Target development for

for EXL / SPARC

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Collaboration: GSI, University of Frankfurt, Uppsala

- **Status of R&D of the Target WG**

  H_2 target
  He target
  target chamber for ESR

- **Experiments Planned at the ESR for 2006/2007**

- **Target area at the NESR**

Target Requirements for Experiments at NESR

Planned Modifications Compared to the ESR Target

- **Density increase by an order of magnitude for H_2 and He (10^{13} to 10^{14} P/cm^2)**
  lower temperatures (20 K) for gas and nozzle cooling

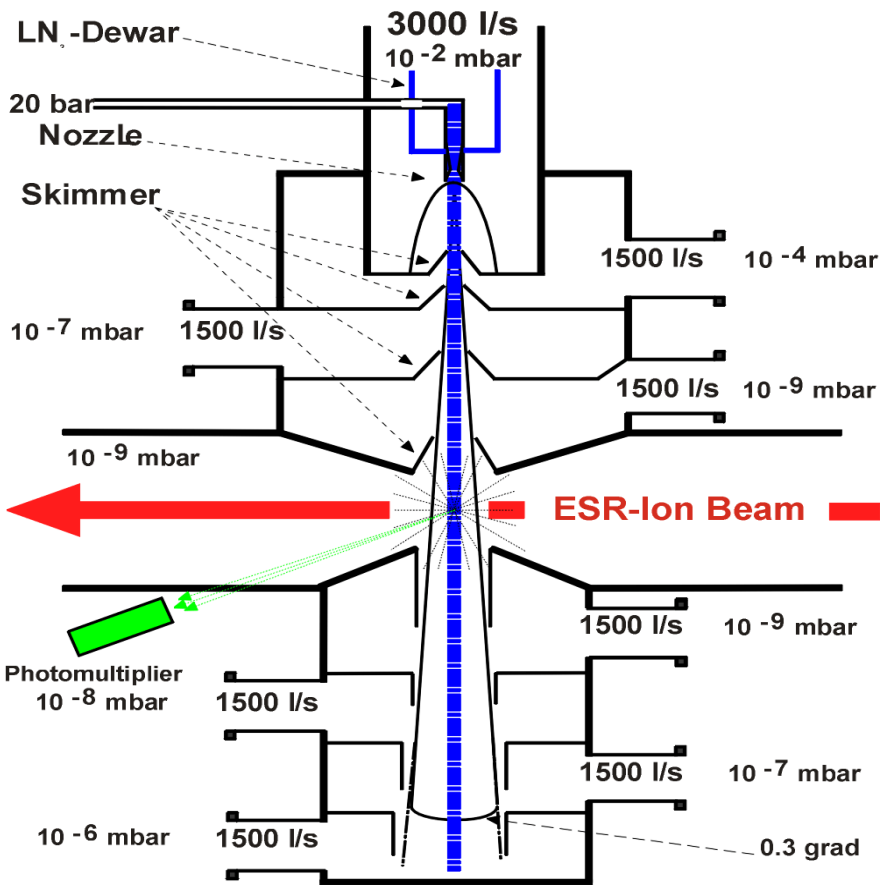
  higher luminosities for low-Z targets

- **Variable/smaller jet-beam diameter (5mm to 1mm)**
  modification of the skimmer geometry

R&D work will be performed at Uppsala until end of 2006
Parts of the Uppsala target will be moved to GSI 2006

The Jet-Target

Supersonic jet, operates in ultra high vacuum environment (10^{-11} mbar)



Target densities

10^{12} – 10^{14} p/cm^3

Single collision conditions

ESR/NESR Target

Reduce jet size to 5-1 mm, but 10^{14} – 10^{15} at/cm^2

Is this realistic?

12 mm ➔ 1 mm jet ➔ ~ 10^{13} at/cm^2

TSL tests

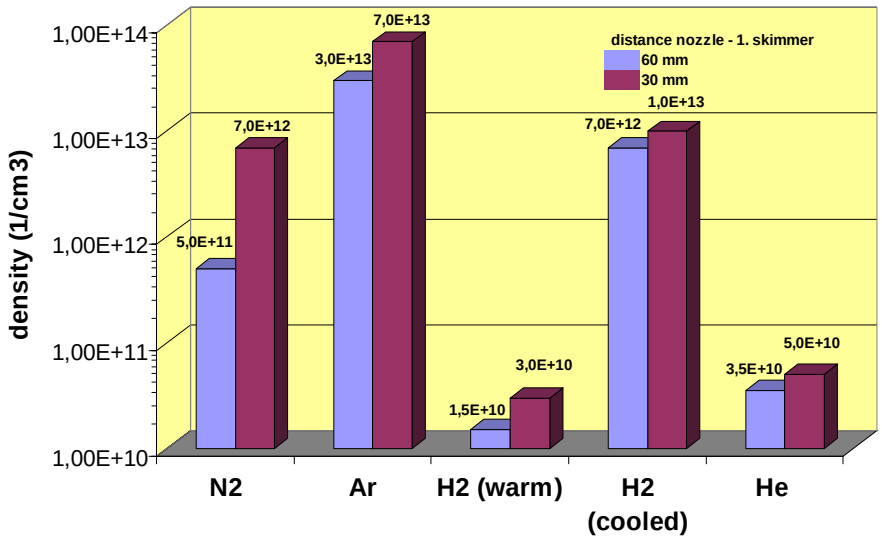
Modification of skimmer geometry

Smaller nozzle, higher pressure

Problem with He cluster formation

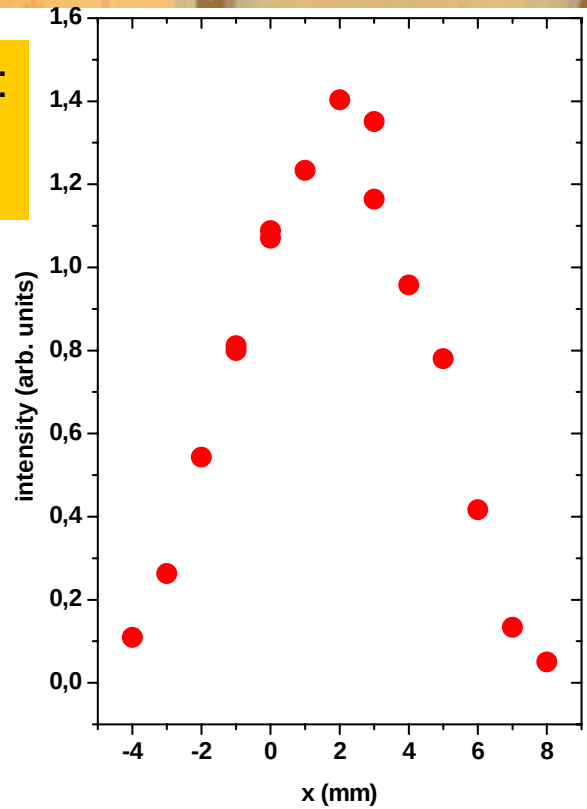
Frankfurt Uni. development of superfluid He liquid jet target for PANDA.

