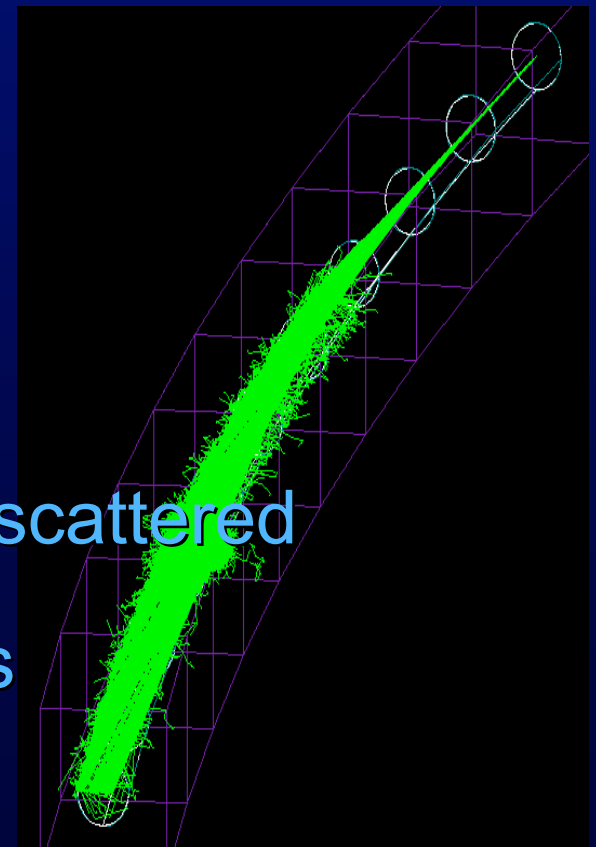


# BDSIM Simulation

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- Introduction
- The BDSIM code
- BDSIM and MOKKA
- Extraction line simulation
- Secondary particles backscattered
- Conclusion and prospects



# Introduction

Geant IV based program originally developed by Grahame Blair (RHUL)

## History:

Track particles through the BDS\*, **BDs SIM**ulation, of a generic LC including particle interactions and production of secondaries in materials

**BDSIM can evaluate background levels at any point along the beam line**

**1<sup>st</sup> public release under CVS Jan 05 (I. Agapov, RHUL)**

\*Beam Delivery System (i.e end of linac to the IP)

# Past, current and future BDSIM applications

## Applied:

- CLIC BDS, ILC BDS, Petra Laser wire ...

## Applying:

- 2mrad & 20mrad extraction line, beam dumps ...

## Will be applied:

- Head-on, 14mrad & CLIC extraction line, ATF2, LHC collimation and upgrades ...

# People



Ilya Agapov

Optics design, beam diagnostics,  
neutron simulation

Grahame Blair

Collimation, muons, backgrounds

John Carter

SR, beam diagnostics, IR layout



Olivier Dadoun

IR layout, extraction line simulation,  
neutron simulation, ROOT event display

# BDSIM code

BDSIM tool is a C++, Geant4 based (all physics processes from Geant4)

- Designed flexibly :

adopting OO each beam-line element is constructed as separate object

- Accelerator tracking code :

Inside beam-pipe new approach (CPU time consuming)

otherwise “normal” G4 tracking inside materials

Use analytic solution to the equations of motion -G4Stepper-

# BDSIM input file

- Originally: MAD “optics” file input

beam-pipe is described with own outer geometry, magnetic fields

rbend, l= 5.5, angle=0.001

drift, l=2.

quadrupole, l=1.5, k1=0.001

- Now GMAD format (Geant-MAD)

we defined also the material, the beam parameters, the processes and precise the sample position

option, beampipeRadius = 10\*cm,

tunnelRadius= 2.0\*m,

beampipeThickness = 0.1\*cm,

thresholdCutCharged = 10\*KeV,

thresholdCutPhotons = 10\*KeV;

ngenerate=5, turnInteractions=1,  
useEMHadronic=0, synchRadOn=0,  
stopTracks=0;

sample,range=mexfoc;

beam, particle="e-",

energy=ener \*GeV,

distrType="guineapig\_slac",

distrFile="beam1.dat";

# BDSIM and MOKKA

MOKKA is a framework for full detector simulation, MySQL input format

**Motivation:** many ILC simulation tools for modeling different aspect

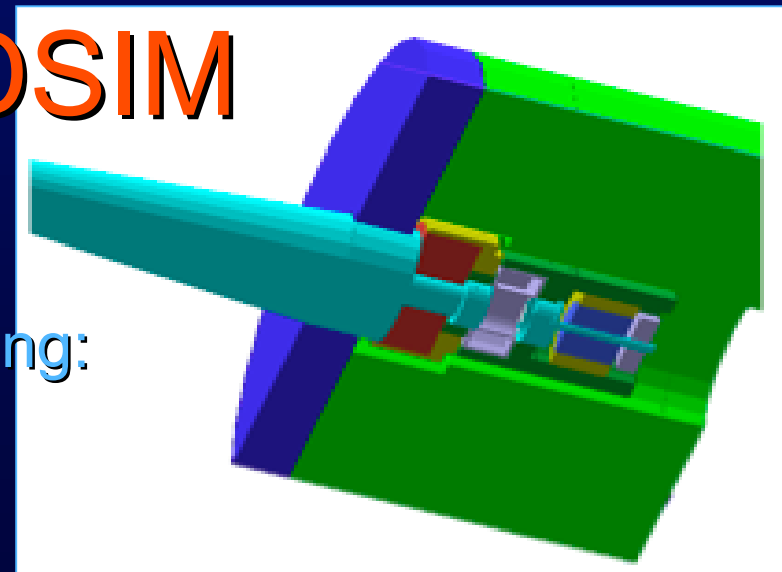
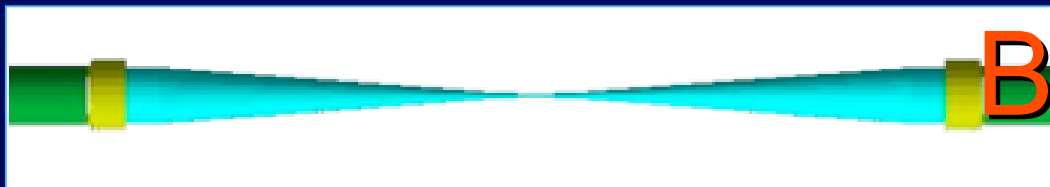
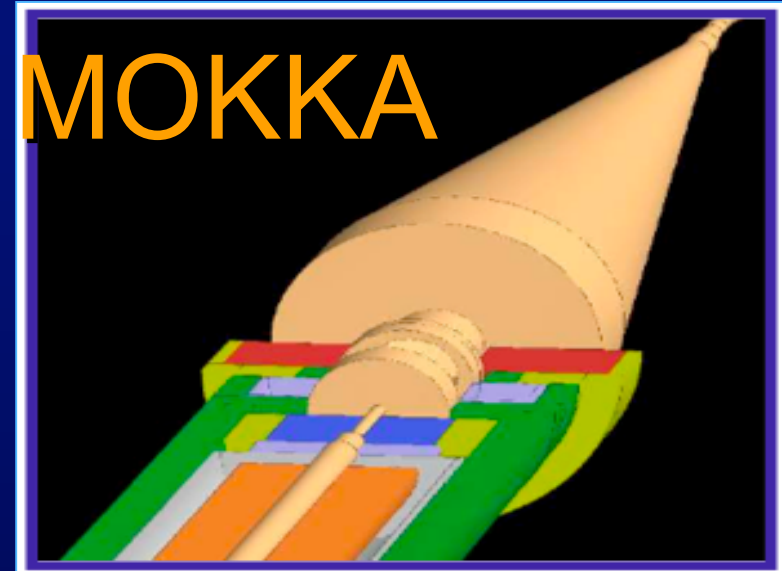
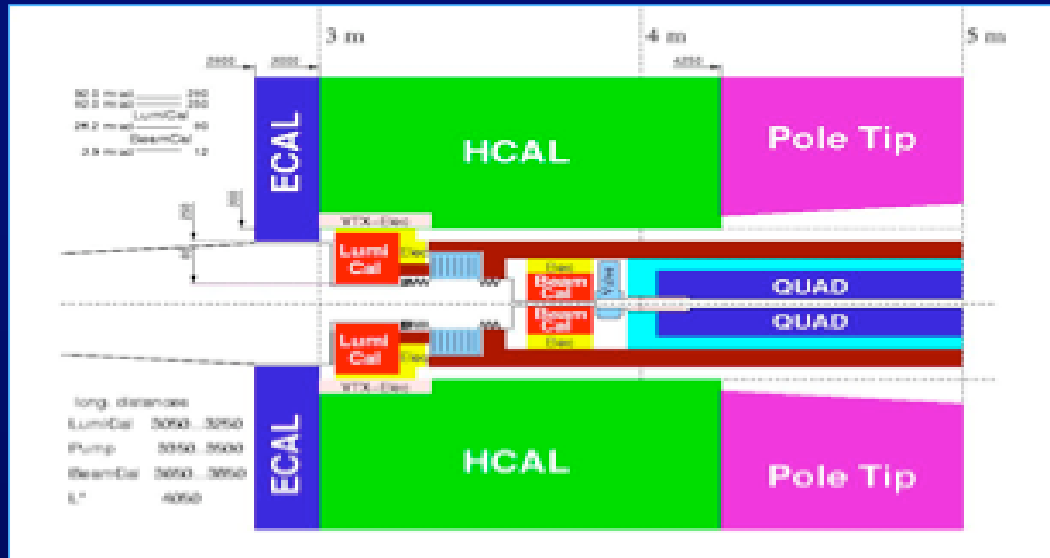
BDSIM & MOKKA are both based on G4, use similar geometry:  
**makes sense to work on a common input**

