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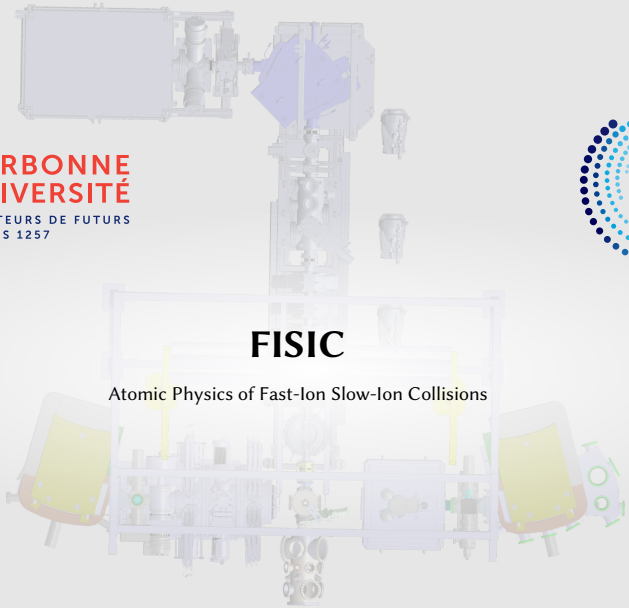
INSP
INSTITUT DES NANOSCIENCES DE PARIS



FISIC

Atomic Physics of Fast-Ion Slow-Ion Collisions

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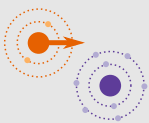
FISIC

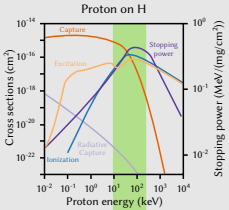
In a nutshell...

Main Goals

FISIC ⟶ Fast-Ion Slow-Ion Collisions

The Fit-FISIC project[s] ultimate goal is to control the experimental conditions and to span from a pure three-body problem (collision between a **bare ion** and a **hydrogenic** target) to a collision system between **dressed partners** (study of the effect of a **controlled number** of **additional electrons**, such as electronic correlations)





⟶ absolute electronic cross sections for ion-ion collisions

⟶ $K_p = \frac{v_e}{v_p} x \frac{Z_t}{Z_e} \simeq 1$

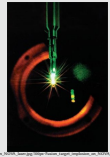
⟶ $\sigma_{capt,ion,exc}$ not well known stopping power maximum

Motivation

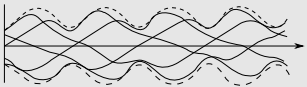
Fundamental Collision Processes

Ion-Electron: $A^{q+} + e^-$
Ion-Photon: $A^{q+} + \gamma$
Ion-Neutron: $A^{q+} + n$
Ion-Atom: $A^{q+} + B^0$
Ion-Ion: $A^{q+} + B^{p+}$
...

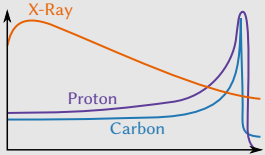
Plasmas
– astrophysical
– fusion



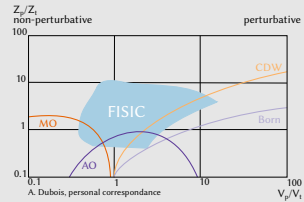
Intra-beam scattering



Ion-Matter interaction
– material damages



Theory Benchmark



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Ion-Ion Collisions

Target ionization: $A^{q+} + B^{p+} \rightarrow A^{q+} + B^{(p+1)+} + e^-$

Projectile ionization: $A^{q+} + B^{p+} \rightarrow A^{(q+1)+} + B^{p+} + e^-$

Charge transfer: $A^{q+} + B^{p+} \rightarrow A^{(q-1)+} + B^{(p+1)+}$

Charge transfer: $A^{q+} + B^{p+} \rightarrow A^{(q+1)+} + B^{(p-1)+}$

Excitation: $A^{q+} + B^{p+} \rightarrow A^{q+(*)} + B^{p+} \rightarrow A^{q+} + B^{p+} + \gamma$

detector — relative energy

$$\sigma = \frac{R}{\epsilon_1 \epsilon_2} \frac{q_1 q_2}{I_1 I_2} \frac{v_1 v_2 \sin\beta}{v_{rel}} F$$

