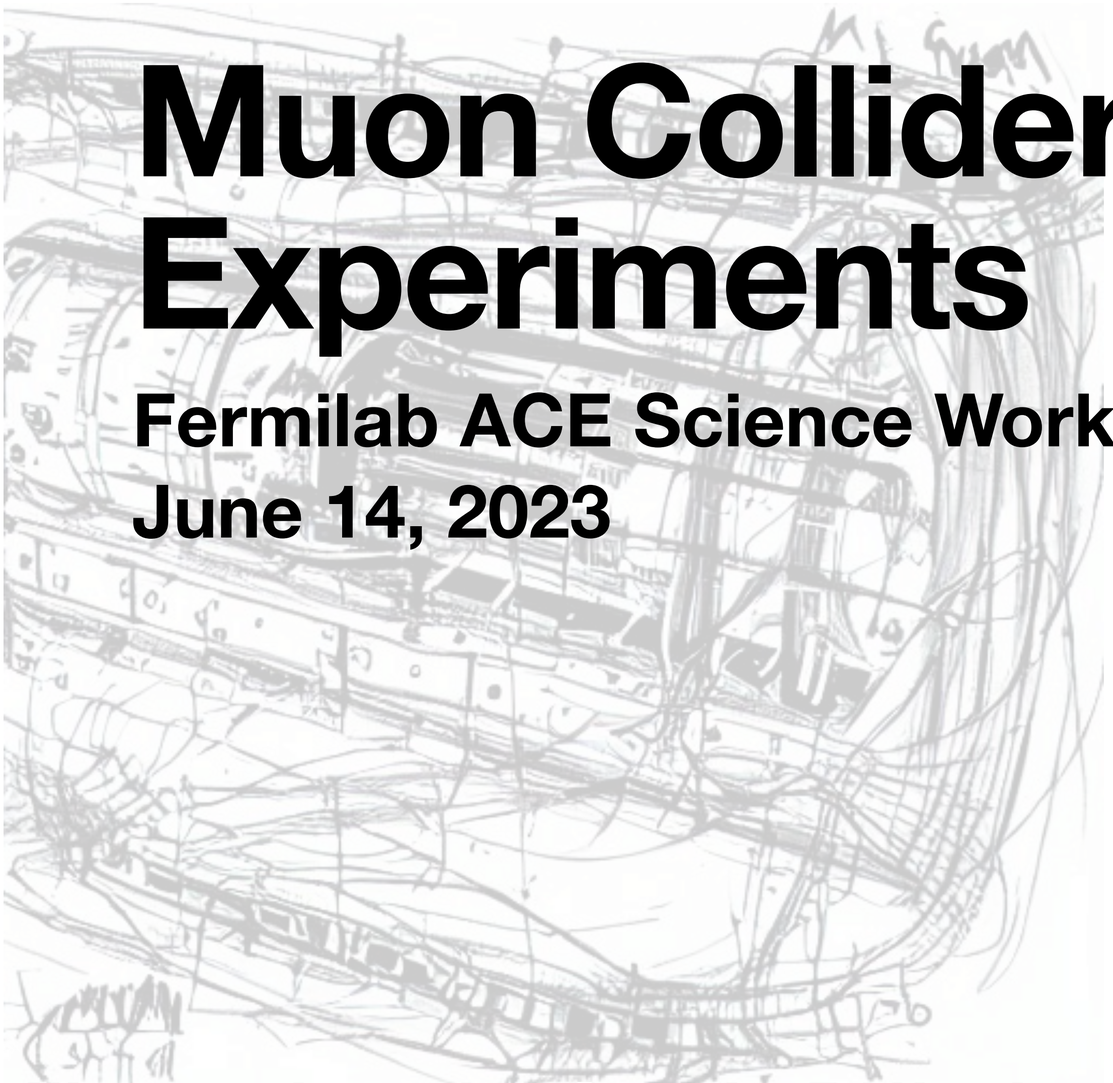


Muon Collider Auxiliary Experiments

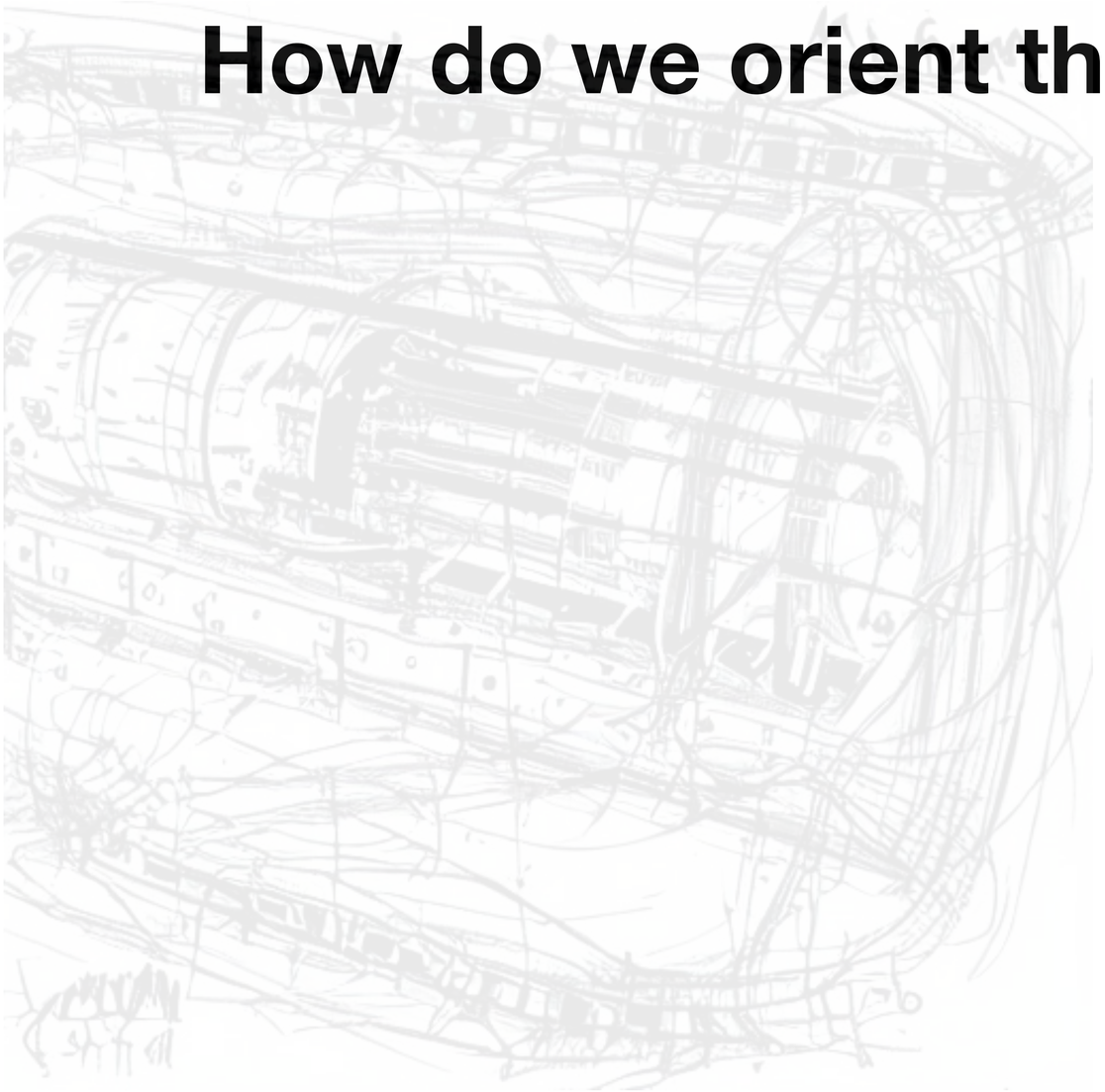
Fermilab ACE Science Workshop
June 14, 2023

