Experiment IS550 P-344:

Study of the di-nuclear system ^{A}Rb + ^{209}Bi ($Z_1 + Z_2 = 120$)

Status report

SPOKESPERSON:

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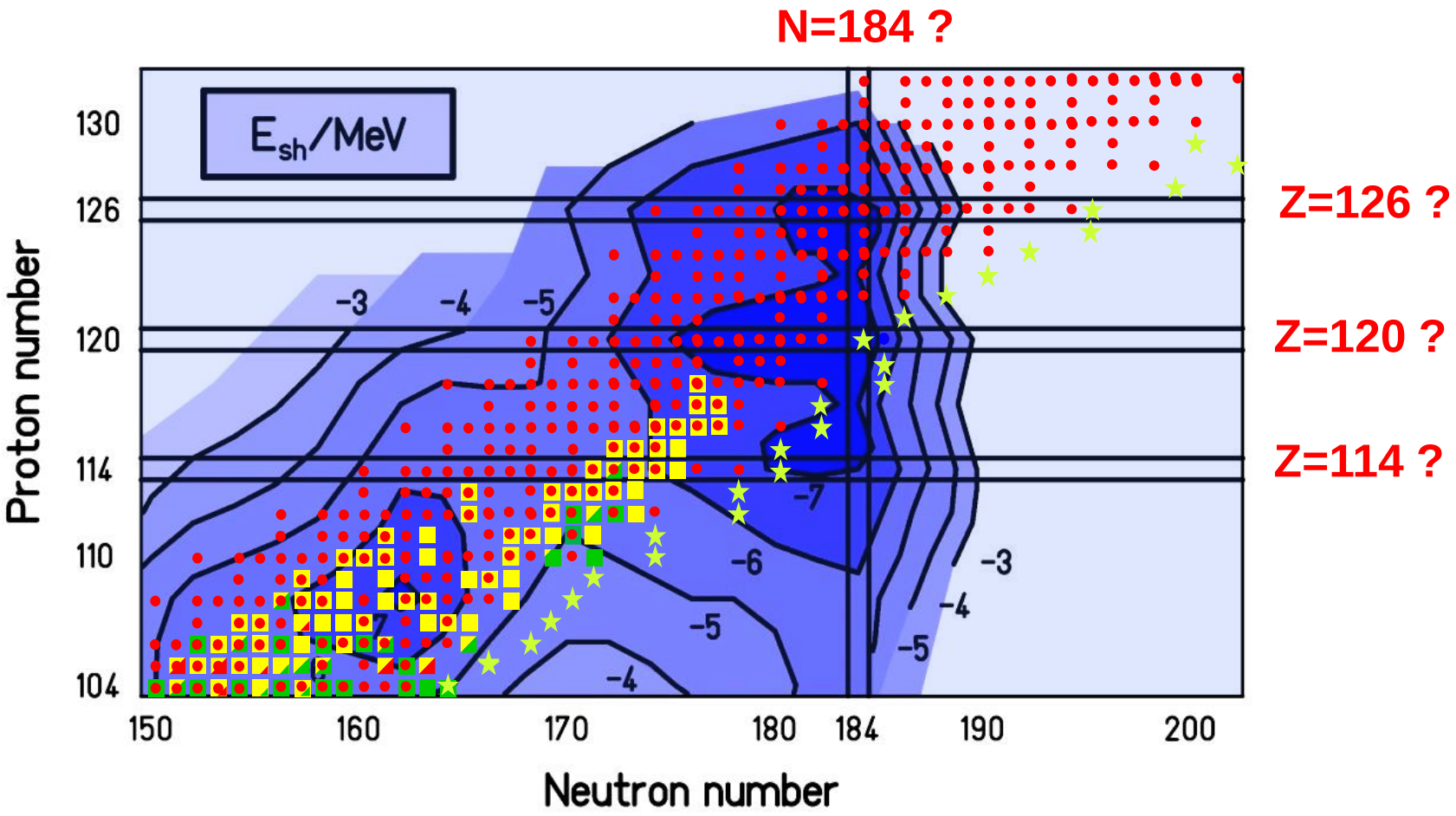
ISOLDE and Neutron Time-of-Flight Experiments Committee
60th meeting of the INTC
7th and 8th November 2018
CERN, Geneva

Magic numbers in superheavy nuclei ?



- fusion with stable projectiles
- fusion with RIBs

Magic numbers in superheavy nuclei ?

Problem:

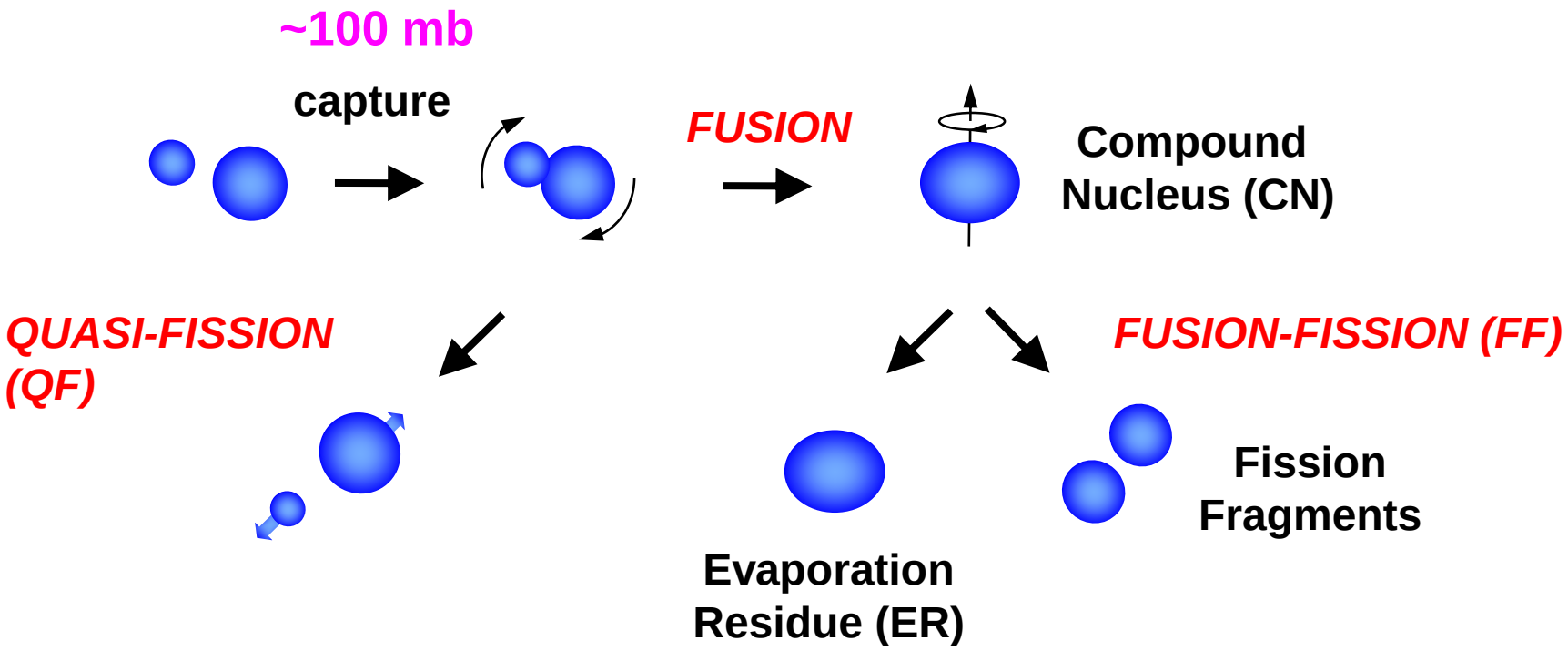
- Nuclear systems with N = 184 cannot be reached in fusion reactions with stable beams

