CLIC Post-Collision Lines

Outline

1) Overview – Design Considerations

2) A Conceptual Design (A. Ferrari)

3) Recent developments

4) Beam Diagnostics in the Post-Collision Lines

5) Summary

Information and help received from many colleagues

Ijaz Ahmed
Hans Braun
Enrico Bravin
Luca Bruno
Thibault Lefevre
Thomas Otto
Daniel Schulte
Rogelio Tomas
Heinz Vincke
Thomas Zickler

Arnaud Ferrari (Uppsala)
Volker Ziemann (Uppsala)
Mike Salt (Cockcroft)
Rob Appleby (Cockcroft)

THANKS !

1) Overview – Design Considerations

conceptual design input:

- need to transport disrupted (spent) beam + beamstrahlung photons to final dump (14 MW) (vacuum chamber exit window etc.)
  also full beam without collisions
- need to deal with huge avalanche of particles of all energies (coherent pairs, total of 330 kW) (zero at ILC)
- “clean up” low energies, keep small particle losses in magnets
- need to install some beam diagnostics (very modest w.r.t. ILC)

-> stay clear of the incoming beam (20 mrad crossing angle)

-> minimize background in the experiment (backscattering)

1) Overview – design considerations

Luminosity and Background Values

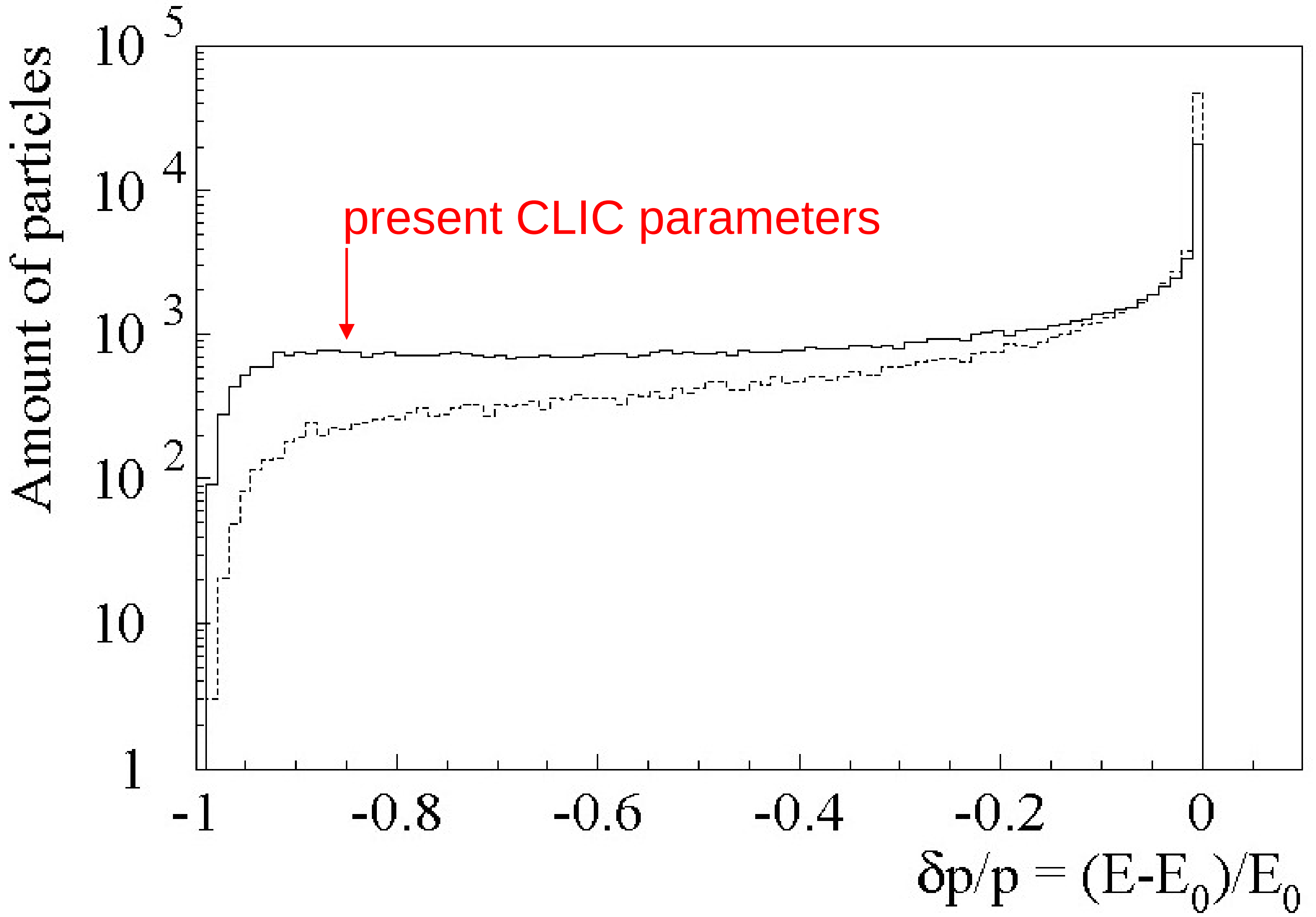
		CLIC	CLIC	CLIC	CLIC(vo)	ILC	NLC
E_{cms}	$[TeV]$	0.5	1.0	3.0	3.0	0.5	0.5
f_{rep}	[Hz]	100	50	50	100	5	120
n_b		312	312	312	154	2820	190
σ_x	$[nm]$	115	81	40	40	655	243
σ_y	$[nm]$	2	1.4	1	1	5.7	3
Δt	$[ns]$	0.5	0.5	0.5	0.67	340	1.4
N	$[10^9]$	3.7	3.7	3.7	4.0	20	7.5
ϵ_y	$[nm]$	20	20	20	10	40	40
L_{total}	$10^{34}cm^{-2}s^{-1}$	2.2	2.2	5.9	10.0	2.0	2.0
$L_{0.01}$	$10^{34}cm^{-2}s^{-1}$	1.4	1.1	2.0	3.0	1.45	1.28
n_γ		1.2	1.5	2.2	2.3	1.30	1.26
$\Delta E/E$		0.08	0.15	0.29	0.31	0.024	0.046
N_{coh}	10^5	0.03	37.0	3.8×10^3	?	—	—
E_{coh}	$10^3 TeV$	0.5	1080	2.6×10^5	?	—	—
n_{incoh}	10^6	0.05	0.12	0.3	?	0.1	n.a.
E_{incoh}	$[10^6 GeV]$	0.28	2.0	22.4	?	0.2	n.a.
$n_\perp$		12.5	17.1	45	60	28	12
n_{had}		0.14	0.56	2.7	4.0	0.12	0.1

~ 0.27

- Note: low energy CLIC parameters just an illustration

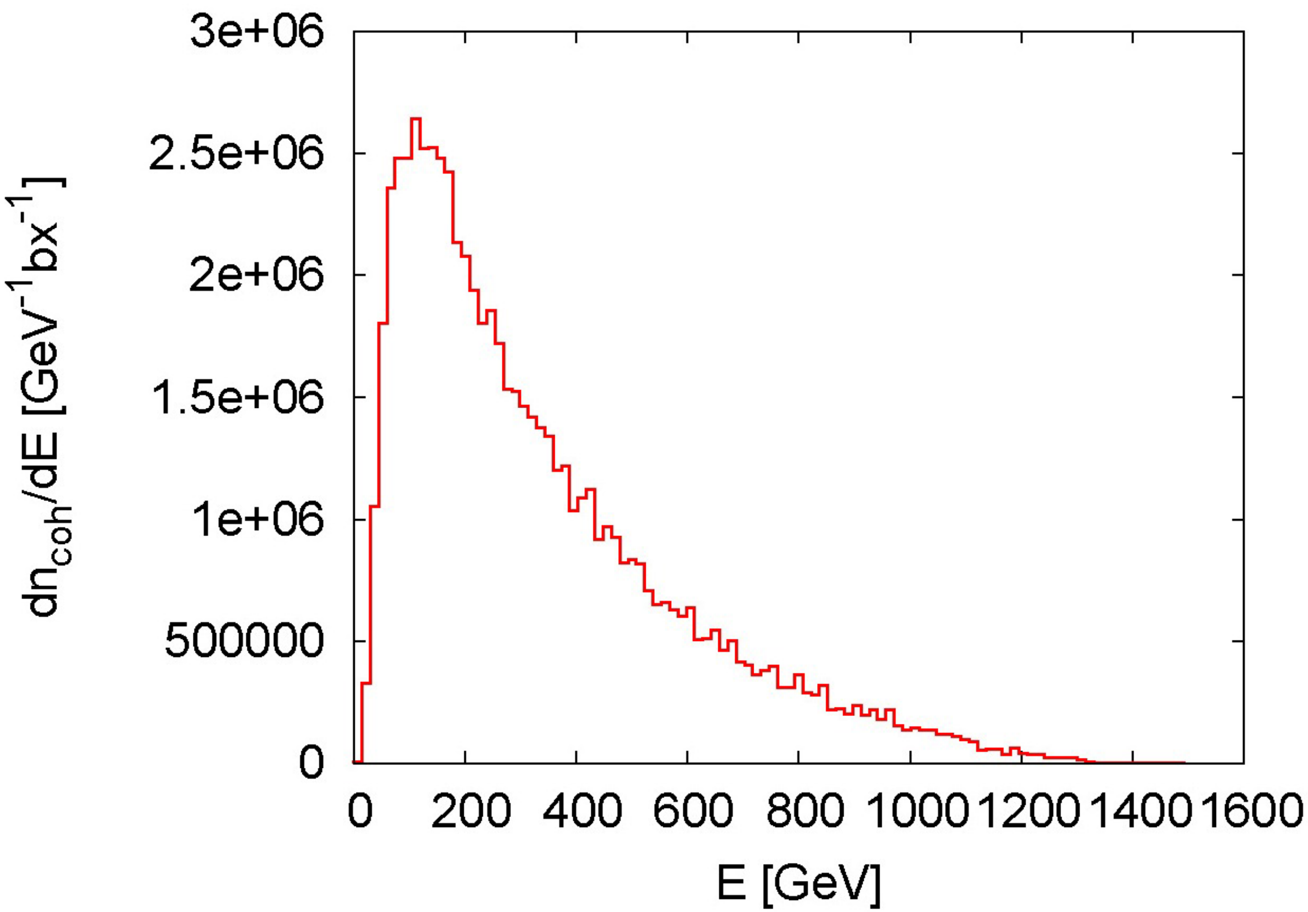
D. Schulte
Sendai, March 2008

disrupted beam at interaction point



Arnaud Ferrari
EUROTEV-Report
2008-021

coherent pairs at interaction point



Daniel Schulte
Sendai, March 2008

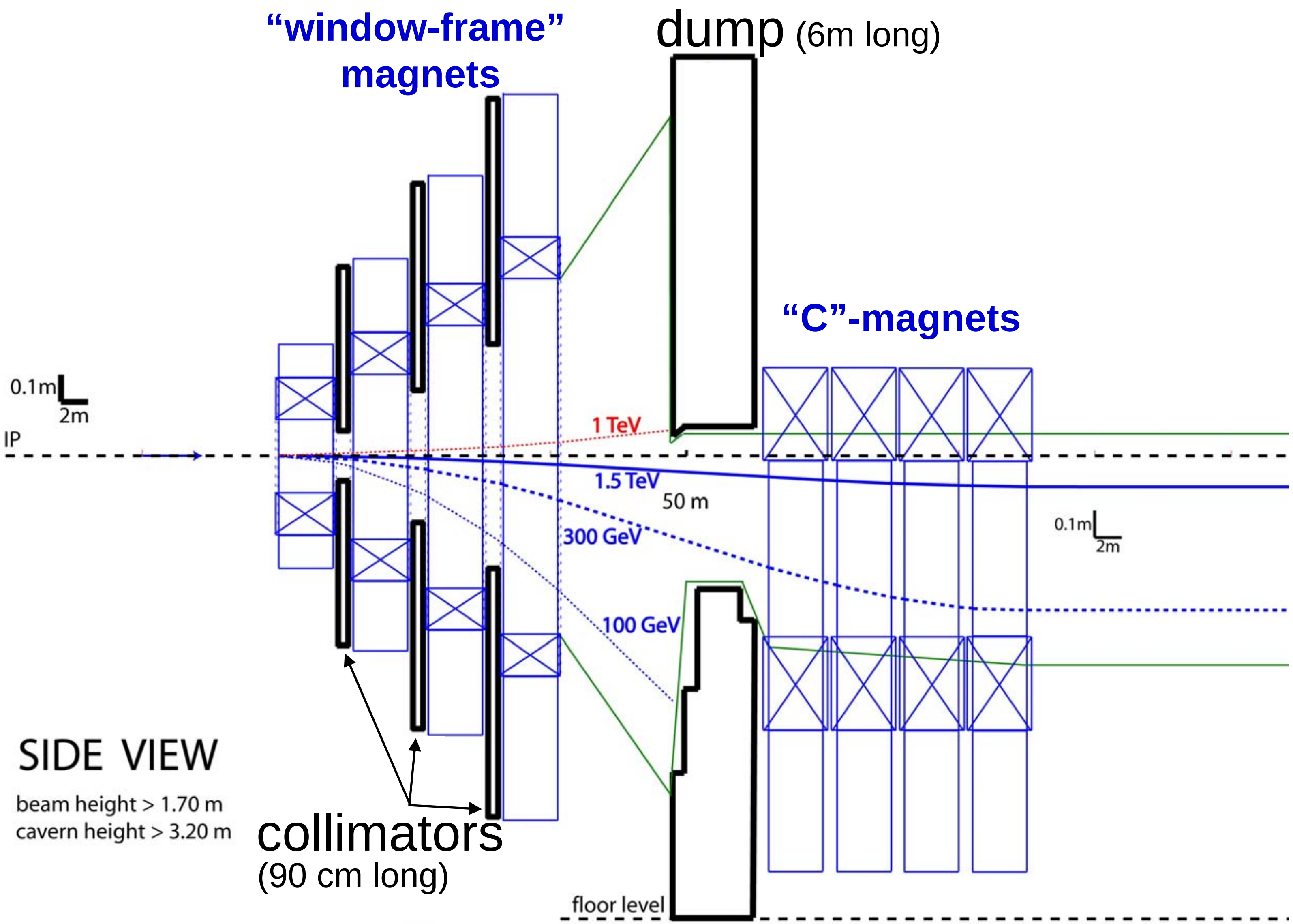
2) A Conceptual Design
(Arnaud Ferrari, Uppsala)

