# Positron Sources WS Daresbury, 11.-13.4.

Preparation for Snowmass

E.Elsen

http://www.astec.ac.uk/id_mag/ID-Mag_Helical_ILC_Positron_Production_Workshop.htm

had strong participation from SLAC and CCLRC

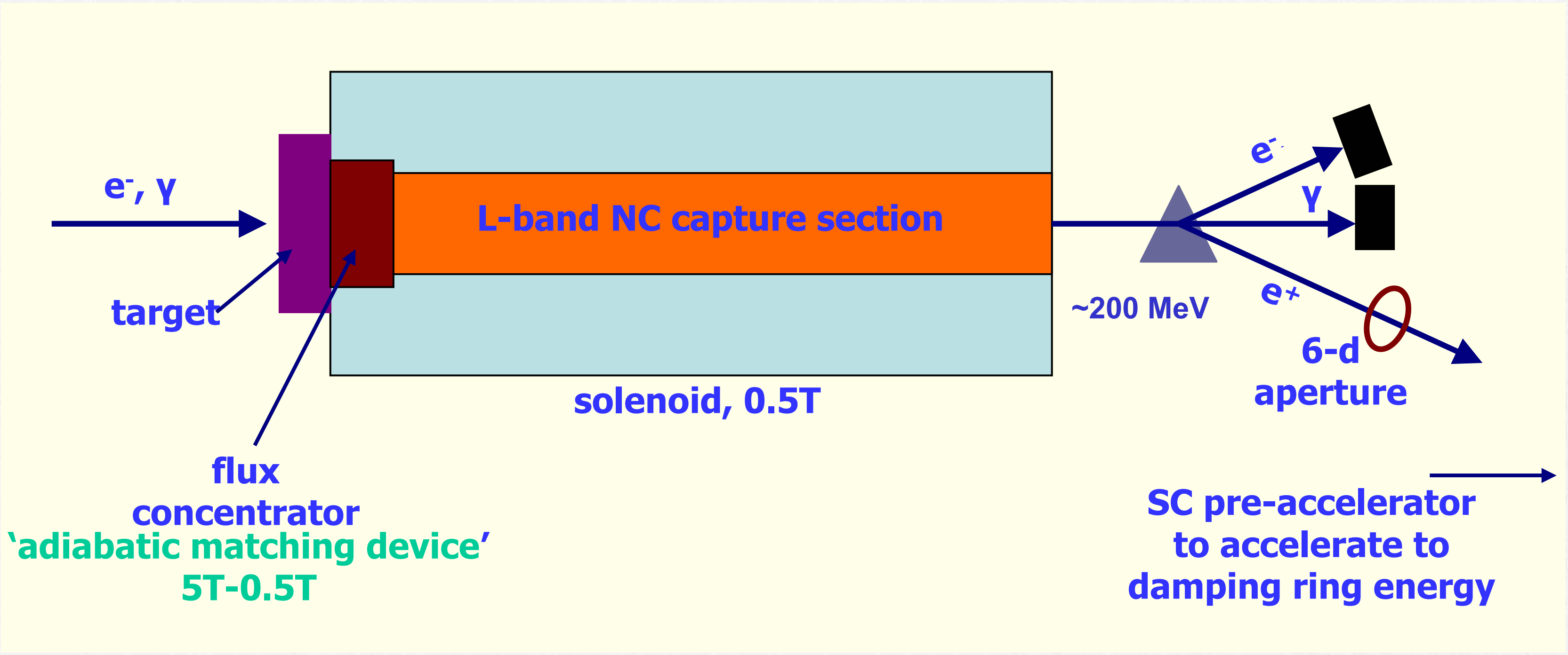
# Topics

- Overview Sources
  - Conventional Targets
  - Undulator Sources
  - Compton Sources
- Targets
- Positron Capture
- Polarised Positron Production
- Operational Aspects

E.E.

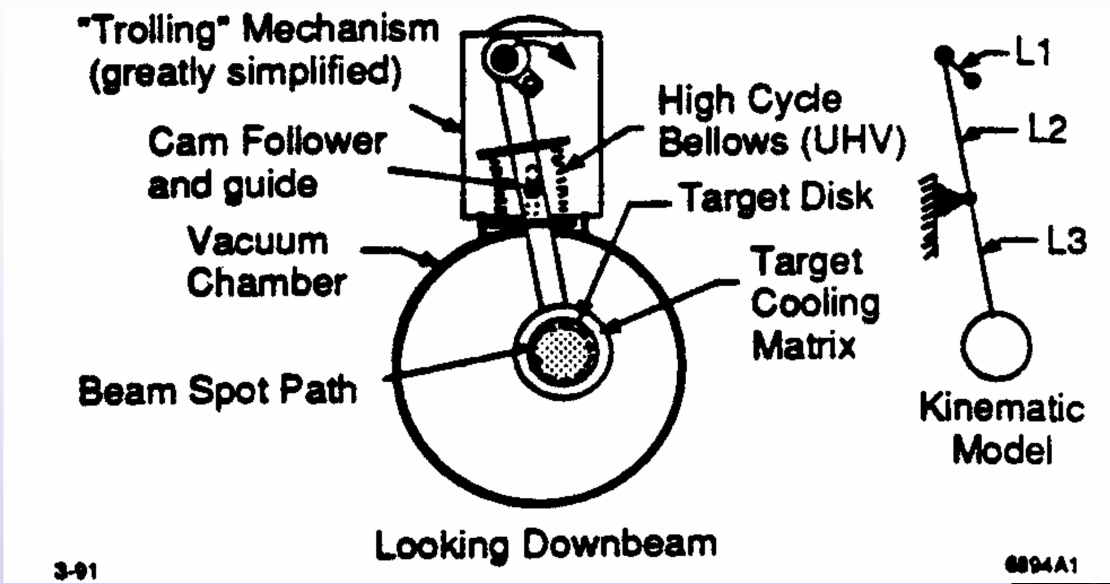
S.R.

