FISIC : an experimental program of Atomic Physics

Fast Ion – Slow Ion collisions

An ion-ion collider @ S3/SPIRAL2/GANIL

- main scientific goals and motivations
- report on the advances …..

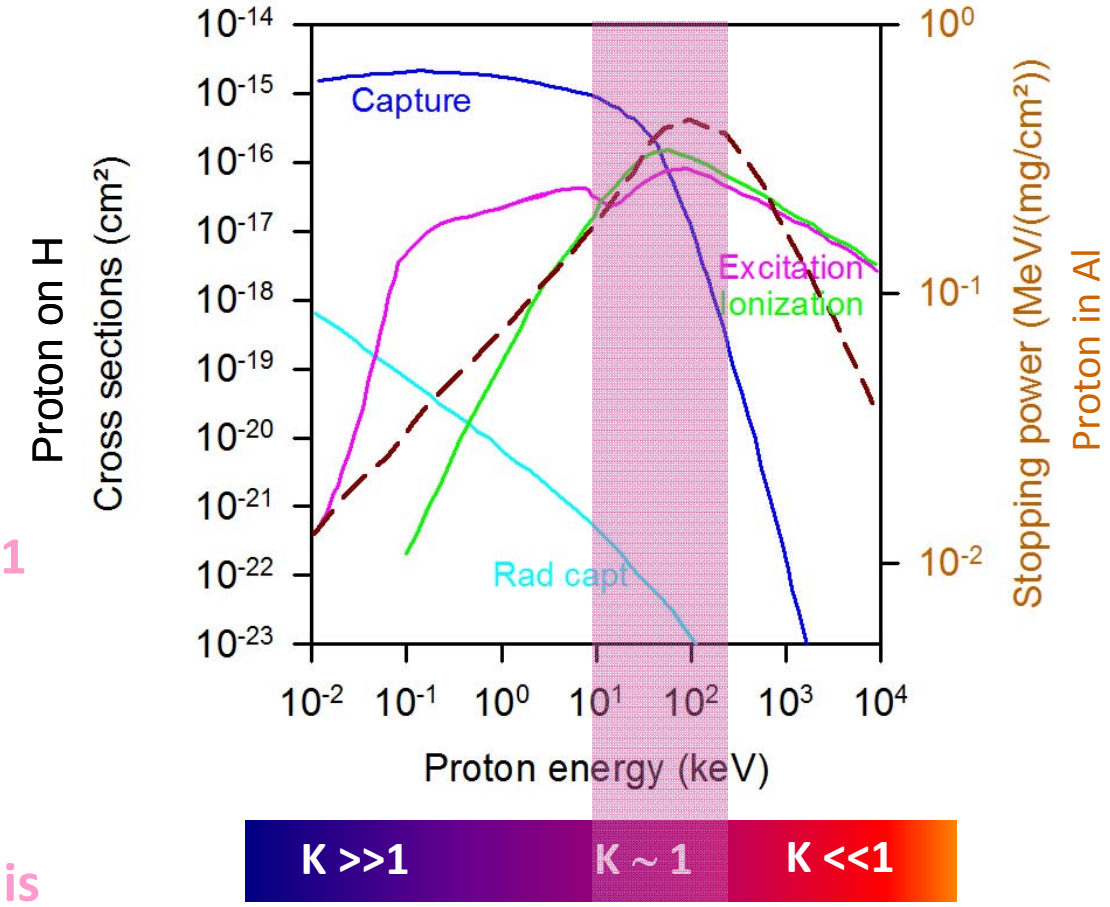
FISIC : an experimental program of Atomic Physics
Main goals and motivations

Ion-ion collisions

- **Determination of absolute cross sections of elementary collision processes**
- **with an ultimate control on dressed orbitals of the projectile AND the target ions**
- **Collision regime of interest:** K ~ 1

$$K_p = \frac{v_e}{v_p} \times \frac{Z_t}{Z_p}$$

(for projectile electrons)



non-pertubative……..to……. pertubative regime

There: the ion stopping power is max ⇒ all the elementary processes have σ max and of the same order of magnitude

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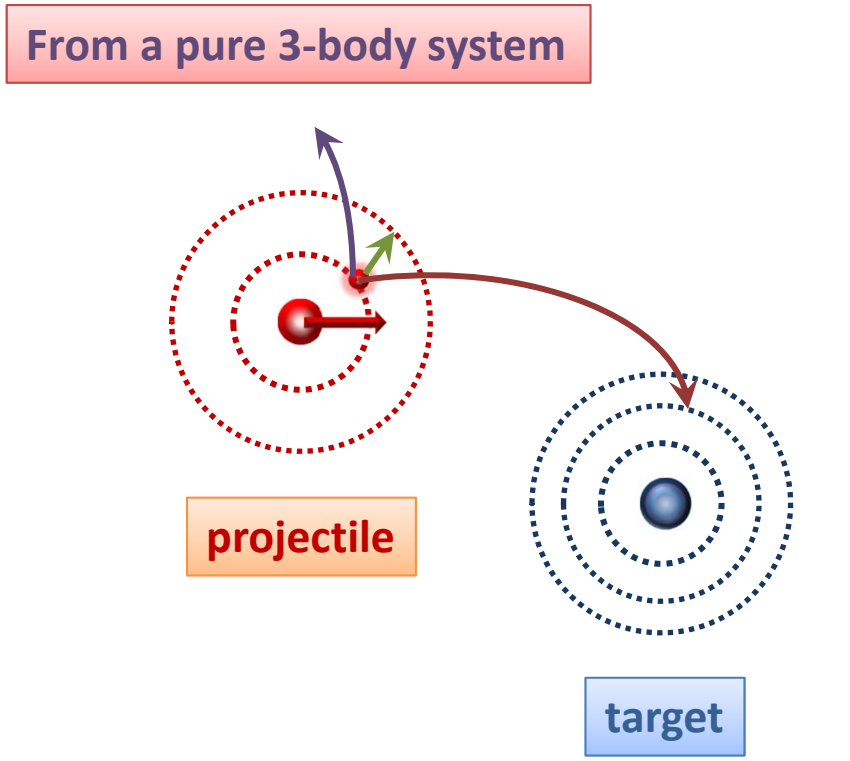

ionization , excitation , capture

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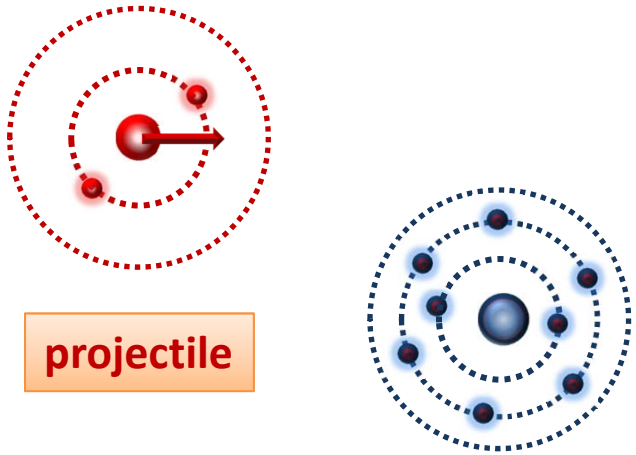
From 3- to N-body systems



