session 1: introduction & overview

welcome & program – Ilan Ben-Zvi

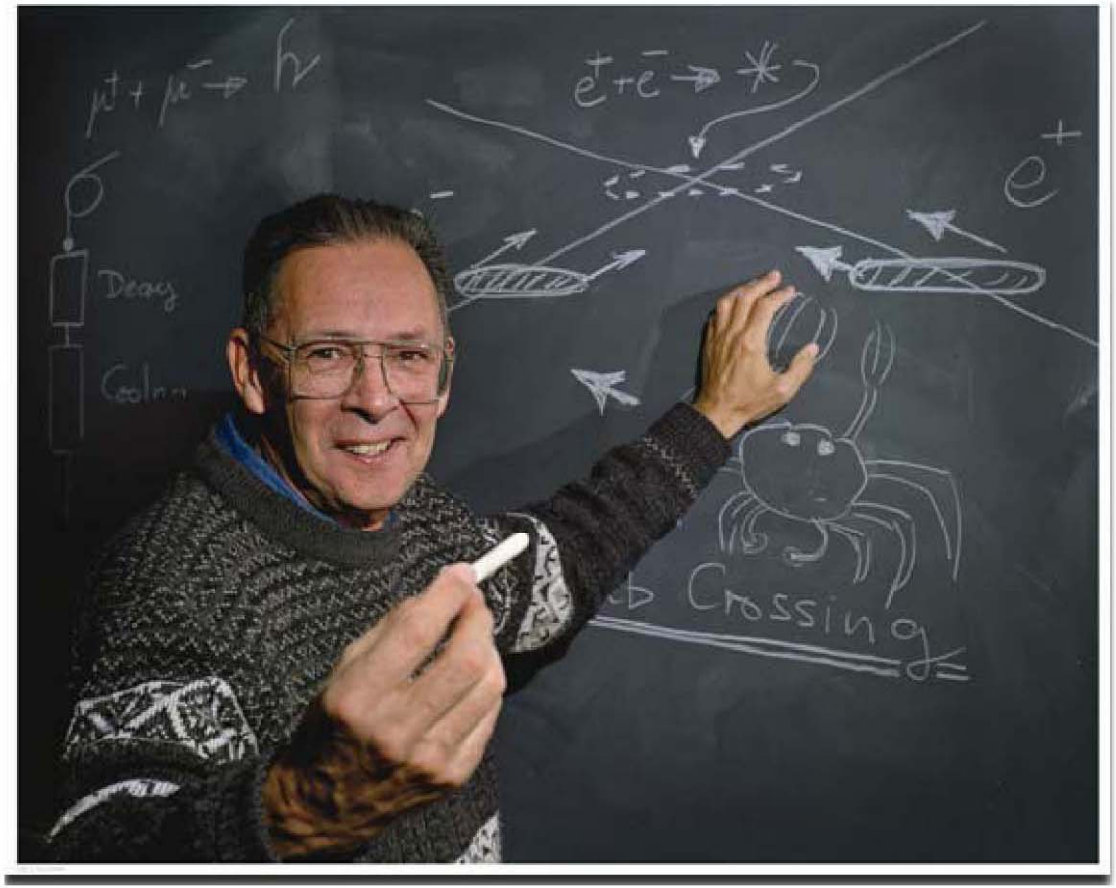
crab history & motivation – Robert Palmer

LHC crab scheme – Rama Calaga

SBIR phase-1 for 800 MHz prototype
– Mike Cole

Welcome LHC-CC08

Bob Palmer:
Two-in-one magnet
Crab crossing



Ilan Ben-Zvi

Collider-Accelerator Department BNL

goals (Ilan)

learn from KEKB

roadmap for LHC crab cavities

time line, time scales

work packages + distribution of tasks

decisions

global or local?, optics, small-angle

strawman? requirements for local scheme?

