

Nuclear Science

Session 1



What *is* nuclear physics...?





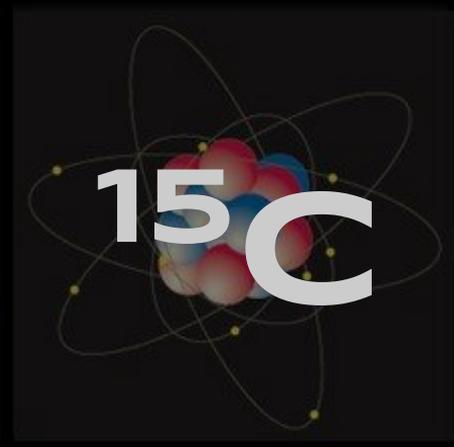
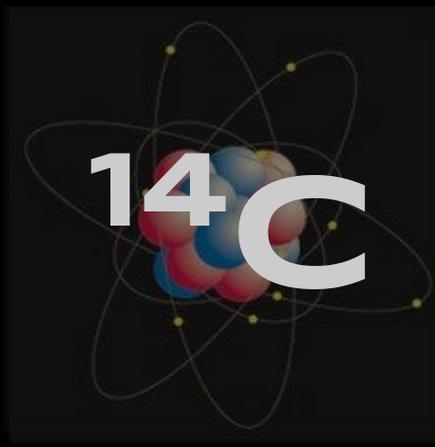
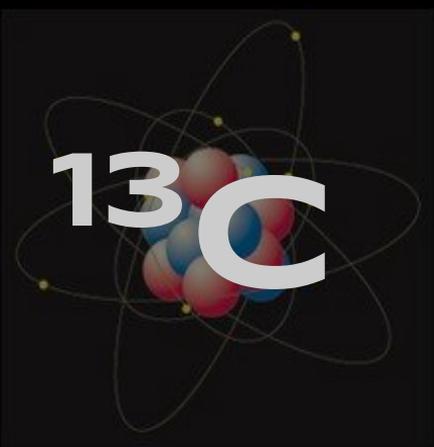
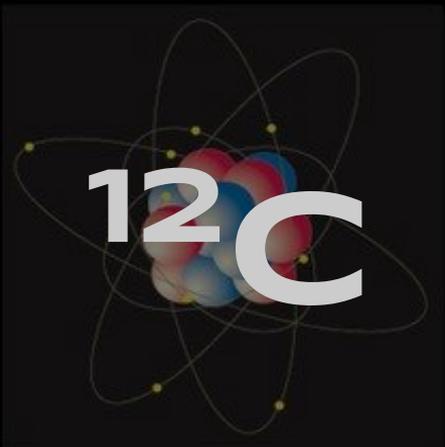
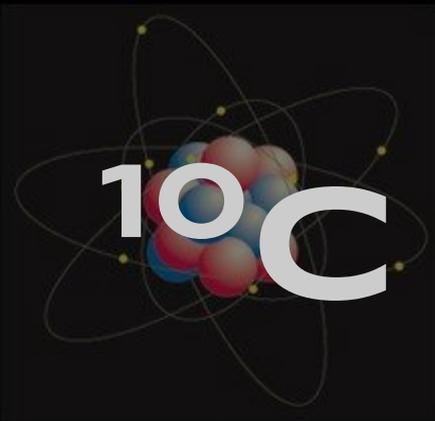
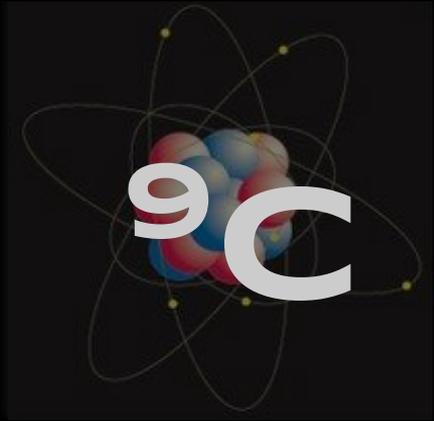
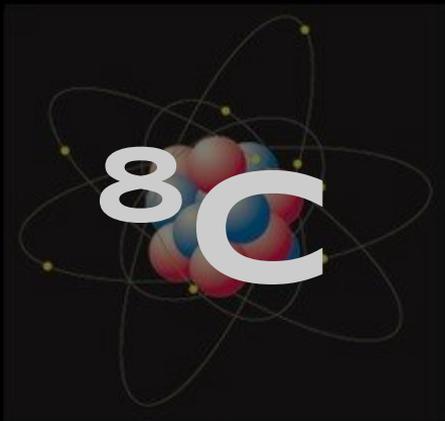
What is an element?



