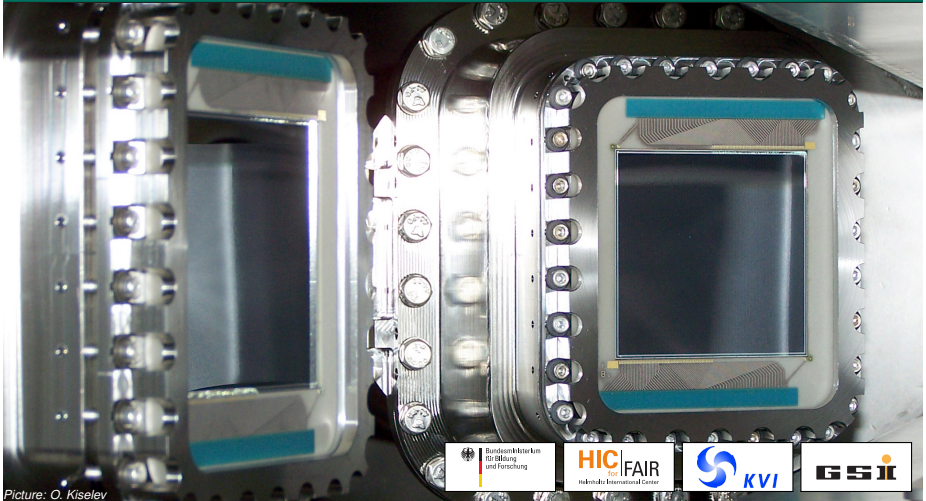


# Status of EXL



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Mirko von Schmid for the EXL collaboration

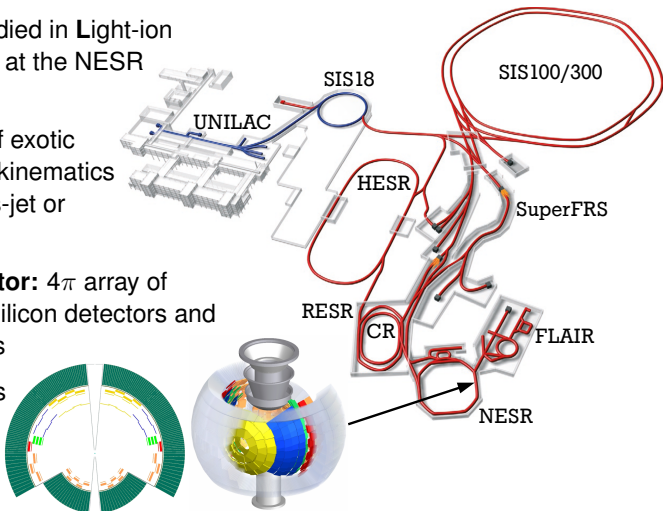


Picture: O. Kiselev



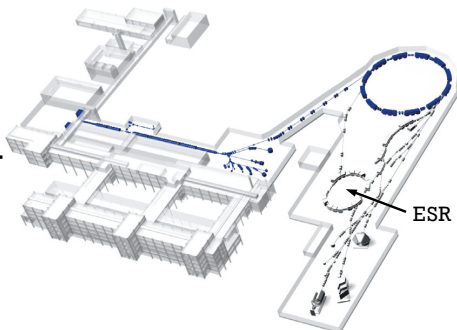
# The EXL project within NUSTAR at FAIR

- ▶ “**EX**otic nuclei studied in **L**ight-ion induced reactions at the NESR storage-ring”
- ▶ Direct reactions of exotic beams in inverse kinematics on an internal gas-jet or droplet target
- ▶ **EXL recoil detector**:  $4\pi$  array of several layers of silicon detectors and scintillator crystals
- ▶ Detection systems for beam-like particles, gammas and neutrons

