NuFact 2016

Progress towards a Neutrino Factory

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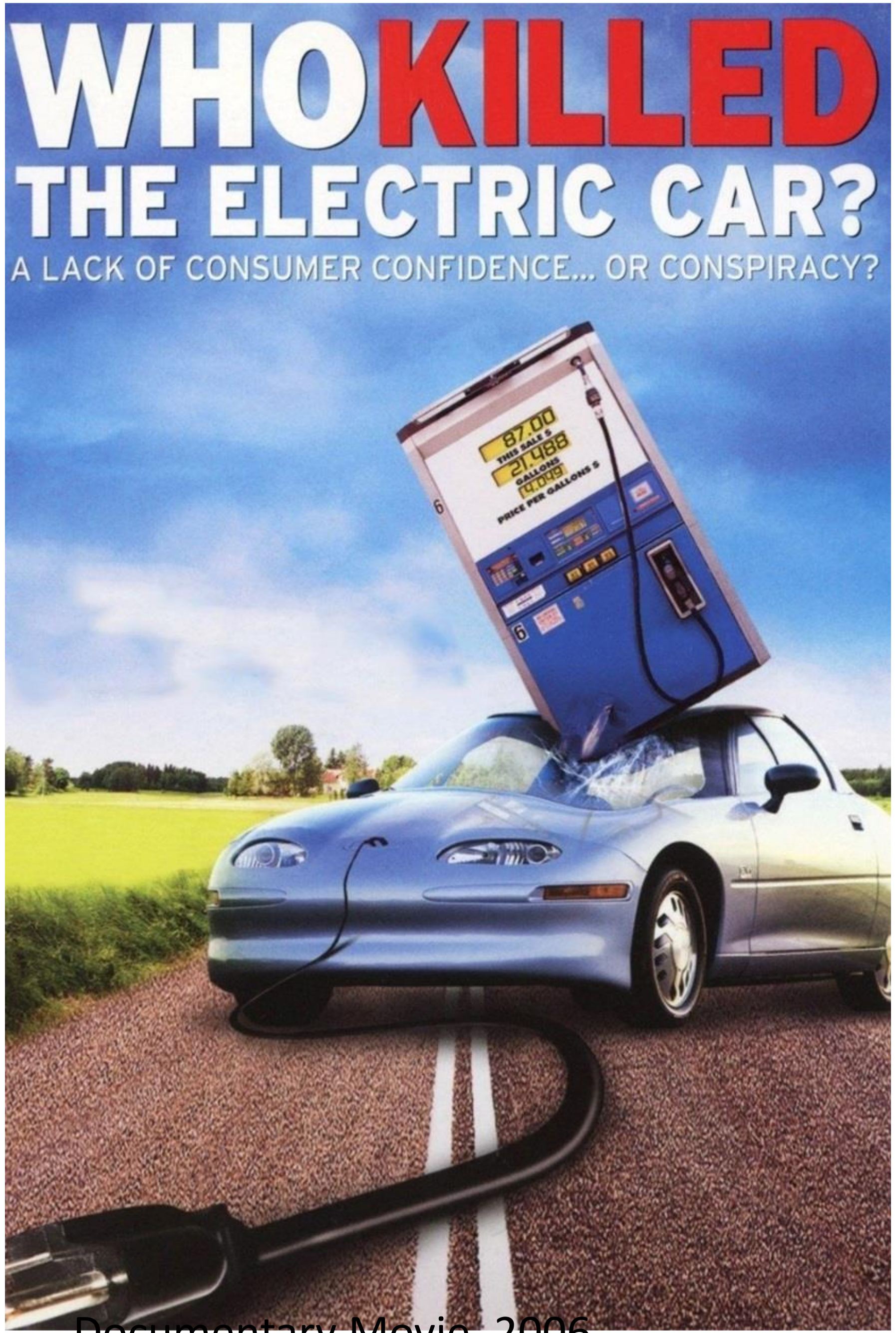

Documentary Movie, 2006

Who Killed Neutrino Factory ⟺ Large Theta13 ???

This is not joke, analogy is real!

But like with car, time will come when people will say we need:

- Multi GeV high intensity proton beam
- High power target station
- High Brightness Pion beam
- High intensity Muon beam
- Cold Muon beam

