Nuclear Physics and Applications

presented by Dr. A. Lagoyannis
on behalf of the NPA Group

CALIBRA

Cluster of Accelerator Laboratories for Ion-Beam Research and Applications - CALIBRA

Single-sited NRI hosted by NCSR “Demokritos”
currently implemented through the CALIBRA project

CALIBRA


5.5 MV Tandem Accelerator

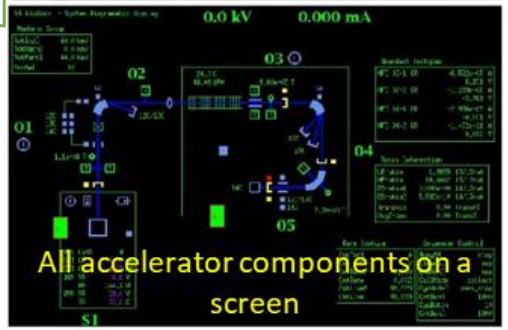

TORVIS multicusp ion source


Convertion to PELLETRON ;
Replacement of existing belt


Full remote control of the accelerator via PC (AccelNET system)

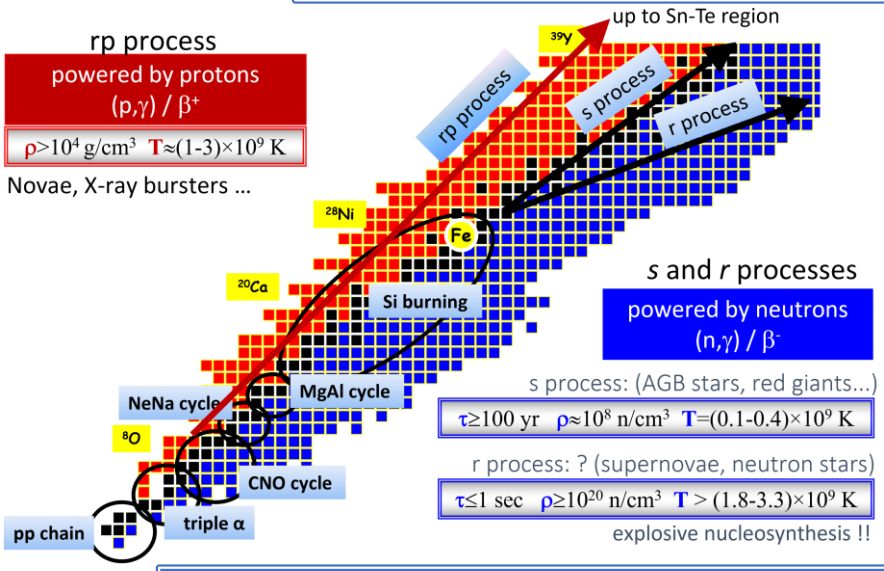

SNICS Sputter source

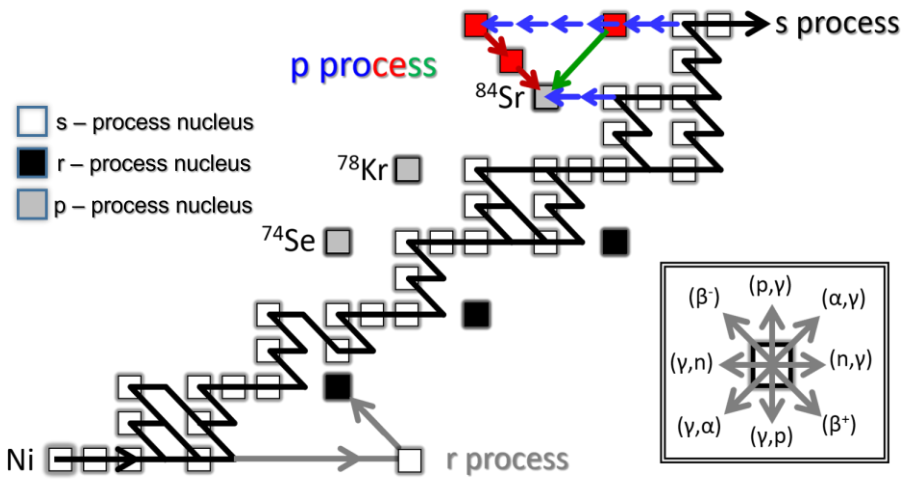

Convertion to Pelletron already performed at the "sister" 5.5. MV Tandem accelerator of Athens, Ohio, USA


