The newly upgraded large COMPASS polarized target

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On behalf of the COMPASS collaboration

- COMPASS's goal and requirement with the polarized target
- Upgraded target set-up compared with previous one
- The large acceptance magnet
- Why a 3-cell target configuration?
- The new microwave cavity
- Preliminary results

The goal :

Determination of the gluon polarization $\Delta G/G$ by :

- the open charm lepto-production channel $\rightarrow D^0$
- high p_T hadron pair events

Accessible from the double spin asymmetry:

$$A^{exp} = \frac{N^{\rightarrow}_{\leftarrow} - N^{\leftarrow}_{\leftarrow}}{N^{\rightarrow}_{\leftarrow} + N^{\leftarrow}_{\leftarrow}} = P_B \underbrace{P_T f} A^{\mu N \rightarrow q\bar{q}X}$$

Must be maximized

P_B Beam polarization
P_T Target polarization
f Dilution factor
N Number of events

$\leftarrow$ Beam polarization orientation

$\Leftarrow$ Target polarization orientation

Requirement & challenge for a polarized target

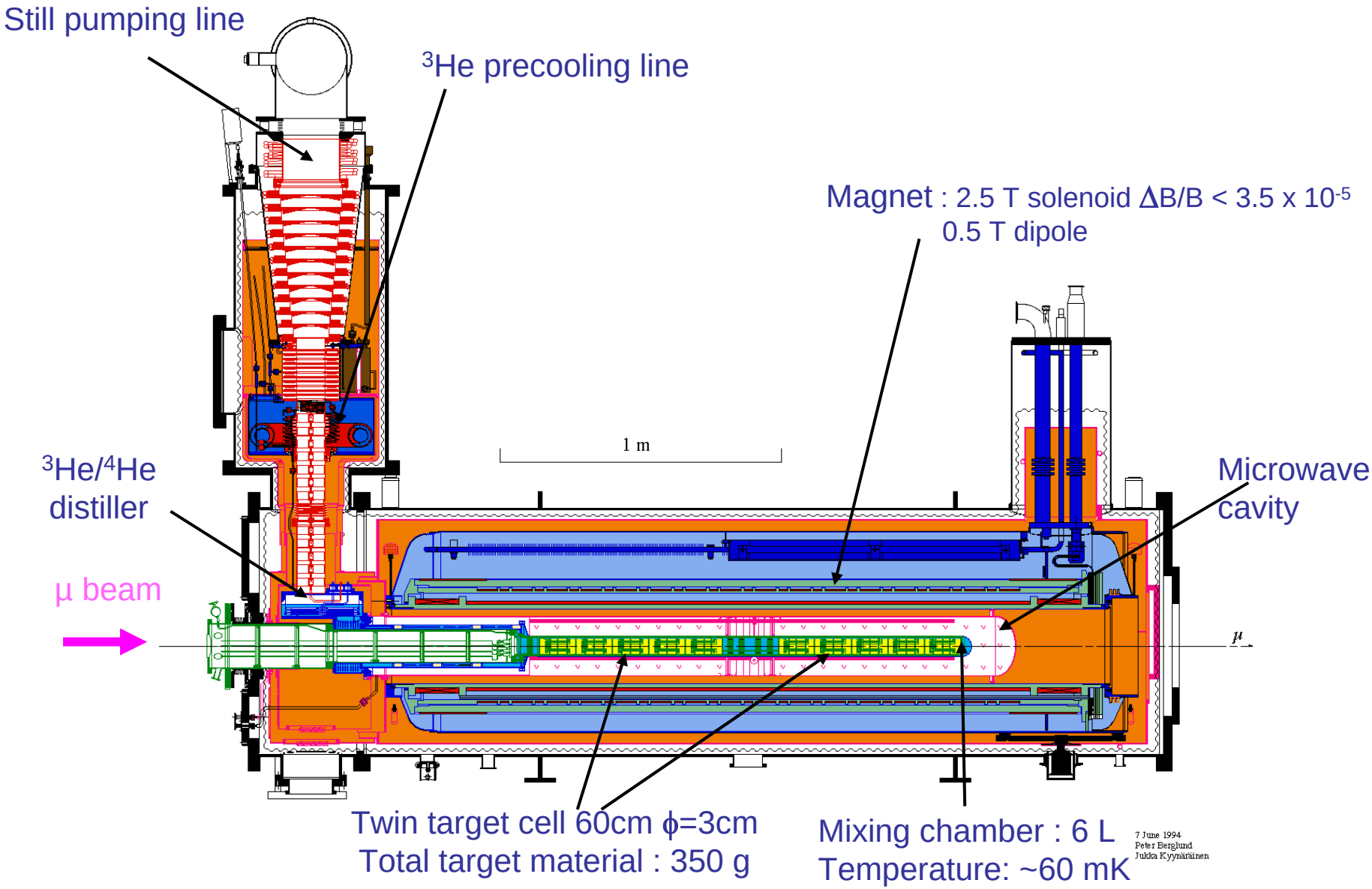
- Statistical accuracy: $\frac{\delta A^{exp}}{A^{exp}} = \frac{1}{\sqrt{2N}\ P_B P_T f A^{phys}}$ (1) (2) (3)

1. Large target
2. High target polar.
3. High dilution factor

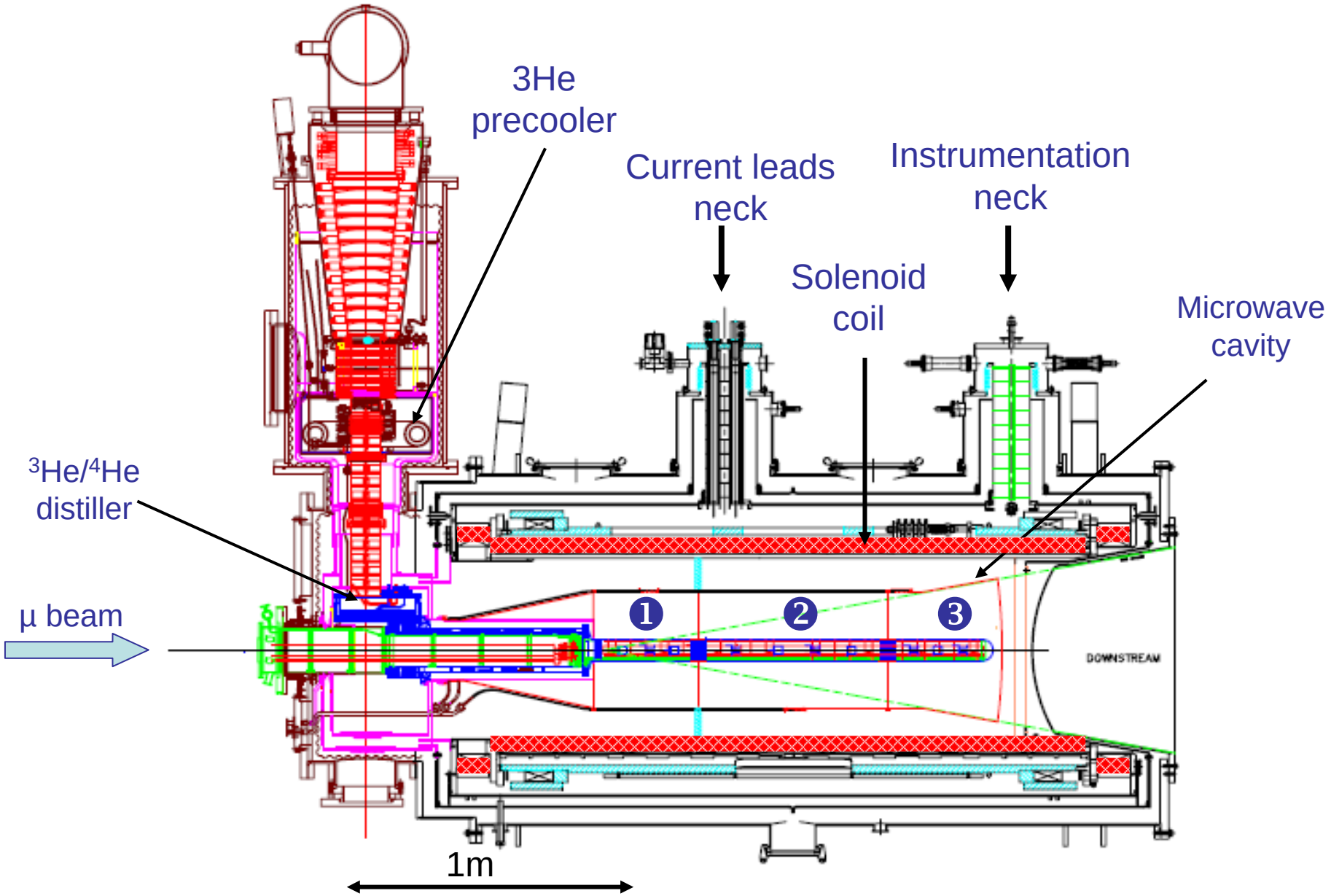
- The challenge for COMPASS:

1. To run the largest solid polarized target = higher statistic
2. To achieve the highest polarization
3. To measure the polarization without disturbing the experiment
4. To reduce multiple scattering = minimizing non-target material
5. To have changes of the sign of polarization = against false asymmetries from acceptance changes

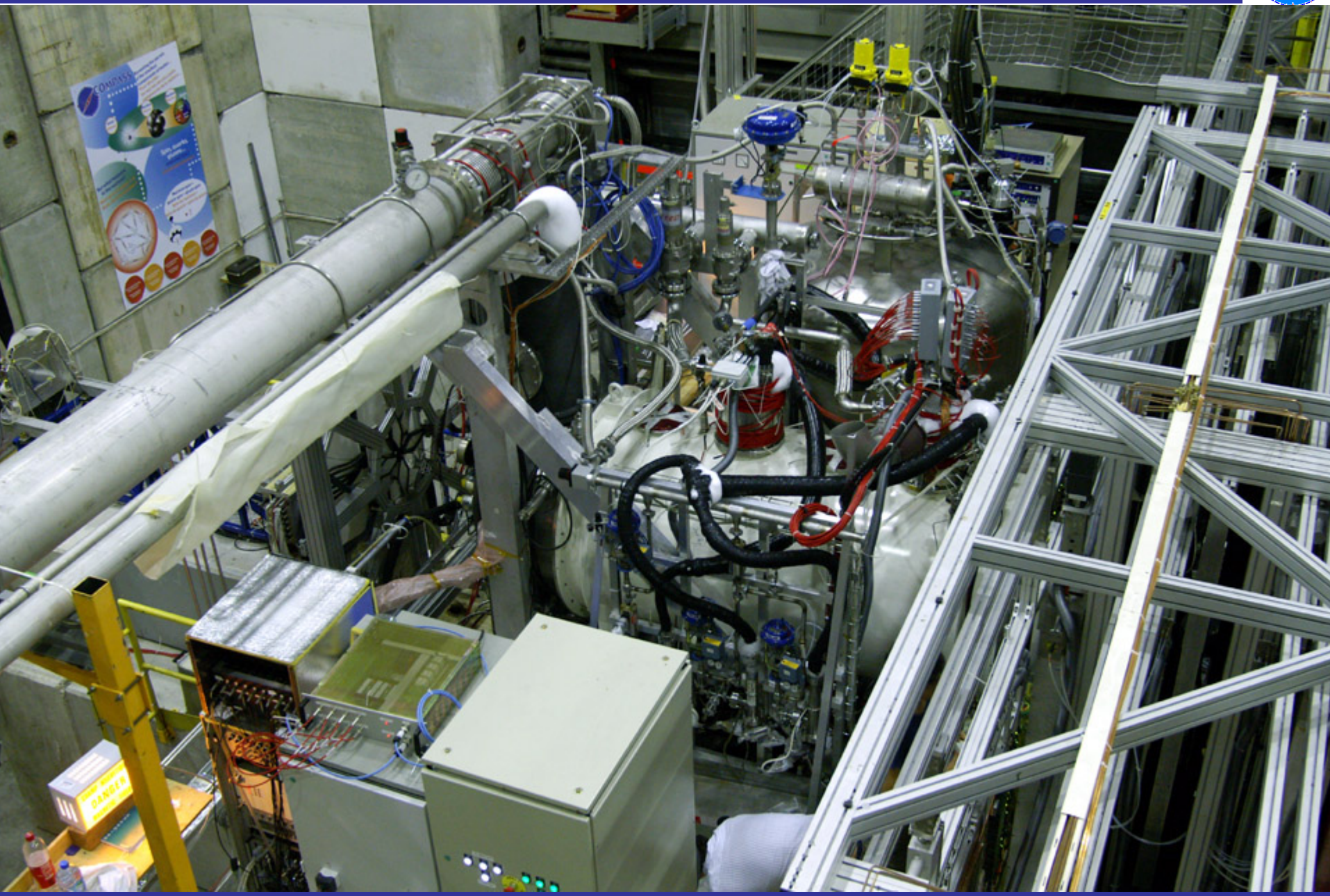
Sketch of the previous target set-up “SMC”:



Sketch of the new target set-up “COMPASS”:

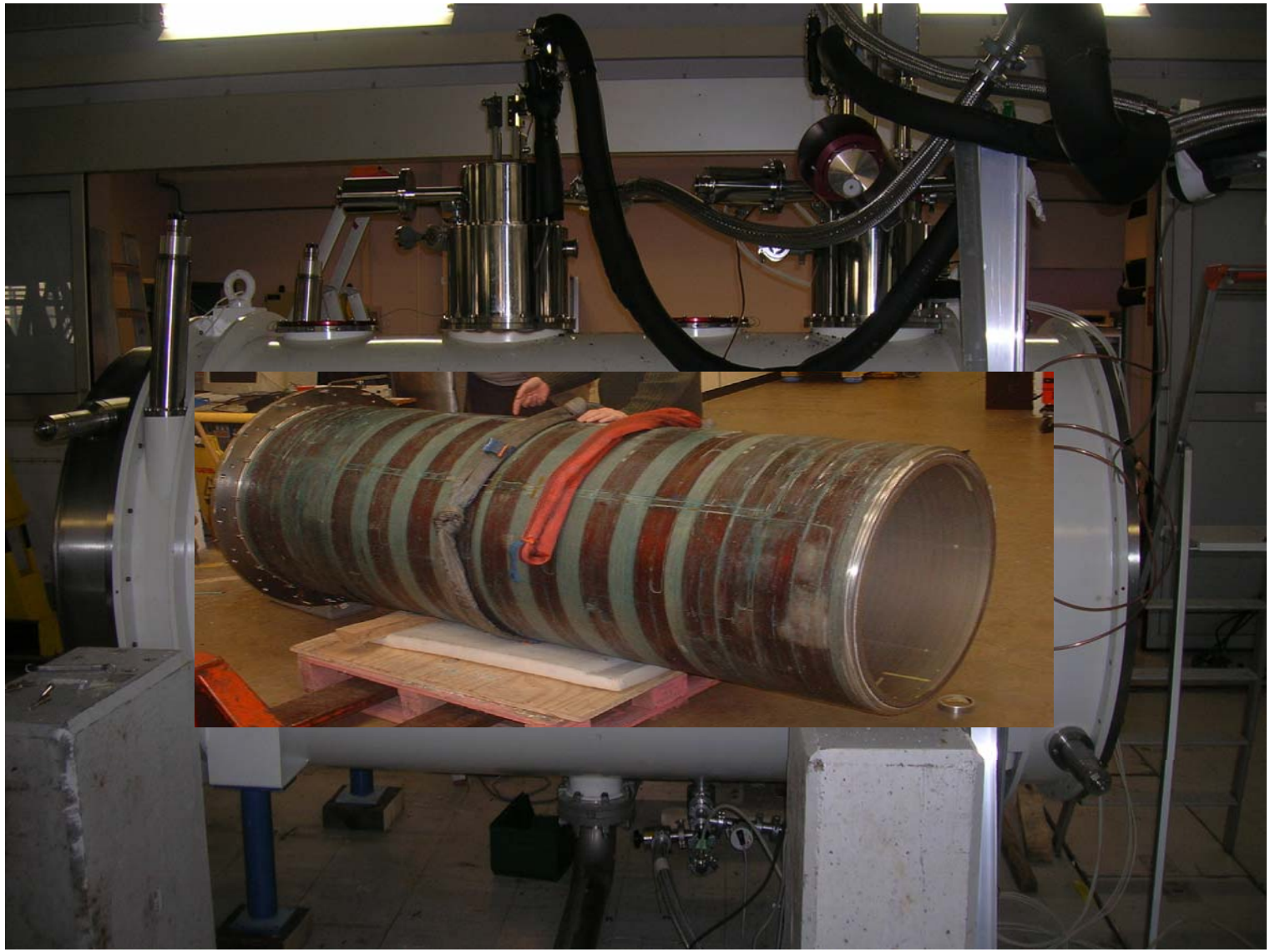


The upgraded COMPASS polarized target



The large acceptance magnet system

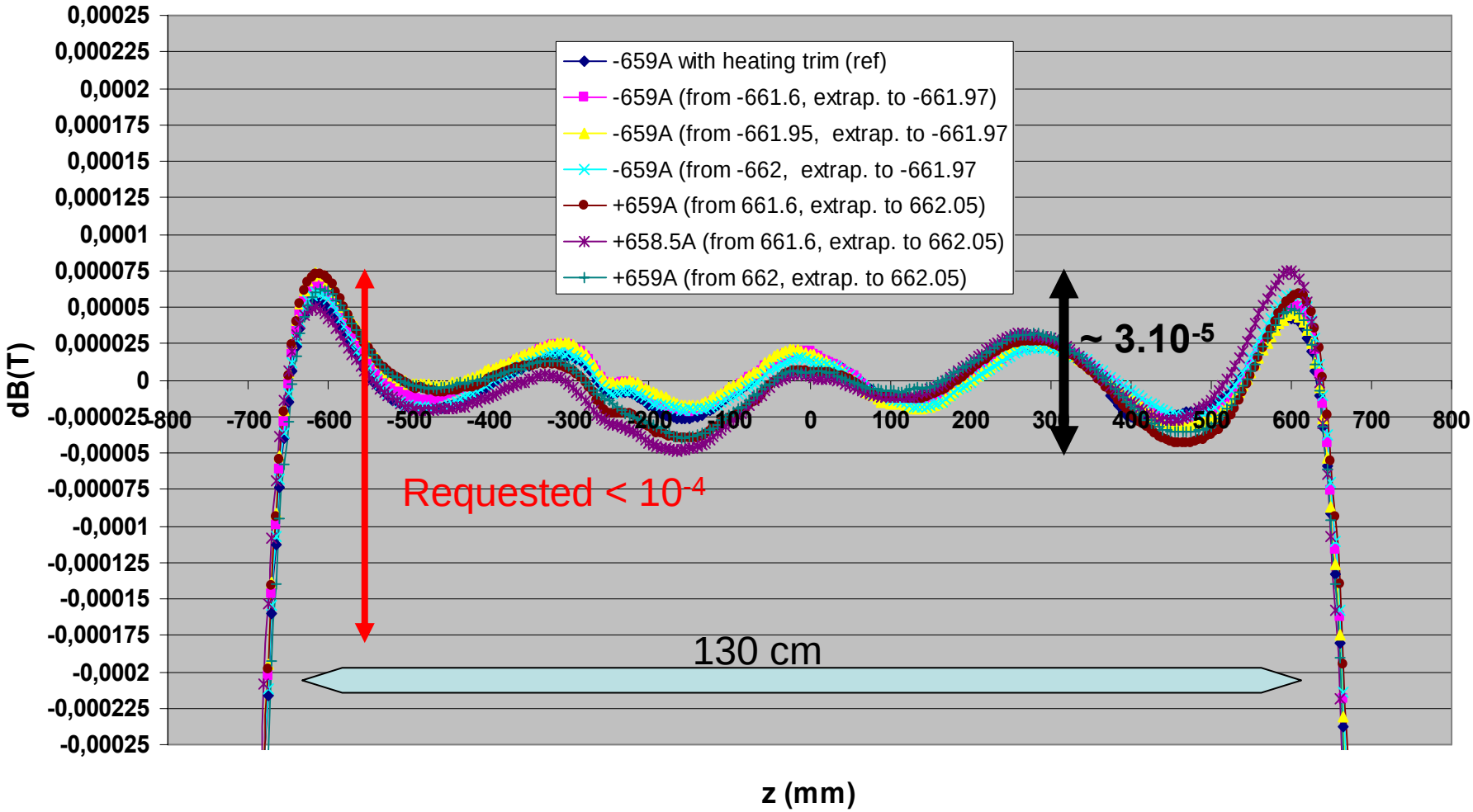
Solenoid and Trim Coils



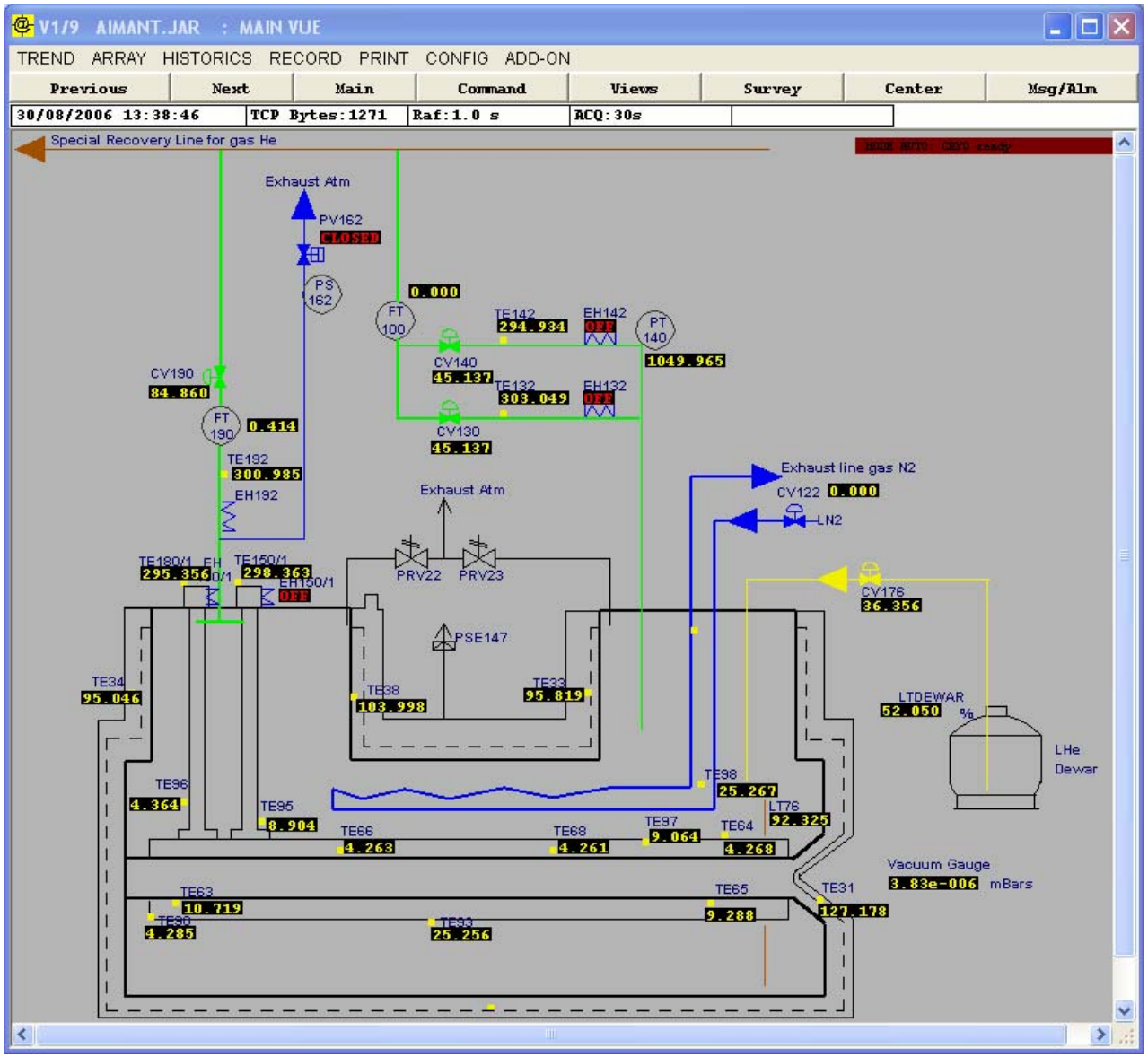
Some stages in the recent magnet's history …