**IR can be built using MySQL linking BDSIM to detector studies**

- BDSIM still uses GMAD format but know how to handle MySQL format
- Work still in progress by John Carter (RHUL) + Adrian Vogel (DESY)
- Solenoid Field Map included in BDSIM

# BDSIM & MOKKA

can produce the same geometry using the same input file

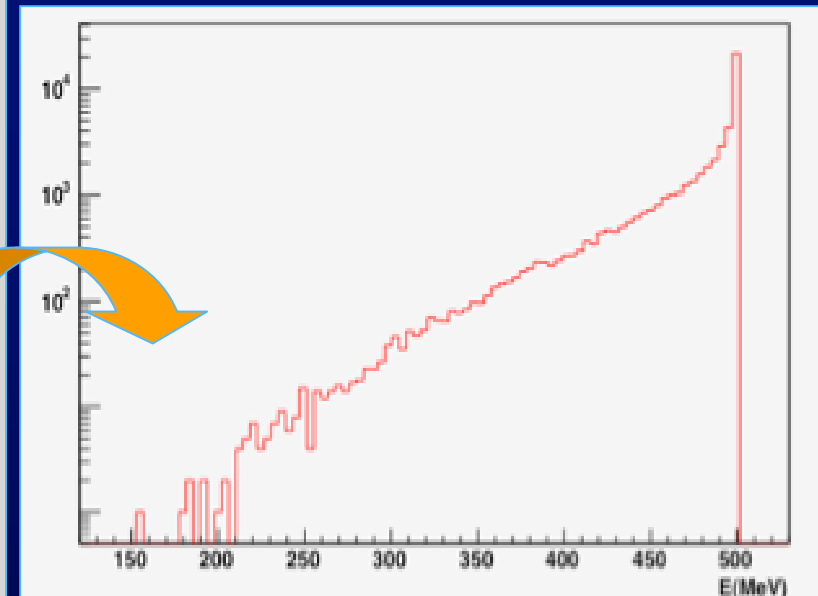


Pictures from John Carter talk

Full IR geo. modeled in BDSIM including:

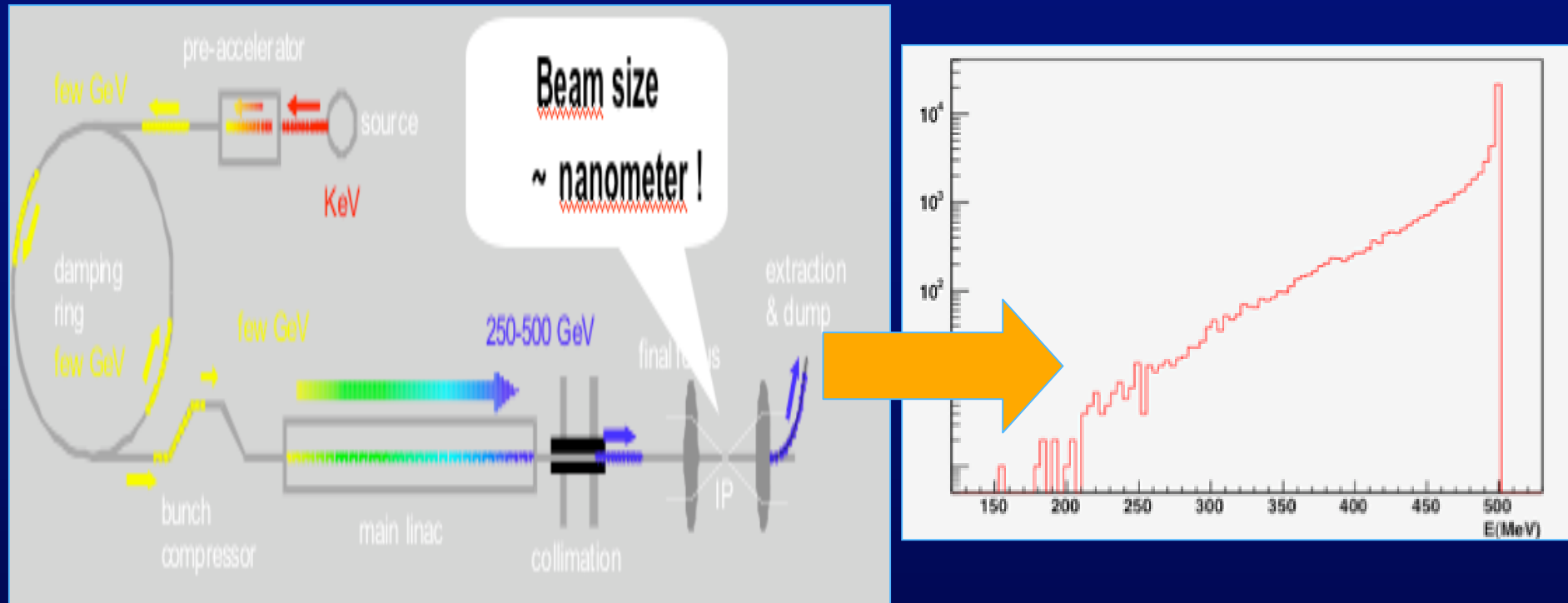
- Solenoid Field
- Ecal, Hcal, Pol Tip

# Challenge of the extraction line simulation



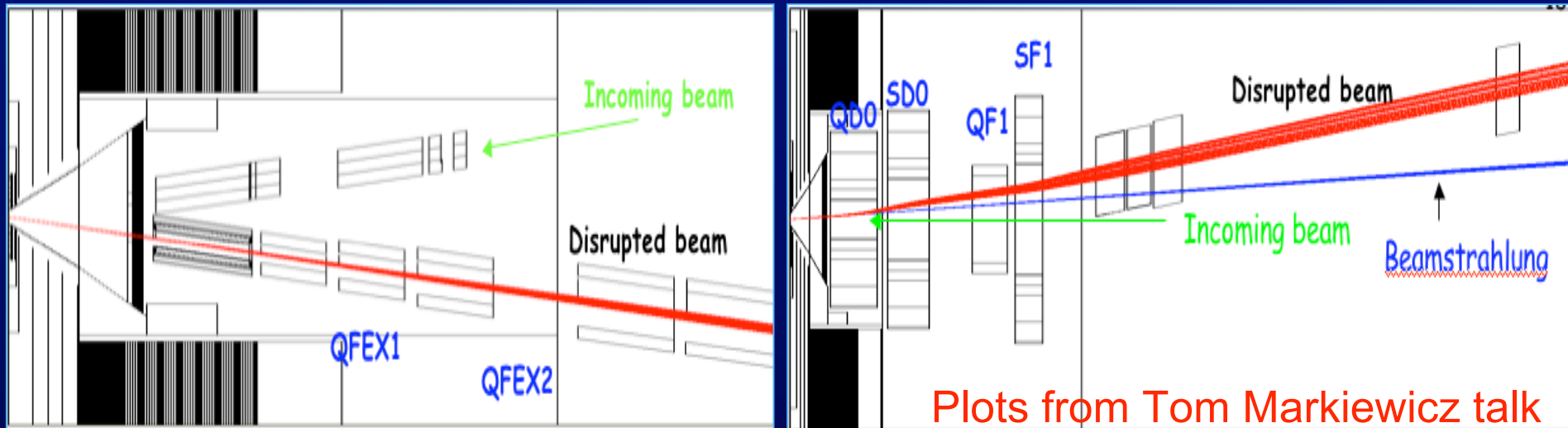
Need to extract the beam after collisions and transport it with minimal losses to the dump

## Evaluate the background this generates in the detector



1. Isolate the elements where the losses occur  
(possible damage on beam magnets, SC for example)
2. What are and how many particles are backscattered into the detector region

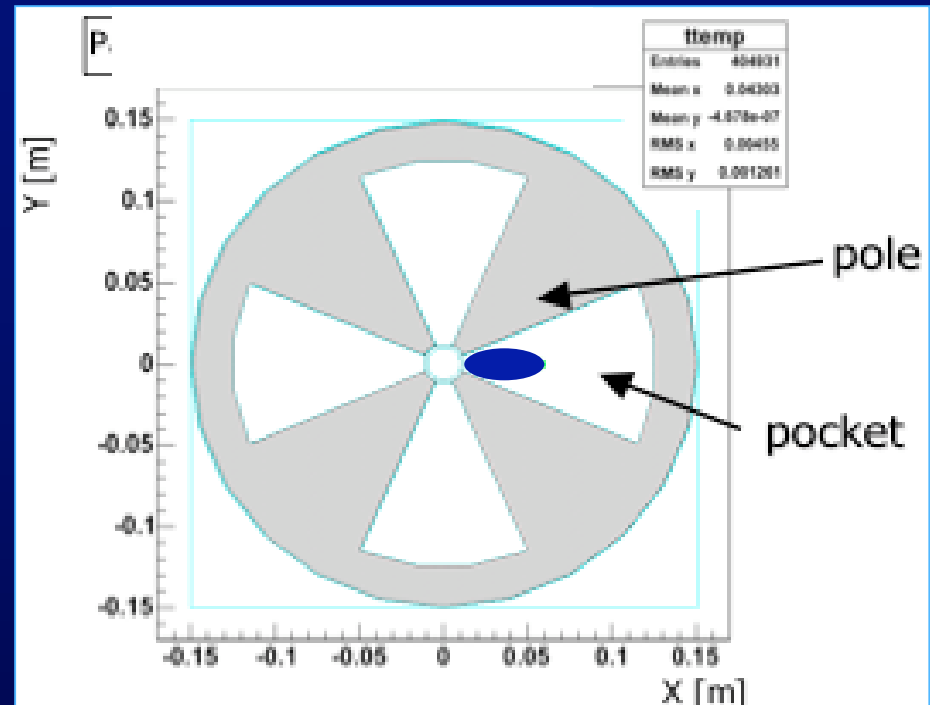
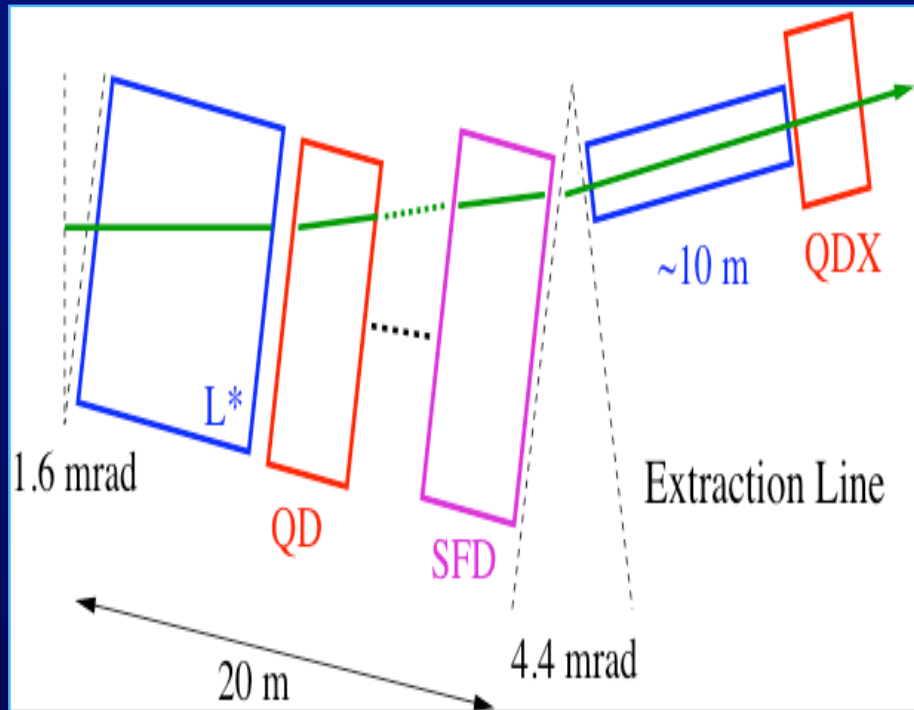
# Large and small crossing angle 20 & 2mrad design



Separate magnets for incoming and outgoing beams in 20mrad  
Length of the extraction line between IP and dump

- ~ 350 m for 20mrad
- ~ 680 m for 2mrad

# 2mrad extraction design



Common elements between incoming and outgoing beam for the first 20m, after separate structure

