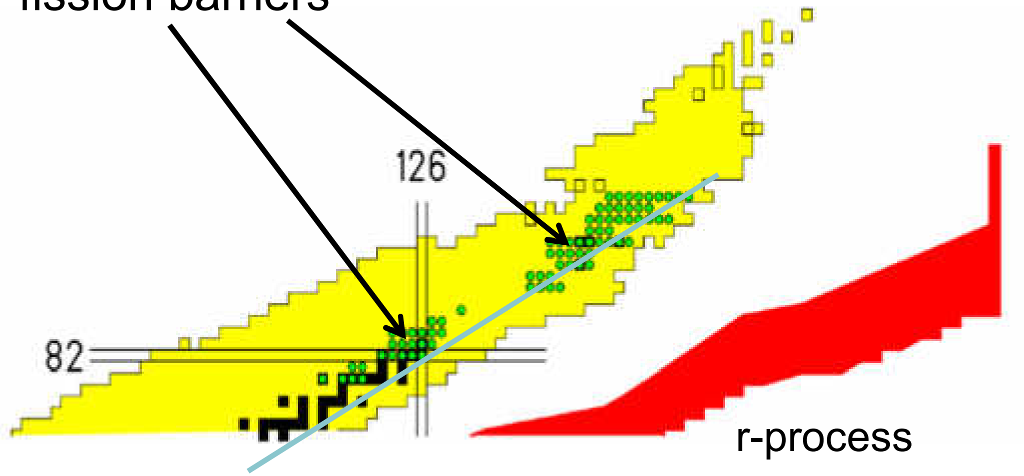
Slopes differ (less) with different reaction theory input

Quasifree (p,pN) scattering of light neutron-rich nuclei near $N = 14$

P. Díaz Fernández,[1,2,3] H. Alvarez-Pol,[2,3] R. Crespo,[4,5] E. Cravo,[6] L. Atar,[7] A. Deltuva,[8] T. Aumann,[7,9] V. Avdeichikov,[10]

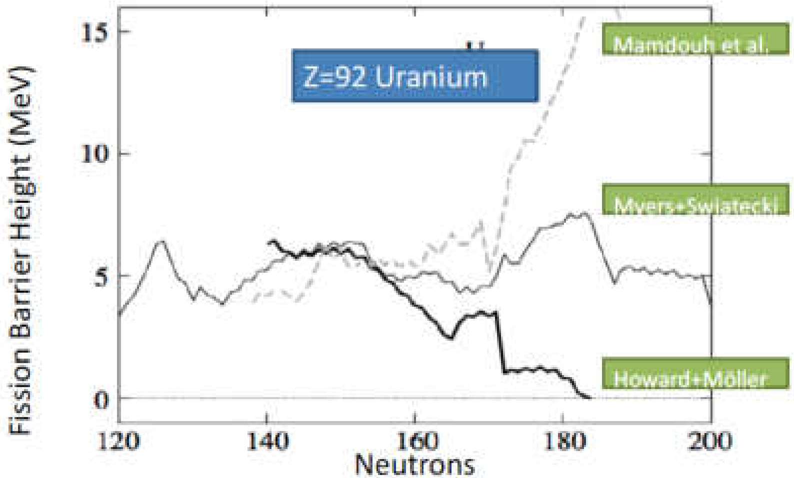
Further studies: (p,2pf)

Experimentally known
fission barriers

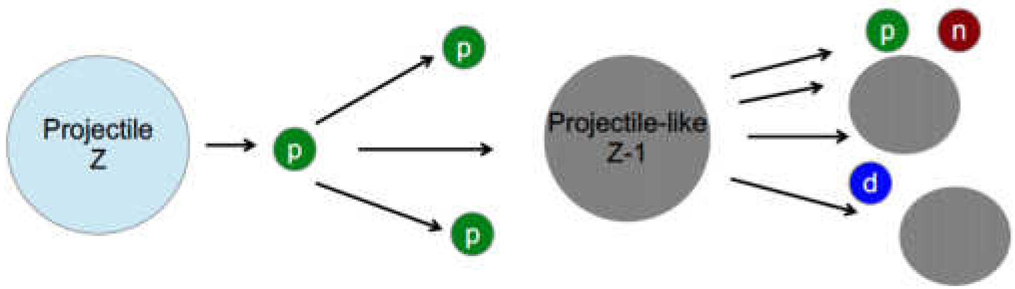


http://www-nds..*iaea.org/RIPL-2*

Uncertainties in Model-predictions of fission barriers



I.V. Panov and F. –K. Thielemann, Astro. Lett. 29 8 (2003)



