

Polarized H^-/D^- Beams at COSY/Jülich

February 13, 2017 | Ralf Gebel

Institute for Nuclear Physics (IKP-4/COSY)

Outline

- Introduction
- Status
- Activities

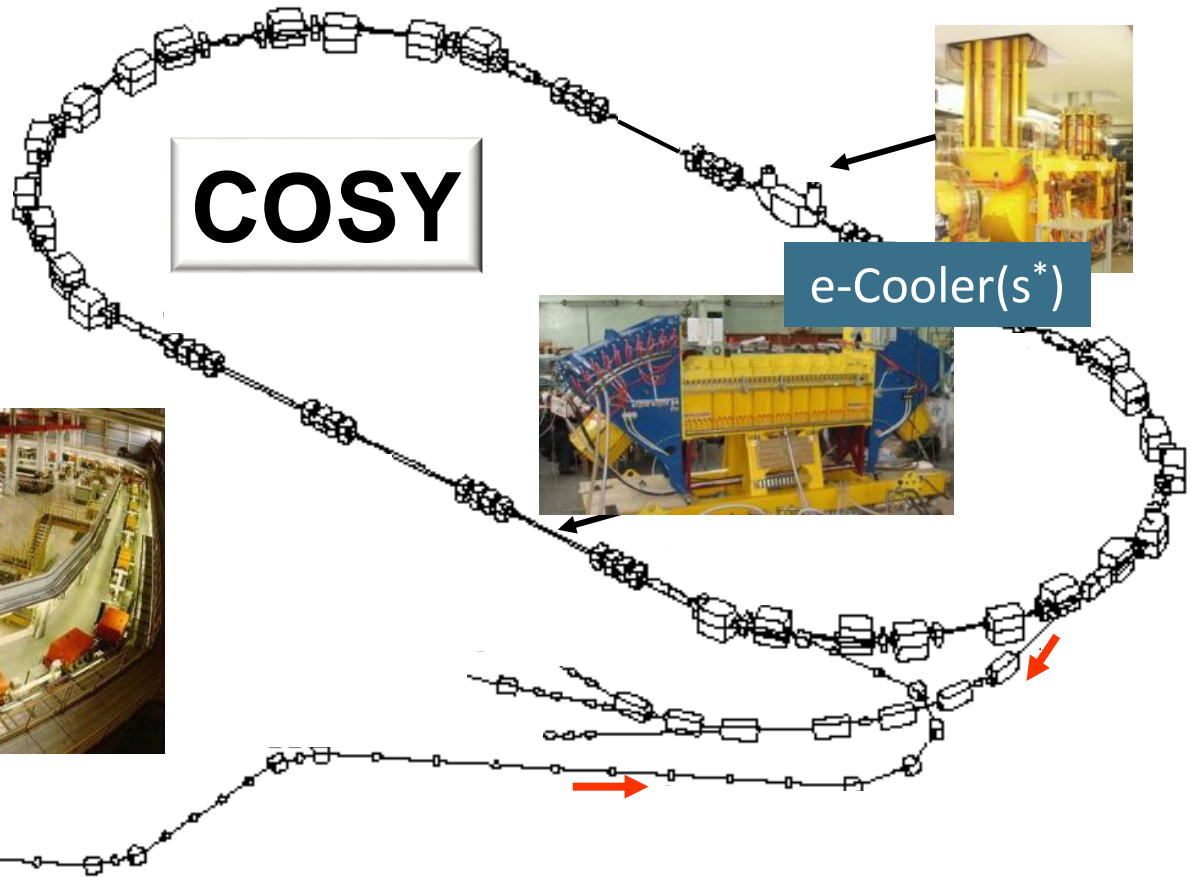


Introduction: COSY

Cooler and storage ring for (polarized) protons and deuterons

$p = 0.3 - 3.7 \text{ GeV}/c$

Phase space cooled internal & extracted beams



Injector cyclotron

Introduction: COSY's Injector



AEG design

Request for quote: 1961

First internal beam: 1968

Upgrade for COSY: 1990

Pole diameter 3.3 m / 700 t iron

$\langle B \rangle_{\max} = 1.35 \text{ T}$ $B_{\text{hill}} = 1.97 \text{ T}$

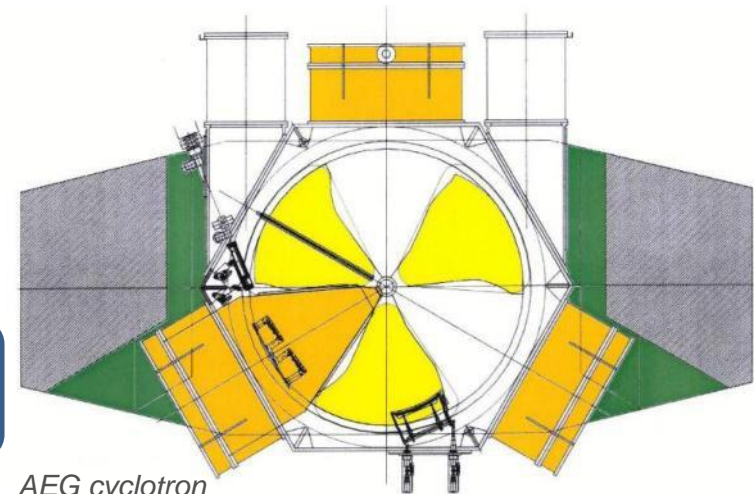
20 – 30 MHz ($h=3$)

22.5-45 MeV/A

2-4.5 keV/A injection

3 ion sources (2 multicusp + pol. CBS)

