GSI Helmholtzzentrum für Schwerionenforschung GmbH

Conversion Rates pbar

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HIC4FAIR Workshop Hamburg

Production Cross Section

Semiempirical formula:
R.P. Duperray et al., Phys. Rev. **D 68**, 094017 (2003)
Fit of experimental data available in 2003.

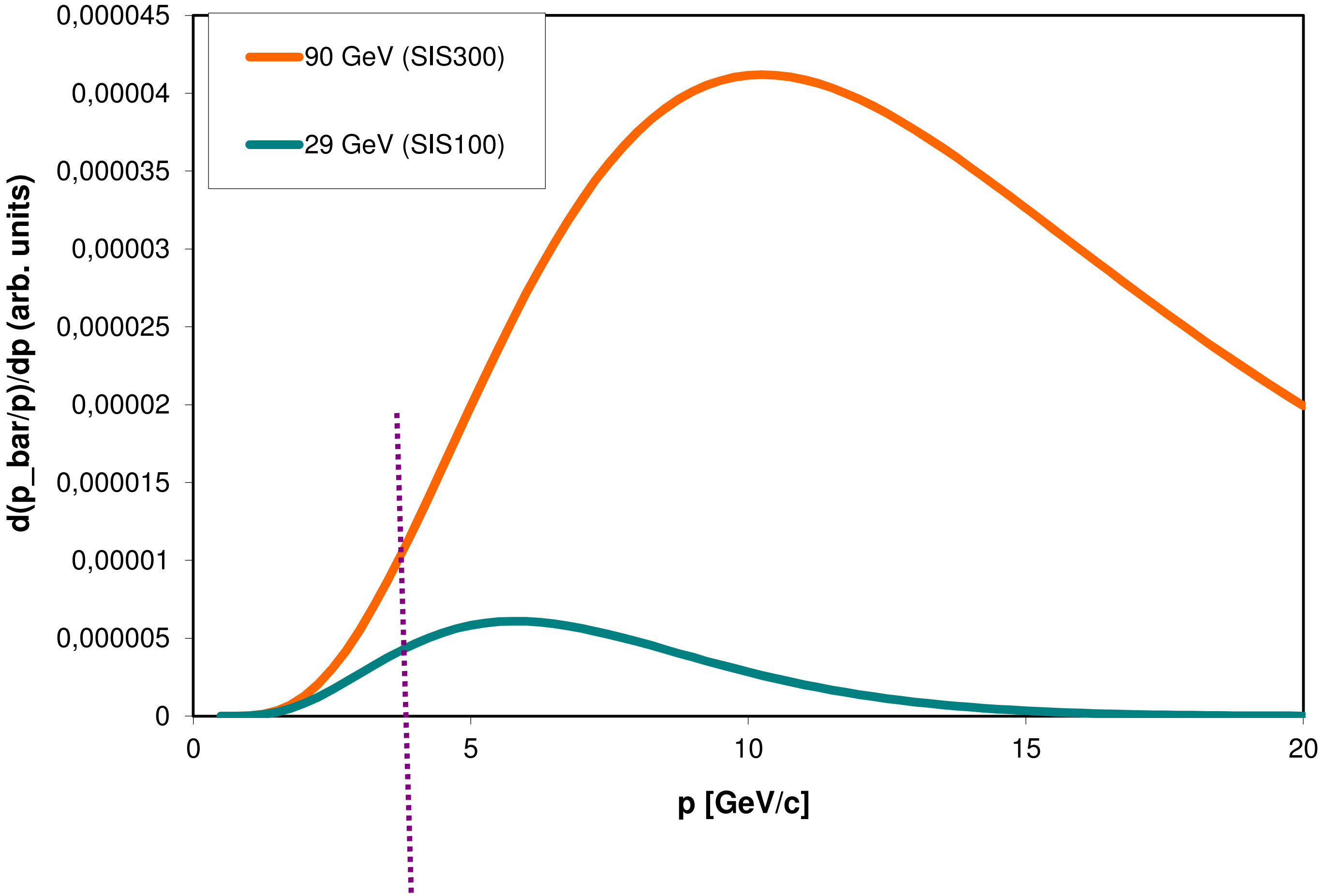
TABLE I. List of the experimental $\bar{p}$ production cross-section data included in the χ^2 minimization procedure, in increasing energy order.

Experience	Target	p_{inc} or $\sqrt{s}$ GeV/c (GeV)	$\bar{p}$ kinematic range GeV/c	θ_{lab} mrad
Sugaya *et al.* KEK-PS 1998 [17]	C, Cu, Al, Pb	12	p_{lab}: 1.0–2.5	89
Marmer *et al.* ANL 1969 [18]	Be, Cu	12.3	p_{lab}: 0.820, 1.030	0, 0.17, 10
Abbott *et al.* BNL 1993 [19]	Al	14.6	m_t: 0–0.3 y: 1.0–1.6	
Allaby *et al.* CERN 1970 [20]	p, Be, Al, Cu, Pb	19.20	p_{lab}: 4.5–18.3	12.5–70
Dekker *et al.* CERN 1965 [21]	p, Be, Pb	18.8, 23.1	p_{lab}: 4–12	0, 100
Eichten *et al.* CERN 1972 [22]	Be, Al, Cu, Pb	24	p_{lab}: 4–18	17–127
Kalmus *et al.* CERN 1971 [23]	Be	24–26	p_{lab}: 0.6–2.5	310
Snow *et al.* BNL 1985 [24]	Pt	28.4	p_{lab}: 0.606–0.730	0–0.17
Barton *et al.* FNAL 1983 [25]	p, C, Cu, Al, Ag, Pb	100	p_{lab}: 30–88 $p_\perp$: 0.3, 0.5	
Johnson *et al.* FNAL 1978 [26]	p	100, 200, 300	$p_\perp$: 0.25–1.5 $0.05<x_R<1.0$	
Baker *et al.* FNAL 1974 [27]	Be	200, 300	p_{lab}: 23–197	3.6
Cronin *et al.* FNAL 1975 [28]	Be, Ti, W	300	$p_\perp$: 0.76–6.91	77
Antreasyan *et al.* FNAL 1979 [29]	p, d, Be, Ti, W	200, 300, 400	$p_\perp$: 0.77–6.91	77
Guettler *et al.* CERN 1976 [30]	p	$23<\sqrt{s}<63$	$p_\perp$: 0.1–0.3 $x_f=0$	
Capiluppi *et al.* CERN 1974 [31]	p	$23.3<\sqrt{s}<63.7$	p_{lab}: 1.5–10	80–350