- **vertical "chicane"** (2 x 3.2 mrad at 1.5 TeV);
  use 2 x 4 deflection magnets

- intermediate collimators and dumps for low energy tails and for opposite sign particles from coherent pairs;

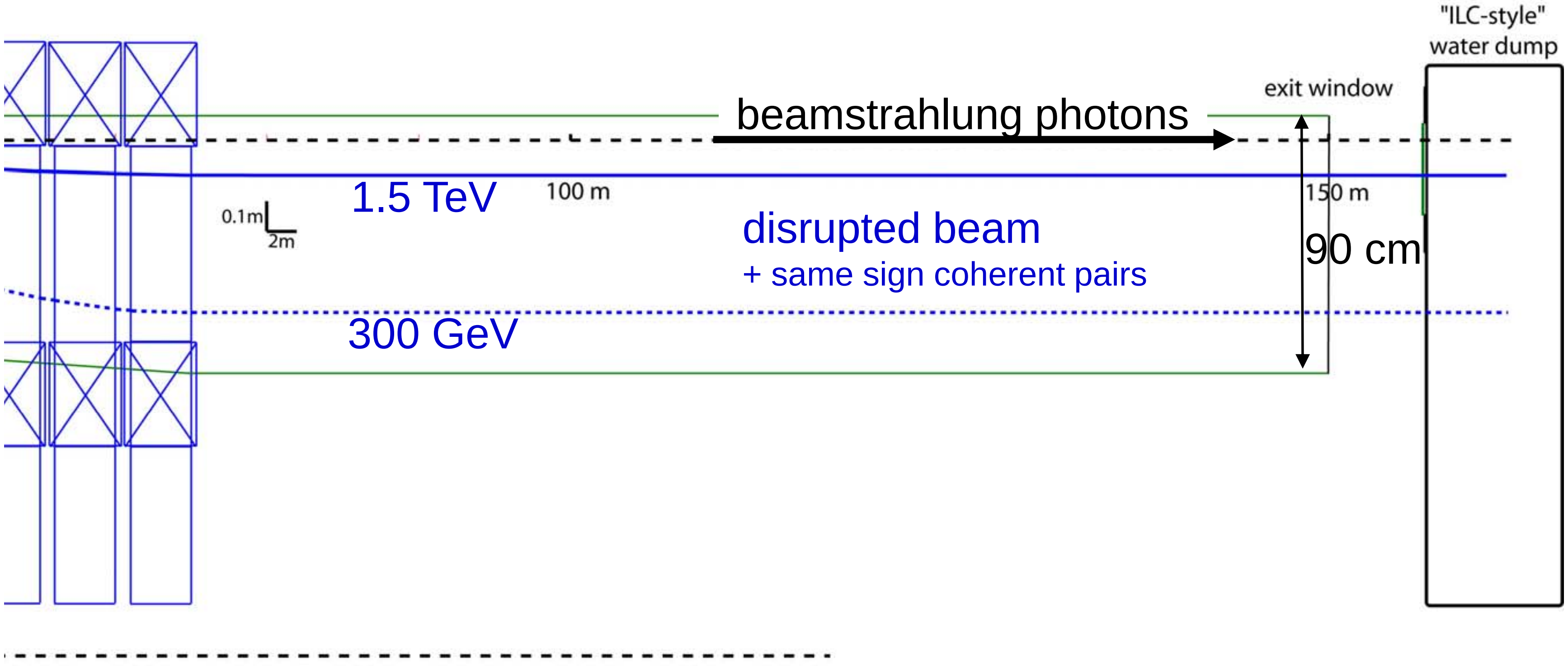
- allow non-colliding beam to grow to acceptable size (to protect vacuum chamber exit window + dump, at ~150 m)

2) Present Conceptual Design (Arnaud Ferrari, Uppsala)



