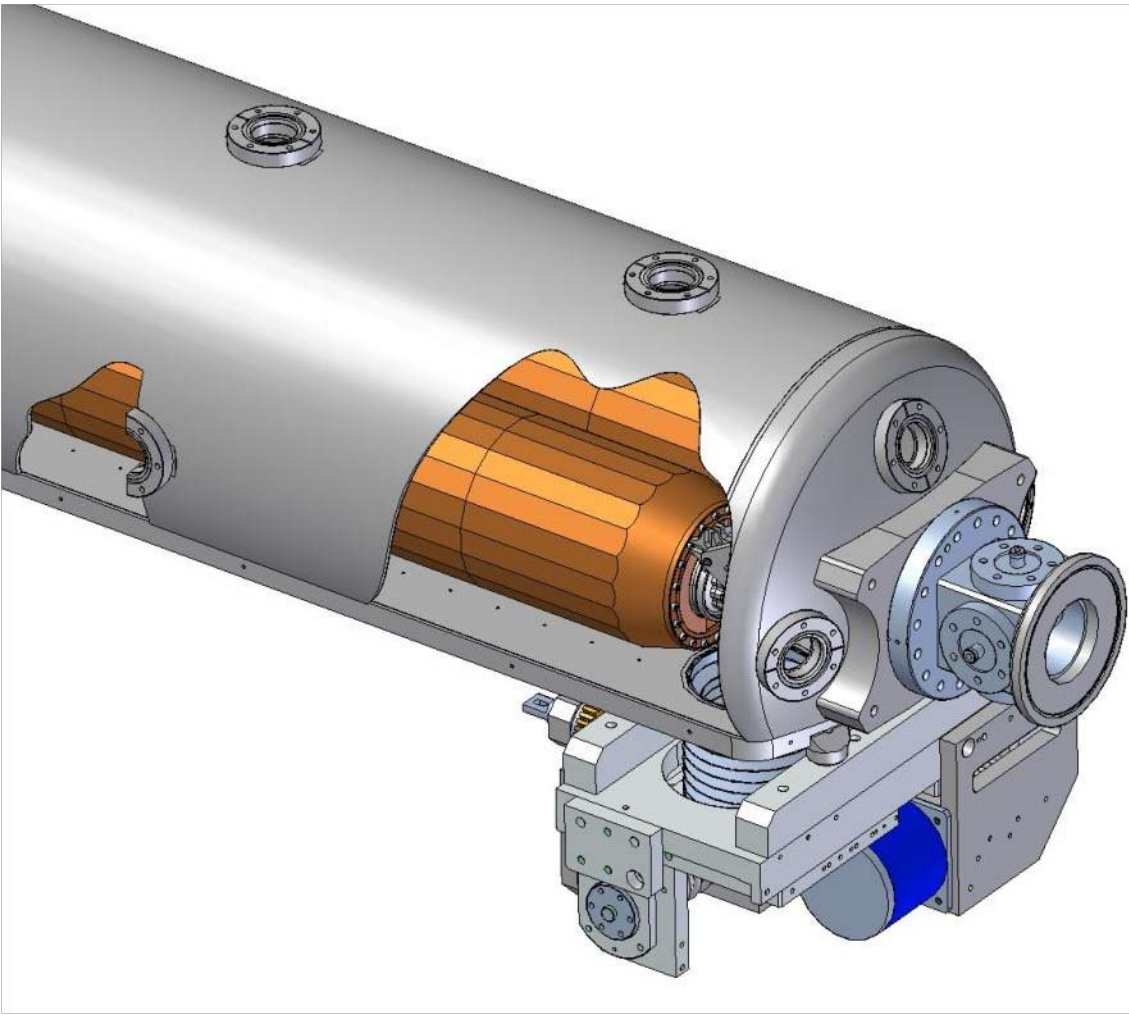


**LARP**

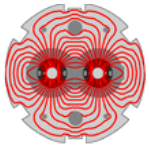
# US LHC Accelerator Research Program

*BNL - FNAL - LBNL - SLAC*



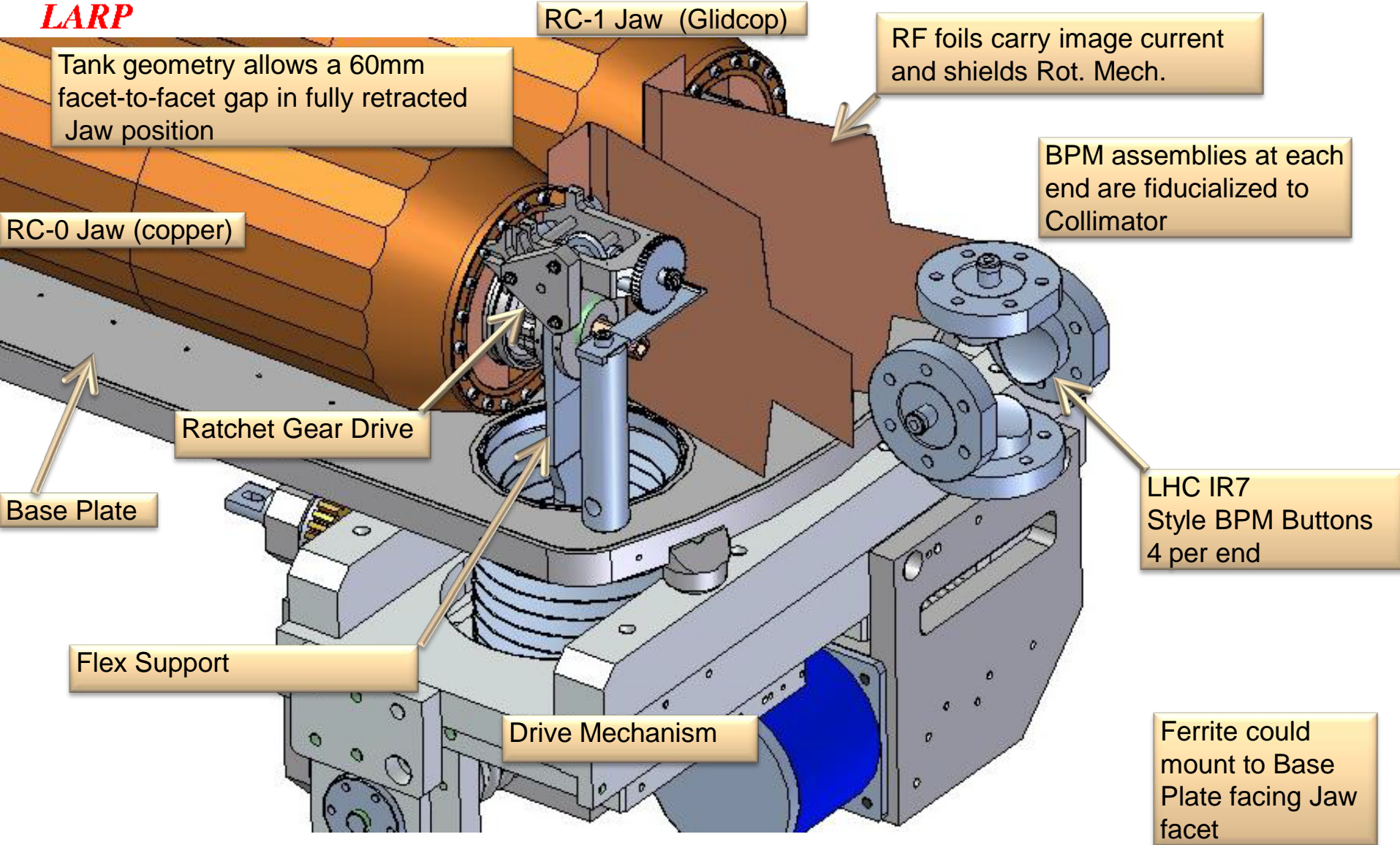
## **RC Status Report**

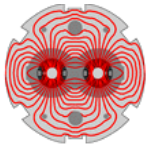
08 November 2010  
LHC CWG Meeting  
Tom Markiewicz/SLAC



**LARP**

# SLAC RC Design Details





## Summary of Last 6 Months

### *LARP*

At CM14 Jeff Smith showed pix/movies of one of the two jaws mounted and the rotation drive functioning

Six months of lab tests uncovered

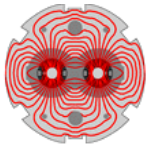
- Deficiencies in the primary and RF bearing designs
- Deficiencies in the design of the drive unit and related hardware
- Problems with testing setup (slippage of parts prior to final welding)

Multiple cycles of test, failure, redesign, manufacture, install, retest

- Missed promised August 1<sup>st</sup> ship date

Rebuilt (& “perfect”) prototype finally moved from test lab (10/28/10) and into vacuum clean room for final welding, assembly, bake out and testing