the kinematical variables used here will always be expressed in the nucleon-nucleon (NN) rather than in the nucleon-nucleus c.m. frame, since the NN c.m. frame is the relevant physical system, the incident nucleon energies being on the scale of 10 GeV while the average binding energy of the nucleon in the nucleus is about 8 MeV. Bound nucleons can be considered as free particles for the incident protons.

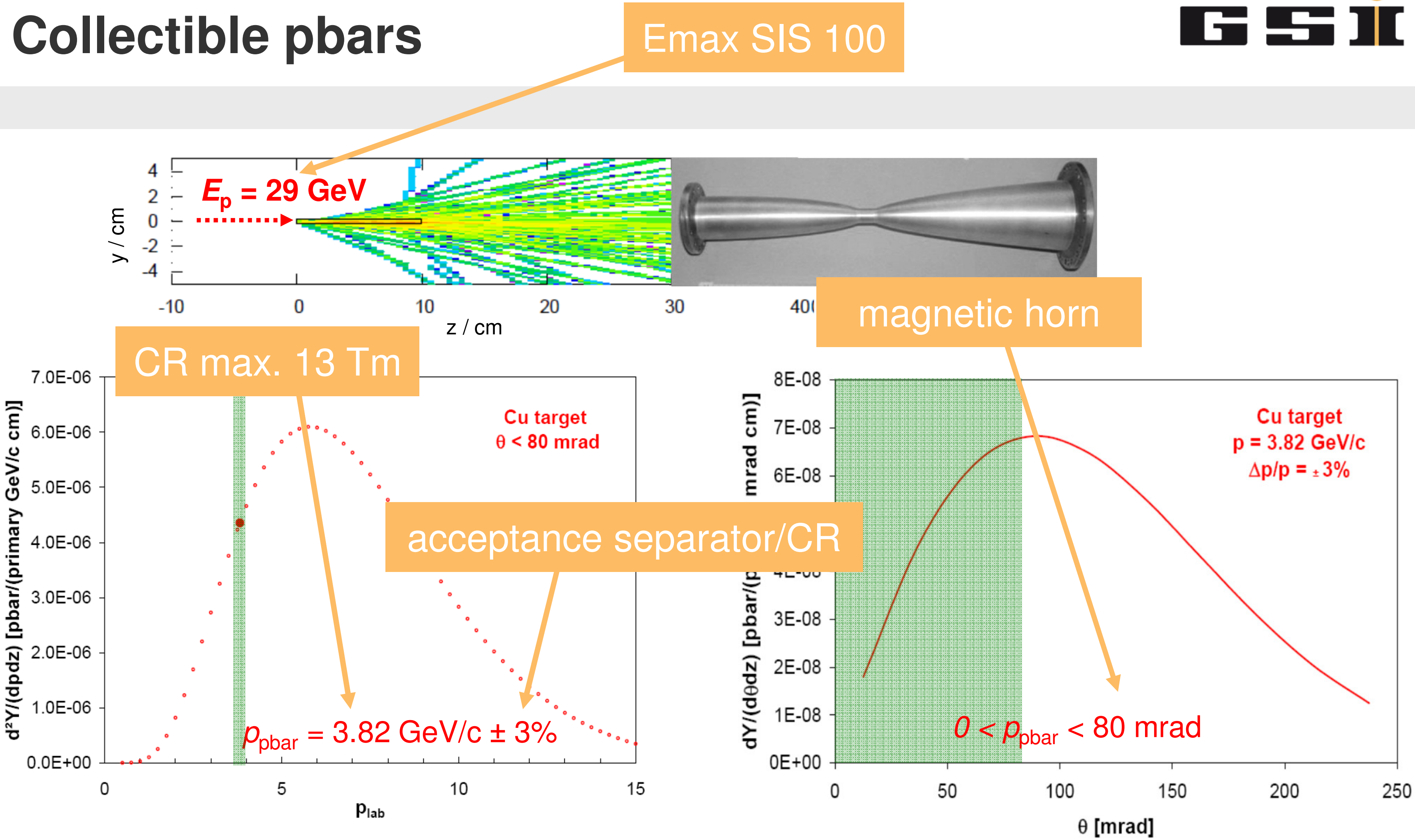
Monte Carlo Codes used in addition:
FLUKA, MARS

