summary of CARE-HHH IR’07

W. Scandale and F. Zimmermann

CARE-HHH-APD Mini-Workshop IR'07, Frascati 7-9 November 07

39 participants, about half of whom from CERN

Scope:

- upgrade of the LHC interaction region (IR),
- experience with the upgraded DAFNE IR & plans for SuperB

Key topics:

- IR-upgrade optics performance and limitations
- optimization of new LHC triplet magnets
- US-LARP magnet strategy (Lucio's challenge)
- heat deposition
- early-separation dipoles
- detector-integrated quadrupoles
- crab cavities, wire compensators, crab-waist collisions

Goals:

1) narrow down the possible LHC IR optics options and converge on magnet parameters.
2) identify ingredients for the two LHC upgrade phases
3) strengthen collaboration with DAFNE/SuperB studies and explore applicability of advanced IR concepts to LHC

web site: http://care-hhh.web.cern.ch/CARE-HHH/IR07 *(incl. link to INDICO)*

workshop programme

session 1 **introduction** (convener W. Scandale): M. Calvetti, C. Milardi, M. Biagini, W. Scandale, S. Peggs, E. Todesco, D. Tommasini

session 2 **IR triplet magnets** (convener J. Strait): P. Wanderer, G.L. Sabbi, G. Ambrosio, A. Zlobin, R. Ostojic

session 3 **early separation** (convener C. Milardi): J.-P. Koutchouk, P. Limon, G. Sterbini, W. Scandale, F. Zimmermann

session 4: **optics** (convener S. Peggs): M. Giovannozzi, R. De Maria, R. Tomas, E. Laface, G. Robert-Demolaize

session 5 **energy deposition** (convener J.-P. Koutchouk): F. Broggi, E. Wildner

session 6 **D0 and Q0 detector interference** (convener P. Limon): M. Nessi, J. Nash, E. Tsesmelis, S. Peggs

session 7 **beam-beam compensation & crab cavities** (convener F. Zimmermann): U .Dorda, C. Milardi, U. Dorda, R. Calaga, F. Zimmermann

session 8 **crab waists, flat beams** (convener M. Biagini): M. Zobov, E. Levitchev, P. Raimondi

session 9 **final round table and conclusions** (convener W. Scandale, F. Zimmermann)

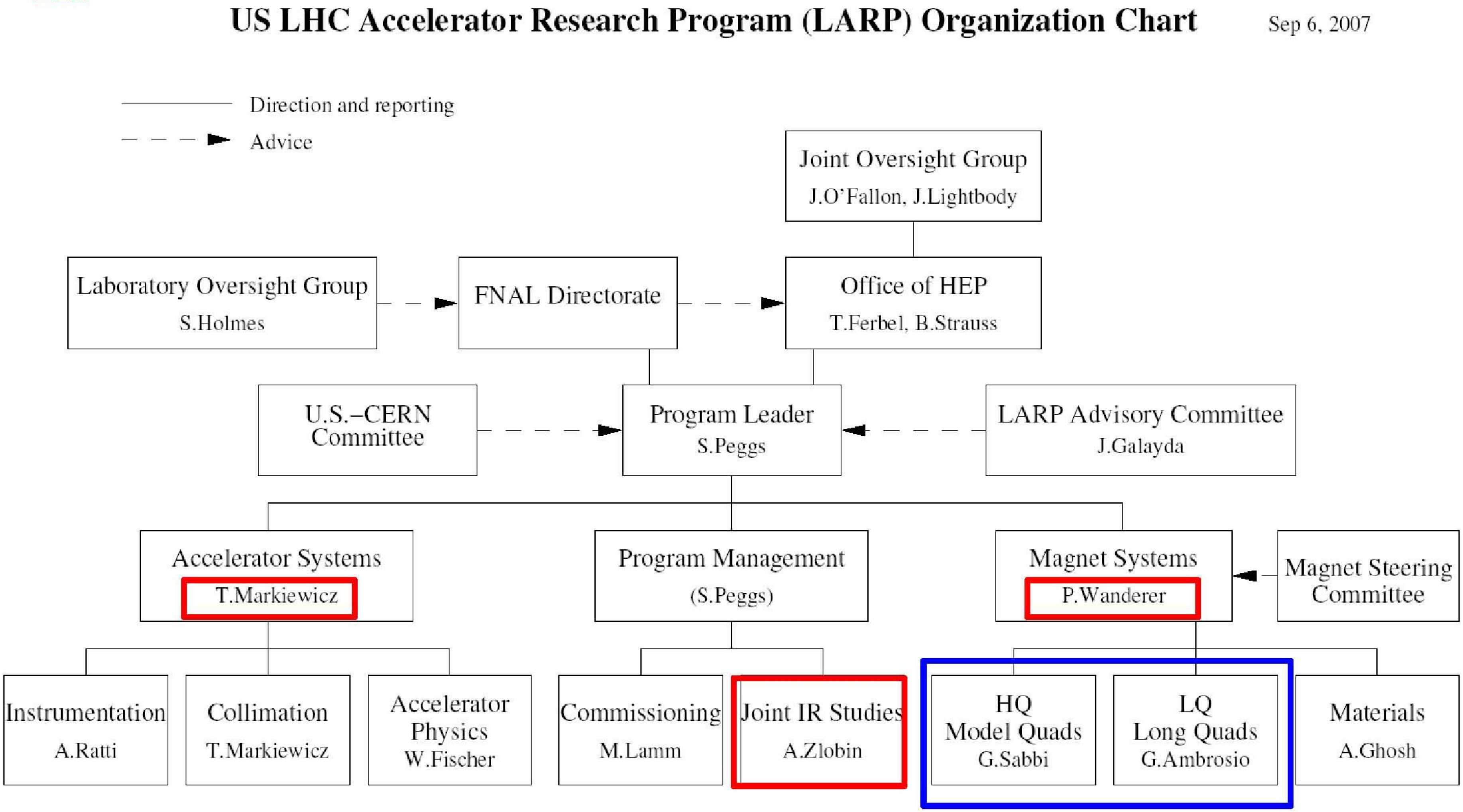
42 talks in 3 days!

some presentation highlights

- **S. Peggs, "News from LARP"**
- **A. Zlobin, "LARP Joint IR Studies"**
- **E. Todesco, "Design Issues in a 130 mm Aperture Triplet"**
- **G.L. Sabbi, "High Field Nb3Sn Magnets"**
- **D. Tommasini, "CERN Plans on High-Field Magnet Development"**
- **J.-P. Koutchouk, "New Results on the Early Separation Scheme"**
- **M. Giovannozzi, "Optics Issues for Phase-1 & 2 Upgrades"**
- **R. De Maria, "Phase-1 Optics: Merits and Challenges"**
- **R. Tomas, "IR Multipolar Correction for the LHC Upgrade"**
- **E. Wildner, "Are large-aperture NbTi magnets compatible with 1e35?"**
- **M. Nessi, "SLHC, ATLAS Considerations"**
- **J. Nash, "CMS Views on SLHC Upgrades"**
- **U. Dorda, "Beam-beam Issues for Phase 1 and Phase 2"**
- **R. Calaga, "Small Angle Crab Crossing"**
- **U. Dorda, "Wire Compensation Performance, MDs, Pulsed System"**
- **M. Zobov, "Crab Waist Collision Studies for e+/e- Factories"**

+ 4 round-table discussions

Arrivals, departures, re-structuring



Jim Kerby replaced Limon as LARPs "Local Leader" at CERN

JIRS: early Nb3S magnets

LARP

DOE Review: "The importance of establishing closer relations between the magnet and accelerator sectors of LARP cannot be overstated, especially in view of the fact that it is not clear what should follow the completion of the LQ magnet."

"Joint IR Studies" merges Magnet & Accelerator folk.

One goal: define & evaluate short list of potential Nb3Sn locns.

According to de Rijk:

- *New magnets are needed for the LHC phase 2 upgrade in about 10 years*
  - *Quadrupoles for the low-beta insertions*
  - *Corrector magnets for the low-beta insertions*

  and possibly
  - *Dogleg dipoles for the cleaning insertions*
  - *Q6 for cleaning insertions*
  - *10 m dipoles for the dispersion suppressors*
  - *Early separation dipole (D0)*

JIRS: crab cavities

DOE Review: "The crab cavity effort seems well matched to the LARP program, and should be given sufficient resources to move forward."

Initial JIRS activities do not include crab cavity issues, although:

- LARP participates in a broad crab cavity collaboration
- CERN & U.S. enthusiasm is mounting
- A crab task may be added to JIRS, eg in FY09.

Advanced Energy Systems Small Business (SBIR) proposal would build a prototype LHC cavity (800 MHz).

Calaga, on the Shanghai workshop (2008), will help merge "deflecting cavity" (light source) and crab (ILC, LHC) topics.

Responding to the challenge

LARP

In Rossi's "hybrid proposal" the U.S. would provide 4 or 8 Nb3Sn quads out of 16 required for the Phase-1 upgrade, with the NbTi complement made at CERN.

This memo ...

Date:	October 26, 2007
To:	File
From:	S. Peggs
Subject:	**U.S. accelerator components for LHC luminosity upgrades**

... responds to the challenge,

1) in the larger context of magnet deliverables for the Phase-2

"Statement of need & CD-0"

LARP

LARP magnet R&D has a single strategic goal: making Nb3Sn magnet technology fully mature for use in Phase-2.

Any LARP magnet R&D for Phase-1 must enhance progress towards this goal, rather than compromising it.

Delivery of Nb3Sn cold-masses is not R&D, and so would require one or two construction projects separate to LARP.

Launching a construction project is synonymous with achieving a "Critical Decision 0" (CD-0), which crucially requires a clear official "statement of need" from CERN.

Nb3Sn magnets provided in Phase-1 would have to perform at least as well as the NbTi magnets built at CERN, otherwise they would not be worth installing.

While Phase-1 tin magnets would be state-of-the-art in 2012, they would be intermediate R&D prototypes on the path to Phase-2.

JIRS Mission and Tasks

JIRS are mostly concerned with the post-LQ magnet series:

- QA quadrupole – accelerator quality magnet.
- QB quadrupole – Phase 2 upgrade magnet.
- “Slim” magnets in front of Inner Triplets.

The framework of JIRS is determined by ***The mission of LARP “Joint Interaction Region Studies”*** **.**

FY08-09 Joint IR Studies tasks and Task Leaders

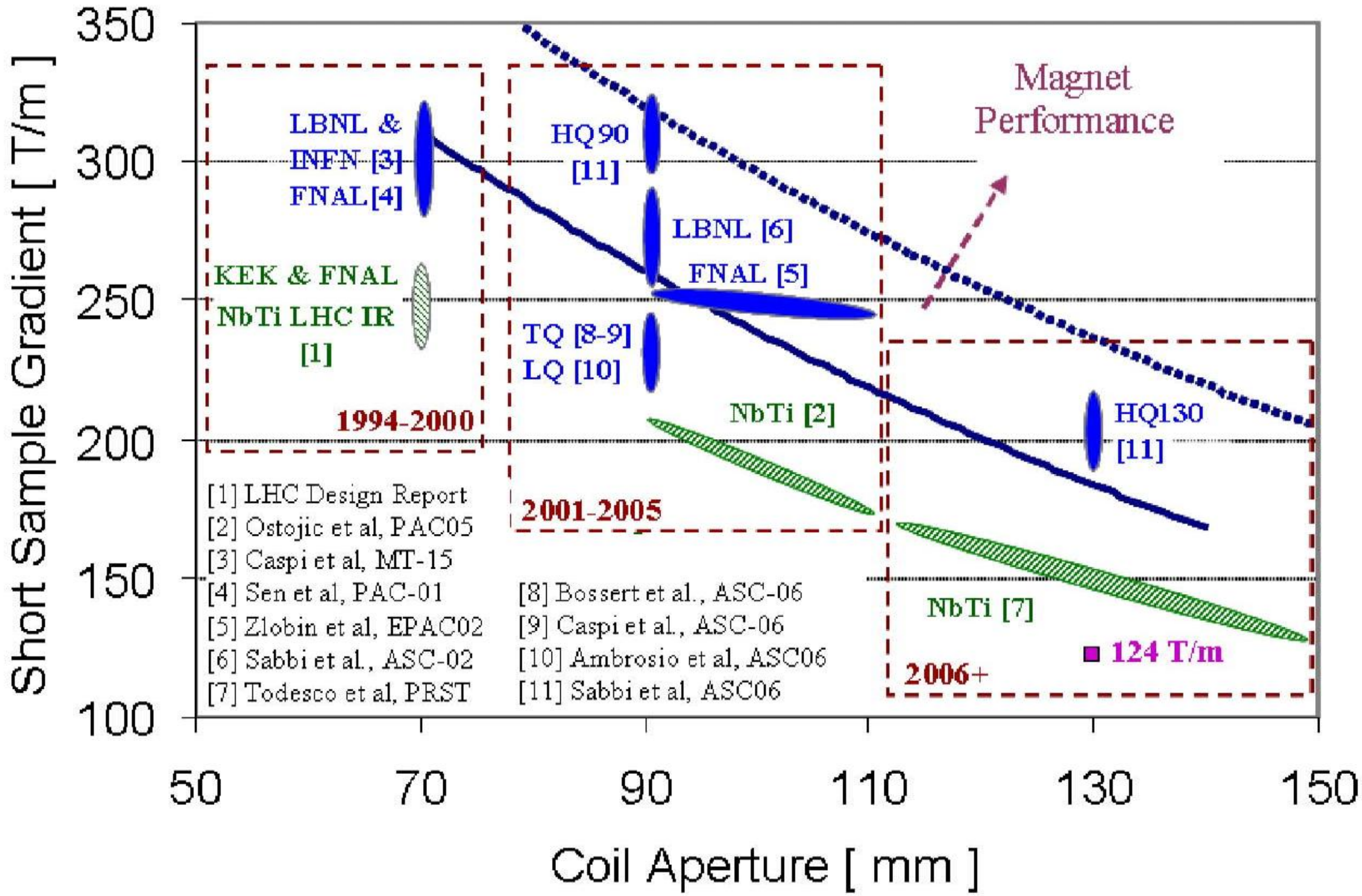
- 3.3 Joint IR Studies – Alexander Zlobin (Fermilab)
- *3.3.1 Simulation*
  - 3.3.1.1 Operating Margins - Nicolai Mokhov (Fermilab)
  - 3.3.1.2 Accelerator Quality & Tracking - Guillaume Robert-Demolaize (BNL)
- *3.3.2 Studies*
- 3.3.2.1. Optics & Layout - John Johnstone (Fermilab)
- 3.3.2.2. Magnet Feasibility Studies - Peter Wanderer (BNL)

FY08 budget 320k$.

CONCLUSIONS

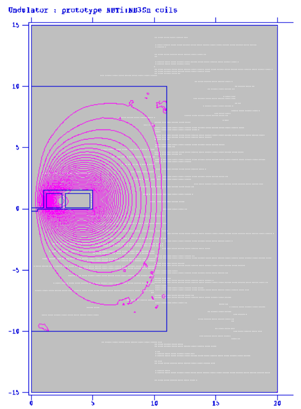
- We outlined the motivations to go for a 130 mm aperture in a Nb-Ti LHC triplet
  - β^*=0.25 m with 3 σ clearance for collimation
- We discussed a conceptual design of the Nb-Ti magnet
  - Field quality, stresses, protection
- We considered the possibility of replacing Q1-Q3 with Nb_3Sn magnets
  - Not possible with the present 10 mm cable
  - With 15 mm cable could be viable, with margin and stresses within limits
  - Optics seems viable, should be validated by exact matching
  - It would give a more than a factor 2 in temperature margin (and would be the first test of Nb_3Sn in operational conditions)

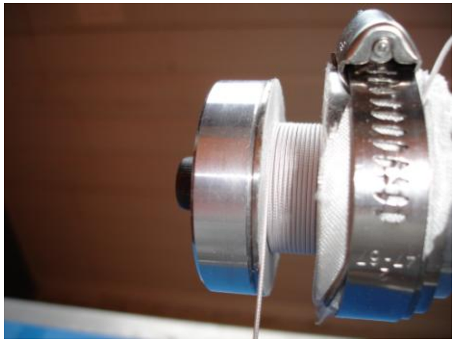
IR Quadrupole Design Space

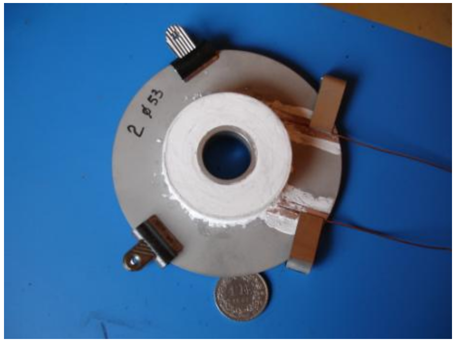


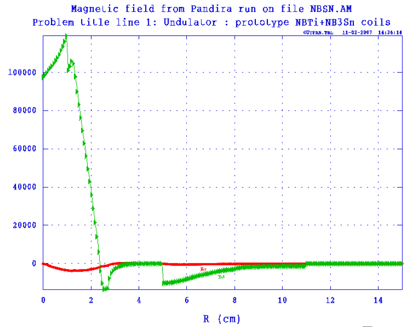
On going : mini dipole split coils

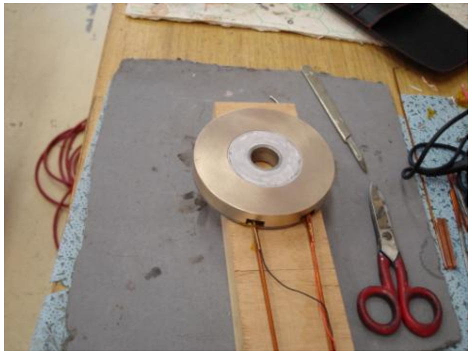
Ceramic wet winding

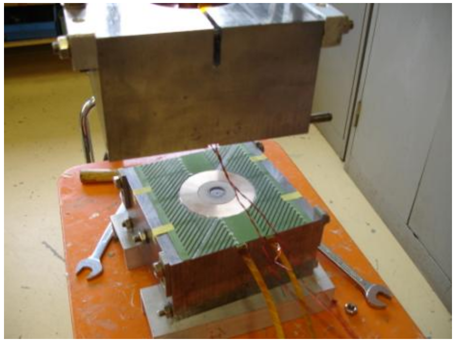












We reached 12 Tesla in the gap,10.5 Tesla on the coils

I max 1250 A (short sample) at 4.2 K with **no** training quenches

Courtesy Remo Maccaferri

D. Tommasini

1- Possible Layouts

1. Field integral of each dipole:

Depends on beta* and position: ~ 5 to 8 Tm for present scheme (positions 3 to 6 m)