cross section — 2 ion beams — collision volume

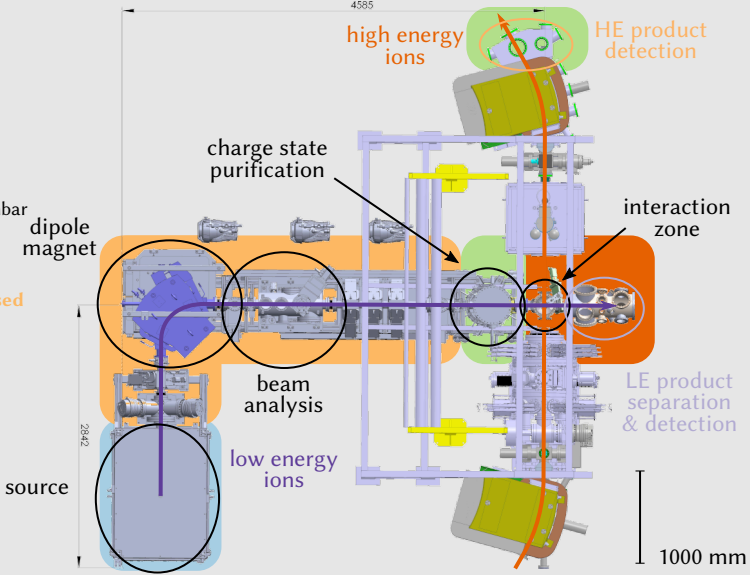
FISIC at CRYRING

$$\sigma = \frac{R}{\epsilon_1 \epsilon_2} \frac{q_1 q_2}{I_1 I_2} \frac{v_1 v_2 \sin\beta}{v_{rel}} F$$

Challenges

- Size
  - Transport
  - Assembling
- Vacuum
  - ~1e-6 mbar ➔ ≤1e-11 mbar
- Beam Overlap

Built & Tested
Built & Being Characterised
Under Construction
Temporary Installation



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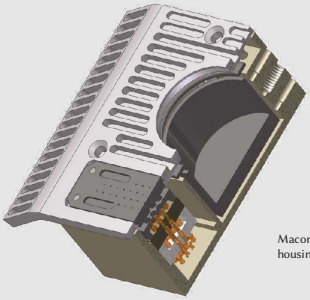
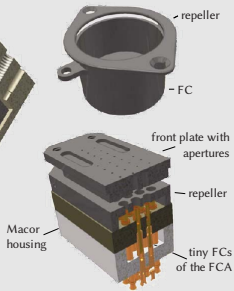
Beam Overlap

$$\sigma = \frac{R}{\epsilon_1\,\epsilon_2}\,\frac{q_1\,q_2}{I_1\,I_2}\,\frac{v_1\,v_2\,\sin\beta}{v_{rel}}\,F$$

Low Energy Ions

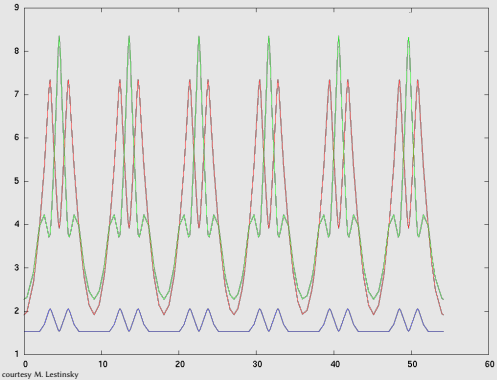


cut view of the detector
with mounted front plate



detection hardware in detail

High Energy Ions



courtesy M. Lestinsky

Rates

$$R \propto \frac{\sigma \, I_1 \, I_2}{q_1 \, q_2}$$

I_1 = 50 μA_e p1 = p2 = 1e-11 mbar τ_{coin} = 80 ns

HE	σ_{capt} (cm^2)	LE	I_2 (μA_e)	σ_{ion} (cm^2)	R_{capt} (s^{-1})	R_{ion} (s^{-1})	BG (s^{-1})	BG (s^{-1})	rd. coinc.
Ar^{18+}	4.5e-18	Ar^{4+}	5	8e-16	42	7.4e3	5e3	2	3
Ar^{18+}	4.5e-18	Ar^{8+}	20	1.8e-16	66	2.6e3	5e3	0.04	1
Ar^{18+}	3.5e-18	Ar^{12+}	15	4.7e-17	30	400	5e3	0.002	0.2
Ar^{18+}	1.6e-18	Ar^{16+}	0.1	1.5e-16	0.2	0.2	5e3	1e-11	<1e-4
Ar^{14+}	1.5e-18	Ar^{4+}	5	8e-16	18	9.5e3	2e3	2	2

