

# ILC WG4 Beam Delivery

*“Friday summary, 1<sup>st</sup> week of Snowmass 2005”*

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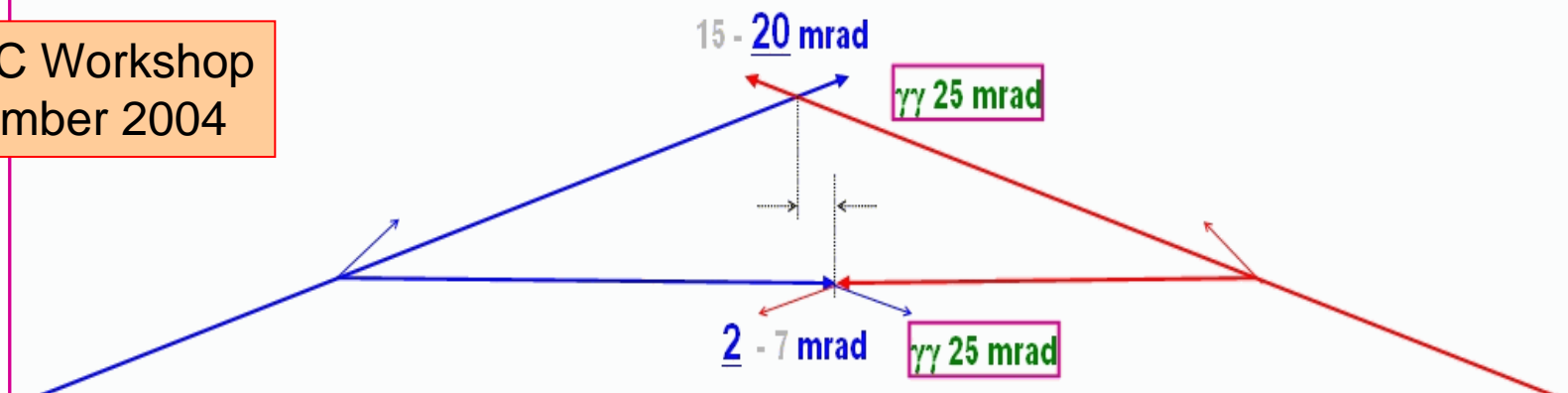
# Discussion sessions (35 talks)

- Optics & layout
- Magnets
- IR design & MDI issues
- Collimation & background
- Beam dumps
- Civil layouts
- Joint WG4/WWS/Detector concepts
- IR configurations (review head-on issues again)
- Instrumentation, feedback, crab-cavity
- Joint w.WG1, stability, BDS tuning

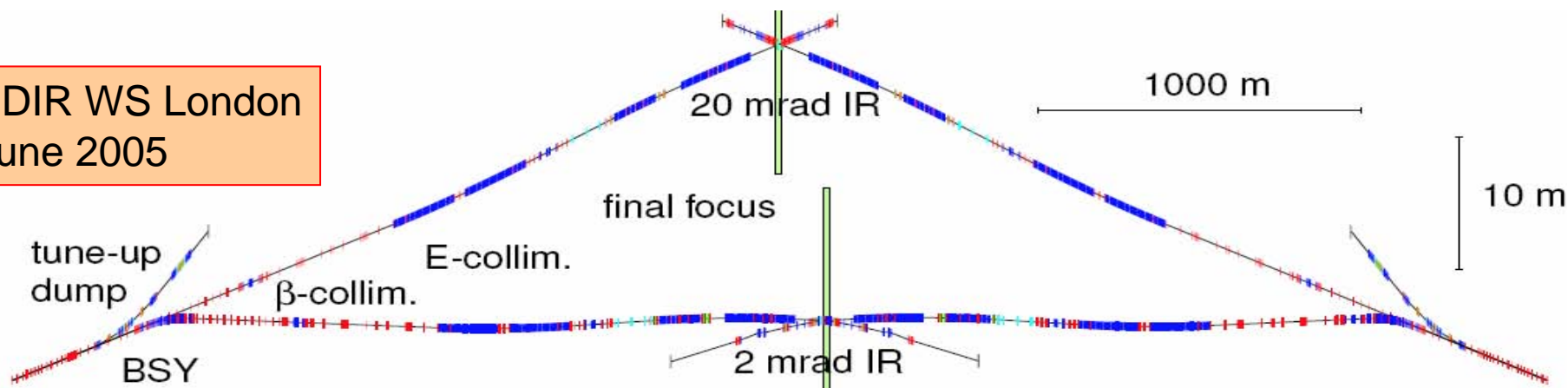
# Recommendations from the WG4

Tentative, not frozen configuration, working hypotheses, "strawman"

1<sup>st</sup> ILC Workshop  
November 2004



BDIR WS London  
June 2005



**Strawman tentative configuration turns into real design:**

Full optics for all beamlines; Mature 20mrad optics and magnets design; Several iteration of optics for 2mrad IR; Upstream and downstream diagnostics for both IRs