2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

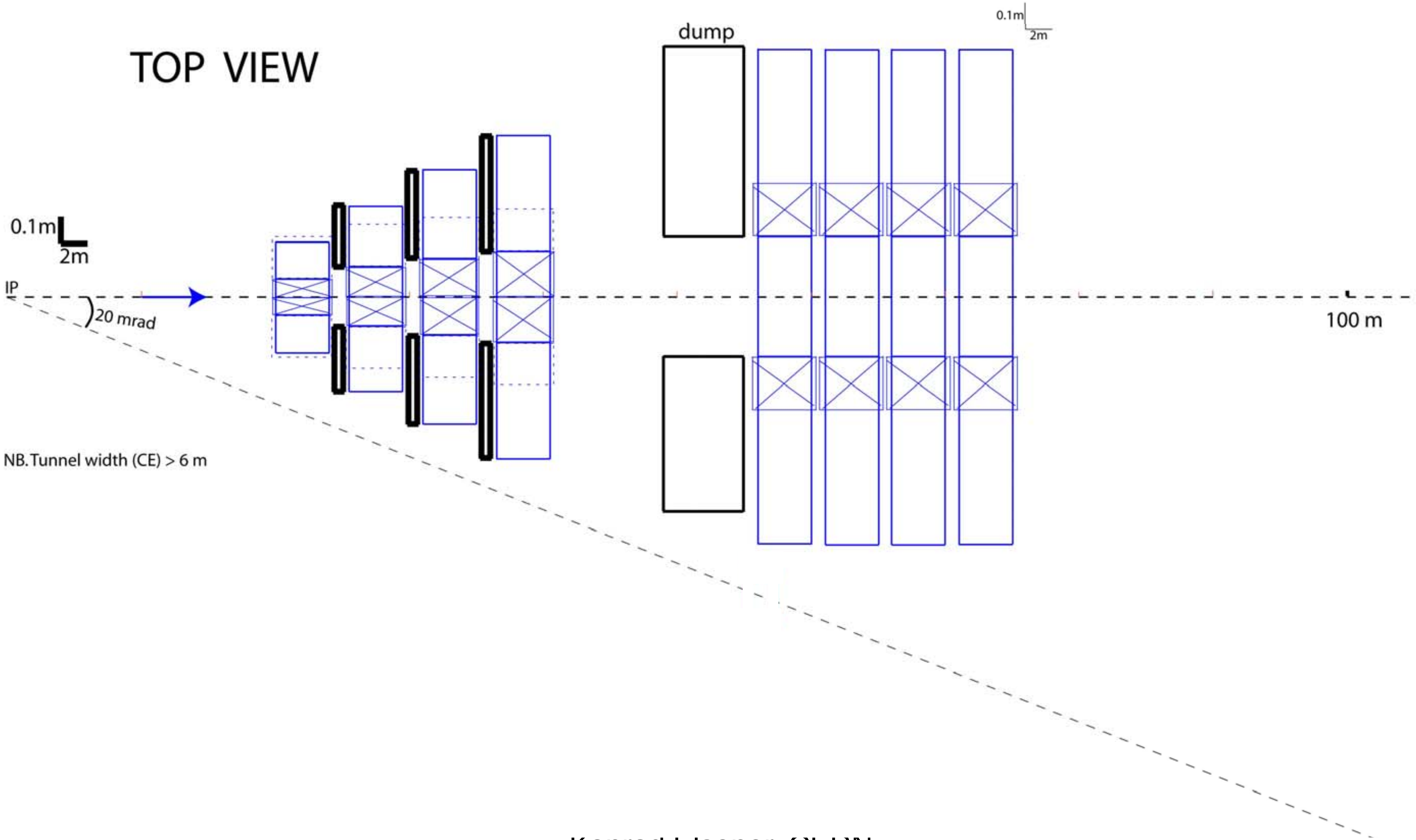
SIDE VIEW



2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

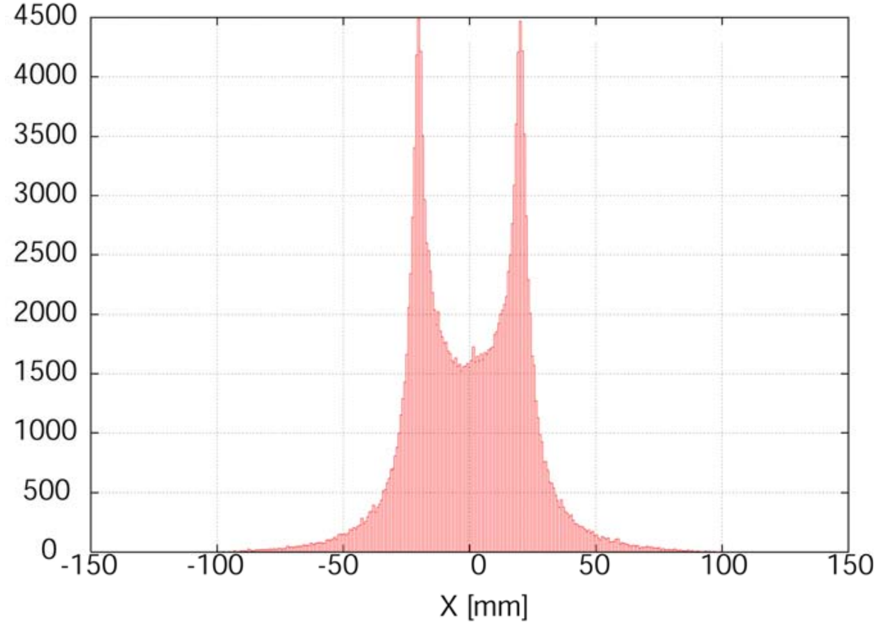
"window-frame" magnets

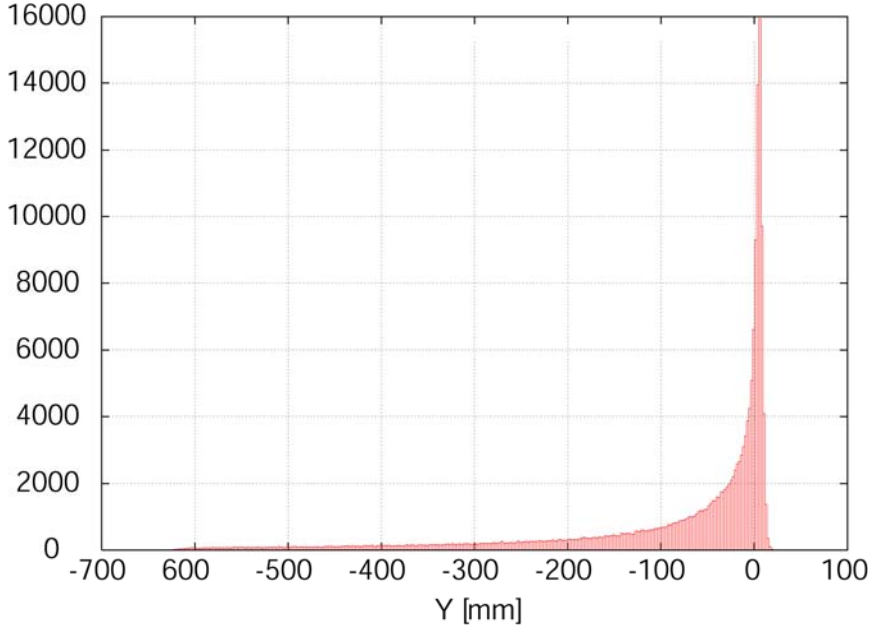
"C"-magnets

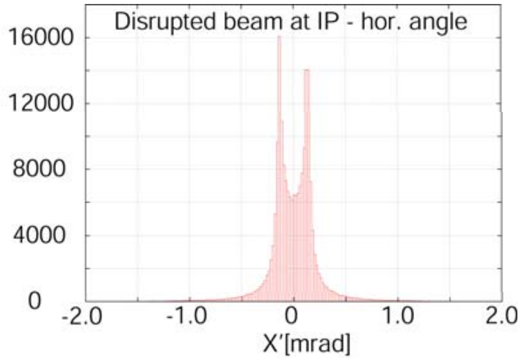


2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

disrupted beam at final dump

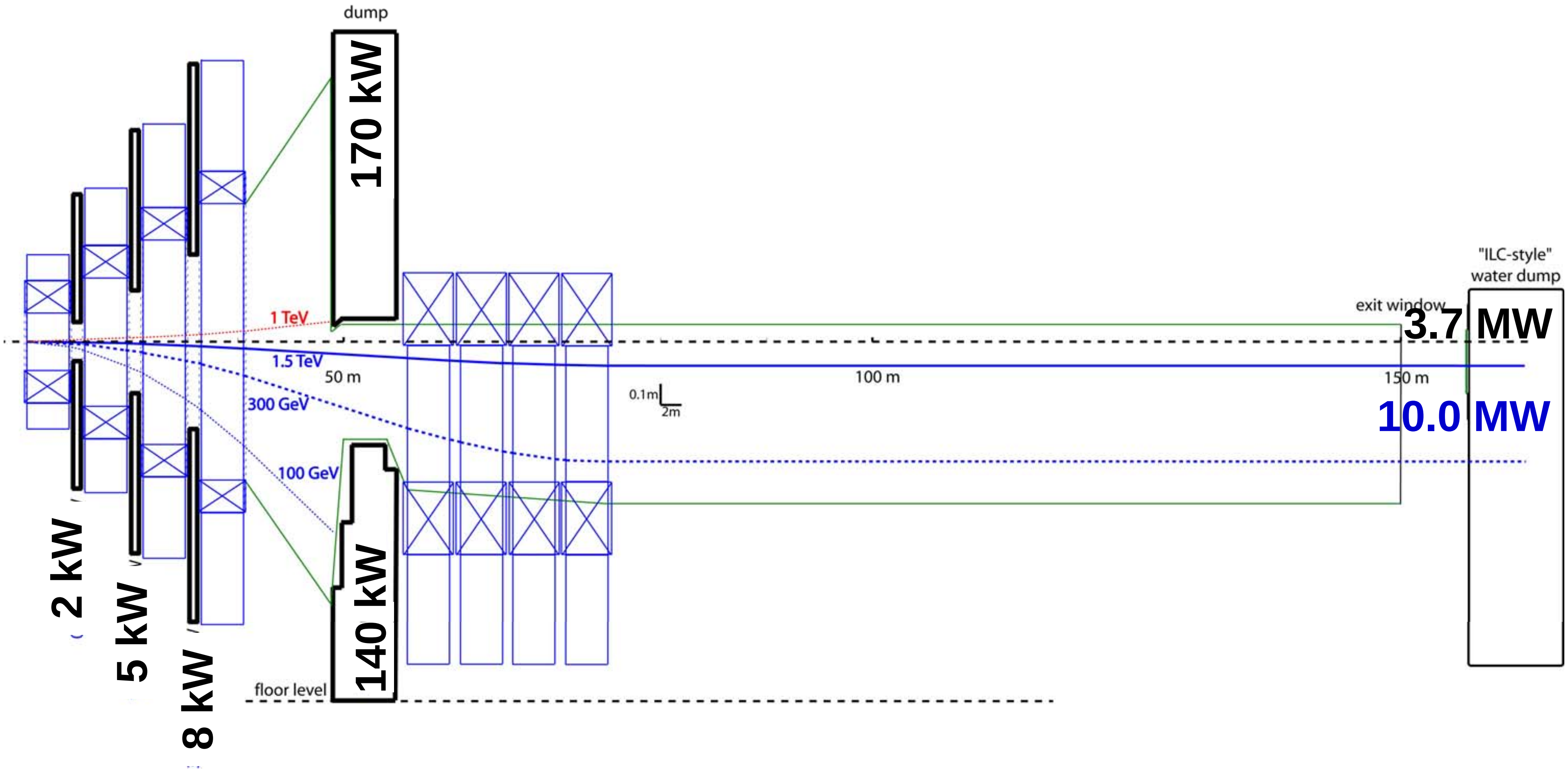






2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

power deposition in collimators and dumps



Critical Issues

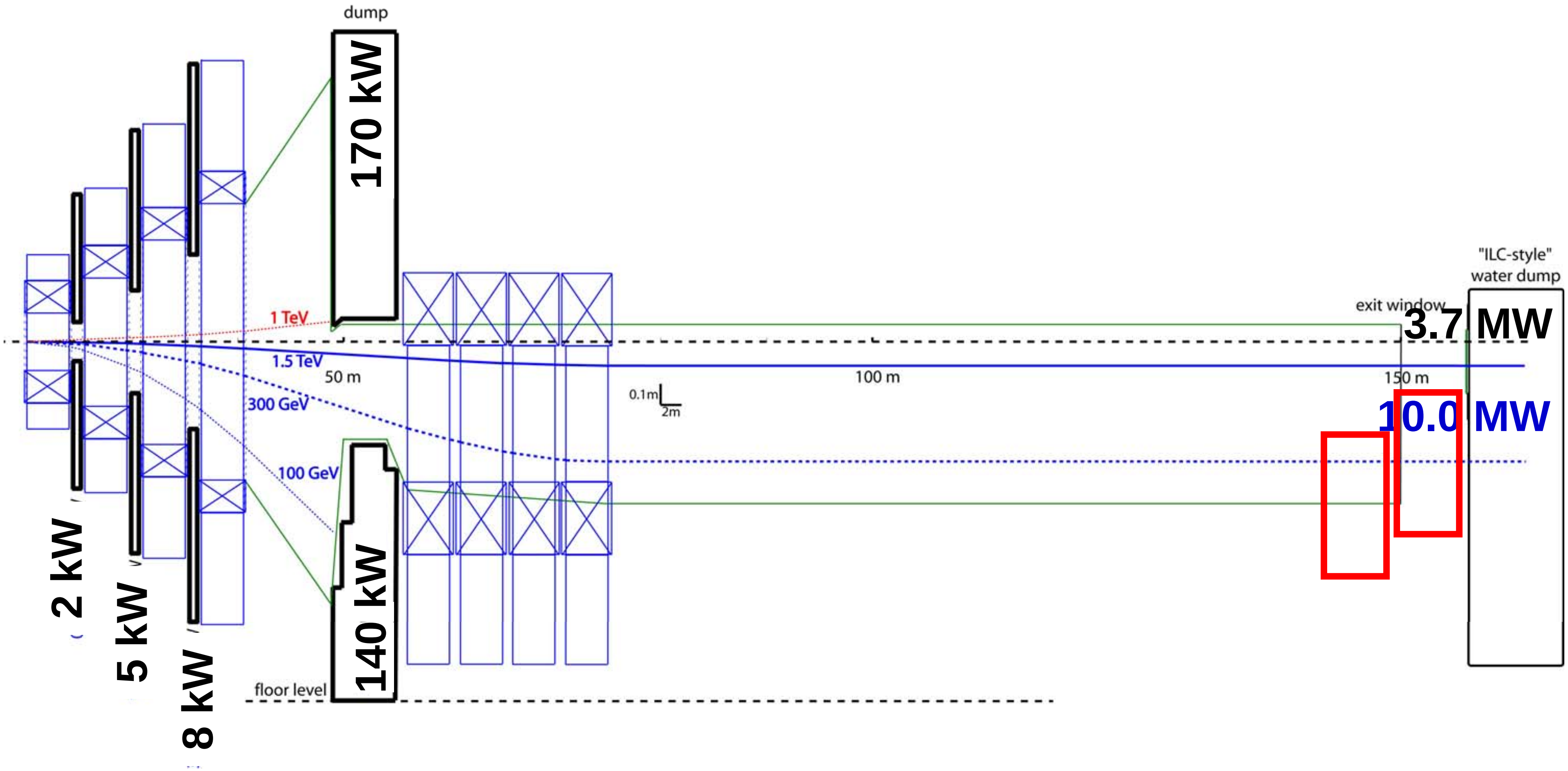
level 1

- main beam dump
  - if water dump at 10 bar –> entrance window ?
  - need to add “tail-catcher(s)” ?
  - if not, what dump ?
    - (cf. 4 MW p-beam dump, EDMS No. 348474)
- radiation in the post-collision line –> equipment, water, air

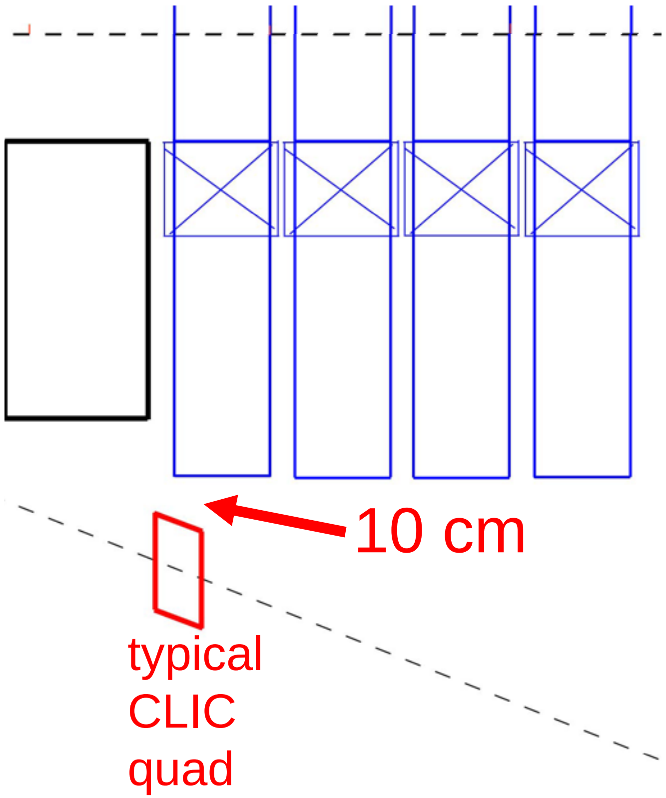
level 2

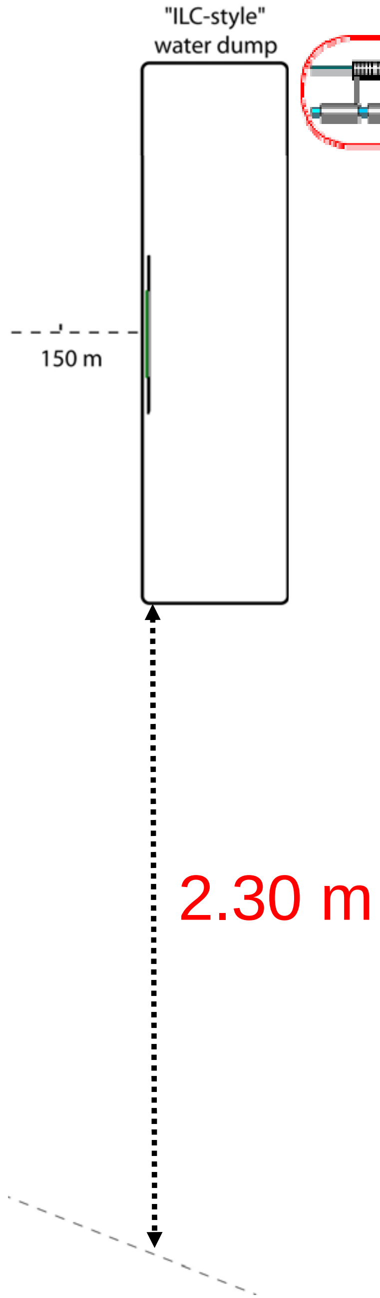
- cooling of dumps and collimators / material choice
- cavern height / need for crane /
- lateral free space (vs. incoming beam)
- longitudinal space (need “stretched” version ?)
  - -> magnet design
- synchrotron radiation
- background in luminosity monitors
  - -> simulations

"tail catchers"



lateral space - examples





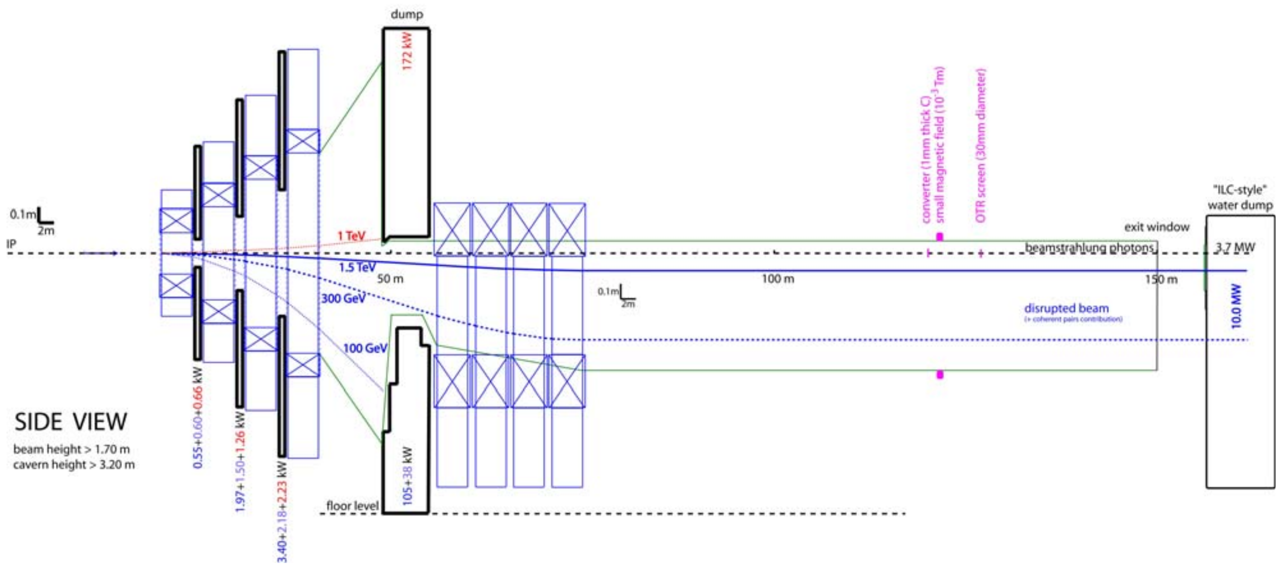
3) Recent Developments

-> remove space constraints by "stretched" version of the post-collision line, magnets at 0.8 instead of 1 T (K.E.)