Cari Cesarotti, MIT CTP

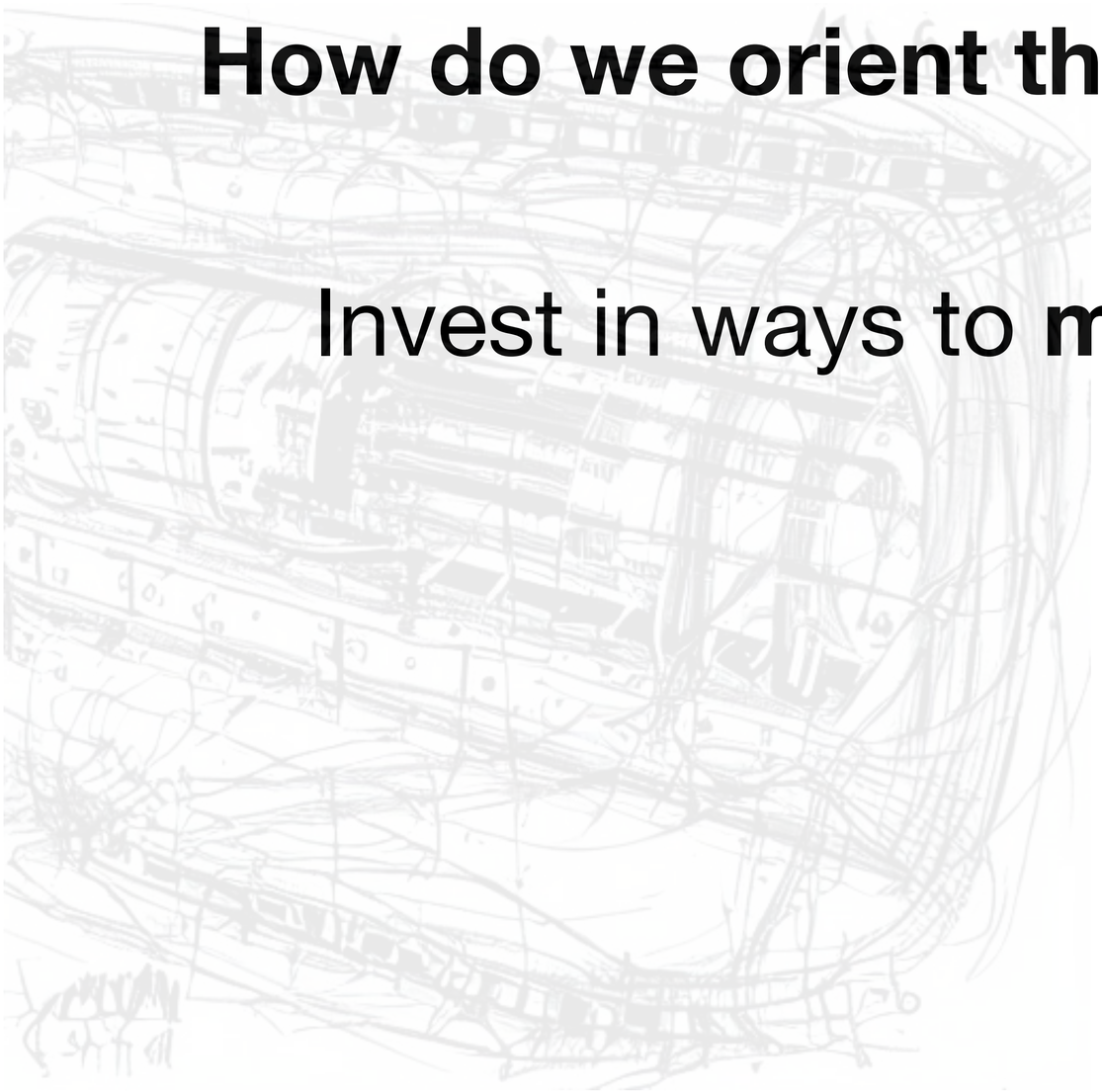
Illustrations by Stable Diffusion

ACE & Community Goals

How do we orient the future of particle physics?



ACE & Community Goals



How do we orient the future of particle physics?

Invest in ways to **maximize** physics potential:

ACE & Community Goals

How do we orient the future of particle physics?

Invest in ways to **maximize** physics potential:

- Search for robust physics
- Serve many parts of the community

ACE & Community Goals

How do we orient the future of particle physics?

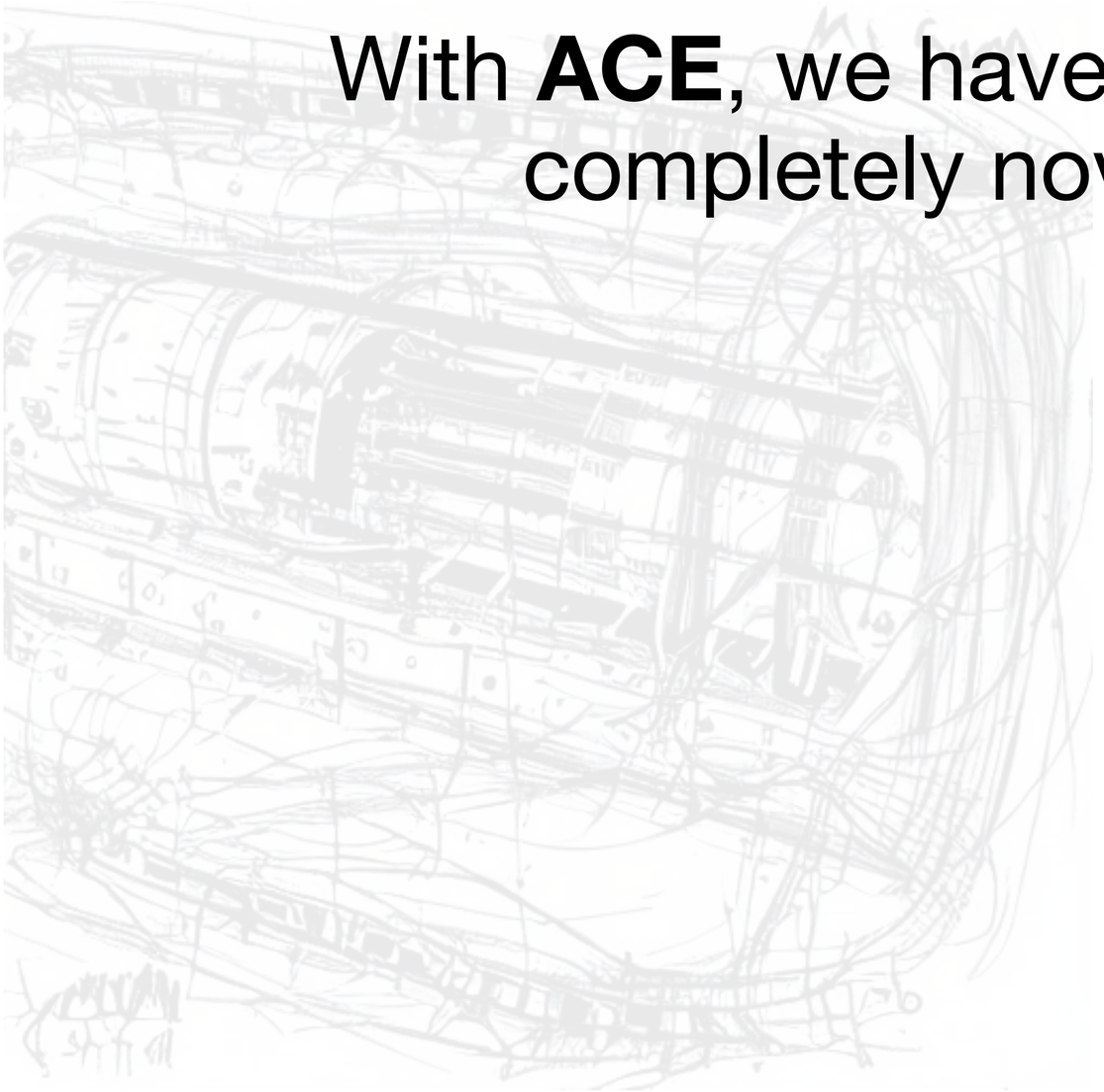
Invest in ways to **maximize** physics potential:

- Search for robust physics
- Serve many parts of the community

ACE is perfect environment!

ACE & Muon Colliders

With **ACE**, we have the possibility for hosting a completely novel collider at **Fermilab**



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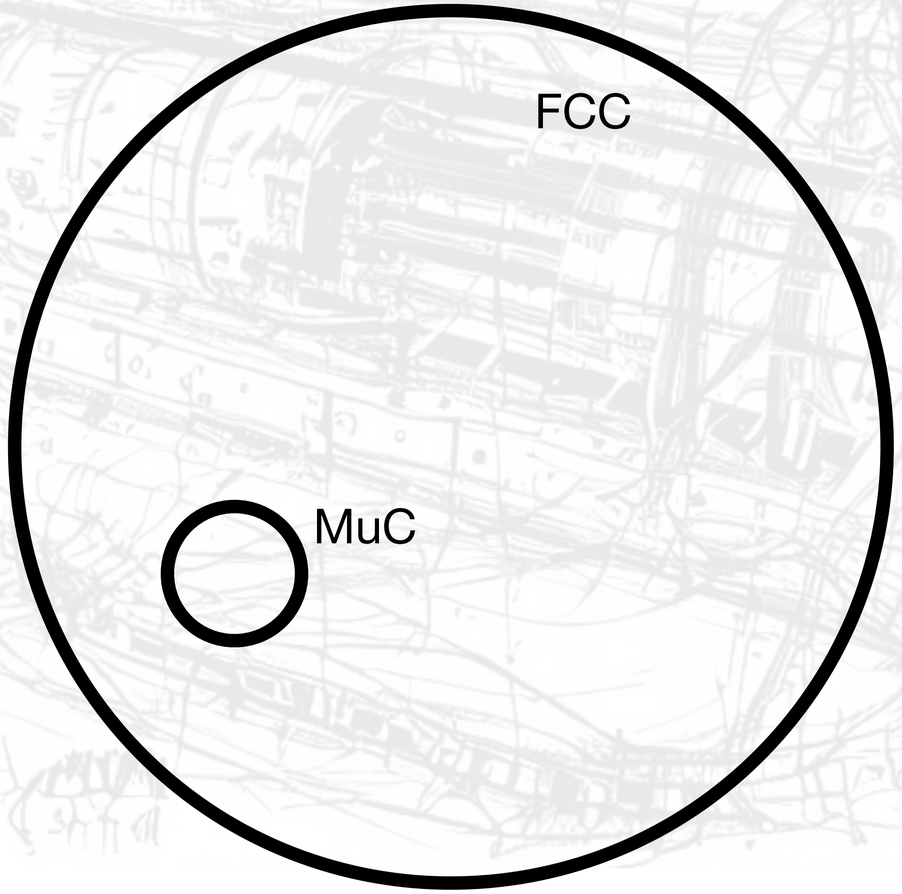

Muon colliders

Energy frontier

Precision Frontier

Compact

Second gen

ACE & Muon Colliders

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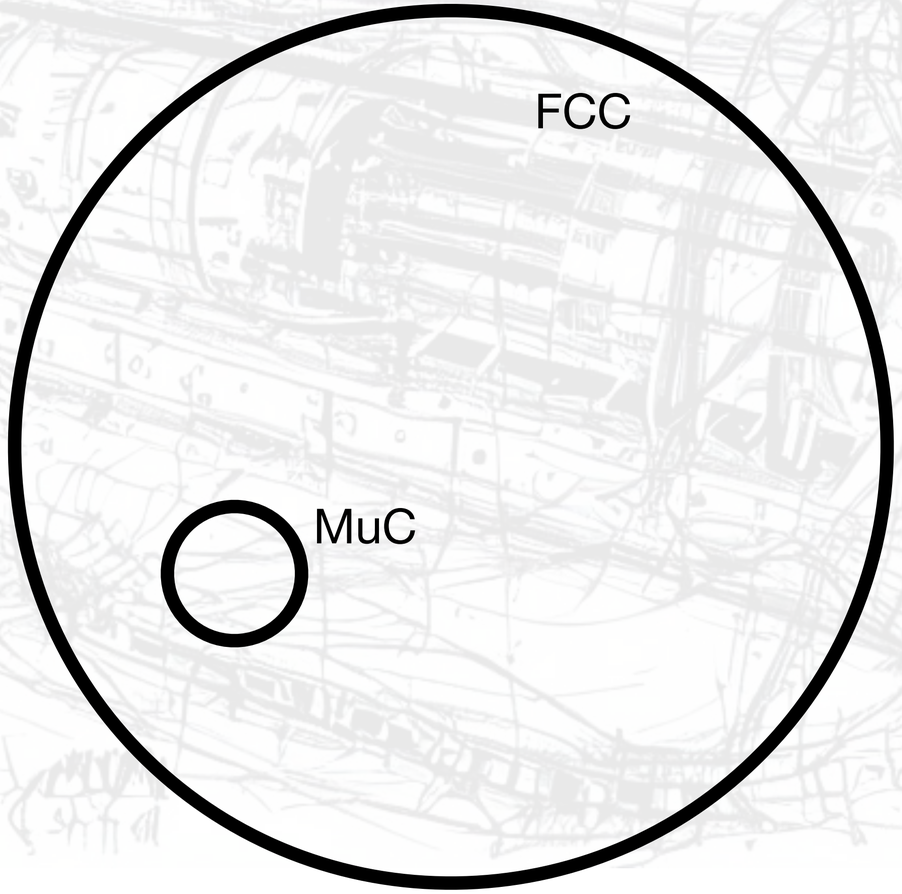

