Experimental Proposal S388

- Title "Search for two-proton decay of ^{30}Ar in flight by tracking technique"
- Spokesman: I. Mukha, GSI
- GSI Contact Person: Y. Litvinov, Heidelberg Univ.
- Year of Approval: 2008
- Shifts: 19 approved (main + parasitic)

  0 used (main + parasitic)

  19 left (main + parasitic)

Physics Motivation

- Nuclear structure beyond the proton drip line,

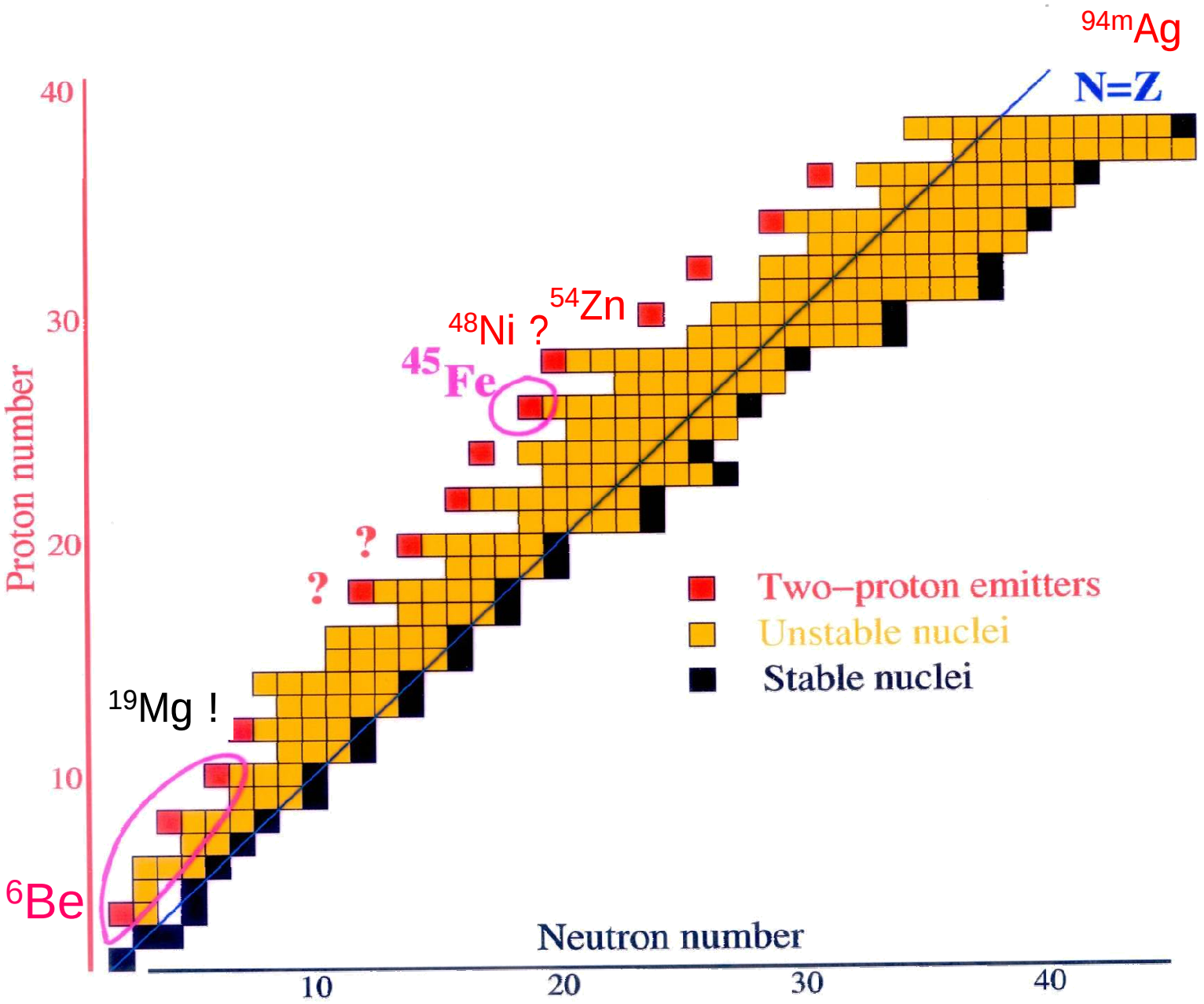
two-proton radioactivity,

unknown 1p, 2p unbound isotopes

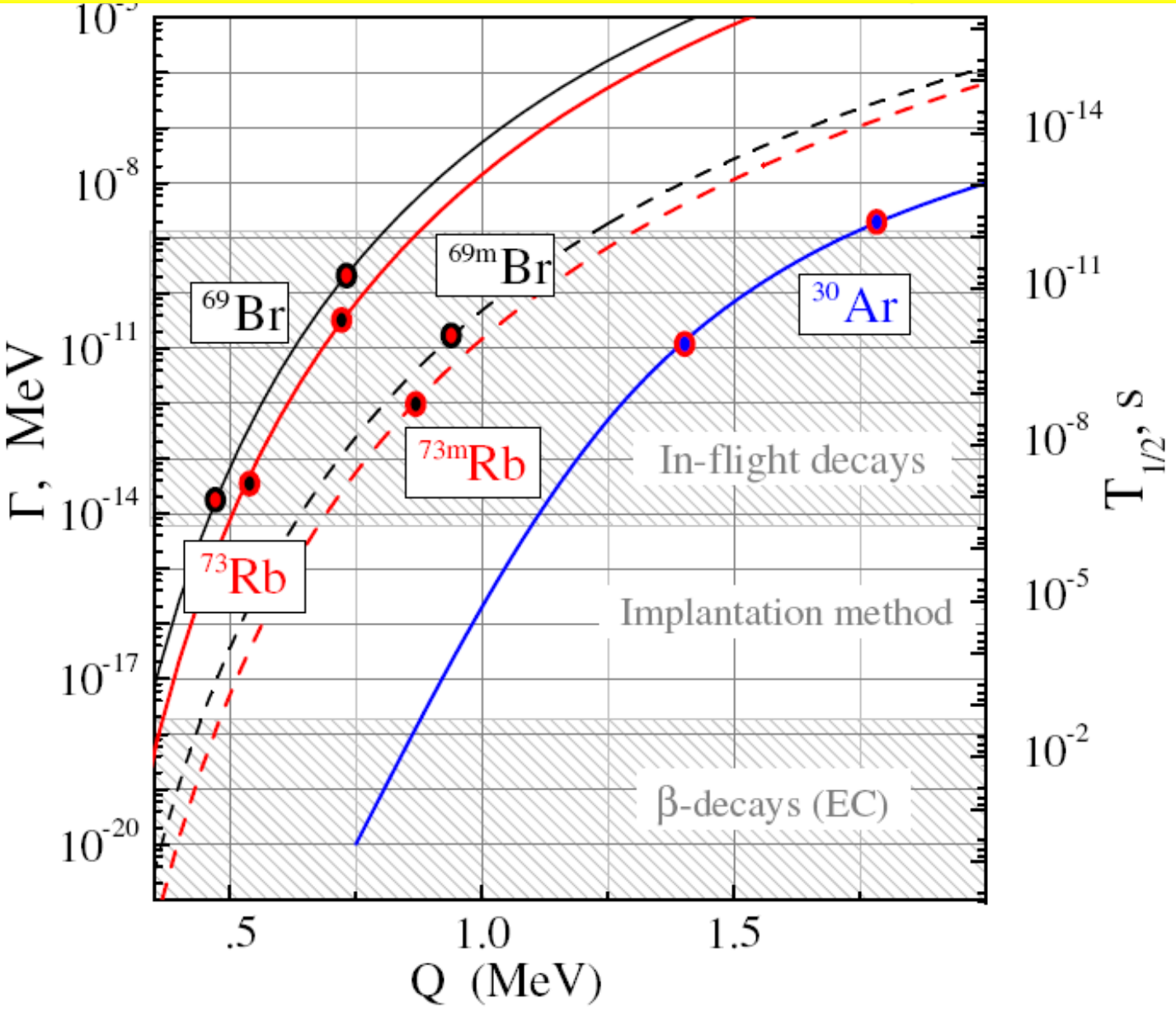
Goals of the experiment

- Search for 2p decays of unknown ^{30}Ar, ^{26}S
- Measurements of 2p decays of ^{16}Ne and ^{12}O
- Measurements of 1p-emitters ^{30}Cl, ^{25}P

