ICOSIM results for different computation of ion cross sections in the collimator material

G Bellodi for the LHC ion collimation group
(with thanks to FLUKA team: A Ferrari, V Vlachoudis)

LHC Collimation WG Phase I, 16.06.08

Ion-collimator physics

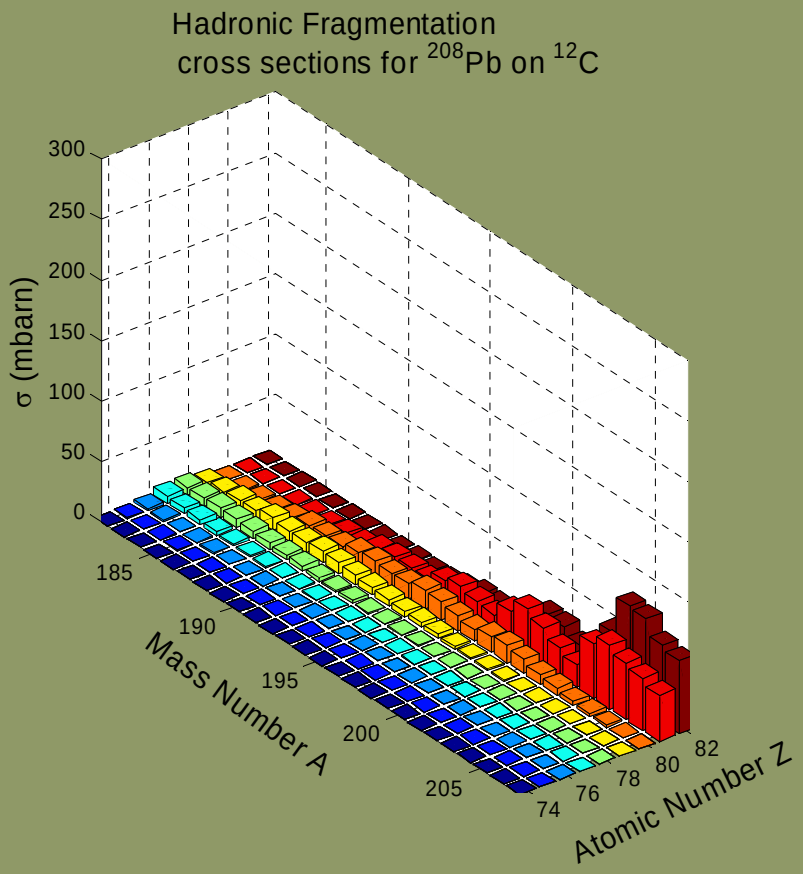
Physics process	Proton	^{208}Pb
$\frac{dE}{Edx}$ due to ionisation	-0.12 %/m -0.0088 %/m	-9.57 %/m -0.73%/m
Mult. Scattering (projected r.m.s. angle)	73.5μrad/m^{½} 4.72μrad/m^{½}	73.5μrad/m^{½} 4.72μrad/m^{½}
Nucl. Interaction length ≈fragment. length for ions	38.1cm 38.1cm	2.5cm 2.5cm
Electromagnetic dissociation length	-	33cm 19cm

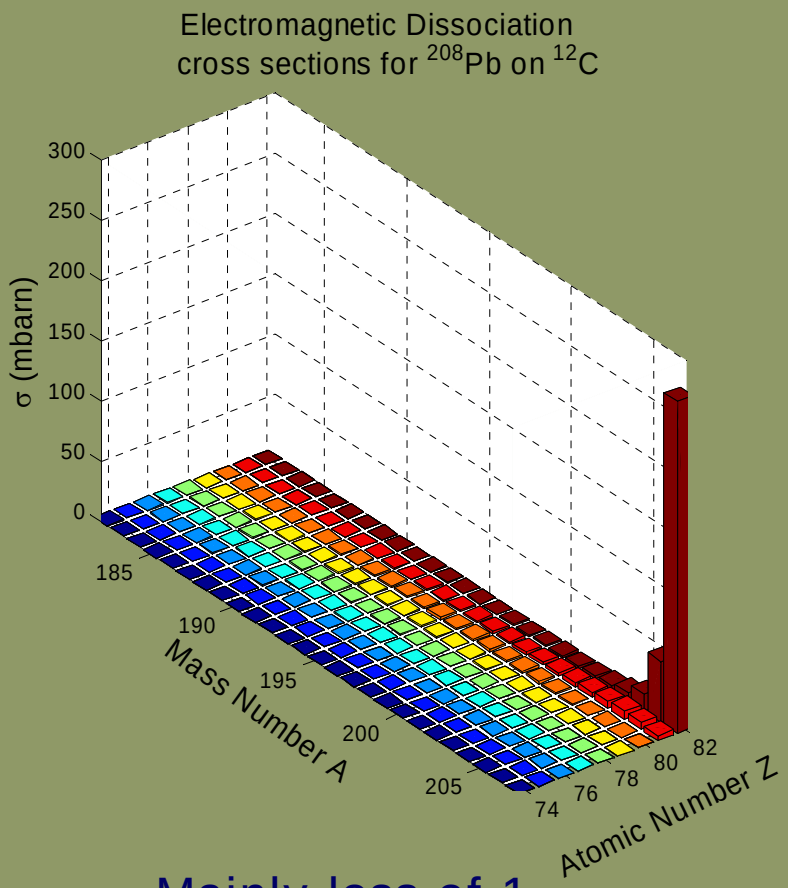
~20 times higher probability of nuclear interactions

At impact on a TCP:

- high probability of nuclear interactions with TCP material
- production of isotopes with different Z/A ratio and momentum and direction almost unchanged (typical transverse momentum transferred in NF ~ 1 A·MeV/c, even smaller for ED processes - compared to ~10 A·MeV/c due to beam emittance).