- Special coordinate transformation
- Multipoles field added

# Systematic studies

Example: 2mrad disrupted beam power losses

## 2mrad Losses - Charged Beam & Tail

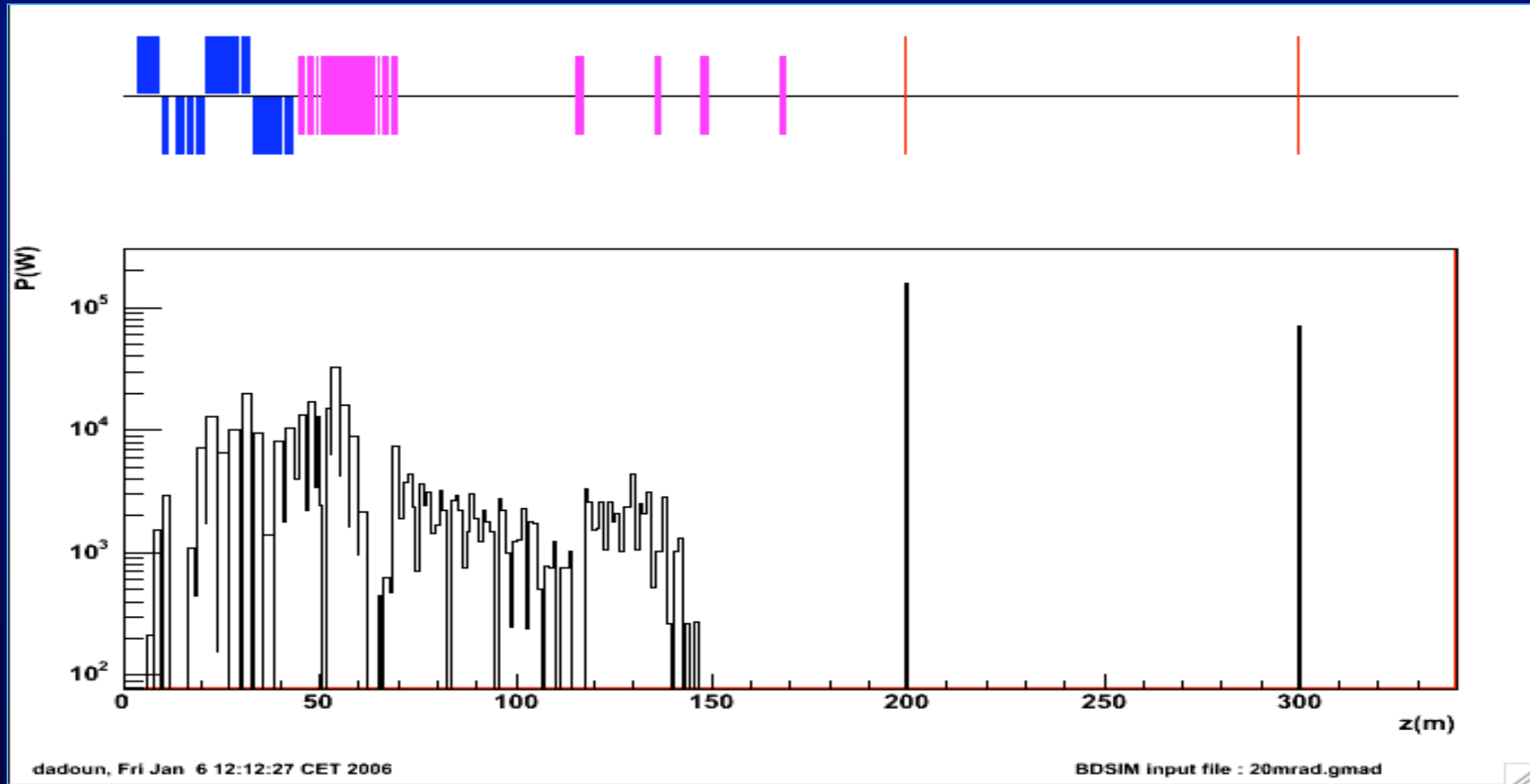
- Tracking in BDSIM to give 'hard losses' with no shower development.
- Assume 100% of track energy is deposited.
- Main Beam files from [h](#)
- Tail files from <http://www>

Beam parameters sets

Elements

| Losses in W       | cs11    | cs11    | cs15     | cs15     | cs21     | cs21     | cs25     | cs25     |
|-------------------|---------|---------|----------|----------|----------|----------|----------|----------|
| Total Ext. Power  | 11.03e6 | 10.89e6 | 10.55e6  | 10.78e6  | 11.14e6  | 10.68e6  | 15.27e6  | 14.36e6  |
| Vect. Offset [nm] | 0       | 200     | 0        | 120      | 0        | 100      | 0        | 80       |
| VD0               | 0       | 0       | 110      | 368      | 0.78     | 4.46     | 10k      | 18k      |
| SD0               | 0       | 0       | 0.36     | 5.71     | 0        | 0.63     | 137      | 1201     |
| SF1               | 0       | 0       | 4312     | 2883     | 0        | 0        | 294      | 1258     |
| ECOLA             | 0       | 0       | 274      | 2381     | 57.8     | 275      | 22k      | 49k      |
| HCOLA             | 0       | 0       | 6.85     | 0        | 0.61     | 1.99     | 1304     | 955      |
| VCOLA             | 1.11    | 4427    | 1204     | 1.06e6   | 69.2     | 65k      | 6881     | 1.00e6   |
| VCOLA2            | 733     | 614     | 66k      | 107k     | 47k      | 114k     | 776k     | 423k     |
| HCOLA2            | 811     | 654     | 882k     | 567k     | 11k      | 34k      | 3.68e6   | 7.05e6   |
| HCOLA3            | 231     | 367     | 10k      | 19k      | 3896     | 6320     | 27k      | 22k      |
| ECOLA4            | 9.78    | 6817    | 28k      | 58k      | 0        | 8947     | 66k      | 409k     |
| ECOLA5            | 136     | 28k     | 12k      | 494k     | 3830     | 106k     | 80k      | 767k     |
| ECOLA6            | 1.53    | 20k     | 45.9     | 430k     | 0        | 133k     | 0        | 269k     |
| ECOLA7            | 0       | 2607    | 0        | 218k     | 0        | 0        | 0        | 80k      |
| Main Beam         | 640k    | 640k    | 625k     | -        | 630k     | 620k     | 635k     | 625k     |
| Tail              | 2 x 10k | 2 x 25k | 2 x 450k | 2 x 500k | 2 x 200k | 2 x 300k | 2 x 175k | 2 x 500k |

# Power losses 20mrad extraction

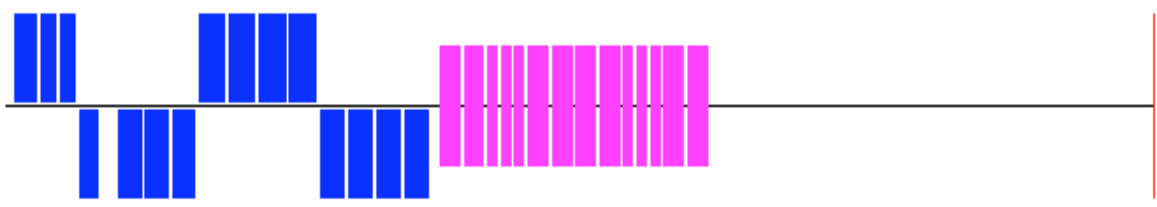


Beam parameters:

High luminosity 1TeV e.c.m, 80 nm offset,  $P \sim 18$  MW

BDSIM ROOT Framework

File Edit View Options Inspect Classes Help



Optics Specs.

