ILC WG4
Beam Delivery

Andrei Seryi, Grahame Blair, Tomo Sanuki

Most of my slides are produced by our colleagues

Contents:

1. What we have done
2. What we will do

ILC WG4

- Every thing after Main Linac
  - Beam delivery
  - Interaction region
  - Beam diagnostics
  - Feedback system
  - Beam dump
  - …

What we have done

Optics

Instrumentation

Beam Test

WG4:
(Beam Delivery, Interaction Region, …)

SUMMARY

Grahame Blair, Tomoyuki Sanuki, Andrei Seryi

On behalf of WG4 participants

15 November 2004

ILC BDIR design choices

- **Crossing Angle**
  - **Head on**
  - **Very small vertical crossing angle**
  - **Small horizontal or crossing angle (~2mrad)**
  - **Large horizontal crossing angle (7-20mrad, ~35 mrad)**
- **Final Doublet Technology**
  - **Compact SC or PM quad, or large bore SC**
- **L***
  - **e.g. 3,4,5m**
- **Detector VXD inner radius**
- **Instrumentation Choices**
- **MPS Questions**
- **Detector Questions**
- **Collimation Choices**
- **Beam Stabilization choices**
- **Risk Mitigation**

Options

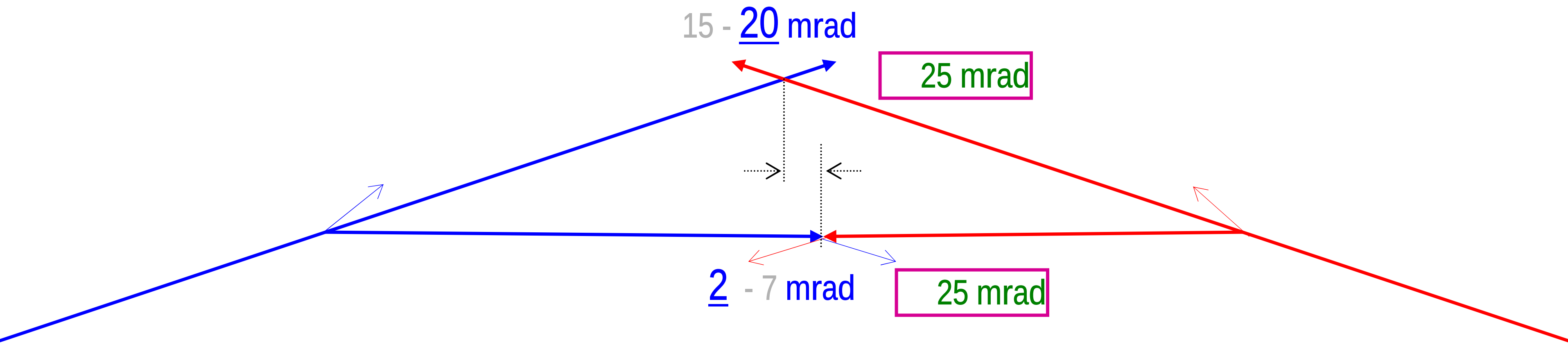
- **Gamma-gamma**
  - **In, particular, consequence of ~35 mrad crossing angle on e+e- luminosity**
- **e- e-**
- **e+ polarized**
- **Above 1 TeV running**
- **Consequence of simultaneous running of both IRs**

Recommendations from the WG4

- **Having considered and discussed the critical design choices,**
- **the Working Group came to consensus on the recommendation for the <u>working hypotheses on the BDIR configuration</u>**
- **With the final decision to be remained to be made by GDI,**
- **the proposed configuration is the direction where WG4 will focus its work**

Recommendations from the WG4

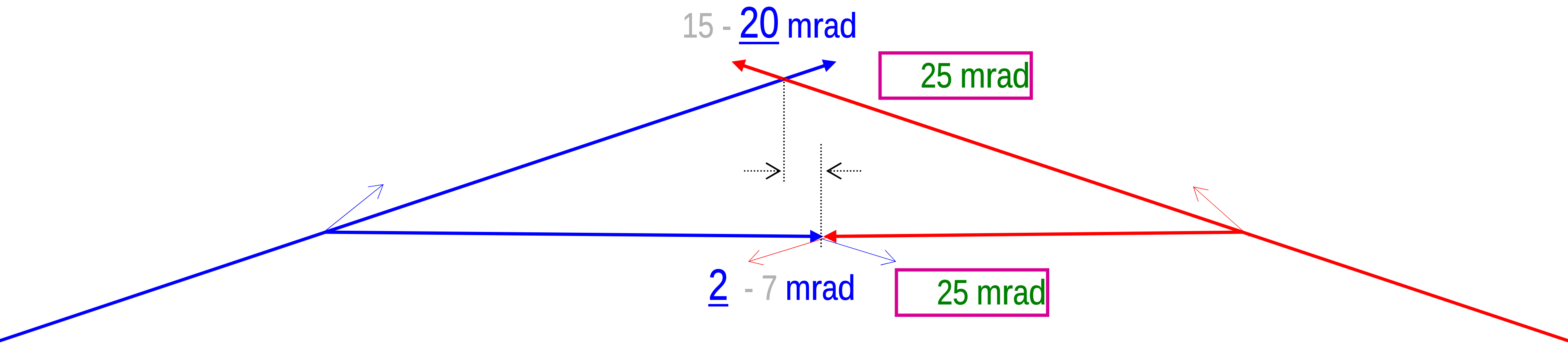
Tentative, not frozen configuration, working hypotheses, “strawman”



- **Urgent work for next 8 month**
  - **Improve and enhance communication within groups working on the design, and with detector community**
  - **Complete optics design for both IRs with all diagnostics and extraction**
  - **Request the physics community to evaluate physics impact of the “strawman” configuration**
  - **Evaluate how detector concepts affect optimization of L*, and what FD technologies are suited best**
  - **Develop civil engineering plans, including provision for option possible at 1st or 2nd IR at maximum energy**

Recommendations from the WG4

Tentative, not frozen configuration, working hypotheses, “strawman”



- **Urgent work for next 8 month (continued)**
  - **Reevaluate background tolerances of the detectors**
  - **Develop engineering design of crab cavity with electronics**
  - **Energy deposition and accidental beam loss studies, reevaluate the beam-beam induced loads in IR**
  - **Evaluate parameter changes options considered by WG1 (e.g. smaller IP beta-functions, bunch charge, separation) and parameters needed for (smaller x size)**
  - **Make more realistic simulations of feedbacks and diagnostics**

