

NLC - The Next Linear Collider Project



# NLC Magnets

## Permanent Magnet Options

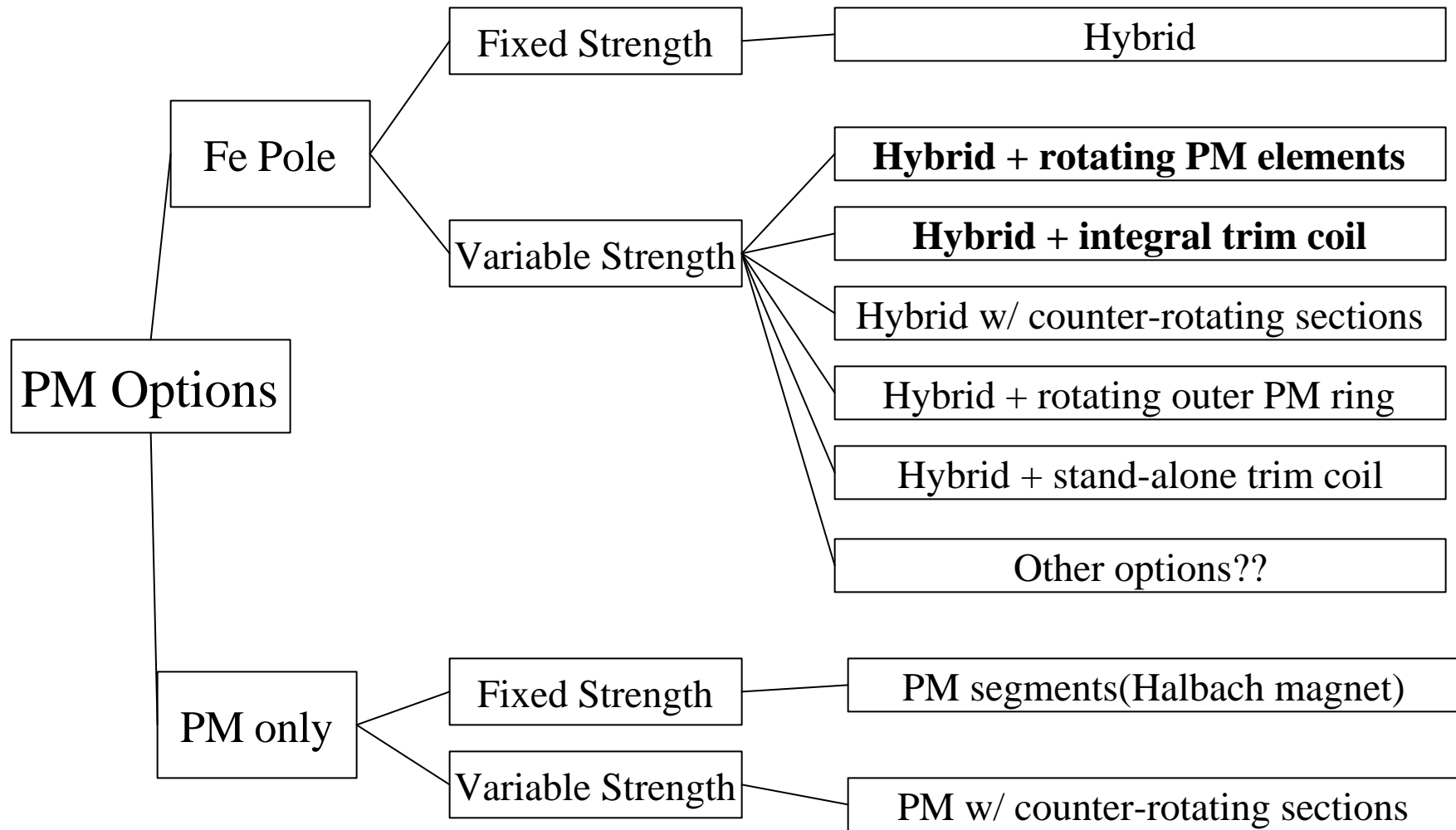
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*11/11/99*



# PM Options, NLC Multipole Magnets





# Permanent vs. Electromagnet

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## Permanent Magnet Pro's

- Eliminate or reduce power supplies(trim supplies)
- Substantial reduction of cableplant
- Eliminate or reduce magnet power dissipation, reduce op. cost
- No cooling water + conv. facilities
- No flow induced vibration from cooling water
- MPS(no coil shorts if all PM)

## Permanent Magnet Con's

- Extra capacity or use several styles to cover the energy range in Linac
- Limits beam energy flexibility
- Strength variation of a few % between PM blocks (requires measurement and matching)
- Center shift during BBA ( $1 \mu\text{m} <$ )
- PM thermal coefficient(.03%-.2%; requires temperature compensator)
- Radiation resistances(Nd-Fe-B)
- More difficult to assemble in some cases



