Possible beta beam scenario(s) in the US

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Outline

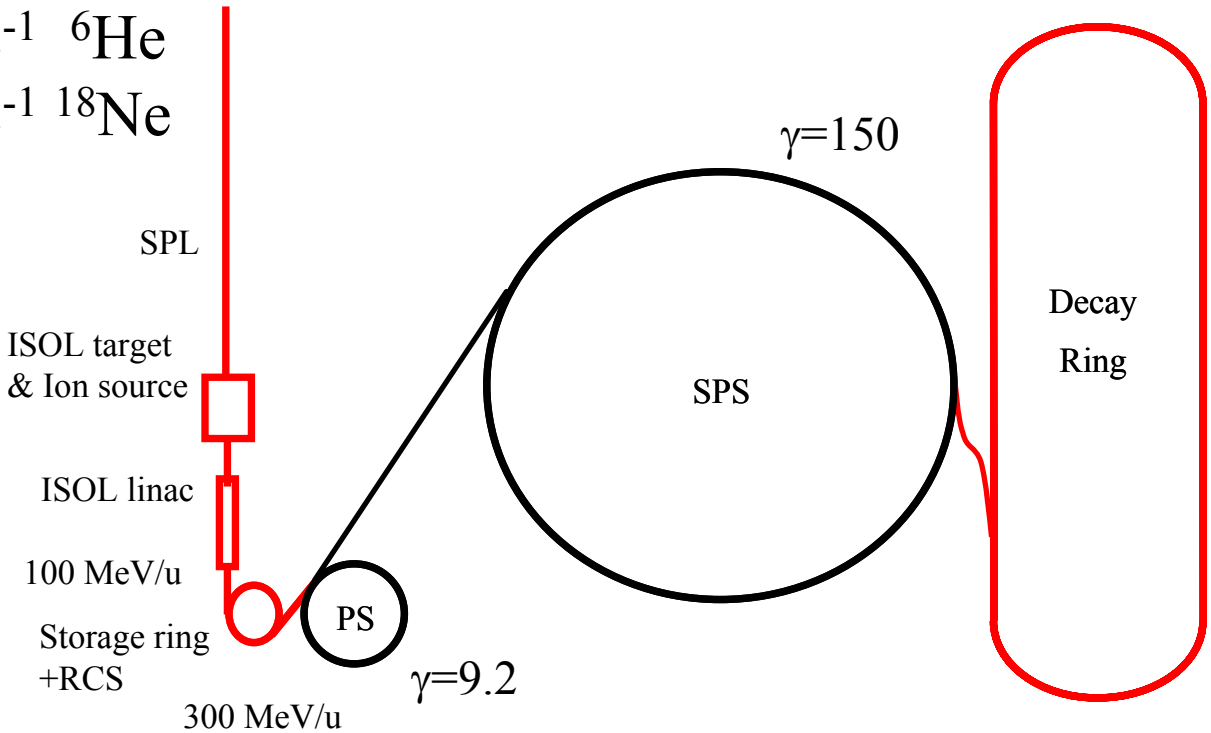
- This talk is far from a blueprint for beta beams at US labs!
- Attempt to look at how US machines could fit into a CERN-like scenario.
- Basic calculations to investigate which US machines could be utilized.

CERN site study

Ions generated:

2 10^{13} s^{-1} ^{6}He

8 10^{10} s^{-1} ^{18}Ne



Decay ring

Bρ = 1500 Tm

B = 5 T

L_{ss} = 2500 m

Ions stored:

2 10^{14} $^{6}He^{2+}$

9 10^{12} $^{18}Ne^{10+}$

(simultaneously in 4+4 10ns bunches)

[Slide from M. Lindroos et al]

CERN Intensities

Stage	^{6}He	^{18}Ne (single target)
From ECR source:	2.0×10^{13} ions per second	0.8×10^{11} ions per second
Storage ring:	1.0×10^{12} ions per bunch	4.1×10^{10} ions per bunch
Fast cycling synch:	1.0×10^{12} ion per bunch	4.1×10^{10} ion per bunch
PS after acceleration:	1.0×10^{13} ions per batch	5.2×10^{11} ions per batch
SPS after acceleration:	0.9×10^{13} ions per batch	4.9×10^{11} ions per batch
Decay ring:	2.0×10^{14} ions in four 10 ns long bunch	9.1×10^{12} ions in four 10 ns long bunch

Only β-decay losses accounted for, add efficiency losses (50%)