Target Densities and Profile (Status ESR May 2005)



Target profile:

FWHM: 5 mm



by cooling to LN2 temperatures a density increase from ≈10^{10} p/cm^3 to ≈10^{13} p/cm^3 has been achieved for H_2

May 2005: Stable operation of the H2 cluster target achieved

Near Future (December 2005):

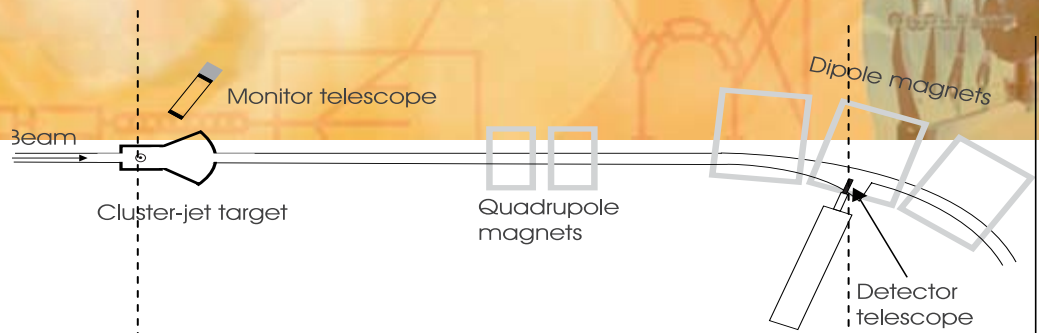
50 µm nozzle ?

two weeks of operation for nuclear physics experiments

The CELSIUS cluster-jet target with helium

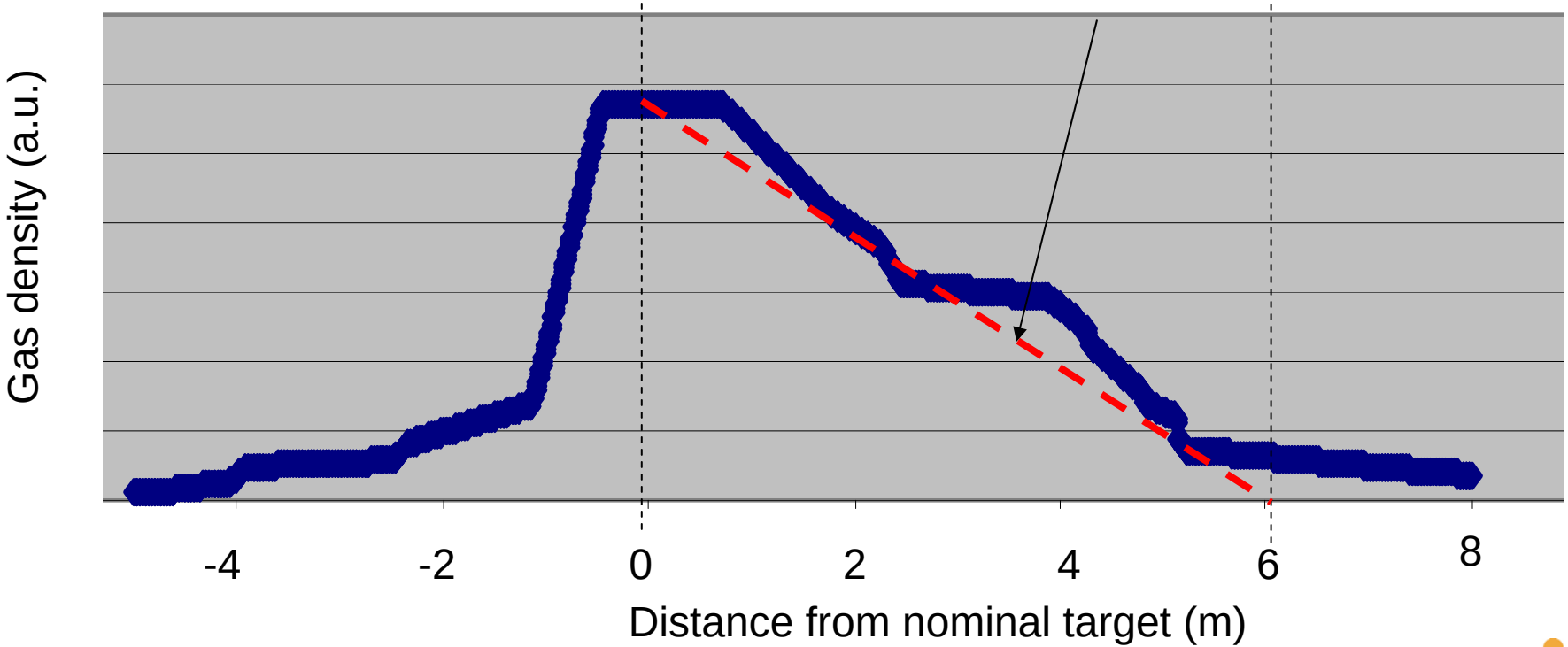
Reactions studied: $d + {}^4He \rightarrow {}^6He + \pi^+$ and $ {}^3He + {}^3He \rightarrow {}^6Li + \pi^-$

Helium gas (^3He and ^4He) does not cluster



Calculation of gas density with VACTRAC (V. Ziemann, TSL)