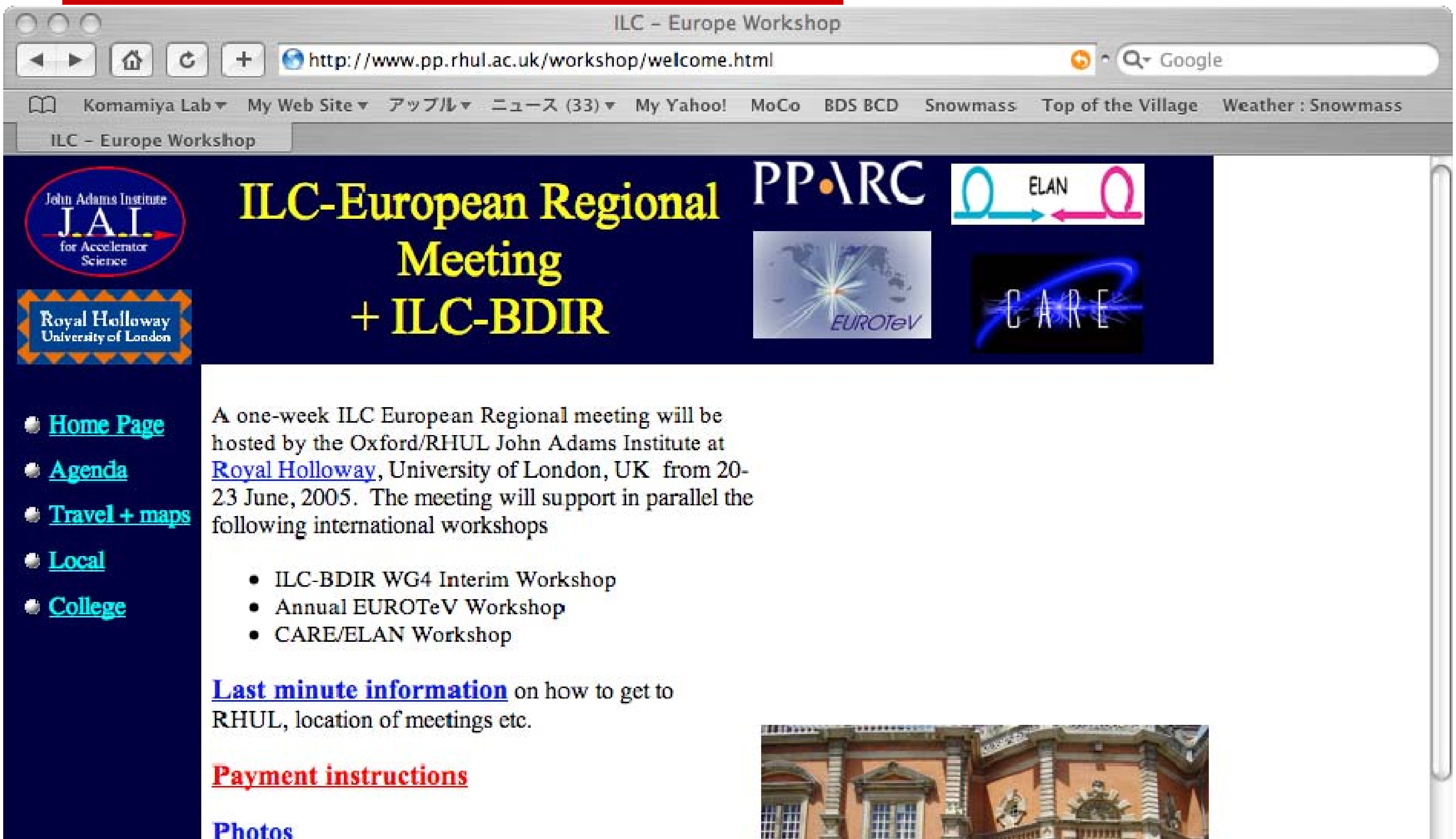
Summary of the summary

- A lot of interest, resources and ongoing work focused on BDIR in many regions and labs
- WG4 made significant progress and was able to come with recommendations on the working hypotheses for the BDIR configuration
- Good communication prior and at this meeting was one of the keys, and enhanced communication will help to make rapid further progress
- The urgent work needed in the next 8 month, to become closer to the complete design, and in many cases the people who will do the work, have been identified
- The MDI workshop (January 6-8, SLAC), the LCWS, and BDIR workshop (Spring 05, Oxford), will be our milestones to bring us to Snowmass (August) with a major progress towards detailed design

After 1st ILC Workshop at KEK

- Nano-project at ATF in December
- MDI & ATF2 WS in January
- LCWS in March
- ATF2 meeting in May
- Nano-project at ATF in May
- Numerous video/phone meetings, e-mail
- BDIR WS at RHUL in June

BDIR WS at RHUL



The ILC Beam Delivery System, plans for Snowmass, Reference Design Report and beyond

