Optical Matching Device

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Positron source KOM - Daresbury

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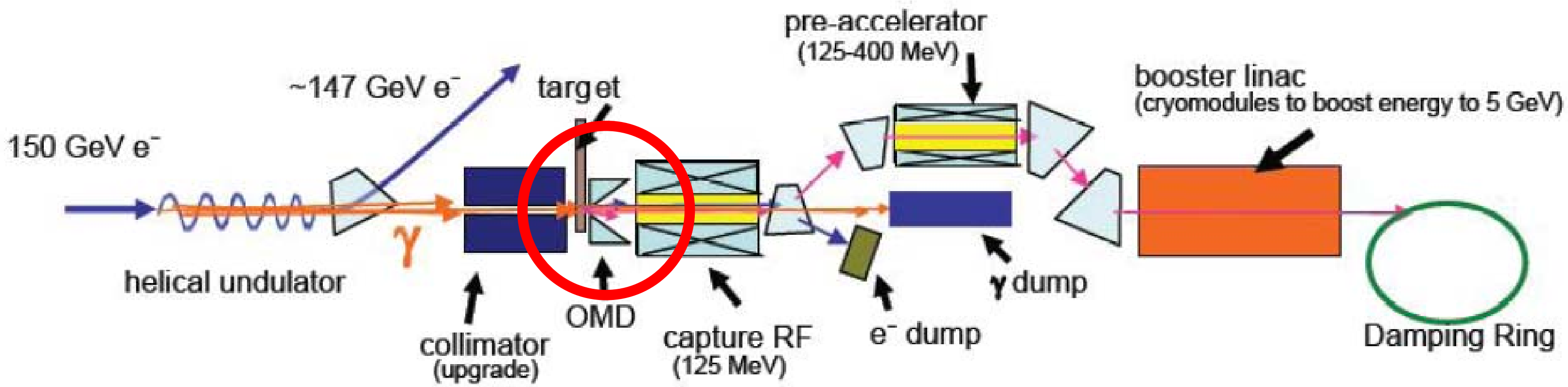
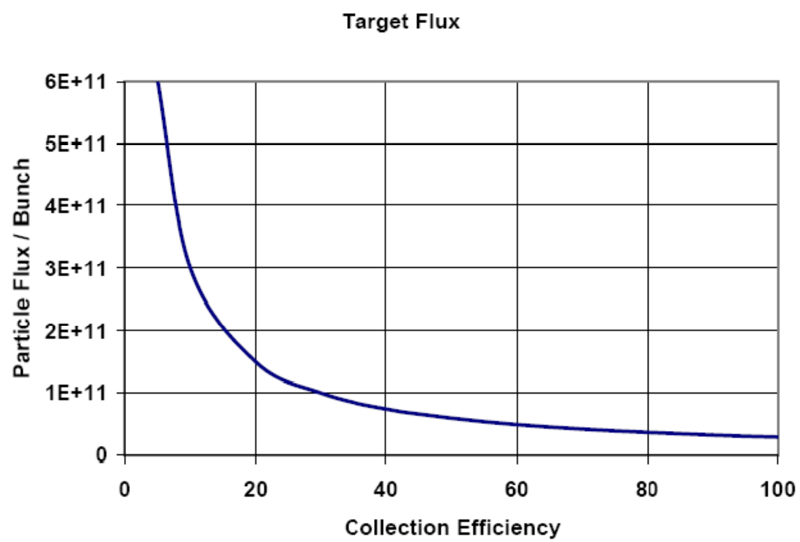
Optical Matching Device



- What is it?
  - **Point to parallel magnetic focusing optic after the target**



- Why is it important?
  - **Improves capture efficiency reduces photon flux required**
    - Shorter wiggler
    - Lower heat load in target
    - Smaller dumps
    - Less radiation

A number of options have been considered

- The capture efficiency for the options have been simulated by SLAC/ANL/Cornell
  - **Capture efficiency varies between 10% and 30%**
- What are the options?
  - **Nothing**
  - **¼ wave solenoid**
  - **Pulsed flux concentrator**
  - **Immersed SC solenoid**
  - **Lithium lens**

OMD		Capture efficiency
Immersed target (6T-0.5T in 20 cm)		~30%
Non-immersed target (0-6T in 2cm, 6T-0.5T 20cm)	**RDR baseline**	~21%
Quarter wave transformer (1T, 2cm)	**Proposed EDR baseline**	~15%
0.5T Back ground solenoid only		~10%
Lithium lens		~29% **(~40%*)**