Fit to measured ^{3}He data



Alternative He-target: Liquid Micro-Jet Targets

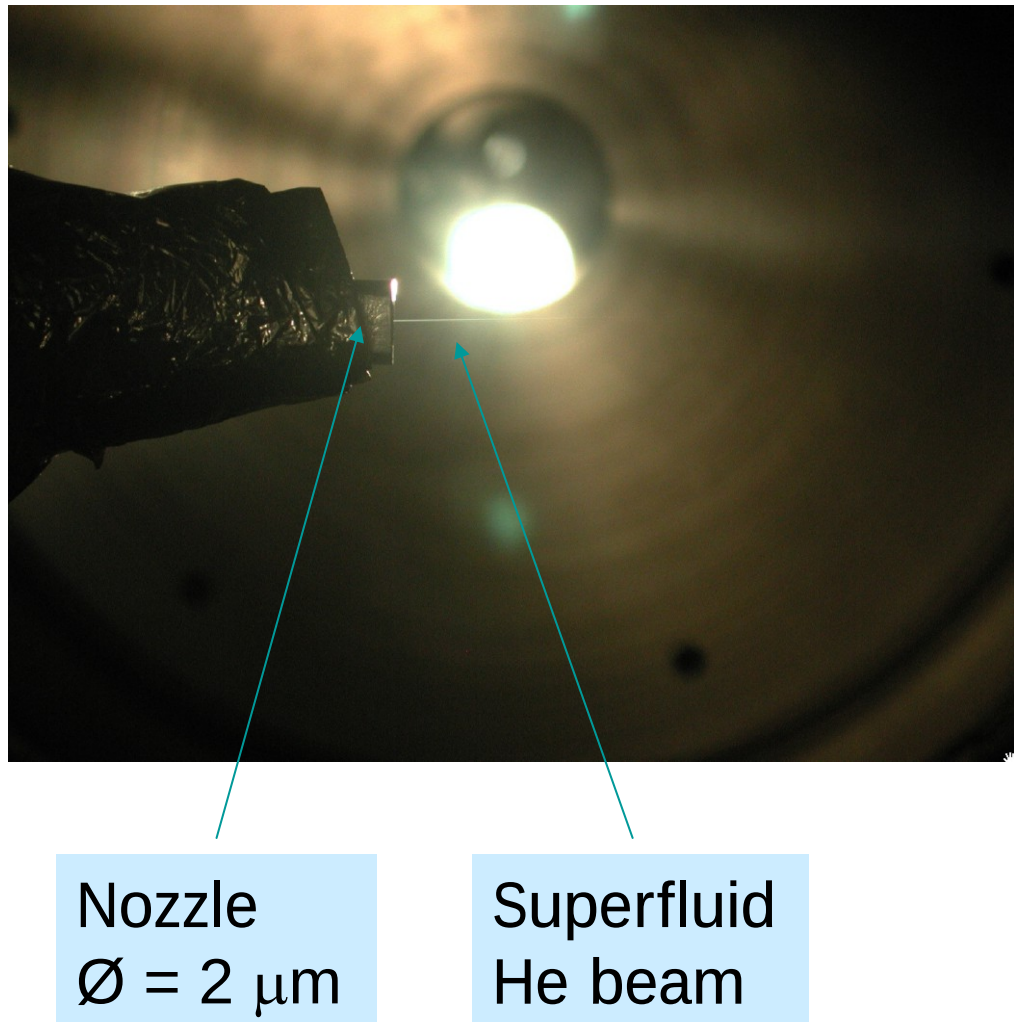
Detailed studies on superfluid helium beams at Frankfurt

Typical parameters:

p_{nozzle} = 3 - 5 bar

T_{nozzle} = 1.5 - 2.5 K

Investigation of the beam geometry and vacuum conditions at a distance of ~ 2 m is in preparation