Bake out over (or before) Xmas and ship January 2011

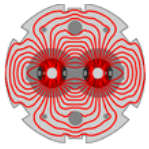


**LARP**

# Abbreviated Punch List of Work Still Required

- Weld bellows to base plate and jaw supports to bellows
- Install final version of all parts
  - Rotation drives with new larger diameter W-S<sub>2</sub> impregnated bearings and shafts
  - Rebuilt primary jaw-support bearings and their housings
  - Ancillary parts which hold thermistors & prevent “oil-canning” of RF shields
- Weld cooling tubes into their feed throughs so that all rotation tests from this point on cause tubes to twist
- Rotation, resistance, & alignment tests
- Tests under vacuum after vessel cover welded: no more access
- Vacuum bake out & RGA scan
  - Estimated three weeks to achieve 9-scale vacuum
- Post bake out rotation tests



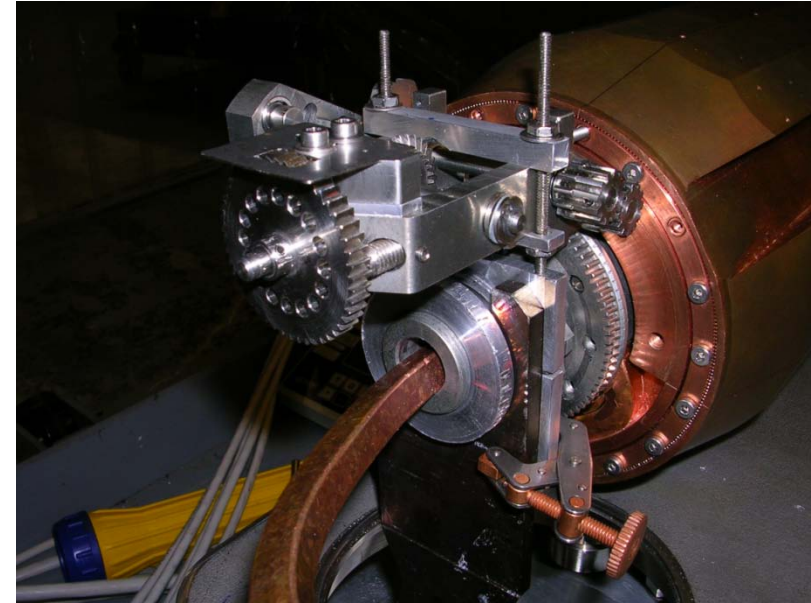


**LARP**

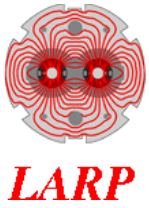
## Last CWG Presentation: 30 August 2010



