DE LA RECHERCHE À L'INDUSTRIE

Collectivity beyond N=40 in neutron-rich Cr and Fe isotopes

Clémentine SANTAMARIA

CEA SACLAY

MINOS
Magic Numbers Off Stability

RIKEN NISHINA CENTER

erc

www.cea.fr

JUNE 22nd 2015

OUTLINE

① MINOS

② TPC performances

③ First experiment with MINOS: collectivity beyond N=40

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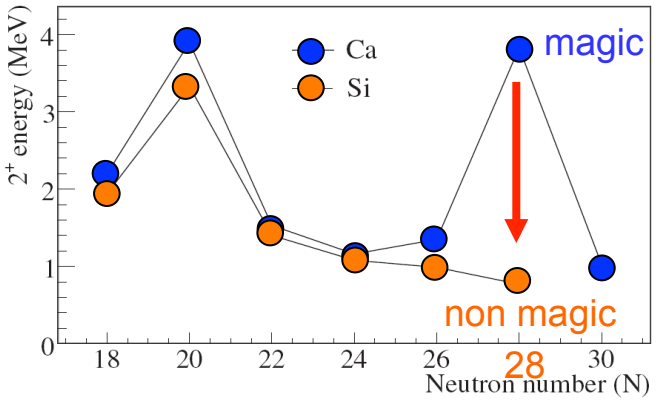
② TPC performances

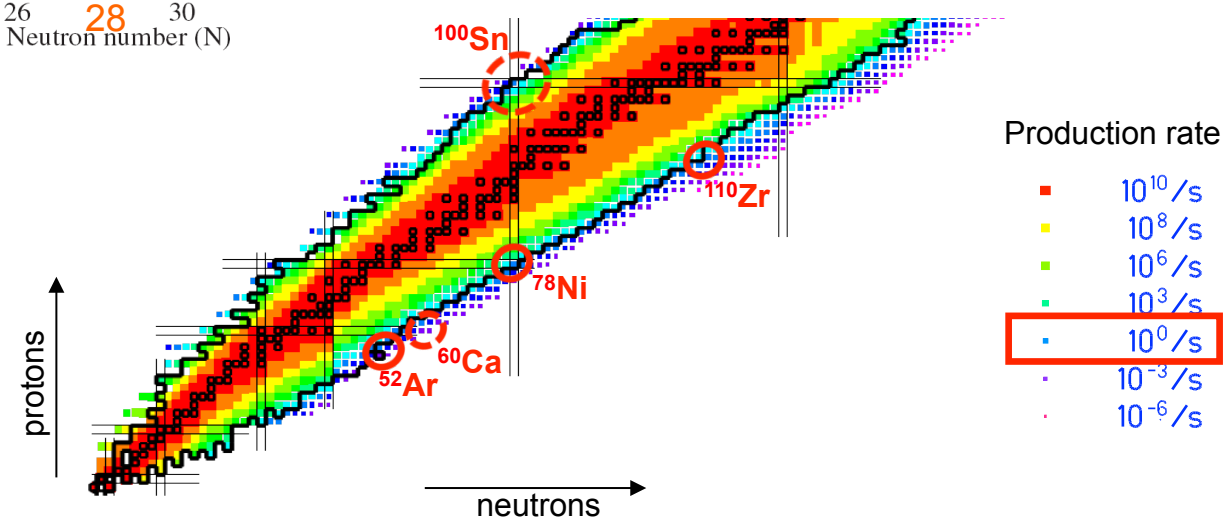
③ First experiment with MINOS: collectivity beyond N=40

SHELL STRUCTURE & EXOTIC NUCLEI

Magic number signature



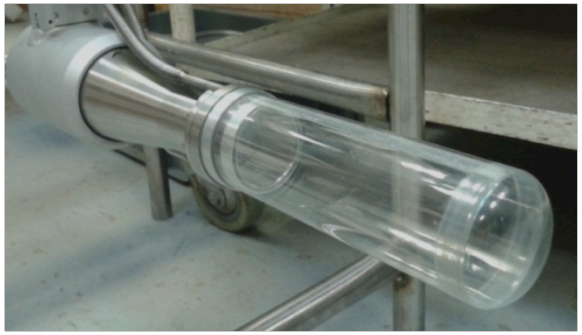
- **Shell** evolution far from the valley of stability
- **Observable** : First excited state energy
- Intensities of the beams of interest = 1-10 pps



⇒ RIKEN : machine with the highest intensities
⇒ Optimized luminosity with the new **MINOS** device

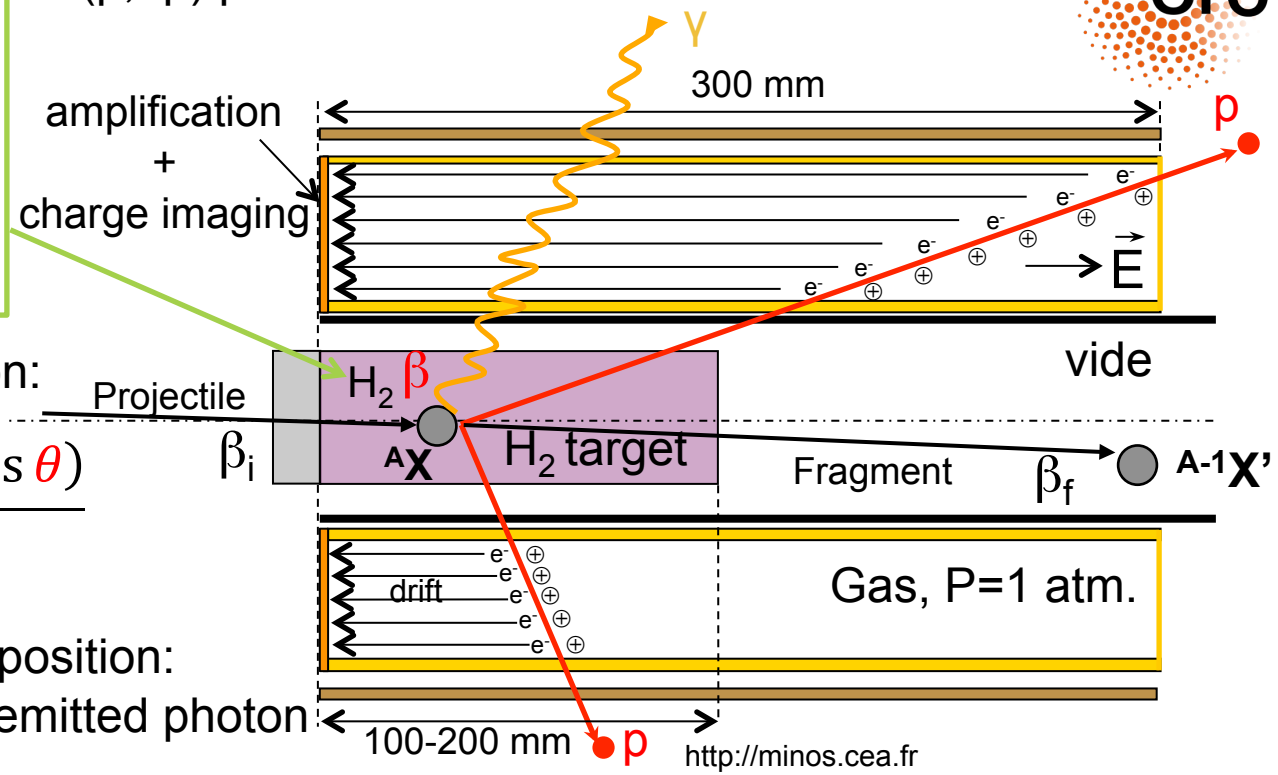
MAGIC NUMBERS OFF STABILITY

Liquid H_2 target



ERC grant (development from 2011)

(p,2p) proton knockout



Doppler correction:

$$E_{\gamma\,Dopp} = \frac{E_\gamma \times (1 - \beta \cos\theta)}{\sqrt{1-\beta^2}}$$

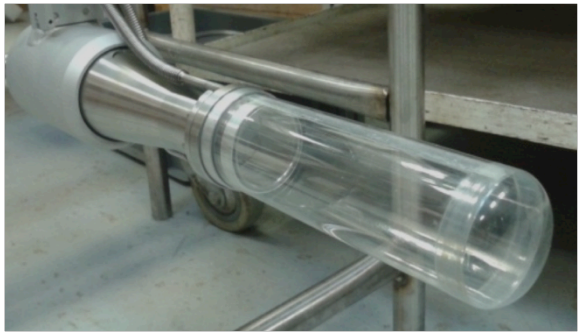
Depends on the vertex position:
β velocity and θ angle of the emitted photon

http://minos.cea.fr
Obertelli *et al*, Eur. Phys. J. A 50, 8 (2014)

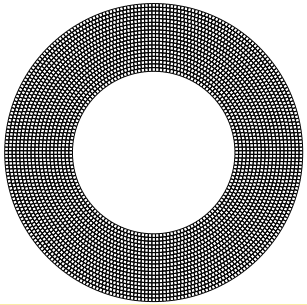
MAGIC NUMBERS OFF STABILITY

ERC grant (development from 2011)

