Variations of the front end for a neutrino factory

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FNAL

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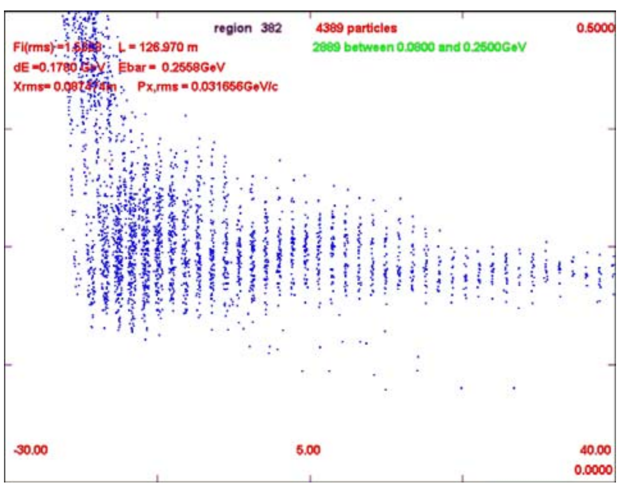
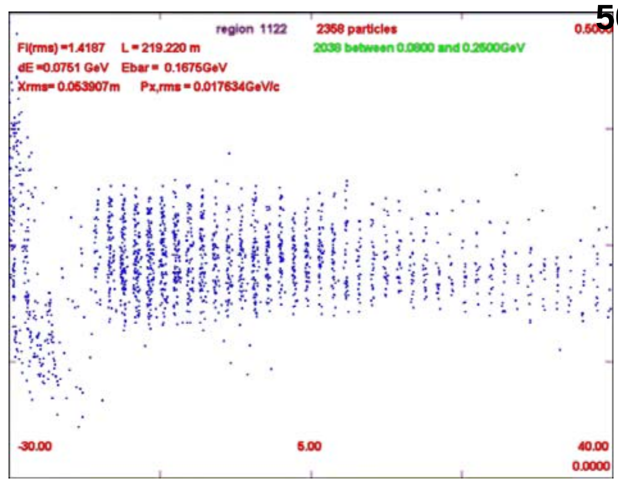
Outline

- **Front End for the Neutrino Factory/MC**
  - Shorter front end example-
    - basis for present study
- **Rf cavities in solenoids?**
  - high gradient cavities may not work in ~2T fields
  - Option explored
    - Use lower fields (B, V')
- **Need baseline design for IDS**
  - need baseline for "5-year Plan"

IDS - Shorter Version

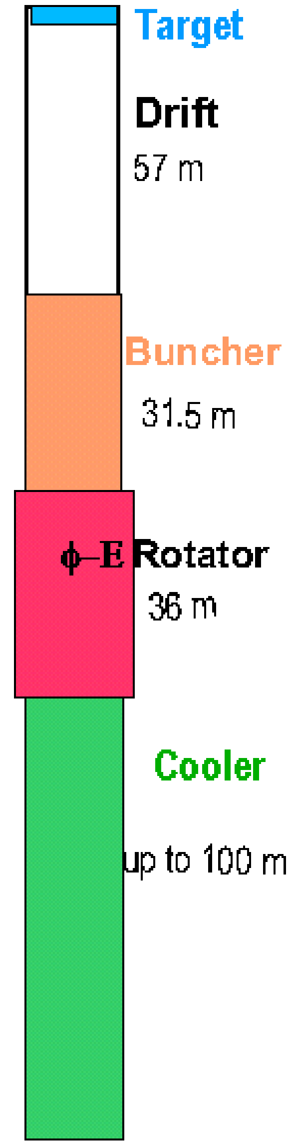
- Reduce drift, buncher, rotator to get shorter bunch train:
  - 217m ⇒ 125m
  - 57m drift, 31m buncher, 36m rotator
  - Rf voltages up to 15MV/m (×2/3)
- Obtains ~0.26 μ/p_{24} in ref. acceptance
  - Similar or better than Study 2B baseline
- Better for Muon Collider
  - 80+ m bunchtrain reduced to < 50m
  - Δn: 18 -> 10