Interaction products





Large variety of daughter nuclei, Monte Carlo calculated specific x-sections

Mainly loss of 1 neutron (59%) or 2 (11%) → 207Pb, 206Pb

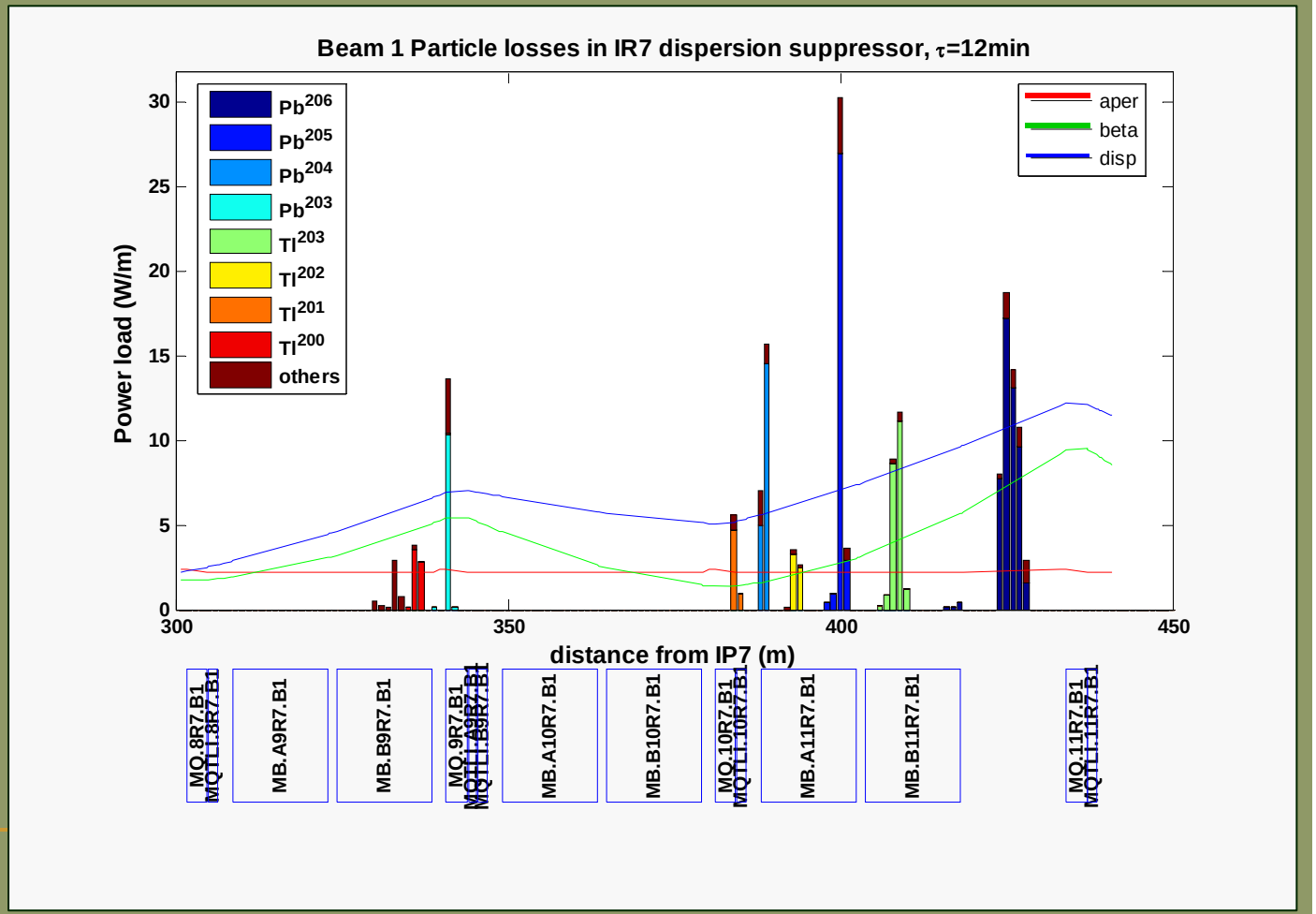
^{204}Pb -1.92%	^{205}Pb -1.44%	^{206}Pb -0.96%	^{207}Pb -0.48%	^{208}Pb 0.0%
^{203}Tl -1.2%	^{204}Tl -0.71%	^{205}Tl -0.23%	^{206}Tl 0.26%	^{207}Tl 0.75%
^{202}Hg -0.46%	^{203}Hg 0.04%	^{204}Hg 0.53%	^{205}Hg 1.02%	^{206}Hg 1.51%

Effective momentum error

acceptance(arcs)=±1%

acceptance(IR3 DS) =±0.3%

Typical loss map in IR7 dispersion suppressor



Motivations of the study:

Present cross sections are calculated with I. Pshenishnov's programs:

- EMD of ultra-rel. Pb nuclei in peripheral collisions calculated with Monte Carlo code RELDIS, based on Weiszäcker-Williams method (1n and 2n emission)
- hadronic cross sections calculated with abrasion-ablation model based on Glauber's theory

(exp validation up to E~158A GeV ^{208}Pb ions)

Cons: large error bars, routines not straightforward to use…

Why look beyond?

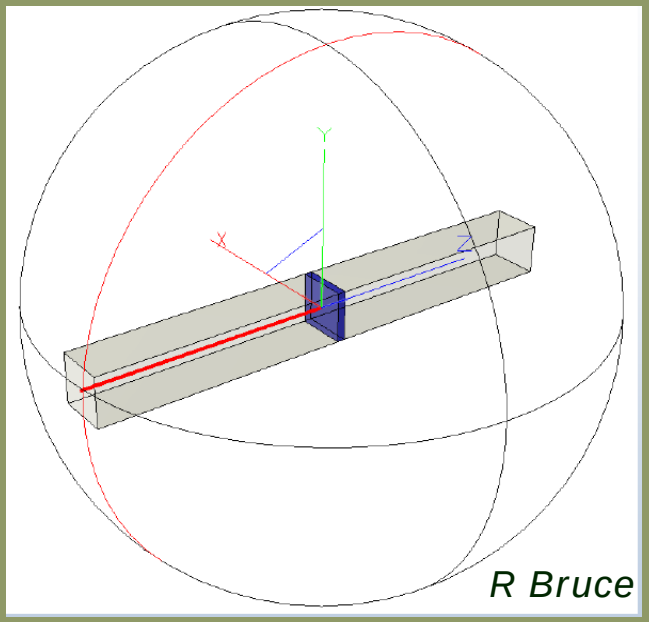
- have cross-check of results
- look for a simpler, user-friendly method of computation (in view of studying different energy points – LHC ramp – and materials for Phase II collimation)

FLUKA and MARS used to simulate thin target experiment

Ion beam hitting target:

- l=3mm, to avoid reinteraction in the material
- sample of 100,000 particles

All fragments produced are counted to calculate total and partial cross sections

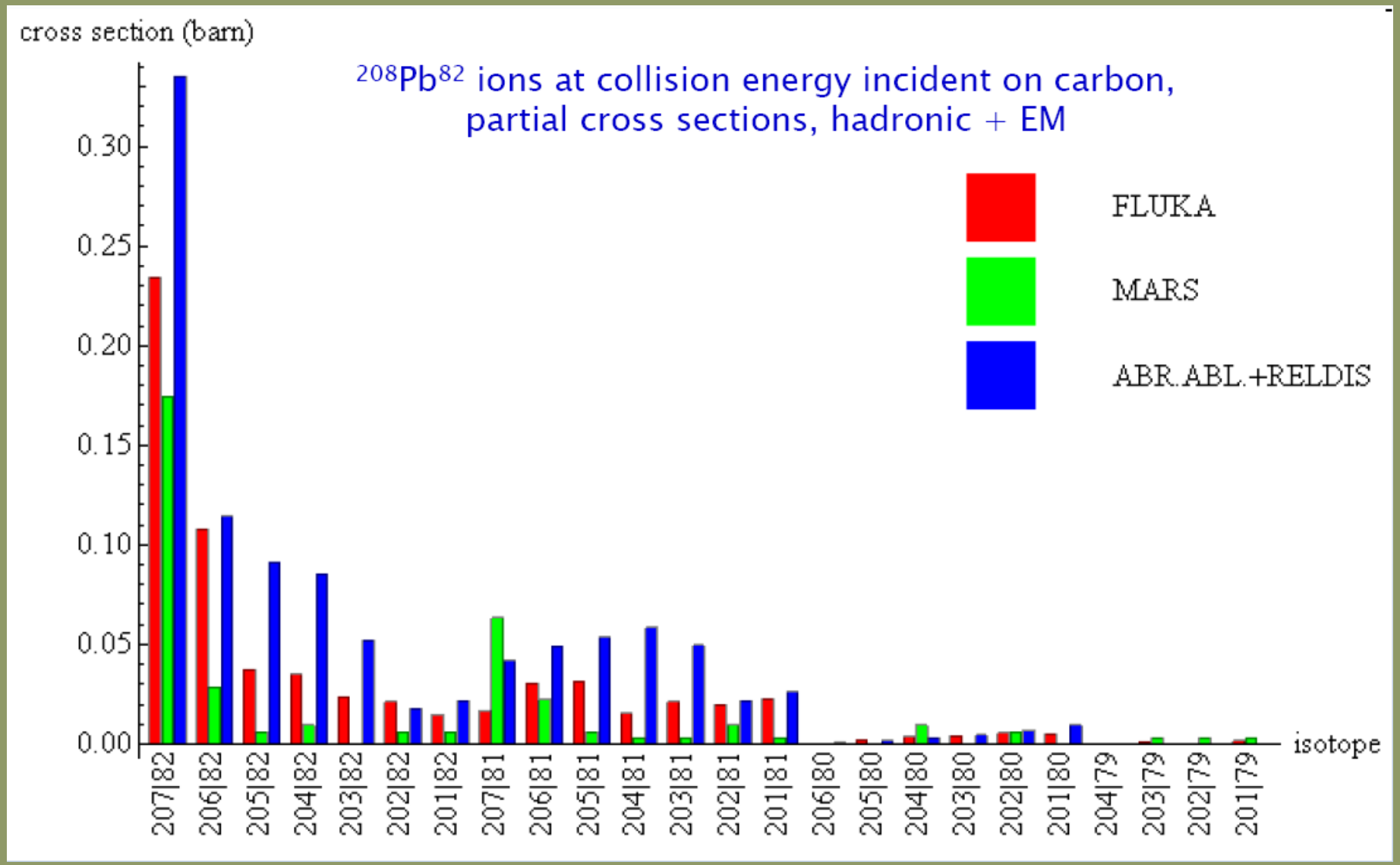


More automatic procedure developed for FLUKA – eldtst program- with simple sampling of ion-material interactions (no geometry or tracking involved, 100% efficiency, less CPU demanding ..)

Typical run over 10,000 particles lasts <1hr on lxplus batch queue for NF+EM physics modules, and *O*(couple of hours) for NF only..

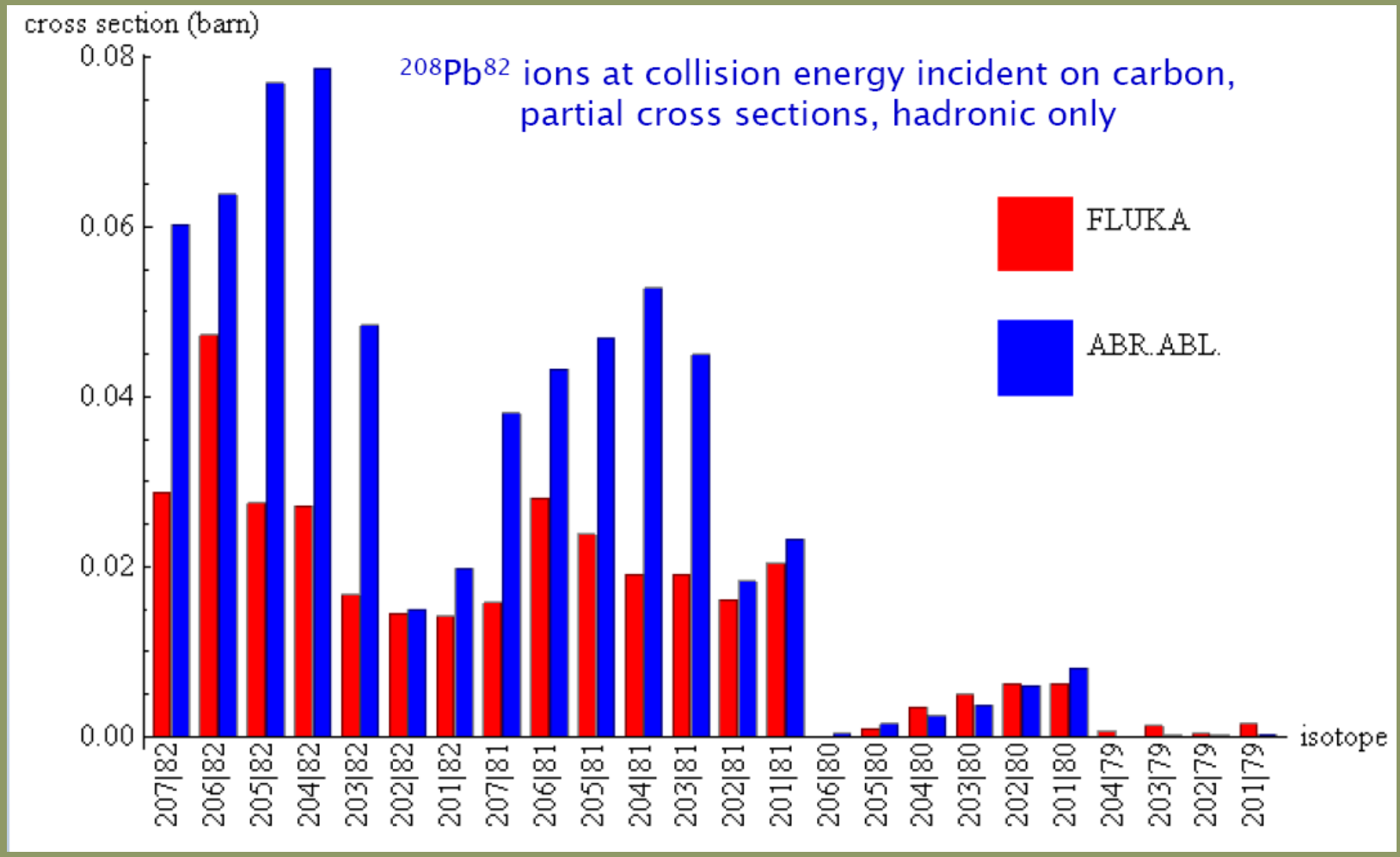
Script to convert FLUKA ouput files directly into ICOSIM input format