2. Position of dipole center from IP

		25 ns	*50 ns*
Full early separation		1.9 m	3.8 m
Partial Early Sep.	1LR @ 5σ	5.6 m	11.25 m
	2LRs @ 5σ	9.4 m	18.8 m

J.-P. Koutchouk

5-Peak luminosity estimates

***Ultimate bunch current**, l*=23 m, beta*=14 cm*

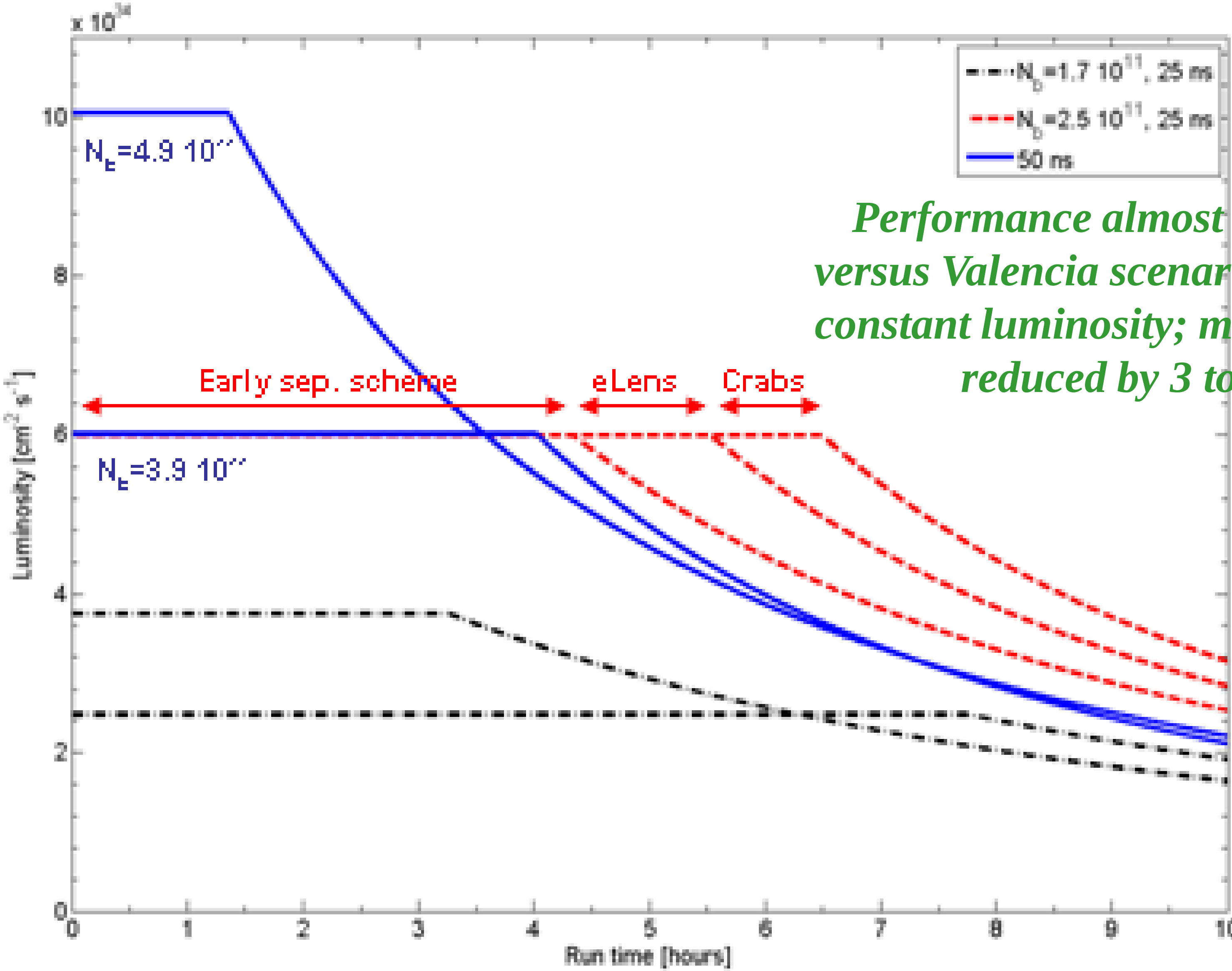
	25 ns	50 ns
No early sep., beta*=25 cm	3.1	1.7
Full early sep. Beta*=14 cm	9.8	4.9
Partial early sep., Beta*=14 cm	5.8	3.1

With weak global crabbing

~7 , with electron lens & separation of 3 sig

~+30% for l*=13m

5- Performance with leveling

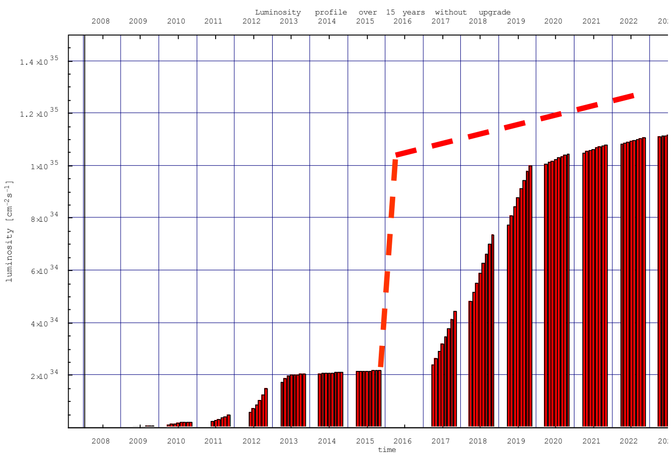


Performance almost doubled versus Valencia scenarios & with constant luminosity; max pile-up reduced by 3 to 4

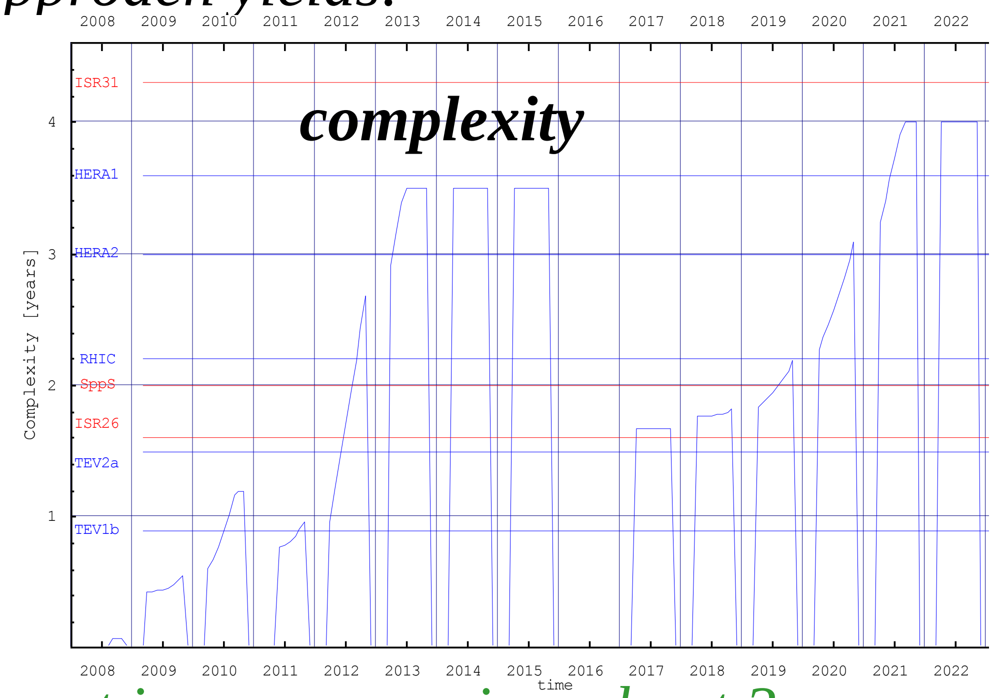
J.-P. Koutchouk

Rise time of performance

Performance rise depends on ***complexity.*** *Statistical law by V. Shiltsev. Using/extending his approach yields:*



luminosity



The strategy with beam current increase requires about <u>*3 years*</u> *after Phase I (4 years without).*

In the ISR, a comparable beta decrease (/7) took a few weeks* ***at reduced current****;* <u>*one year for the LHC at full current?*</u>

J.-P. Koutchouk

Conclusion

If the **modulation of the length of the luminous region** is acceptable, the "native" luminosity leveling of the early separation scheme can suppress the fast luminosity decay with a small loss of integrated luminosity.

When combined with a beam current increase beyond "ultimate" and below or equal to the LPA scenario, the integrated luminosity can be boosted by almost a factor of two with respect to the present parameter lists with a significant decrease of peak pile-up (3 to 4).

The scheme offers similar performance for 25 or 50 ns spacing. Of course the pile-up and bunch charge increase at 50 ns spacing.

The electron lens and/or global crabbing are very useful both to extend the duration of constant luminosity and mitigate risks.

round-table discussion

after sessions 1-3

phase-1 / phase-2 magnets: complementing synergy or divergent goals?

- *need for Nb3Sn in phase-1?*
- *Nb3Sn: better for increased beam losses, larger T margin, available cooling capacity improved (D. Tommasini, A. Zlobin)*
- *experimental verification? some evidence*
- *"not a good return on investment" (P. Limon)*
- *use phase-2 quad in phase-1? radiation survival*
- *be sure that it does not become a failure point! (J. Strait)*

beta* in phase-1?

- *beta*=0.25 m alone gives marginal return (~20% increase in average luminosity)*
- *"phase-1 is to find margins in case" (J.-P. Koutchouk)*
- *must be complemented by other improvements, e.g. crab cavities, collimator upgrade, linac4 (R.O., W.S.)*

Nb3Sn coils at CERN: how fast can this new finding become beneficial (if)? Should it be explored in parallel?

- no expoxy (D. Tommasini)

- mechanical, electrical, & thermal properties to be confirmed

- question perhaps premature

130-mm diameter quadrupoles in US: how fast ?

-(already discussed under point 1)

D0 / Q0 magnets: how to streamline the effort ?

- background studies by experiments needed (P. Limon), but very expensive, need reasonable starting point (J. Nash)

- optimizing shielding for different parameters

- LARP involvement limited (S. Peggs)

- experiments in RHIC on #LR crossings, no final answer soon; need to go in steps & converge with experiments towards optimal solution (J.-P. Koutchouk, J. Nash)

- magnets, support structures, heat load, > 6 m from IP (P.Limon)

mixed quadrupole triplet in competitive bid: efficient idea?

- *"not competitive", "perception is not reality" (S. Peggs)*
- *mandate of CERN LIUWG needs to be adjusted*
- *controversial reactions to challenge (E. Todesco)*
- *"LARP goal: only design, papers and prototype" (P. Limon)*
- *hybrid solution minimizes risk (D. Tommasini)*
- *spare NbTi quadrupoles will be available as backup (D.T.)*

field quality in the mixed triplet

US-LARP strategy; locations and specs for QA magnets in LHC, success-oriented schedule, crab cavities in US LARP

crab cavity experience at KEKB

- *KEKB is running with crab cavities (S. Peggs)*
- *they restore geometric luminosity and even increase beam-beam tune shift;* beam current limited by unrelated problem (R. Calaga)
- *would CERN be ready to install crab cavities in LHC? (S. Peggs)*
- *noise effect could be checked in any hadron storage ring (F.Z.)*

experimental tests of various types of leveling?
(BEAM'07 talks by Lebedev & Shiltsev)

- interpretation controversial

- experimental tests e.g. at RHIC (and LHC) would be useful

luminosity increase via current and/or beta*

- both may be needed

- historical experience: Tevatron and SPS increased luminosity with higher beam current

minimum acceptable luminosity lifetime?

- 5 hours acceptable

- how fast may the experiments be turned on after establishing collisions?

- statement from the experiments

off-momentum beta beating

- *“acceptable for less-critical momentum cleaning”?*
  (J.-P. Koutchouk)
- *needs study of collimation performance*

can we have larger aperture magnets without increasing the outer diameter?

- *yes, already shown*

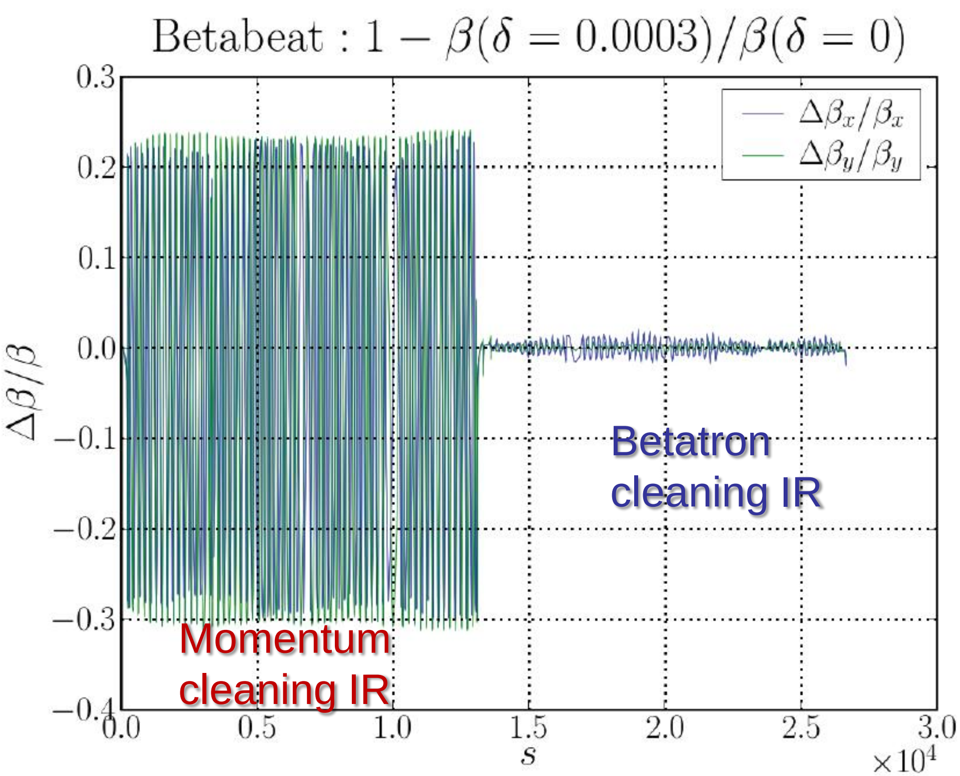
do we need to upgrade the LHC IR cryoplants?

- *only in point 4 for rf (R. Ostojic)*

The path to Phase 1 layout - VI

- Apart on aperture, off-momentum beta-beating has an impact on collimation performance.
- How to chose in which half of the machine the beating has to be corrected?
  - Driving criterion: avoid that a secondary collimator becomes a primary one.

FOR the nominal LHC the correction should be made between IR5 and IR1.