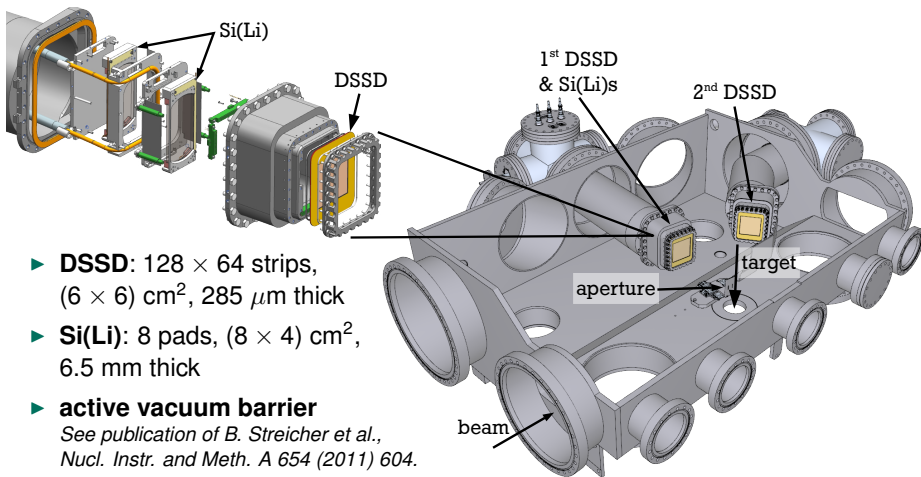


# EXL experiments at the ESR

- ▶ GSI experiment **E105** at the ESR
- ▶ **Commissioning** with stable  $^{20}\text{Ne}$  and  $^{58}\text{Ni}$  beams on  $\text{H}_2$  and  $^4\text{He}$
- ▶ **Physics aim: Nuclear matter distribution in doubly-magic  $^{56}\text{Ni}$  by elastic proton scattering**
- ▶ Proof of principle: GMR in  $^{58}\text{Ni}(\alpha, \alpha')$
- ▶ Experimental parameters  $^{56}\text{Ni}$ :
  - ▶ **beam energy 400 MeV/u**
  - ▶ particles stored  $\approx 3 \cdot 10^6$
  - ▶ target density  $\approx 3 \cdot 10^{13} \text{ cm}^{-2}$
  - ▶ revolution frequency  $\approx 2 \text{ MHz}$
  - ▶ **luminosity of  $\approx 2 \cdot 10^{26} \frac{\text{particles}}{\text{s cm}^2}$**



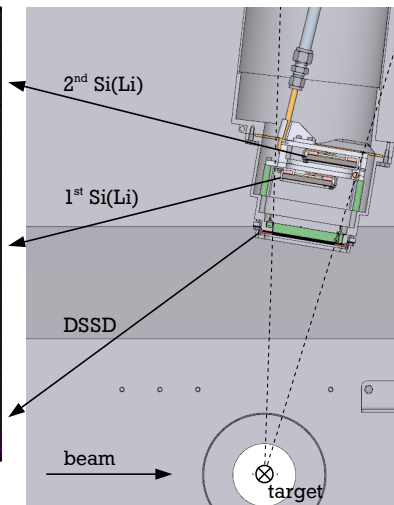
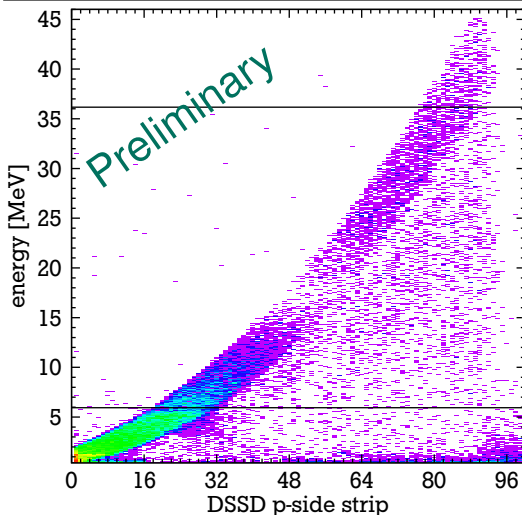
# Experimental setup at the ESR



- ▶ **DSSD:**  $128 \times 64$  strips,  $(6 \times 6)$  cm<sup>2</sup>, 285 μm thick
- ▶ **Si(Li):** 8 pads,  $(8 \times 4)$  cm<sup>2</sup>, 6.5 mm thick
- ▶ **active vacuum barrier**  
*See publication of B. Streicher et al., Nucl. Instr. and Meth. A 654 (2011) 604.*
- ▶ **aperture** to improve angular resolution (1 mm/2 mm slits)

