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Development of a Krypton Target for Cyclone-30 at KFSH&RC

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Contents

- King Faisal Specialist Hospital and Research Center was established on land donated by King Faisal and was opened by King Khalid in 1975 with a current total land area of 920,000 square meters.

- KFSH&RC has over 11,000 employees, of 63 different nationalities

- KFSH&RC is in possession of three medical cyclotrons.

Cyclotrons at KFSHRC

The CS30

-Installed in 1979
-Positive Ions (P,d, alpha and He)
-26 MeV (Fixed energy)

The RDS-111

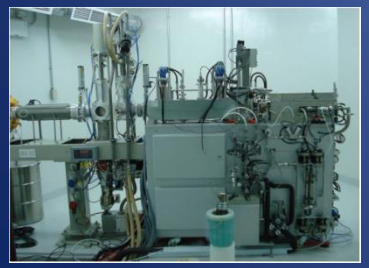
-Installed in 2005
-Self shielded
-Negative ions
-11 MeV

The C-30

-End of 2010
-Negative ions
- 30 MeV (Variable energy)

Outputs radioisotopes

Tl-201	Ga-67	I-123	I-124	Rb-81m	F-18	N-13
γ 135, 167	γ 93,184,300	γ 159	γ 511,602	γ 49,190,446,511	γ 511	γ 511
73.6 Hours	78.2 Hours	13.2 Hours	100.2 Hours	4.57 Hours	110 Minutes	10 Minutes

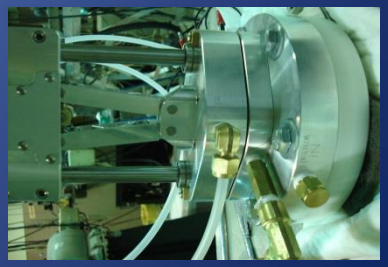


xenon Target
ZAG AG

N-13

Krypton target

Solid target
(Th-201 ,Ga-67 and I-124)

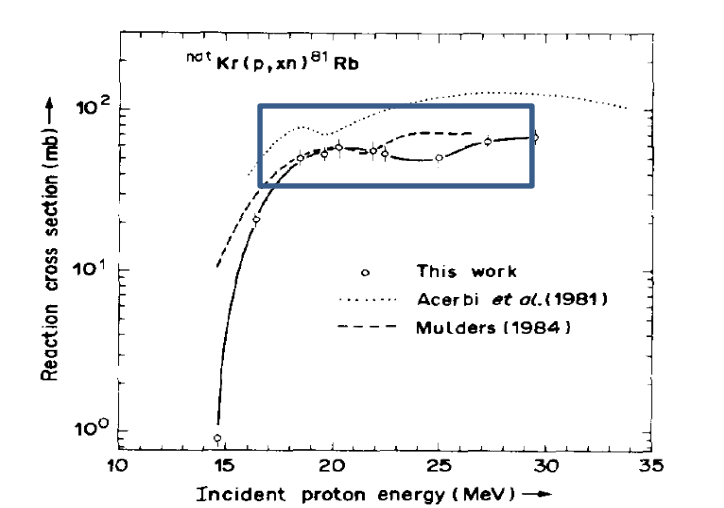


Design Parameters

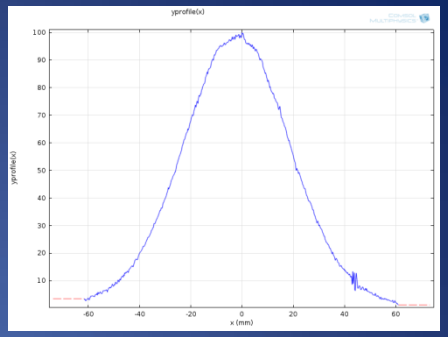
- Following reaction is chosen: $^{Nat}Kr(p,xn)^{81}Rb$
- The effective cross section of producing ^{81}Rb is between 15 and 26 MeV .
- Range and stopping power of the effective cross section were calculated with respect to a gas density of 0.0185 g/cm^3. This value is equivalent to a gas density of 5.0 bar of pressure before irradiation.
- SRIM has suggested a range of 589 mm. However, due to limitation in fabricating such value in our machine shop, the target length is chosen to be 250 mm. Attached to the end of target body is a special water circulating flange 'backpool', its purpose is to absorb the rest of the energy and protons Bragg peak.
- The target body should be made of Aluminum with the inner part being electroplated with nickel.
- The target body is of conical shape as recommended by IAEA (Gas target section).
- The target body should be electrically isolated from other parts to allow accurate beam current reading.

