

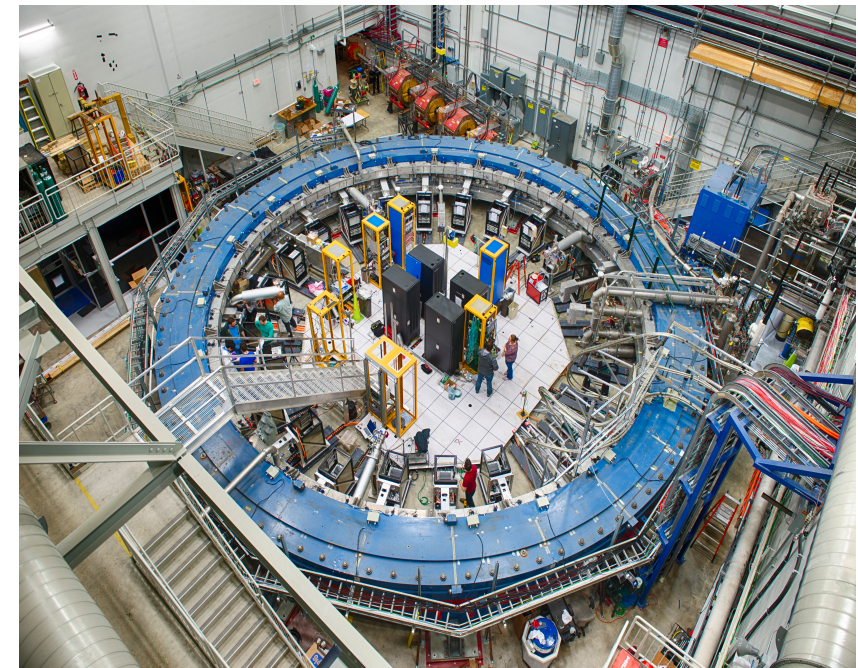
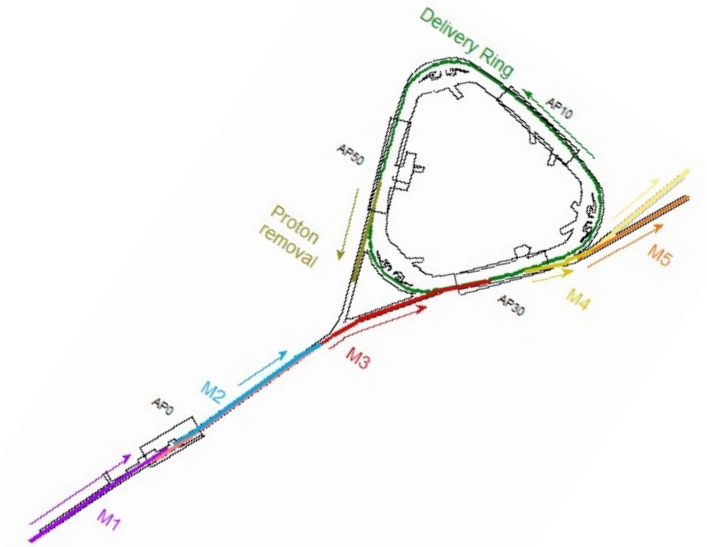
Simulations for $g-2$

Renee Fatemi

March 2, 2022

PACKAGE**FUNCTION**

MARS	Simulates interaction of proton beam with the target and produces distribution of downstream secondary particles.
G4BEAMLINE	A particle tracking simulation program based on GEANT4 and optimized for simulating beamlines. Includes particle interactions such as pion-muon decay and precession of the muon spin as well as interactions with materials. Also used to simulate proton target.
GM2RINGSIM	Customized implementation of GEANT4 within ART framework. Simulates injection into storage ring and interaction of particles materials. Tracks motion inside materials and fields. Package Includes several particle guns.
BMAD	Simulates relativistic charged-particle dynamics in high energy accelerators and storage rings. Capable of tracking particle momentum and spin interactions with fields. Models injection into ring but does not simulate material interactions.
COSY	Same functionality as BMAD, does not include injection. Does include a fully symplectic integrator.



