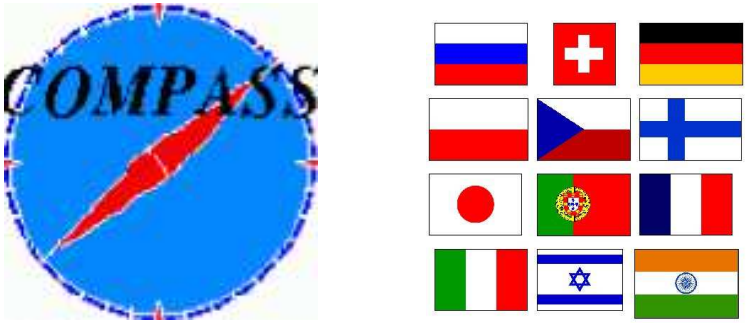
COMPASS Polarized Target

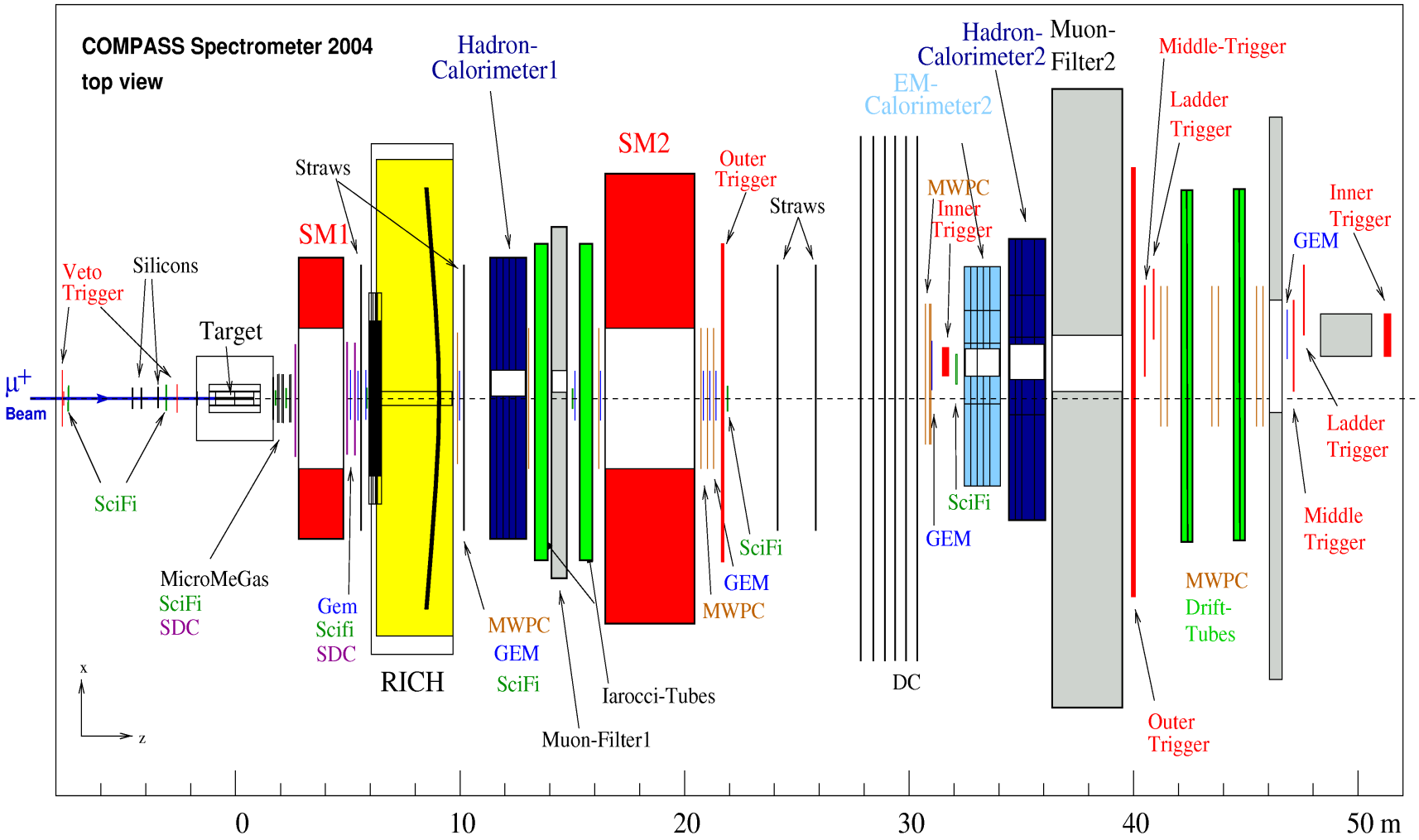


http://wwwcompass.cern.ch

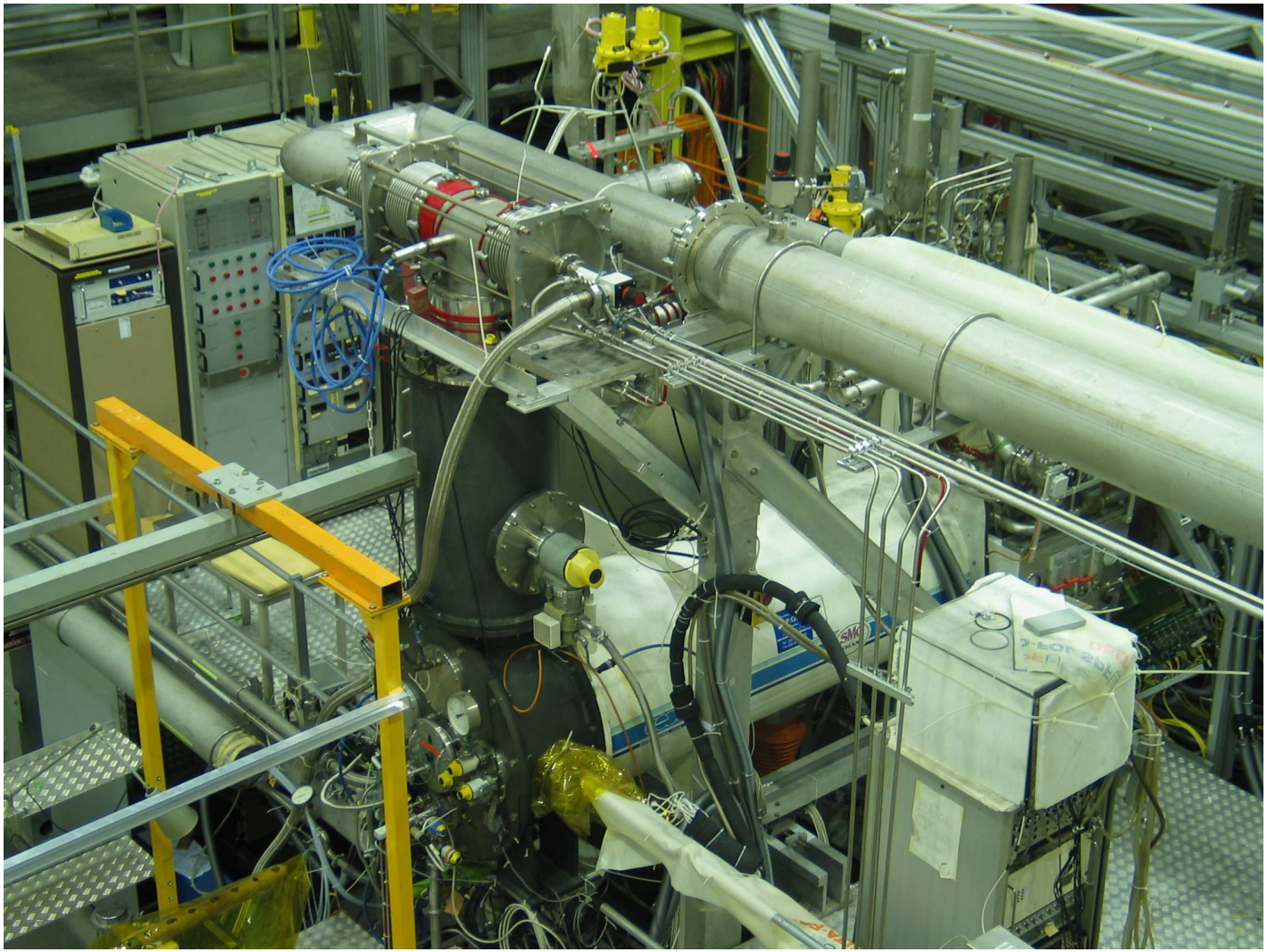
Jaakko Koivuniemi

1. **Spectrometer**
2. **Polarized target**
3. **Physics**
4. **Publications**
5. **Plans to 2006**

