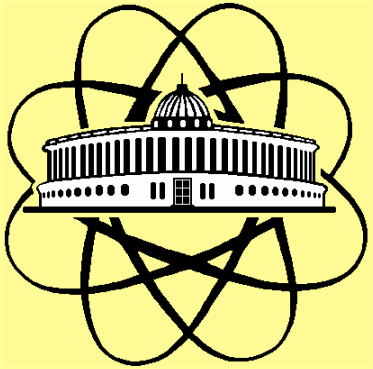

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The possibility of producing the polarized proton (antiproton) beam through hyperon (antihyperon) decay using the internal production target in the accelerators/colliders

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Introduction

The progress in the High Energy Experimental Spin Physics mainly depends on the availability of:

- *the high quality polarized beams*
- *the polarized targets*

Production of the polarized proton beam may be done by:

- acceleration of the polarized protons
- Hyperon-decay (e.g. Λ-decay, [1])

[1] O.E. Overseth and J. Sandweiss, A polarized proton beam from Λ decay. National Accelerator Laboratory, 1969 Summer Study Report, SS-120 2250, vol. 1, pp 28.

Production of the polarized proton beam on the External and Internal Targets

The first polarized proton beam through Λ-decay was produced at E581/E704 experiment at FNAL [2]

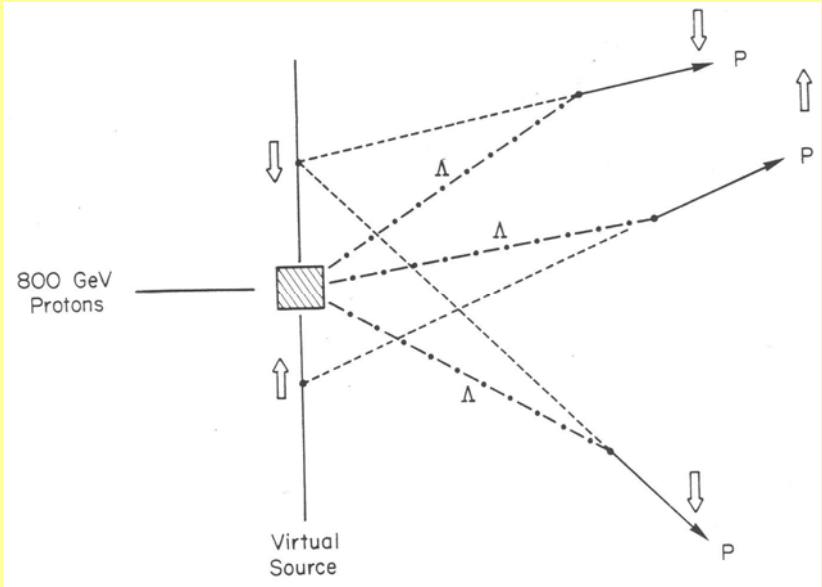


Fig. 1. Diagram of the primary production target, Λ-decay process, and virtual source of polarized protons. The polarization state of the proton is correlated with the position in the plane of the virtual source.

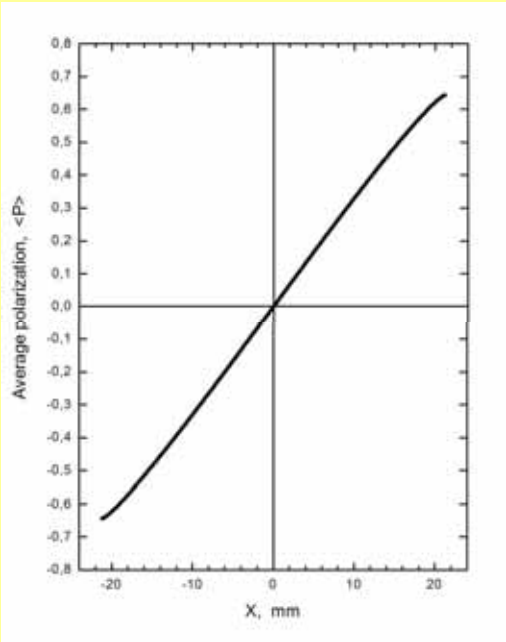


Fig.2. Correlation between the average particle polarization and the horizontal position at the intermediate focus for 70 GeV/c protons.

[2] D. Grosnick et al., Nuc. Instr. Meth. A290 (1990) 269.

