Operation of the Injector Cyclotron JULIC for the Cooler Synchrotron COSY/Jülich

- Facility overview
- Operation
- R&D details
  - Refurbishment activities
  - Ion source investigations
- Summary

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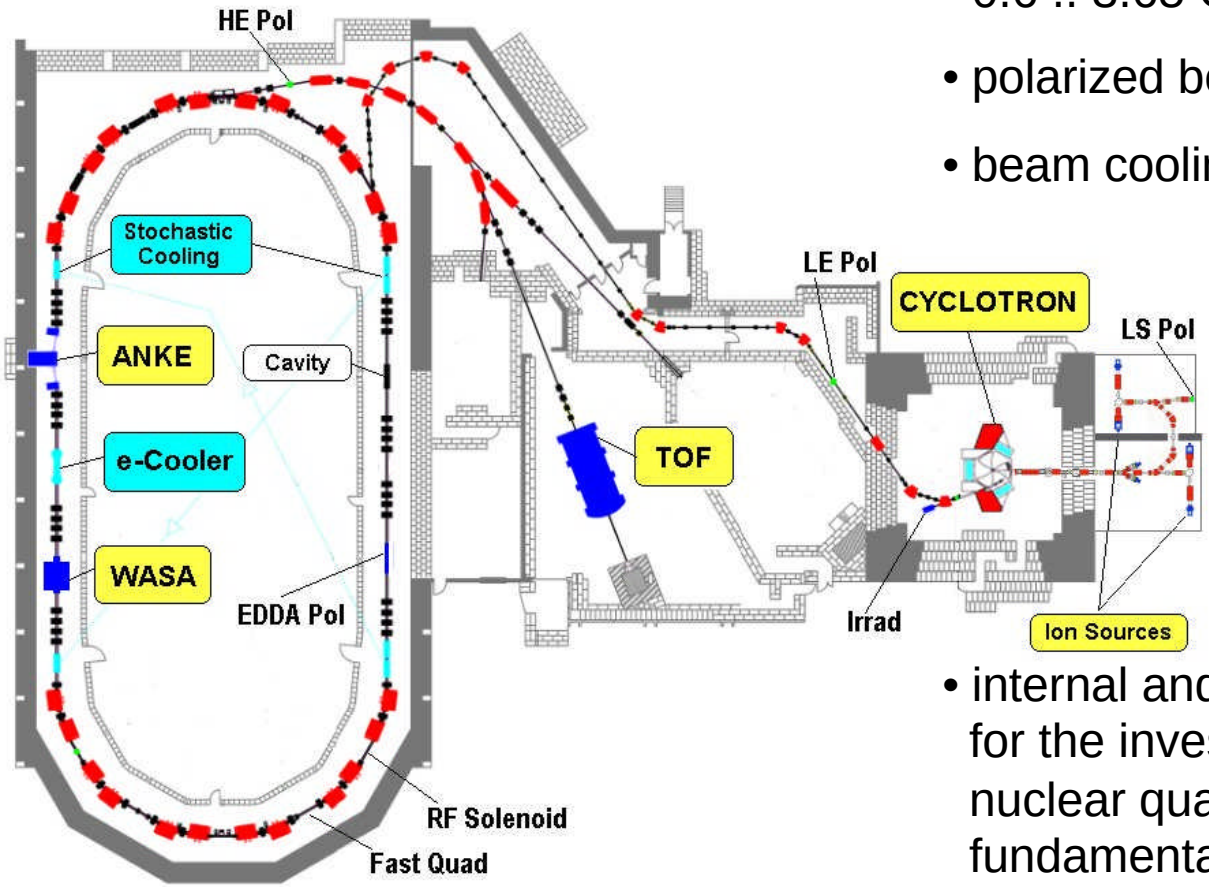
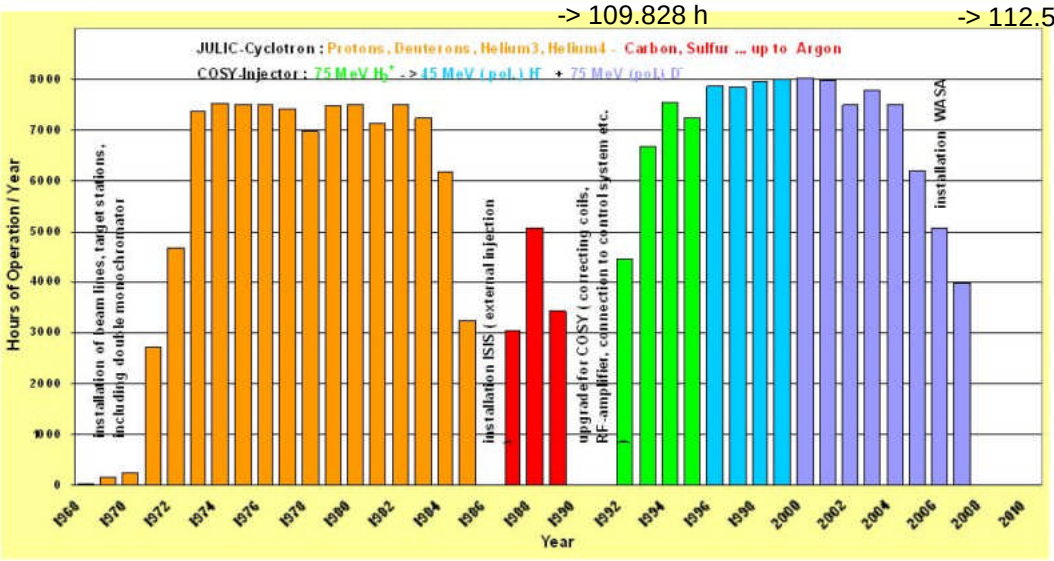
The COSY Facility

COoler SYnchrotron



- 0.6 .. 3.65 GeV/c p and d
- polarized beams
- beam cooling
- internal and external detectors for the investigation of nuclear quark structure and dynamics, fundamental symmetries and e.g. exotic mesons, rare decays