- Fusion reactions with RIBs lead to N=184, but beam intensities are too small for cross-sections $\sigma < 1$ pb

Approach:

Study of **quasi-fission** and **fusion-fission** with RIBs

The Fusion Process in Heavy Systems

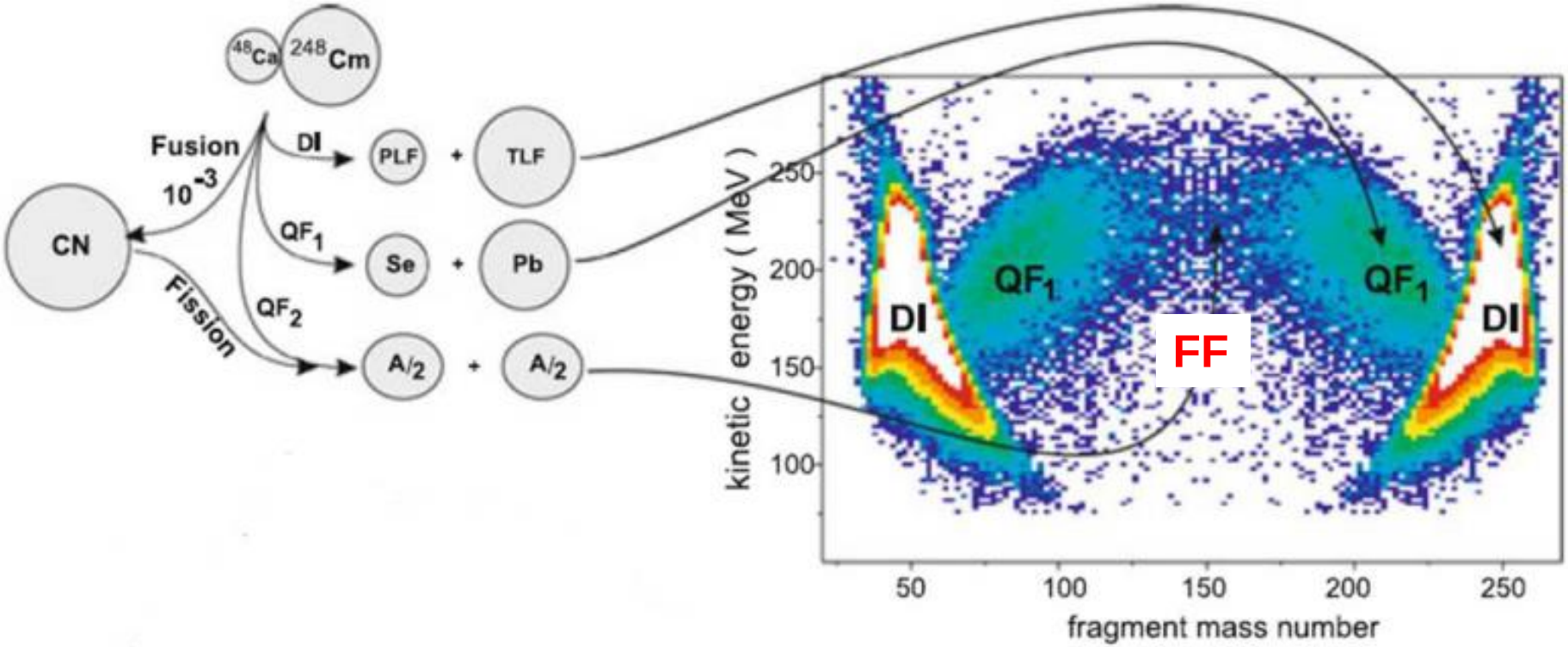


$$\sigma_{ER} = \sigma_{capture} \cdot P_{CN} \cdot P_{survival}$$

Superheavy systems: $\sigma_{ER} << \sigma_{capture}$

$\rightarrow \quad \sigma_{capture} \approx \sigma_{QF} + \sigma_{FF} \approx 100$ mb

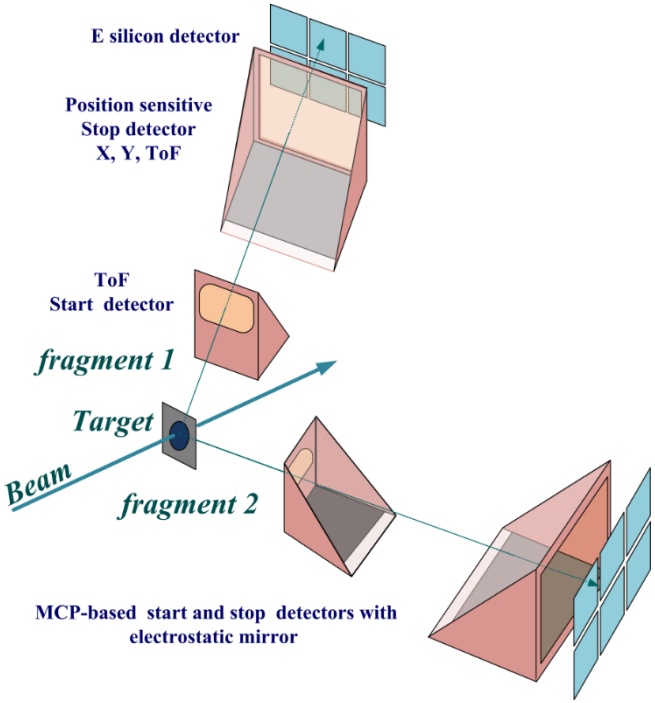
Shell effects are revealed by QF and FF products

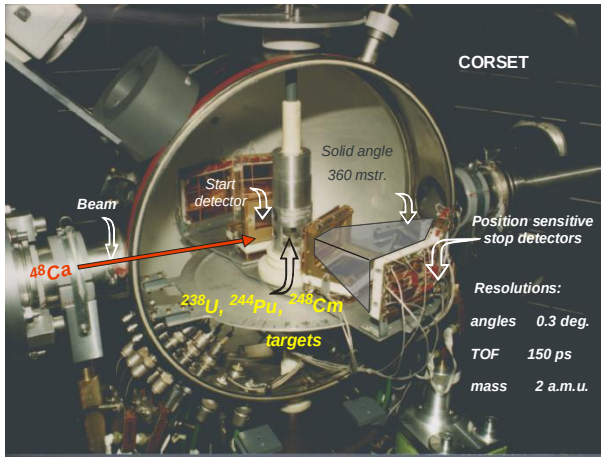


Experimental realization:

Study of mass and energy distributions of QF and FF products as a function of projectile neutron number and beam energy.