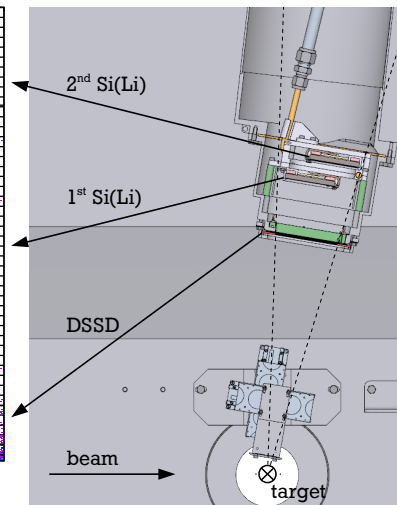
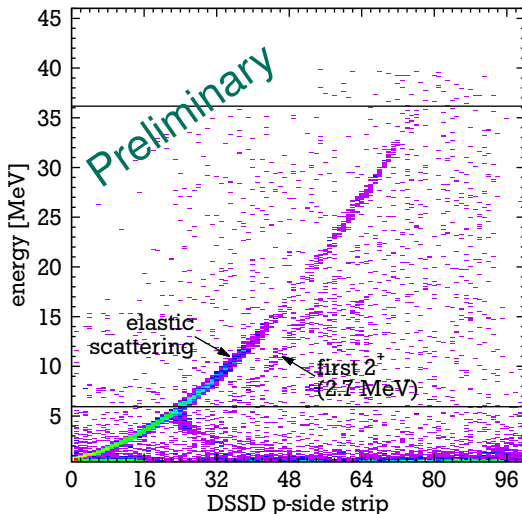
# Preliminary results: $^{56}\text{Ni}(p,p)^{56}\text{Ni}$ at 400 MeV/u

## Energy reconstruction



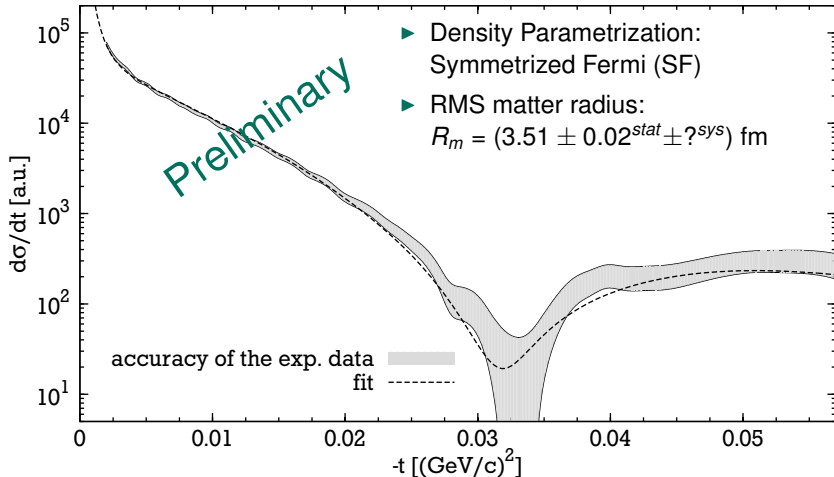
# Preliminary results: $^{56}\text{Ni}(p,p)^{56}\text{Ni}$ at 400 MeV/u