Production Cross Section



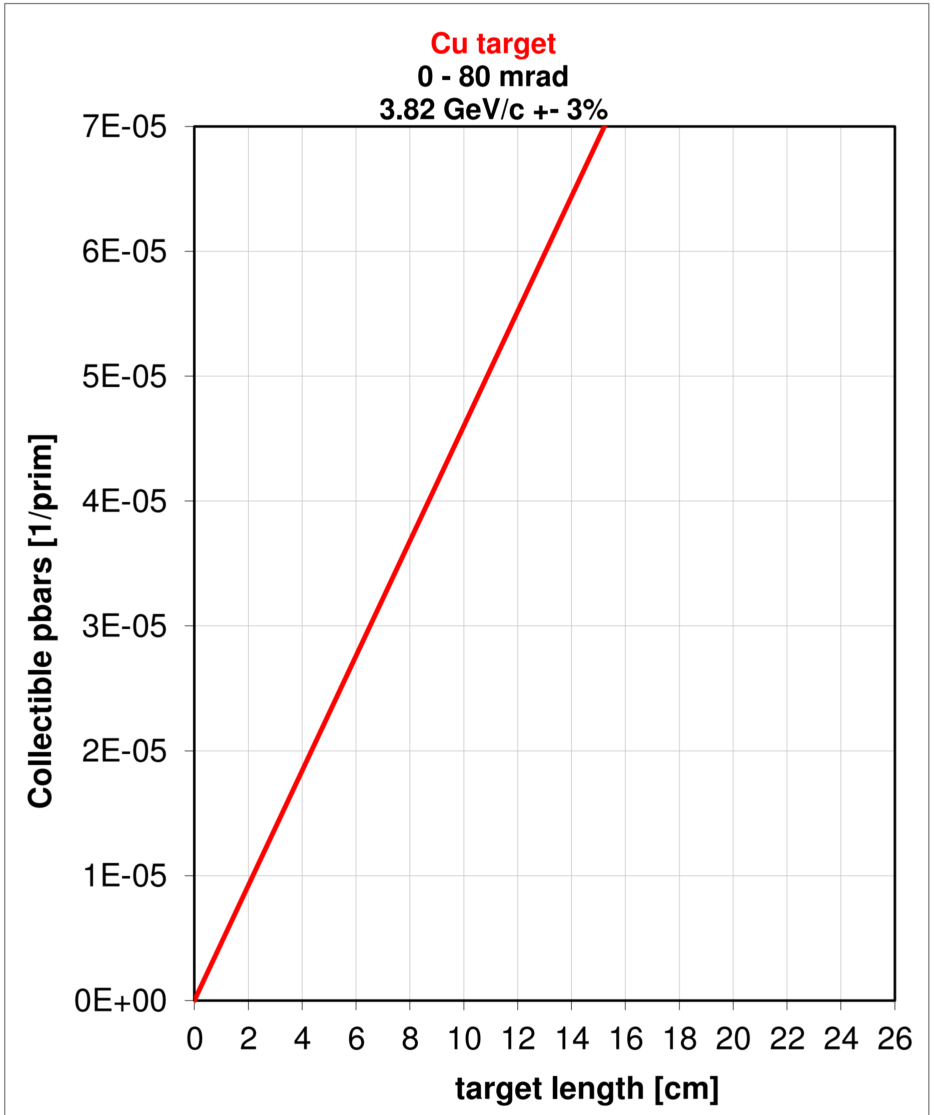
p = 3.82 GeV / c, E = 3 GeV, Bρ = 13 Tm

Collectible pbars

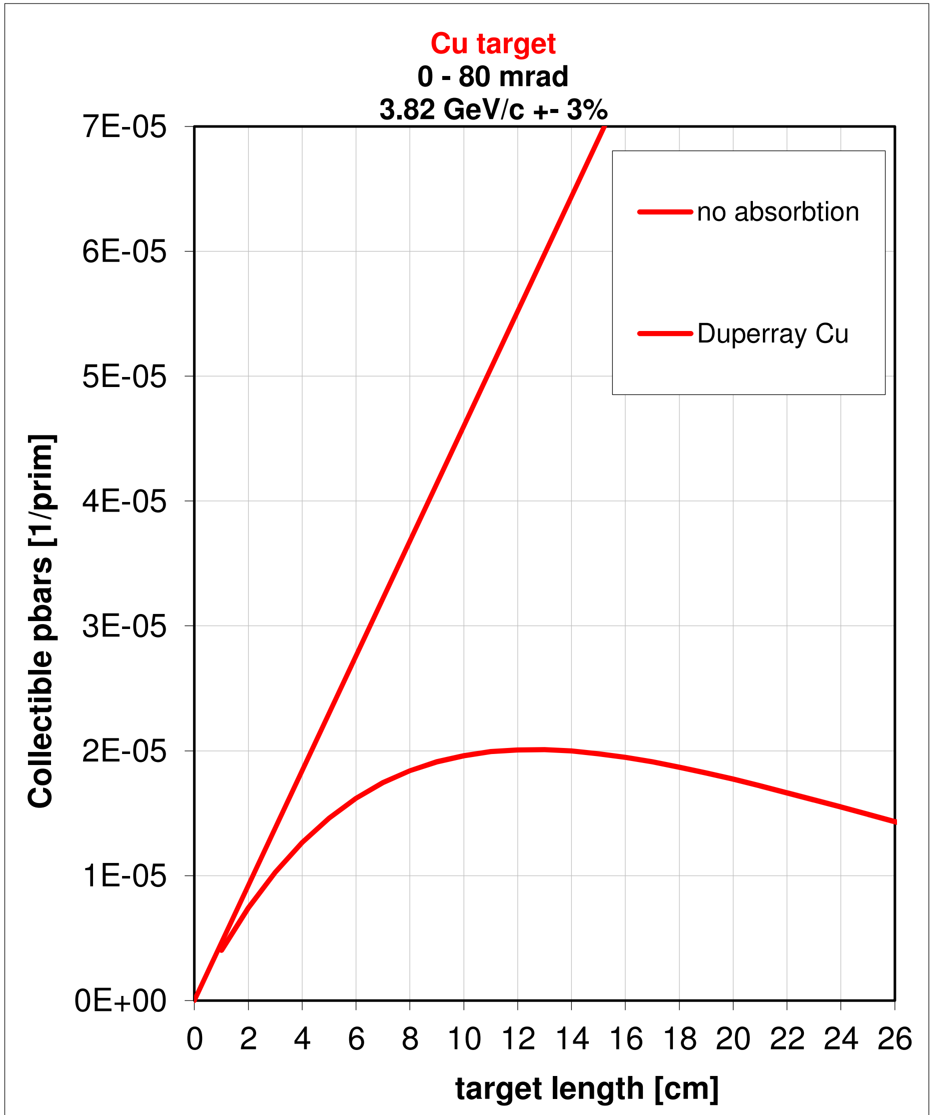


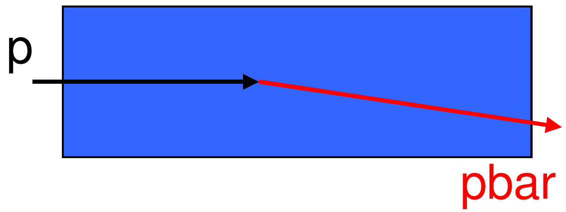
From ~ 2.5×10^{-4} pbar / (p cm target) ~ 5×10^{-6} (or 2 %) are "collectible"