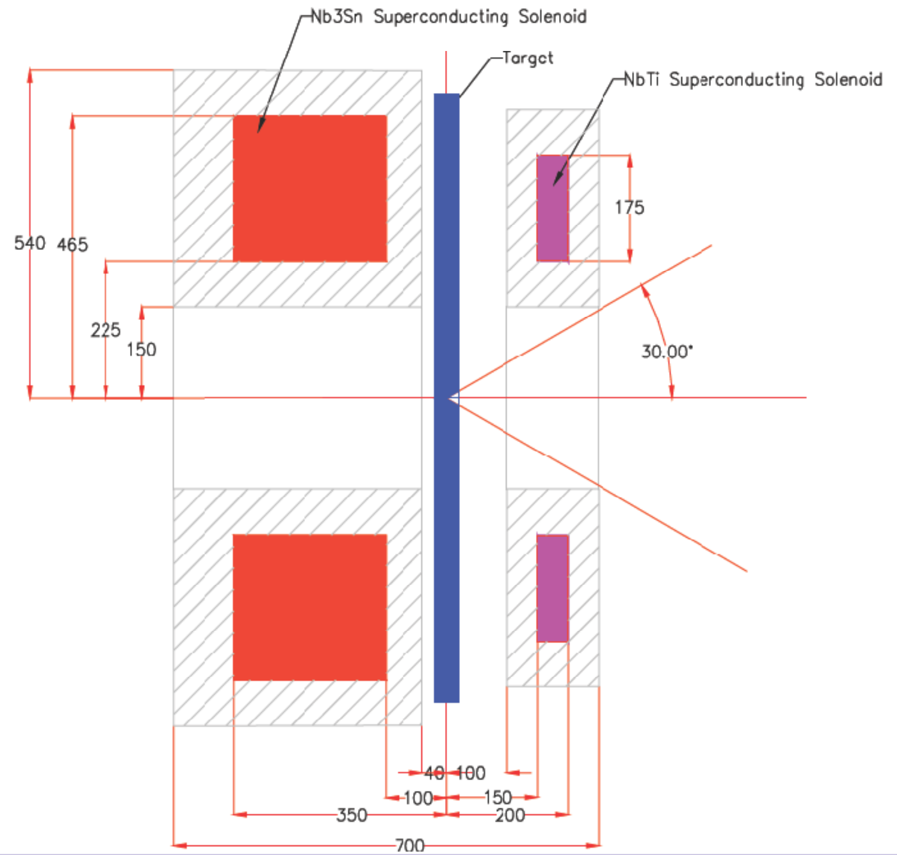
W. Liu

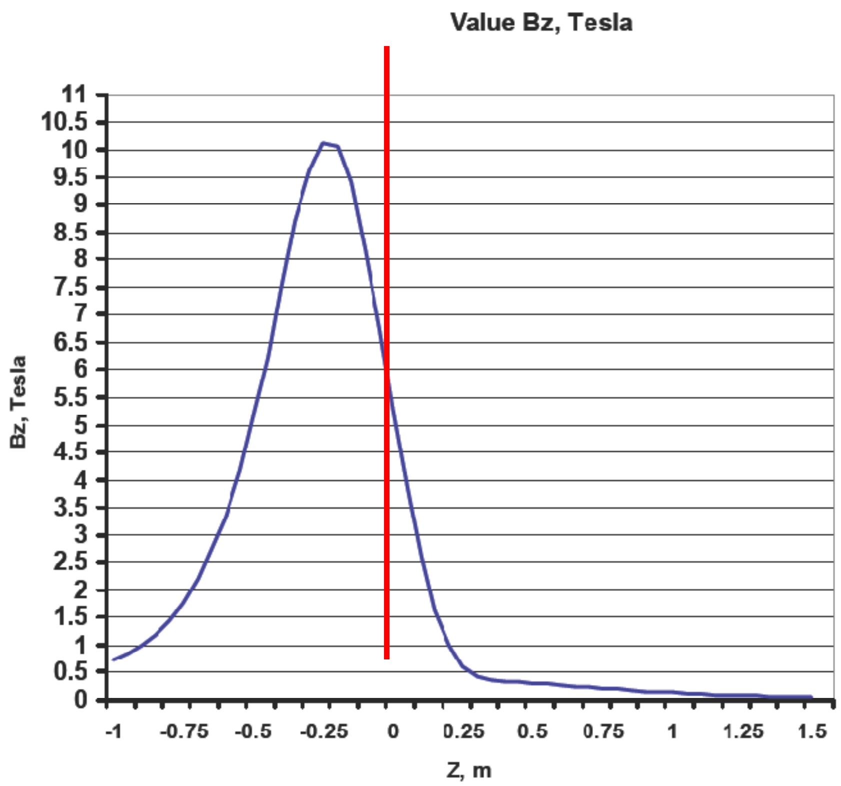
*** K=0.36 undulator**

No OMD idea is completely mature

- What are the issues?
  - **Engineering feasibility of the optic**
    - Can it be engineered?
    - Can it operate in the radiation environment?
    - Can lithium lens survive the energy deposition?
  - **Engineering feasibility of the target**
    - Interaction of magnetic field with spinning target may be a problem
      - Static and pulsed loads on the target
      - Non-conductive materials?
    - Largest possible spot size at the target?
- Any solution is going to require a significant engineering and prototype effort before we are confident.
  - **Can we actually provide a realistic test environment?**