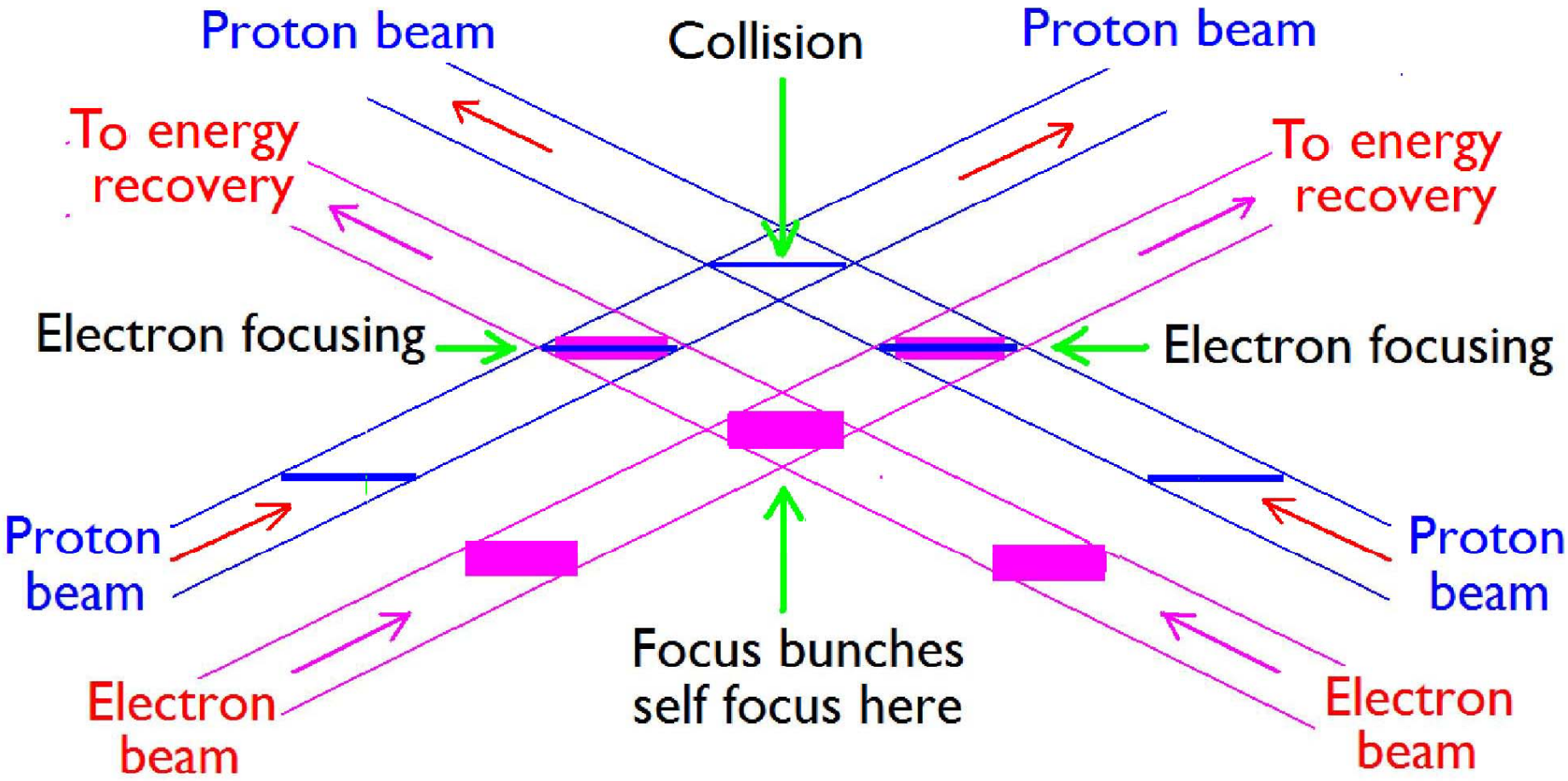
exotic cavities?, choice of rf frequency,

D1 magnet parameters?, engneering

challenges, R&D plan, AES cavity

how do we get started? installation in IR4?

Crab-Super-Disruption



One needs two more electron lenses after the IP to match back into the ring. Not shown here for simplicity. But you get the idea.

R. Palmer

Conclusion

R. Palmer

- Crab crossing was invented for linear colliders
- I never thought it would work in a ring

- Super-disruption was also invented for linear colliders
- I never thought it would work in a ring

- Perhaps I could be wrong twice
- Anyway, I wanted to say something you probably did not know

