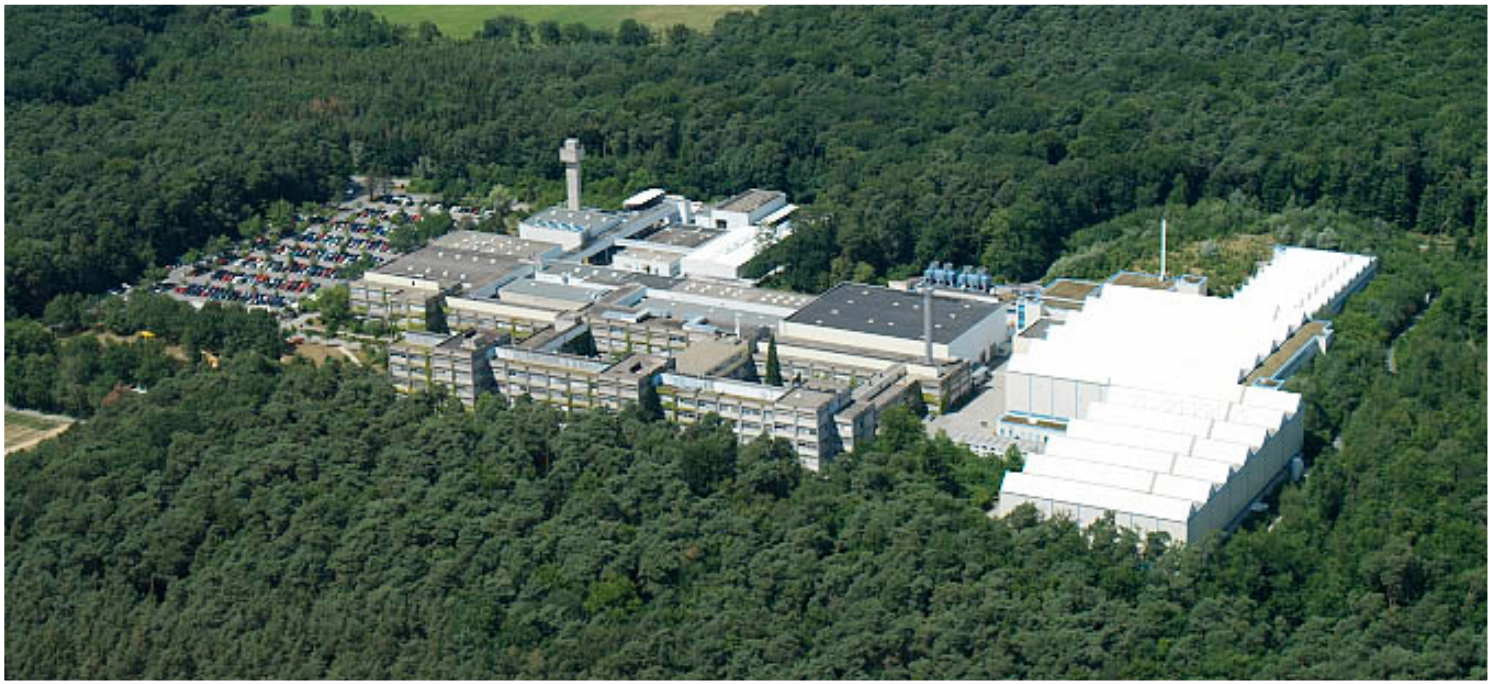
"Proton elastic scattering of unstable nuclei for nuclear density distribution at GSI"

Satoru TERASHIMA

GSI Helmholtzzentrum für
Schwerionenforschung GmbH

on behalf of
GSI-S272 collaboration

GSI



From WEB-SITE
http://www.gsi.de/portrait/ueberblick_e.html

Foundation: 1969
Asociates: Federal Republic of Germany (90%), State of Hessen (10%)
Budget: 108 M Euro (2010)
Staff: 1050 employees, including 300 scientists and engineers
Equipment: UNILAC+SIS18+ESR+PHELIX+.....

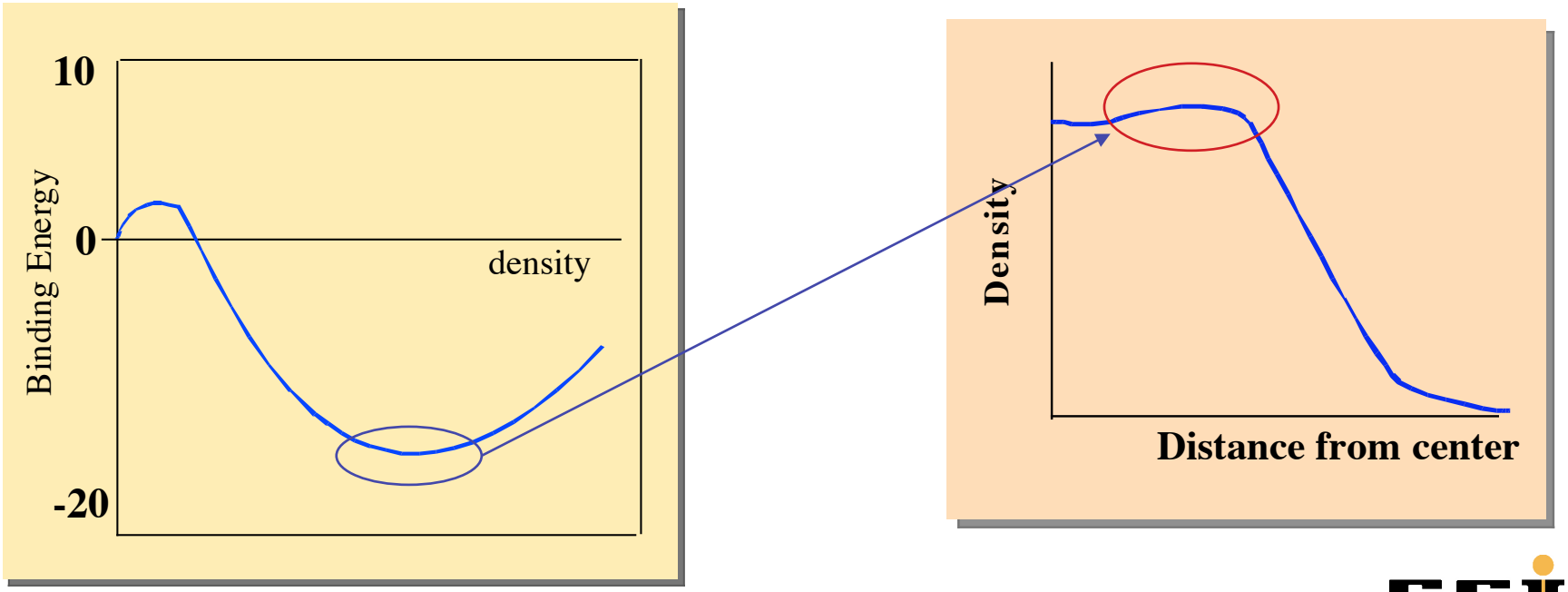
Motivation

Density Distribution and EOS

- **The saturation density of nuclear matter is reflected to the density of nucleus.**

  -> Saturation density of nuclear matter can be determined from density distributions.

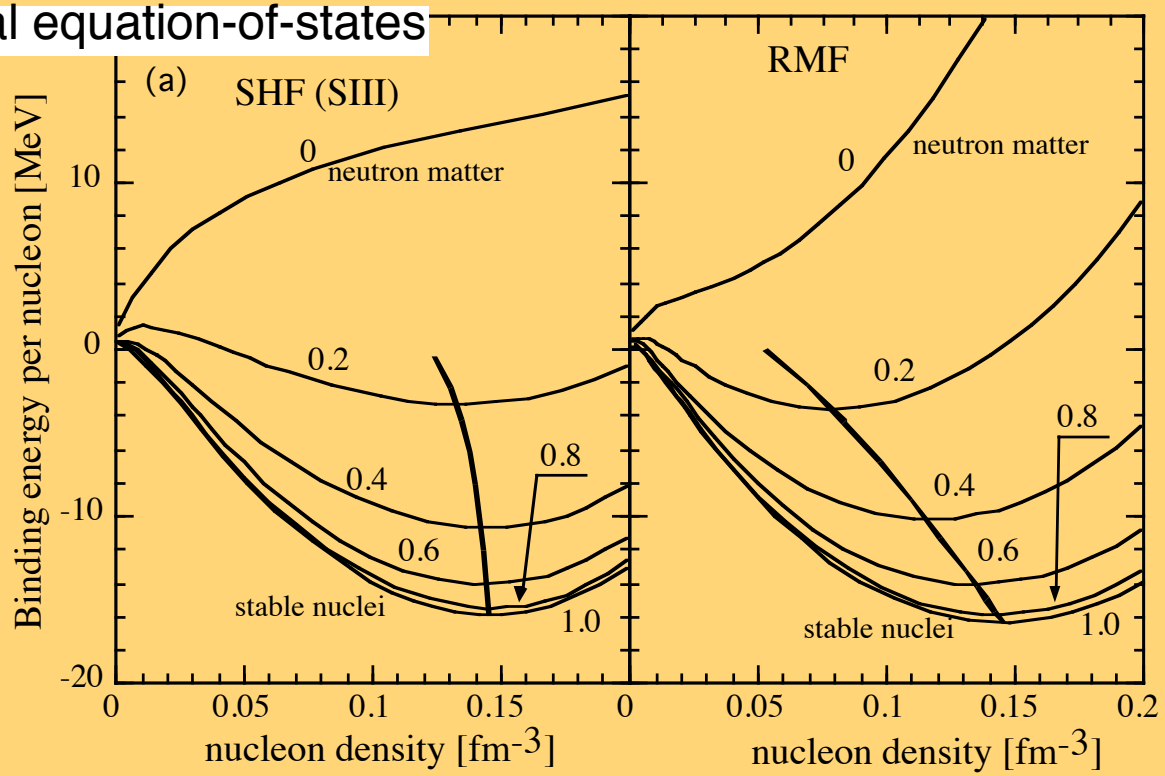
  -> EOS of asymmetric matter can be studied from density distribution of neutron rich nuclei.



