Center for Frontiers in Nuclear Science

sPHENIX

TPC Distortion Calibration Notes

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SBU Group Meeting

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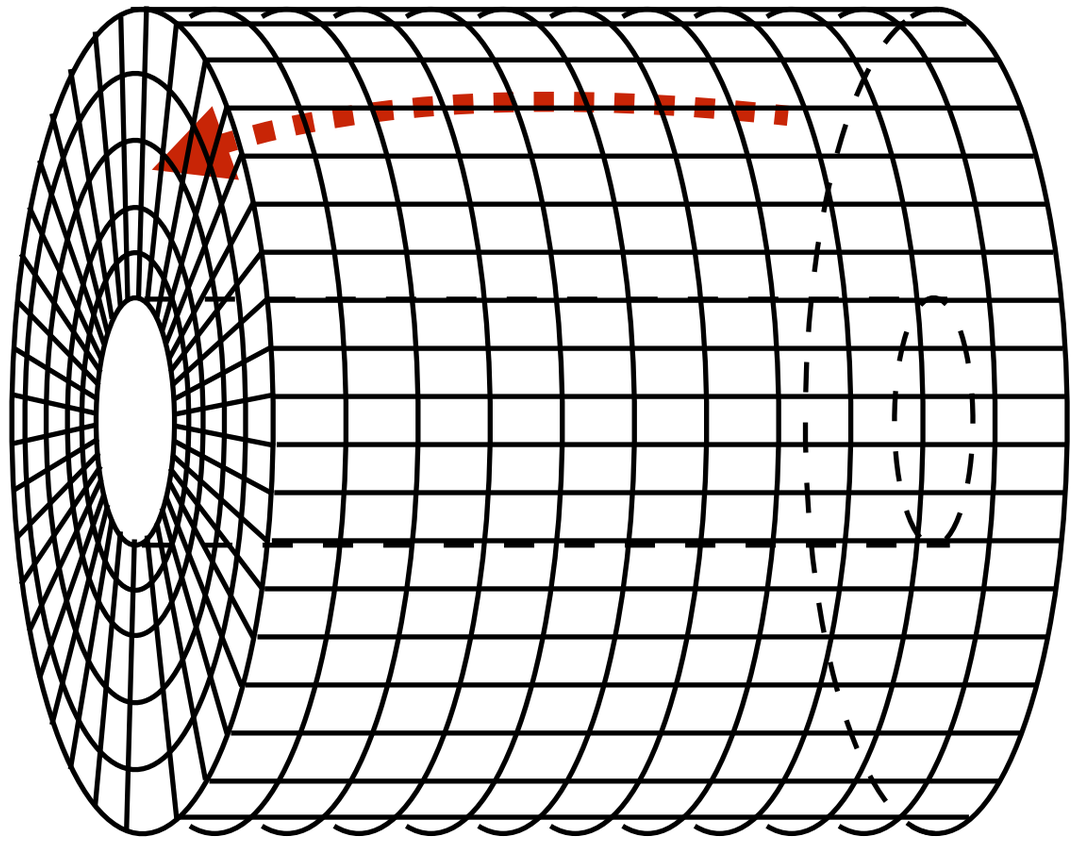
Overview

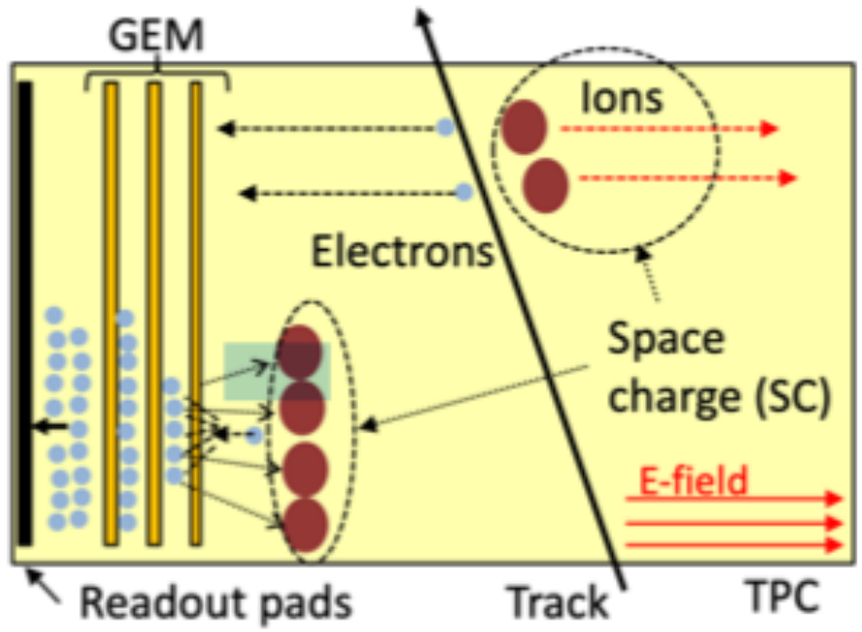
- Physics observables depend on precise momentum vector reconstruction
- In order to reconstruct a track, electrons arriving at the gem planes must be extrapolated back to their origins
- Ions in the TPC produce net spacecharge that distorts electron drift lines.