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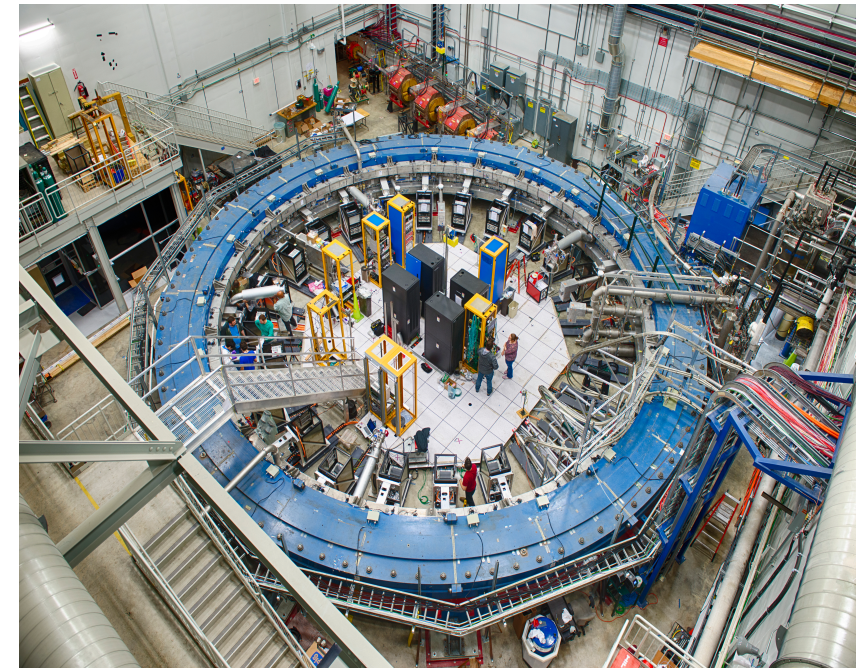
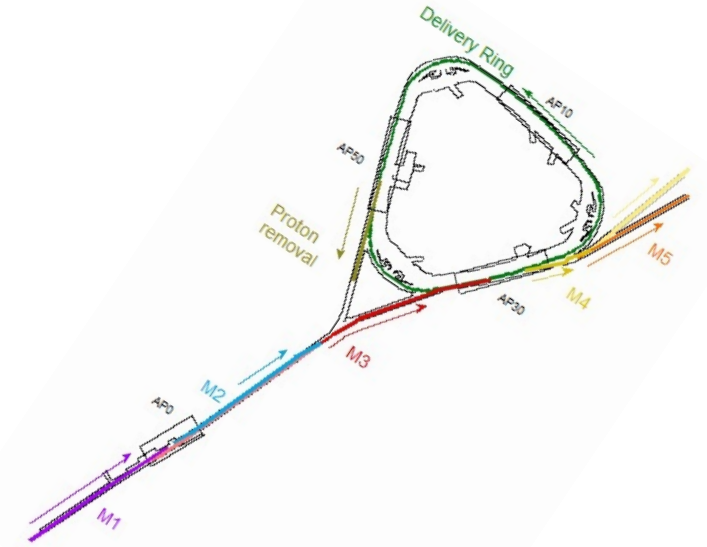
