High Momentum Beam Line at the 50-GeV Proton Synchrotron

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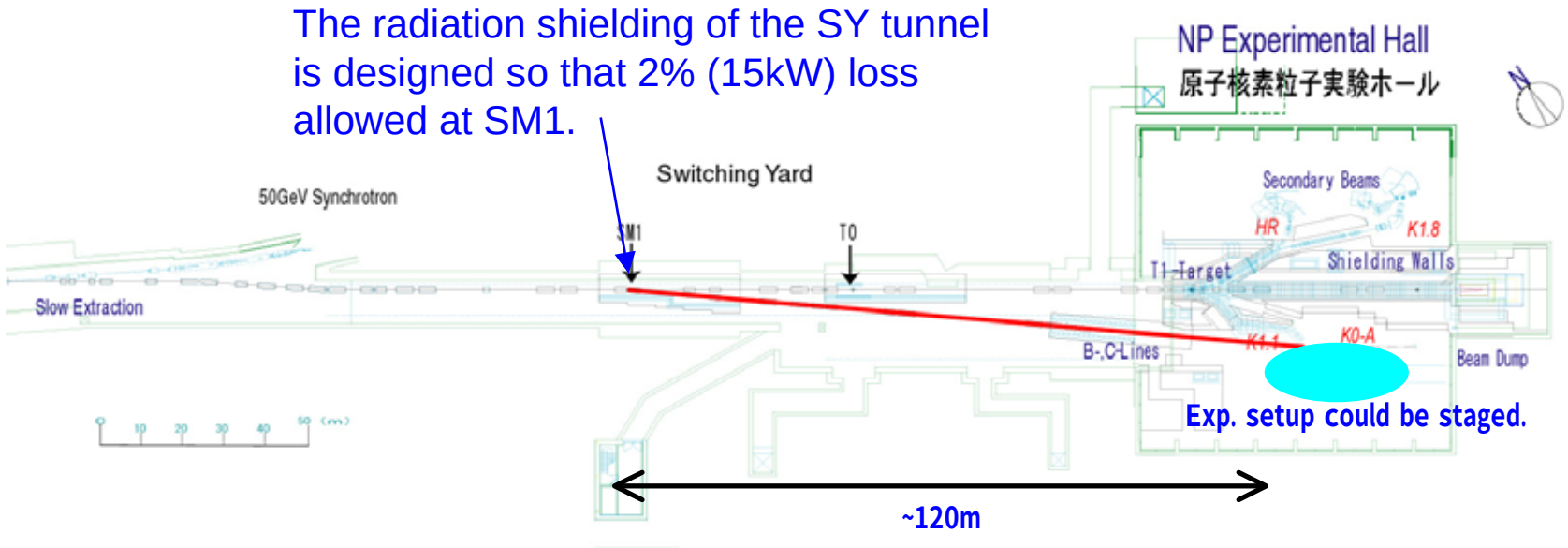
Outline

- Propose to construct a high momentum beam line from SM1, which can accommodate primary beams and secondary beams up to 51 GeV/c, at an early stage of the NP hall operation.
  - Primary beams: proton (Phase 1), polarized proton and heavy ions (future)
  - Secondary beams: proton, pion, kaon, anti-proton, etc.



Physics Interest

- Requirements for a high momentum beam line have been expressed by many physicists/groups.
  - NP02: International Workshop on Nuclear and Particle Physics at 50-GeV PS, Kyoto University, September 2002

Summary of physics topics discussed at nuclear/hadron physics session

			beam			Apparatus	Comment
			low Intensity	high Intensity	future		
	Keynote talk	H. Spinka					
	Possibility of HI and pol-p acceleration	Y. Mori					
	Towards the construction of multi-purpose beam line	K.H. Tanaka					
	Future of structure functions of the nucleon and nuclei	T.-A. Shibata		primary p	pol. p		
	Sturucture function and related physics	N. Saito		primary p	pol. p		
	Muon pair measurements and physics	S. Sawada		primary p			
Sturucture function	The vertex spectrometer of the NA60 experiment	K. Banicz	primary p		HI	dimuon spectrometer	pixel telescope

This letter of intent has been written based on the discussion at NP02.

