ALPS-II

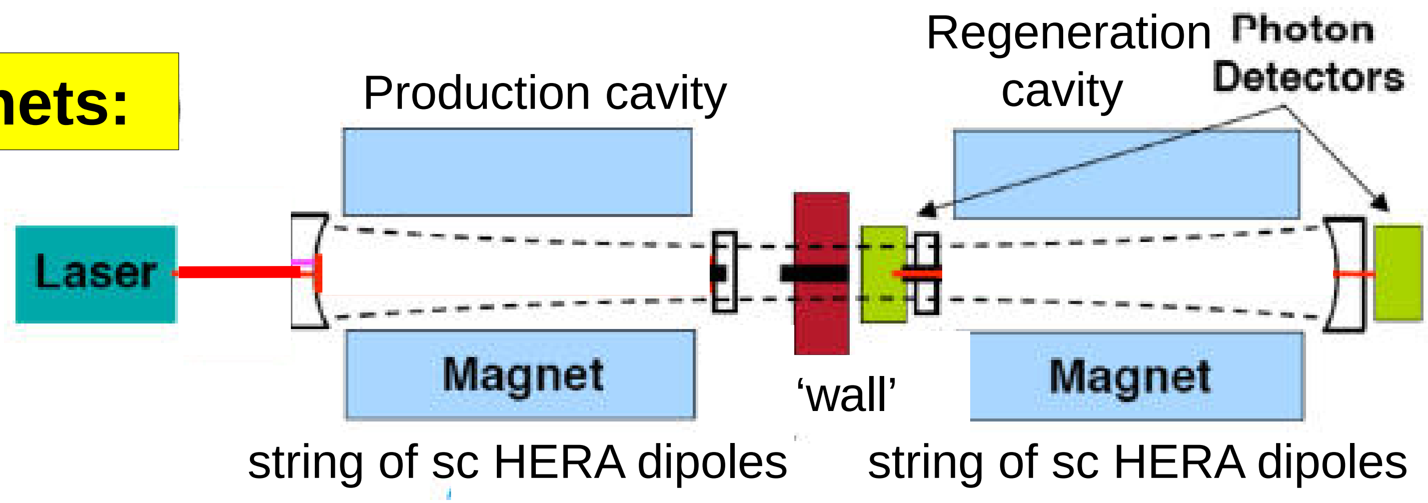
Magnets-Cryogenics-Vacuum

The TDR describes in some detail the status of the work on the superconducting HERA dipoles, the layout of the magnet strings for ALPS-IIc, as well as the concepts for the systems required for the operation of the magnets, namely the power supply, the quench protection system, the cryogenics, and the vacuum systems.

In the following a brief overview of the work will be given

and some news since the submission of the TDR

Magnets:



The **sensitivity** for the detection of Axion Like Particles **scales with B*L**.

Goal:
set up a **string** of s.c. HERA dipoles **as long as possible**.

As explained by Benno Wilke the achievable power buildup
in an optical cavity inside a string of magnets
depends on the aperture of the vacuum pipe inside the magnets.

‘Unfortunately’ for ALPS-II the beam pipe in the HERA dipole is curved

Parameters of the sc HERA dipole

Magnetic Field @ 920 GeV	5,25	T
Magnetic length	8,83	m
Total length	9,77	m
Radius of curvature	585	m
Inner diameter of beam pipe	55,3	mm

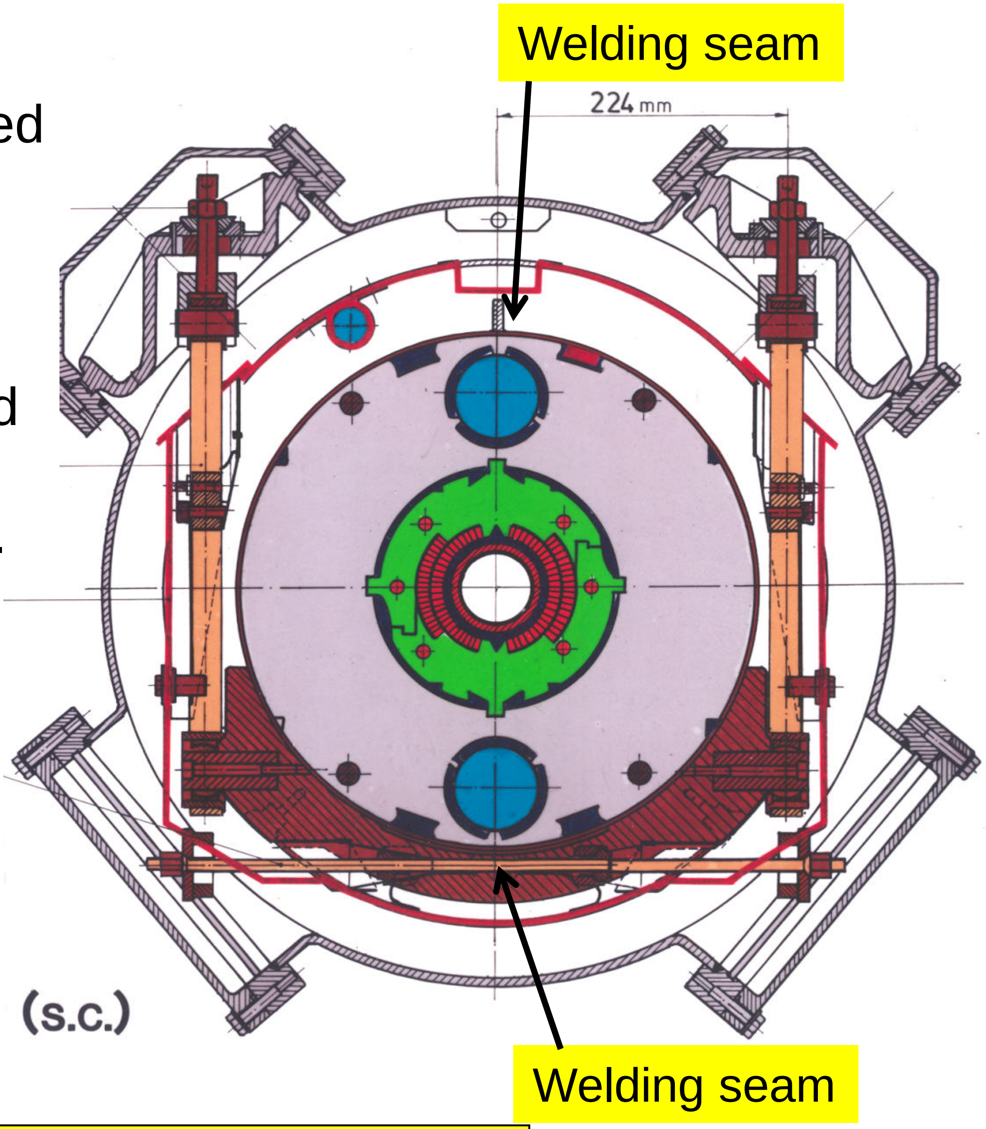
The curvature leaves a usable diameter of 35 mm only
for the optical cavity, which limits the number of HERA dipoles
for a power buildup of 40000 to 2*4.