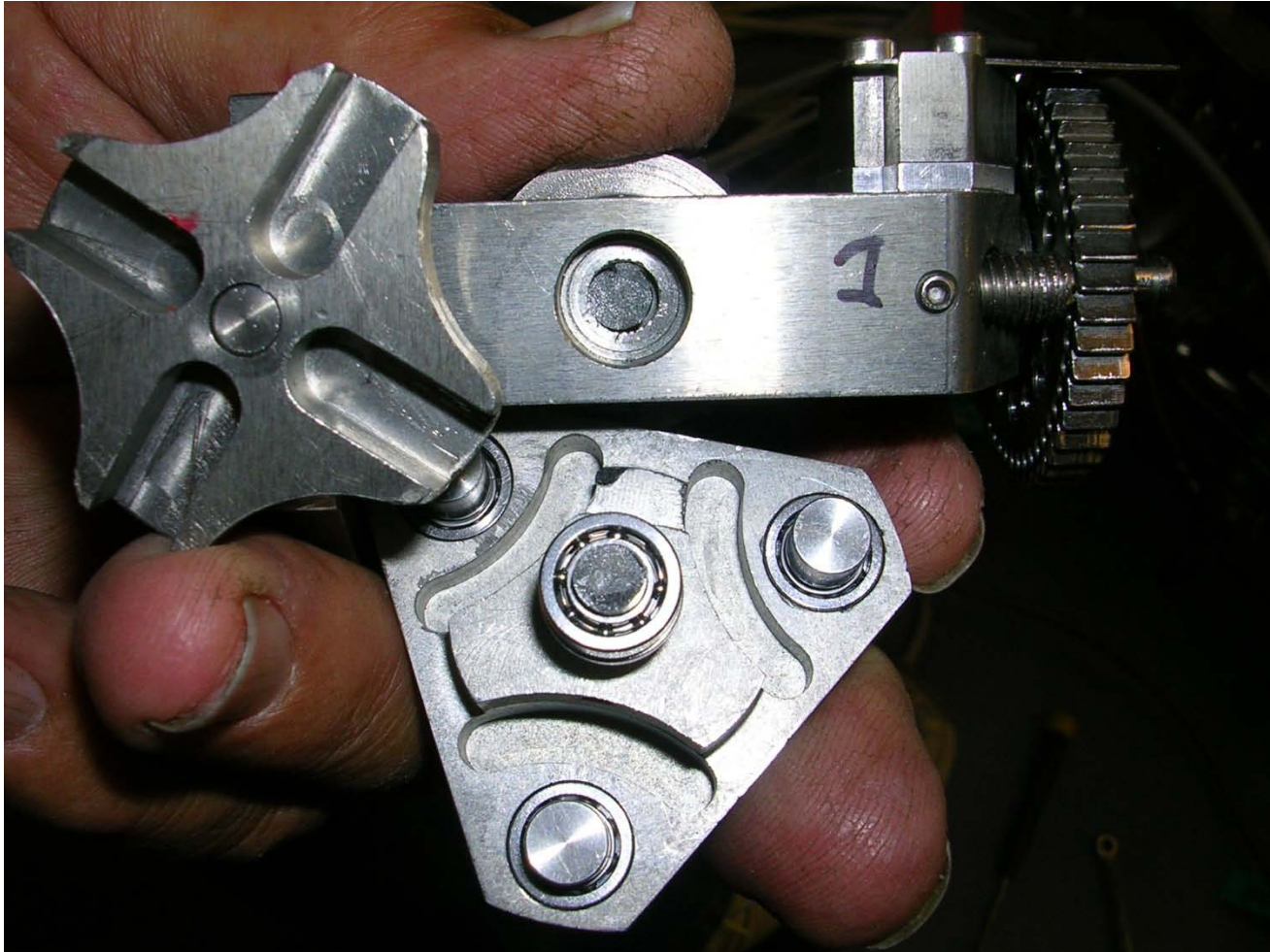
Setup to apply arbitrarily large torque to test rotation drive at many time expected torque required



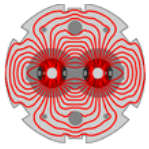
Clamp to prevent rotation of drive unit during testing prior to its final welding



# 01-September: Geneva Drive Axle Breaks at ~300 inch-pounds of torque



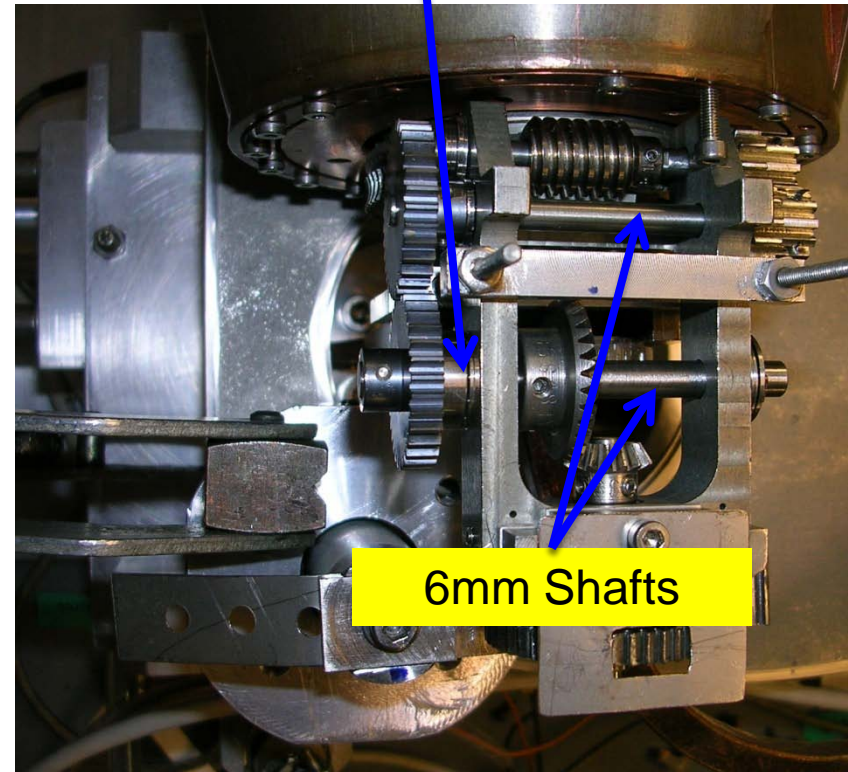
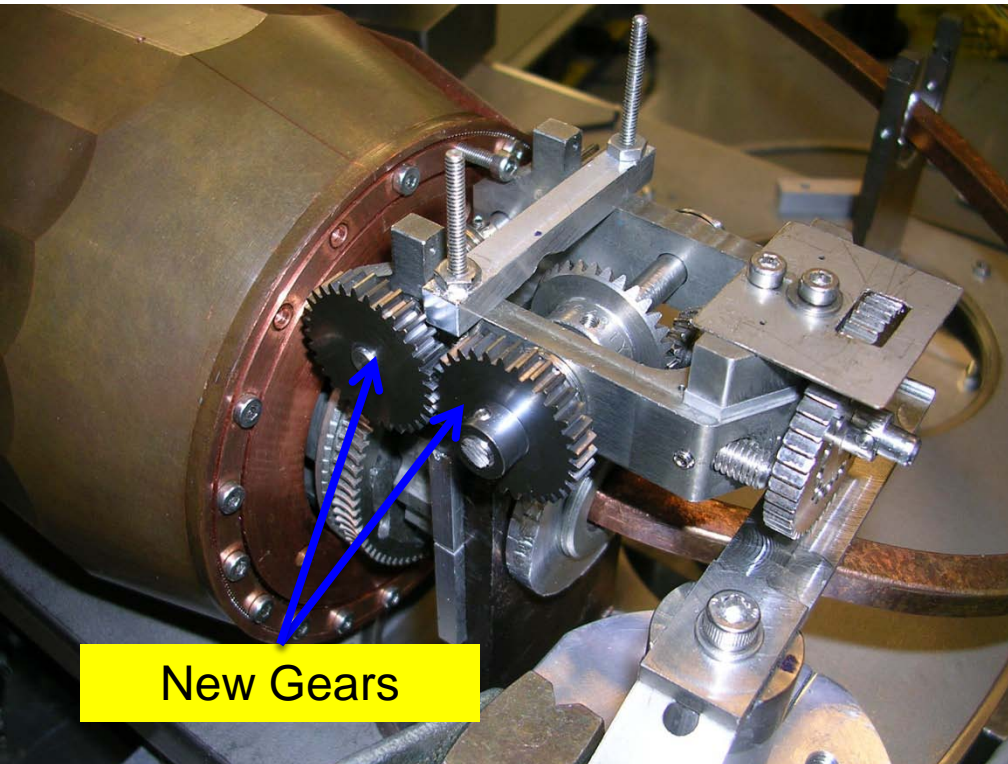