ToF-E spectrometer (CORSET)





Time resolution	**150-180 ps**
ToF base	10-30 cm
ToF arm rotation range	15°-165°
Solid angle	100 -200 msr
Angular resolution	**0.3°**
Mass resolution	**2-4 u**
Energy resolution	**1%**

Measured parameters:

- ToF, X, Y, energy of each fragment

Extracted parameters :

- Velocity, energy, angles and mass of each fragment
- TKE

Approved Beamtime

Requested Beamtime (INTC, October 2012):

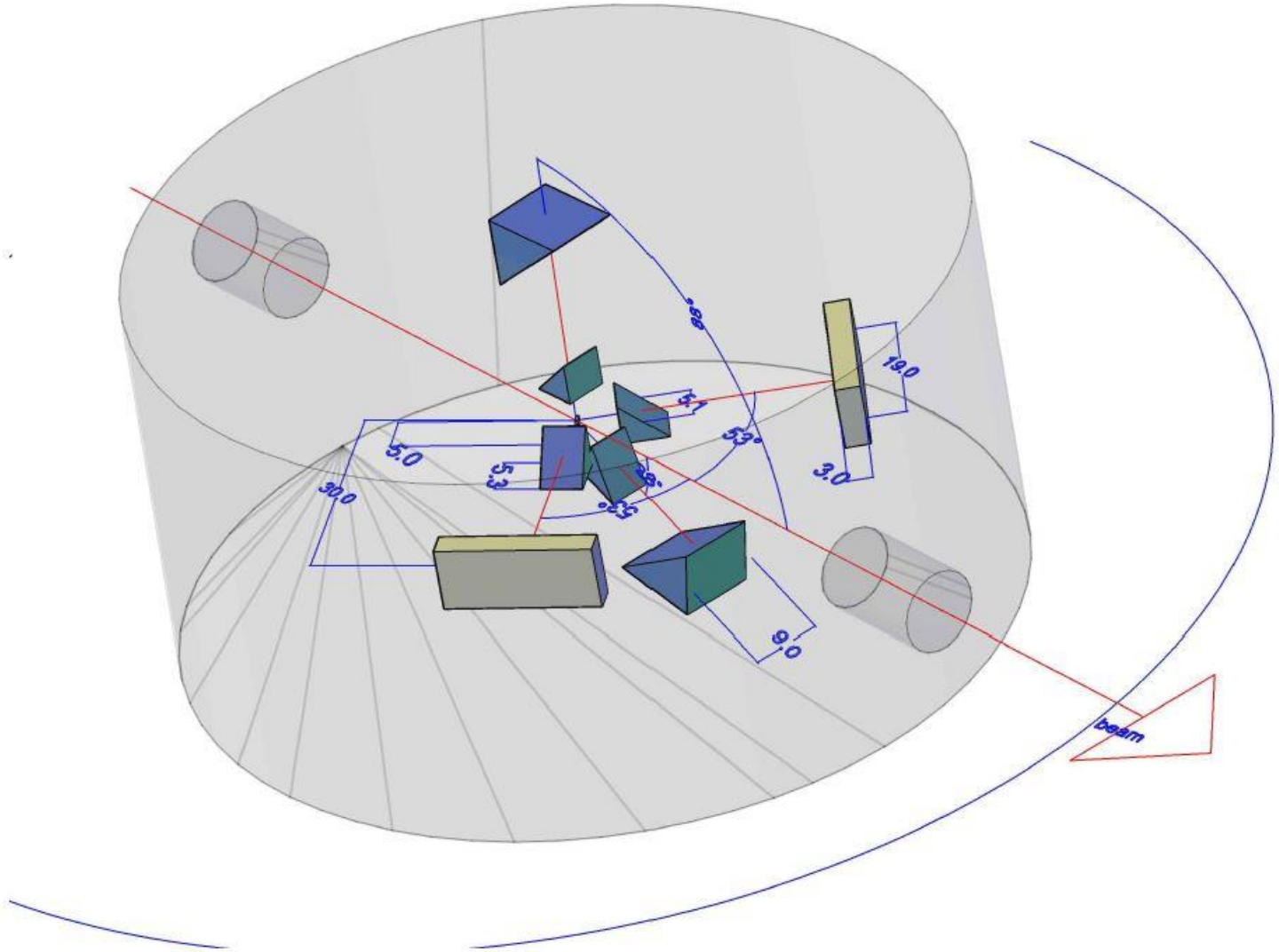
Projectile	^{85,87}Rb (stable)	^{A}Rb (neutron-rich)
beam energy	~ 5 MeV/u	~ (5 – 6) MeV/u
experiment	Tuning of the setup	Excitation functions for QF, FF
shifts	6	3 x 12

Beamtime recommended by INTC: 12 shifts of n-rich Rb

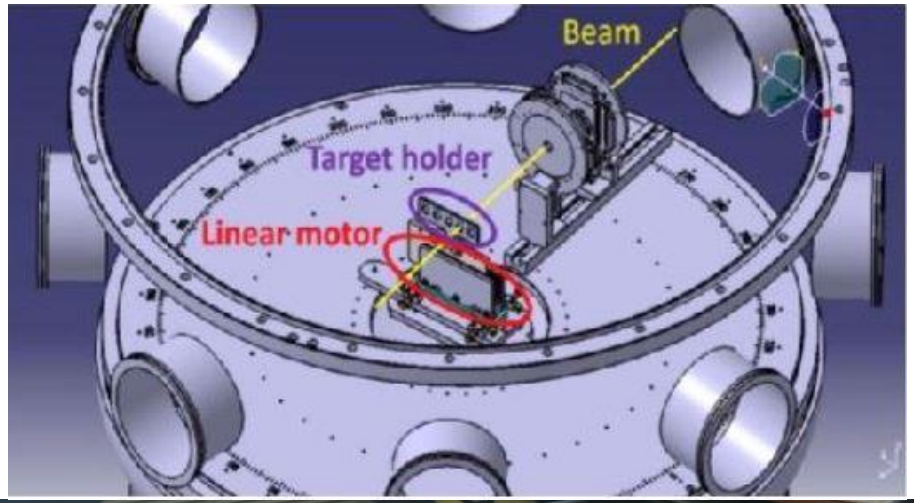
Technical Upgrades / Developments for the run at HIE-ISOLDE

Two additional detector arms

NEW SETUP GEOMETRY



Scattering Experimental Chamber
S E C @ XT03 beamline of HIE-ISOLDE



Disc with suport

structure for the ToF

and DSSD

+ feedthrough for
target stick

New components

1) Electronics (Dubna)