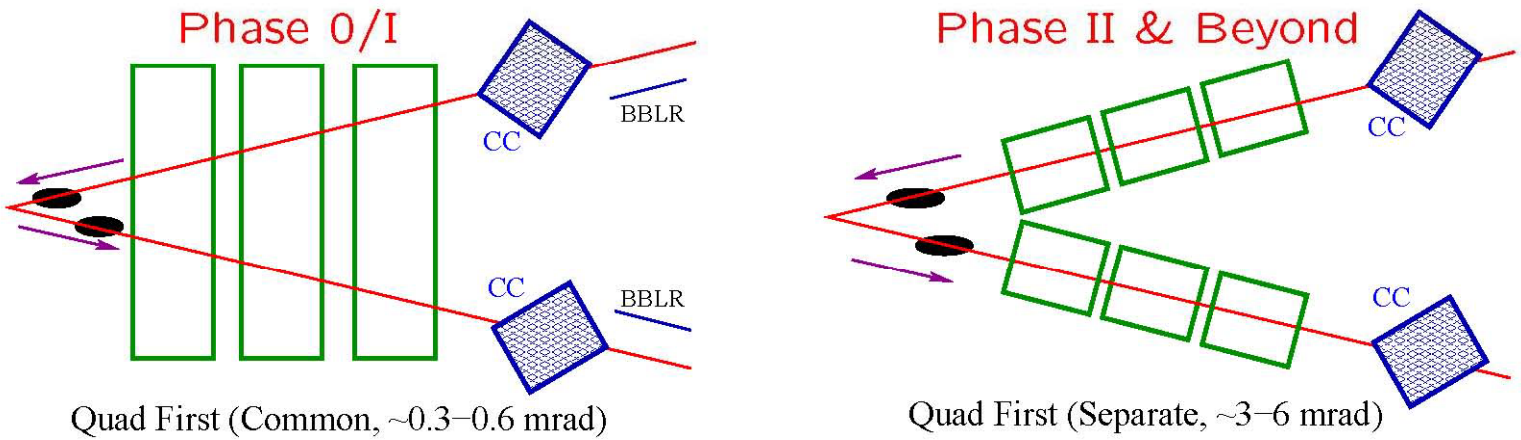
References

1. Crab Crossing: R.B.Palmer; Snowmass Proceedings p 631 (1988), and SLAC-PUB 4708 Dec 1988
2. Super Disruption: R.B.Palmer; SLAC-PUB 3688 (1985)
3. Linear Colliders: R.B.Palmer; Annual Rev. Nuclear Science (1990) 40: p529