File Edit View Options Inspect Classes Help

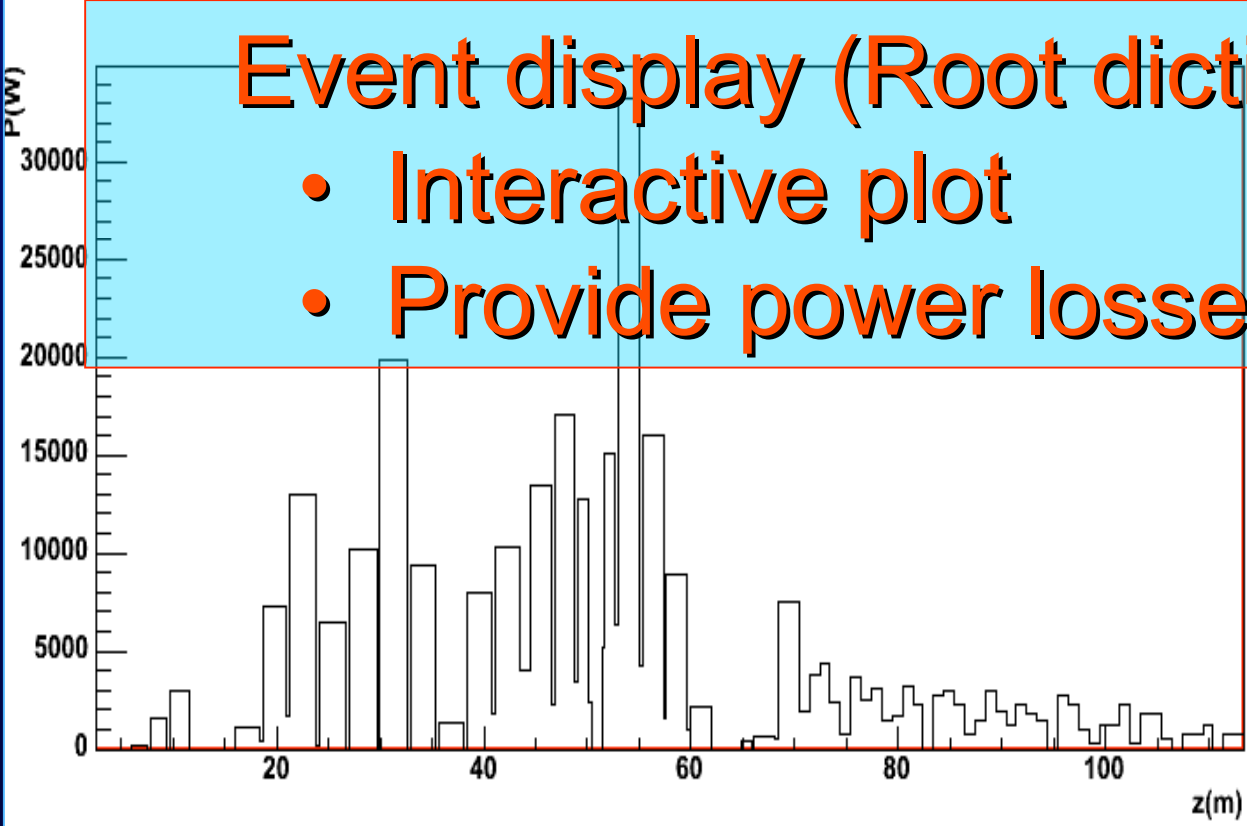
**Opticals Elements specs.**

Name: bvex5e Type :sbend  
@ 59.599098 m with a length of 2.000000 m

k1=0.000000, k2=0.000000  
k3=0.000000, k4=-1.848145

**Event display (Root dictionary) :**

- Interactive plot
- Provide power losses easily



z(m)

display

```

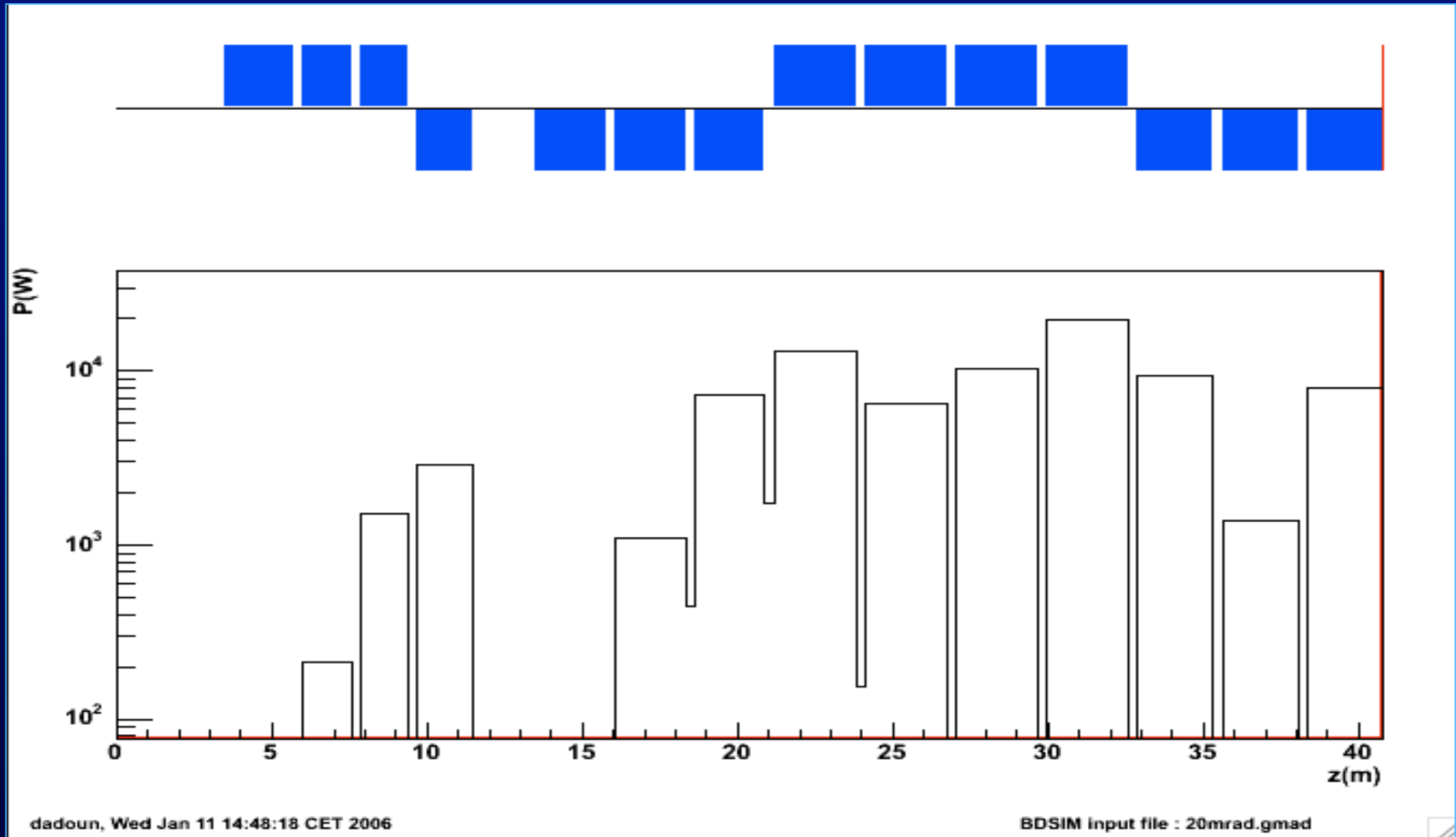
qdex1a 3 5.71 0
dex1a 4 5.71 0
qdex1b 5 7.55088 213.067
dex1b 6 7.85288 0
qdex1c 7 9.39416 1530.06
dex1c 8 9.69416 0
qfex2a 9 11.5 2917.19
dex2a 10 11.5 0
qdex2b 12 16.0583 0
dex2b 13 16.0583 0
qfex2c 13 18.3165 1102.19
dex2c 14 18.6165 441.142
qfex2d 15 20.8748 7250.52
dex2d 16 21.1748 1740.18
qdex3a 17 23.8002 13023.4
dex3a 18 24.1002 155.291
qdex3b 19 26.7257 6506.51
dex3b 20 27.0257 0
qdex3c 21 29.6511 10248.3
dex3c 22 29.9511 0
qdex3d 23 32.5766 19802.9
dex3d 24 32.8766 0
qfex4a 25 35.3872 9376.17
dex4a 26 35.6872 0

