COMPASS

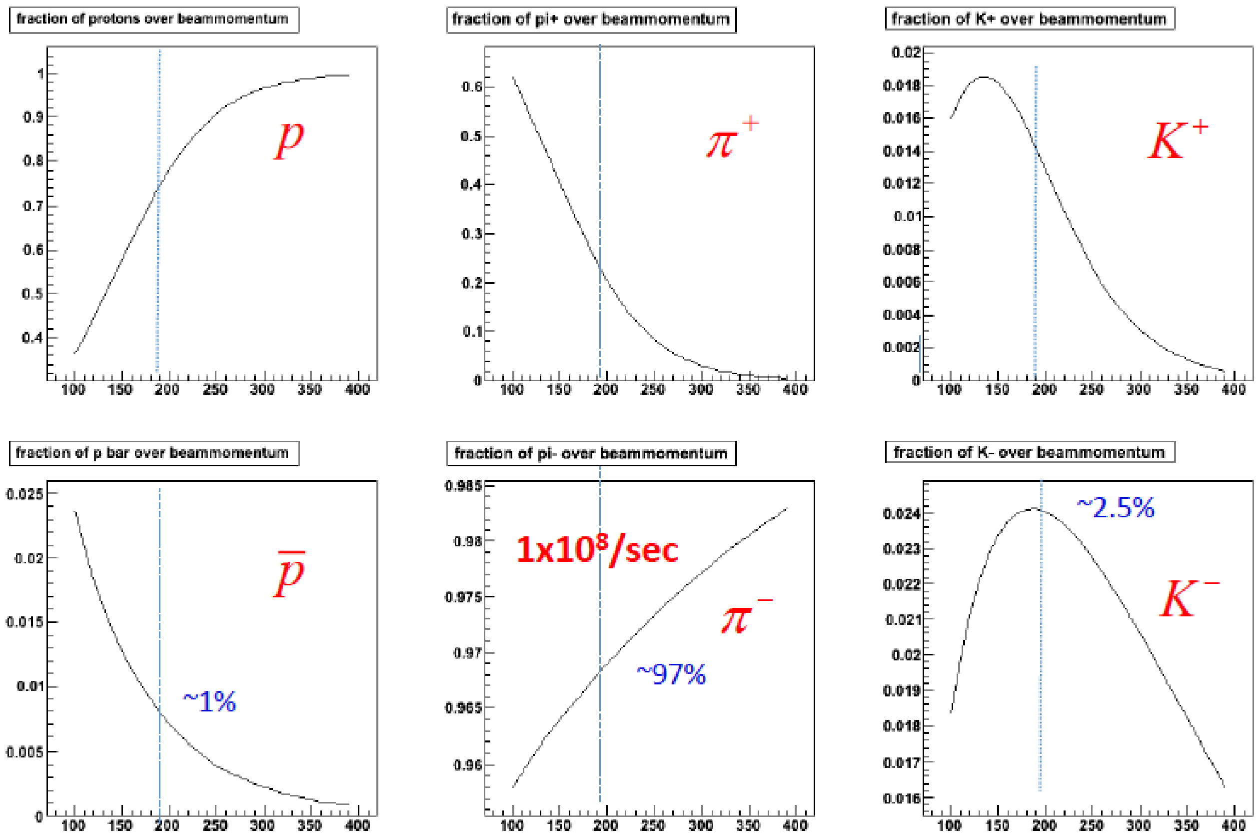
Beyond 2020 Workshop, CERN, March 21-22

Present/Future Hadron Beams

22 March 2016

Hadron Beams: Present I

Fraction of particles in the positive or negative M2-Hadron-beam at COMPASS target http://www.staff.uni-mainz.de/jasinsk/index.htm



Hadron Beams: Present II
Hadron spectroscopy

Hadron spectroscopy (beam intensity is limited by the Spectrometer:

- Total beam intensity ~5×10^6 p/s
- In the case of h^- the beam is dominated by pions (~97%), kaons and antiprotons can be tagged by CEDAR's system (~2% and ~1% respectively)
- In case of h^+ the beam is dominated by protons (~75%), the rest is pions (~24%) and kaons (~1%)

WORLD Largest Data sets

Hadron Beams: Present III
Drell-Yan

Hadron spectroscopy (beam intensity is limited by the Spectrometer:

- Total beam intensity ≤ 10^8 p/s
- In the case of h^- the beam is dominated by pions (~97%), kaons and antiprotons can be tagged by CEDAR's system (~2,5% and ~0.5% Respectively), upgrade is a must
- In case of h^+ the beam is dominated by protons (~75%), the rest is pions (~24%) and kaons (~1%)

Hadron Beams: Present IV
Drell-Yan

Experiment	Particles	Energy (GeV)	x_b or x_t	Luminosity ($cm^{-2}\ s^{-1}$)		P_b or P_t (f)	rFOM#	Timeline
COMPASS (CERN)	$\pi^{\pm} + p^{\uparrow}$	190 GeV $\sqrt{s} = 19$	$x_t = 0.1 - 0.3$	2×10^{33}	0.14	$P_t = 80\%$ f = 0.22	1.0×10^{-3}	2014-2015, 2018
PANDA (GSI)	$p + p^{\uparrow}$	15 GeV $\sqrt{s} = 5.5$	$x_t = 0.2 - 0.4$	2×10^{32}	0.07	$P_t = 90\%$ f = 0.22	1.1×10^{-4}	>2028
AFTER	$p^{\uparrow} + p$	7 TeV $\sqrt{s} = 120$	$x_b = 0.1 - 0.9$	2×10^{32}	0.06	$P_b = 100\%$?	2.3×10^{-5}	>2020
NICA (JINR)	$p^{\uparrow} + p$	collider $\sqrt{s} = 26$	$x_b = 0.1 - 0.8$	1×10^{32}	0.04	$P_b = 70\%$	6.8×10^{-5}	>2023
PHENIX/STAR (RHIC)	$p^{\uparrow} + p^{\uparrow}$	collider $\sqrt{s} = 510$	$x_b = 0.05 - 0.1$	2×10^{32}	0.08	$P_b = 60\%$	1.0×10^{-3}	>2018
fsPHENIX (RHIC)	$p^{\uparrow} + p^{\uparrow}$	$\sqrt{s} = 200$ $\sqrt{s} = 510$	$x_b = 0.1 - 0.5$ $x_b = 0.05 - 0.6$	8×10^{31} 6×10^{32}	0.08	$P_b = 60\%$ $P_b = 50\%$	4.0×10^{-4} 2.1×10^{-3}	>2021
SeaQuest (FNAL: E-906)	$p + p$	120 GeV $\sqrt{s} = 15$	$x_b = 0.35 - 0.9$ $x_t = 0.1 - 0.45$	3.4×10^{35}	---	---	---	2012 - 2017
Pol tgt DY‡ (FNAL: E-1039)	$p + p^{\uparrow}$	120 GeV $\sqrt{s} = 15$	$x_t = 0.1 - 0.45$	4.4×10^{35}	0 – 0.2*	$P_t = 85\%$ f = 0.176	0.15	2018-2019
Pol beam DY§ (FNAL: E-1027)	$p^{\uparrow} + p$	120 GeV $\sqrt{s} = 15$	$x_b = 0.35 - 0.9$	2×10^{35}	0.04	$P_b = 60\%$	1	2020

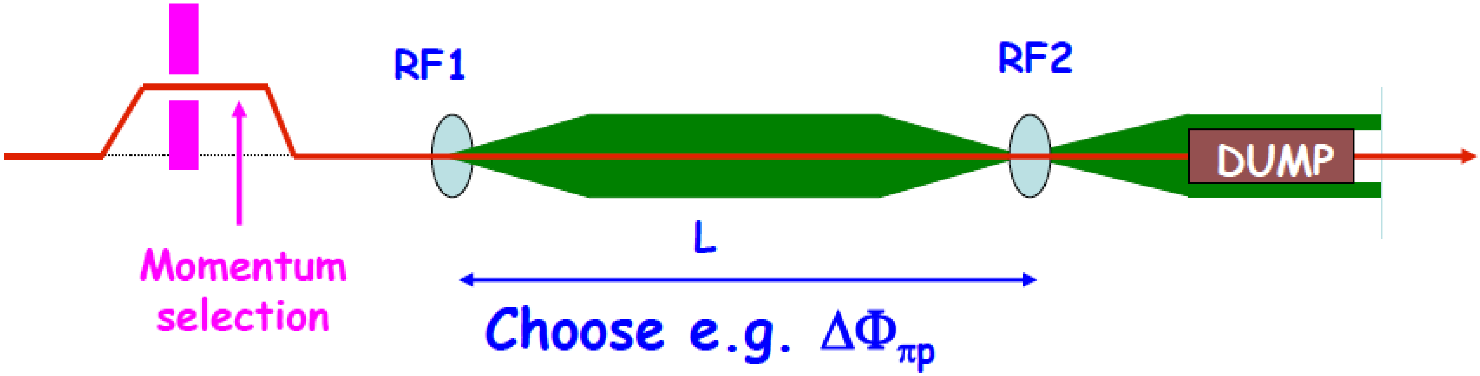
‡ *8 cm NH_3 target* / § *$L = 1 \times 10^{36}\ cm^{-2}\ s^{-1}$ (LH_2 tgt limited) / $L = 2 \times 10^{35}\ cm^{-2}\ s^{-1}$ (10% of MI beam limited)*
**not constrained by SIDIS data* / # rFOM = relative lumi * P^2 * f^2 wrt E-1027 (f=1 for pol p beams, f=0.22 for π^- beam on NH_3)