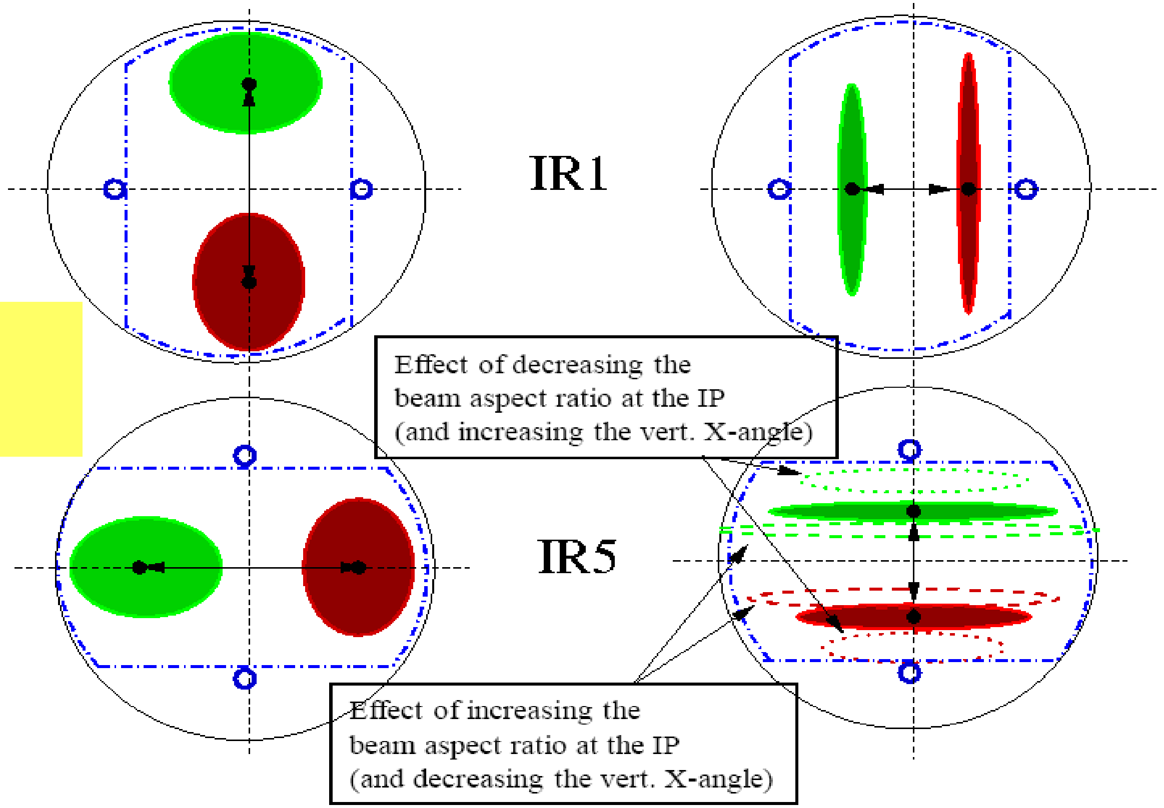
The beneficial effect of flat beams - I

Potential of Flat Beam: Aperture

- Triplet beam screen orientation for H/V crossing

Round beam configuration (V–crossing in ATLAS, H–crossing in CMS)

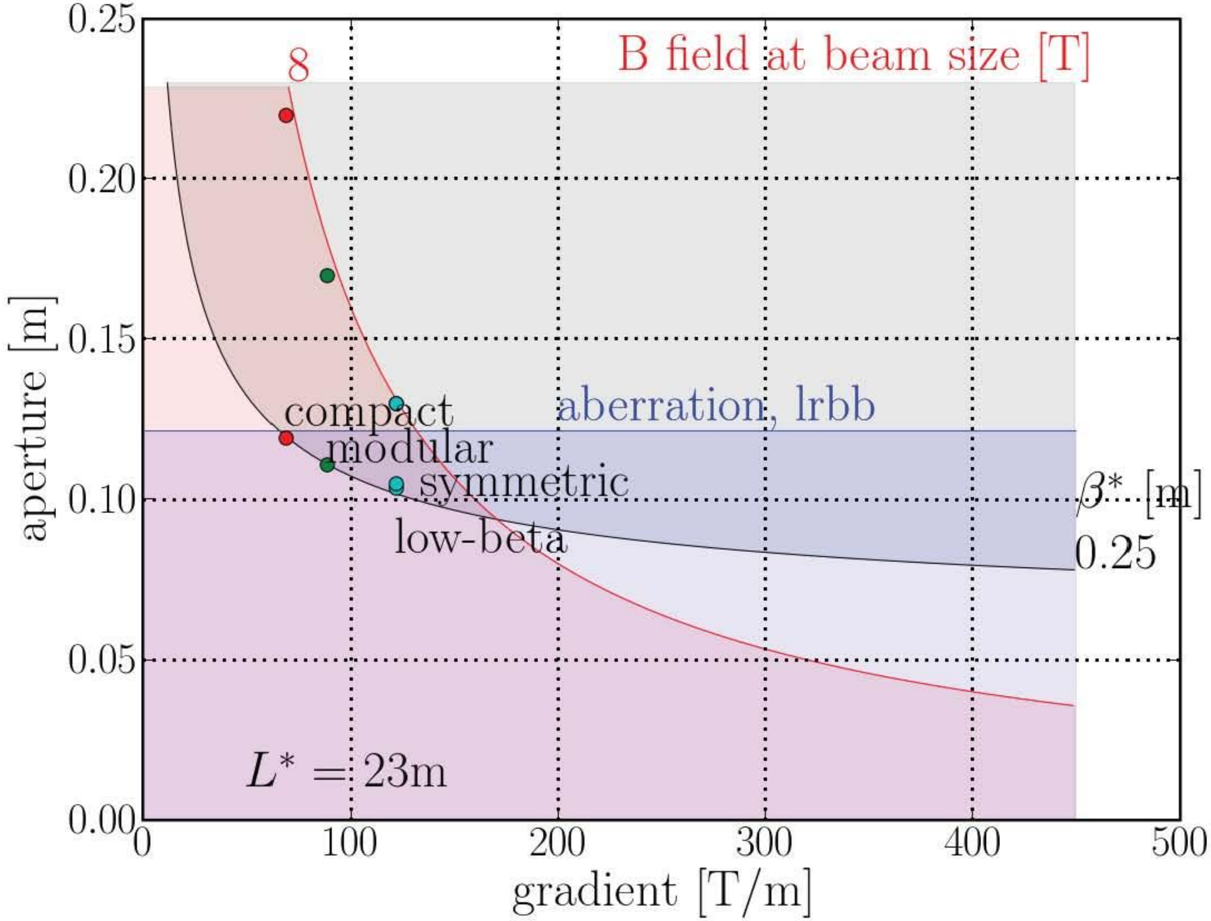
Flat beam configuration (H–crossing in ATLAS, V–crossing in CMS)



→ In all cases, the **average b-b separation is set to 9.5*$\sigma_{x/y}$** (for H/V crossing)

→ Find the optimum between beam-screen and beam aspect ratio

Choice of the gradient



R. De Maria

Layout

	Compact	Modular	Lowbetamax	Symmetric
L* [m]	23	23	24	23
Gradient [T/m]	91,68	115,88,82,84	168,122	122
Module L [m]	12.2,14.6,11	4.8	7.4,5.7,4.9	9.2,7.8
Total L [m]	55	68	40	41
LRBB	23	26	19	19
Aper. MQX [mm]	170,220	130,170	90,130	130
B.S. MQX [mm]	74,79;99,104	54,59;99,104	34,39;54,59	54,59
B.S. D1 [mm]	50,64;45,64	50,64;45,64	50,64;45,64	50,64;45,64

Triplet apertures proposed by Franck Borgnolutti, Ezio Todesco and they are the one which gives the largest aperture margins. What to do with this aperture is an open question (shielding, magnet or beam operational margins). D1 apertures proposed by Stephane Fartoukh.

The beam screen apertures are given in term of half gap and radius. For the MQX the two couple refers to the twos aperture, while for D1 refer to IP1 and IP5.

General remarks

From this studies it is possible to conclude:

- the LSS is pushed to the limits, it is necessarry to understand them better by exploring all the corners of the remaning flexibility in order to design efficiently new optics or propese localized but effective upgrade;
- optimization at the percent level gives rather large difference in performance (see difference between lowbetamax symmetric). The design of a soltution will require many iterations;
- flat beams will be probably the preferred scheme for pushing performance at the edge. This option should be studied as well during the design process to reduce avoidable bottlenecks.

The map & the observable

$$\vec{x}_f = \sum_{jklmn} \vec{X}_{jklmn}\, x_0^j\, p_{x0}^k\, y_0^l\, p_{y0}^m\, \delta_0^n$$

To assess how much two maps, X and X' deviate from each other the following quantity is defined:

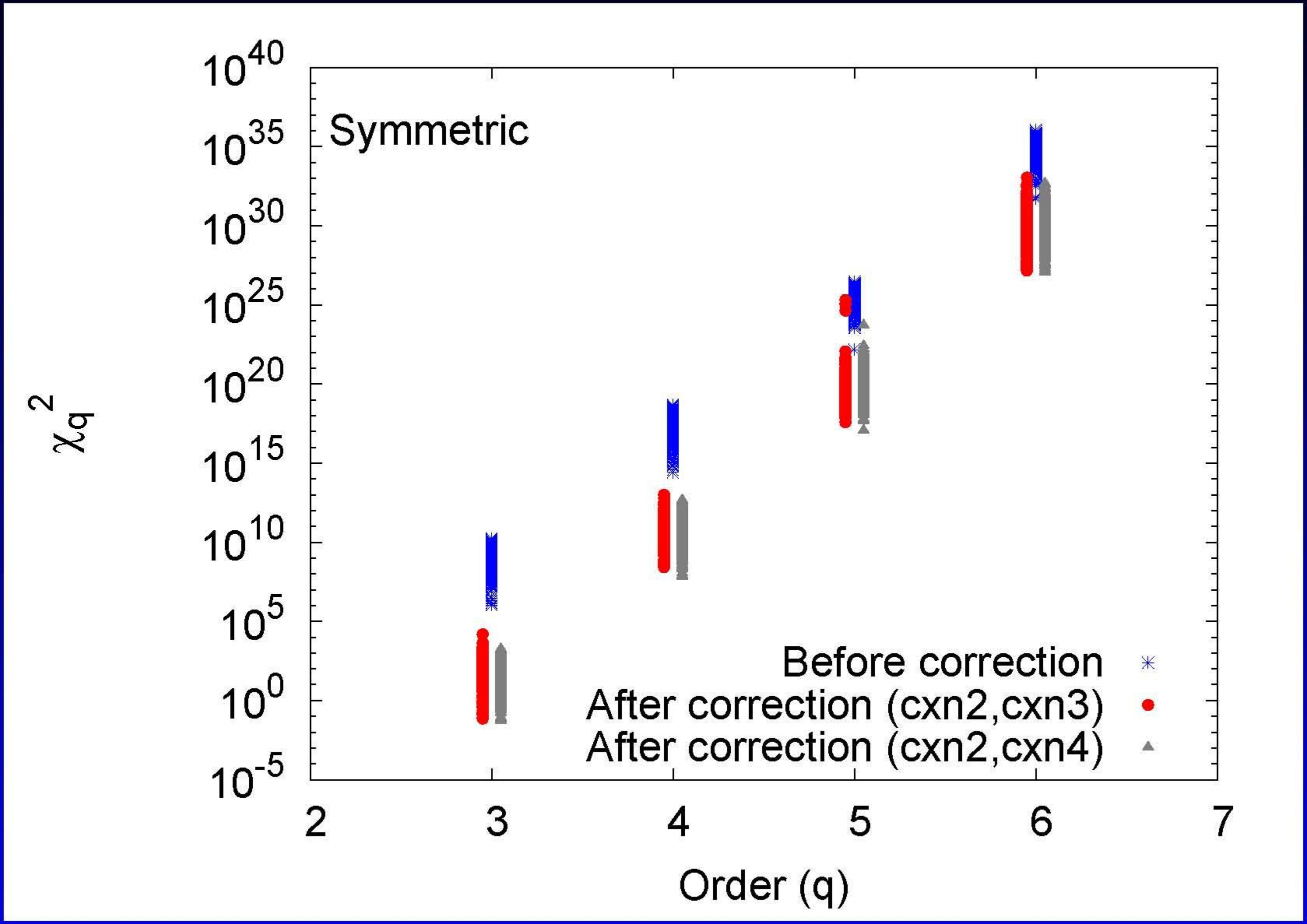
$$\chi^2 = \sum_{jklmn} ||\vec{X}_{jklmn} - \vec{X}'_{jklmn}||$$

Weighting can be implemented. To disentangle the contribution of the different orders on χ^2:

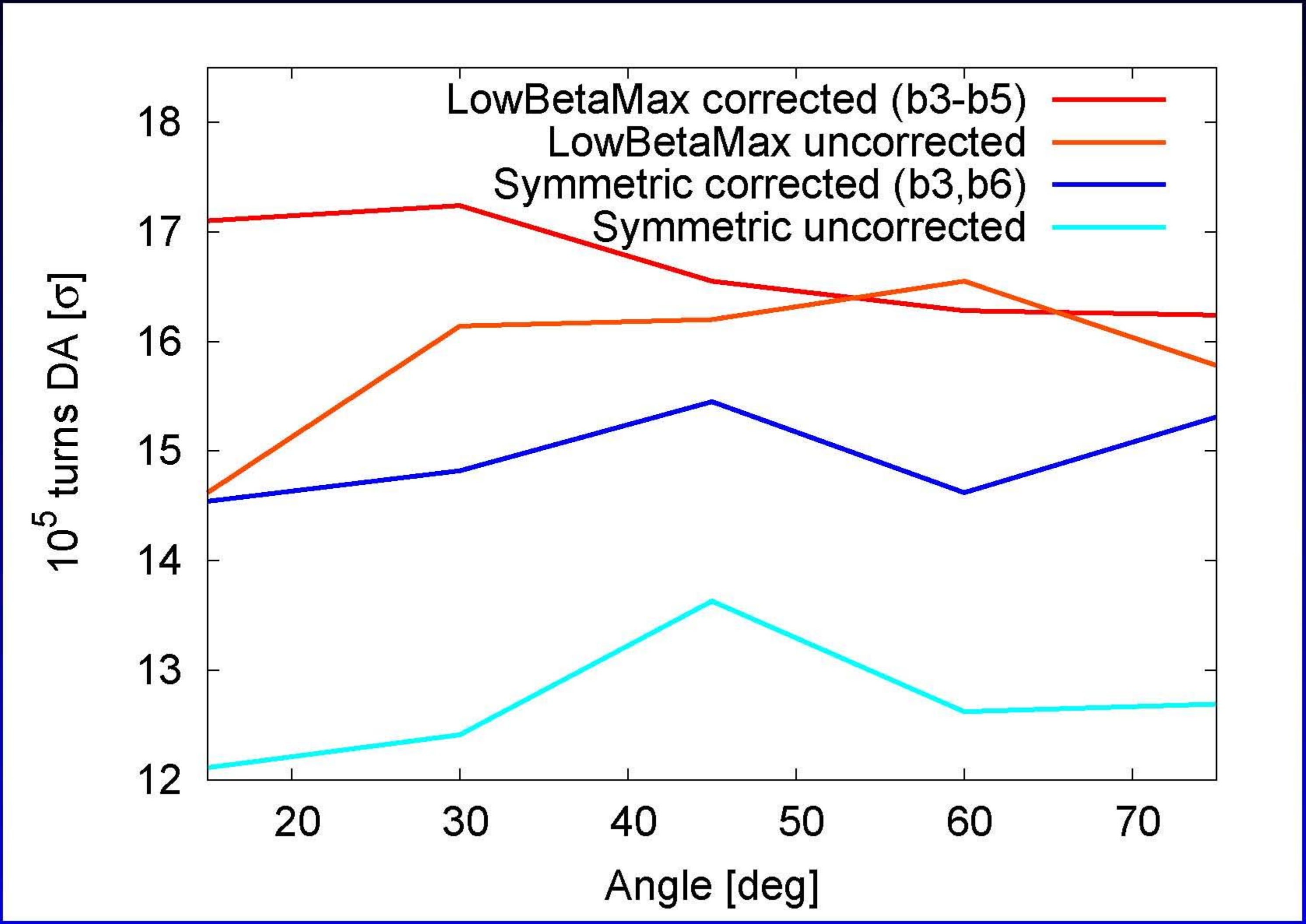
$$\chi_q^2 = \sum_{j+k+l+m+n=q} ||\vec{X}_{jklmn} - \vec{X}'_{jklmn}||$$

This is computed with the Python code MAPCLASS.