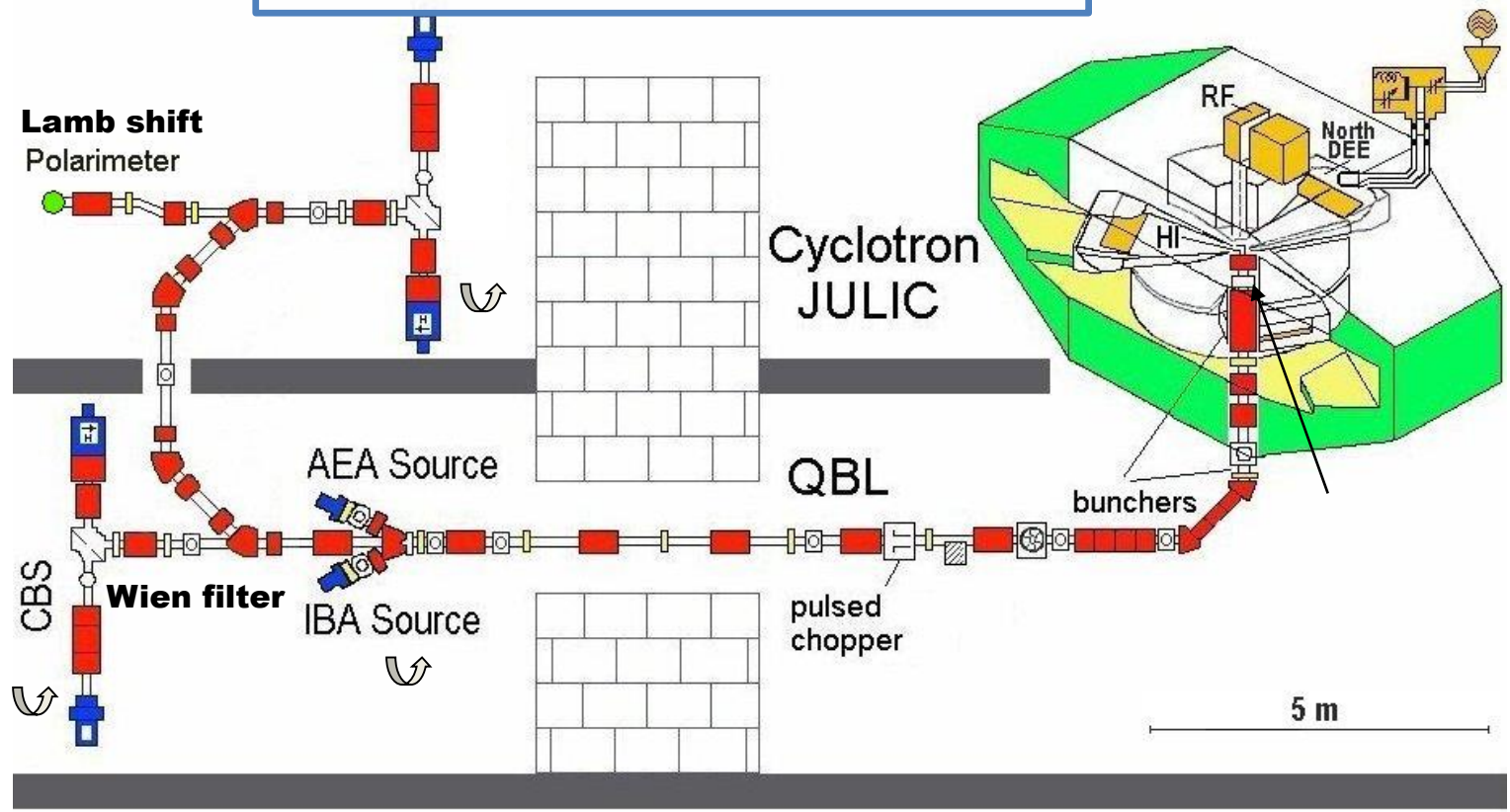
**routinely 45 MeV H⁻ and 75 MeV D⁻ for COSY
with 20 ms stripping injection/cycle**



