Muon Campus Project Plan

Chris Polly & Ron Ray

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Towards an integrated muon program

- November 2 we proposed a plan to maximize the synergy and minimize the overall cost of g-2 & Mu2e
  - → The plan included recommendations from the Mu2e task force to go with a g-2 injection scheme for Mu2e
    - Significant cost savings >$100M
    - Only use 2 Booster batches and run for 3-4 yrs
  - → Synergy further enhanced with Muon Campus plan
    - Build one central Muon Campus with more shared infrastructure
    - Many advantages for g-2 associated with this site
  - → Total cost of $287.5M for this 'facility for the future' and the first two experiments
- Since that time we have been working on optimizing the overall project plan, reviewing costs, and developing timelines that fit within the laboratory budget guidance

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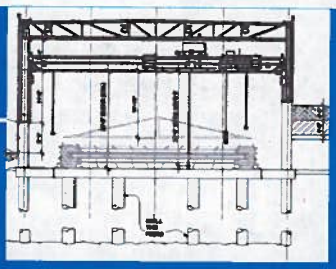
Division into various packages

- Categories
  - → On-project
    - Muon g-2 MIE
    - Mu2e Project
  - → Off-project categories required by g-2
    - MC-1 building to house g-2 storage ring (MC-1 GPP)
    - Disassembly and transportation of E821 equipment (Operations)
  - → Off-Project categories common to g-2 and Mu2e
    - Civil construction of Muon Campus Tunnel (Tunnel GPP)
    - Cryogenic facility to feed both experimental halls (Cryo AIP/GPP)
    - Recycler modifications (Recycler AIP)
    - P1/P2/Debuncher modifications (Debuncher AIP)

MC-1 GPP Justification

- → Would like to reuse TeV infrastructure where possible
  - Booster beam, Recycler, AP0 target hall, pbar complex, local beamlines
- → Existing large, high-bay buildings too remote
  - Current beamlines can't transport 8 Gev (or less) beam without $$$
- → MC-1 building general purpose
  - 80' x 80' high-bay with 30 T crane
  - internal loading dock
  - floor stable, load-bearing to 700 T
  - good temperature control
  - 70' x 70' low-bay for staging, assembly, control room

MC-1 GPP Utilization



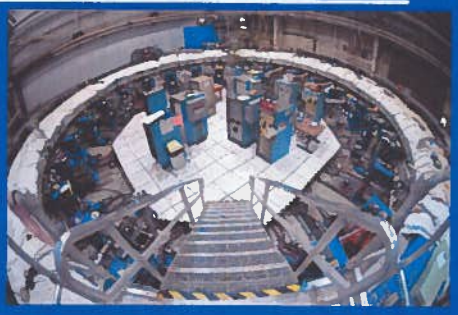
→ Current program
- House the g-2 storage ring
- Beamline magnets for g-2/Mu2e
- Infrastructure for g-2/Mu2e cryo

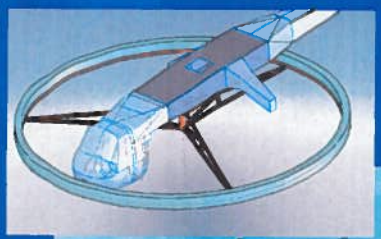
→ Future possibilities
- Future IF experiments, e.g. muon EDM or other CLFV expts (28-700 MeV muons)
- Muon cooling R&D facility (200-400 MeV muons)
- Conveniently located assembly area for Project X era experiments

→ Future sources (expts currently using 8-16 kW beam from Booster)
- In Project X era, Booster will have 75-100 kW available (free)
- Can imagine bringing 200-300kW of Project X era primary beam, or perhaps a secondary beam utilizing the full Project X beam power (~$50M)

BNL E821 Disassembly and Transportation

- DOE recommended we disassemble and transport the g-2 equipment from BNL to FNAL under an operations budget
- Important for the timeline that this (and MC-1) not get tied to the g-2 CD3 schedule
- Transfer includes storage ring, 80 m beamline, and all other E821 equipment





Tunnel GPP - Justification

- → Many advantages to placing g-2 and Mu2e in the same area
  - Avoids some problems with the original g-2 site (transport back through AP0, poor location, proximity of MI stray fields)
  - Can share more infrastructure (utilities, beamline elements, cryo)
- → More efficient and economical to complete civil in one pass
- → Develop one global utility plan
- → Timeline driven by g-2