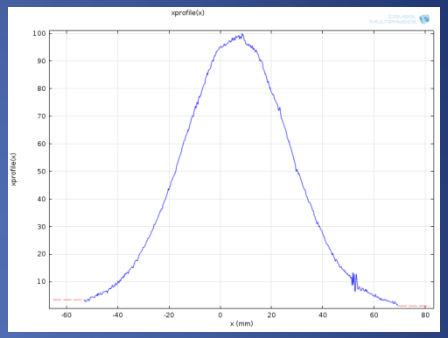
Characterization of beam divergence inside Krypton Gas

- $^{Nat}Kr(p,xn)^{81}Rb$
- Effective length 250 mm.
- This equivalent to energy
- (from 26 to 20 MeV)
- Rest of energy will be stopped in water

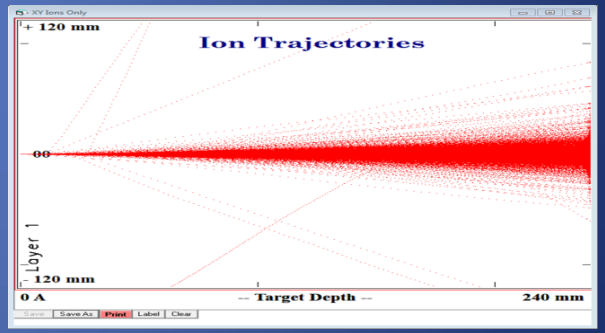


Cross section relevant to Production of $^{81}Rb(^{81m}kr)$
Z. KOVACS, et al., 1991…. …[1]





Beam Profile in the C-30



Bragg Correction = 0.00%
Stopping Units = MeV / (mg/cm2)
See bottom of Table for other Stopping units

Ion Energy	dE/dx Elec.	dE/dx Nuclear	Projected Range	Longitudinal Straggling	Lateral Straggling
15.00 MeV	1.831E-02	8.193E-06	257.42 mm	12.24 mm	18.87 mm
16.00 MeV	1.746E-02	7.740E-06	287.32 mm	13.41 mm	20.93 mm
17.00 MeV	1.670E-02	7.337E-06	318.64 mm	14.60 mm	23.08 mm
18.00 MeV	1.601E-02	6.977E-06	351.35 mm	15.82 mm	25.31 mm
20.00 MeV	1.480E-02	6.357E-06	420.87 mm	19.59 mm	30.04 mm
22.50 MeV	1.355E-02	5.727E-06	515.33 mm	24.90 mm	36.41 mm
25.00 MeV	1.253E-02	5.217E-06	618.02 mm	30.08 mm	43.28 mm
26.00 MeV	1.218E-02	5.038E-06	661.35 mm	31.28 mm	46.16 mm

