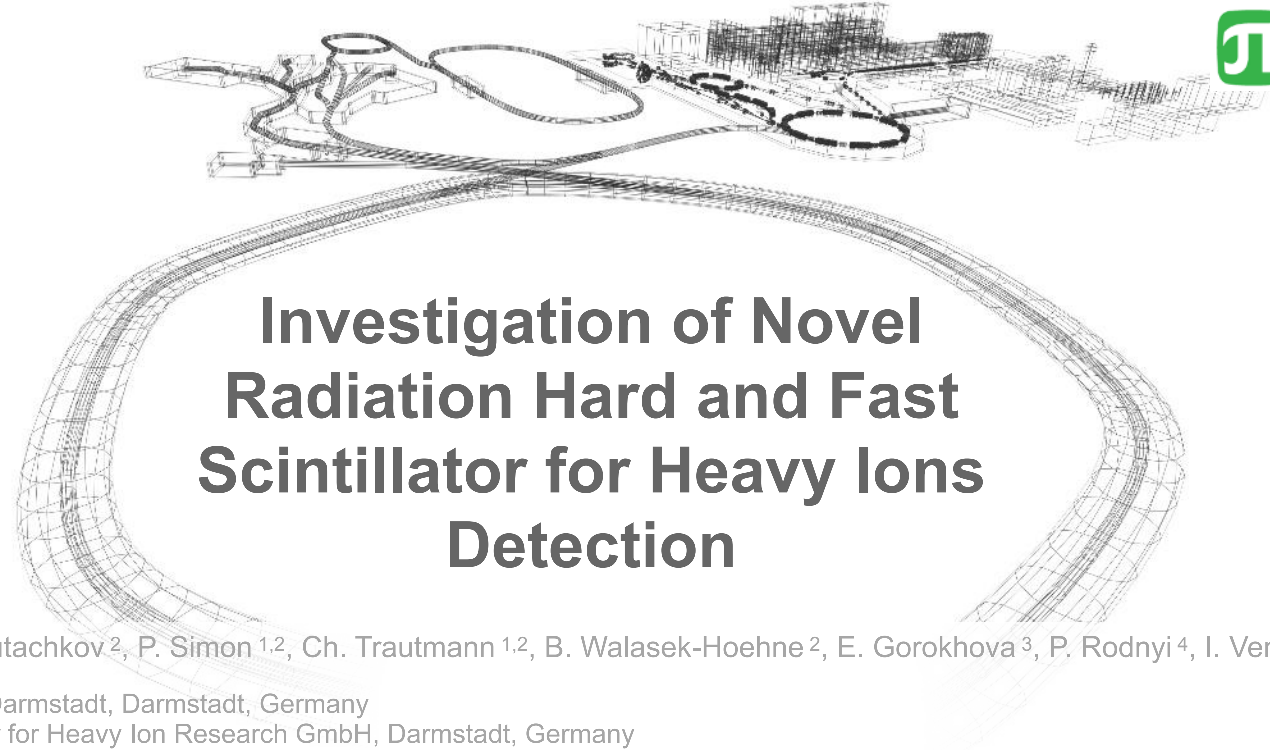

Investigation of Novel Radiation Hard and Fast Scintillator for Heavy Ions Detection

M. Saifulin [1,2], P. Boutachkov [2], P. Simon [1,2], Ch. Trautmann [1,2], B. Walasek-Hoehne [2], E. Gorokhova [3], P. Rodnyi [4], I. Venevtsev [4]

[1] Technical University Darmstadt, Darmstadt, Germany
[2] GSI Helmholtz Center for Heavy Ion Research GmbH, Darmstadt, Germany
[3] Public corporation "Vavilov State Optical Institute" (PC GOI), St. Petersburg, Russia
[4] Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia

IBIC 2020, 14-18 September 2020

Outline

- ZnO scintillator for particles counting at HEBT in GSI
- ZnO response to 300 MeV/u heavy ions
- ZnO scintillation and transmission properties investigated with 4.8MeV/u ^{48}Ca
- Summary

Motivation

- **Scintillator** is the material, which exhibits light emission, when excited by ionizing radiation (x-rays, electrons, protons, ions etc.)

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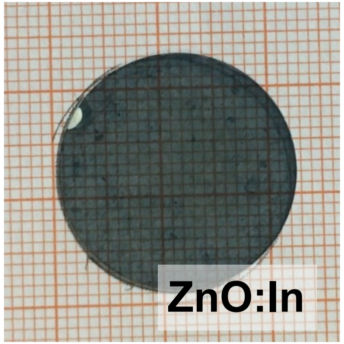

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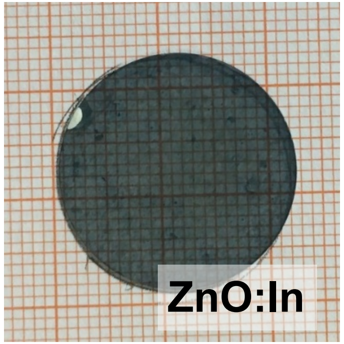

Carbon – Uranium beams @200MeV/u to 1GeV/u

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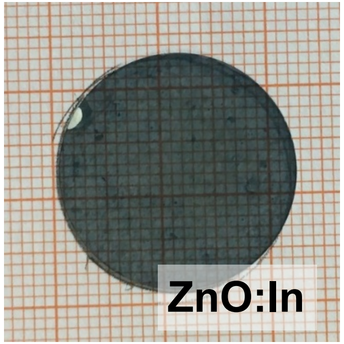
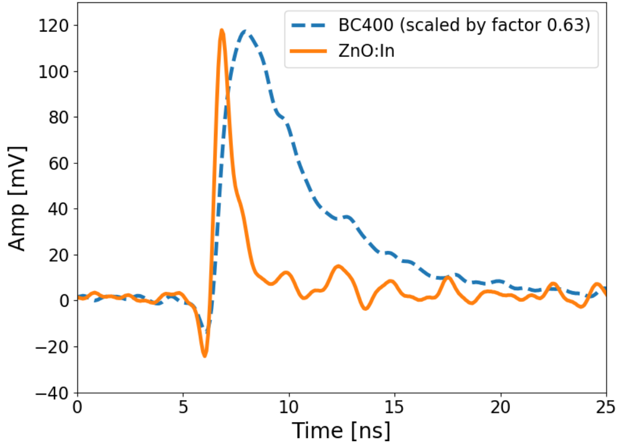


PMT signal ^{238}U@300MeV/u



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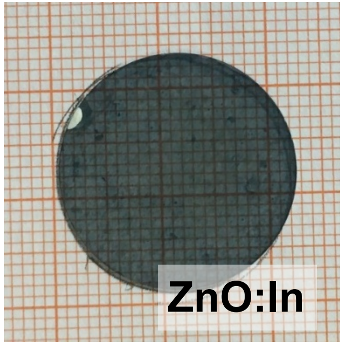

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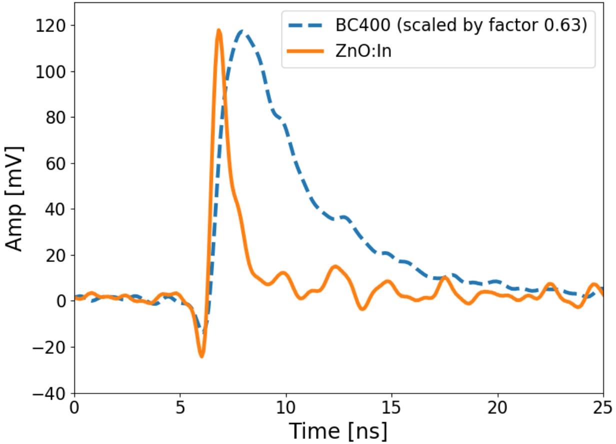


