High Energy
High Intensity
Hadron Beams

APD
Accelerator Physics and synchrotron Design

Energy Deposition in the Triplet and TAS issues

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Outline

- Short recall of last year results of a parametric study about the power deposition in the triplet vs. l*.
  - Overview of the works and items investigated this year.
  - “Back to basics”: Recall of the key parameters and phenomena related to the energy deposition problem.
  - TAS effect.
  - IP1-IP5 configurations and differences, effect of the crossing angle and quad field sequence.
  - MARS-FLUKA comparison.
  - The actual IP1 layout (see PAC07 paper).
  - Aperture effect (future work).

Indications from Power Deposition vs l*

The total power deposed into the quads increases, approaching the IP (about 40 % for l* 23 -13 m)

The power deposition in Q1 and in its first shells increase almost linearly, approaching the IP (about 100 %)

The power deposition in Q3 increase too, but the behaviour is less "linear"

The power distribution in the last quad is more spreaded

The "hottest" quads is Q2a for l* = 23 m while in the other cases the hottest one is Q3

The highest peak power deposition is in Q2a (and it is almost constant for all the cases studied)

The peak power is almost constant for all the situations examined

The power deposed in the TAS is almost constant for all the cases

This Year Work

- TAS Effect (AT-MCS Note 2007-02, E.W.)
- Parametric study (as function of l*)
- Actual IP1 (ATLAS) configuration

{ NO TAS / Adaptive TAS } (PAC 07; C.H.J-P.K., G.S., E.W,F.B.,**F.C.**)

- Comparison between FLUKA and MARS (C.H.)
- External “TAS” Shield (F.B.)
- Crossing plane (H/V) and Quad sequence FDDF/DFFD { V (IP1 - ATLAS) / H (IP5 - CMS) } (F.B.)
- Effect of the Detector Solenoid magnetic field { 2T (ATLAS) / 4T (CMS) } (F.B.)

Particles Source I

DTUJET/DPMJET high energy hadron-hadron, hadron-nucleus, nucleus-nucleus and photon-nucleus interaction model capable to describe interactions from several GeV/n up to the highest cosmic ray energies, based on the Dual Parton Model.

Event cross sections :

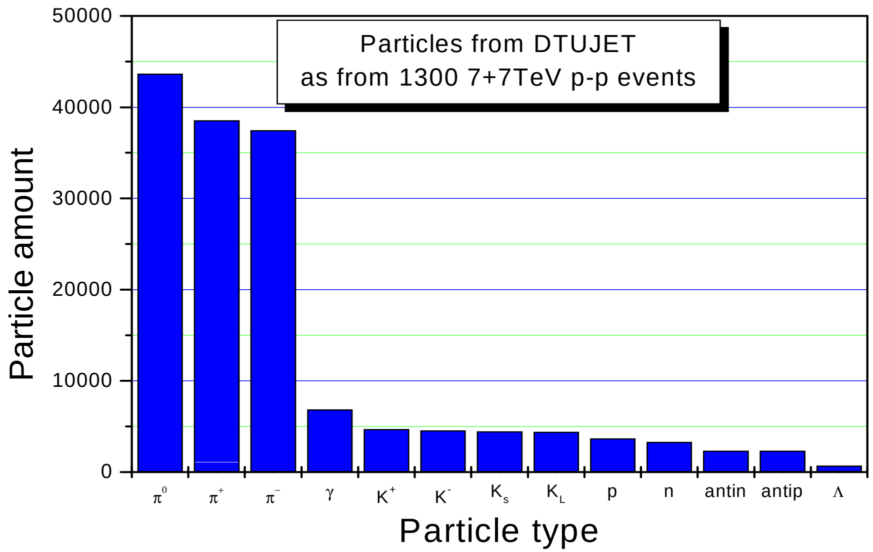
- Single diffractive : 12 mb
- Elastic scattering : 40 mb
- Inelastic scattering : 60 mb
- Total cross section : 125 ± 25 mb (P.V. Landshoff arXiv:0709.0395v1)

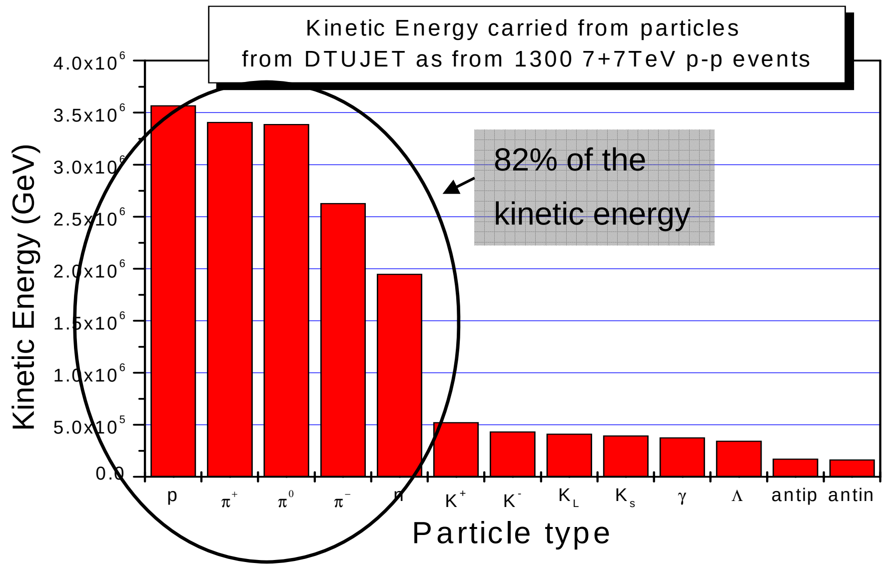
The events from DTUJET for the energy deposition calculation are the inelastic scattering and the single diffractive (72 mb).

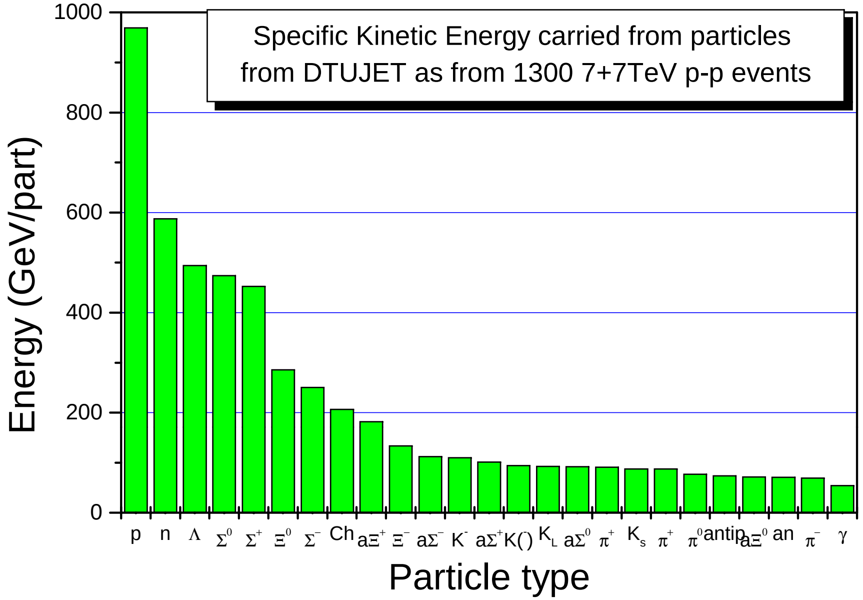
A conservative value of 80 mbarn is used

Particles Source II

Many type of particles produced with wide spread in energy







π are the most numerous (75%, 27% π^0)

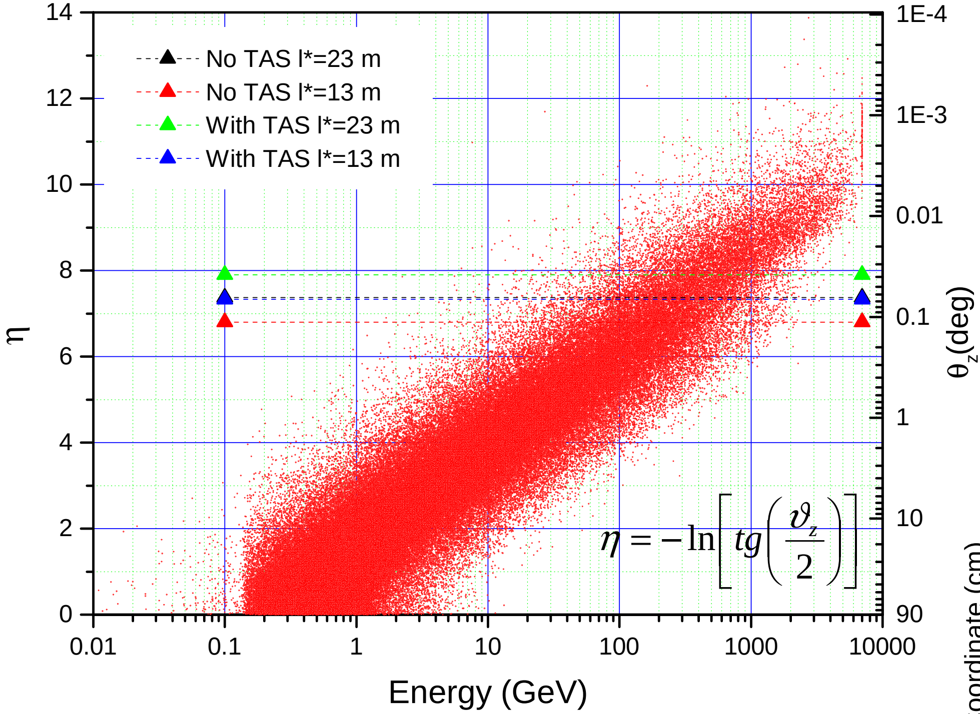
Most of the energy is carried by p (20%), (19% by π^+, 19% by π^0 and 14% by π^-, 11% by n)

p and n have the highest energy per particle

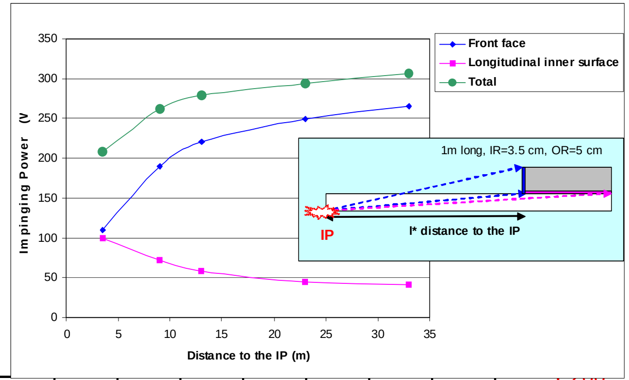
Particles Source III

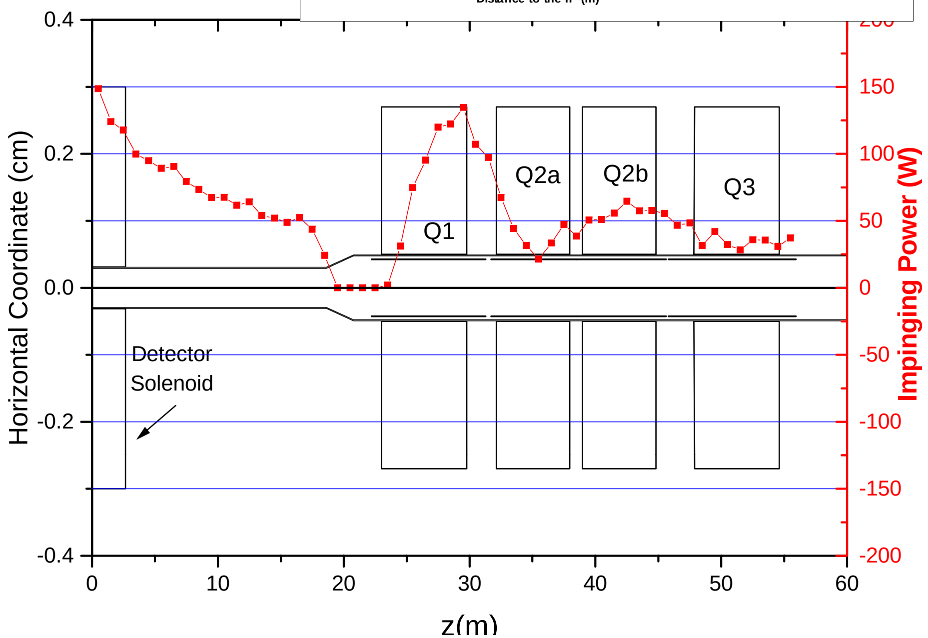
Transverse Momentum (Divergence) of the particles

Pseudorapidity as from 1300 DTUJET
7+7 TeV p-p collisions



Particles inside the angular acceptance of the beam pipe/TAS are the most energetic.