Collectible pbars



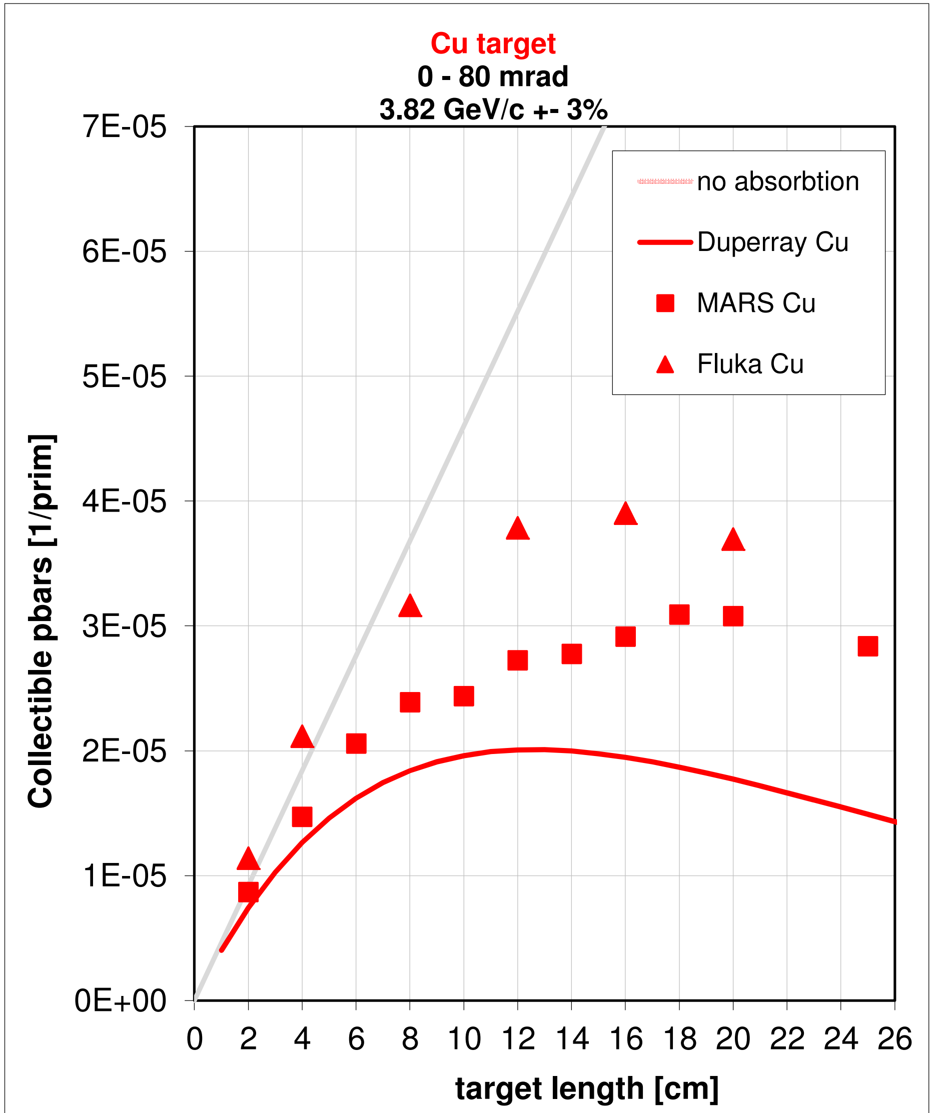
Collectible pbars: Self Absorption

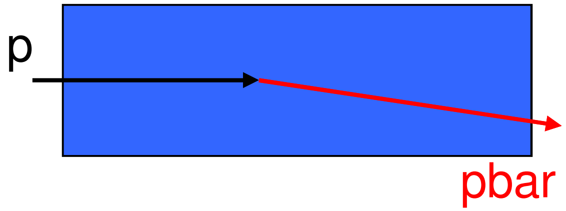




Cu: σ_{pbar} = 0.8 b

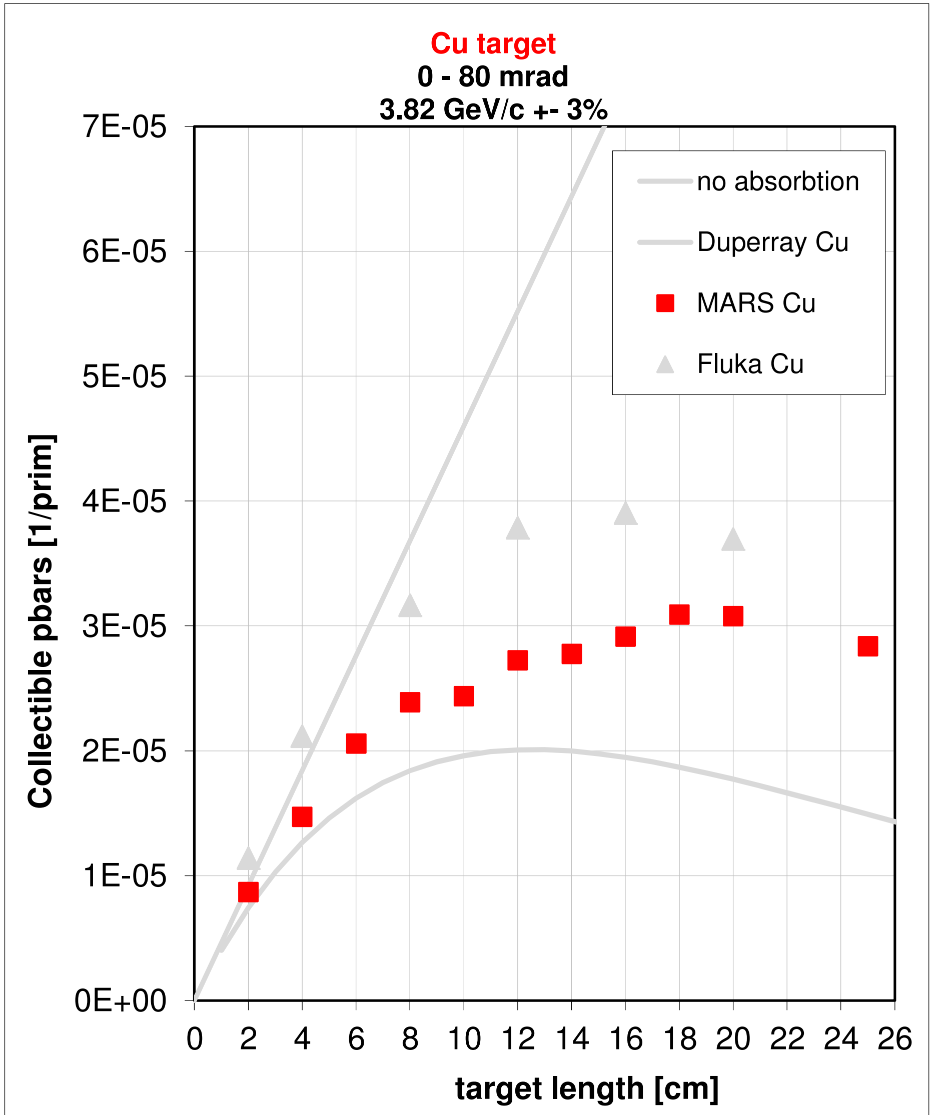
Collectible pbars: MARS/FLUKA

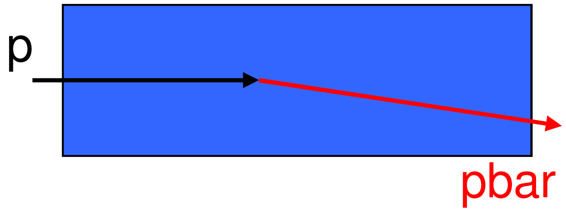




Cu: σ_{pbar} = 0.8 b

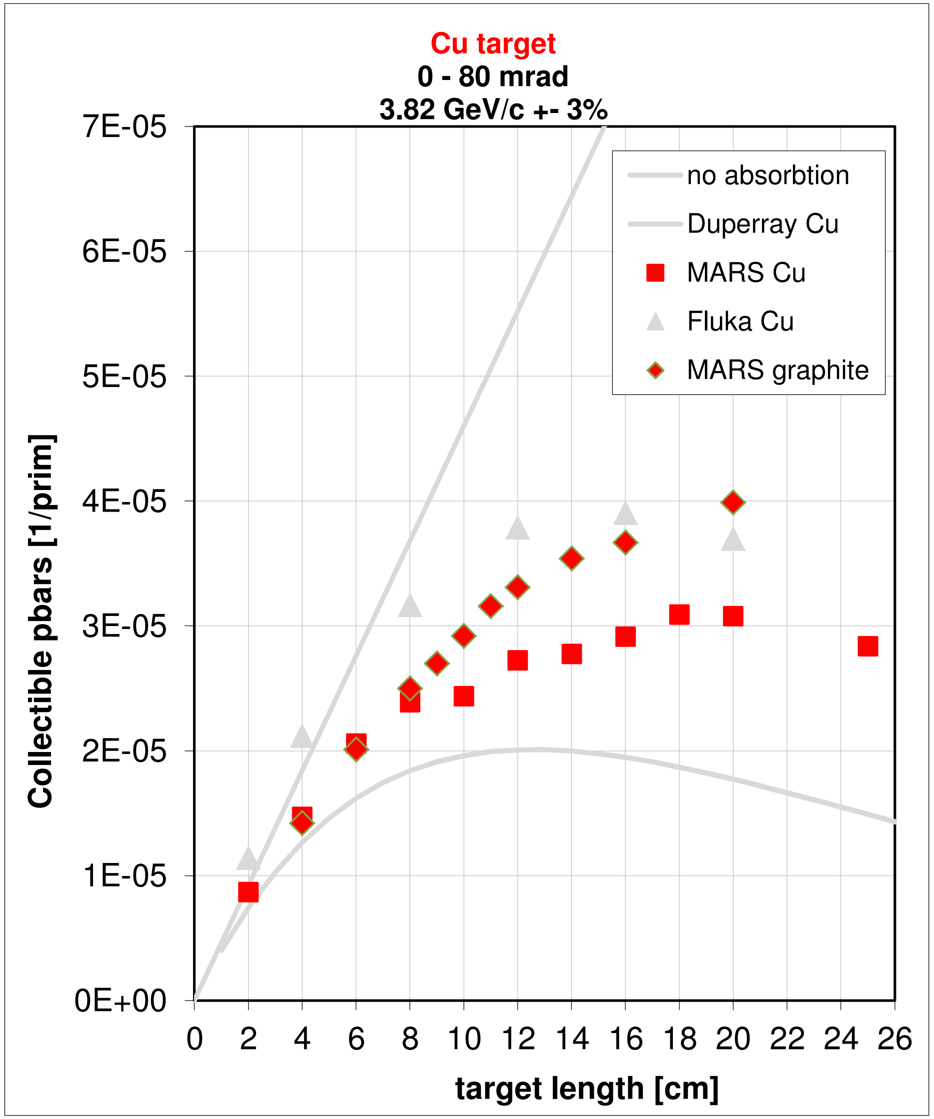
Collectible pbars: MARS