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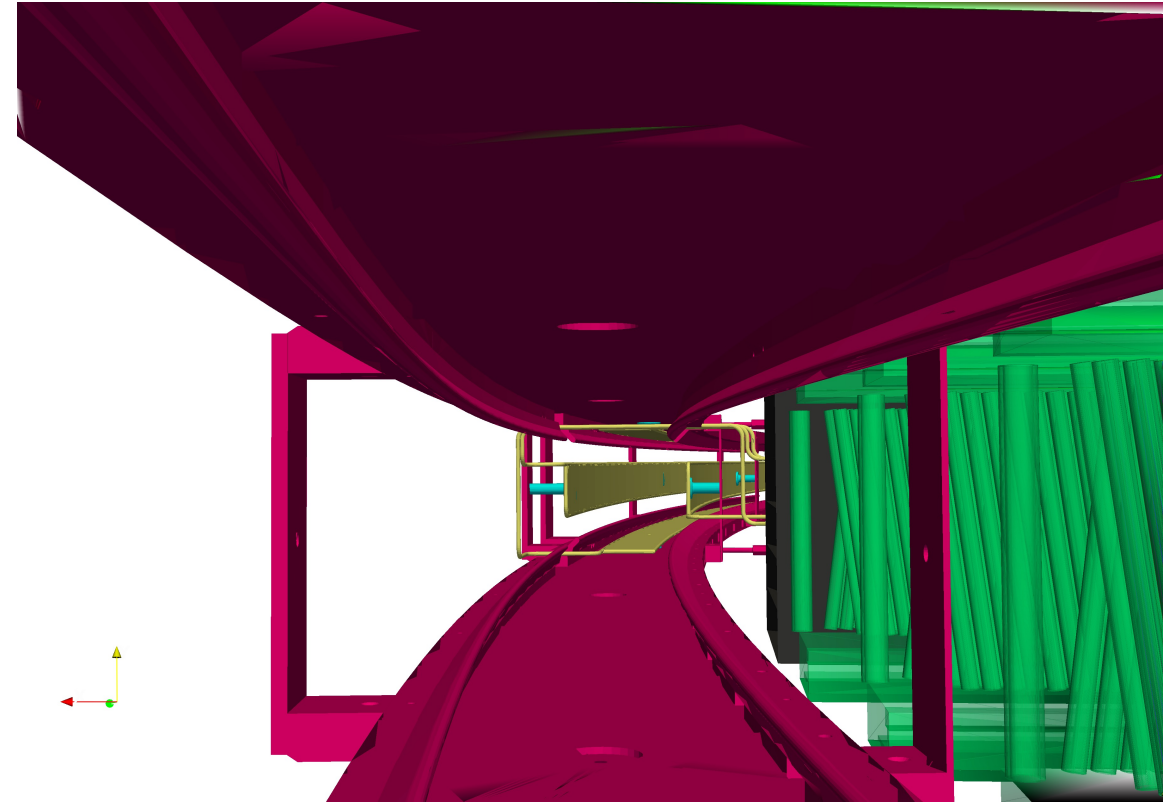
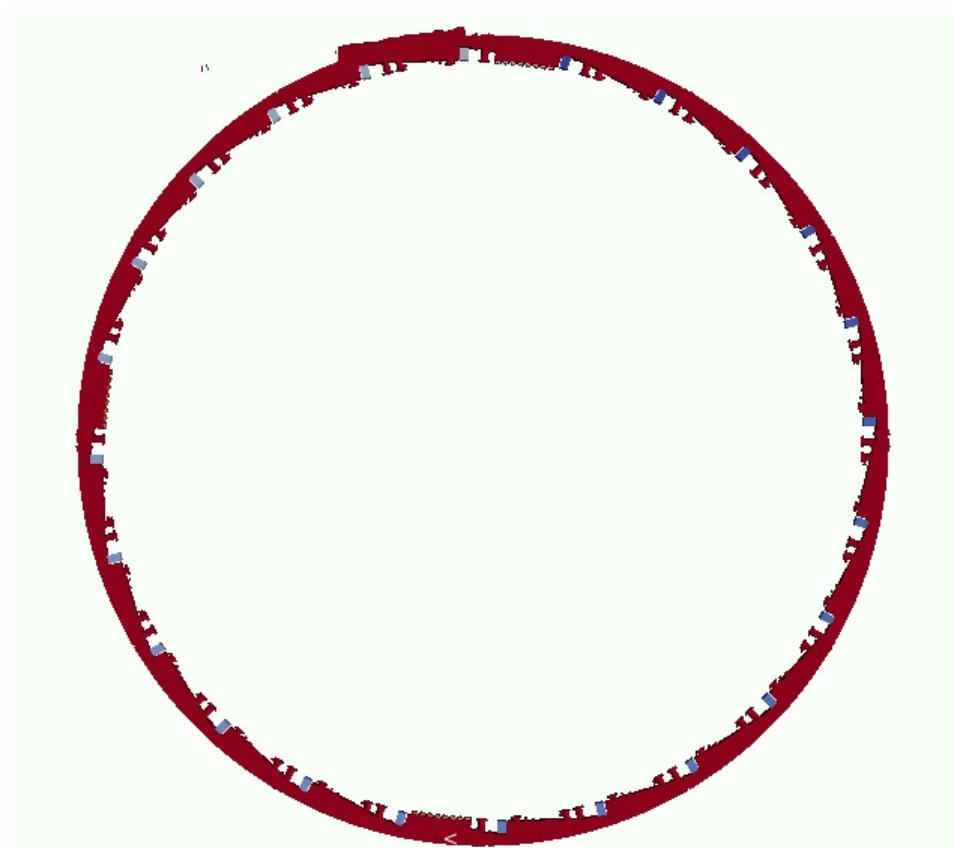
