Accumulator Stacktail Cooling

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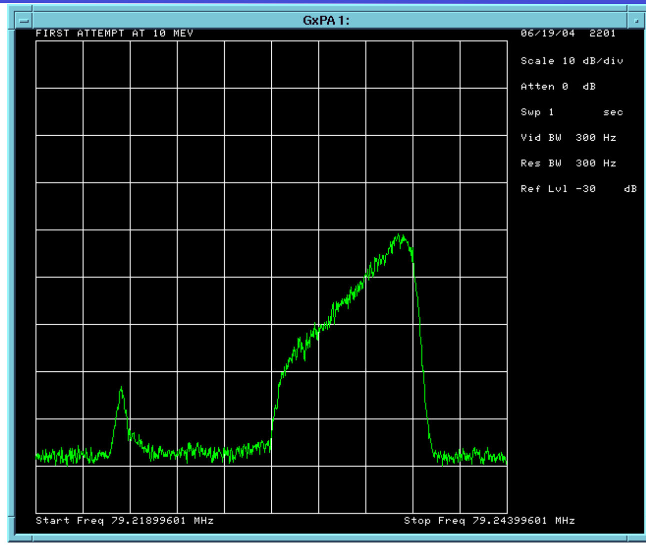
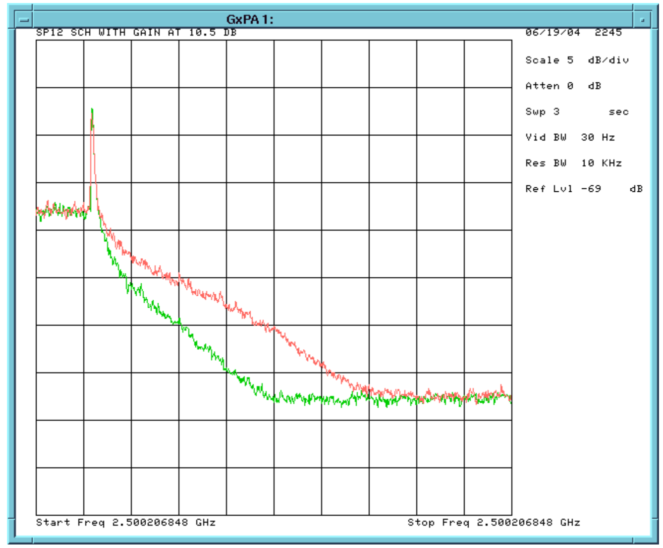
Stochastic Stacking

- van Der Meer solution:
  - Constant Flux: $$\frac{\partial \psi}{\partial t} = \text{constant}$$
  - Solution: $\frac{\partial \psi}{\partial E} = \frac{\psi}{E_d}$, where E_d characteristic of design $\psi = \psi_0 \exp\left[\frac{(E - E_i)}{E_d}\right]$
  - Exponential Density Distribution generated by Exponential Gain Distribution
  - Max Flux = $(W^2 |\eta| E_d)/(f_0 p \ln(F_{max}/F_{min}))$
    - W bandwidth, F_{max} and F_{min} frequency range
    - f_0 beam revolution frequency, p beam momentum
    - $|\eta|$ phase slip factor
    - E_d characteristic gain slope

Current System

- Measurements of bandwidth and slope:
  - 1.2 GHz
  - 10 MeV
- Support ~29.5 mA/hour
  - Design (with 2 GHz bandwidth) ~40 mA/hour
- Deposition orbit measurements: enough gain to clear in 1.5 seconds
- Best performance:
  - 15 mA/hour
  - Limited by input flux





Stacktail Design Scenario

- Goal: 80 mA/hour peak stacking rate in Accumulator
  - x2 design margin above 40 mA/hour
- Accumulate for 30-60 minutes, transfer to Recycler
  - Optimize for maximum flux, not momentum density
  - Maximum stack size 50-60 mA to avoid significant falloff in stack rate
- Change E_d
  - 2-4 GHz
  - 18 MeV gain slope
  - Theoretical Maximum flux ~ 80 mA/hour
- Change Bandwidth & E_d
  - 2-6 GHz
  - 9 MeV gain slope
  - Theoretical Maximum flux ~ 110 mA/hour

