Generation and Application of Stripped Proton Beams at the CSNS Linac

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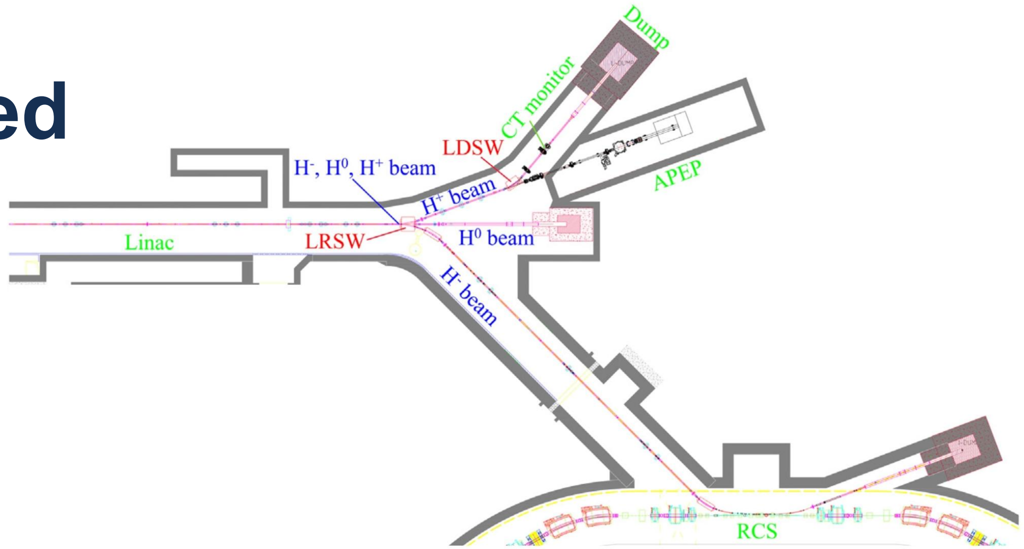