Difference of EOS between models

- Saturation density behaves differently between two typical models. (Skyrme and Relativistic Mean Field)

Two typical equation-of-states

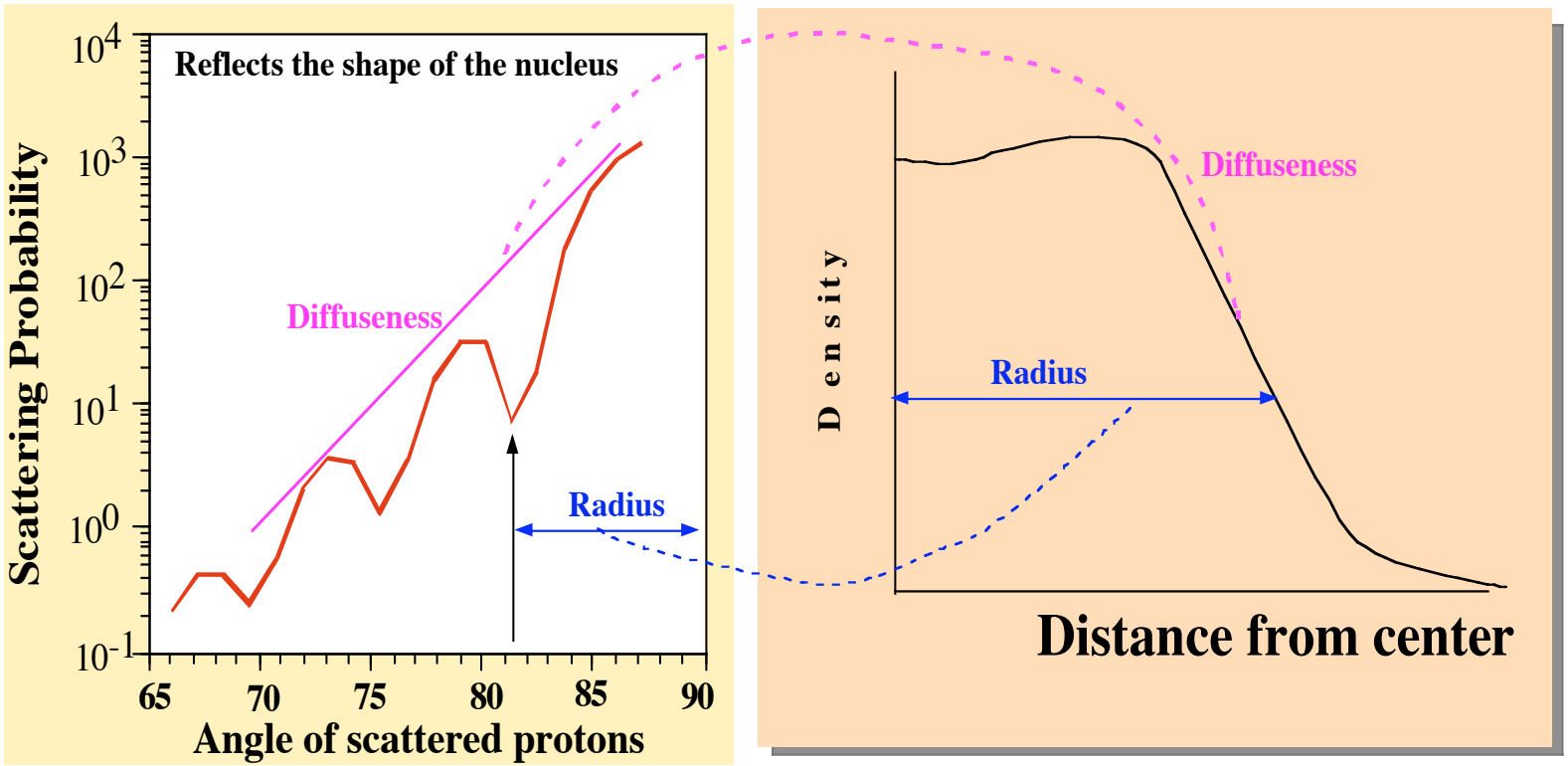


The central density gives a guidance to the correct equation of state

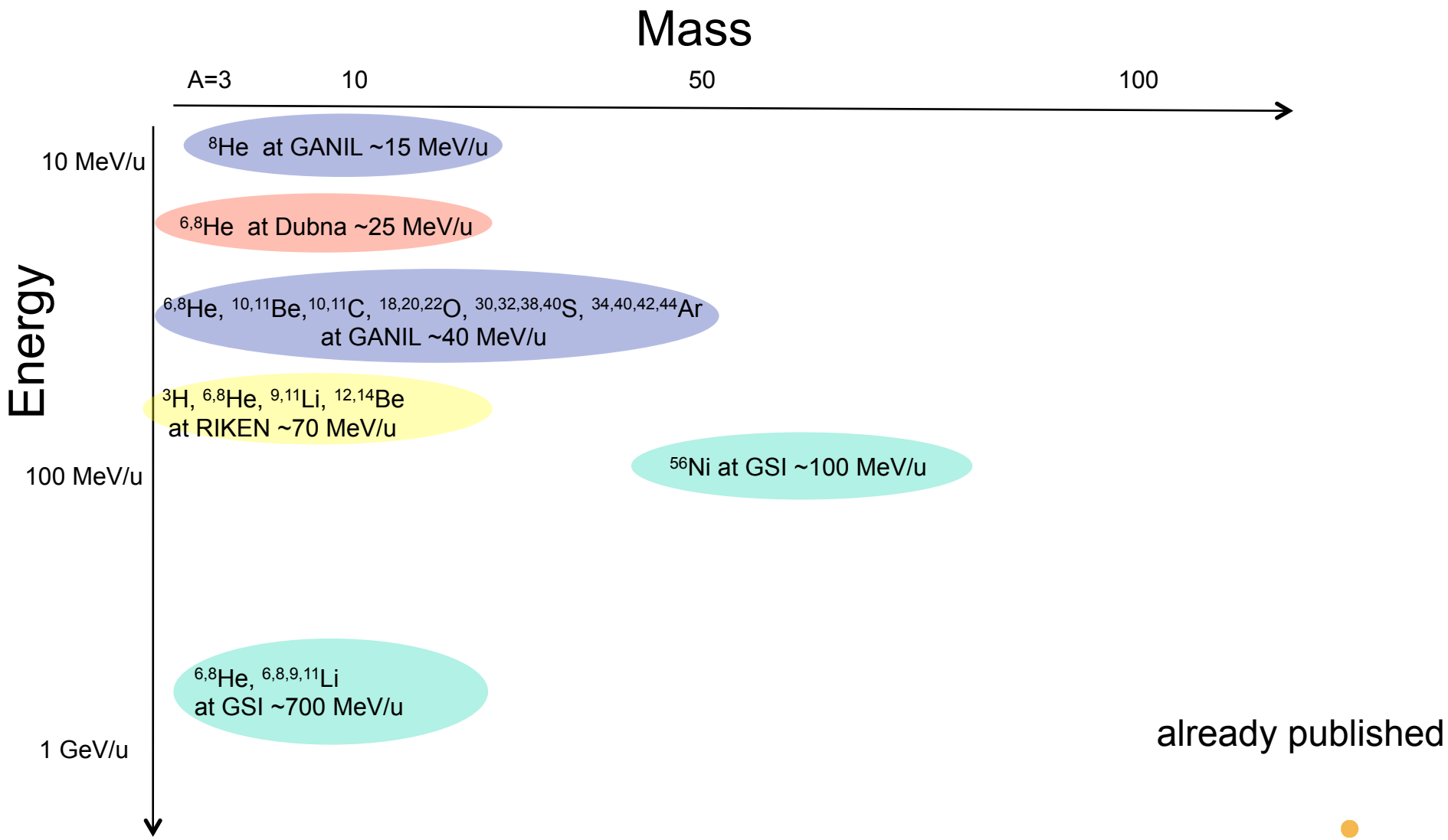
Measurement to be done

- Differential cross section of elastic scattering

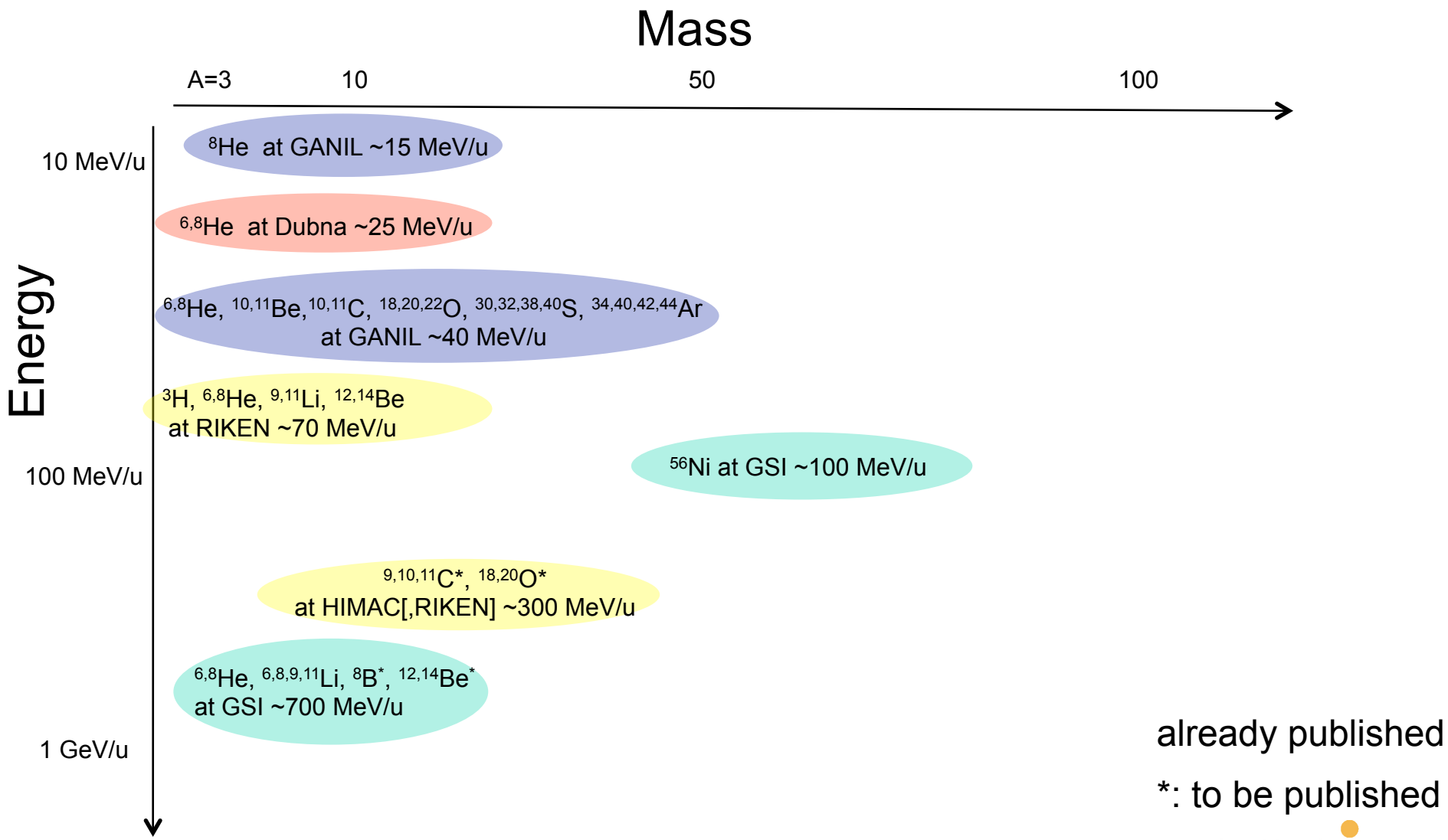
Diffraction Pattern



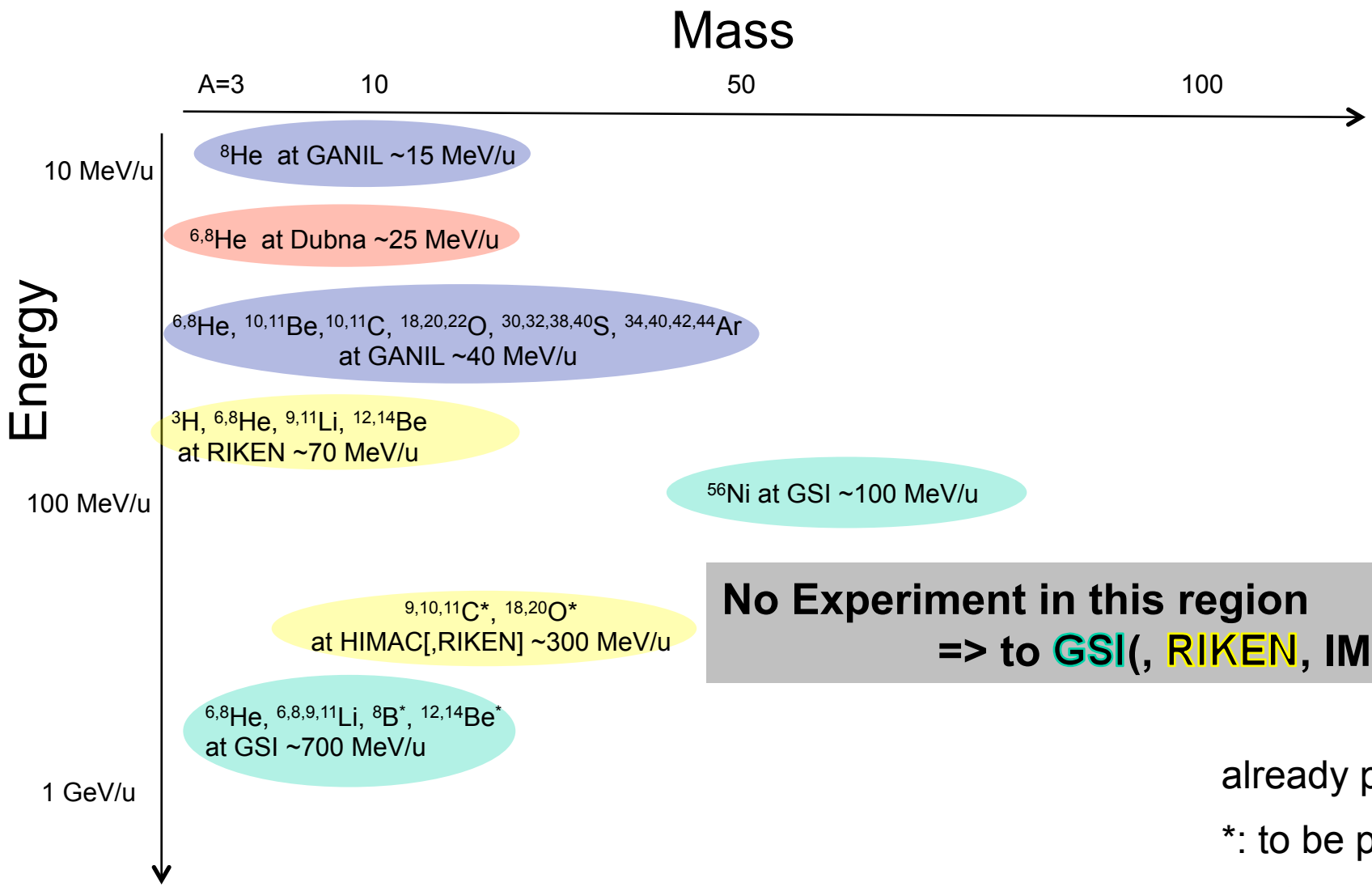
