

## Power Supplies

**Bob Lambiase**

**September 19-20, 2007**

# Power Supply Systems - Introduction

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There are 159 power supplies in the EBIS system. In addition, high isolation, low capacitance transformers are used to provide AC power to supplies located on high voltage platforms or connected in series.

The power supplies are connected to the control system by BNL designed control interfaces. These interfaces provide isolation through fiber optic cables.

Next, we'll look at the scope of the Power Supply System. The detailed configuration of equipment can be seen with the block diagrams at the end of this presentation.

# PS Scope (1/3)

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## EBIS Platform

- 57 Power supplies
  - Platform Pulser and Bias PSs
  - Gun and Anode PSs, including Solenoid & Transverse Magnet PSs
  - Drift Tube PSs
  - Collector and Extraction PSs
- 8 HV Isolation Transformers
  - Two 200kVA, 150kV Pulse Isolation Transformers – EBIS Platform and Collector PS Rectifier Transformers
  - Six smaller isolation transformers to power equipment for decks at other voltage potentials and to stack Trek power supplies.
- 3 Push-Pull Behlke 30kV Solid State Switches

# PS Scope (2/3)

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## LEBT and External Ion Sources

- 48 Power supplies for the LEBT
  - Flat and Spherical Electrostatic Steering
  - Electrostatic Quadrupoles
  - High Current Pulsed Electromagnetic Solenoid
  - Electromagnetic Steering
- 11 Hollow Cathode Ion Source PSs
  - Source Elements: Bias Platform, Lenses, Filters
  - Transport Elements: Electrostatic Deflectors and Quadrupoles
- 7 Liquid Metal Ion Source PSs
  - Source Elements: Bias Platform, Grids
  - Transport Elements: Electrostatic Deflectors and Quadrupoles

## PS Scope (3/3)

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### MEBT, LINAC, and HEBT

- 8 Power supplies for the MEBT
  - Four 450A Fast Pulsed Electromagnetic Quadrupoles
  - Four 20A Slow Pulsed Electromagnetic Steerers
- 6 Power Supplies for the LINAC
  - Six 450A Fast Pulsed Electromagnetic Quadrupoles
- 22 Power Supplies for the HEBT
  - Eight 40A Slow Pulsed Electromagnetic Quadrupoles
  - Twelve 20A Slow Pulsed Electromagnetic Steerers
  - One 3,000A, 250V, Slow Pulsed Supply Powering the Two Big Bend Magnets
  - One 20A Slow Pulsed Back Leg Winding PS for Big Bend Magnet Offset

# Relational Data Base



An Access data base is used to track all power supplies, transformers, switches, and control interfaces. These items are linked to the purchase orders, funding, racks, and other essential data.

Microsoft Access - [PS Models : Table]