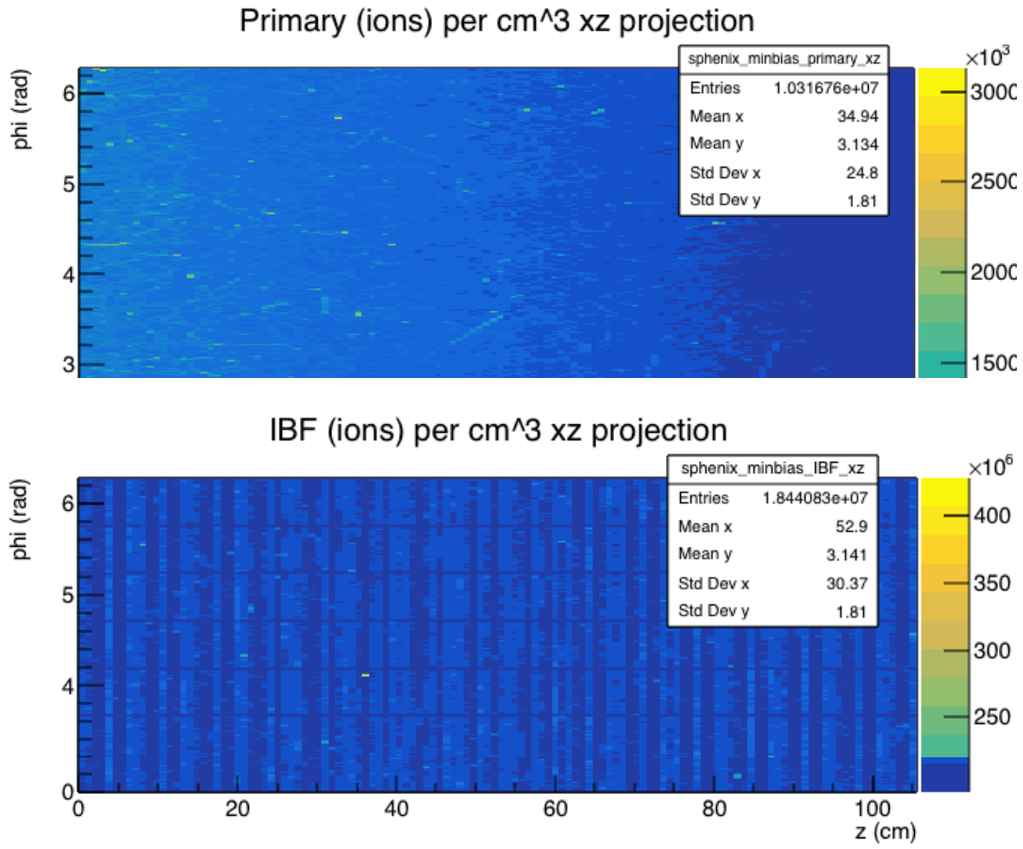


Structure of Spacecharge

$$\rho(r,z) = A\frac{1-bz+c}{r^d}$$

- Heuristic:
  A=Gas and Collider parameters
  b=1/drift length
  c=IBF ions per primary
  d=radial dependence of track density
- Ions drift ~1.3cm/ms (78ms to cross TPC), 5000x slower than electrons
- Pancakes and volume:
  Primary ions are created from charged particles traversing TPC.
  Ion Backflow (IBF) pancakes are created from electrons avalanching at readout.
- Average and fluctuations:
  Average SC governed by luminosity and fixed TPC parameters. Expect few-mm R distortions on average
  Local fluctuations from event-by-event statistics.