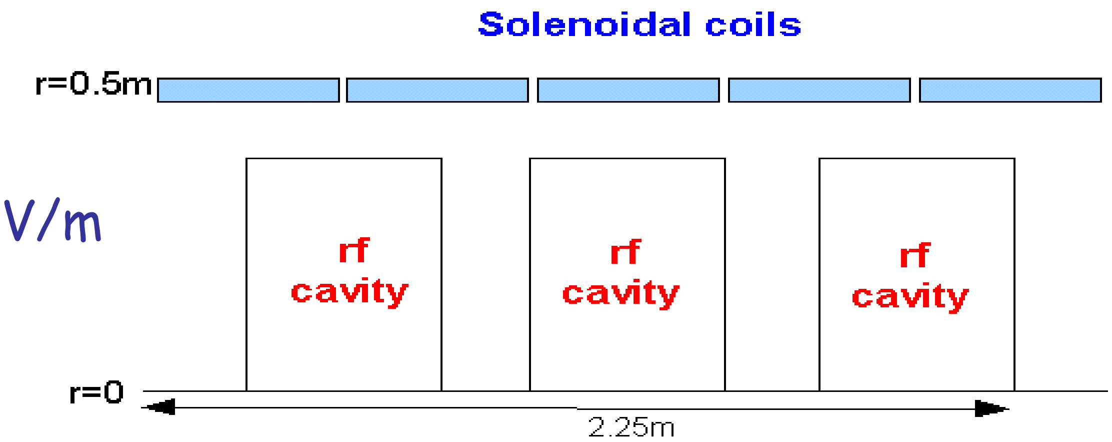
500MeV/c

-30 40m

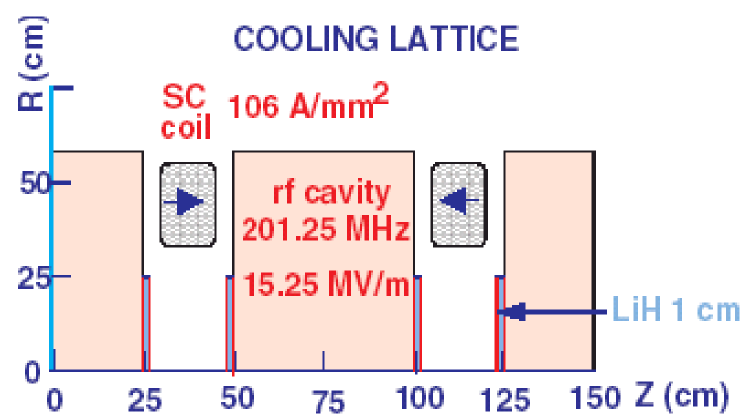


Buncher-Rotator settings

- **Buncher and Rotator have rf within ~2T fields**
  - rf cavity/drift spacing same throughout (0.5m, 0.25)
  - rf gradient goes from 0 to 15 MV/m in buncher cavities
- **Cooling baseline**
  - ASOL lattice
  - 1 cm LiH slabs (3.6MeV/cell)
  - ~15MV/m cavities
  - **also consider H_2 cooling**