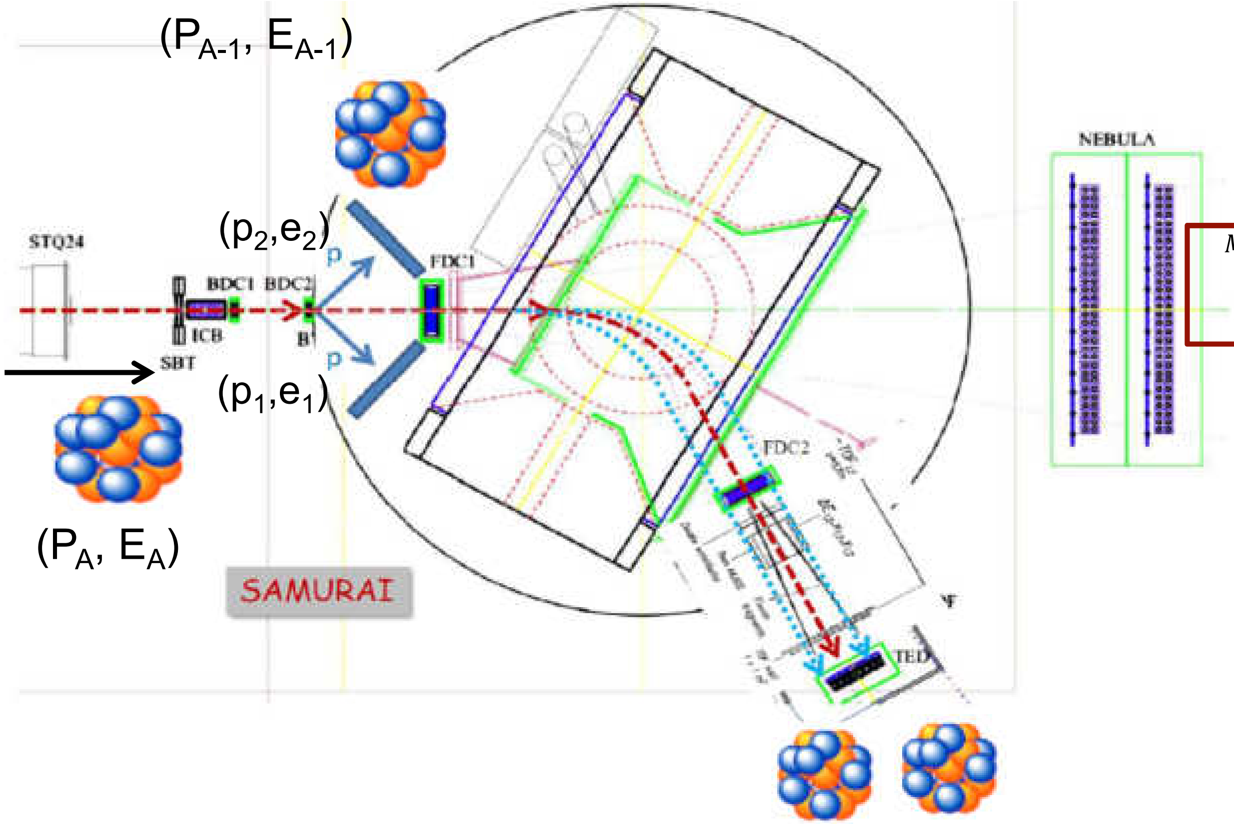
Fission products

QF (p,2p) induced fission reactions:
thick p-target and high beam energy
→ high reaction rate
→ high excitation states
→ clean reaction → less background

First (p,2pf) @ SAMURAI/RIKEN

- Primary ^{238}U @ 350 MeV/u fragmented on Be-target
- Interest of nuclei: north east of ^{208}Pb (Z>82 & N>126)

208Po	209Po	210Po	211Po	212Po	213Po
207Bi	208Bi	209Bi	210Bi	211Bi	212Bi
206Pb	207Pb	208Pb	209Pb	210Pb	211Pb
205Tl	206Tl	207Tl	208Tl	209Tl	210Tl



Energy & Momentum Conservation in QFS

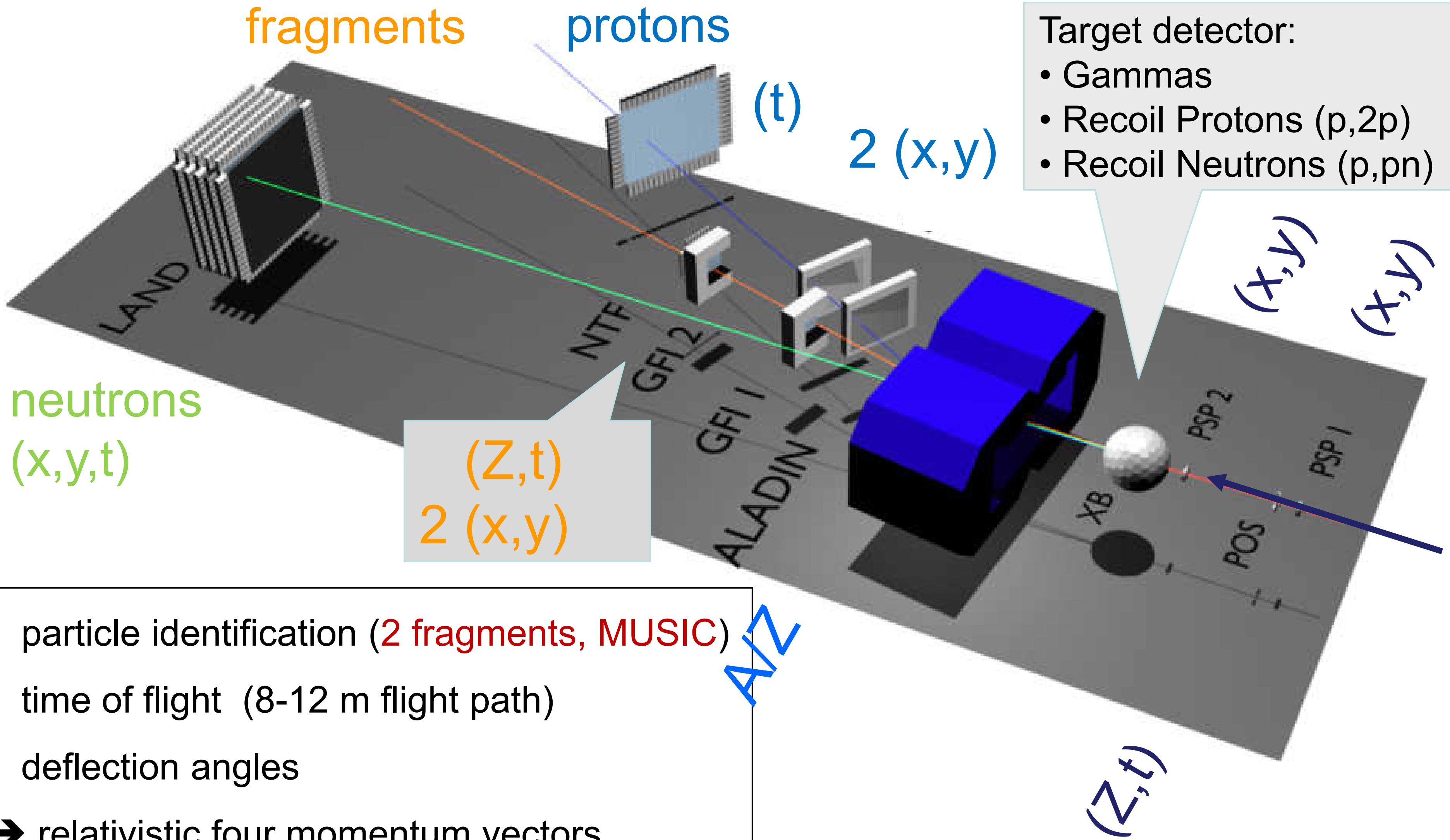
$$M_A^2 + P_A^2 + m_1^2 = m_1^2 + p_1^2 + m_2^2 + p_2^2 + M_{A-1}^2 + P_{A-1}^2$$

$$\overrightarrow{P_{A-1}} = \overrightarrow{P_A} - \overrightarrow{p_1} - \overrightarrow{p_2}$$