$^{208}Pb_{82}$ at 2.76 TeV, EMD+NF



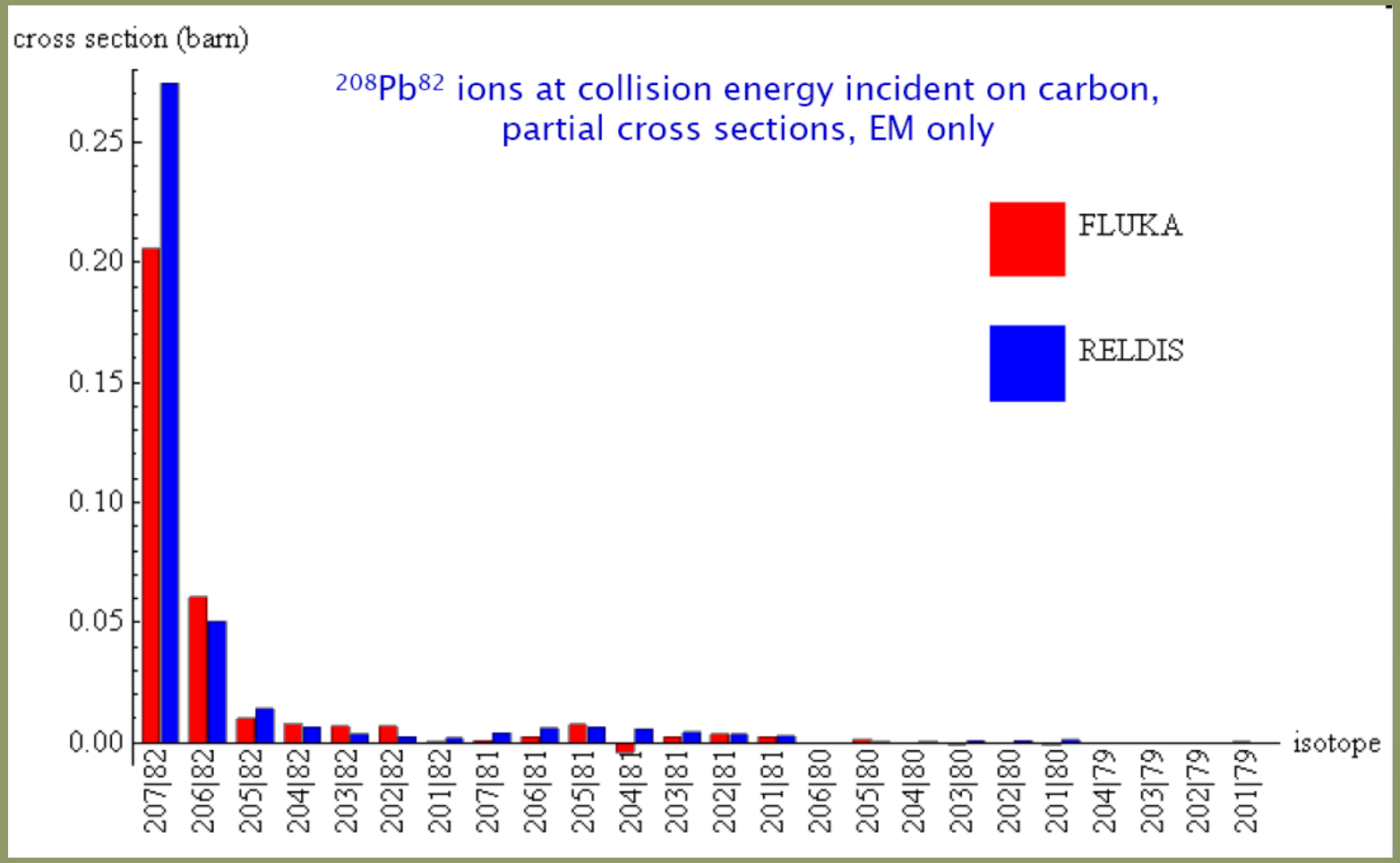
R Bruce

$^{208}Pb_{82}$ at 2.76 TeV, NF only



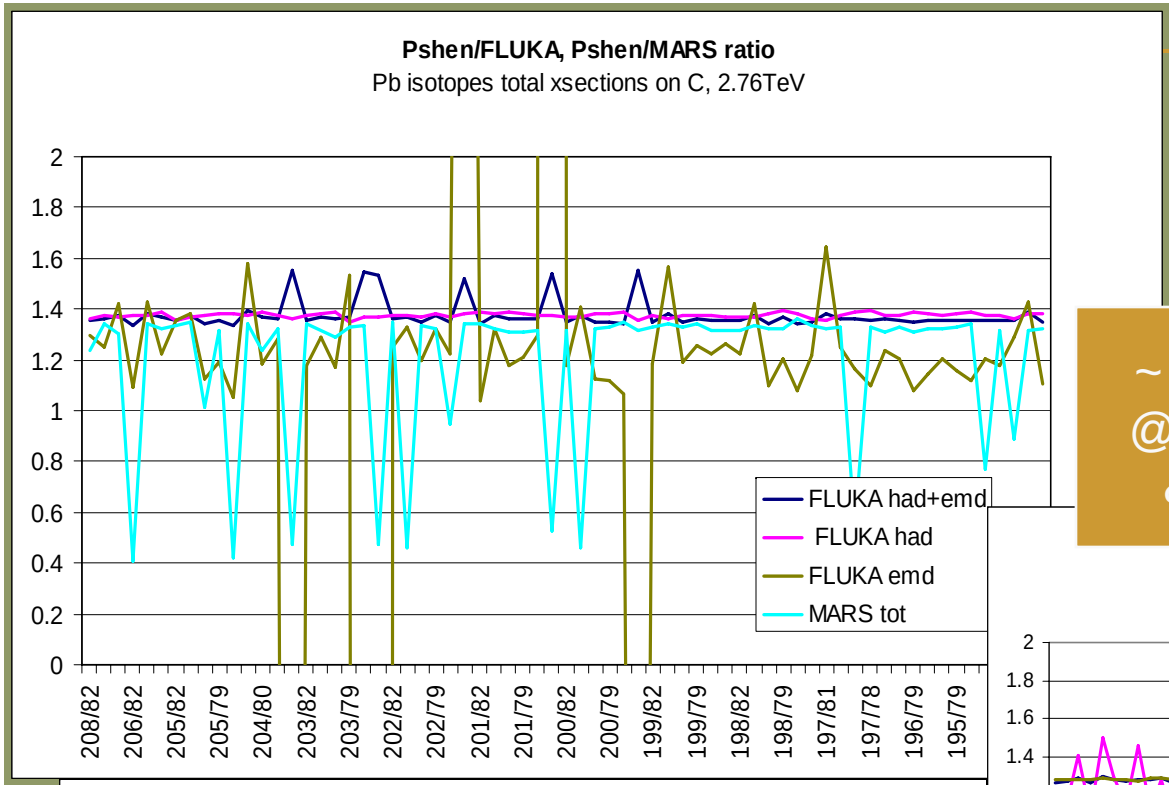
R Bruce

$^{208}Pb_{82}$ at 2.76 TeV, EMD only

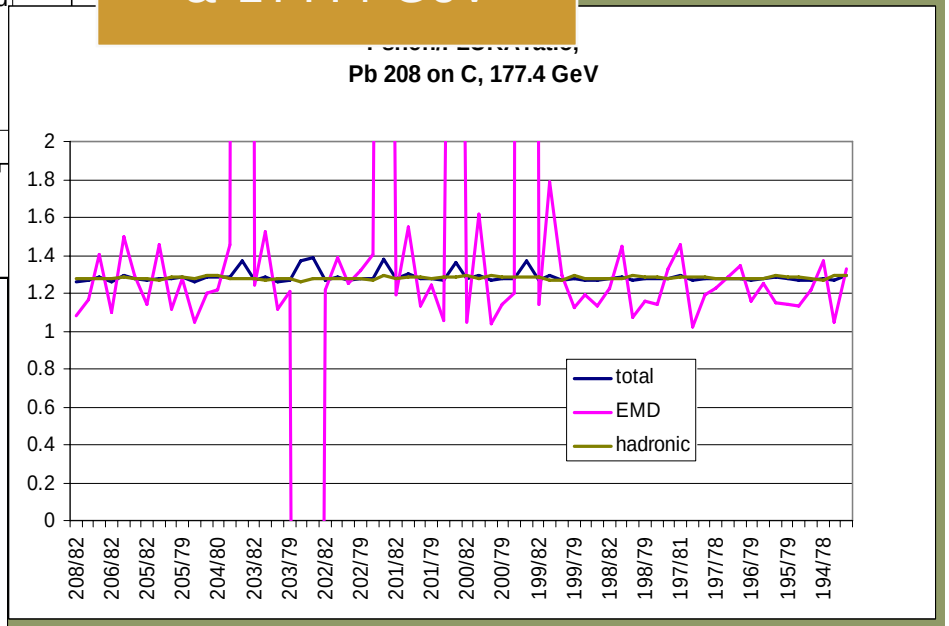


