

# COMPASS Polarized Target: Polarization measurement

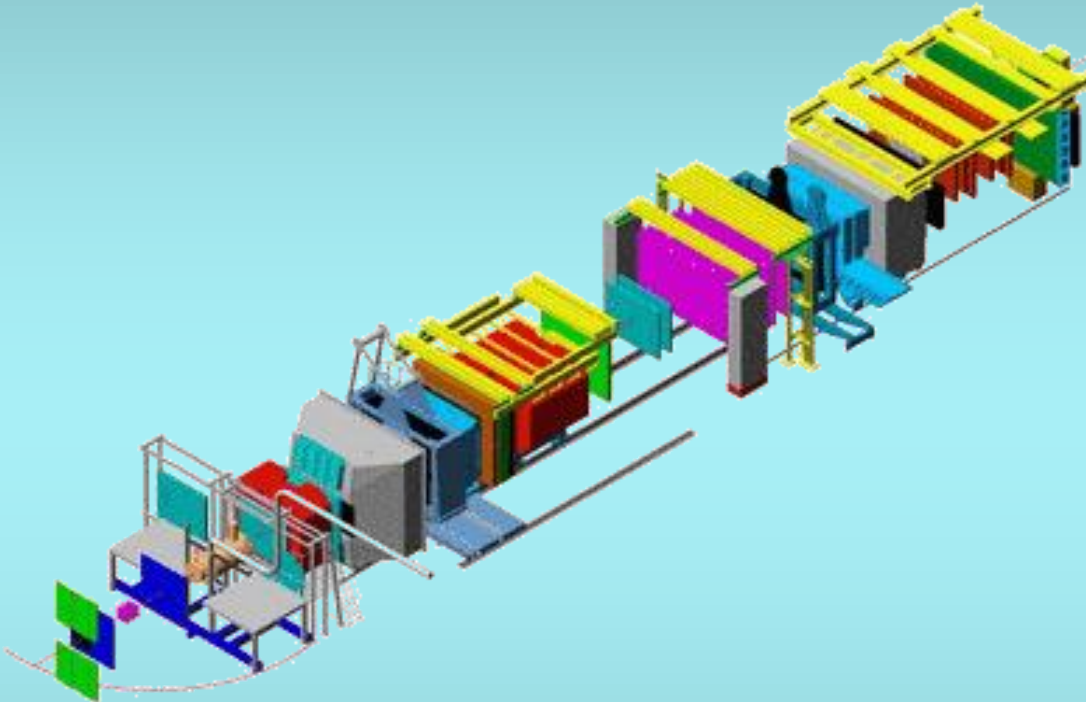
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Spin Praha 13.7.2013

# Outline

- 1) COMPASS experiment
- 2) Polarized target
- 3) Polarization measurement and results
- 4) Conclusion