- **to benchmark the theoretical approaches**
- **to explore the role of additional electrons**
  – one by one –

- tuning closure of different channels
- effect of electron – electron interactions
- multiple processes… often neglected !
- role of Coulomb forces

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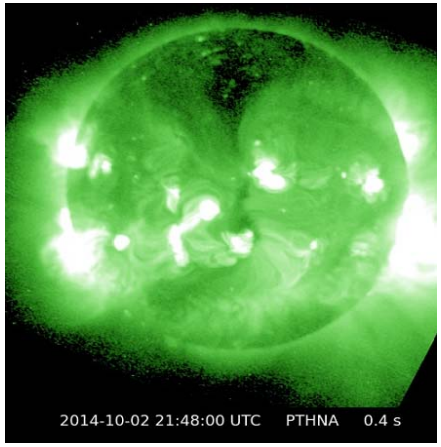
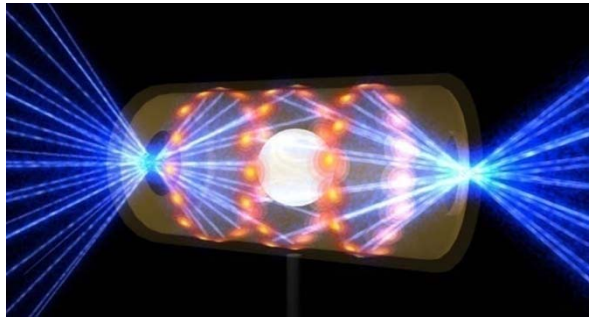
Main goals and motivations

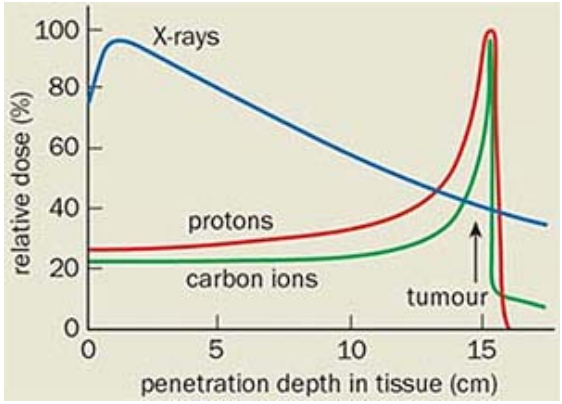
Ion-ion collisions are barely known when ion stopping power is maximum

- in plasmas
  - stellar and interstellar
  - inertial confinement fusion





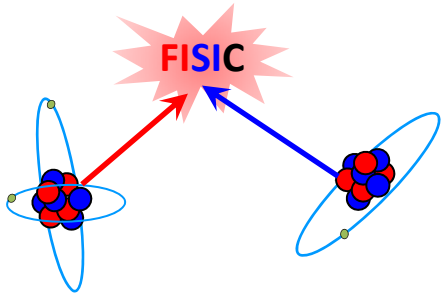
- in ion-matter interaction



FISIC : an experimental program of Atomic Physics

a breakthrough in atomic collision physics
control of the electronic state on both the target and the projectile

a crossed-beam device



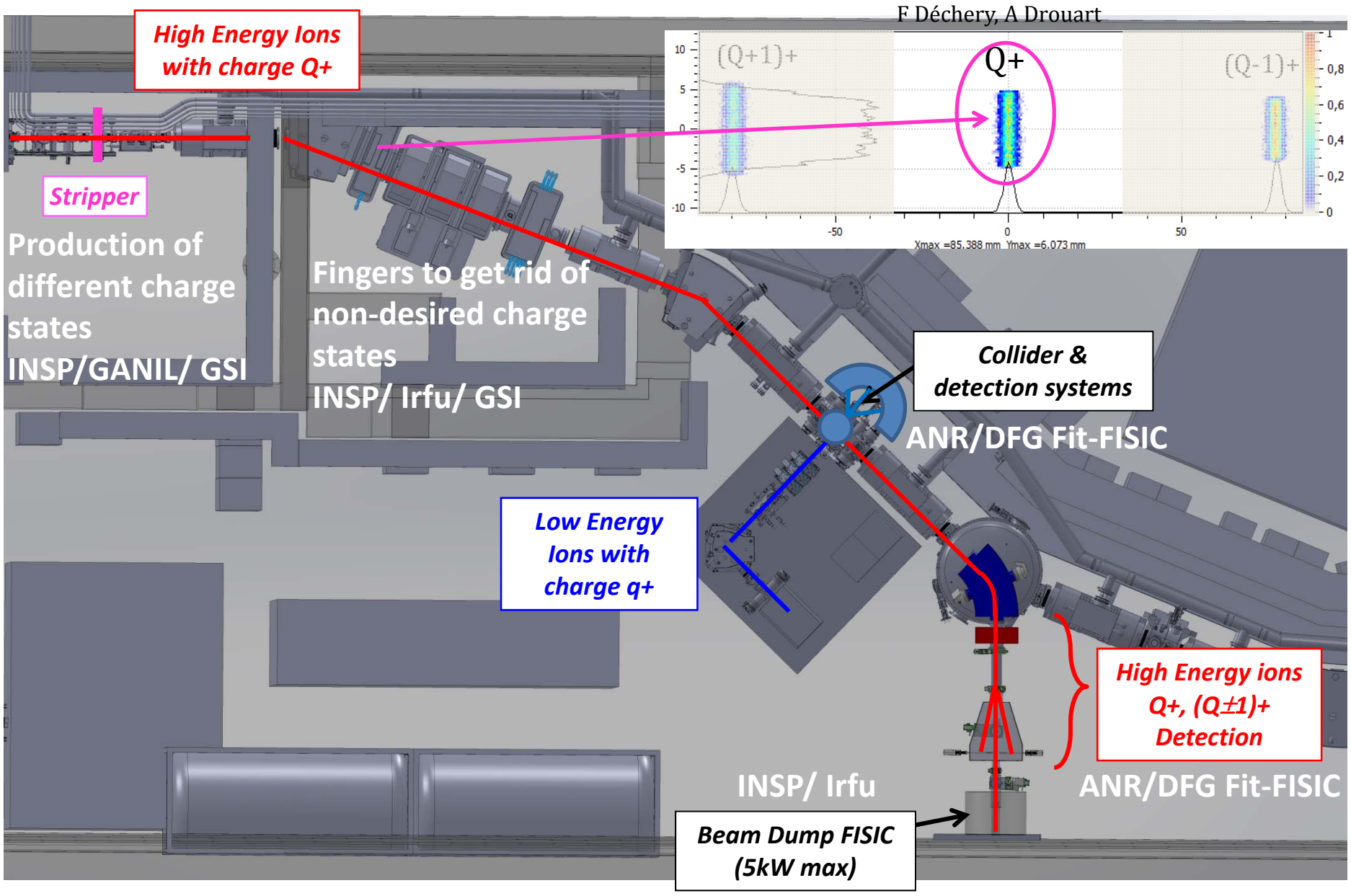
For instance :
Ar^{Q+} + Ar^{q+} @ 8MeV/u