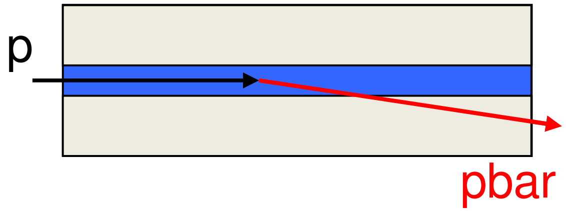




Cu: σ_{pbar} = 0.8 b

Collectible pbars: Graphite Surrounding

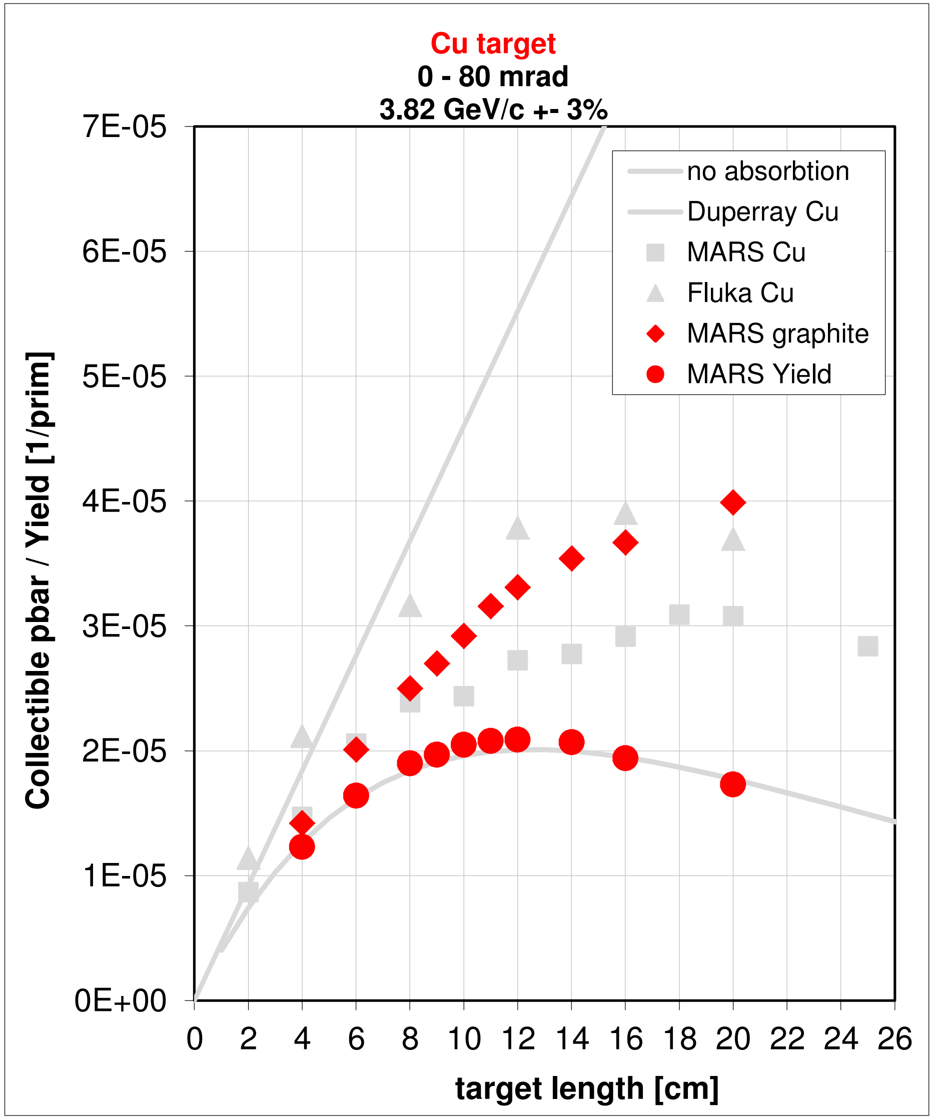


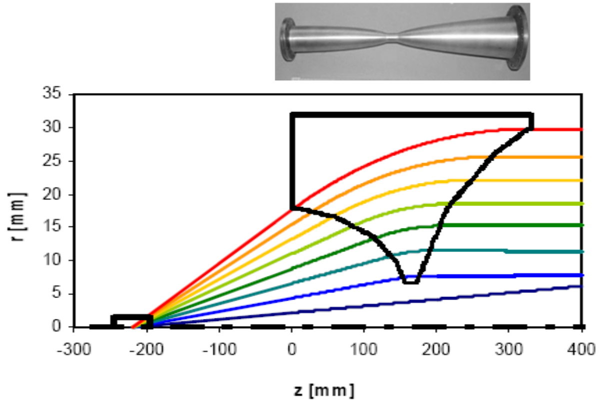


Cu: σ_{pbar} = 8.8 b

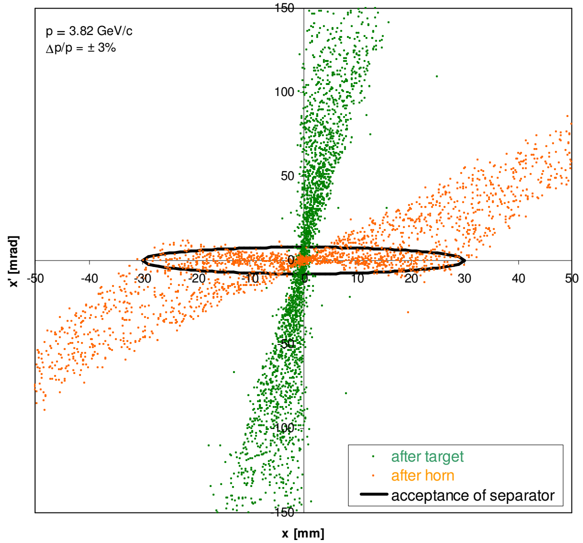
C: σ_{pbar} = 0.42 b

pbar Yield:
Collection efficiency of the magnetic horn