Grahame Blair, Tomoyuki Sanuki, Andrei Seryi

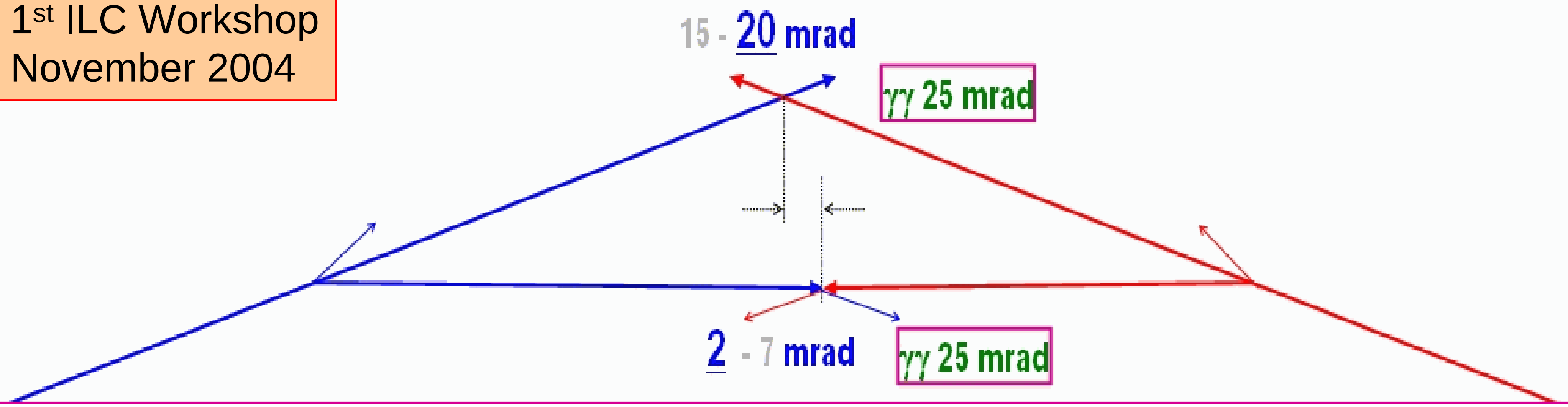
Beam Delivery Workshop, RHUL

June 20, 2005

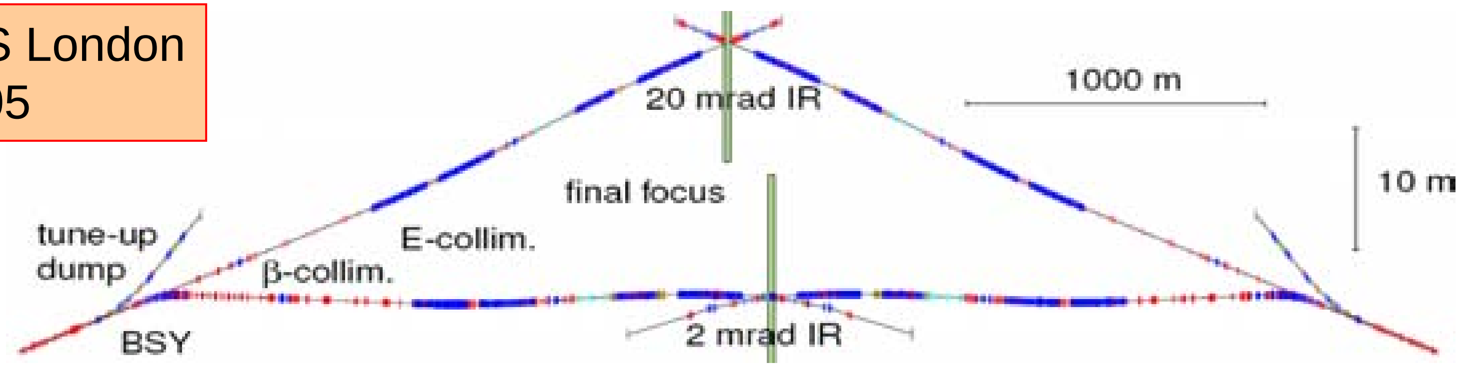
Recommendations from the WG4

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

1st ILC Workshop
November 2004

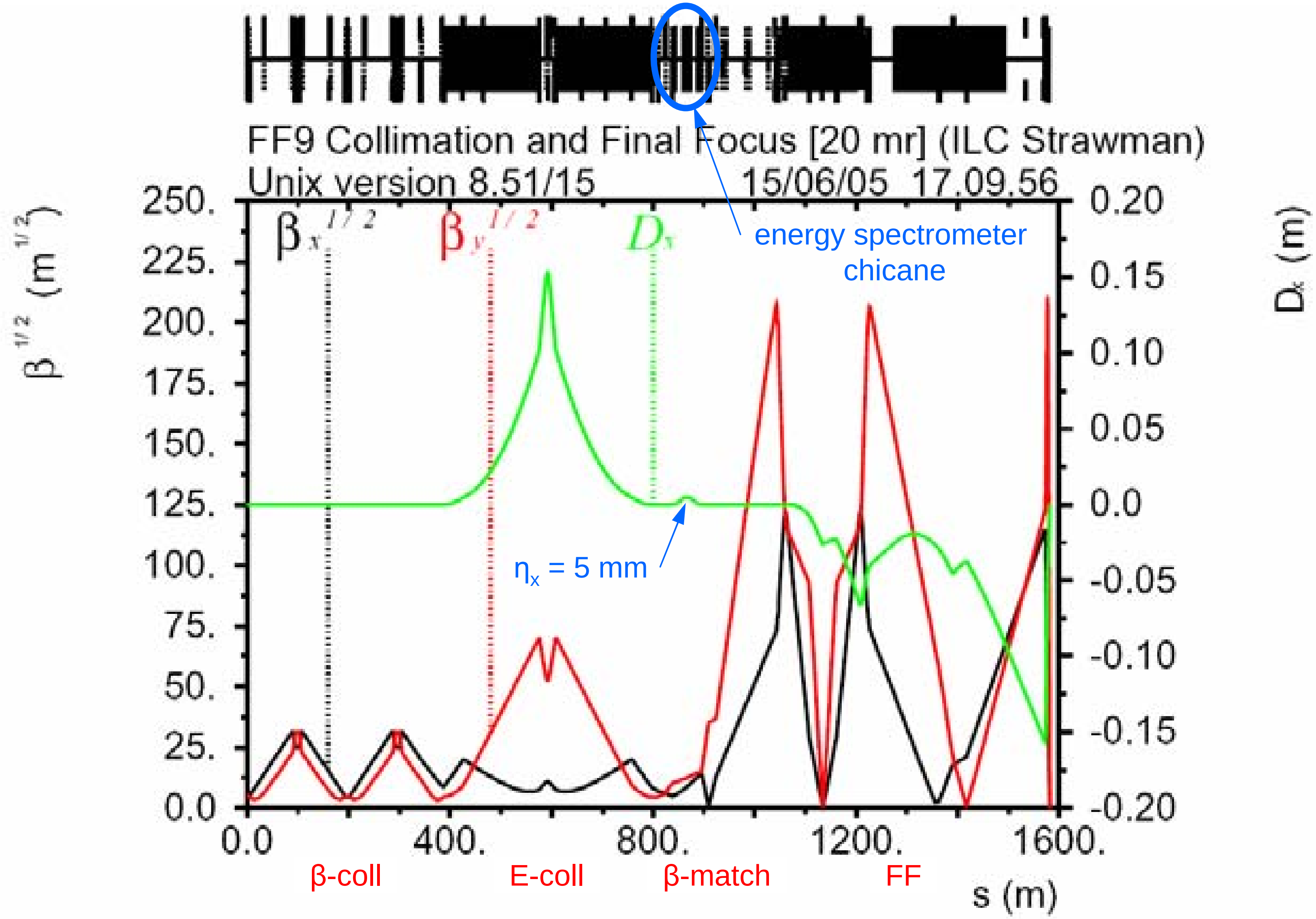


BDIR WS London
June 2005



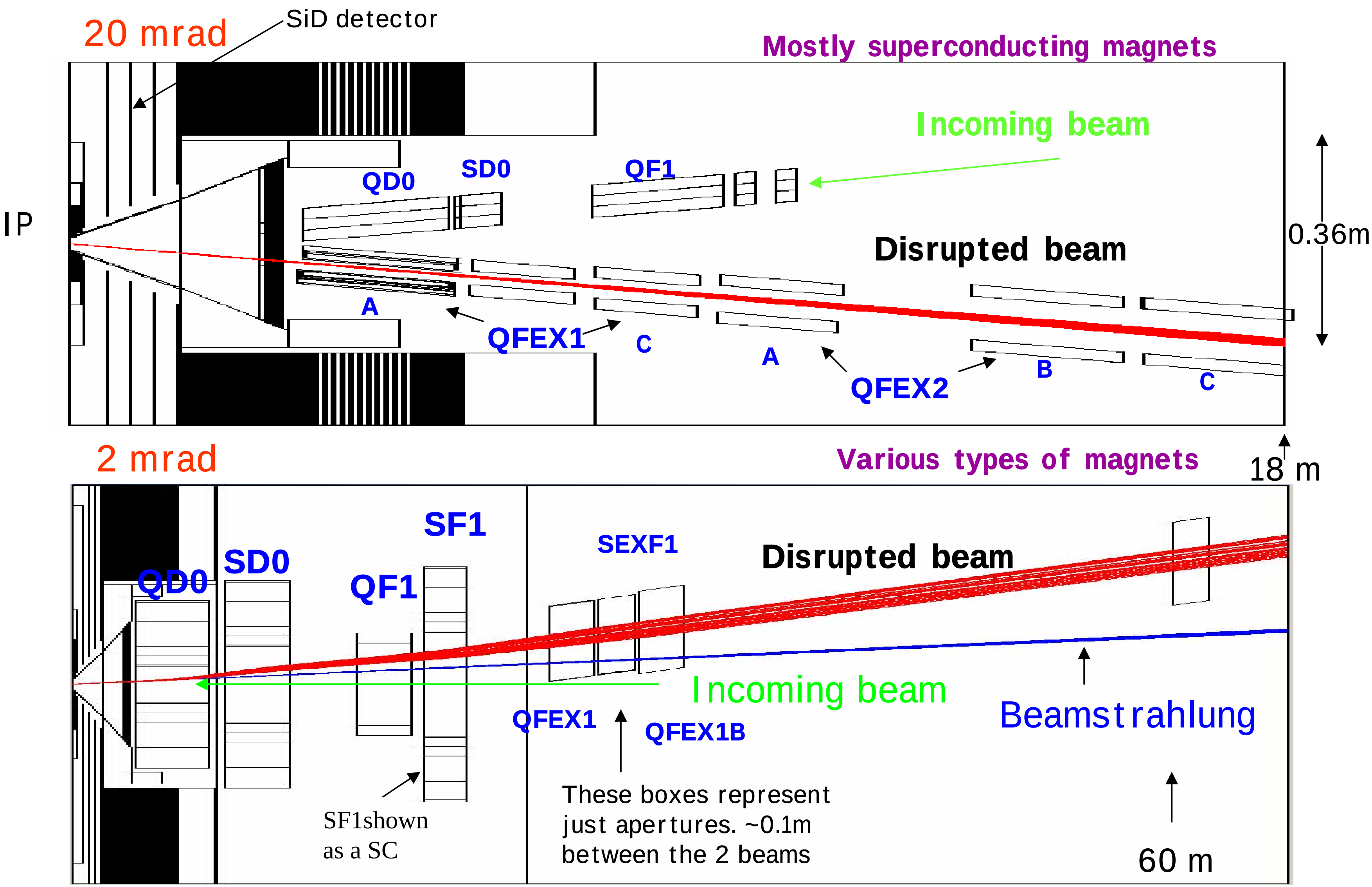
International BDS group is working hard to turn the Strawman tentative configuration into real design

Collimation / Final Focus (20 mrad crossing)



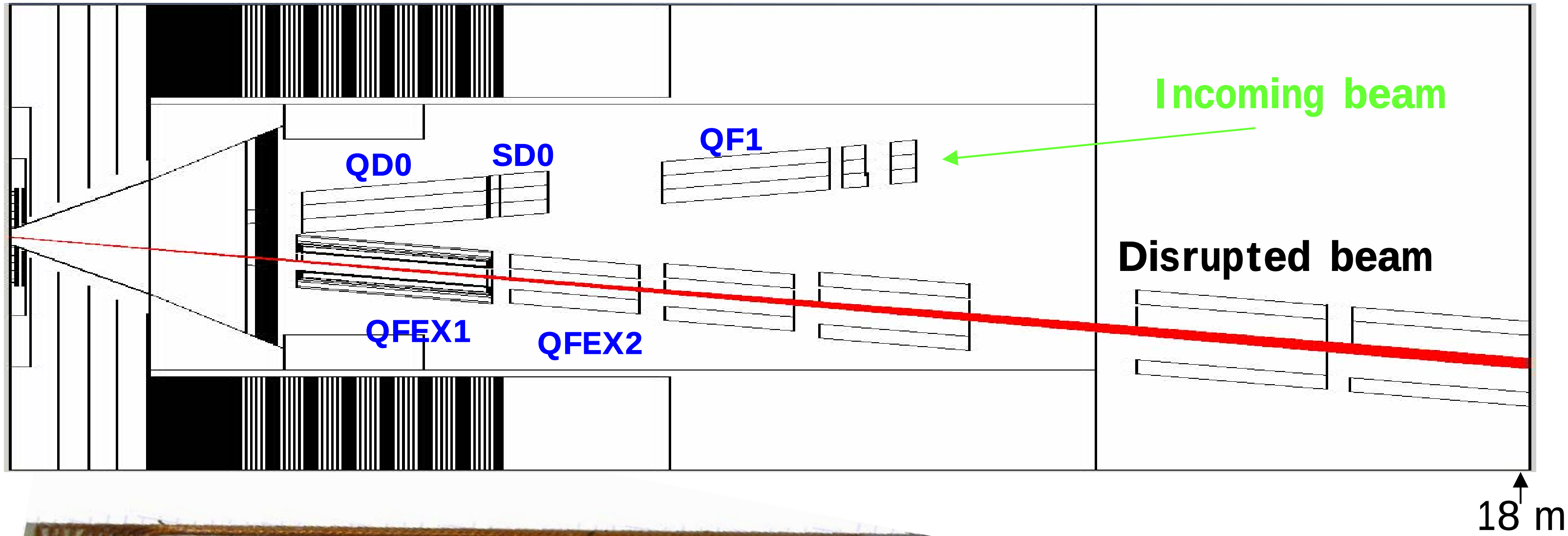
ILC IR and Extraction Line Magnet CHALLENGES

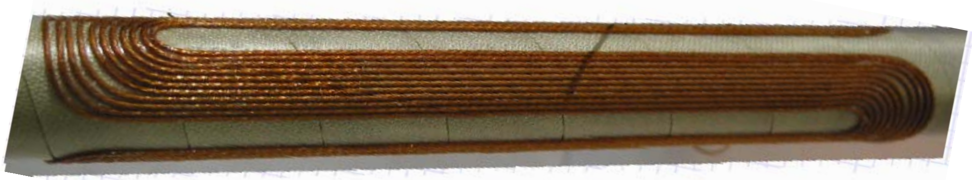
Two possible extraction schemes (with SiD)