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PS Model	Mfg	V Rating	V Unit	I Rating	I Units	Polarity	Cost Est	Mounting	Width	Depth	Height	EC
+ Trek 10/10B	Trek	10	kV	10.0	mA	Bipolar	\$7,982	Rack with Shelf	17	16.4	7.5	CP
- Trek 20/20C	Trek	20	kV	20.0	mA	Bipolar	\$12,960	Rack	19	25.75	11	CP
PS Name	PS Description	Funds	PO	Rack	Controller	WBS3	Req'd V	RV Units	Req'd			
PS223	Extractor Pulsed PS	DoE	124201	NOT ASSIGNED	Function Gen / Single Output PSI	1.5.2	15	kV				
PS180	Ion Lens 0 - 20kV	DoE	124201	LEBT R03	Function Gen / Single Output PSI	1.5.2	20	kV				
PS181	Ion Lens 20 - 40kV	DoE	124201	LEBT R03	Function Gen / Single Output PSI	1.5.2	20	kV				
PS182	Gridded Lens	DoE	124201	LEBT R02	Function Gen / Single Output PSI	1.5.2	20	kV				
PS002	Drift Tube 0 & 1	NASA	124201	EBIS R02	Function Gen / Single Output PSI	1.5.1	20	kV				
PS003	Drift Tube 2	NASA	124201	EBIS R02	Function Gen / Single Output PSI	1.5.1	20	kV				
PS004	Drift Tube 3	NASA	124201	EBIS R02	Function Gen / Single Output PSI	1.5.1	20	kV				
PS005	Drift Tube 4	NASA	124201	EBIS R06	Function Gen / Single Output PSI	1.5.1	20	kV				
PS006	Drift Tube 5 - 8	NASA	124201	EBIS R06	Function Gen / Single Output PSI	1.5.1	20	kV				
PS007	Drift Tube 9	NASA	124201	EBIS R06	Function Gen / Single Output PSI	1.5.1	20	kV				
PS008	Drift Tube 10 & 11	NASA	124201	EBIS R03	Function Gen / Single Output PSI	1.5.1	20	kV				
PS009	Drift Tube 12 & 13	NASA	124201	EBIS R03	Function Gen / Single Output PSI	1.5.1	20	kV				
PS010	Drift Tube 14	NASA	124201	EBIS R03	Function Gen / Single Output PSI	1.5.1	20	kV				
PS011	Deflector Platform Bias PS	DoE	124201	EBIS R06	Function Gen / Single Output PSI	1.5.1	20	kV				
PS024	Cathode Platform Bias PS	DoE	124201	NOT ASSIGNED	Function Gen / Single Output PSI	1.5.1	20	kV				
PS040	Anode PS 0 - 20 kV	NASA	124201	EBIS R01	Function Gen / Single Output PSI	1.5.1	20	kV				
PS041	Anode PS 20 - 40 kV	NASA	124201	EBIS R01	Function Gen / Single Output PSI	1.5.1	20	kV				
*			0				0					
+ Trek 30/20	Trek	30	kV	20.0	mA	Bipolar	\$26,593	Rack				CP
+ Trek 601C-1	Trek	500	V	20.0	mA	Bipolar	\$2,290	Rack with Shelf	8.75	13.2	4.75	CP



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# Tracking Costs



	Current	Baseline	Δ \$	Δ Pct
EBIS Behlke's and Extractor	\$24,482	\$17,680	\$6,802	38%
EBIS Anode and Drift Tube PSs	\$149,560	\$140,800	\$8,760	6%
Collector PS	\$300,803	\$212,030	\$88,773	42%
EBIS Gun end PSs	\$33,850	\$42,846	-\$8,996	-21%
EBIS Platforms	\$38,673	\$32,030	\$6,643	21%
EBIS Collector / Extraction PSs	\$69,487	\$40,088	\$29,399	73%
Cathode Platform Tx and Pulser	\$153,780	\$120,880	\$32,900	27%
LEBT/XIS Lenses and Deflectors	\$137,896	\$110,272	\$27,624	25%
HCIS PSs	\$31,280	\$36,495	-\$5,215	-14%
LMIS PSs	\$26,725	\$11,730	\$14,995	128%
LEBT Lenses	\$105,250	\$106,090	-\$840	-1%
Dipole PSs	\$166,000	\$166,000	\$0	0%
MEBT/Linac Quad PSs	\$188,000	\$192,000	-\$4,000	-2%
MEBT/HEBT Steerer PSs	\$86,720	\$90,220	-\$3,500	-4%
HEBT Quad PSs	\$72,000	\$64,000	\$8,000	13%
	<b>\$1,584,506</b>	<b>\$1,383,161</b>	<b>\$201,345</b>	<b>13%</b>



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# Cost Increase



Where did the \$ 201k cost increase come from?

Inductrol	\$ 72k
Cathode Platform Pulser	\$ 29k
16 Pole Deflector	\$ 29k
Collector PS	\$ 17k
Danfysik Updated Quote	\$ 13k
LM Extractor	\$ 12k
NRTL Requirements	\$ 7k
Other Design and Cost Changes	\$ 22k
Total	\$ 201k