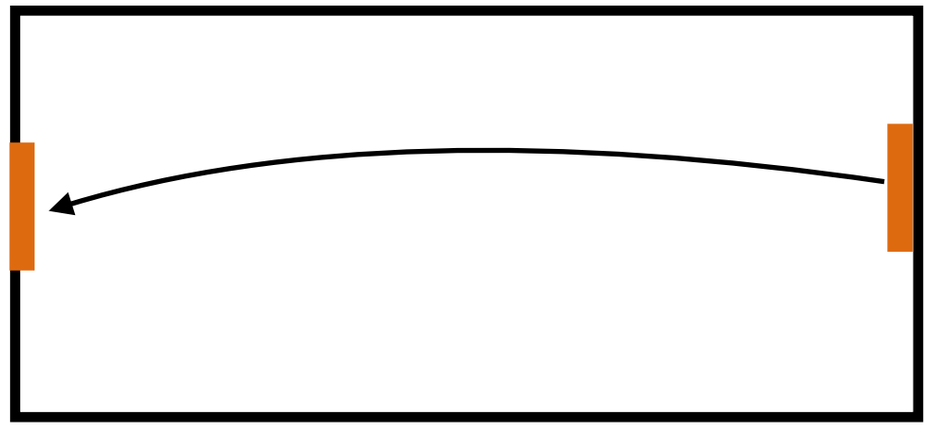


Distortion Types

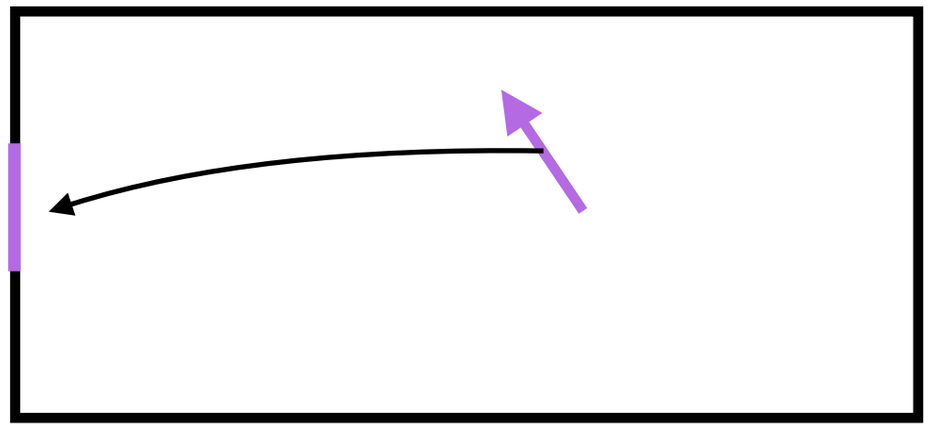
- Static: Arise from alignment w.r.t realistic magnetic and electric fields
- "Long term": external fields change with temperature, pressure, gain, etc.
- "Short term": time-averaged fields from spacecharge change with beam properties
- "Fluctuations": from specific charge layout of individual events differing from the average

Distortion Handles

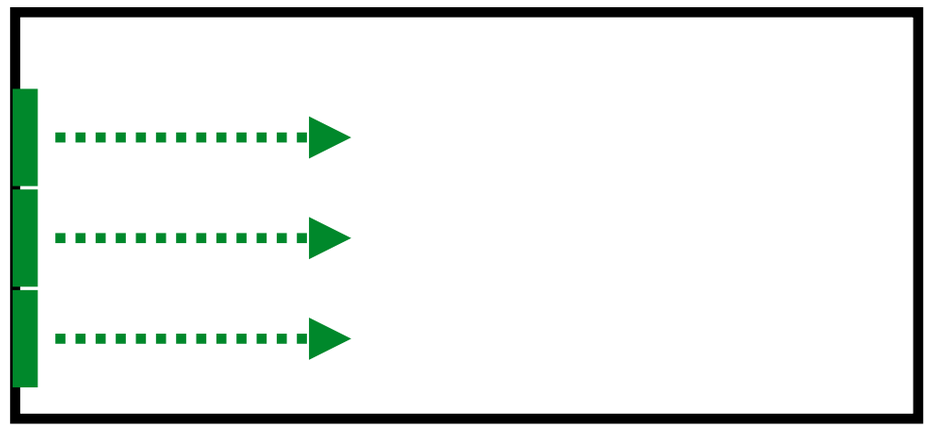
- Central Membrane Stripes: illuminated with laser (kHz), produces clusters at known position, integrates over entire distortion column