Proton elastic scattering of unstable nuclei



Proton elastic scattering of unstable nuclei



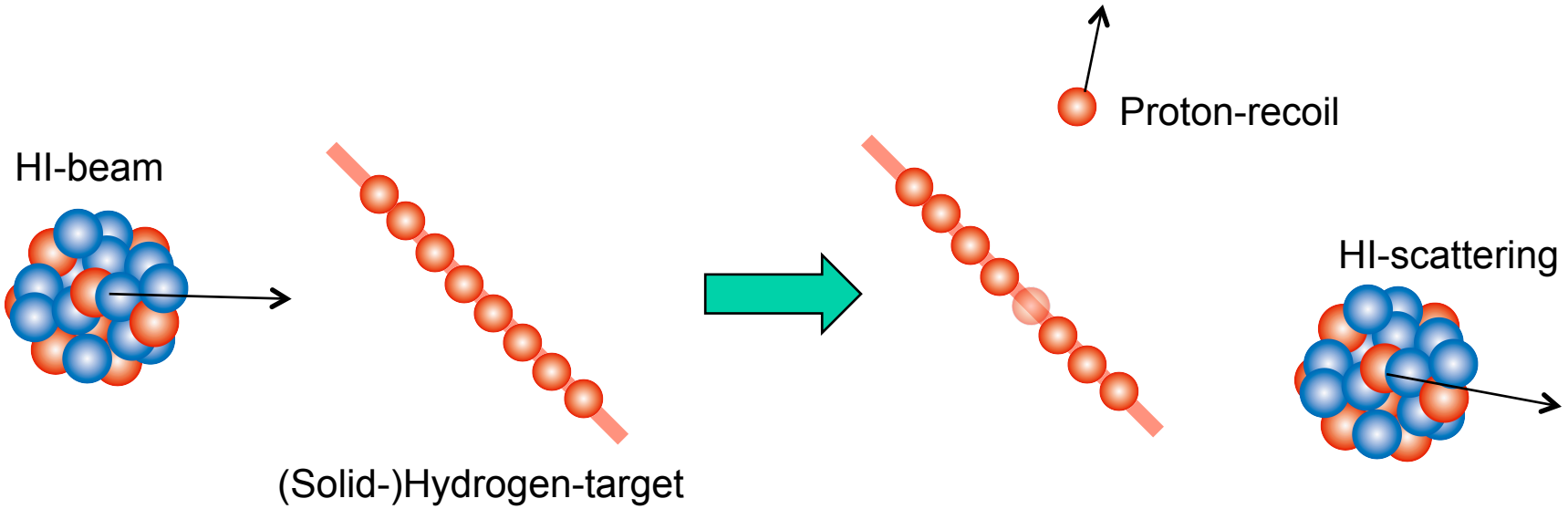
Proton elastic scattering of unstable nuclei



Experimental principle

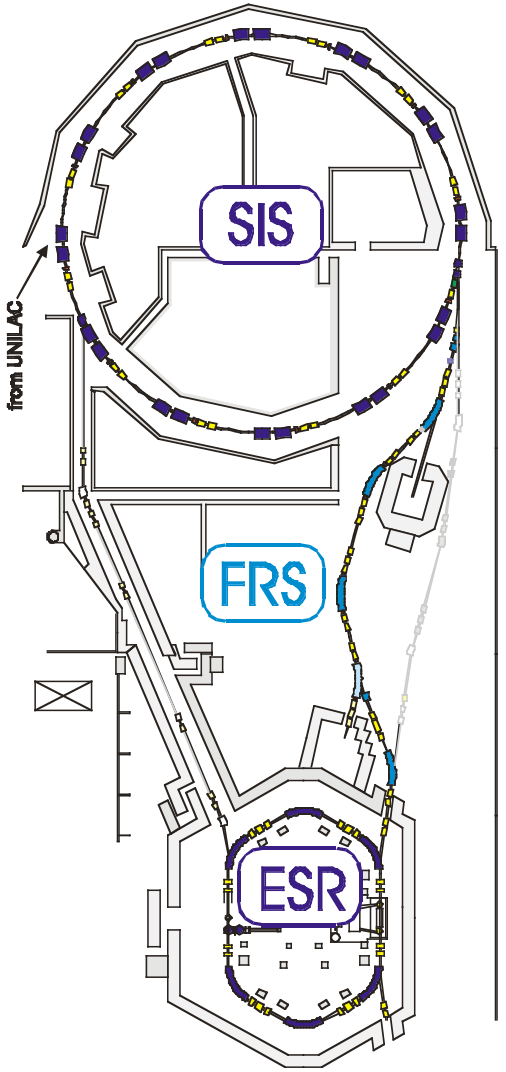
- Missing mass spectroscopy using inverse kinematics

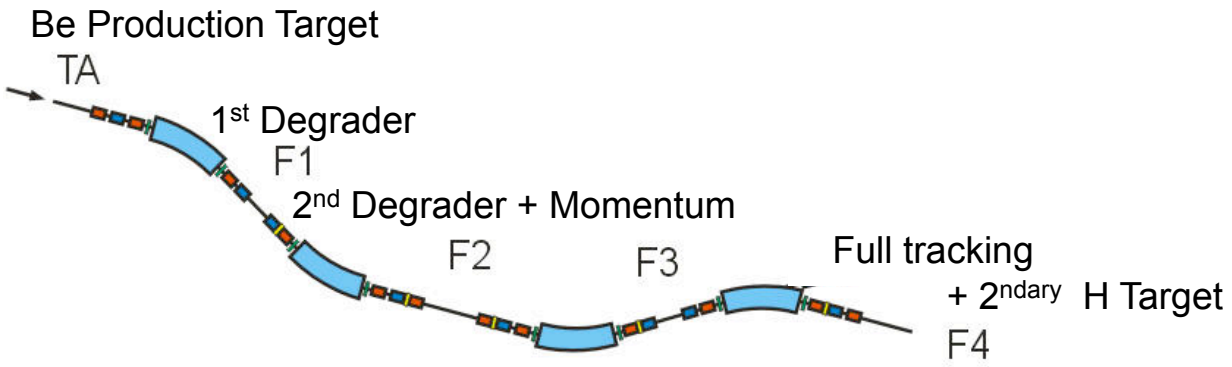
SH(^{A}HI, p) : Full tracking of incident beam on target [x, y, θ, φ, p]
: Position and energy of recoil particle on detector[x, y, p]