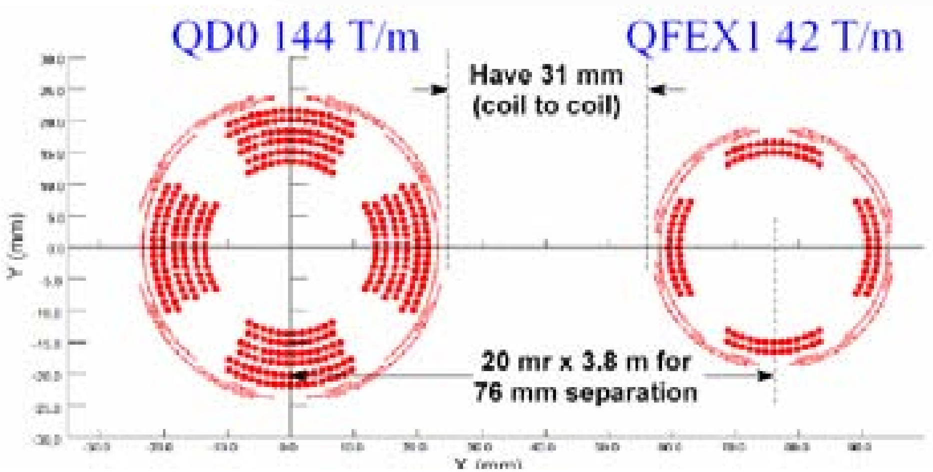


Cherrill Spencer, SLAC and Brett Parker, BNL

20mrad IR, extraction & compact SC quads



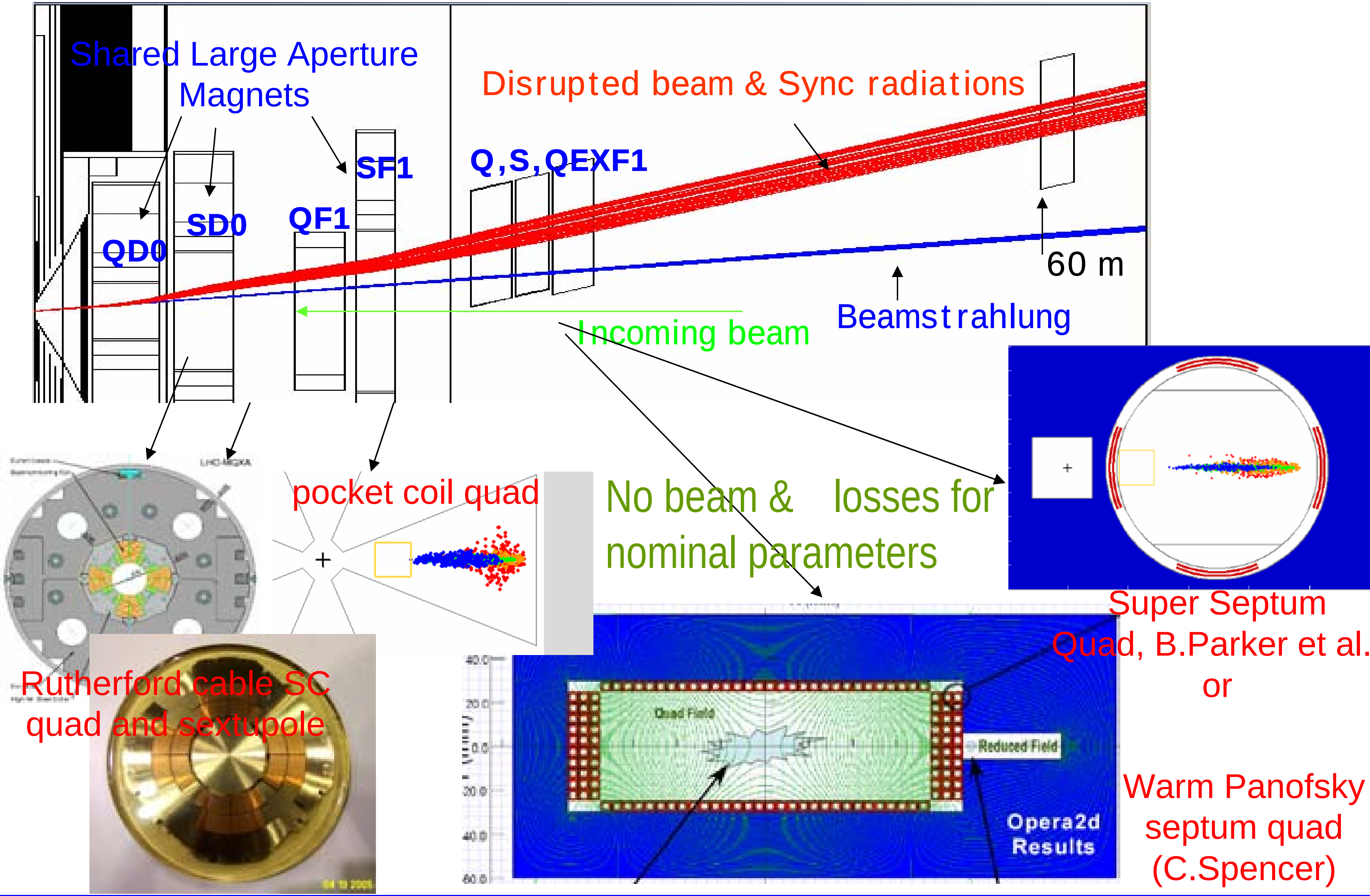




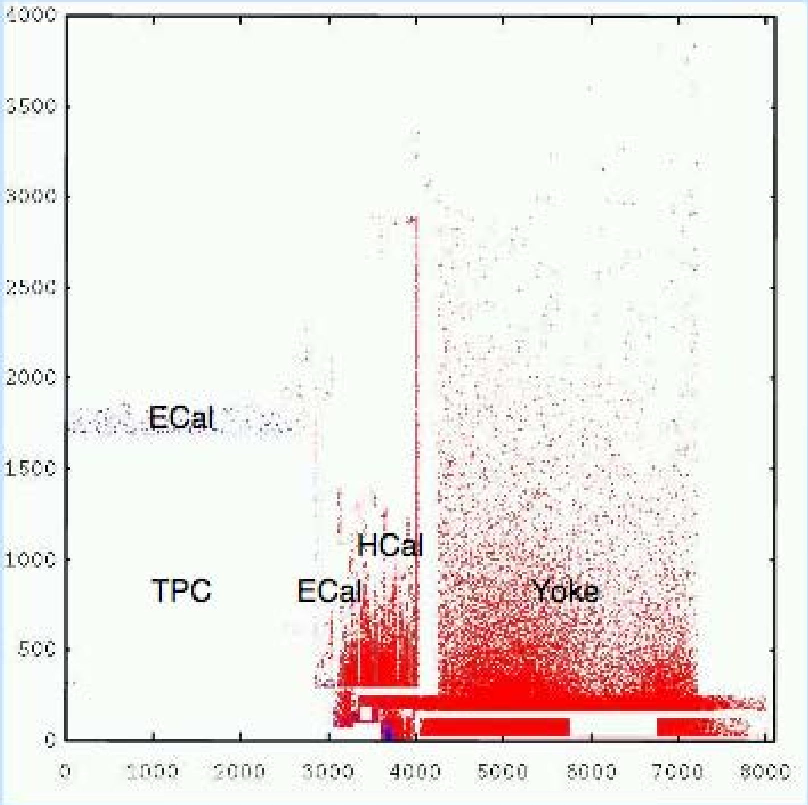
- Based on compact SC quads
- Latest achievements in BNL direct wind technology => even tighter bend radius => quad is more compact => extraction quad has same L*as QD0
- Sixth final layer wound on the QD0 prototype at BNL last week. Next => tests