Phased Upgrades

R. Calaga

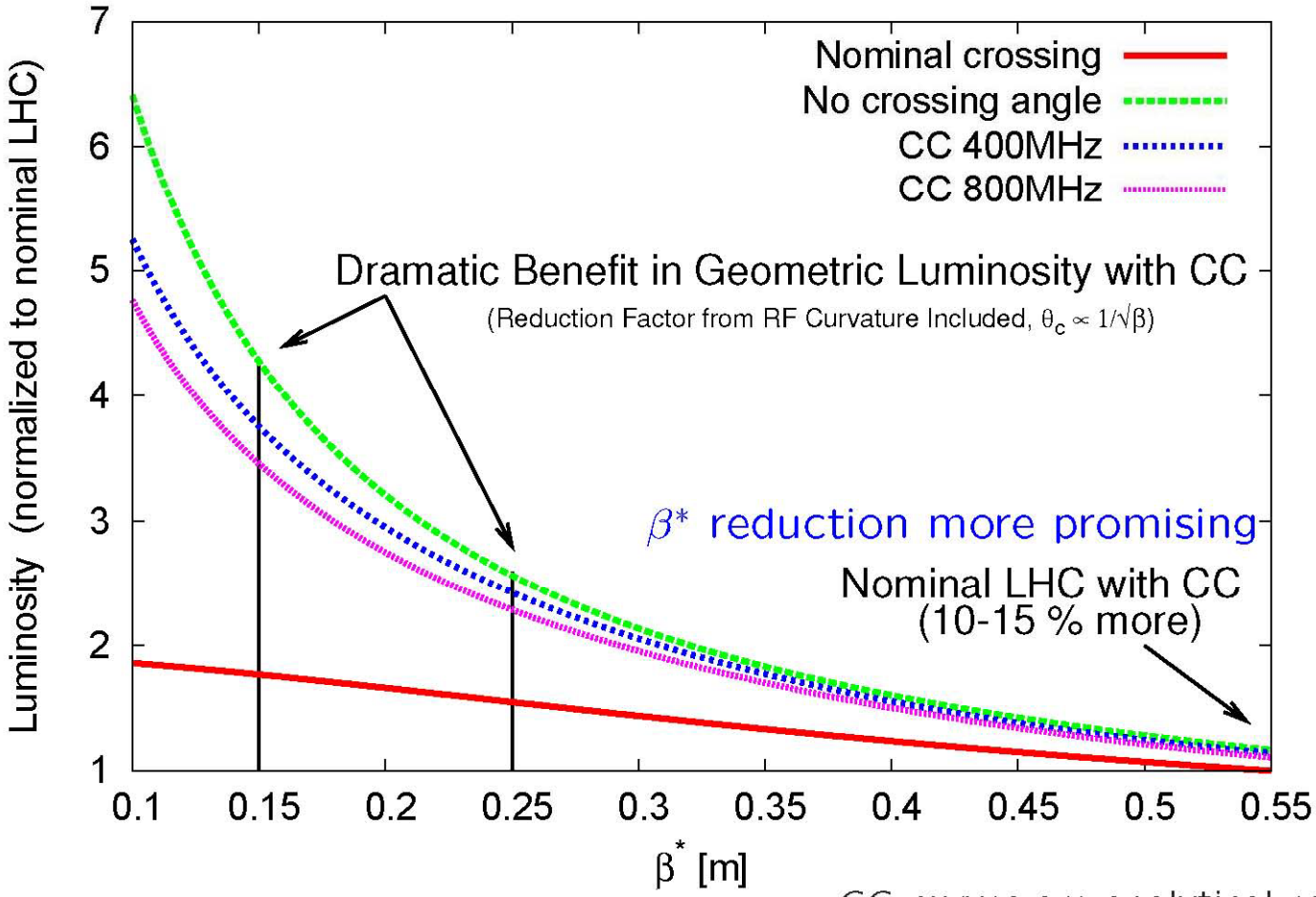
- Phase 0 (Nominal LHC):
  - One crab structure/beam (global cavities @IP4, circa 2010-11)
  - Test SRF limits in deflecting mode & beam testing in LHC/SPS/?
- Phase I (Minimal β^* IR Upgrade, circa 2012-13)
  - New IR optics & magnet parameters to accommodate local cavities (800 MHz)
  - VV crossing scheme favorable, engineering details...
- Phase II (Complete IR Redesign,circa 2016 or beyond)
  - Larger transverse beam separation (>30cm) envisioned
  - Exotic schemes available ? Perhaps separate quad channels ?



Geometric Luminosity

R. Calaga

X-Angle Reduction Factor: $\frac{L}{L_\circ} \approx \left[1 + \left(\frac{\sigma_z}{\sigma_x^*} \tan\left(\theta_c/2\right)\right)^2\right]^{1/2}$