- End of 2004 : OD delivered target solenoid at CEA/Saclay in order to be tested and instrumented (cryogenic control, operation slow control and electric diagnosis& protect)
- February 2005: cold leak appeared during the 1st cool down
- April 2005: magnet energized for the first time : quench
  - one of 16 correction coils ("G2") developed a superconducting short circuit
  - could not be repaired
  - strong coupling between shorted trim coil G2 and solenoid
  - each time solenoid/trim field is modified, G2 get loaded and could trigger the magnet safety system to start a quench
- Special procedure implemented for reliable magnet operation (start, field rotation, ..)
- Reproducible field uniformity (**~ 3.10^{-5}**) achieved on the target volume
- November 2005 : magnet delivered at CERN
- Installation and commissioning from December 2005 to June 2006

Field homogeneity achieved at Saclay

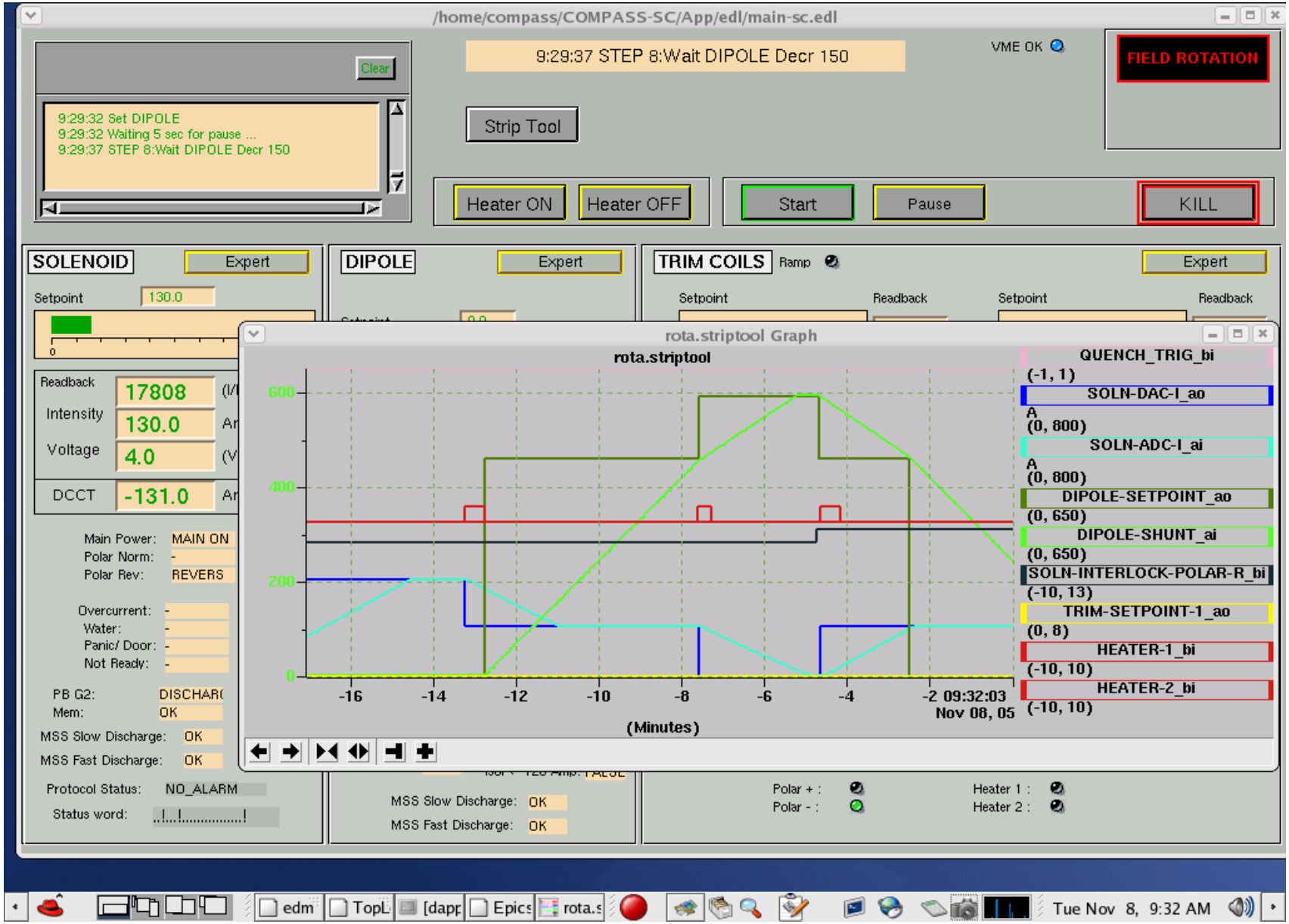


The automatic cryogenic control system of the magnet



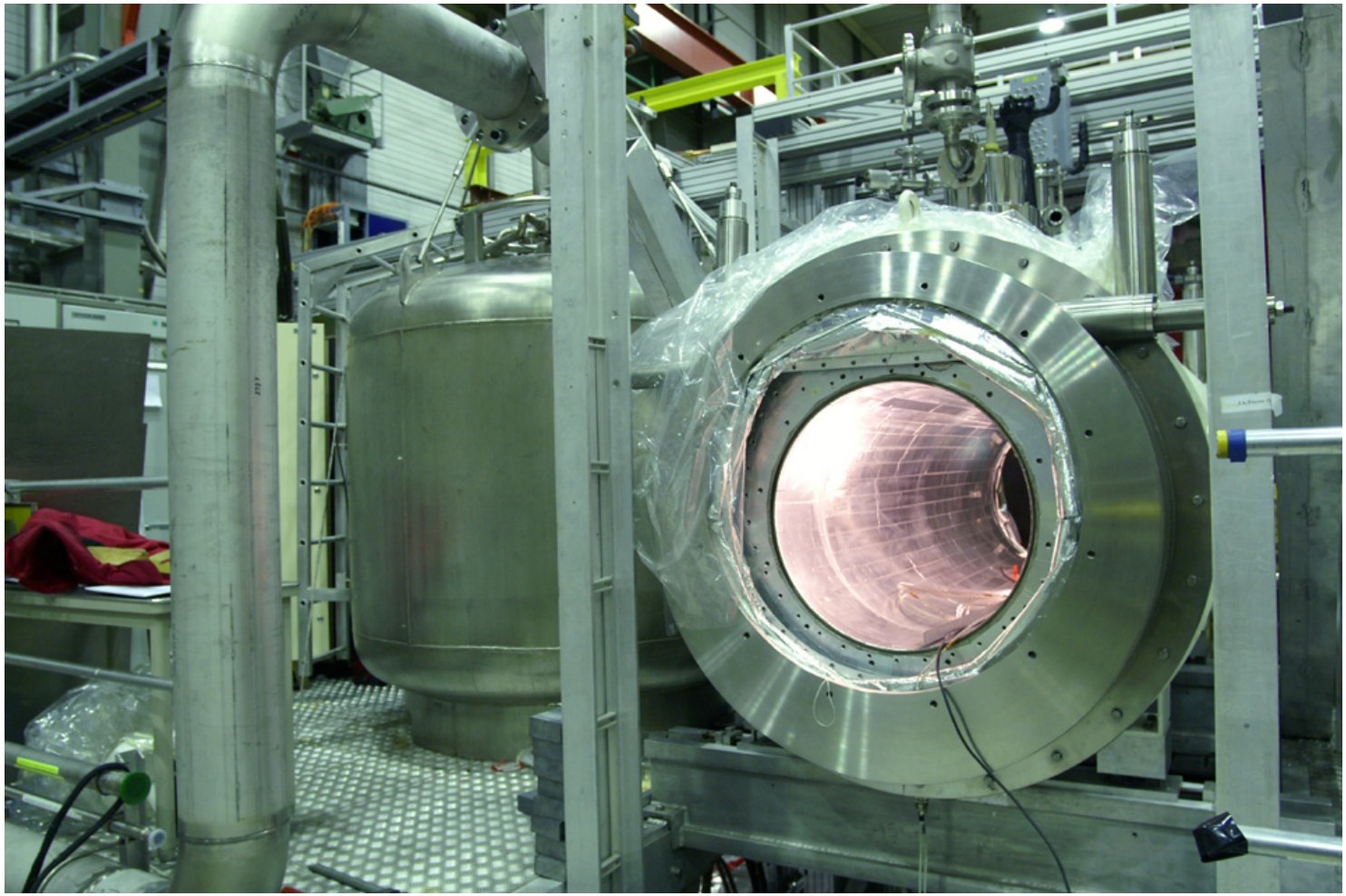
1. Control
2. Remote monitoring
3. DAQ
4. Diagnosis tool