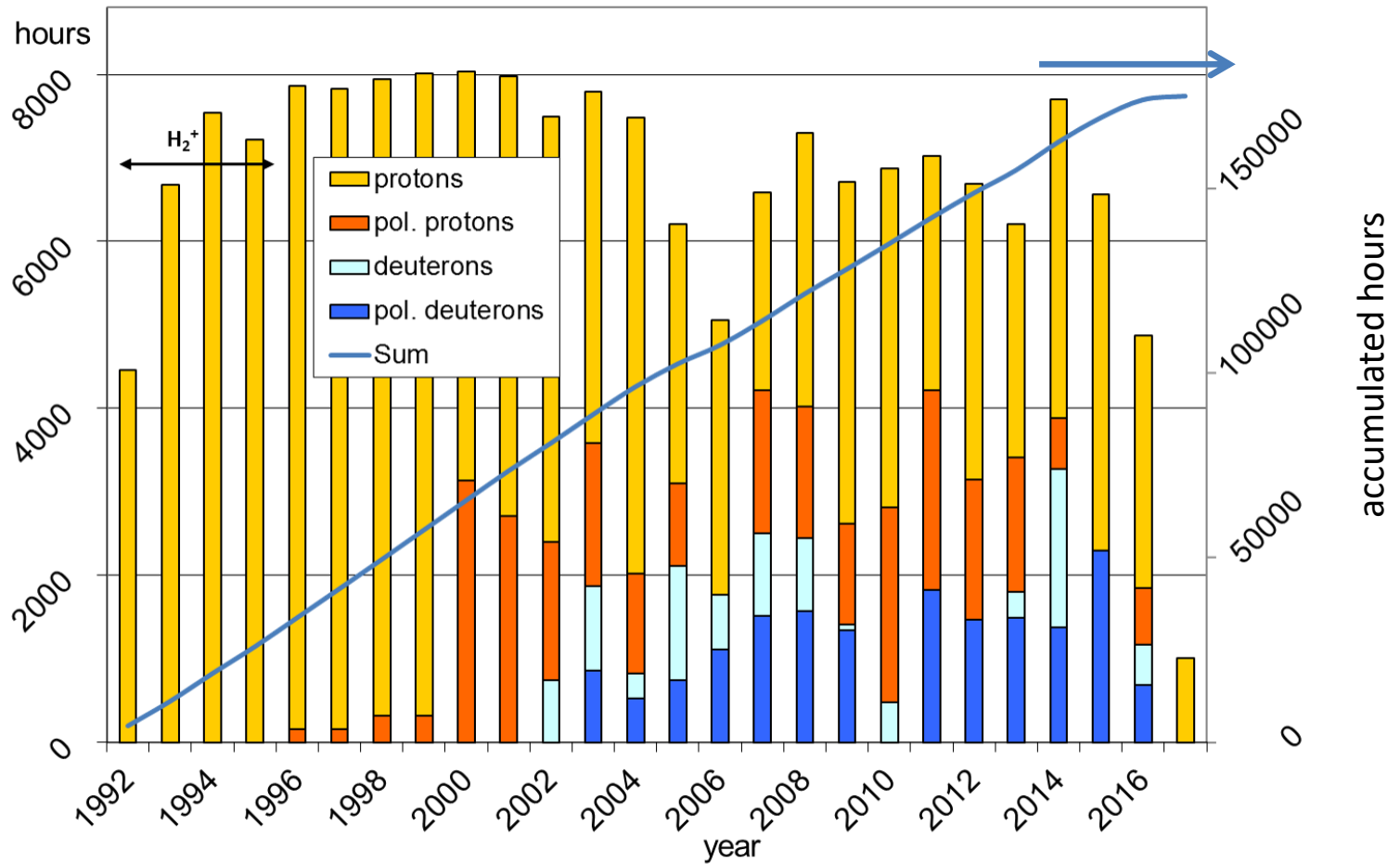
AEG cyclotron

Ion Sources at the Injector Cyclotron

Injection energy: 4.5 +/- 0.02 keV/u
Acceptance: 150 μm rad
Transmission: <0.1



Status: COSY and Cyclotron Operation



Availability (Up time) of the injector cyclotron
Distribution of beam species

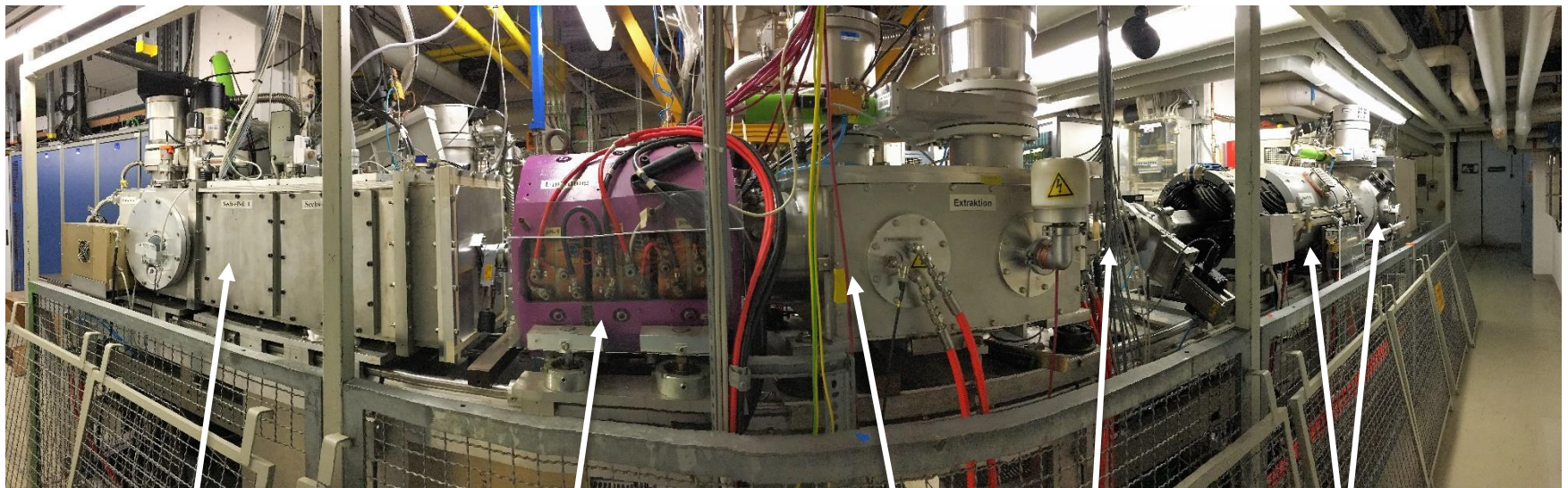
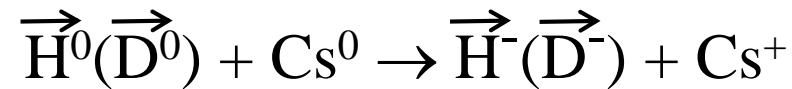
Status: Statistics 2000 –2017

	Protons	Deuterons	pol. Protons	pol. Deuterons
beam hours				
since 2000	66400	9200	25200	16800
	56%	8%	21%	14%
sum	~75600 h		~42000 h	
average/ year	4730 hours/year		2630 hours/year	

Delivered beam species
COSY's availability: > 92% (average)