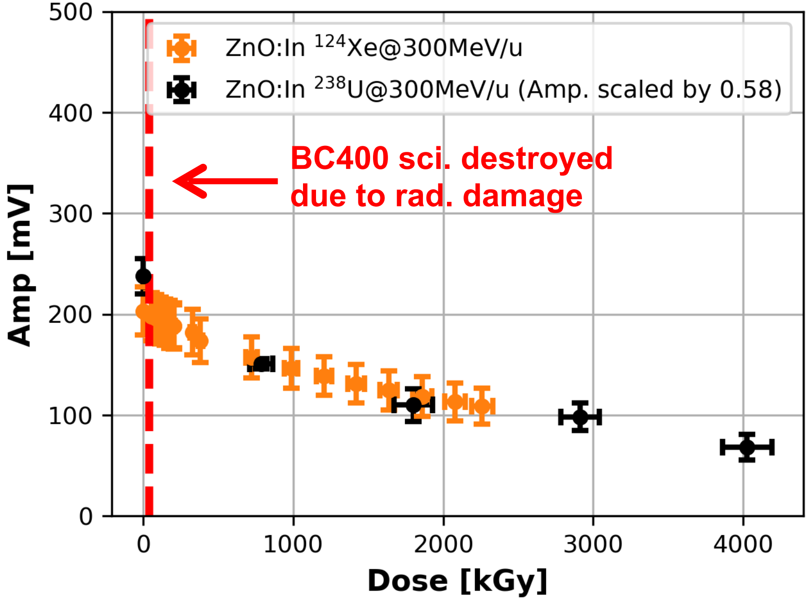
Characteristics of interest:

- **Light output**
- **Light spectrum**
- **Rise and decay time**
- **Radiation hardness**

Carbon – Uranium beams @200MeV/u to 1GeV/u

ZnO:In response @300 MeV/u heavy ions

IBIC-2019, P. Boutachkov et. al.
https://doi.org/10.18429/JACoW-IBIC2019-MOPP005



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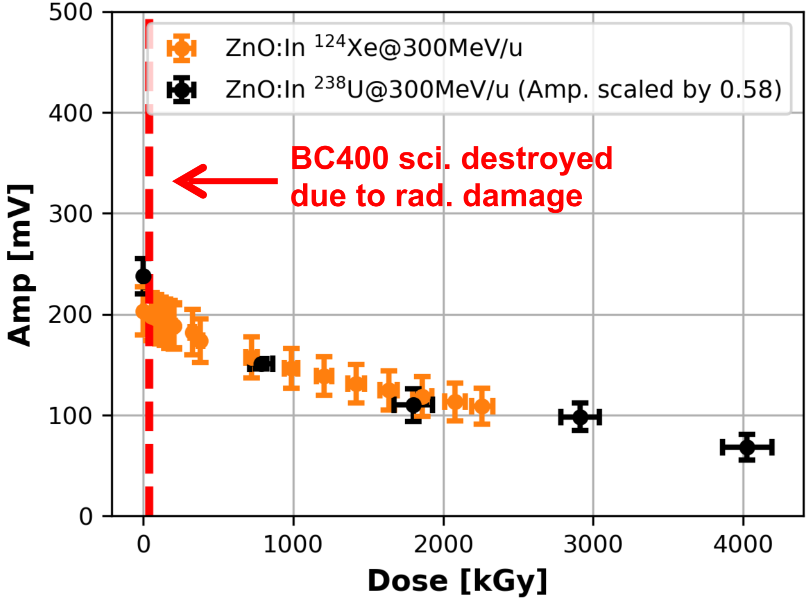

- ZnO:In **operation time is** at least 100 times **longer** than for plastic scintillator

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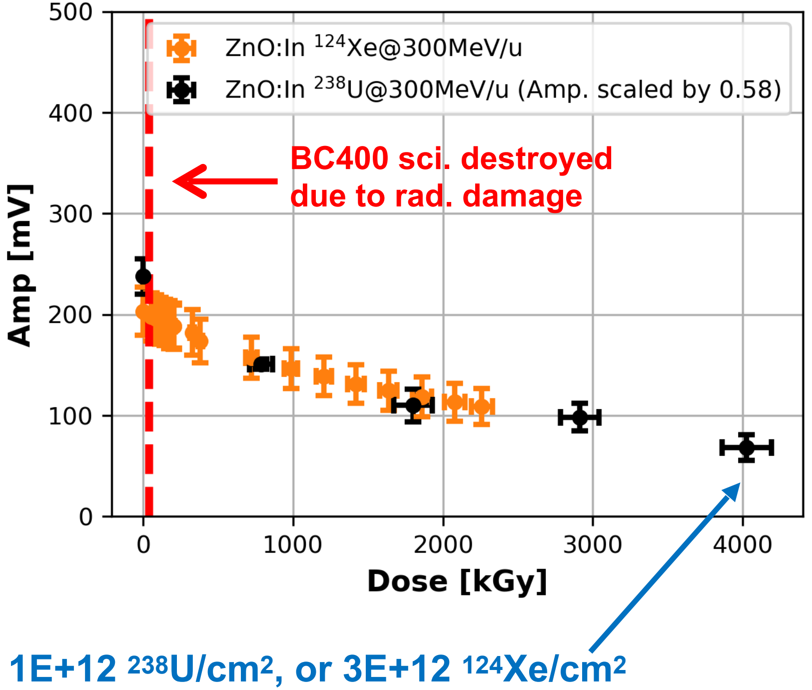

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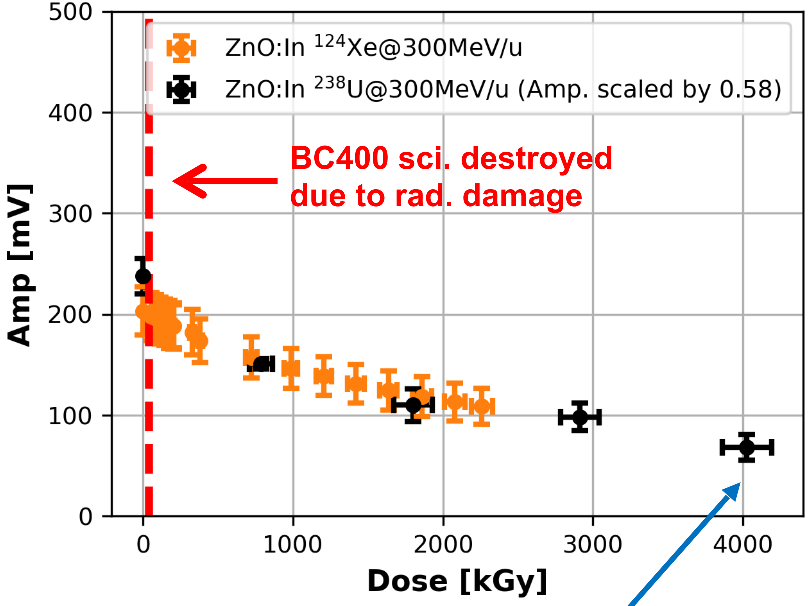