Spectrometer 2004



Polarized target



Target material

Pictures

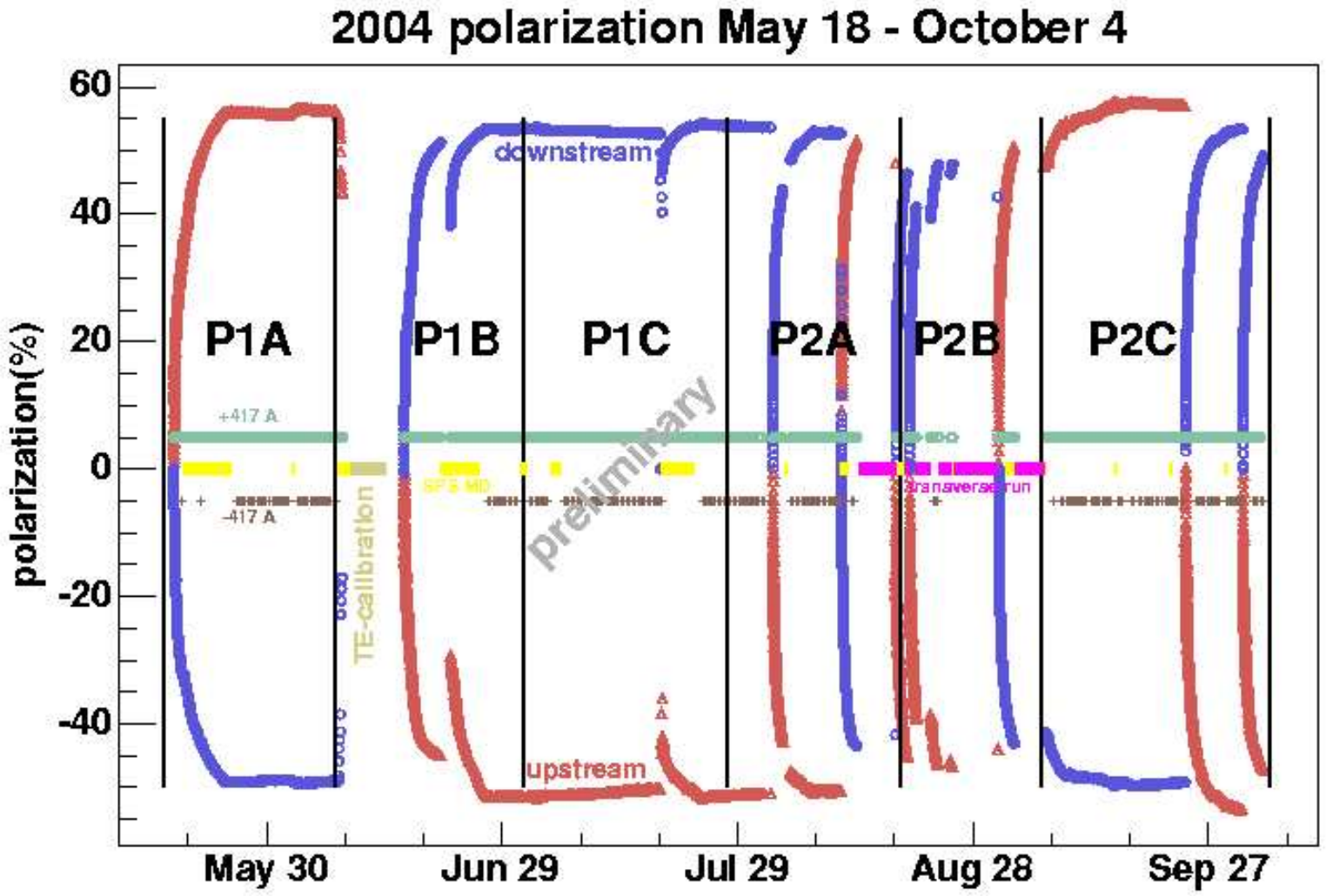
Outer coil on the target cell

Loading target

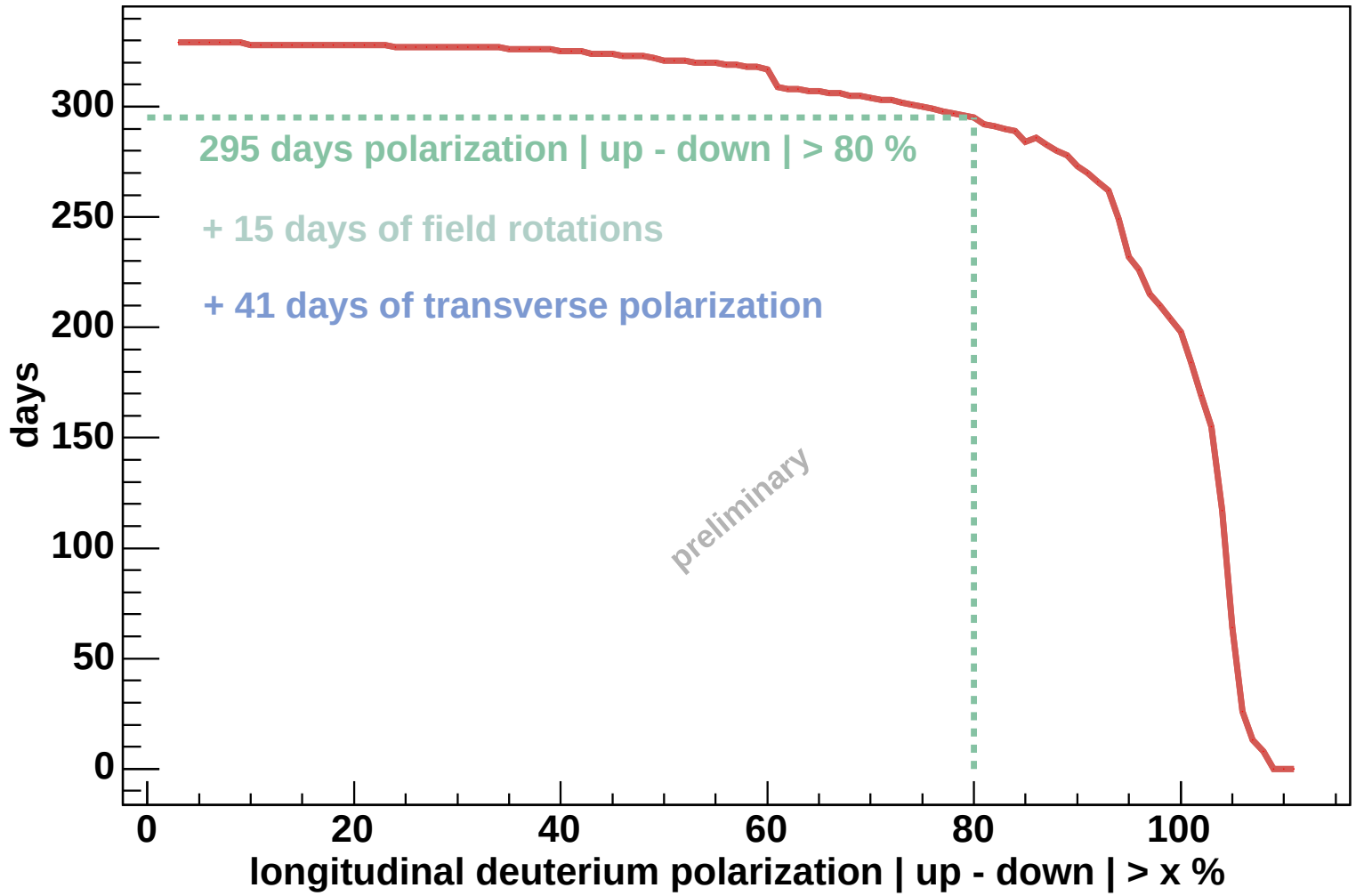
Polarized Solid Targets, 28 Oct. 2003

Kaori KONDO, Naogya Univ.

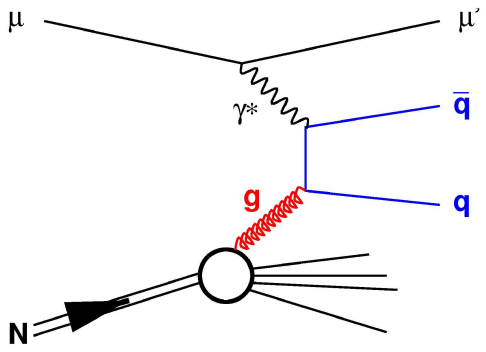
Target polarization 2004



Target availability 2001 - 2004



Deep inelastic kinematics



muon four-momentum $k_\mu = (E, \vec{k})$

virtual photon four-momentum: $q^2 = (k_\mu - k'_\mu)^2$

$Q^2 = -q^2$

probing scale: $\lambda \sim 1/Q \sim 0.06$ fm for $Q^2 \sim 10$ GeV^2

fixed target $p_{lab} = (m_n, \vec{0})$

invariant mass $W^2 = (p+q)^2 = p'^2$, p'^2 sum of outgoing hadron fragments

virtual photon energy: $\nu = E_\mu - E'_\mu \sim 50$ GeV and lifetime $\tau \sim h/\nu \sim 10^{-25}$ s

Deep inelastic kinematics

scaling variables:

$y = \nu/E$

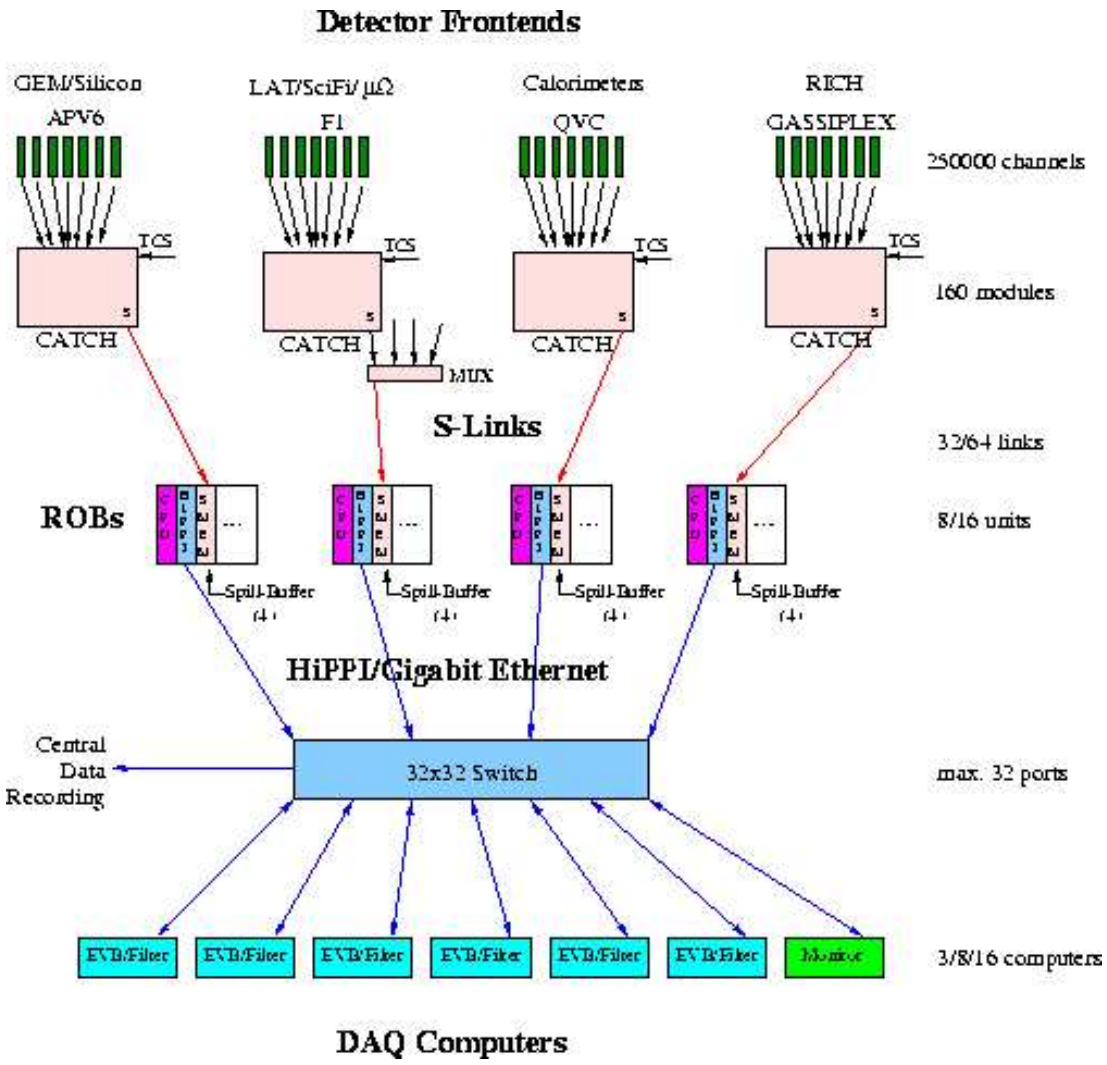
$z = E_h/(E_\mu - E'_\mu)$

Bjorken $x = \frac{Q^2}{2m_n\nu}$ or fraction of parton momentum

Measured asymmetries

- cross sectional asymmetry $A^d = \frac{\sigma^{\uparrow\downarrow} - \sigma^{\uparrow\uparrow}}{\sigma^{\uparrow\downarrow} + \sigma^{\uparrow\uparrow}} \Rightarrow$ longitudinal spin structure function g_1^d
- Collins asymmetry $A_{Coll} = \frac{\sum_q e_q^2 \cdot \Delta_T q \cdot \Delta_T^0 D_q^h}{\sum_q e_q^2 \cdot q \cdot D_q^h}$
- Sivers asymmetry $A_{Coll} = \frac{\sum_q e_q^2 \cdot \Delta_0^T q \cdot D_q^h}{\sum_q e_q^2 \cdot q \cdot D_q^h}$
- $\Delta G/G$ analysing power $a_{LL} = \frac{\Delta\sigma_{\gamma g}^{c\bar{c}}}{\sigma_{\gamma g}^{c\bar{c}}}(y, \hat{s}, Q^2, \Phi)$ (LO)

Data acquisition system



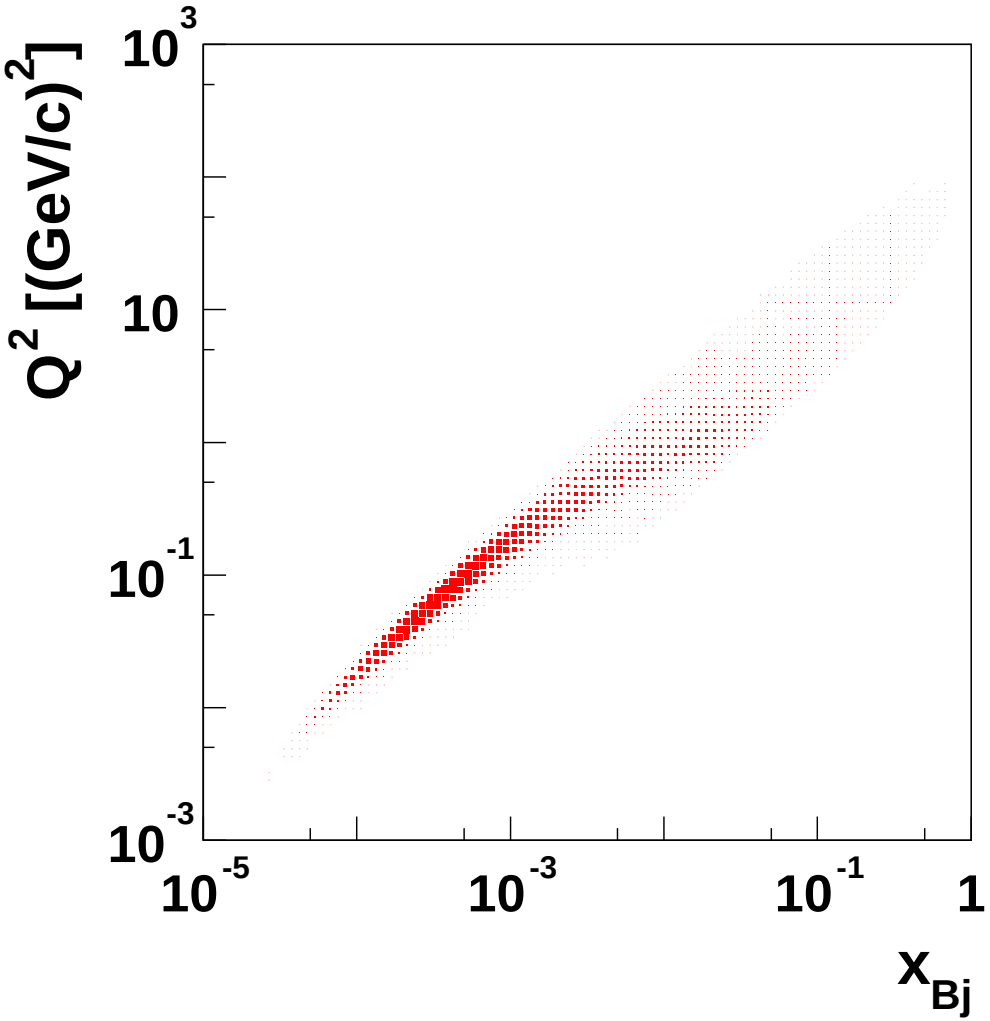
Collected data 2002 - 2004

	2002	2003	2004
data	260 TBytes	270 TBytes	450 TBytes
events	$6 \cdot 10^9$		
Λ		1 250 000	
$\bar{\Lambda}$		640 000	
D^*		1500	3800
D^0		5600	
Ξ^-		18000	
$\Xi(1530)^0$		1700	
$\Phi(1860)^{--}$		< 79	