# PM Material Choices

## CERAMIC

- Strontium ferrite
- Inexpensive
- Radiation resistant
- Low Br, .38 T
- High temp coefficient, .2 % / C° (Br incr., Hc decr. w/ incr. temp)
- Brittle

## RARE EARTH COBALT (REC)

- Sm-Co 1:5, 2:17
- Expensive
- Small industrial base
- Radiation resistant (2:17 good, 1:5 is worse)
- High Br, 1.05 T
- Low temp coefficient, .03% / C° (Br and Hc decr. w/ incr. temp)
- Brittle

## Nd-Fe-B

- Ceramic < \$ < REC
- Large industrial base
- Poor radiation resistance
- Highest Br, 1.2 T
- High temp coefficient, .1% / C°
- Ni plate to prevent corrosion

# Hybrid Design

## (Fermi Recycler Ring Magnets)

- Strontium ferrite “bricks”: large size, magnetized at Fermi
- Bricks excite steel poles; surrounded by an outer steel flux return
- Poles are either solid(special ingot processing) or stamped lams with a backing bar(helps spread flux longitudinally, prevents periodicity)
- Bricks isolate the poles from the flux return, so Al(precision drawn) spacers are used as supports between poles(also support mapping coil)
- Temp. compensator: Fe-Ni sheet(Curie point of 55 F, used in gas meters) placed between bricks along the magnet length
- Ground steel plate(1018) serves as outer flux return; “windmill pattern” allows plates to seat on PM; pin in place
- Steel tuning washers housed in SST tubes located at the four corners
- Core endplates(SST) have additional tuning washers plus end blocks for sextupole(CAM’d from initial map). Map using Morgan Coil
- Fiducialized by taking micrometer drops to precision Al spacers
- One assembly station built and tuned three magnets per day

## PM Technical Issues

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- **Magnetic center shift during BBA**
  - Gradient adjustment element shifts center
    - Shimming variation between poles
    - Backlash in rotation system
    - Material variations: permeability, hysteresis, coercive force
  - Fix by databasing this center shift(factor of two relaxation in tols?)
    - Requires accurate center measurement
    - Database implementation could be difficult
- **Need modular design**
  - Limits number of styles for main linac
  - Could use for upgrades
- **Need to clarify tunnel temperature vs. time specifications**

# PM Cost Estimate

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- Clarify revised CD-1 estimates(SLAC)
- Summarize “strung EM” model(SLAC)
  - Power supplies, cables, racks
  - Conv. Facilities: AC, alcoves, HVAC, LCW, other??
- Bottoms up estimate of Fermi hybrid design(rotating elements)
  - Magnet alone(Fermi)
  - Stepper installed cost(SLAC)
  - Facilities needs(SLAC)

# Summary

## Permanent Magnets for the NLC

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- **PM's look promising (but devil is in the details):**
  - Cost
  - Technical risk (PM's less risky)
  - Potential impact on other systems leading to more cost savings
  - Existing experience at Fermi, up on the learning curve
- **Meeting accomplishments:**
  - Decided hybrid w/ PM adjustment elements was lead option
  - Better understanding of requirements by Fermi
  - Better understanding of hybrid design and manf. by SLAC
  - Mutual experience with PM materials (Ceramic, REC, Neo)
  - Preliminary discussion of solving hybrid technical issues
    - Center shift: techniques for balancing
    - Corrector: Use rare earth (avoids demag of ceramic)
    - Modular design: add and remove bricks as needed





# Goals for 1/00 Meeting

(six working weeks)

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- Cooperative program is the best way to proceed, exploit relative strengths of both labs
- Present cost comparison for NLC
  - Main linac
  - Other candidates(best effort basis)
- Present prototype design
  - Sufficient detail to initiate final design and procurement
  - Plan to build two prototypes
    - Proves reproducibility
    - Allows beamline testing(ASSET) in parallel with field testing
  - Use leftover PM material: bricks from Fermi, elements from SLAC
- Optimize and compare hybrid + trim coil option

## Issues for Meeting 1/00 Goals

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- Requirements verification(are we designing the right thing)
  - Main linac magnet, vacuum, BPM integration
  - Finalize magnetic requirements: Bpt, harmonics, mag. center
  - Revisit center shift tolerance during BBA
- Sufficient manpower vs. priorities
  - Fermi
  - SLAC



## PM Prototype Goals

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- **Technical merits of PM option**
  - Build, tune, and map a hybrid PM quadrupole based on ML 0.5Q12.75 capable of at least 20% strength adjustment
  - Show that the magnet center is stable to a few  $\mu\text{m}$  during adjustment
  - Show that the magnet's strength is stable over time and temp range
- **Cost savings of PM option**
  - Develop “real” prototype costs to reinforce estimates
  - Establish learning curve for cost tradeoff's for other candidates
- **Other**
  - Build mapping coil for small bore magnets; wire techniques
  - Advances SLAC/Fermi collaboration