❑ Targets: low energy ion beams (keV/u);
Optimum intensity, stable and well known initial electronic state

❑ Projectiles: high energy ion beams (MeV/u);
high intensities, good optical quality,
perfect selection of the ion charge state

❑ Coincidence measurements : projectile/target charge changes (excit.)
Efficient detection systems

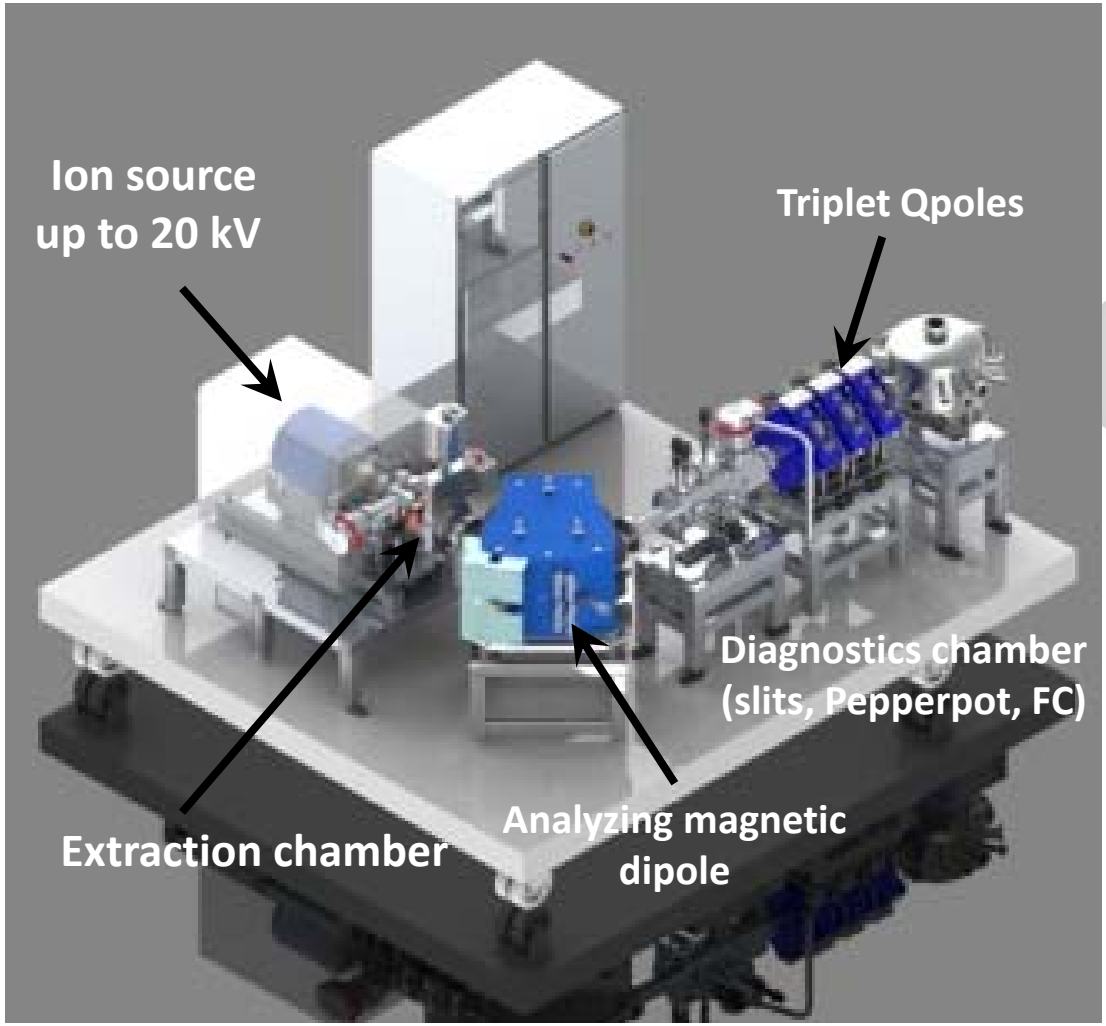
FISIC in the S3 experimental room

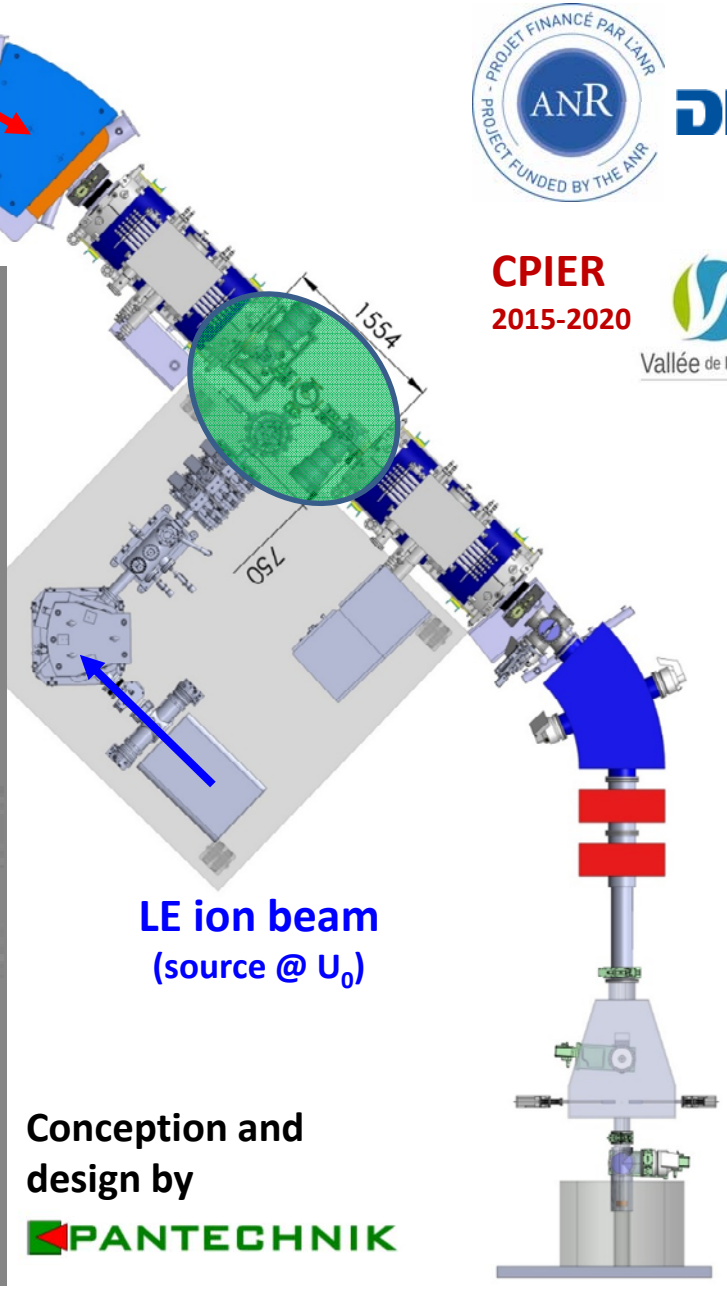


FISIC in the S3 experimental room

Coll. INSP, GANIL, CIMAP

HE ion beam
Q+ (MeV/u)



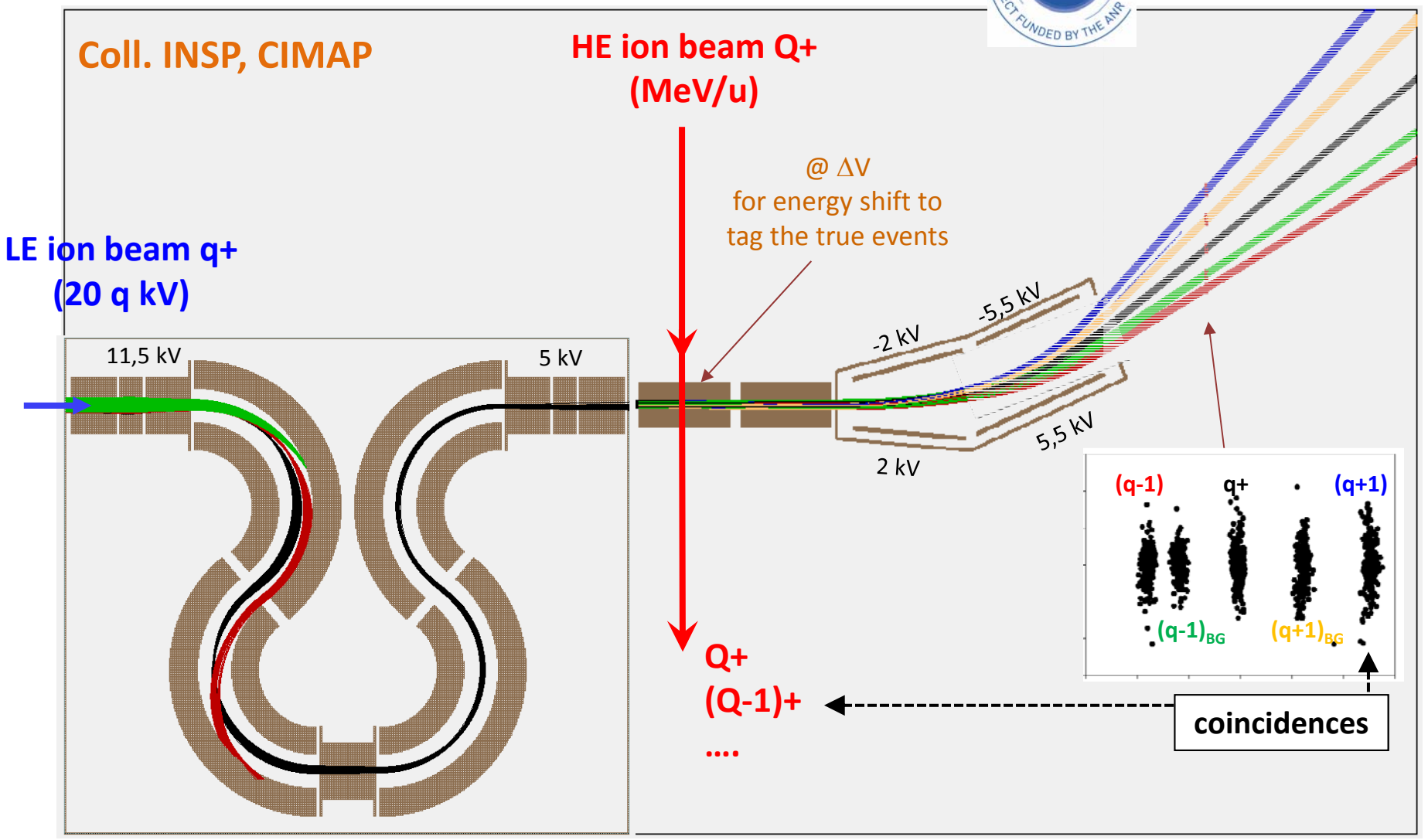


LE ion beam
(source @ U_0)