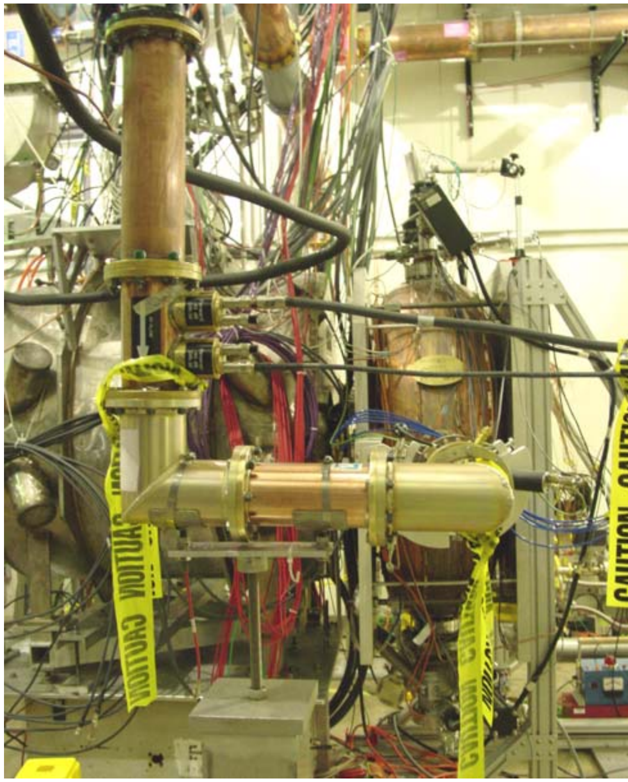
ASOL lattice



Optimizations

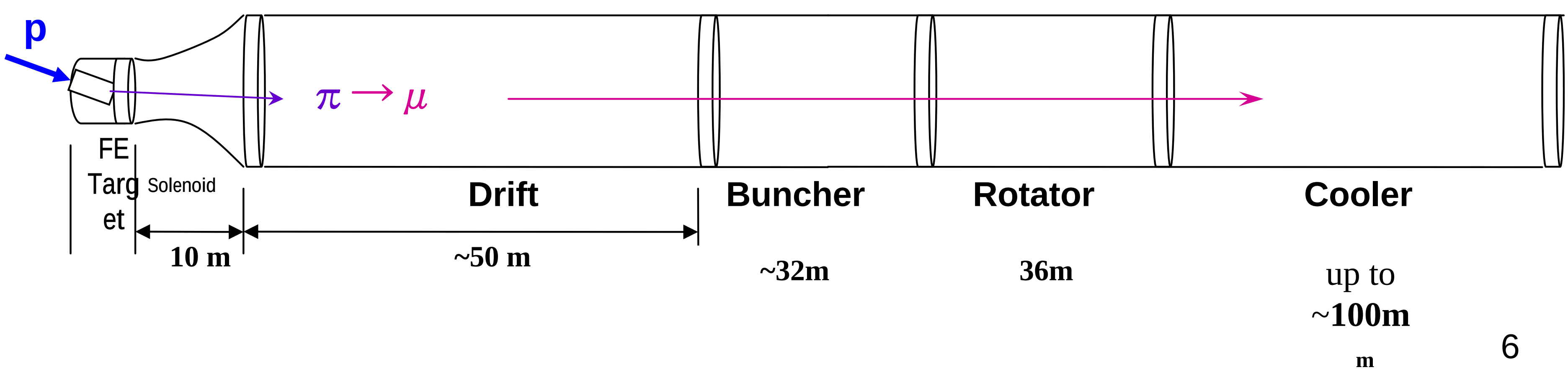
- **Major uncertainty is high-gradient rf within solenoidal fields**
  - V'_{rf} / $B_{solenoid}$???
  - Currently have **B= 1.5 to 2T, V' = 12 to 15 MV/m**
  - baseline frequency is ~200 MHz

- **Experiments have achieved~ 14 MV/m at 2.5-T**
  - (~ 0.75-T at nearest thin Be window)
  - Solenoid near 201 MHz cavity



Current study

- Change magnetic field, V'_{rf} to study limits
- Use "short" front end for studies
  - Baseline had 2T solenoid in drift and buncher
    - 0 to 15MV/m rf
  - 15 MV/m in rotator; 15 MV/m in cooler
    - vary rotator from 9 to 15 MV/m;
    - Cooler 10 to 18 MV/m
      - all in 0.5m rf, 0.25 drift cells
      - with lower gradient



B_0 =2.0T Results

- Muons per 10 8-GeV protons

Cooler/ Rotator	10	12	14	15	17	18 MV/m
10	0.35 (0.63)	0.55 (0.67)	0.66	0.73		
12		0.57 (0.72)	0.754	0.77		0.80
14			0.776	0.80	0.84	
15				0.81	0.85	0.84
	(0.65cm)	(0.8cm)				

Variation is not strong; more rf still means more muons

Next try changing B

- B= 1.25 T (~Study 2)

- match into alternating solenoid
  - Use old R. Palmer match

- As before, lower cooling gradient implies using less absorber per cell
  - 15MV/m – 1cm LiH
  - 12MV/m – 0.8cmLiH (~5% worse than 15MV/m)
  - 10MV/m – 0.65cm (~10% worse than ~15MV/m)

B_0=1.25T Results

- Muons per 10 8-GeV protons

Cooler/ Rotator	10	12	14	15	16	17 MV/m
9	(0.58)			0.68		
10	(0.61)	(0.65)	0.655	0.705		
12		(0.67)		0.75		
14			0.72	0.77		
15				0.78	0.805	0.81
	(0.65cm) z=231m	(0.8cm) z=220m		1.0cm z=204m		