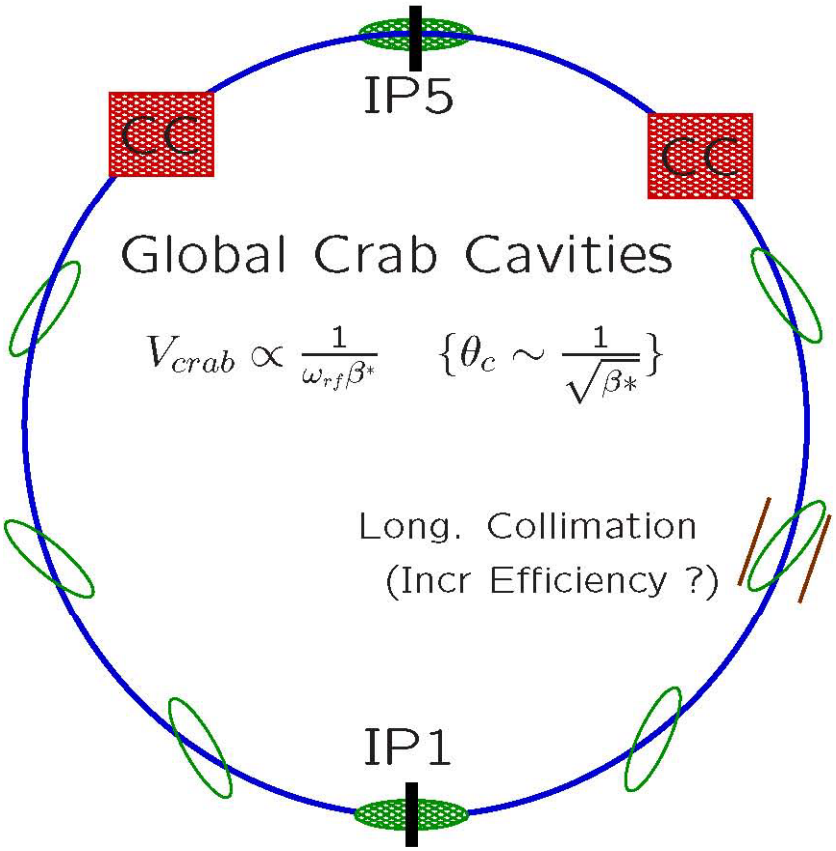


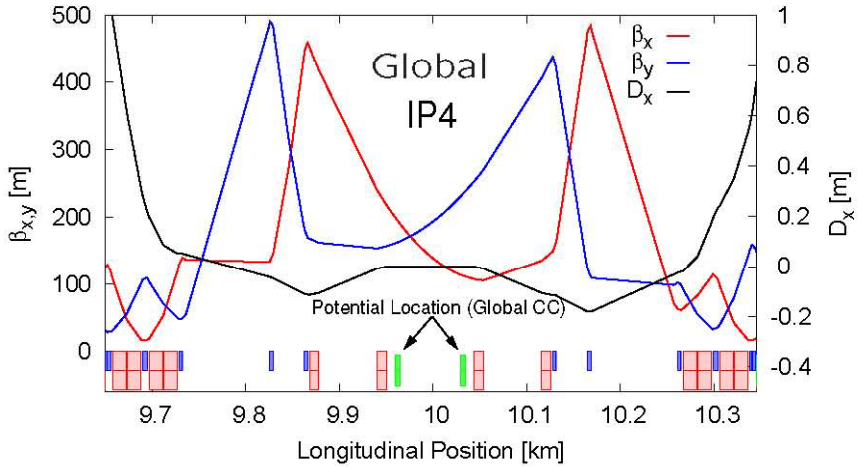
CC curves are analytical estimates

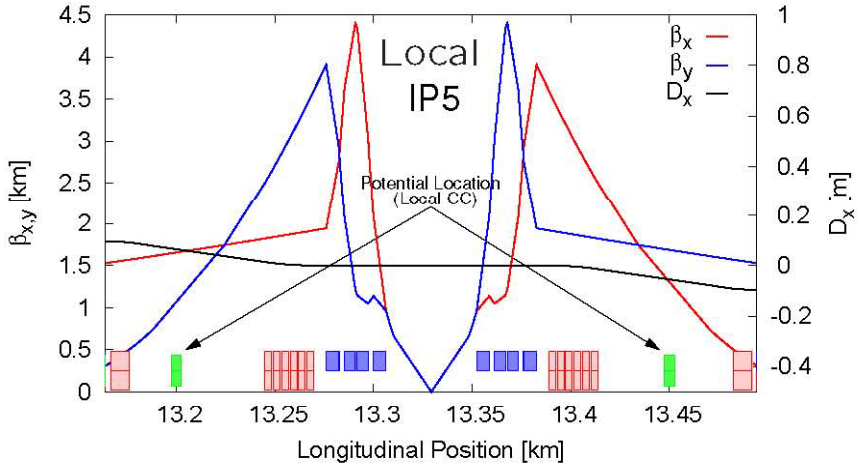
factor 2-3 gain in luminosity

Small θ_c (0.3-0.6 mrad)