And all these at one place is Neutrino Factory

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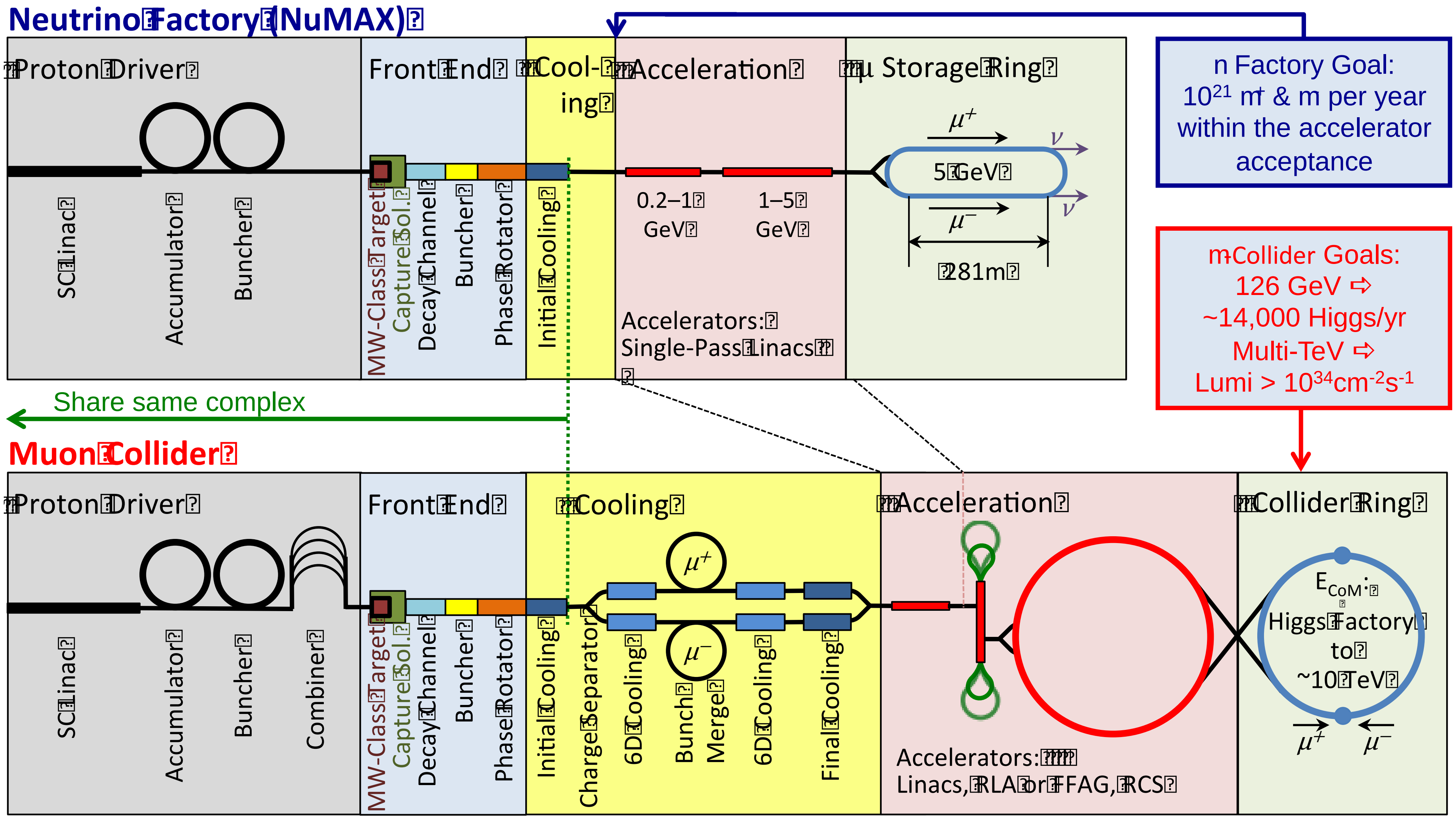

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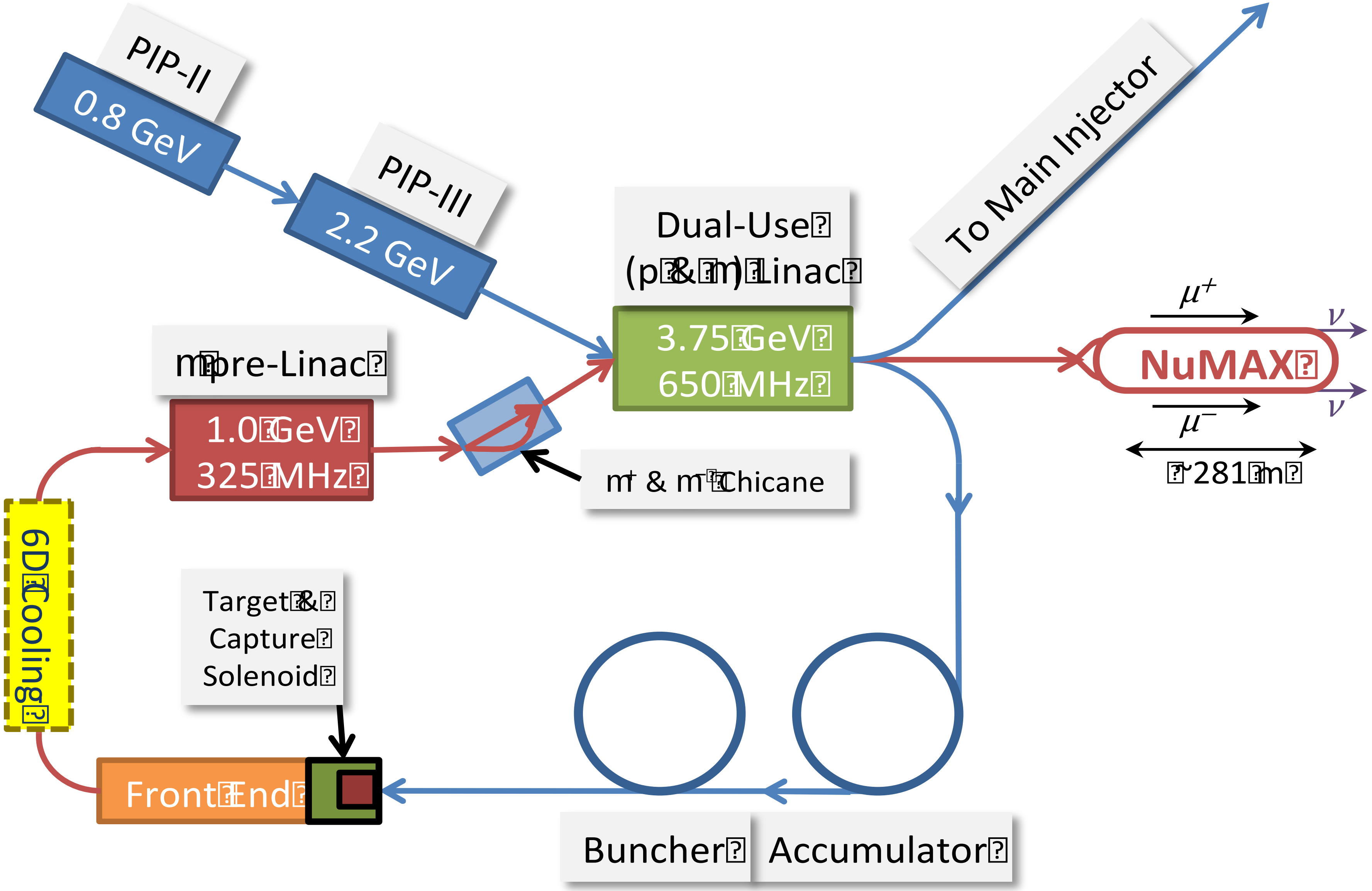
Path to the Future ⇨ Staging