Variation is not strong; more rf still means more muons

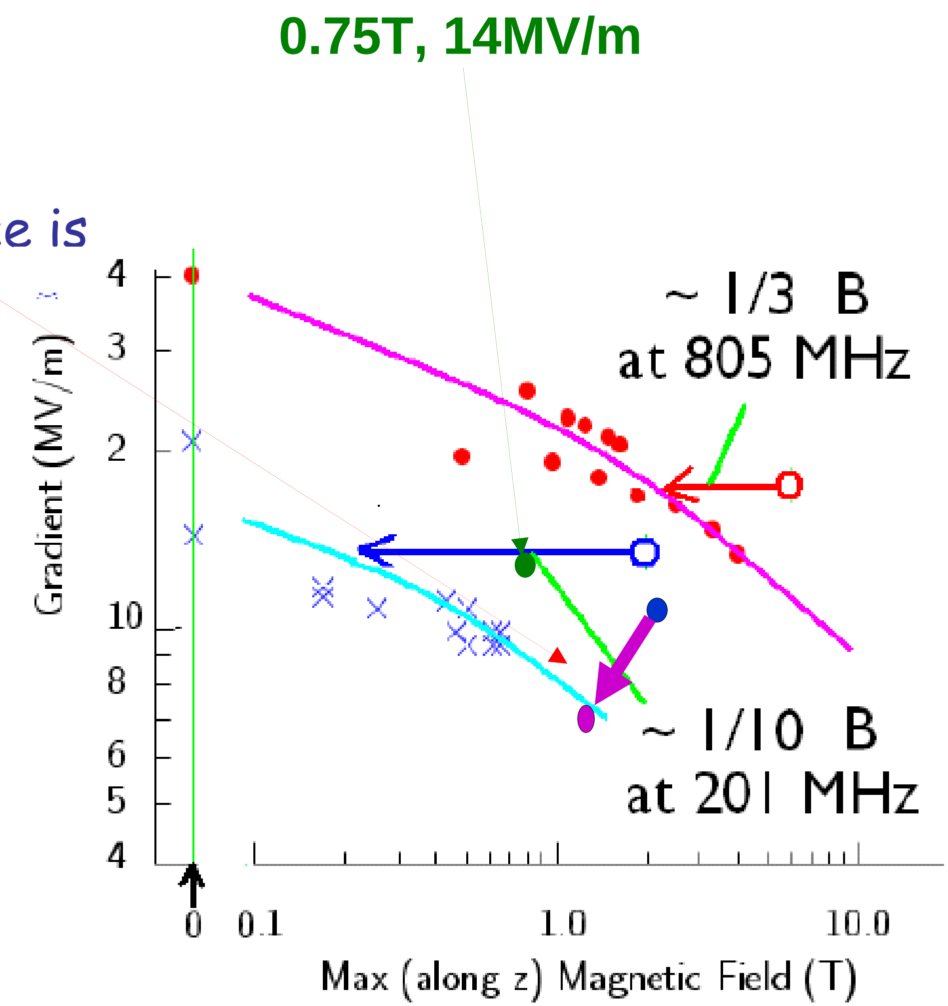
B=2.0T -> 1.25T

- **B=2T is only slightly better than B=1.25T**
  - only ~5% fewer μ/p in acceptance at 1.25T

- **Optimum B is (probably) somewhere in between**
  - B=1.75T for study 2A
  - Cost optimum is (probably) less

Summary

- Adequate acceptance can be obtained by reducing magnetic fields and gradients
- B -> 1.25T, V' -> 10 MV/m ??
  - (10MV/m is 7MV/m real estate gradient; could use 7MV/m if space is filled.)
- Reduced B, V' are relatively certain to work.
- Cost optimum?
  - B=1.5T ?, 12MV/m