## Advantage of the aperture (1 mm)

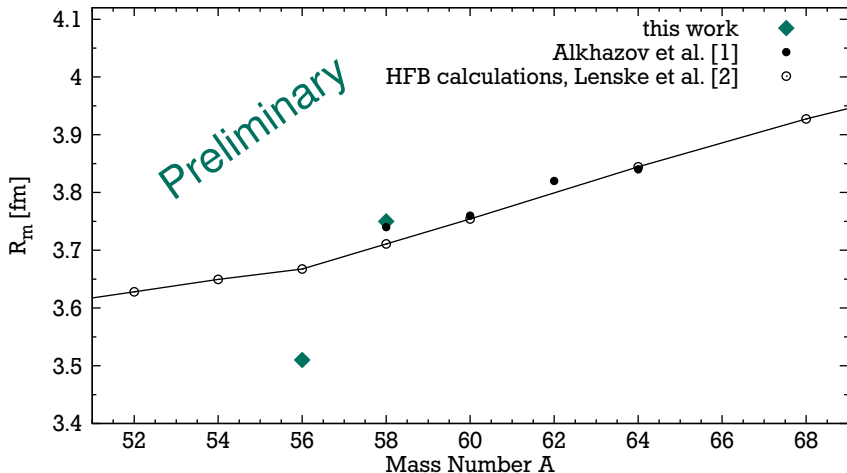


# Preliminary results: $^{56}\text{Ni}(p,p)^{56}\text{Ni}$ at 400 MeV/u

## Cross section fitted with Glauber multiple-scattering theory



# Evolution of total matter radii in Ni isotopes

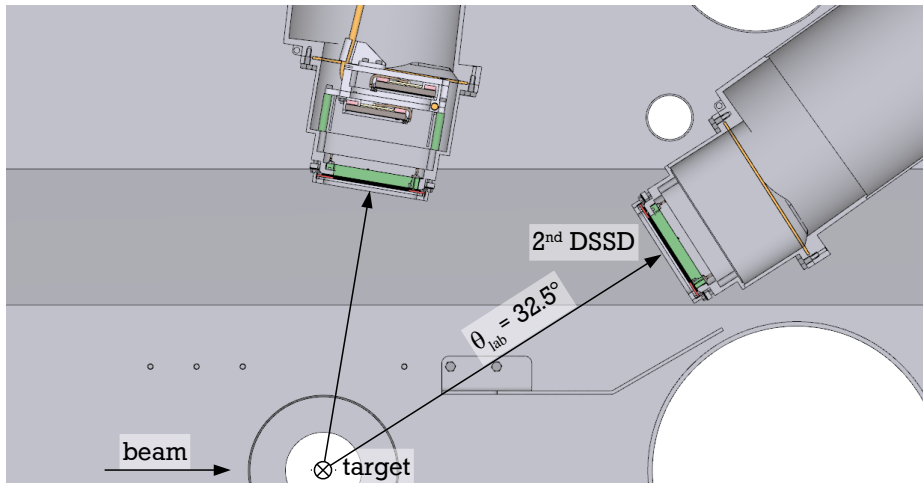


[1] G.D. Alkhazov et al., Physics Letters B 67, 402–404 (1977)

[2] H. Lenske, Physics Letters B 647, 82–87 (2007)

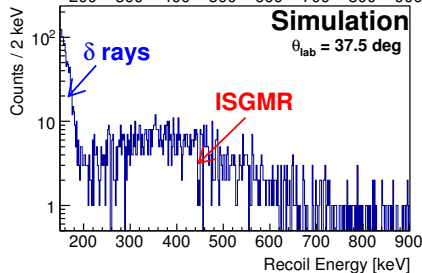
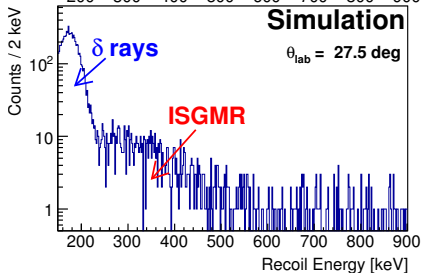
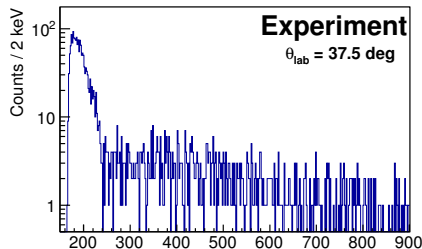
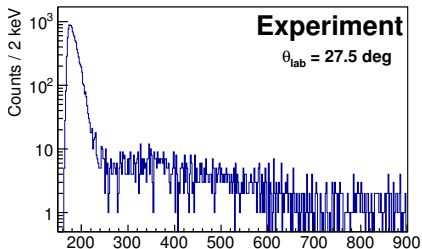


# Data taken with the 2<sup>nd</sup> DSSD at 32.5°



# Preliminary results: $^{58}\text{Ni}(\alpha, \alpha')^{58}\text{Ni}$ at 100 MeV/u

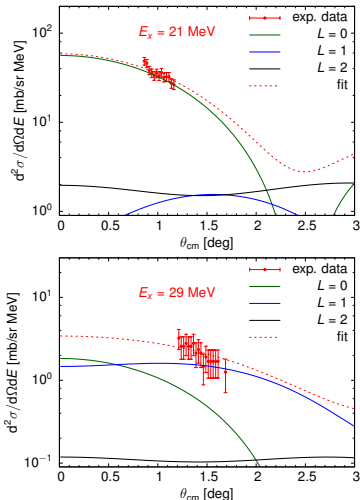
## Alpha inelastic scattering by J.C. Zamora



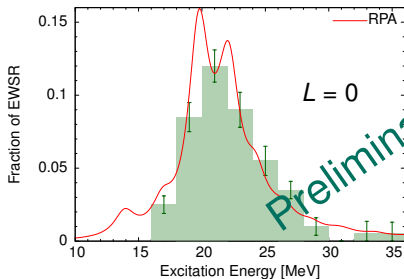
# Preliminary results: $^{58}\text{Ni}(\alpha, \alpha')^{58}\text{Ni}$ at 100 MeV/u