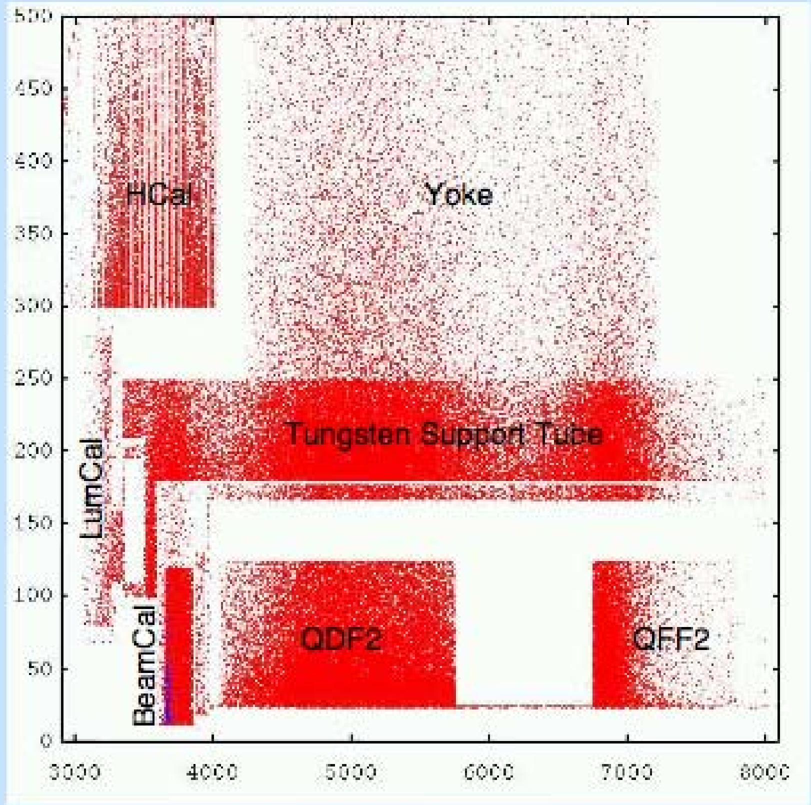
2mrad IP Extraction Line in Geant

SLAC-BNL-UK-France
Task Group



Neutron Production – Cross Section

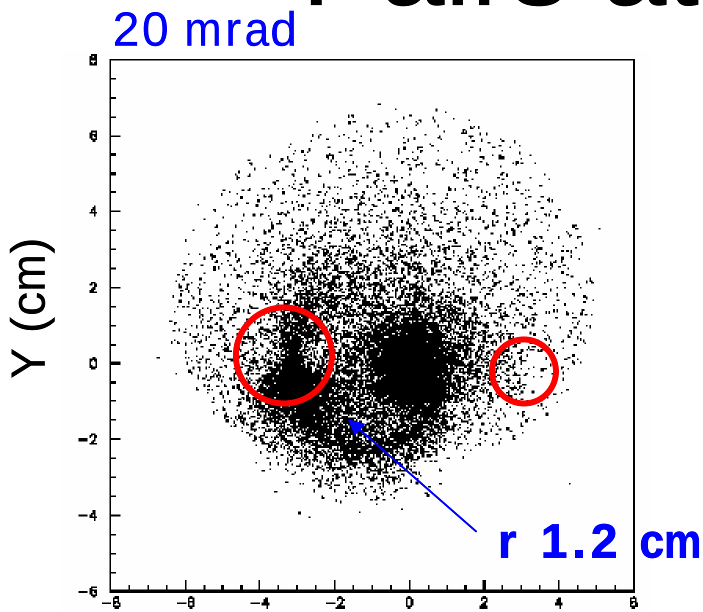


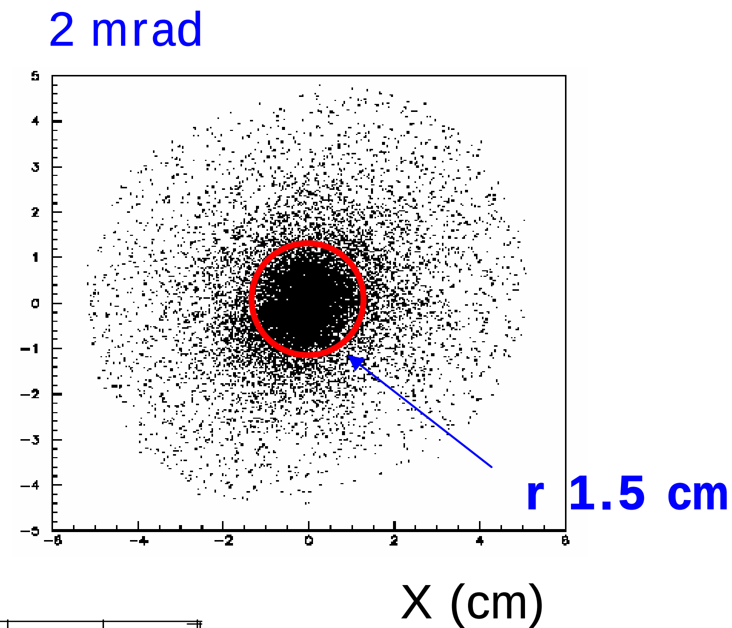


Origins of neutrons (blue ones reach the TPC)

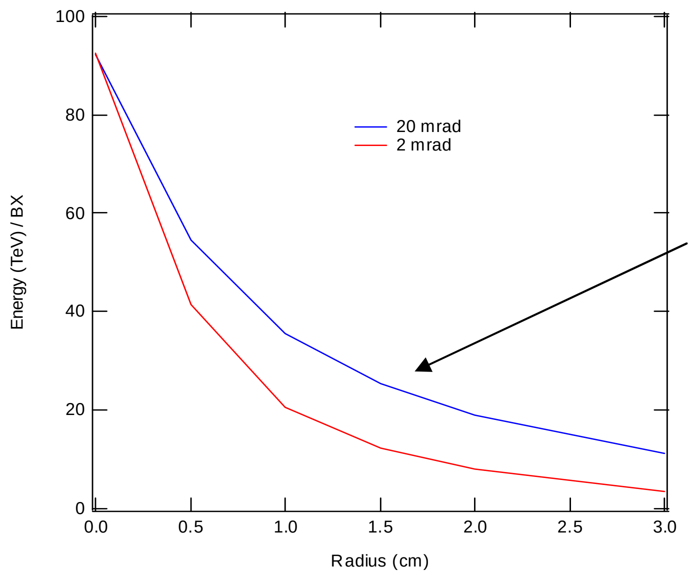
Murayama/Markiewicz

Pairs at Z = 300 cm



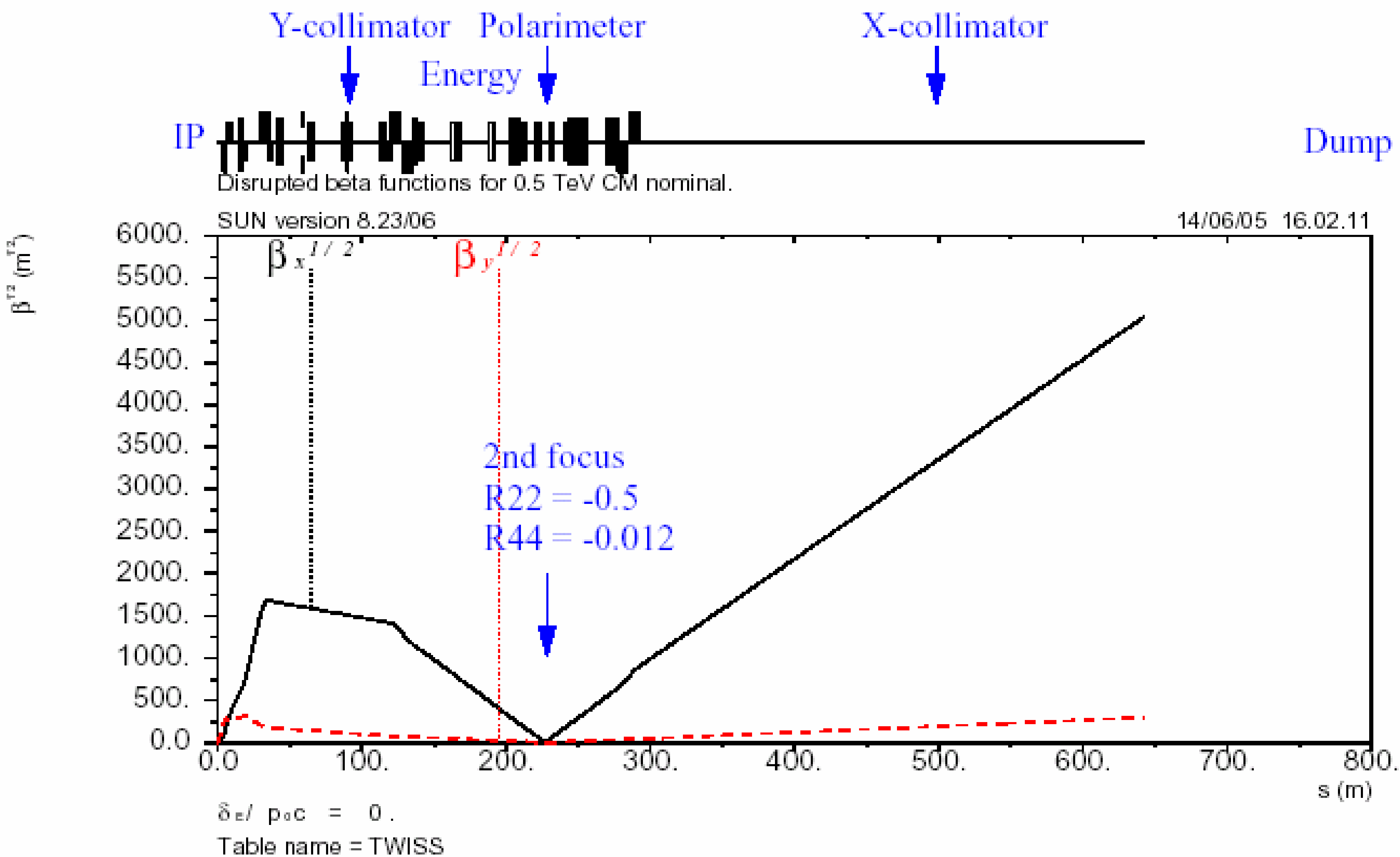


Pair energy
in BeamCal



2 more energy in 20 mrad

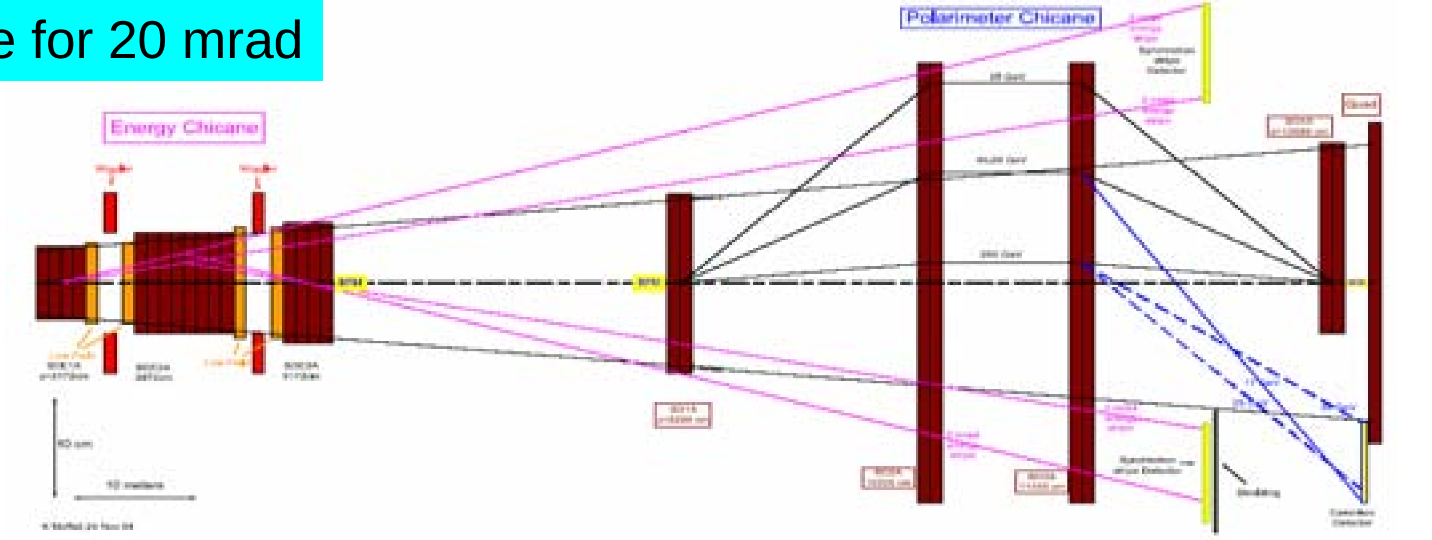
2mrad extraction line with diagnostics chicane