1E+12 ^{238}U/cm^2, or 3E+12 ^{124}Xe/cm^2

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- What is scintillation at higher dose?
- Light spectrum changes are not known
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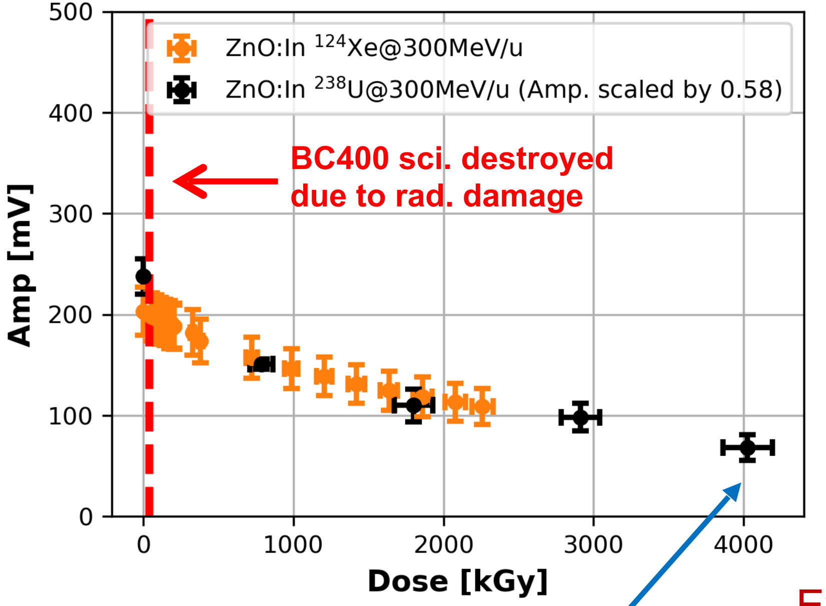

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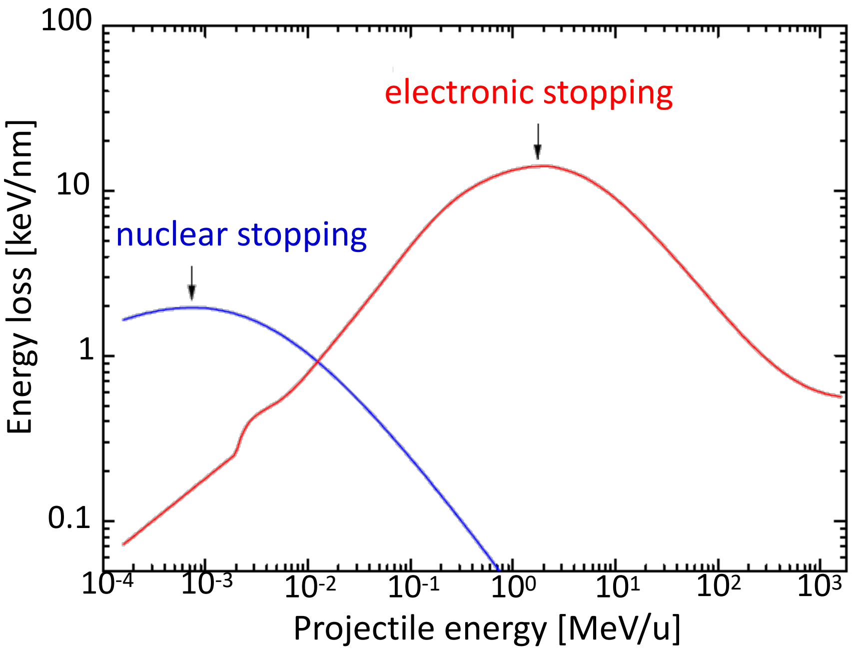
Experiment time ~16 h to reach 4000 kGy with Uranium
Not easy to get beam time @300MeV/u

Swift heavy ion beams form UNILAC as alternative to SIS18 relativistic beams

Relativistic and Swift heavy ion beam

Swift heavy ion beams form UNILAC as alternative to SIS18 relativistic beams



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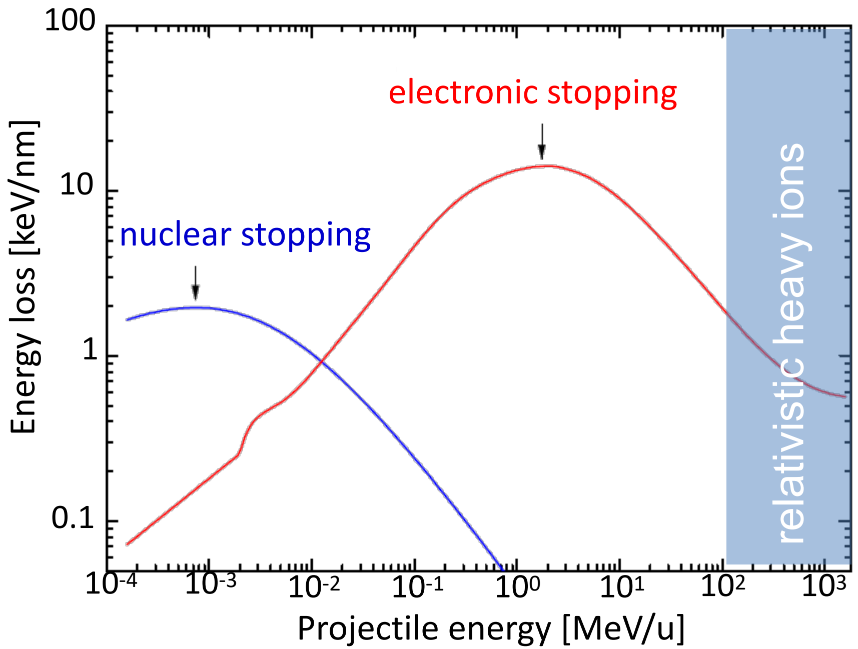

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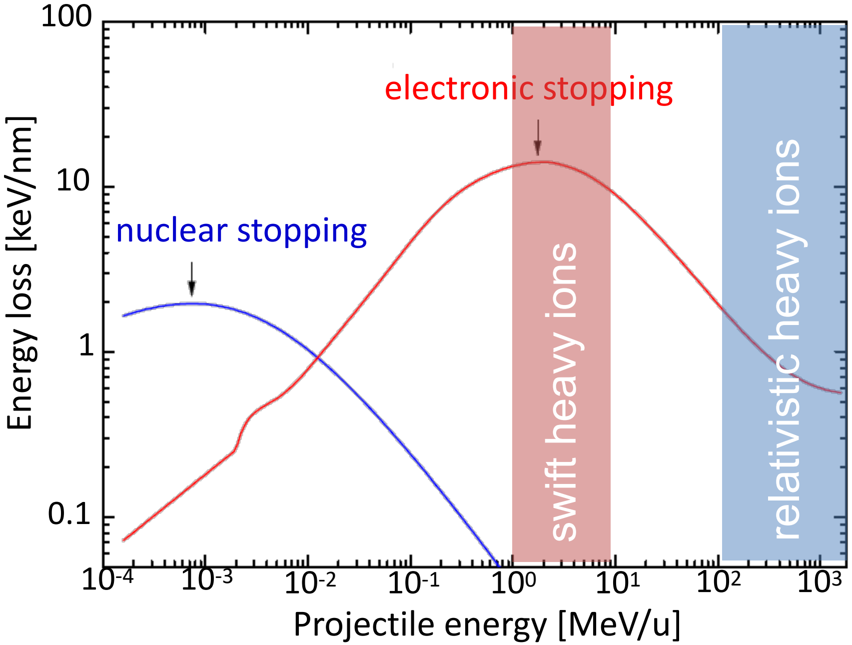