**LARP**

## Drive Rebuilt: tested 16 Sept → >440 inch-pounds

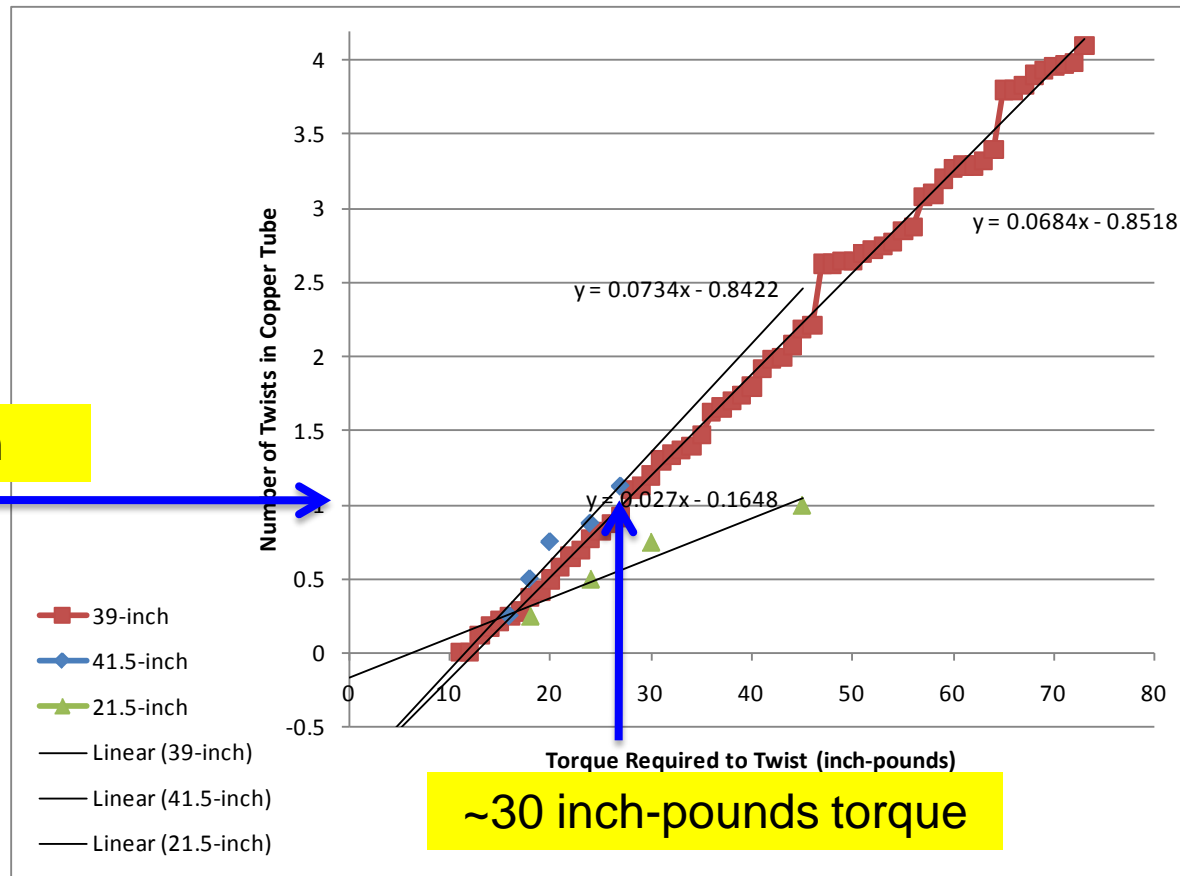
- Add Large Thrust Bearing at end of Axle to prevent bending
- Exchange Geneva Drive for Pair of 1:1 Gears (load reduced x3)
- 5mm Moly shaft (& two bearing sets) → 6mm Steel (& larger bearing sets)