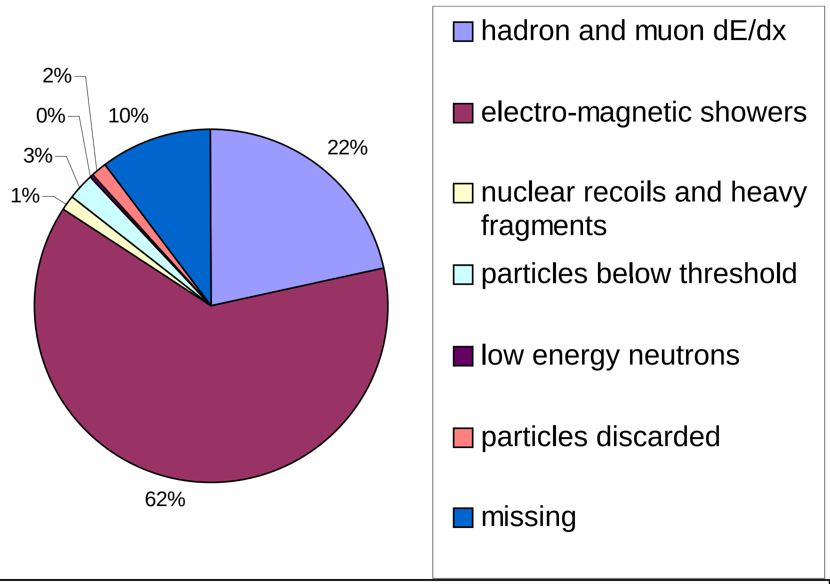




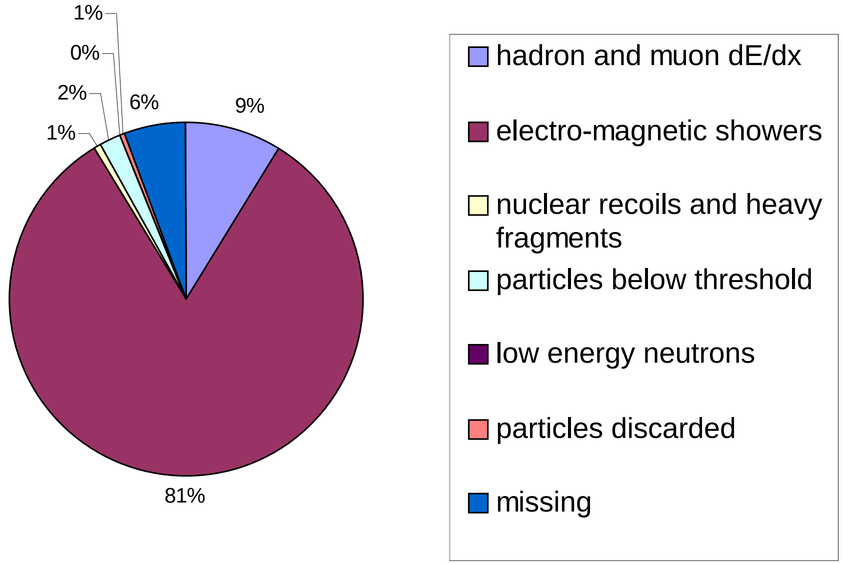
The huge amount of particles with low energy – high transverse momentum goes into the detector or are absorbed/degraded by the beam pipe

Energy Deposition

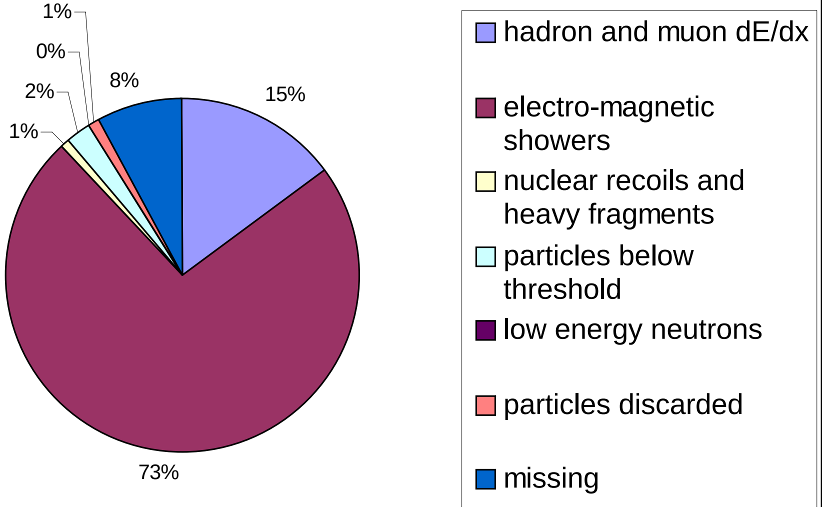
Charged Particles



Neutral Particles



ALL Particles



$L = 8.64 \times 10^{34}\ cm^{2}\ s^{-1}$

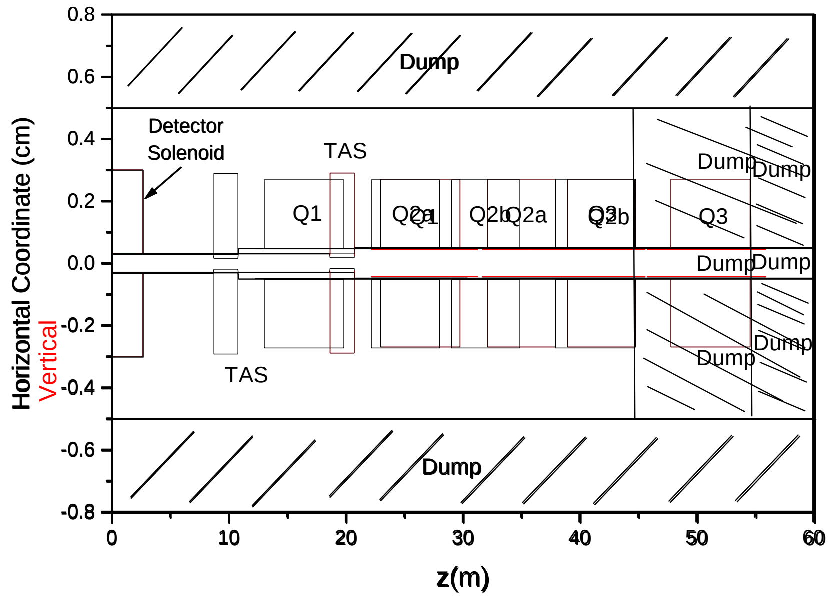
Beam Power ~ 7760 W

Power carried : 60% charged ; 40 % neutral

TAS Effect I

TAS = Target Secondaries Absorber

Tas actions :
- shield Q1
- lower the angular acceptance to the insertion



Last year was dedicated to the parametric study, l* effect with the TAS, constant in aperture, rigidly shifted together with the quads.

The beam dynamics changes, when moving the insertion toward the IP.

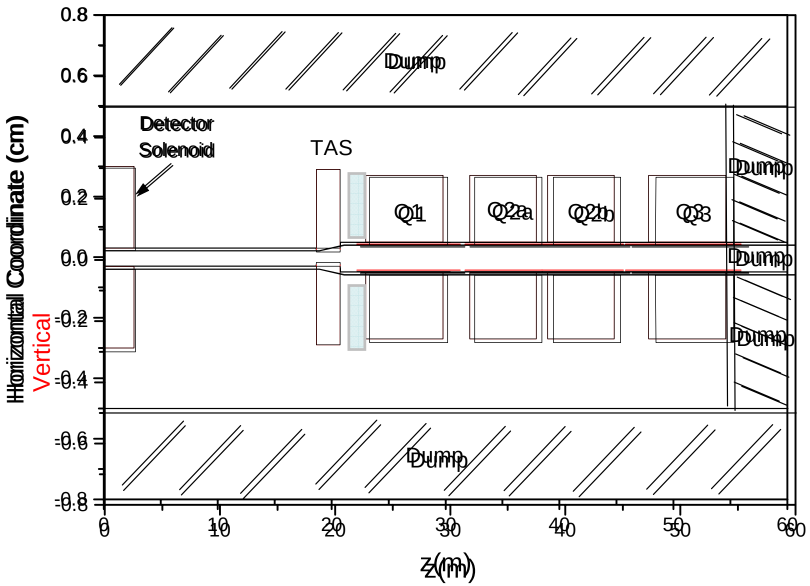
The TAS can/must be adapted too, in order to fit the beam dimensions/separation.
(AT-MCS Note 2007-02, E.W.)