Conception and
design by
PANTECHNIK

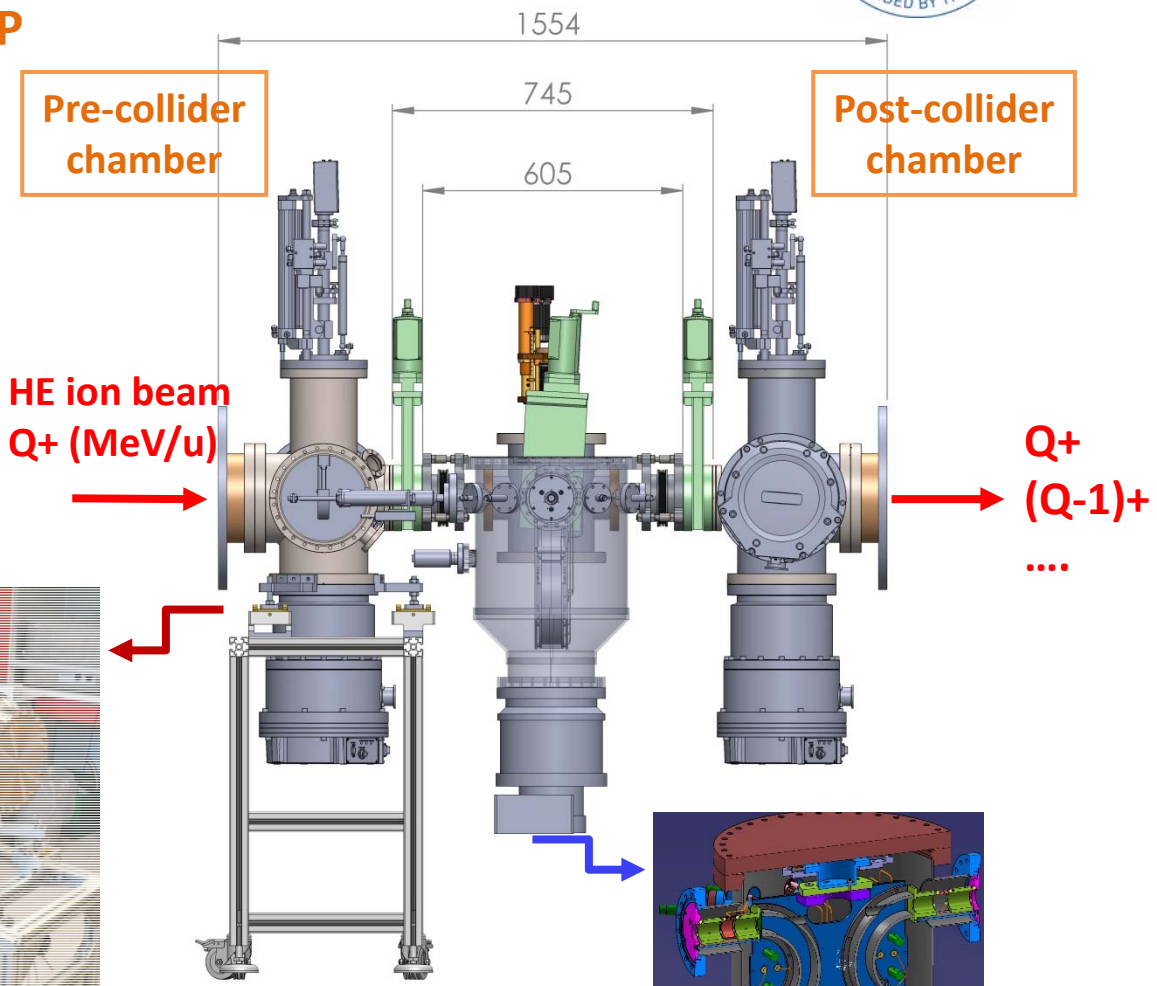
CPIER
2015-2020
Vallée de la Seine

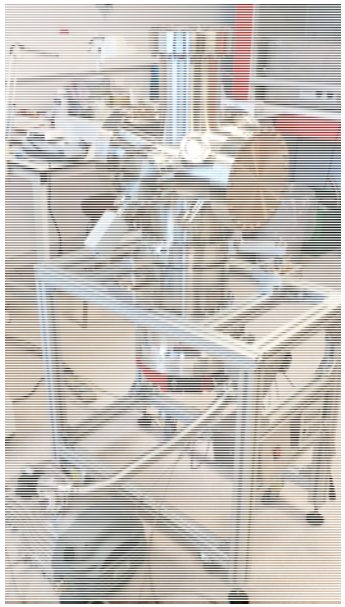
A crossed-beam arrangement

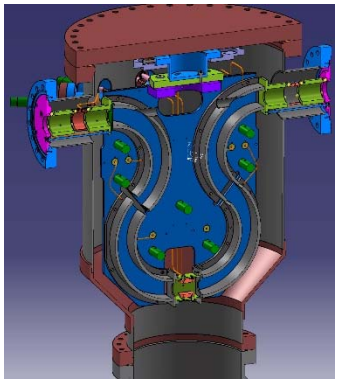


A crossed-beam arrangement

Coll. INSP, CIMAP







Test of the purification system end of 2017

A crossed-beam arrangement

PROJET FINANCÉ PAR L'ANR – PROJECT FUNDED BY THE ANR

DFG Deutsche Forschungsgemeinschaft

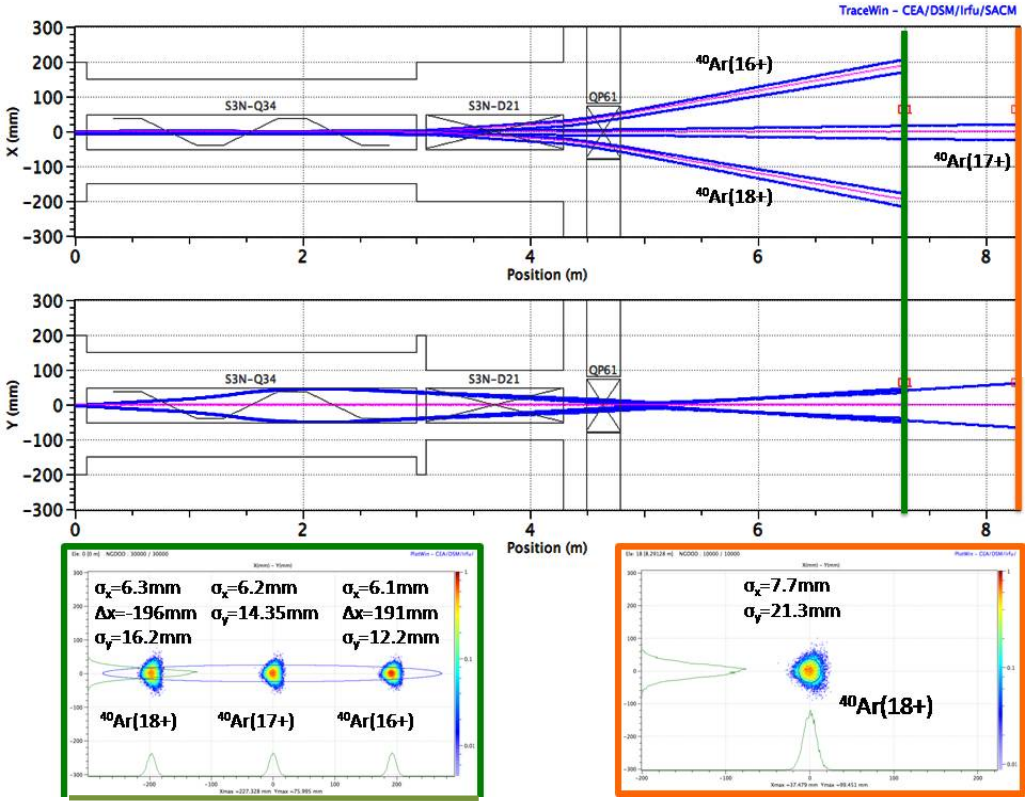
CPIER
2015-2020

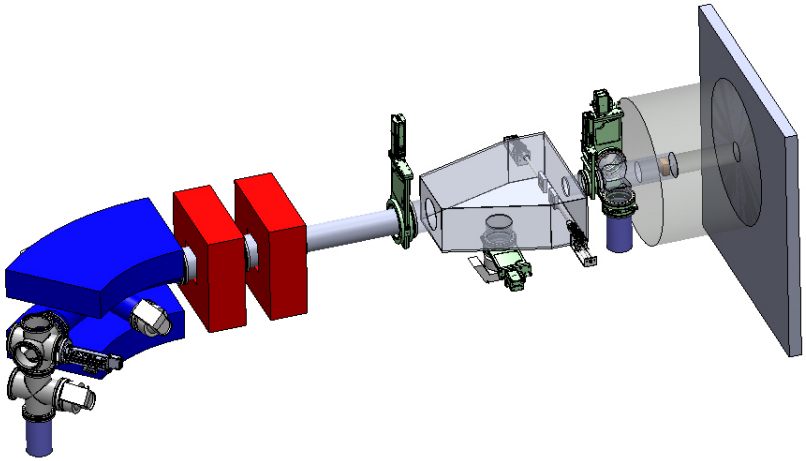
Vallée de la Seine

Coll. INSP, Irfu, GSI

The high energy beam line: optic simulations

Preliminary transport simulations of HE ions