Accepted proposal (p,2pf) @ R3B/FAIR!
2018-19
FAIR phase-0

Data still in analysis

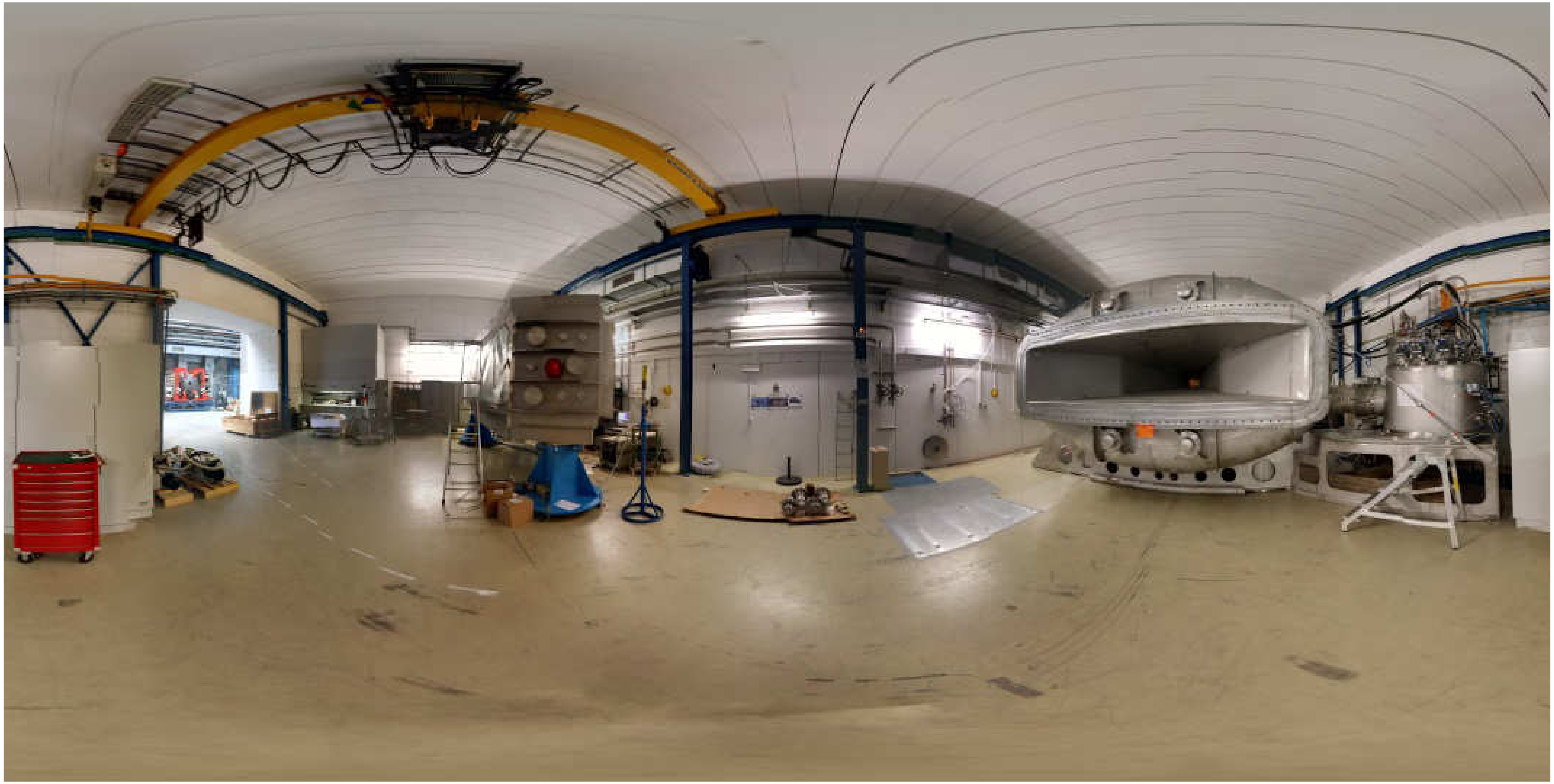
R³B/LAND Setup evolves to R³B/NeuLAND Setup + GLAD (kinematically complete)



- particle identification (2 fragments, MUSIC)
- time of flight (8-12 m flight path)
- deflection angles