0.0 kV
0.000 mA
All accelerator components on a screen

Nuclear Astrophysics (p process: the astrophysical point-of-view)

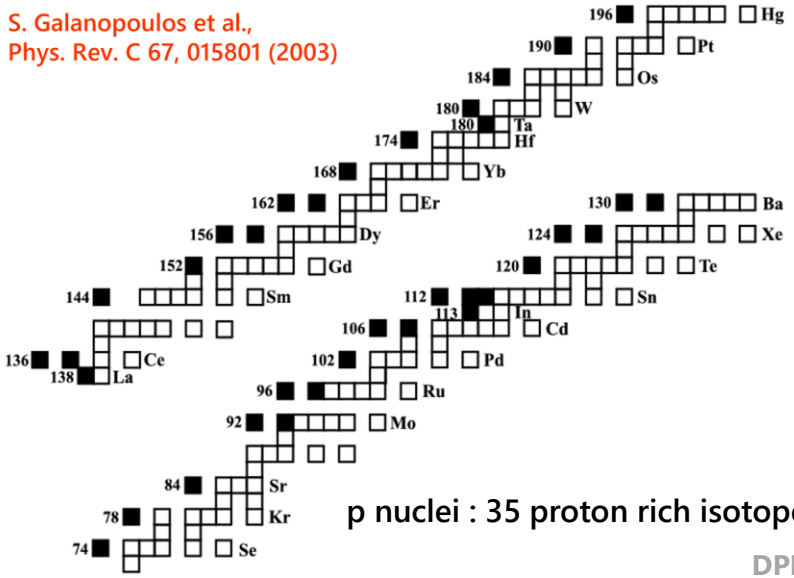
burning cycles and nucleosynthesis across the table of isotopes





p nuclei and their abundances are signatures of the creation of our solar system

S. Galanopoulos et al.,
Phys. Rev. C 67, 015801 (2003)



p nuclei : 35 proton rich isotopes

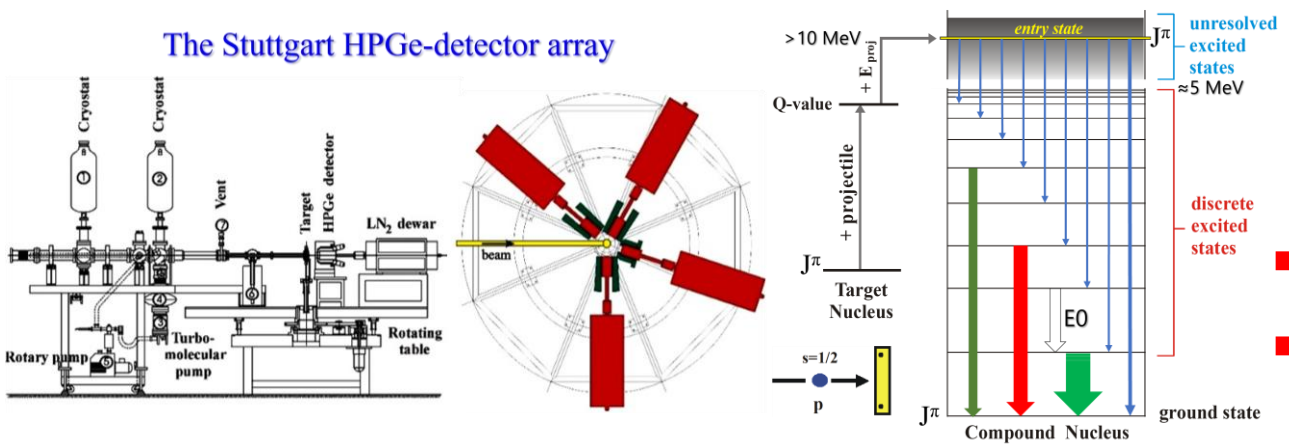
p nucleus	(%)	p nucleus	(%)	p nucleus	(%)
74_Se	0.89	114_Sn	0.65	156_Dy	0.06
78_Kr	0.35	115_Sn	0.34	158_Dy	0.10
84_Sr	0.56	120_Te	0.096	162_Er	0.14
92_Mo	14.84	124_Xe	0.10	164_Er	1.61
94_Mo	9.25	126_Xe	0.09	168_Yb	0.13
96_Ru	5.52	130_Ba	0.106	174_Hf	0.162
98_Ru	1.88	132_Ba	0.101	180_Ta	0.012
102_Pd	1.02	138_La	0.09	180_W	0.13
106_Pd	1.25	136_Ce	0.19	184_Os	0.02
108_Cd	0.89	138_Ce	0.25	190_Pt	0.01
113_In	4.3	144_Sm	3.1	196_Hg	0.15
112_Sn	0.97	152_Gd	0.20		