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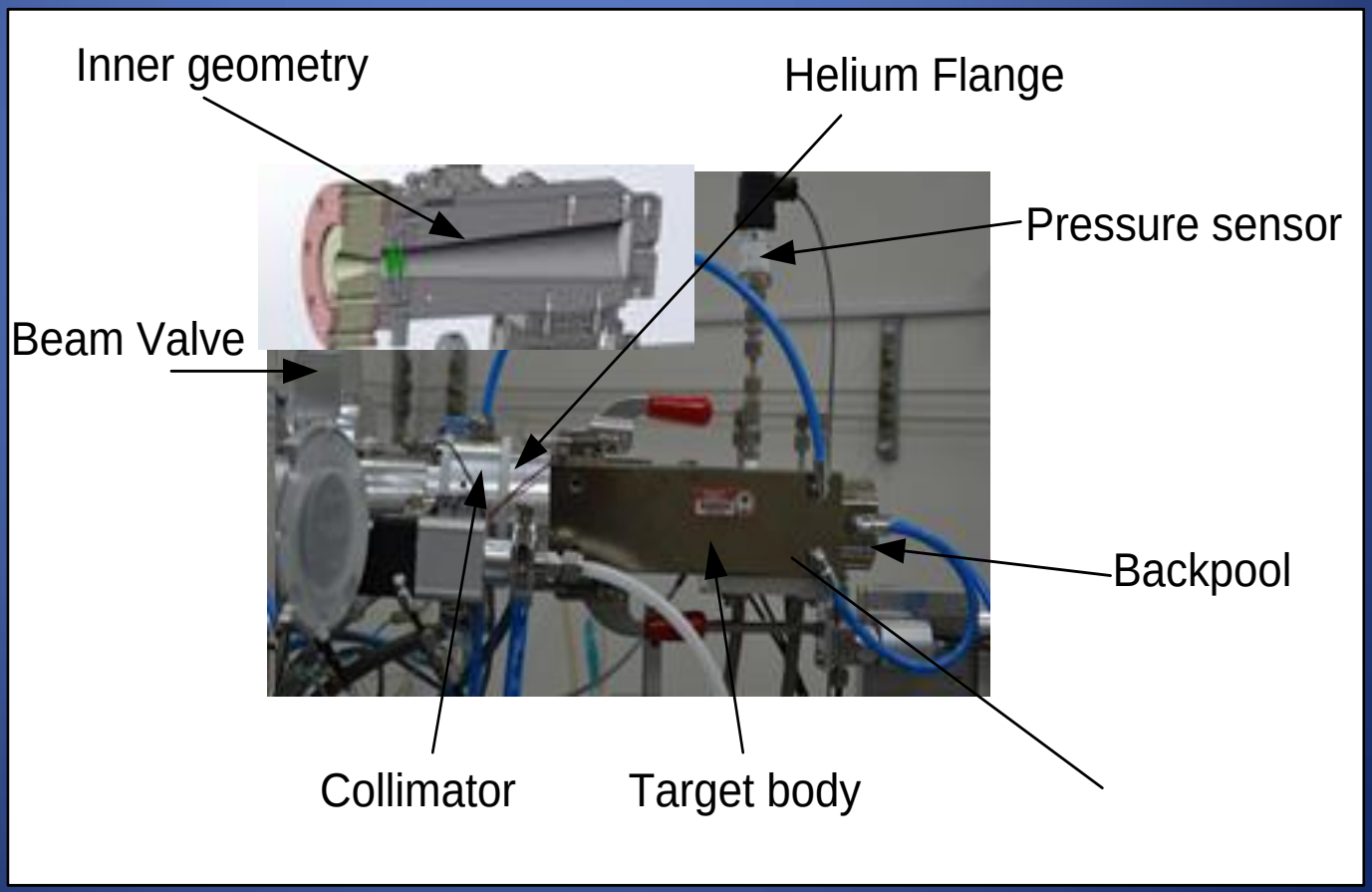