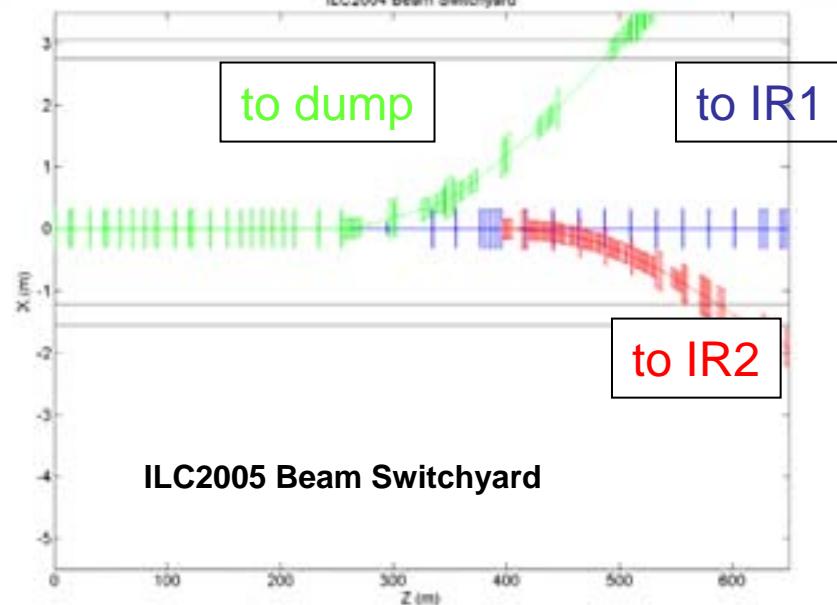
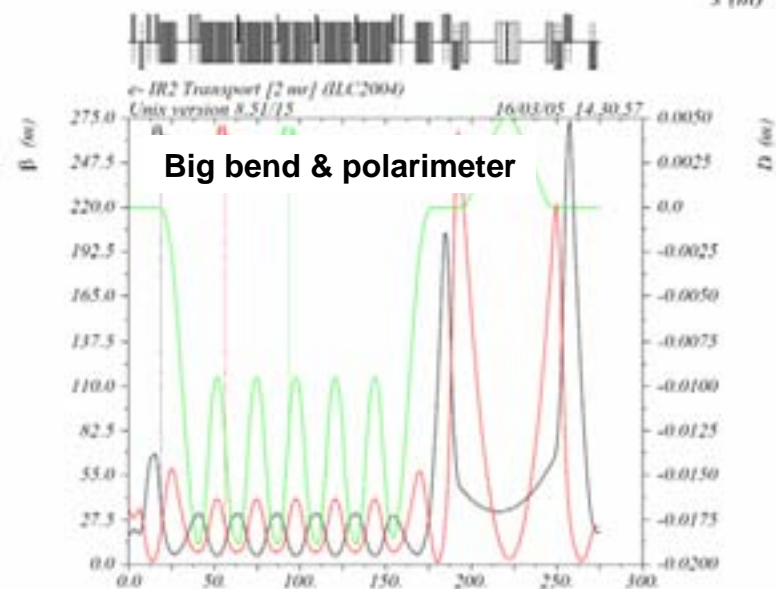
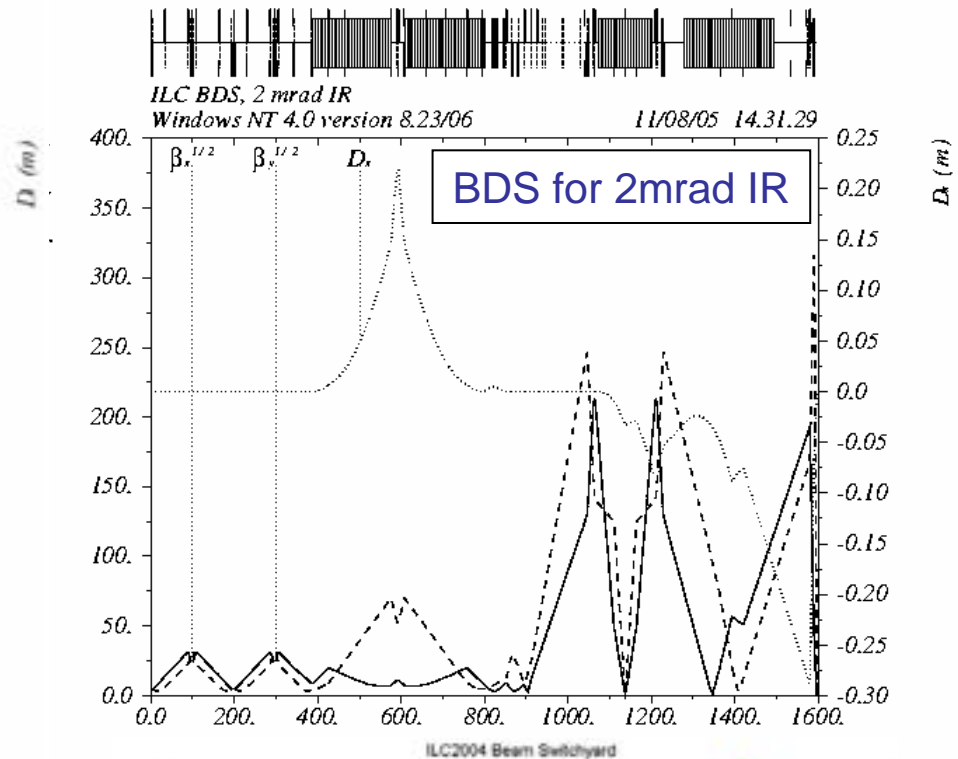
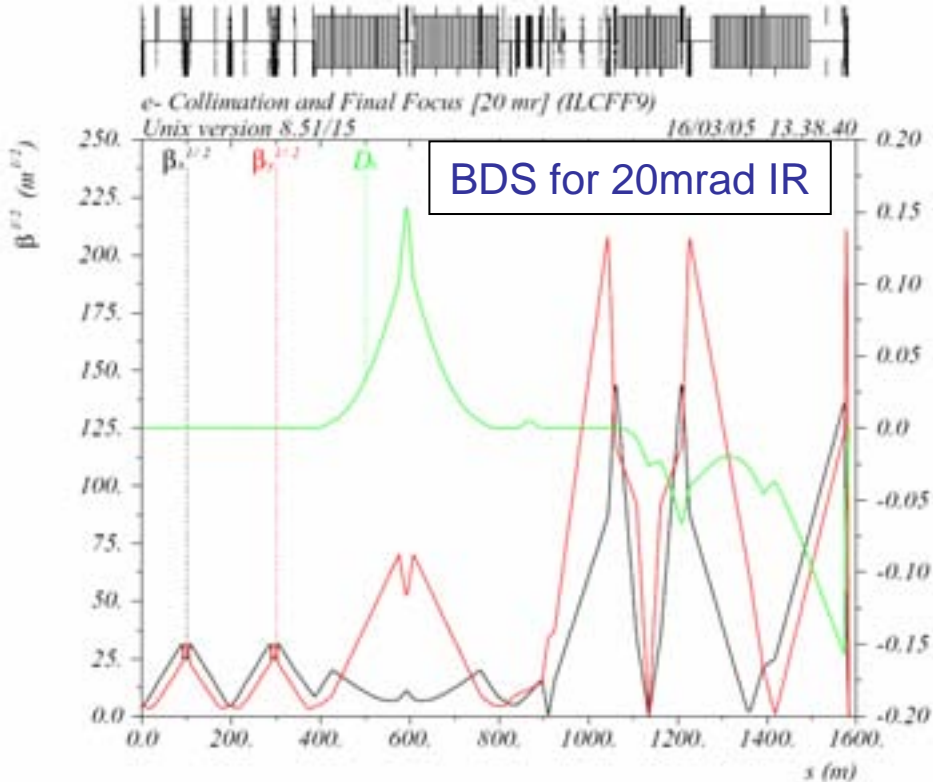
# Baseline for two IRs: proceed with detailed design of

- **20mrad IR**

- stable and mature design
- separate incoming & extraction beamlines
- achieve high luminosity
- clean upstream & downstream diagnostics
- expect good operational margins, flexibility
- may not preclude mTeV or gamma-gamma
- somewhat larger backgrounds

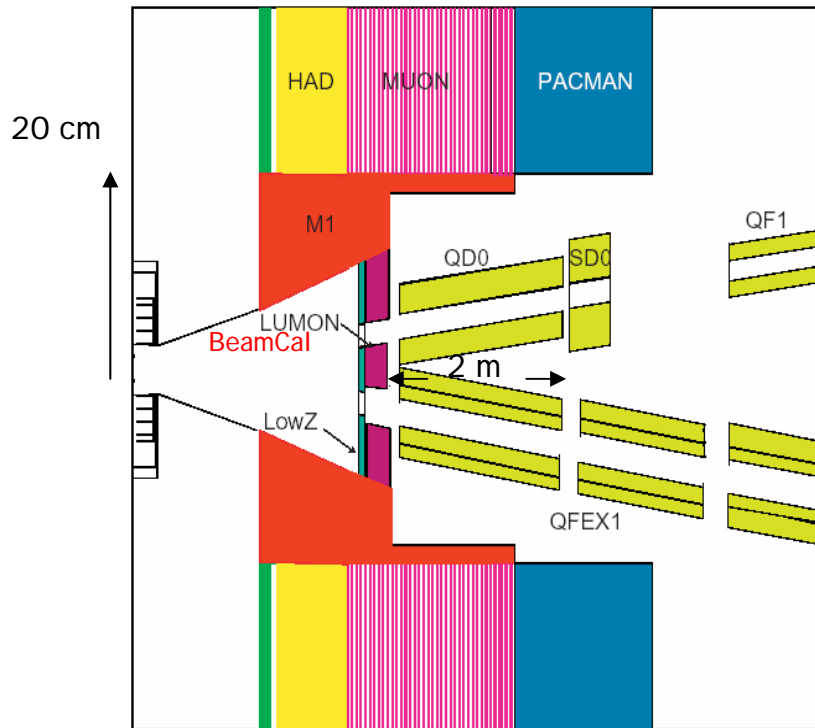
- **2 mrad IR**

- better background & detector hermeticity
- much more advanced design than head-on
- achieve nominal luminosity and possibly somewhat higher
- downstream diagnostics designed but higher background
- more constrained design, less flexible
- may be more difficult in operation