Stacktail Reconfiguration (Phase I)

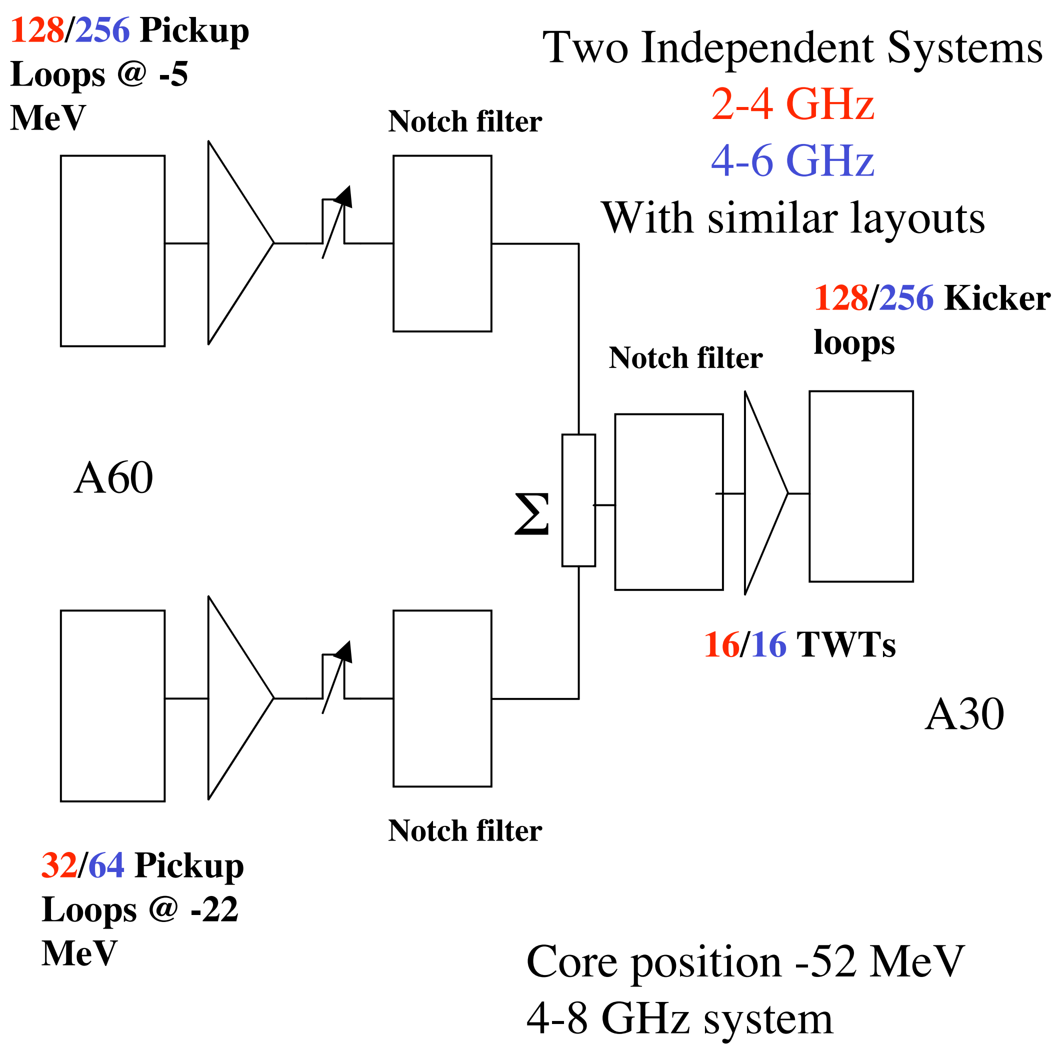
- Move positions of pickups and change electronics settings to change E_d while keeping 2-4 GHz band
  - 1 mm move on 2 tanks
  - 7 mm move on 1 tank
  - No M&S cost
  - Take advantage of increased flux?
- Target $E_d \sim 18$ MeV
- Maximum stacking rate 80 mA/hour
- Simulations sustain 55 mA/hour for 30 minutes
  - Core develops -> stability problems -> lowers max rate
- Requires Recycler as final repository