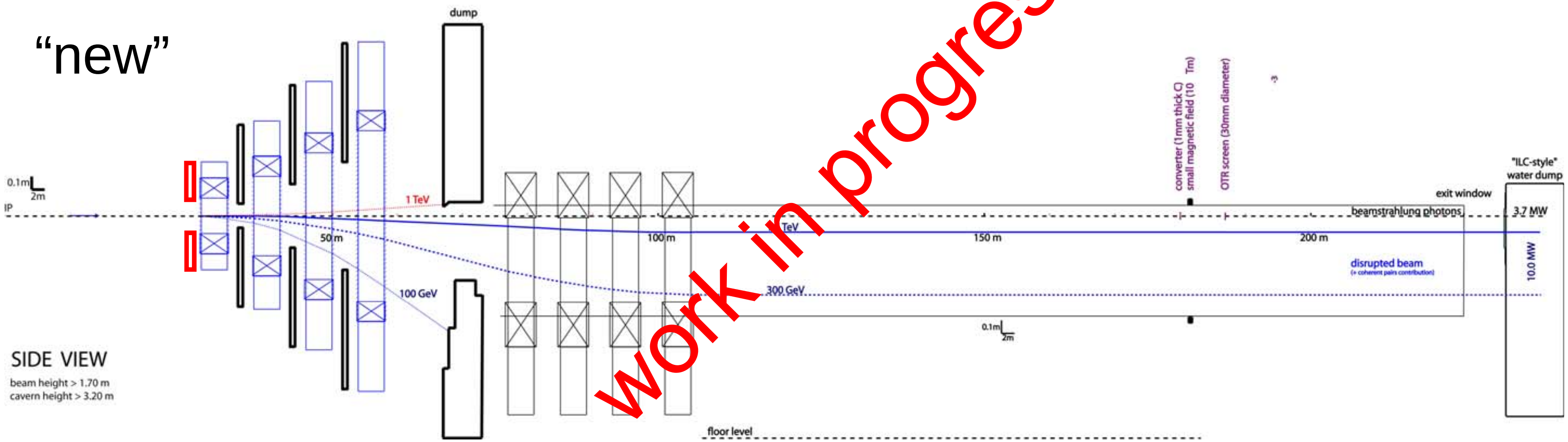
-> intense discussion about radiation to magnets - limits ??
(A. Ferrari: losses 330 W (?) in first magnet)

-> several options under study **(Mike Salt, Cockcroft Inst.)**

“old”



“new”



work in progress

4) Beam Diagnostics in the Post-Collision Lines

NB. Large number of coherent pairs imposes less ambitious diagnostics (w.r.t. ILC) in the post-collision lines

- no energy measurement
- no polarimeter

(both need to be in BDS)

Vague ideas about measuring opposite sign coherent pairs before/in dump (NB. 170 kW dump – instrumentation not obvious !)
cf. Volker Ziemann, EuroTeV-Report 2008-016 – not treated here

somewhat more clear ideas about **luminosity monitoring** devices (below)

4) Beam Diagnostics in the Post-Collision Lines

luminosity monitoring – crucial item

various detectors will measure luminosity (... but: very slow ...)

need fast signal for monitoring / correcting beams

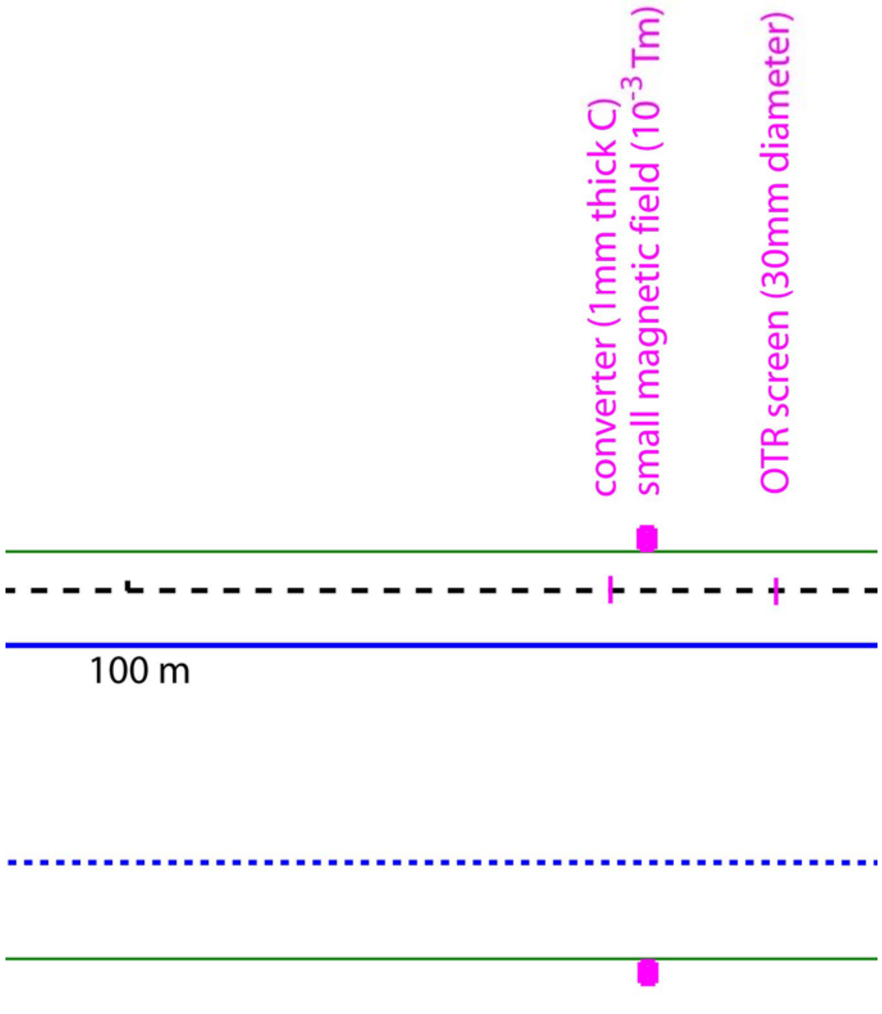
number of beamstrahlung photons is related to the luminosity
(P. Eliasson et al., CLIC note 669 (EPAC 2006))

- measurement per bunch train possible (156 ns, 50 Hz)
- measurement per bunch "impossible"

-> will attempt to "cut" train into few slices

relative changes to luminosity – absolute value from "slow" detectors

4) Beam Diagnostics in the Post-Collision Lines
by Enrico Bravin, July 2007



e+e- pair production

2.5E+12 photons in 156 ns;
energies up to 1.5 TeV

->

5E+9 charged particles

->

Opt. Trans. Radiation
in thin screen
(observation with CCD
or photomultiplier)

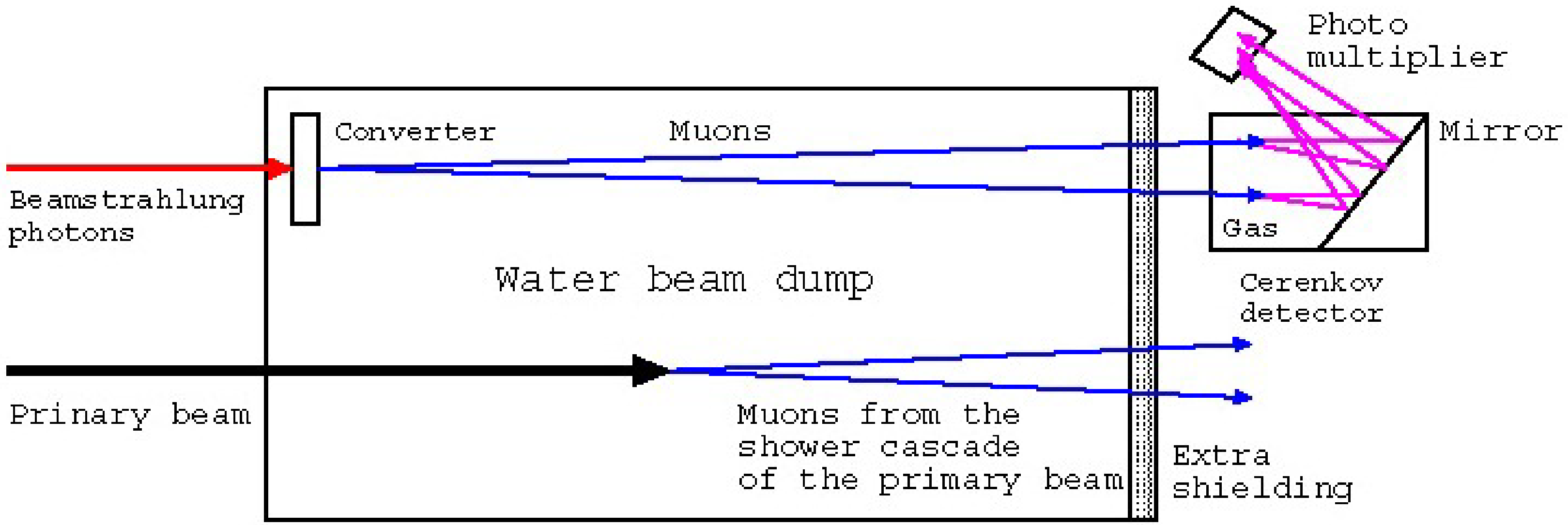
4) Beam Diagnostics in the Post-Collision Lines

by Volker Ziemann (Uppsala)

$\mu^+\mu^-$ pair production

-> Cerenkov light -> observe with photomultiplier
(~ 2E+5 Cerenkov photons per 3.7E+9 particles in a bunch)

EUROTeV-Report-2008- 016 .



5) Summary

- conceptual design of post-collision line exists
  but needs to be improved

- much work to be done on:
  collimators and dumps,
  radiation issues,
  luminosity monitoring + backgrounds,
  etc. etc.

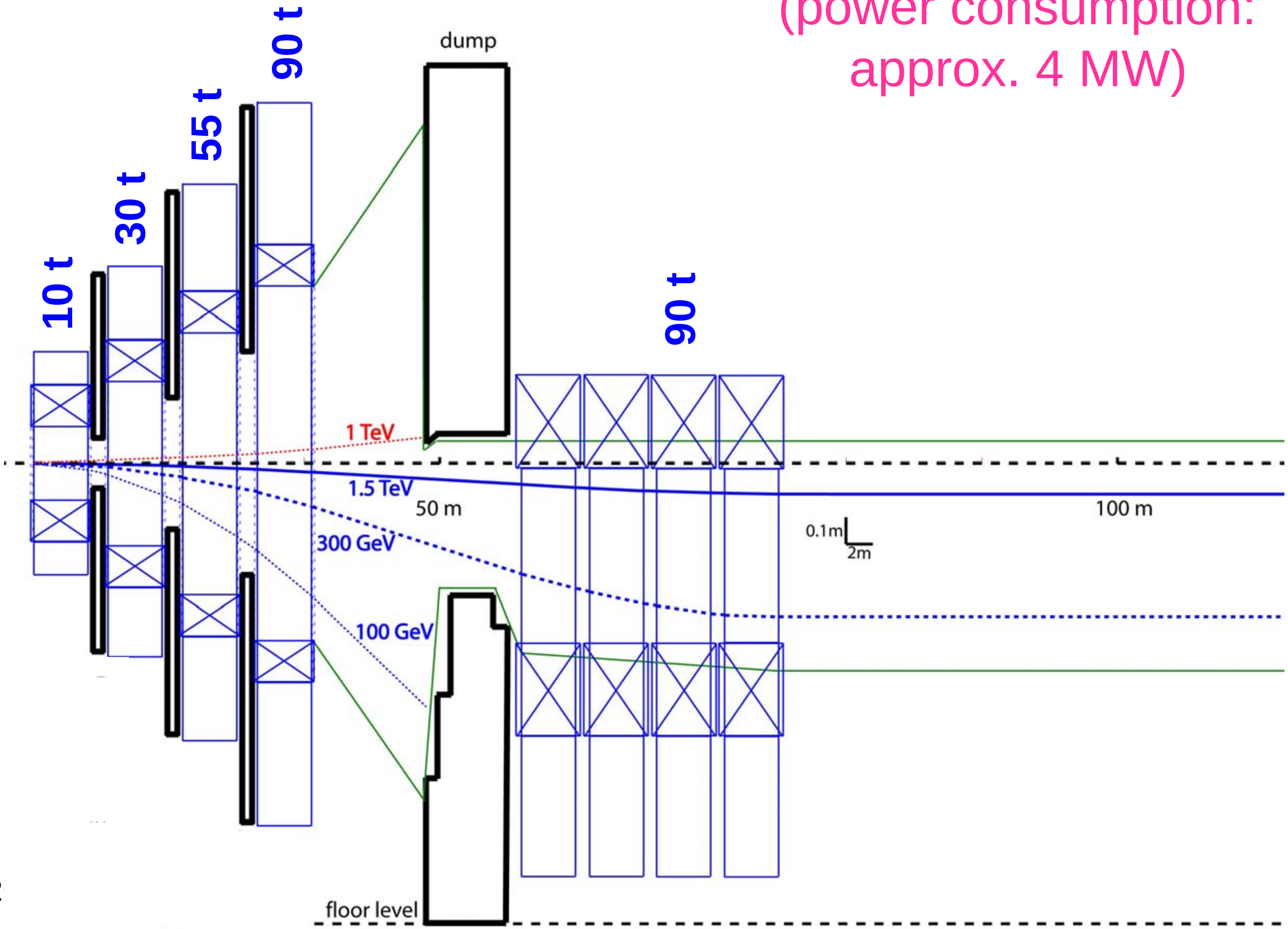
ANY HELP is most WELCOME !