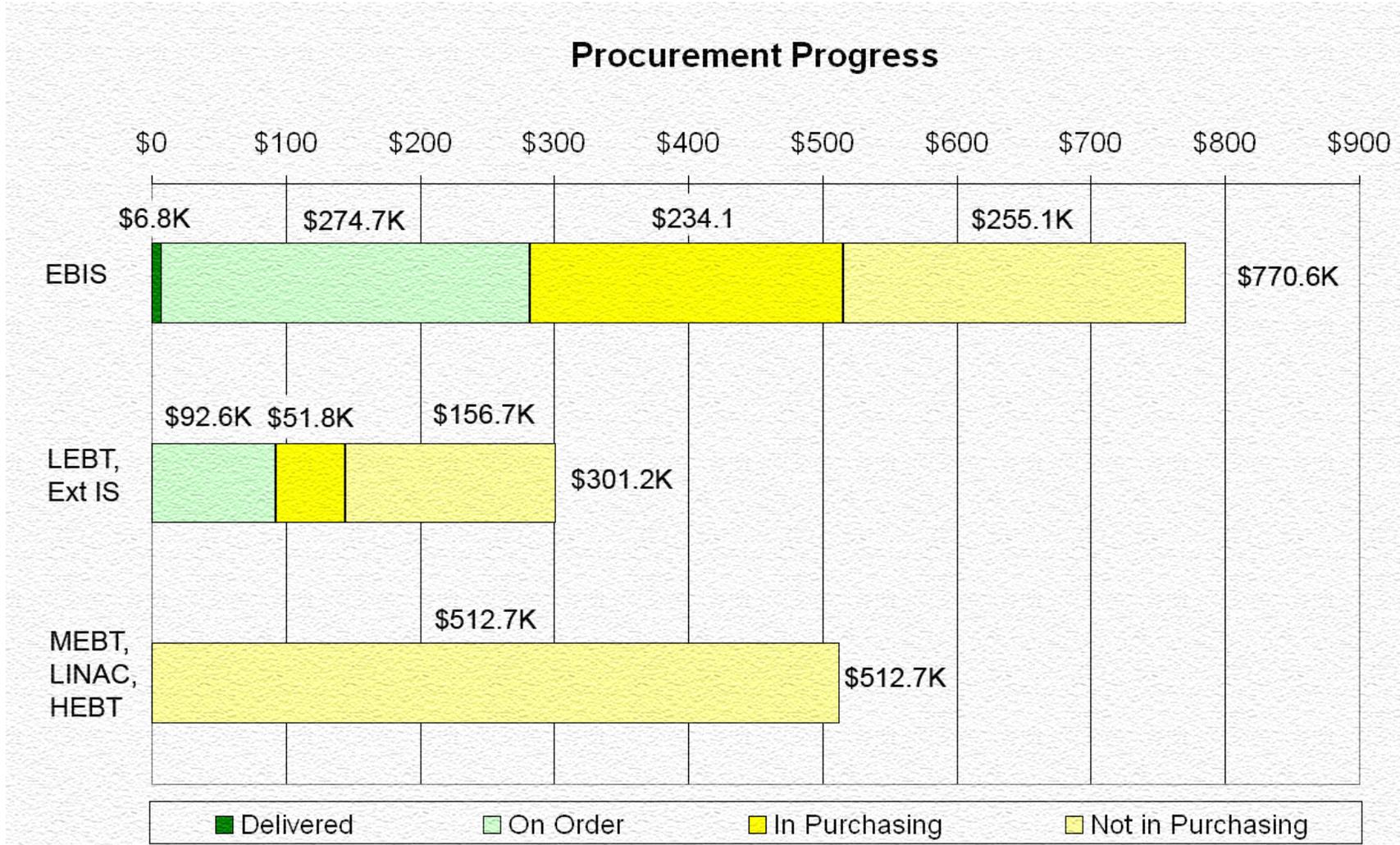
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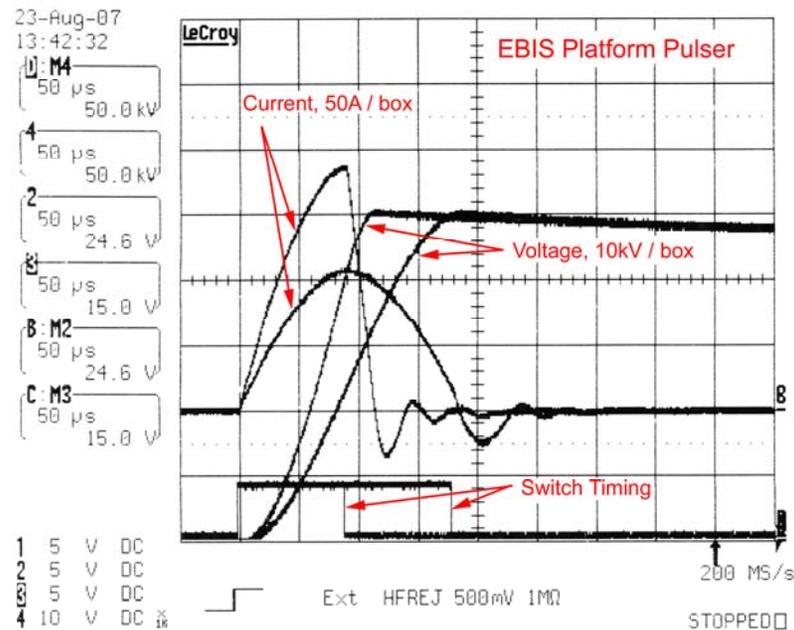
# Procurement Progress



