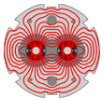


LARP

The U.S. LHC Accelerator Research Program

S. Peggs

Organization & finances

Status & recent progress

IR upgrade strategy

Junior workforce pipeline

Program & project

LARP is a goal oriented R&D program, aimed eg at:

- LHC commissioning
- Preparation for an IR Upgrade Project IRUP

IRUP would be a construction project, for the "full upgrade"

- Deliver Nb_3Sn triplet magnets, slim magnets, ...
- Deliver (possibly) electron lenses, crab cavities, ...

Synchronize an IRUP CD-0 with those of U.S. CMS & ATLAS

- CERN needs time to resolve phase 1 & 2 plans & needs

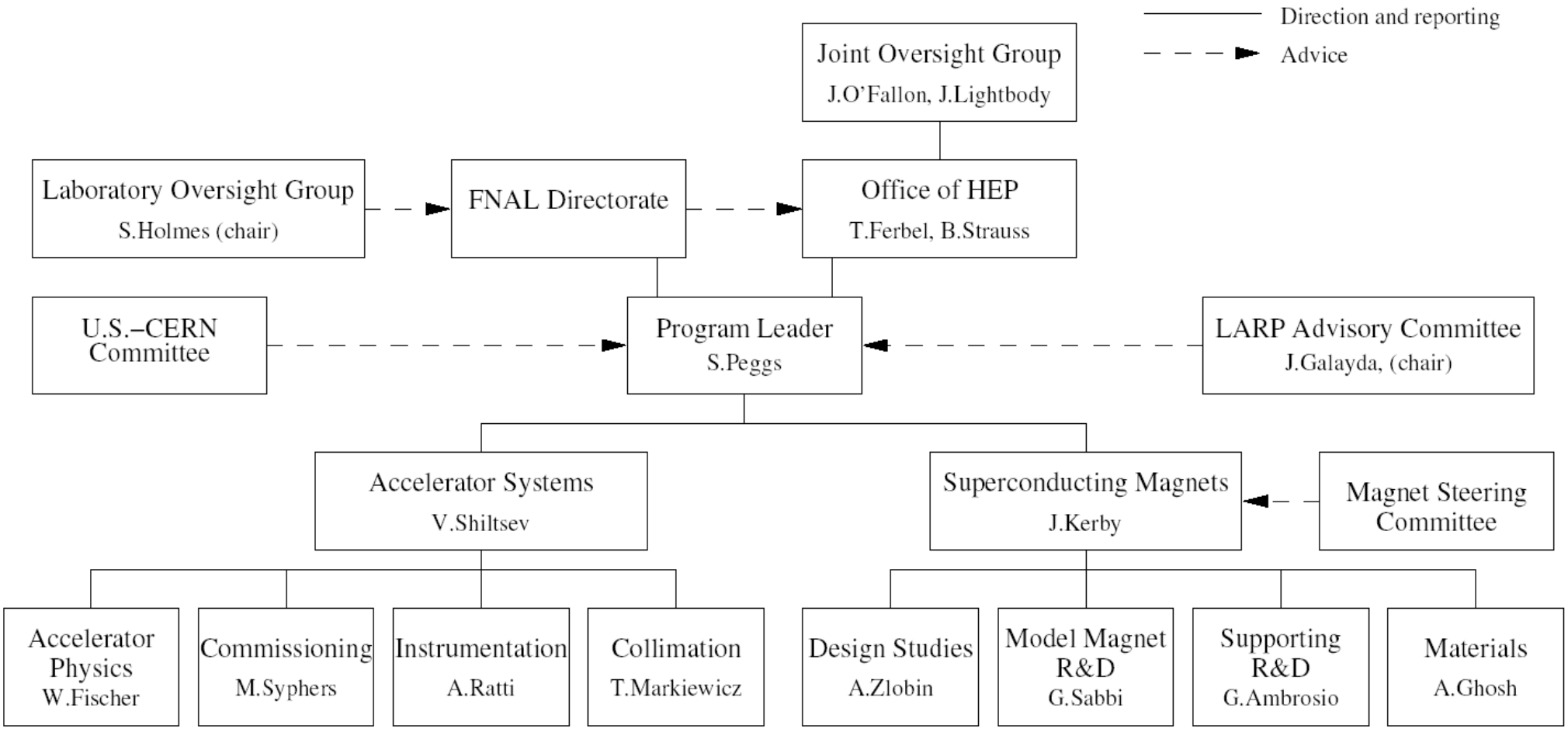
Earlier "in-kind" accelerator contributions could be provided:

- Phase 2 rotatable collimators
- Beam-beam compensation wires (inexpensive)
- Controls software (not a LARP task?)

Organization & finances

US LHC Accelerator Research Program (LARP) Organization Chart

July 25, 2006



LARPAC: J.Galayda (chair), A.Chao, A.Devred, J.Minervini, C.Rode, A.Seryi, K.Wittenburg, A.Yamamoto

LOG: S.Holmes (chair), P.Drell, S.Ozaki, J.Siegrist

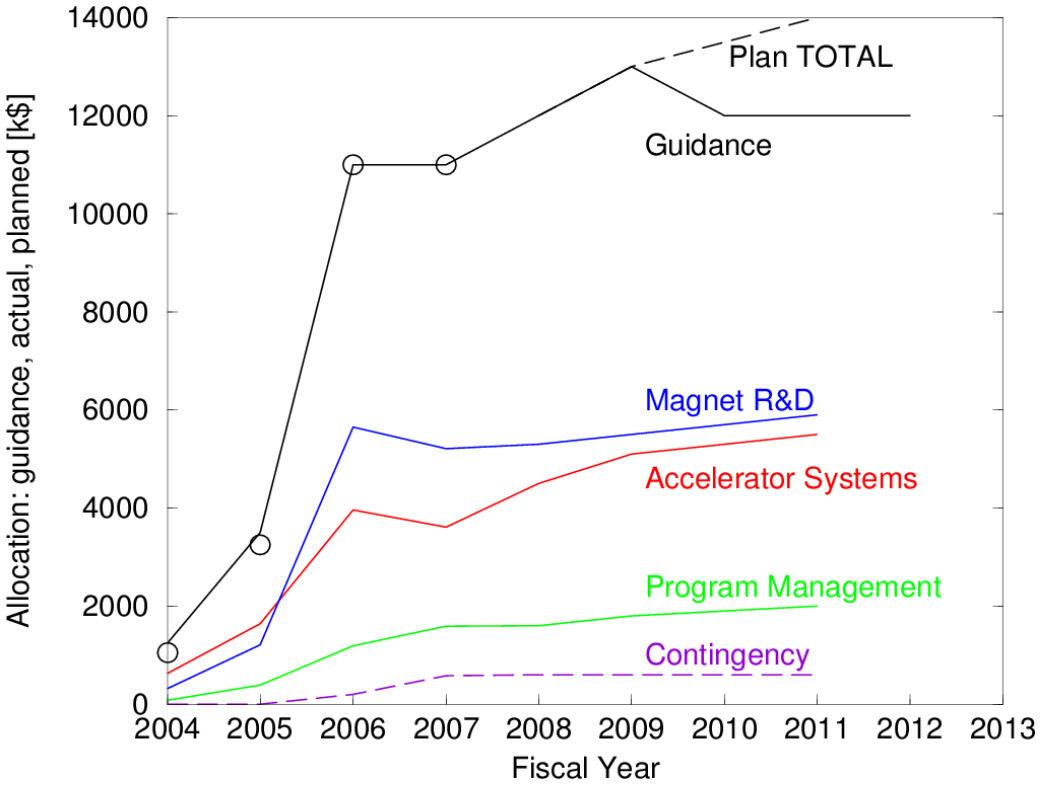
MSC: J.Kerby, G.Ambrosio, A.Ghosh, M.Lamm, G.Sabbi, P.Wanderer, A.Zlobin

