Target Location/Length Study & ISU Plans

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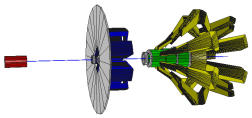
Target Location/Length Study

- Vary the length and central location of target and explore rates and bkgd fractions in main Moller detectors for a given spectrometer/collimation design

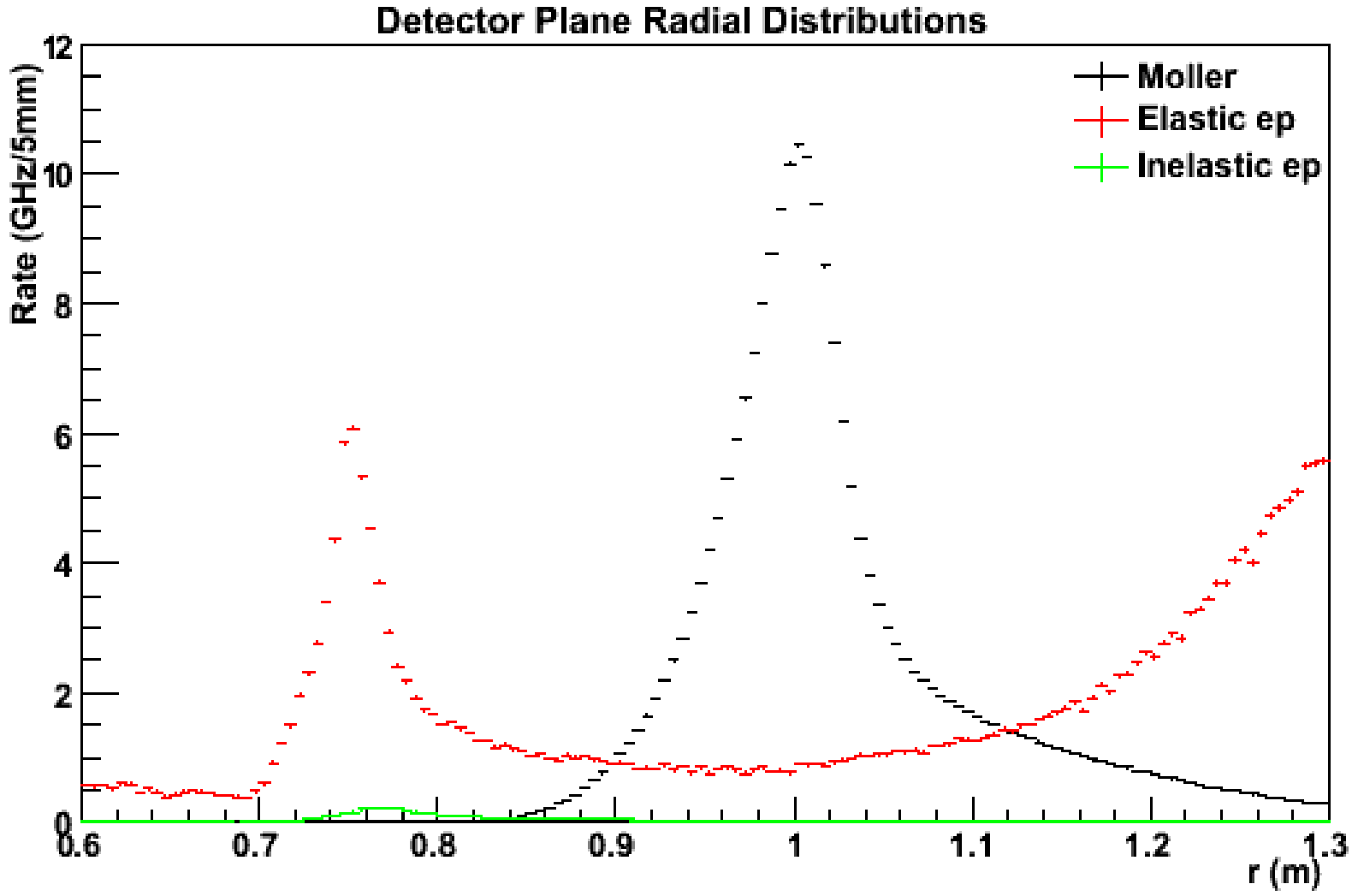
Work presented here done by ISU student
Carlos Bula-Villarreal



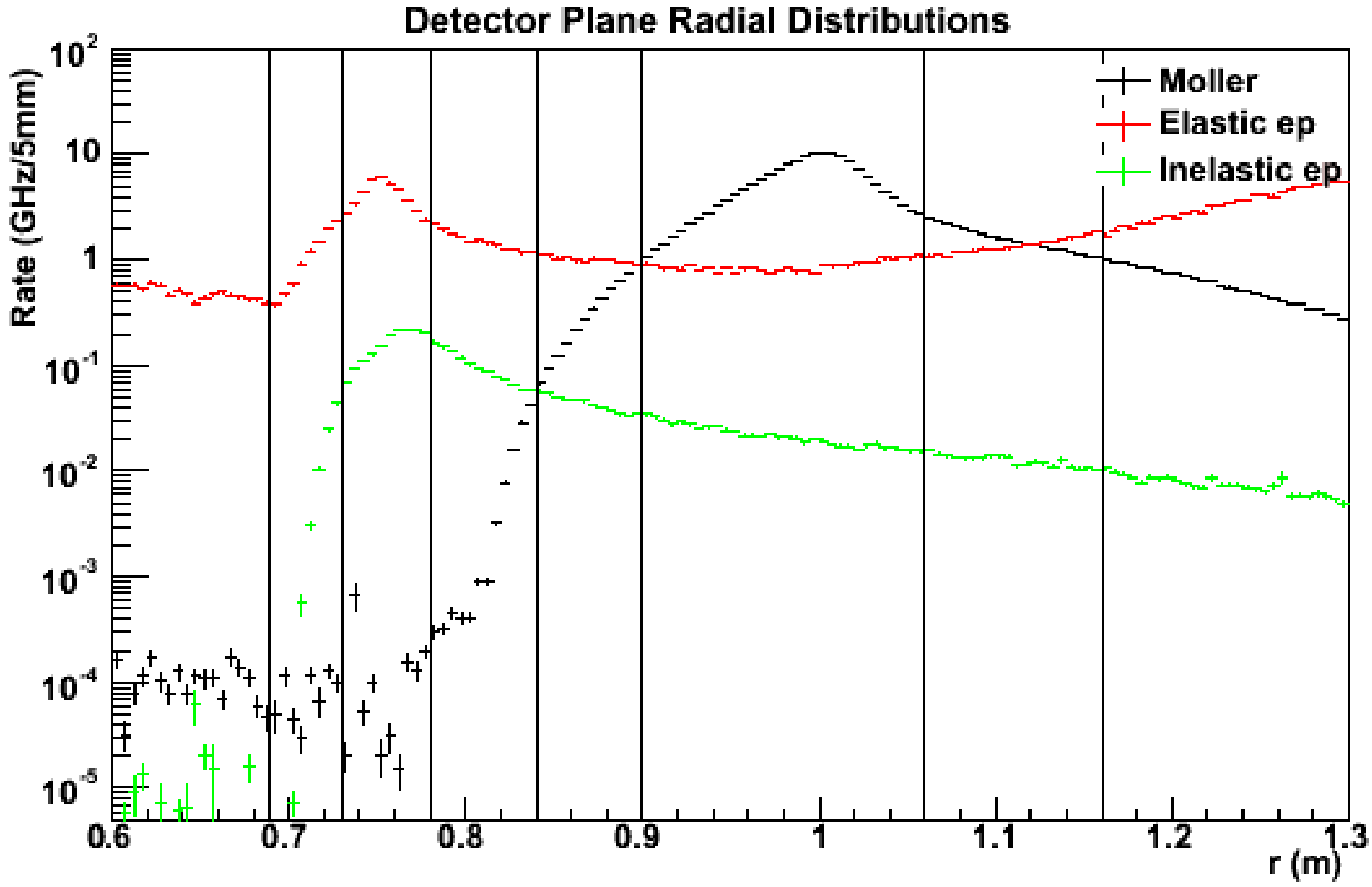
Target Study Specifics

- Used new "remoll" Monte Carlo with nominal magnet spectrometer design (version 3.0)
- Performed study using two different collimation designs: nominal (old) and sculpted (new)
- Generated 10M events for each generator: *ee*, *ep*, and *in*
- Used standard 5mm by 5mm raster and 85μA beam current
- Detector plane z-location fixed at nominal location (28.5m)
- Used three target lengths: 150, 125, 100 cm
- And five central target locations: -50, -25, 0, 25, 50 cm
- For proper comparisons, width of Moller ring held constant at nominal 16cm while radial position shifted (simple algorithm)