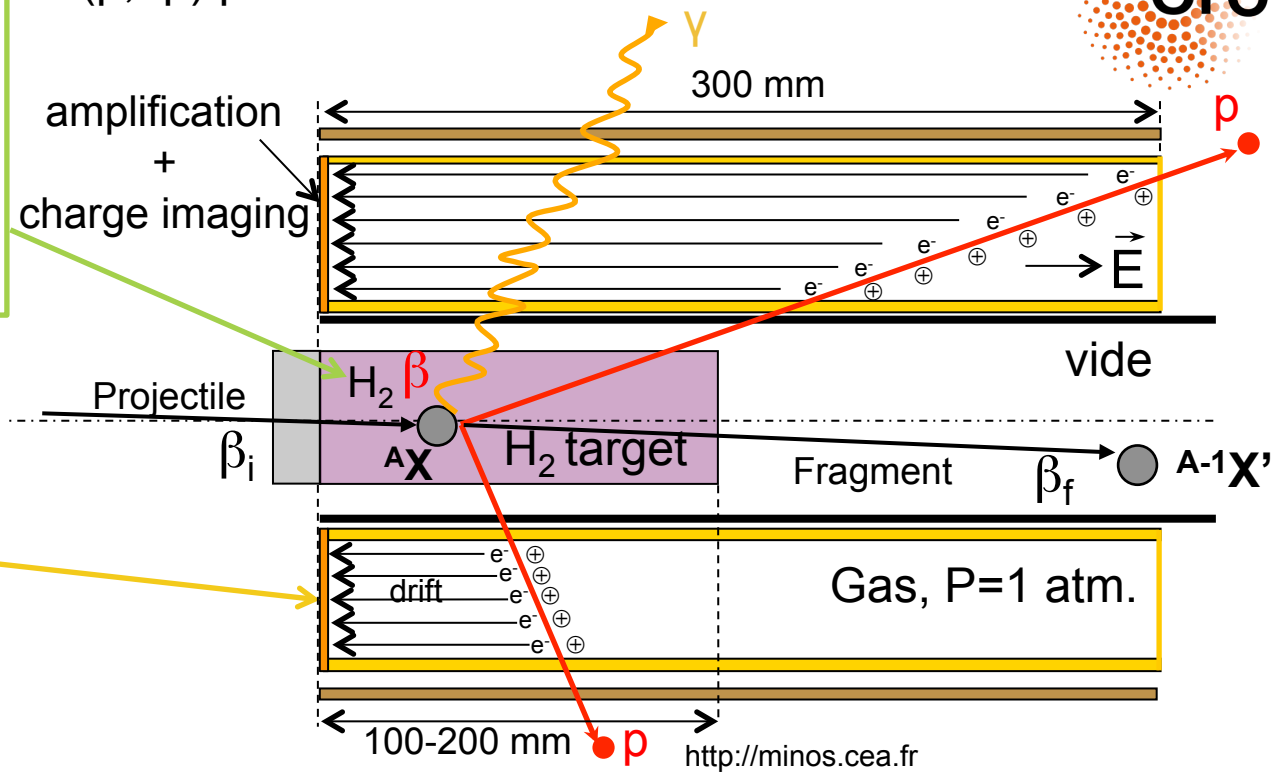
Liquid H_2 target



Bulk MICROMEGAS



(p,2p) proton knockout



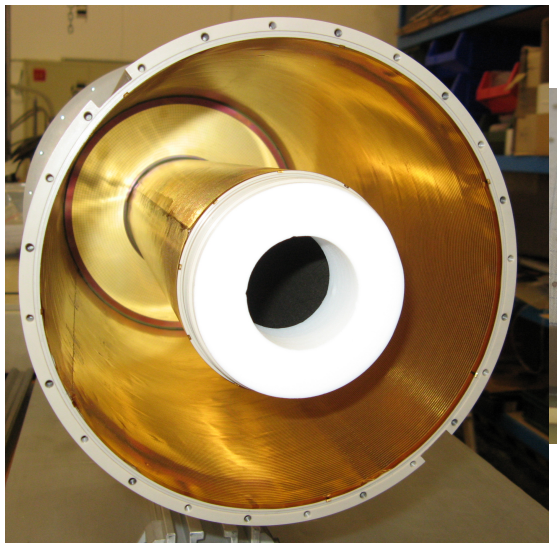
http://minos.cea.fr

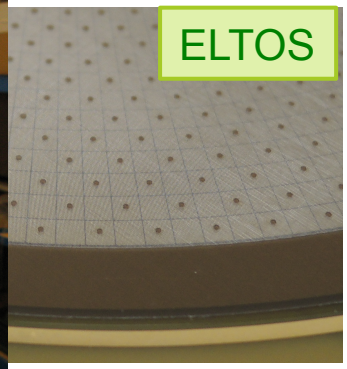
Obertelli *et al*, Eur. Phys. J. A 50, 8 (2014)

Initial goal: vertex resolution~4 mm FWHM, detection efficiency > 80%

Achieved: 4-5 mm FWHM vertex resolution, 87-96% detection efficiency

MINOS TPC & ELECTRONICS





PANDA TPC prototype: L. Fabbietti et al., NIM A **628**, 204 (2011)

- Compact, low-budget material TPC
- **MicroMegas**: 18 rings, 3604 pads
- $Ar\ (82\%) + CF_4\ (15\%) + C_4H_{10}\ (3\%)$ **gas**
- **Drift velocity:** 4.5 cm/µs at 180 V/cm
- Transverse **diffusion** ≤ 200 µm/√cm

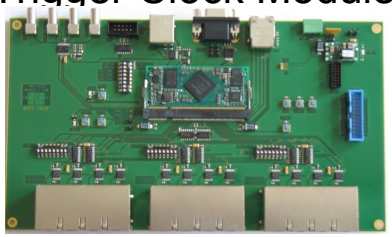
Front-End Cards T2K AGET + FEMINOS + TCM board + MINOS DAQ

D. Calvet, IEEE Trans. Nucl. Sci., vol. 61, N°1, pp. 675-682, February 2014

F. Château (CEA Saclay), based on the Mordicus software

- Dedicated electronics
- 80 µs mean dead time in experiment
- MINOS slave DAQ (external trigger)
- Coupling with event number