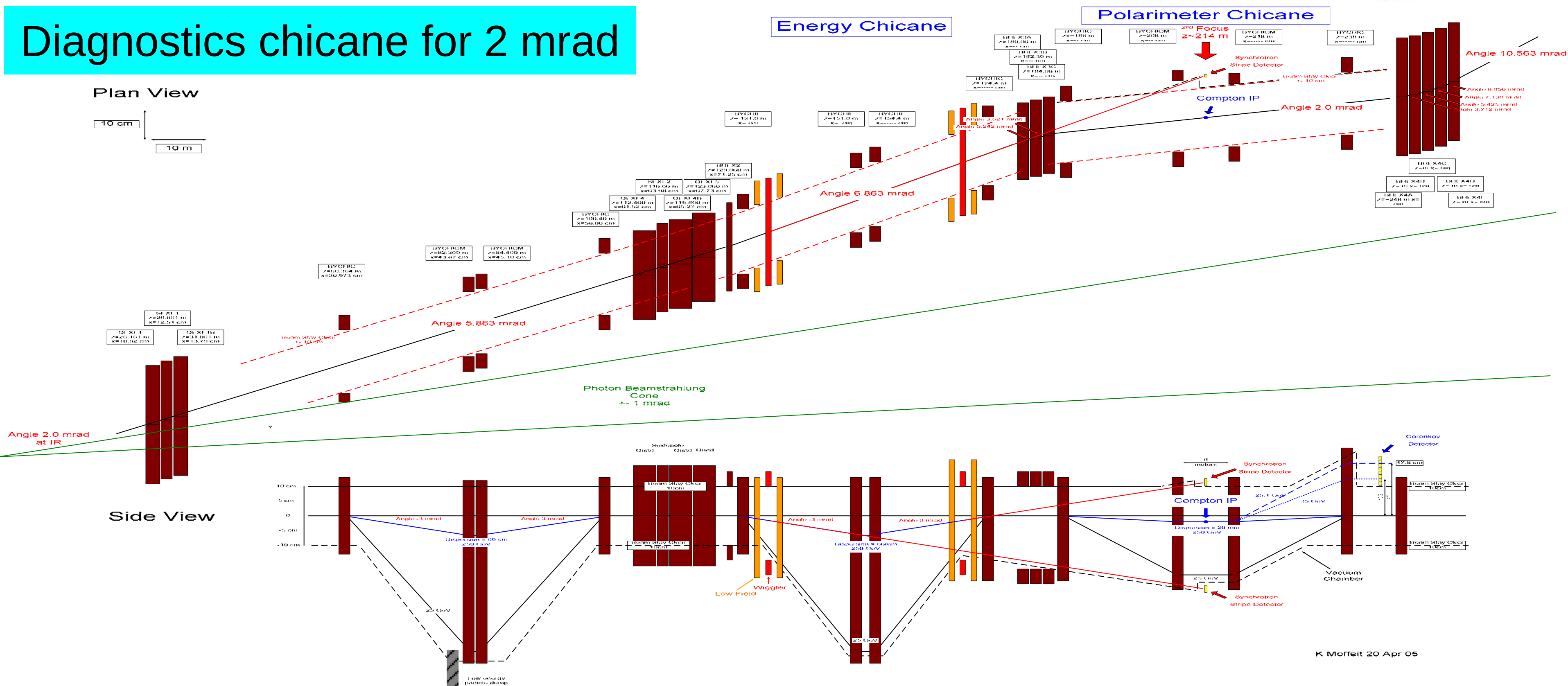
Plot from Yuri Nosochkov

Talk by R. Appleby

Diagnostics chicane for 20 mrad

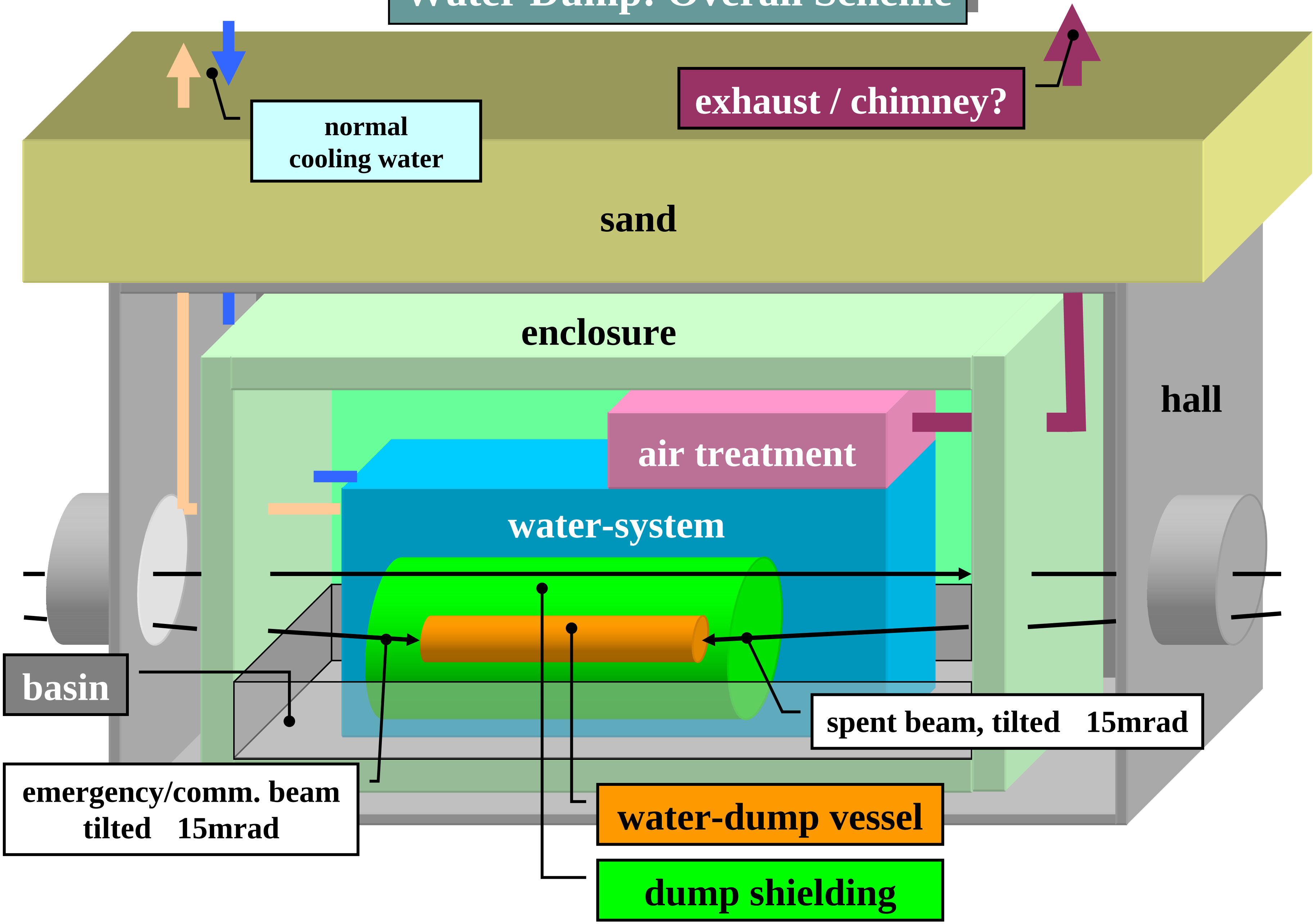


Diagnostics chicane for 2 mrad



Talk by E. Torrence on behalf of Ken Moffeit

Water Dump: Overall Scheme



Talk by M. Schmitz

Gas Dump: First Thoughts

Basic Idea

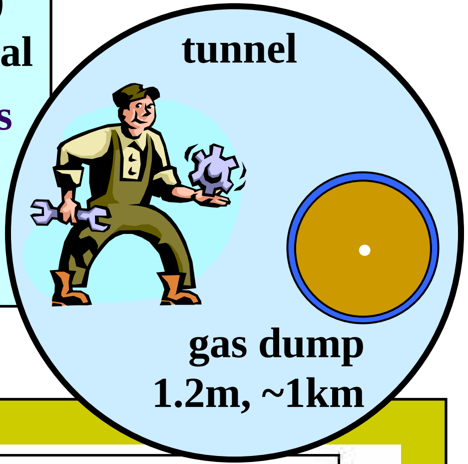
<u>One atomic noble gas core (Ar, Xe) is surrounded by solid material (Fe)</u>

gas core acts as scattering target (only small amount of energy deposition) and distributes energy longitudinally over ~ 1km into surrounding material