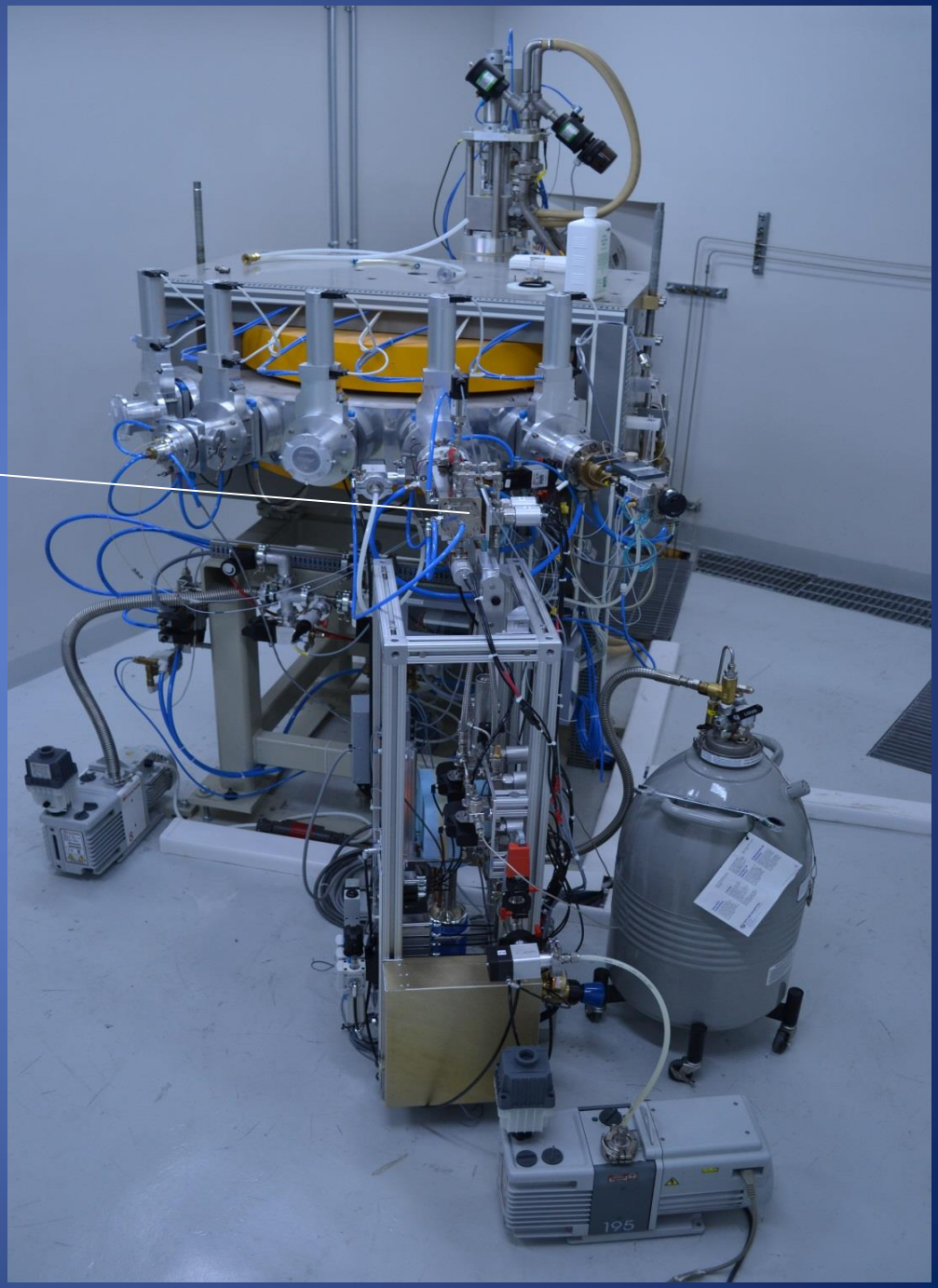
Manufacture of Kr- target