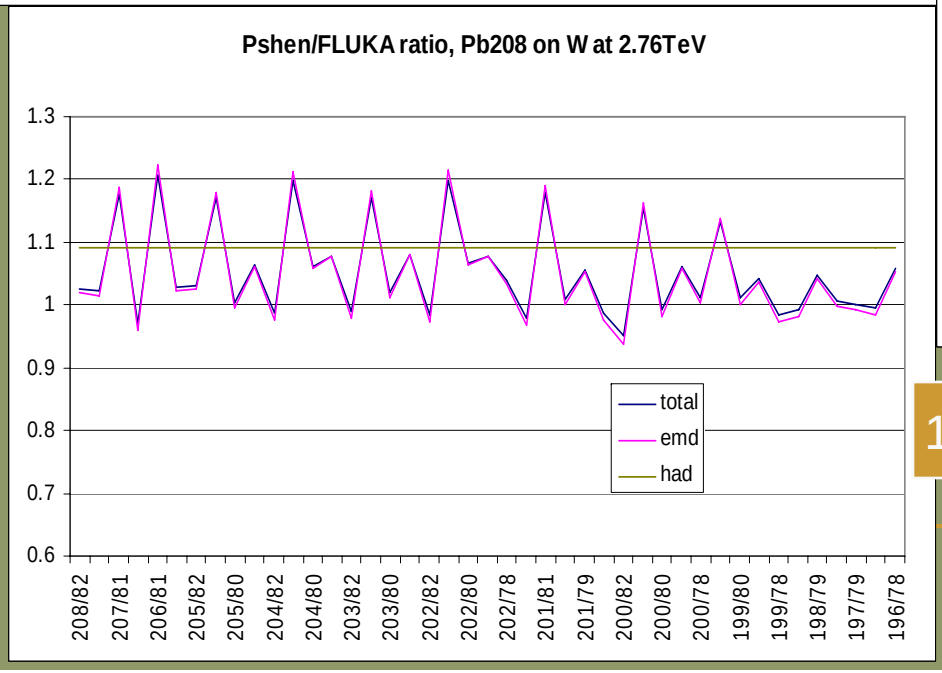
R Bruce

Pb isotopes inclusive x-sections



~30% diff on C @both 2.76TeV & 177.4 GeV

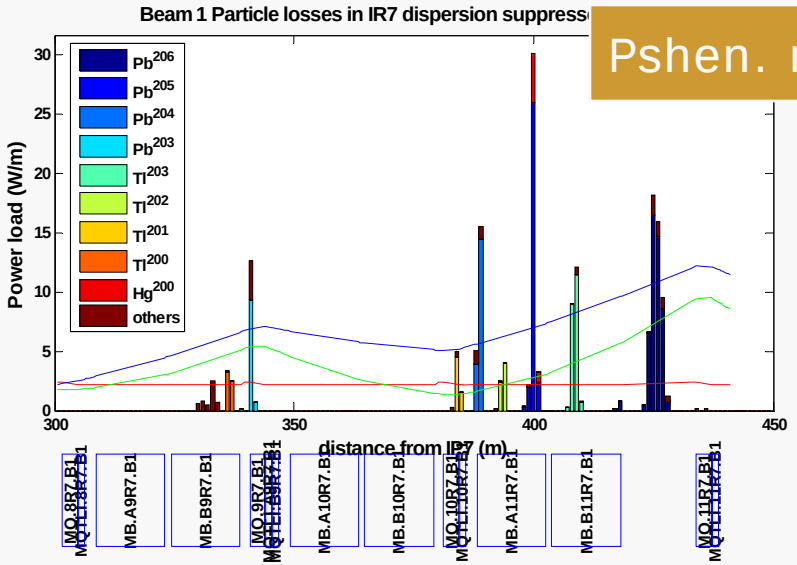




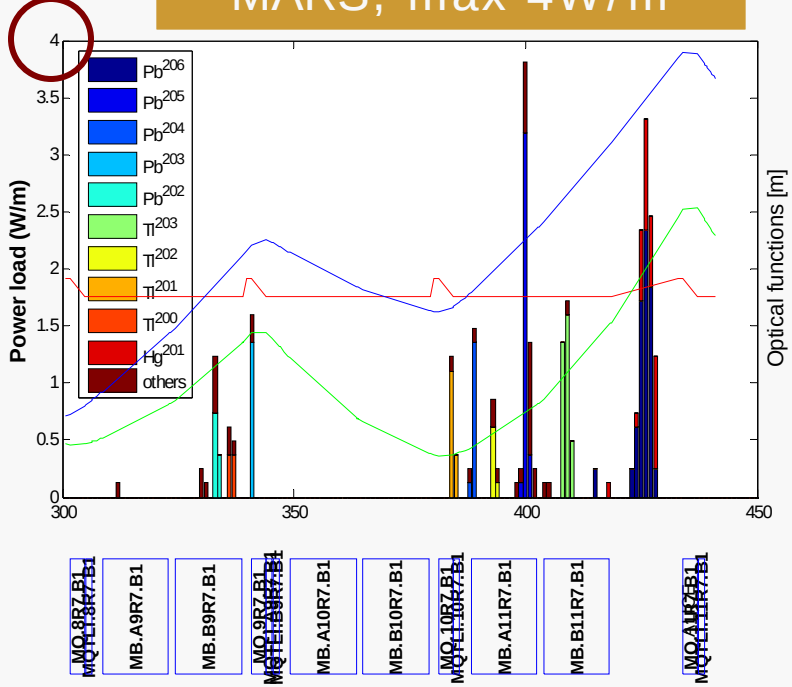
10% diff for W at 2.76TeV

IR7 betatron collimation at 2.76 TeV (C-C)