# COMPASS experiment

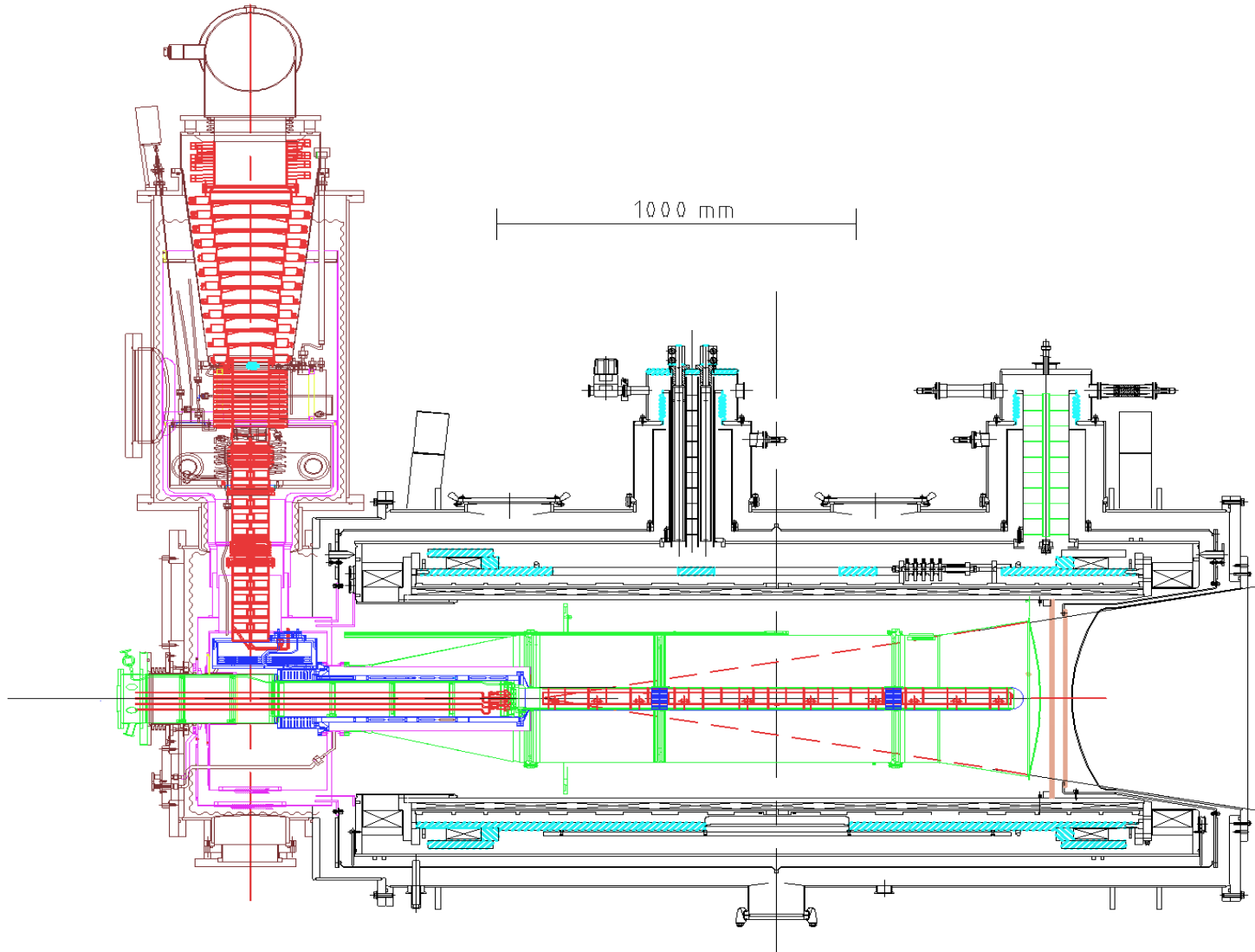


- Two-stage spectrometer+polarized target
- Secondary 160 GeV/c  $\mu$  highly polarized beam from SPS
- Measurement of spin asymmetries

# PT – basic facts

- Dilution refrigerator 5mW@75mK
- SC magnet 0.6T dipole/2.5T solenoid
- Homogeneity of magnetic field  $\sim 10^{-5}$ T
- 10 NMR coils for polarization measurement
- 3 cells in configuration 3-4-3
- Solid  $\text{NH}_3$  (or  ${}^6\text{LiD}$  in past) in form of small balls
- LabView for data taking

# Layout of the target



NMR PC

target\_single\_rate\_variables.vi on HMRPX1 (type) (M45) (HMR\_PX12)

The Network Variable Engine and Variable Client Support must be installed on the BE target. For the application to function properly, if the Network Variable Engine is not supported on the target (e.g., PP-2000 with c3298 of B2M), open the project and move the variable library to the computer in the project. Doing this will deploy the variables to local but will still require that Variable Client Support be installed on the BE target.