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Cryo GPP - Justification

- → Both g-2 and Mu2e need one refrigerator + one spare to provide extra capacity when needed or serve as a backup
  - One cryo plant housing 3 refrigerators instead of 2 + 2 previously planned
- → Can bring one compressed He line over from F0 or A0
  - Saves $$ by not having two locations or having to install compressors locally
- → Cryo plant has cold lines extending to both experimental halls

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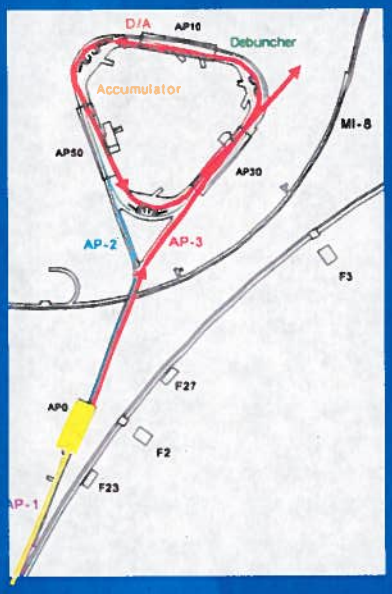
Recycler AIP - Justification

- Muon g-2 and Mu2e need bunched beam that can be prepared in the Recycler
  - → Large cost savings over original Mu2e plan where the rebunching was done in pbar rings
  - → Muon g-2 requires <100 ns wide bunches, more stringent spec than Mu2e
  - → Muon g-2 uses 4 Booster batches per super--cycle, higher rate than Mu2e
  - → System that works for g-2 automatically works for Mu2e
- Cavity productions
  - → Mu2e needs 1-2 cavities installed in the Debuncher that are identical to the 7 being produced for the Recycler
  - → Make them all in one production
- New capability for the Recycler

Recycler AIP - Justification

- Both g-2 and Mu2e need the rebunched beam delivered to the pbar area
  - → Requires kicker
  - → Short connection from Recycler to P1
  - → Has always been a common component needed by the experiments even under the original scenario

P1/P2/Debuncher AIP



→ g-2 & Mu2e P1/P2 transport identical
- A few small aperture magnets replaced
- Instrumentation

→ Injection into the Debuncher
- Originally g-2 was just going to inject with fixed field dipoles for one pass around
- Proton hadronic flash can be removed by staying in Debuncher for 3-4 turns
- Can use Mu2e injection scheme (kicker)
- One less area that would have to be switched between g-2/Mu2e run s

→ Abort system
- Use Mu2e abort system to clean g-2 protons
- All work in AP2 can be completed reducing g-2 downtime for Mu2e upgrades

Total cost for program

MC-1 GPP	$7.5M
E821 Equipment Transfer	$4.9M
Off-project g-2	$12.4M

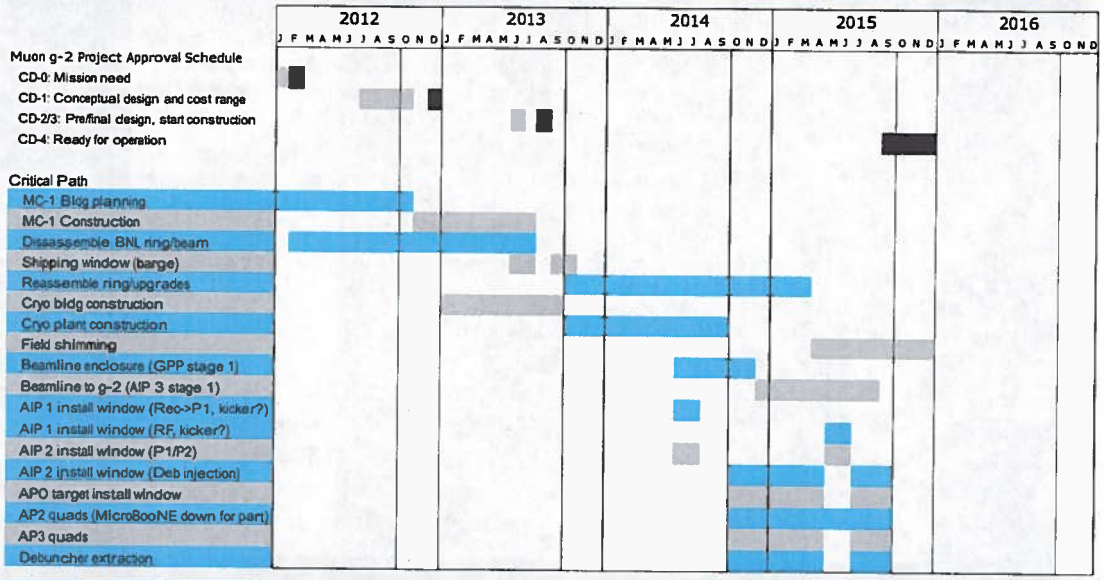
Accelerator	$38M
Civil Construction	$24M
Solenoids	$106M
Muon Channel	$10M
Tracker	$8M
CRV	$5M
DAQ	$6M
Project Management	$16M
Mu2e Project (CD-1)	$213M