No / low effect on the peak deposition, only in the total deposition especially in Q1 is affected by the TAS

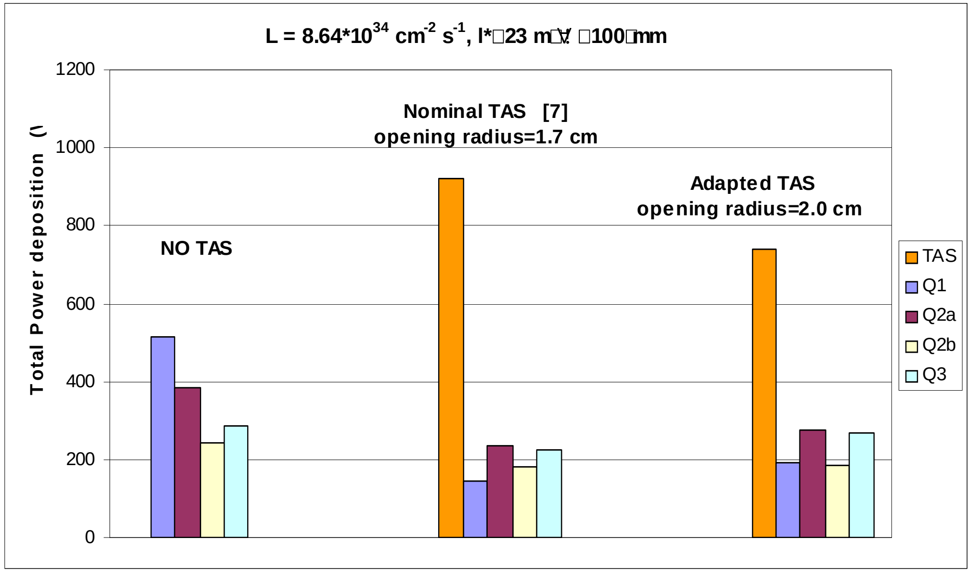
TAS Effect II

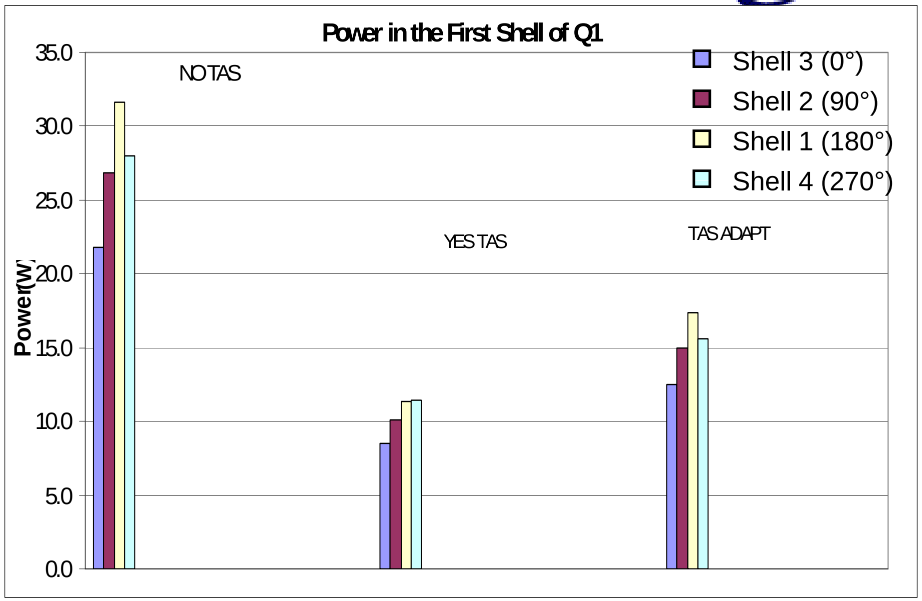
Studies performed

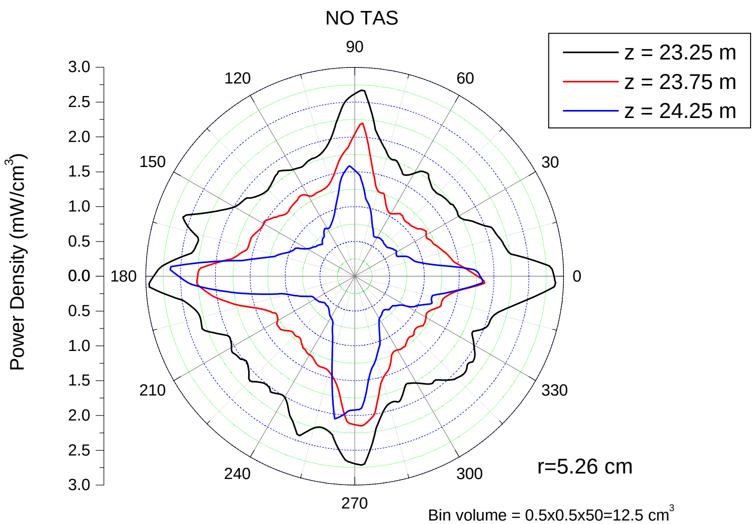
- Adapted TAS
- No TAS at all
- External "TAS", external shield of Q1



TAS Effect III

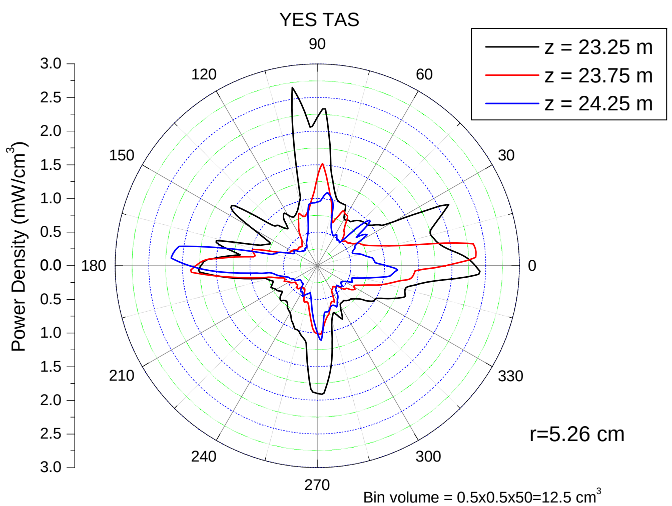






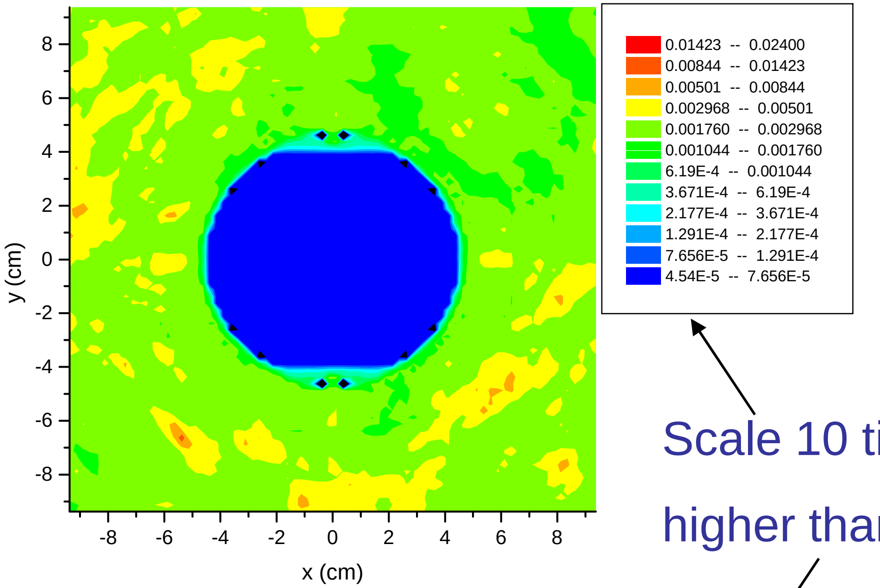
The TAS does not affect the **maximum peak** power in the front part of Q1.

(Beam pipe 1.75 mm thick considered)