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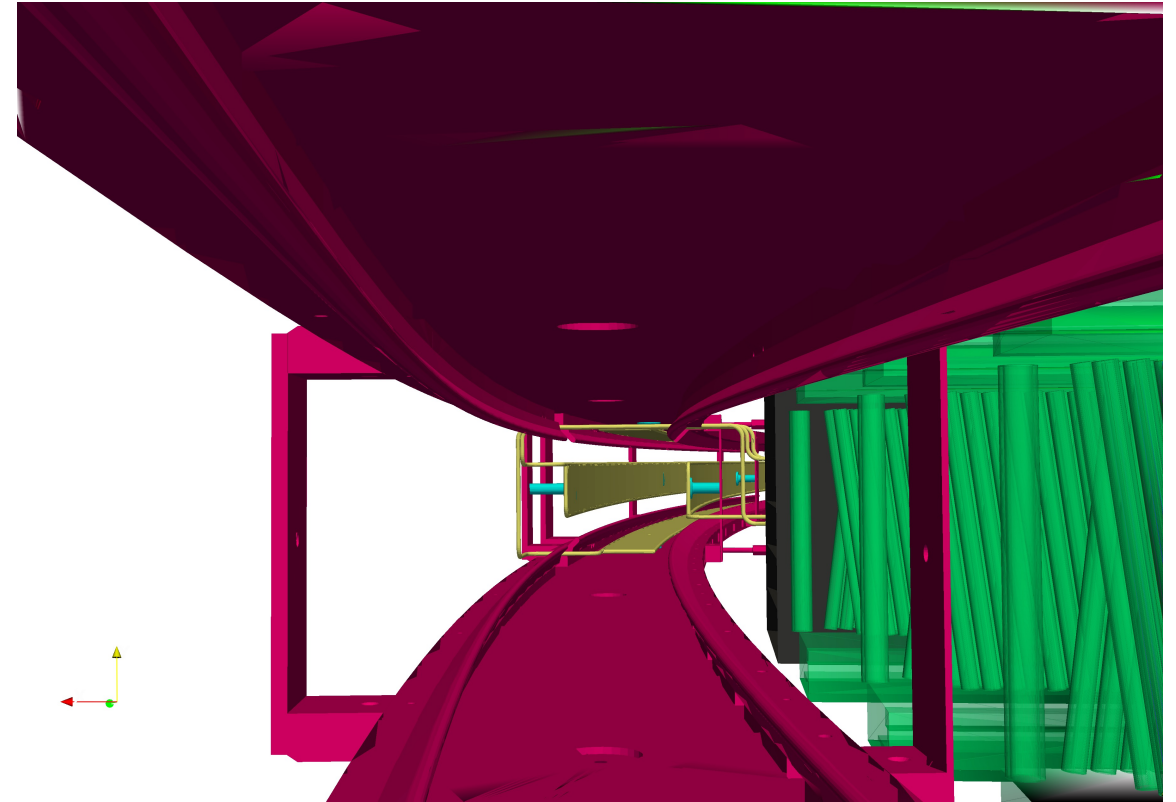
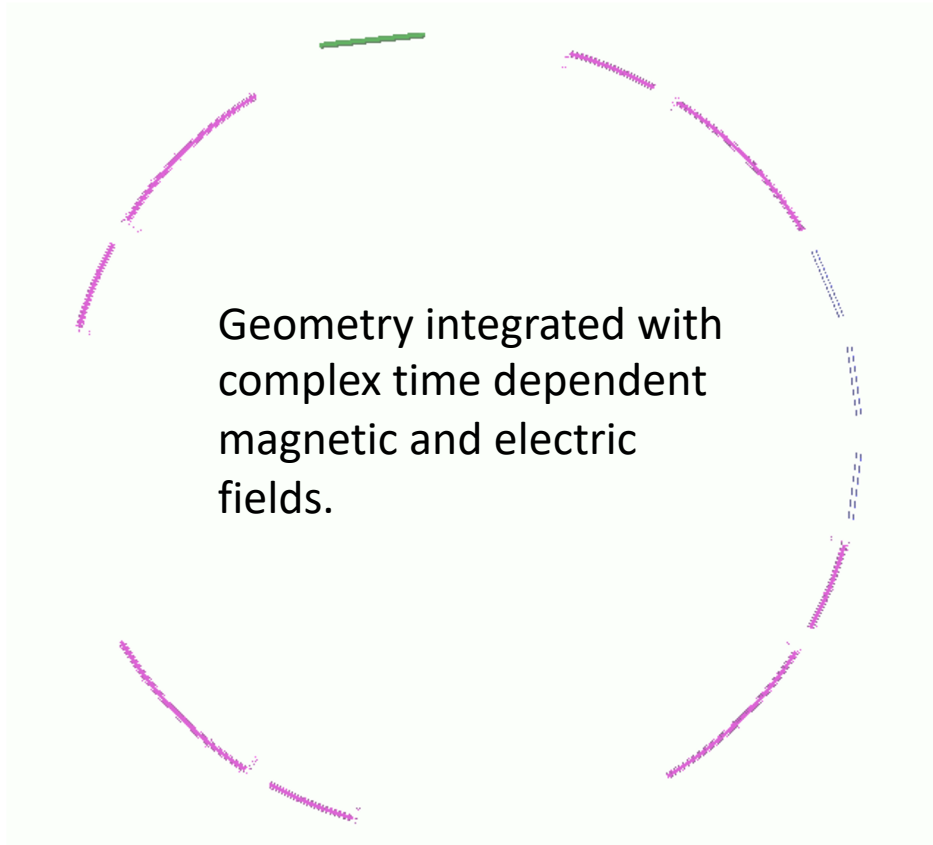