R. Calaga





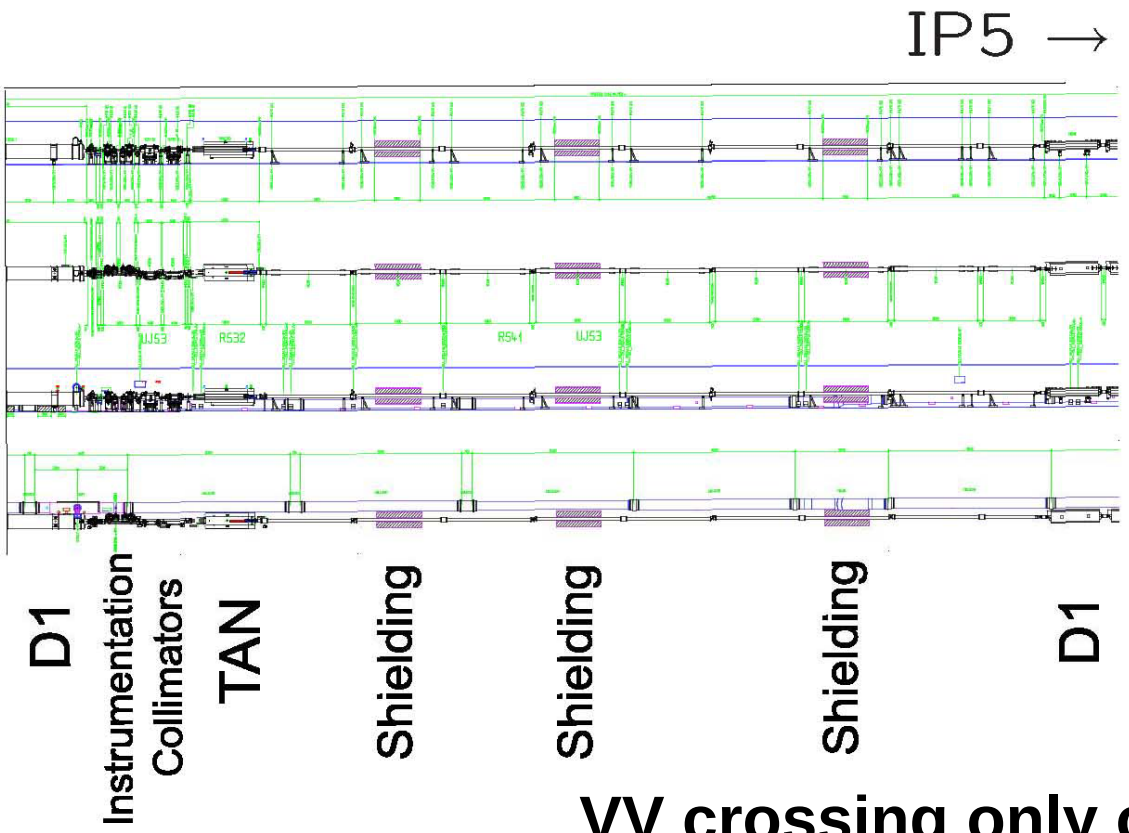


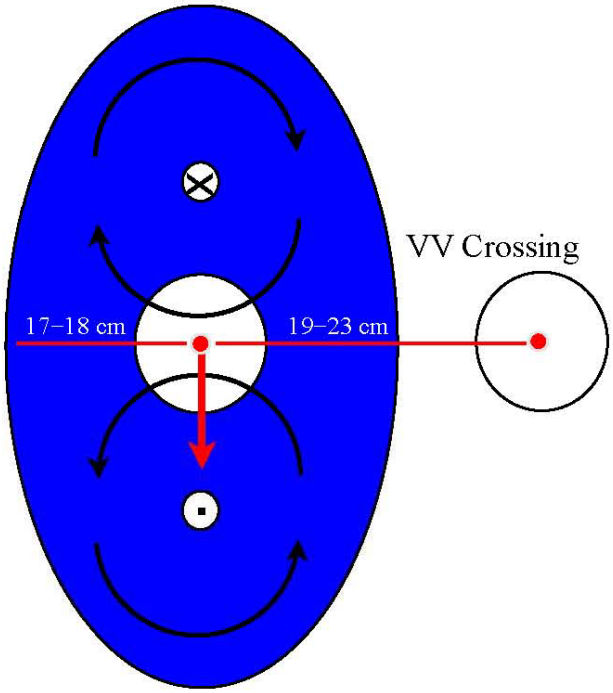
Par	Unit	Nominal [G]		Upgrade [L]	
$IP_{\{1,5\}}$ β^*	[cm]	55		25 (8_{ES})	
β_{CC}	[km]	0.13	0.38	3.0	4.5
CC Volt	[MV]	2.0	5.8	5.4 (9.5)	3.7 (6.4)

Local Scheme: Space Challenge

R. Calaga

- Longitudinal Space $\sim$ 10-15 m (Local, staggered cavities, common cryostat)
- Transverse for nominal $\sim$19 cm, tight margin (VV Crossing)
- Require clever He vessel + integrated cryostat design to accommodate two beams