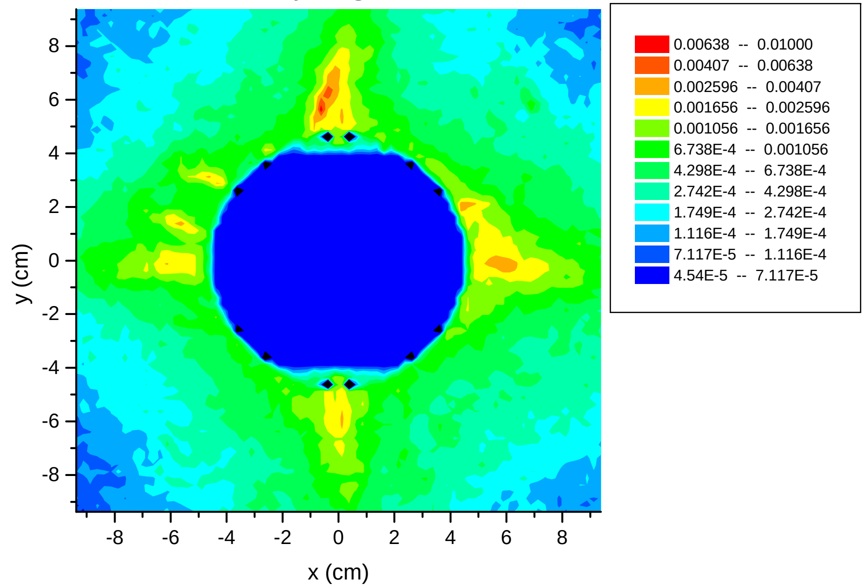


TAS Effect IV

Q1 Front
NO Shield



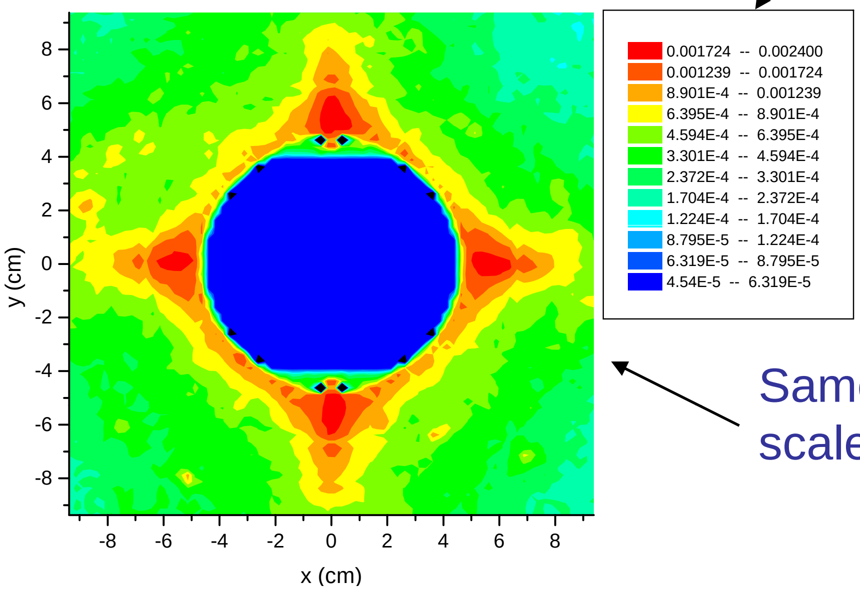
Q1 Front
With TAS



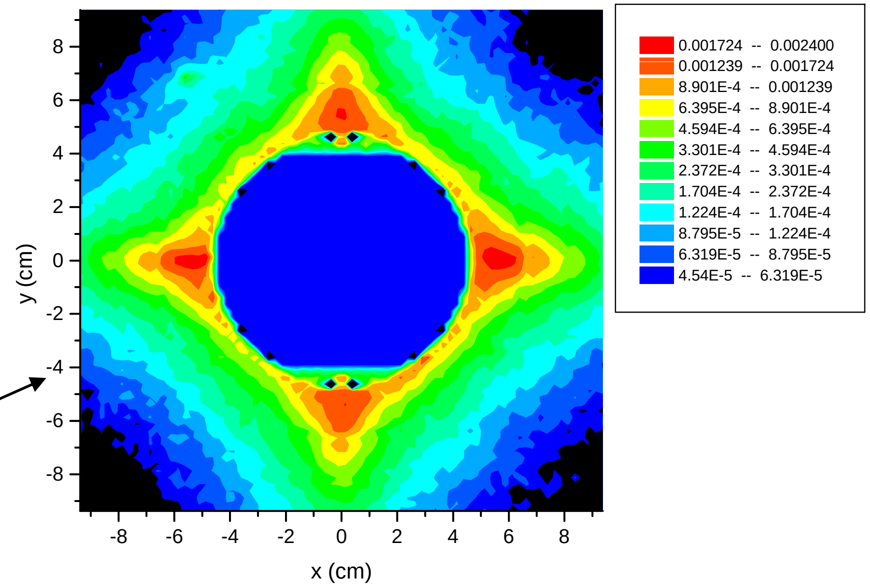
Scale 10 times

higher than

Q1 Front
50 cm Shield



Q1 Front
100 cm Shield

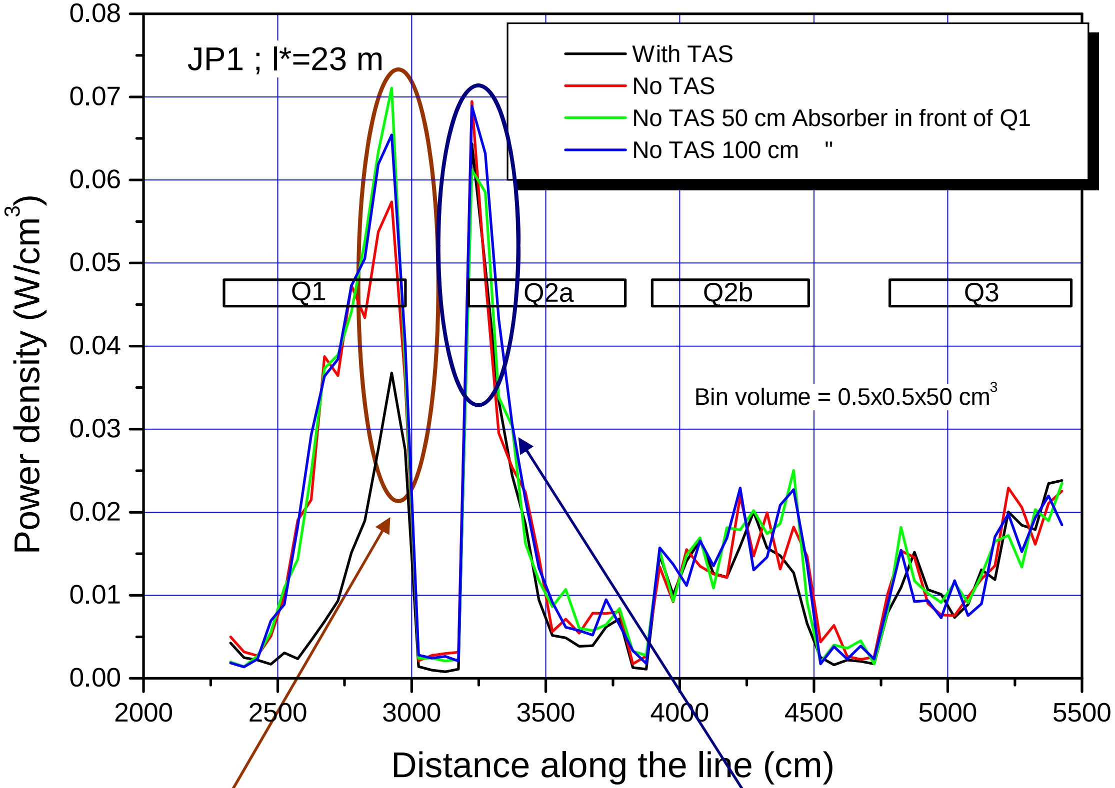


Same
scale

TAS Effect V

(Peak power)

Maximum power density along the line
(whatever the angle)



The value of the maximum of the peak power in Q1 is different

but the maximum value (front of Q2a) is almost the same either with or without the TAS

TAS Effect

(Summary)

	With TAS	External Shield	No TAS
Power in Q1(W)	154	422	660

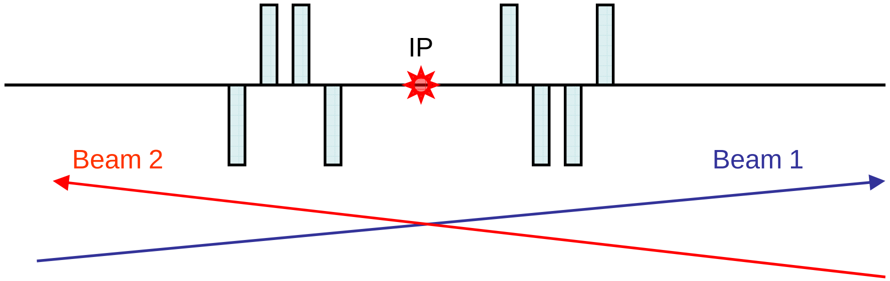
- TAS is efficient to lower the power deposed in Q1
- The front face of Q1 is well shielded by the external shield too, but the action of the external shields is less efficient on the total power deposition, in addition seems negative for the peak power (to be investigated further, if needed)

MARS-FLUKA comparison

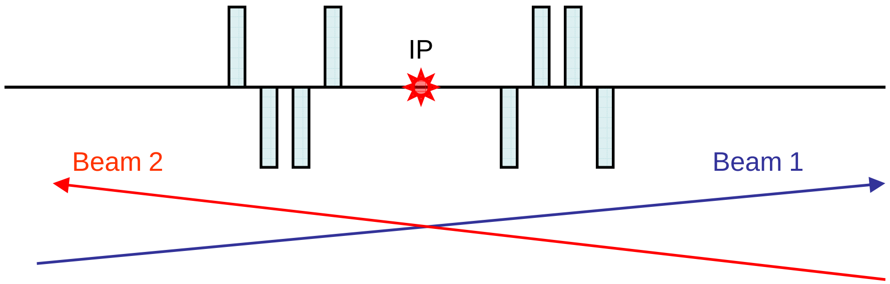
Start Christine’s slides MARS-FLUKA comparison

Quad Sequence

Actual and Upgraded Layout

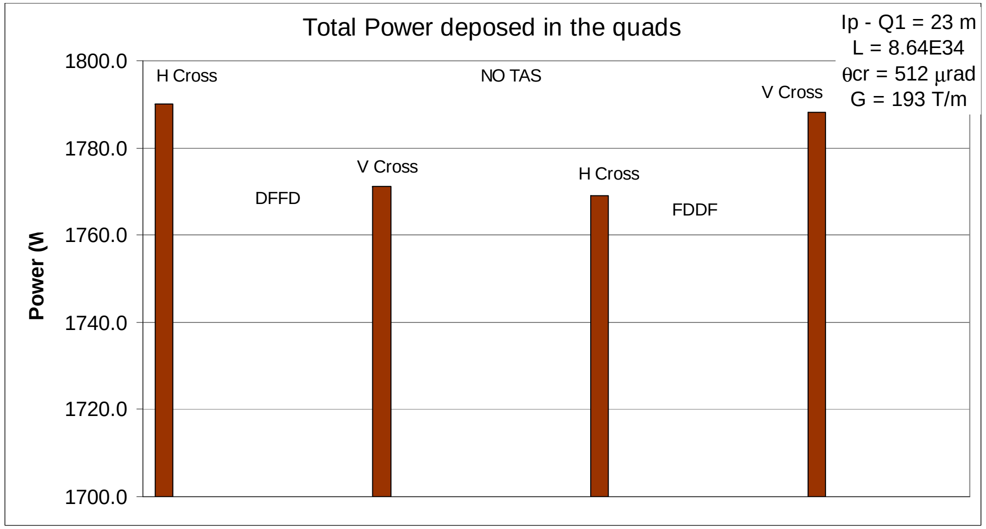


Possible Upgraded Layout



Results I

(Total Power)



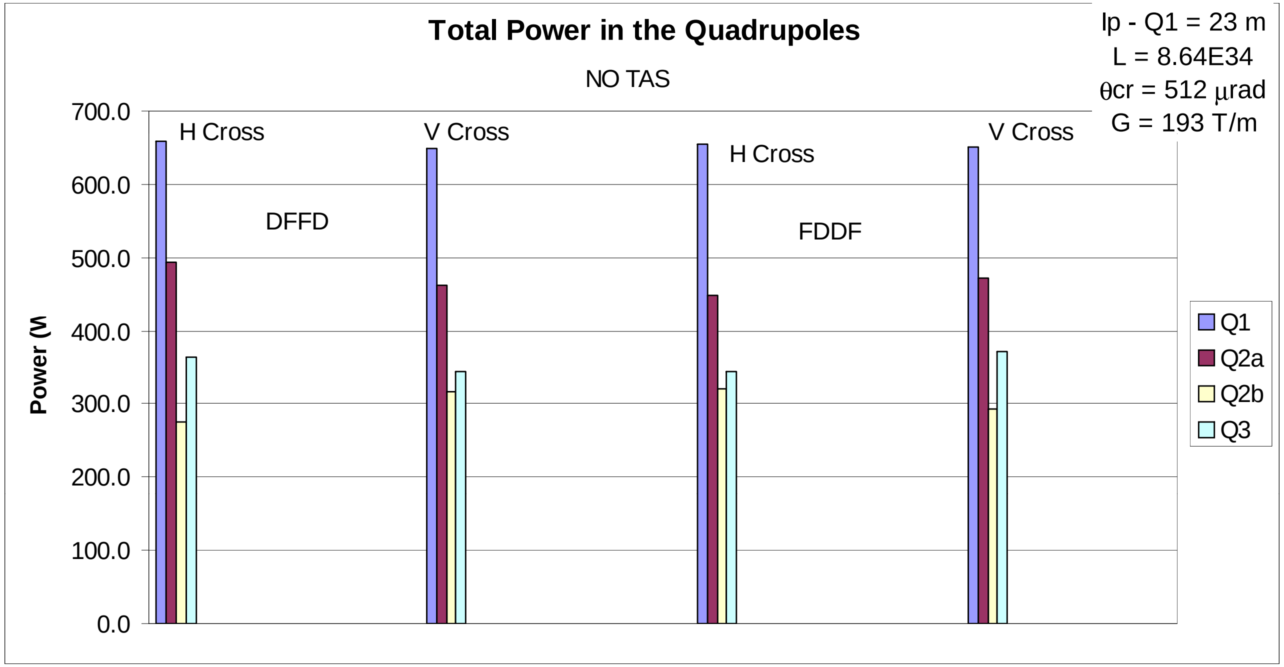
The power deposed depends on the magnetic configurations and on the beam crossing plane