ONE LINAC — THREE STRIPPING MECHANISMS

RESIDUAL-GAS

$\sim 10^{-3}$

Naturally produced H^+

Low-intensity proton beam
→ irradiation at APEP

FOIL

percent level

Intentionally produced H^+

Peripheral-beam collimation
→ beam optimization + applications

INTRA-BEAM

$\sim 10^{-4}$

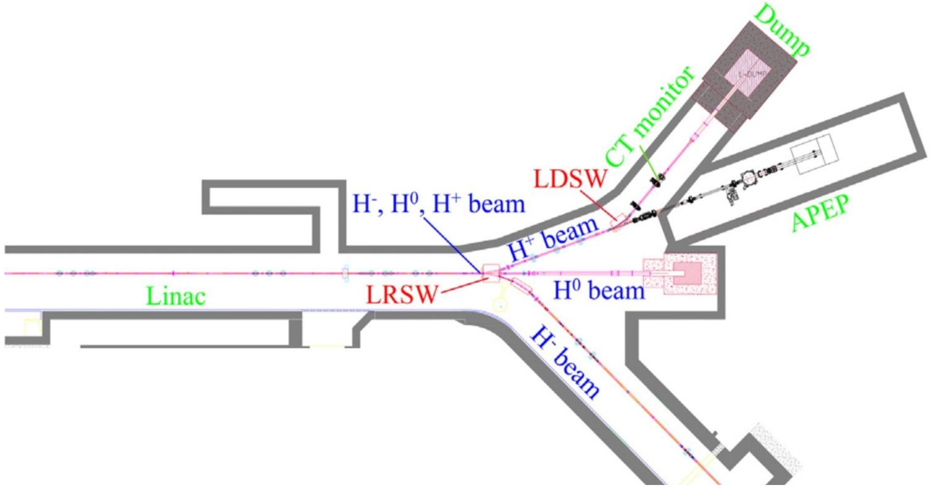
uncontrolled stripping loss

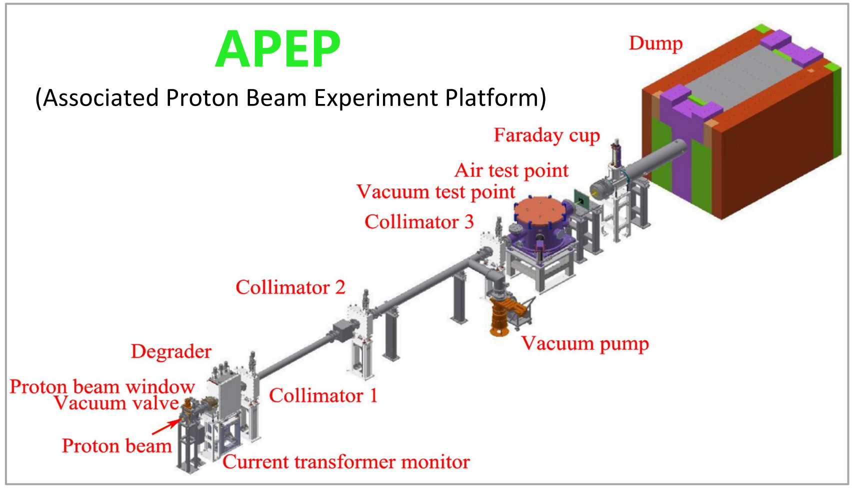
Distributed loss mechanism
→ CSNS-II beam-loss evaluation

Can stripping be more than just a source of beam loss?

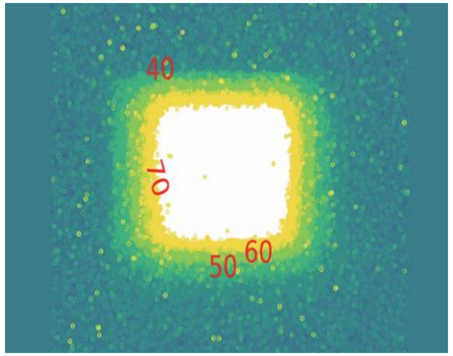
Residual-gas stripping: a useful low-intensity proton beam

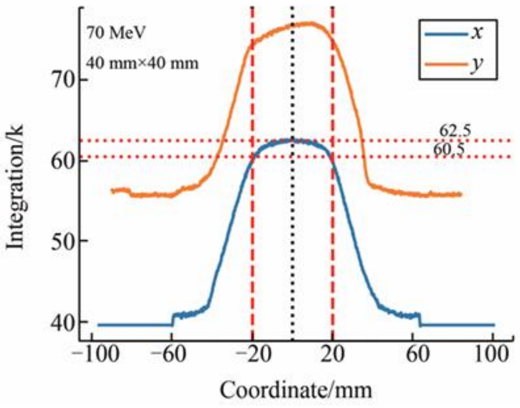
Residual-gas stripping provides the proton beam used by APEP.





APEP uses residual-gas-stripped protons for irradiation studies.





Residual-Gas-Stripped Proton Beam Spot

ASSOCIATED PROTON BEAM

~0.1%

fraction of the primary H^- beam

ENERGY

80 MeV

APEP proton beam

PEAK CURRENT

~10 μA

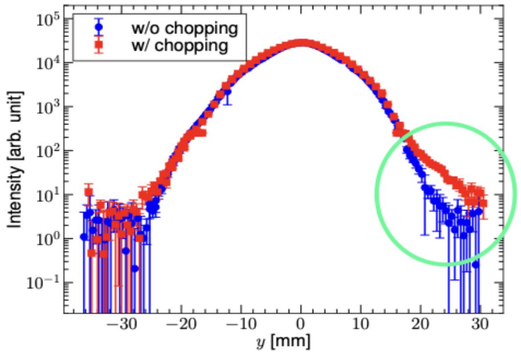
at 100-kW operation

APPLICATIONS

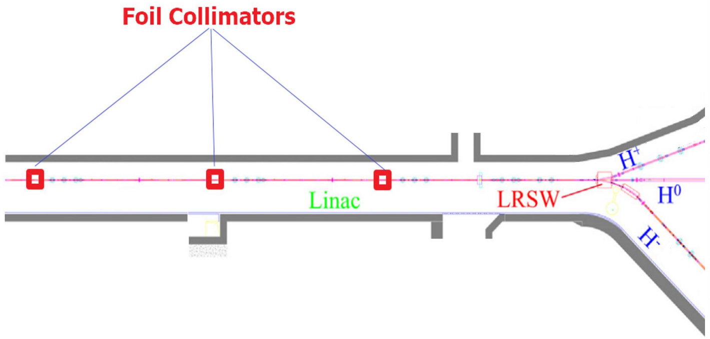
Device/material irradiation
Radiation-effect studies

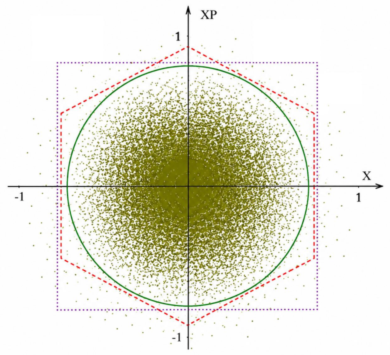
Foil stripping: improve the H$^-$ beam

The system was motivated by measured halo, but operation removes particles from a broader beam periphery.