FNAL – E581/704 Experiment

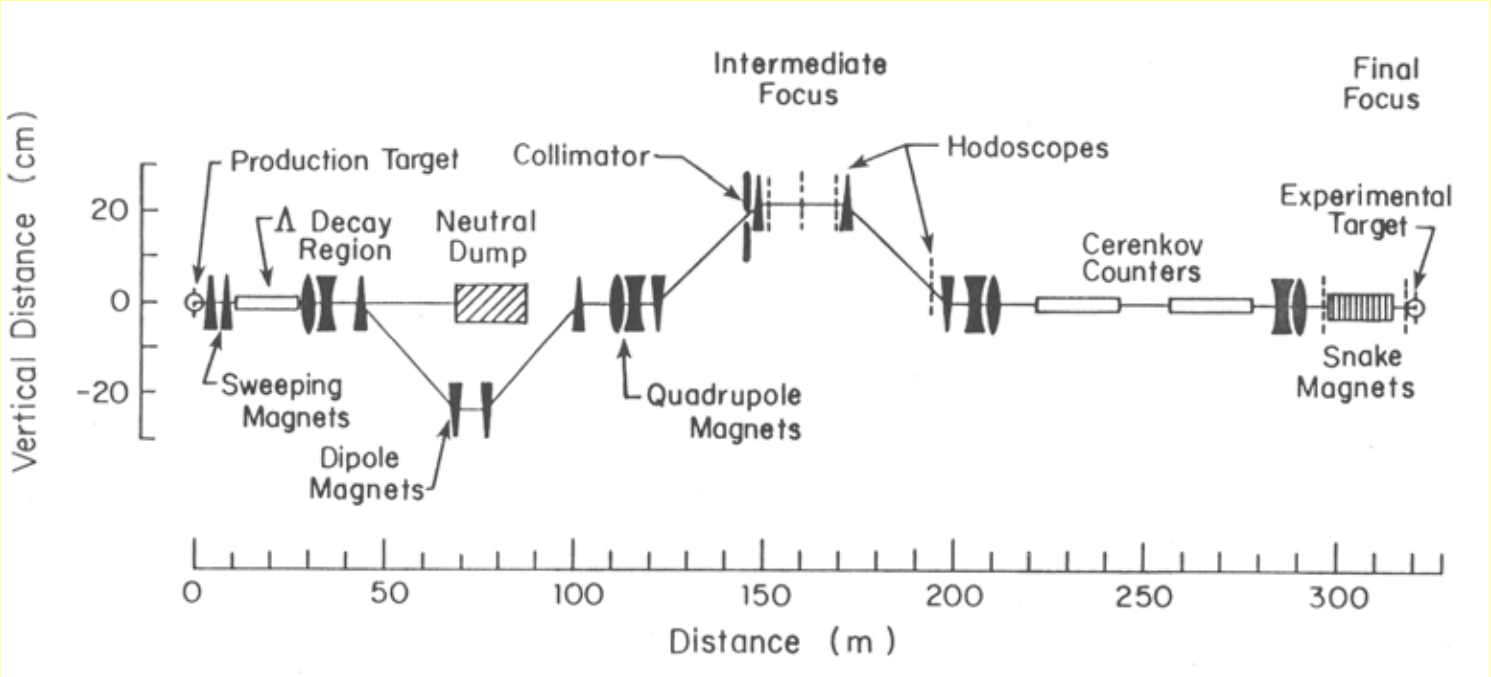


Fig. 3. Layout of elements along the MP polarized beam line. Shown here is a side view of the production target, neutral particle dump, adjustable collimator, beam-tagging region, snake magnets, Cherenkov counters, and experimental target.