Cyclotron Operation

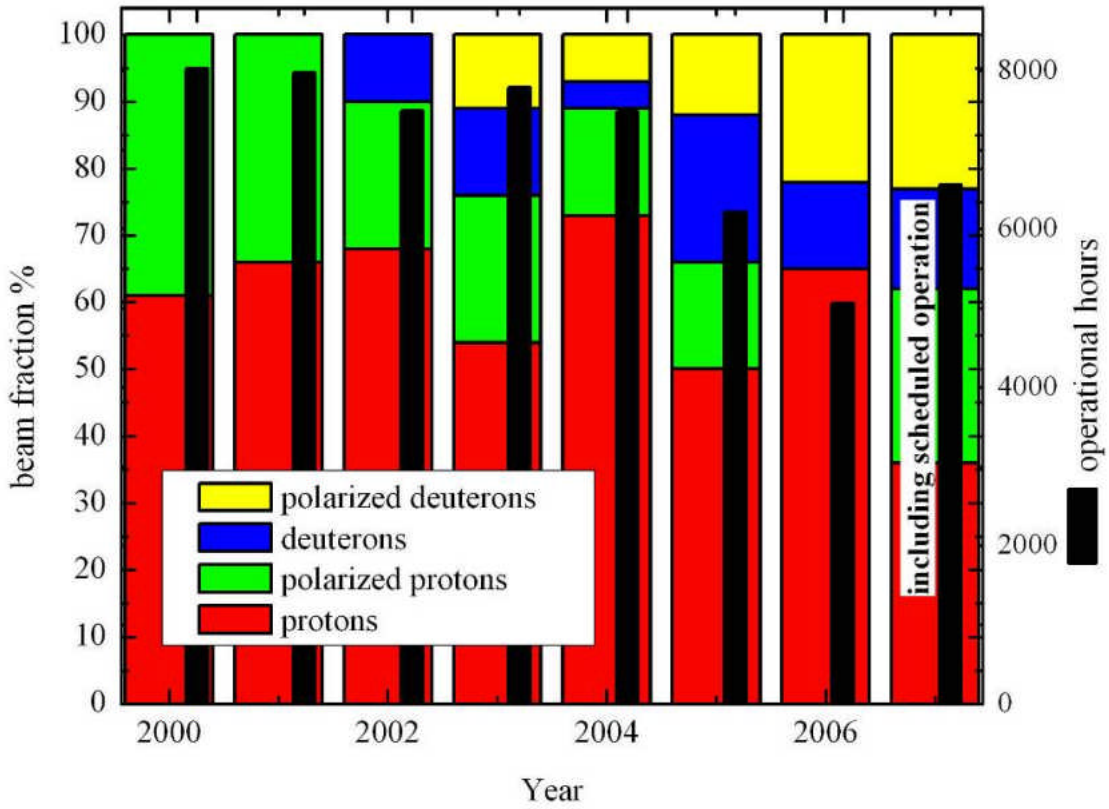


- Detector installation in 2005-2007 (WASA)
- Wear-out symptoms in 2004, 2006
  caused 400 to 500 hours additional downtime

- First deuterons 10.11.1967 - 40 years -
- Almost 222500 hours from commissioning in 1968
- Over 112500 hours as COSY injector
- Introduction of axial injection in 1986
- Positive light ions and heavy ions up to 45 MeV/ n
- Conversion in COSY injector during 90/91
- H_2^+ beams at 76 MeV until the end of 1995
- H^- and pol. H^- at 45 MeV since 1996
  using multicusp and colliding beams sources
- First D^- at 75 MeV in October 2000
- First pol. D^- delivered in 2003

Average availability in average about 93%

Light Ions for COSY



Increasing request for deuteron and polarized beams

Main issues:

- Operational reliability
- Higher (pol.) intensities

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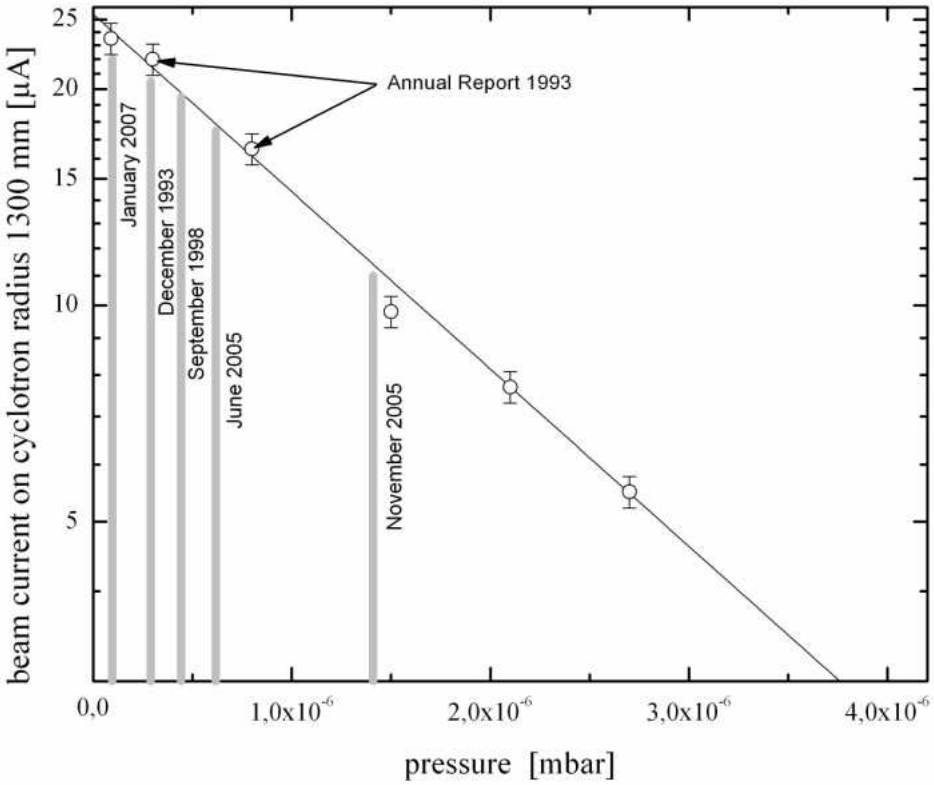
Refurbishment Activities

- Vacuum system
  - Upgrade of computer control /PCL
  - Oil free vacuum pumps
  - Extended leak search
- Magnetic lenses needed attention
- Exchange of aged power supplies
- Septum deflector
  - Pulsed operation
  - Spare parts and appropriate storage
- RF system
  - Air line tuner
  - Tuning capacitors
- …

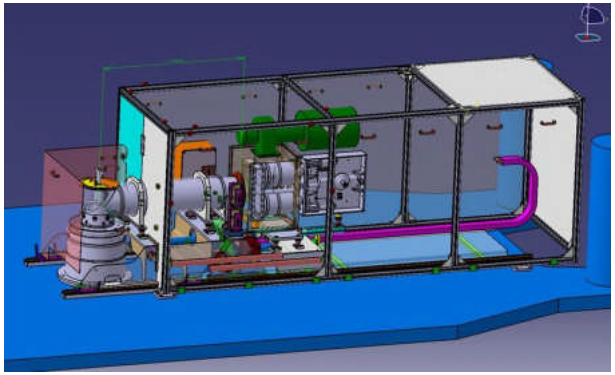
Vacuum Improvement



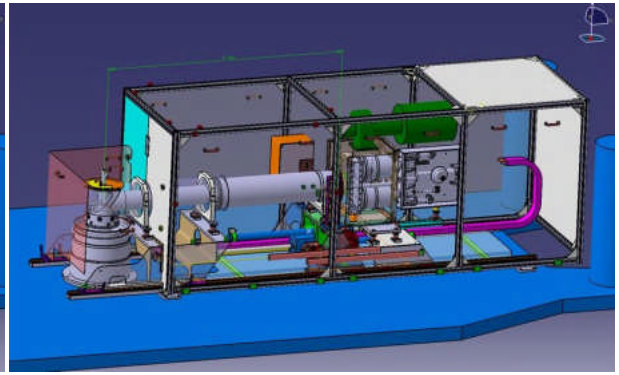
- Several seals got porous
- Welded seams with leak
- Performance of cryopumps low

RF System

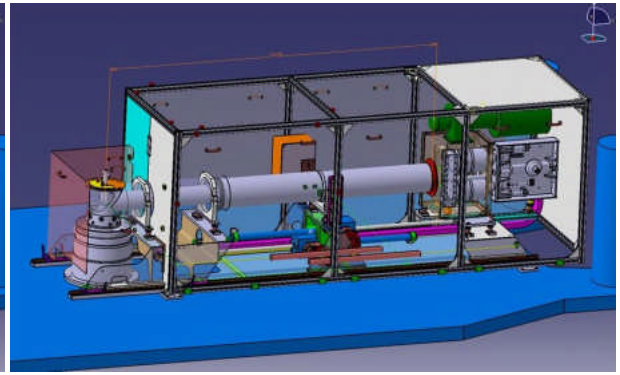
- water leaks of condensators in mid 2005 / replacement in winter 2005/6
- Blocking of air line tuner during routine check after 1st run period 2006
  - refurbish the tuning elements in the summer shutdown 2006
  - replace the carrier successfully in summer shutdown 2007