COSY's Polarized Ion Source

Charge exchange reaction



Atomic beam source

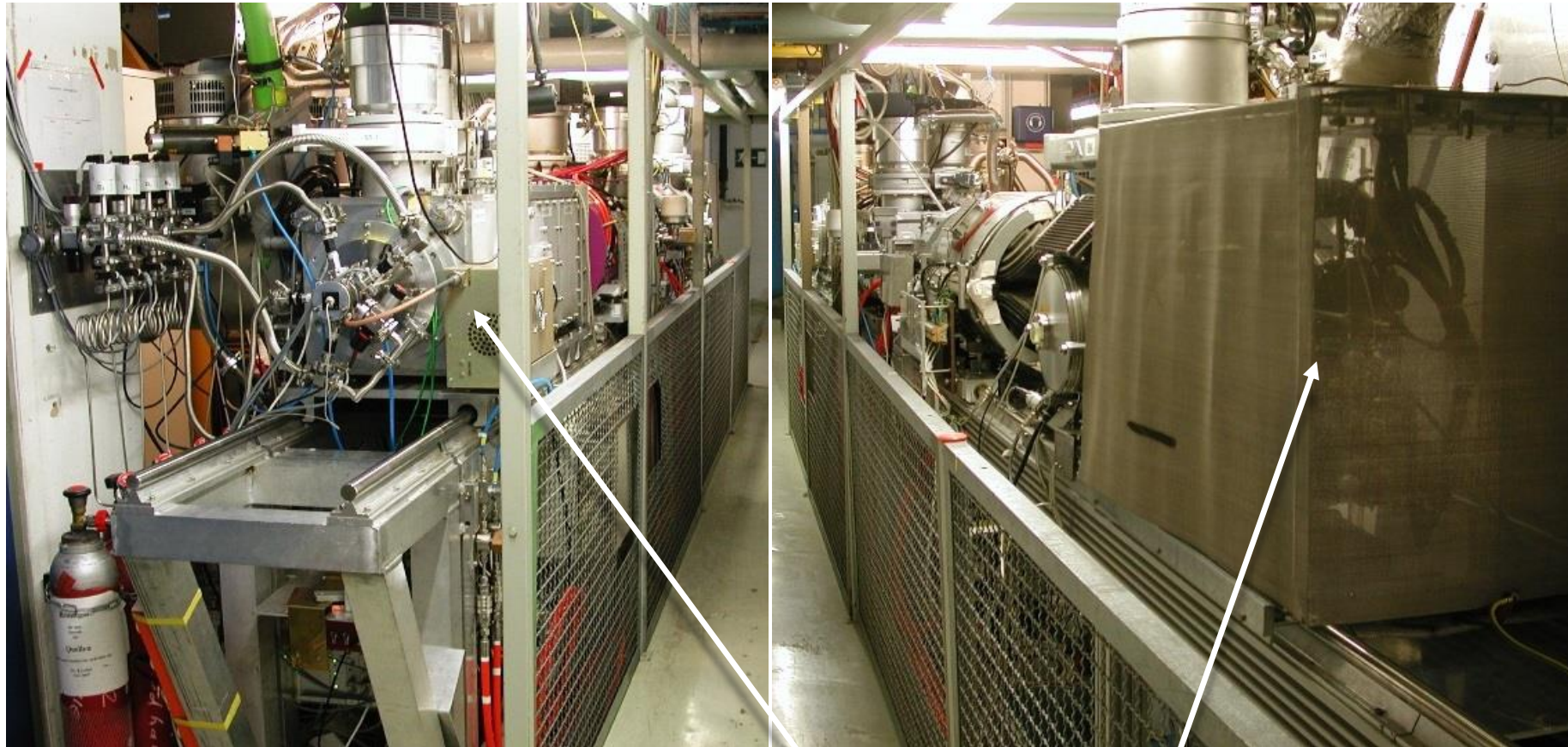
Charge exchange region

Extraction

Cs Neutralizer

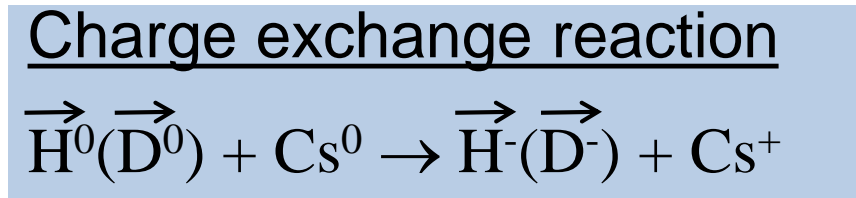
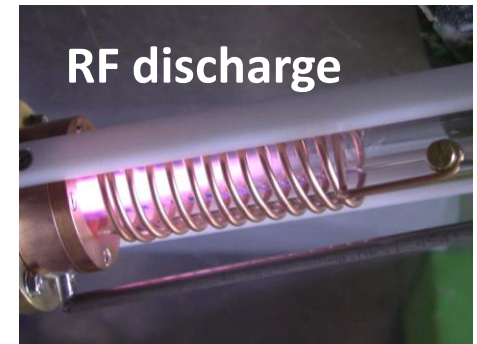
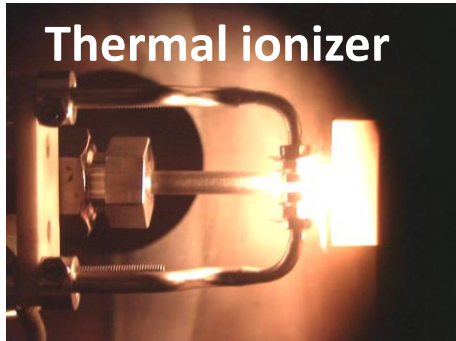
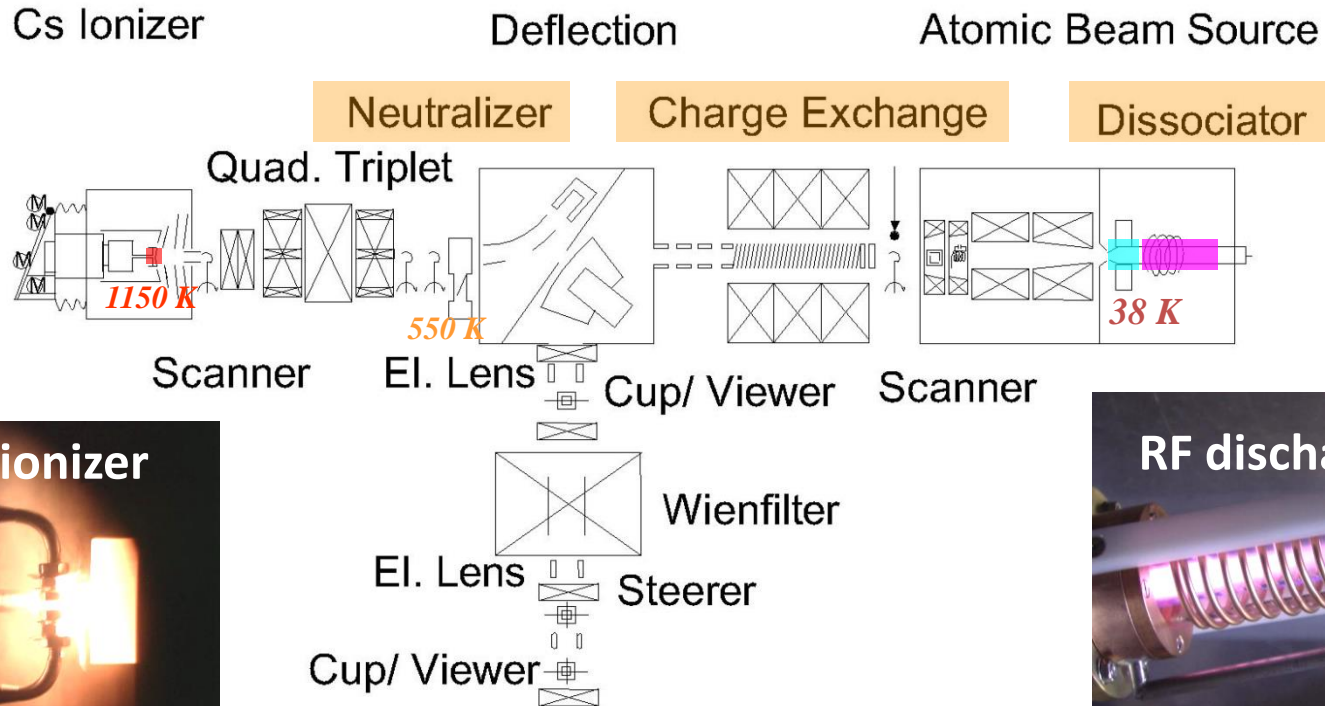
Cs ionization / transport