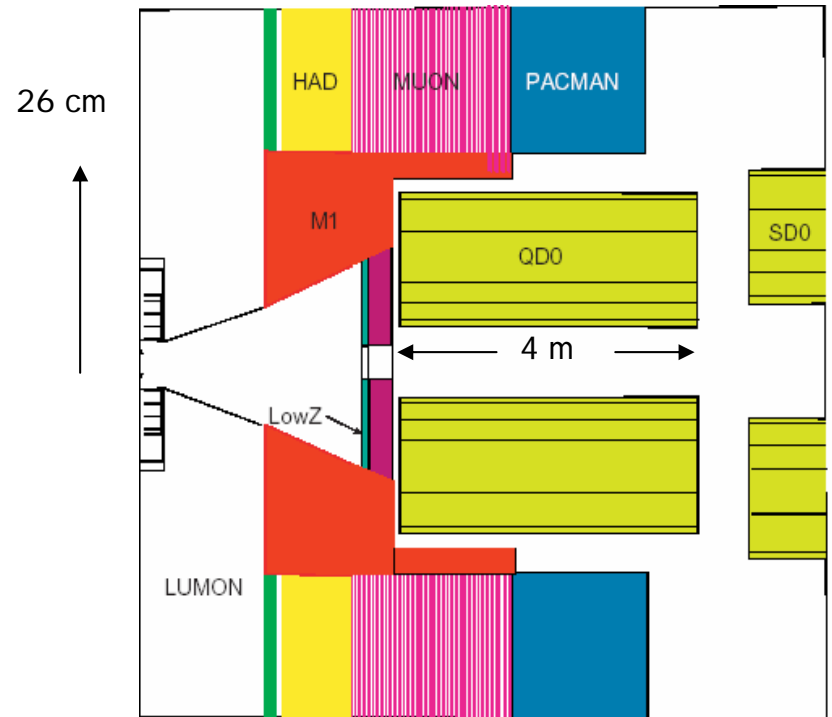


# IR layout for 20 and 2 mrad with SiD and $L^*=3.5$

20 mrad



2 mrad (earlier version)

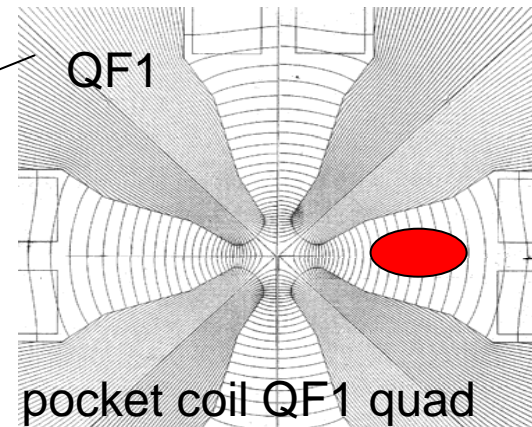
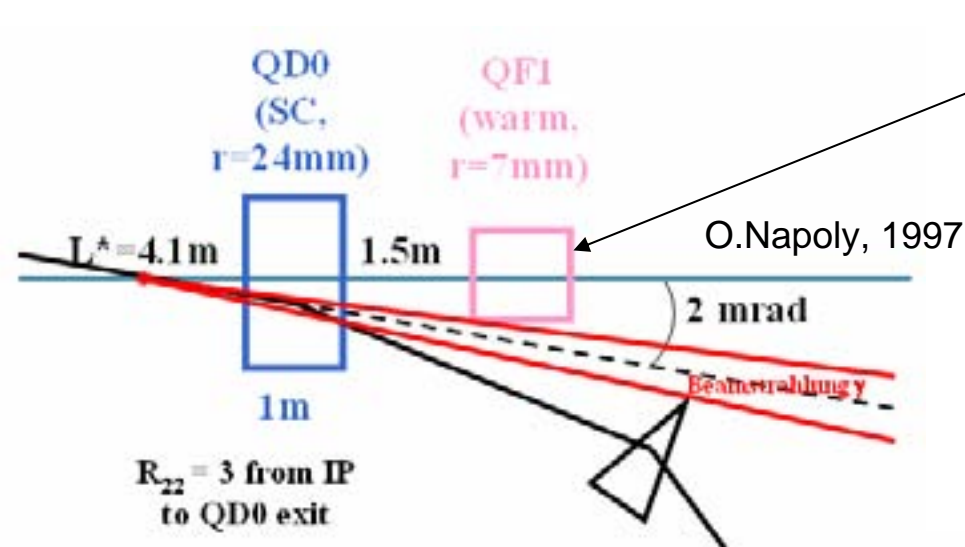


shows the version when FD not rotated w.r.to detector. In reality it is rotated. Geant model of the rotated version was evaluated as well.

- IR layout includes correct sizes of magnets (internal and external), start to include solenoid compensation, feedback BPMs, kickers, and engineering details ...