User interface of magnet slow control



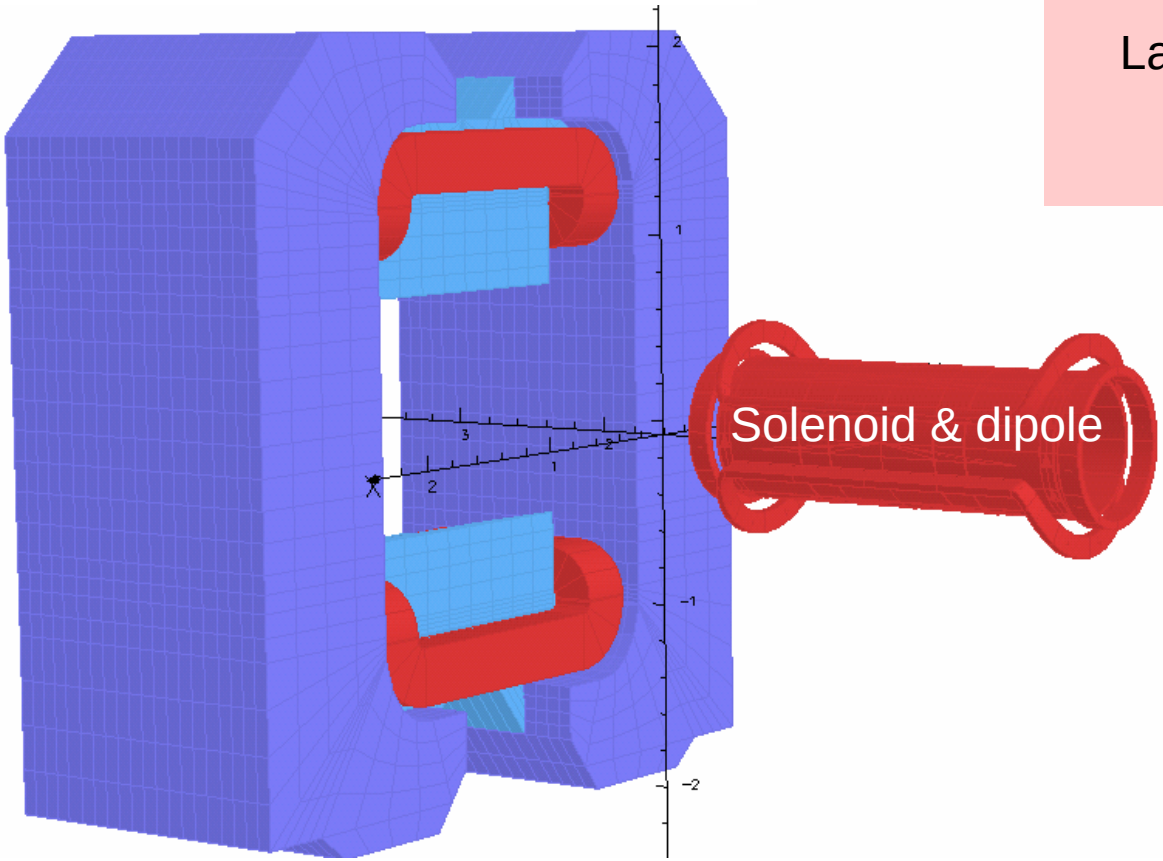
Magnet installed on the target platform

SMC (70mrad) ⇨ COMPASS (180 mrad)



Magnetic environment of the target

First spectrometer magnet
"SM1"



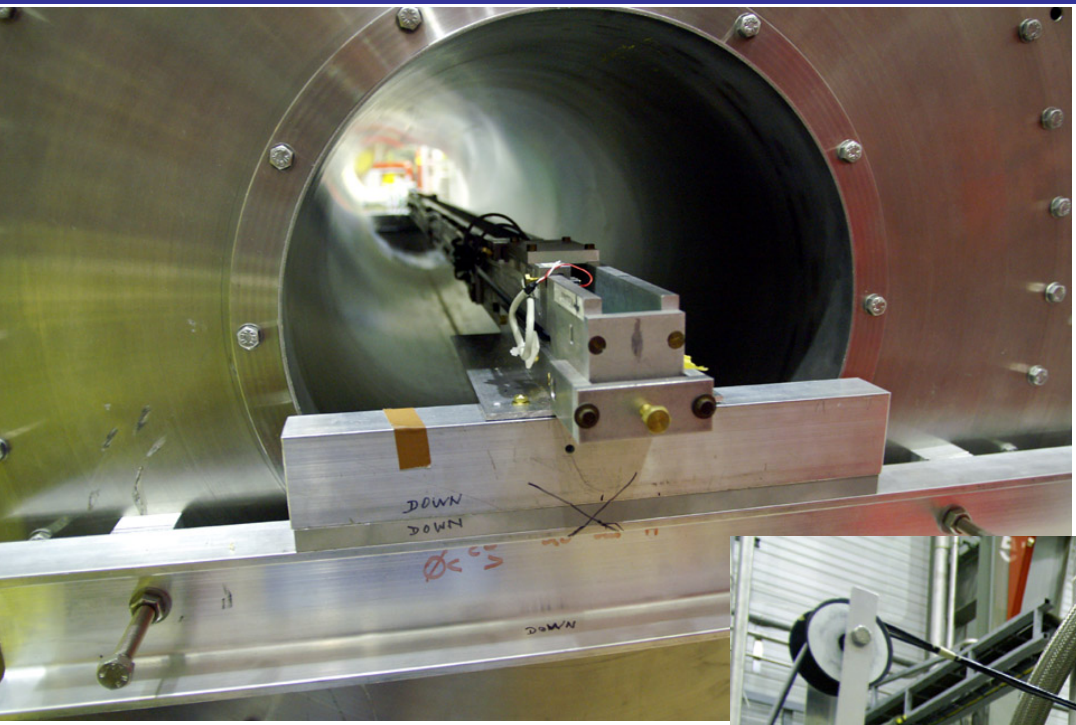
Large acceptance solenoid
= strong fringe field
+
Large amount of iron in the vicinity of the solenoid