COSY's Polarized Ion Source



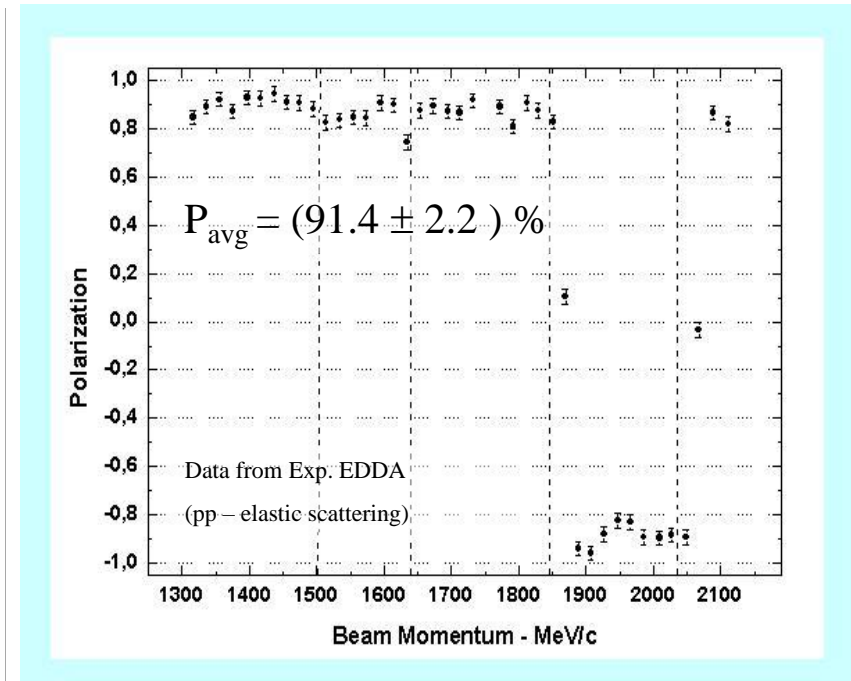
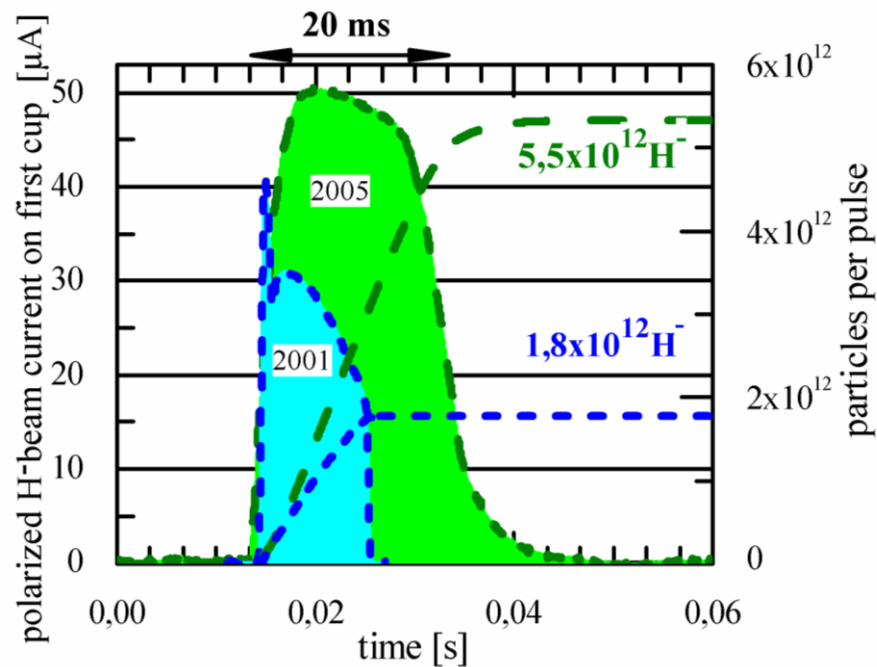
About 6 m from the pulsed ABS to the Cs ionizer

COSY's Polarized Ion Source



Ref.: Haeberli , NIM **62**(1968)

Performance (Reference values 1)

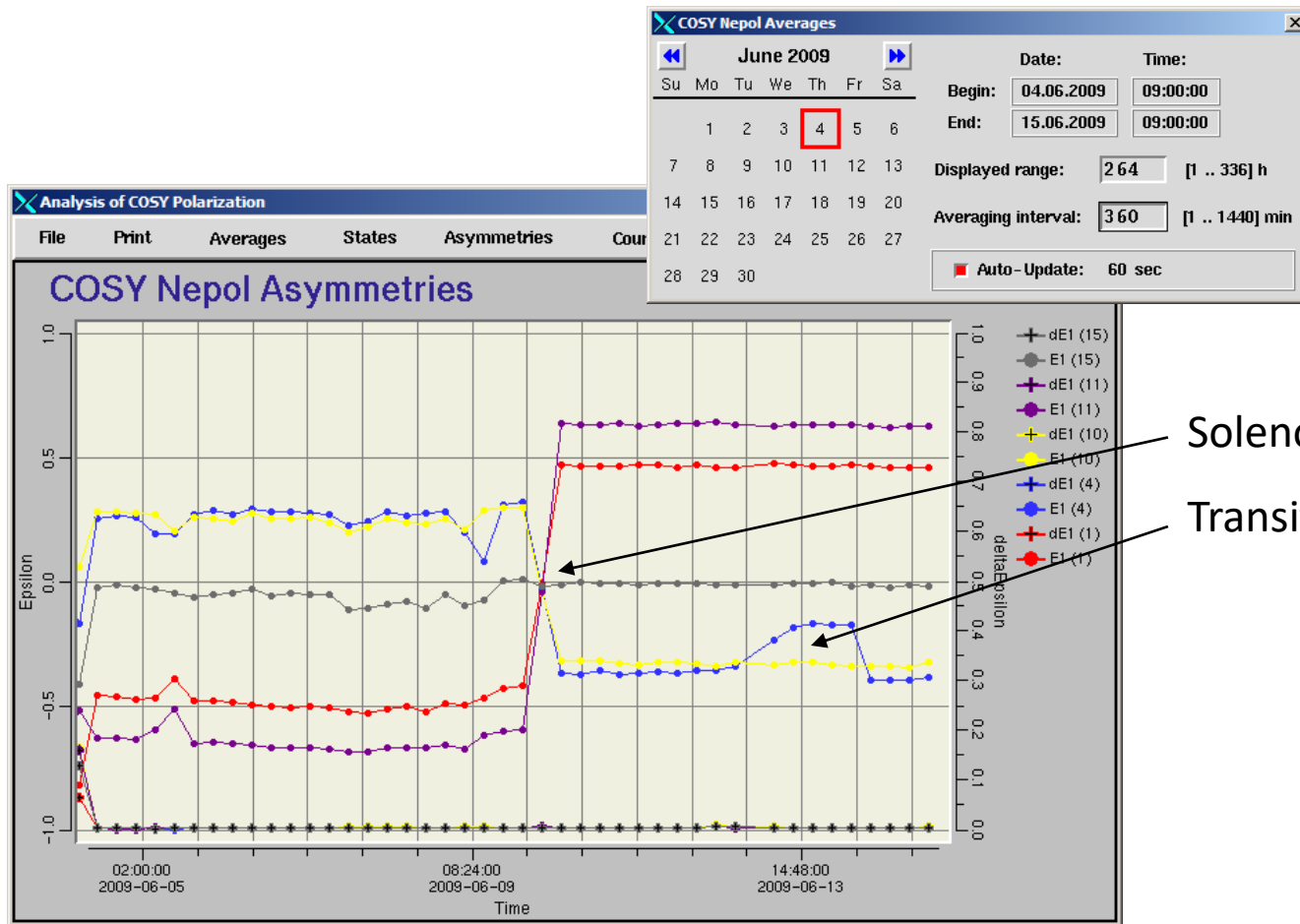


Beam current at the source exit*

* compare to routine COSY fill of a few 10^{10} protons or deuterons
(space charge limit of about 10^{11})