Two-proton radioactivity landscape



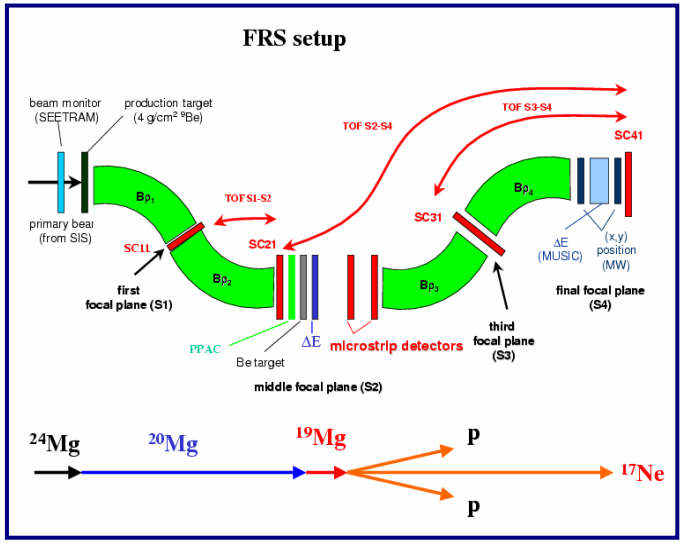
Predicted half-lives of ^{30}Ar, ^{69}Br, ^{72}Rb



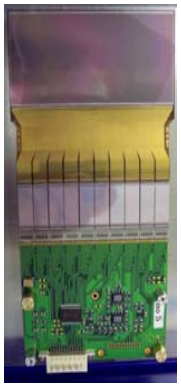
Discovery of ^{19}Mg and it´s two-proton decay in-flight by tracking fragment trajectories with micro-strip detectors

- **The unknown isotope ^{19}Mg is observed by using the novel tracking technique.**
- **Two-proton decay with $T_{1/2}$=4.1(1.5) ps and Q_{2p}=0.75(5) MeV was detected by measuring decay vertices and fragment correlations from coincident ^{17}Ne+p+p events.**
- **Three-body decay mechanism of 2p radioactivity has been confirmed.**