- Tracks: (*eff. ~Hz) produces clusters at uncertain position extrapolated from inner tracking, integrates over partial distortion column



- Digital current: infers spacecharge current directly from electrons at readout (kHz), computes distortions from charge



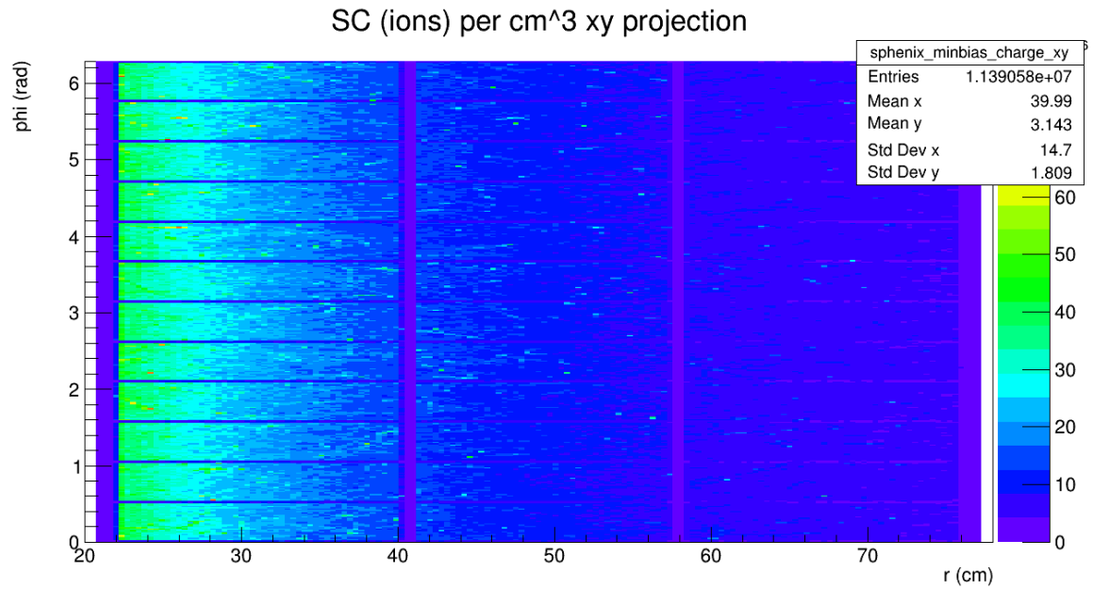
- *Simulation: model expected average spacecharge shape, compute distortions for a given luminosity*