	future	T. Murakami	secondaries		HI	Bragg curve counter	
Nuclear matter physics	Overview of Lattice QCD Calculations – Studies of New Aspects of QCD at JHF –	A. Nakamura					
	Diphoton emission from hot and dense matter near the critical end point	K. Fukushima					
Nuclear force	Very High P_t proton-proton elastic scattering at U-70 and possibly JHF	A.D. Krish/K. Yonehara	primary p	primary p			pol. p target
Meson hadron spectroscopy	Hadron physics with monochromatic KL beam: Z+ search	T. Nakano	1GeV/c pi			charged particle spectrometer + neutron	
	Has the PROMICE/WASA detector at CELSIUS seen the first true dibaryon?	T.J. Goldman					
	Separated K+ beam line and hadron spectroscopy	V. Obraztsov T. Tsuru		secondary K		beam line spectrometer	RF separator

Physics Interest (cnt'd.)

– Letter of Intent called after NP02

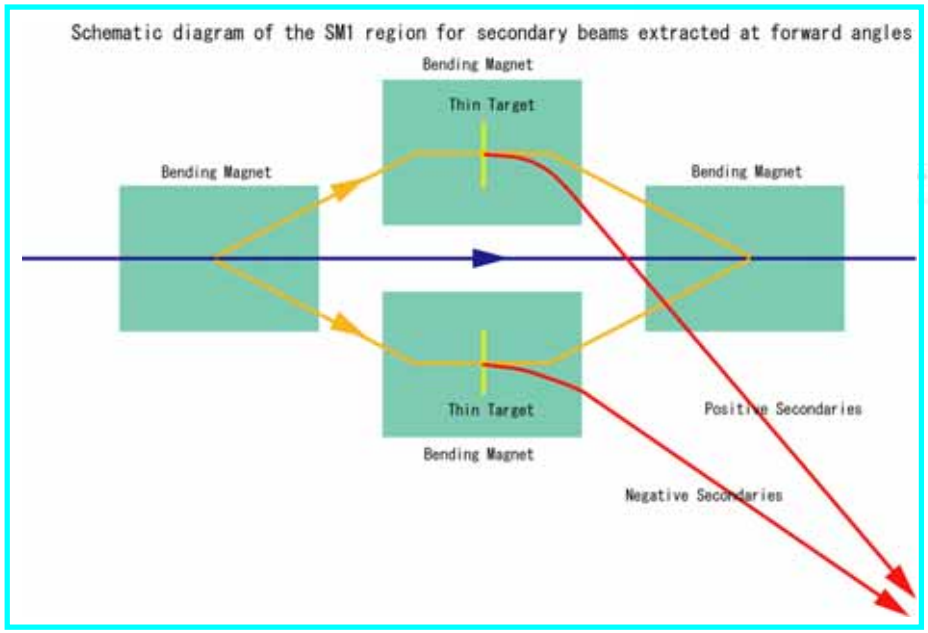
Summary of Requested Beam Lines

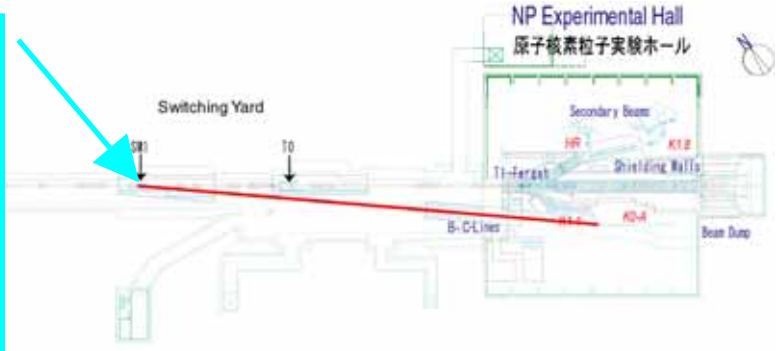
	Contact Person(s)	Requested Beam	Momentum Range (GeV/c)	Phase-1 K1.8	Phase-1 K1.1	Phase-1 K0.8	Phase-1 KL	Phase-1 Test Beam	Phase-1 High Mom.	Phase-1 Neutrino	Phase-2 High-resol line	Future Possibilities Several GeV Separated	Future Possibilities Heavy Ion	Future Possibilities Pol. Proton	Future Possibilities PRISM	Future Possibilities PRISM-II	Future Possibilities Fast Extraction	Future Possibilities NuFact-J
LOI-06	K. Imai	K-	0.8, 1.1, 1.8	○	○													
LOI-07	M. Ieiri	K-, π+	1.0-1.6	○	○													
LOI-08	H. Noumi	π+/-	1.0-1.2								○							
LOI-09	T. Fukuda	K-/π-	0.9/1.0		△						○							