# Generic Sources

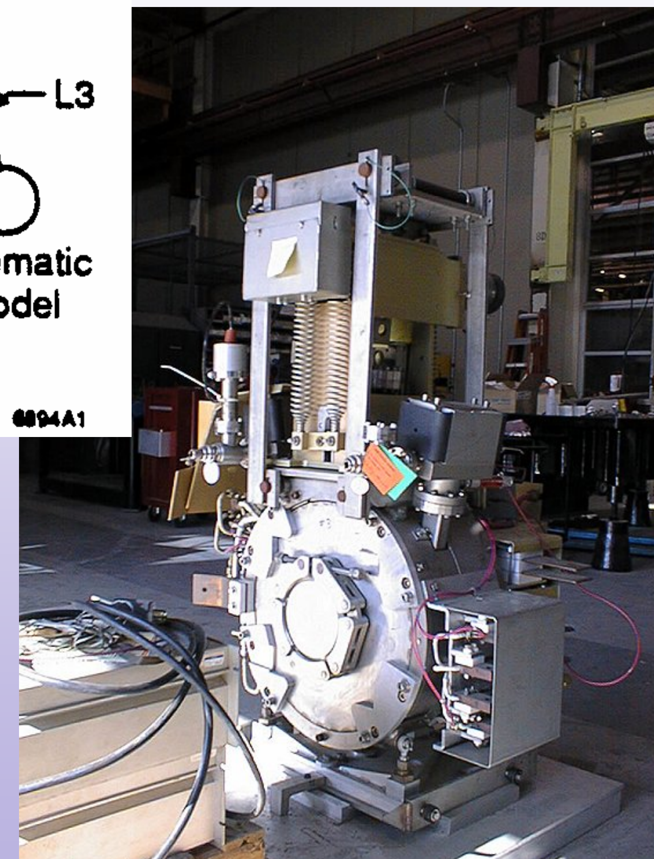



| Power Requirements | |
|---|---|
| SLC | 4 kW |
| ILC | 30 kW |

# SLC Target...

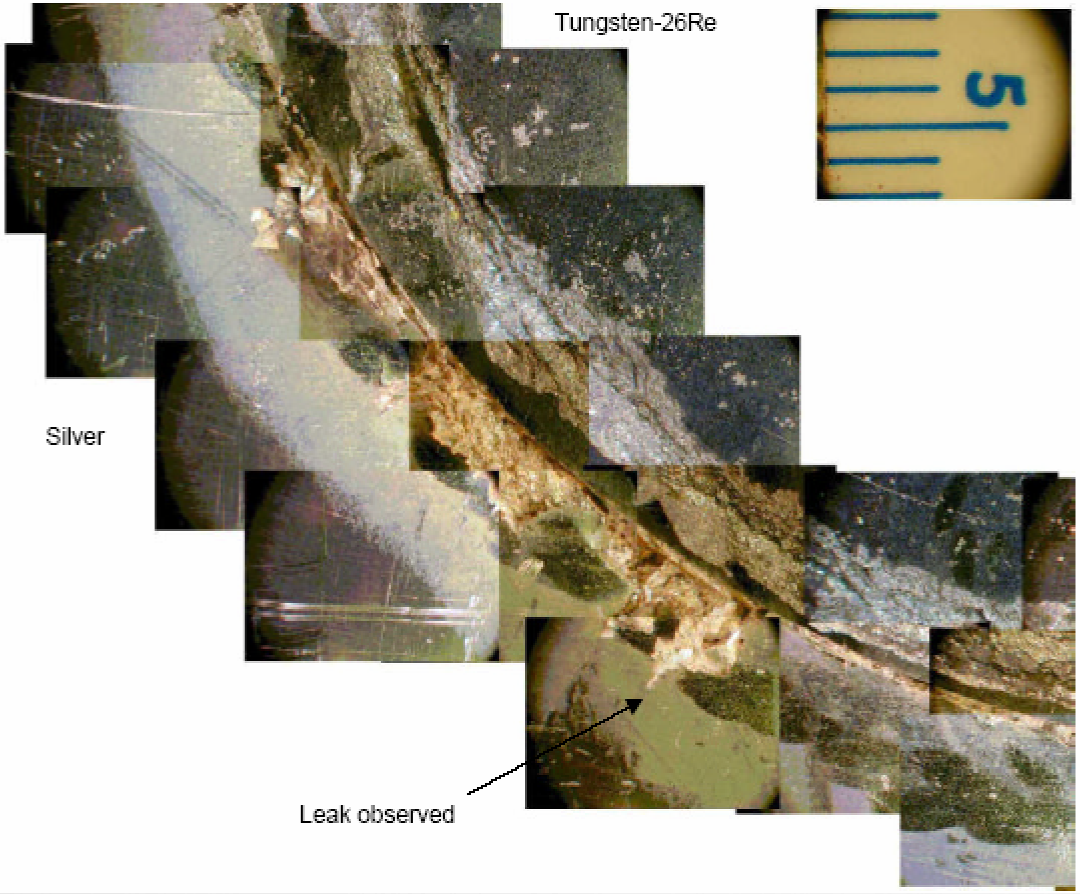



W-25Re Target



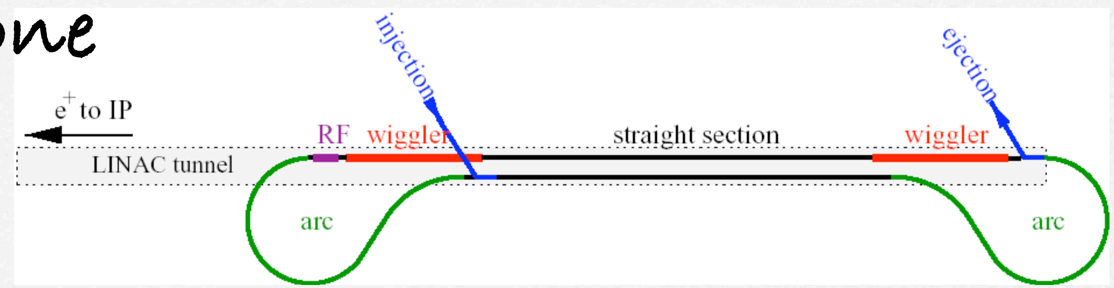
# ...and the result

Exit Side High Magnification Photos




# Damping Ring Requirements

- TESLA dogbone
- 6 km ring
- 3 km ring




<table>
<tr><th colspan="4">Requirements</th></tr>
<tr><td></td><td>damping</td><td>on entry</td><td>time</td></tr>
<tr><td>horizontal</td><td>$\gamma\epsilon_x = 8 \times 10^{-6}\mathrm{m}$</td><td rowspan="2">$\gamma\epsilon = 0.01\mathrm{m}$</td><td></td></tr>
<tr><td>vertical</td><td>$\gamma\epsilon_y = 2 \times 10^{-6}\mathrm{m}$</td><td>$\tau_y = 28\,\mathrm{ms}$</td></tr>
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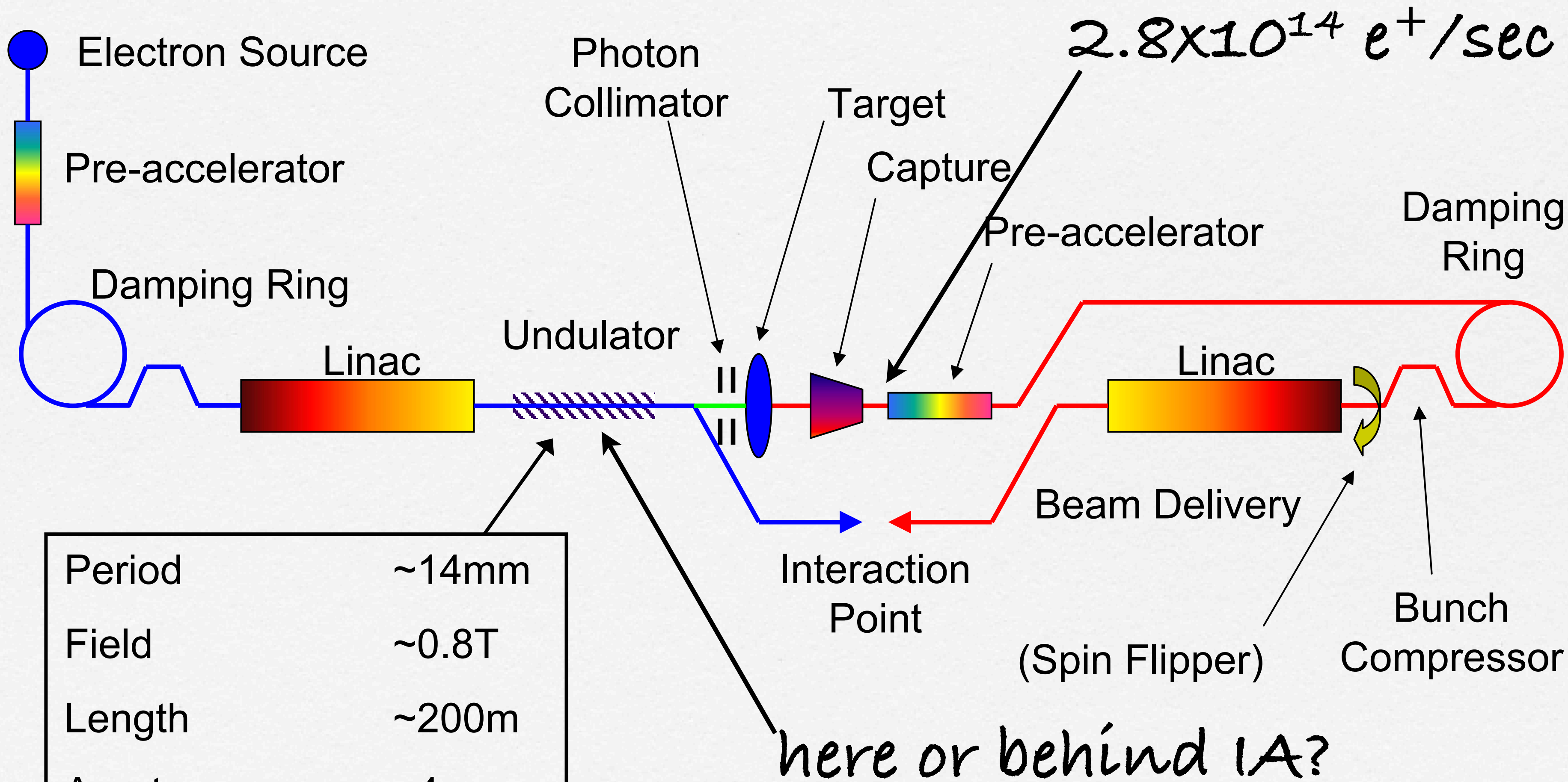
# Undulator Source




| | |
|---|---|
| Period | ~14mm |
| Field | ~0.8T |
| Length | ~200m |
| Aperture | ~4mm |

# Undulator Position

A. Mikhailichenko

- Low intensity conventional target
- Accumulation in DR
- Accelerate in $e^+$-linac

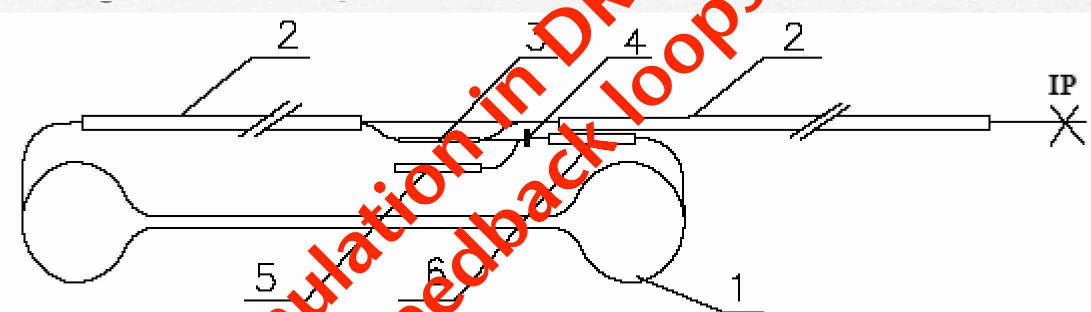



Figure 5: Scheme with undulator before IP. 1–damping ring, 2–linear accelerator, 3–undulator, 4–target, 5–electron linac with energy ~200MeV, 6–pre-accelerator. Spin rotators and some complementary electro-optical elements not shown in this figure.

Issues:
accumulation in DR
critical feedback loops

decouples $e^+$ and $e^-$ production

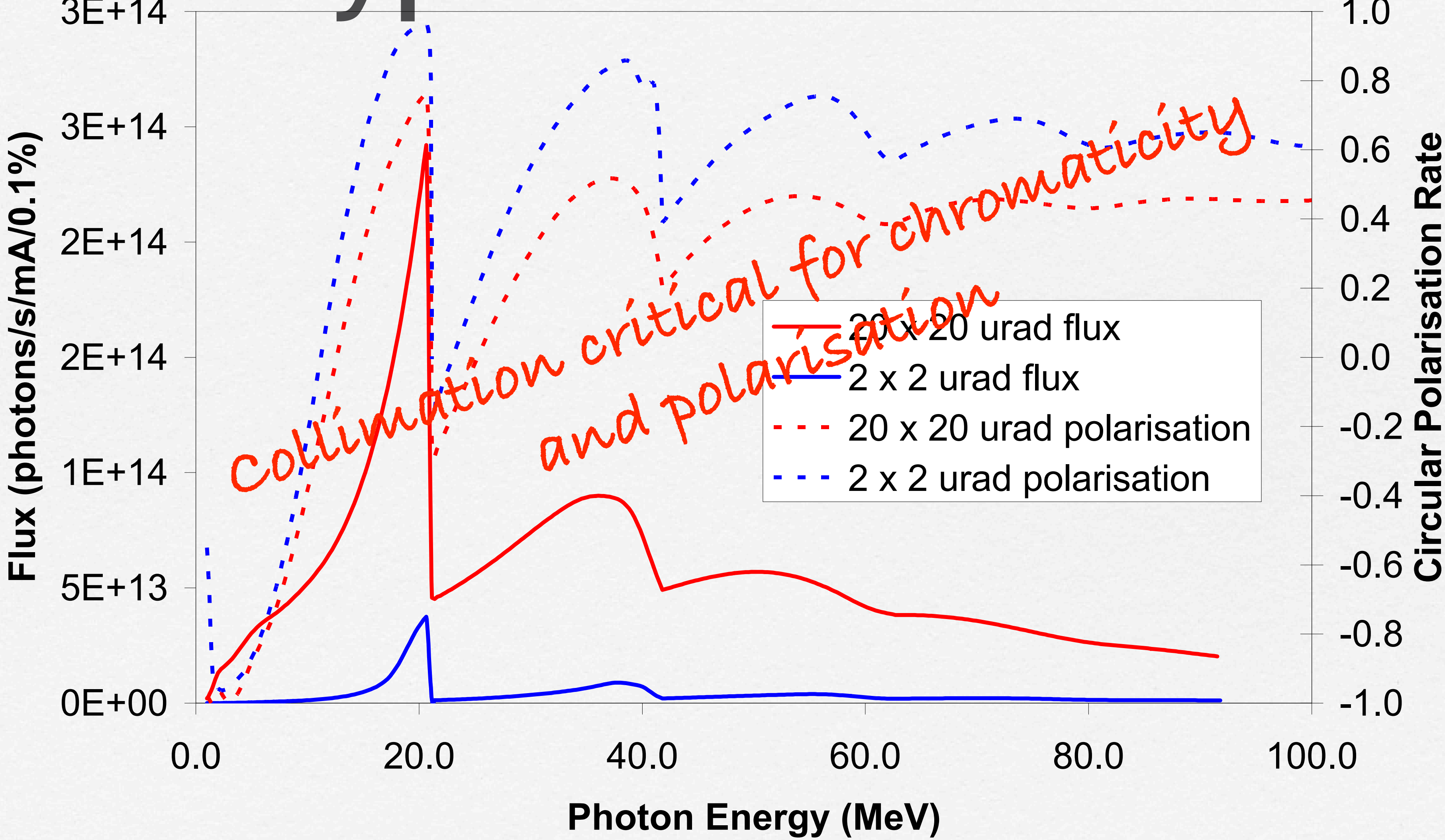
# Undulators

- several planar undulators are in operation
- helical undulator are used for light sources; yield high intensity