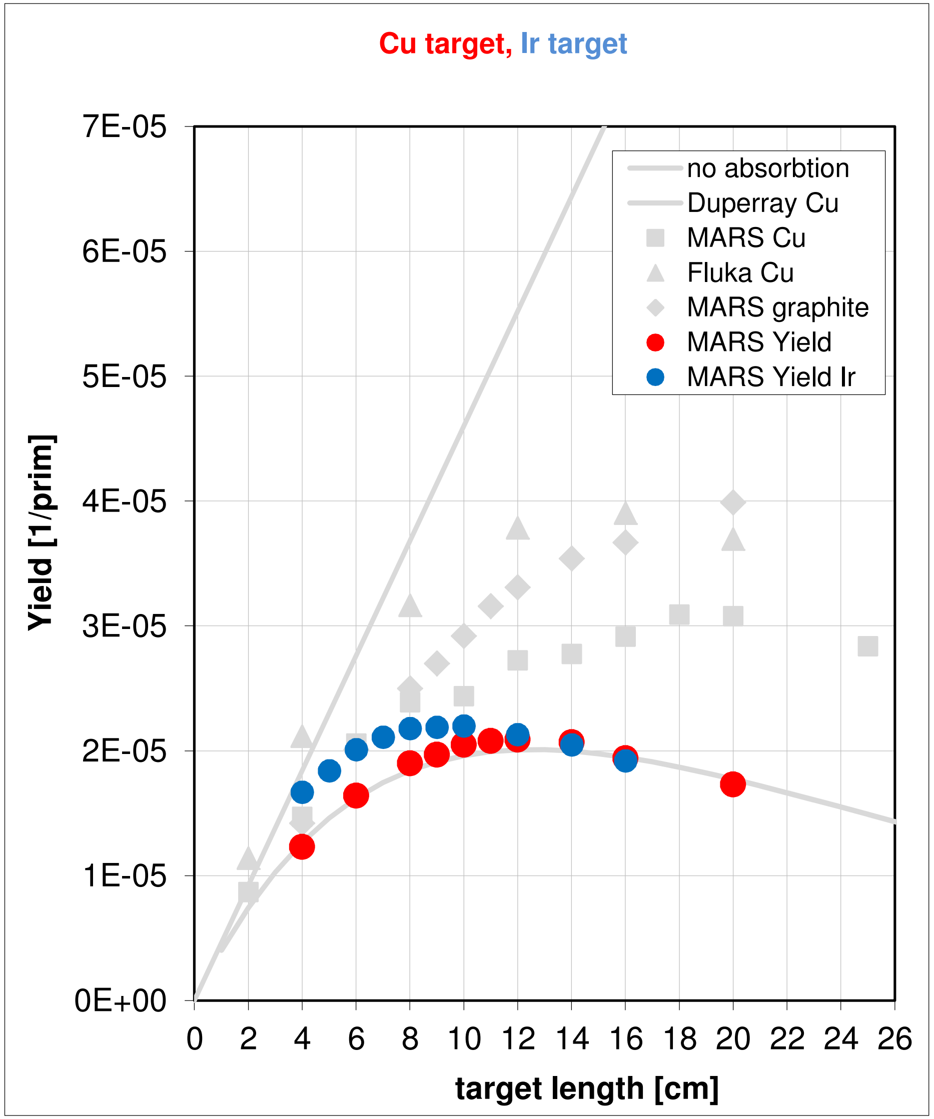


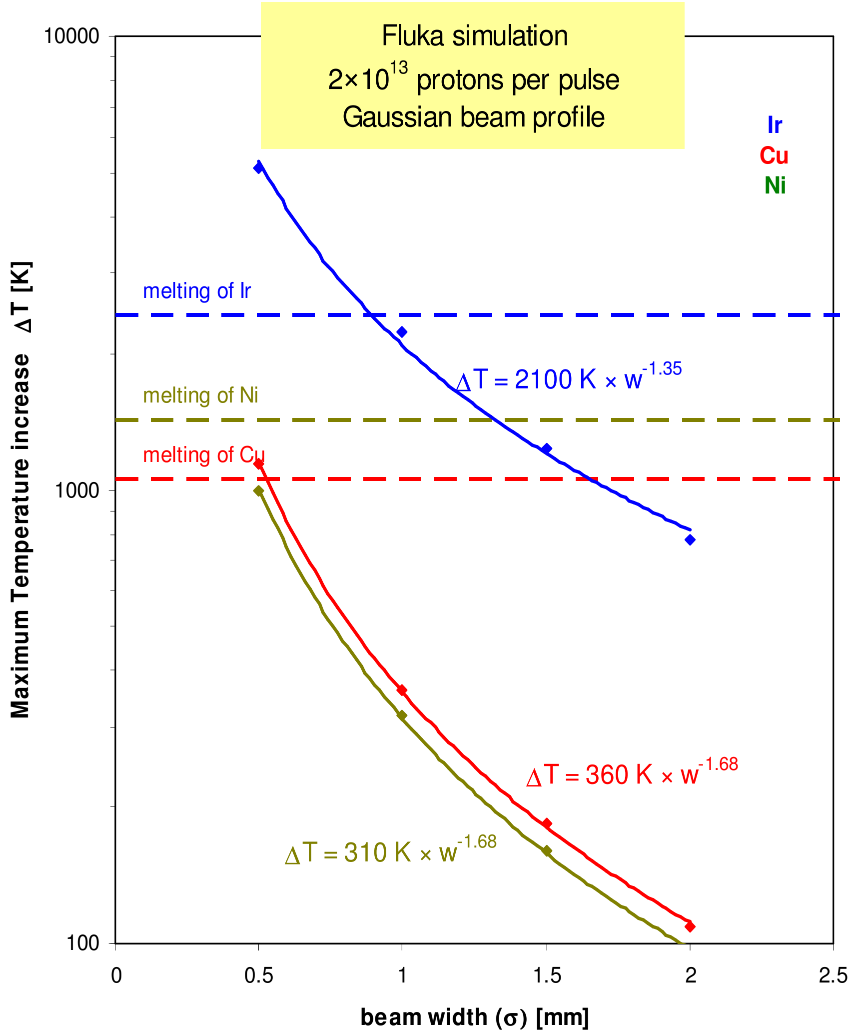


$$\text{yield} = \frac{\text{pbars in the ellipse}}{\text{primary protons}}$$



pbar Yield: Cu vs Ir (8.92 vs 22.65 g/cm³)





pbar Yield: Comparison to CERN Data

To injection orbit of collector ring:

pbar/p = $2\times10^{-5} \times 0.85 \times 0.7 =$ **1.2×10^{-5}**