Goal: **increase aperture by straightening** the HERA dipoles

All parts of the cold mass have **originally** been produced **straight.**

The welding of the half cylinders of the Helium vessel around the yoke was performed in a big tool which forced the cold mass to a given curvature.

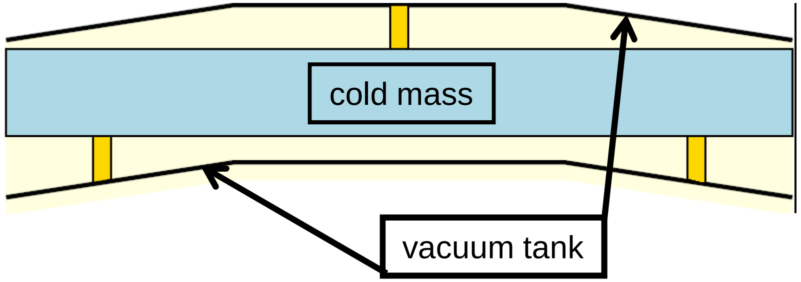
Therefore by a disassembly of the magnet, cutting the seams and re-welding straight half cylinders, a straightening of the HERA dipole should be possible.

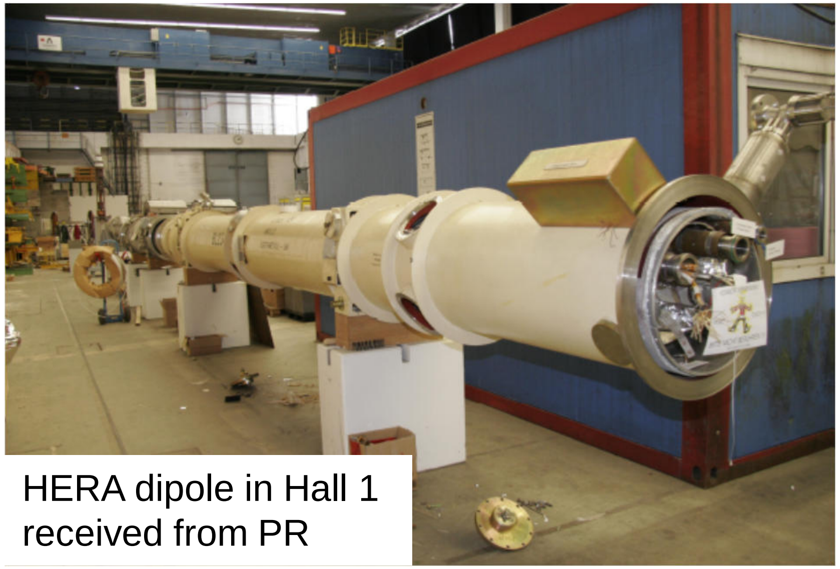


However, the total cost of such an operation, although not known, is considered to be substantial.

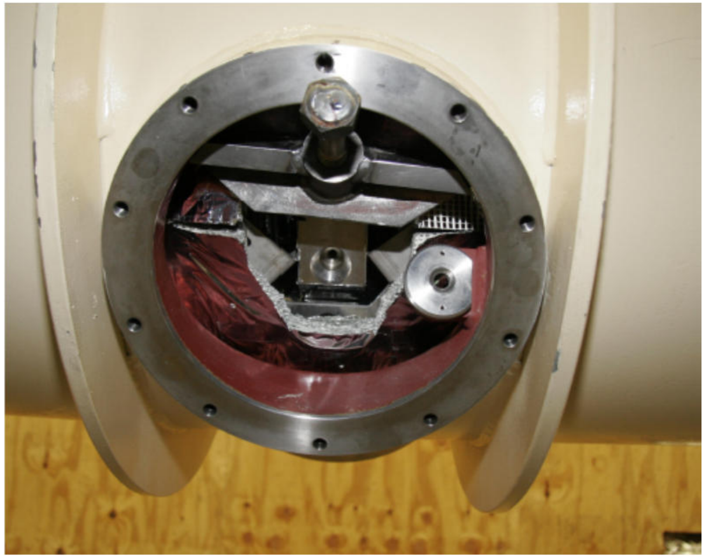
Inexpensive method to increase the aperture of the vacuum pipe in the HERA dipole

Force ends and middle of cold mass towards the center with simple deformation tools