Nominal Radial Rates:
150 cm length, 0 cm position, version 3.0



Nominal Radial Rates:
150 cm length, 0 cm position, version 3.0



Nominal Radial Rates:
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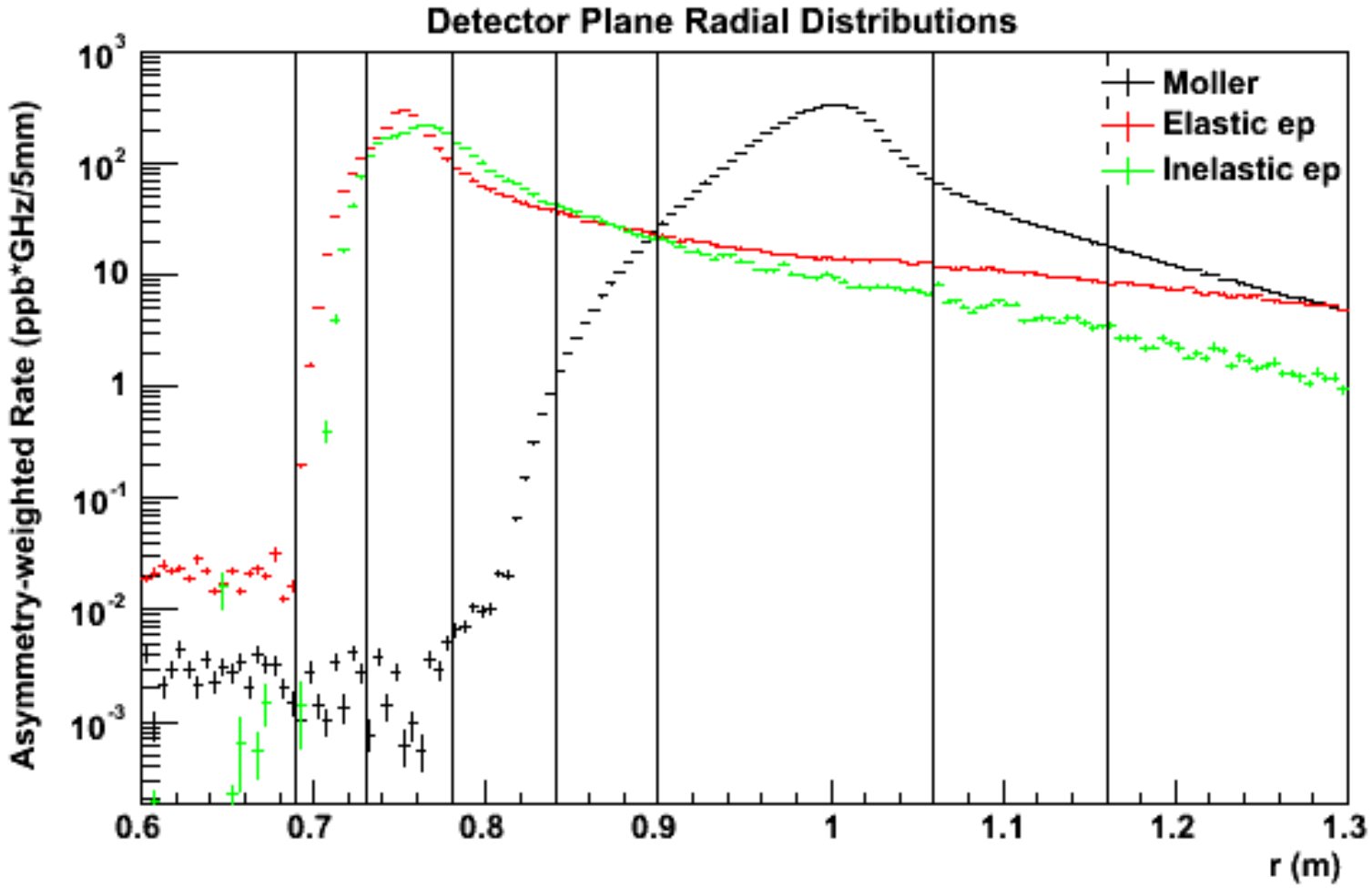
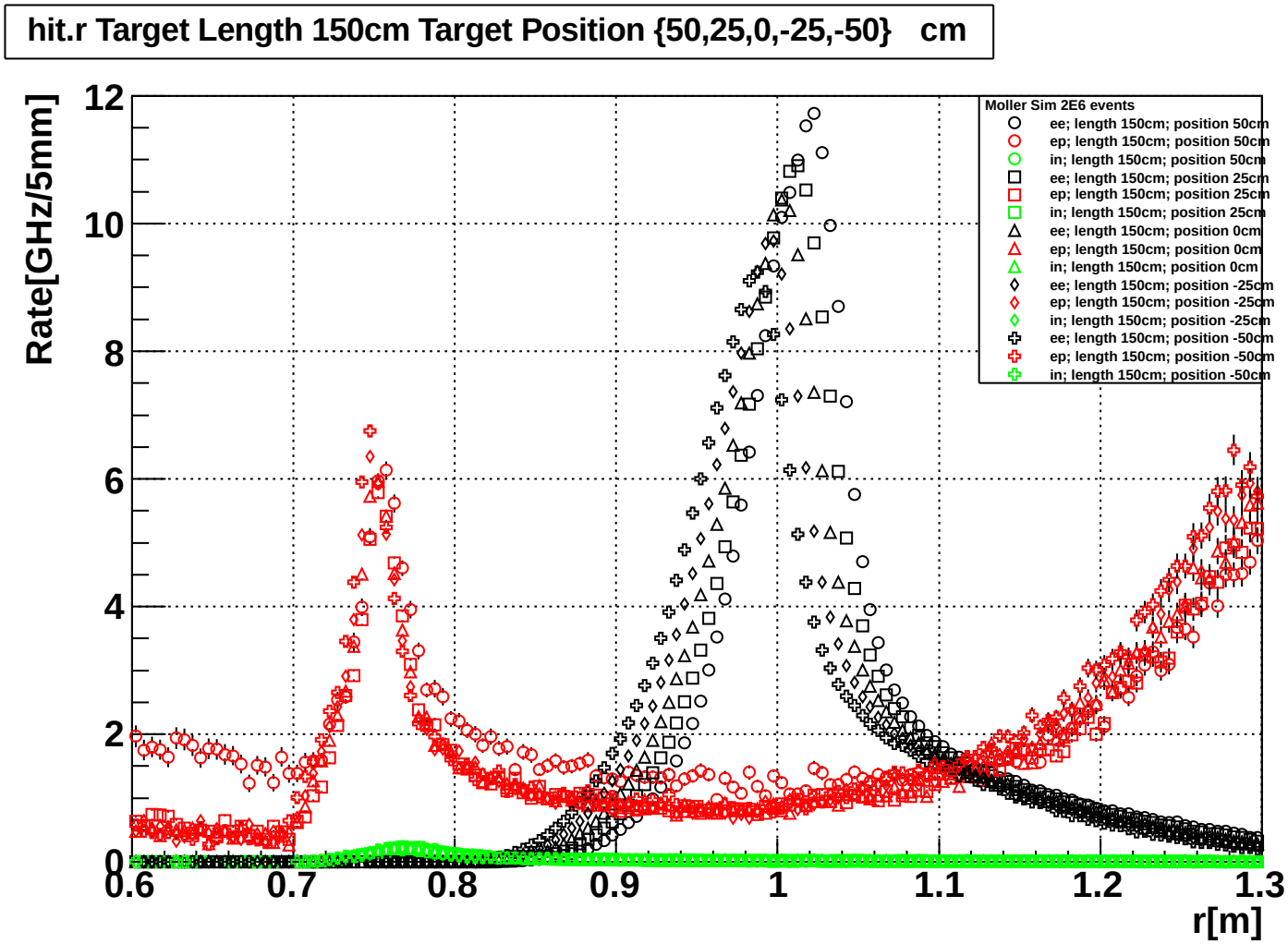
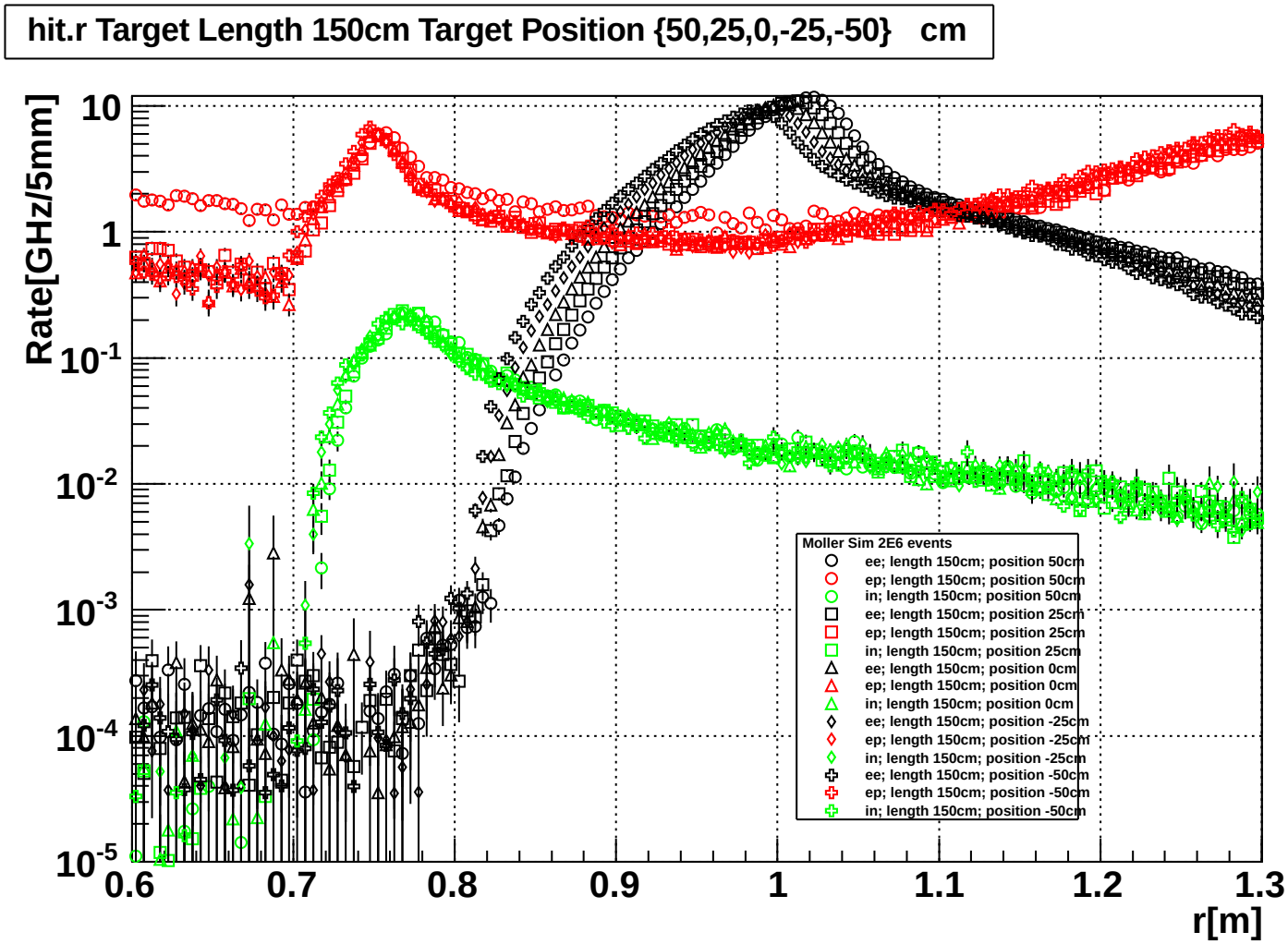