## Giant monopole resonance

### by J.C. Zamora



## Multipole Decomposition Analysis



Preliminary

centroid [MeV]	EWSR [%]	
$22.2^{+1.2}_{-1.8}$	$86^{+15}_{-13}$	present data
$21.5^{+3.0}_{-0.3}$	$74^{+22}_{-12}$	PRC 61, 067307 (2000)
$20.8^{+0.9}_{-0.3}$	$85^{+13}_{-10}$	PRC 73, 014314 (2006)
22.0	108	RPA calculation [3]

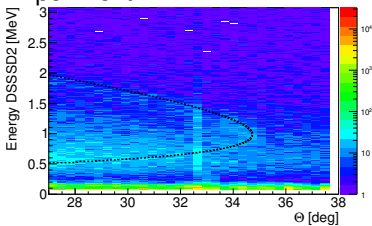
# Preliminary results: $^{20}\text{Ne}(p, d)^{19}\text{Ne}$ at 50 MeV/u

## Transfer reaction from Experiment E087

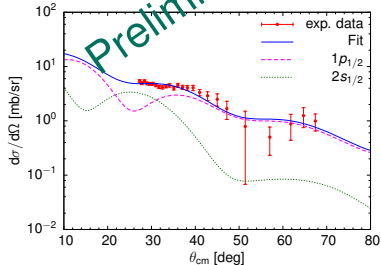
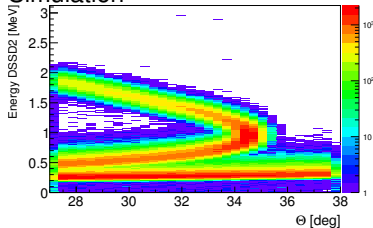
by J.C. Zamora



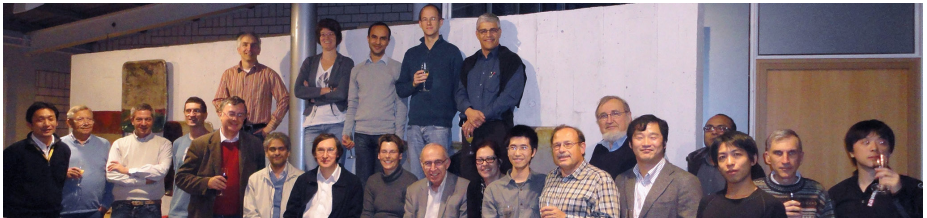
Experiment



Simulation



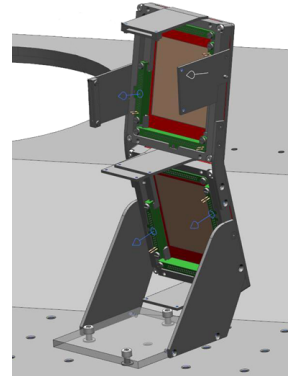
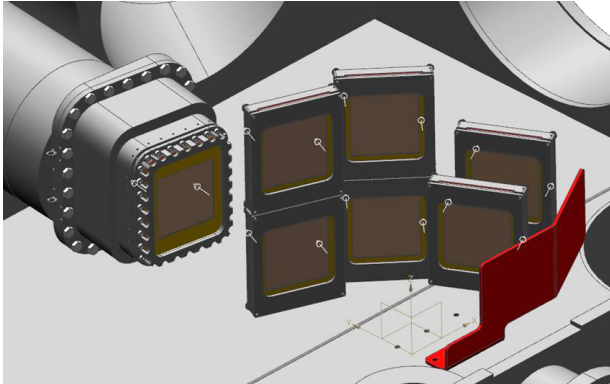
# Conclusion



- ▶ **First successful nuclear reaction experiment with stored exotic beams ever!**
- ▶ Analysis of  $^{56}\text{Ni}(p,p)$  cross section using Glauber multiple-scattering theory:
  - ▶ Preliminary **matter radius** of  $^{56}\text{Ni}$ :  $R_m \approx 3.5$  fm
  - ▶ Model independent analysis using sum-of-gaussians density distribution in the works.
- ▶ Successfully demonstrated the possibility to study **giant resonances** and **transfer reactions** with EXL.

# Outlook

- ▶ Upgraded detector setup covering a substantially larger solid angle is planned



- ▶ Future experiments possible at ESR (GSI), HIRFL-CSR (Lanzhou), TSR@ISOLDE (CERN) and at FAIR.

# Thank you for your attention



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