Experiment

FRagment Separator FRS





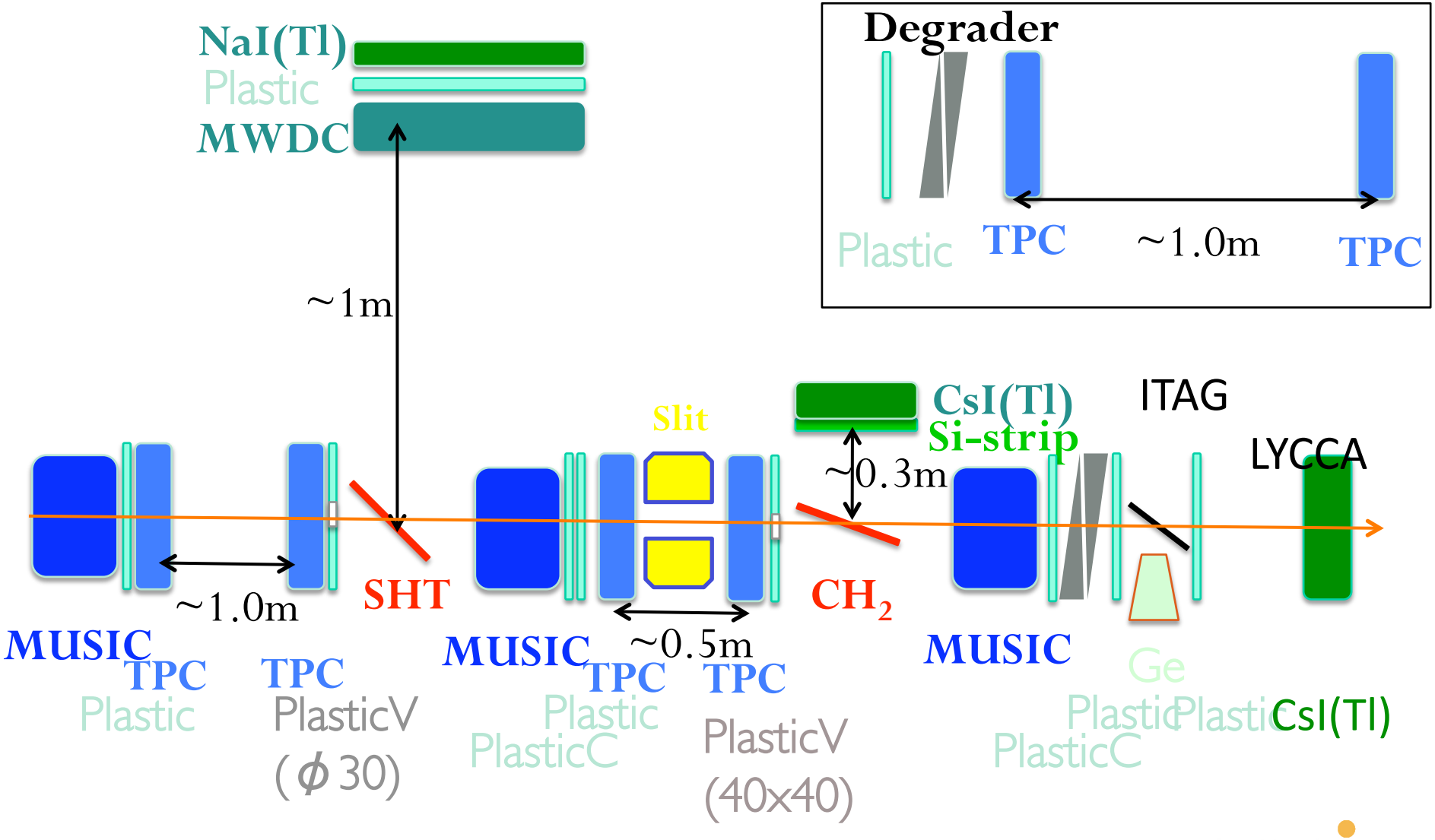
--Beam Parameter--

^{86}Kr 500 MeV/u ~2x10^{10} /spill @TA
[^{58}Ni 320 MeV/u 1x10^{6} /spill]

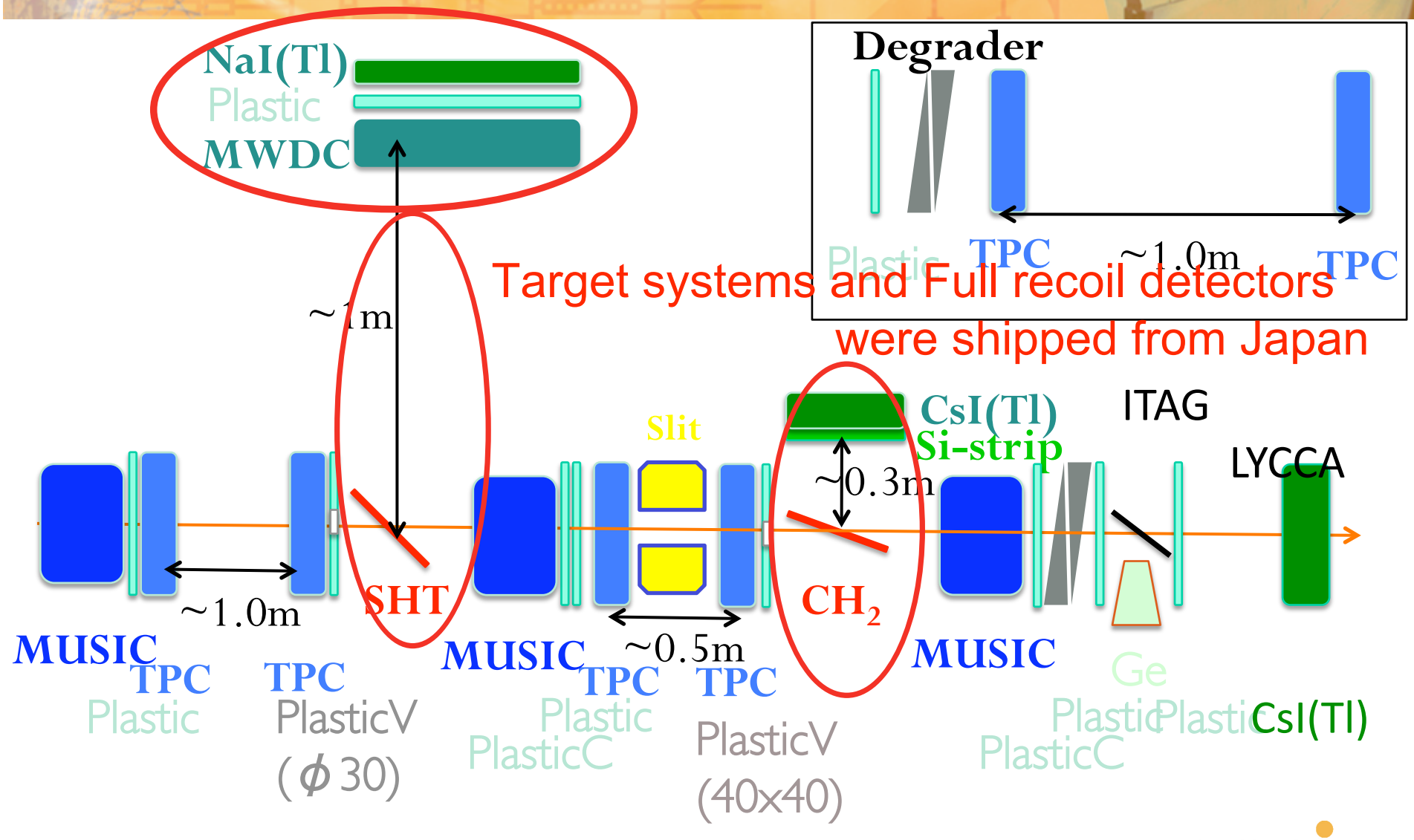
=>^{70}Ni 300 MeV/u ~1x10^{3} /spill
^{66}Ni 300 MeV/u ~2x10^{4} /spill
[^{58}Ni 300 MeV/u 1x10^{6} /spill]

in March-April/2010

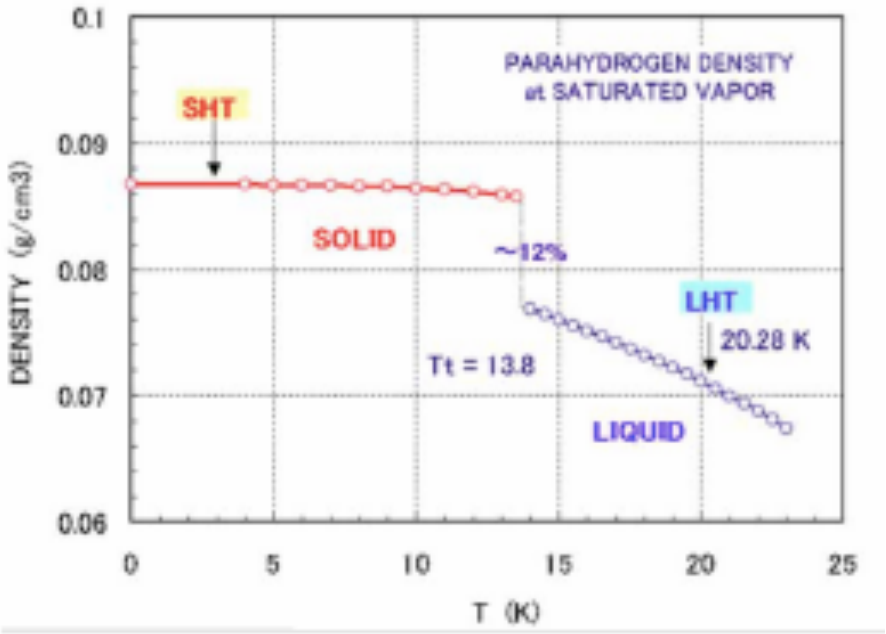
Schematic view of Experimental Setup at S4(S2)



Schematic view of Experimental Setup at S4(S2)



Solid Hydrogen Target [SHT]



Merit ⇔ Liquid

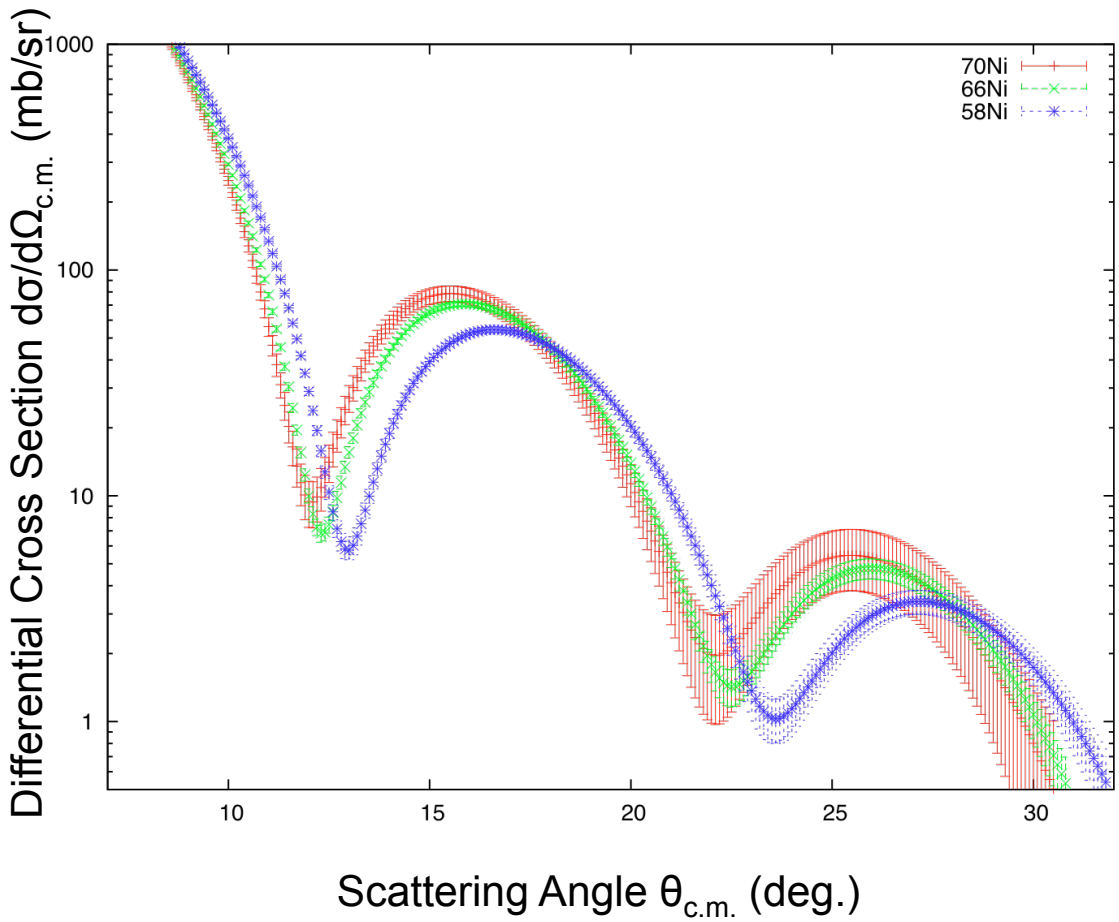
- High Density
  (ex. >+10% Liq.H2)
- No temp. dependence
  (See left figure)
- Flat and Thin target is acceptable
  (down to 1 mm thickness with thin film)