OMD 1: Immersed Field Superconducting Solenoid



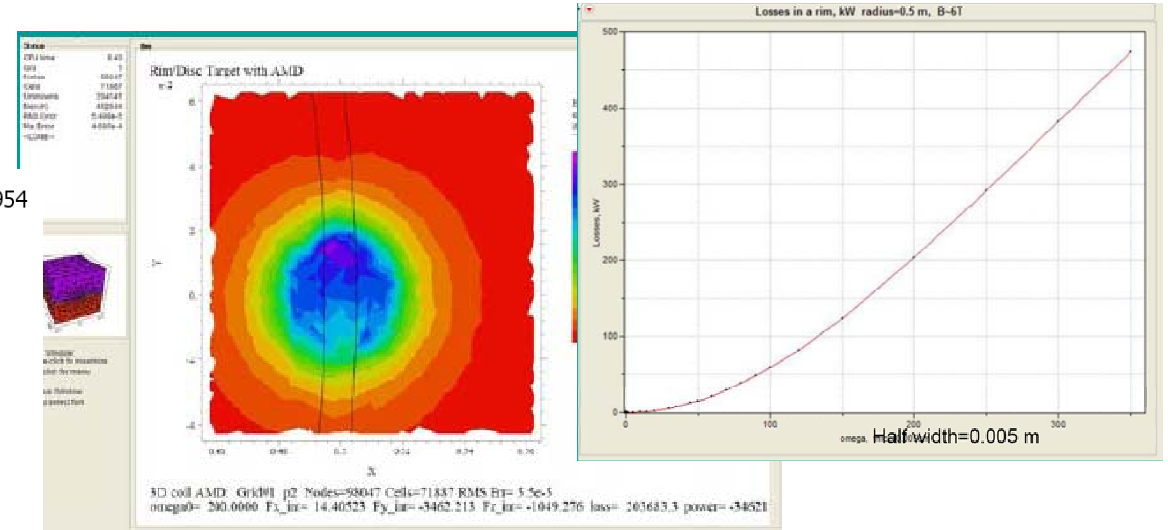


Bharadwaj, Kashikhin

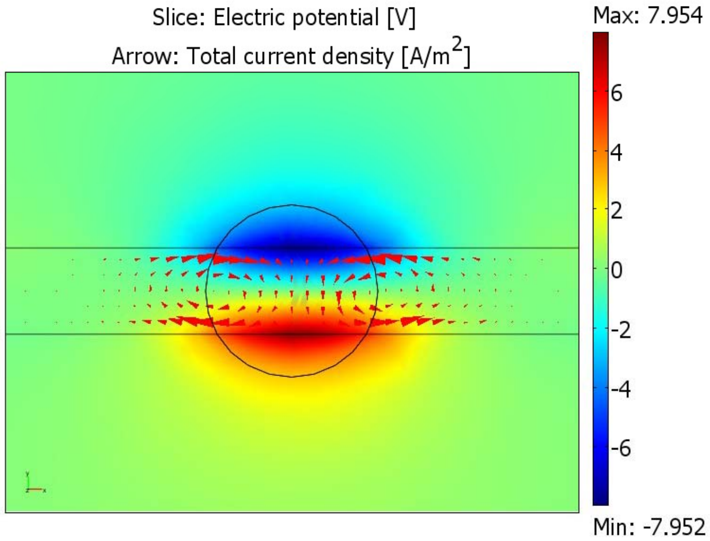
- Provides high capture efficiency
- Similar to other SC solenoids in operation
  - **Questions about quenching in the radiation environment**