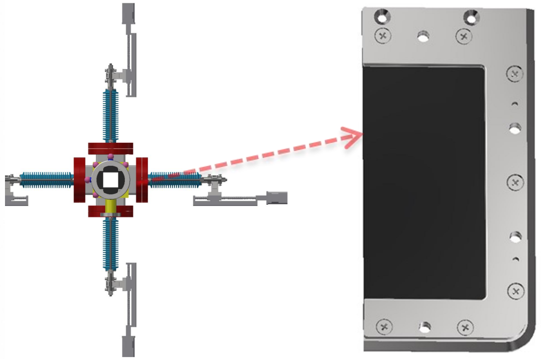


Measured transverse tail / halo at the DTL exit

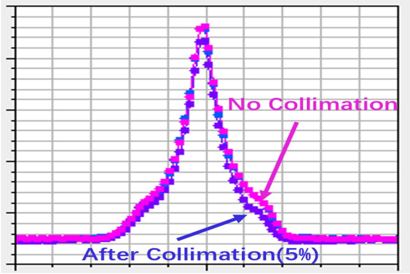




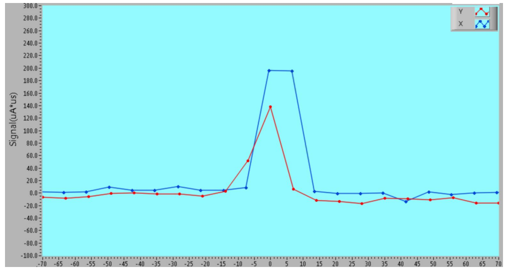
Three foil collimators along the linac and 3-step collimation scheme



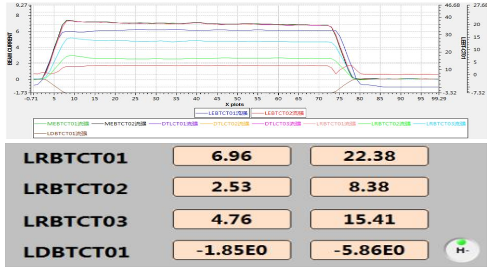
Four-sided foil geometry



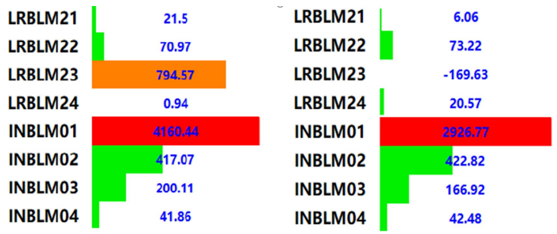
H- beam by wires



Stripped proton beam meas. by wires



Stripped proton beam meas. by CTs



Lower loss in injection section after collimation (Right)

OPERATION

~2% Outer beam distribution is intentionally intercepted.

FOIL SYSTEM

3 stages · ~60° phase advance
100 μg/cm² carbon foil

TWO BENEFITS

Lower loss through restricted injection apertures
larger RCS painting range

The goal is peripheral-beam collimation—not simply halo removal.

Foil stripping: a high-intensity secondary proton beam

Foil stripping produces a much stronger secondary proton beam than residual-gas stripping.