➔ relativistic four momentum vectors

Starting point 2016

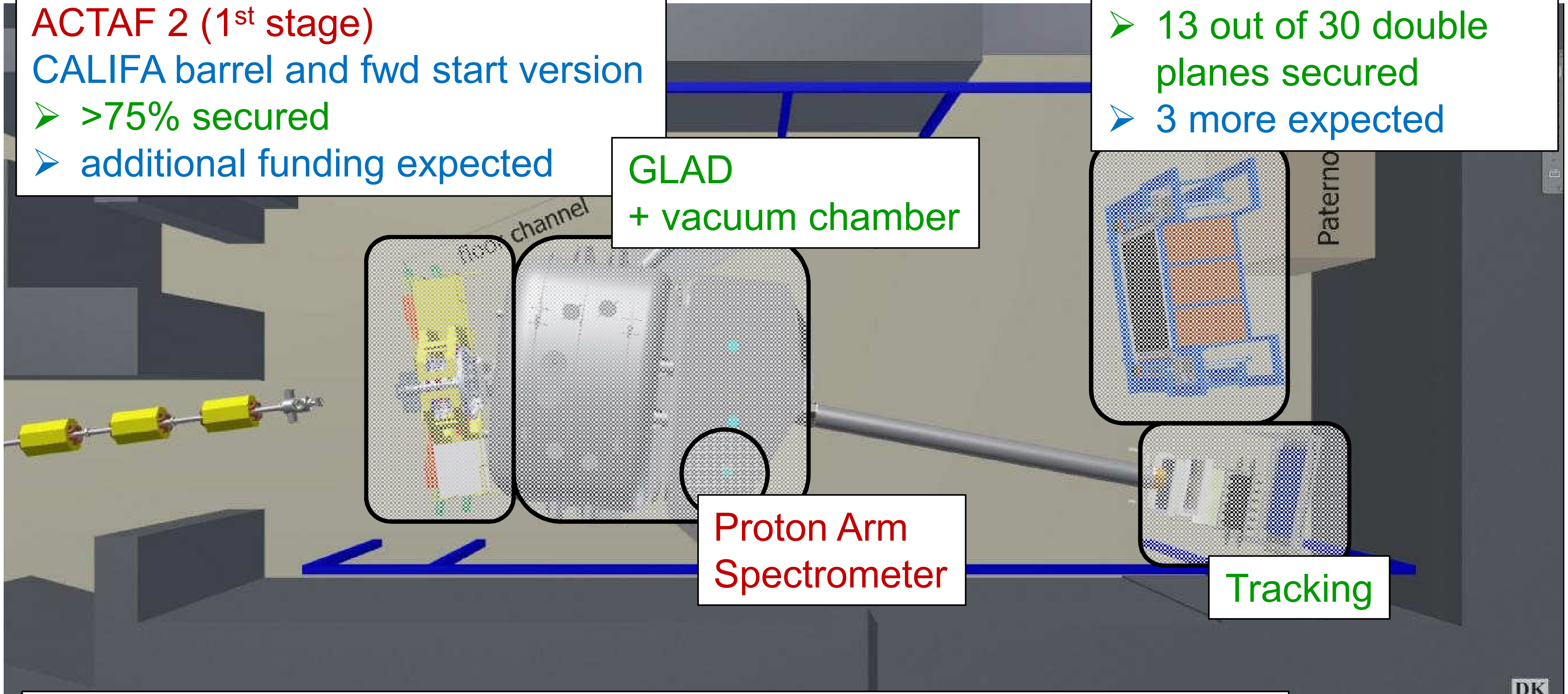


R^3B (Status Phase-0 in 2018)

Tracking
L3T Si tracker
ACTAF 2 (1st stage)
CALIFA barrel and fwd start version
- >75% secured
- additional funding expected

NeuLAND
- 13 out of 30 double planes secured
- 3 more expected

GLAD
+ vacuum chamber



Proton Arm Spectrometer

Tracking

NUSTAR-DAQ (TDR accepted 02/2018)
-Time stamps (first implementation)/local trigger logics/readout libraries
-Online analyss R^3B-Root ← FAIR-Root

All Infrastructure and magnet installed 2013-2016
Commissioning started

R^{3}B /L3T (Si- Tracker)

On going tests @ Daresbury:

- Full inner L3T layer in working condition
- expected energy threshold of 100 keV in verification (150keV achieved)
- Test bench running, first results
- Tests with alpha-source and, subsequently, cosmic rays

➔ Outer layer to be mounted and tested

L3T configuration

-inner layer 6 detector ladders

-outer layer 12 detector ladders (03-04/18)

Double-sided micro-strip Si sensors wire bonded to a dedicated ASIC (RAL: 120'000 channels) + time stamped FPGA based readout

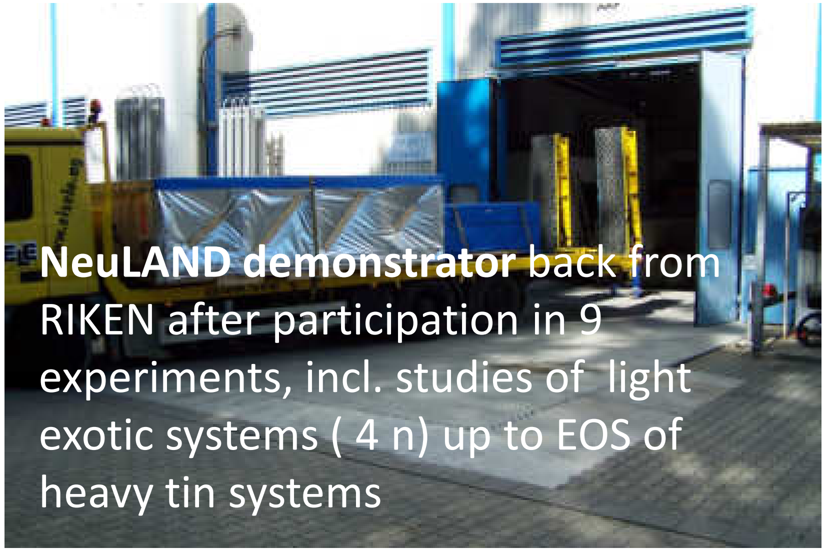
TDR: L3T is a deliverable for the in-kind UK contribution. TDR is not need but R3B collaboration whish the presentation to ECE of an equivalent document including performance evaluation with up-coming tests

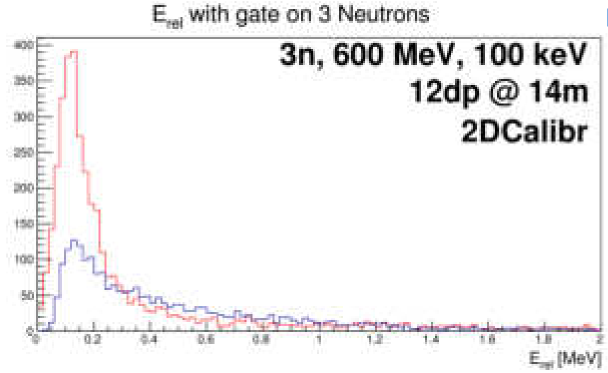
Phase-0 experiment status : Expected a functional detector for Q2-3 /2018

R^3B /NeuLAND

NeuLAND Phase 0 Ok Q2-2018

- 130 cm active depth
- 2600 channels   >40% detector





simulation prediction: **reconstruction efficiency** of the order of 20% for 3 n, 10 % for 4 n (600 MeV, preliminary)

SAT test of in-house developed **NeuLAND electronics** underway:
multichannel front-end electronic card TAMEX for high-resolution time and charge measurements

CALIFA start version: Calorimeter in-flight detection for γ-rays and LCP

Start version:

As of January 2018:

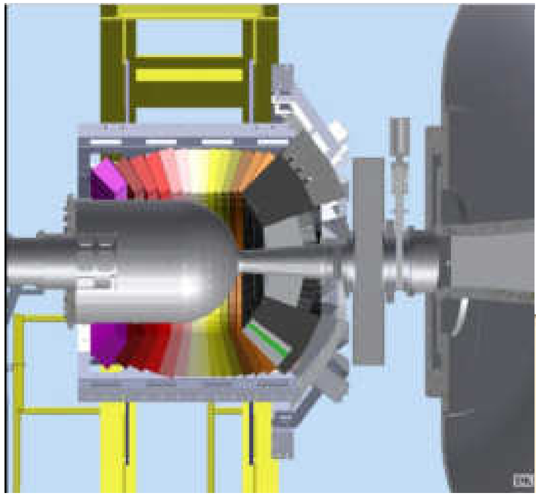
APDs

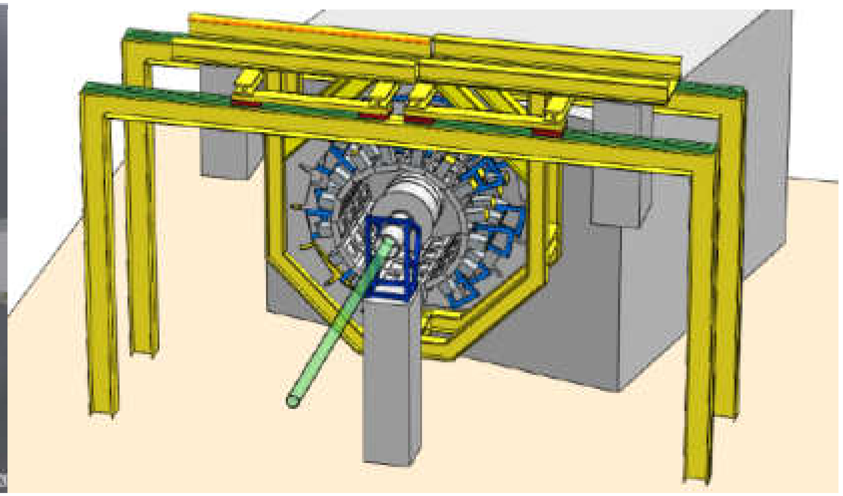
#	Institute
200	IEM
250	LU
360	TUD
320	USC
1130	Total

Crystals and wrapping

# delivered	# tested	Institute
480	450	LU
212	79	TUD
320	192	USC
1012	721	Total

Full detector:



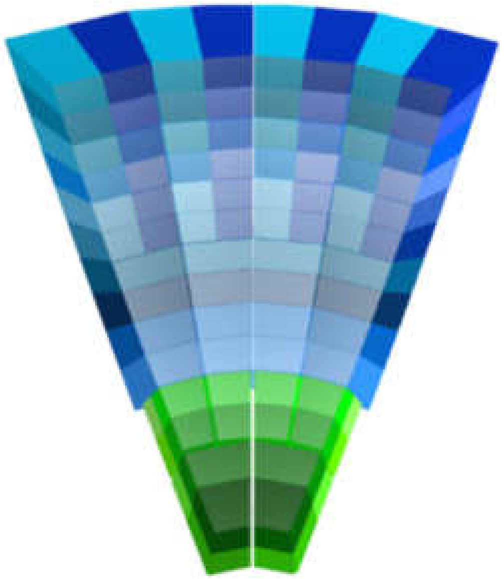


CALIFA : Calorimeter in-flight detection for γ-rays and LCP

CsI(Tl)+LAAPD

2464 units (full detector)

Polar angle 20-140^0



LaBr/LaCl+PM

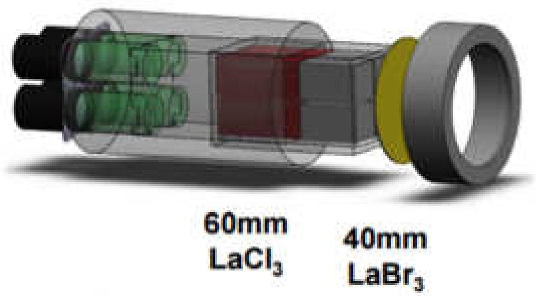
96 units

Polar angle 7-20^0

- CsI (Tl) range between 15-22 cm long
- Packed in groups of four (VM2000 and Carbon fiber)
- APD collecting area 10x20 mm^2

- Good ΔE/E ~6% @ 1 MeV for g and 2 % for p up to 320 MeV
- PID and E determination based on two different intrinsic times of CsI up to 700 MeV ΔE/E ~ 5%
- Background rejection

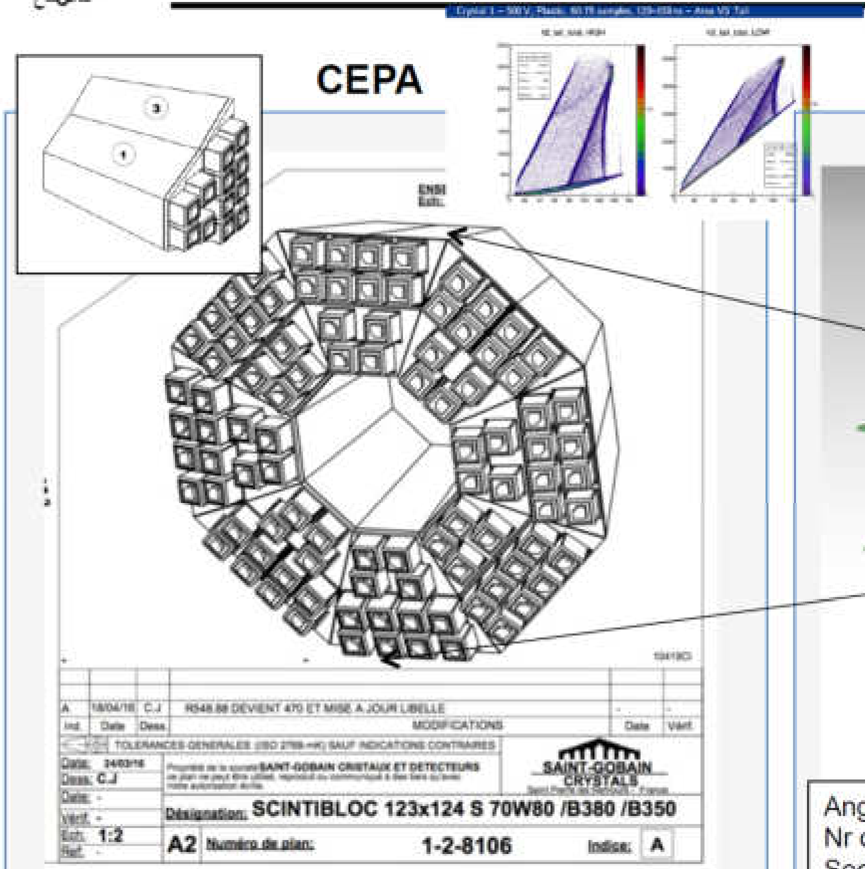
- LaBr 6 cm and LaCl 8 cm long
- Packed in groups (Al cane)
- PM 1.5 ¨ diameter