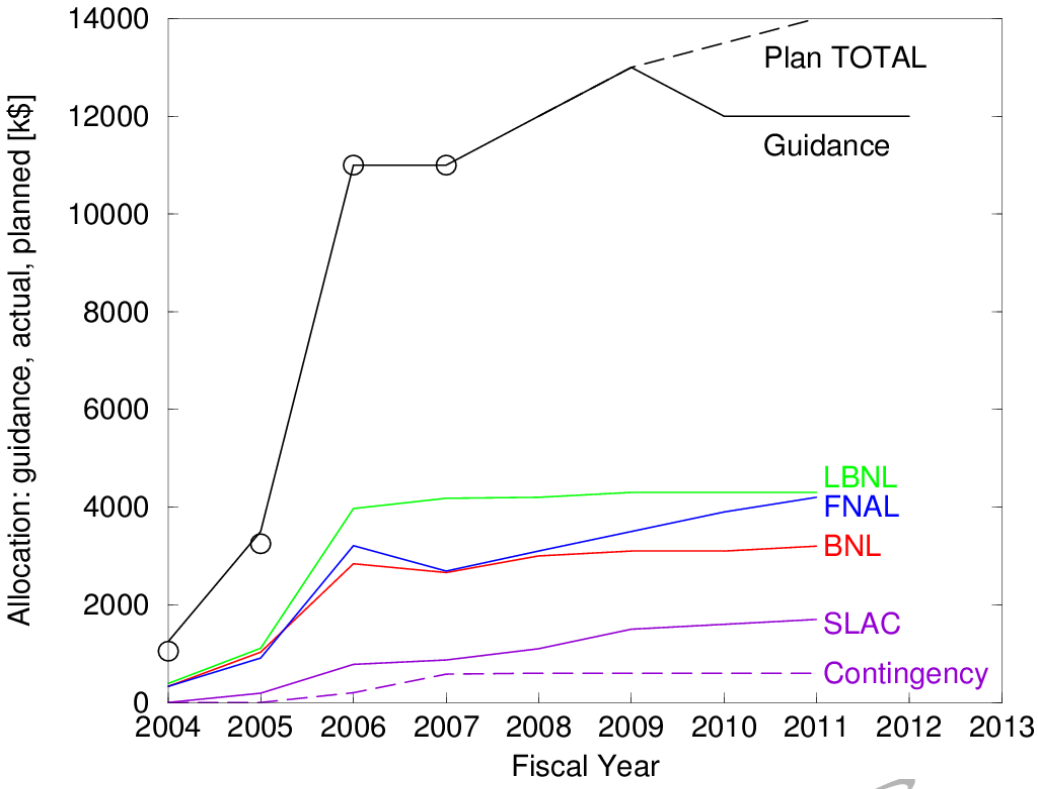
US–CERN Comm: L.Evans, P.Lebrun, S.Myers, L.Rossi, H.Schmickler
P.Drell, S.Holmes, J.Kerby, P.Limon, S.Peggs, V.Shiltsev, J.Siegrist

Five-year plan

The extension of guidance to 2012 signifies that LARP is "continuing", not just "commissioning". Eg:

- speak of Long Term Visitors, not (just) Commissioners
- magnet goals beyond 2009 "proof-of-principle"
- instrumentation beyond the commissioning suite





FY07 budget

LARP

LARP FY07 budget version v2a

Sept 27, 2006 WBS			Total	FY 2007 BNL	FNAL	LBNL	SLAC
US LHC Accelerator Research Program			**11000**	**2664**	**2688**	**4182**	**878**
1	**Accelerator Systems**	**Shiltsev**	**3611**	**648**	**821**	**1314**	**828**
1.1	**Instrumentation**	**Ratti**	1506	315	222	969	0
1.2	**Commissioning**	**Syphers**	540	48	329	145	18
1.3	**Collimation**	**Markiewicz**	930	135	15	0	780
1.4	**Accelerator Physics**	**Fischer**	635	150	255	200	30
2	**Magnet R&D**	**Kerby**	**5212**	**1243**	**1494**	**2475**	
2.1	**Design Studies**	**Zlobin**	526	150	254	122	
2.2	**Model Magnet R&D**	**Sabbi**	1975	61	896	1018	
2.3	**Supporting R&D**	**Ambrosio**	1377	773	113	491	
2.4	**Materials**	**Ghosh**	1334	259	231	844	
3	**Program Management**	**Peggs**	**2177**	**773**	**373**	**393**	**50**

Accelerator Systems, Magnet R&D and Program Management take (33%, 47%, 20%) of the FY07 budget

- Continuing Resolution has not helped, but ok compared to others ...
- contingency and 20% are normally released at mid-year

LARP labor at BNL

	DEPARTMENT / DIVISION			
	Collider C-AD	**Magnets SMD**	**Information ITD**	**Instrument. ID**
Accelerator Systems				
Tune Feedback	1.10			.02
Cleaning efficiency studies	.13			
Electron Cloud	.10		.12	
Beam-Beam Wires	.33			
Magnet R&D				
Inner Triplet Cryo & Heat Xfer		.09		
Long Quad Conceptual Design		.08		
IR Magnet Study		.18		
New Magnet Initiatives		.03		
Racetrack Coil Fab & Test		4.15		
Magnet Testing		.03		
Strand R&D		.89		
Administration				
Accelerator Systems	.13	.50		
Magnet R&D		.46		
Programmatic Travel		.03		
Toohig Fellowship		1.00		
Sub-totals	1.79	7.44	.12	.02
Grand TOTAL	**9.37**			