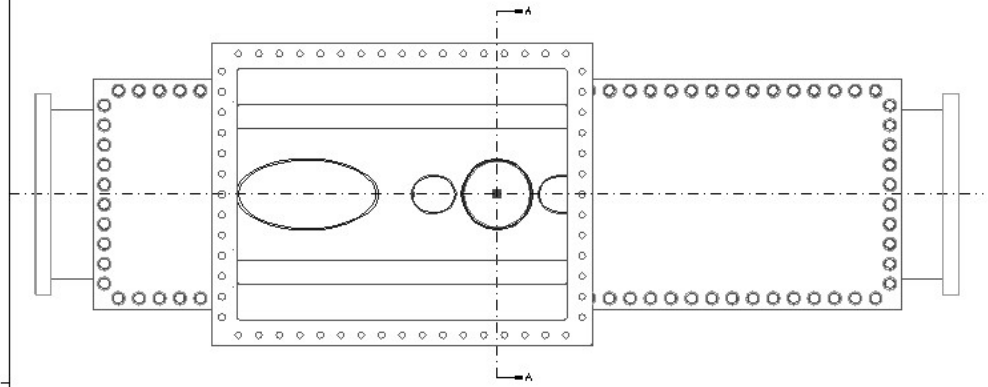


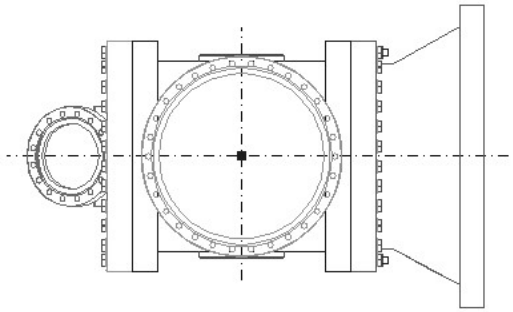
New Target Chamber Concept

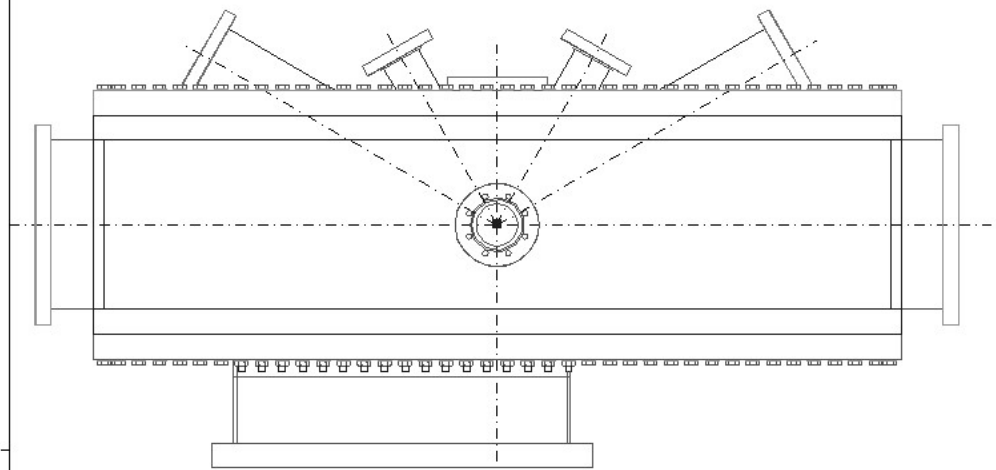
proposal for an new target chamber design for the ESR (L. Westerberg)

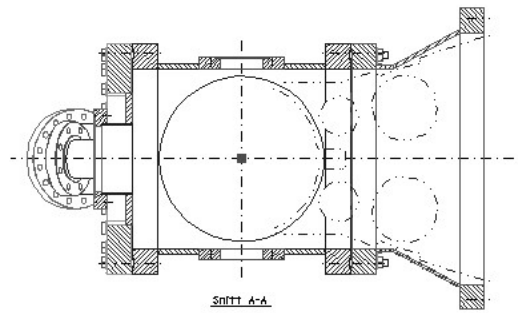
this concept will fulfill the overall vacuum requirements at the ESR

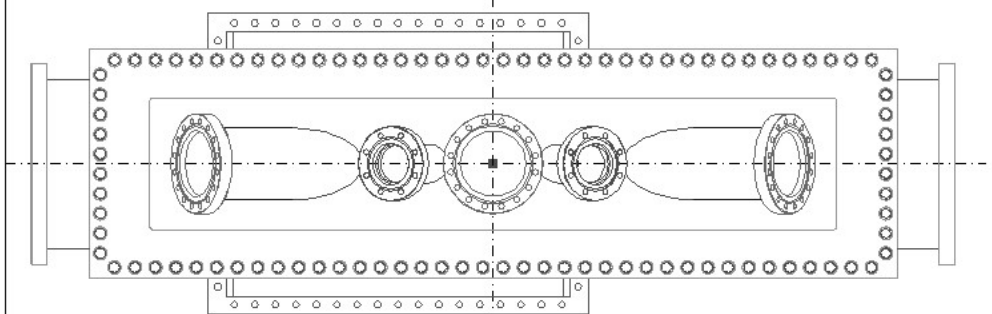
Vacuum conditions required ≈10^{-11} mbar