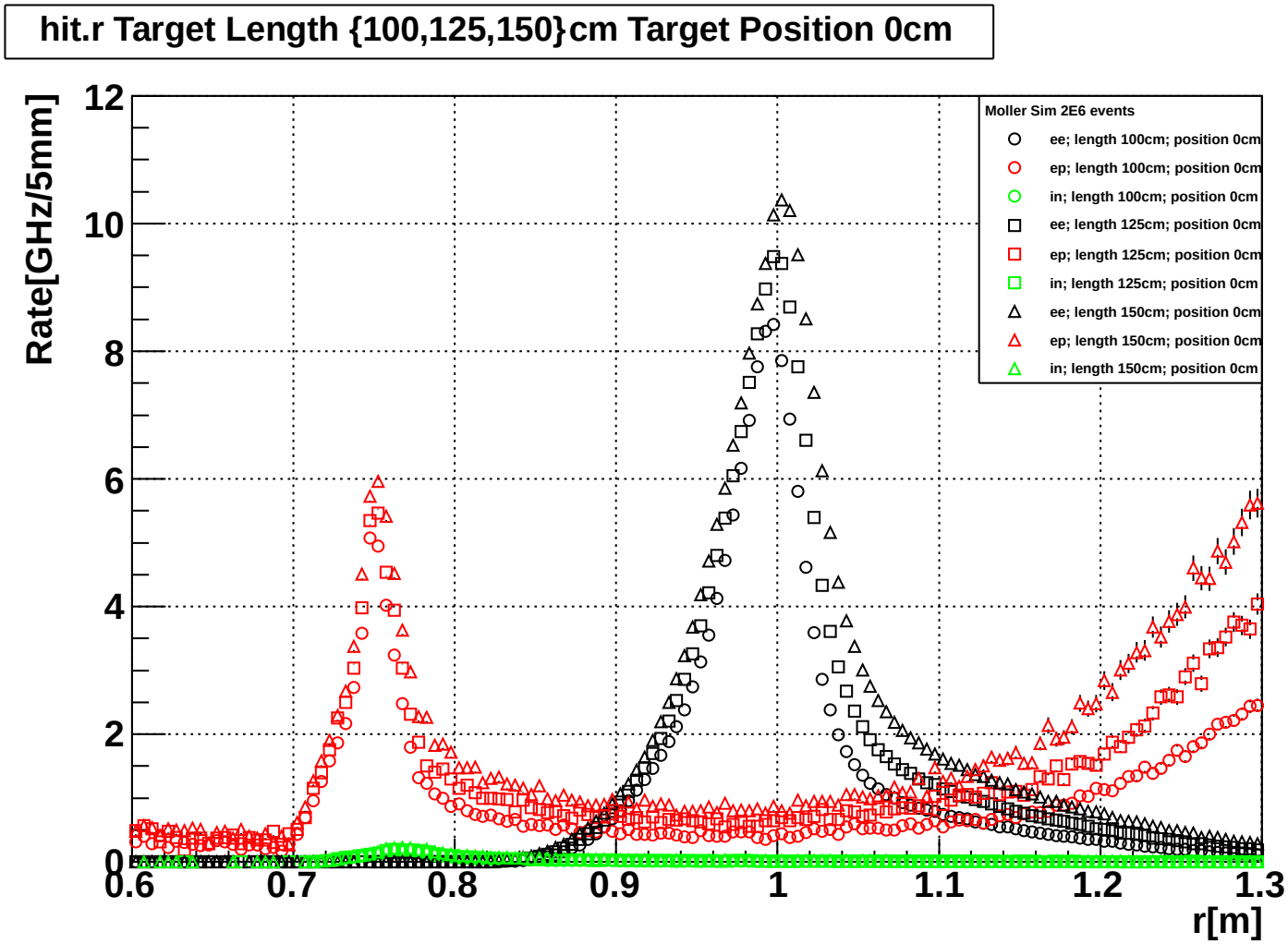
150 cm length: -50, -25, 0, 25, 50 cm positions Nominal (old) Collimation