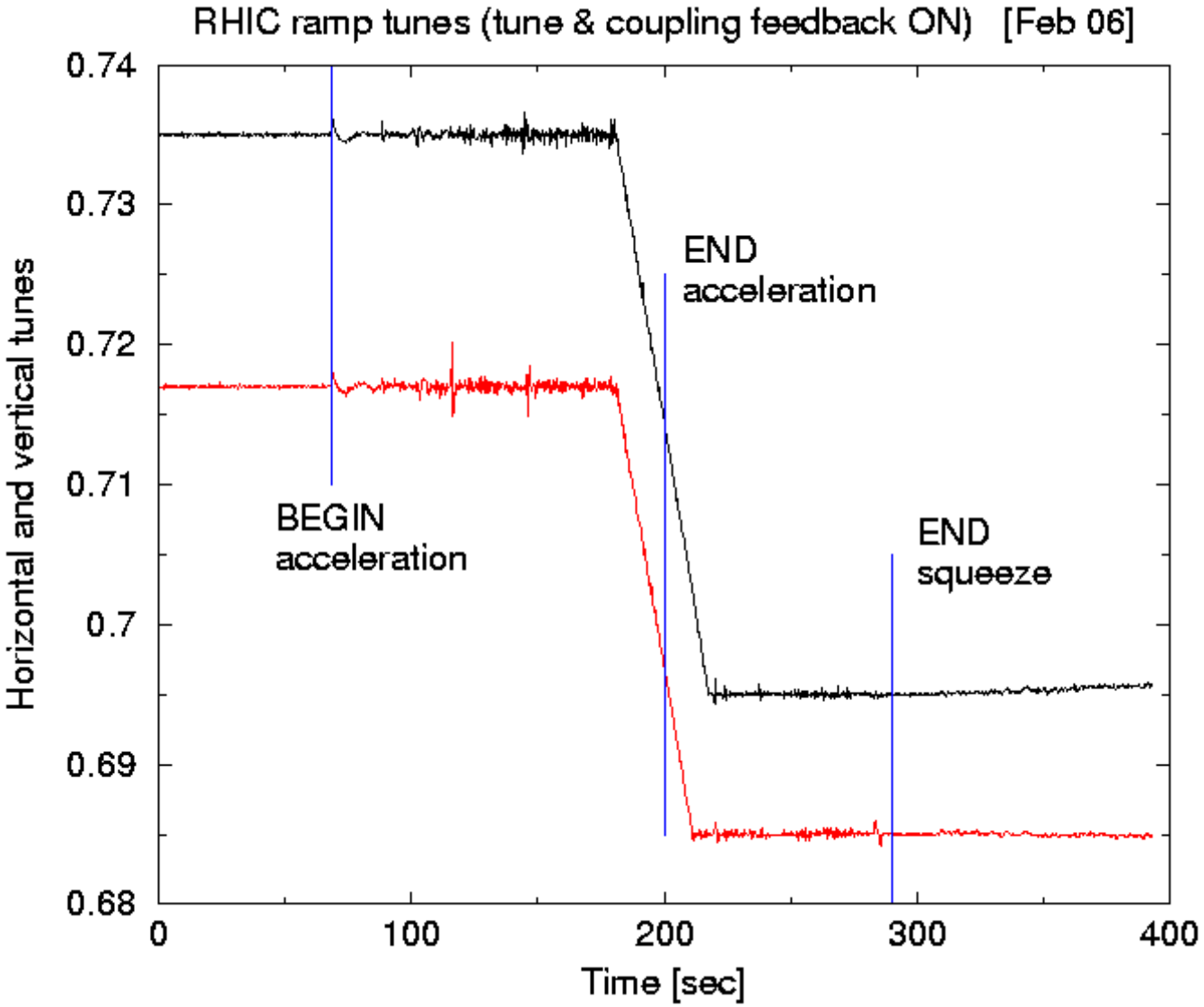
Status & recent progress

Accelerator Systems tasks - 1

INSTRUMENTATION	
Tune Feedback ($0.31M)	Waiting for beam
Luminosity Monitor ($0.99M)	Install at LHC, test in RHIC
Schottky Monitor ($0.12M)	Waiting for beam
AC Dipole ($0.08M)	New: S. Kopp (U. of Texas)
COMMISSIONING	
Beam Commissioning ($0.19M)	Gearing up for FY08
IR Commissioning ($0.29M)	Construction project equip.
Hardware Comm. ($0.58M)	Synergy with FNAL & LBNL

Tune feedback success at RHIC

Non-destructive 4 channels



Simultaneous tune & coupling feedback was demonstrated in RHIC - world first for hadrons!

CERN Courier, May 06

"Military precision"

Ultimate goal: chromaticity feedback during snap-back.

Chromaticity feedback progress at RHIC

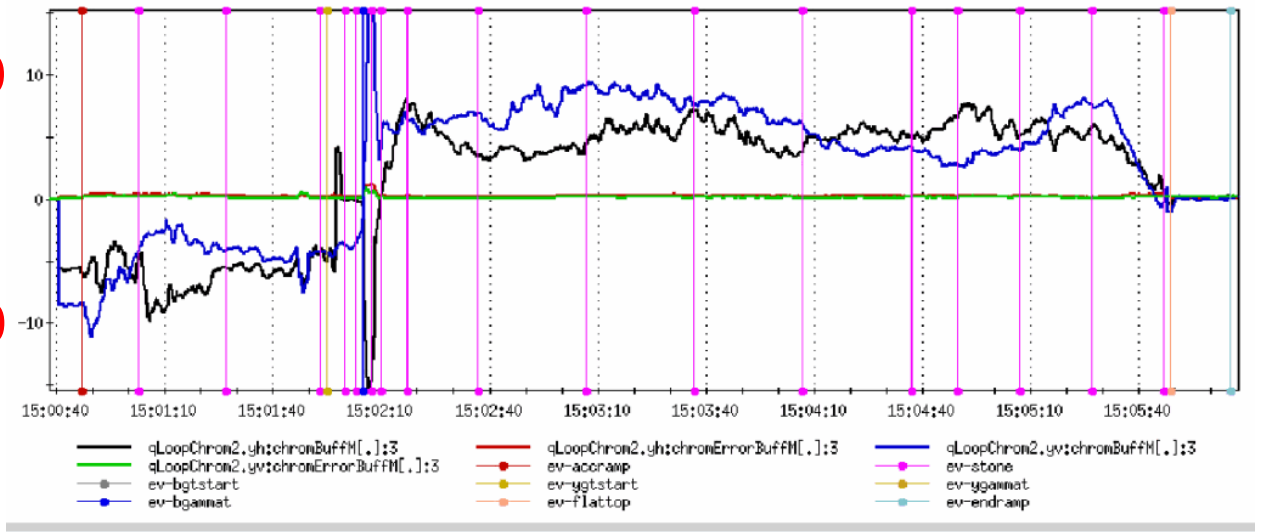
Top: After feed FORWARD (during a 5 minute ramp)
Bottom: Before feed forward
Black: Horizontal chrom.
Blue: Vertical chrom.

Chromaticity has been successfully measured with TF loop closed

Ramping with chromaticity feedback planned for April 25 studies ...