Trigger Clock Module



FEC with 4 chips

FEMINOS

256 channels

① MINOS

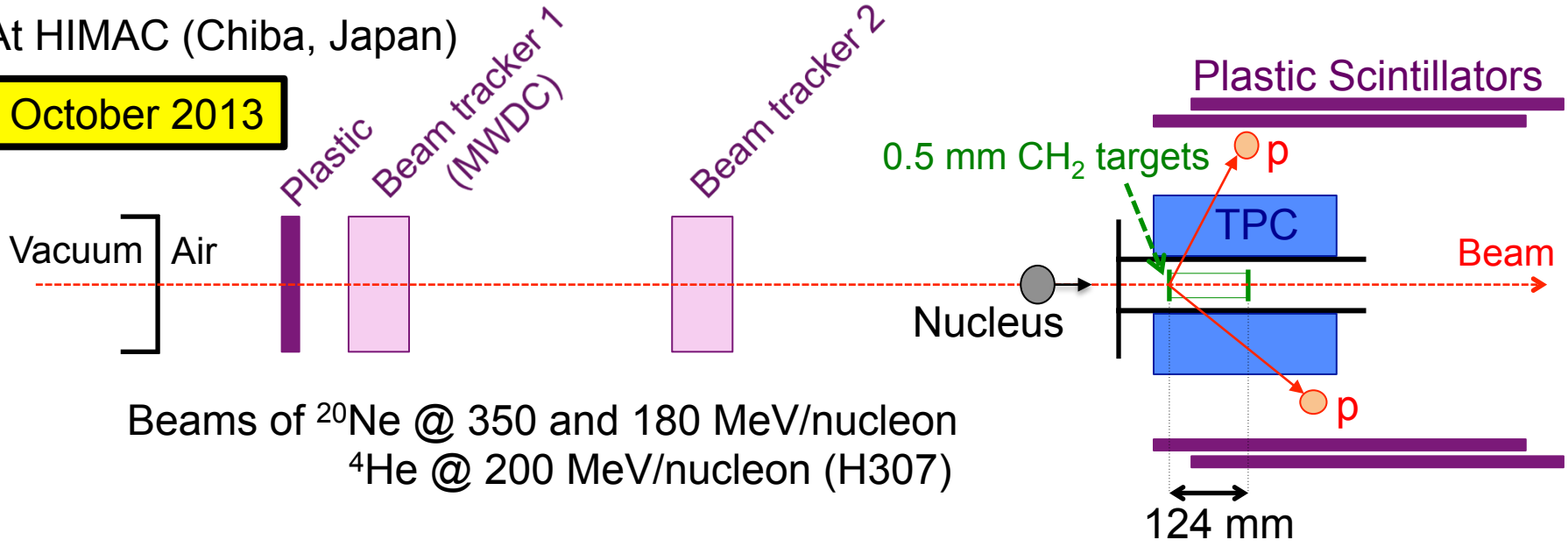
② TPC performances

③ First experiment with MINOS: collectivity beyond N=40

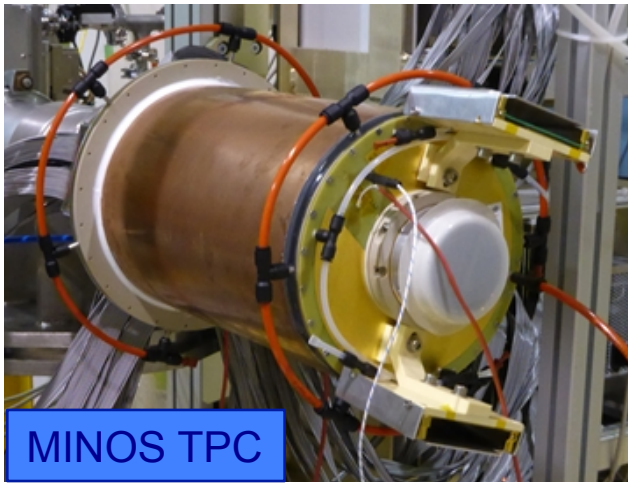
SETUP OF THE PERFORMANCE TEST

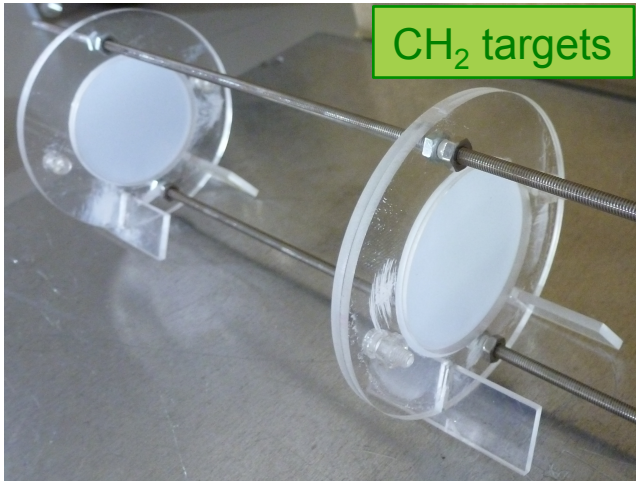
At HIMAC (Chiba, Japan)

October 2013

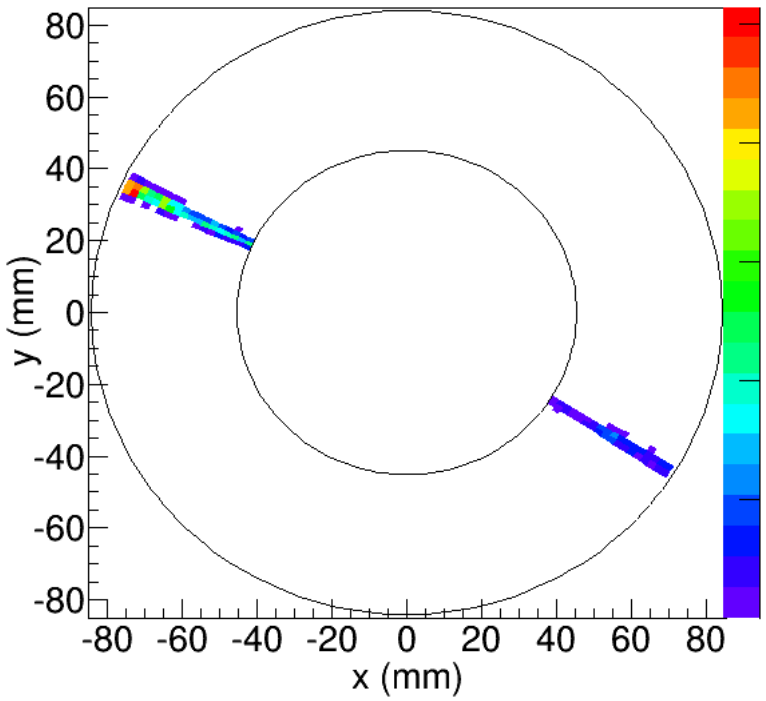


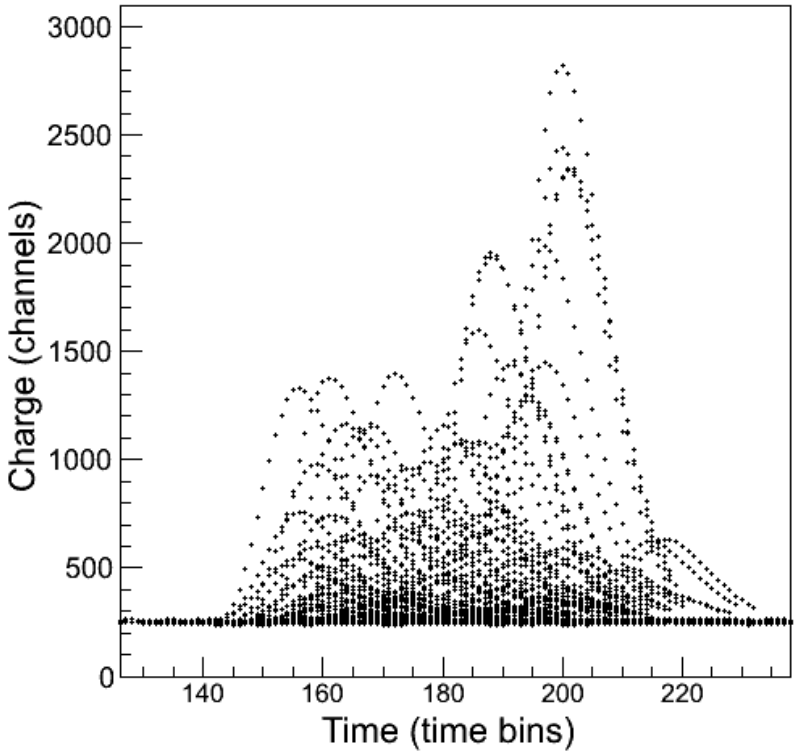
Beams of ^{20}Ne @ 350 and 180 MeV/nucleon
^{4}He @ 200 MeV/nucleon (H307)