Planar Undulator

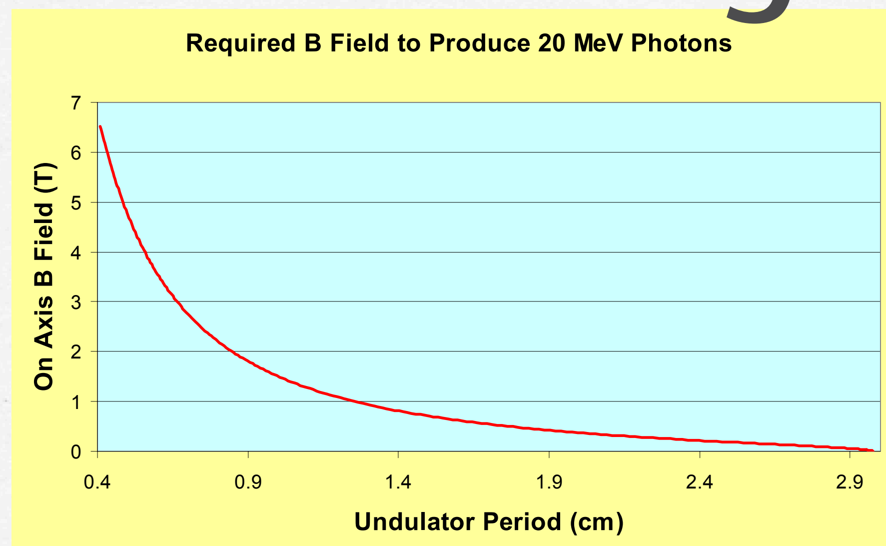
→ added benefit: provide polarised $e^+$

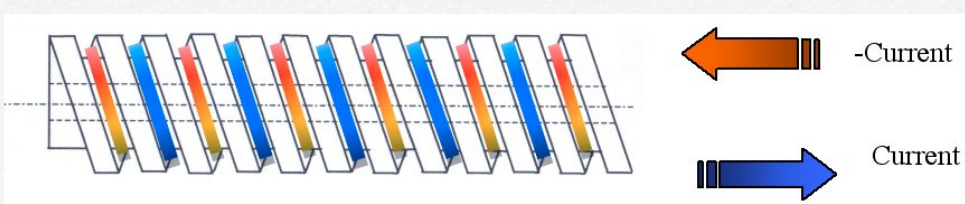
# Typical Undulator



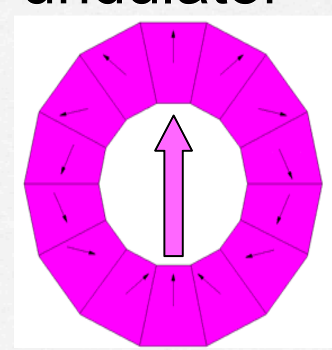
# Possible Undulator Design

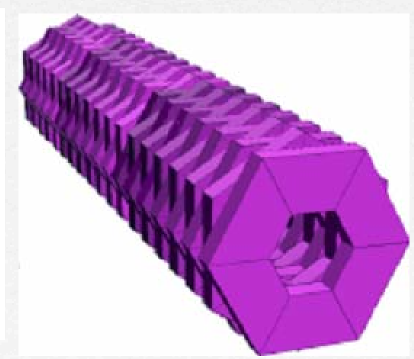
- Need a short period
  - more periods
  - more photons
  - more positrons
- Two competing designs both 14mm period and ~4mm beam aperture:
- Super-Conducting Bifilar helix



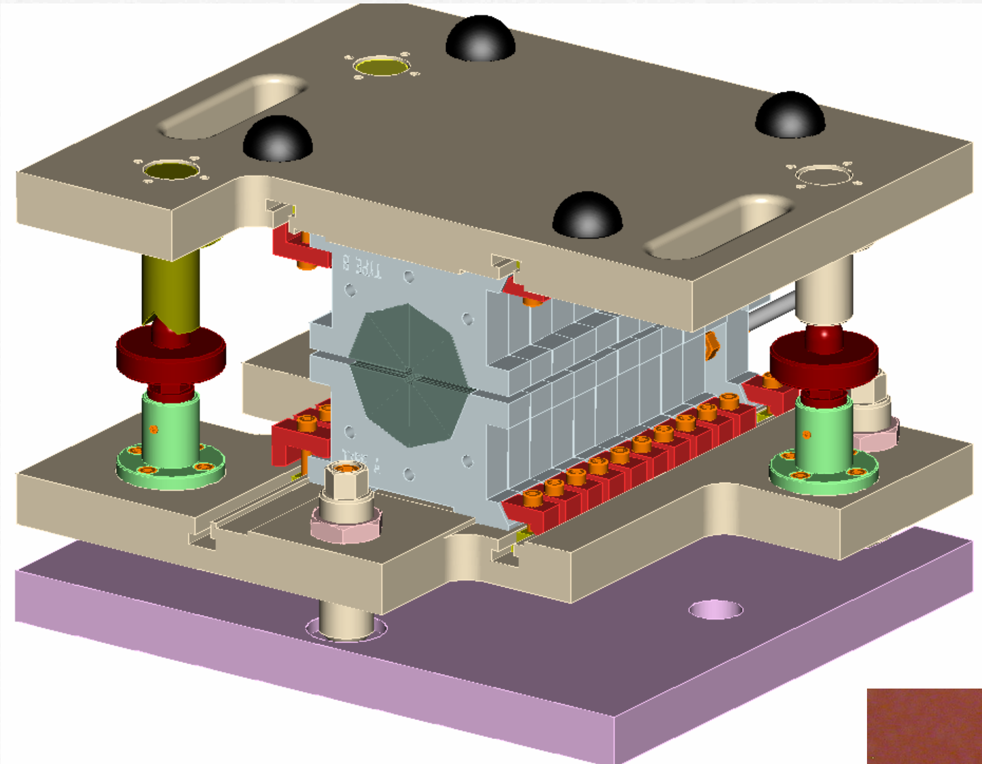




- Permanent Magnet ‘Ring undulator’