A symmetry can be found between

DFFD_H with FDDF_V

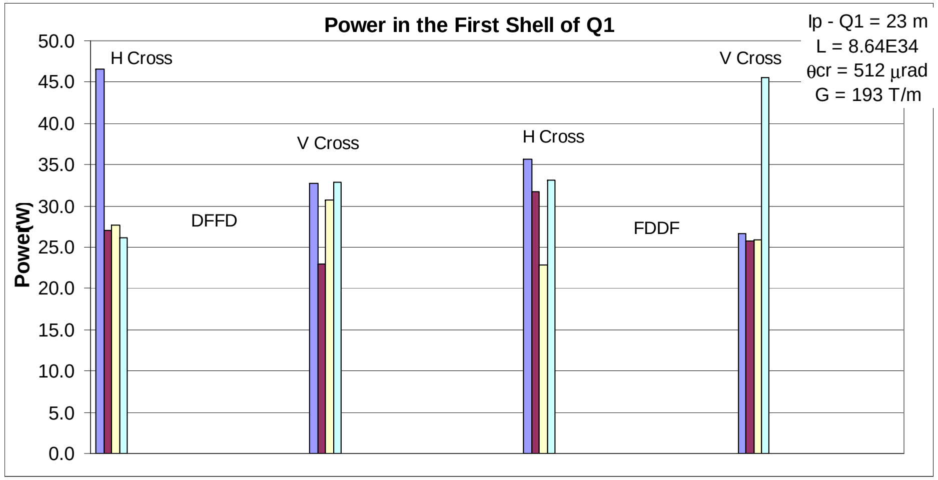
and

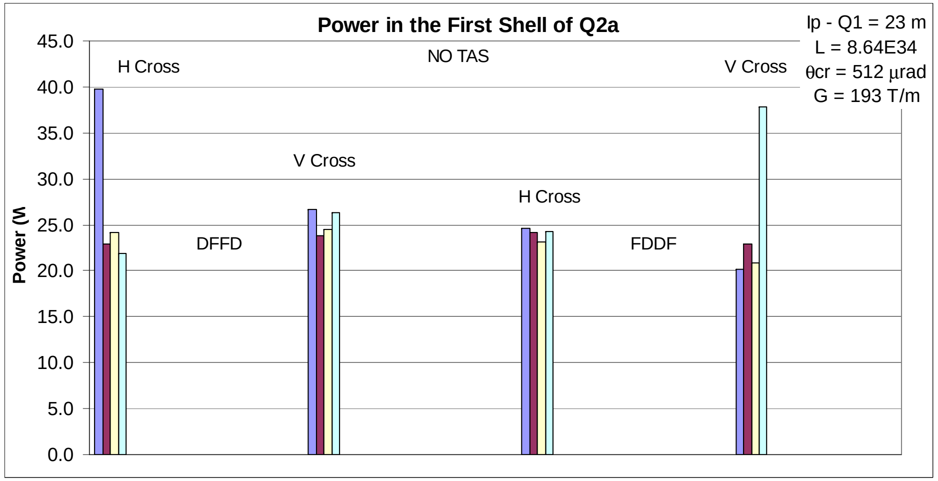
DFFD_V with FDDF_H

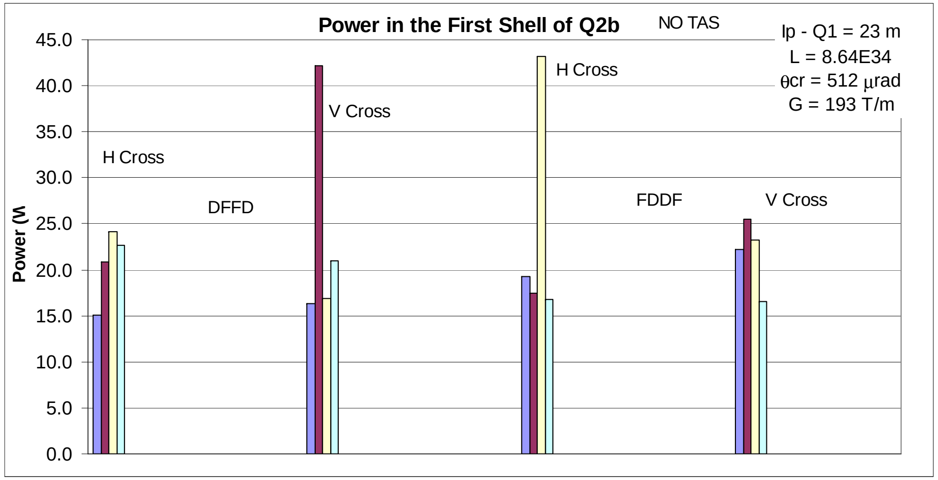


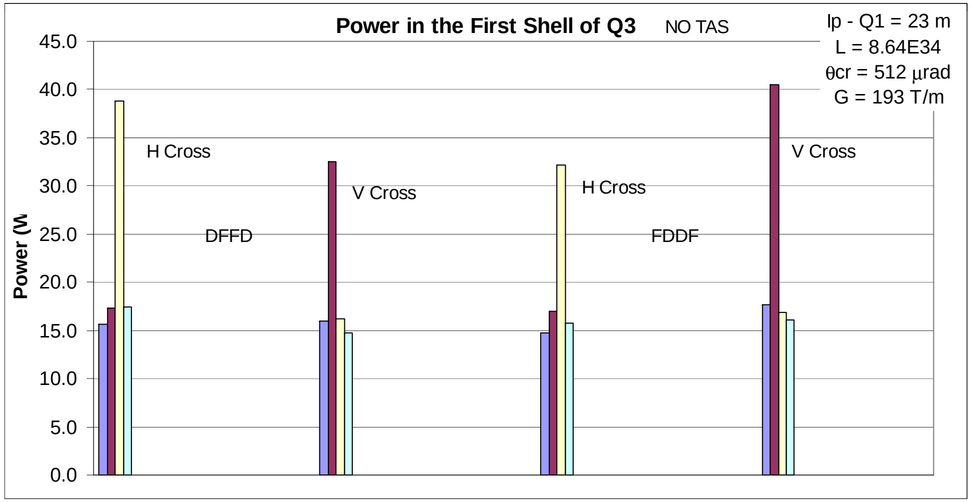
Results II

(Total Power)









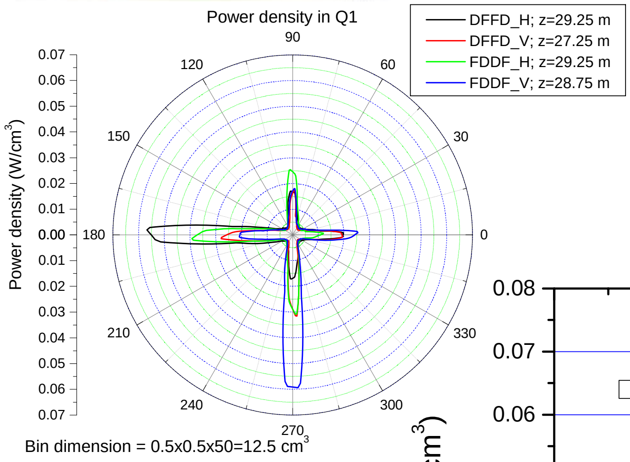
- Shell 3 (0°)
- Shell 2 (90°)
- Shell 1 (180°)
- Shell 4 (270°)

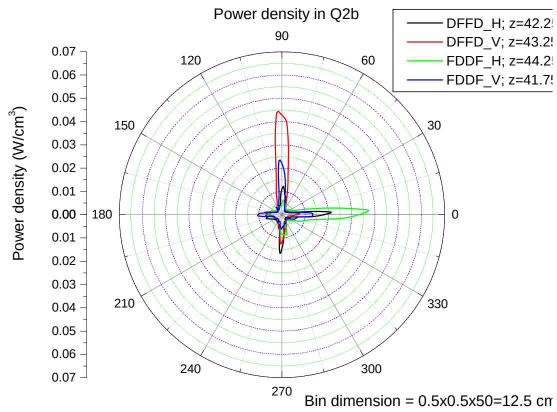
The Symmetry (with 90° rotation) is more evident

Results III

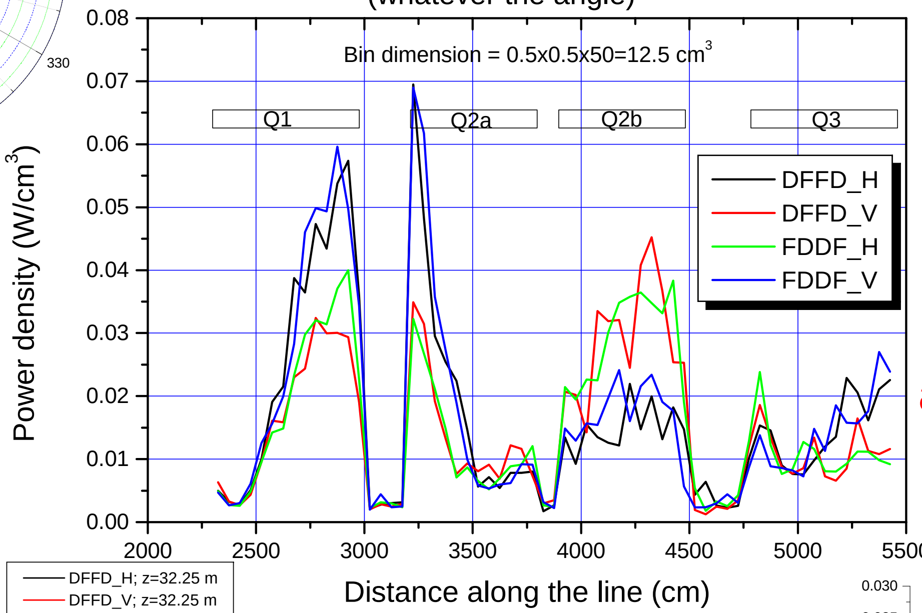
(PeakPower)

The azimuthal distributions refer to the maxima



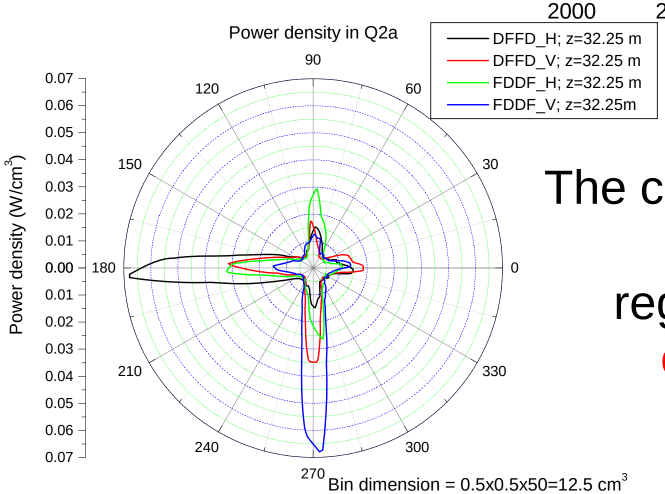


Maximum power density along the line (whatever the angle)



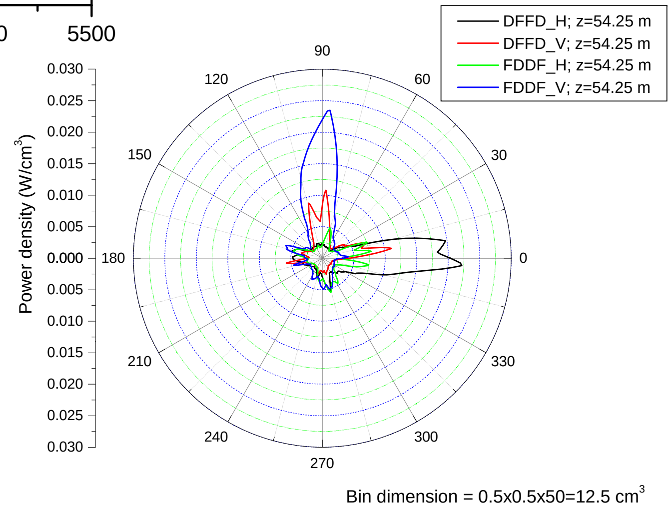
Symmetry is evident but the maxima of the peak power do not occur at the same longitudinal position