scattering losses in air / aluminum   *losses in separator / during injection*

Exp. data from CERN (Baird 1998) to injection orbit:

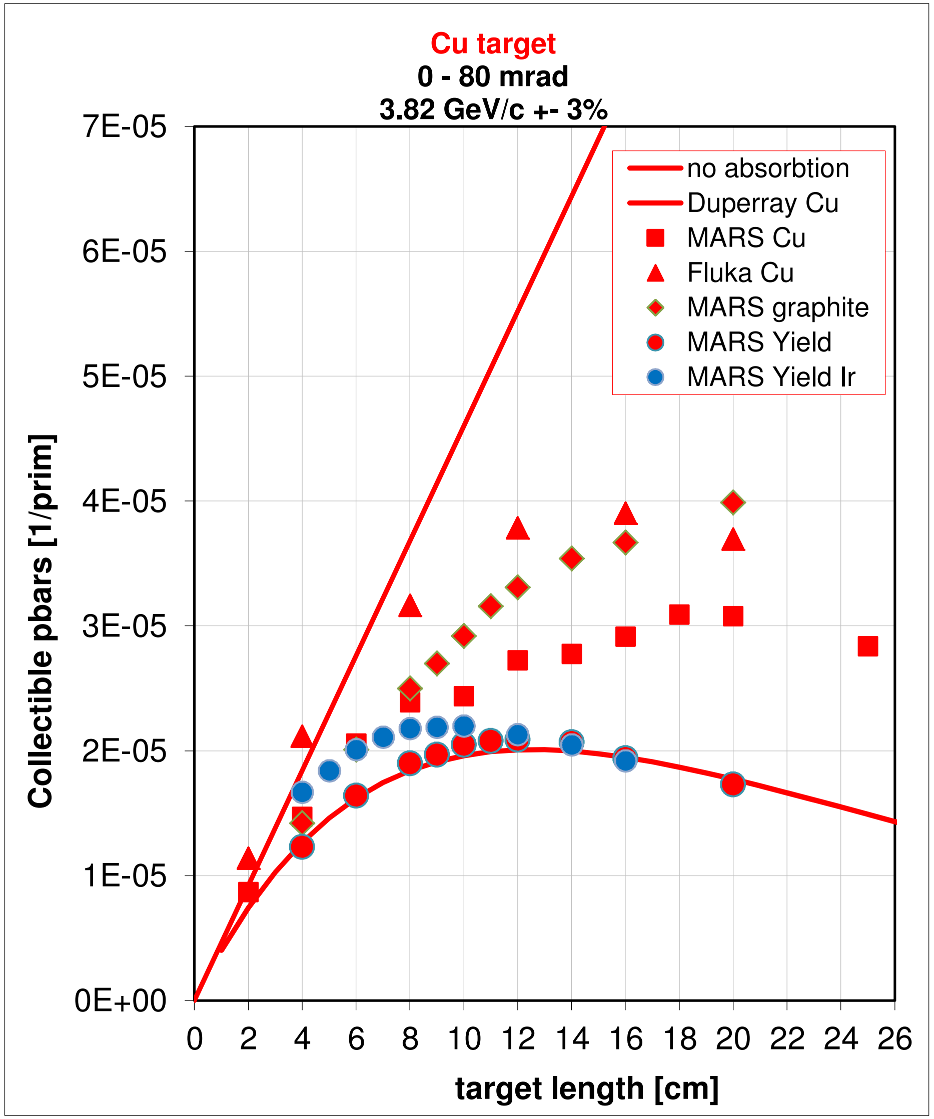
pbar/p = $0.45\times10^{-5} \times 1.5 =$ **0.7×10^{-5}**

correction for different energies and emmitances

Summary

For 1 antiproton in the CR
10^5 primary protons on the target are needed.

I do not see room for significant improvements.
All optimization steps I can imagine are in the order of <20 %.


Cu target
0 - 80 mrad
3.82 GeV/c +- 3%
7E-05
6E-05
5E-05
4E-05
3E-05
2E-05
1E-05
0E+00
Collectible pbars [1/prim]
0 2 4 6 8 10 12 14 16 18 20 22 24 26
target length [cm]
no absorbtion
Duperray Cu
MARS Cu
Fluka Cu
MARS graphite
MARS Yield
MARS Yield Ir