HPX1 (HMR).vi

STOP acquire signal (F1) acquire baseline (F2) load by file save signal Mode: Acquisition

Calculation Save signals Auto Acquire Connect DB

Every 1.000 seconds

NMR Parameter

Center Frequency (MHz) 50.47 Gain 1

Scan Width (MHz) 600 Sweep up

Channels 1024 Sweep down

Sweep 1

TrigIn 32 > 25 DC offset trigger

Date and Time: 17.08.2010 05:42:20

path: C:\NMR\DATA\2010

Last Signal File: NMR\DATA\2010\TR100817\_053607.sig

Background File: NMR\DATA\2010\100817\_125602.bpr

Message Log

Signal View Polarization History Magnet and Transmitter Signal File View Global Parameters

PlotArea.vi

STOP SAVE DATA CLEAR DATA LOAD DATA polarization [v] rel. time [h]

Average Polarization: upstream 80.00 middle 79.47 downstream 78.32

see history table clear table

col 1 col 2 col 3 col 4 col 5 col 6 col 7 col 8 col 9 col 10

start time: 01/12/2010 13:05:23

DELL

# Polarization measurement

- Spin  $\frac{1}{2}$  ensemble - protons in  $\text{NH}_3$   $P = \frac{n_+ - n_-}{n_+ + n_-}$
- Thermal equilibrium of lattice and nuclei  $\Rightarrow P$  can be calculated 
$$P_{TE} = \tanh\left(\frac{\hbar\gamma B_0}{2k_B T}\right)$$
- $P_{TE}$  - very small -  $P=0.25\%$  for protons at 2.5 T and 1 K
- Can be measured by NMR  $\Rightarrow P \sim S_{\text{NMR}}$   
 $\Rightarrow$  idea of TE calibration

# Measurement using NMR

- Actually measurement of susceptibility

$$P \propto \int \chi''(\omega) d\omega$$

- Inductance of coil with material

$$L(\omega) = L_0 [1 + \mu_0 \eta \chi(\omega)]$$

- Measured using Q-meter

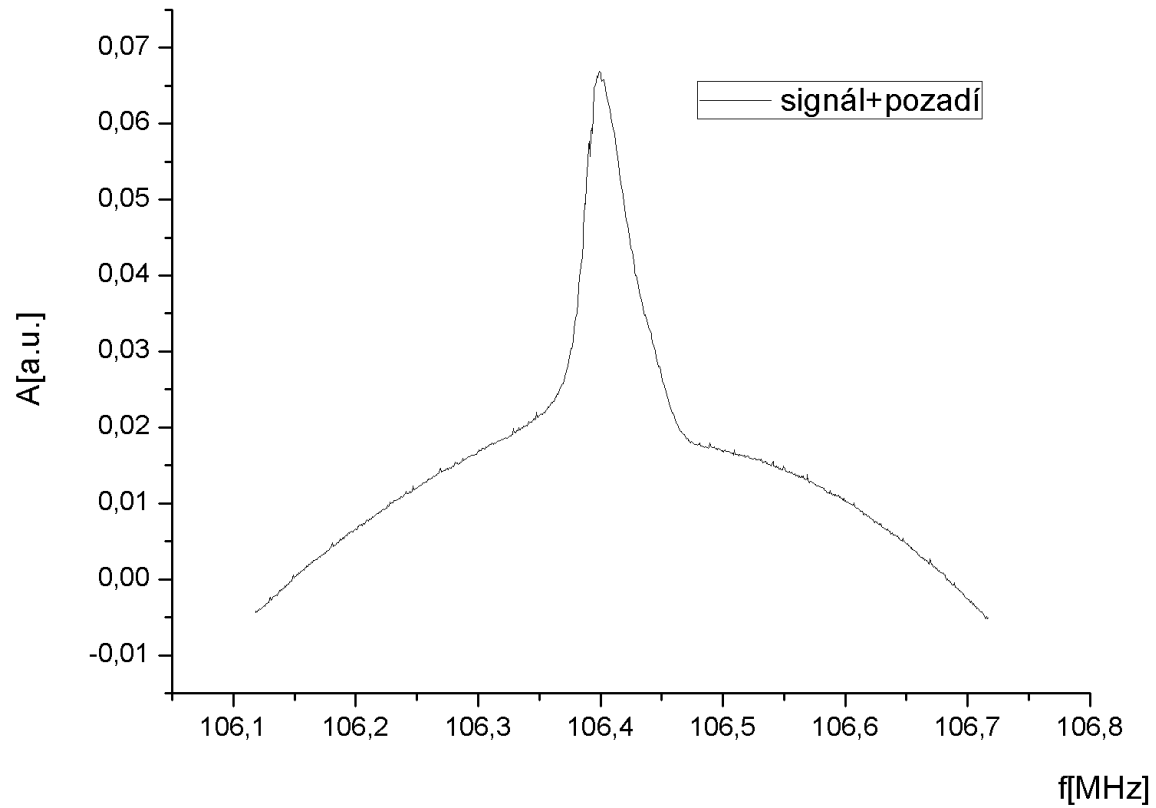
$$V_{NMR}(\omega) \propto \chi''(\omega)$$