Stacktail Frequency Upgrade (Phase II)

- Remove 1/2 2-4 GHz hardware (pickups/kickers)
- Replace with 4-6 GHz hardware (pickups/medium level/kickers)
- Target $E_d \sim 9$ MeV
- Maximum stacking rate 100 mA/hour
- Simulations sustain 75 mA/hour for 30 minutes
  - Core develops -> stability problems -> lowers max rate
- Requires Recycler as final repository

Frequency Upgrade Design

- 2-6 GHz total bandwidth in parallel systems
  - 2-4 GHz band
    - Equivalent to current stacktail
    - Utilize existing hardware
    - Remove 1/2 system
  - 4-6 GHz band
    - New hardware
      - Pickup & Kicker loops
      - Electronics
  - Layout similar for both systems



Internal Review: 26 April 04

Stack Tail Upgrade Review

John Marriner, Chair, FNAL
Kris Anderson, FNAL
Gerry Dugan, Cornell
Flemming Pedersen, CERN

April 29, 2004

General Strategy

The overall plan for the stack tail upgrade is to proceed in two steps. The two steps are:

1. When electron cooling has proven to be effective, the stack tail system will be reconfigured to stack at a higher rate at the cost of the ability to accumulate large antiproton stacks. This modification is referred to as the "stack tail move."

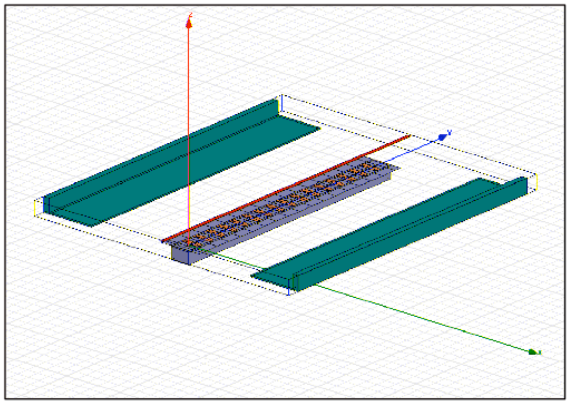
2. When the capabilities of the thus modified stack tail system are exceeded, new pickups and kickers will be added to utilize the 2-6 GHz cooling range. It is possible that the new, high frequency components will not be needed if the antiproton flux is not increased as planned or if the stack tail move performs better than is anticipated.

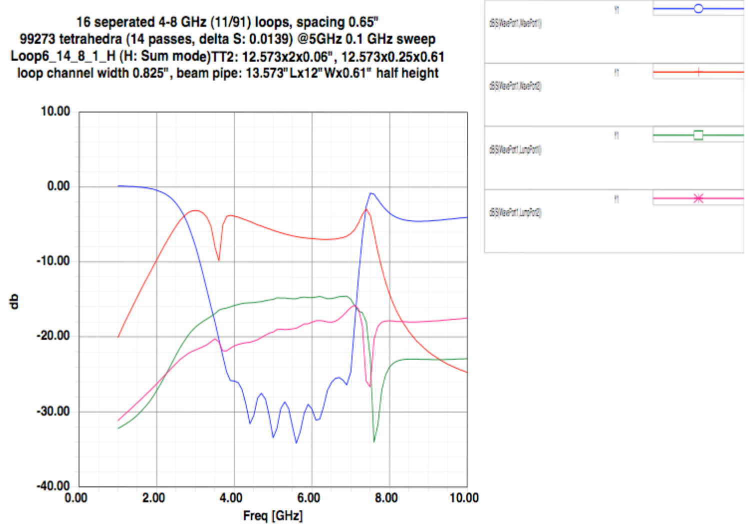
The committee endorses this overall strategy.