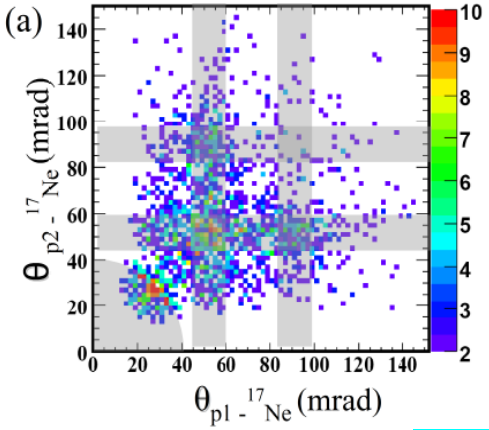
The S271 experiment at GSI, 2006

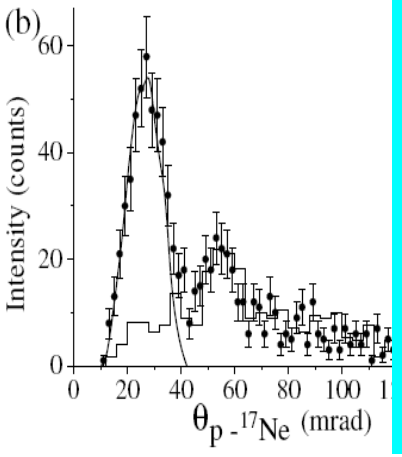


Micro-strip detectors used for tracking



Dimensions 70x40 mm^{2}2, 100μ strip pitch, 1000 channels





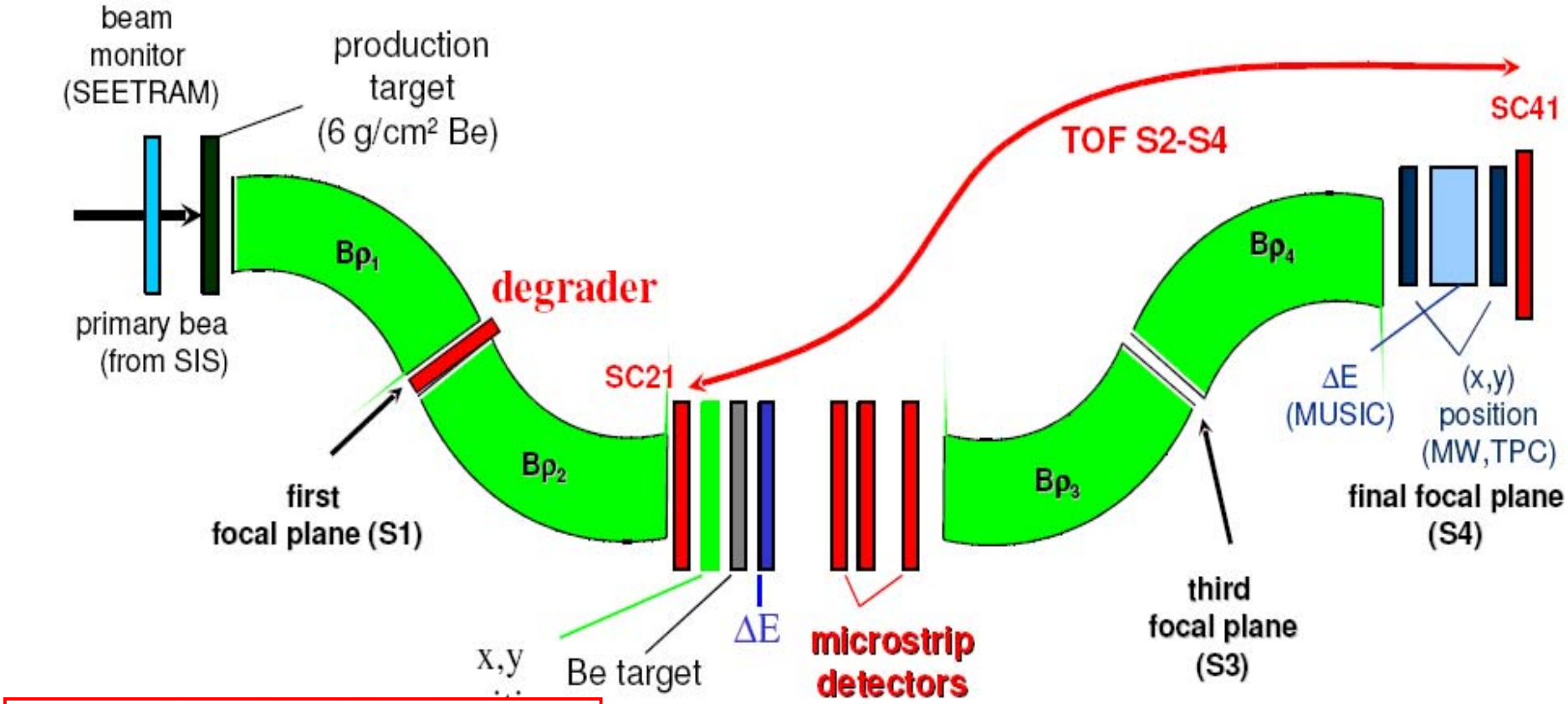
I.Mukha et al., Phys.Rev.Lett. **99,** 182501 (2007)

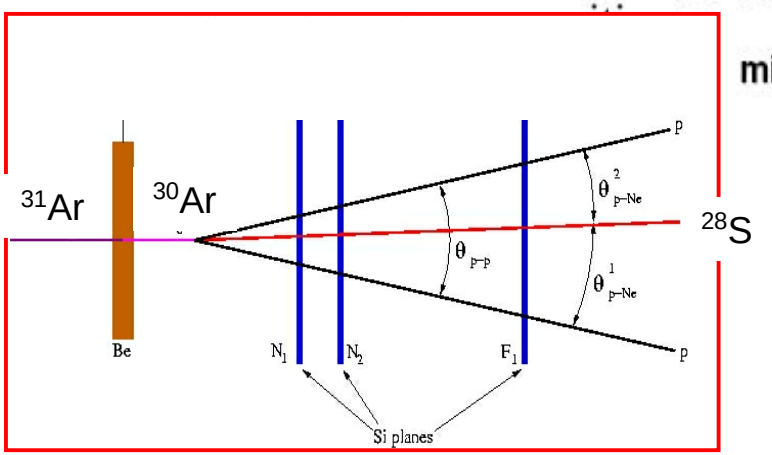
I.Mukha et al., Phys.Rev. C**77,** 061303(R) (2008)

I.Mukha et al., Phys.Rev. C**79,** 061301(R) (2009)

Collaboration: GSI, Sevilla, Huelva, Edinburgh, Moscow, Warsaw, Dubna, Santiago de Compostela.