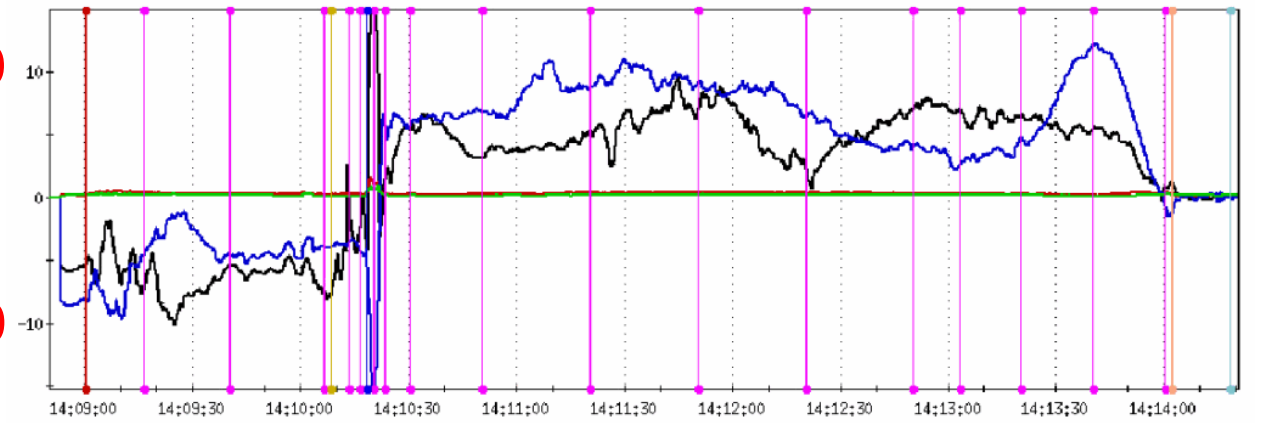
+10

-10

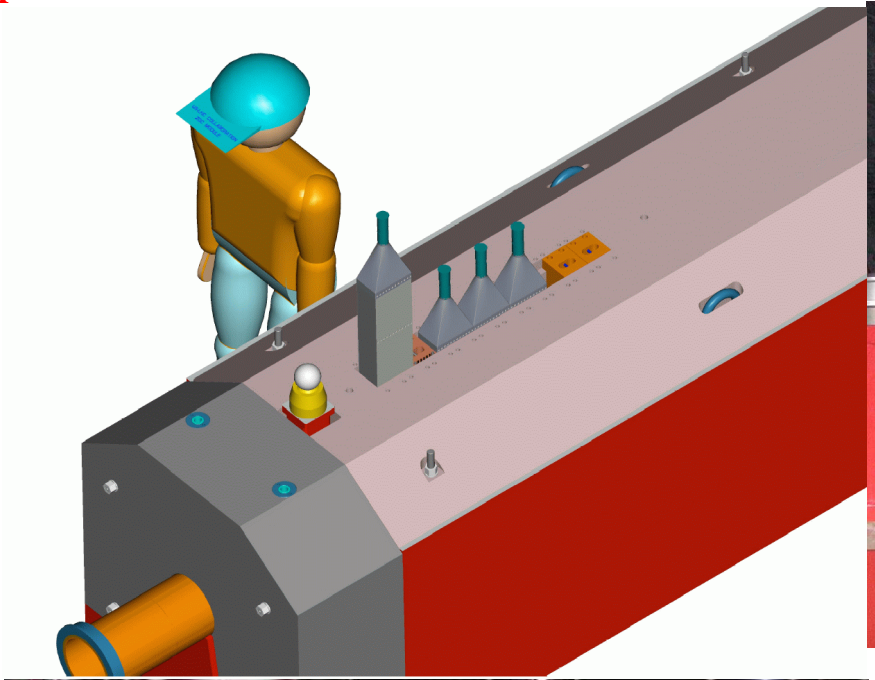


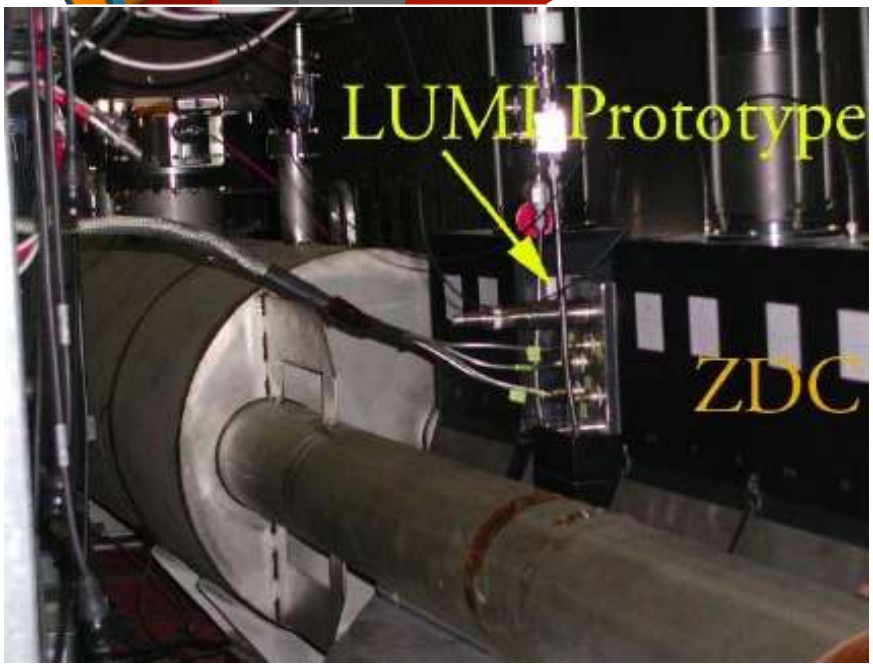
+10

-10



Lumimonitors in RHIC & LHC (Jan 07)





Above: LHC

Left: RHIC

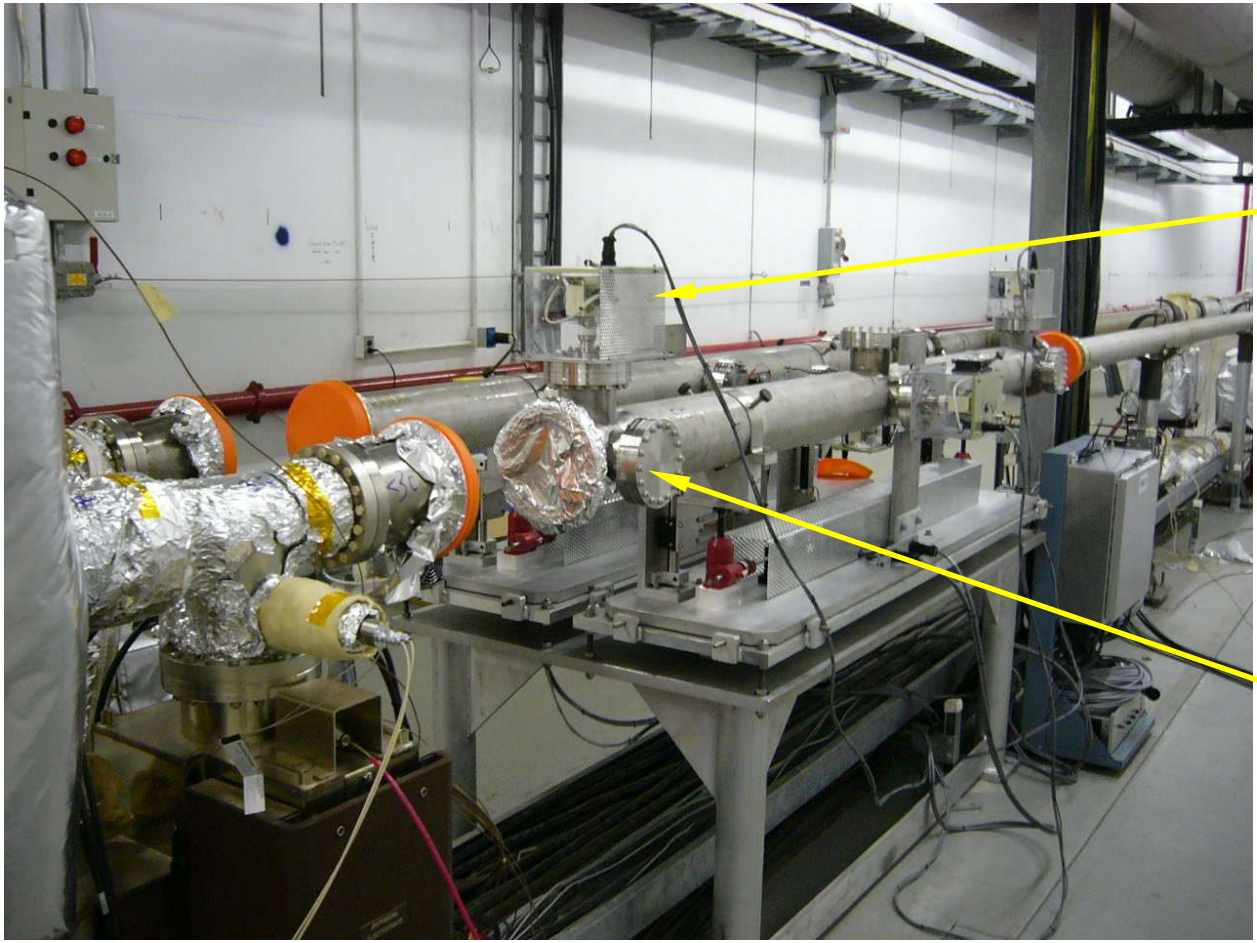
Synergistic cross-calibration with RHIC/LHC ZDC monitors

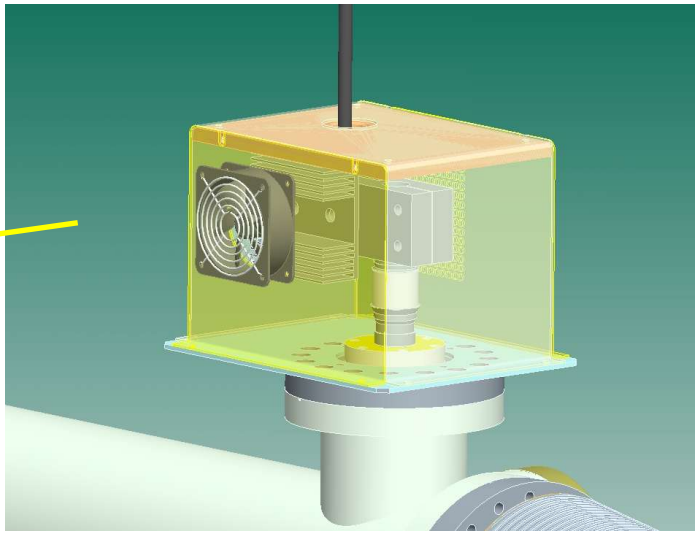
Taking data NOW: (9 MHz?)