150 cm length: -50, -25, 0, 25, 50 cm positions Nominal (old) Collimation



0 cm position: 100, 125, 150 cm lengths Nominal (old) Collimation

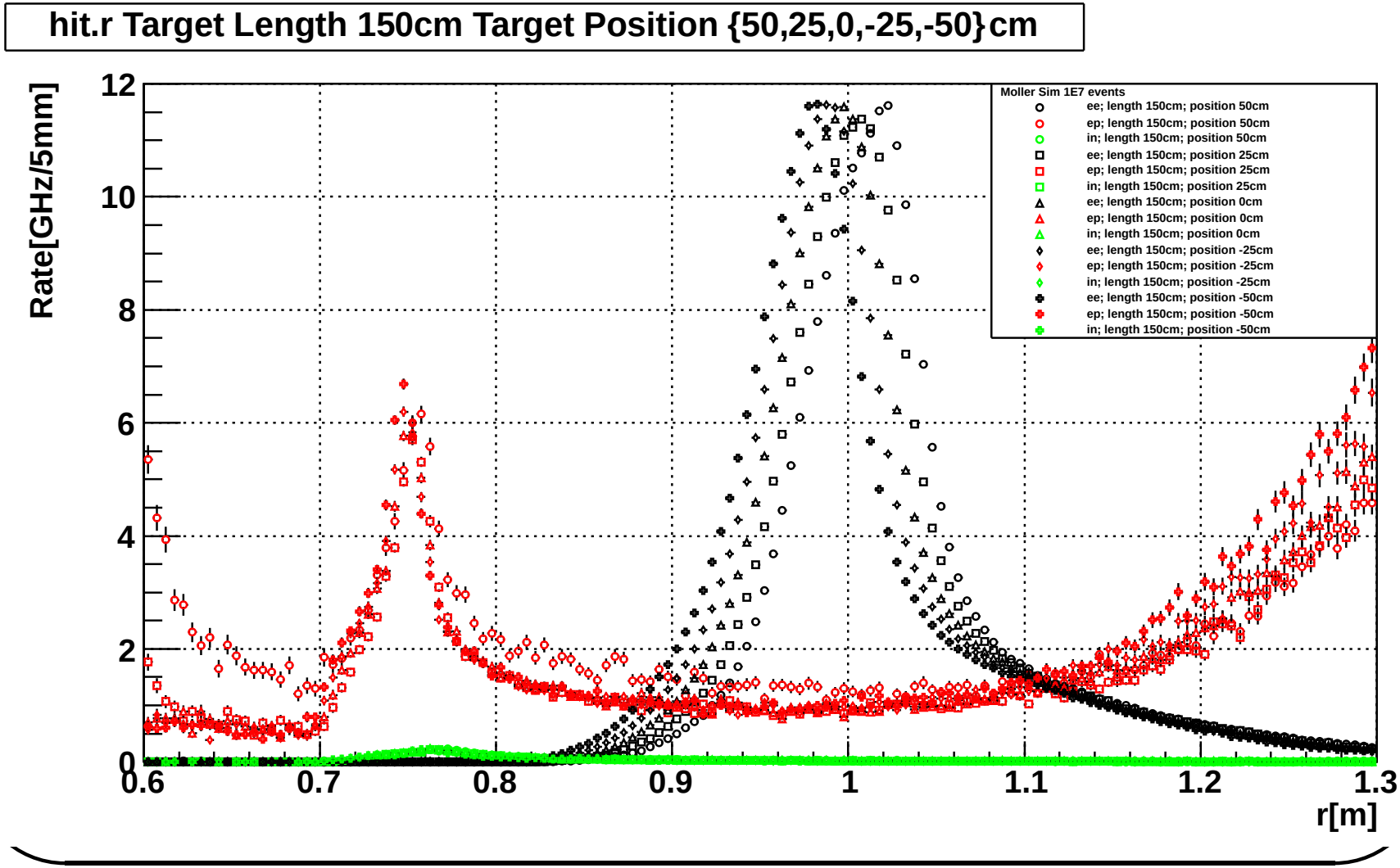


Nominal (old) Collimation Results (magnet 3.0)

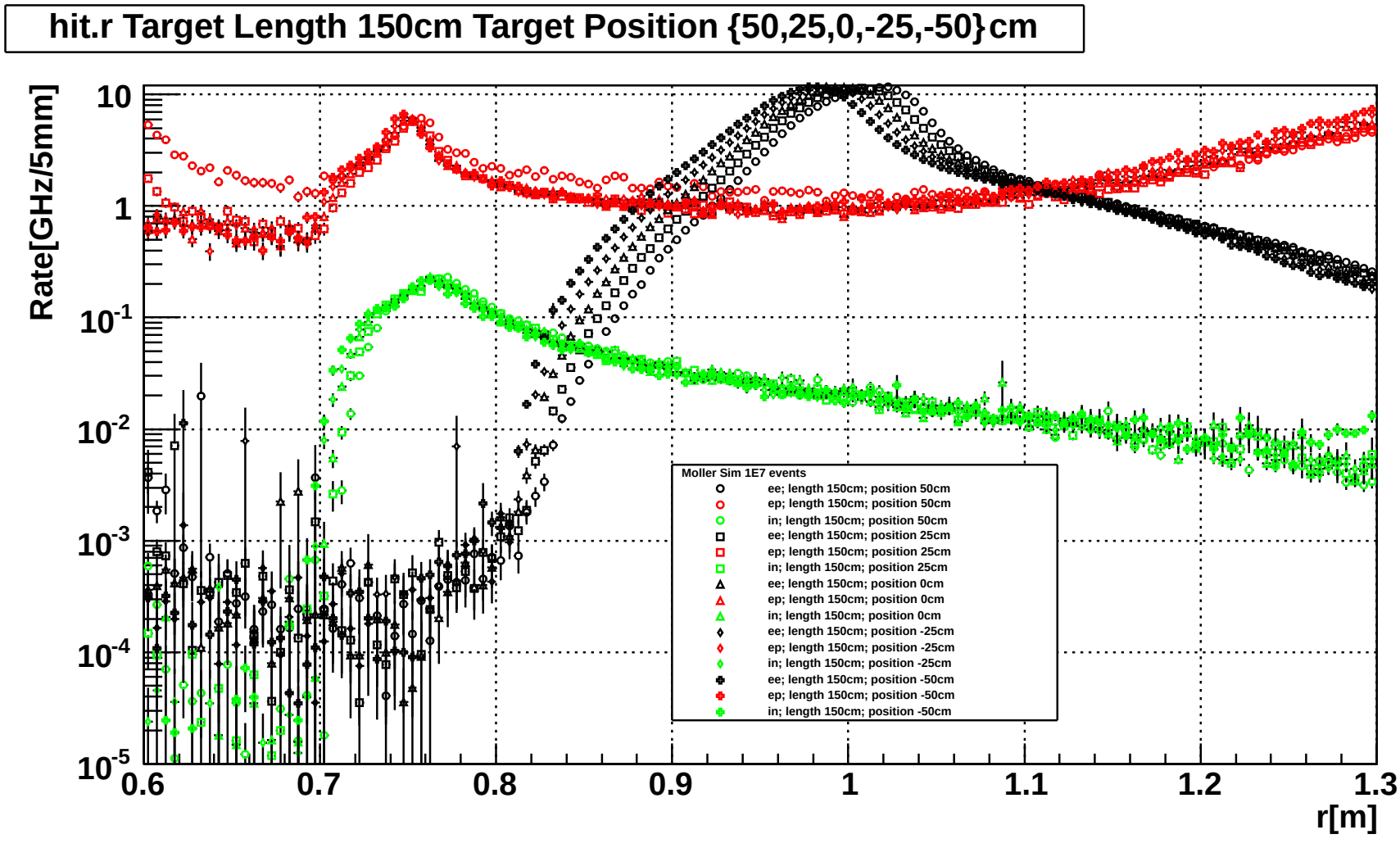
Len (cm)	Pos (cm)	R_{ee} (GHz)	R_{ep} (GHz)	R_{in} (GHz)	R_{ep}/R_{ee} (%)	R_{in}/R_{ee} (%)	r_{min} (cm)	r_{max} (cm)
100	-50	110.4	15.3	0.451	13.8	0.409	87.1	103.1
100	-25	113.3	14.8	0.439	13.0	0.387	88.1	104.1
100	0	116.9	15.1	0.412	12.9	0.353	89.1	105.1
100	25	120.3	14.7	0.415	12.2	0.344	89.6	105.6
100	50	126.9	14.6	0.369	11.5	0.290	91.6	107.5
125	-50	134.5	22.1	0.598	16.4	0.445	87.6	103.6
125	-25	138.4	22.1	0.579	15.9	0.418	88.6	104.6
125	0	142.0	21.6	0.582	15.2	0.410	89.1	105.1
125	25	148.7	21.2	0.550	14.3	0.370	90.6	106.7
125	50	156.4	26.0	0.502	16.7	0.321	92.0	108.0
150	-50	158.1	30.3	0.755	19.2	0.478	88.1	104.1
150	-25	161.0	29.2	0.774	18.1	0.481	88.6	104.6
150	0	167.1	29.4	0.738	17.6	0.442	89.6	105.6
150	25	174.1	28.6	0.722	16.4	0.414	90.6	106.6
150	50	186.1	41.9	0.618	22.5	0.332	93.0	109.0