Eddy currents appear to rule out an immersed field target

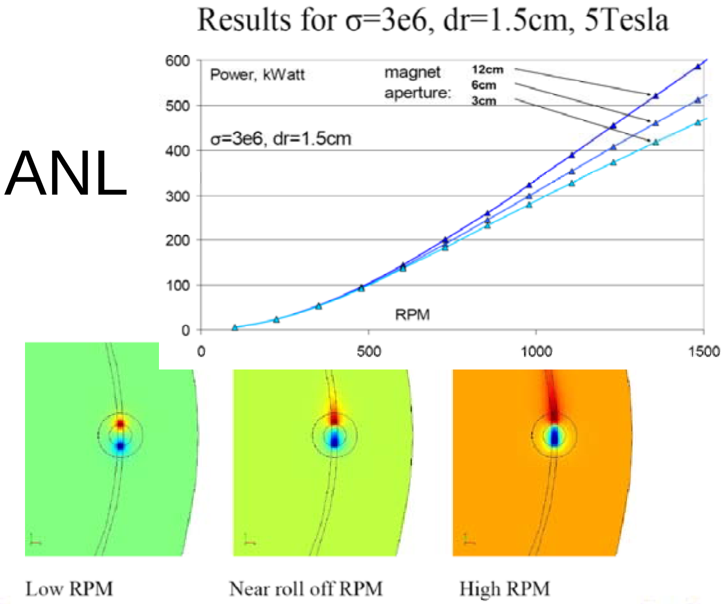
Cornell



LLNL

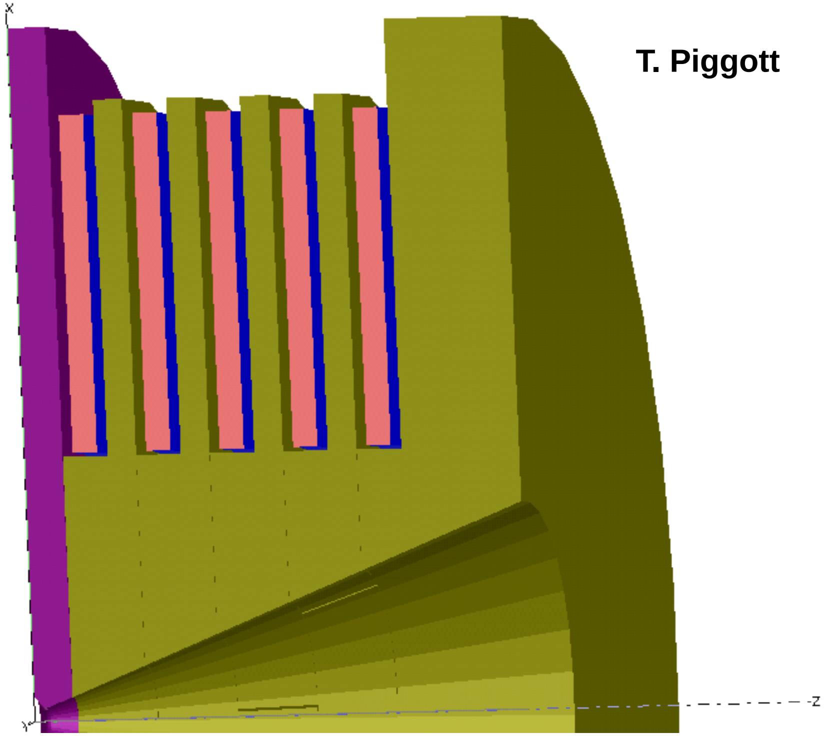


ANL

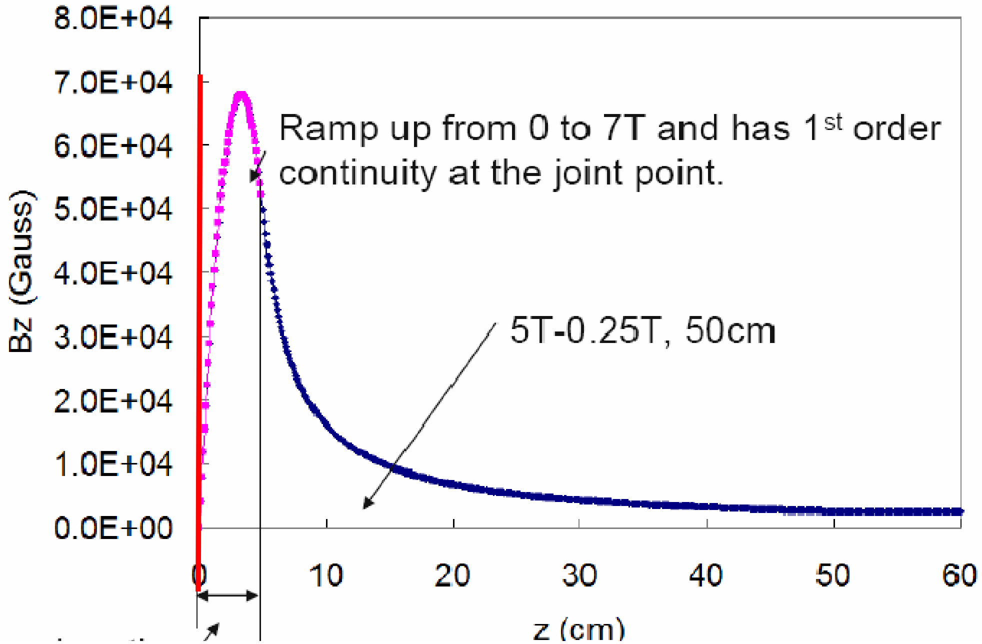


- Simulations show 100's of kW energy depostion
  - **sufficient to rule out immersed target**
- Validated simulations are critical to target design
  - **All options have fringe fields at some level**
  - **What can be tolerated?**

OMD 2: Pulsed Flux Concentrator



T. Piggott



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- Reduces magnetic field at the target
  - **Reduced capture efficiency, 21%**
- Pulsed flux concentrator used for SLC positron target
  - **It is a large extrapolation from SLC to ILC**
  - **1μs -> 1ms pulse length**