# Hardware: EBIS Platform Pulser



Capacitors in the switch unit (top left) are charged up to 1kV. An IGBT discharges this bank into a 1000:1 step up transformer (bottom left). 50kV pulses are shown below with long and short charging times.



# Hardware: Isolation Transformers



The 480VAC – 480VAC transformer, built for the R&D EBIS and designed to be pulsed at 150kV, is shown at left. Its low inter-winding capacitance (1nF), reduces the load on the EBIS platform pulser.

An identical unit is now on order for the production EBIS, and a similar style (200kVA, high isolation, low capacitance) will be used as the collector rectifier transformer.

The successful test results of the first transformer give us confidence for the other two.

# Hardware: Collector PS



The Collector PS is nearly identical to the AGS Anode PS (at left) delivered last year.

Rated 15kV at 30A continuous, this unit also contains arc detection and a crowbar.

The contract for this supply has been placed with the same vendor as the Anode PS. The similarity of design saves cost and manufacturing time.

# Hardware: Configuration of Smaller Supplies

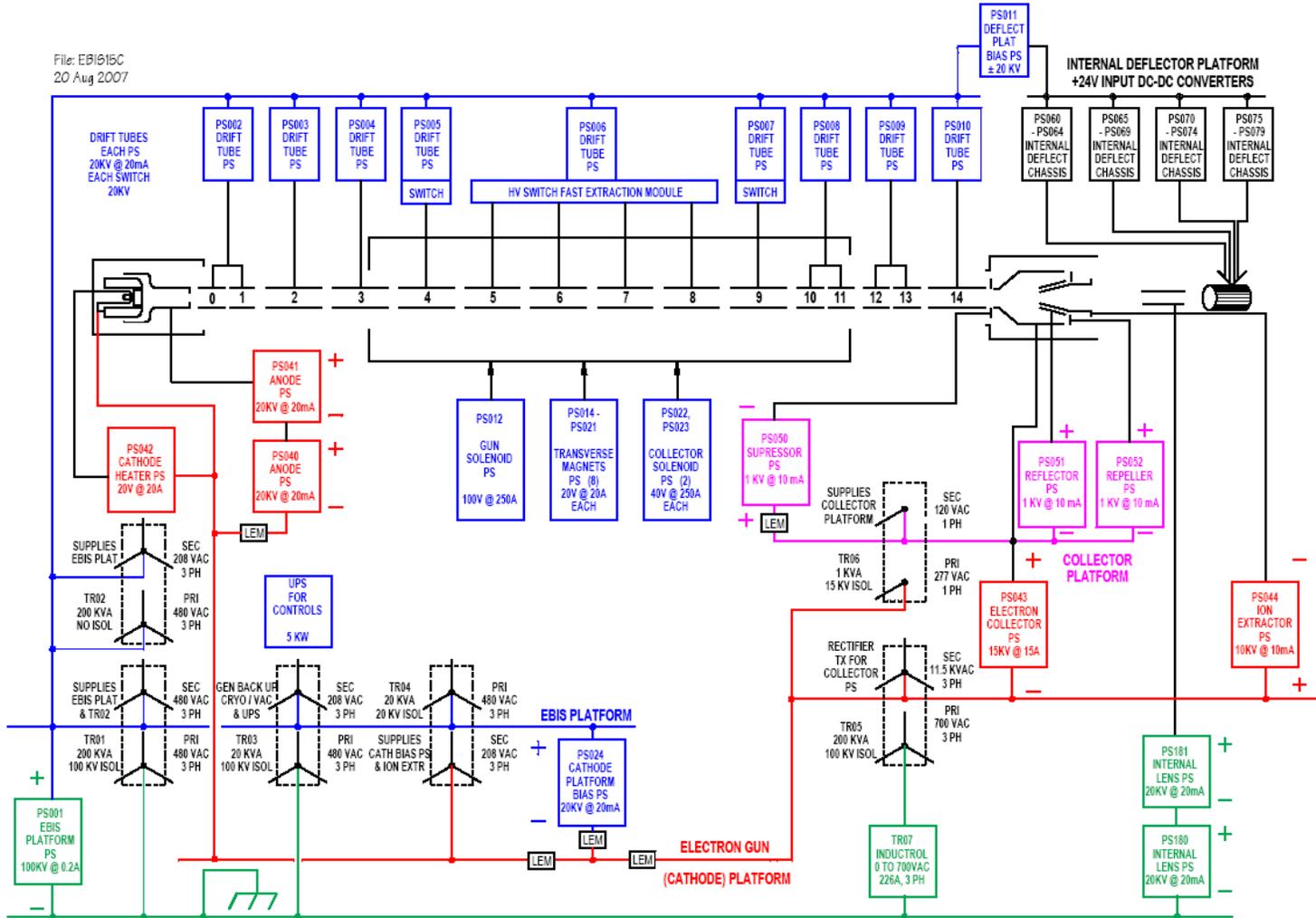


The assembly and deck isolation techniques are directly transferable from experience with the R&D EBIS.