- Very good ΔE/E ~ 3% @ 662 keV for γ
- E determination based on two different time decay of LaBr/LaCl ΔE/E ~ 5%
- Good timing
- Background rejection

CALIFA Front Cap Basics

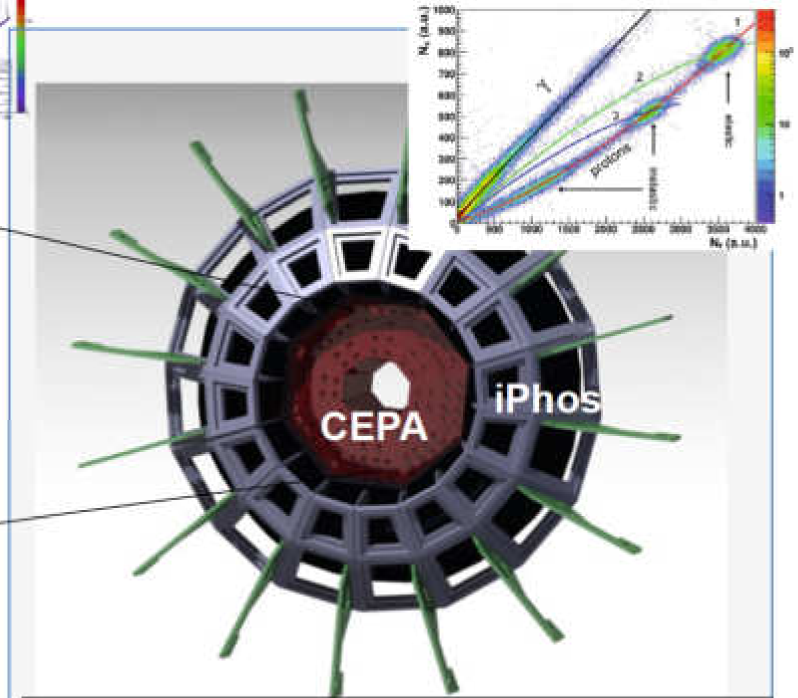
CEPA



Angular cover:	7 – 20 deg.
Nr of crystals:	2 x 96
Scintillators:	LaBr/LaCl

Fully funded via Chalmers. First segment module produced.

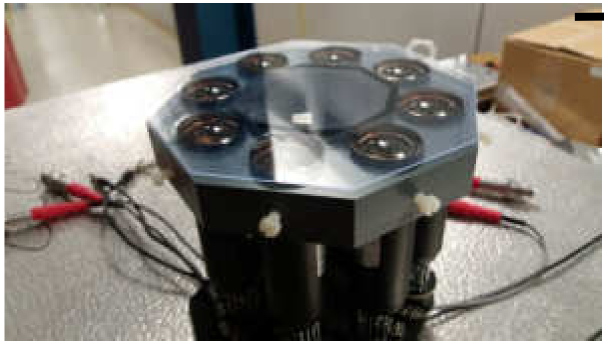
iPhos

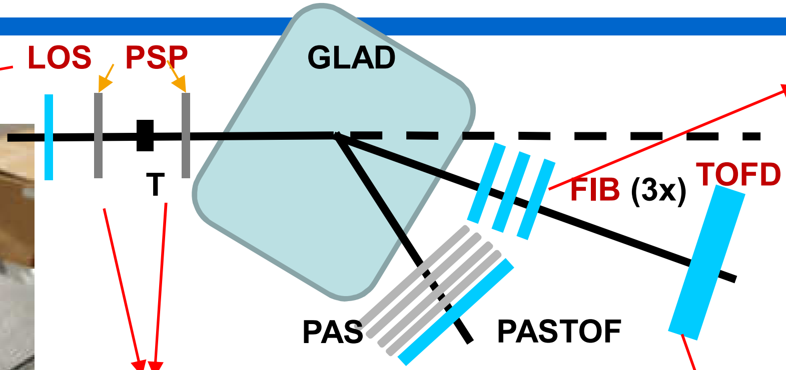


Angular cover:	20 – 43 deg.
Nr of crystals:	480
Sectors:	8
Scintillator:	CsI(Tl) with PSA

The outer part of five sectors are covered by JINR. Two sectors are covered by TUD and one by USC. This makes iPhos 75% funded as of today.