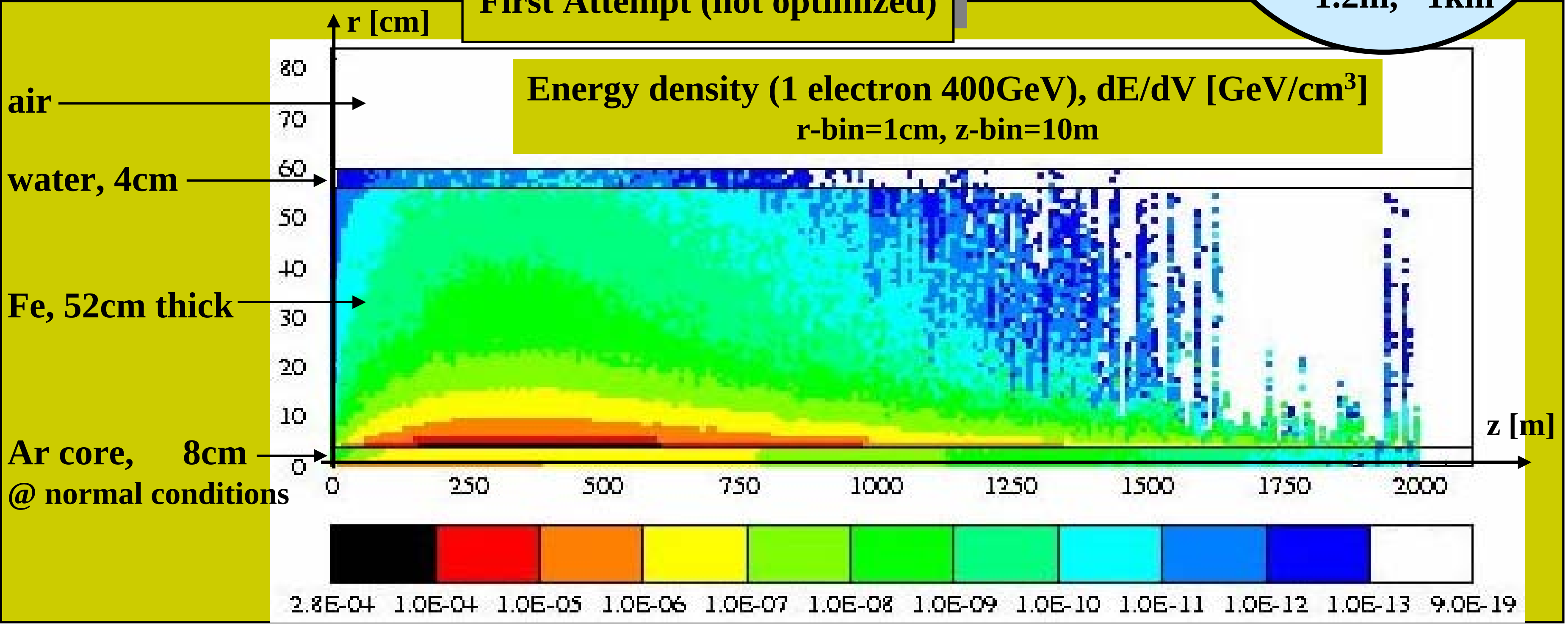
low energy densities, no sweeping, small spot size possible, no radiolysis

surrounding material takes main part of energy

Z 20 reduced tritium production



First Attempt (not optimized)



Talk by M. Schmitz

Before/At BDIR WS

- We have a “transition” :
  - Concepts (Strawmann)
  - Optics
  - Engineering design

BDS Reference Design Report for Snowmass

- From now to Snowmass: Suggest to create web-based description with main features of baseline, R&D for baseline, and options with their R&D

- After Snowmass, turn this description into a document according to common standard

- At this workshop, need to work on this document
  - A very rough draft is shown on next pages

- The Reference Design Report is based on assumption of two interaction regions. The particle physics output and cost of two IRs vs single IR will be evaluated in details

BDS Reference Design Report for Snowmass

BDS Baseline	Baseline R&D	Option and Option R&D
One of IRs with 20+mrad crossing, separate incoming and extraction lines	Many. See specific items below.	15-25mrad
One of IRs with ~2mrad crossing, first FD magnets shared	Many. See specific items below.	Head-on with electrostatic separator or RF kicker; Or same 20mrad for 2nd IR
Compact SC direct wind quads for 20mrad, separate cryostats for QD0 & QEXF	Prototype compact SC QD0	Common cryostat SC quads, other technology?
FF optics based on local chromatic correction	Get experience with compact FF at AFT2	Traditional FF with non- interleaved sextupole pairs
2mrad extraction beamline with E and polarization diagnostics, with separation of e+- and after first extraction line doublet	Prototype SC super septum quads or Panofsky style septum quads	Other ideas for magnets?
Large bore SC magnets for 2mrad, minimal external size, with antisolenoid and movers inside?	Prototype needed?	Alternative SC materials which allow larger aperture, but brittle in manufacturing
Crab cavity based on 1.3 or 3.9GHz located near FD in 20mrad IR and near SD4 in 2mrad IR	Prototype crab cavity with proper damping of high order modes	Crab cavity based on warm RF cavity
Main beam dumps based on water vortex scheme rated for 18MW beam. Common e+- and dump for 20mrad, separate dump for 2mrad	Prototype and tests of beam dump window?	Elliptical wide window.
Betatron collimation based on collimation in FD and IP phase, with survivable spoilers	Measurements of collimator wakefields. Beam damage studies at ESA.	Betatron collimation with consumable spoilers. Their prototype.
IR magnet support with passive vibration protection	IR prototype at ESA	Active stabilization of FD support

Betatron collimation based on collimation in FD and IP phase, with survivable spoilers	Measurements of collimator wakefields. Beam damage studies at ESA.	Betatron collimation with consumable spoilers. Their prototype.
IR magnet support with passive vibration protection	IR prototype at ESA	Active stabilization of FD support
Antisolenoid as part of detector in 20mrad IR	Do we need prototype or design studies sufficient?	No antisolenoid, only skew quad correction
Antisolenoids as part of large bore QD0	Prototype QD0, solve decoupling force on solenoid from the quad	No antisolenoid, only skew quad correction
Detector solenoid with Detector Integrated Dipole for both 20mrad and 2mrad	Design studies sufficient, no prototypes	No DID
Incoming beamline BPMs are cavity based submicron resolution	Prototype large aperture cavity BPMs	Stripline BPMs?
Diagnostics with orthogonal coupling correction section followed by a 4-wire-scanner 2D (projected) emittance measurement section with laser wire system with beam sizes > 17*1.5 microns	Prototype laser wire at PETRA and ATF/ATF2, achieve needed resolution of micron beam	Lengthened diagnostics section with larger beam sizes at laser wire scanners
Fast intra-train digital feedback system with BPMs on the IP face of FD and kickers near FD	Prototype intratrain feedback at ATF and ATF2, beamtest of BPMs in background conditions at ESA	No other options? Analog feedback is an option?
FD movers for 2mrad IR: movers are located inside of the cryostats of the large aperture magnets.	Prototype the movers. Piezo or magnetostrictive technology?	Other techniques?
FD movers for 20mrad IR: mechanical movers for each magnet individually, located outside cryostats, based on FFTB scheme	Prototype at ESA: IR mockup?	Other techniques?
Energy spectrometer based on high resolution cavity BPMs with variable	Prototype at ESA for BPMs, precise magnets, movers, survey system	

FD movers for 20mrad IR: mechanical movers for each magnet individually, located outside cryostats, based on FFTB scheme	Prototype at ESA. IR mockup?	Other techniques?
Energy spectrometer based on high resolution cavity BPMs with variable chicane for upstream beamlines	Prototype at ESA for BPMs, precise magnets, movers, survey system	
Polarimeter for upstream beamlines		
Downstream energy spectrometer based on synchrotron stripe monitor	Prototype at ESA	
Collider halls separated by about hundred meters, size w*l*h meters		
Mover system for main beamline magnets based on FFTB scheme		Mover system based on 6D movable system (SBIR 1, possible SBIR 2)
Tail folding octupoles based on SC magnets with five magnets in each FF branch	Prototype strong octupoles	
Muon and personnel protection wall based on magnetized iron, two per FF branch, 9m and 18m long		Single muon protection wall may be sufficient for lower halo population and higher tolerance for muon background
Emittance diagnostics and correction system upstream of beam switchyard, common system for both IRs		Separate diagnostics in each branch?
Fast luminosity and pairs monitors based on … technology…	Prototype and test at ESA	
IR with cryo-pumping by cold bore magnets		
IP BPMs …		