Table 1: Rates, bkgd fractions, and radial Moller detector ranges. Note statistical precisions are $\sim$ 0.05%, 1.1%, and 1.8% for *ee*, *ep*, and *in* respectively

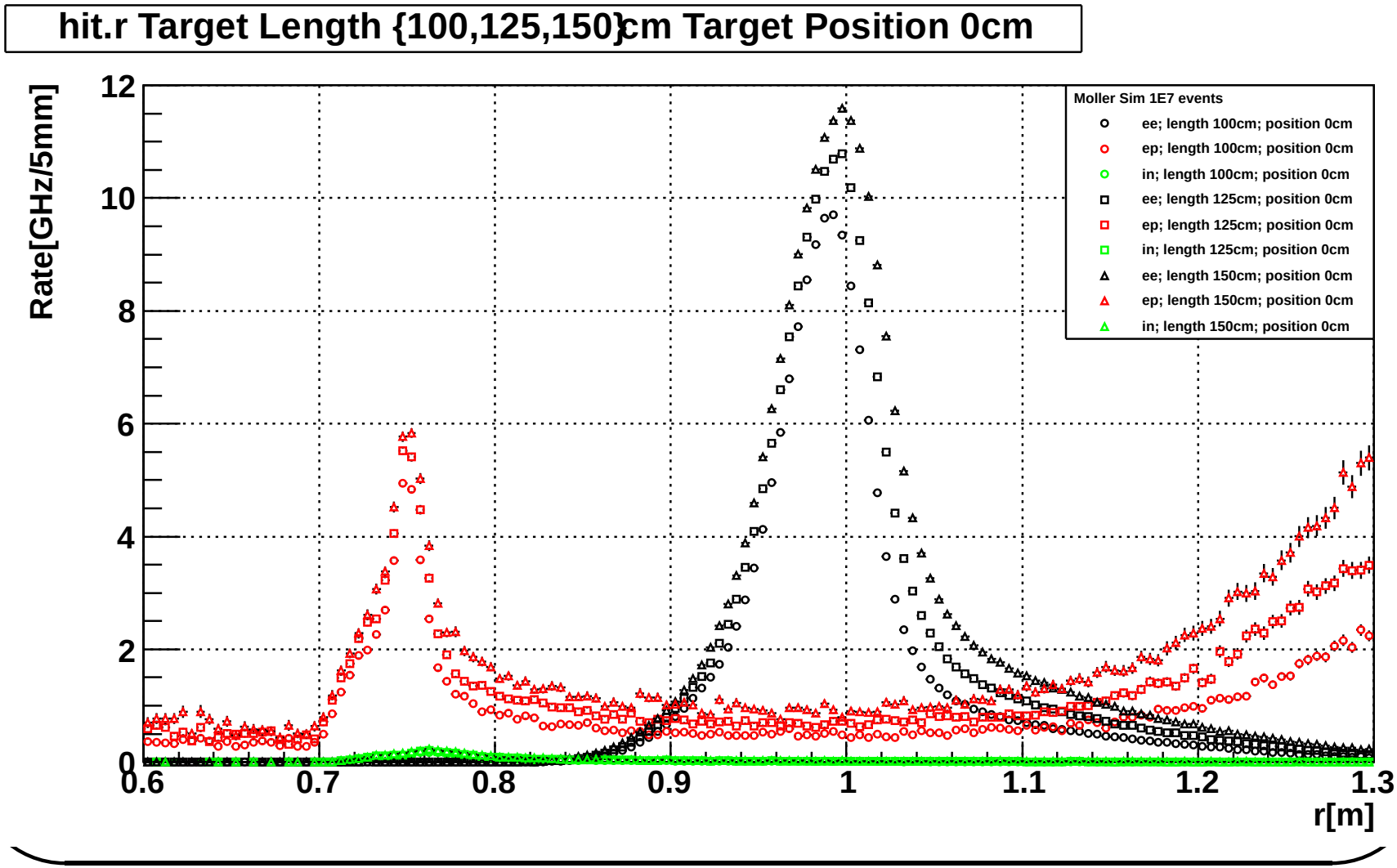
150 cm length: -50, -25, 0, 25, 50 cm positions Sculpted Collimation