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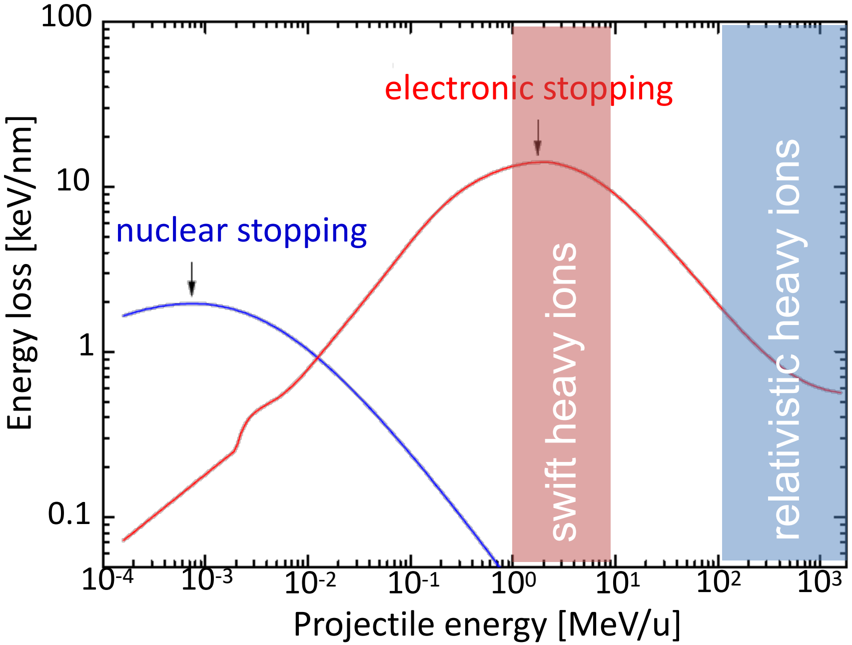

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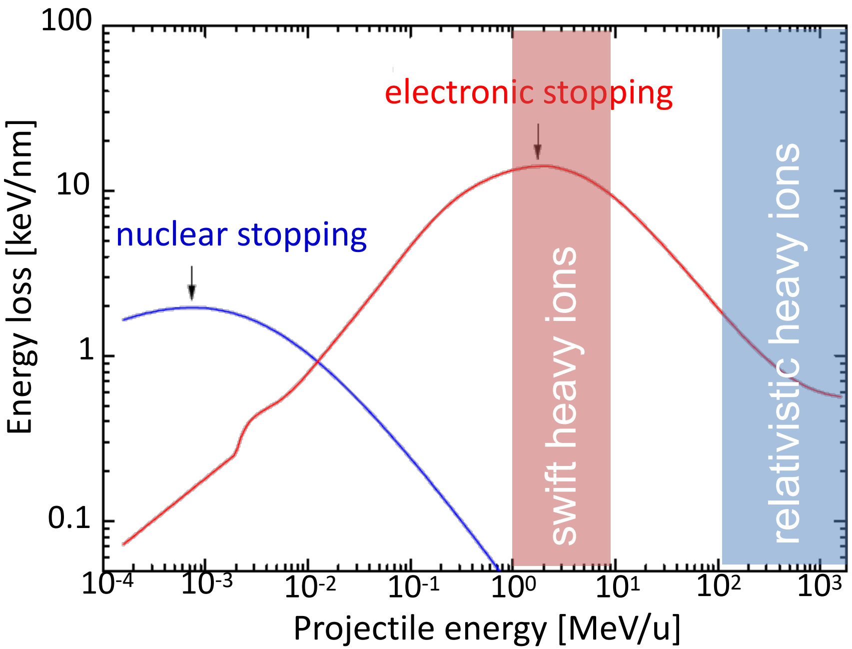

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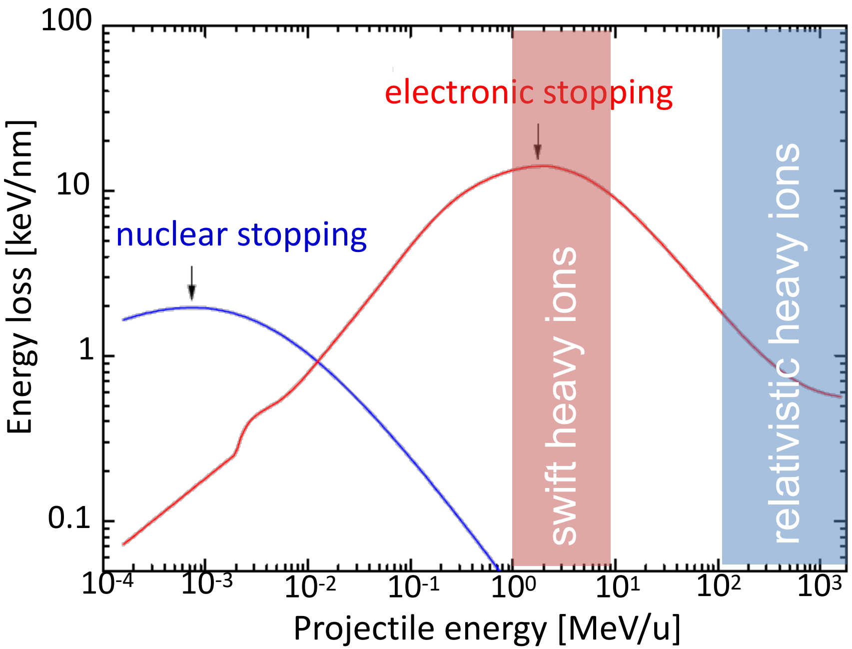

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Faster Dose accumulation
And shorter beam time

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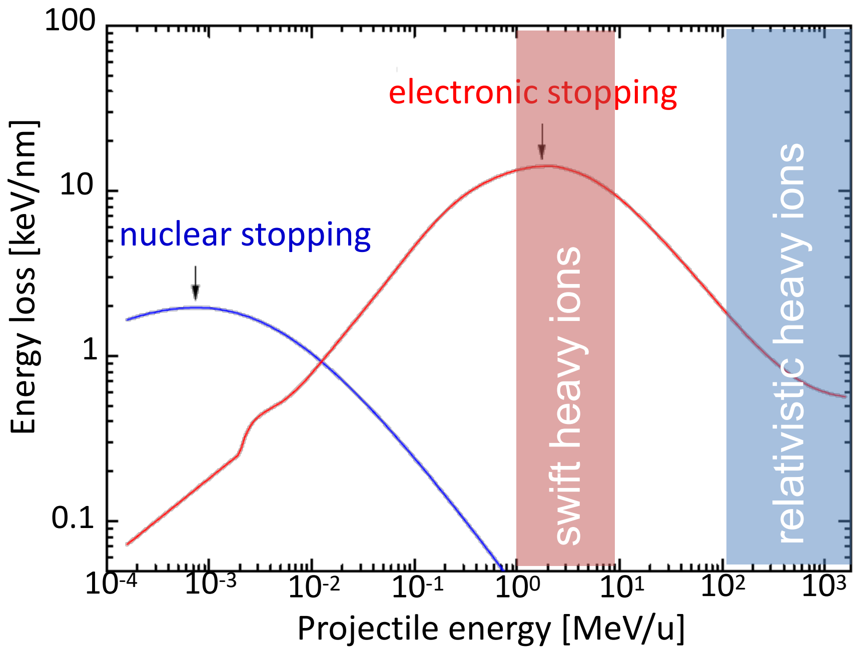