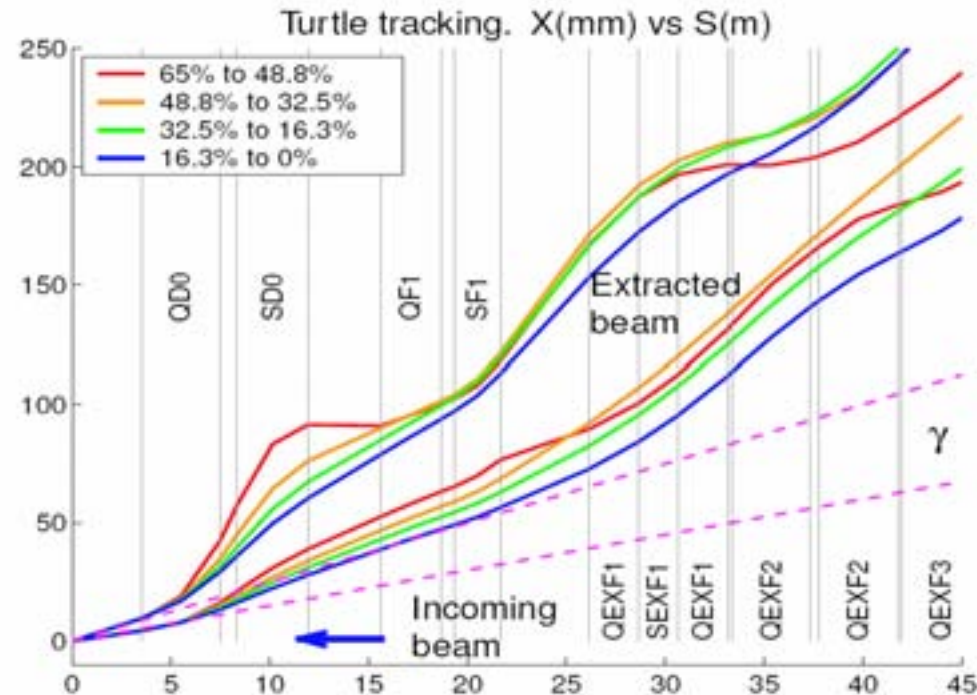
# 2mrad IR: from concept to optics

SLAC-BNL-UK-France  
Task Group



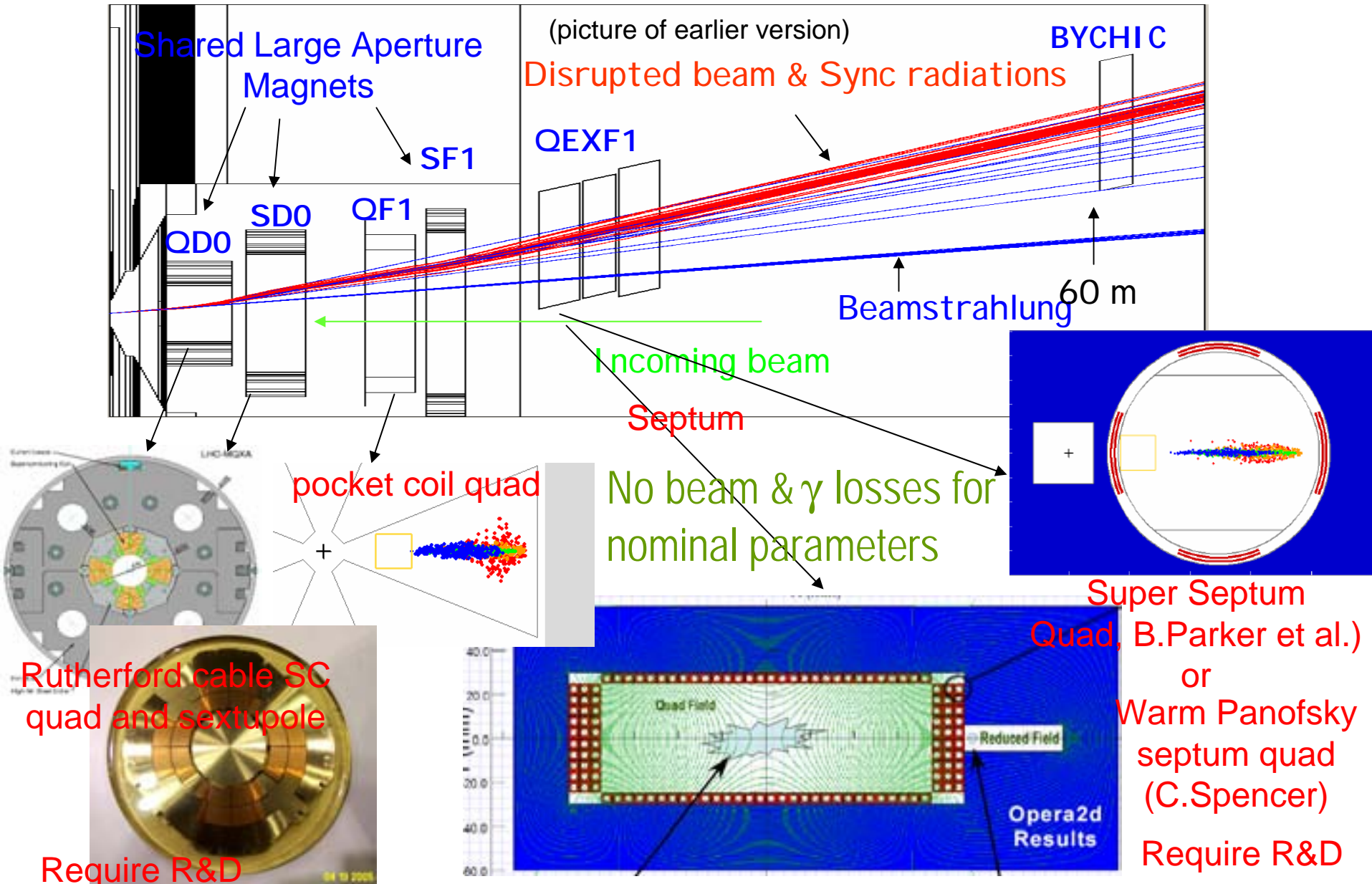
pocket coil QF1 quad  
aperture  $10\text{mm} \Rightarrow 15\text{mm}$  to improve  
collimation depth. C.Spencer, Aug.18

- FF and extraction line optimized simultaneously
- Quads and sextupoles in the FD optimized to
  - cancel FF chromaticity
  - focus the extracted beam
- Latest version works up to 1TeV with more conventional NbTi FD magnets (not Nb<sub>3</sub>Sn)