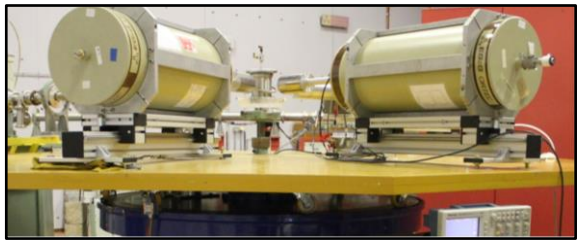
Solar system p-nuclei abundances

Nuclear Astrophysics (σ-measurements: our methods & tools: 1/2)

details in review paper by: Sotirios V Harissopulos, Eur. Phys. J. Plus 133, 332 (2018) https://doi.org/10.1140/epjp/i2018-12185-8

1) γ-angular distribution measurements



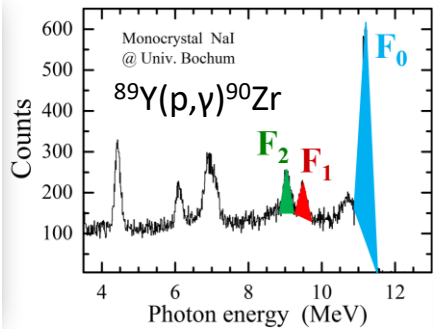


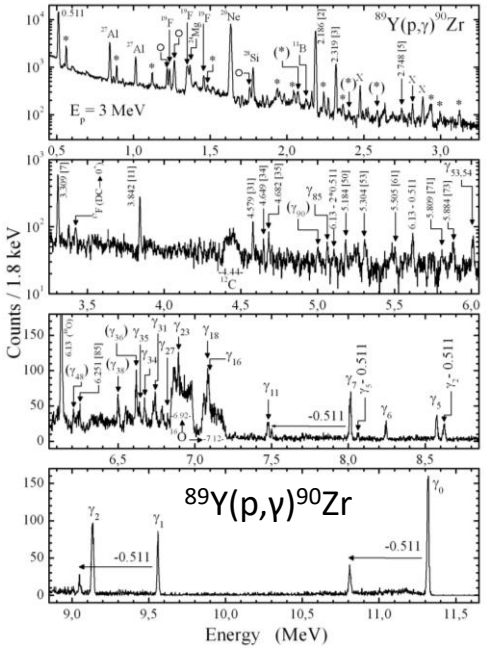
HPGe array now shared between Demokritos – U. Cologne – TU Darmstadt

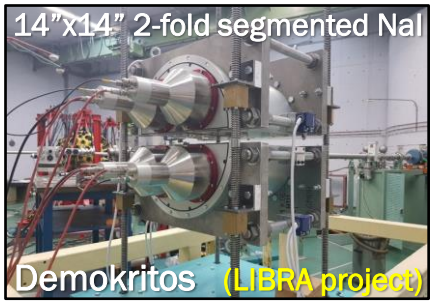
CALIBRA: acquired 3x new HPGe (80%) with BGO Anti-Compton shields