# EBIS Platform PS



File: EB1815C  
20 Aug 2007



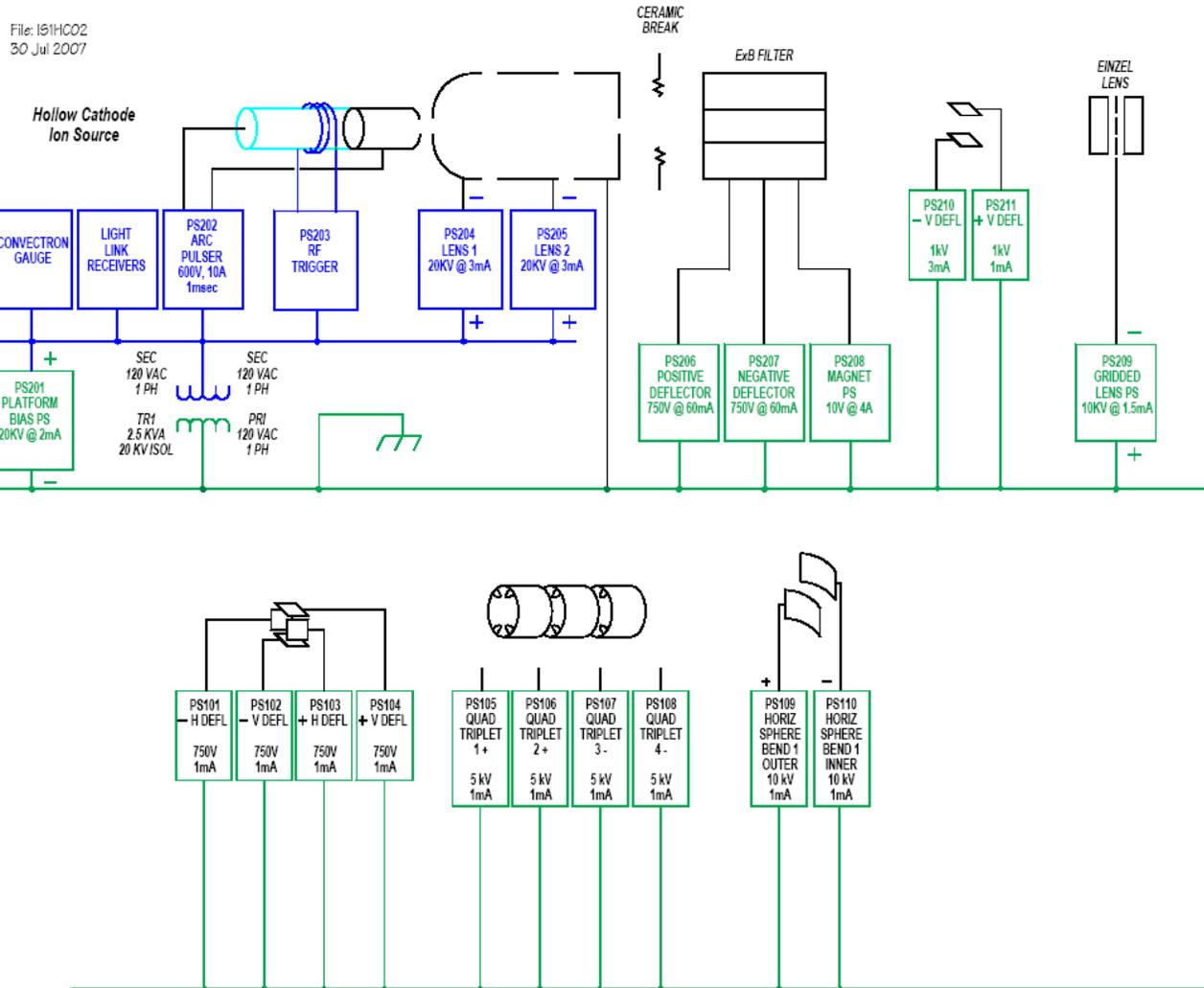