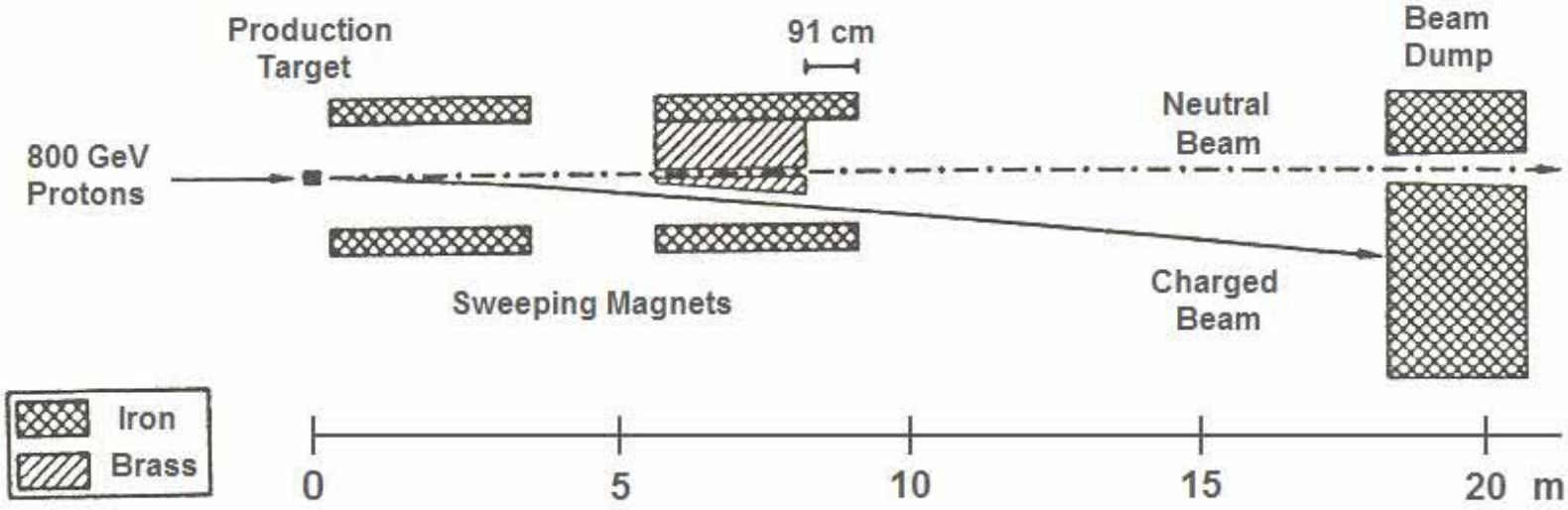


Fig. 4. Side-view layout of the production target and primary beam dump area. Separation of neutral and charged particles by magnetic sweeping of the beam by two dipole magnets is shown. A collimator inside the second magnet determines the size of the neutral beam. The charged particle beam passes below the collimator in the second magnet and is deflected into the charged primary beam dump. The dimensions transverse to the beam are not to scale.

Polarized proton beam at TeVatron

Table 1.

Parameter	External Target (Be, 30cm)
Luminosity at production target, $cm^{-2}s^{-1}$	$6.3 \cdot 10^{34}$
Intensity pol. pr/sec	$5 \cdot 10^{4}$
Polarized beam momentum, p, GeV/c	200
Momentum band, %	±10
Average beam polarization,%	40 ± 2%
Beam profile at final focus, X, Y mm (max)	± 15, ±15
Beam divergence, X', Y' mrad, (max)	±0.8 , ±0.6

Polarized proton beam at U-70 accelerator, External Target

Table 2.

Parameter	External Target (Al, 30cm)
Luminosity at production target, $cm^{-2}s^{-1}$	$3{,}6 \cdot 10^{36}$
Intensity, pol.pr/sec	$3 \cdot 10^{6}$
Polarized beam momentum, p, GeV/c	40
Momentum band, %	±4,5
Average beam polarization,%	40 ± 2%
Beam profile at final focus, X, Y , mm (max)	± 10.6 , ± 8.1
Beam divergence, X′, Y′ , mrad,(max)	±6.5 , ±6.0

[3] Galyaev N.A. et al. IHEP Polarized Proton Beam, IHEP Preprint 92-159, Protvino 1992, p.11, figs. 5, refs.:16