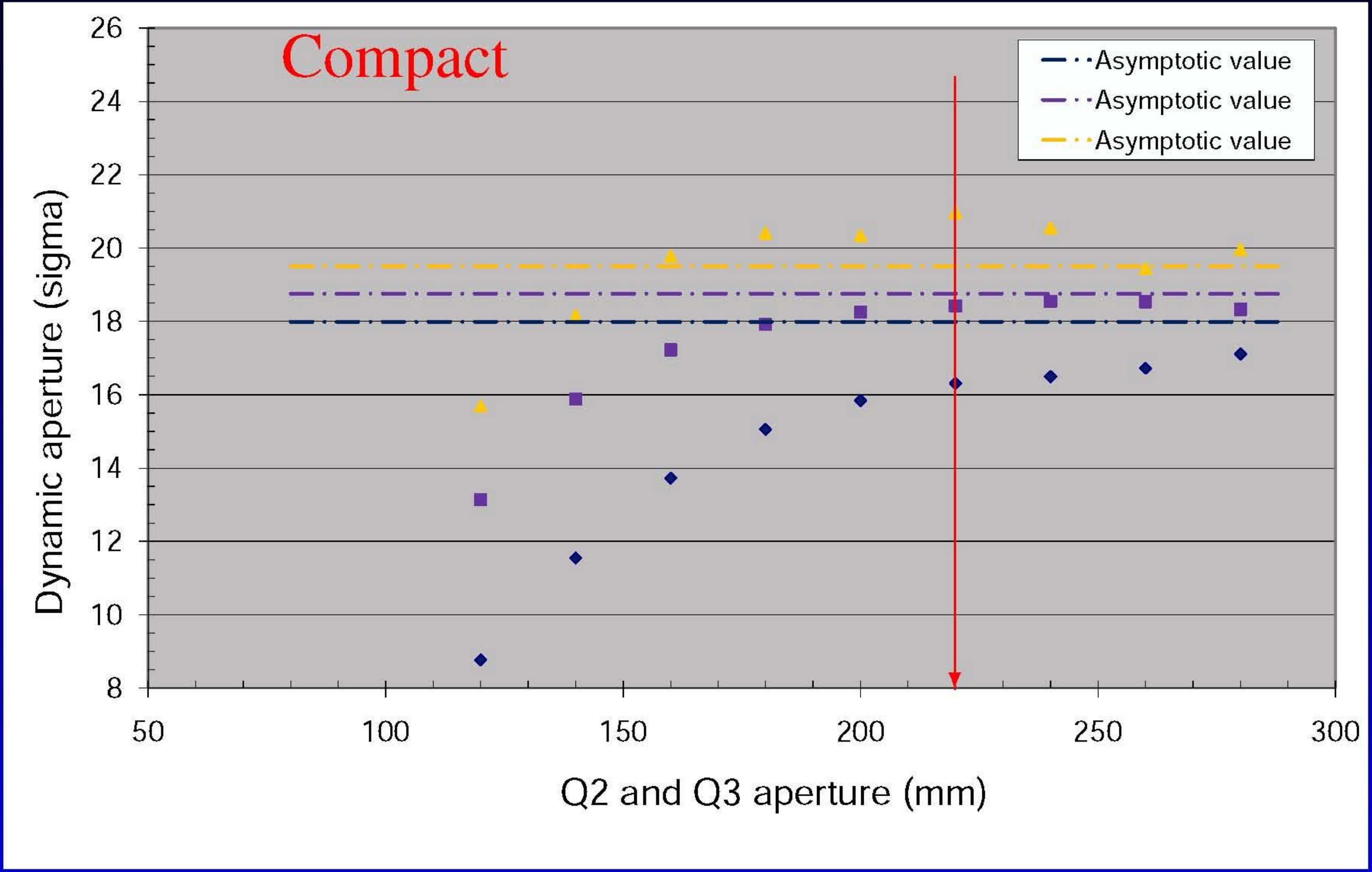
Correction illustration: Symmetric



DA after correction

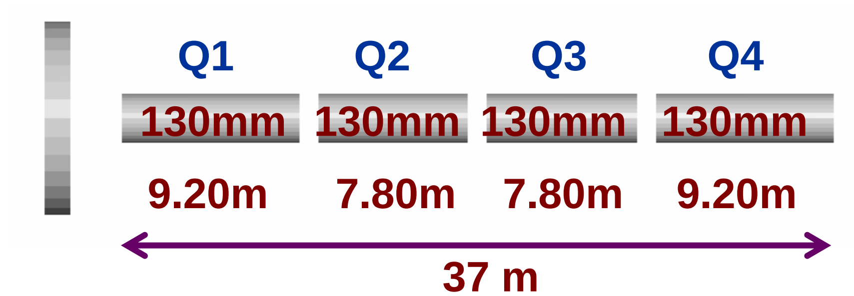


DA versus quadrupole aperture II



Layout

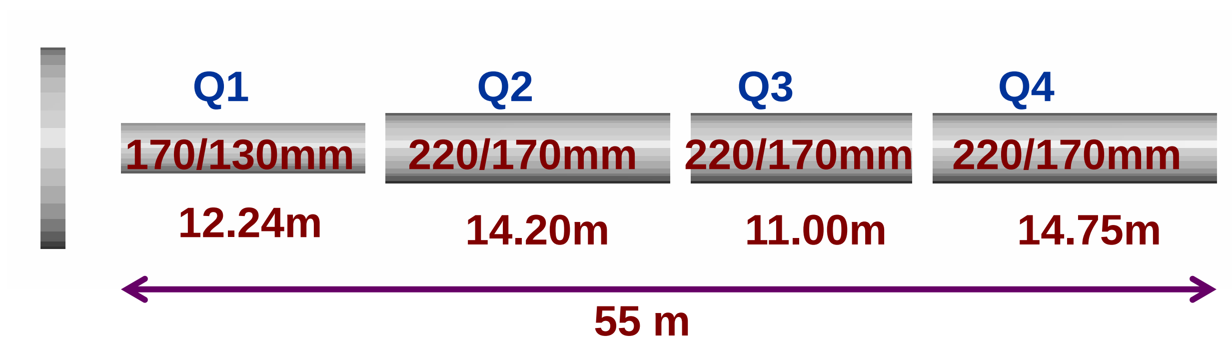
IP1 Symmetric



Positive particle

+ FDDF

IP1 Compact

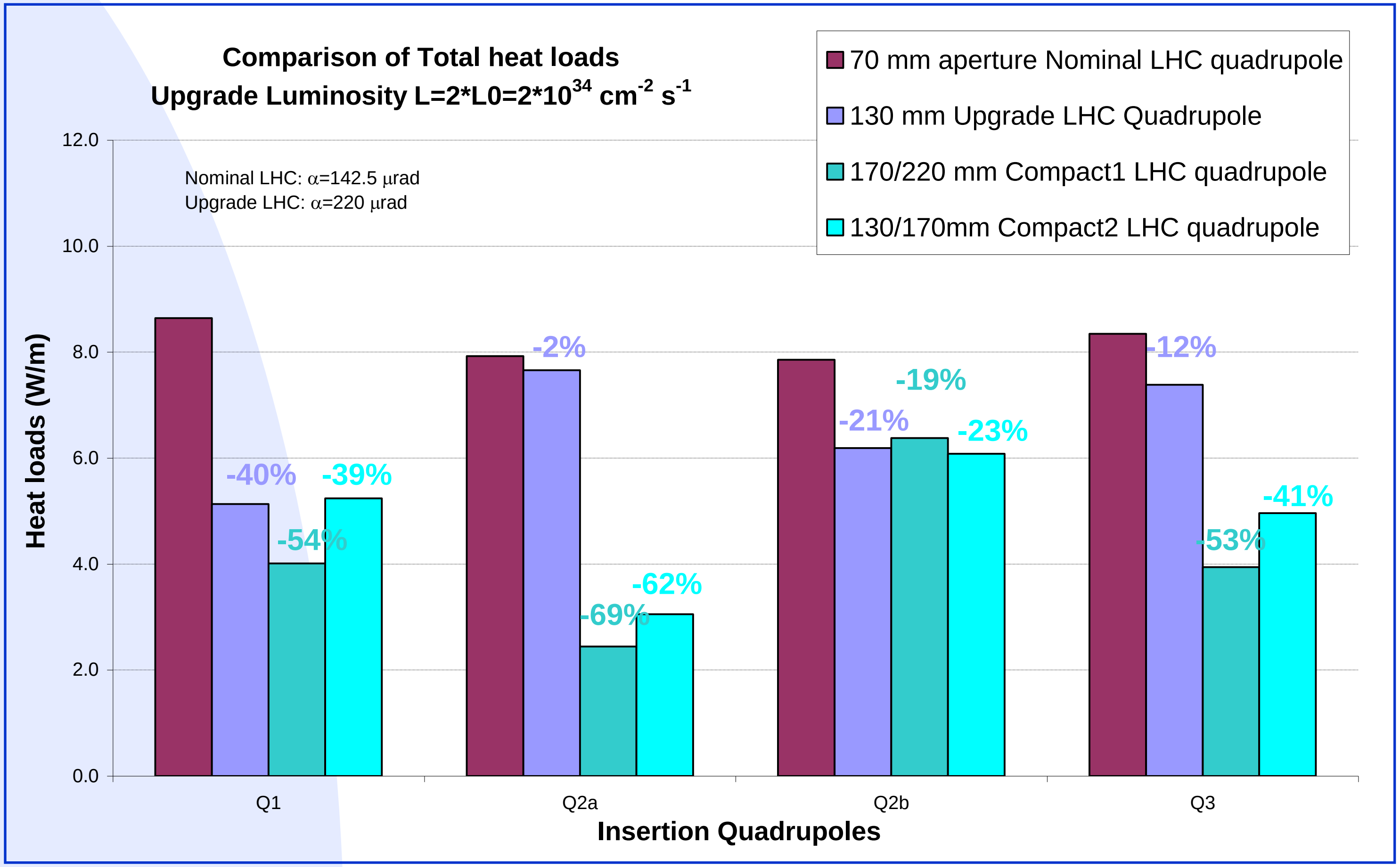


E. Wildner

Total heat loads

Good for comparison between cases only:

Magnet design not optimized for the scenarios



E. Wildner

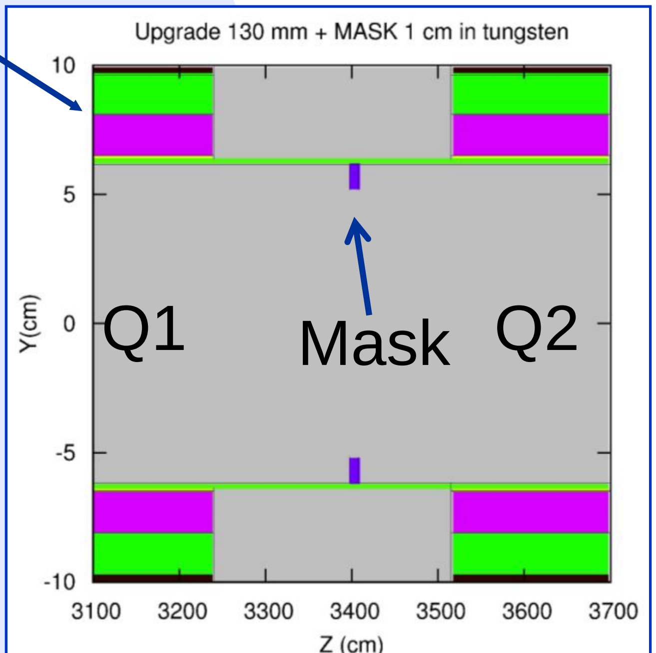
Implementation in model

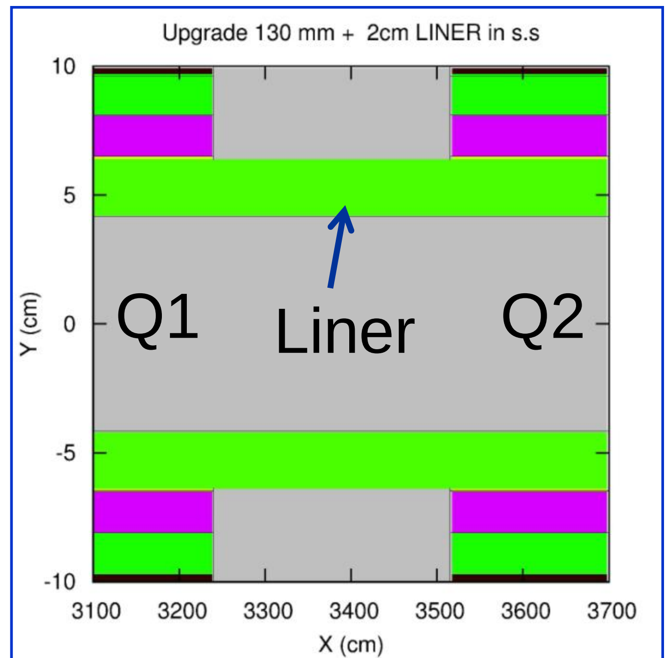
"Symmetric" layout

1 cm MASK in ***tungsten***

2cm LINER in ***stainless steel***

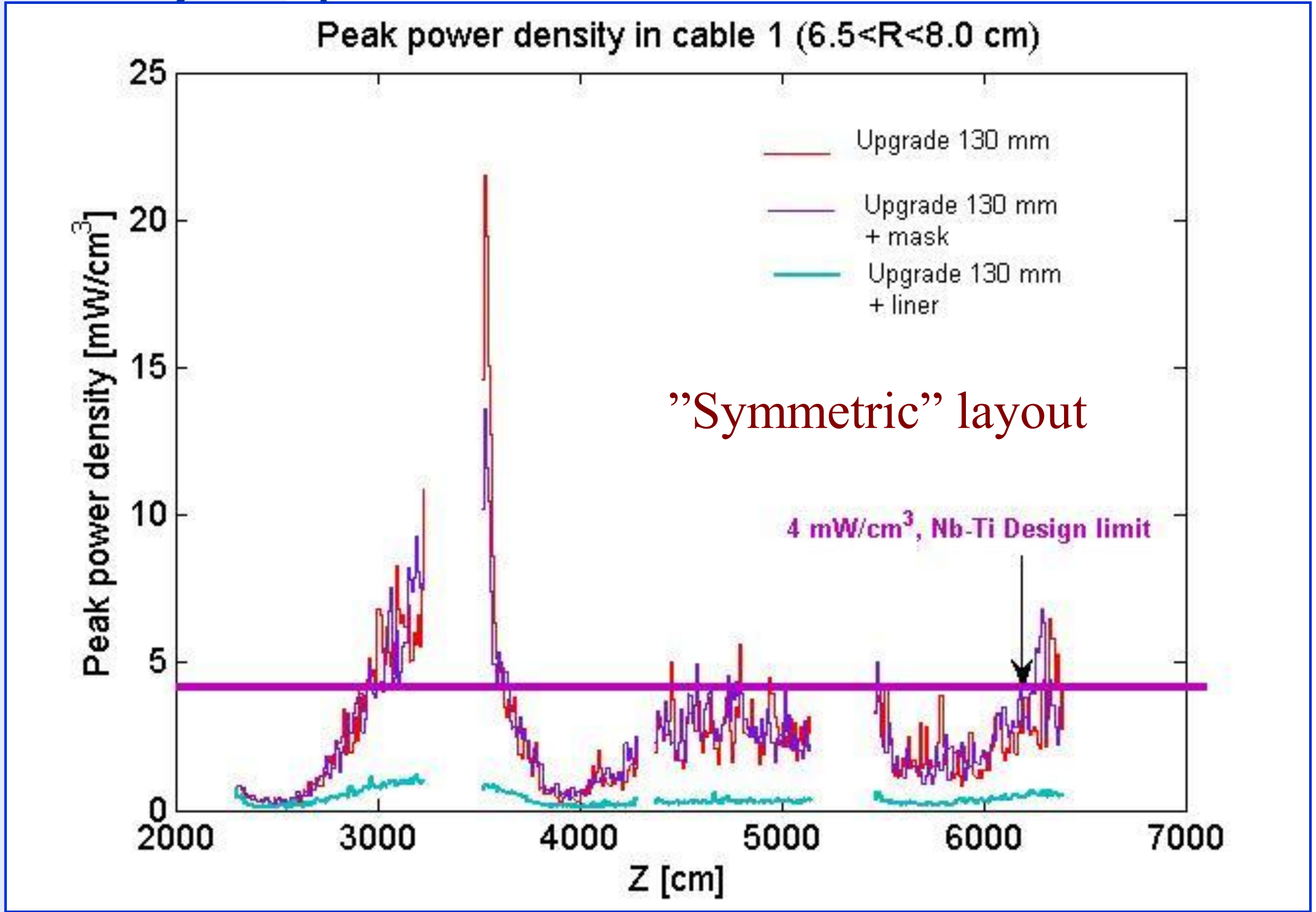
Cables





E. Wildner

Peaks, with mask and liner

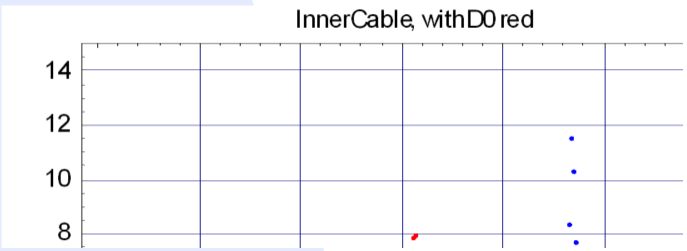


- Mask 1cm in tungsten
  - 21.5 mW/cm^3 to 13.6 mW/cm^3
  - -36 % decrease of the peak:
- Liner 2cm in stainless steel
  - -95% decrease of the peak
  - 21.5 mW/cm^3 to 1.1 mW/cm^3

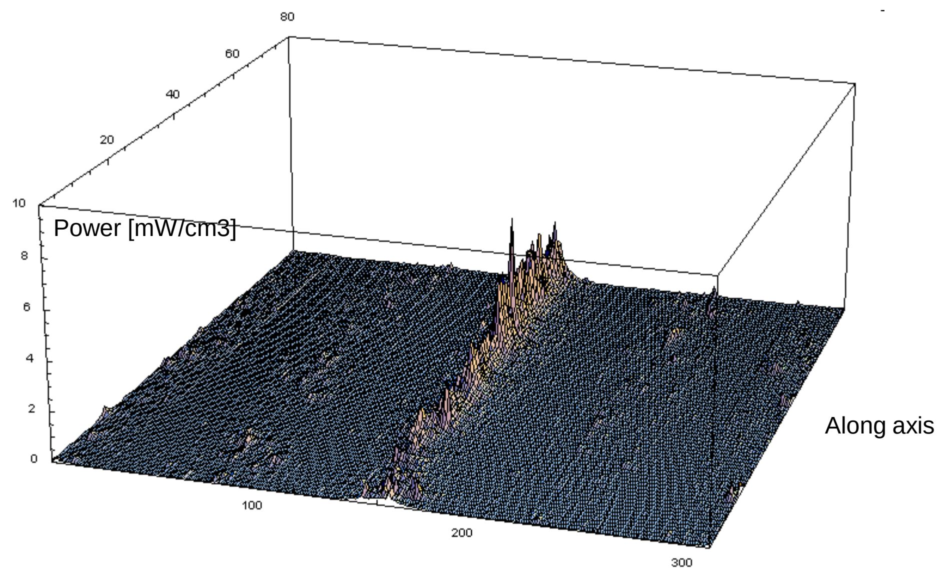
Peak of deposited energy with D0

Peak in second magnet, red with D0 on

Power [mW/cm3]



Azimuth [degrees]