Solenoid field influenced

Field re-measured in situ

Correction coils settings for homogeneity $<10^{-4}$ over 130 cm

Field mapping in the real environment

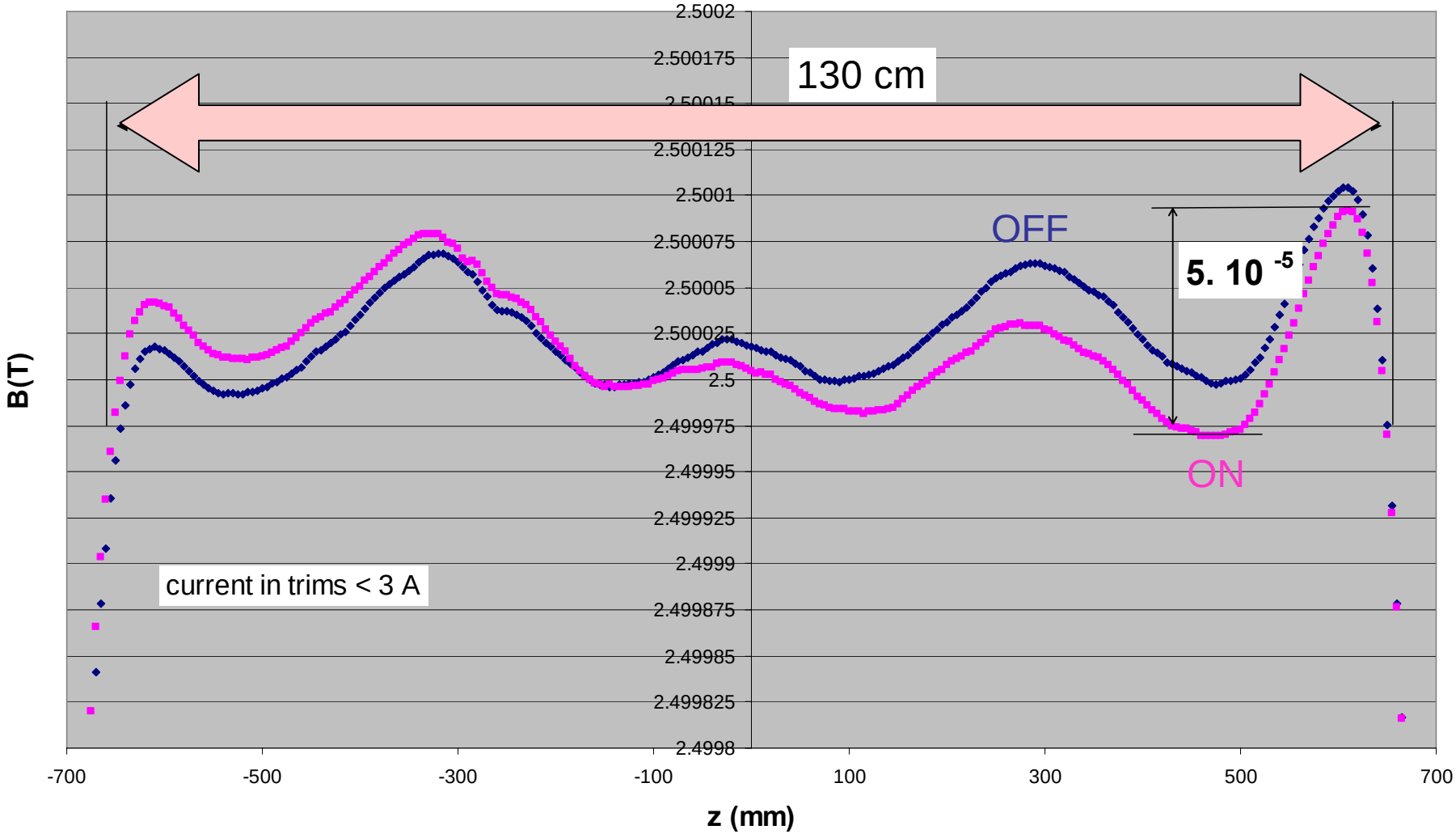


Bench for the field mapping

- Hall probe
- Flux coil
- NMR probe

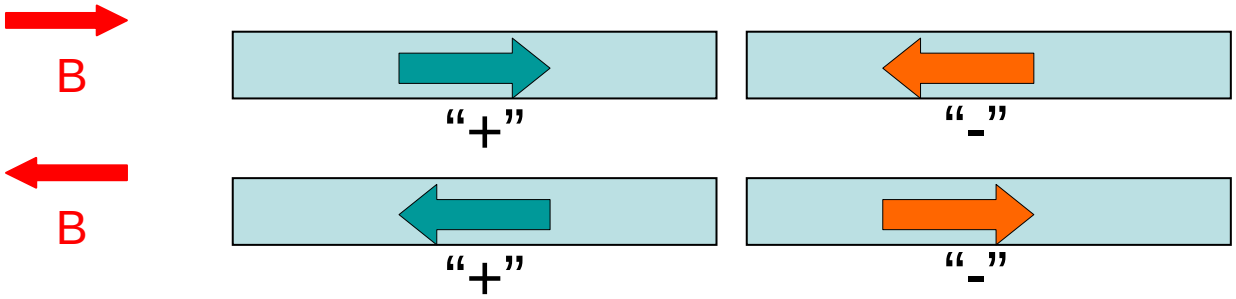
Homogeneity checked within the target volume

Magnetic field homogeneity when SM1 ON or OFF



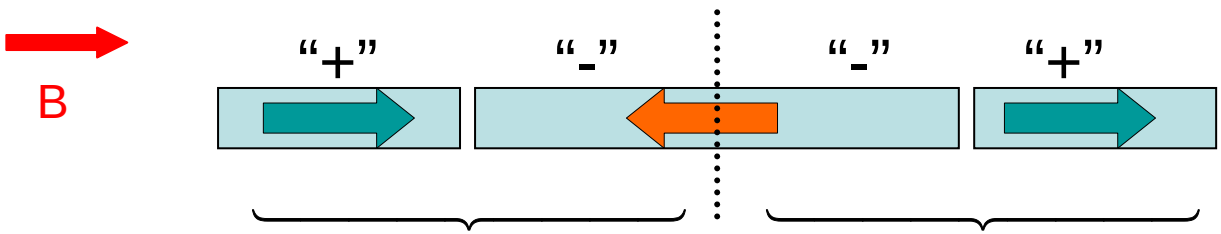
Against false asymmetries: 3 target cells

- 1st configuration (up to 2004): 2 target cells oppositely polarized (reversed by magnetic field rotation)



Only microwaves can reverse polarization wrt to magnetic field !

- 2nd configuration: 3 target cells = 2 opposite configurations simultaneously

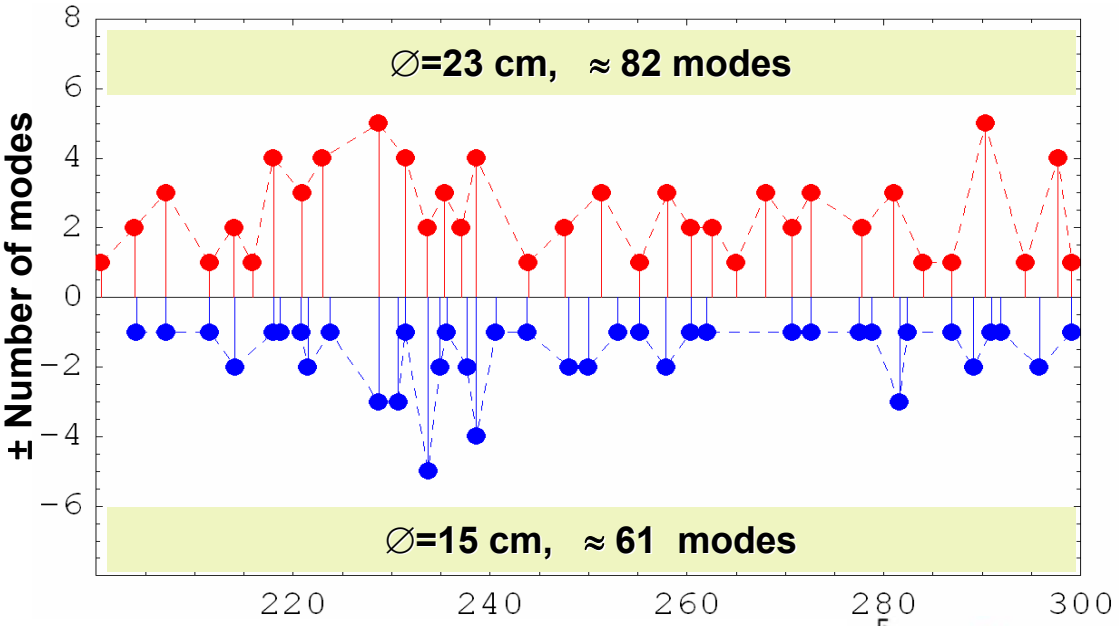


From the existing data: false asymmetries reduced by factor ~10

The new microwave cavity

Requests for the new cavity

1. To match the larger solenoid acceptance
2. To provide the proper polarizing environment for the 3-cells target
3. To provide the best spatial microwave uniformity in the target material as required for a uniform polarization
4. To provide enough resonant excitations of a cavity with high microwave intensity