What we have done

Optics

Instrumentaion

Beam Test

BDS design supported by R&D work at these facilities

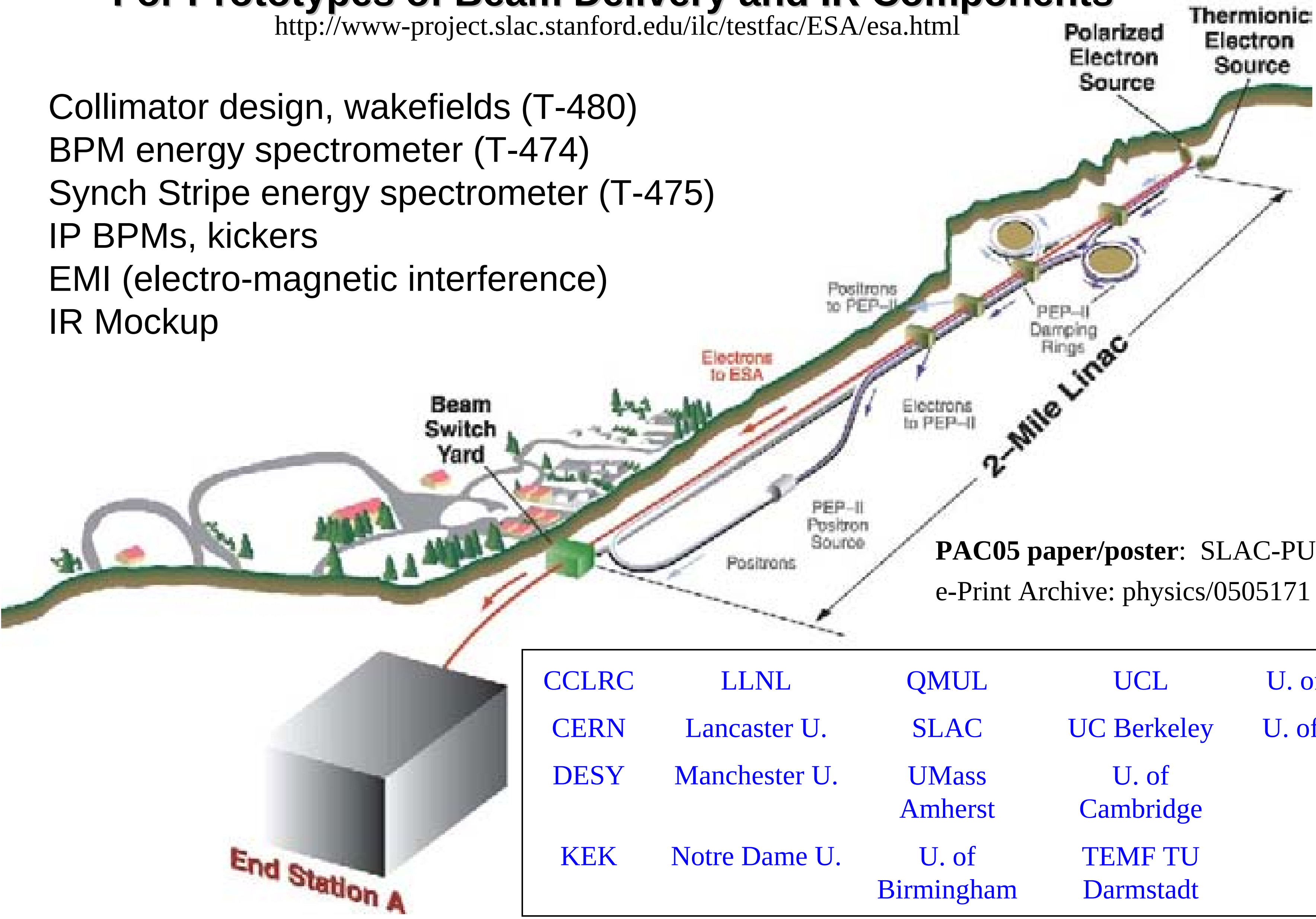
- Proposed End Station A at SLAC
  - Study Interaction Region issues and instrumentation
  - Mockup of full IR
- Existing ATF at KEK (DR and BDS related studies)
  - Instrumentation (Nano-BPM, laser wires, optical anchor)
  - Fast Intra-train feedback (FONT/Feather)
  - nm resolution BPM test & demonstration
  - Preparation of 'ATF-2'
- Proposed ATF-2 at KEK
  - BDS facility, use very low emittance ATF beam

End Station A Test Facility

For Prototypes of Beam Delivery and IR Components

http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html

Collimator design, wakefields (T-480)
BPM energy spectrometer (T-474)
Synch Stripe energy spectrometer (T-475)
IP BPMs, kickers
EMI (electro-magnetic interference)
IR Mockup



PAC05 paper/poster: SLAC-PUB-11180
e-Print Archive: physics/0505171

CCLRC	LLNL	QMUL	UCL	U. of Bristol
CERN	Lancaster U.	SLAC	UC Berkeley	U. of Oregon
DESY	Manchester U.	UMass Amherst	U. of Cambridge	
KEK	Notre Dame U.	U. of Birmingham	TEMF TU Darmstadt	

ATF2 design & goals

Address luminosity challenges of ILC

Follow up on FFTB, create facility

to train young generations of accelerator physicists

(A) Small beam size

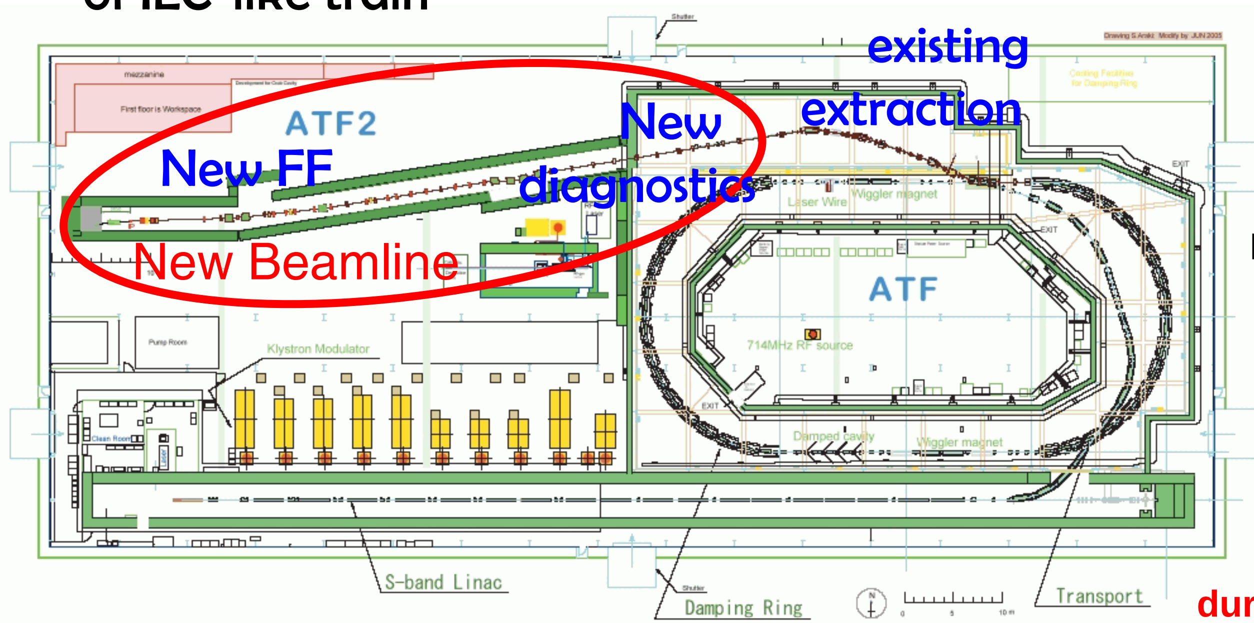
Learn to obtain $_{y}$ ~ 35nm
and maintain for long time

(B) Stabilization of beam center

Learn to keep it stable at IP within < 2nm

using nano-BPM and bunch-to-bunch feedback

of ILC-like train



ATF2 collaboration, presently >88 people from 21 labs and institutions and growing

KEK, Tsukuba
IHEP, Beijing
BINP, Novosibirsk
CCLRC/DL/ASTeC,Daresbury
CEA, Gif-sur-Yvette
CERN, Geneva
Hiroshima University
Kyoto ICR, Kyoto
LAL, Orsay
LLNL, Livermore
NIRS, Chiba-shi
North Carolina A&T State University
Oxford University
Pohang Accelerator Laboratory
Queen Mary University of London
Royal Holloway, University of London
DESY, Hamburg
SLAC, Stanford
UCL, London
University of Oregon
University of Tokyo

ATF2 proposal will be released during this BDIR workshop in London

http://lcdev.kek.jp/ILC-AsiaWG/WG4notes/

23 institutes
102 collaborators

CERN-AB-2005-035
CLIC note 636
DESY 05-148
ILC-Asia-2005-22
JAI-2005-002
KEK Report 2005-2
SLAC-R-771
UT-ICEPP 05-02

ATF2 Proposal

ATF2 Collaboration

August 11, 2005

Items to be discussed

- Layout & Optics
- Magnets
- IR design and MDI issues
- Collimation & Background
- Beam dumps
- Instrumentation & Feedback & Crab Cavity
- WG4/WWS/Detectors
- Joint with WG1:
  - BDS tuning, alignment, ground motion...

Summary

- ILC BDS :
  - concepts => optics => engineering design
- Designing IR
  - Layout (Magnet etc.)
  - Collimation & Background (MC)
  - Beam Dump