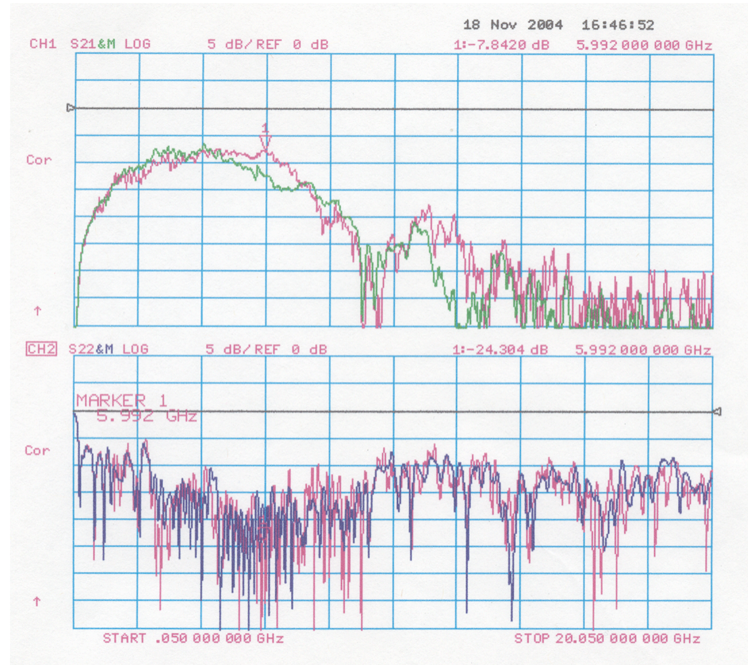
Specific Recommendations

- It is important to test the present stack tail configuration at higher pbar fluxes as soon as these become available: slip stacking, AP2 and Debuncher aperture upgrade.