30 MHz

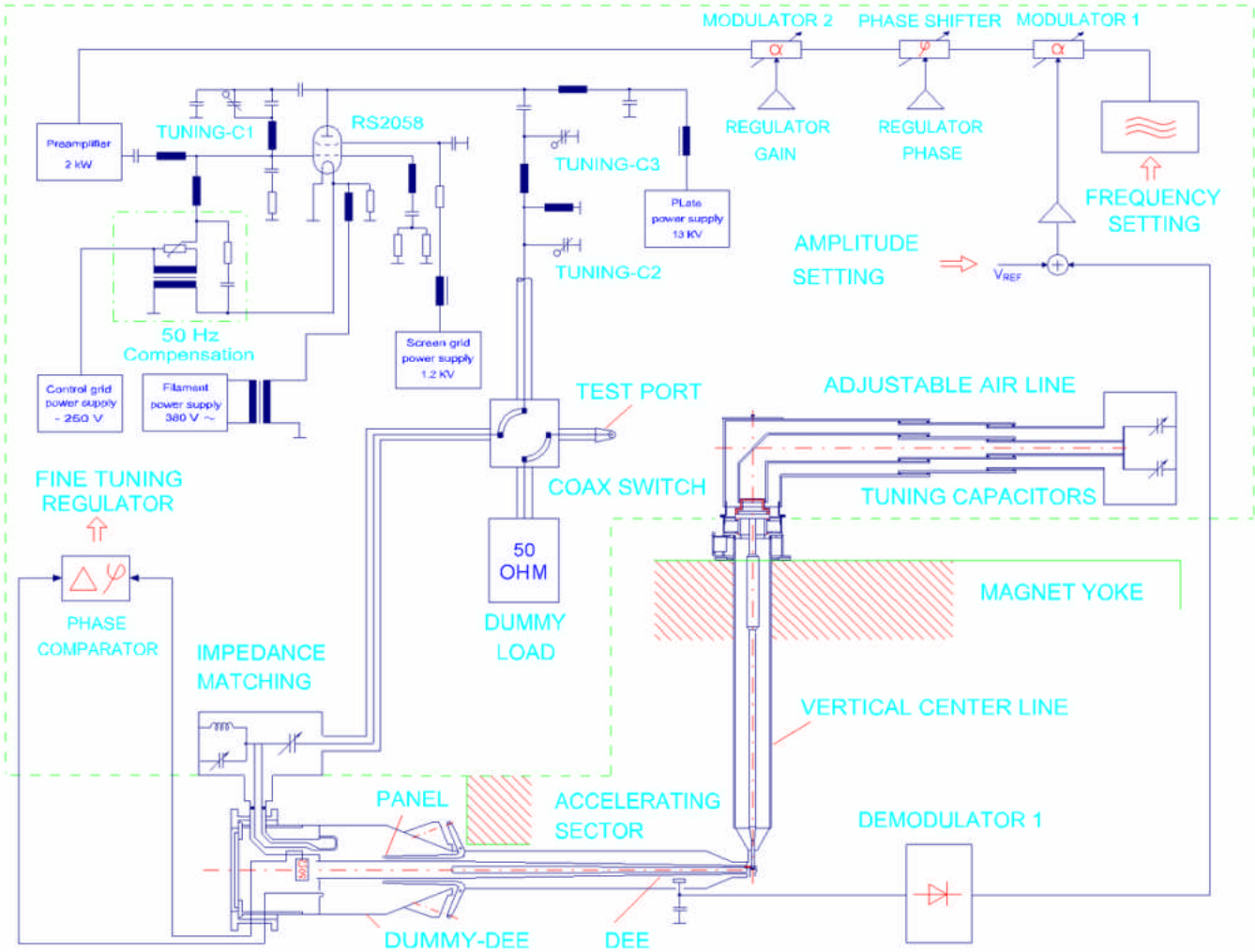


25 MHz



20 MHz

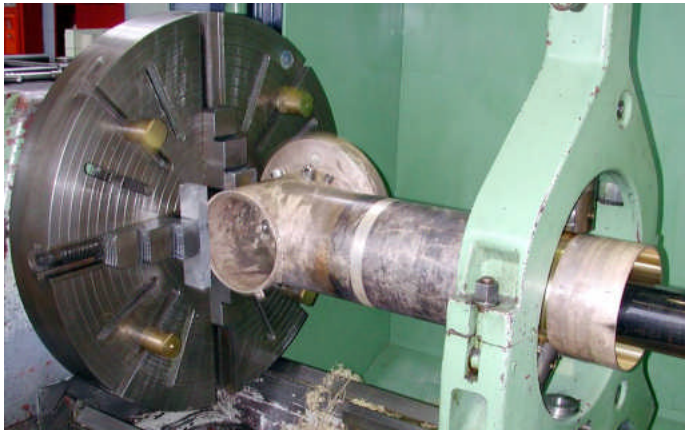
RF System – schematic view

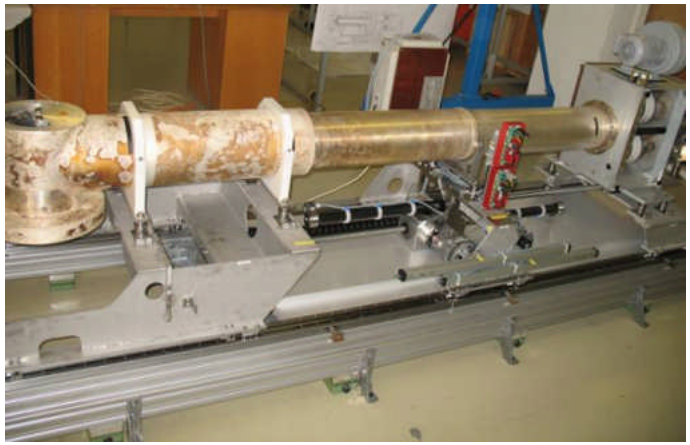


Contact Springs

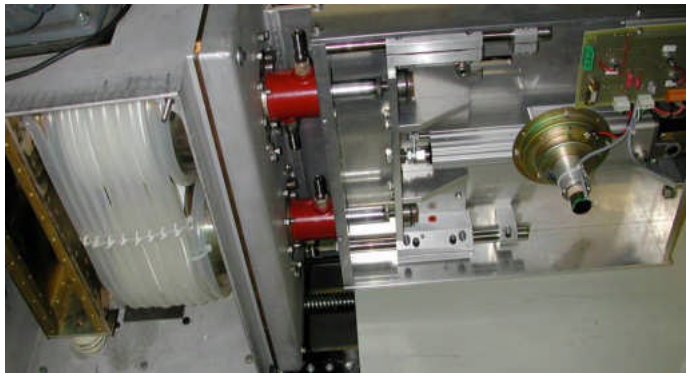
- Replacement of contact spring
- Refurbishment and partly exchange of tubes
  Improve the surfaces, silver plating