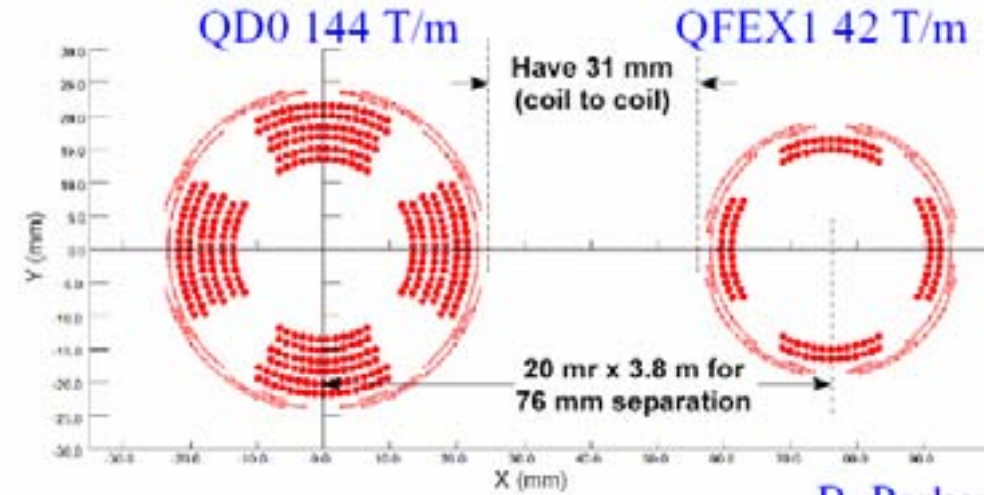


# 2mrad IP Extraction Line in Geant

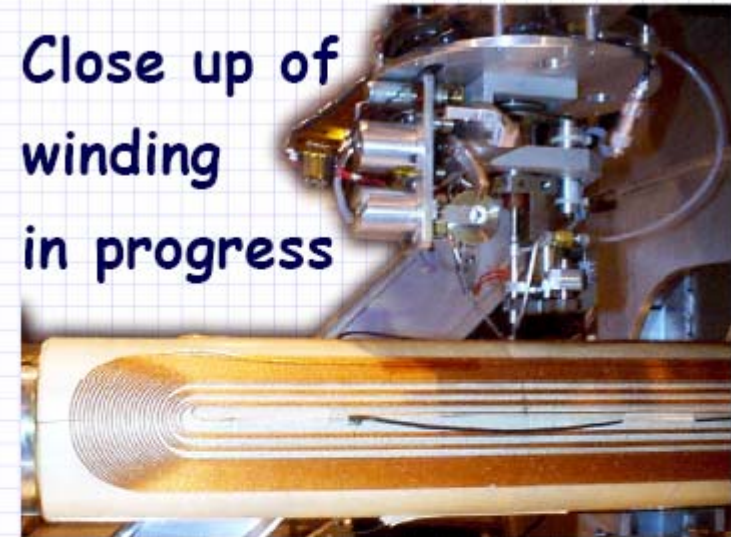
SLAC-BNL-UK-France  
Task Group



# Compact SC Final Doublet for 20mrad IR



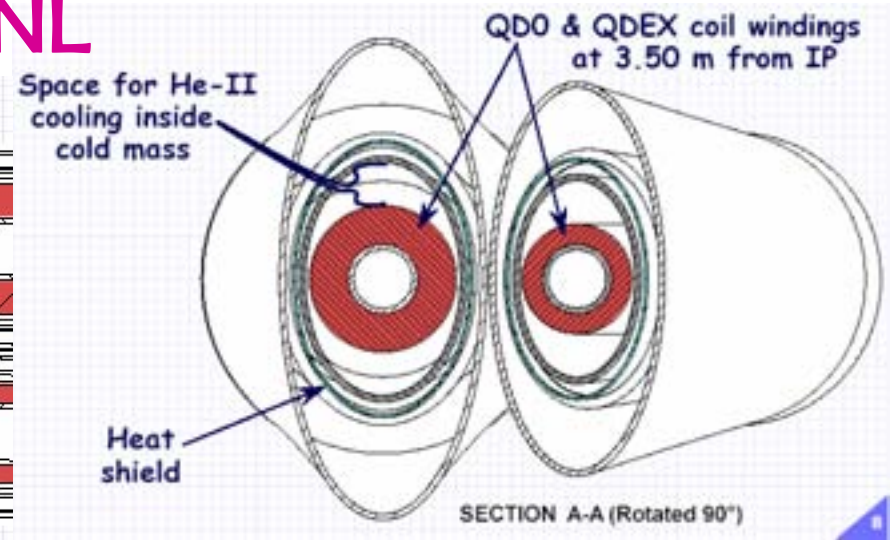
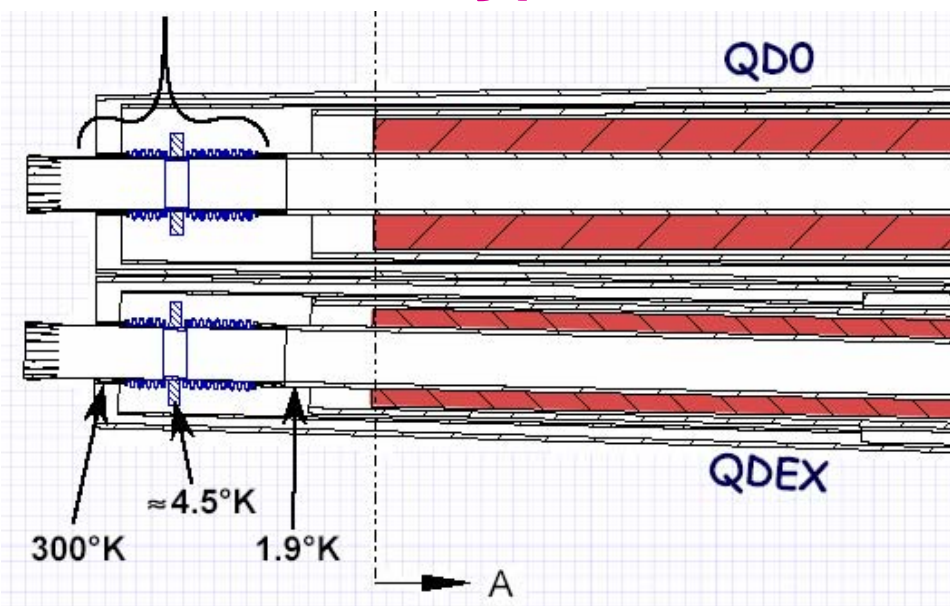
Close up of  
winding  
in progress



Ultrasonic heating  
bonds epoxy coated  
conductor to substrate  
on a support tube  
(tack in place).

- Achievement in BNL direct wind technology allow to make even tighter bend radius => quad is more compact => allow to start the extraction quad at the same distance from IP as QDO

# Compact QDO Mechanical & Cryo-engineering and Prototype Test at BNL



380mm QDO Test Prototype

## QT Quench Test Results

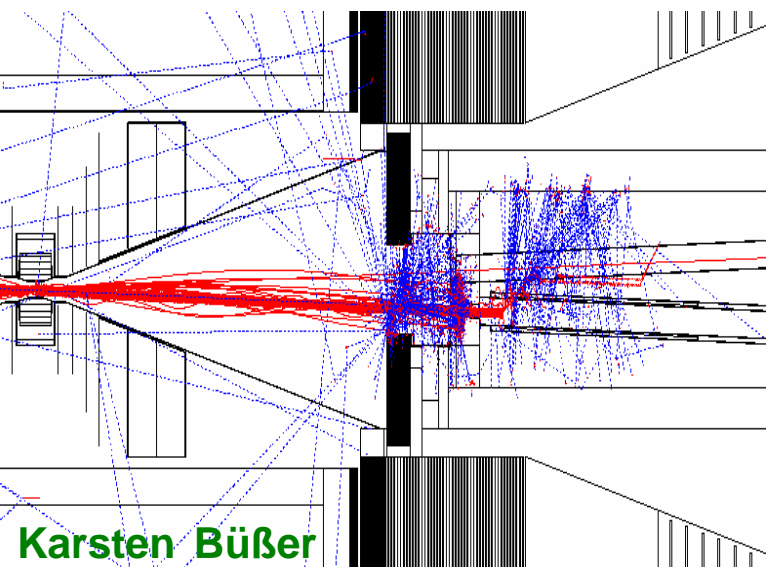
Background Solenoid (T)	Temp (°K)	Gradient (T/m)
3	4.30	158
4	4.22	139
5	4.22	134
6	3.00	137

**Exceeded design goal !**

goal: 140T/m with 3T background field while cooled with pressurized He-II at 1.9K

# 20mrad & 2mrad IR comparison: Background:

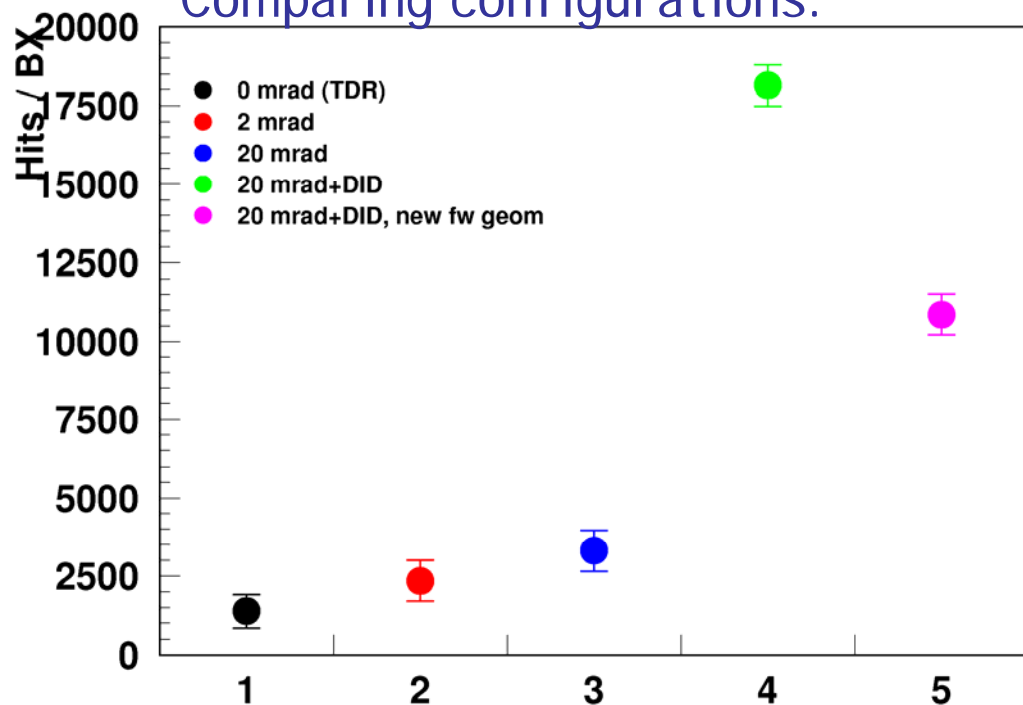
## Hits in the TPC with Solenoid+DID



Karsten Büßer

Origin of TPC photons:  
pairs hit edge of LumiCal

Comparing configurations:

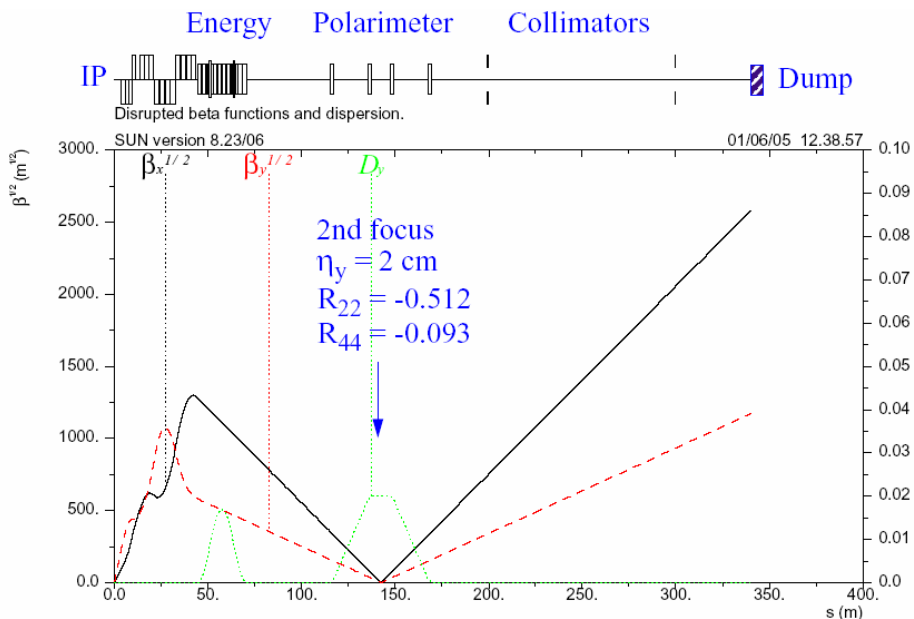


- Formed task force to come up with updated tolerances of detector systems (vetrex, TPC, etc) to background, based on experience of existing detectors => to be done during Snowmass
- Understand how details (e.g. fringe field of QDO) affect flow of pairs
- If still an issue -> DID switch off, less local compensation of IP y-angle

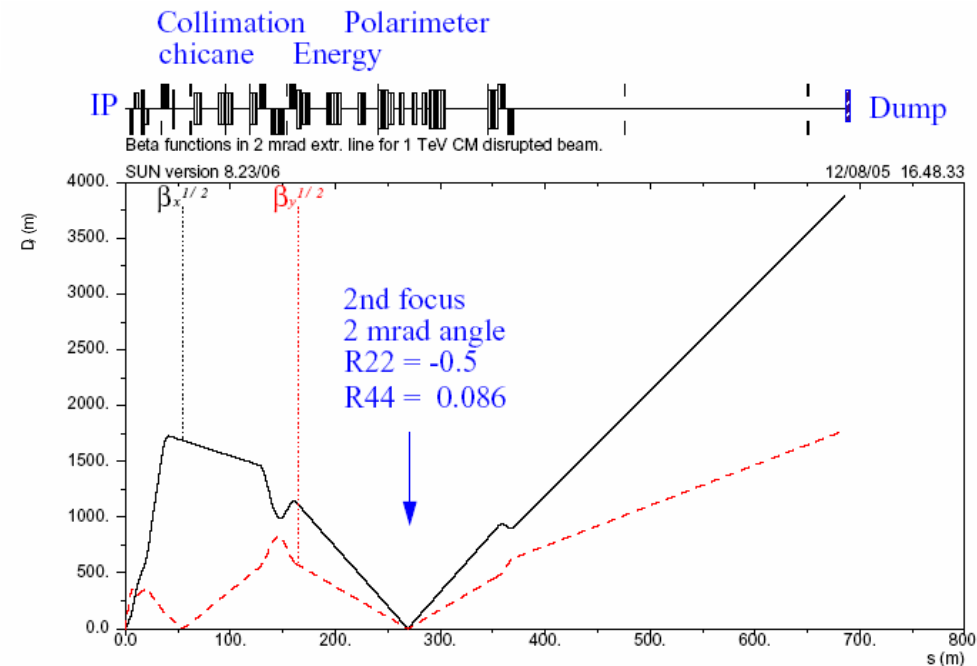
# 20mrad & 2mrad IR comparison: Lumi & diagnostics

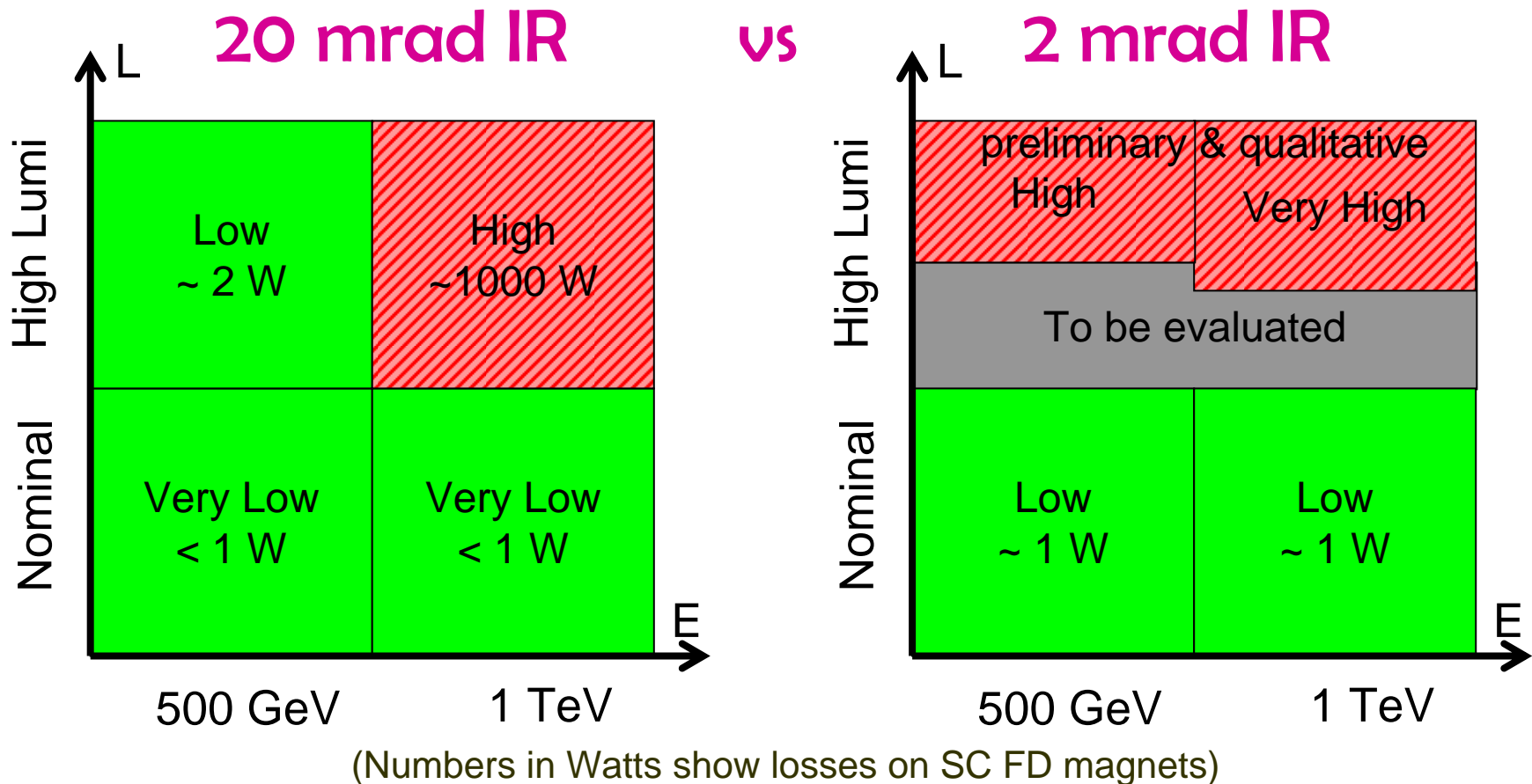
- Luminosity reach of IRs may be different
- Performance of downstream diagnostics may be different
- 20mrad likely the winner for both this criteria
- For Lumi, one of the limiting factors is losses of disrupted beam on SC elements of extraction line