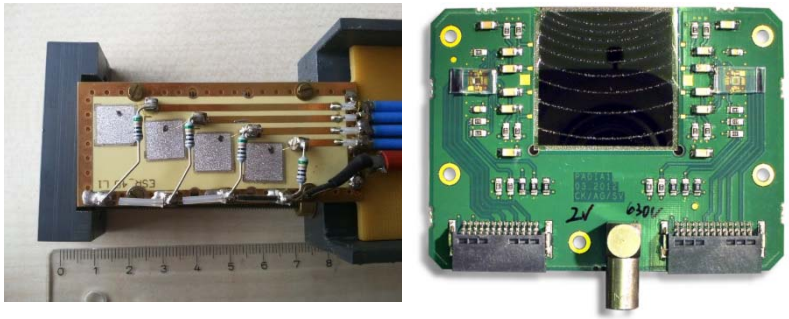
High energy ion detectors

Coll. GSI, INSP

MeV/u to 15 Mev/u Energy range: close to or even in the Bragg peak region ⇒ radiation hardness is an issue: * efficient ion counting rates, * UHV compatible, * active area 1 to 10 cm², * fast time response, * position resolution…

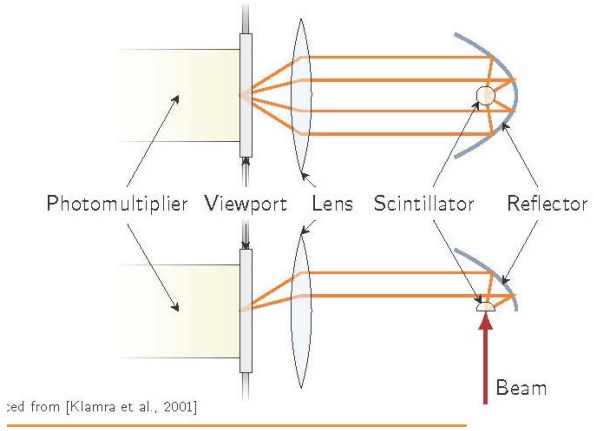
Two options:

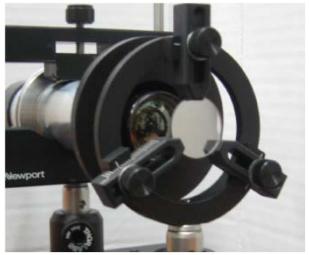
CVD-Diamond detector with position read out



Ch. Kozhuharov et. al

Scintillation detectors

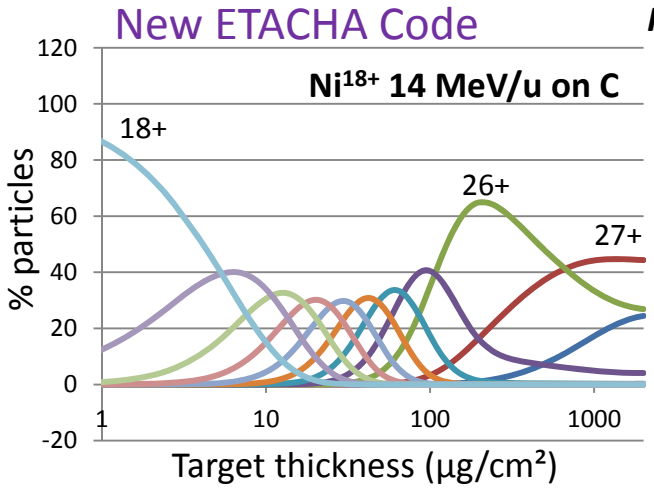




beam time @ IFIN-HH in Bucharest, @ GSI (Darmstadt) and @ FSU Tandem Accelerator (Jena)