Polarized proton beam from the Internal Target at U-70

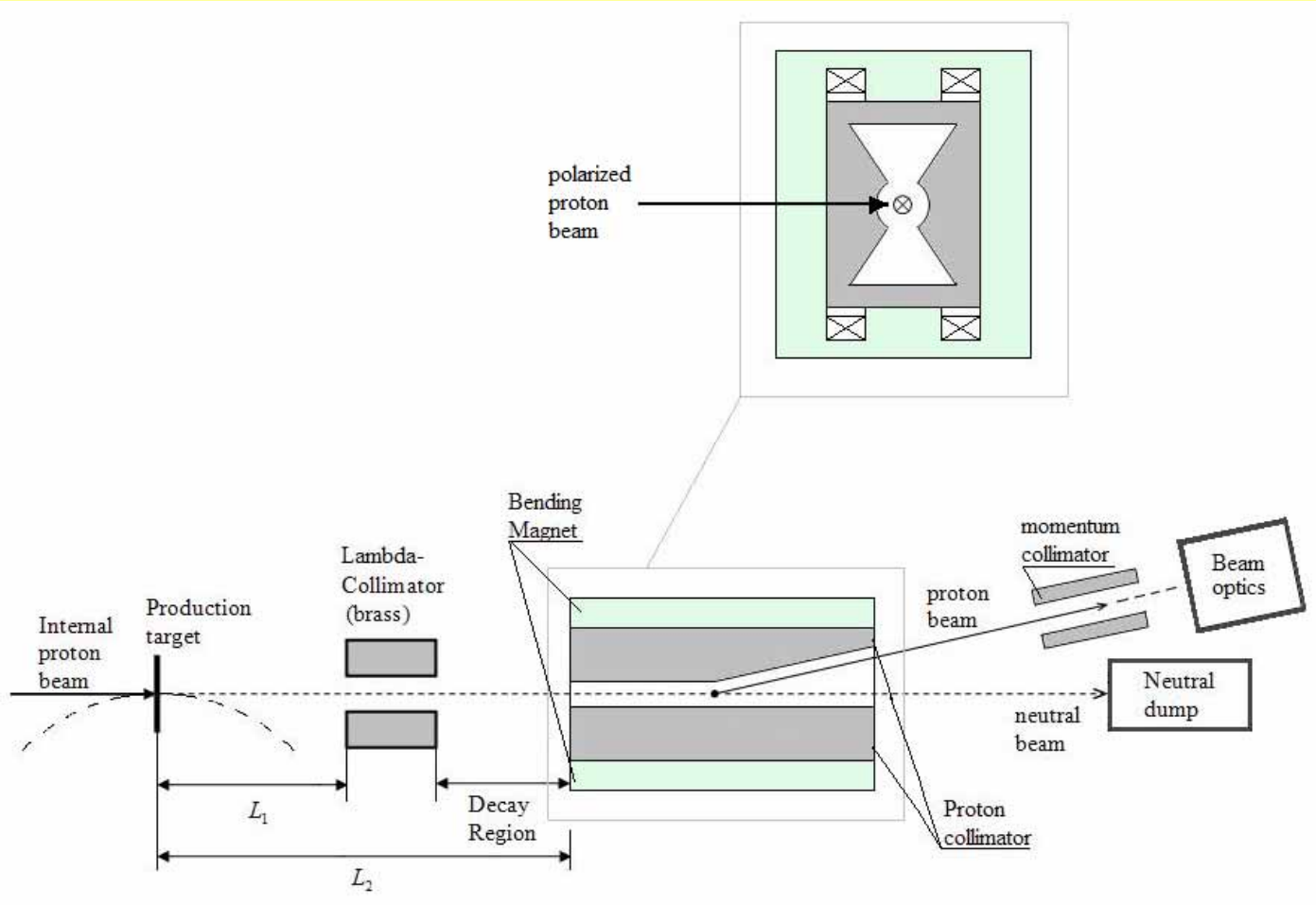