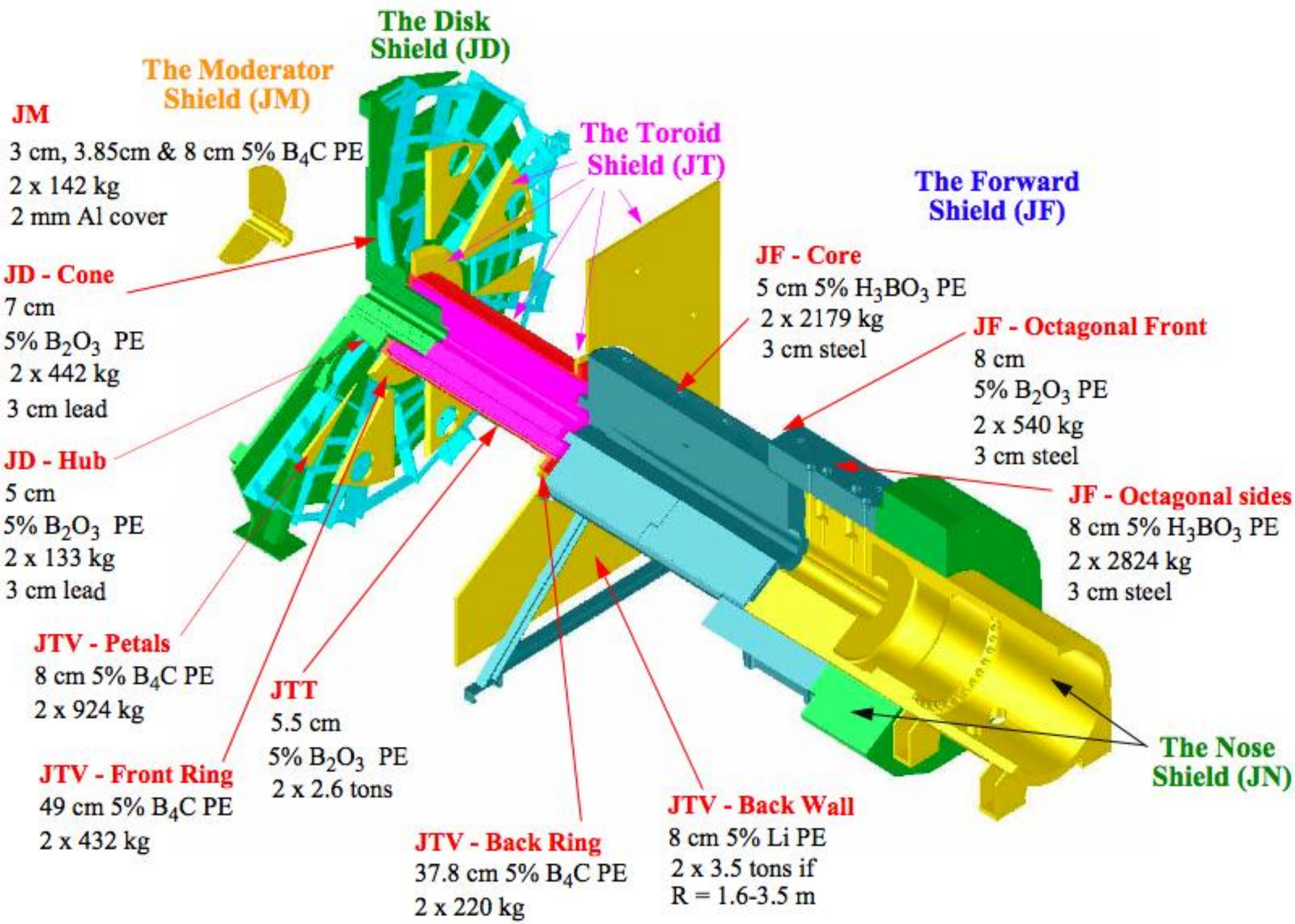


E. Wildner

Summary

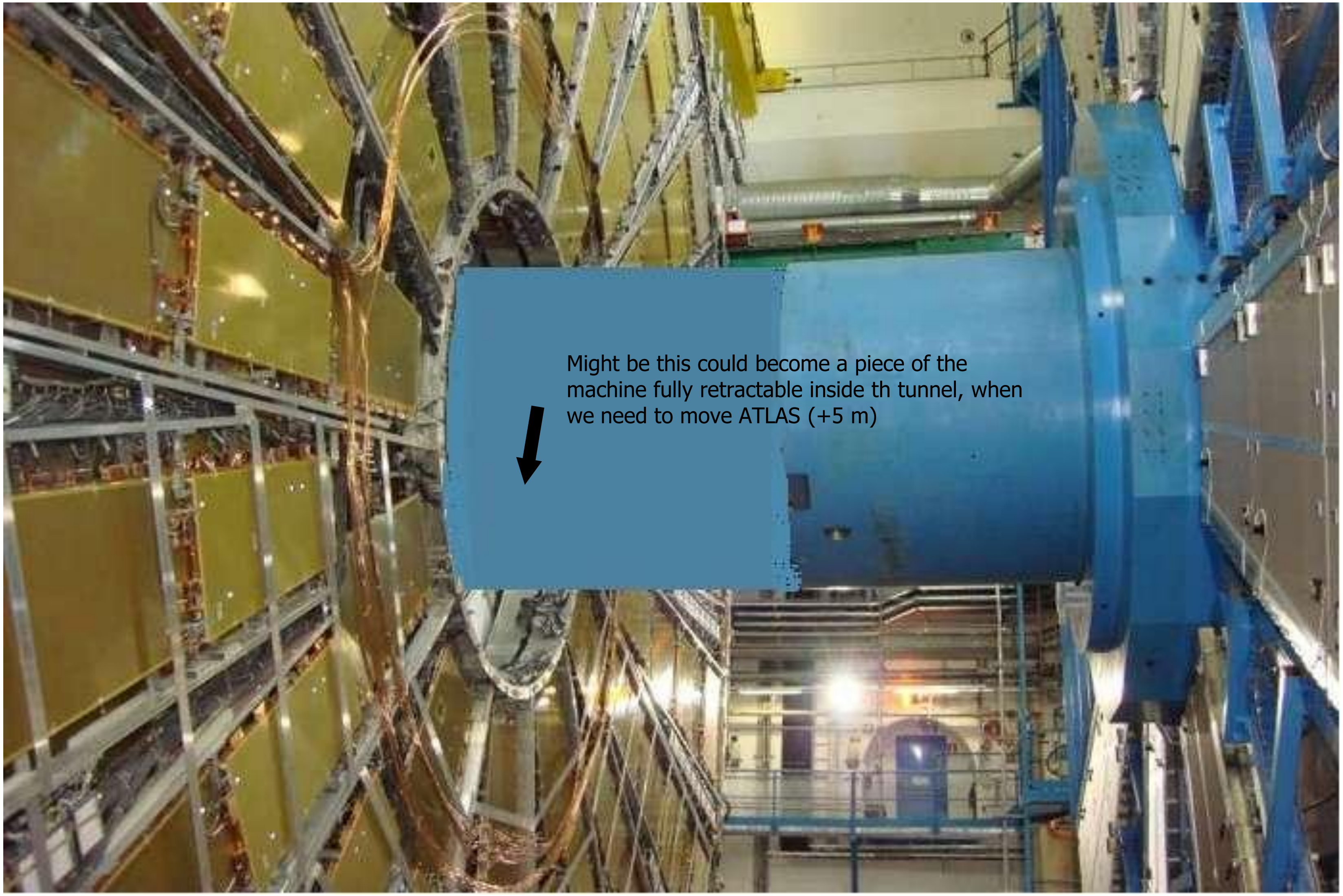
- Scenarios overall similar: they all have high peak deposition
- “Compact 1” (large aperture) most favorable
- A liner of 2 cm reduces the deposited peak energy to ~1 mW/cm3 along the magnets (checked case: “Symmetric”).
- For the option Q0 we may need some more optimization (larger apertures).
- We may improve even more by magnetic arrangements (like D0)
- Crossing angle has a limited impact (<15 %)
- Optimization for L= 1 E 35 $cm^{-2}s^{-1}$ seems a possibility (magnets)
- Backscattering to experiments?

Shielding details



M. Nessi

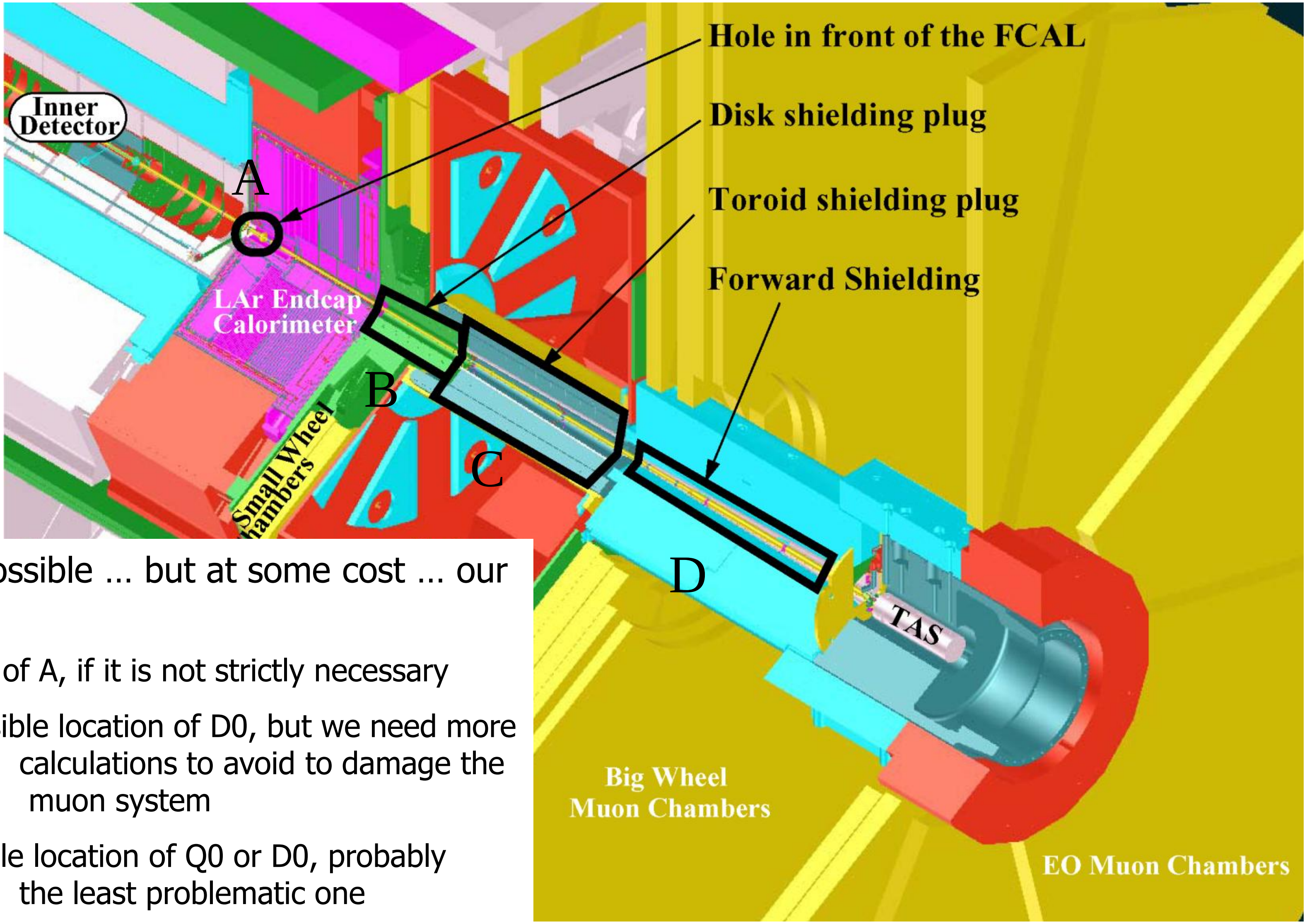
JF /JN region layout (future?)



M. Nessi

Summary: Possible locations we were discussing

M. Nessi



All are possible … but at some cost … our advice:

- stay out of A, if it is not strictly necessary
- B,C possible location of D0, but we need more calculations to avoid to damage the muon system
- D possible location of Q0 or D0, probably the least problematic one
- A new TAS can just be studied in the last 2m of JF, very difficult elsewhere

SLHC is about the physics!

- We should be led by getting the best physics out of an upgraded machine/detector
  - Not by the highest peak luminosity
  - Even largest integrated luminosity may not be the most important metric
  - Issues
    - Integrated luminosity
    - Backgrounds
    - Acceptance
    - Pile-up

Some Physics themes

- Different physics channels require different conditions
- Three main directions
  - Damn the torpedos - FULL Luminosity
  - Lots of quality luminosity
    - Luminosity leveling?
  - Forward acceptance
- We won't know which is the most important until we have first data from the LHC
  - Important not to eliminate a physics opportunity until we are sure it makes sense to do so

Conclusions

- Without optics change, not much need for changes to the forward regions and shielding of CMS
  - Tracker will be the major change
- Pile-up studies are underway
  - Tools now developed, but still some time before we can make a definitive statement on how much pile-up we can withstand
- Changes to the IR can lead to rather costly changes to the CMS infrastructure
  - May be possible to accommodate, but many unresolved issues
    - Can we retain forward calorimeter acceptance
      - Do we need to look at instrumenting D0?
      - Do we need a new HF, new geometry? Very expensive - what happens to the new tracker?
    - Can we build a magnet compatible with CMS operation (ie maintenance, backgrounds induced in the detector)
    - What happens to the shielding/backgrounds if there are substantial changes to the forward region

round-table discussion after sessions 4-6

(chaired by S. Peggs)

Nov 8, 2007

IR07 Thursday afternoon Round Table

How to model a magnet – constant distributed body harmonics plus delta function ends?

Include beam-beam in IR correction analysis?

Need to see what beam will show – accelerator & detector – before finalizing (even) Phase-1 design?? How much/when?

What optics for the Phase-1 upgrade? (Eg, for JIRS use when preliminarily evaluating 4 Q3 and/or 4 D1 Nb3Sn magnets?)

Compact-1? Symmetric? LowBetaMax?

Propose which upgrades and/or tests for installation ASYNCHRONOUSLY with respect to Phase-1 & Phase-2?

INTEGRATION

- Field quality tables – IN or OUT (Mag/Acc. Physicists)?
- Accelerator & detectors, Q0s & D0s
- Working groups – Beam Dynamics / LIUWG / JIRS /…
- Phase 1 – magnets / collimators / IR7
- Nb3Sn & NbTi

An integrated (buried) quad singlet is more or less interesting than quad doublets?

How to compare Q0 and D0 schemes?

Timeline for full (more complete) analyses of buried magnets & TASses? Asymmetric solutions ok?

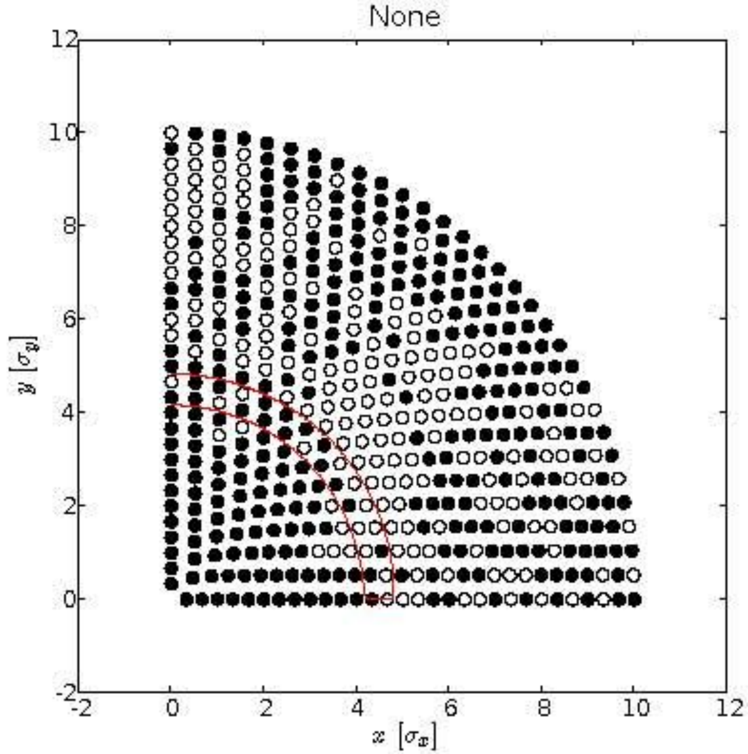
ATLAS: JM, JD, end cap, JF?

CMS: Possibility of complete rejection?