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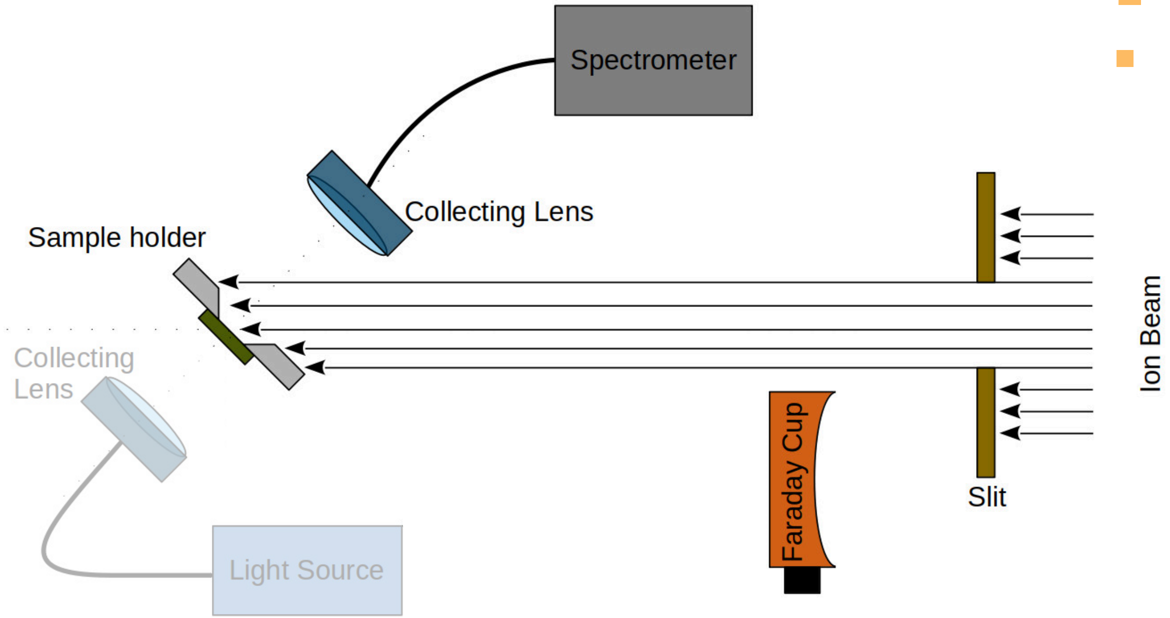
Things to keep in mind!!!

- Different ion range
- Different energy density
- Damage efficiency is different

ZnO:In performance @4.8 MeV/u Energy

^{48}Ca @4.8MeV/u



- **Light spectrum**
- Transmittance

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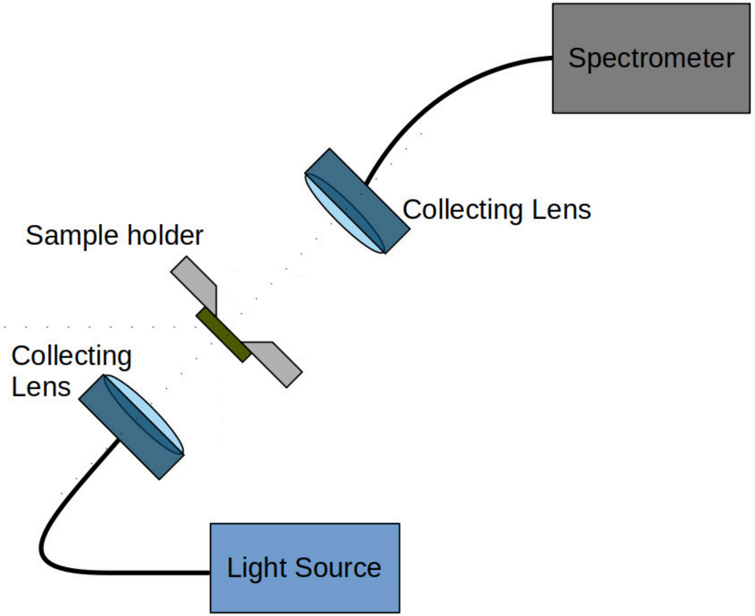
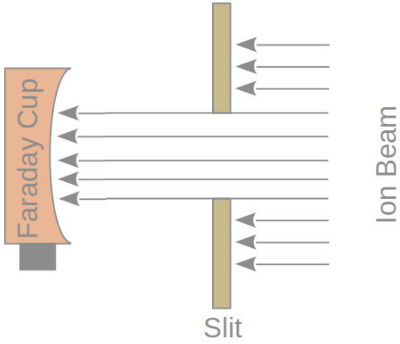


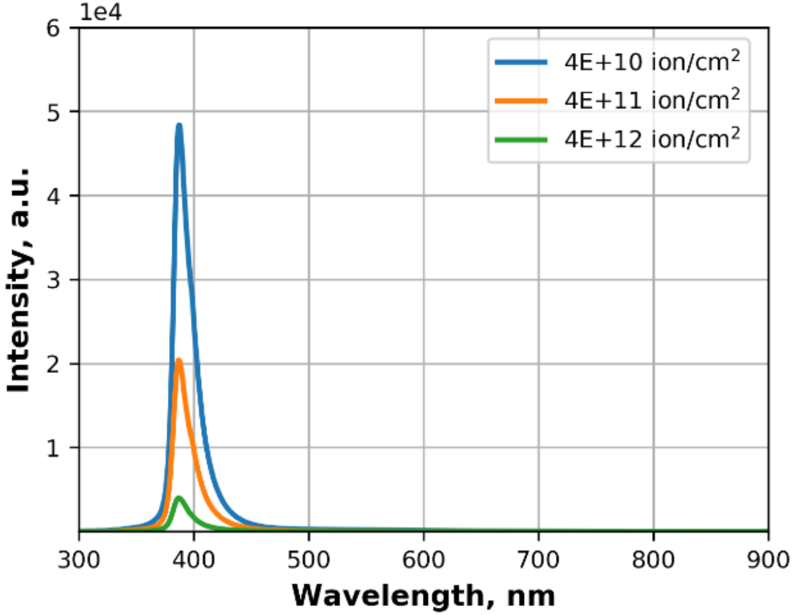


- Light spectrum
- **Transmittance**

Sample thickness ~400 um
Ion range ~30 um

Light spectrum

^{48}Ca @4.8MeV/u, ZnO:In luminescence vs. fluence



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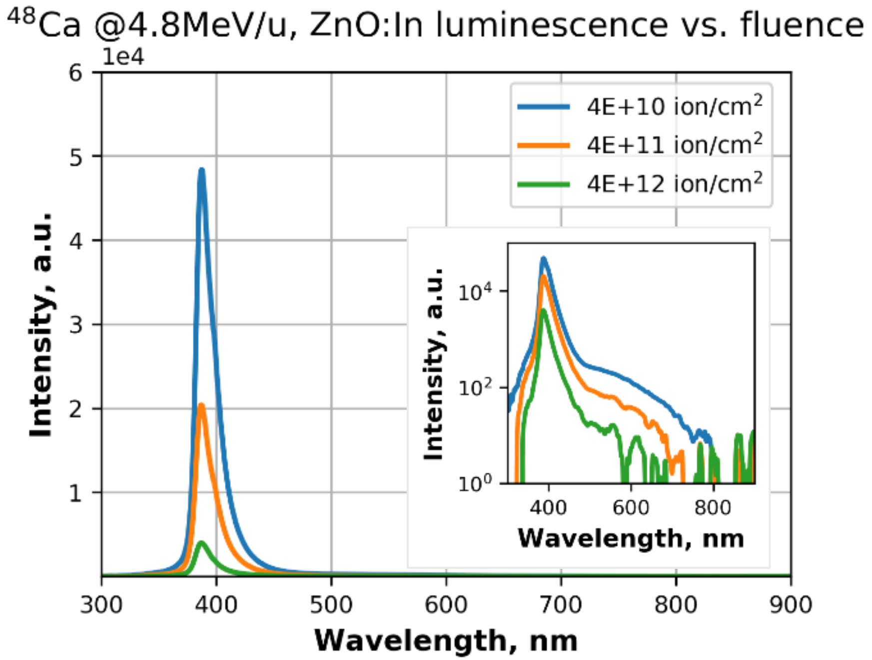