M. Popovic

What to do now

- Superbeam technology will continue to drive initial observations in the coming years
- *However, anomalies and new discoveries will drive our need for precision studies to develop a complete physical understanding*
- Neutrino Factory capabilities (both long- and short-baseline) offer the route to *controlled systematics* and *precise measurements*, which are required to fully elucidate the relevant physics processes

⇨ ***Precision Microscopes for the ν sector!***

What to do now (at Fermilab)

- Measure neutrino cross-section with better than 10% precision
- Take advantage of the existing accelerator complex configuration providing beam to the New Muon g-2 Experiment
- Utilize existing detectors (MicroBooNE, ICARUS)
- Minimize initial investment. Providing a suitable building to house the detector would be the only investment required
- Describe possible improvements in collecting and storing muons that would allow cross-section measurements with a precision of a few percent with a modest additional investment.
- Provide a suitable test facility for future NF

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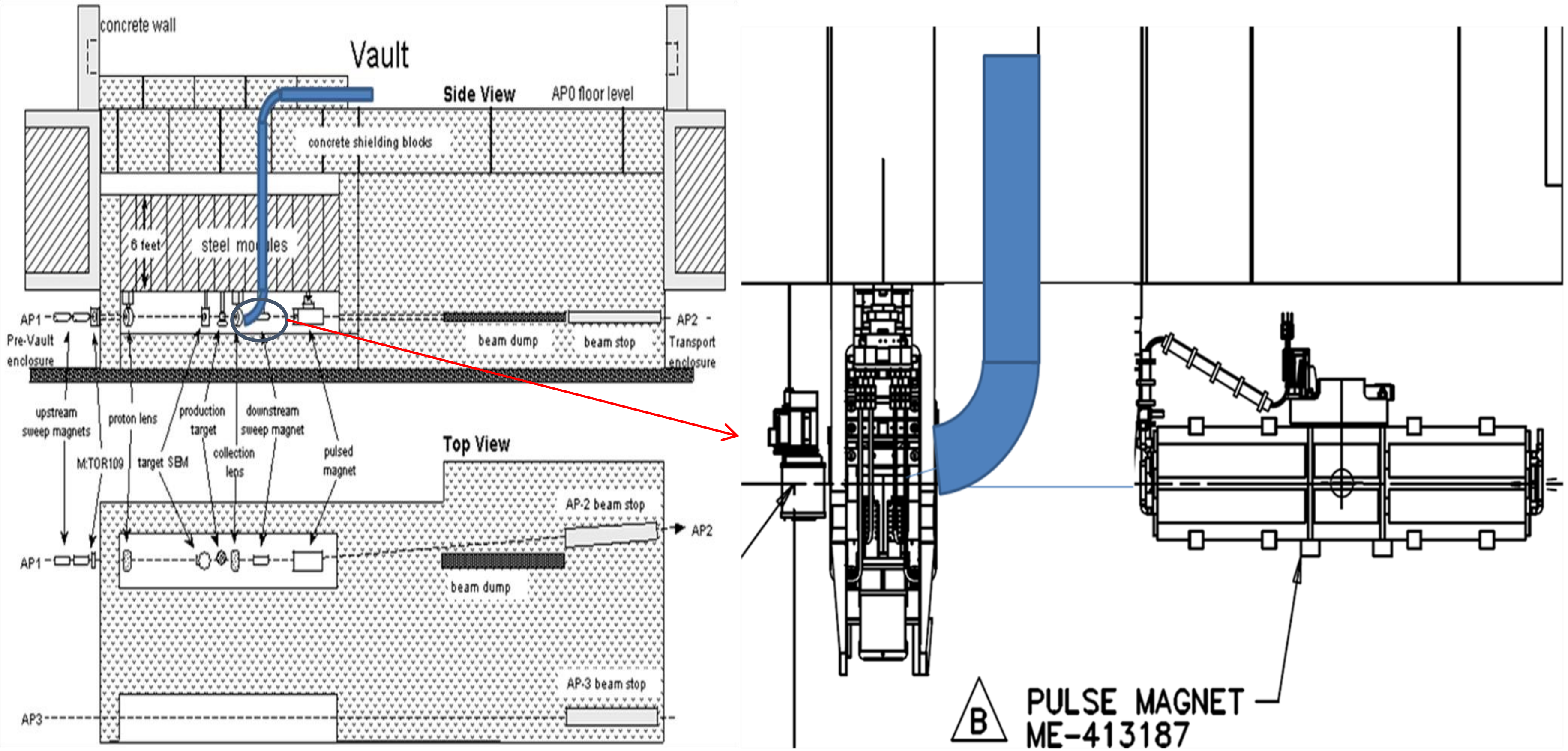
Muon Campus = Mu2e + g-2 + ???(do Neutrino Cross Sections)