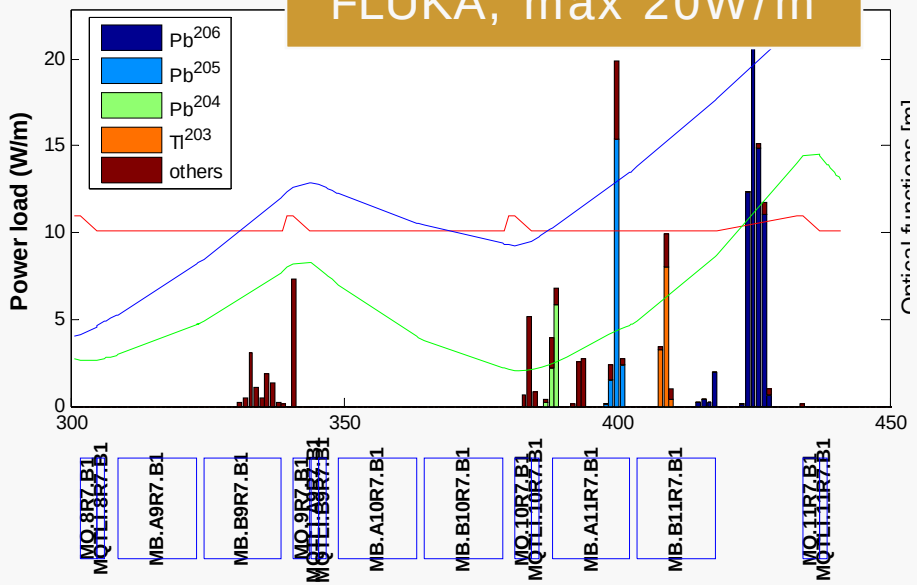
Pshen. max 30W/m



MARS, max 4W/m

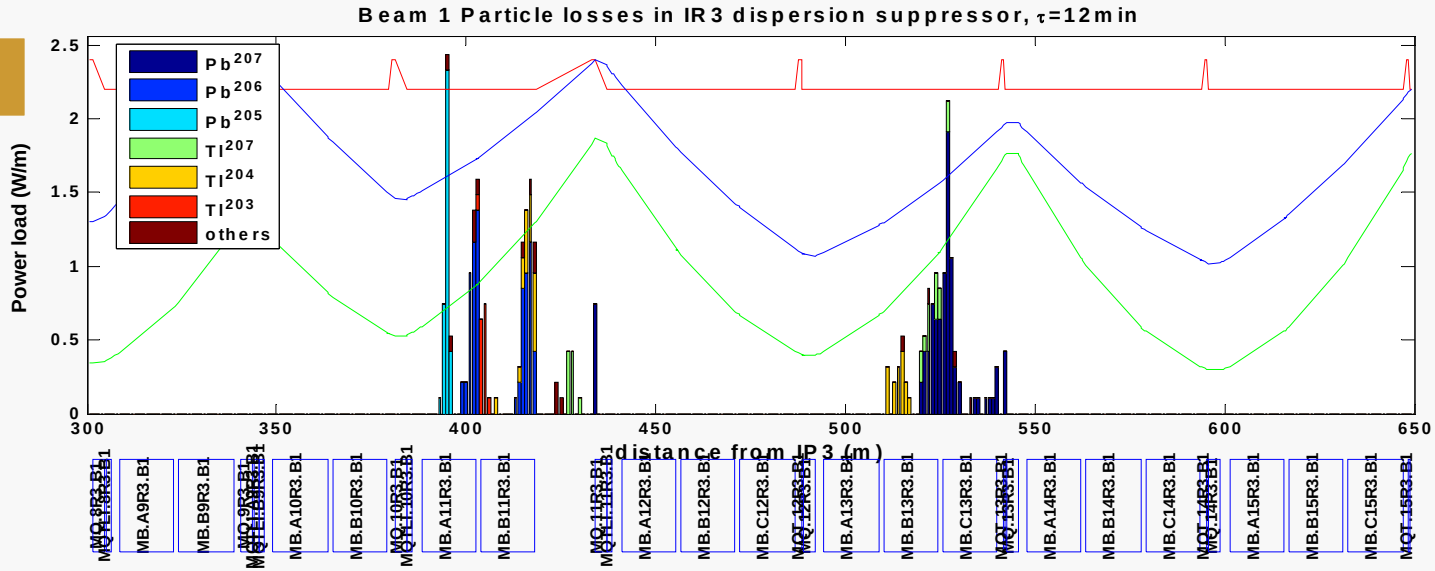


FLUKA, max 20W/m