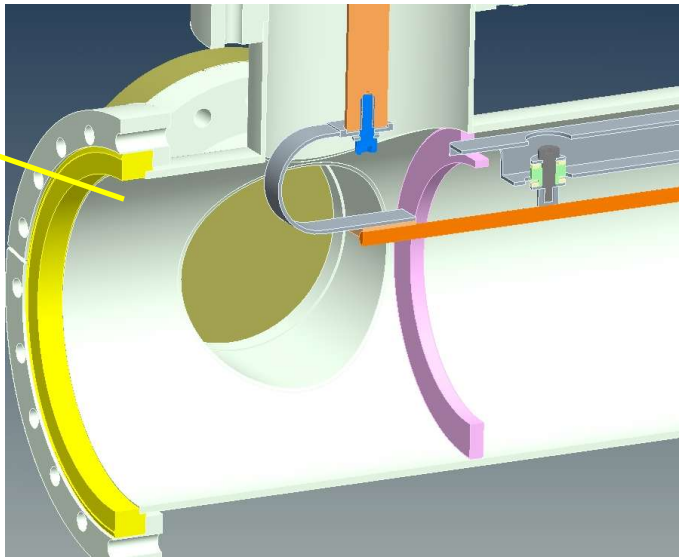
Accelerator Systems tasks - 2

COLLIMATION	
Cleaning Efficiency Studies ($0.05M)	Nearly complete
Rotatable Collimator R&D ($0.78M)	For 1e34 luminosity
Tertiary Collimator Study ($0.02M)	Nearly complete
Irradiation Studies ($0.08M)	Ongoing interest
ACCELERATOR PHYSICS	
Electron Cloud ($0.20M)	Simulation & data taking
IR & Beam-Beam ($0.27M)	Mini-workshop, IRUP
Beam-Beam Wires ($0.15M)	Currently testing at RHIC
New Initiative Studies ($0.02M)	Miscellaneous

Beam-beam (long range) wire compensators







2006 RHIC studies without BBLR

2007 With 2 DC BBLR wires

2008 With AC (pulsed) wires

Magnet strategy to 2009

Pre-eminent goal: Demonstrate that Nb_3Sn magnets are a viable choice for an LHC IR upgrade 2009

TQ Technical Quad (1 m, 90 mm, 200 T/m)

- TQC01,2 & TQS01 achieved gradients close to 200 T/m
- Current emphasis is on mechanical & conductor issues
- Going well, overall ...

LQ Long Quad demonstrator (4 m, 90 mm, 200 T/m)

- Length scale-up critical with brittle coils
- On track for technology choices in CY07:

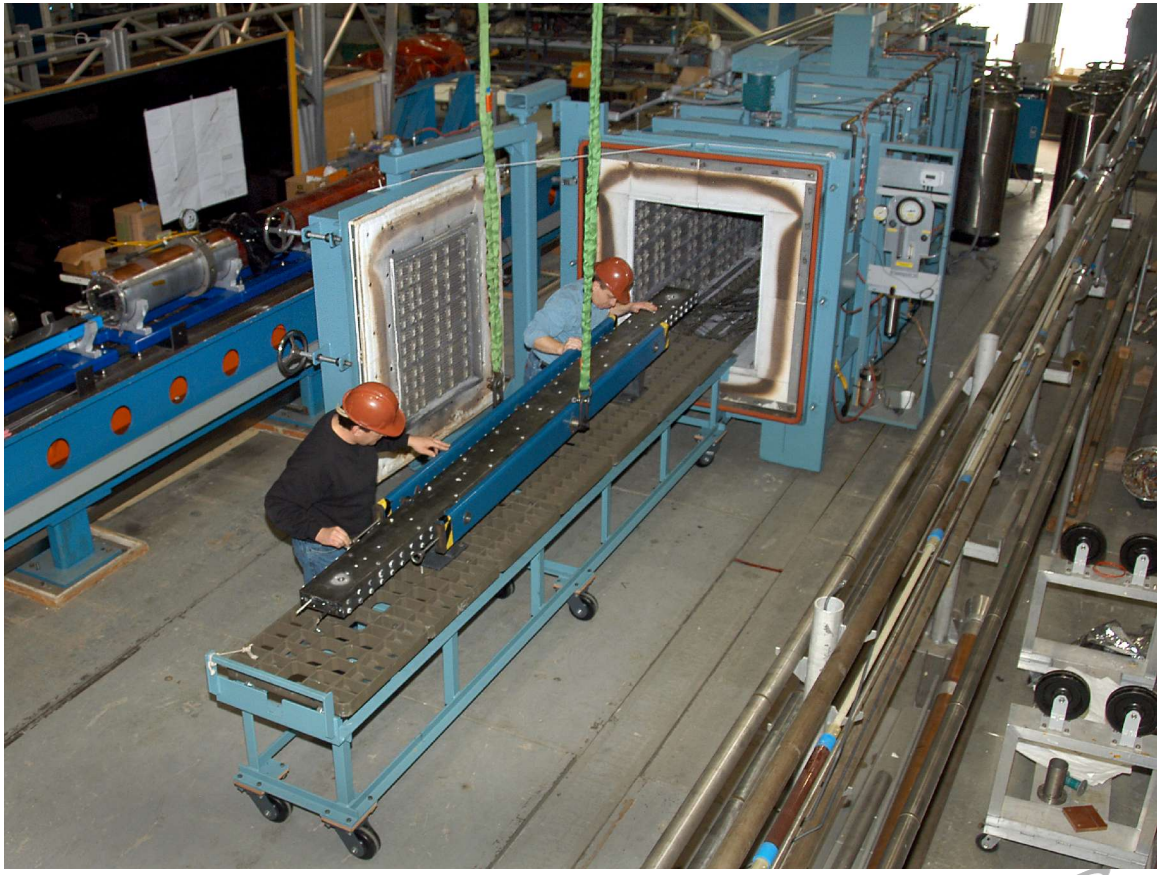
  Coil: 2D design

  Mechanical downselect: Collared, Shell or Hybrid?

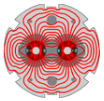
Long Racetrack work at BNL (April 07)