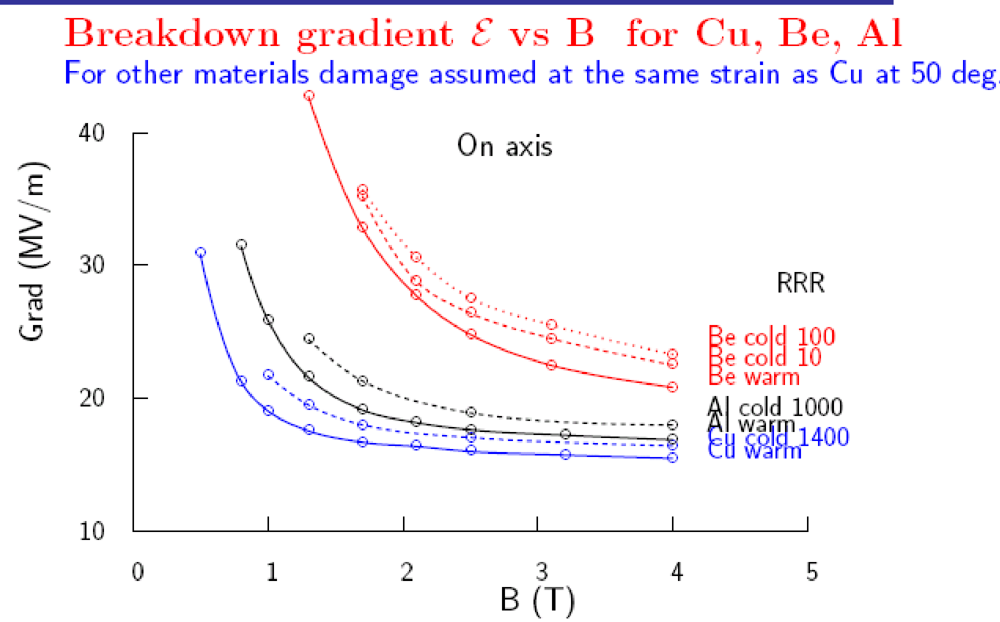


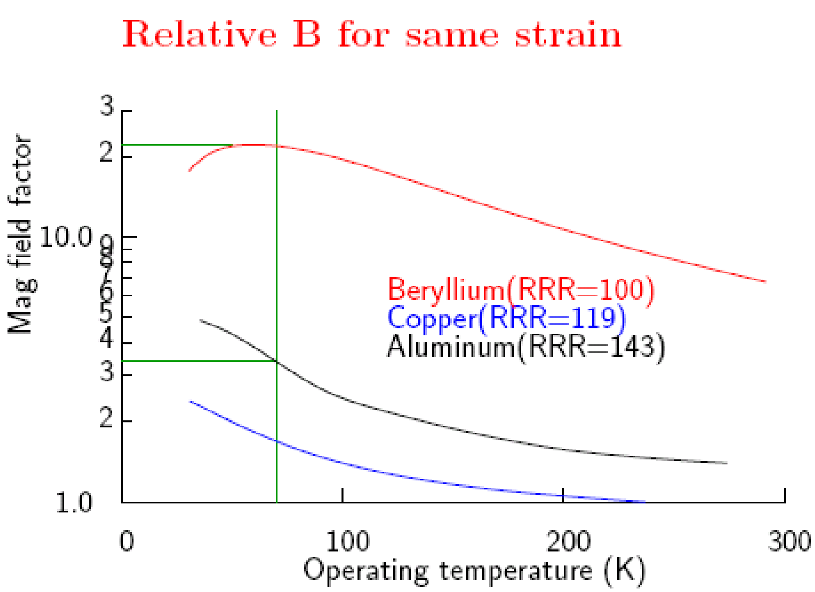
Change cavity material-Palmer

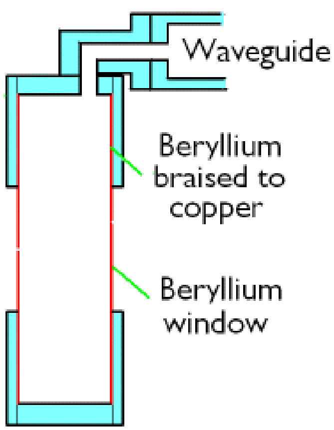
- Tech-X rf breakdown modeling workshop

  Bob is convinced Be would solve the Front End Problem ?

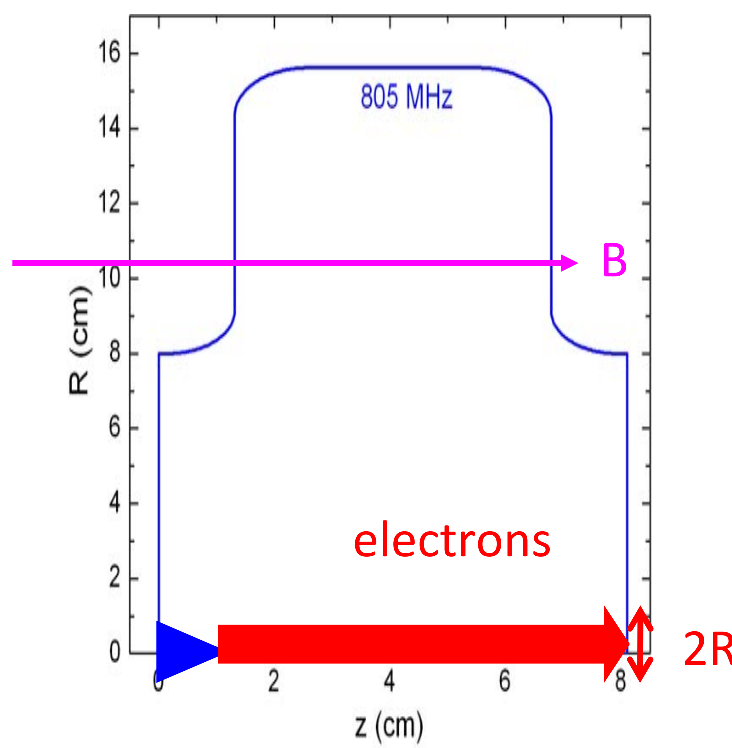
Needs experimental tests !!!