Polarization inside COSY

Monitoring Beam Asymmetries

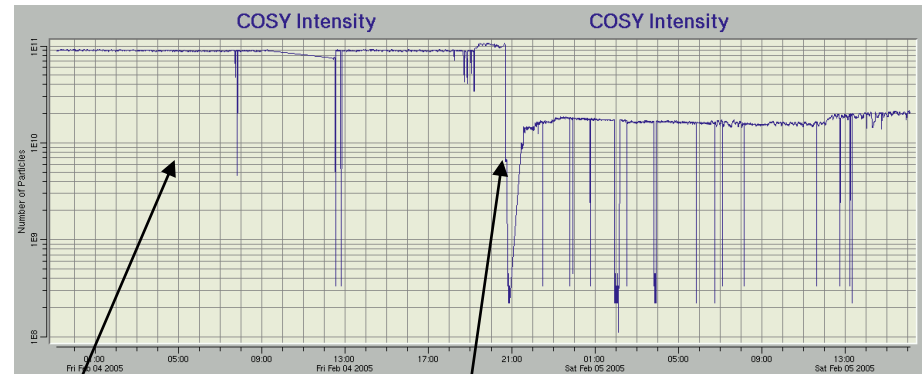
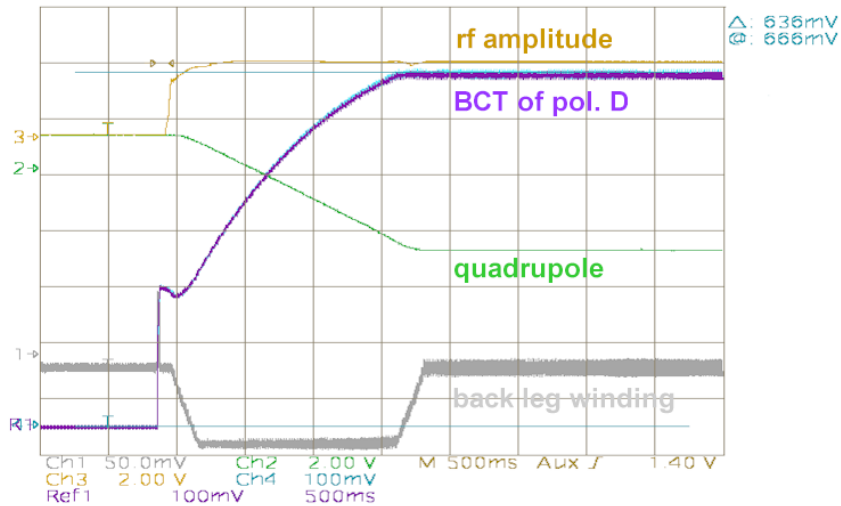


11 days of
deuteron
beam

Solenoid reversal

Transition unit retuned

Performance (Reference values 3)



best values for COSY:
35 mA unpol. D and 6 mA pol. D

unpolarized
deuterons

switching to polarized
deuterons

Performance Milestones

- 1993 Installation
- 1994 ABS: Pulsed operation
- Cs Ionizer: Prototype replacement
- 1998 ABS: PM sextupoles
- Cs dispenser; electron beam heating
- 2000 Pulsed Cs Ionizer
first routine operation for COSY experiments
- 2001 H⁻ extraction with EM-dipole
- D⁻ extraction with PM-EM-dipole
- 2003 routine D⁻ operation for COSY
- ABS: Pulsed mode optimization (with A.S.Belov)
- 2007 Polarimeter improvements
 - Breit Rabi
 - Lambshift
 - 45 MeV
- 2012 New Cs dispenser generation for ionizer
Laser applications

Accelerator Research and Development (ARD)

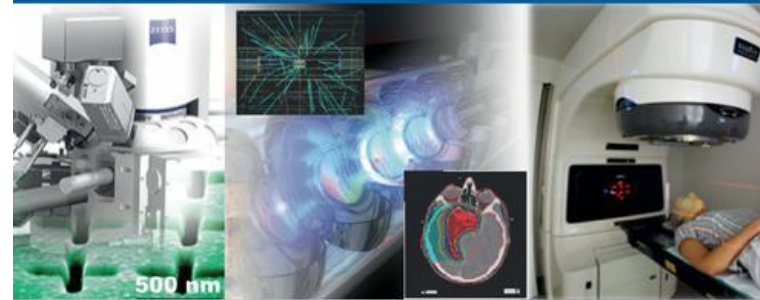


R&D for Hadron Storage Rings

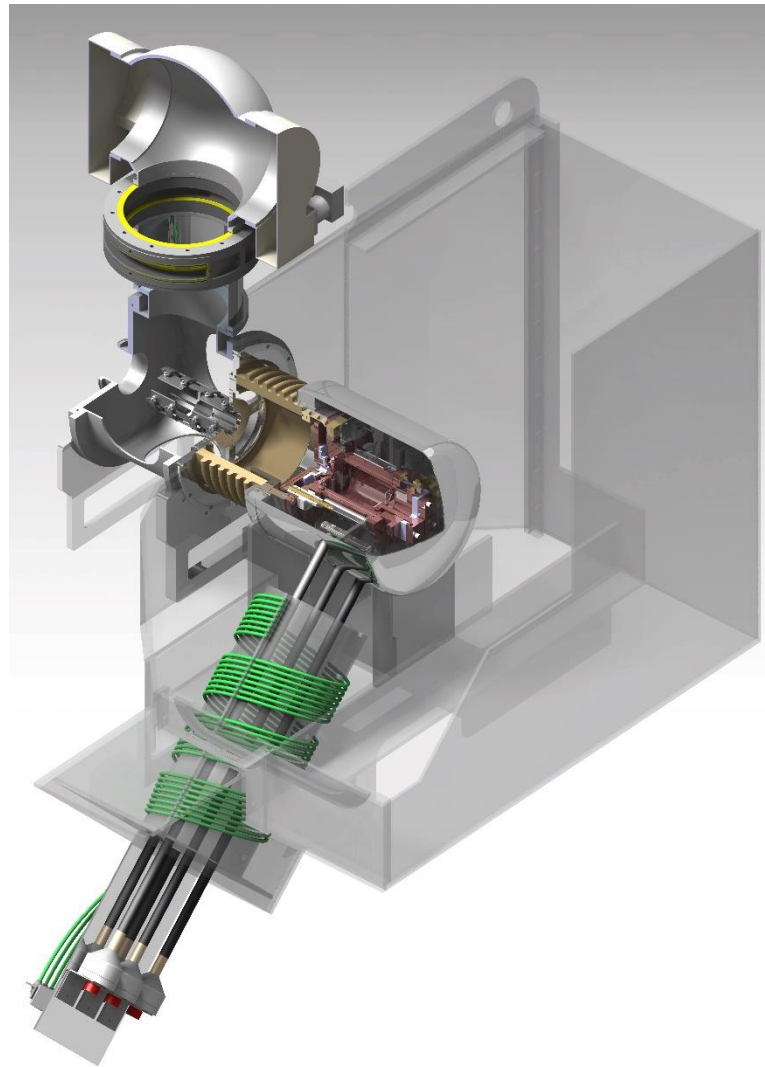
Topics (with FZJ as leading lab)