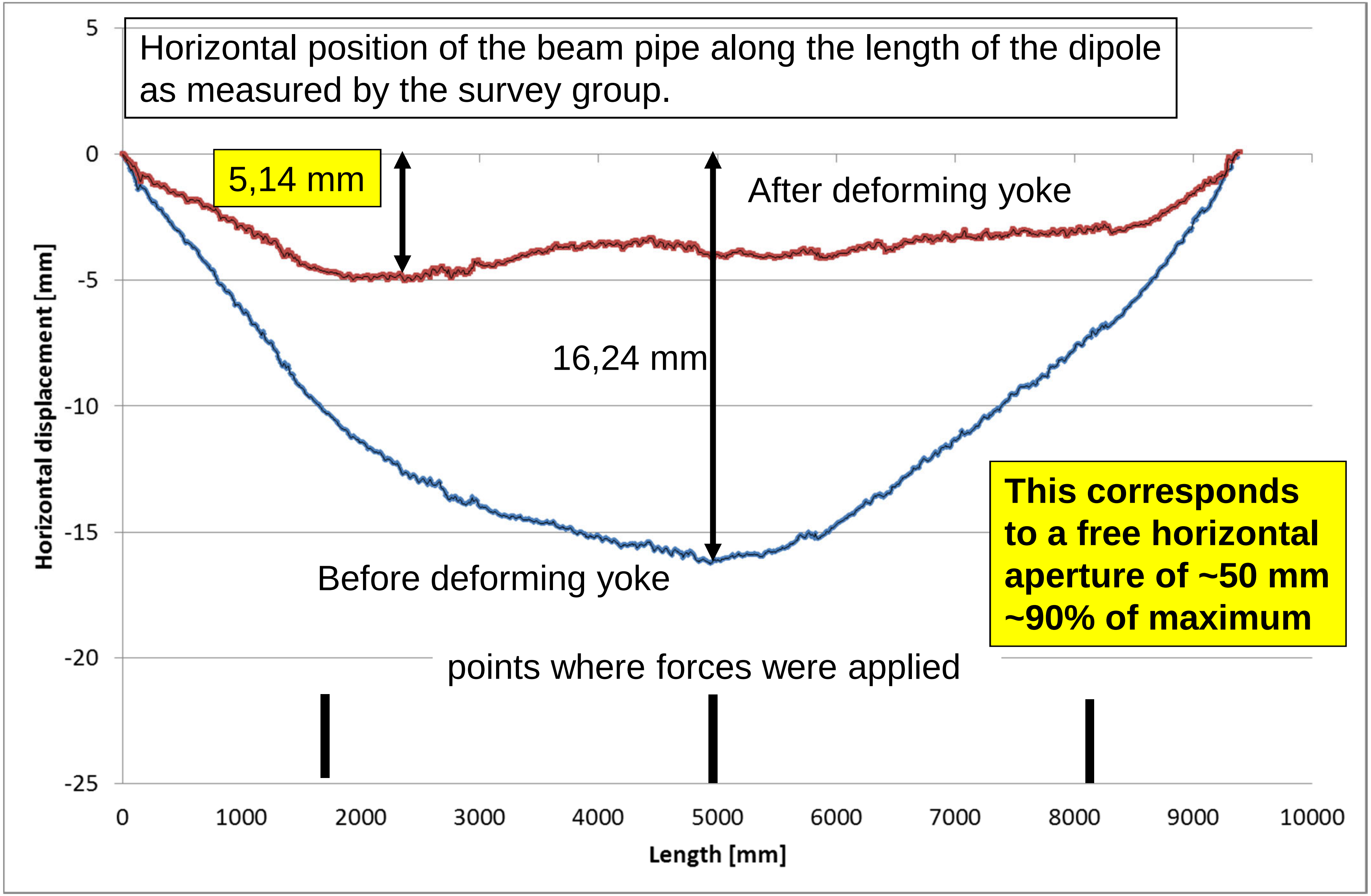




HERA dipole in Hall 1 received from PR



First test of straightening method 6th May 2011

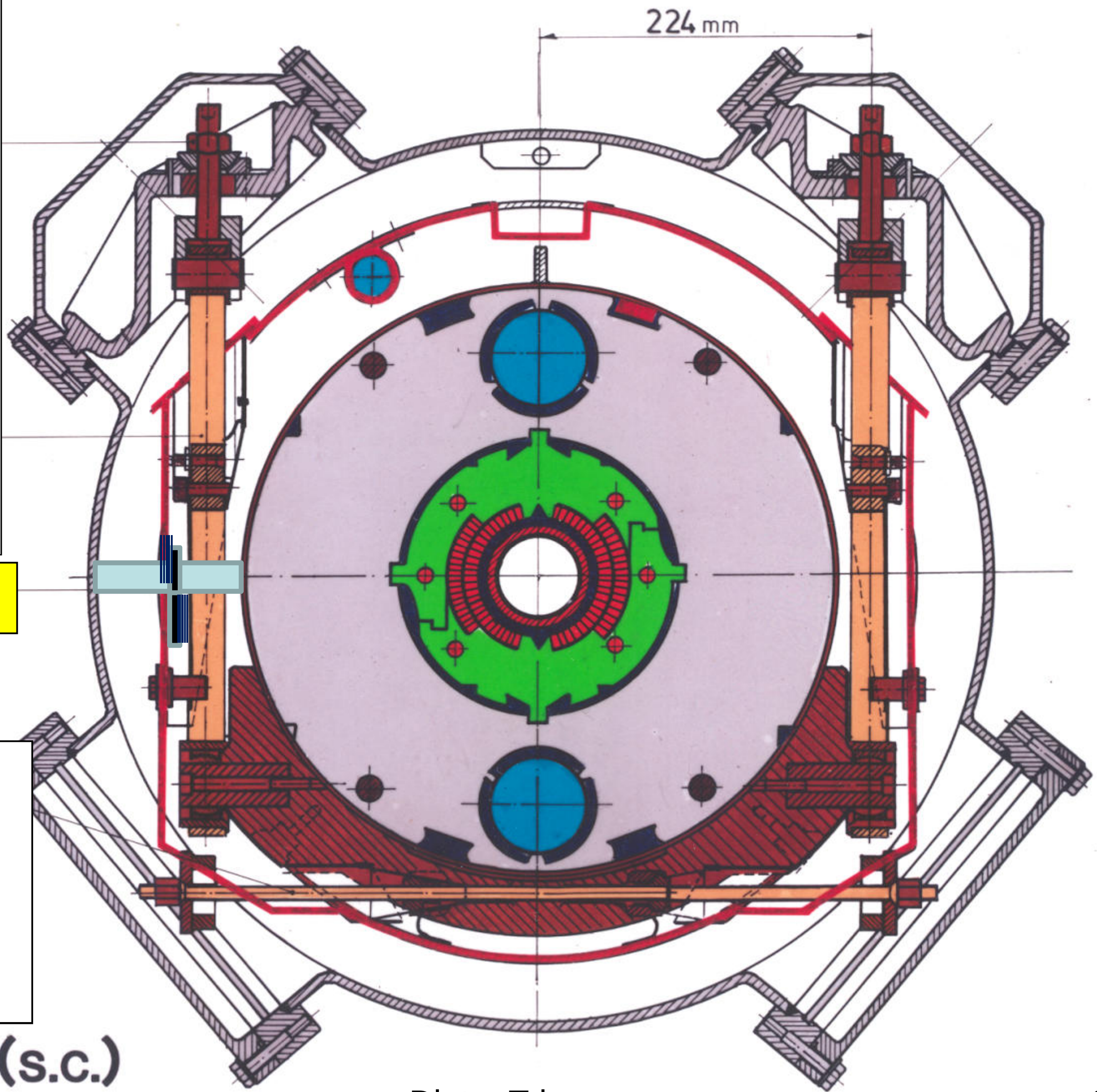


for a power buildup in the regeneration cavity of 40000

Free aperture mm		Number of dipoles	B*L [Tm]	Single string length plus 5 m optical setup
35	HERA curved	2*4	187	44
50	HERA almost straight	2*10	468	103
55	HERA straight	2*12	562	122

The deformation of the yoke is elastic. Therefore the force must be maintained also during cryogenic operation of the dipole.
So, the deformation tools are replaced by **pressure props with a sufficiently low heat flow to the 4K helium vessel**.

pressure prop



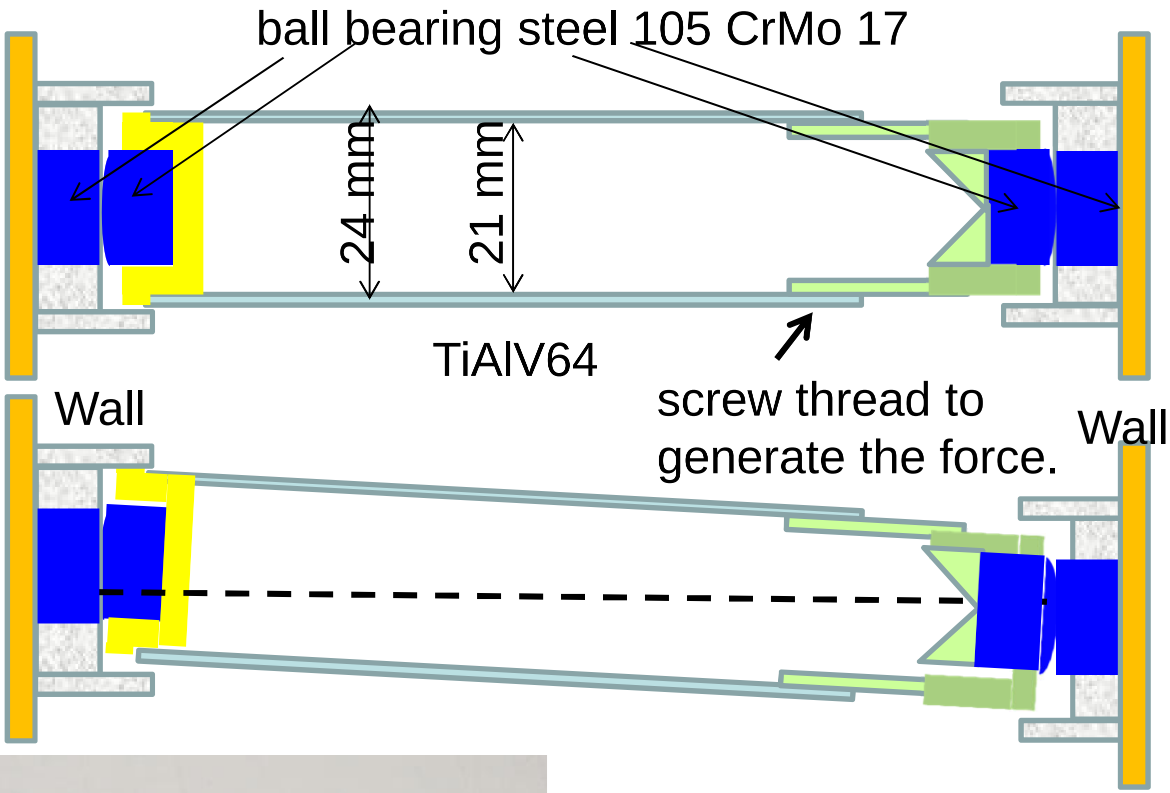
The outer pressure props have to follow the length change of the helium vessel during cool down and warm-up.