Beam collimation + Isotope studies

RESIDUAL-GAS STRIPPING

~0.1%

→

FOIL STRIPPING

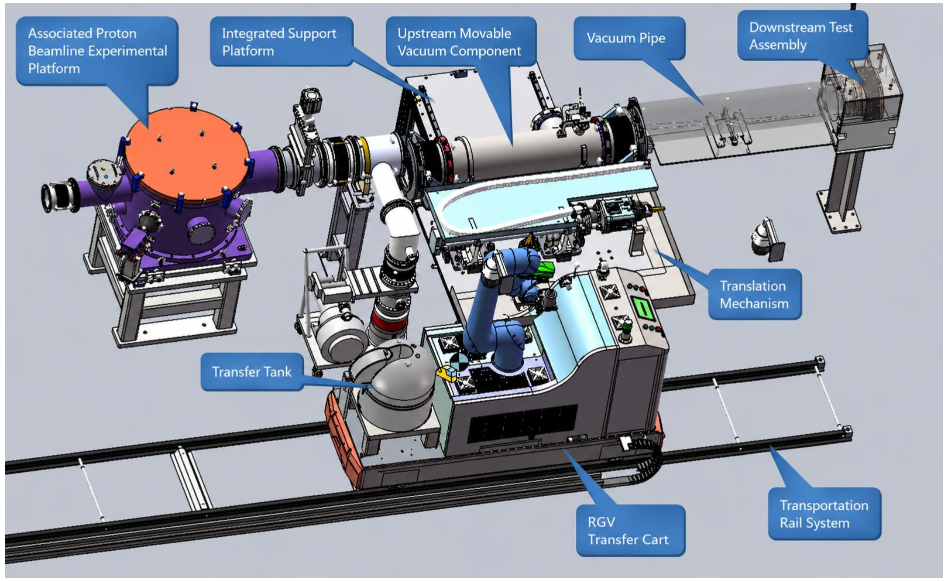
up to 20%

for isotope-production experiments

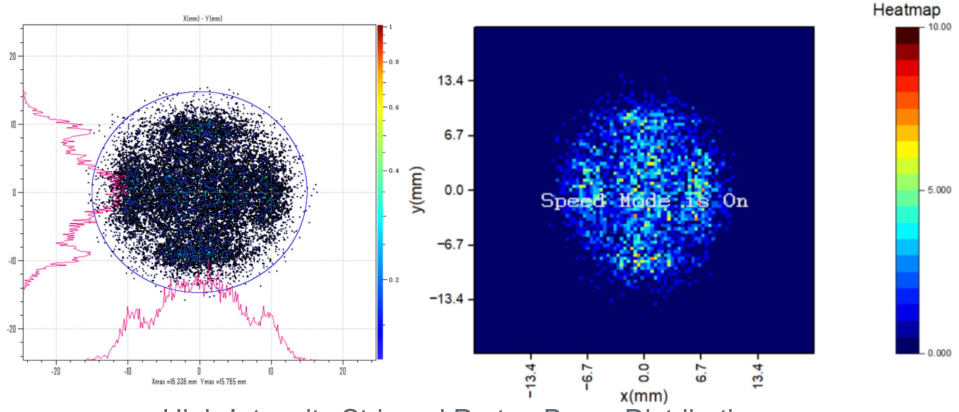
~2 orders of magnitude higher proton fraction

SECONDARY-BEAM VALUE

The 80 MeV stripped proton beam enables isotope-production studies.



Isotope Production Experimental Facility



High-Intensity Stripped Proton Beam Distribution simulation (left) and measurement (right)

Intra-beam stripping: a beam loss concern for CSNS-II

Preliminary analytical-model evaluation using TraceWin beam parameters.

WHY CSNS-II?

80 → 300 MeV

Higher energy and higher current increase the importance of distributed loss.