```

dadoun, Sun Jan 8 16:20:16 CET 2006

BDSIM input file : 20mrad.gmad

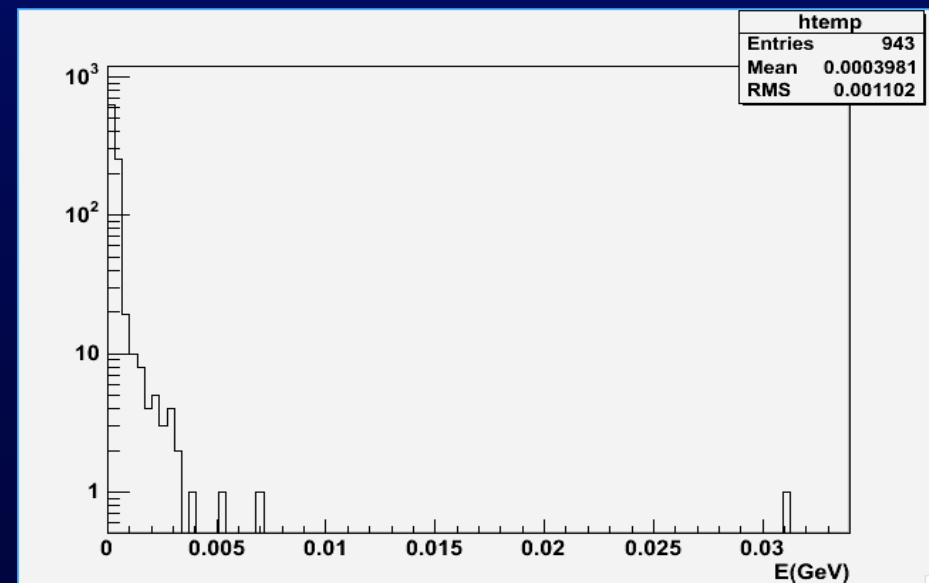
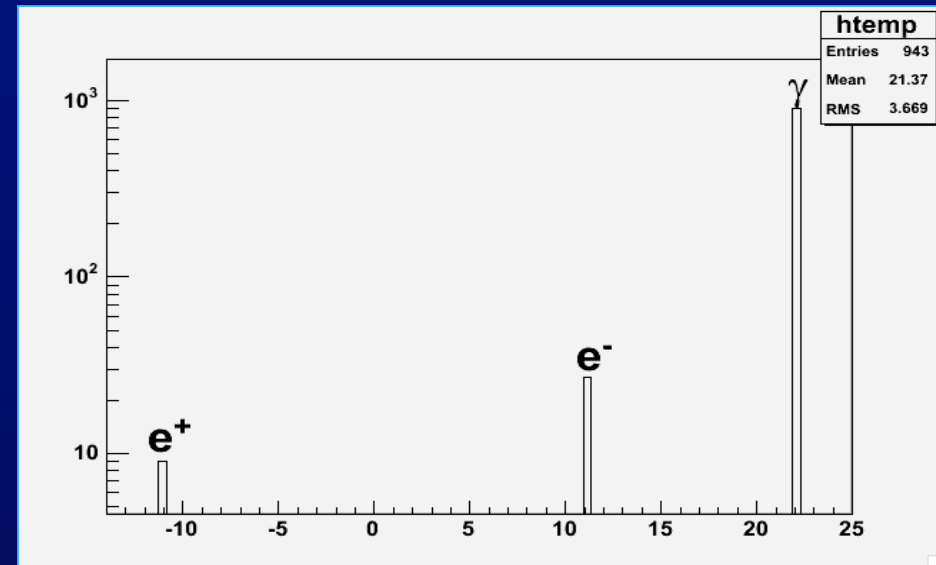
# Disrupted beam power losses



# First look at backscattered particles

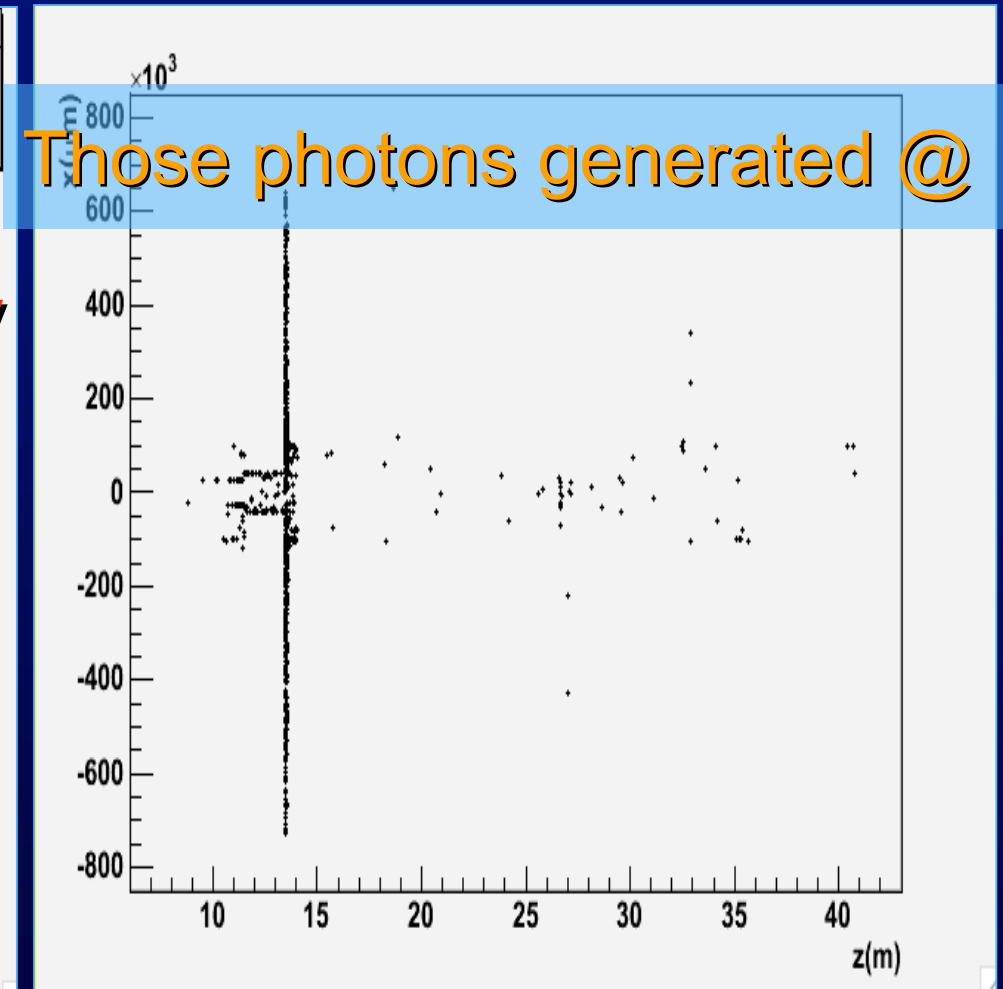
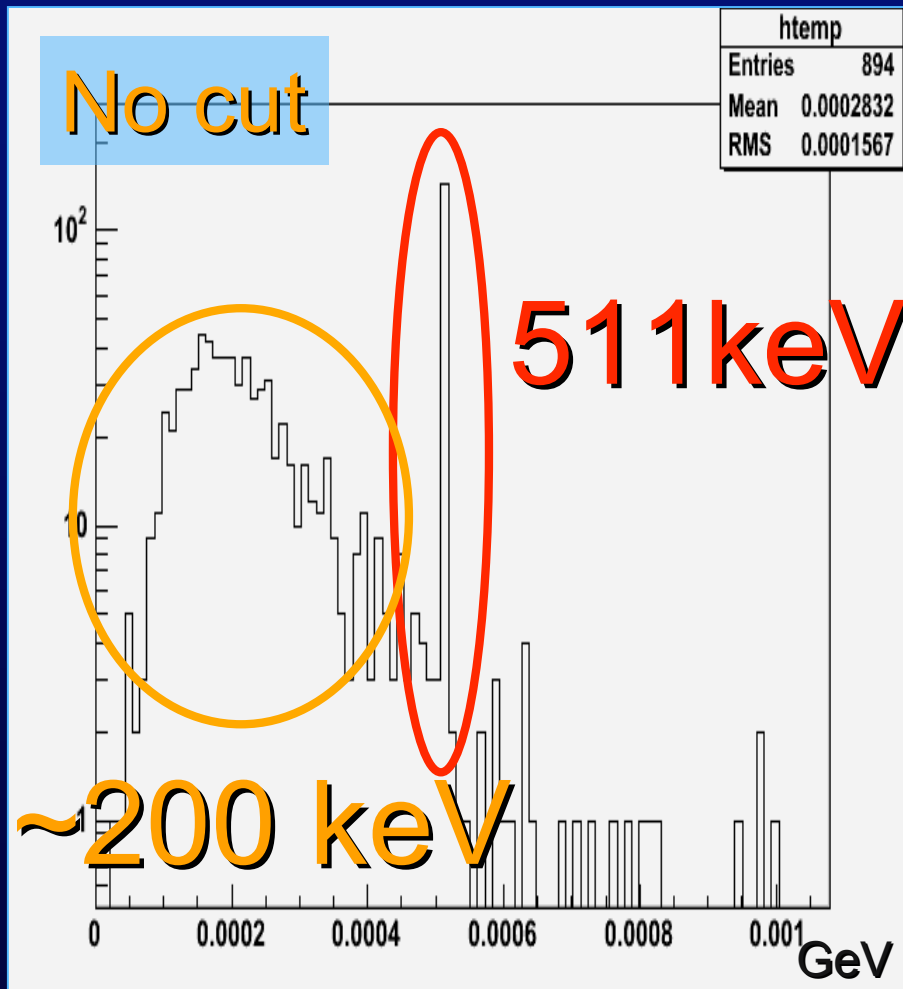
700k particles:

- Sampler @  $z=1\text{mm}$
- Mean energy 400 keV
- 943 part. backscattered (all events ~ photons)

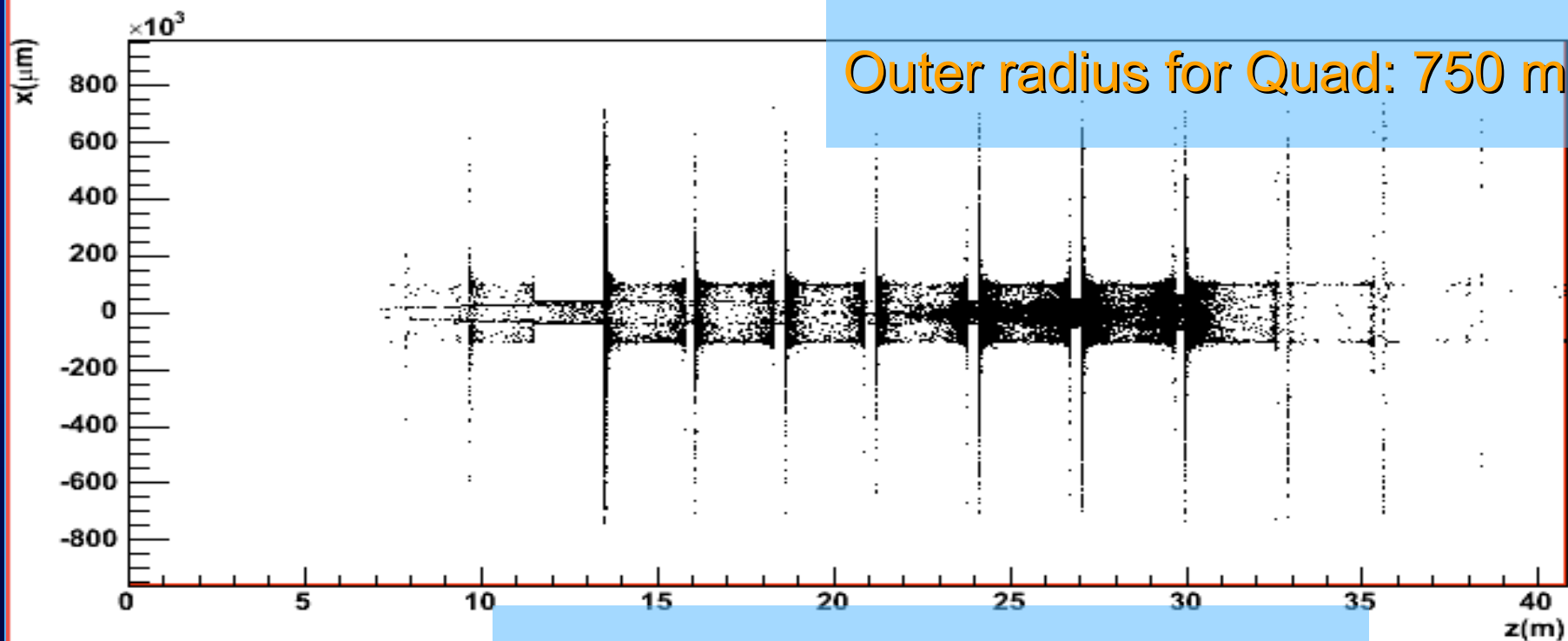
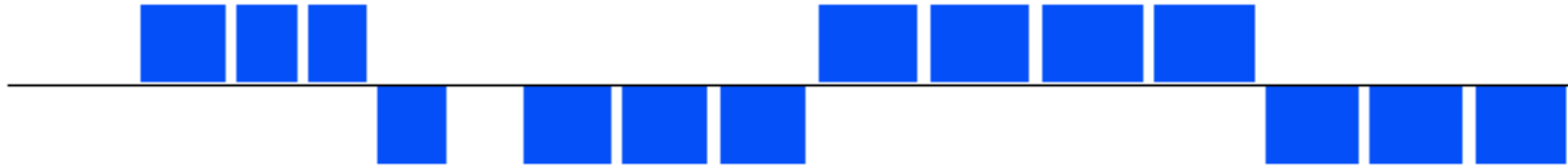