150 cm length: -50, -25, 0, 25, 50 cm positions Sculpted Collimation



0 cm position: 100, 125, 150 cm lengths Sculpted Collimation

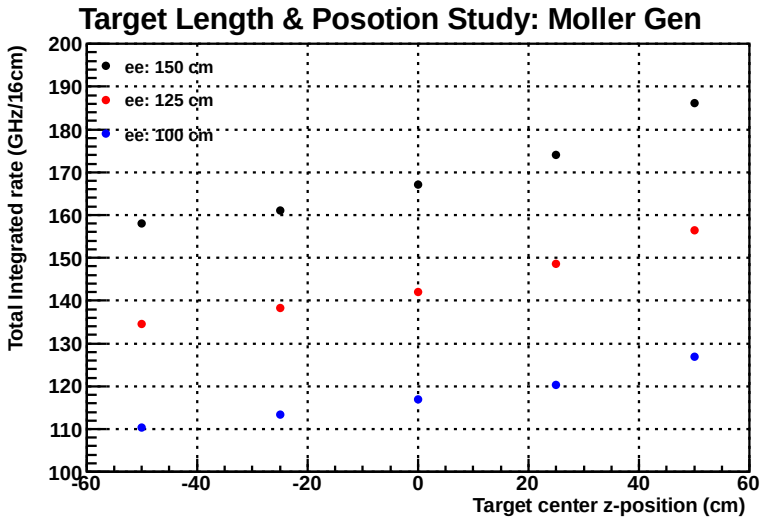


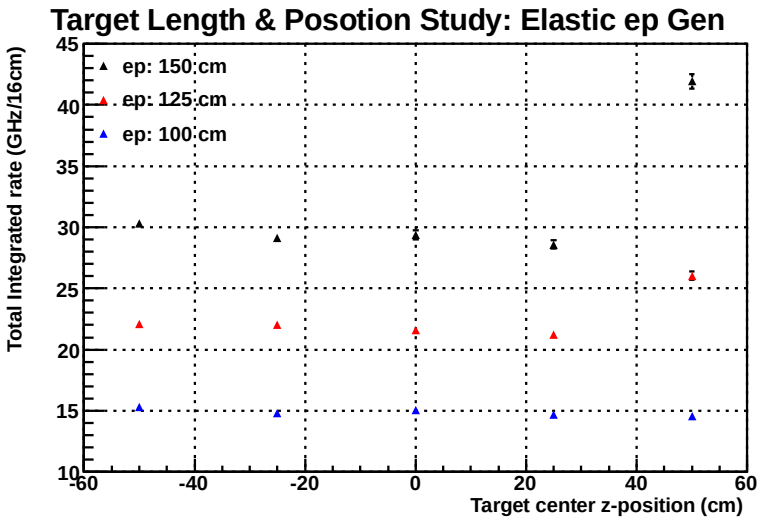
Sculpted Collimation Results (magnet 3.0)

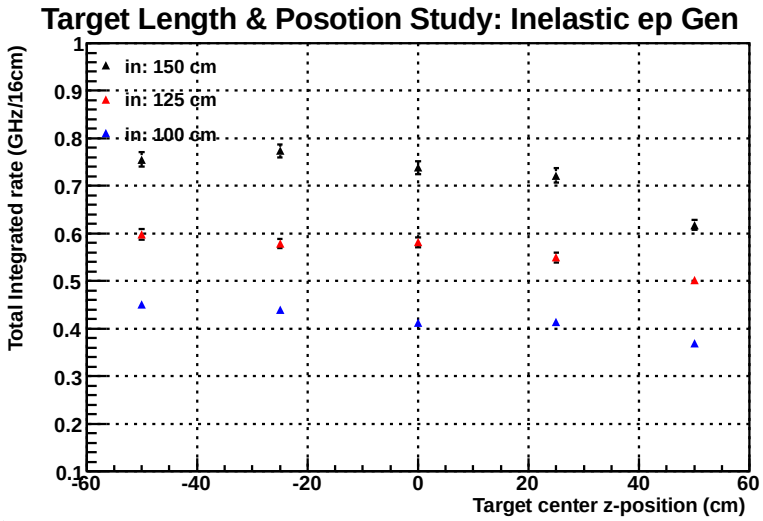
Len (cm)	Pos (cm)	R_{ee} (GHz)	R_{ep} (GHz)	R_{in} (GHz)	R_{ep}/R_{ee} (%)	R_{in}/R_{ee} (%)	r_{min} (cm)	r_{max} (cm)
100	-50	133.4	17.1	0.488	12.8	0.366	87.1	103.1
100	-25	136.0	16.8	0.462	12.3	0.340	88.1	104.1
100	0	137.2	16.5	0.430	12.0	0.313	89.1	105.1
100	25	137.4	15.9	0.416	11.6	0.303	90.1	106.1
100	50	136.9	15.7	0.377	11.4	0.275	91.6	107.6
125	-50	162.6	24.7	0.624	15.2	0.384	87.6	103.6
125	-25	165.1	23.9	0.626	14.5	0.379	88.6	104.6
125	0	166.5	23.4	0.588	14.8	0.353	89.6	105.6
125	25	166.8	22.9	0.557	13.7	0.334	90.6	106.6
125	50	167.2	26.8	0.489	16.0	0.292	92.5	108.5
150	-50	190.3	33.4	0.792	17.6	0.416	88.1	104.1
150	-25	192.6	32.3	0.782	16.8	0.406	89.1	105.1
150	0	194.2	31.5	0.739	16.2	0.381	90.1	106.1
150	25	194.3	31.5	0.701	16.2	0.361	91.1	107.1
150	50	195.6	42.2	0.643	21.6	0.329	93.0	109.0

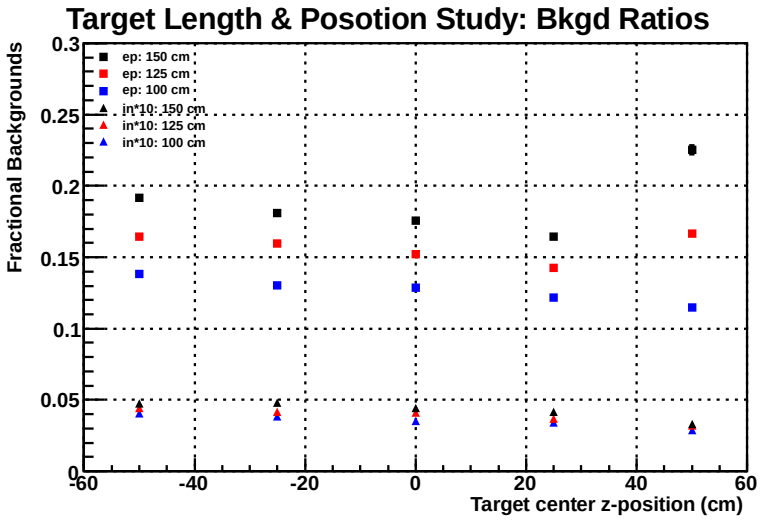
Table 2: Rates, bkgd fractions, and radial Moller detector ranges. Note statistical precisions are $\sim$ 0.05%, 1.1%, and 1.8% for *ee*, *ep*, and *in* respectively

Nominal (old) Collimation Results (magnet 3.0)