spare slides

2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

typical weight of magnets

(power consumption: approx. 4 MW)



lateral space – examples

ILC dump

lateral space – examples

TESLA

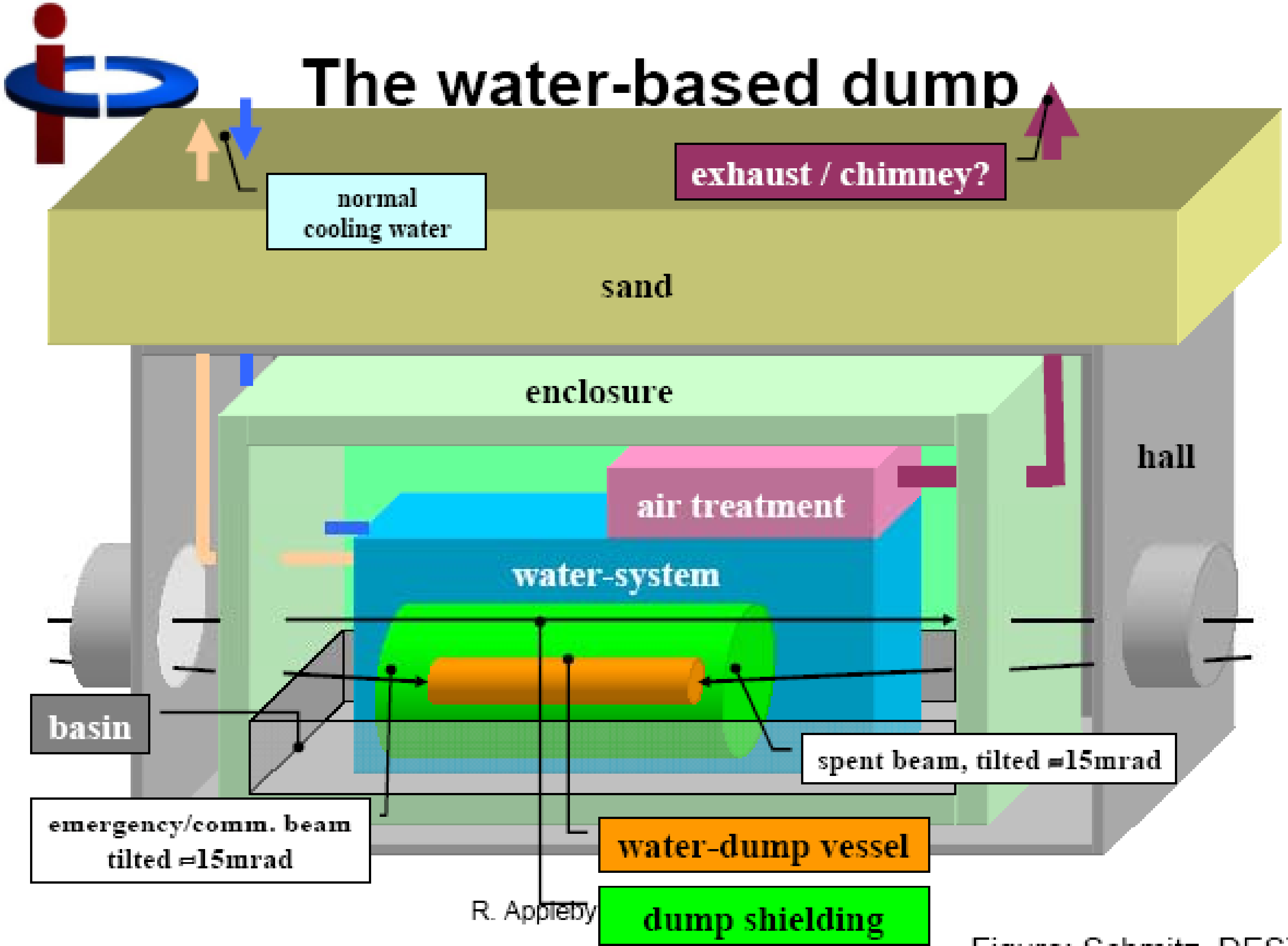
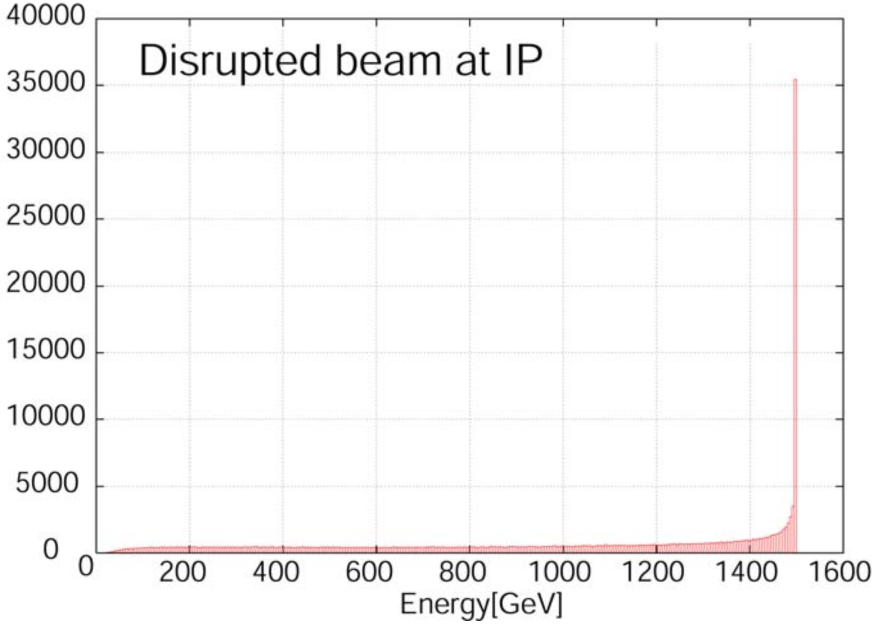
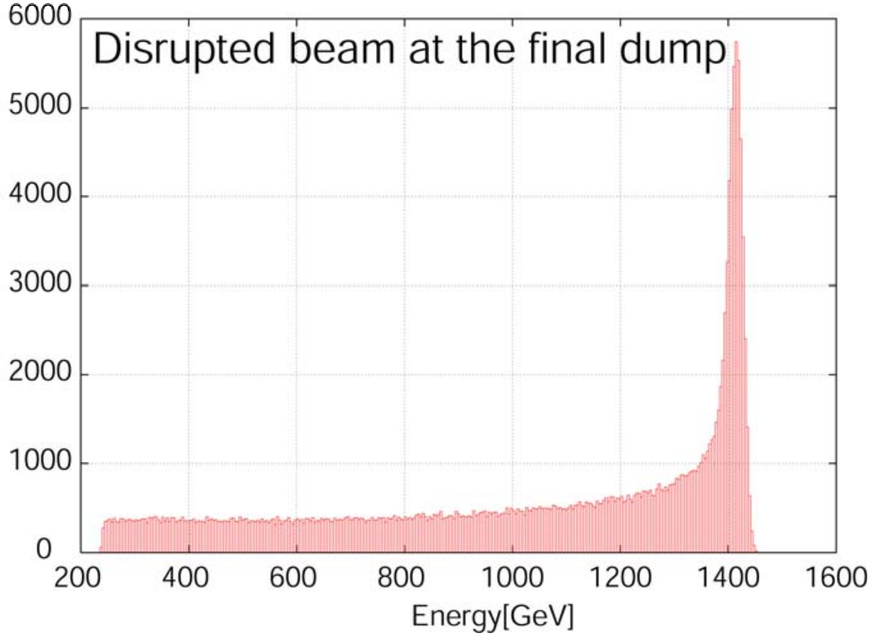


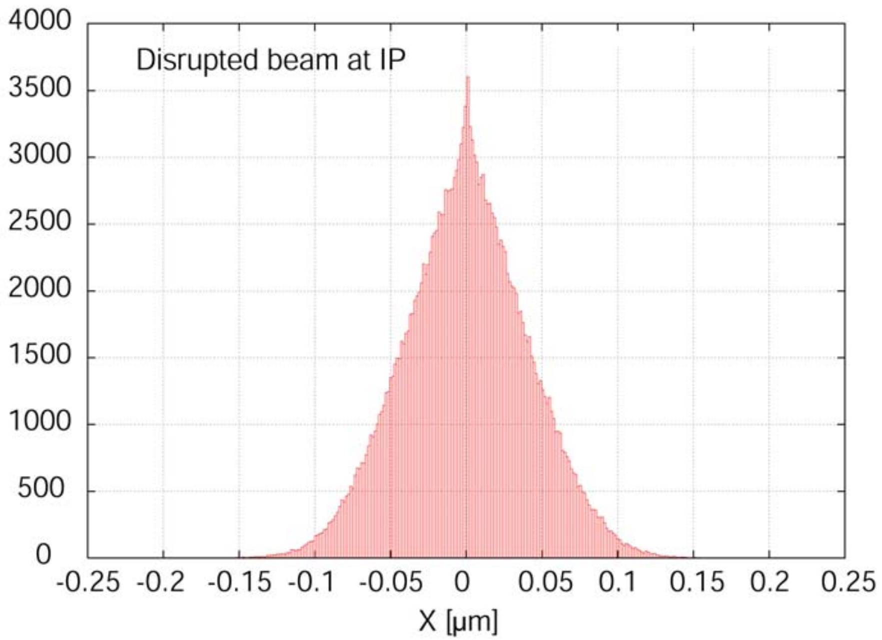
Figure: Schmitz, DESY

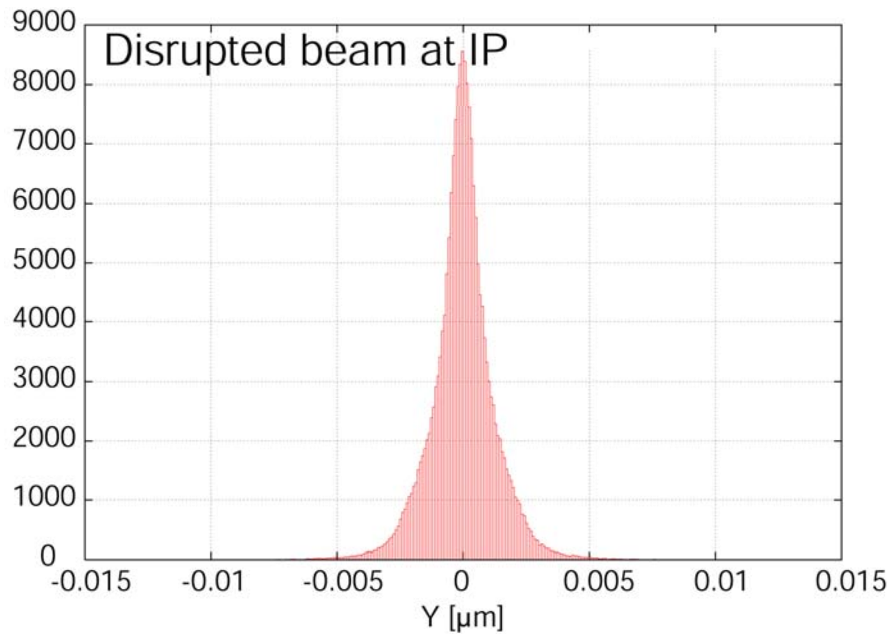
2) Present Conceptual Design (Arnaud Ferrari, Uppsala)





2) Present Conceptual Design (Arnaud Ferrari, Uppsala)