Motivation: ~100kW Target Station

AP0, Old Antiproton Target Station

The building can accommodate small size experiments (10 m x 15 m), but if needed there is room for enlargement of the experimental space.

AP0 Target Station



We envision positioning a vertically bending 90^o magnet right after the Lithium Lens to collect 300 MeV/c π's as shown in figure.

Comparison…

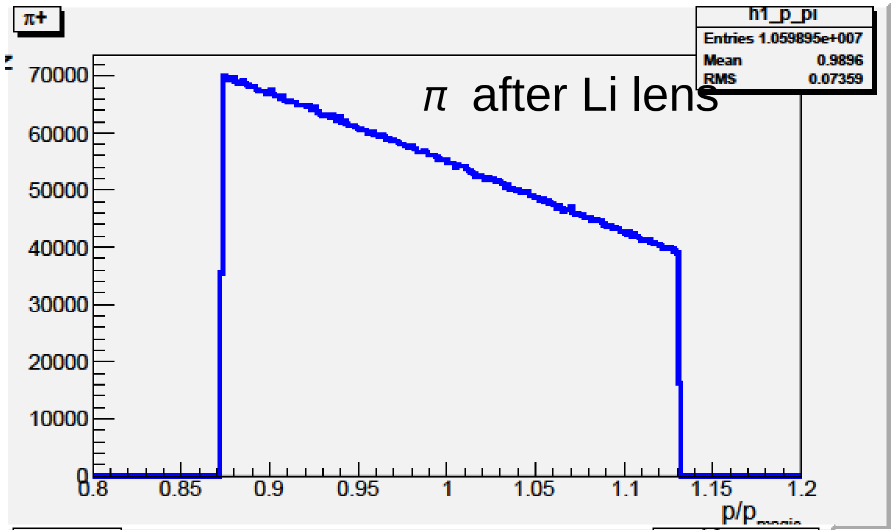
	PSI[(1)] (μE4)	MuSIC	COMET[(2)]	NuFACT[(3)]	AP0 with g-2
Muon intensity (/sec)	3.5×10^{8}	$10^{8\text{-}9}$	10^{11}	$10^{12\text{-}13}$	$\sim10^{8}$
Proton beam energy (GeV)	0.590	0.4	8	8	8
Proton beam power (W)	1.2M	400	56k	4M	~40kW
Production efficiency (muon/W)	292	$2.5\times10^{5\text{-}6}$	1.7×10^{6}	$2.5\times10^{5\text{-}6}$	
Time structure	Continuous	Continuous	Pulsed	Pulsed	Pulsed
Muon momentum (MeV/c)	85-125[(4)]	20-70	20-70	170-500	~20-300
Beam current (μA)	1.8	1	7	Not given	
Production target	Graphite	Graphite	Tungsten	Mercury jet	Inconel
Max Solenoid Field Strength (T)	5.0	3.5	5.0	20	Li Lens