Dipole Magnet (s.c.)

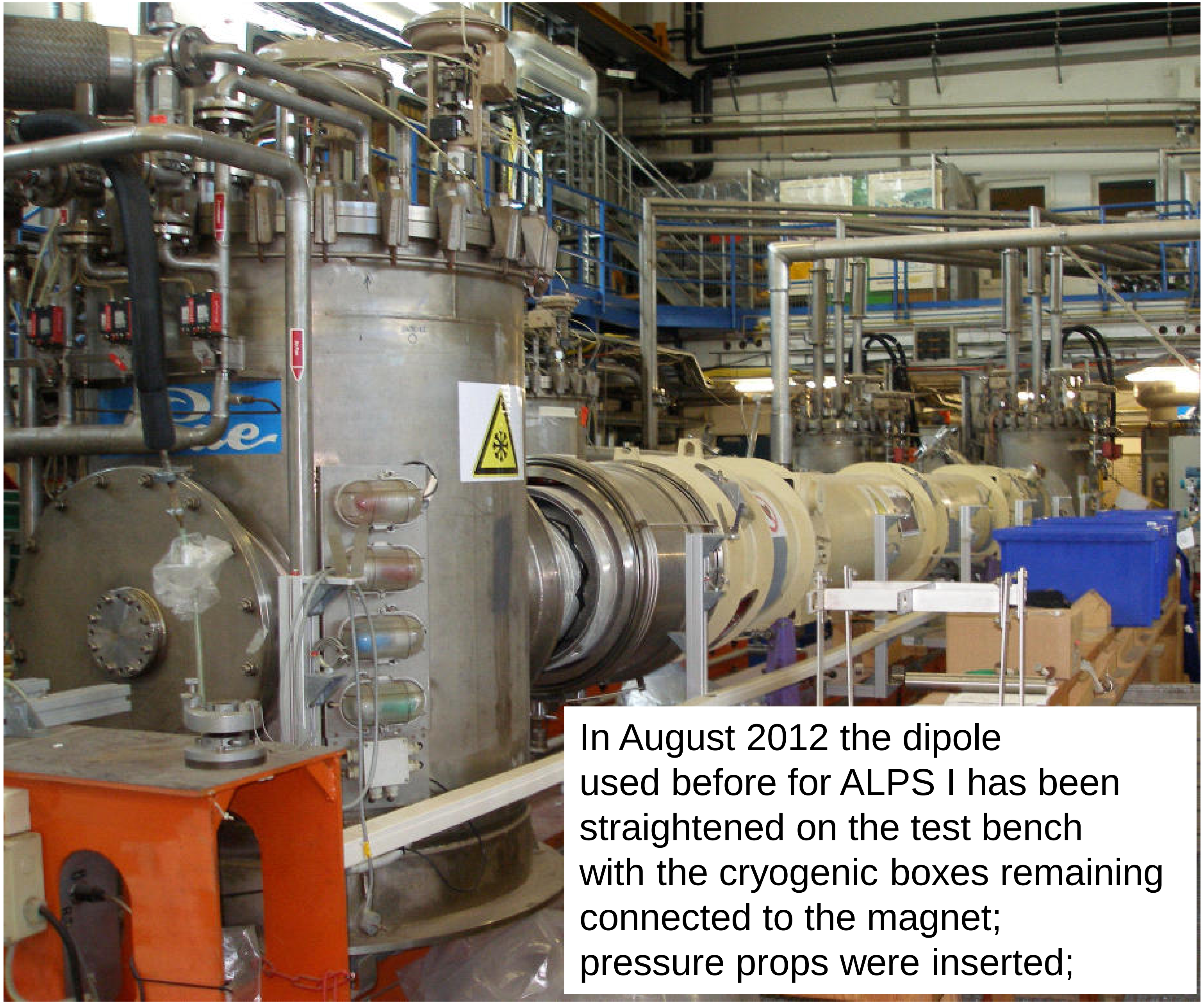
The problem to follow the shrinkage of the cold mass was solved by using the section of a sphere, which rolls with the motion of the cold mass.

Low heat flow pressure prop

The distance between warm and cold wall does not change during roll except for a thermal shrinkage of the pressure prop