Merit ⇔ CH_2

- Effective quontity w/ low multiple scattering
  (ex. ~x10 number of target
  w/ same multiple scattering)
- Less background even w/ thin poly-films
  (S/N[QF from Carbon] > 10)

<u>=> high momentum transfer with moderate resolution</u>

Expected Angular Distribution



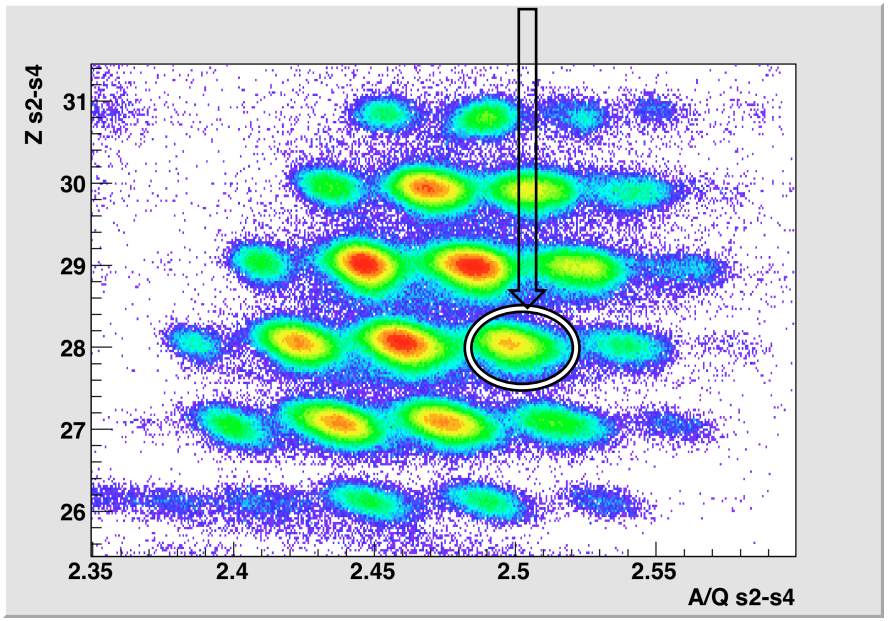
Red :^{70}Ni
Green:^{66}Ni
Blue :^{58}Ni
300 MeV/u elastic only

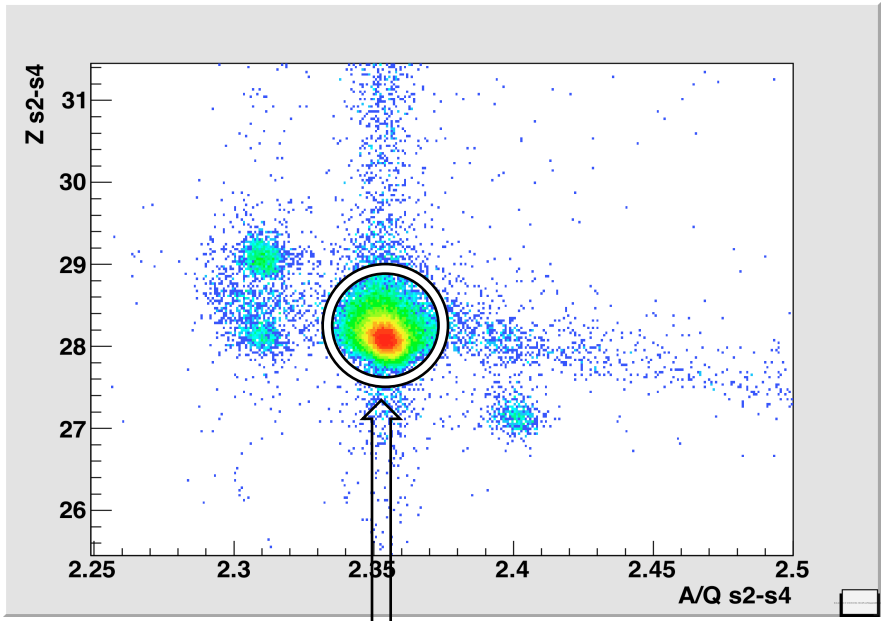
Calculation using the Dirac global potential concerning with expected statistics

Analysis

Particle ID of Fragments

^{86}Kr => ^{70}Ni 10%

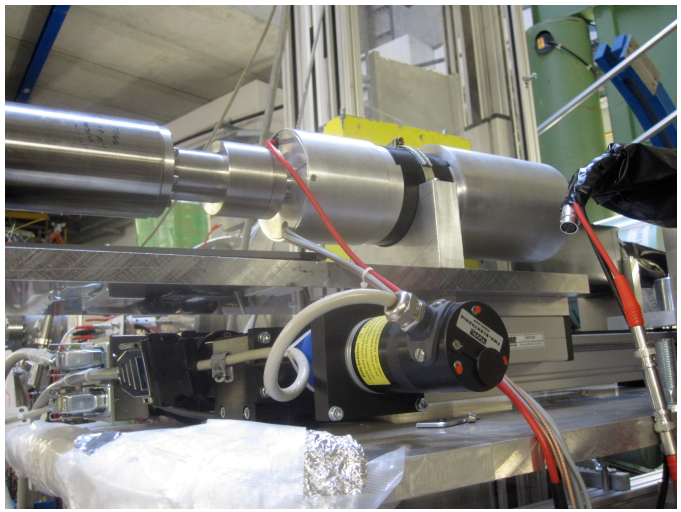




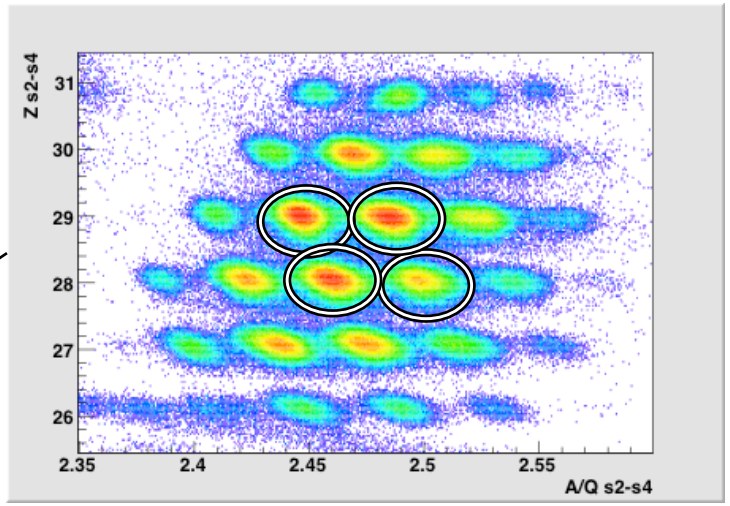
^{86}Kr => ^{66}Ni 70%

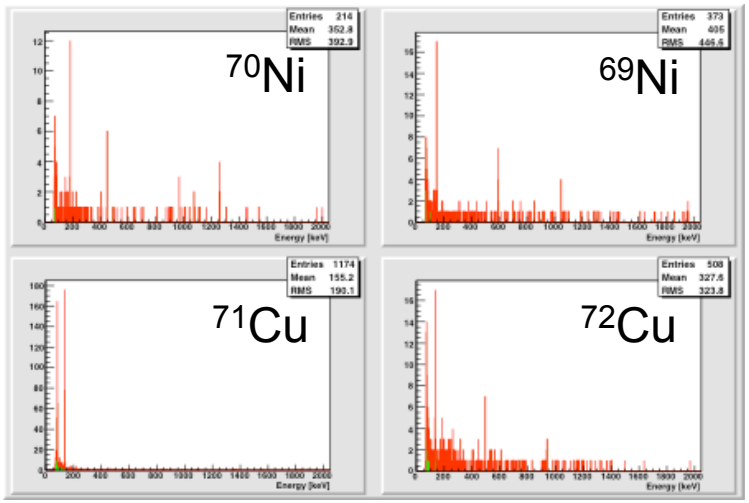
Further improvement is expected

Isomer Tagging for Beam PI and measurement of its ratio



Single Ge crystal
w/ mechanical cooling





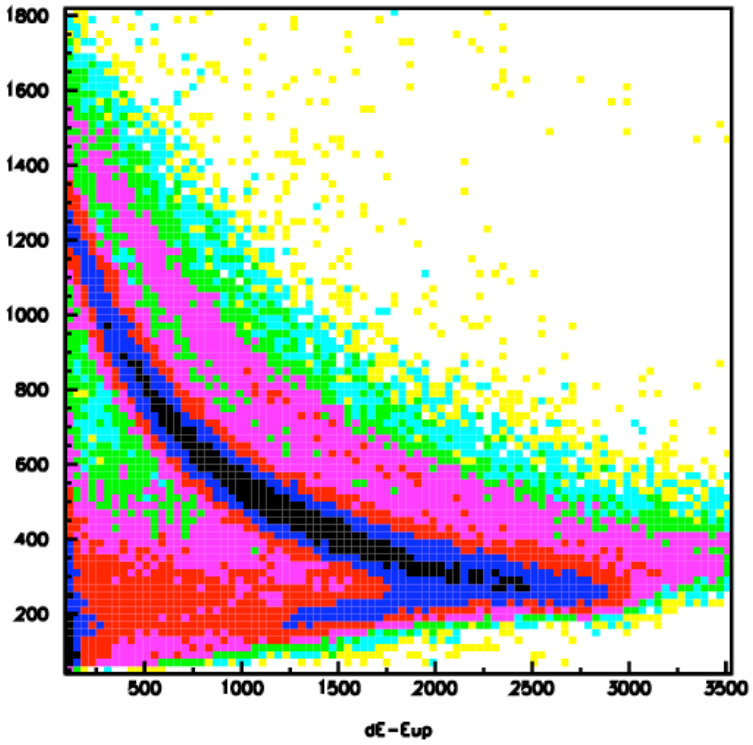
w/ particle identification
and delayed gates [150-3900 nsec]

Isomer contaminations on the hydrogen target
are negligibly small less than 10 %

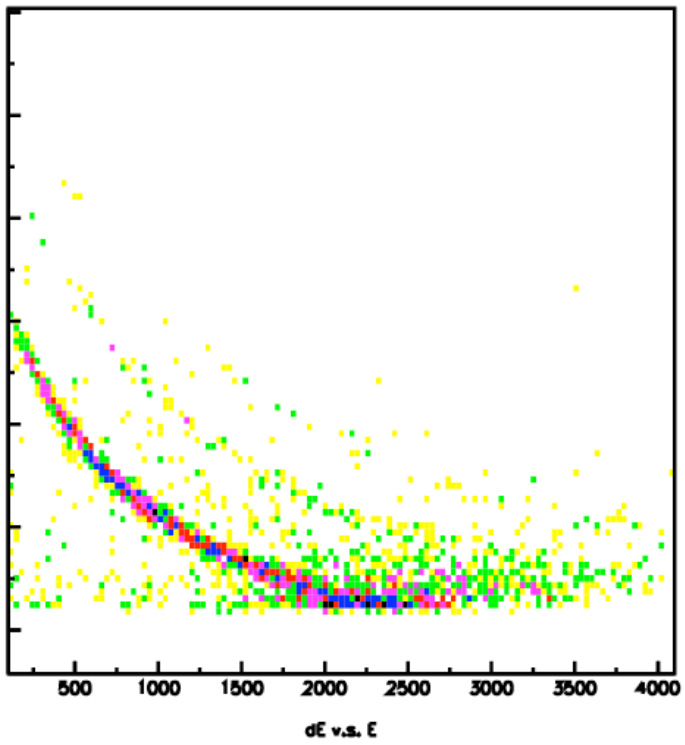
Recoil PI for proton

- dE-E method

Plastic + NaI(Tl)