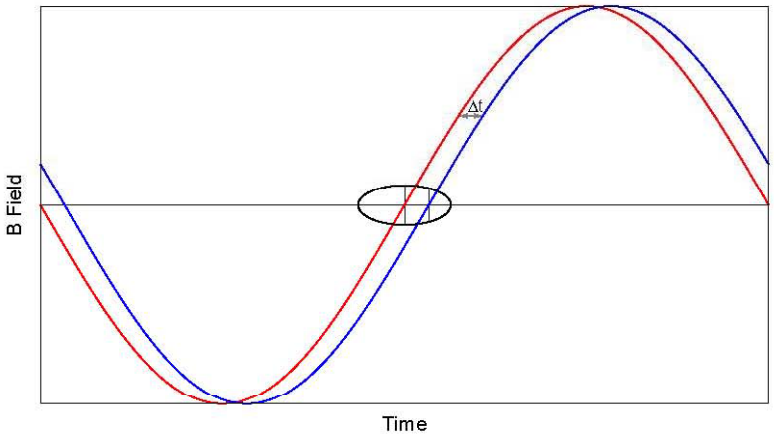
VV crossing only option for local scheme

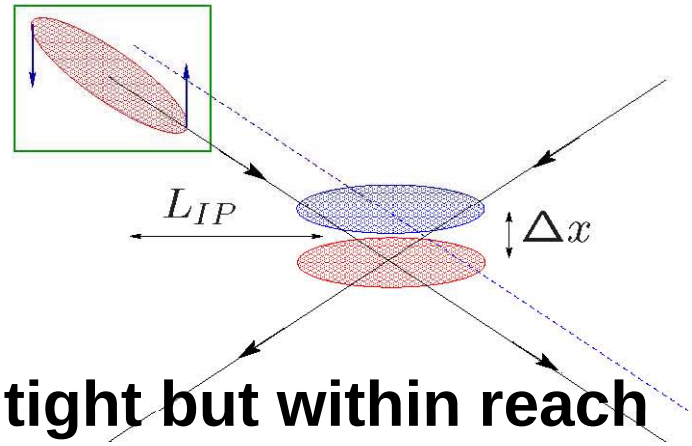
Noise Tolerances

R. Calaga

Phase jitter introduces random offset:

$$\left(\frac{\Delta\epsilon_x}{\Delta t}\right)_{BB} \approx n_{IP} f_r \frac{8\pi^2\xi^2}{\beta_x^*}(\Delta x)^2 \qquad \left\{\Delta x_{IP} = \frac{c\theta_c}{\omega_{RF}}\delta\phi\right\}$$





tolerances tight but within reach

Random Dip Kicks: $\frac{1}{\epsilon}\frac{\Delta\epsilon_x}{\Delta t} \approx \frac{f_r(1-s_0)}{4\sigma_x^*\left(1+\frac{g}{2\pi|\xi|}\right)^2}(\Delta x)^2$ [Y. Alexahin]

For 1% Emittance Growth/Hr, gain=0.2 (Random turn-to-turn)

Jitter Estimate	Amp.	Phase	
		Beam-Beam	Dip. Kicks
Analytical	$\sim$ 0.04%	0.01° (0.006°)	0.006° (0.003°)
Simulation (WS)		0.002°	-
Simulation (SS, K. Ohmi)		$<$ 0.001°	
Feasible Today	0.01%	0.003°	

Technical Objectives

M. Cole

Advanced Energy Systems, Inc.

- The overall technical objective of our project over phase I and II is to design, fabricate, and test an 800 MHz prototype crab cavity.
- We will also generate a preliminary design for a cryomodule for this cavity.
- The Phase I objective is to perform the preliminary design of the crab cavity including; physics design, RF design, initial analysis, and the preliminary mechanical design.
- We will also perform the conceptual design of cryomodule which includes selection of the configuration and the initial layout.

phased SBIR program over 2.5 years, BNL-AES collaboration

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discussion

phase-0 benefit for both IPs? (Ralph); sqrt(2) higher voltage & 45/135deg phase advance can be used to crab in both IPs (with same crossing plane) – Katsunobu Oide

crab-cavity wake fields → "banana effects" – Bob Palmer, H.P.

collimator wake fields for global scheme wake fields excited by tilted bunches passing through collimators → self-consistent calculation needed – H. Padamsee, F. Z.

crab-cavity parameters similar for **local & global scheme**

noise issues possibly relaxed for local scheme – H.P., F.Z.

crab super disruption – could it be applied to LHeC?

dispersion at rf cavity instead of crab cavity? - John Byrd

passive operation for crab cavity test? – John Byrd

separate cooling for easier exchange? – Joachim, Hassan,…