LOI-10	T. Nagae et al.	K-	0.9, 2-3		○							○						
LOI-21	S. Ajimura	K-/π+	0.8/1.0		○													
LOI-01	V.V.Sumachev et a	π+/-	0.6-2.1	△														
LOI-03	A.D. Krisch	p	51						○					○				
LOI-11	S. Yokkaichi	p	31, 51						○				○					
LOI-13	H. Spinka, S. Sawa	π,K,p pol.-p/HI	< 6									○						
LOI-15	J.-C. Peng, S. Saw	p, pol.p, HI							○				○	○				
LOI-18	T. Murakami	p	30						○				○					
		p,π-	4.0-14.0						○									
LOI-23	L. Nemenov	p	30(50)						○									
LOI-04	T.K. Komatsubara	K+	0.6-0.8			○												
LOI-05	T. Inagaki	KL	~2				○											
LOI-16	C. Rangacharyulu	K+				○												
LOI-19	Yu. Kudenko, J. Im	K+	0.6-0.7			○												
LOI-20	S. Shimizu	K+	0.6-0.7			○												
LOI-12	K. Nishikawa	neutrino	~0.8							○								
LOI-17	B.L. Roberts	μ+															○	
LOI-22	Y.K. Semertzidis et	μ+													○			
LOI-25	PRIME Group	μ-																
LOI-02	S. Komamiya	e,μ,π,K,p	0.5-2, <10					○										
LOI-14	S. Sawada	π,K,p, primar	> 5						○			○	○	○				
LOI-24	PRISM Group	μ													○	○		
LOI-26	Y. Kuno, R.S. Haya	anti-p, μ, ..													△		○	△
LOI-27	Y. Kuno, Y. Mori	neutrino																○
LOI-28	V. Obraztsov, T. Ts	K-	~12									△						
LOI-29	T. Kishimoto																	
LOI-30	K. McDonald et al.	p	50														○	

- Many requirements and interesting physics possibilities!

Beam Line Configuration & Optics I

- Secondary Beams:
  - Use a thin (2% = 15kW loss) target at SM1
  - Collect them at forward angles
  - Transfer them for ~120m
- Schematic Layout around SM1:

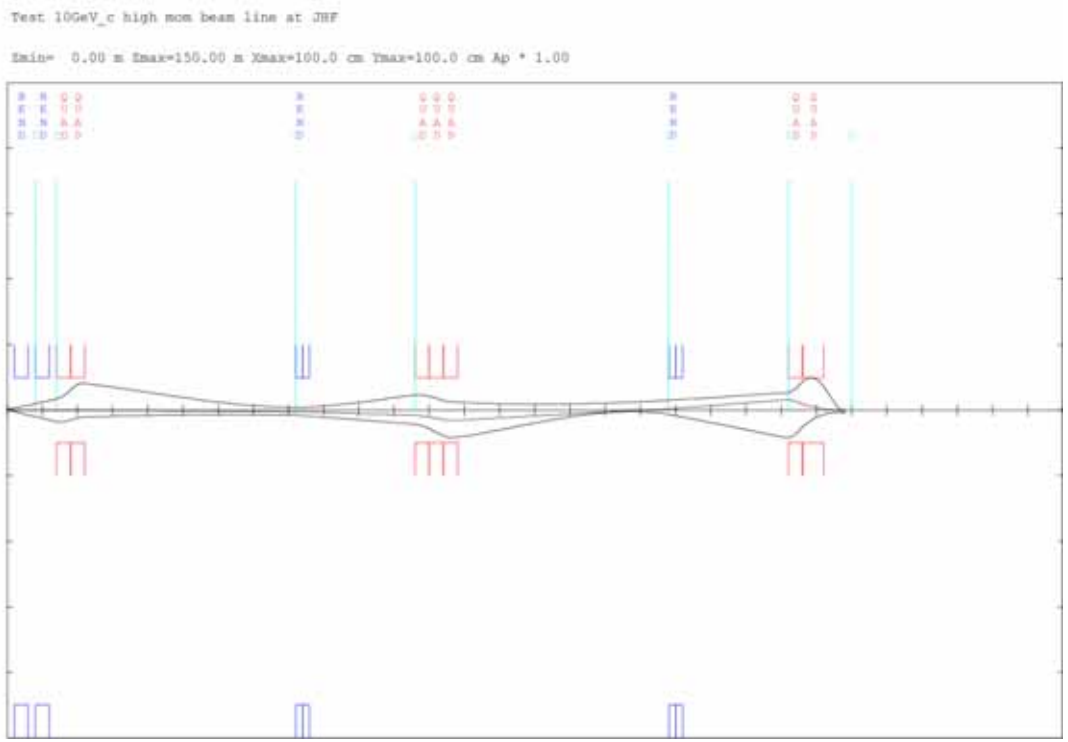




Shielding of the switching yard has been designed to accommodate the loss at SM1

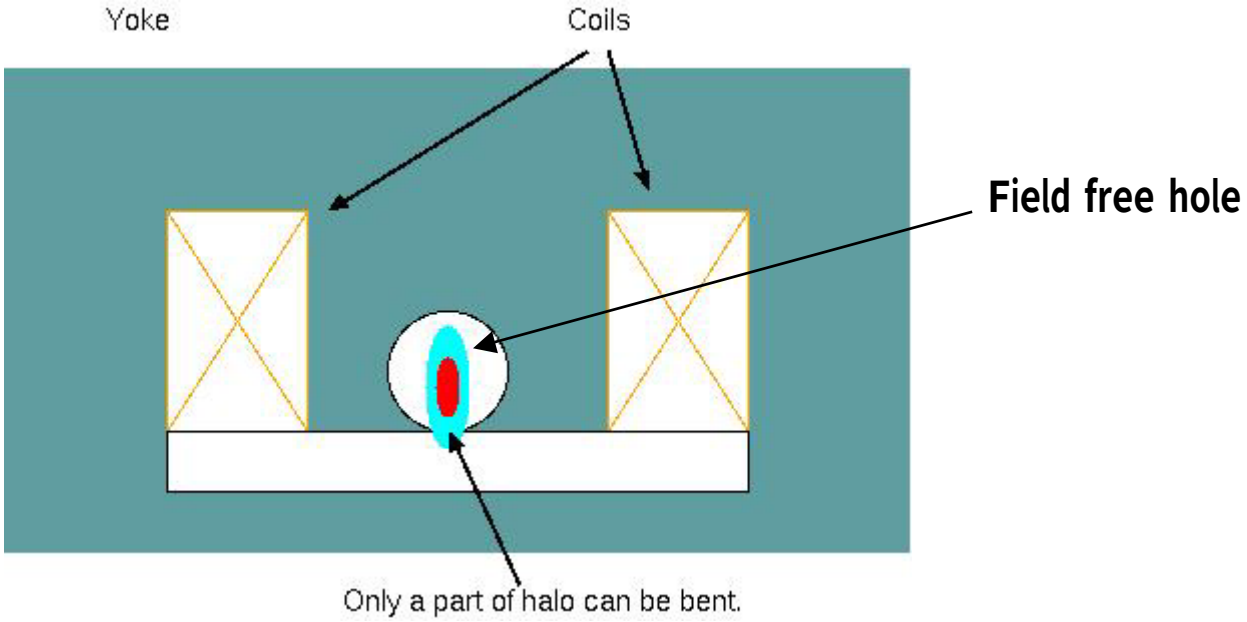
Beam Line Configuration & Optics II

- Beam Optics: a preliminary design has been studied.
  - Example: 10 GeV/c particles
    - Bore radius of the quadrupole magnets is 10 cm or less.
  - 0.2 msr% can be achieved.