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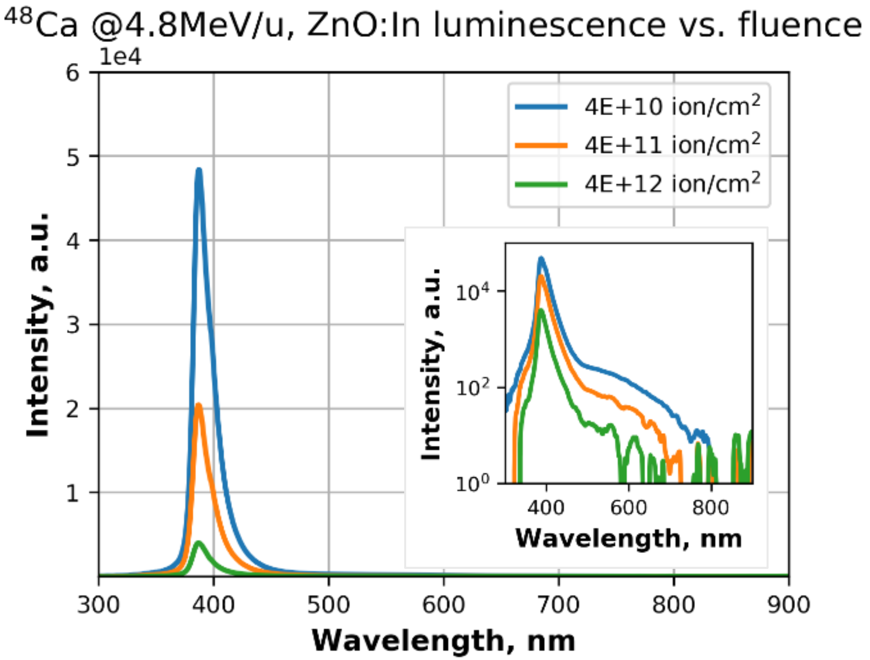

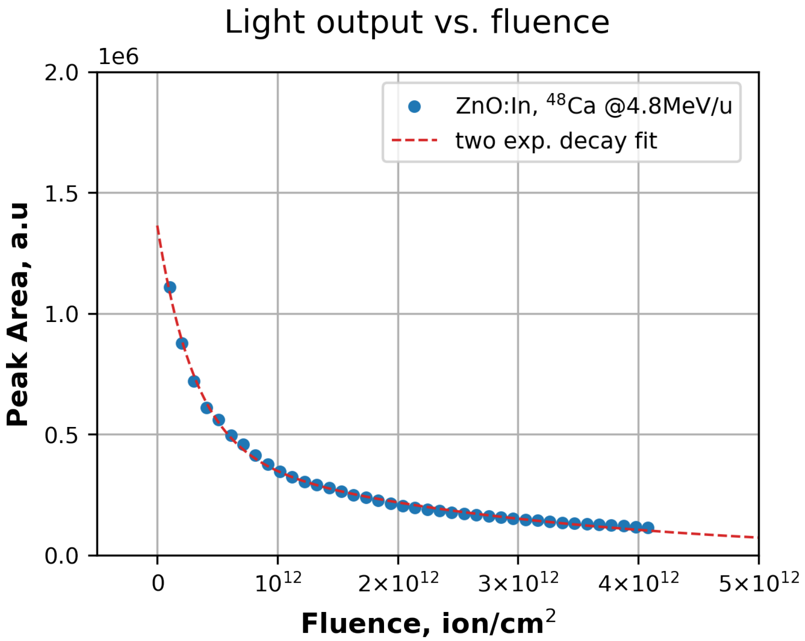

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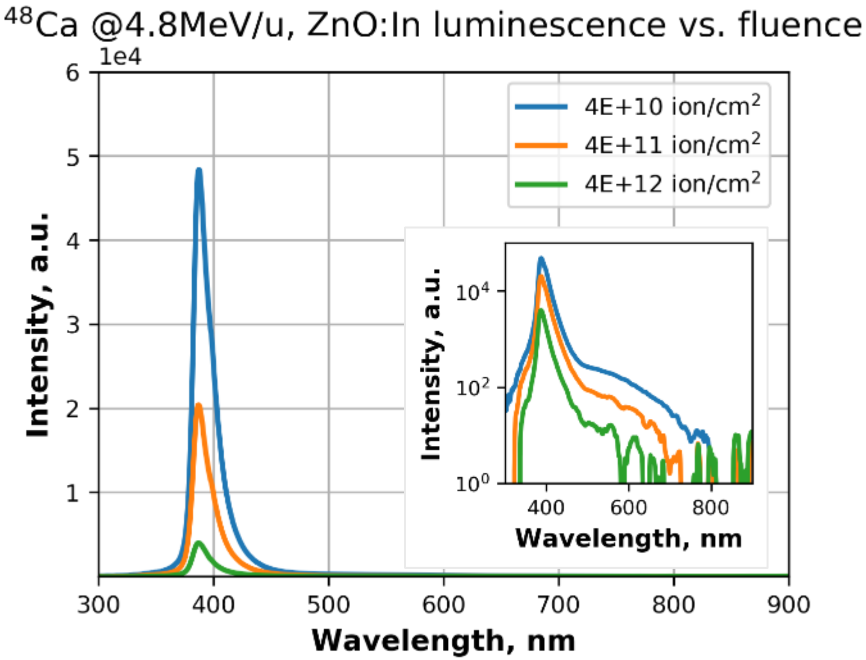
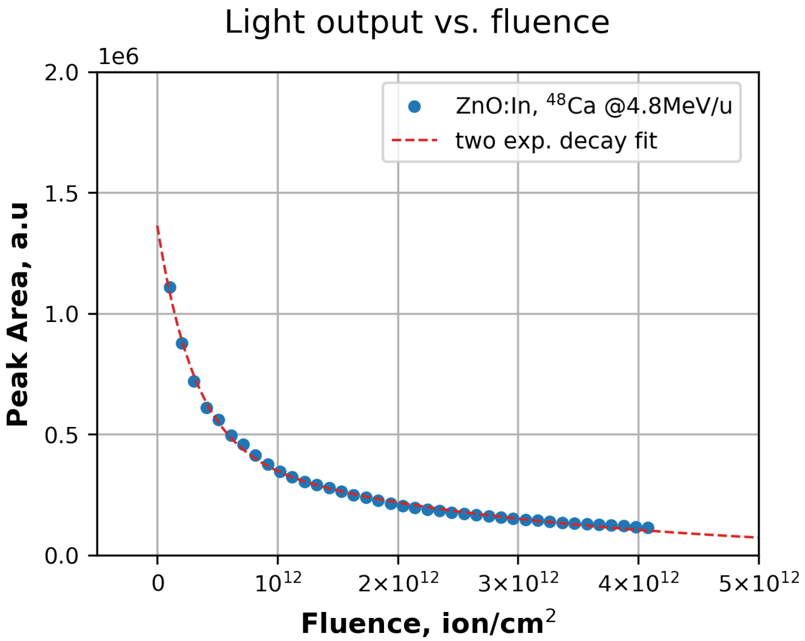
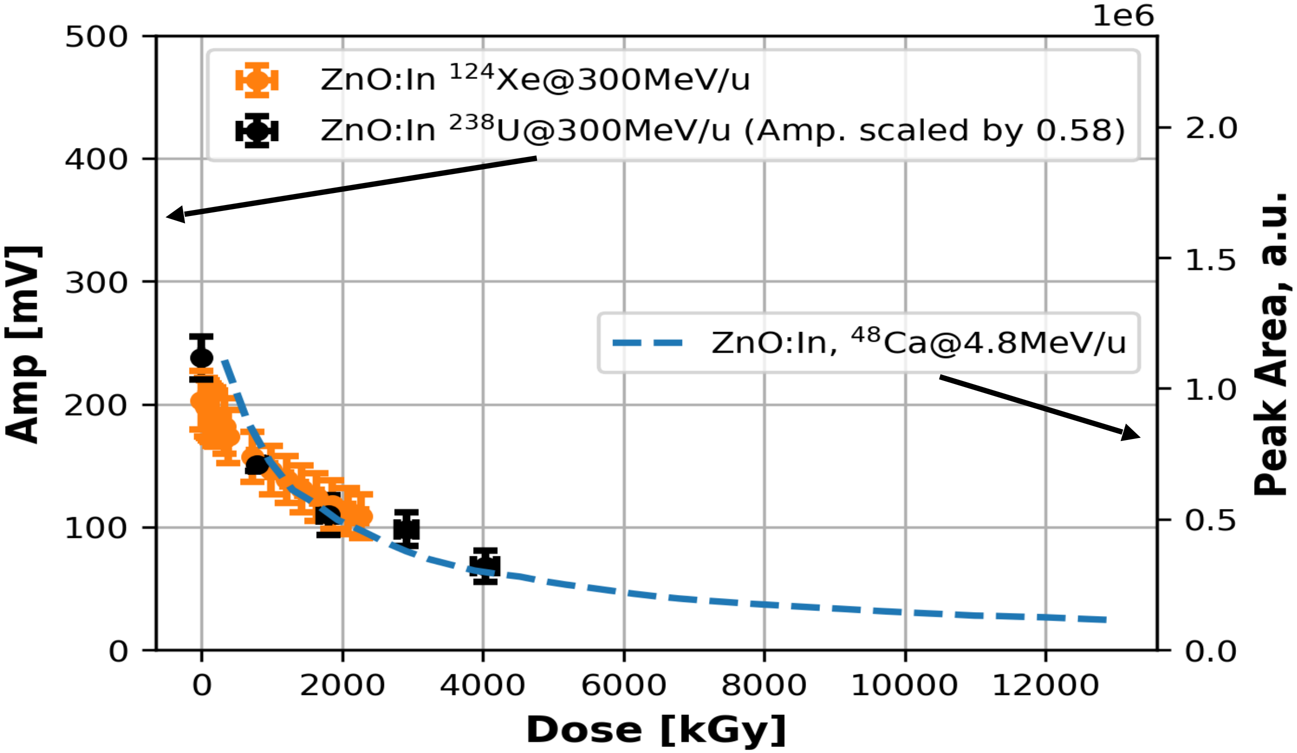