Similar devices have been created before

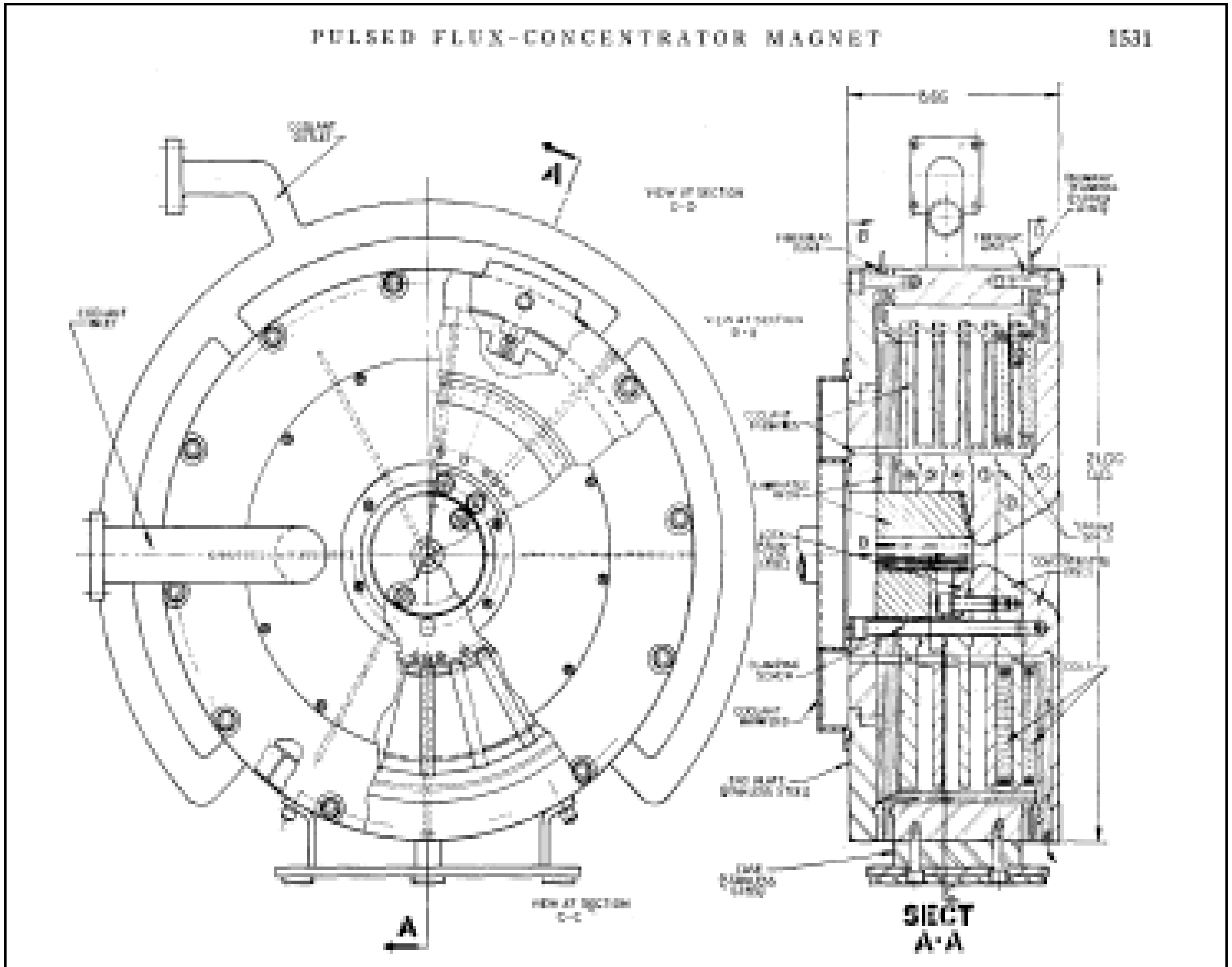


Fig. 4. End view and side section of flux concentrator final design.

- Brechna, et al.
  - **1965**
  - **Hyperon experiment**
- Very preliminary ANL and LLNL simulations do not indicate showstoppers
- No one has stepped up to claim this is "doable"

ILC parameters are close to Brechna

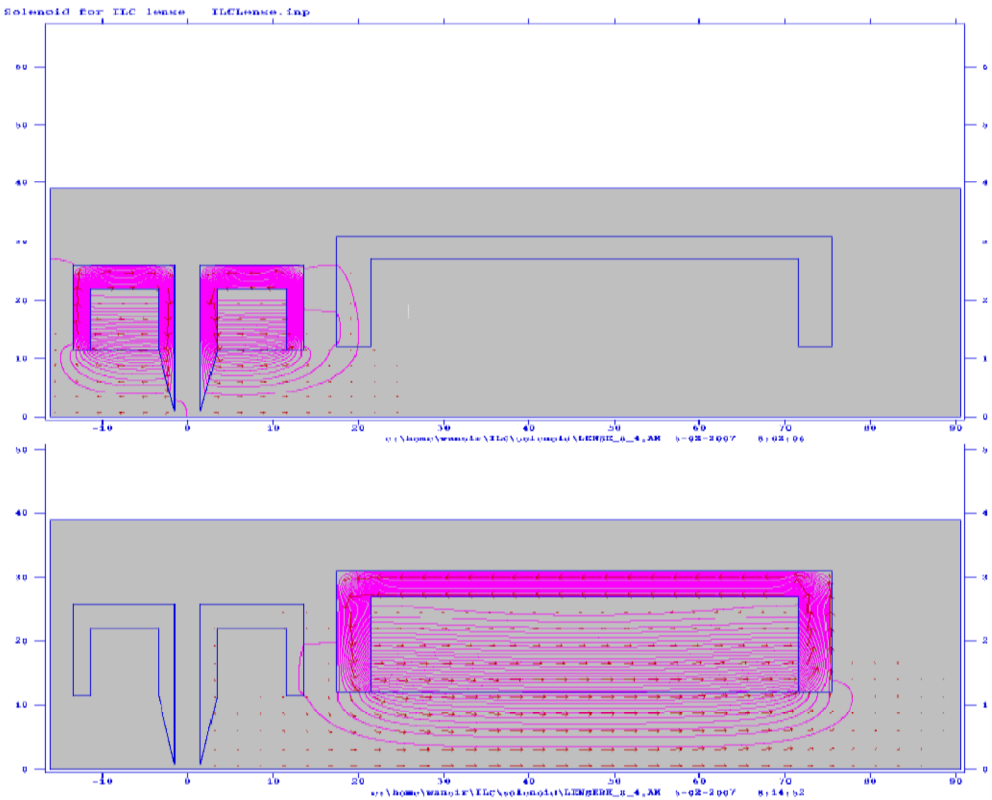
Parameter	Brechna	ILC	Units
Field Strength	10	7	T
Pulse Length	40	1	ms
Repetition Rate	1/3	5	Hz