TYPICAL EVENT

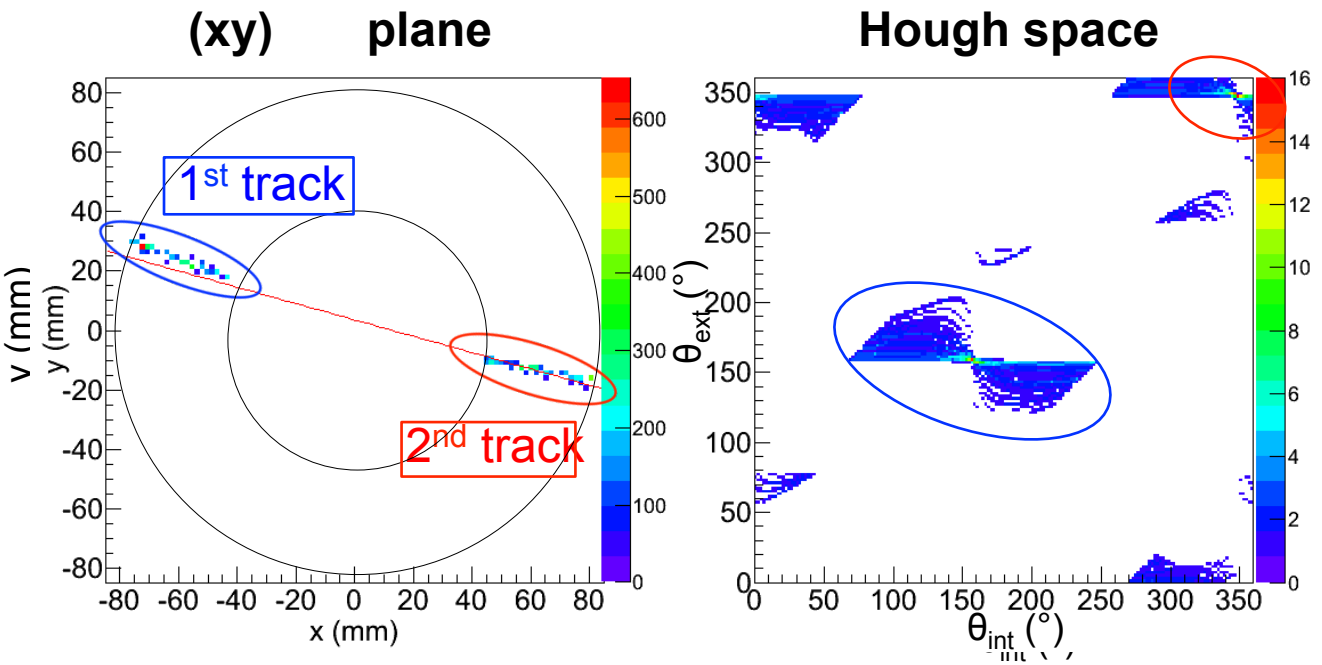




TRACKING ALGORITHM

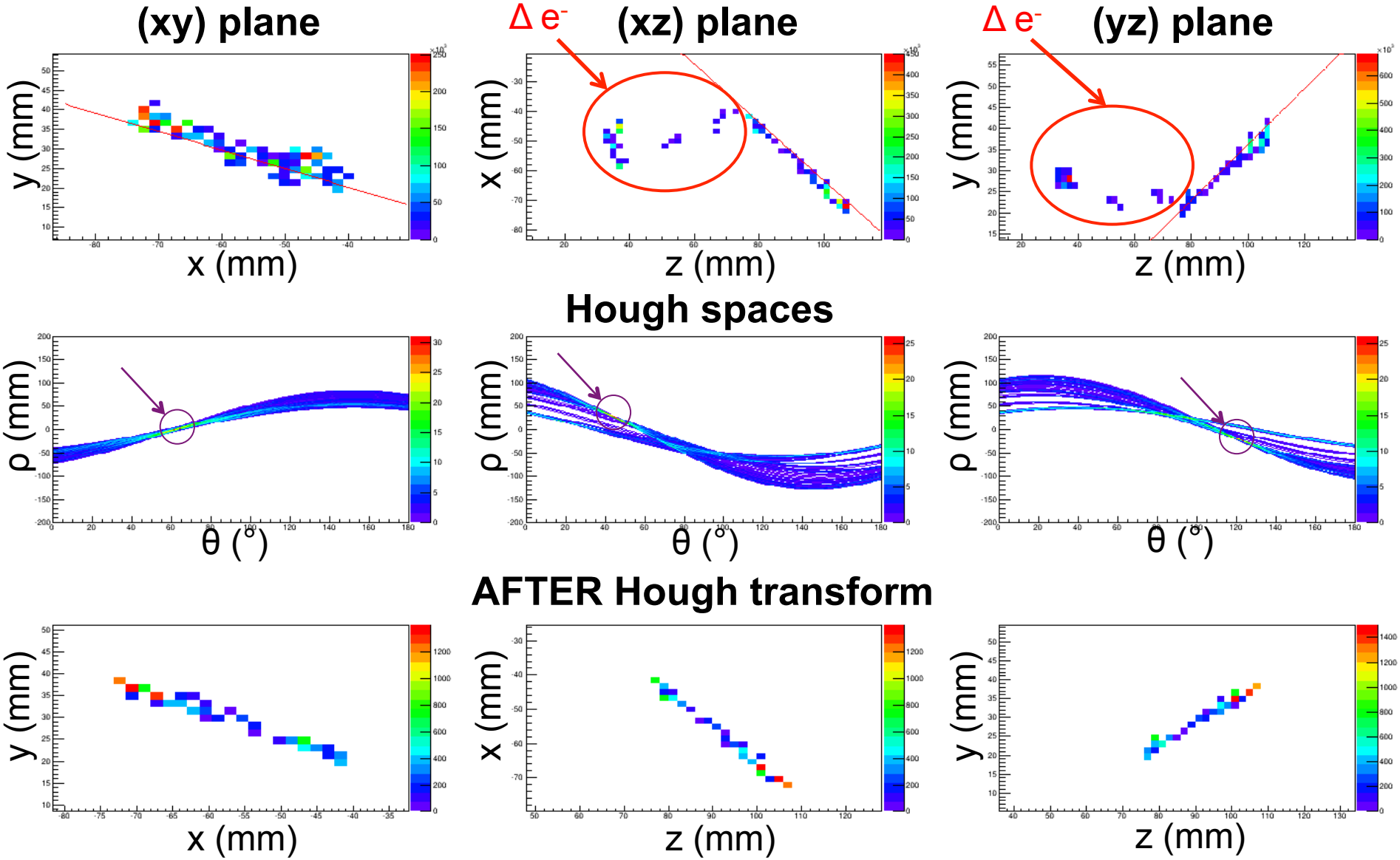
Three steps :
① Find the number of tracks coming from the inner cylinder
② Filter the tracks off possible noise
③ Reconstruct the interaction vertex

① 2D Hough transform : Modified to take into account the detection geometry



② 3D Hough transform : in the three 2D planes (xy) , (xz) , (yz)
③ Linear fit of tracks weighted by charge and vertex reconstruction

TRACKING ALGORITHM



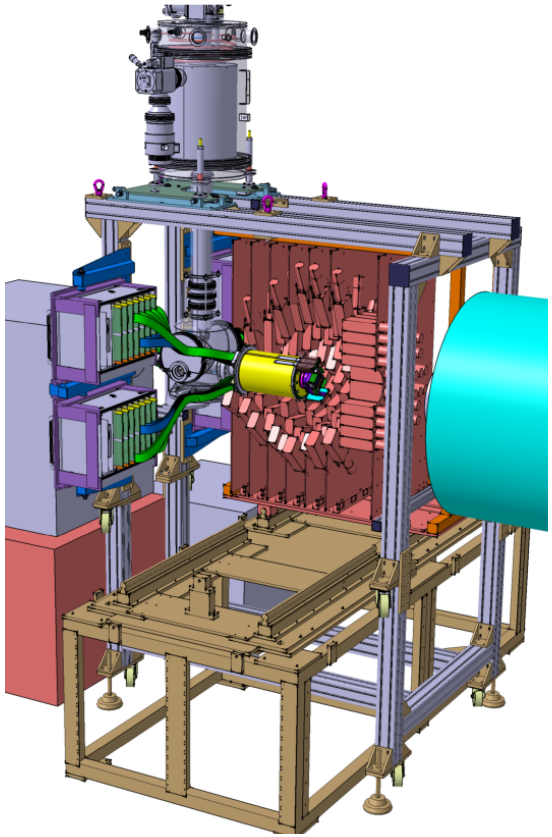
① MINOS

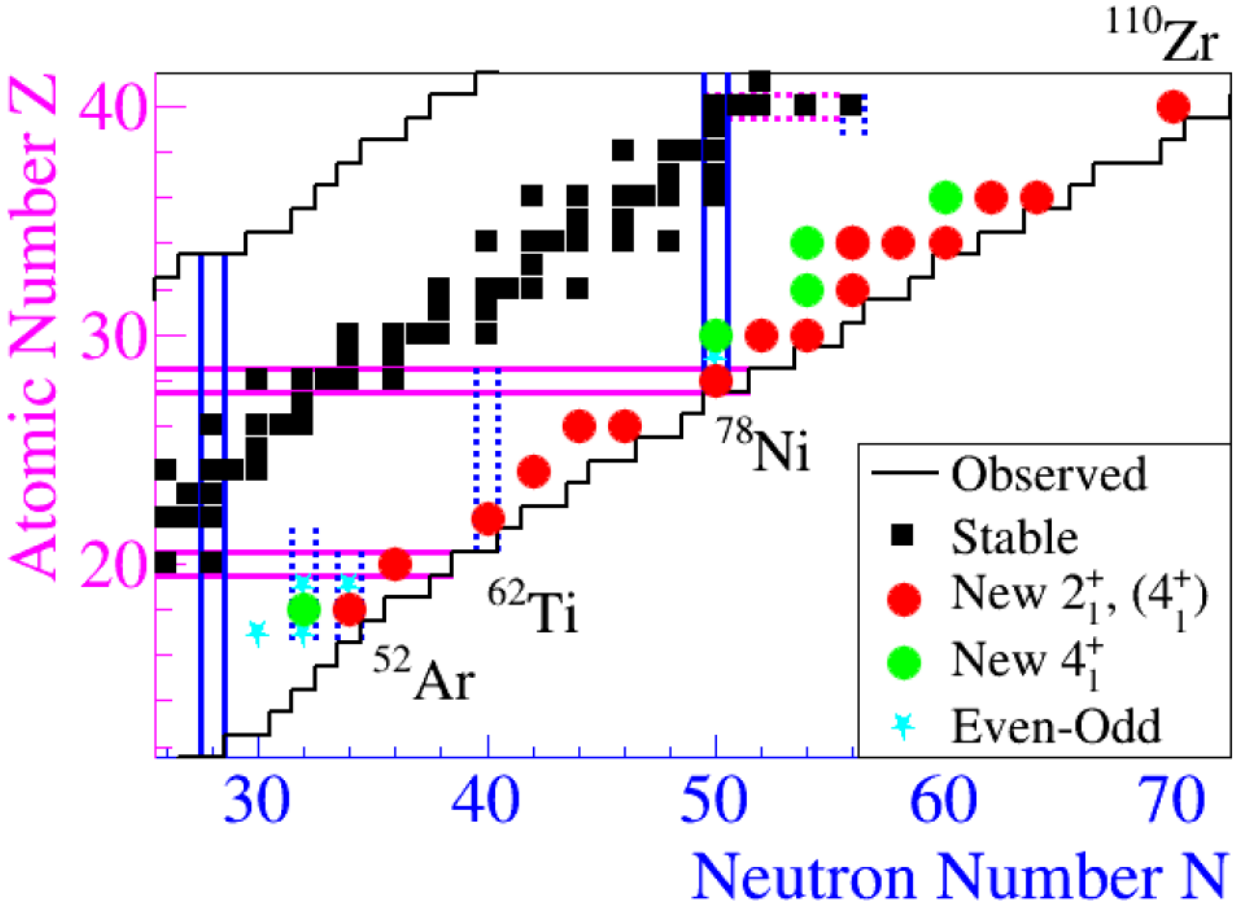
② TPC performances

③ First experiment with MINOS: collectivity beyond N=40

SEASTAR PROGRAM

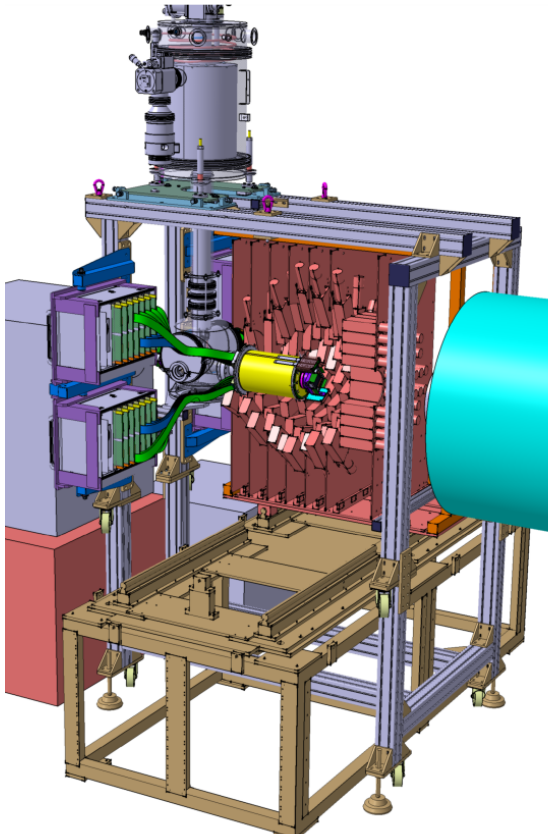
Spokespersons: P. Doornenbal (RIKEN), A. Obertelli (CEA)