# Safety Factor on Torque Required

## Plot is Torque required to twist Annealed Copper Tube

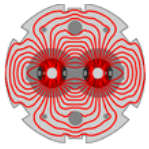


30 in-# to bend each ~1m tube 360 degrees

40 in-# to rotate jaw on moly split ring 1mm ceramic ball support

100 in-# total in this configuration

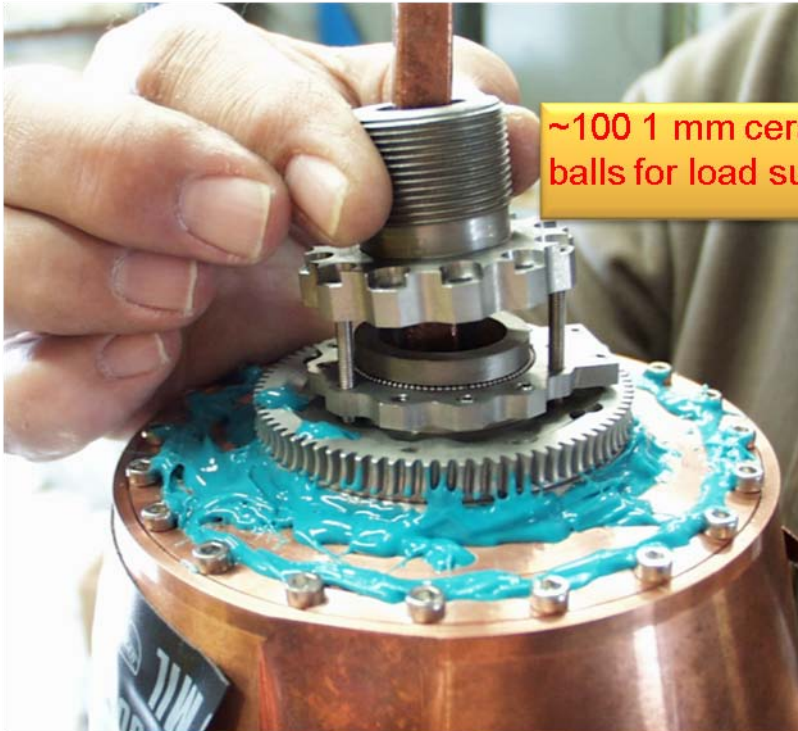




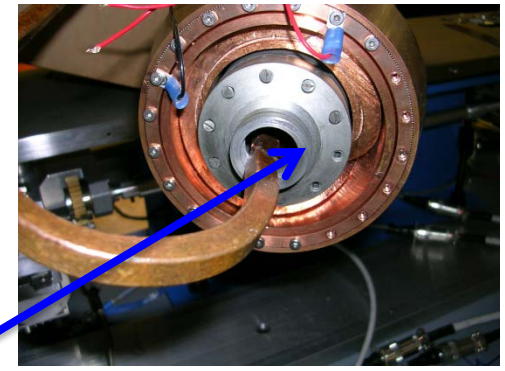
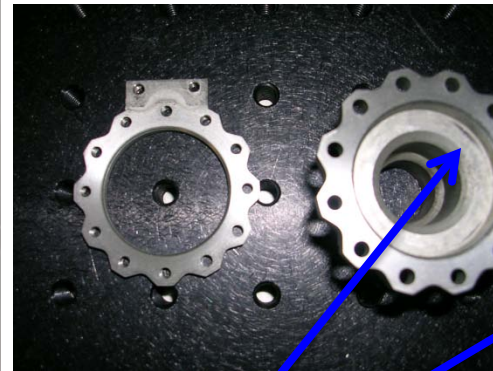
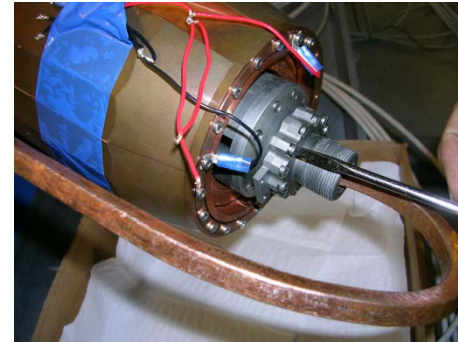
LARP

# Switch Out Primary Ceramic Support Bearing in favor of a 20mm/42mm “Classic” Steel Bearing

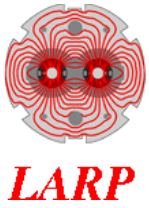
Anticipate friction torque will go to ~ zero and increase safety factor