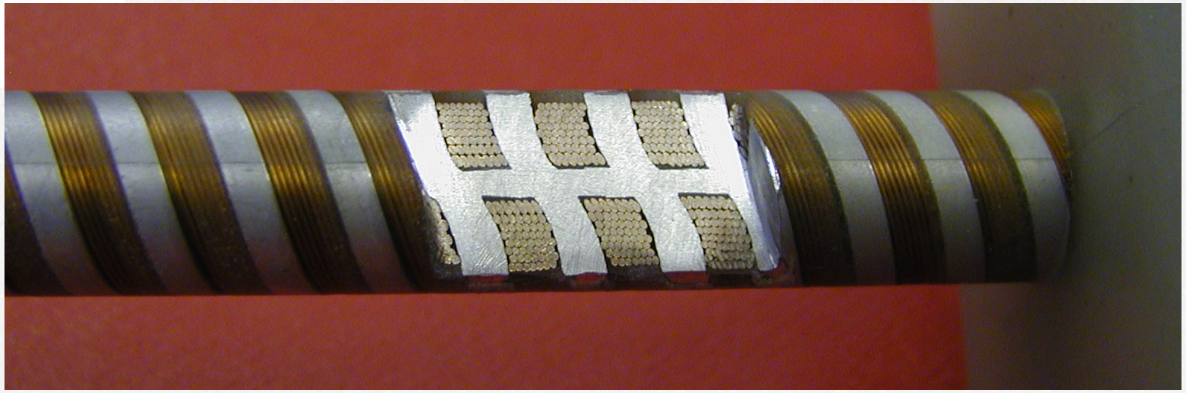


# Undulator Magnet Tests

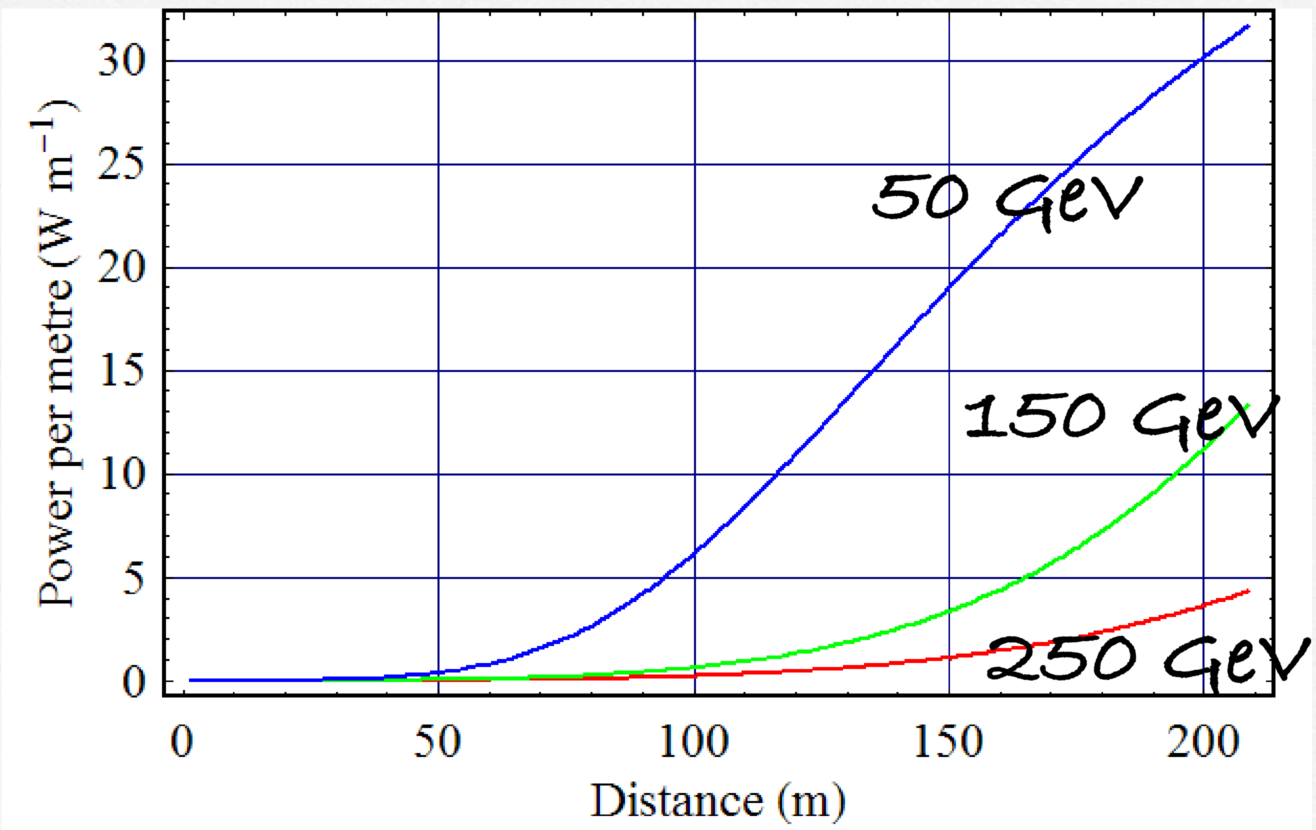


Permanent magnet test at DL & Liverpool

SC coil winding at RAL



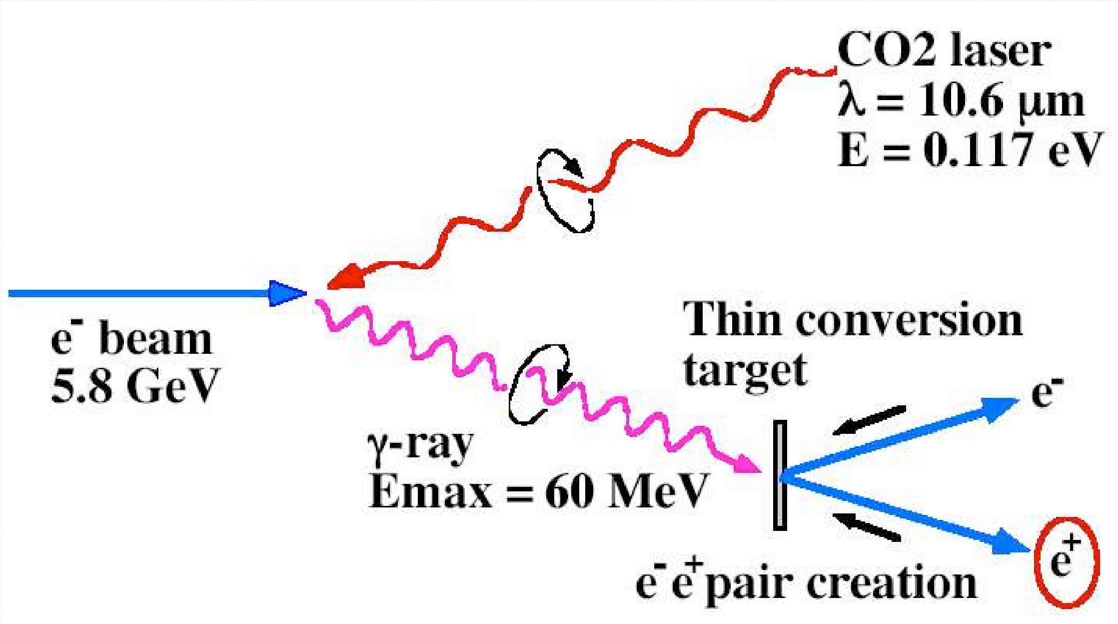
# Power along Undulator Length



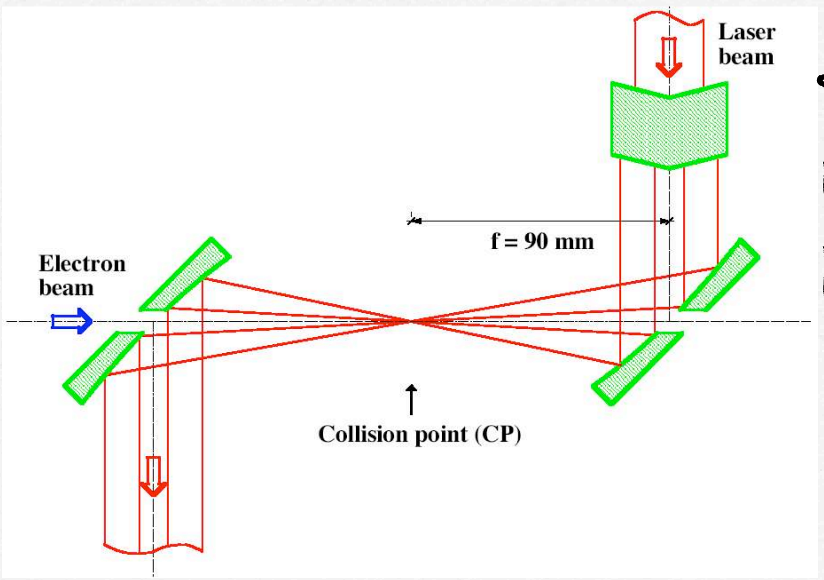

Extra collimation along length of undulator required to shield from synchrotron radiation.

# Compton based Source

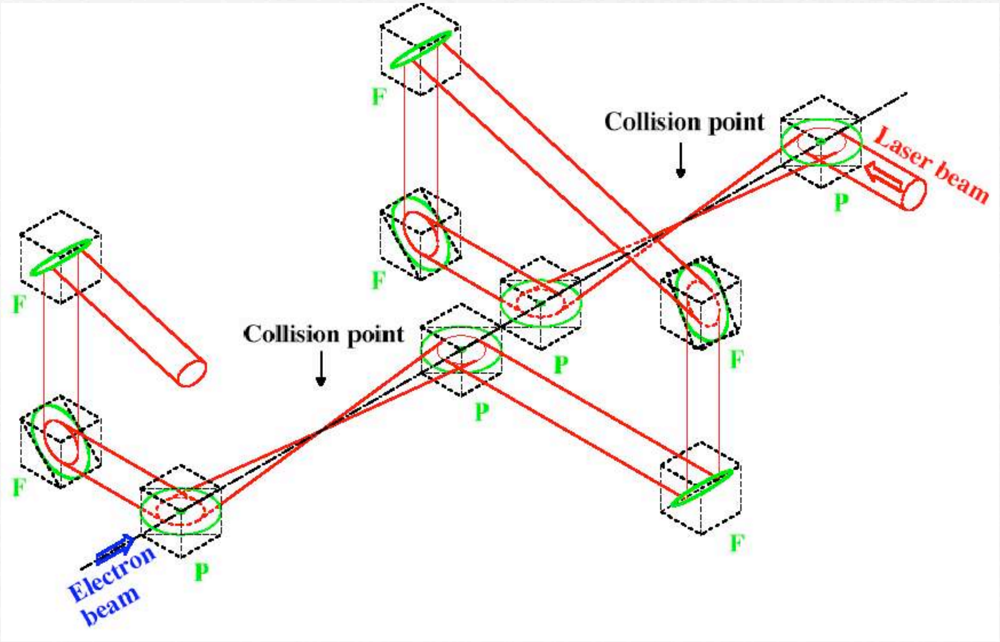
- long photon wavelength
- high energy $e^-$ beam