2) DAQ system

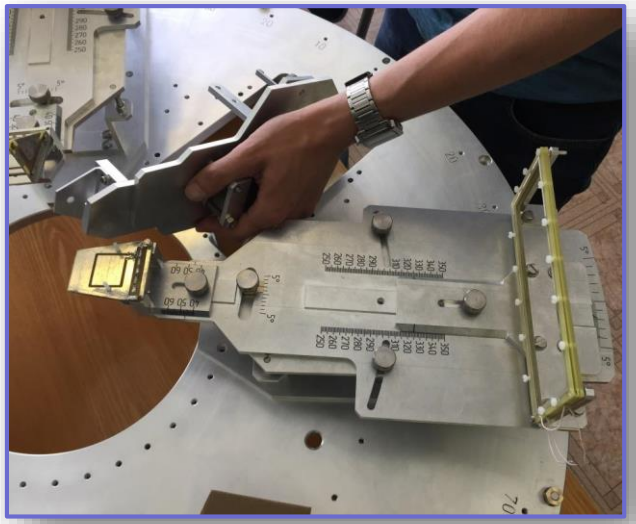
→ **Tested at GSI**
August 2018

3) Mechanics: support disc

4) Support structure for the ToF and DSSD

5) Feedthrough for Target stick

→



100% Ready

Rate Estimate

Cross section: 100mb

Beam Intensity: 10^6 pps

Target Thickness: $2x10^{18}$ atom/cm^2

Efficiency ~ 0.1 (CORSET)

#Events/s :0,2 event/s = 20000 event/day

#Events (total in 4 days): 80000 events

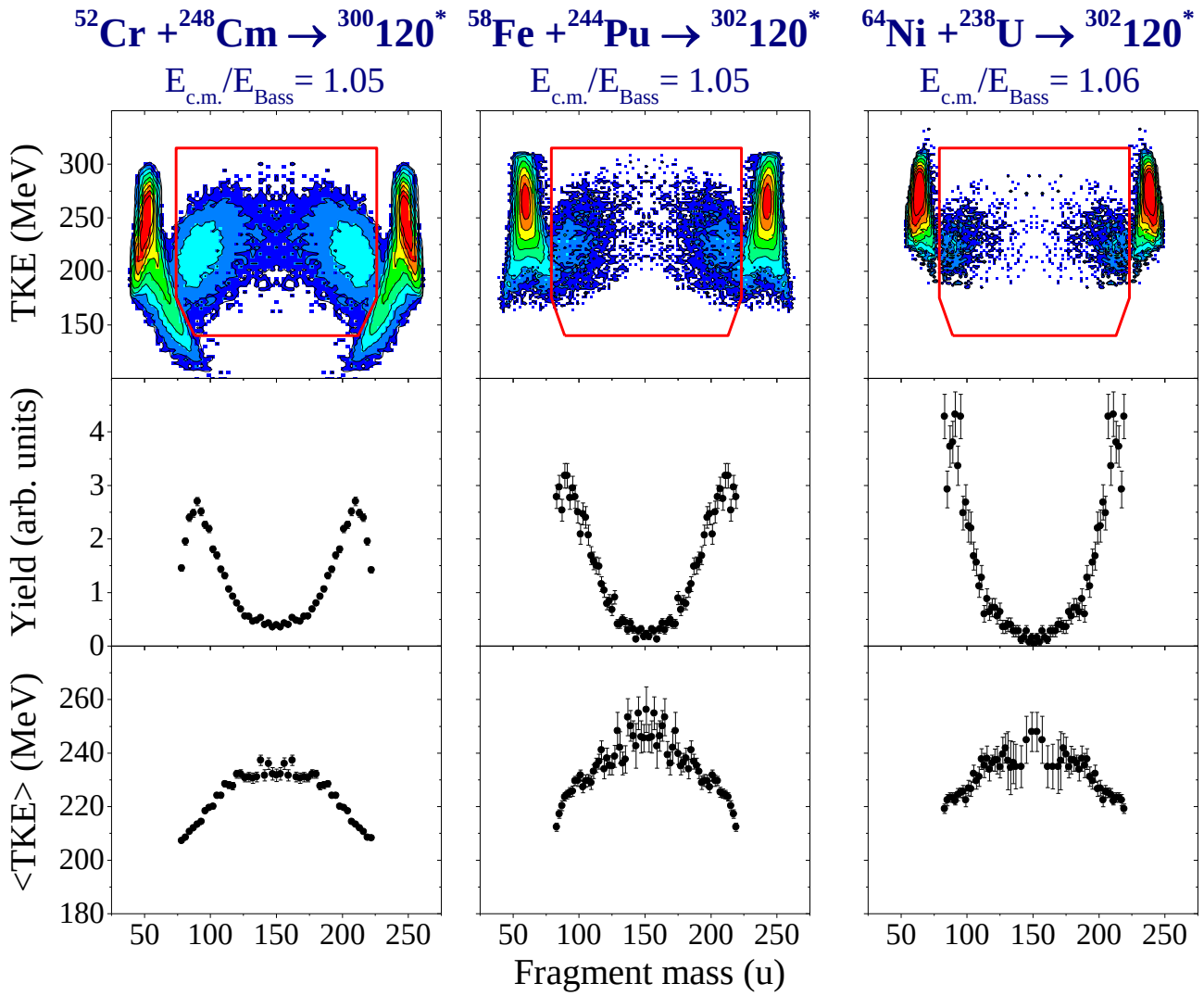
Status of Experiment

Remaining shifts: 12 / 12

Physics case still relevant? yes

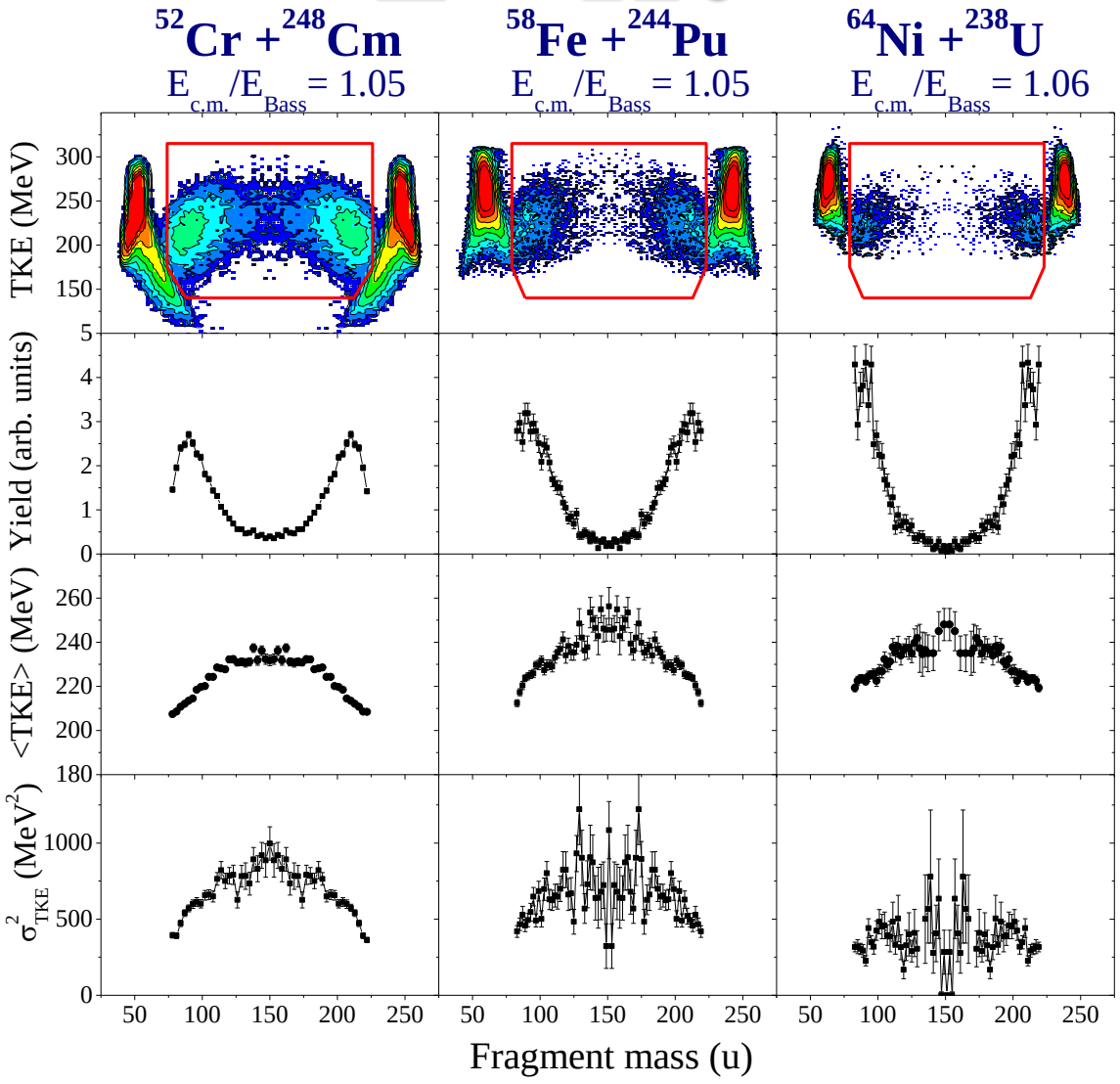
HIE-ISOLDE still unique for this study in >2021 ? yes