The most critic point is between the end of Q1 and the beginning of Q2a

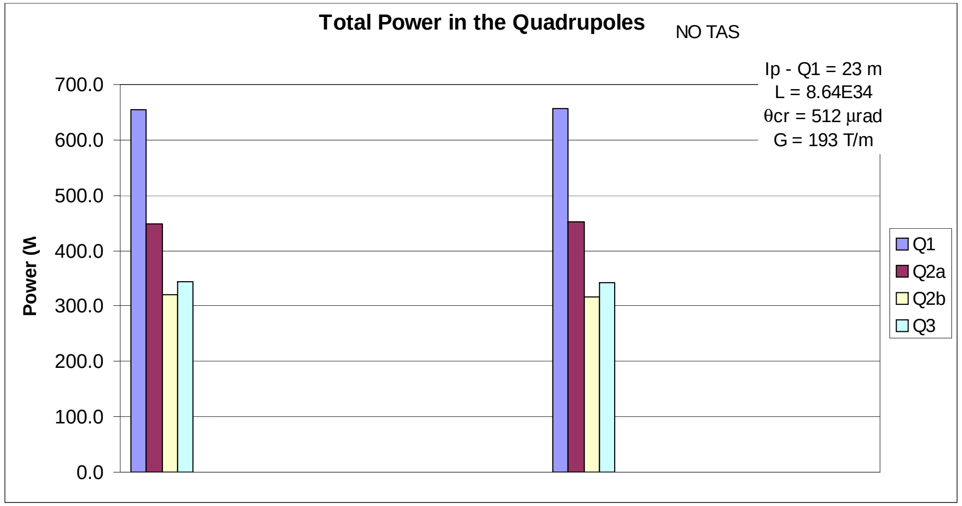


The case FDDF_H and FDDF_V are quite different, regarding the peak power.

CMS is more relaxed



Effect of the detector field I



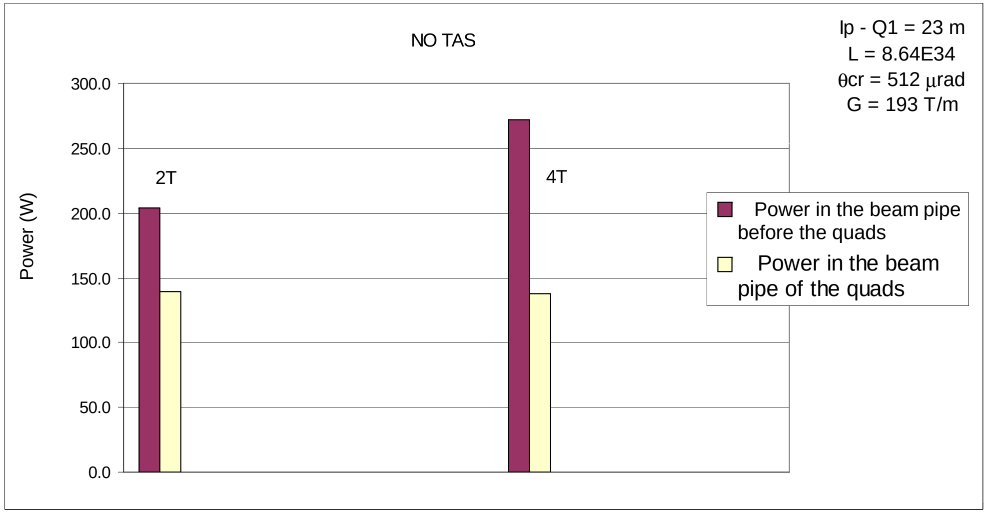
Solenoid parameters

ATLAS (IP1)		CMS (IP5)
2.0	Peak Field (T)	4.0
1.1	Radius (m)	2.95
5.3	Length (m)	12.4

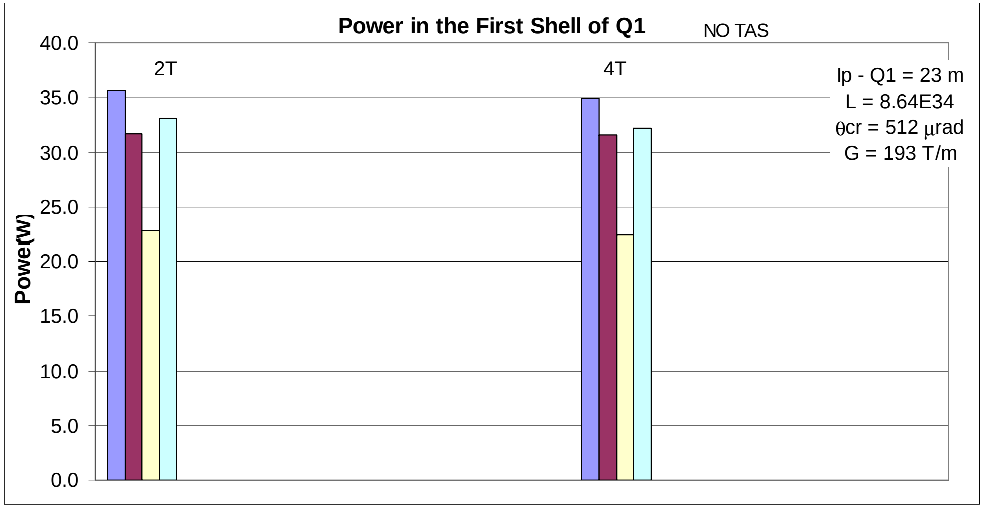
centered at the IP

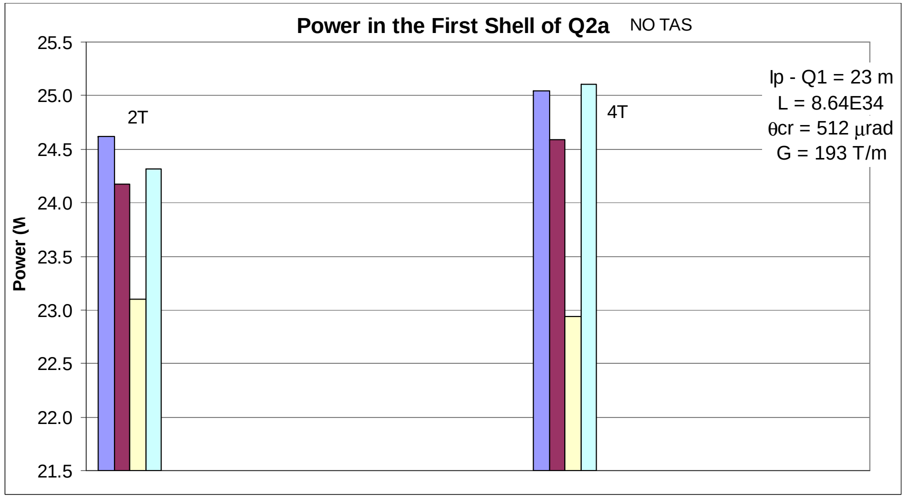
The power deposed in the quads is the same for both the configuration

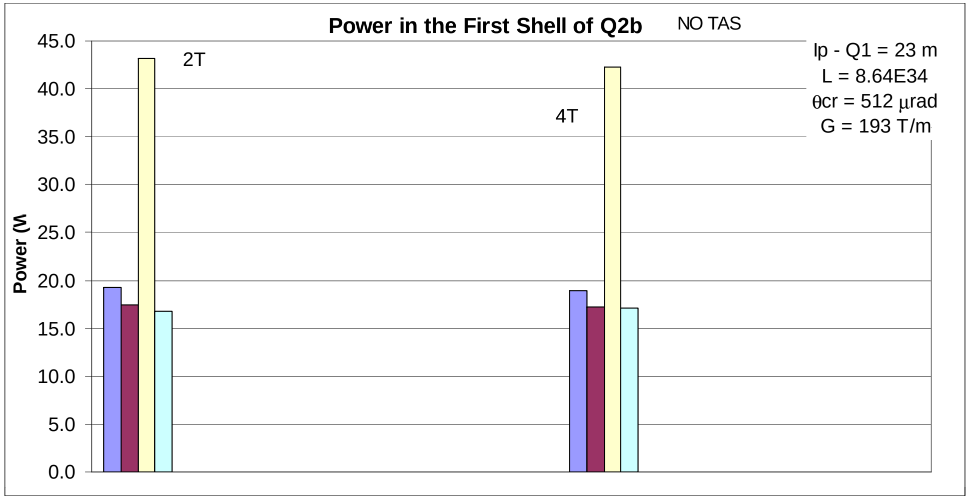
In the 4T case the bending effect to the lower energy particle is higher, leading to a higher energy deposition in the beam pipe before the quad insertion