Muon colliders

Energy frontier

Precision Frontier

Compact

Second gen

2-for-1 machine to **maximize** discovery potential

ACE & Muon Colliders

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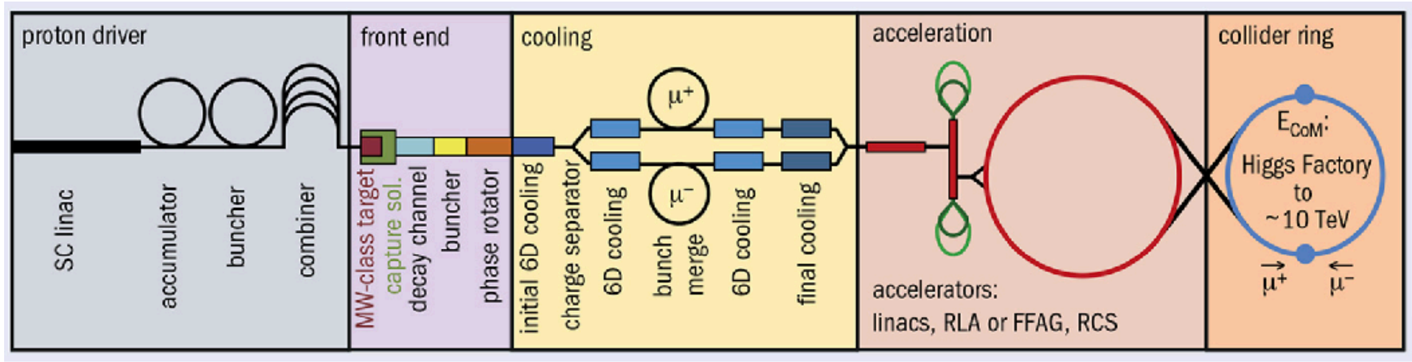
Booster



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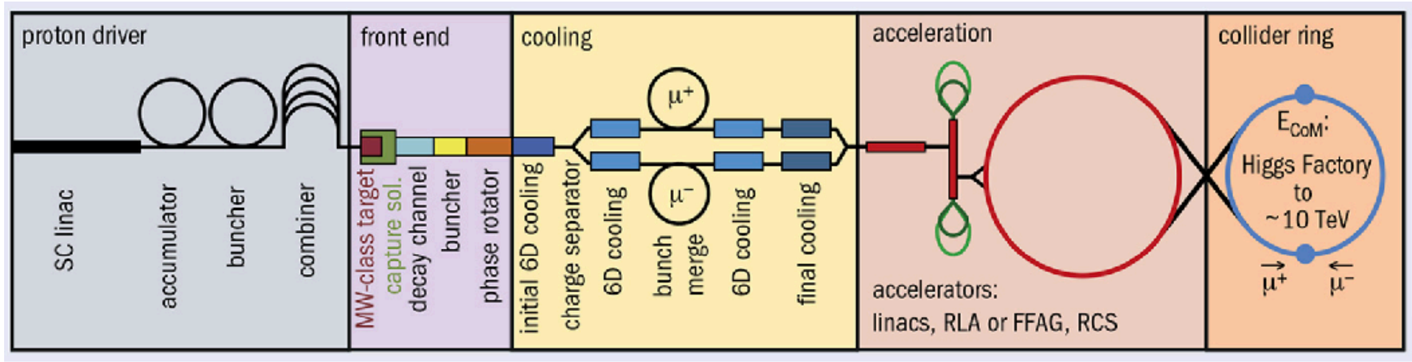


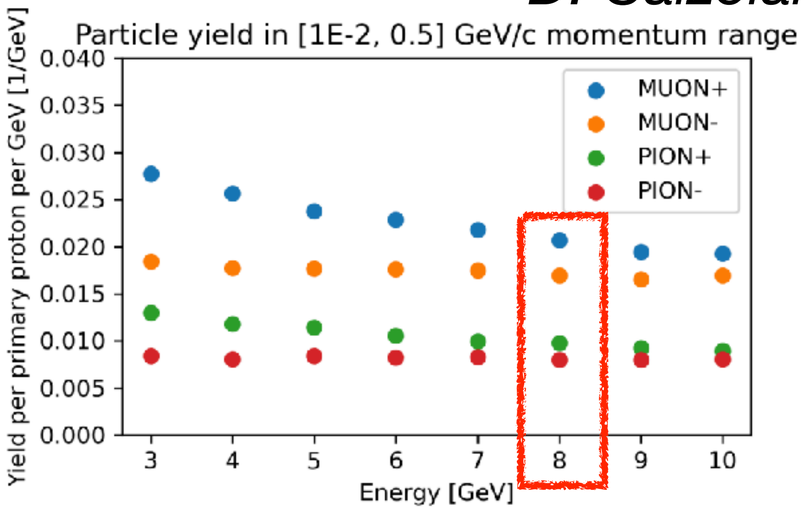
1901.06150

D. Calzolari

After Upgrades

Parameter	PIU scenarios	MuC-PD scenarios
Energy	8 GeV	8-16 GeV
Rep. rate	10-20 Hz	5-20 Hz
Avg. beam power	0.3-1.6 MW	1-4 MW
Proton structure	25-40 e12 over 2 μs ring	40-120 e12 in four 1-3 ns bunches

Thanks, N. Tran!



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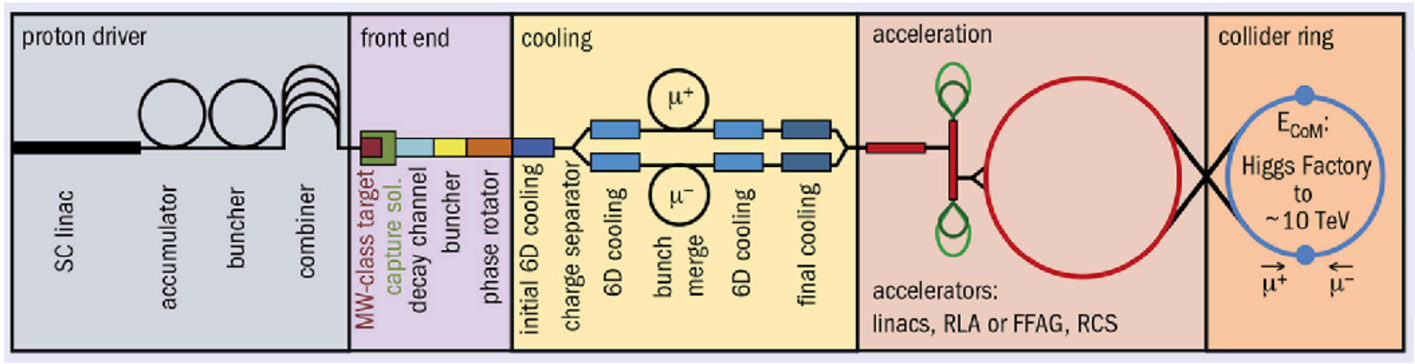
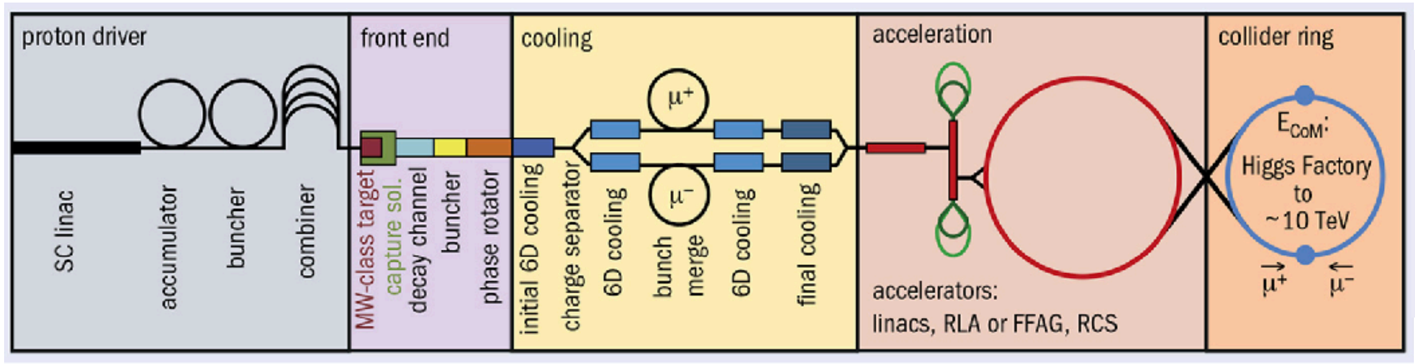