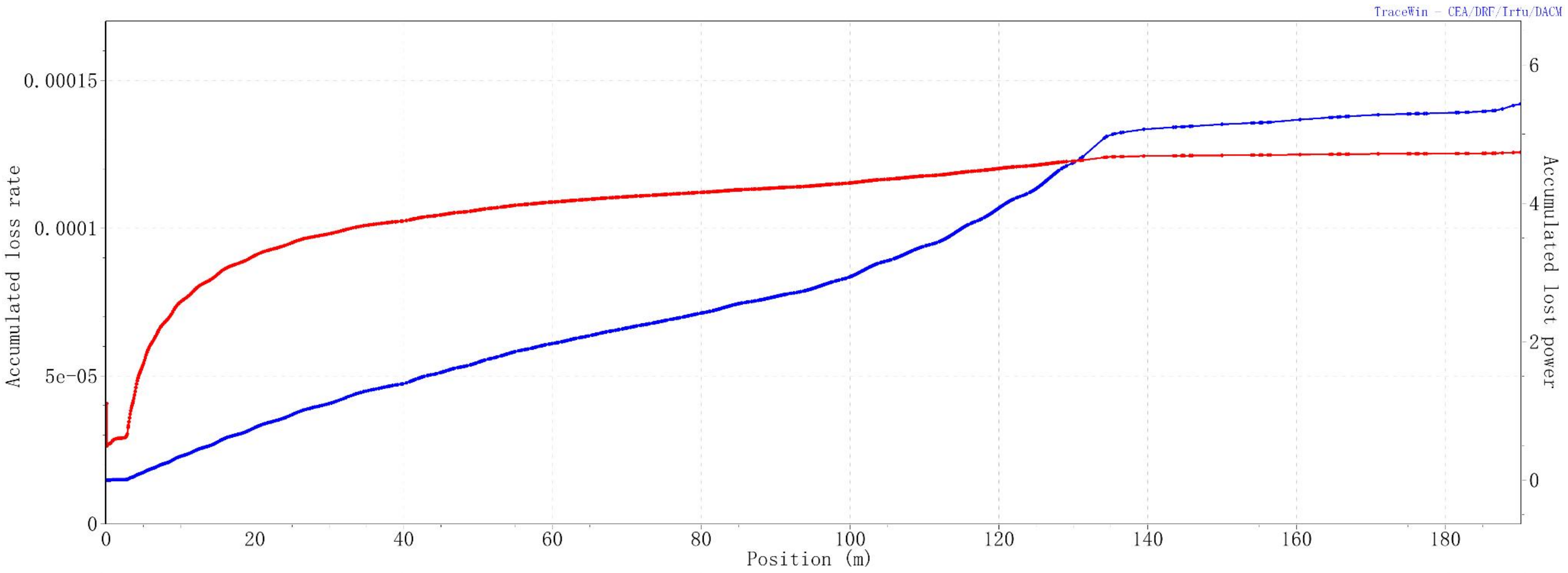
MECHANISM

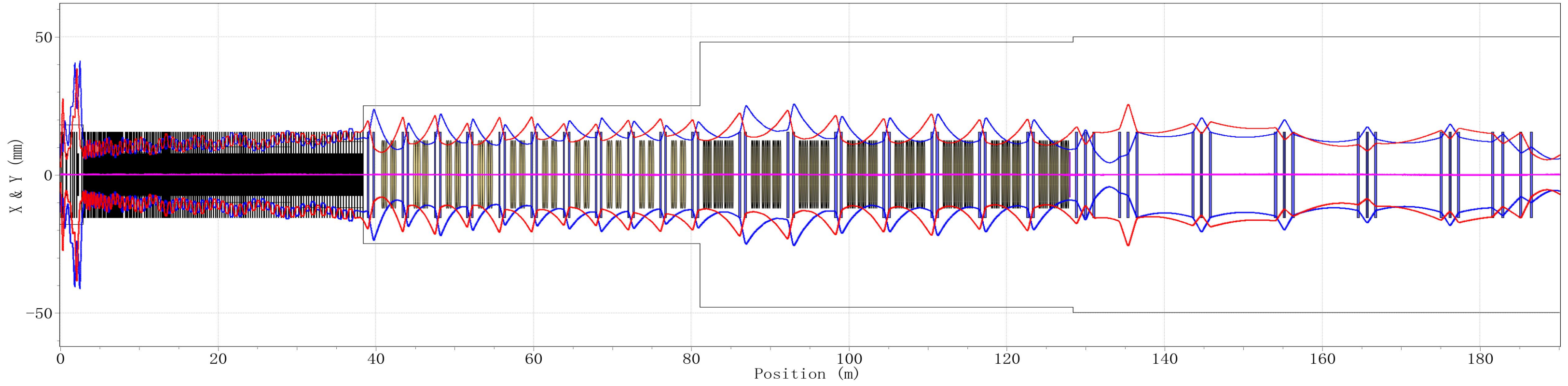
Binary collisions inside the H^- bunch can detach the weakly bound outer electron.

PRELIMINARY RESULT

1.3×10^{-4} / ~5.5 W

Full modeled linac + downstream transport





This distributed loss should be included in the CSNS-II beam-loss evaluation.

Summary

ONE LINAC — THREE STRIPPING ROLES

RESIDUAL-GAS STRIPPING

Low-intensity proton beam

→ APEP irradiation

FOIL STRIPPING

Controlled peripheral-beam stripping

→ beam optimization
+ isotope studies

INTRA-BEAM STRIPPING

Uncontrolled distributed loss

→ CSNS-II beam loss evaluation

Stripping at the CSNS linac is not only a source of beam loss — it can also improve beam performance and enable new applications.

Thank You For Your Attention !