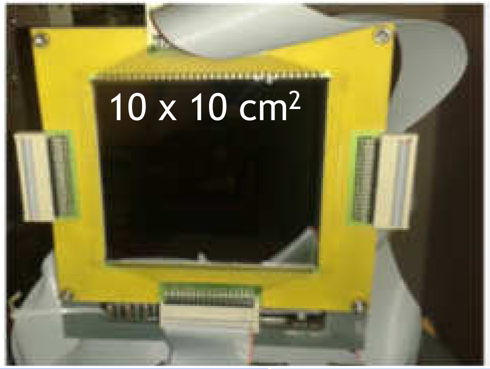
Comm: Tracking Detectors 2018/19+



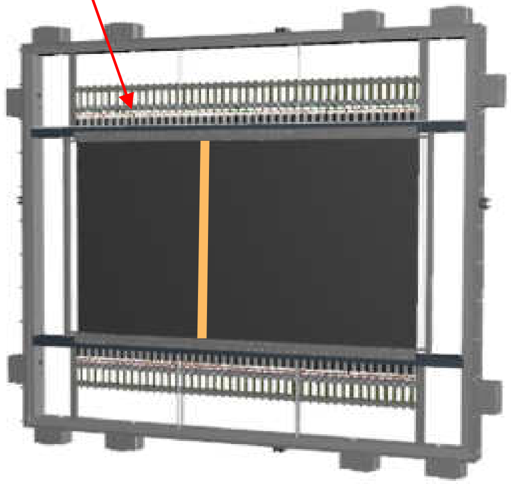


200 μm square fiber for FIB4a
200/500 μm round fiber FIB4b/5

Z separation	**σ_E < 1%**
A separation	**σ_t < 10ps**
Rate	**1 MHz**

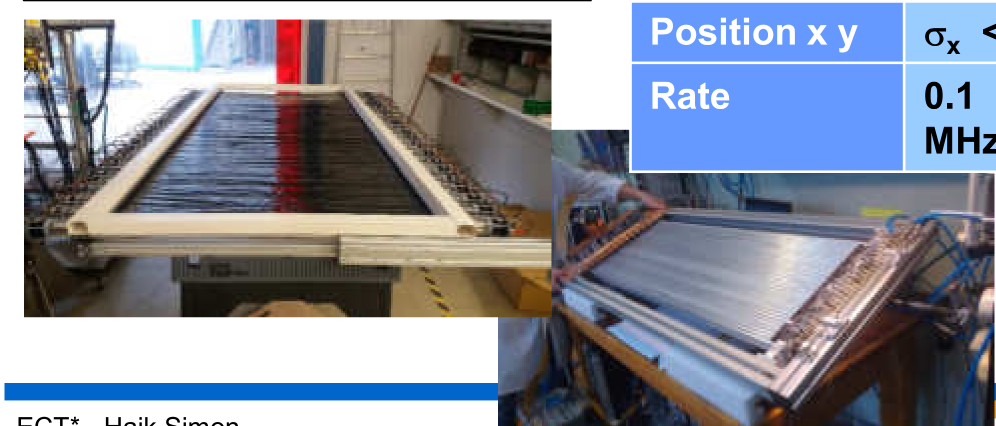


Z separation	**σ_E < 0.5%**
Position x y	**σ_x < 100μm**
Rate	**0.1 MHz/strip**

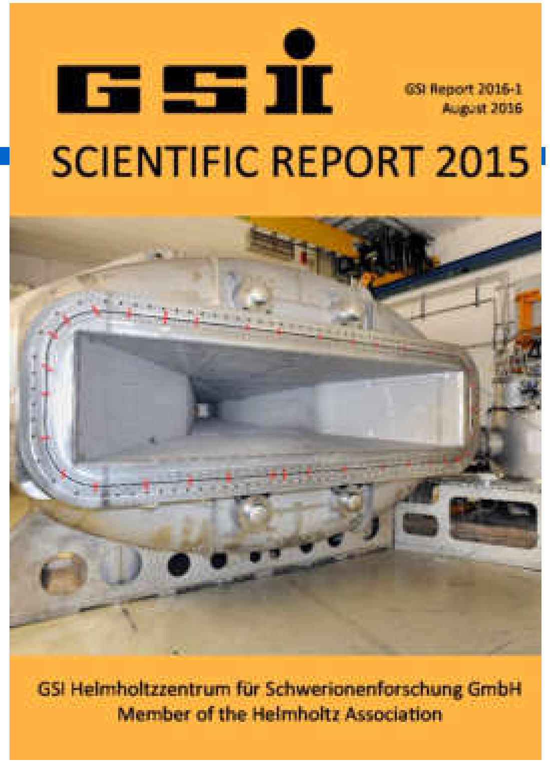


Z separation	**σ_E < 1%**
A separation	**σ_t < 38ps**
Rate	**1 MHz/strip**

Proton Arm Spectrometer



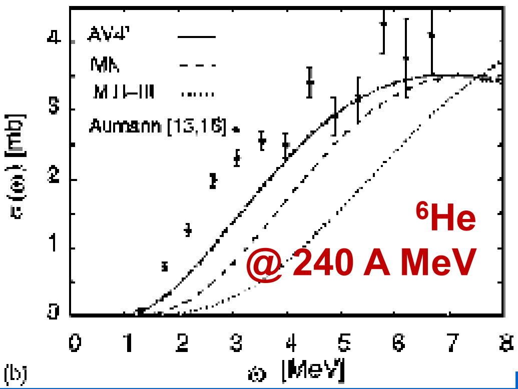
Schedule and first experiments

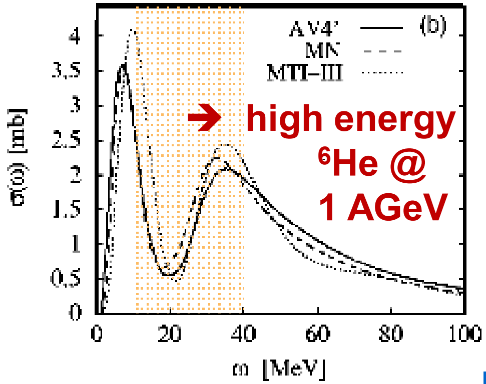


2014	Installation of 20% detectors NeuLAND and CALIFA
2015/17	Construction and installation of detector components
2018	Commissioning of R3B setup (Cave C)
2022	Buildings ready (exp. groundbreaking 2017)
2025	Machines installed and first commissioning
2018-202x	Physics runs at GSI (Cave C) (phase 0)
202x-202x+1	Move to High-Energy Branch building
202x+1 →	Commissioning and first experiments at Super-FRS

Experiments will make use of uniqueness of R^3B:

- Reactions at high beam energies up to 1 GeV/nucleon
- Tracking and identification capability even for the heaviest ions
- Multi-neutron tracking capability, high-efficiency calorimeter





First experiments: e.g.
(simple beam, partial sys. av.)
^{6}He Core vs. halo excitation