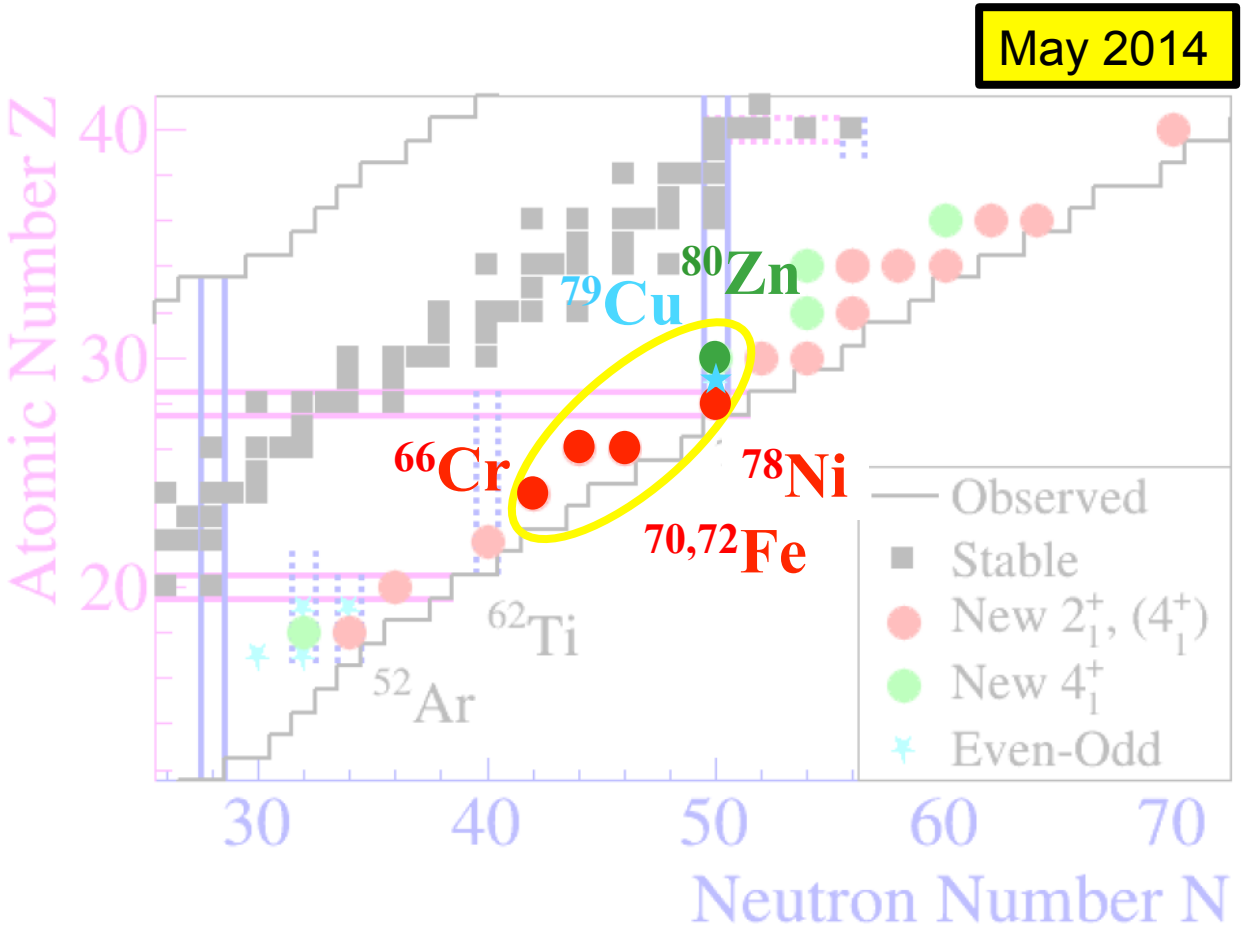




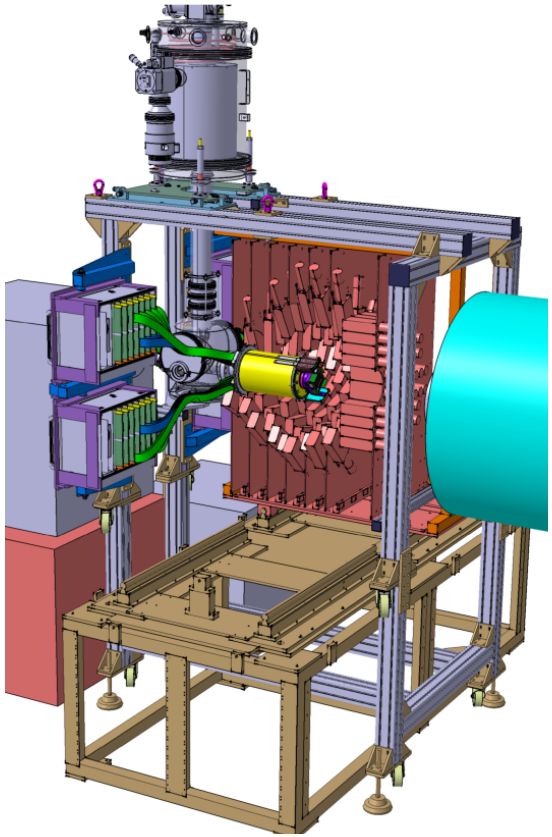
SEASTAR: Shell Evolution And Search for Two-plus states At the RIBF
16 new 2^+ states & 5 new 4^+ states