What is an atom?

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
↓Period																			
1	1 H																		2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo	
Lanthanides			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
Actinides			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		

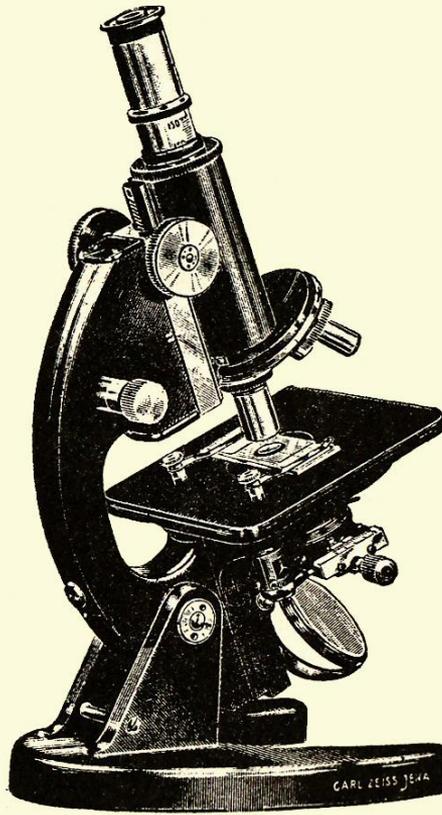
The Periodic Table of Elements



What is an isotope?

Group→	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18															
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1	1 H																	2 He															
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Lanthanides	<table border="1"> <tr> <td>57 La</td> <td>58 Ce</td> <td>59 Pr</td> <td>60 Nd</td> <td>61 Pm</td> <td>62 Sm</td> <td>63 Eu</td> <td>64 Gd</td> <td>65 Tb</td> <td>66 Dy</td> <td>67 Ho</td> <td>68 Er</td> <td>69 Tm</td> <td>70 Yb</td> <td>71 Lu</td> </tr> </table>																		57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
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Actinides	<table border="1"> <tr> <td>89 Ac</td> <td>90 Th</td> <td>91 Pa</td> <td>92 U</td> <td>93 Np</td> <td>94 Pu</td> <td>95 Am</td> <td>96 Cm</td> <td>97 Bk</td> <td>98 Cf</td> <td>99 Es</td> <td>100 Fm</td> <td>101 Md</td> <td>102 No</td> <td>103 Lr</td> </tr> </table>																		89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
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How many isotopes are there?



Why is it hard to study nuclei?

Whether a particular nucleus decays or not is a random event, like rolling a 6 on a dice.

*Start with everyone standing,
if you roll a 6, sit down.*



Name	What?	Characteristics
Alpha, α 	Helium nucleus (2 protons and 2 neutrons)	Heavy, easily stopped, very ionising.
Beta, β 	Electron	Light, quite easily stopped, lightly ionising.
Gamma, γ 	Electromagnetic radiation	Energy (no mass), very hard to stop.