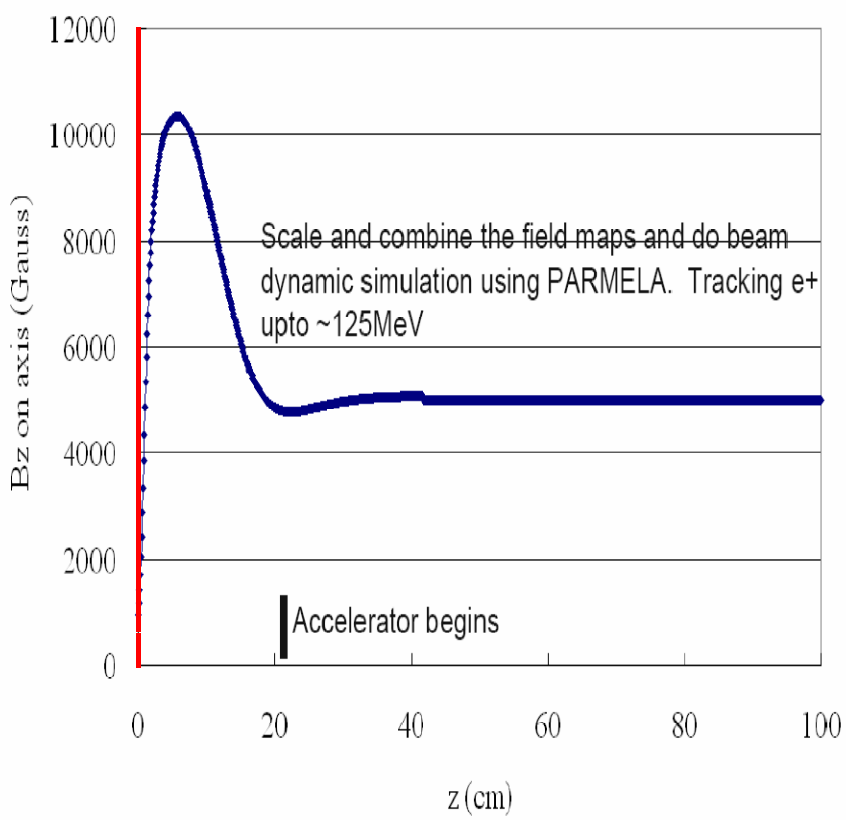
J. Sheppard

- Extrapolation from Brechna to ILC is not large
  - **Lower field**
  - **Lower pulse length**
  - **Pulse length x repetition rate is similar**

- Requires significant design and prototyping effort

OMD 3: Quarter Wave Transform





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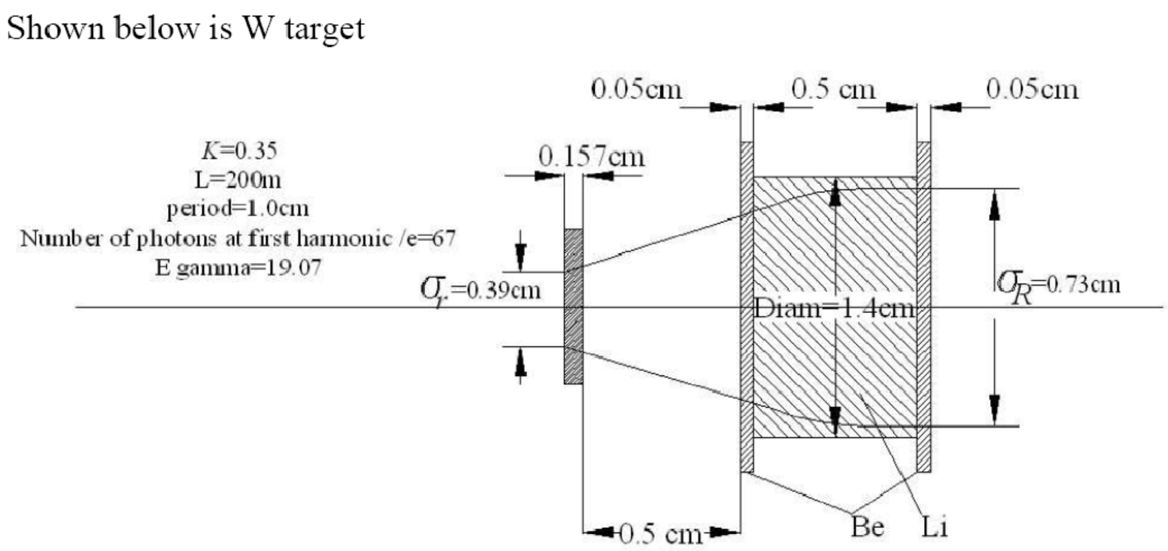
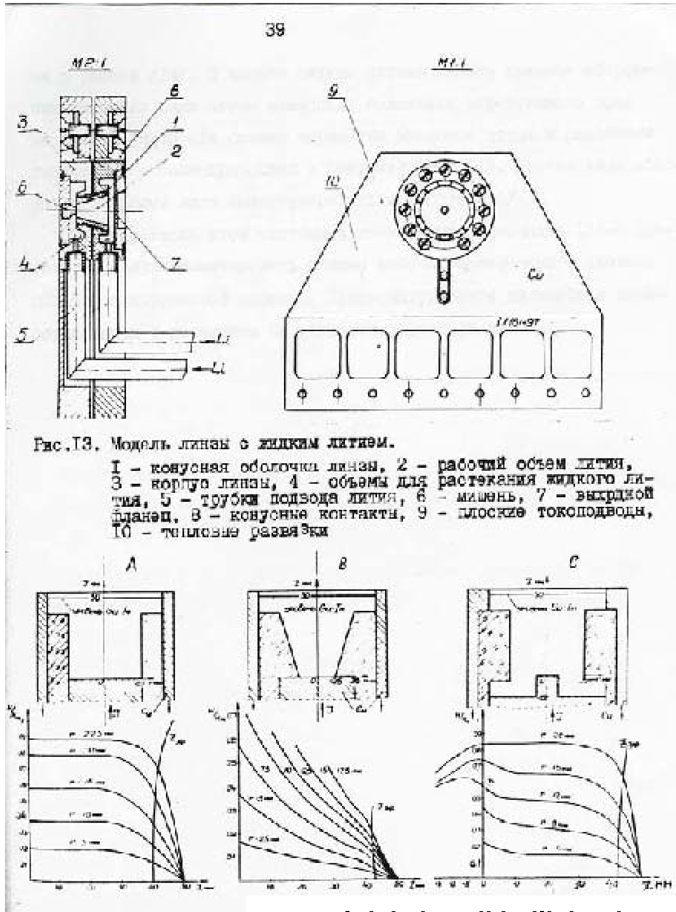
- Low magnetic field at target
- Lower capture efficiency, 15%
- Realizable magnets