# TE calibration

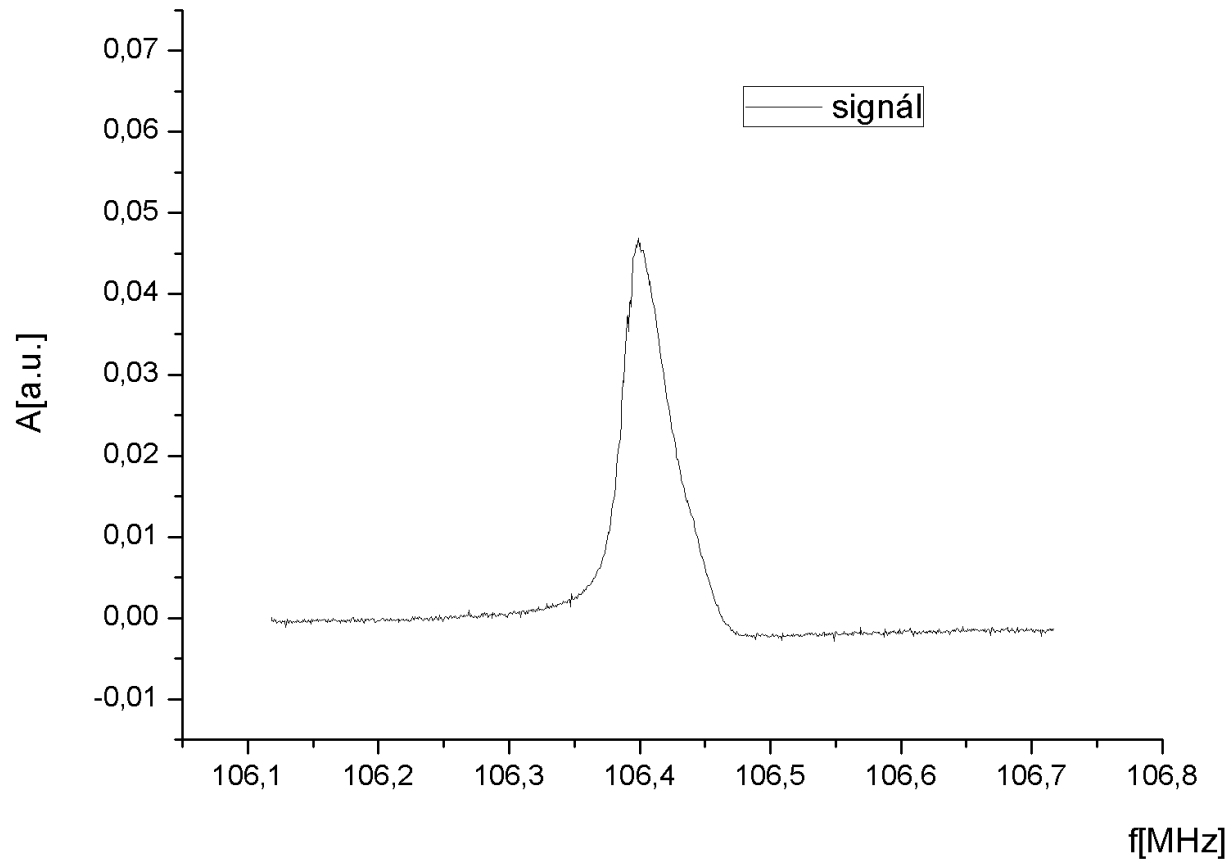
- NMR measurement in target with and without material
- Several different temperatures
- Before and after run
- Analysis is rather delicate ( $S_{TE}$  is small, parasitic signal from target material holder,..)