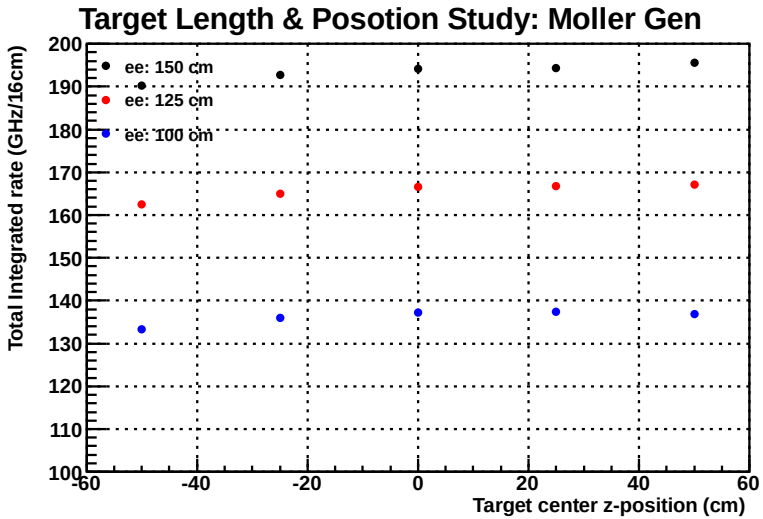


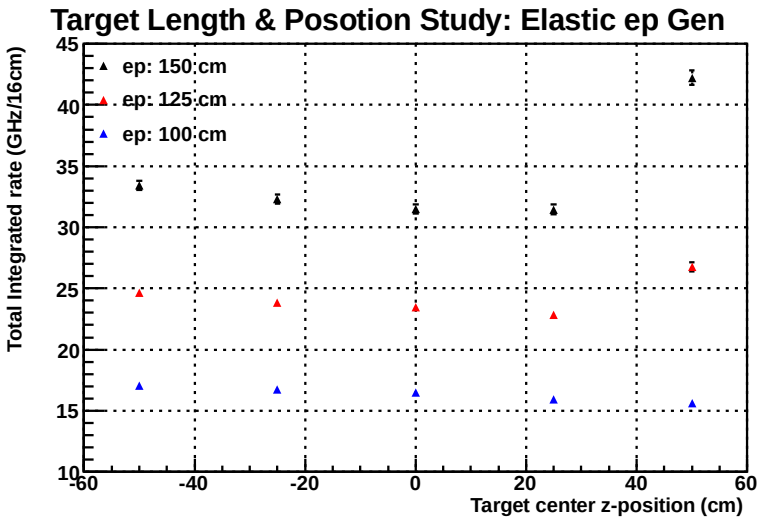


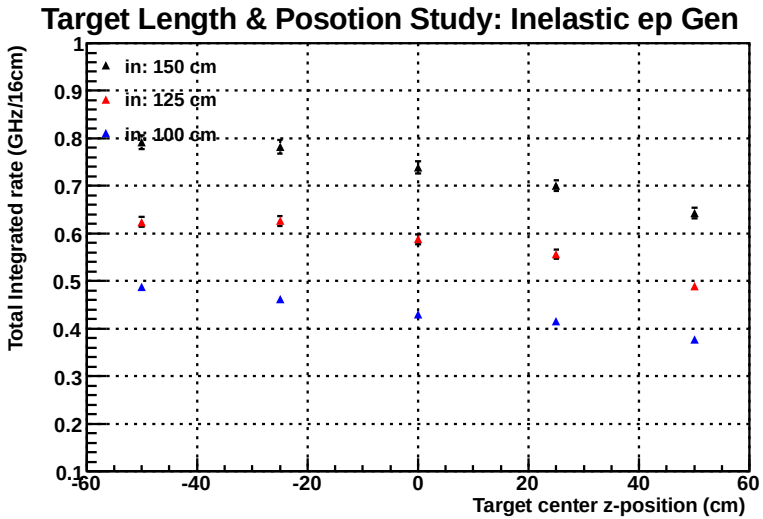


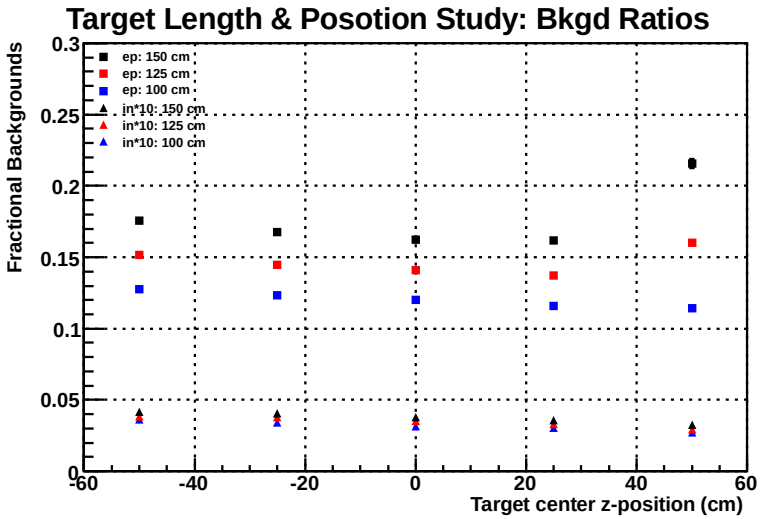


Sculpted Collimation Results (magnet 3.0)









Nominal (old) Collimation Results (magnet 3.0)

Len (cm)	Pos (cm)	R_{ee} (GHz)	R_{ep} (GHz)	ppw (ppm)	ΔA_{raw} (ppb)	bg_{fr} (%)	$\bar{A_{pv}}$ (ppb)	ΔA_{st} (ppb)	$\Delta A_{st}/\bar{A_{pv}}$ (%)
100	-50	110.4	15.3	95.2	0.71	12.2	33.3	0.89	2.69
100	-25	113.3	14.8	94.0	0.70	11.6	33.2	0.88	2.65
100	0	116.9	15.1	92.5	0.69	11.4	33.0	0.86	2.62
100	25	120.3	14.7	91.2	0.68	10.9	32.6	0.85	2.60
100	50	126.9	14.6	88.8	0.66	10.3	32.0	0.82	2.57
125	-50	134.5	22.1	86.2	0.64	14.1	33.0	0.82	2.50
125	-25	138.4	22.1	85.0	0.63	13.8	32.9	0.81	2.46
125	0	142.0	21.6	83.9	0.62	13.2	32.6	0.79	2.44
125	25	148.7	21.2	82.0	0.61	12.5	32.2	0.77	2.40
125	50	156.4	26.0	80.8	0.59	14.1	31.6	0.76	2.42
150	-50	158.1	30.3	79.5	0.59	16.1	32.7	0.77	2.36
150	-25	161.0	29.2	78.8	0.59	15.4	31.3	0.76	2.43
150	0	167.1	29.4	77.4	0.57	15.0	32.2	0.74	2.31
150	25	174.1	28.6	75.8	0.56	14.1	31.8	0.72	2.27
150	50	186.1	41.9	73.3	0.54	18.4	31.2	0.73	2.32

Sculpted Collimation Results (magnet 3.0)

Len (cm)	Pos (cm)	R_{ee} (GHz)	R_{ep} (GHz)	ppw (ppm)	ΔA_{raw} (ppb)	bg_{fr} (%)	$\bar{A_{pv}}$ (ppb)	ΔA_{st} (ppb)	$\Delta A_{st}/\bar{A_{pv}}$ (%)
100	-50	133.4	17.1	86.6	0.64	11.3	32.0	0.81	2.53
100	-25	136.0	16.8	85.8	0.64	11.1	31.8	0.80	2.51
100	0	137.2	16.5	85.4	0.63	10.7	31.7	0.79	2.50
100	25	137.4	15.9	85.3	0.63	10.4	31.5	0.79	2.51
100	50	137.0	15.7	85.4	0.63	11.43	31.5	0.79	2.52
125	-50	162.6	24.7	78.4	0.58	13.2	31.7	0.74	2.34
125	-25	165.1	23.9	77.8	0.58	12.6	31.6	0.73	2.32
125	0	166.5	23.4	77.5	0.58	12.3	31.4	0.73	2.32
125	25	166.8	22.9	77.4	0.57	12.1	31.4	0.73	2.32
125	50	167.2	26.8	77.3	0.57	13.8	31.3	0.74	2.35
150	-50	190.3	33.4	72.5	0.54	14.9	31.4	0.70	2.21
150	-25	192.6	32.3	72.1	0.53	14.4	31.3	0.69	2.20
150	0	194.2	31.5	71.8	0.53	14.0	31.3	0.68	2.18
150	25	194.3	31.5	71.7	0.53	13.9	31.2	0.68	2.19
150	50	195.6	42.2	71.5	0.53	17.7	31.1	0.70	2.26