- (polarized) Ion sources for hadron storage rings
 - Assure high intensity beams for COSY/JEDI
 - Enable experiments at e.g. FAIR with polarized beams
 - Ion source for ELENA@CERN
- Combined electrostatic and magnetic deflectors
 - Search for an electric dipole moment in p , d and He^3
- High energy beam cooling and broad band stochastic cooling
 - Electron cooling up to COSY's maximum momentum
 - Electron cooling for HESR
 - Fast stochastic cooling at different energies

Accelerators – Motors for Discovery and Innovation



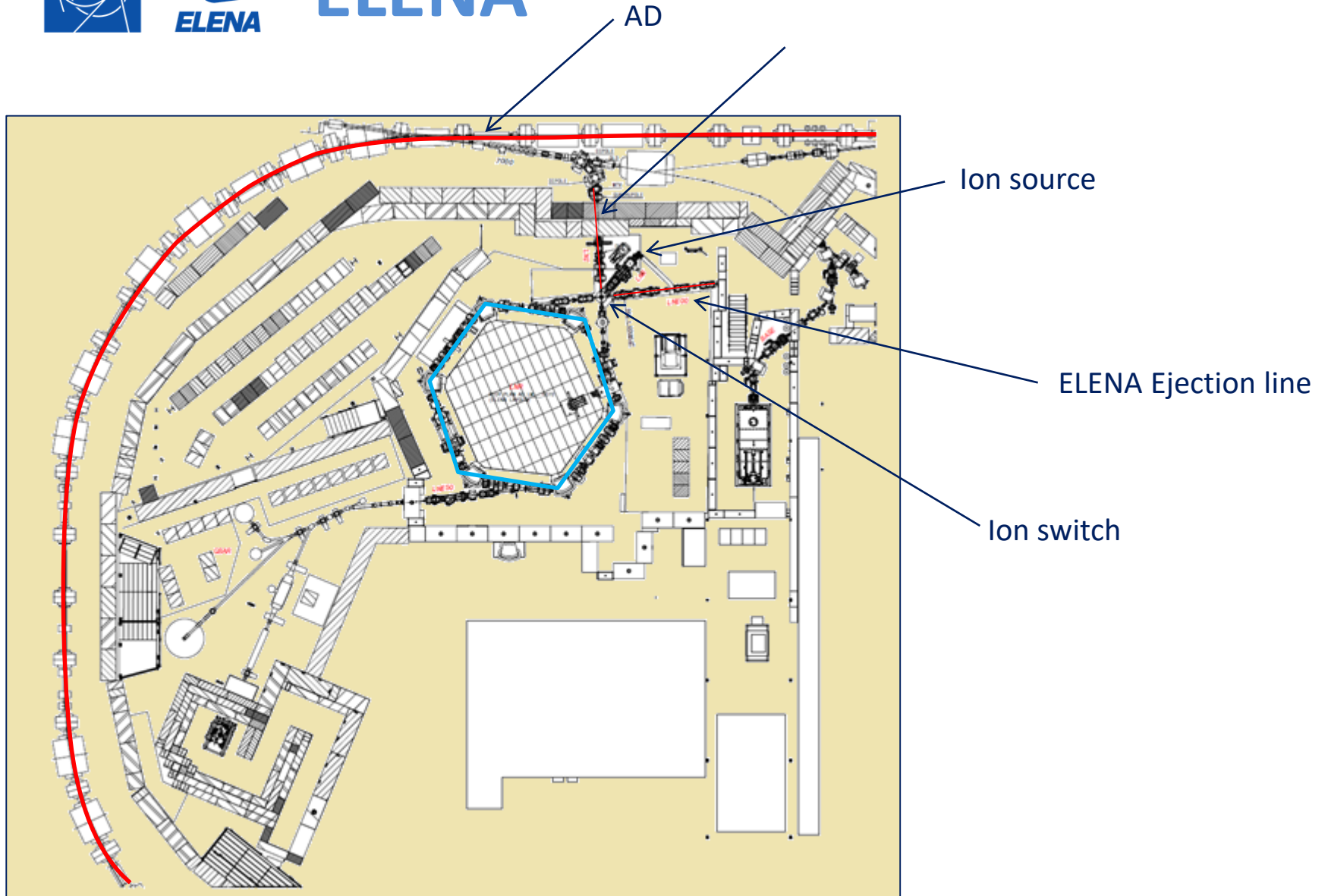
Ion source for ELENA

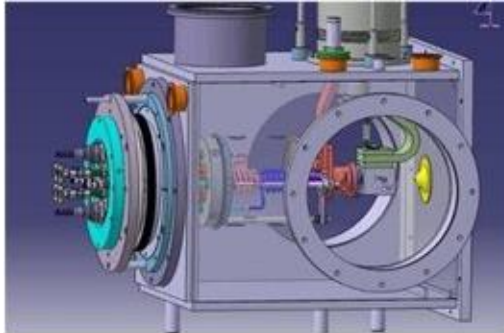


Ion Source for ELENA @ CERN

- 100 keV p or H⁻
- Short pulses
- High brightness
- to be used for commissioning







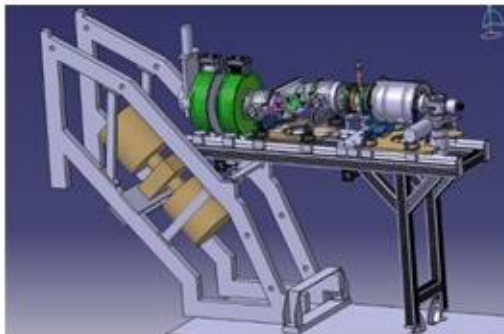
Atomic beam studies

- Intensity
- Density, profiles
- Velocity distribution



Cs beam studies

- Intensity
- Profile/Brightness



Diagnostic tools for pol. beams

Testbench for Atomic beam parts

Used for offline tests of e.g. transition units



Equipment for neutral beams:

Quadrupole mass spectrometer,
TOF spectrometer,
Compression tubes,
Diaphragms, Chopper, Scanner etc.