## 20mrad extraction optics



## 2mrad extraction optics





- Optimization of design and evaluation will continue, but clear that disrupted beam losses on SC elements limit performance
- Better detector hermeticity & background of 2mrad IR comes together with lower luminosity reach
- ( 20mrad IR works well with New High L parameters )  
( 2mrad to be evaluated )

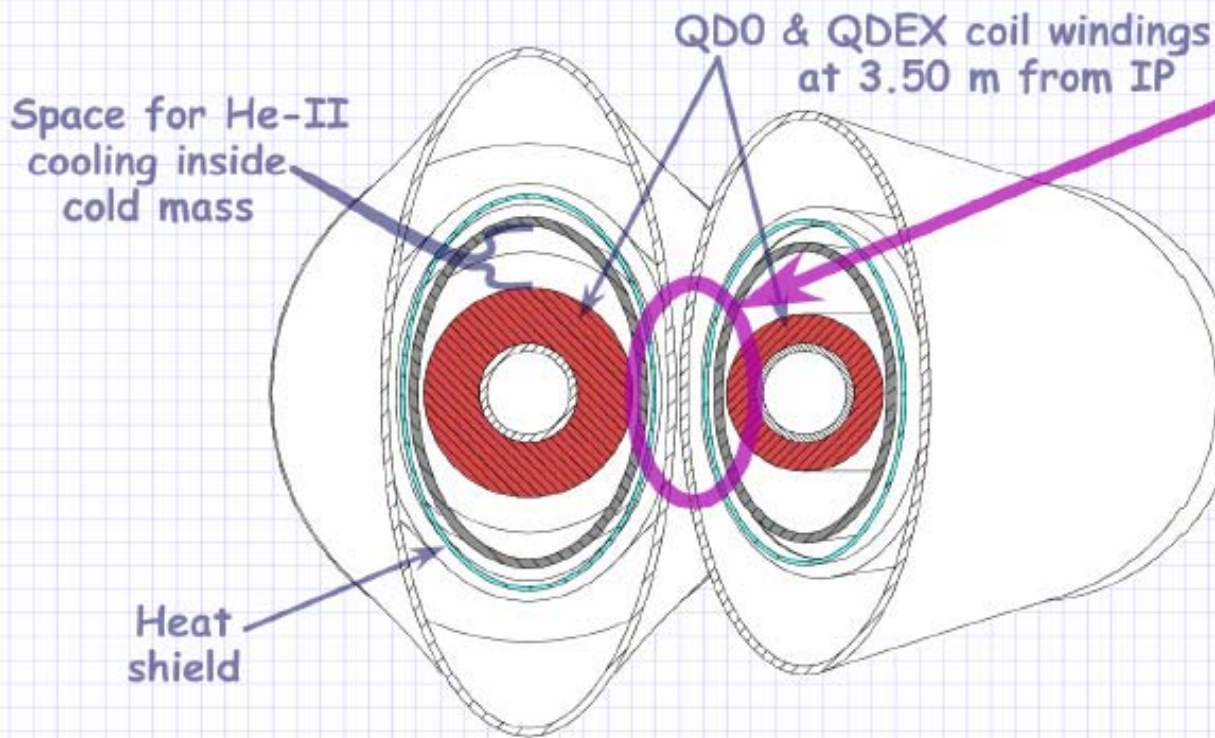
# Joint meeting WWS/WG4/Detector concepts

- Discussion based on 18 questions posed to Detector concepts
- Useful start. Many questions were answered, for some questions evaluation is ongoing
- WG4 will meet on Monday to discuss prioritization of questions, to make work more efficient
- Discussion of layout
  - clearly, all Detector concepts prefer min angle
  - but Detector concepts also prefer reliable machine
  - SiD: “...would be interested in the smallest crossing angle that does not compromise downstream E and P measurement, does not increase backgrounds, does not significantly increase the risk of backgrounds, and does not reduce the reliability of the machine ... . This may well be more than 2 and less than 20 mrad...”
  - GLD: “...If the 2mr encounters a serious difficulty, we would like to suggest a further study on the minimum crossing angle in the range of 2 and 20mr.”

# Discussion of candidates for IR configuration alternatives

- 20 and 2mrad IRs are most advanced and are the baseline
- Alternative is a less developed scheme which promise improved performance
- Considered (again) head-on with rf kicker or electrostatic separator. Numerous issues, considerable r&d required, and absence of anticipation of success make this optics problematic to be included as an alternative
- Intermediate crossing angle, based on compact SC quad technology may be very promising
  - based on tested BNL SC quad design
  - maintain separate incoming & extraction beamlines
  - expect to achieve high luminosity
  - clean upstream & downstream diagnostics
  - does not preclude multi-TeV with proper linac layout & parameters
  - operational margins, flexibility
  - backgrounds expected almost as good as in 2mrad

# Crossing Angle Lower Limits Using Compact Superconducting Magnets



Eliminating some of the structure between the incoming and extraction apertures would allow smaller crossing angles but does have consequences which must be studied.

Brett Parker, BNL

Reference 20 mr X-ing Angle Design

Will proceed with studies of 10-12mrad range

Scenario	$d$ (mm)	Angle Range* (mr)	Issues	Confidence Level
A	70	20 - 15.5	Standard	Recommended
B	53	15 - 11.8	+ Cold Support	Probably OK
C	44	12.5 - 9.8	+ Stronger Comp'	Needs Study
D	38	10.8 - 8.4	+ Give Up Comp'	Highest Risk