# Laser/Beam IA

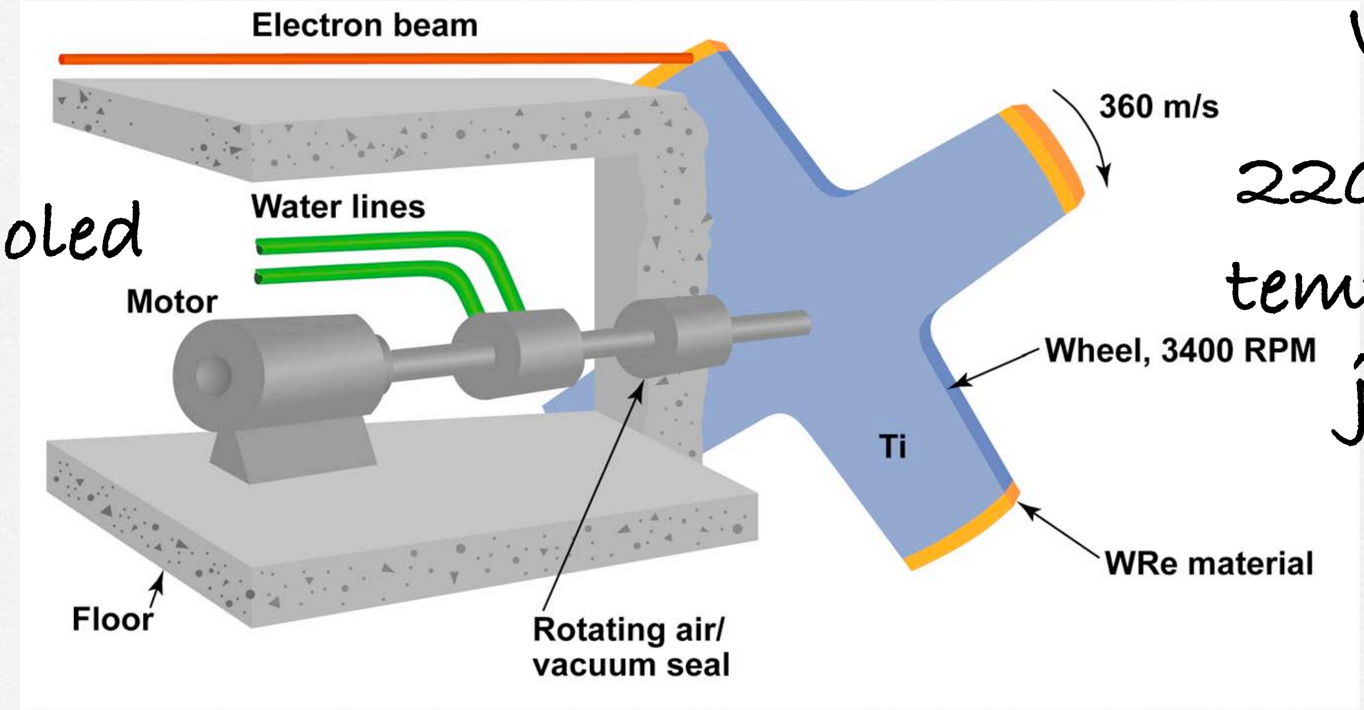



Single Collision Point; mirrors leave hole for beams




Series of Collision Points

# Conventional Target




W.Stein

watercooled

220°C peak
temperature
jump

$4.6\ X_0$

0.7 J/g per bunch
at exit surface

56 kW

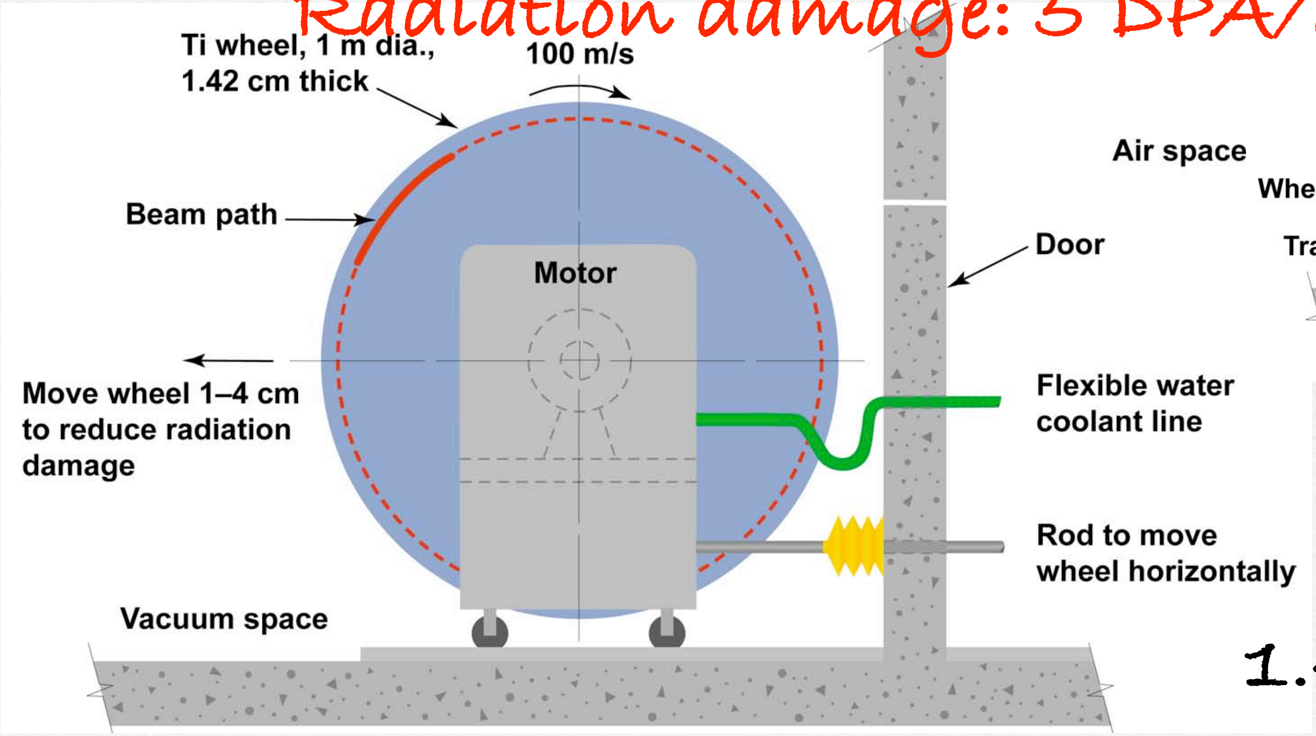
# Undulator Target

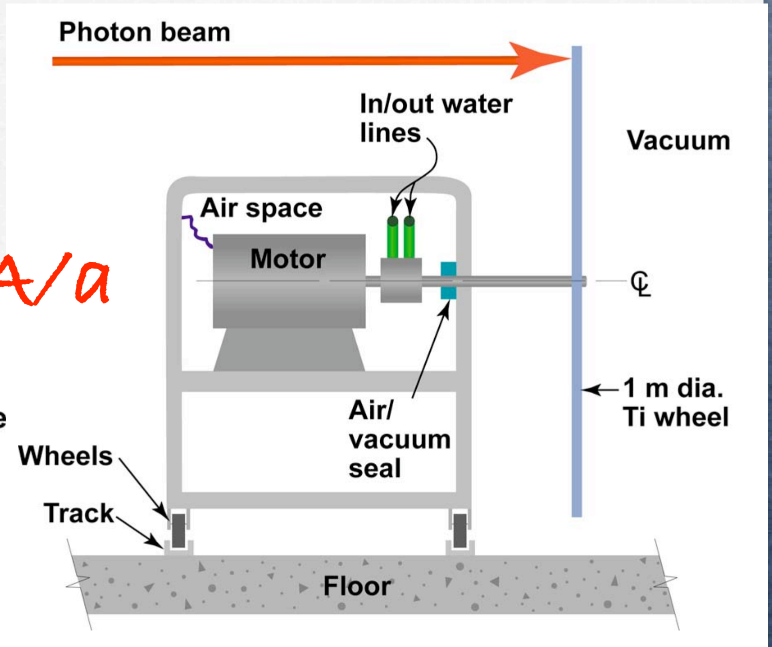
Front view

220 kW in

18 kW deposited

Radiation damage: 5 DPA/a



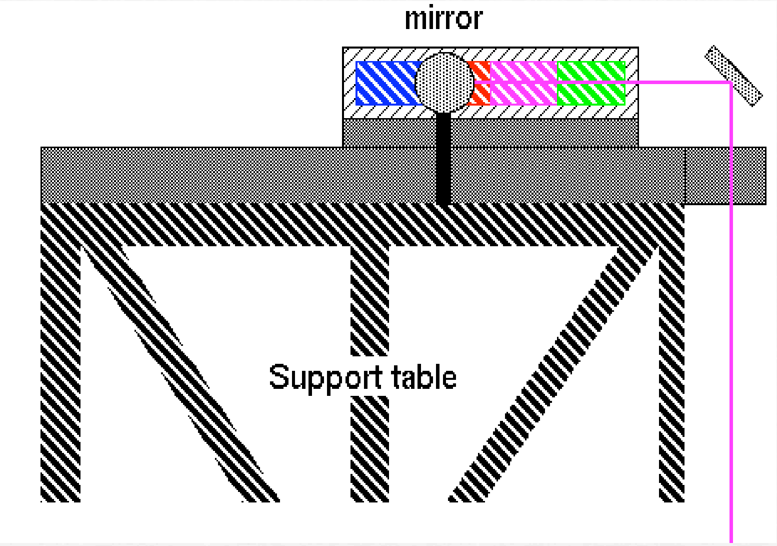

side view

411°C

1.45J/g per bunch

# Target Test at KEKB

Test of target material has been approved by PAC

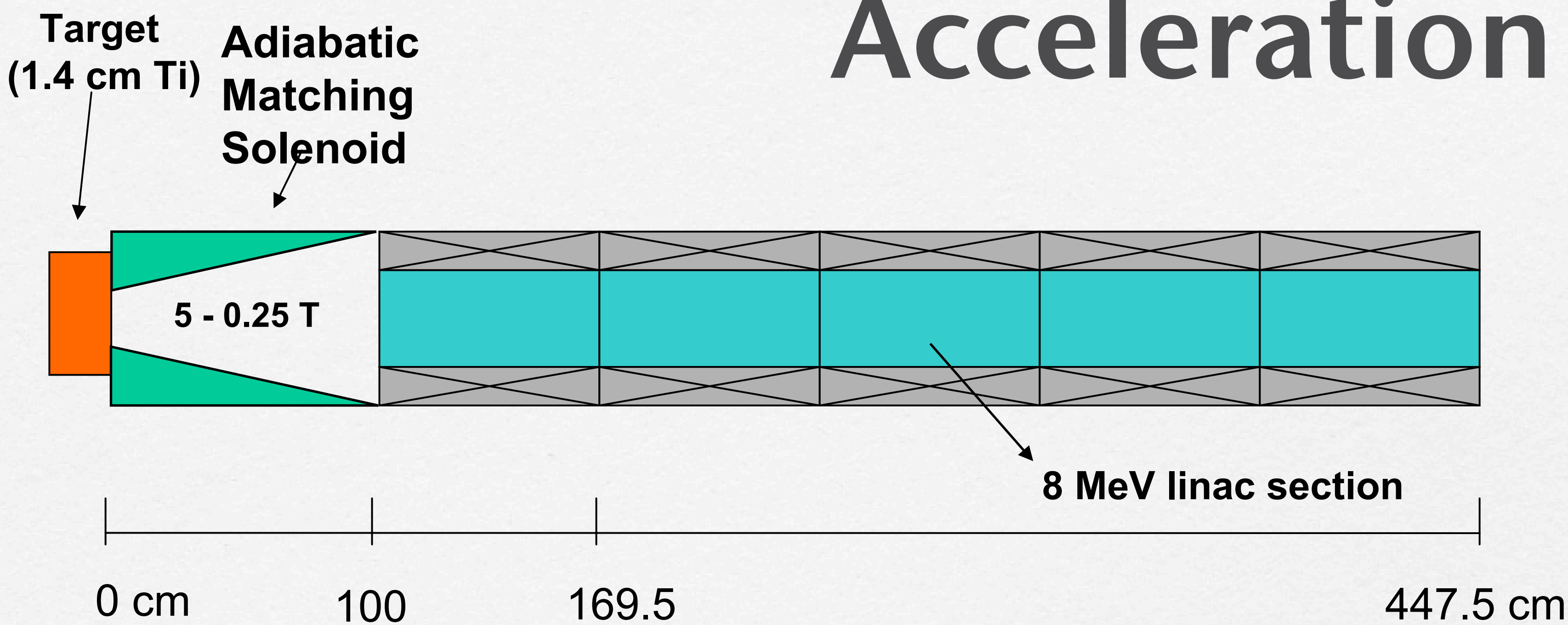


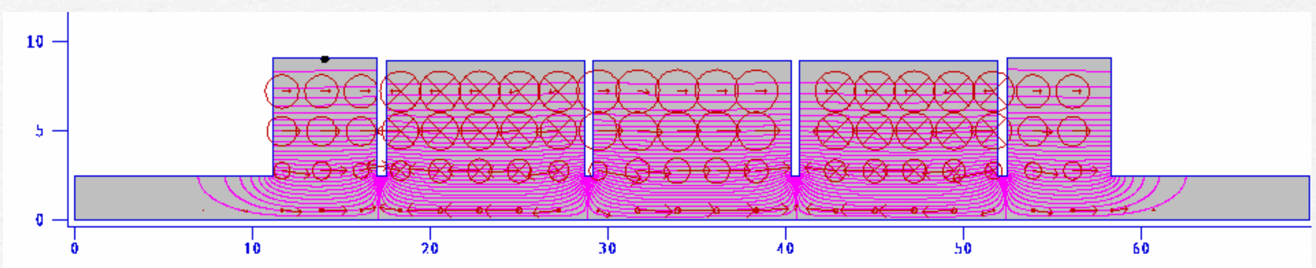

| | E | Charge | Bunch | Ebunch |
|---|---|---|---|---|
| ILC | 6 GeV | 3nC | 2820 | 51 kJ |
| KEKB | 8 GeV | 10 nC | 1300 | 104kJ |