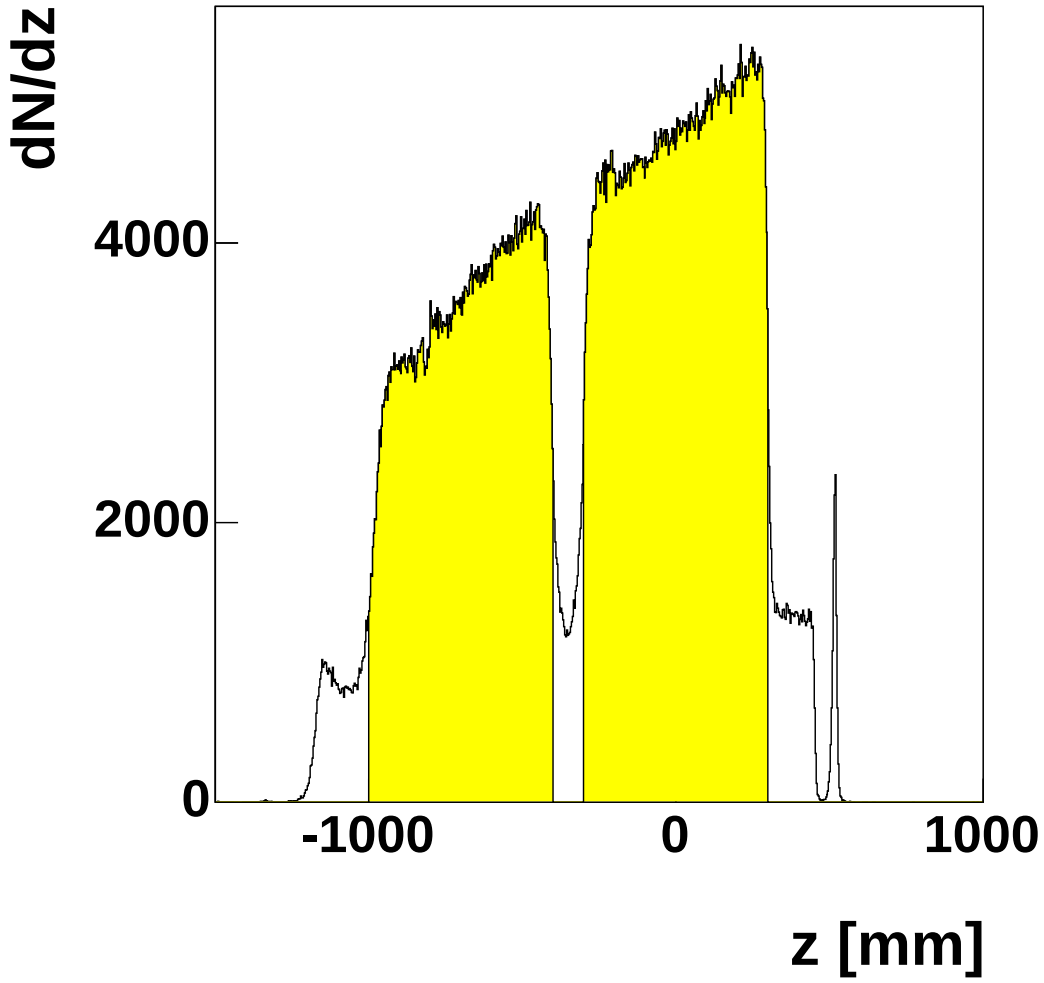
μ beam physics (release folder)

- ΔG/G: charm (D_0, D^*), high p_T (low Q^2, high Q^2)
- longitudinal spin asymmetry A_1^d and spin dependent structure function g_1^d in range 1 GeV^2 < Q^2 < 100 GeV^2 and $0.004 < x < 0.7$
- Λ and $\bar{\Lambda}$ longitudinal polarization, COMPASS note 2005-4
- transversity: 2 hadrons, Collins-Sivers asymmetries, Λ
- exclusive: J/Ψ, ρ
- search for $\Phi(1860)$ pentaquark:
$\Phi(1860) \to \Xi^-\pi^- \to \Lambda\pi^-\pi^- \to p\pi^-\pi^-\pi^-$, comparison with
$\Xi(1530)^0 \to \Xi^-\pi^+$, CERN-PH-EP/2005-009