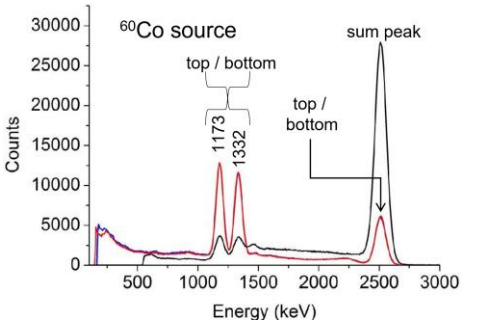
2) 4π γ-summing technique

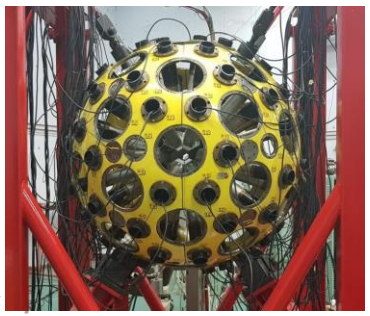
Developed by our Group: A. Spyrou *et al.*, Phys. Rev. C 76, 015802 (2007); http://dx.doi.org/10.1103/PhysRevC.76.015802





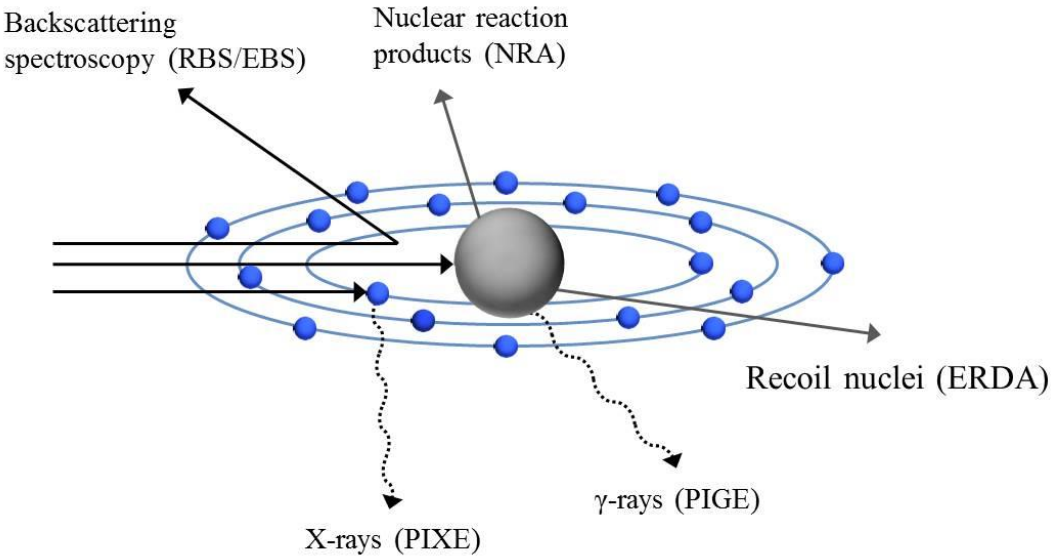






GASPAR Ball (80x BGO Crystals)
loaned by INFN/LNL Italy

Ion Beam Analysis



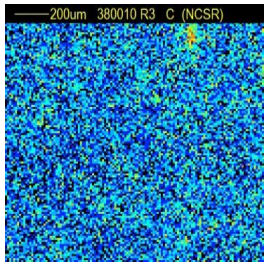
- Ion Beam Analysis (IBA) is based on the interaction of a high-energy charged particle with the electrons and the nuclei of the material atoms.
- This interaction can lead to the emission of particles or radiation the energy of which is characteristic of the elements that constitute the sample material.

Method	Interaction	Ideal for
Backscattering Spectrometry (**RBS/EBS**)	Elastic scattering at backward angles	Depth profiling of heavy elements in light or medium-Z matrices
Elastic Recoil Detection Analysis (**ERDA**)	Elastic recoil at forward angles	Depth profiling of light elements
Nuclear Reaction Analysis (**NRA**)	Nuclear reaction between beam and target nuclei, producing a light charged particle	Depth profiling of light elements in high- or medium-Z matrices
Particle-Induced Gamma–ray Emission (**PIGE**)	Prompt γ-ray emission during ion beam irradiation	Bulk analysis of light elements from hydrogen to silicon
Particle-Induced X-ray Emission (**PIXE**)	Characteristic X-ray emission following ionization by the primary beam	Bulk analysis of elements with Z>11

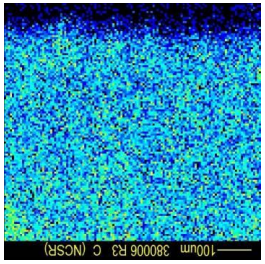
Ion Beam Analysis (JET results)