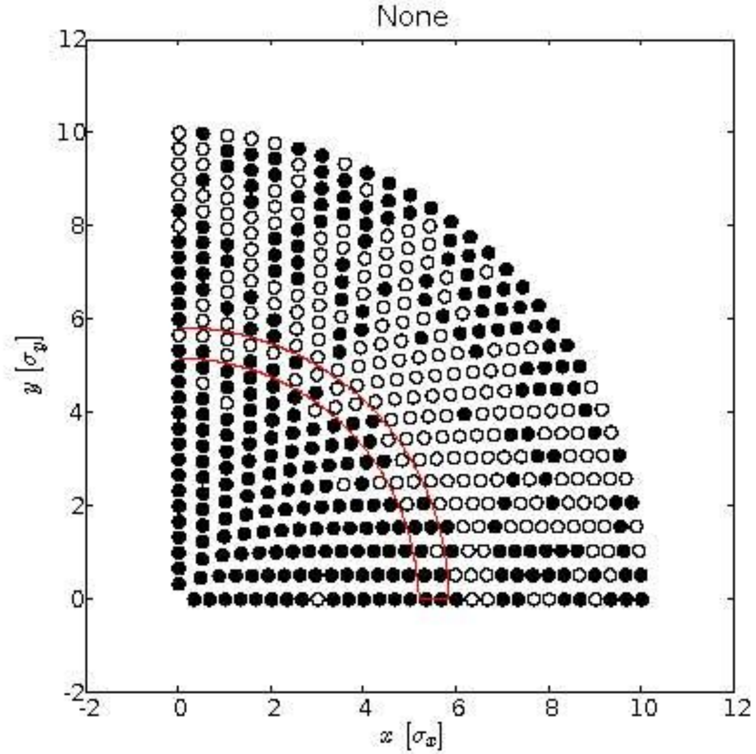

ZEUS

DA with nominal p/bunch

1.15E11 beamcurrent:



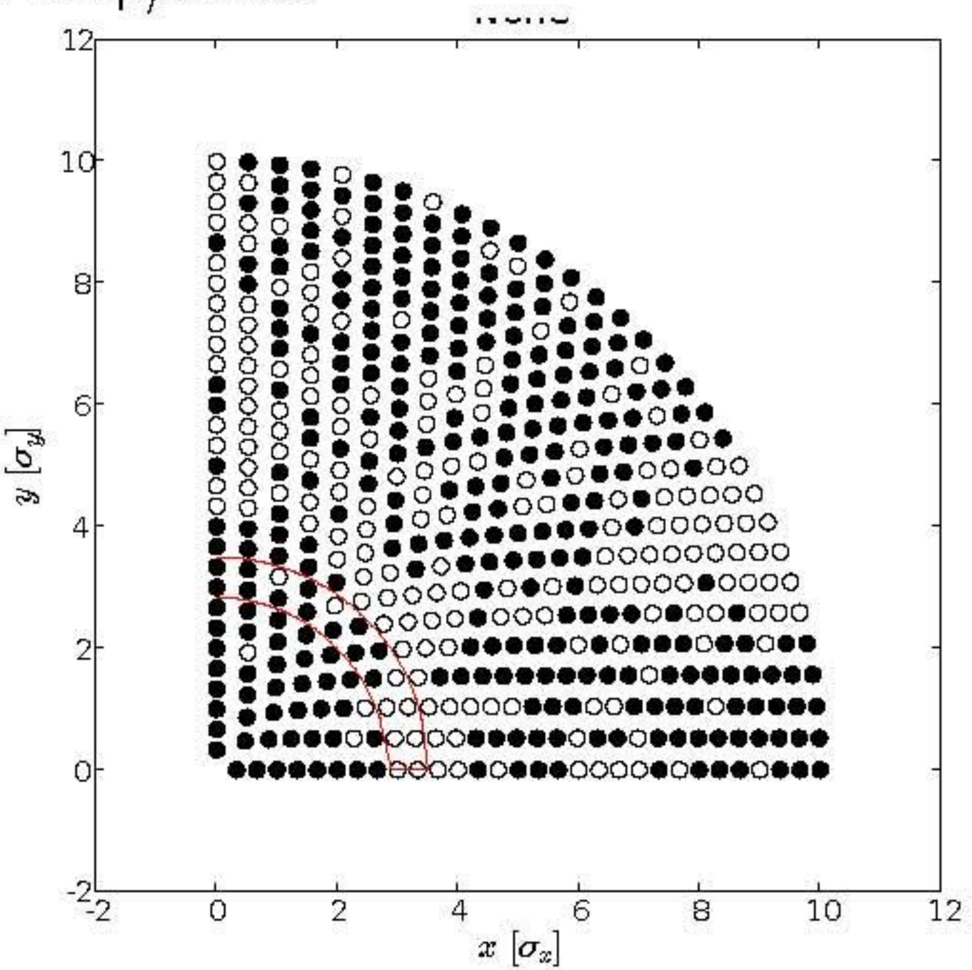
(a) stability for the D0 option



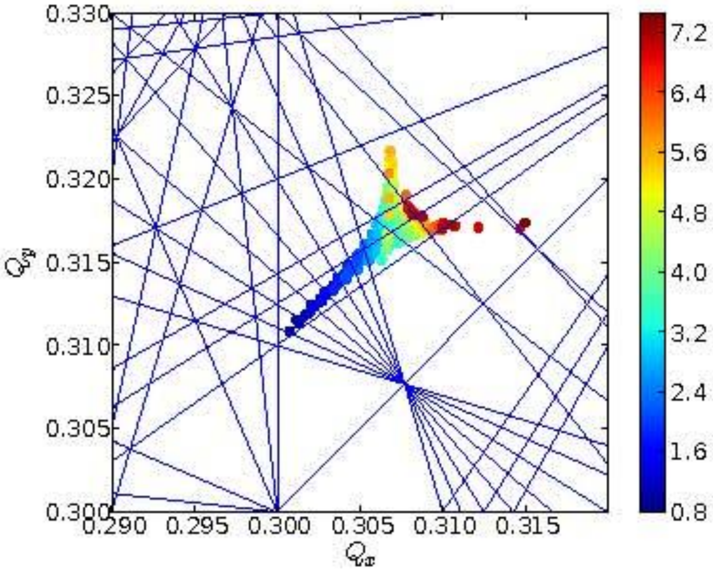
(b) for comparison the stability in the base line low β max optic

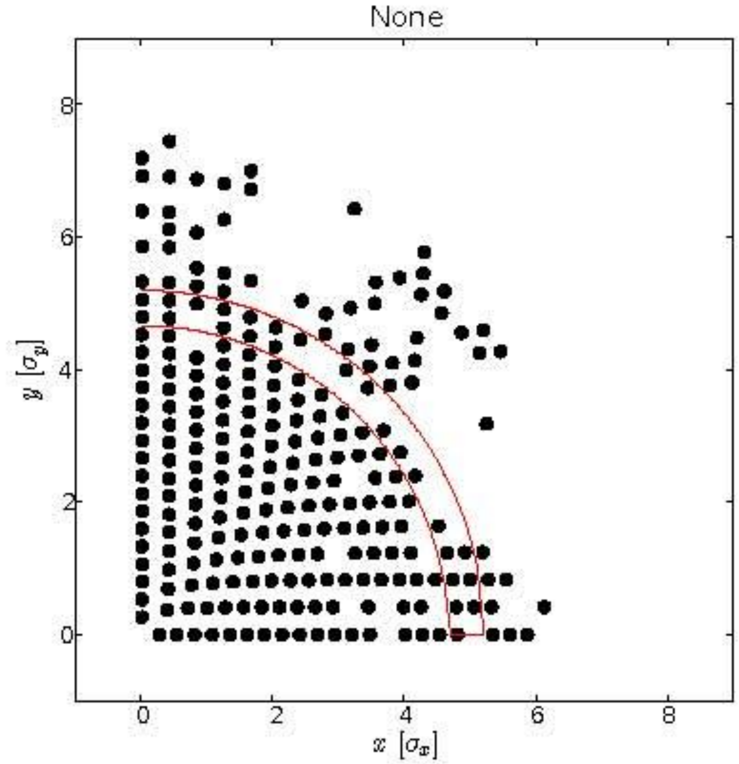
What about the planned beam current

1.7E11p/bunch

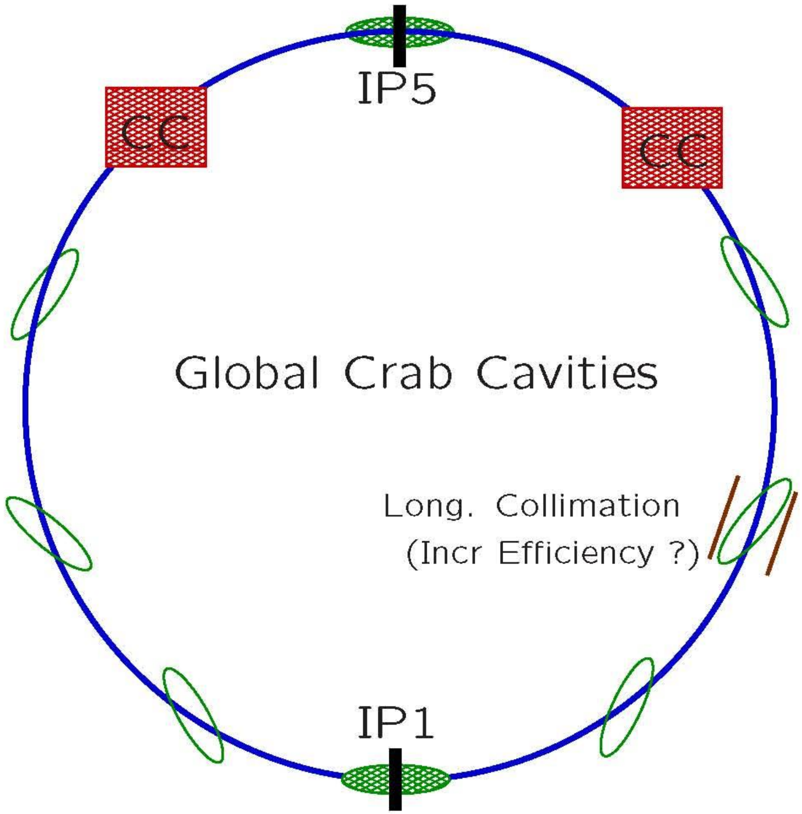


Needs a electron lens for compensation!

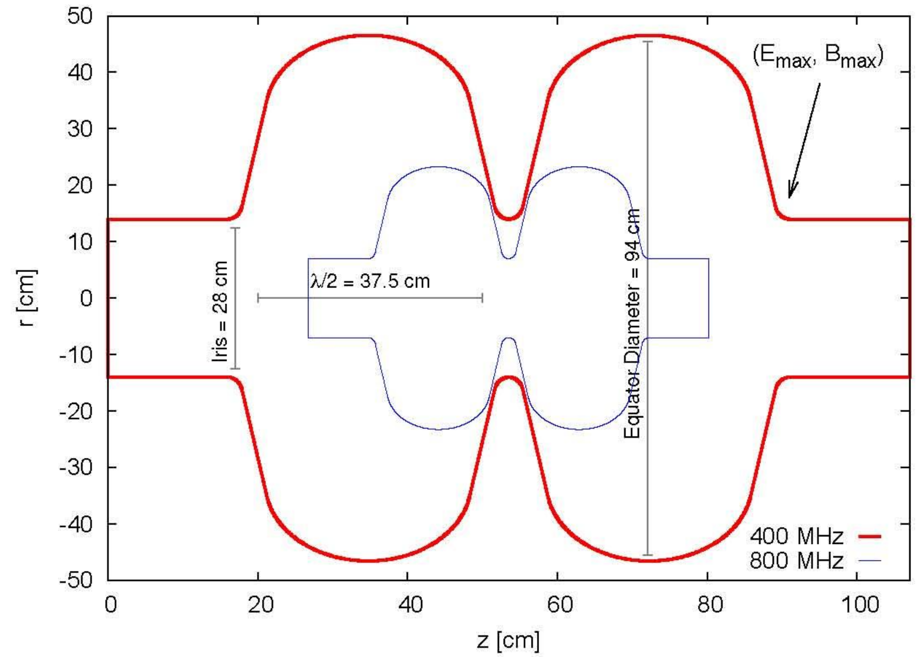

0.330
0.325
0.320
0.315
0.310
0.305
0.300
Q_y
0.290 0.295 0.300 0.305 0.310 0.315
Q_x
7.2
6.4
5.6
4.8
4.0
3.2
2.4
1.6
0.8


None
8
6
4
2
0
$y\ [\sigma_y]$
0 2 4 6 8
$x\ [\sigma_x]$

Small θ_c (0.3-0.6 mrad)



β^*	25 (15) cm
Deflecting Voltage	8.31 (10.73) MV
E_{peak}	< 60 MV
B_{peak}	< 150 mT
RMS Orbit	0.35 (0.45)mm
Peak Orbit	2.4 (3.0) mm
Tune Shift $\{Q_x, Q_y\}$	$\{0.5,1.2\}\times10^{-4}$

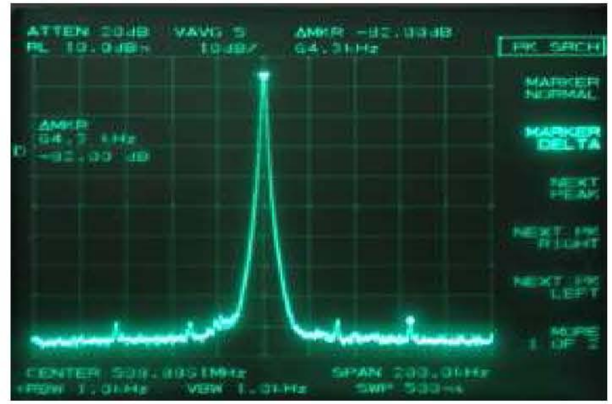


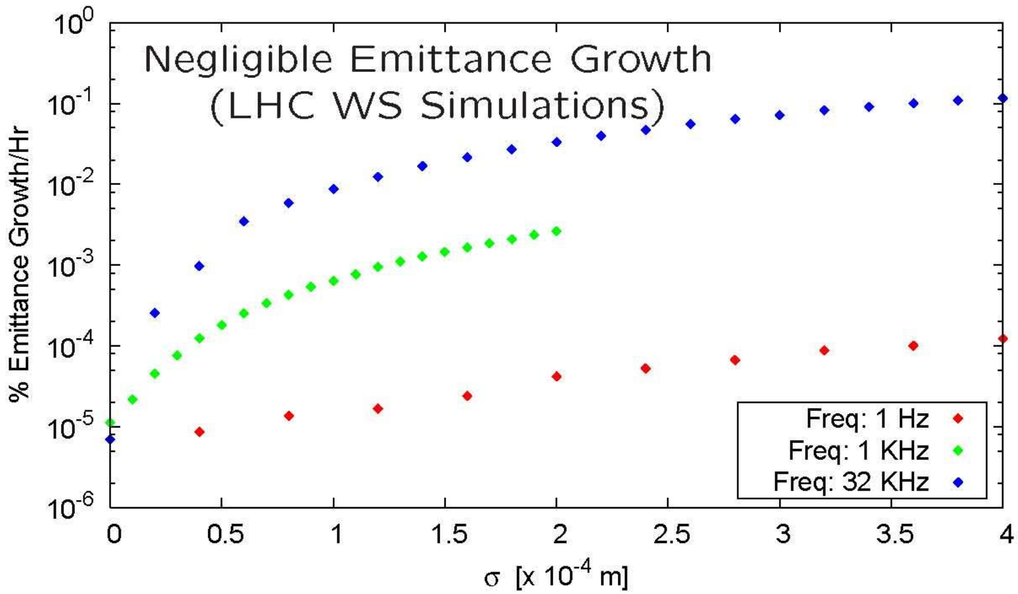
$$V_{crab} \propto \frac{1}{\omega_{rf}\beta^*} \quad \{\theta_c \sim \frac{1}{\sqrt{\beta*}}\}$$