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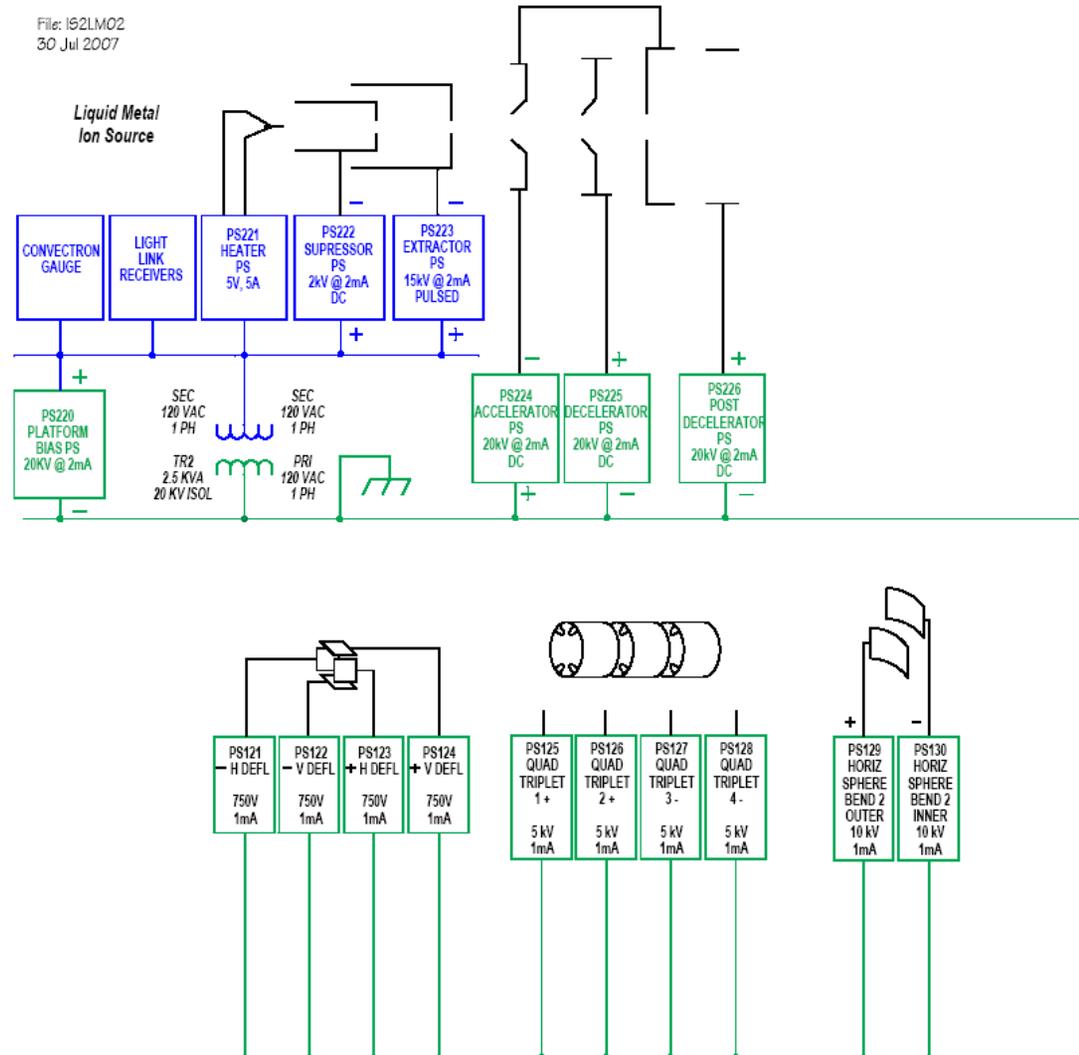