Make & test 4 m Nb_3Sn racetrack coils for possible length effects

Left: coil winder
Below: inserting coil into reaction oven



IR upgrade strategy



Themes & uncertainties

The DG has 3 themes in requesting "white paper" R&D funds

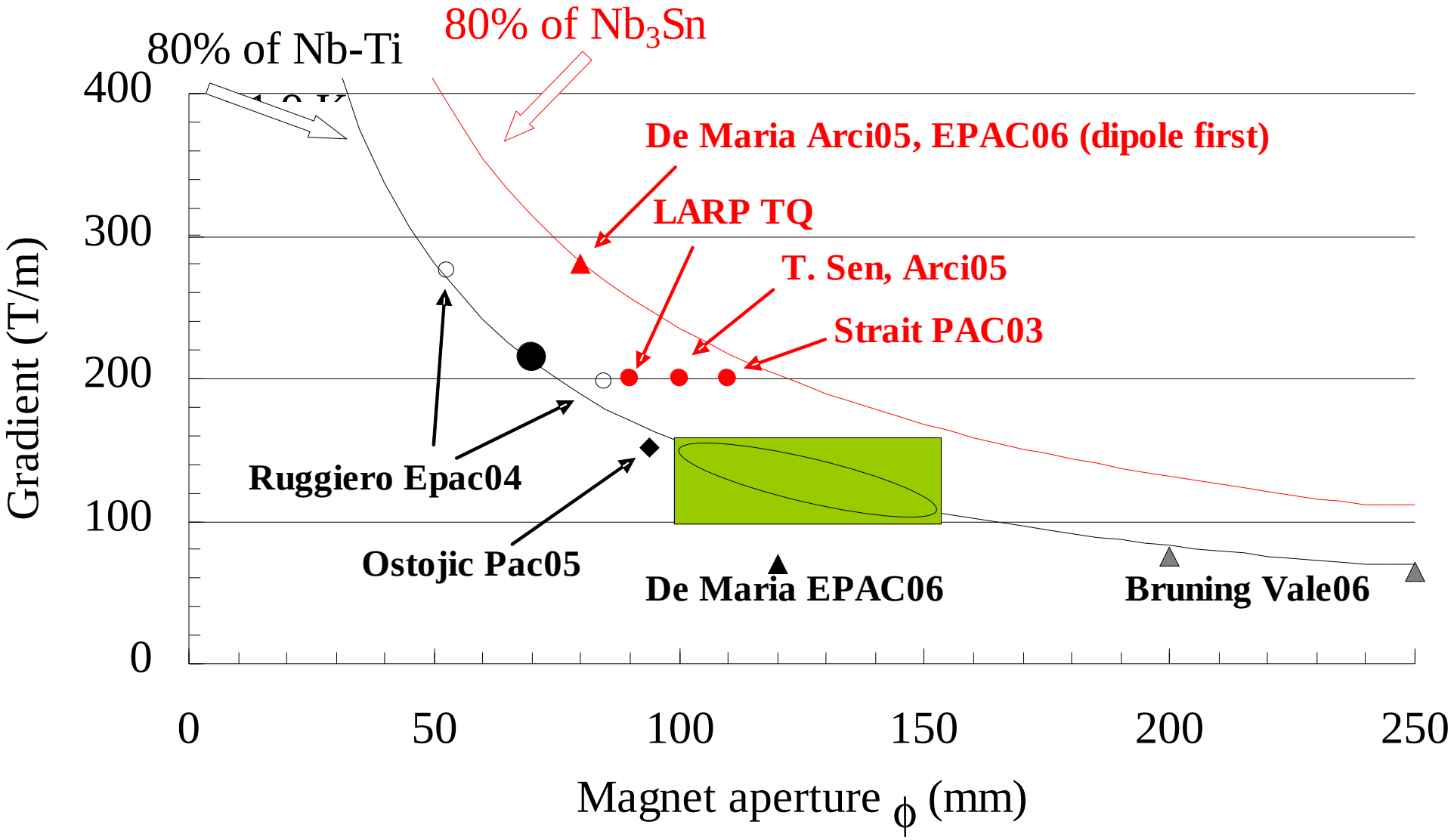
1) optimize LHC operations at design energy
2) renovate injector complex to ensure reliability
3) high luminosity upgrade of accelerator & detectors

2007	Council/SPC decision on R&D funding to CERN
2008/9	CERN & leveraged EU (CARE) R&D funds begin?
2010	Possible "phase 1 upgrade" of IR triplet only?
2015+	"Full phase 2 upgrade" of detectors & accelerator

The following 2 slides are taken verbatim from "Parametric studies for a phase-one LHC upgrade based on NbTi", Koutchouk, Rossi & Todesco.

GOALS OF A PHASE-ONE UPGRADE

– We will explore the region between 100 and 150 mm, at the limit of Nb-Ti



GOALS OF A PHASE-ONE UPGRADE

- Staging the LHC luminosity upgrade in two phases
  - Phase one (asap)
    - Aim: not more than ultimate luminosity (~2.5×10^{34} cm^{-2} s^{-1}), or ways to recover nominal in case that some parameters are not met
      - No modification of detectors – minimal lay-out modifications
    - Larger aperture to reduce part of the limit on intensity due to collimators (presently 40% of nominal, i.e. 1/6 of nominal luminosity)
    - Larger aperture to have stronger focusing (β~0.25 m, L~1.5×10^{34} cm^{-2} s^{-1})
    - Fast: use Nb-Ti quadrupoles with available cable
  - Phase two (the 'real' upgrade)
    - Aim at 10×10^{34} cm^{-2} s^{-1}
    - Upgrade of detectors to tolerate it (6-12 months shut-down ?)
    - Use Nb_3Sn if available to better manage energy deposition and have shorter triplet
    - Crab cavities or D0 to reduce effect of crossing angle
    - … all other possibilities analysed up to now in CARE-HHH and LARP

30th March 2007 – LHC phase-one upgrade based on Nb-Ti - 20

CERN perspective on LARP and the "real" upgrade

Preliminary scope & cost of an IR Upgrade

LARP

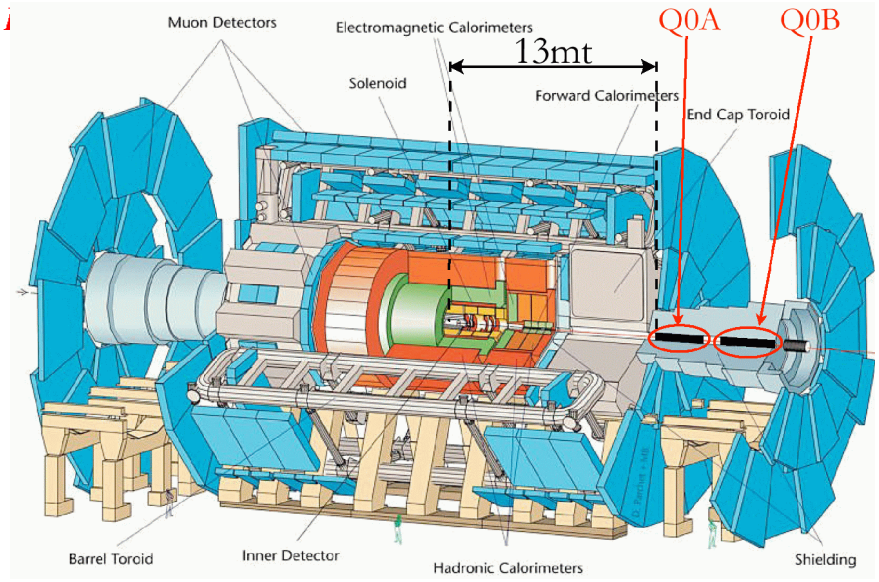
Assuming a 5 year project with a flat funding profile

Item	Total Cost $M	Technical Risk	Lumi Gain	LARP R&D
MAGNETS	**100**			
IR triplet Nb3Sn quads	90	Low	High	Ongoing
Slim magnets in detectors	10	Low	Moderate	FY08+
Magnetized TAS absorbers	-	Moderate	Moderate	
BEAM-BEAM COMPENSATORS	**4**			
Electron lenses for head-on	3	High	High	FY08+
Wires for long range	1	Low	Moderate	Ongoing
Small angle crab cavities	-	High	Moderate	Prelim.

Notes:

- Triplet quads: "low risk" assumes LARP R&D success in 2009.
- Slim magnets: ongoing discussion of scenarios at CERN.
- Electron lenses: R&D with beam at Tev & RHIC to lower risk.
- Crab cavities: back up plan for worst case beam-beam scenario.

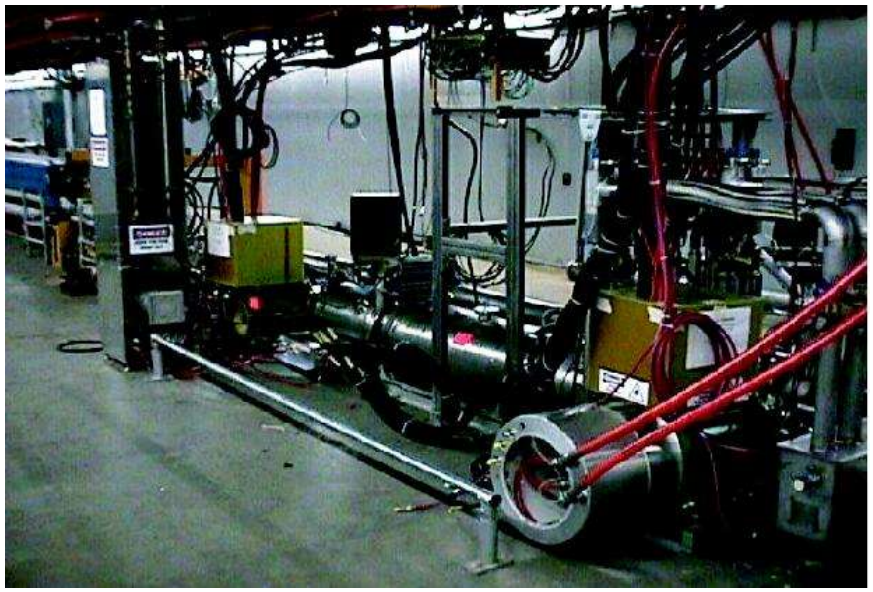
“Slim” magnets, electron lenses, crab cavities