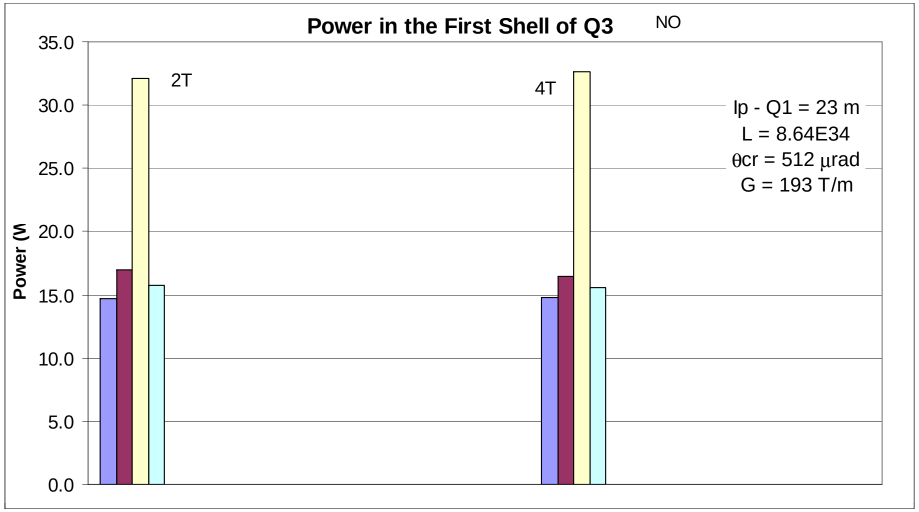


Effect of the detector field II





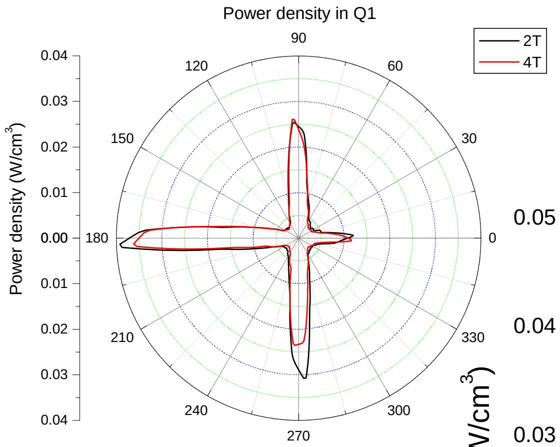




FDDF_H configuration

Only a small variation in Q2a

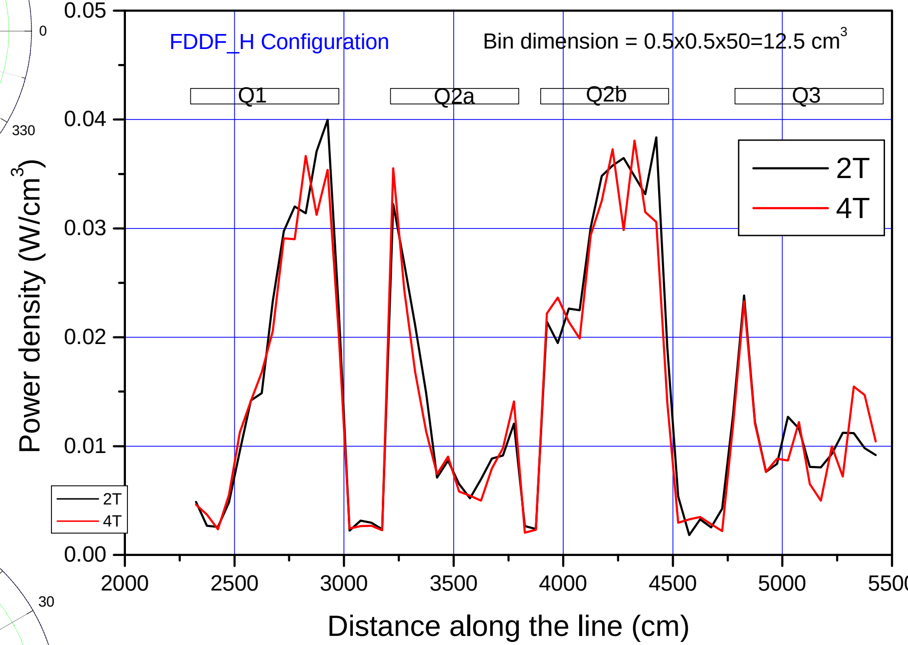
Effect of the detector field III

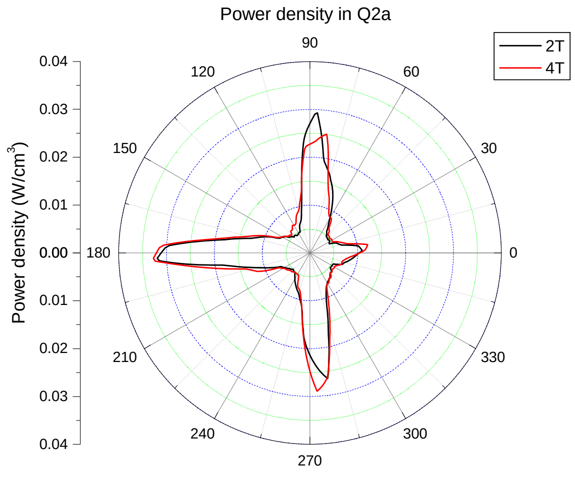


Bin dimension = 0.5x0.5x50=12.5 cm^3

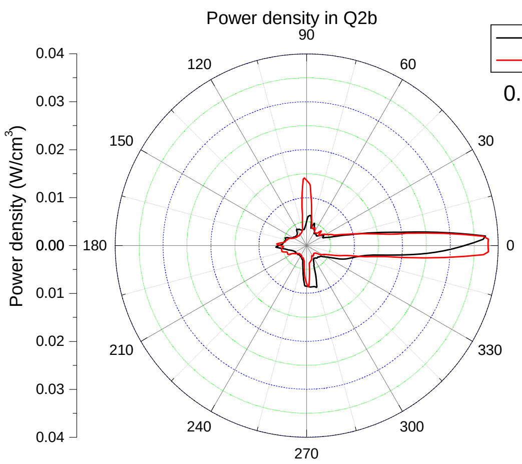
The azimuthal distributions refer to the maxima

Maximum power density along the line (whatever the angle)





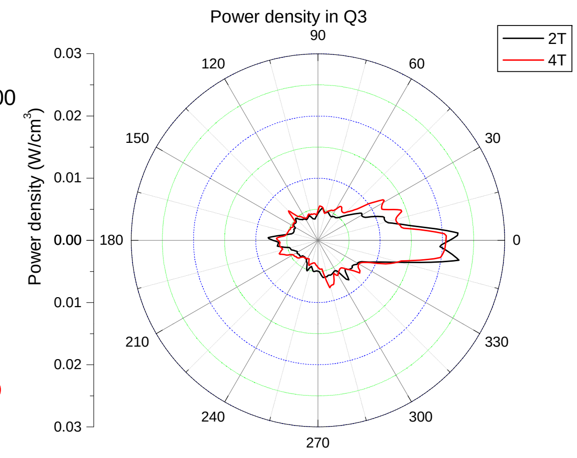
Bin dimension = 0.5x0.5x50=12.5 cm^3



Bin dimension = 0.5x0.5x50=12.5 cm^3

No effect of the detector solenoid field.

The difference between IP1 and IP5 is due to the H or V crossing angle



Bin dimension = 0.5x0.5x50=12.5 cm^3

Summary and perspective

FLUKA-MARS Comparison useful and is satisfactory

The effect of the TAS has been evaluated:
- it is efficient in shielding Q1
- has low effect on the other quads
- has low effect on the peak power

The H or V crossing has very different effect, V crossing (ATLAS) is more critical

The detector solenoid field in uneffective on the power deposition in the triplet.

The power deposition depends on :
- TAS (and its parameters),for the total power into the quads, especially for Q1
- The magnetic field of the quads (peak power)

Evaluate the opening effect, in order to get the full scaling law

$$E_d = E_d(\Phi, l^*, mat, G, \theta_{cr}, l_Q)$$

Not all the variables are independent

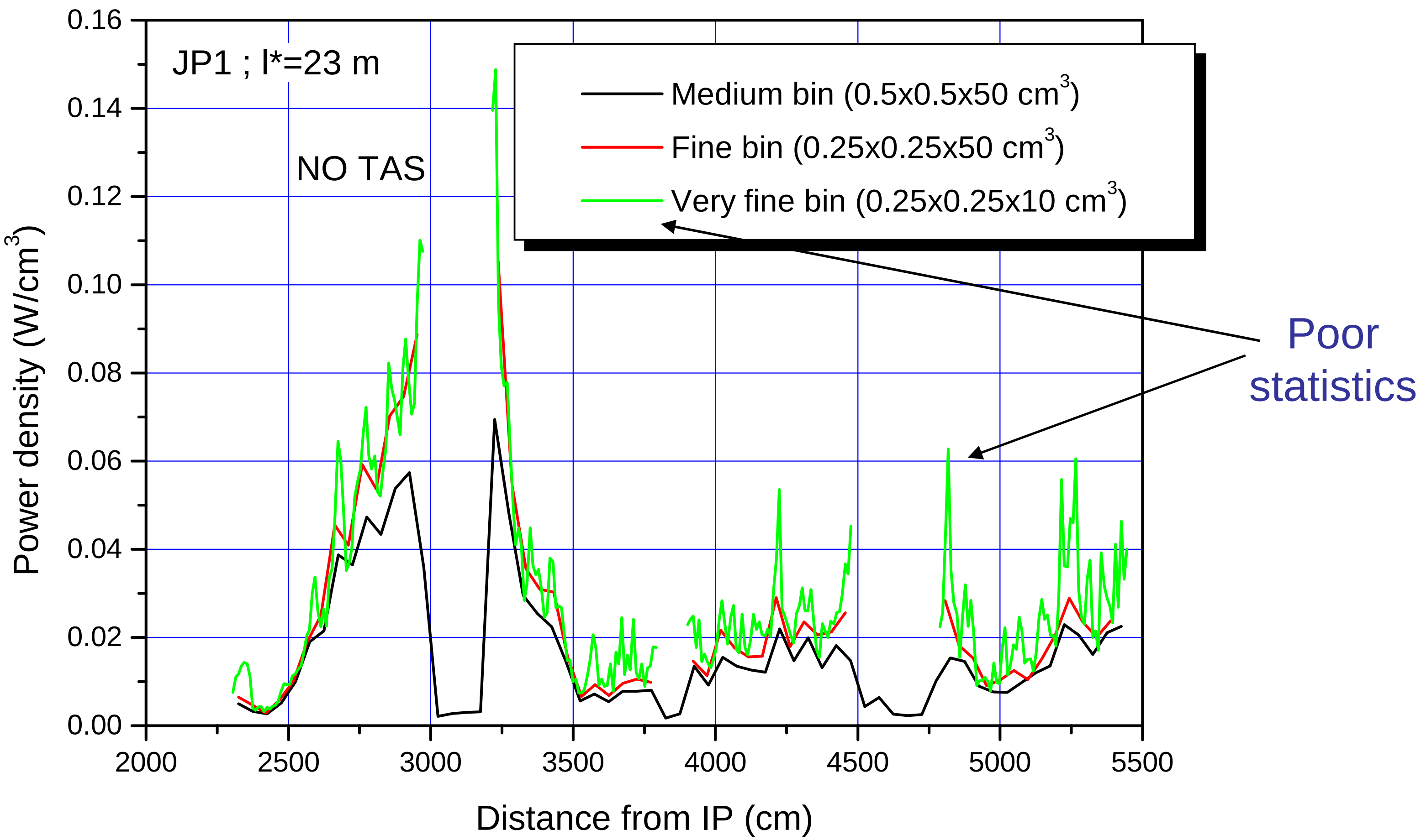
Thanks

- The organizing commitee
- All the people of the AT-MAS group (Christine Hoa, Jean-Pierre Koutchouk, Elena Wildner, Guido Sterbini, Ezio Todesco, Christine Voellinger, E.Laface, L. Rossi)
- The INFN/CERN FLUKA Group (G.Battistoni, A. Ferrari)
- Special thanks to F.Cerutti (CERN FLUKA group) for his assistance and suggestions in using FLUKA

Appendix I

Always specify the volume over which the power density is evaluated

Maximum power density along the line
(whatever the angle)