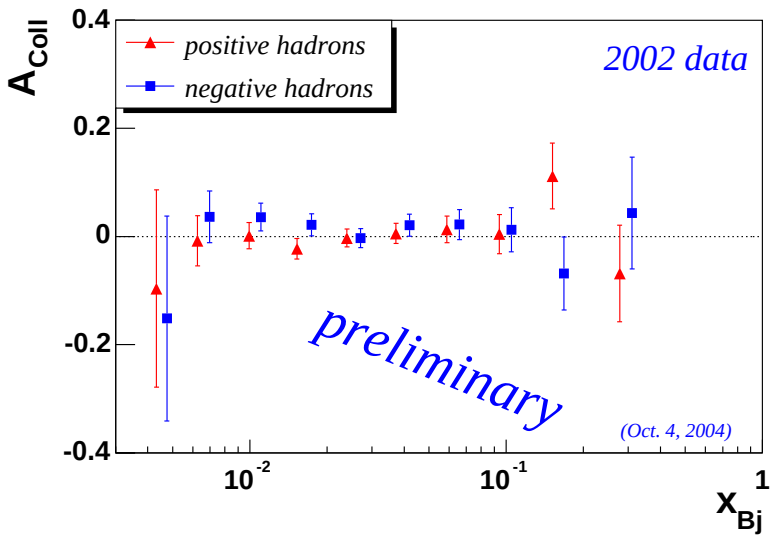
Triggers: transversity kinematics

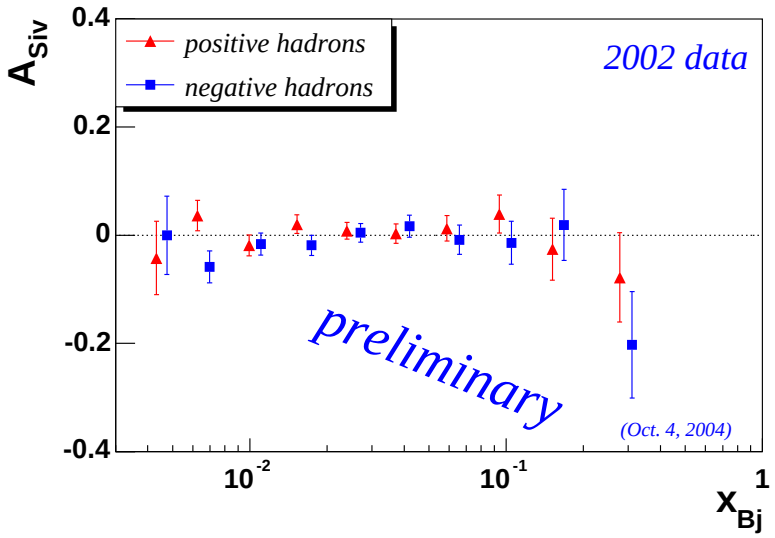


Transversity vertices: geometrical cuts

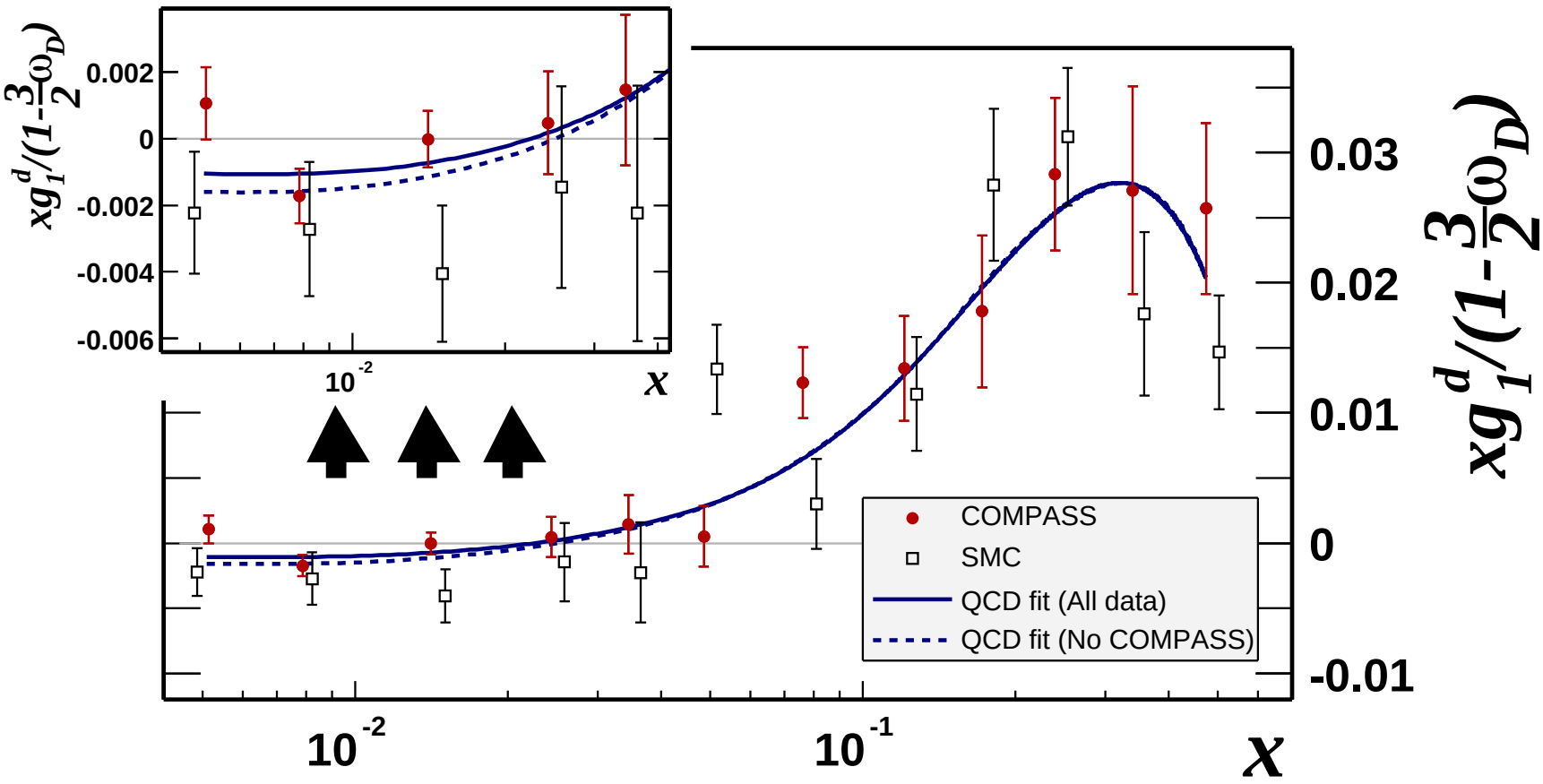


Collins and Sivers asymmetry

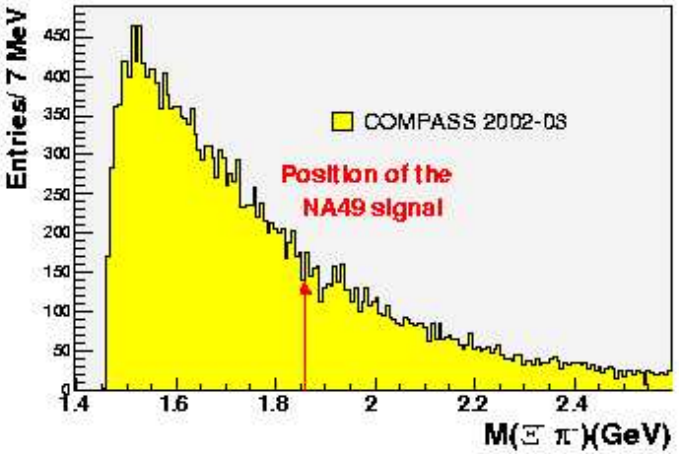


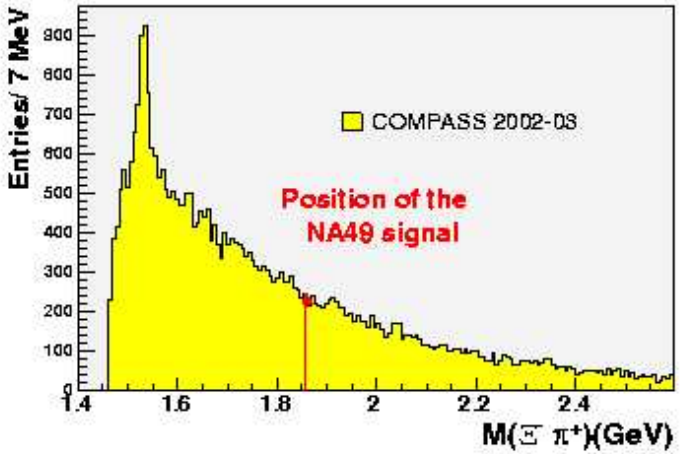


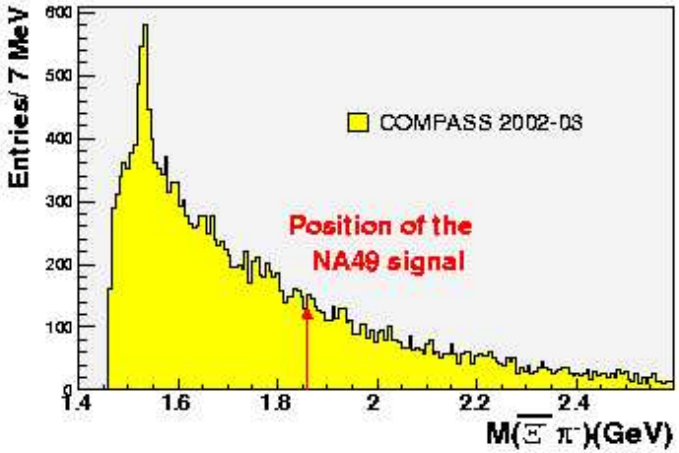
Deuteron spin structure function

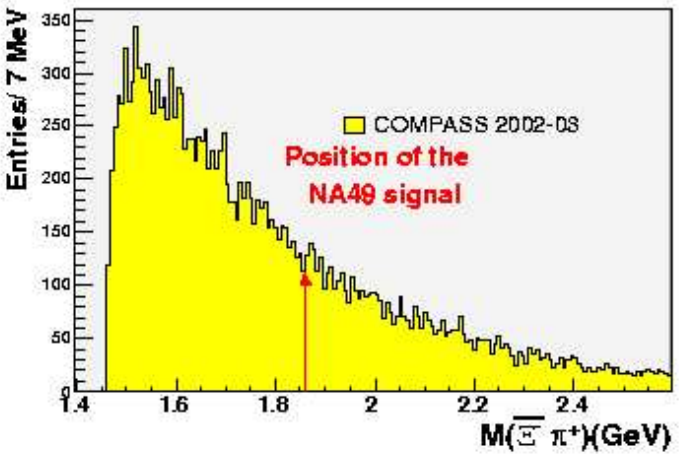


$\Phi(1860)^{--}$ pentaquark search









Collaboration papers

- Measurement of the spin structure of the deuteron in the DIS region, PLB **612** (2005) 154