1ST SEASTAR CAMPAGIN



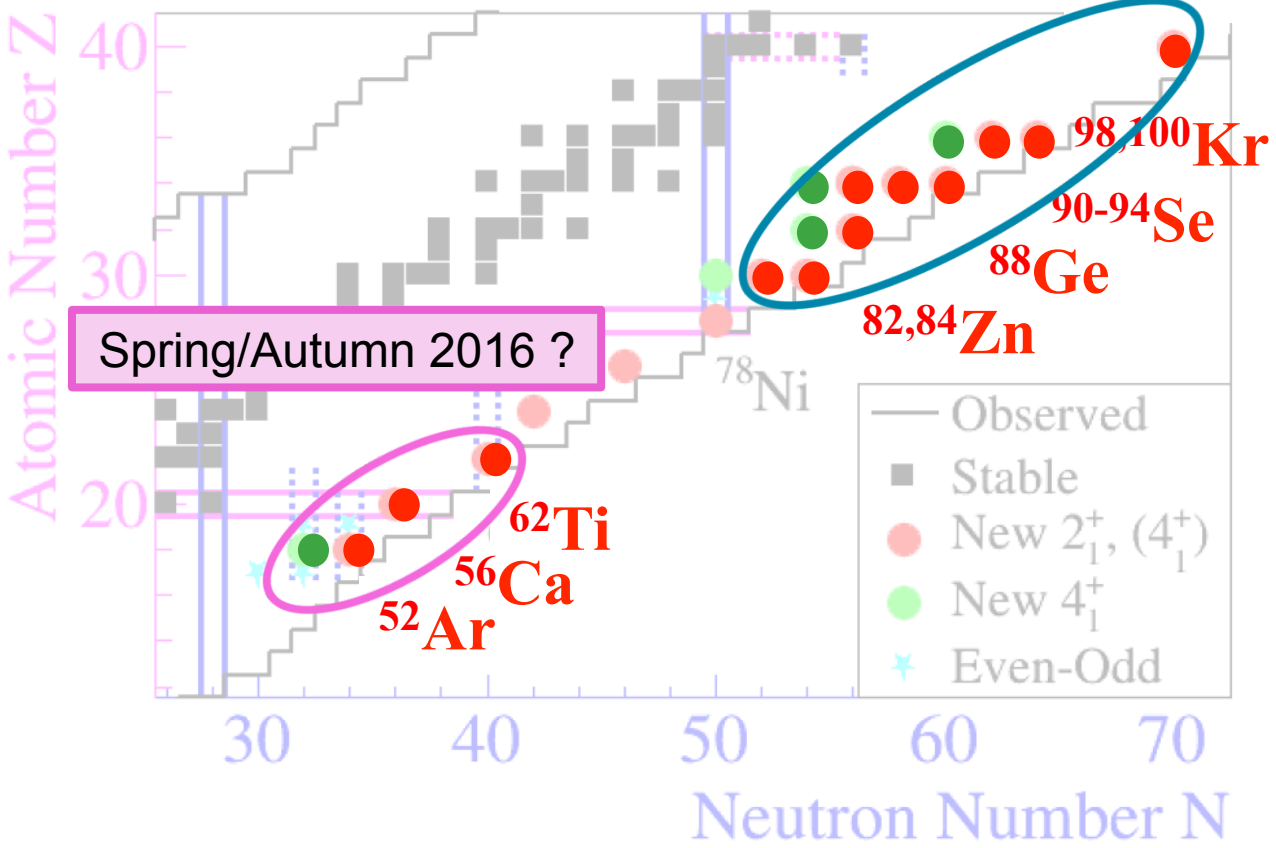


2ND AND 3RD SEASTAR CAMPAIGNS



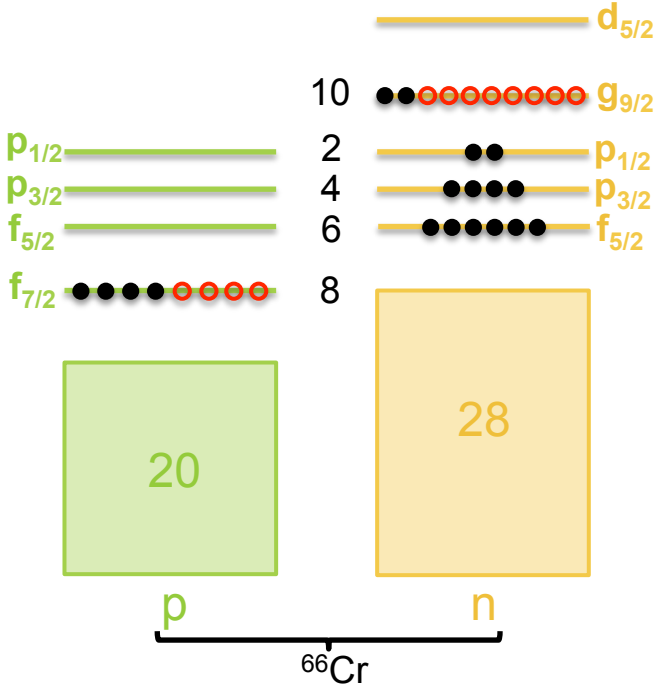
May 2015

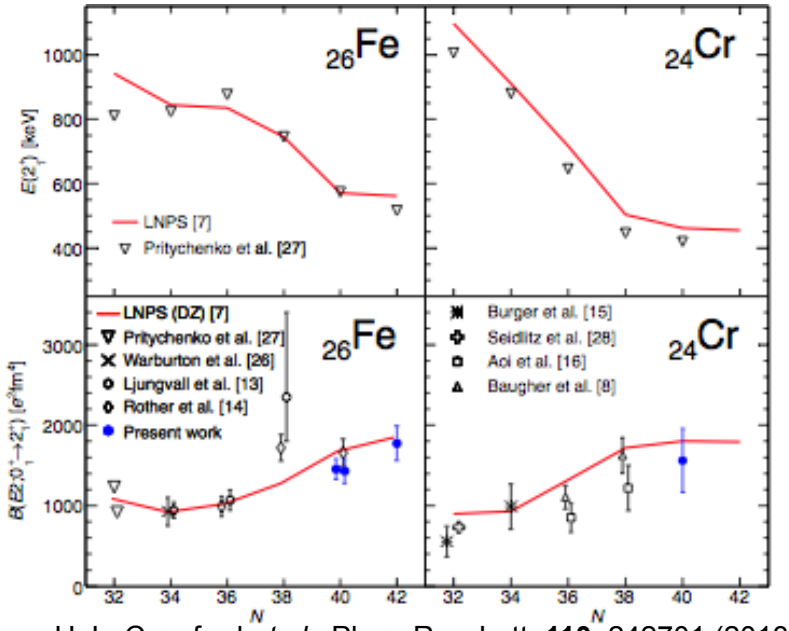
Spring/Autumn 2016 ?



COLLECTIVITY EVOLUTION BEYOND N=40

Development of collectivity at N=40 in Fe and Cr confirmed by recent **measurements** of lifetimes and Coulomb excitations on ^{64,66,68}Fe and ^{64}Cr



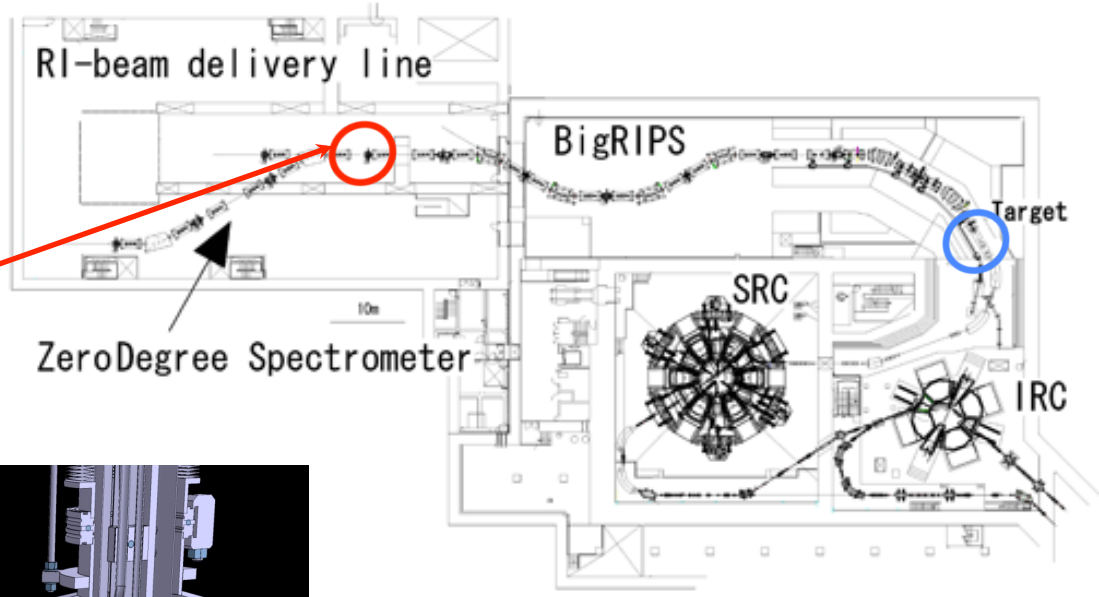


H. L. Crawford *et al.*, Phys. Rev. Lett. **110**, 242701 (2013)

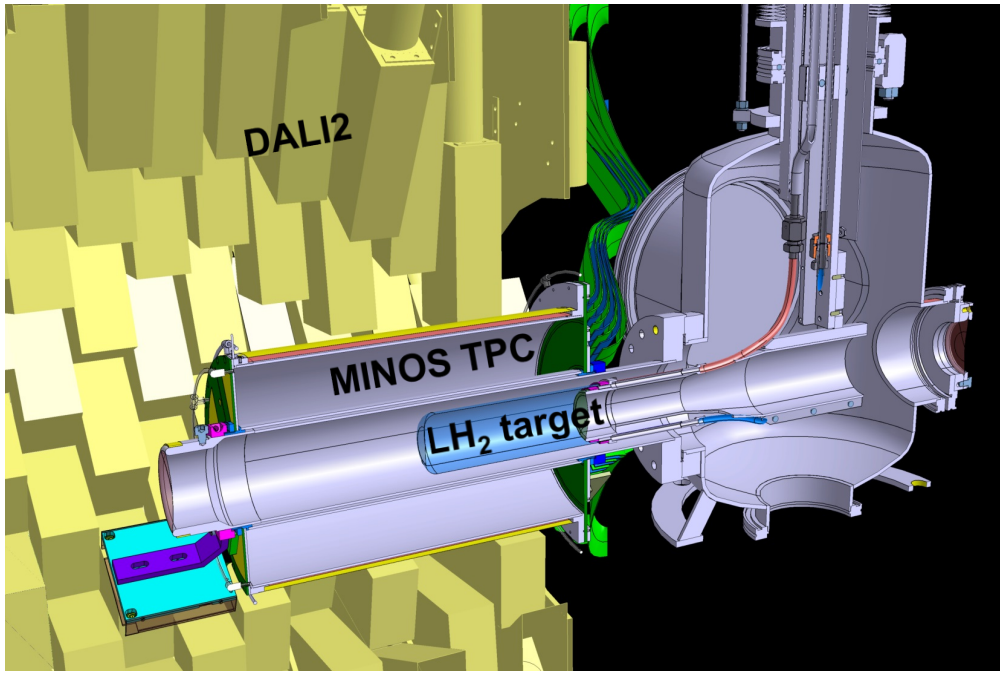
Beyond N=40 :

- Maximum of collectivity ?
- Systematics towards N =50 ?

SEASTAR SETUP



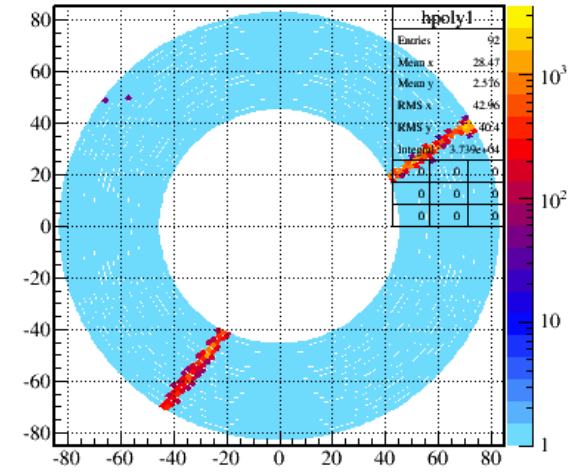
Secondary target in F8
MINOS + DALI2



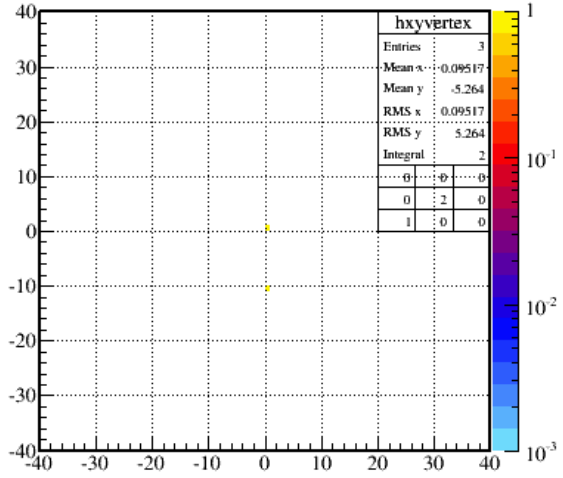
Primary beam: ^{238}U at 345 MeV/nucleon
mean intensity of 13 pnA
F8 energy ≈ 250 MeV/nucleon
Energy at end of target ≈ 200 MeV/nucleon
$\Delta\beta$ = 20%
Total intensity on target ≈ 5000 pps
LH_2 target length = 102(1) mm