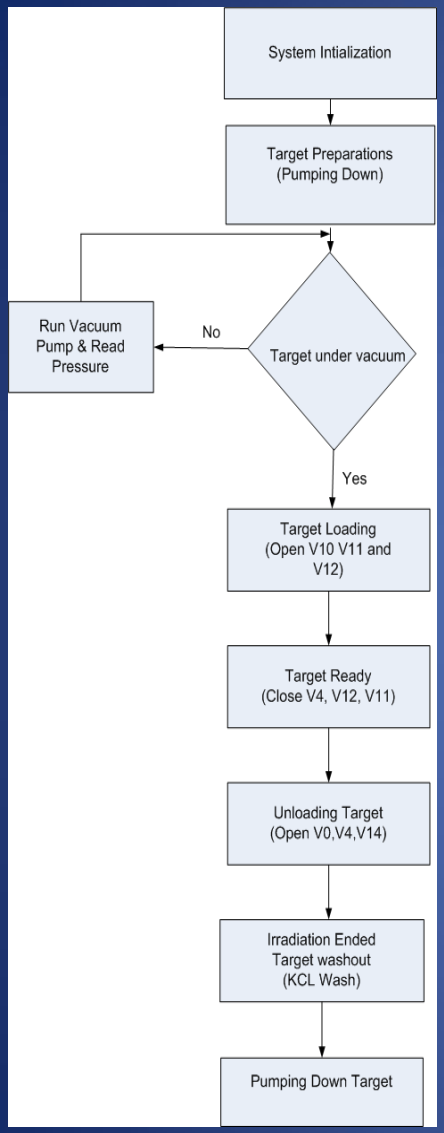
- Total length is 250 mm
- Two double windows: 25 um Havar
- Al target being electroplated by nickel
- Total volume of 200 ml.
- Collimator 2mm.