~100 1 mm ceramic balls for load support

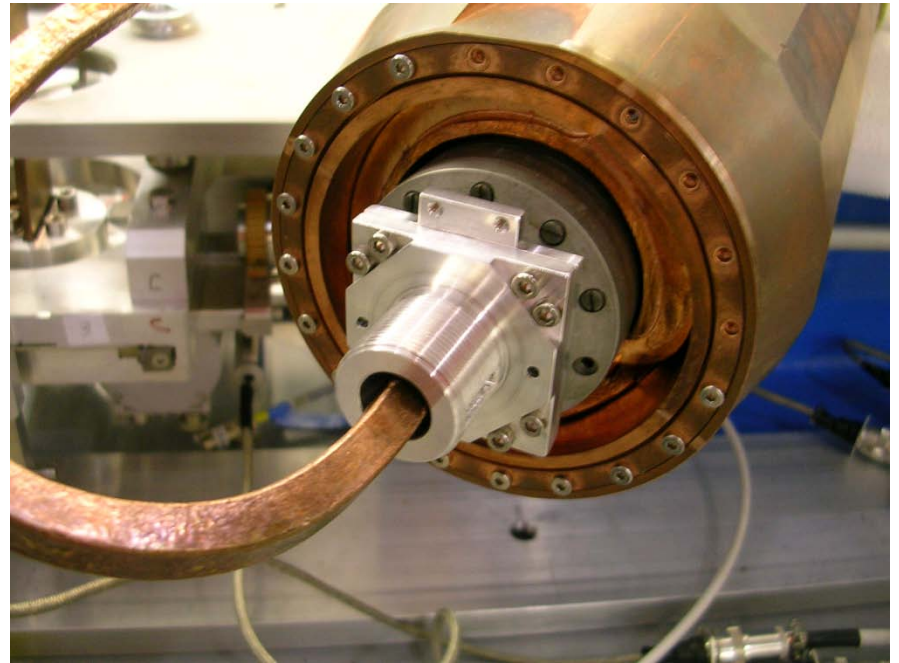
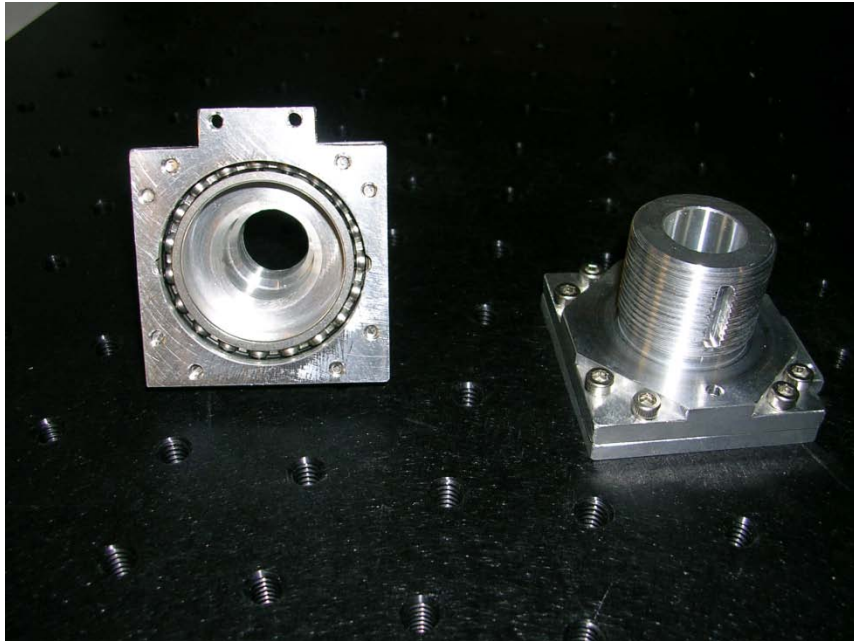


Find that 1mm ceramic balls have crawled on top of each other & have frozen the bearing (note scuff marks in housing and on axle butt)



# New Bearings in Temporary Aluminum Housing

## 1 October 2010



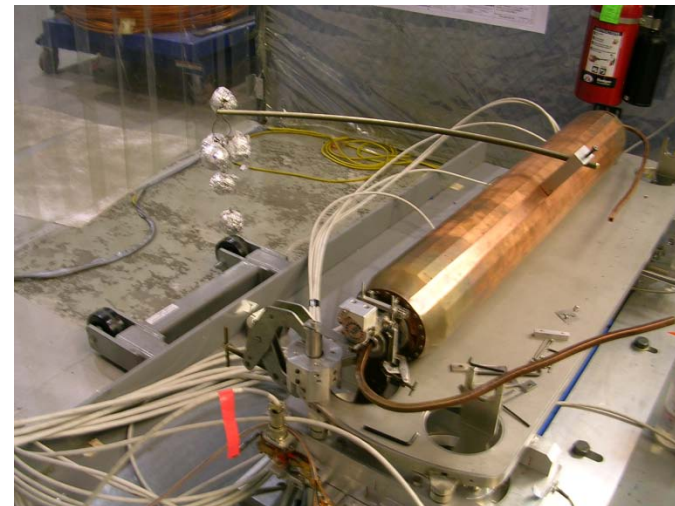
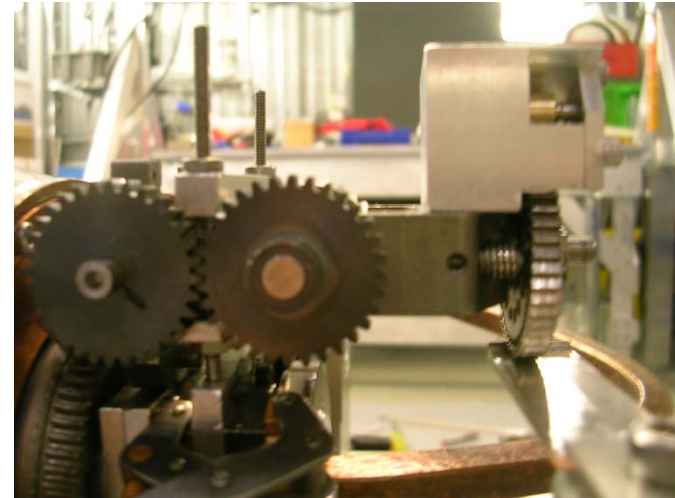
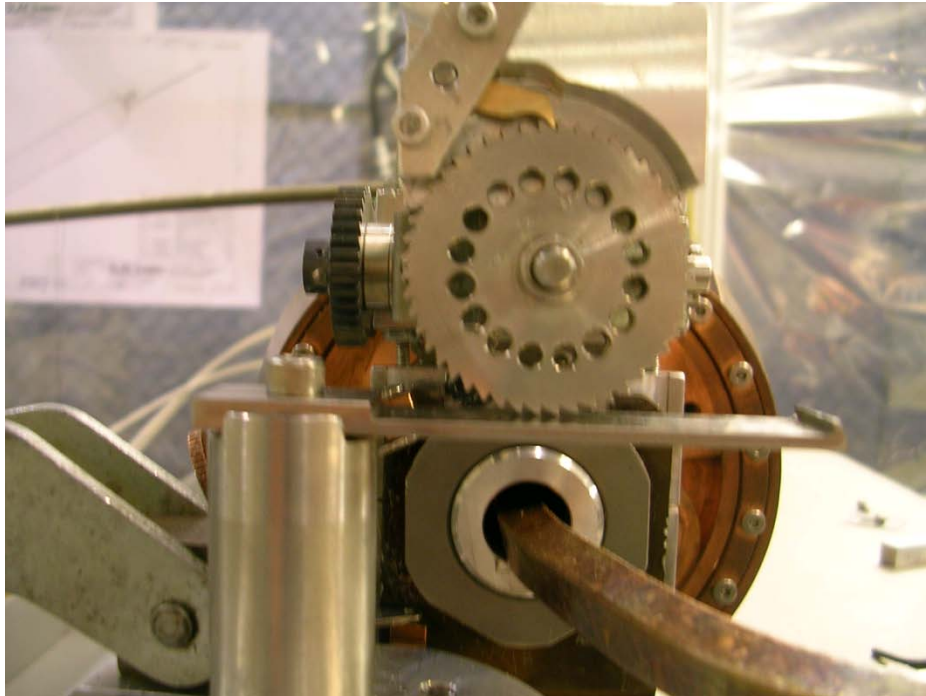
Find that now jaw rotates freely with  $\sim 0$  torque required