Details of Exchanged Parts





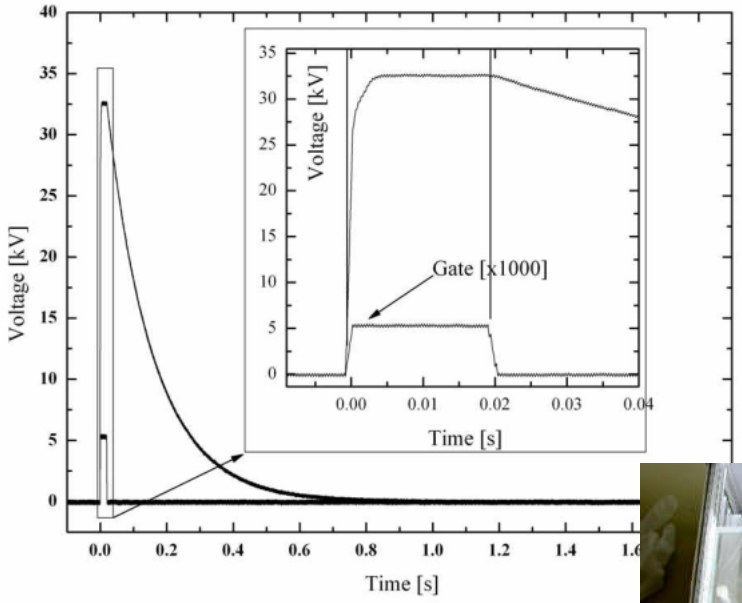
Line tuner



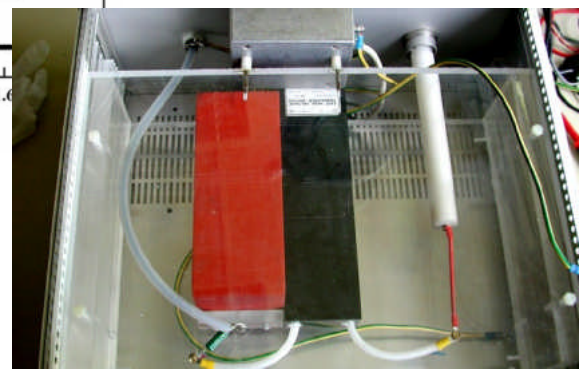
Capacitive tuning element

Pulsed Septum Operation

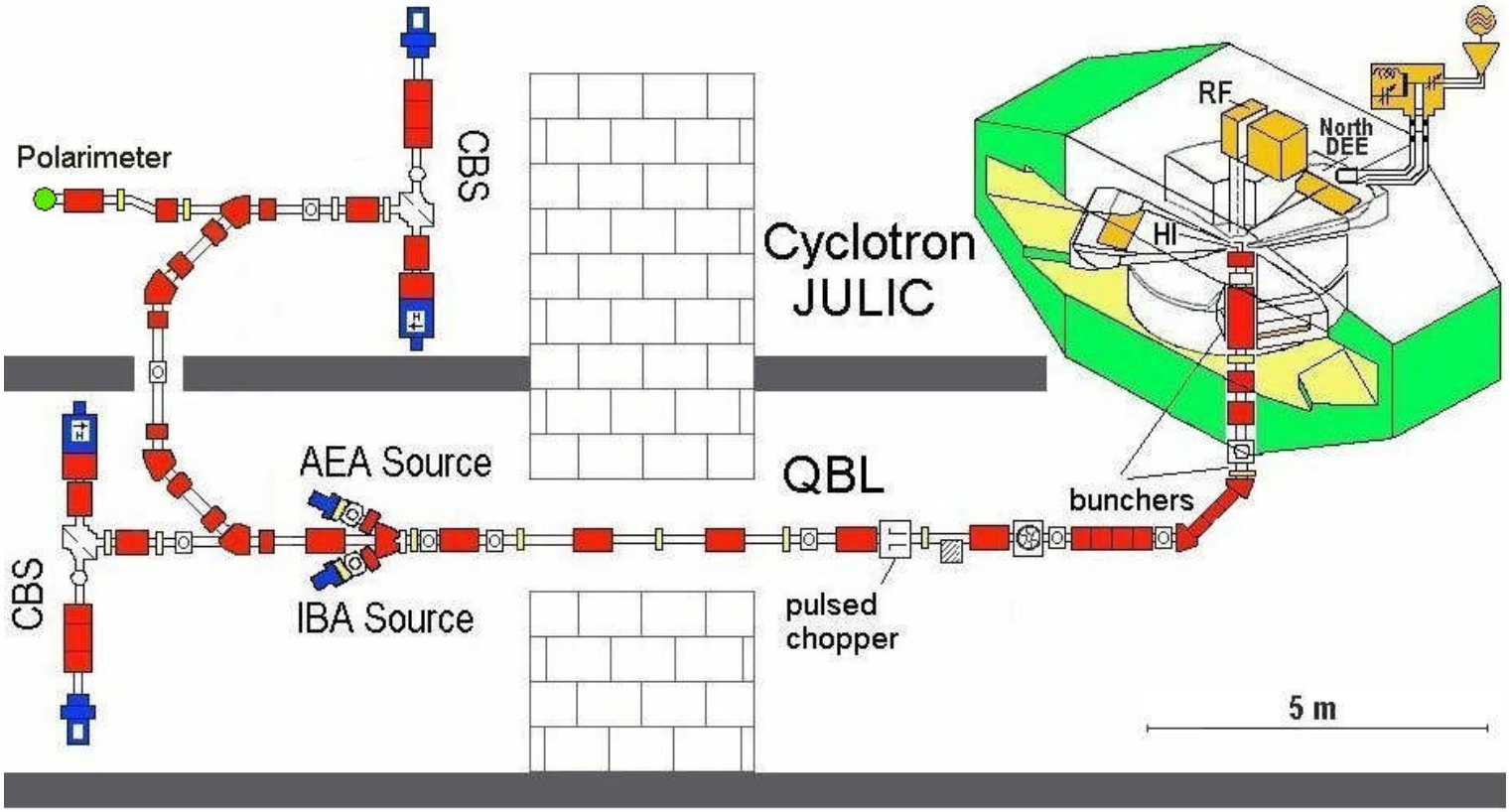
- Long term operation of the extraction septum
  - Extended to 2 1/2 years by pulsed operation



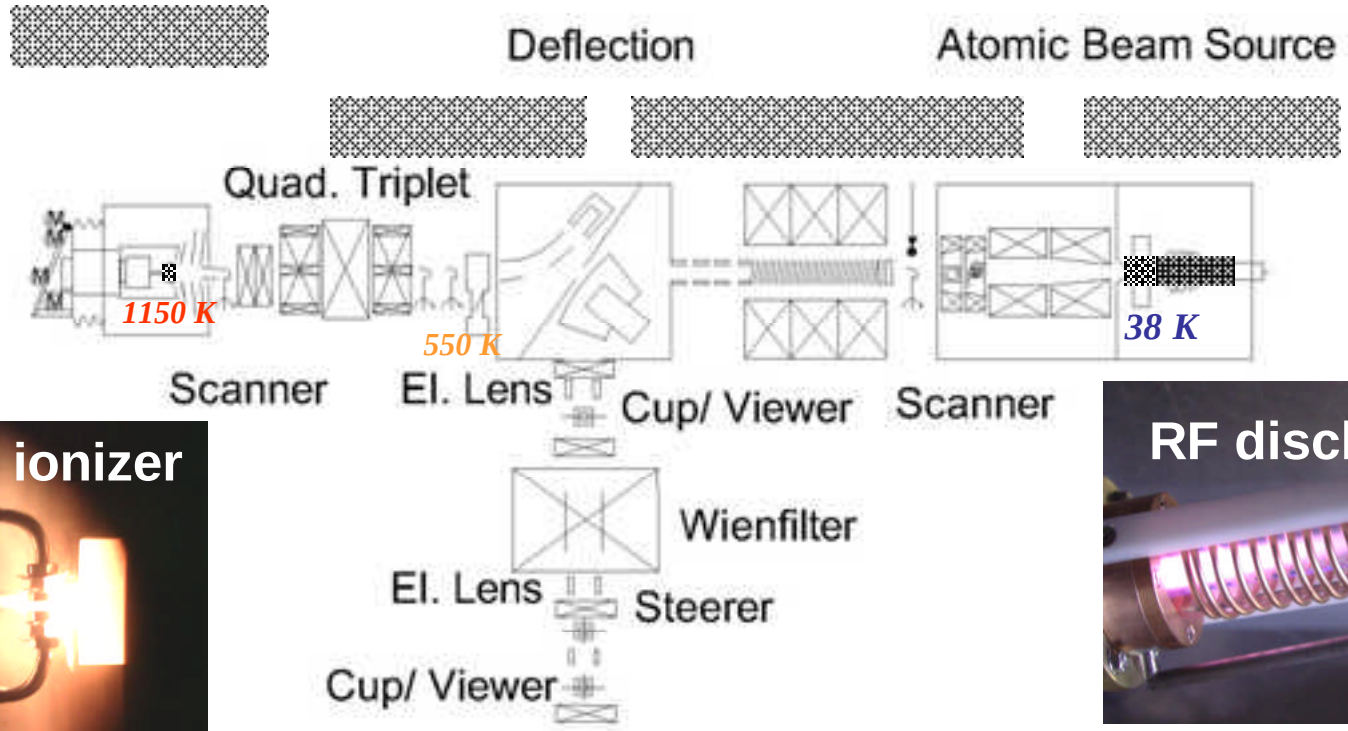
Voltage pulse shape recorded at the septum test stand before installation at the cyclotron.