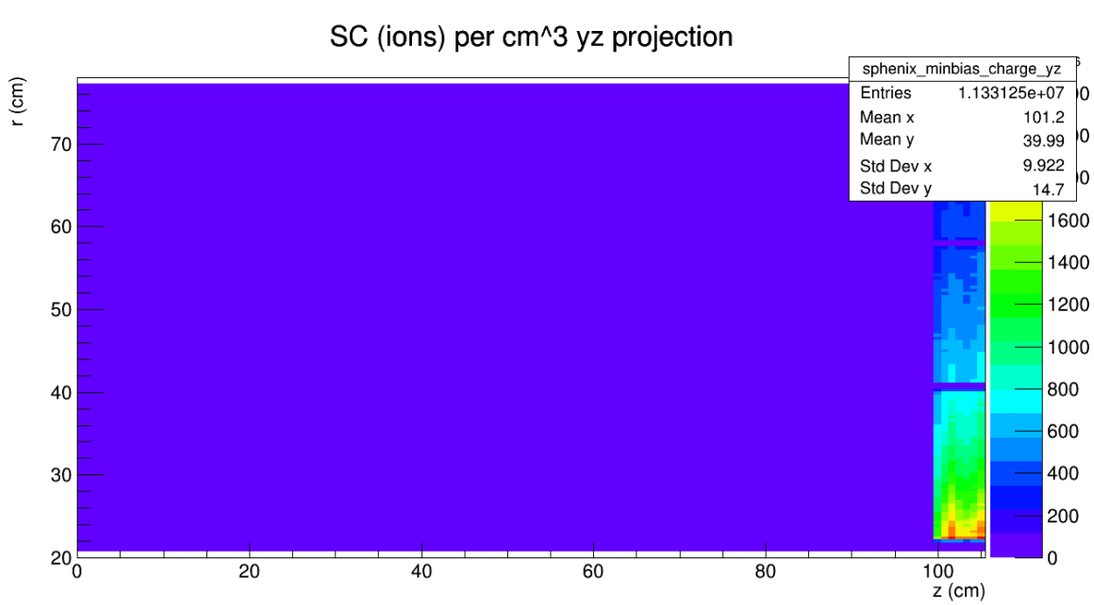
Tasks at Hand

Task	*Pertinent Skills*	*Work by*	2020	
	all: root, c++		Q2	Q3
Inputs	*sPHENIX sim*	*Chris*	HIJING events	
	E&M	*Ross/**Ananya**/**Jordan***	generate distortions from SC	
	sPHENIX sim	***Henry***	distortions in simulations	
Monitoring with currents		*Ross/Evgeny/**Ananya***	**current / SC maps from HIJING (including IBF issues)**	
	E&M, algorithms	*Ross/**Ananya**/**Jordan***	distortions from currents	
Monitoring with laser	*sPHENIX sim*	***Sara***	**Implement laser events in sims**	
	sPHENIX sim	***Sara***	Reconstruct laser events	
		Ross	distortions from laser events	
Monitoring with tracks	*sPHENIX tracking*	*Hugo*	Distortions from reconstructed tracks	
All methods	*various*			Cross-validate the methods
Correcting for distortions	*sPHENIX soft*	*Ross/Chris*	Define correction format	
	sPHENIX sim	*Joe*	Implement corrections in reco	
	various	*Hugo, Tony*	Monitor quality of tracking with/without correction	
Studies of Physics Impact	*various*			pT and Υ Resolution etc.

Spacecharge Model

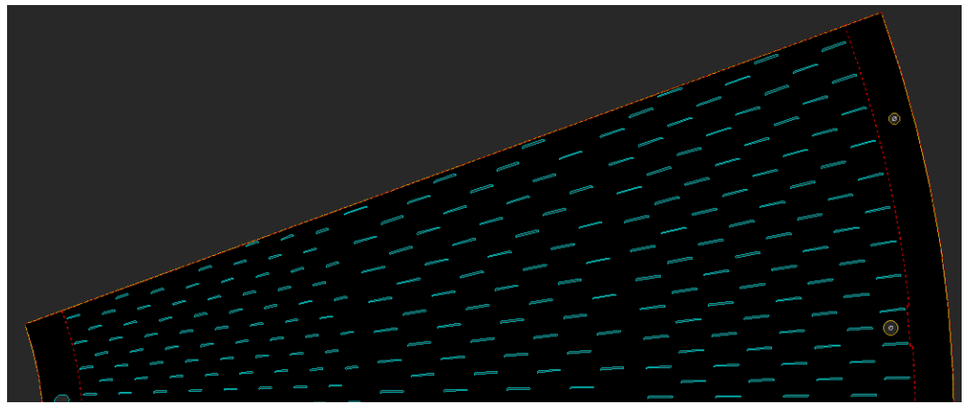
- Ananya Paul (SBU) is implementing proper Poisson statistics in the SC model
- "Zoo" of different rates and variable IBF factors in different regions will allow us to simulate realistic detector scenarios
- High-res (159x360x62) data volume too high: 150MB per full TPC 'frame', 750k (beam xings) frames needed to simulate one full ion drift time