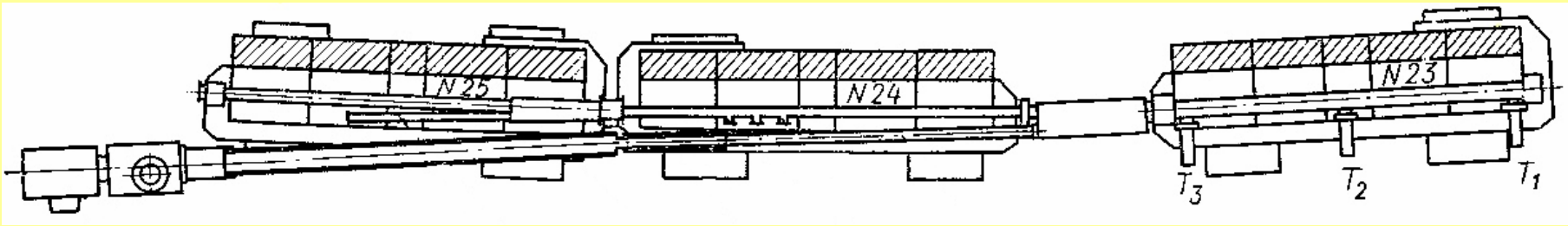
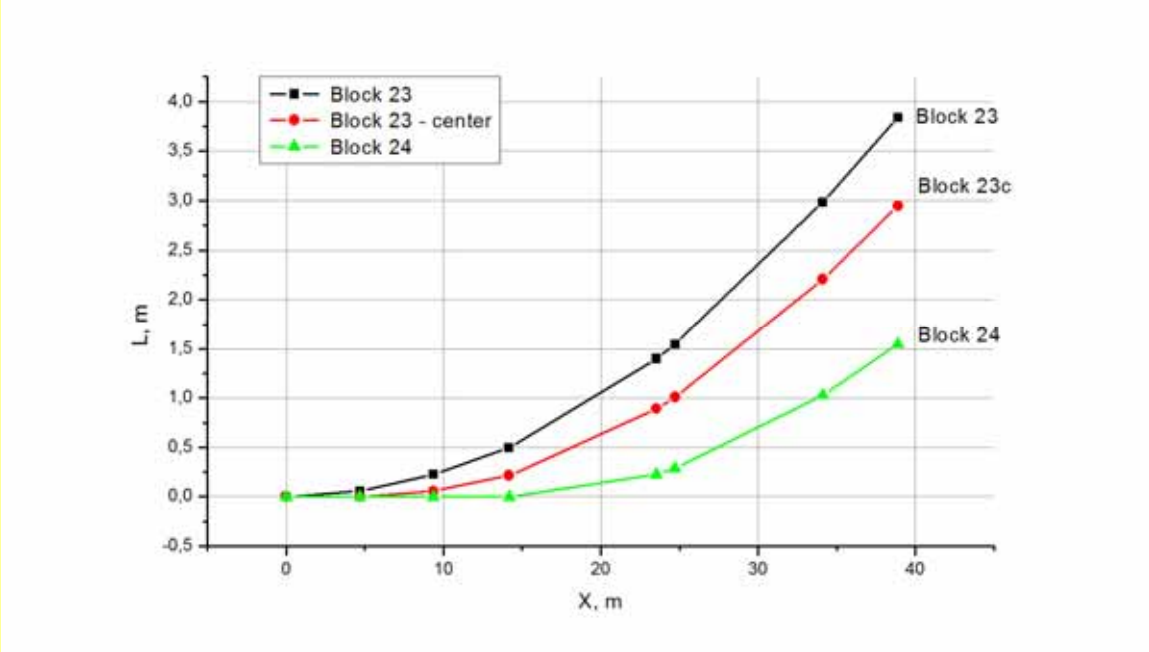