FISIC in the S3 experimental room

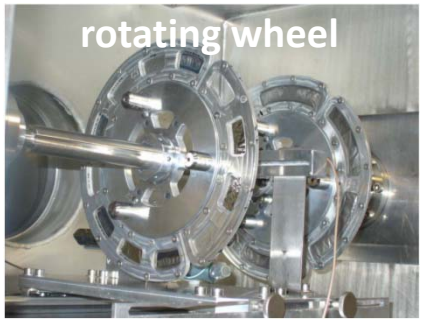
Stripping @high intensity ; Coll. INSP, GANIL, GSI

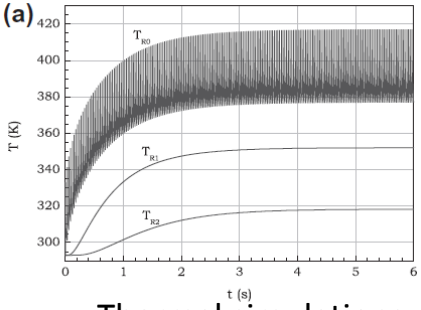


PRA 92, 042703 (2015)

Determination of the most appropriate stripper nature and thicknesses

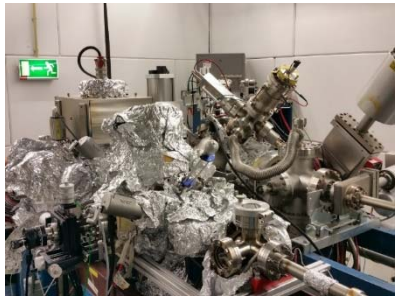
Resistance of solid foils to the high ion intensity