To fully utilize ACE, consider auxiliary experiments

ACE & Muon Colliders

With **ACE**, we have the possibility for hosting a completely novel collider at **Fermilab**

Booster

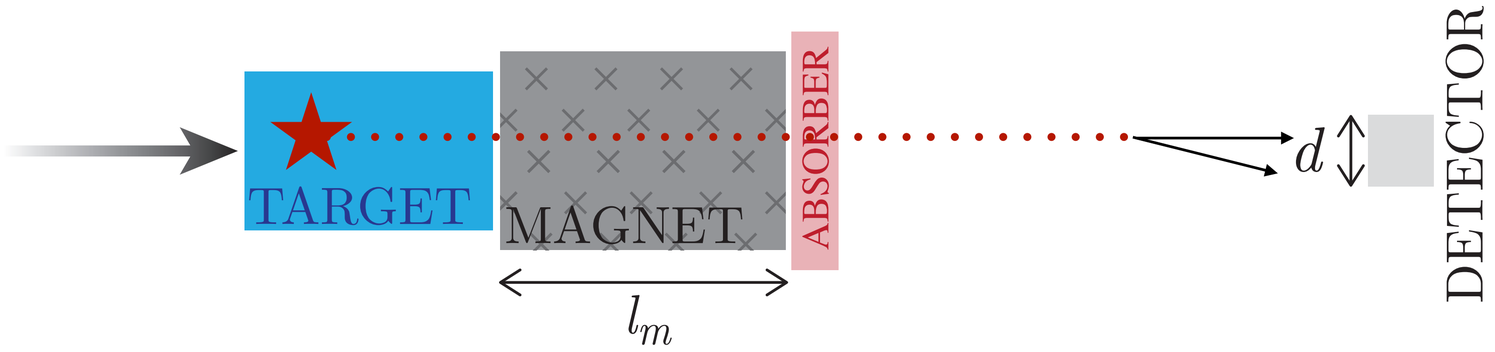


To fully utilize ACE, consider auxiliary experiments

e.g. **Beam dumps** of protons/muons, at high/low energies, in various materials

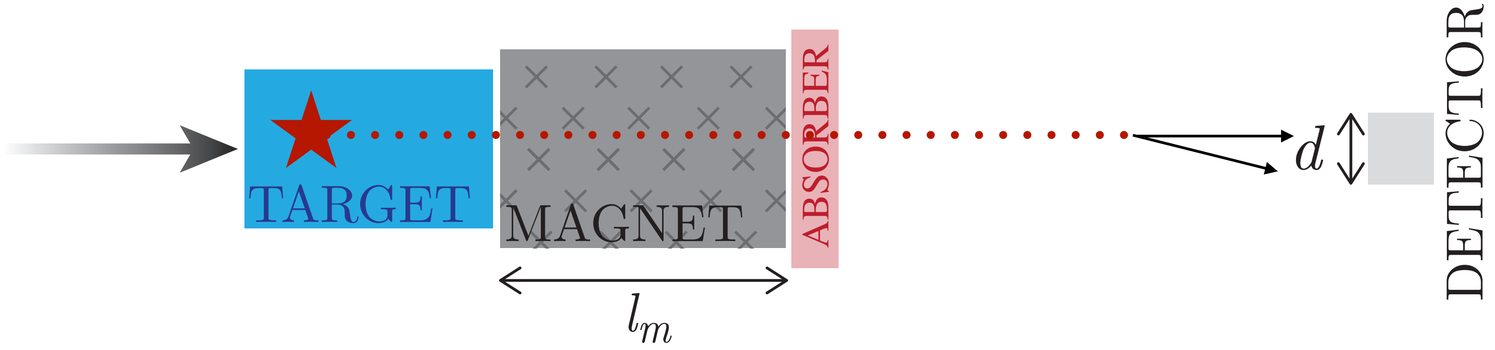
ACE & Beam Dumps

Beam dumps are **low-cost** auxiliary experiments with **complementary** reach to main collider



ACE & Beam Dumps

Beam dumps are **low-cost** auxiliary experiments with **complementary** reach to main collider



Synergistic mode to reach **extremely weakly** coupled physics at **moderate** energies

ACE & Beam Dumps

New physics can be studied at low energy
because of high beam **intensity**

Protons **o**n **T**arget @ 8 GeV

PIP-II
10 kW
↓
10^{20} protons/year

ACE-BR
130 kW
↓
10^{21} protons/year

Thanks Sergo & Patrick!

ACE & Beam Dumps

New physics can be studied at low energy
because of high beam **intensity**

Protons **o**n **T**arget @ 8 GeV

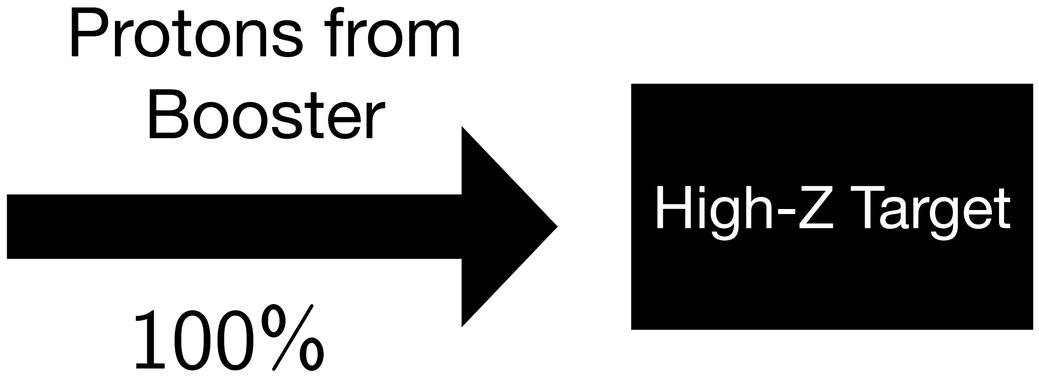
Sufficient for Demonstrators!