The prototype was tested at liquid nitrogen temperature in vacuum

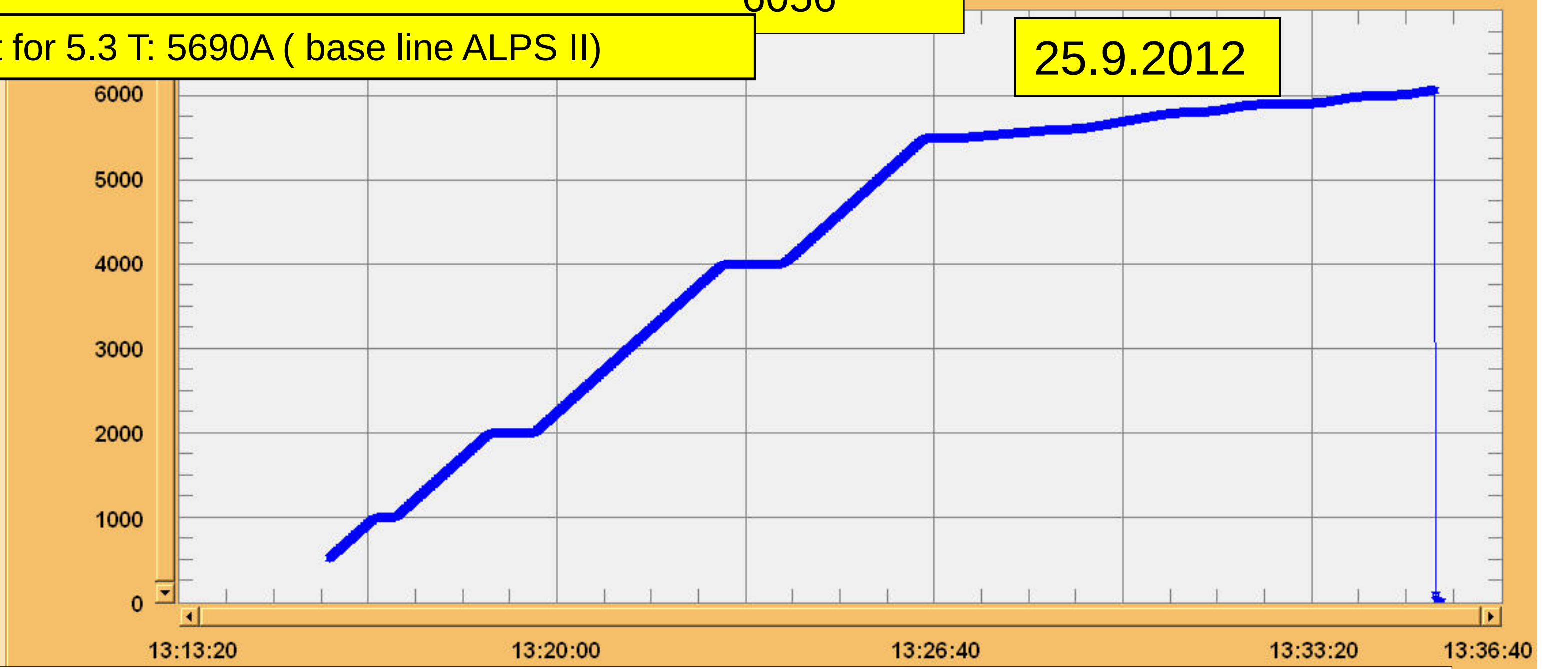


In August 2012 the dipole
used before for ALPS I has been
straightened on the test bench
with the cryogenic boxes remaining
connected to the magnet;
pressure props were inserted;

New result since submission of TDR
Straightened ALPS-I dipole was operated successfully.
Important milestone for ALPS-II

	Quench current [A]
unchanged dipole August 2011	5920
straightened dipole September 2012	6072 6056

Current for 5.3 T: 5690A (base line ALPS II)

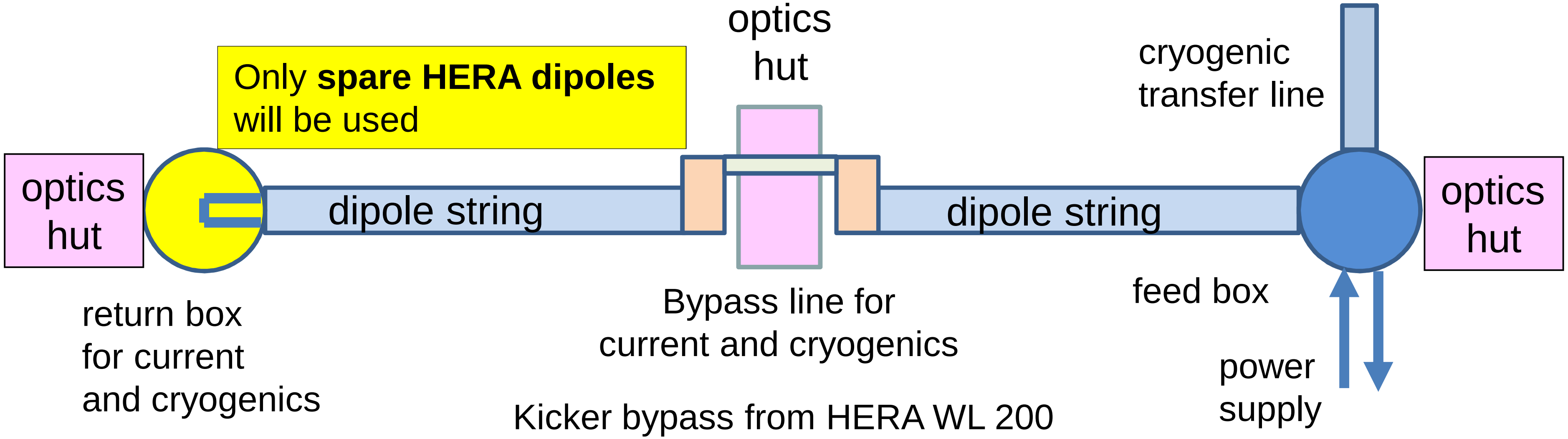


The cryogenic losses of the dipole were as for the unchanged dipole

Dipole was operated continuously for 30 h at the design current of 5700 A

Schematic setup of the experiment in a straight section of the HERA tunnel

Only **spare HERA dipoles** will be used



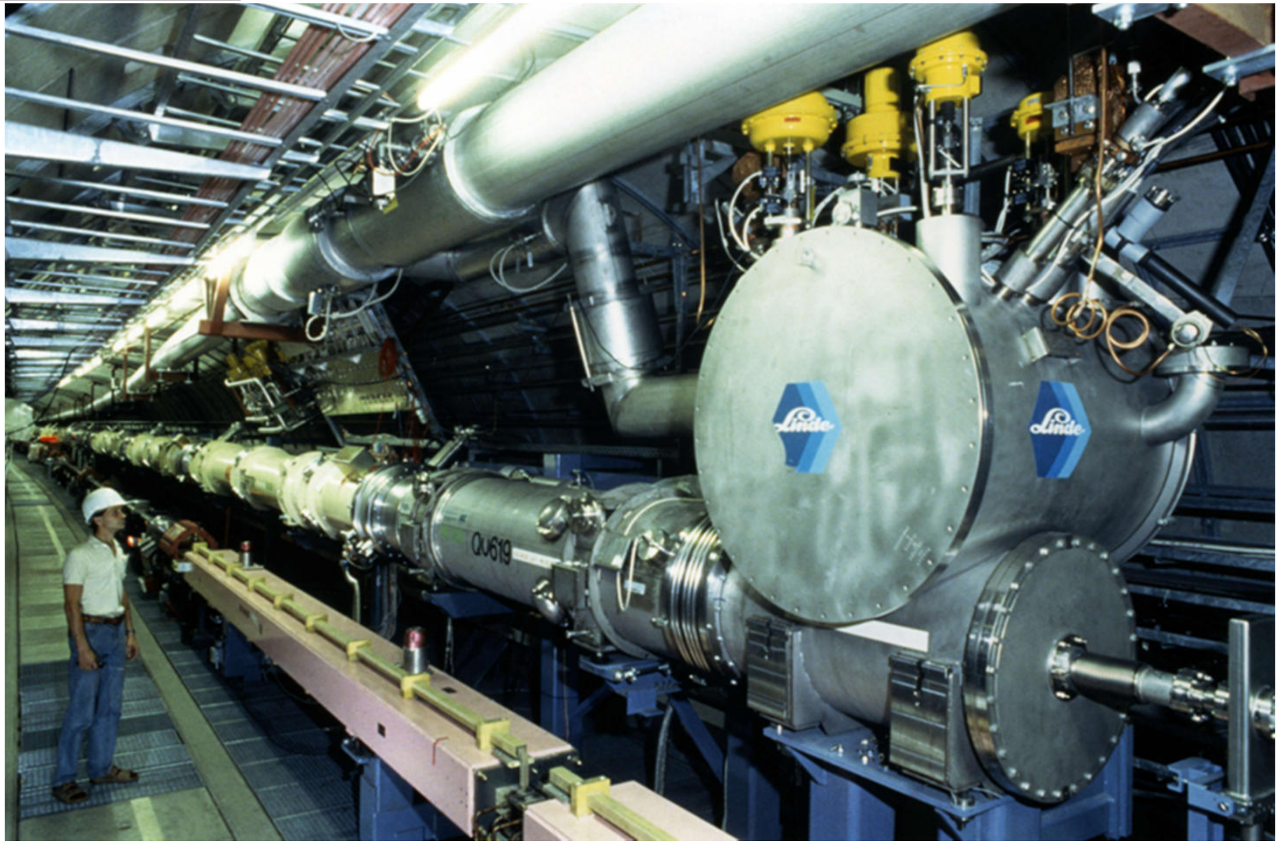
Kicker bypass from HERA WL 200

To guide the magnet current and the cold Helium around the optical setup between the strings the ‘**kicker bypass**’ will be used