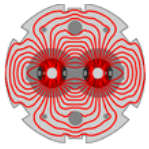


# 3rd Generation Pawl

## 6 October 2010



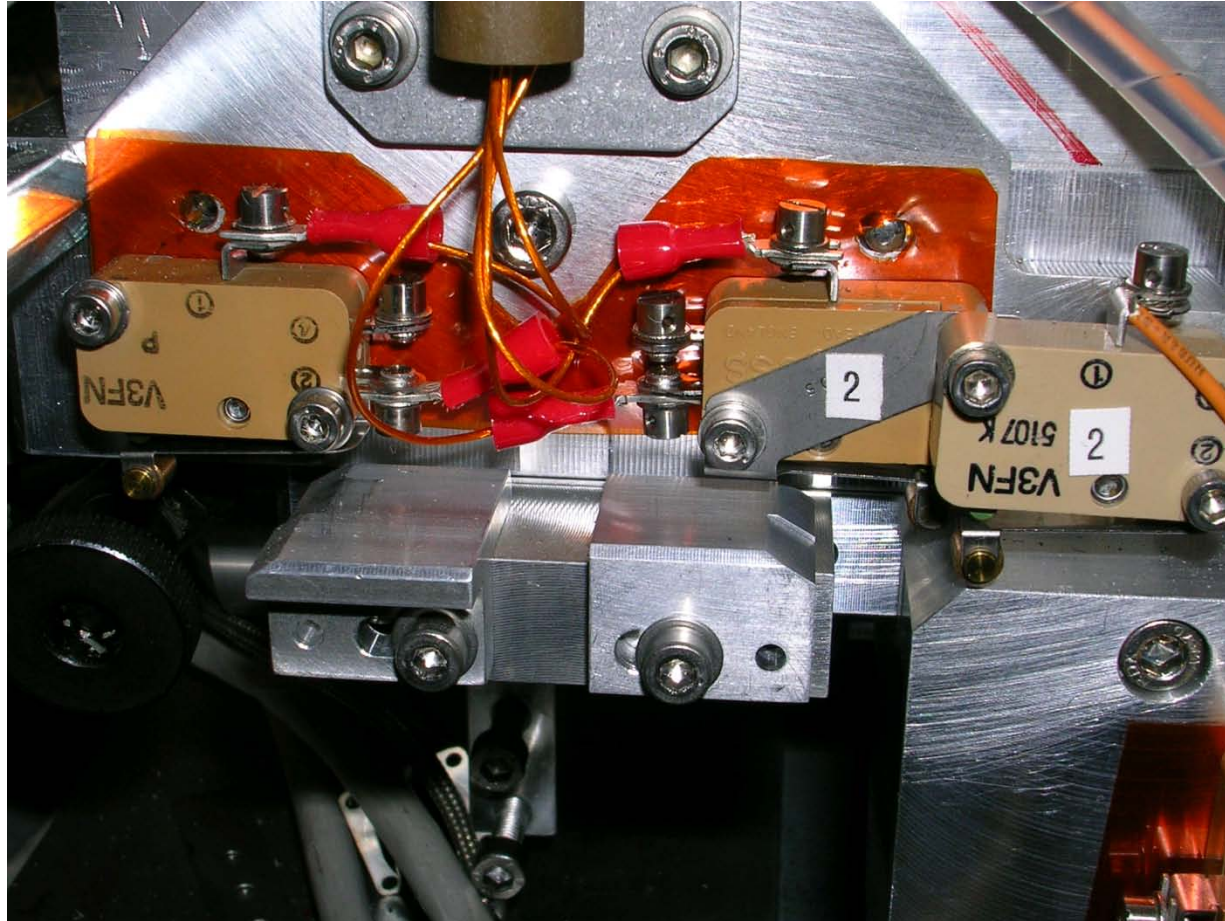


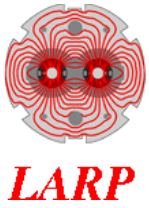


**LARP**

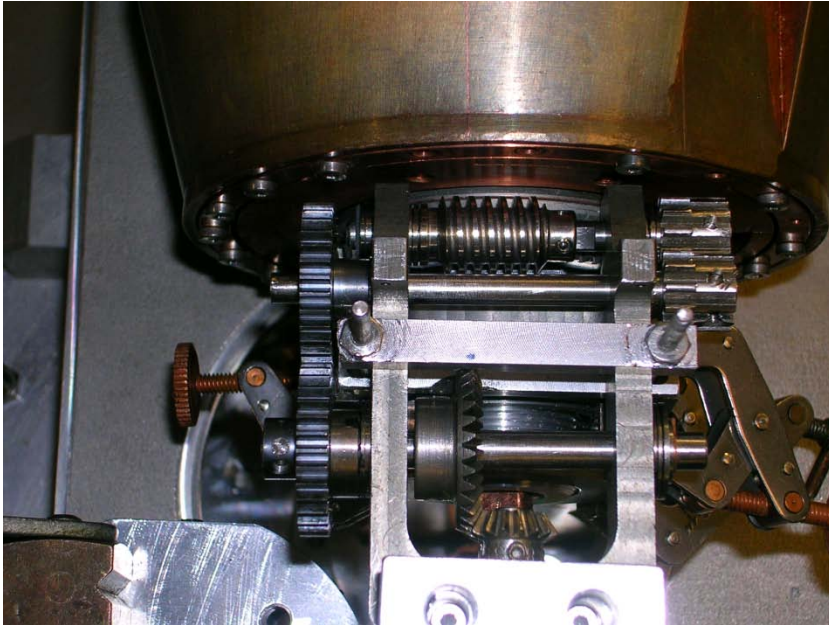
# Stepped Block to Fine Tune Length of Stroke Required to Ratchet a Tooth