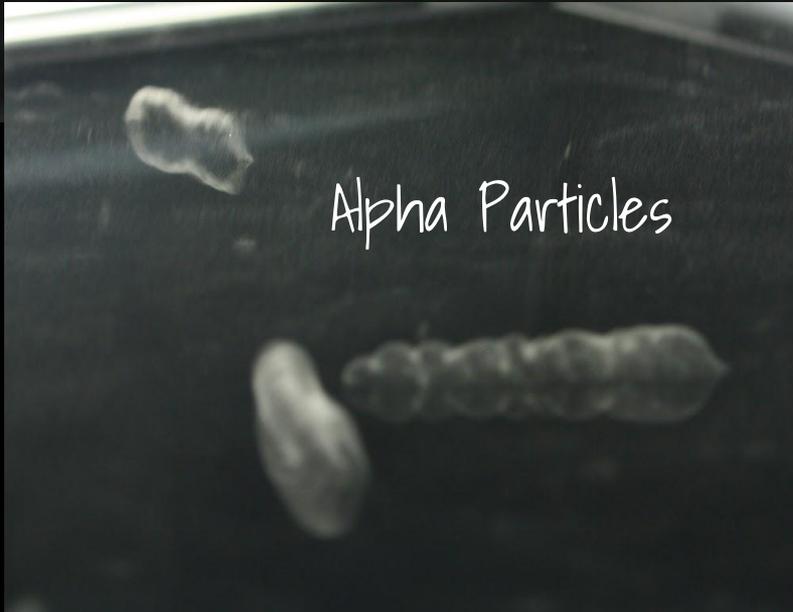


Cloud Chamber

Cosmic Ray



Alpha Particles



Beta Particles





What is activity?

One thing we do when we find a new isotope is determine its **half-life**.



After 1 half-life.

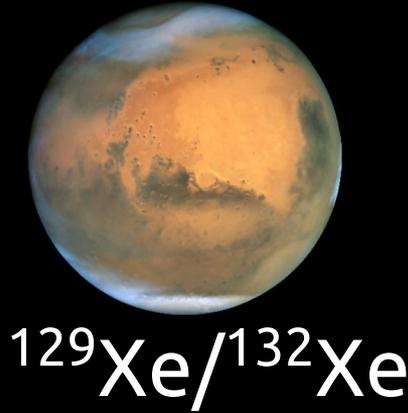
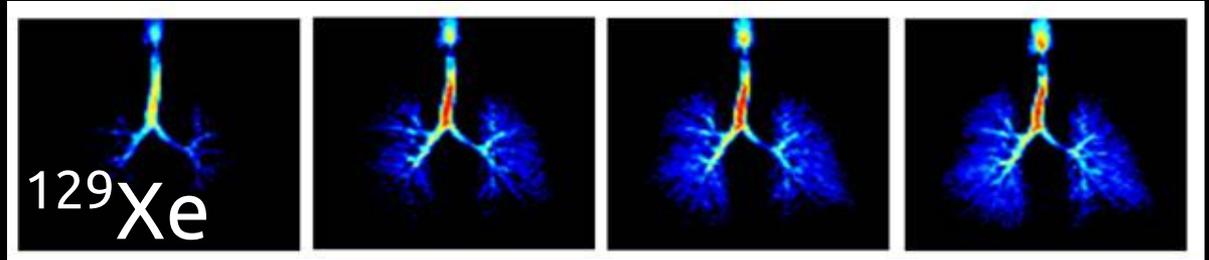


After 2 half-lives.

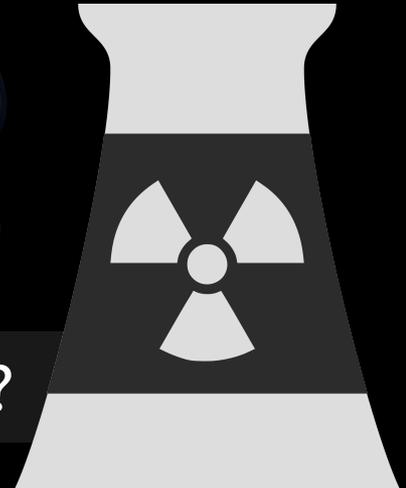


After 3 half-lives.

Case study: Xenon



^{135}Xe



Why do we want to learn about different isotopes?

HAEK No. 20-83-31



Answering fundamental questions.



Oak Ridge National Laboratory, USA



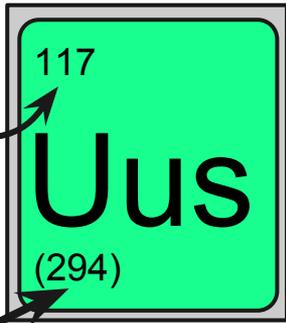
Joint Institute for Nuclear Research, Russia