# Other Target Options

- Liquid Target
  - li Pb Tests at Novosibirsk
- Channeling
  - Diamond and Si test at CERN and KEK

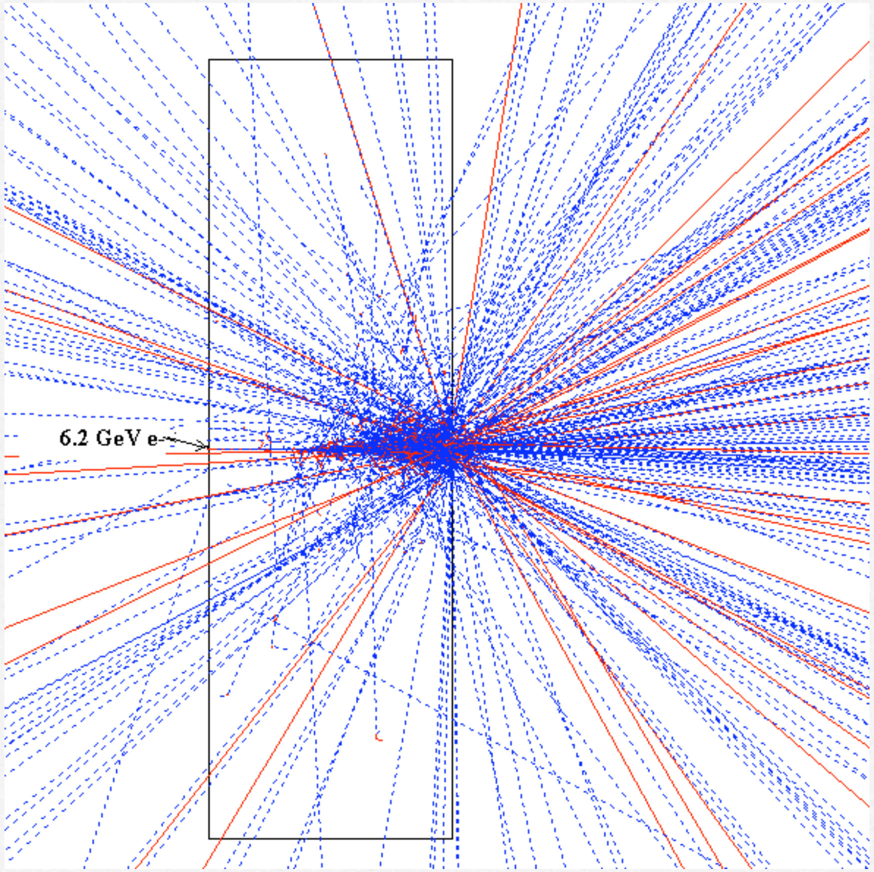
# ADM & Pre-Acceleration



5 cell $\pi$ mode iris loaded L band linac, the aperture D=5cm, T is about 0.74, $E_0T$=12MV/m, P=4.4MW. Total energy gain=8.4 MeV, Q=25000, r/Q=613 Ohm

# Positron Capture

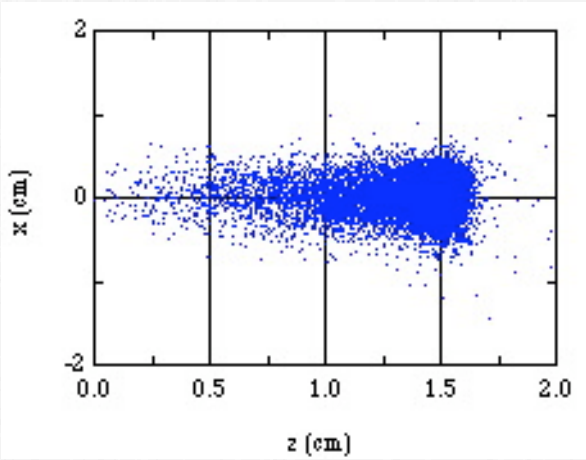


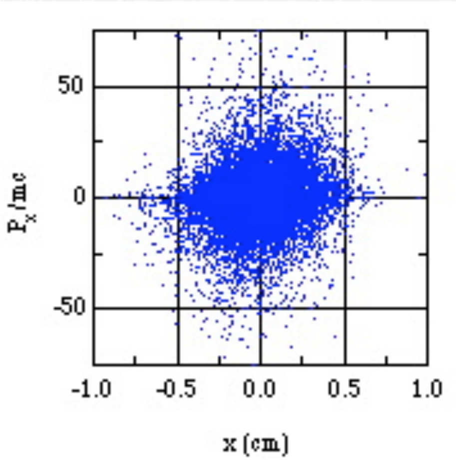

Geant3 simulated shower by 6 GeV incident electron on $4.5\ X_0$ 77W-Re

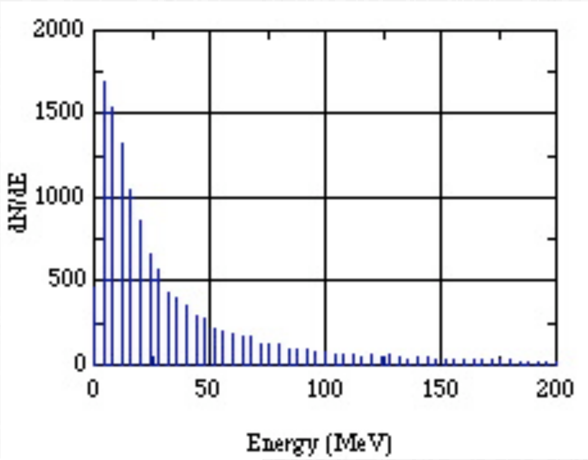
blue photons

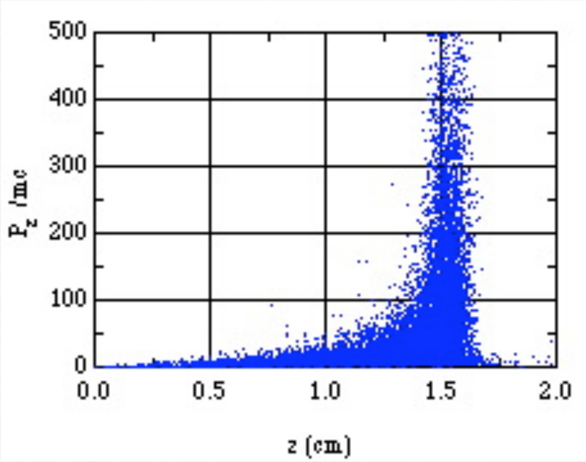
red electrons

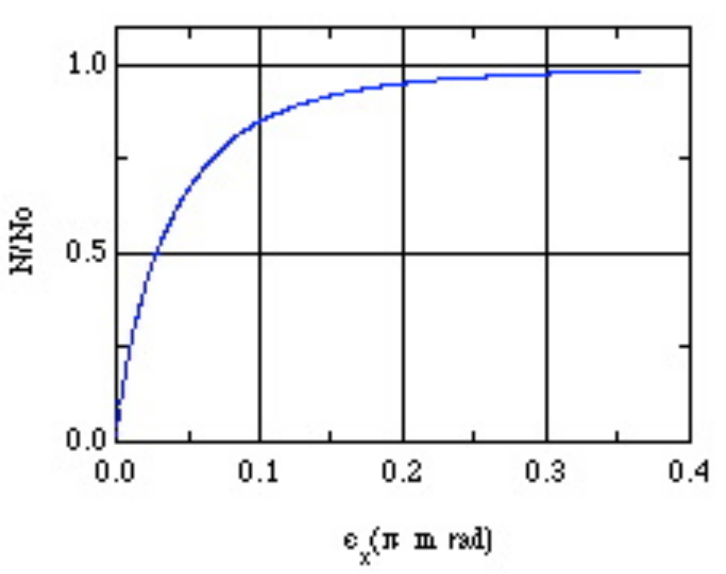
# Behind the thick Target



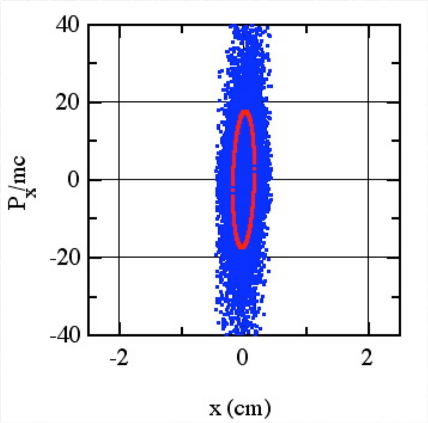



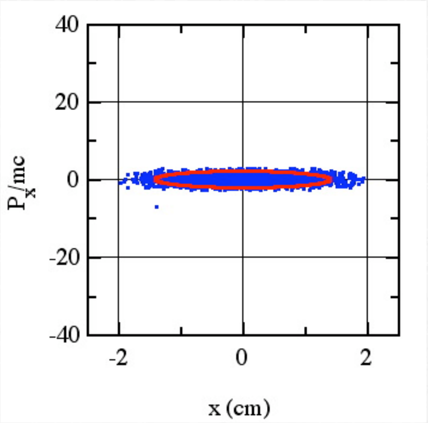



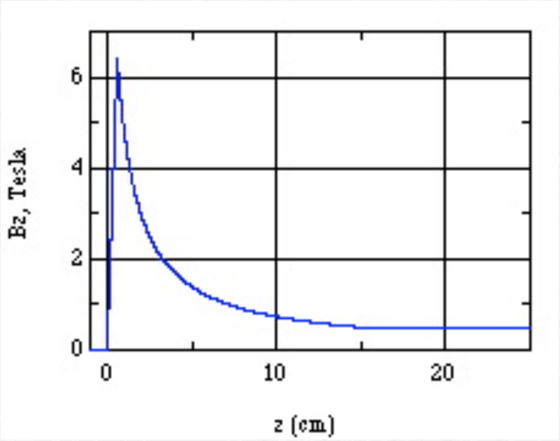
# Adiabatic Transformation




(Blue) transverse beam emittance at the target.
(Red) emittance area of 0.03 π m rad.