\*Angle range is for  $3.5 \text{ m} < L^* < 4.5 \text{ m}$

Brett Parker, BNL

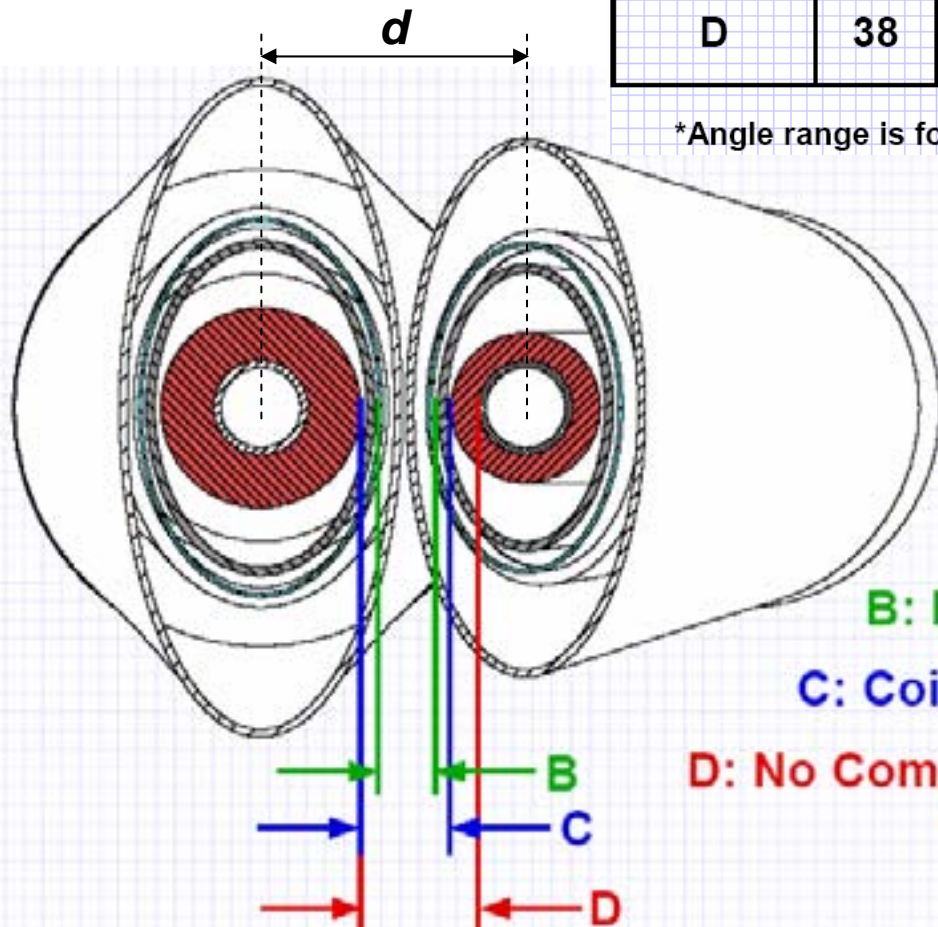
$$\theta_{\min} = d / L^*$$

A: Reference Design

B: Independent Cold Mass

C: Coils Touching

D: No Compensation



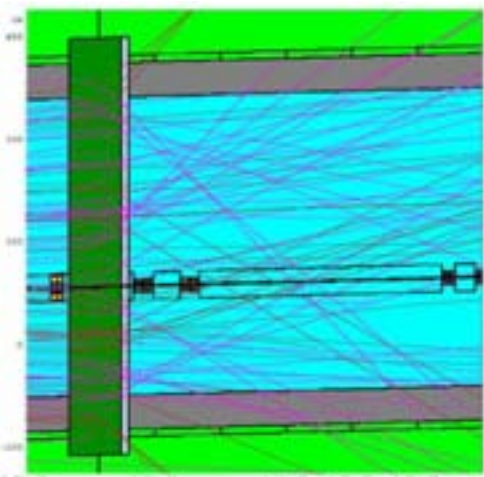
# Baseline

- If the two IR approach is kept, the Baseline is 20/2mrad
- During this week discussed and clarified many features which will go to the Baseline and documented in BCD
  - e.g. beam dump design, emergency extraction scheme, etc.
- The most critical choice, the layout, depends whether two IRs or one IR are adopted
  - the community and the wg4 just started this discussion

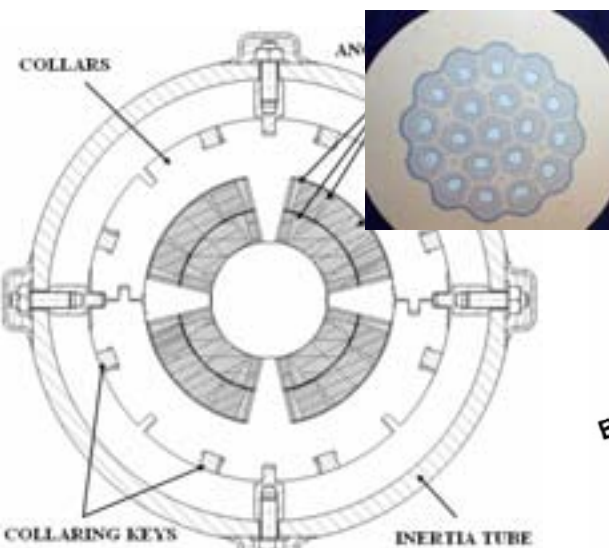
# Discussion of baseline for two or one IRs

- With two IR configuration, which complement each other, may allow one of IRs be more risky in terms of machine performance in expectation of better backgrounds and detector hermeticity
- With one IR configuration, need to put the overall performance, reliability and operability on the first place
- With one IR the optimal baseline may be neither 20mr nor 2mr
- The intermediate crossing angle with compact SC quads will be studied and may turn out to be the best choice

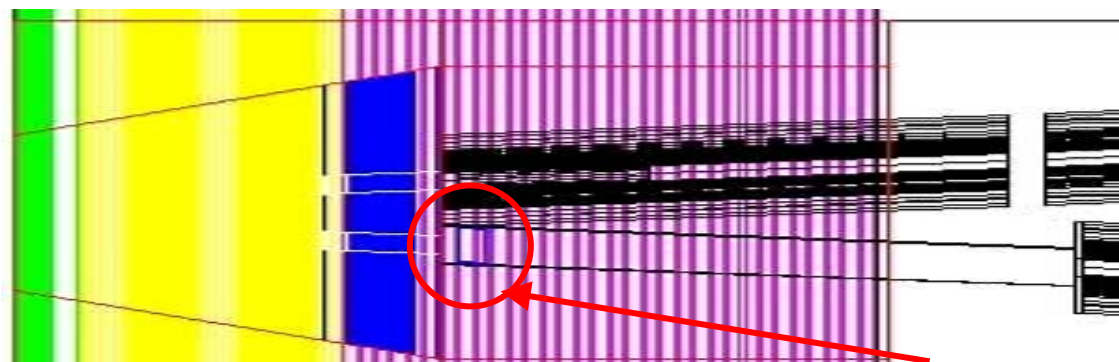
# Detailed design & studies of performance



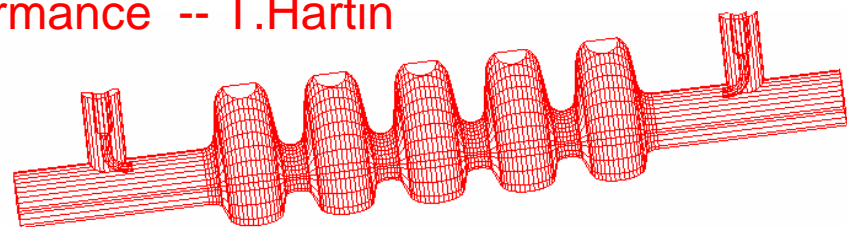
Collimation, machine background – UK, FNAL, SLAC, ...



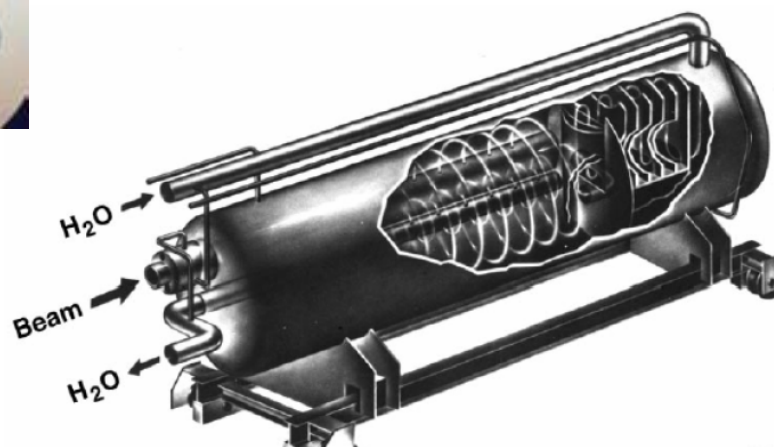
Nb<sub>3</sub>Sn quads – Saclay, LARP



Evaluation of effects of pairs on feedback  
BPM performance -- T.Hartin



Crab cavity design consideration – UK, FNAL, ...



Beam dump design – D.Walz et al

Frwd.reg. design – W.Lohmann et al



# Summary

- The WG4 proceed with design of baseline with 20mrad and 2mrad IRs
- We are discussing the baseline which may be more suitable would one IR configuration be preferred