OMD 4: Lithium Lens



A. Mikhailichenko



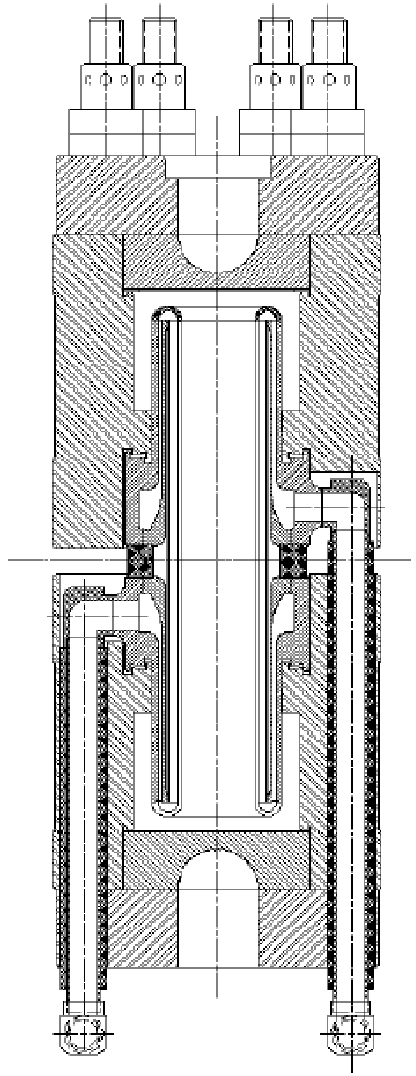
Vsevolojskaja, Mikhailichenko, Silvestrov, Cherniakin

- High capture efficiency, 30%
  - **40% with tuned undulator parameters**
- Low magnetic field at target

Lithium lens is different from the solenoid based options

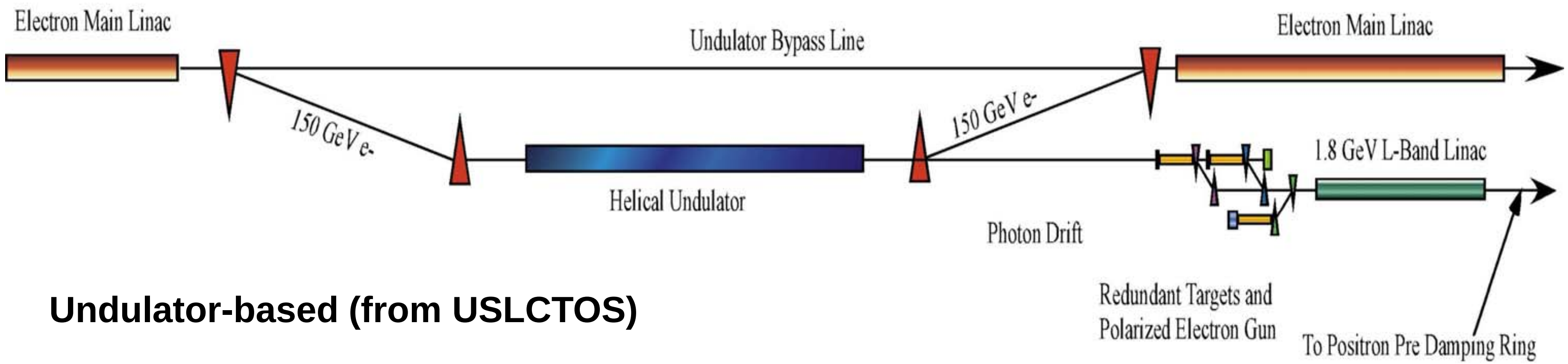
- Lithium Lens is a demonstrated technology
  - **First used for focusing at BINP**
    - 2e11 particles/bunch at 0.7 Hz
  - **Anti-proton collection at FNAL/CERN**
  - **Being developed for muon cooling**

- ILC will have 10^4 greater current
  - **Will lithium cavitate under pulsed heating?**
    - window erosion
    - Current flow disruption
  - **Will shock waves crack the stationary windows?**
  - **Will lithium flow adequately cool the windows?**
    - At 10 m/s and 5 mm length a volume of lithium flowing through the lens will see ½ the beam train
  - **Lens is defocusing for electrons**
    - Increased heating and radiation load in the capture section



P.G. Hurh & Z. Tang

How does the OMD affect the EDR?