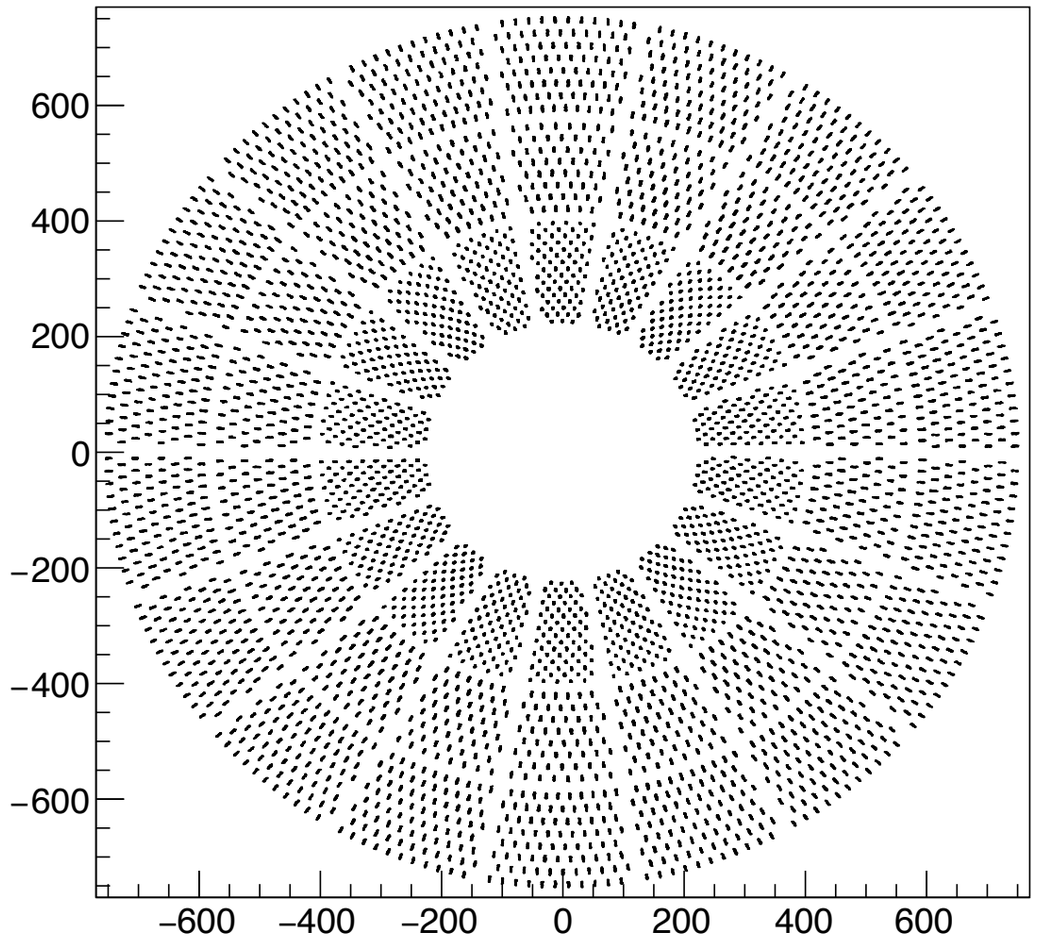


Central Membrane Stripes

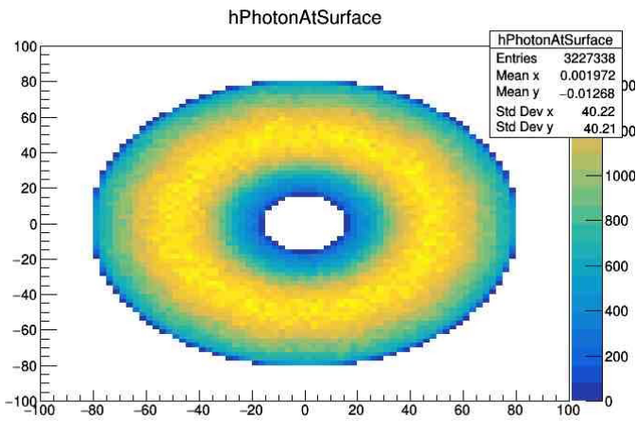
- Sara Kurdi working now to implement real CM stripes in sPHENIX software
- Simulate energy deposits in Fun4All
- laser flash trigger signal
- CM 'tracking' to reconstruct laser events



Pattern



- Nikhil Kumar (SBU) modeling the diffuse laser:



Summary and Milestones

- By Summer's end:
  - Implement realistic distortion models in MC data
    - SC (Ananya, Evgeny), Model (Jordan, Ross), Implementation (Henry)
  - Implement track-, laser-, and current- based reconstruction of distortion maps
    - Tracks (Hugo, ____), Lasers (Sara, Ross), Current (Jordan, Ross)
  - Study, optimize and report on performance
    - Will begin as implementation tasks complete
- Fleshing out intermediate milestones