Total Muon Campus $287.8M

Tunnel GPP	$9.2M
Cryo GPP	$9.5M
Recycler AIP	$9.5M
Debuncher AIP	$8.9M
Off-project common	$37.1M

AP0 Target	$2.0M
AP2/3 Beamlines	$2.0M
Debuncher Extraction	$2.0M
Extraction beamline to bldg	$2.1M
Instrumentation	$1.0M
Ring Reassembly/Upgrades	$10.9M
Project Management	$5.3M
Muon g-2 Project (CD-0)	$25.3M

Important timeline considerations



This timeline has g-2 taking data in 2016, and Mu2e starting 2-3 yrs later

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MC-1 Building	FY12	FY13	FY14	FY15	FY16	Total
Buliding Design	530					530
MC-1 GPP		7000				7000
Total						7530
DOE equip transfer	FY12	FY13	FY14	FY15	FY16	
Disassembly	400	3000				3400
Transport	40	1500				1540
Total						4940
Muon g-2 Project	FY12	FY13	FY14	FY15	FY16	
APO target	200	400	700	700		2000
AP2/AP3 quads	150	300	775	775		2000
Deb extraction	150	300	775	775		2000
Beamline stub	100	200	900	900		2100
Instrumentation	50	100	425	425		1000
Ring reassembly	230	500	6500	3000	700	10930
Project management	950	1305	1344	1384	356	5339
Total						25369
	FY12	FY13	FY14	FY15	FY16	
Recycler AIP	150	300	3550	5500		9500
Debuncher AIP	150	300	3700	4900		8900
Cryo Building		1500				1500
Cryo Plant		2000	3000		3000	8000
MC Tunnel		600	4400	4200		9200
Total						37100
Total by FY	3100	19305	26219	22559	4056	
TOTAL Lab Guidance	23100	43000	45000			
Left for Mu2e Project	20000	23695	23781			

FY Outlay

- FY12 $ allocated from FNAL for g-2 pre-CD0 & $200k BNL match
- Conceptual design for AIPs + $530k for GPP will be done with g-2 current FY12 allocation
- AIPs start in FY13 with preliminary/final design, construction/installation
- Could consider pulling the Recycler AIP back into the g-2 MIE

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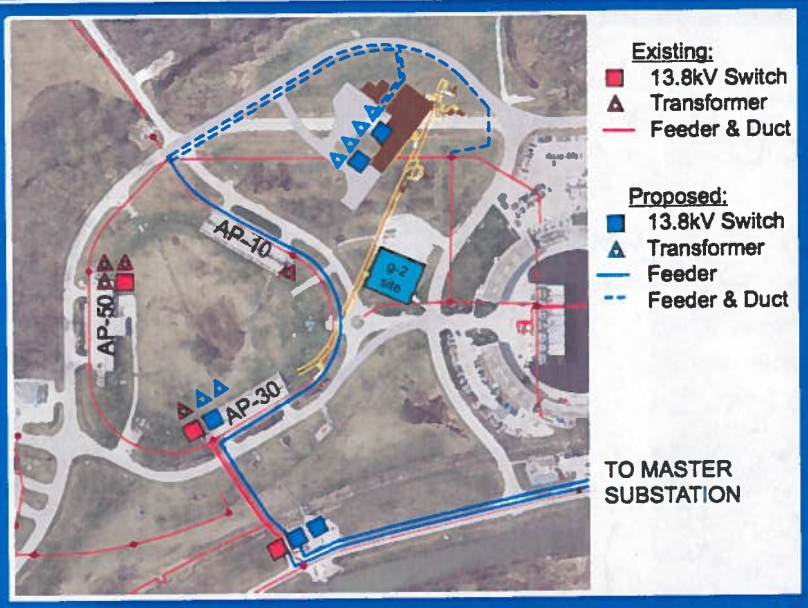

Two centrally located buildings, one with a secondary beam delivered to a surface building, the other an underground facility for primary beam

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