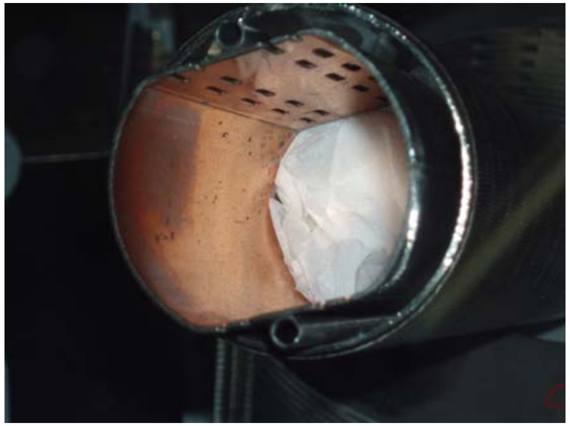


Appendix II

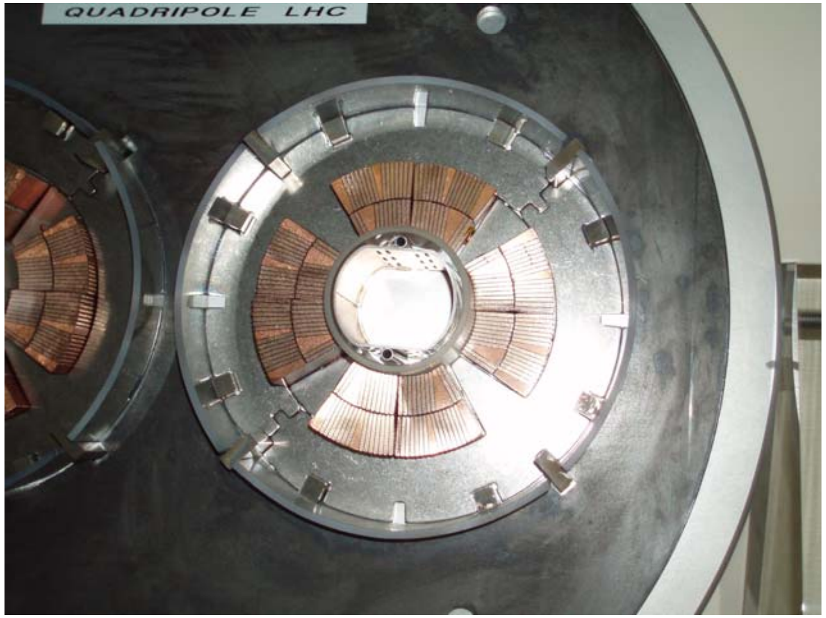
Hypothesis

TRACKING

- Beam pipe aperture 58.0 - 95.5 mm (Beam screens are taken into account)
- Detector Solenoid Field with its fringing field (theoretical)
- Hard edge approx. for the quadrupole field



Cross section = 80 mbarn
(inel.+ single diff. event)

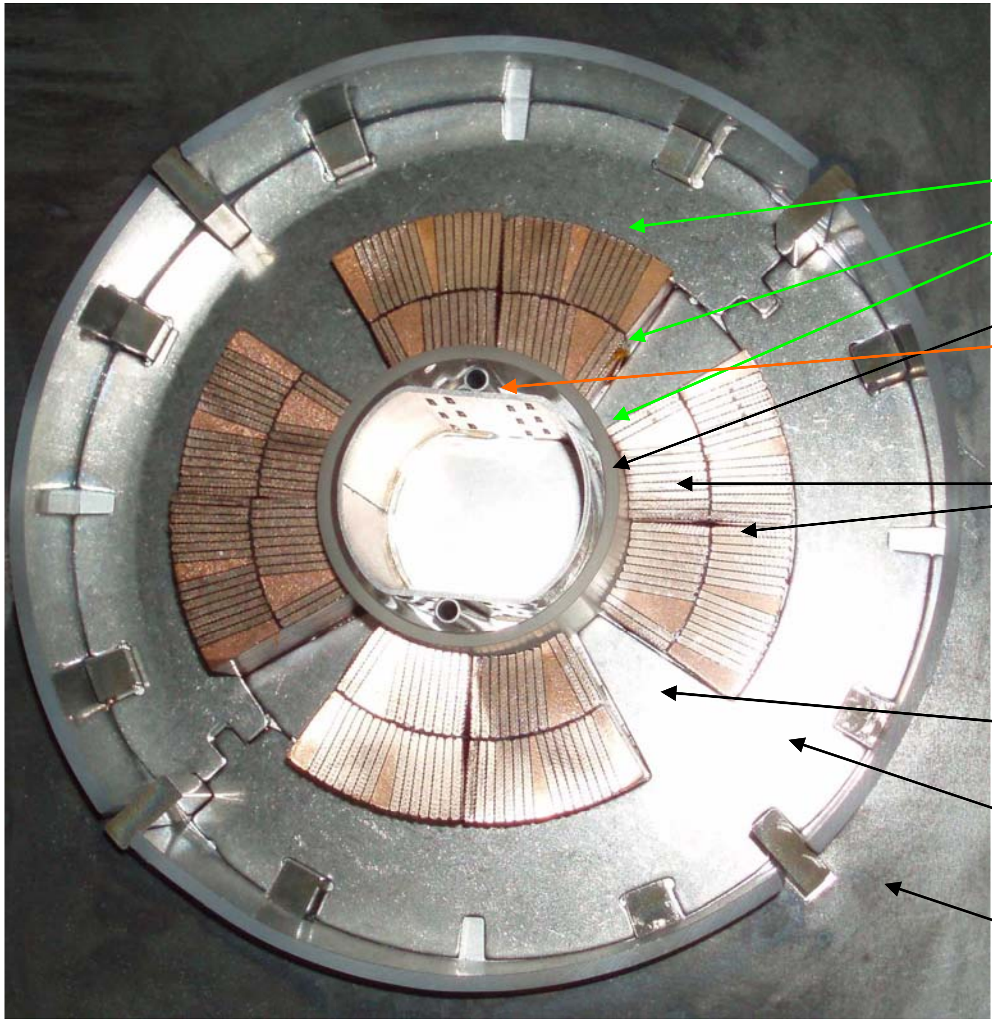


FLUKA

- Quad aperture 100.0 mm
- Accurate definition of the quadrupole structure (current, insulation, wedges, collars, yokes)
- Magnetic field in the quad material (ROXIE)
- Cut off for Hadrons 1 MeV
- Cut off for electrons/positron 1.5 MeV
- Cut off for photons 0.2 MeV
- Cut off for neutrons 0.4 eV

APPENDIX III

Geometry and materials



G10 Insulation (0.2, 0.7, 0.5 mm)

S.S. Beam pipe (1.75 mm)

S.S. Beam screen with cooling tubes

Nb_3Sn Current shells (15 mm, 60°)

S.S. Pole wedges

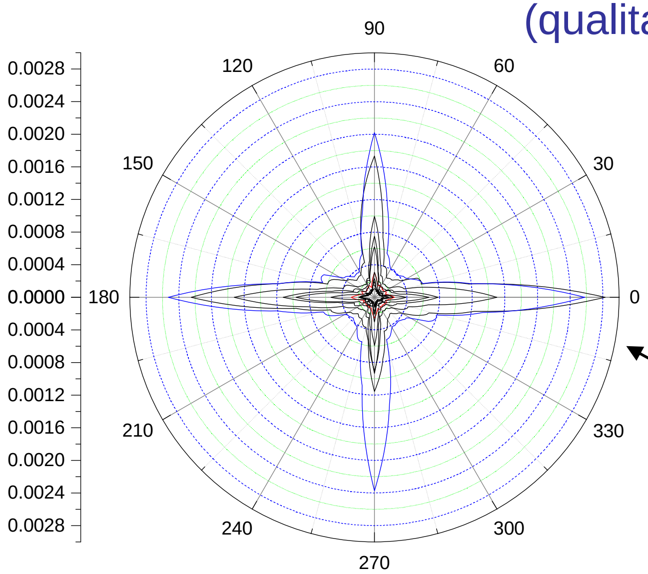
S.S. Collar (20 mm)

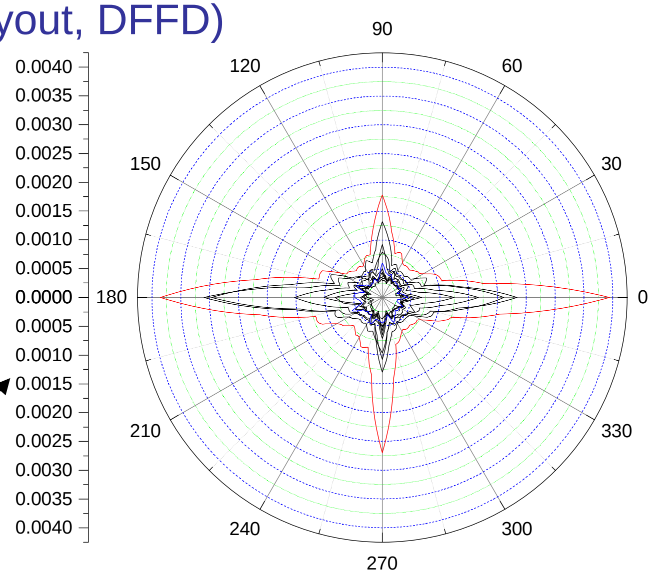
Fe Yoke (18 cm)

APPENDIX IV

Head On Collision

(qualitative, old case and layout, DFFD)



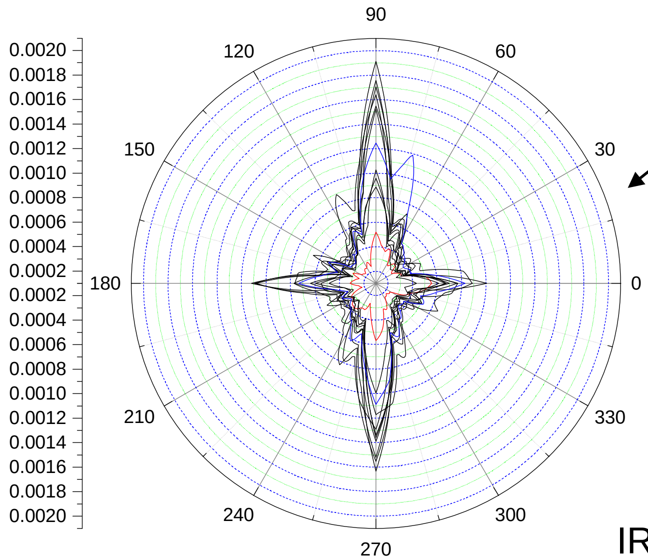


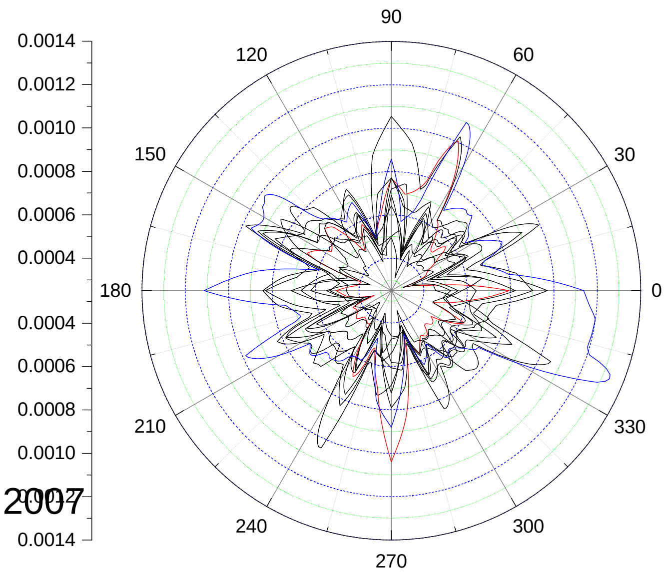
Q1

Q2a

Q2b

Q3





APPENDIX V

Statistic errors

All these numbers comes out from a Montecarlo computation.

It can be seen as a “measurement process”, so it is affect by a measurement error

The statistical error has been evaluated in the previous part of the work (“70-235-80 reference case”).

From different runs with independent random seeds it is about :

- 1% for the region binning
- 3% medium binning (Bin Volume = 0.5x0.5x50 = 12.5 cm^3)
- 4% small binning (" " = 0.25x0.25x50 = 3.1 cm^3)