ONLINE

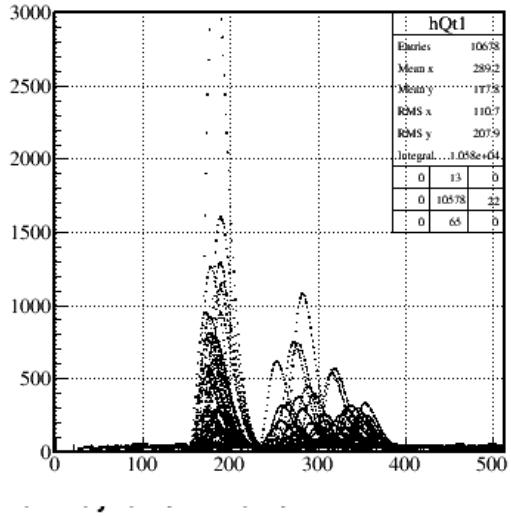
XY view - 1 event



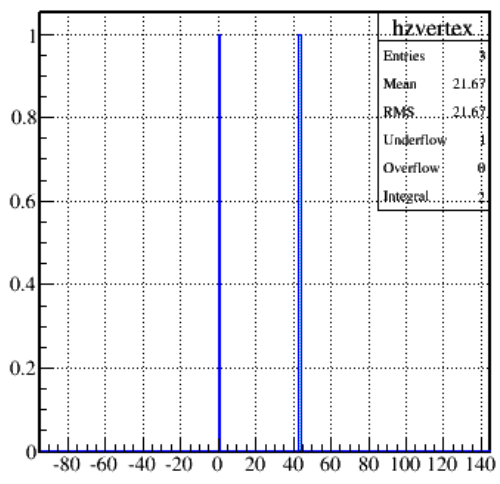
Vertex reconstruction xy



Q(t) signal - 1 event

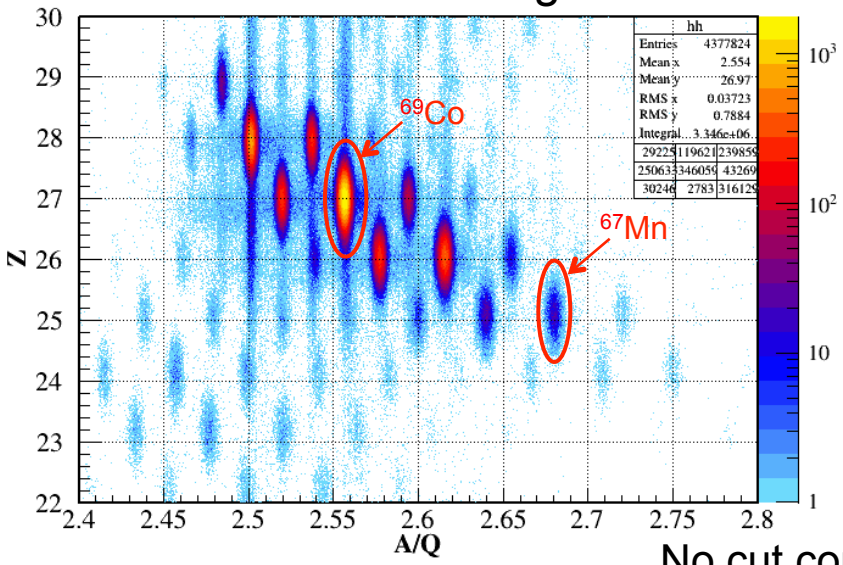


Vertex reconstruction along beam

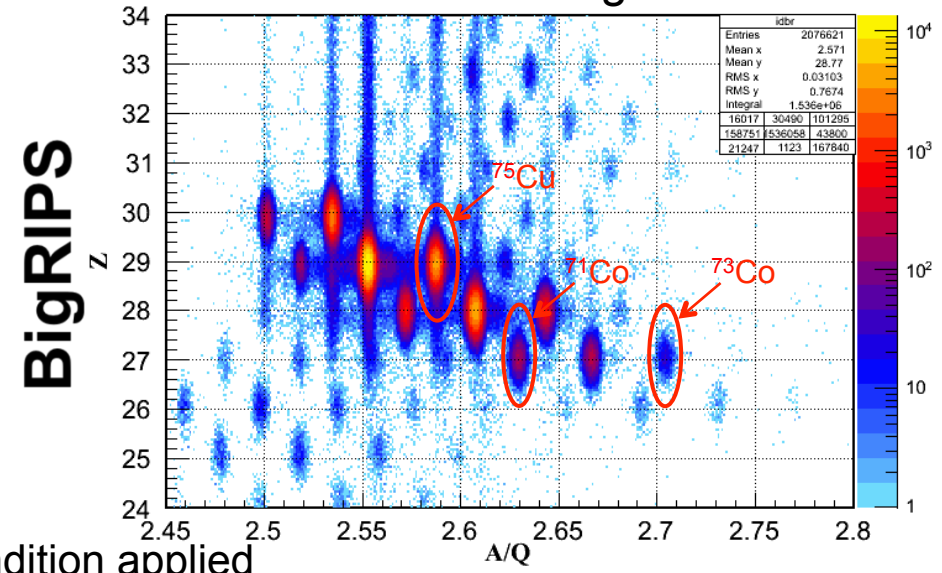


PARTICLE IDENTIFICATION

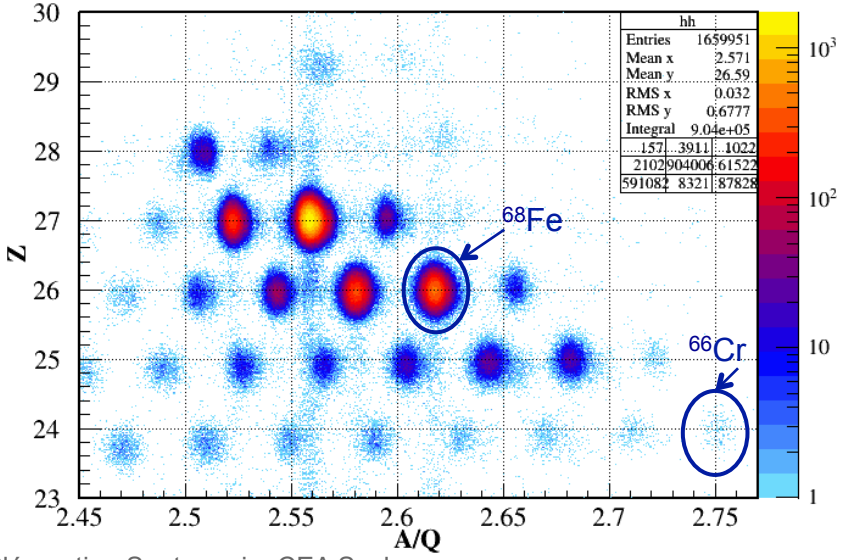
Cr setting

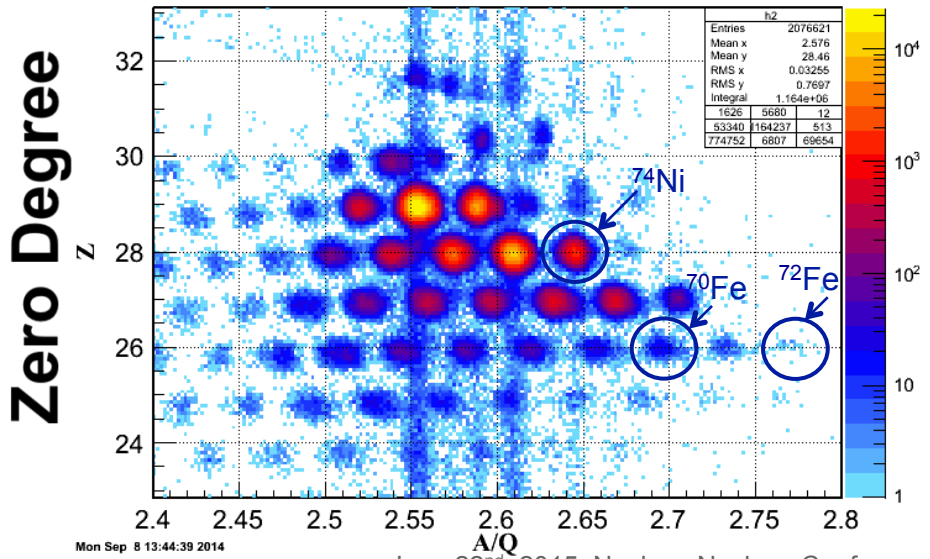


Fe setting



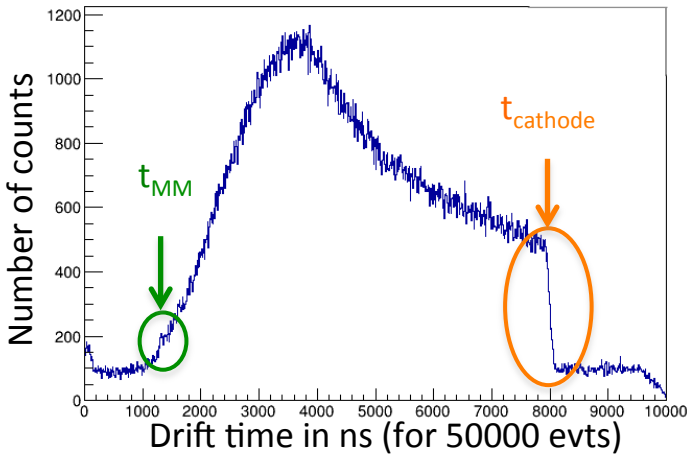
No cut condition applied





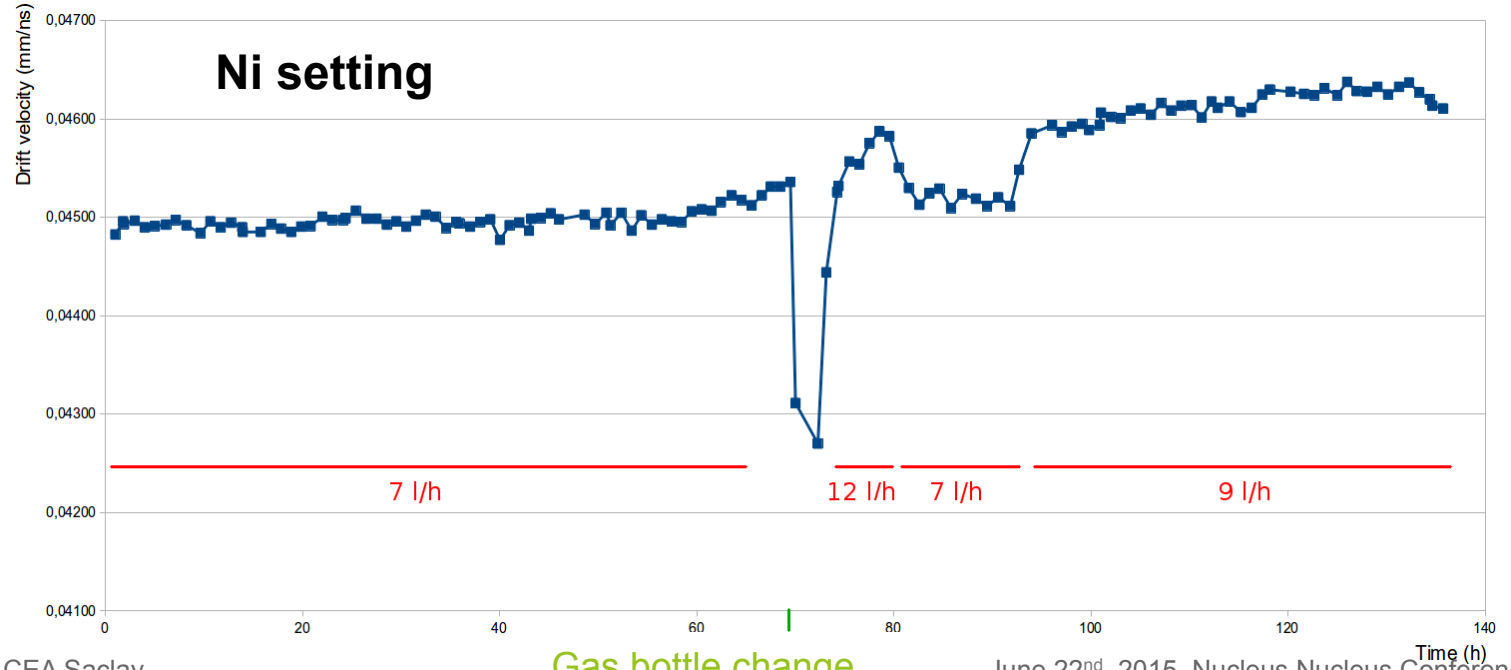
RESULTS: DRIFT VELOCITY

Run during the Cr setting



$$v_{drift} = \frac{L_{TPC}}{t_{cathode} - t_{MM}}$$

In normal conditions :
⇒ 1% /day variation in drift velocity
⇒ 0.8 mm in vertex position



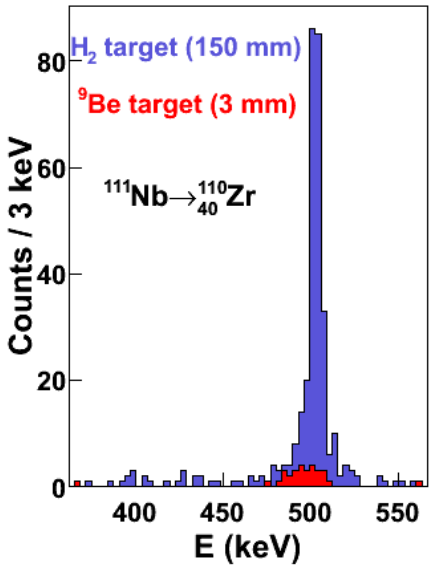
SUMMARY

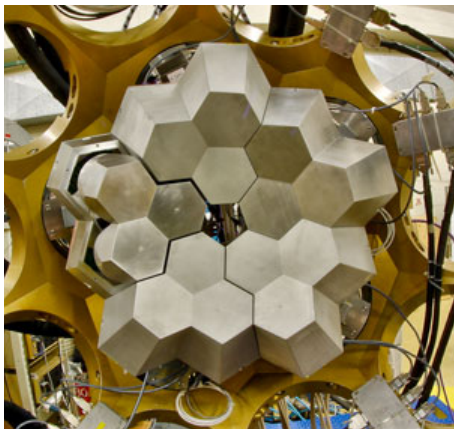
- MINOS TPC operational since 2014
- Vertex resolution below 5 mm, overall efficiency > 90% with physics simulations

Physics program at the RIBF

- First SEASTAR campaign successful (^{66}Cr, ^{70,72}Fe and ^{78}Ni spectroscopy)
- SAMURAI experiment on dineutron correlations in halo nuclei last November
- Second SEASTAR campaign last month (^{238}U with 25 pnA intensity)
- Third SEASTAR campaign on lower-mass nuclei (Spring/Autumn 2016)
- SAMURAI experiment for mass measurement of ^{28}O

- MINOS with new generation high-resolution γ-ray detectors





Simulation at 300 MeV/u
With 10 AGATA TC

THE CEA CREW

Development & Physics

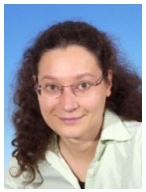

A. Obertelli


A. Corsi


A. Gillibert


C. Santamaria
PhD (2012-15)


E. Pollacco

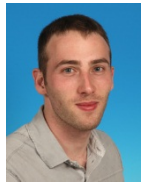