R. Calaga

Modulated Jitter

Span 200 Hz KEK-B Span 200 kHz

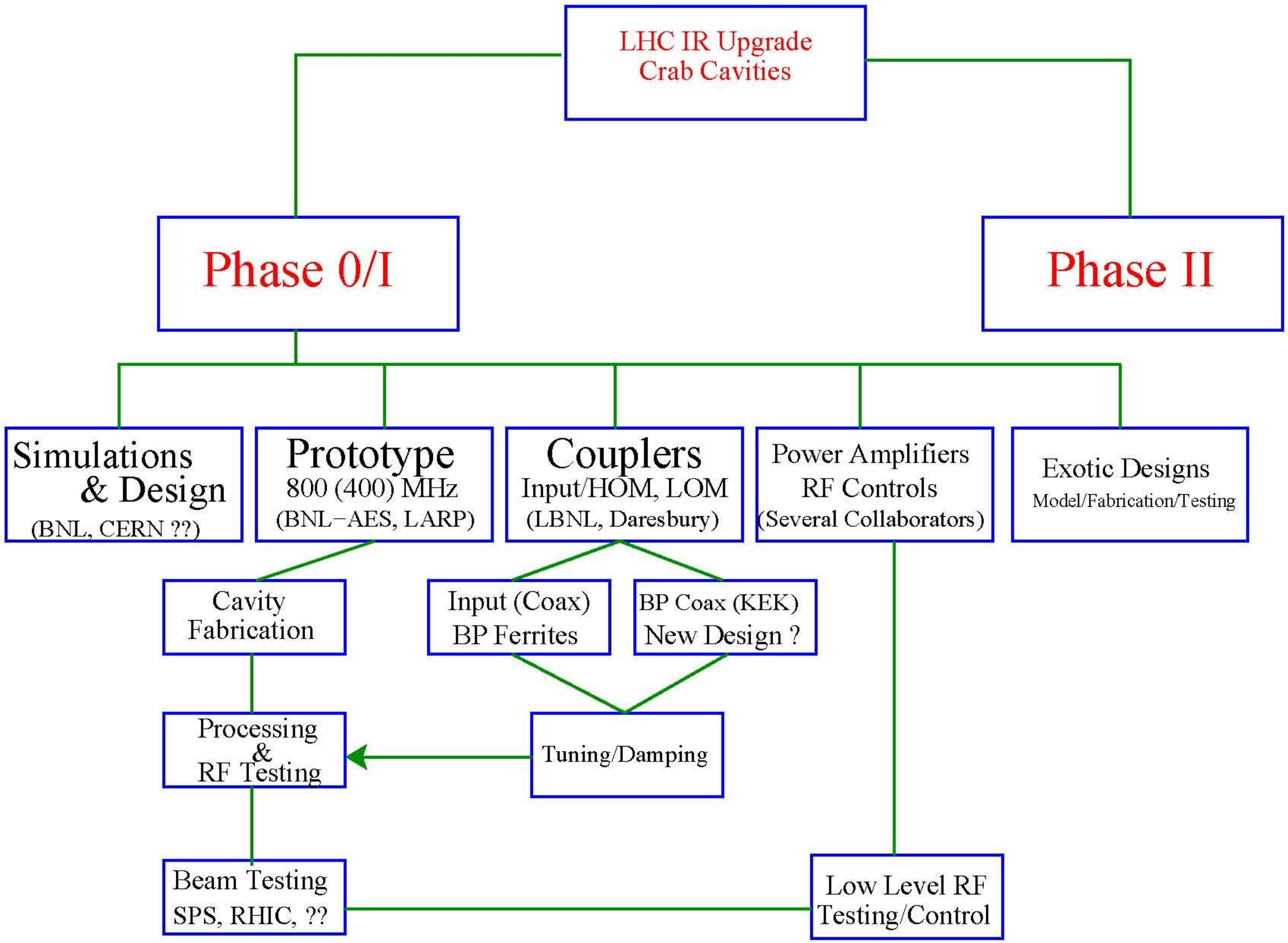




—— Measurements courtesy KEK-B

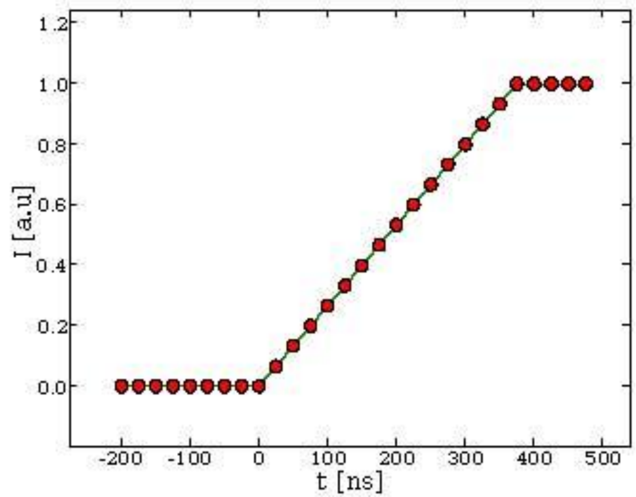
R. Calaga

A Preliminary R&D Proposal

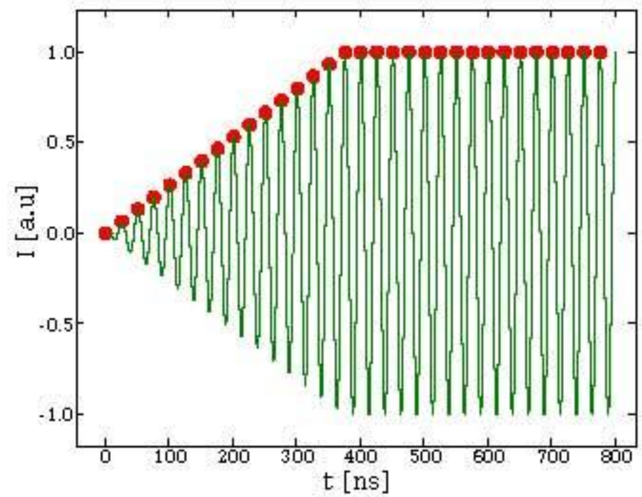


R. Calaga

WHAT IS A RF-BBLR?

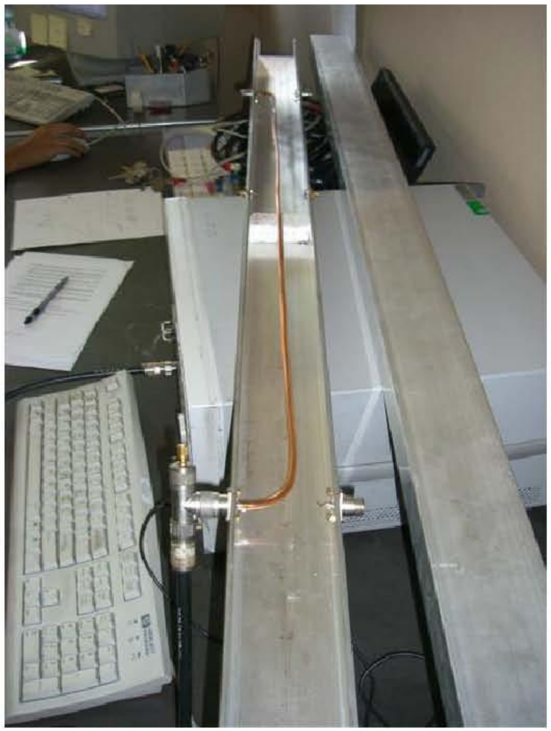


(d) pulsed DC BBLR

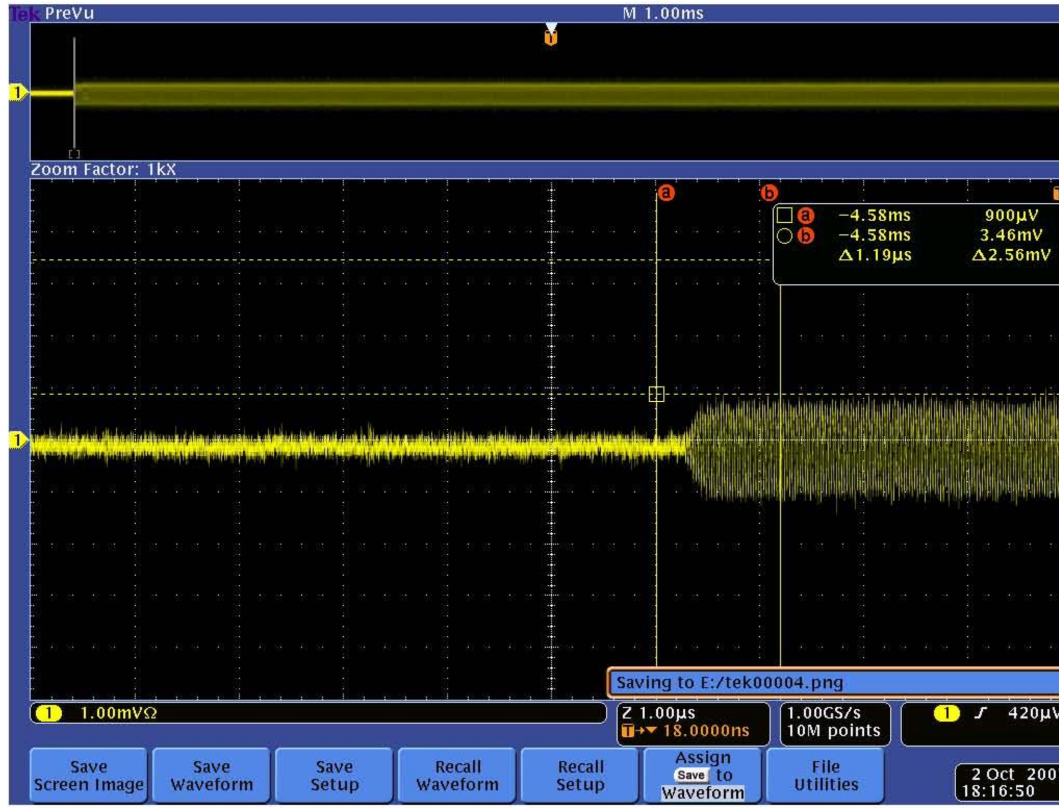


(e) RF-BBLR

EXPERIMENTAL SETUP

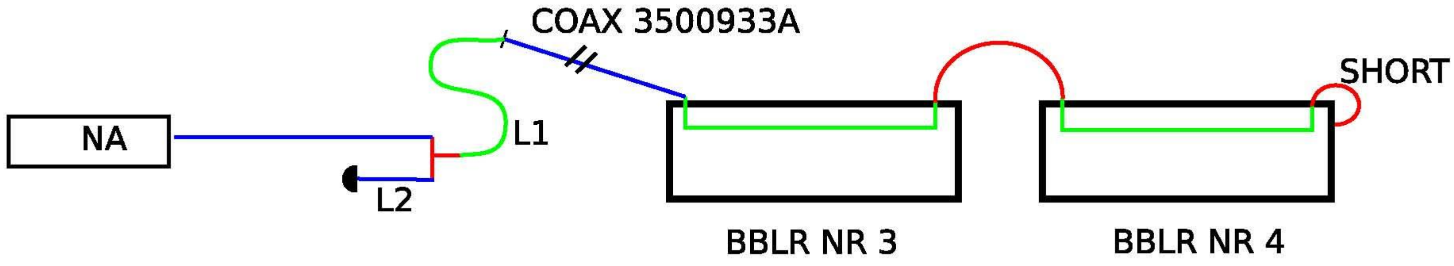


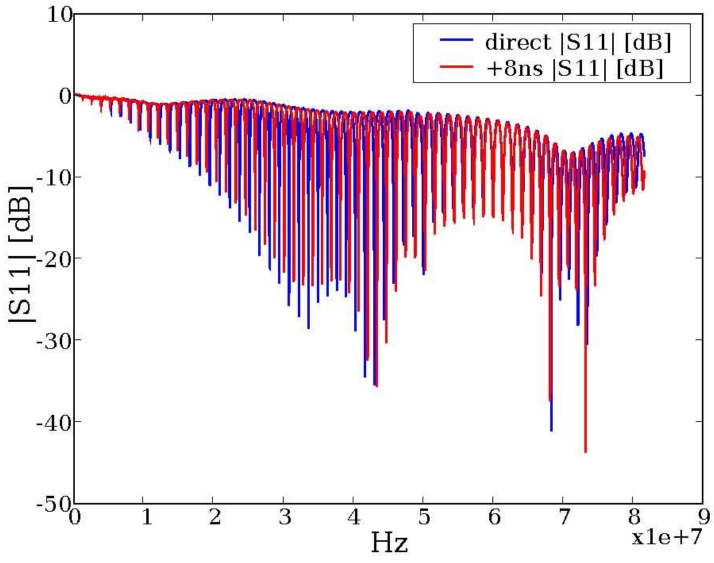
Experimental setup

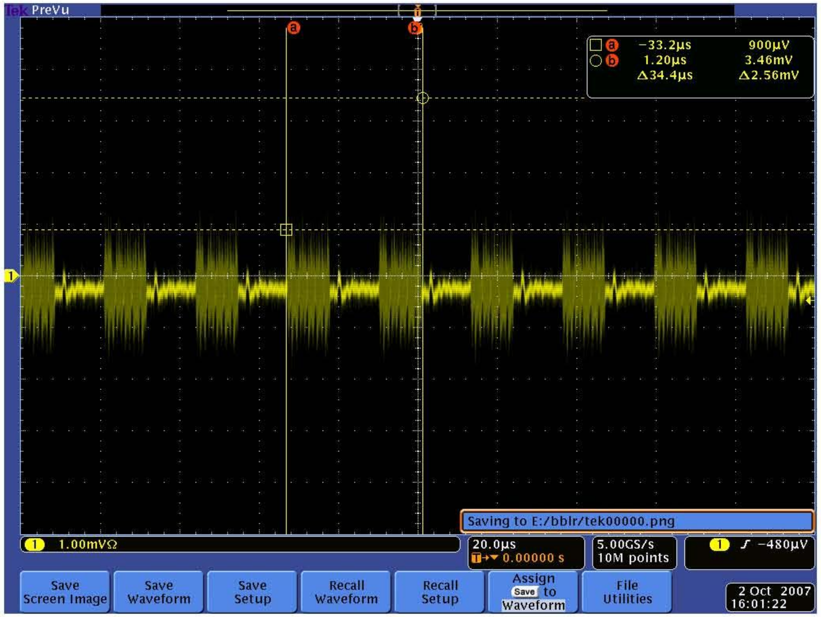


first RF-BBLR

SPS BBLR


COAX 3500933A
NA
L1
L2
SHORT
BBLR NR 3
BBLR NR 4


direct |S11| [dB]
+8ns |S11| [dB]
|S11| [dB]
Hz
x1e+7


Saving to E:/bblr/tek00000.png
20.0µs
5.00GS/s
10M points
Save Screen Image
Save Waveform
Save Setup
Recall Waveform
Recall Setup
File Utilities
2 Oct 2007
16:01:22

round-table discussion

after session 7

long-range beam-beam is getting tougher but no show-stopper

wire compensator important for phase 1 and even before; ~2 sigma gain in aperture

how many low-distance LR encounters can be accepted?

- **beam energy, lattice, chromaticity, tunes,…**
- **experience/experiments at Tevatron, RHIC, SPS**
- **reliable simulation tool**
- **head-on important**

can we open collimators to 9 sigma if dynamic aperture is at 5-7 sigma? (→ Coll. Team)

wire successful at DAFNE (higher average luminosity); good understanding; can compensate with octupole

SPS experiments at 37 and 55 GeV indicate threshold

dc wire does well, RF BBLR does even better

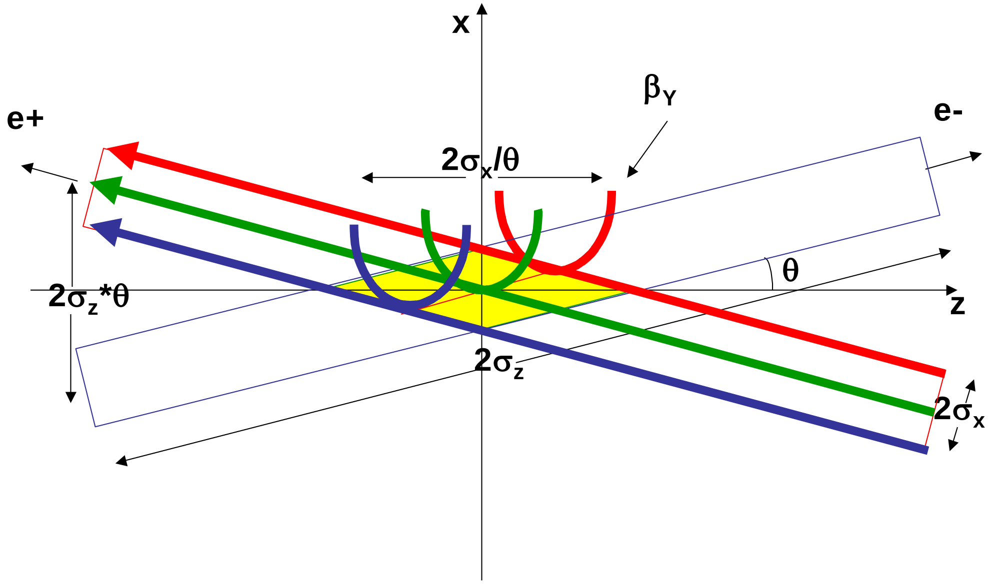
impact of crab cavities on collimation? (→ Coll. Team)

funding: - BBLR for LHC
- RF BBLR prototype
- crab cavity prototype – SBIR

M. Zobov

Crab Waist in 3 Steps

1. Large Piwinski's angle $\Phi = tg(\theta)\sigma_z/\sigma_x$
2. Vertical beta comparable with overlap area $\beta_y \approx \sigma_x/\theta$
3. Crab waist transformation $y = xy'/(2\theta)$



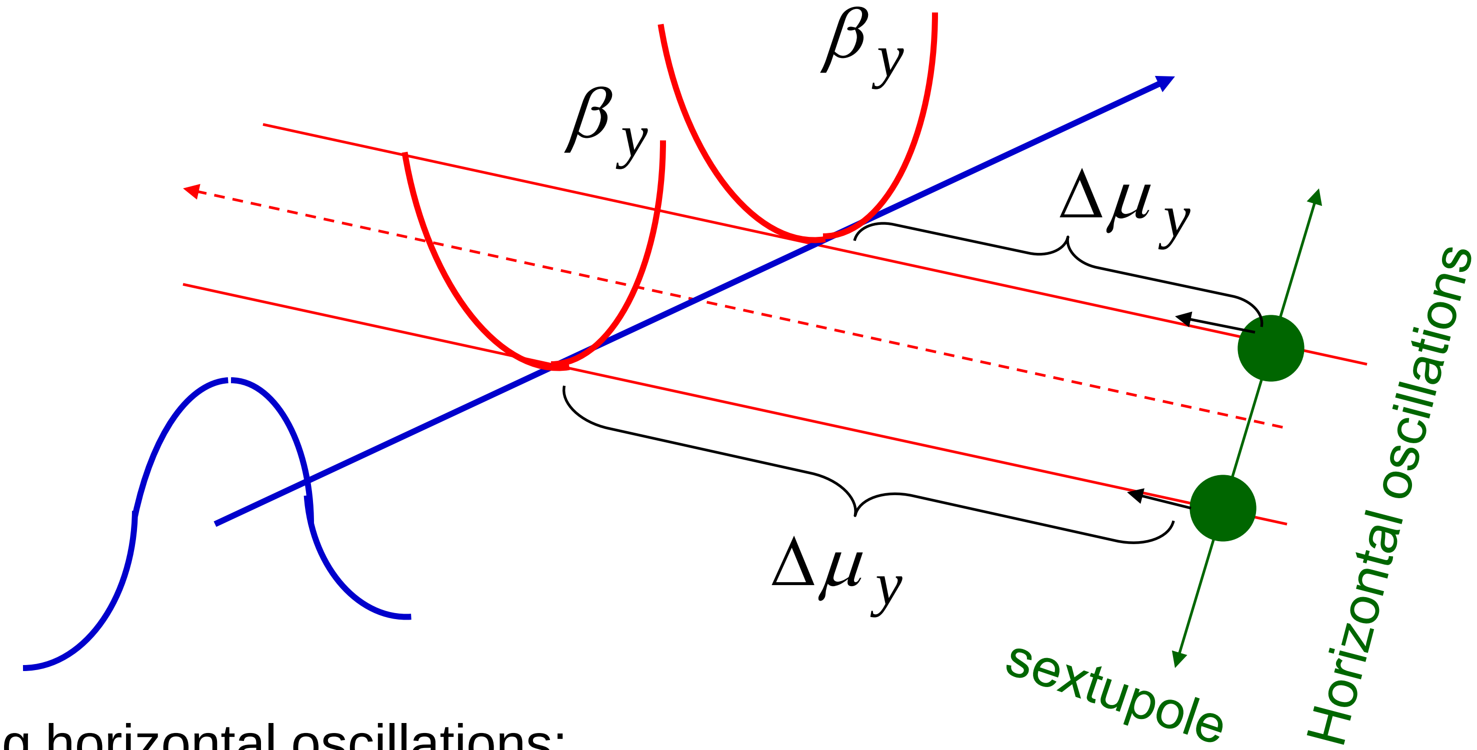
Crabbed waist is realized with a sextupole in phase with the IP in X and at $\pi/2$ in Y