# Hollow Cathode Ion Source PS

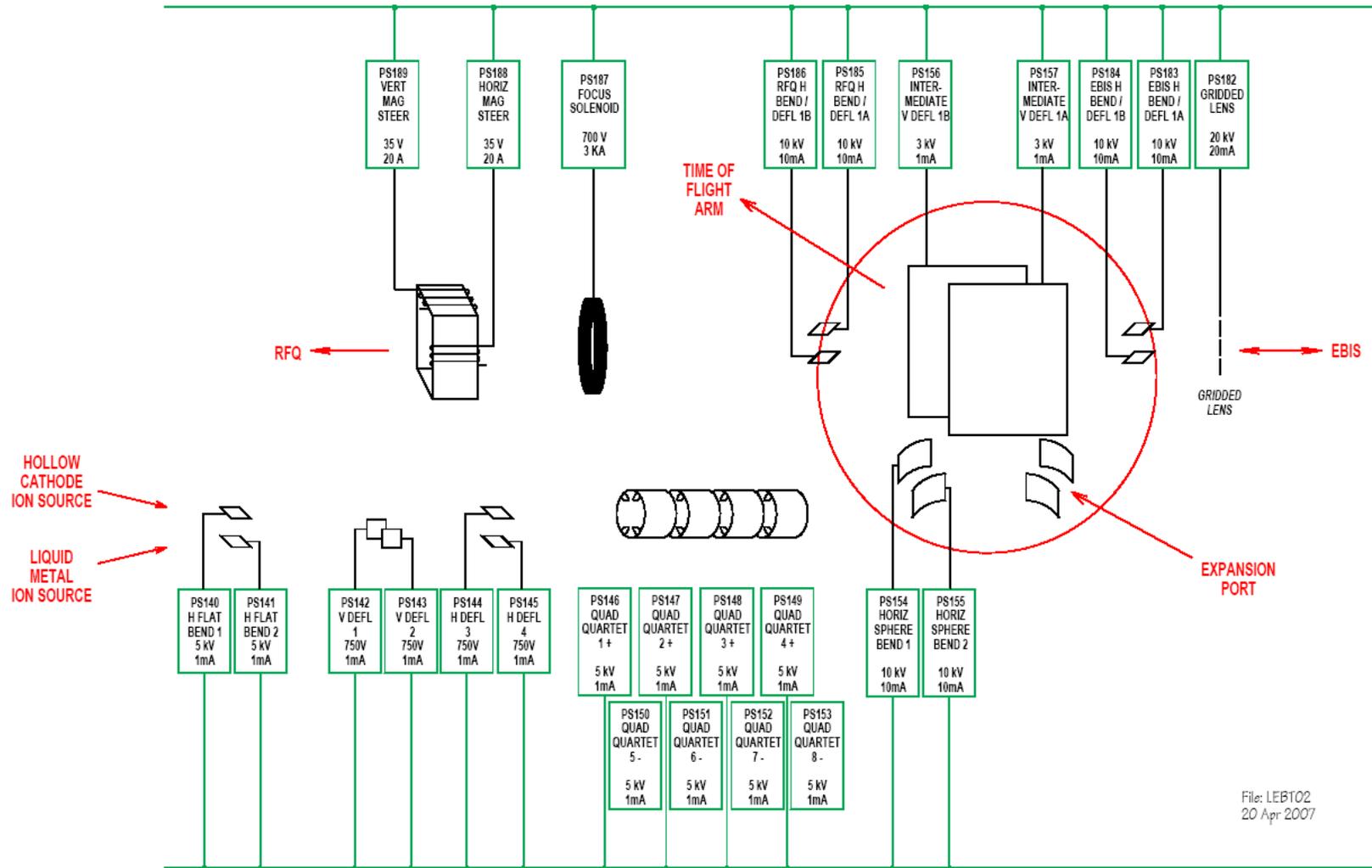


# Liquid Metal Ion Source PS

File: IS2LM02  
30 Jul 2007



# LEBT PS



File: LEBT02  
20 Apr 2007



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# Power Supply Systems - Summary

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The Power Supply System is doing well.

- Tests on the platform pulser and low capacitance isolation transformer have gone well.
- We're now in a period of peak purchasing
- Costs have increased but are close to original estimates