Peak area is reduced 5 times at $2x10^{12}$ ion/cm^2 ~ after 2 hours or irradiation

4.8MeV/u heavy ions comparison to 300 MeV/u



Ion	dE/dx, MeV/(mg/cm²)
^{124}Xe	8
^{48}Ca	14
^{238}U	23

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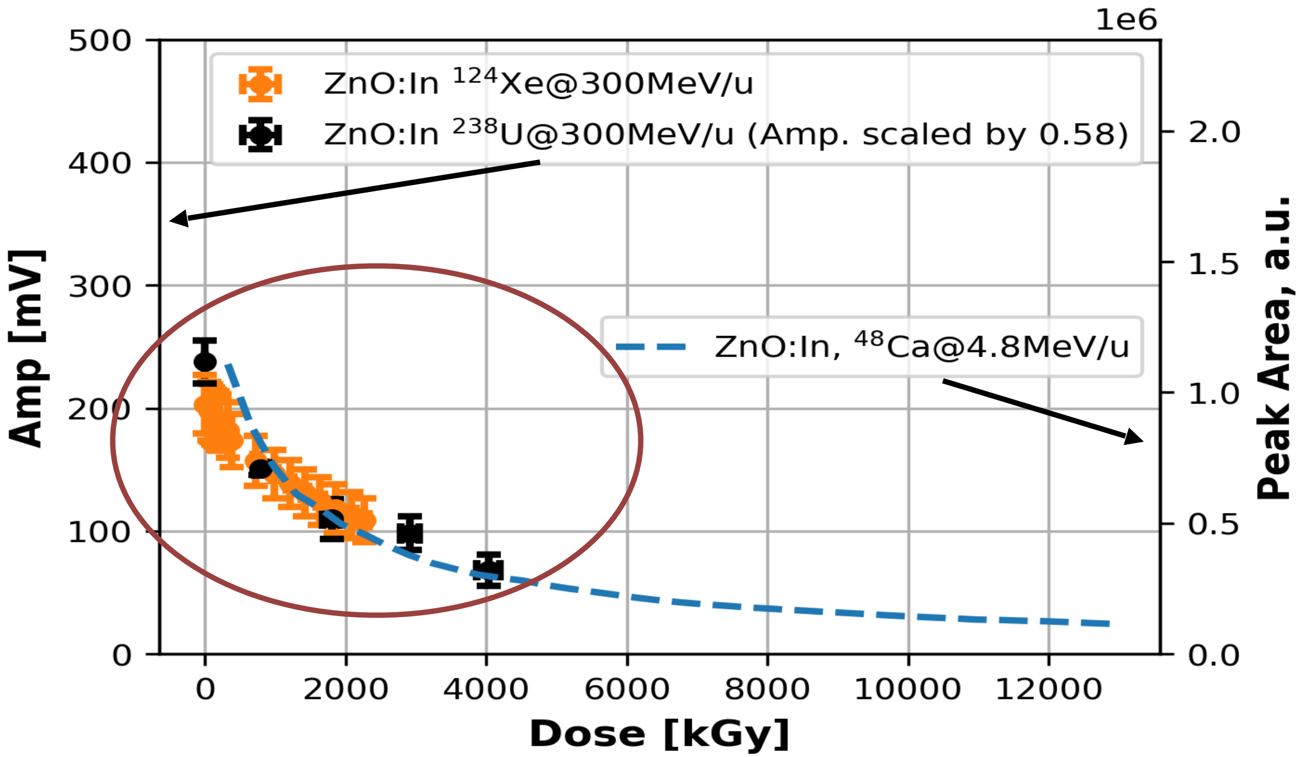

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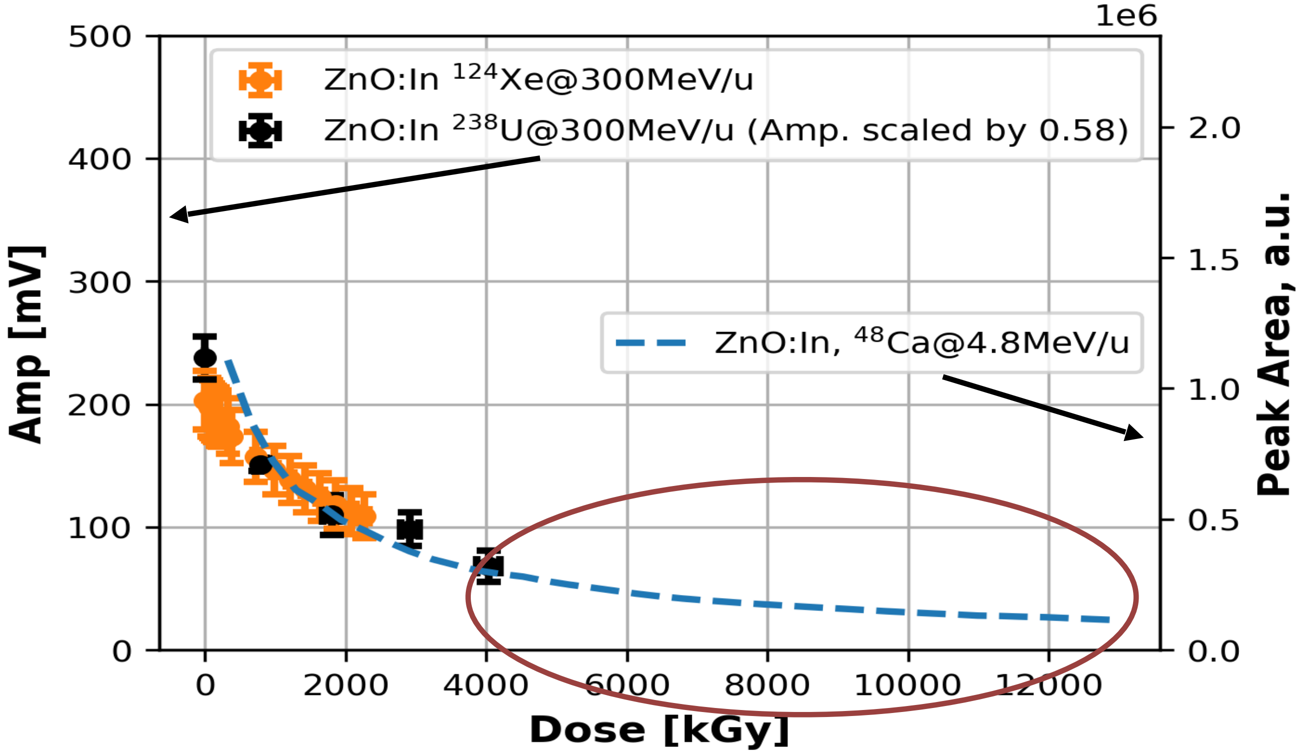