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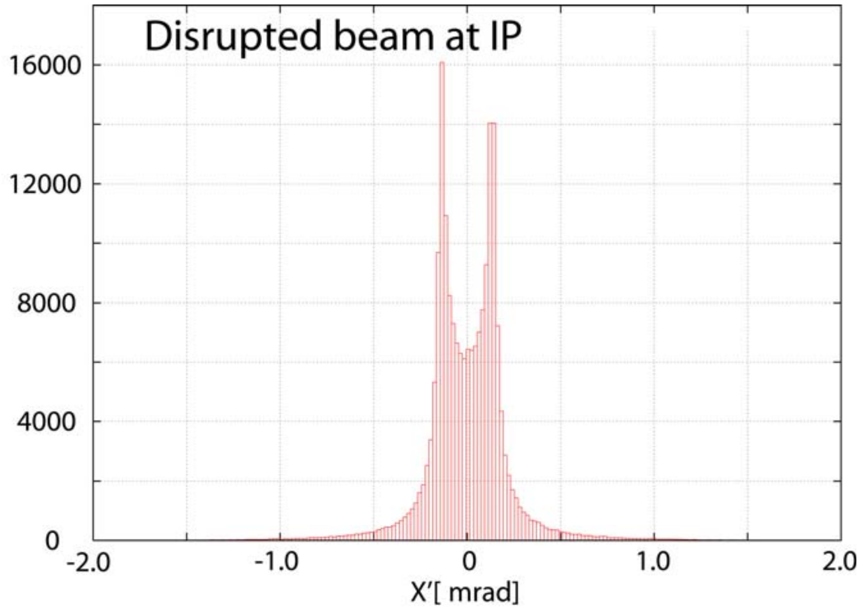
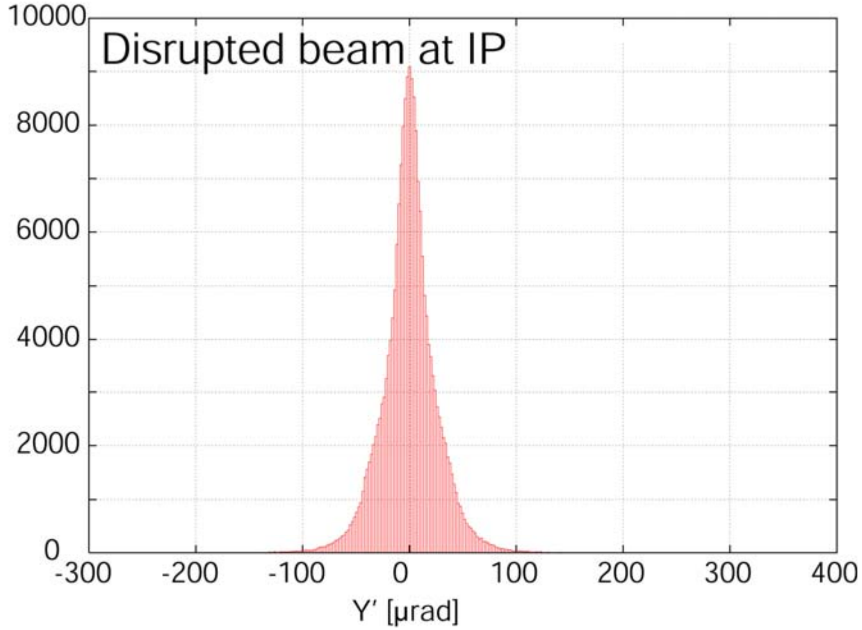
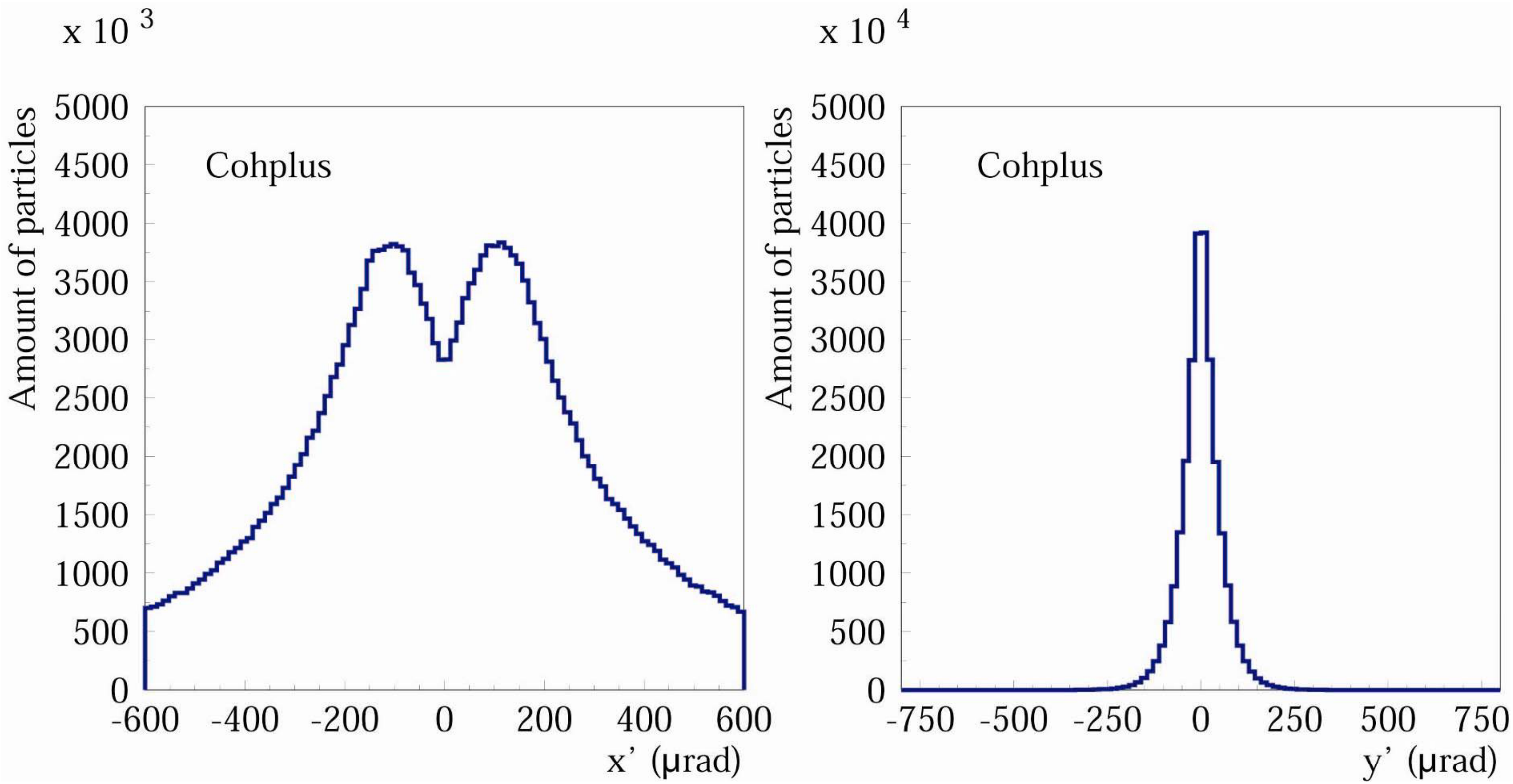


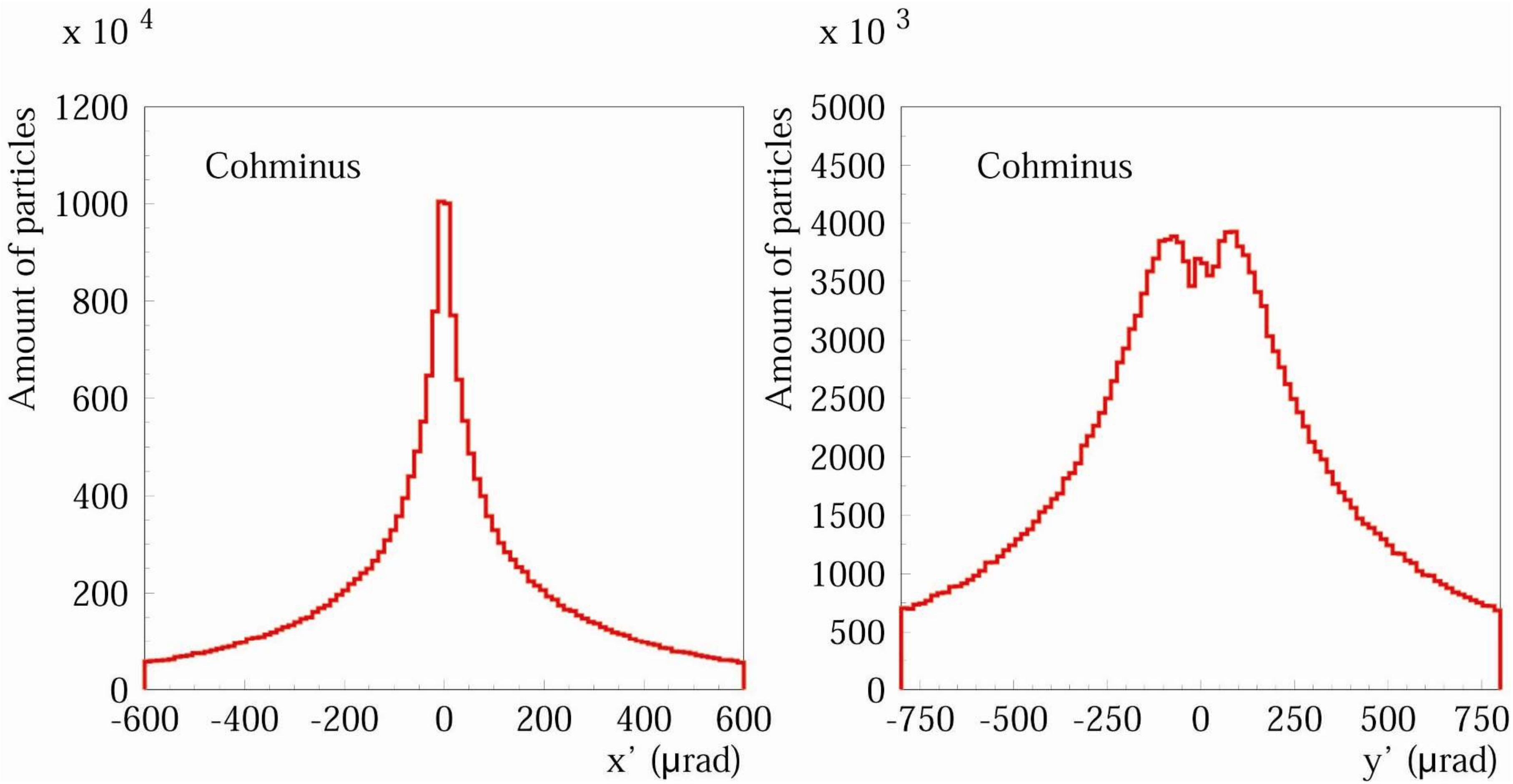


Coherent Pairs – same sign particle angles at IP



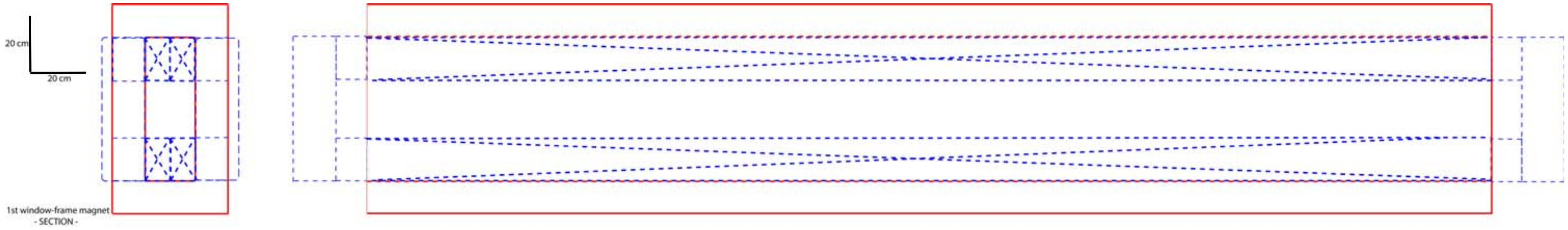
2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

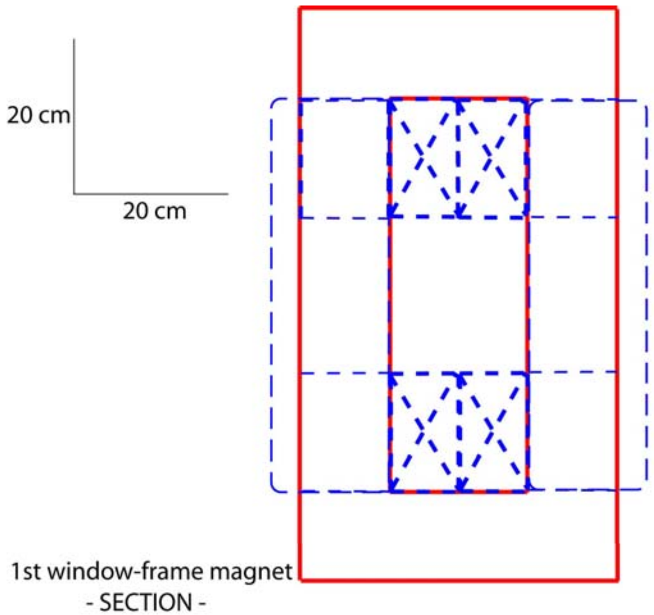
Coherent Pairs – opposite sign particle angles at IP