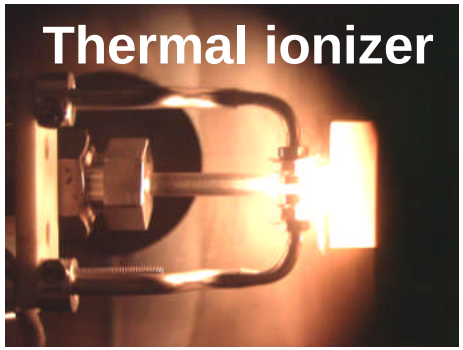


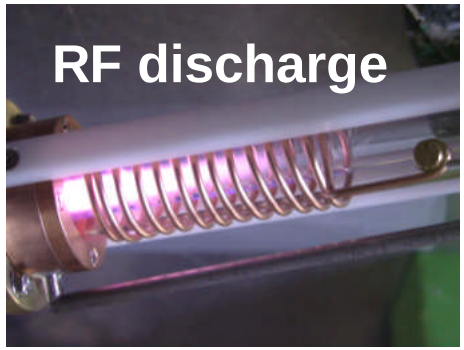
The COSY Injector



The Polarized Ion Source





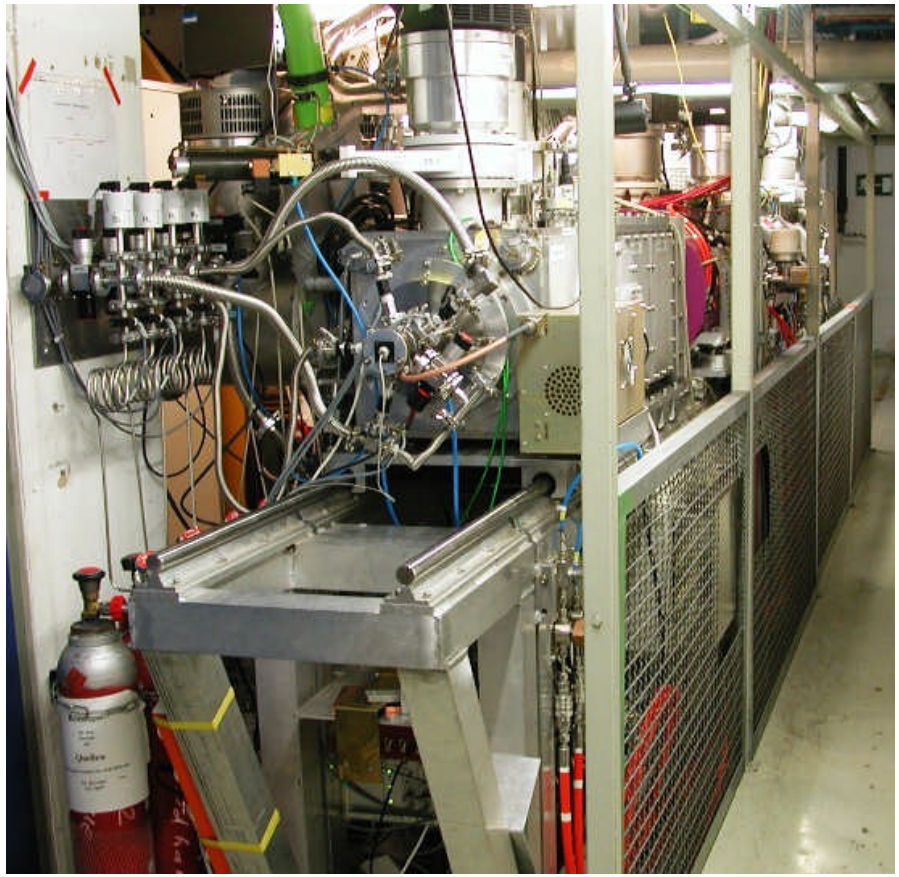


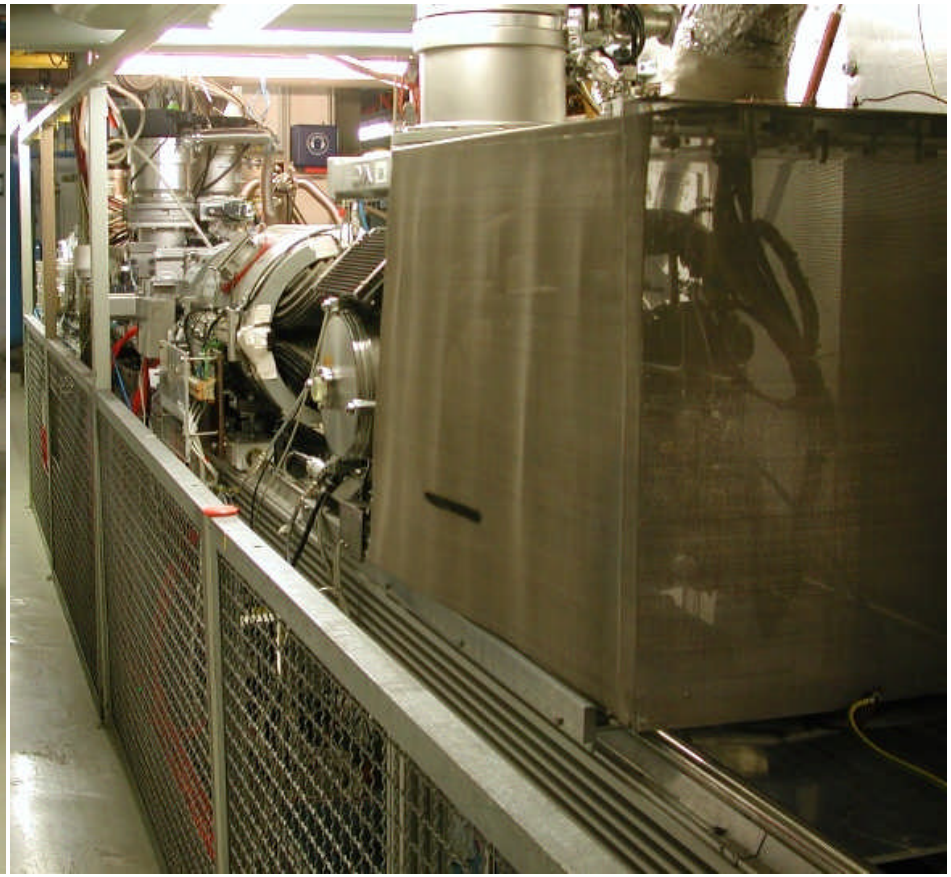
$$I_{H^-} = I_{H^0} \cdot \frac{L \cdot s}{A \cdot v} \cdot I_{Cs^0} = n_{H^0} \cdot L \cdot s \cdot I_{Cs^0}$$