# Backscattered photons

Energy spectrum @  $z=1\text{mm}$



# Photons creations (low stat. 60k)



dadoun, Wed Jan 11 14:31:55 CET 2006

Extraction line radiography

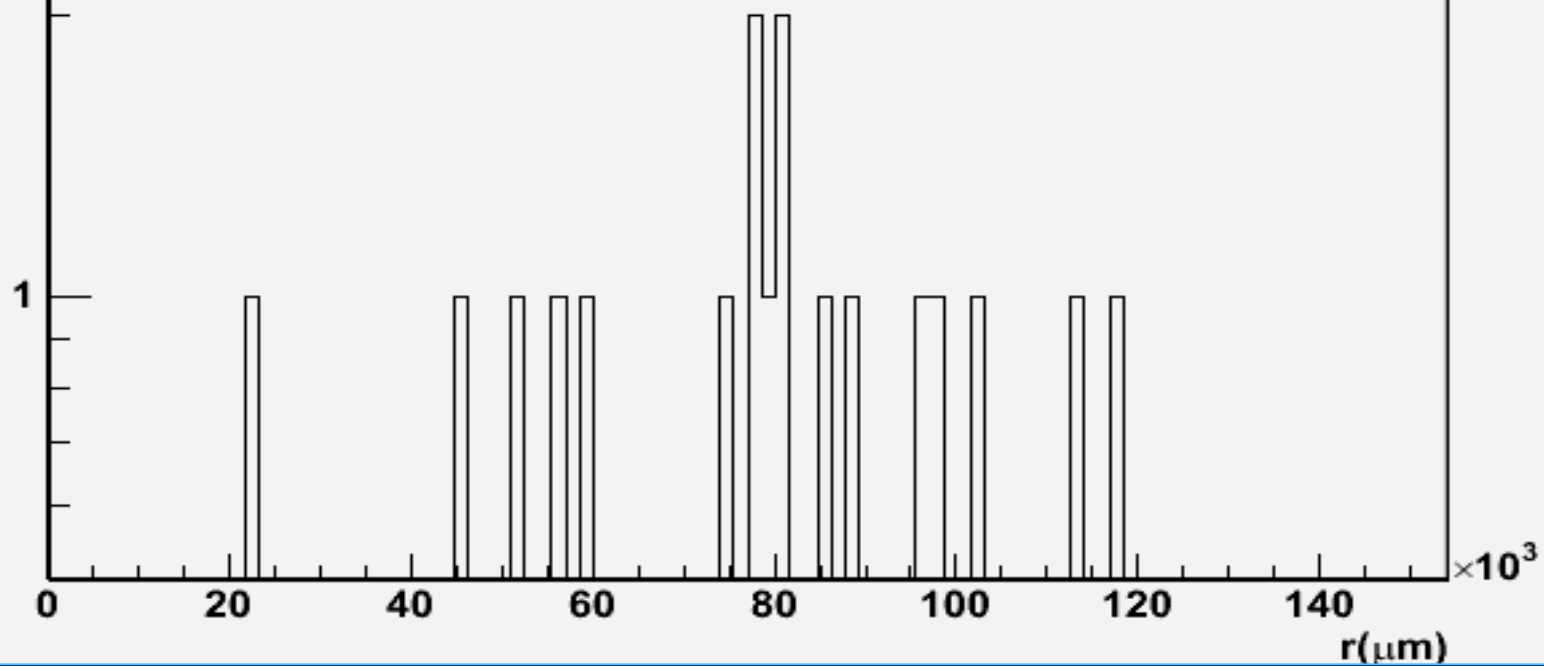
Plot file : 20mrad.gmad

# Particles who can reach the VD

Nb particles  $r < 14$  cm: 18

- 11 photons
- 4 e<sup>-</sup>
- 3 e<sup>+</sup>

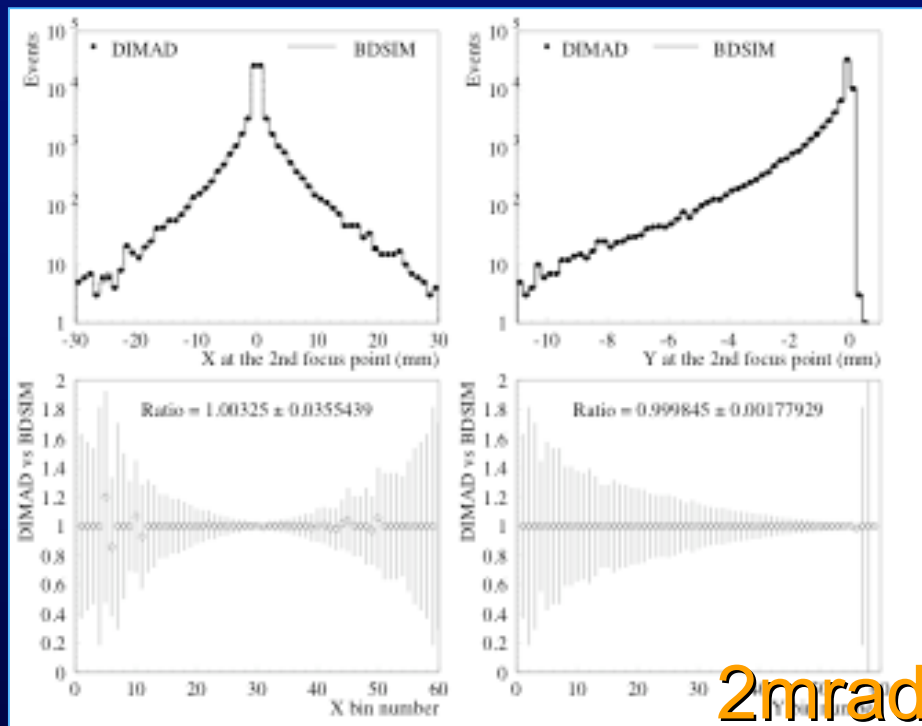
| htemp   |           |
|---------|-----------|
| Entries | 18        |
| Mean    | 7.828e+04 |
| RMS     | 2.355e+04 |



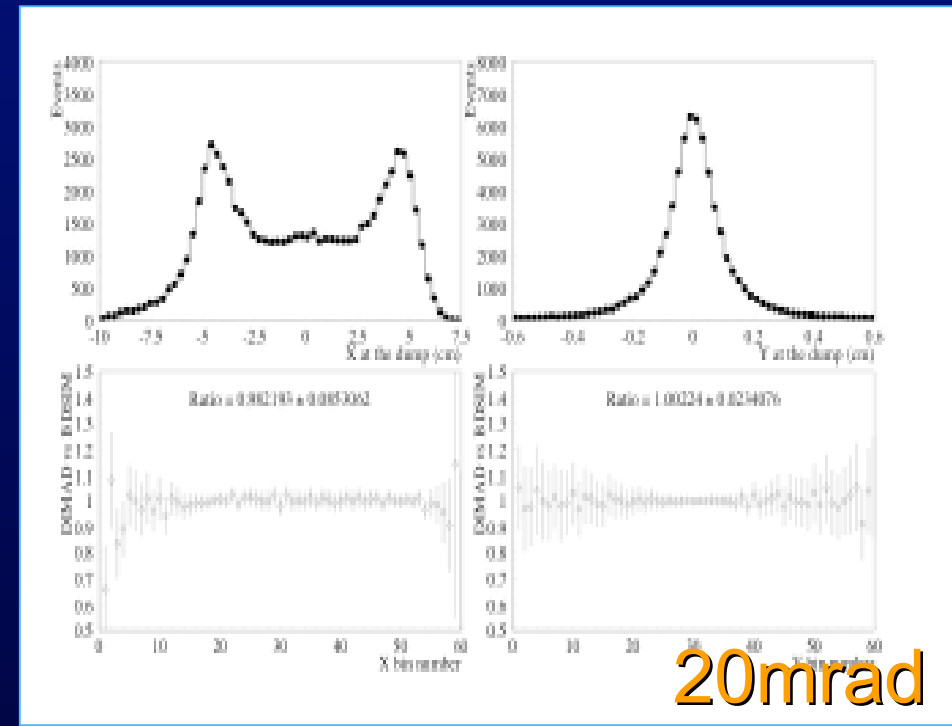
# Summary and prospects

- Good agreement between BDSIM and DIMAD

Disrupted beam tracking comparison (2&20mrad)



2mrad



20mrad

Eurotev paper (EUROTEV-Report-2005-026-1)  
(Robert Appleby, Philip Bambade, Arnaud Ferrari)

# Summary and prospects

- Good agreement between BDSIM/DIMAD
- Customize the existing neutron propagation in Geant4 (CPU time !)
- Run BDSIM onto Data GRID
- Include power losses due to radiative Bhabha
- Comparison of background rates at the detector for 20mrad and for 2mrad crossing angle (in relation with optics design)
- Other topics of interest: background at the post-IP spectrometer and polarimeter, ATF2 beam-line
- Soon BDSIM software publication