Experimental method





Setup

- FRS standard focal planes equipment:

S1: MW11;

S2: MW21,SCI21,TPC21;

S3: SCi31;

S4: MW41,SCI41, TPC40, MUSIC, TPC41

- The same setup to be assembled at S2 as in the previous S271 experiment.
- Non-standard equipment required: microstrip Si detectors + electronics at S2, a wedge degrader at S1.
- No modification or a new DAQ required.
- 1000 MeV/u primary beam of ^{36}Ar with intensity 10^{11} pps.
- 19 shifts are requested in 2010.

Additional/specific information

- The ~200 mrad wedge degrader (the same as in S271) to be re-installed in the pocket at S1.

- The ~1m vacuum tube at S2 to be replaced by the S271 vacuum chamber with the microstrip detectors and 2 Ti vacuum windows on D2 and D3.

- A byproduct study of beta, 2p decays of ^{26}S with the PRESPEC active stopper is possible (optional).

Participants and institutions

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S388 summary

The physics topics:

Nuclear structure beyond proton drip line. Two-proton radioactivity. Nuclear astrophysics.

We intend to search for:

- ***Two-proton decays of the unknown isotopes ^{30}Ar, ^{26}S(optional), their half-life and decay energy.***
- ***One-proton decay of the unknown isotope ^{30}Cl its half-life and decay energy.***

Detection technique:

- ***Tracking of all decay products by micro-strip detectors.***

We are granted:

- ***19 shifts of a 1 GeV/u beam of ^{36}Ar from SIS with intensity 10^{11} pps.***
- ***We need***
- ***MUCIS ion source and FRS with a standard+user setup at S2.***

S388 outlook

Half of the beam request on ^{69}Br and ^{73}Rb is deferred

Nuclear astrophysics.

Next experiment:

- **A search for two-proton radioactivity of ^{26}S,**
  the proposal S414 is deferred.

S388 is a bottleneck for the other experiments:

Expected yields of ^{73}Rb, ^{69}Br, ^{30}Ar

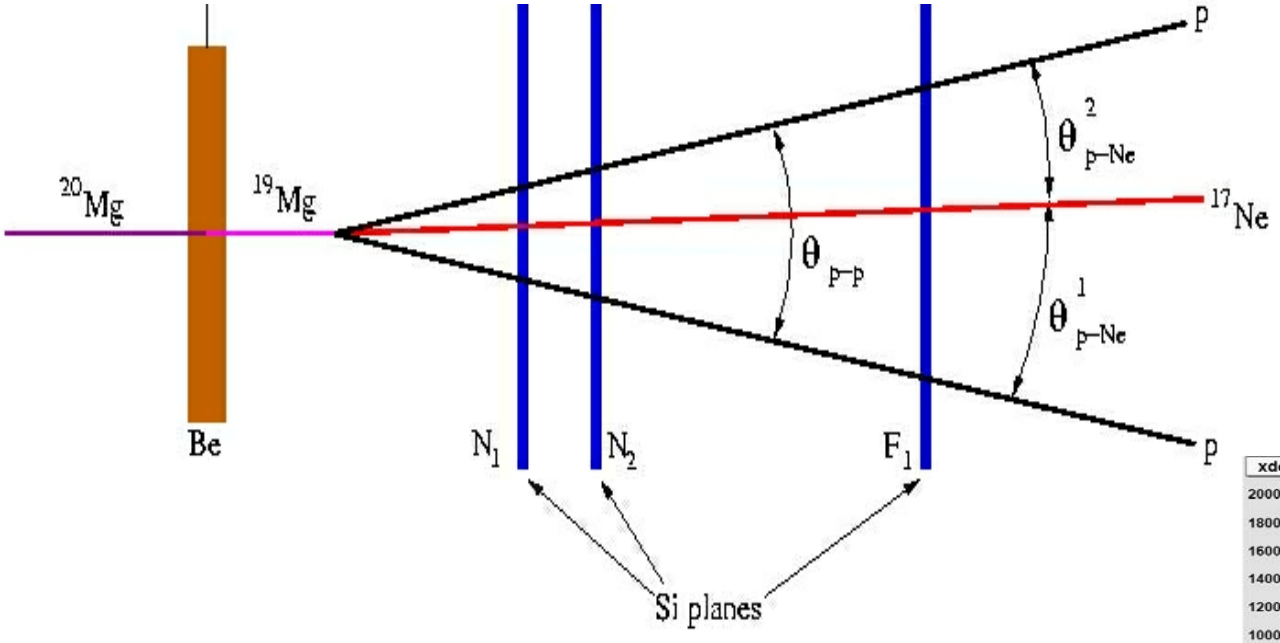
TABLE II: Estimates of production rates of ^{73}Rb, ^{69}Br, ^{30}Ar at FRS by using Monte Carlo simulations [35] and systematics of cross-sections in fragmentation reactions [39]. The ^{78}Kr, ^{36}Ar primary beam intensities are 10^{10} and 10^{11} ions per spill, respectively. The thickness of primary ^{9}Be target is 5 g/cm^2. Production rates of ^{19}Mg and ^{16}Ne were measured [7, 8], and they are estimated for calibration measurements.