PIP-II
10 kW
↓
10^{20} protons/year

ACE-BR
130 kW
↓
10^{21} protons/year

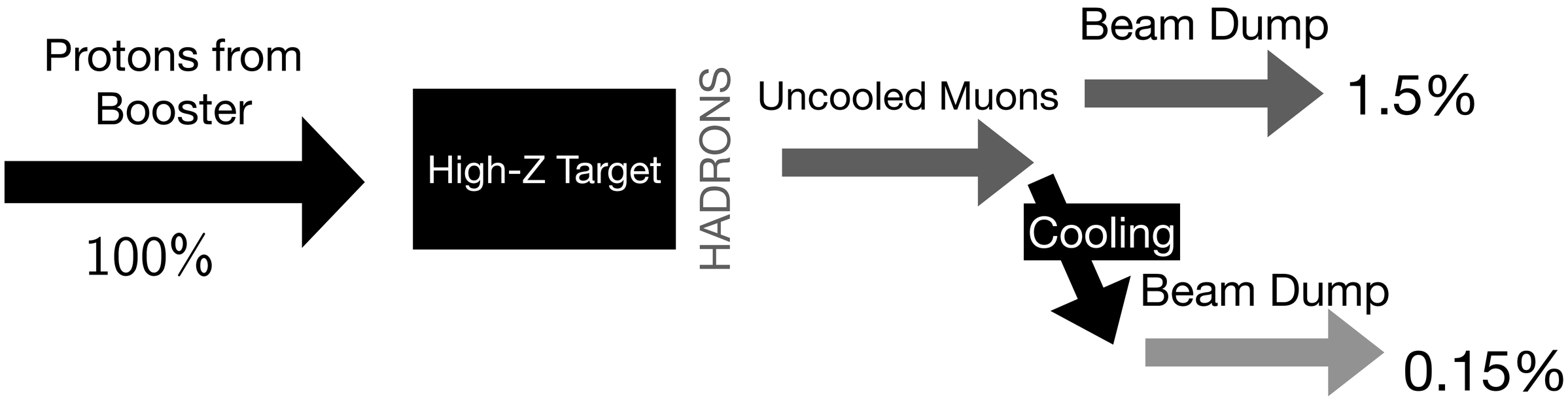
Thanks Sergo & Patrick!