Z = 120



The mass and energy distributions of binary fragments formed in the reactions ^{52}**Cr** + ^{248}**Cm**, ^{58}**Fe** + ^{244}**Pu**, and ^{64}**Ni** + ^{238}**U**, leading to the formation of composite systems with ***Z* = 120** at energies above the Bass barrier.
From top to bottom: the M-TKE matrices of binary reaction products; the mass distributions and the average total kinetic energy as a function of mass of fissionlike fragments inside the contour line on M-TKE matrices

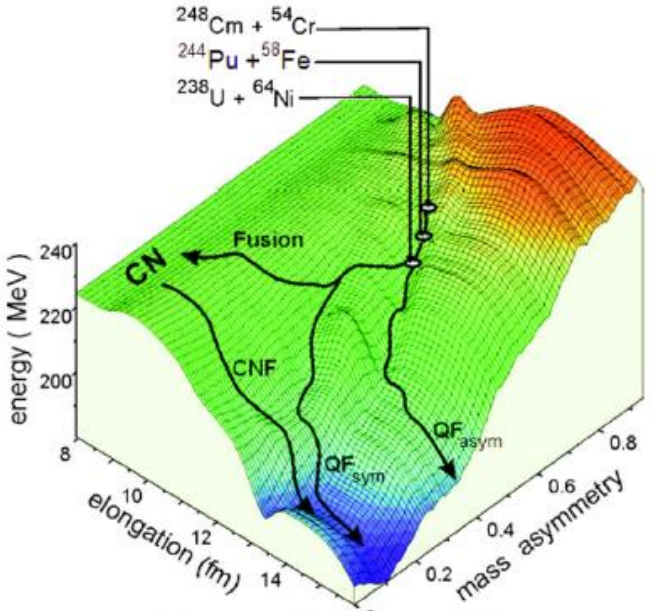
Z = 120

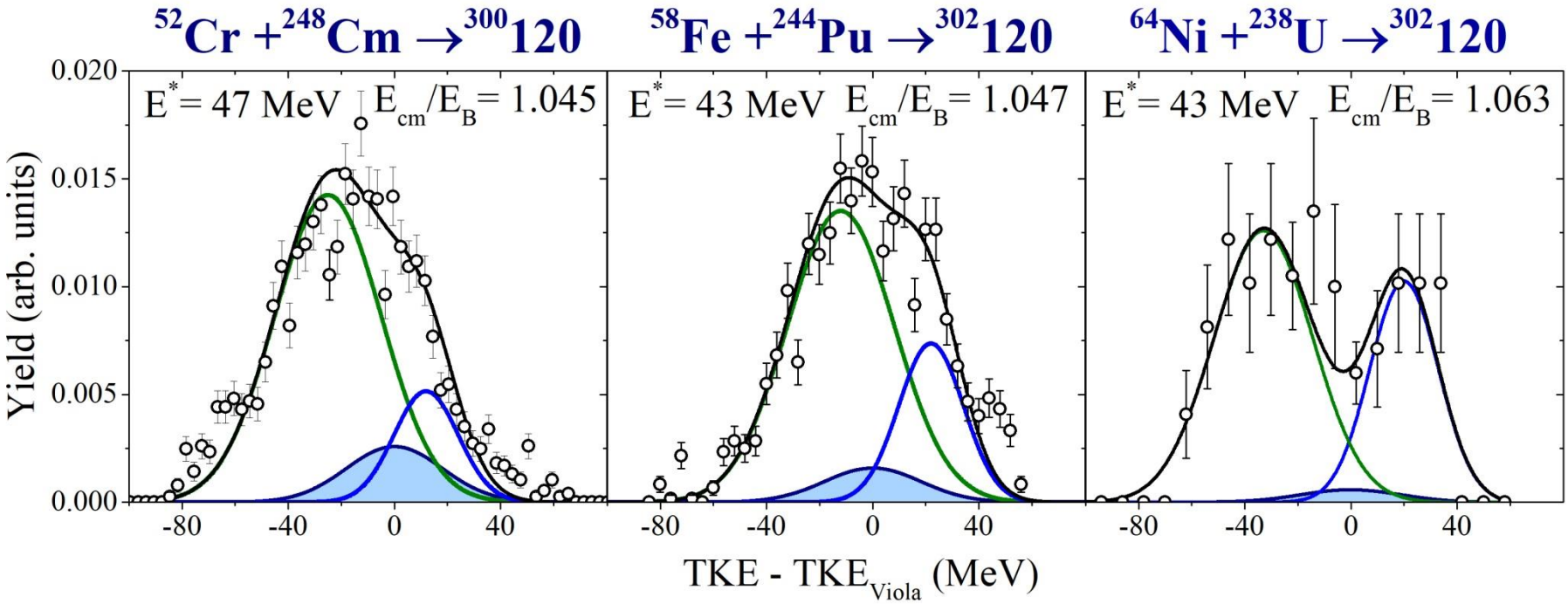


The mass and energy distributions of binary fragments formed in the reactions **^{52}Cr + ^{248}Cm**, **^{58}Fe + ^{244}Pu**, and **^{64}Ni + ^{238}U**, leading to the formation of composite systems with ***Z* = 120** at energies above the Bass barrier.