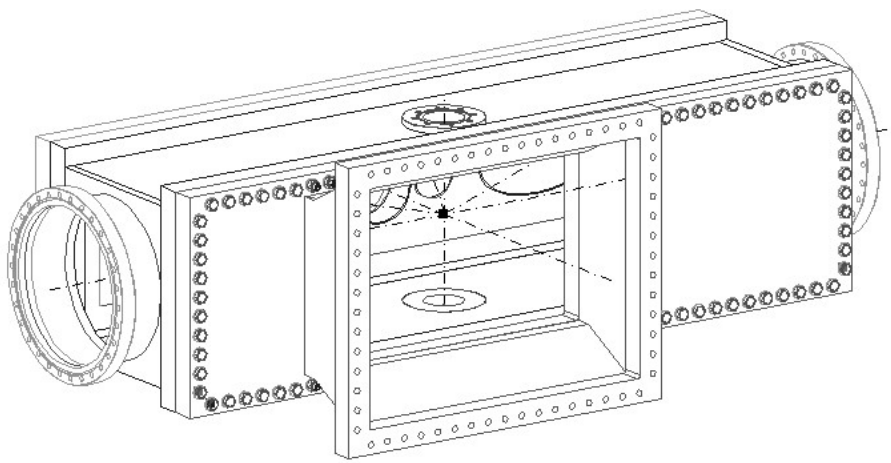




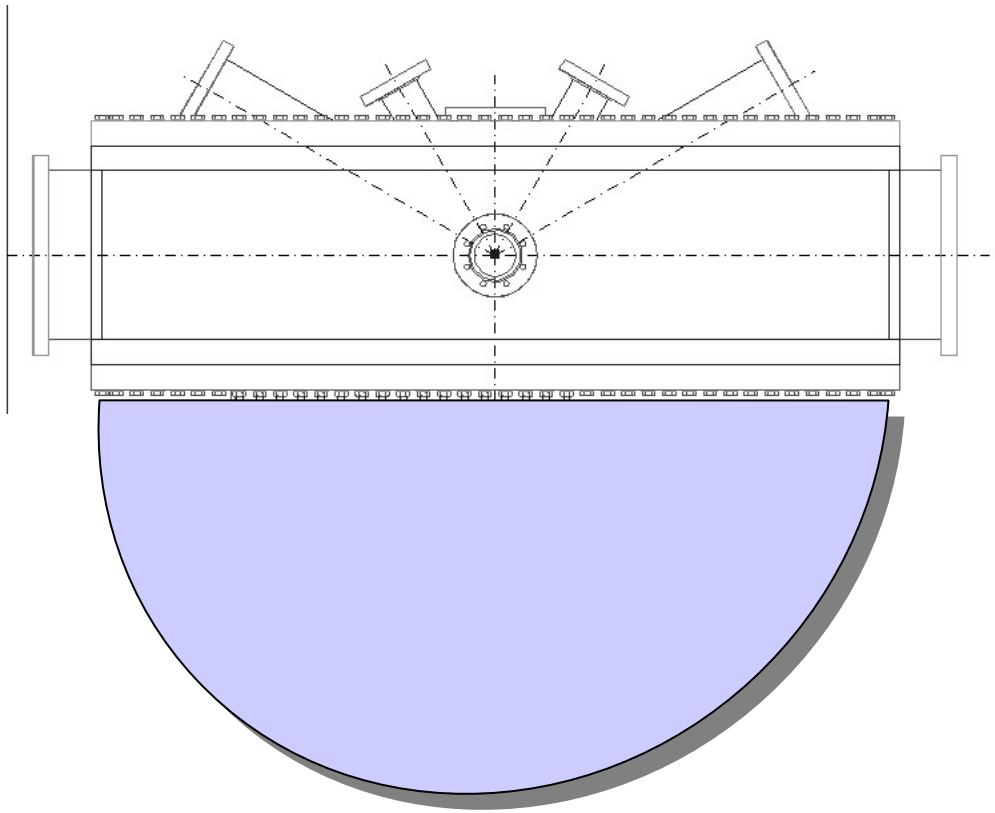








TSL



Timeline 2005/2006

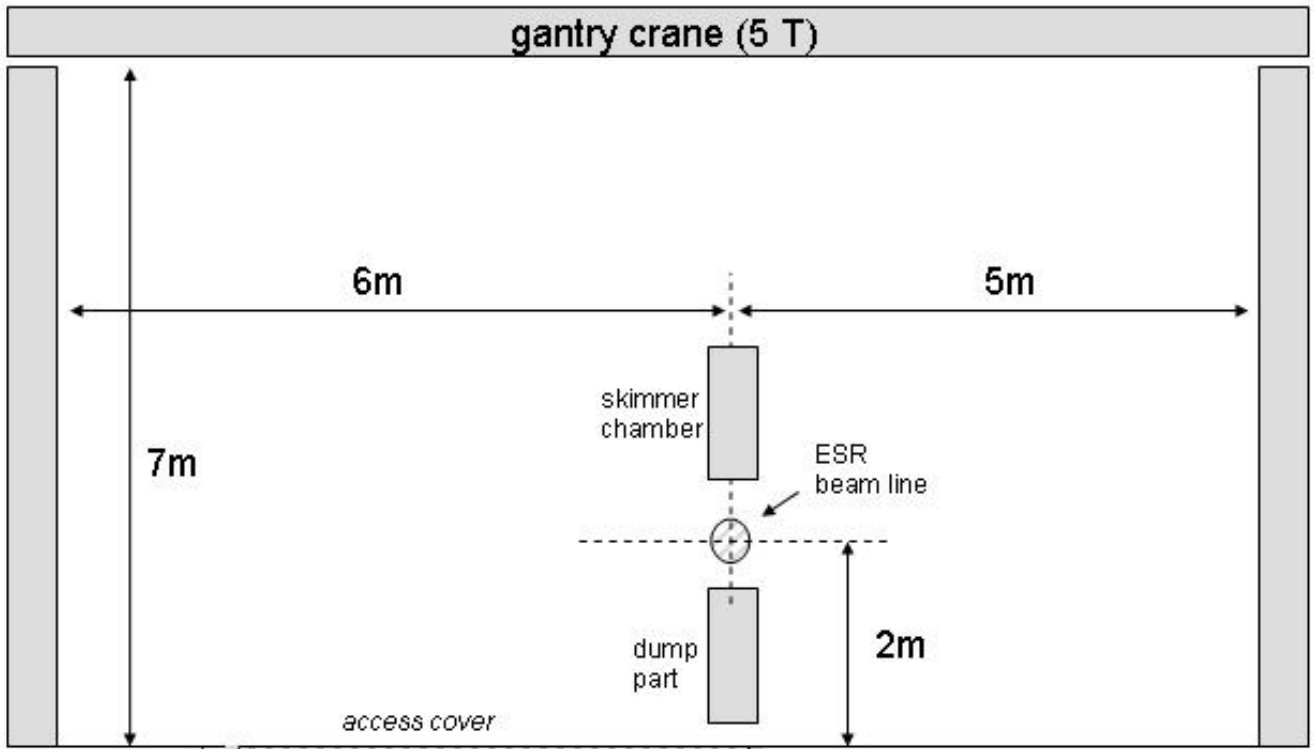
- **experiments are already getting scheduled for 2006 / 2007**
- **we have to agree *now* on a target chamber concept for EXL at the ESR**
- **Design studies and construction work is needed**
- **Target chamber should be available middle/end 2006**
- **Adaption of the parts from the Uppsala target to the ESR target (design work, workshop capacity)**
- **Installation: there must be a request for a time slot for the installation at the ESR for end 2006/ beginning 2007**