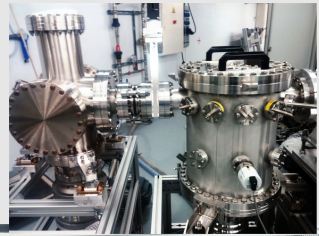
Summary

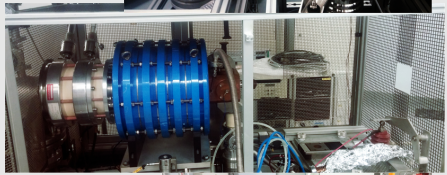
FISIC is
– an international
– crossed-beam
– ion-ion collision
experiment

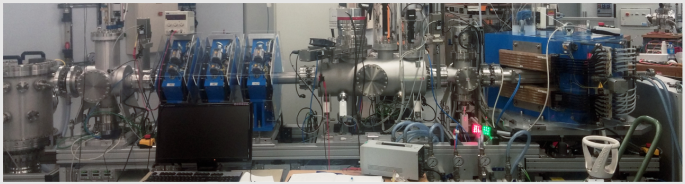
FISIC will
– measure absolute electronic cross sections
– benchmark current theories

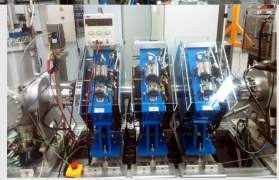
FISIC has
– a working low energy beam line
– a broad acceptance in-line charge state purifier

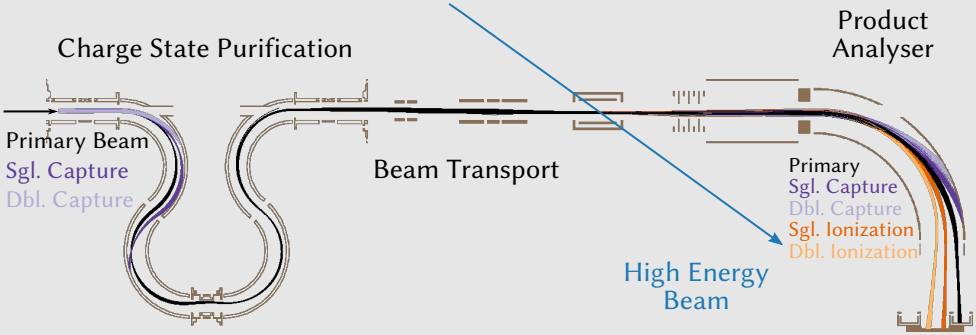
FISIC needs
– the high energy beam line integration chamber
– product detectors



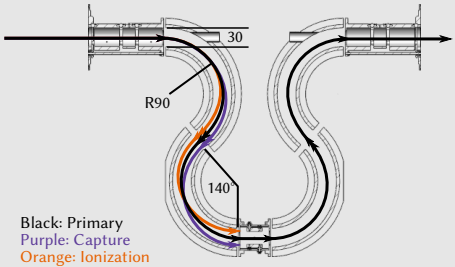


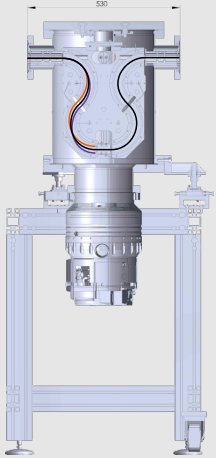






Omega Purifier





– single lens at entry and exit
– vertical steerer in mirror axis
– focussing in vertical plane
– enclosed Matsuda plates for horizontal focussing
– designed for high emittance beam transport (60 π mm mrad)

Interaction Chamber