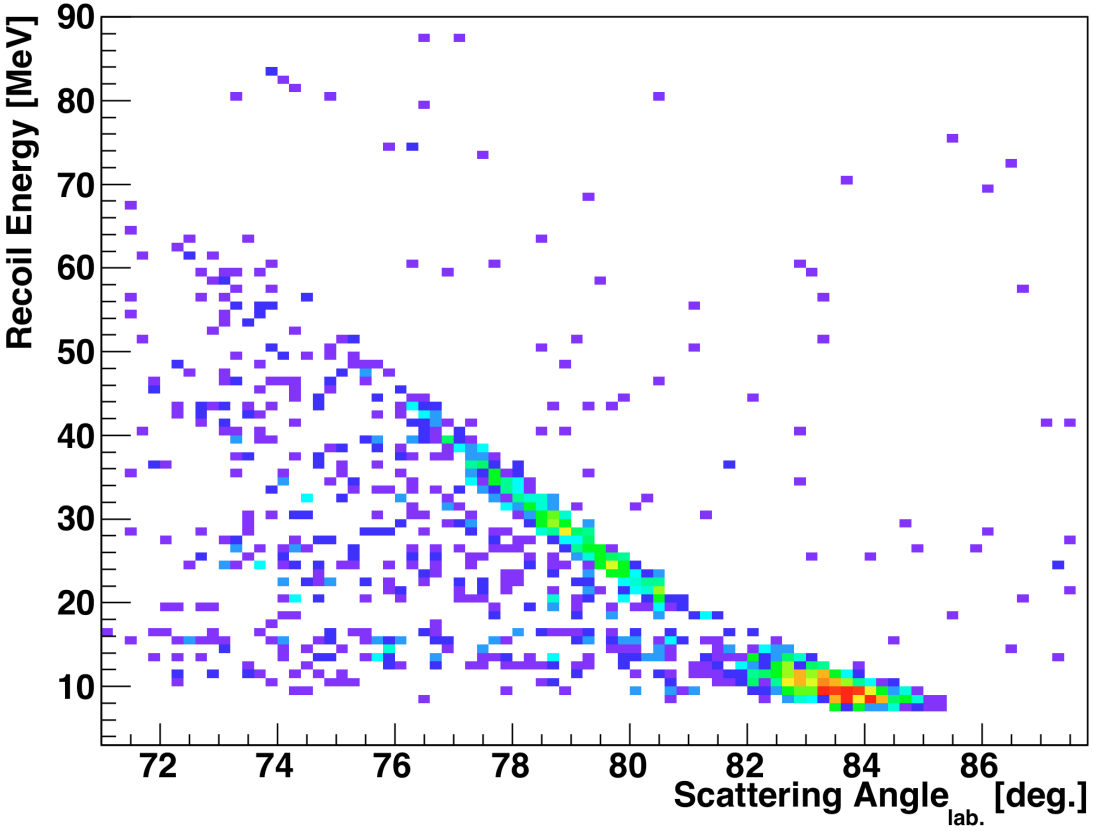


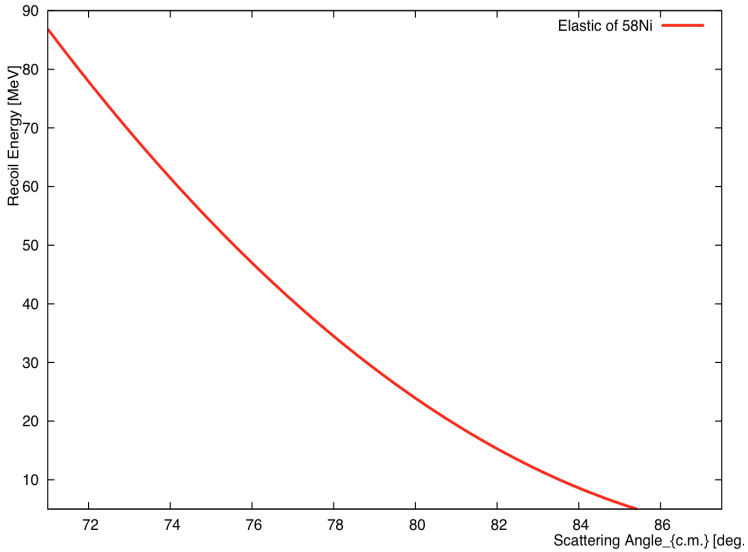
Strip Si + CsI(Tl)



Kinematics Correlation

SH(^{58}Ni,p) 300 MeV/u on SH





expected kinematics
of elastic channel

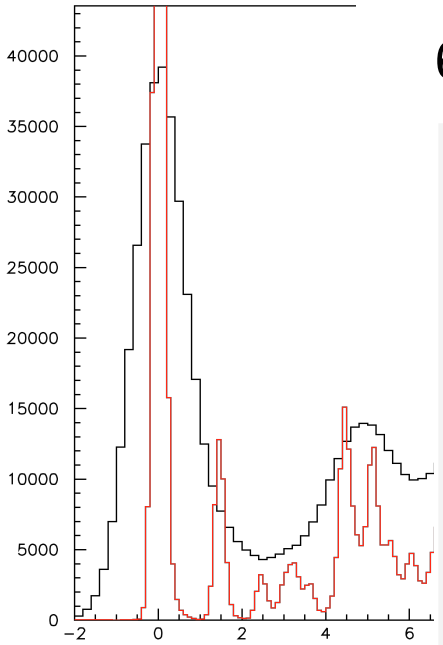
Calculating Q-value
[Excitation Energy]