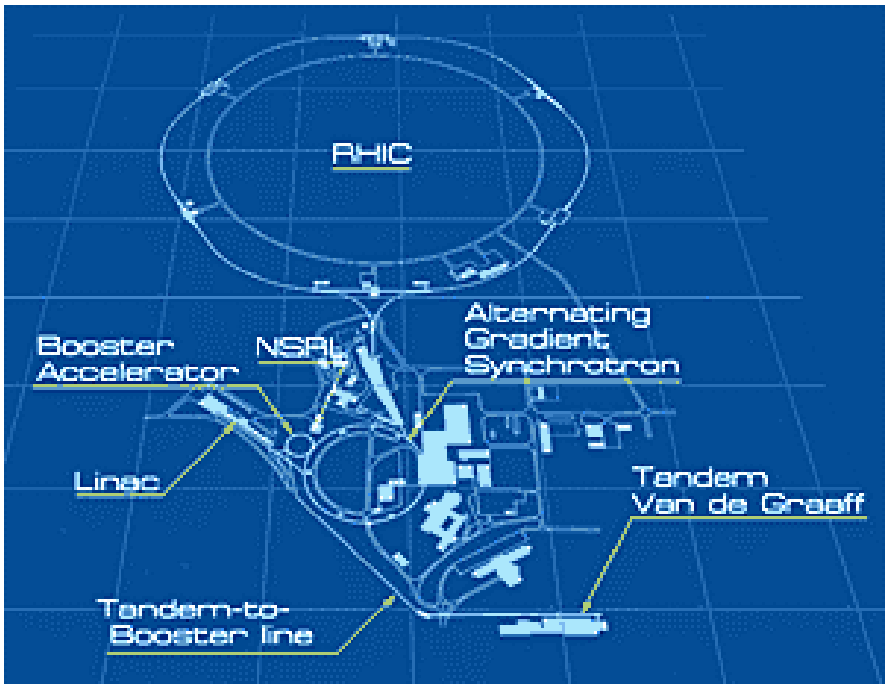
Andreas Jansson, Neutrino Workshop, ANL, March 3-4, 2004

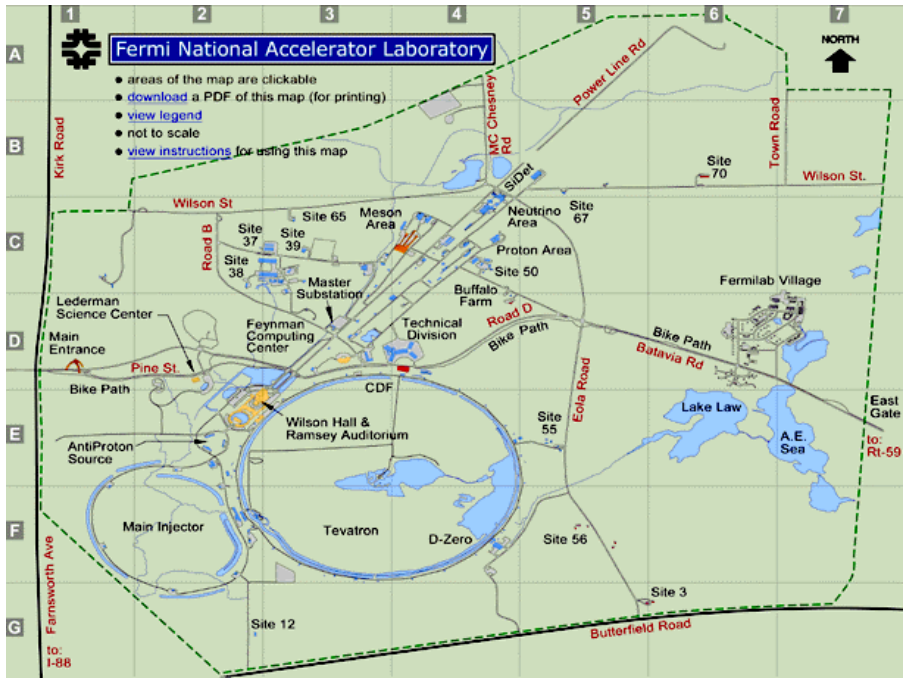
[Slide from M. Lindroos et al]

Different “CERN scenarios”

- “Original” based on max SPS field, γ(He)=150 [**Nufact02**].
- Both species in machine simultaneously, optimum at γ(He)=60 and γ(Ne)=100 [**Nufact03**]
- Higher energies, proposed γ =600 (upgraded SPS). Relaxes beam requirements [**hep-ph/0312068]**
- Low energy (nuclear physics) [**hep-ph/0303222**]