1. *P.Raimondi, 2° SuperB Workshop, March 2006*

2. *P.Raimondi, D.Shatilov, M.Zobov, physics/0702033*

M. Zobov

Suppression of X-Y Resonances



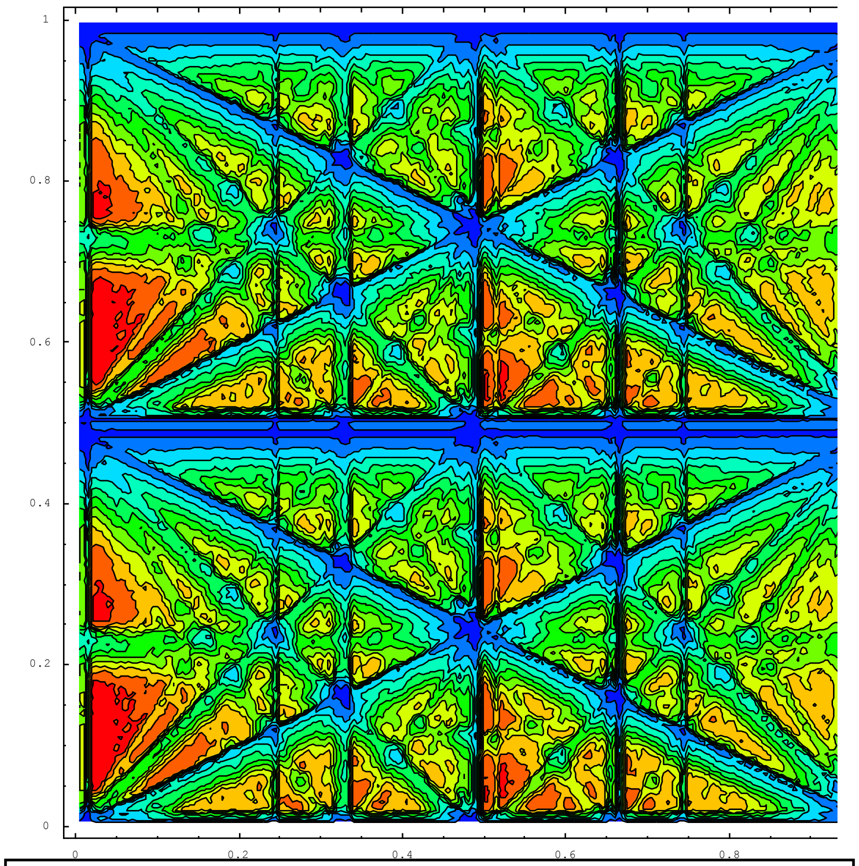
Performing horizontal oscillations:

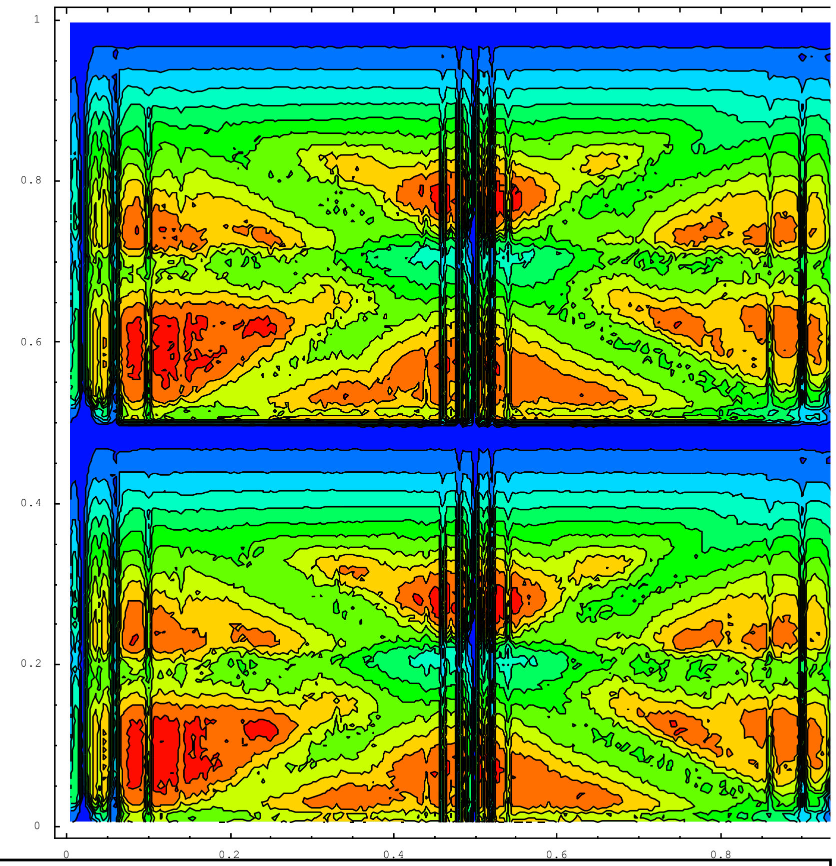
1. Particles see the same density and the same (minimum) vertical beta function
2. The vertical phase advance between the sextupole and the collision point remains the same ($\pi/2$)

M. Zobov

X-Y Resonance Suppression

Much higher luminosity!





Typical case (KEKB, DAΦNE etc.):

1. low Piwinski angle $\Phi < 1$
2. β_y comparable with σ_z

Crab Waist On:

1. large Piwinski angle $\Phi >> 1$
2. β_y comparable with σ_x/θ

Weak-Strong Beam-Beam Simulation for DAΦNE Upgrade

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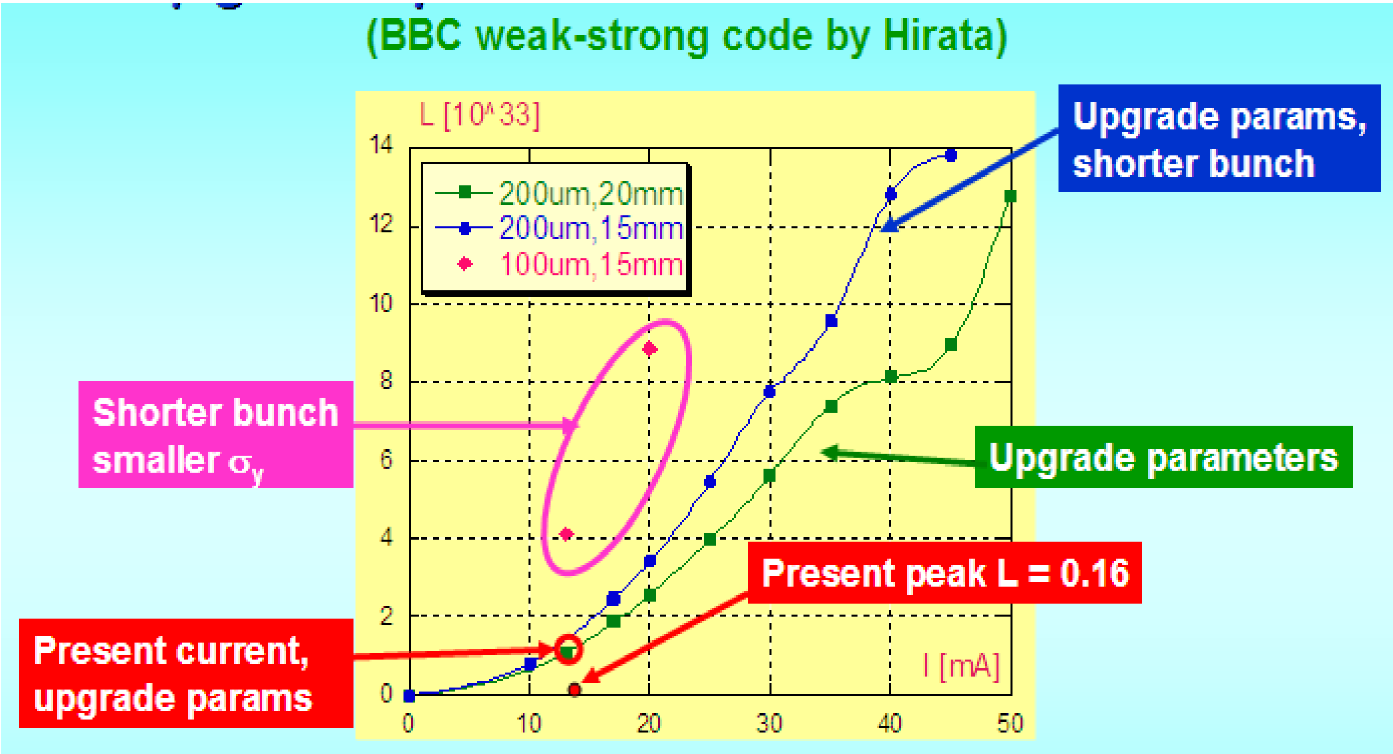

1. With the present DAΦNE parameters (currents, bunch length etc.) a luminosity in excess of 10^{33} cm^{-2} s^{-1} is predicted
2. With 2A on 2A more than $2x10^{33}$ is possible
3. Beam-beam limit is well above the reacheable currents

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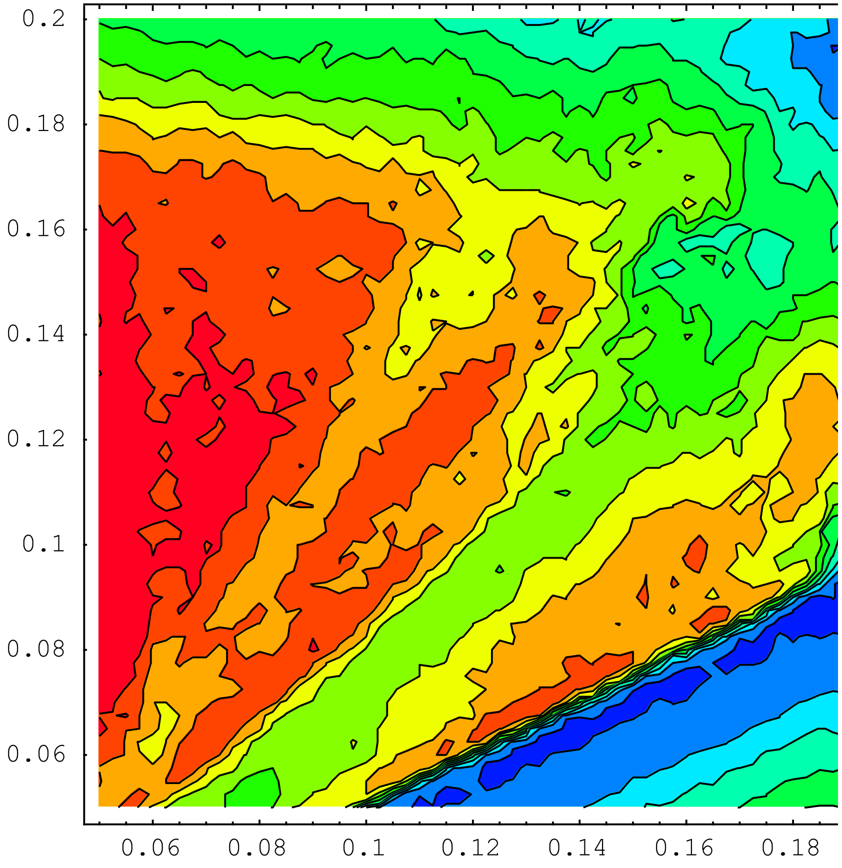
Luminosity vs tunes scan

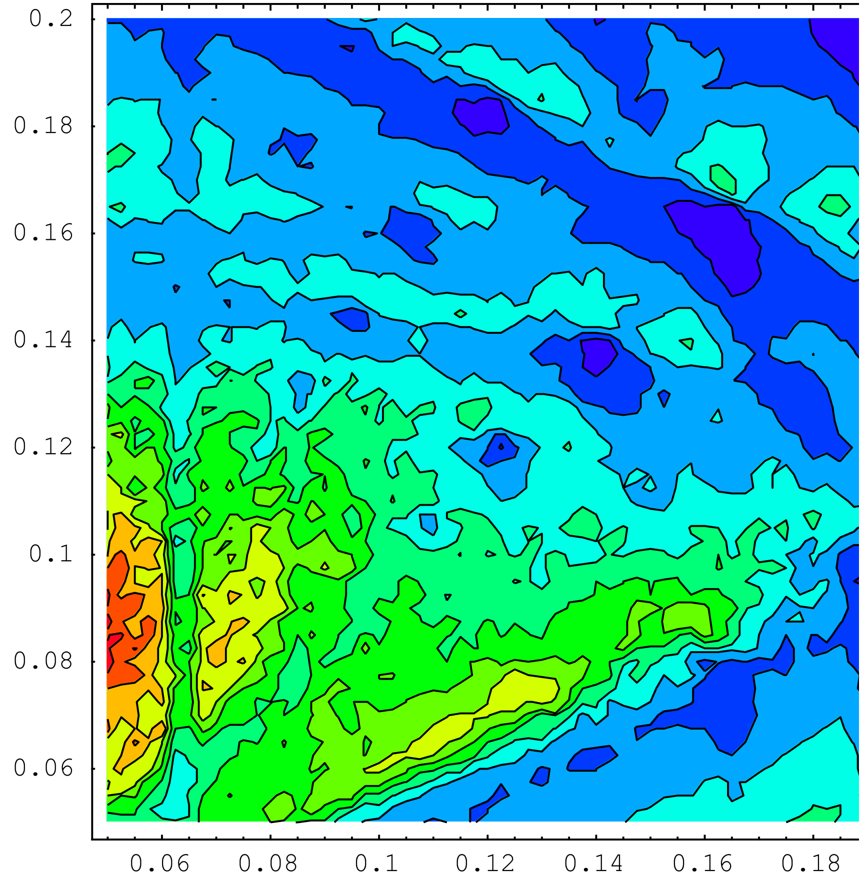
Crab On → 0.6/θ



L_{max} = 2.97x10^{33} cm^{-2}s^{-1}

L_{min} = 2.52x10^{32} cm^{-2}s^{-1}

Crab Off



L_{max} = 1.74x10^{33} cm^{-2}s^{-1}

L_{min} = 2.78x10^{31} cm^{-2}s^{-1}

final round-table discussion and conclusions

questions in final round-table discussion
(animated by Walter and Frank)

strategy for scenarios

leveling & large Piwinski angle – where, how, real test?

when & where trade off between experiments and accelerator?

strategy for magnets

strategy for wires

strategy for crab cavities

strategy for crab waist in hadron colliders

strategy for scenarios

time to converge?!

triplet convergence should be easy, also longest lead time!

D0 or crab cavity for low beta*

higher current in parallel

decouple upgrade components?!

wait for beam before optimizing phase 2 and even phase 1? “what will beam say?”

input to experiments should come now

“need to take risk”

“phase 2 only crab cavities?”

leveling & large Piwinski angle – when, where, real test?

RHIC?, LHC?

- orbit angle with D0
- crab voltage

beta*, could be done from the start

for experiments of interest only for phase 2;

but angle leveling useful for raising beam current above bb limit

IP feedback will assist or perhaps not (RHIC)

strategy for magnets - phase-1 hybrid option

cost, technicalities – power supplies,...?

large aperture D1 as standalone object could be another possibility, asynchronous with phase 1

definition of D1 for phase 2 today? dependence on optics solution; D1 also challenging

time scale; not trivial to make decision now

130 mm from collimator requirements

Nb_3Sn options

financial aspects

strategy for wires

“install as soon as possible in LHC”
or rather
“install as soon as beam current requires it”
paid from operations budget?

strategy for crab cavities

local vs global

small angle vs large angle

“gain experience with small angle crab in phase 1, then could go to large angle in phase 2”

need feedback from collimation

global: most attractive to start with (cheapest, easy to adjust and to go back)

nicely fits to US program

inclusion in FP7?

strategy for crab waist in hadron colliders

could be useful in conjunction with higher brightness from injectors

β^* =15 cm x 30 cm flat optics with NbTi quadrupoles

perhaps a bit smaller with Nb3Sn

apply in large Piwinski angle regime?

combined with very low beta*

wait for DAFNE experience


thank you!