Slim magnets (left)

Fit dipoles/quads within detectors

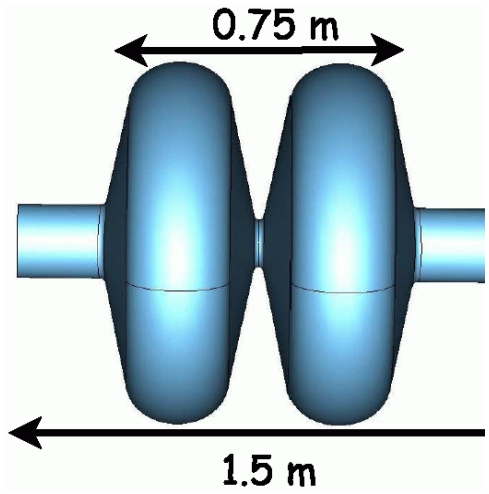
Nb_3Sn, direct wind, HTS?

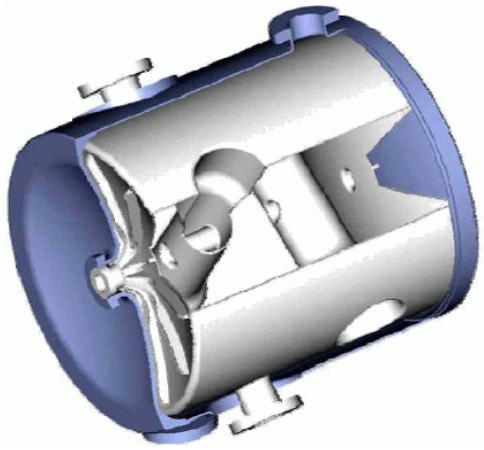


Electron lens (right)

Compress head-on tune footprint

Requires a location with equal betas





Crab cavities (left)

Escape compromise between lumi loss & long range beam-beam

Conventional or exotic solution?

BNL resources & contributions

Triplet Quads
Infrastructure: physicists, engineers, coil-winding, ovens, …
Collaboration: load balancing, optimized skill sets

Slim Magnets
Design and construction resources in place
Direct wind experience with slim quads at CESR, HERA, BEPC

Electron lenses
Must validate & test in RHIC – soon the only U.S. hadron collider
RHIC contemplates funding its own lens – collaborate with LARP

Crab cavities
Synergy with ILC, KEK, Daresbury, ERLs (eg RHIC eCOOL)
R. Calaga (Toohig Fellow) plays a central role

LARP magnet diversification

Diversification goals, while "exploring R&D to
1) exploit, develop & retain U.S. capabilities,
2) increase LHC luminosity"

1) SLIM MAGNETS – Q0 (& D0)

- Valencia consensus: magnets within detectors deserve exploration
- ATLAS & CMS attend bi-weekly meetings at CERN

2) CONDUCTOR DEVELOPMENT

- Expanded (but modest) involvement: pushed Nb_3Sn and HTS
- Entering the standard LARP process, for possible FY08 funding?

3) FAST CYCLING MAGNETS

- A new 50 GeV PS2 might be superconducting?
- Rossi: "I welcome US interest in fast cycling magnets"

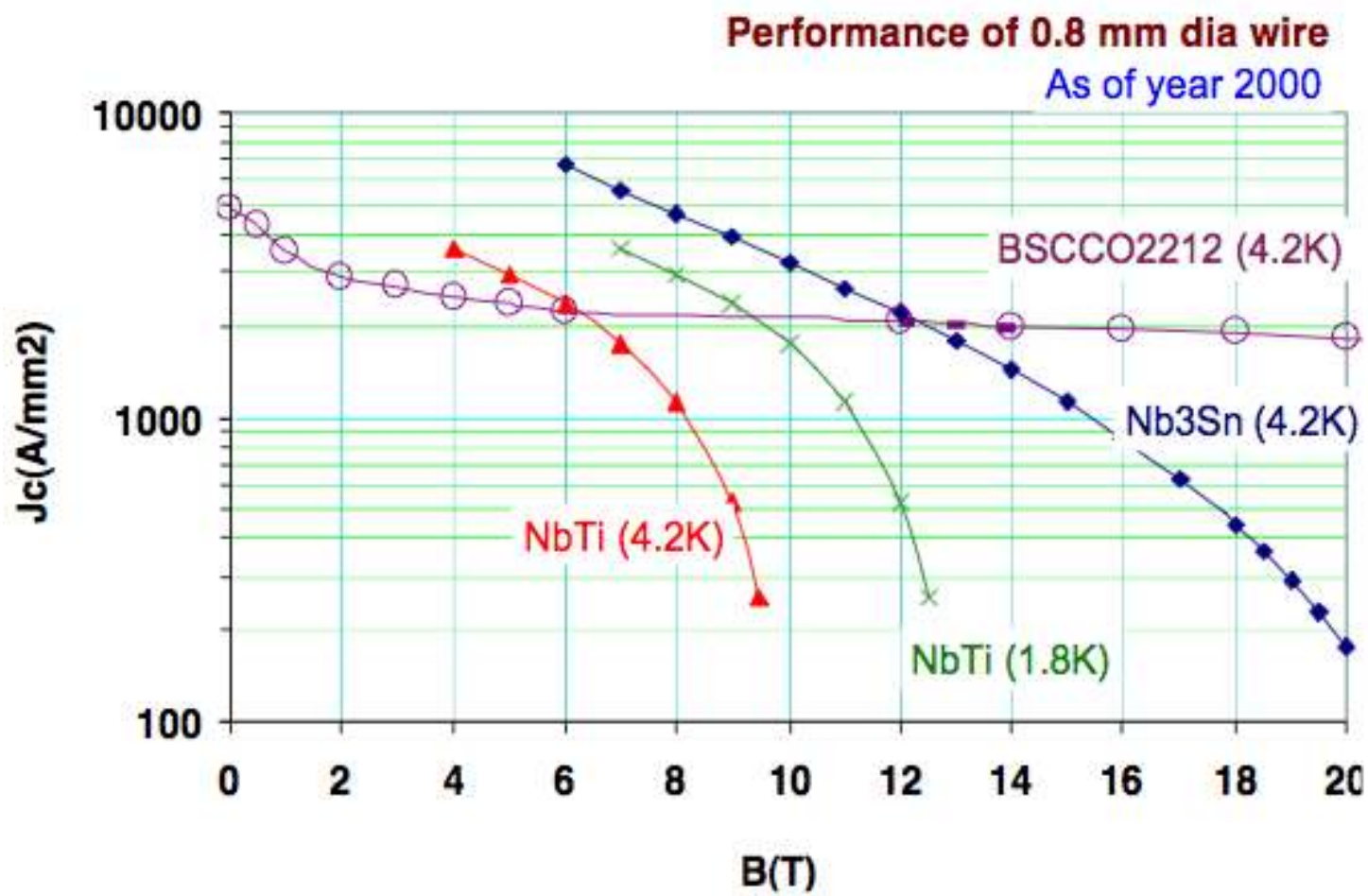
High Temperature Superconductors?

DLHC energy doubler: Increase dipole field from 8T -> 16T (or beyond) for 25 TeV collision energy.