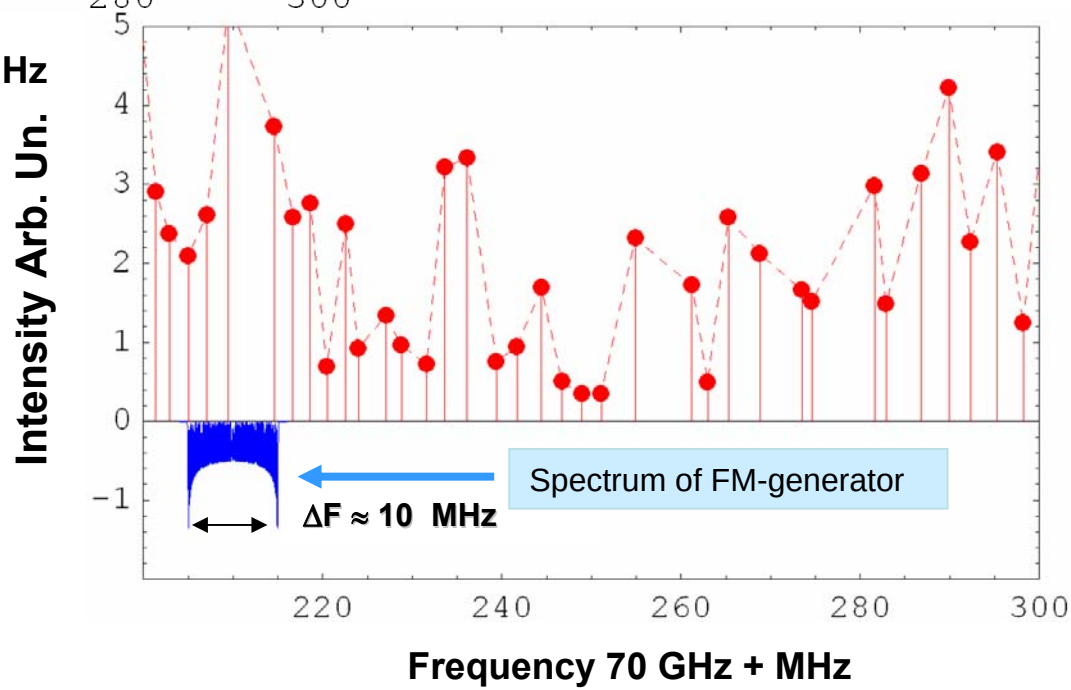


Result of the calculation for cylindrical cavity of different diameter:

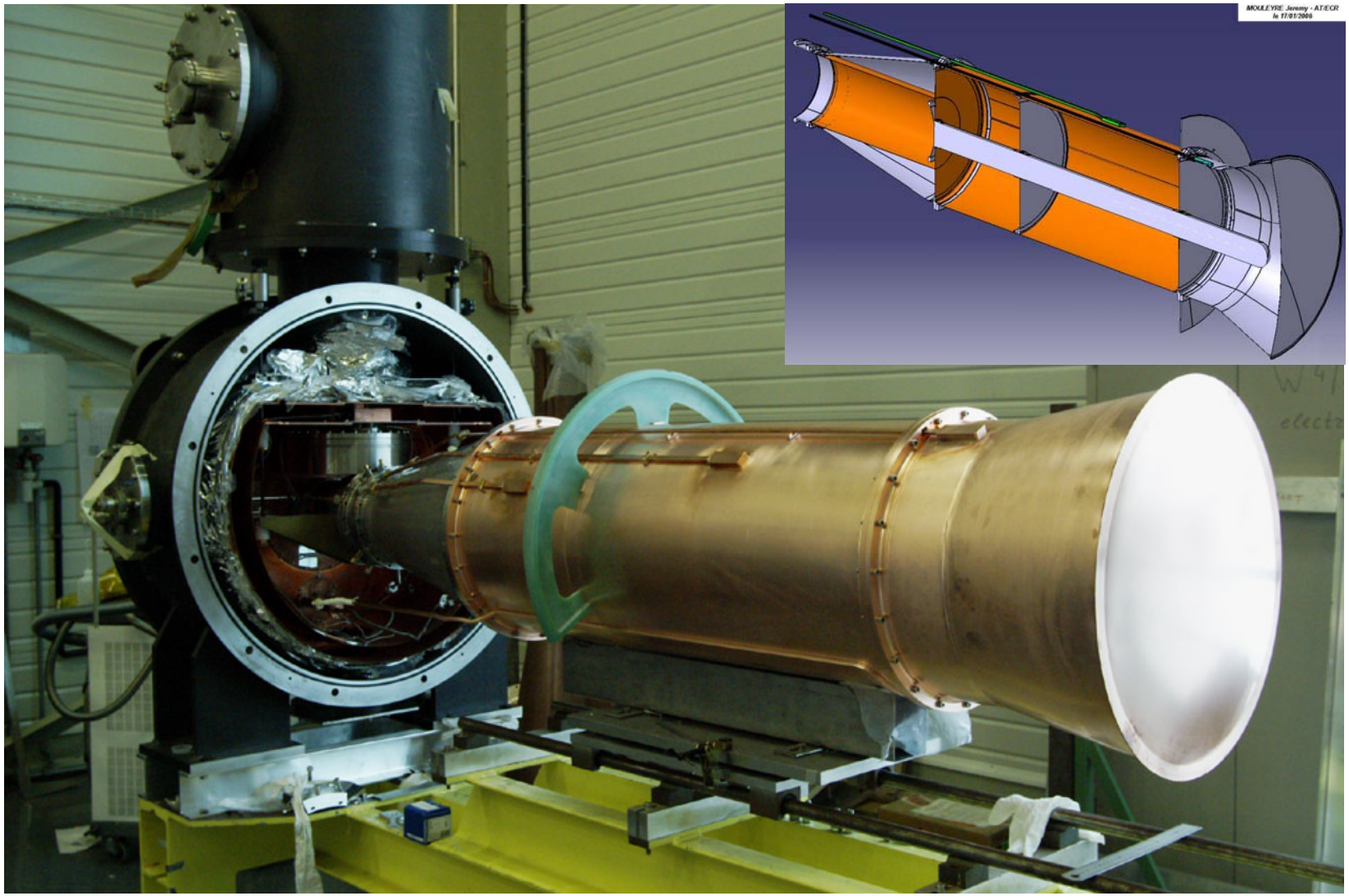
The number of excited modes increases with cavity diameter

Experimental measurements confirm calculations:

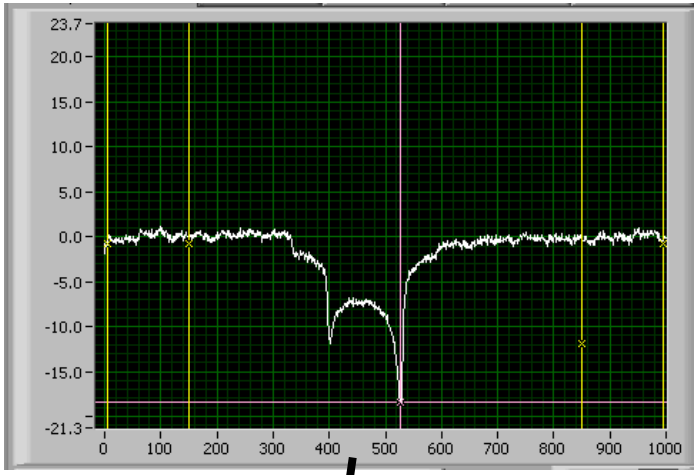
Excited mode density ~4 per 10 MHz



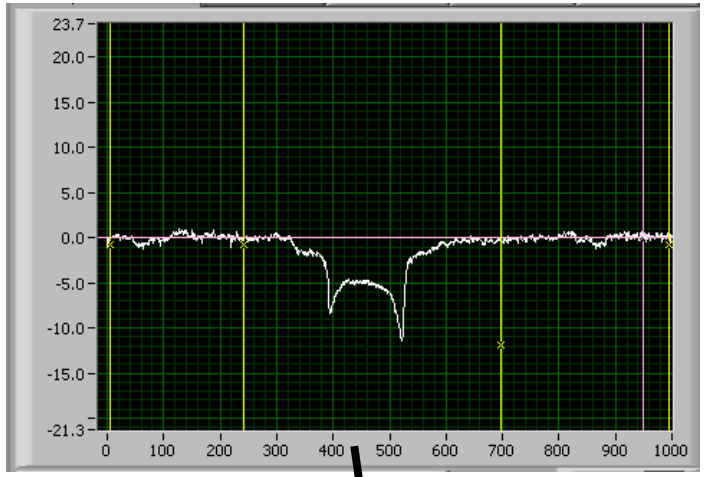
The microwave cavity fully assembled on the refrigerator



First polarization with our new set-up (measured June 14th)



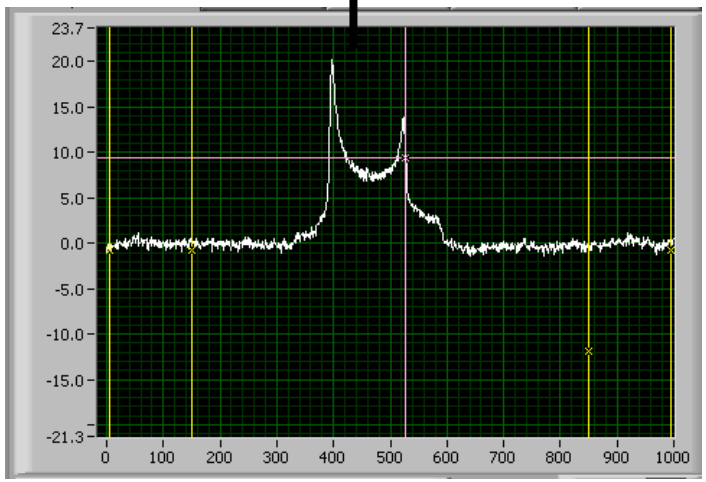
D-butanol



Upstream cell

Central cell

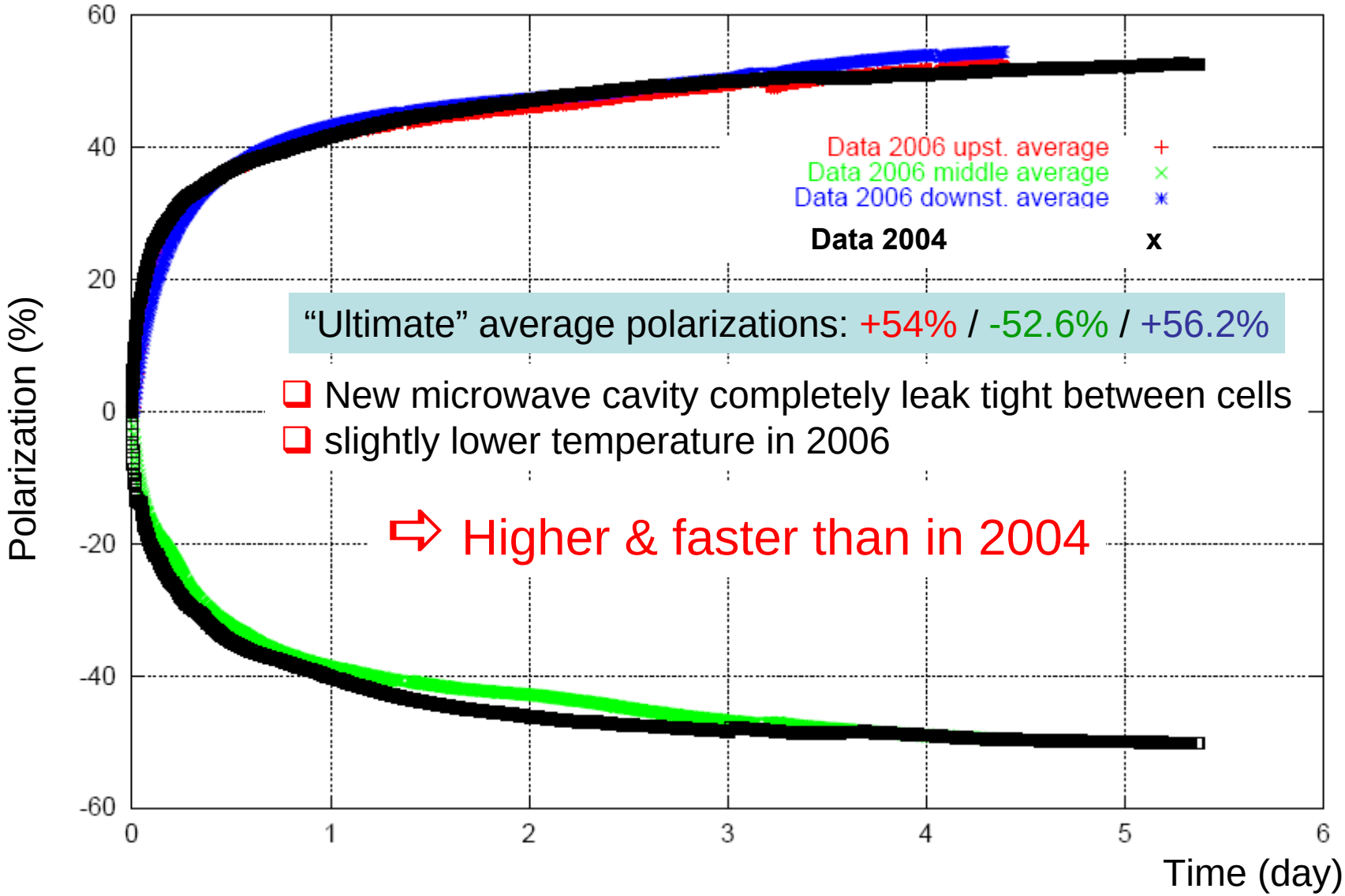
Downstream cell



P=~36% in ~ 3 hours

^{6}LiD polarization performances in 2006

Preliminary results



"Ultimate" average polarizations: +54% / -52.6% / +56.2%

- New microwave cavity completely leak tight between cells
- slightly lower temperature in 2006

⇨ Higher & faster than in 2004

Conclusion

A major upgrade of the COMPASS target made during the 2005 SPS shutdown

New magnet + new microwave cavity + 3-cell target

+ several serious technical problems making the preparation longer

Was not an easy challenge

BUT

- magnet achieved an excellent field homogeneity and works reliably.
- microwave cavity has an optimized design to get the highest achievable polarization
- Very high average polarization obtained at the very first tentative with ^{6}LiD

further improvements to finalize…

- Polarization procedure for proton target (NH_3)
- Proton transverse spin mode

} to be commissioned !