Charge exchange reaction

$$\vec{H}^0(\vec{D}^0) + Cs^0 \rightarrow \vec{H}^-(\vec{D}^-) + Cs^+$$

Operational CBS



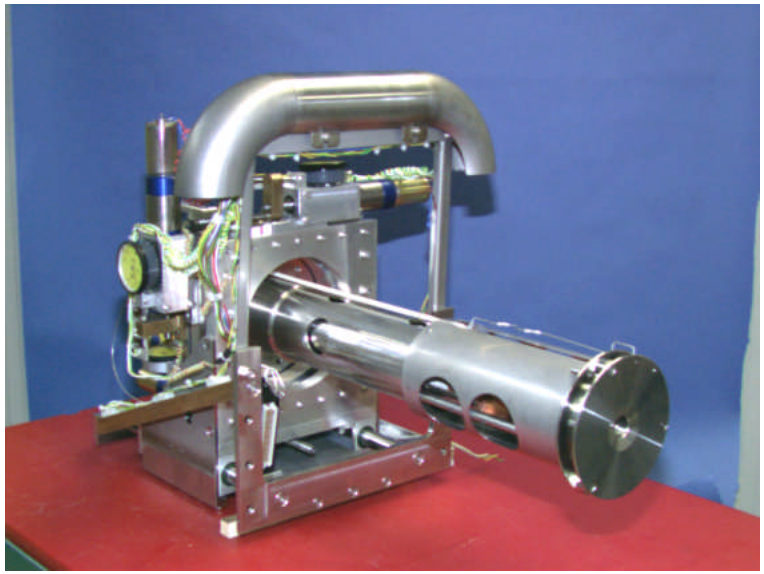


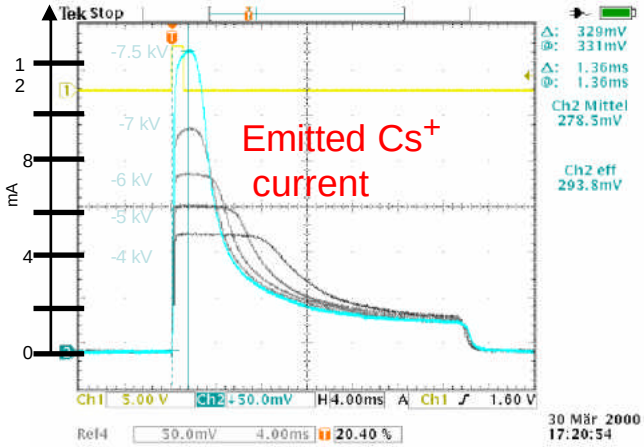
Developments at the Sources

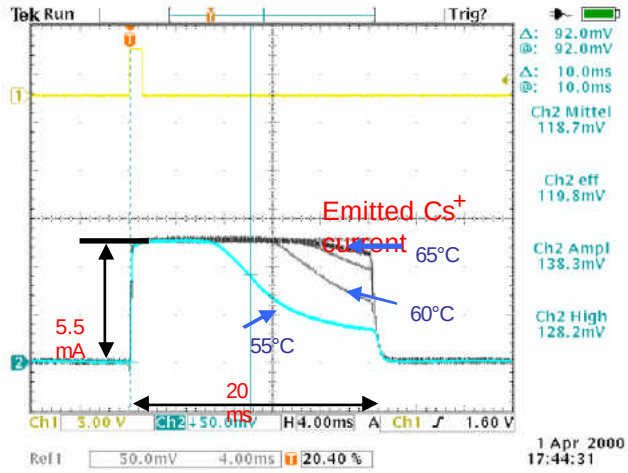
- Ionizer for intense pulsed Cs beams
- Dissociator Improvement
- Tuning of the extraction region
- Lambshift Polarimeter
- Delivery of sequences of deuteron polarization combinations (vector- and tensor polarization)
- Upgrade test bench to a 2nd source
- …

Development of Cs^+ Sources

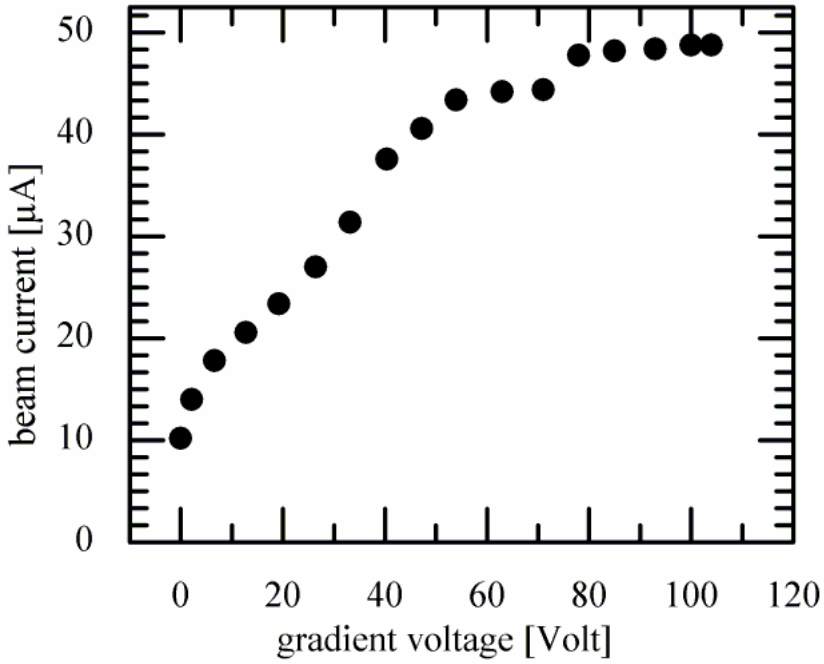
- dc and pulsed operation (0.5- 3 Hz)
- 6 mA routinely @ 45keV – 25 ms 0.5 Hz
- up to 1500 hours continuous operation for COSY and experiments
- 3 sources for exchange