Hadron Beams: Future I

WHAT ABOUT A RF SEPARATED $\bar{p}$ BEAM ???

First and very preliminary thoughts, guided by
- recent studies for P326
- CKM studies by J.Doornbos/TRIUMF, e.g. http://trshare.triumf.ca/~trjd/rfbeam.ps.gz

E.g. a system with two cavities:



$$\Delta\Phi = 2\pi\,(L\,f\,/\,c)\,(\beta_1^{-1} - \beta_2^{-1}) \text{ with } \beta_1^{-1} - \beta_2^{-1} = (m_1^2 - m_2^2)/2p^2$$

Hadron Beams: Future II

VERY PRELIMINARY CONCLUSION

H.W.Atherton formula tells us : 0.42 $\bar{p}$ / int.proton / GeV

Assume target efficiency of 40%

Then for 10^{13} ppp on target one obtains:

$$0.4 \cdot 10^{13} \cdot 0.42 \cdot \pi \cdot 10^{-5} \cdot 2 \cdot 0.8 \;\; \bar{p}pp = \mathbf{8\ 10^{7}} \;\; \bar{\mathbf{p}}\mathbf{pp}$$

Antiprotons ~ 8 x 10^6 /s (normalized to 10^13 ppp) or ~ 3.5 x 10^7 /s
(4x10^13 ppp – maximal possible number of protons per primary target, 10 sec spill)
- gain is a factor of 50 compare to standard beam

The same (or roughly the same) is valid as well for RF separated kaon beam, taking into account maximal possible hadron beam intensity of 10^8 /s the Kaon beam intensity can be 6x10^7 - gain a factor of ~30 compare to standard hadron beam.

Hadron Beams: Future III
Hadron Spectroscopy

RF separated kaon beam, the maximal tolerable (limited by spectrometer) beam Intensity can be reached – 5 x 10^6 /s

No real competitors

JPark - ~10^5 /s, low momenta kaons

Jlab - ~10^4 /s, K^0 long beam, lower momenta

Unique opportunity

Hadron Beams: Future IV
Drell-Yan

RF separated antiproton/kaon beam (~50/50), the maximal possible beam intensity (very raw estimate) of 8×10^7 /s can be reached (3-4 $\times 10^{13}$ protons per 10 second long or 2 x 5 sec long flat tops)

No competitors, unique data

So the over all gain for RF separated beam compare to former experiments is 60 to 500

CEDAR project is of most importance

Hadron Beams: Future V
Drell-Yan unpolarised

- Unpolarised DY (conventional beam (pions end few k, anti) and LH_2):

1. Lam-Tung / BM
2. Kaon/pion structure
3. EMC effects
4. Pion Distribution Amplitude

- Unpolarised DY K/antiproton beams (nuclear + LH_2)

1. BM of proton model independent
2. BM of pion and kaon (combining conventional beams)
3. Kaon/pion structure, kaon Lam-Tung

Hadron Beams: Future V
Drell-Yan polarised

- Polarised DY (conventional beam):

1. ^{6}LD – flavour separation
2. Kaon/pion structure

- Polarised DY K/antiproton beams

1. Model-independent Transversity
2. Sivers Antiproton, Gluon (J/Psi)
3. Proton Transversity

- Polarised DY conventional beam + RPD

1. GPD H_T