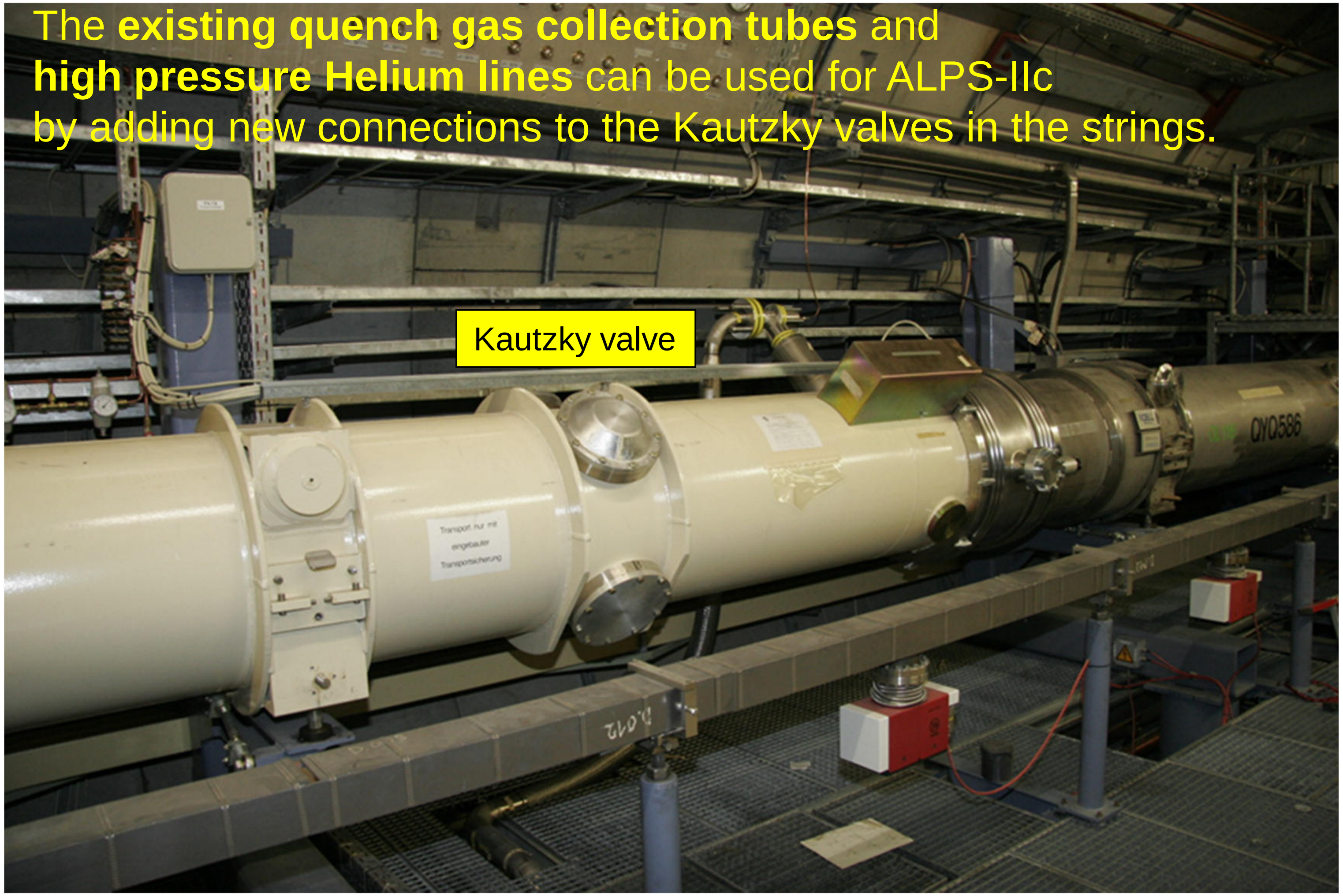
Cryogenics boxes are taken from the straight section selected for the setup of the experiment

The 6000 Ampere power supply for the operation of the H1 experimental solenoid in HERA hall North can be used.

cryogenics: as at HERA



The cold Helium for the operation of the magnet strings will be supplied from the big **cryoplant on the DESY site** using the **existing Helium transfer line** and the **existing cryogenics boxes** in the section HERA North.