Thermal simulations

Charge state selection of the high energy ion beam;
Coll. INSP, Irfu, GSI, GANIL



material desorption that impacts the vacuum conditions

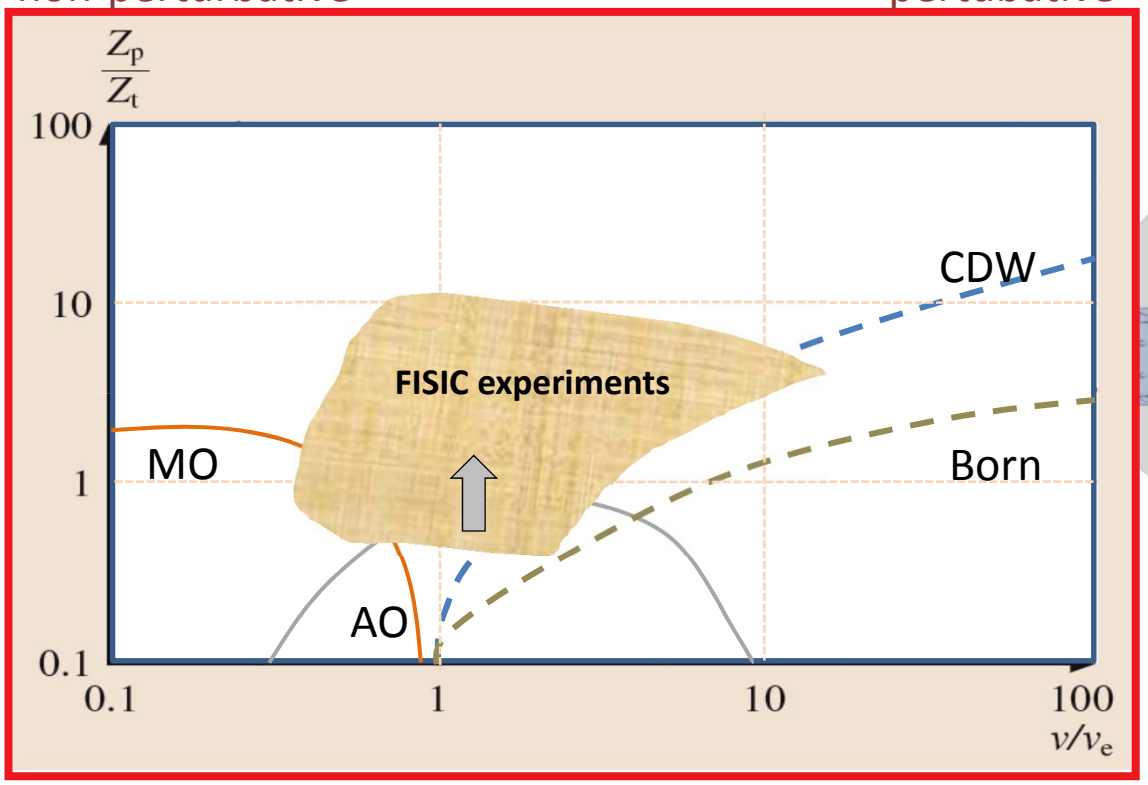
experiments @ GSI, summer 2015 and 2016

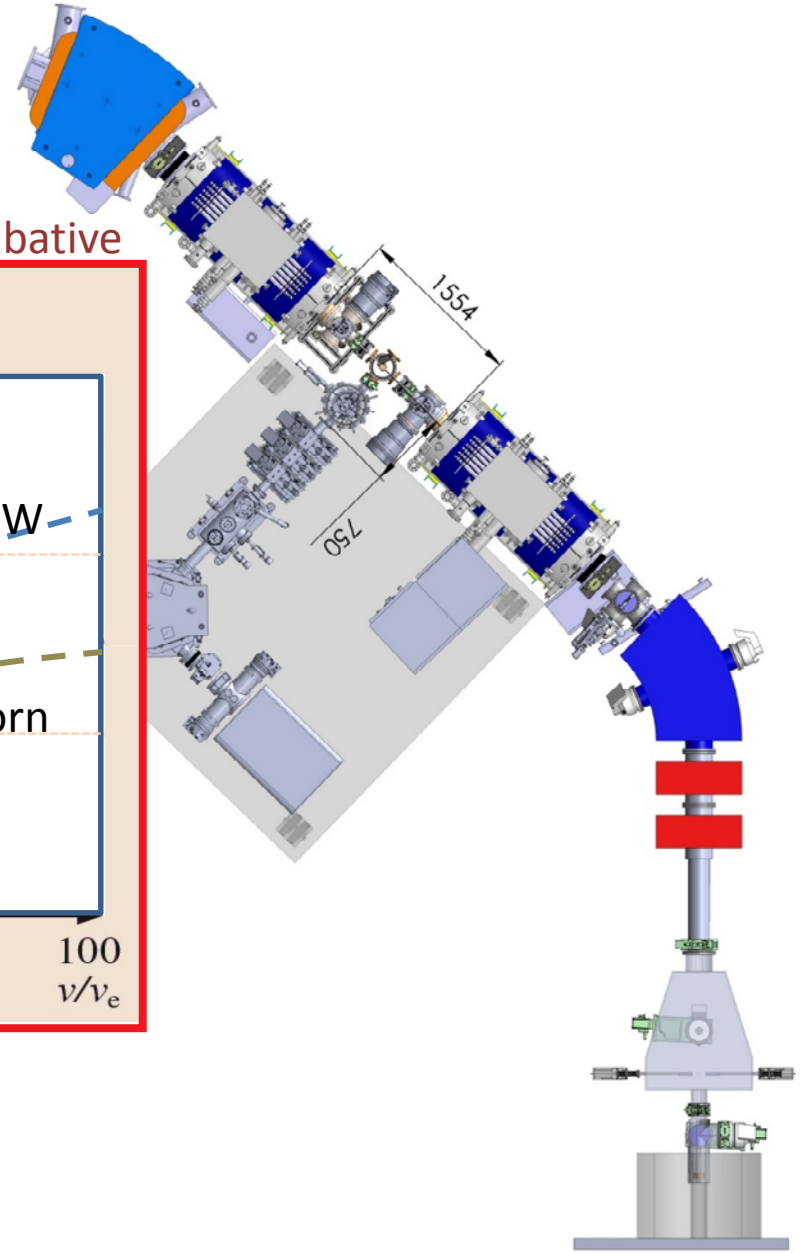
FISIC : Atomic Physics of ion-ion collisions

A collider @ S3/SPIRAL2/GANIL

non-perturbative

pertubative





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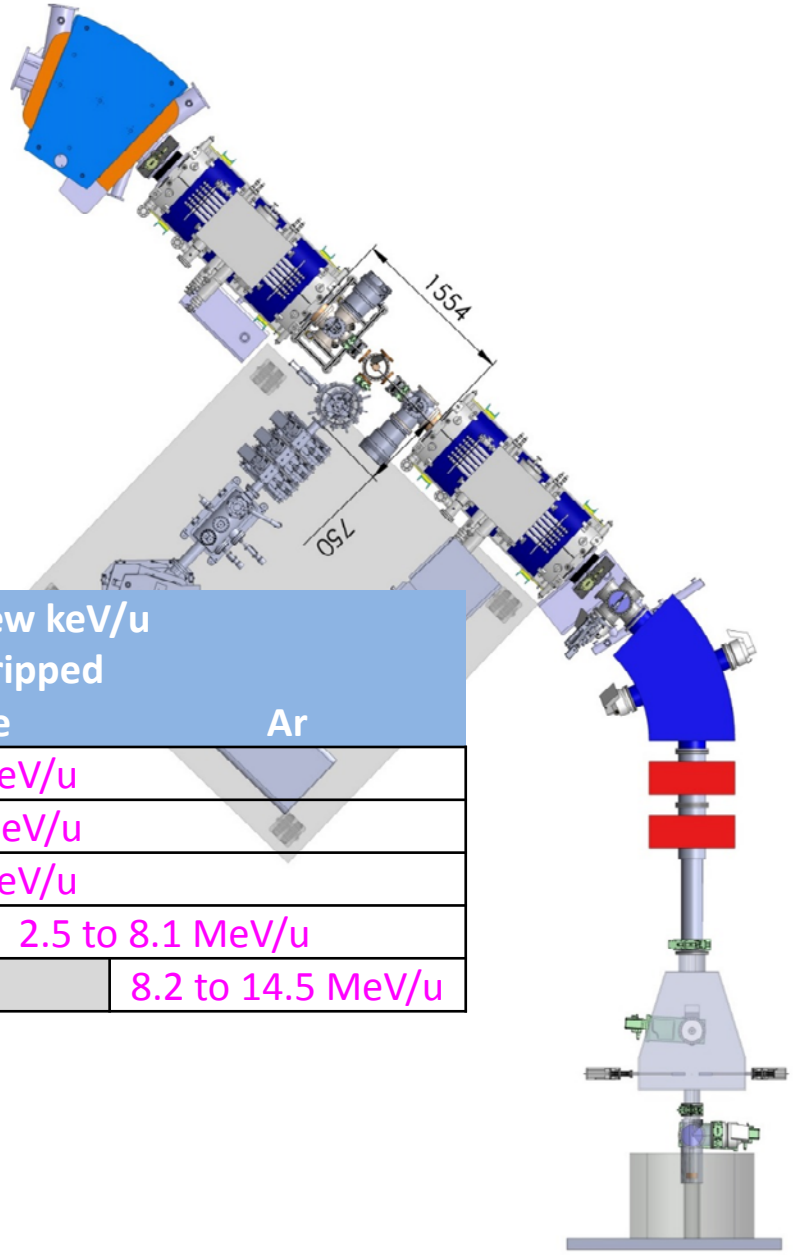

Collision systems available with injector A/q=3

		Slow ions @ a few keV/u 1+ to fully stripped			
		N	O	Ne	Ar
Fast ions	$C^{6+,5+,4+}$	0.9 to 8.1 MeV/u			
	$O^{8+,7+,6+}$	1.2 to 8.1 MeV/u			
	$Ne^{10+,9+,8+}$	1.2 to 8.1 MeV/u			
	$Ar^{18+,17+,16+,15+,14+}$			2.5 to 8.1 MeV/u	
	$Ni^{28+,\ 27+,\ldots\ldots 18+}$				8.2 to 14.5 MeV/u

The FISIC collaboration

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