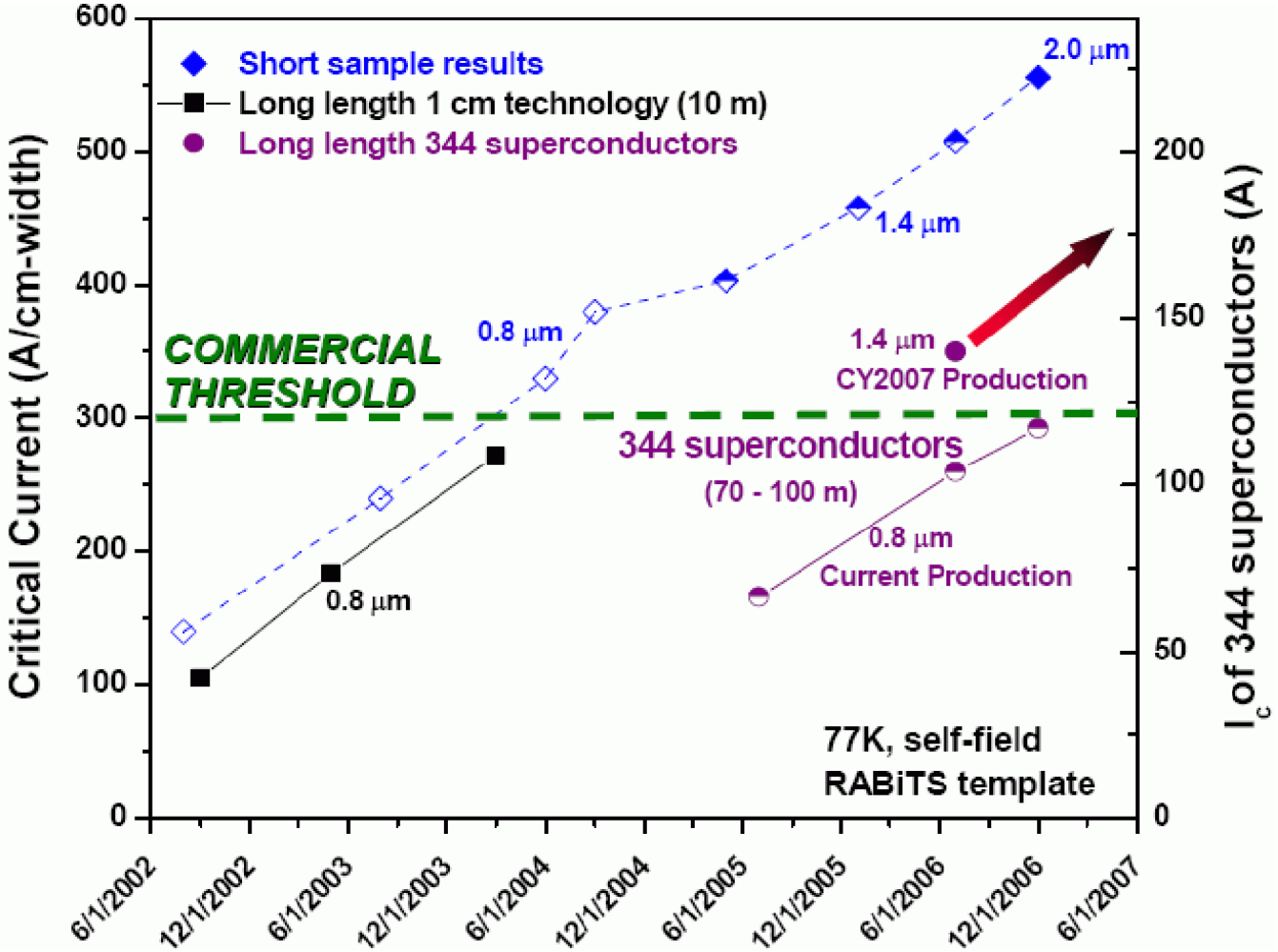
Copious synchrotron radiation ?

HTS, like Nb_3Sn is a difficult material to work in its SC form:

- Brittle
- Strain sensitive
- Easily damaged



Second generation YBCO development



Rapid progress in tape performance (left)

and in cost …

2006 1250 ($/kA.m)
2007 650 ($/kA.m)

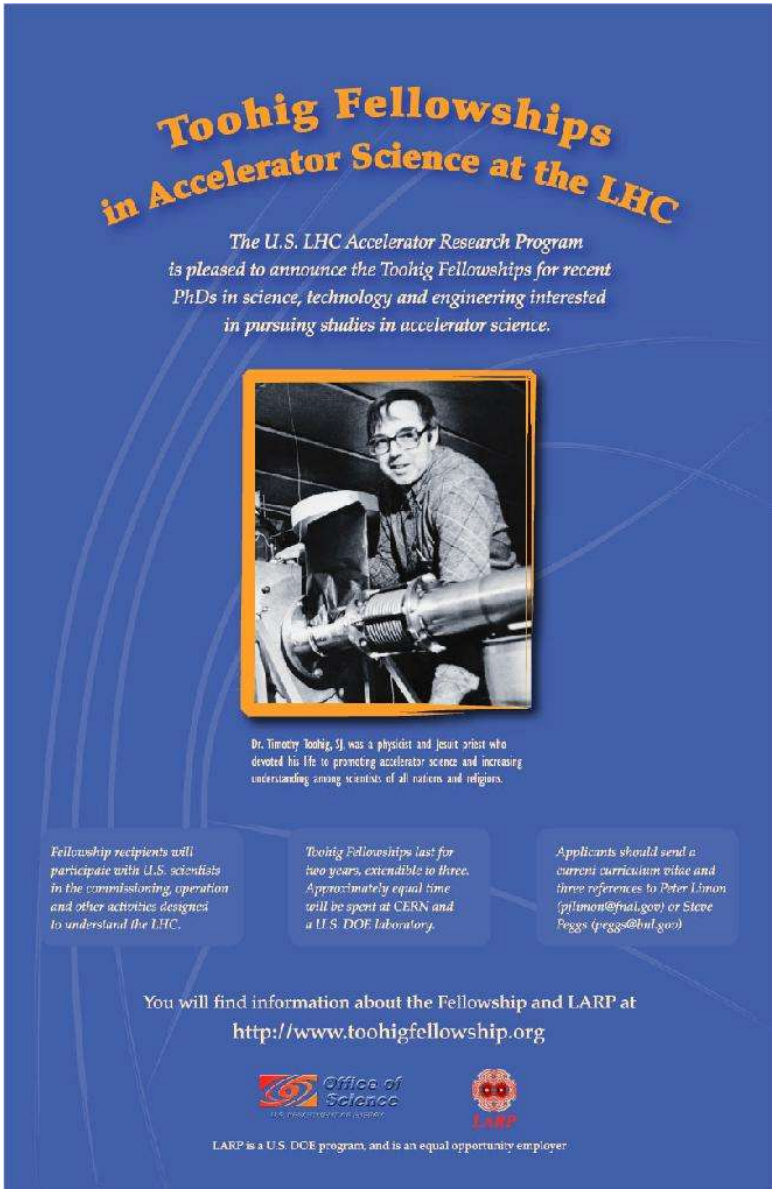
YBCO cable??

Demonstrate HTS feasibility in a “boutique” magnet ?

Eg magnetized TAS internal collimator …. ??

Junior workforce pipeline

Junior workforce pipeline



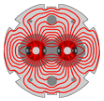
LARP must help to

- hire the best young staff to US labs
- place them for long stays at LHC (50% duty factor)
- attach them to strategic R&D
- show a path to permanent positions for non-Europeans

There is a natural evolution from LHC to ILC

U.S. Labs and U.S.-ILC efforts will suffer unless LARP (& DOE & NSF) deliberately tend the junior workforce pipeline,

Summary



Summary

1) RHIC will soon be the only U.S. hadron collider – BNL "stewardship role" for beam test & development capabilities.

2) BNL has world class resources:

- Nb_3Sn R&D tooling & oven,
- slim magnet experience,
- crab cavity leadership,
- superconductor materials testing capabilities.

3) IRUP (a contruction project) and LARP (an R&D Program) would proceed in parallel.

4) Multiple "full upgrade" scenarios are being discussed – 4 in "slim magnets" alone. Need experience with beam.

5) Junior workforce pipeline needs explicit support from DOE & NSF for BNL & University involvement in LARP.