Unitil now, there are no resources available for target developments

Time-Line

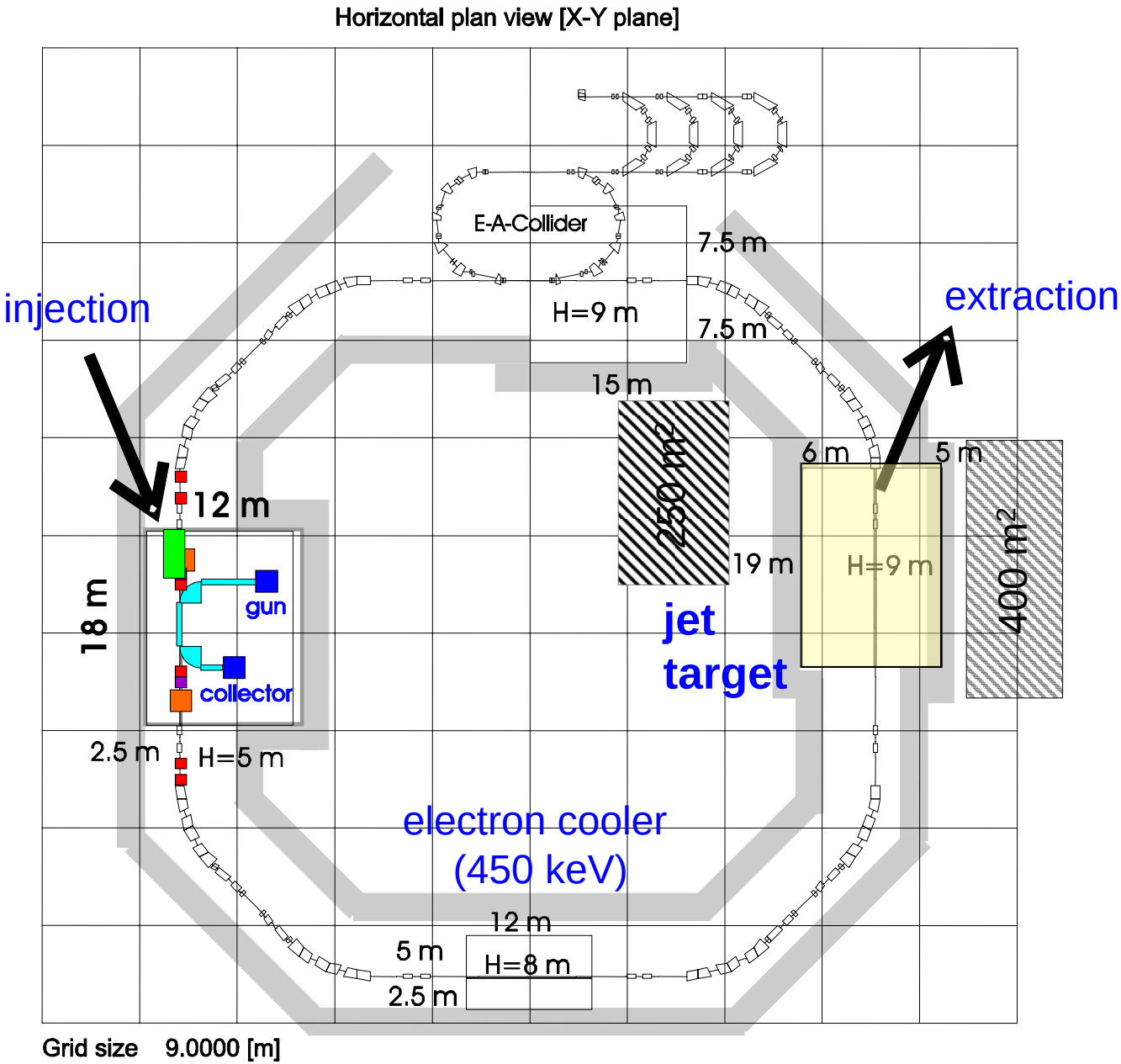
Task	2005				2006				2007			
Skimmer geometry												
Adaptation to GSI												
EXL tests at ESR												
Design of target station												
design of support structure NESR												
design of target chambers NESR												
Reaction Microscope												
HITRAP												

Floor Space Considerations



distance between beam pipe and the outer NESR concrete wall: 5 m
distance between beam pipe and the inner NESR concrete wall: 6 m
length of the experimental area: 19 m
height experimental area: 7 m

NESR


Horizontal plan view [X-Y plane]
E-A-Collider
7.5 m
H=9 m
7.5 m
injection
extraction
15 m
250 m²
6 m
5 m
12 m
19 m
H=9 m
400 m²
18 m
gun
collector
jet
target
2.5 m
H=5 m
electron cooler
(450 keV)
12 m
5 m
H=8 m
2.5 m
Grid size 9.0000 [m]

Annex Facilities needed for experiments at the NESR

Workspace for experiment preparation	400 m^2
Floor space for experiment electronics and controls	250 m^2
Clean room	20 m^2
Laser laboratory	50 m^2
Storage space for equipment and workshops	200 m^2

All annex facilities will be shared with the EXL collaboration

SPARC

STATUS: SPARC Collaborations 2004/2005

March 2004: LoI submitted and 'green light' for Technical Proposal (TP) by PAC of STI

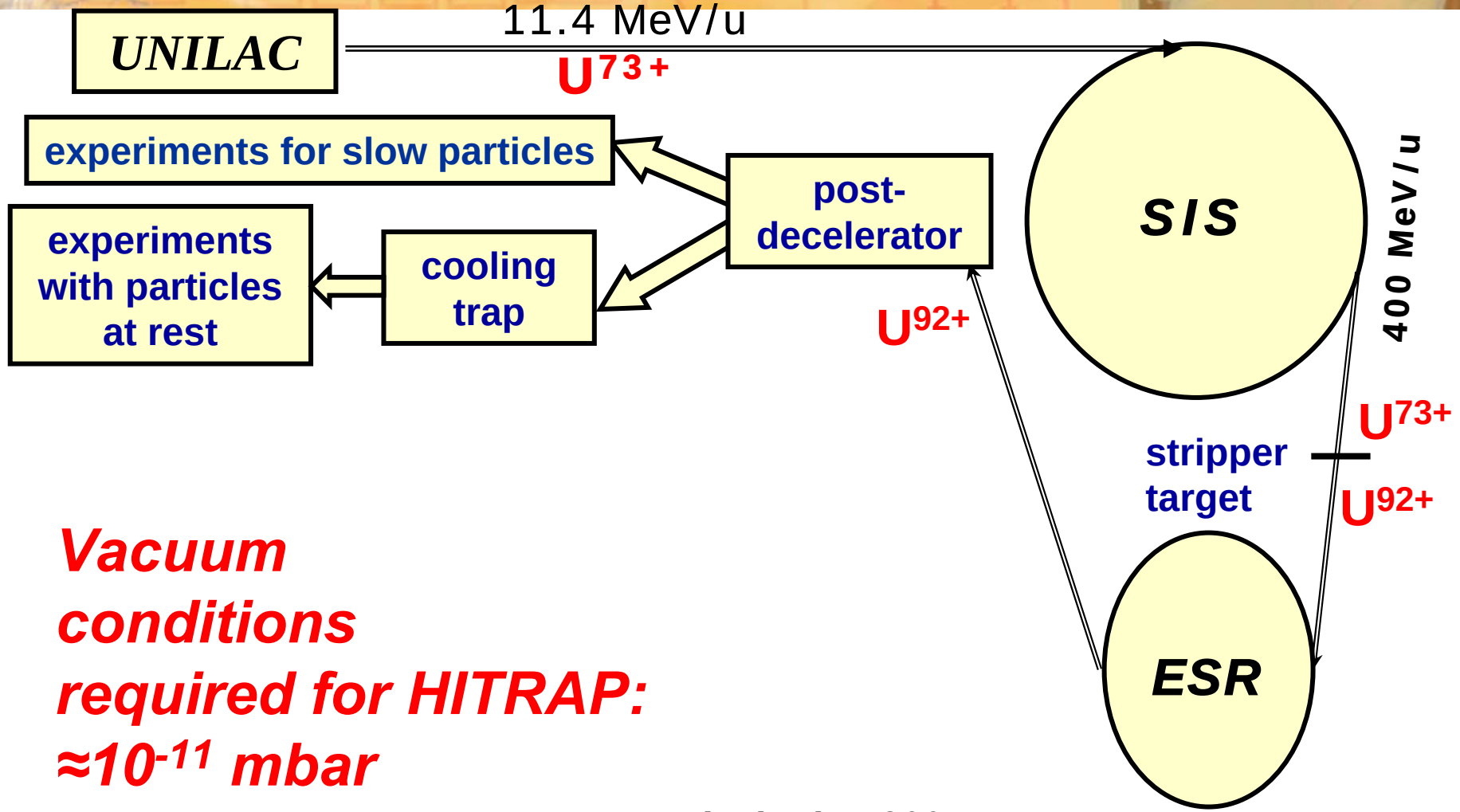
January 2005: Technical Proposal submitted