2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

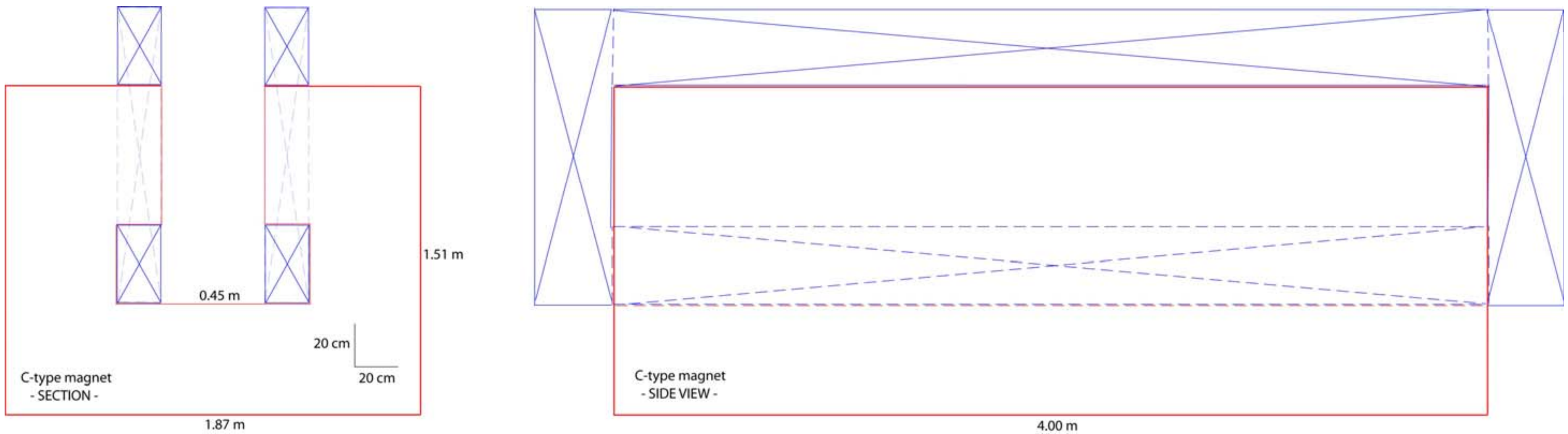
first “window-frame” magnet





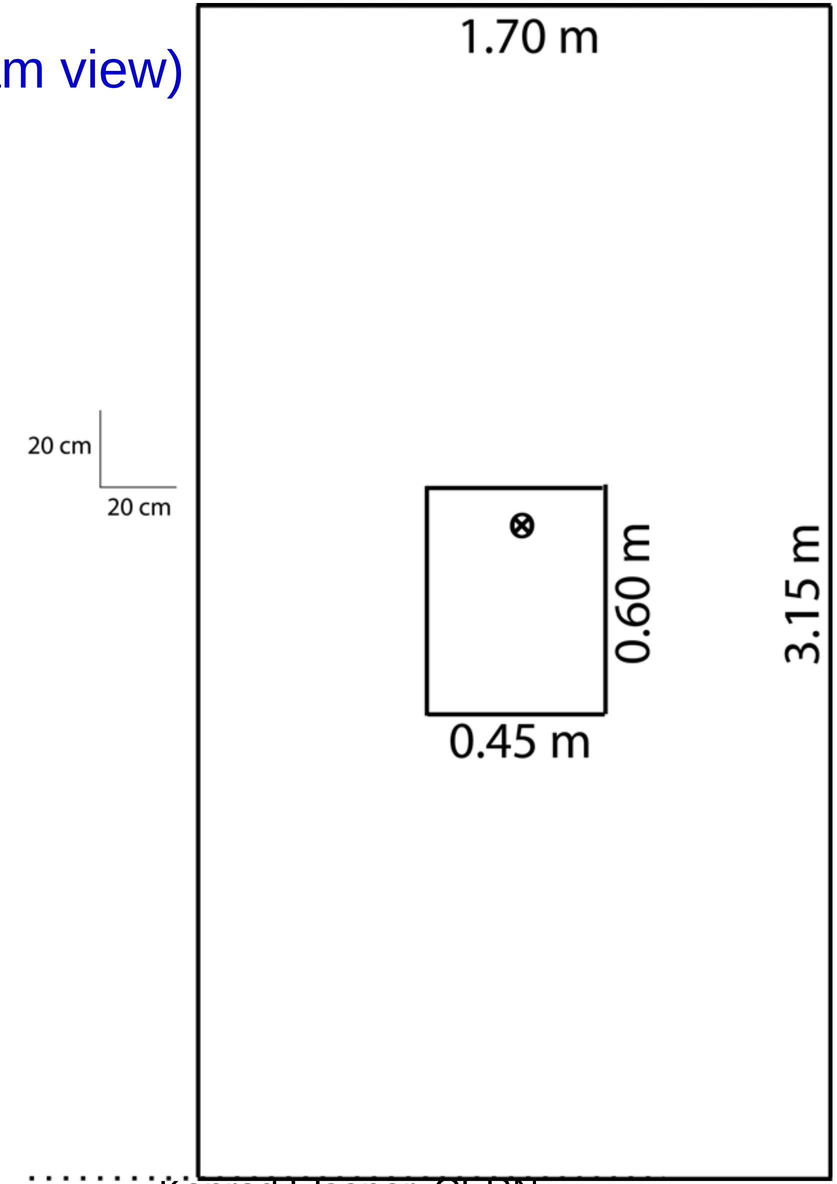
2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

"C-type" magnet



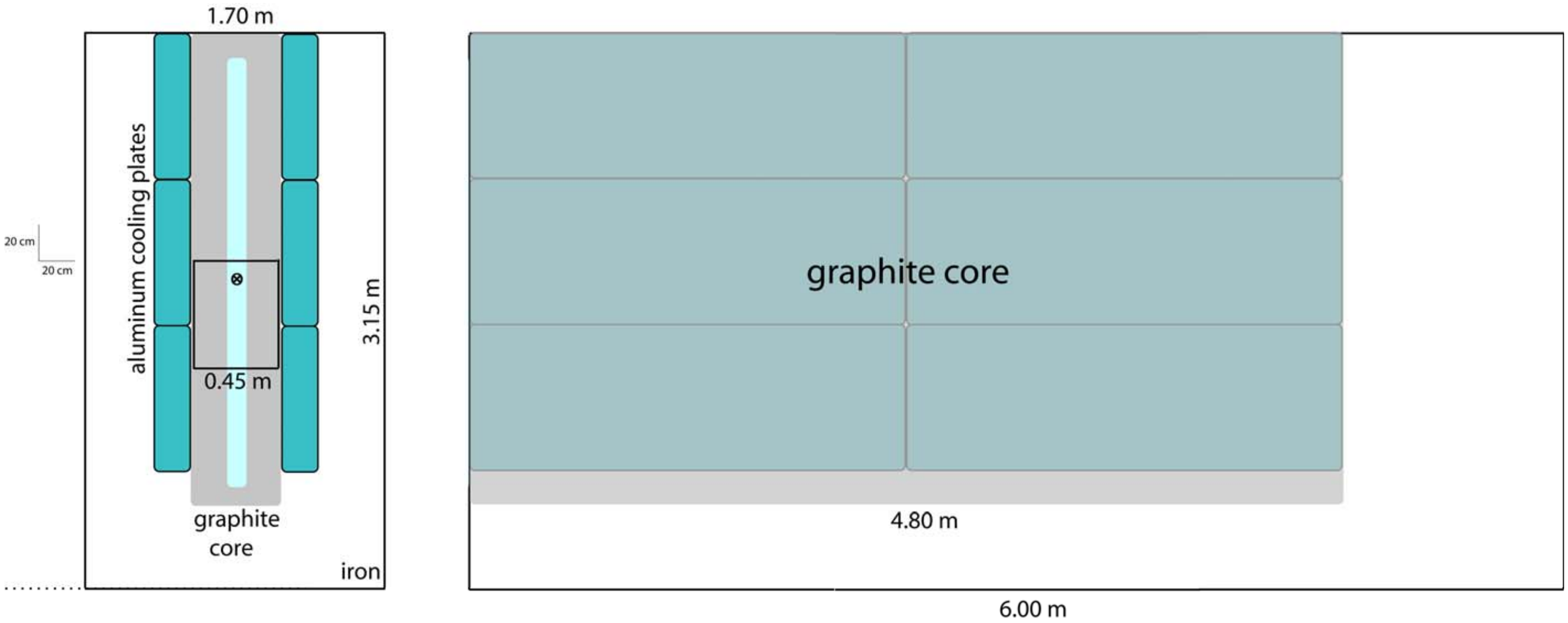
2) Present Conceptual Design (Arnaud Ferrari, Uppsala)

intermediate dump (beam view)



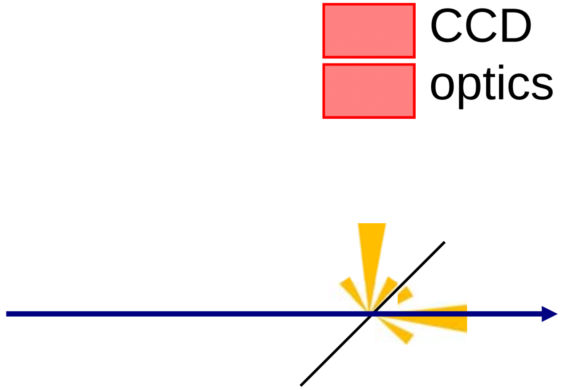
(a wild try – K.E.)

intermediate dump



typical OTR monitor arrangements:

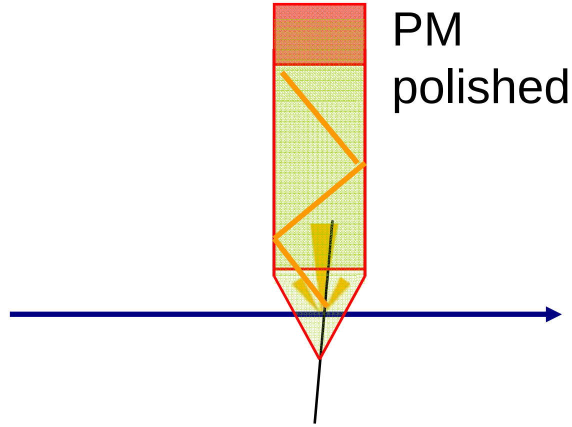
e.g. “intensity” and 2D-profile



works at >10E+11 part.
good pos. resolution
(+ size of beam)

“rad. hard” cameras exist...
very slow

e.g. “intensity” only



almost “single counting”;
very fast (< 1 ns)

“radiation hard”

sensitive to “direct hits”

ATTENTION: No absolute calibration for the intensity !!

background No. 1: synchrotron radiation photons
pair production -> < 50 MeV particles

solution (?): 10^{-3} Tm magnetic field (-> 15 mrad at 20 MeV)
(if possible, sweep low energy particles in H-plane,
observe OTR light in V-plane)

use "small" OTR screen at 5 m from converter / magn. field
(e.g. diameter 30 mm OTR screen)

background No. 2: scattered electrons/positrons of all kinds -> to be studied

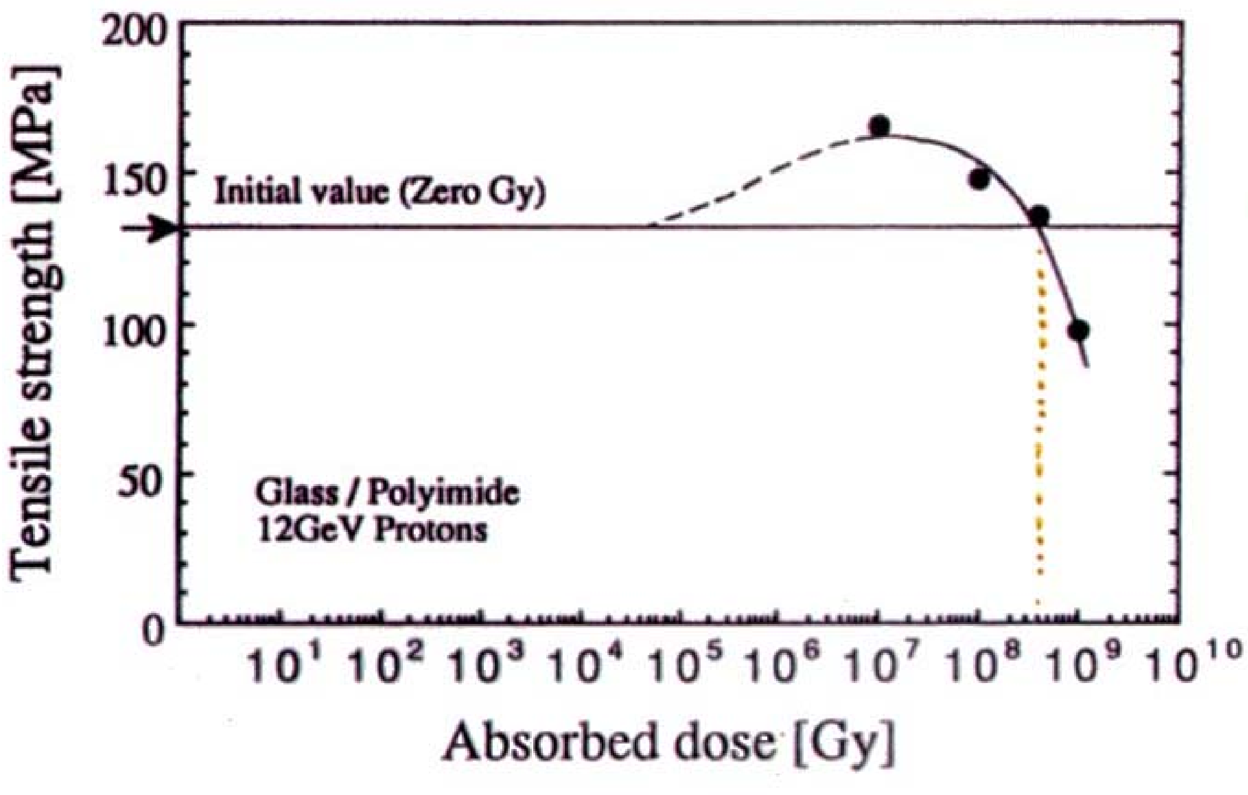
background No. 3: neutrons (stay far away from IP and from dumps) -> to be studied

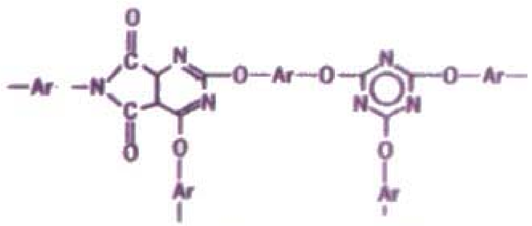
Rad-Hard Magnets

- Polyimide insulation up to 10^8 Gy
- Mineral Insulation Cable up to 10^{11} Gy

from E. Hirose and K. Tanaka (JPARC-nu facility)

Polyimide Insulation





ビスマレイミド・トリアジン樹脂
(BT 樹脂、三菱瓦斯化学)