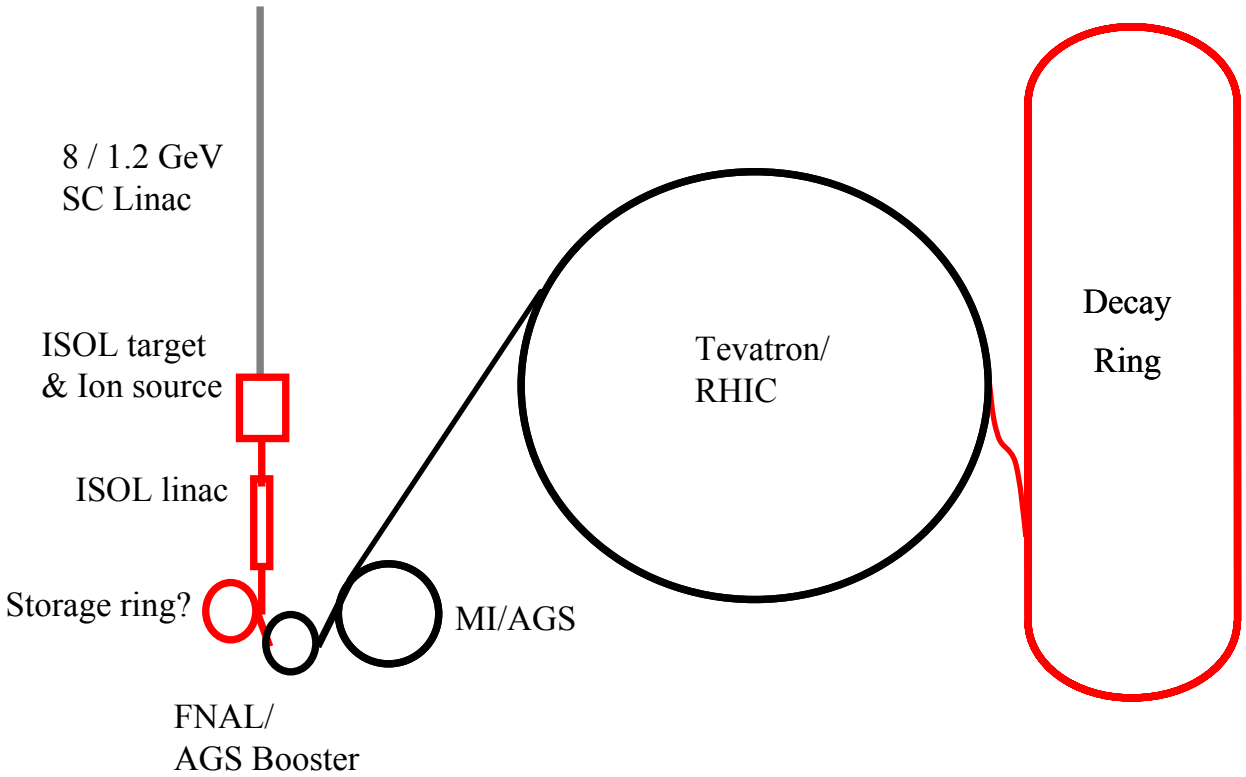
Possible US sites





Only considering high energy beta-beams

Possible US scenario



Note that both labs already have an RCS, as proposed for CERN scenario.
Both labs also have plans for a SC proton driver linac ☺

Brookhaven machines

Machine	Top Energy	Ramp time	Cycle time	Harmonic	Circumference
AGS Booster	8 GeV	1/15 s	2/15 s	1,2,3	208 m
AGS	31 GeV	0.5 s	1 s	6,8,12	807 m
RHIC	500 GeV	75 s	150 s	360, 2520	3800 m

- Energies are for protons

Proposed 1.2 GeV Linac could be used for RI production

Brookhaven machines II

Machine	Gamma	"Average" lifetime	Estimated Decay Loss
AGS Booster	2.8 / 4.5	1.1 s / 2.9 s	4 % / 2 %
AGS	10 / 17	3.7 s / 15.8 s	12 % / 3 %
RHIC	83 / 139	43 s / 183 s	70 % / 24 %

* Values are for 6He2+ / 18Ne10+

Some Brookhaven issues

- Acceleration efficiency (RHIC)
- Associated losses
- Low rep rate*
- Top energies comparable to CERN SPS (or less)**

} Upgrade power supplies?