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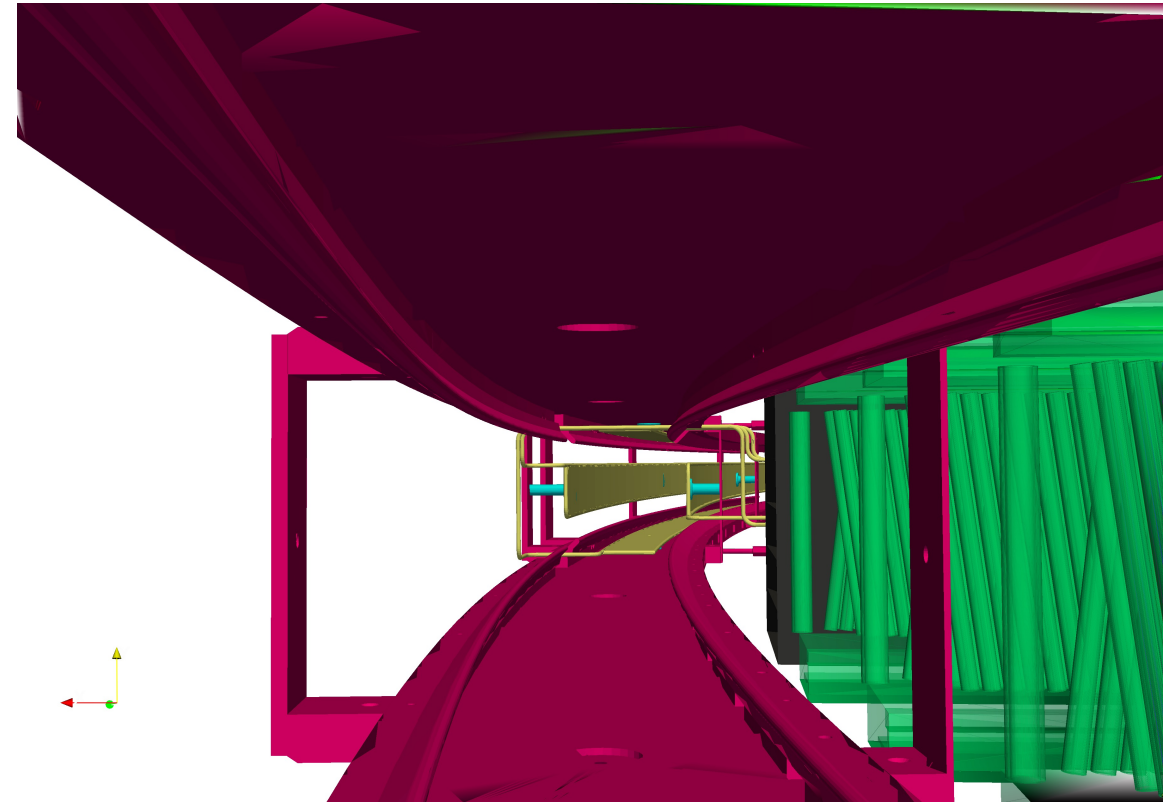
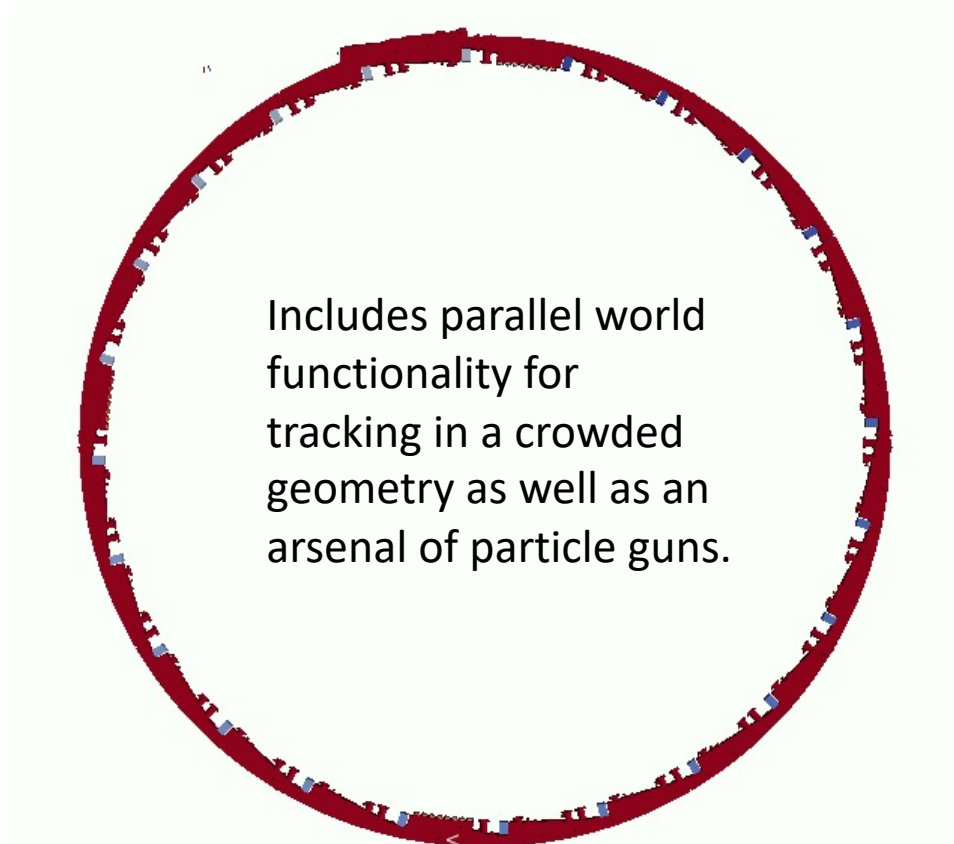