ACE & Beam Dumps

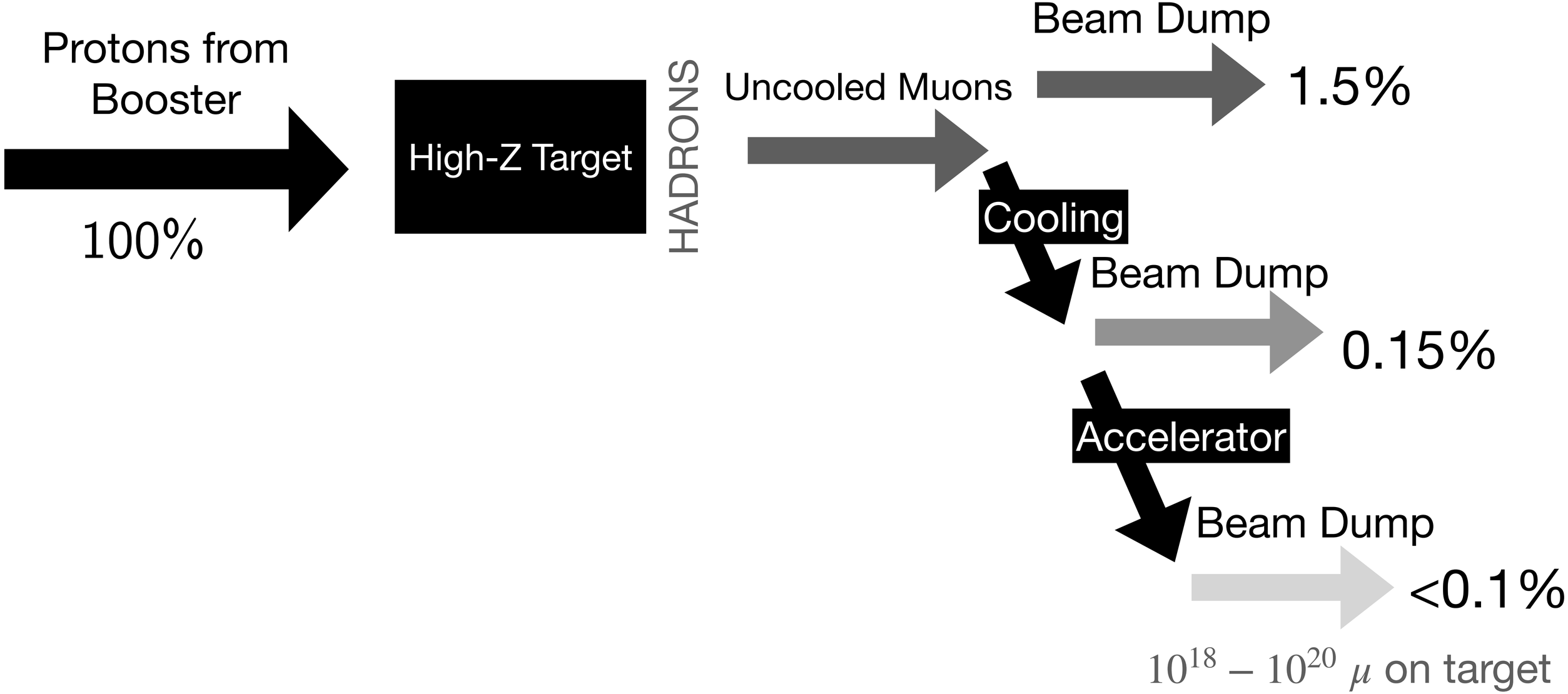


ACE & Beam Dumps

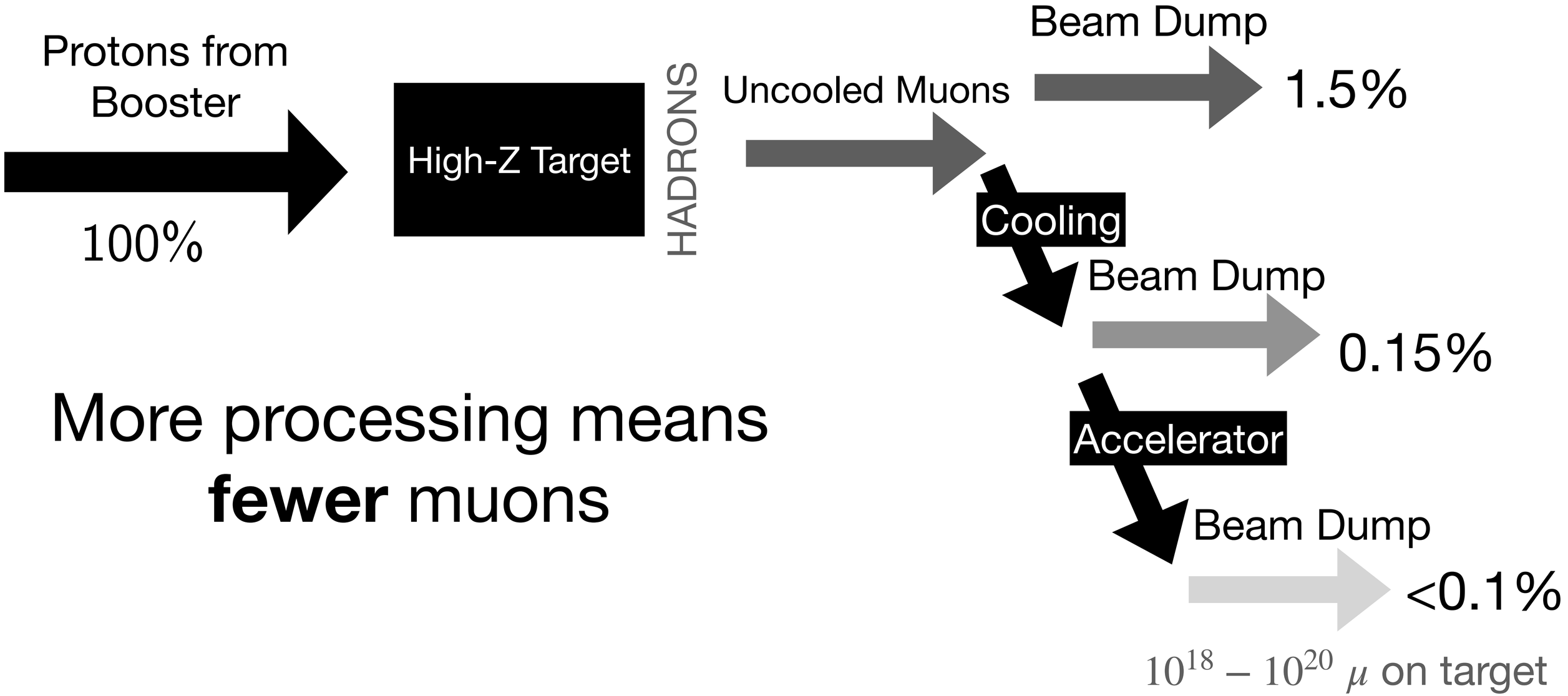
ACE & Beam Dumps



ACE & Beam Dumps



ACE & Beam Dumps



More processing means **fewer** muons

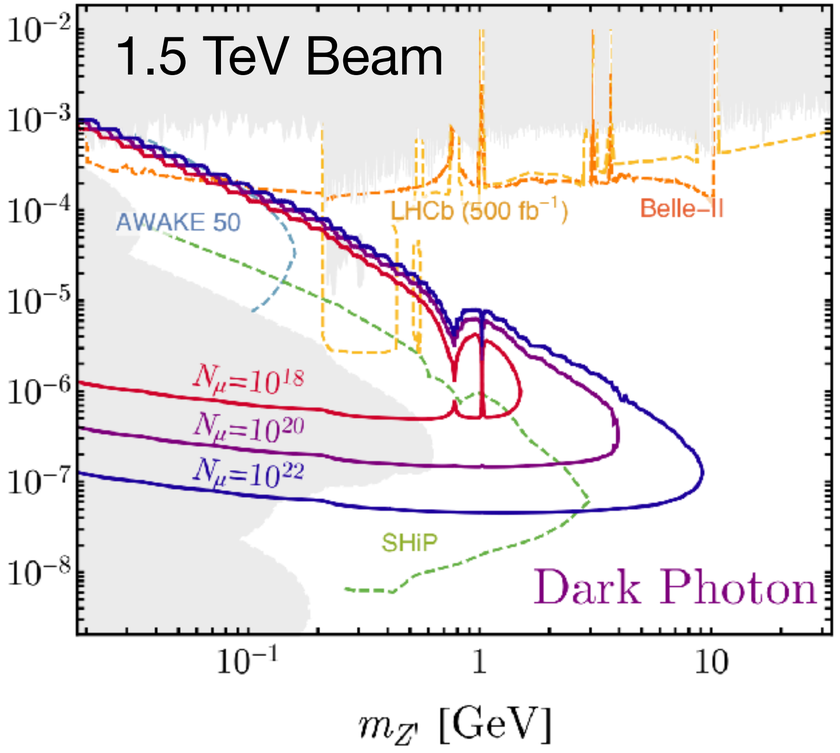
$10^{18} - 10^{20}$ μ on target

ACE & Muon Collider Beam Dump

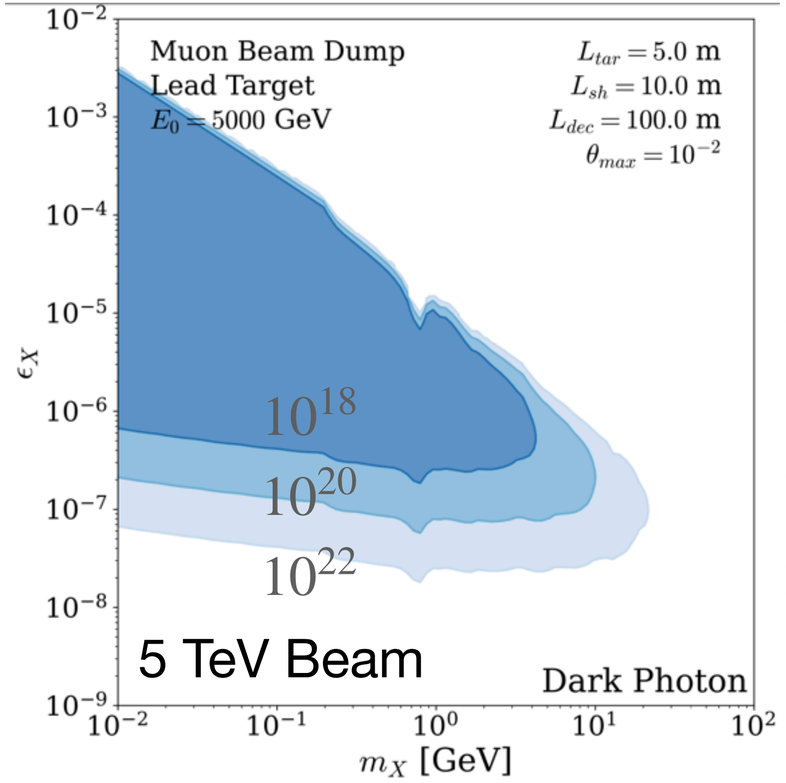
Examples of Physics Deliverables, in reverse order of MuC Maturity