For:

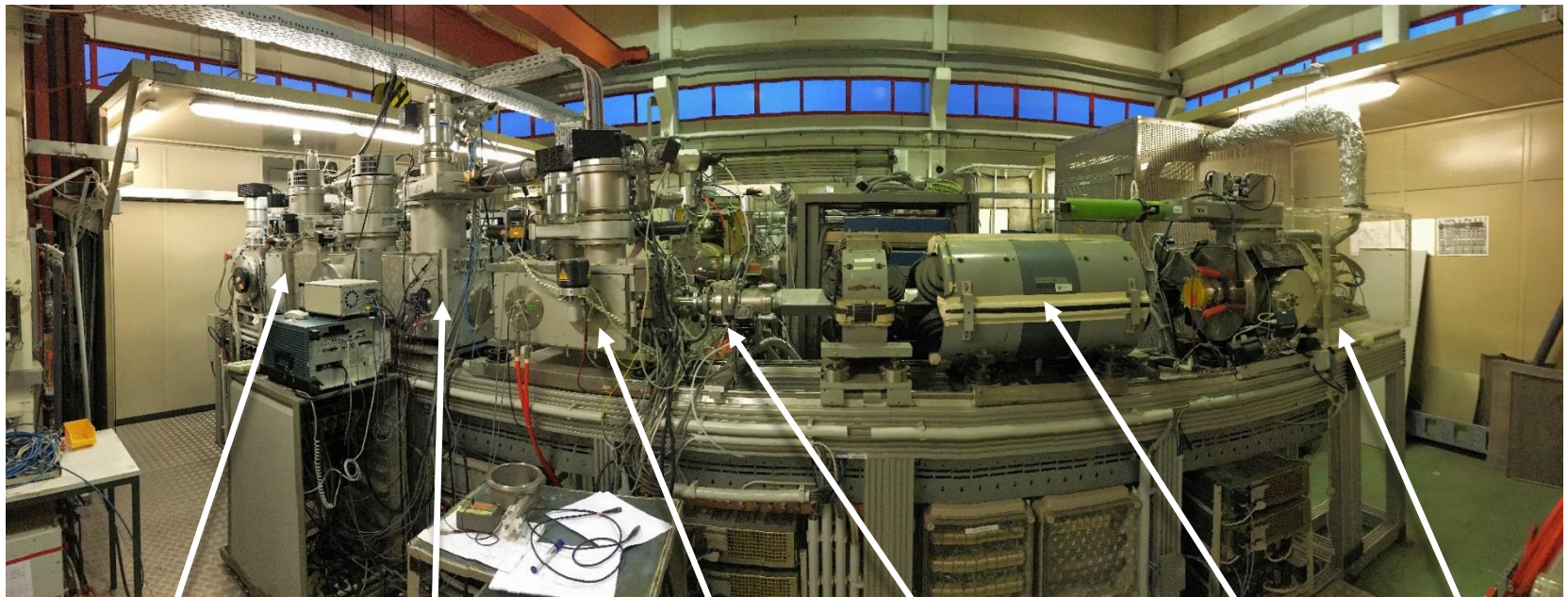
- Intensity
- Density, profiles
- Velocity distribution

cw operation: 4×10^{16} Hydrogen H atoms/s (initial CBS)

Pulsed: 7.5×10^{16} H/s (peak, 20 ms pulses, < 0.5 Hz, COSY operation)

Improved: 11×10^{16} H/s (peak, new dissociator, with spare PM hexapoles (EDDA))

Testbench for polarized sources



Atomic beam source

Diagnostic chamber

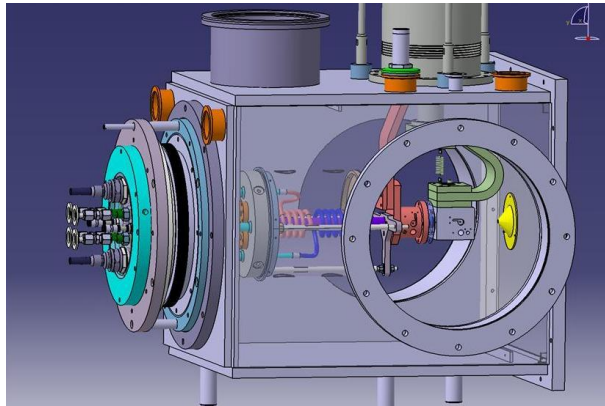
Extraction to LSP

Cs Neutralizer

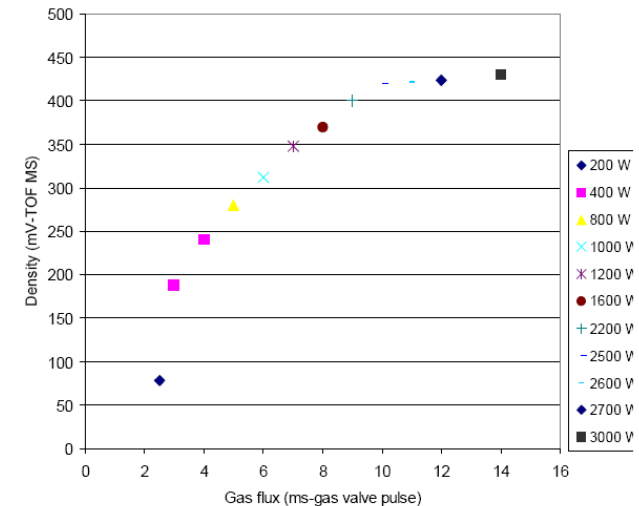
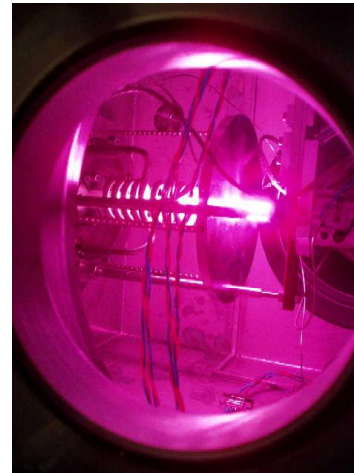
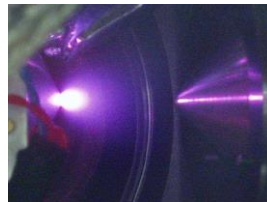
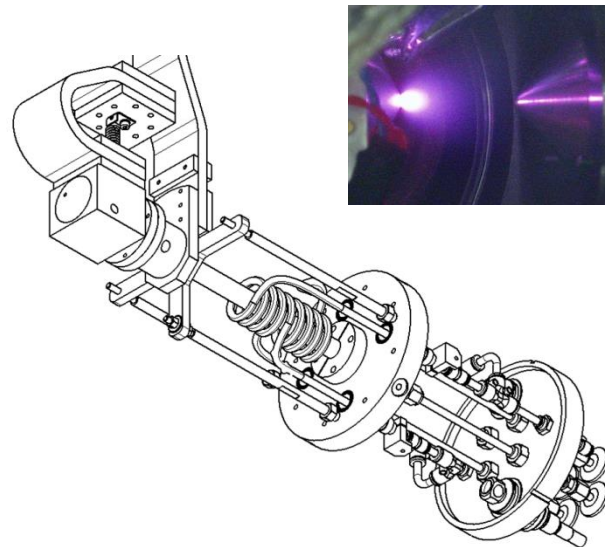
Cs transport

Cs ionization

Pulsed ABS development



- Optimized design for pulsed operation
- Improved performance:
 - doubles density for free atomic beam
 - better beam cooling
 - higher gas flux
 - up to 3 kW RF power



**Thank you for
your attention**