Gm2ringsim is constructed from a mix of native GEANT4 and CADMESH volumes

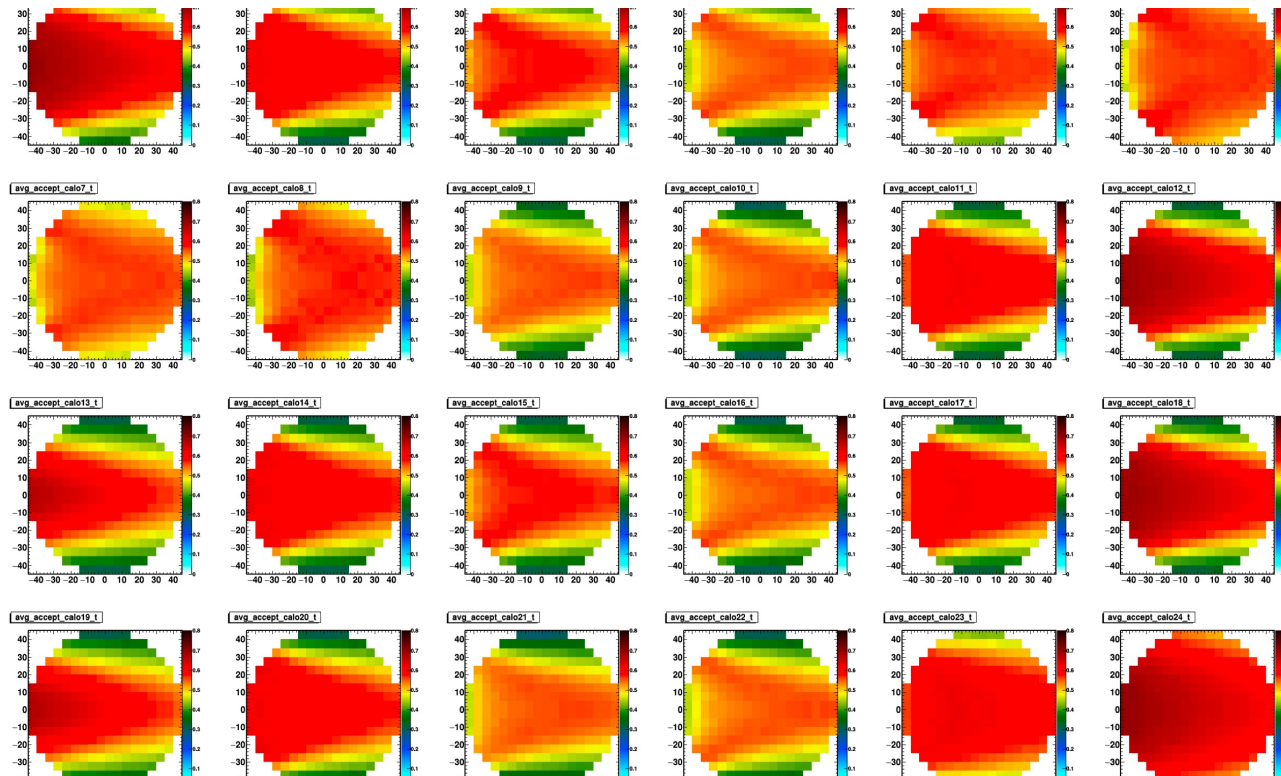


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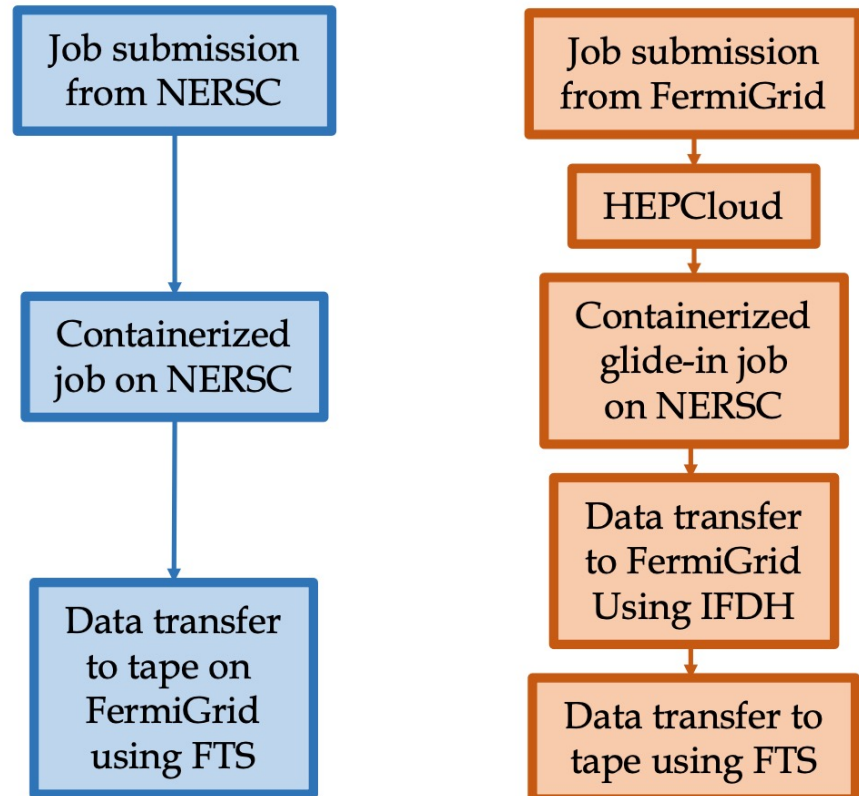
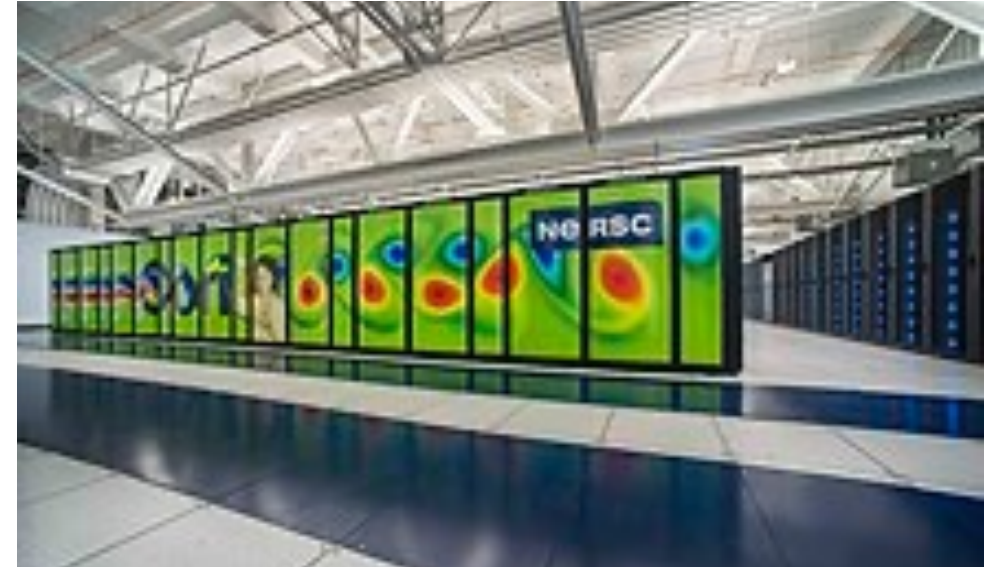
High fidelity maps of positron acceptance and muon asymmetry and phase



- Damaged resistors in quadrupole plate readout resulted in a large pull on the reconstruction precession frequency in the Run 1 analysis.
- Required high fidelity maps of the decay positron acceptance, muon asymmetry and phase as a function of decay position within the ring.
- Use "gas gun" with models beam dynamics and places muon in final decay point.