March 2005: Evaluation of TP => **'green light' to continue**

June 2005: Evaluation of the SPARC Cost Planning for Laser Experiments at SIS100/300 and NESR
=> 'green light' to continue

July 2005: STI Recommendations
SPARC: Part of the core experimental facility of FAIR

The HITRAP Project at GSI



Vacuum conditions required for HITRAP: ≈10^{-11} mbar

commissioning 2007

PAC recommendations on SPARC

The TP merges LOI 21 (SPARC) and 18 (Laser Cooling), as requested by the APPA-PAC. The TP contains all the information requested.

The following four experimental programmes are considered to be specially important and likely to have a high scientific impact. They make use of the unique facilities provided by the FAIR project. They are therefore given the highest priority in SPARC.

- Laser experiments at SIS 100/300 (cooling and spectroscopy) (1.1 – 1.2). They require an interaction zone at SIS 300 and a laser laboratory nearby in building 3.
- Atomic Physics at NESR is the core of the SPARC program. It requires space around the straight sections (internal target, 3.2), laser ports and detector for hyperfine structure measurements, and laboratory space shared with EXL. The cold electron target (second electron cooler, 3.1) is mandatory and might ask for a sur-elevation of the NESR building.
- HITRAP (4.3). Requires FLAIR building and beam-line from NESR.
- High-energy atomic cave (2.1): channeling experiments (2.2). Pair production is very interesting but requires more work (2.3). Most constraints for this cave come from BIOMAT.

The proposed experiments for the low-energy cave (4.2) follow-up on existing experiments, but reach the nonperturbative regime because of the use of slow, high-Z, highly charged ions. These experiments have lower priority, but a general-purpose low-energy cave is indispensable.

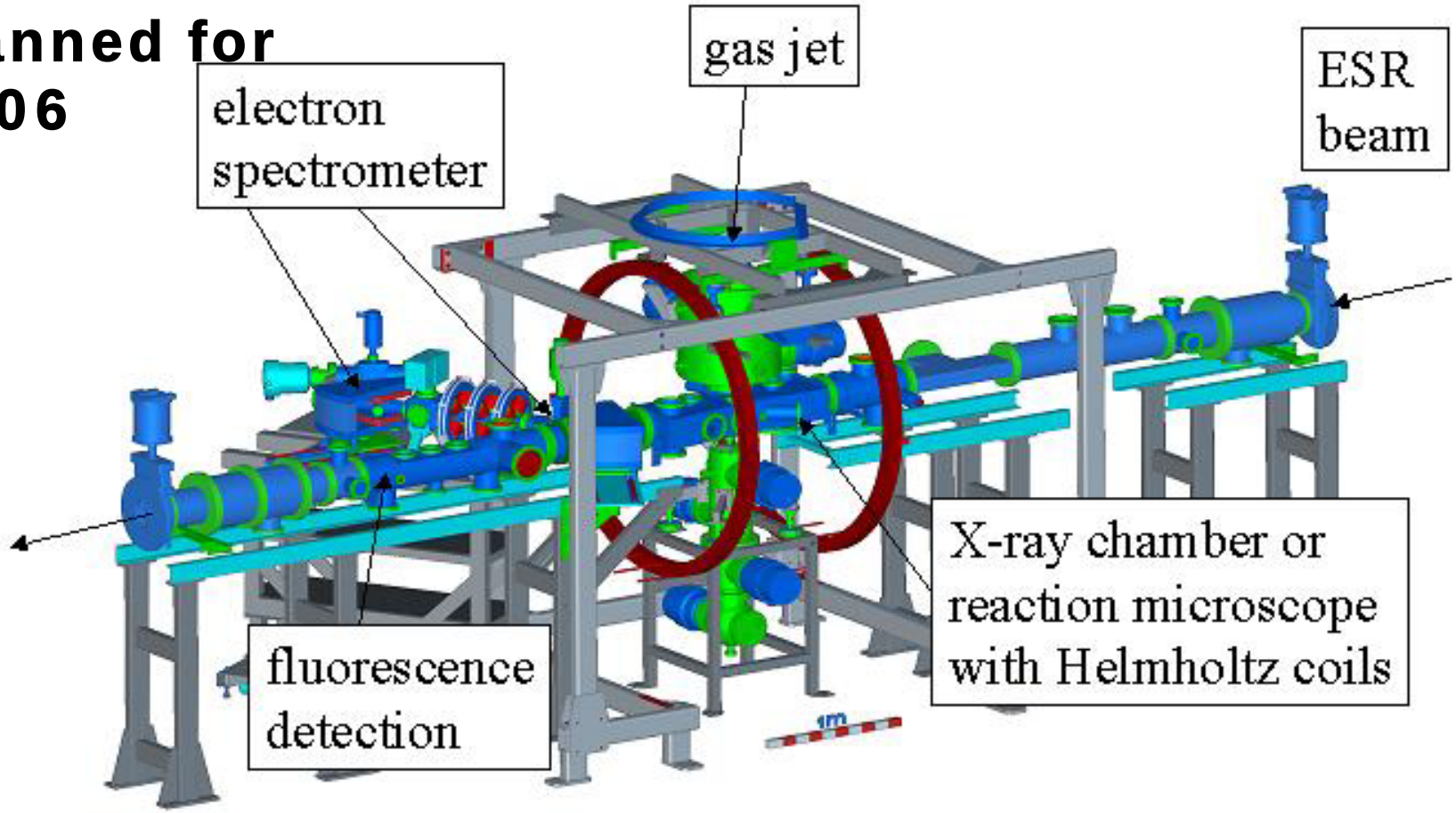
The Thompson back-scattering experiment (3.11c), which may require a beam-line from PHELIX and does require the electron collider, is considered more speculative at this time.