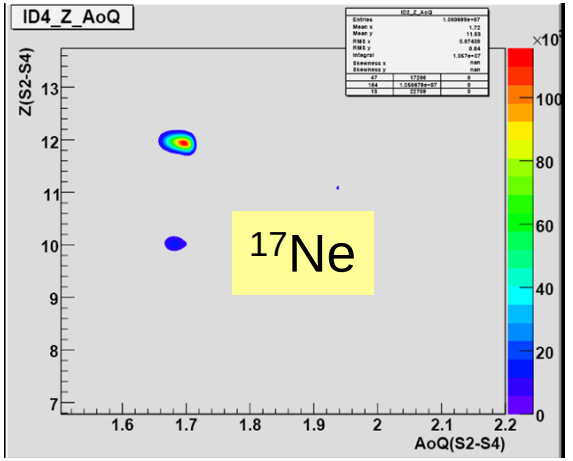
Energy MeV/u	Primary reaction	σ_1, μb	Intensity at S2, ions/spill	Secondary reaction	Target ^{9}Be, g/cm^2	σ_2, mb	Production rate, per 100 spills	Counting rate, per 1 hour
1000	^{9}Be(^{78}Kr,^{74}Rb)	0.15	130	^{9}Be(^{74}Rb,^{73}Rb)	3.6	3.3	10.3	38
1000	^{9}Be(^{78}Kr,^{70}Br)	9.2	8000	^{9}Be(^{70}Br,^{69}Br)	3.6	4.5	860	3000
1000	^{9}Be(^{36}Ar,^{31}Ar)	0.083	420	^{9}Be(^{31}Ar,^{30}Ar)	3.6	0.18	1.8	6
1000	^{9}Be(^{36}Ar,^{20}Mg)	1.9	2000	^{9}Be(^{20}Mg,^{19}Mg)	3.6	0.28	14	50
1000	^{9}Be(^{36}Ar,^{17}Ne)	40	25000	^{9}Be(^{17}Ne,^{16}Ne)	3.6	0.76	460	1600
1000	^{9}Be(^{36}Ar,^{13}O)	50	28000	^{9}Be(^{13}O,^{12}O)	3.6	0.37	250	900

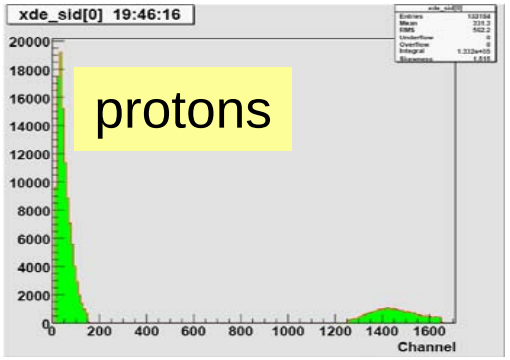
All in all, we request 29 shifts. For the first part, we need 16 shifts of an 1000 MeV/u primary beam of ^{36}Ar from SIS with a maximum intensity of 10^{11} ions per spill. For the second part, we request 13 shifts of a 1000 MeV/u primary beam of ^{78}Kr from SIS with a maximum intensity of 10^{10} ions per spill.

Close-up view

Identification of fragments







Reactions ^{20}Mg→^{19}Mg→^{17}Ne+p+p