Prototype Simulations: HFSS





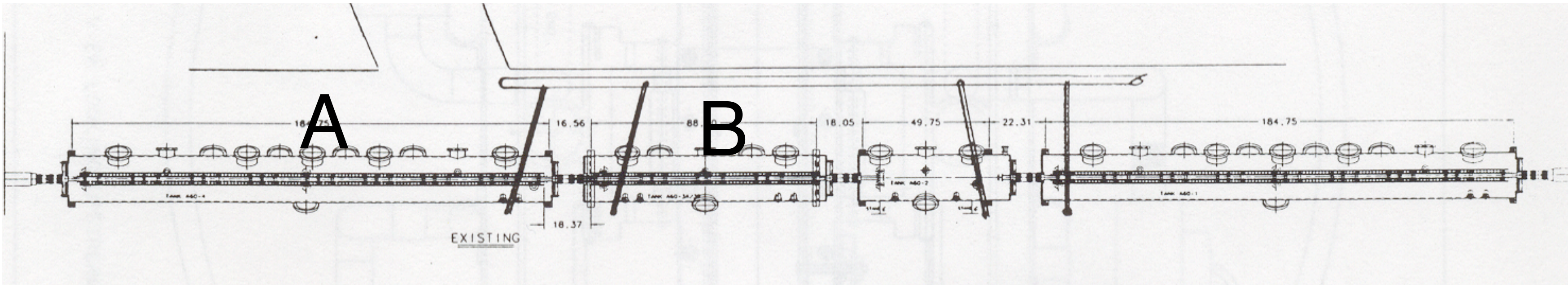


Detailed Simulations and measurements with stretched wires

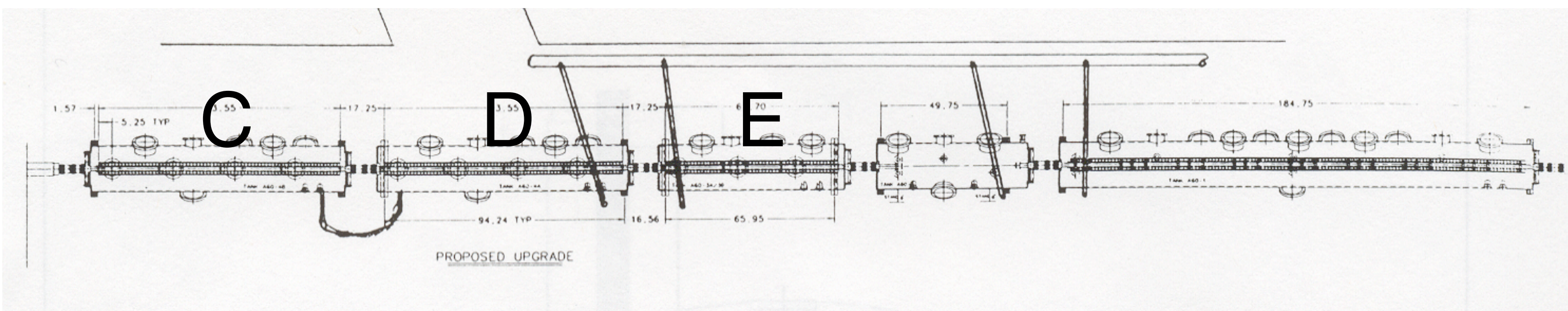
Prototype Tests: Fall 2005

- Test 4-6 GHz pickups with beam measurements
  - Signal/Noise
    - Impedance vs Frequency
    - Transverse position of beam with respect to pickup center
      - Motorized stands to move tank
      - Bumps to move beam
  - With 3 cm x 30 cm transverse aperture
    - Have not measured this frequency range with this aperture
  - Reverse proton: mA of current -> don't need cryogenic cooling
  - Installation in Debuncher
    - Fast installation and measurements
      - ~1 day
      - No vacuum bakeout
    - But…
      - Vertical aperture restriction (~15 π admittance)
      - A short term installation and removal

Prototype Tests: Fall 2005



- Current system: 3 tanks, with pickups at 2 transverse positions
- Upgrade system: replace 2 tanks (A & B above) with 3 tanks (C,D,E below)
- Building equivalent of tank E for installation in Debuncher
  - Full prototype (except for cryo)
  - Test 3-6 loop designs



Prototype Test: Plan

- Day 1:
  - Installation (1 shift)
  - Vacuum pump down (1 shift)
  - S/N measurements with reverse protons
    - At several (~5) positions with respect to pickup center
- Day 2:
  - Swap arrays in tank (1 shift) for different loop designs
  - Vacuum pumpdown (1 shift)
  - S/N measurements with reverse protons
    - At several (~5) positions with respect to pickup center
- Day 3:
  - Remove tank
  - Vacuum pumpdown
  - Return to stacking mode

High Flux Tests: Fall 2005

- High Flux tests with 2-4 GHz system
  - Proton Stacking: ~6x flux (1997 measurements)
  - Find system limits:
    - Debuncher cooling
    - Stacktail cooling
  - Have detailed multiple day study plan
    - Debuncher cooling vs cycle time:
      - Longitudinal and transverse
    - Maximum stacking rate vs cycle time
    - Longitudinal profile development
    - Stability limits:
      - Intensity
      - TWT power
      - Transverse cooling
    - Phase I tests: move tanks and redo stacking measurements

Summary

- Stacktail design:
  - 2-6 GHz system
  - Ed ~ 9 MeV
  - In simulation:
    - Sustain 75 mA/hour for 30 minutes
    - Sustain 45 mA/hour for 60 minutes
- Study period Fall ‘05:
  - Full prototype tests with reverse protons
  - High flux tests with proton stacking
- On track for ‘06 installation