Beam Line Configuration & Optics III

- Primary Beams:
  - Beam line configuration is almost the same as the case for the secondary beams except for equipments at SM1.
  - In order to cut a fraction (10 to 100 ppm) of the primary beam, a beam stealer can be used.
    - 10^{14} primary protons ➔ 10^{9}-10^{10} protons



Beam Line Configuration & Optics IV

- In order to get a few % of the primary beam, an electrostatic septum or a bent crystal will be used.
  - 10^{14} primary protons ➔ ~10^{12} protons
  - High heat and radiation deposit have to be taken into account.
  - More R&D works should be necessary to estimate the beam loss and to finalize the design.
- In order to get 100 % of the primary beam, a conventional bending magnet can be used.
  - Weak primary beam (at the beginning of the accelerator operation, and heavy ion beam or polarized beam in the future).

Yield Estimation (30GeV)

- 30GeV protons + 2% loss copper target. Production angle of 4 degree and $(\Delta p/p)\Delta\Omega$ = 0.2msr%.

	Momentum (GeV/c)	$d\sigma/dpd\Omega$ (mb/sr/GeV/c)	Yield at SM1 (per 10^{14} protons)	Yield at 120m (per 10^{14} protons)
π^+	5	1400	3.7E7	2.4E7
π^+	10	210	1.1E7	8.9E6
π^-	5	1000	2.6E7	1.7E7
π^-	10	130	6.7E6	5.4E6
K^+	5	130	3.3E6	1.3E5
K^+	10	28	1.4E6	2.8E5
K^-	5	61	1.6E6	6.4E4
K^-	10	7.0	3.6E5	7.2E4
pbar	5	11	2.8E5	2.8E5
pbar	10	1.1	5.7E4	5.7E4

- Even with 30 GeV protons, enough intensity can be obtained especially for pions!

Yield Estimation (50GeV)

- 50GeV protons + 2% loss copper target. Production angle of 4 degree and $(\Delta p/p)\Delta\Omega$ = 0.2msr%.

	Momentum (GeV/c)	$d\sigma/dpd\Omega$ (mb/sr/GeV/c)	Yield at SM1 (per 10^{14} protons)	Yield at 120m (per 10^{14} protons)
π^+	5	3700	9.5E7	6.2E7
π^+	10	930	4.7E7	3.8E7
π^-	5	3700	9.5E7	6.2E7
π^-	10	700	3.6E7	2.9E7
K^+	5	440	1.1E7	4.4E5
K^+	10	120	6.2E6	1.2E6
K^-	5	220	5.7E6	2.3E5
K^-	10	56	2.9E6	5.8E5
pbar	5	53	1.4E6	1.4E6
pbar	10	16	8.4E5	8.4E5

- To get more intensity for higher momentum beams, extraction at more forward angles can be considered.

Cost & Schedule: Magnets from the World

- Total cost if constructed from scratch: $5-8M??
- We have no budget so far to construct a high momentum beam line. But we are doing every effort to construct it with as small cost as possible, e.g. reuse of second-hand magnets…
- Already from SLAC, Saclay, CERN, …
- Large dipole magnets from ANL (previously used for the polarized beam line at FNAL) are under process!
- The high momentum beam line can be constructed by using some of these second-hand magnets.
- The high momentum beam line can be constructed even at the beginning of the NP hall operation from the viewpoint of the facility design.

Large dipole magnets at the Meson Pol beam line (FNAL)

Summary

- Propose to construct a high momentum beam line.
  - Branch line from SM1.
  - p < 51 GeV/c, ~120 m, primary and secondary beams.
- Rich physics possibility and many requirements.
  - Needs for test experiments with high momentum beams can also be fulfilled.
- Even with 30 GeV, not only primary protons but also quite enough pions can be obtained.
- Technically feasible, with some R&D's.
- Efforts to reduce the cost have been made.

Recent Activities and Prospects

- Requirements and comments on the design of the beamline should be discussed among this group!
  - A few or several GeV/c kaon beamline? (➔hadron spectroscopy)
  - Should the high momentum beamline be proposed as one proposal, or as a part of a proposal of an experiment?
- Grant-in-Aid (Kakenhi) has been approved for R&D of the high momentum beamline.
  - Beam stealer, bent crystal, ES septum, solid target…
  - Budget is not enough for all of these, but R&D should be started step by step.
  - Your collaboration and input are very much welcome!
- Magnet transfer
  - Magnets from ANL are being transferred, thanks to Hal Spinka.