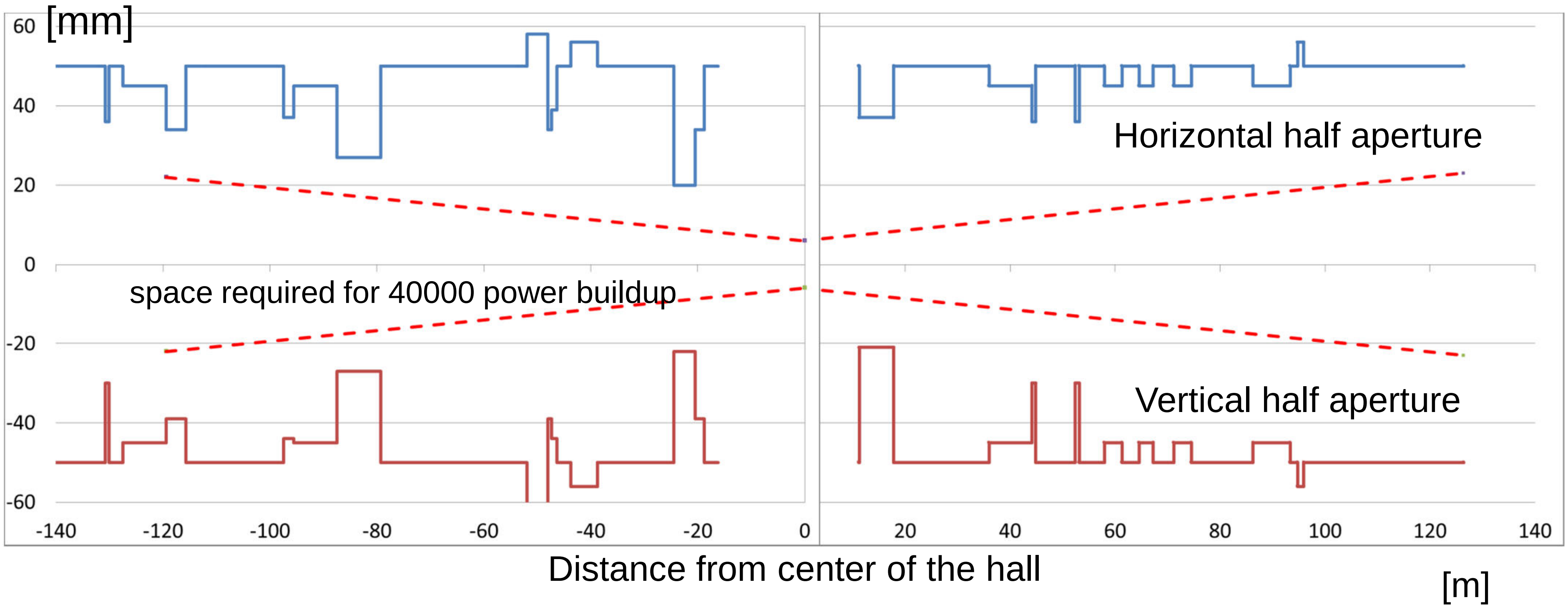


The total heat load of the ALPS II strings at the 4K level amounts to ~140 Watt which is substantially less than the ~400 Watt of a HERA octant:
the **cryogenic operation** of ALPS-IIc **will not pose any problem.**

Vacuum

ALPS-IIb:

The **existing vacuum pipe of the HERA proton ring** will be used.
The pipe has a **large aperture** allowing for very low clipping losses in the optical cavities.
A large number of Ion Getter pumps and Titanium sublimation pumps,
as well as turbo-molecular pump stations are available.

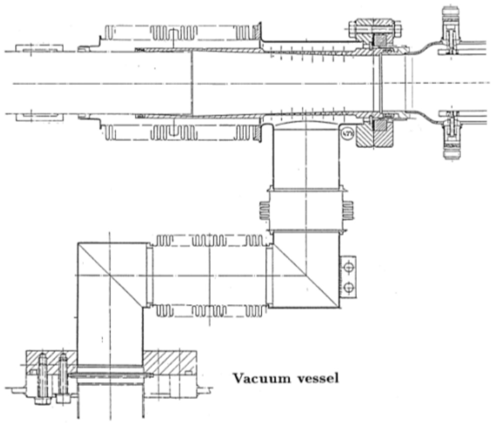


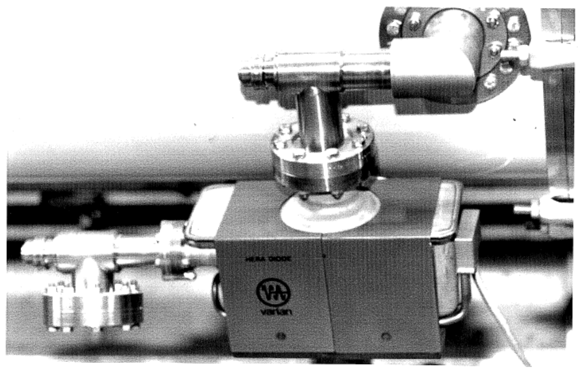
Vacuum

ALPS-IIc: for the magnet strings as at HERA

Ion Getter pumps and as well as turbo-molecular pump stations
are available to evacuate the beam pipe in the magnet strings at room temperature.

The pumps on the beam tube are disconnected
once the strings are at liquid Helium temperature,
as the wall of the beam pipe acts as a cryo-pump.

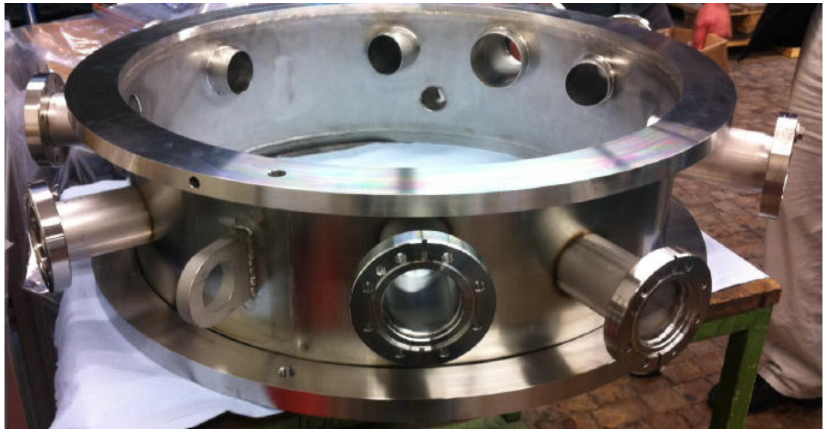


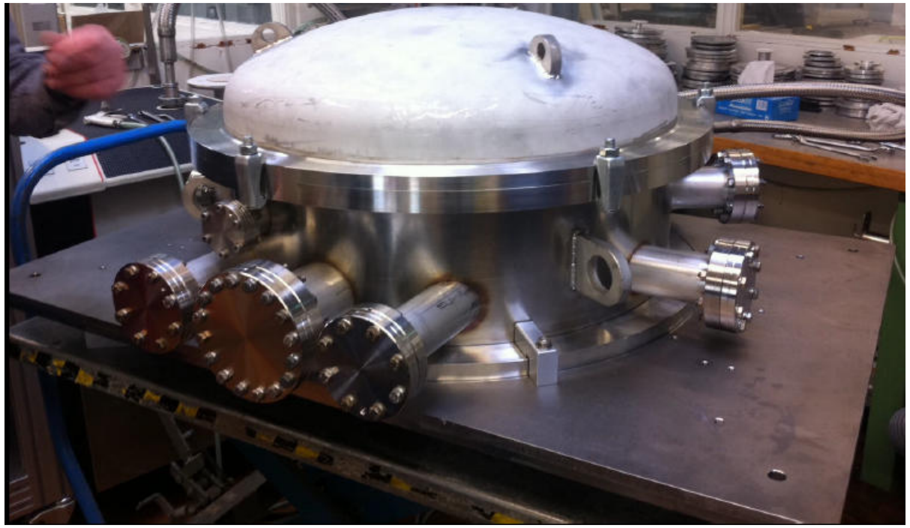


At the outer ends of the strings and in the middle between the strings
there will be vacuum vessels at room temperature for the optical components

The pictures show the vacuum vessel for the optical components and the 'wall' shutter in the middle of the **ALPS-IIa** setup.