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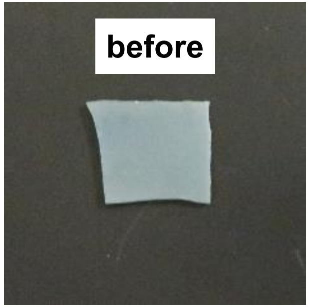
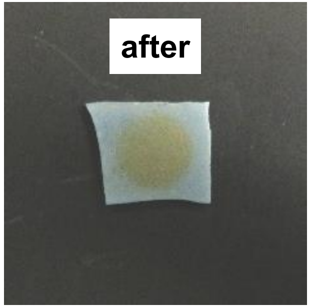
Transmittance

- Radiation damage leads to color change

ZnO:In, ^{48}Ca @ 4.8MeV/u, 5E+12 ion/cm^2

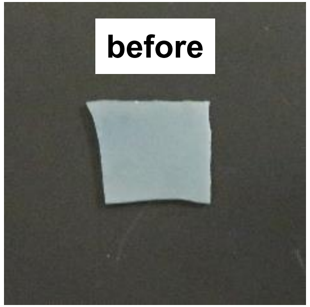


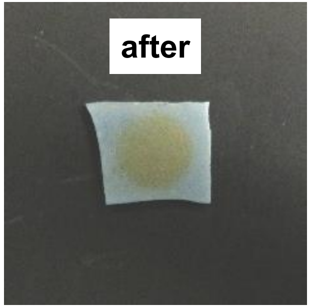


Transmittance

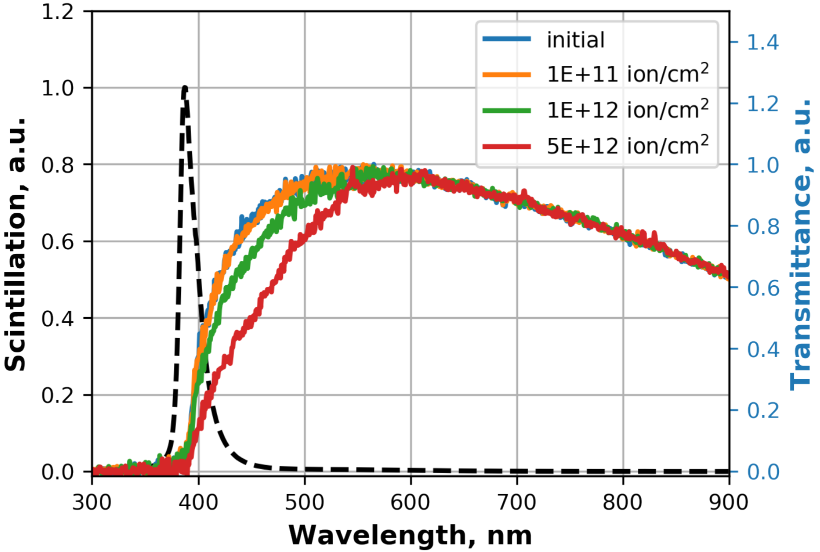
- Radiation damage leads to color change
- Radiation damage leads to loss of transmittance in UV/Vis range

ZnO:In, ^{48}Ca @ 4.8MeV/u, 5E+12 ion/cm^2





^{48}Ca @4.8MeV/u, ZnO:In luminescence and transmittance



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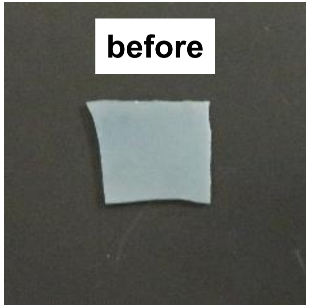

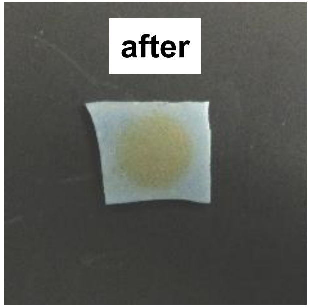

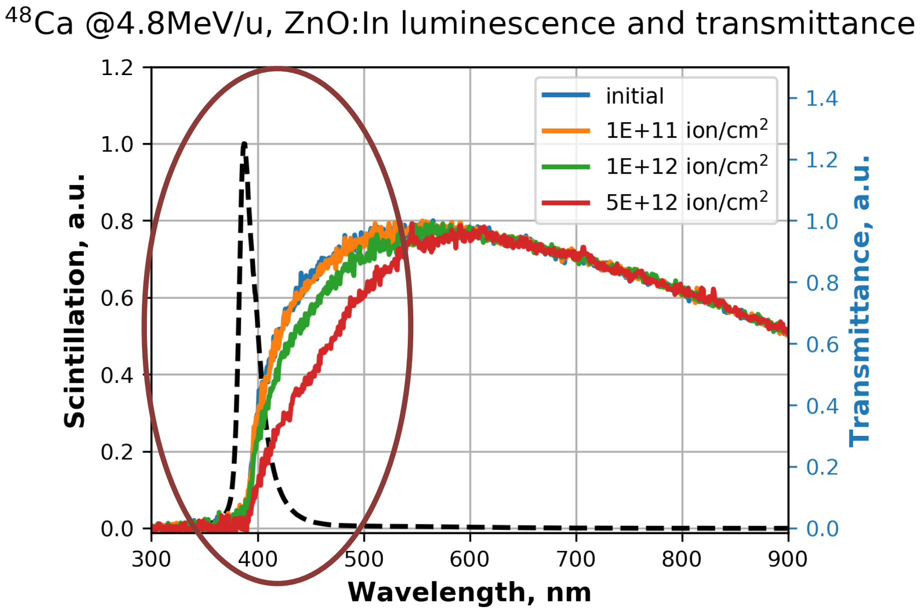

Scintillation light is at the edge of transmission of ZnO:In

Summary ZnO:In scintillation by heavy ions @4.8MeV/u

- Scintillation properties of ZnO:In have been studied with ^{48}Ca @4.8MeV/u
- Scintillation light and transmittance spectra were measured as a function of fluence
- ZnO:In emitted light spectrum exhibit one peak near 386 nm
- Radiation damage leads to loss of light output and transmittance in UV/Vis range
- The loss of light output vs. dose measured with ^{48}Ca@4.8MeV/u irradiation follows the same trend as the data for heavy ions @300MeV/u
- ZnO:In light output falls 5 times at 6500 kGy during ^{48}Ca@4.8MeV/u irradiation, which corresponds to ~5E+12 $^{124}Xe/cm^2$ and ~1.7E+12 $^{238}U/cm^2$ @300MeV/u

Thank you for watching!!!

This work is performed within ERA.NET Plus with Russia in collaboration between:

- GSI Helmholtz Center for Heavy Ion Research GmbH, Darmstadt, Germany
- Peter the Great St. Petersburg Polytechnic University, St. Petersburg, Russia
- Moscow State University, Moscow, Russia
- Vavilov State Optical Institute, St. Petersburg, Russia
- Institute of Solid State Physics of University of Latvia, Riga, Latvia