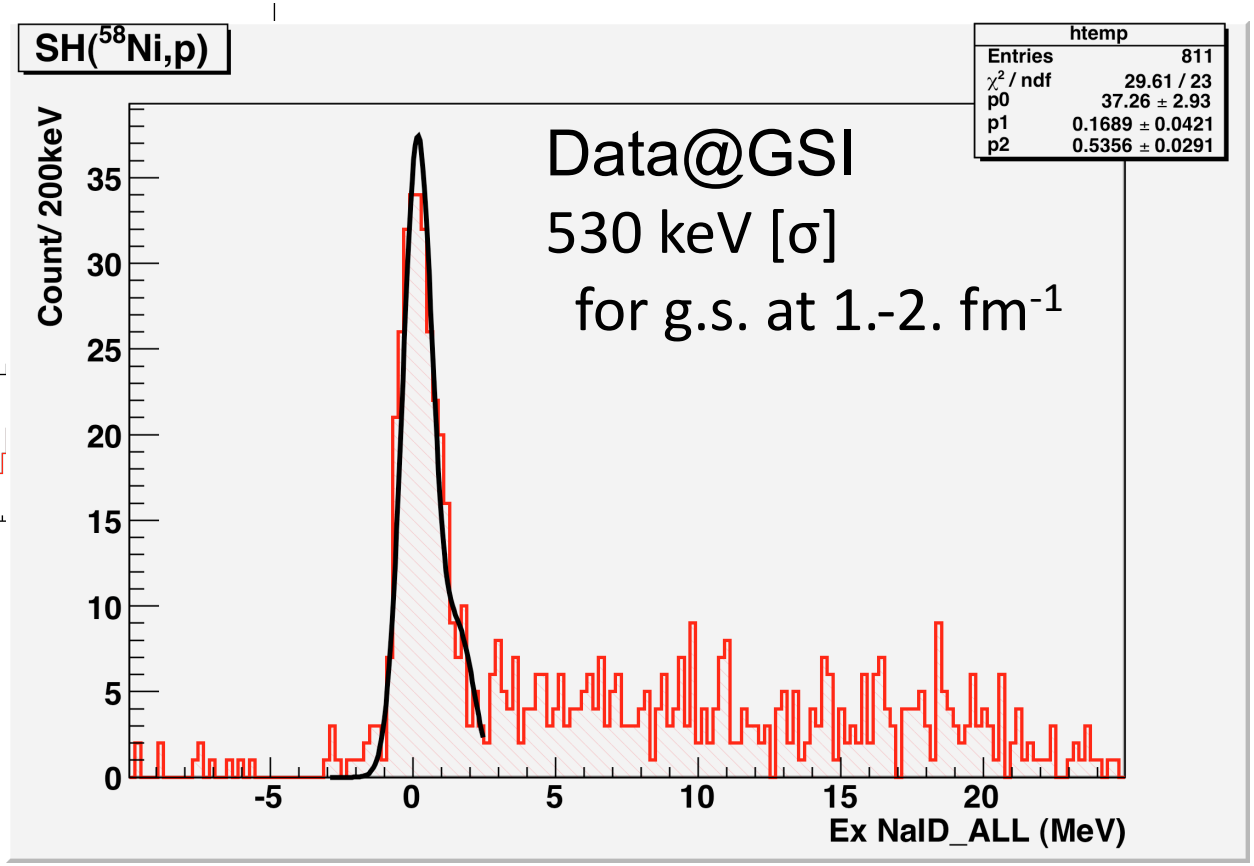
Typical Energy Spectrum

Data@RCNP

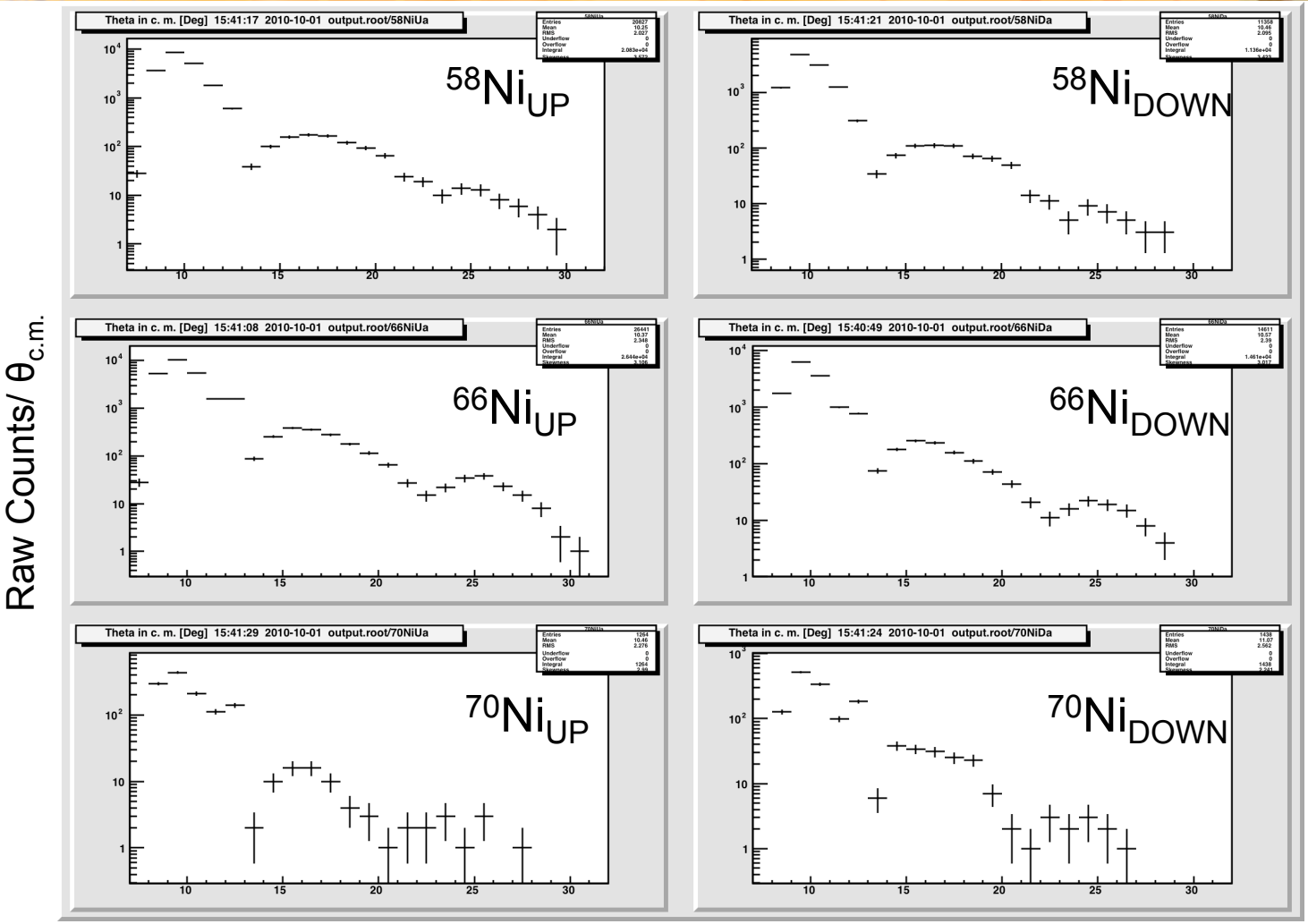
100 keV folding

600 keV folding

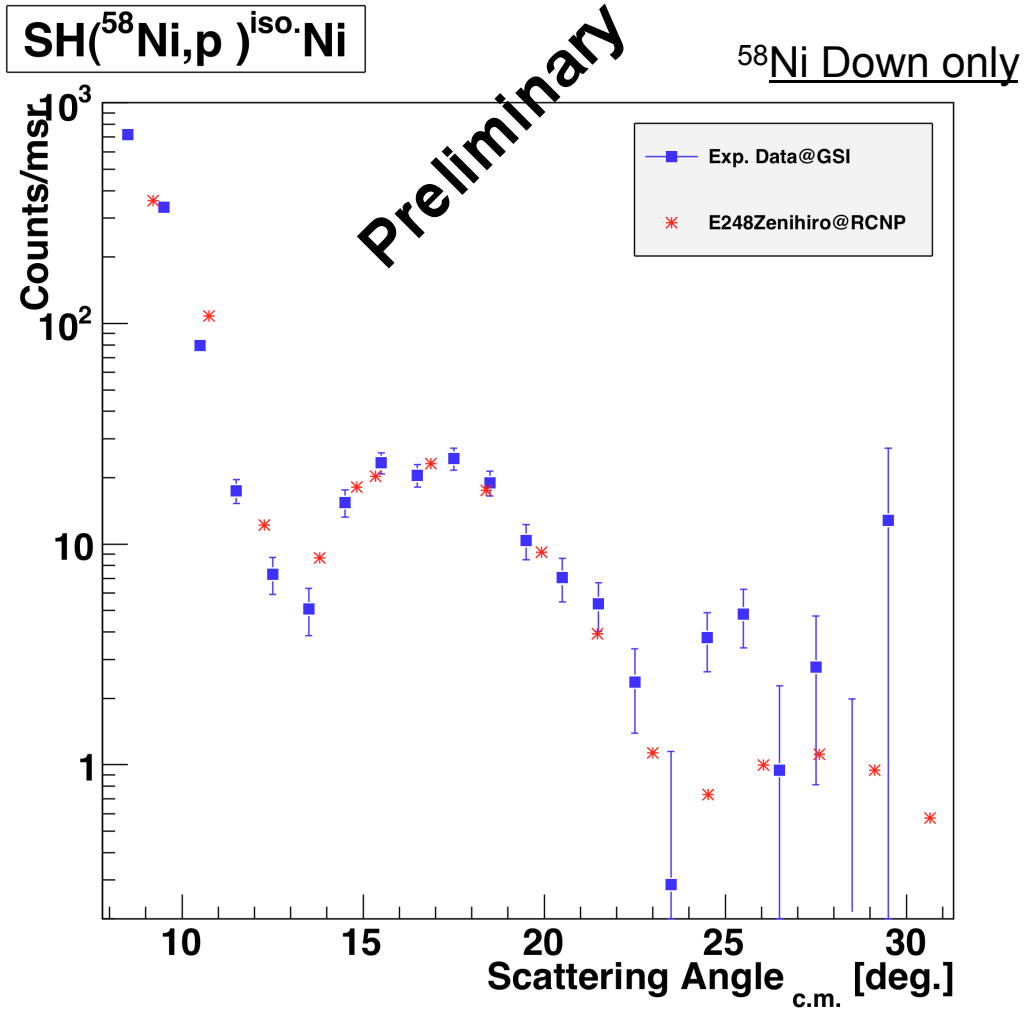




Raw Angular Distribution



Angular Distribution

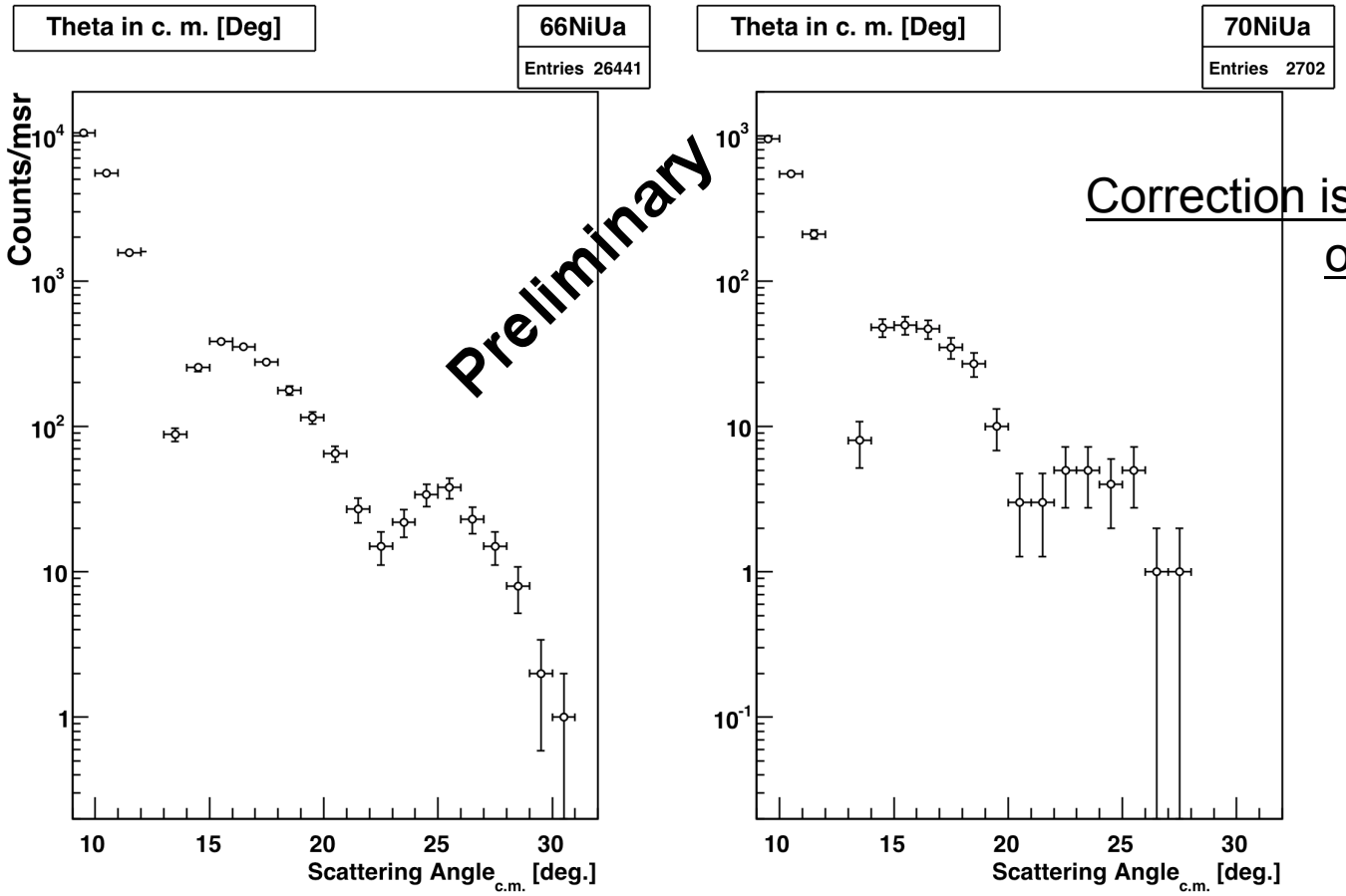


Acceptance correlated,
Efficiency and beam normalizations
is not included (not absolute values yet)

Reference cross sections (red)
are scaled to 16 deg. -18 deg. region.

Consistency of angular distribution can be confirmed.

Angular Distribution of exotic Ni



Correction is same as ^{58}Ni, only acceptance.

Only 1st Target Data[Solid Hydrogen 1 mm^{t}-45^{o} tilt]
Energy: ~300 MeV/u ^{66,70}Ni on SHT

Summary and Perspective

- Proton elastic scattering experiment of Ni isotopes at 300 MeV/u region was performed at GSI to the further understanding of the nuclear EOS.

- Clear diffraction patterns of elastic, ^{58,66,70}Ni, were observed in angular distributions.

- Final differential cross sections will be presented as soon as possible.

- Next targets in the future;

  Light exotic nuclei for study of their specific nuclear structures.

  More neutron-rich Ni isotopes [$^{72,74,\cdots}$Ni] at next generation facilities.

  Double magic nuclei neutron-rich ^{132}Sn using U fission beam.