IWGL (27)

Surface

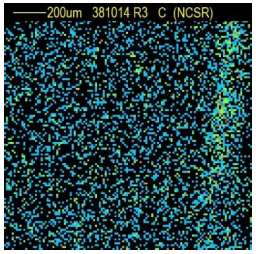


Castellation

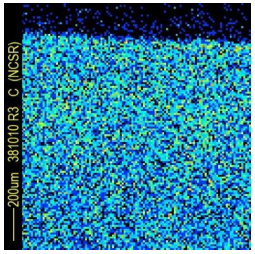


IWGL (174)

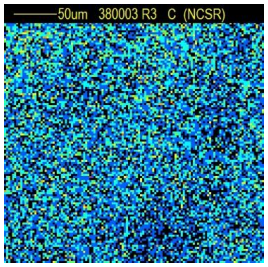
Surface

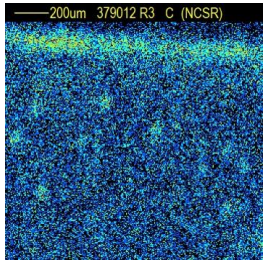


Castellation

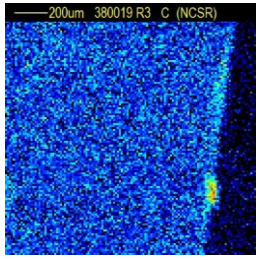


DP (80)

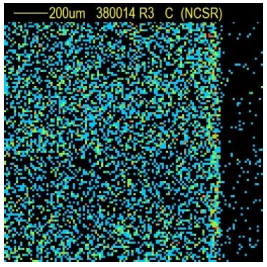


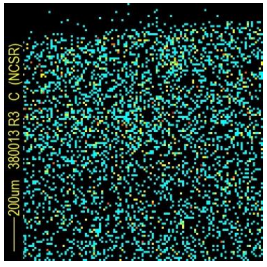


IWGL (191)

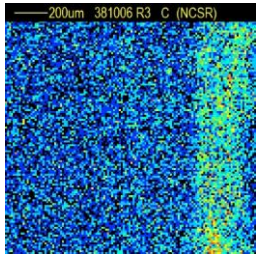


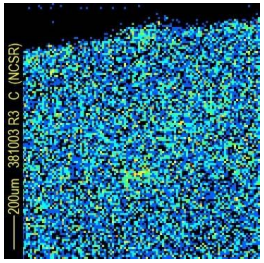
OPL (120)



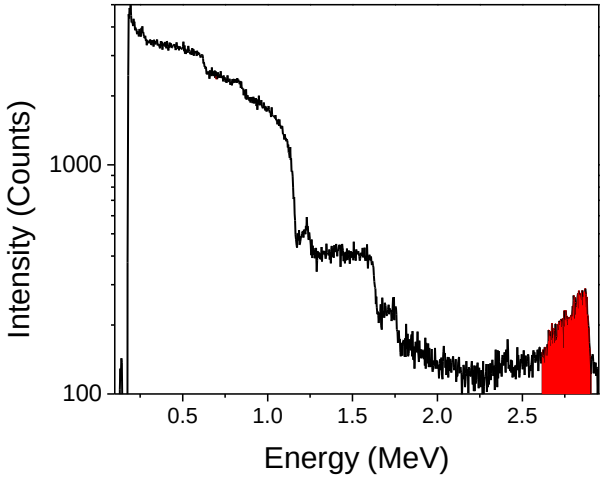


OPL (320)





Ion beam analysis using ^{2}H microbeam of 1.35 MeV and spot size 50×50 μm^2



In some surfaces & castellation sides carbon agglomerates of about 50-200 μm diameter are observed.

WHY:

To pass from troublesome method using standars to a standardless one

HOW:

- Measurement of Differential Cross Sections for light Elements
- Development of a code for bulk analysis

- Electronically controlled turntable
- Initial angles: 0º – 55º – 90º - 165º
- 4 HPGe detectors placed 30 cm from target
- Air cooled target

$^{10}B(p,\alpha\gamma)^{7}Be$