S. Bacca et al.
PRL **89** (2002) 052502
PRC **69** (2004) 057001

The R3B Collaboration

Aksouh, Farouk; Al-Khalili, Jim; Algora, Alejandro; Alkhasov, Georgij; Altstadt, Sebastian; Alvarez, Hector; Atar, Leyla; Audouin, Laurent; Aumann, Thomas; Pellereau, Eric; Martin, Julie-Fiona; Gorbinet, Thomas; Seddon, Dave; Kogimtzis, Mos; Avdeichikov, Vladimir; Barton, Charles; Bayram, Murat; Belier, Gilbert; Bemmerer, Daniel; Michael Bendel; Benlliure, Jose; Bertulani, Carlos; Bhattacharya, Sudeb; Christoph; Calvino, Francisco; Casarejos, Enrique; Catford, Wilton; Cederkall, Joakim; Cederwall, Bo; Chapman, Robert; Alexandre Charpy; Chartier, Marielle; Chatillon, Audrey; Chen, Ruofu; Christophe, Mayri; Chulkov, Leonid; Coleman-Smith, Patrick; Cortina, Dolores; Crespo, Raquel; Csatlos, Margit; Cullen, David; Czech, Bronislaw; Danilin, Boris; Davinson, Tom; Diaz Fernandez, Paloma; Dillmann, Iris; Dominguez, Beatriz; Ducret, Jean-Eric; Duran, Ignacio; Egelhof, Peter; Elekes, Zoltan; Emling, Hans; Enders, Joachim; Eremin, Vladimir; Ershov, Sergey N.; Ershova, Olga; Eronen, Simo; Estrade, Alfredo; Faestermann, Thomas; Fedorov, Dmitri; Feldmeier, Hans; Le Fevre, Arnaud; Fomichev, Andrey; Forssen, Christian; Freeman, Sean; Freer, Martin; Friese, Juergen; Fynbo, Hans; Gacsi, Zoltan; Garrido, Eduardo; Gasparic, Igor; Gastineau, Bernard; Geissel, Hans; Gelletly, William; Genolini, B.; Gerl, Juergen; Gernhaeuser, Roman; Golovkov, Mikhail; Golubev, Pavel; Grant, Alan; Grigorenko, Leonid; Grosse, Eckart; Gulyas, Janos; Goebel, Kathrin; Gorska, Magdalena; Haas, Oliver Sebastian; Haiduc, Maria; Hasegan, Dumitru; Heftrich, Tanja; Heil, Michael; Heine, Marcel; Heinz, Andreas; Ana Henriques; Hoffmann, Jan; Holl, Matthias; Hunyadi, Matyas; Ignatov, Alexander; Ignatyuk, Anatoly V.; Ilie, Cherciu Madalin; Isaak, Johann; Isaksson, Lennart; Jakobsson, Bo; Jensen, Aksel; Johansen, Jacob; Johansson, Hakan; Johnson, Ron; Jonson, Bjoern; Junghans, Arnd; Jurado, Beatriz; Jaehrling, Simon; Kailas, S.; Kalantar, Nasser; Kalliopuska, Juha; Kanungo, Rituparna; Kelic-Heil, Aleksandra; Kezzar, Khalid; Khanzadeev, Alexei; Kissel, Robert; Kisselev, Oleg; Klimkiewicz, Adam; Kmiecik, Maria; Koerper, Daniel; Kojouharov, Ivan; Korsheninnikov, Alexei; Korten, Wolfram; Krasznahorkay, Attila; Kratz, Jens Volker; Kresan, Dima; Anatoli Krivchitch; Kroell, Thorsten; Krupko, Sergey; Kruecken, Reiner; Kulessa, Reinhard; Kurz, Nikolaus; Kuzmin, Eugenii; Labiche, Marc; Langanke, Karl-Heinz; Langer, Christoph; Lapoux, Valerie; Larsson, Kristian; Laurent, Benoit; Lazarus, Ian; Le, Xuan Chung; Leifels, Yvonne; Lemmon, Roy; Lenske, Horst; Lepine-Szily, Alinka; Leray, Sylvie; Letts, Simon; Li, Songlin; Liang, Xiaoying; Lindberg, Simon; Lindsay, Scott; Litvinov, Yuri; Lukasik, Jerzy; Loeher, Bastian; Mahata, Kripamay; Maj, Adam; Marganiec, Justyna; Meister, Mikael; Mittig, Wolfgang; Movsesyan, Alina; Mutterer, Manfred; Muentz, Christian; Nacher, Enrique; Najafi, Ali; Nakamura, Takashi; Neff, Thomas; Nilsson, Thomas; Nociforo, Chiara; Nolan, Paul; Nolen, Jerry; Nyman, Goran; Obertelli, Alexandre; Obradors, Diego; Ogloblin, Aleksey; Oi, Makito; Palit, Rudrajyoti; Panin, Valerii; Paradela, Carlos; Paschalis, Stefanos; Pawlowski, Piotr; Petri, Marina; Pietralla, Norbert; Pietras, Ben; Pietri, Stephane; Plag, Ralf; Podolyak, Zsolt; Pollacco, Emanuel; Potlog, Mihai; Datta Pramanik, Ushasi; Prasad, Rajeshwari; Fraile Prieto, Luis Mario; Pucknell, Vic; Galaviz -Redondo, Daniel; Regan, Patrick; Reifarth, Rene; Reinhardt, Tobias; Reiter, Peter; Rejmund, Fanny; Ricciardi, Maria Valentina; Richter, Achim; Rigollet, Catherine; Riisager, Karsten; Rodin, Alexander; Rossi, Dominic; Roussel-Chomaz, Patricia; Gonzalez Rozas, Yago; Rubio, Berta; Roeder, Marko; Saito, Takehiko; Salsac, Marie-Delphine; Rodriguez Sanchez, Jose Luis; Santosh, Chakraborty; Savajols, Herve; Savran, Deniz; Scheit, Heiko; Schindler, Fabia; Schmidt, Karl-Heinz; Schmitt, Christelle; Schnorrenberger, Linda; Schrieder, Gerhard; Schrock, Philipp; Sharma, Manoj Kumar; Sherrill, Bradley; Shrivastava, Aradhana; Shulgina, Natalia; Sidorchuk, Sergey; Silva, Joel; Simenel, Cedric; Simon, Haik; Simpson, John; Singh, Pushpendra Pal; Sonnabend, Kerstin; Spohr, Klaus; Stanoiu, Mihai; Stevenson, Paul; Strachan, Jon; Streicher, Brano; Stroth, Joachim; Syndikus, Ina; Suemmerer, Klaus; Taieb, Julien; Tain, Jose L.; Tanihata, Isao; Tashenov, Stanislav; Tassan-Got, Laurent; Tengblad, Olof; Teubig, Pamela; Thies, Ronja; Togano, Yasuhiro; Tostevin, Jeffrey A.; Trautmann, Wolfgang; Tuboltsev, Yuri; Turrion, Manuela; Typel, Stefan; Udias-Moinelo, Jose; Vaagen, Jan; Velho, Paulo; Verbitskaya, Elena; Veselsky, Martin; Wagner, Andreas; Walus, Wladyslaw; Wamers, Felix; Weick, Helmut; Wimmer, Christine; Winfield, John; Winkler, Martin; Woods, Phil; Xu, Hushan; Yakorev, Dmitry; Zegers, Remco; Zhang, Yu-Hu; Zhukov, Mikhail; Zieblinski, Miroslaw; Zilges, Andreas;