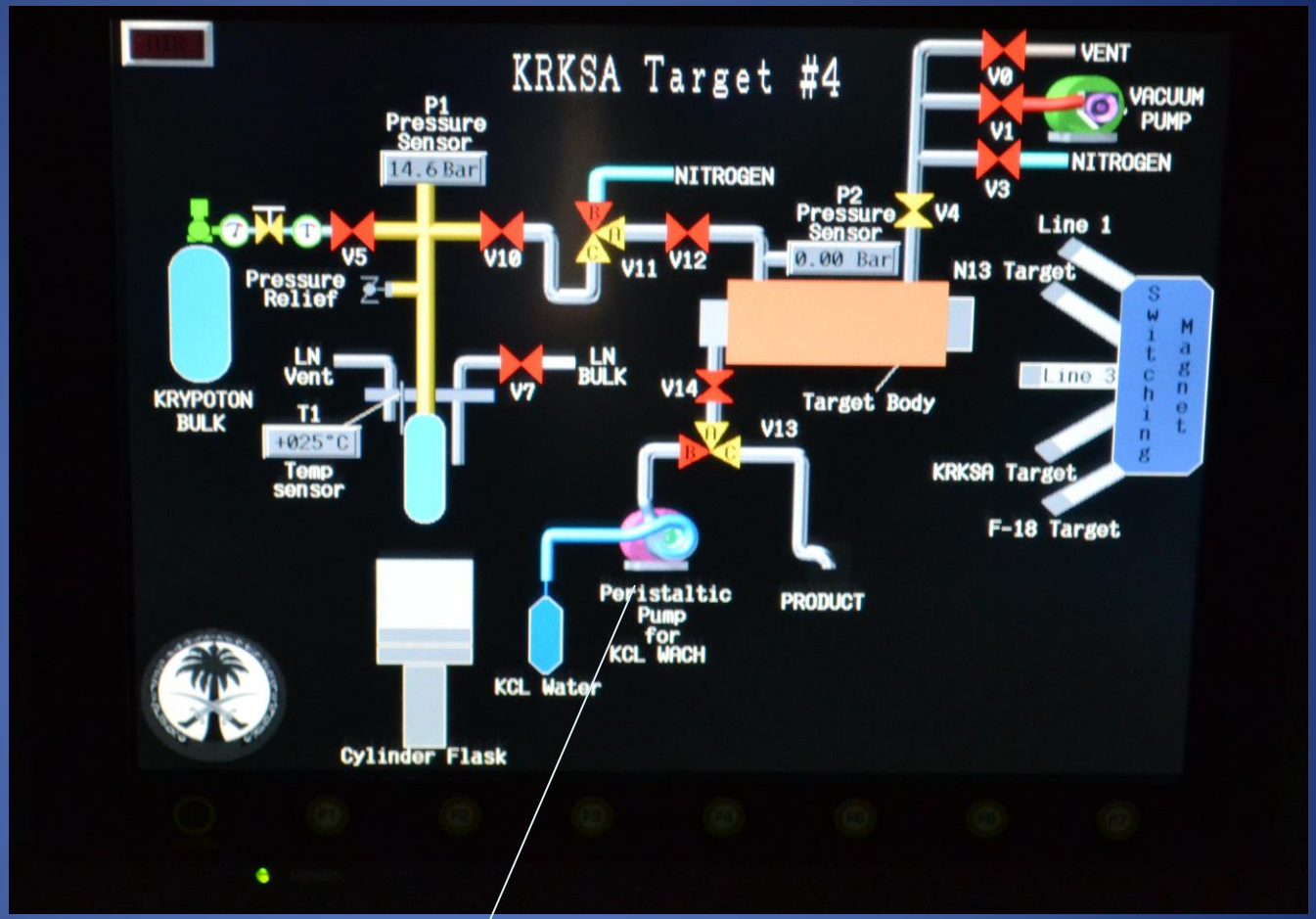




- Two means of cooling system:
  Helium and water

Control System





Series I Pump
Scientific System, inc.

Flow Rate: 0.1 to 40.00 mL/min
Pressure 0 to 750 psi for 40.00 mL/min

Results and Conclusion

- Results clearly showed a fairly good activity of ^{81m}Kr as shown in table 1.
- In all experiments, the radionuclidic purity of ^{81m}Kr was above 99.59%.
- ^{79m}Kr and ^{79}Kr were also measured with a percentage of, respectively, 0.34 and 0.07 %.

- Special attention has to be drawn to last experiment where the yield significantly increased, due to the period where the KCL left inside the target (10 min) before pushing the solution to the Hotcells.

Run#	Date	IBeam	Energy (MeV)	T(period)	P0	PF	Activity(EOB)	Yeild-sat (mCi/uA)	Yeild(mCi/uAhr)	Kr-81 Purity (%)	Volume (ml)
1	19-Mar	10	24	0.5	4.8	6.98	19.99	25.44	3.77	99.59	195
2	23-Mar	10	24	0.5	4.8	7.14	17.28	23.72	3.46	99.64	195
3	26-Mar	10	24	0.5	4.7	7	22.83	28.76	4.15	99.54	195
4	7-May	10	25	0.5	4.84	7.32	25.18	32.04	4.84	99.5	195
5	14-May	10	25	0.5	4.84	7.33	20.09	25.56	3.46	99.34	195
6	21-May	10	25	0.5	4.83	7.2	27.09	37.18	4.75	99.3	195
7	2-Jun	10	25	0.5	4.6	6.72	29.2	33.78	5.31	99.4	195
8	6-Jun	10	26	0.5	4.5	7.42	19.88	25.3	3.98	99.61	195
9	25-Jun	10	26	0.5	5	6.61	13.56	11.22	2.61	99.91	195
10	4-Aug	10	26	0.5	5.17	7.16	25.7	31.18	4.85	99.89	195

Conclusion:

1- We have successfully designed, fabricate the Krypton target

2- Results clearly showed a fairly good activity of Kr-81.

2- Production will start beginning of September 2014.

References

[1]. Z. KOVACS, et al., “Excitation Functions for the Formation of some Radioisotopes of Rubidium in Proton Induced Nuclear Reactions on natKr, 82Kr and 83Kr with Special Reference to the Production of 81Rb(81mKr) Generator Radionuclide” Appl. Radiat. ht. Vol. 42, No. 4. pp. 329-335, 1991.

[2] www. SRIM.COM

Thank you