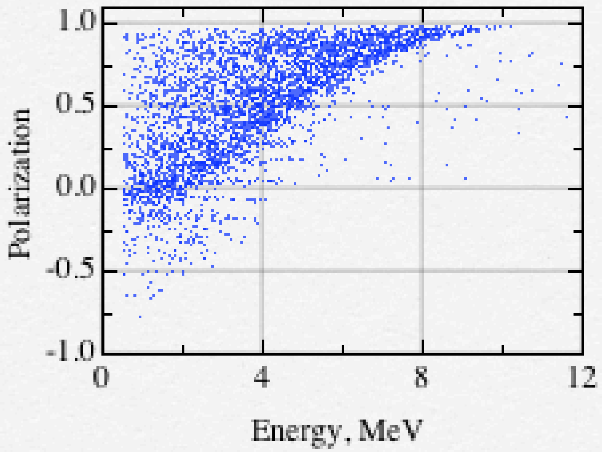


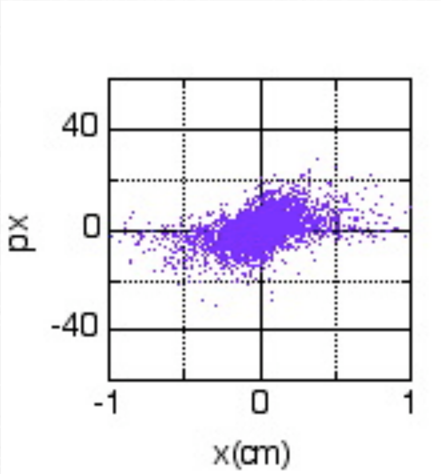

(Blue) transverse beam emittance at 250 MeV.
(Red) emittance area of 0.03 π m rad.

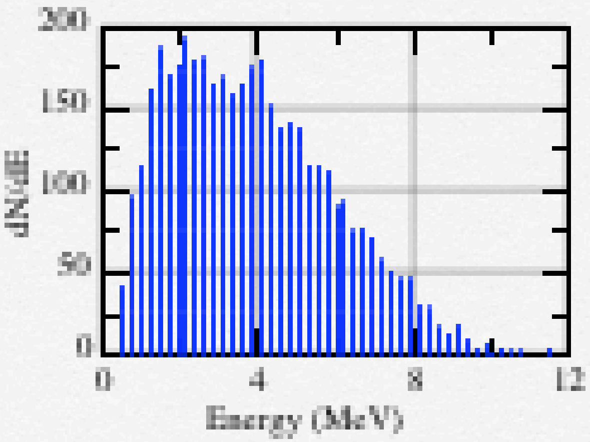


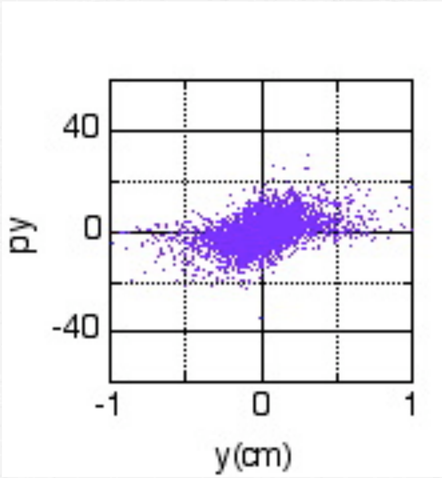

Magnetic field profile in flux concentrator, field profile $B_z = B_{max}/(1 + gz)$.

# Polarised Positron Capture



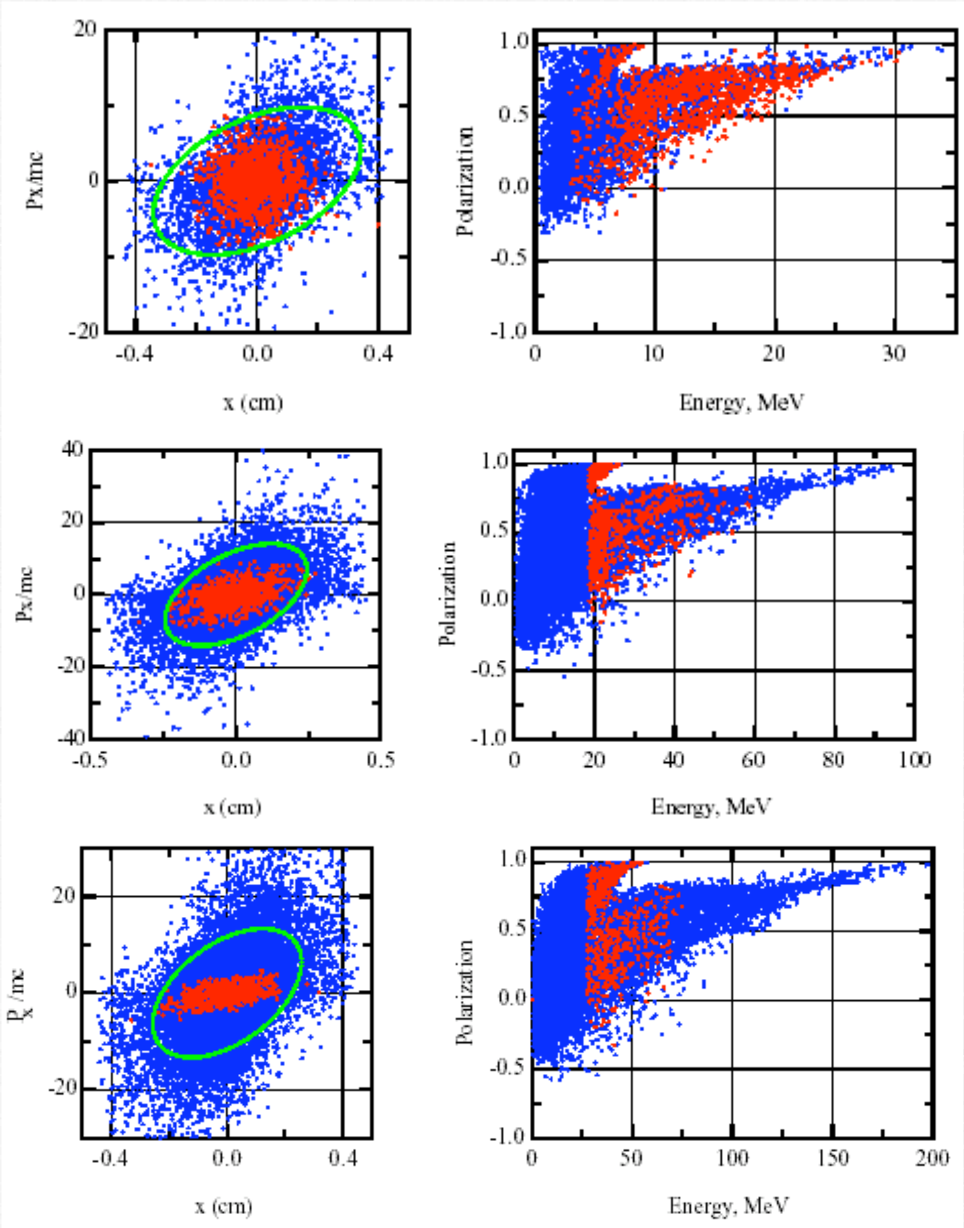




Initial distribution of positrons generated by 11.7 MeV γ – flux.