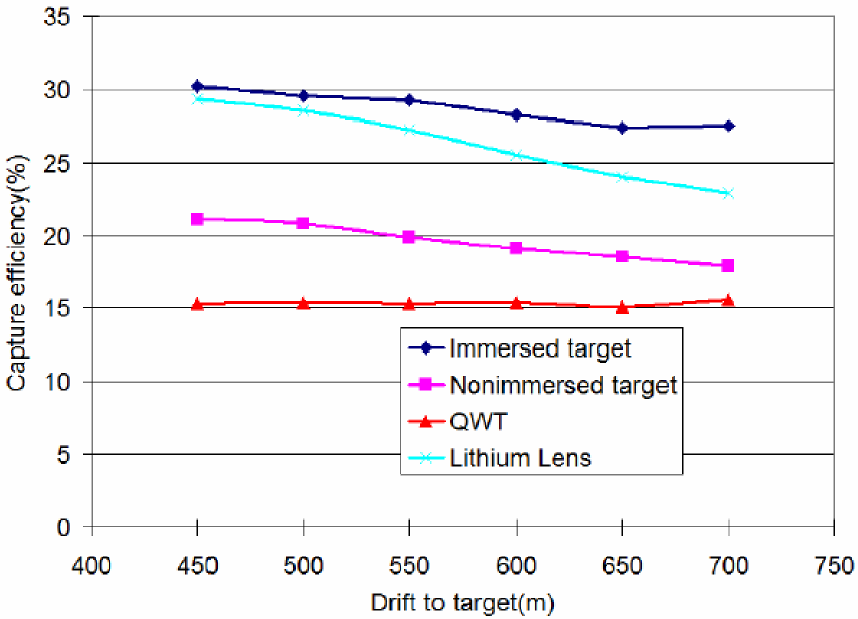
Undulator-based (from USLCTOS)

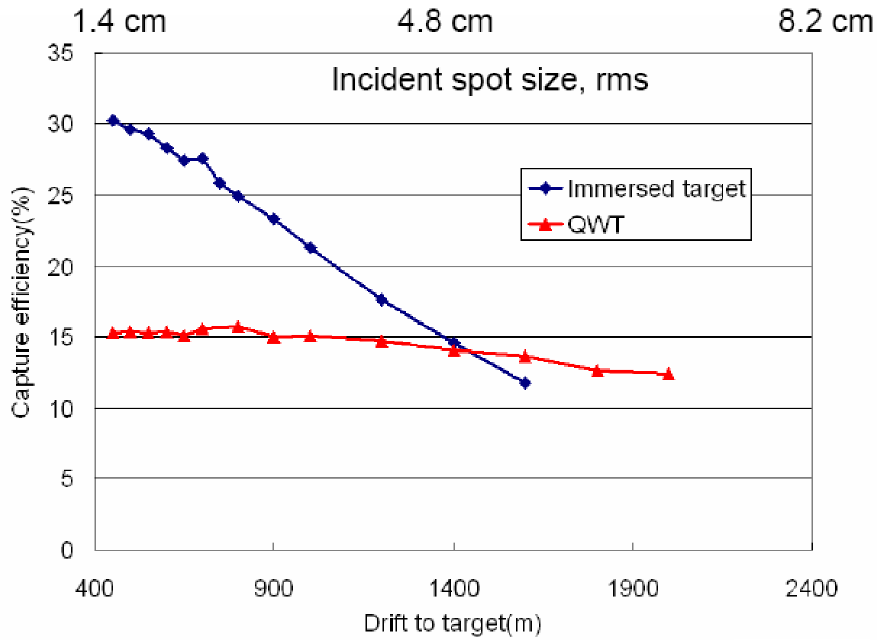
- Cost Mitigation
  - **Capture efficiency directly effects length of helical undulator**
- Risk Mitigation
  - **Target/OMD can be thought of as "plug replaceable"**
    - Possible to update target design at later date
    - Can choose workable baseline and then develop improved alternatives
  - **Photon drift length is set in stone once construction begins**
  - **Can prototypes be run in realistic conditions?**

Target spot size depends linearly on photon drift length

- Energy deposited scales as
  - **1 / efficiency**
- Temperature change scales as
  - **Energy deposited / spot size**

- There is a drift distance that minimizes the stress in the target





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Status

- We want as much capture efficiency as is realistically possible
  - **Cost reduction in the undulator**

- High field at the target seems ruled out
  - **Some work on non-conductive materials has been done**
- Flux concentrator seems to be a challenging engineering problem
- The ¼ wave solenoid seems realizable and appropriate for the baseline

- Lithium lens needs more detailed design to evaluate survivability in the beam

EDR OMD Work Packages

- Baseline work (assume ¼ wave solenoid)
  - **08 Detailed magnet engineering design**
    - Show feasibilty
    - Define fringe fields (target interaction)
  - **09-10 Prototype? (may not be needed)**

- Cost mitigation R&D, Alternatives with greater capture.
  - **08-09 Detailed engineering design of flux concentrator**
    - Calculations of:
      - Fields and Forces
      - Heat dissipation and cooling
  - **Outyears Prototype**

- Test facilities?
  - **Solenoids can be prototyped and demonstrated stand-alone**
  - **A low energy electron beam with the same charge and time structure as ILC could allow testing of components that sit in the beam**
    - Perhaps combined electron source prototype and positron testing facility?