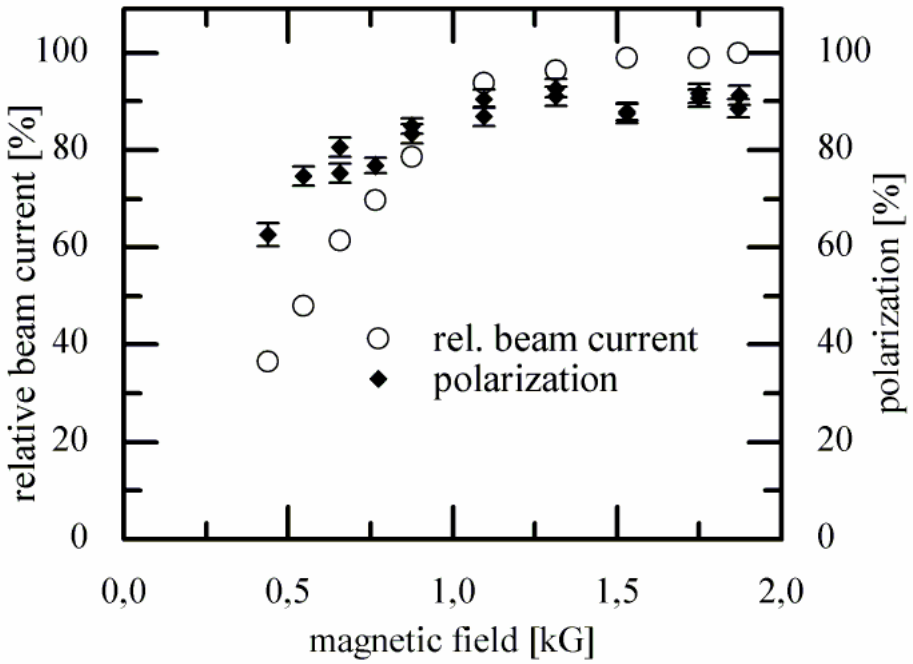




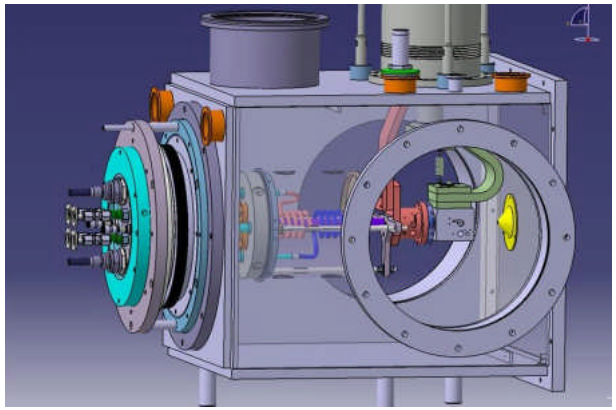


Extraction of Polarized Beam

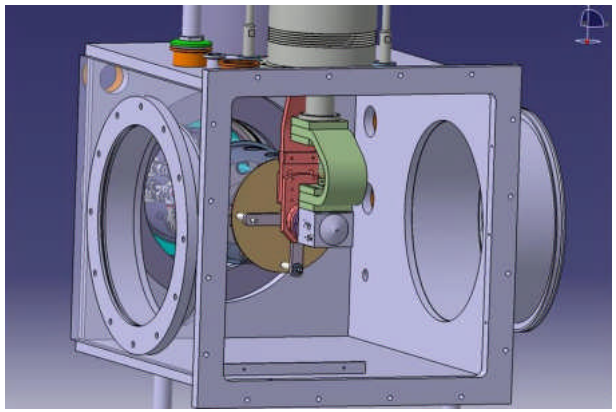


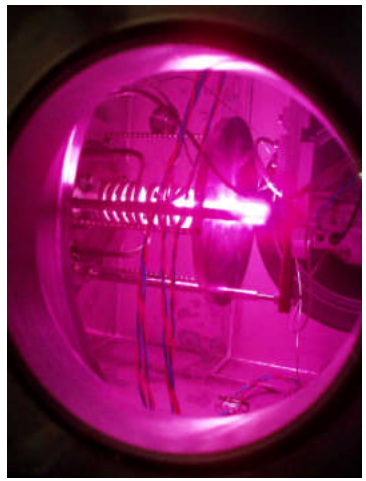


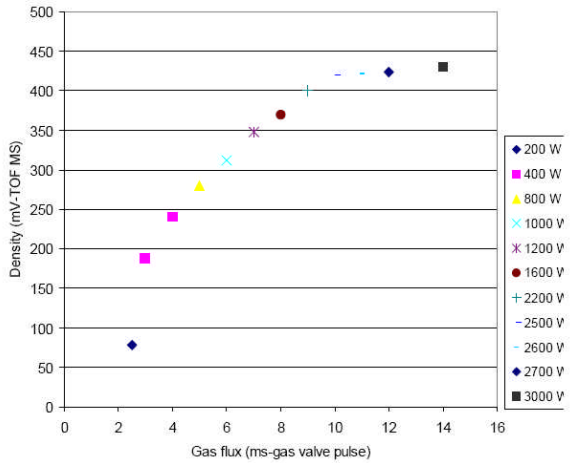
Dissociator Development



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







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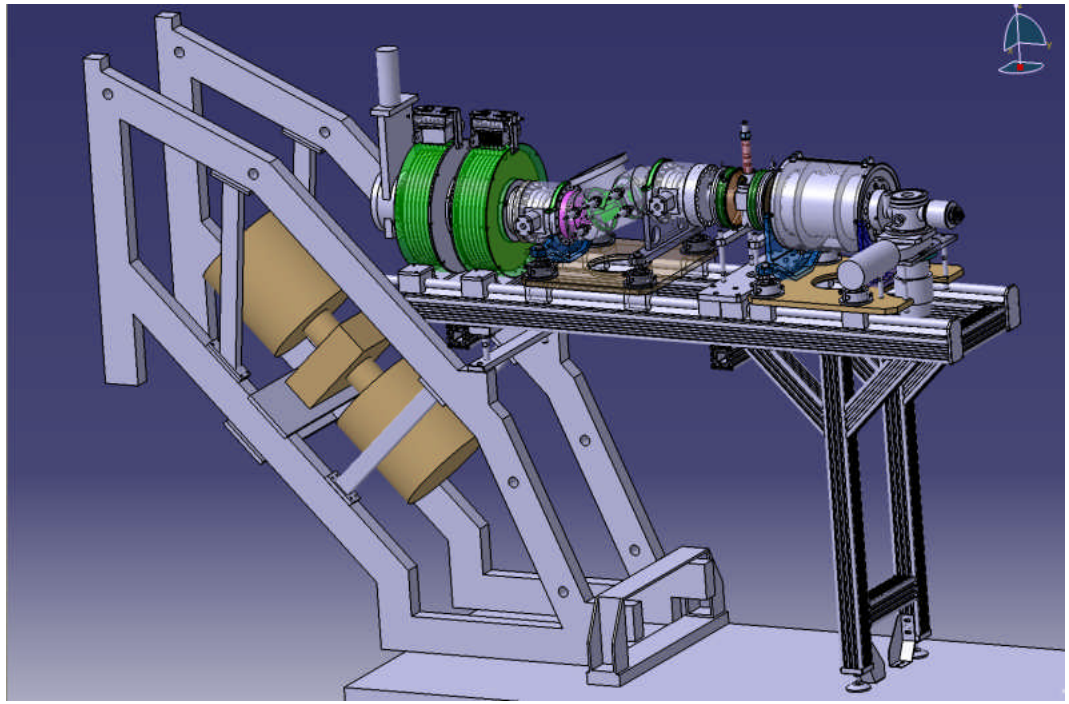
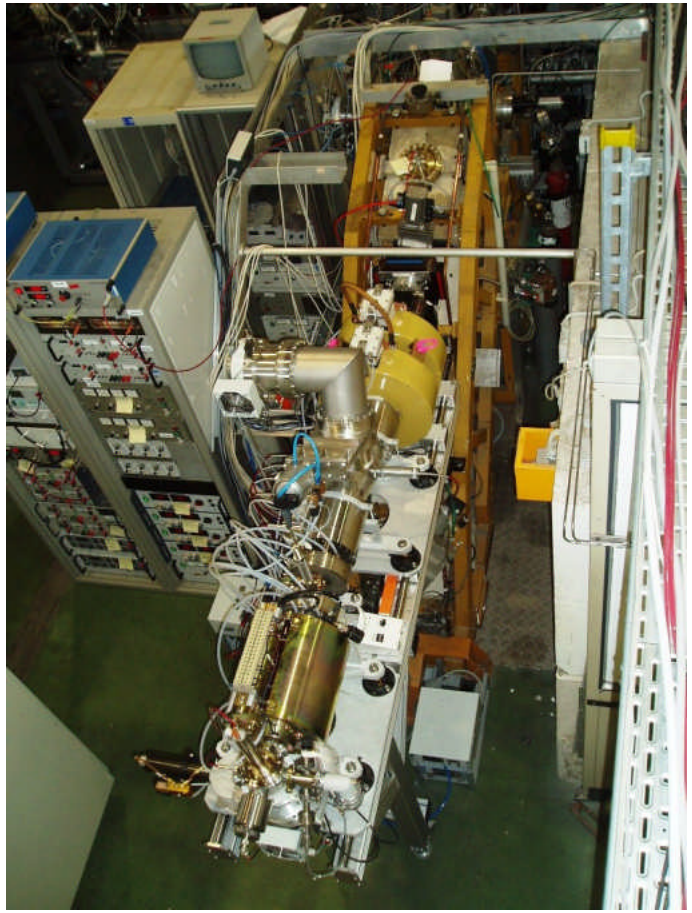
Lambshift Polarimeter