# Capture and Acceleration




10.7 MeV photons

30 MeV

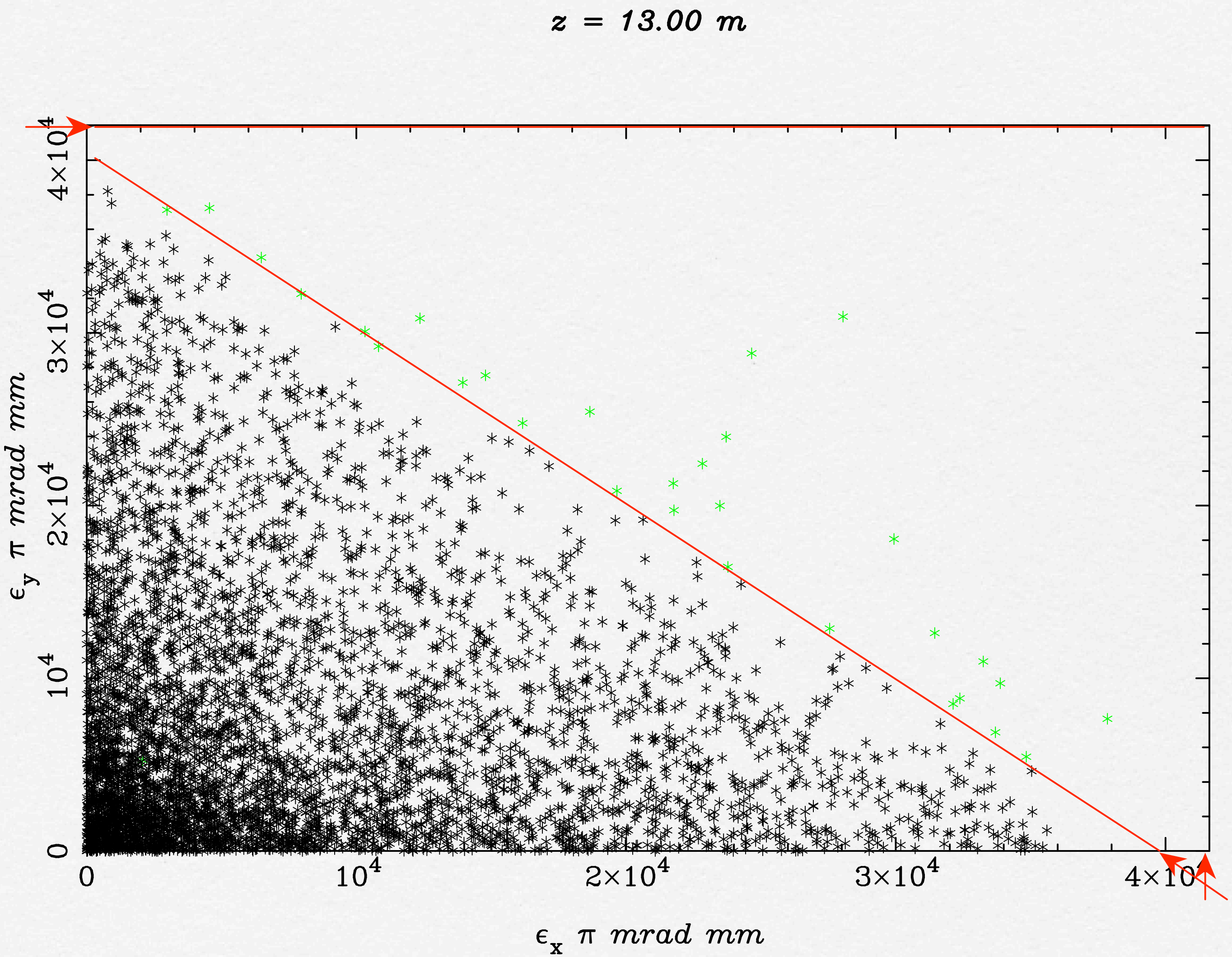
60 MeV

blue: initial $e^+$ distribution generated

red: at 1.98 GeV

green: 0.03 π m rad

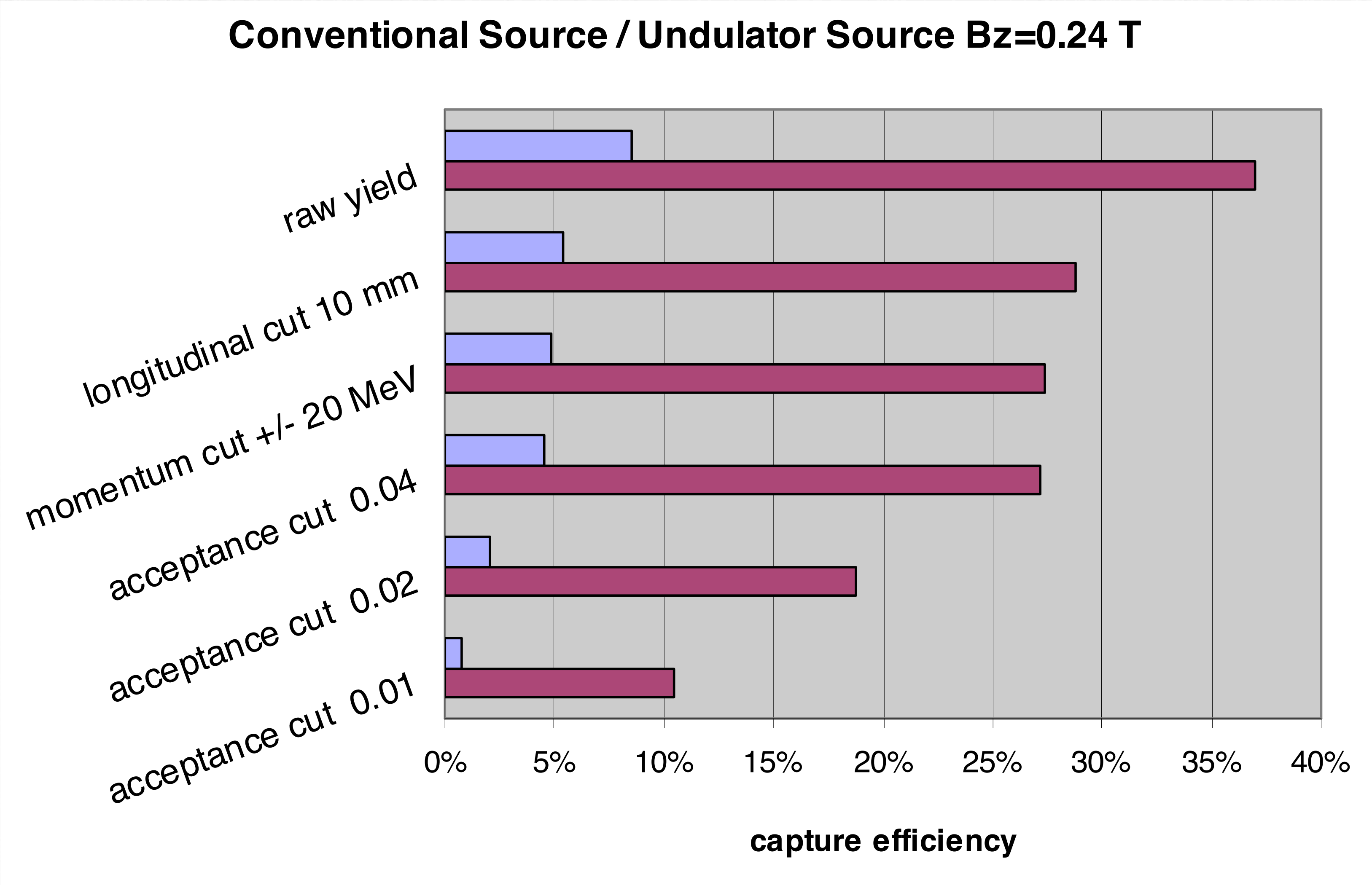
# Transverse Acceptance




Cut at

$\gamma A_x + \gamma A_y = 0.04$

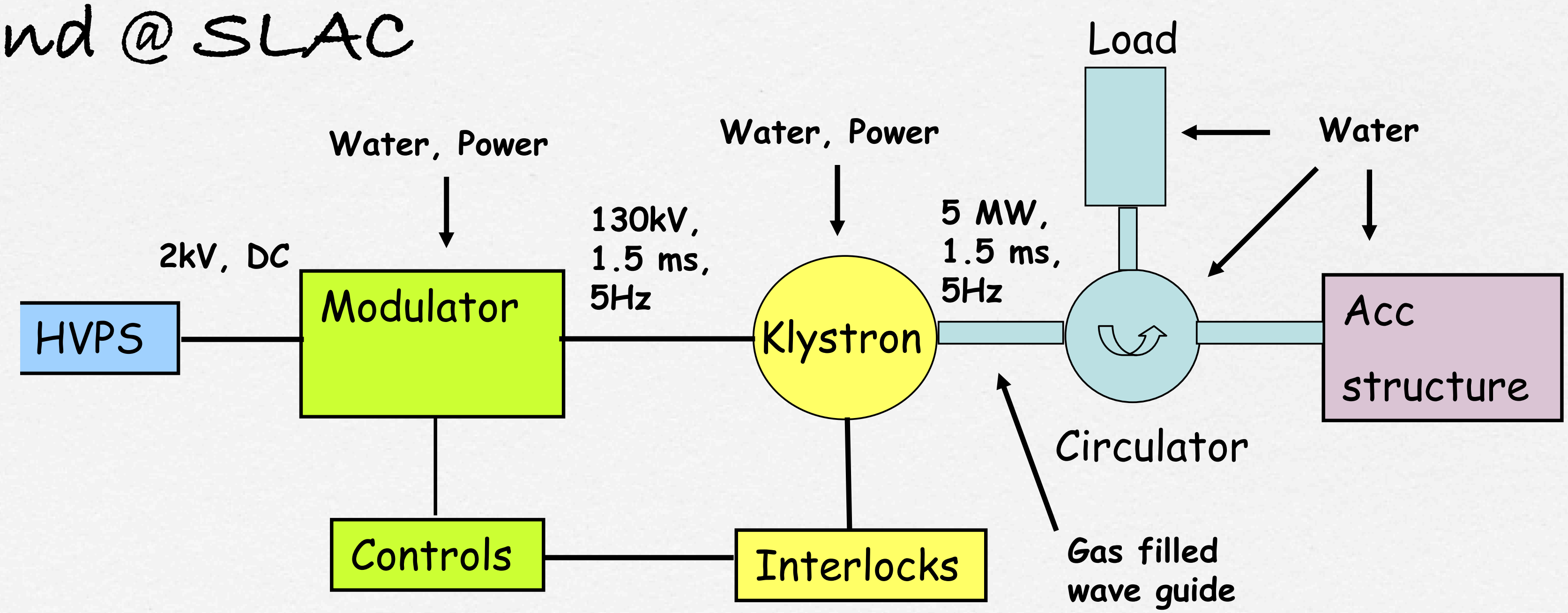
# Conv. Source/Undulator



# RF Structures for Source

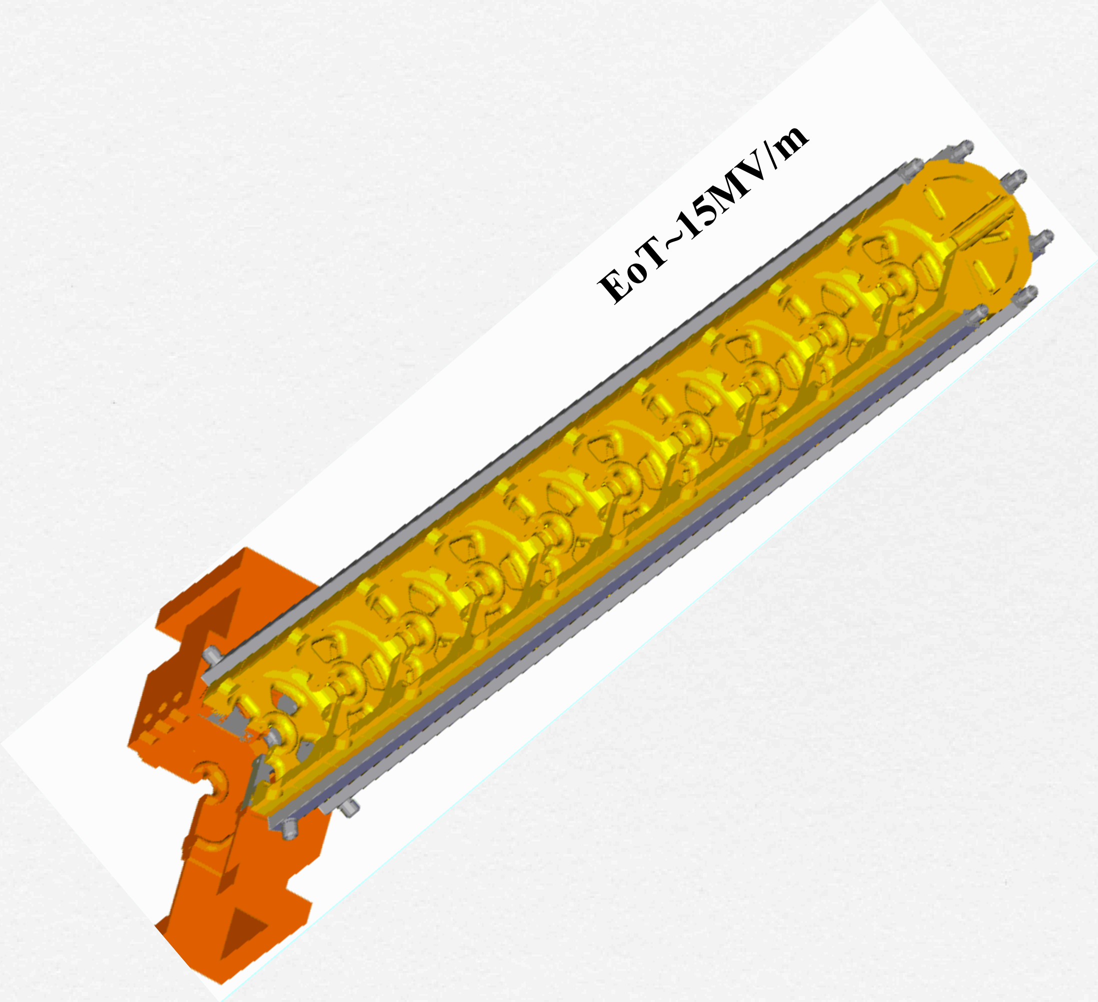
detailed discussion of gradients and cavity structures (J. Wang)

L-Band Test Stand @ SLAC



# Positron Pre-Accelerator

- NC design (V.Paramonov)
  - particle loss
- Capture efficiency (V.A. Moiseev)
  - BDS



# Summary

- Baseline options
  - Helical Undulator
  - Conventional Source
- Polarisation
  - Pol ⇔ Luminosity has to be clarified