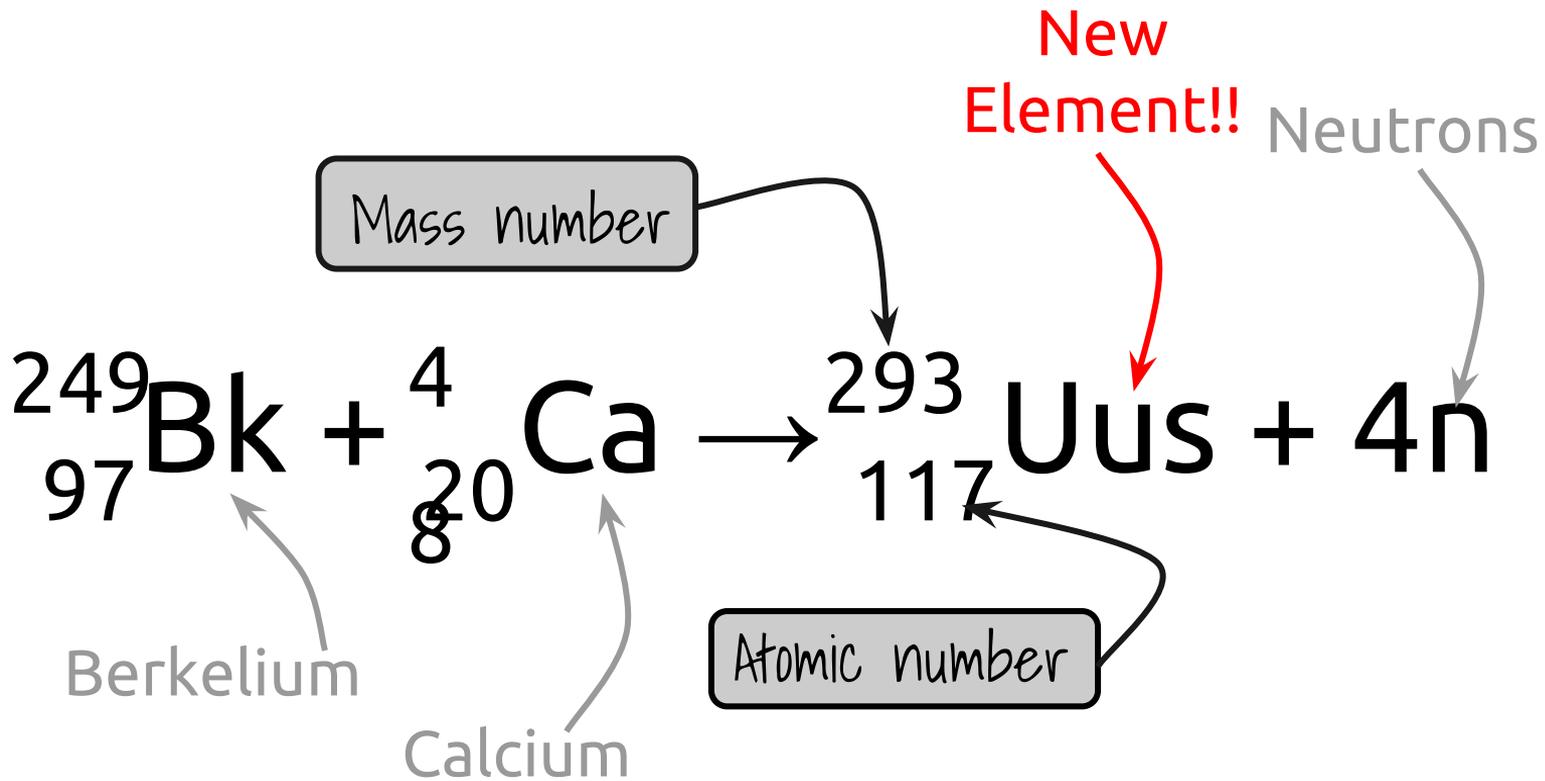
GSI Helmholtz Centre for Heavy Ion Research, Germany

Atomic number

Mass number



Discovering new elements.



Nuclear Reaction

Isotope properties

The **half-life** and **decay modes** (how the isotope decays) are *properties* of the isotope.

It is also important to consider the ***elemental*** and ***group properties*** when choosing the correct isotope for an application.

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Learning Objectives

- Nuclear physics is the study of nuclei.
- Atoms have nuclear properties as well as chemical properties.
- Nuclear properties include the decay mode and the half life.
- Knowing the nuclear properties of a particular isotope helps us identify it.
- Different isotopes of the same element can have different uses.
- Scientists can make new elements and isotopes of elements.