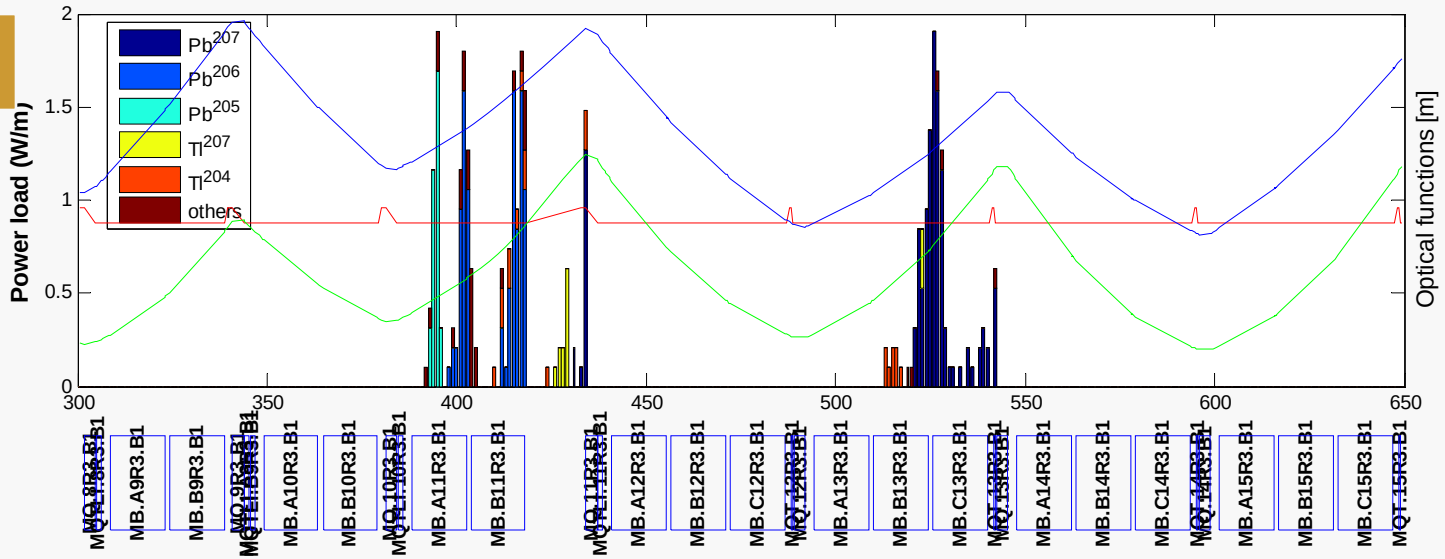


IR3 momentum collimation at 2.76 TeV

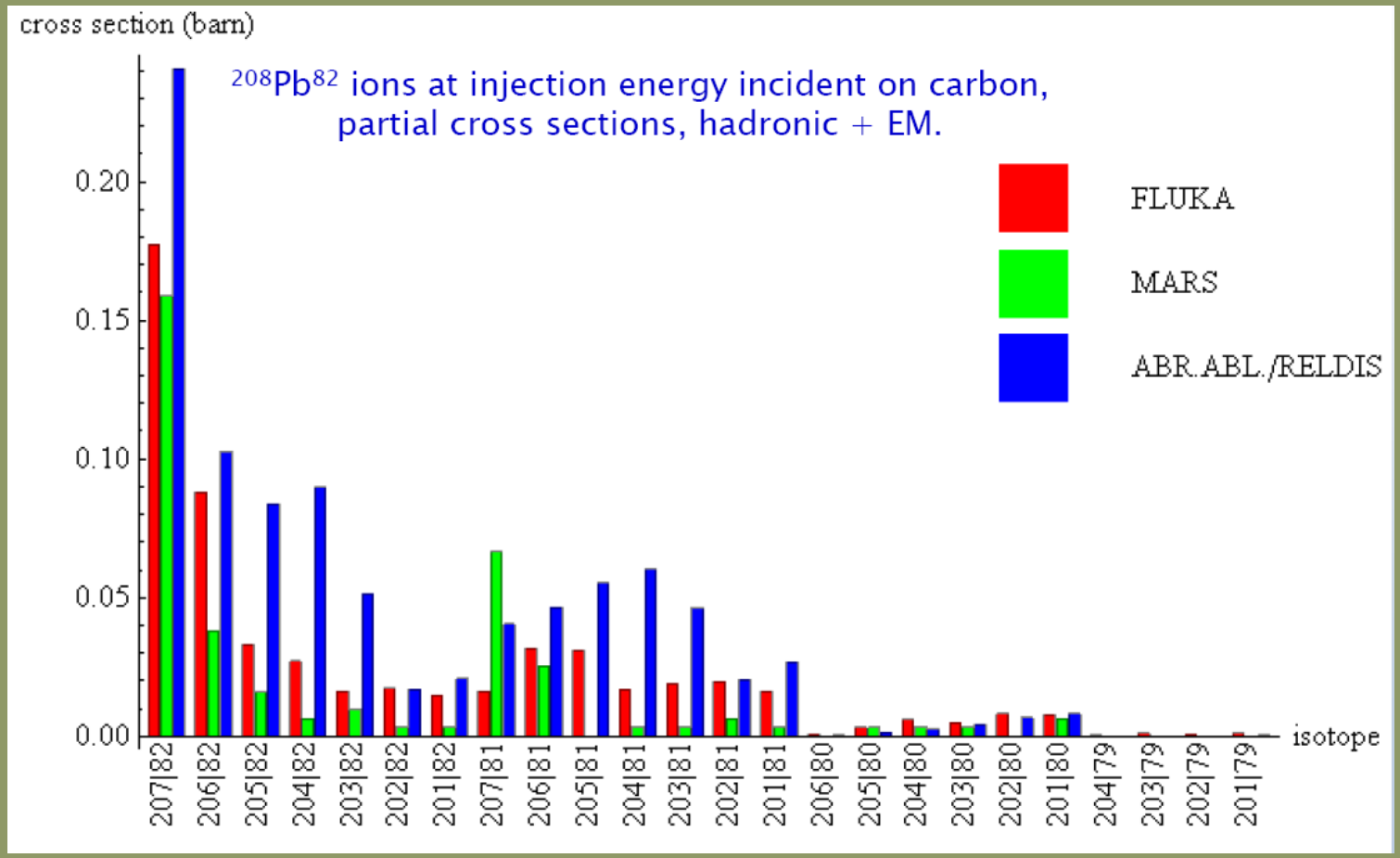
Pshen.