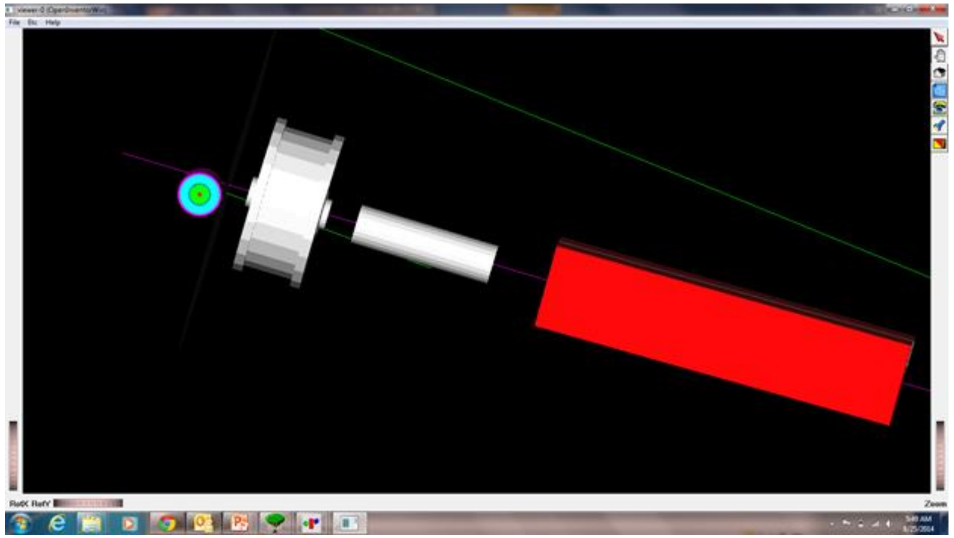
(1) *Based on: "A New High-intensity, Low-momentum Muon Beam for theGeneration of Low-energy Muons at PSI", Prokscha, T.; Morenzoni, E.et al. (Hyperfine Interactions, Vol.159, Issue 1-4, pp. 385-388)*
(2) *COMET CDR*
(3) *Based on The Muon Collider/Neutrino Factory Target System, H.Kirk and K.McDonald (Aug.14,2010) and Study-II report*
(4) *Range over all beamlines*

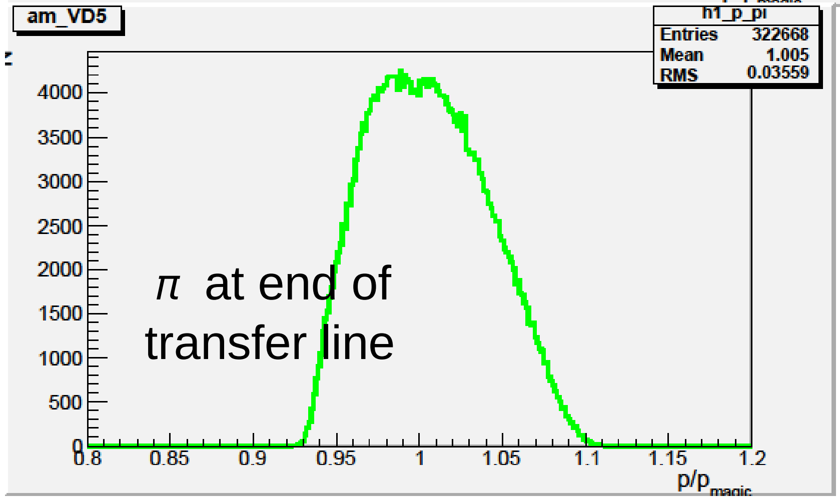
3rd April 2012 Sam Cook 7

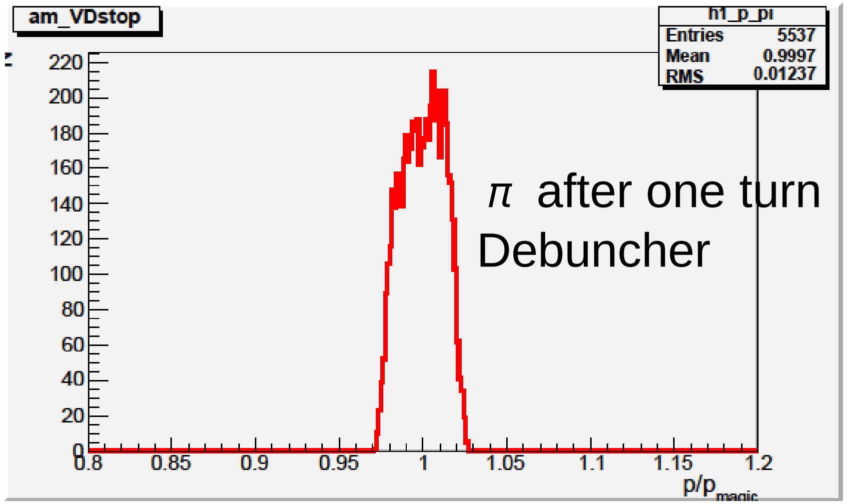
Can we, and should we improve?