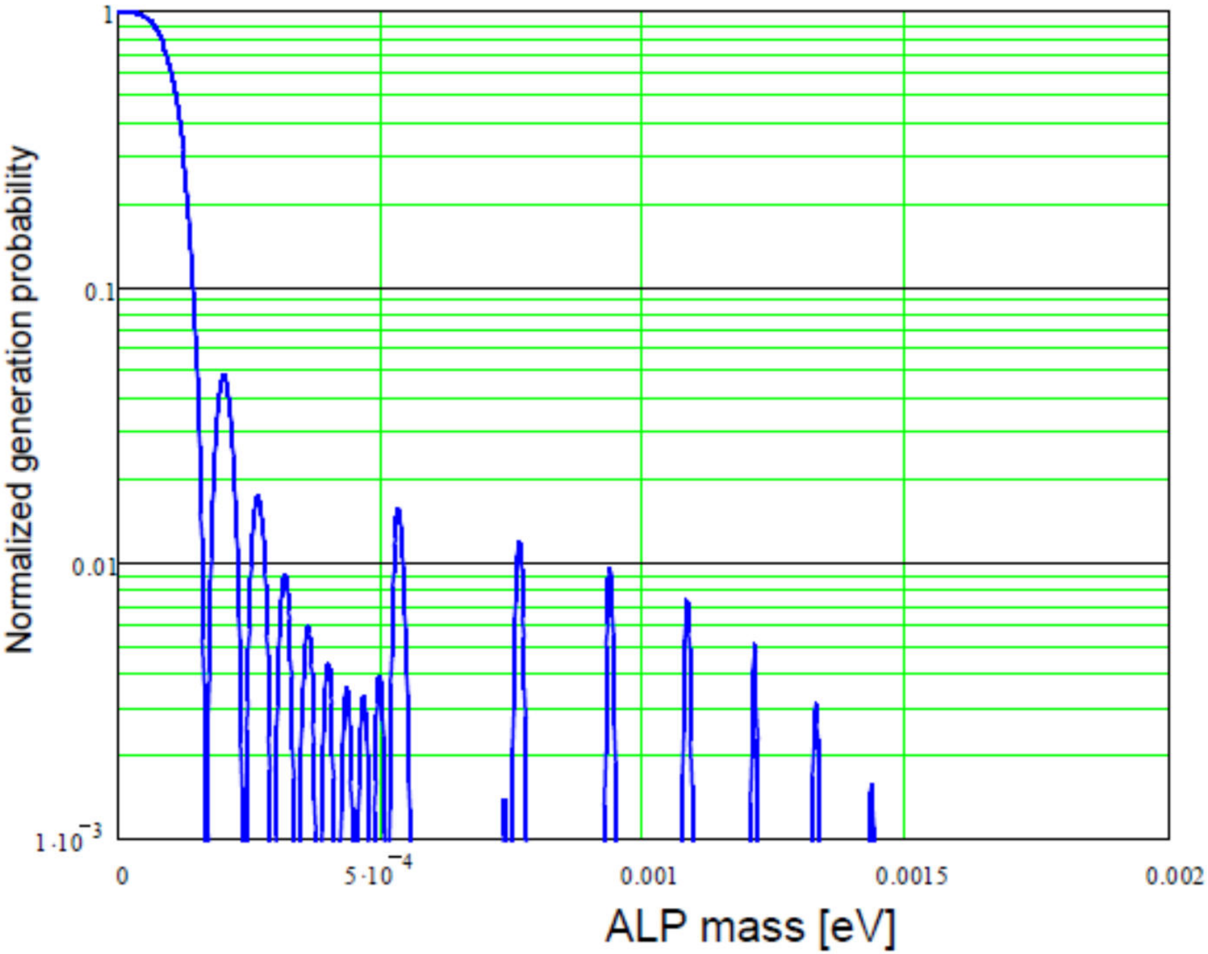
The vessel for ALPS-IIb and ALPS-IIc will be similar





Completed after the submission of the TDR

Normalized production probability as function of the ALP mass
for vacuum in the optical resonator

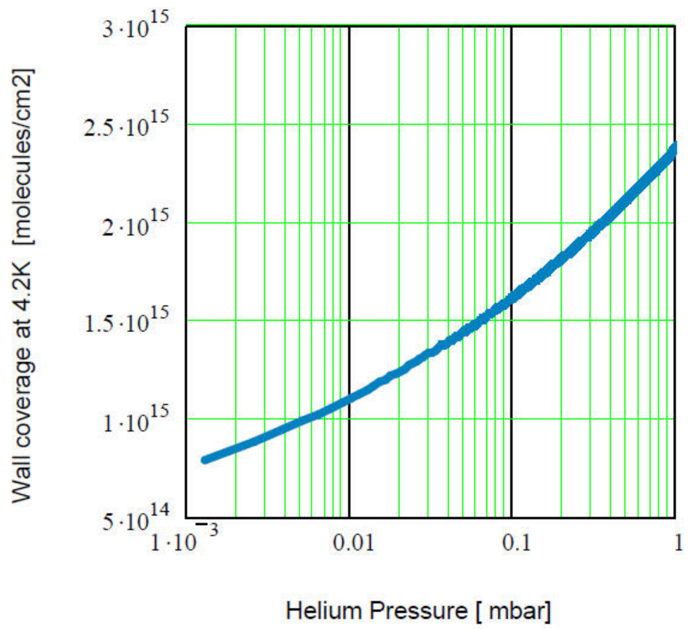


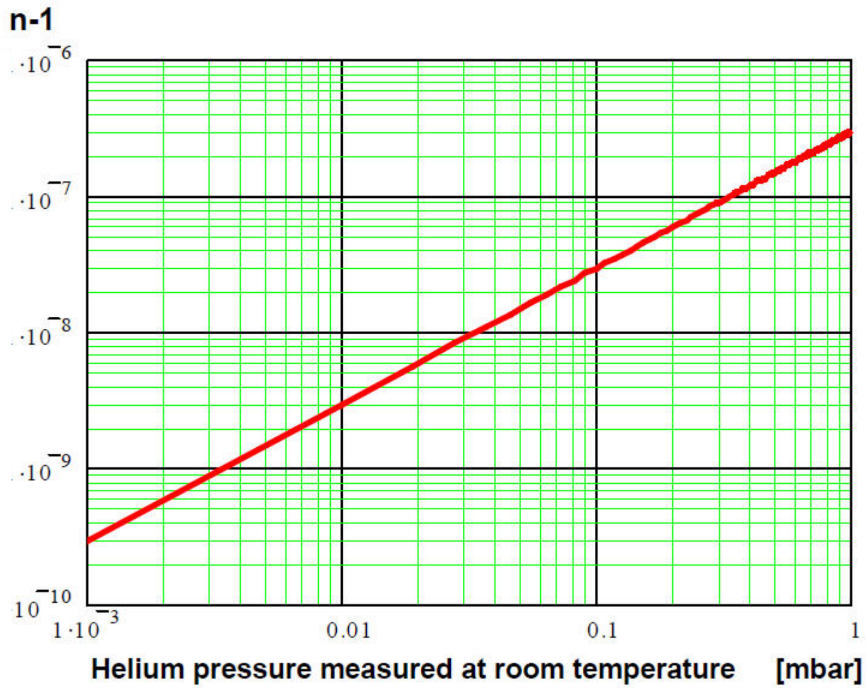
To fill the gaps in the probability distribution for production and regeneration of ALP's and to get a smooth coverage of the ALP's mass range the refractive index n in the optical resonators will be increased

To increase the refractive index, Helium gas will be injected into the vessels at room temperature at the ends of the magnet strings.

After a certain time (~hour) an equilibrium pressure will establish depending on the wall coverage with Helium atoms, which is determined by the amount of Helium gas given into the system.

Note: Only with Helium a noticeable pressure increase in the beampipe at 4K can be achieved.





Range: 0.001 mbar to 0.5 mbar

Summary

An inexpensive way to increase the aperture of the HERA sc dipoles for the optical resonators has been demonstrated successfully allowing for the setup of 2 strings with 10 dipoles each for ALPS-IIc

There are valid concepts for the setup and the operation of the magnet strings in the HERA tunnel including cryogenics and vacuum systems.

End