*Could perhaps interleave RHIC rings to double rep rate?
** Harmonic numbers also similar to CERN ☺

Fermi machines

Machine	Top Energy	Ramp time	Cycle time	Harmonic	Circumference
Booster	8 GeV	1/32 s	1/16 s	84	479 m
Main Injector	150 GeV	0.7 s	1.5 s	28, 588	3219 m
Tevatron	980 GeV	17 s	35 s	1113	6282 m

- Energies are for protons

Proposed 8 GeV Linac could be used for RI production

Fermi machines II

Machine	Gamma	Average lifetime	Estimated Decay Loss
Booster	2.5 / 3.9	1 s / 3.6 s	2 % / 0.6 %
Main Injector	50 / 83	13 s / 54 s	4 % / 1 %
Tevatron	326 / 544	99 s / 423 s	13 % / 3 %

* Values are for 6He2+ / 18Ne10+

Fermi machines III

Machine	Max intensity per Tevatron cycle	Avg. loss power [W/m]	Duty factor
Booster	$1.54\ 10^{13}$ /$1.18\ 10^{13}$	0.3 / 0.3	~ 1 % (?)
Main Injector	$1.52\ 10^{13}$ / $1.18\ 10^{13}$	0.12 / 0.14	3-6 % (?)
Tevatron	$1.32\ 10^{13}$ / $1.14\ 10^{13}$	1 / 1	50 %

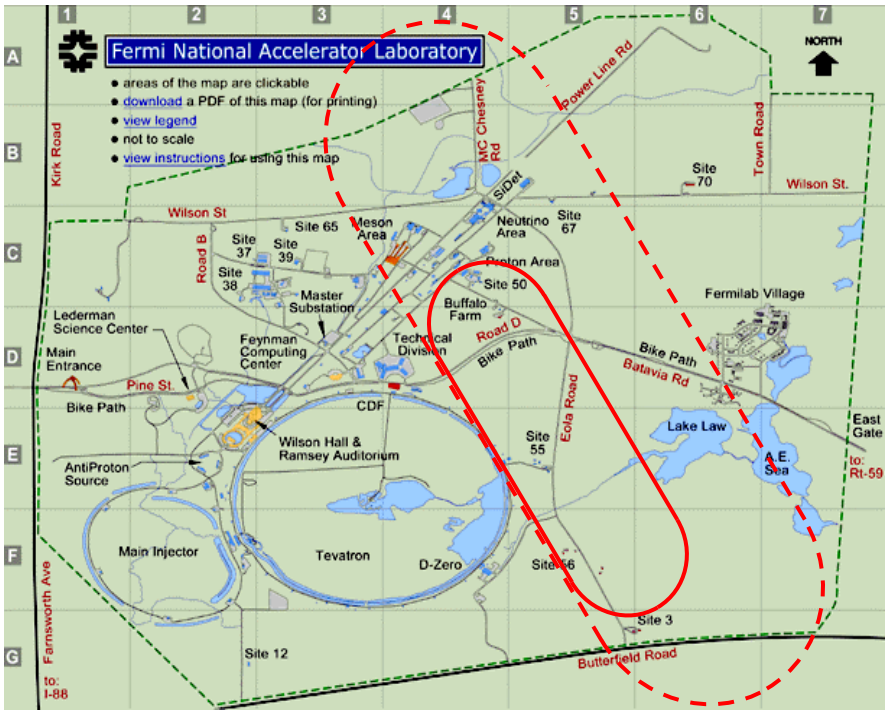
- Values are for 6He2+ / 18Ne10+, calculated to yield 1 W/m on average in Tevatron (not based on ion production)

Some Fermilab issues

- Loss sensitivity of Tevatron (how many RIs can it take all the way to top energy?).
- Relatively long acceleration cycle of Tevatron (lower rep rate than SPS).
- Activation and shielding of Booster (and other machines).
- …

+ all the non-CERN specific issues

Decay ring



- CERN baseline version fits on site
- For higher gamma, site limits size (more space at BNL).
- What direction to experiment (Soudan too far away)?

—— CERN baseline, γ(He)=150

------ Scaled to γ(He)=320

Observations

- Both BNL and Fermilab plan for proton drivers that could be used for RI production
- If RHIC can be made to ramp significantly faster, BNL site may be comparable to CERN for BB
- Main injector can get close to the proposed energies for running both He+Ne simultaneously at CERN.
- Using the Tevatron, could achieve higher gammas !

Studies needed for higher gamma

- Physics gain from going to Tevatron energies (γ_{He}=320 and γ_{Ne}=540).
- Possible experiments and locations.
- Intensity and bunching factor requirements.
- More details on efficiencies, loss limits and intensity limits (i.e. can these requirements be met).
- Longitudinal gymnastics scheme (need new RF?).
- …