G4BeamLine simulations of g-2



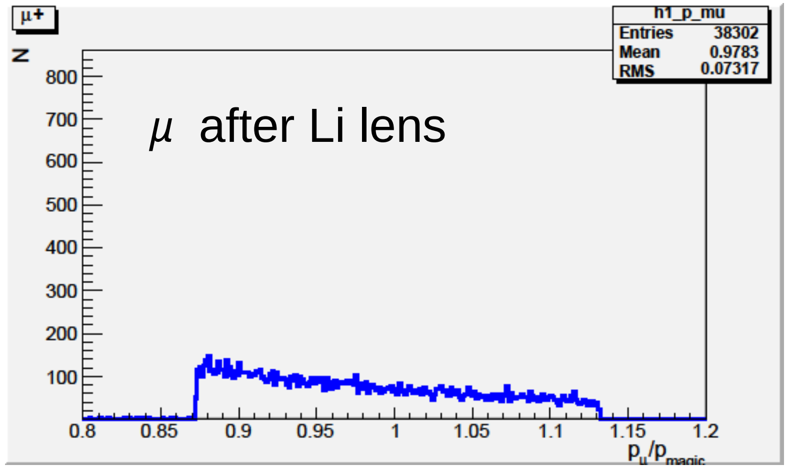


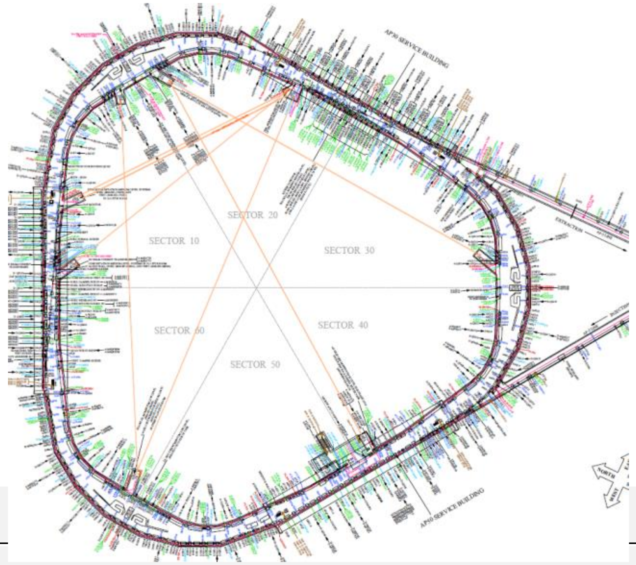


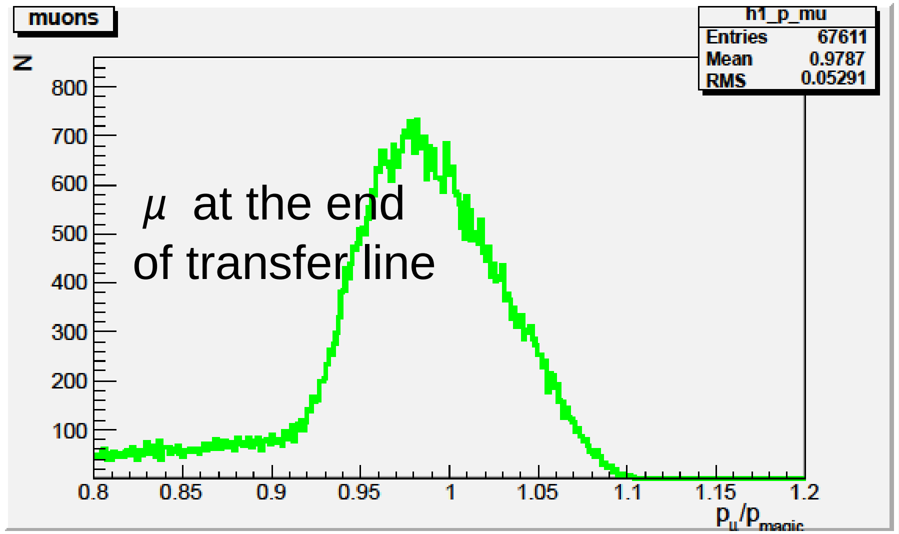


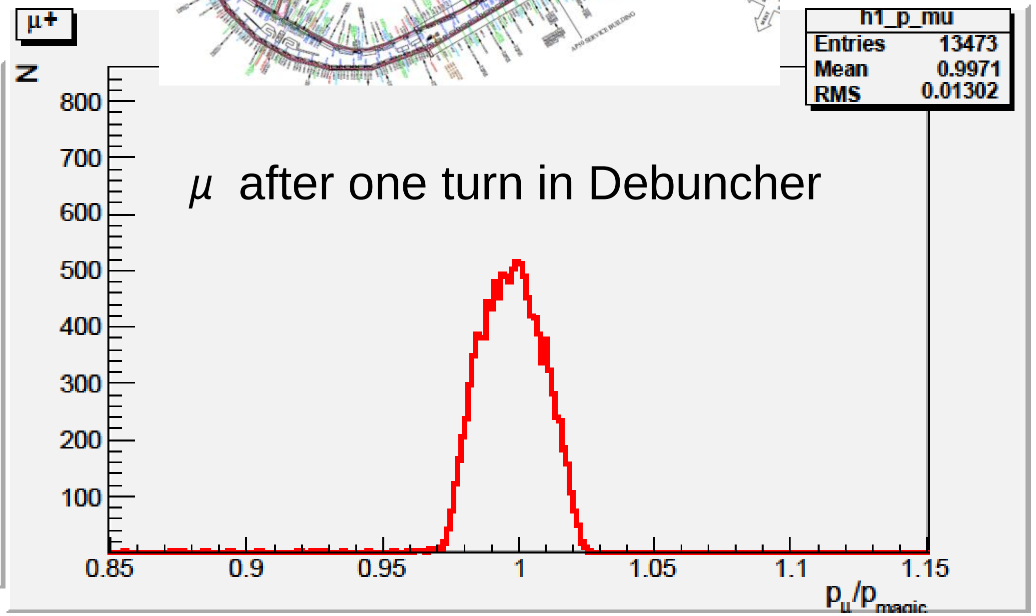
g-2 simulations

$6x10^{-6}$ stored muons in the Debuncher per one 8 GeV proton on target









Proton Beam Like for g-2, but with g-2 off

- $5x10^{12}$ protons in a Booster pulse
- 3 Hz, 8 GeV Booster
- Muons are stored for ~100 turns
- Running time 10^7 Sec (1 year)
- 100 ton detector, 10 meters downstream from ring