STATUS OF THE SPARC PROJECT

SPARC:
Stored Particle Atomic Physics
Research Collaboration

Recoil Ion Chamber Combined and 0-deg Electron Spectrometer

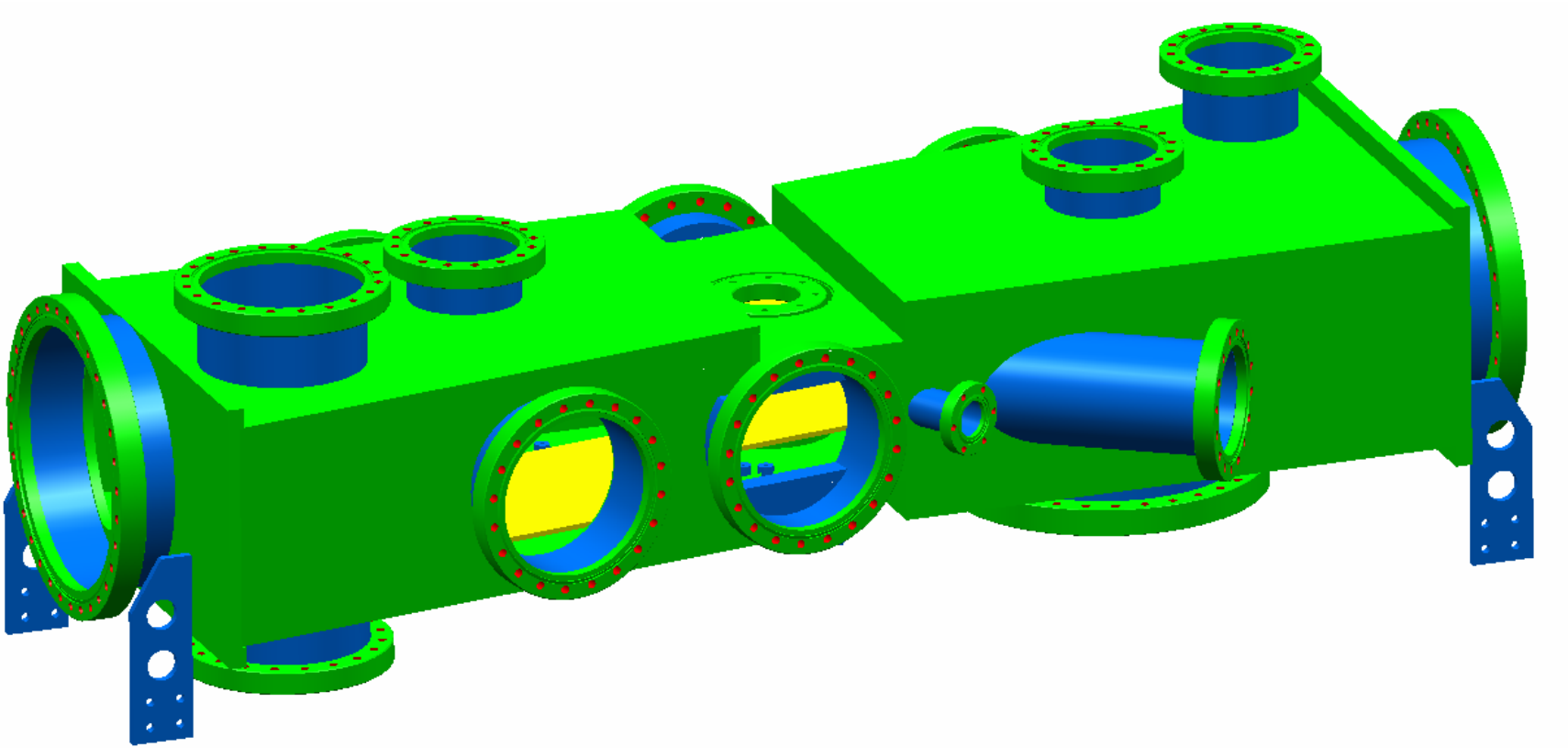
planned for 2006



Recoil ion spectrometer:
A longitudinal **B** field and a
will allow to detect low mom
and target recoil ions

present target chamber will be replaced in 2006 by the recoil ion chamber [should stay in the ring for 6 months]

Recoil-Ion Spectroscopy (2006)



- **Substantial R&D required**
- **Still unsolved issues**
- **No resources**

Recommendations of the STI Working Group on FAIR

SPARC

Part of the basic research program as defined by the CDR	✓
Part of the core experimental facility of FAIR	yes

- The STI requests from the SPARC collaboration a detailed layout of the experimental facility at SIS 300 with space requirements for the ring, for the tunnel and for building No. 3.
- Since all energies from 2 – 45 AGeV will be available in SIS300, the laser experiment collaboration is requested to focus on this machine only.
- The general purpose low-energy cave requires a detailed layout.

The experiment is approved, on the basis of the LOI and the TP, to work towards the TDR.

CORE Review / Result (CORE: Cost Review)

SPARC specific comments:

CORE has discussed two types of experiments sailing under the flag of SPARC, ***atomic physics at NESR*** presented by T. Stoehlker ***and laser experiments*** presented by U. Schramm. All experiments reuse existing equipment and rely heavily on the workshop capacity of the participating laboratories. Only material cost arise, which are reliably estimated. The production cost for the Si(Li) and Ge detectors can only be maintained if the support from Juelich is guaranteed. ***CORE has no further comments to the costing*** and asks only to take account of the general points mentioned above.

ESR – Target Environment