V. Lapoux

SPhN

CC & mechanics


J.-Y. Rousse


D. Loiseau


C. Péron


D. Leboeuf

SIS

Detectors


A. Delbart


A. Peyaud


J.P. Mols


A. Giganon


C. Lahonde


G. Prono

Electronics / DAQ


D. Calvet

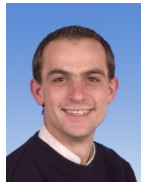

S. Anvar


F. Chateau

SéDI

Target

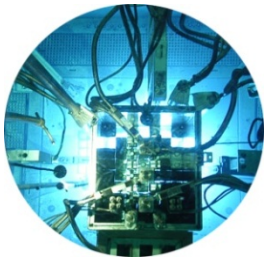

J.-M. Gheller


G. Authelet

SACM

SEASTAR COLLABORATION

CEA Saclay: G. Authelet, D. Calvet, F. Château, A. Corsi, A. Delbart, J.-M. Gheller, A. Giganon, A. Gillibert, C. Lahonde-Hamdoun, V. Lapoux, A. Obertelli, C. Péron, A. Peyaud, E.C. Pollacco, G. Prono, J.-Y. Rousse, C. Santamaria
RIKEN: H. Baba, P. Doornenbal, T. Isobe, H. Liu, M. Matsushita, T. Motobayashi, S. Nishimura, H. Otsu, H. Sakurai, M. Sasano, Y. Shiga, P.A. Soederstroem, H. Suzuki, S. Takeuchi, T. Uesaka, H. Wang, J. Wu, K. Yoneda
TU Darmstadt: M. Lettmann, C. Louchart, V. Werner
ATOMKI: Z. Dombradi, Z. Elekes, Z. Korkulu, Z. Vajta
Brighton : F. Browne
CNS: Y. Kubota, S. Ota, D. Steppenbeck
INST, Hanoi: L. X. Chung
IPHC: R. Lozeva
IPN Orsay: S. Franchoo, A. Gottardo, L. Olivier, G. J. Stefan, D. Suzuki
RCNP : N. Aoi
Surrey : Z. Patel, Podolyak, C. Shand
Tohoku University : T. Sumikama
University of Edinburgh : A. Estrade
University of Hong Kong : J. Lee, Z. Xu
University of Oslo: F. Giacoppo, K. Hadynska-Klek, E. Sahin
University of Tokyo: T. Ando, S. Koyama, Y. Kubota, K. Matsui, T. Miyazaki, S. Momiyama, M. Niikura, R. Taniuchi



Thank you for your attention

Commissariat à l'énergie atomique et aux énergies alternatives
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