~ 400 CC neutrino events

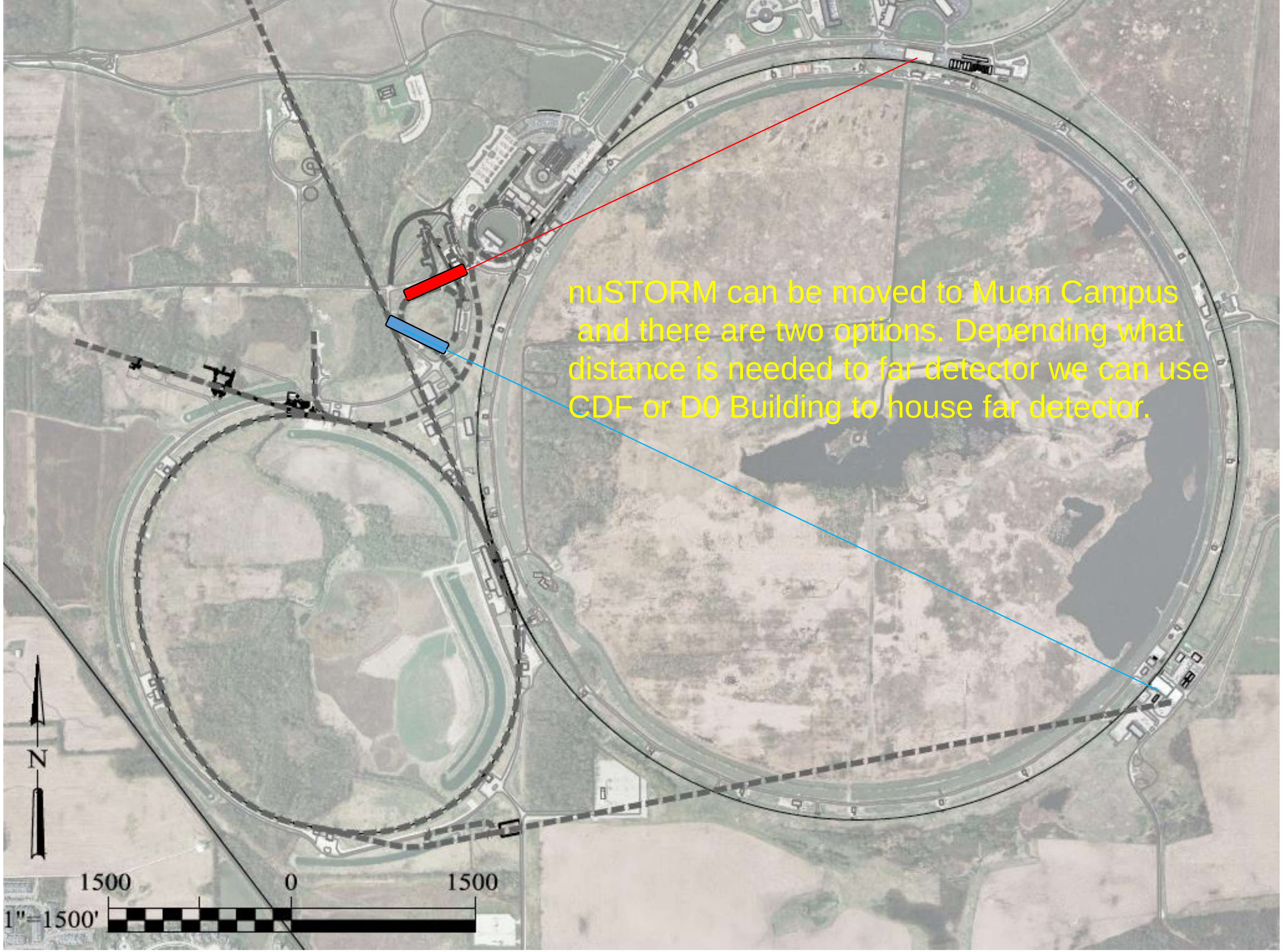
This is for about the cost of moving an existing detector (μBooNE??, 60T) and building new detector housing (about 3M$)

Looking Into the Future (cost~$??)

- $1x10^{13}$ protons from MI (two Booster pulses, slip stacked)
- 1 Hz, 120 GeV MI
- New Li lens r = 2 cm to increase collection of pi's (x1.5)
  CERN has made this size Lens
- Make ring a racetrack (x1.5x2) Provide a suitable test facility for future NF
- Running time 1year($2x10^{7}$ Sec) Fermilab year is ~210^{7} Sec
- Larger detector, ~500 ton detector(x5) ICARUS is 600 ton