FLUKA



$^{208}Pb_{82}$ at 177.4 GeV, EMD+NF



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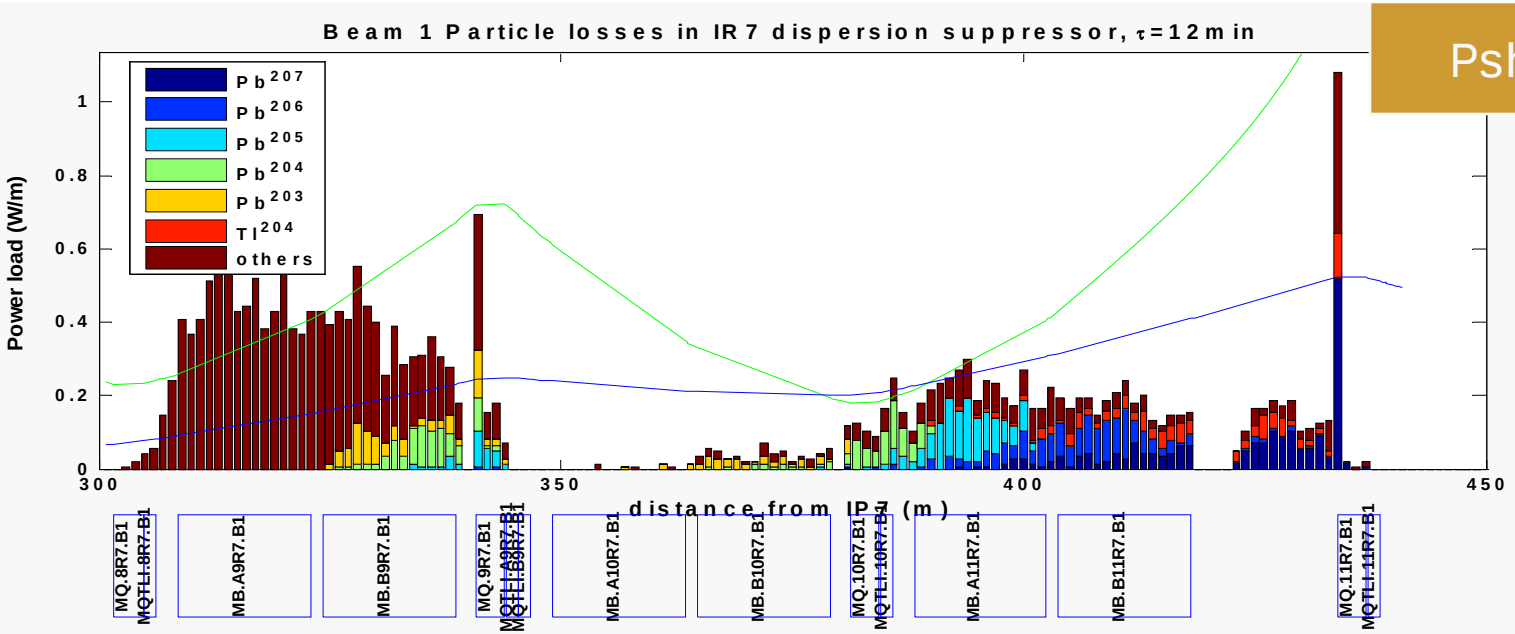
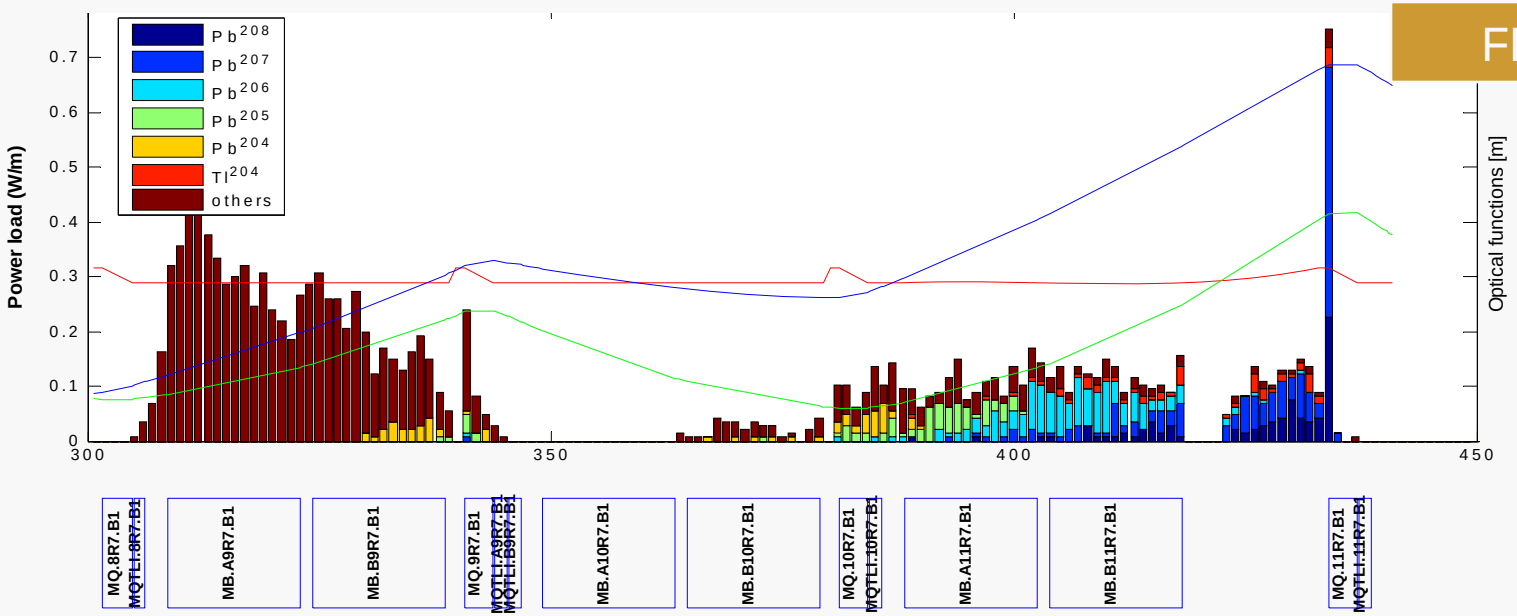
Pshen.


Beam 1 Particle losses in IR7 dispersion suppressor, τ=12 min
Power load (W/m)
Pb207
Pb206
Pb205
Pb204
Pb203
Tl204
others
distance from IP7 (m)
MQ.8R7.B1
MQTLI.8R7.B1
MB.A9R7.B1
MB.B9R7.B1
MQ.9R7.B1
MQTLI.A9R7.B1
MQTLI.B9R7.B1
MB.A10R7.B1
MB.B10R7.B1
MQ.10R7.B1
MQTLI.10R7.B1
MB.A11R7.B1
MB.B11R7.B1
MQ.11R7.B1
MQTLI.11R7.B1

FLUKA


Power load (W/m)
Pb208
Pb207
Pb206
Pb205
Pb204
Tl204
others
Optical functions [m]
MQ.8R7.B1
MQTLI.8R7.B1
MB.A9R7.B1
MB.B9R7.B1
MQ.9R7.B1
MQTLI.A9R7.B1
MQTLI.B9R7.B1
MB.A10R7.B1
MB.B10R7.B1
MQ.10R7.B1
MQTLI.10R7.B1
MB.A11R7.B1
MB.B11R7.B1
MQ.11R7.B1
MQTLI.11R7.B1

Conclusions

- Compared Pb ion cross sections for different codes/models and found differences up to a factor of 2 for all-inclusive xs (with typically MARS < FLUKA < Pshenishnov's programs)
- Even bigger differences for individual channels (hadronic contribution, at both injection and collision energies)
- Heat load from fragments in ICOSIM loss maps scales down correspondingly for FLUKA runs (MARS?)

Propose to move to FLUKA cross sections in the future and use the differences found as an estimate of error bars on simulation results..