2050ish

3, 10 TeV MuC



CC, S. Homiller, R. Mishra, M. Reece PRL



CC, R. Gambhir, S. Alipour-Fard 2306.XXXX

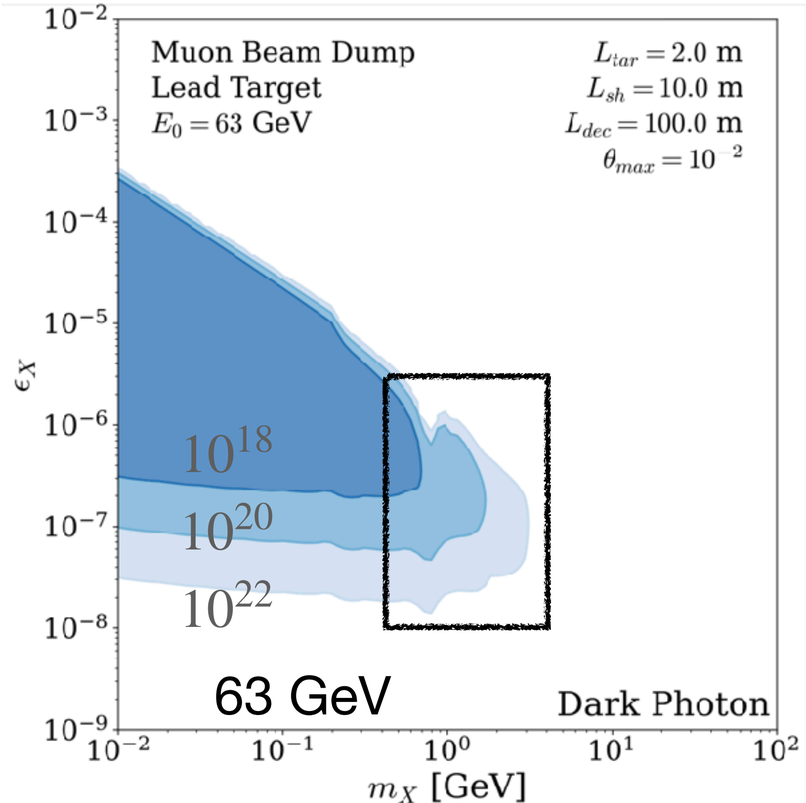
ACE & Muon Collider Beam Dump

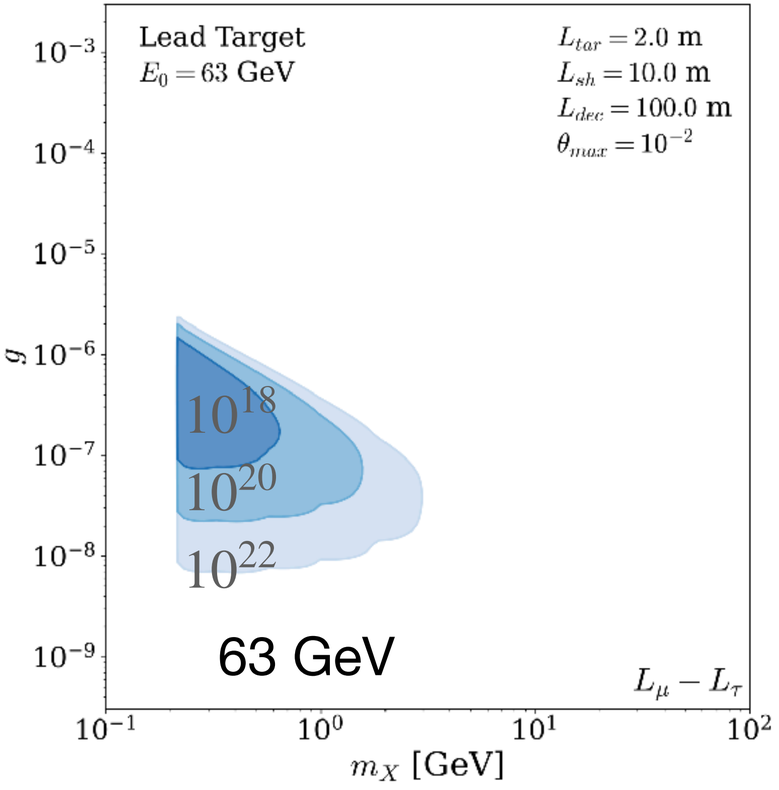
Higgs Threshold MuC

2050ish

3, 10 TeV MuC

CC, R. Gambhir, S. Alipour-Fard
2306.XXXX





ACE & Muon Collider Beam Dump

Demonstrator Facility Era - PIP-II + ACE MI

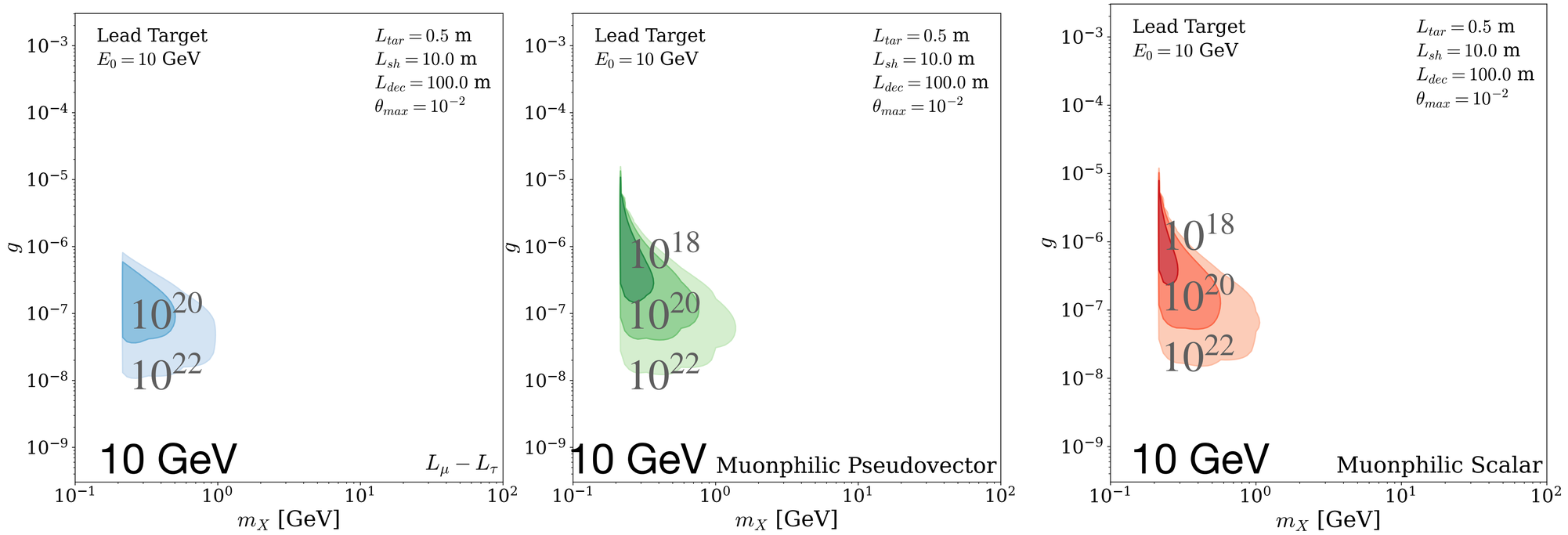
Higgs Threshold MuC

2050ish

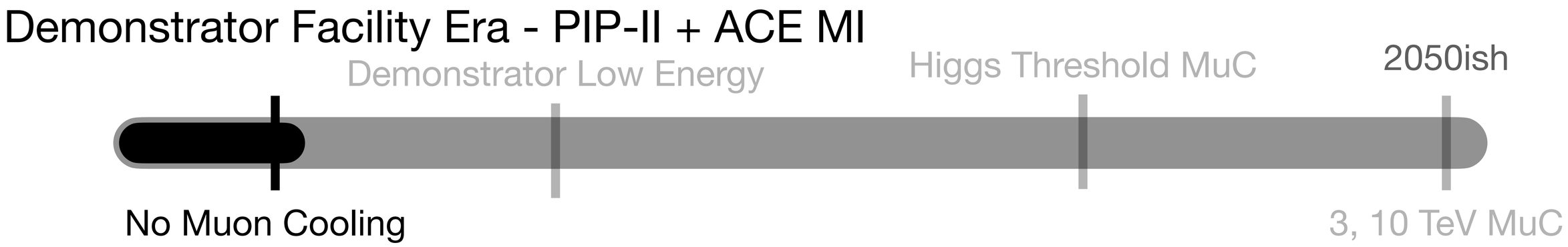
Demonstrator Low Energy

3, 10 TeV MuC

CC, R. Gambhir, S. Alipour-Fard 2306.XXXX



ACE & Beam Dump



Proton Beam Dump?

After LINAC?
At 8 GeV?

Pion Bremsstrahlung?

D. Curtin, Y. Kahn, R. Nguyen

μ at 200 MeV Beam Dump?

WiP w/ M. Furslond & P. Meade

Conclusions

There are **synergies** to be done with **ACE**

We **don’t need to wait** for a full MuC to start probing new physics

Progress to be made with **beam dump** experiments