~100k CC neutrino events

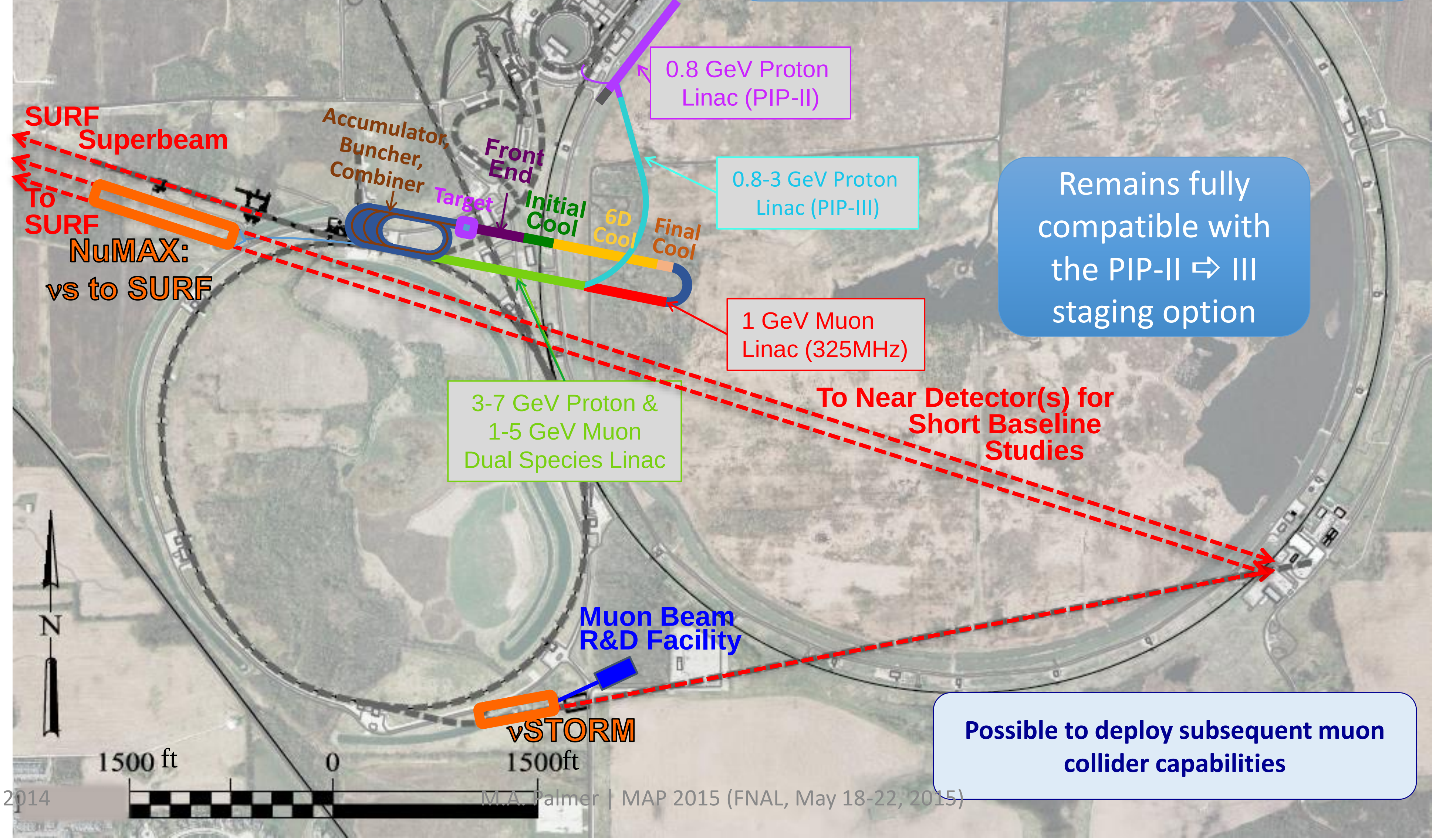
The End and New Beginning
Or
The way to nuSTORM
(everything is used in upgrade)


nuSTORM can be moved to Muon Campus
and there are two options. Depending what
distance is needed to far detector we can use
CDF or D0 Building to house far detector.
N
1500
0
1500
1"=1500'

If Far Detector is in D0

If Far Detector is in CDF

Possibilities for NF Capabilities at Fermilab: νSTORM ➔ NuMAX



MASS NF Parameters

Neutrino Factory Parameters					
Parameters	**Unit**	**nuSTORM**	**NuMAX Commissioning**	**NuMAX**	**NuMAX+**
ν_e or ν_μ to detectors/year	-	3×10^{17}	4.9×10^{19}	1.8×10^{20}	5.0×10^{20}
Stored μ+ or μ-/year	-	8×10^{17}	1.25×10^{20}	4.65×10^{20}	1.3×10^{21}
Far Detector:	Type	SuperBIND	MIND / Mag LAr	MIND / Mag LAr	MIND / Mag LAr
Distance from Ring	km	1.9	1300	1300	1300
Mass	kT	1.3	100 / 30	100 / 30	100 / 30
Magnetic Field	T	2	0.5-2	0.5-2	0.5-2
Near Detector:	Type	SuperBIND	Suite	Suite	Suite
Distance from Ring	m	50	100	100	100
Mass	kT	0.1	1	1	2.7
Magnetic Field	T	Yes	Yes	Yes	Yes
Accelerator: Ring Momentum (P_μ)	GeV/c	3.8	5	5	5
Circumference (C)	m	480	737	737	737
Ionization Cooling	-	No	No	**6D Initial**	**6D Initial**
Proton Beam Power	MW	0.2	1	1	2.75