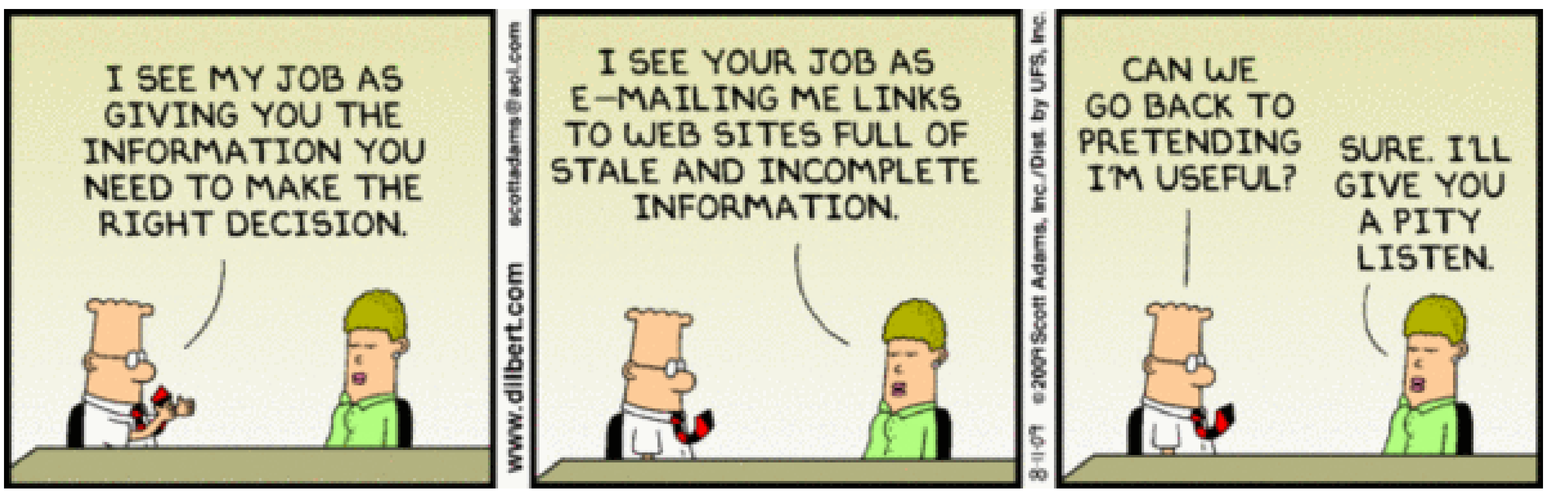


- Cold beryllium gives reduction $B_{damage} > 10$
  should solve the problem for all cases



Plan for IDS

- Need one design likely to work for V_{rf}/B-field
  - rf studies are likely to be inconclusive
  - B=1.25T; V′ = 10MV/m is very likely to work
  - B= 2T; V′ = 15 MV/m should work with Be
- Hold review to endorse a potential design for IDS
  - – likely to be acceptable (V_{rf}/B-field)
  - April 2010 ?
- Use reviewed design as basis for IDS engineering study



Solutions to possible rf cavity limitations

- For IDS, we need an rf cavity + lattice that can work
- Potential strategies:

- Use lower fields (V', B)
  - 10MV/m at 1.5T?
- Use non-B = constant lattices
  - alternating solenoid
- Magnetically insulated cavities
  - Is it really better ???
  - Alternating solenoid is similar to magnetically insulated lattice
- Shielded rf lattices
  - low B-field throughout rf
- Use gas-filled rf cavities
  - same gradient with/without fields
  - but electron effects?