- First measurement of the transverse spin asymmetries of the deuteron in semi-inclusive deep inelastic scattering, PRL **94** (2005) 202002
- Search for the $\Phi(1860)$ pentaquark at COMPASS, EPJ

Target papers

- P. Berglund et al., Dilution refrigerator for COMPASS polarized target, Physica B **248 - 288** (2000) 2012-2013
- J. Ball et al., First results of the large COMPASS 6LiD polarized target, NIMA **498** (2003) 101-111
- K. Kondo et al., Polarization measurement in the COMPASS polarized target, NIMA **526** (2004) 70-75
- J. Koivuniemi et al., NMR line shapes in highly polarized large 6LiD target at 2.5 T, NIMA **526** (2004) 100-104
- Yu. Kisselev et al., Local field in LiD polarized target material, NIMA **526** (2004) 105-109
- N. Doshita et al., Performance of the COMPASS polarized target dilution refrigerator, NIMA **526** (2004) 138-143
- S. Neliba et al., Weight and volume measurement of the large COMPASS target, NIMA **526** (2004) 144-146

Target papers

- F. Gautheron et al., Cryogenic control system of the large COMPASS polarized target, NIMA **526** (2004) 147-152

Submitted target papers

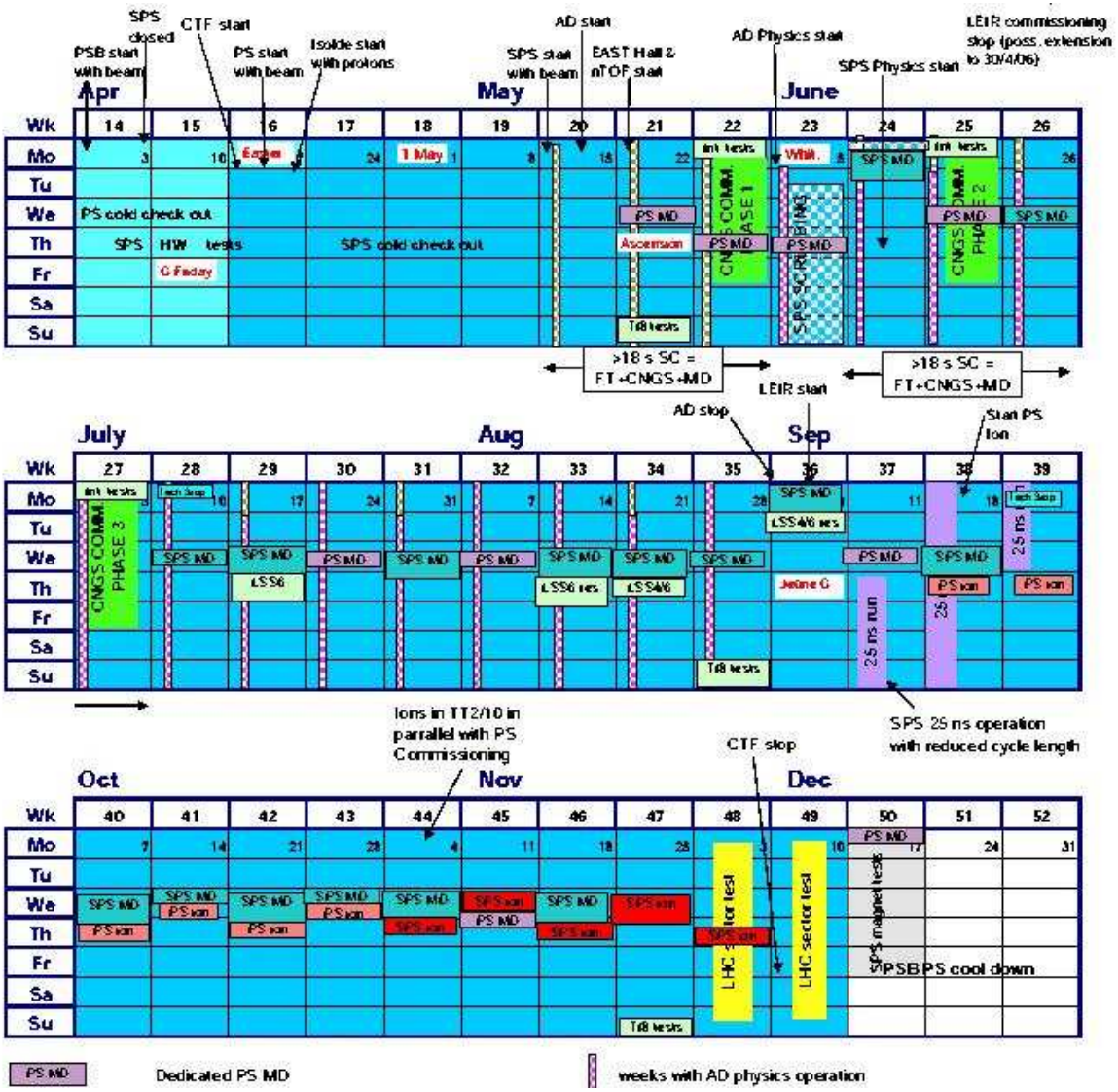
Symmetries and Spin Prague 2004 proceedings

- N. Doshita et al., The COMPASS polarized target, Czech J. Phys.