From top to bottom: the M-TKE matrices of binary reaction products; the mass distributions; the average total kinetic energy and its variance as a function of mass of fissionlike fragments inside the contour line on M-TKE matrices

TKE distribution of symmetric fragments

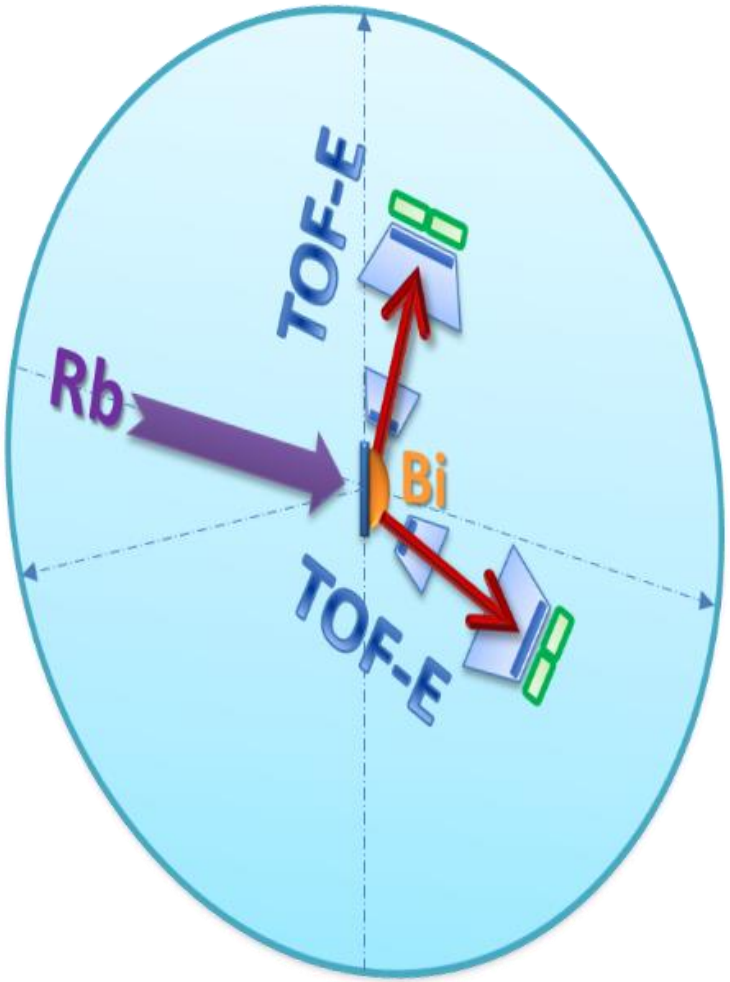


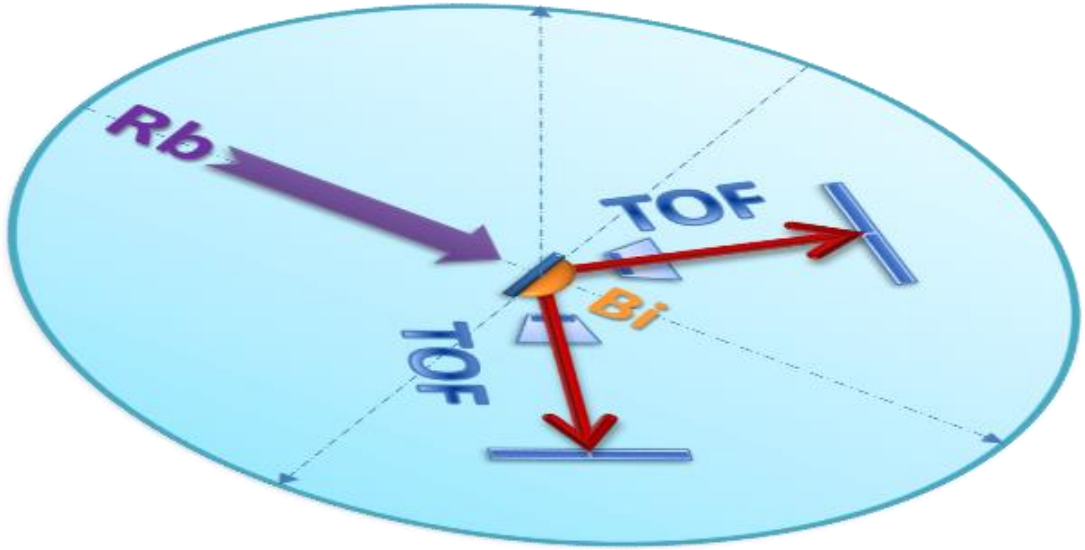


E.M. Kozulin et al., Physical Letters B 686, (2010) 227-232.

CORSET

The main CORSET characteristics	
Time resolution	150-180 ps
ToF base	10-30 cm
Arm rotation range	15°-165°
Solid angle	100-200 msr
Angular resolution	0.3°
Mass resolution	2-4 u
Energy resolution	±2%