13 October 2010





# Shoulder on Worm Gear to Prevent Sliding Prior to Final Pinning and Flattened 1mm Rhodium Coated SS Ball Bearings in Thrust Bearing: Now replaced with 1.3mm Ceramic Balls

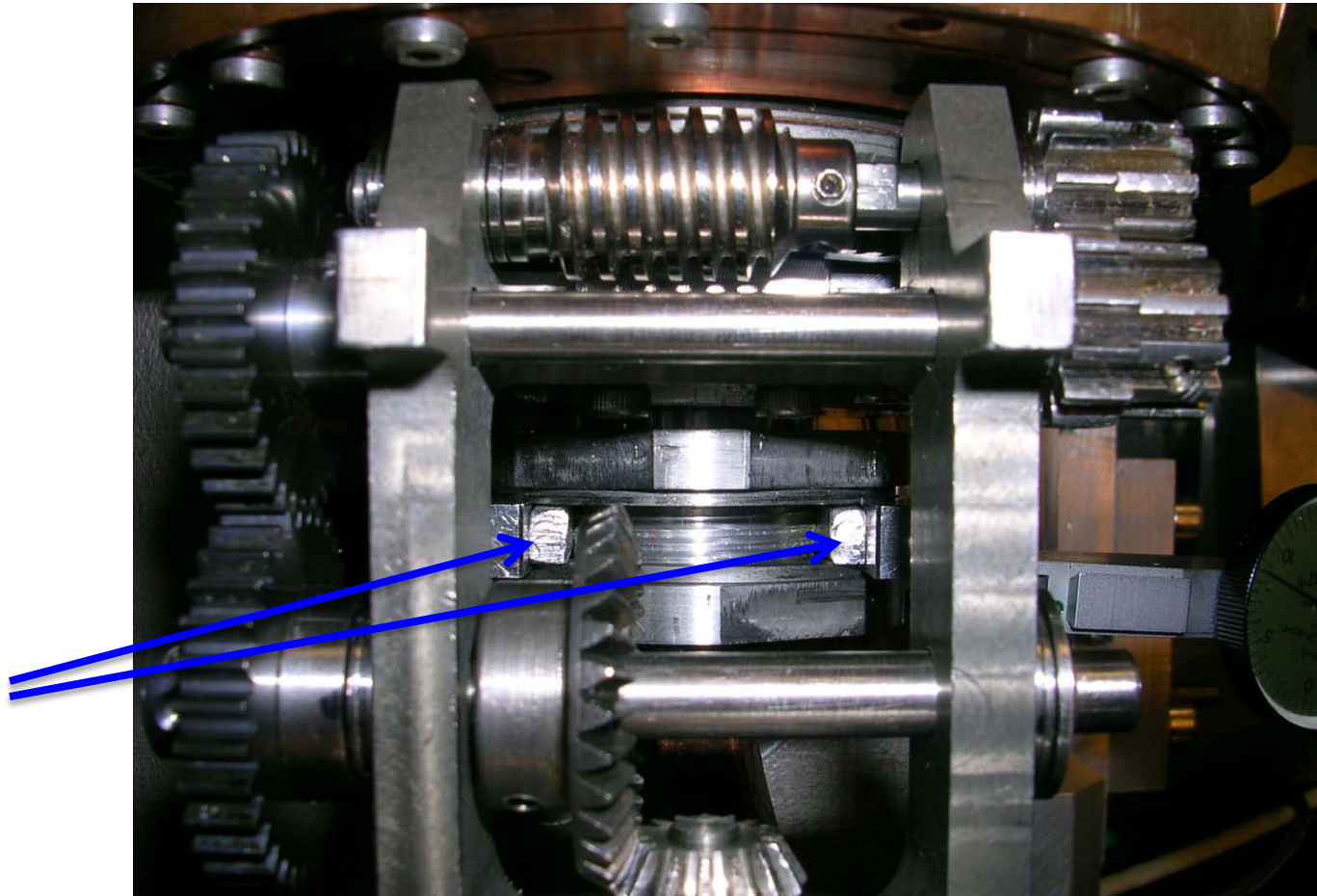




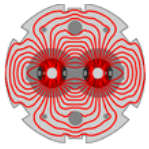


# Anti-Rotation Clamp

22 October 2010







**LARP**

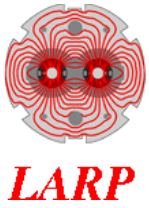
## At End of Lab Tests

Rotation drive operates at 0-300 inch-pounds torque (**x10 expected load**)

- Without “double-ratchet”
- Never missing a ratchet
- Actuator height, initial position, length of stroke and reliable pawl operation all critical

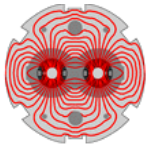
Jaw rotation within 1/384 “clicks” of 20 degrees after rotation of one facet

- Worm gear must not slip
  - Now held by set screw and a shoulder
- Primary bearing housing to which rotation drive mounts must not rotate
  - Held perpendicular to support shaft via flats milled in the piece
  - Eventually will be welded



# Disassembly & Move to Vacuum Lab W-S2 Coated Parts Bagged & Ready





**LARP**

## Next Steps

SLAC vacuum group will handle all final cleaning & welding

- All required fixtures exist

Risks:

1. Many “final version” pieces still required. Single in-house craftsman.
2. Achieving 1 nanoTorr in a finite bake time
3. Operation in vacuum after bakeout

At CERN:

- Location will be prepared for quick plug & play installation
  - Fred Loprete (CERN) here 25-29 October to verify interfacing issues
- Ideally, we install in SPS before LHC turn on 4 February 2011
  - If not, we wait for SPS MD period