Spin 2004 Trieste

- F. Gautheron et al., The COMPASS polarized target
- Y. Kisselev et al., Features of dynamic nuclear polarization in irradiated LiD target material
- J. Koivuniemi et al., Polarization build up in COMPASS 6LiD target

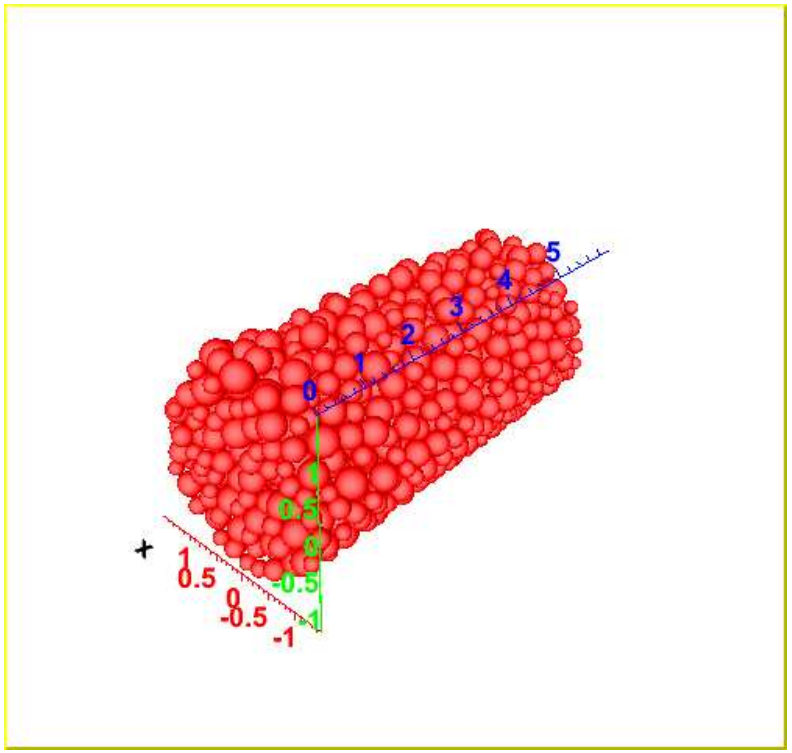
Super Proton Synchrotron 2006

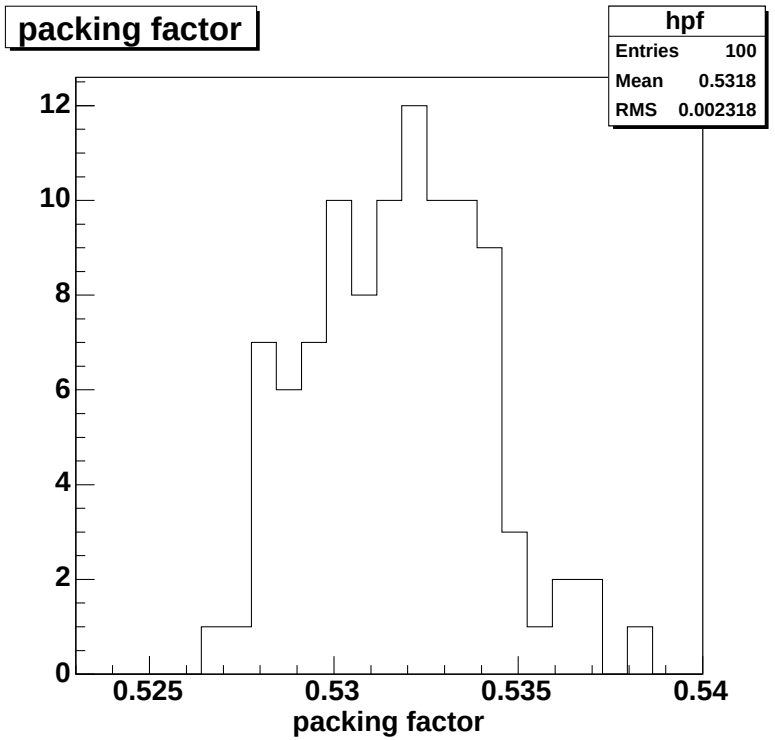


Run 2006

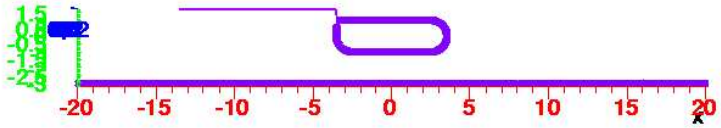
- 100 days longitudinal deuteron target ^{6}LiD
- 30 days transverse proton target NH_3

Material packing





Proton NMR



$$M = \begin{pmatrix} 64.8 \pm 1.5 & 1.3 \pm 0.2 & -9.0 \pm 0.5 \\ 1.3 \pm 0.2 & 70.5 \pm 2.8 & 32.9 \pm 0.3 \\ -8.9 \pm 0.5 & 32.9 \pm 0.3 & 387.8 \pm 7.5 \end{pmatrix} [\mathrm{nH}]$$

$$R = \begin{pmatrix} 0.1359 \\ 0.0096 \\ 0.3079 \end{pmatrix} [\Omega]$$

Jean-Marc: from 2 to 3 cells

- u d

  $++++ \quad ----$

  $$\Delta = \frac{u-d}{u+d} = A_\phi + \frac{a_u - a_d}{a_u + a_d}$$

- u d

  $---- \quad ++++$

  $$\Delta' = -\frac{u'-d'}{u'+d'} = A_\phi - \frac{a'_u - a'_d}{a'_u + a'_d}$$

- $$\frac{\Delta + \Delta'}{2} = A_\phi + \frac{1}{2}\left[\frac{a_u - a_d}{a_u + a_d} - \frac{a'_u - a'_d}{a'_u + a'_d}\right]$$

- if $\frac{a'_u}{a_u} = \frac{a'_d}{a_d}$ then $A_{false} = 0$

- $z_u \neq z_d \Rightarrow \frac{a'_u}{a_u} \neq \frac{a'_d}{a_d} \Rightarrow A_f \propto z_u - z_d$

Jean-Marc: from 2 to 3 cells

- $u_1 \quad d_1 \quad u_2 \quad d_2$

  $++ \quad --\,-- \quad ++$ $\qquad \Delta_1 = \dfrac{u_1 - d_1}{u_1 + d_1} \qquad \Delta_2 = -\dfrac{u_2 - d_2}{u_2 + d_2}$

- $u_1 \quad d_1 \quad u_2 \quad d_2$

  $-- \quad ++\,++ \quad --$ $\qquad \Delta'_1 = -\dfrac{u'_1 - d'_1}{u'_1 + d'_1} \qquad \Delta'_2 = \dfrac{u'_2 - d'_2}{u'_2 + d'_2}$

- $$\frac{\Delta_1 + \Delta'_1}{2} = A_\phi + \frac{1}{2}\left[\frac{a_u - a_d}{a_u + a_d} - \frac{a'_u - a'_d}{a'_u + a'_d}\right]_1 = A_\phi + A_{f1}$$
  $$\frac{\Delta_2 + \Delta'_2}{2} = A_\phi - \frac{1}{2}\left[\frac{a_u - a_d}{a_u + a_d} - \frac{a'_u - a'_d}{a'_u + a'_d}\right]_2 = A_\phi - A_{f2}$$

- $z_{u1} - z_{d1} = z_{u2} - z_{d2} \Rightarrow A_{f1} \approx A_{f2}$

- $\frac{\Delta_1 + \Delta'_1 + \Delta_2 + \Delta'_2}{4} = A_\phi + (A_{f1} - A_{f2})/2$

3 target cells