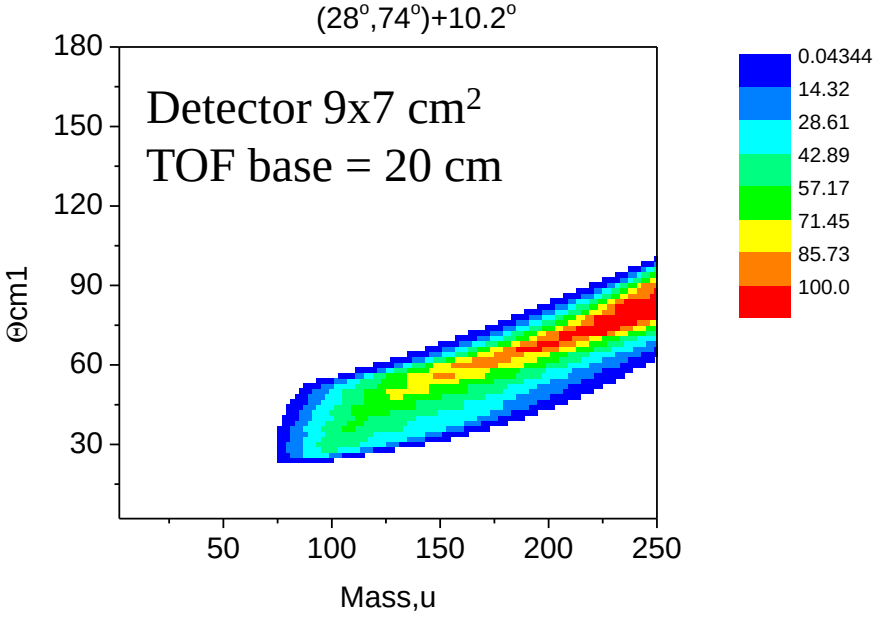


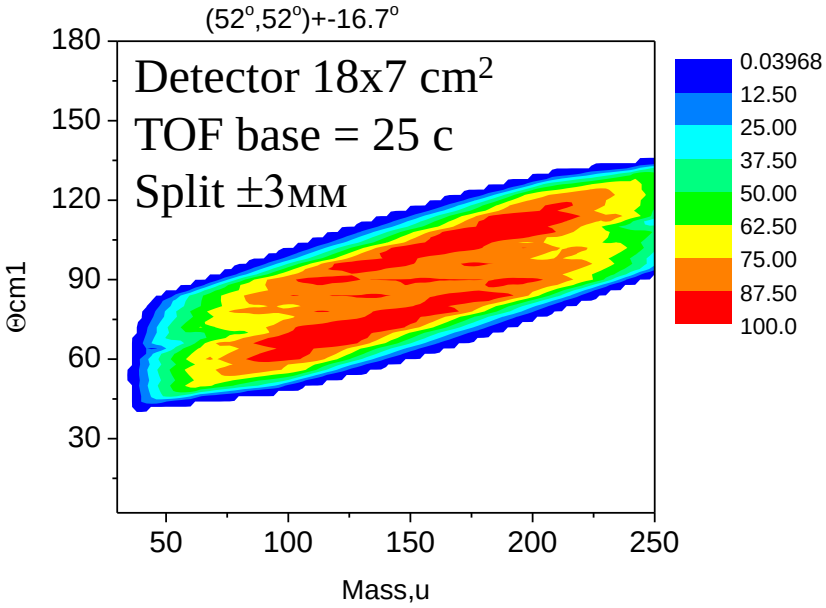


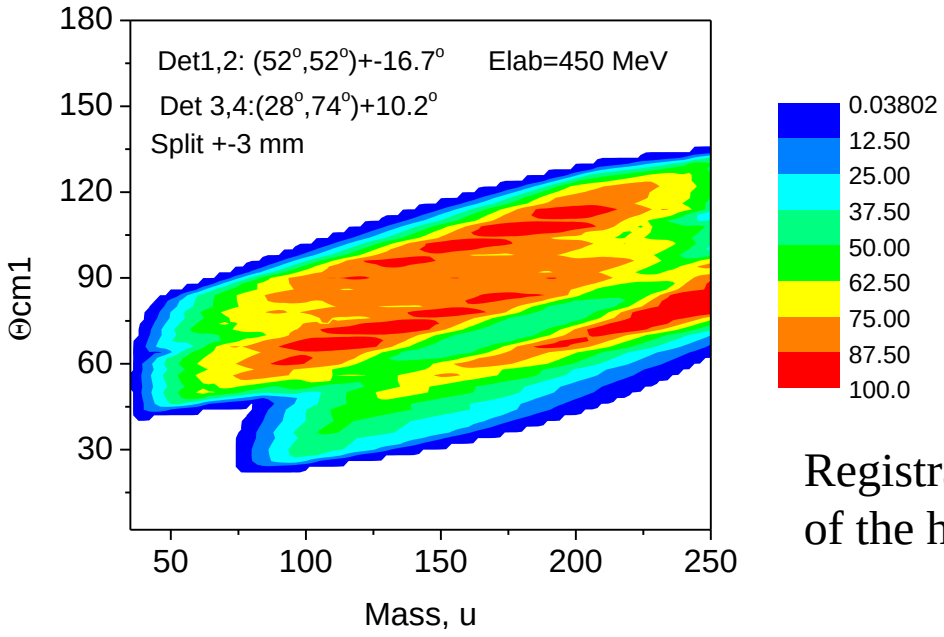
Frame holder

Flange DN160
with 27 LEMO
and
10 SHV connectors

$^{95}Rb + ^{209}Bi$, E_{lab} = 450 MeV

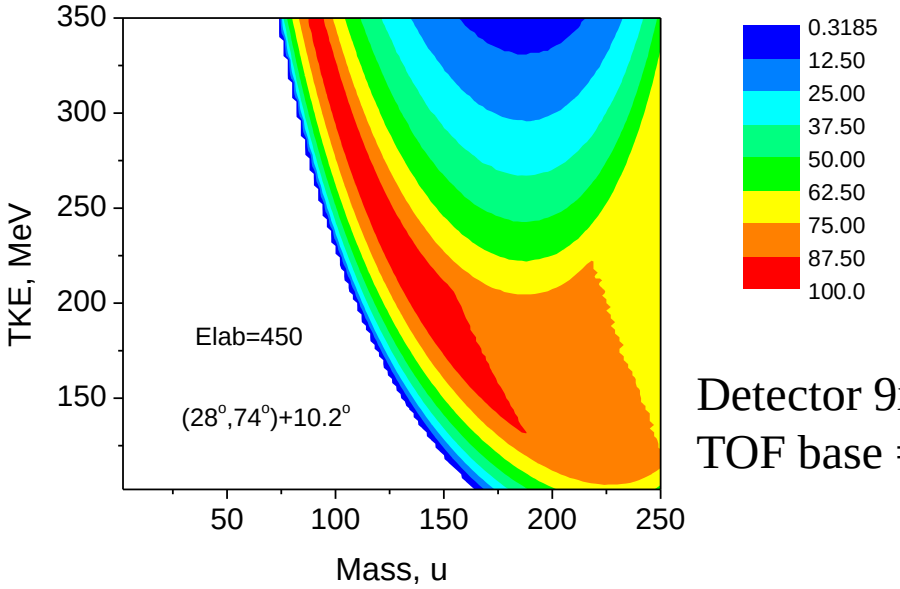




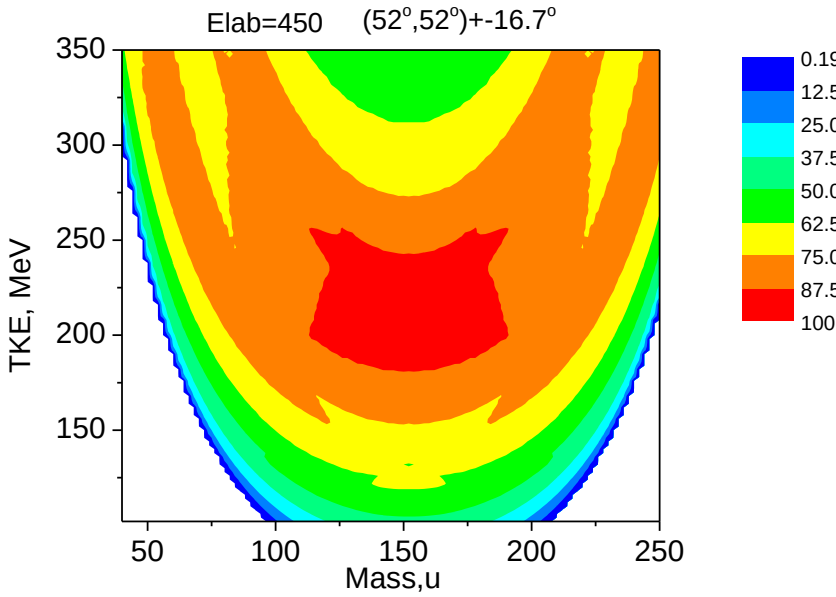


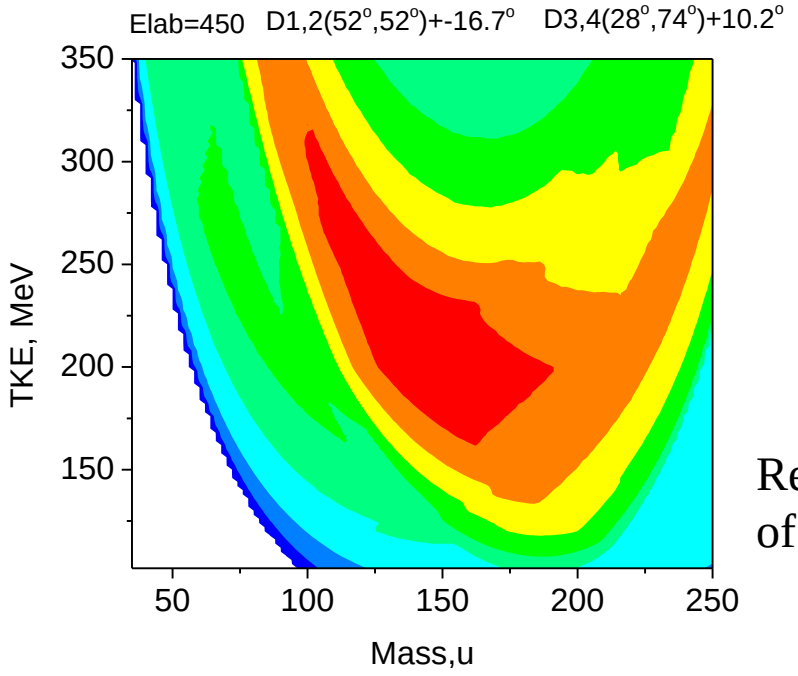
Registration efficiency
of the hole set of detectors

$^{95}Rb + ^{209}Bi$, E_{lab} = 450 MeV



Detector 9x7 cm^2
TOF base = 20 cm

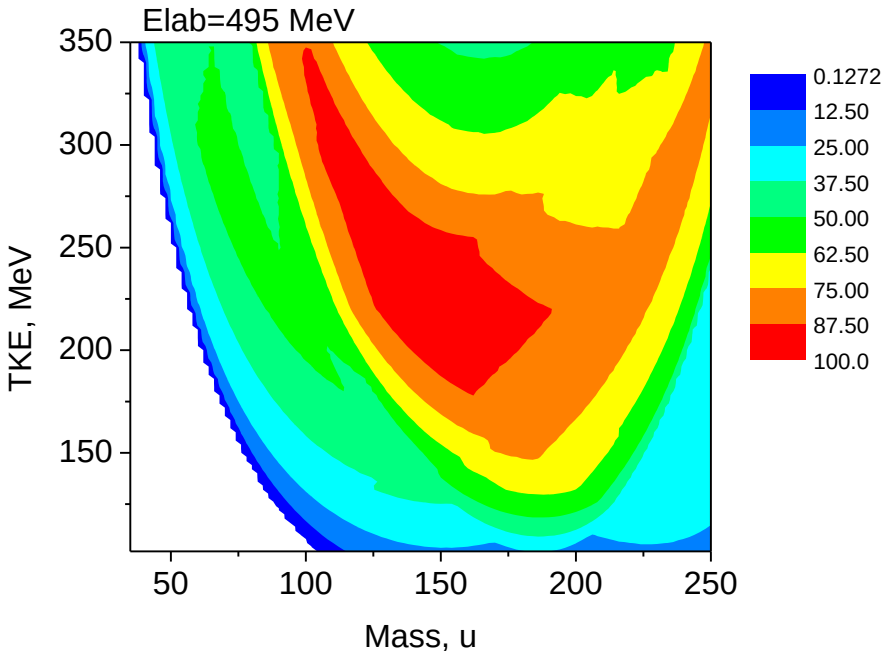


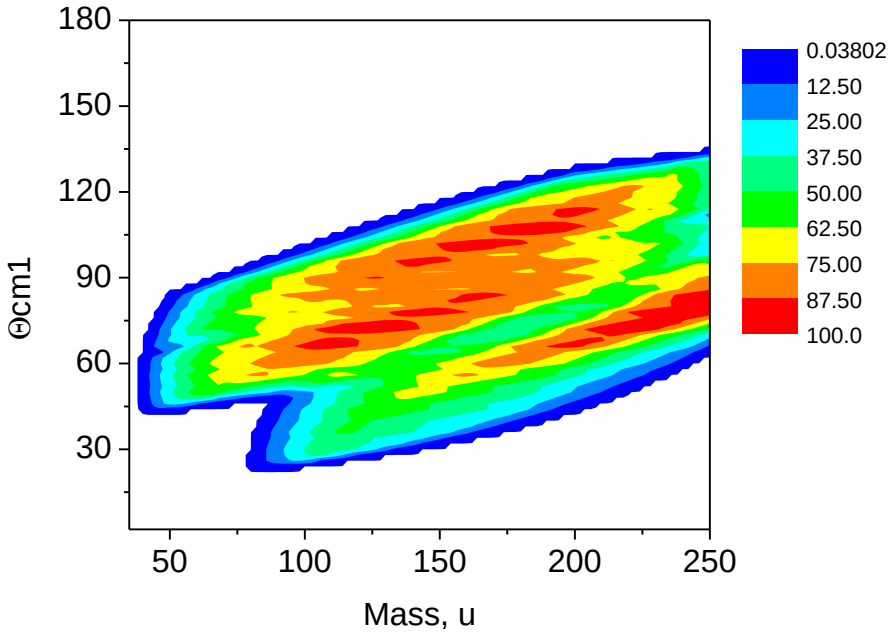


Detector 18x7 cm^2
TOF base = 25 c
Split ±3мм

Registration efficiency
of the hole set of detectors

$^{95}Rb + ^{209}Bi$, E_{lab}= 495 MeV





Registration efficiency of the whole set of detectors

SEC – MEETING ISOLDE MARCH 14-15 2018

SEC web server: http://isolde-sec.web.cern.ch/

ALTERNATIVE A

IS550 95 Rb

1) Arrive in June 10 days for mechanics set-up
2) DAQ and Calibration 5 days
3) RUN July
4) Dismount

IS616

1) Set-up GLORIA August
2) Run Early September

IS561

1) Set up end September
2) RUN October

ALTERNATIVE B

IS561 9Li (t,p)

1) Setup June
2) RUN Early July

IS616

1) Set-up GLORIA August
2) Run Early September

IS550 95 Rb

1) Arrive in mid September 10 days for mechanics set-up
2) DAQ and Calibration 5 days
3) RUN October
4) Dismount

Within the current project to prepare to the IS550 experiment

the following was performed:

1. New detectors based on the microchannel plates (MCP) to measure fragments velocities using time-of-flight (TOF) technic were designed and produced. The registration efficiency of these detectors increased 2 times.
2. To measure fragments energy (TOF-E technic) strip detectors were added in each arm of the spectrometer. The use of strip detectors and TOF-E method allows to increase considerably the quality and reliability of the experimental data.
3. New reaction chamber was designed and produced.
4. Meetings and workshops with colleagues from CERN (Geneve), GSI (Darmstadt, Germany) and the Department of Physics of Jyvaskyla University (Jyvaskyla, Finland) to discuss preliminary experimental data obtained using upgraded CORSET setup as well as the preparations to the experiment at HIE-ISOLDE CERN and optimization of the experimental conditions were hold.
5. Preliminary tuning and calibration of the CORSET spectrometer to prepare completely to the experiment at CERN were performed at the Department of Physics of Jyvaskyla University.
6. The CORSET spectrometer and electronics were transported to CERN and GSI during the reporting period.
7. The experiment was was planned for October-November 2018 year.