Fig. 5. Sketch of obtaining the polarized proton beam from Internal Target (IT) at U- 70

[4] V.A. Chetvertkova and S.B. Nurushev, 2008, Proc. Of XII Advanced Research Workshop on High Energy Spin Physics (DSPIN-07), Dubna, 2007, p.41.



The scheme of blocks N 23, 24, 25 at U-70. The possible positions of production targets (T_1, T_2, T_3)



[5] N.I. Golovnya et al, Atomnaya Energy, 32, 3, p. 244

The parameters of the polarized proton beam expected from IPT at U-70 accelerator

Table 3.

Parameter	Internal Target (C, 0.7 μm)
Luminosity at production target, $cm^{-2}s^{-1}$	$3{,}2 \cdot 10^{36}$
Intensity, pol.pr/sec	$2.8 \cdot 10^{6}$
Polarized beam momentum, p, GeV/c	50 ± 4
Momentum band, %	±10
Average beam polarization,%	40 ± 2%
Beam profile at final focus, X, Y mm (max)	± 4 , ± 4
Beam divergence, X', Y' , mrad (max)	±2 , ±2

Polarized Proton Beam from the External Target at LHC

Table 4.

Parameter	External Target (C, 30cm)
Luminosity at production target, $\frac{1}{spill \cdot cm^2}$	$1{,}1 \cdot 10^{39}$
Intensity, primary pr/sec	$3{,}23 \cdot 10^{14}$
Polarized beam momentum, p, GeV/c	3765
Momentum band, %	±5
Average beam polarization,%	32
Number of polarized protons, pol. prot /sec	$5{,}7 \cdot 10^{8}$
Number of polarized anti-protons, pol. antiprot/sec	$5.7 \cdot 10^{6}$

[6] H. Grote, R. Hagedorn, J. Ranft, Atlas of Particle Production Spectra, CERN, Geneve 1970

LHC

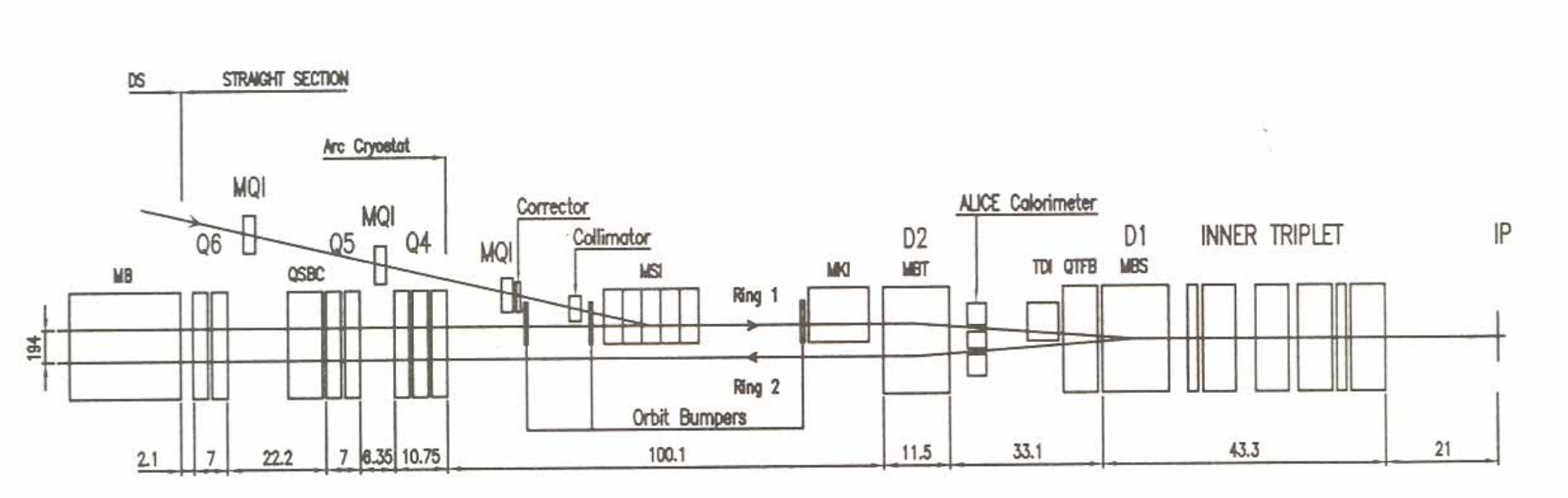


Fig. 6. Layout of the left part of the low-β insertion at IP2

[7] LHC, Conceptual Design, CERN/AC/95-05(LHC), 20 October 1995, p. 44

Polarized Proton Beam from the Internal Target at LHC

Table 5.

Parameter	Internal Target	
Luminosity at production target, $cm^{-2}s^{-1}$	Gas target (H_2):	Carbon target:
	$1{,}1 \cdot 10^{35}$	$2{,}7 \cdot 10^{37}$
Intensity primary pr/sec	$3{,}23 \cdot 10^{14}$	$3{,}23 \cdot 10^{14}$
Polarized beam momentum, p, GeV/c	3765	3765
Momentum band, %	± 5	±5,7
Average beam polarization,%	32	32
Beam life-time	22hrs	34,5 sec
Number of polarized protons, pol. prot /sec	$6 \cdot 10^{6}$	$6{,}6 \cdot 10^{9}$
Number of polarized anti-protons, pol. antiprot/sec	$6 \cdot 10^{4}$	$6.6 \cdot 10^{7}$

Summary

- We estimated the possibility of obtaining the polarized proton beam from the internal target at U-70. Advantages of using very thin internal target:
    1) The multiple Coulomb scattering angle will be small
    2) The absorption of the produced **Λ** by the production target would be negligible in contrast to the external target
    3) Usually the accelerator has several internal targets (e.g., U70). It means, one can simultaneously produce several polarized beam lines
    4) The internal target can operate simultaneously with slow extracted proton beam.
    5) The quality of the internal circulating beam is better than the extracted primary proton beam
    6) We avoid the radiation problem
- For LHC we do not know several beam parameters (Λ-yields, long decay region and special beam optics). Nevertheless LHC might be the source of polarized proton and antiproton beams of highest energy and intensity at present.