S272 Collaborators

RCNP Osaka University, Japan

I. Tanihata[co-spokesperson], H. Sakaguchi, H-J. Ong, J. Zenihiro, K. Hirota

Tohoku University, Japan

Y. Matsuda

Miyazaki University, Japan

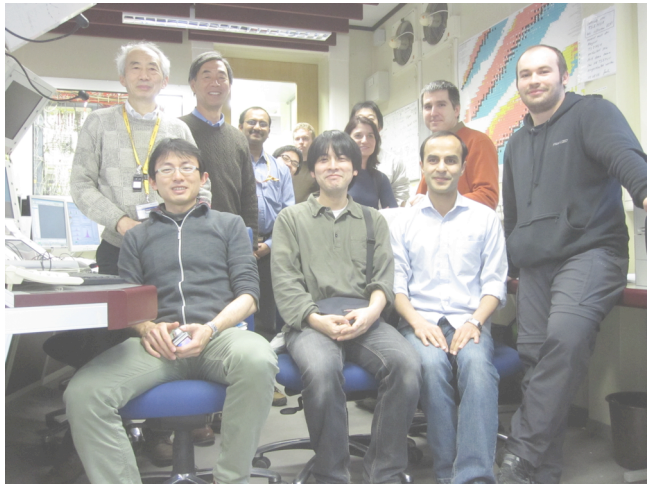
Y. Maeda

RIKEN Nishina Center, Japan

H. Otsu

St. Mary's University, Canada

R. Kanungo[co-spolesperson], M. Uchida



GSI, Germany

S. Terashima, C. Nociforo, H. Weick, M. Winkler, J. Winfield, Y. Livitinov, I. Muhka, J. Kurcewicz, A. Estrade, S. Ilieva, R. Knoebel, A. Prochazka, F. Farinon, B. Riese, S. Petri, P. Boutachkov, P. Egelhof, H. Simon, K. Boretzky, M. Harakeh, H. Geissel, C. Scheidenberger

CUB Bratislava, Slovakia

B. Sitar, R. Janik, P. Strmen

KVI, Netherlans

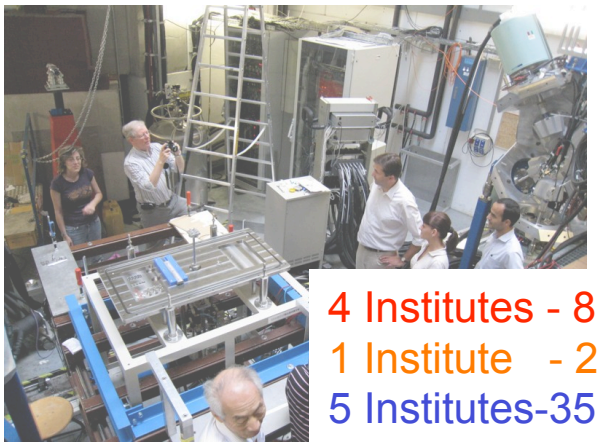
C. Rigollet, J.Walle, T. Adachi, A. Najafi, N. Kalantar

Lund University, Sweden

D. Rudolph, P. Golubev, S. Shende, R. Hoischen

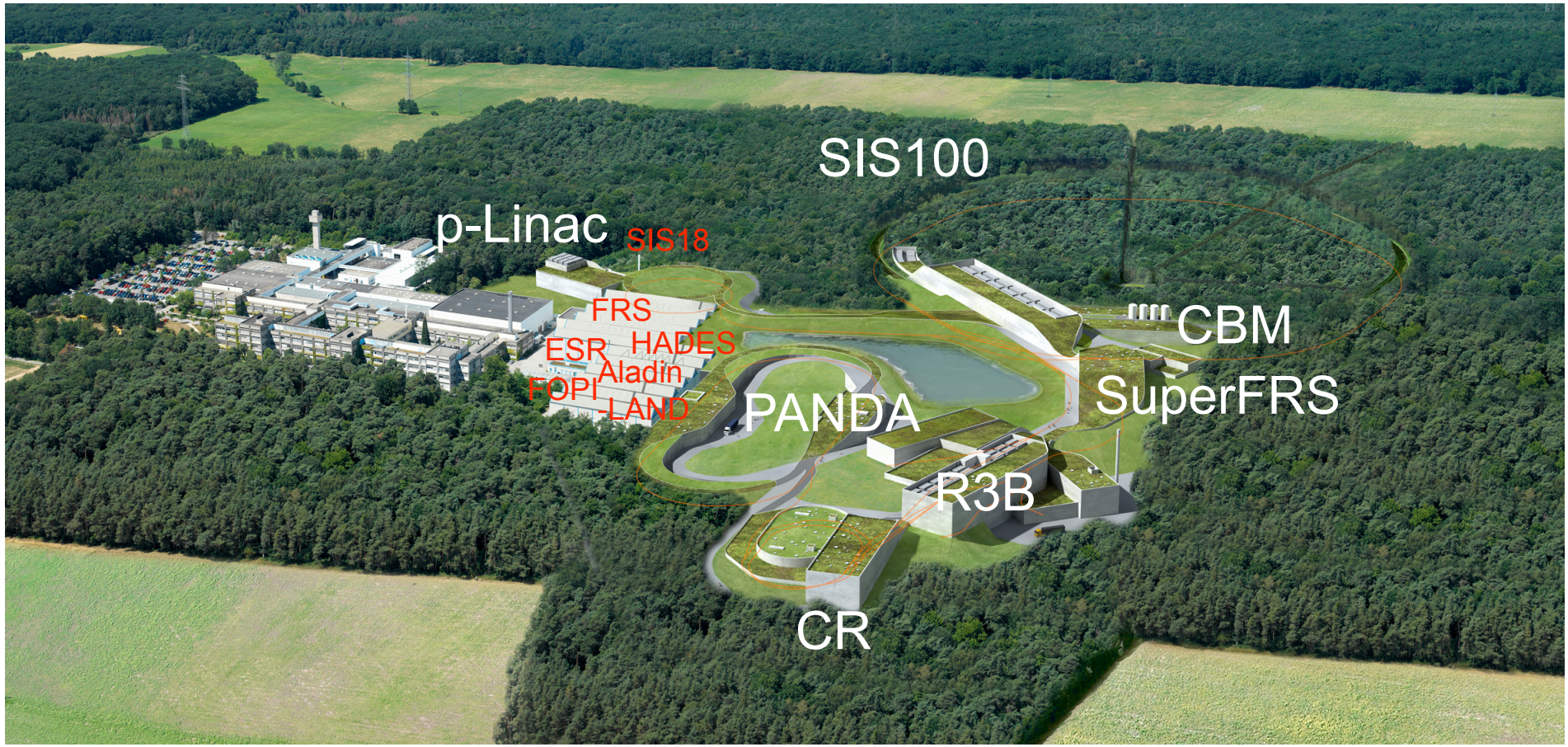
University of Cologne, Germany

A. Wendt



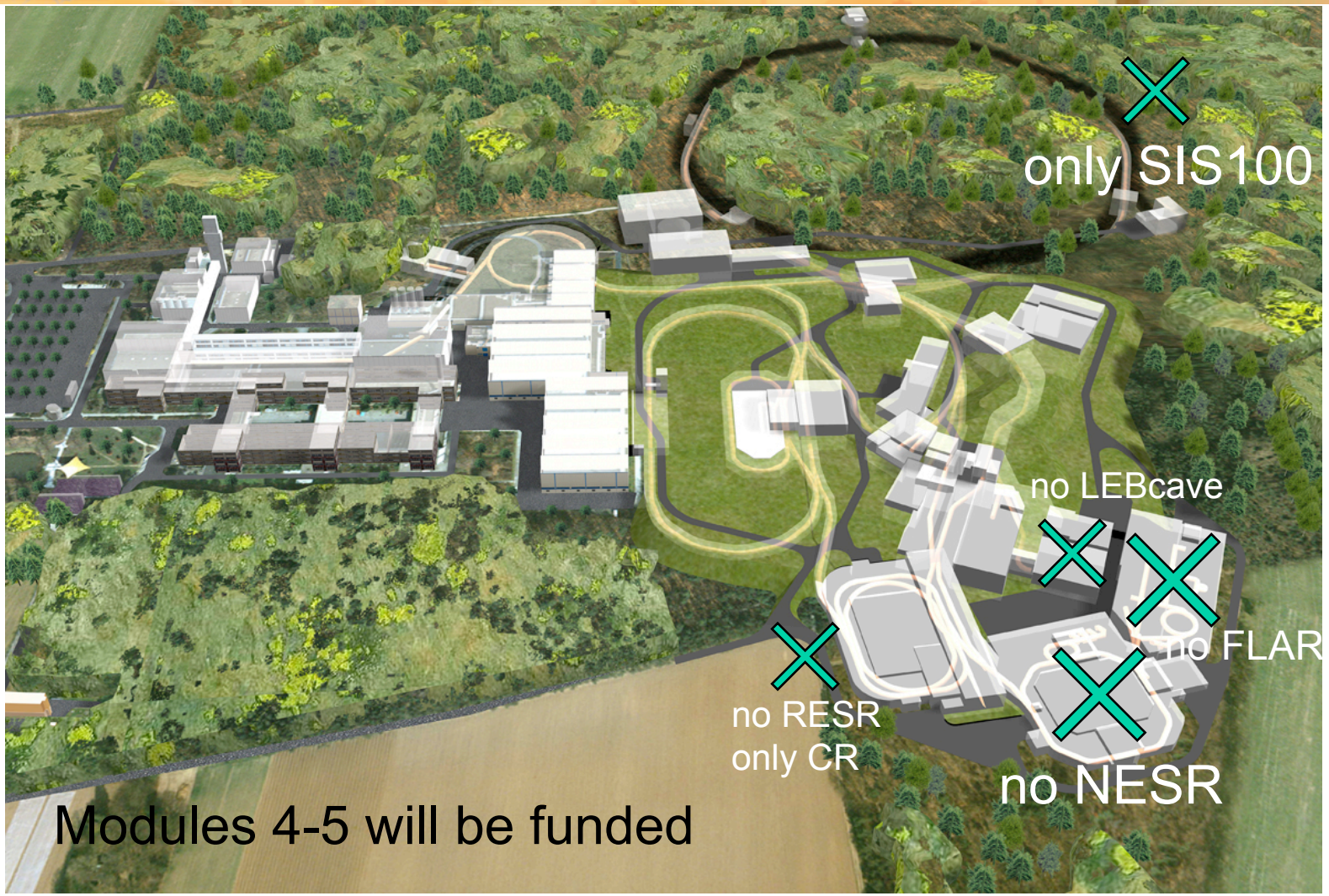
4 Institutes - 8 People-Japan
1 Institute - 2 People-Canada
5 Institutes-35 People-EU

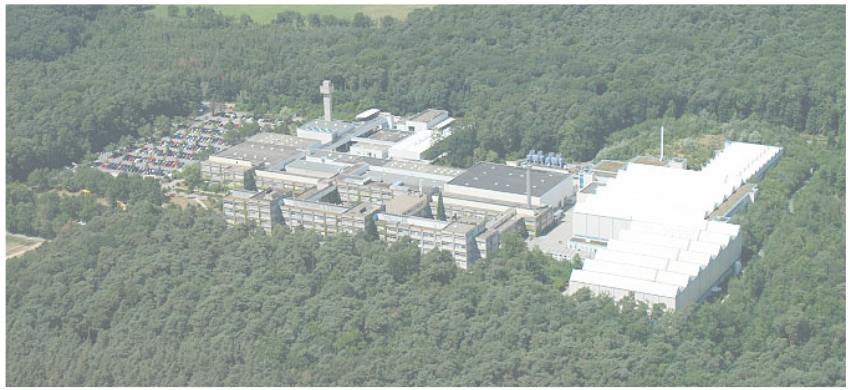
Future FAIR [Start Version]



Recently[4/Oct/2010], FAIR have been established.
Modules 0-3 are funded. [up to 2016 for contruction]

Future FAIR [Start Version]





Thank you for your attention !!