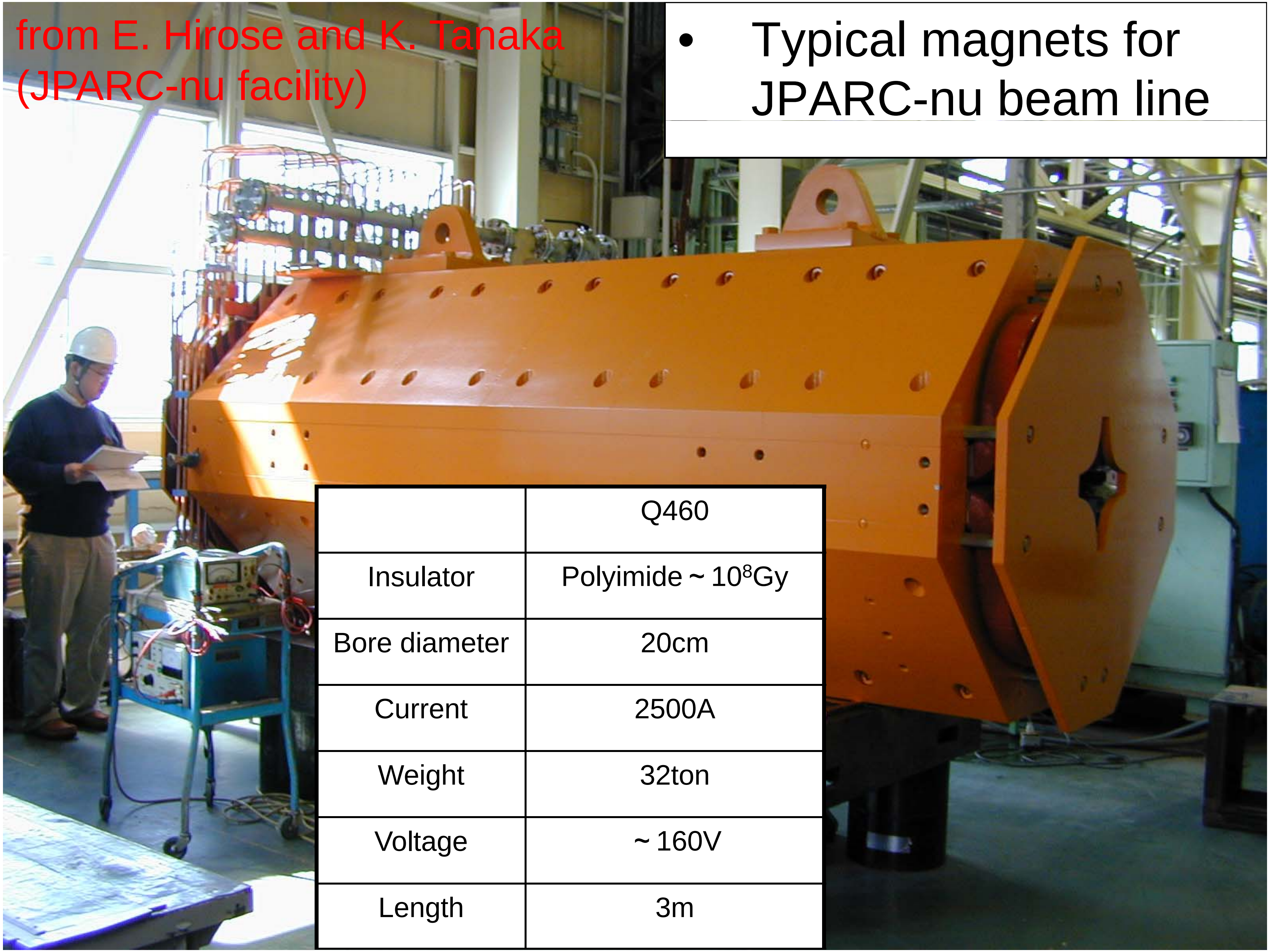
BT resin

Tensile strength of a cured BT resin

reinforced by Boron Free Glass Cloth.

from E. Hirose and K. Tanaka (JPARC-nu facility)

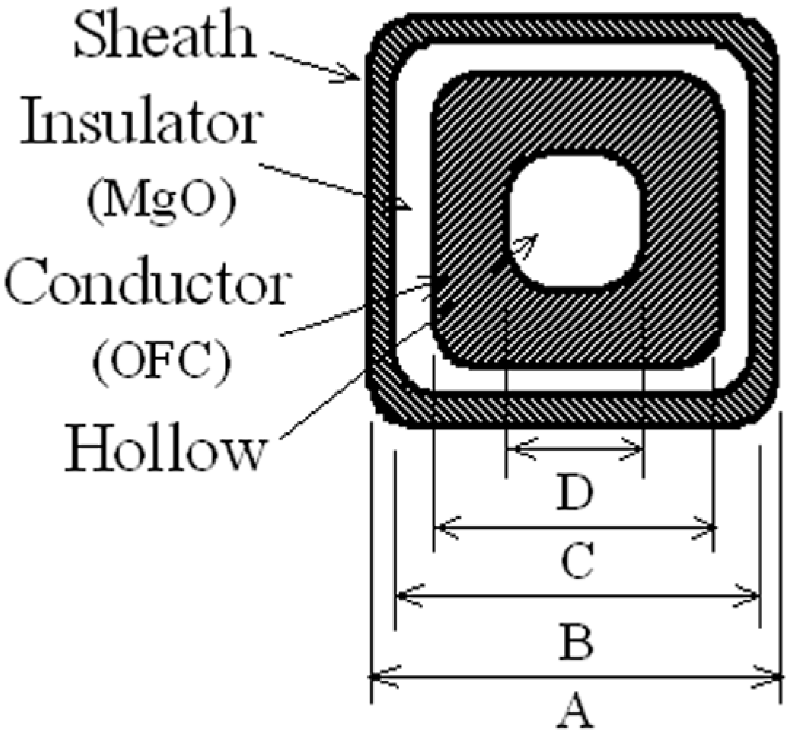
- Typical magnets for JPARC-nu beam line



from E. Hirose and K. Tanaka (JPARC-nu facility)

	Q460
Insulator	Polyimide ~ 10^8Gy
Bore diameter	20cm
Current	2500A
Weight	32ton
Voltage	~ 160V
Length	3m

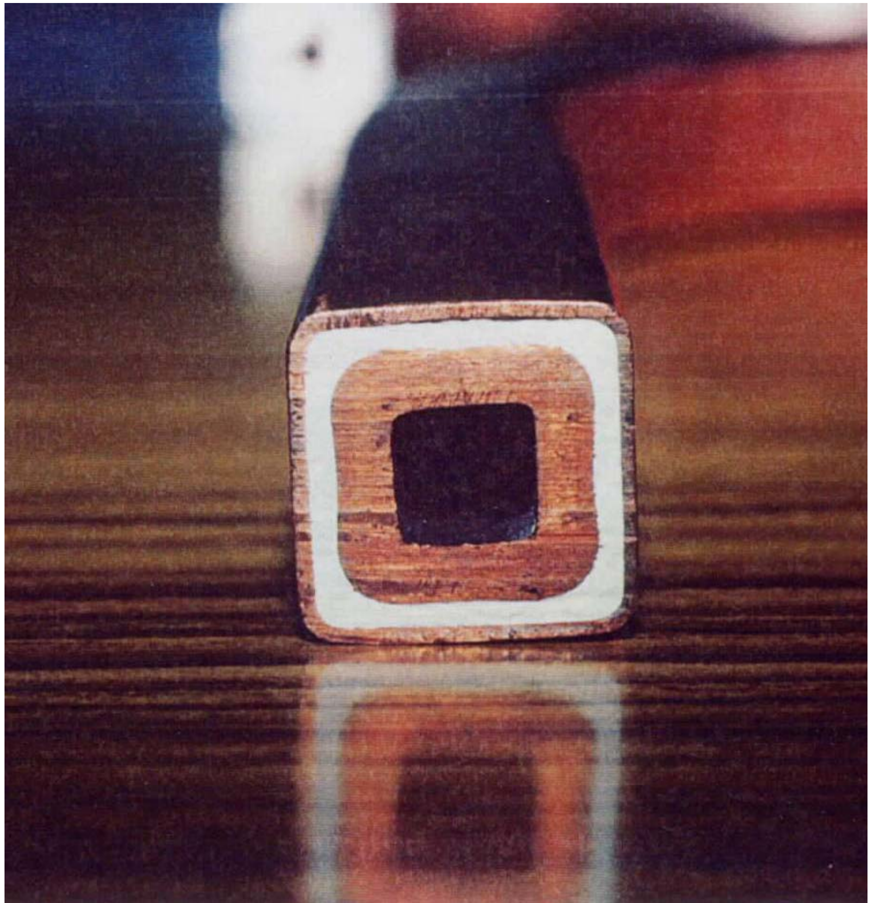
Mineral Insulation Cable



Nominal Current (A)	2000	2500	3000	1000*	2000*
Dimmensions (mm)					
A: Outward Size	20.0	23.8	28.0	18.0	14.0
B: Insulator Size	18.0	21.6	25.0	16.6	12.6
C: Conductor Size	14.6	18.0	20.0	13.2	9.2
D: Hollow Size	7.4	10.0	10.0	--	--
Cross Section (mm^2)					
Conductor	150.9	211.7	293.1	168.4	78.8
Insulator	117.7	153.2	227.4	106.6	79.4
Seath	73.4	95.3	150.6	47.8	36.6

* indicates Solid Conductor MICs. No hollow is in Cu conductor.

from E. Hirose and K. Tanaka (JPARC-nu facility)



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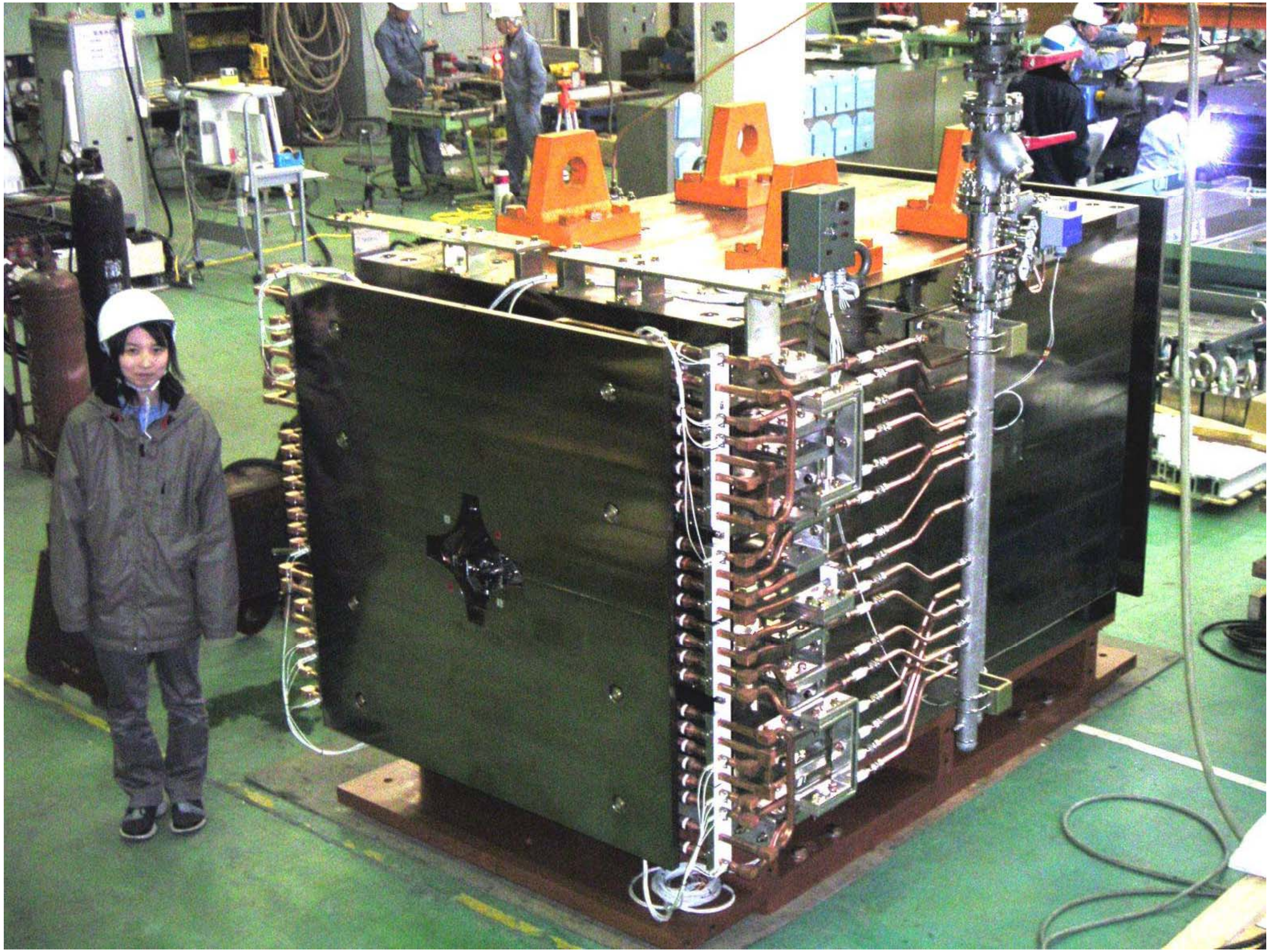

Radiation resistant magnet for J-PARC (Q440MIC)

from E. Hirose and K. Tanaka (JPARC-nu facility)