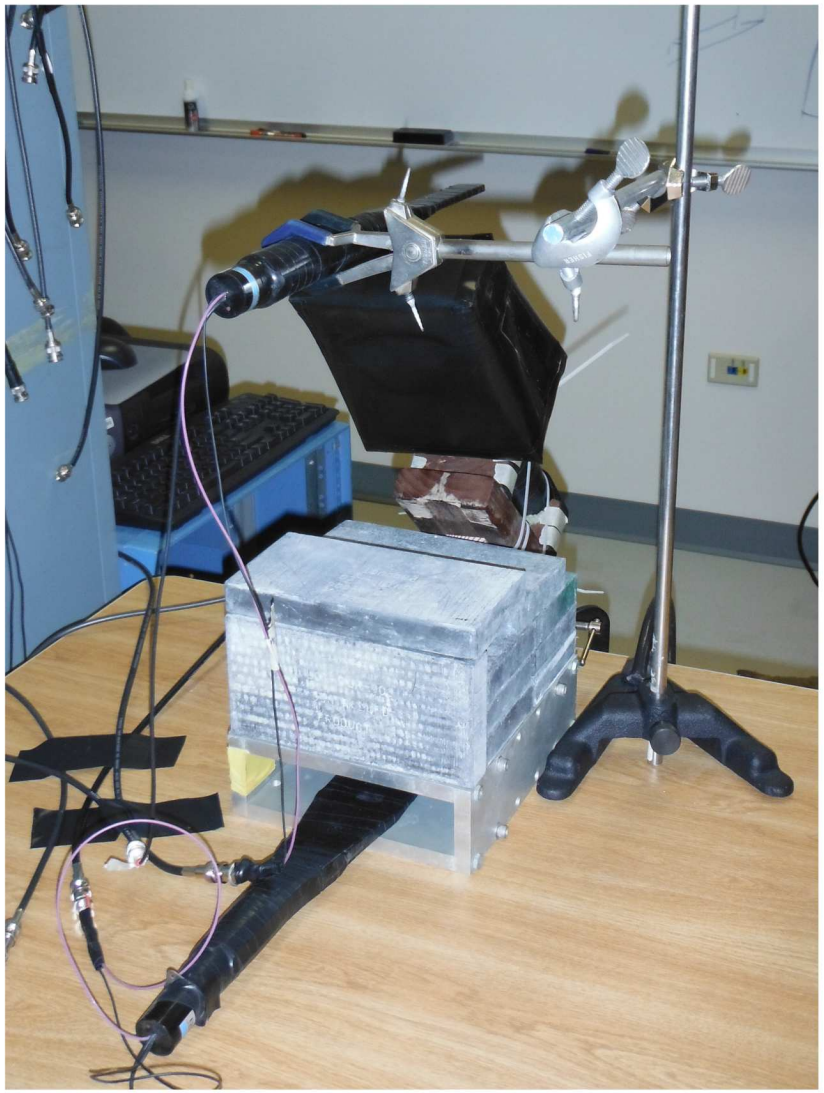
Target Study Summary

- Very preliminary: analysis will be redone as magnet and collimation design evolve
- New sculpted collimation gives overall improvement in FOM ($\Delta A/A$)
- Pushing target downstream increases Moller rate and decreases bkdg fraction, but also slightly decreases A_{pv}...
- A 33% decrease in target length gives 13% worse FOM

ISU Plans
(for CREX which overlap with MOLLER)

- Quartz detector development
  - –Cosmic tests
  - –Beam tests
  - –DAQ and prototype detector working
  - –Purchased quartz pieces (Spectrosil 2000, PREX geometry), and Anolux UVS and other Al mirrors
  - –Student working with Solid Works CAD
- Linearity Studies: LEDs→PMT→ADC
  - –qWeak ADC
  - –Hall A PV ADC

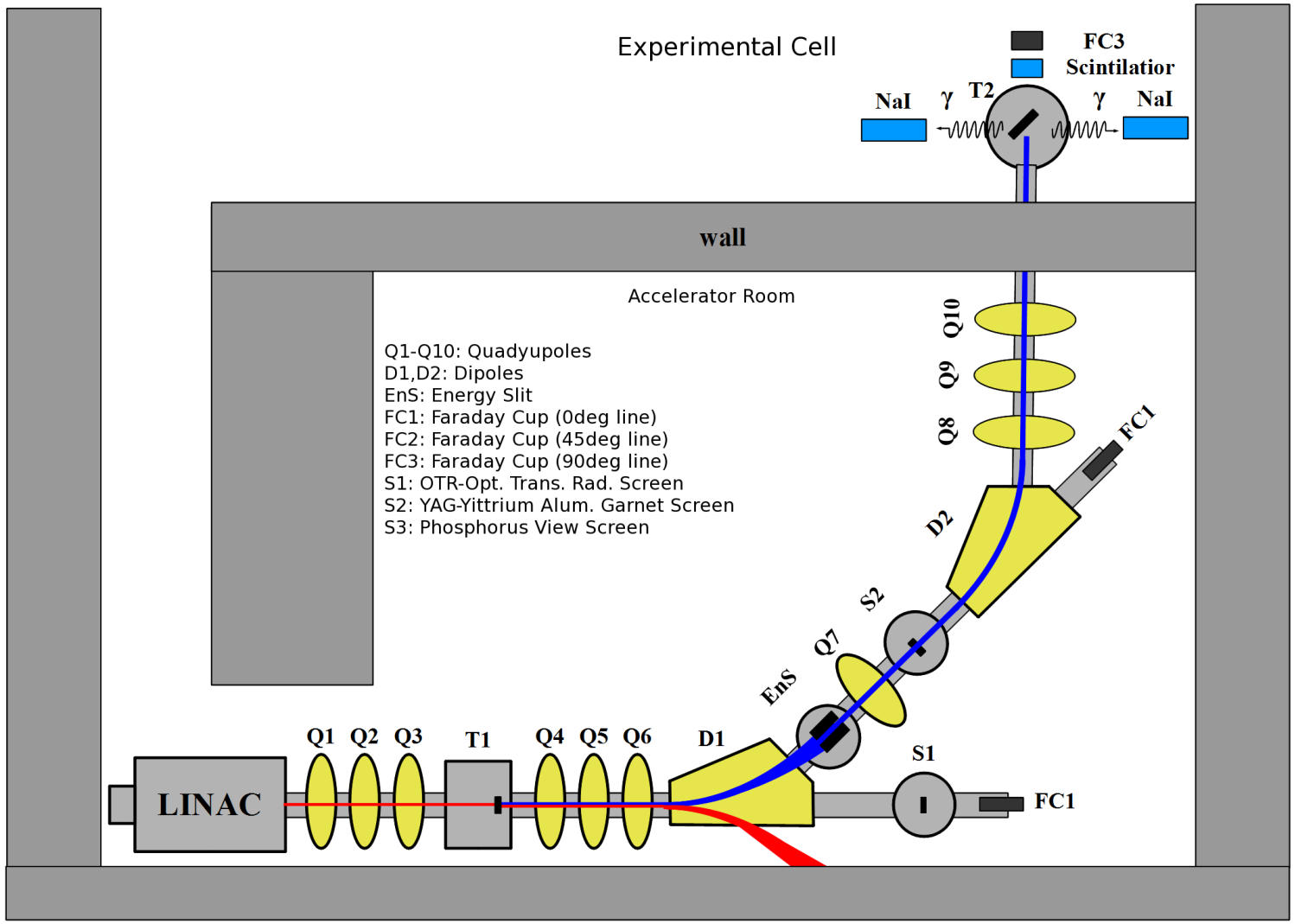
DAQ and Cosmic Test Stand (preliminary setup)



ISU HRRL Facility

- HRRL: High Repetition Rate Linac (name is just historical)
  - –S-band linear electron accelerator with thermionic gun
  - –Maximum Energy: 16 MeV
  - –Peak Current: $\leq$ 100 mA
  - –Repetition Rate: $\leq$ 300 Hz
  - –Pulse Width: $\geq$ 20 ns
- Facility has various beam diagnostic capabilities
  - – Faraday cups for beam current
  - –Optical Transition Radiation Screen for emittance measurements
  - –Phosphorus view screen for beam-target alignment

ISU HRRL Beamline Schematic (not to scale)



ISU HRRL Beamline Photo: 0^o Beamline

ISU HRRL Beamline Photo: 0^o Beamline

ISU HRRL Beamline Photo: 45° Beamline

ISU HRRL Beamline Photo: 90° Beamline

Plans Summary

- Established VME-based DAQ using CODA
- Proof of principle cosmic tests underway
- Formal detector designs are being fabricated
- Planned HRRL run this August to assess ability to use beam for detector characterization
- Start development of linearity test setup this fall; equipment loans for qWeak and hall A ADCs underway (Thanks Paul King and Bob)