- **High sensitivity**
- **Tuning polarization without cyclotron**

Ready for first beam!

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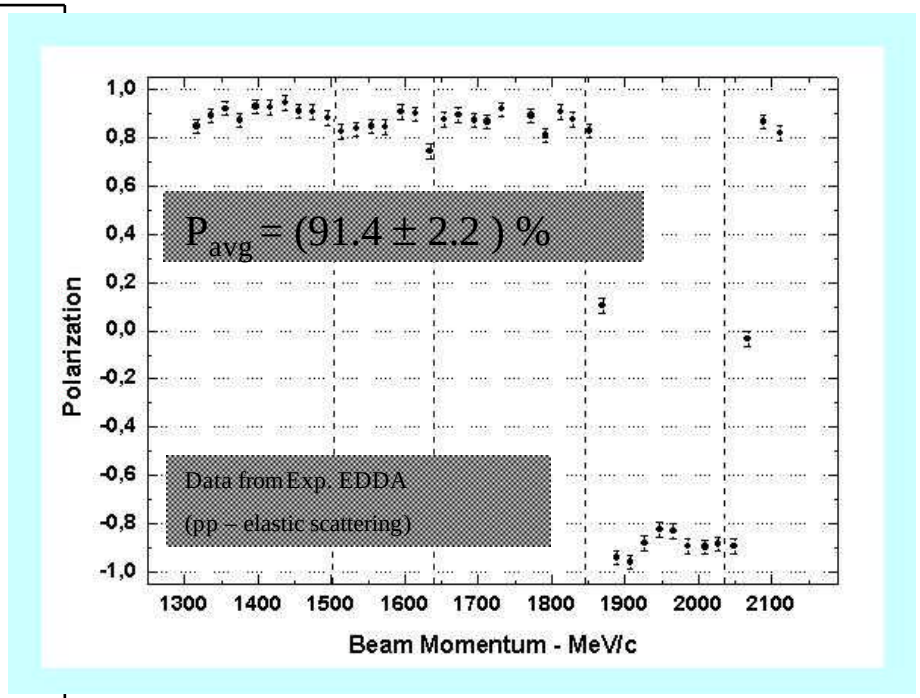
Summary: Intensity and Polarization

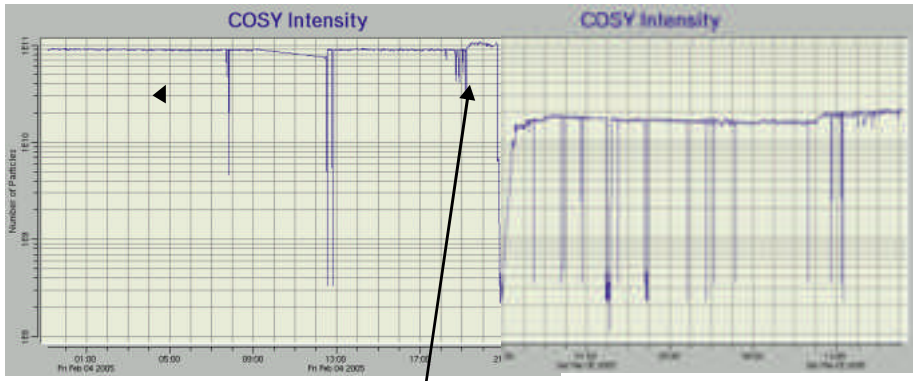
Beam current at the source exit



Polarization inside COSY

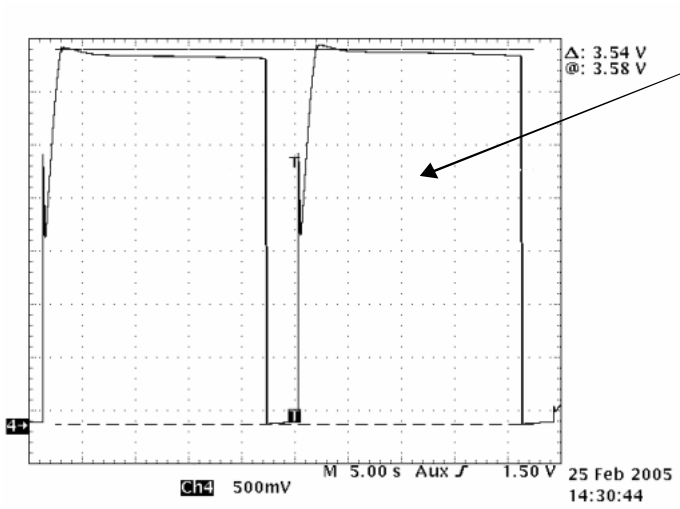
Summary: Beam in COSY

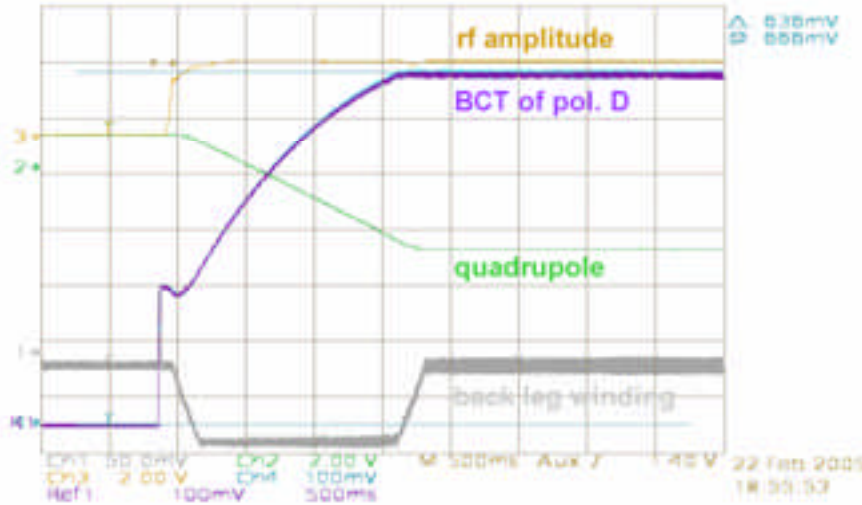
- injector availability > 93 %
- increased source performance
- matching of beams to COSY
- best values for COSY:
  35 mA unpol. D and 6 mA pol. D



unpolarized deuterons

switching to polarized deuterons





Thank you for your attention

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