# TE calibration

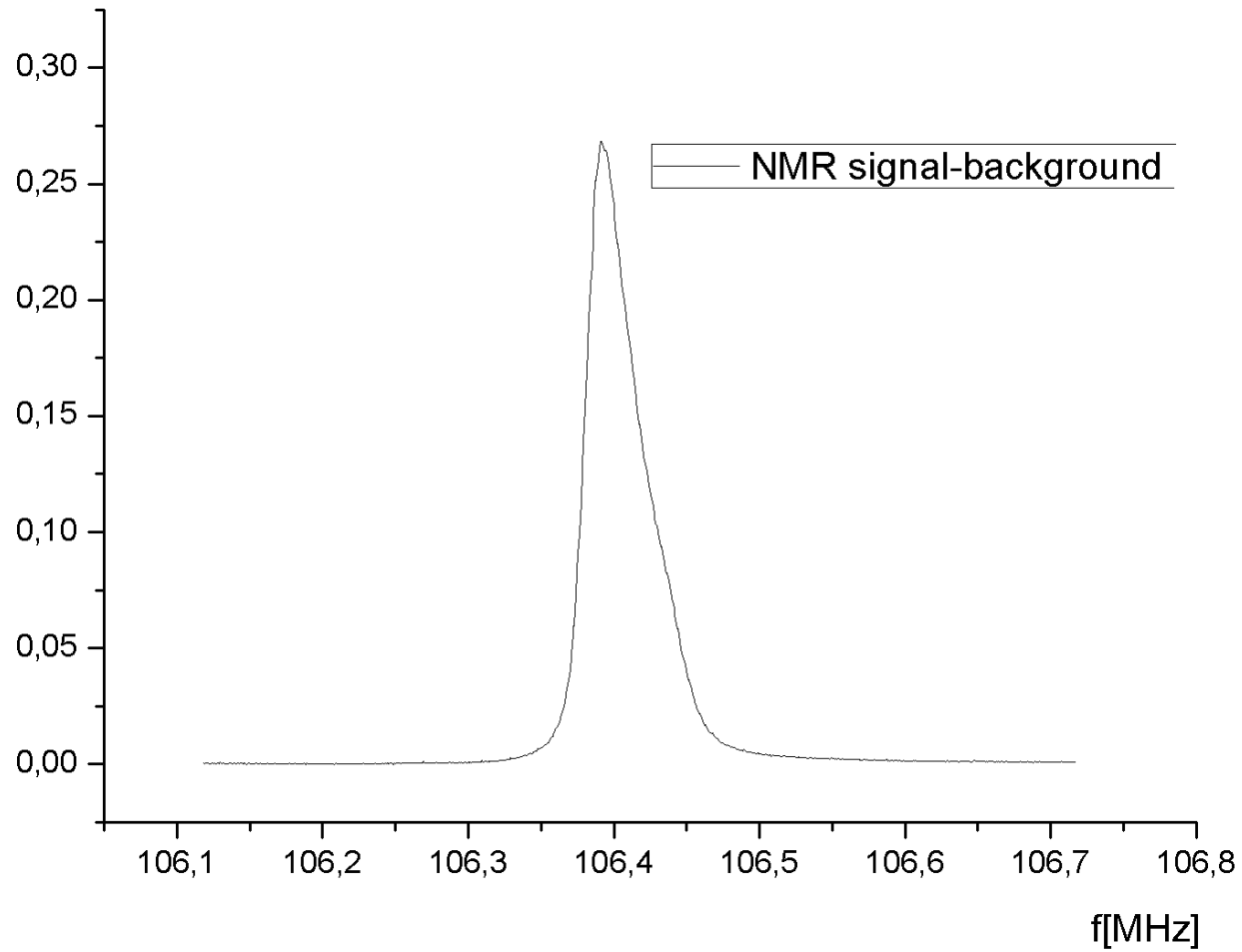


app 200x. amplified

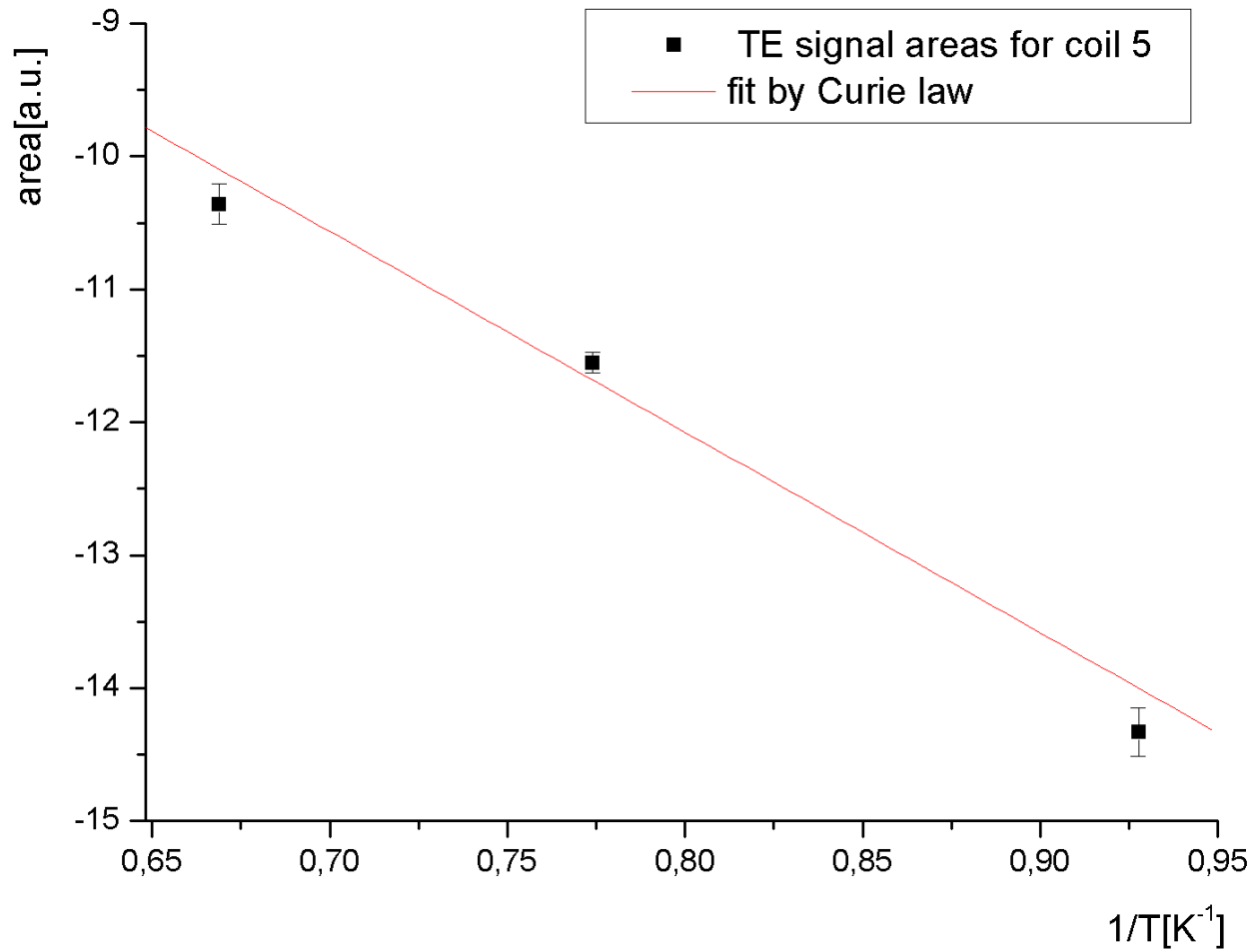
# TE calibration



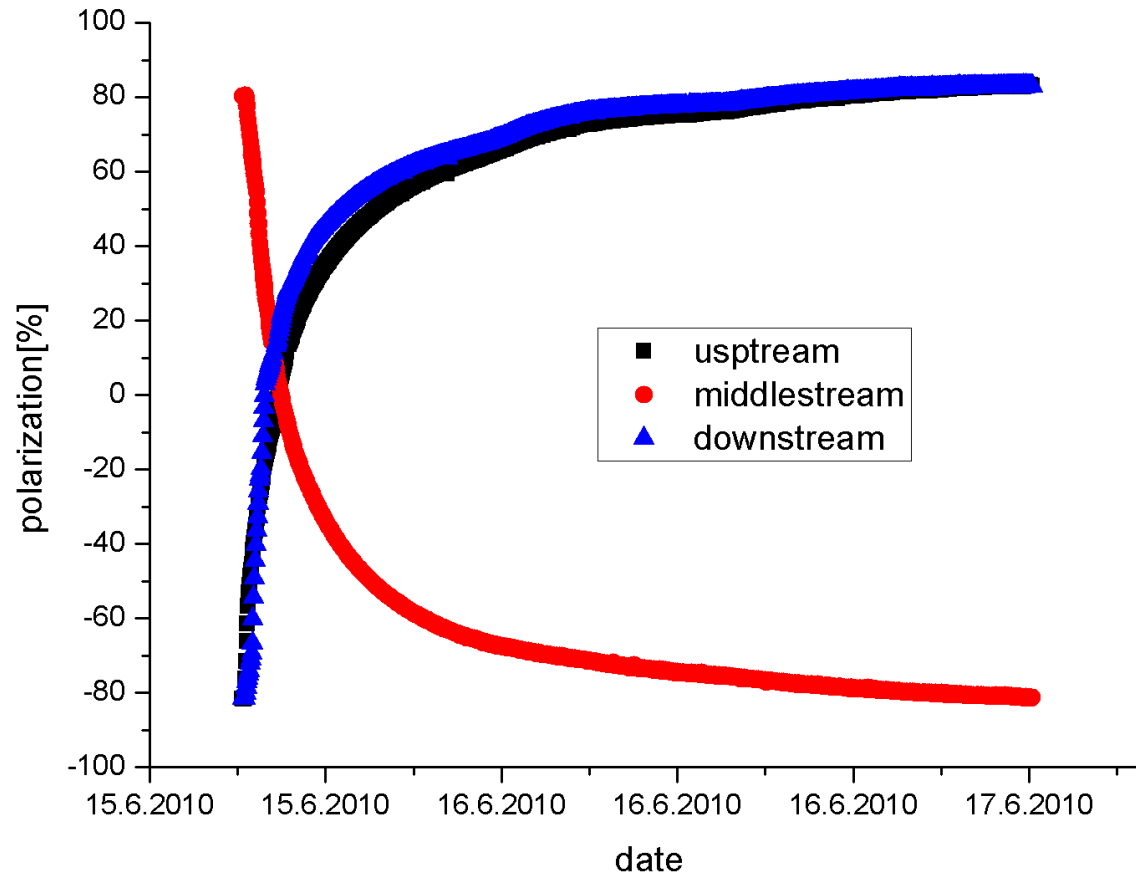
# Enhanced signal



# TE calibration



- Example of polarization buildup in 2010



# Relaxation rates

- Relaxation of polarization very slow in 0.6T dipole (even slower in 2.5T solenoid)=>

$$T_{\text{up}} = (7,0 \pm 1,7) \cdot 10^3 \text{h}$$

$$T_{\text{middle}} = (5,7 \pm 0,7) \cdot 10^3 \text{h}$$

$$T_{\text{down}} = (5,7 \pm 1,2) \cdot 10^3 \text{h}$$

- 2011 relaxation not determined

# Few comments of systematics

- Temperature
- TE fitting
- Circuit nonlinearities
- Field polarity
- ....



# Results on polarization

- Average polarization       $\sim 80\%$  in 2010
- $\sim 85\%$  in 2011
- Statistical uncertainty     $\sim 2.0\%$
- Systematic uncertainty    $\sim 3.5\%$

# Conclusion

- PT performed well during 2010 & 2011
- It will be used for polarized DY after modifications
- I would like to thank whole COMPASS PT group and many other members of collaboration for their hospitality and help.

Thank you for your attention