Gm2ringsim

Simulations on NERSC

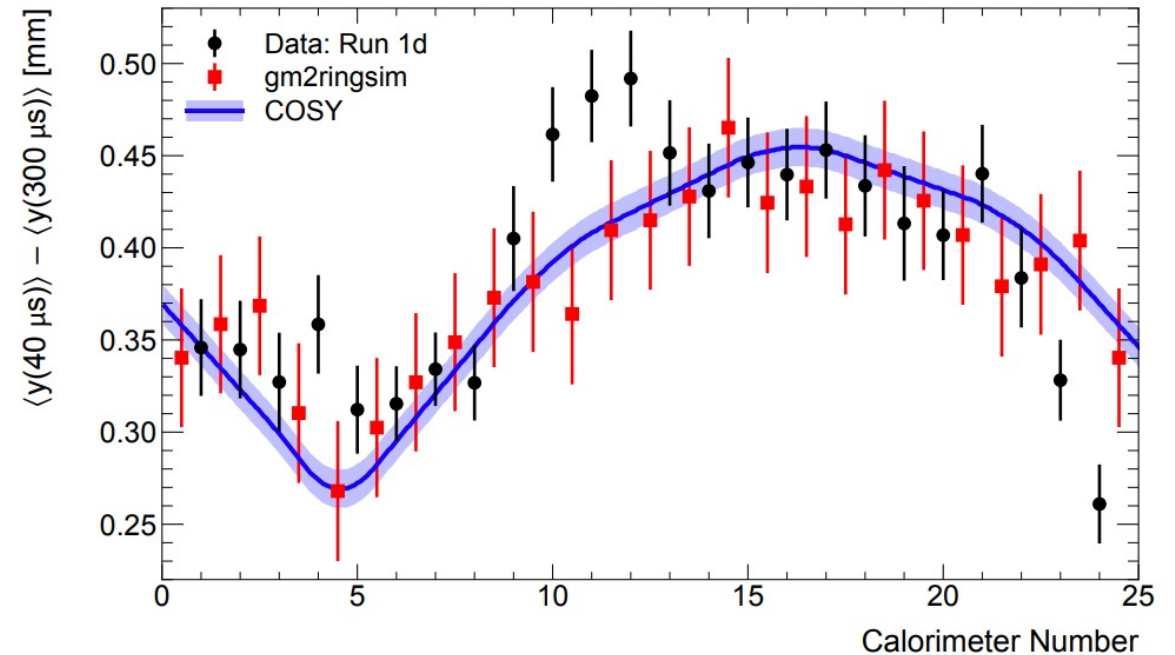


PHASE 1	PHASE 2
1B events	10.8B events
25781 files	269988 files
51.5 TB	540 TB

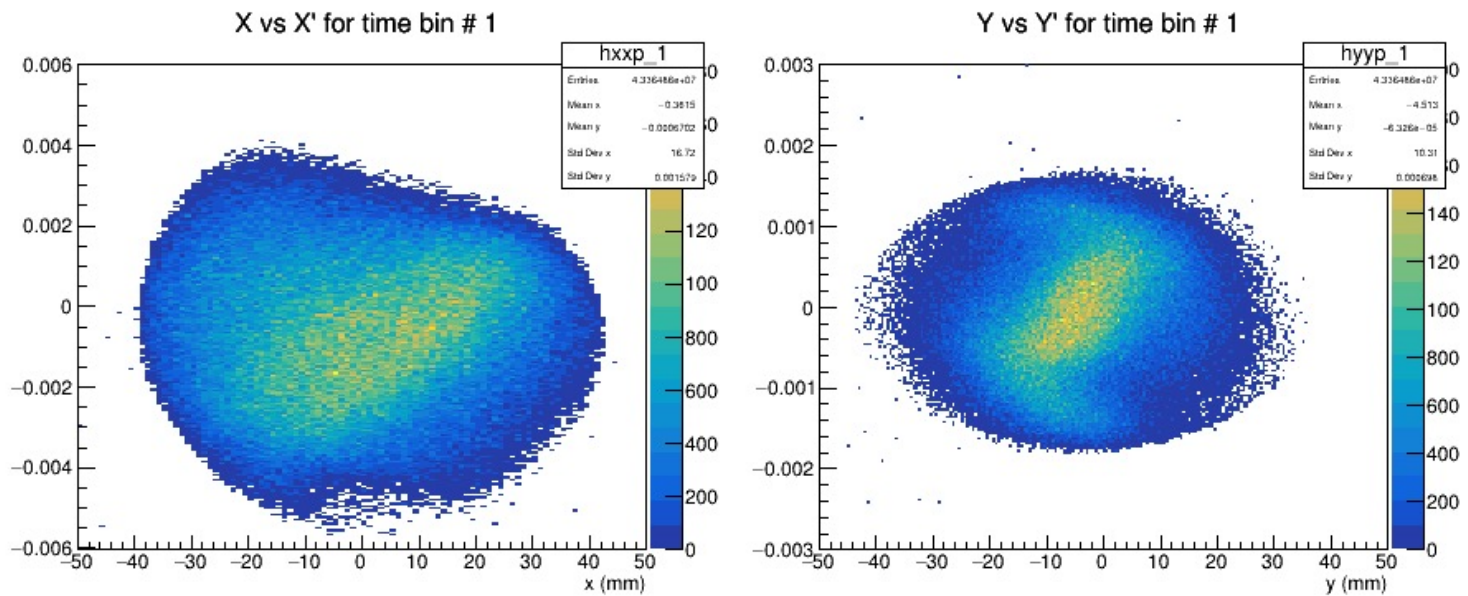
Led by Eremey Valetov in collaboration with Pengfei Ding, Steve Timm and Andrew Norman

Beam Gun Simulations on Fermigrid

- “Inject” muons into storage ring
- Turn off decay, muons stored up to 700us
- Evaluate motion of beam around the ring as a function of time
- Change in vertical RMS is due to bad resistors at single point on the ring.
- Final production for Run 1
 - 7 settings
 - Each ranging from 3-4.5M
 - ~20TB in total
 - Running time ~35 days
- Similar productions will be needed for Runs 2+3. Running time will be order of magnitude smaller due to fixed resistors.



Stored Muon Gun



- Inject muons with decay turned off
- Kills them after 5 us
- Record x , x' , y , y' positions of stored muons at 5us.
- Use stored muon kinematics to run simulations.
- Speeds up running time for subsequent simulations.
- Only useful for small to medium sized simulation samples.

Run 2-3 Simulation Needs

- At this time we don't think we need to remake the high-fidelity gas gun maps.
- We will repeat the no-decay beam gun studies with updated conditions.
- It is possible we will want a very large (~10-100B) beam gun sample with decay turned on. This will allow us to extract beam dynamics from tracker and calorimeter responses to positrons, as we do in the data. Project we can produce 10B in 60 day running with gm2pro and ~2K slots. Default footprint (all dataproductions) ~ 1PB.
- 100B beam gun sample would require running at NERS